Vacuum Technology Division
Room 203B - Session VT-TuM

Large Vacuum Systems and Accelerator Vacuum Technology

Moderator: Yevgeniy Lushtak, SAES Getters USA

8:00am **VT-TuM1 Design of Vacuum Control System for the Linac Coherent Light Source II (LCLS-II) at SLAC National Accelerator Laboratory***, **Shweta Saraf**, S. Kwon, G. Lanza, D. Gill,* SLAC National Accelerator Laboratory **INVITED**

The LCLS-II (Linac Coherent Light Source II), a revolutionary new X-ray laser, is currently being built at SLAC National Accelerator Laboratory. The LCLS-II Vacuum System consists of a combination of particle free and non-particle free areas and includes the beamline vacuum, RF system vacuum, cryogenic system vacuum and supporting systems vacuum. The Vacuum Control System includes the controls and monitoring of different types of gauges, pumps and residual gas analyzers (RGA). The Vacuum Control System uses Allen Bradley PLC (Programmable Logic Controller) to perform interlocking to isolate bad vacuum areas. In particle free areas, a voting scheme is implemented for slow and fast shutter interlock logic to prevent spurious trips. Additional auxiliary control functions and high level monitoring of vacuum components is reported to global control system via an Experimental Physics and Industrial Control System (EPICS) input output controller .This paper will discuss the design and status of the LCLS-II Vacuum Control System.

8:40am **VT-TuM3 Vacuum System Design for Advanced Light Source Upgrade (ALS-U)***, **Sol Omolayo**,* Lawrence Berkeley Lab, University of California, Berkeley

A project is underway to upgrade the existing Advanced Light Source (ALS) synchrotron. The goal of the project is to lower the horizontal emmitance to <75pm resulting in a 2 orders of magnitude increase in soft x-ray brightness. The design utilizes a multi-bend achromat (MBA) lattice which requires a small magnetic aperture of about 24mm. Consequently the vacuum aperture is very small down to 6mm in some areas. This narrow posses a challenge to the vacuum design due to the conductance limitation and space constraints for vacuum chambers. We present the conceptual vacuum design for the ALS-U.

9:00am **VT-TuM4 Vacuum System for CHESS-U: Design, Manufacturing, and Installation***, X. Liu, D.C. Burke, A.T. Holic, **Yulin Li**, A. Lyndaker,* Cornell University

A sextant of Cornell Electron Storage Ring (CESR) is currently being upgraded with Double Bend Achromat (DBA) lattice and CHESS Compact Undulators (CCUs) in order to significantly boost the performance of Cornell High Energy Synchrotron Source (CHESS). With this upgrade, dubbed CHESS-U, CESR is converted from a counter-propagating two-beam ring to a single-beam ring, and the beam energy will be increased from 5.3 GeV to 6 GeV. The beam current for normal operation will also be increased, from 120 mA to 200 mA. The beampipe aperture of this new section is much smaller than the rest of CESR, and therefore the beam pipes and vacuum pumping are quite different from the rest of CESR too.

The beam pipes are mainly made of three types of aluminum extrusions, fitting inside quadrupole magnets, dipole magnets, and undulators respectively. The dipole extrusion includes an ante-chamber for distributed pumping using NEG strips (SAES St 707). An exception is the dipole chamber from which the undulator X-ray beam exits. This chamber is instead made of two machined halves that are welded together.

In this presentation, we will give a brief overview of the design of the vacuum system, and then show some important details in chamber production and installation, such as extrusion bending by stretch forming, chamber welding and distortions, NEG strip pumping, etc. Base vacuum performance will be reported as well. Details regarding the crotch absorber will be reported in a separate presentation.

9:20am **VT-TuM5 Design and Fabrication of CHESS-U Crotch Absorbers***, Y. Li, **Xianghong Liu**, A. Lyndaker, K. Smolenski, A. Woll, L. Smieska,* Cornell Laboratory of Accelerator-based Sciences and Education

A major upgrade project (CHESS-U) will elevate performance of Cornell High Energy Synchrotron Source (CHESS) to a state-of-the-art 3rd generation light source. In the CHESS-U project, ~80 meters of Cornell Electron Storage Ring (CESR) will be upgraded with a Double Bend Achromat (DBA) lattice and CHESS compact undulators (CCUs), together with new CHESS front-ends and X-ray beamlines. Tremendous progresses have been made in the design, construction, and test of all required new accelerator components (such as magnets, vacuum chambers, etc.), and we are on schedule for the CHESS-U installation in late 2018.

One of the most challenging vacuum components is the crotch absorbers at the synchrotron radiation (SR) exit ports at the ends of dipole bending chambers. CHESS-U is designed for 250-mA maximum beam current at 6-GeV beam energy. The crotches need to safely absorb 5.1 kW of SR power generated by the dipole magnets at small angles of incidence, while allowing the undulator beams produced by the canted CCUs to pass. We present a design for a compact crotch which can effectively dissipate this high SR power and will be compatible with the ultra-high vacuum system of CESR.

