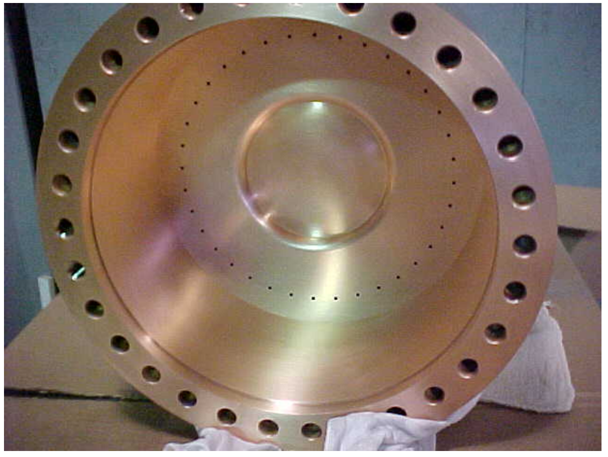
Cavity for All Seasons

Design - Mike Neubauer, Al Dudas, Sergey Kurennoy

Construction – Rick Kunzelman (Device Technologies)

Assembly - Gene Flanagan, Grigory Kazakevich,

Testing – Al Moretti, Gene Flanagan, Grigory, Kazakevich, Masa Notani



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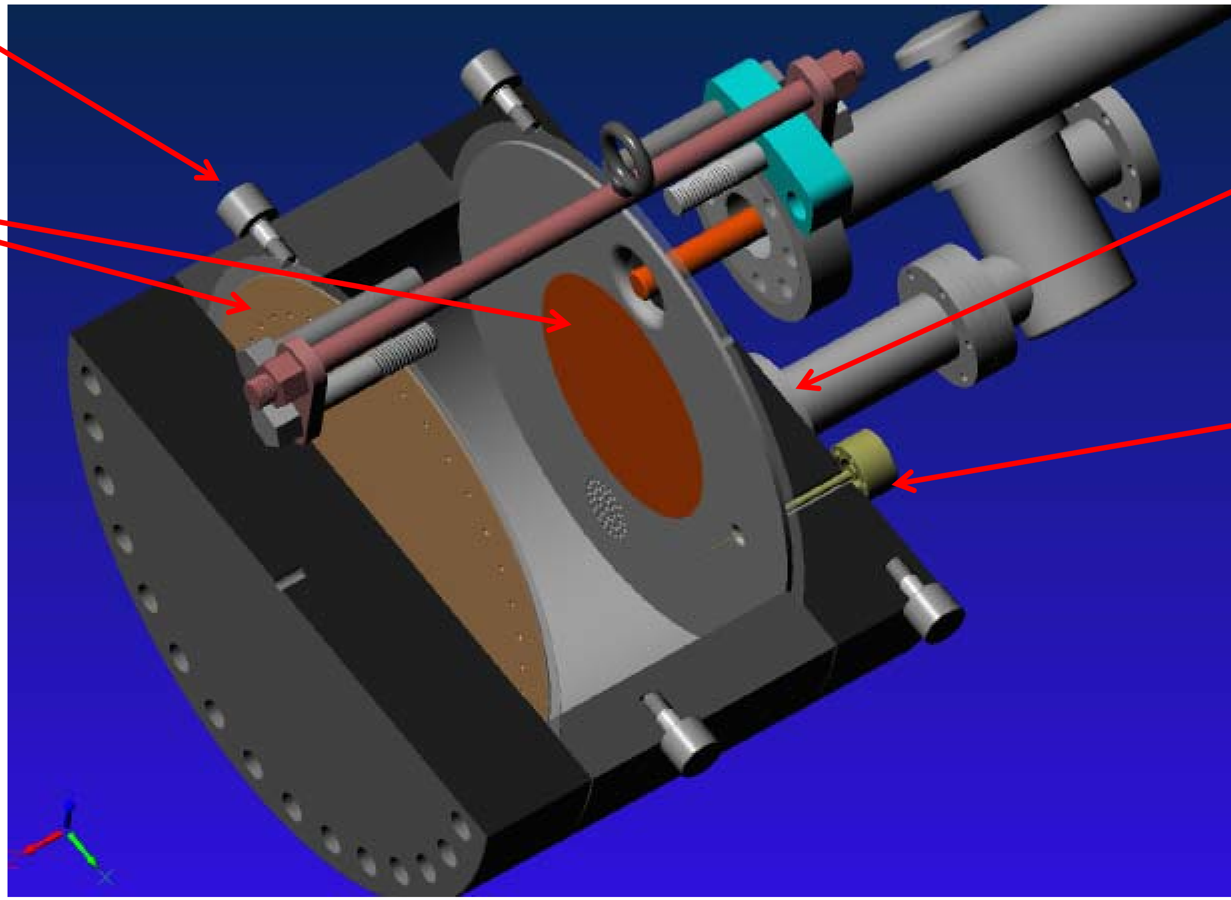
Cavity for All Seasons

-to do anything for anyone
-study with vacuum or High Pressure
-magnetic field (fits in MTA magnet)
-materials (Cu, Al, Be, ALD,…)
-windows (Be, grids, shapes,…)
-breakdown (removable surface samples)
-no electrodes, a true pillbox cavity
-bolted together- easy examination, reconfiguration -
-built under contract for LANL

View of the major cavity parts for vacuum operation



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Major Design Constraints

RF

Ideal TM01 pillbox cavity

- Flat surfaces (no field enhancement sites)
- Coax feed

β=.8

Mechanical

- Replaceable "window" materials
- Vacuum (10^{-6} torr) and high pressure (1500 psi)

805 MHz RF Design

Cavity Radius: a = λ/ 2.61274

2a= ***11.223 in.*** (28.51 cm)

Machined to 11.161 +.002/-.000 for 809.5 MHz at STP and copper plated .001-.0015 thickness

Sensitivities:

72 KHz/.001 inch change in diameter

14 KHz/C^o change in temperature

THIS IMPLIES THERE MAY BE NO NEED FOR TUNING with machining tolerances of +/- .001

Cavity Length: d=$\beta\lambda/2$= ***5.865 in***. (14.9 cm)

TM01 Calculations (Cu and E_0=25 Mv/m)

$$Q = \frac{\eta}{R_s} \frac{2.405}{2\left(\frac{a}{d}+1\right)} = 31263$$

Optimistic may be 20,000? in reality

Stored energy, U (joules), at 25 Mv/m gradient

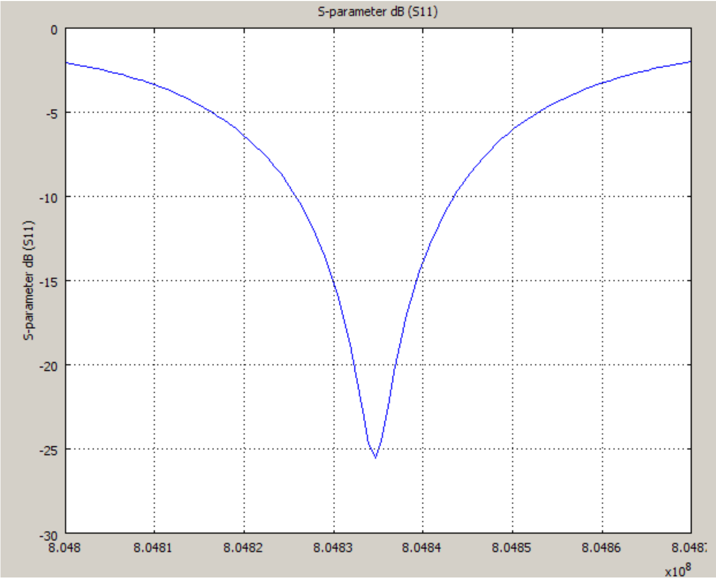
$$U = \pi \varepsilon d E_0 \left(\frac{a^2}{2}\right) J_1^2(ka) = 7.09$$

