MEDSI 2016

MECHANICAL ENGINEERING DESIGN OF SYNCHROTRON RADIATION EQUIPMENT AND INSTRUMENTATION

COSMOCAIXA Science Museum
Barcelona, Spain

September 11-16, 2016

Hosted by
ALBA Synchrotron Light Source
www.medsi2016.org

www.albasynchrotron.es

During the 9th Mechanical Engineering Design of Synchrotron Radiation Equipment and Instrumentation edition, about 200 foremost engineers delegates from synchrotron facilities from all over the world, will have the opportunity to showcase and exchange cutting-edge developments in mechanical design and engineering of synchrotron-based instrumentation. We believe this is an excellent opportunity for networking, exchanging information and ideas among different professionals and also disclosing these ultimate developments in an unique environment.

Hosted by the ALBA Synchrotron, the scientific program of MEDSI'16 event features up to 4 invited tutorial contributions, 42 regular oral contributions and 125 posters on the most relevant fields of synchrotron engineering. The MEDSI'16 venue includes a full-equipped auditorium for regular sessions and nicely equipped lecture room and foyer for tutorials, as well as an industrial and poster exhibition space in a very peculiar venue: the Science Museum of Barcelona, with full access for delegates.
Barcelona is an avant-garde, cosmopolitan city, but has inherited many centuries of history. Its geographic location and the open character of its inhabitants are only some of the reasons why the city is being culturally enriched all the time. It has a valuable architectural and monumental heritage, the most splendid exponents of which are its gothic and modernist buildings. Nine of those buildings have been designated World Heritage Sites. The entire city guarantees that visitors will enjoy taking a stroll along the streets which are replete with charm. Barcelona enjoys a Mediterranean climate, with mild winters and warm summers. It is a coastal city and has over four kilometers of urban beaches and large areas of nearby forest.

We are pleased to welcome you to this exceptional location for the ninth MEDSI, and look forward to meeting you at Barcelona.

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WELCOME from the Chairman and the Host Institution

We welcome all the attendees to the conference. From the Local Organizing Committee we have done a hard work to take care up to the smallest detail in all aspects, from the venue to the scientific programme and the authors to offer you the greatest possible comfort. We looked for a venue that we think is the most suitable place in terms of space, adequacy and attendee's welfare and also both, a science promoting museum and an incomparable environment. The sessions have been redefined in cooperation with the International Organizing Committee in order to give full coherence to the scientific-technical content. MEDSI has joint JACoW publication platform for the first time and we expect this will promote paper contributions and enhance the scientific formalization of the contributions of our authors. Welcome and enjoy these conference days in Barcelona.

Carles Colldelram Peroliu
Chairman, Local Organizing Committee
Transversal Section Head (Engineering Division at ALBA Synchrotron Light Source)

Welcome to Barcelona and to the ninth Mechanical Engineering Design of Synchrotron Radiation Equipment and Instrumentation, MEDSI'2016. It is being an honor for ALBA to organize this event that has been faced with great enthusiasm and professionalism by all our staff. The Local Organizing Committee, comprising staff from up to four different divisions, illustrates how this project has been assumed by our institution as a whole.
We are in a very unique moment, in which some of the older facilities are in a more or less advanced process of machine upgrade while quite a number of the younger facilities, like us, are developing new beamlines to complete the first phases of facility construction. This means a lot of mechanical engineering activity, as well as fluid dynamics engineering, vacuum engineering, survey and alignment engineering, civil engineering ... The MEDSI International Conference is the right forum to share our solutions, inventions, developments or designs in all these fields. With more than 160 scientific contributions and more than 28 industrial sponsors, you are about to discover a new edition of the MEDSI full of content. And for the little free time... enjoy the city of Barcelona!

Joan Casas Bullich
Head of the Engineering Division at ALBA Synchrotron Light Source

WELCOME from the Scientific Committee

Welcome to 2016 MEDSI event. This year the participation of contributions has risen up significantly. We thank our delegates for such spirit that enhances the conference outcomes. The Scientific committee has prepared an internal peer review for selecting the contributions and distributing them in oral and posters presentations. This is the first time that poster presentations have been split in different sessions in order to give enough time to all posters. In addition, we have organized a poster prize evaluation committee with two different profiles, technical and from the communication point of view. We did our best to ensure that most relevant abstracts get an oral contribution slot and we encourage to all MEDSI delegates, attendees, to continue with this high initiative for next MEDSI events.

Carles Colldelram Peroliu, Marcos Quispe Flores, Joan Casas Bullich
Chairmen, Scientific Committee

HOST INSTITUTION

ALBA is the Spanish 3rd generation synchrotron light source, located in Cerdanyola del Vallès, near Barcelona, and constitutes the largest scientific infrastructure in the country. The facility consists of the accelerator systems providing 3 GeV electron beam and several experimental beamlines, with photon energies currently ranging from UV up to hard X-rays of tens of KeV. Different synchrotron radiation techniques are available including diffraction, spectroscopies and imaging.

ALBA is composed of a linear accelerator (LINAC) – where electrons are speeded up to 100 MeV – and a low-emittance, full-energy booster – where electrons are accelerated to 3GeV, almost reaching speed of light. The Booster (250 m of circumference) and the Storage Ring (269 m) are both hosted in the same tunnel. The lattice is optimized for high photon flux density, with a nominal current of 250 mA. There is a large number of straight sections (24) available, despite the relatively short circumference, thanks to the very compact lattice design, which incorporates quadrupolar field component in the dipoles.

The vacuum chamber has up to 34 windows for the light extraction. Eleven of them are presently used (2 for accelerator diagnostics, 9 for the Phase-I and Phase-II Beamlines), and the others witness the large potentiality of ALBA for the future.

ALBA is in operation since May 2012 with seven beamlines dedicated to different scientific fields, mainly physics, chemistry, life sciences, materials science, cultural heritage, biology, nanotechnology. Two new beamlines were initiated in 2014, devoted to infrared microspectroscopy and angle-resolved photoemission spectroscopy. These beamlines are expected to receive friendly users by the end of 2016 and 2018, respectively.

This scientific infrastructure produces 5.700 hours of beamtime per year and is available for the academic and the industrial sector to give service to more than 1.000 researchers every year.

www.albasynchrotron.es

CONFERENCE COMMITTEES

LOCAL ORGANIZING COMMITTEE / ALBA SYNCHROTRON

Conference chair

- **Carles Colldelram**
  Head of the Transversal Section at the Engineering Division Mechanical Engineering Group Leader

Committee members

- **Joan Casas**
  Head of the Engineering Division
- **Marcos Quispe**
  Transversal Section Deputy Head at the Engineering Division
- **Ana Belén Martínez**
  Communications & Outreach
- **Yolanda Ruiz**
  Engineering Division Secretary
- **David López**
  JACoW's Editor, Software Engineer

INTERNATIONAL ORGANIZING COMMITTEE

- **JAMES KAY**
  MEDSI IOC Chairman
  Diamond Light Source
  Head of Engineering
- **SUSHIL SHARMA**
  Brookhaven National Laboratory
  Head of the Mechanical Engineering (ME) Group in the Accelerator Systems Division
- **DEMING SHU**
  APS/Argonne National Laboratory
  Senior Engineer and Captain for Nanopositioning Supporting Lab
- **NICHOLAS M. KELEZ**
  Linac Coherent Light Source SLAC National Accelerator Laboratory
  Director Mechanical Engineering & Operations
- **YVES DABIN**
  European Synchrotron Radiation Facility
  Head of Advanced analisys and modeling (Instrumentation services and Development division)
- **JUNE-RONG CHEN**
  National Synchrotron Radiation Research Center (NSRRC)
  Research Fellow (Instrumentation Development Division, NSRRC)/ Professor(Joint Appointment, NTHU)

SCIENTIFIC COMMITTEE / ALBA SYNCHROTRON

DETAILED CONFERENCE PROGRAMME
Programme at Glance

	Sunday 11th	Monday 12th	Tuesday 13th	Wednesday 14th	Thursday 15th	Friday 16th
8:30 - 9:30		Bus from Meeting Points to the Venue	Bus from Meeting Points to the Venue	Bus from Meeting Points to the Venue	Bus from Meeting Points to the Venue	Bus from Meeting Points to the Venue
9:30 - 9:50		Registration	Conference Welcome	Session 2: Fac. Des. & Up. Session 3: Calculation, Simulation & FEA Methods	Session 6: Beam Lines	Session 6: Beam Lines
9:50 - 10:10		Morning Tutorials: Roberto Kersevan Josep Nicolás				
10:10 - 10:50			Session 1: Precision Mechanics			
10:50 - 11:20		Coffee Break	Coffee Break	Coffee Break	Coffee Break	Coffee Break
11:20 - 12:00		Morning Tutorials: Roberto Kersevan Josep Nicolás	Session 1: Precision Mechanics	Session 3: Cal. Sim & FEA Session 4: Core Technology Developments	Session 6: Beam Lines	Session 6: Beam Lines
12:00 - 12:40					Bus from the Venue to ALBA	
12:40 - 14:00		Lunch	Lunch	Lunch	Lunch	Farewell Lunch
14:00 - 15:20		Afternoon Tutorials: Bran Brajuskovic Zeus Martí	Session 1: Precision Mechanics	Session 4: Cor. Tec. Dev. Session 5: Light Sources	Visit to ALBA	
15:20 - 15:50		Tea Break	Tea Break	Tea Break	Tea Break	
15:50 - 17:00	Registration & "Pica - Pica"	Afternoon Tutorials: Bran Brajuskovic Zeus Martí	Session 1: Prec. Mec. Session 2: Facility Design & Upgrades	Session 5: Light Sources Session 6: Beam Lines	Visit to ALBA	
17:00 - 18:00		Poster Session 1	Poster Session 2	Poster Session 3	Bus from ALBA to the Meeting Points	
18:00 - 19:00		Bus from the Venue to the Meeting Points	Bus from the Venue to the Meeting Points	Bus from the Venue to the Meeting Points		
19:00 - 20:00						
20:00 - 21:00			Bus from Meeting Points to Observatori		Drassanes Maritum Museum of Barcelona Conference Dinner	
21:00 - 22:00			Welcome Reception Observatori Fabra Cocktail Dinner			
22:00 - 23:00						
23:00 - 23:30			Bus from Observatori to the Meeting Points			
23:30 - 24:00						

PRACTICAL INFORMATION

Transportation

Dedicated buses are foreseen to transport delegates from two different meeting points to the Conference Venue (in the morning) and from the venue to the meeting point (in the afternoon). A total of three buses will be available for this purpose.

TIME SCHEDULE MEETING POINTS

Morning at 8:30h.
Afternoon at 18:00h.

MEETING POINT 1

L'illa Diagonal
Calle Deu i Mata, 69-99,
08029 Barcelona

MEETING POINT 2

Av. Diagonal, 568,
08021 Barcelona

PRACTICAL INFORMATION

Registration

Registration and Information desk is located on the -2nd floor of the venue during these times:

Sunday, September 11th: 16:00h to 20:00h, including a Welcome "pica-pica" at the CosmoCaixa Garden.

Monday, September 12th: 9:00h to 18:00h.

Tuesday, September 13th: 9:00h to 9:50h.

In order to distribute the registration comfortably there are two desks.

- Desk 1: For regular delegates
- Desk 2: For Sponsors

Information Desk

The Information Desk will remain open throughout the week, on the -2nd floor of the venue, from 09:00 to 18:00 h.

Conference Badge

Delegates will receive a personal badge upon registration. This badge is the official pass and must be visible to access to all conference spaces. The badge contains also the detailed programme and the tickets for the social events.

The Museum access card, which gives you access to all conference spaces, is a single day pass card. Daily pass card has to be picked up every morning before the start of the conference at the corresponding registration desk.

PRACTICAL INFORMATION

Internet Access

Wi-Fi is available in all conference venue sponsored by Cosmocaixa, check your conference Badge for the Wi-Fi password.

Lunches and Coffee-Tea Breaks

During the conference, all the lunches and coffee-tea breaks are included from Monday 11th to Friday 16th September. Catering stations will be located in the Patio of CosmoCaixa, next to the Exhibition area, located in -3rd floor.

Lunches will be served from 12:40 to 14:00 h.
Coffee breaks will be served from 10:50 to 11:20 h.
Tea breaks will be served from 15:20 to 15:50 h.

A Welcome Registration ("pica-pica") will be provided for MEDSI delegates on Sunday, September 11th from 16:00h to 20:00h at the CosmoCaixa Garden.

On Thursday 15th September, Lunch and Tea Break will take place in the ALBA Synchrotron Light Source, during the visit to the facility.

On Tuesday 13th September, a Welcome Reception is planned at the Observatory Fabra, including also dinner. The Conference Gala Dinner will be held on Thursday 15th September at the Drassanes Maritime Museum of Barcelona. Further information is available in the following pages (Social Events' section).

Local Information

The city of Barcelona offers great opportunities for sightseeing and tourism. Detailed information is available at:
http://www.barcelonaturisme.com/

Touristic Information Point
Plaça de Catalunya, 17-S
Barcelona
Tel. +34 932 853 834

USEFUL TELEPHONE NUMBERS

EMERGENCY PHONES
Unified emergency telephone: 112
Health Emergencies: 061
Fire: 080
Police (city): 092
Police (national): 088
Pharmacy: +34 934 810 060

TRANSPORT
TMB (Bus, Metro): +34 902 07 50 27
Ferrocarrils Generalitat:
+34 932051515
Renfe: +34 902.240.202
Airport (information):
+34 902404704
Taxis: +34 932250000 /
+34 933033033
Taxis for disabled:
+34 934208088

MEDSI 2016 PLACES

VENUE

COSMOCAIXA BARCELONA

C/ Isaac Newton, 26

http://obrasocial.lacaixa.es/laCaixaFoundation/home_en.html

The conference is being held in CosmoCaixa, the science museum of Barcelona, designed to stimulate people's knowledge and opinion of science through exhibitions and a wide variety of activities.

The Conference will be in the auditorium (-2nd floor) and Tutorials in Alfa & Beta rooms (-2nd floor).

CosmoCaixa offers interactive, enjoyable science. It boasts the Geological Wall and the Amazon Flooded Forest, which features more than 100 plant and animal species that convince visitors they have been transported from the Mediterranean to the very heart of the tropical jungle. **All the congress' attendees will have free access to the museum during the whole MEDSI 2016.**

SOCIAL EVENTS

WELCOME RECEPTION AT THE OBSERVATORI FABRA

Camí de l'Observatori s/n, 08035 Barcelona
Tuesday 13th September
Bus pick-up time: 20.00 h at the Meeting Points

At 415 meters above the sea level, there is the Fabra Observatory, one of the oldest astronomical observatory in operation in the world.

The Royal Academy of Sciences and Arts of Barcelona (www.racab.es) was created in 1764 by a group of educated citizen of Barcelona under the name of "Physico-Mathematical Conference" to follow the progress of science and technology. A few years later, the "Conference" was recognized as an Academy by King Charles III. From its early years, the Academy was especially active in Astronomy, Meteorology and Seismology. That was the reason to construct two domes at the top of the rebuild site of the Academy in the Ramblas of Barcelona, at the end of the XIX century. But in 1902 and thanks to a donation from Camil Fabra i Fontanills the Academy decided to install an observatory at the top of Tibidabo, the mountain which close the city of Barcelona. The Fabra Observatory was finished in 1904 an inaugurated by King Alfonso XIII. The building is an intrinsic part of the skyline of Barcelona and has run without interruption since its inauguration.

SOCIAL EVENTS

CONFERENCE DINNER AT THE DRASSANES MARITIME MUSEUM OF BARCELONA

Avda. De les Drassanes s/n, 08001 Barcelona
Thursday 15th September

The building of the Maritime Museum of Barcelona, a wonderful place built in the fourteenth century to host the Royal Shipyards.

The building of the Royal Shipyards of Barcelona, as well as being the headquarters of the Maritime Museum of Barcelona, is a vital building in the maritime history of the city. The initial construction of these shipyards dates back to the fourteenth century, when Peter III of Aragon (called Peter the Great) ordered the construction of an exclusive space for the royal where they could build and maintain the galleys and the royal fleet. In 1390, under the reign of John I, a major expansion was carried out. Between 1641 and 1644, on the occasion of the War of the Reapers, the enclosure was fortified. According to last studies, the main body of the building was built in the second half of the sixteenth century.

SOCIAL EVENTS

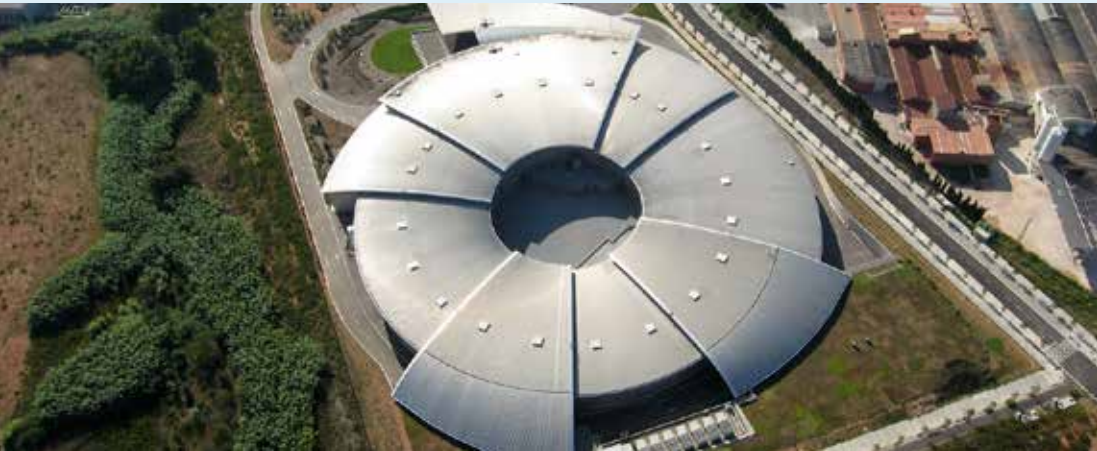
VISIT TO THE ALBA SYNCHROTRON LIGHT SOURCE

Carrer de la Llum 2-26, 08193 Cerdanyola del Vallès (Barcelona)
Thursday 15th September
Bus pick-up time: 12.00 h at the venue

ALBA is the Spanish 3rd generation synchrotron light source and constitutes the largest scientific infrastructure in the country.

The facility consists of the accelerator systems providing 3 GeV electron beam and several experimental beamlines, with photon energies currently ranging from UV up to hard X-rays of tens of KeV. Different synchrotron radiation techniques are available including diffraction, spectroscopies and imaging.

The visits will be organized jointly with IBIC'16 participants in groups of 20 people from 14:00 to 16:30 h. Lunch and Tea break is included.



INDUSTRIAL EXHIBITION

Exhibition Location

The exhibition location is placed on the Patio of the CosmoCaixa at the -3rd floor.

Exhibition Timetable

Booth preparation
From Sunday 11th at 08:00 to Monday 12th at 10:00h.

Exhibition times
Monday, September 12th: 9:00h – 18:00h.
Tuesday, September 13th: 9:00h – 18:00h.
Wednesday, September 14th: 9:00h – 18:00h
Thursday, September 15th: 9:00h – 12:00h
Friday, September 16th: 9:00h – 14:30h

Booth dismantling
Friday, September 16th from 15:00 to 20:00h.

Elevator Pitch

During coffees and lunch time, from Monday 12th to Wednesday 14th, there will be a **Sponsors Elevator Pitch** at the Àgora room (-3rd floor), next to the Patio. A total of **29 talks from collaborators of 5 minutes approximately.**

SPONSORS

PRINCIPAL COLLABORATOR OF THE MEDSI 2016

"la Caixa" Foundation

Consistent with the founding values of "la Caixa" and its commitment to society, Welfare Projects seeks to be an entity that is an international point of reference, committed to human rights, peace, justice and people's dignity. With a budget of 500 million euros, "la Caixa" Foundation reached out to 9.9 million people in 2015 through the 46,209 initiatives the organisation promoted.
obrasociallacaixa.org

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www.a-v-s.es

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Accelerator and X-Ray Instrumentation for Laboratories, National Facilities and Industry. From consultancy to full project execution: Beamline components and full beamline solutions, Monochromator and mirror systems, Experimental stations for X-rays and particles, X-ray microscopes, Insertion devices, Accelerator components and Soft X-ray sources and laboratory instrumentation.
www.axilon.de/website

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www.bestec.de

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www.cinel.com

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www.dmp.aero

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Blumeprot leads projects for manufacturing of prototypes and pre-series for departments of IDi, entrepreneurship, technological centres and foundations throughout Spain.
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www.lesker.com

LAB Motion Systems - founded originally under the name Leuven Air Bearings end 2005 as a spin-off from University Leuven (Belgium) – is a manufacturer of positioning systems for automation, production and measurement applications, with a focus on beamline and X-ray systems. The company has specialised in high-precision rotary air bearing stages (20 to 100nm run-out) and linear stages, including motion control. Next to a wide range of standard products, also granite based multi-axis systems are offered, using air bearing as well as conventional bearing technology.
www.labmotionsystems.com

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The Vacuum-Projects S.L.U, formerly Trinos Vacuum-Projects, S.L. has focused their strategy in development of singular projects related with vacuum and cryogenics.
web2.vacuum-projects.net

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SCIENTIFIC PROGRAMME / PRACTICAL INFORMATION

Oral Sessions

Oral sessions will take place in the Auditorium from Tuesday morning, September 13th, to Friday morning, September 16th.
Closing remarks will be after the last oral contribution on Friday 16th and before the lunch.

Audiovisual Means

Oral presentations will be made electronically by means of projection equipment provided by the conference venue. Guidelines for speakers are provided at the conference website. All presentations must be loaded to the lectern laptop the day before of the presentation. Audiovisual manager is at the backdrop of the Auditorium.

MEDSI contributions are registered with a Jacow ID number and organized with a conference program code. This code corresponds to the time of each contribution through the oral and poster sessions slots.

Program Codes

All contributions have a programme code in the conference timetable. This code indicates the Day, Type, Location and Sequence Number.
Example:

WE B A 02			
WE: ***DAY***	B: ***TYPE***	A: ***LOCATION***	02: ***SEQUENCIAL NUMBER***

Day:	Type:	Location:
MO *Monday*	A *Oral Before Coffee*	A *Auditorium*
TU *Tuesday*	B *Oral After Coffee*	B β *Beta room*
WE *Wednesday*	C *Oral After Lunch*	C γ *Gamma room*
TH *Thursday*	P *Poster*	E *Exhibition hall*
FR *Friday*	T *Tutorial*	

WEBA02 it is an oral contribution on Wednesday after the coffee break at the Auditorium at 11:40h.

SCIENTIFIC PROGRAMME / PRACTICAL INFORMATION

Poster Sessions

There are three poster sessions. This means a session per day from Monday the 12th to the Wednesday the 14th.
Poster sessions are at the exhibition room from 16:50h to 18:00 on. This time slot is the time when poster presenter must be attending the contribution.
Each day is a different poster session. So poster presenters must be available only one day from 16:50 to 18:00 on.
The poster must be placed at the assigned location early morning before the starting of the first coffee break at 10:50h. Poster Session Managers will be available with the necessary material for display.
The poster shall be removed after 18:00h of the corresponding session.
Authors are reminded that no contributions are accepted for publications only. Any poster accepted for presentation which is not presented at the conference will be excluded from the proceedings.
The Scientific Committee reserves the right to refuse papers for publication if they have not been properly presented during the conference. Conference contributions are not accepted as publication and the corresponding contribution paper must be written and submit before the conference start.
Each poster has an assigned location on a poster panel placed in the exhibition hall identified by the program code. A label on the panel is indicating the poster code. A layout of the exhibition area and the rooms' distribution of the venue is to be found at the end of this booklet.

Example:

TU P E 02			
TU: ***DAY***	P: ***TYPE***	E: ***LOCATION***	02: ***SEQUENCIAL NUMBER***

Day:	Type:	Location:
MO *Monday*	A *Oral Before Coffee*	A *Auditorium*
TU *Tuesday*	B *Oral After Coffee*	B β *Beta room*
WE *Wednesday*	C *Oral After Lunch*	C γ *Gamma room*
TH *Thursday*	P *Poster*	E *Exhibition hall*
FR *Friday*	T *Tutorial*	

TUPE02 is a Poster Contribution on Tuesday at the Exhibition hall

SCIENTIFIC PROGRAMME / PRACTICAL INFORMATION

POSTER PRIZE

Two Poster Prizes are awarded during the conference:
The best young delegate poster. This is awarded to the best poster by the authors younger than 30 years old.
The best poster. This is awarded to the best poster of the conference. Prize is about 1000 € free of taxes.
Poster committee is the joint committee of the Local Organizing Committee and the Scientific Committee. This gives the prize evaluation a review from all point of view a part of technical content like for example from the communication point of view, presentation, etc...

