

Radioactive Source Insertion System for the Nab Experiment

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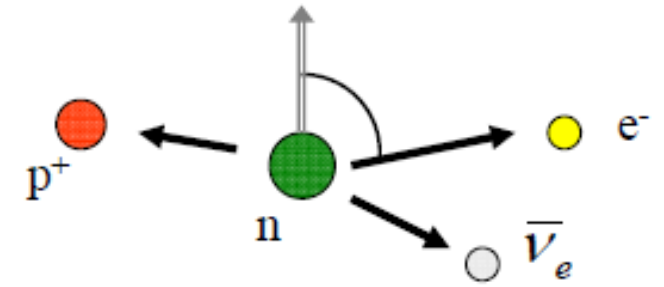
DNP Fall meeting: October-2019

Remembering Yu Qian



Yu Qian

Goals of the Nab Experiment



- Measure the Electron Neutrino Angular Correlation Coefficient (a) with an improvement to the relative uncertainty on the order of $\delta a/a = 10^{-3}$

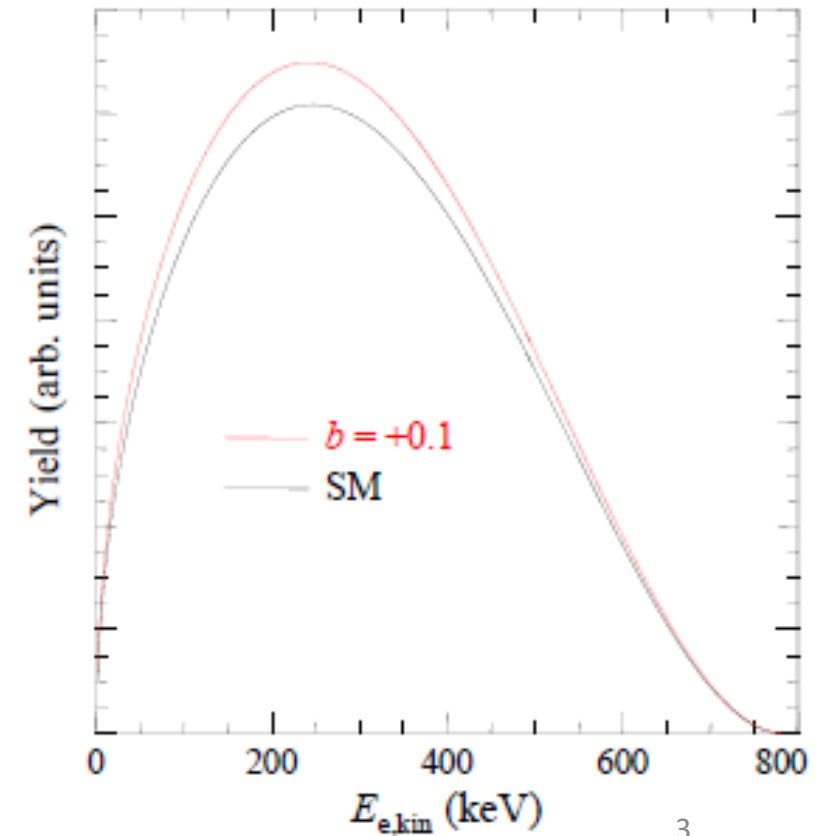
$$a \equiv \frac{1 - |\lambda|^2}{1 + 3|\lambda|^2}$$

$$\lambda = g_A/g_V = -1.2732 \pm 0.0023$$

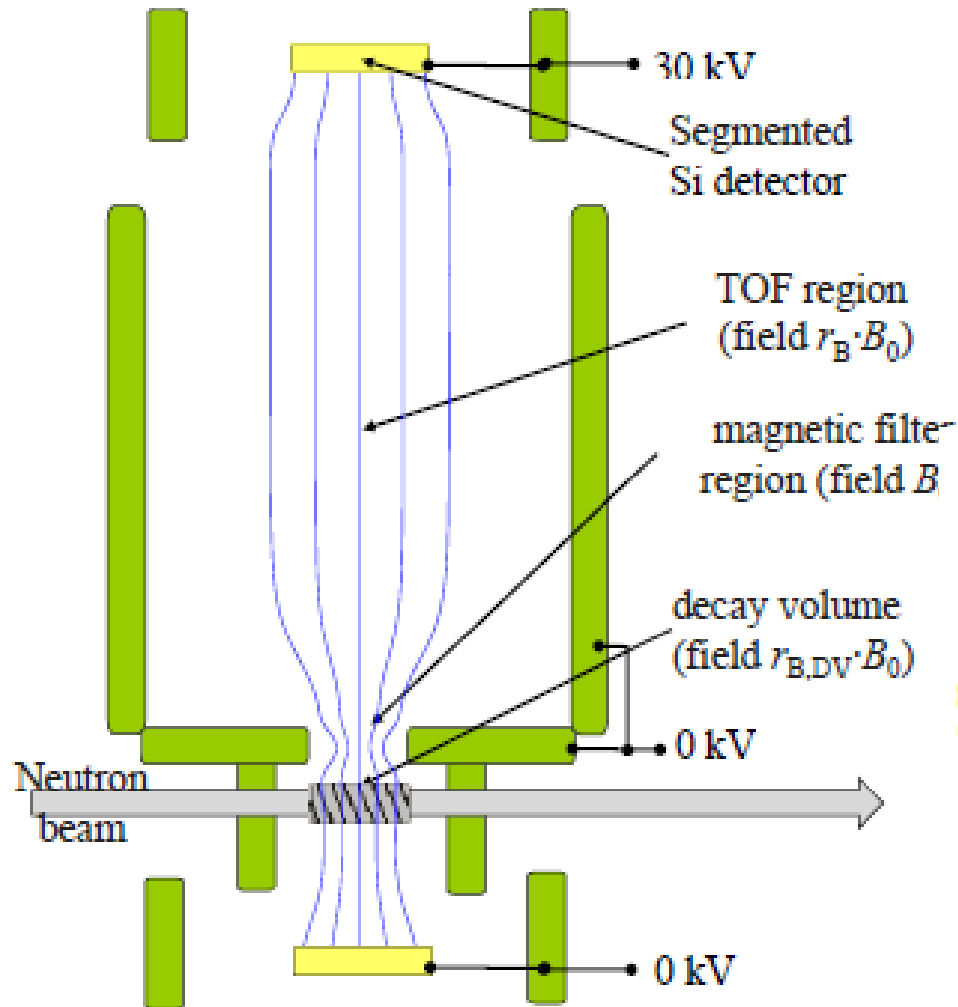
$$\Gamma = |V_{ud}|^2 |g_V|^2 G_f^2 (1 + 3|\lambda|^2)$$