The crotch is a composite of a 5-mm thick beryllium outer ring, which acts as a SR diffuser, and an axially water cooled copper cylinder, similar to the existing CHESS crotches that have been in operation for decades. The outer beryllium ring is bonded to the copper cylinder via vacuum furnace braze using Cusiltin (60% Ag - 30% Cu - 10% Sn) braze alloy. Thermal analysis has shown no surface temperatures higher than 325°C. However, the calculated maximum thermal stress (on the surface of the beryllium) is near beryllium's ultimate strength. As a practical validation of the CHESS-U crotch design, an existing CHESS crotch was removed from CESR for microscopic inspection. Though the CHESS crotch was exposed to slightly higher SR power (5.7 kW) during operations, no sign of fracture, surface melting, or other visible defect was detected on the beryllium surface. To ensure the good bonding of the beryllium diffuser ring to the copper cylinder, scanning X-ray fluorescence (XRF) inspections of the brazed crotches were performed at CHESS A1 beamline. The XRF inspection verified the presence of a continuous braze layer (corresponding to 10-30 µm thickness of Cusiltin) between the beryllium and the copper, indicating good braze joint. Five CHESS-U crotch assemblies have been successfully fabricated and XRF inspected, to fulfill the need for 4 crotches required for the CHESS-U project.

9:40am **VT-TuM6 Simulation and Measurement of the Tritium Retention in the Beamline of the KATRIN Experiment***, **Joachim Wolf**,* Karlsruhe Institute of Technology, Germany

The objective of the KATRIN neutrino experiment is the determination the effective mass of electron anti-neutrinos with an unprecedented sensitivity of 0.2 eV/c^2 by measuring the energy spectrum of b-electrons from tritium decays close to the endpoint of the spectrum. The decays take place in a high-intensity windowless gaseous tritium source (WGTS). The electrons are guided by strong magnetic fields through a beamline with super-conducting solenoids to the huge main spectrometer for energy measurement. Since only a fraction of $2 \cdot 10^{-13}$ of all electrons have a kinetic energy within 1 eV below the spectral endpoint, the sensitivity of the measurement depends on a low background rate in the spectrometer. Therefore the tritium flow from the source (10^{-3} mbar) has to be reduced by at least 14 orders of magnitude before it reaches the spectrometer section. This large reduction in the 90-mm-diameter beamline is achieved with a combination of a differential pumping section (DPS), using turbo-molecular pumps (TMP) and a cryogenic pumping section (CPS) with an argon frost layer at around 3 K.

This talk describes the Test Particle Monte Carlo (TPMC) simulation of the beamline for the differential and cryogenic pumping sections both for the non-radioactive gas deuterium and for tritium with MolFlow+. Since the gas flow through the CPS is reduced by far more than 7 orders of magnitude, the simulation is done in several consecutive steps. The results are combined in the post processing of the TPMC results. In the post processing algorithm we also investigate the time dependence of the reduction factor by considering a finite sojourn time of the molecules on the cryogenic argon layer. This leads to a slow migration of deuterium in downstream direction. In a final step the half-life and migration of tritium is taken into account by a reduced sojourn time.

After finishing the construction of the KATRIN setup, the final commissioning of the experiment started in October 2016. The results of the commissioning measurements with deuterium will be compared with the TMPC simulations. First traces of tritium are planned to be admitted into the beamline in May 2018. This work has been supported by the German BMBF (05A17VK2).

11:00am **VT-TuM10 NSLS-II Beamline Vacuum Challenges: Design, Commissioning, and Operations***, **Robert Todd**, C. Hetzel,* Brookhaven National Laboratory

The NSLS-II facility now has 23 beamlines in operation and 5 others nearing operational readiness. This talk will focus on general vacuum requirements common to all synchrotron beamlines as well as hardware and design considerations needed to meet them. Topics to be covered include: beamline vacuum system design, leak checking, bakeout, commissioning, and operation. Particular attention will be given to the successes and challenges experienced to date.

11:20am **VT-TuM11 Thin film Heterostructures for Superconducting Photocathode Applications***, **Mark Warren**,* Illinois Institute of Technology

In the application of high pulse rate (100 MHz) CW light sources, superconducting RF guns serve as ideal photoinjectors as they dissipate significantly less power than normal metal Cu. An integral component of a photoinjector, the photocathode, must produce an electron beam with stringent requirements on emittance, temporal response, and quantum efficiency (QE). The photoinjector wall material is most commonly Nb which itself has a low QE (10-6). So, it is proposed that Nb photocathodes be coated with thin films of Mg which have a much higher QE (0.1% with laser cleaning) and can be induced into the superconducting state via the proximity effect. Results on the fabrication and testing of Nb/Mg bilayers including the resiliency of thin films in high RF fields (up to 60 MV/m) will be presented. In addition, the study of semiconducting overlayers is presented including promising QE values in ultra-thin layers of Cs2Te on Nb.

11:40am **VT-TuM12 TPD Results on Electrode Materials for Pulsed Power Vacuum Environments***, **Ronald Goeke**, S.C. Simpson, K.R. Coombes, M.K. Alam, D.P. Adams,* Sandia National Laboratories

Next generation pulsed power systems require a better understanding of current loss and the ability to predict the scaling of current coupling. Plasma formation occurs in these devices at both the anode and cathode at high current densities. These plasmas are formed from desorbed and ionized surface and bulk electrode contaminants, expand into the anode-cathode gaps of the transmission lines (a phenomenon referred to as plasma closure), and potentially lead to shunting of current away from the fusion targets. Contaminants are pervasive on typically manufactured hardware and common on pulsed power vacuum systems. Understanding the physics of neutral desorption from electrode surfaces is a critical requirement for accurately predicting plasma formation (current loss) in pulsed power machines, We will present Temperature Programmed Desorption (TPD) results of common electrode materials, including machined wrought stainless steel and additively manufactured 304L stainless steel.

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