Experimental Validation of Critical Radiation Exposed Materials for RIB Fragmentation Target System

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Highlights

- Brief description of the company
- Brief description of the project
- Goals of the project
- Description of the cryostat
- Current status of the project
- Future steps to be taken

The Company

- I.C.Gomes Consulting & Investment Inc was incorporated in 2000 in the state of Illinois.
- At the beginning the company was involved in the early RIA studies and simulations.
- High Power Accelerator targets was a focus of the company.
- The company proposed the two-step target with Dr. Jerry Nolen from ANL.
- In 2001 the company was granted a STTR for the development of a code system for high power targets.
- One of the issues was Heavy Ion interactions and the MCNPX upgrade started under that grant.
- The codes CINDER, Heating, TRAC-M (thermal-hydraulics), and several interfaces were also part of the package.

The Company

- There were several attempts to have a fully funded Tilted Target research but only Phase-I grants were obtained.
- In 2004 it was proposed to couple the ANL TRAC code to MCNPX for integrated magnetic and radiation transport.
- In 2005 proposed the development of a large aperture magnet for RIA applications.
- In 2006 Irradiation of HTS conductors at cryogenic temperature (this presentation)
- In 2007 got to represent exclusively Pantechnik ECR ion Sources in North America
- In 2008 Thin Target Plates development
- In 2009 two Patent applications: "A Compact Accelerator-Driven Neutron Multiplier for Mo-99 Production" and "Production of Ac-225 and Bi-213 Isotopes by Th-232" jointly with Jerry Nolen of Argonne.
- In 2009, Alpha Emitter, MAFF type development, Swift Heavy Ions, etc.

