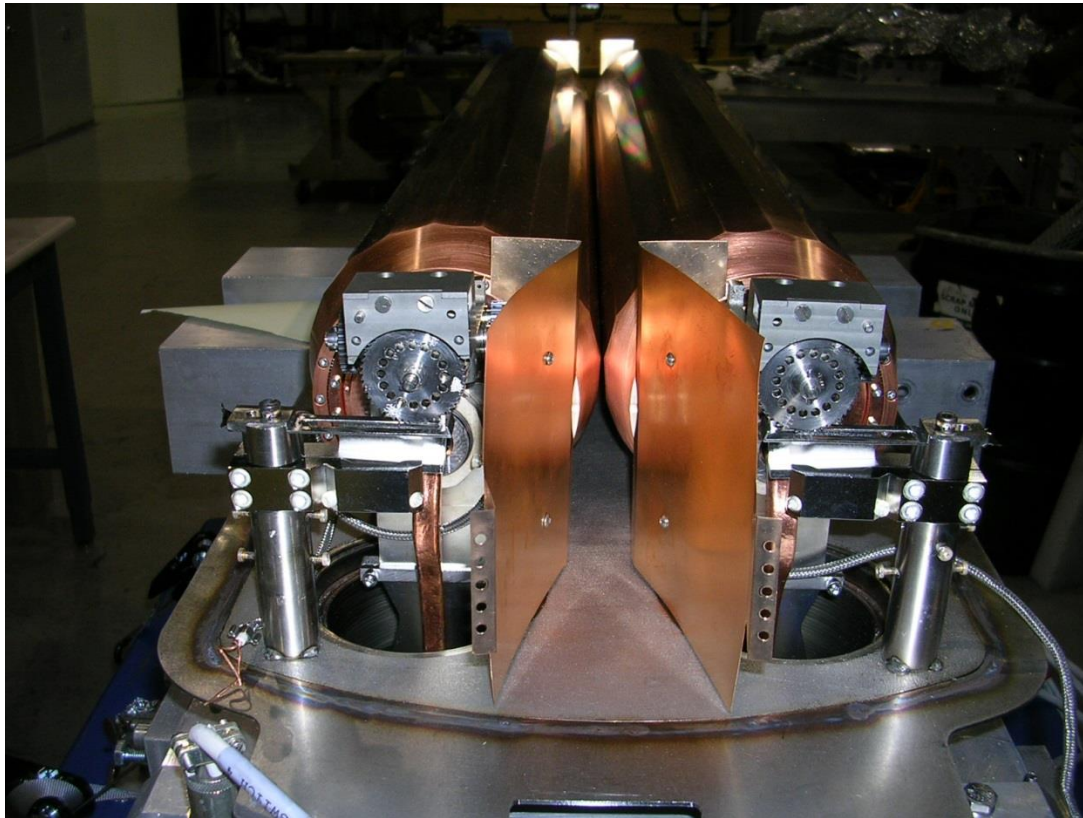


LARP

US LHC Accelerator Research Program

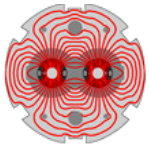
BNL - FNAL - LBNL - SLAC

Status of the LARP Phase II Secondary Collimator Prototype



Last Photo Before Tank Cover Welded - October 14, 2013

14 November 2013
Hi-Lumi LHC
LARP CM21
Daresbury Lab, UK
T. Markiewicz/SLAC



LARP

The LARP Rotatable Collimator Prototype Candidate for a Phase II Secondary Collimator

Two jaw collimator made of Glidcop

- Rotate jaw after 1MJoule beam abort failure accident occurs

Each jaw is a cylinder with an embedded brazed cooling coil

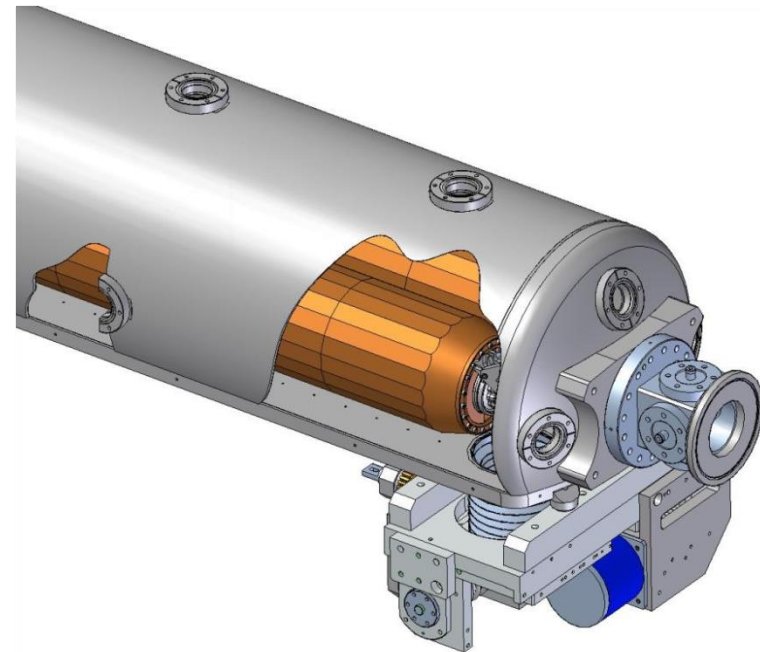
- No vacuum-water braze; 12kW/jaw cooling; minimal thermal distortion
- Maximum radius cylinder possible given beam pipe separation
- BPMs integrated on ends of tank

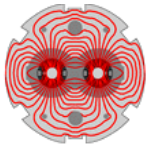
Advantages:

- Not exotic material
- High Z for better collimation efficiency & more debris absorption
- Low resistance for better impedance
- Elemental for high radiation resistance

Disadvantages:

- Glidcop **WILL** be damaged in asynchronous beam abort



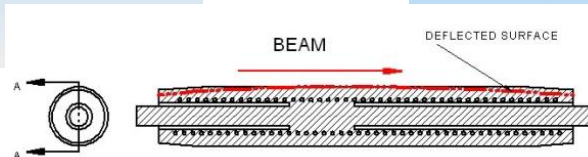
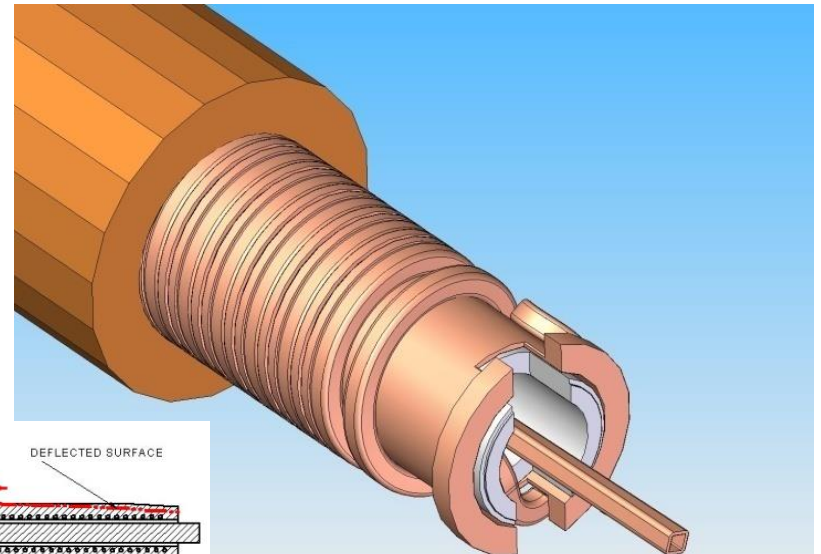
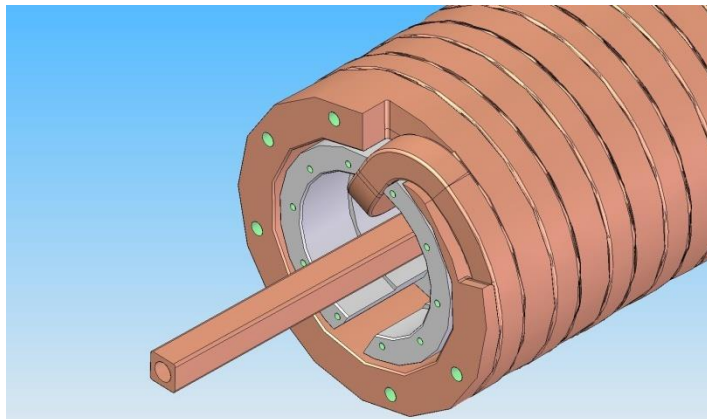
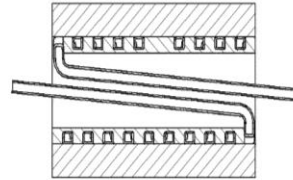


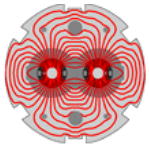
LARP

Jaw Designed to Minimize Thermal Distortion

1 hour beam → 12kW with 10 second transients x5 → 60kW

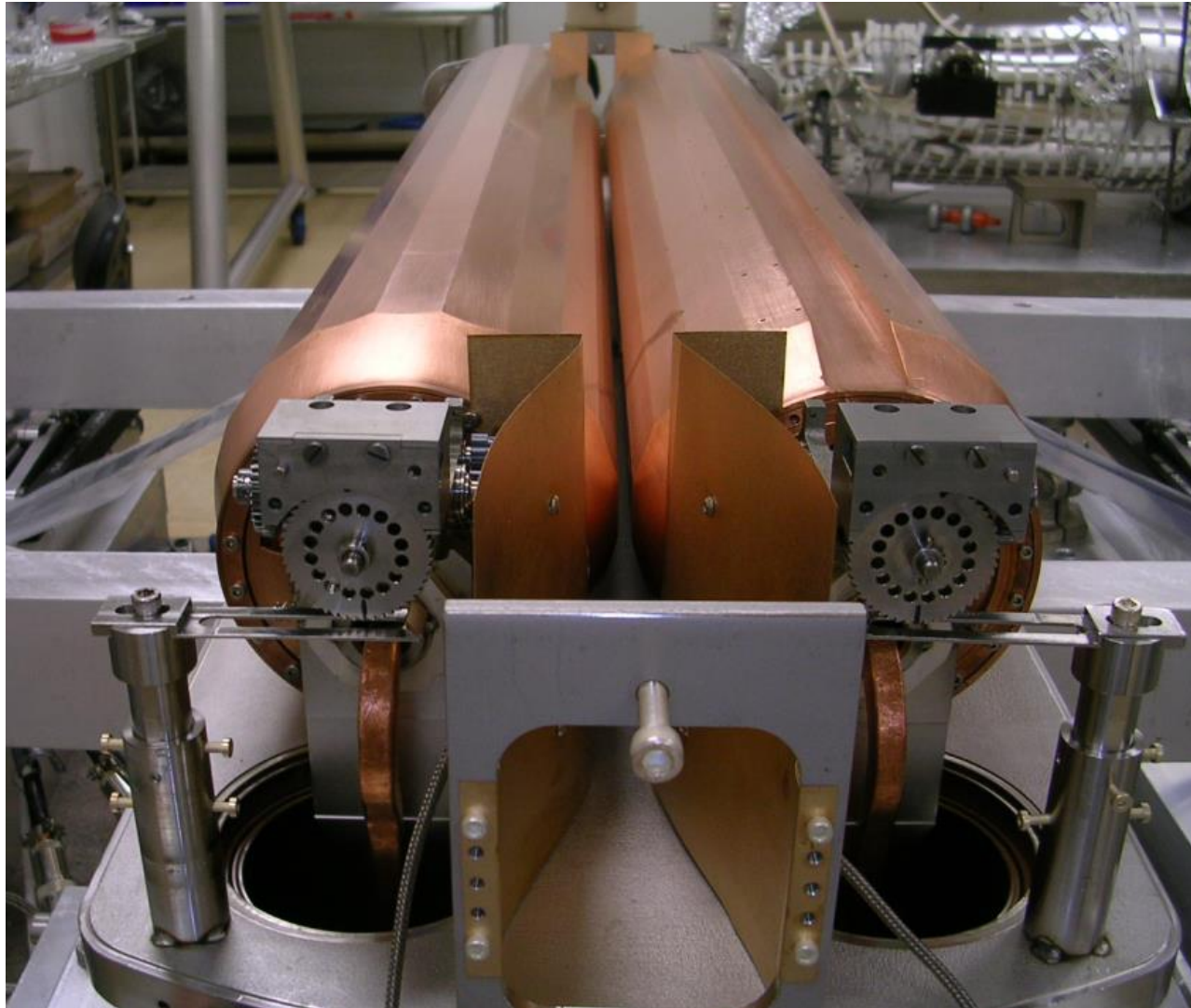
- Continuous 15m copper tube wrapped on copper mandrel
 - Tube enters from far end of mandrel then begins spiral to provide ~1m free length that can twist to allow rotation
- 25mm thick Glidcop “jaw” brazed to mandrel
 - 20 “20mm wide facets” 25um flat are the collimating surfaces
- Molybdenum shaft with 2mm “heat expansion gap” from mandrel
 - Mandrel held at midpoint only by a brazed Glidcop “hub”