CONFERENCE PROCEEDINGS

MEDSI2016 is the first MEDSI event affiliated to JACoW. Scientific programme is published under this platform.
http://www.jacow.org/

Authors are reminded that all conference contributions must be accompanied by a paper publication. Paper submission deadline was September 11th.

Templates for papers are available at JACoW Website:
http://www.jacow.org/index.php?n=Authors.HomePage

During the conference papers must be submitted and they are being reviewed by JACoW editors during all conference days. The editors office is the **T** room next to the registration desk at -2 floor. At the entrance of the editor's room a screen is showing the status of the paper edition.

- Paper needs revision by the Author.
- Paper needs minor revision by the Author.
- Paper is ready for publication.

Authors must check the status of their papers and in case of a revision is needed ask to the editors for clarifications.

PROGRAMME AND ABSTRACTS

MOTB — Tutorials

MOTB01 09:50 170 **Advanced Computational Methods for Vacuum Technology With Application to Synchrotron Radiation Light Sources**

R. Kersevan *(CERN)*

Following the progress in the design and improvement of their performances, the new generations of light sources have come to a point where diffraction-limited x-ray beams are a reality. This evolutionary trend has required a parallel evolution of the design of their vacuum systems, and the application of cross-disciplinary discoveries in the field of materials, surface treatments, thin-films, pumping technology, and more. This 2 $\frac{1}{2}$ hour tutorial will follow the following program: • Basics of gas dynamics: outgassing, conductance, pumping speed. • Basics of synchrotron radiation (SR), with examples relevant to vacuum design. • SR-induced desorption. • Computational methods for vacuum: a review. • Practical examples of analysis, simulation, and design of key components of light sources. • Summary and conclusions.

MOTB02 14:00 170 **Finite Element Analysis in Design of Synchrotron Instrumentation - Issues, Good Practices and New Horizons**

B. Brajuskovic *(ANL)*

Finite Element Analysis(FEA) is a design tool widely implemented in the design of synchrotron instrumentation to predict behavior of a particular design under the assumed real life conditions. Although FEA is a very popular and trusted design tool in use for several decades, it is of paramount importance to emphasize that it is only as accurate as the user's input into the analysis and the interpretation of the results. In its introduction the tutorial will cover the importance of accurate inputs into the analysis and correct interpretation of the results as well as the best practices in how to improve said accuracies. Second part will cover the nature of the phenomena analyzed with thermal and structural simulations with the emphasis on the seemingly paradoxical fact that thermally loaded structures frequently fail only upon load removal. The third part will cover thermal and structural simulations with several examples. The tutorial will be concluded with alternate applications of FEA in the design of synchrotron instrumentation. Examples of multi-physic and vibration analysis, component weight optimization, and the analysis of the acoustic levitation supports will be presented.

MOTC — Tutorials

MOTC01 09:50 170 **Optics and Mechanics of Mirror Benders**

***J. Nicolás**, C. Colldelram, C. Ruget (ALBA-CELLS Synchrotron)*

We will explain the basic concepts of optics regarding focusing with grazing incidence reflective surfaces. The concept of aberration and figure error, and the aberrations associated to the typical geometric surfaces found in mirrors will be described with some detail. We will describe how mirror benders can approximate these geometrical figures, how to compute the required mechanical characteristics, and the optical effect of the residual errors. Finally, we will describe, and illustrate with examples, the main aspects that have to be considered in the mechanical implementation, their characterization and their operation in the beam-line.

MOTC02 14:00 170 **Accelerator Physics: An Introduction**

***Z. Martí** (ALBA-CELLS Synchrotron)*

This tutorial aims professionals working at accelerators facilities but have not been introduced to the motivations and details behind such complex machines. The underlying physical phenomena are explained and linked to typical devices in synchrotron light facilities like dipoles, quadrupoles or RF cavities. The content covers a friendly overview of the core of accelerator physics and its technologies.

MOPE01 **Stabilization Methodes for Force Actuators and Flexures**

***C. Colldelram**, J. Nicolás, C. Ruget (ALBA-CELLS Synchrotron)*

In the framework of the design of an adaptive optics for x-ray mirrors a stabilization system* for force actuators and flexure hinges have been conceived. This corrector allows to deform the mirror surface at nanometre level but for this purpose it requires resolutions better than 0.02, by using ultra-low constant springs, and to preserve the introduced deformation it is needed to be stable at the same level. The corrector needs to be insensitive when dismantling and remounting the mirror. In the other hand in order to support the corrector its structure is attached to the bender frame and the spring force is transmitted through a level arm by means a bearing articulation. This introduces a small friction but it is still preferably to eliminate it. A new method based -k spring-like constant principle is proposed. Based on this technique it is possible to stabilize the force exerted on the mirror below 0,02N for an error range more than 1 mm. In addition applying the principle to a flexure it allows to compensate it in an angular range in within the torque variation tend to be null, below 0,005 Nm, thus becoming a short range, frictionless and zero torque articulation.

MOPE02 **Studies on Flow-Induced Vibrations for the New High-Dynamics DCM for Sirius**

***R.M. Caliari**, R.R. Geraldes, R.P. Parise, M. Saveri Silva, L., Jr. de Souza (LNLS)*

The monochromator is known to be one of the most critical optical elements of a synchrotron beamline, since it directly affects the beam quality with respect to energy and position. Naturally, the new 4th generation machines, with their small emittances, start to bring about higher stability performance requirements, in spite of factors as high power loads, power load variation, and vibration sources. A new high-dynamics DCM (Double Crystal Monochromator) is under development at the Brazilian Light Source for the Sirius EMA beamline (Extreme Condition X-ray Methods of Analysis). The disturbances induced by the coolant flows are known to be among the most detrimental influences to a DCM performance, however, quantitative force numbers involved in such disturbances are not commonly investigated. According to the novel dynamic concept, these forces should be predictably translated into stability performance. Therefore, experimental setups that allow the indirect measurement of such forces in conditions close to those of operation were designed. The results comparing different indirect cooling profiles and manufacturing processes (brazing and additive manufacturing) are shown.

MOPE04 **Dynamically Isotropic Hexapods for High-Performance 6-DOF Manipulation**

***B. Afzali-Far** (MAX IV Laboratory, Lund University)*

Recent advances in synchrotron facilities have led to a growing need for 6-DOF precise manipulation. Hexapods are the most widely used parallel robots which provide 6 DOFs. To obtain high precision and high dynamic performance in hexapods, it is necessary to design them in such a way that low eigen frequencies are avoided (while the eigenf requencies are also functions of the complex 3D geometry of hexapods). Theoretically, maximizing the lowest eigen frequency leads to a condition where multiple eigen frequencies become equal, which is known as (complete or partial) dynamic isotropy. Thus, one may consider a dynamically isotropic hexapod as the optimal design solution, where precision and dynamic performance is a goal. In this work, we analytically address this problem and establish a practical guideline in order to design generalized hexapods with complete dynamic isotropy. The findings are based on the recently defended PhD dissertation by Behrouz Afzali-Far.

MOPE05 **Mechanical Design of Secondary Source Slits for Hard X-ray Beamlines at Taiwan Photon Source**

***H.Y. Yan**, C.H. Chang, S. H. Chang, C.Y. Chen, C.Y. Huang, J.M. Lin, D.G. Liu, D.-J. Wang (NSRRC)*

The secondary source slits have been developed for specific hard X-ray beam-lines at Taiwan Photon Source. Especially for Coherent X-ray Scattering and X-ray Nanoprobe beam-lines, severe specifications of the slits are more necessary to define proper beam sizes in horizontal and vertical directions at sample. The opening size of each pair of slits assembled orthogonally is usually needed to range within several microns, so the UHV-compatible piezo-driven stages with closed-loop system were adopted for the purposes of fine adjustment, precise positional accuracy and repeatability. To reduce X-ray scattering effect, the rectangular single-crystal film was bonded on the edge of the slit blade. The machined rotary weak-link structure and piezo-driven actuators were used to slightly adjust parallelism of each pair of the blades with the method of single-slit diffraction. To enhance structural and thermal stability, the granite plinths with specified shape were designed and the precise temperature controlling system will be set up recently. The overall design, mechanical specifications and procedure of testing for secondary source slits will be introduced in this paper.

MOPE06 **The Mechanical Stability and the Correlated Beam Performance at TPS**

***J.-R. Chen**, M.L. Chen, W.Y. Lai, Z.-D. Tsai, I.C. Yang (NSRRC)*

The correlation between the mechanical stability and the beam performance at TPS was studied. Strong correlation was observed between the air temperature fluctuation and the fluctuations of the beam size and beam position. It was found that different temperature sources were responsible for the fluctuations of the beam position in different directions (vertical and horizontal). The sensitivity factors of the fluctuations of the beam performance to the temperature fluctuation were measured.

MOPE07 **Ground Motions Measurements for Synchrotron**

***D.T. Ziemianski** (CUT)*

For more than two decades, ground vibration measurements were made by different teams for feasibility studies of linear accelerators. Recent measurements were performed in the SPS tunnel and at different CERN sites on the surface. The devices to measure vibrations of magnitude ranging in nanometres, the analysis techniques and the results are critically discussed and compared with the former measurements. The implication of the measured integrated R.M.S. displacements for the Crab cavities cavern is mentioned. The equipment used in this study consists of 2 state-of-the-art Guralp broadband triaxial seismometers. Models CMG-T60-0004 performed measurements in three directions V, N/S and E/W. The first analysis was to evaluate the power spectral density for each direction of sensors and event. The power spectral density is calculated from the auto power spectrum. The power spectral density shows a typical curve for the geophones with theμseismic peak between 0.2 and 0.4 [Hz]. It is import ant to point that ground vibrations should not be ignored in planning accelerator facility. Actually it is one of the limiting factor in the optimization of future accelerators.

MOPE08 **The LNLS Metrology Building**

***H.G.P. Oliveira**, C. Esper Neto, P.T. Fonseca, R.R. Geraldes, B.C. Meyer, M.A. Pereira, G.L.M.P. Rodrigues, L. Sanfelici, L.G. da Silva (LNLS) L. Buccianti, M.H.A. Costa (Biotec Controle Ambiental) C. Prudente (Prudente Engenharia Ltda.)*

The increasing demands of instrumentation projects for SIRIUS require more sensitive equipment to be developed and characterized in theμand nanometer scale. To achieve this level of precision it is necessary to work within a controlled environment,

minimizing instabilities and disturbance effects such as temperature variation and vibrations. Based on metrology labs as those at BESSY, ESRF, DLS and others, a new facility is currently under final construction stage at the LNLS, which will be dedicated to high precision optical and mechanical metrologies. The building itself is an 840 m2 thermally isolated shed kept within a gradient of ±1,5°C. Inside there are two 100 m2 inertial bases, around them, four rooms were erected: two rooms for general assemblies, vacuum tests and dimensional analysis; and other two for mechanical and optical metrology. The assembly rooms have relaxed environmental requirements (±0,5°C and ±10% RH), whereas both of the metrology laboratories are more restrict (±0,1°C and ±5% RH). The optical lab is also an ISO7 cleanroom. This work describes in detail the project of the new LNLS Metrology Building.

MOPE09 **Preliminary Design and Test of Damping Mechanism for Reduction Vibration of TPS SR Vacuum Chamber**

K.H. Hsu*, C.M. Cheng, H.C. Ho, C.K. Kuan, W.Y. Lai, S.Y. Perng (NSRRC)*

Since flow-induced vibration of vacuum chamber of storage ring may affect the stability of the electron beam of Taiwan Photon Source (TPS), a damping mechanism was designed and installed to reduce the vibration. The damping mechanism was composed of a clamper of vacuum chamber, a base fixed on the girder and a sandwiched stainless steel support with damping material inside. Different kinds of damping material were applied in the damping mechanism for vacuum chamber. The vibration of vacuum chamber were obtained and compared. The design and vibration measurement results of damping mechanism for vacuum chamber would be presented in this paper.

MOPE10 **Dynamic Analysis and Measurement of Ground Motion for the Solaris National Synchrotron Radiation Centre in Cracow**

D.T. Ziemianski *(CUT) M.P. Nowak (Solaris National Synchrotron Radiation Centre, Jagiellonian University)*

The paper presents the results of the ground motion measurements and dynamic analysis performed in the Polish synchrotron radiation facility Solaris. The analysis has been carried out within the framework of the installation experimental lines inside Solaris building and accelerator tunnel. The equipment used in this study consists of 4 seismic, high sensitivity, ceramic flexural ICP accelerometer Models 393B31 (PCB), which performed measurements in one vertical directions. The first analysis was to evaluate the power spectral density for each sensors and event. The power spectral density is calculated from the auto power spectrum. The power spectral density shows a typical curve with theμseismic peak between 0.2 and 0.4 Hz. It is important to point that ground vibrations should not be ignored in planning accelerator facility. All over the measurement, the RMS integrated level in the vertical direction at 1 Hz were calculated and presented in paper.

MOPE11 **Preliminary Active Vibration Elimination Study of the TPS Girder System**

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

The Taiwan Photon Source (TPS) had delivered the first synchrotron light on the last day of 2014 and is to open to the users from September 2016 after one and half years of commissioning and insertion devices installation. However, the instability is still an obvious problem to the beam quality and the deviation amplification factor of the magnets to the electron beam plays an important contribution role. Since the magnets are firmly installed on the girders and the contribution is mainly transferred from the girder vibration. This study tries to eliminate the obvious vibration frequencies amplitude exerted on the girder from outside sources such as the utility system with the PZT actuators installed on the locking wedges between girder and pedestals. By

the amplitude and inverse phase searching iteration, some vibration frequency peaks in phase domain can be eliminated and the instability is also reduced.

MOPE12 **Development and Characterization of a Large Range Small Angle Generator**

G.K. Kortaberria, *G.A. Aizpurua, A.D. Delgado, A. Olarra (Fundación TEKNIKER)*

This work reports on development and characterization of a new concept of Large Range Small Angle Generator, LRSAG. The device is used for the calibration of high precision angle measuring systems, such as autocollimators, levels and encoders. The state of art requirements for the SAG according to autocollimator manufacturers and users are: ±3600" stroke, 0.001" resolution, high stability and portability. The key element behind the angular motion generation consists on a flexure mechanism. This approach makes possible to reduce the overall size of the LRSAG. Moreover, the mechanism consists on a Parallel Kinematic Mechanism that supports the end effecter, enabling high stiffness and high eigenfrequencies. The mechanisms is actuated by two piezo linear stages that provide large stroke (20 mm) and very high resolution (2 nm in closed loop mode). Two independent measuring systems are also integrated in the angle generator. These systems provide feedback about the position of the moving platform based on imaging systems. One of the measuring systems is a novel "planar differential absolute 3 DOF measurement device". The second system consists on linear encoder technology.

MOPE13 **The 20m/s CERN Fast Vacuum Wire Scanner - Conceptual Design and Implementation**

J. Herranz *(Proactive Research & Development) W. Andreazza, N. Chritin, B. Dehning, J. Emery, D. Gudkov, P. Magagnin, S. Samuelsson, J.L. Sirvent Blasco, R. Veness (CERN) A. Barjau (Universitat Politécnica de Catalunya)*

In the next years the luminosity of the LHC will be significantly increased. Therefore a much higher accuracy of beam profile measurement than actually achievable by the current wire scanner is required. The new performance demands a wire travelling speed up to 20 m/s and a position measurement accuracy of the order of 1 μm. In order to minimize the error source of the wire position measurement, a challenging concept has been developed which consists of the placement of the motor rotor and the angular position sensor in vacuum. The implementation of this new concept requires the use of a magnetic brake, hybrid vacuum bearings, the design and production of very thin (<0.5mm) wall vacuum chamber regions and the production of titanium components by 3D adding technologies. The implementation of this new concept has required different optimization processes as the structural optimization under dynamic load of the most critical rotating elements or the optimization of the control system and the motion pattern. This contribution gives an overview of the new device design and shows the different technical solution applied to develop the new concept in a successful way.

MOPE14 **Optical Laser in-Coupling of the SCS Instrument at the European XFEL**

J.T. Delitz, *R. Carley, M. Izquierdo (XFEL. EU) C. Broers, A. Scherz (European XFEL)*

To facilitate pump-probe time-resolved studies, an optical laser in-coupling device (LIN) will be located on the Scattering and Coherent Spectroscopy instrument between the Kirkpatrick-Baez (KB) X-ray focusing mirrors and the exchangeable interaction chamber. The main function of the LIN is to bring the optical pump laser to the sample. Optical pump laser pulses can be generated in a range of wavelengths, pulse energies and pulse durations and are synchronized to the FEL pulse sequence. The main feature of the LIN is a set of four in-vacuum mirrors for different wavelengths

that can be selected without breaking vacuum. The mirror stack is mounted on a vertical translator with ball-screw- driven linear guides attached to the base granite for stability. Each 2-inch piezo driven mirror holder allows an on-axis or off-axis configuration with respect to the X-ray beam. With a total length of 940 mm the LIN also includes a proper image based diagnostic for the pump laser as well as the FEL beams. To maintain the pressure in the KB mirror chamber two-stages of differential pumping are also included in the setup.

MOPE15 **Cam Mover Alignment System Positioning with Wire Position Sensor Feedback for CLIC**

***J. Kemppinen**, Z.S. Kostka, H. Mainaud Durand (CERN) **J. Kemppinen** (ETH)*

Compact Linear Collider (CLIC) is a study of an electron-positron collider with nominal energy of 3 TeV and luminosity of $2{\cdot}10^{34}$ $cm^{-2}{\cdot}s^{-1}$. The luminosity goal leads to stringent alignment requirements for single quadrupole magnets. Vertical and lateral offset deviations with regards to a given orbit reference in both ends of a quadrupole shall be below 1 μm and quadrupole roll deviation shall be below 100 μrad. Translation in the direction of particle beam is not controlled but mechanically locked. A parallel kinematic platform based on cam movers was chosen as system for detailed studies. Earlier studies have shown that cam movers can reach the CLIC requirements through an iterative process. The paper presents new modular off-the-shelf control electronics and software including three optional positioning algorithms based on iterations as well as a more advanced algorithm which can reach target position in one movement. The advanced algorithm reads wire position sensors (WPS), calculates quadrupole orientation based on the readings and updates the remaining trajectory during motion. All of the optional positioning methods reach the CLIC positioning requirements within minutes.

MOPE16 **RIXS Manipulator**

***H. Jöhri** (PSI)*

The RIXS Manipulator (RIXS = Resonant Inelastic X-ray Scattering) is a further development of the Carving Manipulator. The carving manipulator has six independent degree of freedom. (Three translations and three rotations). All three rotations are exactly in the middle of the sample surface. The head of the manipulator is in UHV and the sample can be cooled down to 10K. For the RIXS manipulator there is a new requirement to have a field of view from 0-180^{o}. There are mainly two parts in the carving manipulator that set the probe in the shadow of the beam at small angles. - A bellow - The bearings To solve these problems we shifted the bellow behind the pivot point. This give some strange movements of the bellows and we had to analyse this in a separate test installation. For the bearings, we developed a goniometer bearing with ceramic bearing shells. Meanwhile the RIXS manipulator is implemented and in routine operation

MOPE17 **OCTOGLIDE - Table Positioning Device for Diffraction Applications**

***G. Olea**, N. Huber (HUBER Diffraktiontechnik GmbH&Co.KG)*

A new table positioning device for high precision and heavy load manipulation has been developed. Conceived as an alternative to the actual precision hexapods it fulfils the gap of sample (and/or, instruments) positioning in small available working spaces(height) of Diffractometers (Dm). The newly concept is a Redundant Parallel Kinematic Structure (Rd-PKS) with four legs (Quattropod) having 2 dof active joints (actuators). In this Proof of Concept (PoC) step, a stacked solution has been adopted for actuators design using the existent XY translation Positioning Units (Pu). The symmetrically modular 6-4(PP)PS precision mechanism - OCTOGLIDE having eight (8) gliding actuators (P) is implying also a pair of wedges - Elevation (El) and socket/ball - Guiding (G) Pu, as passive joints (P and S) forming one of the Positioning

modules (Pm). Spatial positions can be reached without any singularities; planar motions along/around X or Y axis are performed very intuitively with some of the actuators (decoupled) motion. The first tests of the prototype are revealing both, high accuracy (repeatability, etc) and stiffness capabilities [*].

MOPE18 **Real-time Motor Control System for Beamlines**
C.F. Chang *(NSRRC)*
To improve the stability and accuracy of motor control system for beamlines, the beamlines with motor adjustment mechanism collocate with the real-time firmware motor control system through the high-definition motor mechanism. Because the real-time motor control system does not need to be connected with the computer for a long time, it improves the speed, stability and accuracy of closed loop operation and thus promotes the controlling ability of motor. As a result, the real-time motor control system will improve the stability and accuracy of the entire motor control system with beamlines.

MOPE19 **Mechatronics Concepts for the New High-Dynamics DCM for Sirius**
R.R. Geraldes*, R.M. Caliari, G.B.Z.L. Moreno (LNLS)*
The monochromator is known to be one of the most critical optical elements of a synchrotron beamline, since it directly affects the beam quality with respect to energy and position. Naturally, the new 4th generation machines, with their small emittances, start to bring about higher stability performance requirements, in spite of factors as high power loads, power load variation, and vibration sources. A new high-dynamics DCM (Double Crystal Monochromator) is under development at the Brazilian Light Source for the Sirius EMA beamline (Extreme Condition X-ray Methods of Analysis). The target for stability between crystals is only a few tens of nrad, even during the Bragg angle motion for flyscans. Therefore, the system is based on high-dynamics concepts, properly combining stiff and compliant elements to achieve a control bandwidth in the order of 200 Hz. As a result, a lot of the known disturbances can be attenuated or suppressed as well as internally excited modes can be effectively handled. The mechatronics concepts and analyses, including the metrological details, are shown.

MOPE20 **Ultra Stiffness And Ultra Low Wawing LM Guide**
M. Miret *(THK GmbH Sucursal en España)*
The abstract porpoise is explain how is providing the LM Guide for high performance machine by realizing the waving of Nano-level and achieves super-low waving and ultra-high rigidity by adopting 8 rows of raceways in the LM Guide. These models adopt (1) 8 rows of raceways, (2) small-diameter balls and (3) super-long blocks, in order to realize super-low waving and ultra-high rigidity that surpass the conventional LM Guide. With this approach, the number of effective balls is substantially increased, and the amplitude of the rolling element in motion is minimized. The new models realize super-low waving comparable to hydrostatic guides. In addition, the deformation of the ball is minimized to achieve ultra-high rigidity that surpasses even roller guides. Primary applications Super-precision processing machines/High-precision machining centre/Lathe/Surface grinder/Semiconductor manufacturing equipment/FPD manufacturing machines/High-performance measuring machines. [Waving evaluation] The waving values are approximately 1/10 of that (100 to 300 nm) of conventional ordinary LM Guides.

MOPE21 **The Tripod Unit 6 Axes High Precision Sample Adjustment in UHV**
F. Eggenstein*, P. Bischoff, A. Erko, F. Schäfers, F. Senf, T. Zeschke, A. Sokolov (HZB)*
At BESSY-II we have recently set up a new UV- and XUV optics beamline *,** with an in-house developed versatile reflectometer *** for at-wavelength metrology on

reflective and diffractive live sized optical elements up to 4 kg load. High precision measurements of the reflection and polarization properties are feasible by a 360° azimuthal rotation of the sample around the beam of light, where samples can be adjusted reproducibly with a novel UHV-Tripod within arcsec and µm precision. By the tripod the sample is adjustable in 6 degree of freedom: Translations Tx,Ty an Tz and rotations Rx,Ry and Rz while the goniometers rotate the tripod. The two years of operation of the tripod system helped to develop a new tripod geometry for better performance. A new tripod design is presented and compared to the existing system.

MOPE22 **Mechanical Design of the MID Split-and-Delay Line at the European XFEL**
***B. Friedrich**, S. Eisebitt, T. Noll (MBI) S. Eisebitt, **B. Friedrich** (Technische Universität Berlin) W. Lu, T. Roth (European XFEL) A. Madsen (XFEL. EU)*
A new split-and-delay line (SDL) is under development for the Materials Imaging and Dynamics (MID) end station at the European XFEL.* The device utilises Bragg reflection to provide pairs of X-ray pulses with an energy of (5 - 10) keV and a continuously tunable time delay of (-10 - 800) ps - thus allowing zero-crossing of the time delay. The mechanical concept features separate positioning stages for each optical element. Those are based on a serial combination of coarse motion axes and a fine alignment 6 DoF Cartesian parallel kinematics**. That allows to meet the contradictory demands of a fast long-range travel of up to 1000 mm and in the same time a precise alignment with a resolution in the nanometer range. Multiple laser interferometers monitor the position of the optical elements and allow an active control of their alignment. All optical elements and mechanics will be installed inside an UHV chamber, including the interferometer and about 100 stepper motors. With this paper we present the mechanical design for the SDL. It will additionally show the design of a prototype of a positioning stage which allows extensive testing of the implemented concepts and techniques.

