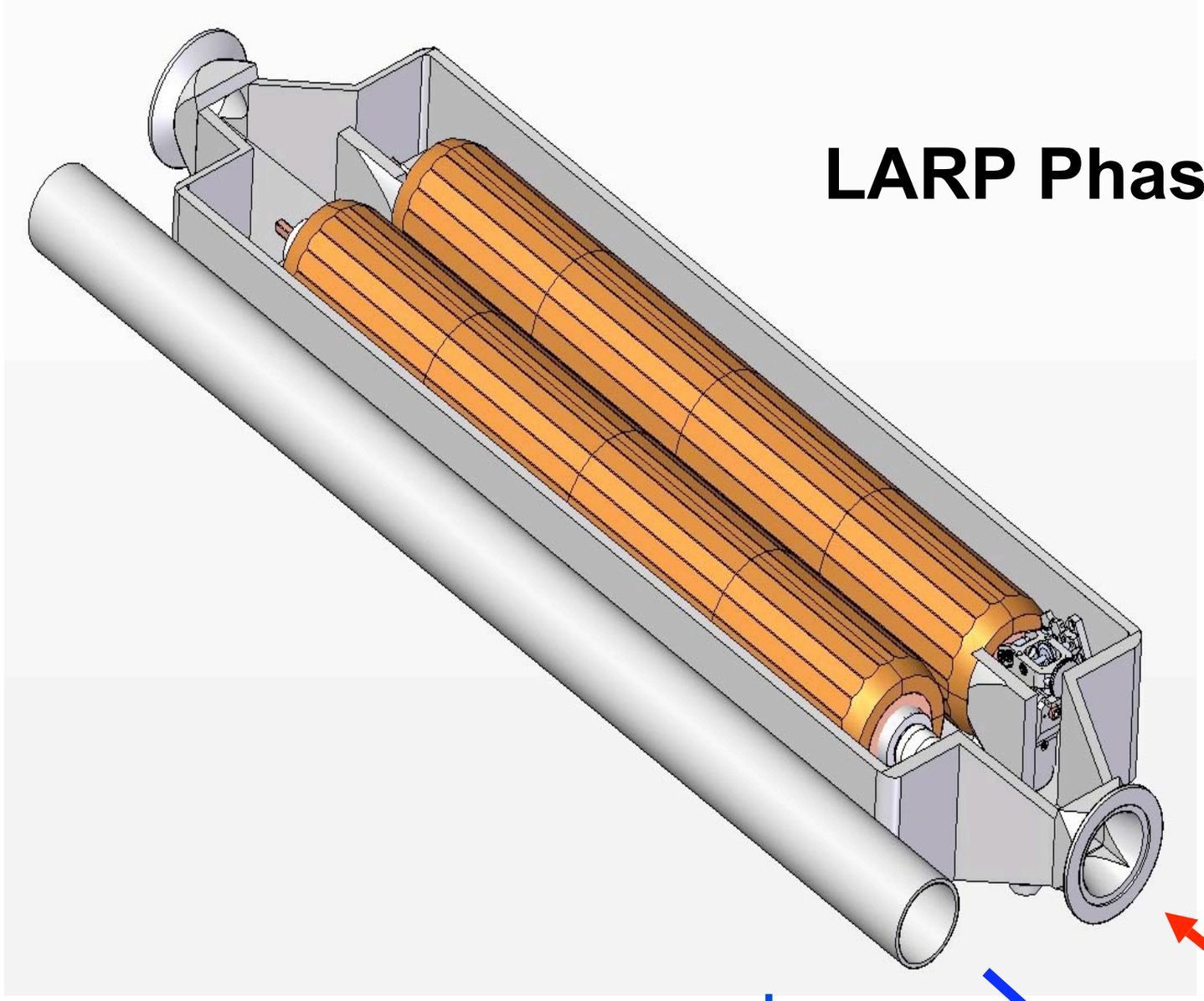
US LHC Accelerator Research Program

BNL - FNAL- LBNL - SLAC



LARP Phase II collimator Progress and Plans

4 March 2008

LARP Collimator Video Meeting

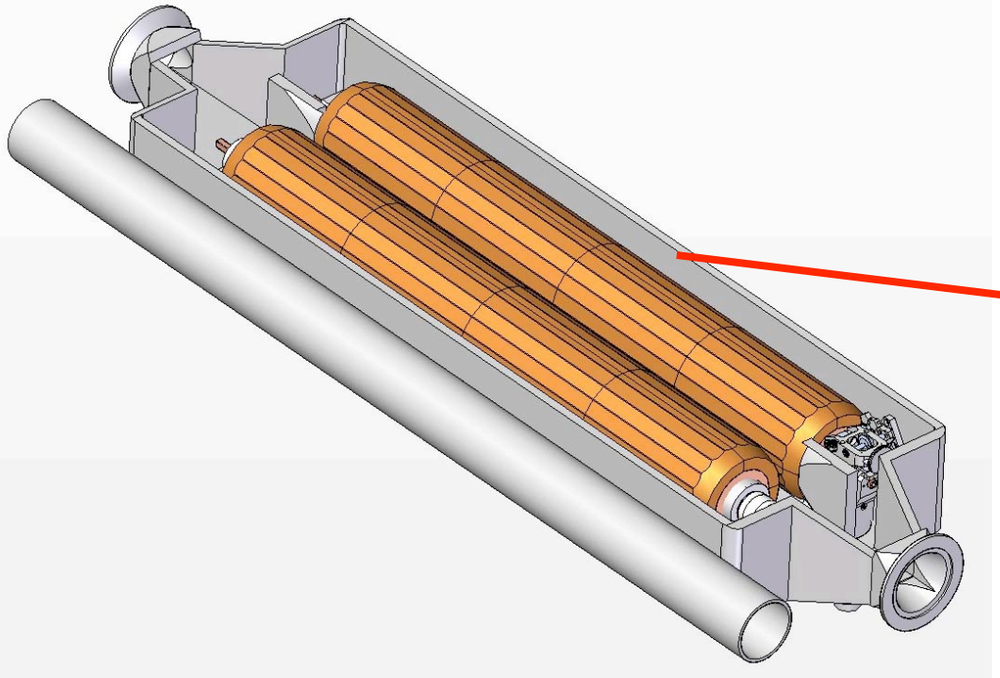
- Gene Anzalone, Eric Doyle, Lew Keller, Steve Lundgren, Tom Markiewicz & Jeff Smith

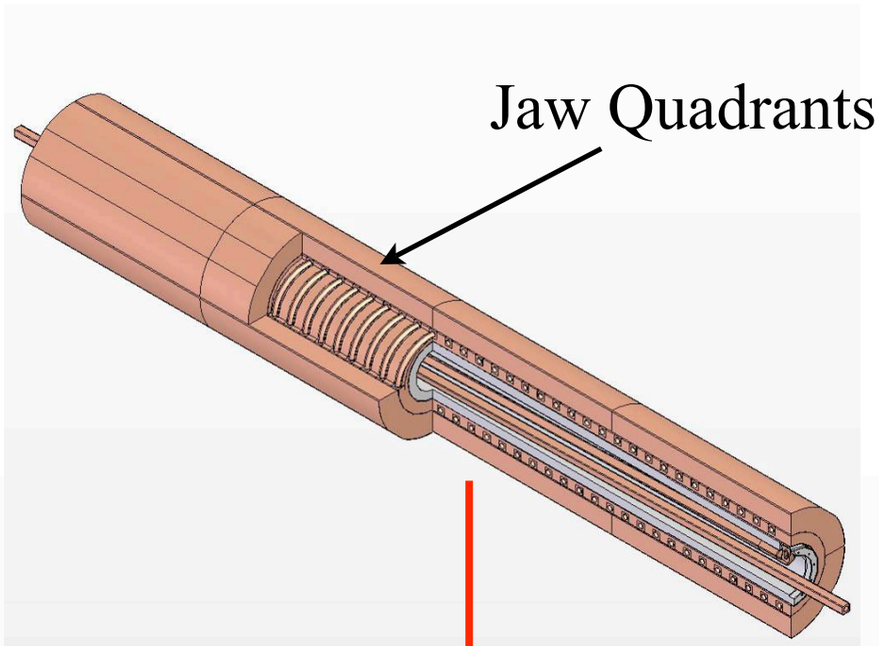
Recent Progress

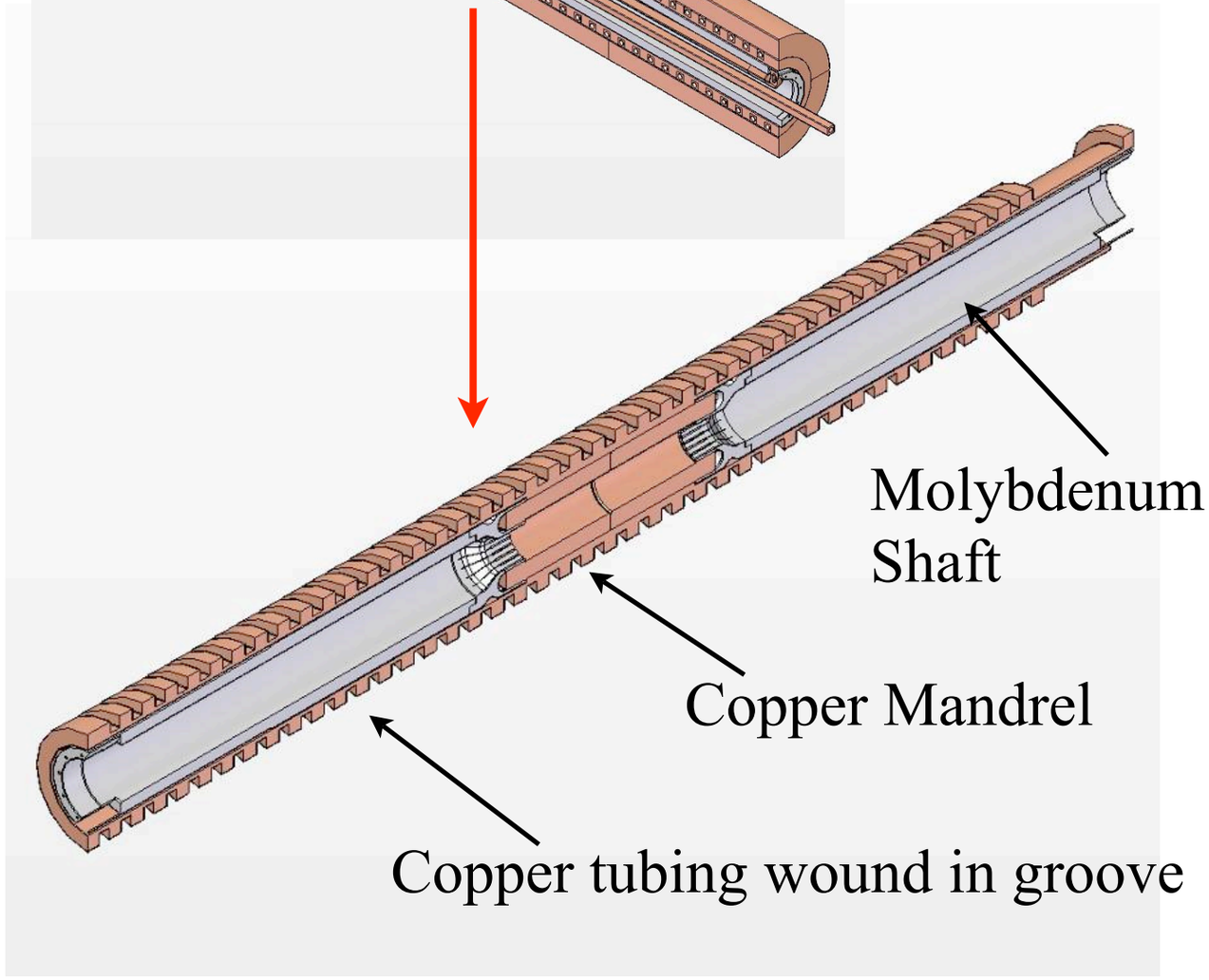
- Mandrel Brazing
- Mandrel Machining
- Phase I graphite collimator operational at SLAC
- RF contact measurements
- Trapped mode simulations
- Considering LHC tracking simulations at SLAC
- Low frequency impedance measurements

