ABSTRACTS

11TH INTERNATIONAL CONFERENCE ON MECHANICAL ENGINEERING DESIGN OF SYNCHROTRON RADIATION EQUIPMENT AND INSTRUMENTATION

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MEDSI2020 is hosted by the Advanced Photon Source/Argonne National Laboratory

MEDSI 2020

CONFERENCE TOPICS

- Insertion devices and magnets
- Beamline optics and end-station instruments
- Front ends and XBPMs
- Major facility upgrades
- Simulation techniques
- Core technology in Cryogenic, vacuum, etc.
- High precision mechanics and more

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MOIO — Monday Keynote and Invited Oral

Chair: K. Tavakoli (SOLEIL)

MOIO01 **Superconducting Undulators - A Novel Source of Radiation for Synchrotron and FEL Light Sources**

E. Gluskin *(ANL)*

Superconducting (SC) magnets have been used at many accelerators for several decades. In the last several years noticeable progress in the use of SC undulators (SCUs) at the Advanced Photon Source (APS) has taken place. SCUs outperform most advanced permanent magnet-based undulators. This motivated APS to significantly invest in the development of SCU technology. More than a decade of effort by the APS SCU team has culminated in several engineering advances in cryogenic, magnet, and magnet measurement designs applied to SCUs. Successful SCU prototypes led to construction of three SCUs that are currently quite reliably operated at the APS. Two of them are planar SCUs, and one is a helical SCU. Currently as part of the APS-U project, the APS SCU team builds new SCU systems, each comprising two long SC undulators housed in a 5-m-long cryostat. It also works on a quite challenging device, an arbitrary polarizing SCU called SCAPE. At the same time, the APS team, in collaboration with FNAL and LBNL, is working on the development and construction of a planar Nb_3Sn SCU and will be collaborating with SLAC on the development of an SCU FEL module.

MOIO02 **BM18, The New ESRF-EBS Beamline For Hierarchical Phase-Contrast Tomography**

F. Cianciosi, *A.-L. Buisson, P. Tafforeau (ESRF)*

BM18 is an ESRF-EBS beamline developed for hierarchical tomography, it will combine sub-micron precision and the possibility to scan very large samples. Main applications will be biomedical imaging, material sciences and cultural heritage. It will allow scanning a complete human body at 25 µm, and then to zoom-in in any location down to 0.7 µm. BM18 is exploiting the high-energy-coherence beam of the new EBS storage ring. The X-ray source is a short tripole wiggler that gives a 300 mm-wide beam at the sample position placed at 172 m from the source. Due to this beam size, nearly all the instruments are developed in-house. A new building was built to accommodate the largest synchrotron experimental hutch worldwide. The main optical components are 1D and 2D refractive lenses, slits, filters, and a chopper (2 kHz). No crystal monochromator is present, but combinations of the optical elements will provide high quality filtered white beams, as well as inline monochromator systems. The energy range will span from 30 to 350 keV. In the EH, connected by a 120 m long vacuum pipe ending with a large window, there are a last set of slits, the sample stage and a detector girder. The sample stage can position and monitor with sub-micron precision, while rotating, samples up to 2,5 x 0.6 m and 300 kg; the resulting machine is 4 x 3 x 5 m, and 50 Tons. The detector girder has a 2 x 5 m granite breadboard; it carries up to 9 detectors on individual 2 axis stages, and it moves on air-pads on a precision marble floor up to 38 m behind the sample stage, to perform phase contrast at very high energy on large objects. The commissioning is scheduled beginning of 2022, first friendly users are expected in March 2022 and full operation in September 2022.

26-Jul-21 11:15 – 12:15 Session A

MOOA — Monday Contributed Oral Session A

Chair: J.H. Grimmer (ANL)

MOOA01 Overcoming Challenges During the Insertion Device (ID) Straight Section Component Production and Tuning Phase of the Advanced Photon Source Upgrade (APSU)

J.E. Lerch *(ANL)*

The Advanced Photon Source Upgrade (APSU) scope for insertion devices (IDs) and ID vacuum systems is extensive. Thirty-five of the 40 straight sections in the storage ring will be retrofitted with new 4.8-meter-long Superconducting Undulators (SCUs) or a mix of new and reused Hybrid-Permanent Magnet Undulators (HPMUs). All 35 ID straight sections will require new vacuum systems and new HPMU control systems. Production is well underway at multiple manufacturing sites around the world for these components. Simultaneously, ID assembly and HPMU tuning is occurring onsite at Argonne National Laboratory (ANL). In addition to component production and assembly/tuning activities, our team also started the ID swap out program at the Advanced Photon Source (APS) in late 2020. This program allows us to remove HPMUs intended for reuse from the APS storage ring and retune them to meet the APSU magnetic specifications to reduce the tuning workload during dark time. These activities have presented technical and logistical challenges that are as unique as the components themselves. Additionally, the ongoing Covid-19 pandemic presented unforeseen challenges that required new work processes to be created to sustain pace and quality of work while maintaining the high workplace safety standards required at Argonne. This paper will summarize the many challenges we encountered during the course of the project and how they were overcome.

MOOA02 **Experience with the Vacuum System for the First Fourth Generation Light Source: MAX IV**

E. Al-Dmour, *M.J. Grabski, K.~Åhnberg (MAX IV Laboratory, Lund University)*

The 3 GeV electron storage ring of the MAX IV laboratory is the first storage-ring-based synchrotron radiation facility with small aperture and with the inner surface of almost all the vacuum chambers along its circumference coated with non-evaporable getter (NEG) thin film. This concept implies challenges during the whole project phase from design into operation. The fast conditioning of the vacuum system and over five years of reliable accelerator operation have demonstrated that the chosen design proved to be good and does not impose limits on the operation. A summary of the vacuum system design, production, installation and performance is presented.

MOOA03 **Design Study of Vacuum System for a 4th Generation Storage Ring in Korea**

T. Ha *(PAL)*

It will be presented a new concept vacuum system for a 4th generation storage ring which consists of the distributed pumping and photon absorbing by aluminuim extracted chamber with pill type getters.

26-Jul-21 11:15 – 12:15	Session B

MOOB — Monday Contributed Oral Session B

Chair: M.V. Fisher (ANL)

MOOB01 **ESRF Double Crystal Monochromator - Design and Working Modes**

***R. Baker**, R. Barrett, P. Bernard, G. Berruyer, J. Bonnefoy, M. Brendike, L. Ducotté, H. Gonzalez, T. Roth, P. Tardieu (ESRF)*

The ESRF-Double Crystal Monochromator (ESRF-DCM) has been designed and developed in-house to enable several spectroscopy beamlines to exploit the full potential of the ESRF-EBS upgrade, implemented in 2019 - 2020. To reach concomitant beam positioning accuracy and stability, particular attention has been paid to mechanical and thermal stability, which has imposed the implementation of several innovative design concepts. To meet the extremely challenging specifications of the ESRF DCM implies not only high precision mechanical design, but also a mechatronic system enabling the active correction of the parallelism between crystals. Online metrology, associated with a controller capable of real-time signal processing have been implemented. A prototype has been partially validated and production of the first batch (two ESRF DCMs) is in progress. This presentation will give an overview of the DCM design principles and operating modes, then show how the calibration process is performed in situ on the beamline, using X-rays and associated instrumentation, and will explain the working principle of the active correction mode. To conclude, some characterisations of the DCM performances with X-rays will be presented.

MOOB02 **ALBA BL20 New Monochromator Design**

***A. Crisol**, C. Colldelram, M.L. Llonch, R. Monge, J. Nicolás, L. Nikitina, M. Quispe, L. Ribó, M. Tallarida (ALBA-CELLS Synchrotron)*

LOREA beamline (BL20) at ALBA Synchrotron is a new soft X-ray beamline dedicated to investigate electronic structure of solids by means ARPES technique. Optical design has been developed in-house so as most of beamline core opto-mechanics like Monochromator. The design made for LOREA is based on a Hettrick-Underwood grating type that operates without entrance slit. Experience cumulated over years allowed to face the challenge of designing and building UHV Monochromator. The large energy range of LOREA (10-100 eV) requires a device with 3 mirrors and 4 gratings with variable line spacing to reduce aberrations. Monochromator most important part, gratings system, has been carefully designed to be isolated from external disturbances as cooling water, and at the same time having high performances. Deep analytical calculations and FEA simulations have been carried out, as well as testing prototypes. The most innovative part of Monochromator is gratings cooling with no vacuum guards or double piping that are well-known source of troubles. Heat load is removed by copper straps in contact with a temperature controller device connected to fixed water lines. In addition, motion mechanics and services (cabling, cooling) are independent systems. Designs

involved give high stability (resonance modes over 60Hz) and angular resolution below 0.1 ţrad over 11ž range. On mirrors side, it has been used gonio mechanics from MIRAS plus an eutectic InGa interface between cooling and optics to decouple them. Grating and mirror holders are fully removable from main mechanics to be able to assembled at lab measuring to achieve the best fit. Instrument has been already assembled and motions characterization or stability measurements are giving expected results matching with specifications.

MOOB03 **Bendable KB Type Focusing Mirrors Designed for TPS IR Beamline**

***T.C. Tseng**, H.C. Ho, K.H. Hsu, C.S. Huang, D.-G. Huang, C.K. Kuan, W.Y. Lai, C.J. Lin, S.Y. Perng, H.S. Wang (NSRRC)*

A new IR beamline has been scheduled at TPS beamline construction Phase III. The new beamline optical design is following the structure of the existed TLS IR beamline. However, the focusing mirrors has to be re-deign according to different situation. These KB type mirrors (HFM and VFM) are same thickness flat stainless plates assembled with bending arms and bended with single motor each to fit quintic polynomial surface profiles for focusing and also modifying arc source effect of bending section. For a same thickness plate in addition with the bending arms effect to form a desired polynomial surface profile, it demands specific width distribution. With the drawing method and FEM iteration simulation, the optimized surface polynomial equation and width distribution design of the mirror plates were defined. The detailed design sequences will be described.

MOPB — Monday Poster PM Session B

MOPB01 Power From Insertion Device Reflected by Heat Absorber in MAX IV 1.5 GeV Storage Ring

K.~Åhnberg, *E. Al-Dmour, M.J. Grabski (MAX IV Laboratory, Lund University)*

Temperature readings of a few MAX IV 1.5 GeV vacuum chambers downstream a crotch absorber was higher than expected. Accordingly, SynRad simulations and finite element analysis (FEA) to support the troubleshooting and development of a new absorber design was performed. The heating of the chamber was caused by reflected radiation from the absorber surfaces. The new absorber was manufactured and installed, the temperature levels on the chamber were significantly improved.

MOPB02 Cryogenic Systems for Optical Elements Cooling at Sirius/LNLS

M. Saveri Silva, *M.P. Calcanha, G.V. Claudiano, A.F.M. Fontoura, B.A. Francisco, L.M. Kofukuda, F.R. Lena, F. Meneau, G.B.Z.L. Moreno, G.L.M.P. Rodrigues, L. Sanfelici, H.C.N. Tolentino, L.M. Volpe (LNLS) J.H. Řežende (CNPEM)*

Sirius, the Brazilian 4th-generation light source at the Brazilian Synchrotron Light Laboratory (LNLS), presents high-performance requirements in terms of preserving photon-beam quality, particularly regarding wavefront integrity and position stability. In this context, it is imperative that many silicon optical elements be effectively cooled, such that temperatures and their control-related parameters can be precisely handled to the point in which thermal effects are acceptable concerning figure distortions and drifts at different timescales. For this class of precision equipment, the required performance can only be achieved with robust thermal management. For this, relevant aspects related to the implementation of liquid nitrogen cooling systems need to be emphasized. Currently, two solutions are present at the first-phase beamlines, according to the component thermal load: (1) an in-house low-cost system for components under moderate loads (< 50 W), such as the mirror systems and the four-bounce monochromators, comprising a commercial cryostat connected to an instrumented vessel, whose level and pressure are controlled by the standard beamline automation system that can automatically feed it from a secondary service unit or a dedicated transfer line; (2) a commercial cryo-cooler for high-heat-load applications (50 - 3000 W), such as the double-crystal monochromators. This work presents the in-house solution: requirements, design aspects, operation range, as well as several discoveries and improvements deployed during the commissioning of the CATERETÊ and the CARNAÚBA beamlines, such as the prevention of ice formation, stabilization of both thermal load and flowrate, and auto-filling parameters, among others.

MOPB03 **Commissioning and Prospects of the High-Dynamic DCMs at Sirius/LNLS**

R.R. Geraldes, *J.L. Brito Neto, R.M. Caliari, M.A.S. Eleoterio, S.A.L. Luiz, M.A.L. Moraes, A.V. Perna, M.S. Silva, G.S. de Albuquerque (LNLS)*

The High-Dynamic Double-Crystal Monochromator (HD-DCM) is an opto-mechatronic system with unique architecture, and deep paradigm changes as compared to traditional beamline monochromators. Aiming at unmatching scanning possibilities and positioning stability in vertical-bounce DCMs, it has been developed since 2015 for hard X-ray beamlines at Sirius Light Source at the Brazilian Synchrotron Light Laboratory (LNLS). Two units are currently operational at the MANACA (macromolecular crystallography) and the EMA (extreme conditions) undulator beamlines, whereas a model for extended scanning capabilities in the energy range between 3.1 to 43 keV, the so-called HD-DCM-Lite, is in advanced development stage for two new beamlines, namely: QUATI (quick absorption spectroscopy), with a bending-magnet source; and SAPUCAIA (small-angle scattering), with an undulator source. In this work, online commissioning and operating results of the HD-DCMs are presented with emphasis on: the 10 nrad RMS (1 Hz - 2.5 kHz) pitch-parallelism performance; energy calibration; energy-dependent beam motion at sample; and flyscan with monochromator-undulator synchronization, which is a well-known control challenge at beamlines. To conclude, the Sirius HD-DCM family prospects, including the HD-DCM-Lite, are discussed.

MOPB04 **Four-Bounce Crystal Monochromators for the Sirius/LNLS beamlines**

M. Saveri Silva, *L.M. Kofukuda, S.A.L. Luiz, A.P.S. Sotero, H.C.N. Tolentino (LNLS) L. Martins dos Santos, J.H. Řežende (CNPEM)*

Beamlines of new 4th-generation machines present high-performance requirements in terms of preserving beam quality, in particular wavefront integrity and position stability at micro and nanoprobe stations. It brings about numerous efforts to cope with engineering challenges comprehending high thermal load, cooling strategy, crystal manufacturing, vibration sources, alignment and coupled motion control. This contribution presents the design and performance of a four-bounce silicon-crystal monochromator for the Sirius beamlines at the Brazilian Synchrotron Light Source (LNLS), which is basically composed of two channel-cut crystals mounted on two goniometers that counter-rotate synchronously. The mechanical design ascertained the demands for the nanoprobe and coherent scattering beamlines - namely, CARNAÚBA and CATERETÊ - focusing on solutions to minimize misalignments among the parts, to grant high stiffness and to ensure that the thermal performance would not impair beam characteristics. Hence, all parts were carefully simulated, machined, and measured before assembling. This work details mechanical, thermal, diagnostics, and dynamic aspects of the instruments, from the design phase to their installation and initial commissioning at the beamlines.

26 Jul – Mon

MOPB05 **Stability Performance of the Cryocooled Horizontal Double Crystal Monochromator for DanMAX**

L. Mateos *(FMB Oxford)*

The new 4th generation storage rings beamlines with improved smaller emittance require an increasingly vibrational stability on every beamline component to maintain a high beam quality. The horizontal double crystal monochromators (H-DCM) are specially well suited for these, providing an outstanding beam energy and position stability while coping with high power loads and maintaining UHV conditions. FMB Oxford has recently delivered a new generation cryocooled H-DCM for DanMAX beamline at MAX IV, this is an evolved version of the previous designs already installed at MAX IV and other facilities. The redesign features have improved the excellent stability performance of the system and its usability. Particularly, it includes an axial cooling feedthrough which allow the cooling lines to the optics to remain short and they don't need to accommodate the scanning motion of the crystal cage. After the system was installed in the optics hutch of DanMAX, onsite measurements at operating conditions were performed achieving a relative pitch stability of 22nrad RMS and a vertical stability as low as 3.30nrad RMS. We are awaiting beam stability results to correlate with our findings.

MOPB06 **Installation and Commissioning of the Exactly-constrained X-Ray Mirror Systems for Sirius/LNLS**

L.M. Volpe*, J.L. Brito Neto, C.S.N.C. Bueno, G.V. Claudiano, J.C. Corsaletti, H. Geraissate, R.R. Geraldes, G.N. Kontogiorgos, F.R. Lena, S.A.L. Luiz, B.C. Meyer, G.B.Z.L. Moreno, R.F. Oliveira, A.V. Perna, A.C. Pinto, H. Rigamonti Junior, G.L.M.P. Rodrigues, M.S. Souza, L. Wu, V.B. Zilli (LNLS)*

Innovative exactly-constrained thermo-mechanical designs for beamline X-ray mirrors have been developed since 2017 at the 4th-generation Sirius Light Source at the Brazilian Synchrotron Light Laboratory (LNLS). Due to the specific optical layouts of the beamlines, multiple systems cover a broad range of characteristics, including: power management from a few tens of mW to tens of W, via passive room-temperature operation, water cooling or indirect cryocooling using copper braids; mirror sizes ranging from 50 mm to more than 500 mm; mirrors with single or multiple optical stripes, with and without coatings; and internal mechanics with one or two degrees of freedom for optimized compromise between alignment features, with sub-100-nrad resolution, and high dynamic performance, with first resonances typically above 150 Hz. Currently, nearly a dozen of these in-house mirror systems is operational or in commissioning in 5 beamlines at Sirius: MANACÁ, CATERETÊ, CARNAÚBA, EMA and IPÊ, whereas a few more are expected by the end of 2021 with the next set of the forthcoming beamlines. This work highlights some of the design variations and describes in details the workflow and the lessons learned in the installation of these systems, including: modal and motion validations, as well as cleaning, assembling, transportation, metrology, fiducialization, alignment, baking and cooling. Finally, commissioning results are shown for dynamic and thermal stabilities, and for optical performances.

MOPB07 **Carbon-Steel Radiation Enclosures for the Sirius Beamlines**

***L. Sanfelici**, F.H. Cardoso, D.F. Peixoto, J.E. dos Santos (LNLS) F.A. Bacchim Neto, I.C. Moraes (CNPEM) P. Berkvens (ESRF)*

Carbon steel hutches have shown to be a viable option for medium energy 4th generation synchrotron light sources, being able to cope well with synchrotron, gas-bremsstrahlung and neutrons in most applications, aside from providing mechanical and constructive advantages. After a long period of development in partnership with national companies, Sirius currently has a set of fifteen steel hutches installed and another four in the process of being installed, no lead hutches have been required so far. This work will provide an overview of this project, presenting premises, radiological simulations, cost comparisons, typical module joints/interfaces and some key aspects observed during the design, manufacturing and installation phases. In addition, it will discuss the application this solution in synchrotron and gas-bremsstrahlung spectra of other machines.

MOPB08 **Vibration Assessment at the CARNAÚBA Beamline at Sirius/LNLS**

***C.S.N.C. Bueno**, F.A. Borges, G.R.B. Ferreira, R.R. Geraldes, L.M. Kofukuda, M.A.L. Moraes, G.B.Z.L. Moreno, D.V. Rocha e Silva, M.H.S. Silva, H.C.N. Tolentino, L.M. Volpe, V.B. Zilli (LNLS)*

CARNAÚBA (Coherent X-ray Nanoprobe Beamline) is the longest beamline at Sirius Light Source at the Brazilian Synchrotron Light Laboratory (LNLS), working in the energy range between 2.05 and 15 keV and hosting two stations: the sub-microprobe TARUMÃ, with coherent beam size varying from 550 to 120 nm; and the nanoprobe SAPOTI, with coherent beam size varying from 150 to 30 nm. Due to the long distances from the insertion device to the stations (136 and 143 m) and the extremely small beam sizes, the mechanical stability of all opto-mechanical systems along the facility is of paramount importance. In this work we present a comprehensive set of measurements of both floor stability and modal analyses for the main components, including: two side-bounce mirror systems; the four-crystal monochromator; the Kirkpatrick-Baez (KB) focalizing optics; and the station bench and the sample stage at TARUMÃ. To complement the components analyses, we also present synchronized long-distance floor acceleration measurements that make it possible to evaluate the relative stability through different floor slabs: the accelerator slab, over which the insertion device and first mirror are installed; experimental hall slab, which accommodates the second mirror; and the slabs in satellite building, consisting of three inertial blocks lying over a common roller-compacted concrete foundation, the first with the monochromator and the remaining ones with an station each. In addition to assessing the stability across this beamline, this study benchmarks the in-house design of the recently-installed mirrors, monochromators and end-stations.

MOPB09 **The Design and Manufacturing of Superconducting Undulator Magnets for the Advanced Photon Source Upgrade**

***E.A. Anliker**, Q.B. Hasse, Y. Ivanyushenkov, M. Kasa, Y. Shiroyanagi (ANL)*

The Advanced Photon Source Upgrade (APSU) will include four full length Superconducting Undulators (SCUs). These SCUs require new undulator magnets to achieve the required performance of the new machine. The magnets are fabricated from low carbon steel and wound with NbTi superconductor. To meet the needs of the users of the new machine these magnets will be manufactured in different lengths and magnetic periods to accommodate SCUs in both inline and canted configurations. Because the magnets for the SCUs cannot be shimmed like permanent magnet undulators, they need to have very tight tolerances for the poles and the winding grooves. This poses unique manufacturing and fabrication challenges. This paper will cover the design of the 1.9 m long magnets for the inline SCUs, their measurement data, lessons learned from manufacturing, and an overview of design changes that were made for the magnets to be used in the canted SCU configurations.

MOPB10 **Advanced Photon Source Upgrade (APSU) Superconducting Undulator (SCU) Component Database (CDB) Utilization**

***G.C. Avellar**, E.A. Anliker, J.E. Lerch, M.E. Szubert (ANL)*

The Component Database (CDB) is a database management platform created by the Advanced Photon Source Upgrade (APSU) Project. It serves two major functions, a centralized location to link all data relating to the upgrade and specific components, and to track the components throughout the machine's 25-year lifetime. There are four (4) Superconducting Undulators (SCUs): two (2) Inline 16.5mm period devices, one (1) Canted 16.5mm period device, and one (1) Canted 18.5mm period device. Through the process of engineering these devices, tracking all components between the three (3) different designs of SCUs has proven to be a logistical issue, as there are uniform components among all 4 devices, and many unique components as well. The Assembly Listing function can link and track inventory, helping to maximize efficiency for future procurements, particularly important as Inline SCU #1 functioned as an R&D scope. As the scope evolved to a production process, the CDB has been critical in communicating with a growing team, allowing anyone to identify a part or assembly and access all its design and manufacturing data. The 4.8-meter long SCUs in this scope are the first of their kind, and require thorough onsite inspections, assembly procedurals, and safety protocols, utilizing the electronic traveler feature. Providing a straightforward and clear process for technicians to follow eliminates miscommunication and the risk of unsafe practices. The CDB plays a vital role in simplifying and optimizing the transition of the SCU from an R&D unit to a production scope, from procurement to installation, and throughout the lifespan of machine maintenance.

MOPB11 **The Advanced Photon Source Upgrade (APSU) Straight Section Vacuum Systems First Article Fabrication**

***M.E. Szubert**, E.A. Anliker, G.C. Avellar, J.E. Lerch (ANL)*

The Advanced Photon Source Upgrade (APSU) includes forty (40) straight sections, thirty-five (35) of which will be outfitted with Superconducting Undulators (SCUs) or Hybrid-Permanent Magnetic Undulators (HPMUs). The vacuum systems for these devices are fabricated from aluminum extrusions and are required to provide Ultra-High Vacuum (UHV) continuity between storage ring (SR) sectors for a nominal distance of ~5.4 meters. Each vacuum system has unique fabrication challenges, but both first articles have been produced successfully. The first articles arrived onsite at Argonne installation-ready but have undergone functional testing activities to verify the production and vacuum certification processes. The Insertion Device Vacuum Chamber (IDVC), used in HPMU sectors, is produced by SAES Rial Vacuum (Parma, Italy). The SCU vacuum system components are produced by two vendors, Cinel Instruments (Venice, Italy) and Anderson Dahlen (Ramsey, MN, USA). Based on the reliable outcomes of the first articles, construction of the straight section vacuum systems production units is underway.