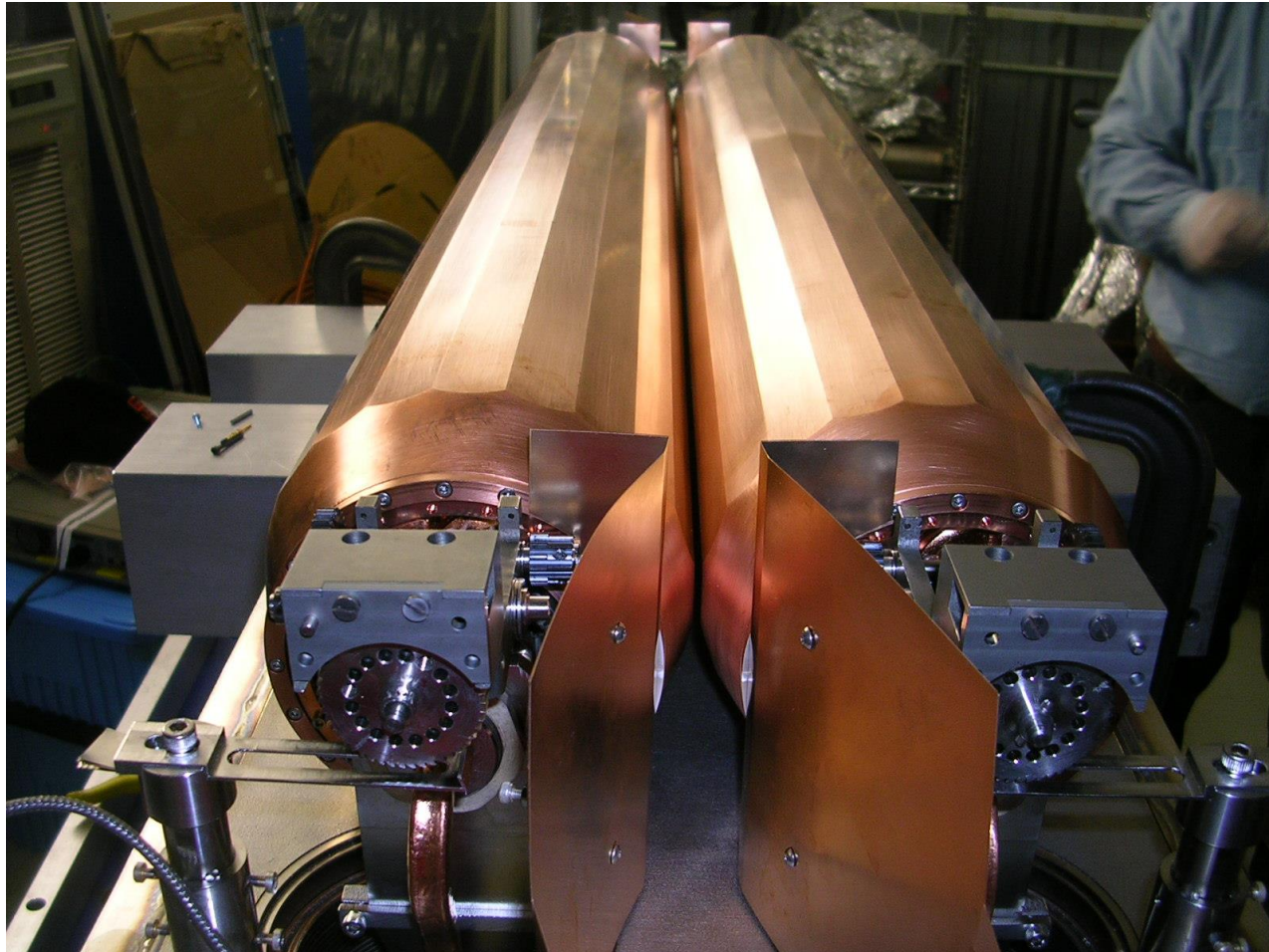
LARP

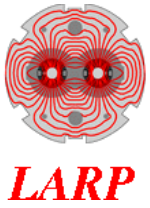
1st Collimator Assembled 13-Mar-11 Mechanical & Resistance Tests Good but find both cooling tubes damaged



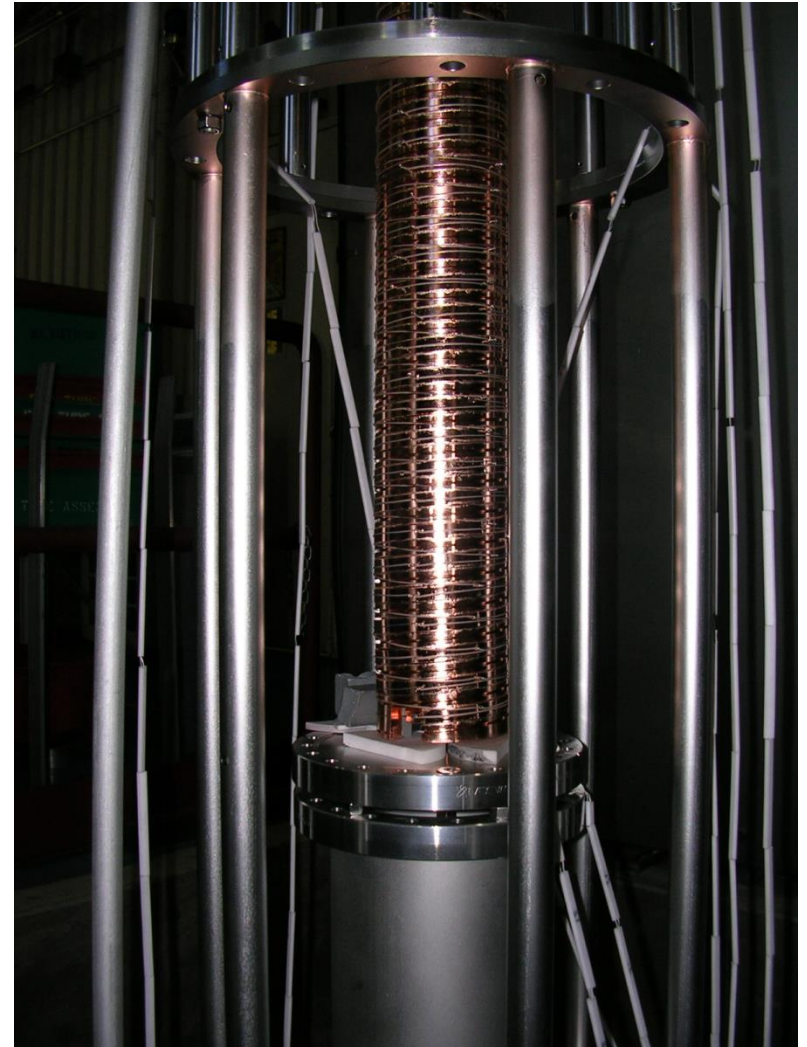
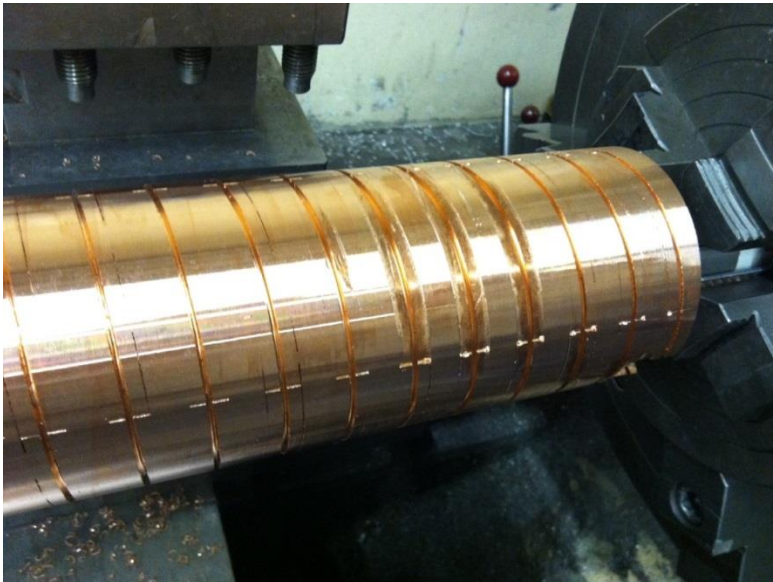
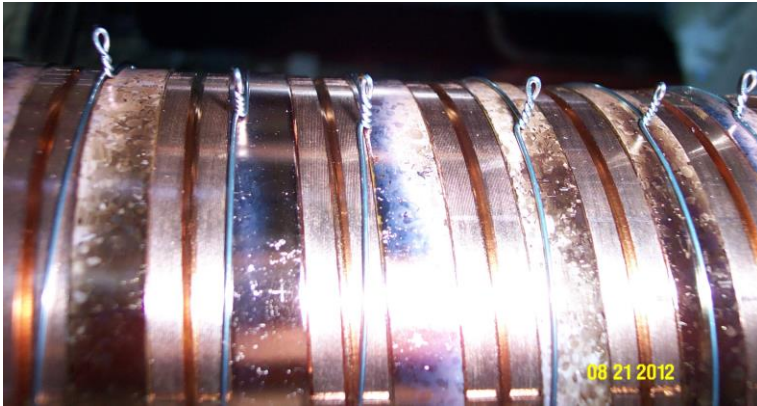


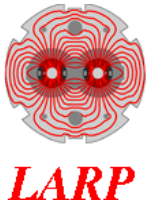
2nd Collimator Assembled 18-Sept-13 Mechanical & Resistance Tests Good



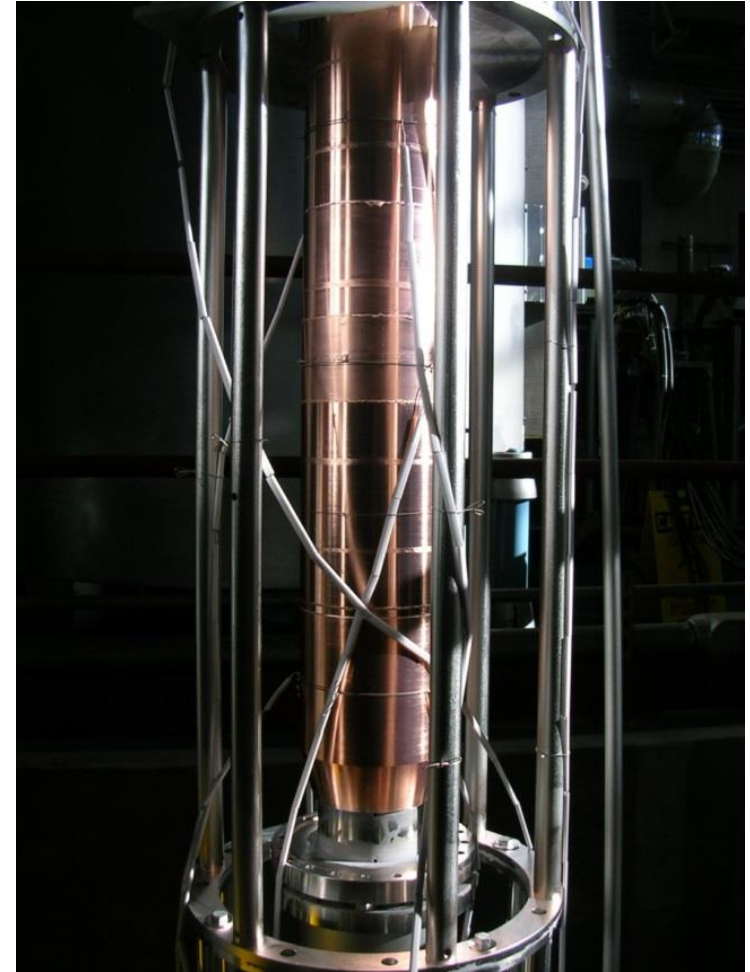


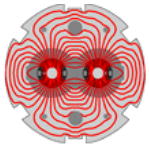
- 1) Wind 10mm x 10mm cooling coil into over-deep grooves
- 2) Protect coil with shims,
- 3) Braze
- 4) Machine to braze tolerance