Mandrel Brazing

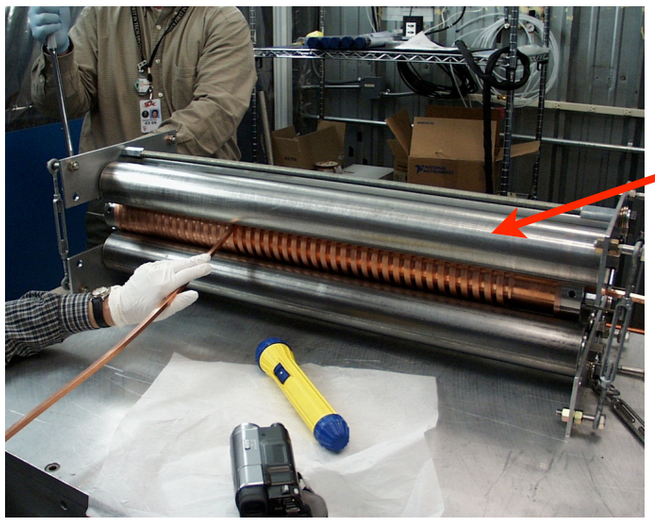
Mandrel brazing







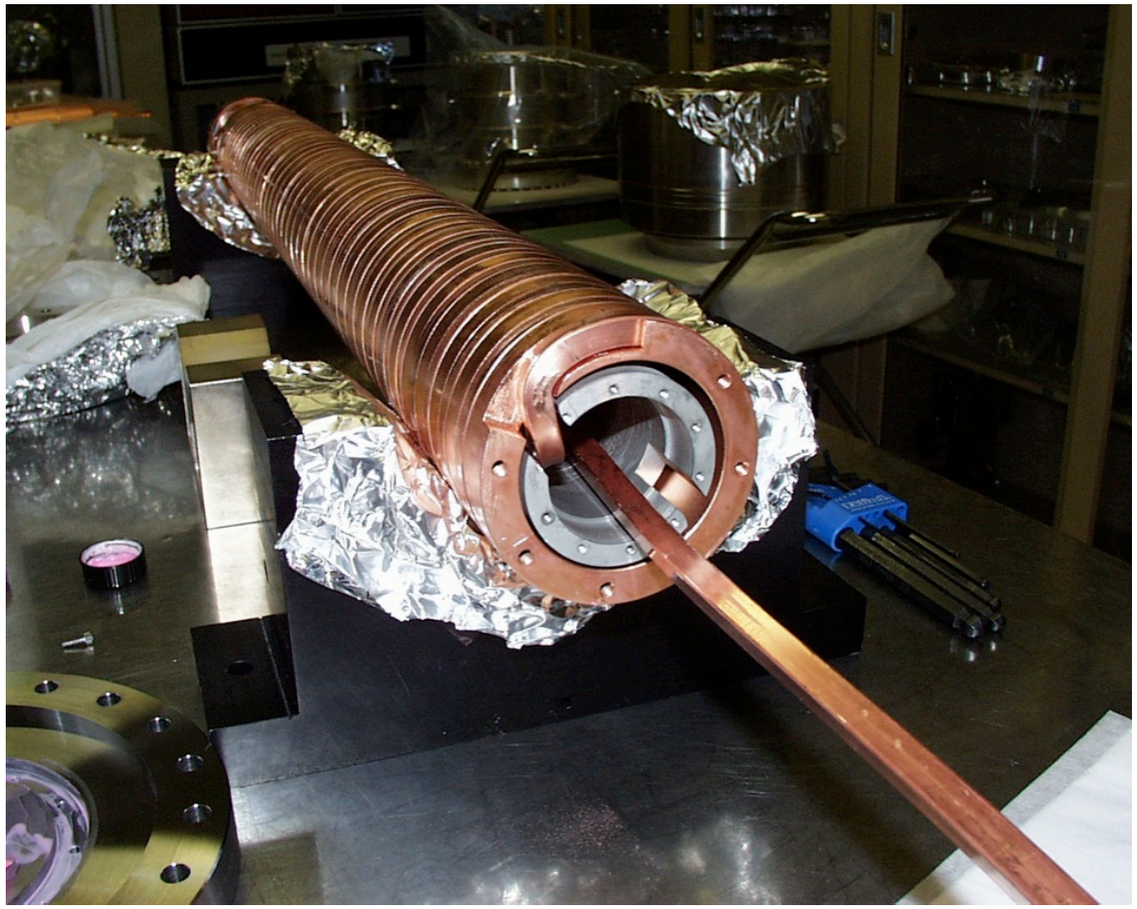
- Jaw composed of molybdenum shaft and copper mandrel wound with copper tubing for cooling. Exterior Jaw quadrants brazed on top of mandrel



Coil winding already performed

First Brazing Preparation

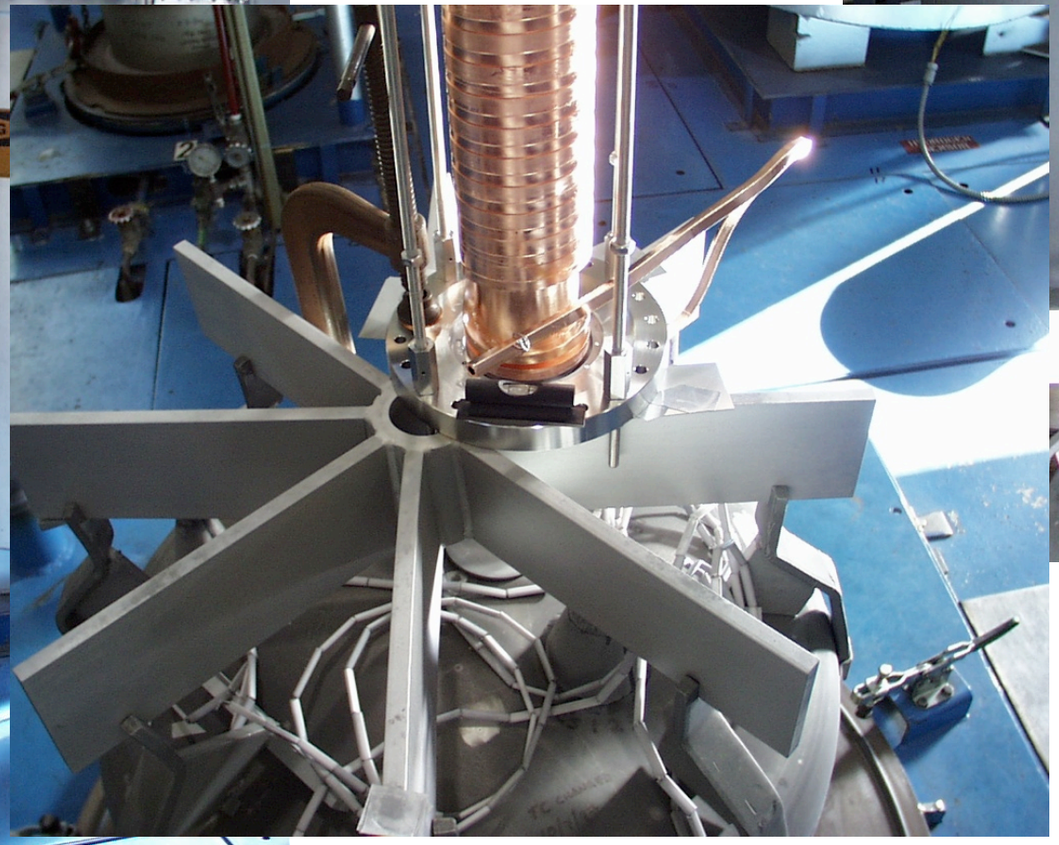
- Three brazing steps.
  1. braze Moly shaft and hub to Mandrel
  2. braze copper coil to Mandrel
  3. braze jaw quadrants to mandrel
- Here are pictures showing preparation for second brazing

