June 1, 2023

Design of the magnet vessels for nTMM measurements at GP-SANS instrument at HFIR

For measurement of neutron Transition Magnetic Moment (nTMM) two identical low-field magnets will be used with the following envelope: length $1970\ mm$ and diameter $\sim 216\ mm$ (8.5”). Magnets will be installed inside the GP-SANS 16-m vacuum neutron guide in the last two downstream sections of the 8-section guide. Magnets will operate in vacuum. Figure 1 below shows the location of the magnets (blue) in the last two sections of the guide. Between the magnets a sheet of 3.5 mm Cd will be installed for neutron absorption (shown in black).

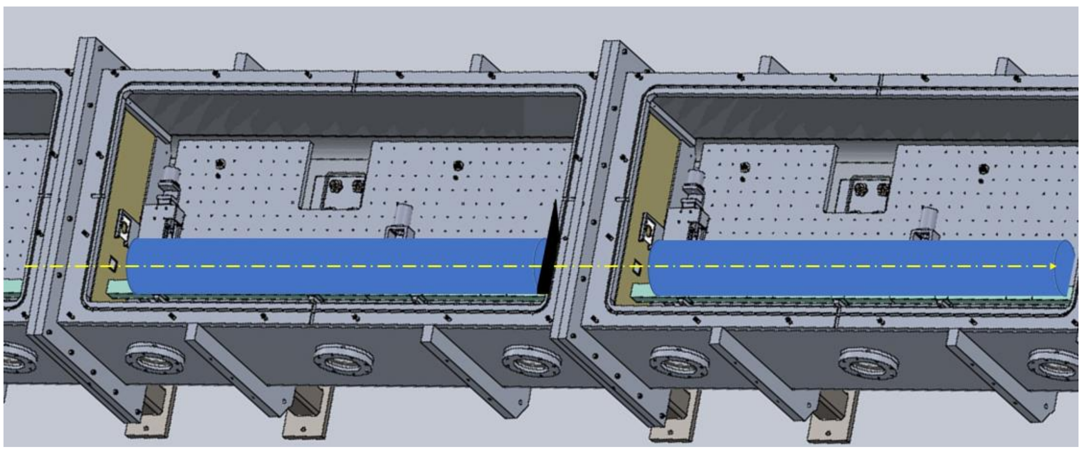


Fig. 1 Position of two magnets inside the vacuum neutron guide at the GP-SANS beamline.

Each magnet will be mounted on two kinematic supports shown schematically in Figure 2 and 3. The support structure will be installed on the existing breadboards inside two sections of the guide.

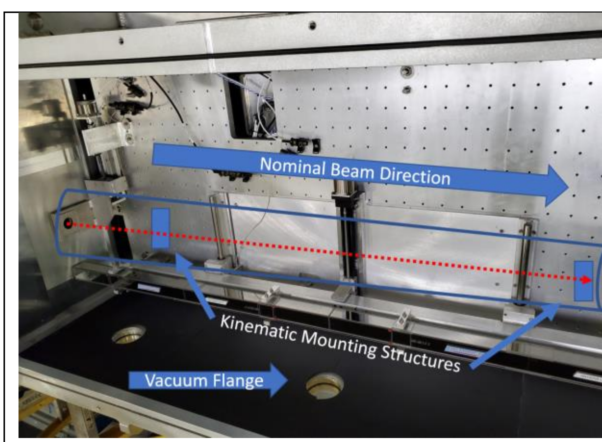


Figure 2. Top view of the one of the guide sections showing approximate position of kinematic support mounts of the magnet tube.

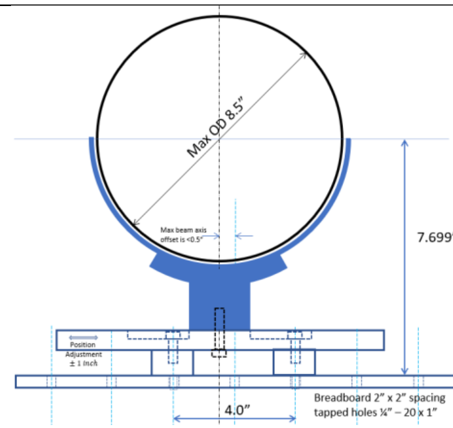
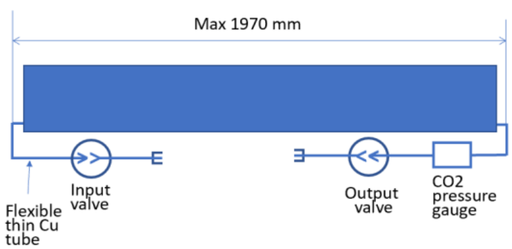


Figure 3. Magnet tube kinematic supports mounted on the breadboard inside the vacuum neutron guide. Width of the supports is 2.0 inches (along the beam axis).

As an experiment requirement, the neutrons should pass through the magnetic field in the atmosphere of CO_2 gas at the pressure 1.25 atm (or 127 KPa, or 18.4 psi). Gas will be contained in the cylindrical volume with two small gas valves and a pressure gauge as shown in Figure 4. The gas inlet and outlet will be connected to the gauge and valves with 1/8" copper flexible tubes as shown in Figure 4. Gauge and valves will be tied up to the magnet support structure (Figure 3) for fixation.