- Measure the Fierz Interference Term (b) to an absolute uncertainty $\delta b = 10^{-4}$:
 - I. Measures small departure in the decay rate
 - II. Considered to be physics BSM

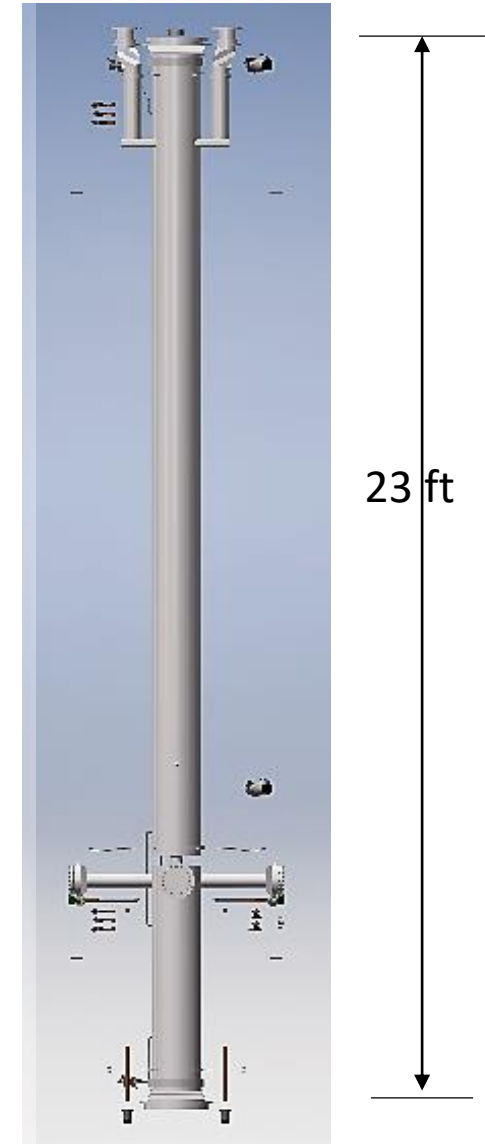
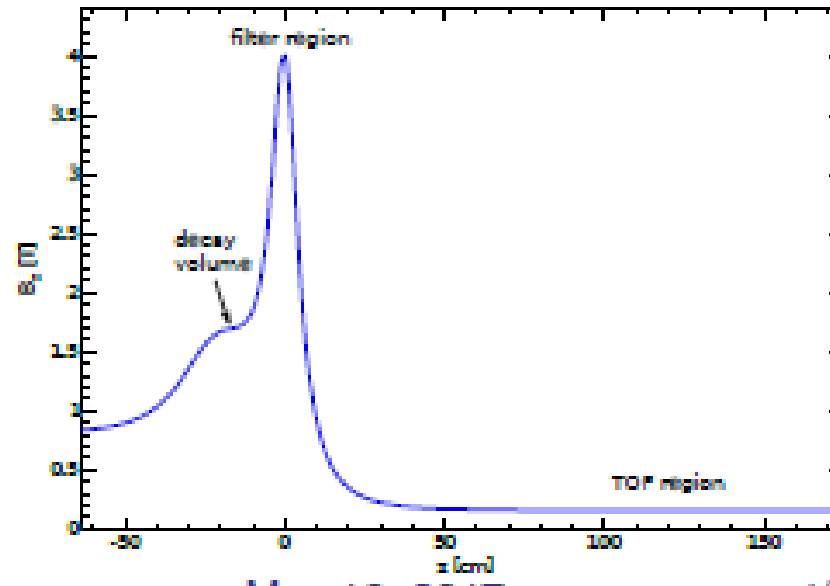
Electron spectrum:



The Nab Magnet Spectrometer

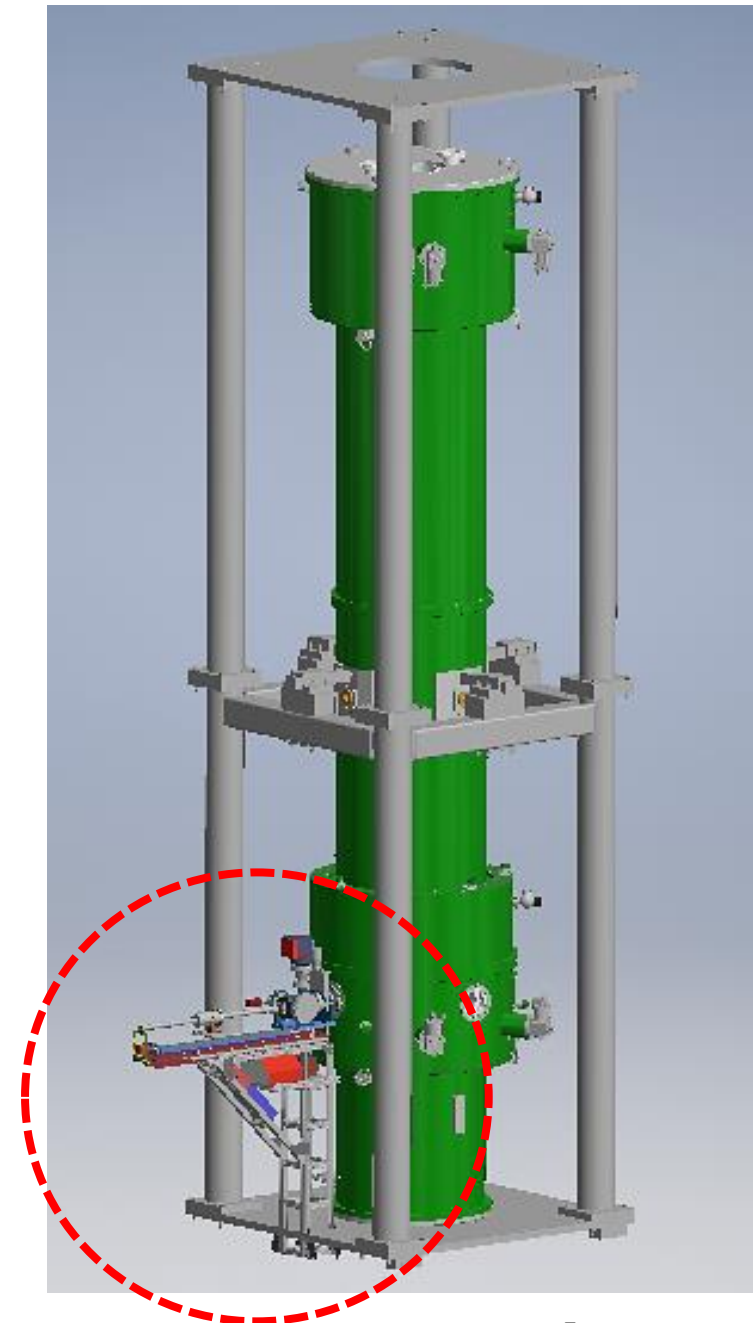
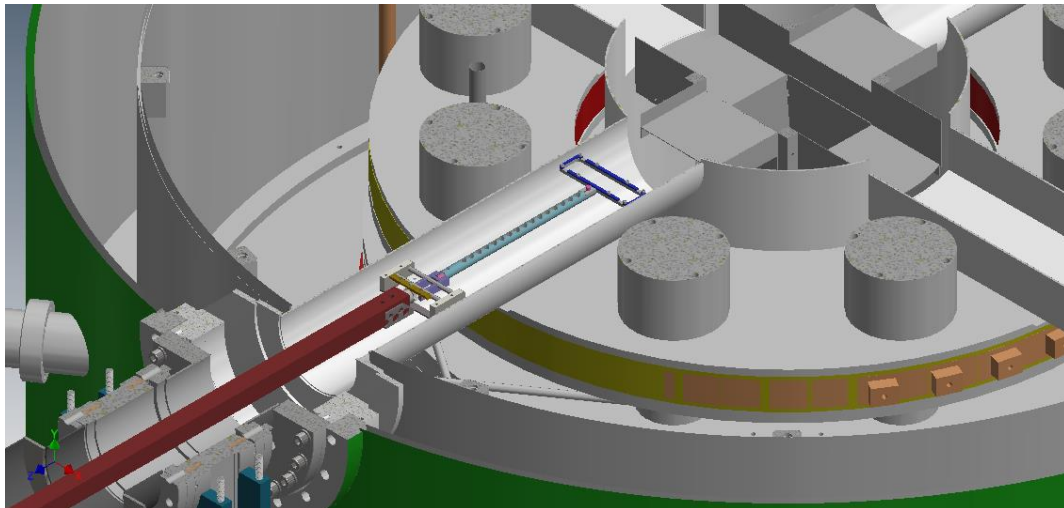