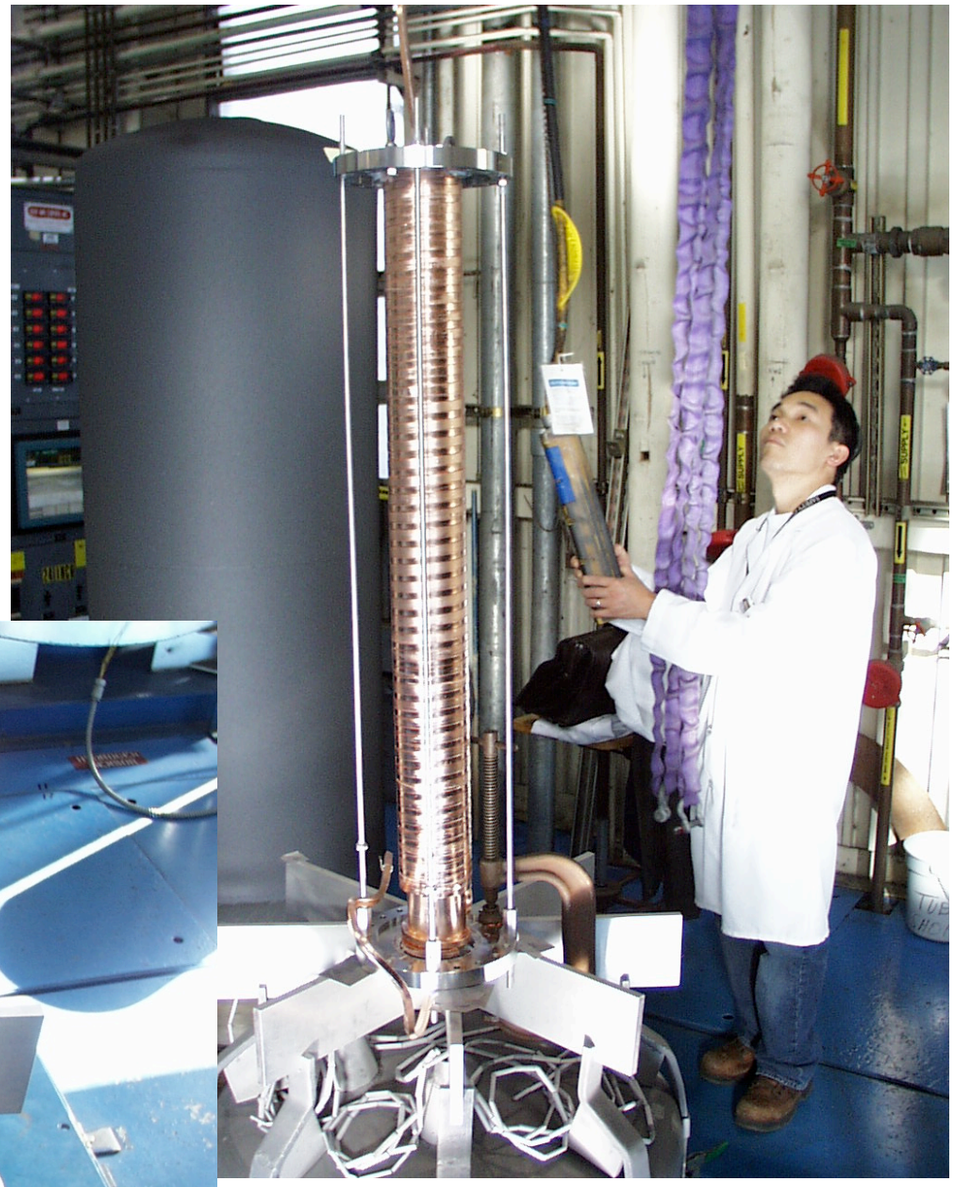


Brazing Coil to mandrel

LARP

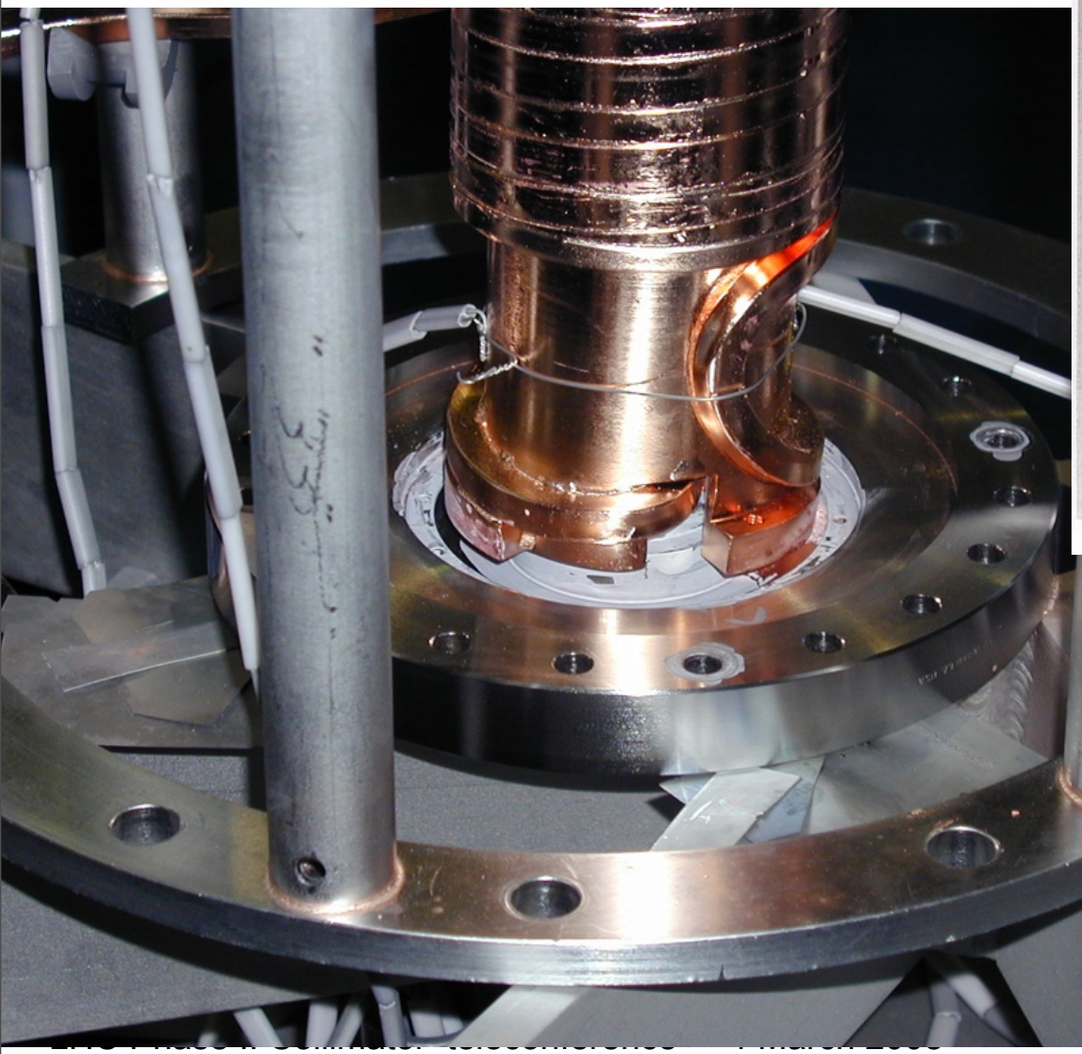
- Brazed coil in three brazing cycles
  - Examining quality of braze between cycles
- Here are pictures for second braze cycle

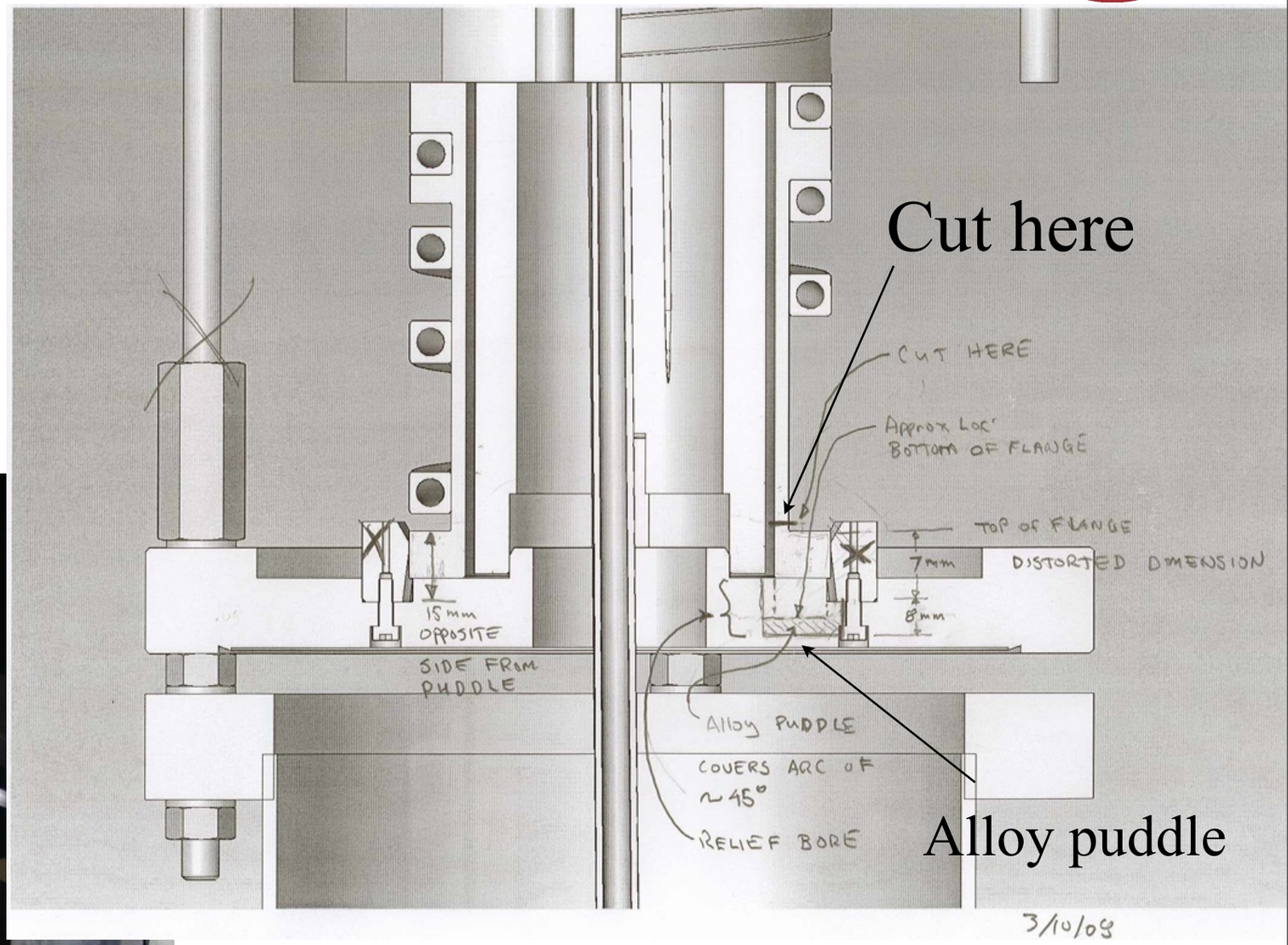




Mandrel brazing

- Ran into some problems with brazing.
- Too much braze material was apparently used and our mandrel was brazed to the furnace mount during third braze!
- Had to saw off braze flange



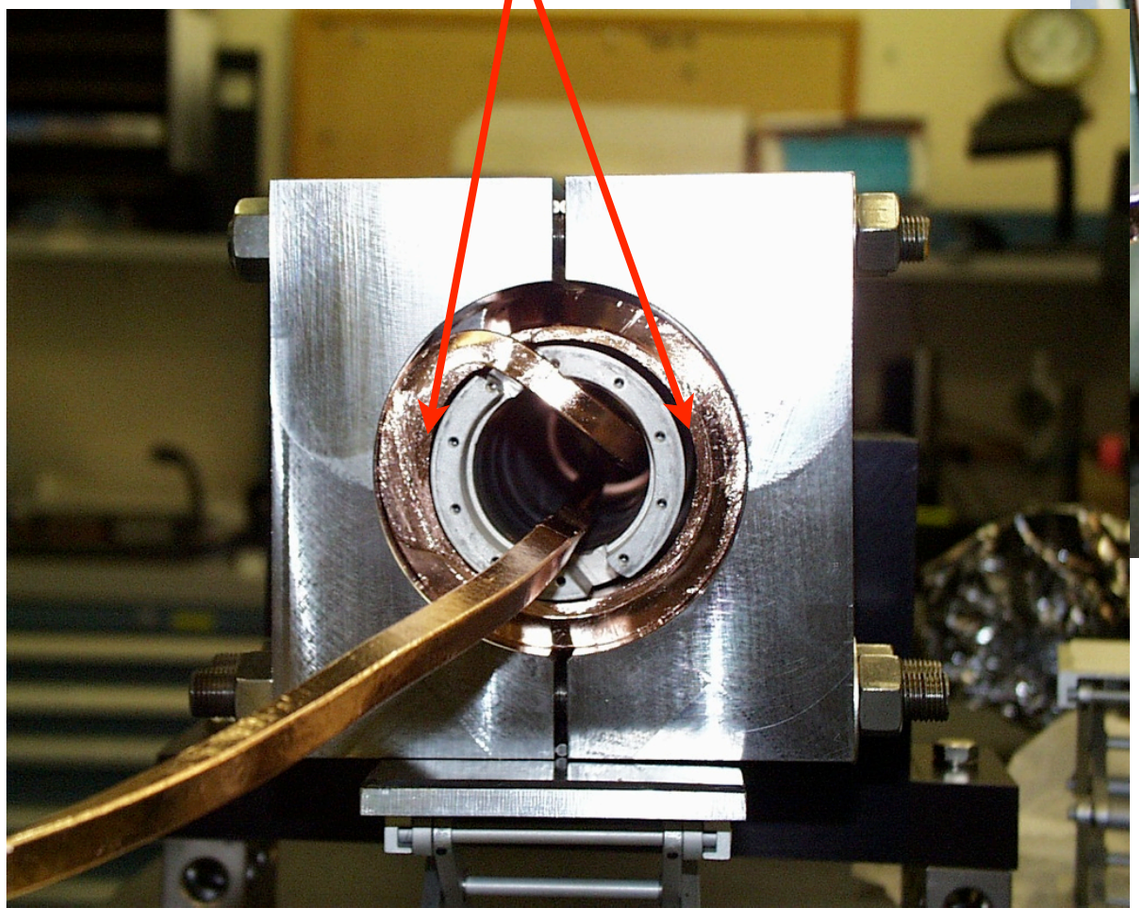


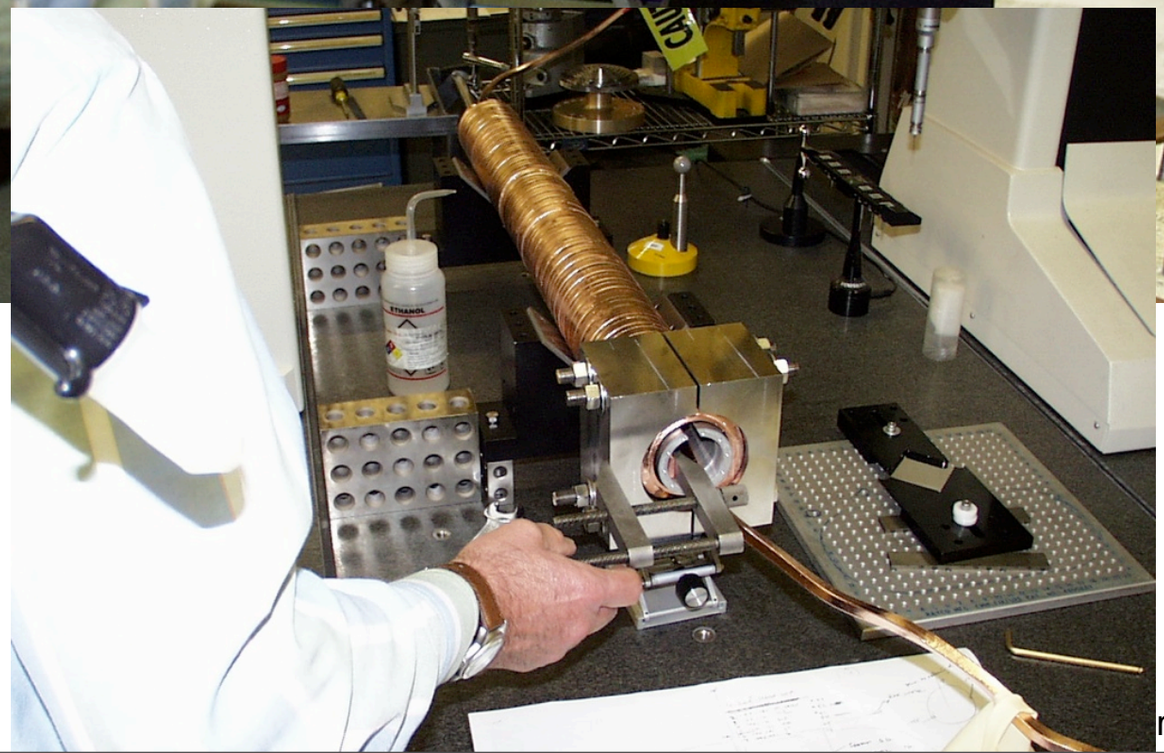
- Brazing error resulted in bending of end of mandrel attached to furnace table.

