Tuesday Morning, September 23, 2025

Vacuum Technology
Room 205 ABCD W - Session VT1-TuM

Measurement, Simulations and Accelerator Vacuum Systems

Moderators: Jacob Ricker, NIST, **Julia Scherschligt**, National Institute of Standards and Technology

8:00am **VT1-TuM-1 ORNL Second Target Station (STS) Vacuum System*, Austin Chaires,*** Oak Ridge National Laboratory, USA **INVITED**

The STS is a $2 Billion, Department of Energy project to be constructed at the ORNL Spallation Neutron Source (SNS).The STS will provide wholly new capabilities for the study of a broad range of materials with neutron scattering and support thousands of users from the physical, materials, and applied sciences industries. The science capabilities provided by the instrument suite at the STS will complement those of the two existing DOE Office of Science neutron scattering user facilities at ORNL, the First Accelerator Station (FTS) of the SNS and the High Flux Isotope Reactor (HFIR). The STS will deliver the highest peak brightness of cold neutrons in the world, which together with advances in neutron optics, instrumentation, and detectors, will ensure US leadership in neutron scattering for decades to come.

The STS Accelerator Systems group is responsible for the design, fabrication, installation, and testing of all hardware necessary to transport the 700 kW, 15 Hz proton beam to a rotating tungsten target, to create 22 beams of moderate neutrons.

The Ring to Target Beam Transport Beamline vacuum system branches off the existing RTBT's vacuum system and stretches ~230 meters until it ends at the STS's proton beam window (PBW) to the target. The RTST vacuum volumeis essentially an 8" diameter cylinder from beginning to end and mostly located concentrically about the beam axis. It is also pocketed with additional spaces at crosses and instrument & shielding housings. The RTST is divided into 7 isolatable sections using all-metal gate valves. All sections contain:magnet vacuum chambers (VC), drift VCs adaptors, bellows, beam instrumentation VCs, pumps, Pirani gauges (TCG), cold-cathode gauges (CCG), a pumpdown access location, an RGA, and various other valves. Additionally, several large detector vessels and a core vessel are in early design and require systems to obtain low to high vacuum. Positive pressure gas distribution and vacuum analysis capabilities are also required for these systems.

This talk will also offer a cursory glance at the following additional vacuum systems:

1. Proton Beam Window Inflatable Seal and Interstitial Space Vacuum Systems
2. Cryogenic Moderator Vacuum Systems
3. Neutron Guide Beamlines and In-Bunker Vacuum System

8:30am **VT1-TuM-3 Robotic Assembly of SRF Cavity Pair*, Adam Duzik,*** *Roger Ruber,* Jefferson Laboratory

Superconducting Radio Frequency (SRF) cavities for particle accelerators require tight tolerances, ultrahigh vacuum, and strict cleanliness during assembly. As in the semiconductor industry, defects such as particles and residues are deleterious to performance, possibly rendering a cavity unfit for use. This problem is addressed primarily through cleanroom assembly during sensitive steps and rigorous chemical processing to prevent and remove such defects. Human workers are often the largest source of contamination, even with proper gowning and practices. The semiconductor industry has long integrated robots in cleanroom operation, but this has not occurred for SRF cavity production; SRF cavities, unlike wafers, are complex shapes, require more hands-on mechanical assembly, and are low-volume production items.

At Jefferson Laboratory, a co-operative robot (cobot) has been setup to overcome these problems. Cobots are safe for use alongside human workers and can integrate new tools such as a 3D camera part detection and gripper for item manipulation. Therefore, cobots represent a promising avenue for reducing particulate generated during a variety of assembly tasks. A mockup of a cavity pair and coupler was setup and the cobot programmed to automatically pick up the coupler and place on the mating cavity flange. Particle counting methods were setup to measure human vs cobot assembly particulate generation inside a cavity mockup. Other potential uses will be discussed for further improving SRF cavity assembly steps, where a cobot can replace or assist a human operator, and what potential gains are expected.

8:45am **VT1-TuM-4 Emergency Vacuum Repairs in an Aging Accelerator: Case Studies and Lessons Learned*, Marcy Stutzman,*** Jefferson Lab

Jefferson Lab operates the CEBAF electron accelerator at energies to 12 GeV for the Department of Energy Nuclear Physics program. The CEBAF injector beamline was designed and built in the early 1990s. Although many of the vacuum components have been upgraded and replaced, many unique, original components are still installed and operating daily. Over the past 3 years, several vacuum leaks have occurred in ageing components leading to emergency repairs on a tight timeline. These include an edge welded bellows and RF power ceramic feedthrough, both of which had been in use for at least 25 years. The nature of these vacuum component failures will be discussed, along with the difficulties in repair due to the age and availability of parts, lessons learned, and what steps are being taken to minimize similar failures going forward.