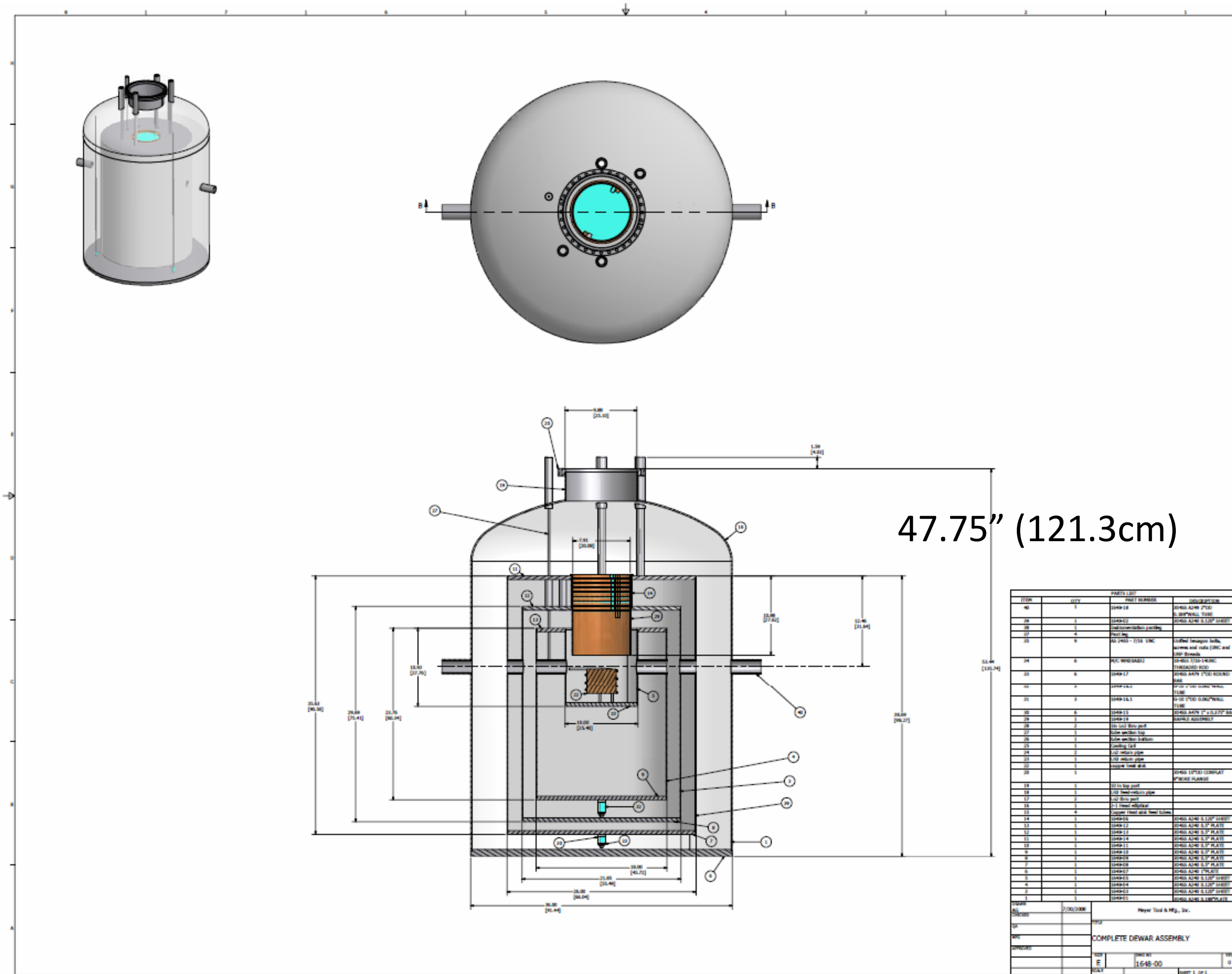
HTS Irradiation - Initial Proposal

- This presentation is about a Phase-II project underway.
- The motivation for the project was to address the two main radiation damage concerns in the Fragmentation room of FRIB – HTS and permanent magnets
- HTS magnets can be used near the fragmentation target
- Permanent magnets can be used in the lithium pump.
- The permanent magnet issues were not pursued.
- HTS will potentially be exposed to MGy doses.
- A large number of neutrons with energies up to 100MeV or more will hit the magnets.
- There is previous experience with LTS but not much with HTS, and none with HTS at cryogenic temperature.

HTS Irradiation

- The key issue is the annealing – most are irradiated at room temperature and Ic is measured at 4-60K
- In this project a cryostat was designed to have the irradiation and Ic measurements at cryogenic temp.
- 4 samples can be irradiated at the same time.
- Sample holder temperature can be varied.
- LN2 and LHe are used to cool the cryostat.
- The cryostat can operate in a controlled way anywhere between LN2 and LHe temperatures.
- The are 5 current leads to the sample holder; 4 bringing current in and one return bus bar.
- The samples are electrically insulated from each other.

Cryostat



47.75” (121.3cm)
Meyer Tool & Mfg., Inc.
COMPLETE DEWAR ASSEMBLY
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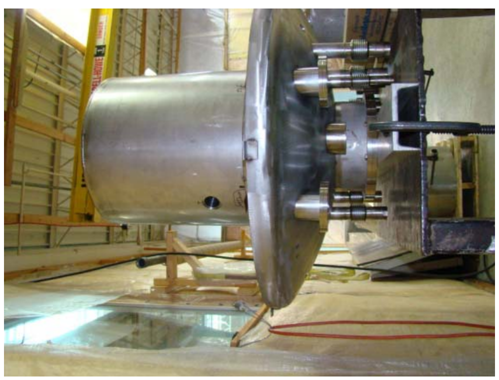
1648-00