The Aftermath...

- Most of mandrel OK but end had to be fixed
- Used custom made clamps to “press” mandrel back into shape.

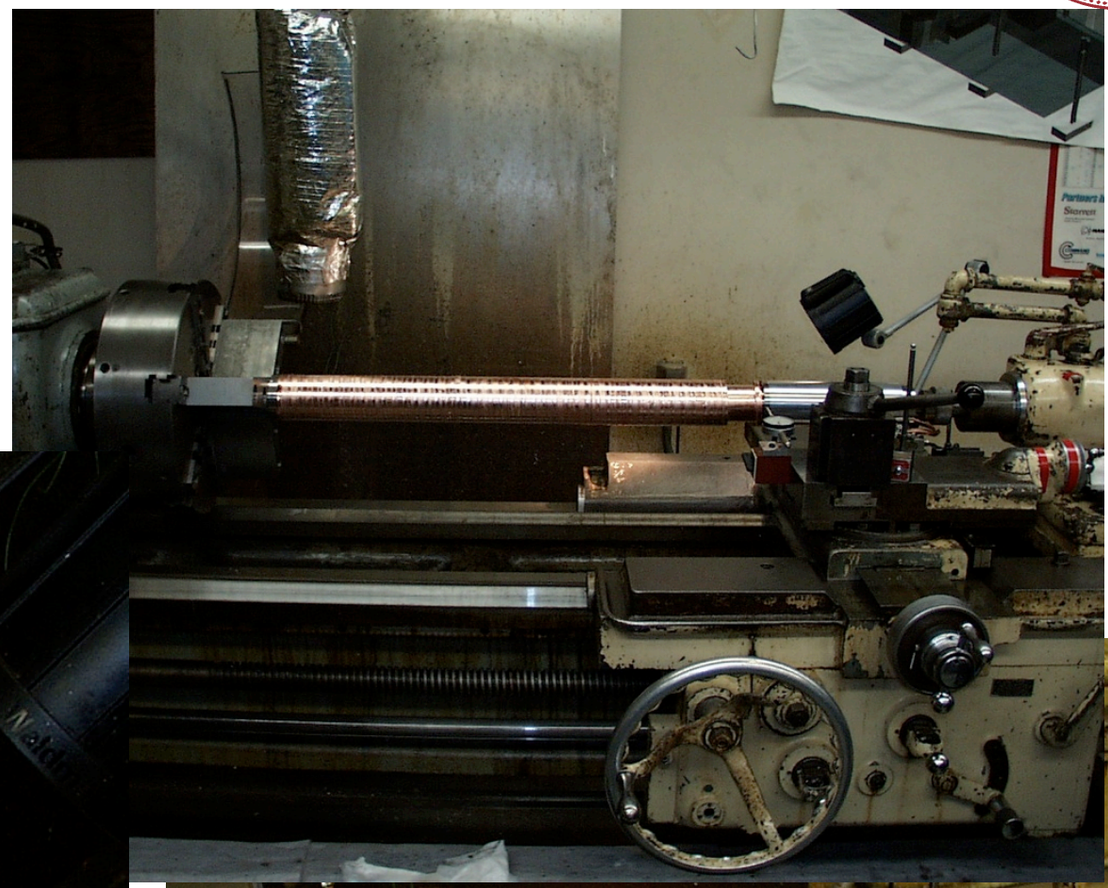
Center shaft not in center of mandrel due to bend mandrel

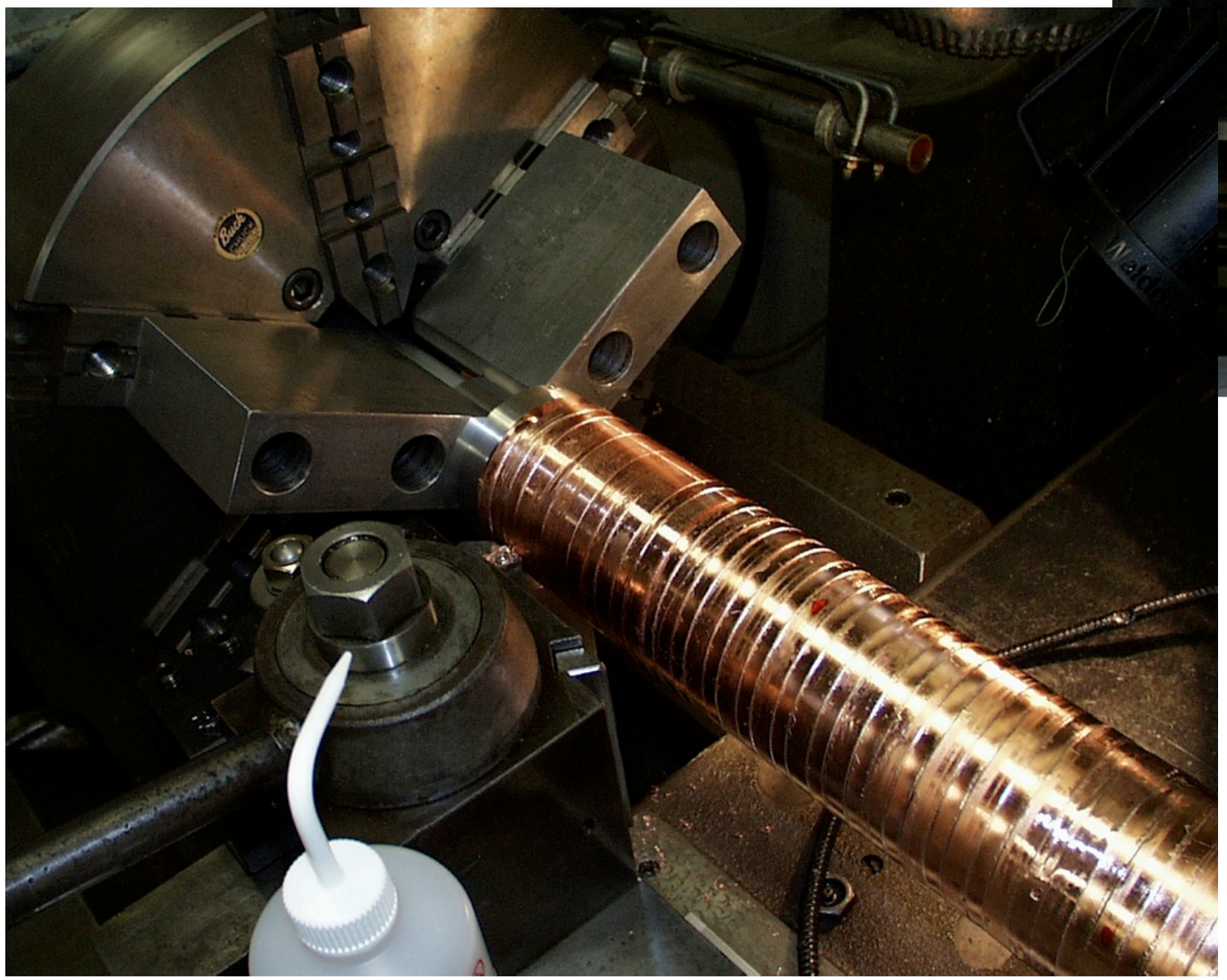


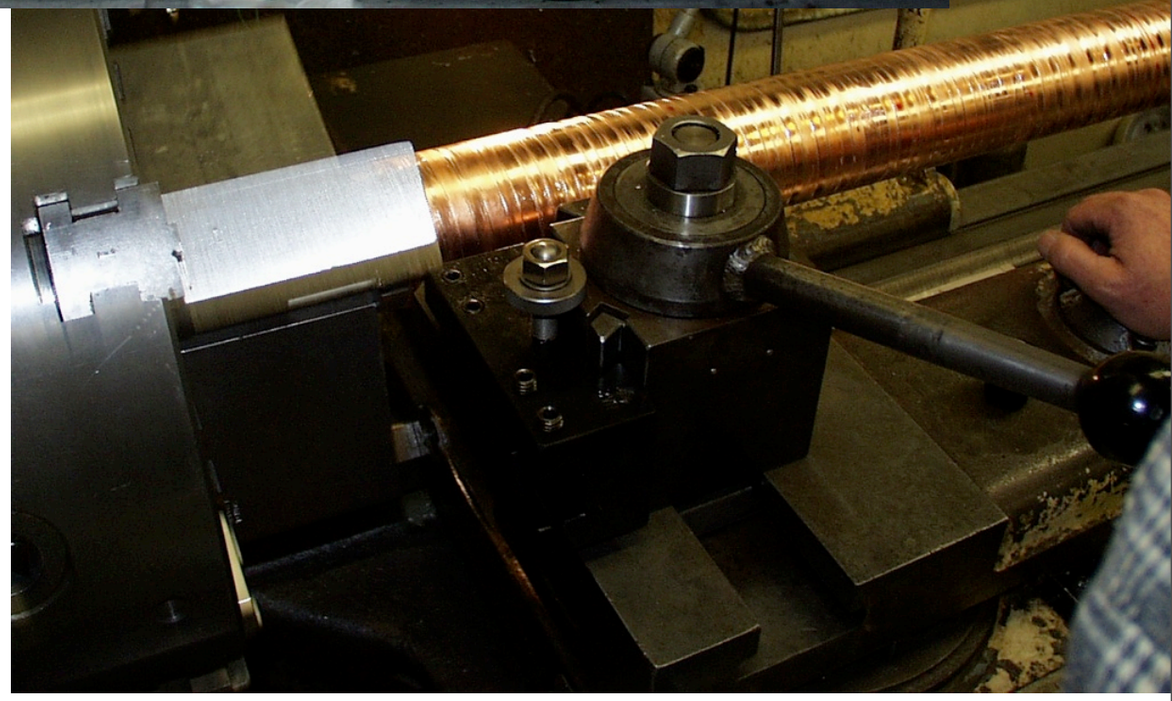


Machining of mandrel surface

- Mandrel concentricity looks OK now after repairs
- Surface must be machined flat for reception of Jaws quadrants
- Slight kink in mandrel had to also be bent out

