IBIC 2019

International Beam Instrumentation Conference

ABSTRACT BOOK

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LNLS

CNPEM

MINISTRY OF SCIENCE, TECHNOLOGY AND INNOVATIONS

PÁTRIA AMADA BRASIL BRAZILIAN GOVERNMENT

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MOAO — Overview and Commissioning

MOAO01 **Beam Diagnostics in the Advanced Plasma Wakefield Experiment AWAKE**

***A.-M. Bachmann**, P. Muggli (MPI)*

In AWAKE a self-modulated proton bunch drives wakefields in a plasma. Recent experiments successfully demonstrated many aspects of the self-modulation of the drive bunch as well as acceleration of test electrons. Next experiments will focus on producing a multi-GeV accelerated electron bunch with low emittance and low energy spread. The experiment requires a variety of advanced beam diagnostics to characterize the self-modulated proton bunch at the picosecond time scale. These include optical transition radiation and a streak camera for short and long time scale detailed imaging of self-modulation and hosing, coherent transition radiation for modulation frequency measurements in the 100-300 GHz frequency range and multiple fluorescent screens for core and halo measurements. An overview of these diagnostics will be given.

MOAO02 **Initial Experiences With Beam Diagnostics During Sirius Commissioning**

***H.O.C. Duarte**, S.R. Marques, D.O. Tavares (LNLS)*

This work will describe the first results for Sirius beam diagnostics, alongside with the interrelated experiences, studies, problems and their solutions during the first months of the machine commissioning.

MOAO03 **Commissioning of the CSNS Beam Instrumentation System**

***J.L. Sun**, W.L. Huang, F. Li, P. Li, R.Y. Qiu, Zh.H. Xu, T. Yang (IHEP CSNS) M. Meng, J.M. Tian, T.G. Xu, L. Zeng (IHEP)*

China Spallation Neutron Source (CSNS) accelerator complex consists of a front end, an 80 MeV DTL LINAC, and a 1.6 GeV Rapid Cycling Synchrotron (RCS). It is designed with a beam power of 100 kW in the first phase and reserves upgrade capability to 500 kW in the second phase. CSNS has started user operation at 20 kW after the initial beam commissioning in 2018, the beam power is quickly up to 50 kW and 80 kW by two times beam commissioning in between the user beam time 2019, and finally reached 100kW, the design goal, in February 2020. This talk gives the experiences and most recent status of beam instrumentation system of CSNS during the beam power ramping, as well as future upgrade plan for CSNS-II.

MOA004 **Beam Instrumentation Performances through the ESRF-EBS Commissioning**

L. Torino *(ALBA-CELLS Synchrotron) N. Benoist, F. Ewald, E. Plouviez, J.L. Pons, B. Roche, K.B. Scheidt, F. Taoutaou, F. Uberto (ESRF)*

The upgrade of the European Synchrotron Radiation Facility (ESRF) storage ring has lead to the construction of a new machine called the Extremely Brilliant Source (EBS). EBS has been successfully commissioned in less than three month and reached the targeted parameters for user mode. The success of the EBS commissioning also depended on the performances and the reliability of the beam instrumentation used to monitor the beam. In this paper a summary of the EBS commissioning is presented with a special focus on the beam instrumentation performances.

MOA005 **Beam Instrumentation System for Shanghai Soft X-ray FEL Test Facility**

L.W. Lai*, F.Z. Chen, J. Chen, J. Chen, W. Fang, C. Feng, B. Gao, R. Jiang, Y.B. Leng, Y.B. Yan, L.Y. Yu, R.X. Yuan, N. Zhang, W.M. Zhou (SSRF) S.S. Cao, L.F. Hua (SINAP)*

Shanghai Soft X-ray FEL (SXFEL) test facility was designed and built to demonstrate EEHG and HGHG schemes and verify key technologies for the future hard X-ray FEL facility (SHINE). After three years commissioning 8.8 nm FEL radiation with peak power of 1 MW had been achieved at the end of 2019. The design, fabrication, commissioning and operation of BI system including Stripline-BPM, Cavity-BPM, screen monitor, bunch length monitor, beam arrival monitor, bunch energy monitor, will be introduced in this paper. Several lessons learned during design stage and beam commissioning stage will be addressed as well.

TUAO — Beam Charge, Beam Loss, Machine Protection and Feedback Systems

TUAO01 **Precise Bunch Charge Measurement Using BPM Pickup**

J. Chen, *S.S. Cao, F.Z. Chen, B. Gao, L.W. Lai, Y.B. Leng, L.Y. Yu, R.X. Yuan, Y.M. Zhou (SSRF)*

Precise bunch charge measurement is the fundamental of charge feedback, beam lifetime measurement, beam loss monitor, as well as the basis of the related interlocking work. Beam position monitor (BPM) is often used for high-precision bunch charge measurement due to its superior performance. In this paper, the pros and cons of different types of BPM for measurement of bunch charge in storage ring and free electron laser (FEL) will be discussed. The related simulations, beam experiment and signal processing methods are also mentioned. The beam experiments results show that the relative bunch charge resolution of the Button BPM can reach 0.02 % in SSRF, 0.073 % and 0.021 % of the SBPM and CBPM in SXFEL, respectively. Besides, based on the method of beam experiments, we systematically studied the position dependence of BPM pickup and related compensation algorithms for high-precision bunch charge measurement.

TUAO02 **Diagnostics for Collimator Irradiation Studies in the Advanced Photon Source Storage Ring**

J.C. Dooling, *W. Berg, M. Borland, J.R. Calvey, G. Decker, L. Emery, K.C. Harkay, R.R. Lindberg, A.H. Lumpkin, G. Navrotski, V. Sajaev, S.E. Shoaf, J.B. Stevens, Y.P. Sun, K.P. Wootton, A. Xiao (ANL)*

The Advanced Photon Source (APS) is building a fourth-generation storage ring (4GSR), replacing the present double-bend achromat lattice with a multibend achromat system thereby allowing the production of ultra-bright x-ray beams. The new lattice enables a two-order-of-magnitude reduction in horizontal beam emittance and a factor of two increase in beam current. The result is an electron beam of very high energy- and power-densities. Initial predictions suggest virtually any material struck by the undiluted electron beam will be damaged. Two experimental beam abort studies have been conducted on collimator test pieces in the present APS SR to inform the design of a fully-functional machine protection system for APS 4GSR operations at 200 mA. A comprehensive suite of diagnostics were employed during the studies The diagnostics used in these experiments are not new, but employed in different ways to obtain unique data sets. With these data sets now in hand, we are developing new numerical tools to guide collimator design.

TUA003 **Ionization Chamber for Electron Beam Monitoring at Ultra High Dose Rate**

***C. Lahaye**, S. Salvador (CNRS/IN2P3/LPC CAEN) J.-M. Fontbonne, J. Thariat (LPC)*

Ultra high dose rate (FLASH) electron beam therapy consists in treating tumors by delivering a dose above 1 Gy in pulse of μ1μs. Despite ionization chambers are reference detectors in dose monitoring, no real-time beam monitor based on ionization chambers exists for such ultra high dose rates. In this study, we present the response of an ionization chamber to ultra high dose rates. Simulations were performed to compute the current measured by a chamber using a 1D transport model. The transport equations included recombination, electron capture and electric field change due to space charge. Simulations were compared to measurements performed using a 800 μm gap, 1 cm^2 active surface ionization chamber irradiated by 5 MeV electron pulses up to 4 Gy/μs, and varying high voltage from 400 V/mm up to 1200 V/mm. Despite high recombination rates, the signal produced by the electrons moving in the chamber was proportional to the dose rate up to ~100 ns. Preliminary results suggest that a real-time dose measurement can be done by considering only the signal induced by the electrons. This opens the development for a real-time dose rate monitor based on ionization chambers.

TUA004 **Investigation of Novel Radiation Hard and Fast Scintillator for Heavy Ions Detection**

***M. Saifulin**, P. Boutachkov, P. Simon, C. Trautmann, B. Walasek-Höhne (GSI) E.I. Gorokhova (GOI) P. Rodnyi, I.D. Venevtsev (SPbPU)*

ZnO is a well known semiconductor material, that has found application in many fields of technology: phosphors, scintillators, varistors, gas sensors, etc. Recently it was found that fast near-band-edge luminescence in ZnO ceramics can be significantly enhanced by introducing In^{3+} and Ga^{3+} impurities. Due to this property, doped ZnO is of great interest for fast counting applications, in particular for beam diagnostics application at future FAIR facility. In this contribution, we present the results of swift heavy ion induced luminescence measurements of ZnO(In) ceramics performed at GSI. Samples were irradiated with 4.8 MeV/u 48Ca and 197Au ions up to fluences of $5{\cdot}10^{+12}$ and $2{\cdot}10^{+11}$ ion/cm^2 respectively. Ionoluminescence spectra were monitored on-line as a function of fluence. ZnO(In) and ZnO(Ga) ceramics demonstrate several orders of magnitude higher radiation hardness than plastic scintillators. This investigation is part of a larger research program for beam intensity, spill structure and beam profile measurements with ZnO fast scintillators.

TUA005 **System Identification and Stability Considerations for Closed Orbit Feedback at SIS-18**

***R. Singh**, S.H. Mirza (GSI)*

A new fast feedback system designed for fast ramping synchrotron SIS-18 at GSI. First controlled tests with beam were performed in the previous engineering run beam-time. The system was tested for robustness by operation under mismatched spatial model for several controller settings. This contribution discusses the open and closed loop system identification efforts as well as the first experiences with respect to the stability limits of this COFB system.

TUPP01 **Bunch Purity Measurement and Improvement**
***J. He**, J.H. Yue (IHEP)*
A signal electron level purity is mandatory for a nuclear resonant scattering experiment. For the establishing such kind of beamlines on High Energy Photon Source (HEPS), a new time-correlated single photon counting system has been implemented on the storage ring of Beijing Electron-Positron Collider II (BEPCII), which is used to monitor the purity. The system could track the purity deterioration process. The possible reason of impurity growth is analysed, the measurement results confirmed that Touschek scattering and pre-accelerators of the storage ring are the main mechanisms of impurity growth. A bunch cleaning technique based on a sinusoidal signal mixed a pseudo-square wave has been verified which could improve the purity to the level of 10^{-7}. This paper mainly describes the experiment details and measurement results of purity measurement and improvement.

TUPP04 **Simulated Beam Loss Events in the FRIB Linac**
***R. Shane**, S. Cogan, S.M. Lidia (FRIB)*
Beam loss is an ever-present issue in accelerators and can lead to degraded beam quality, activation, and machine damage. It is crucial to be able to pinpoint the source of beam loss so that the cause can be addressed. Towards this end, beam loss studies were performed at the Facility for Rare Isotope Beams (FRIB) in which beam spills were simulated at various locations within the accelerator. Beam spills were achieved by adjusting the magnetic fields or turning off selected RF cavities. This defocused or moved the beam such that particles impacted the walls, apertures, and other surfaces in the beam transport volume, creating measurable radiation. Losses were monitored on a suite of detectors including neutron detectors, pressurized ion chambers, and halo monitor rings. These data were used in conjunction with calculated beam profiles and statistical analyses in order to correlate loss detection patterns with beam spill location.

TUPP05 **X-Ray Beam Size Monitor Enclosure for the Advanced Photon Source Upgrade**
***K.P. Wootton**, W.X. Cheng, G. Decker, S.H. Lee, B.X. Yang (ANL)*
Confirmation of pm rad scale emittances from the Advanced Photon Source Upgrade electron storage ring necessitates direct measurement of the electron beam size. In the present work, we motivate design choices for the X-ray beam size monitor shielding enclosure for the Advanced Photon Source Upgrade. Particular emphasis is given to outlining design choices from the perspectives of safety, overall project construction schedule and eventual beamline operations.

TUPP06 **Inclined X-ray Beam Position Monitors to Reduce Influence of Filling Pattern for the SPring-8 Photon Beamlines**
***H. Aoyagi**, Y. Furukawa, S. Takahashi (JASRI/SPring-8)*
The X-ray beam position monitors (XBPMs) equipped with blade-type detector heads in SPring-8, which operate in photoemission mode, are required to withstand severe high heat loads. In addition, they must work in a variety of several-bunch mode operations. However, as bunch current in the storage ring increased, influence of bunch filling patterns on XBPM performance increased year by year. We have performed a systematic evaluation of the influence of the filling patterns. We found that the cause of the influence is suppression of the XBPM current signal due to the space charge effect, and that it can be quantified by observing the behavior of the current signal while changing the voltage of a photoelectron collection electrode. We have designed and manufactured new blade-type detector heads in inclined configuration for the purpose of mitigation the space charge effect. It has been demonstrated that the influence of filling patterns is reduced to a few μm . We also report that, as a result of a series of efforts against existing XBPMs for all ID beamlines, the influence has been reduced to about 5 μm RMS.

TUPP07 **Beam Position Monitor Calibration Using Channel Switching**
***R.L. Hulsart**, R.J. Michnoff (BNL)*
One of the requirements for electron cooling at RHIC is a small relative angle between the ion and electron beams as they co-propagate. In order to achieve an alignment of <50 micro-radians, BPM measurements of either beam must be very accurate. Achieving this accuracy requires good electronic calibration of the associated cables and RF components, due to their imperfections. Unfortunately, these are typically frequency dependent, especially in the RF filter and amplifier stages. The spectral content of the ion vs. electron bunch signals varies dramatically, presenting a challenge of how to calibrate for both signals, simultaneously. A scheme of rapidly swapping the BPM signals between the two sampling channels, using in-tunnel switches mounted upstream of the amplifiers was implemented to combat these calibration issues. Successful transverse cooling of the RHIC ion beam has been verified only after using this switching technique to calibrate the BPM electronics. Details of the hardware and software methodology to achieve this result will be discussed.

