Instrumentation Front-End at NSLS-II

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Abstract

The Instrumentation Front End (IFE) is the upstream end of a R&D beamline at NSLS-II for testing new design concepts needed for the future upgrade of NSLS-II and other accelerator facilities. The IFE utilizes a refurbished U68 planar undulator as the source of high intensity synchrotron radiation (x-rays). The main components of the IFE are the undulator source, a fixed mask, two slits with integral XBPMs, and a test photon shutter. The first planned test will establish thermal fatigue design criteria for a copper alloy, CuCrZr, adopted recently for most of the high-power beam stops and slits. A beam stop of Soleil-II (France) made from powder CuCrZr will also be tested for its thermal fatigue life. Another planned test will evaluate a new XBPM design that will help improve the X-ray beam stability. In the second phase the IFE will be extended to a test beamline on the experimental floor. This poster serves to showcase its main features and capabilities, and present future possibilities.

Primary Capabilities & Goals

The purpose of this instrument is to test new design concepts, materials, thermal fatigue life, and radiation resistance of various components.

- Absorbers, masks and slits → To develop compact and cost-effective designs
- XBPMs → To develop high-resolution designs to improve beam stability
- Optical Components → To test scintillator materials and detectors
- New materials → R&D for thermal fatigue (CuCrZr), outgassing
- Radiation hardness of materials (PMQ's)
- Radiation protection configurations (Shadow shields vs. collimators)
- To verify accuracy of ANSYS thermal modeling methods
- To enhance the performance of front ends of NSLS-II and NSLSII-U
  - Establish high beam current limit for FE components
  - Improve beam stability by using upgraded, novel XBPMs
  - Reduce the cost of front ends
- R&D on Electron-Ion Collider vacuum chambers
- R&D for high performance beamlines (Phase 2)
- Develop/maintain expertise

Planned Tests

- **Thermal-cycling CuCrZr test body / Advantages of using CuCrZr**
  - CuCrZr is a hard copper alloy. It remains hard at temperatures < 400° C
  - Compared to GlidCop it is inexpensive (20% the cost of Glidcop) and is readily available (1-week vs 6-months)
  - CuCrZr can be welded to itself or SS304, thus eliminating the brazing step
  - Many CuCrZr components have been fabricated and are in-use in facilities around the world
  - Vacuum-sealing knife edges are machined in the bodies (BNL patent – S. Sharma)
  - The thermal-fatigue life of these components is not well understood
  - For 30,000 thermal fatigue cycles, CuCrZr is expected to withstand the same maximum temperature (350° C) as Glidcop. The IFE will help establish new design criteria for CuCrZr
- **Slit-mounted XBPM's**
  - Using the protection of the slits (already included in front-ends), tungsten blades of the XBPMs can be positioned very close the center of the beam, thereby providing a much higher signal/noise performance
  - The tungsten blades are brazed onto cooled copper rods and protrude only 25 microns beyond the slit body tapered surfaces
  - The XBPM head is electrically isolated using a ceramic break
- **Soleil-II powder CuCrZr beam stop**
  - This design has been submitted and is being reviewed for suitability. The objective is to test the thermal fatigue limits of *powdered* CuCrZr for use as an end-of-the-line beam stop (burn-thru)

