CESR-TA Wiggler Chambers and RFA Diagnostics

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Work supported by NSF & DoE

Outline

1. RFA wiggler beampipe design
   - → Design parameters and criteria
   - → The design

2. Wiggler beampipe fabrication @ LBNL

3. RFA assembling
   - → Description of the RFA assembly
   - → RFA assembly process
   - → Final assembly and Installation
   - → Device performance

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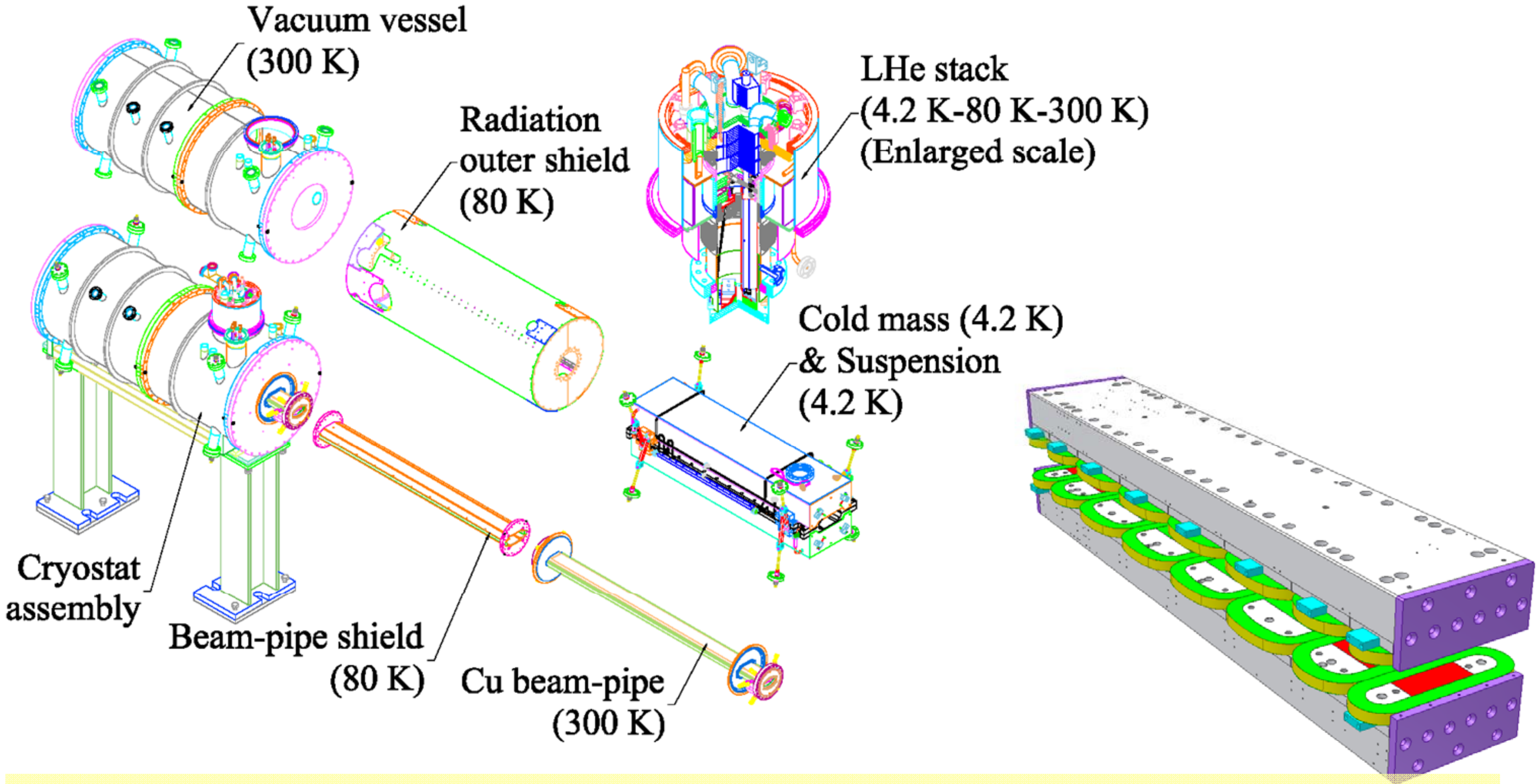
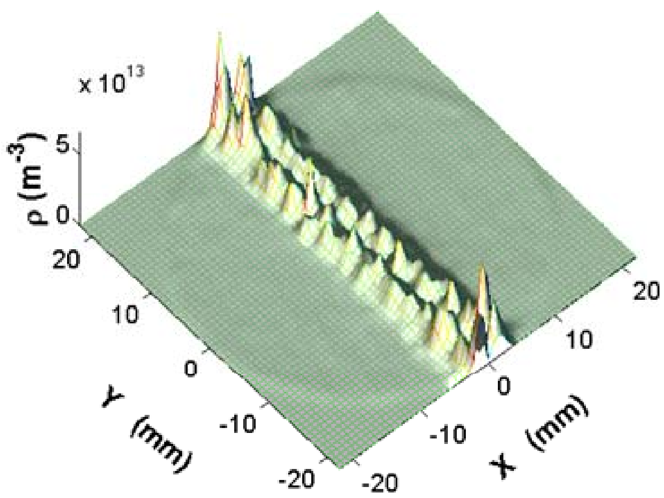
CESR-c SC Wiggler in One Slide