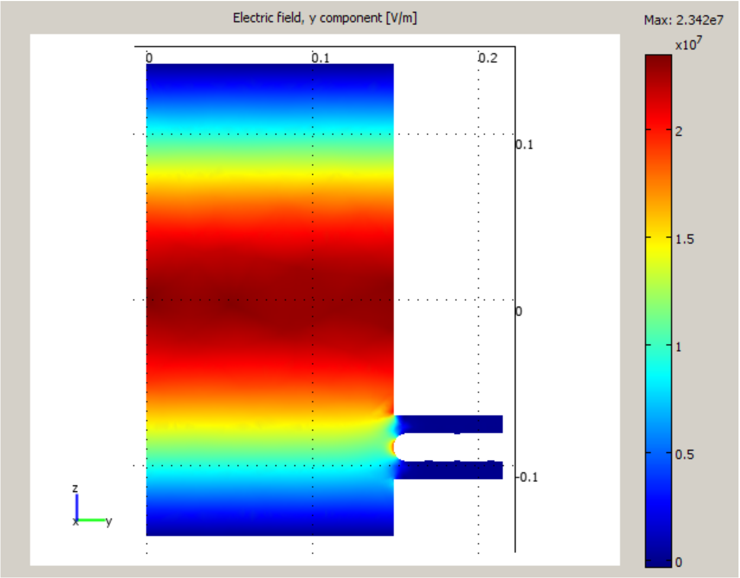
Watts supplied and dissipated in the copper walls

$$W = \frac{\omega U}{Q} = 1.147 \text{ Mw}$$

Well within klystron range even with lower Q

3D Comsol Calculations with Coax input to the copper cavity





- A 1 Mw input produced 23.4 Mv/m (which is the same as a theoretical calculation).
- An input S11=-25 db (for a VSWR=1.12) was calculated with the 50 Ω coax center conductor flush with the end wall as shown.
- With the coax the resonant frequency was calculated to be 804.853 MHz and without the coax, 805.046 . A change of –193 KHz is anticipated for the coax line.

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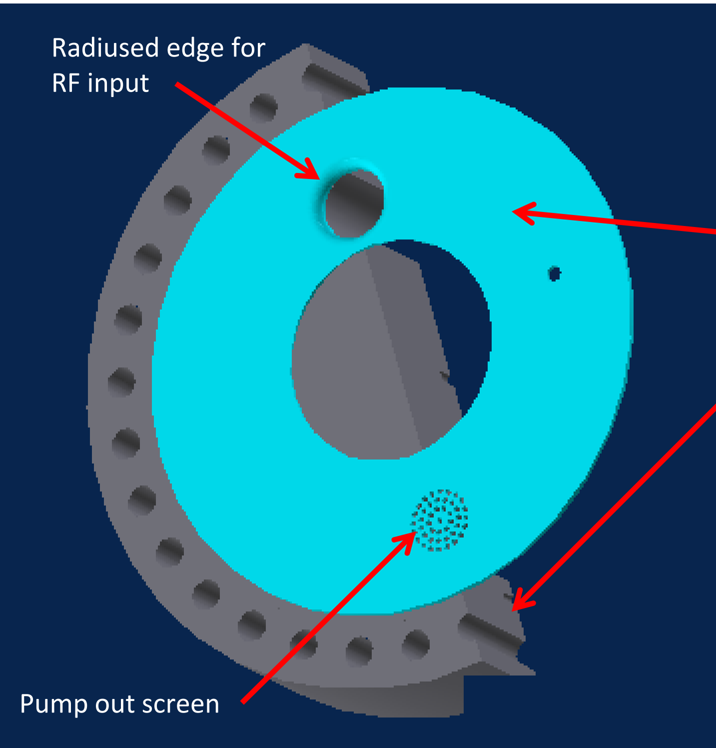
Mechanical Design for the Replaceable Window Materials

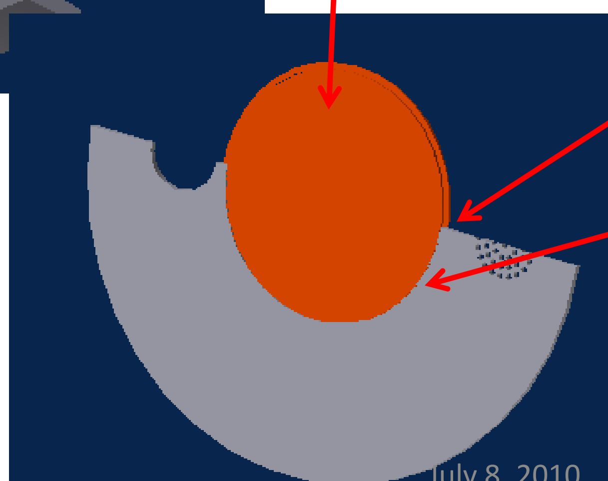
- The "top" window test plate will be 5.5 inches in diameter in an assembly held in place by a "test plate holder". This will be solid copper plated SS for the first test.
- The "bottom" window test plate will be a simple disk over the entire end wall with pumpout holes for virtual leaks.
- Other attributes will include a means for maintaining equal pressure on both sides of the window test plates.
- If there is a need to add a tuner we can put shims centered behind the "bottom" window test plate.

"Top" Window Test Plate Assembly



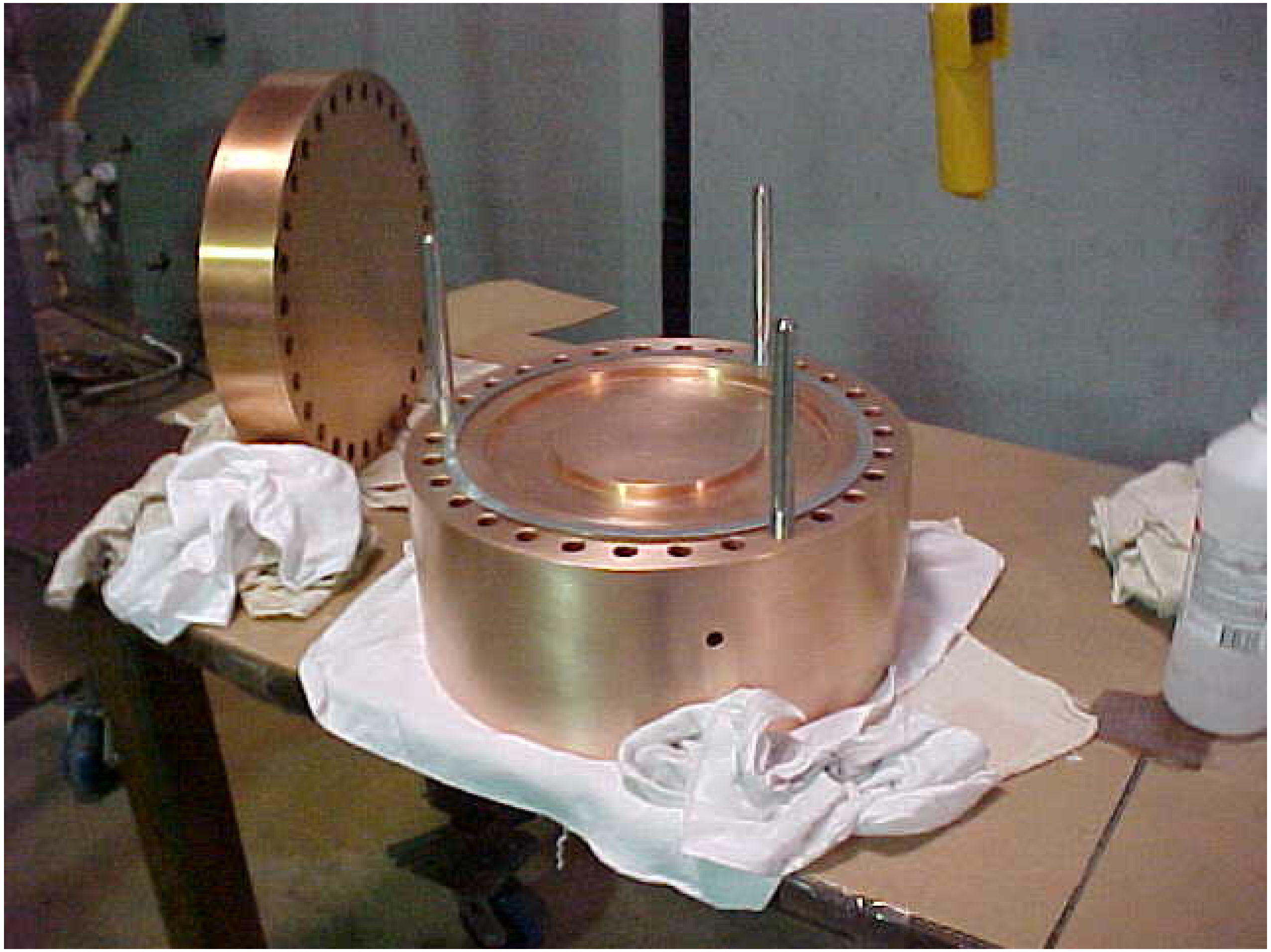
The test plate assembly is made of three pieces:

1. Copper plated s.s. test plate holder
2. Pressure plate
3. Test plate of a window material



The assembly may include:
a press fit of the test plate into the holder, and,
a final fly-cut to remove any sharp edges and to blend the surfaces.