Future Tests

- **Photon Desorption Studies**
  - U68 will produce ~ 5e18 photons/sec (as calculated by O. Chubar)
  - The flux is 10 times higher than that delivered by a 3PW
  - Desorption studies for EIC can be done in ~23 days in IFE as compared to ~ 290 days in 14-BM front end
- **Radiation Hardness Testing**
  - Evaluate radiation resistance of permanent magnet materials
    - A prototype of the Halbach CF PMQ will be installed and left for 2 years to observe any effects on the harmonics
  - Investigate radiation tolerance of new sensor materials and electronics for hard x-ray detectors
- **X-Ray BPM Development R&D**
  - Development effort in progress for an in-house design of an X-ray beam position monitor
  - Can be optimized for enhanced S/N ratio and thermal efficiency
  - Readout electronics developed, implemented, and supported in-house
  - Facilitate capability to continue development of next-generation XBPM Electronics
  - Collaboration with sister institutions for XBPM detector development, and electronics systems development
  - Explore options to implement Photon Feed-back
  - IFE would provide a suitable location to adequately test a new design
- **Emittance Monitor Development R&D**
  - There is a pervasive problem with the emittance measurement at the 3-pole wiggler location that does not agree well with the measured emittance at the BM-A source or the theoretical emittance
  - Ongoing R&D is required to develop alternative solutions for emittance monitors
  - A 3rd pinhole camera can potentially be installed in the IFE using the ID (U68) as a source
- **X-Ray Beam Profile Monitor development (X-ray Flag)**
  - The IFE is ideally suited for testing new designs, new scintillator materials and new optics (e.g., Beam Loss Monitors)
- **Proposal for Experimental Hutch – Phase 2**
  - Instrumentation Front End will be converted to a fully functional front end
  - Will require some additional components, two shadow shields, two safety shutters, a photon shutter, and a ratchet wall collimator
  - Will provide beam time for collaborations across the DOE complex, with universities and industry for the development and innovation of a number of devices including monochromators, mirror benders, and development and testing of detectors
  - Provide a platform to perform calibrations of beamline instrumentation in aspects that require at-wavelength metrology, or require actual beamline conditions such as flux, spectral bandwidth, delivered power or source size
  - Allow developing in-situ metrology techniques, to be used as an in-situ diagnostic in user-oriented beamlines