MOPB12 **APS Leading Experience in Design of Novel Magnet Structures for Free Electron Lasers and Superconducting Undulators**

***E. Trakhtenberg**, K.J. Suthar, A. Zholents (ANL)*

In the field of designing magnetic devices for the synchrotron radiation facilities including Free Electron Laser (FEL) facilities, the Advanced Photon Source (APS) has played a crucial role. In many instances, APS has been at the forefront of the technology due to dedicated and experienced staff. In this paper, we are going to explain the lesson learned from experienced mechanical engineers' perspectives. This paper provides a bird's-eye view of designing principles of several magnetic devices and undulators in the recent past and is meant to document the principles derived from the wide experience of APS mechanical engineers.

MOPB13 **Automated Mechanical Inspection and Calibration of Insertion Devices in APS Storage Ring**

***N.R. Weir** (ANL)*

A novel technique has been developed to automatically inspect and calibrate the 53 permanent magnet insertion devices in the Advanced Photon Source (APS) storage ring. This technique employs standard frequency domain analysis to create easily identifiable signatures in an actionable format. We will discuss the mechanisms and actions taken behind various observed trends and its application for continuous monitoring and predictive maintenance of these devices. This technique has enabled predictive maintenance and provided new insights into optimizing device performance.

26 Jul – Mon

MOPB15 **A Comparative Evaluation of Front-End Design Requirements**

S.K. Sharma *(BNL)*

Front ends of the NSLS-II storage ring have numerous design requirements to ensure equipment and personal safety aspects of their designs. These design requirements, especially many pertaining to ray tracings, have gradually become overly stringent and a review is underway to simplify them for building future front ends. As a part of this effort we have assembled the front-end design requirements used in several other light sources. In this paper the assembled design requirements are discussed in comparison with those currently in use at NSLS-II.

MOPB16 **Lessons Learned During Sirius' First Beamlines Construction - Improving Processes, Project Management and the Engineering Groups' Organization**

L. Sanfelici*, H.F. Canova, G.P. Esteves, R. Junqueira Leão, B.C. Meyer, M.A.L. Moraes, D.F. Peixoto, G.L.M.P. Rodrigues, H. Westfahl Jr., L. Wu, M.M. Xavier (LNLS) C. Ambrosio (CNPEM)*

Fostering the national industry is a very strong postulate in the Sirius project, the 4th generation Brazilian synchrotron light source with 11 beamlines in different stages of operation (3), commissioning (2) and assembly (6). In 2013, when the development of first beamlines took off, a set of enabling projects were introduced to support the growth, equipping and training of the teams, the acquisition of knowhow in strategic technologies and services, and the development of standardized key-components and systems that could be applied to the 15 planned beamlines. At that time, most of the house experienced professionals were deeply involved in the design of the building and accelerators, accentuating the challenges for the young beamlines engineering team. Although the enabling projects strategy was effective, the rapid transition from the design stage to the production, assembly and installation phases of the first 6 beamlines brought to light bottlenecks that could not be addressed in due time. To exemplify, one can cite the workload with suppliers' management and quality control, flawed receipt and storage of materials, understaffing in the assembly, metrology and installation teams, and competition for resources dedicated to new designs, not to mention the difficulties imposed by the COVID-19 pandemic. This work presents the mitigation to these slowdowns, covering operational and strategic actions such as task forces, organizational changes, processes and interfaces improvements, plus adaptions in the project management. Based on that, the work fronts involved in the design and construction of the next batch of beamlines shall interact smoothly, while the teams gain adequate visibility and control of the processes for each project.

MOPC — Monday Poster PM Session C

MOPC01 Mechanical Design of a Soft X-Ray Beam Position Monitor for the Coherent Soft X-Ray Scattering Beamline

C. Eng, *S. Hulbert, C. Mazzoli, B. Podobedov (BNL) D. Donetski, J. Liu (Stony Brook University)*

Achieving photon beam stability, a critical property of modern synchrotron beamlines, requires a means of high resolution, non-invasive photon beam position measurement. While such measurement techniques exist for hard X-ray beamlines, they have yet to be achieved for soft X-ray beamlines. A new soft X-ray beam position monitor (SXBPM) design based on GaAs detector arrays is being developed and will be installed in the first optical enclosure of the Coherent Soft X-ray Scattering (CSX) beamline at the National Synchrotron Light Source II (NSLS-II). The SXBPM assembly contains four water-cooled blade assemblies, each of which will have a GaAs detector assembly mounted within it, that can be inserted into the outer edges of the CSX undulator beam with sub-micron accuracy and resolution. The primary challenges in design of the SXBPM include: 1) mechanical stability of the assembly, 2) management of the heat load from the undulator X-ray beam to protect GaAs detector assemblies from unwanted illumination, 3) assembly compactness to fit within the first optical enclosure (FOE) of the CSX beamline, and 4) accessibility for modifications. Balancing the unique design requirements of the SXBPM along with their associated constraints has resulted in the design of a non-invasive beam position monitor which will be installed in the CSX FOE as a prototype for testing and iterative improvement. The ultimate goal is development of a widely useful SXBPM instrument for soft X-ray beamlines at high brightness synchrotron storage ring facilities worldwide. The following work seeks to present an overview of the current design of the SXBPM and an analysis of the challenges encountered and the proposed solutions by which they will be addressed.

MOPC02 Minimally Invasive Diamond Fluorescent Screens

S.P. Antipov, *E. Gomez (Euclid TechLabs) S. Stoupin (Cornell University (CLASSE), Cornell Laboratory for Accelerator-Based Sciences and Education) A.M. Zaitsev (CUNY)*

X-ray beamlines at user facilities dynamically change their beam parameters – flux, size, shape and X-ray energy – to meet user needs. The beam optimization procedure requires beam monitoring devices with fast feedback, calibrated flux response and wide dynamic range. We study ultra-thin diamond fluorescent screens for transmission mode scintillator with minimal X-ray absorption for real-time X-ray beam characterization. In this paper we demonstrate a significant enhancement of X-ray excited optical luminescence in a 100-micron-thick diamond plate by introduction of defect states via electron beam irradiation and subsequent high-temperature annealing. The resulting X-ray transmission-mode scintillator absorbs only 3% of incoming hard X-rays (15.9 keV) pro-

viding a linear response to incident photon flux in the range of 7.6×10^8 to 1.26×10^{12} photons/s/mm^2 using exposure times from 0.01 to 5 s.

MOPC03 **Diamond Refractive Optics Fabrication and Other Applications of Laser Ablation for X-Ray Beamline Components**

***S.P. Antipov**, E. Gomez (Euclid TechLabs)*

The next generation light sources will require X-ray optical components capable of handling large instantaneous and average power densities while tailoring the properties of the X-ray beams for a variety of scientific experiments. Diamond being radiation hard, low Z material with outstanding thermal properties is proposed for front pre-focusing optics applications. Euclid Techlabs had been developing X-ray refractive diamond lens to meet this need. Standard deviation of lens shape error figure gradually was decreased to sub-micron values. Post-ablation polishing procedure yields ~ 10nm surface roughness. In this paper we will report on recent developments towards beamline-ready lens including packaging and compound refractive lens stacking. Diamond lens fabrication is done by femtosecond laser micromachining. We had been using this technology for customization of other beamline components. Several application cases will be highlighted in this presentation: diamond anvils, X-ray flow cells and in-beam mirrors.

MOPC04 **Instrumentation Development, Evaluation & Analysis (IDEA) Beamline for the APS-U**

***M.G. Frith**, T. Graber, D. Haeffner, M.J. Highland, M. Ramanathan, O.A. Schmidt, R. Winarski (ANL)*

The Instrumentation Development, Evaluation & Analysis Beamline (IDEA Beamline) will characterize the performance of the state-of-the-art X-ray optics and devices planned for the Advanced Photon Source Upgrade (APS-U). The expected two orders of magnitude increase in brightness along with the increased power density due to the circular aspect ratio of the X-ray beam produced by the Multi-bend Achromat (MBA) magnetic lattice in the upgraded storage ring will set new demanding performance requirements on optical components. The upgrade offers a coherent source that many beamlines will utilize for proposed experimental studies, and it is essential that the chosen optics preserve the coherence of the X-ray beam from undulator to sample. The scientific goal of the IDEA Beamline is to obtain performance metrics for proposed beamline optics and components for the APS-U to ensure the best performance of both the planned featured beamlines and the enhanced beamlines. Questions being explored at the IDEA beamline are wavefront and coherence preservation, monochromator stability, optics surface quality, and effects of high heat loads on optical components. One of the objectives is to directly map monochromator vibration and crystal surface roughness to wavefront degradation. Currently the APS-U does not have a suitable testing location for X-ray optics and components that provides the necessary flux or brightness to simulate the planned APS-U source. The IDEA beamline fills this gap. Measurements will simulate the expected MBA upgraded operating conditions for the tested systems and the data obtained will be used to validate, optimize, or re-engineer for best possible performance.

MOPC05 **Beamline Alignment and Characterization with an Autocollimator**

***M.V. Fisher**, A.A. Khan, J.J. Knopp (ANL)*

A compact electronic autocollimator is a valuable tool that can assist in the initial alignment of optical beamline components such as mirrors and monochromators. It is also a powerful tool for in-situ diagnosing the mechanical behavior of such components. This can include the repeatability of crystals, gratings and mirrors as they are rotated, the parasitic errors of these same optical elements as they are rotated and/or translated and the repeatability and parasitic errors as bendable mirrors are actuated. The autocollimator can even be used to establish a secondary reference in the event that such components require servicing. This paper will provide examples of such alignments, diagnoses and references that have been made with an autocollimator on existing and recently commissioned beamlines at the APS. In addition, this paper will discuss how this experience influenced the specification and subsequent design of the new primary high heat load mirror systems that are currently under fabrication for six of the APS-U feature beamlines. There are a total of 13 individual mirror substrates for these six beamlines. Each mirror was specified to provide in-situ line of sight access for an autocollimator to either the center of the mirror's optical surface or to a smaller polished surface centered on the backside of each mirror substrate. This line of sight will be used for initial alignment of the mirror and will be available for in-situ diagnosing if required in the future.

MOPC06 **Gravity Feed Water Systems for APS Beamline Vibration Sensitive Equipment**

***R.D. Wright**, J.T. Collins, E. Swetin (ANL)*

The stability and performance of vibration sensitive water-cooled components, such as monochromators and mirror systems, may be improved by delivering the cooling water via a gravity-fed water system in place of a more traditional forced flow pumped water system. Although closed loop gravity-fed water systems have been successfully used at the APS for nearly two decades, these systems require routine maintenance in order to maintain proper water quality. A new system design has been developed that allows the gravity-fed water system to act as a closed loop system but operate in an open loop fashion. The open loop system design compared to a recirculating system reduces complexity and significantly reduces maintenance requirements. The new system operates with PID level control, and the PLC control platform interfaces via HMI and EPICS software providing very robust control and monitoring capabilities. The paper will discuss the system design along with the advantages as compared to a recirculating system.

MOPC07 **Weldable Copper Chromium Zirconium Mask Design**

***T.J. Bender**, O.A. Schmidt, W.F. Toter (ANL)*

A novel design for a weldable copper chromium zirconium (CuCrZr) mask has been developed for use in Advanced Photon Source Upgrade (APSU) beamlines. In the past, welding has been avoided for CuCrZr; however, the approach this alternative utilizes promises to drastically reduce cost and lead time over traditional brazed CuCrZr and welded Glidcop mask designs. Multiple thermal analyses of the mask have predicted that it will meet required mechanical and thermal requirements suitable for high heat load applications. As of the writing of this paper, a prototype is being fabricated for installation and testing on the 28-ID Coherent High Energy X-ray (CHEX) beamline.

MOPC08 **Compact X-Ray and Bremsstrahlung Collimator for LCLS-II**

***N.A. Boiadjieva**, D.M. Fritz, T. Rabedeau (SLAC)*

Beam collimation is crucial to maintaining machine and personnel safety during LCLS-II operation. The high density of optics and beam transport components needed to steer the beam to multiple beam lines places a premium on compact collimator design. This presentation discusses a compact collimator consisting of an X-ray beam power collimator, a burn through monitor (BTM) designed to detect failure of the X-ray beam collimator, and a Bremsstrahlung collimator. The collimator body is a monolith machined from CuCrZr (C18150) that eliminates costly braze operations and reduces assembly time and complexity. Sintered high thermal conductivity SiC is employed as the X-ray absorber with design provisions incorporated to permit the inclusion of additional absorbers (e.g. diamond). The allowed FEL beam power is limited to 100W. Finite element analyses ensure that the power absorber remains in safe temperature and stress regimes under the maximum power loading and smallest expected beam dimensions. The beam power will be limited via credited controls placed on the electron beam. Beam containment requirements stipulate the inclusion of a monitor to detect burn through events owing to absorber failure. The BTM is a gas-filled, thin wall vessel which, if illuminated by the beam, will burn through and release the contained gas and trip pressure switches that initiate beam shutdown. The beam absorber and BTM shadow the Bremsstrahlung collimator shielding after appropriate propagation of manufacturing, assembly, and installation tolerances. Tooling is developed to minimize assembly complexity and ensure minimal alignment errors.

MOPC09 **Design of the Beam-Defining Aperture for the ISN Beamline in APS-U**

***T.J. Bender**, S.P. Kearney, J.J. Knopp, J. Maser (ANL)*

The In-Situ Nanoprobe (ISN) beamline, located at 19-ID of the Advanced Photon Source Upgrade (APS-U) Project, will enable the investigation of nanoscale complex, functional materials and materials systems during synthesis, operation, and under actual environmental conditions. A beam-defining aperture (BDA)that can withstand the heat generated at photon energies as high as 30 keV and act as a secondary source point for the instrument located downstream is needed to enable sub-10 nm resolution for successful operation. The BDA consists of two pairs of water-cooled Glidcop bodies that each define the beam aperture in either the horizontal or vertical directions. Each pair resides in a temperature-stabilized enclosure on a support structure designed to minimize thermal drift and maximize vibrational stability.

MOPC10 **Mechanical Design Progress of the In Situ Nanoprobe Instrument for APS-U**

***S.P. Kearney**, S. Chen, B. Lai, J. Maser, T. Mooney, D. Shu (ANL)*

The In Situ Nanoprobe (ISN, 19-ID) beamline will be a new best-in-class long beamline to be constructed as part of the Advanced Photon Source Upgrade (APS-U) project. To achieve long working distance at high spatial resolution, the ISN instrument will be positioned 210 m downstream of the X-ray source, in a dedicated satellite building, currently under construction. The ISN instrument will use a nano-focusing Kirkpatrick-Baez (K-B) mirror system, which will focus hard X-rays to a focal spot as small as 20 nm, with a large working distance of 61 mm. The large working distance provides space for various in situ sample cells for X-ray fluorescence tomography and ptychographic 3D imaging, allows the use of a separate, independent vacuum chambers for the optics and sample, and provides the flexibility to run experiments in vacuum or at ambient pressure. A consequence of the small spot size and large working distance is the requirement for high angular stability of the KB mirrors (5 nrad V-mirror and 16 nrad H-mirror) and high relative stability between focus spot and sample (4 nmRMS). Additional features include fly-scanning a maximum of a 2 kg sample plus in situ cell at 1 mm/s in vertical and/or horizontal directions over an area of 10 mm x 10 mm. Environmental capabilities will include heating and cooling, flow of fluids and applied fields, as required for electrochemistry and flow of gases at high temperature for catalysis. To achieve these features and precise requirements we have used precision engineering fundamentals to guide the design process. We will discuss in detail the current design of the instrument focusing on the precision engineering used to achieve the stability, metrology, and positioning requirements.

MOPC11 **Discrete Photon Absorbers for the APS-Upgrade Storage Ring Vacuum System**

***O.K. Mulvany**, B. Billett, B. Brajuskovic, J.A. Carter, A. McElderry, R.R. Swanson (ANL)*

The APS-Upgrade (APS-U) storage ring arc vacuum system features a diverse set of photon beam-intercepting components, including five discrete photon absorbers and a series of small-aperture vacuum chambers that shadow downstream components. The discrete photon absorbers typically fabricated from electron beam-welded GlidCop AL-15 are subject to heat loads ranging from approximately 560 to 3400 watts, with a peak power density up to approximately 250 watts per millimeter squared at normal incidence. Four of the five photon absorber designs are housed in vacuum chambers, including three that are mounted to

the antechambers of curved aluminum extrusion-based L-bend vacuum chambers and one that is mounted to a stainless steel vacuum-pumping cross. Furthermore, two of the photon absorbers that are mounted to L-bend vacuum chambers are equipped with position-adjustment mechanisms which are necessitated by the challenging design and fabrication of the curved vacuum chambers. The fifth photon absorber, unlike the rest, is a brazed design that is integral in sealing the vacuum system and intercepts approximately 170 watts. Each photon absorber design was optimized with thermal-structural finite element analyses while ensuring functional and spatial requirements were met. Some of these requirements include meeting internal high heat load component design criteria, respecting challenging component interfaces and alignment requirements, and minimizing RF impedance effects. Furthermore, photon beam scattering effects called for the use of scattering shields on three designs to minimize potential heating of vacuum chambers. This paper details the careful balance of functionality, manufacturability, and the overall design process followed to achieve the final designs.

MOPC12 **A New Magnetic Measurement System for the Future Low Emittance NSLS-II Storage Ring**

***M. Musardo**, T.M. Corwin, F.A. DePaola, L. Doom, R. Faussete, D.A. Harder, S.K. Sharma, T. Tanabe (BNL) J. DiMarco (Fermilab) C.L. Doose, A.K. Jain (ANL)*

A new magnetic measurement system is under construction at BNL for accurate field harmonic measurements and fiducialization of magnets for a future upgrade of the NSLS-II storage ring. The entire storage ring is envisioned to be replaced with a new lattice concept, known as Complex Bend, which superimposes dipole and high-gradient quadrupole fields. The magnetic measurement system will use rotating wire and a PCB rotating coil specifically designed for small-aperture (< 15 mm) high gradient magnets. In this paper we describe in detail the mechanical design, the data acquisition hardware and software, the calibration measurement results and the final test and commissioning of the entire measurement system.

MOPC13 **Recent Studies on the Vibration Response of NSLS-II Girder Support System**

***S.K. Sharma**, C.J. Spataro (BNL)*

The designs of various girder support systems were reviewed recently in a MEDSI School tutorial. A comparison of their horizontal transmissibility values in (2-100) Hz band showed that the NSLS-II girder support system had a lower horizontal transmissibility despite its first natural frequency being the lowest (~30 Hz). Detailed vibration tests and FE analyses have been performed to understand this anomaly and to assess the role of viscoelastic damping pads underneath the NSLS-II girders. The analyses were extended to include harmonic response to model viscoelastic properties and random vibrations to obtain relative motions between the magnets. The results of these new tests and FE analyses are discussed in this paper.

MOPC14 **Vacuum Pumping Crosses and Keyhole Vacuum Chambers for the APS Upgrade Storage Ring Vacuum System**

***A. McElderry**, B. Billett, J.A. Carter, O.K. Mulvany (ANL)*

The Advanced Photon Source Upgrade (APS-U) storage ring arc consists of a diverse system of narrow-aperture chambers in compact magnet assemblies with gaps often less than 1 mm. The vacuum system contains two stainless steel pumping crosses and two keyhole-shaped vacuum chambers, as well as eight non-evaporative getter (NEG)-coated aluminum chambers and crosses per sector (40 total sectors). Each chamber contains a 22 mm diameter electron beam aperture, and the keyhole components also feature a photon extraction antechamber. Each design balances functionality, manufacturability, and installation needs. The design process was aided by a flexible CAD skeleton model that allowed for easier adjustments. Synchrotron radiation heat loads applied to inline chamber photon absorbers and photon extraction beam envelopes were determined via a 3D raytracing CAD model. The inline photon absorber and the keyhole shapes were optimized using iterative thermal-structural FEA. Focus was put into mesh quality to model the <0.5 mm tall synchrotron radiation heat load absorbed across the length of the chamber to verify cooling parameters. The design process also required careful routing of the water system and vacuum pumps. The designs incorporate beam physics constraints of the inline absorbers, cross-housed discrete absorbers, and pumping slots. The group of chambers require complex manufacturing processes including explosion bonding, EDM, NEG and copper coating, extruded and drawn tubing, e-beam welding, challenging TIG welding, UHV cleaning, and critical dimensional measurements. The 528 chambers entered the production phase starting in 2019 with some design evolution reflecting the vendors' capabilities. This paper details the design, analysis, and manufacturing of these chambers.

MOPC15 **Mechanical Design of ALS-U Swap-out Kicker Stripline Electrodes**

***T. Oliver** (LBNL)*

The Advanced Light Source Upgrade (ALS-U) is an ongoing upgrade of the ALS facility at Lawrence Berkeley National Laboratory. The project utilizes an on-axis swap-out injection between a new Storage Ring (SR) and a full-energy Accumulator Ring (AR) to enable small dynamic apertures to deliver higher brightness. The ALS-U injection scheme plans to use a pulsed stripline kicker design based off of a successful research and development kicker that was installed on the existing ALS Storage Ring. A key challenge in the ALS-U Swap-out kicker is optimizing the distance between the electrodes to balance the benefits of tight spacing to lower required pulser voltage and the challenges to the mechanical design that comes from higher electrode thermal expansion due to increased synchrotron and beam induced heating. Structural and thermal analysis shows that adapting high emissivity coatings, an accommodating mechanical supports design and using molybdenum as an electrode material provide a robust solution.

MOPC16 **Validation of APS-U Magnet Support Design Analysis and Prediction**

***Z. Liu**, J. Nudell, C.A. Preissner (ANL)*

The Advanced Photon Source Upgrade (APS-U) accelerator magnets have stringent stability requirement. The project schedule and budget did not allow for full prototyping of the final design. Therefore, the engineers relied on accurate simulation to ensure that the design would meet the specifications. Recently, assembly and free-boundary vibration tests have been done on the first article of the upstream quadrupole Doublet, Longitudinal gradient dipole and Multipole module (DLM-A). The free-boundary condition modal test results were used to validate the FEA analysis used in the DLM-A design. This validation then confirms the predicted performance of the magnet support system design. Mode shapes and corresponding frequencies from the FEA modal analysis agree with the experimental modal analysis within an acceptable tolerance. The validation approves not only the procedure for accurate modeling of magnet support system that APS-U has developed, but also provides confidence in predicting the accelerator performance.

TUIO — Tuesday Keynote and Invited Oral

Chair: L. Zhang (SLAC)

TUIO01 **System and Subsystem Engineering of Long Baseline Detectors**

F. Matichard *(LBNL)*

This talk will give an overview of the system and subsystem engineering and development of long baseline detectors, with a focus on neutrino experiments such as DUNE, and gravitational wave detectors such as LIGO. It will emphasize common features to the development and execution of these decade long programs, across the various phases of technology development and system integration. It will highlight key features of the development process to handle the complexity of these large systems. The presentation will cover the various phases of the system development, starting from definition of requirements and general system architecture, driven on the one hand by high level science goals and on the other hand by technology readiness. Continuing with the conceptual design phases, and the selection of most suitable technology to meet not only the science requirements, but also the project constraints on cost and schedule, and operations goals on duty-cycle, reliability and longevity. We will cover the important steps of prototyping and testing necessary to demonstrate technology readiness and to inform the final design. Following up with phases of interface definitions in between sub-systems and with conventional facilities, and related system integration steps. We will describe the final design and engineering phases with respect to the subsequent steps of installation, testing, commissioning and operations.