Building the Cryostat

Outside Vessel

Sample Holder Support - Heat Sink

Current Leads Feedthrough

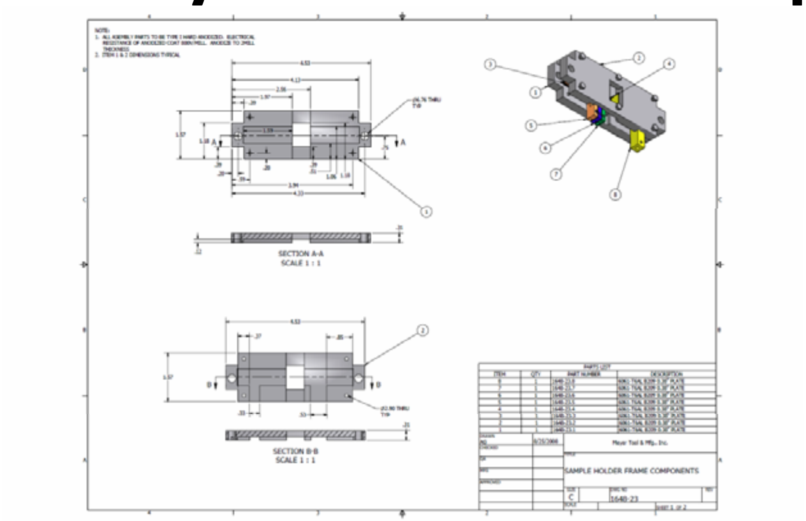


Cryostat Cap with Current Leads

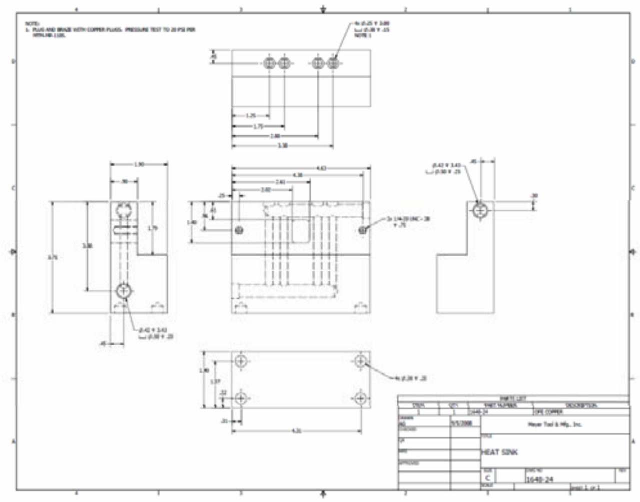
Cryostat Thermal Insulation

Sample Holder Housing with Current Leads Feedthrough

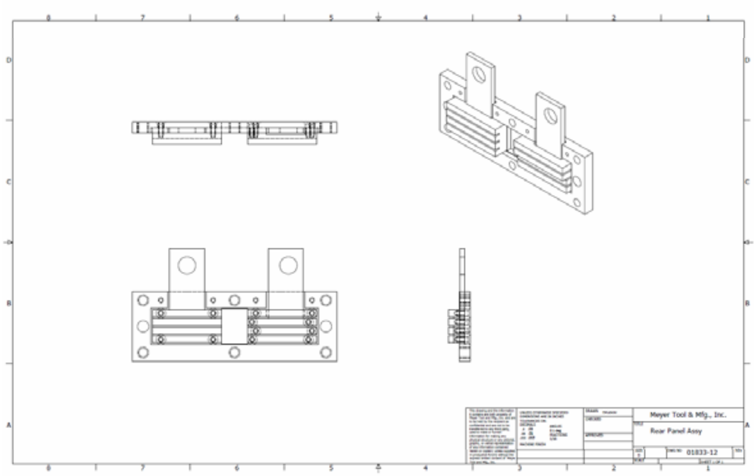
Cryostat – Sample Holder Design



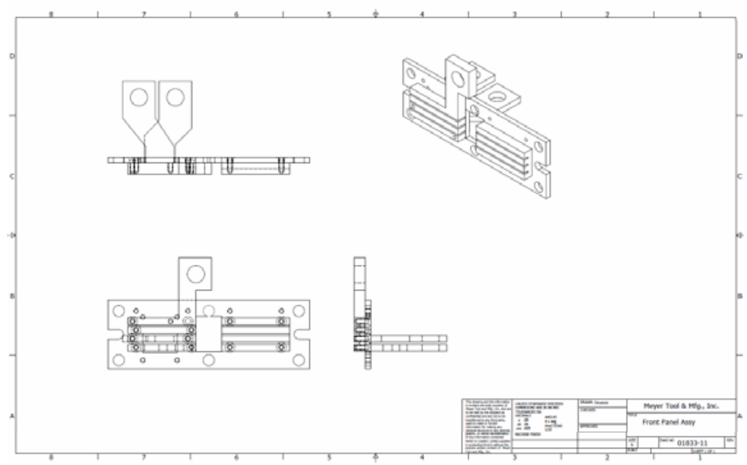
