18th International Conference on Accelerator and Large Experimental Physics Control Systems

Tracks

1. General
Project Status Reports
Control System Upgrades
Device Control and Integrating Diverse Systems
Experiment Control

2. Software
Software Technology Evolution
User Interfaces and User eXperience (UX)
Data Management
Data Analytics

3. Hardware
Hardware Technology
Timing Systems, Synchronization and Real-Time Applications
Control System Infrastructure

4. Subsystems
Human Aspects, Collaborations, Management
Functional Safety Systems for Machine Protection, Personnel Safety
Feedback Control, Machine Tuning and Optimization

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14-22 October 2021

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Abstract Booklet

Contents

Contents

Contents

Contents

Program

18-Oct-21 12:00 – 12:05
12:00 – 12:05 MOOL — Opening Session

18-Oct-21 12:05 – 12:30
12:05 – 12:30 MOKL — Keynote Session I
MOKL01 Highlights of Accelerator R&D at Shanghai Light Sources Cluster
Z.T. Zhao (SSRF)

18-Oct-21 12:30 – 13:15
12:30 – 13:15 MOAL — Project Status Reports I
MOAL01 Maturity of the MAX IV Laboratory in Operation and Phase II Development
V.H. Hardion (MAX IV Laboratory, Lund University)
MOAL02 Status of the National Ignition Facility (NIF) Integrated Computer Control and Information Systems
M. Fedorov (LLNL)
MOAL03 From SKA to SKAO: Early Progress in the SKAO Construction
J. Santander-Vela (SKAO)

18-Oct-21 12:30 – 13:15
12:30 – 13:15 MOAR — Control System Upgrades I
MOAR01 Modernizing the SNS Control System
K.S. White (ORNL) K.L. Mahoney (ORNL RAD)
MOAR02 Modernizing Digital Video Systems at the National Ignition Facility (NIF): Success Stories, Open Challenges and Future Directions.
V.K. Gopalan (LLNL)
MOAR03 LOFAR2.0: Station Control Upgrade
T. Juerges (ASTRON)

18-Oct-21 13:15 – 14:30
13:15 – 14:30 MOBL — Software Technology Evolution I
MOBL01 The ELT Control System: Recent Developments
G. Chiozzi (ESO)
MOBL02 Real-time framework for ITER control systems
W.R. Lee (ITER Organization) S. Lee (KFE) D.R. Makowski (TUL-DMCS) A. Winter (MPI/IPP)
MOBL03 Machine Learning Platform: Deploying and Managing Models in the CERN Control System
J.-B. de Martel (CERN)
MOBL04 Karabo Data Logging: InfluxDB Backend and Grafana UI
G. Flucke (EuXFEL) D.P. Spruce (MAX IV Laboratory, Lund University)
MOBL05 Photon Science Controls: A Flexible and Distributed LabVIEW Framework for Laser Systems
B.A. Davis (LLNL)

18-Oct-21 13:15 – 14:30
13:15 – 14:30 MOBR — Device Control and Integrating Diverse Systems I
MOBR01 ROMULUSlib: An autonomous, TCP/IP-based, multi-architecture C networking library for DAQ and Control applications
A. Yadav (CERN)
MOBR02 Control, Readout and Monitoring for the Medium-Sized Telesopes in the Cherenkov Telescope Array
U. Schwanke (HU Berlin) D. Melkumyan (DESY Zeuthen) I. Oya (CTA)
MOBR03 Hexapod Control System Development Towards Arbitrary Trajectories Scans at Sirius/lnls
A.Y. Horita (LNLS) G.G. Silva (UNICAMP)
MOBR04 Generic data acquisition control system stack on the MTCA platform
J. Krasna (COSYLAB, Control System Laboratory)
MOBR05 Motion Software Stack Developments for Powerpmac(r) in the Australian Synchrotron
N. Afshar (AS - ANSTO) M. Clift (ASCo)

18-Oct-21 14:30 – 15:30
14:30 – 15:30 MOPV — Posters

MOPV001 Status of the SARAF-Phase2 Control System
F. Gougnaud (CEA-DRF-IRFU) D. Darde (CEA-IRFU) H. Isakov (Soreq NRC) T. Zchut (CEA LIST)
MOPV002 CENBG Control System and Specific Instrumentation Developments for SPIRAL2-DESIR Setups
L. Daudin (CENBG)
MOPV003 LASER MEGAJOULE FACILITY OPERATING SOFTWARE OVERVIEW
J-P. Airiau (CEA)
MOPV005 Towards a New Control System for PetraIV
R. Bacher (DESY)
MOPV006 The New Small Wheel LV Power supply DCS for the ATLAS experiment
C. Paraskevopoulos (NTUA) A. Bruni (INFN/CNAF)
MOPV007 Progress of The HIAF Control System
W. Zhang (IMP/CAS)
MOPV008 Development of Computer Centralized Control System for Large- Scale Equipment
Ms. Yao (CAEP)
MOPV009 The High Voltage DCS System for the New Small Wheel upgrade of the ATLAS experiment
E. Karentzos (CERN) A. Bruni (INFN/CNAF)
MOPV010 Working under pandemic conditions: contact tracing meets technology
E. Blanco Vinuela (CERN)
MOPV011 The Inclusion of White Rabbit into the Global Industry Standard IEEE 1588
M. Lipinski (CERN)
MOPV012 The ESRF-EBS Simulator: a commissioning booster.
S.M. Liuzzo (ESRF)
MOPV013 A Dynamic Beam Scheduling System for the FAIR Accelerator Facility
S. Krepp (GSI)
MOPV014 Upgrade of the NewSUBARU control system
N. Hosoda (JASRI) T. Fukui (RIKEN/SPring-8)
MOPV015 Control System of the SRILAC Project at RIBF
A. Uchiyama (RIKEN Nishina Center) A. Kamoshida (National Instruments Japan Corporation) K. Kaneko (SHI Accelerator Service Ltd.)
MOPV016 Design and Implement of Web Based SCADA System for HUST Field-Reversed Configuration Device
F.Y. Wu (HUST) W. Zheng (Huazhong University of Science and Technology, State Key Laboratory of Advanced Electromagnetic Engineering and Technology,)
MOPV017 CERN SCADA Systems 2020 Large Upgrade Campaign Retrospective
L.G. Goralczyk (CERN)
MOPV018 Linac-200 gun control system: status and plans
M.A. Nozdrin (JINR)
MOPV019 Pvecho: Design of a VISTA/EPICS Bridge for the ISIS Control System Transition
K.R.L. Baker (STFC/RAL/ISIS)
MOPV020 Digitisation of the Analogue Waveform System at ISIS
W.A. Frank (STFC/RAL/ISIS)
MOPV021 Upgrading the National Ignition Facility's (NIF) Integrated Computer Control System to Support Optical Thompson Scattering (OTS) Diagnostic
A.I. Barnes (LLNL)
MOPV022 Upgrade of Hardware Controls for the STAR Experiment at RHIC
D. Tlusty (Creighton University)
MOPV024 vscode-epics, a VSCode Module to Enlight Your Epics Code
V. Nadot (CEA-IRFU)
MOPV025 TangoGraphQL: A GraphQL binding for Tango control system Web-based applications
J.L. Pons (ESRF)
MOPV026 Integrating OPC UA Devices in EPICS

19-Oct-21 12:30 – 13:15
12:30 – 13:15 TUAL — Hardware Technology
TUAL01 CompactPCI-Serial Hardware Toolbox for SLS 2.0
B. Kalantari (PSI)
TUAL02 Development a Single Cavity Regulation Based on microtca.4 for SAPS-TP
W. Long (IHEP) Y. Liu (DNSC)
TUAL03 R&D Studies for the Atlas Tile Calorimeter Daughterboard.
E. Valdes Santurio (FYSIKUM, AlbaNova, Stockholm University) C. Bohm (Stockholm University)

19-Oct-21 12:30 – 13:15
12:30 – 13:15 TUAR — Control System Upgrades II
TUAR01 UPGRADE OF THE CMS ECAL DETECTOR CONTROL SYSTEM DURING THE CERN LARGE HADRON COLLIDER LONG SHUTDOWN II
L. Marchese (ETH)
TUAR02 The Phase-1 Upgrade of the ATLAS Level-1 Calorimeter Trigger
A.G. Kazarov (PNPI) T. Mkrtchyan (KIP)
TUAR03 The Control System of the Linac-200 Electron Accelerator at JINR
A. Trifonov (JINR)

19-Oct-21 13:15 – 14:30
13:15 – 14:30 TUBL — Software Technology Evolution II
TUBL01 Distributed Caching at Cloud Scale With Apache Ignite for the C2MON Framework
T. Marques Oliveira (CERN)
TUBL02 Implementing an Event Tracing Solution With Consistently Formatted Logs for the SKA Telescope Control System
S.N. Twum (SARAO) A. Bridger (ROE, UTAC) A. Bridger (SKAO)
TUBL03 Tango Controls RFCs
P.P. Goryl (S2Innovation) S. Blanch-Torné (ALBA-CELLS Synchrotron) A. Gotz (ESRF) V.H. Hardion (MAX IV Laboratory, Lund University) L. Pivetta (Elettra-Sincrotrone Trieste S.C.p.A.)
TUBL04 CI-CD Practices at SKA
M. Di Carlo (INAF - OAAB) M. Dolci (INAF - OA Teramo) P. Harding (Catalyst IT) J.B. Morgado (GRIT) U. Yilmaz (SKAO)
TUBL05 Pysmlib: a Python Finite State Machine Library for EPICS
D. Marcato (INFN/LNL) M.A. Bellato (INFN- Sez. di Padova)

19-Oct-21 13:15 – 14:30
13:15 – 14:30 TUBR — Device Control and Integrating Diverse Systems II
TUBR01 Nominal Device Support (NDSv3) as a Software Framework for Measurement Systems in Diagnostics
R. Lange (ITER Organization) M. Astrain (UPM-I2A2) J. Moreno (GMV)
TUBR02 Design Patterns for the SKA Control System
S. Vrcic (SKAO)
TUBR03 Control System for 6 MeV Linear Accelerator at LINAC Project PINSTECH
N.U. Saqib (PINSTECH)
TUBR04 Control System of Cryomodule Test Platforms for SHINE
H.Y. Wang (SSRF)
TUBR05 Integrating OPC UA Devices into EPICS Using the Open62541 Library
S. Marsching (Aquenos GmbH) E. Blomley (KIT)

19-Oct-21 14:30 – 15:30
14:30 – 15:30 TUPV — Posters

TUPV001 The Mirror System Benches Kinematics Development for Sirius/LNLS
G.N. Kontogiorgos (LNLS)
TUPV002 Motion Control Improvements for the Kirkpatrick-Baez Mirror System for Sirius/LNLS EMA Beamline

TUPV029 Controls.kt - a multiplatform API for device servers
A.A. Nozik (MIPT)
TUPV030 Redesign of the VELO Thermal Control System Forfuture Detector Development
S.A. Lunt (UCT Physics) B. Verlaat (CERN)
TUPV031 LHC Vacuum Supervisory Application for Run 3
S. Blanchard (CERN)
TUPV032 Challenges of Automating the Photocathode Fabrication Process at CERN
C. Charrondière (CERN)
TUPV033 Distributed Transactions in CERN's Accelerator Control System
F. Hoguin (CERN)
TUPV034 Development of an Automated High Temperature Superconductor Coil Winding Machine at CERN
H. Reymond (CERN) H. Felice (LBNL)
TUPV035 Continuous Integration for PLC-based Control System Development
B. Schofield (CERN)
TUPV036 An Evaluation of Schneider M580 HSBY PLC Redundancy in the R744 System A Cooling Unit
D.I. Teixeira (University of Cape Town) L. Davoine (CERN)
TUPV037 MODULAR SOFTWARE ARCHITECTURE FOR THE NEW CERN INJECTOR WIRE-SCANNERS
A. Guerrero (CERN)
TUPV038 OPC UA Controls for ATCA Back-End Electronics
P. Moschovakos (CERN)
TUPV039 A Reliable Monitoring and Control System for Vacuum Surface Treatments
J. Tagg (CERN)
TUPV040 A Python Package For Generating Motor Homing Routines
A.S. Palaha (DLS)
TUPV042 Collision Avoidance Systems In Synchrotron SOLEIL
C. Engblom (SOLEIL) S. Bouvel (EFOR)
TUPV043 BLISS at the heart of ESRF Data Acquisition
M. Guijarro (ESRF)
TUPV044 Remote User Operation with Karabo at the European XFEL
A. Silenzi (EuXFEL) D.P. Spruce (MAX IV Laboratory, Lund University)
TUPV045 Mamba: The experimental control and data acquisition software system for next generation beamlines in HEPS
Y. Zhang (IHEP) C.P. Chu (Nanjing University, College of Engineering and Applied Sciences)
TUPV046 Modification of Data Acquisition System in HLS-II XMCD Experimental Station
Z.Z. Zhang (USTC/NSRL)
TUPV047 Controlling the Cern Experimental Area Beams
B. Rae (CERN) L. Gatignon (Lancaster University)
TUPV048 Updates and Remote Challenges for IBEX, Beamline Control at Isis Pulsed Neutron and Muon Source
F.A. Akeroyd (STFC/RAL/ISIS)
TUPV049 The IBEX Script Generator
J.C. King (STFC/RAL/ISIS)
TUPV050 Control system upgrade of the High-Pressure cell for pressure-jump x-ray diffraction
R. Mercado (DLS)

20-Oct-21 12:00 – 12:30
12:00 – 12:30 WEKL — Keynote Session III
WEKL01 Digital Transformation of Urban Economy and Case Study
D.J. Ning (SARI-CAS)

20-Oct-21 12:30 – 13:15
12:30 – 13:15 WEAL — Feedback Control, Machine Tuning and Optimization I
WEAL01 Image Processing Alignment Algorithms for the Optical Thomson Scattering Laser at the National Ignition Facility
A.A.S. Awwal (LLNL)
WEAL02 A framework for high level machine automation based on behavior tree

Program

THBL01 Control System Management and Deployment at MAX IV
B. Bertrand (MAX IV Laboratory, Lund University)
THBL02 Explore the Capability of Ethercat as an Alternative of Real-Time Control System for the Alma Observatory
T.C. Shen (ALMA Observatory) R.A. Augsburger (Universidad de La Frontera)
THBL03 The State of Containerization in CERN Accelerator Controls
R. Voirin (CERN)
THBL04 Kubernetes for EPICS IOCs
G. Knap (DLS)

21-Oct-21 13:15 – 14:30
13:15 – 14:30 THBR — Timing Systems, Synchronization and Real-Time Applications
THBR01 Renovation of the Trigger Distribution in CERN's Open Analogue Signal Information System Using White Rabbit
D. Lampridis (CERN) D. Michalik (Aalborg University)
THBR02 White Rabbit and MTCA.4 use in the LLRF upgrade for CERN's SPS
T. Wlostowski (CERN)
THBR03 Prototype of White Rabbit Based Beam-Synchronous Timing Systems for SHINE
P.X. Yu (SSRF)
THBR04 Nanosecond machine learning with BDT for high energy physics
T.M. Hong (University of Pittsburgh)
THBR05 An integrated scheme for online correction of laser focal position
N.M. Cook (RadiaSoft LLC) S.K. Barber (LBNL)

21-Oct-21 14:30 – 15:30
14:30 – 15:30 THPV — Posters

THPV001 Supervisory System for the Sirius Scientific Facilities
L.C. Arruda (LNLS)
THPV004 Open-Hardware Knob System for Acceleration Control Operations
E. Munaron (INFN/LNL)
THPV005 Virtual Reality and Control Systems: How a 3D System Looks Like
L. Pranovi (INFN/LNL)
THPV006 Design of real-time alarm system for CAFe
N. Xie (IMP/CAS)
THPV007 Fast Creation of Control and Monitor Graphical User Interface for Pepc of Laser Fusion Facility Based on Icsff
L. Li (CAEP)
THPV008 Signal metadata management interface for Spring-8
M. Celary (S2Innovation) K. Uchida (COSYLAB Japan)
THPV009 Web Gui Development and Integration in Libera Instrumentation
D. Bisiach (I-Tech)
THPV010 Scaling Up the Alba Cabling Database and Plans to Turn Into an Asset Management System
I. Costa (ALBA-CELLS Synchrotron)
THPV011 Notifications With Native Mobile Application
B. Bertrand (MAX IV Laboratory, Lund University) E. Laface (ESS)
THPV012 LHC Collimation Controls System for Run III Operation
G. Azzopardi (CERN) G. Valentino (University of Malta, Information and Communication Technology)
THPV013 WRAP - A Web-based Rapid Application Development Framework for CERN's Controls Infrastructure
E. Galatas (CERN)
THPV014 Adopting PyQt For Beam Instrumentation GUI Development At CERN
S. Zanzottera (CERN)
THPV015 New Timing Sequencer Application in Python with Qt - Development Workflow and Lessons Learnt

A. Costa (INAF-OACT)

THPV046 Virtualized Control System Infrastructure at LINAC Project, PINSTECH
N.U. Saqib (PINSTECH)

THPV047 High Level Applications for HEPS
X.H. Lu (IHEP CSNS) H.F. Ji (IHEP)

THPV048 Novel Control System for the LHCb Scintillating Fibre Tracker Detector Infrastructure
M. Ostrega (CERN)

THPV049 Virtualisation and Software Appliances as Means for Deployment of SCADA in Isolated Systems
P. Golonka (CERN)

22-Oct-21 12:00 – 12:30

12:00 – 12:30 FRKL — Keynote Session V

FRKL01 Laser Ion Accelerator and Its Applications
C. Lin (PKU)

22-Oct-21 12:30 – 13:45

12:30 – 13:45 FRAL — Project Status Reports II

FRAL01 THE LASER MEGAJOULE FACILITY STATUS REPORT
H. Cortey (CEA)

FRAL02 DISCOS Updates
S. Poppi (INAF - OAC) M. De Biaggi (INAF - IRA) M. Landoni (INAF-Osservatorio Astronomico di Brera) F.R. Vitello (INAF IRA)

FRAL03 CERN Cryogenic Controls Today and Tomorrow
M. Pezzetti (CERN)

FRAL04 The Control System of the New Small Wheel Electronics for the ATLAS experiment
P. Tzanis (NTUA) A. Bruni (INFN/CNAF)

FRAL05 Mace Camera Electronics: Control, Monitoring & Safety Mechanisms
S.K. Neema (BARC) J. Hariharan (Bhabha Atomic Research Centre (BARC))

22-Oct-21 12:30 – 13:30

12:30 – 13:30 FRAR — User Interfaces and User eXperience (UX) II

FRAR01 Taranta, the No-Code Web Dashboard in production
M. Eguiraun (MAX IV Laboratory, Lund University) V. Alberti (INAF-OAT) M. Canzari (INAF - OAAB) H.R. Ribeiro (Universidade do Porto, Faculdade de CiÃªncias)

FRAR02 canone3: a new service and development framework for the web and platform independent applications
L. Zambon (Elettra-Sincrotrone Trieste S.C.p.A.)

FRAR03 A Major update of web based development toolkit for control system of large-scale physics experiment device
X.H. Xie (HUST) W. Zheng (Huazhong University of Science and Technology, State Key Laboratory of Advanced Electromagnetic Engineering and Technology,)

FRAR04 Phoebus Olog
K. Shroff (BNL) G. Weiss (ESS)

22-Oct-21 13:45 – 15:00

13:45 – 15:00 FRBL — Data Analytics

FRBL01 Machine Learning for Anomaly Detection in Continuous Signals
A.A. Saoulis (STFC/RAL/ISIS)

FRBL02 Tackling Black Box Machine Learning Algorithms for Light-Beam Performance
T.Y. Chen (Association for Computing Machinery)

FRBL03 A Literature Review on the Efforts Made for Employing Machine Learning in Synchrotrons
A. Khaleghi (IKIU) F.A. Ahmad Mehrabi (ILSF)

FRBL04 Real-Time Azimuthal Integration of X-Ray Scattering Data on FPGAs
Z. Matej (MAX IV Laboratory, Lund University) C. Johnsen (NBI) C. Weninger (Max Planck Institute for the Physics of Complex Systems)

MOOL — Opening Session

MOKL — Keynote Session I

Highlights of Accelerator R&D at Shanghai Light Sources Cluster

Z.T. Zhao (SSRF)

In order to establish a world-class photonic science research center, several large-scale facilities including synchrotron radiation light source and free electron lasers had been scheduled at SARI. SSRF had been completed at the end of 2010 and currently in operation as the only third-generation synchrotron radiation source in China. SXFEL-TF has completed and demonstrated EEHG-HGHG mode at the end of 2020. This facility will be upgraded to a EXFEL-UF in 2021. The SHINE project started Infrastructure construction and key instruments development from 2018. Currently the injector tunnel is ready for accelerator installation and commissioning. To ensure the smooth construction of the aforementioned accelerator facilities, the accelerator team has carried out research on a number of key technologies: including superconducting acceleration modules, room temperature high-gradient acceleration technology, advanced undulator technology, and digital beam diagnostics and control technology. This article will briefly introduce the construction and operation of the above-mentioned large scientific facilities, as well as the latest progress of key technology development.

MOAL — Project Status Reports I

Maturity of the MAX IV Laboratory in Operation and Phase II Development

V.H. Hardion, P.J. Bell, M. Eguiraun, T. Eriksson, J.M. Klingberg, M. Lindberg, Z. Matej, S. Padmanabhan, A. Salnikov, P. Sjöblom, D.P. Spruce (MAX IV Laboratory, Lund University)

MAX~IV Laboratory, the first 4th generation synchrotron located in the south of Sweden, entered operation in 2017 with the first three experimental stations. In the past two years the project organisation has been focused on phase II of the MAX IV Laboratory development, aiming to raise the number of beamlines in operation to 16. The KITS group, responsible for the control and computing systems of the entire laboratory, was a major actor in the realisation of this phase as well as in the continuous up-keep of the user operation. The challenge consisted principally of establishing a clear project management plan for the support groups, including KITS, to handle this high load in an efficient and focused way, meanwhile gaining the experience of operating a 4th generation light source. The momentum gained was impacted by the last extensive shutdown due to the pandemic and shifted toward the remote user experiment, taking advantage of web technologies. This article focuses on how KITS has handled this growing phase in term of technology and organisation, to finally describe the new perspective for the MAX IV Laboratory, which will face a bright future.

Status of the National Ignition Facility (NIF) Integrated Computer Control and Information Systems

M. Fedorov, A.I. Barnes, L. Beaulac, G.K. Brunton, A.D. Casey, J.R. Castro Morales, J. Dixon, C.M. Estes, M.S. Flegel, V.K. Gopalan, S. Heerey, R. Lacuata, V.J. Miller Kamm, M. Paul, B.M. Van Wonterghem, S. Weaver (LLNL)

The National Ignition Facility (NIF) is the world's most energetic laser system used for Inertial Confinement Fusion (ICF) and High Energy Density Physics (HEDP) experimentation. Each laser shot delivers up to 1.9 MJ of ultraviolet light, driving target temperatures to in excess of 180 million K and pressures 100 billion times atmospheric ' making possible direct study of conditions mimicking interiors of stars and planets, as well as our primary scientific applications: stockpile stewardship and fusion power. NIF control and diagnostic systems allow physicists to precisely manipulate, measure and image this extremely dense and hot matter. A major focus in the past two years has been adding comprehensive new diagnostic instruments to evaluate increasing energy and power of the laser drive. When COVID-19 struck, the controls team leveraged remote access technology to provide efficient operational support without stress of on-site presence. NIF continued to mitigate inevitable technology obsolescence after 20 years since construction. In this talk, we will discuss successes and challenges, including NIF progress towards ignition, achieving record neutron yields in early 2021.
LLNL-ABS-821973

Funding: This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344

From SKA to SKAO: Early Progress in the SKAO Construction

J. Santander-Vela, M. Bartolini, M. Miccolis, N.P. Rees (SKAO)

The Square Kilometre Array telescopes have recently started their construction phase, after years of pre-construction effort. The new SKA Observatory (SKAO) intergovernmental organisation has been created, and the start of construction (T0) has already happened. In this talk, we summarise the construction progress in our facility, and the role that agile software development and open-source collaboration, and in particular the development of our TANGO-based control system, is playing.

MOAR — Control System Upgrades I

MOAR01

Modernizing the SNS Control System

K.S. White, K.-U. Kasemir, K. Vodopivec, D.C. Williams (ORNL) K.L. Mahoney (ORNL RAD)

The Spallation Neutron Source at Oak Ridge National Laboratory has been operating since 2006. An upgrade to double the machine power from 1.4 MW to 2.8 MW is currently underway and a project to add a second target station is in the preliminary design phase. While each project will add the controls needed for their specific scope, the existing control system hardware, software, and infrastructure require upgrades to maintain high availability and ensure the system will meet facility requirements into the future. While some systems have received new hardware due to obsolescence, much of the system is original apart from some maintenance and technology refresh. Software will also become obsolete and must be upgraded for sustainability. Further, requirements for system capacity can be expected to increase as more subsystems upgrade to smarter devices capable of higher data rates. This paper covers planned improvements to the integrated control system with a focus on reliability, sustainability, and future capability.

MOAR02

Modernizing Digital Video Systems at the National Ignition Facility (NIF): Success Stories, Open Challenges and Future Directions.

V.K. Gopalan, A.I. Barnes, G.K. Brunton, J. Dixon, C.M. Estes, M. Fedorov, M.S. Flegel, B. Hackel, D.J. Koning, S.L. Townsend, D. Tucker, J.L. Vaher (LLNL)

The National Ignition Facility (NIF), the world's most energetic laser, completed a multi-year project for migrating control software platforms from Ada to Java in 2019. Following that work, a technology refresh of NIF's Digital Video (DVID) systems was identified as the next important step. The DVIDs were facing long-term maintenance risk due to its obsolete Window XP platform, with over 500 computers to be individually upgraded and patched, 24 camera types with a variety of I/O interfaces and proprietary drivers/software with their licensing needs. In this presentation, we discuss how we leveraged the strengths of NIF's distributed, cross platform architecture and our system migration expertise to migrate the DVID platforms to diskless clients booting off a single purpose-built immutable Linux image, and replacing proprietary camera drivers with open-source drivers. The in-place upgrades with well-defined fallback strategies ensured minimal impact to the continuous 24/7 shot operations. We will also present our strategy for continuous build, test, and release of the Linux OS image to keep up with future security patches and package upgrades.

LLNL IM Document Release Number: LLNL-ABS-822092

Funding: This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

MOAR03

LOFAR2.0: Station Control Upgrade

T. Juerges, J.J.D. Mol, T. Snijder (ASTRON)

After 10 years of operation, the LOw Frequency ARray (LOFAR) telescope is undergoing a significant hardware upgrade towards LOFAR2.0. The hardware upgrade will enable the phased array telescope to observe at 10^{-90} MHz and at 120-240 MHz frequencies at the same time. With the upgrade comes also the chance to review LOFAR's Control System and to make it ready for the next 10 years of operation at the forefront of low-frequency astronomy. In this work we will give a brief overview over the LOFAR telescope with its more than 50 geographically distributed receiver locations (LOFAR Stations), and the software that is necessary to monitor and control every single one of them. We will then describe the Station Control architecture, with its software design and how it is implemented in Python 3 with Tango Controls, OPC-UA clients and deployed as Docker containers. Lastly we will report on the successful use of open stack software like ELK and, Grafana.

MOBL — Software Technology Evolution I

The ELT Control System: Recent Developments

G. Chiozzi, L. Andolfato, J. Argomedo, N. Benes, C. Diaz Cano, A. Hoffstadt Urrutia, M. Kiekebusch, N. Kornweibel, U. Lampater, F. Pellegrin, M. Schilling, B. Sedghi, H. Sommer, M. Suarez Valles (ESO)

The Extremely Large Telescope (ELT) is a 39m optical telescope under construction in the Chilean Atacama desert. The design is based on a five-mirror scheme, incorporating Adaptive Optics (AO). The primary mirror consists of 798 segments with 1.4m diameter. The main control challenges can be identified in the number of sensors (~25000) and actuators (~15000) to be coordinated, the computing performance and small latency required for phasing of the primary mirror and the AO. We focus on the design and implementation of the supervisory systems and control strategies. This includes a real time computing (RTC) toolkit to support the implementation of the AO for telescope and instruments. We will also report on the progress done in the implementation of the control software infrastructure necessary for development, testing and integration. We identify a few lessons learned in the past years of development and major challenges for the coming phases of the project.

Real-time framework for ITER control systems

W.R. Lee, B. Bauvir, T.H. Tak, A. Zagar (ITER Organization) S. Lee (KFE) D.R. Makowski, P. Perek (TUL-DMCS) A. Winter (MPI/IPP)

The ITER Real-Time Framework (RTF) is a middleware providing common services and capabilities to build real-time control applications in ITER such as the Plasma Control System (PCS) and plasma diagnostics. The RTF dynamically constructs applications at runtime from the configuration. The principal building blocks that compose an application process are called Function Blocks (FB), which follow a modular structure pattern. The application configuration defines the information that can influence control behavior, such as the connections among FBs, their corresponding parameters, and event handlers. The consecutive pipeline process in a busy-waiting mode and a data-driven pattern minimizes jitter and hardens the deterministic system behavior. In contrast, infrastructural capabilities are managed differently in the service layer using non-real-time threads. The deployment configuration covers the final placement of a program instance and thread allocation to the appropriate computing infrastructure. In this paper, we will introduce the architecture and design patterns of the framework as well as the real-life examples used to benchmark the RTF.

Machine Learning Platform: Deploying and Managing Models in the CERN Control System

J.-B. de Martel, R. Gorbonosov, N. Madysa (CERN)

Recent advances make machine learning (ML) a powerful tool to cope with the inherent complexity of accelerators, the large number of degrees of freedom and continuously drifting machine characteristics. A diverse set of ML ecosystems, frameworks and tools are already being used at CERN for a variety of use cases such as optimization, anomaly detection and forecasting. We have adopted a unified approach to model storage, versioning and deployment which accommodates this diversity, and we apply software engineering best practices to achieve the reproducibility needed in the mission-critical context of particle accelerator controls. This paper describes CERN Machine Learning Platform - our central platform for storing, versioning and deploying ML models in the CERN Control Center. We present a unified solution which allows users to create, update and deploy models with minimal effort, without constraining their workflow or restricting their choice of tools. It also provides tooling to automate seamless model updates as the machine characteristics evolve. Moreover, the system allows model developers to focus on domain-specific development by abstracting infrastructural concerns.

MOBL04

Karabo Data Logging: InfluxDB Backend and Grafana UI

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The photon beam lines and instruments at the European XFEL (EuXFEL) are operated using the Karabo* control system that has been developed in house since 2011. Monitoring and incident analysis requires quick access to historic values of control data. While Karabo's original custom-built text-file-based data logging system suits well for small systems, a time series data base offers in general a faster data access, as well as advanced data filtering, aggregation and reduction options. EuXFEL has chosen InfluxDB** as backend that is operated since summer 2020. Historic data can be displayed as before via the Karabo GUI or now also via the powerful Grafana*** web interface. The latter is e.g. used heavily in the new Data Operation Center of the EuXFEL. This contribution describes the InfluxDB setup, its transparent integration into Karabo and the experiences gained since it is in operation.

* Steffen Hauf et al., J. Synchrotron Rad. (2019). 26, 1448-1461 ** https://docs.influxdata.com/influxdb/ *** https://grafana.com/grafana/

MOBL05

Photon Science Controls: A Flexible and Distributed LabVIEW Framework for Laser Systems

B.A. Davis, B.T. Fishler, R.J. McDonald (LLNL)

LabVIEW software is often chosen for developing small scale control systems, especially for novice software developers. However, because of its ease of use, many functional LabVIEW applications suffer from limits to extensibility and scalability. Developing highly extensible and scalable applications requires significant skill and time investment. To close this gap between new and experienced developers we present an object-oriented application framework that offloads complex architecture tasks from the developer. The framework provides native functionality for data acquisition, logging, and publishing over HTTP and WebSocket with extensibility for adding further capabilities. The system is scalable and supports both single process applications and small to medium sized distributed systems. By leveraging the framework, developers can produce robust applications that are easily integrated into a unified architecture for simple and distributed systems. This allows for decreased system development time, improved onboarding for new developers, and simple framework extension for new capabilities.

Funding: This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

MOBR — Device Control and Integrating Diverse Systems I

ROMULUSlib: An autonomous, TCP/IP-based, multi-architecture C networking library for DAQ and Control applications

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The new generation of Radiation Monitoring electronics developed at CERN, called the CERN RadiatiOn Monitoring Electronics (CROME), is a Zynq-7000 SoC-based Data Acquisition and Control system that replaces the previous generation to offer a higher safety standard, flexible integration and parallel communication with devices installed throughout the CERN complex. A TCP/IP protocol based C networking library, ROMULUSlib, was developed that forms the interface between CROME and the SCADA supervision software through the ROMULUS protocol. ROMULUSlib encapsulates Real-Time and Historical data, parameters and acknowledgement data in TCP/IP frames that offers high reliability and flexibility, full-duplex communication with the CROME devices and supports multi-architecture development by utilization of the POSIX standard. ROMULUSlib is autonomous as it works as a standalone library that can support integration with supervision applications by addition or modification of parameters of the data frame. This paper discusses the ROMULUS protocol, the ROMULUS Data frame and the complete set of commands and parameters implemented in the ROMULUSlib for CROME supervision.

Control, Readout and Monitoring for the Medium-Sized Telesopes in the Cherenkov Telescope Array

U. Schwanke, G. Spengler (HU Berlin) D. Melkumyan, T. Murach, T. Schmidt, P. Wagner (DESY Zeuthen) I. Oya (CTA)

The Cherenkov Telescope Array (CTA) is the next-generation ground-based gamma-ray observatory. Its design comprises close to 100 imaging atmospheric Cherenkov telescopes deployed at a southern (Paranal, Chile) and a northern (La Palma, Canary Islands, Spain) site. The inclusion of various array elements, like Large-Sized, Medium-Sized and Small-Sized Telescopes, instruments for atmosphere monitoring, etc, into the Array Control and Data Acquisition System (ACADA) poses a particular challenge which is met by an appropriate software architecture and a well-defined interface for array elements. This conference contribution describes exemplarily how the interface is implemented for the Medium-Sized Telescopes (MSTs, 12m diameter). The implementation uses the ALMA Common Software (ACS) as a framework for software applications facilitating the readout and control of telescope subsystems like the drive system or the pointing camera; the communication with subsystems takes advantage of the OPC UA protocol. It is also discussed what technologies (e.g. data bases) are used for the acquisition and storage of telescope-specific monitoring data.