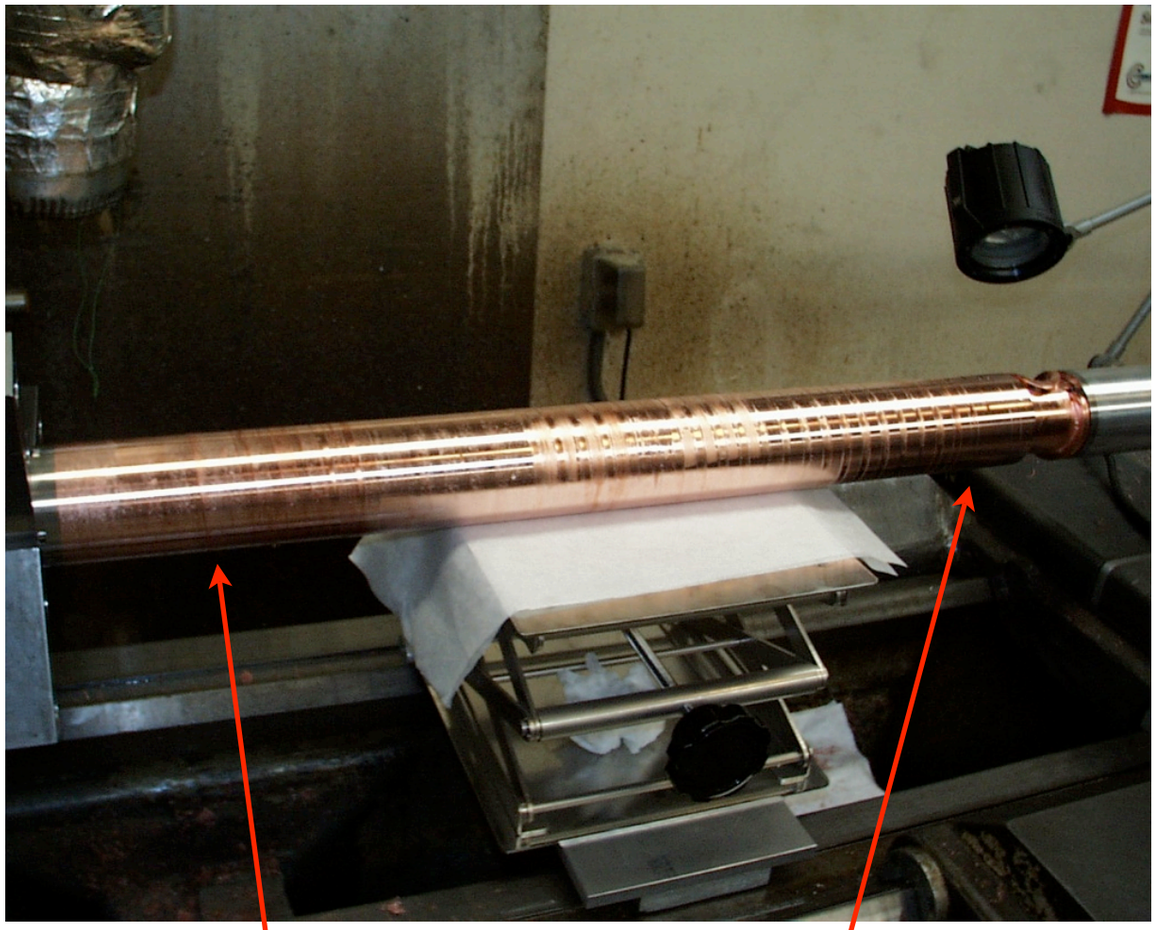






Jaw Quadrants

- Surface machined and ready for reception of jaw quadrants
- Slightly different outer diameters.
- left side in picture at 232.5 mm o.d. spec. Right side will require slightly modified jaws to fit on diameter. Add material to fill gap.
- Want very good thermal contact between jaws and cooling coil around mandrel.

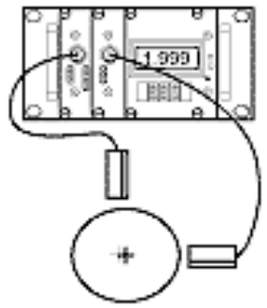


Design Changes

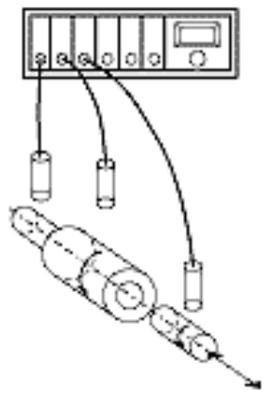
- Reconsidering how much braze alloy we apply
  - We needed a lot to fill up cavities and crevices due to coil winding
  - Coil “keystones” as it’s wound creating large gaps to fill
- Considering alternative winding techniques or methods to fill gaps without using braze

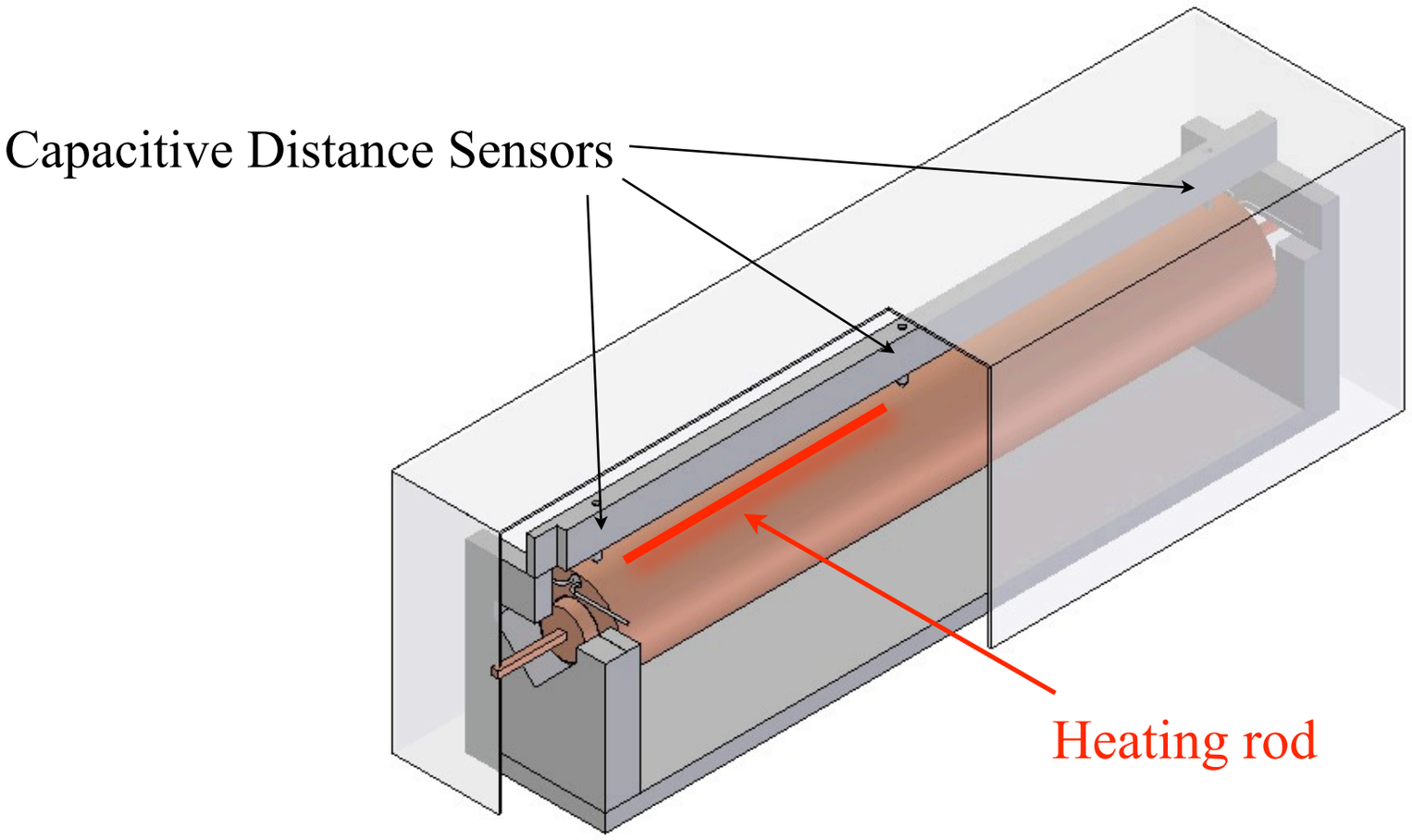
First Full Length Jaw Thermal Tests

- This jaw will undergo thermal tests using two 5 kW heaters placed along jaw surface (simulation steady state beam heating)
- Sensors will then measure thermal deflection to confirm ANSYS simulations.