TUPP08 **BPM Low ß Calibration Test Stand**
***C.J. Richard** (MSU) S.M. Lidia (FRIB)*
Capacitive pickups such as beam position monitors (BPMs), are sensitive to the electric field distribution produced by the beam. For relativistic fields, the fields are flattened therefore they well represent the longitudinal bunch shape. However, for non-relativistic beam, ß<0.1, the field at the pickups can extend past the bunch which affects the measurements from the BPM. This effect from non-relativistic fields is currently accounted for with theory and simulations, however a test stand is also desired that can replicate the field distribution and the bunch velocity. To accomplish this a test stand using a helical transmission line

was designed and constructed which propagates with phase velocity of ~0.03c. Presented are measurements of the phase velocity, dispersion, and impedance of the helical transmission line and compared to simulations and theory. Also demonstrated is the ability for the helical transmission line to propagate pulses with minimal deformation and the fields from the helix well represent a particle bunch.

TUPP09 **Multiplexer System for the SPEAR3 Booster BPM Upgrade**
***F. Toufexis**, P. Boussina, L. Campana, W.J. Corbett, J.J. Sebek (SLAC)*
BPM measurements in booster synchrotrons are often only critical during accelerator commissioning or when a problem occurs. As a result, many facilities do not make large investments in booster BPM signal processors; they either have very few BPMs and/or use older generation processors. The SPEAR3 booster BPM processor system, for instance, has operated since 1990 with commercial multiplexers to switch between BPM button signals into a single dated analog BPM processor that was developed at SLAC. This system has reached its end-of-life so we are in the process of upgrading to modern multiplexers that feed a pair of turn-by-turn Libera SPARK-ERXR processors. This low-cost solution gives us the ability to arbitrarily multiplex between BPM signals during the energy ramp with modern BPM processors. The system can either measure 2 BPMs turn-by-turn in parallel during the entire energy ramp, or sequentially measure all BPMs (2 at a time) at different time slices within the ramp. Here we show measurements of the MiniCircuits switch we chose as well as our architecture for the upgrade.

TUPP10 **X-Ray Beam Position Monitor Silicon Photodiode Measurements for the Advanced Photon Source Upgrade**
***K.P. Wootton**, H. Cease, M. Erdmann, S.M. Oprondek, M. Ramanathan, B.X. Yang (ANL)*
To best leverage the orders of magnitude average brightness increase of multi-bend achromat synchrotron radiation storage rings, ambitious beam stability requirements are imposed. One system that will be employed at the Advanced Photon Source Upgrade in support of photon beam stability will be X-ray beam position monitors. In the present work, electrical characterisation of several types of photodiodes are evaluated for potential use in X-ray beam position monitors.

TUPP11 **Beam Instrumentation Data Acquisition Using Gigabit Ethernet Communication Protocol**
***N. Eddy**, J.S. Diamond, R.R. Santucci, V.E. Scarpine, A. Semenov, D. Slimmer, D.C. Voy (Fermilab)*
Fermilab's PIP-II accelerator is pursuing the developing a new generalized DAQ system using gigabit ethernet as the communication protocol. The system uses standard rackmount servers and commodity ethernet switches for the front-end, which is a very low cost compared to standard platforms such as VME and uTCA. We use our own client-server protocol for GigE communication between the server and our custom in-house FPGA based digitizers. This allows for a lot of flexibility such that a single server can serve multiple different front-end systems (BPMs, current

monitors, BLMs, etc). At PIP2IT, we have configured a system utilizing a single rackmount server and a 10-gigabit switch communicating with two VME crates housing digitizers for the BPM system. Each digitizer card is connected directly to the switch. The VME crates are just used for power and cooling. This talk will present the system architecture and initial results of operation at PIP2IT.

TUPP12 **Automated Management of Libera SPARK Module IOCs in SPEAR3**

F. Toufexis, *S. Condamoor, W.J. Corbett, D.A. Morataya Campos, C.S. Ramirez, J.J. Sebek, C. Wermelskirchen (SLAC) P. Leban, M. Žnidarčič (I-Tech)*

We are actively upgrading BPM processors in the SPEAR3 accelerator complex as several of the existing systems are reaching end-of-life. To consolidate the resources required for development and maintenance we have evaluated and installed several processors from the Libera SPARK hardware series. We found that two common deployment methods typically used with these modules, micro-SD card and network boot, are either hard to maintain or lack flexibility. Instead we have developed an automated method based on a network boot scheme where an external EPICS soft IOC manages the assignment of specific SPARK modules to physical BPMs in the accelerator. Each module queries the soft IOC at boot time to determine which BPM it is assigned to and then starts its IOC with the appropriate BPM prefix for the PV names. This deployment method allows for quick, seamless swapping of SPARK modules by machine operators or physicists. It addition, it allows us to bring additional modules online for testing, or to move modules to different locations with a different PV prefix for the new location. This method is applicable to other EPICS-enabled devices where the device hardware also hosts an IOC.

TUPP13 **A New Flexible and Interactive Control System for the INFN-LNS Accelerators and Beamlines**

G. Vecchio, *S. Aurnia, S. Cavallaro, L. Cosentino, B.F. Diana, E. Furia, P.S. Pulvirenti, A.D. Russo (INFN/LNS)*

Interactive Graphics User Interfaces (GUI) and a new message exchange protocol are parts of the modern Control System designed and developed to control and monitor the accelerators and beamlines at Istituto Nazionale di Fisica Nucleare - Laboratori Nazionali del Sud (INFN LNS). We used the most innovative open source frameworks and architectures to build several kinds of applications: a web-based application, an interactive synoptic panel and a mobile app. The new protocol for the message exchange between the field devices and the control user interfaces uses the in-memory data structure store Redis as a message broker. Several outline tools allow the calculation of the beam intensity and the automatic acquisition of the beam contour for future beam replication. Moreover, a relational database is used to store all the machine and beamlines parameters every day for each experiment.

TUPP15 **DEOS: A New Scheme for Recording Electron Bunch Shapes With High Resolution and Record Recording Length - Principle and Tests at EuXFEL**

S. Bielawski *(PhLAM/CERCLA) C. Evain, E. Roussel, C. Szwaj (PhLAM/CERLA) C. Gerth, B. Steffen (DESY) B. Jalali (UCLA)*

Recording electron bunch longitudinal profiles in single-shot, and non-destructively is largely needed in accelerator operation. A common strategy consists in probing the near-field of the bunch using femtosecond laser pulses. These two last decades, such electro-optic detection schemes have evolved to compact and reliable techniques. However, serious limitations have been limiting the time-resolution, when long recording lengths are needed. This has been recognized as a fundamental bottleneck and even coined the term "Fourier limit". We present here a novel electro-optic sampling strategy that is theoretically capable to overcome this limit and achieve femtosecond resolution for any recording length. This new approach is based on the mathematical concept of information diversity. We present first results of DEOS (Diversity Electro-Optic Sampling) obtained both in table-top experiments, as well as at the European XFEL. This technique opens the way to electric field shape characterization with femtosecond resolution in new situations, including longitudinal bunch profile monitoring, studies of microbunching instabilities, and THz pulses generated at free-electron lasers.

TUPP17 **Direct Observations of Sub-micropulse Electron-Beam Effects from Short-range Wakefields in TESLA-Type Superconducting RFCavities**

A.H. Lumpkin*, D.R. Edstrom, J. Ruan, R.M. Thurman-Keup (Fermilab) J.A. Diaz Cruz, A.L. Edelen, B.T. Jacobson, F. Zhou (SLAC)*

The preservation of the low emittance of electron beams during transport in the accelerating structures of large facilities is an ongoing challenge. In the cases of the TESLA-type superconducting rf cavities currently used in the European X-ray Free-electron Laser (FEL) and the under construction Linac Coherent Light Source upgrade (LCLS-II), off-axis beam transport may result in emittance dilution due to transverse long-range and short-range wakefields (SRW). To investigate such effects, experiments were performed at the Fermilab Accelerator Science and Technology (FAST) facility with its unique two-cavity configuration after the photocathode rf gun. We used optical transition radiation (OTR) imaging with a UV-visible synchroscan streak camera to display sub-micropulse y-t effects in the 41-MeV beam. The head-tail transverse kicks within the 11-ps-long micropulses were observed at the 100-micron level for steering off-axis in one cavity and several 100 microns for two cavities. Since the SRW kick angles go inversely with energy, these results may inform the commissioning plans of the LCLS-II injector where beam will be injected at ~1 MeV into a cryomodule.

TUPP18 **Observations of Optical Synchrotron Radiation from Ultra-low Charges (aC) Stored in a Ring Operating at 425 MeV**
A.H. Lumpkin *(AAI/ANL) K.P. Wootton (ANL)*
The initial observations of optical synchrotron radiation (OSR) emitted over millions of passes from a few electrons circulating in the Particle Accumulator Ring (PAR) at the Advanced Photon Source have been done with a digital CMOS camera and a synchroscan streak camera operating at 117.3 MHz. The discrete changes of integrated counts in the CMOS image region of interest are ascribed to single electron steps at ~3500 cts per electron. Circulations of a single electron at 375 MeV and at 425 MeV were demonstrated in the 12-bit digital FLIR USB3 camera images. The Hamamatsu C5680 streak camera operating at the 12th harmonic of the fundamental revolution frequency at 9.77 MHz was used to measure the zero-current bunch length from 0.5 nC circulating charge down to 10s of electrons or <10 aC. The latter cases were performed with 6-ps temporal resolution for the first time anywhere, to our knowledge. We report a preliminary effective bunch length of 276 ± 36 ps for 57 electrons (9.1 aC) stored based on a fit to a single Gaussian peak. The results will be compared to the standard zero-current model for the ring.

TUPP20 **Bunch Length Measurements Using Beam Position Monitors**
C.J. Richard *(MSU) S. Cogan, S.M. Lidia (FRIB)*
Capacitive Beam Position Monitors (BPMs) are broadband pickups. For measurements of RF bunched beams, however, they typically use narrowband filters to measure one harmonic of the beam current to reduce noise and simplify the signal processing. If several harmonics are measured simultaneously, the longitudinal bunch shape, in principle, may also be measured. This can be accomplished by recording the waveforms from the BPMs with an oversampling measurement scheme before the narrowband analysis is applied. In order to reconstruct the bunch shape, the measured spectra should be corrected for non-relativistic effects, cable attenuation and filtering, and the geometry and impedance of the BPM pick up. These corrections are discussed as well as the procedure for calibrating the BPM system for measuring multiple harmonics. Measurements are presented that were taken in the medium energy beam transport line and the first linac section at the Facility for Rare Isotope Beams and are compared to simulations and measurements with a fast Faraday cup. Resolution and uncertainties of the reported bunch length measurements are described.

TUPP21 **Transition Radiation Based Diagnostics for Non-Relativistic Ion Beams**
R. Singh*, T. Reichert, B. Walasek-Höhne (GSI)*
The usage of optical transition radiation for profile monitoring of non-relativistic electron beams is well known. In this contribution, we study the application of transition radiation in optical and GHz regime for non-relativistic ion beams. The light emitted from a metal target after ion beam irradiation consists of polarized transition radiation as well as significant amount of unpolarized photons. The dependence of light

yield on beam current and comparison of measured transverse profiles with alternative devices is shown. Simulations and pilot measurements demonstrating the potential usage of coherent transition radiation in GHz regime for bunch-by-bunch longitudinal profile measurements is also discussed.

TUPP23 **Streak Camera Measurement of Electron Beam Energy Loss Per Turn in the Advanced Photon Source Particle Accumulator Ring**
***K.P. Wootton**, J.R. Calvey, J.C. Dooling, K.C. Harkay, A.H. Lumpkin, Y. Sun, B.X. Yang (ANL)*
Relativistic electron beams in storage rings radiate a significant fraction of beam energy per turn. As demonstrated in previous experiments, with the radiofrequency accelerating structures off, the turn-by-turn time of arrival of the electron bunch can be observed from the synchrotron radiation that it produces using a streak camera. In the present work, we present measurements of the energy loss per turn of an initially short electron bunch (~1 ps RMS) from a photocathode electron gun in the Advanced Photon Source Particle Accumulator Ring (375 MeV, 10^2 ns revolution period). With the streak camera synchroscan locked to the twelfth harmonic of the revolution frequency (117.3 MHz), we observe an injection transient in the horizontal direction.

TUPP24 **LOCO Corrections for Beam Trajectory Optimisation on the ISIS Accelerator**
***E.J. Brookes**, H.V. Cavanagh, B. Jones (STFC/RAL/ISIS)*
The ISIS facility at the Rutherford Appleton Laboratory, UK, produces neutron and muon beams for condensed matter research. Its 50 Hz, 800 MeV proton synchrotron delivers a mean beam power of 0.2 MW to two tungsten spallation targets. The beam optics correction technique implemented in this work is Linear Optics from Closed Orbits (LOCO). LOCO modifies existing accelerator models according to a measured orbit-response matrix (ORM). This correction technique identifies imperfections in the machine lattice, and discrepancies between the machine and model. The identification of erroneous elements through analysis of the measured ORM is demonstrated in this work. In comparison to the operational settings achieved through the existing correction techniques, the initial test of the LOCO code demonstrates a 17 % improvement to the RMS trajectory deviation in the horizontal plane.

TUPP27 **Monitor for Microbunching Instability in X-ray Free Electron Laser**
***C. Kim**, H.-S. Kang, G. Kim, I.S. Ko, J.H. Ko (PAL)*
The microbunching instability is an important issue in an X-ray Free Electron Laser (XFEL) because the intensity of the FEL can be reduced significantly when the microbunching instability is generated. In the X-ray Free Electron Laser of the Pohang Accelerator Laboratory (PAL-XFEL), a visible CCD camera was installed in the existing coherent radiation monitor (CRM) for the bunch length monitoring. The measurement result shows that the CCD camera can be used as a direct monitor to diagnose the mi-

crobunching instability and can be used to optimize the FEL lasing in the PAL-XFEL.

TUPP28 **Simulation of Cherenkov Diffraction Radiation for Various Radiator Designs**

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Studies performed during the last few years at different facilities have indicated that the emission of Cherenkov Diffraction Radiation (ChDR) can be exploited for a range of non-invasive diagnostics. The question remains of how to choose an optimal dielectric material and which radiator shapes give the most promising results. This contribution presents a semi-analytical framework for calculating the electromagnetic field of a charged particle beam, taking into consideration its interaction with surrounding structures. It allows us to directly compute ChDR at arbitrary probe positions inside the radiator. Several configurations will be discussed and presented, including flat and cylindrical radiators of various dimensions and electrical properties, as well as multilayer structures obtained by adding coatings of metallic nanolayers.