Hexapod Control System Development Towards Arbitrary Trajectories Scans at Sirius/lnls

A.Y. Horita, F.A. Del Nero, G.N. Kontogiorgos, M.A.L. Moraes (LNLS) G.G. Silva (UNICAMP)

Modern 4th generation synchroton facilities demand high precision and dynamic manipulation systems capable of fine position control, aiming to improve the resolution and perfomance of their experiments. In this context, hexapods are widely used to obtain a flexible and accurate 6 Degrees of Freedom (DoF) positioning system, as they are based on Parallel Kinematic Mechanisms (PKM). Aiming the customization and governability of this type of motion control system, a software application was entirely modeled and implemented at Sirius. A Bestec hexapod was used and the control logic was embedded into an Omron Delta Tau Power Brick towards the standardization of Sirius control solutions with features which completely fill the beamline scan needs, e.g. tracing arbitrary trajectories. Newton-Raphson numerical method was applied to implement the PKM. Besides, the kinematics was implemented in C language, targeting a better runtime performance when comparing to script languages. This paper describes the design and implementation methods used in this control application development and presents its resulting performance.

MOBR04

Generic data acquisition control system stack on the MTCA platform

J. Krasna (COSYLAB, Control System Laboratory)

Cosylab is the world leading integrator of control systems for big physics facilities. We frequently integrate high speed data acquisition devices on the MicroTCA platform for our customers. To simplify this process we have developed a generic control system stack that allows us to support a large set of MicroTCA hardware boards with minimal firmware and software modifications. Our firmware supports generic data acquisition up to 32 bit sample width and also generic data generation. The firmware modules are implemented in a way so that support for MRF timing modules can be added and allow the board to act as a MRF timing receiver. On the software side we implemented the control software stack in NDS which means that we offer support for EPICS and TANGO control system out of the box.

MOBR05

Motion Software Stack Developments for Powerpmac(r) in the Australian Synchrotron

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M. Clift (ASCo)

Australian Synchrotron has standardised on Omron PowerBrickLV(r). In order to utilise the advanced features of these controllers while maintaining the complexity that comes with the versatile and multi-purposed controller, DLS developers team have led the community by producing the first EPICS module for the PowerPMAC. We reviewed and customized the DLS ppmac software stack to support fractional readbacks in engineering units from controller, improve R/W performance, add protections and interlocking at the controller level and improve homing routines. We have also developed our own toolsets for generating controller configuration files from templates (PSYCH), and Ppmac IOC template system (bluecat), and automated test tools (EATSIT). Our beta version of the software stack, with an improved Motor Record, driver and IOC templates has been under validation testing since March 2021. We have also been developing a python 'caproto' based Ppmac IOC (CAPMAC), with a Simplified Motor Record interface intending to move most of native Motor Record functions to the controller. The CAPMAC IOC code is deployed from pypi and configured from a readable Yaml configuration file.

MOPV — Posters

Status of the SARAF-Phase2 Control System

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SNRC and CEA collaborate to the upgrade of the SARAF accelerator to 5 mA CW 40 Mev deuteron and proton beams and also closely to the control system. CEA is in charge of the Control System (including cabinets) design and implementation for the Injector (upgrade), MEBT and Super Conducting Linac made up of 4 cryomodules hosting HWR cavities and solenoid packages. This paper gives a detailed presentation of the control system architecture from hardware and EPICS software points of view. The hardware standardization relies on MTCA.4 that is used for LLRF, BPM, BLM and FC controls and on Siemens PLC 1500 series for vacuum, cryogenics and interlock. CEA IRFU EPICS Environment (IEE) platform is used for the whole accelerator. IEE is based on virtual machines and our MTCA.4 solutions and enables us to have homogenous EPICS modules. It also provides a development and production workflow. SNRC has integrated IEE into a new IT network based on advanced technology. The commissioning is planned to start late summer 2021.

CENBG Control System and Specific Instrumentation Developments for SPIRAL2-DESIR Setups

L. Daudin, P. Alfaurt, A. Balana, M. Corne, M. Flayol, A.A. Husson, B. Lachacinski (CENBG)

The DESIR facility will be in few years the SPIRAL2 experimental hall at GANIL dedicated to the study of nuclear structure, astrophysics and weak interaction at low energy. Exotic ions produced by the new S3 facility and SPIRAL1 complex will be transferred to high precision experiments in the DESIR building. To guaranty high purity beams to perform high precision measurements on specific nuclei, three main devices are currently being developed at CENBG: a High Resolution Separator (HRS), a General Purpose Ion Buncher (GPIB) and a double Penning Trap named 'PIPERADE'. The Control System (CS) developments we made at CENBG are already used to commission these devices. We present here beamline equipment CS solutions and the global architecture of this SPIRAL2 EPICS based CS.To answer specific needs, instrumental solutions have been developed like PPG used to optimize bunch timing and also used as traps conductor. Recent development using the cost efficient Redpitaya board with an embedded EPICS server will be described. This device used to drive a FCup amplifier and is also used for particle counting and time of flight measurements using our FPGA implementation called 'RedPiTOF'.

LASER MEGAJOULE FACILITY OPERATING SOFTWARE OVERVIEW

J-P. Airiau, V. Denis, H. Durandeau, P. Fourtillan, N. Loustalet, P. Torrent (CEA)

The Laser MegaJoule (LMJ), the French 176-beam laser facility, is located at the CEA CESTA Laboratory near Bordeaux (France). It is designed to deliver about 1.4 MJ of energy on targets, for high energy density physics experiments, including fusion experiments. The first bundle of 8-beams was commissioned in October 2014. By the end of 2021, ten bundles of 8-beams are expected to be fully operational. Operating software tools are used to automate, secure and optimize the operations on the LMJ facility. They contribute to the smooth running of the experiment process (from the setup to the results). They are integrated in the maintenance process (from the supply chain to the asset management). They are linked together in order to exchange data and they interact with the control command system. This talk gives an overview of the existing operating software and the lessons learned. It finally explains the incoming works to automate the lifecycle management of elements included in the final optic assembly (replacement, repair, etc.).

MOPV005

Towards a New Control System for PetraIV

R. Bacher, T. Delfs, D. Mathes, T. Tempel, T. Wilksen (DESY)

At DESY, an upgrade of the PETRA III synchrotron light source towards a fourth-generation, low emittance machine PETRA IV is currently being actively pursued. The basic concept of the control system of PETRAIV is to exploit synergies between all accelerator facilities operated by DESY. The key figures of PETRAIV's new accelerator control system include the DOOCS control system framework, high-end MTCA.4 technology compliant hardware interfaces for triggered, high-performance applications and hardware interfaces for conventional slow-control applications compliant with industrial process control standards such as OPC UA, and enhanced data acquisition and data storage capabilities. In addition, the suitability of standards for graphical user interfaces based on novel Web application technologies will be investigated. Finally, there is a general focus on improving quality management and quality assurance measures, including proper configuration management, requirements management, bug tracking, software development, and software lifetime management. The paper will report on the current state of development.

MOPV006

The New Small Wheel LV Power supply DCS for the ATLAS experiment

C. Paraskevopoulos (NTUA) A. Bruni (INFN/CNAF)

The present ATLAS Small Wheel detector will be replaced with the New Small Wheel(NSW) which is expected to be installed in the ATLAS underground cavern by the end of the LS2. Due to its complexity and long-term operation, NSW requires the development of a sophisticated Detector Control System. The use of such a system is necessary to allow the detector to function consistently as a seamless interface to all subdetectors and the technical infrastructure of the experiment. The central system handles the transition between the possible operating states while ensuring monitoring and archiving of the system's parameters. The part that will be described is the modular system of Low Voltage. The new LV Intermediate Control Station will be used to power all the boards of the NSW and through them providing readout and trigger data while functioning safely. Among its core features are remote control, split of radiation sensitive parts from parts that can be housed in a hostile area and compatibility with operation under radiation and magnetic field as in the ATLAS cavern.

MOPV007

Progress of The HIAF Control System

W. Zhang (IMP/CAS)

High Intensity Heavy-ion Accelerator Facility (HIAF) is one of the 16 projects of the 12th Five-Year Plan (2012-2030). It is a next-generation heavy ion scientific research device with international leading level and wide range of subject uses. The task of the control system is to complete the task of overall control, including the overall structure of the control system, the standard of the control system interface, the time system, the database system, the network system. At present, the overall task and subsystem control scheme design and verification have been basically completed. The standard of unified control system software interface under EPICS frame is established and the middle-layer software development platform based on Python+C+C++ is developed, which facilitates the development of hardware layer and application layer personnel. Hardware selection and functional testing have also been completed. By the end of this year, we will have completed the time system prototype, next year began to purchase hardware equipment, 2022-2024 on-site equipment installation and commissioning.
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MOPV008

Development of Computer Centralized Control System for Large- Scale Equipment

Ms. Yao, Z. Ni, X. Zhou (CAEP)

The Computer centralized control system is the command center of SG-III large-scale equipment. It controls and integrates the major systems of the equipment, forms a centralized and complete operation control and management platform, completes the control, monitoring, experimental analysis and other functions of the equipment, and analyzes the operation and maintenance status of the equipment data. The Computer centralized control system is mainly composed of computer centralized control platform , control software, synchronization system and each specific function control subsystems. This paper analyzes the design of computer centralized control platform. Prepare to discuss the control structure, hardware/software hierarchy, controlling business processes, integration process, and software design,data management,etc.

The High Voltage DCS System for the New Small Wheel upgrade of the ATLAS experiment

E. Karentzos (CERN) A. Bruni (INFN/CNAF)

The ATLAS muon spectrometer will exceed its design capabilities in the high background radiation as expected during the upcoming runs and at HL-LHC. In order to cope with the foreseen limitations, it was decided to replace the SW with a New SW (NSW) system, by combining two prototype detectors, the sTGC & and resistive Micromegas. Both technologies are 'aligned' to the ATLAS general baselines for the NSW upgrade project, maintaining in such way the excellent performance of the muon system beyond Run-3. Complementary to the R&D of these detectors, an intuitive control system was of vital importance. The Micromegas DCS (MMG HV) and the sTGC DCS (STG HV) for the NSW have been developed, following closely the existing look, feel and command architecture of the other Muon sub-systems. The principal task of the DCS is to enable the coherent and safe operation of the detector by continuously monitoring its operational parameters and its overall state. Both technologies will be installed in ATLAS and will be readout and monitored through the common infrastructure. Aim of this work is the description of the development and implementation of a DCS for the HV system of both technologies.
This abs has been submitted on behalf of the ATLAS Muon Coll. Final speaker will be selected at a later stage.

Working under pandemic conditions: contact tracing meets technology

E. Blanco Vinuela, B. Copy, S. Danzeca, Ch. Delamare, R. Losito, A. Masi, E. Matli, T. Previero, R. Sierra (CERN)

Covid-19 has dramatically transformed our working practices with a big change to a teleworking model for many people. There are however many essential activities requiring personnel on site. In order to minimise the risks for its personnel CERN decided to take every measure possible, including internal contact tracing by the CERN medical service. This initially involved manual procedures which relied on people's ability to remember past encounters. To improve this situation and minimise the number of employees who would need to be quarantined, CERN approved the design of a specific device: the Proximeter. The project goal was to design a wearable device, built in a partnership* with industry fulfilling the contact tracing needs of the medical service. The proximeter records other devices in close proximity and reports the encounters to a cloud-based system. The service came into operation early 2021 and 8000 devices were distributed to personnel working on the CERN site. This publication reports on the service offered, emphasising on the overall workflow of the project under exceptional conditions and the implications data privacy imposed on the design of the software application.
* Terabee. https://www.terabee.com

The Inclusion of White Rabbit into the Global Industry Standard IEEE 1588

M. Lipinski (CERN)

White Rabbit (WR) is the first CERN-born technology that has been incorporated into a global industry standard governed by the Institute of Electrical and Electronics Engineers (IEEE), the IEEE 1588 Precision Time Protocol (PTP). This showcase of technology transfer has been beneficial to both the standard and to WR technology. For the standard, it has allowed the PTP synchronisation performance to be increased by several orders of magnitude, opening new markets and opportunities for PTP implementers. While for WR technology, the review during its standardisation and its adoption by industry makes it future-proof and drives down prices of the WR hardware that is widely used in scientific installations. This article provides an insight into the 7-year-long WR standardisation process, describing its motivation, benefits, costs and the final result. After a short introduction to WR, it describes the process of reviewing, generalising and translating it into an IEEE standard. Finally, it retrospectively evaluates this process in terms of efforts and benefits to conclude that basing new technologies on standards and extending them bears short-term costs that bring long-term benefits.

The ESRF-EBS Simulator: a commissioning booster.

S.M. Liuzzo, L.R. Carver, J.M. Chaize, L. Farvacque, A. Gotz, D. Lacoste, N. Leclercq, F. Poncet, E.T. Taurel, S.M. White (ESRF)

The ESRF-Extremely Brilliant Source (ESRF-EBS)* is the first-of-a-kind fourth-generation high-energy synchrotron. After only a 20-month shutdown, scientific users were back to carry out experiments with the new source. The EBS Simulator (EBSS) played a major role in the success of the commissioning of the new storage ring. Acting as a development, sandbox and training platform, the machine simulator allowed control room applications and tools to be up and ready from

day one. The EBSS can also be seen as the initial block of a storage ring digital twin. The present article provides an overview of the current status of the EBS Simulator and presents the current roadmap foreseen for its future.
* J.C.Biasci et al., "A Low-Emittance Lattice for the ESRF.' Synchrotron Radiation News 27.6 (2014)

MOPV013

A Dynamic Beam Scheduling System for the FAIR Accelerator Facility

S. Krepp, J. Fitzek, H.C. Hüther, R. Mueller, A. Schaller, A. Walter (GSI)

The new Accelerator Control System for GSI/FAIR is now being used productively for the GSI accelerator facility. As the central component for online beam orchestration, the Beam Scheduling System (BSS) is situated between the FAIR Settings Management System and the FAIR timing system. Besides device settings, the Settings Management System provides timing schedules for beam production. The primary purpose of the BSS is to define which of the beam schedules are executed by the timing system, how often and in which order. To provide runtime decisions in pre-planned execution options (e.g. skipping of a particular beam), it processes external signals like user input, experiment requests or beam prohibits provided by the interlock system. More recently, advanced features have been added that allow for dynamic execution control required by storage ring mode features such as breakpoints, repetitions, skipping and manipulations. This contribution gives an overview of the Beam Scheduling System including its interfaces.

MOPV014

Upgrade of the NewSUBARU control system

N. Hosoda, Y. Hamada, M. Ishii, A. Kiyomichi, K. Okada, T. Sugimoto (JASRI) T. Fukui (RIKEN/SPring-8)

NewSUBARU has constructed a new dedicated injector in order to separate the operation from SPring-8 and to operate independently. In designing this injector, we tried to share the same components as those of the Tohoku Synchrotron Radiation Facility, which will be completed in 2023, in order to make effective use of human resources. The control system of the injector and the existing storage ring must be constructed as unified system, so the file server, DB server, backbone network, etc. were redesigned using the control system used in SPring-8/SACLA as a control framework. MTCA.4 was used to control the injector, and EtherCAT was used to communicate with the PLC. For the control of the storage ring, the existing equipment configuration was retained and the control framework was migrated. In this paper, we report the details of the NewSUBARU control system.

MOPV015

Control System of the SRILAC Project at RIBF

A. Uchiyama, M. Fujimaki, N. Fukunishi, Y. Higurashi, E. Ikezawa, H. Imao, O. Kamigaito, M. Kidera, M. Komiyama, K. Kumagai, T. Nagatomo, T. Nakagawa, T. Nishi, J. Ohnishi, K. Ozeki, N. Sakamoto, K. Suda, T. Watanabe, Y. Watanabe, K. Yamada (RIKEN Nishina Center) A. Kamoshida (National Instruments Japan Corporation) K. Kaneko, R. Koyama, T.O. Ohki, K. Oyamada, M. Tamura, H. Yamauchi, Y.A. Yusa (SHI Accelerator Service Ltd.)

At RIKEN Nishina Center, the SRILAC project has been launched for the search experiments of super-heavy-elements with atomic numbers of 119 and higher. The main points of the SRILAC project are as follows. Superconducting RIKEN Linear Accelerator (SRILAC) was newly installed at downstream of existing accelerator (RIKEN Linear Accelerator: RILAC) to enhance beam energy. Additionally, a new RIKEN 28-GHz superconducting electron cyclotron resonance ion source has been implemented at the frontend of SRILAC to increase beam intensity. With that, the SRILAC control system requires corrections and upgrades to the shortcomings of previous RILAC control system, for example control methods for electromagnet power supplies, an machine protection system and an archive system. Moreover, there was also a issue to be solved for methods of integration with small LabVIEW-based systems. To operate efficiently in the SRILAC project, a distributed control system utilizing EPICS should be adopted as in RIBF, a higher-level application protocol needs to be integrated to EPICS Channel Access protocol. In this conference, we report the system implementation, developed tool in detail about SRILAC project.

Design and Implement of Web Based SCADA System for HUST Field-Reversed Configuration Device

F.Y. Wu, X.H. Xie (HUST) W. Zheng (Huazhong University of Science and Technology, State Key Laboratory of Advanced Electromagnetic Engineering and Technology,)

As a large complex fusion research device for stud-ying field reversed configuration (FRC) plasma, HUST FRC(HFRC) is composed of many subsystems. In order to coordinate all systems and ensure the correct, orderly and stable operation of the whole experimental device, it is very important to have a unified and powerful control system. HFRC SCADA(Supervisory Control And Data Ac-quisition) system has selected the in-house developed CFET'Control system Framework for Experimental Devices Toolkit'as the control framework, with ad-vantages of strong abstraction, simplified framework, transparent protocol and flexible extension due to Web technology.

CERN SCADA Systems 2020 Large Upgrade Campaign Retrospective

L.G. Goralczyk, A.F. Kostopoulos, B. Schofield, J-C. Tournier (CERN)

In this paper we report the experience from a large-scale upgrade campaign of SCADA control systems performed during the second LHC Long Shutdown at CERN. Such periodical upgrades are dictated by the ever evolving SCADA WinCC OA system and the CERN frameworks evolution used in those control systems. These upgrades concern: accelerator control systems, e.g. quench protection system, powering interlocks, magnet alignment; control systems devoted to accelerator facilities such as cryogenics, vacuum, gas... and other global technical infrastructure systems as well as the CERN electrical distribution system. Since there are more than 200 SCADA projects covering the CERN accelerator complex and technical infrastructure, any disruption requires careful coordination, planning and execution with process owners. Having gained experience from previous campaigns and reaching a new level of automation we were able to make visible improvements by shortening the required time and reducing the personnel required. Activities, lessons learned and further improvements are presented as well as a comprehensive statistical insight of the whole campaign.

Linac-200 gun control system: status and plans

M.A. Nozdrin, V.V. Kobets, V.F. Minashkin, A. Trifonov (JINR)

Due to the development of the global Tango-based control system for Linac-200 accelerator, the new electron gun control system software was developed. Major gun electronics modification is foreseen. Current gun control system status and modification plans are reported.

Pvecho: Design of a VISTA/EPICS Bridge for the ISIS Control System Transition

K.R.L. Baker, I.D. Finch, G.D. Howells, M. Romanovschi, A.A. Saoulis (STFC/RAL/ISIS)

The migration of the ISIS Controls System from Vsystem to EPICS presents a significant challenge and risk to the day-to-day operations of the accelerator. An evaluation of potential options has indicated that the most effective migration method to mitigate against this risk is to make use of a `hybrid' system running Vsystem and EPICS simultaneously. This allows for a phased porting of controls hardware from the existing software to EPICS. This work will outline the prototype Vsystem/EPICS bridge that will facilitate this hybrid operation, referred to as pvecho. The bridge has been developed in Python, utilising existing communication from Vsystem to an MQTT broker developed as part of a previous project. Docker containers have been used for its development to create an isolated test environment to allow the software to communicate with other services currently used at ISIS.

Funding: UKRI / STFC

Digitisation of the Analogue Waveform System at ISIS

W.A. Frank, B.R. Aljamal, R.A. Washington (STFC/RAL/ISIS)

The Analogue Waveform System (AWS) at the ISIS Neutron and Muon Source is a distributed system that allows operators to select and monitor analogue waveforms from equipment throughout the facility on oscilloscopes in the Main Control Room (MCR). These signals originate from key accelerator systems in

the linear accelerator and synchrotron such as the ion source, magnets, beam diagnostics, and radio frequency (RF) systems. Historical data for ISIS is available on the control system for many relevant channels. However, at present, to avoid disrupting the oscilloscope displays in the MCR, only an hourly image capture of the AWS waveforms is stored. This is largely inadequate for potential data-intensive applications such as anomaly detection, predictive maintenance, post-mortem analysis, or (semi-)automated machine setup, optimization, and control. To address this, a new digital data acquisition (DAQ) system is under development based on the principle of large channel count, simultaneous DAQ. This paper details the proposed architecture of the system and the results of initial prototyping, testing, and commissioning.

Funding: UKRI/STFC

MOPV021

Upgrading the National Ignition Facility's (NIF) Integrated Computer Control System to Support Optical Thompson Scattering (OTS) Diagnostic

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With the ability to deliver 2.1 MJ of 500 TW ultraviolet laser light to a target, the National Ignition Facility (NIF) is the world's most energetic laser. This combination of energy and power allows the study of materials under conditions similar to the center of the sun. On fusion ignition experiments, plasma generated in the interior of the target shell can detrimentally impact the implosion symmetry and the resulting energy output. We are in the final stages of commissioning a significant new diagnostic system that will allow us to better understand the plasma conditions and improve our symmetry control techniques. This Optical Thompson Scattering (OTS) system consists of two major components: a probe laser beamline capable of delivering a world first 1 J of energy at 211 nm, and a diagnostic that both reflects the probe laser into the target and collects the scattered photons. Between these two components, the control system enhancements required integration of over 450 components into the existing automation suite. This talk will provide an overview of the system upgrade approach and the tools used to efficiently manage and test changes to both our data and software.

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MOPV022

Upgrade of Hardware Controls for the STAR Experiment at RHIC

D. Tlusty (Creighton University)

The STAR experiment has been delivering significant physics results for more than 20 years. Stable operation of the experiment was achieved by using a robust controls system based on the Experimental Physics and Industrial Control System (EPICS). Now an object-oriented approach with Python libraries, adapted for EPICS software, is going to replace the procedural-based EPICS C libraries previously used at STAR. Advantages of the new approach include stability of operation, code reduction and straightforward project documentation. This poster will introduce the STAR experiment, give an overview of the EPICS architecture, and present the use of Python for controls software. Specific examples, as well as upgrades of user interfaces, will be shown.

MOPV024

vscode-epics, a VSCode Module to Enlight Your Epics Code

V. Nadot, A. Gaget, F. Gohier, P. Lotrus, S. Tzvetkov (CEA-IRFU)

vscode-epics is a Visual Studio Code module developed by CEA Irfu that aims to enlight your EPICS code. This module makes developer life easier, improves code quality and helps standardizing EPICS code. It provides syntax highlighting, snippets and header template for EPICS file and provides snippets for WeTest*. This VSCode module is based on Visual Studio Code language Extension and it uses basic JSON files that make feature addition easy. The number of downloads increases version after version and the different feedback motivates us to strongly maintain it for the EPICS community. Since 2019, some laboratories of the EPICS community have participated in the improvement of the module and it seems to have a nice future (linter, snippet improvements, specific language support, etc.). The module is available on Visual Studio Code marketplace** and on EPICS extension GitHub***. CEA Irfu is open to bug notifications, enhancement suggestions and merge requests to continuously improve vscode-epics.

* https://github.com/epics-extensions/WeTest ** https://marketplace.visualstudio.com/items?itemName=nsd.vscode-epics *** https://github.com/epics-extensions/vscode-epics

TangoGraphQL: A GraphQL binding for Tango control system Web-based applications

J.L. Pons (ESRF)

Web-based applications have seen a huge increase in popularity in recent years, replacing standalone applications. GraphQL provides a complete and understandable description of the data exchange between client browsers and back-end servers. GraphQL is a powerful query language allowing API to evolve easily and to query only what is needed. GraphQL also offers a WebSocket based protocol which perfectly fit to the Tango event system. Lots of popular tools around GraphQL offer very convenient way to browse and query data. TangoGraphQL is a pure C++ http(s) server which exports a GraphQL binding for the Tango C++ API. TangoGraphQL also exports a GraphiQL web application which allows to have a nice interactive description of the API and to test queries. TangoGraphQL* has been designed with the aim to maximize performances of JSON data serialization, a binary transfer mode is also foreseen.
https://gitlab.com/tango-controls/TangoGraphQL

Integrating OPC UA Devices in EPICS

R. Lange (ITER Organization) R.A. Elliot, K. Vestin (ESS) B. Kuner (BESSY GmbH) C. Winkler (HZB) D. Zimoch (PSI)

OPC Unified Architecture (OPC UA) is an open platform independent communication architecture for industrial automation developed by the OPC Foundation. Its key characteristics include a rich service-oriented architecture, enhanced security functionality and an integral information model, allowing to map complex data into an OPC UA namespace. With its increasing popularity in the industrial world, OPC UA is an excellent strategic choice for integrating a wealth of different COTS devices and controllers into an existing control system infrastructure. The security functions extend its application to larger networks and across firewalls, while the support of user-defined data structures and fully symbolic addressing ensure flexibility, separation of concerns and robustness in the user interfaces. In an international collaboration, a generic OPC UA support for the EPICS control system toolkit has been developed. It is used in operation at several facilities, integrating a variety of commercial controllers and systems. We describe design and implementation approach, discuss use cases and software quality aspects, report performance and present a roadmap of the next development steps.

The Evolution of the DOOCS C++ Code Base

L. Froehlich, A. Aghababyan, S. Grunewald, O. Hensler, U. Jastrow, R. Kammering, H. Keller, V. Kocharyan, M. Mommertz, F. Peters, A. Petrosyan, G. Petrosyan, L.P. Petrosyan, V. Petrosyan, K. Rehlich, V. Rybnikov, G. Schlesselmann, J. Wilgen, T. Wilksen (DESY)

This contribution traces the development of DESY's control system DOOCS from its origins in 1992 to its current state as the backbone of the European XFEL and FLASH accelerators and of the future Petra IV light source. Some details of the continual modernization and refactoring efforts on the 1.5 million line C++ codebase are highlighted.

Application of Epics Software in Linear Accelerator

Y.H. Guo, H.T. Liu, B.J. Wang, R. Wang, N. Xie (IMP/CAS)

The institute of modern physics (IMP) has two sets of linear accelerator facilities, they are CAFe (China ADS front-end demo linac) and LEAF (Low Energy Accelerator Facility). The Main equipment of LEAF facility consists of ion source, LEBT (Low Energy Beam Transport), RFQ (Radio Frequency Quadrupole) and some experiment terminals. Compare with LEAF, CAFe equipment has more and adds MEBT (Middle Energy Beam Transport) and four sets of superconducting cavity strings at the back end of RFQ. In the process of commissioning and running linac equipment, The EPICS Archiver application and Alarm system are used. According to the refined control requirements of the facility sites, we have completed the software upgrade and deployment of the archiver and alarm systems. The upgraded software systems have made the operation of linac machines more effective in term of monitoring, fault-diagnostic and system recovery, and becomes more user-friendly as well.

MOPV031

THE DEPLOYMENT TECHNOLOGY OF EPICS APPLICATION SOFTWARE BASED ON DOCKER

R. Wang, Y.H. Guo, B.J. Wang, N. Xie (IMP/CAS)

StreamDevice, as a general-purpose string interface device's Epics driver, has been widely used in the control of devices with network and serial ports in CAFe equipment. For example, the remote control of magnet power supply, vacuum gauges, and various vacuum valves or pumps, as well as the information reading and control of Gauss meter equipment used in magnetic field measurement. In the process of on-site software development, we found that various errors are caused during the deployment of StreamDevice about the dependence on software environment and library functions, which because of different operating system environments and EPICS tool software versions. This makes StreamDevice deployment very time-consuming and labor-intensive. To ensure that StreamDevice works in a unified environment and can be deployed and migrated efficiently, the Docker container technology is used to encapsulate its software and its application environment. Images will be uploaded to an Aliyun private library to facilitate software developers to download and use.

MOPV032

Design of a Component-Oriented Distributed Data Integration Model

Z. Ni, L. Li, J. Liu, J. Luo, X. Zhou (CAEP)

The control system of large scientific facilities is composed of several heterogeneous control systems. As time goes by, the facilities need to be continuously upgraded and the control system also needs to be upgraded. This is a challenge for the integration of complex and large-scale heterogeneous systems. This article describes the design of a data integration model based on component technology, software middleware(The Apache Thrift*) and real-time database. The realization of this model shields the relevant details of the software middleware, encapsulates the remote data acquisition as a local function operation, realizes the combination of data and complex calculations through scripts, and can be assembled into new components.
*The Apache Thrift software framework, for scalable cross-language services development, combines a software stack with a code generation engine to build services that work efficiently.

MOPV033

Web client for Panic alarms management system

M. Gandor, P.P. Goryl, W.T. Kitka, M. Nabywaniec (S2Innovation)

Alarms are one of the most important aspects of control systems. Each control system can face unexpected issues, which demand fast and precise resolution. As the control system starts to grow, it requires the involvement of more engineers to access the alarm's list and focus on the most important ones. Our objective was to allow users to access the alarms fast, remotely and without special software. According to current trends in the IT community, creating a web application turned out to be a perfect solution. Our application is the extension and web equivalent to the current Panic GUI application. It allows constant remote access using just a web browser which is currently present on every machine including mobile phones and tablets. The access to the different functionalities can be restricted to the users provided just with appropriate roles. Alarms can be easily added and managed from the web browser as well as adding new data sources is possible. From each data source, an attribute can be extracted, and multiple attributes can be combined into composer being the base for further analysis or alarms creation.

MOPV034

Migration of Tango Controls Source Code Repositories

M. Liszcz, M. Celary, P.P. Goryl, K. Kedron (S2Innovation) G. Abeille (SOLEIL) B. Bertrand (MAX IV Laboratory, Lund University) R. Bourtembourg, A. Gotz (ESRF) T. Braun (byte physics e.K.) A.F. Joubert (SARAO) A. López SÃ¡nchez, C. Pascual-Izarra, S. Rubio-Manrique (ALBA-CELLS Synchrotron) L. Pivetta (Elettra-Sincrotrone Trieste S.C.p.A.)

At the turn of 2020/2021, the Tango community faced the challenge of a massive migration of all Tango software repositories from GitHub to GitLab. The motivation has been a change in the pricing model of the Travis CI provider and the shutdown of the JFrog Bintray service used for artifact hosting. GitLab has been chosen as a FOSS-friendly platform for storing both the code and build artifacts and for providing CI/CD services. The migration process faced several challenges, both technical, like redesign and rewrite of CI pipelines, and non-technical, like coordination of actions impacting multiple interdependent repositories. This paper explains the strategies adopted for migration, the outcomes, and the impact on the Tango Controls collaboration.

Funding: Tango Community

Development of Alarm and Monitoring System Using Smartphone

W.S. Cho (PAL)

In order to find out the problem of the device remotely, we aimed to develop a new alarm system. The main functions of the alarm system are real-time monitoring of EPICS PV data, data storage, and data storage when an alarm occurs. In addition, an alarm is transmitted in real time through an app on the smartphone to communicate the situation to machine engineers of PLS-II. This system uses InfluxDB to store data. In addition, a new program written in Java language was developed so that data acquisition, analysis, and beam dump conditions can be known. furthermore Vue.js is used to develop together with node.js and web-based android and iOS-based smart phone applications, and user interface is serviced. Eventually, using this system, we were able to check the cause analysis and data in real time when an alarm occurs. In this paper, we introduce the design of an alarm system and the transmission of alarms to an application.

Porting Control System Software From Python 2 to 3 - Challenges and Lessons

A.F. Joubert, M.T. Ockards, S. Wai (SARAO)

Obsolescence is one of the challenges facing all long-term projects. It not only affects hardware platforms, but also software. Python 2.x reached official End Of Life status on 1 January 2020. In this paper we review our efforts to port to the replacement, Python 3.x. While the two versions are very similar, there are important differences which can lead to incompatibility or changes in behaviour. We discuss our motivation and strategy for porting our code base of approximately 200 k source lines of code over 20 Python packages. This includes aspects such as internal and external dependencies, legacy and proprietary software that cannot be easily ported, testing and verification, and why we selected a phased approach rather than "big bang". We also report on the challenges and lessons learnt - notably why good test coverage is so important for software maintenance. Our application is the 64-antenna MeerKAT radio telescope in South Africa - a precursor to the Square Kilometre Array

ALBA Controls System Software Stack Upgrade

G. Cuni, F. Becheri, S. Blanch-Torné, C. Falcon-Torres, C. Pascual-Izarra, Z. Reszela, S. Rubio-Manrique (ALBA-CELLS Synchrotron)

ALBA, a 3rd Generation Synchroton Light Source located near Barcelona in Spain, is in operation since 2012. During the last 10 years, the updates of ALBA's Control System were severely limited in order to prevent disruptions of production equipment, at the cost of having to deal with hardware and software obsolescence, elevating the effort of maintenance and enhancements. The construction of the second phase new beamlines accelerated the renewal of the software stack. In order to limit the number of supported platforms we also gradually upgraded the already operational subsystems. We are in the process of switching to the Debian OS, upgrading to the Tango 9 Control System framework including the Tango Archiving System to HDB++, migrating our code to Python 3, and migrating our GUIs to PyQt5 and PyQtGraph, etc. In order to ensure the project quality and to facilitate future upgrades, we try to automate testing, packaging, and configuration management with CI/CD pipelines using, among others, the following tools: pytest, Docker, GitLab-CI and Salt. In this paper, we present our strategy in this project, the current status of different upgrades and we share the lessons learnt.