- Generates large B-fields with superconducting coils
- UHV in the inner bore at 70K



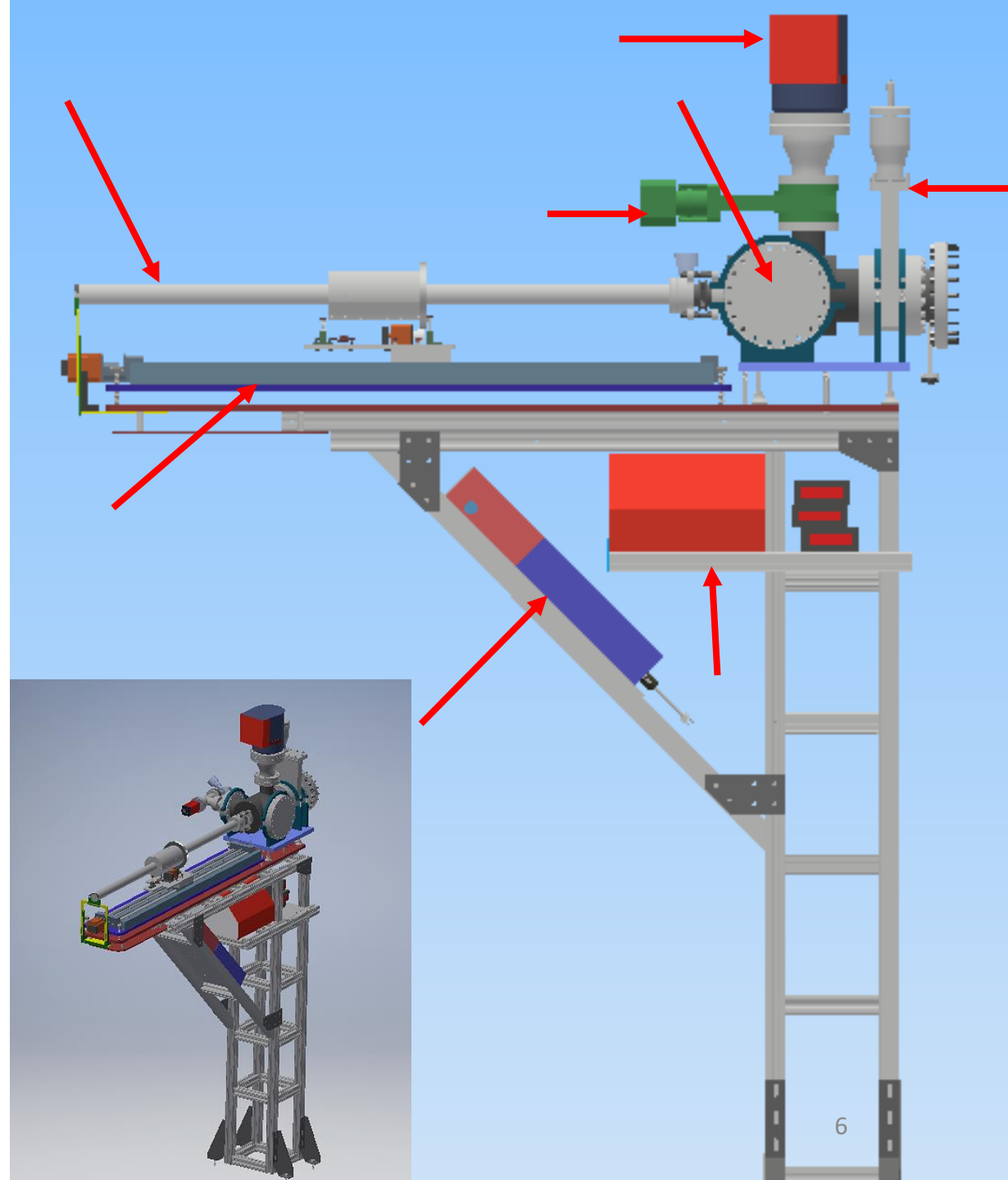
Radioactive Source Insertion System for Nab Experiment

- Complex electro-mechanical device designed to insert weak conversion-electron test sources into the inner bore of the Nab magnet-spectrometer.
- Radiological sources determine beta-response functions of individual pixels on two segmented Si detectors for evaluation of energy loss, timing, and detector calibration.
- Require precise alignment of the device to get to the neutron decay volume.