TUPP30 **Non-Invasive Dispersion Function Measurement During Light Source Operations**

B. Podobedov*, Y. Hidaka (BNL)*

We implemented a completely parasitic measurement of lattice dispersion functions in both horizontal and vertical planes, which is fully compatible with light source user operations. The measurement is performed by applying principle component analysis and adaptive filtering to very small residual orbit noise components introduced by the RF system and detected in the beam orbit data, sampled at 10 kHz. No changes in RF frequency are required. The measurement, presently performed once a minute, was shown to be robust and immune to changes in the beam current, residual orbit noise amplitude and frequency content as well as other factors. At low current it was shown to provide similar accuracy to the traditional method (which shifts the 500 MHz RF frequency by ±500 Hz). In this paper we will explain our measurement technique and present typical dispersion function stability achieved during NSLS-II operations.

TUPP31 **Micro-Bunching Measurements at FERMI**

M. Veronese*, E. Allaria, S. Di Mitri, M. Ferianis, L. Giannessi, G. Penco, P. Rebernik Ribič, S. Spampinati, C. Spezzani, M. Trovò (Elettra-Sincrotrone Trieste S.C.p.A.) E. Ferrari (PSI) G. Perosa (Università degli Studi di Trieste) P. Rebernik Ribič (University of Nova Gorica) E. Roussel (PhLAM/CERLA)*

The origin and evolution of micro-bunching (u-B) in a LINAC is very important for Free Electron laser (FEL), a key knowledge to full control and highest quality of the FEL radiation. The experimental u-B characterization is not simple, due to the measurement complexity, considering the u-B extended spectral range and its interplay with other machine effects. At FERMI, we have measured u-B signatures using different techniques,

including intensity characterization of Coherent OTR(visible range) and the FFT based modulation analysis performed on the spectrometer images. The latter available both at the first bunch compressor and at the diagnostics beam dump. The beating of two laser pulses at laser heater has been used to induce narrow-band micro-bunching modulations, used as a known probe, to study the FEL / u-B instability spectra. As spectral measurement technique, the distribution of Coherent-TR in the IR region, using BP filters and PbSe detectors, has been implemented. More recently, a new IR spectrometer based on a CaF_2 prism and a scanning technique has been developed and installed. Here we present techniques and the experimental results obtained and future perspectives.

TUPP32 **Development of Novel Non-Destructive 2D and 3D Beam Monitoring Detectors at the Bern Medical Cyclotron**

C. Belver-Aguilar, *S. Braccini, T.S. Carzaniga, A. Gsponer, P. Haeffner, P. Scampoli, M. Schmid (AEC) G. Molinari (TERA) P. Scampoli (Naples University Federico II)*

The Laboratory for High Energy Physics (LHEP) at the University of Bern is developing novel beam monitoring detectors for the 18 MeV medical cyclotron in operation at the Bern University Hospital (Inselspital). A 2D non-destructive beam monitor - named Pi2 - was developed, based on a thin aluminium foil coated with P47 scintillating material and a camera. It measures the transverse position, shape, and intensity of the beams for several applications, as radiation hardness or radioisotope production studies. This detector allows the processing of data in real time and a reconstruction of the transverse phase space. Based on the Pi2, a first prototype of a 3D beam monitoring detector - named Pi3 - was conceived, constructed, and tested. It is based on the same scintillating foil mounted on a movable support with a miniaturized camera. The Pi3 detector allows for the study of the beam evolution along a beam line, even inside a magnet, and the reconstruction of the beam envelope. In this paper, we report about the design, construction and beam tests performed with these two detectors. Further developments will be also presented and discussed.

TUPP33 **Commissioning and Operational Experience of the AGS Electron-Collecting Ionization Profile Monitors**

C. Liu, *W.C. Dawson, S.E. Jao, M.G. Minty, J. Morris, V. Schoefer, S. Tepikian (BNL)*

Electron-collecting Ionization Profile Monitors (eIPMs) installed in the Alternating Gradient Synchrotron (AGS) were commissioned successfully in 2017 and have been used since during beam operation regularly. This report will present the modifications made to improve the system performance of the AGS eIPMs. In addition, the impact of the AGS eIPMs on beam operation and the efforts to cross-calibrate beam emittance measurements will be reported as well.

TUPP34 **Beam Experiments with the Multi-purpose Iris Diaphragm Beam Detector**

***A. Liu**, C.-J. Jing (Euclid TechLabs, LLC) J.H. Shao (ANL)*

Non-Gaussian beam distributions around the Gaussian core can be formed in an accelerator in both the transverse and longitudinal directions. Since there are no clearly defined criteria to distinguish the halo from the core, the measurement of the halo structure without affecting the core is challenging. Previously, a novel design of an iris diaphragm detector for transverse beam halo distributions and transverse profile was reported by Euclid Techlabs. This multi-purpose design not only measures the transverse beam distribution but may also work as a tunable collimator or an adjustable BPM. In this paper, the beam experiments using the ~ 1 MeV electron beam at the AWA Cathode Teststand (ACT) of ANL and the 200 keV TEM beam at Euclid are discussed for the most up-to-date version of this new apparatus: Iris Diaphragm e-beam Apparatus Series -Halo (IDEAS-Halo).

TUPP35 **Development of a Thermal Response Model for Wire Grid Profile Monitors and Benchmarking to CERN LINAC4 Experiments**

***A. Navarro Fernandez**, F. Roncarolo (CERN) M. Sapinski (GSI)*

The operation of wire grids as beam profile monitors, both in terms of measurement accuracy and wire integrity, can be heavily affected by the thermal response of the wires to the energy deposited by the charged particles. A comprehensive model to describe such interaction has been implemented including beam induced heating, all relevant cooling processes and the various phenomena contributing to the wire signal such as secondary emission and H^- electron scattering. The output from this model gives a prediction of the wire signal and temperature evolution under different beam conditions. The model has been applied to the wire grids of the CERN LINAC4 160 MeV H-beam and compared to experimental measurements. This successful benchmarking allowed the model to be used to review the beam power limits for operating wire grids in LINAC4.

TUPP36 **Experimental Investigation of Spectral-Angular Cherenkov Radiation Characteristics From 855 MeV Electrons**

***A. Potylitsyn**, S.Yu. Gogolev, A.V. Vukolov (TPU) G. Kube, A.I. Novokshonov (DESY) W. Lauth (IKP)*

Radiation based beam diagnostics is a versatile tool, especially for transverse beam profile measurements. While the use of Optical Transition Radiation (OTR) has long history since developed, the application of Cherenkov Radiation (ChR) having comparatively higher intensity and tunable frequency spectrum just arouse interest. In order to investigate the ChR properties, an experiment has been carried out at the 855 MeV electron beam of the Mainz Microtron MAMI (University of Mainz, Germany). The beam size was 370 μm in horizontal and 6.5 μm in vertical direction. A 200 μm thick fused silica was used as radiator. The beam images were recorded with a standard CMOS camera and an objective lens. While the detector was at a fixed observation angle (much larger

than 46.77 degrees - the Cherenkov angle for a fused silica), the radiator could be rotated with respect to the beam direction such that the ChR angular distribution was measured as a function of the radiator orientation. In addition, a spectrometer was used to get the ChR emission spectrum orientation dependency. This report gives an overview of the experiment together with measurements and first theoretical comparisons.

TUPP37 **A Beam Profile Monitor for High Energy Proton Beams Using Microfabrication Techniques**

I.M. Mateu, *W. Farabolini, A. Gilardi, B. Gkotse, A. Mapelli, V. Meskova, G. Pezzullo, F. Ravotti, O. Sidiropoulou (CERN) D. Bouvet, J.M. Sallese (EPFL)*

In High Energy Physics experiments it is a common practice to expose electronic components and systems to particle beams, in order to assess their level of radiation tolerance when operating in a radiation environment. One of the facilities used for such tests is the Proton Irradiation Facility (IRRAD) at CERN. In order to properly control the 24 GeV/c proton beam, Beam Profile Monitor (BPM) devices are used. The current BPMs are fabricated as standard flexible PCBs featuring a matrix of metallic sensing pads. When exposed to the beam, secondary electrons are emitted from each pad, thus generating a charge proportional to the particle flux. The charge is measured individually for each pad using a dedicated readout system, and so the beam shape, position and intensity are obtained. The beam profile determination with this technique requires thus the usage of non-invasive and radiation tolerant sensing elements. This study proposes a new fabrication method using microfabrication techniques in order to improve the BPMs performance while greatly reducing the device thickness, thus making them also appropriate for the monitoring of lower energy and intensity particle beams.

WEAO01 **Novel Trends in Bunch Length Diagnostics Based on Coherent Polarization Radiation**

A. Curcio *(NSRC SOLARIS)*

Bunch length and temporal profile diagnostics is of primary importance for accelerator facilities. It provides a huge variety of applications, ranging from the optimization of the accelerators' performances to the delivery of light bursts of controlled duration for experiments. During the last years, efforts have been made in demonstrating the beneficial aspects of exploiting Coherent Cherenkov Diffraction Radiation for bunch length characterizations, as its non-intercepting nature, the directionality, the tunability, the high resolution and the high signal-to-noise level. This technique has been compared to others based on more standard mechanisms of polarization radiation as Coherent Transition and Diffraction Radiation. Bunch length measurements have also been benchmarked with more conventional techniques as the use of RF-deflectors and time-domain measurements of Optical Transition Radiation. In conclusion we report on diagnostic solutions already adopted or foreseen in the next future for the SOLARIS facility, both for the LINAC injector and the storage ring.

WEAO02 **Terahertz Detection Techniques Overview**

F. Mazzocchi*, D. Strauß (KIT IAM-AWP) E. Bründermann, A.-S. Müller, T.A. Scherer (KIT)*

In recent years, the THz part of the electromagnetic spectrum has attracted special attention due to the broad range of possible applications deriving from it and its presence in multiple natural phenomena. T-rays are able to pass almost unobstructed through a wide range of non-polar materials such as fabrics, paper, wood, ceramics, plastics and plasma. Radioastronomy, spectroscopy, molecular sensing, plasma diagnostics, security and biomedical imaging are only a few possible uses of the THz spectrum. Such wide range of possible applications demands a similarly wide range of detection techniques and devices. The methods presented in this overview have been organized in four groups, based on the physical principia they rely on: thermal, direct detection, superhet and sampling detection. For each of the techniques, the operational limits and the most frequent applications are also presented.

WEA003 **Optimization of Lasers in Electron Accelerator Applications**
S. Vetter *(SLAC)*

Lasers are increasingly used at electron accelerator facilities both to produce high brightness beams and to modify the properties of the bunches to optimize FEL performance at the LCLS. We describe techniques for controlling and measuring the position, intensity and spatial profile of the laser at the cathode. These measurements must be performed on a bunch by bunch basis in order to monitor stability and pulse to pulse jitter at 120 Hz in our copper linac and up to 1 MHz in the new superconducting linac for LCLS-II. Additionally, IR laser beams are overlapped with the electron beam within a wiggler to modulate the energy of the electron bunch to increase the slice energy spread and offset microbunching instabilities that degrade the FEL performance. We describe the critical laser parameters for such laser heaters and the techniques for controlling the spatial and temporal overlap of laser and electron beams. Moreover diagnostics such as cross-correlation measurements are performed to verify the cathode drive laser pulse length. Finally, we give an overview of laser measurements applied to novel bunch compression schemes for producing attosecond bunches at the XLEAP experiment.

WEA004 **Non-invasive Longitudinal Profile Measurements of Electron Bunches Simultaneously to FEL Operation at MHz Rates**
N.M. Lockmann*, C. Gerth, B. Schmidt, S. Wesch (DESY)*

Hard X-ray FELs require ultra-short electron bunches with peak currents of several kiloamperes. Therefore, longitudinal bunch profile characterization with femtosecond resolution is essential for a successful operation and control of the accelerator as well as a wide field of photon experiments. The high electron beam energies of hard X-ray FELs enable non-invasive longitudinal form factor monitoring down to a few micrometers utilizing coherent diffraction radiation spectroscopy. For this purpose, a 4-staged grating spectrometer has been recently installed at European XFEL. Here, current profiles are reconstructed with femtosecond time resolution based on phase retrieval algorithms which are in excellent agreement to results obtained with a transverse deflecting structure. The fast pyroelectric detectors allow, for the first time, to measure the current profile of all bunches inside the bunch train with repetition rates of up to 2.2 MHz. The low latency electronic readout of the 120 channels of the spectrometer provides high potential for fast compression feedbacks and machine learning applications.

WEPP01 **Filling Pattern Measurement Using a 500 MHz Digitizer at Soleil and APS Storage Rings**
***D. Bisiach**, M. Cargnelutti, P. Leban, M. Žnidarčič (I-Tech) A.R. Brill, N. Sereno (ANL) N. Hubert, D. Pédeau (SOLEIL)*
Filling pattern was measured at SOLEIL and APS storage ring using a 500 MHz digitizer. Various filling patterns were measured: from a single bunch to multi-bunch hybrid fill. The digitizer has 14-bit granularity and locks the sampling clock to exact RF frequency (352 MHz). Signals were sampled from the standard BPM pickup and from APD diode. Data were retrieved using Matlab and Labview interfaces and compared to existing systems.

WEPP02 **CIEL: Current Injection Efficiency and Lifetime**
***R. Broucquart** (SOLEIL)*
We will introduce a new acquisition system for storage ring beam current monitor. It is based on the co-developped PandBox electronics, associated with a 24 bits 128kS/s ADC. It offers the possibility of fast, triggered captures to measure injected current even during bursted injections. We'll show the results of the first tests and the integration of this new measure.