The EPIC(S) Battle Between Individualism and Collectivism

S.C.F. Rose (ESS)

ESS uses a customized version of the EPICS build system in order to manage a small number of consistent EPICS environments for all of the integrators on site. In order to maintain this, we use in particular Gitlab CI/CD to build, test, and deploy our EPICS modules. We will present our work on how we maintain control over our EPICS environment while still allowing integrators the easy ability to build and test their control software.

MOPV039

UCAP: A Framework for Accelerator Controls Data Processing @ CERN

L. Cseppento, M. Buttner (CERN)

The Unified Controls Acquisition and Processing (UCAP) framework provides a means to facilitate and streamline data processing in the CERN Accelerator Control System. UCAP's generic structure is capable of tackling classic "Acquisition - Transformation - Publishing/Presentation" use cases, ranging from simple aggregations to complex machine reports and pre-processing of software interlock conditions. In addition to enabling end-users to develop data transformations in Java or Python and maximising integration with other controls sub-systems, UCAP puts an emphasis on offering self-service capabilities for deployment, operation and monitoring. This ensures that accelerator operators and equipment experts can focus on developing domain-specific transformation algorithms, without having to pay attention to typical IT tasks, such as process management and system monitoring. UCAP is already used by Linac4, PSB and SPS operations and will be used by most CERN accelerators, including LHC by the end of 2021. This contribution presents the UCAP framework and gives an insight into how we have productively combined modern agile development with conservative technical choices.

MOPV040

Introducing Python as a Supported Language for Accelerator Controls at CERN

P.J. Elson, C. Baldi, I. Sinkarenko (CERN)

In 2019, Python was adopted as an officially supported language for interacting with CERN's accelerator controls. In practice, this change of status was as much pragmatic as it was progressive - Python has been available as part of the underlying operating system for over a decade and unofficial Python interfaces to controls have existed since at least 2015. So one might ask: what really changed when Python's adoption became official? This paper will discuss what it takes to officially support Python in a controls environment and will focus on the cultural and technological shifts involved in running Python operationally. It will highlight some of the infrastructure that has been put in place at CERN to facilitate a stable and user-friendly Python platform, as well as some of the key decisions that have led to Python thriving in CERN's accelerator controls domain. Given its general nature, it is hoped that the approach presented in this paper can serve as a reference for other scientific organisations from a broad range of fields who are considering the adoption of Python in an operational context.

MOPV041

Modernisation of the Toolchain and Continuous Integration of Front-end Computer Software at CERN

P. Mantion, S. Deghaye, L. Fiszer, F. Irannejad, J. Lauener, M. Voelkle (CERN)

Building C++ software for low-level computers requires carefully tested frameworks and libraries. The major difficulties in building C++ software are to ensure that the artifacts are compatible with the target system's (OS, Application Binary Interface), and to ensure that transitive dependent libraries are compatible when linked together. Thus developers/maintainers must be provided with efficient tooling for friction-less workflows: standardisation of the project description and build, automatic CI, flexible development environment. The open-source community with services like Github and Gitlab have set high expectations with regards to developer user experience. This paper describes how we leveraged Conan and CMake to standardise the build of C++ projects, avoid the "dependency hell" and provide an easy way to distribute C++ packages. A CI system orchestrated by Jenkins and based on automatic job definition and in-source, versioned, configuration has been implemented. The developer experience is further enhanced by wrapping the common flows (compile, test, release) into a command line tool, which also helps transitioning from the legacy build system (legacy makefiles, SVN).

MOPV042

Plcverif: Status of a Control Logic Formal Verification Tool

J-C. Tournier, B. Fernandez Adiego, I.D. Lopez-Miguel (CERN)

Programmable Logic Controllers (PLC) are widely used for industrial automation including safety systems at CERN. The incorrect behaviour of the PLC control system logic can cause significant financial losses by damage of property or the environment or even injuries in some cases, therefore ensuring their correct behaviour is essential. While testing has been for many years the traditional way of validating the PLC control system logic, CERN developed a model checking platform to go one step further and formally verify PLC logic. This platform, called PLCverif, first released internally for CERN usage in 2019, is now available to anyone since September 2020

via an open source licence. In this paper, we will first give an overview of the PLCverif platform capabilities before focusing on the improvements done since 2019 such as the larger support coverage of the Siemens PLC programming languages, the better support of the C Bounded Model Checker backend (CBMC) and the process of releasing PLCverif as an open-source software.

CERN Controls Configuration Service - Event-Based Processing of Controls Changes

B. Urbaniec, L. Burdzanowski (CERN)

The Controls Configuration Service (CCS) is a core component of the data-driven Control System at CERN. Built around a central database, the CCS provides a range of client APIs and graphical user interfaces (GUI) to enable efficient and user-friendly configuration of Controls. As the entry point for all the modifications to Controls system configurations, the CCS provides the means to ensure global data coherency and propagation of changes across the distributed Controls sub-systems and services. With the aim of achieving global data coherency in the most efficient manner, the need for an advanced data integrator emerged. The Controls Configuration Data Lifecycle manager (CCDL) is the core integration bridge between the distributed Controls sub-systems. It aims to ensure consistent, reliable, and efficient exchange of information and triggering of workflow actions based on events representing Controls configuration changes. The CCDL implements and incorporates cutting-edge technologies used successfully in the IT industry. This paper describes the CCDL architecture, design and technology choices made, as well as the tangible benefits that have been realised since its introduction.

Lessons learned moving from Pharlap to Linux RT

C. Charrondière, O.O. Andreassen, J. Tagg, T. Zilliox (CERN)

The start of the Advanced Proton Driven Plasma Wakefield Acceleration Experiment (AWAKE) facility at CERN in 2016 came with the need for a continuous image acquisition system. The international scientific collaboration responsible for this project requested low and high resolution acquisition at a capture rate of 10Hz and 1 Hz respectively. To match these requirements, GigE digital cameras were connected to a PXI system running PharLap, a real-time operating system, using dual port 1GB/s network cards. With new requirements for a faster acquisition with higher resolution, it was decided to add 10GB/s network cards and a Network Attached Storage (NAS) directly connected to the PXI system to avoid saturating the network. There was also a request to acquire high-resolution images on several cameras during a limited duration, typically 30 seconds, in a burst acquisition mode. To comply with these new requirements PharLap had to be abandoned and replaced with Linux RT. This paper describes the limitation of the PharLap system and the lessons learned during the transition to Linux RT. We will show the improvement of CPU stability and data throughput reached.

Data-Centric Web Infrastructure for CERN Radiation and Environmental Protection Monitoring

A. Ledeul, C.C. Chiriac, G. Segura, J. Sznajd, G. de la Cruz (CERN)

Supervision, Control and Data Acquisition (SCADA) systems generate large amounts of data over time. Analyzing collected data is essential to discover useful information, prevent failures, and generate reports. Facilitating access to data is of utmost importance to exploit the information generated by SCADA systems. CERN's occupational Health & Safety and Environmental protection (HSE) Unit operates a web infrastructure allowing users of the Radiation and Environment Monitoring Unified Supervision (REMUS) to visualize and extract near-real-time and historical data from desktop and mobile devices. This application, REMUS Web, collects and combines data from multiple sources and presents it to the users in a format suitable for analysis. The web application and the SCADA system can operate independently thanks to a data-centric, loosely coupled architecture. They are connected through common data sources such as the open-source streaming platform Apache Kafka and Oracle Rdb. This paper describes the benefits of providing a feature-rich web application as a complement to control systems. Moreover, it details the underlying architecture of the solution and its capabilities.

MOPV046

Tango Controls Device Attribute extension in Python3

T. Snijder, T. Juerges, J.J.D. Mol (ASTRON)

The Tango Controls Device Attributes represent a container for read-only or read-write data types. However the Attribute read/write functions need to be individually implemented for accessing structured data in hardware devices. This exposes a pattern of replicated code in the read and write functions. Maintaining this code becomes time consuming to maintain when a Device exposes tens or more Attributes. The solution we propose is to extend Tango Control Attributes. For that we combine a hardware access class (accessor) that reads and writes the structured data in hardware together with a small addition to the original Attribute declaration. The extended Attribute constructor provides information that describes how the accessor can locate a value in the hardware. This information is then used to provide the extended Attribute with a parameterised read or write function. The benefits of our solution are that various methods of hardware access can be efficiently and easily implemented and that new extended Attributes can be added with a single line of code. We have successfully used the extended Attributes with OPC-UA, SNMP, and INI-files in ASTRON's LOFAR2.0 Station Control program.

MOPV047

Upgrading Oracle Apex Applications at Lawrence Livermore National Lab's National Ignition Facility

A. Bhasker, R.D. Clark, R.N. Fallejo (LLNL)

As with all experimental physics facilities, NIF has software applications that must persist on a multi-decade timescale. They must be kept up to date for viability, sustainability and security. We present the steps and challenges involved in a major application upgrade project from Oracle APEX v5 to Oracle APEX v19.2. This upgrade involved jumping over 2 major versions and a total of 5 releases of Oracle APEX. Some applications that depended on now legacy Oracle APEX constructs required redesigning, while others that broke due to custom JavaScript needed to be updated for compatibility. This upgrade project, undertaken by the NIF Shot Data Systems team at LLNL, involved reverse-engineering functional requirements for applications that were then redesigned using the latest APEX out-of-the-box functionality, as well as identifying changes made in the new Oracle APEX built-in 'plumbing' to update custom-built features for compatibility with the new Oracle APEX version. As NIF enters into its second decade of operations, this upgrade allows these aging applications to function in a more sustainable way, while enhancing user experience with a modernized GUI for Oracle APEX web-pages.

MOPV048

Fast Multipole Method (FMM)-based Particle Accelerator Simulations in the Context of Tune Depression Studies

M.H. Langston, R. Lethin, P.D. Letourneau, J. Wei (Reservoir Labs)

As part of the MACH-B (Multipole Accelerator Codes for Hadron Beams) project, we have developed a Fast Multipole Method (FMM**)-based tool for higher fidelity modeling of particle accelerators for high-energy physics within Fermilab's Synergia* simulation package. We present results from our implementations with a focus on studying the difference between tune depression estimates obtained using PIC codes for computing the particle interactions and those obtained using FMM-based algorithms integrated within Synergia. In simulating the self-interactions and macroparticle actions necessary for accurate simulations, we present a newly-developed kernel inside of a kernel-independent FMM in which near-field kernels are modified to incorporate smoothing while still maintaining consistency at the boundary of the far-field regime. Each simulation relies on Synergia with one major difference: the way in which particles interactions were computed. Specifically, following our integration of the FMM into Synergia, changes between PIC-based computations and FMM-based computations are made by changing only the method for near-field (and self) particle interactions.

* J. Amundson et al. "Synergia: An accelerator modeling tool with 3-D space charge". J.C.P. 211.1 (2006) 229-248. ** L. Greengard. "Fast algorithms for classical physics". Science (Aug 1994) 909-914.

Funding: U.S. Department of Energy DOE SBIR Phase I Project DE-SC0020934

Standardizing a Python Development Environment for Large Controls Systems

S.L. Clark, P.S. Dyer, S. Nemesure (BNL)

Python provides broad design freedom to programmers and a low barrier of entry for new software developers. These aspects have proven that unless standardized, a Python codebase will tend to diverge from a common style and architecture, becoming unmaintainable across the scope of a large controls system. Mitigating these effects requires a set of tools, standards, and procedures developed to assert boundaries on certain aspects of Python development – namely project organization, version management, and deployment procedures. Common tools like Git, GitLab, and virtual environments form a basis for development, with in-house utilities presenting their capabilities in a clear, developer-focused way. This paper describes the necessary constraints needed for development and deployment of large-scale Python applications, the function of the tools which comprise the development environment, and how these tools are leveraged to create simple and effective procedures to guide development.
Funding: Work supported by Brookhaven Science Associates, LLC under Contract No. DE-SC0012704 with the U.S. Department of Energy.

DevOps and CI/CD for WinCC Open Architecture Applications and Frameworks

R.P.I. Silvola (CERN) L. Sargsyan (ANSL)

This paper presents the Continuous Integration and Continuous Deployment (CI/CD) tool chain for WinCC Open Architecture applications and frameworks developed at CERN, enabling a DevOps oriented approach of working. By identifying common patterns and time consuming procedures, and by agreeing on standard repository structures, naming conventions and tooling, we have gained a turnkey solution which automates the compilation of binaries and generation of documentation, thus guaranteeing they are up to date and match the source code in the repository. The pipelines generate deployment-ready software releases, which pass through both static code analysis and unit tests before automatically being deployed to short and long-term repositories. The tool chain leverages industry standard technologies, such as GitLab, Docker and Nexus. The technologies chosen for the tool chain are well understood and have a long, solid track record, reducing the effort in maintenance and potential long term risk. The setup has reduced the expert time needed for testing and releases, while generally improving the release quality.

TUKL — Keynote Session II

Large-scale Quantum Communication Network

J. Yin (USTC)

Free-space quantum communication with satellites opens a promising avenue for global secure quantum network and large-scale test of quantum foundations. Here we report a serial of experimental progresses on free-space quantum communication over long distance. In the meantime, Chinese Quantum Science Satellite has been launched on August 16th 2016. Through nearly one year of efforts, we have achieved the three major scientific goals'satellite-based entanglement distribution over 1200km, ground-to-satellite quantum teleportation and satellite-to-ground quantum key distribution. Intercontinental quantum communication between China and Europe at locations separated by 7600 km has also been demonstrated, using the satellite as a relay. In this report, we will first introduce the latest experimental progress through Micius, such as the first realization of entanglement-based QKD over 1,120 kilometres without the need for trusted relays, integrated space-to-ground quantum communication network over 4,600 kilometres, and satellite-based quantum-secure time transfer.

TUAL — Hardware Technology

CompactPCI-Serial Hardware Toolbox for SLS 2.0

B. Kalantari, W. Koprek, P. Pollet (PSI)

Motivated by upcoming large upgrade projects at PSI, most prominently SLS2.0, and due to increasing demands for performance (handling more data, faster processing) in various subsystems of the accelerator and beamlines, our electronics and control system experts had the task to evaluate alternatives to the existing VME technology and build a new portfolio of electronic hardware tools accordingly. CompactPCI-Serial was chosen as the standard platform for building our future modular control and data acquisition systems. We are currently developing two CompactPCI-Serial FPGA boards: FMC+ carrier and the COM-I/O. Both cards use the same family of Xilinx MPSoC (Zynq UltraScale+) as their processing building block. Combination of these two boards, together with COTS hardware should provide our system architects with enough flexibility to build systems with required budget and performance (high-end and/or low-cost) for various applications. We report on the state of the current challenging developments and describe system architectures for building high performance control and data acquisition systems using our hardware toolbox.

Development a Single Cavity Regulation Based on microtca.4 for SAPS-TP

W. Long, X. Li, S.H. Liu (IHEP) Y. Liu (DNSC)

A domestic hardware platform based on MTCA.4 is developed for a single cavity regulation in Southern Advanced Photon Source Test Platform (SAPS-TP). A multifunction digital processing Advanced Mezzanine Card (AMC) works as the core function module of the whole system, implement high speed data processing, Low-Level Radio Frequency (LLRF) control algorithm and interlock system. Its core data processing chip is a Xilinx ZYNQ SOC, which is embedded an ARM CPU to implement EPICS IOC under embedded Linux. A down-conversion and up-conversion RTM for cavity probes sensing and high power RF source driver can communi-cate with AMC module by a ZONE3 connector. A hosted tuning control FPGA Mezzanine Card (FMC) combines both the piezo controlling and step-motor controlling functions for independent external drive devices. The design of the hardware and software of the platform electronics and some test results are described in this paper. Further test and optimization is under way.

R&D Studies for the Atlas Tile Calorimeter Daughterboard.

E. Valdes Santurio, K.E. Dunne, S. Lee (FYSIKUM, AlbaNova, Stockholm University) C. Bohm, H. Motzkau, S.B. Silverstein (Stockholm University)

The ATLAS Hadronic Calorimeter DaughterBoard (DB) interfaces the on-detector with the off-detector electronics. The DB features two 4.6 Gbps downlinks and two pairs of 9.6 Gbps uplinks powered by four SFP+ Optical transceivers. The downlinks receive configuration commands and LHC timing to be propagated to the front-end, and the uplinks transmit continuous high-speed readout of digitized PMT samples, detector control system and monitoring data. The design minimizes single points of failure and mitigates radiation damage by means of a double-redundant scheme. To mitigate Single Event Upset rates, Xilinx Soft Error Mitigation and Triple Mode Redundancy are used. Reliability in the high speed links is achieve by adopting Cyclic Redundancy Check in the uplinks and Forward Error Correction in the downlinks. The DB features a dedicated Single Event Latch-up protection circuitry that power-cycles the board in the case of any over-current event avoiding any possible hardware damages. We present a summary of the studies performed to verify the reliability if the performance of the DB revision 6, and the radiation qualification tests of the components used for the design.

TUAR — Control System Upgrades II

TUAR01

UPGRADE OF THE CMS ECAL DETECTOR CONTROL SYSTEM DURING THE CERN LARGE HADRON COLLIDER LONG SHUTDOWN II

L. Marchese, D.R.S. Di Calafiori, G. Dissertori, L. Djambazov, R.J. Jiménez Estupinan, W. Lustermann (ETH)

As part of the Compact Muon Solenoid (CMS) experiment, the Electromagnetic Calorimeter (ECAL) Detector Control System (DCS) is undergoing a large software and hardware upgrade during the second long shutdown (LS2) of the CERN Large Hadron Collider (LHC). The DCS software running under the WinCC Open Architecture (OA) platform, required fundamental changes in the architecture as well as several other upgrades on the hardware side. The extension of the current long shutdown (2019-2021) is offering a unique opportunity to perform more updates, improve the detector safety and robustness during operations and achieve new control features with an increased modularity of the software architecture. Starting from the main activities of the ECAL DCS upgrade plan, we present the updated agenda for the LS2. This covers several aspects such as the different software migrations of the DCS, the consolidation of toolkits as well as some other improvements preceding the major ECAL upgrade foreseen for the next long shutdown (2025-2026).

TUAR02

The Phase-1 Upgrade of the ATLAS Level-1 Calorimeter Trigger

A.G. Kazarov (PNPI) , T. Mkrtchyan (KIP)

The ATLAS level-1 calorimeter trigger (L1Calo) is a hardware-based system that identifies events containing calorimeter-based physics objects, including electrons, photons, taus, jets, and missing transverse energy. In preparation for Run 3, when the LHC will run at higher energy and instantaneous luminosity, L1Calo is currently implementing a significant programme of planned upgrades. The existing hardware will be replaced by a new system of FPGA-based feature extractor (FEX) modules, which will process finer-granularity information from the calorimeters and execute more sophisticated algorithms to identify physics objects; these upgrades will permit better performance in a challenging high-luminosity and high-pileup environment. This talk will introduce the features of the upgraded L1Calo system and the plans for production, installation, and commissioning. In addition, the expected performance of L1Calo in Run 3 will be discussed.
Submitting as TDAQ Speakers committee, on behalf of actual authors. The presenter will be identified later.

TUAR03

The Control System of the Linac-200 Electron Accelerator at JINR

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The linear accelerator Linac-200 at JINR is constructed to provide electron test beams with energy up to 200 MeV to carry out particle detector R&D, to perform studies of advanced methods of beam diagnostics, and to work as an irradiation facility for applied research. While the accelerator largely reuses refurbished parts of the MEA accelerator from NIKHEF, the accelerator control system is completely redesigned. A new distributed control system has been developed using the Tango toolkit. The key subsystems of the accelerator (including focusing and steering magnets control, vacuum control system, synchronization system, electron gun control system, precise temperature regulation system) were redesigned or deeply modernized. This report presents the design and the current status of the control system of the Linac-200 machine.

TUBL — Software Technology Evolution II

Distributed Caching at Cloud Scale With Apache Ignite for the C2MON Framework

T. Marques Oliveira, M. Bräger, B. Copy, S.E. Halastra, D. Martin Anido, A. Papageorgiou Koufidis (CERN)

The CERN Control and Monitoring platform (C2MON) is an open-source platform for industrial controls data acquisition, monitoring, control and data publishing. Its high availability, fault tolerance and redundancy make it a perfect fit to handle the complex and critical systems present at CERN. C2MON must cope with the ever-increasing flows of data produced by the CERN technical infrastructure, such as cooling and ventilation or electrical distribution alarms, while maintaining integrity and availability. Distributed caching is a common technique to dramatically increase the availability and fault tolerance of redundant systems. For C2MON we have replaced the existing legacy Terracotta caching framework with Apache Ignite. Ignite is an enterprise grade, distributed caching platform, with advanced cloud-native capabilities. It enables C2MON to handle high volumes of data with full transaction support and makes C2MON ready to run in the cloud. This article first explains the challenges we met when integrating Apache Ignite into the C2MON framework, and then demonstrates how Ignite enhances the capabilities of a monitor and control system in an industrial controls environment.

Implementing an Event Tracing Solution With Consistently Formatted Logs for the SKA Telescope Control System

S.N. Twum, W.A. Bode, A.F. Joubert, K. Madisa, P.S. Swart, A.J. Venter (SARAO) A. Bridger (ROE, UTAC) A. Bridger (SKAO)

The SKA telescope control system comprises several devices working on different hierarchies on different sites to provide a running observatory. The importance of logs, whether in its simplest form or correlated, in this system as well as any other distributed system is critical to fault finding and bug tracing. The SKA logging system will collect logs produced by numerous networked kubernetes deployments of devices and processes running a combination off-the-shelf, derived and bespoke software. The many moving parts of this complex system are delivered and maintained by different agile teams on multiple SKA Agile Release Trains. To facilitate an orderly and correlated generation of events in the running telescope, we implement a logging architecture which enforces consistently formatted logs with event tracing capability. We discuss the details of the architecture design and implementation, ending off with the limitations of the tracing solution in the context of a multiprocessing environment.
Funding: South African Radio Astronomy Observatory

Tango Controls RFCs

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In 2019, the Tango Controls Collaboration decided to write down a formal specification of the existing Tango Controls protocol as Requests For Comments (RFC). The work resulted in a Markdown-formatted specification rendered in HTML and PDF on Readthedocs.io. The specification is already used as a reference during Tango Controls source code maintenance and for prototyping a new implementation. All collaborating institutes and several companies were involved in the work. In addition to providing the reference, the effort brought the Community more value: review and clarification of concepts and their implementation in the core libraries in C++, Java and Python. This paper summarizes the results, provides technical and organizational details about writing the RFCs for the existing protocol and presents the impact and benefits on future maintenance and development of Tango Controls.

TUBL04

CI-CD Practices at SKA

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The Square Kilometre Array (SKA) is an international effort to build two radio interferometers in South Africa and Australia forming one Observatory monitored and controlled from global headquarters (GHQ) based in the United Kingdom at Jodrell Bank. SKA is highly focused on adopting CI/CD practices for its software development. CI/CD stands for Continuous Integration
& Delivery and/or Deployment. Continuous Integration is the practice of merging all developers' local copies into the mainline frequently. Continuous Delivery is the approach of developing software in short cycles ensuring it can be released anytime, and Continuous Deployment is the approach of delivering the software into operational use frequently and automatically. This paper analyses the decisions taken by the Systems Team (a specialized agile team devoted to developing and maintaining the tools that allow continuous practices) to promote the CI/CD practices with the TANGO-controls framework.

TUBL05

Pysmlib: a Python Finite State Machine Library for EPICS

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In the field of Experimental Physics and Industrial Control Systems (EPICS)*, the traditional tool to implement high level procedures is the Sequencer*. While this is a mature, fast, and well-proven software, it comes with some drawbacks. For example, it's based on a custom C-like programming language which may be unfamiliar to new users and it often results in complex, hard to read code. This paper presents pysmlib, a free and open source Python library developed as a simpler alternative to the EPICS Sequencer. The library exposes a simple interface to develop event-driven Finite State Machines (FSM), where the inputs are connected to Channel Access Process Variables (PV) thanks to the PyEpics** integration. Other features include parallel FSM with multi-threading support and input sharing, timers, and an integrated watchdog logic. The library offers a lower barrier to enter and greater extensibility thanks to the large ecosystem of scientific and engineering python libraries, making it a perfect fit for modern control system requirements. Pysmlib has been deployed in multiple projects at INFN Legnaro National Laboratories (LNL), proving its robustness and flexibility.
* L. R. Dalesio, M. R. Kraimer, and A. J. Kozubal. "EPICS architecture." ICALEPCS. Vol. 91. 1991. ** M. Newville, et al., pyepics/pyepics Zenodo. http://doi.org/10.5281/zenodo.592027

TUBR — Device Control and Integrating Diverse Systems II

Nominal Device Support (NDSv3) as a Software Framework for Measurement Systems in Diagnostics

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Software integration of diverse data acquisition and timing hardware devices in diagnostics applications is very challenging. While the implementation should manage multiple hardware devices from different manufacturers providing different applications program interfaces (APIs), scientists would rather focus on the high level configuration, using their specific environment such as EPICS, Tango, the ITER Real-Time Framework or the MARTe2 middleware. The Nominal Device Support (NDSv3) C++ framework, conceived by Cosylab and under development at ITER for use in its diagnostic applications, uses a layered approach, abstracting specific hardware device APIs as well as the interface to control systems and real-time applications. ITER CODAC and its partners have developed NDS device drivers using both PXIe and MTCA platforms for multifunction DAQ devices, timing cards and FPGA-based solutions. In addition, the concept of an NDS-System encapsulates a complex structure of multiple NDS device drivers, combining functions of the different low-level devices and collecting all system-specific logic, separating it from generic device driver code.

Design Patterns for the SKA Control System

S. Vrcic (SKAO)

The Control System for the Square Kilometre Array, a project to build two large Radio-Telescopes, is based on the TANGO Controls framework. The SKA Telescopes comprise a large number of diverse elements and instruments; this paper presents the key design patterns for the implementation of the SKA Control System.

Control System for 6 MeV Linear Accelerator at LINAC Project PINSTECH

N.U. Saqib, M. Ajmal, A. Majid, D.A. Nawaz, F. Sher, A. Tanvir (PINSTECH)

At LINAC Project PINSTECH, 6 MeV electron linear accelerator prototypes are being developed for medical as well as industrial purposes. Control system of the linear accelerators is a distributed control system mainly comprised of EPICS and PLCs. Graphical User Interface (GUI) are developed using Phoebus Control System Studio (CSS) and Siemens WinCC Advanced software. This paper focuses on design, development and implementation of accelerator control system for various subsystems such as RF, vacuum, cooling as well as safety subsystems. The current status of the control system and services is presented.

Control System of Cryomodule Test Platforms for SHINE

H.Y. Wang, G.H. Chen, J.F. Chen, J.G. Ding, M. Li, Y.J. Liu, Q.R. Mi, H.F. Miao, C.L. Yu (SSRF)

Shanghai HIgh repetition rate XFEL aNd Extreme light facility (SHINE) is under construction. The 8 GeV superconducting Linac consists of seventy-five 1.3 GHz and two 3.9 GHz cryomodules. A cryomodule assembling and test workshop is established. Multiple platforms have been built for cryomodule and superconducting cavity test, including two vertical test platforms, two horizontal test platform, one multiple test platform and one liquid helium visualization platform. The local control systems are all based on Yokogawa PLC, which monitor and control the process variables such as temperature, pressure, liquid level and power of the heater. PID and other algorithms are used to keep liquid level and power balance. EPICS is adopt to integrate these platforms'along with vacuum devices, solid state amplifiers, LLRF and RF measurement system, etc. The details of the control system design, development and commissioning will be reported in this paper.

Integrating OPC UA Devices into EPICS Using the Open62541 Library

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OPC UA is a standardized network protocol for integrating diverse control systems. In recent years, this protocol has gained support from many vendors of both hardware and software components, thus significantly reducing the efforts needed to integrate components from different vendors. We have developed an EPICS device support that is based on the open62541 open-source library for use at the accelerator facilities operated by the Karlsruhe Institute of Technology. This device support acts as an OPC UA client, enabling the integration of hardware components (e.g. programmable logic controllers) as well as software components (e.g. third-party control-system frameworks) into our EPICS based control systems. In this contribution, we present this EPICS device support, which is publicly available under an open-source license.

TUPV — Posters

The Mirror System Benches Kinematics Development for Sirius/LNLS

G.N. Kontogiorgos, A.Y. Horita, L. Martins dos Santos, M.A.L. Moraes, L.F. Segalla (LNLS)

At Sirius, many of the optical elements such as mirror systems, monochromators, sample holders and detectors are attached to the ground with high stiffnesses to reduce disturbances at the beam during experiments. Granite benches were developed to couple the optical device to the floor and allow automatic movements, via com-manded setpoints on EPICS that runs an embedded kinematics, during base installation, alignment, commis-sioning and operation of the beamline. They are com-posed by stages and each application has its own geome-try, a set number of Degrees-of-Freedom (DoF) and mo-tors, all controlled by Omron Delta Tau Power Brick LV. In particular, the mirror system was the precursor motion control system for other benches. Since the me-chanical design aims on stiffness, the axes of mirror are not controlled directly, the actuators are along the granite bench. A geometric model was created to simplify the mirror operation, which turn the actuators motion trans-parent to the user and allow him to directly control the mirror axes.

Funding: Ministry of Science, Technology and Innovation (MCTI)

Motion Control Improvements for the Kirkpatrick-Baez Mirror System for Sirius/LNLS EMA Beamline

G.N. Kontogiorgos, M.A.L. Moraes, C.S.B.N. Roque (LNLS)

The Kirkpatrick-Baez (KB) mirror system is composed of a vertical focusing mirror (VFM) and a horizontal fo-cusing mirror. Both concave mirrors focus the X-ray beam by reflecting it at small grazing angles. The relocation of this system from UVX XDS beamline to Sirius EMA beamline facilitated a full revision of the motion control system, whose controller was migrated to Omron Delta Tau Power Brick LV. The beam focus is controlled by bending the mirrors through camshaft mechanisms cou-pled to low current Faulhaber motors. Although the am-plifier is designed for higher currents, controller settings allowed the use of lower currents. Another improvement made is the ability to drive both bender motors in gantry mode and still control the lag between them. Each bender has a capacitive sensor to monitor the position of the center of the mirror, which is read by the analog input of the controller and made available by EPICS [1]. The VFM is supported by a tripod and a new kinematics was devel-oped to reference the center of the mirror as the point of control. This paper presents the implementation of the new motion control KB system and its results at Sirius EMA beamline.

Funding: Ministry of Science, Technology and Innovation (MCTI)

The Control System of the Four-Bounce Crystal Monochromators for Sirius/LNLS Beamlines

L. Martins dos Santos, P.D. Aranha, L.M. Kofukuda, G.N. Kontogiorgos, M.A.L. Moraes, J.H. Řežende, M. Saveri Silva, H.C.N. Tolentino (LNLS)

CARNAÃBA (Coherent X-ray Nanoprobe) and CATERETÃ (Coherent and Time Resolved Scattering) are the longest beamlines in Sirius - the 4th generation light source at the Brazilian Synchrotron Light Laboratory (LNLS). They comprise Four-Bounce Crystal Monochromators (4CM) for energy selection with strict stability and performance requirements. The motion control architecture implemented for this class of instruments was based on Omron Delta Tau Power Brick LV, controller with PWM amplifier. The 4CM was in-house designed and consists of two channel-cut silicon crystals whose angular position is given by two direct-drive actuators. A linear actuator mounted between the crystals moves a diagnostic device and a mask used to obstruct spurious diffractions and reflections. The system is assembled in an ultra-high vacuum (UHV) chamber onto a motorized granite bench that permits the alignment and the operation with pink-beam. This work details the motion control approach for axes coordination and depicts how the implemented methods led to the achievement of the desired stability, considering the impact of current control, in addition to benchmarking with manufacturer solution.

Funding: Ministry of Science, Technology, and Innovation (MCTI)

TUPV004

The FPGA-based Control Architecture, EPICS Interface and Advanced Operational Modes of the High-Dynamic Double-Crystal Monochromator for Sirius/LNLS

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The High-Dynamic Double-Crystal Monochromator (HD-DCM) has been developed since 2015 at Sirius/LNLS with an innovative high-bandwidth mechatronic architecture to reach the unprecedented target of 10 nrad RMS (1 Hz - 2.5 kHz) in crystals parallelism also during energy flyscans*. After the initial work in Speedgoat's xPC rapid prototyping platform, for beamline operation the instrument controller was deployed to NI's CompactRIO (cRIO), as a rugged platform combining FPGA and real-time capabilities. Customized libraries needed to be developed in LabVIEW and a heavily FPGA-based control architecture was required to finally reach a 20 kHz control loop rate. This work summarizes the final control architecture of the HD-DCM, highlighting the main hardware and software challenges; describes its integration with the EPICS control system and user interfaces; and discusses its advanced operational modes, including the integration with an undulator source, through different coordination strategies.
*Geraldes, R. R., et al. "The status of the new High-Dynamic DCM for Sirius." Proc. MEDSI 2018 (2018).
Funding: Ministry of Science, Technology and Innovation (MCTI)

TUPV005

OPC UA Data Acquisition for the C2MON Framework

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The CERN Control and Monitoring Framework(C2MON) is a monitoring platform developed at CERN and since 2016 made available under an LGPL3 open source license. It stands at the heart of the CERN Technical Infrastructure Monitoring (TIM) that supervises the correct functioning of CERN's technical and safety infrastructure. This diverse technological infrastructure requires a variety of industrial communication protocols. OPC UA [2], an open and platform-independent architecture, can be leveraged as an integration protocol for a large number of existing data sources, and represents a welcome alternative to proprietary protocols. With the increasing relevance of the open communication standard OPC UA in the world of industrial control, adding OPC UA data acquisition capabilities to C2MON provides an opportunity to accommodate modern and industry-standard compatible use cases. This paper describes the design and development process of the C2MON OPC UA data acquisition module, the requirements it fulfills, as well as the opportunities for innovation it yields in the context of industrial controls at CERN.