First assembly



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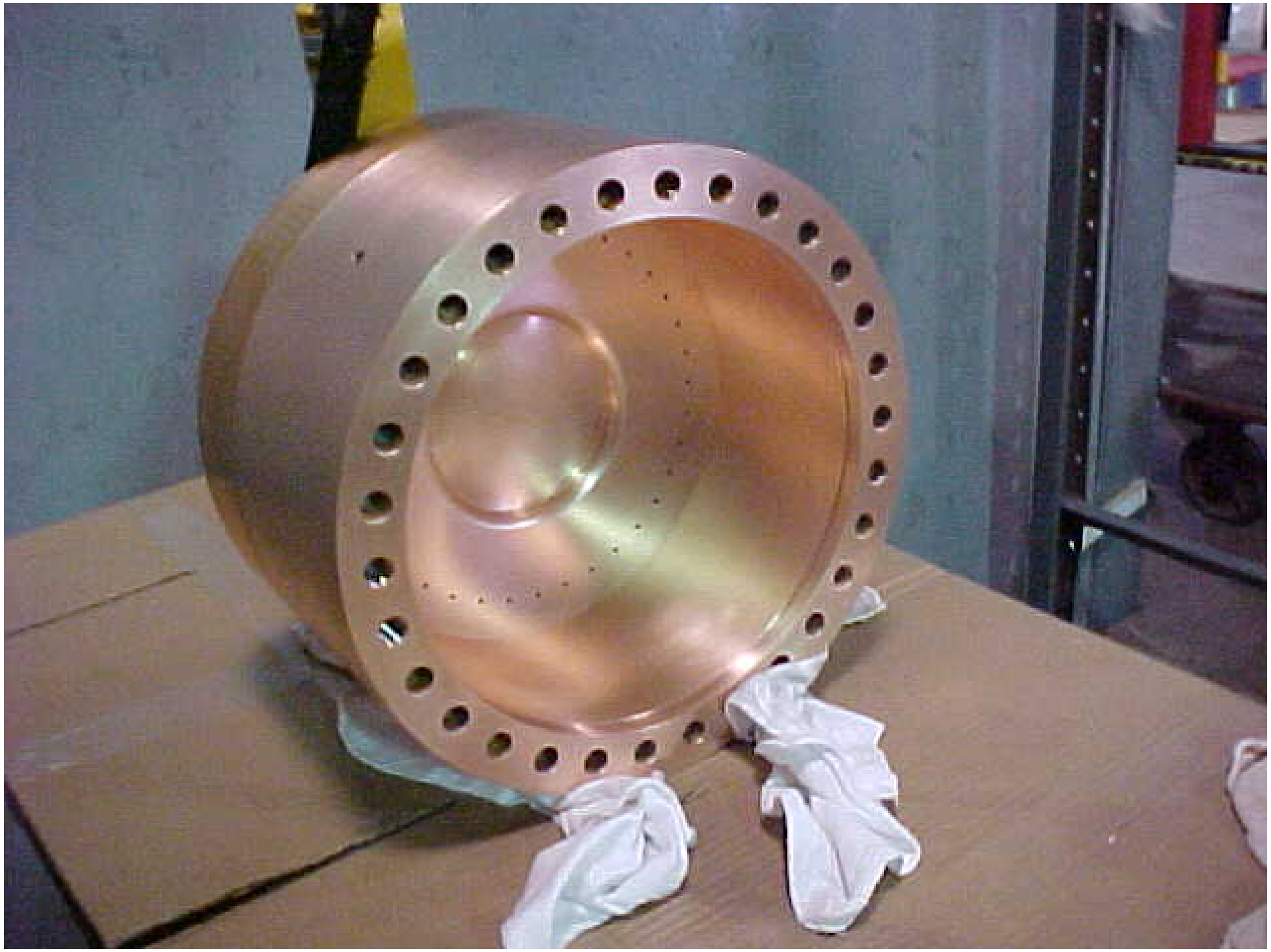

