# Superconducting Undulator Alignment Strategy at APS*

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## Abstract

The first prototype superconducting undulator insertion device, SCU0, (Figs. 2 -3) has been assembled at Argonne National Laboratory and is currently undergoing rigorous testing before installation at the Advanced Photon Source (APS) . This poster describes the alignment strategy for the SCU0.

## Introduction

The shorter undulator period length made possible by superconducting technology is an attractive option for APS users who seek high brilliance at higher photon energies (20–25 keV in the first harmonic).

This poster outlines the strategy and methods proposed for the alignment of the APS SCU0 within specified tolerances. Optical tooling in combination with a laser tracker is the technology of choice (Fig. 4). Although the alignment process is relatively straight forward, there are two challenging issues that remain to be investigated and rigorously tested; a) the stability and repeatability of novel Kevlar band suspension system (Fig. 1) and b) the impact of cryogenic cooling on the shape and position of the SCU0 vacuum chamber within the reference framework of the vacuum vessel.

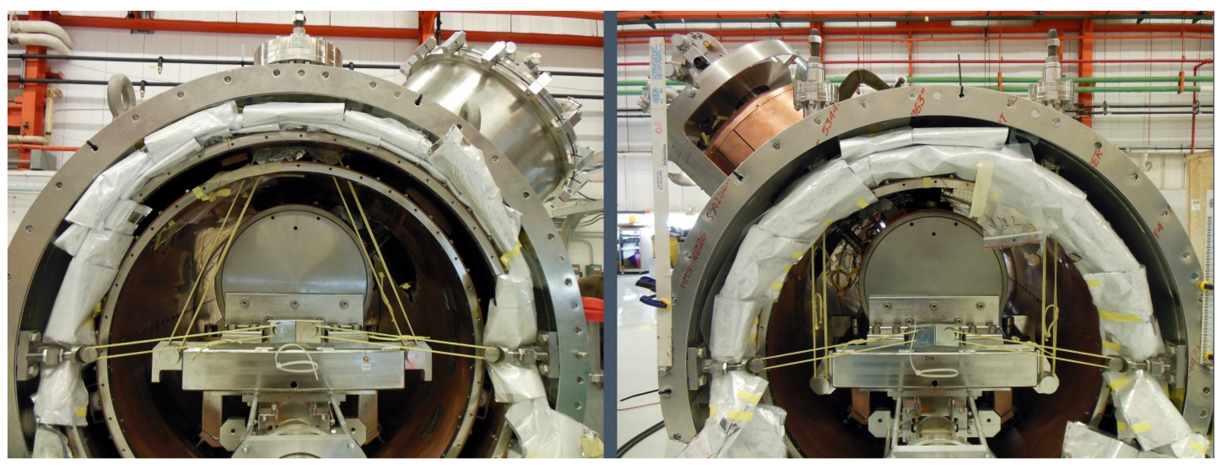

**Figure 1**. Kevlar band suspension system.

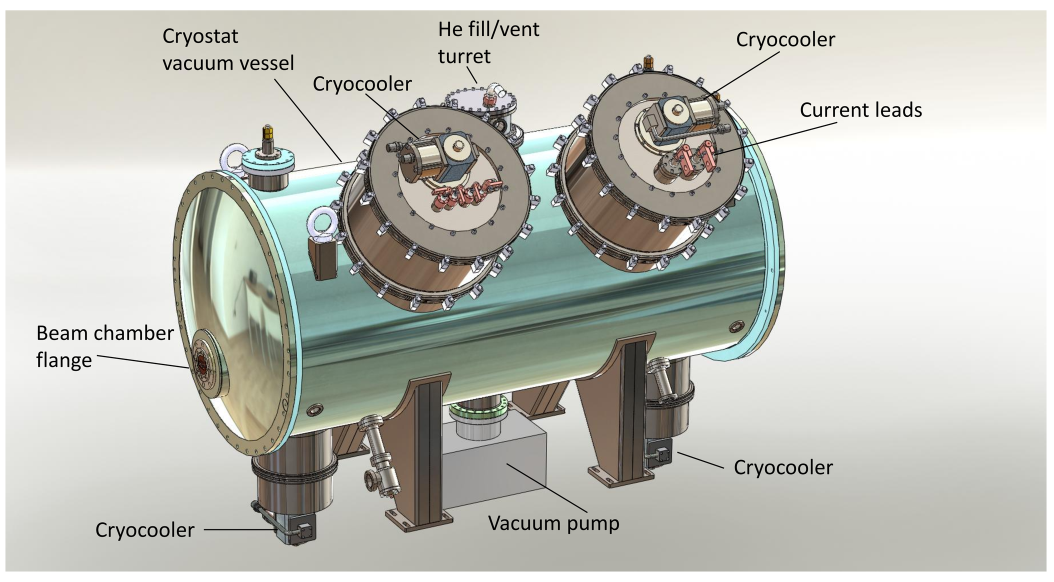


**Figure 2**. Cryostat.

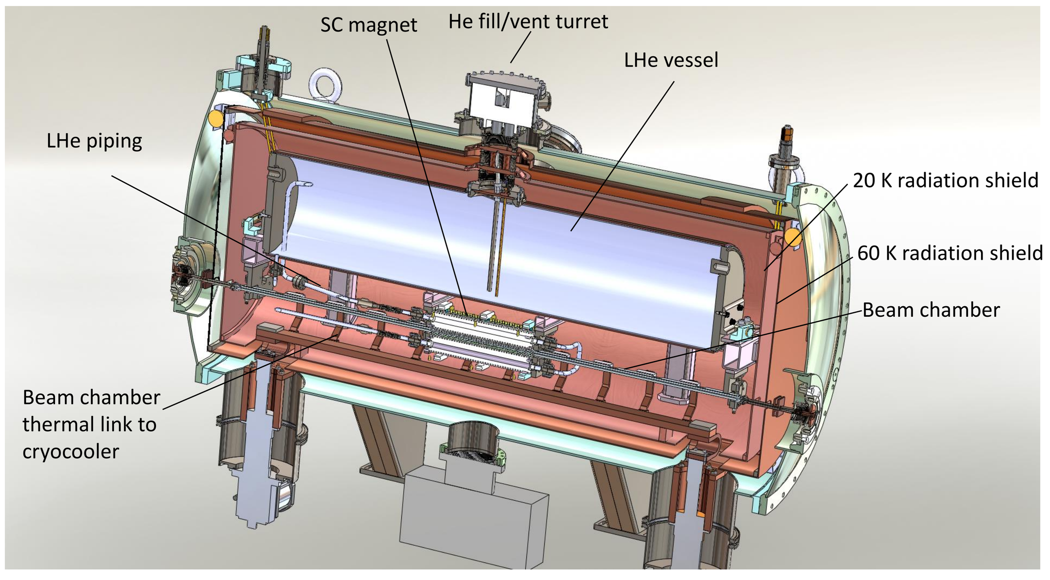


**Figure 3**. Cryostat cross section.

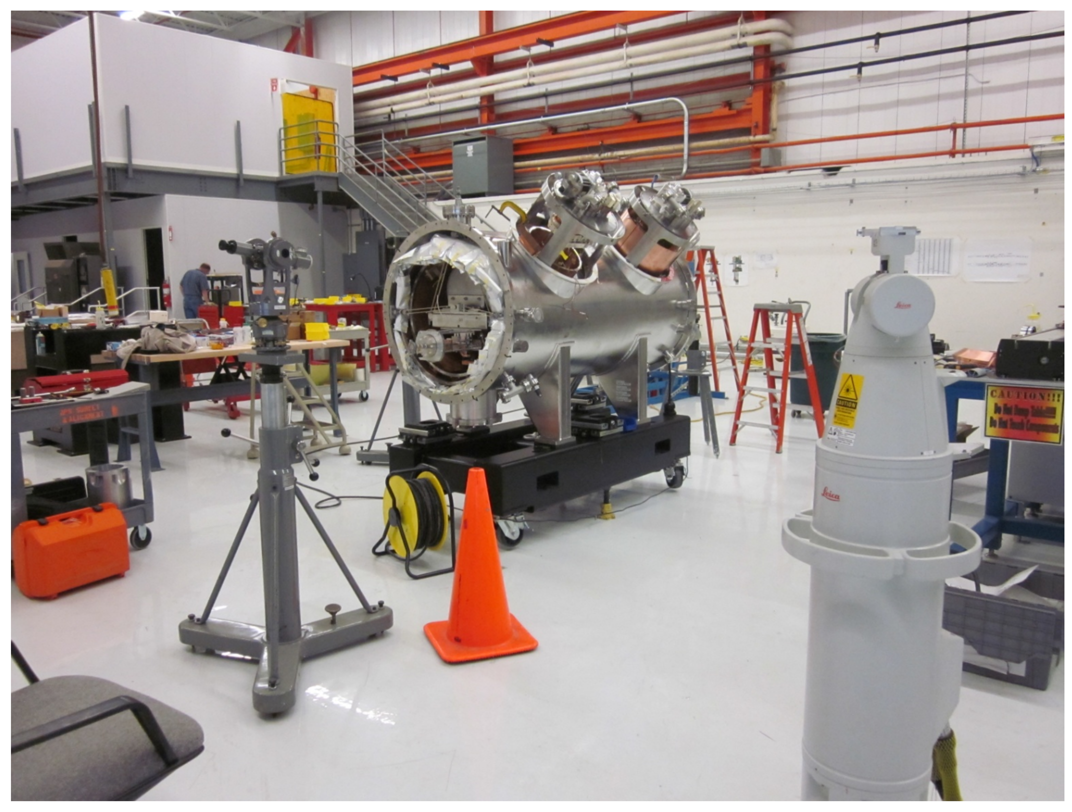