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TUIO02 Mechatronics Approach for the Development of a Nano-Active-Stabilization-System

T. Dehaeze, *J. Bonnefoy (ESRF) C.G.R.L. Collette (ULB)*

With the growing number of fourth generation light sources, there is an increased need of fast positioning end-stations with nanometric precision. Such systems are usually including dedicated control strategies, and many factors may limit their performances. In order to design such complex systems in a predictive way, a mechatronic design approach also known as "model based design", may be utilized. In this paper, we present how this mechatronic design approach was used for the development of a nano-hexapod for the ESRF ID31 beamline. The chosen design approach consists of using models of the mechatronic system (including sensors, actuators and control strategies) to predict its behavior. Based on this behavior and closed-loop simulations, the elements that are limiting the performances can be identified and re-designed accordingly. This allows to make adequate choices concerning the design of the nano-hexapod and the overall mechatronic architecture early in the project and save precious time and resources. Several test benches were used to validate the models and to gain confidence on the predictability of the final system's performances. Measured nano-hexapod's dynamics was shown to be in very good agreement with the models. Further tests should be done in order to confirm that the performances of the system match the predicted one. The presented development approach is foreseen to be applied more frequently to future mechatronic system design at the ESRF.

TUOA — Tuesday Contributed Oral Session A

Chair: K.J. Suthar (ANL)

TUOA01 **Surface Twist Characterization and Compensation of an Elliptically Bent Hard X-Ray Mirror**

Z. Qiao, *J.W.J. Anton, L. Assoufid, S.P. Kearney, S.T. Mashrafi, J. Qian, X. Shi, D. Shu (ANL)*

Deformable optics, including mechanically-bent and bimorph mirrors, are essential optical elements for X-ray beam dynamical focusing and wavefront correction. Existing mechanical bender technology often suffers from poor repeatability and does not include twist compensation. We recently developed an elliptically bent mirror based on a laminar flexure bending mechanism that yielded promising results. In this work, the mirror surface twist was characterized using a Fizeau interferometer under different bending conditions. By applying a shimming correction, the surface twist was successfully reduced from 50 urad to 1.5 urad. The twist angle variation from no bending to the maximum bending is less than 0.5 urad. Our simulation results show that these numbers are significantly lower than the required values to ensure optimum optical performance. The study demonstrates the effectiveness of the twist compensation procedures and validates the mirror bender design parameters.

TUOA02 **Conceptual Design of the Cavity Mechanical System for Cavity-Based X-Ray Free Electron Laser**

D. Shu, *J.W.J. Anton, W.G. Jansma, S.P. Kearney, K.-J. Kim, R.R. Lindberg, S.T. Mashrafi, Yu. Shvyd'ko, W.F. Toter, M. White (ANL) H. Bassan, F.-J. Decker, G.L. Gassner, Z. Huang, G. Marcus, T.-F. Tan, D. Zhu (SLAC)*

The concept behind the cavity-based X-ray FELs (CBXFELs) such as the X-ray free-electron laser oscillator (XFELO) and the X-ray regenerative amplifier free-electron laser (XRAFEL) is to form an X-ray cavity with a set of narrow bandwidth diamond Bragg crystals. Storing and recirculating the output of an amplifier in an X- ray cavity so that the X-ray pulse can interact with following fresh electron bunches over many passes enables the development of full temporal coherence. One of the key challenges to forming the X-ray cavity is the precision of the cavity mechanical system design and construction. In this paper, we present conceptual design of the cavity mechanical system that is currently under development for use in a proof-of-principle cavity-based X-ray free electron laser experiment at the LCLS-II at SLAC.

TUOA03 Zero-Length Conflat Fin-Type Nonevaporable Getter Pump Coated with Oxygen-Free Palladium/Titanium

Y. Sato *(Yokohama National University, Graduate School of Engineering Science) A.H. Hashimoto, M. Yamanaka (NIMS) T. Kikuchi, K. Mase (KEK) T. Miyazawa (Sokendai, The Graduate University for Advanced Studies) S. Ohno (Yokohama National University)*

We have developed a zero-length conflat fin-type nonevaporable getter (NEG) pump that uses oxygen-free palladium/titanium (Pd/Ti). After baking at 150 degrees centigrade for 12 h, the pumping speeds of the NEG pump for H_2 and CO were 2350~800 L/s and 1560~20 L/s, respectively, in the pumped-quantity range 0.01~30 Pa L. The morphologies of oxygen-free Pd/Ti films on the partition plates and the base plate were examined by scanning electron microscopy, scanning transmission electron microscopy, and energy-dispersive X-ray spectroscopy. The Ti was completely coated with Pd on the bottom, whereas the partition plates were covered by Pd/Ti nanostructures. Our new NEG pump is ideal for maintaining ultrahigh vacuums in the range 10^{-8} to 10^{-9} Pa, because (a) its pumping speeds for H_2 and CO are quite large, (b) it can evacuate H_2O and CO_2 when an ionization gauge is used in the vacuum system, (3) it can be activated by baking at 150 degrees centigrade for 12 h, (c) its pumping speed does not decrease even after 9 cycles of pumping, baking, cooling to room temperature, and exposure to air, (5) it requires neither a dedicated power supply nor electric feedthroughs, and (6) it is space saving and lightweight.

TUOB — Tuesday Contributed Oral Session B

Chair: C.A. Preissner (ANL)

TUOB01 **Exactly-constrained KB Mirrors for Sirius/LNLS Beamlines: Design and Commissioning of the TARUMÂ Station Nanofocusing Optics at CARNAÚBA Beamline**

G.B.Z.L. Moreno, *C.S.N.C. Bueno, R.R. Geraldes, F.R. Lena, S.A.L. Luiz, H.C.N. Tolentino, Y.R. Tonin (LNLS)*

Next-generation nanoprobes, empowered by diffraction-limited storage rings, as Sirius/LNLS, present high-performance requirements aiming at high spatial resolution and throughput. For the focusing optics, this means assuring a small and non-astigmatic probe, high flux density, and remarkably high position stability, while also preserving beam wavefront. At stations further dedicated to spectromicroscopy and in-situ experiments, these requirements add up to having achromatic design and suitable working distance, respectively. In this way, Kirkpatrick-Baez (KB) mirrors have been chosen as the most appropriate solution for Sirius focusing optics. At TARUMÂ, the first delivered nanoprobe at Sirius, the KB focuses the beam down to a 120 nm spot size (>8 keV) with a 440 mm working distance. This brought the requirements on the mirror's angular stability to less than 10 nrad RMS, surface quality to single-digit nanometers, and alignment tolerances to the range of hundreds of nrad, which can be even tighter for other nanoprobes. Such specifications are particularly challenging regarding clamping, vibration, and thermal expansion budgets, even testing optical metrology limits during alignment and validation phases. The resulting KB mechanism is an opto-mechanical system with an exactly-constrained, deterministic design, and suspension modes well above 250 Hz, sufficiently coupling optics to sample in the same 6-DoF base. It provides low-order aberration corrections by single degree-of-freedom alignment with piezo actuators, while higher order aberrations from clamping and thermal deformations are mitigated by gluing each mirror to flexure-based mounting frames. This contribution presents the design, assembly, and commissioning of the KB system at TARUMÂ as a reference case.

TUOB02 **Development of a Passive Tuned Mass Damper for Ultra-High Vacuum Beamline Optics**

F. Khan, *D. Crivelli, J.H. Kelly, A. Male (DLS)*

Vibration in beamline optics can degrade the quality of experiments: the resulting movement of a mirror increases the X-ray beam position uncertainty, and introduces flux variations at the sample. This is normally dealt with by averaging data collection over longer periods of time, by slowing down the data acquisition rates, or by accepting lower quality / blurred images. With the development of faster camera technology and smaller beam sizes in next generation synchrotron upgrades, older optics designs can become less suitable, but still very expensive to redesign. Mechanically, mirror actuation systems need to be a balance between repeatability

of motion and stability. This normally leads to designs that are 'soft' and have resonant modes at a relatively low frequency, which can be easily excited by external disturbances such as ground vibration and local noise. In ultra-high vacuum applications the damping is naturally very low, and the amplification of vibration at resonance tends to be very high. At Diamond we designed a process for passively damping beamline mirror optics. First, we analyse the mirror's vibration modes using experimental modal analysis; we then determine the tuned mass damper parameters using mathematical and dynamic models. Finally, we design a flexure-based metal tuned mass damper which relies on eddy current damping through magnets and a conductor plate. The tuned mass damper can be retrofitted to existing optics using a clamping system that requires no modification to the existing system. In this conference paper we show a case study on a mirror optic on Diamond Light Source's small molecule single crystal diffraction beamline, I19.

TUOB03 **Ultra-Precision Mechanics for Fourth-Generation Sources**

R. Doehrmann, *S. Botta, P. Wiljes (DESY)*

Fourth-generation synchrotrons, with their extremely good beam conditions, offer experimental possibilities that go far beyond the current technological state of the art. These extremely brilliant X-ray sources enable, among other things with new focusing optics, focal sizes in the nanometer range with the highest intensity and thus allow for highly dynamic experiments also on this scale. In order to guarantee the required beam quality all the way down to the experiment, optimal conditions must be generated for the end stations and for the beamline optics. An optimum of stability and precision can unfortunately only be achieved if, on the one hand, the infrastructure that shields the experiments and enables undisrupted operation is planned very carefully. On the other hand, the scientific instruments must also be optimized and improved. Our strategy for the construction of the PETRA IV experiments is based on five pillars (low vibration, stable environment, rigid construction, optimized design and fast feedback). In this contribution, we describe these concepts in more detail. Furthermore, we present illustrative examples of a possible implementation at PETRA IV.

TUPA — Tuesday Poster AM Session A

TUPA01 Oxygen-Free Ti Thin Film as a New Nonevaporable Getter (NEG) with an Activation Temperature as Low as 185 °C

M. Ono, *I. Yoshikawa, K. Yoshioka (University of Tokyo) T. Kikuchi, K. Mase (KEK) , K. Mase (Sokendai, The Graduate University for Advanced Studies) Y. Masuda, Y. Nakayama (Tokyo University of Science) S. Ohno (Yokohama National University) K. Ozawa (TIT) Y. Sato (Yokohama National University, Graduate School of Engineering Science)*

Although nonevaporable getter (NEG) pumps are widely used in synchrotron radiation facilities, pure metal Titanium (Ti) has not been used as a NEG because the activation temperature of a Ti thin film deposited by DC magnetron sputtering was reported to be 350-400 °C. Recently Miyazawa et al. found that high-purity Ti deposited under ultra-high vacuum (UHV) followed by N_2 introduction works as a NEG with an activation temperature of 185 °C. Since the concentration of impurities such as O, C, and N in the Ti thin film prepared by this method is 0.05% or less, we named this as oxygen-free Ti. In this study, we evaluated the pumping properties of oxygen-free Ti thin films after high-purity N_2 introduction by total and partial pressure measurements. A vacuum vessel with oxygen-free Ti deposited on the inner walls was found to pump H_2, H_2O, O2, CO and CO_2 even after 30 cycles of high purity N_2 introduction, air exposure, pumping, and baking at 185 °C. Furthermore, we analyzed the oxygen-free Ti thin films after high-purity N_2 or air introduction by synchrotron radiation X-ray photoelectron spectroscopy. The results show that more TiN was formed when high-purity N_2 was introduced after oxygen-free Ti deposition. High purity of the Ti thin film and TiN formation on the surface seem to be responsible for the reduced activation temperature as low as 185 °C.

TUPA02 Design of Remote Helium Mass Spectrometer Leak Detector

H.Y. He, *H. Song (IHEP) G.Y. Wang (IHEP CSNS)*

Leak detection is the key to get a good vacuum system. For the dangerous areas, or facility with complicit structure required to be detected online, it is a hard mask to seek for the suspected leaks one after another. After studying the basic principle of helium mass leak detection, design a remote leak detector based on the PLC, as well as multi monitoring cameras, which can achieve successful injection and sniffer probe leak detection in the range of 270 degree. Compared with the manual operation, this device aims at accurately and reliably detecting leak rate, which can greatly provide technique support of online leak detection. And it can bring the value of reducing the labor intensity and ensuring personal safety.

27 Jul – Tue

TUPA03 **Design of Johann-Type Five Crystal Spectrometer Using a Single Motor Axis**

***H. Cherukuvada** (AS - ANSTO)*

This is a design exploration of 5 crystal spherically bent Johann-type spectrometer to be used on Spectroscopy based beam-lines. Traditionally, a 4-axis motorised unit is required for each crystal and a 3-axis unit is required for detector positioning, making the total motorized axis greater than 23 for the spectrometer. This design is an attempt to follow the Roland circle/geometry paths using multi-bar linkage mechanisms requiring only one motorised axis for the whole system. The proposed system is comprised of 3 separate but inter-linked mechanisms driven by a one motor. Design Specification: Ø100 x 5-spherically bent crystals, repeatability ±50 µm, SDD detector, 500 mm Roland circle. The intent of the design is to simplify operation, reduce weight, reduce complexity, reduce costs and reduce maintenance aspects as compared to how it is done in current commercially available systems. This design a radical re-think of the Johann-type spectrometer mechanics.

TUPA04 **Invistigations on Beamline Optics Support Structure Stability**

***W.F. Sheng**, H. Liang (IHEP)*

With the development of the 4th generation light source, the stability of beamline optics is cruicial to the beamline performance. The vibration transmitting behavior of supporting structure contributes a lot to the stability of the optics. To design better optics, several types of support structures was tested, and the transfer behavior was calculated. The result shows that a wedge generally has the lowest transfer rate, and certain type of support should be avoided.

TUPA05 **Research on Vibration Stability of SAPS Foundation**

***G.Y. Wang** (IHEP CSNS) L. Kang, R.H. Liu (IHEP)*

The construction of the South Advanced Light Source Platform will be completed in 2021. Among them, the high-precision test hall requires that the effective value of the micro-vibration of the foundation be controlled within the vibration range of 25nm, which has already met the requirements of nanometer level. Research at dongguan machinery group, therefore, in view of the high precision testing hall, south of advanced light source is proposed to geological environment factors, carry out detailed geological survey measurement, focus on the advanced light source foundation vibration test, resistance to vibration and vibration characteristics research foundation and anti-vibration scheme research and the advanced light source is the key equipment vibration reduction technology research, through to the light source address of the proposed foundation vibration test, the vibration of foundation design, synchrotron radiation device key equipment comprehensive analysis and research of vibration reduction technology, formed a series of foundation vibration and key equipment solution, for the later construction of the southern light source to lay a solid foundation.

TUPA06 **Study the Active Vibration Control System of the Parallel 6-DOF Platform**

***R.H. Liu**, G.Y. Wang (Institute of High Energy Physics, CAS) H.Y. He (IHEP CSNS) L. Kang (IHEP) J.B. Yu (DNSC)*

The parallel 6-DOF platform has the characteristics of high adjustment precision and high stiffness ratio that can be widely used in the attitude adjustment system of the synchronous radiation source precision equipment. The active vibration control system bases on parallel 6-DOF platform can effectively isolate the external low-frequency micro-vibration interference of the Synchrotron Radiation Source's equipment. But control of the parallel vibration isolation platform is generally difficult which is due to the strong coupling among its input and output channel. Firstly, the dynamic model of the parallel 6-DOF platform is established by Newton-Euler method which is based on the kinematic decoupling of the platform. Secondly, the coupling characteristics between the channels of the platform are analyzed in detail. Effectiveness of the decoupling approach is verified through the secondary channel identification and vibration isolation experiments in the end. And the experiments' results show that the vibration of the platform are attenuated obviously by the active control.

TUPA07 **Ground Vibration Measurements and Analysis for the SHINE Project**

***F. Liu**, Z. Wang (ShanghaiTech University) R. Deng, N. Mao, L. Zhang, W. Zhu (Shanghai Advanced Research Institute) Y. Liu (Shanghai Institute of Optics and Fine Mechanics)*

The Shanghai HIgh repetitioN rate XFEL and Extreme light facility (SHINE) is the first hard X ray free electron laser facility in China. The facility is located in Zhanghai HighTech Park in Shanghai, with a total length of 3.1 km, consisting of three tunnels which are around 29 meters underground and 5 shafts. The 1st shaft is for injection, the 2nd shaft is for electron switches, the 3rd shaft is for beam dumps, the 4th shaft is the near experimental hall, while the 5th shaft is the far experimental hall. As such a long facility, the stability caused by the environmental vibrations is always a big concern. In this report, several vibration sensors, including accelerometers, seismometers, and velocity sensors were compared to find out the frequency range of the sensors. The vibration on the ground of the 1st shaft as well as underground were measured and analyzed. Furthermore, the ground vibrations were also compared with SSRF and SULF. To investigate the ground vibration effect on the beam transportation, the real vibration PSDs were imported into finite element analysis (FEA) model for random vibration analysis, the angular vibrations of the model were analyzed and tested.

TUPA08 **Performance of a Double Crystal Monochromator with Water Cooling**

***H. Liang**, W.F. Sheng, H. Shi, L.R. Zheng (IHEP)*

The performance of monochromator affects directly to the beamline performance, especially in a 4th generation synchrotron beamline. To find out the performance of the monochromator prototype built for the HEPS project, it was tested online with water cooling. The short term stability was tested with synchrotron beam under various cooling condition, and the result between 4.4 nrad to around 400 nrad were observed. The energy drift in 9 hours since the beam hit the beamline was 0.4 eV at the Cu K edge. The reapeatability in 1 hour was about 0.1 eV. The cooling of the crystals was measured by rocking curve broadening at different energy and no alarming result was observed. Also the temperature stability in the optical hutch was measured for a long term. In conclusion, some requirements of the HEPS beamlines can be met, but more improvements should be carried out accordingly.

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TUPA09 **Beamline Design Consideration on the Thermal Deformation for High Energy Photon Source**

***F.G. Yang**, Y.H. Dong, L. Gao, M. Li, W.F. Sheng, H.R. Wang, X.W. Zhang (IHEP)*

To exploit the high quality of the X-ray beam generated by the new advanced light source, high precision optics instruments are necessary. However, the heat-loading optics including monochromator and white beam mirror have been a big issue, which introduces the wavefront distortion. In this paper, we present the effect of the thermal deformation on the beamline performance, and show the simulation results in our new high energy source - HEPS. Accordingly, the requirement of the thermal deformation is provided for different application.

TUPA10 **Design of Magnet Girder System for Siam Photon Source II**

***O. Utke** (Synchrotron Light Research Institute (SLRI)) S. Chaichuay, S. Klinkhieo, S. Pongampai, P. Sittisard, S. Srichan (SLRI)*

The new Siam Photon Source II (SPS-II) storage ring is designed with a circumference of 327.502 m. It consists of 14 DTBA cell, where each cell requires 6 magnet girders. For the new storage ring of SPS II we developed a magnet girder system which uses wedgemounts for the precision alignment. The girder alignment uses a 3-2-1 alignment method and requires 3 wedgemounts to control Z direction, 2 wedgemounts to control Y-direction and 1 wedgemount for the X-direction. The magnet alignment is based on mechanical tolerances. Therefore, the girders top plate is prepared with precision surfaces with a flatness tolerance of 30 µm. During the development process of the girder system deformation and vibration FEA analysis were carried out and the results were used to improve the design regarding low deformation and high natural frequencies. In this paper FEA analysis results are presented as well as the design of the girder, pedestal and its wedgemount based alignment system.

TUPA11 **Development of Long Trace Profiler at Synchrotron Light Research Institute**

S. Srichan, *M. Phanak, P. Photongkam, N. Wongprachanukul (SLRI)*

Synchrotron Light Research Institute (SLRI) is the national synchrotron research facilities of Thailand. The Long Trace Profiler (LTP) has been developing to measure the curvature of X-ray mirror for the optical metrology laboratory since 2018. The main design configuration includes a moving optical sensor head, an air-bearing slide and adjustable mirror stand. It can support a length of mirror up to 1.5 meters with slope accuracy <1 µrad RMS. Recent development is measurement correction process. This paper describes the specifications and capability of LTP at SLRI. To achieve the correction process, we have added and modified some parts of the system, this process also described.

TUPA12 **The Design and Prototype Test for the Tunnel Foundation of High Energy Photon Source**

F. Yan *(IHEP)*

HEPS is being built in China with challenging beam stability requirements. To fulfill the 25nm ground motion restriction on the main tunnel slab, two prototype slabs with different design schemes were constructed on the HEPS site. The first scheme adopted an 1m reinforced concrete with replacement layer of an 1m sand and stone underneath. The second scheme employed an extra 5m grouting layer below the previously mentioned two layers. A series of tests had been carried out. The prototype slab with grouting layer is testified to have comparable vibration level with the bare ground, which is under 25nm without traffic inside the HEPS campus, while the vibration level is amplified a lot on the other prototype slab. However it is hard to make the grouting layer homogeneously under the kilometer-scale tunnel and besides the cost is unacceptable for 5m grouting with such a large scale. The finalized design is fixed to be an 1m reinforced concrete slab and 3m replacement layer underneath using plain concrete. In this paper, the design and the test results will be presented, and new problems raised during the construction will also be mentioned.

TUPA13 **The Research of Bellow Shield Structure Applied to the BPM**

X.J. Nie, *L. Kang, R.H. Liu, S.K. Tian (IHEP) J.X. Chen, H.Y. He, L. Liu, C.J. Ning, A.X. Wang, G.Y. Wang, J.B. Yu, Y.J. Yu, J.S. Zhang, D.H. Zhu (IHEP CSNS)*

The design of shield structure for bellow is an important content for the research of beam position monitor (BPM). The bellow shield structure consists of contact fingers and spring fingers. The minimum dimension of the shield structure was decided based on the length of BPM with the stress condition. Several alternative schemes for bellow shield were achieved based on BPM detailed structure. The optimal scheme was achieved by the impedance simulation analysis with CST. Based on the final scheme, the prototype was manufactured for further research.

27 Jul – Tue

TUPA14 **Stability Study of HEPS Storage Ring Magnet Support**

***Z.H. Wang**, C.H. Li, H. Wang (IHEP)*

The stability of the beam is affected by the stability of the magnet girder. The High Energy Particle Source requires that the natural frequency of the storage ring magnet girder be better than 54Hz. In order to meet the stability requirement, the connection stiffness of the girder and the fixed stiffness of the plinth are studied in this paper. The main contents of this paper includes: dynamic stiffness test, the prototype of the plinth fixed stiffness test. According to the test results and finite element simulation method, the stability of magnet girder is guaranteed.

TUPA15 **Design of the HEPS GRID-XBPM Prototype**

***J.B. Yu**, R.H. Liu (IHEP CSNS) L. Kang (IHEP)*

In order to optimize the detection electronics in the actual front-end and test the properties of mechanical and stability, the GRID-XBPM prototype is designed, and it will be installed at BSRF-1W2 in August. This paper will show the design of the prototype.

TUPA16 **Design and Development of the Advanced Diffraction and Scattering Beamline at the Australian Synchrotron**

***B.J. McMahon** (AS - ANSTO) B. Mountford (ASCo)*

The ADS beamlines are the fifth and sixth beamlines being built within the Australian Synchrotron/ANSTO BRIGHT program The two beamlines (ADS-1 and ADS-2) will operate independently with the beam generated by a powerful super-conducting multipole wiggler (SCMPW). ADS-1 will have tunable collimating optics that will combine with a fixed exit double crystal Laue monochromator (DCLM) to provide white, pink and monochromatic beam (50-150 keV) to a large end-station located outside the main synchrotron building. ADS-1 will accommodate experiments using a variety of sample stages capable of positioning large and heavy samples (up to 300 kg). The second ADS beamline, ADS-2, will take a deflected beam from the main beam using a side-bounce monochromator (SBM) that produces three monochromatic energies from 45 keV–90 keV. The SCMPW source for the beamline produces a beam of 45 kW at 4.5 T. The major optics of the beamline include a cryogenic SBM and a cryogenic DCLM, a transfocator and multilayer VFM. The high heat load on the front end and upstream monochromator represented key challenges for the beamline design. Innovative approaches to thermal management have been developed. The high radiation environment required additional safety protocols to be implemented for beamline operation. The primary beamline endstation utilises a large gantry robot to independently position up to 4 detectors in an envelope of up to 8 x 3 x 0.3 m with a positional repeatability of ± 0.01 mm. The large motion envelope gives users access to large Q-range and allows flexibility for users to utilise large bespoke sample environments. The ADS beamlines project encompasses design, procurement, build/installation and commissioning phases. The beamline will commence user operations in July 2023.