WEPP03 **Bunch Purity Measurement for SSRF**
***B. Gao**, S.S. Cao, Y.B. Leng (SSRF) L.W. Lai, X.Q. Liu (SARI-CAS)*
SSRF is currently working on the beam line phase-II project, which has moved toward laser/x-ray pump-probe experiments. In order to quantify the bunch pattern and charge purity of the probe pulse, a bunch purity monitor based on the time-correlated single-photon counting system has been installed. This system has very good time resolution of 22ps, and high dynamic range of more than seven orders of magnitude. In this paper, system setup, system evaluation and optimization process, a series of experimental studies and initial application will be described.

WEPP04 **Modernization and Operation of Ionization-proportional Gas Counter at INR RAS Proton Linac**
***A.A. Melnikov**, S.A. Gavrilov (RAS/INR) S.A. Gavrilov, **A.A. Melnikov** (MIPT)*
Multianode gas counter is used as a detector for low intensity proton beam diagnostics at INR RAS linac. The device consists of ionization chamber to measure beam current and two proportional chambers, based on stripe geometry, to measure beam profiles. The data is processed with Labview software. The models and methods predicting operational characteristics of the counter in ionization and proportional mode are presented. An analytical model of recombination was tested to predict the saturation voltage for ionization mode. Beam test results and operational characteristics of the counter are presented as well as results of investigations of counter degradation under the beam. A new design of a gas filled counter is also discussed.

WEPP05 **Reentrant Cavity Resonator as a Beam Current Monitor (BCM) for a Medical Cyclotron Facility**

***S. Srinivasan**, P.-A. Duperrex, J.M. Schippers (PSI)*

At PSI, a dedicated proton therapy facility, with a superconducting cyclotron, delivers 250 MeV beam energy, pulsed at 72.85 MHz. The measurement of beam currents (0.1-10 nA) is generally performed by ionisation chambers (ICs), but at the expense of reduced beam quality, and scattering issues. There is a strong demand to have an accurate signal with a minimal beam disturbance. A cavity resonator, on fundamental resonance mode, has been built for this purpose. The cavity, coupled to the second harmonic of the pulse rate, provides signals proportional to the beam current. It is installed in a beamline to measure for the energy range 238-70 MeV. Good agreement is reached between the expected and measured sensitivity of the cavity. The cavity delivers information for currents down to 0.15 nA with a resolution of 0.05 nA when integrated over one second. Its application is limited to a machine-safety monitor to trigger inter-locks, within the existing domain of the proton therapy due to the low beam current limits. With new advancements in proton therapy, especially FLASH, the cavity resonator's application as an online beam-monitoring device is feasible.

WEPP06 **Investigation of an Optical-Fiber Based Beam Loss Monitor at the J-PARC Extraction Neutrino Beamline**

***S.V. Cao**, M.L. Friend (KEK)*

Optical fibers, which at once generate and guide Cherenkov light when charged particles pass through them, are widely used to monitor the beam loss at accelerator facilities. In this report, we investigate this application at the J-PARC extraction neutrino beamline, where a 30GeV proton beam with eight bunches of ~20ns (1σ) bunch width and 581ns bucket length, is extracted from the Main Ring, guided, and hit onto a graphite target to produce a highly intense beam of neutrinos. Three 30m-length 200 μm -core-diameter optical fibers, which are arranged flexibly to form 60m or 90m length fibers, were installed in the beamline. The beam loss signal was observed with the Muti-Pixel Photon Counters. We will discuss the result and prospects of using optical fibers for monitoring and locating the beam loss source.

WEPP07 **The Insertable Beam Stop in the ESS SPK Section**

***E.M. Donegani**, T.J. Grandsaert, T.J. Shea, C.A. Thomas (ESS)*

This paper deals with the Insertable Beam Stop (IBS) to be installed at the transition between the normal conducting and superconducting sections of the ESS linac. The IBS will be used to avoid beam losses in the cryogenic cavities during tuning and commissioning of the ESS linac. The IBS will stop protons in the energy range from 73 MeV to 92 MeV. The proton beam has a current up to 62.5 mA, and $50{\cdot}10^{-6}$ or 5E-6s long pulses at a rate of 1 or 14 Hz, respectively. Firstly, the IBS was designed in MCNPX/ANSYS to withstand thermal and structural stresses, while minimizing neutron production and limiting the deposited power in the cryogenic cavities below 0.2 W/m. Secondly, the prompt background and residual dose in

the vicinity of the IBS were computed, as well as the activation of the IBS components themselves. Finally, a feasibility study was performed to determine if the IBS can be profitably used as a beam-profile monitoring device. The results will serve as input for calculations of the expected signal in beam loss monitors. Moreover, they will enable the design of the nearby shielding limiting the activation of surrounding structures and allowing maintenance works.

WEPP09 **New Beam Loss Monitor System at SOLEIL**

***N. Hubert**, A. Bence, M. El Ajjouri, D. Pédeau (SOLEIL)*

SOLEIL has recently upgraded its Beam Loss Monitor (BLM) system from pin-diode detectors to plastic scintillators associated with photosensor modules. This new kind of monitor, associated to its dedicated electronics, is able to measure slow or fast losses. Monitors have been carefully calibrated with a Cesium source, and installed at systematic locations on the storage ring to provide reliable loss amplitude comparison between them. SOLEIL storage ring is now equipped with 80 BLMs. Installation setup, calibration procedure and resulting measurements will be presented.

WEPP10 **Proton-Induced SEY From Beam Interceptive Devices in the ESS Linac**

***E.M. Donegani** (ESS)*

During the ESS linac commissioning, a wealth of beam-interceptive devices will be exposed to protons with nominal and non-nominal energies spanning from 75 keV to 2 GeV. Therefore, a database of proton-induced Secondary Emission Yield (SEY) values was prepared for the structural materials of insertable devices into the ESS linac. The database relies on calculations of stopping powers in MCNPX and the Sternglass theory applied to protons in the [1 keV, 2 GeV] energy range. Results are reported for 16 relevant materials to wire scanners, bunch shape monitors and target imaging systems, including: TZM, Ni, SiC and graphite of various densities. In the future, the results can be used also for determining the impact of secondaries on emittance or beam-current measurements with Emittance Monitor Units or Faraday cups of the ESS linac, respectively. Moreover, the database can be extended to critical structural materials of the ESS linac itself, in order to estimate the impact of secondary electrons on the overall beam quality.

WEPP11 **Analysis of the Bunch Position Monitoring in Long Bunch Trains at FLASH**

***N. Baboi**, B. Lorbeer (DESY)*

Multi-bunch beams are routinely being accelerated at the FLASH Free Electron Laser at DESY, Hamburg. More than hundred Beam Position Monitors (BPMs) measure the transverse offset of every single bunch in each train with a bunch repetition frequency of up to 1 MHz and a length of several hundreds of microseconds. Various types of monitors are being used: button, stripline and cavity BPMs, each type with several designs. The performance differs from type to type, with resolutions from one to tens of micrometers. However so far only the first bunch in the

train was investigated in detail. In this paper we study every bunch along long bunch train for several BPM designs and locations.

WEPP12 **Simulation of the Signal Processing for the New Interaction Region BPMs of the High Luminosity LHC**
D.R. Bett *(JAI) A. Boccardi, M. Krupa, M. Wendt (CERN)*
New stripline beam position monitors (BPMs) will be installed at the Interaction Regions of the ATLAS and CMS experiments as part of the High-Luminosity upgrade to the LHC. These BPMs will be located in sections of the beamline where the two counter-propagating proton beams co-exist within a single pipe, such that the signal observed on each output port is a combination of the signals generated by each beam. The use of the BPMs as the input for a possible luminosity feedback system places a demanding requirement on the long-term accuracy of the BPMs. Accurate measurement of the position of each beam requires a method for isolating the individual beam signals. A simulation framework has been developed covering all stages of the measurement process, from generation of the signals expected for beams of a given intensity and orbit through to digitization, and has been used to evaluate several candidate methods for extracting the position of each beam in the presence of the unwanted signal from the other.

WEPP13 **Design and Test of of CBPM Prototypes for SHINE**
S.S. Cao *(Private Address) R. Jiang, Y.B. Leng, R.X. Yuan (SSRF)*
SHINE (Shanghai High repetition rate XFEL aNd Extreme light facility) is designed to be an extremely high-performance hard X-ray free-electron laser facility located at Zhangjiang, Shanghai. As one of the key parameters of the facility, the resolution of the beam position measurement in the undulator section is required to be under 200 nm at a low bunch charge of 100 pC and better than 10 μm at 10 pC. To achieve this, a pre-study based on cavity beam position monitors is under development. Four sets of cavity monitors with different frequencies or load quality factors have been designed and are now manufactured by four different companies. It aims to select the cavity with the best performance and select the most capable company. This paper will briefly introduce the motivation, cavity design considerations, and cold test results.

WEPP14 **BPM Studies and Prototype Design for the SOLEIL Upgrade**
M. El Ajjouri*, F. Alves, A. Gamelin, N. Hubert (SOLEIL)*
Synchrotron SOLEIL is preparing a machine upgrade with a reduction by more than a factor 10 the horizontal electron beam emittance (< 100 pm.rad)., the future multibend achromat lattice will be composed of a large number of magnet elements. Quadrupole and sextupole strengths will impose a drastic reduction of the vacuum chamber dimensions and in particular its diameter that will be reduced to 10 mm. One of the challenges for the beam position monitors will be the mechanical integration of the 4 buttons and feedthroughs on such a small beam pipe. In this context we have realized a first prototype with Component Off The Shelf 3 mm buttons diameter, to validate this mechanical integration and are

starting the 3D electromagnetic simulations to study the impedance characteristics, the RF parameters, the heating and thermal issues.

WEPP15 **Experiments With a Quadrated Dielectric-Filled Reentrant Cavity Resonator as a Beam Position Monitor (BPM) for a Medical Cyclotron Facility**

***S. Srinivasan**, P.-A. Duperrex, J.M. Schippers (PSI)*

Low beam currents (0.1-10 nA) are used for tumour treatment in the proton radiation therapy facility at PSI. The facility houses a superconducting cyclotron with extraction energy of 250 MeV pulsed at 72.85 MHz. Online measurement of the beam position is traditionally performed with the help of ionisation chambers (ICs), however, at the expense of reduced beam quality and scattering issues. There is a strong demand to have this measurement performed with minimal beam disturbance since the beam position is directly associated with the dose-rate applied. A cavity resonator, working on the principle of an electric dipole mode resonance, whose frequency is coupled to the second harmonic of the pulse rate, has been built to measure beam position in a purely non-invasive manner. Followed by a reasonable agreement between the test-bench and the simulation results, the cavity is installed in one of the beamlines. Here, we report on the measurement of the cavity BPM as a function of beam current and position and its shortcomings. The cavity BPM can deliver position information within the accuracy and resolution demands of 0.50 mm, when measured with a spectrum analyzer.

WEPP16 **Advanced Light Source High Speed Digitizer**

***J.M. Weber**, J.C. Bell, M.J. Chin, W.E. Norum, G.J. Portmann (LBNL)*

The Advanced Light Source (ALS) is developing the High Speed Digitizer (HSD), a data acquisition system based on the latest Radio Frequency System-on-Chip (RFSoC) technology. The system includes 8 channels of 4GHz 4Gsps analog input, programmable gain, self calibration, and flexible data processing in firmware. The initial motivation for the HSD project was to develop a replacement for aging ZTEC oscilloscopes that would be more tightly integrated with the ALS Control System and Timing System than any available commercial oscilloscope. However, a general approach to the design makes the HSD system useful for other applications, including a Bunch Current Monitor, as well as for other facilities beyond ALS.

WEPP17 **Upgrade and First Commissioning of Transverse Feedback System for SSRF**

***N. Zhang**, B. Gao, L.W. Lai, R.X. Yuan (SSRF)*

To be a part of the transverse feedback system upgrade plan in SSRF PHASE II project, a set of Dimtel feedback processors was installed to replace the previous set. In the commissioning, the ability of supressing the trans-verse oscillation was tested and evaluated, also, beam diagnostics and control tools of the processors was used for injection transients analysis, tune tracking and bunch cleaning. The results of the commissioning and data analysis will be presented in this paper.

WEPP18 **Stochastic Cooling Pickup/Kicker Developments for a High-Precision Spectrometer Ring**

***G. Zhu**, Z. Du, Y. Wei, J.X. Wu (IMP/CAS) F. Caspers (CERN)*

Stochastic cooling of the Spectrometer Ring (SRing) at the High Intensity heavy-ion Accelerator Facility (HIAF) project in China, which is used mainly for experiments with radioactive fragment beams, is applied to speed up the cooling process of a stored ion beam. In this study, both a Faltin traveling wave structure and a novel slot-ring standing wave structure based on a ceramic vacuum chamber are discussed and evaluated for the pickup/kicker of the SRing stochastic cooling system. The slot-ring structure should significantly improve the shunt impedance due to the Cerenkov effect. For the Faltin-type structure, the results for the pickup shunt impedance obtained from simulations and from beam measurements agree well. Good agreement is also found between the simulated and measured results for the pickup shunt impedance of the slot-ring structure. Cooling process simulations using the Fokker-Planck equation based on the shunt impedance results for the Faltin and slot-ring type pickups are also presented.

WEPP19 **Non-Destructive Monitoring of Electron Beam Micro-Bunching Periodicity**

***I.V. Konoplev**, H. Zhang (JAI) G. Doucas (Oxford University, Physics Department)*

Electron beam microbunching can either occur naturally in high current accelerator facilities, or can be induced artificially for wide range of studies. Microbunching has applications in LINAC driven tunable sources of coherent radiation and wakefield acceleration. In all cases, an accurate, non-destructive monitoring of the beam microbunching is needed to validate theory, improve the accelerator and light source operations and understanding of the phenomenon observed. However, it is still a challenge to monitor the beam microbunching non-destructively and we discuss the possibility of measuring the femtosecond periodic microstructure of the beam without strong interference (i.e. in a non-destructive way) via analysis of the amplitude modulation of the coherent Smith-Purcell radiation (cSPr) signal generated by a partially or fully microbunched beam. The results of the numerical studies of the cSPr generated by the partially and fully microbunched beam and proof-of-principle experiments demonstrating the measurements of the distance between microbunches will be presented. The theoretical predictions are compared with the experimental data and the limitations are discussed.