- 1) Machine Glidcop Cylinders
- 2) Copper “flash”
- 3) Load with braze wire & sheet
- 4) Assemble over mandrel & braze
- 5) Machine facets centered on rotation axis





LARP

New Ceramic Main Bearings with Restraint Clip

2011 version WS2 impregnated SS; falls of shaft during bake



“Naked” Hub Screwed to Axle



Bearing on Hub



Spacer Ring & Bearing in Housing



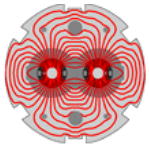
Bearing Restraining Clip



Ring, Bearing in Housing & Clip



Oversize Outer Housing w/ Flats that prevent rotation in jaw supports



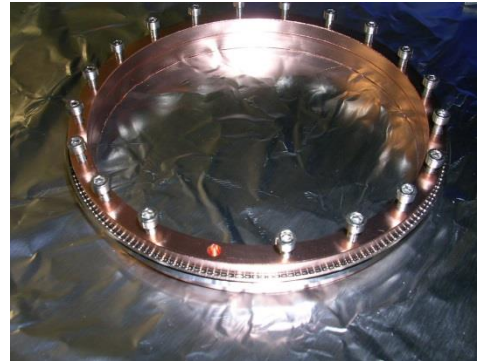
LARP

New RF Bearing Assembly

2011 version hand made with 1mm Rhodium coated balls



Ceramic bearing in race & the 2 rings that capture it



Assembled bearing package that will hold the RF Foil



Trapped bearing in ring that is fixed to the collimator jaw



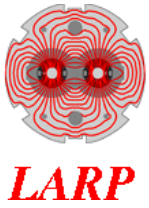
Attaching outer ring to collimator



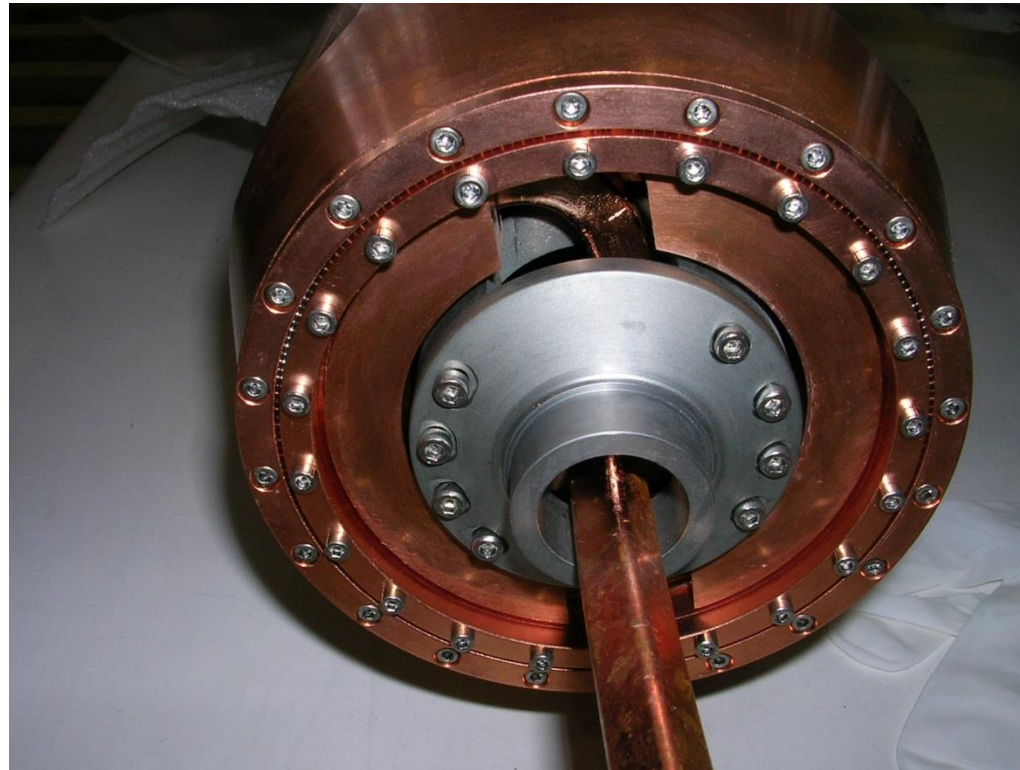
Close-up of ridge where bearing rolls

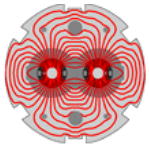


Before outer ring screwed on



Final RF Bearing Installed





LARP

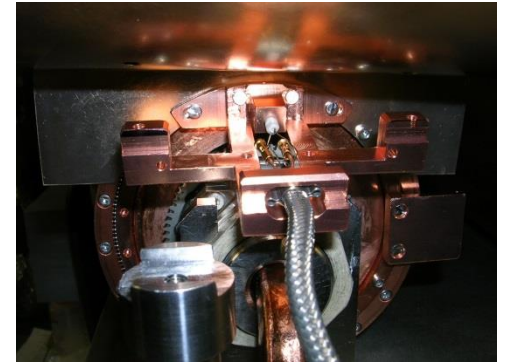
BeCu RF Foils, Rhodium plated “wipers”, Clamps to keep RF Foil from dragging during jaw rotation



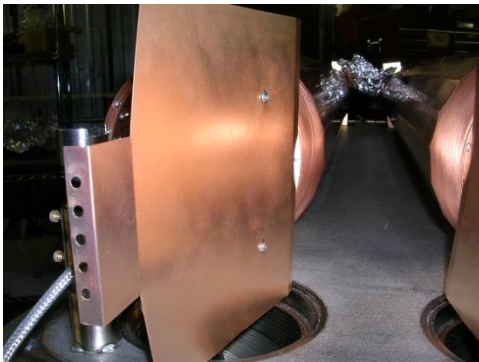
Foils, wipers & clamps



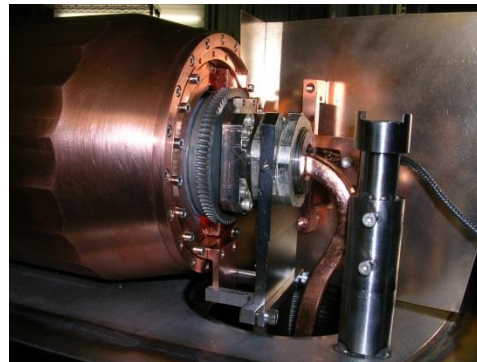
Thermistor/Foil/Wiper Holder



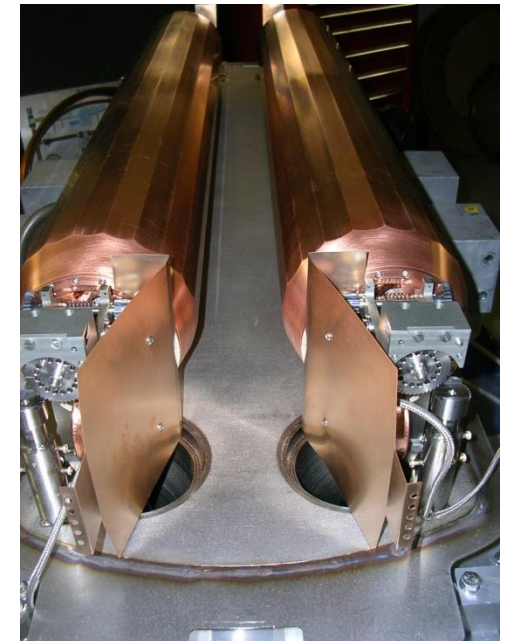
Holder w/Wiper/Foil Attached to Inner Ring of Bearing Holder

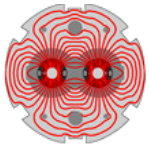


Beam-side View



View Behind Foil w/ Clamp Attached

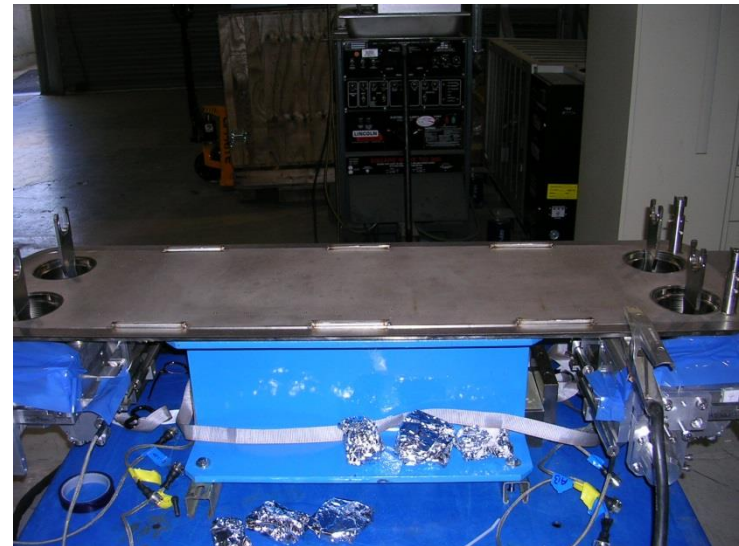
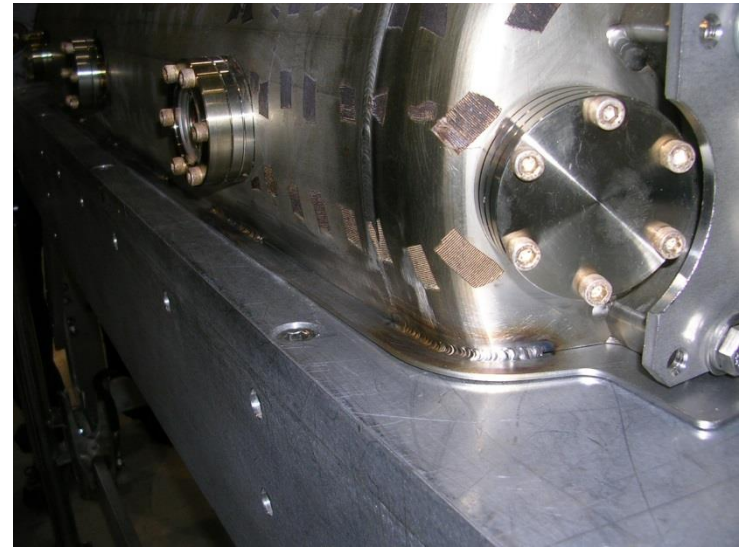


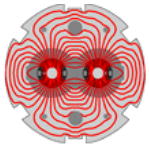


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Welding Flanges Attached to Tank Cover and Baseplate