**Figure 4**. Optical tooling in combination with the laser tracker.

## Assembly and Fiducialization

1. Starting with the support frame resting on a flat surface in an upside down position, the magnet structure and vacuum chamber will be assembled and aligned to ±75 microns using conventional optical tooling methods (Fig. 5).

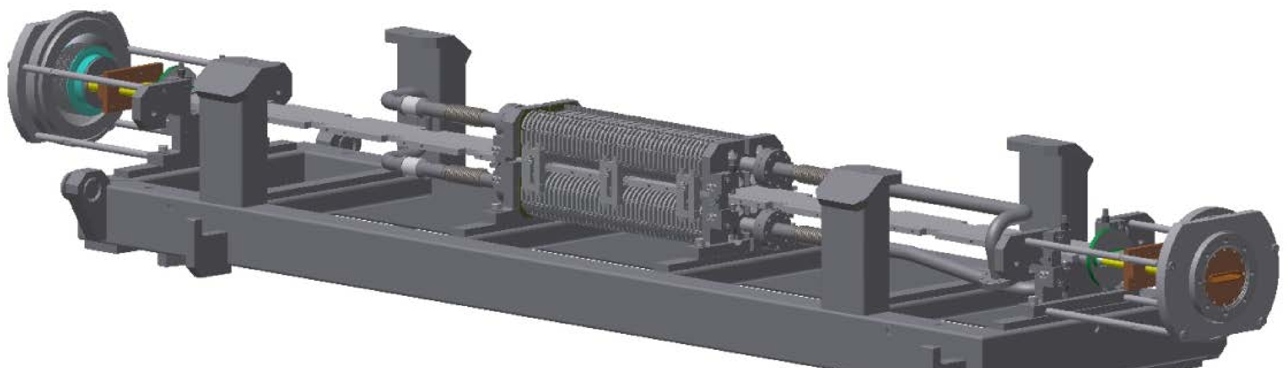

**Figure 5**. Magnet structure - vacuum chamber assembly.

2. The support frame will then be turned over and oriented in the upright position for installation of the helium tank. Then the vacuum chamber assembly will be fiducialized using A, B, C, D fiducials on top of the support frame (Fig. 6). These fiducials are precisely machined to fit both the laser tracker and optical targets (Fig. 7). 3D coordinates will be obtained by combining optical and laser tracker measurements.