MOPE23 **An Assembling Calibration Method of XBPM Diamond Blades in TPS**
***H.C. Ho**, M.L. Chen, K.H. Hsu, D.-G. Huang, C.K. Kuan, W.Y. Lai, C.J. Lin, S.Y. Perng, T.C. Tseng, H.S. Wang (NSRRC)*
Diamond blade type X-ray Beam Position Monitors (XBPM) were adopted to monitor photon position at the beamline front-end in Taiwan Photon Source (TPS). Due to the thin thickness (125um) and fragile characteristic, the assembling precision of the diamond blades are hard to measure and influence the accuracy of monitor. A non-contact method was thus developed by using a led laser with telecentric objective lens and a CCD-array to calibrate the diamond blades assembling configuration within micrometer accuracy. According to the measurement results, XBPM can be correlated to four fiducial points for survey network. This paper describes this method and calibrating results in detail.

MOPE24 **The Precision Adjustment Holder for Montel Mirrors**
***B.Y. Chen**, S. H. Chang, H. Y. Chen, C. Y. Lee, B. H. Lin, M. T. Tang, S. C. Tseng, J. X. Wu, G. C. Yin (NSRRC) M. W. Hong (National Taiwan University) J. R. Kwo (NTHU)*
The focusing of X-ray nanoprobe at TPS relay upon the special designed Montel mirrors and its adjustment holder. The holder includes two major parts: (1) fundamental-position alignment part and (2) relative-position adjustment part. The fundamental-position alignment part has the ability to adjust the two mirrors together in 6 DOF., such as X, Y, Z, pitch, roll, and yaw. These translation stages have several-tens mm travel range and nm resolution, while the rotational stages have 40 mrad azimuthal angular range and 0.1~0.01 µrad resolution. The relative-position adjustment part can further adjust the two mirrors to minimize the focal spot. During the pre-alignment process, one of the mirrors can be manual adjusted by micrometer heads in three

translation directions with several mm travel range and micro-meters resolution. These micrometer heads also provide this mirror three rotational degree of freedoms with sub-mrad resolution. For the further alignment in vacuum, the additional four piezo-motor actuators can precisely adjust the other Montel mirror in the Y and Z direction with several nm resolution, and its pitch and roll with 1 urad and 0.05 urad resolution, respectively.

MOPE25 **In Vacuum Gonionmeter for the IXS High Resolution Monochromator at P01**

F.U. Dill *(DESY)*

Starting April 2017, beamline P01 at Petra III (DESY) will deliver x-rays from the hard x-ray regime all the way down to energies of 2.5 keV. Due to high absorption of 2.5 keV photons in air (more than 99,9% at 100mm) our high precision goniometers (three independent stages) for the high resolution monochromator will have to be put into high vacuum (1x10-7mbar). To our knowledge there is no vacuum compatible high precision goniometer at the market for this range of vacuum. Our approach to solving this problem is to use piezo actuators (a long travel range of the chosen actuator) combined with a high precision spindle ball bearing to make a simple setup of an in vacuum high precision goniometer. The goal is to achieve an angular resolution of 10 nanorad - a movement that will be monitored and controlled by an in vacuum encoder. The piezo driven angular range is set to be $\pm 20^{o}$ and all three goniometers will move independently, along and perpendicular to the beam. Two Pin Diodes, movable in two directions, are going to allow us to monitor the flux before and after the beam hits the crystals.

MOPE26 **Front End Photon Shutter Water Leak to Vacuum at Canadian Light Source**

G.R. Henneberg*, G.R. Barkway (CLS)*

In early July 2016 CLS experienced a water to vacuum leak in the storage ring. The source of the leak was a pin hole in the absorbing surface of Photon Shutter 1 in the front end of the HXMA Beamline. The leak was caused by high velocity cooling water erosion of the internal cooling water path of the copper photon shutter block. The poster will present the root cause analysis of the leak, implications for other identical photon shutters and currently in service and the current remedial action plan.

MOPE27 **The Influences of Material Properties to Micro Damages on Vacuum Chamber CF Flanges**

S. Vilcins *(DESY)*

The European XFEL, a 3.3 km long X-Ray laser facility powered by a 17.5 GeV superconducting linear accelerator is located in Hamburg. For the diagnostic ultra high vacuum components with high mechanical precision and additional strict requirements on particle cleanliness had to be developed, designed and produced. For the screen systems of the facility, enabling to observe the size and shape of the electron beam, massive vessels, precisely milled out of stainless steel blocks 1.4435 (316L) have been produced. For these chambers all flange-connections are milled into these blocks. This poster will report ofµdamages in these flanges, as well as simulations of the damage mechanisms. It will also describe the influences of material properties of the two different stainless steel brands, effects on the "knife edge" due to the penetration into the gaskets as well as the non-elastic deformation of the sealing area. The dependence of tightening forces under special conditions, like the very clean conditions in particle free applications due to the non-lubricated conditions will reported. A "cooking recipe" to avoid suchµdamages will be given.

MOPE28 **Vacuum System of SESAME Storage Ring**

M.A. Al-Najdawi*, H. Al-Mohammad, E. Huttel, F. Makahleh, M.M. Shehab (SESAME)*

SESAME* is a third-generation synchrotron light source under construction near Amman (Jordan). The storage ring has 16 Dipole arc chambers, 8 short and 8 long straight chambers. The general layout and detailed design of the vacuum chambers, crotch absorbers, RF bellows, injection and RF sections will be presented in this contribution, also the testing of the chambers prototype, bake out process and final installation.

MOPE29 **Vacuum System of Hefei Light Source II**

Y. Wang, *W. Wei, B. Zhang (USTC/NSRL)*

Hefei Light Source (HLS) has been operated for more than twenty-five years. In 2014 we began to upgrade the machine, which is called HLS-II. The emittance is reduced to 40 nmrad, five insertion devices are added and the injection energy increases to 800MeV. Now the new machine has been operated for nearly 2 years. The typical life time is more than 5 hours at 300mA, 800MeV. The average pressures of static and dynamic vacuum are below $2{\cdot}10^{-8}$ Pa and $1.2{\cdot}10^{-7}$ Pa, respectively. The design, installing and commissioning of the vacuum system of the storage ring are detailedly stated in in this paper.

MOPE30 **The Development of CuCrZr High Heat Load Absorber in TPS**

I.C. Sheng, *C.K. Chan, C.-C. Chang, C. Shueh, L.H. Wu (NSRRC)*

TPS project in National Synchrotron Radiation Research Center (NSRRC) in Taiwan has reached 500mA design goal. Several upgrades and design enhancements is also under development. CuCrZr copper alloy material has been selected to examine its UHV compatibility, machinability and high heat load sustainability. Most importantly, the absorber is made entirely by CuCrZr (including two end flanges) and installed in the mid-section of double minimum of tandem EPU48 undulators to shadow beam miss-steered synchrotron radiation from upstream EPU. Both the result and fabrication time (without brazing) are promising.

MOPE31 **Dynamic Performance of a Support System for BBA Components in SXFEL**

F. Gao, *R.B. Deng, L. Yin (SINAP)*

The electron beam orbit stability is very important for the Free Electron Laser (FEL) facility. The high beam position stability requirement results in the high position stability for the FEL key components, such as quadruple magnet (Q) and beam position monitor (BPM). This work focus on the research of the dynamic performance of a mechanical support system composed of mechanical supports - including sheets and adjustments - and a granite block mounted on them. It will be applied for the beam based alignment (BBA) Q magnet and BPM for the Soft X-ray FEL project (SXFEL). The Finite-element -FE- calculations of the model characteristics were carried out to guide the subsequent tests. The test results show that the support system can meet the requirement of the SXFEL project.

MOPE32 **Preliminary Design and Analysis of the FODO Module Support System for the APS-U Accelerator**

J. Nudell, *H. Cease, J.T. Collins, Z. Liu, C.A. Preissner (ANL)*

The most technically challenging module of the planned APS Upgrade (APS-U) project is the Focusing-Defocusing (FODO) module. The girder for the FODO must support a ~6m long string of three Q-bend and four quadrupole mag-nets. The challenges which emanate from retrofitting the existing APS tunnel with new hardware along with the stringent requirements for alignment and vibrational stability * necessitate a unique engineering solution for the magnet support system. FEA is heavily relied upon in order to create an optimized solution and reduce the number of design iterations required to meet specifications. The prototype FODO magnet support design is presented from the ground up, along with FEA justification and the expected vibrational performance of the module.

MOPE33 **The Cooling Structure for the Cryogenic Permanent Magnet Undulator Prototype at SSRF**

Y. Liu, *Y.Z. He, X. Hu, H.F. Wang, J. Wang, L. Wang, S.H. Wang, L. Yin, W. Zhang, Q.G. Zhou (SINAP) L. Zhang (SSRF)*

A cryogenic permanent magnet undulator (CPMU) prototype, based on the in-vacuum undulator technology, is under development at Shanghai Synchrotron Radiation Facility (SSRF). The prototype has a magnetic period length of 20 mm and effective peak field 1.04 T (gap 6 mm) at cryogenic temperature. The hybrid type magnetic assembly consists of NdFeB permanent magnet blocks and iron poles. A liquid nitrogen closed loop is adopted for cooling the magnet blocks to about 140 K. The cooling system is well designed to achieve a uniform temperature along the assembly and the temperature gradient is less than 1.5 K per meter. This paper presents the details of the cooling structure design for magnet blocks and iron poles, the mechanical structure of the copper-nickel foil with spring loaded tension mechanism and end tapers, as well as the test results off-line and on-line.

MOPE34 **Preliminary Design of the Magnet Support and Alignment Systems for the Aps-U Accelerator**

J.T. Collins, *H. Cease, S.J. Izzo, Z. Liu, J. Nudell, C.A. Preissner (ANL)*

As part of the Advanced Photon Source Upgrade project (APS-U), the accelerator will be upgraded by using a multi-bend achromat (MBA) lattice *. It will provide dramatically enhanced hard x-ray brightness and coherent flux to beamline experiments in comparison to the present machine. The accelerator physics requirements for the upgrade impose very stringent alignment assembly and installation tolerances and tight vibrational tolerances on the magnet support and alignment system designs. The short installation duration dictates a need for transporting groups of fully assembled magnet modules into the accelerator enclosure while preserving magnet-to-magnet alignment. The current magnet support and alignment systems preliminary design status for the APS-U accelerator will be presented along with an overview of the R&D program required to validate design performance. Magnet module transportation and installation logistics will also be discussed.

MOPE35 **A New Generation of UHV Instruments for X-Ray Spectrometry at the SR Facilities BESSY II, ELETTRA and SOLEIL and the BLiX Laboratory**

J. Lubeck, *B. B. Beckhoff, J. Weser (PTB) D. Grötzsch, B. K. Kanngießer (Technische Universität Berlin)*

A versatile UHV instrument was developed and commissioned by Germany's national metrology institute PTB for SR based X-Ray Reflectometry (XRR) and Spectrometry (XRS) nanoanalytical techniques at BESSY II*. A 9-axis manipulator allows for a sample alignment in all degrees of freedom and provides a rotational and translational movement of photodiodes as well as a translational movement of a beam-geometry defining aperture system. Traceable reference-free, total-reflection and grazing-incidence X-Ray Fluorescence (XRF) analyses were enabled with options for XRR and polarization-dependent X-ray absorption fine structure analyses on up to 100 mm samples aiming at compositional information, species and elemental depth profiles. Three technology transfer projects of adapted instruments enhanced XRS research activities within Europe at the SR facilities ELETTRA (IAEA)** and SOLEIL (CEA/LNE-LNHB) as well as at the X-ray innovation laboratory BLiX (TU Berlin)*** where different sources are used****. The expertise gained here lead to a next generation development enabling a very flexible use at four different SR beamlines for XRS and hard X-ray emission spectroscopy of up to 150 mm samples.

MOPE36 **Construction of Hard X-Ray Beamlines at Synchrotron Light Research Institute**

***S. Srichan**, D. Bumrungkoh, S. Chaichuay, M. Phanak, S. Pongampai (SLRI)*
A high field multipole wiggler (MPW) 2.4 T was installed at the 1.2 GeV storage ring of the Synchrotron Light Research Institute (SLRI) to meet the increasing user demands for hard X-ray synchrotron radiation in Thailand. The wiggler radiation fan of horizontal 15.93 mrad has been split in to three branches to be equipped with three beamlines for BL1.1W: multiple X-ray techniques, BL1.2W: X-ray imaging & X-ray Tomographic microscopy and BL1.3W: small/wide angle X-ray scattering. These three beamlines were successfully installed during machine shutdown in summer 2015 and will be fully operated in the end of 2016. The construction works for three branches beamlines that are mechanical engineering design, fabrication and installation of beamline components will be presented.

MOPE37 **Diamond Multi-Bend Achromats for Low Emittance and New Insertion Devices**
***J. Kay**, N.P. Hammond (DLS)*
Diamond Light Source is pioneering the move to a Multi Bend Achromat storage ring lattice for low emittance combined with the creation of new straight sections available for Insertion Devices (ID). Diamond is at an advanced stage of replacing one Double Bend Achromat (DBA) cell of the existing storage ring with a Double Double Bend Achromat (DDBA). The DDBA cell which is to be installed in Autumn 2016 has 4 dipoles and has been designed with a new straight section in the middle. This allows a new ID source point to be installed on an existing Bending Magnet port in the shield wall for a new micro-focus protein crystallography beamline called VMX-m. This same principle will be applied to the proposed Diamond II project which will be based on a Double Triple Bend Achromat (DTBA) with 6 dipoles per cell achieving even lower emittance whilst providing many more IDs. This paper describes the engineering challenges of these projects.

MOPE38 **Milliprobe Scanner Station**
***J. Divitcos** (ANSTO)*
The research team at Synchrotron Light Source Australia together with the Commonwealth Scientific & Industrial Research Organisation, have developed a high energy detector referred to as the Maia. The rapid scanning, high resolution detector offers new technological advances, including non-invasive technical study of highly valued artworks. A vital application of the Maia detector is scanning x-ray fluorescence microscopy for obtaining the elemental composition of a large number of materials. This innovation allows the connection between scientists & art communities to increase their understanding of historical artworks, broadening the field of authentication, potentially aiding the fight against art forgery as one example. We have designed a new dedicated station that offers improvements in high stability, motion control and mounting. It is designed to support & scan various samples in size as well as shape powered by X & Y stages. A slide & hold clamping concept has been implemented which provides ease & rapid assembling of samples. This arrangement provides excellent interchangeability, supporting a variety of planar & non-planar samples for scanning.

MOPE39 **Challenges in Project Management & Project Engineering at Scientific Facilities**
***R.W. Connatser** (CLS)*
This talk discusses the purpose of project management and some of the challenges found at scientific facilities related to project management and execution. It provides a high level overview of what project management is and why it is important to meeting the tactical and strategic goals of scientific facilities such as synchrotrons, particularly in the arena of engineering.

MOPE40 **Designing the Flash II Photon Diagnostic Beamline and Components**
***D. Meissner**, M. Hesse, U. Jastrow, H. Mahn, F. Marutzky, E. Plönjes, M. Roehling, H. Schulte-Schrepping (DESY)*
From 2013 to 2016 the free electron laser FLASH at DESY in Hamburg, Germany was upgraded with a second undulator line, photon diagnostic line, beam distribution and experimental hall connected to the same linear accelerator. This paper shows the layout of the photon diagnostic section and an overview of the civil engineering challenges. The mechanical design of selected components, e.g. vacuum components, diagnostic equipment and safety related components is presented.

MOPE41 **Design and Construction of a PW Experimental System of HV Chamber Adaptable, Modular and Stable**
***A. Carballedo**, C. Colldelram, J.R. García, R. Monge, L. Nikitina (ALBA-CELLS Synchrotron) J. Hernandez-Toro, L. Roso (CLPU)*
In the recent years, the number of high power lasers devoted to particle acceleration has increased in Europe. Additionally to this, some synchrotrons and accelerators are integrating these lasers in its lines, increasing the scientific synergies. The HP laser must be transported in HV. The use of HV also permits good cleanliness in the optical set up. As addition, is necessary to create an adaptable and modular design where several chambers could be assembled together. One additional constrain is the stability. A new model of HV chambers is presented. These consist in a frame where the walls are exchangeable panels, which make easier the introduction of a new configuration of ports. The system was designed as construction blocks. For a proper connection of the chambers a new interior fixation and pushers system was designed. Thanks to this, coupling new HV chambers, the volume total can be also easily modified. Finally, a third generation decoupled system is integrated inside, consisting of a stable breadboard, this supported by six columns that implement a preloaded kinematical mount, providing both an outstanding stability and a fine regulation (1st RM: 77Hz).

MOPE42 **Experimental and Numerical Study of the ALBA LINAC Cooling System**
***M. Ferrater** (UPC) J.J. Casas, C. Colldelram, D. Lanaia, R. Muñoz Horta, F. Pérez, M. Quispe (ALBA-CELLS Synchrotron)*
This work investigates experimentally and numerically the performance of the ALBA LINAC cooling system. The main objective is to enhance the hydraulic system in order to significantly improve its thermal and water flow stability. In normal operation some problems have been identified that affect the performance of the LINAC: flowrate below the nominal values and water flow decreasing in time. The cooling subsystems have been experimentally characterized in terms of the pressure drop and flowrate. The measurements were taken using a portable hydraulic unit made at ALBA as well as a set of ultrasonic flowmeters. For the numerical studies the cooling network has been simulated using the software Pipe Flow Expert. The experimental results have shown that a number of components are too restrictive. In some cases the possibility to increase the flowrate is limited. The numerical results show that the velocity magnitude is inadequate in some places, producing air bubble entrapment, high pressure drop at pipes and insufficient flow. Based on this study several modifications are presented in order to raise the nominal flow and to adequate the water flow velocities between 0.5 and 3 m/s.

MOPE43 **Hydraulic Failure Caused by Air in Pipelines of the Experimental Area Ring of ALBA Synchrotron Light Source: Research, Simulations and Solutions**
***L.M. Macià** (UPC) J.J. Casas, C. Colldelram, M. Quispe (ALBA-CELLS Synchrotron)*
After five years in operation of the ALBA Synchrotron Light Source a hydraulic failure

caused a maximum decreasing of water flow about 40% of its nominal value, hampering the refrigeration of the local components. The problem was mainly caused by the air accumulated in pipes due to very low velocities of water flow. A literature review was conducted about the minimum water flow velocity for removing air in pipelines as design criteria. The aim of this work is to develop hydraulic solutions in order to achieve the minimum flowrate in pipelines of the Experimental Area (EA) ring. In the short term it is proposed to install a controlled bypass in the EA. A numerical simulation using the software Pipe Flow Expert has been implemented in order to determine the requirements of the bypass that works under different conditions to assure a minimum flowrate all along the ring. The velocity map in EA ring is simulated for different scenarios: 180 and 360 degrees distribution for both clockwise and anticlockwise rotation. For the long term a design of pipes with variable cross section is proposed which optimizes the flow velocity magnitude in EA ring in agreement with the design criteria.

TUAA — Precision Mechanics

TUAA01 10:10 20 **Precision Mechanical Design of a Miniature Dynamic Mirror Bender for the SSRF Beamline Upgrade Project**

D. Shu, *W.J. Anton, S.P. Kearney (ANL) W.J. Anton (University of Illinois at Chicago) A. Li, C. Mao, Y. Pan (SINAP)*

Dynamic mirror benders which enable high precision figuring of planar substrates for x-ray focusing are widely used as conventional optical equipment in various synchrotron radiation beamlines. Especially, in cases for x-ray focusing optics coated with multilayers in a Kirkpatrick-Baez configuration as the final focusing elements immediately upstream of the sample, the dynamic mirror benders provide high precision figuring to allow the mirror figure to be tuned to optimize the focusing at different incidence angles to cover a wide energy range *. Recently, collaboration between Argonne National Laboratory and Shanghai Institute of Applied Physics (SINAP) has produced designs of a new miniature dynamic mirror bender with Argonne's laminar nanopositioning flexure technique ** for beamline upgrade project at the Shanghai Synchrotron Radiation Facility (SSRF). The mechanical design and finite element analyses of the miniature dynamic mirror bender, as well as its initial mechanical test results with laser interferometer are described in this paper.

TUAA02 10:30 20 **Earth, Wind, and Fire: The New Fast Scanning Velociprobe**

C.A. Preissner, *J. Deng, C. Jacobsen, B. Lai, F.S. Marin, J. Maser, S.T. Mashrafi, C. Roehrig, S. Sullivan, S. Vogt (ANL)*

The Advanced Photon Source Upgrade (APS-U) project will include a suite of new beam-lines. In preparation for this, a team at the APS is developing an X-ray microscope with a novel granite (Earth), air bearing (Wind) supported stage to take advantage of the two orders of magnitude increased coherent flux (Fire) that will be available with the APS-U. The instrument will be able to operate as a scanning probe for fluorescence microscopy and as a ptychoprobe for the ultimate in spatial resolution. Both are combined with tomography. The goals for the instrument while operating at the current APS are to demonstrate fast scanning of large samples at high resolution and ptychography at the highest resolution (speed and resolution limited by available flux). This presentation will discuss the unique mechanics, interferometry scheme, the advanced scanning control, and instrument integration.

TUBA01 11:20 20 **The Design of a Precision Mechanical Assembly for a Hard X-ray Polarizer**

***S.P. Kearney**, D. Shu, T. S. Toellner (ANL)*

Hard x-ray polarisers are commonly applied in synchrotron radiation research to produce photons in a pure polarization state, and as polarization filters to analyse the photon's polarization state after their interaction with a sample medium. We present the design of a mechanical assembly suitable for a hard X-ray polariser that requires multiple degrees of freedom with the base stage capable of handling at least 2-3 kg loads. The intermediary stages (roll, yaw, and translation directions) consist of commercially available tip/tilt and translational stages (Kohzu Precision Co., LTD). However, the requirements of the pitch stage are much more demanding and require a custom-designed flexure-based rotation stage. The design and analysis of this flexure-based rotation stage will be discussed in this study. This will include FEA analysis of the dynamic response and rotation range capabilities which will then be compared to mechanical performance test results using laser interferometers and accelerometer sensors.

TUBA02 11:40 20 **The New ID11 Nanoscope End-Station - A Nano-Tomography Scanner**

***L. Ducotte**, J.M. Clement, H. Gleyzolle, J. Wright (ESRF)*

The Nanoscope end-station is currently commissioned at beamline ID11. This end-station is designed for nano-focusing applications and dedicated to diffraction and microscopy experiments using nano diffraction tomography techniques, with a 100 nm size X-ray beam. The distinctive characteristic of this end-station is the integration of commercial nano-positioning stages on top of a high precision air-bearing rotary stage for continuous rotation scans with infinite rotation. For this purpose, a customised electrical slip-ring has been integrated in such a way as to maintain the intrinsic guiding performances of the main rotation stage, i.e. axial and radial errors < 20nm. This slip-ring is designed to carry signals from capacitive probes, encoders, piezo actuators, and is coupled to a rotary joint for vacuum. Another key component is a high precision linear stage for scanning the sample across the beam by moving the rotation axis with a resolution and repeatability < 10nm at the sample position and over a stroke of 10 mm. It has been designed, assembled and characterised at ESRF. The critical design aspects of this end-station and the metrology characterisations will be presented.

TUBA03 12:00 20 **The Generic Mirror Chamber for the European XFEL**

***T. Noll** (BESSY GmbH) H. Sinn, A. Trapp (XFEL. EU)*

For the high demanding requirements of the beam-lines of the European XFEL [*] new mirror chambers were developed, designed and tested. A prototype contains the main features of all needed ten units which are tested extensively. The concept of the mirror chamber is a further development of our Cartesian parallel kinematics for X-ray optics in the UHV [**]. The stiffness and vibration behaviour were further improved and the position resolution was increased compared to earlier implementations at Bessy and Flash. For that the drives were redesigned and now feature a stroke of 100 mm with nanometer resolution.