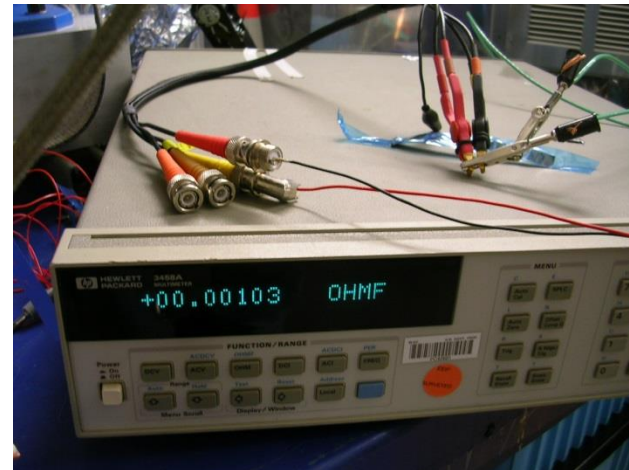
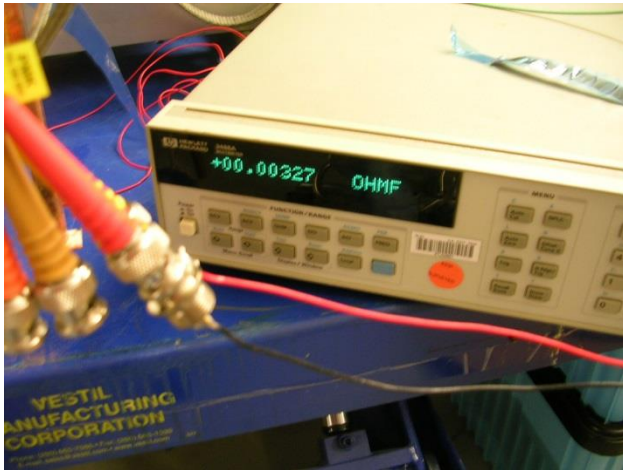
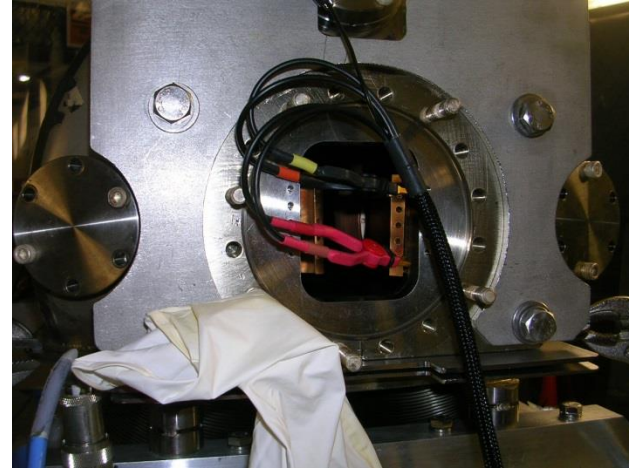
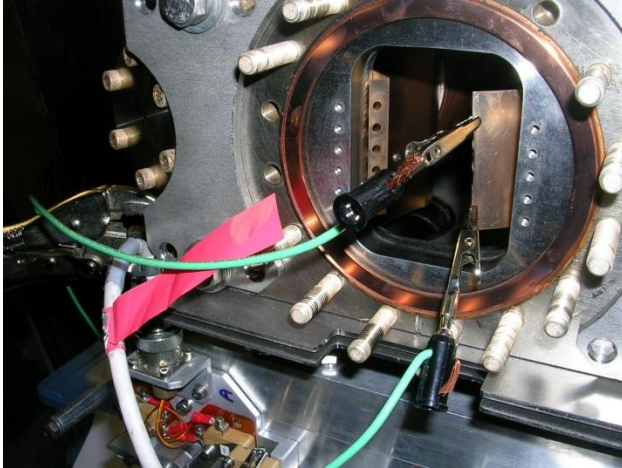
Make up saw kerf from proto I and permit multiple weld/grind/weld

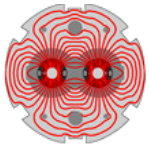




LARP

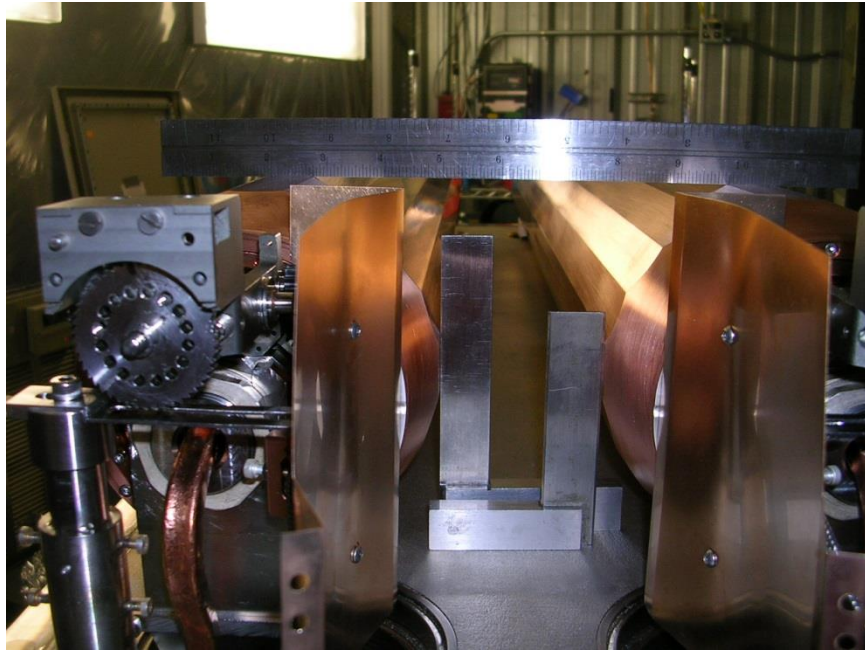
Test Fit Cover & Resistivity Test: 1 mOhm/side



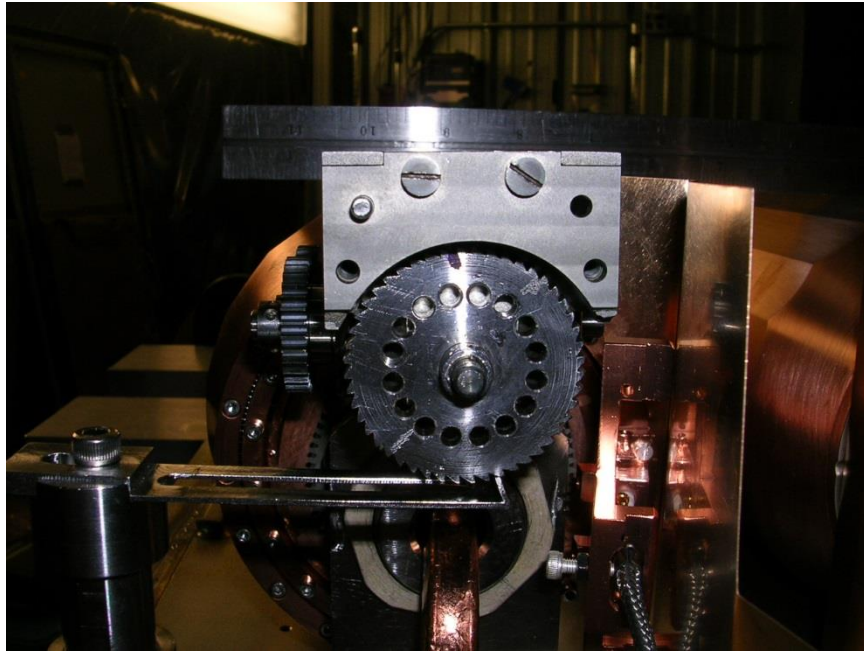


LARP

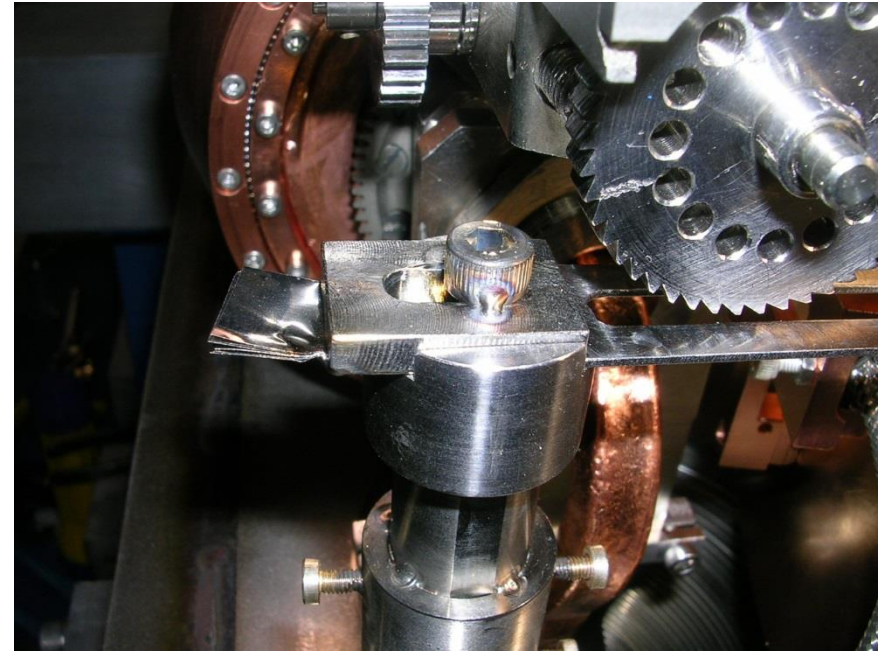
Jaw Alignment & CMM



Adjust Rotation Actuator & Rotation Drive Wheel



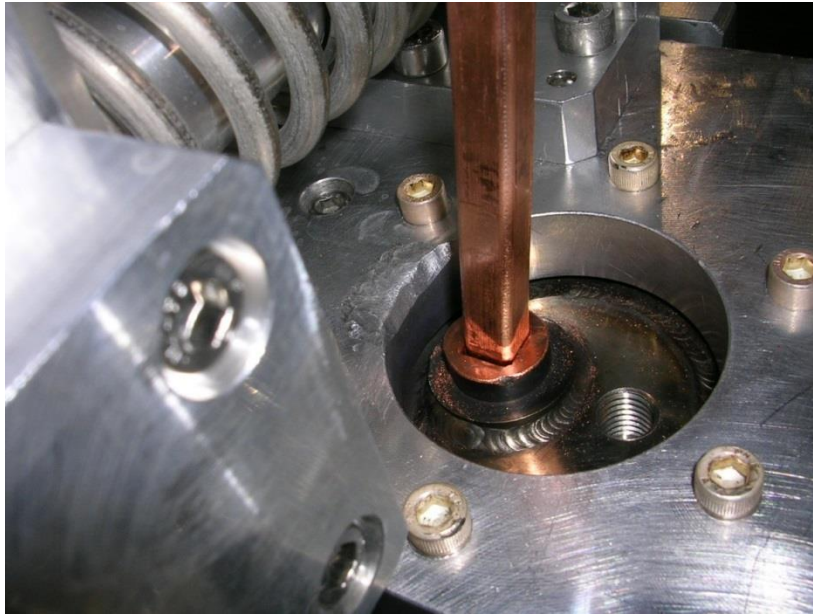
Left-Right Adjustment is relative to Jaw “Inner Limit Switch”



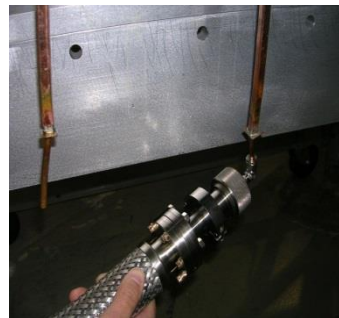
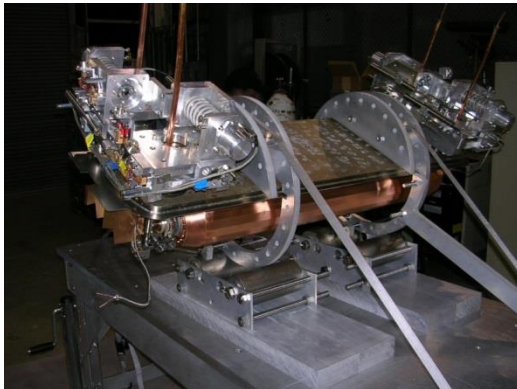
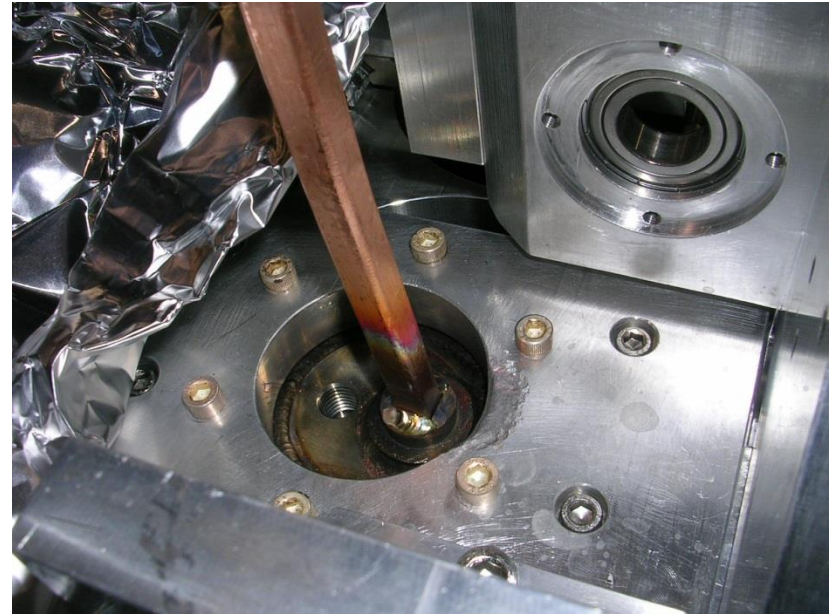
Up/Down Clearance Problematic Here: Shim & Weld as in 2011

