Vacuum Technology
Room Ballroom A - Session VT-ThP
Vacuum Technology Poster Session

VT-ThP-1 Maintenance, Upgrade, and Vacuum System Optimization of the LCLS Superconducting Injector During 2026 Long Downtime, ***TC Chen***, SLAC National Accelerator Laboratory

The LCLS-II superconducting (SC) photoinjector at SLAC National Accelerator Laboratory is designed to produce high-brightness electron beams at repetition rates up to 1 MHz. The injector system integrates a Cs_2Te photocathode, RF gun, buncher, cryomodule, and extensive vacuum infrastructure to maintain ultra-high vacuum (UHV) conditions critical for cathode lifetime and beam quality. Following extended operation, component aging, vacuum degradation risks, and reliability concerns necessitate a comprehensive maintenance and upgrade campaign during the scheduled 2026 long downtime (LDT).

The maintenance strategy involves coordinated interventions across three major subsystems: the photocathode loadlock system, RF gun, and low-energy beamline (LEB). Key activities include removal of auxiliary hardware, such as cables, waveguides, tuners, cooling water hoses, and the 1.3 GHz cryomodule (CM) endcap support to provide access of parts being replaced , followed by replacement of failed and aging components including vacuum pumps, pneumatic gate valves, residual gas analyzers (RGAs), and RF waveguide windows.

VT-ThP-2 Design and Construction of a Calibration Chamber and Pressure Control System for Automated Calibration of Capacitance Diaphragm Gauges and Other Vacuum Standards, ***Jacob Ricker***, *Jay Hendricks, Kevin Douglass, Ifenna Anakor, Thomas Howard,* NIST

The calibration of vacuum gauges from 13 mPa to 130 kPa has been done for the last 40 years using liquid column manometers. NIST new Fixed Length Optical Cavity (FLOC) pressure standards will be replacing these standards, however because they are based on gas refractivity, they require high purity gas. The current manifold is contaminated with mercury and oil from the manometers, so NIST has been designing and constructing a new manifold capable of automatically adjusting pressures and calibrating customer gauges against the standard. The automated system must be able to precisely control flow to set pressures in the chamber to within mPa accuracy at low pressure, however it must have capability for fast flow when filling pressures near atmospheric pressure. This presentation will describe the design, assembly, and testing of a low-cost calibration system capable of calibrating vacuum gauges over the range of 13 mPa to 130 kPa.

VT-ThP-3 Vacuum Considerations for the Next Generation of DC High Voltage Polarized Electron Gun at Jefferson Lab, ***Marcy Stutzman***, Thomas Jefferson National Accelerator Facility

The polarized electron source at Thomas Jefferson National Accelerator Facility (JLab) has delivered highly polarized electron beams for the nuclear physics program for over 20 years using a series of custom DC high voltage electron guns. We achieve pressure approaching 10^{-12} Torr in the electron gun by applying NEG coatings to heat treated stainless steel chambers, installing a large array of NEG modules and an ion pump, and baking the system for several days prior to use. The operational lifetime of the system is strongly affected by the vacuum level, as residual gasses ionized by the electron beam can damage the photocathode. Recent research on the electron guns has focused on improving high voltage performance by iterating the cathode electrode and insulator designs necessary for operation at a DC bias of -200 kV, with only minimal changes to the vacuum systems. However, the next generation polarized electron gun is now being designed to deliver at least 10x higher current to generate a polarized positron beam. The design for the high voltage, vacuum, and electrostatic beam optics must all be optimized, and some of the design choices that improve one aspect adversely affect other aspects. Vacuum system options will be discussed, such as chamber material, cathode electrode material, and pumping optimization, as well as the status of balancing the optimal design for both the high voltage and vacuum systems.

VT-ThP-4 Microreactor for Quantitative Reactivity Measurements and In Situ Infrared Spectroscopy on Single-Crystal Model Catalysts, *Adam Lagin, Johannes Filzmoser, Ulrike Diebold, Michael Schmid, Gareth Parkinson,* ***Jiři Pavelec***[1], TU Wien, Austria

Single-crystal model catalysts provide an ideal platform for elucidating reaction mechanisms and benchmarking computational models. Yet, accurately determining intrinsic reaction kinetics on low-surface-area single crystals at realistic pressures remains challenging [1]. Direct comparability with theory therefore requires tight control of gas-flow dynamics and exceptionally low background signals. Here, we present the design of a dedicated high-pressure reaction cell that addresses key limitations of conventional “pressure-gap” approaches through rigorous vacuum engineering and flow optimisation.

A defining feature of the microreactor design is operation in the molecular-flow regime within the narrow cell gap at pressures around 1 mbar. In this regime, quantitative turnover frequency (TOF) measurements can be obtained without the complex fluid-dynamic modelling or diffusion corrections typically required at higher pressures. The system retains the capability for operation up to atmospheric pressure (~1 bar). Trace product formation is detected by coupling the exhaust to a high-sensitivity mass spectrometer equipped with liquid-helium cryogenic pumping. In parallel, molecules on the catalyst surface are monitored using a home-built in situ IRAS setup optimised for the low reflectivity of metal oxides [2].