TUBA04 12:20 20 **Mechanical Design and Development of Compact Linear Nanopositioning Flexure Stages with Centimeter-Level Travel Range and Nanometer-Level Resolution**

***D. Shu**, W.J. Anton, S.P. Kearney, B. Lai, W. Liu, J. Maser, C. Roehrig, J.Z. Tischler (ANL) W.J. Anton (University of Illinois at Chicago)*

Nanopositioning techniques present an important capability to support the state-of-the-art synchrotron radiation instrumentation research for the APS operations and

upgrade project. To overcome the performance limitations of precision ball-bearing-based or roller-bearing-based linear stage systems, two compact linear nanopositiioning flexure stages have been designed and developed at the APS with centimeter-level travel range and nanometer-level resolution for x-ray experimental applications. The APS T8-54 linear flexure stage is designed to perform a precision wire scan as a differential aperture for the 3-D diffraction microscope at the APS sector 34, and the APS T8-56 linear flexure stage is designed for a horizontal sample scanning stage for a hard x-ray microscope at the APS sector 2. Both linear flexure stages are using a similar improved deformation compensated linear guiding mechanism which was developed initially at the APS for the T8-52 flexural linear stage *. The mechanical design and finite element analyses of the APS T8-54 and T8-56 flexural stages, as well as its initial mechanical test results with laser interferometer are described in this paper.

TUCA01 14:00 20 **Investigation of the Vibrational Stability of Synchrotron X-Ray Optics Using a Differential Interferometer**

***R. Doehrmann**, J. Heuer, J. Horbach, H. Schulte Schrepping, I. Sergeev (DESY)*

Advanced synchrotron radiation experiments for example for investigations at the nanoscale place extreme demands on the stability and precision of all components of modern beamlines. This is of particular importance for high precision X-ray optics, as mirrors or double crystal monochromators (DCM), which should keep the beam stable. The DCM is the first optical element in most synchrotron beamlines, which has to operate under high heat load. Thus, the cryogenic cooling and high vacuum are necessary conditions for the DCM operation in most cases. Unfortunately, cryogenic cooling is a source of the vibrational instability that has to be reduced in order to improve the beamline performance. Here, we present a method to measure vibration directly at the DCM crystals. This method was used to study and improve vibrational stability of several PETRA III monochromators. The results of the measurements allow us to discover common sources of instabilities. These results will be shown and discussed and we will describe in detail the modifications performed on the LN2 system and the monochromator design, which leads to the improvement of the angular stability at the best down to 50 nrad RMS.

TUCA02 14:20 20 **Structural Dynamic Modelling and Measurement of SwissFEL Bunch Compressor**

***X. Wang**, H. Jöhri, F. Löhl, M. Pedrozzi, T. Stapf (PSI)*

Magnetic chicanes are used in accelerator facilities to longitudinally compress the accelerated particle bunches. The second compression chicane (BC2) of SwissFEL consists of four dipole magnets bending the beam on the horizontal plane along a C-shaped orbit and has a total length of 17 m. The position of the two central dipoles can be continuously adjusted to achieve the required transverse offset in order to realize a wide range of compression schemes. To ensure the requires mechanical stability of the accelerator components sitting on the long and movable steel girder (7.7 m), it is essential to design a stiff support structure with high eigen frequencies. In the design stage, displacement frequency responses are calculated in a modal based linear dynamic analysis using finite element method to ensure vibration amplitude below 1 micrometer. Special considerations are given to the modelling of linear guide systems, as they introduce nonlinear support conditions and need to be adequately simplified in the calculation. After completing the BC2 assembly, vibration measurements were performed. Finally, the validation of the numerical model by measurement results will be presented.

TUCA03 14:40 20 **Estimation of the Temperature Fluctuations Harshness With Respect to the Thermal Stability of Support Structures**

***N. Jobert**, F. Alves, S.K. Kubsky (SOLEIL)*

Thermally induced distortions are a key contributor to the overall positional and pointing performance of high-stability systems. Though stability scales with temperature fluctuations, there is some hidden complexity is the subject. Firstly, not all temperature oscillations will distort the structure: fast variations will hardly propagate into the structure, little change in overall dimensions but primarily pointing errors. Conversely, slow variations will result in quasi uniform temperature fields that change dimensions, hence mainly positional errors. Secondly, there is randomness in temperature fluctuations which obscures the actual severity of a given environment: randomness occurs timewise, but also space-wise. For highly stable situations,

random part of the temperature field becomes prominent, and discarding this component becomes questionable. No harshness indicator exists that could help quantifying the actual severity of a given thermal environment. It is the objective of this paper to provide some insight on the matter, and propose a simple yet efficient numerical method allowing the evaluation of actual structural response to any realistic thermal environment.

TUCA04 15:00 20 **Vibrational Stability of a Cryocooled Horizontal-Bounce Double Crystal Monochromator**

P. Kristiansen *(FMB Oxford)*

There is an increasing demand on monochromators to preserve the performance of the latest ultra-stable storage rings. One method of obtaining near-complete vertical preservation of the ring stability is to arrange the crystals in a horizontal diffracting geometry. We present the vibrational performance of a fixed offset Horizontal Double Crystal Monochromator. We have made direct measurements, at cryocooled conditions, on a H-DCM currently deployed at MAX IV that has a relative pitch stability of 25 nrad RMS, 1-2500 Hz, and an absolute pitch stability of 18 nrad RMS, 2-2500 Hz, when running the cryocooler in a condition that allows 1.5kW to be extracted via the circulating liquid nitrogen. These results demonstrate the advantage in terms of vibrational stability of circulating the liquid nitrogen high pressures, which enables the flow velocities to be reduced to obtain equivalent cooling performance. The value of performing live measurements is illustrated as we show that a vibration of the in-vacuum cryoline support structure is not translated into relative crystal vibrations, contrary to the intuitive assumption that this would be the primary source of beam instability.

TUCA05 15:50 20 **The New High-Dynamics DCM for Sirius**

R.R. Geraldes*, R.M. Caliari, G.B.Z.L. Moreno, L. Sanfelici, M. Saveri Silva (LNLS)*

The monochromator is known to be one of the most critical optical elements of a synchrotron beamline, since it directly affects the beam quality with respect to energy and position. Naturally, the new 4th generation machines, with their small emittances, start to bring about higher stability performance requirements, in spite of factors as high power loads, power load variation, and vibration sources. A new high-dynamics DCM (Double Crystal Monochromator) for the range between 2.3 to 38 keV is under development at the Brazilian Light Source for the Sirius EMA beamline (Extreme Condition X-ray Methods of Analysis). Having the target for stability between crystals of a few tens of nrad (even during the Bragg angle motion for flyscans) and taking the limitations of the present DCMs into account, this new DCM reviews the system as a whole. In order to achieve a highly repeatable dynamic system, with a servocontrol bandwidth in the range of 200 Hz, solutions are proposed for a few topics, including: actuators and guides, metrology and feedback, LN2 indirect cooling, crystal clamping, thermal management and shielding. The full concept of this high-dynamics DCM will be presented.

TUCA06 16:10 20 **The Girders System for the New ESRF Storage Ring**

F. Cianciosi*, T. Brochard, Y. Dabin, L. Goirand, M. Lesourd, P. Marion (ESRF)*

The ESRF is proceeding with the design and procurement of its new low emittance storage ring (Extremely Brilliant Source project). This completely new storage ring requires a high performance support system, providing high stability (first resonance frequency about 50Hz) and a precise alignment capability (50µm, manual in transverse direction and motorized in the vertical one). In order to meet these requirements we decided to support the magnets of each of the 32 cells of the synchrotron with four identical girders that was considered the best compromise between cost, complexity

and performances. Each of the resulting 128 girders is 5.1m long, carries about seven tons of magnets, and its weight including fixed basement and adjusting system is six tons. The adjustment system relies on modified commercial wedges; their stiffness was evaluated through laboratory tests. The FEA calculations carried out to optimize the design will be presented, together with the results obtained on a complete prototype girder system which was built and extensively tested and confirmed the modal calculations.

TUCA07 16:30 20 **An Overview of the European Spallation Source**

X. Permanyer *(ESS)*

ESS, the European Spallation Source, will be a major user facility at which researchers from academia and industry will investigate scientific questions using neutron beams. ESS will be a slow neutron source of unparalleled power and scientific performance. The ESS is divided in three main areas: accelerator, target and experiments. The accelerator creates protons at the ion source, accelerates them to an appropriate energy and steers them to a solid, rotating tungsten target. The target converts the high energy proton beam into low-energy neutron beams via the spallation process with the greatest possible efficiency. The neutrons will be delivered to a suite of research instruments, each devised to extract different kinds of information from the samples studied. ESS will reach its full design specifications in 2025, with a suite of 22 research instruments.

TUPE01 **DMM Thermal Mechanical Design**
J.H. Kelly *(DLS)*
A Double Multilayer Monochromator (DMM) was designed in-house for the VMXi beamline. Thermal mechanical finite element analysis was performed to design a novel optic geometry, employing In/Ga eutectic cooling. The integration of a DMM into the existing beamline required additional power management components, such as a low energy power filter, a power detector and compact CuCrZr masks. This paper describes the thermal management challenges and their solutions. The DMM has been fully commissioned and is operational within the original I02 beamline.

TUPE02 **Experimentally Validated CFD Analysis on Helium Discharge**
J.-C. Chang*, Y.C. Chang, F. Z. Hsiao, S.P. Kao, H.C. Li, W.R. Liao, C.Y. Liu (NSRRC)*
National Synchrotron Radiation Research Center in Taiwan (NSRRC) had set up three cryogenic systems to provide liquid helium to superconducting rf cavities, insertion devices, and highly brilliant hard X-ray. The first one could produce liquid helium 134 LPH, with maximum cooling capacity of 469 W at 4.5 K. The second one could produce liquid helium 138 LPH, with maximum cooling capacity of 475 W at 4.5 K. The third one could produce liquid helium 239 LPH, with maximum cooling capacity of 890 W at 4.5 K. However, large liquid helium discharge in a closed space will cause personnel danger of lack of oxygen. We performed Computational Fluid Dynamic (CFD) simulation to analyze helium discharge through a superconducting rf cavity in the Taiwan Photon Source (TPS) tunnel. We simulated cases of helium discharge flow rates from 0.1 kg/s to 4.2 kg/s with and without fresh air supplied from the air conditioning system. We also set up both physical and numerical models within a space of 2.4m in length, 1.2m in width and 0.8m in height with helium discharge insides to validate the CFD simulation.

TUPE03 **2.8 Meter In-Vacuum Undulator Split Girder Design FEA Analysis for Gap Variable Loads**
H.C. Fernandes*, P.L. Cappadoro, C.A. Kitegi, M. Musardo, J. Rank, T. Tanabe (BNL)*
The 2.8 meter In-vacuum Undulator installed at the NSLS-II ring has a split in-vacuum girder design. At varying gap values, it was found, through magnetic measurement and encoder readings, that the device did not maintain a uniform magnetic gap throughout its entire range. In order to compensate for a perceived and subsequently measured deflection of the out of vacuum girders at various gap values, external, load compensating springs were installed. This excessive external girder deflection along with an inadequate joint between the two halves of the internal girder was attributed to be the culprit causing the inconsistent magnetic performance at varying gap values. In order to improve the design, mechanical FEA was conducted for various gap values, incorporating a combination of magnetic, gravitational and spring loads. The purpose of this study is to quantify the girder deflection with these varying loads. Then, a modification to the undulator can be incorporated using the knowledge obtained from this analysis, to possibly reduce, if not eliminate, the non-uniform magnetic measurements encountered at varying gap values.

TUPE04 **Coherent Soft X-Ray EPU Vacuum Chamber Thermal Analysis for Synchrotron Radiation Protection**
H.C. Fernandes*, P.L. Cappadoro, D.A. Hidas, C.A. Kitegi, M. Musardo, J. Rank, T. Tanabe (BNL)*
The NSLS-II ring stores a 3GeV beam which needs to be maintained via the injection

system, which operates in top-off mode, and is intended to cause minimal disturbance to the storage ring. The CSX (Coherent Soft X-Ray) EPU (Elliptically Polarized Undulator) vacuum chamber was analysed using FEA, for beam offset and beam mis-steer. The result of this would be an increase in the heat load on the chamber. FEA analysis was done to determine the theoretical thermal effects of this extreme condition on the CSX EPU vacuum chamber. Studies were then carried out on the actual vacuum chamber, whose vertical aperture is 8.0 mm, during intentional beam mis-steer and mis-alignment tests in order to raise the vacuum chamber to its maximum operating set-point temperature. FEA thermal analysis for extreme beam mis-alignments and mis-steers were conducted and the results were compared with field tests for extreme beam mis-alignments and mis-steers, which were performed in the NSLS-II storage ring.

TUPE05 **Numerical Simulation of the ALBA Synchrotron Light Source Cooling System Response for Failure Prevention**

X. Escaler *(UPC) J.J. Casas, C. Colldelram, M. Prieto, M. Quispe (ALBA-CELLS Synchrotron)*

The ALBA Synchrotron Light Source cooling system is designed with a common return pipe that interconnects the four consumption rings. Such configuration is believed to compromise its optimal operation. To understand its thermo-fluid dynamic behaviour, a detailed 1D model has been built comprising all the components such as the pipes, fittings, bends, valves, pumping stations, heat exchangers and so on, and the various regulation mechanisms. Preliminarily, the model results in steady state operating conditions have been compared with experimental measurements and the maximum deviations have been found below 13%. Then, a series of transient numerical simulations have been carried out to determine the system response. Specifically, effects of the blockage and leakage of a consumption line as well as the increase and decrease of heat duty for the tunnel rings have been investigated. As a result, the stability of the system has been evaluated and the operational limits have been estimated in front of hydraulic and thermal load variations. Moreover, particular behaviors have been identified which can be used to design monitoring and control strategies to prevent unexpected failures.

TUPE06 **Thermo-Fluid Numerical Simulation of the Crotch Absorbers' Cooling Pinholes for ALBA Storage Ring**

X. Escaler*, V. Arbo Sangüesa (UPC) J.J. Casas, C. Colldelram, M. Prieto, M. Quispe (ALBA-CELLS Synchrotron)*

The ALBA Synchrotron Light Facility crotch absorbers, that remove the unused storage ring radiation, incorporate an internal cooling system composed by a number of parallel pinholes and by the corresponding stainless steel inner tubes inserted into each of them. Water flows in the resulting annular sections to evacuate the total heat power. Around each inner tube, a spiral wire is fixed along the whole length with a given pitch height in order to enhance the convection heat transfer. The influence of several design parameters on the absorber thermo-fluid behavior has been evaluated by means of the CFD software ANSYS CFX. In particular, the wall heat transfer coefficients and the pressure losses through a single pinhole have been evaluated for a range of different flow rates and pitch heights. Moreover, some modifications of the end wall geometry have been simulated as well as the effect of reversing the flow direction inside the channels. Finally, the critical crotch absorber type 3 has also been simulated and the limiting pitch height-flow rate combinations have been found based on the available driving pressure of the cooling system.

TUPE07 **Bend and Cooling Design for the Bragg Crystal of High-Heat-Load Bragg-Laue Monochromators**

***Z. Liu**, K.A. Beyer, K.W. Chapman, P.J. Chupas, G.J. Halder, C.A. Kurtz, L.W. Ribaud, X.B. Shi, W.Q. Xu, A.A. Yakovenko (ANL)*

A newly redesigned Bragg-Laue monochromator will be used to accelerate materials synthesis * at 17-BM, a Rapid Acquisition Powder Diffraction beamline at the Advanced Photon Source. To achieve energies up to 55 keV, a Laue-Laue monochromator **,*** was modified by replacing its first crystal with a water cooled, bendable Bragg crystal. Direct cooling allows the Bragg crystal to accept the high heat load from the source, while the bend design enhances its vertical focusing. These improvements reduce x-ray attenuation, provide a narrower energy band width, and increase its flux. The authors believe this to be the first design to bend and cool a Bragg crystal subjected to high heat loads.

TUPE08 **Finite Element Analysis of a Photon Absorber Based on Volumetric Absorption of the Photon Beam**

***K.J. Suthar**, P.K. Den Hartog, B.K. Stillwell (ANL)*

Designing photon absorbers for next generation multibend achromat storage rings can be challenging considering the high power densities and limited space that will typically be present. The potential for problematically high material temperatures and thermal gradients can be expected to be greater than that for previous generation machines on account of the shorter source-to-receiving surface distances. Conventionally, photon absorbers are made from copper which is highly opaque to x-rays. A consequence of this is that the majority of the heat is absorbed within a very short distance of the surface. Utilizing materials that allow a more volumetric absorption of the radiation can improve the efficiency of heat removal as it can keep surface temperatures and thermal gradients lower than would otherwise be possible. This paper discusses multiphysics analysis of a crotch absorber for the APS Upgrade project (APS-U) via full-coupling of heat-transfer and structural mechanics. The simulation results are discussed in detail.

TUPE09 **Thermo-Fluid Study of the UPC Race-Track Microtron Cooling System**

***X. Escaler**, V. Blasco, Yu.A. Kubyshin, J.A. Romero, A. Sanchez (UPC) , M. Prieto (ALBA-CELLS Synchrotron) V.I. Shvedunov (SINP MSU)*

The cooling system of the race-track microtron (RTM), which is under construction at the Universitat Politècnica de Catalunya (UPC), has been simulated by means of a computational fluid dynamics (CFD) software. The hydraulic and thermal performance of the system has been studied for various operation conditions. Firstly, the hydraulic model has been validated by comparison with experimental measurements at different flow rates. Then, the cooling fluid temperatures and the pressure losses of the system have been determined and the capacity of the current design to remove the generated heat at nominal power has been confirmed. Finally, the wall maximum and average temperatures and heat transfer coefficients inside the magnets and the accelerating structure have been calculated. These results have allowed us to localize sections of the cooling system with a low convection due to detached flows where, therefore, a risk of zones of high temperatures exists. An optimization of the cooling circuit with the aim to reduce such high temperature zones has been proposed.

TUPE10 **A Thermal Exploration of Different Monochromator Crystal Designs**

***J.S. Stimson**, M.C.L. Ward (BCU) S. Diaz-Moreno, P. Docker, J. Kay, J. Sutter (DLS)*

Eight different monochromator crystal designs were subjected to a combination of three different beam powers on two different footprints. The temperature and thermal deformation were plotted for each. It was found that thermal deformation of the lattice is negligible, and that while the thinnest crystal wafer showed the smallest temperature increase, crystals cooled from the bottom alone demonstrated a far more uniform thermal deformation and a larger radius of curvature.

TUPE11 **Study on Thermal Mechanical Design and Optimization Analysis for the ALBA Infrared Microspectroscopy Beamline (MIRAS) Extraction Mirror Based on Finite Element Analysis**

***M. Quispe**, A. Carballedo, J.J. Casas, C. Colldelram, A.C. Crisol, G. Peña, L. Ribo, I. Sics, I. Yousef (ALBA-CELLS Synchrotron)*

This paper reports design, modelling, simulation and optimization results for the ALBA MIRAS infrared radiation extraction mirror. Finite element analysis (FEA) was used to simulate the thermal mechanical behaviour of the device. With the aim to ensure a good thermal performance, conservative assumptions were applied: all of the incident Bending Magnet (BM) radiation is absorbed at the mirror surface, constant bending magnetic field and low thermal contact between the mirror Al 6061 and the OFHC copper arm. A novel solution has been implemented in order to provide an effective cooling by a natural convection on the in-air part of extraction mirror assembly. This has voided the necessity for a water cooling that often causes problems due to the associated vibrations. The power conditions were calculated by using SynRad+. The main ALBA Storage Ring design parameters are: 3 GeV, 400 mA and 1.42 T. According to these conditions, the mirror absorbs 15 W with a peak power density of 0.51 W/mm2. The peak temperature calculated was 63.2 ºC. The real measurements reported during the commissioning stage showed a good thermal performance, in agreement with the results predicted by FEA.

TUPE12 **Develop White Beam Components of TPS Beamline 24A**

***M.H. Lee** (NSRRC)*

The TPS 24A, the Soft X-ray Tomography (SXT) beam-line, is one of the beam-lines in the second construction phase at the Taiwan Photon Source (TPS). This bending magnet beam-line has high flux in the range between 260 eV and 2600 eV. It is designed for transmission full-field imaging of frozen-hydrated biological samples. At the exit slit, the beam flux optimized in 520 eV is 282 billion photons/second with resolving power 2000, the beam size is 0.05 mm × 0.06 mm (V × H, FWHM) and the beam divergence is 1.73 mrad × 1.57 mrad (V × H, FWHM). By contributions of the generic beam-line components project in recent years, modular mechanisms would be used in this beam-line such as mask, X-ray Beam Position Monitor (XBPM), Photon Absorber (PAB), and screens. However, these beam-line components were designed for ID beam-lines, so they should be redesigned for BM beam-lines. This paper generally introduce these beam-line components, especially white beam ones, decided and redesigned for the TPS 24A. They will play important roles at the BM beam-lines in the future.

TUPE13 **Numerical Simulation of the ALBA Synchrotron Light Source Cooling System Response to Pump Start-Up and Shut-Down**

***X. Escaler**, D. Juan Garcia (UPC) J.J. Casas, C. Colldelram, M. Prieto, M. Quispe (ALBA-CELLS Synchrotron)*

The ALBA Synchrotron Light Source cooling system is submitted to regular pump start-ups and shut-downs. Moreover, pumps can trip due to motor power failures. As a result, the piping system can be subjected to surges and pressure oscillations. The 1D thermo-fluid simulation software Flowmaster has been used to predict these transient conditions taking into account the fluid compressibility, the pipe elasticity, the characteristic time response of the check valves and the pump/motors moments of inertia. During pump start-ups, significant pressure rises are detected that can be reduced by readjusting the PID controller parameters. Unexpected pump shut-downs do not appear to provoke significant water hammer conditions. However, pressure fluctuations are generated mainly in the same pumping line but also in the rest of the system due to the particular common return configuration. In all the cases the

pressure regulation mechanisms acting on the pump rotating speeds serve to attenuate the consequences of these transients. Finally, the feasibility of the model to simulate the effect on the system response of trapped air inside the pipes has also been evaluated.

TUPE14 **Study, Design and Optimization Analysis of the ALBA LOREA Dipole Vacuum Chamber and Crotch Absorbers Based on Finite Element Analysis**
***M. Quispe**, J. Campmany, J.J. Casas, C. Colldelram, A.C. Crisol, J. Marcos, G. Peña, M. Tallarida (ALBA-CELLS Synchrotron)*
This work deals with the FEA study, design and optimization of the LOREA dipole vacuum chamber and Glidcop Al-15 crotch absorbers. At present LOREA is the ninth beam-line being designed at ALBA with an Insertion Device (ID) consisting of an Apple II-type helical undulator. For the standard dipole chamber the vertical polarized light hits the walls because of the very narrow vertical aperture between the cooling channels. In vertical mode the ID vertical divergence equals ± 2.2 mrad and the peak power density and total power are 5.6 kW/mrad^2 and 5.5 kW, respectively. Due to the high power a temperature as high as more than 600 ºC is calculated. In consequence the dipole chamber has to be modified and the absorbers have to withstand the Bending Magnet (BM) and ID radiation. The new absorbers have to be thicker and its cooling channels are farer from BM power deposition than the standard absorbers. The thermal mechanical simulations show good results, the new absorbers are in a safe range, the maximum temperature, stress and strain are 309.2 ºC, 164.2 MPa and 0.14%, respectively. The main ALBA Storage Ring design parameters used in the simulations are: 3 GeV, 400 mA and 1.42 T (BM).

TUPE15 **Thermal Management and Crystal Clamping Concepts for the New High-Dynamics DCM for Sirius**
***M. Saveri Silva**, R.M. Caliari, R.R. Geraldes, R.P. Parise, L. Sanfelici, L., Jr. de Souza (LNLS)*
The monochromator is known to be one of the most critical optical elements of a synchrotron beamline, since it directly affects the beam quality with respect to energy and position. Naturally, the new 4th generation machines, with their small emittances, start to bring about higher stability performance requirements, in spite of factors as high power loads, power load variation, and vibration sources. A new high-dynamics DCM (Double Crystal Monochromator) is under development at the Brazilian Light Source for the Sirius EMA beamline (Extreme Condition X-ray Methods of Analysis). In order to achieve high-bandwidth control and stability of a few nrad, as well as to prevent unpredicted mounting and clamping distortions, new solutions are proposed for crystal fixation and thermal management. Since the design is based on flexural elements, it should be indeed highly predictable, so that the work was developed using mechanical and thermal FEA, including CFD. Efforts were made to predict thermal boundaries associated with the synchrotron beam, including incident, diffracted and scattered power, for which the undulator spectrum was employed in the Monte Carlo simulation package - FLUKA *.