WEPP20 **Measurements of Ultraviolet FEL Seed Laser Pulse Width Broading in Thin ß-BBO Crystals**

***C.L. Li**, X.T. Wang, W.Y. Zhang (Shanghai Advanced Research Institute) L. Feng, B. Liu (SARI-CAS)*

Short pulse, high power seed lasers have been implemented to improve the longitudinal coherence and shot-to-shot reproducibility of Free Electron Lasers (FEL). The laser pulse duration is typically 100 - 200 fs with wavelengths in the 260 nm range produced from third harmonic gener-

ation of a Ti:sapphire laser. The pulse duration must be measured accurately for seeded FEL operation. The Ultraviolet (UV) pulse width measurement can be carried out with intensity cross-correlation based on the difference frequency generation (DFG) in ultrathin ß-Barium Borate (BBO) crystals. The DFG output pulse broadened due to group velocity mismatch between the 266.7 nm and 800 nm components. The broadening effect depends on the BBO crystal thickness so we explored 0.015 mm, 0.055 mm and 0.1 mm thick samples. To the best of our knowledge, this is the first time that ß-BBO crystal with thickness of only 0.015 mm has been used to measure the UV seed laser pulse width. Experiment results show the measured pulse width broadens with increased BBO thickness in agreement with a theoretical model.

WEPP21 **Evaluation of a Novel Pickup Concept for Ultra-Low Charged Short Bunches in X-Ray Free-Electron Lasers**

***B.E.J. Scheible**, A. Penirschke (THM) W. Ackermann, H. De Gersem (TEMF, TU Darmstadt) M.K. Czwalinna, H. Schlarb (DESY)*

The all-optical synchronization systems used in various Xray free-electron lasers (XFEL) such as the European XFEL depend on transient fields of passing electron bunches coupled into one or more pickups in the Bunch Arrival Time Monitors (BAM). The extracted signal is then amplitude modulated on reference laser pulses in a Mach-Zehnder type electro-optical modulator. With the emerging demand of the experimenters for future experiments with ultra-short FEL shots, fs precision is required for the synchronization systems even with 1 pC bunches. Since the sensitivity of the BAM depends in particular on the slope of the bipolar signal at the zero crossing and thus, also on the bunch charge, a redesign with the aim of a significant increase by optimized geometry and bandwidth is inevitable. In this contribution a possible new pickup concept is simulated and its performance is compared to the previous concept. A significant improvement of slope and voltage is found. The improvement is mainly achieved by the reduced distance to the beam and a higher bandwidth.

WEPP22 **Submicropulse Energy-Time Correlations of 40-Mev Electron Beams at Fast**

***R.M. Thurman-Keup**, A.H. Lumpkin (Fermilab)*

We have recently extended our ability to explore submicropulse effects in relativistic electron beams to energy-time (E-t) correlations. The Fermilab Accelerator Science and Technology (FAST) facility consists of a photoinjector, two superconducting TESLA-type capture cavities, one superconducting ILC-style cryomodule, and a small ring for studying nonlinear, integrable beam optics called IOTA. The linac contains, as part of its instrumentation, an optical transport system that directs optical transition radiation (OTR) from an Al-coated Si surface to an externally located streak camera for bunch length measurements. For the first time, an OTR screen after the spectrometer magnet was used for measurements of submicropulse E-t correlations. The projected, micropulse time profile was fit to a single Gaussian peak with sigma = 11.5 ± 0.5 ps for 500

pC/micropulse and with a 200-micropulse synchronous sum, in agreement with the upstream bunch-length measurement at a non-energy-dispersive location. The submicropulse E-t images were explored for four rf phases of CC1, and the E vs. t effects will be presented.

WEPP23 **Optimization of GaAs Based Field Effect Transistors for THz Detection at Particle Accelerators**

***R. Yadav**, S. Preu, S. Regensburger (IMP, TU Darmstadt) A. Penirschke (THM)*

For pump probe experiments employing a free-electron laser and a near infrared (NIR) laser, there is no natural locking between the two. Therefore only the repetition rate of the two lasers can be synchronized leading to jitter and drift on the picosecond scale. GaAs-based field-effect transistors (FETs) allow for simultaneous detection of the amplitude and timing of picosecond-scale THz and NIR pulses. They cover the whole THz band and beyond up to the MIR (0.1 - 22 THz) with the exception of the GaAs Reststrahlen band. Large-area FETs feature a high damage threshold (>65 kW) and large linearity range. Antenna-coupled FETs show a noise equivalent power (NEP) of 250 pW/$\sqrt{}$Hz at 600 GHz. FET based THz detectors can be used both for THz beam on a single pulse level, as well as for the beam diagnosis. For further optimization of the detector for the needs of beam diagnosis with low incident intensity, a more precise modeling of the FET is developed. Therefore, the incoupling of THz to the rectifying element is investigated. The S-Parameters of the 2DEG are measured with on-wafer probes up to 67 GHz and de-embedded with on-wafer TRL calibration.

WEPP24 **Prototype Design of Bunch Arrival Time Measurement System Based on Cavity Monitor for SHINE**

***Y.M. Zhou**, S.S. Cao, J. Chen, Y.B. Leng (SSRF)*

The Shanghai high repetition rate XFEL and extreme light facility (SHINE) is planned to be built into one of the most efficient and advanced free-electron laser user facilities over the world to provide a unique tool for kinds of cutting-edge scientific research. The measurement of bunch arrival time is one of the key issues to optimize system performance. This is because the FEL facility relies on the synchronization of electron bunch and seeded lasers. Currently, there are mainly two methods to measure the bunch arrival time: the electro-optical sampling method and the RF cavity-based method. Considering the latter one has a simpler system and lower cost, the method has been adopted by SXFEL. The previous results show that the measurement uncertainty of bunch arrival time has achieved to be 45 fs, which can be further optimized. For SHINE, the bunch arrival time resolution is required to be better than 25 fs@100pC, and 200 fs@10 pC. The RF cavity-based method will also be applied. This paper will present the system prototype design and related simulation results.

WEPP25 **Photoinjector Driver Laser Temporal Shaping and Diagnostics for Shanghai Soft X-ray Free Electron Laser**

***C.L. Li**, X.T. Wang, W.Y. Zhang (Shanghai Advanced Research Institute) L. Feng, B. Liu (SARI-CAS)*

It is known that the intensity distribution plays an important role in the electron bunch character, such as its transverse emittance, longitudinal structure. Compared with longitudinal Gaussian distribution, Driver laser pulse with longitudinal flattop structure can produce electron bunch with lower emittance. This paper presents electron beam structure and emittance under different driver laser structure, specifically, laser pulse temporal shaping method for producing Gaussian beam and flattop beam are presented. The advantage and disadvantage of the two method are also discussed. Flattop beam produced from BBO stacking is more benefit for producing electron beam with lower emittance, but significantly increase the microbunch effect. However, Gaussian beam has the advantage to help reducing the mircobunch effect. Moreover, cross correlation method for characterization the laser pulse temporal structure are also presented, particularly, the group velocity mismatch effect induced by the sum frequency BBO crystal are discussed.

WEPP26 **Effect of phase modulation on the transverse beam size and emittance of the HLS-II ring**

***Y.K. Zhao**, S.S. Jin, B.G. Sun, J.G. Wang, F.F. Wu, T.Y. Zhou (USTC/NSRL)*

In this paper, the radio-frequency (RF) phase modulation method is exploited to investigate the variations in the transverse beam size and emittance at Hefei Light Source (HLS-II). Meanwhile, a certain quantitative analysis was performed on the stability and practicability of the beam transverse profile measurement systems. The experiments show that the RF phase modulation method can effectively explore the robustness and stability of beam transverse profile measurement systems over the range of 20.0-22.5 kHz, which is close to the first-harmonic of the synchrotron frequency. It is concluded that when the modulation amplitude of the external phase perturbation is less than 0.04 rad, this optical system can be capable of maintaining reliable and stable working status. This is also useful for analyzing the influence of RF phase noise on the subsequent beam measurement and diagnostics, which including the deterioration of beam quality, emittance blowup, beam jitter, and beam loss.

WEPP27 **An Alternative Processing Algorithm for the Tune Measurement Systems in the LHC**

***L. Grech**, D. Alves (CERN) G. Valentino (University of Malta, Information and Communication Technology)*

The betatron tune in the Large Hadron Collider (LHC) is measured using a Base-Band-Tune (BBQ) system. Processing of these BBQ signals is often perturbed by 50Hz noise harmonics present in the beam. This causes the tune measurement algorithm, currently based on peak detection, to provide incorrect tune estimates during the acceleration cycle with values that clearly oscillate between neighbouring harmonics. The LHC tune

feedback cannot be used to its full extent in these conditions as it relies on stable and reliable tune estimates. In this work we present two alternative tune measurement algorithms, designed to mitigate this problem by ignoring small frequency bands around the 50Hz harmonics and estimating the tune from spectra with gaps. One is based on Gaussian Processes and the other is based on a weighted moving average. We compare the tune estimates of the new and present algorithms and put forward a proposal that can be implemented during the renovation of the BBQ system for the next physics run of the LHC.

WEPP28 **High-Accuracy Diagnostic Tool for Beam Position Monitor Troubleshooting in SSRF Based on Clustering Analysis**

***R. Jiang**, J. Chen, Y.B. Leng (SSRF)*

Beam position monitors (BPMs) are important to monitor the beam moving steadily. In spite of some data is viewed and analysed, a large fraction of data has never been effectively analysed in accelerator operation. It lead to some useful information not coming to the surface during the beam position monitor troubleshooting processing. We will describe in this paper our efforts to use clustering analysis techniques to pull out new information from existing beam data. Our focus has been to look at malfunction of BPM, associating basic running data that is ß oscillation of X and Y directions, energy oscillation and doing predictive analysis. Clustering analysis results showed that 140 BPMs could be classify into normal group and fault group and abnormal BPM could be separated. Based on the results, the algorithm could locate fault BPM and it could be an effective supplement for data analysis in accelerator physics.

WEPP29 **Energy Gain Measurement for Electrons Accelerated in a Single-Cycle THz Structure**

***S.V. Kuzikov**, S.P. Antipov, P.V. Avrakhov (Euclid TechLabs, LLC) S. Bodrov, A.E. Fedotov, A.N. Stepanov, A.A. Vikharev (IAP/RAS)*

Gradients on the order of 1 GV/m have been obtained via single cycle (~1 ps) THz pulses produced by the conversion of a high peak power laser radiation in nonlinear crystals (~1 mJ, 1 ps, up to 3% conversion efficiency). For electron beam acceleration with such broadband (0.1- 5 THz) pulses, we propose arrays of parabolic focusing micro-mirrors with common central. To measure energy gain of electrons in the THz structure we propose applying a voltage (up to 400 kV) to the structure respecting the cathode and anode. Electrons become preliminary accelerated at the entrance that makes design of the structure simpler, because velocity of particles is near to be constant and almost equals the speed of light. On the other hand, the anode can be reached only by the electrons accelerated in the THz field so that one can directly measure the resulting energy gain at the anode.

WEPP31 **Design of the Beam Diagnostic System for the New 3 GeV Light Source in Japan**

H. Maesaka, *T. Fukui (RIKEN SPring-8 Center, Innovative Light Sources Division) H. Dewa, T. Fujita, M. Masaki (JASRI/SPring-8) S. Takano (Japan Synchrotron Radiation Research Institute (JASRI), RIKEN SPring-8 Center) K. Ueshima (National Institutes for Quantum and Radiological Science and Technology (QST))*

We present a design overview of the beam diagnostic system for the new 3 GeV light source being constructed in Tohoku, Japan, and some test results obtained at SPring-8. This light source will generate brilliant x-rays from a high-quality electron beam having 1 nm rad emittance and 400 mA maximum stored current. To achieve the design performance and stability, we must monitor various beam parameters precisely. The beam position should be detected precisely: single-pass resolution < 0.1 mm (0.1 nC injected beam), COD resolution < 0.1 μm (more than 100 mA stored current), position stability < 5 μm for 1 month. We will use 112 button-type BPMs in the storage ring for these purposes. The stored beam current and beam size are also monitored with a DCCT and an x-ray pinhole camera. We will install a 3-pole wiggler to a straight section for the pinhole camera and other optical diagnostics. A stripline BPM and a stripline kicker will be installed to another straight section to suppress the beam instability and to measure betatron tune. We will use FPGA-based high-speed electronics for instability suppression with a bunch-by-bunch feedback method and real-time tune monitoring.

WEPP33 **Progress of Profile Measurement Refurbishment Activities at HIPA**

R. Dölling, *E. Johansen, M. Roggli, M. Rohrer (PSI)*

At PSI's High Intensity Proton Accelerator facility some 180 profile monitors and 10 radial probes are in use to measure transverse beam profiles in beam lines and cyclotrons at energies of 0.87 to 590 MeV. Mechanical malfunctions and increased noise in some devices, a lack of spare parts and the obsolescence of most of the driver and read-out electronics as well as extended requirements to the measurement, necessitate the development of improved versions of the electronics and of several monitors. At IBIC 2019 and Cyclotrons'19 we reported on the start of three projects in this regard: A renewed profile monitor and BPM at 590 MeV in high radiation environment, a radial probe in the Ring Cyclotron and new loss monitor electronics, which should also serve as a basis for the profile monitor readout. We give an update on the status of these developments.

WEPP34 **First Beam Profile Measurements by Beam Induced Fluorescence at the J-PARC Neutrino Extraction Beamline**

M.L. Friend, *S.V. Cao, K. Nakayoshi, K. Sakashita (KEK) M. Hartz (Kavli IPMU) Y. Koshio (Okayama University, Faculty of Science) A. Nakamura (Okayama University)*

A Beam Induced Fluorescence (BIF) profile monitor is under development at the J-PARC neutrino extraction beamline, where neutrinos are produced using 30 GeV protons from the J-PARC MR accelerator. Towards

the goal of continuously and non-destructively measuring the 1.3MW proton beam profile spill-by-spill using fluorescence from proton interactions with injected gas, a full working prototype monitor was installed in the beamline in 2019. The prototype includes a scheme for pulsed injection of N_2 gas into the ultra-high vacuum beampipe and two optical readout arms, a conventional one using an Image Intensifier coupled to a CID camera, along with an array of optical fibers coupled to a Multi-Pixel Photon Counter array. Initial beam tests of the system were carried out in early 2020, and BIF light was successfully observed in both optical systems. Details of the prototype monitor, along with first proton beam profile measurement results, will be shown. Improvement plans towards continuous operation of the new profile monitor will also be discussed.