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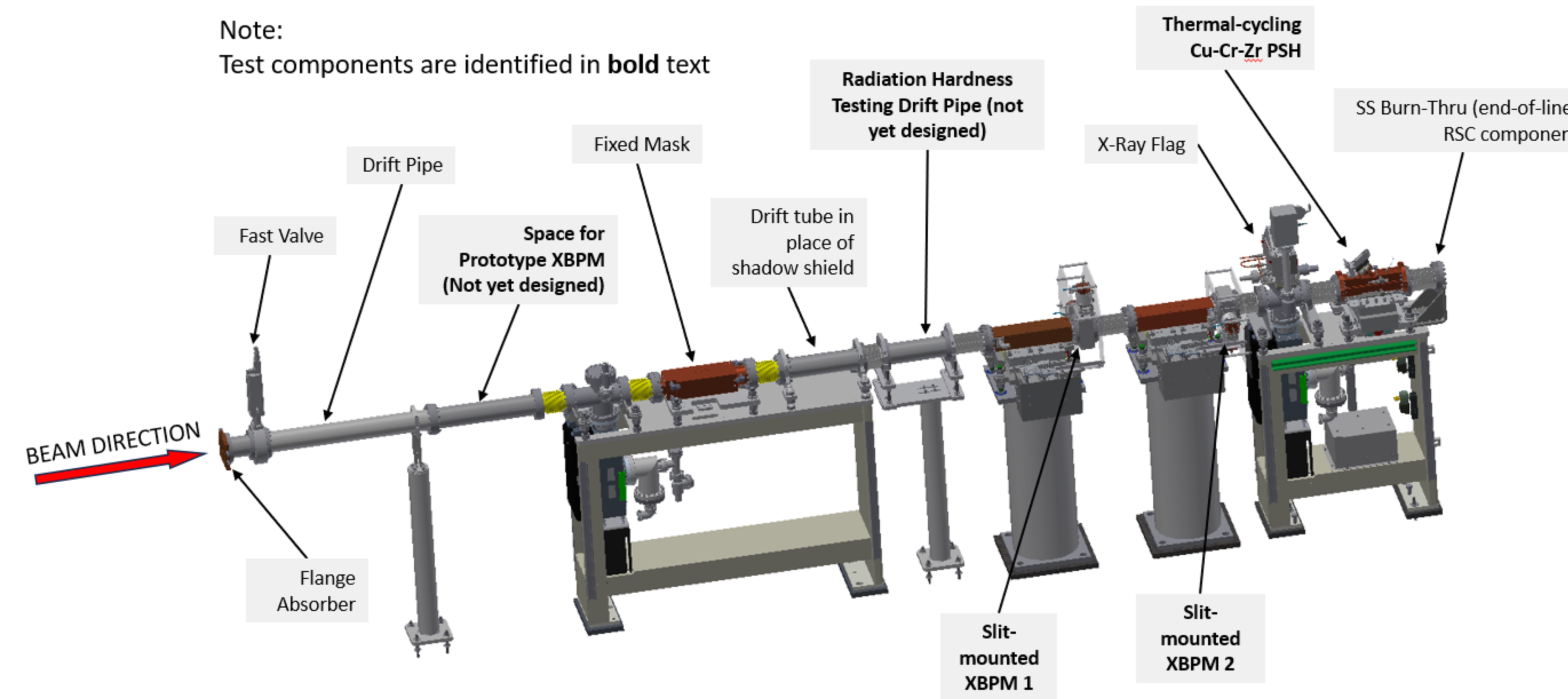
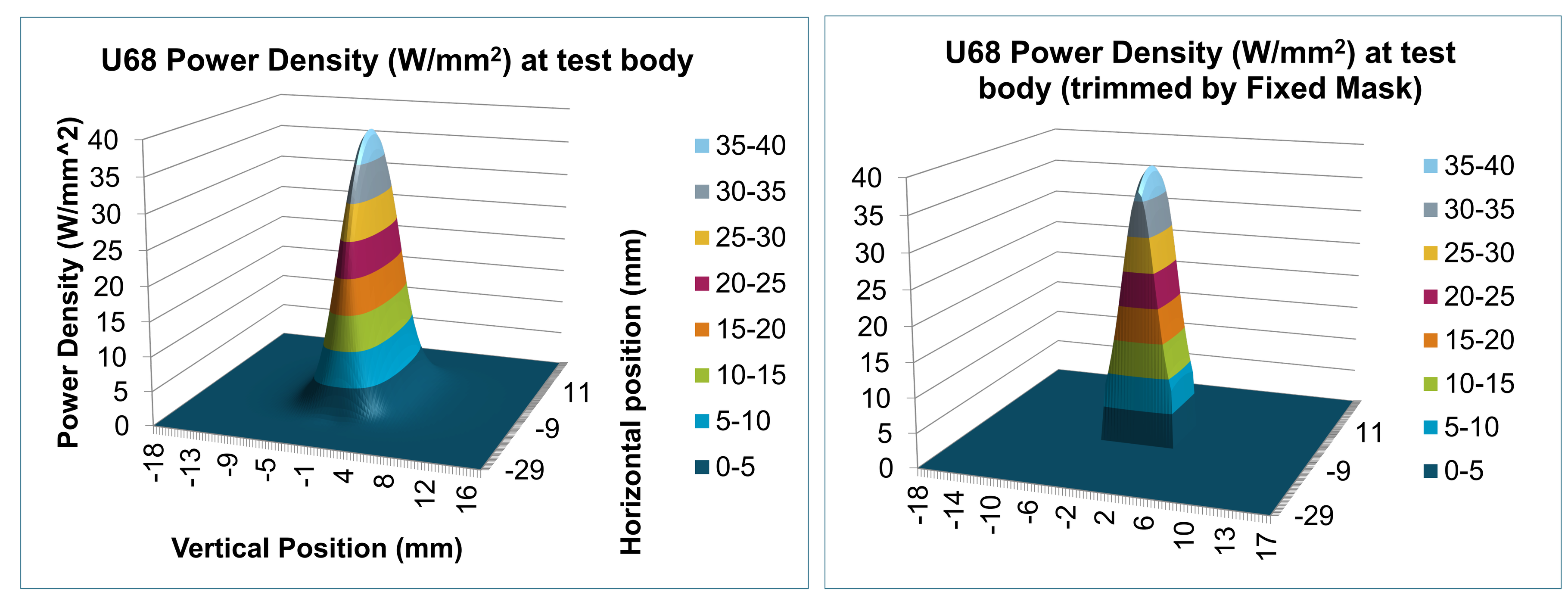
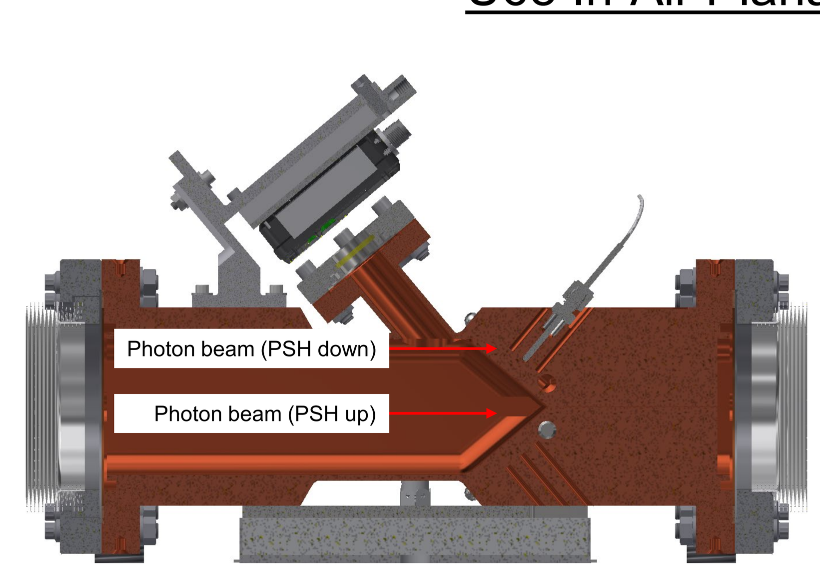