TUPV006

Control System of the Spiral2 Superconducting Linac Cryogenic System

A.H. Trudel, G. Duteil, A. Ghribi, Q. Tura (GANIL) P. Bonnay (CEA/INAC)

The SPIRAL2 cryogenic system has been designed to cool down and maintain stable operation conditions of the 26 LINAC superconducting resonating cavities at a temperature of 4.5 K or lower. The control system of the cryogenic system of the LINAC is based on an architecture of 20 PLCs. Through an independent network, it drives the instrumentation, the cryogenic equipment, the 26 brushless motors of the frequency tuning system, interfaces the Epics Control System, and communicates process information to the Low Level Radio Frequency, vacuum, and magnet systems. Its functions are to ensure the safety of the cryogenic system, to efficiently control the cooldown of the 19 cryomodules, to enslave the frequency tuning system for the RF operation, and to monitor and analyze the data from the process. A model based Linear Quadratic regulation controls simultaneously both phase separators the liquid helium level and pressure. This control system also makes it possible to perform a number of virtual verification tests via a simulator and a dedicated PLC used to develop advanced model based control, such as a real time heat load estimator based on a Luenberger Filter

Motorized Regulation Systems for the Saraf Project

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CEA is in charge of the tuning regulation systems for the SARAF-Linac project. These tuning systems will be used with LLRF to regulate the 3 Rebuncher cavities and the HWR cavities of the 4 cryomodules. These systems were already tested on the Rebuncher and Equipped Cavity Test stands to test respectively the warm and cold tunings. This paper describes the hardware and software architectures. Both tuning systems are based on Siemens PLC and EPICS-PLC communication. Ambiant temperature technology is based on SIEMENS motor controller solution whereas the cold one combines Phytron and PhyMOTION solutions.

Status of Bluesky deployment at BESSY II for machine commissioning

P. Schnizer, J. Bengtsson, T. Birke, J. Li, T. Mertens, M. Ries (HZB)

HZB is hosting two light sources: BESSY II and MLS. As for any light source regular commissioning task are required for monitoring machines performance next to developing and establishing new operation modes. The current modernization of the commissioning software itself is based on the BlueSky software stack. A digital twin is used as backend for testing the software itself next to providing a tuneable online machine model. We describe our users experience, exemplify commissioning tools simplifications due to the Bluesky software framework and describe the design choices made for the used digital twin.

OpenCMW - a Modular Open Common Middle-Ware Library for Equipment- and Beam-Based Control Systems at FAIR

R.J. Steinhagen, H. Bräuning, D.S. Day, A. Krimm, T. Milosic, D. Ondreka, A. Schwinn (GSI)

OpenCMW is an open-source modular event-driven micro- and middle-ware library for equipment- and beam-based monitoring as well as feedback control systems for the FAIR Accelerator Facility. Based on modern C++20 and Java concepts, it provides common communication protocols, interfaces to data visualisation and processing tools that aid engineers and physicists at FAIR in writing functional high-level monitoring and (semi-)automated feedback applications. The focus is put on minimising the required boiler-plate code, programming expertise, common error sources, and significantly lowering the entry-threshold that is required with the framework. OpenCMW takes care of most of the communication, data-serialisation, data-aggregation, settings management, Role-Based-Access-Control (RBAC), and other tedious but necessary control system integrations while still being open to expert-level modifications, extensions or improvements.

Integration of OPC UA at ELBE

K. Zenker, M. Kuntzsch, R. Steinbrück (HZDR)

The Electron Linac for beams with high Brilliance and low Emittance (ELBE) at Helmholtz-Zentrum Dresden-Rossendorf (HZDR) is in operation since 2001. It is operated using the SCADA system WinCC by Siemens. The majority of ELBE systems is connected to WinCC via industrial Ethernet and proprietary S7 communication. However, in recent years new subsystems had to be integrated into the existing infrastructure, which do not provide S7 communication interfaces. Instead, OPC UA has been chosen for system integration. We will show how we use OPC UA as a common communication layer between industrial and scientific instruments as well as proprietary and open source control system software. For example, OPC UA support has been implemented for the ChimeraTK framework developed at DESY. ChimeraTK is used at ELBE e.g. for integrating MicroTCA.4 based subsystems like the digital LLRF system. Furthermore, we are developing a machine data interface for ELBE users. In combination with a certification authority, which hands out user certificates for data access, external users can gain read and write access to different ELBE subsystem data provided by a single OPC UA server.

TUPV011

Interfacing Epics and Labview Using Opc Ua for Slow Control Systems

J. Mostafa, A. Beglarian, S.A. Chilingaryan, A. Kopmann (KIT)

The ability of EPICS-based control systems to adapt to heterogeneous architectures made EPICS the defacto control system for scientific experiments. Several approaches have been made to adapt EPICS to LabVIEW-based cRIO hardware but these approaches including NI EPICS ServerI/O Server: (1) require a lot of effort to maintain and run especially if the controllers and the process variables are numerous; (2) only provide a limited set of metadata; or (3) provide a limited set of EPICS features and capabilities. In this paper, we survey different solutions to interface EPICS with LabVIEW-based hardware then propose EPICS OPCUA device support as an out-of-the-box interface between LabVIEW-based hardware and EPICS to preserve most of EPICS features and provide reasonable performance for slow control systems.

TUPV012

Automated Device Error Handling in Control Applications

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When integrating devices into a control system, the device applications usually contain a large fraction of error handling code. Many of these errors are run time errors which occur when communicating with the hardware, and usually have similar handling strategies. Therefore we extended ChimeraTK, a software toolkit for the development of control applications in various control system frameworks, such that the repetition of error handling code in each application can be avoided. ChimeraTK now also features automatic error reporting, recovery from device errors, and proper device initialisation after malfunctioning and at application start.

TUPV013

Back end event builder software design for INO mini-ICAL system

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The Indian-based Neutrino Observatory collaboration has proposed to build a 50 KT magnetized Iron Calorimeter (ICAL) detector to study atmospheric neutrinos. The paper describes the design of back-end event builder for Mini-ICAL, which is a first prototype version of ICAL and consists of 20 Resistive Plate Chamber (RPC) detectors. The RPCs push the event and monitoring data using a multi-tier network technology to the event builder which carries out event building, event track display, data quality monitoring and data archival functions. The software has been designed for high performance and scalability using asynchronous data acquisition and lockless concurrent data structures. Data storage mechanisms like ROOT, Berkeley DB, Binary and Protocol Buffers were studied for performance and suitability. Server data push module designed using publish-subscribe pattern allowed transport & remote client implementation technology agnostic. Event Builder has been deployed at mini-ICAL with a throughput of 3MBps. Since the software modules have been designed for scalability, they can be easily adapted for the next prototype E-ICAL with 320 RPCs to have sustained data rate of 200MBps

TUPV014

Control System of a Portable Pumping Station for Ultra-High Vacuum

M. Trevi, E. Mazzucco, L. Rumiz, D. Vittor (Elettra-Sincrotrone Trieste S.C.p.A.)

Particle accelerators operate in Ultra High Vacuum conditions, which have to be restored after a maintenance activity requiring venting the vacuum chamber. A compact, independent and portable pumping station has been developed at Elettra Sincrotrone Trieste to pump the vacuum chamber and to restore the correct local pressure.. The system automatically achieves a good vacuum level and can detect and manage vacuum leaks . It has been designed and manufactured in-house, including the mechanical, electrical and control parts. By means of a touch screen an operator can start all the manual and automatic operations, and monitor the relevant variables and alarms. The system archives the operating data and displays trends, alarms and logged events; these data are downloadable to a removable USB stick. Controlled devices include two turbomolecular pumps, one primary pump, vacuum gauges and one residual gas analyser. The control system has been implemented with a Beckhoff PLC with RS-485 and Profibus interfaces. This paper focuses in particular on the events management and object-oriented approach adopted to achieve a good modularity and scalability of the system.

EPICS Based High-Level Control System for ESS-ERIC Emittance Measurement Unit Device

M.G. Giacchini, M. Montis (INFN/LNL) C.S. Derrez, J.P.S. Martins, R. Tarkeshian (ESS)

For low energy linear accelerators, a typical method for measuring the transverse emittance consists in a slit and grid system. In ESS-ERIC* dedicated Emittance Measurement Units (EMUs) are used to calculate the transverse phase space (horizontal and vertical) and they are composed by a slit and grid system. This system let users reconstruct the distribution of particles in x and x' (or y and y'), position and angle between particle trajectory and z axis, respectively. The EMU aims to measure the transverse emittance by sampling the transverse phase space. Considering control system aspect, a single EMU device is composed by different sub-systems (acquisition, motion, etc.). In this paper the software layer developed in EPICS** and realized to orchestrate the entire apparatus and control the different sub-systems will be described.
* https://europeanspallationsource.se/ ** https://epics-controls.org/

Design and Development of the New Diagnostics Control System for the SPES Project at INFN-LNL

G. Savarese, G. Arena, D. Bortolato, F. Gelain, D. Marcato, V. Martinelli, E. Munaron, M. Roetta (INFN/LNL)

The need to get finer data to describe the beam is a relevant topic for all laboratories. For the SPES project at Laboratori Nazionali di Legnaro (LNL) a new diagnostic control system with more performing hardware, with respect to the one used in legacy accelerators based on Versabus Module Eurocard (VME) ADCs, has been developed. The new system uses a custom hardware to acquire signals in real time. These data and ancillary operations are managed by a control system based on the Experimental Physics and Industrial Control System (EPICS) standard and shown to users on a Control System Studio (CSS) graphical user interface. The new system improves the basic functionalities, current read-back over Beam Profilers (BP) and Faraday Cups (FC) and handlings control, with new features such as: multiple hardware gain levels selection, broken wires correction through polynomial interpolation and roto-translations taking into account alignment parameters. Another important feature, integrated with the usage of a python Finite State Machine (FSM), is the capability to control an emittance meter to quickly acquire data and calculate beam longitudinal phase space through the scubeex method.

The GEM Gas Monitoring System: Using a Gaseous Detector as a Gas Detector for CMS Triple-GEM Safe Operation

D. Fiorina (Pavia University)

The CMS experiment will exploit the Gas Electron Multiplier (GEM) technology for the first time during the next LHC run. Maintain the gas mixture quality and concentration is fundamental for the safe and correct operation of such gaseous detectors. An Ar concentration 1% higher or lower will respectively increase or decrease the detector gain of almost 15%. The CMS GEM Group decided to develop a monitoring system of the gas concentration by exploiting a small Triple-GEM detector. The gain measurement of this test chamber, fed by the gas mixture derived from the CMS GEM gas system, allows retrieving information about the Ar/CO_2 ratio. Detection of wrong gas concentrations in the test chamber will allow to trigger warnings or alarms before sending the gas to the GEM detectors and eventually to real-time tune the working point. This contribution will describe the GEM Gas Monitoring system from the design to the commissioning foreseen for end 2021. It will report about the calibration procedure, illustrating all the necessary steps to detect gain changes of around 5% corresponding to a systematic variation of Argon (or CO_2) concentration of 0.33%.

KEK LUCX facility Laser-to-RF&RF-to-RF stability study and optimization

K. Popov (Sokendai) A. Aryshev, N. Terunuma, J. Urakawa (KEK)

KEK LUCX facility* is a linear accelerator devoted to the beam instrumentation R&Ds for present and future accelerator systems and colliders including ILC. According to the ILC TDR**, it is necessary to achieve RF-gun Laser-to-RF&RF-to-RF phase stability of 0.35^{o}(RMS) and amplitude stability of 0.07%(RMS) with implementation of the Digital LLRF feedback based on commercially available FPGA board and digital trigger system. As the first step to achieve ILC stability level at KEK-LUCX facility, present Laser-to-RF&RF-to-RF phase and

amplitude jitters were measured using time- and frequency-domain techniques. After that, jitter influence on beam parameters after RF-gun and main solenoid magnet was simulated with ASTRA tracking code*** and results were cross-checked during LUCX facility beam operation. Finally, stable digital trigger system and digital LLRF feedback based on HighLand Technology T564 and RedPitaya SIGNALlab-250 modules were implemented. This report demonstrates the results of Laser-to-RF&RF-to-RF phase and amplitude jitter measurements cross-checked with ASTRA simulation and real beam parameters measurements before and after LUCX facility stabilization.
*A. Aryshev et al., Appl. Phys. Lett. 111, 033508 (2017). **International Linear Collider Reference Design Report, ILC-REPORT-2007-001, 2007. ***https://www.desy.de/~mpyflo/

TUPV019

Control System for 30 keV Electron Gun Test Facility

D.A. Nawaz, M. Ajmal, A. Majid, N.U. Saqib, F. Sher (PINSTECH)

At LINAC Project PINSTECH, an electron gun test facility for indigenously developed 30 keV electron guns is developed to control and monitor various beam parameters by performing electron beam tests and diagnostics. After successful testing, electron gun is then integrated into 6 MeV standing wave linear accelerator. This paper presents the control system design and development for the facility.

TUPV020

Automatic RF and Electron Gun Filament Conditioning Systems for 6 MeV LINAC

A. Majid, D.A. Nawaz, N.U. Saqib, F. Sher (PINSTECH)

RF conditioning of vacuum windows and RF cavities is a necessary task for eliminating poor vacuum caused by outgassing and contamination. Also, startup and shutdown process of linear accelerator requires gradual increase and decrease of electron gun filament voltage to avoid damage to the filament. This paper presents an EPICS based multi-loop automatic RF conditioning system and Electron Gun filament conditioning system for Klystron based 6 MeV Linear Accelerator.

TUPV021

Application Research of Inovance Plc in Accelerator Control System

Y.C. He (Institute of High Energy Physics, CAS) X. Wu (IHEP CSNS) Y.L. Zhang (IHEP)

In order to make the system stable and reliable, Programmable Logic Controllers (PLCs) are widely used to realize the slow control and interlock control of the accelerator control system. EPICS is a set of software tools used to build control systems for large scientific instruments such as particle accelerators. A prototype of communication between Inovance PLC and EPICS IOC was built by using a Inovance AC812 PLC controller. In order to simplify the system structure and reduce the development cost, the EPICS IOC was run in the AC812 PLC controller while running standard PLC program. The PLC program running in the AC812 PLC controller communicates with the EPICS IOC through the Modbus protocol, so as to integrate the data from the AC812 PLC controller into the EPICS IOC. Based on the brief introduction of EPICS, AC812 PLC controller and EPICS Modbus driver, the communication between the AC812 PLC controller and the EPICS IOC using EPICS Modbus drivers was tested. The test results show that the communication between the AC812 PLC controller and the EPICS IOC using the EPICS Modbus driver is smooth.

TUPV023

Ximea XiApi Camera Plugin for Lima

G.W. Kowalski, L. Zytniak (S2Innovation)

The XiApi pluign for Lima provides support for Ximea cameras using the XiApi interface. In addition to standard Lima interface, the plugin supports many of additional and camera specific features. This allows using Ximea cameras in experiments developed for other Lima cameras as well as enables detailed camera configuration. The plugin was tested at ESRF with a MX377MR PCIe camera and will soon be available via the esrf-bcu conda channel.

Preliminary Design of LLRF System for Polfel Accelerator

J. Szewinski, P.R. Bartoszek, K. Chmielewski, T. Kowalski, P. Markowski, D. Rybka, M. Sitek, Z. Wojciechowski (NCBJ)

PolFEL stands for Polish Free Electron Laser, and it is new facility which will be located in the National Centre for Nuclear Research in Świerk in Poland. PolFEL will be Free Electron Laser based on the 200 MeV linear superconducting electron accelerator made of the TESLA type cavities, targeting VUV, IR and THZ wavelengths. Described accelerator will be able to operate in the pulsed wave (PW) mode, but the main operational mode will be continuous wave (CW). PolFEL will operate in the single cavity regulation mode using solid state amplifiers - one per RF structure. Custom and flexible LLRF system will be needed to achieve goals described above. This contribution will present concept of the LLRF system for PolFEL, proposed technologies and techniques, and results of the first successful closed loop operation, performed in the laboratory with the prototype system and copper cavity.

Control System of Upgraded High Voltage for Atlas Tile Calorimeter

F. Martins, F.M.O. Cuim, G.G. Evans, R.P. Fernandez, A. Gomes, L. Gurriana (LIP) J.A. Soares Augusto (FCUL)

The preparation of the upgrade of the ATLAS electronics for High Luminosity LHC is in full swing. Tile Calorimeter is preparing the upgrade of its readout electronics and power distribution systems. One of such systems is the high voltage (HV) regulation and distribution system. The new system is based on HVRemote boards mounted in crates located at the counting room. The HV will be delivered to the on-detector electronics using 100 m long cables. The crates will be equipped with a system-on-chip (SoC) that will be responsible to manage the control and monitoring of the HV boards. The control of the HVRemote and its dedicated HVSupply boards is done by means of a dedicate serial peripheral interface (SPI) bus. A SCADA component is under development to communicate with and supervise the crates and boards, and to integrate the HV system in the detector's control system. The control system will be able to send notifications to the operators when the monitored values are out of range, archive the monitored data and if required, perform automated actions.

EPICS DAQ System of BPM for the KOMAC Linac and Beamlines

Y.G. Song, S.Y. Cho, J.H. Kim (Korea Atomic Energy Research Institute (KAERI))

The KOMAC facility consists of low-energy component, including a 50-keV ion source, a low energy beam transport (LEBT), a 3-MeV radio-frequency quadrupole (RFQ), and a 20-MeV drift tube linac (DTL), as well as high-energy components, including seven DTL tanks for the 100-MeV proton beam. The KOMAC has been operating 20-MeV and 100-MeV proton beam lines to provide proton beams for various applications. Approximately 20 stripline beam position monitors (BPMs) have been installed in KOMAC linac and beamlines. A data-acquisition (DAQ) system has been developed with various platforms in order to monitor beam position signals from linac and beamlines. This paper describes the hardware and software system and test results.

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TUPV028

The Control and Archiving System for the Gamma Beam Profile Station at ELI-NP

G. Chen, V. Iancu, C. Matei, F. Ramirez, G. Turturica (IFIN-HH)

The Variable Energy Gamma (VEGA) System of Extreme Light Infrastructure - Nuclear Physics (ELI-NP) is based on the Inverse Compton Scattering of laser light on relativistic electron bunches provided by a warm radio-frequency accelerator. The system will deliver quasi-monochromatic gamma-ray beams with a high spectral density and a high degree of linear polarization. The Beam Profile Station, which will be used for 'ner target alignment and spatial characterization of the gamma-ray beam, is one of the diagnostics stations under implementation at ELI-NP. An EPICS Control and Archiving System (CAS) has been developed for the Beam Profile Station at ELI-NP. This paper describes the design and the implementation of the EPICS CAS for the Beam Profile Station, including the device modular integration of the low-level IOCs for the CCD camera Trius-SX674 and Mclennan PM600 Stepper Motor Controller, the design of the high-level GUI for real-time image acquisition and motion control, as well as the configuration of the archiving system for browsing the historic images and parameters.
* The work is supported by ELI-NP Project (http://www.eli-np.ro/)

TUPV029

Controls.kt - a multiplatform API for device servers

A.A. Nozik (MIPT)

Large-scale control frameworks have a number of features, but they share several problems which make them hard to use for small-scale setups: * In order to control a single device, one needs to perform a complicated setup of industrial-scale applications and network tools. * Different systems have incompatible data protocols in their core, so a device, designed for one system, could not be plugged into another one. * Designing the device server requires a deep understanding of the system it is used in. * Most device server use synchronous calls, which impacts system scaleability. Controls.kt (https://github.com/mipt-npm/controls.kt) is an experimental lightweight device server API based on the Kotlin-Multiplatform technology, which allows it to be used in conjunction with most other systems. It is designed with asynchronous communication in mind and does not rely on any specific transport protocol. Instead one can create lightweight connectors to external frameworks to make it easily portable from one control system to another.
Funding: JetBrains Research

TUPV030

Redesign of the VELO Thermal Control System Forfuture Detector Development

S.A. Lunt (UCT Physics) B. Verlaat, L. Zwalinski (CERN)

The Detector Technologies group at CERN has developed a Two-Phase Accumulator Controlled Loop (2PACL) test system for future detector development, using reused hardware from the LHCb Vertex Locator (VELO) Thermal Control System. The fluid, electrical and control systems have been redesigned and simplified by removing redundant components because it is no longer a critical system. The fluid cycle was updated to allow both 2PACL and integrated 2PACL cycles to be run and the chiller was replaced with an air-cooled unit using hot gas bypass to achieve a high turndown ratio. The electrical systems were upgraded with new hardware to improve usability and practicality. The control system logic is being developed with the CERN's Unified Industrial Control System (UNICOS) framework. This paper presents thedetails of the design and implementation.

TUPV031

LHC Vacuum Supervisory Application for Run 3

S. Blanchard, N. Chatzigeorgiou, R. Ferreira, J.D. Francisco Rebelo, P. Gomes, C.V. Lima, G. Pigny, A.P. Rocha, L. Zygaropoulos (CERN)

The LHC Vacuum Supervisory Control and Data Acquisition application has been upgraded to fulfil the new requirements of Long Shutdown 2 and Run 3. The number of datapoint elements has been increased from 700k to 1.5M, which constitutes a challenge in terms of scalability. The new configuration of pumping station control hardware has led to an increase in the number of permanently connected PLCs from 150 to almost 300. A new concept has been developed and deployed, in which the PLC configuration is updated online. The goals were to automate, and to speed up periodic updates of the control system. Integrating of the wireless mobile equipment had led to the acquisition of expertise in dealing with temporary connections and dynamic insertion of device representation in the synoptic. Other new features include: the introduction of an innovative remote control and representation in synoptic panel of hardware interlocks, the development of a pre-configured notification system, and the integration of asset management into the user interface.

Challenges of Automating the Photocathode Fabrication Process at CERN

C. Charrondière, O.O. Andreassen, E. Chevallay, T. Zilliox (CERN)

The CERN Photoemission Laboratory was founded in 1989 with the goal of studying laser-driven electron sources, for producing high-brightness electron beams within the framework of the Compact Linear Collider (CLIC) study. To produce these photocathodes, two processes run in parallel. The first process, which is slow and asynchronous, controls and monitors the evaporation of photoemissive material. For this first step several power supplies are controlled to evaporate different metals through the Joule effect, with the power maintained constant in time and the thickness deposited monitored. The second process is synchronized with a laser trigger ranging from 0.1 to 50Hz, where the photocurrent and laser energy are measured to calculate the Quantum Efficiency. The control system for these processes has recently been renovated to benefit from the modularity of a PXI-based real-time environment using the standard CERN MiddleWare communication layer (CMW). This paper describes the challenges of the fabrication process as well as the flexibility introduced by using a PXI system.

Distributed Transactions in CERN's Accelerator Control System

F. Hoguin, S. Deghaye, R. Gorbonosov, J. Lauener, P. Mantion (CERN)

Devices in CERN's accelerator complex are controlled through individual requests, which change settings atomically on single Devices. Individual Devices are therefore controlled transactionally. Operators often need to apply a set of changes which affect multiple devices. This is achieved by sending requests in parallel, in a minimum amount of time. However, if a request fails, the Control system ends up in an undefined state, and recovering is a time-consuming task. Furthermore, the lack of synchronisation in the application of new settings may lead to the degradation of the beam characteristics, because of settings being partially applied. To address these issues, a protocol was developed to support distributed transactions and commit synchronisation in the CERN Control system, which was then implemented in CERN's real-time frameworks. We describe what this protocol intends to solve and its limitations. We also delve into the real-time framework implementation and how developers can benefit from the 2-phase commit to leverage hardware features such as double buffering, and from the commit synchronisation allowing settings to be changed safely while the accelerator is operational.

Development of an Automated High Temperature Superconductor Coil Winding Machine at CERN

H. Reymond, M. Dam, A. Haziot, P.D. Jankowski, P.J. Koziol, T.H. Nes, F.O. Pincot, S.C. Richter (CERN) H. Felice (LBNL)

Within the framework of technology studies on future accelerators, CERN has initiated a five-years R&D project aimed at the evaluation of the REBCO (Rare Earth Barium Copper Oxide) High Temperature Superconductors (HTS). The study covers a number of areas from material science to electromechanical properties. The REBCO high-field tape will be tested on different HTS magnet prototypes, such as HDMS (HTS Demonstrator Magnet for Space), GaToroid (hadron therapy Gantry based on a toroidal magnetic field) and other smaller coils that will be fabricated to study the tape's potential. To assemble the HTS coils, a new automatic winding station has been designed and constructed at CERN. A touch panel combined with an embedded controller running software developed in-house provides a sophisticated, yet intuitive and user-friendly system aimed at maintaining perfect coil winding conditions. In this paper, we describe the mechanical choices and techniques used to control the seven HTS spool tapes and the winding machine. We also present the analysis of several coils already produced.

Continuous Integration for PLC-based Control System Development

B. Schofield, E. Blanco Vinuela, J.H.P.D.C. Borrego (CERN)

Continuous Integration and Continuous Deployment (CI/CD) is a software engineering methodology which emphasises frequent, small changes committed to a version control system, which are verified by a suite of automatic tests, and which may be deployed to different environments. While CI/CD is well established in software engineering, it is not yet widely used in the development of industrial controls systems. However, the advantages of using CI/CD for such systems are clear. In this paper we describe a complete CI/CD pipeline able to automatically build Siemens PLC projects from sources, download the program to a PLC, and run a sequence of tests which interact with the PLC via both a Simulation Unit Profibus simulator and an OPC UA interface provided by

Simatic NET. To achieve this, a gRPC service wrapping the Simatic API was used to provide an interface to the PLC project from the pipeline. In addition, a Python wrapper was created for the Simulation Unit API, as well as for the OPC UA interface, which allowed the test suite to be implemented in Python. A particle accelerator interlock system based on Siemens S7-300 PLCs has been taken as a use case to demonstrate the concept.

TUPV036

An Evaluation of Schneider M580 HSBY PLC Redundancy in the R744 System A Cooling Unit

D.I. Teixeira (University of Cape Town) L. Davoine, W.K. Hulek, L. Zwalinski (CERN)

The Detector Technologies group at CERN has developed a 2-stage transcritical R744 cooling system as a service for future detector cooling. This is the first system in operation at CERN where Schneider HSBY (Hot Standby) redundant PLCs are used. This cooling system provides a good opportunity to test the Schneider redundant PLC system and understand the operation, limitations and probability of failure in a con-trolled environment. The PLC redundancy is achieved by connecting Schneider M580 HSBY redundant PLCs to the system where one is the primary which operates the system and the other is in standby mode. A series of tests have been developed to understand the operation and failure modes of the PLCs by simulating different primary PLC failures and observing whether the standby PLC can seamlessly take over the system operation.

TUPV037

MODULAR SOFTWARE ARCHITECTURE FOR THE NEW CERN INJECTOR WIRE-SCANNERS

A. Guerrero, D. Belohrad, J. Emery, S. Jackson, F. Roncarolo (CERN)

In the scope of the LHC injector upgrade, new wire-scanner devices have been installed in the LHC injector circular accelerators. This paper outlines the software architecture and choices taken in order to provide the scanner experts with comprehensive diagnostics as well as operators with straightforward size measurements. The underlying electronics acquire large amounts of data that need to be accessible for expert and machine develop-ment use and need to be processed before being present-ed for daily operational use, in the shape of a beam pro-file and its derived size. Data delivery and measurement computation are accomplished by means of a modular structure, using functionally distributed real-time process-es that handle the different data views, with minimal interference in the processing, and minimal exchange of data among modules.

TUPV038

OPC UA Controls for ATCA Back-End Electronics

P. Moschovakos, P.P. Nikiel, S. Schlenker (CERN)

The AdvancedTCA standard is employed as a back-end platform by system upgrades of ATLAS replacing the VME standard for new electronics systems. To extend the ATLAS controls functionality, a solution based on the OPC UA middleware was developed, managing ATCA shelves via their shelf manager SNMP interface and providing control and monitoring of the device. While focusing on ATCA, the solution is compatible with the broader range of xTCA device family. The ATCA OPC UA server, a modularized software application, models selected parts of the ATCA standard functionality in an object-oriented design. Code generation techniques are used to implement the selected device functions. The SNMP based back-end is a C++ wrapper of the Net-SNMP library and provides a generic interface to any SNMP device. In addition, the solution provides features such as hardware discovery to automatically create a device map, making their functionality available to OPC UA clients. Finally, a set of associated tools, allowing for easy client deployment in the SCADA applications, are part of the ATCA software solution making the integration into the ATLAS controls an easy and efficient task.

TUPV039

A Reliable Monitoring and Control System for Vacuum Surface Treatments

J. Tagg, E. Bez, M. Himmerlich, A.K. Reascos Portilla (CERN)

Secondary electron yield (SEY) of beam-screens in the LHC puts limits on the performance of the accelerator. To ramp up the luminosity for the HiLumi LHC project, the vacuum surface coatings team are coming up with ways to treat the surfaces to control the electron cloud and bring the SEY down to acceptable levels. These treatments can take days to weeks and need to work reliably to be sure the surfaces are not damaged. An embedded control and monitoring system based on a CompactRIO is being developed to run these processes in a

reliable way. This paper describes the techniques used to create a LabVIEW-based real-time embedded system that is reliable as well as easy to read and modify. We will show how simpler approaches can in some situations yield better solutions.

A Python Package For Generating Motor Homing Routines

A.S. Palaha, G. Knap (DLS)

Diamond Light Source uses hundreds of Delta Tau Turbo PMAC2 based motion controllers that control motors with precision and repeatability. Homing is critical to these requirements; it safely moves axes to a well-known position using a high-precision device for detection, leaving the overall system in a well-known state and ready for use. A python package called 'pmac$_{m}$otorhome' has been developed to generate homing routines for multiple motors across multiple motion controllers, allowing the user to write a script that is terse for standard/typical routines but allows for customisation and flexibility where required. The project uses jinja templates as `snippets' to generate the homing routine code written in Delta Tau PLC notation. The snippets can be re-ordered and grouped together, supporting the design of homing routines for multi-axis systems with mechanical limitations that require an orchestrated approach to safely home the axes. The python script using the package is kept terse using a context manager and can group axes together to the same homing group easily.

Collision Avoidance Systems In Synchrotron SOLEIL

C. Engblom, S. Akinotcho, L. Amelineau, D.C. Corruble, P. Monteiro, L.E. Munoz, B. Pilliaud, G. Thibaux, S. Zhang (SOLEIL) S. Bouvel (EFOR)

Beamlines at Synchrotron SOLEIL are finding that their experimental setups (in respect to their respective sample environments, mechanical systems, and detectors) are getting more constrained when it comes to motorized manoeuvrability - an increasing number of mechanical instruments are being actuated within the same workspace hence increasing the risk of collision. We will in this paper outline setups with two types of Collision Avoidance Systems (CAS): (1) Static-CAS applications, currently being employed at the PUMA and NANOSCOPIUM beamlines, that use physical or contactless sensors coupled with PLC- and motion control- systems; (2) Dynamic-CAS applications, that use dynamic anti-collision algorithms combining encoder feedback and 3D-models of the system environment, implemented at the ANTARES and MARS beamlines but applied using two different strategies.

BLISS at the heart of ESRF Data Acquisition

M. Guijarro (ESRF)

Since the restart of the User Program after the Extremly Brilliant Source ugrade, BLISS is the new beamline control system at ESRF. 16 ESRF beamlines are controlling their experiments with BLISS. Full deployment is aimed on all beamlines by the end of 2023. BLISS is an all-in-one solution for beamline experiments, ranging from experiment control sequences and data acquisition to live visualization. BLISS is entirely written in Python and integrates seamlessly into Python tool chains. ESRF beamline staff and users alike can benefit from thousands of Python packages at their fingertips to improve data acquisition sequences. The BLISS team, which is part of the Beamline Control Unit within the Software Group, is in charge of the BLISS development. All primary objectives have been reached and nowadays the BLISS team is working on improving parts of the system ; most notably, focus is put on the interaction with other ESRF software like Daiquiri, our web framework for graphical applications, or online data analysis. This paper describes the actual state of BLISS and presents newest, most innovative features, that put BLISS at the heart of the ESRF data acquisition ecosystem.

TUPV044

Remote User Operation with Karabo at the European XFEL

A. Silenzi, V. Bondar, C. Carinan, R. Costa, W. Ehsan, S.G. Esenov, R. Fabbri, G. Flucke, G. Giovanetti, D. Goeries, S. Hauf, D.G. Hickin, A. Klimovskaia, A. Lein, J. Malka, D. Mamchyk, A. Parenti, J. Szuba, K. Wrona, C. Youngman (EuXFEL) D.P. Spruce (MAX IV Laboratory, Lund University)

At the European XFEL, scientific instruments are operated using the Karabo control system which has been developed in-house to serve the need of a tight integration of experiment control, data acquisition and data processing for fast experimental feedback. Karabo uses broker-based communication between its pluggable components, so-called devices. The generic, PyQt-based graphical user interface (GUI) interacts with the system via a TCP connection to a GUI server device. The travel and contact restrictions enacted in response to the COVID-19 pandemic have prevented many facility users from coming on site. In order to enable an easier remote user participation in experiments, a read-only version of the GUI server has been developed ad-hoc, and made available during Summer 2020. Obviously, easy and safe remote access has advantages beyond the current travel restrictions. Therefore, activities to provide a web-technology based front-end to Karabo have been accelerated. Perspectively, this interface aims to ensure remote accessibility, while conforming to scientific data and general privacy policies relevant for the European XFEL.

TUPV045

Mamba: The experimental control and data acquisition software system for next generation beamlines in HEPS

Y. Zhang, J.S. Cao (IHEP) C.P. Chu (Nanjing University, College of Engineering and Applied Sciences)

The launch of Mamba data acquisition software project is aiming to offer a unified science-oriented software solution for experimental control and data acquisation in the High Energy Photon Source (HEPS) of China, a diffraction limited storage ring synchrotron light source with an estimated completion in 2025. The main features for Mamba is the separation of control and data management functionalities, with the highly layered control part designed on top of the Bluesky (NSLS II) and data management part tailored for HEPS needs using original codes and innovative in-house designed frameworks. Mamba also has a server-client design to make it more user-friendly with sophisticated GUI application developments and automated metadata acquisition schemes. Within the Mamba framework, two specialized software projects will be launched, with the Mamba data worker serves as a data multiplexing and management tool to address challenges of implementing high throughput area detectors and data processing of multimodal experiments in HEPS, and the Mamba GUI studio as an dedicated OPI for GUI application of HEPS beamlines and other python based data acquisition and analysis software systems.