WEPP35 **Simulation and Experiments of Transverse Emittance Measurements with Slit scan and Quadrupole scan at ELBE SRF Gun**

***S. Ma**, A. Arnold, P.E. Evtushenko, A.A. Ryzhov, J. Schaber, J. Teichert, R. Xiang (HZDR) J. Schaber (TU Dresden)*

Emittance is one of the most important parameters for electron injectors and accelerator facilities. Two traditional methods, the single slit-scan, and quadrupole scan are used in most emittance measurements. Although the experiment condition is the same, one may receive different emittance results. The difference between simulation and experiment in the beamline will be discussed in this paper. As a statistical sampling, the error of the slit-scan system is related to bunch transverse distribution, bunch charge, slit width and thickness, beamlet number, drift distance, and screen resolution. In suitable conditions, the space-charge dominated beam will become emittance dominated beam after slits and emittances from slit-scan are reliable. The error quadrupole scan depends on the quadrupole field's measurement accuracy and bunch distribution. In this paper, we use a simple way to calibrate quadrupole focus strength. Space charge usually can't be avoided and will lead to some errors for quadrupole scan.

WEPP36 **Recent Progress on the Commissioning of a Gas Curtain Beam Profile Monitor Using Beam Induced Fluorescence for High Luminosity LHC**

***S. Mazzoni**, M. Ady, O.R. Jones, I. Papazoglou, C. Pasquino, A. Rossi, S. Sadovich, G. Schneider, R. Veness (CERN) P. Forck, S. Udrea (GSI) N. Kumar, A. Salehilashkajani, C.P. Welsch, H.D. Zhang (Cockcroft Institute) N. Kumar, A. Salehilashkajani, C.P. Welsch, H.D. Zhang (The University of Liverpool)*

For the high-luminosity upgrade of the Large Hadron Collider, active control of proton/ion beam halo will be essential for safe and reliable operation. Hollow Electron Lenses can provide such active control by enhancing the depletion of halo particles, and are now an integral part of the high luminosity LHC collimation system. The centring of the proton beam within the hollow electron beam will be monitored through imaging the fluorescence from a curtain of supersonic gas. In this contribution we report on the recent progress with this monitor and its subsystems, in-

cluding the development of an LHC compatible gas-jet injection system, the fluorescence imaging setup and preliminary test measurement in the LHC

WEPP37 **Transverse Phase Portrait Tomography of Proton Beams at INR RAS Linac**

***A.I. Titov**, S.A. Gavrilov (RAS/INR) S.A. Gavrilov, **A.I. Titov** (MIPT)*

Measuring of the parameters of the transverse phase portraits is crucial for beam dynamics. A method of tomographic reconstruction is implemented at INR RAS linac as an alternative to already existing quadrupole variation method. In this work new feature of disturbing online measurements of phase portrait parameters and important experimental results are discussed. Comparison of tomographic method with quadrupole variation method is presented.

WEPP38 **Diamond Beam Halo Monitor**

***S.V. Kuzikov**, S.P. Antipov, P.V. Avrakhov, E.W. Knight, Y. Zhao (Euclid TechLabs, LLC) J.G. Power (ANL)*

Beam halo measurement is important, because novel x-ray free electron lasers like LCLS-II have very high repetition rates, and the average power in the halo can become destructive to a beamline. Diamond quad detectors were previously used for electron beam halo measurements at KEK. Diamond is the radiation hard material which can be used to measure the flux of passing particles based on a particle-induced conductivity effect. However, the quad detectors have metallic contacts for charge collection. Their performance degrades over time due to the deterioration of the contacts under electron impact. We recently demonstrated a diamond electrodeless x-ray flux monitor based on a microwave measurement of the change in the resonator coupling and eigen frequency. We propose similar measurements with a diamond put in a resonator that intercepts the halo. Without electrodes, such a device is more radiation resistant. By measuring the change in RF properties of the resonator, one can infer the beam halo parameters. In a similar manner to traditional beam halo monitors, the diamond plate can be scanned across the beam to map its transverse distribution.

THAO — Transverse Profile, Emittance Monitors and Machine Learning

THAO01 **Machine Learning-based Beam Size Stabilization**

S.C. Leemann *(LBNL)*

In state-of-the-art synchrotron light sources the overall source stability is presently limited by the achievable level of electron beam size stability. This source size stability is presently on the few-percent level, which is still 1-2 orders of magnitude larger than already demonstrated stability of source position/angle (slow/fast orbit feedbacks) and current (top-off injection). Until now, source size stabilization has been achieved through corrections based on a combination of static predetermined physics models and lengthy calibration measurements (feedforward tables), periodically repeated to counteract drift in the accelerator and instrumentation. We now demonstrate for the first time [PRL 123 194801 (2019)], how application of machine learning allows for a physics- and model-independent stabilization of source size relying only on previously existing instrumentation in ALS. Such feed-forward correction based on neural networks that can be continuously online-retrained achieves source size stability as low as 0.2 microns rms (0.4%) which results in overall source stability approaching the sub-percent noise floor of the most sensitive experiments.

THAO02 **Using Machine Learning Tools to Predict Accelerator Failure**

M. Reščič*, R. Seviour (University of Huddersfield) W. Blokland (ORNL)*

Modern particle accelerator facilities are continuously introducing improved beam diagnostics, data acquisition, storage and analysis capabilities. Although the increased volume of data this generates makes manual analyse and understand the acquired data very difficult. In this paper we propose the use of machine learning to better understanding of beam failures. The proposed methods allow for both precognitive failure prediction and failure classification, determined using existing beam diagnostics infrastructure. Where we present the concept of tuning classifier parameters and pulse properties to refine datasets. As a demonstrator we apply our machine learning algorithm to analysis the vast data generated by the Oakridge Spallation Neutron Source (SNS) Differential Beam Current Monitoring (DBCM) diagnostics system. We show that analysis of the SNS DBCM data using machine learning, particle accelerator failure can be identified prior to the actual machine failure with 92% accuracy. Importantly, our research shows that emergent behavior regarding machine failure is encoded in the beam pulses prior to failure actually occurring.

THA003 **Source Size and Emittance Measurements for Low-Emittance Light Sources**

N. Samadi *(PSI) L.D. Chapman, L.O. Dallin (CLS) , X. Shi (ANL)*

Radiation-based techniques for measuring electron source sizes are widely used as emittance diagnostics at existing synchrotron sources. In this presentation, we review different radiation-based methods which are being considered as source diagnostics for low emittance synchrotron storage rings. Three of these systems - pinhole imaging, double-slit interferometry, and a K-edge filter-based beam position and size monitor (ps-BPM) system - are studied in detail and optimized for small source size measurements. Each method has its advantages and limitations and provides complementary information. Pinhole imaging is the most commonly used technique which has the simplest setup but with limited resolution. Double-slit interferometry gives the highest sensitivity among the three methods. The ps-BPM system has reasonable resolution in measuring source size and divergence, and at the same time, provides real-time information on source position and angle. A combination of multiple techniques is recommended for the full characterization of the source.

THA004 **Beam Coupling Impedance Analyze Using Bunch-by-Bunch Measurement**

X.Y. Xu *(University of Chinese Academy of Sciences, SSRF, SINAP) Y.B. Leng (SSRF)*

Beam coupling impedance is very important parameters for advanced synchrotron radiation facilities. Till now there is no online method to measure beam impedance directly. But some beam parameters such as betatron tune amplitude and frequency, synchrotron phase, bunch lifetime and so on, can be modulated by beam impedance effects. So wake field and beam impedance information could be retrieved by measuring bunch-by-bunch beam 3D positions and analyzing bunch index dependency of above beam parameters. A bunch-by-bunch 3D positions and charge measurement system had been built at SSRF for this purpose and the performance is not good enough for beam impedance analyze due to cross talk between bunches. We upgraded the measurement system to minimize cross talk and improve resolution this year. New beam experiment results and corresponding analyze will be introduced in this paper.

THA005 **Advanced Laser-Driven Plasma Accelerator Electron-Beam Diagnostics with COTR Techniques**

A.H. Lumpkin *(Fermilab) M. Downer, M. LaBerge (The University of Texas at Austin) A. Irman (HZDR) D.W. Rule (Private Address)*

A significant advance in laser-driven plasma accelerator (LPA) electron-beam diagnostics has recently been demonstrated based on coherent optical transition radiation (COTR) imaging. We find COTR signal strengths from a microbunched subset of beam exiting the LPA to be several orders of magnitude higher than that of incoherent optical transition radiation (OTR). The transverse sizes are only a few microns as deduced from the point-spread-function-related lobe structure. In addition, the far-field COTR interferometric images obtained on the same shot provide

beam-size limits plus divergence and pointing information at the sub-mrad level when compared to an analytical model with a recent revision. The integrated image intensities can be used to estimate the microbunching fraction and relatable to the LPA process. Initial results in a collaborative experiment at the Helmholtz-Zentrum Dresden-Rossendorf LPA will be reported for electron beam energies of about 215 MeV.

THA006 **Features of the Metal Microstrip Detectors for Beam Profile Monitoring**

V.M. Pugatch, *O.S. Kovalchuk, D. Ramazanov (NASU/INR)*

Features of Metal Microstrip Detectors (MMD) are presented for application in beam profile monitoring of charged particles and synchrotron radiation beams. Through an innovative plasma-chemistry etching production process, thin metal micro-strips only 1-2μm thick are aligned. Because of the very thin nature of the strips, the MMD is nearly transparent, and can be used in-situ for measuring, tuning and imaging the beam online. Metal structure of sensors guaranties high radiation tolerance (about 100MGy) providing their stable response to the beam particles (by the secondary electron emission) independent upon the accumulated fluence. The spatial resolution of the MMD is determined by the strips pitch constituting from 5 to 100μm in currently manufactured samples. The data were obtained with MMDs read out by the low noise X-DAS system providing integration time from 1 to 500ms, and the ability to process signals in real time. The scope of MMD & X-DAS is scientific and applied research using beams: in control systems of accelerators and synchrotron radiation sources. New possibilities are discussed for equipment requiring high spatial resolution and radiation hardness.

THPP01 **Development of a Cavity Beam Intensity Monitor for HUST Proton Therapy Facility**

J.Q. Li, *Q.S. Chen (HUST) K. Fan (Huazhong University of Science and Technology, State Key Laboratory of Advanced Electromagnetic Engineering and Technology,)*

In a proton therapy facility, non-destructive beam diagnostic devices are essential to the online measurement during patient treatment. The beam intensity has a wide dynamic range, varies from the order of sub-nano ampere to nano ampere, to meet the clinical requirements, which requires the beam diagnostic system has the capability of measuring the beam intensity precisely. However, the beam with extremely low intensity and non-relativistic energy creates great challenges to the design of the non-destructive beam diagnostics system because of the ultra-small induced signal from the beam. A cavity-type beam intensity monitor system is being developed for the Huazhong University of Science and Technology Proton Therapy Facility (HUST-PTF). This system consists of a reentrant cavity working in TM010 mode and a magnetic coupling loop for extracting output signal whose amplitude is proportional to the beam intensity. The output signal is amplified and detected by a lock-in amplifier. The electromagnetic simulation and the test bench measurement result are presented in this paper. The comparison of simulation and test bench measurement shows a good agreement.

THPP02 **RMS-R3 - Radiation Hard System for Beam, Background and Luminosity Monitoring at the Upgraded LHCb Experiment**

V. Dobishuk, *S. Chernyshenko, O. Okhrimenko, V.M. Pugatch (NASU/INR) F. Alessio (CERN)*

The results of a performance study of the upgraded Radiation Monitoring System (RMS-R3) for the LHCb experiment are presented. The RMS-R3 is built out of the eight Metal-Foil Detectors (MFD) placed at 2 m from IP-8 around the beam pipe in a backward hemisphere. The system is designed for monitoring beams interaction rate (relative luminosity) and background at the LHCb nominal instantaneous luminosity of p-p collisions 5 times increased in RUN3. The feasibility of monitoring of relative contribution from the beams luminous region (IP-8) and collimators is illustrated by the data accumulated with a similar RMS during RUN1 and RUN2 campaigns. An advantageous feature of the MFD, its high radiation tolerance of a GGy level, originates from the principle of its operation due to secondary electron emission from a surface of a metal sensor resulting in a positive charge in it which is readout by charge integrator. Simple structure of the detector modules, low operating voltage (about 20 volts), commercially available DAQ boards further improve their figure of merit. The RMS-R3 perfect linear response in a dynamical range of 1:100000 is demonstrated in tests with r/a source and X-rays.

THPP04 **Testbed Development for the Characterisation of an ASIC for Beam Loss Measurement Systems**
***F. Martina**, C. Zamantzas (CERN)*
A high-performance, radiation-hardened, application-specific integrated circuit (ASIC) is under development at CERN for digitising signals from beam losses monitoring systems in some of the harshest radiation environments at CERN. To fully characterise and validate both the analogue and digital parts of these ASICs, an automated testbed has been developed. Here we report on the components used to build this setup, its capabilities as well as the methodology of the data analysis. Focus is given to the high frequency data collection, the automation and the efficient computation methods developed to extract the merit factors of two different ASIC designs from prototype manufacturing runs.