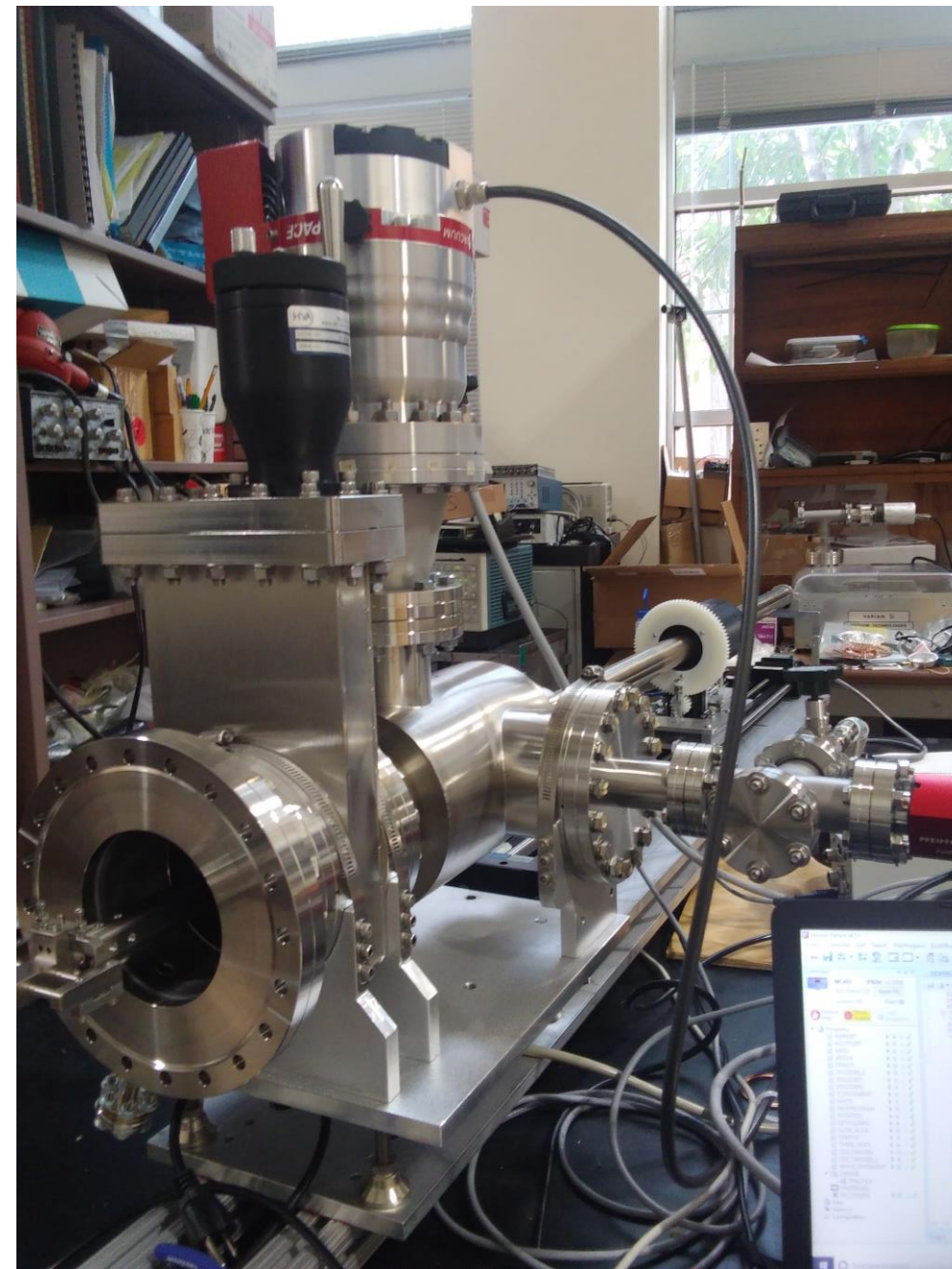
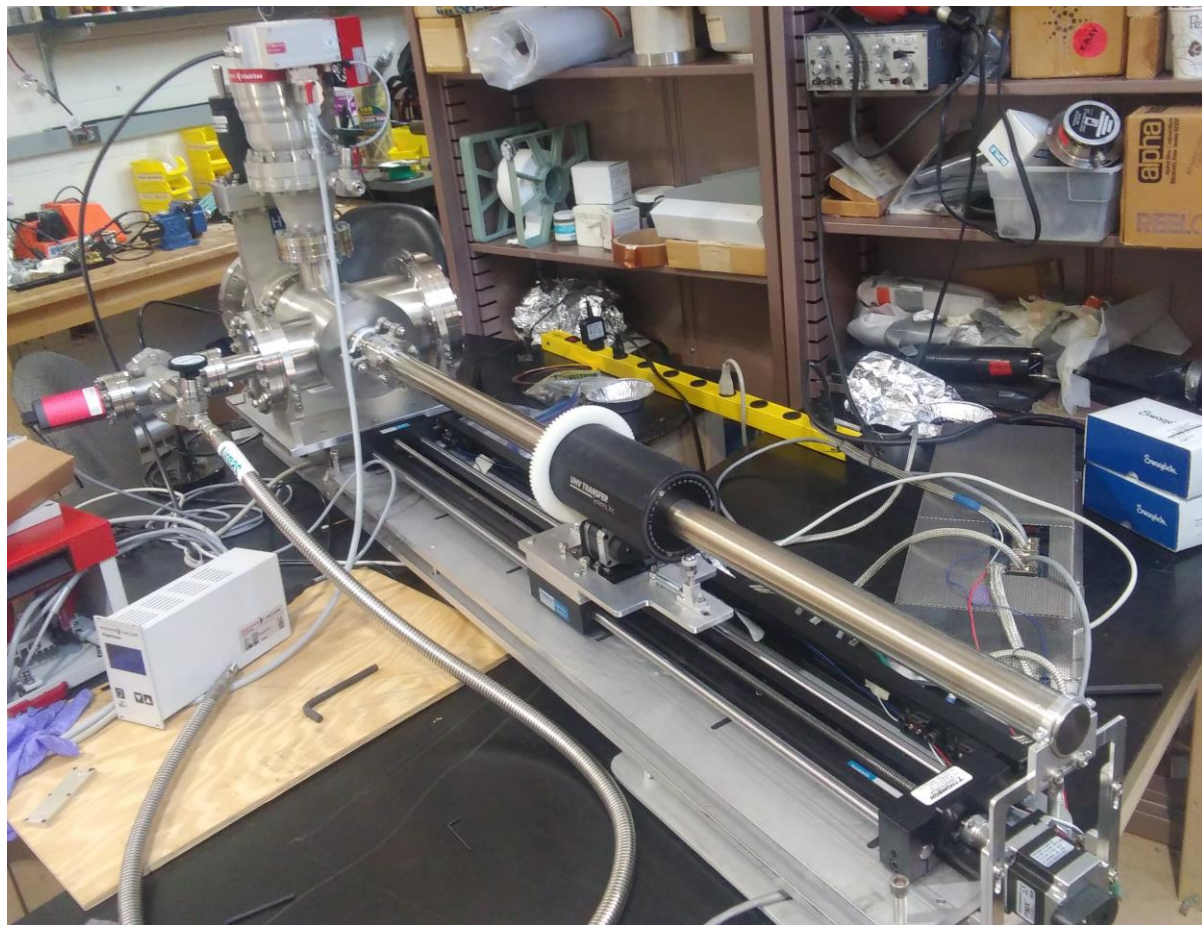