O-ring-free sealing is achieved by mating two optically flat surfaces [3]: the single-crystal sample and an IR-transparent diamond window. This “hard-seal” concept suppresses background contamination during high-pressure experiments. The design is prepared for full integration with standard UHV surface-science infrastructure. This enables controlled surface preparation and post-reaction characterisation by X-ray photoelectron spectroscopy, low-energy ion scattering, and scanning tunnelling microscopy facilitating direct correlation of atomic-scale structure with quantitative reactivity.

Essential aspects of the design have been supported by modelling, mainly in COMSOL Multiphysics, including vacuum-flow studies, heat transport, mechanical and optical simulations, as well as coupled multiphysics calculations. These studies guided critical design choices and will be showcased in this contribution.

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VT-ThP-5 New Developments in the Use of Fixed Length Optical Cavities as a Photonic Pressure Standard, ***Thomas Howard***, *Thinh Bui, Jacob Ricker, Kevin Douglass, Jay Hendricks,* NIST-Gaithersburg

The Fixed Length Optical Cavity (FLOC) is an optical pressure standard based on gas refractometry. Three different FLOC technologiesare being developed at NIST to cover a wide pressure range from micropascal to megapascal. Typical FLOC instruments determine pressure by measuring the shift in the beat note frequency between two separate lasers coupled to a dual cavity system. Recent advances allow the use of only a single laser source, reducing cost and complexity while maintaining the high (part-per-million level) precision and accuracy of the typical two laser system. Results and comparisons to previous FLOC pressure measurements will be discussed here.

VT-ThP-7 Plasma Fueling Guide Tube Design with Propellant Removal for the Sparc Tokamak, ***Steven Meitner***, Oak Ridge National Laboratory

Cryogenic hydrogen isotope pellet injection provides a mechanism for continuous supply of fuel ions for high-performance magnetically confined fusion devices. Cryogenic pellet injection enables direct core fueling by overcoming the high neutral screening encountered when fueling the plasma through gas puffing.Light gas guns and centrifuges are the two primary methods available for accelerating cut fueling pellets into the plasma.Oak Ridge National Laboratory (ORNL) is collaborating with Commonwealth Fusion Systems (CFS) to deliver a continuous pellet injector with the light gas gun technique for the SPARC tokamak.

The pellets will be accelerated with 60 barg helium gas, which must be removed before it enters the plasma.An evacuated guide tube system, complete with pellet mass and speed diagnostics, transports the pellets from the light gas gun to the tokamak.Gaps along the guide tube provide

[1] **JVST Highlighted Poster**

regions that allow the propellant gas to expand and be pumped away while allowing the pellets to continue towards the plasma.Because SPARC is designed to demonstrate net fusion gain (Q > 1), the fueling system must reliably deliver intact pellets while maintaining proper containment of the hydrogen isotopes.This paper will detail the pellet guide tube design, the fuel containment boundaries, and calculations used to evaluate propellant removal.

This work was supported by the U.S. Department of Energy's Office of Fusion Energy Sciences Compact Toroidal Concepts program, namely "Fueling, Power Exhaust, and Particle Control Studies on MAST-U, NSTX-U and SPARC"; Oak Ridge National Laboratory is operated for the DOE by UT-Battelle, LLC under contract DEAC0500OR22725.

VT-ThP-8 Empirical Methodology for Estimating Gas Evolution Rates from Operating Isol Targets Using Archived Vacuum-System Data*, Dimo Yosifov,* *Farhad Rahimi,* TRIUMF, Canada

Abstract

Reliable estimates of gas evolution from isotope-separation-on-line (ISOL) targets are required for the design of target vacuum, pumping, radioactive-gas collection, storage, and controlled-release systems. During the design of the ARIEL facility at TRIUMF, practical estimates of operational gas loads were needed to establish radioactive-gas inventories and operating- and decay-storage capacity. Empirical data directly applicable to these engineering calculations were limited.

This paper presents a methodology for deriving such estimates from archived operational data acquired at the ISAC facility. Two complementary approaches are used. The first estimates local beam-associated gas load from target-station ion-gauge pressure and effective pumping speed, using an engineering estimate of approximately 1900 L/s for the delivered pumping speed. The second determines the average gas load collected by the radioactive-gas management system from pressure accumulation in a known 231-L primary operating-storage volume. Archived proton-beam current is used to identify representative production intervals.

The methodology is applied to six UCx target campaigns. Local beam-associated gas-load estimates span approximately 3.2×10^{-4} to 1.2×10^{-3} Torr·L/s at beam currents near 10 μA. Analysis of operating-storage accumulation gives collected system gas loads of approximately 2.6×10^{-3} to 7.9×10^{-3} Torr·L/s. These ranges are interpreted as empirical operational gas loads rather than intrinsic material outgassing coefficients, reflecting target condition, system contamination, conductance, pumping-speed uncertainty, gauge response, and known background outgassing.

The resulting ranges provide experimentally grounded design information for target vacuum and pumping systems, radioactive-gas inventory assessment, operating- and decay-storage sizing, and interfaces with controlled-release and nuclear ventilation systems. The work also demonstrates how archived accelerator data can be repurposed to support reliability and systems-engineering decisions in radiological accelerator environments.

Keywords: Radioactive Gas Management; Radioactive Gas Inventory; ISOL; Target Outgassing; Vacuum Systems; Operating Storage; Decay Storage; Nuclear Ventilation; Controlled Release; Accelerator Reliability; Archived Operational Data

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