THPP05 **Properties of Cherenkov Diffraction Radiation as Predicted by the Polarisation Currents Approach for Beam Instrumentation**
***D.M. Harryman**, K.V. Fedorov, P. Karataev (JAI) M. Bergamaschi, R. Kieffer, K.~Łasocha, T. Lefèvre, S. Mazzoni (CERN) L. Bobb (DLS) A. Potylitsyn (TPU) A. Schloegelhofer (TU Vienna)*
Cherenkov-Diffraction Radiation (ChDR) appears when a charged particle moves in the vicinity of a dielectric medium with velocity higher than the phase velocity of light inside the medium. As the charged particle does not contact the medium, the emission of ChDR is a phenomenon that can be exploited for a range of non-invasive beam diagnostics. Experimental tests are underway on the Booster To Storage-ring (BTS) test stand at Diamond Light Source to explore the use of dielectric radiators as Beam Position Monitor (BPM) pickups by measuring the incoherent ChDR emission. In order to compliment the experiments on the BTS test stand, ChDR simulations have been performed using the Polarisation Currents Approach (PCA) model. This paper explores the PCA simulations for the BTS test stand, and the application for future diagnostics.

THPP08 **Development of Abnormal Beam State Monitoring Processor on SSRF Storage Ring**
***L.W. Lai**, Y.B. Leng, Y.B. Yan (SSRF)*
An abnormal beam state monitoring processor has been developed on SSRF, which is based on the hardware of self-developed digital BPM processor. By applying digital signal processing algorithms in the on-board FPGA, the processor keeps monitoring the beam running state. Once abnormal event is detected, the processor will record the abnormal event type and store the turn-by-turn beam position data before and after the event for later analyzing. The abnormal events including beam loss and beam position jump.

THPP10 **Influence of a Bellow to a Cavity BPM for SINBAD**
***D. Lipka** (DESY)*
A cavity beam position monitor acts for the detection of the beam location within a pipe with high precision and best resolution. Some of them are used as a fixed point to refer the other parts of the beamline. To be able to fix the monitor against the other vacuum components bellows need

to be adapted next to the monitor to relax the other part of the vacuum chamber. The bellow itself can create a resonance which would influence the resonator of the cavity beam position monitor. In this study the influence of a the bellow to a cavity beam position monitor is investigated with simulations for a SINBAD project. The result is that the influence to the dipole resonator is below 0.1%.

THPP11 **Study of Multi-Bladed Photon BPM Designs**
Y.E. Tan *(AS - ANSTO)*
New beamlines will be installed at the AS in the next few years and photon BPMs will be part of the front end design. A theoretical study of the potential benefits of a multi-bladed photon BPM design has been simulated using beam profiles from SPECTRA. The results show that it is possible to remove the gap/field dependence of the photon BPM by a least squares fit of the distribution, in this test case a Gaussian distribution, to the beam profile sampled by the multiple blades.

THPP12 **Characterization Study of a Button BPM with an Approach to Automated Measurements**
Y. Verma *(Indian Institute of Science Education and Research) M. Aggarwal, V.J. Joshi, A. Sharma (IUAC)*
Beam position monitors (BPMs) are one of the very im-portant diagnostic components of any accelerator systemgiving information about beam position. It is a class of non-intercepting devices which use the coupling of the EM fieldaround a charged particle bunch to some sort of conductorelectrodes to recover beam position information from thebeam-induced signals. In this paper, a characterization studyof an in-house developed Button BPM including sensitivitymeasurement and transfer impedance studies is presented. Sensitivity measurement was done using the stretched wiremethod by passing current pulses through the wire of differ-ent diameters like 0.5 mm and 1 mm, thus mimicking thebehavior of the actual beam. Sensitivity information wasthen used to reciprocate the 2-D position map of the device. Owning to the time taken for such huge measurements, anautomated BPM test bench approach of the whole setup isdeveloped by remote interfacing over LAN. A substantialdecrease in measurement time was observed along with areduction in measurement error.

THPP13 **Self-Configuring IO Brick for General Purpose Data-Acquisition**
R.W. Dickson *(ORNL)*
This talk will describe a simple, general-purpose data acquisition system that requires minimal configuration and no software programming by the user. The idea is to have a ready system that can be quickly placed in the field to perform a variety of measurements. Support for digital I/O, relays, analog input and output, thermocouple measurement, and strain (bridge) measurements are provided. The system uses National Instruments CompactRIO hardware and communicates to the user via an EPICS interface. All the user need do is plug in the type of modules needed for the measurement, and the system will auto discover this hardware, configure itself and communicate to EPICS EDM (and CSS BOY) screens. The

screens will then also configure for the hardware selected. The system also supports hot-swapping to add or change hardware on-the-fly. Any changes are then reflected in the system's displays. This system is being used in several instances at the SNS in a more permanent capacity than it was intended. In these cases, more specific EDM screens have been developed to visualize the same data that would normally be viewed with the dynamic screens.

THPP14 **Standardising of Application Specific Implementations at the Australian Synchrotron - ANSTO**

***R.B. Hogan**, A. Michalczyk, A. Ng (AS - ANSTO)*

There is a need for a flexible stand-alone device that can be a base platform for a distributed control system. It will need to support a core functionality such as; high-resolution timestamping, standardised software API's and a well defined expansion card interface. We are proposing the Chameleon device that will be designed around a Xilinx Zynq System on Module (SoM) and include a standard VITA 57.1 HPC FMC for application specific functionality. The proposed solution will allow the use of COTS or in-house designed FMC modules and integrate to the control system through a PoE+ interface, allowing both power and communication through the same cable. The Chameleon device is also intended to be plugged into a White Rabbit network to utilise the high performance synchronisation capabilities and timestamping as needed. This device will reduce the cost of implementing application specific solutions, across the accelerator and beamlines, to better support the growing demands of scientific research at the Australian Synchrotron - ANSTO.

THPP15 **Upgrade and Operational Status of Transverse Feedback System at the Canadian Light Source**

***T. Batten** (CLS)*

The Canadian Light Source (CLS) is third-generation Synchrotron with 24 operational beamlines. Instabilities in the storage ring significantly impact both machine and beamline experiments. To improve stability and provide additional diagnostic tools the Transverse Feedback System (TFBS) was upgraded to incorporate Dimtel equipment in October 2019. This system is currently being used to actively damp the transverse betatron oscillations associated with coupled bunch instabilities, for bunch cleaning and for continuous tune measurements using the notch method. This new system has also allowed the facility to move forward with a tune feedback system that is currently being commissioned. The tune feedback system will allow us to stabilize the tune when components in the Storage ring are moving or changing. The Dimtel hardware supports the ability to accurately measure the growth and damping rates for various beam instabilities. In the future we intend to use this system to evaluate the modal instabilities inherent in our machine. This will ultimately allow us to more accurately characterize our machine and provide a more stable light source to our users.

THPP16 **Septum Orbit Feedforward Correction at the AS**

C.N. Lehmann *(University of Queensland) M.P. Atkinson, Y.E. Tan (AS - ANSTO)*

The leakage fields generated by the septum in the injection straight perturbs the beam by as much as 130 µm horizontally and 80 µm vertically during injection. Passive shielding with copper collars and Mu metal sheets has reduced the perturbation but not removed them. The remainder of the perturbation will be corrected using an active feedforward system. This report will discuss the design of the system and the effectiveness of the prototype.

THPP19 **Measurement of Cs_2Te Cathode Response in a High-Gradient Photoinjector**

G. Loisch*, M. Groß, D.K. Kalantaryan, C. Koschitzki, M. Krasilnikov, X. Li, O. Lishilin, D. Melkumyan, R. Niemczyk, A. Oppelt, F. Stephan, G. Vashchenko, T. Weilbach (DESY Zeuthen) Y. Chen (DESY) L. Monaco, D. Sertore (INFN/LASA)*

Cesium-Telluride is a widely used semiconductor photocathode material in electron photoinjectors for its high quantum efficiency and its stability in a high-gradient RF-gun environment. Even though the properties of such cathodes have been studied in the past decades, the emission process is still not fully modeled. One of the parameters that has not been directly quantified in experiment is the lengthening of electron bunches in Cs_2Te with respect to the incident UV laser pulse length - often referred to as cathode response time - due to photon penetration depth variations and scattering processes. Especially for applications such as novel accelerator technologies, ultrafast electron diffraction and free electron lasers with ever higher demands on short bunch durations, the minimum attainable bunch length from the electron gun is a decisive quantity. We present the first direct measurement of Cs_2Te cathode temporal response by measuring electron bunch lengths and profiles with a few tens of femtoseconds resolution at the Photoinjector Test facility at DESY Zeuthen (PITZ). We also show first results on the impact of photocathode properties on cathode response.

THPP20 **Virtual Slit for Improved Resolution in Longitudinal Emittance Measurement**

K.J. Ruisard*, A.V. Aleksandrov, A.P. Shishlo (ORNL)*

A technique to reduce point-spread originating from physical slit width in emittance measurements is described. This technique is developed to improve phase resolution in a longitudinal emittance apparatus consisting of a dipole magnet, energy-selecting slit and bunch shape monitor. In this apparatus, the energy and phase resolutions are directly proportional to the width of the slit, but the virtual slit method enables sub-slit resolution. The bunch phase profile is measured at two points in the energy distribution with a separation less than the physical slit width. The difference of these two profiles is used to reconstruct the profile from a virtual slit of width equal to the separation.

THPP21 **Design and Development of a Novel Stripline Fast Faraday Cup to Measure Ion Beam Profile**

***A. Sharma**, R.K. Gangwar (IIT (ISM)) B.K. Sahu (IUAC)*

Present day heavy ion accelerators use bunched ion beams of sub-nanosecond time scale for beam acceleration. In order to monitor its longitudinal profile, fast faraday Cups are employed. Owing to the advent of microstrip technology and its fabrication process, planar structures have become easier to fabricate. A novel design using the same is developed with a special provision for mounting edge launch connectors through a microstripline, followed by a microstrip to stripline transistion to again a microstrip structure in the beam interaction hole. The entire structure is a 50 Ω & is bidirectional. An experimental study on via placement around central strip has also been conducted to not only ensure the field containment around the strip but also for bandwidth enhancement. To measure ion beam currents from 10-100 nA and a bunch width of < 1ns, device has been beam interaction hole of around 10mm. 3 dB bandwidth is measured >6 GHz with a rise time of ~60 ps. The devices are also provided with a bias ring on the topmost layer of the 3 layer architecture for electron suppression. In this paper, design, fabrication and RF testing stripline fast faraday cup is presented.

THPP22 **A THz-Driven Split Ring Resonator for Temporal Characterization of Femtosecond MeV Electron Beam**

***Y. Song**, K. Fan (Huazhong University of Science and Technology, State Key Laboratory of Advanced Electromagnetic Engineering and Technology,)*

The use of THz-driven split ring resonator (SRR) as a streak camera for sub-ps bunch length measurement has been proposed for a few years. Since then, the feasibility of such a method has been experimentally demonstrated for both keV and MeV electron beam. The structural dimensions of SRR has a substantial impact on the resonance frequency, the field enhancement factor and the interaction region of the streaking field, eventually determining the temporal resolution of the bunch length measurement. Here we discuss the quantitative dependence of the streaking field on the structural dimensions of SRR. Combining with an analytical streaking model, we propose a method to optimize the structural dimensions of SRR such that the finest temporal resolution is achieved with given THz pulse.

THPP23 **Tracking Frequency Reference Phase Changes at Point of Use Based on BPM Measurements**

***A. Tipper**, M.G. Abbott, G. Rehm (DLS)*

Multibunch Feedback systems in Diamond use the RF reference signal to sample the BPM signals. Uncertain reference phase variations due to upstream adjustments to the RF system previously necessitated regular manual realignment of the sampling phase. Locking the sampling phase to the measured beam phase has been investigated to improve the stability and robustness of the system and remove the dependence on absolute RF phase. Significant improvements have been achieved using a

Beam Locked Loop architecture based on an IQ modulator and cartesian feedback to phase align the local 500MHz reference signal to the BPM RF frequency component under closed loop digital control with remote management via EPICS. The system has been successfully deployed on the storage ring at Diamond and has been operating live since October 2019. Live data captured from the operational storage ring demonstrates the ability to tolerate a wide variation in beam phase whilst maintaining accurate beam sampling and robust acquisition of the reference phase over the operating range of beam currents and fill patterns.

THPP24 **Optimization of SRRs Structure for Electron Bunch Length Measurements**

Y. Xu *(HUST)*

Ultra-fast electron pulse meets spatial and temporal resolution requirements for direct real-time observation during ultra-fast processes such as atoms' movement. Bunch length describes a high-quality electron bunch to ensure the parameters of the beam. Split-ring resonators (SRRs) excite intense terahertz (THz) fields, which have been recently proposed to streak electron bunches for their temporal characterization. Compared to the RF deflection cavity, THz fields from SRRs with high amplitude have the potential capability of achieving few-femtosecond temporal resolution. SRR geometries will affect the field strength, resonance frequency and field distribution in the gap, ultimately affect the resolution of the bunch. The most conventional configurations are circular and rectangular SRRs. Besides, there are cases of double C type and multiple SRR superposition. Different structures of SRR have been studied to compare the performance and to improve the temporal resolution of electron bunches.

THPP25 **Measurements of Ion Instability and Emittance Growth for the APS-Upgrade**

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Ions are produced in an accelerator when the beam ionizes residual gas inside the vacuum chamber. If the beam is negatively charged, ions can become trapped in the beam's potential, and their density will increase over time. Trapped ions can cause a variety of undesirable effects, including instability and emittance growth. Because of the challenging emittance and stability requirements of the APS-Upgrade storage ring, ion trapping is a serious concern. To study this effect at the present APS, a gas injection system was installed. A controlled pressure bump of Nitrogen gas was created over a 6m straight section, and the resulting ion instability was studied using several different detectors. Measurements were taken using a pinhole camera, spectrum analyzer, bunch-by-bunch feedback system, and a gas bremsstrahlung detector. Studies were done under a wide variety of beam conditions, and at different pressure bump amplitudes. In this paper we report on the results of some of these measurements, and discuss the implications for present and future electron storage rings.