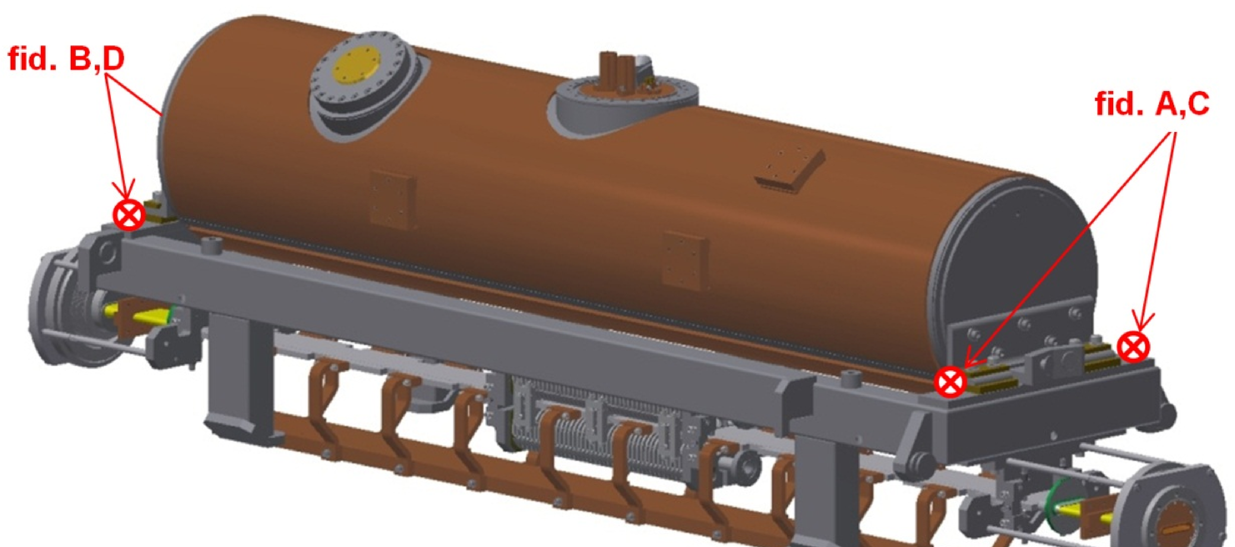


**Figure 6.** Cold mass assembly.

**Figure 7**. 0.25" Fiducial targets.

3. After fiducialization, the cold mass assembly will be lifted onto the assembly fixture and the 20 copper thermal links will be fastened to the vacuum chamber (Fig. 8).

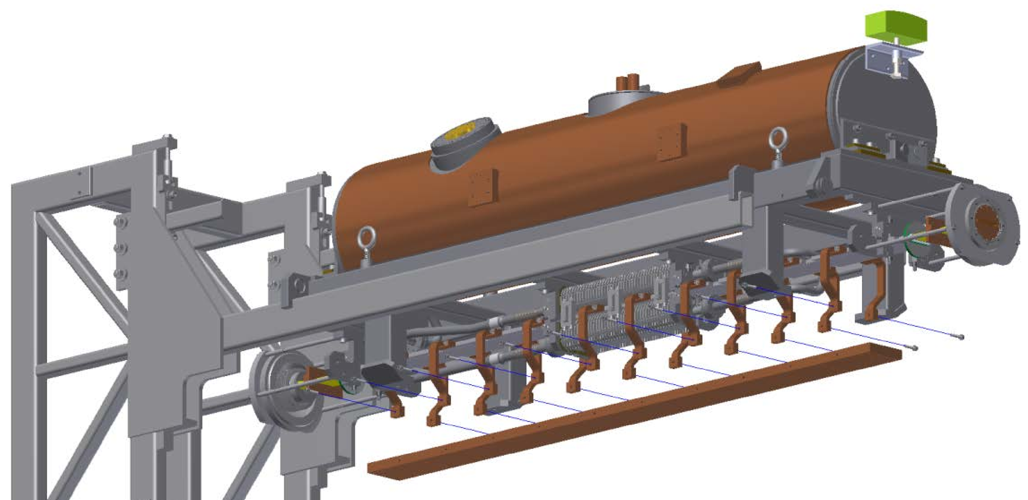

**Figure 8.** Cold mass assembly fixture.

4. The vacuum vessel is moved onto the cold mass and aligned. The position of the cold mass within the vacuum vessel assembly will be adjusted using the Kevlar suspension bands (Fig. 1), while the coordinates of the vacuum vessel fiducials E, F, G, H and cold mass fiducials A, B, C, D are monitored with the laser tracker (Fig. 9). Throughout the process the optical level and four additional vertical fiducials J, K, L, M on the top of the vacuum vessel will be used to supplement the laser tracker data and improve the accuracy of the vertical alignment.