Instrumentation Front-End Layout

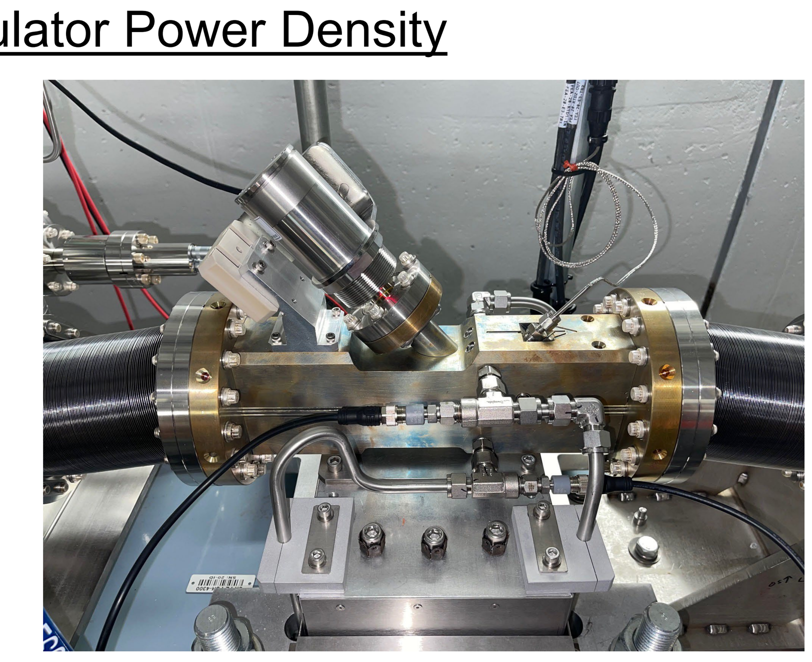


U68 power density (**~16 kW/mrad²**) is smaller than the nominal power density for a typical front end (100 kW/mrad²). Total Power = **~5.2 kW** @ 500 mA

