Recent developments in surface conditioning measurements and vacuum simulations

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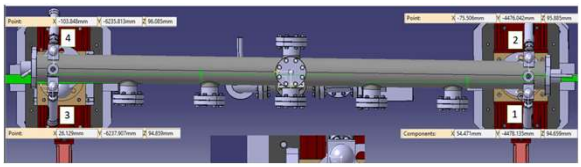
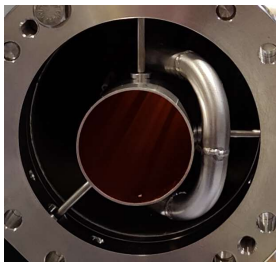
FCC-BESTEX beamline

The beam screen test bench experiment (BESTEX) is a beamline installed at the KARA synchrotron at KIT, to measure the photo-stimulated desorption (PSD) of beam screen and beam pipe prototypes for the FCC-hh and FCC-ee.



3D model of BESTEX used for alignment of sample in the beamline.

Samples are placed to intercept the SR at grazing incidence angle over a distance of 1.8 m. Bayard-Alpert gauges and an RGA are used to measure the resulting pressure increase, and determine the desorbed gas species. From this, the PSD (molecules/ph) can be calculated and the surface conditioning curves are obtained.
At the same time, photoelectron generation is monitored by applying a voltage on an electrode located at the center of the beam screen.



End view of 1.8 m long sample.

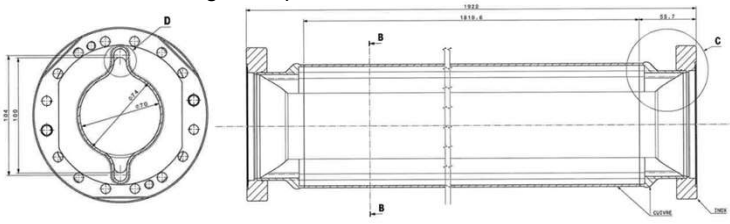
FCC-hh beam screens

Currently installed is a Cu beam screen prototype with sawtooth geometry. Measurements are planned for the period of KARA user operation at the end of June 2023.
The following sample will be Cu coated with approximately 150 nm Ti + 100 nm C. The SEY of the coating has been measured to 1.07 at 300 eV.

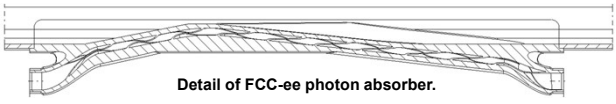
Cathode used for Ti + C deposition on the next FCC-hh beam screen prototype. Credit to P. C. Pinto and his team, in particular S. Fiotakis for making the coating.

FCC-ee beam pipe

Preparations for PSD measurements of an FCC-ee beam pipe prototype are underway. The sample will be a 1.8 m long fully NEG-coated beam pipe of Ø 70 mm (excluding winglets), mated to a stainless steel flange compatible with installation in BESTEX.



Illustrations of FCC-ee beam pipe prototype.



Detail of FCC-ee photon absorber.

We wish to thank the personell at the KARA synchrotron for their hospitality, assistance and collaboration. Particularly Dr. Robert Ruprecht and the KIT vacuum team are instrumental in the continued successful operation of BESTEX.

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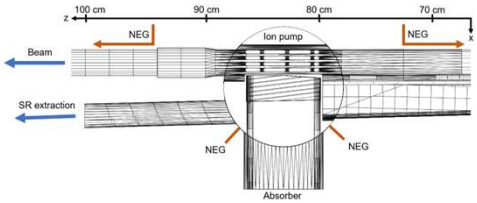
VacuumCOST

Vacuum chamber conditioning and saturation simulation tool (VacuumCOST) enables open-source time-dependent simulations of vacuum systems in molecular flow by providing the framework for automatically running repeated simulations through the MolFlow command-line interface.

VacuumCOST can be used to simulate pressure evolution in the various accelerator regions, taking into account both surface conditioning and saturation of NEG-coated regions. In addition, other effects such as the impact of leaks can be investigated.

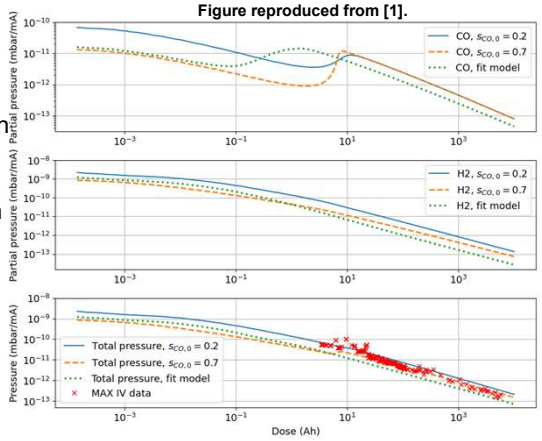
Code validation

VacuumCOST has been used to simulate the NEG-coated region near a crotch absorber in the MAX IV synchrotron



Details of simulated crotch absorber region in MAX IV. Figure reproduced from [1].

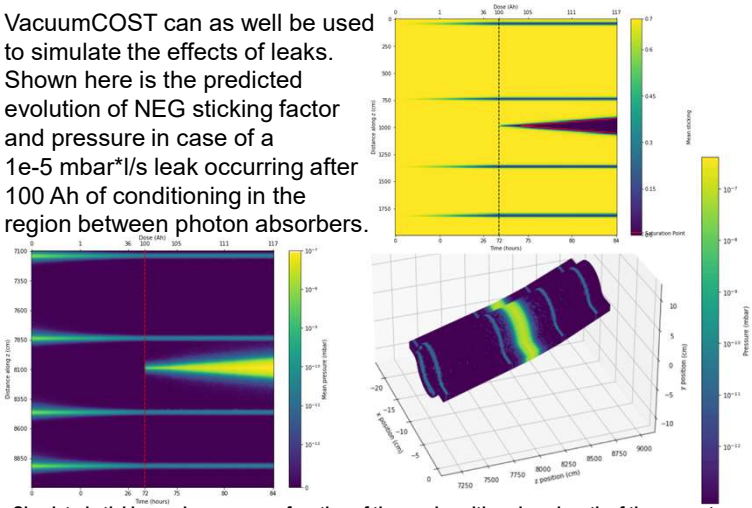
Depending on the model chosen for evolution of NEG-sticking as function of pumped molecules, the pressure evolution predicted by VacuumCOST closely matches the measured pressure at MAX IV.



Pressure evolution as function of dose. Figure reproduced from [1].

Simulating a leak in the FCC-ee beam pipe

VacuumCOST can as well be used to simulate the effects of leaks. Shown here is the predicted evolution of NEG sticking factor and pressure in case of a 1e-5 mbar*l/s leak occurring after 100 Ah of conditioning in the region between photon absorbers.



Simulated sticking and pressure as function of time and position along length of the geometry.

[1] P. L. Henriksen, M. Ady, R. Kersevan: Vacuum chamber conditioning and saturation simulation tool (VacuumCOST): Enabling time-dependent simulations of pressure and NEG sticking in UHV chambers. Vacuum Volume 212, June 2023, 111992. DOI: 10.1016/j.vacuum.2023.111992

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