TUPA17 **Development of a Pair of Medium Energy X-Ray Absorption Spectroscopy Beamlines at Australian Synchrotron**

B.A. Pocock *(AS - ANSTO) C. Glover, B. Mountford (ASCo)*

The Medium Energy X-ray absorption spectroscopy (MEX) beamlines are designed to perform routine, high throughput XAS experiments in the energy range 1.7 to 13.6 keV; split over two beamlines. This energy range is often overlooked but allows access to useful absorption K-edges of Si, P, S, Cl and Ca. Individual components of this system are relatively common, however the large number of components and broad functionality makes for a difficult integration challenge. Both beamlines are supplied by a single bending magnet, with the MEX2 beam being separated away by a pair of side bounce, cylindrically bent mirrors. MEX1 utilises a pair of multi stripe mirrors (Si, B4C and Rh) to access the desired energy range. Energy selection is performed by Double Crystal Monochromators (DCM), which are designed for both step and slew scanning. The end stations of both beamlines have Silicon Drift Detectors (SDD) and multiple ion chambers to facilitate fluorescence and transmission measurements. Sample temperatures can be controlled with any of the three helium recirculating cryostats or heaters. High Energy Resolution Fluorescence Detection (HERFD) experiments can be performed using either the single crystal spectrometer (MEX2) or the five crystal spectrometer (MEX1). MEX1 also includes a microprobe which uses a Kirkpatrick-Baez (KB) mirror to focus to a several micron spot. Given the energy range, attenuation of the photons is a particular challenge. These end stations are designed to minimise beam attenuation and maximise experiment versatility by selectively allowing high vacuum or helium environments in different regions. Removable windows and custom designed interfaces between components minimises the number of windows in the beam path which would have further attenuated photons.

TUPA18 **Nanoprobe Beamline Stability Optimization at the Australian Synchrotron**

M. Semeraro*, N. Afshar, C.M. Kewish (AS - ANSTO) B. Mountford (ASCo) M.D. de Jonge (ANSTO)*

The Nanoprobe beamline is one of the most technically challenging beamlines within the Australian Synchrotron ANSTO BRIGHT program. The Nanoprobe will host a suite of X-ray mapping capabilities at spatial resolutions down to 60 nanometres. This extreme resolution target requires an overall length of over 100 m entailing high stability for optical components. The first part of the beamline will be sitting on the main building floor and will include two mirrors, two monochromators (DMM and DCM), a Secondary Source Aperture, plus all ancillary components. The end station will be situated in a satellite building, connected to the main building by a tunnel hosting the 50m UHV beam transfer pipe. The end station will host a pair of KB mirrors, the sample stages, multiple detectors and several beam inspection devices. There are several mechanical challenges that need to be overcome in the realisation of the beamline. Within the main building, we need to ensure the mechanical stability of the mirrors, the monochromators and the secondary source aperture. To reduce the vibration impact on the vertical displacement, we have opted for an all-horizontally deflecting optical scheme. Separated and isolated slabs are required, as well as mechanical isolation of vibration sources from the optical components. Thermal stability requirements are also challenging. Fundamental height above floor level requires thermal stability better than 0.05 C under the mirrors. Careful attention to materials selection and design is required for the end station to contain thermal drifts. Achieving these stabilities requires a careful approach as conventional HVAC systems bring vibration and air turbulence. This paper describes the design strategies adopted to optimize beamline components stability.

TUPB — Tuesday Poster PM Session B

TUPB01 The LEAPS-INNOV 5.2 Interferometers Based Online Metrology Development Program

P. Marion *(ESRF) Y.-M. Abiven (SOLEIL) C. Colldelram (ALBA-CELLS Synchrotron)*

As part of the LEAPS-INNOV pilot project, Task 5.2 is dedicated to interferometers based online metrology developments applied to photon science instrumentation. One of the main objectives of Task 5.2 is to explore and develop the possibilities offered by interferometers (in particular fiber connected systems) to measure the sample position and its motions during typical synchrotron experiments. This four year program started in April 2021, with the participation to Task 5.2 of ALBA-CELLS, ESRF, HZB, PTB and SOLEIL. The objective of the poster is diffuse information on Task 5.2 current plans and to gather information on existing / on-going works and possible collaborations in the field of interferometers based metrology. LEAPS: The League of European Accelerator-Based Photon Sources LEAPS-INNOV is a pilot project submitted in reply to the INFRAINNOV-04-2020 European Union call for the implementation of open innovation and new strategies and tools for partnership with industry within the photon science community. It involves in particular the European synchrotron radiation light sources and free electron laser large-scale research infrastructures.

TUPB02 Vibration Investigations at PETRA III

S. Botta *(DESY)*

One of the most challenging problems for experimental setups at third-generation and especially fourth-generation synchrotrons are vibrations. In order to keep vibrations on a as low as possible level one must not only take extremely care in the design of all components but also have a profound knowledge of the sources of vibrations. We started a project to map the vibrations at PETRA III both locally and timely in order to get a better understanding of the influencing factors and possible consequences for the ongoing PETRA IV project. In this contribution we will report on our first results of this project.

TUPB03 The Use of Vibration to Achieve Precision

P. Docker *(DLS)*

The work here describes how vibration and the acoustics it produces have been embraced to achieve precision in the macro, micro, nano and pico regime. On the macro scale it has been harnessed to develop smart structures that use resonance and its subsequently high Q to accurately determine positioning and preloads on assemblies. These structures can be machined into support assemblies to ensure consistency in the results they produce as they are integral and never removed. This ensures the data they give is directly comparable pre and post service. The high Q they offer promises new levels of accuracy in assembly and a potential for an audit trail. The other application this work describes is the use of vibration to generate acoustic levitation for room temperature and time resolved sample delivery encompassing the micro, nano and pico regimes. Our methodology moves away from traditional Langevin horn cavities used by previous workers for levitation experiments to low power tractor beam ones specifically designed for light source applications. This has been complimented with the exciting technology of Poly Pico who can use acoustics to eject sample droplets in the order of 10 picolitres and at a rate of 50 kHz and on demand. These two technologies compliment each other beautifully for mixing experiments facilitating 'watching' reactions taking place within a protein. Finally work describing how TEM grids can be filled for CryoEM using the Polypico technology and electro-steering to remove the need for any moving parts delivering discrete sample aliquots and at kHz time scales with micron accuracy.

TUPB04 **Advanced Photon Source Water Systems History and Maintenance**

R.D. Wright, *E. Swetin* *(ANL)*

Particle accelerators require significant amounts of water to cool components and devices. Care and planning are required to maintain these large systems. The purpose here is to provide insight into the operation and maintenance of water systems at the Advanced Photon Source (APS), Argonne National Laboratory. Low Conductivity Water (LCW) systems are integral in the design of particle accelerators. Initial design requirements often change over time to accommodate new requirements. Some of the issues seen over the 23-year operation of the APS are erosion, clogging, and the need for more precise temperature control. Water chemistry, flow velocity, type of control systems and sensors, along with maintenance practices all contribute to successful operation. We will discuss our successes and failures in regards to water quality, temperature stability, reliability and longevity of the system, as well as equipment maintenance and repair. These aspects of water system design and maintenance are all critical to reliable operations of the APS. This document will provide useful information for institutions that intend to design, build, and/or maintain a particle accelerator.

TUPB05 **Investigation of Thermal Instabilities in the ALBA Cooling System, Based on Numerical Simulations and Experimental Measurements**

F. Hernández *(ESEIAAT) E. Ayas, J.J. Casas, Ll. Fuentes, J. Iglesias, M. Quispe (ALBA-CELLS Synchrotron)*

This paper presents an investigation into the thermal instability problems that currently affect the ALBA Cooling System. During these periods of instabilities, which occur for a few hours every week of operation, there are average deviations of up to +1.5°C, concerning the nominal temperature of 23 ± 0.2°C, in the four rings of ALBA: Service Area, Booster, Storage and Experimental Hall. This problem has a direct impact on the quality of the beam of the Accelerator. Previous studies have preliminarily concluded that the causes of this problem are due to (1) thermo-hydraulic anomalies in the operation of the external cogeneration plant, which supplies cold water to ALBA, and (2) cavitation problems in the pumping system (the water flow has been reduced to 58% of its nominal regime to temporarily mitigate the cavitation). In order to confirm these hypotheses and propose solutions to the problem, an investigation has been developed making use of one-dimensional thermo-hydraulic simulations, performing Computational Fluid Dynamic (CFD) studies, statistical evaluations of data taken from our control system, and systematic flow measurements in critical areas, with ultrasonic flow-meters. As result of this research, a set of solutions and recommendations are finally proposed to solve this problem.

TUPB06 **Design of Miniature Waveguides and Diamond Window Assembly for RF Extraction and Vacuum Isolation for the CWA**

B.K. Popovic, *S.H. Lee, S.S. Sorsher, K.J. Suthar, E. Trakhtenberg, G.J. Waldschmidt, A. Zholents (ANL) A.E. Siy (UW-Madison)*

This paper outlines the design of a diamond vacuum window and a millimeter wavelength (mmWave) waveguide assembly that will hold vacuum but still allow the mmWaves to propagate out of the structure for diagnosis and thermal management purposes. Currently under development at Argonne is a corrugated wakefield accelerator (CWA) that will operate at mmWave frequencies, with its fundamental mode of operation at 180 GHz, and relatively high power levels, up to 600 W. The fundamental mode needs to be extracted from the accelerator at approximately every 0.5 m to prevent the unwanted heating of the accelerator structure. Therefore, the structure is intentionally designed so this fundamental mode does not propagate further, instead it is transmitted through the waveguide assembly under vacuum and out via the vacuum window. As a result of the relatively high mmWave power densities, CVD diamond was chosen as the vacuum window material, due to its low electromagnetic losses, mechanical strength, and for its superior thermo-physical properties. Mechanically it is necessary to be able to hold the tight tolerances necessary for windows performance at millimeter wavelengths. Other mechanical difficulties involve assembly of the window due to CVD diamond material and preservation of ultra high vacuum even if the integrity of the CVD diamond window is somehow compromised.

TUPB07 **Vacuum Analysis of a Corrugated Waveguide Wakefield Accelerator**

K.J. Suthar, *E. Trakhtenberg, A. Zholents (ANL)*

The vacuum level in a 2 mm diameter,0.5 m-long copper corrugated waveguide tube proposed for a compact high repetition rate wakefield accelerator has been investigated. The analytical calculations have been found to be in good agreement with a result of computer modeling using a finite element method. A representative experiment has been conducted using a smooth copper tube with the same diameter as the corrugated tube and a 1/3 length of the corrugated tube. The vacuum level calculated for this experiment agrees well with the measurement.

TUPB08 **High-Precision Synchrotron Kappa Diffractometer**
***G. Olea**, N. Huber, J. Zeeb (HUBER Diffraktiontechnik GmbH&Co.KG)*

A new research product aiming to work in a 3th generation synchrotron facility (PAL/PLS II) has been developed. Based on increased energy X-ray synchrotron radiation tool and well-known Kappa geometry device principle, the product is expected that will investigate atomic and molecular structures of materials at nanoscale level using several X-ray diffraction techniques. The Kappa diffractometer (K-Dm) machine is maintaining the common structural principle of its family, but working with an extreme precision and load, which is far of the competition. The main body is consisting from customized Kappa goniometer (KGm) device with vertical axis of rotation for high-precision sample (cryostat) manipulation, versatile detector arm (Da) for manipulating in horizontal plan different detectors (optics, slits, etc.) after X-ray beam is scattered and stable alignment base (Ab) for roughly adjusting the product around the X-ray beam. In addition, a XYZ cryo-carrier inside of the KGm is included for fine (submicron) sample adjustments. The kinematic, design and precision concepts applied, together with the obtained test results are all in detail presented.

TUPB09 **New UHV Angle Encoder for High Resolution Monochromators, a Modern Spare Part for the Heidenhain UHV Ron 905**
***F. Eggenstein**, L. Schwarz, J. Viefhaus, T. Zeschke (HZB)*
A large number of soft X-ray monochromators for high-resolution synchrotron radiation experiments are in operation worldwide. Many of them being plane-grating monochromators with HEIDENHAIN UHV RON905 angle encoders, thirty-six of those encoders are in use at BESSY II. Since decades, those angle encoders are successfully in operation. As of today, this type of encoders became a legacy product and repairing is getting expensive. Therefore, we have developed a new angle encoder, a mechanically compatible "drop-in" replacement of the RON905. A correspondingly manufactured prototype, based on RENISHAW absolute encoders, was investigated on a high precision angle drive test bench. Fourier analysis of the encoder data allowed to determine the accuracy for different angle ranges and shows a better accuracy for the case of the new angle encoder. Furthermore, we will introduce two different methods to increase the system accuracy by plane grating monochromators in collimated light employing the newly developed encoder. The first one is an on-line, in-situ method based on electron/absorption spectroscopy whereas the second, off-line method utilizes an electronic autocollimator.

TUPB10 **Spider - A Mobile Test-Platform for 3D Scanning With Nanometer-Foci**
***P. Wiljes** (DESY)*
During the past years multiple experiments were designed and built at facilities world wide to do 3D tomography scans on the low nanometer scale. At this resolution effects like vibrations, thermal drifts and manufacturing tolerances become more and more critical even when state of

the art components are used. In preparation of the PETRA IV upgrade at DESY, a test device will be designed and used both in the lab as well as at the beamlines to develop and test alignment routines for nano-optics and the sample environment. To keep track on positions and vibration levels during experiments, metrology like interferometers are foreseen within the device.

TUPB11 **Cryogenics Monitoring and Control System for EMBL Facilities at PETRA III**

***M. Bueno**, S. Fiedler, L. Kolwicz-Chodak, J. Meyer, U. Ristau (EMBL)*

At the integrated facility for structural biology of the EMBL at PETRA III on the DESY campus in Hamburg, several devices need cryogenic cooling with liquid nitrogen (LN2): cryo-coolers for the DCMs, cold gas stream units for cryo-crystallography (cryo-stream) at the beamlines and for an automatic crystal harvesting system, robotic sample mounting systems at the beamlines (MARVINs) and an additional one for sample transfer from the automatic crystal harvesting system. The cryo-coolers and phase separator are connected to the central LN2 supply operated by DESY. A local LN2 phase separator installed above one the beamlines is supplying the cryo-streams, the MARVIN systems and LN2 emergency reservoir. For the cryogenic devices local servers and clients exist that monitor and operate the corresponding sensors, actuators and provide the safety logic. In addition, the local cryo-clients are integrated in a cryogenics supervision client. The supervision client allows password protected access at a monitoring level, an operator and an expert level. At the monitoring level, it offers a fast overview of the status of all sub-systems at one glance. At the higher access levels, also the control of the cryogenic sub-systems is accessible. The application can be used from remote via a VPN connection, TeamViewer software or a web client (in preparation). Because of the heterogeneity of the cryogenic devices different protocols such as TINE, EtherCAT, ADS-OCX (BECKHOFF Automation) and EPICS for interfacing had to be applied.

TUPB12 **Assessment of the Corrosion of Copper Components in the Water Cooling System of ALBA Synchrotron Light Source; Presentation of a Proposal to Mitigate the Corrosion Rate of Copper**

***M. Quispe**, E. Ayas, J.J. Casas, C. Colldelram, Ll. Fuentes, J.C. Giraldo, J. Iglesias, M. Pont (ALBA-CELLS Synchrotron) J. Buxadera, M. Punset (Technical University of Catalonia, The Biomaterials, Biomechanics and Tissue Engineering)*

This paper presents the most recent results on the corrosion of copper components in ALBA water cooling system. The studies have been carried out using a variety of techniques: Scanning Electron Microscopy (SEM), Energy-Dispersive X-ray Spectroscopy (EDS) and X-ray Diffraction (XRD). Representative samples of the Accelerator Facility were examined: Storage Ring Absorbers, Front End Masks, Radio Frequency Cavity Pipes, Experimental Line Mask, Radio Frequency Plant Pipes at Service Area and Booster Quadrupole. The studies show the presence of intergranular, pitting and generalized corrosion. The presence of copper oxide is con-

firmed, as well as other elements such as Aluminum, Carbon, Sulfur, Silver, Calcium, Silicon, Titanium and Iron in some regions of the samples. Likewise, other elements from circulating water such as Potassium and Chlorine have also been detected. The depth of pitting corrosion is less than 119.4 um for the samples studied, after 10 years of operation. To minimize the corrosion problem, an upgrade of the ALBA cooling system is in process. The objective is to reduce the current corrosion rate by a conservative factor of 5. This change is possible by modifying the characteristics of the cooling water, reducing the dissolved oxygen content to values below 10 ppb and increasing the pH above 7.5. Technical aspects of this upgrade are discussed in this paper.

TUPB13 **Modular Solid-State Power Amplifiers for Particle Accelerator Facilities**

M. Lau, *M. Ehinger, M. Schweizer (TRUMPF Huettinger) G. Baumann, M. Beyer, R. Heilig, J. Weber (HBH Microwave GmbH)*

The need for individual power levels and control interfaces results in unique power amplifier systems used to accelerate particles via microwaves. Solid-state power amplifiers (SSPA) offer the advantage of a good modularity and scalability to address these needs. However, the design, development, and production of such a complex SSPA system with sufficient reliability is challenging and expensive, due to the customized requirements. We are addressing this issue by offering a high flexibility with our modular design in combination with our in-house developed control software. Based on our experience we are eliminating potential downsides by industrialization and still offering a high grade of flexibility to meet the individual needs. At the best practice example of our circulator tracking, developed for low frequencies around 80MHz, we will demonstrate how customization and industrialization can come along together.

TUPB14 **Challenges in Fabrication 0.5 Meter-Long and 2-mm-Diameter Corrugated Waveguides Produced Using Electroforming Process in Parts**

K.J. Suthar, *S.S. Sorsher, E. Trakhtenberg, A. Zholents (ANL)*

Thermal stresses due to the electromagnetic heating by the wakefields generated by electron bunches traveling through a miniature copper-based corrugated tube with a 2-mm inner-diameter are responsible for limiting the maximum bunch repetition rate to about 20 kHz in a collinear wakefield accelerator (CWA) proposed in Argonne National Laboratory for a future free-electron laser facility. It is expected that tensile-yield failure on the surface of the < 200-micrometer wide trough regions of the corrugations may lead to arcing and beam losses. To avoid the possible generation of RF breakdown voltage that may bring accelerator to an inoperable condition and thermal stresses, we need to fabricate the entire structure considering these issues. Therefore, the fabricate of the entire structure is challenging. In this paper, we discussed various challenges we faced to produce 0.5 m long waveguide and the plan to mitigate them and fabricate the entire structure.

TUPB15 Fabrication of the Transition Section of a CWA via Laser Micromachining

***P. Bado**, M. Dugan, A.A. Said (Translume, Inc.) A.E. Siy (UW-Madison) K.J. Suthar, A. Zholents (ANL)*

A cylindrical, corrugated wakefield accelerating (CWA) structure is being designed to facilitate sub-terahertz Cerenkov radiation produced by an electron bunch propagating in a waveguided structure comprising accelerating sections and transition sections. The accelerating structure consists of several copper-based 50-cm long sections of internally corrugated tubes with 2-mm inner-diameter. These sections are coupled together using transition sections, which are also copper-based. The transition section has a main body diameter ranging from 2mm to 3.2mm and its length is about 14mm. Two sets of four orthogonal waveguides radiate from the central body. Beside their mechanical coupling function, these transition sections provide for periodic monitoring of the centering of the electron bunch, and for removal of unwanted higher-order EM modes. The fabrication of these transition sections is presented. The fabrication process is based on the use of a sacrificial fused silica glass mandrel, whose body corresponds to the inner volume of the copper element. This fused silica mandrel is subsequently electroplated. The micro-fabrication of a prototype of the transition section is underway. Modelling of various fabrication errors was undertaken to understand their effect and to determine tolerances. Source of machining imperfections are reviewed and their impact compared to the modelling results.

TUPB16 Design and Analysis of Bellow Assembly to Join Multiple Corrugated Waveguide Accelerator Modules

***K.J. Suthar**, S.H. Lee, S.S. Sorsher, E. Trakhtenberg, G.J. Waldschmidt, A. Zholents (ANL) A.E. Siy (UW-Madison/PD)*

Researchers at Argonne are developing a 2 mm internal-diameter corrugated wakefield accelerator (CWA), that will operate at a sub-terahertz (180 GHz) frequency with relatively high power levels, up to 600 W. The Mode Coupler Transition (MCT) section is located between two modules joining fragile corrugated waveguides that are joined together with a bellow section with merely a 5 mm gap. The alignment requirement between these waveguides makes this section challenging to design. While traditional bellows can take movements in lateral directions, they are quite stiff in transverse directions. This requires developing the bellow assembly so that the bellow would be flexible to the extent that it would allow the waveguide to be misaligned during the installation and operation; this required flexibility in the order of freely moving part for a very small length. The design of the MCT section needs to be optimized mechanically and electrically. We are presenting the design of MCT that would have flexibility in a few 10s of micrometers.

TUPC — Tuesday Poster PM Session C

TUPC01 Study of Copper Micro Structure Produced by Electroforming for the 180 GHz Frequency Corrugated Waveguide

K.J. Suthar, *G. Navrotski, G.J. Waldschmidt, A. Zholents (ANL)*

Fabrication of the corrugated structure that generates a field gradient 100 m^{-1} at 180 GHz is challenging and required an unconventional method of production. The corrugated waveguide with 2 mm inner diameter will be produced by electroplating copper on the aluminum mandrel as proposed in the reference. A thin seed layer is usually applied to achieve uniform wetting to plate copper on the aluminum mandrel. The copper waveguide is retrieved by removing aluminum and the seed layer. Therefore, uniform copper plating and etching of the seed layer and the Aluminum mandrel is a crucial step to keep the surface free of impurities that are especially necessary for the RF application. Previous studies suggest that electroplated copper has variations in both electrical and mechanical properties compared with those of bulk copper from the batches of production. In this paper, we discuss the copper microstructure produced by the electroforming method and literature study on the variations, which can be attributed to the disparity of the crystallinity of grains structure in plated material.

TUPC02 Bringing the Ground Up (When Is Two Less Than One?)

A.A. Khan, *C.A. Preissner (ANL)*

The Advanced Photon Source Upgrade project has employed the use of high heat load dual mirror systems in the new feature beamlines being built. Due to the shallow operating angles of the mirrors at a particular beamline, XPCS, the two mirrors needed to be approximately 2.5 m apart to create a distinct offset. Two separate mirror tanks are used for this system. However, it is unclear if the vibrational performance of these tanks would be better if they were both mounted on one large plinth or each mounted on a small plinth. Using accelerometers at the installation location, the floor vibrations were measured. The resulting frequency response function was then imported into a Finite Element Analysis software to generate a harmonic response analysis. The two different plinth schemes were modeled and the floor vibration was introduced as an excitation to the analysis. The relative pitch angle (THETA Y) between the mirrors was evaluated as well as the relative gap between the mirrors (XMAG). Results showed that a single plinth reduces the relative XMAG (RMS) compared to two plinths by approximately 25%. However, the relative THETA Y (RMS), which is arguably more critical, is significantly lower by approximately 99.7% in two plinths when compared to a single plinth. Therefore, it is more effective to use two separate plinths over a longer distance as opposed to a single longer granite plinth.

TUPC03 An Interferometric Setup for the Metrology and Characterization of Adaptive Mirror Optics

***S.T. Mashrafi**, J.W.J. Anton, L. Assoufid, S.P. Kearney, J. Qian, Z. Qiao, X. Shi, D. Shu (ANL) K.A. Goldberg, A. Wojdyla (LBNL) G. Gunjala, L. Waller (University of California, Berkeley)*

An interferometric setup was designed and built at the Advanced Photon Source to measure and quantify the response function of deformable mirrors. The setup is based on a commercial compact Fizeau interferometer with a 100-mm-diameter aperture, giving a range of capabilities, such as measuring and quantifying the mirror surface shape, tilt, and twist, and the dynamic response of the bending mechanism. This work focuses on the mechanical design and the commissioning of the assembly. Keywords: Adaptive optics, deformable mirrors, compact Fizeau interferometer

TUPC04 Air-Conditioning System for the Carnaúba Beamline Sub-Micro (Tarumã) and Nano (Sapoti) End-Stations at Sirius

***A.F.M. Fontoura**, D.F. Peixoto, L. Sanfelici (LNLS)*

CARNAÚBA is a state-of-the-art multi-technique beamline at the Sirius, a 4th-generation Lizt Source in operation at the Brazilian Synchrotron Light Laboratory (LNLS), exploiting high coherence at two end-stations: TARUMÂ, for in-air tender X-ray sub-micro analysis; and SAPOTI, for in-vacuum scanning analysis by ptychography for tomographic imaging. The stringent mechanical stability required for the optical and experimental systems at these end-stations imposes rigorous specifications for the air-conditioning system in terms of particulate to avoid samples contamination, air velocity and acoustic noise to minimize induced vibrations, besides to control temperature and humidity for keeping thermal cycles coupled to mechanical and electronic systems within acceptable levels. The proposed system aims to guarantee the temperature at 24°C with stability of ± 0.02°C and homogeneity of 0.5°C along each enclosure, the relative humidity at 50% ± 5%, the particulate level compliant with ISO7, the air velocity inflated at 0.03 m/s and the acoustic noise level down to 35 dBA. Apart from the thermal-isolated air ducts network, the system consists of a cascade of special air handling units (AHUs) with noise dampers embedded. Acoustic treatment is present across the system – shielding of ducts, noise dampers and curtains on the walls of the hutches. Additionally, high efficiency filter modules, speed equalizer lining, plus a set of high precision/accuracy industrial instruments and controllers. This work presents an overview of the air-conditioning system - specification, architecture, design and construction details, beyond commissioning results.