Original Sample Holder Design



Sample Holder Support

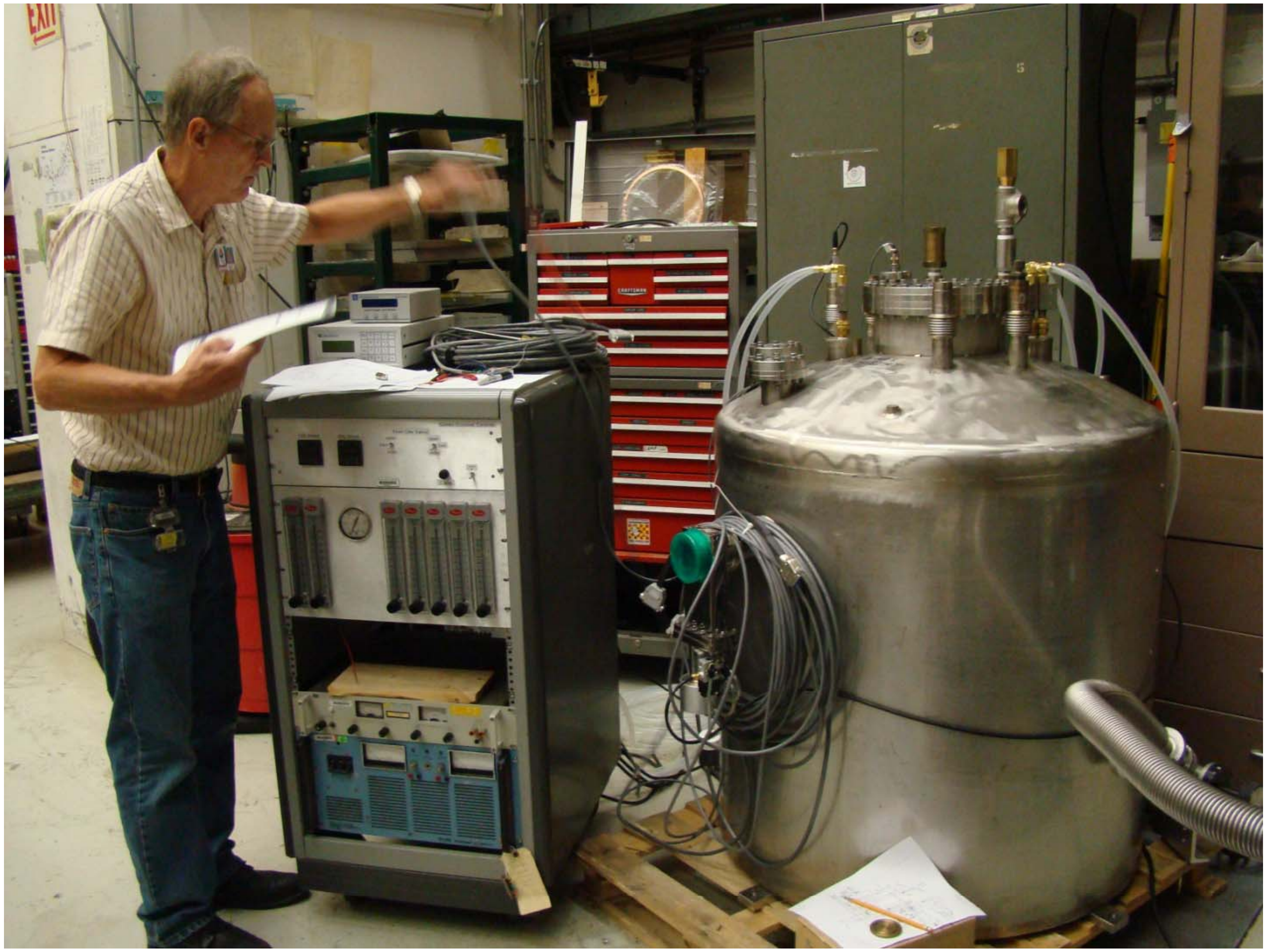


Current Sample Holder Design



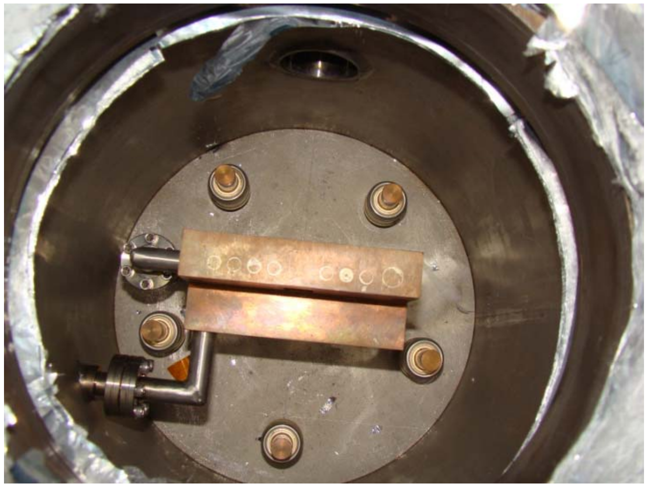
Current Sample Holder Design

Current Status

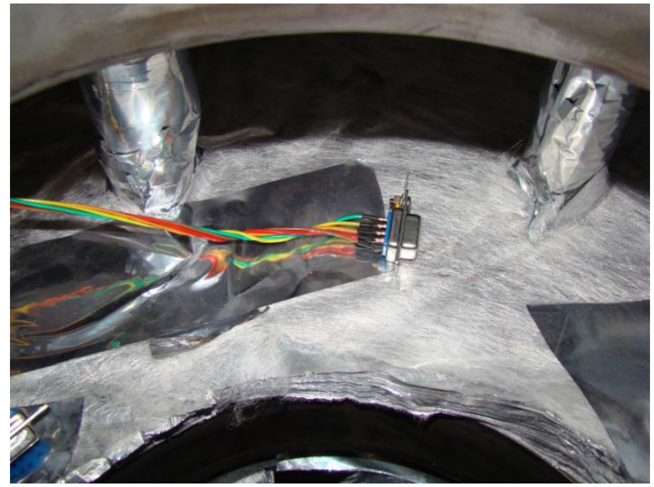


Current Status of the Cryostat and Control System at ANL

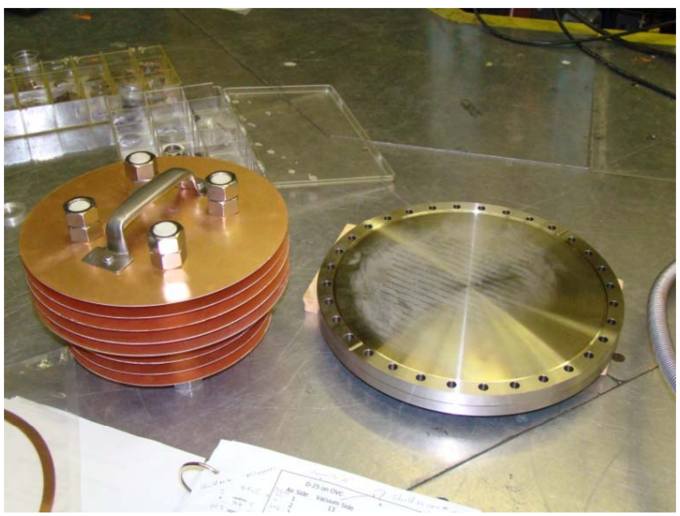
Current Status