Images from www.capacitec.com

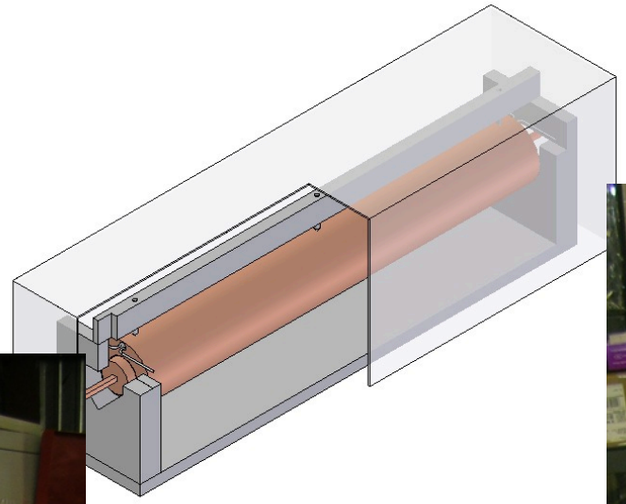




Thermal test setup

- Results by EPAC08

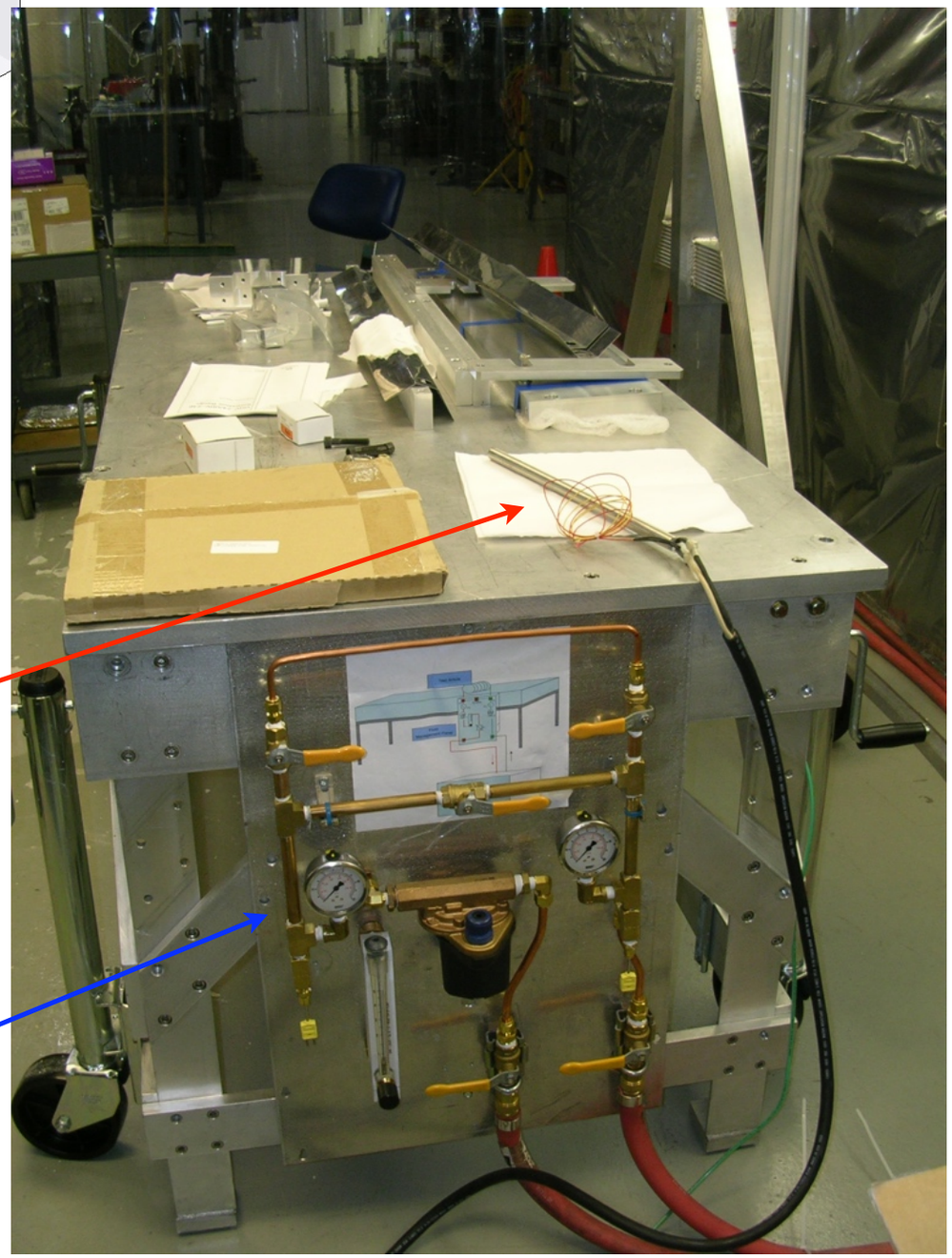
Power Rack



Heaters

Water flow control

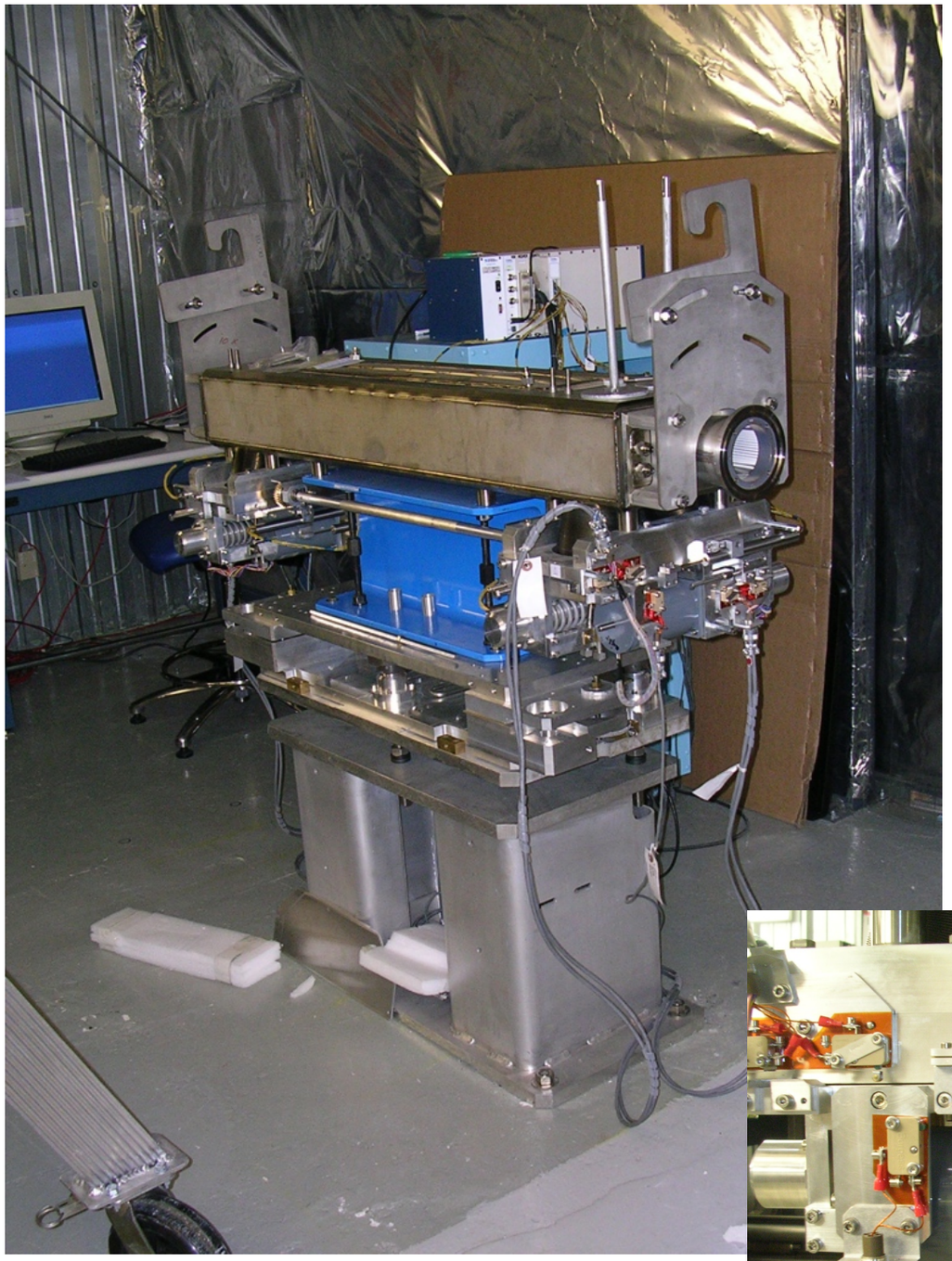
Test table

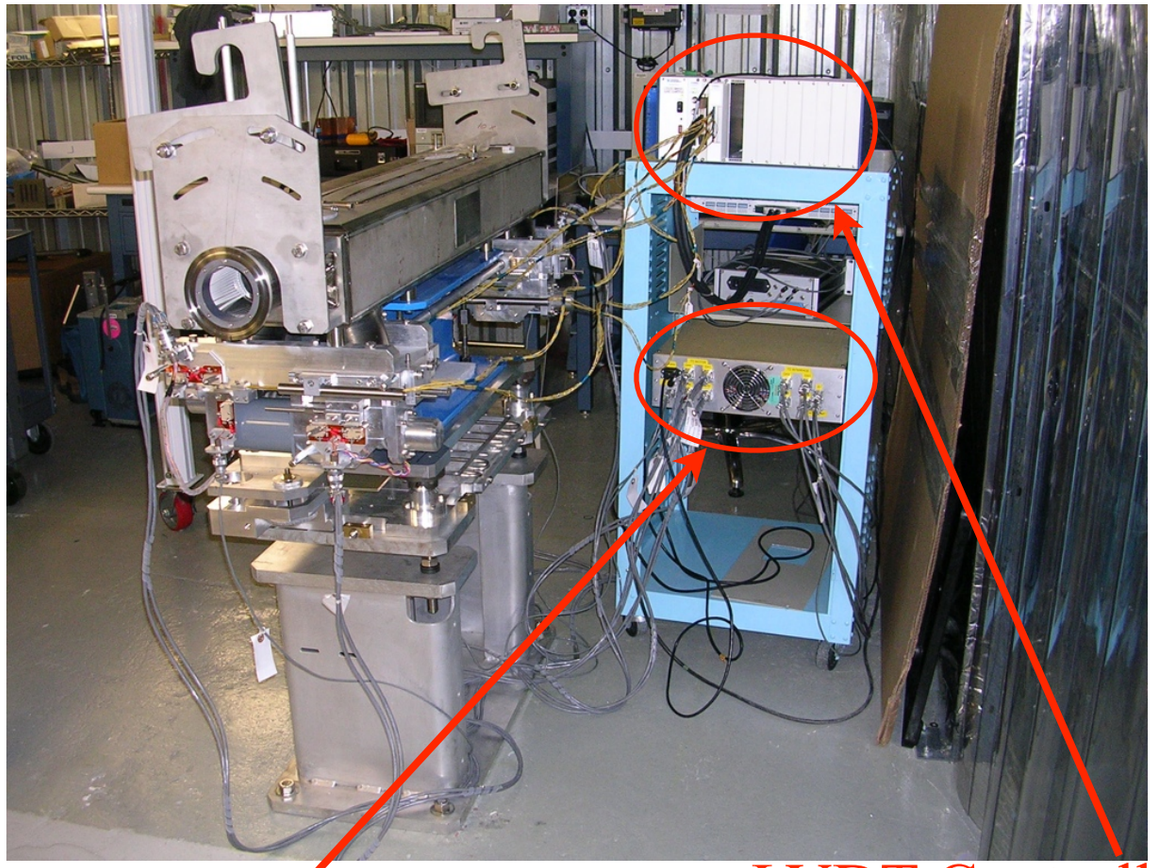


Considerations for RC1

- Discovered several complications in machining/assembling/brazing first full length jaw.
- Experience will be considered before continuing on the full RC1 prototype.
  - May change:
    - design (a little, rather fixed at this point)
    - fabrication
    - assembly
    - materials
  - Separate issue, but RF design is not finished and waiting various RF tests and simulations.

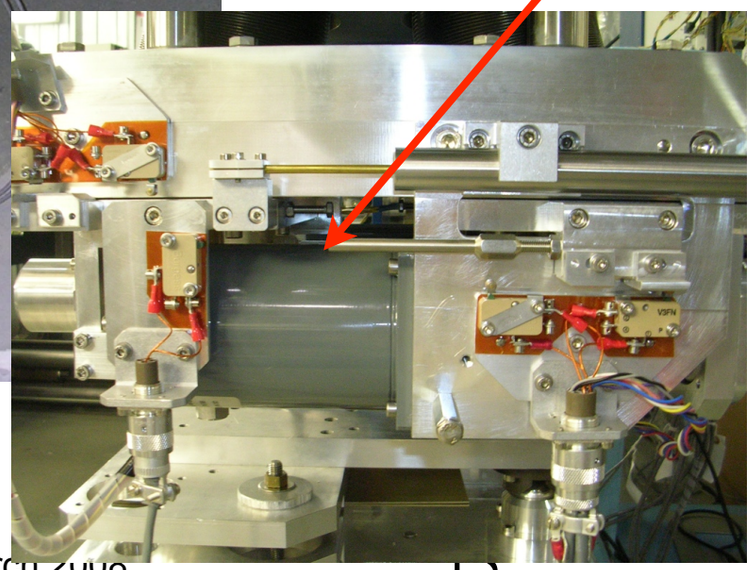
Phase I Graphite Collimator mounted and set up in our lab