Prep & “CuSil” the Cooling Tubes to the Bellows Feedthroughs

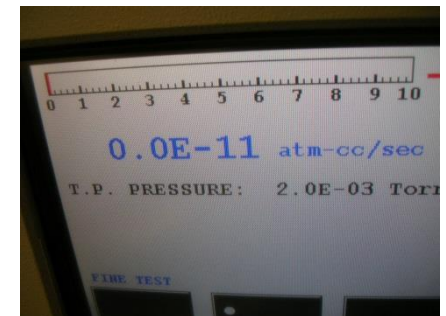
Before

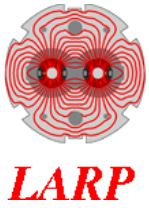


After



Leak Check
Tubes Again

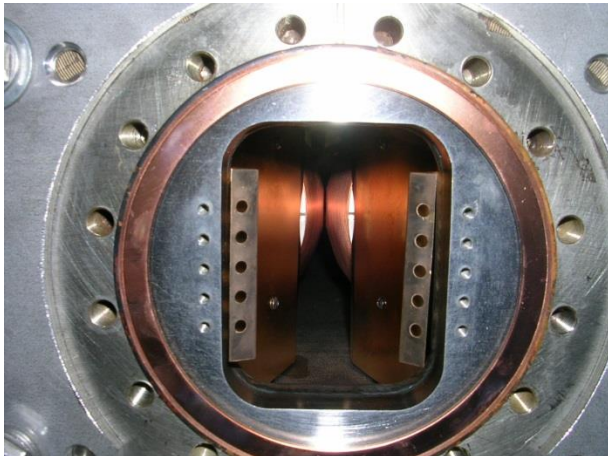




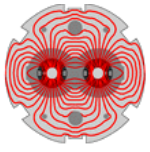
Install Tank Cover, Install Thermistor Feedthrough Flanges, Simulate Weld with Vise Grips and Test Rotation Drive (1 Oct)



Verify thermistors read ~110 through BNC vacuum feedthroughs



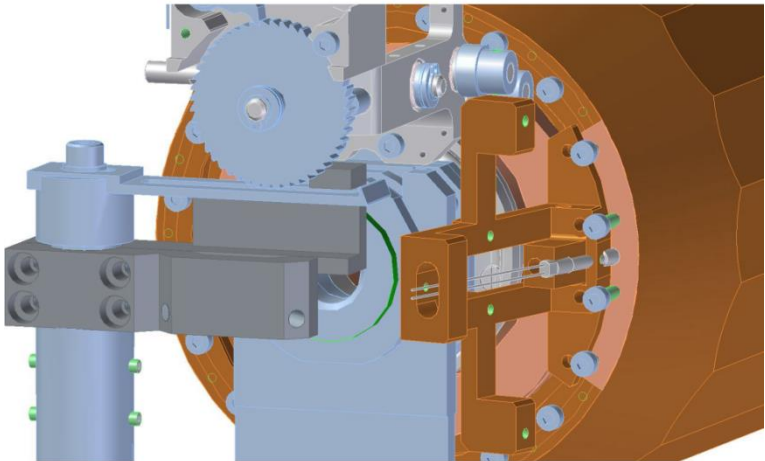
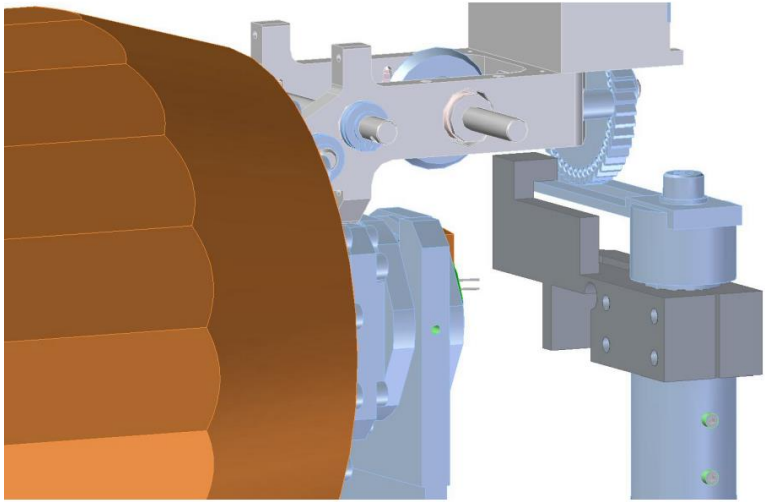
Simulated weld causes baseplate to bend enough to cause rotation actuator to miss drive wheel



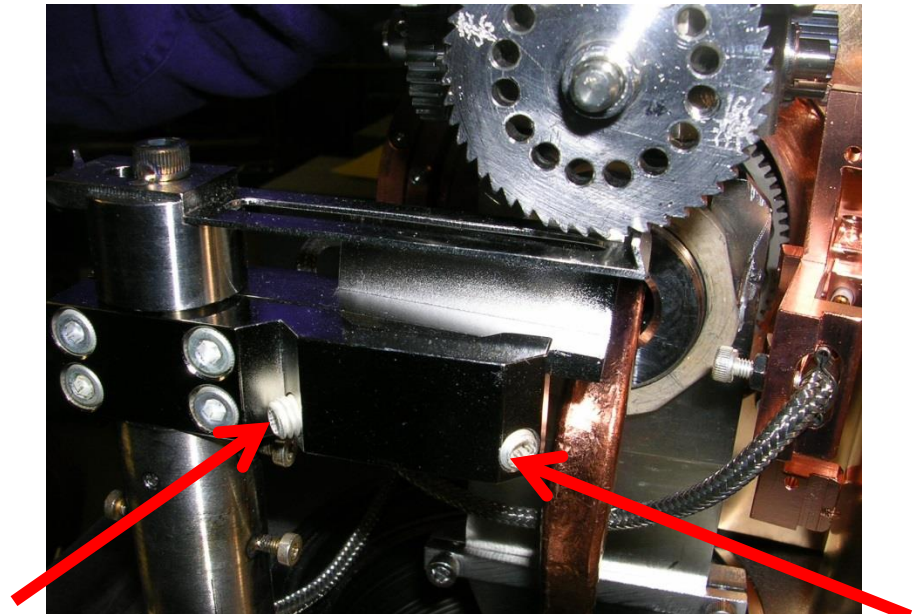
LARP

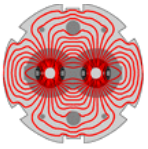
Design, Fab, Install, Adjust & Test Flexure to Precisely Set Actuator Height 1-10 OCT

(can always be accessed through flange openings and adjusted if needed)