Sample Holder Support & Housing



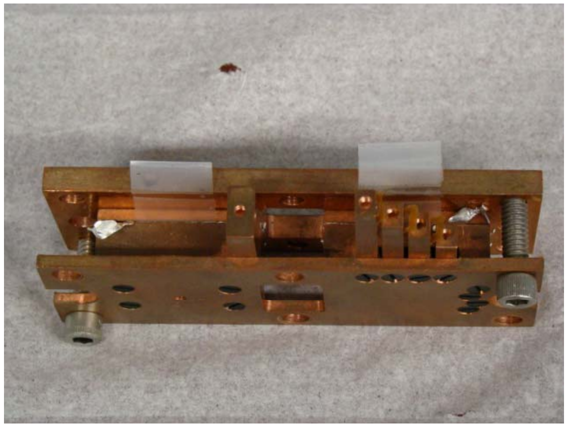
Connectors for the Sample Holder



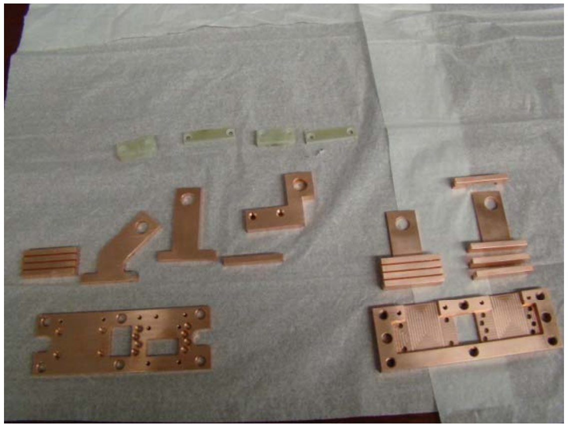
Radiation Baffle and Top Flange

Top of the Cryostat when Open – ID ~ 23cm

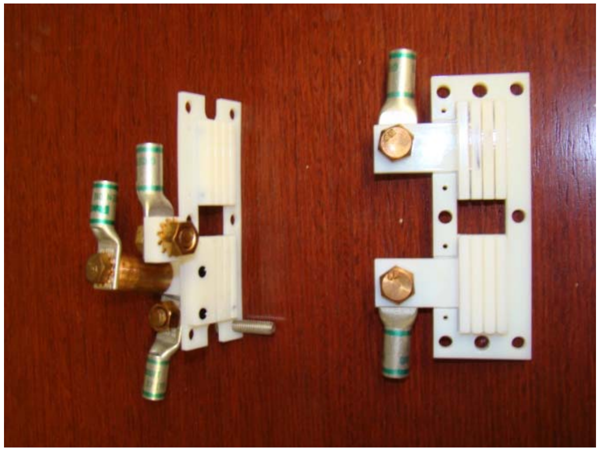
Sample Holder



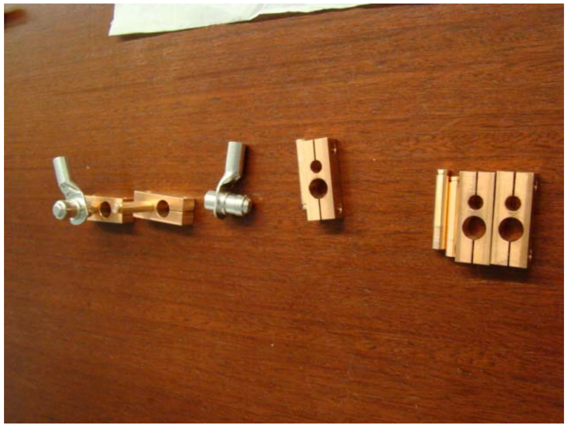
Original design of the Sample Holder



Current Sample Holder unassembled.