27 Jul – Tue

TUPC05 **Design and Fabrication of a Waveguide for Conductivity Measurement of Electroplated Copper at 170GHz - 200GHz**

***A.E. Siy**, N. Behdad, J.H. Booske (UW-Madison) S.H. Lee, S.S. Sorsher, K.J. Suthar, E. Trakhtenberg, G.J. Waldschmidt, A. Zholents (ANL)*

Beam driven wakefield accelerators offer great potential for the realization of compact, low-cost X-ray free electron laser (XFEL) sources. Achieving high accelerating gradients in these devices requires the use of mm-wave RF structures which present a range of fabrication challenges due to their small size and tight dimensional tolerances. One promising technique for manufacturing these structures involves electroplating a mandrel with copper and subsequently dissolving the mandrel to leave behind the desired metal cavity. Because the resulting copper shell is electroplated, its purity, grain structure, and surface finish will be different from that of conventionally machined copper. Understanding the electrical and thermal performance of the electroformed components requires experimental measurement of the plated copper material properties. In this paper, an experiment for measuring the conductivity of electroplated copper at 170 GHz-200 GHz using a WR-5 waveguide meander is presented and the results are applied to the design of a corrugated waveguide wakefield accelerator.

TUPC06 **A Review of Ultrasonic Additive Manufacturing for Particle Accelerator Applications**

***J.A. Brandt** (Enrico Fermi Institute, University of Chicago)*

Additive manufacturing (AM) technologies have been used for prototyping and production parts in many industries. However, due to process limitations and the unknown material properties of AM parts, there has been limited adoption of the technology in accelerator and light-source facilities. Ultrasonic Additive Manufacturing (UAM) is a hybrid additive-subtractive manufacturing process that uses a solid-state ultrasonic bonding mechanism attached to a CNC mill to join and machine metal parts in a layer-by-layer manner. The solid-state and hybrid nature of UAM ensures base material properties are retained and mitigates process limitations which traditionally inhibit integration of parts produced by other AM processes. This paper presents a review of the UAM process and its potential application to accelerator and beamline needs. Several specific areas are discussed including: replacement of traditional manufacturing approaches, such as explosion bonding to join dissimilar metals; improved internal cooling channel fabrication for thermal management; and imbedding of electronics and materials for more accurate remote sensing and radiation shielding.

TUPC07 **Utilizing Additive Manufacturing to Create Prototype and Functional Beamline Instrumentation and Support Components**

***D.P. Jensen Jr.** (ANL)*

The world of beamline science is often fast-paced and dynamic. One of the major challenges in this environment is to be able to design, manufacture and then implement new items for use on the beamlines in a

fast and accurate manner. Many times, this involves iterating the design to address unknown or new variables which were not present at the beginning of the project planning task. Through the use of additive manufacturing, I have been able to support the user programs of various (APS) Advanced Photon Source beamlines across multiple scientific disciplines. I will provide a few detailed examples of Items that were created for specific beamline applications and discuss what benefits they provided to the pertinent project. I will also talk about why choosing consumer-level printer options to produce the parts has been the direction I went and the pros and cons of this decision. Primarily, this choice allowed for quicker turnaround times and the ability to make more frequent changes in an efficient manner. Currently, we are utilizing only the fused deposition modeling (FDM) type printers but I am exploring the addition of UV-activated resin printing, exotic materials that can be utilized using the current toolset, and the possibility of commercial metal printing systems. This technology has been a game-changer for the implementation of new support items and instrumentation over the last couple of years for the different disciplines I am supporting. I will discuss how the roadmap ahead and what the evolving technologies could potentially allow us to do.

TUPC08 **Design and Development of AI Augmented Robot for Surveillance of the High Radiation Facilities**

K.J. Suthar, *M. White (ANL) G.K. Mistri (MSB) A.K. Suthar, S.K. Suthar (NVHS)*

Scientific instruments and utility equipment during the operation of high radiation facilities such as the Advanced Photon Source at the Argonne National laboratory express a challenge to monitor. To solve this, we are developing a self-guided artificially intelligent robot that can allow us to take images to create a thermal and spatial 3D map of its surroundings while being self-driven or controlled remotely. The overall dimension of the robotic vehicle is 20 in length,7 in width, and 10 in height, which carries a depth perception camera to guide the path, an IR camera for thermography, as well as a cluster of sensors to assist in navigation and measure temperature, radiation, and humidity of the surrounding space. This inexpensive robot is operated by an Nvidia Jetson NanoTM. All controlling and image acquisition programs and routines are written in python for ease of integration with institution-specific operating systems such as EPICS.

TUPC09 **Progress of Nano-Positioning Design for the Coherent Surface Scattering Imaging Instrument for the Advanced Photon Source Upgrade Project**

J.W.J. Anton, *M. Chu, Z. Jiang, S. Narayanan, D. Shu, J. Strzalka, J. Wang (ANL)*

As part of the Advanced Photon Source Upgrade (APS-U) project, the Coherent Surface Scattering Imaging (CSSI) instrument is currently being developed. One of the most important components of the CSSI instrument at the 9-ID beamline of the APS-U, the Kirkpatrick-Baez (K-B) mirror system, will focus hard X-rays to a diffraction-limited size of 500 nm at a working distance of about 650 mm. High angular stability (19 nrad for the horizontal mirror and 14 nrad for the vertical mirror) is specified no just for the focused beam size but, more importantly, to ensure the beam stability at the detector position that is up to 24 m from the K-B mirrors. A large sample-to-detector distance (up to 23 m), one of the beamline's unique features for achieving a sufficient coherent-imaging spatial oversampling, requires sample angular stability of 50 nrad. In CSSI scattering geometry, the vertically placed sample reflects X-rays in the horizontal direction at an extremely shallow angle. The design includes two high-precision rotary stages for sample pitch (vertical axis) and yaw (horizontal axis). The current design of the instrument will be discussed, focused on the nano-positioning stage and metrology engineering to satisfy the stability and positioning requirements.

27 Jul – Tue

TUPC10 **Modular Nanopositioning Flexure Stages Development for APS Upgrade K-B Mirror Nanofocusing Optics**

D. Shu, *J.W.J. Anton, L. Assoufid, S.J. Bean, D. Capatina, V. De Andrade, E.M. Dufresne, T. Graber, R. Harder, D. Haskel, K. Jasionowski, S.P. Kearney, B. Lai, W. Liu, J. Maser, S.T. Mashrafi, S. Narayanan, C.A. Preissner, M. Ramanathan, O.A. Schmidt, X. Shi, J.Z. Tischler, K.J. Wakefield, J. Wang, X. Zhang (ANL)*

Kirkpatrick and Baez (K-B) mirror-based nanofocusing optics will be applied to many beamlines endstation instruments for the APS-Upgrade (APS-U) project. Precision nanopositioning stages with nanometer-scale linear positioning resolution and nanoradian-scale angular stability are needed as alignment apparatus for the K-B mirror hard X-ray nanofocusing optics. For instance, at the APS-U 19-ID In Situ Nanoprobe beamline endstation, to maintain stability of a 20-nm focal spot on the sample, nanofocusing K-B mirror system with 5-nrad angular stability is required. Similar angular resolution and stability are also required for APS-U 9-ID CSSI, APS-U 34-ID ATOMIC and other beamline endstation instruments. Modular nanopositioning flexure stages have been developed for the K-B mirror nanofocusing optics, which includes: linear vertical and horizontal flexure stages, tip-tilting flexure stages, and flexure mirror benders for bendable nanofocusing K-B mirrors, to overcome the performance limitations of precision ball-bearing-based or roller-bearing-based stage systems. The mechanical design and preliminary test results are described in this paper.

TUPC11 **The HD-DCM-Lite: a High-Dynamic DCM with Extended Scanning Capabilities for Sirius/LNLS Beamlines**

A.V. Perna, *H.O.C. Duarte, R.R. Geraldes, M.A.L. Moraes, M. Saveri Silva, M.S. Souza, G.S. de Albuquerque (LNLS)*

After successfully designing, installing and commissioning the High-Dynamic Double-Crystal Monochromator (HD-DCM) at the MANACÁ (crystallography) and the EMA (extreme conditions) beamlines, QUATI (quick absorption spectroscopy) and SAPUCAIA (small-angle scattering) are two forthcoming Sirius beamlines demanding an HD-DCM at the

Brazilian Synchrotron Light Laboratory (LNLS). Since these new beamlines require a smaller energy range (3.1 to 43 keV), the total gap stroke of the instrument can be significantly reduced from 9 mm to about 2.75 mm, such that an opportunity is created to adapt the existing design towards the so-called HD-DCM-Lite. Removing the long-stroke mechanism for the large gap adjustments allows not only for cost reduction and simplification in the assembly, but also for significant improvement in dynamics. By reducing the main inertia by a factor of 6, the HD-DCM-Lite is expected to deliver energy flyscans of hundreds of eV up to at least 4 to 40 times per second, while keeping fixed exit and the pitch stability in the range of 10 nrad RMS (1 Hz - 2.5 kHz). This creates an unparallel bridge between slow step-scan DCMs, and channel-cut quick-EXAFS monochromators, which may be faster but suffer from offset variation. Thus, QUATI (superbend-based) may take full advantage of this capability in time-resolved analysis, whereas new science opportunities may be explored for SAPUCAIA. This work presents the in-house development of the HD-DCM-Lite, focusing on its mechanical design, expected performance and discussions on the ultimate scanning constraints that push the architecture to its limits in terms of rotary stage torque, voice-coil forces, interferometers and encoders readout speed limits and subdivisional errors, thermal management and control strategies.

TUPC12 **Flexure Based Motion Actuation of White Beam Variable Aperture Photon Mask (Slits) for the APS-Upgrade**

J.J. Knopp, *O.A. Schmidt (ANL)*

Accurate motion actuation of variable aperture white beam slits becomes increasingly important as the Advanced Photon Source (APS) becomes a 4th generation synchrotron lightsource. Precision and stability of the slits can have a profound impact on beamline performance. A flexure-based actuation system was designed and tested at the 23-ID beamline for implementation at feature beamlines in the APS upgrade. The design is flexible in that in can be used for both high heat load and canted beam slit geometries. This flexure-based system has shown to provide a significant increase in accuracy and stability from previous designs.

TUPC13 **Design and Development of Quadrupole With Flexures for Compact Wakefield Accelerator**

D.S. Scott, *M. Kasa, M.F. Qian, Y. Shiroyanagi, S.S. Sorsher, N.O. Strelnikov, E. Trakhtenberg, J.Z. Xu, A. Zholents (ANL)*

Argonne National Laboratory is currently developing a compact wakefield accelerator where a half meter long accelerator module will contain a quadrupole wiggler with 20 alternating polarity quadrupoles. The permanent magnet based quadrupole was designed with an ability to manipulate magnetic center with accuracy and precision of a few micrometers. The magnetic device design has the bore with radius of 1.5 mm and ability to produce peak magnetic field gradient 0.96 T/mm. The quads unique flexure hinge design uses a differential screw system that can position a fragile corrugated waveguide in the X and Y to ±25micrometer with a high level of stability. There are two flexure hinges on one quad, each driven

by a differential screw system, which manipulates the magnetic center location. The separate carriage system positions the quadrupoles in the Z and also provides for angular positioning about the Y axis. Each quad is individually assembled, positioned, and aligned using the aforementioned flexure and carriage systems in conjunction with a pulsed wire feedback system. Once the quads are positioned the sides are removed and the corrugated waveguide system is installed transversely. Then, using a kinematic support system for accuracy, the quad sides are replaced. The combination of the flexure, differential screws, carriage, and kinematic systems have made this a highly accurate and reliable positioning system for the corrugated waveguide. This system, or portions of, could easily be adapted to solve a multitude of positioning challenges in other applications.

TUPC14 Copper Braid Heat Conductors for Sirius/LNLS Cryogenic X-Ray Optics

F.R. Lena*, C.S.N.C. Bueno, G.V. Claudiano, J.C. Corsaletti, R.R. Geraldes, D.Y. Kakizaki, R.L. Parise, G.L.M.P. Rodrigues, M. Saveri Silva, M.S. Souza, L.M. Volpe (LNLS)*

The 4th-generation synchrotron beam aspects result in high energy densities and power loads, which challenges the design of beamline optics such as mirrors and monochromators, since the introduction of thermal stresses may lead to optical surface deformation and beam degradation. For monocrystalline silicon optics at Sirius beamlines, one of the standard design concepts for beam-load deformation suppression is the use of liquid nitrogen cryostats for cooling the elements down to around 125K, where its coefficient of thermal expansion is virtually zero and deformations due to thermal gradients are minimized. In this context, low-stiffness copper braids are widely used to thermally couple the optics to the cryostats while limiting the mechanical coupling between them, such that external vibration disturbances are avoided and the desired kinematic is preserved. Even though commercial solutions for cryogenic copper braids exist worldwide, the high costs, long lead time and customization limitations stimulated the development of an in-house solution with local partners . The basic manufacturing process consists in cold closed-die forging electrolytic copper ropes and bulk blocks with high strain rate for better thermal coupling between the ropes and the terminations. Then, the modules are machined and further gold-plated, resulting in high thermal conduction efficiency up to 90% of the theoretical values. For special applications, either because of complex geometry or heat extraction capacity, smaller braided modules can be soldered into larger systems using low temperature fillers. This work addresses these manufacturing techniques in details and presents operational designs.

TUPC15 **A New Ultra-Stable Variable Projection Microscope for the APS Upgrade of 32-ID**

***S.J. Bean**, V. De Andrade, A. Deriy, K. Fezzaa, T. Graber, J. Matus, C.A. Preissner, D. Shu (ANL)*

A new nano-computed tomography projection microscope (n-CT) is being designed as part the Advanced Photon Source Upgrade (APS-U) beamline enhancement at sector 32-ID. The n-CT will take advantage of the APS-U source and provide new capabilities to the imaging program at 32-ID. A Kirkpatrick and Baez (K-B) mirror-based nanofocusing optics will be implemented in this design. To meet the n-CT imaging goals, it is the desire to have sub 10 nanometer vibrational and thermal drift stability over 10-minute measurement durations between the optic and the sample. In addition to the stability requirements, it is desired to have a variable length sample projection axis of up to 450 mm. Such stability and motion requirements are challenging to accomplish simultaneously due to performance limitations of traditional motion mechanics and presents a significant engineering challenge. To overcome these limitations, the proposed n-CT design incorporates granite air bearing concepts initially used in the Velociprobe. These types of granite stages have been incorporated into many designs at APS and at other synchrotron facilities. Utilizing the granite air bearing concept, in tandem with other design aspects in the instrument, the requirements become reachable. A novel multi-degree of freedom wedge configuration is also incorporated to overcome space limitations. The design of this instrument is described in this paper.
Keywords: stability, vibration, thermal drift, granite, air bearings, instrumentation, nanofocusing, nanopositioning, imaging, synchrotron

TUPC16 **Precision Electrochemical Fabrication of Corrugated Waveguides**

***D.X. Liu**, H.M. Garich, T.D. Hall, M.E. Inman, S.T. Snyder, E.J. Taylor (Faraday Technology, Inc.) X. Lu (Northern Illinois University) X. Lu, J.G. Power, D.S. Scott, J. Shao (ANL)*

Advancements in high energy physics require continuous innovations in hardware to support the generation, amplification, transmission, modulation, and detection of radio frequency (RF) electromagnetic waves. Waveguides have garnered increasing interest due to their integral function in the transmission, amplification, and/or manipulation of electromagnetic waves. Waveguides operating in higher than conventional frequency ranges, e.g., 30 to 300 GHz, are of particular interest given the scaling of gradient and shunt impedance with frequency. These higher frequencies necessitate features, such as corrugations, with significantly smaller dimensions. However, traditional manufacturing approaches are inadequate, in terms of manufacturing precision and cost, to meet these requirements - thus, novel fabrication strategies are required. Herein, an economic fabrication approach for electroforming high-purity 26 GHz cylindrical copper waveguides with internal corrugations is presented. A custom, low-additive electrolyte was employed to mitigate impurity inclusion within the copper electroform, ensuring high-purity copper waveguides. Pulse-modulated waveforms employed during copper elec-

trodeposition selectively controlled ionic transport as well as the subsequent deposit morphology and thus facilitate complete copper filling of the corrugations. Scale-up from ~2- to ~6-inch waveguides were demonstrated and confirm the versatility of the pulse-modulated electroforming strategy. A cold test of the ~2-inch copper waveguide using a vector network analyzer (VNA) was conducted. The results of the S-parameter measurements and the bead-pull test indicate reasonable agreement with the design by CST simulation, which validates the novel pulse-modulated electroforming approach.

WEIO — Wednesday Keynote and Invited oral

Chair: W.C. Hutcheson (LBNL)

WEIO01 **The Extremely Brilliant Source (EBS) Project**

J.C. Biasci *(ESRF)*

The EBS project required the shutdown and dismantling of the existing storage ring, and the design, construction, and installation of a new synchrotron source in a limited period with minimal disruption to the ongoing user program. From 2015 to 2018, in addition to keeping the existing accelerator operational more than 1,000 magnets, 900 m of vacuum chambers, and several thousand other components were designed, procured, and pre-assembled. On December 10, 2018, ESRF stopped the beam of the original accelerator for just 17 months to dismantle the existing accelerator, install and commission the new one, before the start of beamlines program at the end of August 2020. The EBS produced its first stored beam as scheduled, thanks to ESRF staff and international teams who have worked tirelessly to make this possible. One of the major challenges of this upgrade program was to replace these 32 cells, within the existing infrastructure, by new ones whose magnet density made engineering much more complicated. The new ring comprises over 10 000 components, each precision-aligned to within 50 µm over the storage ring length. The timing of different activities and the coordination of teams during all phases was another challenge, but the expertise, team spirit, commitment and responsiveness of teams and management to deal with unforeseen situations or technical problems greatly contributed to the success of the project. After such a project, several lessons are to be learned, first it is necessary to capitalize on all the positive aspects, then technical issues needs to be analyzed, in order to keep the knowledge and expertise. This presentation will cover the different phases of the project by highlighting the difficulties encountered and the lessons to be learned.

28 Jul – Wed

WEIO02 LCLS Chemrix in-Vacuum Liquid Sample Delivery System

H. Wang *(SLAC)*

In the past decade, LCLS has been using in-vacuum liquid jet to deliver nanocrystals, microcrystals or other samples to the experimental station. Recently, LCLS has developed a new type of liquid jet, known as sheet-jet, with tunable thickness from little over than 1 µm to 20 nm. This new type jet greatly reduces the X-ray absorbed by the liquid solutions, especially for soft X-ray and tender X-ray applications. In the first part of presentation, the author will describe the optimization processes of such jets using computational fluid dynamics (CFD) tool. The second part will describe the development of the liquid jet sample delivery system for chemRIXS in LCLS. The chemRIXS endstation has been designed in a way it can take both solid and liquid samples. Because solid sample experiments require a UHV environment, to be able to deliver the liquid sample jets to the same vacuum chamber, a special loadlock chamber and sample transport system have been developed to isolate the liquid system from the main vacuum chamber. When solid sample system is extracted, a fully automated system can then drive the liquid jet to the sample/beam interaction point. A recirculation catcher will collect the liquid waste, so the chamber can remain at high vacuum.

WEOA — Wednesday Contributed Oral Session A

Chair: D. Capatina (ANL)

WEOA01 CAD Integration for PETRA-IV

***B. List**, L. Hagge, M. Hüning, D. MIller, P.-O. Petersen (DESY)*

The PETRA-IV next-generation synchrotron radiation source planned at DESY is currently in preparation as successor of PETRA-III, with a completely new accelerator and a new experimental hall, while existing buildings, tunnels and experimental beamlines will be retained where possible. The Technical Design Report is due to be completed by the end of 2022. A CAD integration model has been set up for the complete accelerator and photon science complex. It combines the contributions of all relevant trades, the accelerator components, supply infrastructure, installations, frames, tunnels and buildings, and the design of the campus. The CAD model structure is aligned with the project's part breakdown structure (PBS) and the Work Breakdown Structure (WBS) to facilitate integration with systems engineering and reflect responsibility within the project organization. Within the model, it is possible to switch between different levels of detail for space allocation (DG1 - "black box"), interface definition (DG2 - "grey box") and detailed design (DG3 - "white box"), separating layout from design, while ensuring their consistency. Placement of accelerator components is directly governed by the lattice through direct access to spreadsheet data, allowing fast design changes after a lattice update and ensuring consistency between mechanical and lattice design. The resulting model will support the complete facility lifecycle, from layout and design to fabrication, installation and operation. The presentation explains the tasks and requirements of the CAD integration process and uses examples to explain the structure and the modeling methodology of the CAD integration model.

WEOA02 Design of Girders for Magnet Support on the New Upgrade Lattice at Soleil

***J.L. Giorgetta**, A. Lestrade, A. Mary, K. Tavakoli (SOLEIL)*

The current girder set of SOLEIL features 4 girder types weighing from 1.85t to 3t, with a respective mass payload varying from 4.1t to 8t and lengths from 2.40 m to 4.80 m. The smaller size of magnets used for the present version of the SOLEIL upgrade allows a dramatic size and weight reduction of the magnet-girder assemblies. On the other hand, the number of magnets and girders has increased by a factor of 3, implying longer alignment and installation operations. Another constraint is due to the high compactness of the new lattice causing some limitations and access restrictions in the area between girders and tunnel wall. Several setups involving a number of girders from 116 to 212, various magnet layouts and binding systems have been studied. Dynamic and thermal performances have been evaluated by FEA analysis. This approach gives to accelerator physicists the performance of each solution, and thus a great versatility in the choice of the best setup in terms of dynamic and thermal stability.

Alignment constraints, installation schedule reducing "dark time" period and economic considerations have also been taken into account during all the design phase.

WEOA03 **Updated High Heat Load Front-Ends for SLS 2.0**

D.M. Just, *U. Frommherz, N. Gaiffi, L. Patthey, C. Pradervand, T. Schmidt, H. Siebold, P. Wiegand, P.R. Willmott (PSI)*

The Swiss Light Source (SLS) at the Paul Scherrer Institut (PSI) in Switzerland will undergo from 2021 to 2024 an upgrade named SLS 2.0 to increase brightness and coherence. This upgrade will have a significant impact on the existing front-ends. Due to the proven reliability and good concept, we plan a refurbishment strategy for all front-end (FE) components where possible. New source points for all beam-lines – resulting in shifts both lateral and tangential, newly developed insertion devices and bending magnets as well as spatial restrictions due to the multi bend achromat (MBA) design challenges this strategy. We demonstrate how we plan to deal with these challenges for the case of high heat load FEs. We will address how the acceptance of the FE was chosen due flux and power calculations of the insertion device and the design and thermal analysis of a novel primary aperture. The adaptions that will be made to the tungsten blade X-ray beam positioning monitors (W-XBPM) and modifications on the photon shutter will be discussed. Furthermore, we will take a brief excursion on how we want to organize the refurbishment during the shutdown period of the upgrade.