Play movie if time permits

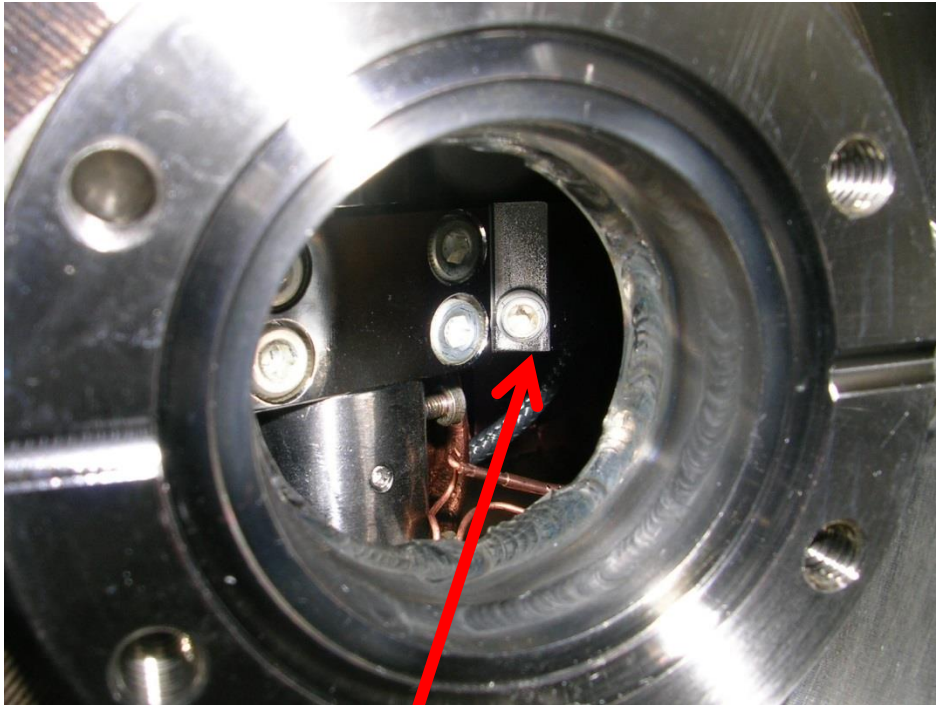




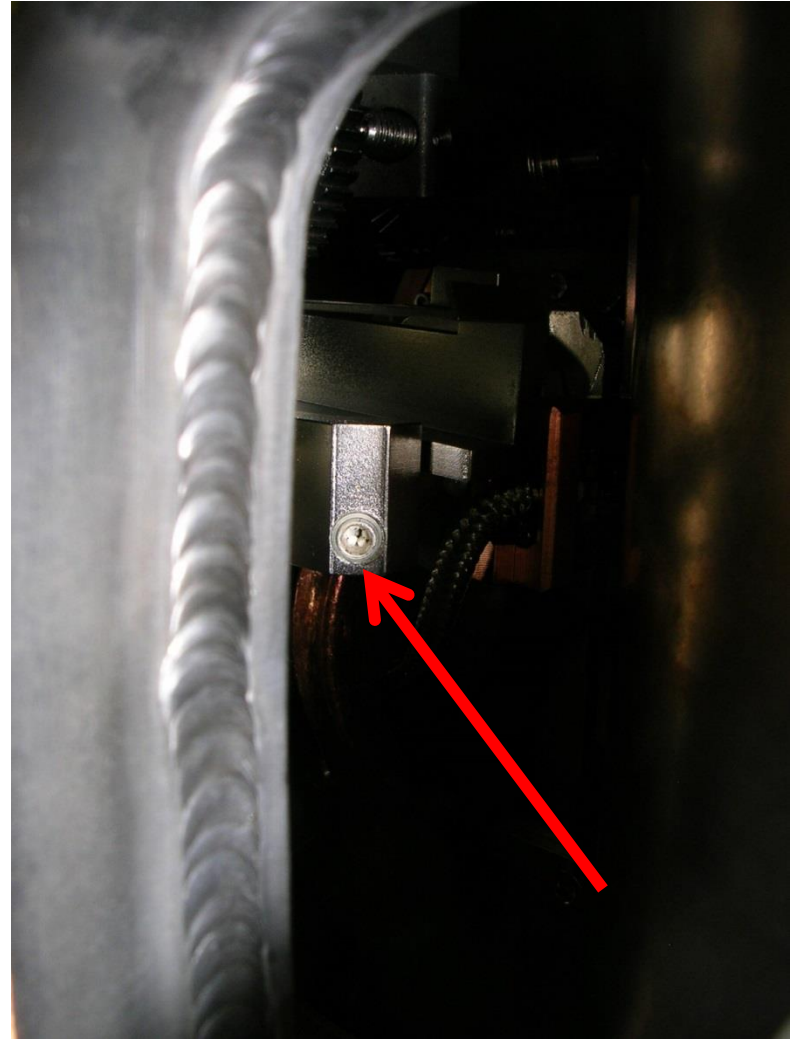
LARP

Access to Actuator Adjustor

Thermistor
Port

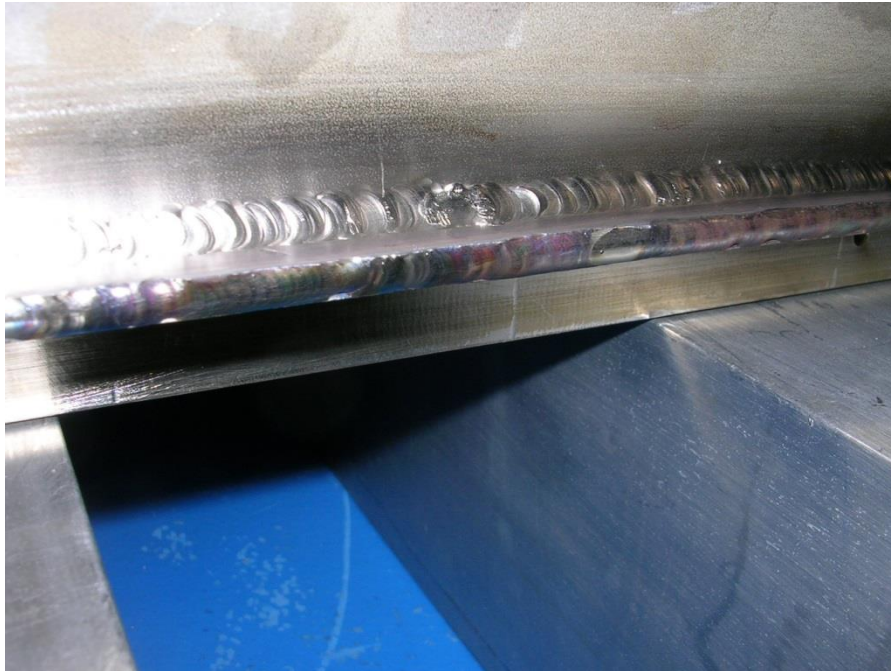


Beam Port

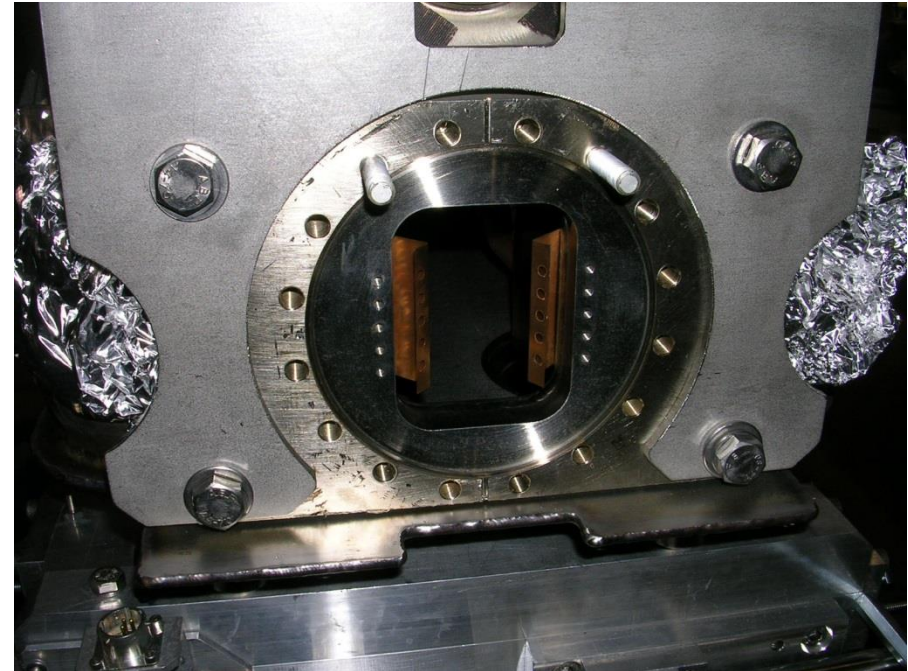




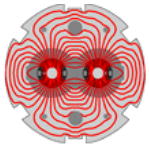
16 OCT: Tank Flange Welded



Edge weld can be ground away &
re-welded if access needed



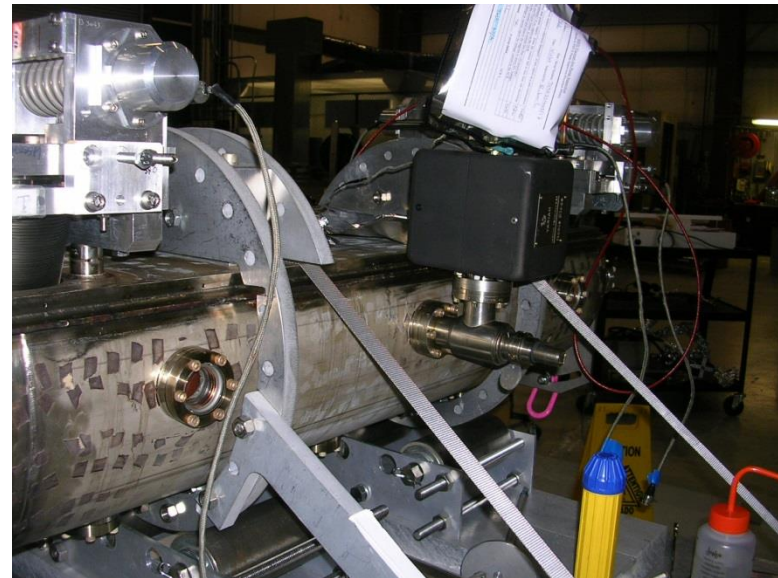
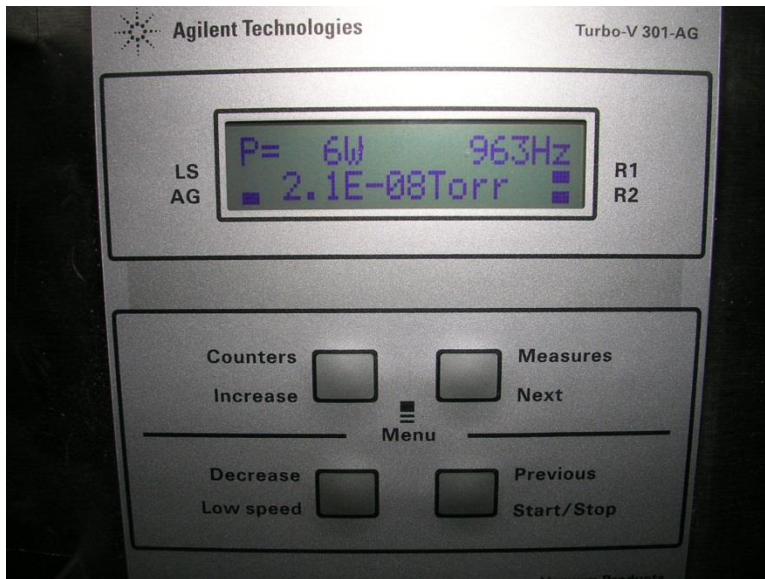
Interference with 6" flange

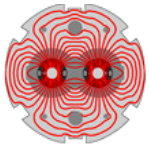


LARP

17-31 OCT: Leak Testing

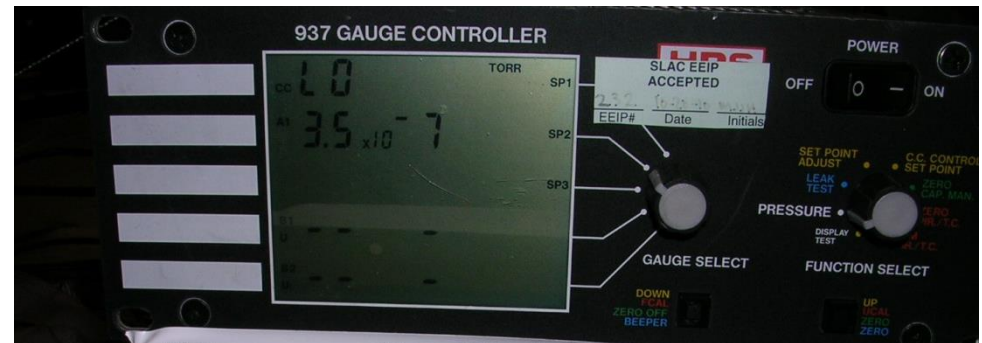
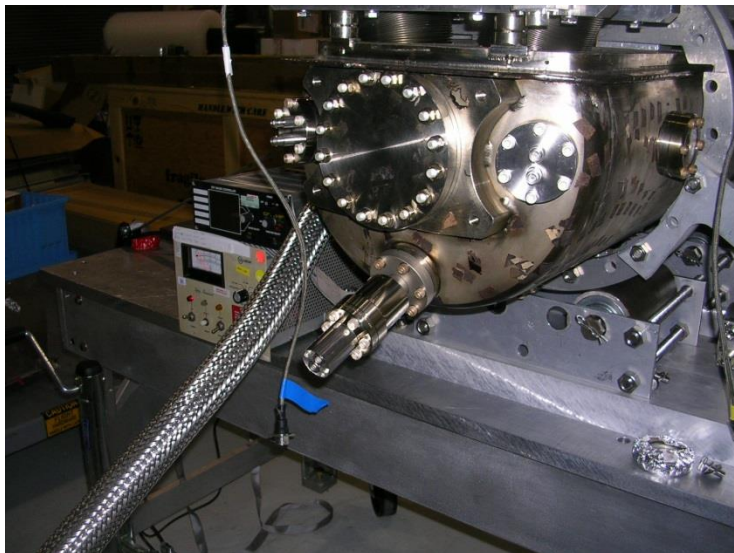
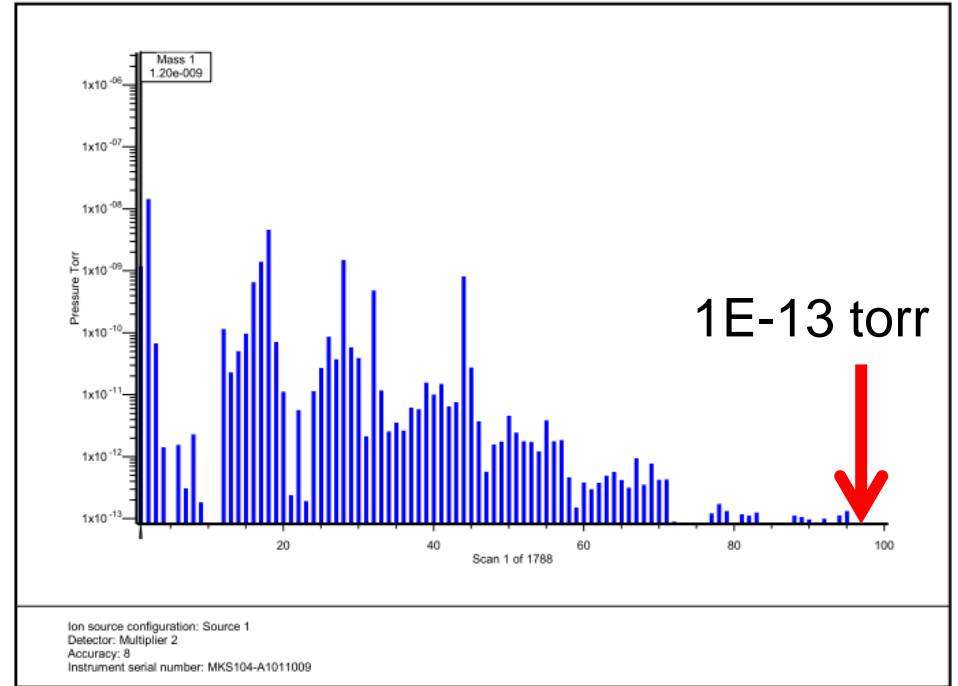
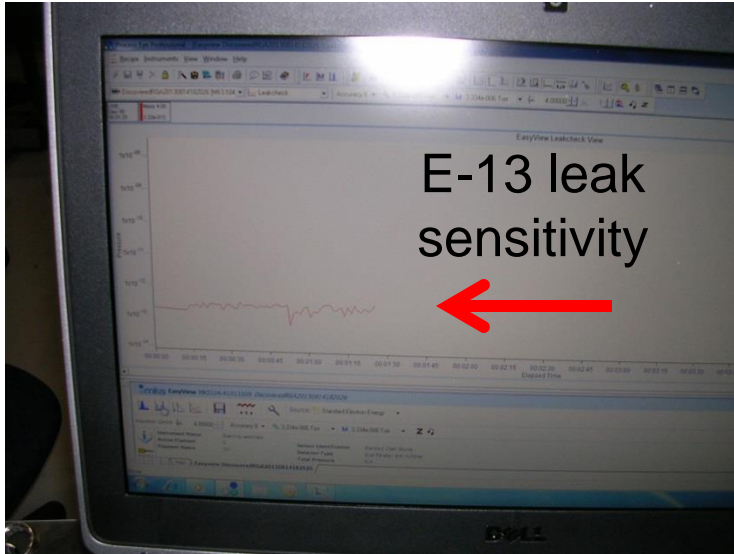
| Hardware | Pressure @ Pump (Torr) | Leak Rate (Torr-l/sec) | Leaks |
|---------------------------------------|------------------------|------------------------|--------------------------------------|
| He Leak Tester | 6E-6 | 6E-6 | 2 CuSil Pinholes 1 Flange Pinhole |
| RGA Turbo Cart w/20 l/sec Ion Pump | 6E-8 | 1E-11 | 1 CuSil Pinhole |
| | 2.1E-8 | 1E-13 | No leaks |