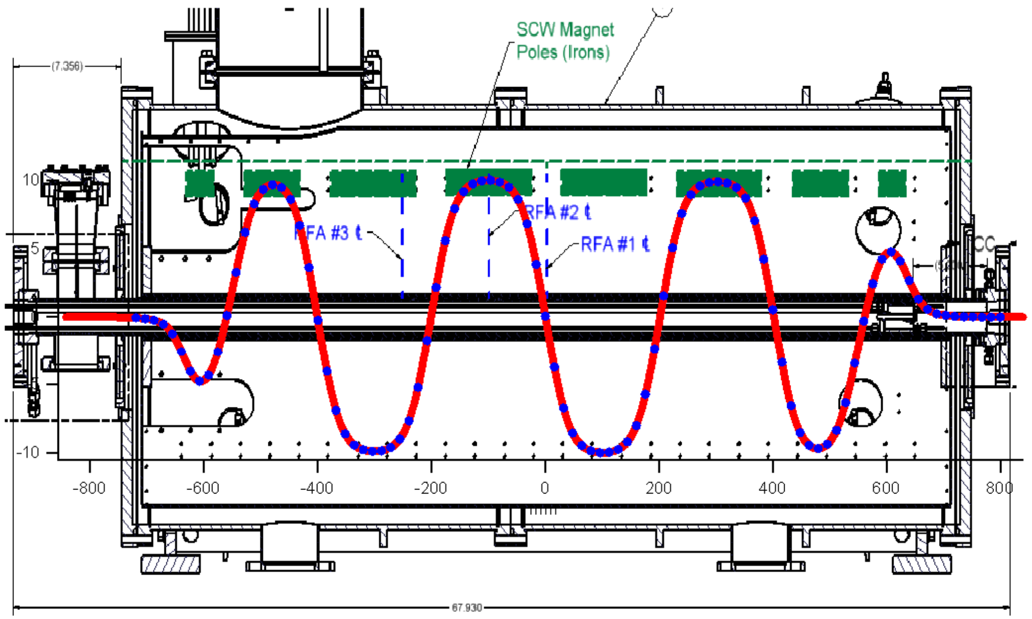
- *12 8-pole superconducting wigglers were successfully operated for CESR-c program*
- *Up to 2.2T peak field, meeting ILC-DR requirements*

RFA Diagnostic Requirements

- Measure E-cloud growth and suppression in wiggler field
- There RFAs located at strategic locations along longitudinal direction
- Each RFA to have capability to measure E-cloud distribution in transverse (X-axis) direction.
- The retarding field grids to be biased to >300 V, with independent potential adjustment

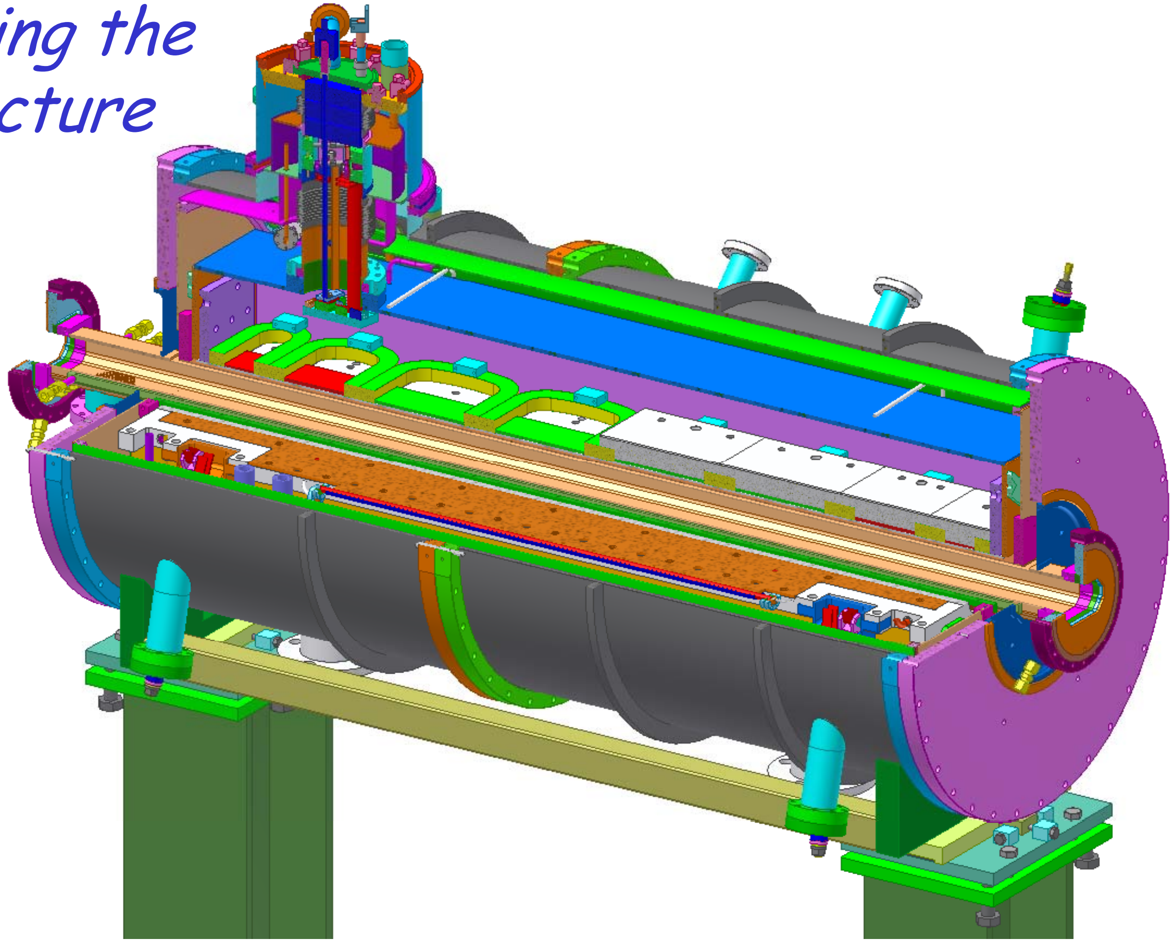


E-Cloud in Wiggler
(L. Wang, ILCDR'06)

