Wednesday Afternoon, November 12, 2014

Vacuum Technology
Room: 303 - Session VT-WeA

Accelerator and Large Vacuum Systems II
Moderator: James Fedchak, National Institute of Standards and Technology (NIST)

2:20pm **VT-WeA1 Load locks, Transfer arms, and other In-Vacuum Motions in the Cornell DC Photoelectron Gun Development Project**, ***Karl Smolenski***, *X. Liu, B. Dunham, L. Cultrera, J. Conway*, Cornell University **INVITED**

The Cornell DC photoelectron guns pose a series of challenging vacuum engineering problems. These high brightness electron sources have produced the highest currents (0.075A) yet achieved from a photocathode source and are prototypes for future state of the art accelerators. The guns operate in the XHV (<1e-11 Torr) with massive NEG pumping and require exchange of the photocathode wafer periodically for continuous operation. The scale of the vacuum vessel, set by the extreme high voltages, requires the use of meter scale transfer arms to load and extract the photocathode holder with minimal disruption to the vacuum level and without particulate generation. These transfers are required to be rapid and simple to minimize operational downtown.

We have developed a series of mechanisms to retain the photocathodes, magnetic and bellows-coupled transfer arms to move samples between chambers, and load locks to introduce cathodes into the vacuum systems. More recently vacuum suitcases have been employed to move photocathodes from remote labs to our accelerators and to other laboratories for testing. This talk will present our experiences maintaining large scale systems with extensive in-vacuum motions under extreme requirements.

3:00pm **VT-WeA3 Vacuum Performance of 5-mm Undulator Chamber for Cornell High-Energy Synchrotron Source**, ***Yulin Li***, *X. Liu, A. Lyndaker, A. Temnykh*, Cornell University

To significantly enhance the X-ray beam performance at Cornell High-Energy Synchrotron Source (CHESS), a 3.9-m long, 5-mm vertical aperture undulator vacuum chamber were designed, constructed and tested at Cornell Electron Storage Ring (CESR). The vacuum chamber is constructed of aluminum (Type 6061-T6) extrusions with an electron beam aperture (with nominal 5-mm vertical and 90-mm horizontal apertures), a pump ante-chamber and a cooling channel. To minimize the undulator magnet pole gap, pockets were machined on top and bottom of the extrusion in the middle portion. With the top and bottom wall thickness of 0.6 mm, the effective beam vertical aperture is reduced to 4.5mm owing to deflection from the atmospheric pressure. The undulator vacuum chamber was tested at its final designated location in CESR near a strong dipole magnet, intercepting high synchrotron radiation (SR) power and flux. To handle very high distributed gas load due to SR-induced desorption, six non-evaporable getter/ion pumps (NexTorr D100-5, SAES Getters) were installed along the undulator chamber. The test chamber was equipped with four cold cathode ionization gauges (CCGs) and a residual gas analyzer (RGA) to monitor vacuum performance. In this talk, we will present the construction, mechanical and vacuum qualifications, and the beam conditioning history of the undulator vacuum chamber. We will summarize the experiences learnt from the successful week-long beam tests.

3:20pm **VT-WeA4 Near-XHV Pressure Characterization for the Jefferson Lab Polarized Electron Source**, ***Marcy Stutzman***, *P. Adderley*, Thomas Jefferson National Accelerator Facility, *M.A. Mamun, A.A. Elmustafa*, Old Dominion University, *M. Poelker*, Thomas Jefferson National Accelerator Facility

Long operational lifetime at the Jefferson Lab high polarization electron source requires vacuum approaching XHV ($1x10^{-10}$ Pa). Determining the ultimate pressure in a chamber requires minimizing outgassing rate, maximizing pumping, and accurately measuring pressure. Two systems were used to study the ultimate pressure that could be achieved: test chambers that were fabricated to characterize the effects on outgassing of different chamber material processing and coatings, and a cryopumped electron source sized chamber. This paper presents both the characterization of XHV gauges and the ultimate pressure achieved in the various chambers. The extent to which temperature dependent outgassing rate can be exploited to improve ultimate pressure will also be discussed. Finally, progress on reconciling the persistent discrepancies between calculated and measured pressure will be presented.