TUPE16 **Design of A Leaf Spring Bender for Double Laue Crystal Monochromator at SSRF**
***H.L. Qin** (SSRF)*
A leaf spring bender geometry for water-cooled double Laue crystal monochromator (DLM) is presented. The DLM will be employed to acquire high energy monochromatic X-ray (60keV to 120keV) on the ultra-hard applications beamline at Shanghai Synchrotron Radiation Facility (SSRF). A compact bending mechanism is designed in order to get focused high energy monochromatic X-ray. The DLM applies a pair of thin asymmetric crystal and leaf spring bending mechanism which push the crystal

to a sagitally bent radius as small as 1.5 meter by a pair of symmetry moments. An optimized crystal geometry is achieved by taking into account the meridional and sagital bending coupled and defined by the anisotropic elasticity of the asymmetric crystal. Furthermore, thermal slope error and structural stress of the silicon bent crystal are analysed by finite element method.

TUPE17 **The development of CVD Diamond Based FEL Photon Stoppers in LCLSII**
***H. Wang**, Y. Feng, J. Krzywinski, E. Ortiz, M. Rowen (SLAC)*
Safety stoppers are required to absorb and stop the LCLS-II Free-Electron Laser (FEL) beam, which has the unique combination of extremely high peak fluence per pulse and enormous average power density. This is unprecedented at the existing 3rd generation synchrotron or current 4th generation low repetition rate FEL source, so that new solutions are required. CVD diamond has been proposed as the absorber material, for its low Z number, high thermal conductivity and high thermal shock resistance. The Photon Stopper design consists of a perimeter cooled CVD diamond absorber, clamped in between two copper (OFHC) heat sinks, with one looped with a water cooling line. The thermal studies include both steady state and instantaneous analysis. Diamond damage test results using LCLS FEL beam will also be reported.

TUPE18 **Design and FEA of a 3D Printed Detector Window Frame**
***W. Tizzano** (DLS)*
The purpose of the project was to design and simulate a window assembly to be used in GISAX (Grazing Incidence Small Angle X-ray scattering) experiments. The window lies between the sample and the WAXS (Wide Angle X-ray Scattering) detector, a modified, in-vacuum detector, with modules removed to allow scattered radiation to pass through to a SAXS (Small Angle X-ray Scattering) detector positioned downstream. The window uses 0.075 mm Kapton film and given the size, pressure and the short distance to the sensors, it was necessary to support it on a frame. To avoid any information loss due to shadowing on the detector, a frame was designed so that shadows will be projected into the detector intermodule gaps. The geometry was such that DMLS (Digital Metal Laser Sintering) was an effective way of producing the item. Given the slenderness of the structure and the forces it supports, the material approaches or exceeds its yield point, so an isotropic bilinear hardening material model was chosen; moreover, large deflections were enabled. Also, the contacts were modelled with augmented Lagrange frictional formulation. All these assumptions made the analysis strongly non-linear.

TUPE19 **Application of a NEG Coated Chamber at the Canadian Light Source**
***S.Y. Chen**, D. Bertwistle, K. Kei, T.M. Pedersen (CLS)*
In the Fall of 2015 a 4800 mm long NEG coated chamber was installed in the Canadian Light Source in cell 9 straight section. The chamber will occupy to majority of the straight length. The chambers vacuum has been monitored for +1 year and no obvious issues has been found. The chamber body is 10 mm thick and the aperture is an ellipse with a 8 mm height and a 65 mm width. A design feature of the chamber is a lack of support in-between the ends of the chamber. The lack of support space is due to the double elliptically polarizing undulator (54 mm, and 180 mm period). This proceeding details the following: a.The structure design and Finite Element Analysis for the deflection and strength; b.Heat loads and cooling calculation; c.Supports design; d.Deflection and correction with the supports; e.Current strips installation f.Activation;

TUPE20 **Noble Gases Flow Management in the European XFEL Project UHV Photon Transport System**
***J.R. Villanueva Guerrero** (XFEL. EU)*
The European XFEL facility in Hamburg is based on a linear accelerator and three

Free-Electron-Laser beam-lines covering the energy range from 250 eV to 24 keV. It will provide 2700 pulses in trains of 600 microsecond duration at a repetition rate of 10 Hz. For the photon beam diagnostics, several gas-based devices have been developed and placed in the beam transport system. They operate with different noble gases (Xe, Ne, Ar) with pressures up to $1{\cdot}10^{-4}$ mbar. Having a windowless beam-line, and a limited capability for noble gases that can be provided by the distributed array of ion pumps sustaining the UHV environment, a turbo-molecular based differential pumping section has been developed. This modular system is able to minimize the gas flow to the rest of the beam transport system, also offering a large optical clear aperture between pumping stages, and enabling the required installation and alignment flexibility in all the tunnel locations (up to 10), including variations as floor and ceiling-mounted versions. An overview of the vacuum system analysis, validation procedures, and structural and alignment concept, as well as installation status is reported.

TUPE21 **CLSI BMIT Super-Conducting Wiggler Cryogenic Safety Improvements**
***L.X. Lin**, T.W. Wysokinski (CLS)*
The 4.1 T superconducting wiggler on CLS Biomedical Imaging and Therapy (BMIT) beam-line developed a critical problem in the cryogenic safety relief path when operating at sub-atmospheric pressures. Ice blockage formed and prevented helium(He)gas from relieving during LHe refill procedure. This resulted in a pressure built up which cause expelling of the LHe and cold GHe from the wiggler He chamber - a significant safety concern. Several improvements were performed over the years including a replacement of the original rupture disk, replacement of the pressure relief valves and installation of metal O-ring seals at external ports. Followed these improvements, a major upgrade on the wiggler safety relief path was implemented by adding a new vent pipe directly connected to the He chamber for a barrier free exhaust. The LHe refill path was also modified to eliminate possibility of ice blockage. During initial tests after the upgrades we experienced significant heat load increase which was linked to the thermal acoustic oscillation in the LHe transfer line. The problem was resolved with a super insulation assembly added into the direct vent pipe along with a plug at the refill path.

TUPE22 **Low-Order Aberrations Correction of Extreme Ultraviolet Imaging Objective with Deformable Multilayer Mirrors**
***M. Toyoda**, R. Sunayama, M. Yanagihara (Tohoku University, Institute of Multidisciplinary Research for Advanced Materials)*
For at-wavelength observation of a lithography mask, recently, we proposed an EUV microscope consisting of multilayer-mirror objective (operating wavelength: 13.5 nm, numerical aperture: 0.25). To provide diffraction-limited spatial resolution below 30 nm, reduction of wave aberrations of low order, i.e., spherical aberration, coma, and astigmatism, should be key technical challenge for the microscope. In this paper, firstly, we describe detail of optical design and instrumentation of the point diffraction interferometer (PDI), so as to provide high enough sensing accuracy of 100 pm, which would be required for an optical axis adjustment of the EUV objective. Next, experimental results of wave front correction on the EUV objective are reported. We corrected spherical aberration and coma by precisely aligning an optical axis of the mirrors, while effects of astigmatism were also minimized with a figure-deformable mirror which can control radius of curvature in two mutually orthogonal directions. We confirmed that these low order terms should be less than 0.3 nm RMS.

TUPE23 **Glidcop Brazing in Sirius' Front-end High Heat Load Components**
***G.V. Claudiano**, O.R. Bagnato, P.T. Fonseca, F.R. Francisco, A. Gilmour, R.P. Parise, L. Sanfelici (LNLS)*

Sirius is a 4th generation synchrotron light source in project. Some of Sirius' beamlines will have a very high power density, more than 50 kW/mrad^2, to be dissipated in components that have a limited space condition. Thus, the refrigeration of these components is complex when one has in mind that the coolant flow cannot be too turbulent in order to not induce much vibration in the components. Oxygen Free Electrolytic Cu (OFEC) has been replaced by the Glidcop, on 4th generation synchrotron applications, due to its good thermal conductivity and preservation of mechanical properties after heating cycles. However, as this material is not very workable in terms of union with other materials, which led to the development of a brazing process for Glidcop and stainless steel union. Glidcop samples were submitted to a Cu-electroplating process and a silver base alloy (BVAg-8) was used to join the parts in a high vacuum furnace. Electroplating was used to improve the filler metal wettability. The results were very satisfactory, ensuring water and vacuum tightness. A desirable characteristic not yet proved is the virtual leak property. This paper will discourse about this brazing method.

TUPE24 **Electro-Formed Copper Cooling Block for AGIPD @ European XFEL**
A. Delfs *(DESY)*
The European XFEL will generate ultrashort X-ray flashes with a brilliance a billion times higher than that of the best conventional X-ray radiation sources. The AGIPD (Adaptive Gain Integrating Pixel Detector) is a high speed detector for XFEL. It allows single pulse imaging at 4.5 a MHz frame rate with a dynamic range allowing single photon detection and detection of more than 10,000 12.4 keV photons per pixel in the same image. This development is a collaboration between DESY, the University of Hamburg, the University of Bonn (all in Germany) and the Paul Scherrer Institute (PSI) in Switzerland. Four AGIPD modules are mounted on a cooling block using silicone oil as a coolant. The total heat load is about 200 W per cooling block. The aim is to achieve -20^{o}C sensor temperature with a non-uniformity of less than 5 K on the sensors and to cool electronic components with the return flow. The detector components are operated in vacuum. Following first tests with different materials and production methods, the copper cooling blocks were manufactured by electroforming. The poster gives information on production details and results on cooling tests done on the final detector assembly.

TUPE25 **Metallurgical Evaluation of Dissimilar Metal Joints for Accelerator Vacuum Chamber Construction at the Advanced Photon Source Upgrade Project**
G. Navrotski*, B. Brajuskovic (ANL)*
Tubular vacuum chamber assemblies made of aluminum, copper and stainless steel alloys will be used in the new Multi Bend Achromat (MBA) lattice storage ring complex that is being developed at Advanced Photon Source (APS). Details of the new lattice magnet system design and ring impedance considerations continue to drive these vacuum chambers to smaller dimensions and thinner walls with tight geometric tolerances under increasing thermal loads. As a practical matter, it is important to devise methods to join these dissimilar metal components without compromising their primary strength, permeability, electrical and thermal properties while still creating structures that are ultra-high vacuum compatible and leak-tight. This paper visually details the underlying metallurgical changes that occur when joining various combinations of aluminum, OFE copper, GlidCop® and stainless steel using brazing, bonding and welding techniques. Each of the techniques has its advantages and disadvantages with engineering and economic consequences.

TUPE26 **Carbon-Steel/Polyethylene Radiation Enclosures for Sirius**
L. Sanfelici*, F.H. Cardoso, R. Madacki, M.L. Roca Santo, M.S. Silva, J.E. dos*

Santos (LNLS) M.H.A. Costa, E. Palombarini (Biotec Controle Ambiental)
Lead enclosures have been used over the past decades for radiation protection at mid and high-energy light-sources, requiring nearly 10% of the investment needed to set up a new beamline. Besides, due to the increasing concern about neutron levels, the existing constructive models were revisited, and a new constructive approach based on Carbon-Steel and Polyethylene is proposed for the SIRIUS beamlines, leading to increased overall radiation protection and lower cost. This work is going to show simulation results from FLUKA, cost-comparison, as well as mechanical design details.

TUPE27 **A New Generation of X-ray Absorbers for the EBS Storage Ring**
***E. Gagliardini**, J.C. Biasci, D. Coulon, Y. Dabin, T. Ducoing, F. Ewald, P. Marion, F. Thomas (ESRF)*
The X-ray absorbers are essential components of the storage ring vacuum system. Their function is to protect the vacuum chambers from the high power density produced by the dipole magnets synchrotron radiation. In the EBS storage ring, the 430 kW total heatload will be stopped by 400 individual absorbers of twelve different types. In order to simplify their design and reduce their costs, a new material will be used (CuCr1Zr) associated with a novel design integrating the vacuum sealing flange in the CuCr1 absorber body and avoiding any brazed or welded junctions. This alloy, used for other applications (ITER-Fusion for Energy), offers an alternative to Glidcop with a very good compromise between thermal and mechanical characteristics. The exact location of each absorber is established through precise ray-tracing studies, which define the best place between the optical elements. The design of the absorbers will be described including technological aspects, together with the investigations on the CuCr1Zr material, the prototypes and tests carried out to validate the novel design choices.

TUPE28 **Characterization of the Acoustic Wave Divergence**
***A.C. Chavan** (GIT/ECE) A. DiChiara, B. Hu, K.J. Suthar (ANL)*
The acoustic levitator utilizes two transducers that emit acoustic waves. A standing wave is generated between the two transducers that allows for the levitation of particles at the nodes of the standing wave. These levitated particles experience an instability. In order to aid in the process of solving this instability, the acoustic field created by one of the transducers was characterized in this experiment. This characterization helps to understand the intensity of the acoustic field at different points throughout the region and how the acoustic wave diverges as it travels away from the transducer.

TUPE29 **Integration of a Stripline Kicker Prototype for CLIC Project Into ALBA Storage Ring**
***R. Monge**, Giraldo, J. C. Giraldo, J. Ladrera Fernández, M.L. Llonch, L. Nikitina, M. Pont, M. Quispe (ALBA-CELLS Synchrotron)*
The Compact Linear Collider (CLIC) project is an international collaboration with CERN for developing a high-energy and high-luminosity machine which accelerates and collides electrons and positrons at energies up to several tera-electron volts. The extraction system for the Damping Rings of the CLIC shall follow very tight requirements in order to maintain the ultra-low emittance of the extracted bunches. A first prototype of the extraction kicker based on stripline technologies has been built and characterized at CERN without beam. The stripline chamber will be shortly installed in the ALBA Synchrotron to be tested under beam. In situ measurements of the impedance, transversal field homogeneity and flat-top ripple aims to complete its characterization. This contribution presents the design of the set up for the integration of the stripline chamber in one of the medium straight sections of ALBA storage ring.

TUPE30 **Design of the Straight Sections of the EBS Storage Ring**
***B. Ogier**, J.C. Biasci, J. Chavanne, L. Goirand, J. Jacob (ESRF)*
The new lattice will require the complete substitution of the 32 arcs of the storage ring by a new hybrid multi-bend achromat. The length of the straight sections will be 5m. This new lattice results in different geometrical characteristics that require a new design of all transitions chambers, photon absorbers, in-vacuum undulators and also adjustment of the insertion device layout for existing sections longer than 5m. The Radiofrequency straight sections are also upgraded by replacing existing 5-cells cavities with single cell HOM damped cavities.

TUPE31 **Manufacturing of Photon Beam-Intercepting Components from CuCrZr**
***F.A. DePaola**, C. Amundsen, S.K. Sharma (BNL)*
Photon beam-intercepting components in synchrotron light sources have usually been made as water-cooled Glidcop bodies brazed to stainless steel conflate flanges. This fabrication method involves many manufacturing steps which result in increased cost, long procurement time and lower reliability. A new design approach was recently proposed which simplifies fabrication by eliminating brazing and utilizes a readily available copper alloy, CuCrZr. This paper describes the manufacturing experience gained at NSLS-II from fabricating many components of this new design. Results of an investigation of various techniques for joining CuCrZr to itself and to SS304 and AL-6061 are also presented.

TUPE32 **A Girder-Free Magnet Support System Design**
***S.K. Sharma** (BNL)*
Magnet support systems for the new light sources are required to satisfy several rigorous performance specifications. The support system must be rigid so that its static deflection under its own weight and the combined weight of the magnets is small and repeatable. For vibration stability the lowest natural frequency of the magnet-support assembly should be greater than 50 Hz. To meet thermal stability requirements it is desirable to minimize bending deformation of the support system when subjected to temperature changes. In addition, the magnet support system should be easy to transport, easy to align, and cost effective. Altogether these requirements are difficult to satisfy, especially if the main structural component of the support system is a girder of length greater than 3 meters. In this paper we propose a magnet support system design consisting of column-type supports joined by removable C-beams. The column-type supports provide a superior stability performance without compromising the alignment capability. Analysis results are presented to characterize the performance of this support system.

TUPE33 **NSLS-II Beam Aperture Slit Vibration Studies**
***C.J. Spataro**, H. Bassan, S.K. Sharma (BNL)*
Beam aperture slits mounted on stepper-motor driven X-Y stages are used in NSLS-II frontends to define the beam size and to limit thermal loads on downstream optical components. The X-Y stages have stability and resolution requirements of 1 μm and 0.1 μm, respectively. This is achieved by micro-stepping the stepper motor by a Delta-Tau GeoBrick-LV-NSLS-II controller. During the initial operation of the X-Y stages unacceptable levels of vibration when the stages were in motion, and an intermittent sharp squealing when they were at rest, were discovered. In this paper we present the studies that were undertaken to investigate these issues and the solutions that were implemented.

TUPE34 **Development of a Vertically Focusing Combined Function Dipole Magnet for Chess-U**
***S. T. Barrett** (Cornell University (CLASSE), Cornell Laboratory for Accelerator-Based Sciences and Education)*

There is an on-going major upgrade program for the Cornell High-Energy Synchrotron Source (CHESS) to boost the photon beam brilliance by an order of magnitude. In this project upgrade, dubbed CHESS-U, approximately an 80 meter section of the Cornell Electron Storage Ring (CESR) will be replaced by 12 compact double-bend achromats (DMA's) to lower electron beam emittance by a factor of three. The critical element in the achromat is a 2.3 meter long combined function (CF) dipole magnet which has a curved geometry. In this cost-effective and transversely compact design, the magnet has a "C-shape" laminated core of dimensions 260 x 412 mm and with a tapered pole shape. This vertically focusing bending magnet will produce a nominal field of 0.651 T and a gradient of 9.365 T/m. A short, 37 cm CF dipole magnet prototype was constructed and is presently being tested. In this paper, design considerations, fabrication techniques, and assembly methods of the CF magnet are discussed. Characterization results of the 37 cm CF prototype magnet will also be presented.

TUPE35 **Challenges in the Mechanical Design of the Injection Zone in the New ESRF Storage Ring**

***T.R. Mairs**, S.M. White (ESRF)*

Most documents describing the lattice and performance of low emittance light sources concentrate on the standard cells where x-rays are produced. The requirements of the standard cells are different from those of the injection cell where electrons are introduced into the storage ring. The difficulties in adapting the existing injection facilities at the ESRF together with the integration of new injection elements in the storage ring are described. The new ESRF storage rings is extremely limited in space availability and, in particular, the positioning of the kicker magnets and the septa magnets have posed specific problems. An introduction to the various different electron trajectories together with a description of the specific elements and their functions in the injection process is made. The mechanical engineering design solutions that have been adopted are outlined.

TUPE36 **Ground Vibration Monitoring for SXFEL Construction at SSRF**

***R.B. Deng**, F. Gao, L. Yin (SINAP)*

Shanghai X-ray Free Electron Laser test facility (SXFEL) began foundation construction on March 2015. It is quite important to monitor the ground vibration influenced by the construction at Shanghai Synchrotron Radiation Facility (SSRF), because the SXFEL is just in the north of SSRF and the nearest distance is only 20m. In this paper, the results of ground vibration measurement during the construction period at SSRF experimental hall near the SXFEL site are shown. Vibrations at different hours, frequency bands and directions are discussed to provide more detailed information on the influence of SXFEL construction to SSRF.

TUPE37 **The European XFEL Photon Beam Transport System**

***M. Dommach** (XFEL. EU)*

European XFEL, the fourth generation Free-Electron-Laser facility in Hamburg (Germany), is going to start user operation in early 2017. In full operation the novel facility will produce at MHz repetition rate coherent femtosecond pulses with unprecedented brilliance in the energy range from 250 eV to 25 keV. The facility comprises of a linear accelerator and three beam-lines: SASE1 and SASE2 that operate in the hard X-ray regime and SASE3 that covers the soft X-ray range up to 3 keV. The installation of the windowless 800-meter long ultra-high vacuum beam transport system of the SASE1 beam-line is almost completed and the assembly of the SASE3 beam-line is ongoing. Challenges of the installation are the implementation of a particle-free assembly of the vacuum system around x-ray mirrors and avoiding particle transport through the beam pipe. The control and interlock system is a custom build Programmable Logic Controller (PLC) to detect a fault vacuum condition and to prevent damage to the

beam-line hardware. The poster will report about the installation status and provides an overview of the control system as well as the interlock concepts.

TUPE38 **Progress and Mechanical Engineering of FEL Projects at SINAP**
***L. Yin**, W. Fang, Y. Liu, L. Wang, W. Zhang (SINAP)*
Free electron laser (FEL) technology is the next focus at Shanghai Institute of Applied Physics (SINAP). Shanghai Deep Ultraviolet Free-Electron Laser (SDUV-FEL), a test facility for new FEL principles, was operated for 5 years and got a serial of important results. Dalian Coherent Light Source (DCLS), a 50~150nm wavelength FEL user facility based on a 300MeV linac located at Dalian Institute of Chemical Physics (DICP), started beam commissioning in August. Shanghai X-ray Free-Electron Laser (SXFEL), a soft X-ray FEL test facility based on an 840MeV linac, will be installed in this month and the commissioning is scheduled at the end of 2016. The Progress of the FEL projects and the mechanical engineering in the design and construction are presented in this paper.

TUPE39 **Feasibility of a 4.5-T Cryogenic Permanent-Magnet Wavelength Shifter**
***C.-H. Chang**, H.-H. Chen, J.C. Huang, C.-S. Hwang, Y.T. Yu (NSRRC) C.-S. Hwang (NCTU)*
A three-pole wavelength shifter with a cryogenic permanent magnet is designed to extend the critical photon energy in a 3-GeV storage ring to 27-keV Xrays. The cryogenic wavelength shifter has a PrFeB permanent magnet and a vanadium-cobalt-steel (Permendur) pole to produce a magnetic field of flux density 4.5 T at fixed gap 5 mm. The magnet structure is optimized to prevent irreversible demagnetization of the permanent magnet near 300 K. A 77-K cryo-cooler is used to cool the magnets and to maintain the magnets at a uniform temperature, 77 K, in the vacuum vessel. This work describes the advanced design of the magnetic field and the simulations of the cooling temperature for the compact wavelength-shifter magnet.

TUPE40 **Cryo-Ready Undulator U15 : Passing SOLEIL's 2 Meters Threshold in Useful Magnetic Length**
***M. Tilmont**, F. Briquez, N. Béchu, L. Chapuis, M.-E. Couprie, J.M. Dubuisson, J.P. Duval, C. Herbeaux, A. Lestrade, J.L. Marlats, M. Sebdaoui, K.T. Tavakoli, C. de Olivera (SOLEIL)*
The U15 is an in-vacuum undulator designed to operate at room temperature and at 70K. It is the first in-vacuum undulator designed, assembled and which will be used in SOLEIL's storage ring that have support beams for magnets longer than 2 meters. A clear gap is felt in the technologies used for manufacturing and assembling compared to our standard 2m length in-vacuum undulators. This is due, in part, to the tolerances imposed by the maximum phase error admissible in SOLEIL's storage ring. The poster will shine lights on those difficulties from a design and manufacturing point of view.

TUPE41 **Design and Development of a Hybrid Type of Magnetic Field Measurement System for Cryogenic Undulator**
***C.H. Chang**, S.D. Chen, J.C. Huang, C.-S. Hwang, C.K. Yang (NSRRC)*
Nowadays cryogenic permanent magnet undulators (CU) served as producing hard X-ray source in worldwide medium energy facilities have turned into the most important scheme. In which of one set with period length 15 mm and 2 m long is under developing at NSRRC. To obtain magnetic field distribution of the 2 m long CU15 after cooled down to operating target temperature below 80 Kelvin, a hybrid type device combined Hall probe and stretch wire methods has been designed and developed to acquire data in low temperature and vacuum environment. The Hall probe is used to measure the on-axis field of the transverse and vertical direction and the stretch wire

is utilized to measure field integral of vertical and horizontal direction in the horizontal plane. Unlike the conventional field measurement system in air, the innovation system shall be located in limited clearance of ultra-high-vacuum environment. This paper mainly describes the whole system, including the kernel components, control systems and preliminary test results in detail.

TUPE42 **Insertion Device Installation Status at MAX IV**
A. Thiel *(MAX IV Laboratory, Lund University)*
At present the first five insertion devices have been installed in the 3GeV-ring of MAX IV. Two of these are in house built Apple II devices with period lengths 48mm and 53mm. These two undulators cover the entire available straight section length and are designed for a minimum mechanical gap of 11mm. The flat extruded aluminium vacuum chamber is supported by 5 points of suspension in order to minimize bending effects. Magnetic and mechanical shimming was finished and both undulators have been fiducialized before the installation. The final alignement in the ring bases on their magnetic centre as reference. With the weight of 13.5t per undulator ground transportation was demanding. A special transport frame has been designed and mounted to ease air cushion and fork lift transport.