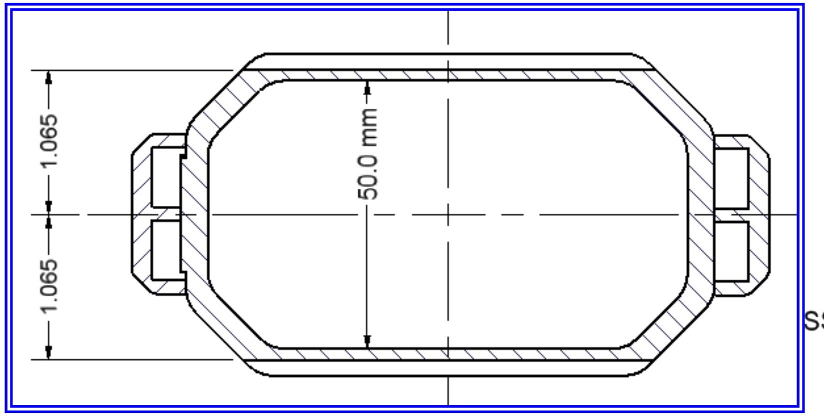


Beampipe Construction Requirements

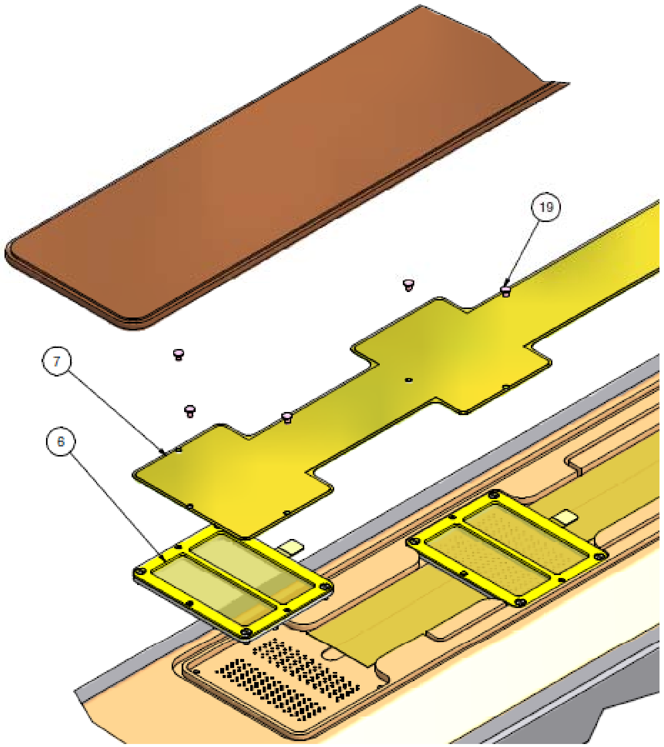
- *Must fit within the space within the cold-mass thermal shield.*
- *Install the RFA diagnostic beam pipe without dissembling and without disturbing the wiggler magnet structure*
  *(**Huge saving without dissemble/re-assemble the magnets !!**)*
- *Ultra-high vacuum compatibility*