4:20pm **VT-WeA7 Design Optimization and Fabrication Progress of ITER's Large Custom Vacuum Pumps**, ***Robert Pearce***, *M. Dremel, L. Worth*, ITER Organisation, France, *L. Baylor, S. Meitner*, Oak Ridge National Laboratory **INVITED**

ITER is under construction in the south of France in order to demonstrate the feasibility of fusion as a clean power source. It is one of the world's largest scientific and engineering collaborations. The civil structures, to house the ITER machine, are progressing, and the key systems and components are moving from design to manufacturing.

The ITER vacuum system will be one of the largest, most complex vacuum systems ever to be built. There are a number of large volume systems including: the cryostat (~ 8500m3), the torus (~1330 m3), the neutral beam injectors (~180m3 each) and a number of lower volume systems including: the service vacuum system, diagnostic systems, and electron cyclotron transmission lines. In total there are more than 400 vacuum pumps of 10 different technologies required to pump the systems. The most demanding vacuum pumping applications are served by 18 large cryogenic pumps of 3 distinct custom designs.

The ITER vacuum vessel and cryostat are to be pumped by a total of 8 cylindrical cryo-sorption pumps with integral 800 mm all metal vacuum valves. The "build-to-print" design of these pumps has been optimised and finalised and the first pump is being manufactured.

The ITER neutral beam systems are each pumped by a pair of open structure panel style cryo-sorption pumps with a length of 8 m, and height of 2.8 m. They should achieve a pumping speed of 4500 m3/s for hydrogen. The final design of these pumps has involved development of new fabrication methods so as to significantly reduce the cost and manufacturing time for the thousands of cryo-panels and thermal shields within the pumps. The design is ready for manufacture, with the first pump destined for the ITER neutral beam test facility (MITICA).

During plasma operations, to pump the mixture of gasses originating from the regenerations of torus and neutral beam cryo-pumps, the roughing system will utilize 6 cryogenic viscous flow compressors (CVC). The principle of the CVC is that it will cryogenically condense hydrogen isotope mixtures, while providing first stage compression of helium ash originating from the fusion process. Each CVC is designed for throughputs of 200 Pam3/s and consists of a tube heat exchanger housed in a cryostat of diameter ~1 m and height 2.5 m. The very novel nature of this pump requires a full size prototype, which has been manufactured and will go through a test campaign.

In this paper an overview is given of the ITER construction. Examples of the cryo-pump 'value engineering' and design optimization for manufacturing are given. Progress and challenges in the "First of a Kind"(FOAK) vacuum pump manufacturing are given.

5:00pm **VT-WeA9 Commissioning of the KATRIN Main Spectrometer**, ***Joachim Wolf***, Karlsruhe Institute of Technology, Germany

The objective of the **Ka**rlsruhe **Tri**tium **N**eutrino experiment (KATRIN) at the Karlsruhe Institute of Technology (KIT) is the measurement of the electron neutrino mass with an unprecedented sensitivity of 200 meV by using electrons from the beta-decay of tritium. A central component is the electro-static main spectrometer (MS), where the energy of the beta-electrons (18.6 keV) will be measured with high precision. It consists of a large ultra-high vacuum vessel with a volume of 1240 m^3 and a surface of 690 m^2, instrumented with a complex inner wire-based electrode system, which almost doubles the inner surface of the MS.

The pumping system of the MS consists of 6 turbo-molecular pumps (10 000 l/s), a large-scale getter pump (3000 m NEG strips, St707, 10^6 l/s) and three cryo-baffles (6.8 m^2) at LN_2 temperature. The vacuum system has three major tasks: (I) the ultimate pressure, dominated by H_2, has to be kept in the range of 10^{-11} mbar in order to maintain a low background rate. (II) In conjunction with a differential pumping section and a cryogenic pumping section of the electron beam line, which connects the gaseous tritium source with the spectrometer, it has to keep the partial pressure of tritium in the MS below 10^{-21} mbar. (III) The NEG strips are known to emanate a small amount of radon atoms, increasing the intrinsic background rate. Therefore cryogenic baffles at LN_2 temperature have been installed in front of the NEG pumps, which are expected to capture most of the radon atoms, before they can enter the sensitive volume of the MS. This paper describes the design of the vacuum system and reports on measurements of the vacuum performance during the first commissioning of the whole spectrometer system.

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