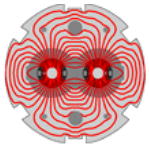


LARP

1 Nov: Pre-Plasma Cleaning Vacuum Status



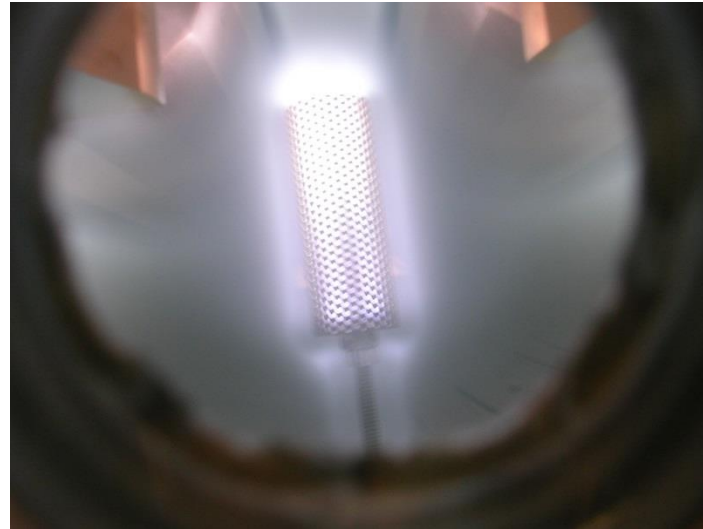
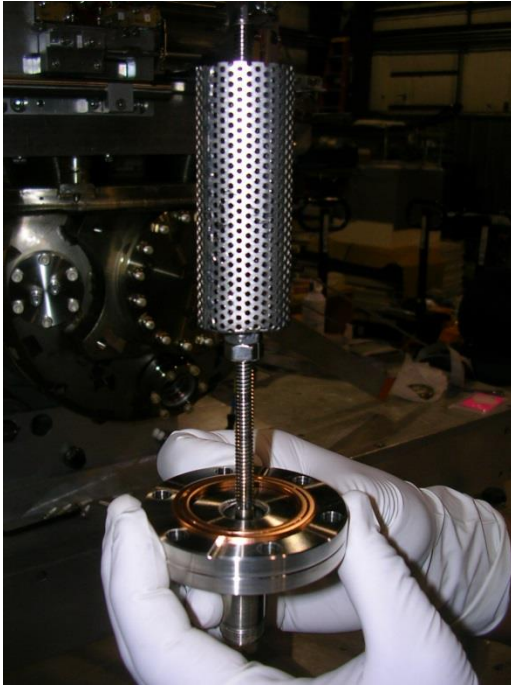
Cold Cathode Gauge & Controller



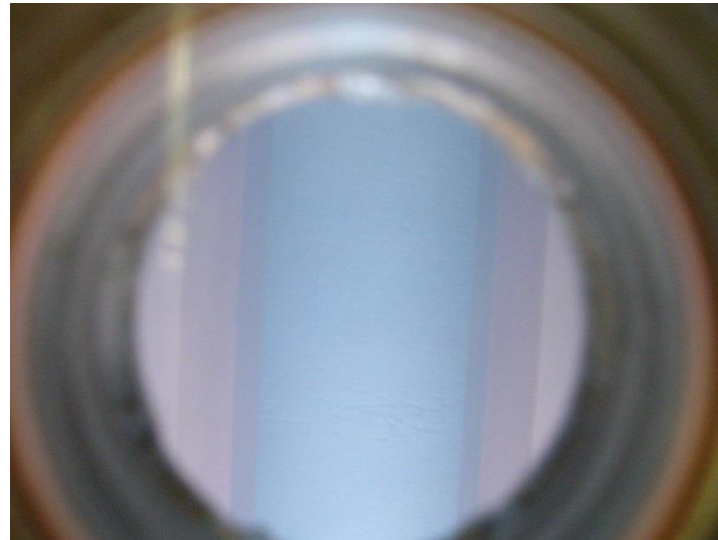
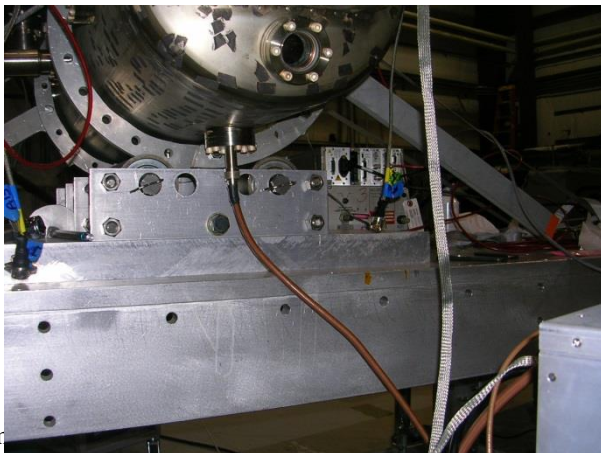
LARP

1 Nov: Plasma Cleaning then Pump w/RGA Turbo (only) Over Weekend

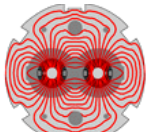
1 hour O₂
then
2 hours H₂



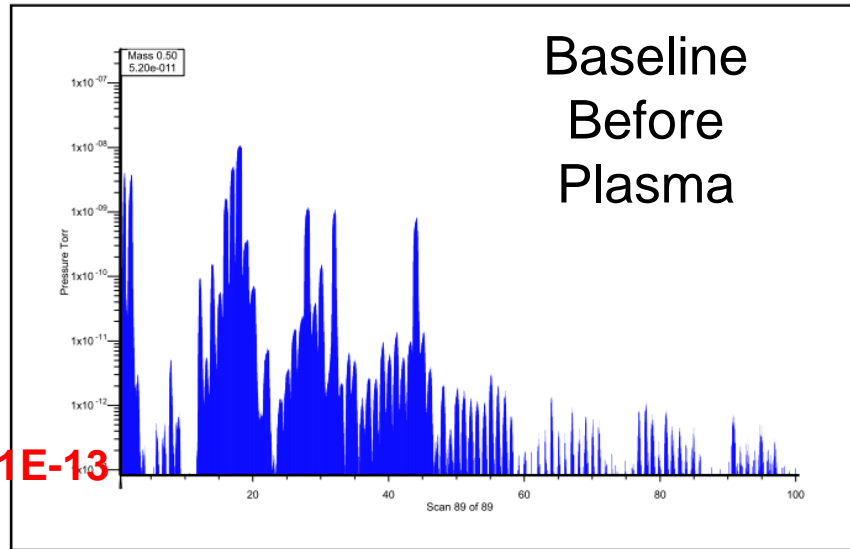
Plasma at
antenna



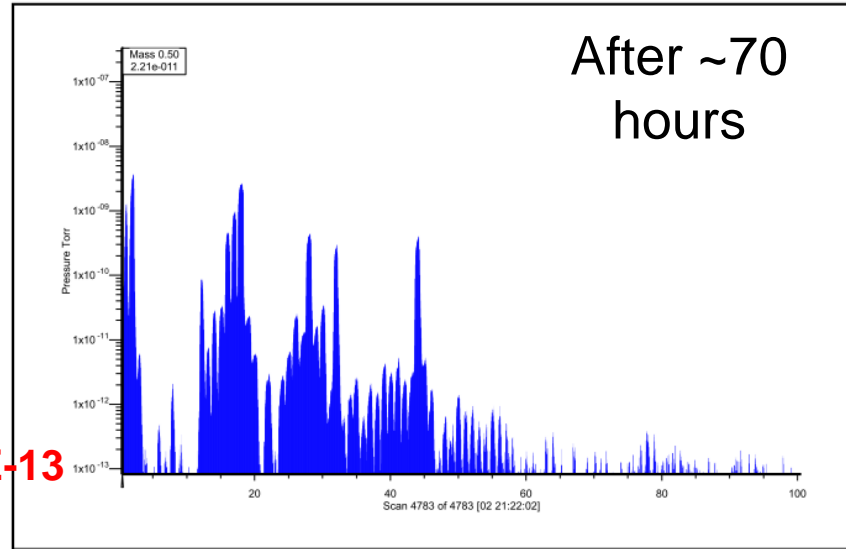
Plasma at
far end
~1m away



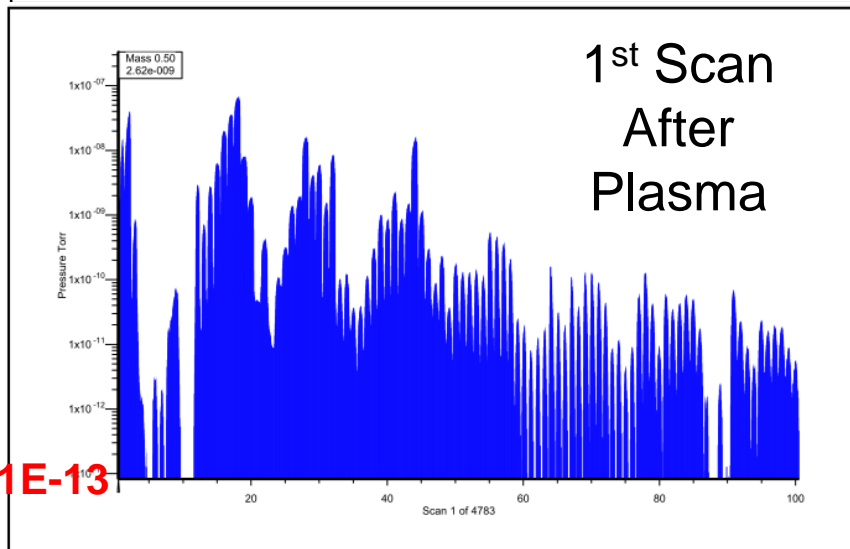
4 Nov RGA: P=3.1E-8 Torr at RGA & 1E-6 Torr at CCG



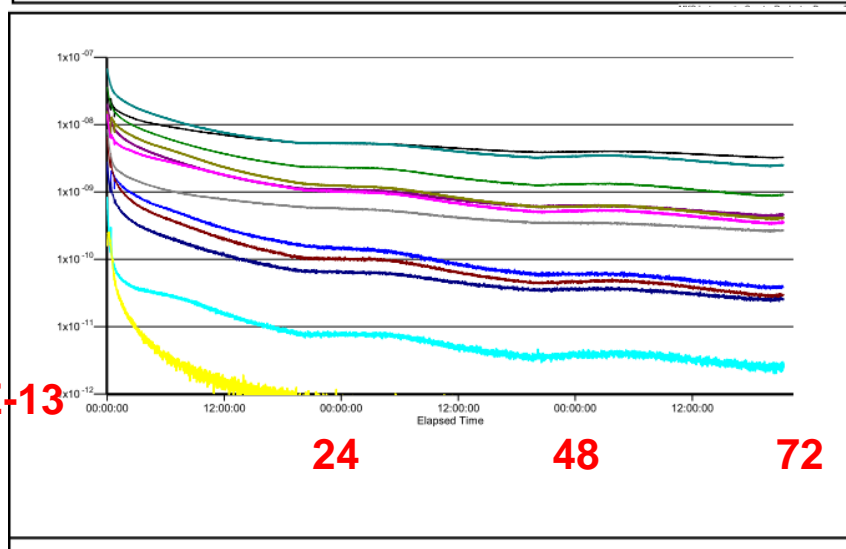
Ion source configuration: Source 1
Detector: Multiplier 3
Accuracy: 3
Instrument serial number: MKS104-A1011009



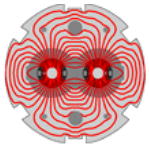
Ion source configuration: Source 1
Detector: Multiplier 3
Accuracy: 3
Instrument serial number: MKS104-A1011009



Ion source configuration: Source 1
Detector: Multiplier 3
Accuracy: 3
Instrument serial number: MKS104-A1011009