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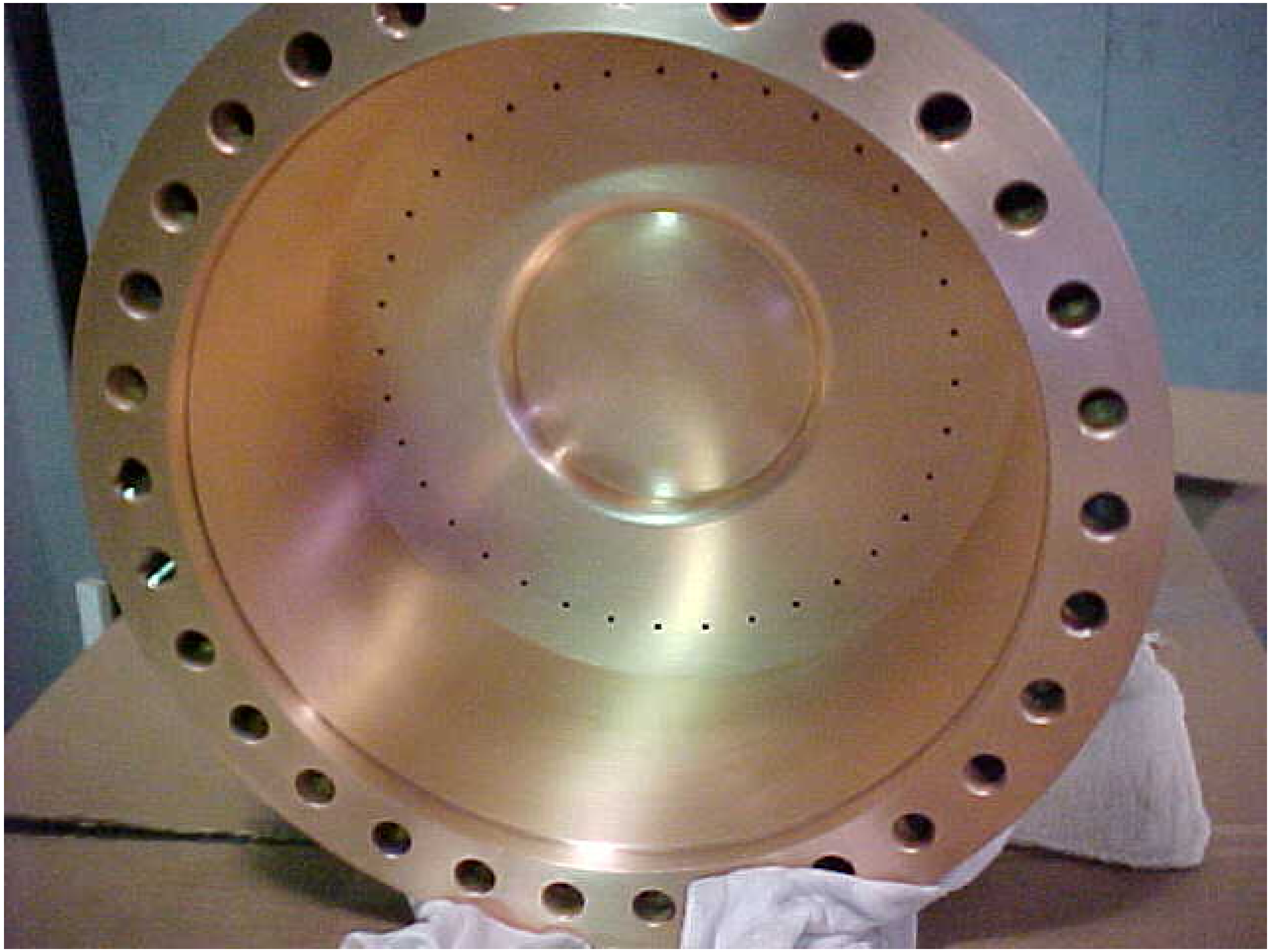
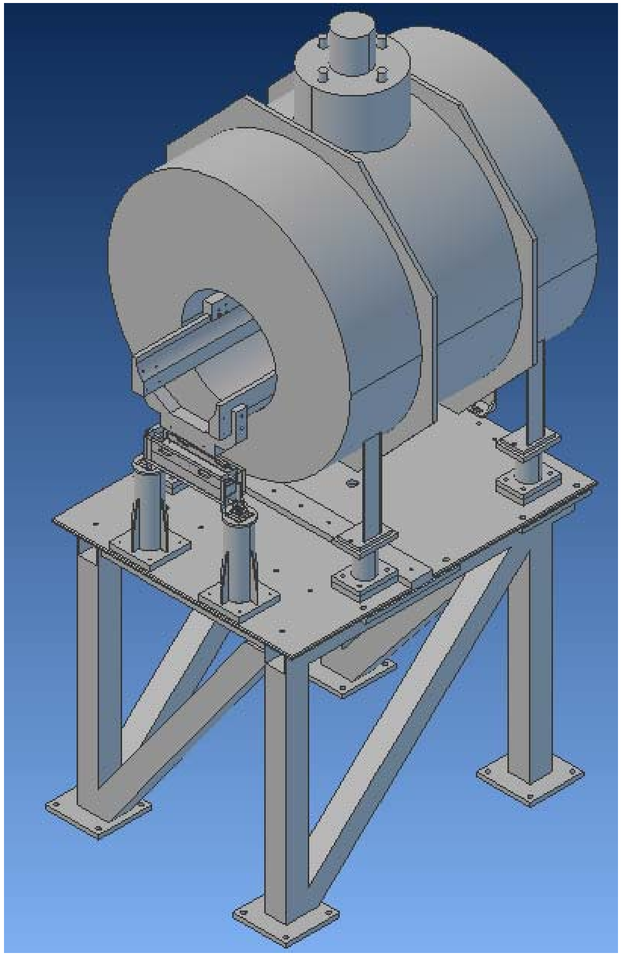
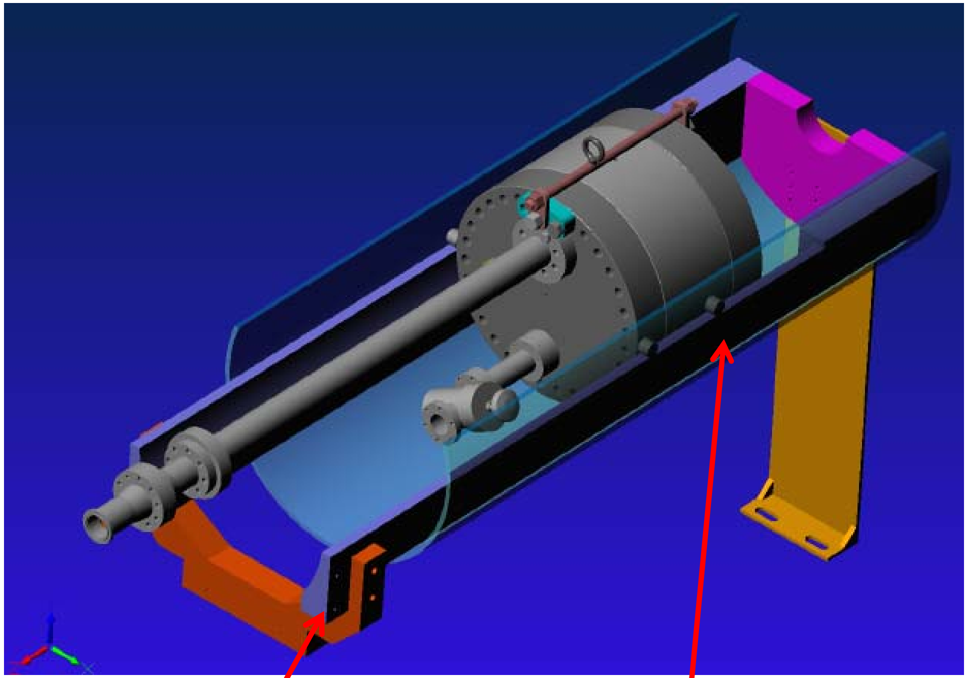


Vacuum and Pressure Seals

- The input coax line with the epoxy pressure window has been tested at 1500 psi and 10^{-6} torr vacuum at 12 MW
- The main cavity vacuum/pressure seals and coax flange seals are made with flat aluminum gaskets .015 thick. (Now thicker)

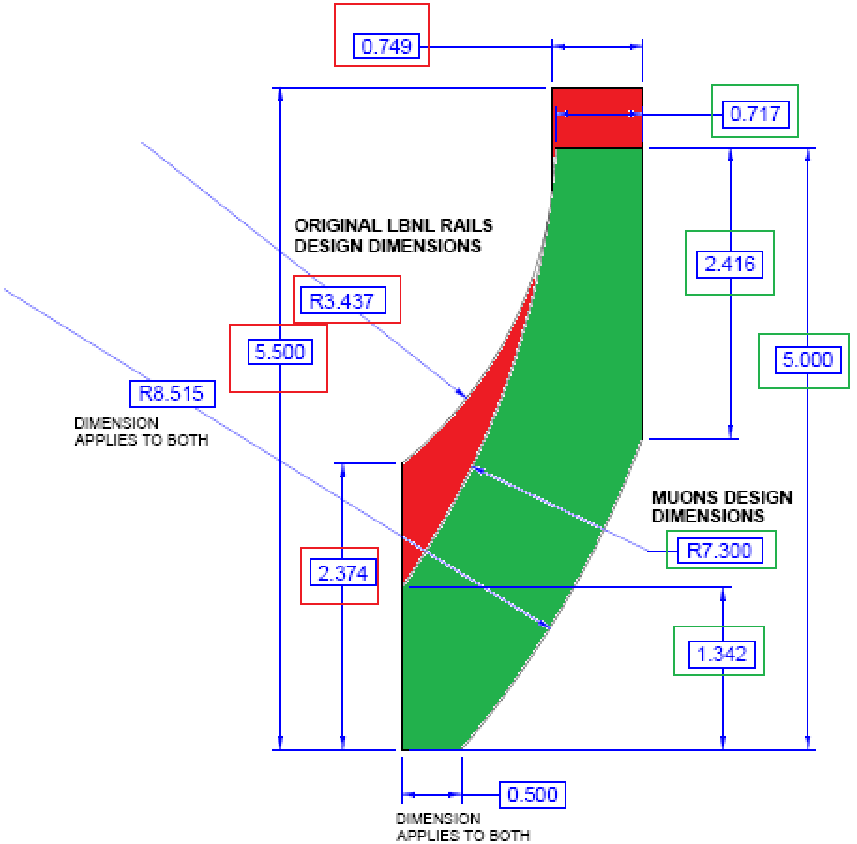
Assembly into the magnet





- The only MTA magnet modification is to replace the rails for the cavity to roll into place (4 screws).
- The cavity is rolled into place from the transportation fixture on rollers fixed to the cavity.