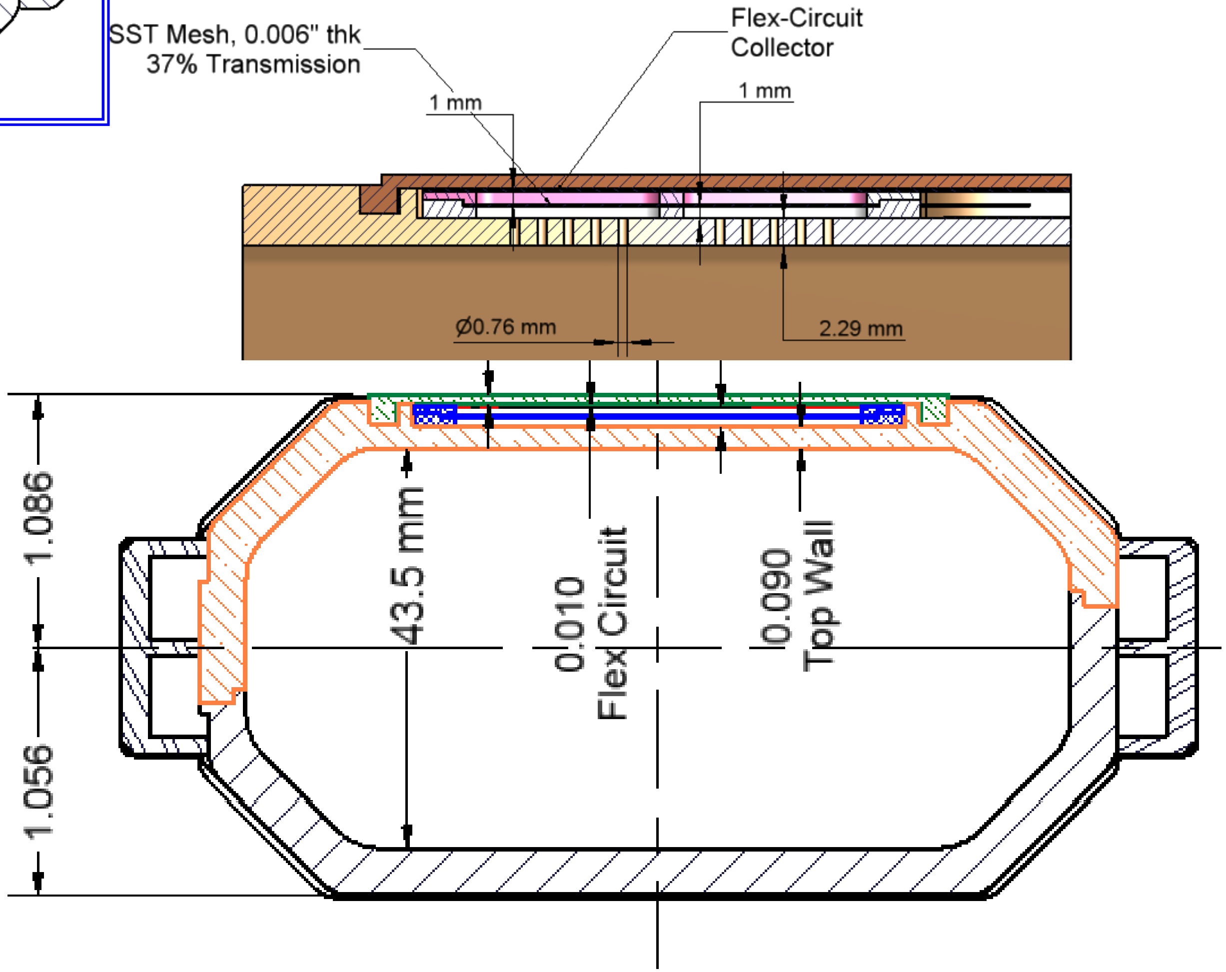


The Thin RFA Structure



Reduced beam vertical aperture by 6.5 mm to 'squeeze' in the 2.5 mm-thick RFAs





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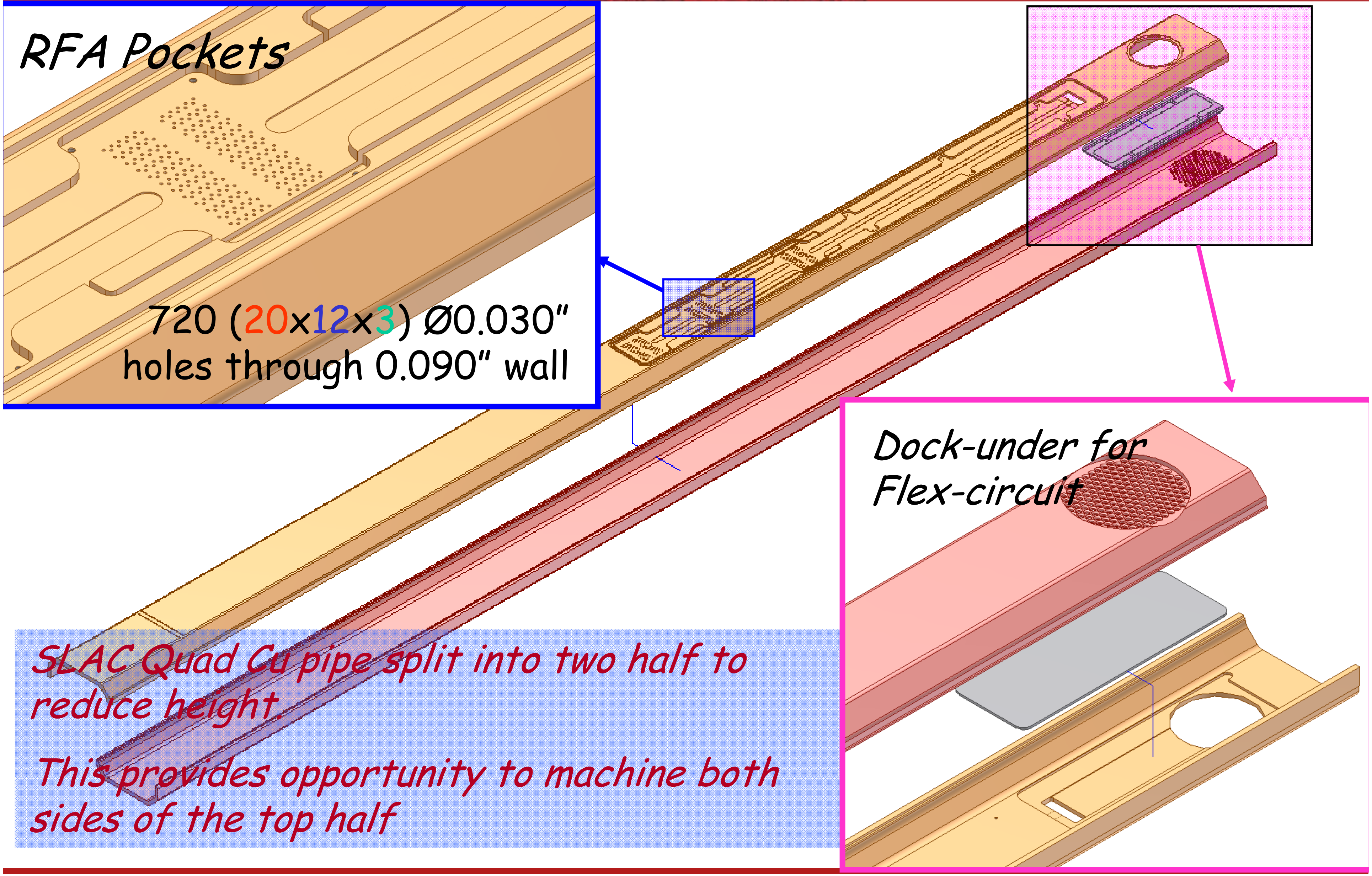
Beampipe Design



SLAC Quad Cu pipe split into two half to reduce height.

This provides opportunity to machine both sides of the top half

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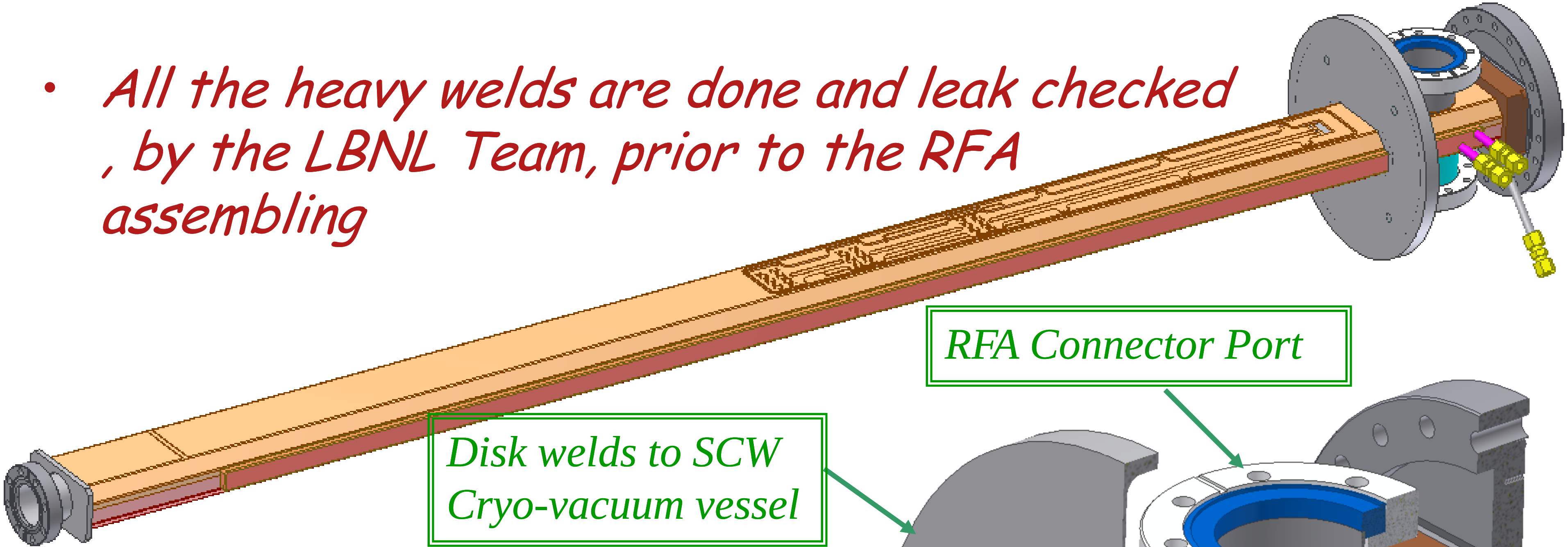
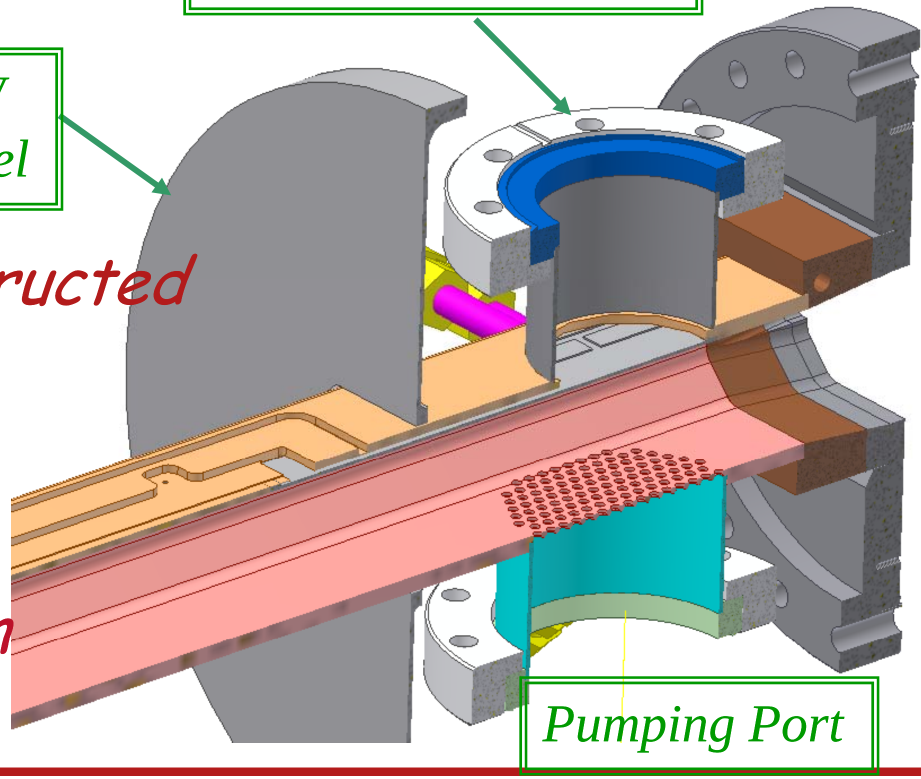
The Delivered Beampipe