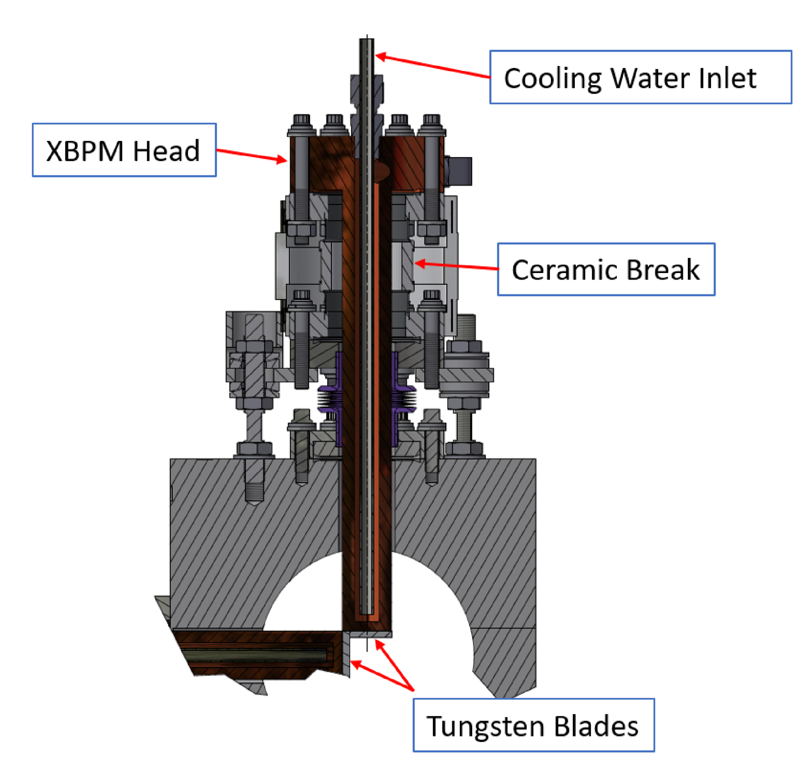
U68 In-Air Planar Undulator Power Density