TUPV046

Modification of Data Acquisition System in HLS-II XMCD Experimental Station

Z.Z. Zhang, G. Liu (USTC/NSRL)

With the proposal of the concept of super-facility in recent years, users of experimental stations only need to pay attention to data with scientific significance, and the management of massive experimental data are assisted by the super-facility technical support platform to effectively improve user efficiency. Based on this theory, we modified the data acquisition system of the XMCD experimental station in HLS-II. We continue to use LabVIEW software to reduce development workload. Meanwhile, we have added the interaction program with the high-level application in the original data acquisition process under the principle of keeping the user habits of XMCD experimental station. We have modularized the XMCD experimental software and redesigned the experimental architecture into 4 modules: Swiping Card Module, Experimental Equipment Control Module, Storage System Interaction Module and Data Management System Interaction Module. In this way, we have completed the collection of rawdata and metadata, the docking of the data persistent storage system, and the docking of data centralized management.

Controlling the Cern Experimental Area Beams

B. Rae, V. Baggiolini, D. Banerjee, J. Bernhard, M. Brugger, L. Burdzanowski, N. Charitonidis, M. Gabriel, A. Gerbershagen, R. Gorbonosov, M. Hrabia, M. Peryt, C. Roderick, G. Romagnoli (CERN) L. Gatignon (Lancaster University)

The CERN fixed target experimental areas are comprised of more than 8km of beam line with around 800 devices used to control and measure the beam. Each year more than 140 groups of users come to perform experiments in these areas, with a need to access the data from these devices. The software to allow this therefore has to be simple, robust, and be able to control and read out all types of beam devices. This contribution describes the functionality of the beamline control system, CESAR, and its evolution. This includes all the features that can be used by the beamline physicists, operators, and device experts that work in the experimental areas. It also underlines the flexibility that the software provides to the experimental users for control of their beam line during data taking, allowing them to manage this in a very easy and independent way. This contribution also covers the on-going work of providing MAD-X support to CESAR to achieve an easier way of developing and integrating beam optics. An overview of the on-going software migration of the Experimental Areas is also given.

Updates and Remote Challenges for IBEX, Beamline Control at Isis Pulsed Neutron and Muon Source

F.A. Akeroyd, K.V.L. Baker, L. Cole, J.R. Harper, D.P. Keymer, J.C. King, A.J. Long, T. Löhnert, C. Moreton-Smith, D.E. Oram, B. Rai (STFC/RAL/ISIS)

IBEX is the EPICS based experiment control system now running on most of the beamlines at the ISIS Neutron and Muon Source, with plans to deploy to all remaining beamlines by the end of the upcoming long shutdown. Over the last couple of years we have added support for reflectometry and muon instruments, developed a script generator, moved from Python 2 to Python 3, and continued to build on our suite of device emulators and tests. The reflectometry inclusions required the development of a framework to maintain the complex motion control requirements for that science technique. Whilst it is desirable that IBEX is easily configurable, not all operations should be available to all users, so we have implemented functionality to manage such access. The COVID-19 pandemic has meant we have also had to adapt to greater amounts of remote experiment access, for which we developed systems covering both IBEX and the old SECI control system. This presentation will aim to provide a brief update on the recent changes to IBEX, as well as outlining the remote operation solutions employed

The IBEX Script Generator

J.C. King, J.R. Harper, A.J. Long, T. Löhnert, D.E. Oram (STFC/RAL/ISIS)

Experiment scripting is a key element of maximising utilisation of beam time at the ISIS Neutron and Muon Source, but can be prone to typing and logic errors. The IBEX Script Generator enables collaboration between instrument users and scientists to remove the need to write a script for many experiments, so improving reliability and control. For maximum applicability, the script generator needs to be easily configurable. Instrument scientists define action parameters, and functions for action execution, time estimation and validation, to produce a "script definition". A user then generates a Python script by organising a table of actions and their values, which are validated in real time, and can then be submitted to a script server for execution. Py4J is used to bridge a Java front end with Python script definitions. An iterative user-focused approach has been employed with Squish UI testing to achieve a behaviour-driven development workflow, along with Jenkins for continuous integration. Further planned development includes dynamic scripting ' controlling the execution of actions during the experiment ' action iteration and user experience improvement.

Control system upgrade of the High-Pressure cell for pressure-jump x-ray diffraction

R. Mercado, N.L. Griffin, P. Holloway, S.C. Lay, P.J. Roberts (DLS)

This paper reports on the upgrade of the control system of a sample environment used to pressurise samples to 500 MPa at temperatures between -20 ^{o}C and 120 ^{o}C. The equipment can achieve millisecond pressure jumps for use in X-ray scattering experiments. It has been routinely available in beamline I22 at Diamond. The millisecond pressure-jump capability is unique. Example applications were the demonstration of pressure-induced formation of super crystals from PEGylated gold nanoparticles and the study of controlled assembly and disassembly of nanoscale protein cages. The project goal was to migrate the control system for the improved integration

to EPICS and the GDA data acquisition software. The original control system uses National Instruments hardware controlled from LabView. The project looked at mapping the old control system hardware to alternatives in use at Diamond and migrating the control software. The paper discusses the choice of equipment used for ADC acquisition and equipment protection, using Omron PLCs and Beckhoff EtherCAT modules, a custom jump-trigger circuit, the calibration of the system and the next steps for testing the system.

WEKL — Keynote Session III

Digital Transformation of Urban Economy and Case Study

D.J. Ning (SARI-CAS)

The speaker hopes to help audience understand the internal driving force of China's urban economic digital transformation from the perspective of logic thinking, and help entrepreneurs clarify the internal basic logic and main entry points of enterprises, industry parks and other urban entities to carry out digital transformation and upgrading through case analysis.

WEAL — Feedback Control, Machine Tuning and Optimization I

WEAL01

Image Processing Alignment Algorithms for the Optical Thomson Scattering Laser at the National Ignition Facility

A.A.S. Awwal, T.S. Budge, R.R. Leach, R.R. Lowe-Webb, V.J. Miller Kamm, S. Patankar, B.P. Patel, K.C. Wilhelmsen (LLNL)

Understanding plasma performance in the world's largest and most energetic laser facility, the National Ignition Facility (NIF), is an important step to achieving the goal of inertial confinement fusion in a laboratory setting. The optical Thompson scattering (OTS) laser has been developed to understand the target implosion physics, especially for under-dense plasma conditions. A 5w probe beams can be set up for diagnosing various plasma densities. Just as the NIF laser with 192 laser beams are precisely aligned, the OTS system also requires precision alignment using a series of automated closed loop control steps. CCD images from the OTS laser (OTSL) beams are analyzed using a suite of image processing algorithm. The algorithms provide beam position measurements that are used to control motorized mirrors that steer beams to their defined desired location. In this paper, several alignment algorithms will be discussed with details on how they take advantage of various types of fiducials such as diffraction rings, contrasting squares and circles, octagons and very faint 5w laser beams.
*This is released as LLNL-ABS-821809

Funding: *This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

WEAL02

A framework for high level machine automation based on behavior tree

G. Gaio, P. Cinquegrana, S. Krecic, G. Scalamera, G. Strangolino, F. Tripaldi, M. Trovo, L. Zambon (Elettra-Sincrotrone Trieste S.C.p.A.)

In order to carry out complex tasks on particle accelerators, physicists and operators need to know the correct sequence of actions usually performed through a large number of graphical panels. The automation logics often embedded in the GUIs prevents its reuse by other programs, thus limiting the level of automation a control system can achieve. In order to overcome this limitation we have introduced a new automation framework for shifting the logics from GUIs to server side, where simple tasks can be easily organized, inspected and stacked up to build more complex actions. This tool is based on Behavior Trees (BT) which has been recently adopted in the gaming industry for in-game AI player opponents. They are able to create very complex tasks composed by simple decoupled self-contained tasks (nodes), regardless how they are implemented. The automation framework has been deployed in the Elettra and FERMI TANGO-based control systems to implement autonomous operations. A dedicated Qt GUI and a web interface allow to inspect the BTs and dynamically go through a tree, visualize the dependencies, monitor the execution and display any running action.

WEAL03

The status of Fast Obit feedback System of HEPS

P. Zhu, D.P. Jin, L. Zeng, Y.L. Zhang (IHEP) M.T. Kang, Z.X. Xie (IHEP CSNS) D.Y. Wang (DNSC)

In order to further meet the needs of major national strategies and basic scientific research, High Energy Photon Source (HEPS) will be a high-performance fourth-generation synchrotron radiation source in Beijing, which will build more than 90 high-performance beamline stations. In order to ensure the high-performance operation of each beam line, the stability of the beam orbit near the light source output point is extremely important. As one of the key guarantees for the stability of the electron beam orbit, The FOFB system can suppress the beam orbit disturbance within a certain bandwidth to an acceptable range. This article introduces the currently progress of the FOFB system, including: the overall architecture scheme and key technical routes; the substation design following the ATCA mechanical architecture; the BPM data acquisition and high-speed transmission using high-performance Rocket I/O transmission Mechanism; embedded high-performance DSP for fast multiplication calculation to realize SVD, etc. The entire system design is progressing in an orderly manner.

WEAR — Human Aspects, Collaborations, Management

Tango-Controls Collaboration Status in 2021

A. Gotz, R. Bourtembourg, D. Lacoste, N. Leclercq (ESRF) G. Abeille (SOLEIL) B. Bertrand, V.H. Hardion (MAX IV Laboratory, Lund University) G. Brandl (MLZ) T. Braun (byte physics e.K.) P.P. Goryl, M. Liszcz (S2Innovation) A.F. Joubert, A.J. Venter (SARAO) C. Pascual-Izarra, S. Rubio-Manrique (ALBA-CELLS Synchrotron) L. Pivetta (Elettra-Sincrotrone Trieste S.C.p.A.)

The Tango Controls collaboration has continued to grow since ICALEPCS 2019. Multiple new releases were made of the stable release V9. The new versions include support for new compiler versions, new features and bug fixes. The collaboration has adopted a sustainable approach to kernel development to cope with changes in the community. New projects have adopted Tango Controls while others have completed commissioning of challenging new facilities. This paper will present the status of the Tango-Controls collaboration since 2019 and how it is helping new and old sites to maintain a modern control system.

Adaptations to Covid-19: How Working Remotely Has Made Teams Work Efficiently Together

R. Lacuata, B. Blackwell, G.K. Brunton, M. Fedorov, M.S. Flegel, D.J. Koning, P. Koning, S.L. Townsend, J. Wang (LLNL)

The National Ignition Facility (NIF) is the world's largest 192 laser beam system for Inertial Confinement Fusion (ICF) and High Energy Density Physics (HEDP) experiments. The NIF's Integrated Computer Control System (ICCS) team conducts quarterly software releases, with two to three patches in between. Each of these software upgrades consists of deployment, regression testing, and a test shot. All of these are done with the team members inside the NIF control room. In addition, the NIF ICCS database team also performs the Database Installation and Verification Procedure dry run before each software upgrade. This is to anticipate any issue that may arise on the day of the release, prepare a solution for it, and make sure that the database part of the upgrade will be completed within the allotted time slot. This talk is about how the NIF ICCS software teams adapted when the LLNL workforce began working remotely due to the COVID-19 pandemic. These adaptations led to a better and more efficient way of conducting the NIF ICCS software upgrades.
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Agility in Managing Experiment Control Software Systems

K.V.L. Baker, F.A. Akeroyd, T. Löhnert, D.E. Oram (STFC/RAL/ISIS)

Most software development teams are proponents of Agile methodologies. Control system software teams, working at science facilities, are not always just developers, they undertake operations work, and may also be responsible for infrastructure from computer hardware to networks. Parts of the workflow this team interacts with may be Agile, but others may not be, and they may enforce deadlines that do not align with the typical agile implementations. There is the need to be more reactive when the facility is operating, which will impact any development work plans. Similarly, friction can occur between an Agile approach and more familiar existing long-standing risk-averse organisational approaches used on hardware projects. Based on experiences gained during the development of IBEX, the experiment control software used at the ISIS Pulsed Neutron and Muon source, this presentation will aim to explore what being Agile means, what challenges a multi-functional team can experience, and some solutions we have employed.

WEBL — Data Management

WEBL01

FAIRMAT - A CONSORTIUM OF THE GERMAN RESEARCH-DATA INFRASTRUCTURE (NFDI)

H. Junkes, P. Oppermann, R. Schlögl, A. Trunschke (FHI) M. Krieger, H. Weber (FAU)

A sustainable infrastructure for provision, interlinkage, maintenance, and options for reuse of research data shall be created in Germany in the coming years. The consortium FAIRmat meets the interests of experimental and theoretical condensed-matter physics. This also includes, for example, chemical physics of solids, synthesis, and high-performance computing. All this is demonstrated by use cases from various areas of functional materials. The necessity of a FAIR data infrastructure in the FAIRmat* research field is very pressing. We need and want to support the actual, daily research work to further science. Besides storing, retrieving, and sharing data, a FAIR data infrastructure will also enable a completely new level of research. In the Area D "Digital Infrastructure" a Configurable Experiment Control System is to be developed here as a reference. EPICS was selected as an initial open source base system. The control system of the newly founded CATlab** in Berlin will be fully implemented according to the FAIRmat specifications.
FAIRmat : https://www.fair-di.eu/fairmat/fairmat$_{/}$consortium CatLab : https://www.helmholtz-berlin.de/projects/catlab/index$_{e}$n.html

WEBL02

Prototype of Image Acquisition and Storage System for SHINE

H.H. Lv, D.P. Bai, X.M. Liu, H. Zhao (SSRF)

Shanghai HIgh repetition rate XFEL aNd Extreme light facility (SHINE) is a quasi-continuous wave hard X-ray free electron laser facility, which is currently under construction. The image acquisition and storage system has been designed to handle a large quantity of image data generated by the beam and X-ray diagnostics system, the laser system, etc. A prototype system with Camera Link cameras has been developed to acquire and to reliably transport data at a throughput of 1000MB/sec. The image data are transferred through ZeroMQ protocol to the storage where the image data and the relevant metadata are archived and made available for user analysis. For high-speed frames of image data storage, optimized schema is identified by comparing and testing four schemas. The image data are written to HDF5 files and the metadata pertaining to the image are stored in NoSQL database. It could deliver up to 1.2GB/sec storage speed. The performances are also contrasted between a stand-alone server and the Lustre file system. And the Lustre could provide a better performance. Details of the image acquisition, transfer, and storage schemas will be described in the paper.

WEBL03

Managing high-performance data flows and file structures

J.M.C. Nilsson, T.S. Richter (ESS) J.R. Harper (STFC/RAL/ISIS) M.D. Jones (Tessella)

The beam intensity at the European Spallation Source will necessitate a high performance acquisition and recording system for the data from the user experiments. In addition to high neutron counts rates the expected large number of dynamic measurements per day calls for a flexible system that supports a high variability in sample set-ups. Apache Kafka has been chosen as the central data switchboard to handle all the event driven data sources from detectors as well as from the EPICS controls system. The file writing system centres around a facility wide pool of HDF5 file-writers that uses Apache Kafka also for command and control. File-writing jobs are posted to a topic on Apache Kafka and picked up by individual workers. This centralises and optimises resources, as I/O load can be balanced between different neutron instruments. Command messages embed a NeXus compliant structure to capture the raw data in a community agreed format. To simplify correctly defining the file structure, physical device locations can the visualised. Data inspection can be applied to find available data sources and easily allocate them locations in the file.

Manage the Physics Settings on the Modern Accelerator

T. Zhang, K. Fukushima, T. Maruta, P.N. Ostroumov, A.S. Plastun, Q. Zhao (FRIB)

The Facility for Rare Isotope Beams (FRIB) at Michigan State University is a unique modern user facility composed of a large-scale superconducting linac capable of accelerating heavy-ion beams from oxygen to uranium. An advanced EPICS-based control system is being used to operate this complex facility. High-level physics applications (HLA) developed before and during the staged commissioning of the linac were one of the critical tools that resulted in achieving the commissioning goals quickly, within several shifts. Many of these HLAs are expandable to other EPCIS controlled accelerators. Recent developed HLAs deal with the management of extensive data to achieve the repetitive high performance of ion beams in the entire linac measured by non-destructive diagnostics instruments, and open the possibilities to explore the extra values out of the data. This paper presents our recent significant development and utilization of these HLAs.

* T. Zhang et al. 'High-level Physics Controls Applications Development for FRIB', ICALEPCS'19, TUCPR07, NY, USA, 2019.

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FAIR Meets EMIL: Principles in Practice

G. Günther, M. Bär, N. Greve, R. Krahl, M. Kubin, O. Mannix, W. Smith, S. Vadilonga, R. Wilks (HZB)

Findability, accessibility, interoperability, and reusability (FAIR) form a set of principles required to ready information for computational exploitation. The Energy Materials In-Situ Laboratory Berlin (EMIL) at BESSY II, with its unique analytical instrumentation in direct combination with an industrially-relevant deposition tool, is in the final phase of commissioning. It provides an ideal testbed to ensure workflows are developed around the FAIR principles; enhancing usability for both human and machine agents. FAIR indicators are applied to assess compliance with the principles on an experimental workflow realized using Bluesky. Additional metadata collection by integrating an instrument PID, an electronic laboratory book, and a sample tracking system is considered along with staff training. Data are collected in Nexus format and made available in the ICAT repository. This paper reports on experiences, problems overcome, and areas still in need of improvement in future perspectives.

WEBR — Functional Safety Systems for Machine Protection, Personnel Safety

WEBR01

Romlibemu: Network Interface Stress Tests for the CERN Radiation Monitoring Electronics (CROME)

K. Ceesay-Seitz, H. Boukabache, M. Leveneur, D. Perrin (CERN)

The CERN RadiatiOn Monitoring Electronics are a modular safety system for radiation monitoring that is remotely configurable through a supervisory system via a custom protocol on top of a TCP/IP connection. The configuration parameters influence the safety decisions taken by the system. An independent test library has been developed in Python in order to test the system's reaction to misconfigurations. It is further used to stress test the application's network interface and the robustness of the software. The library is capable of creating packets with default values, autocompleting packets according to the protocol and it allows the construction of packets from raw data. Malformed packets can be intentionally crafted and the response of the application under test is checked for protocol conformance. New test cases can be added to the test case dictionary. Each time before a new version of the communication library is released, the Python test library is used for regression testing. The current test suite consists of 251 automated test cases. Many application bugs could be found and solved, which improved the reliability and availability of the system.

WEBR02

Towards the Optimization of the Safety Life-Cycle for Safety Instrumented Systems

B. Fernandez Adiego, E. Blanco Vinuela, Th. Otto, R. Speroni, G. de Assis Schmidt (CERN)

The design and development of Safety Instrumented Systems (SIS) according to the IEC 61511 standard is a long and costly process. Although the standard gives recommendations and guidelines for each phase of the safety life-cycle, implementing them is not a simple task. Access to reliability data, hardware and systematic safety integrity analysis, software verification, generation of reports, guarantee of traceability between all the phases and management of the project are some of the main challenges. In addition, some of the industrial processes or test-benches of large scientific installations are in continuous evolution and changes are very common. This adds extra complexity to the management of these projects. This paper presents an analysis of the safety life-cycle workflow and discusses the biggest challenges based on our experience at CERN. It also establishes the basis for a selection of the tools for some of the safety life-cycle phases, proposes report templates and management procedures and, finally, describes the roles of the different members in our functional safety projects.

WEBR03

The fast protection system for CSNS accelerator

Y.L. Zhang, D.P. Jin, P. Zhu (IHEP)

The fast protection system for CSNS accelerator is a FPGA based protection system. The VME bus and SFP was adopted by the FPS. The FPS includes one central station and several sub-stations, and connnections between the central and the sub-stations are in star style. Two kinds of beam stopping modes are designed and implemented by FPS, one is the transient beam stopping and auto recovery mode, the other is the permanent beam stopping mode. The measured response time for the FPS is less than 1.5 micro-seconds.

WEBR04

Safeguarding Large Particle Accelerator Research Facility- A Multilayer Distributed Control Architecture

F. Tao (SLAC)

Personnel Protection System (PPS) at SLAC is a global safety system responsible for protecting personnel from radiation hazards. The system design shares similar concepts with machinery safeguarding, though the complexity of PPS is much higher due to its wide geographic distribution and multiple sources of hazards. In this paper, we will first introduce the multilayer distributed control system architecture of SLAC's PPS, which serves three beam program that co-exist in the same 4km linear accelerator infrastructure, e.g. LCLS, LCLS-II and FACET-II. Composed of 40+ sets of redundant safety PLCs and 20+ access control PLCs, SLAC's PPS consists of four layers:

beam program, beam permit and switching, zone safety control and sensor/shutoff subsystems. With this system architecture, safety functions often involve multiple controllers across multiple layers, make it a challenge on system analysis. Therefore, in this paper, we will discuss representative safety functions, SIL verification, system validation and relevant issues on functional safety implementation and compliance.

Integrated supervision for conventional and machine-protection configuration parameters at ITER

D.A. Karkinsky, J. Jignesh, A. Marqueta, I. Prieto Diaz, W. Van Herck (ITER Organization)

Configuration parameters for ITER's I&C systems are predominantly high-coupled due to the nature of the process under control. Subsequently, I&C re-configuration requires an integrated supervision approach that addresses coupling through abstraction, automation, scalability, changeability, robustness and re-usability. Moreover, high-coupling might manifest at any tier of the I&C, and certainly spans configuration parameters across both conventional and machine-protection I&C. Stemming from ITER design guidelines, the handling of machine-protection configuration parameters needs to meet the goals of IEC61508-3. These goals are mostly in congruence with the main concerns of integrated supervision identified above. However they also extend requirements that bind the supervision process with traceability and audit capabilities from sources to final self-test (run-time) diagnostics. This presentation describes the provisions for integrated supervision at ITER and elaborates how these provisions can be used to handle machine-protection parameters in compliance with IEC61508-3.

WEPV — Posters

WEPV001

Temperature Control for Precision Beamline Systems of Sirius/LNLS

J.L. Brito Neto, C.S.N.C. Bueno, R.R. Geraldes, F.R. Lena, M.A.L. Moraes, M. Saveri Silva, L.M. Volpe (LNLS)

Precision beamline systems, such as monochromators and mirrors, as well as sample stages and sample holders, may require fine thermal management to meet performance targets. Regarding the optical elements, the main aspects of interest include substrate integrity, in case of high power loads and densities; wavefront preservation, due to thermal distortions of the optical surfaces; and beam stability, related to thermal drift. Concerning the sample, nanometer positioning control, for example, may be affected by thermal drifts and the power management of some electrical elements. This work presents the temperature control architecture developed in house for precision elements at the first beamlines of Sirius, the 4th-generation light source at the Brazilian Synchrotron Light Laboratory (LNLS). Taking some optical components as case studies, the predictive thermal-model-based approach, the system identification techniques, the controller design workflow and the implementation in hardware are described, as well as an analysis of the influences of temperature stability on the photon-beam position.

Funding: Ministry of Science, Technology and Innovation (MCTI)

WEPV002

Position Scanning Solutions at the TARUMà Station at the CARNAÃBA Beamline at Sirius/LNLS

C.S.N.C. Bueno, L.G. Capovilla, R.R. Geraldes, L.C. Guedes, G.N. Kontogiorgos, L. Martins dos Santos, M.A.L. Moraes, G.B.Z.L. Moreno, J.R. Piton, H.C.N. Tolentino (LNLS)

TARUMà is the sub-microprobe station of the CARNAÃBA beamline at Sirius/LNLS*. Covering the range from 2.05 to 15keV, the probe consists of a fully-coherent monochromatic beam varying from 550 to 120nm with flux of up to 10^{11}ph/s/100mA after the achromatic focusing optics. Hence, positioning requirements span from nanometer-level errors for high-resolution experiments to fast continuous trajectories for high throughput, whereas a large flexibility is required for different sample setups and simultaneous multi-technique X-ray analyses, including tomography. To achieve this, the overall architecture of the station relies on a pragmatic sample positioning solution, with a rotation stage with a range of 220^{o}, coarse stages for sub-micrometer resolution in a range of 20mm in XYZ and a fine piezo stage for nanometer resolution in a range of 0.3mm in XYZ. Typical scans consist of continuous raster 2D trajectories perpendicularly to the beam, over ranges that vary from tens to hundreds of micrometers, with acquisition times in range of milliseconds. Positioning is based on 4th order trajectories and feedforward, triggering includes the multiple detectors and data storage is addressed

* Geraldes, R.R., et al. 'Design and Commissioning of the TARUMà Station at the CARNAÃBA Beamline at Sirius/LNLS' Proc. MEDSI20 (2020).

Funding: Ministry of Science, Technology and Innovation (MCTI)

WEPV003

The Dynamic Modeling and the Control Architecture of the New High-Dynamic Double-Crystal Monochromator (HD-DCM-Lite) for Sirius/LNLS

G.S. de Albuquerque, J.L. Brito Neto, R.R. Geraldes, M.A.L. Moraes, A.V. Perna, M. Saveri Silva, M.S. Souza (LNLS)

The High-Dynamic Double-Crystal Monochromator (HD-DCM) has been developed since 2015 at Sirius/LNLS with an innovative high-bandwidth mechatronic architecture to reach the unprecedented target of 10 nrad RMS (1 Hz - 2.5 kHz) in crystals parallelism also during energy flyscans. Now, for beamlines requiring a smaller energy range (3.1 to 43 keV, as compared to 2.3 to 72 keV), there is the opportunity to adapt the existing design towards the so-called HD-DCM-Lite. The control architecture of the HD-DCM is kept, reaching a 20 kHz control rate in NI's CompactRIO (cRIO). Yet, the smaller gap stroke between crystals allows for removing the long-stroke mechanism and reducing the main inertia by a factor 6, not only simplifying the dynamics of the system, but also enabling faster energy scans. With sinusoidal scans of hundreds of eV up to 20 Hz, this creates an unparalleled bridge between slow step-scan DCMs, and channel-cut quick-EXAFS monochromators. This work presents the dynamic error budgeting and scanning perspectives for the HD-DCM-Lite, including feedback controller design options via loop shaping, feedforward considerations, and leader-follower control strategies.

Funding: Ministry of Science, Technology and Innovation (MCTI)

Experiment Automation Using EPICS

D.D. Cosic, M. Vicentijevic (RBI)

Beam time at accelerator facilities around the world is very expensive and scarce, prompting the need for experiments to be performed as efficiently as possible. Efficiency of an accelerator facility is measured as a ratio of experiment time to beam optimization time. At RBI we have four ion sources, two accelerators, ten experimental end stations. We can obtain around 50 different ion species, each requiring a different set of parameters for optimal operation. Automating repetitive procedures can increase efficiency of an experiment and beam setup time. Currently, operators manually fine tunes the parameters to optimize the beam current. This process can be very long and requires many iterations. Automatic optimization of parameters can save valuable accelerator time. Based on a successful implementation of EPICS, the system was expanded to automate reoccurring procedures. To achieve this, a PLC was integrated into EPICS and our acquisition system was modified to communicate with devices through EPICS. This allowed us to use tools available in EPICS to do beam optimization much faster than a human operator can, and therefore significantly increased the efficiency of our facility.

Automated operation of ITER using behavior tree semantics

W. Van Herck, B. Bauvir, G. Ferro (ITER Organization)

The inherent complexity of the ITER machine and the diversity of the ways it will be operated in different phases, like commissioning or engineering operation, poses a great challenge for striking the right balance between operability, integration and automation. To facilitate the creation and execution of operational procedures in a robust and repeatable way, a software framework was developed: the Sequencer. As a supporting framework for tasks that are mostly goal-oriented, the Sequencer's semantics are based on a behavior tree model that also supports concurrent flows of execution. In view of its intended use in very diverse situations, from small scale tests to full integrated operation, the architecture was designed to be composable and extensible from the start. User interactions with the Sequencer are fully decoupled and can be linked through dependency injection. The Sequencer library is currently feature-complete and comes with a command line interface for the encapsulation of procedures as system daemons or simple interactive use. It is highly maintainable due to its small and low complexity code base and dependencies to third party libraries are properly encapsulated.

Machine learning projects at the 1.5 GeV synchroton light source DELTA

D. Schirmer (DELTA)

In recent years, several ML-based projects have been developed to support automated monitoring and operation of the DELTA electron storage ring facility. This include a self-regulating global and local orbit correction of the stored electron beam, a betatron tune feedback system as well as an electron transfer rate (injection) optimization. Furthermore, the implementation for a machine learning based chromaticity control is currently prepared. Some of the processes were initially simulated and then successfully transferred to real machine operation. This report provides an overview of the current status of these projects.

Online automatic optimization of the Elettra synchrotron

G. Gaio, S. Krecic, F. Tripaldi (Elettra-Sincrotrone Trieste S.C.p.A.)

Online automatic optimization is a common practice in particle accelerators. Beside the tryouts based on Machine Learning, which are effective especially on non-linear systems and images but are very complex to tune and manage, one of the most simple and robust algorithms, the simplex Nelder Mead, is extensively used at Elettra to automatically optimize the synchrotron parameters. It is currently applied to optimize the efficiency of the booster injector by tuning the pre-injector energy, the trajectory and optics of the transfer lines, and the injection system of the storage ring. It has also been applied to maximize the intensity of the photon beam on a beamline by changing the electron beam position and angle inside the undulator. The optimization algorithm has been embedded in a TANGO device that also implements generic and configurable multi-input multi-output feedback systems. This optimization tool is usually included in a high level automation framework based on behavior trees in charge of the whole process of machine preparation for the experiments.

WEPV010

R&D of the KEK Linac Accelerator Tuning using Machine Learning

A. Hisano, M. Iwasaki (OCU) H. Nagahara, Y. Nakashima, N. Takemura (Osaka University, Institute for Datability Science) T. Nakano (RCNP) I. Satake, M. Satoh (KEK)

We have developed a machine-learning-based operation tuning scheme for the KEK $e^{|-|}/e^{+}$ injector linac (Linac), to improve the injection efficiency. The tuning scheme is based on the various accelerator operation data (control parameters, monitoring data and environmental data) of Linac. For the studies, we use the accumulated Linac operation data from 2018 to 2021. To solve the problems on the accelerator tuning of, 1. A lot of parameters (∼1000) should be tuned, and these parameters are intricately correlated with each other; and 2. Continuous environmental change, due to temperature change, ground motion, tidal force, etc., affects to the operation tuning; We have developed, 1. Visualization of the accelerator parameters (∼1000) trend/correlation distribution based on the dimensionality reduction using Variational Autoencoder (VAE), to see the long-term correlation between the accelerator operation parameters and the environmental data, and 2. Accelerator tuning method using the deep neural network, which is continuously updated with the short-term accelerator data to adapt the environment changes. In this presentation, we report the current status of the R&D.

WEPV011

Research on Correction of Beam Optical Parameters of HLS-II Storage Ring Based on Deep Learning

Y.B. Yu, C. Li, W. Li, G. Liu, W. Xu, K. Xuan (USTC/NSRL)

The beam stability of the storage ring determines the light quality of synchrotron radiation. The beam stability of the storage ring will be affected by many factors 'such as magnetic field error, installation error, foundation vibration, temperature variation, etc., so it is inevitable to correct the beam optical parameters to improve the beam stability. In this paper, the deep learning technology is used to establish the HLS-II storage ring beam stability model, and the beam optical parameters can be corrected based on the model. The simulation results show that this method realizes the simulation correction of the Beta function of the HLS-II storage ring, and the correction accuracy precision meets the design requirements.

WEPV012

Beam Fast Recovery Study and Application for CAFe

J.S. Li, Y.X. Chen, J. Wang, F. Yang, H. Zheng (IMP/CAS)

Based on the MASAR (MAchine Snapshot, Archiving, and Retrieve) system, a beam fast recovery system was designed and tested in CAFe (Chinese ADS Front-end Demo Superconducting Linac) at IMP/CAS for high cur-rent CW (Continuous Wave) beam. The proton beam was accelerated to about 20 MeV with 23 SC (Superconduct-ing) cavities, and the maximum current reaches about 10 mA. The fast-recovery system plays a major role in the 100-hours-100-kW long-term test, during which the aver-age time of the beam recovery is 7 second, achieving the availability higher than 90%. The system verifies the possibility for high current beam fast recovery in CiADS (China initiative Accelerator Driven sub-critical System).

WEPV013

Design of Magnet Measurement System Based on Multi-Hall Sensor

B.J. Wang, Y.H. Guo, R. Wang, N. Xie (IMP/CAS)

High-precision magnetic field measurement and control technique significantly guarantees the accurate realization of the magnetic confinement of accelerators. Using real-time magnetic field intensity as the feedback to adjust the magnetic field current input can be a promising strategy. However, the measurement accuracy of the Hall-sensor is hard to meet feedback requirements because of multiple affection from external factors. Meanwhile, the NMR(Nuclear Magnetic Resonance sensor), which can provide high-precision magnetic field measurement, can hardly meet the requirements against the real-time control due to its strict requirements on the uniformity of the measured magnetic field, as well as its low data acquisition speed. Therefore, a magnetic field measurement system based on multi-Hall sensors is designed to solve this problem. Four Hall-sensors are used to measure the target magnetic field in this system. An Adaptive fusion algorithm is used to fused collected values to obtain the best estimate of the magnetic field intensity. This system effectively improves the accuracy of magnetic field measurement and ensures the instantaneity of the measurement.

Development of the RF phase scan application for the beam energy measurement at KOMAC

S.Y. Cho, J.J. Dang, J.H. Kim, Y.G. Song (Korea Atomic Energy Research Institute (KAERI))

The Korea Multi-purpose Accelerator Complex (KOMAC) proton accelerator consists of 11 Drift Tube Linac (DTL) tanks, and each tank's RF phase setting must be matched to increase synchronous acceleration of continuous tanks. A series of processes operate on the basis of JAVA and MatLAB languages, and the phase scanning program and the analytical program are classified and used independently. To integrate the two programs, the new integrated program of the RF scan application is developed based on python and epics scan module for the stability with some upgrade functions.