- *All the heavy welds are done and leak checked , by the LBNL Team, prior to the RFA assembling*





- *Two beam pipes were constructed*
  - → *Plain copper*
  - → *TiN thin film (D. Wright, etc. SLAC)*
- *Beampipes were received on Sept 5th at Cornell*

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U.S. DEPARTMENT OF ENERGY

Fabrication of Two CESR-TA RFA Wiggler Chambers at Lawrence Berkeley National Lab

Presented by Dawn Munson

International Linear Collider Workshop 2008
LCWS08 and ILC08

November 17, 2008

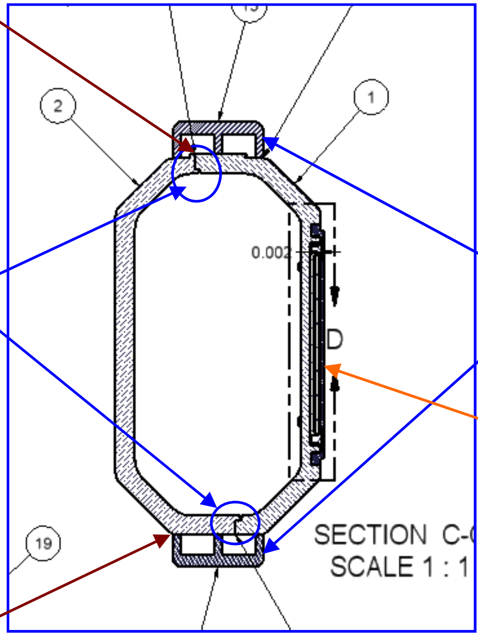
International Linear Collider – Damping Ring Test at the Cornell Electron Storage Ring (CESR)

- Lawrence Berkeley Lab (LBNL) in collaboration with Cornell built two Wiggler Vacuum Chambers for Electron Cloud Suppression and CESR-TA Studies.
- Two wiggler chambers were fabricated, assembled, and dimensionally measured at LBNL, Summer 2008.
  - Longitudinal slitting of chambers
  - Machining of all chamber details and peripheral hardware.
  - Facilitated the electron beam welding of the chamber halves and water cooling channels
  - Performed welding of exterior hardware
  - Zeiss measurements of the chamber profiles