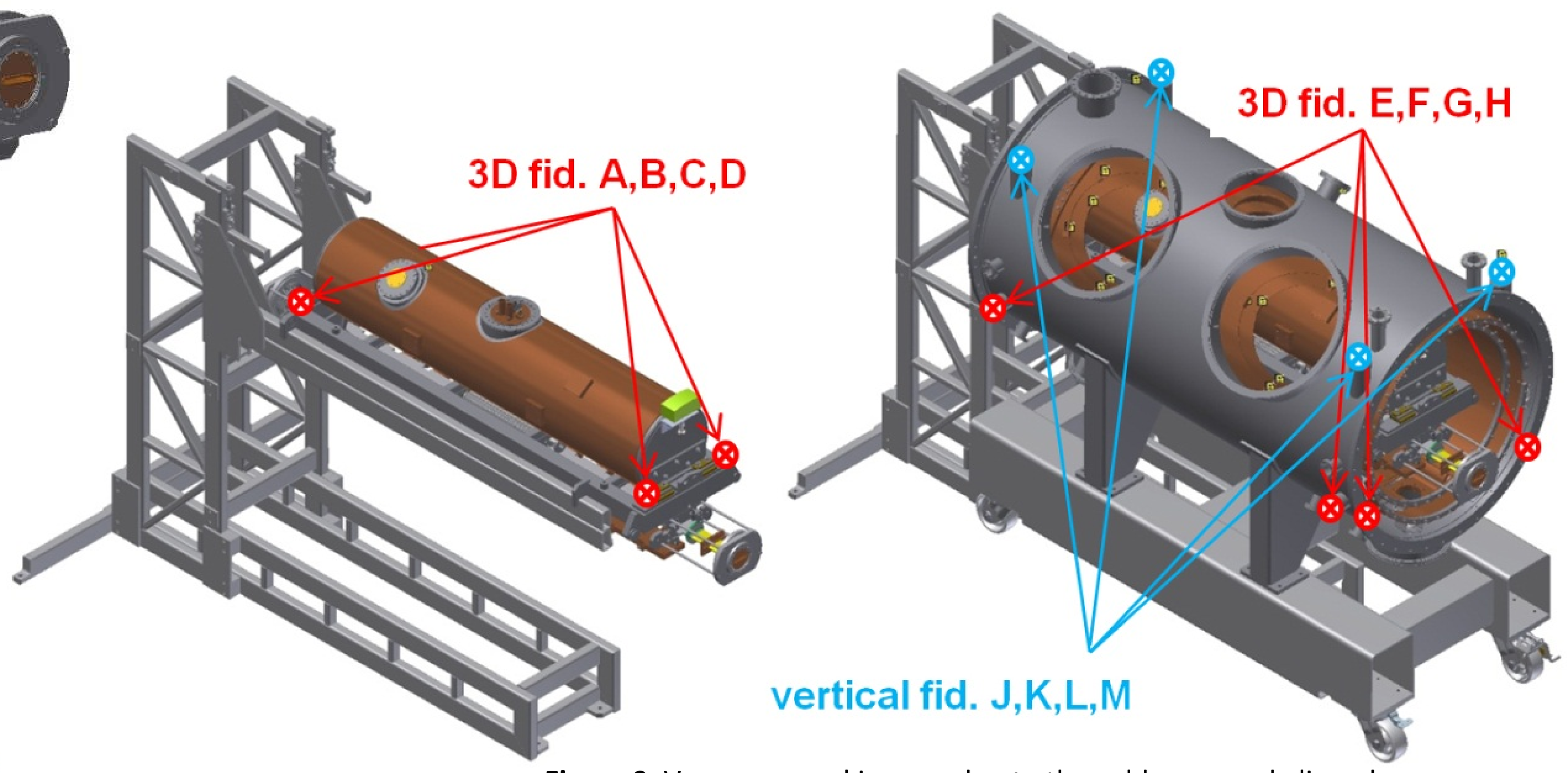


**Figure 9.** Vacuum vessel is moved onto the cold mass and aligned.

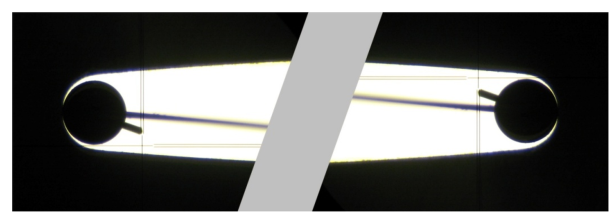

**Figure 10.** Spherical target inside the prototype of the SCU0 vacuum chamber. Test photographed through the alignment scope of the optical level.

## Cooling Displacement Test

The SCU0 will be positioned in the storage ring using fiducials of the vacuum vessel. Prior to positioning, a series of cooling displacement tests will be conducted. This is done by performing assembly and alignment at room temperature. The SCU0 will then be subjected to the a cooling process while displacements are monitored and quantified. The straightness of the vacuum chamber must be verified as well. Since no more cold mass fiducials are visible at this point, the aperture of the vacuum chamber will be monitored through the glass viewports. This is done using series of spherical target pairs that will be placed in the chamber at 12-inch intervals. The pairs of sphere targets are "spring-loaded" with stiff wire and engage the cylindrical profile of the chamber in the horizontal plane (Fig. 10). By observing the top and bottom edges of the spheres not only location but also the roll of the chamber can be measured both in the warm and cold state.