The Automatic LHC Collimator Beam-Based Alignment Software Package

G. Azzopardi, B. Salvachua (CERN) G. Valentino (University of Malta, Information and Communication Technology)

The Large Hadron Collider (LHC) at CERN makes use of a complex collimation system to protect its sensitive equipment from unavoidable beam losses. The collimators are positioned around the beam respecting a strict transverse hierarchy. The position of each collimator is determined following a beam-based alignment technique which determines the required jaw settings for optimum performance. During the LHC Run 2 (2015-2018), a new automatic alignment software package was developed and used for collimator alignments throughout 2018*. This paper discusses the usability and flexibility of this new package describing the implementation in detail, as well as the latest improvements and features in preparation for Run 3 starting in 2022. The automation has already successfully decreased the alignment time by 70% in 2018** and this paper explores how to further exploit this software package. Its implementation provides a solid foundation to automatically align any new collimation configurations in the future, as well as allows for further analysis and upgrade of its individual modules.
*G.Azzopardi,et al"Software Architecture for Automatic LHC Collimator Alignment using ML",ICALEPCS19.
**G.Azzopardi,et al"Operational Results on the Fully-Automatic LHC Collimator Alignment",PRAB19.

The Linac4 Source Autopilot

M. Peryt, M. Hrabia, D. Noll, R. Scrivens (CERN)

The Linac4 source is a 2MHz, RF driven, H^- ion source, using caesium injection to enhance H^- production and lower the electron to H^- ratio. The source operates with 800μs long pulses at 1.2 second intervals. The stability of the beam intensity from the source requires adjustment of parameters like RF power used for plasma heating. The Linac4 Source Autopilot improves the stability and uptime of the source, by using high-level automation to monitor and control Device parameters of the source, in a time range of minutes to days. This paper describes the Autopilot framework, which incorporates standard CERN accelerator Controls infrastructure, and enables users to add domain specific code for their needs. User code typically runs continuously, adapting Device settings based on acquisitions. Typical use cases are slow feedback systems and procedure automation (e.g. resetting equipment). The novelty of the Autopilot is the successful integration of the Controls software based predominantly on Java technologies, with domain specific user code written in Python. This allows users to leverage a robust Controls infrastructure, with minimal effort, using the agility of the Python ecosystem.

Renovation of the beam-based feedback controller in the LHC

L. Grech, D. Alves, A. Calia, M. Hostettler, S. Jackson, J. Wenninger (CERN) G. Valentino (University of Malta, Information and Communication Technology)

This work presents an extensive overview of the design choices and implementation of the Beam-Based Feedback System (BBFS) used in operation until the LHC Run 2. The main limitations of the BBFS are listed and a new design called BFCLHC, which uses the CERN Front-End Software Architecture (FESA), framework is proposed. The main implementation details and new features which improve upon the usability of the new design are then emphasised. Finally, a hardware agnostic testing framework developed by the LHC operations section is introduced.

WEPV020

Learning to Lase: Machine Learning Prediction of FEL Beam Properties

A.E. Pollard, D.J. Dunning (STFC/DL/ASTeC)

Accurate prediction of longitudinal phase space and other properties of the electron beam are computationally expensive. In addition, some diagnostics are destructive in nature and/or cannot be readily accessed. Machine learning based virtual diagnostics can allow for the real-time generation of longitudinal phase space and other graphs, allowing for rapid parameter searches, and enabling operators to predict otherwise unavailable beam properties. We present a machine learning model for predicting a range of diagnostic screens along the accelerator beamline of a free-electron laser facility, conditional on linac and other parameters. Our model is a combination of a conditional variational autoencoder and a generative adversarial network,which generates high fidelity images that accurately match simulation data. Work to date is based on start-to-end simulation data, as a prototype for experimental applications.

WEPV021

Machine Learning for RF Breakdown Detection at CLARA

A.E. Pollard, D.J. Dunning, A.J. Gilfellon (STFC/DL/ASTeC)

Maximising the accelerating gradient of RF structures is fundamental to improving accelerator facility performance and cost-effectiveness. Structures must be subjected to a conditioning process before operational use, in which the gradient is gradually increased up to the operating value. A limiting effect during this process is breakdown or vacuum arcing, which can cause damage that limits the ultimate operating gradient. Techniques to efficiently condition the cavities while minimising the number of breakdowns are therefore important. In this paper, machine learning techniques are applied to detect breakdown events in RF pulse traces by approaching the problem as anomaly detection, using a variational autoencoder. This process detects deviations from normal operation and classifies them with near perfect accuracy. Offline data from various sources has been used to develop the techniques, which we aim to test at the CLARA facility at Daresbury Laboratory. These techniques could then be applied generally.

WEPV022

Sample Alignment in Neutron Scattering Experiment using Deep Neural Network

J.P. Edelen, K. Bruhwiler, A. Diaw, C.C. Hall (RadiaSoft LLC) S. Calder (ORNL RAD) C.M. Hoffmann (ORNL)

Access to neutron scattering centers, such as Oak Ridge National Laboratory (ORNL) and the NIST Center for Neutron Research, has provided beam energies to investigating a wide variety of applications such as particle physics, material science, and biology. In these experiments, the quality of collected data is very sensitive to sample and beam alignment, and stabilization of the experimental environment, requiring human intervention to tune the beam. While this procedure works, it is inefficient and time-consuming. In the work we present progress towards using machine learning to automate the alignment of a beamline in neutron scattering experiments. Our algorithm uses convolutional neural network to both learn a surrogate of the image data of the sample and to predict the sample contour using a u-net. We tested our algorithm on neutron camera images from the H_2-BA powder diffractometer and the Topaz single crystal diffractometer beamlines of ORNL.

feedback, feed-forward, adaptive control, intelligent automation, expert systems, machine learning, automatic tuning, artificial neural networks, anomaly detection

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WEPV023

Development of a smart alarm system for the CEBAF Injector

D.T. Abell, J.P. Edelen (RadiaSoft LLC) B.G. Freeman, R. Kazimi, D.G. Moser, C. Tennant (JLab)

RadiaSoft and Jefferson Laboratory are working together to develop a machine-learning-based smart alarm system for the CEBAF injector. Because of the injector's large number of parameters and possible fault scenarios, it is highly desirable to have an autonomous alarm system that can quickly identify and diagnose unusual machine states. We present our work on artificial neural networks designed to identify such undesirable machine states. In particular, we test both autoencoders and inverse models as possible tools for differentiating between normal and abnormal states. These models are being developed using both supervised and unsupervised learning techniques, and are being trained using CEBAF injector data collected during dedicated machine studies as well as during regular operations. Lastly, we discuss tradeoffs between the two types of models.

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X-Ray Beamline Control with Machine Learning and an Online model

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We present recent developments on control of x-ray beamlines for synchrotron light sources. Effective models of the x-ray transport are updated based on diagnostics data, and take the form of simplified physics models as well as learned models from scanning over mirror and slit configurations. We are developing this approach to beamline control in collaboration with several beamlines at the NSLS-II. By connecting our online models to the Blue-Sky framework, we enable a convenient interface between the operating machine and the model that may be applied to beamlines at multiple facilities involved in this collaborative software development.

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Initial Studies of SRF Cavity Fault Prediction at Jefferson Laboratory

L.S. Vidyaratne, A. Carpenter, R. Suleiman, C. Tennant, D.L. Turner (JLab) K.M. Iftekharuddin, M. Rahman (ODU)

The Continuous Electron Beam Accelerator Facility (CEBAF) at Jefferson Laboratory is a CW recirculating linac that utilizes over 400 superconducting radio-frequency (SRF) cavities to accelerate electrons up to 12 GeV through 5-passes. Recent work has shown that, given RF signals from a cavity during a fault as input, machine learning approaches can accurately classify the fault type. In this paper we report on initial results of predicting a fault onset using only data prior to the failure event. A data set was constructed using time-series data immediately before a fault ('unstable') and 1.5 seconds prior to a fault ('stable') gathered from over 5,000 saved fault events. The data was used to train a binary classifier. The results gave key insights into the behavior of several fault types and provided motivation to investigate whether data prior to a failure event could also predict the type of fault. We discuss our method using a sliding window approach and report on initial results. Recent modifications to the low-level RF control system will provide access to streaming signals and we outline a path forward for leveraging deep learning on streaming data

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Multi-Channel Heaters Driver for Sirius Beamline's Optical Devices

M.M. Donatti, D.H.C. Araujo, F.H. Cardoso, G.B.Z.L. Moreno, L. Sanfelici, G.T. Semissatto (LNLS)

Thermal management of optomechanical devices, such as mirrors and monochromators, is one of the main bottlenecks in the overall performance of many X-Rays beamlines, particularly for Sirius: the new 4th generation Brazilian synchrotron light source. Due to high intensity photon beams some optical devices need to be cryogenically cooled and a closed-loop temperature control must be implemented to reduce mechanical distortions and instabilities. This work aims to describe the hardware design of a multi-channel driver for vacuum-ready ohmic heaters used in critical optical elements. The device receives PWM signals and can control up to 8 heaters individually. Interlocks and failure management can be implemented using digital signals input/outputs. The driver is equipped with a software programmable current limiter to prevent load overheating and it has voltage/current diagnostics monitored via EPICS or an embedded HTTP server. Enclosed in a 1U rack mount case, the driver can deliver up to 2A per channel in 12V and 24V output voltage versions. Performance measurements will be presented to evaluate functionalities, noise, linearity and bandwidth response.

Expandable and Modular Monitoring and Actuation System for Engineering Cabinets at Sirius Light Source

P.H. Nallin, J.G.R.S. Franco, R.W. Polli (LNLS) G.F. Freitas (CNPEM)

Having multipurpose hardware architectures for controls and monitoring systems has become a need nowadays. When it comes to modular and easy expandable devices, it brings together a system

which is easy to maintain and can reach many applications. Concerning Sirius accelerators, which is a 4th generation light source, monitoring environment variables becomes crucial when it comes to accelerator stability and reliability. Several cabinets take part of engineering infrastructure and monitoring and acting over their environment such as internal temperature, pressure and fan status, increases overall system reliability. This paper presents a non-expensive hardware topology to deal with multiple sensors and actuators mainly designed to monitor cabinets and prevent beam quality loss due to equipment faults.

WEPV028

CompactRIO Custom Module Design for the Beamline's Control System at Sirius

L.S. Perissinotto, F.H. Cardoso, M.M. Donatti (LNLS)

The CompactRIO (cRIO) platform is the standard hardware choice for data acquisition, controls and synchronization tasks at Sirius beamlines. The cRIO controllers are equipped with a processor running a Real-Time Linux and contains an embedded FPGA, that could be programmed using Labview. The platform supports industrial I/O modules for a large variety of signals, sensors, and interfaces. Even with many commercial modules available, complex synchrotron radiation experiments demands customized signal acquisition hardware to achieve proper measurements and control system's integration. This work aims to describe hardware and software aspects of the first custom 8-channel differential digital I/O module (compatible with RS485/RS422) developed for the Sirius beamlines. The module is compliant with cRIO specification and can perform differential communication with maximum 20 MHz update rate. The features, architecture and its benchmark tests will be presented. This project is part of an effort to expand the use of the cRIO platform in scientific experiments at Sirius and brings the opportunity to increase the expertise to develop custom hardware solutions to cover future applications.

WEPV030

Testing of the RTM Carrier Boards for the ESS Accelerator

J. Szewinski, P.R. Bartoszek, K. Chmielewski, T. Kowalski, P. Markowski, D. Rybka, M. Sitek, Z. Wojciechowski (NCBJ)

As a part of Polish in-kind contribution to the European Spallation Source (ESS), National Centre for Nuclear Research has developed low cost AMC board, which is used in the MTCA based ESS LLRF system to support RTM units in the crate. Board due to its primary function has been called 'RTM Carrier', which may be confusing, because it is an AMC. The low cost board, that by concept shall be simple, without own functionality except providing PCIe access from MTCA backplane to the RTM device, has required significant amount of work to create complete firmware and software to cover all board functionality, which was needed to perform factory acceptance tests (FAT) of the described boards. This contribution will describe structure of the FPGA firmware and software used for the RTM Carrier acceptance testing, including techniques used for testing individual functions and features of the board.

WEPV031

Status of the uTCA Digital LLRF design for SARAF Phase II

J. FernÃ¡ndez, P. Gil, J.G. Ramirez (7S) G. Ferrand, F. Gohier, N. Pichoff (CEA-IRFU)

One of the crucial control systems of any particle ac-celerator is the Low-Level Radio Frequency (LLRF). The purpose of a LLRF is to control the amplitude and phase of the field inside the accelerating cavity. The LLRF is a subsystem of the CEA (Commissariat à l'Energie Atomique) control domain for the SARAF-LINAC (Soreq Applied Research Accelerator Facility ' Linear Accelera-tor) instrumentation and Seven Solutions has designed, developed, manufactured, and tested the system based on CEA technical specifications. The final version of this digital LLRF will be installed in the SARAF accelerator in Israel at the end of 2021. The architecture, design, and development as well as the performance of the LLRF system will be presented in this paper. The benefits of the proposed architecture and the first results will be shown.

WEPV033

Architecture of a Multi-Channel Data Streaming Device with an FPGA as a Coprocessor

J.M. Nogiec, P. Thompson (Fermilab)

The design of a data acquisition system often involves the integration of a Field Programmable Gate Array (FPGA) with analog front-end components to achieve precise timing and control. Reuse of these hardware systems can be difficult since they need to be tightly coupled to the communications interface and timing requirements of the specific ADC used. A hybrid design exploring the use of FPGA as a coprocessor to a traditional CPU in a dataflow architecture is presented. Reduction in the volume of data and gradual transitioning of data processing

away from a hard real-time environment are both discussed. Chief design concerns, including data throughput and precise synchronization with external stimuli, are addressed. The discussion is illustrated by the implementation of a multi-channel digital integrator, a device based entirely on commercial off-the-shelf (COTS) equipment.
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Equipment and Personal Protection Systems for the Sirius Beamlines

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The beamlines and front ends at Sirius, the Brazilian 4th generation synchrotron light source, require monitoring and protection systems for personal and equipment safety in general, due to the high beam power dissipated along the beamline, vacuum safety, secure radiation levels, use of robots, special gases, cryogenic systems, and other highly sensitive and costly equipment throughout the facility. Two distinct programable logic controllers (PLC) were then deployed to create the Equipment Protection System (EPS) and the Personal Protection System (PPS). This work presents an overview of the EPS/PPS - requirements, architecture, design and deployment details, and commissioning results for the first set of beamlines.
*Work supported by the Brazilian Ministry of Science, Technology and Innovation lucas.arruda@lnls.br
Funding: Ministry of Science, Technology and Innovation (MCTI)

LMJ Target Center Diagnostic Module

R. Clot (CEA)

The Laser MegaJoule (LMJ), the French 176-beam laser facility, is located at the CEA CESTA Laboratory near Bordeaux (France). It is designed to deliver about 1.4 MJ of energy on targets, for high energy density physics experiments, including fusion experiments. The first bundle of 8-beams was commissioned in October 2014. By the end of 2021, ten bundles of 8-beams are expected to be fully operational. Due to energy levels achieved, optical components located at the end of the bundles are highly subject to damage stresses. This is particularly the case with vacuum windows whose integrity is critical. To measure these damages, identify the growth laws, and prevent their degradation (through blockers), the Target Chamber Diagnostic Module (TCDM) was integrated into the LMJ installation in 2019. This diagnostic, which also measures the windows transmission rate, as well as the spatial energy distribution at the end of the bundles, has been designed to operate automatically at night, between two experiments. This presentation describes this 2 years feedback of TCDM and presents the areas for improvement which have been identified to optimize its efficiency and reduce its timeline.

Development of a Voltage Interlock System for Normal-Conducting Magnets in the Neutrino Experimental Facility at J-PARC

K. Nakayoshi, Y. Fujii, K. Sakashita (KEK)

We are upgrading a beamline of neutrino experimental facility at J-PARC to realize its 1.3MW operation. One of the upgrade items is to strengthen machine protection interlocks at the beamline. So far, we have developed an interlock system that monitors the output current of the power supplies for normal-conducting(NC) magnets at the primary beamline. On the other hand, we observed an event that a coil-short in one of bending magnets at a beam transport line at J-PARC (3-50BT) happened in 2019 and it caused a drift of beam orbit over the time. Our present interlock system can not detect a similar coil-short in the magnet while such change of the beam orbit may cause a serious trouble. One of possible way to detect such coil-short is to monitor a voltage of the magnet coil. Actually, a significant voltage drop between layers of the coil was observed for the 3-50BT magnet coil-short. Focusing on the fact, we are developing a system that constantly monitors the voltage value of the magnets at primary beamline and issues an interlock when there is a fluctuation exceeding a threshold value. We report the progress of development of the system.

WEPV038

Performance Verification of New Machine Protection System Prototype for RIKEN RI Beam Factory

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We report on performance verification of a prototype of a new machine protection system for the RIKEN Radioactive Isotope Beam Factory (RIBF). This prototype was developed to update a beam interlock system (BIS) in operation since 2006. The new system, like the BIS, is configured using a programmable logic controller (PLC). We applied the prototype to a small part of RIBF and started its operation in Sept., 2020. It consists of two separate PLC stations, and there are 28 digital inputs and 23 analog inputs as interlock signals, and 5 digital outputs are used to stop a beam in total. The observed response time averaged 2 ms and 5.7 ms, respectively, within one station and with both stations. When deploying the prototype in the same scale as the BIS, which consists of 5 PLC stations with roughly 400 signals, the response time is estimated to be over 10 ms, which means that it is too long to protect the equipment when the intensity of the beam accelerated at RIBF becomes higher. Therefore, we are starting to redesign a system by adding a field-programmable gate array (FPGA) to shorten the response time significantly rather than repeating minor improvements to save a few milliseconds.

WEPV039

Novel Personnel Safety System for HLS-II

Z.Y. Huang, C. Li, G. Liu, X.K. Sun, S. Xu, K. Xuan (USTC/NSRL)

The Hefei Light Source-II (HLS-II) is a vacuum ultraviolet synchrotron light source. The Personnel Safety System (PSS) is the crucial part to protect staff and users from radiation damages. In order to share access control information and improve the reliability for HLS-II, the novel PSS is designed based on Siemens redundant PLC under EPICS environment which is composed by the safety interlock system, access control system and the radiation monitoring system. This paper will demonstrate the architecture and the specific design of this novel PSS and shows the operation performance after it has been implemented for 2 years.
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WEPV040

Design of Machine Protection System for SXFEL-UF

C.L. Yu, J.G. Ding, H. Zhao (SSRF)

Shanghai Soft X-ray Free-Electron Laser (SXFEL) facility is divided into two phases: the SXFEL test facility (SXFEL-TF) and the SXFEL user facility (SXFEL-UF). SXFEL-TF has met all the design specifications and has been available in beam operating state. SXFEL-UF is currently under commissioning and is planned to generate 3 nm FEL radiation using a 1.5 GeV electron LINAC. To protect the critical equipment rapidly and effectively from unexpected damage, a reliable safety interlocking system needs to be designed. Machine Protection System (MPS) is designed by Programmable Logic Controller (PLC) and Experimental Physics and Industrial Control System (EPICS) which is based on a master-slave architecture. In order to meet different commissioning and operation requirements, the management and switching functions of eight operation modes are introduced in the MPS system. There are two FEL line in user facility named SXFEL beamline project (BSP) and undulator (UD) , and the corresponding design of MPS is completed. This paper focuses on the progress and challenges associated with the SXFEL-UF MPS.

WEPV041

Implementation of a VHDL Application for Interfacing Anybus CompactCom

S. Gabourin, A. Nordt, S. Pavinato (ESS)

The European Spallation Source (ESS ERIC), based in Lund (Sweden), will be in a few years the most powerful neutron source in Europe with an average beam power of 5 MW. It will accelerate proton beam pulses to a Tungsten wheel to generate neutrons by the spallation effect. For such beam, the Machine Protection System (MPS) at ESS must be fast and reliable, and for this reason a Fast Beam Interlock System (FBIS) based on FPGAs is required. Some protection functions monitoring slow values (like temperature, mechanical movements, magnetic fields) need however less strict reaction times and are managed by PLCs. The communications protocol established between PLCs and FBIS is PROFINET fieldbus based. The Anybus CompactCom allows an host to have connectivity to industrial networks as PROFINET. In this context, FBIS represents the host and the application code to interface the AnyBus CompactCom has been fully developed in VHDL. This paper describes an open source implementation to interface a CompactCom M40 with an FPGA.

Applying Model Checking to Highly-Configurable Safety Critical Software: The SPS-PPS PLC Program

B. Fernandez Adiego, E. Blanco Vinuela, F. Havart, T. Ladzinski, I.D. Lopez-Miguel, J-C. Tournier (CERN)

An important aspect of many particle accelerators is the constant evolution and frequent configuration changes that are needed to perform the experiments they are designed for. This often leads to the design of configurable software that can absorb these changes and perform the required control and protection actions. This design strategy minimizes the engineering and maintenance costs, but it makes the software verification activities more challenging since safety properties must be guaranteed for any of the possible configurations. Software model checking is a popular automated verification technique in many industries. This verification method explores all possible combinations of the system model to guarantee its compliance with certain properties or specification. This is a very appropriate technique for highly configurable software, since there is usually an enormous amount of combinations to be checked. This paper presents how PLCverif, a CERN model checking platform, has been applied to a highly configurable Programmable Logic Controller (PLC) program, the SPS Personnel Protection System (PPS). The benefits and challenges of this verification approach are also discussed.

Generic Software for CERN's LIU Beam Loss Monitoring Systems from LINAC4 to SPS Injection

D. Medina (CERN)

The real-time software for the Beam Loss Monitoring Systems (BLM) configures, instruments, optimizes and protects the machine in the framework of CERN's LHC Injectors Upgrade (LIU). Initially designed to fulfil the needs of the new LINAC4 linear accelerator, the software has evolved during CERN's LS2 to cover the additional requirements of the Proton Synchrotron Booster (PSB) and Proton Synchrotron (PS) accelerators, as well as all the interconnecting transfer lines up to the Super Proton Synchrotron (SPS), and the PS East Experiment Area. This paper outlines how the software has been designed to cover all these needs, while maintaining a homogenous software core. It will highlight the challenges in achieving this goal, as well as detailing how the special cases in the PS and TT10 transfer line were specifically addressed.

Beam Profile Measurements as Part of the Safe and Efficient Operation of the New SPS Beam Dump System

A. Topaloudis, E. Bravin, S. Burger, S. Jackson, F.M. Velotti, E. Veyrunes (CERN)

In the framework of the LHC Injectors Upgrade (LIU) project, the Super Proton Synchrotron (SPS) accelerator at CERN is undergoing a profound upgrade including a new high-energy beam dump. The new Target Internal Dump Vertical Graphite (TIDVG#5) is designed to withstand an average dumped beam power as high as 235 kW to cope with the increased intensity and brightness of the LIU beams whose energies in the SPS range from 14 to 450 GeV. Considering such highly demanding specifications, the constant monitoring of the device's status and the characteristics of the beams that are dumped to it is of utmost importance to guarantee an efficient operation with little or no limitations. While the former is ensured with several internal temperature sensors, a Beam Observation system based on a scintillating screen and a digital camera is installed to extract the profile of the beam dumped in TIDVG#5 for post mortem analysis. This paper describes the overall system that uses the BTV images to contribute to the safe and efficient operation of the SPS Beam Dump System (SBDS) and hence the accelerator.

Supporting Flexible Runtime Control and Storage Ring Operation With the FAIR Settings Management System

R. Mueller, J. Fitzek, H.C. Hüther, H. Liebermann, D. Ondreka, A. Schaller, A. Walter (GSI)

The FAIR Settings Management system has now been used productively for the GSI accelerator facility operating synchrotrons, storage rings, and transfer lines. The system's core is being developed in a collaboration with CERN, and is based on CERN's LHC Software Architecture (LSA) framework. At GSI, 2018 was dedicated to integrating the Beam Scheduling System BSS. Major implementations for storage rings were performed in 2019, while 2020 the main focus was

on optimizing the performance of the overall control system. Integrating with the BSS allows us to configure the beam execution directly from the settings management system. Defining signals and conditions enables us to control the runtime behavior of the machine. The storage ring mode supports flexible operation with features allowing to pause the machine and execute in-cycle modifications, using concepts like breakpoints, repetitions, skipping, and manipulation. After providing these major new features and their successful productive use, the focus was shifted on optimizing their performance. The performance was analyzed and improved based on real-word scenarios defined by operations and machine experts.

WEPV048

An Archiver Appliance Performance and Resources Consumption Study

R.N. Fernandes, S. Armanet, H. Kocevar, S. Regnell (ESS)

At the European Spallation Source (ESS), 1.6 million signals are expected to be generated by a (distributed) control layer composed of around 1500 EPICS IOCs. A substantial amount of these signals - i.e. PVs - will be stored by the Archiving Service, a service that is currently under development at the Integrated Control System (ICS) Division. From a technical point of view, the Archiving Service is implemented using a software application called the Archiver Appliance. This application, originally developed at SLAC, records PVs as a function of time and stores these in its persistent layer. A study based on multiple simulation scenarios that model ESS (future) modus operandi has been conducted by ICS to understand how the Archiver Appliance performs and consumes resources (e.g. RAM) under disparate workloads. This paper presents: 1) The simulation scenarios; 2) The tools used to collect and interpret the results; 3) The storage study; 4) The retrieval study; 5) The resources saturation study; 6) Conclusions based on the interpretation of the results.

WEPV049

Controls Data Archiving at the Isis Neutron and Muon Source for in-Depth Analysis and ML Applications

I.D. Finch, G.D. Howells, A.A. Saoulis (STFC/RAL/ISIS)

The ISIS Neutron and Muon Source accelerators are currently operated using Vsystem control software. Archiving of controls data is necessary for immediate fault finding, to facilitate analysis of long-term trends, and to provide training datasets for machine learning applications. While Vsystem has built-in logging and data archiving tools, in recent years we have greatly expanded the range and quantity of data archived using an open-source software stack including MQTT as a messaging system, Telegraf as a metrics collection agent, and the Influx time-series database as a storage backend. Now that ISIS has begun the transition from Vsystem to EPICS this software stack will need to be replaced or adapted. To explore the practicality of adaptation, a new Telegraf plugin allowing direct collection of EPICS data has been developed. We describe the current Vsystem-based controls data archiving solution in use at ISIS, future plans for EPICS, and our plans for the transition while maintaining continuity of data.

Funding: UKRI / STFC

WEPV050

Containerised Control Systems Development at Isis and Potential Use in an Epics System

G.D. Howells, I.D. Finch (STFC/RAL/ISIS)

Control system developers at the ISIS Neutron and Muon Source have been using Docker container technology as an efficient means to trial and develop interconnected software systems. We outline how the group has been able to use pre-existing container images in the traditional style for recording system metrics (e.g., TIG stack) and other telemetry. Furthermore, with the ISIS control system migrating from Vsystem to EPICS, we report how core components of these systems have been built and used within containers. We finally discuss whether such container technology could be used to implement the end goal of a full EPICS control system, or whether it is best suited to exploratory investigations.

Funding: UKRI / STFC

THKL — Keynote Session IV

Infrared Remote Sensors for Chinese Meteorological Satellites

L. Ding (Shanghai Institute of Technical Physics, Chinese Academy of Sciences)

An infrared hyper-spectral sounder, Geostationary Interferometric Infrared Sounder (GIIRS) on-board FY-4A satellite, is the first interferometer with less than 1 wavenumber spectral resolution that works on geostationary orbit. GIIRS takes measurements of three dimensional atmospheric structure from interference of split light beams, complementing the advanced IR sounders in polar orbit. It measures the infrared radiation spectrum distribution in the middle and long wave infrared spectra of the earth by using the Fourier spectroscopic technique. GIIRS provides breakthrough measurements with the temporal, horizontal, and vertical resolution needed to resolve the quickly changing water vapor and temperature structures associated with severe weather events. Through the atmospheric detection made by GIIRS, the weather trend is calculated for the numerical weather prediction model, and the large-scale, rapid, continuous and long-term meteorological measurements have been realized. The international Meteorological community is eager to use the new type of data and get experience with it, as Dr. Tillmann Mohr, former Director-General of EUMETSAT , mentioned.

THAL — Feedback Control, Machine Tuning and Optimization II

THAL01

Machine Learning Tools Improve BESSY II Operation

L. Vera Ramirez, T. Birke, G. Hartmann, R. Mueller, M. Ries, A. Schaelicke, P. Schnizer (HZB)

At the HZB user facility BESSY II Machine Learning (ML) technologies aim at advanced analysis, automation, explainability and performance improvements for accelerator and beamline operation. The development of these tools is intertwined with improvements of the prediction part of the digital twin instances at BESSY II [*] and the integration into the Bluesky Suite [**,***]. On the accelerator side, several use cases have recently been identified, pipelines designed and models tested. Previous studies applied Deep Reinforcement Learning (RL) to booster current and injection efficiency. RL now tackles a more demanding scenario: the mitigation of harmonic orbit perturbations induced by external civil noise sources. This paper presents methodology, design and simulation phases as well as challenges and first results. Further ML use cases under study are, among others, anomaly detection prototypes with anomaly scores for individual features.

[*] P. Schnizer et. al, IPAC21 [**] D. Allan, T. Caswell, S. Campbell and M. Rakitin, Synchrot. Radiat. News 32 19-22, 2019 [***] W. Smith et. al, this conference

THAL02

Bayesian Techniques for Accelerator Characterization and Control

R.J. Roussel, A.L. Edelen, C.E. Mayes (SLAC) J.P. Gonzalez-Aguilera, Y.K. Kim (University of Chicago)

Accelerators and other large experimental facilities are complex, noisy systems that are difficult to characterize and control efficiently. Bayesian statistical modeling techniques are well suited to this task, as they minimize the number of experimental measurements needed to create robust models, by incorporating prior, but not necessarily exact, information about the target system. Furthermore, these models inherently take into account noisy and/or uncertain measurements and can react to time-varying systems. Here we will describe several advanced methods for using these models in accelerator characterization and optimization. First, we describe a method for rapid, turn-key exploration of input parameter spaces using little-to-no prior information about the target system. Second, we highlight the use of Multi-Objective Bayesian optimization towards efficiently characterizing the experimental Pareto front of a system. Throughout, we describe how unknown constraints and parameter modification costs are incorporated into these algorithms.

Funding: This work was supported by the U.S. National Science Foundation under Award No. PHY-1549132, the Center for Bright Beams.

THAL03

Machine Learning Based Middle-Layer for Autonomous Accelerator Operation and Control

S. Pioli, B. Buonomo, C. Di Giulio, G. Piermarini (INFN/LNF)

The Singularity project, led by National Laboratories of Frascati of the National Institute for Nuclear Physics (INFN-LNF), aim to develop automated machine-independent middle-layer to control accelerator operation through machine learning (ML) algorithms like Reinforcement Learning (RL) and Cluster integrated with accelerator's sub-systems. In this work we will present architecture and of the middle-layer made with main purpose to drive user requests through the control framework backend and allow users to enjoy a better User Experience (UX) handling system performances without facing problems due to the interaction with control system. We will report the strategy to develop autonomous operation control with RL algorithms together with the fault detection capability improved by Clustering approach as breakdown and waveguide and RF cavity thermal stability monitor. Results of the first period of operation of this system, currently operating at the electron-positron LINAC of the Dafne complex in Frascati, autonomously controlling accelerator performance in terms of beam transport, beam current optimization and RF cavity phase-jitter compensation will be reported.

Machine Learning Based Tuning and Diagnostics for the ATR line at BNL

J.P. Edelen, C.C. Hall (RadiaSoft LLC) K.A. Brown, P.S. Dyer (BNL)

Over the past several years machine learning has increased in popularity for accelerator applications. We have been exploring the use of machine learning as a diagnostic and tuning tool for transfer line from the AGS to RHIC at Brookhaven National Laboratory. In our work, inverse models are used to either provide feed-forward corrections for beam steering or as a diagnostic to illuminate quadrupole magnets that have excitation errors. In this talk we present results on using machine learning for beam steering optimization for a range of different operating energies. We also demonstrate the use of inverse models for optical error diagnostics. Our results are from studies that use combine simulation and measurement data.

Funding: This material is based upon work supported by the U.S. Department of Energy, Office of Science, Office of Nuclear Physics under Award Number DE-SC0019682.

THAR — User Interfaces and User eXperience (UX) I

THAR01

MINT, an ITER tool for interactive visualization of data

L. Abadie, G. Carannante, I. Nunes, J. Panchumarti, S.D. Pinches, S. Simrock, M. Tsalas (ITER Organization) S.S. Kalsi (Tata Consultancy Services) D.R. Makowski, P. Mazur, P. Perek (TUL-DMCS) A. Neto (F4E)

ITER will produce large volumes of data that need to be visualized and analyzed. This paper describes the development of a graphical data visualization and exploration tool, MINT (Make Informative and Nice Trends), for plant engineers, operators and physicists. It describes the early development phase from requirements capture to first release covering the mistakes, lessons learnt and future steps. The requirements were collected by interviewing the various stakeholders. The initial neglect of the architecture and user-friendliness turned out to be key points when developing such a tool for a project with a long lifetime like ITER. Modular architecture and clear definition of generic interfaces (abstraction layer) is crucial for such a long lifetime project and makes it ready for future adaptations to new plotting, processing and GUI libraries. The MINT application is based upon the development of an independent plotting library, which acts as a wrapper to the underlying graphical library. This allows scientists and engineers to develop their own specific tools, which are immune to changes of graphical library. The development based on Python uses Qt5 as the visual backend.