Plastic print of the Current Sample Holder

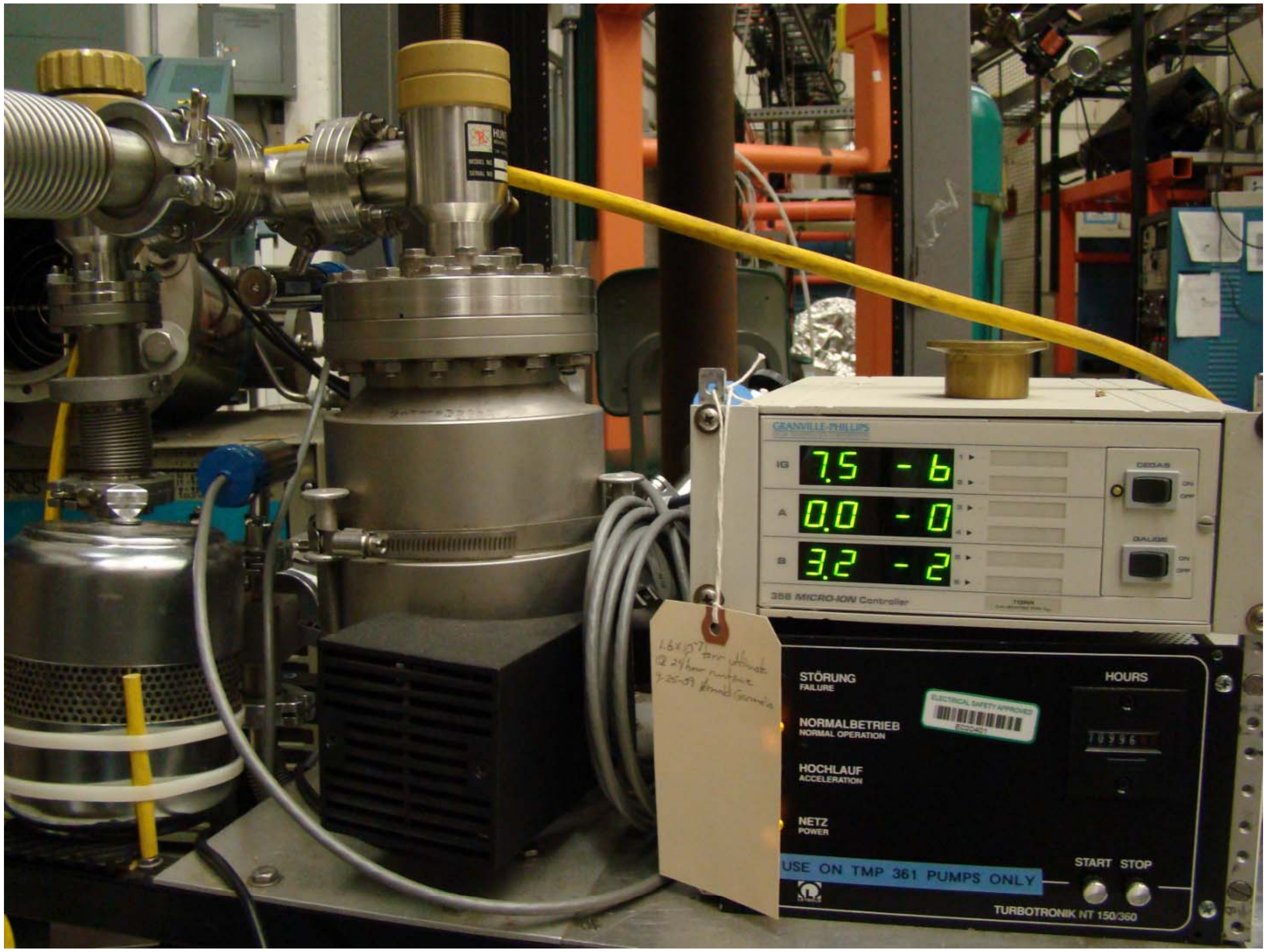


Current lead connectors to the Sample Holder

Current Status - Calibration

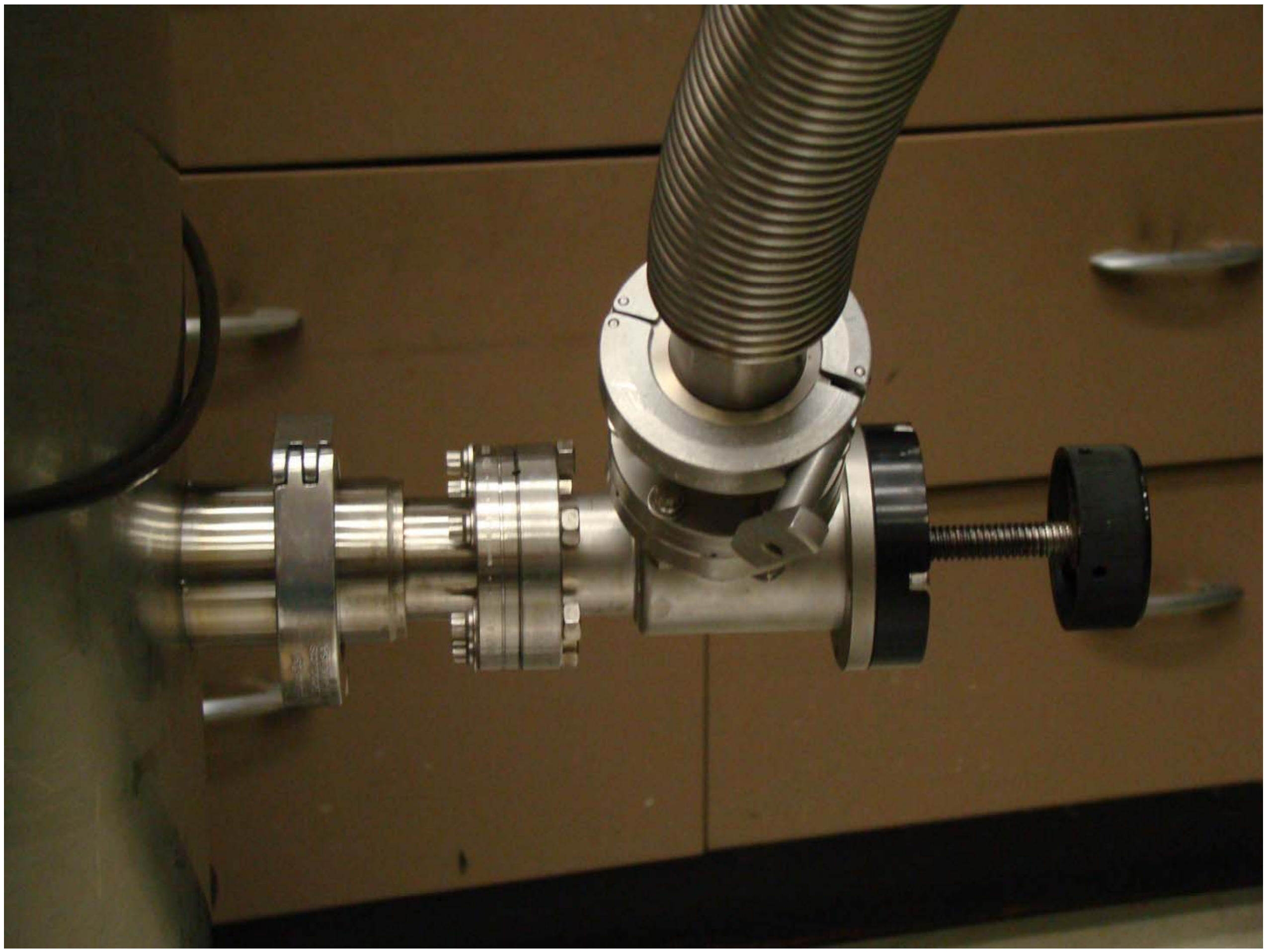
- Currently we are in the process of “calibrating” the Cryostat.
- The goal is to measure the sample temperature as a function of the power deposition and Helium vapor flow through the sample holder support.
- The power deposition will be simulated by placing a heater on the sample.
- The temperature will be measured directly on the sample. This will provide a correlation between the temperature of the sample in the beam spot with the temperature reading from the sensor on the heat sink. This does not need to be precise.