Essential Parts of the RSIS

- **Magnetic Transporter Unit**
36 inch extension arm
- **Vacuum Chamber**
Housing for radiological sources
- **Linear translation Table (X-table)**
- **Turbopump/Turbopump Station**
HiCube Eco Station with 300H turbopump
- **Electrical box(Black Box)**
Houses motion control computer and 24V DC power supply
- **Two 6 inch Gate Valves**
- **8020 support structure**

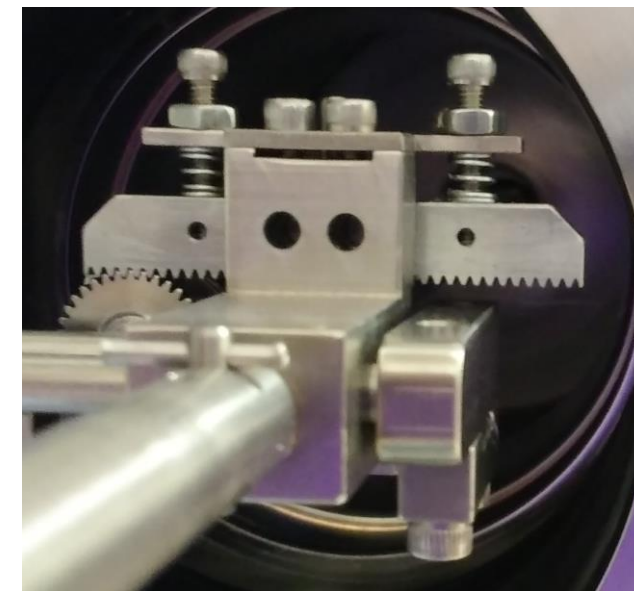
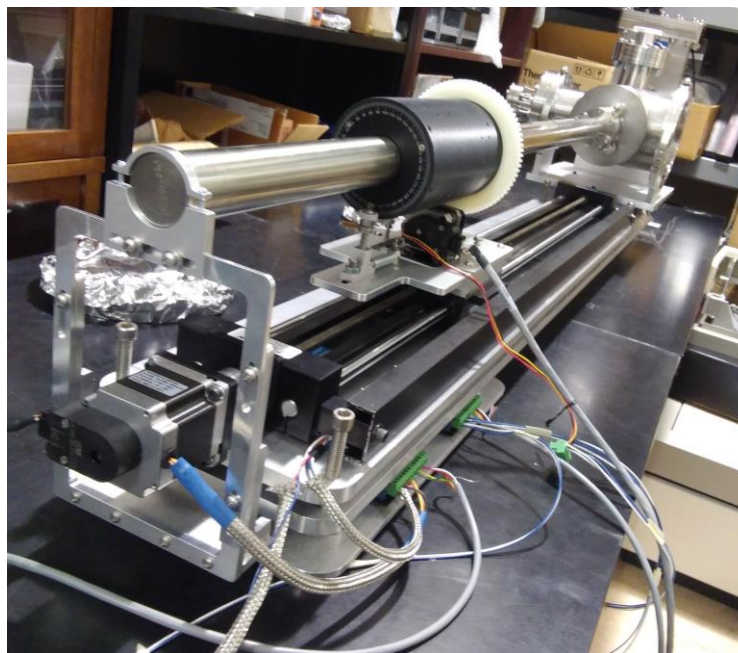
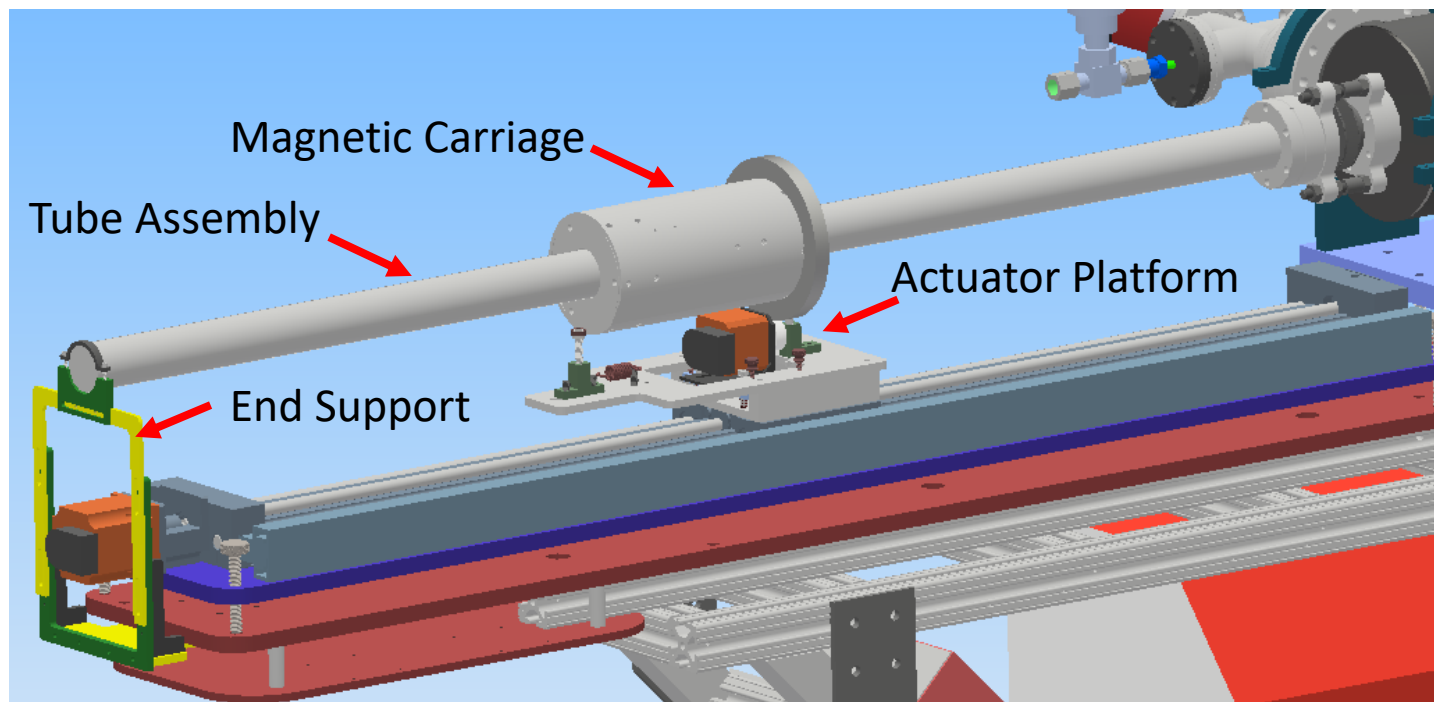