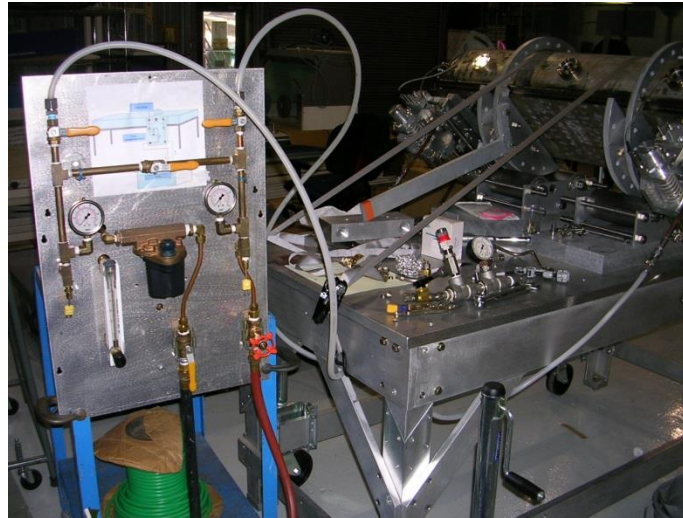


Hydrogen : From 3.60e-008 To 3.26e-009
Carbon 12 : From 2.48e-009 To 3.83e-011
Nitrogen 14 : From 2.78e-009 To 2.62e-011
Hydrocarbon 15 : From 6.46e-009 To 3.01e-011
Oxygen 16 : From 1.99e-008 To 4.64e-010
OH group : From 3.57e-008 To 9.02e-010
Water : From 6.68e-008 To 2.52e-009
Nitrogen : From 1.56e-008 To 4.14e-011
Oxygen : From 8.38e-009 To 2.72e-010
Argon : From 8.31e-010 To 2.74e-012
Carbon dioxide : From 1.41e-008 To 3.56e-010
Photoresist 64 : From 1.61e-010 To 3.08e-013



LARP

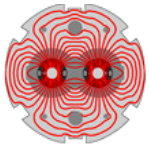
Water Fittings: Flow & Pressure Test



CuSil Metric Swagelok



| | |
|------------------|------------|
| Pressure(in) | =50psi |
| Pressure(out) | =8psi |
| Pressure drop | =2.8 bar |
| Flow | =2.1 gal/m |
| | =8 liter/m |
| Pressure(static) | =360psi |
| | =24 bar |

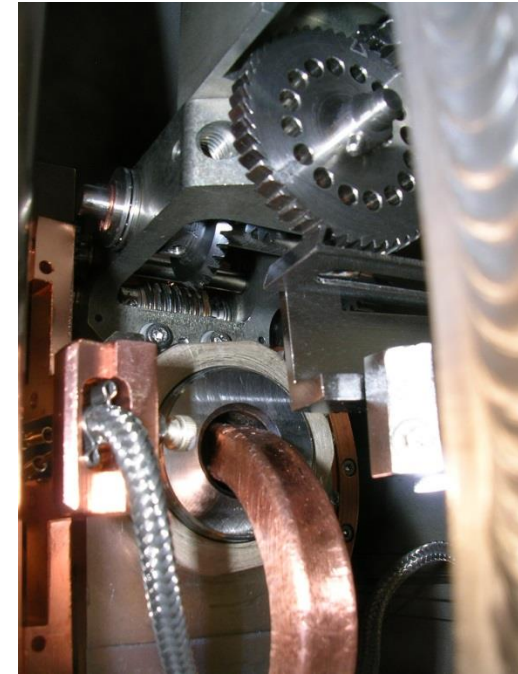
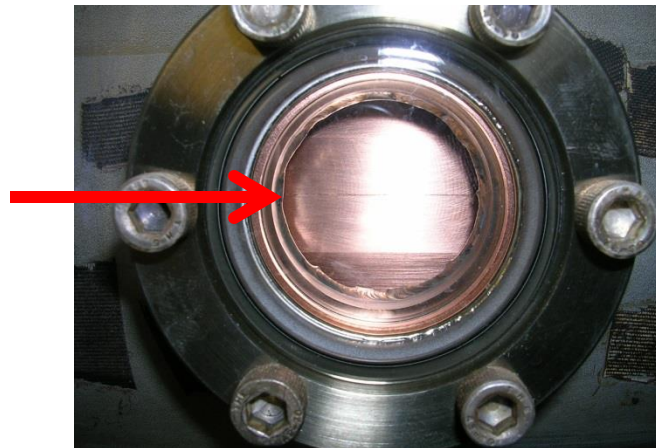
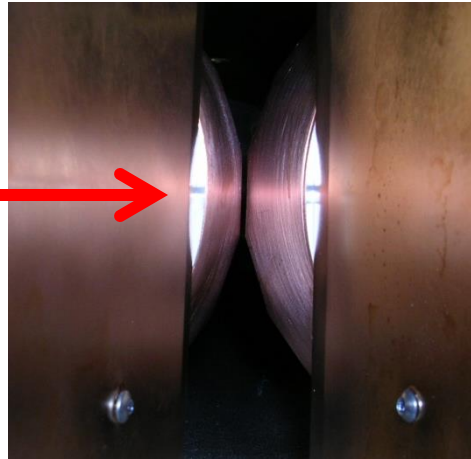
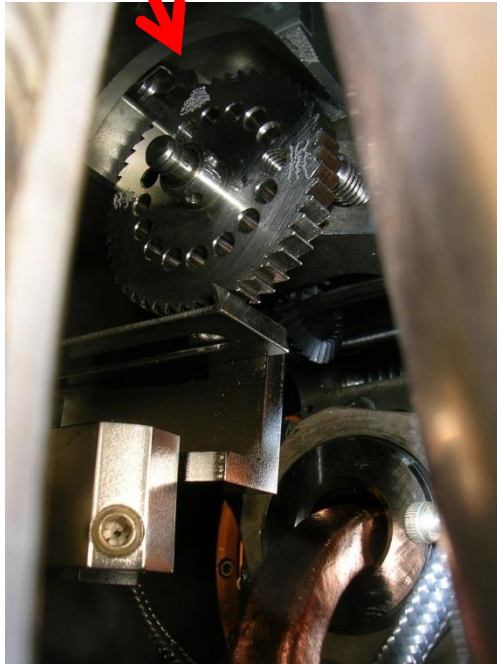


LARP

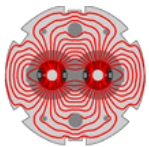
Final Tube Vacuum & Facet Rotation Tests

8 rotations of 48 tooth wheel (384 total) rotates 1 facet = $360^\circ/20=18^\circ$
1 click = $818\mu\text{rad}$ → $16\mu\text{m}$ over 20mm facet width; 160nm over beam size
Each Jaw Rotated “2+0/8+0/48” Facets
“Pawls” at scribed “ Δ ” when facets plumb; visible if RF foils end unscrewed
Scribed centerline on each facet visible in windows at either end

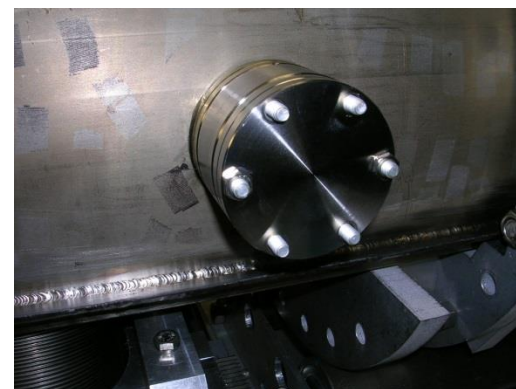
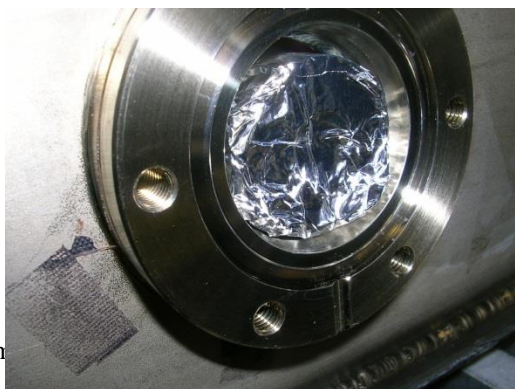
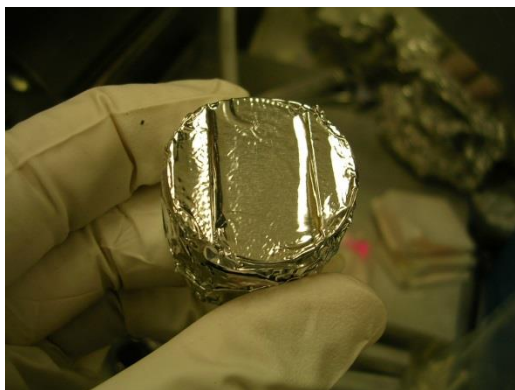
Each jaw moved
29.6mm from OLS



Immobilize Jaws for Shipment w/ 3D Printed Mating Blocks

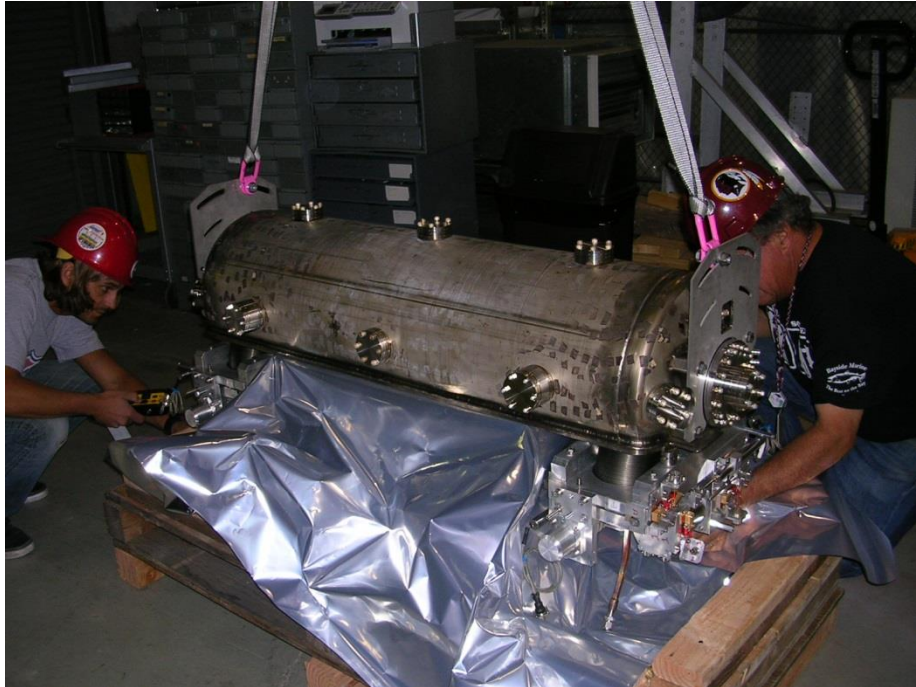


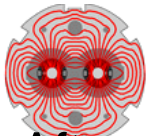
LAPP





Backfilled with N₂, Sealed, Blocked, Crated & delivered to SLAC Shipping 11 Nov





Work List

~~After that, wind 2nd mandrel, then~~
~~LARP~~

~~Prep with strips & braze coils and inner hub/shafts to mandrels (2 of 2 done)~~

~~Machine assembly round & concentric to axis at diameter to accept Glidcop jaws~~

~~Machine & Cu plate Glidcop jaws~~

~~Prep and braze jaws to mandrels (2nd done 8-Apr-13)~~

~~Machine facets, end features (2nd done 28-May-13)~~

~~Install RF bearing housing~~ → **Began 3-June-2013**

~~Install shaft support bearings and rotation drives~~

~~Test prior to installation in vacuum system~~

~~Prep existing vacuum base plate to receive new collimators~~

~~Mount, align & test~~ → **Began 6-Sept-2013**

~~Decide details of how vacuum cover will be attached to vacuum base plate & machine appropriately~~

~~Mate cover & baseplate~~

~~Test rotation after welding, pre and post vacuum~~

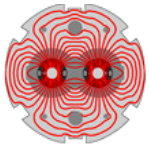
~~Vacuum bakeout Plasma cleaning~~ → **Began 16-Oct-2013**

~~Test after Plasma Cleaning~~

~~Ship~~

SLAC

SLAC?



LARP

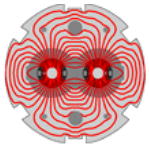
Suggested Plan That Needs More Discussion

At SLAC, prepare to ship:

- Small box of parts needed for operation
 - 11-2.75" flanges with windows, 2-6" blank flanges, 4 tooling balls
- Instructions for how to disassemble, assemble, operate
- Final mechanical drawing package and software

At CERN

- Recover BPM flanges & BPMs shipped to CERN July 2010
- Decide whether to open vacuum tank cover or not
- Off beam tests:
 - Function, metrology, impedance, vacuum
 - Bakeout (???)
- SPS tests (???)
- Hi Rad Mat Tests & Subsequent Analysis



LARP

Last Photo Before Tank Welded