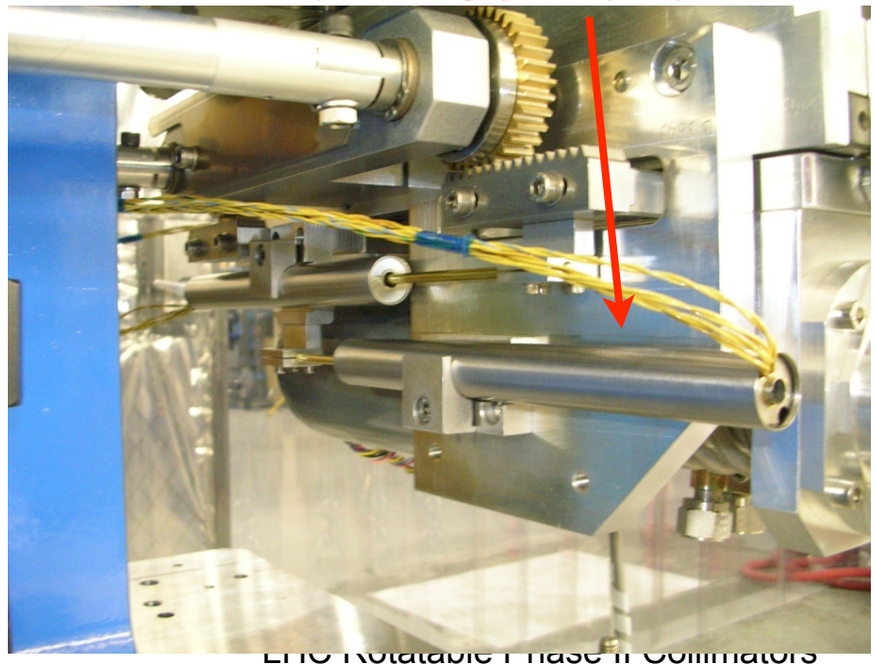




Stepper Controller

LVDT Controller

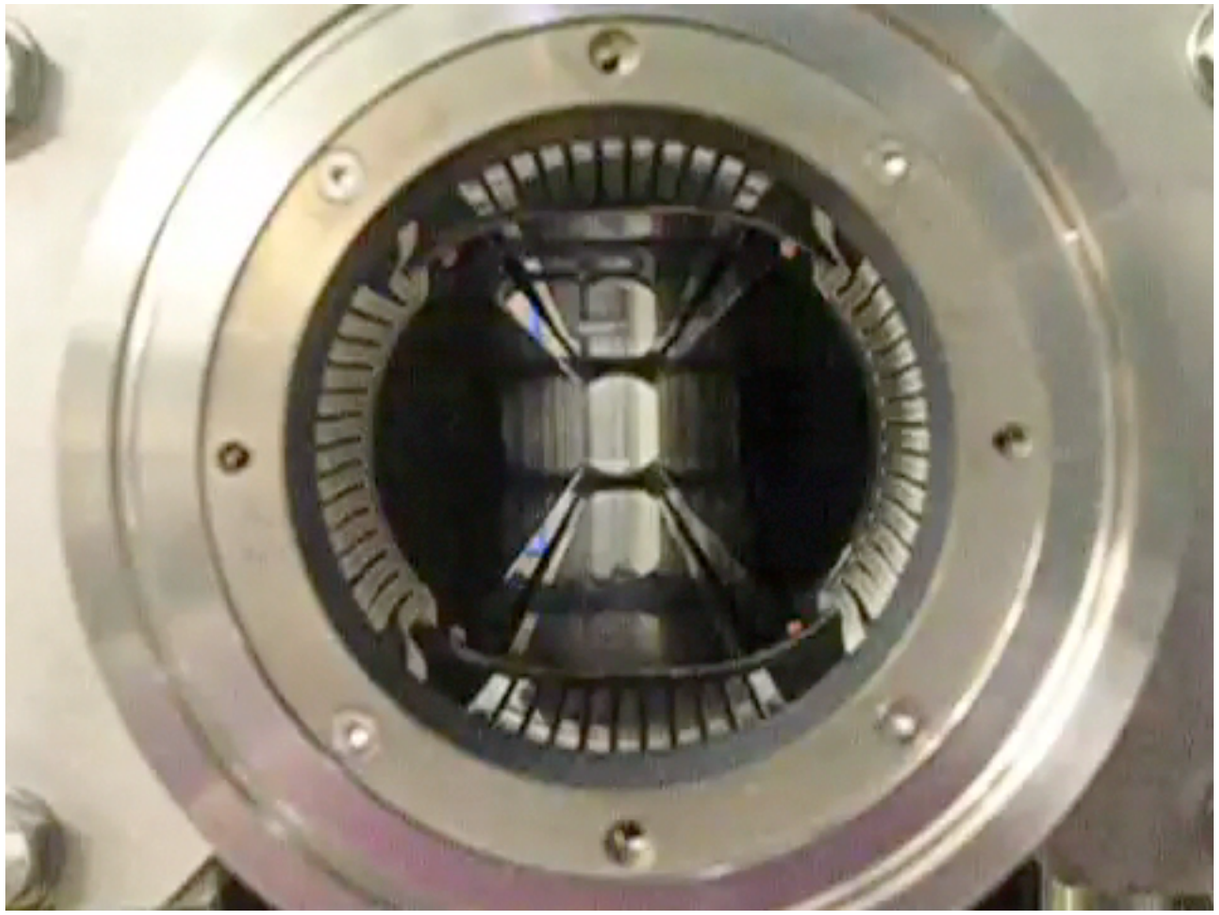




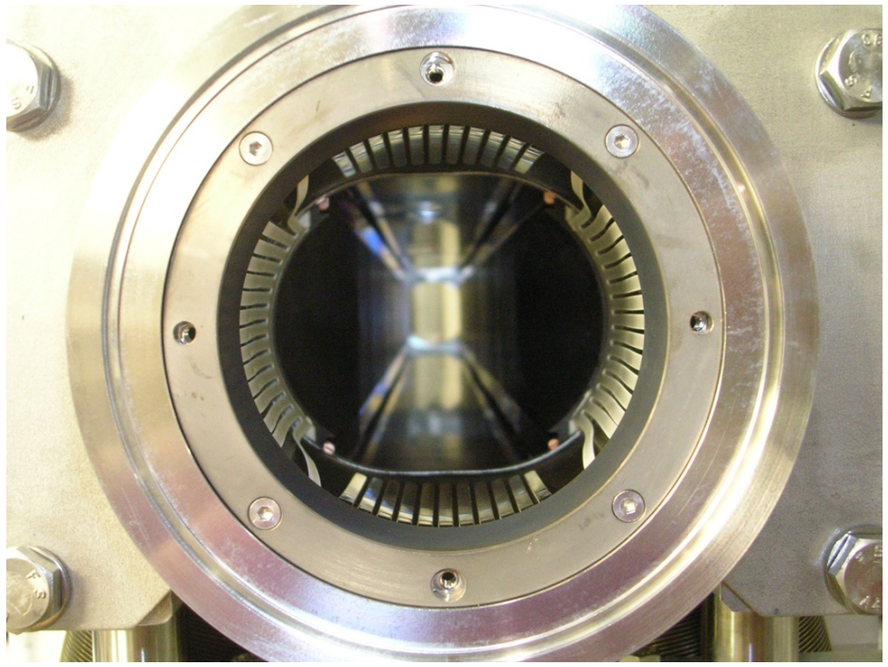
Motion Control

- CERN LabView control software modified and working with our controllers.
- Verified full motion of jaws
- Here is a video of motion below:

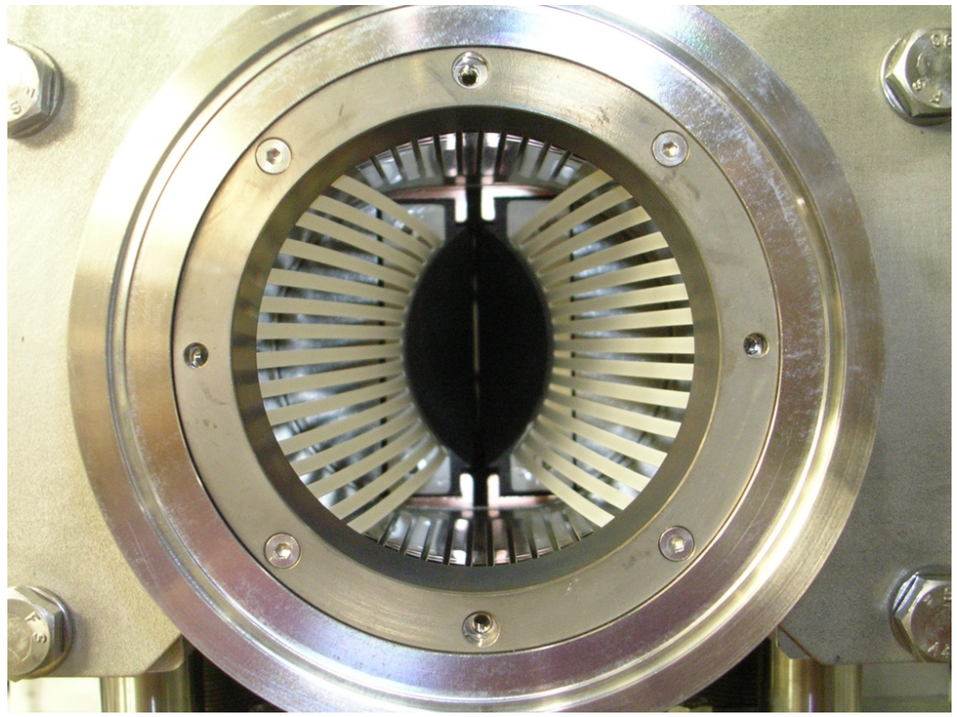
Sorry for the bad camera work
(camera had a tough time focusing!)



Open



Closed



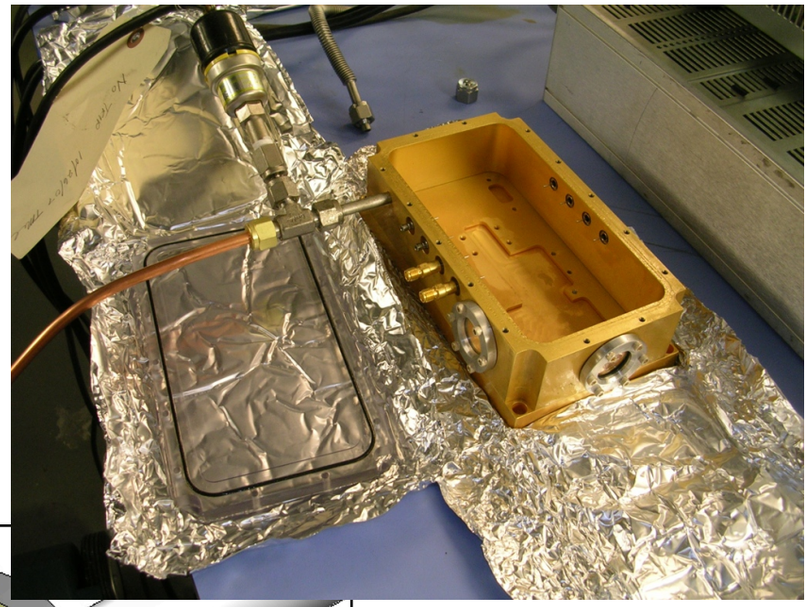
Vacuum pressure effects

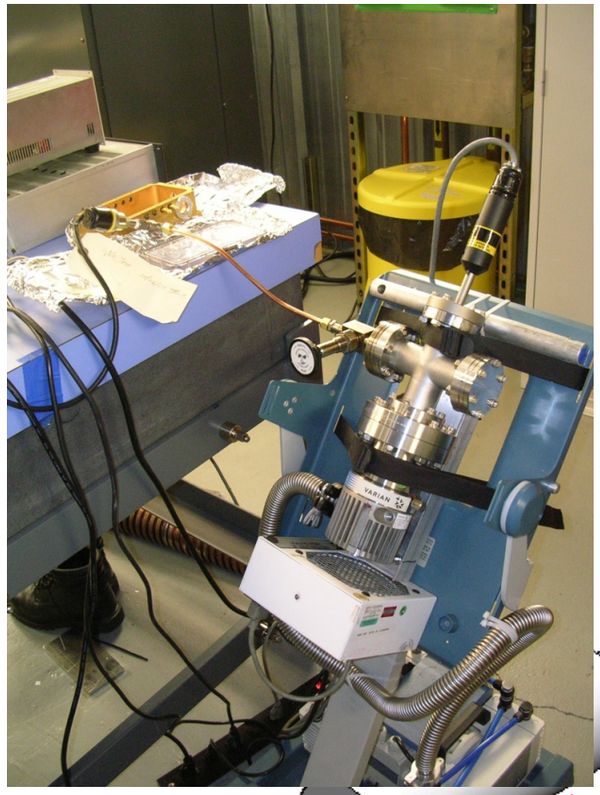
- Realized that evacuated collimator chamber presents pressure on bellows to remain straight. This force is absent while at atmospheric pressure but works against motors.
- Will be evacuating chamber to before making any modifications to test with all typical forces
  - Any reason evacuating chamber will cause problems? (it is a damaged unit)
  - Our understanding is the damage will not impede motion under vacuum provided we do not use water cooling lines
- However, testing motion with heavier jaws will be problematic under vacuum
  - Investigating other ways to simulate the vacuum pressure
    - Possibly use springs on jaws applying appropriate force
    - Or add more weight to the jaws (not quite correct when changing jaw orientation)