THPP26 **Transverse broad-band impedance studies of the new in-vacuum cryogenic undulator at BESSY II storage ring**
***M. Huck**, J. Bahrdt, H. Huck, A. Meseck, M. Ries (HZB)*
The first radiation from the cryogenic permanent magnet undulator (CPMU17) has been observed in December 2018 at the BESSY II storage ring at HZB, and since then this device has served as a light source for beamline commissioning. It is the first in-vacuum undulator installed at the BESSY II, and a new in-vacuum APPLE undulator (IVUE32) is planned to be installed in near future. Thus, a detailed study of the interactions between such an in-vacuum device and the electron beam is required. A beam based measurement using orbit bump method has been applied to estimate the vertical impedance of CPMU17. For CPMU17 the first results of broad-band impedance studies are presented.

THPP27 **Study of Current-Dependent Beam Lifetime at VEPP-2000 Electron-Positron Collider Complex**
***M.V. Timoshenko**, E. Perevedentsev, Yu.A. Rogovsky, D.B. Shwartz (BINP SB RAS) E. Perevedentsev, Yu.A. Rogovsky, D.B. Shwartz (NSU)*
The collider complex incorporates a booster ring BEP and a collider ring VEPP-2000. In the both rings, the current-dependence of the beam lifetime is dominated by the Touschek effect where the bunch dimensions are strongly affected by Intra-Beam Scattering (IBS), and therefore their dependence on current forms a self-consistent problem. Another complication comes from combined action of the impedance effect and IBS on the bunch lengthening. We present an experimental analysis of the beam lifetime where the Touschek lifetime needs first to be separated from other contributions.

THPP29 **Application of Wavelet Algorithm in Tune Measurement**
***X. Yang** (SINAP) F.Z. Chen, L.W. Lai (SSRF) **X. Yang** (UCAS)*
Tune is a very important parameter for storage ring of advanced synchrotron radiation facilities. At present, fast Fourier transform (FFT) is the core algorithm of the beam spectrum analysis used in tune measurement. Taking into account the nonlinear effect in the accelerator, tune changes during the process of storage ring injection and booster energy upgrading. However, the Fourier method is used to analyse the global sampling point, and the ability to distinguish the local variation of the tune in the sampling time is poor. This paper leads wavelet analysis method as the core algorithm into beam spectrum analy-sis method, further analyses the change of the tune with beam amplitude in sampling time, and compares this new algorithm with the traditional Fourier method. New experimental results and corresponding analysis for the data from SSRF will be introduced in this paper.

THPP30 **Prototype Development of the Beam Diagnostics Instruments for the HUST-PTF**
***Q.S. Chen**, A.T. Chen, K. Fan, J.Q. Li, X. Liu, B. Qin (HUST)*
A proton therapy facility is under construction in the Huazhong University of Science and Technology (HUST-PTF). The facility is based on a 250 MeV isochronous superconducting cyclotron and uses a graphite-wedged

energy degrader to modulate the beam energy to 70 ~ 240 MeV. This paper reports the current status of the beam diagnostic system development of the transport line. As a compromise between the cost issue and the diagnostic performance, fluorescent screens are used in the fixed beamlines to measure the beam position and profile, while ionization chambers are used in the gantries. Faraday cups are installed in front of each treatment room as a current calibration method and also as a beam stop for emergency. Now the prototypes of the three kinds of detectors have been developed and off-line tested. The design considerations and testing results, as well as the hardware architecture, are introduced.

THPP31 **Consideration and Design of HEPS Beam Instrumentation**

J.H. Yue, *J.S. Cao, Y.Y. Du, J. He, F. Liu, Z. Liu, Y.H. Lu, H.Z. Ma, Y.F. Sui, L. Wang, S.J. Wei, T.G. Xu, J. Yang, Q. Ye, D. Yin, L. Yu, X.E. Zhang, J.X. Zhao, X.Y. Zhao, Y. Zhao, D.C. Zhu (IHEP)*

High Energy Synchrotron Photon Source (HEPS) is an ultra-low emittance light source, of which the energy is 6 GeV, the current is 100-200mA, so it is more difficult to the physics design and hardware design. To the beam instrumentation, sub-micron level beam position measurement and controlling system, sub-micron synchrotron measurement system based x-ray and bunch by bunch feedback system are the technologies which we need to master and to develop. Beam position measurement system is based on digital technology; it is difficult to design and home-made. Emittance measurement of storage is relied on the accuracy measurement of beam profile, of which the resolution is sub-micron level; x ray KB mirror imaging system can meet such high resolution requirement and a good choice. bunch by bunch feedback systems are used to restrin the beam instabilities. In this article, the author introduces the beam instrumentations in detail.

THPP32 **Feasibility Study of a Non-Rad Camera for the SNS Ring Injection Dump Imaging System**

W. Blokland, *A. Rakhman (ORNL)*

The Proton Power Upgrade (PPU) increases the the Spallation Neutron Source (SNS) accelerator power from 1.4 MW to 2.8 MW and calls for a modification of the Ring Injection Dump beam line. The charge exchange injection technique to accumulate proton beam in the SNS ring results in multiple beam spots on the ring injection dump window. To properly setup the new injection beam line, the size and locations of the beam spots must be measured. We plan to use a camera to look at a fluorescent coating made of Chromium Oxide doped Aluminum Oxide. To simplify the optical path, we want to place the camera in the tunnel. While radhard cameras are available, they typically are more expensive and have worse performance. To study the feasibility of non-radhard cameras, we measured the radiation in the tunnel in unshielded and shielded locations. We compare the radiation measurements with results from a CERN HiRadMat study and tested the cameras during full power beam to show that the non-radhard camera is an option for the Ring Injection Dump Imaging System.

THPP33 **Simulation Methods for Transverse Beam Size Measurement Using the Heterodyne Near Field Speckles of Hard X-rays**

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The Heterodyne Near Field Speckles (HNFS) is a special type of interferometry technique where radiation is scattered by nanoparticles suspended in a medium. The scattered waves and the transmitted radiation form an interference pattern, which is modulated by the spatial coherence of the radiation and by the scattering properties of the nanoparticles. The superposition of many such interference patterns results in a speckle pattern, from which the spatial coherence of the radiation and thus the transverse beam profile can be determined. In this contribution we present approaches for simulating the HNFS patterns from hard X-ray radiation and compare then with data from experiments at the ALBA synchrotron.

THPP34 **Calibration and Image Restoration for the Beam Profile Measurement System**

***L.X. Hu**, K.Z. Ding, Y. Song (ASIPP) Y.C. Wu (HFCIM)*

The beam profile parameters are one of the important parameters which represent the beam quality. And the transverse beam profile parameters are closely related to the beam tuning and optimization of the cyclotron. Machine Vision is a branch of computer science that has really grown over the last 20 years. In order to improve the precision and efficiency of beam profile measurement, machine vision techniques have been developed for the analysis and processing of the beam profile images. A new calibration method has been designed for the calibration of the imaging system. Moreover, a new image noise reduction algorithm has been developed to improve the image quality, and then to improve the accuracy of the beam profile parameters measurement. And image restoration algorithm has also been adopted to eliminate the effects of defocusing blur. The experiment results show that the calibration of the imaging system enables the system can provide quantitative information for beam diagnosis. The image noise reduction and restoration algorithm greatly improve the accuracy of beam profile parameters measurement.

THPP35 **Calibration and Resolution Measurement of Beam Size Measurement Stations for the Thomx Project**

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ThomX is a novel compact X-ray light source, utilising a laser and 50 MeV electron storage ring to produce X-ray photons via Compton scattering. Screens, observed by zoom lenses and optical cameras, can be used to monitor the transverse beam profile at various points. An issue with the implementation of this system is that after adjusting the zoom one needs to recalibrate the the optical system, measuring the resolution of the op-

tical system and deducing the transformation from pixel space observed on the camera to geometrical space in the laboratory. To calibrate and measure the resolution limit of the cameras a USAF 1951 resolution chart that can be moved into or out of the screen position is used. We will report on and demonstrate the use of open source computer vision libraries to compute this calibration, and the affine transformation between the camera image plane and the screens can be deduced. We will also comment on how consumer available Canon EF mount lenses may be used as a remote controllable optical system.

THPP36 **Prototype Design of Wire Scanner for SHINE**

J. Wan *(SINAP) F.Z. Chen, J. Chen, B. Gao, Y.B. Leng, K.R. Ye, L.Y. Yu, W.M. Zhou (SSRF)*

SHINE is a high repetition rate XFEL facility, based on an 8 GeV CW SCRF linac, under development in Shanghai. In order to meet the requirements of measuring the beam profile of SHINE in real time and without obstruction, a new diagnostic instrument, wire scanner has been designed. This paper mainly describes the design of wire scanner in SHINE, and some simulation results are also shown and discussed.

FRA001 **Developing Electronics for Radiation Environments**
S. Danzeca *(CERN)*
In every particle accelerators installed, electronics are exposed to a radiation field of mixed particles over a wide range of energies. There are several radiation-induced effects, some of which affect directly the functionalities of the electronic systems, as they have a direct impact upon the accelerator's availability and experiment acquisitions. The risks related to radiation and to a radiation tolerant project flow, are investigated. In addition, the key concepts and challenges are described, aiming for high reliability in a radiation field. Finally, the development methodologies and the radiation hardness assurance procedures will be analysed with examples from the LHC.

FRA002 **Direct Digitization and ADC Parameter Trade-off for Bunch-by-Bunch Signal Processing**
I. Degl'Innocenti*, L. Fanucci (Università di Pisa) A. Boccardi,* ***I. Degl'Innocenti****, M. Wendt (CERN)*
With the technology improvements of analog-to-dgital converters in terms of sampling rate and achievable resolution, direct digitization of beam signals is of growing interest in the field of beam diagnostics. The selection of a state-of-the-art analog-to-digital converter for such a task imposes a trade-off between sampling frequency and resolution. Understanding the dependency of the system performance on these features is fundamental. This paper presents an analysis and design methodology for such architectures. Analytical tools are used to guide the designer and to estimate the system performance as a function of the analog-to-digital converter performance. These estimations are then validated by Monte-Carlo simulations. As an example of this methodology an analysis for the next-generation electronics of the Large Hadron Collider beam position monitoring system is presented. The analytical model and the results obtained are discussed, along with comparisons to beam measurements obtained at the Large Hadron Collider.

FRA003 **BPM Electronics With Self-Calibration at the ALS**
G.J. Portmann*, M.J. Chin, W.E. Norum, J.M. Weber (LBNL)*
As light source electron beam sizes shrink, orbit stability demands increase. There are many factors that contribute to orbit stability. This paper will focus on beam position monitor (BPM) electronics and describe a self-calibration technique implemented at the ALS. The ALS commissioned new BPM electronics about 3 years ago. The electronic design is similar to that of the NSLS-II BPMs. For instance, the digital front end is the same as the NSLS-II design. The ALS team changed the analog front end (although conceptually similar) and the FPGA firmware to further the pilot tone calibration method begun at NSLS-II. The choice of bandpass filters is critical to the success of a pilot tone calibration scheme, as is the digital processing applied to the beam signal and pilot tones. The initial

goal was to accurately track and calibrate slow thermally induced position errors. This capability has been expanded to track and remove differences between the BPM channels up to the system bandwidth of about 5kHz.

FRA004 **Commissioning of the Beam Energy Position Monitor System for the Superconducting RIKEN Heavy-ion Linac**

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The beam commissioning for the RIKEN Heavy-ion Linac (RILAC) upgrade, including the new Superconducting Linac (SRILAC) has been successfully completed. These RILAC upgrade aims at promoting superheavy element searches and the radioactive isotope (RI) production for medical use. When we accelerate the beam by the SRILAC, we must definitely reduce the beam loss under 1 W/m. To constantly monitor the beam nondestructively, we have developed the new system (BEPM) measuring simultaneously not only the beam position but also the beam energy by measuring the time of flight of the beam. This system has the great advantage that can handle time-chopped beam by synchronizing the measurement system with the beam-chopping signal. At the beginning of the commissioning, the beam was chopped to 3% duty to make the SRILAC cavity protected from the beam loss. Even though the beam intensity was 15 enA, the beam position and energy were accurately measured. We measure the beam position to an accuracy of ±0.1 mm and the beam energy to that of several 10^{-4}. Here, we present details concerning the BEPM system and commissioning results.

FRA005 **High Performance Data Acquisition for a Modern Accelerator**

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The modern and state-of-the-art technology provides great potential to acquire accelerator high speed data, and the possibility to fine tune the particle beam. The widely use of embedded controllers, like field-programmable gate arrays (FPGA, enriches the opportunity to collect fast data from accelerator technical subsystem, for example diagnostics and low-level radiofrequency (LLRF) for monitoring, statistics, diagnostics or fault recording of like. A modern embedded controller may contain several gigabytes of memory for such purposes. This presents a number of challenges related to data acquisition and data management to collect, transfer, manage, and utilize a large amount of data from numerous controllers. Currently at APS Upgrade project, a general purpose DAQ system is under active development, which interfaces with a number of technical subsystems to provide time-correlated and synchronously sampled data acquisition for commissioning, performance monitoring, troubleshooting and early fault detection. This paper will present the status and progress of APS-U general purpose DAQ system, and its use cases at APS-U project.

FRA006 **HEPS Storage Ring BPM Development**

S.J. Wei, *J.S. Cao, Y.Y. Du, H.Z. Ma, Y.F. Sui, J. Yang, Q. Ye, J.H. Yue, X.E. Zhang (IHEP)*

Beam Position Monitors BPM is the most important and frequent non-destructive diagnostics used at nearly all synchrotrons. In HEPS project, the BPM electronics have been developed all by the BI group staffs. There are 4 main parts are involved in development: the hardware of AFE (RF analog circuit) and DFE (Digital signal processing circuit), the firmware of algorithm, the data acquisition software (DAS), and the BPM testing system. In order to get a better performance, the RF analog circuit (AFE) is design carefully, and the algorithm (HDL in DFE) has been designed and optimized. At the same time, several related techniques are studied to improve the system long-term resolution, such as the thermally controlled racks, 2-way analog switching, the thermal compensation algorithm, etc. Moreover, testing system for BPM is a very important during the BPM electronics development, in manufacturing stage, it can provide the testing tools for the hardware and firmware. And in system running stage, it can be used for a diagnose tools, calibration tools, and monitoring tools for the BPM system. So the BPM testing system can make the system more robust.

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