Wiggler Chamber Cross Section Schematic

Electron Beam Weld – Two Seam Welds

Chamber Split & Weld Prep



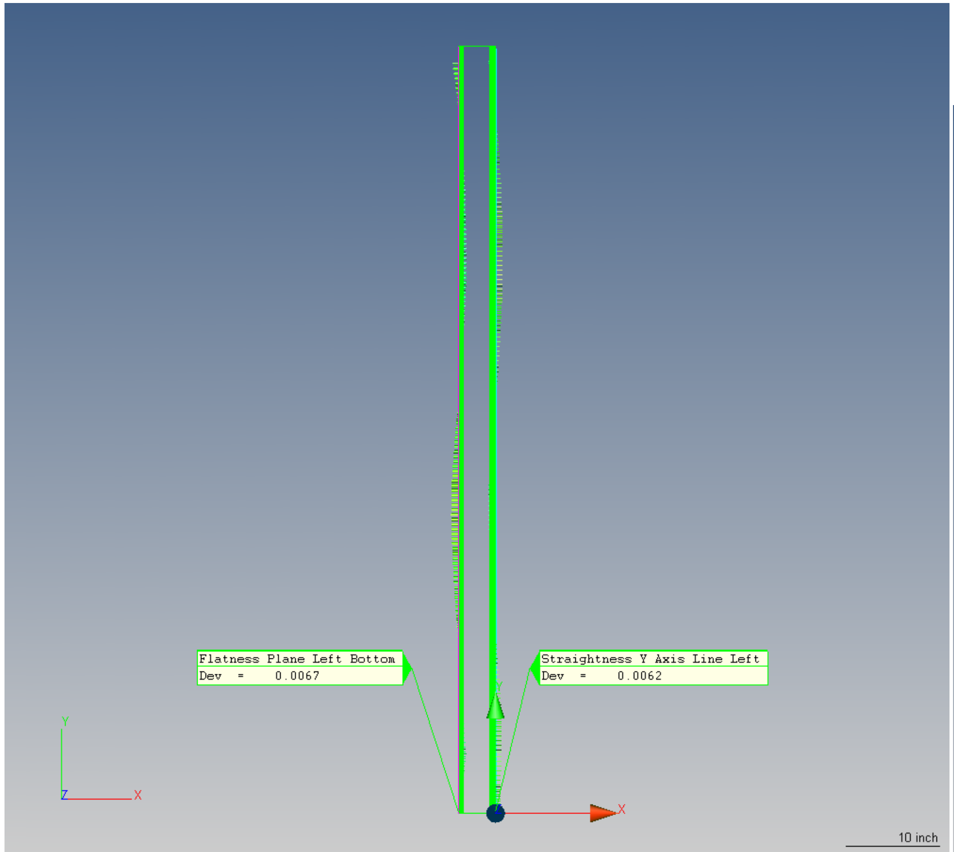
Cooling Channels

Chamber Machined Features

Electron Beam Weld – All Around Cooling Channels

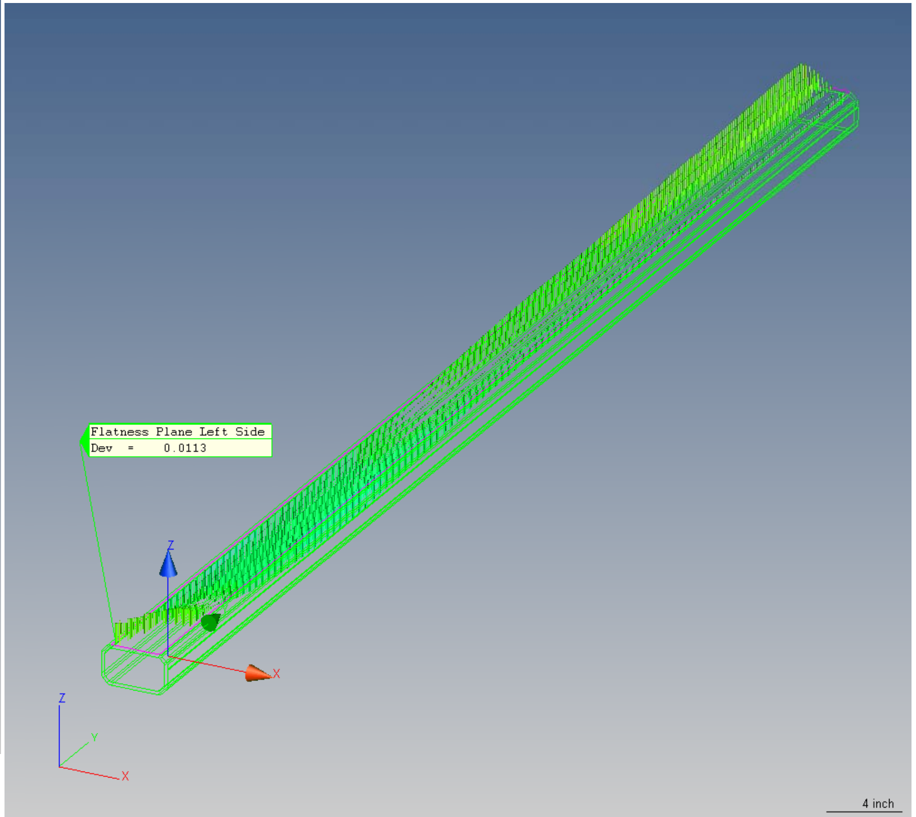
Step 1: Inspect and Measure Extrusions as Delivered