TUPE43 **Preliminary Design of a Stretch Wire Magnetic Measurement System**
B. Zhang *(USTC/NSRL)*
A stretch wire magnetic measurement system was designed to measure the magnetic field of the insertion device. The system is composed of adjustable support, translation stages, wire and control system. The support is made of granite with high stiffness and thermal stability. Translation stages with 1 um motion accuracy will be adopted to obtain a high measurement precision. The theory and principle, mechanical design and evaluation of measurement error will be stated in this paper.

TUPE44 **Optimization for the APSU Magnet Support Structure**
Z. Liu*, H. Cease, J.T. Collins, J. Nudell, C.A. Preissner (ANL)*
The Advanced Photon Source Upgrade (APSU) is to replace the existing storage ring with a multi-bend achromats (MBA) accelerator lattice *. For the APS-U removal and installation, current planning calls for a 12-month shutdown and testing period, prior to resumption of operations. It calls for quick installation of the magnet support system with assembly and installation alignment tolerance. A three-point, semi-kinematic vertical mount for the magnet modules is the approach to reduce time for alignment. The longest section is the curved FODO section (four quads with three Q-bends interleaved, and a three-pole wiggler). All magnets of the FODO section sit on a single piece of support structure in order to have a good control over the magnet-to-magnet alignment tolerance. It brings challenge to minimize the top surface deflection and maximize the first mode frequency of the magnet support structure that is supported at three points. These constraints call for the need of optimizing the magnet support structures. Details of the optimization, including three-point positioning, material selection, and topology optimization, are reported in this study.

WEAA01 09:30 20 **The ESRF Accelerator Upgrade: Overview, Technical Challenges and Solutions in the Engineering Design**

***P. Marion**, J.C. Biasci, Y. Dabin, L. Goirand (ESRF)*

An engineering overview of the ESRF Extremely Brilliant Source (EBS) project will be presented. The ESRF EBS consists of replacing the current double-bend achromat storage ring by a new ring based on a 7-bend achromat lattice. This will enable a reduction of the electron beam horizontal emittance by a factor of 30 (140pm horizontal emittance) and an increase of the brilliance and coherence of the photon beam. As a consequence, the storage ring stability (vibrational and thermal) is of major importance, which implies specific design issues. The engineering design of standard cell components is now completed, some prototypes have been built and most of the large procurement contracts have been placed with the objective to pre-assemble equipped girders from mid 2017 and install them from beginning 2019. After introducing the context and the expected gain from the new storage ring, this talk will focus on the main technical challenges and present the mechanical design solutions adopted for the magnets and other strategic components *. This presentation is given on behalf of the ESRF EBS engineering team.

WEAA02 09:50 20 **X-Ray Absorber Design and Calculations for the EBS Storage Ring**

***F. Thomas**, J.C. Biasci, D. Coulon, Y. Dabin, T. Ducoing, F. Ewald, E. Gagliardini, P. Marion (ESRF)*

The Extremely Brilliant Source (EBS) of the ESRF will hold new type of X-Ray absorbers: a new material will be used (CuCr1Zr suggested by *) together with a novel design integrating: - CF flange are machined in the absorber body. No weld, no braze. - Optimized toothed surface profile, reducing the induced thermal stresses. - Compton and Rayleigh scattering integrated blocking shapes. - Concentric cooling channels. A brief overview of the new design and concepts will be given. The presentation will then focus on thermo-mechanical absorber ANSYS calculations, combining both Computational Fluid Mechanics (CFD). The calculations and the calculation process will be discussed as well as the design criteria chosen by the team. The CFD calculations will show that an heat transfer coefficient between the water and the copper part can be estimated as well as the pressure drop through the absorber. Finally, the stress analysis will be emphasized. The type of stresses (tensile, compressive or shear) and their nature (primary or secondary) will be linked to the choice of design criteria.

WEAA03 10:10 20 **Thermal Stability of the New ESRF Extremely Brilliant Source**

***B. Tampigny**, J.C. Biasci, J-F. B. Bouteille, Y. Dabin, M. Diot, L. Farvacque, F. Favier, A. Flaven-Bois, T. Marchial, D. Martin, P. Raimondi, P. Roux-Buisson (ESRF) F. Thomas (ILL)*

In the frame of the Extremely Brilliant Source project (EBS), studies dedicated to disturbances have been more intensively investigated. Engineering instabilities have two origins: mechanical and thermal. Major thermal issues are: - air conditioning presents a temperature ramp up of 2°C along the sector - storage ring requires a warm up period of 4 days for reaching a stable orbit These effects have been observed and corrected for 20 years. With EBS requirements, we need to identify these thermal effects in order to reduce the disturbances, thus improving more systematically the source stability. The study is lead by the comparison between the present and the new thermal system. To do so, it is necessary to evaluate the heat balance in this system, as well as to identify the thermal time constant of each component. FEA models have been performed to reveal sensitivity of these thermal issues. A full scale mock-up cell equipped with a prototype girder is measured with power cables inside. A FEA model

was also developed for the present storage ring to analyse the air stream. Although investigations have already been developed, some others remain to be achieved by the end of 2016.

WEAA04 10:30 20 **Novel Numerical method for Calculating the Shadow Projection and Collision Mapping of a Multi-Axis Goniometer at Diamond**

V. Grama, *A. Wagner (DLS)*

Beamline I23 is a long-wavelength macromolecular crystallography beamline at Diamond Light Source. The end station is a unique instrument with a bespoke multi-axis goniometer and a Pilatus 12M detector in a high vacuum environment. As experiments are limited by radiation damage to the crystals, optimised strategies are needed to orient crystals in the most efficient way to obtain a complete dataset with a minimal X-ray dose. Two key factors affect the optimisation strategies. Firstly, shadowing on the detector by the goniometer resulting in data loss in this region and secondly, collisions between the goniometer and other components in the end station restricting the angular range for sample centering and data collection. Although complex models for shadow rendering and collision prediction are available in the animation industry, there are no readily available or easily adaptable models for accurately calculating these two aspects for a multi-axis goniometer. This paper focuses on the numerical method for calculating the shadowing of a multi-axis goniometer on a semi-cylindrical detector and collisions with neighboring components.

WEBA01 11:20 20 **Nostradamus and the Synchrotron Engineer: Key Aspects of Predicting Accelerator Structural Response**

C.A. Preissner, *H. Cease, J.T. Collins, Z. Liu, J. Nudell (ANL) B.N. Jensen (MAX IV Laboratory, Lund University)*

MBA designs are placing stringent mechanical tolerances on the magnet support systems. At the APS-U the mag-net-to-magnet vibration tolerances are about 10 nm *. Timelines, installation requirements, and budgets constrain the resources available for prototyping and physical testing. Reliance on FEA to predict dynamic response is para-mount in insuring the tolerances are met. However, obtaining accurate results from a magnet support structure FEA is not as simple as analysing the CAD model of the structure. The 16th century author Nostradamus published a collection of prophecies that since his time, have been held up as predictions of various world events. While it is attractive to think his collection of short poems can be used to foretell the future, in reality it is only the vagueness and absence of any dates that make them easy to apply in a posthoc basis. Arguably, a similar statement can be made about the use of FEA in predicting accelerator support response. In this presentation the important contributors to FEA dynamic modelling will be discussed along with techniques that can be used to generate necessary data for models that can accurately predict response.

WEBA02 11:40 20 **Minimization of Mechanical Constraint Effects of Eutectic GaIn as Thermal Interface**

L. Zhang, *D. Cocco, J.H. James, N.M. Kelez, D.S. Morton (SLAC)*

Eutectic Gallium-Indium (eGaIn: 75% Gallium + 25 Indium) is widely used as the thermal interface in water-cooled X-ray optics. The thermal contact resistance of the eGaIn can be smaller than 0.1 mm2. K/W. The LCLS-II KB mirrors will be water cooled, and mostly dynamically bendable. The requirement on the bending accuracy can be expressed as residual slope error after the subtraction of the ideal ellipsoidal shape. This residual slope error should be smaller than 0.1rad, which is at least 4 orders of magnitude smaller than the mirror bent slope. Therefore, the mechanical constraint force from the eGaIn interface should be at least 4, and mostly 5 orders of magnitude smaller than the bending forces with the bending arm length comparable to the mirror length. But what is the mechanical constraint force of the eGaIn interface? What are the mechanical properties of the eGaIn in terms of Youngs or shear modulus. How should this eGaIn interface optimized, for instance the thickness of this interface? In this paper, we will present experimental studies conducted at SLAC to answer these questions, and propose a solution to minimize the constraint forces of the eGaIn.

WEBA03 12:00 20 **Recent Progress on the New Designs of High-Heat-Load Components**

S.K. Sharma, *C. Amundsen, F.A. DePaola (BNL)*

A new design was recently proposed for the high power masks and slits of the front-ends at the 2014 MEDSI Conference. The main features of the new design are integrated knife edges in high conductivity copper alloys, interception of the photon beam only on horizontal surfaces, replacing Glidcop® with readily available CuCrZr, and thermal optimization with internal fins. Numerous components based on this design have been built for NSLS-II front-ends and some of the design features have been incorporated into other high-heat-load components such as beamline masks and crotch absorbers. In this paper we describe recent progress at NSLS-II in further advancing this design approach by FE analysis, fabrication and testing.

WEBA04 12:20 20 **A Discussion on Utilization of Heat Pipes and Vapor Chambers for Photon Absorbers in Particle Accelerators**

***K.J. Suthar**, P.K. Den Hartog, B.K. Stillwell (ANL)*

The basic problem for photon absorbers in a particle accelerator is to remove a large quantity of heat from a small space. Heat pipes and vapor chambers excel at precisely this so it is natural to consider them for the application. However, even though this technology has been proven to be an excellent thermal management solution for cooling everything from laptops to satellite shields in space, they have yet to be adopted for use in particle accelerators. The use of heat pipes and vapor chambers are thermal transport devices which work on the principle of capillary-force-driven two-phase flow. These devices are highly customizable and offer very high effective thermal conductivities (5,000-200,000 W/m/K) depending on many factors including size, shape, and orientation. This paper discusses feasibility of the use of heat pipes and vapor chambers as the primary heat transport devices in particle accelerator photon absorbers. We discuss their limitations and advantages via careful consideration of analysis and simulation results assuming properties described in the literature and manufacturer specifications.

WECA01 14:00 20 **Low-Cost, High-Performance Non-Evaporable Getter (NEG) Pumps Using NEG Pills**

***K. Mase**, T. Kikuchi (KEK) H. Kodama, S. Ohno, M. Tanaka (Yokohama National University) K.K. Okudaira, M. Tanaka (Chiba University)*

Non-evaporable getter (NEG) pumps are widely used for maintaining a clean ultra-high vacuum (UHV) of ≤10^{-8} Pa because of their high pumping speeds for hydrogen and active gases in the UHV region. In addition, they are oil free, evaporation free, sputtering free, sublimation free, magnetic field free, vibration free, economical, compact, lightweight, and energy saving. In the present paper, we report a new NEG pump which is composed of commercial 60 NEG pills (Dia.10 mm × t3 mm; 70 wt% Zr, 24.6 wt% V, and 5.4 wt% Fe), titanium parts, a DN 40 conflat flange, and a tantalum heater. The NEG pills are vertically and radially aligned around the heater to maximize the effective area for pumping. After activation at 400 ^{o}C for 30 min, the pumping speeds of the NEG pump were measured with the orifice method. Pumping speeds of 140-130, 200-140, 190-130, and 35-17 L/s were estimated for H2, CO, CO2, and N2 gasses, respectively, in a pumped-quantity range of 0.01-0.1 Pa·L. Since the NEG pump is composed of a heating unit and a NEG module, the pumping speeds can be improved by increasing the number of NEG modules. These NEG pumps are favourable alternatives to sputtering ion pumps.

WECA02 14:20 20 **ESRF EBS Project: Vacuum Chambers and RF Fingers**

***L. Goirand**, J.C. Biasci, T. Brochard, P.M. Brumund, F. Cianciosi, J. Pasquaud, P. Van Vaerenbergh (ESRF)*

The ESRF - EBS new lattice implies a high level of requirement for all components. This talk will focus on the mechanical design solutions adopted for the chambers to fulfil the geometrical, thermal, vacuum and RF requirements. The main challenges are the small distance between the poles of the magnets, the small distance between the magnets and the impedance budget. In that respect the novel design of the vacuum chambers and the RF fingers will be presented.

WECA03 14:40 20 **Commissioning of the U15-Undulator for SwissFEL and New Developments for the Athos Beamline**

***P. Boehler**, H. Jöhri (PSI)*

The development of the U15 undulator was presented at the MEDSI Conference 2012 in Shanghai. Meanwhile the undulator line is finished. The presentation will explain the experience with the production, the assembling and the commissioning of the undulators. We succeeded to implement a robotic system, that did the final adjustment of all the magnets automatically. Therefore, we were able to reduce the time for the adjustment of the magnets dramatically. A whole loop with measuring, adjustment of the columns and final adjustment with the robotic system for the magnets takes 3 days. The presentation will explain these steps. For the next beam-line, we will profit from the experience of the U15 undulator development, but there are new requirements, because it will be a polarized undulator with a period of 38mm. We are developing a new arrangement of the drives, a further development of the magnet keepers and a vacuum-pipe with only 0.2mm of wall thickness.

WECA04 15:00 20 **Compact Horizontal-Gap Vertically-Polarizing Undulator (HGVPU) with Dynamic Spring Compensation**

***O.A. Schmidt**, E. Trakhtenberg, J.Z. Xu (ANL)*

The Horizontal-Gap Vertically-Polarizing Undulator (HGVPU) is a compact, innovative insertion device design developed by Argonne National Laboratory for the LCLS-II HXR beam-line at SLAC. A full sized 3.4 meter long prototype has been built and

fully tested meeting all LCLS-II undulator specifications. This compact, innovative insertion device will produce vertically polarized x-rays. Attractive magnetic forces of the undulator jaws are compensated by an array of conical springs. These springs are designed to exhibit non-linear spring characteristics that can be closely tuned to match the force curve exerted by the magnetic field, thereby minimizing the overall deflection of the strongbacks. The HGVPU also utilizes the existing LCLS-I support and motion system along with other existing equipment and infrastructure, thus lowering overall cost and installation downtime.

WECA05 **Superconducting RF System Plans at CLS**
15:50 20
C.N. Regier *(CLS)*

Canadian Light Source (CLS) in Saskatoon, Canada has several cryogenic systems. One of the most critical is a 4.4 K liquid helium system for a superconducting RF cavity. This system consists of a Linde TCF-50 liquid helium plant coupled to a Cornell-designed CESR-B 500 MHz cavity and cryomodule via a 52 metre multi-channel transfer line. Over the years CLS has evaluated failures on the system as well as risks for downtime, and has come up with plans for a major upgrade to the superconducting RF system to improve reliability. An overview of performance and issues to date is presented. Some of the specifics of the risk analysis and upgrade plan will be examined, and details of the process flow discussed.

WECA06 **Mechanical Engineering Solutions for COXINEL Project**
16:10 20
K.T. Tavakoli*, T. André, I.A. Andriyash, C. Basset, C. Benabderrahmane, P. Berteaud, S. Bobault, S. Bonnin, F. Bouvet, F. Briquez, L. Chapuis, M.-E. Couprie, D. Dennetière, Y. Dietrich, J.P. Duval, M. El Ajjouri, T.K. El Ajjouri, C. Herbeaux, N. Hubert, M. Khojoyan, M. Labat, N. Leclercq, A. Lestrade, A. Loulergue, O. Marcouillé, F. Marteau, A. Mary, P. N'gotta, F. Polack, P. Rommeluère, M. Sebdaoui, F. Thiam, M. Valléau, J. Vétéran, D. Zerbib, C. de Olivera (SOLEIL) G. Lambert, V. Malka, A. Rousse, K. Ta Phuoc, C. Thaury (LOA) E. Roussel (Elettra-Sincrotrone Trieste S.C.p.A.)*

COXINEL (COherent Xray source INferred from Electrons accelerated by Laser) is a European Research Council (ERC) advance grant aims at demonstrating Free Electron Laser amplification at 200 nm with 180 MeV electrons generated by laser plasma acceleration. A special electron beam transfer line with adequate diagnostics has been designed for this project. Strong-focusing variable-field permanent magnet quadrupoles, energy de-mixing chicane and a set of conventional quadrupoles condition the electron beam before its entrance to an In-Vacuum U20 undulator. This presentation describes some of the features incorporated into the design of the magnets, girders, vacuum vessels and diagnostic equipment for this experimental machine. Progress on the equipment preparation and installation is presented as well.

WECA07 **Engineering Challenges of the VMXi Beamline**
16:30 20
J.H. Kelly *(DLS)*

The in-situ versatile macromolecular X-tallography (VMXi) beamline delivers a high flux density, taking data directly from crystallisation experiments within the plate, using a fully automated endstation. A double multilayer monochromator (DMM) was designed in-house to deliver a 60 fold increase in flux. Two robots and an automated load-lock pass the plates from the crystallisation storage units to the goniometer. A compact endstation was designed to accept the high flux and take data with acquisition times down to a millisecond. This paper gives an overview of the beamline layout and the interesting pieces of engineering design. The beamline is planned to take first user at the end of 2016.

WEPE01 **Combined Fixed Mask, Photo Shutter, Safety Shutter, and Collimator Design for BXDS IVU at the CLS**

***M.J.P. Adam**, C. Bodnarchuk (CLS)*

The first shutter assembly outside of the Front End (FE) for Brockhouse X-Ray Diffraction and Scattering Sector (BXDS) beamline required a unique design solution to accommodate all components into required safety shutter position. Located between the IVW high energy wiggler monochromator and POE1 wall, the total envelope size approximated 1m x 0.660m (LxW). Accommodating a smaller space required an alternative shutter design than traditionally used implemented at the CLS. The alternative proposed design combined the collimator (CLM), safety shutter (SSH), photon shutter (PSH) and Fixed Mask (FM) into one chamber. Finite Element Analysis (FEA) was conducted on the FM and PSH assembly to verify that geometric designs were adequate for reasonable operation in the beamline. FEA was used to determine the steady-state thermal and static-structural response in both operating positions. Missteer was analyzed for both operating positions to a maximum of 2.5mm (commonly accepted missteer used at the CLS) from center. Finally, two extreme position (5mm) analyses were completed for determination of potential, but unlikely operating conditions.

WEPE02 **Performance Evaluation of Fast Closing Shutter System at the SPring-8 Front-end**

***S. Takahashi** (JASRI/SPring-8) M. Sano, A. Watanabe (Japan Synchrotron Radiation Research Institute (JASRI/SPring-8))*

The fast closing shutter (FCS) system plays an important role in protecting the ultra-high vacuum in the SPring-8 storage ring from a sudden vacuum accident in the beam-lines. In order to predict the transit time of the shock wave and the following pressure increase, a shock tube system with an inner diameter of 35 mm and a total length of 10 m was prepared to measure the shock Mach number. Experiments have been conducted that simulated an inrush of the atmosphere into the high-vacuum ($\sim 10^{-3}$ Pa) pipe by using a trigger system that combines of a thin cellophane diaphragm with a plunger. Special ionization gauges with a high-speed amplifier are distributed about every 1 m to detect the transit time of the shock wave and to measure the pressure in a low-pressure chamber after the actuation of the FCS system. By inserting vacuum components with various cross-sectional shapes including actual front-end components into the shock tube, the attenuation in the shock wave was systematically investigated.

WEPE03 **Beamline Front Ends at the 2.5-GeV Photon Factory Storage Ring**

***H. Miyauchi**, S. Asaoka, T. Tahara (KEK)*

Since the first commissioning in 1982, the 2.5-GeV Photon Factory storage ring has been upgraded three times in 1986, 1997 and 2005, in order to reduce the beam emittance and to create new four short straight sections for in-vacuum short period undulators. To satisfy the new boundary conditions of the upgrades, the beamline front ends were re-designed. We look back on the history of the beamline front-end components at the Photon Factory.

WEPE04 **Design of X-Ray Beam Position Monitor for High Heat Load Front Ends of the Advacned Photon Source Upgrade**

***S.H. Lee**, J. Mulvey, M. Ramanathan, B.X. Yang (ANL)*

Accurate and stable x-ray beam position monitors (XBPMs) are key elements in obtaining the desired user beam stability in the Advanced Photon Source (APS). Currently, the APS is upgrading its facility to increase productivity and to provide far more highly coherent and brilliant hard x-rays to beamline experiments with a new storage ring

magnet lattice based on a multi-bend achromat (MBA) lattice. To improve the beam stability, one of the proposed beam diagnostics is the grazing-incidence insertion device x-ray beam position monitor (GRID-XBPM) for high heat load (HHL) front ends (FEs) at the APS. In this paper, final design of the GRID-XBPM and the high-power beam test results at beamline 27-ID-FE will be addressed.

WEPE05 **Innovative Design of Radiation Shielding for Synchrotron Light Sources**
M.G. Breitfeller *(BNL)*
Over the course of decades, the shape of the bulk shielding walls for synchrotron light sources has developed into a standard configuration, including a ratchet shape of the outer storage ring wall, to accommodate the clearance needs for front end and first optical enclosure assemblies. New state of the art light sources will have low emittance, high energy beams, which will give potential for higher energy losses. These losses will yield higher radiation dose rates at the downstream wall and stricter safety requirements in the first optical enclosure. Throughout the installation of local shields at NSLS-II, verification dose rate studies of various shielding configurations were performed. Analysis of these studies revealed that circular bulk shield walls will greatly reduce the dose rate to the users who work near the front end optical components. This presentation discusses the benefits of round bulk shield walls verses the challenges of component installation near the wall and ways to mitigate them.

WEPE06 **High Heat Load Front End for Sirius**
L.M. Volpe*, P.T. Fonseca, A. Gilmour, H.G.P. Oliveira, G.L.M.P. Rodrigues, L. Sanfelici, M. Saveri Silva (LNLS)*
Currently under construction, the Sirius is a 3GeV, fourth generation synchrotron light source. Its 5BA cell structure achieves a bare lattice emittance of 0.25nm.rad in a 518m circumference composed of 20 straight sections. A Front end is a group of components connecting the storage ring to the beamline, they are responsible for defining the final aperture, absorbing exceeding beam power, radiation protection, storage ring vacuum protection and photon-beam diagnostics. The first 5 Sirius beamlines are planned to use in-vacuum and elliptically polarized undulators. An IVU19 front-end was first designed since it is the ID that will generate the most critical thermal stress, with a peak power density of 55.7 kW/mrad2 and a total power of 9.3kW at 500mA. This paper will present the requirements, design and prototyping details.

WEPE07 **A High Heat Load Front-End for the Superconducting Wiggler Beamline at SSRF**
Y. Li*, D. Jia, S. Xue, M. Zhang, W. Zhu (SINAP)*
A superconducting wiggler (SCW) will be first employed to generate high energy X-rays for ultra-hard X-ray applications beamline at Shanghai synchrotron radiation facility (SSRF). The front-end will handle a peak power density of 45kW/mrad^2, and a heat load of 44.7kW, which is much higher than the commissioned ones at SSRF. Overall design of the high heat load front-end has been completed, including one short absorber with a length of 300mm and three long absorbers longer than 500mm. Long absorbers have been designed to be made by medium speed wire-cut electrical discharge machining (WEDM-MS) or electron beam welding (EBW). Thermal analyses of all absorbers have also been done to comply with the failure criteria of SSRF.

WEPE08 **Blade XBPMs Optimizations for Sirius**
L.M. Volpe*, P.T. Fonseca, A. Gilmour, S.R. Marques, L. Sanfelici (LNLS)*
Blade XBPMs are used to acquire the photon beam position without invade the central cone of the beam. The fourth generation light source Sirius will be equipped with two blade XBPMs in all its front ends to provide position and angular information of the beam for beamline users and possibly to the Orbit Feedback System. Optimizations

was made to define the best blades position for IVU19 beamlines and to minimize thermal deformations of its support. This poster will demonstrate the concepts and developments adopted.

WEPE09 **Designing the Photon Beamline Frontends in the PETRAIII Extension Project**

***H. Krueger**, M. Hesse, F. Marutzky, H.-B. Peters, M. Roehling, H. Schulte-Schrepping (DESY)*

The new insertion device beamlines in the PETRAIII extension project are arranged in three new sector types. Following will present the designs of the photon beamlines frontends for these sectors. The designs are based on the original design concept developed for the photon beamline frontends at PETRAIII. The aim of this generic approach was to minimize the number of specialized components for all beamlines. The existing girder concept allows a fast and reliable installation phase. The newly designed frontends aimed at using the same proven components and minimizing of the number of girder variations. There will be 4 new sectors with two undulator IDs in each sector. The canting angle between the undulators has been increased from 5mrad to 20mrad in difference to the generic beamlines. Additionally, two of the straight sections are modified. One straight section will be transformed in a side station sector with a 1mrad canting angle. The other straight section with the 40m long damping wiggler will be used as a single beamline with a hard X-ray source. The modifications of the original frontend design, the components and the deviations between the sector types are being presented.