28 Jul – Wed

WEOB — Wednesday Contributed Oral Session B

Chair: G. Navrotski (ANL)

WEOB01 Engineering Challenges in BioSAXS for Australian Synchrotron

***S. Venkatesan**, L. Barnsley, C.J. Roy (AS - ANSTO) G. Conesa-Zamora, R. Grubb, H. Hamedi, B. Jensen, C.S. Kamma-Lorger, V.I. Samardzic-Boban (ANSTO)*

The Biological Small Angle X-ray Scattering (BioSAXS) beamline is the third beamline designed, developed and soon to be installed as part of BRIGHT Program at the Australian Synchrotron. The BioSAXS beamline will allow highly radiation sensitive samples to be studied at high flux. The beamline will offer increased efficiency, and data quality, for all liquid phase scattering experiments, allowing measurement of new and novel samples, and experiments, that otherwise would not be possible. The BioSAXS beamline will accommodate a wide range of experiments by offering a q-range of ~ 0.001 - 4 Å-1 and an optical design optimized for high flux (~5x10^{14} ph/s) X-rays. At this flux rate, BioSAXS will offer users one of the highest flux beamlines in the world. To achieve this, the beamline will use a superconducting undulator insertion device, double multilayer monochromator, and vertical and horizontal bending mirrors, providing flexibility in optical configurations. The beamline will primarily collect data in a fully unfocussed mode. BioSAXS will also be able to achieve a fully focused and a vertically focussed beam. This subsequent variation in the beam position at sample is accommodated through fully automated motion in 5 axes at the in-vacuum detector stage and 4 axes in the sample table. The design of these components allows smooth transition in camera lengths and improved signal to noise ratio. This paper presents the various engineering challenges in this high flux design, including thermal management of critical components, design developments to accommodate the various operational modes and various stages of the Photon Delivery System and Experimental Station components. The paper aims to present details of design, FEA results and approaches taken to solve problems.

WEOB02 Flexible X-Ray Focusing using CRL Transfocators for in situ GISAXS/WAXS Experiments at MiNaXS/P03

***J.R. Rubeck**, A. Chumakov, S. Roth, M. Schwartzkopf (DESY)*

P03 operates a micro- and nanofocus endstation both capable of transmission as well as grazing-incidence X-ray scattering experiments. The beam sizes range from typically 22 x 13 nm^2 to 350 x 250 nm^2. Common, unique features of the different focusing schemes are the exceptional long focal distance, allowing for a variety of advanced in situ and operando sample environments. The newly commissioned CRL3-system consists of two binary stacks of one-dimensional 1D BeCRL mounted on an in-vacuum lens-exchanger with two train units, piezo-driven motors and a hexapod for generating a round-shaped microfocus beam with increased flux at 600 mm focal distance. An additional condenser system CRL4

for beam parallelization prior to focusing systems will increase the flux at both endstations. CRL4 consists of two Smarpods in-vacuum stages, both equipped with a stepped cascade of 1D lenses each for decoupled horizontal and vertical focusing. We will present the different focusing schemes incl. projected performances as well as current status of both new CRL-stations and technical challenges, e.g., space constraints, precise positioning, stability and high-vacuum compatibility.

WEOB03 **Development of a Linear Fast Shutter for BM05 at ESRF and BEATS at SESAME**

C. Muñoz Pequeño, *J.M. Clement, P. Thevenau, P. Van Vaerenbergh (ESRF)*

This paper presents the design of a new linear fast shutter for topography and tomography. A prototype will be assembled and tested at the BM05 beamline at ESRF, and another unit will be installed in the future BEATS beamline at SESAME. The application of the shutter in X-ray diffraction topography allows performance of long exposure cycles of monochromatic beam on crystal samples while preventing irradiation of the detector during readout. It can be also used during sample alignment and acquisition of X-ray tomography scans. Particularly for white-beam tomography, which uses a very high photon flux, minimizing exposure is critical to protect the sample and detector from radiation damage. This highlights the importance of obtaining a short and uniform exposure time over the beam aperture. To fulfill this objective, a new shutter based on the synchronization of two tantalum blades driven by linear brushless DC motors is under development. This versatile design can be used with both monochromatic and white-beam, and it can achieve exposure times ranging from 50 ms to 60 s for a beam size of H 80 mm x V 20 mm. The linear motors allow for a much smoother operation, preventing vibration issues reported with the old shutter. In addition, the use of linear motors rather than solenoids allows an unlimited exposure time, where the previous version used solenoids that could overheat if kept open for too long. A test bench has been constructed for the characterization of the sequence produced by the linear motors, and exposure times of 50 ms with a maximum error of 1 ms have been measured. This article describes the main features of the shutter prototype and its associated motion control system, and the results of the measurements with the motor test bench are discussed as well.

WEPA — Wednesday Poster AM Session A

WEPA01 Development of a Double Detector Stage Setup at the Powder Diffraction and Total Scattering Beamline P02.1

***M. Wendt**, M. Etter (DESY)*

A new detector setup has been assembled at DESY/PETRA III's Powder Diffraction and Total Scattering beamline P02.1. The setup consists of two parallel motorized stages which enables the simultaneous movement of two area detectors. The setup allows the detectors to be moved within the linear xyz-range as well as an orthogonal rotation with respect to the X-ray beam. Due to these features, it is possible to conduct powder diffraction and total scattering experiments simultaneously as an increased Q range on one of the detectors can be offered. In addition to that, the design enables a less time-consuming change of standard detector devices to pool detector devices and offers air-cooling for the main area detectors in order to reduce thermal noise.

WEPA02 New Sample-Environment-Modules for the General-Purpose-Experiment at P02.2 at PETRA III

***M. Wendt**, K. Glazyrin, H.P. Liermann (DESY)*

The P02.2 is a micro diffraction beamline dedicated to extreme conditions research at high pressure and simultaneous high/low temperature created in diamond anvil cells (DAC). It offers two experimental setups a) the laser heating (LH) and b) the general purpose (GP) experiment. The GP experiment is heavily used for all types of heating work such as resistive heated, laser heated or cryogenically cooled DACs. As such the setup requires inherently great flexibility to accept different types of sample environments. For this purpose we developed recently a system to easily exchange different types of sample stacks that are optimized for certain sample environments. During this larger upgrade the GP experiment was equipped with two complete new sample stacks. The two new setups enable the positioning of a) large and heavy cryo-sample-chamber as well as b) samples with nanometer precision of super high-pressure powder and single crystal diffraction experiments making optimal use of the micron and sub-micron high-energy X-ray beam. Within this presentation we present the current status of this new development and give a first impression of the expected capabilities of the setup.

WEPA03 Current Status of TPS XBPM System

***J.-Y. Chuang** (NSRRC)*

The blade type X-ray beam position monitor is operating in the TPS front end. After a complete calibration process, the XBPM performed a high precision measurement for beam position monitor. This paper reports the current statuses of XBPMs in phase I TPS that discussed with the calibration method and the results after calibration. A long term record of photon beam stability will also be described in this paper.

WEPA05 **Mechanical Aspects of the New Shutter Design at European XFEL**

N. Kohlstrunk, *M. Di Felice, M. Dommach, D. La Civita, H. Sinn, M. Vannoni, F. Yang (EuXFEL) W. Clement (DESY)*

The European XFEL is a research facility which started operation in September 2017 and generates ultrashort X-ray flashes for photon science experiments with an outstanding peak brilliance. To operate the facility at full performance, an upgrade of the radiation safety system is needed. For this purpose nine Frontends and three Shutters have to be modified. This upgrade includes several mechanical changes like the replacement of the B4C absorber with a diamond and B4C absorber. Since also a new burn through monitor with a graphite block inside has to be installed in the absorber chamber the holder of the B4C has to be changed because of the space constraints in the chamber. This holder consists also of a special flexure plate fixed with springs and screws to allow a certain flexibility of the B4C. For attaching the CVDs to the absorber holder a special CVD clamp system has to be created to release the stress on the diamond and avoid their destruction.

WEPA06 **The Beamline Motor Control System of Taiwan Photon Source**

C.F. Chang, *C.Y. Liu (NSRRC)*

Different experiments have different features, so does the optical design; however, all of them are necessary to be adjusted according to mechanism. For example, adjusting mechanism of optical element is often based on stepper motor, for stepper motor possesses high resolution ability, which can adjust mechanism to precise location. This study illustrates how motor system of our Taiwan Photon Source integrates adjusting mechanisms of stepper motor on beamline. In addition, the firmware of close-loop system is cooperated to further improve veracity of location.

WEPA07 **The Fizeau System Instrument at ALBA Optics Laboratory**

L.R.M. Ribó, *C. Colldelram, J. Nicolás (ALBA-CELLS Synchrotron)*

The ALBA optics laboratory has recently acquired a new Zygo Verifire HD Fizeau interferometer. The instrument has been integrated into a positioning stage to allow stitching of long X-ray optical elements. The mechanical set up, with four axes, allows for automatic positioning and alignment of the interferometer aperture to the surface under test. The longitudinal movement allows for scan of X-ray mirrors up to 1500 m long. The positioning platform includes two angles, roll and yaw, and two translations, vertical and longitudinal translations. The longitudinal translation is a custom designed linear stage. The yaw rotation is based on a sine arm mechanism. The vertical and roll motions are combined in a single stage, closely integrated around the main linear stage. The system reaches repeatabilities better than 1 μm or 1 μrad for all axes. The system is mounted on top of a vibration isolated bench in the clean room of the laboratory. The control software of the instrument allow direct control of every individual axis, and allows selecting the center of rotation for both roll and yaw. The system includes inclinometers and autocollimators to control the relative orientation between the interferometer and the mirror under test. The system is integrated to the software of the interferom-

eter, and includes features for automatic alignment of the interferometer to the mirror, or for automatic stitching acquisition, with selectable parameters. The system allows for full three-dimensional characterization of the optical surface of mirrors and gratings, and provides height map reconstructions with accuracy in the order of 1 nm, for flat or curved surfaces with lengths up to 1500 mm.

WEPA08 **Investigating of EBW Process Weldment Connections Stresses in ILSF 100 MHz Cavity by Simufact. Welding Software**

M. Moradi *(ILSF) A. Adamian, N.B. Arab (PPRC)*

The cavity is one of the main components of all accelerators, which is used to increase the energy level of charged particles (electrons, protons, etc). The cavities increase the energy level of the charged particle by providing a suitable electric field to accelerate the charged particle. Here, information about electron beam welding analysis in 100 MHz cavities of ILSF design will be explained. According to studies performed in most accelerators in the world, connections in cavities are made by various methods such as explosive welding, brazing, electron beam welding, etc. Many articles on large cavities state that the connection of the side doors must be done by electron beam welding. Therefore, in the present research, the three-dimensional model of the cavity, after simplification and networking, is implemented into Simufact. Welding software, and then the heat source of electron beam welding and other welding factors such as beam power, Gaussian distribution, etc. are simulated in the software, as well. The purpose of this study is to calculate the number of residual stresses during the EBW process in the 100 MHz cavities of ILSF.

WEPA09 **A Three-Signal 2D-Beam-Position-Monitor Based on a Segmented Ionization Chamber**

M. Goerlitz*, W.A. Caliebe (DESY)*

At the DESY-beamline P64 a new three-signal beam position monitor (BPM) was constructed and tested in 2020. The BPM is based on the working-principle of an Ionization Chamber with splitted electrodes and a 120^{o}-symmetry. The chamber is filled with an inert gas, which is ionized in presence of a beam. The gas can be changed, and the absorption can be adjusted in dependency of the X-ray-energy. The 2D-position is calculated out of three signals by a multiple-linear regression, where the position can be obtained by using a coordinate-transformation, similar to the Park-transformation, which is well-known in the field of drive control. Calibration factors have been evaluated in detail by using linear optimization algorithms including weighted residuals. The calculation is an inverse problem, which can be solved either by Simplex-algorithm or by Moore-Penrose-Pseudoinverse. The different results have been compared. Moreover, in order to validate the feasibility, calibration factors have been compared in regard to different beam sizes. Non-linearities are shown for a grid of 3 x 3 mm.

WEPA10 **Design and Ray-Tracing of the Beats Beamline of SESAME**

***G. Iori**, M.A. Al-Najdawi, A. Lausi (SESAME) M. Altissimo, I. Cudin (Elettra-Sincrotrone Trieste S.C.p.A.) A. Kaprolat, J. Reyes-Herrera, P. Van Vaerenbergh (ESRF) T. Kolodziej (NSRC SOLARIS)*

The BEAmline for Tomography at SESAME (BEATS) will operate an X-ray micro tomography station providing service to scientists from archaeology, cultural heritage, medicine, biology, material science and engineering, geology and environmental sciences. BEATS will have a length of 45 m with a 3-pole-wiggler source (3 T peak magnetic field at 11 mm gap). Filtered white and monochromatic beam (8 keV to 50 keV, dE/E: 2% to 3% using a double-multilayer-monochromator) modalities will be available. In this work we present the beamline optical design, verified with simulation tools included in OASYS. The calculated flux through 1 mm^2 at the sample position will be as high as 8.5×10^9 Ph/s/mm^2 in 0.1% of the source bandwidth, for a maximum usable beam size of 70×15 mm^2. Beam transverse coherence will be limited to below 1 µm by the horizontal size of the X-ray source (~2 mm FWHM). For phase contrast applications requiring enhanced coherence, front end slits can be closed to 0.5 mm horizontally, with a reduction of the available beam size and photon flux. The BEATS beamline will fulfill the needs of the tomography community of SESAME.

WEPA11 **Design of Monochromatic and White Beam Fluorescence Screen Monitors for XAIRA Beamline at the ALBA Synchrotron**

***J.M. Alvarez** (ALBA-CELLS Synchrotron)*

The optical layout of XAIRA, the hard X-ray microfocus beamline of ALBA, includes three monochromatic fluorescence screens and one water cooled white beam monitor, mounting respectively YAG:Ce and polycrystal CVD as scintillator screens. All monitors share the same design scheme, with a reentrant viewport for the visualization system that allows reducing the working distance to the minimum, and the scintillator screen held by this CF63 flange itself, making the whole system very compact and stable. The flange is driven by a stepper motor actuated linear stage in order to position or retract the screen with respect to the beam path. In addition, in order to cope with the high incoming flux (18.6 W/ m^2) at the 100^2ţm CVD diamond of the white beam monitor, a new InGa-based cooling system has been developed. The general design of the new fluorescence screens, to be used also in ALBA's upcoming beamlines, with particular detail on the water-cooled white beam monitor is described here.

WEPA12 **X-ray Facility for the Characterization of the ATHENA Mirror Modules at the ALBA Synchrotron**

***A. Carballedo** (ALBA-CELLS Synchrotron)*

Minerva will be a new X-ray facility to be built at the ALBA synchrotron specially designed to support the development of the ATHENA (Advanced Telescope for High Energy Astrophysics) mission. The beamline design is originally based on the monochromatic pencil beam XPBF 2.0 from the Physikalisch-Technische Bundesanstalt (PTB), at BESSY II already in use at this effect. MINERVA will be arranged with the necessary metrology

equipments to integrate the stacks produced by the cosine company in a mirror module (MM) and characterize them. MINERVA is a fixed photon energy beamline and will produce photons at 1.0 keV. The beam will have a residual divergence of less than 1 x 1 arcsec2 rms for dimensions adjustable from 10 x 10 um2 to 8 x 8 mm2. The beamline is made up of three main subsystems. First, a water-cooled multilayer toroidal mirror based on a high precision mechanical goniometer. Second, the core of the beamline, the sample stage, with a combination of linear stages and vacuum hexapods to enable rapid scans and give full mobility to the MM jig to align it with the beam. And the last, the X-ray detector, placed 12 m away from the sample and assembled on a 4-axis positioning system, which allows movement on a cylinder shape to perfectly follow the excursions of the focus when scanning a mirror module. The interoperability between MINERVA and XPBF 2.0 will be preserved in order to strengthen and boost the production and characterization of mirror modules. MINERVA is funded by the European Space Agency (ESA) and the Spanish Ministry of Science and Innovation. Still in the detailed design phase, MINERVA will take 2 years to be completed to operate in 2022.

WEPA13 **Design of a High-Precision Position Adjustment System for the HL-LHC Heavy Components in the Interaction Region**

***F. Micolon**, T. Lehtinen, M. Sosin (CERN)*

Given the high radiation area and the tight alignment tolerances, the HL-LHC interaction region components are designed to be realigned remotely using motorized supporting jacks, as human intervention in these zones must be strictly limited. Such a position adjustment system is designed to allow a vertical and horizontal displacement of each jack support by ±5mm with a resolution of less than 10ţm. The weight of the supported elements of up to 17 tons and transverse loads reaching 3 tons must be actuated remotely by the mechanical systems exposed to high cumulated radiation dose of up to 2 MGy during the system lifetime of 15 years. To comply with these requirements, a vast design effort has been initiated at CERN to study the different possible system layouts. This includes prototyping various solutions, studying subsystems through dedicated test setups and using structural simulations to get a clear understanding of the mechanical principles at play. This paper reports on the work undertaken to design the high-precision position adjustment system, the various mechanical analysis studies and their main outcome. It reviews the proposed solution and its expected alignment performances.

WEPA14 **All Applications of the ALBA Skin Concept**

***A. Crisol**, A. Carballedo, C. Colldelram, N~González, J. Juanhuix, J. Nicolás, L.R.M. Ribó, C. Ruget (ALBA-CELLS Synchrotron) J.B. González Fernández (MAX IV Laboratory, Lund University)*

During ALBA design phase the protein macromolecular protein crystallography beamline, XALOC, required several in-house developments. The major part of these design was at the end station where the necessity of customization is always much higher. The most relevant of these instruments was the beam conditioning elements table. This accurate stage includes the four movements of the axes in the plane perpendicular to the beam path to align the components row to the beam and position the diffractometer. This design compacts translation and angular movements in a pair of single stages, with a couple of stages for all four excursions. This solution maximizes the stiffness but still enabling half tone of payload and preserving a resolution close to 0.1 µm. But this concept was not only applied at XALOC diffractometer and detector table, thanks to its compactness and prominent performances it has been widely adopted at several ALBA beamlines: NCD as a detector table and sample table, MSPD beamline as the KB table, at NOTOS beamline metrology table, under detailed design phase, and also included the new ESA MINERVA beamline for the sample mirror modules positioning, still under design phase. But, the beamlines have not been the only application also different king of instrumentation like an in-vacuum hall probe measuring bench, and even and stitching platform for the ALBA optics laboratory. Moreover, the concept has outreach ALBA and have been adopted also at other facilities worldwide but not only synchrotrons but also some of scientific instrumentation suppliers at Europe. We present here most of the application and their main measured performances.

WEPA15 A Rapid Two Axis Scanner for Vacuum Environments With High EMP

C. Deiter, *M. Kitel, J. Schulz (EuXFEL)*

We present a two axis scanner for the rapid scanning of solid samples up to 10 Hz in vacuum under harsh EMP conditions. The samples are carried by a standardized sample frame system developed in the EUCALL project (2015-2018, WP6 HIREP) and can be transferred without breaking the vacuum conditions of the interaction chamber. All electronic devices inside the chamber, where the high-power laser shot and the FEL's X-ray pulses hit the sample, can be disconnected with 10 Hz. To ensure a continuous monitoring of the sample's position, the role of the encoder is taken over by an interferometer with only optical components inside the chamber. The linear stages are powered by high frequency piezo motors capable to do power cycles with up to 1 kHz. The scanner is controlled by the Beckhoff EtherCAT automation system with an in-house software framework.

WEPA16 Development and Applications of the White Beam Position Monitor for Bending Magnet Beamlines

C.Y. Chang, *C.F. Chang, C.H. Chang, S.H. Chang, L.C. Chiang, R. Lee, B.Y. Liao, C.Y. Liu, H.Y. Yan (NSRRC)*

We developed a white beam position detector to be applied in beamlines with bending magnets. By 0.1 mm light-receiving opening, the beam is split and converted to a photocurrent intensity which can be used to detect the size and position of the beam is less than or equal to 50 mm, and to locate the positions of the beamline components. This is a stop-beam measurement method, so it cannot be used to monitor the beam in real time. The motorized stage of the detector has a range of motion up to ± 25 mm with position accuracy not more than 1 micrometer and vacuum capability not more than 5 × 10 -10 Torr, which is compatible with

ultra-high vacuum environments. In addition, taking the thermal load 62.89 W of the TPS 02A beamline as an example, the thermal deformation of the analog detector opening lead to a result that the measured value will have a maximum of 2 micrometer from the center of the beam. Finally,and the whole system has been successfully applied in the TPS 02A beamline.all features are verified and the performance meets the requirements, Besides the positioning tasks of Mask and Slits1 was completed and the position change of the light source was detected.

WEPA17 **Current Status of the Optical and End Station Developments of Xaira, the New Microfocus Mx Beamline at the ALBA Synchrotron**

N~González, *C. Colldelram, J. Juanhuix, J. Nicolás (ALBA-CELLS Synchrotron)*

The new BL06-XAIRA microfocus macromolecular crystallography beamline at the ALBA synchrotron light facility, which is foreseen to enter into user operation in 2023, is currently in the commissioning phase of optical components and in the design phase of the end-station. The aim of XAIRA is to provide a 4–14 keV stable, high flux beam focused to $3\times1\,\mu m^2$. The beamline includes a novel monochromator design combining a channel-cut and DMM for high stability and flux, new mirror benders equipped with dynamical thermal bump and figure error correctors, and the monitoring and feedback of critical optical elements by interferometry. In addition, the end station will consist on a helium chamber enclosing the sample and the detector, with a new helium bearing goniometer, which will be operational also in air. Here we present the current status of the optical components and end station design of the beamline.

WEPB — Wednesday Poster PM Session B

WEPB01 CLS LINAC Sections' Replacement

***X. Li**, X. Shen (CLS)*

The Canadian Light Source Inc. (CLSI) located in Saskatoon, Saskatchewan, Canada is a third-generation synchrotron light source facility with a 2.9 GeV storage ring, and opened in 2004. CLSI was built based on the Saskatchewan Accelerator Laboratory (SAL) with its original LINAC. The LINAC was built in 1962 and was refurbished to operate at 250 MeV in 2002. The LINAC is keeping a steady performance through all these years, along with many repairs and replacements. The original 7 Varian type accelerating LINAC Sections were planned to be replaced gradually by SLAC type Sections through the years. Section 3 and 4 are two of the original Varian type sections - with over 55 years of service. These sections have kept accumulating water leakage and vacuum leak problems from time to time and are planned to be replaced in 2020. The main mechanical design considerations of the replacement include the modification of Wave guides, modification of water systems and supporting structures, preparation before installation and deploying the sections inside the LINAC tunnel.

WEPB03 The Magnet Measurements for the Advanced Photon Source Upgrade

***S.J. Izzo**, C.L. Doose, A.K. Jain, W.G. Jansma (ANL)*

The Advanced Photon Source-Upgrade (APS-U) project is under construction and will incorporate a new Multi-Bend Achromat (MBA) lattice. With this design, the new storage ring will require over 1320 new magnets that are being produced under build-to-print contracts to several vendors across the globe. Magnetic measurements are needed to characterize and fiducialize all these magnets to ensure field quality and alignment requirements are met. Seven specialized test benches were designed and built to meet the measurement requirements. These measurement benches may be classified into two groups. The first group is the field quality measurement that includes the strength of the main field and higher harmonics. The multipole magnets are measured using four rotating coil benches, whereas the longitudinal gradient dipoles are mapped using a Hall probe system. The second group is fiducialization that locates the magnetic center of the magnet using a rotating wire and relates it to magnet fiducials and reference surfaces using a laser tracker. This information accompanies each magnet through the module assembly and final installation in the ring to ensure that the magnet is aligned within the allowable tolerance. To date, about 65% of all magnets needed for the storage ring have been measured and fiducialized. Mechanical design of the measurement benches will be presented.