Extrusion QC-4-2-Left Side

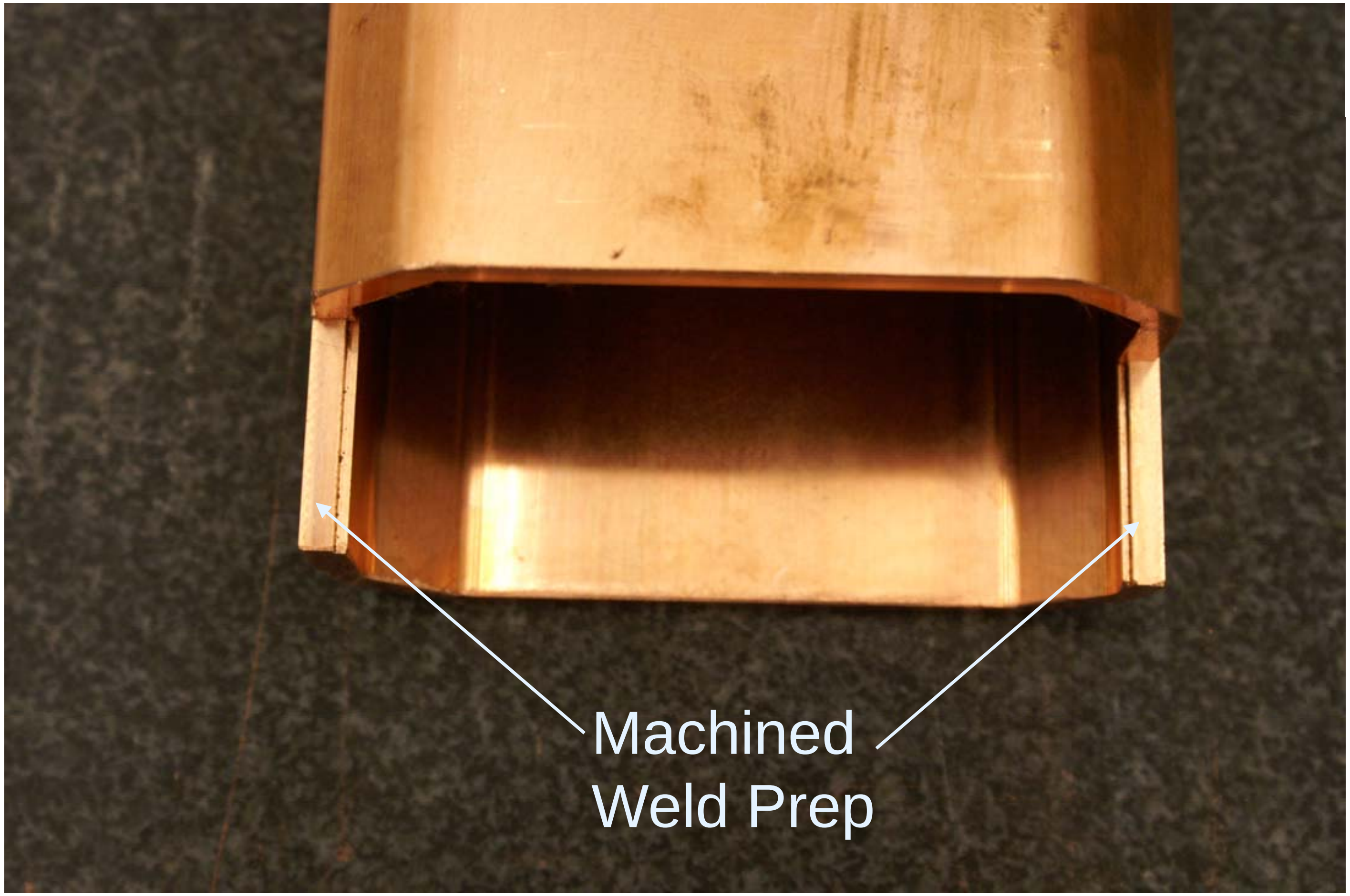


Straightness and Flatness of Y Axis Line and Bottom Plane

Flatness of Plane Left Side



Step 2: Split and Machine Extrusion Chambers



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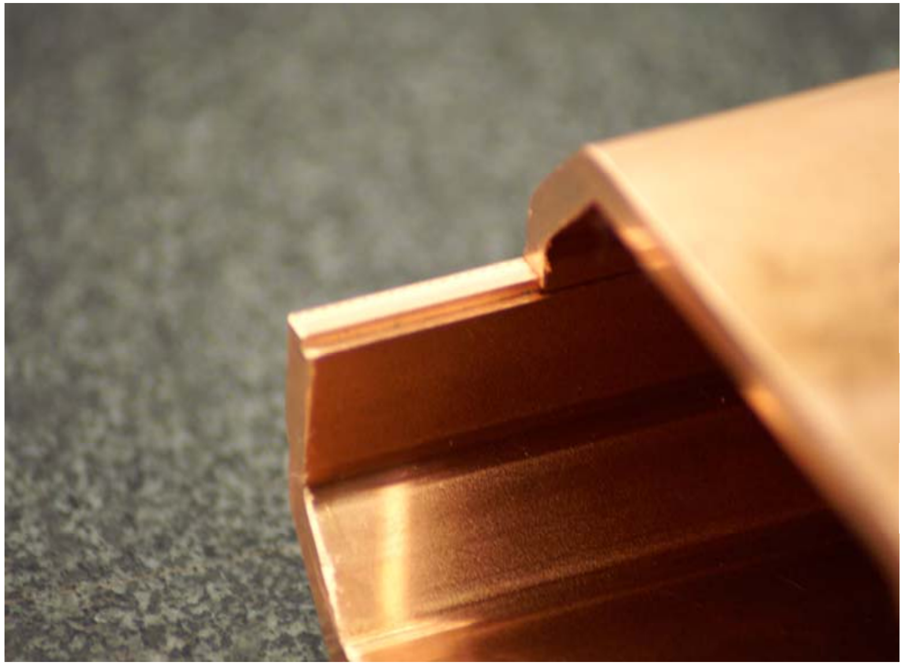

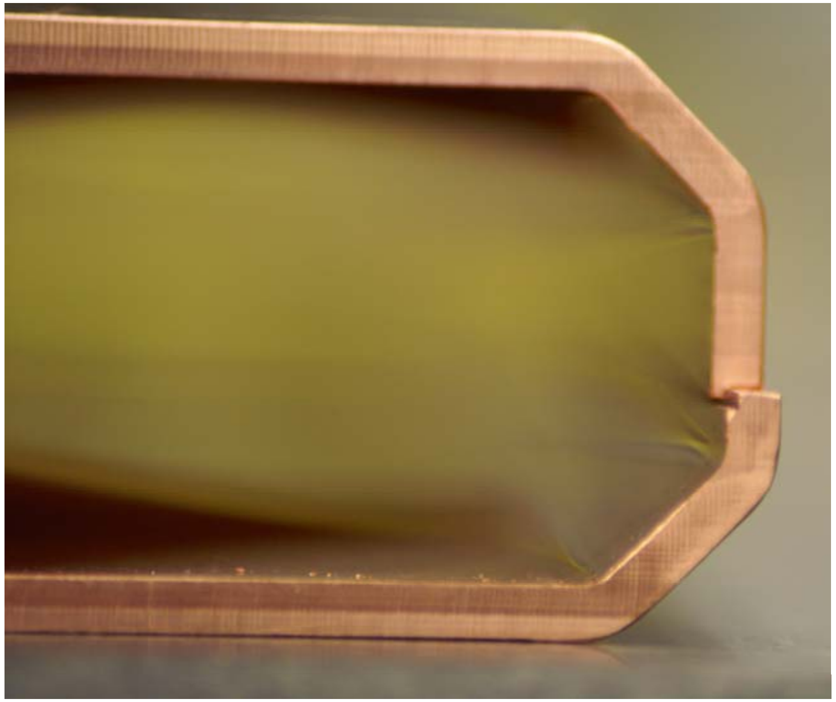

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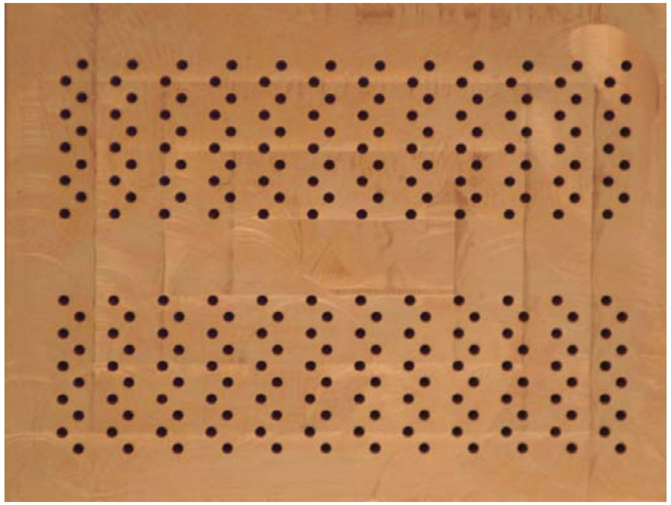
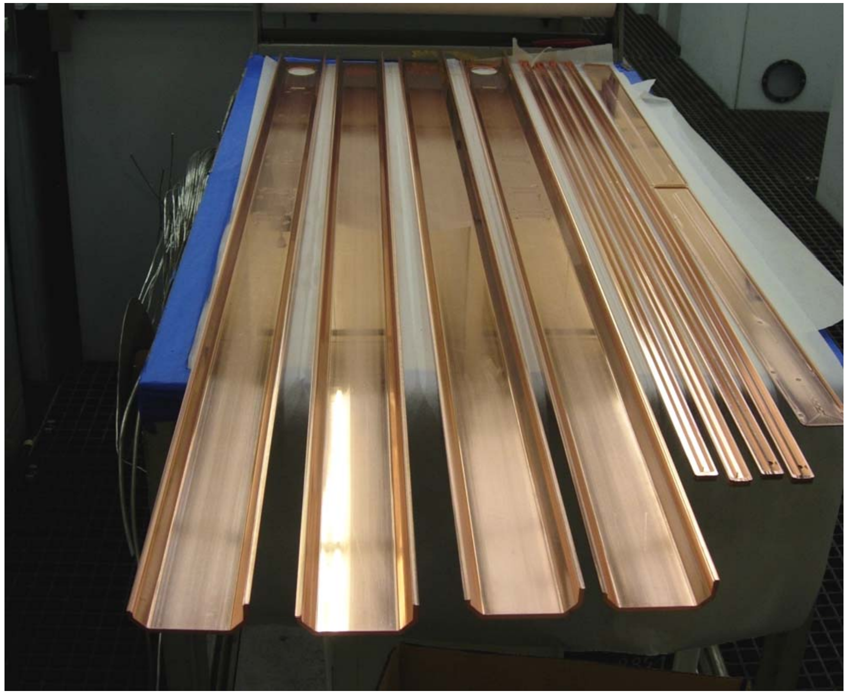