WEPE10 **Mechanical Design of Pulse-by-Pulse X-Ray Beam Position Monitor Using Diamond Heat Sink**

***H. Aoyagi**, S. Takahashi (JASRI/SPring-8)*

The pulse-by-pulse X-ray beam monitor equipped with microstripline structure had been developed at SPring-8. This monitor has a potential to function as (1) a pulse intensity monitor, (2) a pulse-by-pulse X-ray beam position monitor (XBPM), and (3) a pulse timing monitor. In insertion device beamlines, however, it cannot be used without further improvement because of heat-resistance problem. Therefore, we examined a pulse-by-pulse XBPM for insertion device beamlines by introducing heat resistance structure, which employed a diamond heat sink. Thermal finite element analysis was carried out to design an effective structure of a detector head and the holder. Evaluation tests of the prototype will be also presented in this contribution.

WEPE11 **Update on the Front Ends Project Status at MAX IV**

***A. Bartalesi** (MAX IV Laboratory, Lund University)*

The MAX IV laboratory is a Swedish national laboratory for synchrotron radiation hosted by the Lund University. It will operate two storage rings to produce synchrotron light of very high intensity and quality over a broad wavelength range. A linear accelerator will feed these storage rings in topping up mode as well as serve as an electron source for a short pulse facility built on its extension. The storage rings have different sizes and operate at different energies: the MAX IV 1.5 GeV ring has 12 straight sections optimized for soft x-rays; while the MAX IV 3.0 GeV ring, has 20 straight sections, optimized for harder x-rays. In the initial stage of the project, five beamlines are foreseen to operate on the 3.0 GeV storage ring and an additional five on the 1.5 GeV ring. Each beamline requires a front end to interface the different characteristics in terms of vacuum level, heat loads, radiation safety, beam size and position, with respect to the storage ring. This document describes the most recent developments of the different Front Ends project at MAXIV.

WEPE12 **From CAD Beamline Design to Tunnel Installation at XFEL**

***N. Kohlstrunk**, H. Sinn (XFEL. EU)*

The European XFEL will generate up to 27000 ultra short X-ray pulses per second with a brilliance that is a billion times higher than that of the best conventional X-ray radiation sources. The outstanding characteristics of the facility are unique worldwide. Starting 2017, it will open up completely new research opportunities for scientists and industrial users *. To built up the more than 3km long Photon beam transport system it was necessary to create a complete CAD integration model with placeholders of optical and diagnostic elements and beam-line sections. The detailed 3D model has to be placed into this so called "overview assemblies". Later workshop and installation drawings were created from this overview assembly. This drawings helped the technicians/engineers to built up the whole system in the underground tunnel.

WEPE13 **Design and Performance Evaluation of the Next Generation Beamlines at New KEK Light Source (KEK-LS)**

N. Igarashi, *K. Amemiya, T. Kikuchi, T. Mori, Y. Takeichi, H. Tanaka, Y. Uchida (KEK)*

KEK has been operating two SR sources, the PF-ring and the PF-AR, for about thirty years. We have made a proposal of constructing a new SR facility, tentatively called KEK light source (KEK-LS). An extremely low-emittance storage ring based on the hybrid multi-bend achromatic (HMBA) lattice has been designed as a successor of the aged two rings. The undulator brightness almost approaches 10^{22} or exceeds 10^{22} in the soft X-ray to hard X-ray region. It is higher by two orders of magnitude than those of present 3rd generation light sources and by four orders from the PF-ring. The coherent fractions reach 10 % and 1 % at 1 keV and 10 keV, respectively. The KEK-LS will serve as the platform to advance the frontier of science using nanobeam, high-energy resolution beam and high coherent beam. We are conducting necessary studies to fully utilize the high brilliance beams emitted from KEK-LS. We designed beamline optics systems at 1 keV and 10 keV, respectively, and evaluated the beam performance. Also, we are making careful considerations as for the state-of-the-art technology of optics elements. Here, we present the typical beamline designs and the performance by lay-tracing simulations.

WEPE14 **Minimizing Grating Slope Errors in the IEX Monochromator at the Advanced Photon Source**

M.V. Fisher, *J.L. McChesney, J.Q. Qian, R. Reininger, F. M. Rodolakis (ANL)*

The IEX Beam-line at the APS is currently in the commissioning phase. The energy resolution of the beam-line was not meeting original specifications. The monochromator can house four gratings and is currently configured with a medium and a high resolution grating. Experimental results indicated that both gratings were contributing to the energy resolution problem and this led to venting the monochromator to investigate. The initial suspicion was that a systematic error in the ruling process had occurred on the two variable line spaced gratings, but that proved to not be the case. Eventually the problem was isolated to mechanical constraints used to mount the gratings into their respective side-cooled holders. Modifications were made to the original holders that maintained required features while eliminating problematic constraints. Metrology performed on the gratings in the original and modified holders demonstrated a 50-fold improvement in the surface profile error and this was consistent with FEA performed in support of the modifications. Two gratings were successfully reinstalled and subsequent measurements with beam show a dramatic improvement in energy resolution.

WEPE15 **High Frequency UHV Mechanical X-Ray Beam Chopper**

N. Gonzalez, *C. Colldelram, C.E. Escudero, S. Ferrer (ALBA-CELLS Synchrotron)*

A mechanical chopper* has been designed and built to perform X-ray Absorption Spectroscopy (XAS) experiments with operating liquid electrochemical cells at NAPP end station of ALBA Synchrotron (BL24, CIRCE). When operating the cell, to separate the weak currents induced by the X-ray absorption process at the electrode in contact with the electrolyte (TEY signal) from the faradaic current set between the electrodes, the incoming beam must be chopped at a certain frequency (w). Then, using a lock in amplifier, the signal at this frequency w can be extracted and measured. When the chopper is located in the beam path, it produces pulses with a frequency w, modulating the TEY signal. The chopper developed at ALBA, with variable frequency, improves previous designs which used piezo-actuated choppers constrained to work at fixed oscillating frequencies**. The design consists of a slotted disk that spins around an axis by means of an UHV stepper motor. A LED and photodiode based UHV sensor ensures that frequency drifts do not affect the measurements. The motor is hold by an internally water cooled OFHC support, which allows long duration experiments at high speeds without stopping.

WEPE16 **High Power Load Monochromator for Computed Tomography Program at BMIT at Energies 25-150 keV**

T.W. Wysokinski*, G. Belev, L.D. Chapman, C.D. Miller (CLS) N. Huber (HUBER Diffraktiontechnik GmbH&Co.KG) M. Renier (ESRF) P. Suortti (Helsinki University, Department of Physics)*

A high power load monochromator has been constructed for computed tomography (CT) studies at the BioMedical Imaging and Therapy (BMIT) facility located at the Canadian Light Source. A non-dispersive pair of bent Laue-type crystals is used, with the first crystal water-cooled. The monochromator operates at energies from 25 to 150 keV, and the maximum width of the beam is 190 mm at crystal location. The beam intensity is between 10^{13} and 10^{14} photons/s/mm^2 under typical operating conditions. In normal mode of operation, if the first crystal is bend with 3 N*m and the second crystal with 2 N*m torque, the measured FWHM of the spectral bandwidth at 50 keV is 1%. With the improved design of the holding springs, the monochromator is quite insensitive to vibrations, it can operate with small turbo pump attached for medium resolution imaging at 20-50 keV. Due to high power loads, the system experiences high out-gassing and a proper filter set to protect the crystal and to reduce the thermal drift is required. High level of radiation inside the monochromator vessel is the reason the operation of the system must be based only on mechanical end-switch calibration.

WEPE17 **Rotary Slit to Define a Secondary Horizontal Source at the ANATOMIX Beam-Line of Synchrotron SOLEIL**

J.L. Giorgetta*, M. Scheel, T. Weitkamp (SOLEIL)*

ANATOMIX is a new long beam-line (200 m) devoted to full-field tomography at the SOLEIL synchrotron facility. It will operate in the energy range from 5 to 30 KeV, and feature 4 operation modes via versatile optics configurations, including direct white beam propagation. Aimed for tomography in the 17-25 KeV range, one of the operating modes implies the use of a wide beam achieved by a pair of mirrors focusing in the horizontal direction at a distance of 160 m from the experimental station. To define a secondary source, a specially-designed slit is located in the focal plane. The aperture is adjustable from 0 to 500 μm and a transverse movement allows scan of the whole slit at constant gap. A pair of tungsten cylinders act as slit blades, they are mounted on a support rotating around a vertical axis. The distance between the cylinders is fixed (500 μm), the actual beam aperture is the projection of the gap between the cylinders, defined by the rotation angle. The rotating block is mounted on a translation stage used both for slit scan and to remove the slit from the beam for direct beam operation. The cylinders are cooled through copper braids linked to water-cooled heat sinks.

WEPE18 **APS 2-ID Beamline, Upgrade to Canted Configuration**
***D. Capatina**, M.A. Beno, B. Lai, E.R. Moog, C. Roehrig, S. Vogt (ANL)*
To provide independent operation of the two 2-ID beamline experimental stations, a new canted beamline design is being developed. The constrain of keeping the existing front end limits the canting angle. The optimal canting angle was determined to be 400 urad and is achieved by using a permanent magnet. A coil is added to the canting magnet to provide a steering adjustment of maxi-mum 40 to 50 urad. In order to increase the beam separation as well as to provide power filtering and higher harmonics rejection for the downstream optics, a dual mirror system with focusing capability is used as the first optic at approximately 28 m from the center of the straight section. The inboard mirror (2.6 mrad) reflects the inboard beam outboard while the outboard mirror (4.1 mrad) reflects the outboard beam inboard. The beam presented to the dual mirror system is defined by two 1 mm x 1 mm apertures. The maximum power absorbed by each mirror is 200 W. Two vertically deflecting monochromators with minimum offset of 17 mm are located in the First Optical Enclosure on the outboard branch. The monochromator for the inboard branch is located in the corresponding experimental station.

WEPE19 **Present Status of PF BL-13A/B, Vacuum Ultraviolet and Soft X-Ray Undulator Beamlines for Surface Chemistry and STXM**
***K. Mase**, K. Amemiya, T. Kikuchi, Y. Takeichi, H. Tanaka, A. Toyoshima (KEK) T. Miyazawa (Sokendai, The Graduate University for Advanced Studies)*
An APPLE-II-type variable polarization undulator was installed at BL-13A/B in Photon Factory (PF) in the end of FY2014, and the user experiments were started in FY2015. Photon flux at BL-13 increased by nearly one order of magnitude compared to the previous one. BL-13A is mainly used for scanning transmission X-ray microscopy (STXM) measurements, while BL-13B is mainly dedicated to surface science using angle-resolved photoelectron spectroscopy (ARPES), high resolution X-ray photoelectron spectroscopy (HR-XPS), and X-ray absorption spectroscopy (XAS) [*]. Present status of PF BL-13A/B will be presented in the poster.

WEPE20 **KB Mirror Design for the LCLS-II SXR Beam Line**
***D.S. Morton**, D. Cocco, N.M. Kelez, L. Zhang (SLAC)*
One of the key components of the beam transport, in the SXR beam-line is the bendable focusing mirror system, operated in a Kirkpatrick-Baez Configuration. For the first time in the Synchrotron or FEL world, the large bending needed to focus the beam will be coupled with a cooling system, since the full FEL power is delivered through all of the optics to the sample. In this paper we will discuss the key design elements of the KB mirror system. We will cover the flexure hinge based bender mechanism which provides a well-defined axis of rotation. The flexure based twist and height correction mechanisms which allow correction for manufacturing and assembly tolerances. The parallel leaf spring lever arms which allow the use of relatively low bending forces with high resolution and do so while maintaining a constant direction of force application. The epoxy joint which was designed to minimize the tensile loading of the epoxy to increase its performance. We will then go on to discuss the cooling scheme which allows us to mechanically decouple the cooling system from the mirror.

WEPE21 **Optical and Mechanical Design of the EMIL Beamlines at BESSY-II**
***S. Hendel**, G. Reichardt, F. Schäfers (HZB) T. Gießel (Bestec GmbH) M. Hävecker (FHI)*
The Energy Materials In-Situ Laboratory Berlin (EMIL) at BESSY-II is currently under completion *. The setup for EMIL consists of two canted undulators, providing a wide energy spectrum of 70 - 10.000 eV, three monochromators (two plane grating monochromators and one LN2-cooled double crystal monochromator) and ten

mirror chambers for radiation dispersion and focusing into two separate pathways of 65 m length. Split-mirror chambers distribute the desired photon energy to one (or simultaneously to two) of five experimental endstations. The maximum lateral distance between all beamline elements is not more than one meter. This narrow design, selectable monochromators and several beam crossings require advanced modification of all vacuum chambers to enable variable beam routes. Long pathways demand a very high mechanical and thermal stability as well as a reproducible motion of all optical elements. The chosen constant strut-length hexapod design for the mirror chambers provides a wide range of movement in six degrees of freedom. We report on the optics of the beamline, monochromator characteristics and mechanics, proposed timelines and present first commissioning results.

WEPE22 **F-Switch: Novel Random Access Manipulator for Large Numbers of Compound Refractive Lenses**

G.M.A. Duller *(DLS)*

The F-switch is a new concept of device for the manipulation of large arrays of 2D CRLs or similar disc-shaped optical elements (12mm dia, 2mm thick) under high vacuum. Unlike the well-known transfocator devices the optical elements are randomly selectable. This enables a number of potential modes of operation, including the fine adjustment of focal length by adjusting the effective lens centre position when using CRLs or the use of some positions within the array to implement filters or reference foils. Actuation and guidance is achieved within the thickness of the element, so that the overall length of the device is minimised. The device has been in user operation on the I04 MX beamline at Diamond Light Source (DLS) since 2015. Other devices are being assembled for use on the I02 and I11 beamlines at DLS. It is also hoped to install another device on the I03 beamline. We present details of the mechanical design of the device and some examples of its operation

WEPE23 **Automatic Beam Attenuation**

M. Ribbens *(SOLEIL)*

Synchrotron SOLEIL's SixS beam-line is equipped with a 2D hybrid pixel detector coupled with an automatic attenuators system that allows data recording for (strong) intensity variations, preserving the 2D detector in its safe and linear range. The acquisition system is based on a "fly-scan" mode, providing very fast acquisition speeds. The fast automatic attenuators system (<10ms) inserts the attenuators using a binary sequence and the fast data acquisition allows to perform quantitative measurements of systems that can evolve in short time.

WEPE24 **Live Animal Imaging Program at BMIT Facility at the Canadian Light Source**

M.A. Webb*, G. Belev, C.D. Miller, T.W. Wysokinski, N. Zhu (CLS) M. Gibbons (University of Saskatchewan)*

The live animal imaging program at the BMIT facility at the Canadian Light Source has been developing for the last 5 years and continues to grow. It is expected to become a large portion of the user activity as numerous groups work towards the goal of live animal studies. Synchrotron-based imaging of live animals is an opportunity for great science that also brings challenges and specific requirements for the experimental end-station. The beam-line currently provides basic support and has been improving the facilities available. For example, there have been changes to the lab to allow for longer rodent housing and improved housing during measurements. Remote control of heat lamps and of flow rate for gas anaesthesia allow a vet or animal care person to make adjustments without interrupting the imaging. Integration of user equipment such as heart/breathing monitoring and ultrasound equipment with the beam-line systems can be used for gating control of imaging. Future improvements will be done with consultation with university veterinarians and the user groups.

WEPE25 **Large Focal Length on-Axis Optics for X-Ray Scattering Experiments**
J.R. Rubeck *(DESY)*

PETRA III as a third generation synchrotron source allows realizing new experimental methods. The MiNaXS beamline P03 is dedicated to aμand a nanofocus end-station. To the 2 existing CRL,the plan is to install two additional ones. The CRL3-system consists of a vacuum tank, a lens-exchanger with two train units and piezo driven motors and a Hexapod for alignment in the beam. At the train units are stacks of 1D BeCRL (1,2,4,8,16,32) to decouple horizontal and vertical focusing. The control of the piezo motors is done by an SPS and the separately moving train units by a normal stepper motor controller. CRL3 will allow for a focal distance of 600 mm with a small beam size below 3 μm, being especially adapted to complex in-situ setups [*,**,***].The CRL4 system will consist of two SpaceFab vacuum stages where on each one a "step shaped" arrangement of lenses is located, one for horizontal and one for vertical focusing. This is done to parallelize the beam shape and thus obtain a higher flux for the three downstream CRL systems and the nanofocus end station. We will present the technical challenges as well as the current status of both new CRL-station.

WEPE26 **Upgrade the Beamline PF-AR NW14A for the High-Repetition-Rate X-Ray Pump-Probe Experiments**
S. Nozawa *(KEK)*

We report the upgrade of the x-ray pump probe system to high repetition rate at the beamline PF-AR NW14A. A 400 fs high-repetition rate fiber laser system (Amplitude, Tangerine) was newly installed. The fiber laser system, which is operated at 10^{30} nm fundamental wavelength, is capable of reaching up to 0.1 mJ pulse with a repetition rate of 400 kHz. A higher harmonic generation system enlarges the spectral range from UV to mid-infrared. To increase the laser power density at a sample position, the x-ray was additionally focused by a polycapillary lens (Polycapillary Optics, XOS). The synchronization of X-ray and laser pulses is based on the RF master clock of the storage ring. The delay between the laser and the X-ray is controlled by changing the emission timing of the laser with a Trigger & Clock Delay Module (84DgR5CO1, CANDOX). The high repetition rate system increases experimental efficiency 400 times.

WEPE27 **The Sample Environment Group of the European XFEL**
C. Deiter*, R. Graceffa, M. Kitel, K. Lorenzen, L. Moore, J. Schulz, P. Thute (European XFEL)*

The European XFEL will start user operation early 2017. The unique bunch structure of 600μs long bunch trains @ 10Hz delivering up to 2.700 bunches set strong demands on sample delivery. Each bunch will be intense enough to completely disintegrate the sample. Therefore, the Sample Environment group * develops fast replacement techniques of samples to operate experiments at the high rep rate of the Eur. XFEL. Serial femtosecond crystallography and single particle imaging on biological samples will be performed at the SPB/SFX instruments of the Eur. XFEL. The Sample Environment group will organize the biological user support. Main sample delivery methods will be microscopic liquid jets for SFX and aerosol sources for SPI. Some experiments will require quickly changing samples that are delivered on surfaces or on x-ray transparent windows. For this type of samples, the Sample Environment group develops a fast solid sample scanner with load-lock exchange system. For experiments on the reaction of materials to fast changing external fields the Sample environment group develops in collaboration with the ESRF and DESY a compact pulsed magnets in the 30 Tesla range (pulse length ~1ms).

WEPE28 **Minimizing Experimental Setup Time and Effort at Aps Sector 1-Id Through Modular Instrumentation Design**

***E. Benda**, D. Almer, P. Kenesei, A.-. Mashayekhi, J.S. Okasinski, J.S. Park, R. Ranay, S.D. Shastri (ANL)*

Sector 1-ID at the APS accommodates a number of different experimental techniques in the same spatial envelope of the E-hutch end station. These include high energy small and wide angle x-ray scattering (SAXS and WAXS), high energy diffraction microscopy (HEDM, both near and far field modes) and X-ray tomography. These techniques are frequently combined to allow the users to obtain multimodal data with 1 um spatial resolution and 0.05o angular resolution. Furthermore, these techniques are utilized while the sample is thermo-mechanically loaded to mimic real operating conditions. The instrumentation required for each of these techniques has been designed and configured in a modular way with a focus on stability and repeatability between changeovers. This not only allows the end station to be used for a greater number of techniques but it also results in a reduction of time and effort typically required for set up and alignment. Key instrumentation design features and layout of the end station are presented.

WEPE29 **A Novel Filter Auto-Mounter for the BioXAS Beamlines at the CLS**

***S.R. Carriere**, D. Beauregard, B.A. Schneider, G.A. Steel, D.M. Taylor (CLS)*

The BioXAS beam-lines are a recently completed group of beam-lines at the Canadian Light Source (CLS). The BioXAS EXAFS beam-lines host three 32-element germanium detectors. There was a need to introduce an exchangeable filter between the soller slits and the 32-element germanium detectors. It was further required to have an automated filter exchange system so that users could quickly vary filter thicknesses and types to determine the effect on the signal. An auto-mounting filter system was created to meet these requirements and allows users to quickly exchange filters without breaking experimental hutch lockup. The auto-mounter cartridge can hold up to ten slides that measure 100mm X 55mm in cross-section. The device inserts slides in an extremely small envelope between the soller slits and the liquid helium cryostat. The auto-mounter assembly also houses the stages required to actuate the soller slits laterally and vertically. During device commissioning we performed 800 consecutive successful filter exchanges as part of a stress test. The spatial constraints, mechanics, and fabrication of the device will be presented. Software development will also be discussed.

WEPE30 **Introduction to Neutron Scattering Instruments - How are they Different?**

***R.W. Connatser** (CLS)*

This talk provides a brief introduction to neutron scattering, the technical components of neutron scattering instruments, and discussion of the engineering challenges found in the design and construction of these instruments. Neutron scattering is a complementary technique to x-ray scattering scientifically, but while there are similarities, there are some unique challenges in the design, construction, and operation.

WEPE31 **MRT LIFT - a High Accuracy Positioning System for Biomedical Imaging and Therapy Program at BMIT**

***T.W. Wysokinski**, G. Belev, M. Bree, L.D. Chapman, C.D. Miller (CLS) J. Boire (RMD Engineering Inc.) N. Huber (HUBER Diffraktiontechnik GmbH&Co.KG) M. Renier (ESRF)*

The Microbeam Radiation Therapy (MRT) Lift is a large, high precision, eight stage positioning and scanning system installed at BMIT Facility. In order to guarantee a uniform exposure rate of the sample, the vertical speed of the main stage (Zscan) is constant with <1% error over the 700 mm vertical excursion. It may reach 200 mm/s. The main CT stage (PHI1) can rotate 120 kg load with speed up to 30 rpm. The verified accuracy of the motion is less than 5 Um. Other stages include: Ytrans - horizontal positioning of the vertical rotational axis to the beam, PHI2 - kappa axis

used for specimen positioning, PHI3 - rotary axis used for specimen positioning and Xpos, Ypos , Zpos: fine positioning stages. Alignment of the sample using the MRT Lift is a time consuming and challenging task. The BMIT Group has developed a Python-based MRT Lift positioning and control program that uses a combination of computational and iterative methods to independently adjust the sample's X, Y, Z, pitch and roll positions. Integration with the SolidWorks modelling platform allows high quality renderings of the MRT Lift in its current or proposed position to be displayed in real time.

WEPE32 **Floor Reinforcing Works and Evaluation for Improving an X-ray Beam Stability at KEK PF**

***A. Matsuoka**, N. Igarashi, A. Koyama, Y. Yamada (KEK)*

Recent macromolecular crystallography beamlines are targeting smaller crystals. Minimum crystal size is now less than 10 microns. Microfocus beamline is one of essential tools for the structure determination using such smaller crystals. At microfocus beamline, more stable beam operation is required. BL-17A is a macromolecular crystallography beamline at the Photon Factory in Japan and was renewed for structural studies using smaller crystals in summer shutdown of 2014 and 2015. In order to reduce the vibration defect originated from the experimental hall floor, we have reinforced a particular section of the floor, where the main optical components of BL-17A are placed. The thickness of the concrete of the floor was increased from 200 mm to 500 mm with more dense reinforcement grid and the new concrete was tightly connected to the floor frame. To evaluate the effects of the floor improvement, we measured the distortion of the floor by weighting with an autocollimator and observed the fluctuation of the beam position and intensity by dropping a weight around the beamline. The results showed that the beam stabilization was sufficiently improved after the reinforcing works.

WEPE33 **Development of Scanning Transmission X-Ray Microscopy for In-Situ/ Operando Chemical Analysis at UVSOR-III**

***T. Ohigashi**, N.K. Kosugi, Y.I. Yuichi (UVSOR)*

A scanning transmission X-ray microscopy (STXM) is a powerful tool to analyze 2-dimensional chemical states with high spatial resolution. In UVSOR Synchrotron (Okazaki, Japan), the STXM beam-line has been opened for general users since 2013 and has been improved for two significant features; in-situ/operando measurement and use of low energy photons. We have been developing in-situ/operando measurements, such as humidity control, electrochemistry and polarization dependence of oriented molecules*. Furthermore, feasibility of quantitative 3-dimensional (3D) morphological analysis by computed tomography has been tested to perform 3D chemical state analysis. UVSOR Synchrotron has an advantage of photon fluxes in the low energy region from VUV to soft X-rays. In this region, not only the K-edges of light elements but also a lot of L-edges and M-edges of metals can be targets of the chemical analysis. Therefore, we have been exploring for the lower energy analysis; that is, one of our targets is the Li K-edge. Currently, the energy from 100 to 770 eV is available. In this presentation, recent progress of BL4U and development of in-situ/operando measurement methods will be reported.