Existing MTA Rail and New Rail



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The LANL cavity Status report

G. Kazakevich

To improve vacuum, the cavity design has been corrected in following manner:

- ► The cavity cover SS surfaces contacting the sealing rings were turned and polished with Tungsten wires avoiding radial scratches, Fig. 1.
- ► The back side of each test plate was turned together with the cavity cylinder so they will be contacted uniformly by the sealing ring Fig. 2.
- ► The front of a test plate is shown, Fig. 3.
- ► The Cavity cylinder was turned to remove cooper plating and was polished with Tungsten wire to get good surface for sealing, Fig. 4.
- ► The 0.04” Aluminum sealing rings were polished with SS wires avoiding radial scratches, Fig. 5.
- ► The 5/8”-18 SS 316 bolts were sent for plating with Silver to get lower friction, that will provide higher forces for sealing

Nov. 12/2010

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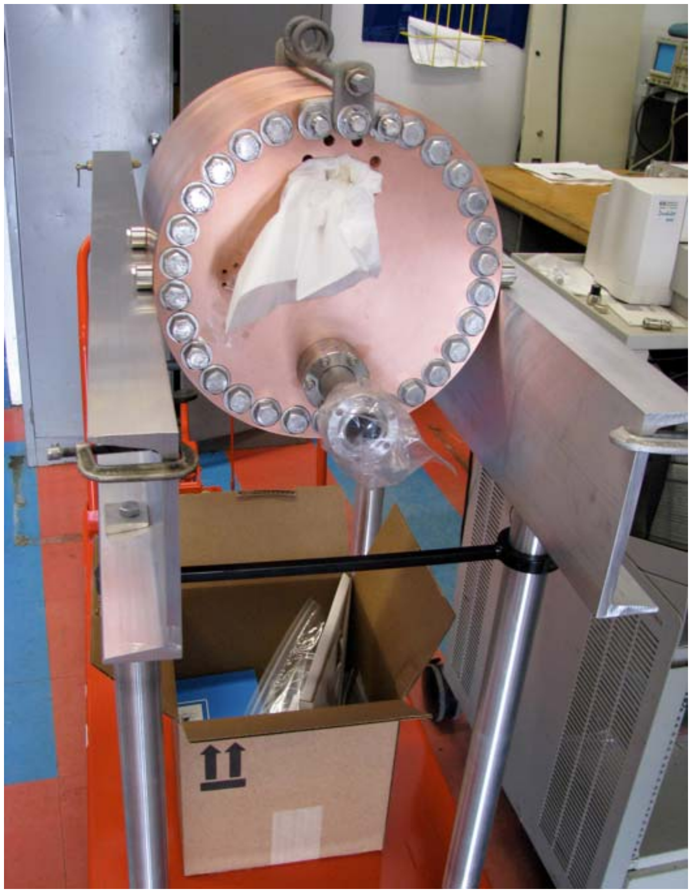
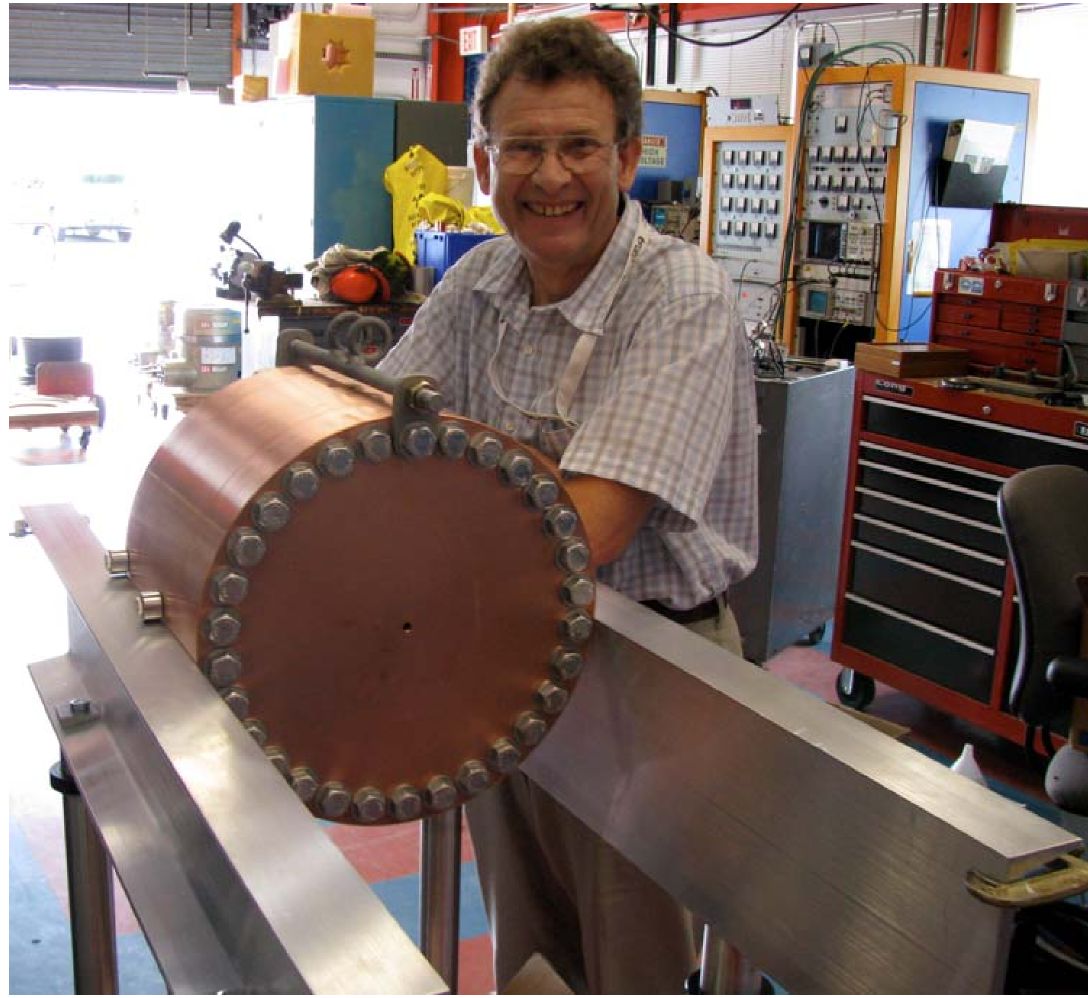
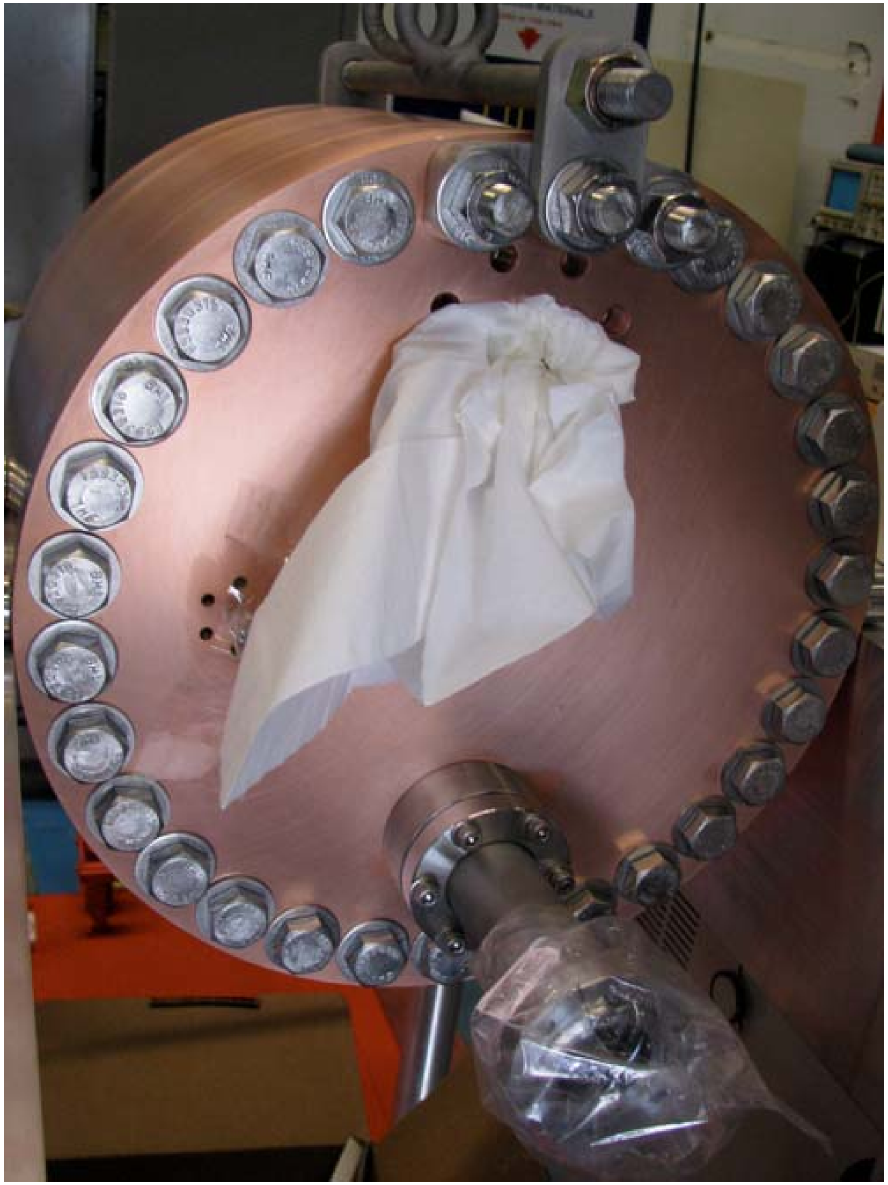
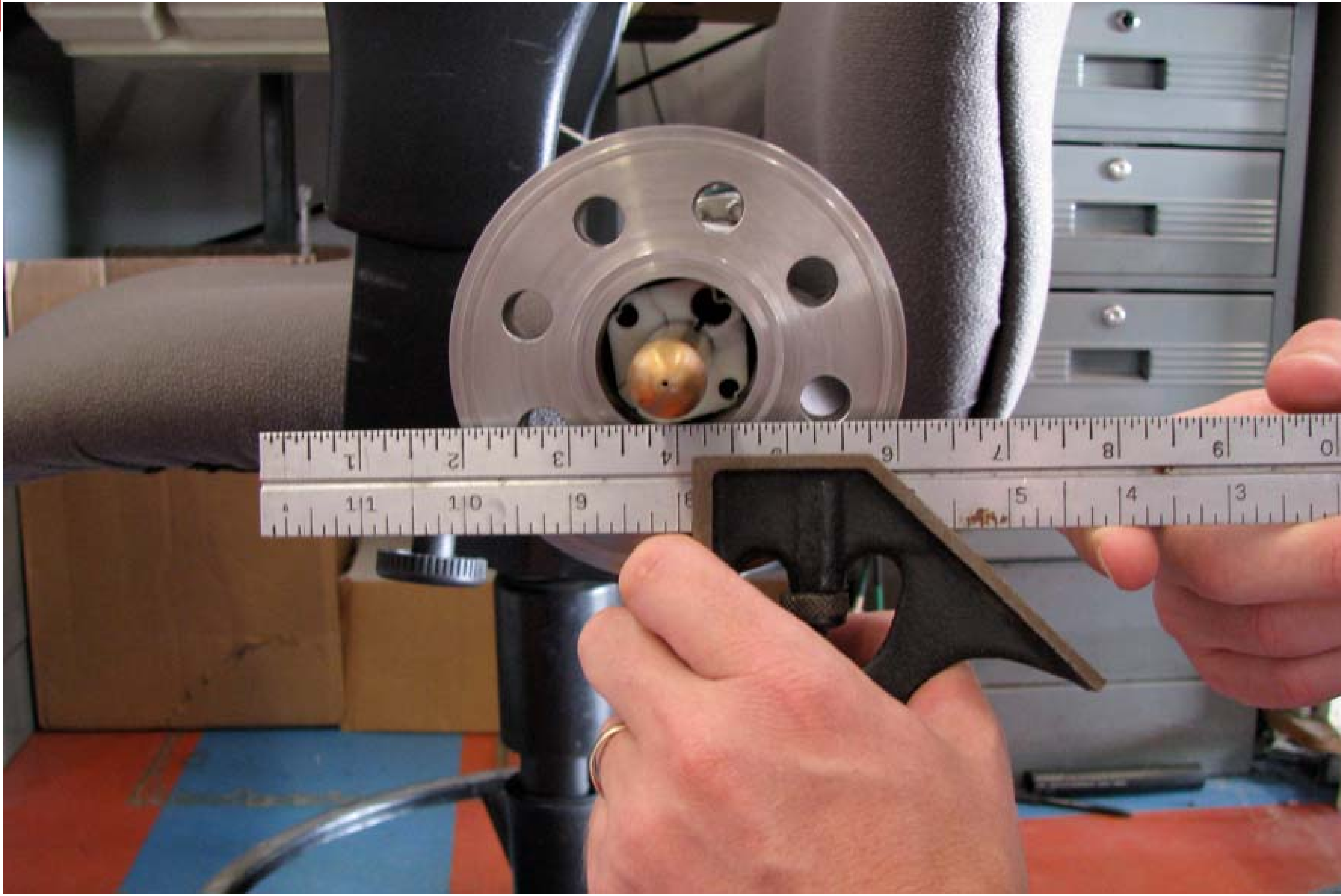
LANL RF cavity