WEPB04 **Design and Fabrication Challenges of Transition Section for the CWA Module**

***S.H. Lee**, W.G. Jansma, S.S. Sorsher, K.J. Suthar, E. Trakhtenberg, G.J. Waldschmidt, A. Zholents (ANL) A.E. Siy (UW-Madison/PD)*

At the Argonne National Laboratory, an effort to build a compact collinear wakefield accelerator (CWA) with four CWA modules based on a miniature copper corrugated waveguide is under progress. to extract the wakefield and to house a beam position monitor at the downstream of each CWA module, a design of 45mm long transition section has been proposed and designed. The transition section consists of an electro-formed copper core, a machined copper base, eight seamless rectangular or oval flexible waveguides, and a stainless steel bellows assembly with a vacuum port to connect the vacuum pump, which should be all brazed together (or TIG welded) for vacuum leak tight by multi-step brazing processes with filler material of successively lower temperatures to maintain the integrity of previously brazed joints. For precise replication of the vacuum surface geometry of the core, electro-forming process starting from an aluminum mandrel shaped with inner vacuum volume can be used. Also, to manufacture the copper base connecting to waveguide tubing for extraction of the wakefield, micro-manufacturing processes such as high-precision milling and thin wire EDM can be used. In this paper, we will discuss the design and fabrication challenges for production and integrating the transition section of the CWA module.

WEPB05 **Mechanical Design of a Compact Collinear Wakefield Accelerator**

***S.H. Lee**, D.S. Doran, W.G. Jansma, S.S. Sorsher, K.J. Suthar, E. Trakhtenberg, G.J. Waldschmidt, A. Zholents (ANL) A.E. Siy (UW-Madison/PD)*

The Argonne National Laboratory is developing a compact collinear wakefield accelerator (CWA) based on a miniature copper corrugated waveguide as proposed. The accelerator is supposed to operate at 20 kHz bunch repetition rate and accelerate a 0.3 nC witness bunch to 5 GeV by a 180 GHz wakefield of a 10 nC drive bunch with the field gradient of 100 MV/m. In this paper, we discuss specific challenges in the mechanical design of the CWA module. The module consists of series of small quadrupole magnets with a high magnetic field gradient that houses a 2mm-diameter and 0.5m long corrugated waveguide with brazed water-cooling channels and a transition section. A 45mm long transition section is used to extract the wakefield and to house a beam position monitor and a bellow assembly with a vacuum port to connect the vacuum pump. The module assembly requires seven brazing joints that will be achieved via four brazing processes with filler metals of successively lower temperatures to maintain the integrity of previously brazed joints.

WEPB06 **Mechanical Design of the Booster to Storage Ring Transfer (BTS) Line for APS Upgrade**

***J. Liu**, M. Borland, T.K. Clute, J.S. Downey, M.S. Jaski, U. Wienands (ANL)*

APS Upgrade selected the horizontal injection scheme which requires exchanging the x and y emittances in the BTS transport line through a series of six skew quadrupoles, as well as matching the beam parameters to the APS Upgrade storage ring through two dipoles and a conventional pulsed septum. This paper presents the layout of this BTS line section in the storage ring tunnel and key components in this section including the mechanical design of dipole magnet, quadrupole and skew quad magnets, the vacuum system, the diagnostics system, and the supports. Finally, detailed mechanical design of this BTS line section in modules and some consideration for fabrication and installation are addressed.

WEPB07 **Magnet Module Assembly for the APS Upgrade**

***K.J. Volin**, R. Bechtold, A.K. Jain, W.G. Jansma, Z. Liu, J. Nudell, C.A. Preissner (ANL)*

With APSU well into the procurement phase of the project, the APSU assembly team has completed a "DLMA Practice Assembly", comprising of the support system, and all magnets required to complete a module. The purpose of this test was to verify assembly and documentation procedures, ensure proper fit between mating components, and verify that alignment specifications can be met. The results of this exercise are presented. Though this test was completed on the Argonne site, work continues on building 981, the APSU offsite warehouse, where our first production plinths and girders have been shipped, and where production modules will be assembled. This space has been outfitted by Argonne contractors and APSU Assembly technicians with 1) 5 parallel DLM/FODO module assembly stations, each complete with a 3 tn. overhead crane, retractable cleanroom, staging tables, and tools, and 2) 2 QMQ module assembly stations each complete with a 5 tn. gantry crane, assembly support stands, staging tables, and tools. An overview of this production assembly space is also presented.

WEPB08 **Multibody Simulations with Reduced Order Flexible Bodies Obtained by FEA**

***P. Brumund**, T. Dehaeze (ESRF) T. Dehaeze (PML)*

Tighter specifications in synchrotron instrumentation development force the design engineer more and more often to choose a mechatronics design approach. This includes actively controlled systems that need to be properly designed. The new nano-end-station for the ESRF beamline ID31 was designed with such an approach. During the end-station development a multi-body model approach was chosen. Significance of such models depend strongly on its input and consideration of the right stiffness of the system's components and subsystems. For that matter, we considered sub-components in the multi-body model as reduced order flexible bodies representing the component's modal behavior with reduced mass and stiffness matrix obtained from finite element analysis

(FEA) models. These matrices were created from FEA models via modal reduction techniques, more specifically the component mode synthesis (CMS). This makes this design approach a combined multibody-FEA technique. We validated the technique with a test bench that confirmed the good modelling capabilities using reduced order flexible body models obtained from FEA for an amplified piezoelectric actuator. Our intention with this work is to present others this approach as a possibility for similar projects.

WEPB09 **An FEA Investigation of the Vibration Response of the BEATS Detector Stage Design**

T.F. Mokoena, *A. Kaprolat, P. Van Vaerenbergh (ESRF) G. Iori (SESAME)*

As for all Synchrotron Radiation based installations, floor vibrations lead to unreliable results if transmitted to sensible equipment like sample environment and detection systems. It is important to design the optical and experimental equipment of a beamline in a way to minimize the effect of the vibrations. This project investigates the design of the detector stage in SESAME's tomography beamline BEATS by using random vibration analysis to determine the rigidity of the structure. The design analysis of the detector stage takes the approach of using an existing installation at beamline ID28 of the European Synchrotron Radiation Facility by measuring the power spectrum density of the floor on which the structure is mounted on as well as the response of the structure stage as it is subjected to an excitation from ambient floor noise. A finite element analysis numerical model was established and validated against the experimental data. Once the model is validated within acceptable range, the technique will be applied to the BEATS detector stage design by applying the floor power spectrum density of the SESAME synchrotron and calculating the response of the structure. It is assumed that the random vibration process in this case follows a Gaussian normal distribution. The response power spectrum density Root Mean Square value at the location of interest should be at least 6 times less than the pixel size of the camera that will be used in detector. For the ID28 case, the model was validated by comparing the natural frequency measured and the experimental output RMS value against the model output RMS value. The model natural frequencies deviated from the experimental results by 4.53% and the model RMS values deviated from the experimental results by 1.91%.

WEPB10 **Two Shielded End-Stations at MARS Beamline of SOLEIL Synchrotron: Specific Devices for the Highly Irradiating Materials Analysis**

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Since the mid-2000s, the engineers and researchers of CEA and SOLEIL synchrotron facility have worked together to design a world unique beamline for the study of radioactive matter: MARS (Multi Analyses on Radioactive Samples Beamline). The facility works in the hard X-ray domain (between 3.0 and 35 keV) combining both X-ray spectroscopy and X-ray diffraction/scattering techniques on two end-stations: CX2 and CX3. MARS beamline is authorized by the ASN (French Nuclear Safety Authority) to analyze samples with radioactivities up to 18.5 GBq per sample for alpha and beta emitters and up to 2 GBq for gamma and neutron emitters. One of its main objectives is to be able to analyze these highly irradiating samples, such as spent nuclear reactor fuel or irradiated nuclear material (solid, liquid), to study their structural and chemical evolutions after irradiation. This article describes the components designed and realized with the major contribution of CEA to analyze such kind of samples: #1 air-tight sample holders; #2 positioning mechanical systems on the X-ray beam; #3 local analyzer devices; #4 two shieldings to safeguard users; #5 a mobile-shielded cask to transport samples.

WEPB11 **Design of an Advance Detector Support to Allow High Quality GISAXS/GIWAXS Experiments on the MARS Beamline at SOLEIL**

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The MARS beamline, operating at SOLEIL since 2010, has been developed to provide researchers with advanced X-ray techniques to characterize nuclear materials. The diversity in users' demands has driven the development of the most suitable detector support to accommodate novel experiments that have not been specified at the time of design. The choice complied with constraints related to the installation in a narrow experimental hutch along with easy transport and maintenance. The system consists of a long-range linear table (Ts) mounted on a wide angular (-1^o; +65^o) Rx rotation; Rx can be moved off the beam axis (Tx) to align the detector with the transmitted/reflected beam. It accommodates for any detector by only changing the kinematic interface with Ts. It is worth remarking on the wide angular range with a potential concentration of mass at the end of the arm (payload: 55 kg). FEA was done to study its structural behavior. Performing movements with low SOC values not only puts constraints on the mechanics, but also on control system. As such, Delta Tau Powerbrick controller has been implemented. The design project is complete and built with commissioning work to be done.

WEPB12 **Formax Endstation - a Novel Design Combining Full-Field Tomography With Small- and Wide-Angle X-ray Scattering**

***J.B. González Fernández**, S.A. McDonald, K. Nygard, L.K. Roslund (MAX IV Laboratory, Lund University)*

ForMAX is a new beamline at the MAX IV Laboratory, combining small- and wide-angle X-ray scattering (SWAXS), scanning SWAXS imaging, and full-field microtomography for multi-scale structural characterization of hierarchical materials from nm to mm length scales. The principal elements of the endstation consist of two units of beam conditioning elements, a sample table, a flight tube and a detector gantry. The beam conditioning units include a diamond vacuum window, an attenuator system, a fast shutter, two scatterless slit collimation systems, two sets of compound refractive lenses, three X-ray beam intensity monitors, a beam viewer and a telescopic vacuum tube. The sample table permits heavy loads with sub-micron resolution motions and high stability performance. In addition, the endstation is equipped with a stationary, eight metre long and one metre diameter evacuated flight tube, enabling the sample-detector position for small-angle X-ray scattering (SAXS) to be easily adjusted under vacuum conditions. Finally, the detector gantry, a two metre high and two metre wide granite gantry, allows both the X-ray microscope for tomography and the detector for wide-angle X-ray scattering (WAXS) to be mounted. To facilitate propagation-based phase-contrast imaging and mounting of bulky sample environments, the gantry is mounted on motorized floor rails. Furthermore, two independent linear stages permit independent and easy movement of the tomography microscope and WAXS detector in and out of the beam. All these characteristics will allow to combine multiple techniques sequentially in the same experiment with fast efficient switching between setups. The ForMAX endstation is presently in the design and construction phase, with commissioning expected to commence early 2022.

WEPB13 **Design and Commissioning of the TARUMÂ Station at the CARNAÚBA Beamline at Sirius/LNLS**

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TARUMÂ is the sub-microprobe station of the CARNAÚBA (Coherent X-ray Nanoprobe Beamline) beamline at Sirius Light Source at the Brazilian Synchrotron Light Laboratory (LNLS). It has been designed to allow for simultaneous multi-analytical X-ray techniques, including diffraction, spectroscopy, fluorescence and luminescence and imaging, both in 2D and 3D. Covering the energy range from 2.05 to 15 keV, the fully-coherent monochromatic beam size varies from 550 to 120 nm after the achromatic KB (Kirkpatrick-Baez) focusing optics, granting a flux of up to 10^{11}ph/s/100mA at the probe for high-throughput experiments with flyscans. In addition to the multiple techniques available at TARUMÂ, the large work-

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ing distance of 440 mm after the ultra-high vacuum (UHV) KB system allows for another key aspect of this station, namely, a broad range of decoupled and independent sample environments. Indeed, exchangeable modular setups outside vacuum allow for in situ, in operando, cryogenic and/or in vivo experiments, covering research areas in biology, chemistry, physics, geophysics, agriculture, environment and energy, to name a few. An extensive systemic approach, heavily based on precision engineering concepts and predictive design, has been adopted for first-time-right development, effectively achieving altogether: the alignment and stability requirements of the large KB mirrors with respect to the beam and to the sample; and the nanometer-level positioning, flyscan, tomographic and setup modularity requirements of the samples. This work presents the overall station architecture, the key aspects of its main components, and the first commissioning results.

WEPB14 High-Precision RIXS Instrumentation at the European XFEL

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The SCS Instrument at the European XFEL provides instrumentation for high-resolution resonant inelastic scattering (RIXS) with a variable detection angle. This instrumentation consists of two endstations: CHEM endstation for liquid-phase experiments and XRD for solid samples, as well as a high-resolution RIXS spectrometer which can be operated with both endstations. In this talk we will present the mechanical challenges of this setup. In particular the mechanical solution allows to remove and bring back the RIXS spectrometer with high precision onto the rotation point. The two endstations can be exchanged by a docking mechanism for air pads at the rotation and interaction position, with a precision better than 30 µm. The RIXS spectrometer itself can be rotated around the XRD end station with an angular range from 35°–130° , while maintaining ultra-high vacuum conditions. The rotation around the interaction point of the XRD endstation is realized by three coupled rotating flanges, which are differentially pumped. The spectrometer itself floats on air-pads over a high-precision floor with a gap of roughly 20 µm and is guided on a curved rail and driven by a friction wheel. The 5 m long RIXS spectrometer allows a large travel range between grating and detector chamber, distance ranging from 2196–3422 mm under ultra-high vacuum conditions. This is realized by moving the detector chamber longitudinally and vertically to the beam propagation, as well as tilting the detector chamber at the same time.

WEPB15 **A Novel Vacuum Chamber Design for the APS Upgrade of the 26-ID Nanoprobe**

***S.J. Bean**, P.N. Amann, M. Bartlein, Z. Cai, T. Graber, M. Holt, D. Shu (ANL)*

An enhancement design of an existing 26-ID nanoprobe at APS is being completed as part of work for the APS-Upgrade (APS-U) project. As part of this enhancement design, a new vacuum chamber geometry configuration has been implemented that balances the desired simultaneous X-ray measurement methods with accessibility and serviceability of the nanoprobe. The main enabling feature on the vacuum chamber is a slanted mid-level vacuum sealing plane. The new chamber design geometrically optimizes the ability to perform simultaneous diffraction, fluorescence and optical or laser pump probe measurements on the sample. A large diffraction door geometry is strategically placed near the sample for ease of access. The newly designed chamber can be readily serviced by removal of the upper chamber section, on which most larger instrument assemblies or beamline attachments are not interfaced. The mechanical design intent and geometry of this chamber concept is described in this paper. Keywords: X-ray nanoprobe, X-ray microscopy, X-ray fluorescence, nanodiffraction, vacuum chamber, instrumentation, synchrotron

WEPB16 **CFD Predictions of Water Flow Through Impellers of the ALBA Centrifugal Pumps and Their Aspiration Zone. An Investigation of Fluid Dynamics Effects on Cavitation Problems**

***A. González Romero** (ESEIAAT) J.J. Casas, C. Colldelram, M. Quispe (ALBA-CELLS Synchrotron)*

Currently, the ALBA refrigeration system pumps present cavitation problems when operating at their nominal regime. To alleviate this phenomenon temporarily until a definitive solution was found, the water flow was reduced to 67% of the nominal value. As this flow exchanges heat with the cold cooling water produced in an external cogeneration plant, modifying the working point of the pumps resulted in a reduction of the Accelerator cooling capacity. However, even at such low flow conditions, the flow has an anomalous oscillatory behaviour in the distributor of the aspiration zone, implying that the cause may be in a bad dimensioning of that distributor. This paper presents a study of Computational Fluid Dynamics (CFD), applied to the aspiration zones of the pumps, to investigate the effects of fluid dynamics on cavitation problems and understand what may be happening in the system. The need for such research arises from the urge to recover the accelerator cooling capacity and the constant pursuit for the improvement of the system. The geometries for this study include the general manifold in the aspiration zone and a simplified model of the pump impeller. The simulations have been carried out with the ANSYS-FLUENT software. Studies performed include considering the total water flow in nominal and under current operating conditions. In addition, the cases in which the flow is distributed through the manifold tubes in uniform and non-uniform ways have been treated separately. Pressure and velocity fields are analysed for various turbulence

models. Finally, conclusions and recommendations to the problem are presented.

WEPB17 A Fast Simulation Tool to Calculate Spectral Power Density Emitted by Wigglers and Short Insertion Devices

***J. Reyes-Herrera**, M. Sanchez del Rio (ESRF)*

The analysis of thermal stress of beamline components requires a comprehensive determination of the absorbed power profile. Consequently, accurate calculations of beam power density and its dependency on the photon energy are required. There exist precise tools to perform these calculations for undulator sources, like several methods available in the OASYS toolbox considering, for example, the contribution of the different harmonics of the undulator radiation or using ray-tracing algorithms. This is not the case for wiggler sources, in particular for short insertion devices that are used as source for the bending magnet beamlines in some upgraded storage rings like the ESRF-EBS. Wiggler radiation is incoherent and although it is possible the use of undulator methods for calculating it, this is very inefficient. In this work, we describe a tool that performs fast calculations of spectral power density from a wiggler source. The emission is calculated starting from a tabulated magnetic field and computes the power spatial and spectral density. It uses concepts inspired from Tanaka's work. It is implemented in a user-friendly widget in OASYS and can be connected to widgets to calculate absorbed and transmitted power density along the beamline components. The accuracy of the method is verified by calculating three examples and comparing the results with ray-tracing. The three insertion devices simulated are: the EBS-ESRF-3PW, the ESRF W150 (a high power wiggler) and the 3PW for the BEATS project at the SESAME synchrotron source.

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WEPC01 **Robotic Sample Changer for Remote and Mail-In In Situ X-ray Scattering Experiments and Adjustable Beam Attenuation System**

***B.L. Monk**, A.A. Yakovenko (ANL)*

The COVID-19 pandemic has resulted in a highly increased need for remote beamline operations. Usually, in situ X-ray scattering experiments require significant onsite user and beamline staff presence, making them difficult and often impractical during limited operations. One of the major problems was the switching of capillary samples for in situ heating/cooling experiments. Therefore, we developed a specialized robotic system for changing samples utilizing easily accessible standardized parts and 3-D printing. The first version of this design is fully operational and has been installed at the 17-BM beamline. This system allows for changing between 14 capillary based samples by using three stepper motor based translational stages and pneumatic gripper. The destination can be intercrossed with hot or cold air blower stream, allowing users to remotely collect X-ray powder diffraction data from multiple samples at various temperatures. Currently, we are working on the development of a second robotic system, which will fit entirely onto one breadboard. This will allow us to move the system from one beamline to another if needed. The second piece of instrumentation we have developed is a remotely operated beam attenuation system with adjustable attenuation level. The system uses electric solenoids that push tantalum foils in and out of the beam. Five solenoids each hold different numbers of foils, and can be controlled independently, allowing for a total of 32 unique attenuation levels. A 6th solenoid holds a beamstop which can be used as a fast shutter. The control and communication is performed by an Arduino Yun microcontroller. All structural parts were 3-D printed, making for a cost-effective alternative to systems currently on the market.

WEPC02 **A Cryogenic Sample Environment for the TARUMÂ Station at the CARNAÚBA Beamline at Sirius/LNLS**

***F.R. Lena**, C.S.N.C. Bueno, F.H. Cardoso, J.C. Carvalho, M.M. Donatti, R.R. Geraldes, L.M. Kofukuda, L.S. Perissinotto, E. Piragibe, C. Sato, H.C.N. Tolentino, W.H. Wilendorf (LNLS)*

TARUMÂ is the sub-microprobe station of the CARNAÚBA (Coherent X-ray Nanoprobe) beamline at Sirius Light Source at the Brazilian Synchrotron Light Laboratory (LNLS). Covering the tender-to-hard energy range from 2.05 to 15 keV with achromatic fixed-shape optics, the fully coherent focused beam between 550 and 120nm can be used for multiple simultaneous advanced micro and nanoscale X-ray techniques that include ptychography coherent diffraction imaging (ptychoCDI), absorption spectroscopy (XAS), diffraction (XRD), fluorescence (XRF) and luminescence (XEOL). In addition to that, the large working distance of 440 mm after the ultra-high vacuum (UHV) KB system allows for another key aspect of this station, namely, a broad range of decoupled and independent sample environments outside vacuum. Among the broad range of materials of interest, studies of light elements present in soft tissues and other biological systems put TARUMÂ in a unique position in the Life and Environmental Sciences program at LNLS. Yet, to mitigate the detrimental effect of the focused beam with a photon flux of 10^{11} ph/s/100 mA due to radiation damage, cryocooling may be required. Here we present the design and first thermal and mechatronic results of a novel open-atmosphere cryogenic system for online sample conditioning around 150 K. The high-stiffness and thermally-stable sample holder follows the predictive design approach based on precision engineering principles to preserve the nanometer-level positioning requirements, whereas a commercial nitrogen blower is used along with a cold gas flow exhaustion system that has been developed in order to avoid unwanted cooling of surrounding parts and water condensation or icing.

WEPC03 **Electrochemistry and Microfluidic Environments for the TARUMÂ Station at the CARNAÚBA Beamline at Sirius/LNLS**

W.H. Wilendorf, *R.R. Geraldes, L.M. Kofukuda, I.T. Neckel, H.C.N. Tolentino (LNLS) P.S. Fernández (UNICAMP)*

CARNAÚBA (Coherent X-ray Nanoprobe Beamline) is a state-of-the-art multi-technique beamline at the 4th-generation Sirius Light Source at the Brazilian Synchrotron Light Laboratory (LNLS), with achromatic optics and fully-coherent X-ray beam in the energy range between 2.05 and 15 keV. At the TARUMÂ station, the in-vacuum KB focusing system has been designed with a large working distance of 440 mm, allowing for a broad range of independent sample environments to be developed in open atmosphere to benefit from the spot size between 550 to 120 nm with a flux in the order of 10^{11} ph/s/100 mA. Hence, together with a number of different detectors that can be simultaneously used, a wide variety of studies of organic and inorganic materials and systems are possible using cutting-edge X-ray-based techniques in the micro and nanoscale, including coherent diffractive imaging (CDI), fluorescence (XRF), optical luminescence (XEOL), absorption spectroscopy (XAS), and diffraction (XRD). Even though samples over the centimeter range can be taken at Tarumã, the small beam and relatively low energies point towards optimized and reduced-size sample holders for in situ experiments. This work describes two related setups that have been developed in-house: a small-volume electrochemical cell with static fluid; and another multi-functional environment that can be used both as a microfluidic device and as an electrochemistry cell that allows for fluid control over samples deposited on a working electrode. The mechanical design of the devices, as well as the architecture for the fluid and electrical supply systems, according to the precision engineering concepts required for nanopositioning performance, are described in details.

WEPC04 **A Compact X-ray Emission (mini-XES) Spectrometer at CLS - Design and Fabrication Methods**

***T.W. Wysokinski**, M. Button, B. Diaz Moreno, A.F.G. Leontowich (CLS)*

A compact X-ray emission spectrometer (mini-XES) has been designed and fabricated for use at the BXDS undulator beamline at the Canadian Light Source (CLS). The mini-XES uses cylindrical von Hamos geometry tuned for the Fe K-edge, and a Pilatus 100K area detector from Dectris. It is based on a design implemented at the APS. The BXDS mini-XES design was developed to be as simple to fabricate and as easy to operate as possible. The number of components was minimized so there are only two main parts that create a chamber joined together by an NW-80 flange. From start, the design was trying to achieve no tools assembly, alignment, and operation. For lower precision alignment we decided to use the centering ring of the NW-80 flange which, together with two posts integrated with the chamber, provides an adequate method for joining the two parts of the enclosure. Bubble level vials were implemented for horizontal adjustment of the holder for the 10 crystals. For high precision alignment of the holder of the crystal, we used the Thorlab KC1/M kinematic mount, which had the adjustment screws accessible from outside of the chamber. The fabrication was done in-house using a uPrint SE Plus 3D printer and ABS-P430 model material. The main two components of the spectrometer used the maximum printing envelope of the printer: 203 × 203 × 152 mm^3 (8" × 8" × 6"). Woods Waterproof Silicone Spray was used to seal the plastic walls, and we used a Kapton window to close the top of the chamber, next to the area detector. The first tests of the spectrometer were completed and were successful. Future improvements will aim to reduce the background scatter and better position the detector, to improve the fill.

WEPC05 **An Improved, Compact High Temperature Sample Furnace for X-ray Powder Diffraction**

***E. Haas** (BNL)*

A compact sample furnace was designed and tested at the X-ray Powder Diffraction (XPD) beamline at NSLS-II. This furnace is designed to heat small samples to temperatures of 2000 - 2300^{o}C while allowing the XPD photon beam to pass through with adequate downstream opening in the furnace to collect diffraction data. Since the XPD samples did not reach the desired temperatures initially, engineering studies, tests, and incremental improvements were planned and undertaken to improve performance. The design of the sample furnace will be presented as background, and engineering details will be presented in this paper describing work undertaken to improve the furnace design to allow sample temperatures to reach 2000 - 2300^{o}C or more.