Current Status - Calibration



Cryostat Pressure (at room Temperature) Reading - 7.5e-06 Torr (4.e-07 Torr cool)

Current Status - Calibration



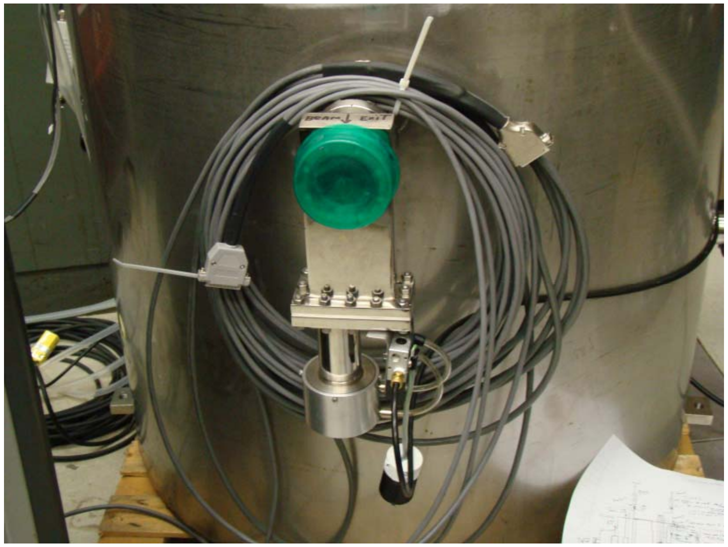
Vacuum Pump Connection to the Cryostat

Beam Line Collimator



A collimator helps to monitor the beam position and it might be helpful to keep the activation of the cryostat low. A G-10 tube was designed to be inserted in the beam line pipe and restrict the beam to the 1x2 cm^2 opening of the sample holder. Both the upstream and downstream pipes have a collimator. Three carbon sleeves were placed inside the each G-10 tube to take any beam spill outside of the prescribed 1x2cm^2 (the downstream opening is bigger than the 1x2cm^2). The carbon sleeves have wires to read the beam current on each carbon piece and provide to the operator a reading of any beam misalignment.