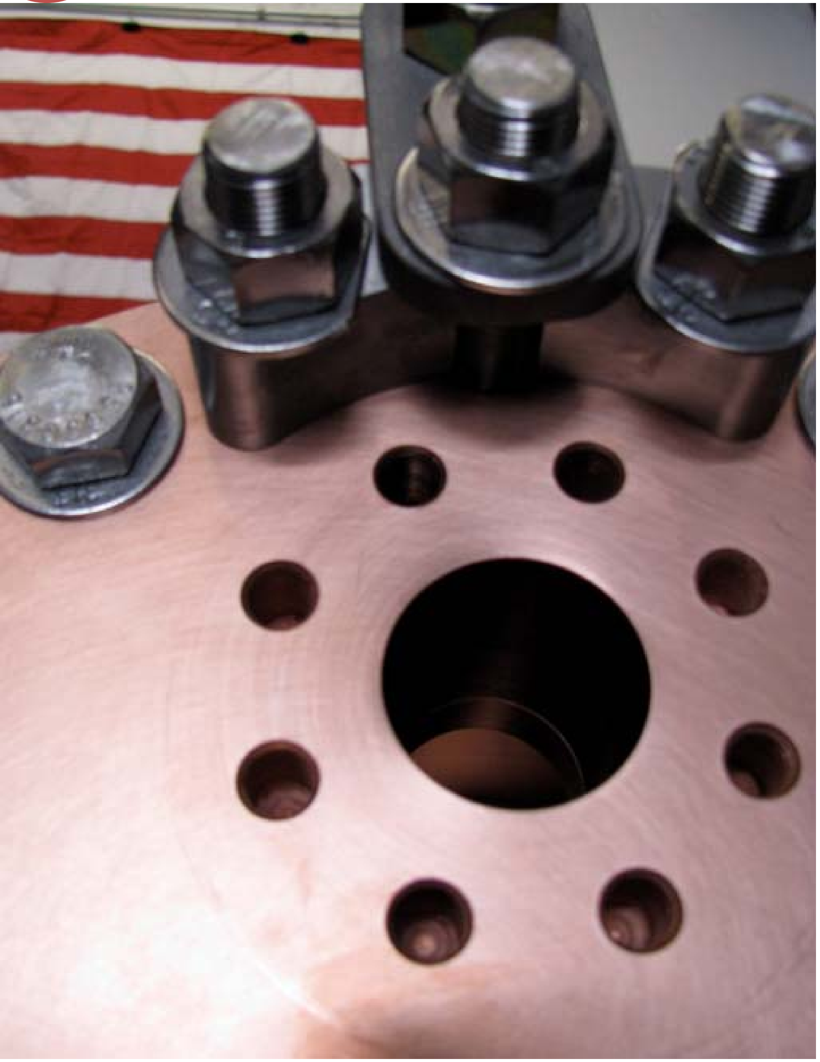
Delivered to Fermilab 9/14/2010
Take photo 9/15/2010