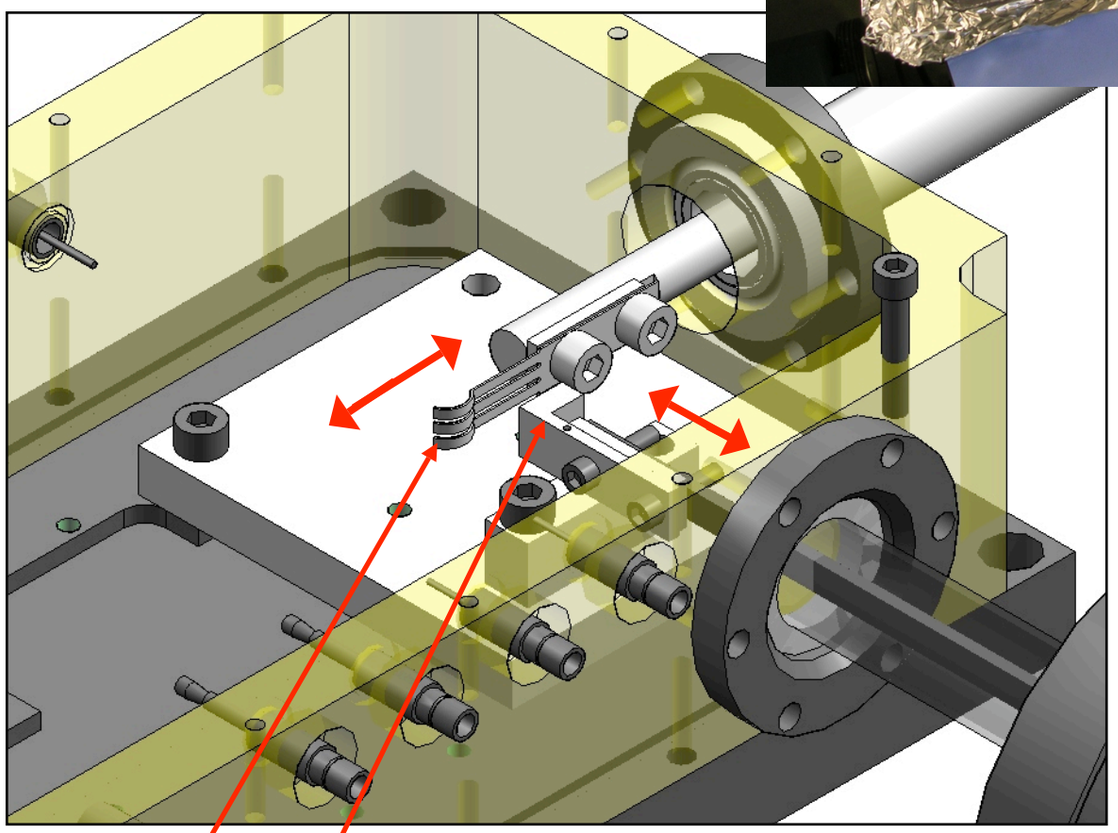
RF Contact Measurements Setup

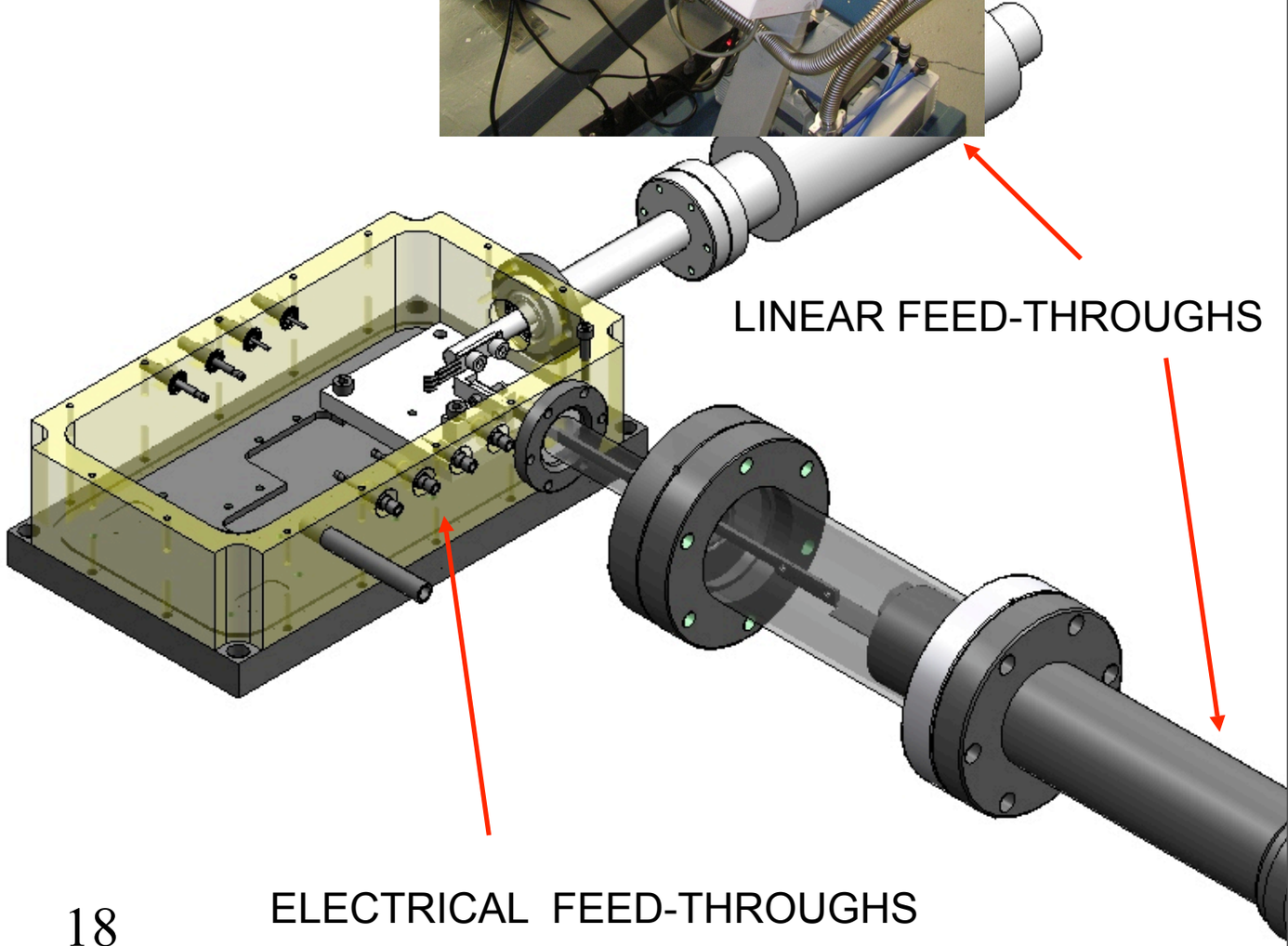
LARP

Test critical RF contacts
Proceeding... currently performing vacuum tests
Results by EPAC08

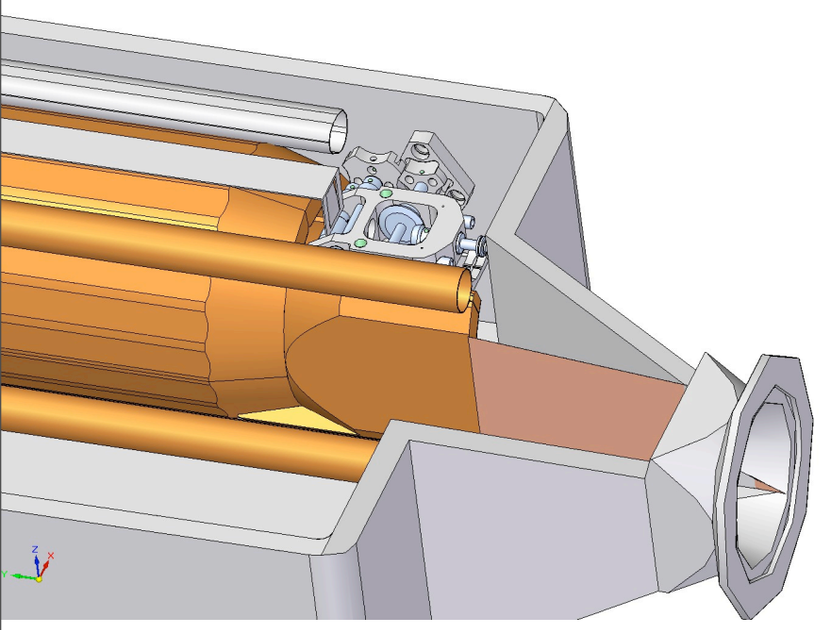








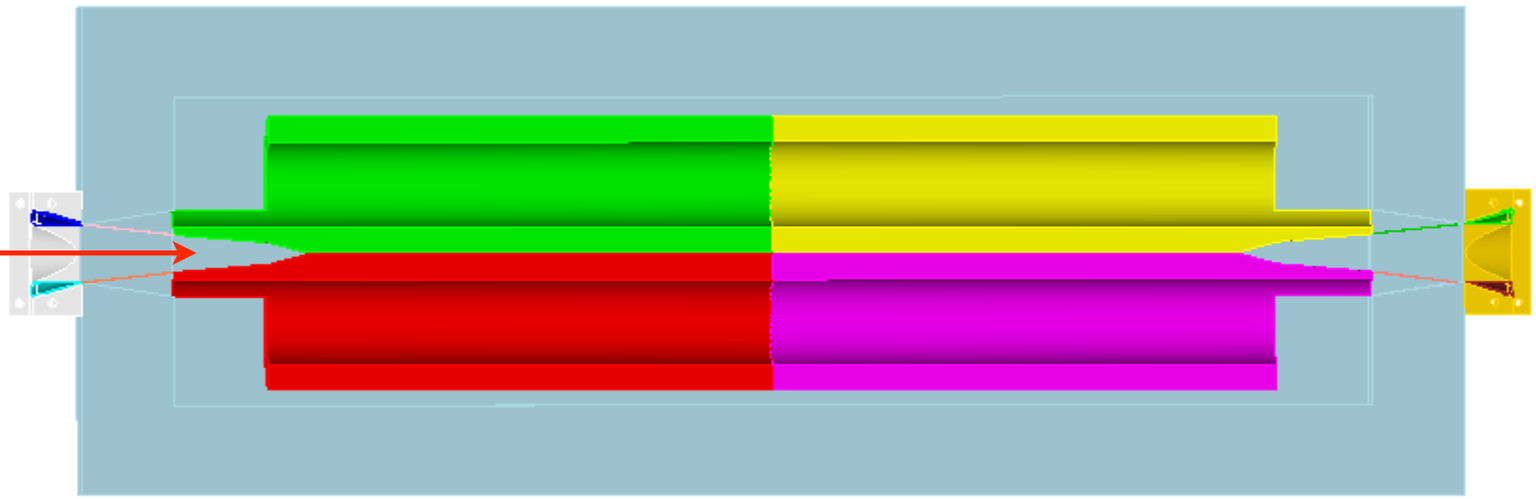
RF Trapped Modes studies



- Studies have begun on looking into trapped modes in our collimator design
- Many cavities and crevices, hour-glass shape
- Will RF leak out into chamber behind jaws?
- Cause wakefields effecting beam?
- Chamber heating?
- Studies being carried out by Cho Ng and Liling Xiao.
  - Omega3P uses the finite-element method and parallel processing. The finite-element method allows high-fidelity representation of complex geometries so that accurate calculations can be obtained. Parallel processing helps tackle large-scale problems and shorten computational time.

Model of collimator in Omega3P with jaws fully inserted

Beam path



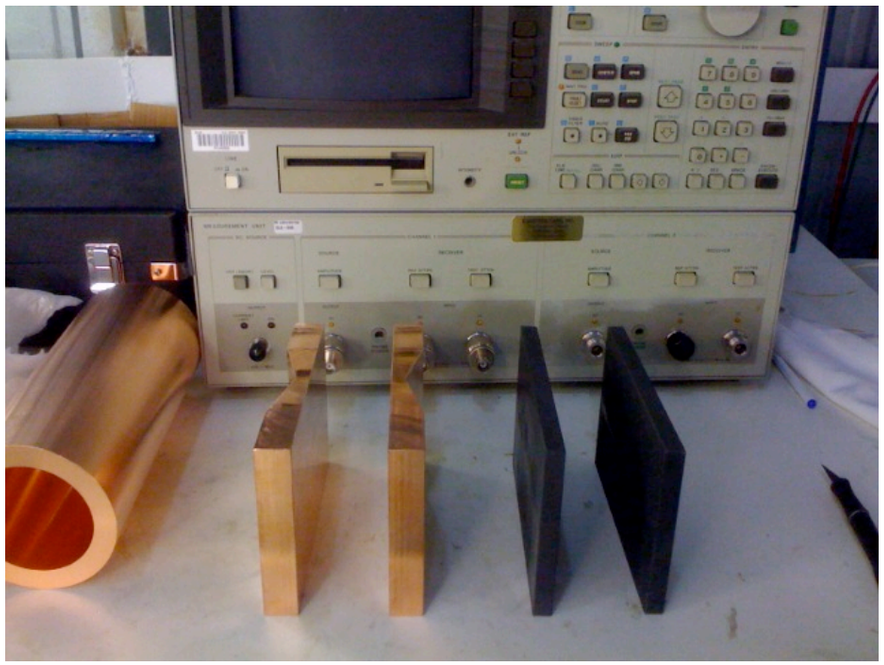
SixTrack simulations @ SLAC

- There is growing interest to start performing SixTrack simulations at SLAC to support several LARP projects
  - Rotatable Collimators
    - General collimation efficiency studies
  - Crystal Collimation
    - Incorporating crystal channeling code into SixTrack (has this been done yet?)
  - Crab Cavities
    - Simulations of the effects beta beat and dispersion effects with crabbed beams
- SLAC is eager to begin SixTrack simulations in conjunction with CERN people
  - Have clusters with idle time waiting for numbers to crunch.

SLAC obtained the first of Sun Microsystem's "Black Box" self-contained data centers. With the addition of a second just installed, now totaling 2056 CPU cores.

Bench-top Impedance Measurements

- Obtaining LCR meter for low frequency transverse impedance measurements
  - Discovered we were using a broken network analyzer giving spurious results
  - Expected better results with LCR meter (LCR measurement works better at low frequency than VNA)
- Goal is to have good measurements by EPAC08.
  - measure inductive by-pass in graphite plates
  - measure impedance of phase I graphite collimator
  - begin measuring impedance of components for our collimators



Schedule

Full length jaw completed	May 2008
Thermal tests on full length Jaw	EPAC08
Bench-top impedance measurements	First substantial results by EPAC08
RF contact resistance measurements	EPAC08
Test phase I collimator assembly and motion with heavier jaws. Design modifications.	Summer 08
2 full length jaws with full motion control in vacuum tank available for mechanical & vacuum tests in all orientations (“RC1”)	~Winter 2008
Final prototype (“RC2”) compatible with CERN Control System and deliverable to CERN	? Will depend on what modifications will be needed to RC1 (and LHC schedule).