THAR02

Daiquiri: A Web Based User Interface Framework for Beamline Control and Data Acquisition

S. Fisher, M. Cotte, W. De Nolf, J.M. Meyer, M. Oskarsson, V. Valls (ESRF)

Daiquiri is a web based User Interface (UI) framework for control system monitoring and data acquisition. It provides simple, intuitive, and responsive interfaces to control and monitor hardware, launch acquisition sequences, and manage associated metadata. Daiquiri concerns itself only with the UI layer, it does not provide a scan engine or controls system but can be easily integrated with existing systems. Daiquiri is implemented with a traditional client / server methodology with the intention of producing a generic extensible framework for acquisition. The server is implemented in Python 3 and provides a REST API and SocketIO service for real-time feedback. The client is implemented in javascript es6 making use of the popular front end framework React along with Redux. Daiquiri is currently deployed on the scanning X-ray microscope beamline ID21, as well as the BioSAXS beamline BM29 [1], and will be extended to BM23, ID24, ID27, and BM18. In the future daiquiri will be the standard interface by which users and scientists interact with the controls system on beamlines at ESRF. Further information can be found at https://ui.gitlab-pages.esrf.fr/daiquiri-landing

[1] M. Oskarsson et al., From MXCuBE3 to BSXCuBE3 a Web Application for BioSAXS Experiment Control. JACoW Publishing, Geneva, Switzerland (2020), doi:10.18429/jacow-icalepcs2019-wepha115.

THAR03

Automated Scheduler Software Based on Metro Ui Design for Mace Telescope

M. Punna, S. Mohanan, P. Sridharan (BARC) PadeepC. Chandra, S.V. Godambe (Bhabha Atomic Research Centre (BARC))

MACE Scheduler software generates automated schedule for the observations of preloaded high energy gamma-ray sources. The paper presents the design of MACE Scheduler software covering; source rise/set time calculation algorithms; auto and manual schedule generation; various data visualizations provided for schedule and source visibility reports. The schedule generation for a specific period is automated using a filter workflow. The sources are selected for scheduling by processing the sources through a series of customizable user defined filters; source visibility filter, priority filter, priority resolution filter. The workflow provides flexibility to apply any user tailored filter criteria that can be loaded dynamically using XML schema. Loosely coupled design allowed decoupling the astronomical timing calculation algorithms from schedule preparation workflow. Scheduler provides metro UI based interface for source filtering workflow generating auto-schedule, updating the generated schedules. Tree-map visualization helped to represent hierarchical multi-dimensional schedule information for the selected date range. WPF flat UI control templates focused more on content than chrome

THBL — Control System Infrastructure

Control System Management and Deployment at MAX IV

B. Bertrand, A. Freitas, V.H. Hardion (MAX IV Laboratory, Lund University)

The control systems of big research facilities like synchrotron are composed of many different hardware and software parts. Deploying and maintaining such systems require proper workflows and tools. MAX IV has been using Ansible to manage and deploy its full control system, both software and infrastructure, for quite some time with great success. All required software (i.e. tango devices, GUIs...) used to be packaged as RPMs (Red Hat Package Manager) making deployment and dependencies management easy. Using RPMs brings many advantages (big community, well tested packages, stability) but also comes with a few drawbacks, mainly the dependency to the release cycle of the Operating System. The Python ecosystem is changing quickly and using recent modules can become challenging with RPMs. We have been investigating conda as an alternative package manager. Conda is a popular open-source package, dependency and environment management system. This paper will describe our workflow and experience working with both package managers.

Explore the Capability of Ethercat as an Alternative of Real-Time Control System for the Alma Observatory

T.C. Shen, A. Sepulveda (ALMA Observatory) R.A. Augsburger, S.A. Carrasco, P. Galeas, F. Huenupan, R.S. Seguel (Universidad de La Frontera)

The ALMA Observatory was inaugurated in 2013, after the 8 years of successful operation, obsolescence has started to emerge in different areas. One of the most critical areas is the control bus of the hardware devices located the antenna, which is based on a customized version of CAN bus. Initial studies were performed to explore alternatives, and one of the candidates could be a solution based on EtherCAT. In this paper, the existing architecture will be presented and new architecture will be proposed, which would not only be compatible with the existing hardware devices but also allow prepared the ground for new subsystems that come with ALMA 2030 initiatives. This document reports the progress achieved in a proof of concept project that explores the possibility to embed the existing ALMA monitor & control data structure into EtherCAT frames and use EtherCAT as the main communication protocol to control hardware devices in all the subsystems that comprise the ALMA telescope.

The State of Containerization in CERN Accelerator Controls

R. Voirin, T. Oulevey, M. Vanden Eynden (CERN)

In industry, containers have dramatically changed the way system administrators deploy and manage applications. Developers are gradually switching from delivering monolithic applications to microservices. Using containerization solutions provides many advantages, such as: applications running in an isolated manner, decoupled from the operating system and its libraries; run-time dependencies, including access to persistent storage, are clearly declared. However, introducing these new techniques requires significant modifications of existing computing infrastructure as well as a cultural change. This contribution will explore practical use cases for containers and container orchestration within the CERN Accelerator Controls domain. We will explore challenges that have been arising in this field for the past two years and technical choices that we have made to tackle them. We will also outline the foreseen future developments.

Kubernetes for EPICS IOCs

G. Knap, T.M. Cobb, Y. Moazzam, U.K. Pedersen, C.J. Reynolds (DLS)

EPICS IOCs at Diamond Light Source are built, deployed, and managed by a set of in-house tools that were implemented 15 years ago. This paper will detail a proof of concept to demonstrate replacing these tools and processes with modern industry standards. IOCs are packaged in containers with their unique dependencies included. IOC images are generic, and a single image is required for all containers that control a given class of device. Configuration is provided to the container in the form of a start-up script only. The configuration allows

the generic IOC image to bootstrap a container for a unique IOC instance. This approach keeps the number of images required to a minimum. Container orchestration for all beamlines in the facility is provided through a central Kubernetes cluster. The cluster has remote nodes that reside within each beamline network to host the IOCs for the local beamline. All source, images and individual IOC configurations are held in repositories. Build and deployment to the production registries is handled by continuous integration. Finally, a development container provides a portable development environment for maintaining and testing IOC code.

THBR — Timing Systems, Synchronization and Real-Time Applications

Renovation of the Trigger Distribution in CERN's Open Analogue Signal Information System Using White Rabbit

D. Lampridis, T. Gingold, A. Poscia, M.H. Serans, M.R. Shukla, T.P. da Silva (CERN) D. Michalik (Aalborg University)

The Open Analogue Signal Information System (OASIS) acts as a distributed oscilloscope system that acquires signals from devices across the CERN accelerator complex and displays them in a convenient, graphical way. Today, the OASIS installation counts over 500 multiplexed digitisers, capable of digitising more than 5000 analogue signals and offers a selection of more than 250 triggers for the acquisitions. These triggers are mostly generated at a single central place and are then distributed by means of a dedicated coaxial cable per digitiser, using a "star" topology. An upgrade is currently under way to renovate this trigger distribution system and migrate it to a White Rabbit (WR) based solution. In this new system, triggers are distributed in the form of Ethernet messages over a WR network, allowing for better scalability, higher time-stamping precision, trigger latency compensation and improved robustness. This paper discusses the new OASIS trigger distribution architecture, including hardware, drivers, front-end, server and application-tier software. It then provides results from preliminary tests in laboratory installations.

White Rabbit and MTCA.4 use in the LLRF upgrade for CERN's SPS

T. Wlostowski, K. Adrianek, M. Arruat, P. Baudrenghien, A.C. Butterworth, G. Daniluk, J. Egli, J.R. Gill, T. Gingold, J.D. Gonzalez Cobas, G. Hagmann, P. Kuzmanovic, D. Lampridis, M. Lipinski, S. Novel Gonzalez, J.P. Palluel, M. Rizzi, A. Spierer, M. Suminski, A. Wujek (CERN)

The Super Proton Synchrotron (SPS) Low-level RF (LLRF) system at CERN was completely revamped in 2020. In the old system, the digital signal processing was clocked by a submultiple of the RF. The new system uses a fixed-frequency clock derived from White Rabbit (WR). This triggered the development of an eRTM module for generating very precise clock signals to be fed to the optional RF backplane in MTCA.4 crates. The eRTM14/15 sandwich of modules implements a WR node delivering clock signals with a jitter below 100 fs. WR-clocked RF synthesis inside the FPGA makes it simple to reproduce the RF elsewhere by broadcasting the frequency-tuning words over the WR network itself. These words are received by the WR2RF-VME module and used to produce beam-synchronous signals such as the bunch clock and the revolution tick. This paper explains the general architecture of this new LLRF system, highlighting the role of WR-based synchronization. It then goes on to describe the hardware and gateware designs for both modules, along with their supporting software. A recount of our experience with the deployment of the MTCA.4 platform is also provided.

Prototype of White Rabbit Based Beam-Synchronous Timing Systems for SHINE

P.X. Yu, Y.B. Yan (SSRF)

Shanghai HIgh repetition rate XFEL aNd Extreme light facility (SHINE) is under construction. SHINE requires precise distribution and synchronization of the 1.003086MHz timing signals over a long distance of about 3.1 km. Two prototype systems were developed, both containing three functions: beam-synchronous trigger signal distribution, random-event trigger signal distribution and data exchange between nodes. The frequency of the beam-synchronous trigger signal can be divided according to the accelerator operation mode. Each output pulse can be configured for different fill modes. A prototype system was designed based on a customized clock frequency point (64.197530MHz). Another prototype system was designed based on the standard White Rabbit protocol. The DDS (Direct Digital Synthesis) and D flip-flops (DFFs) are adopted for RF signal transfer and pulse configuration. The details of the timing system design and test results will be reported in this paper.

THBR04

Nanosecond machine learning with BDT for high energy physics

T.M. Hong, S.T. Roche (University of Pittsburgh)

We present a novel implementation of classification using boosted decision trees (BDT) on FPGA. Our BDT approach offers an alternative to existing packages, including those that implement neural networks on FPGA, with less dependence of DSP utilization that is replaced by other resources. Our design philosophy is to remove clocked operations in favor of combinatoric logic through High Level Synthesis. The firmware implementation of binary classification requiring 100 training trees with a maximum depth of 4 using four input variables gives a latency value of about 10ns at various clock speeds. We optimize the parameters using a software package, which interfaces to Xilinx Vivado through High Level Synthesis. Such a tool may enable the FPGA-based trigger systems at the Large Hadron Collider to be more sensitive to new physics at high energy experiments. The work is described in https://arxiv.org/abs/2104.03408

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THBR05

An integrated scheme for online correction of laser focal position

N.M. Cook, S.J. Coleman, J.P. Edelen, R. Nagler (RadiaSoft LLC) S.K. Barber, J. van Tilborg (LBNL)

High repetition-rate, ultrafast laser systems play a critical role in a host of modern scientific and industrial applications. We present a prototype diagnostic and correction scheme for controlling laser focal position for operation at 10s of Hz. Our strategy is to couple fast wavefront sensor measurements at multiple positions to generate a focal position prediction. We then train a neural network to predict the specific adjustments to adaptive actuators along the beamline to provide the desired correction to the focal position at 10s of ms timescales. Our initial proof-of-principle demonstrations leverage pre-compiled data and pre-trained networks operating ex-situ from the laser system. We then discuss the application of a high-level synthesis framework for generating a low-level hardware description of ML-based correction algorithms on FPGA hardware coupled directly to the beamline. Lastly, we consider the use of remote computing resources, such as the Sirepo scientific framework*, to actively update these correction schemes in the presence of new data

*M.S. Rakitin et al., 'Sirepo: an open-source cloud-based software interface for X-ray source and optics simulations," Journal of Synchrotron Radiation25, 1877-1892 (Nov 2018).

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THPV — Posters

Supervisory System for the Sirius Scientific Facilities

L.C. Arruda, G.T. Barreto, M.P. Calcanha, H.F. Canova, J.V.B. Franca (LNLS)

A general supervisory system for the scientific facilities is under development at Sirius, the Brazilian 4th generation synchrotron light source. The data generated by different classes of equipment are generally available via EPICS or industrial protocols such as OPC-UA provided by commercial automation systems. However, as the number of beamlines and laboratories expands, the effort to properly gather, display and manage this data also scales up. For this reason, an aggregating supervisory system is proposed to monitor the systems: power distribution, personal safety, beamline components, cryogenic fluids; mechanical utilities, air conditioning, among others. This work presents the overall system architecture, functionalities, and some user interfaces.

Work supported by the Brazilian Ministry of Science, Technology and Innovation lucas.arruda@lnls.br

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Open-Hardware Knob System for Acceleration Control Operations

E. Munaron, M. Montis, L. Pranovi (INFN/LNL)

Nowadays technologies in LINAc facilities brought the common Human-Machine Interfaces (HMIs) to be more aligned to the standards coming from the information technology (IT) and the operators started to interact to the apparatus with the common computers' instruments: mouse and keyboard. This approach has both pro and cons. In order to minimize the cons and with the idea of providing an alternative to interact with HMIs, we tried to design and realize an open-hardware knob system solution.

Virtual Reality and Control Systems: How a 3D System Looks Like

L. Pranovi, M. Montis (INFN/LNL)

Virtual Reality (VR) technology and its derivatives are mature enough to be used in environments like a nuclear research laboratory, to provide useful tools and procedures to optimize the tasks of developers and operators. Preliminary tests were performed [*] to understand the feasibility of this technology applied to a nuclear physics laboratory with promising feedback. Due to the fact this technology is rapidly diffusing in several different professional heterogeneous environments, such as medicine, architecture, the military and industry, we tried to evaluate the impact coming from a new kind of Human-Machine Interface based on VR.

* L.Pranovi et al., 'Vr as a Service: Use of Virtual Reality in a Nuclear Accelerator Facility', ICALEPCS 2019, New York, NY, USA

Design of real-time alarm system for CAFe

N. Xie, Y.H. Guo, B.J. Wang, R. Wang (IMP/CAS)

In accelerator control, the alarm system is a very im-portant real-time monitoring and control system. In order to find specific failures of accelerator-related equipment in time, improve the high availability of the equipment, and ensure the long-term operation of the accelerator. An accelerator alarm system based on Kafka was designed and built on the CAFe. The system uses Phoebus for ar-chitecture deployment. Kafka is used as the streaming platform of the alarm system, which effectively improves the throughput of the system and realizes real-time alarms. In order to realize the function of remote monitor-ing of data in the central control room, CS-Studio is used to draw the opi interface to deploy to the enterprise WeChat platform to realize remote data monitoring. This system greatly improves the response speed of fault han-dling and saves a lot of valuable time for accelerator fault handling.

THPV007

Fast Creation of Control and Monitor Graphical User Interface for Pepc of Laser Fusion Facility Based on Icsff

L. Li, J. Luo, Z. Ni (CAEP)

Plasma electrode Pockels cell (PEPC) is the key unit of the multi-pass amplify system in laser fusion facility, whether the PEPC is effective determined the success rate of the facility experiment directly. The operator needs to conduct remote control and monitor during the facility is running, also can automatically judge whether the pulse discharge waveform is regular online. We have designed a software framework (ICSFF) that loads all GUI widget elements related to control and monitor into board through plug-ins, and then by setting the respective properties, data source and built-in script of each widget achieve patterns like point control, flow control and other complex combined control, can also achieve data acquisition and varied display effects. It allows the operator drag and drop widget freely and configure the widget properties through the interface in a non-programming mode to quickly build the GUI they need. It not only apply to PEPC in facility, but also to other system in the same facility. ICSFF supports Tango control system right now, and more control systems will be supported in the future.

THPV008

Signal metadata management interface for Spring-8

M. Celary (S2Innovation) K. Uchida (COSYLAB Japan)

The system for handling the synchrotron metadata registration process at Spring 8 was developed by Cosylab/S2Innovation. Web application was based on Tornado, a Python framework which was chosen for it's support for non-blocking network I/O, making it ideal for long polling and enabling it to scale to large number of open connections. Main functionalities that were implemented include: signal metadata check, signal registration, database backup/restore and signal registration history administration. The paper presents result of the project and challenges faced during it's realization.

THPV009

Web Gui Development and Integration in Libera Instrumentation

D. Bisiach, M. Cargnelutti, P. Leban, P. Paglovec, L. Rahne, M. Skabar, A. Vigali (I-Tech)

During the past 5 years, Instrumentation Technologies expanded and added to the embedded OS running on Libera instruments (beam position instrumentation, LLRF) a lot of data access interfaces to allow faster access to the signals retrieved by the instrument. Some of the access interfaces are strictly related to the user environment Machine control system (Epics/Tango), and others related to the user software preferences (Matlab/Python). In the last years, the requirement for easier data streaming was raised to allow easier data access using PC and mobile phones through a web browser. This paper aims to present the development of the web backend server and the realization of a web frontend capable to process the data retrieved by the instrument. A use-case will be presented, the realization of the Libera Current Meter Web GUI as a first development example of a Web GUI interface for a Libera instrument and the starting point for the Web GUI pipeline integration on other instruments. The HTTP access interface will become in the next years a standard in data access for Libera instrumentation for quick testing/diagnostics and will allow the final user to customize it autonomously.

THPV010

Scaling Up the Alba Cabling Database and Plans to Turn Into an Asset Management System

I. Costa, A. Camps Gimenez, R. Cazorla, T. FernÃ¡ndez Maltas, D. Salvat (ALBA-CELLS Synchrotron)

The "Cabling and Controls Database" (CCDB) is a central repository where the different teams of ALBA manage the information of installed racks, equipment, cables and connectors, and their connections and technical specifications. ALBA has modernized this web application for sustainability reasons and fit new needs detected throughout the last years of operation in our facility. The application has been linked to Jira to allow tracking problems in specific installed equipment or locations. In addition, it also connects to the ALBA Inventory Pools application, the warehouse management system, where the stock of physical equipment and components are maintained to get information on the life cycle of the different devices. These new features, integrated with proprietary products like Jira and Insight, aim to become ALBA's asset management system. This paper aims to describe the main features of the recent application upgrade, currently in continuous development.

Notifications With Native Mobile Application

B. Bertrand, J. Forsberg (MAX IV Laboratory, Lund University) E. Laface, G. Weiss (ESS)

Notifications are an essential part of any control system. Many people want to be notified of specific events. There are several ways to send notifications: SMS, e-mails or messaging applications like Slack and Telegram are some common ones. Those solutions frequently require some central configuration to record who will receive messages, which is difficult to maintain. ESS developed a native mobile application, both for iOS and Android, to manage notifications. The application allows the users to subscribe to the topics they are interested in, removing the need for a central configuration. A web server is used as gateway to send all notifications following Apple and Google protocols. This server exposes a REST API that is used both by clients to send messages and mobile applications to retrieve and manage those messages. This paper will detail the technical implementation as well as the lessons learnt from this approach.

LHC Collimation Controls System for Run III Operation

G. Azzopardi, M. Di Castro, S. Redaelli, B. Salvachua, M. Solfaroli Camillocci (CERN) G. Valentino (University of Malta, Information and Communication Technology)

The Large Hadron Collider (LHC) collimation system is designed to protect the machine against unavoidable beam losses. The collimation system for the LHC Run 3, starting in 2022, consists of more than 100 movable collimators located along the 27 km long ring and in the transfer lines. The cleaning performance and machine protection role of the system critically depend on the accurate positioning of the collimator jaws. The collimation control system in place enables remote control and appropriate diagnostics of the relevant parameters. This ensures that the collimators dynamically follow optimum settings in all phases of the LHC operational cycle. In this paper, an overview of the top-level software tools available for collimation control from the control room is given. These tools range from collimator alignment applications to generation tools for collimator settings, as well as collimator scans, settings checks and machine protection sequences. Amongst these tools the key upgrades and newly introduced tools for the Run 3 are presented.

WRAP - A Web-based Rapid Application Development Framework for CERN's Controls Infrastructure

E. Galatas, A. Asko, E. Matli, C. Roderick (CERN)

To ensure stable operation of CERN's accelerator complex, many Devices need to be controlled. To meet this need, over 500 custom Graphical User Interfaces (GUI) have been developed using Java Swing, Java FX, NetBeans, Eclipse SWT, etc. These represent a high maintenance cost, particularly considering the global evolution of the GUI technology landscape. The new Web-based Rapid Application Platform (WRAP) provides a centralized, zero-code, drag-n-drop means of GUI creation. It aims to replace a significant percentage of existing GUIs and ease new developments. Integration with the Controls Configuration Service (CCS) provides rich infrastructure metadata to support application configuration, whilst following the associated equipment lifecycle (e.g. renames, upgrades, dismantling). Leveraging the CERN Accelerator Logging Service (NXCALS) and the Unified Controls Acquisition and Processing (UCAP) platform, allows WRAP users to respectively, create GUIs showing historical data, and interface with complex data-stream processing. The plugin architecture will allow teams to further extend the tool as needed. This paper describes the WRAP architecture, design, status, and outlook.

Adopting PyQt For Beam Instrumentation GUI Development At CERN

S. Zanzottera, S. Jackson, S. Jensen (CERN)

As Java GUI toolkits become deprecated, the Beam Instrumentation (BI)group at CERN has investigated alternatives and selected PyQt as one of the suitable technologies for future GUIs, in accordance with the paper presented at ICALEPCS19. This paper presents tools created, or adapted, to seamlessly integrate future PyQt GUI development alongside current Java oriented workflows and the controls environment. This includes (a) creating a project template and a GUI management tool to ease and standardize our development process, (b) rewriting our previously Java-centric Expert GUI Launcher to be language-agnostic and (c) porting a selection of operational GUIs from Java to PyQt, to test the feasibility of the development process and identify bottlenecks. To conclude, the challenges we anticipate for the BI GUI developer community in adopting this new technology are also discussed.

THPV015

New Timing Sequencer Application in Python with Qt - Development Workflow and Lessons Learnt

Zs. Kovari, G. Kruk (CERN)

PyQt is a Python binding for the popular Qt framework for the development of desktop applications. By using PyQt one can leverage Qt's aspects to implement modern, intuitive, and cross-platform applications while benefiting from Python's flexibility. Recently, we successfully used PyQt 5 to renovate the Graphical User Interface (GUI) used to control the CERN accelerator timing system. The GUI application interfaces with a Java-based service behind the scenes. In this paper we introduce the generic architecture used for this project, our development workflow as well as the challenges and lessons we learned from using Python with Qt. We present our approach to delivering an operational application with a particular focus on testing, quality assurance, and continuous integration.

THPV016

Developing an Alarm Philosophy for the EPICS Control System at ISIS

S.A. Medley, I.D. Finch, M. Romanovschi (STFC/RAL/ISIS) A. Kurup (Imperial College of Science and Technology, Department of Physics)

The ISIS Muon and Neutron Source control system alarms have been growing organically during the 30+ years of ISIS's operation. The upcoming migration from the Vista Control Systems product Vsystem to EPICS provides the right opportunity and framework for a `fresh start' to review and rationalise the alarms. Internationally recognised good engineering practice is defined in the IEC-62682 / ISA 18.2 Standards for the Management of Alarm Systems for the Process Industries, which describe the Alarm Management Lifecycle: an ongoing process of continuous improvement to be used to manage alarms in control systems. The Lifecycle begins with the development of an Alarm Philosophy, which establishes the basic definitions, principles and processes to design, implement and maintain an alarm system. The development of an Alarm Philosophy for the new EPICS Control system at ISIS is outlined, setting out the basis for the identification, classification and prioritisation of alarms. The challenges of managing the transition of the alarms from Vsystem to EPICS are discussed, including the outcome of initial work applying the Alarm Philosophy to rationalising the existing Vsystem alarms.

THPV017

A cloud based toolbox for accelerator controls interfaces and optimization

J.P. Edelen, E. Carlin, M.V. Keilman, P. Moeller, R. Nagler (RadiaSoft LLC)

Modern particle accelerator facilities generate large amounts of data and face increasing demands on their operational performance. As the demand on accelerator operations increases so does the need for automated tuning algorithms and control to maximize uptime with reduced operator intervention. Existing tools are insufficient to meet the broad demands on controls, visualization, and analysis. We have developed a cloud based toolbox featuring a generic virtual accelerator control room for the development of automated tuning algorithms and the analysis of large complex datasets. This framework utilizes tracking codes combined with with algorithms for machine drift, low-level control systems, and other complications to create realistic models of accelerators. These models are directly interfaced with control toolboxes allowing for rapid prototyping of tuning algorithms. In this paper, we will provide an overview of our interface and demonstrate its utility for building beamline controls displays directly from accelerator simulation lattices. We will also demonstrate the use of our interface for testing online optimization and control algorithms.

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THPV018

Infrastructure-independent Device Control

A. Sukhanov, J.P. Jamilkowski (BNL)

In modern accelerator control systems there is often a need for controlling devices which have been developed with interface to a different control infrastructure. For example, the future EIC collider will have mixture of EPICS-controlled and ADO-controlled devices. In this paper we describe the control tools and middle-level interface which allows to control the devices independently of their dedicated architecture. The tools are implemented in python and currently they include a pypet, an imageViewer, and a pvplot. The pypet a spreadsheet-based advanced parameter editing tool which covers functionality of the EDM, MEDM and PET. The imageViewer is interactive image

analysis tool, supporting AreaDetector, USB and ADO - controlled cameras. The pvplot is simple parameter plotting tool. The tools are operational at RHIC collider and they provide control for devices from various infrastructures (ADO, EPICS and liteServer).

Funding: Work supported by Brookhaven Science Associates, LLC under Contract No. DE-SC0012704 with the U.S. Department of Energy.

TATU: A FLEXIBLE FPGA-BASED TRIGGER AND TIMER UNIT CREATED ON CompactRIO FOR THE FIRST SIRIUS BEAMLINES

J.R. Piton, D. Alnajjar, D.H.C. Araujo, J.L. Brito Neto, L.P. Do Carmo, L.C. Guedes, M.A.L. Moraes (LNLS)

In the modern synchrotron light sources, the higher brilliance leads to shorter acquisition times at the experimental stations. For most beamlines of the fourth-generation source SIRIUS, it was imperative to shift from the usual software-based synchronization of operations to the much faster triggering by hardware of some key equipment involved in the experiments. As a basis of their control system for devices, the SIRIUS beamlines have standard CompactRIO controllers and I/O modules along the hutches. Equipped with a FPGA and a hard processor running Linux Real-Time, this platform could deal with the triggers from and to other devices, in the order of ms and μs. TATU (Time and Trigger Unit) is a code running in a CompactRIO unit to coordinate multiple triggering conditions and actions. TATU can be either the master pulse generator or the follower of other signals. Complex trigger pattern generation is set from a user-friendly standardized interface. EPICS process variables (by means of LNLS Nheengatu*) are used to set parameters and to follow the execution status. The concept and first field test results in at least four SIRIUS beamlines are presented.

* D. Alnajjar, G. S. Fedel, and J. R. Piton, "Project Nheengatu: EPICS support for CompactRIO FPGA and LabVIEW-RT", ICALEPCS'19, New York, NY, USA, Oct. 2019, paper WEMPL002.

MRF Timing System Design At SARAF

A. Gaget (CEA-IRFU)

CEA Saclay Irfu is in charge of an important part of the control system of the SARAF LINAC accelerator based at Soreq (Israel). This includes, among other, the control of the timing system (synchronization and timestamping). CEA has already installed and uses successfully the timing distribution with MRF on test benches for ESS or IPHI, so it has been decided to use the same technologies. The reference frequency will be distributed along the accelerator by a master oscillator Wenzel and the UTC time will be based on a Meridian II GPS, these 2 devices will be connected to the Event Master (EVM) card which is the main element of the timing system architecture. Through an optical fiber network, the MRF timing system allows to distribute downstream and upstream events with a μs propagation time. Currently, we are working on development in order to also use it for the machine protection system of the accelerator. In this paper, hardware, timing architecture, software developments and tests will be presented.

A New Timing System for PETRA IV

T. Wilksen, A. Aghababyan, K. Brede, H.T. Duhme, M. Fenner, U. Hurdelbrink, H. Kay, H. Lippek, H. Schlarb (DESY)

At DESY an upgrade of the PETRA III synchrotron light source towards a fourth-generation, low emittance machine PETRA IV is currently being actively pursued. The realization of this new machine implies a new design of the timing and synchronization system since requirements on beam quality and controls will significantly change from the existing implementation at PETRA III. The technical design phase of the PETRA IV project is in mid-phase and supposed to deliver a Technical Design Report by end of next year. The conceptual layout of the timing system will follow the successful MTCA.4-based approach as in use at the European XFEL. It will be enhanced to meet the requirements of a synchrotron facility and its booster and linac pre-accelerators. We present general concepts of the timing system, its integration into the control system as well as first specifications of the MTCA.4-based hardware components.

THPV027

Application of the White Rabbit System at SuperKEKB

H. Kaji (KEK) Y. Iitsuka (EJIT)

The timing system is one of the most important components in large-scale accelerators. Its roles are increasing in modern accelerator projects and it works not only for providing the timing signal to the beamline hardware. For installing the distributed data acquisition system to SuperKEKB, we consider utilizing the White Rabbit system. Two slave modules based on the SPEC board are tentatively installed at the main ring of SuperKEKB in the 2020 spring run. We confirm the usefulness of the timestamp synchronization. Then we apply a small improvement to the SPEC firmware to enhance the functions. It is utilized for the delivery of the beam gate signal in the 2021 spring run. Another point we should mention is that our modules are controlled with EPICS. We report our activities to understand and evaluate the White Rabbit system and we introduce the example of applications for the SuperKEKB accelerator.

THPV028

Analysis of AC Line Fluctuation for Timing System at KEK

D. Wang (Sokendai) Y. Enomoto, K. Furukawa, H. Kaji, F. Miyahara, M. Sato, H. Sugimura (KEK)

The timing system controls the injection procedure of the accelerator by performing signal synchronization and trigger delivery to the devices all over the installation. The trigger signals not only synchronize with 50 Hz AC line which originates from requirements of power supply system but also require a at least 18 ms interval due to klystron charging time. However, AC line synchronization conflicts with bucket selection process of SuperKEKB low energy ring (LER) which stores positron beam. The positron beam is firstly injected into a damping ring (DR) to lower the emittance before entering desired RF bucket in LER. A long bucket selection cycle for DR and LER makes it difficult to coincide with AC line every injection pulse. This is overcome by grouping several injection pulses into various of injection sequences and manipulating the length of sequences to adjust the AC line arrival timing. Therefore, the timing system is sensitive to drastically AC line fluctuation. The failure mode of timing system caused by strong AC line fluctuation and solutions are introduced in this work.

THPV029

Development of Timing Read-Back System for Stable Operation of J-PARC

M. Yang (Sokendai) N. Kamikubota (KEK) N. Kikuzawa (JAEA/J-PARC) K.C. Sato (J-PARC, KEK & JAEA) Y. Tajima (Kanto Information Service (KIS), Accelerator Group)

Since 2006, the Japan Proton Accelerator Research Complex (J-PARC) timing system has been operated successfully. However, there were some unexpected trigger-failure events, typically missing trigger events, during the operation over 15 years. When a trigger-failure event occurred, it was often challenging to find the one with the fault among many suspected modules. To solve the problem more easily, a unique read-back system was developed for reading back timing signals. The core hardware of the system is a triggered scaler module, which was designed as a PLC-type I/O module. The software development is based on Experimental Physics and Industrial Control System (EPICS). Some customized applications with a triggered scaler module have been developed. They read back some of the delayed-trigger signals for J-PARC Main Ring, such as an opt-gate signal for a trim-coil short-circuit system or a start signal for a pulsed-bend magnet power supply. Each of them has an unexpected-trigger detection mechanism. The development and demonstration of the applications are given in the paper, followed by a future plan.

THPV031

Upgrade of Timing System at HZDR ELBE facility

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The ELBE center for high power radiation sources is operating an electron linear accelerator to generate various secondary radiation like neutrons, positrons, intense THz and IR pulses and Bremsstrahlung. Timing system, that is currently in operation, has been modified and extended in the last two decades to enable new experiments. At the moment parts of this timing system are using obsolete components which makes maintenance a very challenging endeavour. To make ELBE timing system again a more homogenous system, that will allow for easier adaption to new and more complex trigger patterns, an upgrade based on Micro Research Finland (MRF) hardware platform is currently in progress. This upgrade will enable parallel operation of two electron sources and subsequent kickers to serve multiple end stations at the same time. Selected hardware enables low jitter emission of timing patterns and a long-term

delay compensation of the distribution network. We are currently in the final phase of development and with plans for commissioning to be completed in 2021.

The Demonstrator of the HL-LHC ATLAS Calorimeter

E. Valdes Santurio (FYSIKUM, AlbaNova, Stockholm University) , P. Tsotskolauri (Tbilisi State University)

The High Luminosity Large Hadron Collider (HL-LHC) has motivated R&D to upgrade the ATLAS Tile Calorimeter. The new system consists on an optimized analogue design engineered with selected radiation-tolerant COTS and redundancy layers to avoid single points of failure. The design will provide better timing, improved energy resolution, lower noise and less sensitivity to out-of-time pileup. Multiple types of FPGAs, CERN custom rad-hard ASICs (GBTx), and multi-Gbps optical links are used to distribute LHC timing, read out fully digital data of the whole TileCal, transmit timing and calibrated energy per cell to the Trigger system at 40 MHz, and provide triggered data at 1 MHz. To test the upgraded electronics in real ATLAS conditions, a hybrid demonstrator prototype module containing the new calorimeter module electronics, but still compatible with TileCal's legacy system was tested in ATLAS during 2019-2021. An upgraded version of the demonstrator with finalized HL-LHC electronics is being assembled to be tested in testbeam campaigns at the Super Proton Syncrotron (SPS) at CERN. We present current status and results for the different tests done with the upgraded demonstrator system.
Abstract presented on behalf of the ATLAS Tile Calorimeter System

THPV032

Reusable Real-Time Software Components for the Sps Low Level Rf Control System

M. Suminski, K. Adrianek, B. Bielawski, A.C. Butterworth, J. Egli, G. Hagmann, P. Kuzmanovic, S. Novel Gonzalez, A. Rey, A. Spierer (CERN)

In 2021 the Super Proton Synchrotron has been recommissioned after a complete renovation of its low level RF system (LLRF). The new system has largely moved to digital signal processing implemented as a set of functional blocks (IP cores) in Field Programmable Gate Arrays (FPGAs) with associated software to control them. Some of these IP cores provide generic functionalities such as timing, function generation, data resampling and signal acquisition, and are reused in several components, with a potential application in other accelerators. To take full advantage of the modular approach, IP core flexibility must be complemented by the software stack. In this paper we present steps we have taken to reach this goal from the software point of view, and describe the custom tools and procedures used to implement the various software layers.