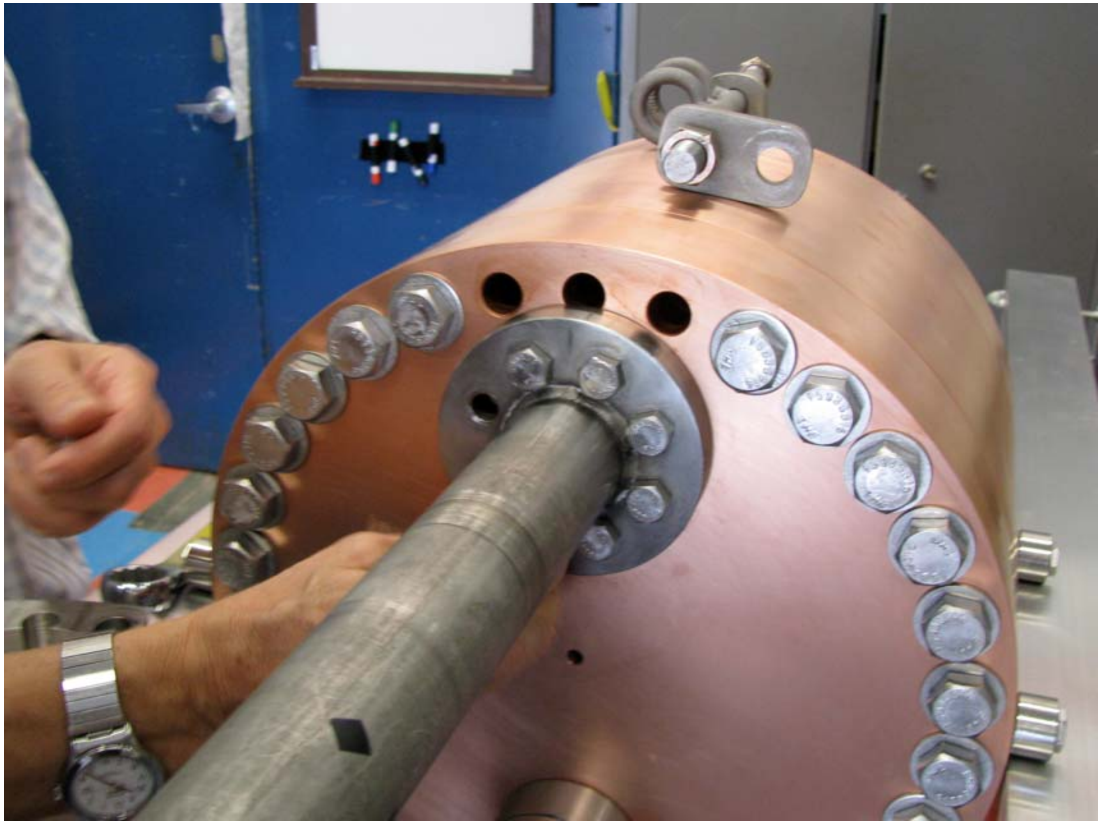












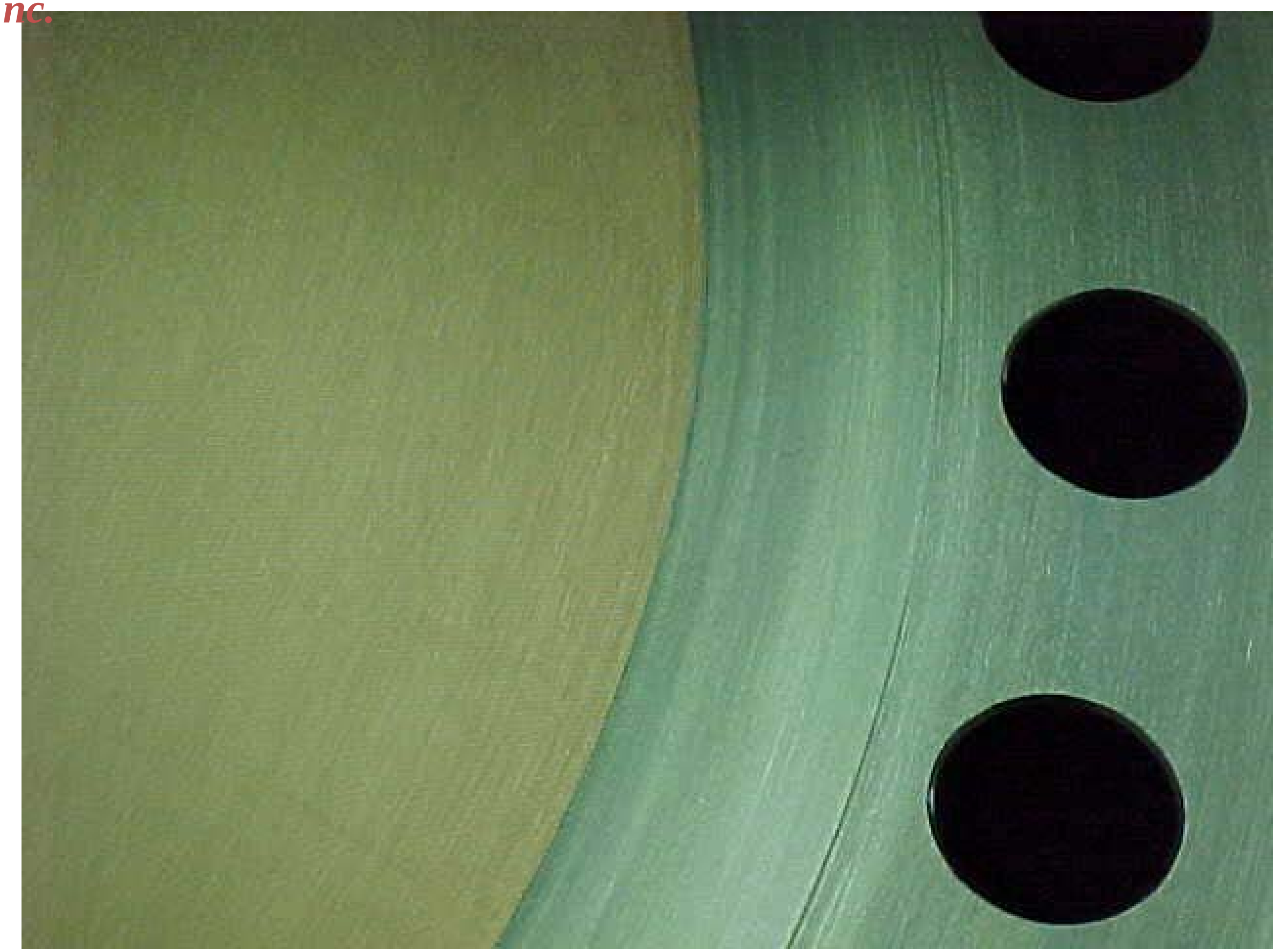


Fig. 1 Turned and polished with Tungsten wire to get low roughness the cavity cover.