Pictures of the RSIS



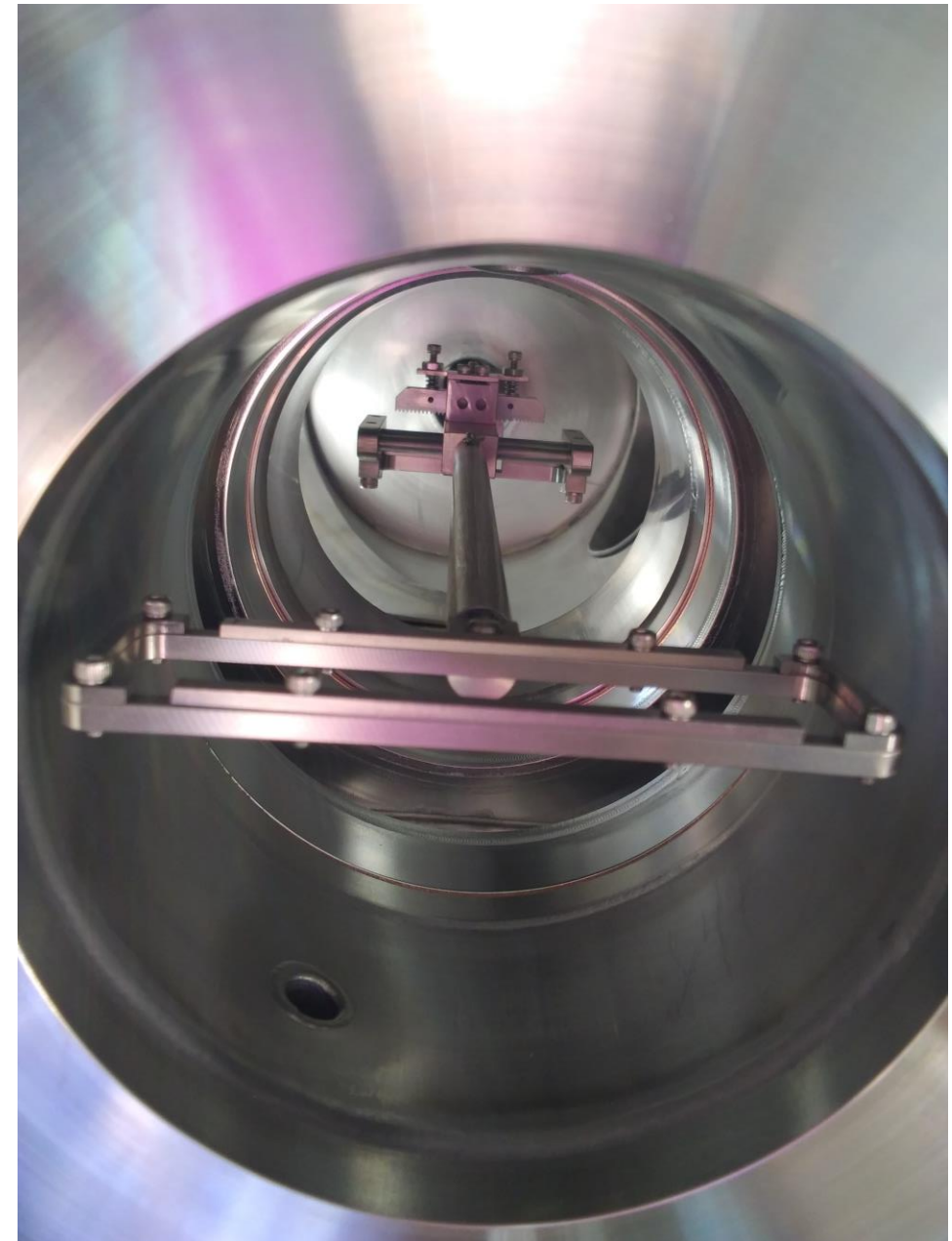
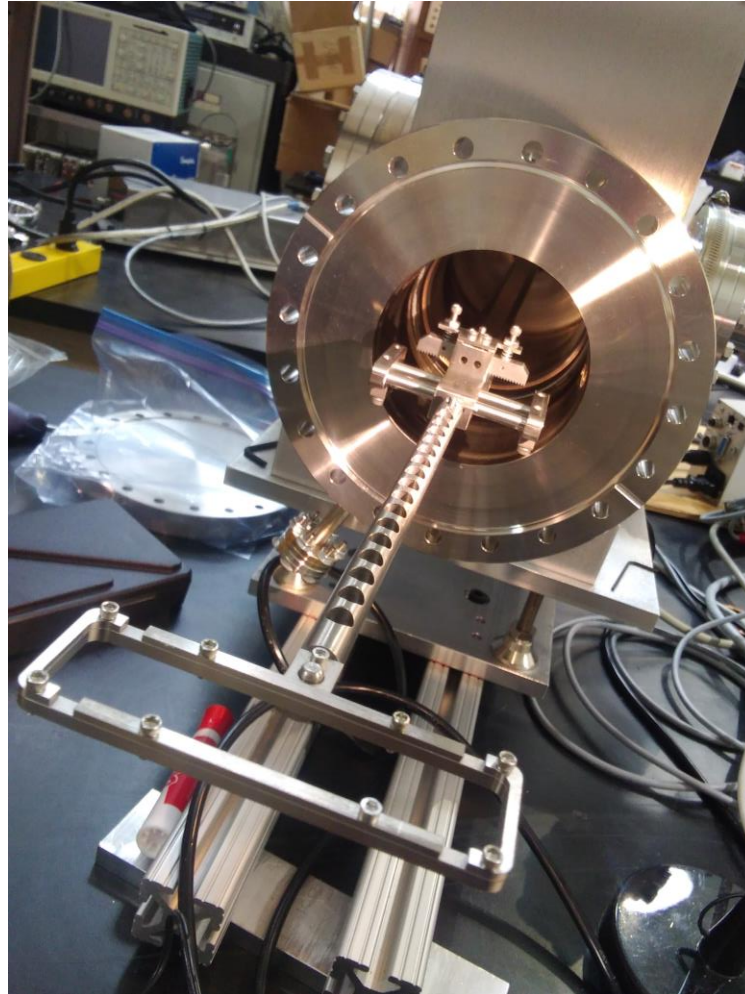
Magnetic Transporter Unit