WEPE34 **Economy Endstation for Small/Wide Angle X-Ray Scattering Beamline at Synchrotron Light Research Institute**

***S. Pongampai**, S. Srichan (SLRI)*

An endstation for the beamline BL1.3W: small/wide angle X-ray scattering experiments at Synchrotron Light Research Institute (SLRI) was designed and fabricated by in-house engineering team. Reducing cost and improving efficiency of experimental station will be presented.

WEPE35 **Design of Double-Walled Bellow Cooling Pipes for Silicone Oil used for the DSSC Detector Project @ European XFEL**

F.O. Okrent *(F.O.) M. Bayer, M.L. Lemke (DESY)*

DSSC (DEPMOS Sensor with Signal Compression) is a non-linear gain DEPFET sensor for the energy range 0.5-6 keV. This is a development project for Eu-XFEL led by the MPG's Semiconductor Laboratory. This is a silicon detector with ~40000 um^2 hexagonal pixels. The Photon Science Detector Group at DESY has the responsibility for the Mechanics/Thermal Workpackage of DSSC. This presents a challenge particularly because ~400 W are put out by the electronics in the in-vacuum detector head (by sensors and electronics boards). The heat load distributes in four cooling blocks (which are movable) where the cooling-tubes welded in. The aim is to achieve -20^{o}C sensor temperature on each Sensor (four per block). The detector components (very sensitive and expensive electronics) will be operated in vacuum. Therefore it is important that coolant-liquid is safe enclosed. From that idea starts the design of double-walled bellow cooling pipes, this has few benefits. More reliability with the silicone fluid inside the pipes to prevent the inner detector parts from condensation or leakage inside the vessel, Insulating vacuum between the coolant bellows for more performance.

WEPE36 **Large (Metre) Scale Positioning Systems for Imaging Program at BMIT**

T.W. Wysokinski*, G. Belev, L.D. Chapman, C.D. Miller (CLS) J. Boire (RMD Engineering Inc.) M. Renier (ESRF)*

The BioMedical Imaging and Therapy (BMIT) facility provides synchrotron-specific imaging and radiation therapy capabilities. We describe here the main mechanical stages on the insertion device (ID) beam-line 05ID-2, with the beam terminated in SOE-1 experimental hutch. The main mechanical components within the second optics hutch (POE-3) are: tiltable optics table that provides support for a set of filters, shutters and ion chambers and a moveable shielding assembly. The table provides 0.24 m vertical travel range and tilt capability of -8^{o} to +13^{o} (with respect to the horizontal) and 200 kg load capacity. Moveable shielding provides 2030 kg load capacity, with vertical travel range of 0.7 m and has two sets of photon/safety shutters, which are required for the KES imaging angle range of +12.3^{o} to -7.3^{o}. SOE-1 hutch is 6 m wide, 5 m tall and 10 m long and accommodates the large animal positioning system (LAPS) capable of positioning and manipulating samples up to 907 kg, over 2.7 m vertical travel range. This end-station also includes a unique camera positioner with a 320 kg load capacity, vertical travel range of 4.9 meters and ability to tilt the stage for KES and DEI modes.

WEPE37 **Upgrade of the Super Advanced X-Ray Spectrometer (SAXES) of the RIXS Endstation for Better Resolution and Larger Detector Size**

St. Maag*, P. Hirschi, L. Nue, T. Schmitt, X. Wang (PSI)*

The RIXS endstation of ADRESS beamline at Swiss Light Source (SLS) is equipped with an ultrahigh resolution X-ray spectrometer. The spectrometer with a length of 5 m is installed on a rotating girder platform and allows varying scattering angles from 30^{o} to 130^{o}. The position of the CCD detector is longitudinally adjustable on the girder and vertically adjustable on a moving frame to allow an angle between 2^{o} to 15^{o} in the vertical plane. In the scope of a CCD camera upgrade, the modification of the vertical alignment of the guiding structure and ultra-high vacuum tanks became necessary. The new camera with a higher resolution and larger detector size weights around 25 kg. It is required to have a vibration amplitude well below 2 micrometer. We will present the critical design parameters of the upgrade, and the effort to increase bending stiffness of vacuum guide structure while keeping major geometry parameters. In addition, kinematic overdeterminacy was removed. After the upgrade we performed vibration measurements verifying that dynamic stability of the camera is improved,

and design goal is reached. The site acceptance test confirmed the proper operation of the new mechanism.

WEPE38 **The Mechanics of the Vekmag Experiment**

T. Noll *(MBI) F. Radu (HZB)*

For the experiments at synchrotron radiation source BESSY II synchrotron of the Helmholtz-Zentrum Berlin a new end station and a new beam-line were developed and are now in user operation. The end station contains a 9-2-1 Tesla vectorial magnet and a cryostat with manipulator for the sample cooling and positioning, an UHV deposition chamber, and an UHV detector chamber. We report here on the technical design of the detector chamber which is placed below the magnet chamber and is also connected to the deposition chamber. Because of various constrains a sophisticated mechanics had to be developed to provide integrated functionality for both the detector holder and the sample transfer units. The detector unit consists of a tubular holder of 5 cm diameter which travels more than 60 cm vertically and exhibits an unlimited rotation degree of freedom of 360 degrees within the magnet bore. The sample transfer unit consists of a telescopic movement mechanism allowing for the sample holder vertical travel within the detector tubular holder. The functionality challenges and their resolve were addressed in an innovative mechanical design.

WEPE39 **Fabrication, Assembly, and Metrology Methods to Optimize an Adjustable Exit Slit for a Soft X-ray Beamline**

J.H. Takakuwa*, C.D. Hernikl, T.M. Lipton, T.A. Stevens, T. Warwick (LBNL)*

Exit slit edge geometry and paired edge parallelism can directly impact performance of a synchrotron beamline. At the same time, maximizing the performance of an existing design is often a financial and logistical necessity. The construction project for beamline 7.0.1 (BL7.0.1, COherent Scattering and MICroscopy (COSMIC)) at the Advanced Light Source (ALS) facility located at Lawrence Berkeley National Laboratory (LBNL) consists of two branch lines, each of which has vertical and horizontal slit assemblies. These assemblies were fabricated from a preexisting design, positively impacting project schedule and budget. Apart from orientation, the slit assemblies are identical. The goal for parallelism is ± 2 microns over the full 25 mm length. The each slit blade edge can travel ± 5 mm about the beam center with the resolution of a micron; slits can scan over that range with a nominal size of about 10 microns. A variety of fabrication and metrology techniques were implemented to maximize the performance of the current design and future areas of improvement in fabrication, metrology, and design were identified.

WEPE40 **Two-rotation Mechanism for an in Vacuum Beamstop**

J.B. Gonzalez Fernandez*, C. Colldelram, A. Fontsere Recuenco, G. Jover-Mañas, J. Ladrera Fernández, M. Malfois, J.C. Martinez Guil (ALBA-CELLS Synchrotron)*

At Small-angle X-ray Scattering beamlines (SAXS), beamstops are needed to block the intense primary beam that has not been scattered by the sample in order to protect the detector from any damage. Beamstops are usually confined inside a vacuum tube minimizing air space between the sample and the detector. For certain experiments, a motorized beamstop is required to achieve a precise positioning in different regions of the detector active area. ALBA has developed a new motorized beamstop* consisting of a two-rotation mechanism inside vacuum that composes a movement able to cover all range of the active area of the detector. The presented solutions involves a main rotation reached by a gear and a worm drive actuated by a stepper motor and a second rotation relative to the main one produced by a piezo rotation stage. For each position appear two different solutions. This characteristic permits take two equivalent images in the detector with the same beamstop position but different orientation in

the beamstop support; thus permitting the compensation of the support shadow on the active area of the detector.

WEPE41 **IMBL Patient Position System**

L.W.S. Adamson *(ASCo)*

A patient positioning system (PPS) is required to position human patients for high sensitivity, high resolution imaging in IMBL radiation enclosure 3B. The core requirement is the access of any section of a human body for imaging within a large range of orientations (rotation and tilt) using X-ray beams between 1.4 and 2.1m from the enclosure floor whilst allowing a direct path for the X-rays to pass through the area to be imaged and onto the detector. The system will normally use the horizontal monochromatic X-ray beam at 1420mm from the floor but will have a working envelope allowing the use of a beam inclined at 7^{o} from the horizontal and produced several meters upstream from enclosure. The area of interest is from the top of the shoulders to the ankles. A collaboration with BEC Engineering has lead to the robotic solution. A Kuka robot will be suspended from 8m linear rail suspended from a gantry mounted to the hutch wall. A custom modular chair has been designed for the robot knuckle, it will accommodate the range of positions required for imaging and with adjustable and removable sections to allow a clear path for the beam.

THAA01 09:30 20 **Design, Construction and Commissioning of Two Highly Integrated Experimental Stations for Micro-Focusing Macromolecular Crystallography (Mx) Beamlines at Nsls-Ii**

D.K. Bhogadi, *B.A. Andi, L. Berman, M.R. Fuchs, J. Jakoncic, B.S. Martins, S. McSweeney, S.F. Myers, D.K. Schneider (BNL)*

We present the final engineering design and first commissioning results of two highly integrated experimental stations for the micro-focusing (FMX) and the highly automated (AMX) MX beamlines at the NSLS-II. These beamlines will support a broad range of biomedical structure determination methods. The experimental stations are designed and fabricated in-house to meet the challenging requirements resulting from the small beam size of 1 µm and the extremely short working distance of only 190 mm from the beam exit window to the FMX focal spot. The compact beam conditioning unit contains, within 140 mm, a beam position monitor, an attenuator, primary slits, an intensity monitor, a sub-millisecond shutter, and secondary slits. The diffractometers consist of an interchangeable dual axis air bearing-based goniometers with a target sphere of confusion of 100 nm, an on-axis microscope, an x-ray fluorescence detector and dynamic beam shaping slits. The end stations are integrated in a compact space on a granite machine bed with high modularity for future upgrades and extensions. Real-time autonomous robotic systems are being implemented for high through-put cryogenic sample handling.

THAA02 09:50 20 **Mechanical Engineering of a Cryo STXM at CLS**

C.N. Regier *(CLS)*

A Scanning Transmission X-ray Microscope (STXM) is a useful imaging tool, but its application to certain types of samples is limited by significant rates of x-ray damage to the sample. Cooling samples to liquid nitrogen temperatures can delay radiation damage, but must be done in a vacuum environment to prevent rapid formation of ice on the sample. The Canadian Light Source (CLS) has constructed a Cryo-STXM, which can maintain sample temperatures at 100 K in an ultra-high vacuum environment and rotate the samples in the beam to collect tomographic data sets. This presentation will discuss the mechanical engineering aspects of the development of this Cryo-STXM including the finite element analysis (FEA) for stresses and vibrations, and present the performance parameters being achieved by the instrument.

THAA03 10:10 20 **Mechanical Design of New Dual Pinhole Mini-Beam Collimator With Motorized Pitch and Yaw Adjuster Provides Lower Background for X-Ray Crystallography**

S. Xu, *R. Fischetti, O. Makarov, S. Stepanov, N. Venugopalan (ANL)*

The GM/CA developed, quad-mini-beam collimator[*,**], advanced rastering and vector data-collection software tools[***], have enabled successful data collection on some of the most challenging problems in structural biology. There are two main sources of X-ray scattering (besides the sample) that reach the detector, contribute to back-ground and limit data resolution. These are scattering within the collimator that escapes the exit aperture and air-scattering of the direct beam before it terminates in the beamstop. Scattering from the collimator can be reduced by decreasing the exit aperture size. A quad mini-beam collimator was built consisting of 5/50, 10/70, 20/100 and 150/300 µm beam defining/exit aperture combination, respectively. Previous collimators were positioned in the X-ray beam by two motorized translational motions and two manual angular adjustments via a kinematic mount. Due to reduced tolerance in the new design, aligning each of the pin-hole combinations to high-precision required motorizing both translational and angular motions. Design and

con-struction of the improved mini-beam collimator and the extent of background reduction will be discussed.

THAA04 10:30 20 **Upgrading a Transmission SAX/WAX Beamline to Allow High Quality GISAX/GIWAX Experiments for Soft Matter Thin Films**

A.R. Marshall *(DLS)*

The project required a sample environment to deliver experiments in vacuum or helium, with high humidity, including capacity to use aggressive solvents. The compact, transportable system incorporates a high precision in-vacuum manipulator/ positioning stage (with repeatability better than 1 micron/ 1mdeg) allowing for multiple sample configurations. Current sample mounts include in-situ film formation (Doctor Blade), thermal annealing/drying heater stage, sample cooling and multiple sample stages, the system has been designed to accommodate many sample substrate formats. The existing end station camera system has been upgraded to include 2, in-vacuum, WAX and SAX area detectors, which are custom builds based on the Pilatus 6M. The SAX detector module includes three in vacuum, independent ,configurable SAX beam stop manipulators to block GISAXS transmitted, reflected and specular flare as well as isotropic and anisotropic SAX, a photon sensitive detector shutter plate is included. The 4mm diameter tungsten beam stops each include a miniature photodiode to measure beam intensity and can be positioned to within 10 microns precision in X and Y over 250mm x 230mm motion range.

THBA01 11:20 20 **An End Station with Cryogenic Coils Contributing to a 0.5 Tesla Field and 30-400k Sample Thermal Control**

G.A. Scharfstein *(LBNL)*

The Engineering Division of Lawrence Berkeley National Laboratory presents a design for an End Station to enable X-ray Photon Correlation Spectroscopy (XPCS), which is a method to study temperature-induced fluctuation in hard and soft condensed matter systems. XPCS, when applied to a magnetic system, can yield information about how domains fluctuate as the system goes through a phase transition; these phase transitions can occur at low temperatures (< 100K) and at an applied magnetic field. Therefore, requirements for the End Station include a 0.5 Tesla field at the sample and temperature control of the sample from 30K to 400K. The magnetic system is based on a two-dimensional vector magnet design with vanadium permendur as the pole material and 5000 amp-turn coils as the magnetic source. The sample is cooled by a coaxial flow cryostat that is attached to a trunnion which rotates the sample. The trunnion sits atop two translation stages at six degrees to produce motion normal to the beam. The End Station is in the final stages of design and scheduled to be commissioned in the first half of 2017 with final tests wrapping up by the end of 2016.

THBA02 11:40 20 **Enabling Investigations of Fluids and Fluid - Solid - Interfaces With Soft X-Ray Excitation at UHV Conditions**

D. Grötzsch *(MPI CEC) B. B. Beckhoff, A. N. Nutsch, C. Streeck (PTB) P. D. Dietrich, C. N. Nietzold, W. U. Unger (BAM) A. Jonas, B. K. Kanngießer, W. Malzer, K.W. Witte (Technische Universität Berlin) W. Martyanov (MBI)*

Capturing biochemical markers by bio-molecular films is one of the most promising approaches for the development of highly sensitive and highly selective diagnosis. In particular, future innovative tools for in vitro or point of care diagnostics are expected to rely on this principle. Analytical techniques which can provide information on coverage, orientation and chemical state of biochemical films are capable of contributing to a purposeful development of such diagnostics. We present fluid cells, which were designed to facilitate the application of soft X-ray spectrometry for the in situ analysis of bio-molecular films at solid-liquid interfaces. It allows for - the analysis through a silicon nitride window with a thickness of about 150 nm - in situ preparation of successive layers by rinsing the window Currently, after the first successful soft X-ray experiments on liquids and gases, we are improving the versatility of the fluid cells. Spectrometry in transmission and in various emission geometries will be feasible. Also transmission- and emission-measurements in parallel are tested. Further control devices for the experimental conditions will be added.

FRAA01 09:30 20 **Engineering Challenges on the I14 Nanoprobe Beamline**
A. Peach *(DLS)*
An overview of the double branch 185m I14 Nanoprobe beam-line under construction at DLS will be presented together with the end-station design in further detail. This consists of a split vacuum vessel containing a KB mirror configuration (at UHV) and the sample environment (at HV) which is just 50mm from the end of the final KB optic. An in-vacuum detector is mounted between the KB and the sample whilst two externally mounted detectors will operate between 0.25m Â– 3m from the sample. Four cryogenic samples can be brought into the vessel at a time and transferred remotely to the sample position with cooling provided by a Helium pulse tube cooler. With an initial 50nm size beam (and smaller in future), stability is absolutely critical and careful attention has been paid in the design to mitigate any thermal and structural sources of vibration. An array of interferometers reference the KB mirrors and sample position and will be used to actively correct for any drifts. The very tight space constraints involved has greatly increased the complexity and duration of the design but testing of prototypes is now underway and the system is scheduled for build and test through the Autumn 2016.

FRAA02 09:50 20 **Optimizing X-Ray Mirror Thermal Performance Using Variable-Length Cooling for High-Repetition-Rate FELs**
C.L. Hardin*, L. Amores, D. Cocco, N.M. Kelez, D.S. Morton, V. N. Srinivasan, L. Zhang (SLAC) M.C-D. Carlucci-Dayton (BNL)*
SLAC National Accelerator Laboratory is developing LCLS-II, a superconducting linear accelerator based free electron laser capable of a repetition rate up to 1 MHz. To deliver the FEL beam with minimal power loss and wavefront distortion, we need grazing-incidence plane mirrors with height errors below 1nm rms, under operational conditions. We also need to mitigate thermal effects of a complex photon energy-dependent thermal profile. We discuss a mirror cradle that minimizes figure error using variable length water cooling through a gallium-indium eutectic bath, and curve correction with an off-axis bender. We present thermal and mechanical analysis, design and prototyping results of figure sensitivity under bender corrections.

FRAA03 10:10 20 **Development and Installation of MIRAS, Infrared Microspectroscopy Beam Line at ALBA Synchrotron**
L.R.M. Ribó*, C. Colldelram, A.C. Crisol, A.A. Gevorgyan, R. Monge, L. Nikitina, I. Sics (ALBA-CELLS Synchrotron)*
The infrared microspectroscopy beamline is composed of different mechanical systems designed for a high stability mirror positioning and enclosed in a vacuum system of different levels. A brazed CVD diamond window separates the vacuum shared with the storage ring, from the vacuum sections of the Experimental Area. The IR light is extracted from a bending magnet of the ALBA Storage Ring by inserting a retractile mirror. A system of 8 mirror positioners transport the extracted light outside the tunnel until the first End Station, located on the Experimental floor. Mirror mechanics are comprised of double axis angular goniometers enabling high accuracy positioning. Transport mirrors themselves are made in polished aluminium with an unprotected gold coating for better IR reflectivity. Toroidal and parabolic shaped mirrors are used to focus the beam at a focal point F1, just downstream the CVD diamond window, and F2 before the first End Station, which is composed of FTIR spectrometer coupled to a microscope and an opto mechanical assembly, to adjust the shape and position of the IR beam. The beamline is able to accept two more End Stations using beam splitter devices.

FRAA04 **Soft X-Ray Grating Monochromator at the European XFEL**
10:30 20
***D. La Civita**, H. Sinn (XFEL. EU)*
European XFEL, the Free-Electron-Laser facility in Hamburg (Germany), is going to start user operation in early 2017. In full operation the novel facility will produce at MHz repetition rate coherent femtosecond pulses with unprecedented brilliance in the energy range from 250 eV to 25 keV. The facility comprises of a linear accelerator and three beam-lines: SASE1, SASE2 and SASE3 that covers the soft X-ray energy range up to 3 keV. The almost diffraction-limited beam is propagated along the beam-line with very long, cooled and super-polished mirrors. The plane VLS grating monochromator provides monochromatised beam and the optical layout consists of two alternatively insertable pre-mirrors and three gratings. All the optics are installed in the same vessel and mounted on a single in-vacuum baseplate. Degrees of freedom of the device are chosen and designed to guarantee the needed tunability and the maximum stability. The device has been mechanically tested and the vibrational performance measured to guarantee the adequate stability for the optics. This work reports about the concept, design, and test results of the monochromator with emphasis on the vibrational behaviour.

FRBA01 11:20 20 **A New Crystal Bender for the ID31 Laue-Laue Monochromator**
***M. Magnin-Mattenet**, P. Got, V. Honkimaki, A. Vivo, H. WIitsch (ESRF)*
The ID31 beamline is able to provide X-Ray energies ranging from 20 to 150keV. The energy range 50-150keVis covered by a Laue-Laue monochromator located at 100meters from the source. Two asymmetrically cut Si crystals equipped with benders, based on a new concept, provide an energy resolution ranging from few hundreds of eV down to the Darwin width of few eV. The bender principle, design, manufacture and first commissioning will be described. The virtual source, produced with a white beam transfocator, can be before or after the monochromator. Therefore the bending mechanism must allow both concave and convex configuration with bending radius from 20m to infinite. Each bender is equipped with two home made piezo-jacks in close loop with capacitive sensor. The system is liquid Nitrogen cooled. The thermal behaviour will be described in detail and thermo-mechanical finite element analysis presented.

FRBA02 11:40 20 **The Nanobender a New X-Ray Mirror Bender with Nanometer Figure Correction**
***C. Colldelram**, J. Nicolás, L. Ribo, C. Ruget (ALBA-CELLS Synchrotron)*
Over time X-Ray mirrors are demanded for better focusing, closer to sample refocusing, spot size as well as better beam uniformity at sample position. Based on the experience of ALBA Phase I beam lines a new alter-native design of a mirror bender* is proposed. The system includes two main functionalities: the mirror bender mechanism and mirror figure error correc-tion. Both mechanisms are based on the introduction of a force constrain on the mirror surface instead of a geometrical one. As being based on a force mechanism they could reach high resolution and especially for the correctors which can achieve nanometre resolution. The correctors are designed to provide high force stability in the mirror side, eliminating the crosstalk between bending and figure correction, and minimizing the sensitivity to drifts. With such controlled deformation of the mirror substrate it is possible to obtain the desired surface figure not only to correct mirror figure errors but also to adapt it to the incident wavefront, thus becoming adaptive system. The mechanical solutions are presented which are able to correct mirror surfaces with a resolution of 1 nm reaching slope errors below 100 nrad.

FRBA03 12:00 20 **Design of the Diamond Light Source DMM for the VMXi Beamline**
***D.J. Butler** (DLS)*
A Double Multilayer Monochromator (DMM) was designed in-house for the VMXi beam-line. This paper describes the novel engineering solutions employed to build a high stability instrument. PiezoMotor® actuators drive sine-arm Bragg axes for both optics providing the coarse and fine motion in a single actuator. The long translation of the second multilayer is driven externally via a linear shift to eliminate in-vacuum pipe & cable motions. A high stability air bearing translates the whole DMM across the two multilayer stripes. The optics are water cooled via an Indium / Gallium eutectic alloy bath to minimise coupled vibrations. The DMM is operational on the VMXi beam-line, experimental and performance data is presented.

FRBA04 12:20 20 **LCLS-II KB Mirror Systems: Technical Challenges and Solutions**
***L. Zhang**, D. Cocco, N.M. Kelez, D.S. Morton (SLAC)*
Based on the success of the Linac Coherent Light Source (LCLS) at the SLAC National Accelerator Laboratory, the Department of Energy has funded the LCLS-II - a billion-dollar project. In addition to the existing LCLS copper linac that delivers FEL pulses at

120 Hz, the LCLS-II project will provide a 4 GeV superconducting (SC) linear accelerator to deliver high-repetition-rate FEL pulses, up to 1 MHz. The average power of the FEL beam from the SC linac will range from 20 to 200 W, and potentially to 600 W. The FEL beam has ultra-short pulse length (down to a few fs), narrow energy band width (down to less than 10-4, thanks to self-seeding technology), and is fully coherent beam. The preservation of the wavefront is essential to maintain the outstanding FEL beam properties. In this paper, we will describe the technical challenge of the optics design to preserve the FEL beam wavefront. We will focus on the KB mirror system for LCLS-II instruments. We will especially discuss the aspects of cooling technology to minimize the thermal deformation and the management and minimization of the mechanical coupling between the mirror bending and the cooling.

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MAP

MECHANICAL ENGINEERING DESIGN OF SYNCHROTRON RADIATION EQUIPMENT AND INSTRUMENTATION

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MECHANICAL ENGINEERING DESIGN OF SYNCHROTRON
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