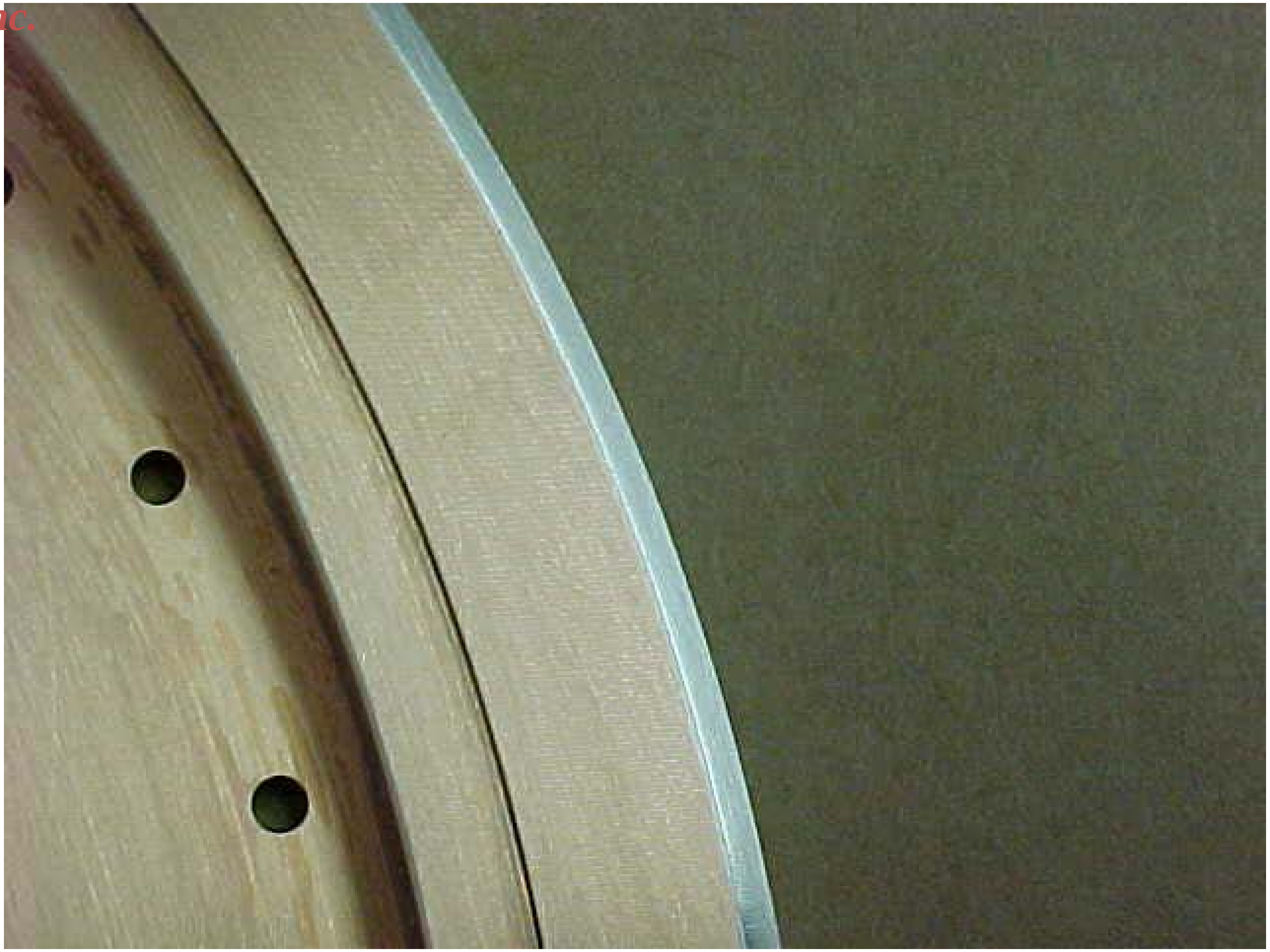


Fig. 2. Planed back side of the test plate (external side). The test plate was turned together with the Cavity cylinder to plan the surface contacted with sealing ring

Fig. 3. The internal side of the test plate has cooper coating for good contact

Fig. 4. The Cavity cylinder was turned to remove cooper plating. The turned surface was polished with Tungsten wire to get good surface for sealing.

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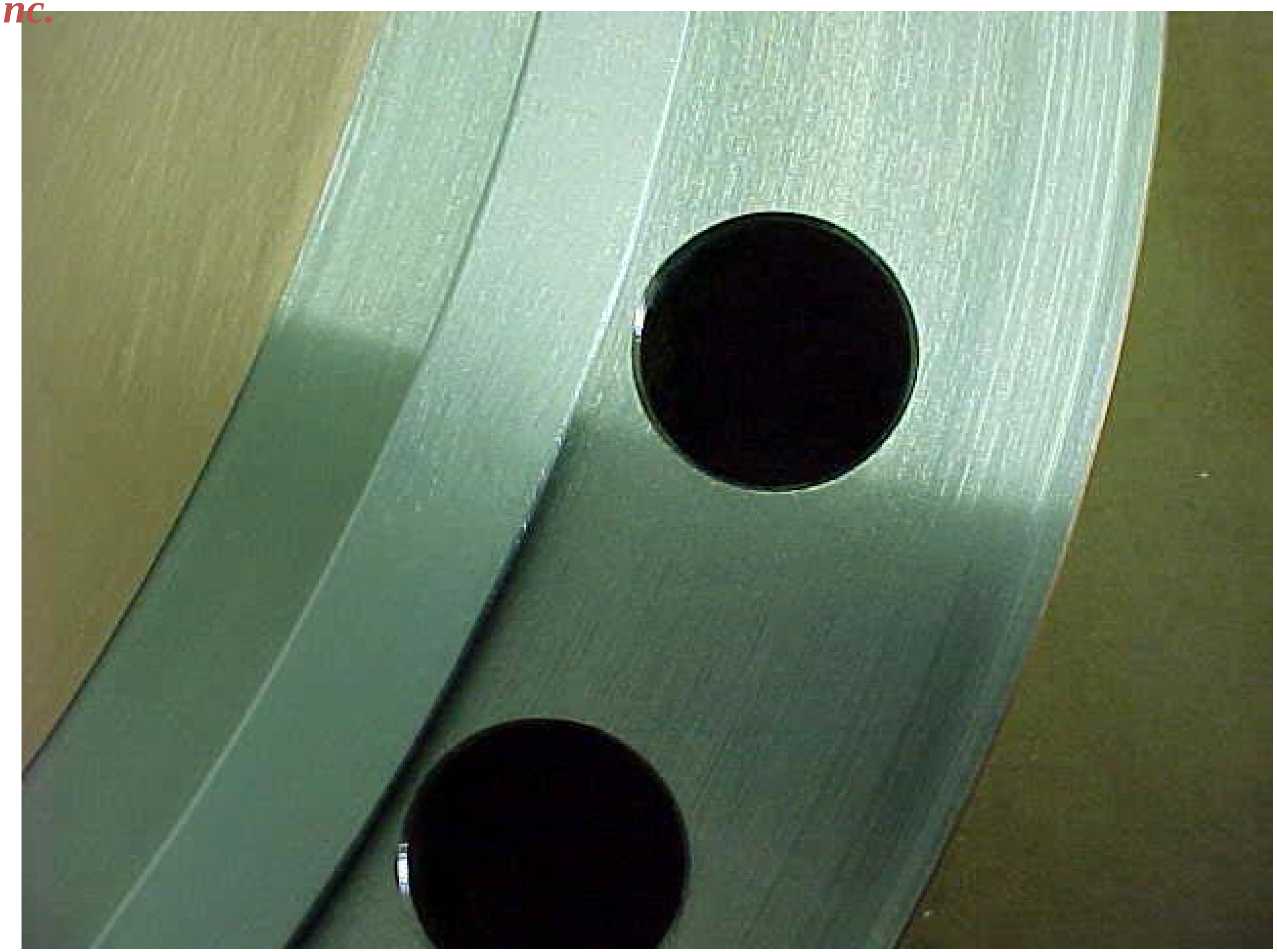

Fig. 5. Polished with SS wires Aluminum sealing ring installed on treated cavity cover

Nov. 12/2010

Tentative Program (after SBIR deadline)

- Assemble with new seals – vacuum to 10^{-6} Torr
- Condition with baseline Cu surfaces in MTA
- Condition in LBNL Magnet
  - (reproduce earlier work)
- Prepare new inserts with excellent Cu surfaces
- Condition in LBNL Magnet
- Prepare new inserts with Be surfaces
- Condition in LBNL Magnet
- Get safety approval for pressurized operation
- Condition in GH2
  - (reproduce earlier work)