- Custom built by UHV Transfer Systems
- One linear and one rotational degree of freedom
- Extension arm has a reach of about 36 inches from home
- Rotational motion of the magnetic carriage transmitted by a NEMA 17 stepper motor
- Rack & pinion gear system provides L/R motion for the radioactive source holder

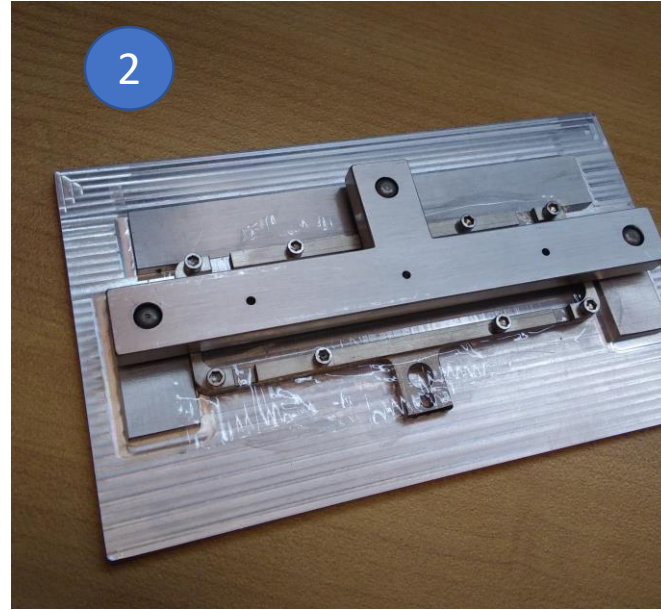
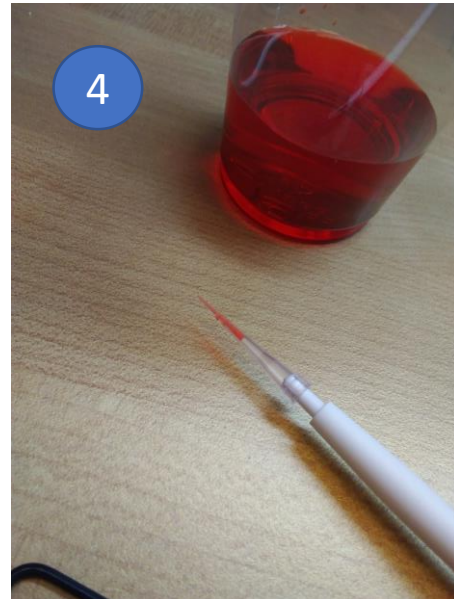