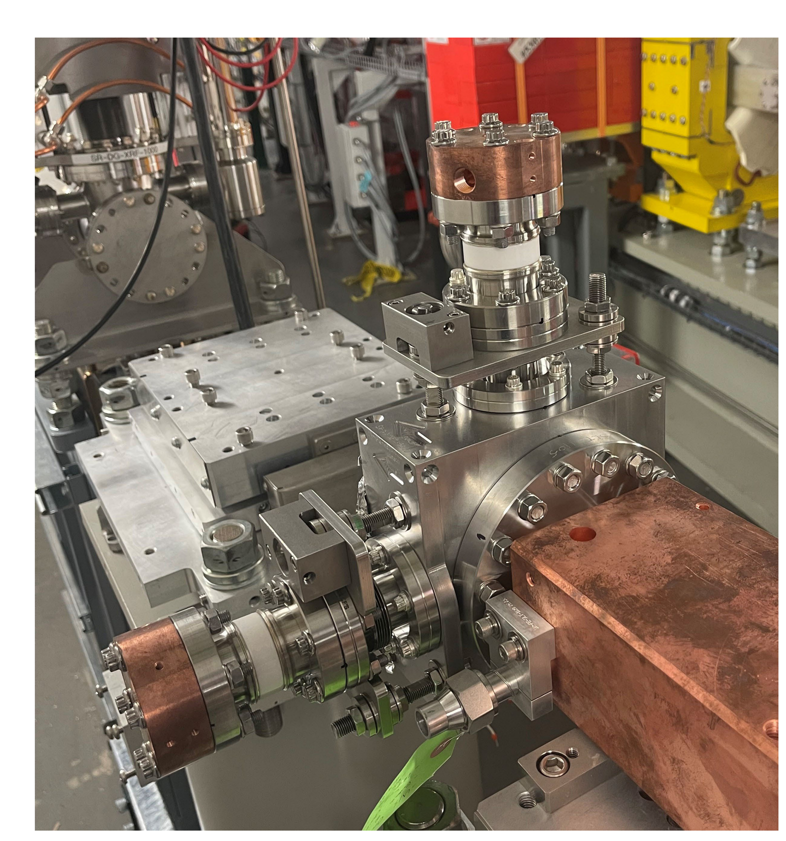
CuCrZr thermal-cycling test body



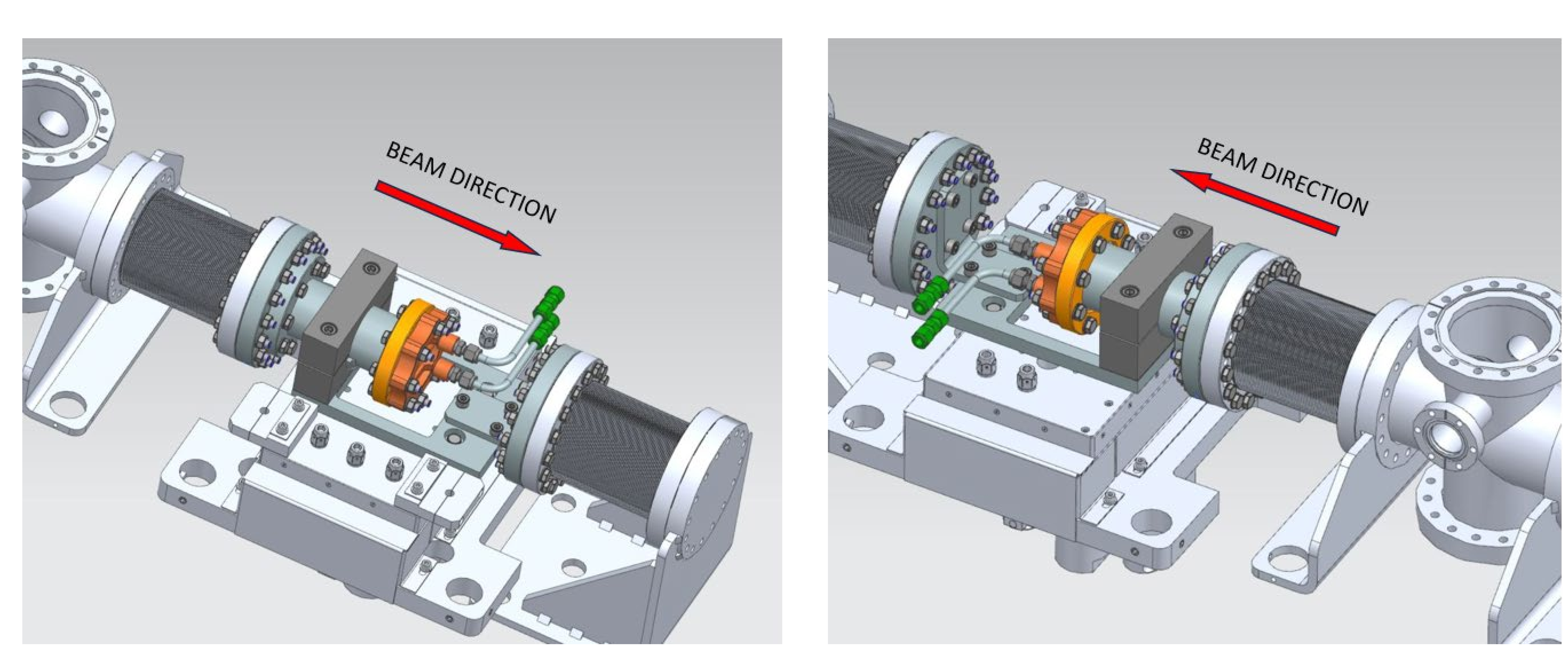
Installed CuCrZr thermal-cycling test body



Slit-mounted XBPM design



Installed Slit-mounted XBPM



Soleil-II Powder CuCrZr Beam Stop

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