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, United States Minor Outlying Islands (the)

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, **Jiri Pavelec**,* 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.

[1] Beck, A.; Paunovic, V.; Van Bokhoven, J. A. *Nature Catalysis* 2023, *6* (10), 873–884.

[2] Rath, D.; Mikerásek, V.; Wang, C.; Eder, M.; Schmid, M.; Diebold, U.; Parkinson, G. S.; Pavelec, J. *Review of Scientific Instruments* 2024, *95* (6).

[3] Kraushofer, F.; Mirabella, F.; Xu, J.; Pavelec, J.; Balajka, J.; Müllner, M.; Resch, N.; Jakub, Z.; Hulva, J.; Meier, M.; Schmid, M.; Diebold, U.; Parkinson, G. S. *The Journal of Chemical Physics* 2019, *151* (15), 154702.

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-6 The Vacuum System Design for the Extreme Photonics Applications Centre (EPAC)*, **Keith Middleman**,* Science & Technology Facilities Council - STFC, UK

The EPAC facility currently under construction at the STFC Rutherford Appleton Laboratory is a new UK national facility that provides a unique opportunity to develop laser driven accelerator research, enabling a plasma wakefield accelerator facility with multi-GeV electron beams and spatially coherent x-ray and gamma-ray beams for cutting-edge experiments in plasma physics, laboratory astrophysics and condensed matter and material science.

This paper describes the design of the vacuum systems for Experimental Area 1 of the EPAC facility where high intensity lasers interact with a high density of gas molecules to ignite a plasma. The EPAC facility will run in the High Vacuum (HV) range with a typical operating pressure of 10^{-6} – 10^{-7} mbar. However, at the interaction point where the plasma is ignited there will be a gas injection nozzle that will provide the required gas density. It is anticipated that the expected gas pressure at the interaction point could be in the range of 10^0 – 10^2 mbar.

The vacuum design is presented showing what has been done to minimise the spread of the localised high-pressure gas from the target location into the laser delivery beamline. This is essential to avoid laser breakdown and non-linear effects occurring before the laser reaches its peak intensity at the focus. The differential pumping configuration will be explained and there will be an overview of the gas dynamics work done across the pressure regimes from transitional flow to molecular flow.

The outcome of this work is a vacuum system capable of the demands put upon it from localised gas densities to the performance of the laser optics in delivering the required laser intensities. It is anticipated that this new UK user facility will open in late 2026.

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