Brass Panel-Mount On/Off Valve with Nickel-Plated Ball, Yor-Lok Fitting for 1/8" Tube OD

Compression Fitting, 90 Degree Elbow for 1/8" Copper Tube x 1/8 NPTF Male

Pressure Transmitter for Compressed Air, 1/8 NPT Male Pipe Connection, 0.6-5V DC. Range 14.5 – 145 psi.

Figure 4. Connection of the vessel to gas filling system (McMaster-Carr catalog)

Magnetic coils will be tightly winded up with 1.1 mm spacing in two layers on the outer surface of the 8" OD Aluminum tube with insulated copper wire (18 AWG). Nominal magnetic field of 25 Gauss should be reached at the current 1.1 A. Resistance of the wire length per magnet is $\sim 48\ \Omega$. Power, ~ 60 W per magnet, will be dissipated in vacuum by radiation with the temperature increase by $\Delta T = 7.8$°C. Two layers of wire will be wrapped in the μ-metal tape for reducing environmental magnetic field non-uniformity.

Gas vessel:

Classification: For nominal gas pressure 1.25 atm=18.37 psia (differential to vacuum) required in experiment we can set the max allowable gas pressure in the vessel as 1.5 atm=22.05 psia (differential to vacuum). During the experiment, the gas vessels will be isolated, and the pressure will not be changed. Thus, maximum pressure × volume product will not exceed 47.7 psi-ft^3, that is less than 73 psi-ft^3 classifying the volume as a "pressure vessel".

Aluminum tube: 8" OD x 0.125" Wall x 7.75" ID Aluminum Round Tube 6061-T6-Extruded is selected.

https://www.onlinemetals.com/en/buy/aluminum/8-od-x-0-125-wall-x-7-75-id-aluminum-round-tube-6061-t6-extruded/pid/7083

Al end-windows (2 per magnet) shown in Fig. 5 will be welded to the tube as shown in Fig. 6.

Thickness of the end window is 1/16” = 1.5875 mm. End window will be machined at UT 5-axes CNC machine from the whole piece of aluminum. First, the inner spherical surface with R = 5.3” will be machined. During the machining of the outer spherical surface for the prevention of aluminum material flexing by machining tools, the inner section of the sphere will be filled with wax. The latter will be removed after machining. UT Physics machine shop has necessary experience in precision machining and in welding aluminum allows.

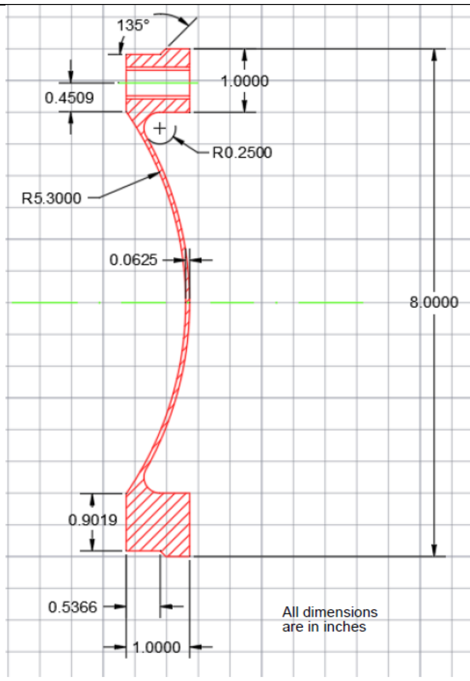


Figure 5. Aluminum end window

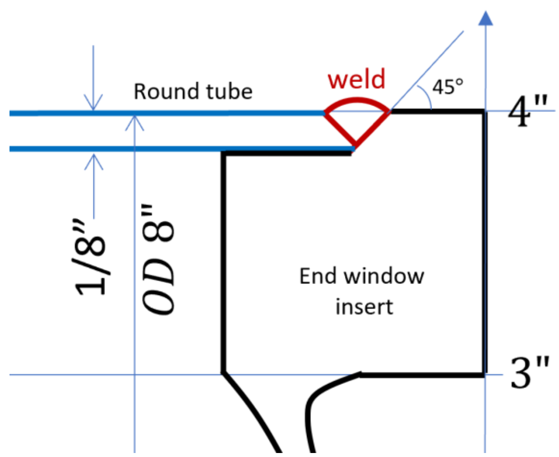


Figure 6. Welding tube and end window

Testing: Welded tubes with end-windows will be tested at UT. Designed for nominal working pressure 18.37 psia vessels will be tested at the pressure 50 psig (differential) for 5 days in the laboratory with the leak rate recorded.

After testing, the vessels one-by-one will be transported to UKY (to Chris Crawford) for magnet coil wiring, installation of the magnetic shielding and electrical testing.

After that, magnets will be returned to UT for gas filling and then will be transported to HFIR when needed for installation.

Design and procedures are agreed by	signature	date
Lisa Debeer-Schmitt, GP-SANS instrument scientist:		
Matthew Frost, Research Scientist:		
Leah Broussard, N-N’ Experiment Leader:		
Christopher Crawford, UKY Professor:		
Rick Huffstetler, UTK Craft Supervisor:		
Yuri Kamyshkov, UTK Professor:	Yuri A Kamyshkov	June 1 , 2023
ORNL Inspecting Engineering:		