THPV033

Data Analysis and Rapid Prototyping using Dashboards

R. Kammering (DESY)

Today most control system frameworks offer sophisticated GUI toolkits and designers. Despite its capabilities in data visualisation these toolkits still require additional processing and computation power when it comes to the exploration of new kinds of data and its hidden analysis potential. Modern dashboard technologies as used in data science do not offer only rapid prototyping of the data analysis chain but also provide complex processing power combined with smart visualisation techniques. This enables a quick turn-around when modifying and adapting the data analysis implementation itself. In modern data analytics dashboards are considered to be a key element for enabling investigative data science. For a project analysing the accelerator machine availability, we implemented a web application using the Streamlit framework. The ease of use and the rich set of possibilities further encouraged us to use this technology for some data science related tasks. The seamless interplay between complex preprocessing and the multitude of visualisation possibilities demonstrate, that these dashboard technologies are very well suited for explorative science related projects.

THPV034

THPV035

Photon Distribution from The ILC Helical Undulator at The Target

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A long helical superconducting undulator is planned as baseline to produce polarised positrons at the International Linear Collider (ILC). The power deposition of the photon beam in undulator walls was studied and shown that the peak power deposition in the undulator walls is above 20 W/m. The power deposition in the undulator walls should be below the acceptable limit of 1W/m since it is a superconducting undulator and also to fulfill the vacuum requirements. To protect the undulator walls from synchrotron radiation, masks must be inserted along the undulator line. The power deposited at these masks is studied in order to design the photon masks. Furthermore, the effect of adding photon masks on the photon power and polarization ('') at the target plane is discussed. Both, ideal and non-ideal (realistic) helical undulators are considered.

THPV036

Laser Driver State Estimation Oriented Data Governance

J. Luo, L. Li, Z. Ni, X. Zhou (CAEP)

Laser driver state estimation is an important task dur-ing the operation process for the high-power laser facility, by utilizing measured data to analyze experiment results and laser driver performances. It involves complicated data processing jobs, including data extraction, data cleaning, data fusion, data visualization and so on. Data governance aims to improve the efficiency and quality of data analysis for laser driver state estimation, which fo-cuses on 4 aspects ' data specification, data cleaning, data exchange, and data integration. The achievements of data governance contribute to not only laser driver state estimation, but also other experimental data analy-sis applications.

THPV037

The Implementation of the Beam Profile Application for Komac Beam Emittance.

J.H. Kim, S.Y. Cho, S. Lee, Y.G. Song, S.P. Yun (Korea Atomic Energy Research Institute (KAERI))

Korea Multi-purpose Accelerator Complex(KOMAC) has been operating a 100 MeV proton linear accelerator that accelerates a beam using ion source, a radio frequency quadrupole(RFQ), 11 drift tube linac(DTL). And the accelerated protons are transported to target rooms that meets the conditions required by the users. It is important to figure out the beam profile of the proton linac to provide the proper beam condition to users. We installed 8 wire scanners to measure beam emittance of KOMAC at beam lines. And beam profile application to measure beam emittance has been implemented using EPICS and python. This paper will describe the implementation of the beam profile application for KOMAC beam emittance.

wirescanner emittance

Funding: This work was supported by the Ministry of Science, ICT & Future Planning of the Korean Government.cu

THPV038

Plug-in-Based Ptychography & Cdi Reconstruction User Interface Development

S.W. Kim, K.H. Ku, W.W. Lee (PAL)

Synchrotron beamlines have a wide range of fields, and accordingly, various open source and commercial softwares are being used for data analysis. Inevitable, the user interface differs between programs and there is little shared part, so the user had to spend a lot of effort to perform a new experimental analysis and learn how to use the program newly. In order to overcome these shortcomings, the same user interface was maintained using the Xi-cam framework, and different analysis algorithms for each field were introduced in a plugin method. In this presentation, user interfaces designed for ptychography and cdi reconstruction will be introduced.

Machine learning applications for accelerator failure prevention at MAX IV

J.E. Petersson, B. Meirose (MAX IV Laboratory, Lund University)

Machine learning (ML) applications have received renewed interest in recent years. The reason behind this lies in advances in ML methods, data availability and increased computational power. Application of ML techniques to diagnose or even prevent accelerator failures is an area of particular interest not least because of the ample data that is routinely gathered in all modern accelerators to conduct reliability studies. In this contribution we present preliminary results of the application of unsupervised learning to diagnose and decrease accelerator failure rates at MAX IV, focusing on systems and methods that presented the best results.

New Machine Learning Model Application for the Automatic LHC Collimator Beam-Based Alignment

G. Azzopardi (CERN) G. Ricci (Sapienza University of Rome)

A collimation system is installed in the Large Hadron Collider (LHC) to protect its sensitive equipment from unavoidable beam losses. An alignment procedure determines the settings of each collimator, by moving the collimator jaws towards the beam until a characteristic loss pattern, consisting of a sharp rise followed by a slow decay, is observed in downstream beam loss monitors. This indicates that the collimator jaw intercepted the reference beam halo and is thus aligned to the beam. The latest alignment software introduced in 2018 relies on supervised machine learning (ML) to detect such spike patterns in real-time*. This enables the automatic alignment of the collimators with a significant reduction in the alignment time**. This paper analyses the first-use performance of this new software focusing on solutions to the identified bottleneck caused by waiting a fixed duration of time when detecting spikes. It is proposed to replace the supervised ML model with a Long-Short Term Memory model able to detect spikes in time windows of varying lengths, waiting for a variable duration of time determined by the spike itself. This will allow to further speed up the automatic alignment.
*G. Azzopardi,et al."Automatic spike detection in beam loss signals for LHC collimator alignment",NIMA 2019. **G. Azzopardi, et al."Operational Results of LHC collimator alignment using ML",IPAC'19.

Innovative methodology dedicated to the CERN LHC cryogenic valves based on modern algorithm for fault detection and predictive diagnostics

M. Pezzetti, A. Amodio, L. Iodice (CERN) P. Arpaia (Naples University Federico II, Science and Technology Pole) F. Gargiulo (University of Naples Federico II)

The European Organization for Nuclear Research (CERN) cryogenic infrastructure is composed of many equipment, among them there are the cryogenic valves widely used in the Large Hadron Collider (LHC) cryogenic facility. At present time, diagnostic solutions that can be integrated into the process control systems, capable to identify leak failures in valves bellows, are not available. The authors goal has been the development of a system that allows the detection of helium leaking valves during normal operation using available data extracted from the control system. The design constraints has driven the development towards a solution integrated in the monitoring systems in use, not requiring manual interventions. The methodology presented in this article is based on the extraction of distinctive features (analyzing the data in time and frequency domain) which are exploited in the next phase of machine learning. The aim is to identify a list of candidate valves with a high probability of helium leakage. The proposed methodology, which is at very early stage now, with the evolution of the data set and the iterative approach is aiming toward a cryogenic valves targeted maintenance.

Evolution of the CERN Beam Instrumentation Offline Analysis Framework (OAF)

A. Samantas, M. Gonzalez-Berges, J-J. Gras, S. Zanzottera (CERN)

The CERN accelerators require a large number of instruments, measuring different beam parameters like position, losses, current etc. The instruments' associated electronics and software also produce information about their status. All these data are stored in a database for later analysis. The Beam Instrumentation group developed the Offline Analysis Framework some years ago to regularly and systematically analyze these data. The framework has been successfully used for nearly 100 different analyses that ran regularly by the end of the LHC run 2. Currently it is being updated for run 3 with modern and efficient tools to improve its usability and data analysis power. In particular, the architecture has been reviewed to have a modular design to facilitate the maintenance and

the future evolution of the tool. A new web based application is being developed to facilitate the users' access both to online configuration and to results. This paper will describe all these evolutions and outline possible lines of work for further improvements.

* "A Framework for Off-Line Verification of Beam Instrumentation Systems at CERN", S. Jackson et al., ICALEPCS 2013 San Francisco

THPV043

Using AI for Management of Field Emission in SRF Linacs

A. Carpenter, P. Degtiarenko, R. Suleiman, C. Tennant, D.L. Turner, L.S. Vidyaratne (JLab) K.M. Iftekharuddin, M. Rahman (ODU)

Field emission control, mitigation, and reduction is critical for reliable operation of high gradient superconducting radio-frequency (SRF) accelerators. With the SRF cavities at high gradients, the field emission of electrons from cavity walls can occur and will impact the operational gradient, radiological environment via activated components, and reliability of CEBAF's two linacs. A new effort has started to minimize field emission in the CEBAF linacs by re-distributing cavity gradients. To measure radiation levels, newly designed neutron and gamma radiation dose rate monitors have been installed in both linacs. Artificial intelligence (AI) techniques will be used to identify cavities with high levels of field emission based on control system data such as radiation levels, cryogenic readbacks, and vacuum loads. The gradients on the most offending cavities will be reduced and compensated for by increasing the gradients on least offensive cavities. Training data will be collected during this year's operational program and initial implementation of AI models will be deployed. Preliminary results and future plans are presented.

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THPV045

Monitoring, Logging and Alarm Systems for the Cherenkov Telescope Array: Architecture and Deployment

A. Costa, E. Sciacca (INAF-OACT)

The Array Control and Data Acquisition System (ACADA) is responsible for the telescope control operations in The Cherenkov Telescope Array (CTA). We present the software architecture of the Monitoring, Logging and Alarm subsystems in the ACADA framework. The Monitoring System (MON) is the subsystem that addresses the acquisition of the monitoring and logging information from the CTA array elements. The MON will also support corrective and predictive maintenance to minimize the downtime of the system. The Array Alarm System (AAS) is the subsystem that is responsible for collecting alarms from telescopes, array calibration and environmental monitoring instruments, and the ACADA systems itself. The final software deployment is expected to manage about 200.000 monitoring points sampled between 1 and 5 Hz for a maximum data rate for writing operations of 26 Mbps for the monitoring system including the alarms, and a maximum rate of about 1 Gbps for the aggregated log information. This paper presents the architecture and deployment for MON and AAS subsystems which are currently being tested with a simulated set of monitoring points and log events.

THPV046

Virtualized Control System Infrastructure at LINAC Project, PINSTECH

N.U. Saqib, F. Sher (PINSTECH)

IT infrastructure is backbone of modern big science accelerator control systems. Accelerator Controls and Electronics (ACE) Group is responsible for controls, electronics and IT infrastructure for Medical and Industrial NDT (Non-Destructive Testing) linear accelerator prototypes at LINAC Project, PINSTECH. All of the control system components such as EPICS IOCs, Operator Interfaces, Databases and various servers are virtualized using VMware vSphere and VMware Horizon technologies. This paper describes the current IT design and development structure that is supporting the control systems of the linear accelerators efficiently and effectively.

THPV047

High Level Applications for HEPS

X.H. Lu (IHEP CSNS) H.F. Ji, Y. Jiao, J.Y. Li, C. Meng, Y.M. Peng, Q. Ye, Y.L. Zhao (IHEP)

The development of beam commissioning software of HEPS started this year. It was planned to use EPICS as the control system and Python as the main development tools for high level applications (HLA). Python has very rich and mature modules to meet the challenging requirements of HEPS commissioning and operation, such as PyQt for graphical user

interface (GUI) application development, PyEPICS and P4P for communicating with EPICS. A client-server framework was proposed for online calculations and always-running programs. Model based control is also one important design criteria, all the online commissioning softwares should be easily connected to a powerful virtual accelerator (VA) for comparison and predict the real beam behavior. It was planned to use elegant and Ocelot as the core calculation model of VA.

Novel Control System for the LHCb Scintillating Fibre Tracker Detector Infrastructure

M. Ostrega, M.A. Ciupinski, S. Jakobsen, X. Pons (CERN)

During the Long Shutdown 2 of the LHC at CERN, the LHCb detector is upgraded to cope with higher instantaneous luminosities. The largest of the new trackers is based on the scintillating fibres (SciFi) read out by SIlicon PhotoMultipliers (SiPMs). The SiPMs will be cooled down to -40°C to minimize noise. For performance and space reasons, the cooling lines are vacuum insulated. Ionizing radiation requires detaching and displace the readout electronics from Pirani gauges to a lower radiation area. To avoid condensation inside the SiPM boxes, the atmosphere inside must have a dew point of at most -45°C. The low dew point will be achieved by flushing a dry gas through the box. 576 flowmeters devices will be installed to monitor the gas flow continuously. A Condensation Prevention System (CPS) has been introduced as condensation was observed. The CPS powers heating wires installed around the SiPM boxes and the vacuum bellows isolating the cooling lines. The CPS also includes 672 temperature sensors to monitor that all parts are warmer than the cavern dew point. The temperature readout systems are based on multiplexing technology at the in the front-end and a PLC in the back-end.

Virtualisation and Software Appliances as Means for Deployment of SCADA in Isolated Systems

P. Golonka, L. Davoine, M.Z. Zimny, L. Zwalinski (CERN)

The paper discusses the use of virtualisation as a way to deliver a complete pre-configured SCADA (Supervisory Control And Data Acquisition) application as a software appliance to ease its deployment and maintenance. For the off-premise control systems, it allows for deployment to be performed by the local IT servicing teams with no particular control-specific knowledge, providing a "turn-key" solution. The virtualisation of a complete desktop allows to deliver and reuse the existing feature-rich Human-Machine Interface experience for local operation; it also resolves the issues of hardware and software compatibilities in the deployment sites. The approach presented here was employed to provide replicas of the "LUCASZ" cooling system to collaborating laboratories, where the on-site knowledge of underlying technologies was not available and required to encapsulate the controls as a "black-box" so that for users, the system is operational soon after power is applied. The approach is generally applicable for international collaborations where control systems are contributed and need to be maintained by remote teams

FRKL — Keynote Session V

Laser Ion Accelerator and Its Applications

C. Lin (PKU)

The concept of laser plasma acceleration was first proposed by Tajima and Dawson in 1979, and was soon extended from accelerating electrons with gas targets to accelerating ions with solid targets. It is considered as a promising candidate for future compact accelerator and radiation source. Laser ion acceleration is a very high gradient explosive process'when an ultrahigh-intensity laser irradiates on a solid target, the established acceleration field can exceed TV/m, accelerating ions to high energy within tens of micron distance. The laser-driven pulsed high-current ion sources may enable significant advances in many fields, such as tumor therapy, proton radiograph, warm dense matter and fast ignition of fusion cores. In this presentation, we will introduce several main acceleration mechanisms and the latest research progress of laser ion acceleration. We will also introduce some frontier developments of laser proton accelerator in Peking University. With the support of the Ministry of Science and Technology of China, a prototype of proton radiotherapy system based on PW (10 15 W) laser accelerator is under construction.

FRAL — Project Status Reports II

THE LASER MEGAJOULE FACILITY STATUS REPORT

H. Cortey (CEA)

The Laser MegaJoule (LMJ), the French 176-beam laser facility, is located at the CEA CESTA Laboratory near Bordeaux (France). It is designed to deliver about 1.4 MJ of energy on targets, for high energy density physics experiments, including fusion experiments. The first bundle of 8-beams was commissioned in October 2014. By the end of 2021, ten bundles of 8-beams are expected to be fully operational. In this paper, we will present: - The LMJ Bundles Status report - The main evolutions of the LMJ facility since ICALEPS 2019: the new target diagnostics commissioned and a new functionality to manage final optic damage with the implementation of blockers in the beam. - the result of a major milestone for the project : `Fusion Milestone'

DISCOS Updates

S. Poppi, M. Buttu, G. Carboni, A. Fara, C. Migoni (INAF - OAC) M. De Biaggi, A. Orlati, S. Righini (INAF - IRA) M. Landoni (INAF-Osservatorio Astronomico di Brera) F.R. Vitello (INAF IRA)

DISCOS is the control software of the Italian Radio Telescopes and it is based on the Alma Control Software. The project core started during the construction of the Sardinia Radio Telescope and it has been further developed to support also the other antennas managed by INAF, which are the Noto and the Medicina antenna. Not only does DISCOS control all the telescope subsystems like servo systems, backends, receivers and active optic, but also allows users to execute the needed observing strategies. In addition, many tools and high-level applications for observers have been developed over time. Furthermore, DISCOS development is following test driven methodologies, which, together with real hardware simulation and automated deployment, speed up testing and maintenance. Altogether, the status of the DISCOS project is described here with its related activities, and also future plans are presented as well.

CERN Cryogenic Controls Today and Tomorrow

M. Pezzetti, Ph. Gayet (CERN)

The CERN cryogenic facilities demand a versatile, distributed, homogeneous and highly reliable control system. For this purpose, CERN conceived and developed several frameworks (JCOP, UNICOS, FESA, CMW), based on current industrial technologies and COTS equipment, such as PC, PLC and SCADA systems complying with the requested constraints. The cryogenic control system nowadays uses these frameworks and allows the joint development of supervision and control layers by defining a common structure for specifications and code documentation. Such a system is capable of sharing control variable from all accelerator apparatus. The first implementation of this control architecture started in 2000 for the Large Hadron Collider (LHC). Since then CERN continued developing the hardware and software components of the cryogenic control system, based on the exploitation of the experience gained. These developments are always aimed to increase the safety and to improve the performance. The final part will present the evolution of the cryogenic control toward an integrated control system SOA based CERN using the Reference Architectural Model Industrie 4.0 (RAMI 4.0).

The Control System of the New Small Wheel Electronics for the ATLAS experiment

P. Tzanis (NTUA) A. Bruni (INFN/CNAF)

The present ATLAS Small Wheel Muon detector will be replaced with a New Small Wheel(NSW) detector in order to cope up with the future LHC runs of high luminosity. One crucial part of the integration procedure concerns the validation of the electronics for a system with more than 2.1 M electronic channels. The readout chain is based on optical link technology connecting the backend to the front-end electronics via the FELIX,which is a newly developed system that will serve as the next generation readout driver for ATLAS. For the configuration,calibration and monitoring path the various electronics boards are supplied with the GBT-SCA ASIC and its purpose is to distribute control and monitoring signals to the electronics. Due to its complexity,NSW electronics requires the development of a sophisticated Control System. The use of such a system is necessary to allow the

electronics to function consistently,safely and as a seamless interface to all sub-detectors and the technical infrastructure of the experiment. The central system handles the transition between the probe's possible operating states while ensuring continuous monitoring and archiving of the system's operating parameters.

Mace Camera Electronics: Control, Monitoring & Safety Mechanisms

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MACE Telescope installed in Ladakh Region of India comprises of many functionally diverse subsystems, Camera being the most important one. Mounted at the focal plane of 21 m diameter parabolic reflector dish, event driven Camera system comprises of 10^{88} PMTs, with 16 PMTs constituting one Camera Integrated Module (CIM). Central Camera Controller (CCC), located in Camera housing, manages and coordinates all the actions of these 68 Modules and other camera subsystems as per the command sequence received from Operator Console. In addition to control and monitoring of subsystems, various mechanisms have been implemented in hardware as well as embedded firmware of CCC and CIM to provide safety of PMTs against exposure to ambient bright light, bright star masking and detection and recovery from loss of event synchronization at runtime. An adequate command response protocol with fault tolerant behavior has also been designed to meet performance requirements. The paper presents the overall architecture and flow of camera control mechanisms with a focus on software and hardware challenges involved. Various experimental performance parameters and results will be presented.

*MACE camera controller embedded software: Redesign for robustness and maintainability,S.Srivastava et.al., Astronomy and Computing Volume 30

FRAR — User Interfaces and User eXperience (UX) II

Taranta, the No-Code Web Dashboard in production

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The remote control and monitoring of accelerators and experimental setup has become an essential enabler when remote work has become the norm for the last 2 years. Unlike the desktop user interfaces which have been developed for the use of physical workstations, Web application are naturally accessible remotely via the ubiquitous web browsers. On the other hand, Web technology development need a specific knowledge which has yet to be disseminate in the control system engineering. And desktop frameworks still have the benefit of rapid and easy development even for the non-specialist. Taranta Suite is a collection of web applications jointly developed by MAX IV Laboratory and the SKA Organization, for the Tango Control System. Totally in line with the 'no-code' trend, truly little knowledge of web technologies is needed. An operator can create a graphical user interface on-the-fly and then, can share instantly this application. Authentication and authorization ensure to give the right level access to the users. This paper will describe the system, the React and GQL implementation and the first usage at the different facilities.

canone3: a new service and development framework for the web and platform independent applications

L. Zambon, G. Strangolino (Elettra-Sincrotrone Trieste S.C.p.A.)

On the wake of former web interfaces developed at ELETTRA as well as in other institutes, the service and development framework for the web and platform independent applications named PUMA has been substantially enhanced and rewritten, with the additional objectives of high availability, scalability, load balancing, responsiveness and customization. Thorough analysis of Websocket limits led to an SSE based server technology relying on channels (Nchan over NGINX) to deliver the events to the clients. The development of the latter is supported by JQuery, Bootstrap, D3js, SVG and QT and helps build interfaces ranging from mobile to dashboard. Ultimate developments led to successful load balancing and failover actions, owing to the joint cooperation of a dedicated service supervisor and the NGINX upstream module.

A Major update of web based development toolkit for control system of large-scale physics experiment device

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The deployment of the control system called CODAC (Control, Data Access and Communications) is necessary for the operation of large-scale experimental facilities. CFET (Control system framework for experimental devic-es toolkit) is a flexible SCADA (supervisory control and data acquisition) software tool, which is used for the construction of a CODAC. CFET is fully based on open web technologies, it is easy to integrate all kinds of systems and devices into CFET. This paper has undergone a major iteration of CFET. HMI has been redesigned and implemented. The control engineer can use a web based WYSIWYG HMI editor to compose the HMI. In CFET, InfluxDB has been integrated. It is used to store the engineering data, and also visualize the data on the website. Docker based microservices architecture has been designed, putting CFET and dependent packages into a lightweight container. At present, CFET has been used in the CO-DAC system of J-TEXT tokamak and HUST Field-Reversed Configuration facility.

Funding: Most from Ministry of Science and Technology of the people's Republic of China

Phoebus Olog

K. Shroff (BNL) , G. Weiss (ESS)

Phoebus Olog is an online logbook used for recording operational and experimental events by users or other applications. The Phoebus Olog service is an evolution of the Olog web service. It uses modern nosql data stores like mondoDB and elastic which provide horizontal scalability, improved performance, and

complex querying functionality like fuzzy searches. The improvements of the server side are accompanied with several new UI clients; smartphone apps for convenient viewing of logs, logbook client in Phoebus CS-Studio which provides integration with various other applications like alarms, OPI, etc and a web application.

FRBL — Data Analytics

Machine Learning for Anomaly Detection in Continuous Signals

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High availability at accelerators such as the ISIS Neutron and Muon Source is a key operational goal, requiring rapid detection and response to anomalies within the accelerator's subsystems. While monitoring systems are in place for this purpose, they often require human expertise and intervention to operate effectively or are limited to predefined classes of anomaly. Machine learning (ML) has emerged as a valuable tool for automated anomaly detection in time series signal data. An ML pipeline suitable for anomaly detection in continuous signals is described, from labeling data for supervised ML algorithms to model selection and evaluation. These techniques are applied to detecting periods of temperature instability in the liquid methane moderator on ISIS Target Station 1. We demonstrate how this ML pipeline can be used to improve the speed and accuracy of detection of these anomalies.

Funding: UKRI / STFC

Tackling Black Box Machine Learning Algorithms for Light-Beam Performance

T.Y. Chen (Association for Computing Machinery)

Synchrotron light sources produce light in various wavelengths by accelerating electrons to emit light in controlled beams. However, operators encounter a number of problems, including fluctuations in the overall light-beam performance across an entire facility and the instability therein. To computationally facilitate adjustments that stabilize the size of light beams for experiments, ongoing work is harnessing the predictive power of high-powered machine learning algorithms. Artificial neural networks (ANNs), a form of biologically-inspired machine learning that roughly simulates the structure of the human brain, has emerged as a potential answer to this problem. Specifically, they have identified the magnitudes to which various device parameters affected the width of the electron beam by learning from large supervised (labeled) datasets. We synthesize current work in this area and propose future opportunities to harness ANNs for stability in this area. However, we particularly focus on the interpretability of the deep learning models, as neural networks are notorious 'black boxes' - how can we improve humans' understanding the inner decision making processes of the algorithms?

A Literature Review on the Efforts Made for Employing Machine Learning in Synchrotrons

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Using machine learning (ML) in various contexts is in-creasing due to advantages such as automation for every-thing, trends and pattern identification, highly error-prone, and continuous improvement. Even non-computer experts are trying to learn simple programming languages like Python to implement ML models on their data. De-spite the growing trend towards ML, no study has re-viewed the efforts made on using ML in synchrotrons to our knowledge. Therefore, we are examining the efforts made to use ML in synchrotrons to achieve benefits like stabilizing the photon beam without the need for manual calibrations of measures that can be achieved by reducing unwanted fluctuations in the widths of the electron beams that prevent experimental noises obscured measurements. Also, the challenges of using ML in synchrotrons and a short synthesis of the reviewed articles were provided. The paper can help related experts have a general famil-iarization regarding ML applications in synchrotrons and encourage the use of ML in various synchrotron practices. In future research, the aim will be to provide a more com-prehensive synthesis with more details on how to use the ML in synchrotrons.

FRBL04

Real-Time Azimuthal Integration of X-Ray Scattering Data on FPGAs

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Azimuthal integration (AZINT) is a procedure for reducing 2D-detector image into a 1D-histogram. AZINT is used extensively in photon science experiments, in particular in small angle scattering and powder diffraction. It improves signal to noise ratio and data volumes are reduced by a factor of 1000. The underlaying procedure i.e. bin-counting has other applications. The potential of FPGAs for data analysis originates from recent progress in FPGA software design with complexity matching the scientific requirements. We implemented AZINT on FPGAs using OpenCL and synchronous message exchange (SME). It is demonstrated AZINT can process 600 Gb/s streams, i.e. about 20'40 Gpixels/s, on a single FPGA. FPGAs are usually more energy-efficient than GPUs, they are flexible so they can fit a specific problem and outperform GPUs in relevant applications, in particular AZINT here. Beside high throughput FPGAs allow data processing with well-defined and low latencies for real-time experiments. Radiation tolerance of FPGAs brings more synergies. It makes them ideal components for extra-terrestrial scientific instruments (e.g. Mars rovers) or detectors at spaceflights and satellites.

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FRBL05

RemoteVis: An Efficient Library for Remote Visualization of Large Volumes Using NVIDIA Index

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Advancements in X-ray detector technology are increasing the amount of volumetric data available for material analysis in synchrotron light sources. Such developments are driving the creation of novel solutions to visualize large datasets both during and after image acquisition. Towards this end, we have devised a library called RemoteVis to visualize large volumes remotely in HPC nodes, using NVIDIA IndeX as the rendering backend. RemoteVis relies on RDMA-based data transfer to move large volumes from local HPC servers, possibly connected to X-ray detectors, to remote dedicated nodes containing multiple GPUs for distributed volume rendering. RemoteVis then injects the transferred data into IndeX for rendering. IndeX is a scalable software capable of using multiple nodes and GPUs to render large volumes in full resolution. As such, we have coupled RemoteVis with slurm to dynamically schedule one or multiple HPC nodes to render any given dataset. RemoteVis was written in C/C++ and Python, providing an efficient API that requires only two functions to 1) start remote IndeX instances and 2) render regular volumes and point-cloud (diffraction) data on the web browser/Jupyter client.

*NVIDIA IndeX, https://developer.nvidia.com/nvidia-index

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FRBR — Experiment Control

Process Automation at Soleil: Two Applications Using Robot Manipulators

L.E. Munoz, Y.-M. Abiven, F. Briquez, J. Da Silva, E. Elkaim, A. Noureddine, V. Pinty, M. Valléau (SOLEIL) S. Bouvel (EFOR)

Robot manipulators are an important component in most autonomous systems in the industry. Arc welding, machine tending, painting, picking, are only some examples where the robot manipulators are widely employed. In Synchrotrons some process can benefit from robotic approaches in order to improve automation. Automatic Sample Changer on beamlines is the most common example of automation. This paper describes two robotic applications developed at Synchrotron SOLEIL. Both applications use the SOLEIL robotic standard introduced some years ago [1]. The first application aims to automate the exchange of samples for powder diffraction experiment on the CRISTAL beamline. Hence, a pick-and-place robot is used to automate the process of picking up the sample holders and placing them on the goniometer. The second application, also of the pick-and-place type, is dedicated to the automation of the magnetic characterization of magnet modules of an U15 undulator. These modules, built with a permanent magnet and two poles, are measured using a pulsed wire method [2]. In this case, the robot picks the modules stored in boxes to then place them on the test bench of the U15 undulator.

*Y.-M. Abiven et al., Robotizing SOLEIL Beamlines to Improve Experiments Automation **M. Valléau, et al., Measurements of soleil insertion devices using pulsed wire method

An Integrated Data Processing and Management Platform for X-Ray Light Source Operations

N.M. Cook, P. Moeller, R. Nagler, B. Nash (RadiaSoft LLC) M.S. Rakitin (BNL)

The design, execution, and analysis of light source experiments requires the use of increasingly complex simulation, controls and data management tools. Existing workflows require significant specialization to account for beamline-specific operations and pre-processing steps in order to collect and prepare data for more sophisticated analysis. Recent efforts to address these needs at the National Synchrotron Light Source II (NSLS-II) have resulted in the creation of the Bluesky data collection framework*, an open-source library providing for experimental control and scientific data collection via high level abstraction of experimental procedures, instrument readouts, and data analysis. We present a prototype data management interface that couples with Bluesky to support guided simulation, measurement, and rapid processing operations. Initial demonstrations illustrate application to coherent X-ray scattering beamlines at the NSLS-II. We then discuss extensions of this interface to permit analysis operations across distributed computing resources, including the use of the Sirepo scientific framework, as well as Jupyter notebooks running on remote computing clusters**.

* M.S. Rakitin et al., Proc. SPIE 11493, Advances in Computational Methods for X-Ray Optics V, 1149311 (Aug 2020).
** M.S. Rakitin et al., Journal of Synchrotron Radiation 25, 1877-1892 (Nov 2018).

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Status of Bluesky Deployment at BESSY II

W. Smith, S. Kazarski, R. Mueller, P. Schnizer, S. Vadilonga, L. Vera Ramirez (HZB)

The modernization plan for the experimental DAQ at the BESSY II is underpinned by the capabilities provided by the Bluesky software ecosystem. To interface with the hardware Bluesky relies on the Ophyd library, that provides a consistent high-level interface across a wide-range of devices. Many elements of the accelerator, some beamlines and endstations are adopting the Bluesky software. To meet FAIR data obligations, the capture of metadata with Bluesky and the export into a permanent and easily accessible storage called ICAT are investigated. Finally, initial studies to investigate the integration of ML methods, like reinforcement learning were performed. This paper reports on the work that has been done so far at BESSY II to adopt Bluesky, problems that have been overcome and lessons learned.

FRBR04

Continuous Scanning with Position-Based Hardware Triggers at MAX IV beamlines

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At beamline end-stations, data taking that relies on traditional step scanning, in which motors are repeatedly started and stopped, leads to inefficient usage of the x-ray source. This also increases the risk of sample radiation damage. We have developed a system where scans are performed while continuously moving the motors. To ensure stable repeatable measurements, the detector triggers are generated, in hardware, from the motor encoder positions. Before the scan starts, a list of positions is generated and as the scan progresses a trigger is produced as each successive position in the list is reached. The encoder signals from the motors are connected both to the IcePAP motion controller for closed loop operation, and a PandABox which is used as the trigger source. Control is from Tango and Sardana with a TriggerGate controller that calculates the motor positions and configures the PandABox. The scanned motor can be either a single motor, for example a sample positioner, or a combined motion like a monochromator. When combined motions are required, these make use of the parametric trajectory mode of the IcePAP. This enables continuous scans of coupled axes with non-linear paths.

FRBR05

Hexapod Control Upgrade at Synchrotron Soleil: Method and Results

L. Amelineau, Y.-M. Abiven, C.B. Bourgoin, D.C. Corruble, C. Engblom, B. Leluan, A. Lestrade, F. Polack, M. Sebdaoui (SOLEIL)

A Stewart Platform, a hexapod parallel robot variant, is comprised of six actuators providing movements in six degrees-of-freedom. In order to facilitate operation and maintenance, Low-level control has been successfully transferred from its original proprietary controller to a SOLEIL-standardized controller (Delta Tau Power Brick). Low-level control includes direct and reverse kinematics which can be adapted and tuned to the specific mechanical/geometric features of any Stewart Platform of similar build. The embedded (and therefore generic to Stewart Platforms) software also interfaces with generic and existing Tango devices making it easily accessible by users. The transition from 'black-box' hardware and embedded software to standardized controllers with fully mastered control kinematics, provides hexapod users with SOLEIL durable operational support and maintenance. Dimensional metrology of the hexapod has shown dynamic and static performance to be equivalent to the old system. A new metrological method linking measurements and kinematics has been developed to compensate mechanical imperfections in order to improve performance. This paper will present the results of this work.

FRBR06

Automated ML-based Sample Centering for Macromolecular X-Ray Crystallography with MXAimbot

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MXAimbot is a neural network based tool, designed to automate the task of centering samples for macro-molecular X-ray crystallography experiments before exposing the sample to the beam. MXAimbot uses a convolutional neural network (CNN) trained on a few thousands images from an industrial vision camera pointed at the sample to predict suitable crystal centering for subsequent X-ray data collection. The motivation for this project is that the machine vision automated sample positioning allows X-ray laboratories and synchrotron beamlines to offer a more efficient alternative for the manual centering, which is time consuming and difficult to automate with conventional image analysis, and for the X-ray mesh scan centering, which can introduce radiation damage to the crystal. MXAimbot can be used to improve results of standard LUCID loop centering for fully automated data collection in fragment-screening campaigns. No need for sample rotation should be an additional advantage.

FRXL — Workshop Summary

FRZL — Closing Session

Author Index

A

B

C

D

E

F

G

H

L

M

N

O

P

R

S

T

U

V

W

X

Y

Z

Author Index