9:00am **VT1-TuM-5 Commissioning and Early Operations of the APS-Upgrade Storage Ring Vacuum System*, Jason Carter,*** Argonne National Laboratory, USA **INVITED**

The Advanced Photon Source's (APS) upgraded storage ring was brought online and began commissioning in April 2024. APS was rebuilt with a new 1100-meter length storage ring vacuum system, a complex assembly of over 2500 custom vacuum components. In 2024 and 2025 APS-U has successfully commissioned the vacuum system reach the designed pressure levels and allowing the machine to reach key performance parameters and for the facility to provide reliable beam to the users. This presentation will share results and analysis of the vacuum system commissioning along with lessons learned from the installation and operations phases.

9:30am **VT1-TuM-7 Design and Construction of a Vacuum End Station for Ion Irradiation in Magnetic Field Environments at the Tennessee Ion Beam Materials Laboratory*, Henry Osborne,*** University of Tennessee Knoxville*; Kendall Trellue,* University of New Mexico*; Miguel Crespillo,* University of Tennessee Knoxville*; Eric Lang,* University of New Mexico*; Khalid Hattar,* University of Tennessee Knoxville

As nuclear fusion reactors progress closer to becoming a reality, it is important to understand how materials that compose the heart of such reactors behave under the coupled extreme environments. Such intense temperatures, displacement damage, and magnetic field can have a significant impact on the thermal, mechanical, and radiation stability of most candidate alloys. It is essential to have this fundamental understanding for the development of physics-based models, however, this has been under studied due to lack of experimental capabilities. This presentation will detail the design and construction of a custom ion accelerator end station that will permit such experiments at the Tennessee Ion Beam Materials Laboratory (TIBML). This end station design will be compatible with either the MV tandem accelerator already at TIBML or the 300 kV implanter that is soon to arrive. The high vacuum design incorporated for this end station should permit vacuum pressures between $1x10^{-5}$ Pa and $1x10^{-6}$ Pa and easy transfers between beamlines. In addition, the end station achieves a maximum magnetic field strength of 1.44 Tesla by inserting the sample from the loading portion of the end station through the gate valve into the center of the large switching magnet of the ion accelerator using a 914 mm long linear translator. The exact magnetic field will be measured via hall probe at the sample location during the experiment. It similarly achieves cryogenic temperatures through liquid nitrogen cooling conducted to the sample via copper braids. Due to the extreme conditions created by the cryogenic, magnetic, and radiation environments, several precautions had to be taken in the design, material selection, and development of this end station. Initial results of this new end station design to study the microstructural evolution of materials will be presented. Finally, this presentation will highlight the varied and future potential fusion energy-related experiments that will be made possible through the utilization of this end station. The development of this magnetic end station at TIBML will allow the fusion materials community to better understand coupled extreme environments.

9:45am **VT1-TuM-8 Boosting Sticking-Dependent Transmission Studies to a Single TPMC Simulation*, Jan Beckmann,*** *Klaus Bergner, Stefan Kiesel,* VACOM, Germany

In the simulation of molecular flow through complex vacuum geometries, the transmission probability is a key parameter, particularly when modeling systems with surface adsorption or desorption effects, such as NEG-coated pipes or cryogenic beamlines. Traditionally, calculating the impact of varying sticking coefficients on transmission requires separate Test Particle Monte Carlo (TPMC) simulation runs for each coefficient, posing a significant computational burden often exceeding many hours of computation time in simulation frameworks like Molflow+.

We present a novel approach that enables the extraction of transmission probabilities for arbitrary sticking coefficients using only a single TPMC simulation conducted with zero sticking (s = 0). This method leverages the statistical distribution of particle bounces before exiting the system. By recording the number of wall interactions for each particle in a single simulation and applying a bounce-weighted exponential scaling factor of the form $(1 - s)^N$, we can reconstruct transmission probabilities for any s with high accuracy.

This methodology was validated using Molflow+ in an elbow-shaped vacuum geometry. The resulting predictions for various s-values closely matched full simulation results, confirming the reliability and computational efficiency of this approach. This technique enables rapid conductance analyses significantly reducing the total computation time to few minutes and supports more efficient vacuum system design across a wide range of applications.

Author Index

Bold page numbers indicate presenter