WEPC06 **Notch Geometry Optimization of APS Upgrade High Heat Load Mirror Systems**

J.J. Knopp *(ANL)*

Thermal deformation of X-ray optics can have a profound impact on beamline performance. The thermal deformation of these X-ray optics due to heat loads of the X-ray beam has been previously shown to be able to be partially mitigated by adding a groove or notch on the side of the optic and below the optical surface. This notch acts as a thermal break which allows for anti-clastic bending and the notch geometry can be optimized for various heat loads. By optimizing the notch height, depth, and distance from the optical surface the thermal deformation on the optic can be minimized. The High Heat Load Mirror systems of the Advance Photon Source (APS) feature beamlines rely on this notch geometry to be able to take full advantage of the new source of the APS Upgrade.

WEPC07 **Thermal Model Validation for the Cryogenic Optical Systems for Sirius/LNLS**

L.M. Volpe*, C.S.N.C. Bueno, G.V. Claudiano, J.C. Corsaletti, B.A. Francisco, R.R. Geraldes, F.R. Lena, M.S. Silva, V.B. Zilli (LNLS) J.H. Řežende (CNPEM)*

Sirius the fourth-generation synchrotron light sources that came into operation in 2020 in the Brazilian Synchrotron Light Laboratory (LNLS), providing a photon beam with a much lower emissivity than the previous second-generation light source in Brazil (UVX). One of the challenges to deal with in such a light source is the high power density that may affect the beamline optical elements by causing figure deformations that deteriorate the quality of the beam. Indeed, surface specifications for height errors of X-ray mirrors are often within a few nanometers, possibly going below 1 nm. To deal with this power management challenges, thermo-mechanical designs based on cryogenic silicon have been developed, taking advantage of the fact that the coefficient of thermal expansion of the material is nearly zero in temperatures of about 125 K. A liquid nitrogen (LN2) cryostat connected to the optics by copper braids has been used handle moderate power loads, reducing costs as compared to closed-circuit LN2 cryocoolers and mechanically decoupling flow-induced vibrations from the optics. To guarantee the functionality of such systems, lumped mass thermal models were implemented together with auxiliary finite elements analyses, considering heat transfer by conduction, convection and radiation among multiple bodies. These models were of paramount importance to optimize the systems with limited computational cost, either in defining the geometry of the components, or for tuning the PID thermal controllers. With the first systems in operation, it has been possible to compare and validate the developed models, and to carry out optimizations to improve them for future projects, by adjusting parameters such as emissivity, thermal contact and copper braid conductance, among others.

WEPC08 Assessment of SR Peak Power Limit on Absorbers by 1D Analytical Approximation

J. Rank *(BNL)*

Water-cooled absorbers "trim" radiation fans to protect downstream components from Insertion Device and Bending Magnet sources. Absorber surfaces onto which synchrotron radiated power is incident are generally constructed from Glidcop. Adopting the failure criterion of 300^{o}C, maximum allowable temperature is limited by thermal fatigue properties of Glidcop Al-15 per the NSLS2 Synchrotron Radiation Protection (SRP) protocol. Typically, 3+ GeV synchrotrons develop sufficiently high peak power deposition that limiting temperatures can be reached with a short pulse of steady mis-steered beam heating measured in just hundreds of milliseconds. Using classical 1D Fourier approximation, we explore the behavior over these periods to glean a general understanding of practical conservative thermal limits of beam power absorbers for easy pass/fail evaluation.

WEPC09 Temperature Dependent Elastic Constants and Young's Modulus of Silicon Single Crystal

Z. Liu *(ANL)*

Silicon crystals have been widely applied for X-ray monochromators. It is an anisotropic material with temperature dependent properties. Values of its thermal properties from cryogenic to high temperature are available in literature for expansion, conductivity, diffusivity, heat capacity, but elastic constants or Young's modulus. X-ray monochromators may be liquid-nitrogen cooled or water cooled. Finite Element Analysis (FEA) is commonly used to predict thermal performance of monochromators. The elastic constants and Young's modulus over cryogenic and high temperature are now collected and derived from literature, with the purpose of assisting to provide accurate prediction of FEA.

WEPC10 Design of Vacuum Chamber With Cryogenic Cooling of Samples for Bragg-Plane Slope Error Measurements

J.W.J. Anton*, P. Pradhan, D. Shu, Yu. Shvyd'ko (ANL)*

Wavefront preservation is essential for numerous X-ray science applications. Research is currently underway at the Advanced Photon Source to characterize and minimize Bragg-plane slope errors in diamond crystal optics. Understanding the effect of cooling the optics to cryogenic temperatures on Bragg-plane slope errors is of interest to this research. Through the use of a finite element model a custom, compact vacuum chamber with liquid nitrogen cooling of samples was designed and manufactured. The design process and initial results are discussed in this paper.

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WEPC11 **Integrated Optomechanical Design for High-Resolution Experimental Stations: A Proposal for Analytic Coupled Modeling of Engineering, Optics, and Experiment Requirements**

G.B.Z.L. Moreno*, A.C. Pinto, H.C.N. Tolentino (LNLS) A.R. Fioravanti (UNICAMP)*

The significant enhancement brought by new-generation light sources has driven experimental stations and optomechanical instrumentation to increasingly ambitious designs: precision engineering, optics design, and experimental techniques are being pushed to the limit of what is achievable, aiming at delivering the best spatial, spectral and temporal resolution to the measurements. The extreme brilliance making diffraction-limited focusing feasible, also sets new sensitivity baselines for vibrations, clamping and thermal deformations, demanding stiffer mechanics and tighter tolerances for fabrication, metrology and alignment, as well as creative commissioning and experiment control strategies. Such interdisciplinary design often requires cross-checking between mechanical, optical, and experimental station designs, where shared variables might induce conflicting behavior, stressing specifications and tolerances throughout every design step. In this manner, a group of integrated analytical models targeting globally optimal designs could act as a more assertive starting point to a broader, model-based assessment, pruning the decision space for subsequent finite-element analysis. Identifying the main variables influencing the global design objectives may add to design quality, and guide future efforts in further improving scientific instrumentation performance. This contribution suggests key parts of such an integrated model, using as example some tools and design decisions that went in this direction during the development phases of the first Sirius/ LNLS beamlines and beamline instrumentation.

WEPC12 **A New Experimental Station for Liquid Interface X-ray Scattering At NSLS-II Beamline 12-ID**

D.M. Bacescu*, L. Berman, S. Hulbert, B. Ocko, Z. Yin (BNL)*

Open Platform and Liquids Scattering (OPLS) is a new experimental station recently built and currently being commissioned at the Soft Matter Interfaces (SMI) beamline 12-ID at NSLS-II. The new instrument expands SMI's beamline scientific capabilities via the addition of X-ray scattering techniques from liquid surfaces and interfaces. The design of this new instrument, located inside the 12-ID beamline shielding enclosure (hutch B), is based on a single Ge (111) crystal deflector, which bounces the incident X-ray beam downward towards a liquid sample which must be maintained in a horizontal orientation (gravity-driven consideration). The OPLS instrument has a variable deflector-to-sample distance ranging from 0.6 m to 1.5 m. X-ray detectors are mounted on a 2-theta scattering arm located downstream of the sample location. The 2-theta arm is designed to hold up to three X-ray detectors, with fixed 2-theta angular offsets, each dedicated to a different X-ray technique such as X-ray reflectivity, grazing-incidence X-ray scattering, and small- and wide-angle X-ray scattering. Currently, the OPLS experimental station intercepts the

SMI beam that otherwise propagates to the experimental endstation located in hutch C and can be retracted to a 'parking' position laterally out of this beam to allow installation of a removable beam pipe that is needed to support operations in hutch C. The design of OPLS is flexible enough to quickly adapt to a planned future configuration of the SMI beamline in which a OPLS is illuminated separately from the main SMI branch via a second, canted undulator source and a separate photon delivery system. In this future configuration, both branches will be able to operate independently and simultaneously.

WEPC13 **Sample and Detector Positioning Instruments for the Wide Angle XPCS End Station at 8-ID-E, a Feature Beamline for the APS Upgrade**

***K.J. Wakefield**, S.J. Bean, D. Capatina, E.M. Dufresne, M.V. Fisher, M.J. Highland, S. Narayanan, A. Sandy (ANL)*

The X-ray Photon Correlation Spectroscopy (XPCS) beamline at the Advanced Photon Source (APS) has been selected as one of nine feature beamlines being designed to take advantage of the increase in coherent flux provided by the APS Upgrade. The 8-ID-E enclosure at the beamline will have a dedicated instrument for performing Wide Angle XPCS (WA-XPCS) measurements across a range of length and time scales. The instrument will feature a high-stability 6-circle diffractometer, a moveable Long Distance Detector Positioner (LDDP) for positioning a large pixel array detector, and a removable flight path assembly. For intermediate sample to detector distances of 1.5 to 2 meters, a detector will be positioned on the diffractometer detector arm. For longer sample to detector distances up to 4 meters in a horizontal scattering geometry, a detector will be positioned using the LDDP. The LDDP will consist of a large granite base on which sits a combination of motorized stages. The base will sit on air casters that allow the LDDP to be coarsely positioned manually within the enclosure. Final positioning of the detector will be achieved with the mounted stages. The spatial relationship between the sample and the free moving LDDP will be monitored using a laser tracking system. A moveable flight path will be supported by the diffractometer arm and a mobile floor support to minimize air scattering while using the LDDP. The WA-XPCS instrument has been designed with users and beamline staff in mind and will allow them to more efficiently utilize the upgraded beam provided by the APS Upgrade.

WEPC14 **Sample and Detector Positioning Instruments for the Small Angle XPCS End Station at 8-ID-I, a Feature Beamline for the APS Upgrade**

***K.J. Wakefield**, S.J. Bean, D. Capatina, E.M. Dufresne, M.V. Fisher, M.J. Highland, S. Narayanan, A. Sandy (ANL)*

The X-ray Photon Correlation Spectroscopy (XPCS) beamline at the Advanced Photon Source (APS) has been selected as one of nine feature beamlines being designed to take advantage of the increase in coherent flux provided by the APS Upgrade. The 8-ID-I enclosure of the beamline will primarily perform Small Angle XPCS measurements and occasionally be used for Ultra Small Angle XPCS measurements. Critical to a successful XPCS measurement is precise, low vibration positioning of a sample and the ability to position a detector a significant distance from the sample while minimizing air scattering. These requirements will be facilitated by two new major instruments. The experimental samples will be positioned by a high-stability granite air bearing table. The table will allow users and beamline staff to easily switch between two sample stations, a rheometer station for in-situ rheology-XPCS measurements and a stack of general-purpose positioning stages for various sample environments. Easy changing between the stations will be facilitated by motorized air bearings on the granite table. The detectors at the end of the enclosure will be positioned by a bellows-based vacuum flight path. Two detectors will be mounted outside of vacuum to stages on a traveling platform. With the expansion and contraction of the bellows, the detectors can be placed from 3 to 11.5 meters from the sample on the granite table. The entire assembly will be mounted to curved rails, allowing it to pivot from 0 to 5 degrees about the sample center, further expanding the options for positioning the detectors in a wide range of locations. These two instruments have been designed with users and beamline staff in mind and will allow them to more efficiently utilize the upgraded beam provided by the APS Upgrade.

WEPC15 **Nylon Mesh Holder for Serial Crystallography Experiments**

D.A. Sherrell *(ANL)*

Over the last two years, we have developed a 3D printed nylon mesh holder for serial synchrotron crystallography (SSX) experiments. We are moving away from the complications in some devices to a cheap, easy, and user-friendly format. The device uses a new, patented, two-layer (one rigid and one flexible) substrate technique developed at Argonne. The SSX device and method, which incorporates a modular high-performance computing data analysis backend, was used to demonstrate never-before-seen molecular dynamics and discovered the methylated form of the SARS-CoV-2 Nsp10/16 protein complex. Named ALEX (Advanced Lightweight Encapsulation for Crystallography) for short, we are actively using, upgrading, and reaching out to collaborators. We are using ALEX for serial experiments at APS but feel the design might be useful for other applications.

WEPC16 **The PtychoProbe Instrument for the Advanced Photon Source Upgrade**

C.A. Preissner*, S.J. Bean, A.L. Bernhard, J. Deng, M. Erdmann, B. Lai, Z. Liu, J. Maser, T. Mooney, V. Rose, R. Winarski (ANL) W. Diete, U. Wiesemann (AXILON AG)*

The PtychoProbe X-ray microscope is a new instrument to be built as part of the Advanced Photon Source Upgrade (APS-U) at sector 33-ID. The PtychoProbe will take advantage of then 100 times increase in coherent flux of the APS-U. It will enable chemical and structural imaging by combining X-ray fluorescence and ptychography with beams focused down to about 5 nm. Scanning will be done at 1000 times the rate compared with the current APS. To enable this cutting-edge scientific performance, innovative engineering is required. This paper will provide an overview of the critical subsystems of the PtychoProbe instrument, including the two-axis granite stage system, vacuum chamber, optics and sample positioning systems, optics-to-sample metrology, and ptychographic detector system. The high performance and many-faceted levels of integration presents numerous engineering challenges which will be discussed along with the proposed solutions.

WEPC17 **The Atomic Instrument for the Advanced Photon Source Upgrade**

C.A. Preissner*, S.J. Bean, W. Cha, R. Harder, S.J. Izzo, J. Maser, O.A. Schmidt, X. Shi, D. Shu (ANL)*

Atomic is a new coherent diffraction imaging (CDI) instrument to be built as part of the Advanced Photon Source Upgrade (APS-U) at sector 34-ID. The unprecedented hard X-ray coherent flux from the APS-U will allow for structural imaging at a resolution that approaches atomic dimensions, with measurements times of a few tens of minutes. Significant engineering and X-ray optics challenges are being addressed to enable Atomic. Novel, coherence-preserving, zoom-capable Kirkpatrick-Baez mirrors will focus the X-rays to a 50 nm spot. A high precision three-circle goniometer with about a 50 nm sphere of confusion will keep the area of interest of the sample in the focused beam (single grain or domain) while trajectory scanning. The large diffraction detector will track the Bragg peak at up to a 5 m radius during the scan. The close integration of optics and sample, high-precision, and trajectory scanning present numerous engineering challenges which will be discussed along with the proposed solutions.

THIO — Thursday Keynote and Invited Oral

Chair: D. Shu (ANL)

THIO01 **Design of Next Generation Beam Line Equipment by Applying Advanced Mechatronic Principles**

T.A.M. Ruijl *(MI-Partners)*

Next generation experiments clearly require beamline equipment with fast and accurate positioning of samples and ultra-stable positioning of optics. Going from the classical quasi-static positioning (point to point) to scanning applications requires a different kind of equipment. The approach to design quasi-static equipment versus scanning equipment with high dynamic performance is very different as well. The shift required in such design approach takes a significant amount of time as it involves new technologies and design experience, to fulfill the high-end requirements finally with sufficient reliability. A market segment, where ultra-precision manufacturing equipment is already required for several decades, is the semiconductor manufacturing industry. Starting with high-end mechatronic equipment in the 90's, involvement of mechatronics in this area increased very rapidly over the last years. Extremely high precision, with ultra-fast and reliable equipment to fulfill the throughput demands pushes mechatronic developments. Nowadays this equipment requires stages moving at velocities of several m/s, with several tens of m/s2 of accelerations while reaching nm positioning accuracy. Besides extreme reliability to achieve the targets of 100% uptime during 24/7 production, throughput is a driving parameter. Over the years, design principles have been developed to reach these extreme performances. These strategies and principles can also be used for the design next generation beam line equipment. This paper will address some of the principles and how they are applied in a double crystal monochromator at Brazilian light source (LNLS).

THIO02 Determination of Operating Conditions of the Compact High Repetition Rate Wakefield Accelerator Using Electromagnetic Heating and Multiphysics Approach

K.J. Suthar, *W.G. Jansma, S.H. Lee, S.S. Sorsher, E. Trakhtenberg, G.J. Waldschmidt, A. Zholents (ANL) A.E. Siy (UW-Madison/PD)*

Thermal stresses generated due to the electromagnetic (EM) heating is a defining phenomenon in the mechanical design of the miniature copper-based corrugated wakefield accelerator (CWA). We investigate the effect of the EM heating due to the high repetition rate electron bunches traveling through a corrugated tube with 1-mm-inner-radius. The steady-state thermal analysis is coupled with computational fluid dynamics, and structural mechanics to determine the thermal effect on the operating conditions of CWA. It could carry a 10 nC drive bunch through the center of corrugated structure that generates a field gradient 100 Mv/m at 180 GHz, accelerating a trailing 0.3 nC witness bunch to 5 GeV. The wakefield produced by the traveling bunches can deposit about 600 W to 3000 W of energy on the inner wall of the device. Also, the instabilities in e-beam trajectories caused by thermal expansion, and the resulting stresses associated high-frequency repetition rate of 10 kHz to 50 kHz are the main concern for the waveguide. Tensile-yield failure due to moderate heating on the surface of the <200 micrometer wide trough regions of the corrugated tube may lead to arcing and loss of the wakefield.

THOA — Thursday Contributed Oral Session A

Chair: S.P. Kearney (ANL)

THOA01 A Family of High-Stability Granite Stages for Synchrotron Applications

C.A. Preissner, *S.J. Bean, M. Erdmann (ANL) M. Bergeret, J.R. Nasiatka (LBNL)*

Engineers at the APS have developed a granite, air-bearing stage concept that provides many millimeters of motion range and nanometer-level vibrational stability. This technique was first conceptualized and used on the Velociprobe X-ray microscope. The success of that design spurred adaption of the approach to about 70 devices, including many new instruments at the APS and high performing instruments at other synchrotrons. This paper details the design concept, some performance measurements, and new developments allowing for a six-degree-of-freedom device.

THOA02 A New Traveling Interferometric Scheme for the APS Upgrade of the 2-ID Bionanoprobe

S.J. Bean, *S. Chen, T. Graber, C. Jacobsen, B. Lai, E.R. Maxey, T. Mooney, C.A. Preissner, X. Shi, D. Shu, J. Tan, W. Wojcik (ANL)*

An upgrade of an existing cryogenic Bionanoprobe is being designed as part of the Advanced Photon Source Upgrade (APS-U) beamline enhancement at sector 2-ID. The new Bionanoprobe II (BNP-II) will take advantage of the APS-U source and provide new capabilities for the microscopy program at 2-ID. A 10 nm Fresnel zone plate (FZP) nanofocusing optic will be implemented in this design. To meet the BNP-II scanning goals, it is desirable to have sub-2 nm measurement of the relative scanned position between the optic and the sample. The ability to measure this information with a metrology design on the sample (given desired scanning performance, the constraints of the cryogenic configuration around the sample, the desired sample positioning motions, and the detector configuration inside the nanoprobe) presents a significant engineering challenge. To overcome this challenge, the proposed BNP-II metrology design incorporates a new traveling interferometer concept for the sample. A traveling interferometer platform tracks a cryogenic sample cylindrical reference in the horizontal plane, and is decoupled from the other degrees of freedom of the sample. A strategic set of stationary global interferometers measure information both from the reference and from the traveling platform. An additional set of global interferometers, which don't move, are utilized to measure the FZP optic's position. The combination of information from the relative and global measurements gives information on all six degrees of freedom of the sample, and of the relative scanned position with respect to the FZP. The mechanics and configuration of this interferometer scheme are described in this paper.

THOA03 **Status Report on the Sirius Beamlines Alignment**

H. Geraissate, *R. Junqueira Leão, G.R. Rovigatti de Oliveira (LNLS)*

The new Brazilian Synchotron Light Source had its first friendly users late in 2019. During 2020, the first experimental stations were aligned and had the first beam succesfully at the sample. The reference network of points used for the storage ring alignment was connected to an external network located in the experimental hall. Following this step, it was possible to extend these references to the hutches environment, where the beamlines components are installed. During the alignment of the first beamlines, a sequence of common tasks was performed, beginning with the marking of the hutches footprints and as-built measurements of the radiation shielding and slabs interfaces; the tasks were then followed by demarcation of holes for pedestals and supporting structures, components' fiducialization, components' pre-alignment, baking, and, finally, their fine alignment. The position and orientation deviation of the front-ends and main components will be presented for the Manacá, Cateretê, Ema, and Carnaúba beamlines. Two specific measurement strategies used for aligning special components will also be presented: (1) an indirect fiducialization procedure developed for most of the mirrors and their mechanisms using a mix of coordinate measuring machine and articulated measuring arm measurements, and (2) a multi-station setup arranged for the alignment of a 30 meters long detector carriage, using a mix of laser tracker, physical artifacts, and a rotary laser alignment system used as a straightness reference.

THOB — Thursday Contributed Oral Session B

Chair: K.J. Suthar (ANL)

THOB01 **Thermal Contact Conductance in a Typical Silicon Crystal Assembly Found in Particle Accelerators**

P. Sanchez Navarro *(DLS)*

Every mirror at Diamond Light Source (the UK's Particle Accelerator) has been installed with the premise of clamping the cooling copper manifolds as lightly as possible to minimize distortion. The problem with this approach is that the Thermal Contact Conductance (TCC) depends on the applied pressure among other factors. The assembly is usually a symmetric stack of Copper - Indium Foil - Silicon Crystal - Indium Foil - Copper. Variables that interest the most are those that are easily adjustable in the set-up assembly (number of clamps, pressure applied and cooling water flow rate) PT100 temperature sensors have been used along the surface of the crystal and along the surface of the copper manifolds. Custom PCB units have been created for this project to act as a mean of collecting data and Matlab has been used to plot the temperature measurements vs. time. Another challenge is the creation of an accurate model in Ansys that matches reality up to a good compromise where the data that is being recorded from the sensors matches Ansys results within reason.

THOB02 **Heat Load Simulation for General Used Optic Materials at European XFEL**

F. Yang*, D. La Civita, H. Sinn, M. Vannoni (EuXFEL)*

The European XFEL GmbH, located in Hamburg area in Germany, is the X-ray free electron laser light source which has been in the operation since 2017. It is designed to provide users high intensity X-ray beam with 27000 pulses/s repetition rate in the photon energy range from 0.5 to 25 keV. In the beam transport system, the optic components which have direct contact with the beam, e.g. mirror, absorber and beam shutter, etc., could get up to 10 kW heat load on a sub-mm spot in 0.6 ms. Therefore, the thermo-mechanical performance of these optic components is playing an important role in the safety operation of the facility, restricting the maximum allowed beam power delivered to each experiment station. In this contribution, using finite element simulation tools, a parametric study about coupled thermo-mechanical behavior of some general used materials, e.g. CVD diamond, B4C, silicon, etc. is presented. Based on the design of several devices which are already in operation at European XFEL, an initial damage threshold for these materials is established, with respect to the corresponding beam parameters. Furthermore, the relevant analytical and numerical solutions are discussed and compared, taking the material and geometrical nonlinearities into account. These simulation results can be referred as design and operation benchmark for the optic elements in the beamlines.

THOB03 **Innovative and Biologically Inspired Petra IV Girder Design**

S. Andresen *(Alfred-Wegener-Institut) N. Meyners, D. Thoden (DESY)*

DESY (Deutsches Elektronen Synchrotron) is currently expanding the PETRA III storage ring X-ray radiation source to a high-resolution 3D X-ray microscope providing all length scales from the atom to millimeters. This PETRA IV project involves an optimization of the girder magnet assemblies to reduce the impact of ambient vibrations on the particle beam. For this purpose, an innovative and biologically inspired girder structure has been developed. Beforehand, a large parametric study analyzed the impact of different loading and boundary conditions on the eigenfrequencies of a magnet-girder assembly. Subsequently, the girder design process was generated, which combined topology optimizations with biologically inspired structures (e.g., complex Voronoi combs, hierarchical structures, and smooth connections) and cross section optimizations using genetic algorithms to obtain a girder magnet assembly with high eigenfrequencies, a high stiffness, and reduced weight. The girder was successfully manufactured from gray cast iron and first vibration experiments have been conducted to validate the simulations.

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