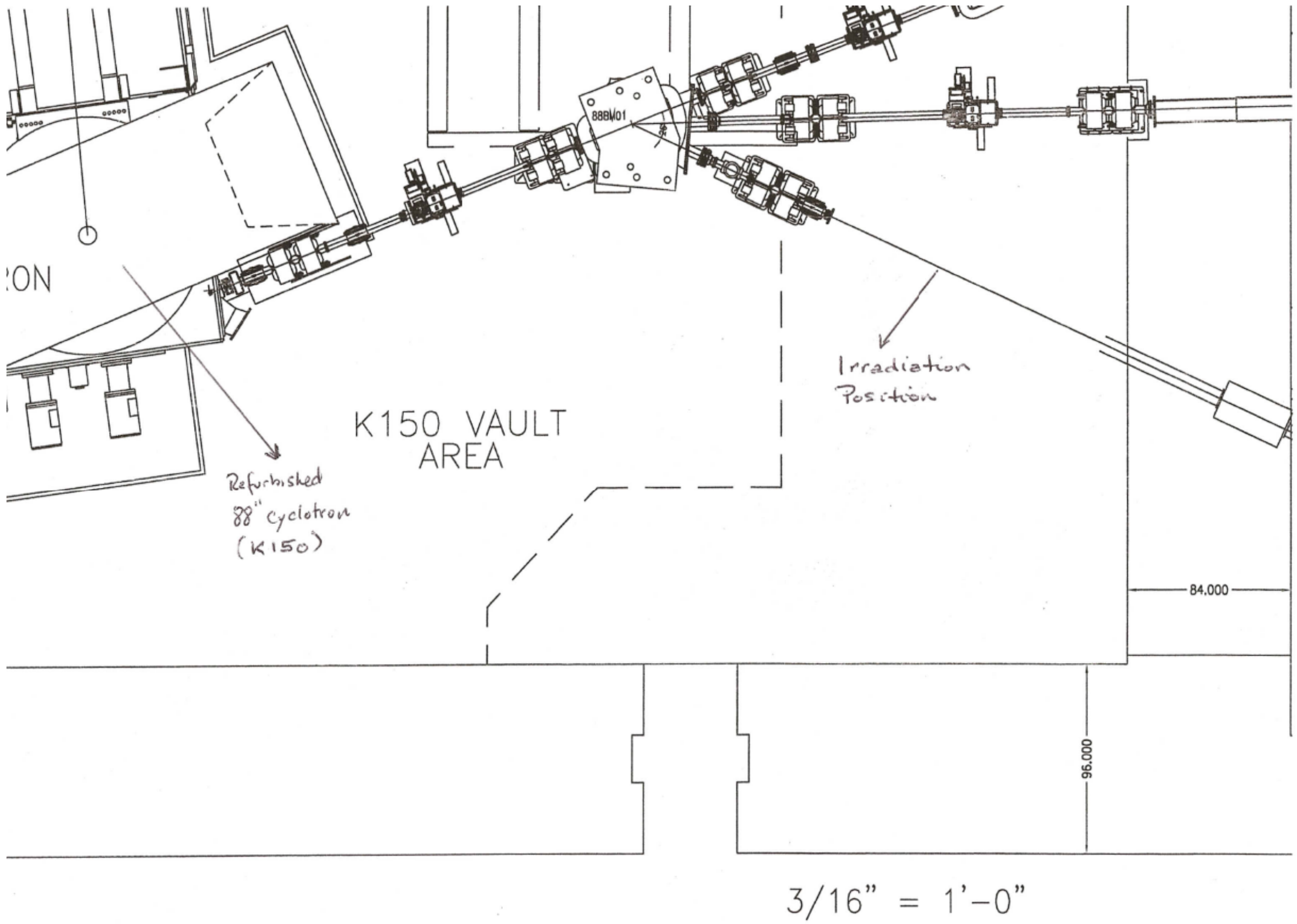
Control System



<= Pneumatic beam line pipe valves, used to isolate the beam pipe vacuum from the cryostat vacuum. The valves are opened when there is an equilibrium between the beam pipe vacuum and the cryostat vacuum. During irradiation the beam pipe and the cryostat share the same vacuum.

LN2 and LHe level sensor reader (top) and Temperature Sensor reader (bottom) already connected to the cryostat.

Current Status – Texas A&M



Irradiation Beam Line at Texas A&M to be Used in the Project

Current Status – Texas A&M

- The beam line is already built and they are performing tests with the beam.
- They already achieved more than 20 MeV proton beam and current up to 20 µAmps.
- The goal is to irradiate with 55 MeV protons to a fluence of 1.e+17 to 1.e+18 protons/cm^2 over a 2cm^2 area.
- At a current of 20 µAmps, 1e+18 p/cm^2 can be achieved in 4½ hours of irradiation.
- Currently we are checking accessibility to the cryostat during beam shutdown time. It takes about 20 min. to open and close the access door to the irradiation position.

Current Status – Texas A&M

Courtesy of Henry Clark

Beam Line Out of the Cyclotron K-150

The Switching Magnets

Past Switching Magnets

End of Beam Line to Cryostat

Current Status – Texas A&M

- LHe supply can be done by a 500liter dewar.
- LHe consumption is expected to be about 32 liters per hour at 20 μAmps and 50 MeV.
- The LHe vessel has a volume of ~59 liters (15.5 gallons).
- The LN2 vessel has a volume of ~143 liters (37.7 gallons).
- The irradiation campaign can be done as follows:

A) Measurement of critical current without irradiation.

B) 15 minutes irradiation; Ic measurement.

C) 1 hour irradiation; Ic measurement.

D) Follows 1 hour irradiation and Ic measurement until Ic drops.

- The LHe and LN2 vessels can be refilled during measurements or when radiation levels allow.

Future Work

- In the next few weeks it is expected to finish the calibration and “validation” of the cryostat
- The system and all connections and support equipment will be tested and prepared for deliver to Texas A&M.
- We are in the process of checking what will be needed to take to Texas A&M and what can be provided locally there.
- There is a proposal to DOE to add magnetic field to the Ic measurements. If successful, a few more months will be required to make the modifications to the cryostat and new testing plan.