## Kevlar Suspension System Test

The cold mass is attached and aligned to the vacuum vessel via the Kevlar band suspension system (Fig. 1). The system is stress-relieved for transportation from the assembly hall to the storage ring using four jack screws. When the SCU0 is at its final destination the jack screws will be retracted and the cold mass should return to its aligned position. The repeatability of the system must be thoroughly tested in the assembly hall before the cylindrical thermal shields are closed and vacuum vessel flanges are attached. Several cycles of engaging the jacking screws, simulated transportation, and retraction of the jacking screws will be performed while the fiducials of both the cold mass and vacuum vessel are monitored by the laser tracker and optical level.

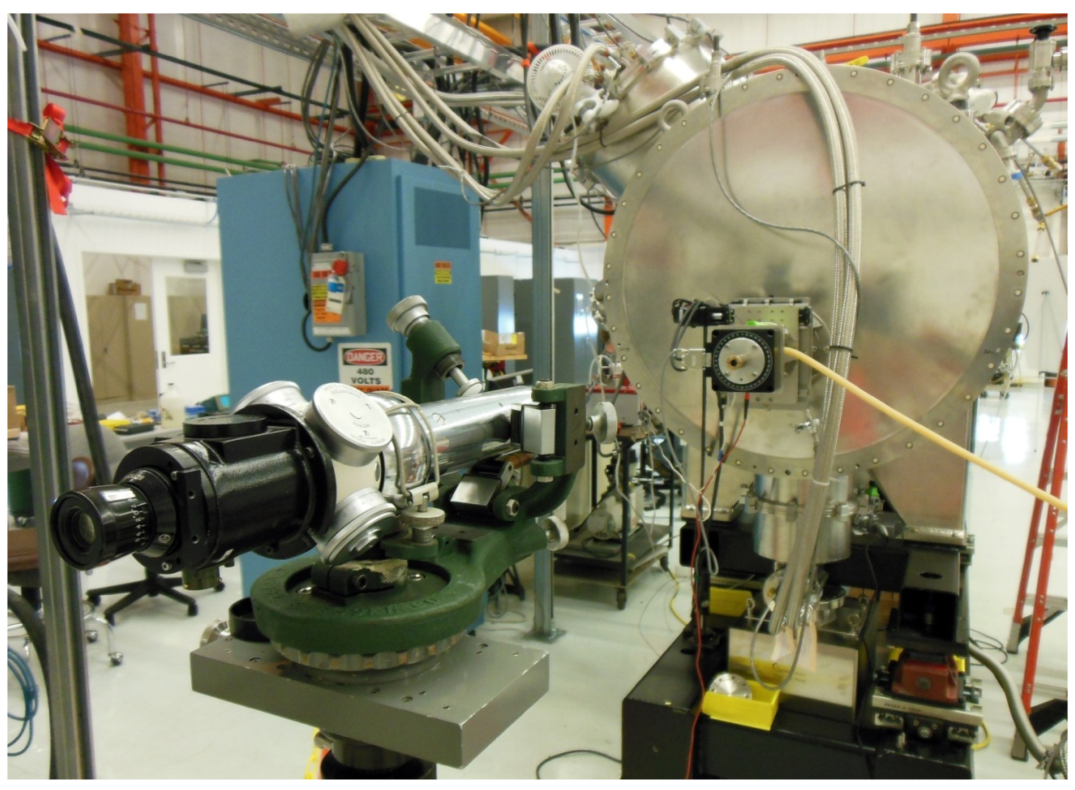

**Figure 11.** Alignment scope with dual axis micrometer monitors the Hall probe's location.

## Magnetic Mapping Alignment Support

Magnetic measurement of SCU0 is done by inserting a stainless steel tube in the vacuum chamber and aligning it to the ideal beam centerline. Also the Hall probe on its long translation stage will be aligned to the ideal centerline as established from the fiducials of the vacuum vessel. A laser tracker and optical level will be used to accomplish this task. To know the exact profile of the steel tube guiding the Hall probe, a carbon fiber tubing with a single strand of fiber optic cable placed in its center will be inserted into the stainless steel tube and used as an alignment target. An alignment scope with dual axis micrometer will be used to monitor this target traveling through the stainless steel tube (Fig. 11).

## Final Alignment in the Storage Ring

Optical tooling methods will be utilized to position the SCU0 at its ideal location. An optical level and precision transit-square will be used to achieve the ±0.150 mm x and y alignment tolerances.

A laser tracker oriented to the storage ring control network will be used to provide a redundant quality assurance check on the alignment and to map the final position of the device within the APS storage ring lattice.

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