Pictures of the Radioactive Source Holder

- Source holder arm made from Titanium
- Low Thermal contraction coefficient



Placing Radiological Dots on Thin Foil

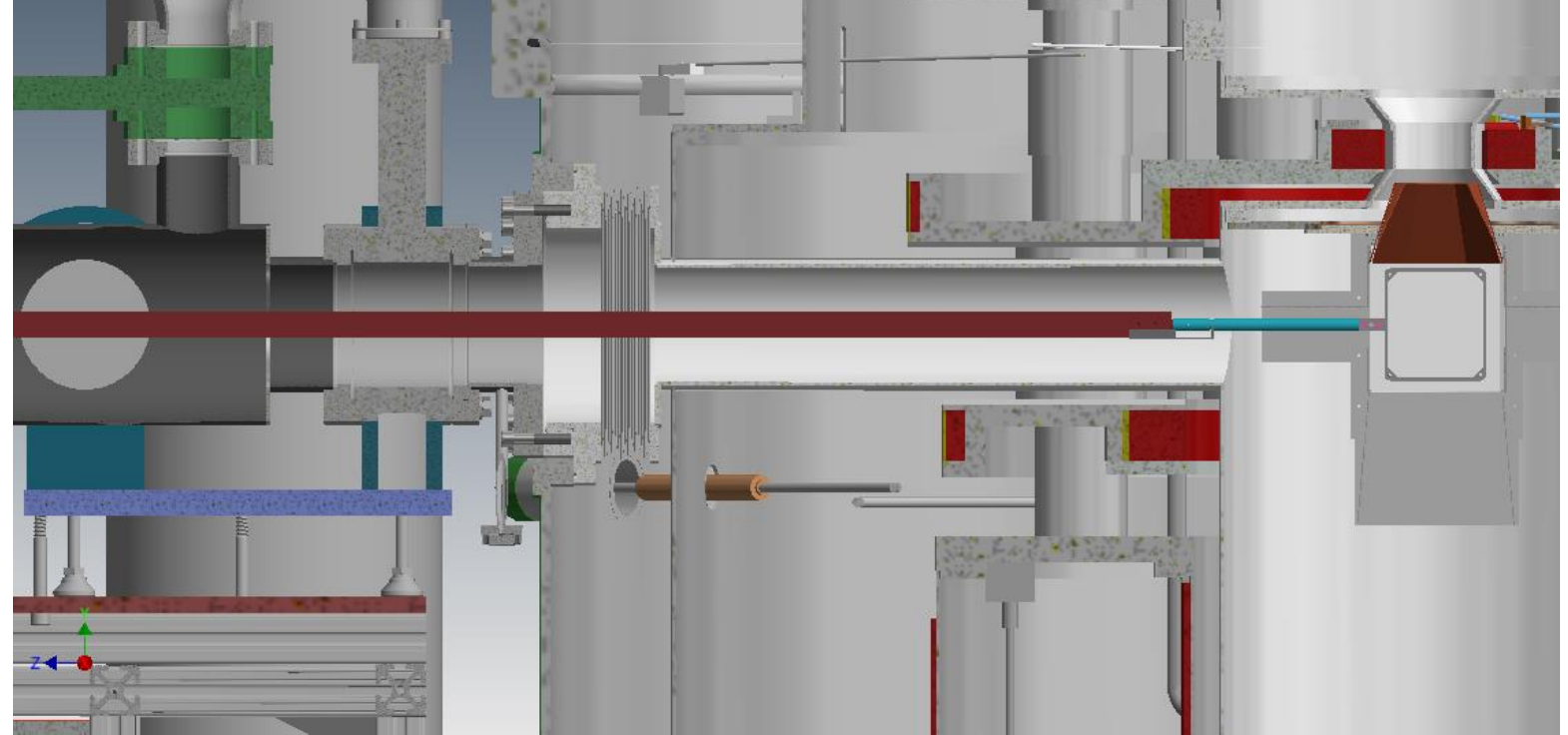
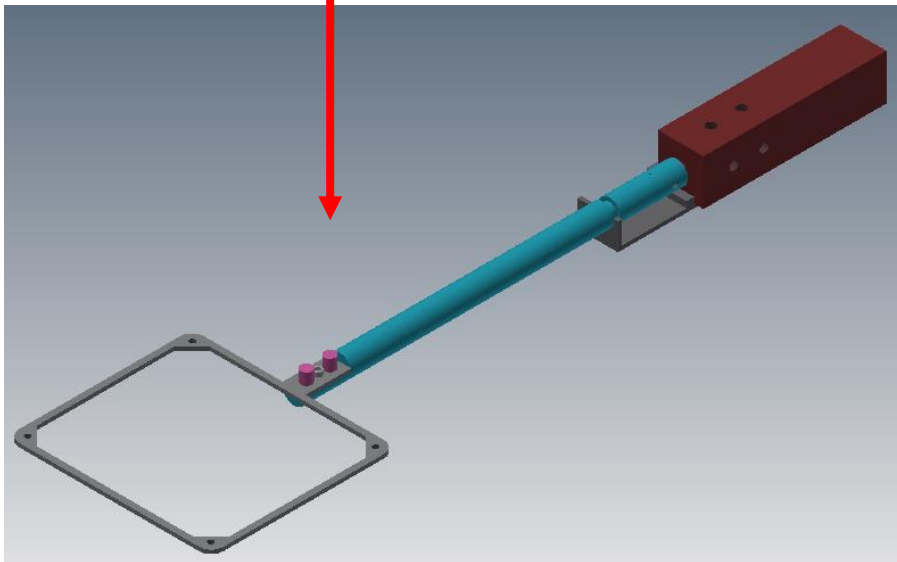


Pictures during testing for precise positioning



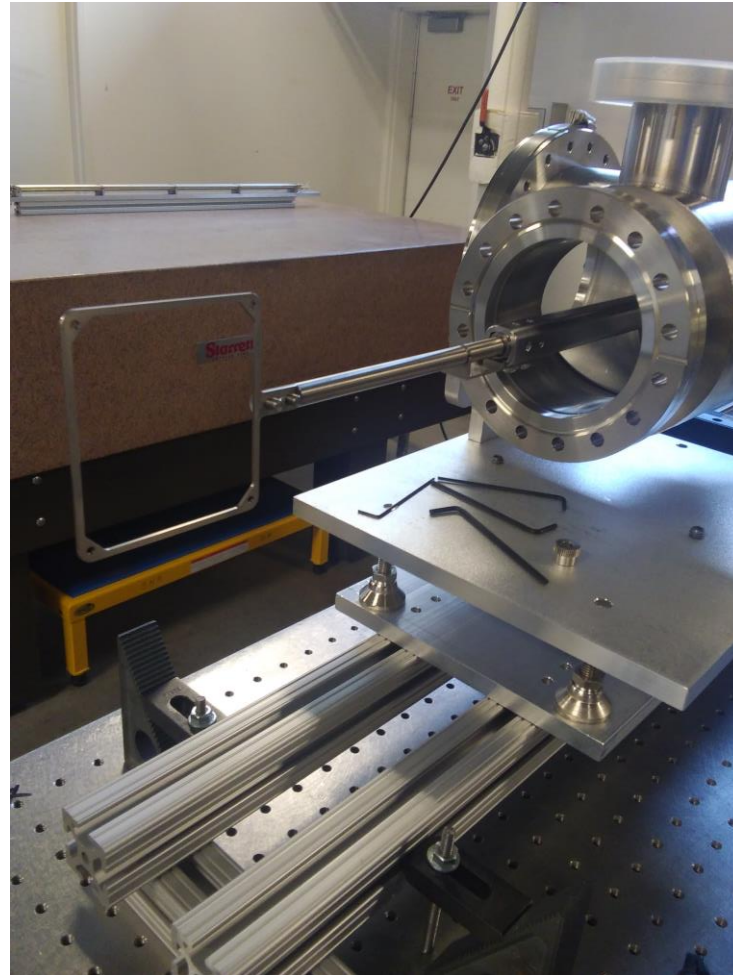
Measurement of the Neutron Beam Profile

Beam Profile monitor arm



- Requirement to measure the neutron beam profile at the center of the Nab magnet
- Fit thin copper foil on the frame of the BPM arm and irradiate the foil with neutrons
- Activation on foil is proportional to the neutron beam intensity $I=I(x,y)$ striking the foil.
- Intensity profile can be transferred to a phosphor imaging plate using photo stimulated luminescence

Pictures of the beam profile Monitor Arm



Summary

- *It took us two years to design and build the RSIS used characterize a set of two pixelated silicon detectors on the Nab experiment*
- *Device can also be used to measure the neutron beam profile*
- *Device not fully installed yet but were working on it.*

Thank you for your time

Pictures of the Electrical Box