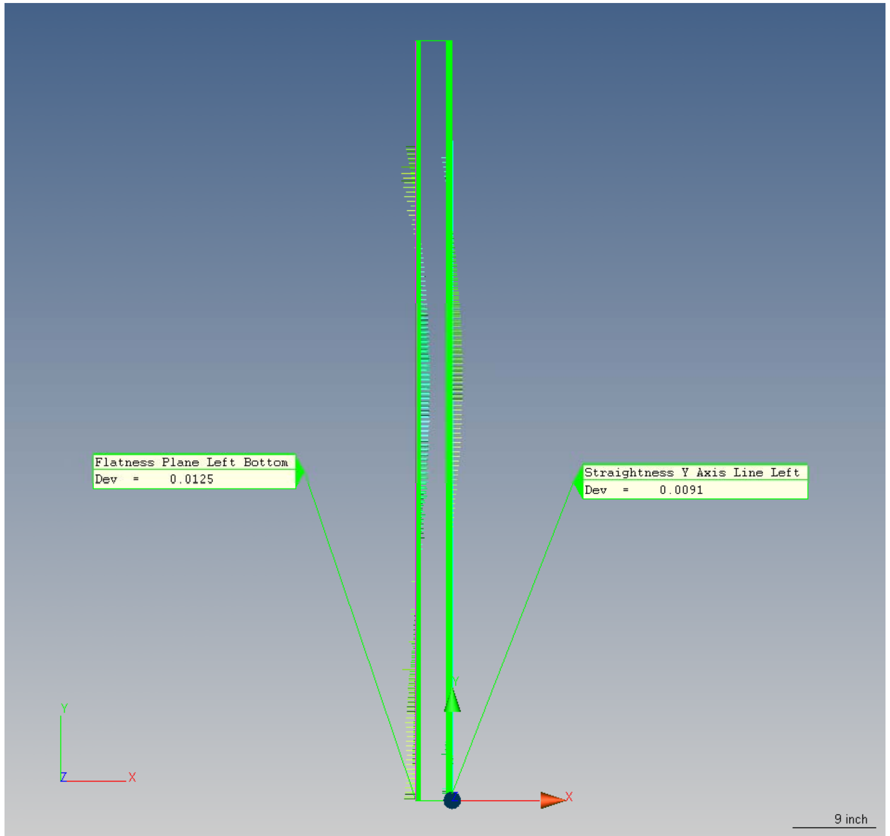
Two wiggler chambers, RFA covers and water channels. Parts are completely machined and UHV cleaned.

Detail of 0.030” Ø holes for the RFA.



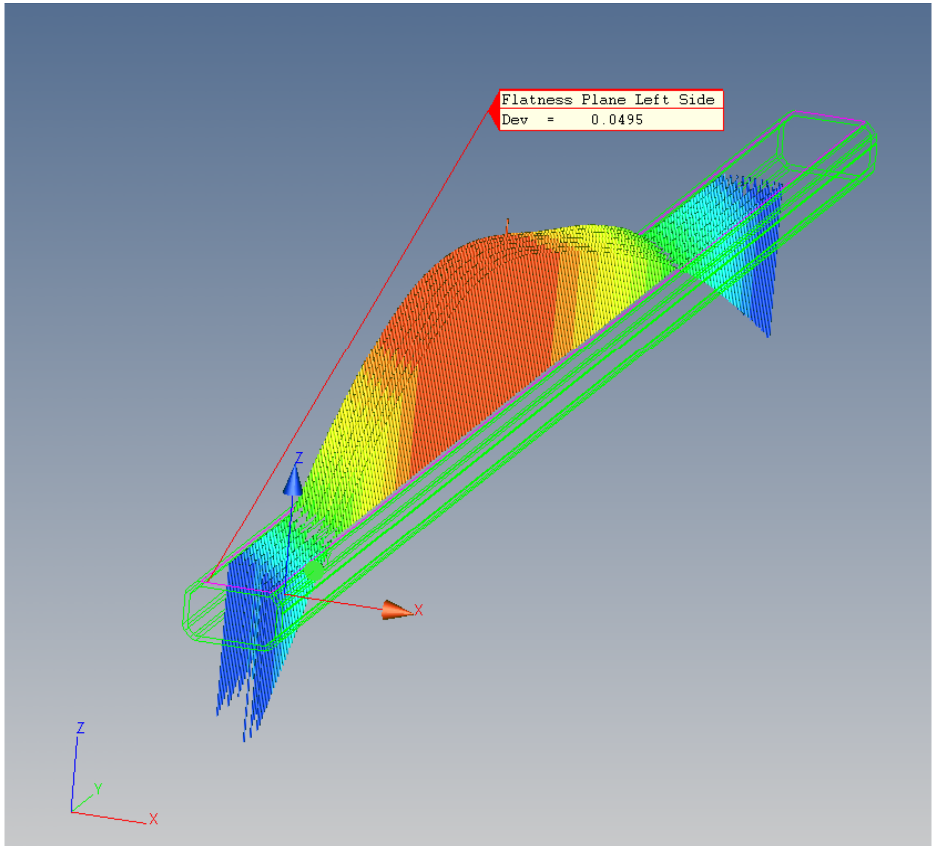
Step 3A: Measurement of Split Chambers

Extrusion QC-4-2-Left Side- After Cutting



Straightness and Flatness of Y Axis Line and Bottom Plane

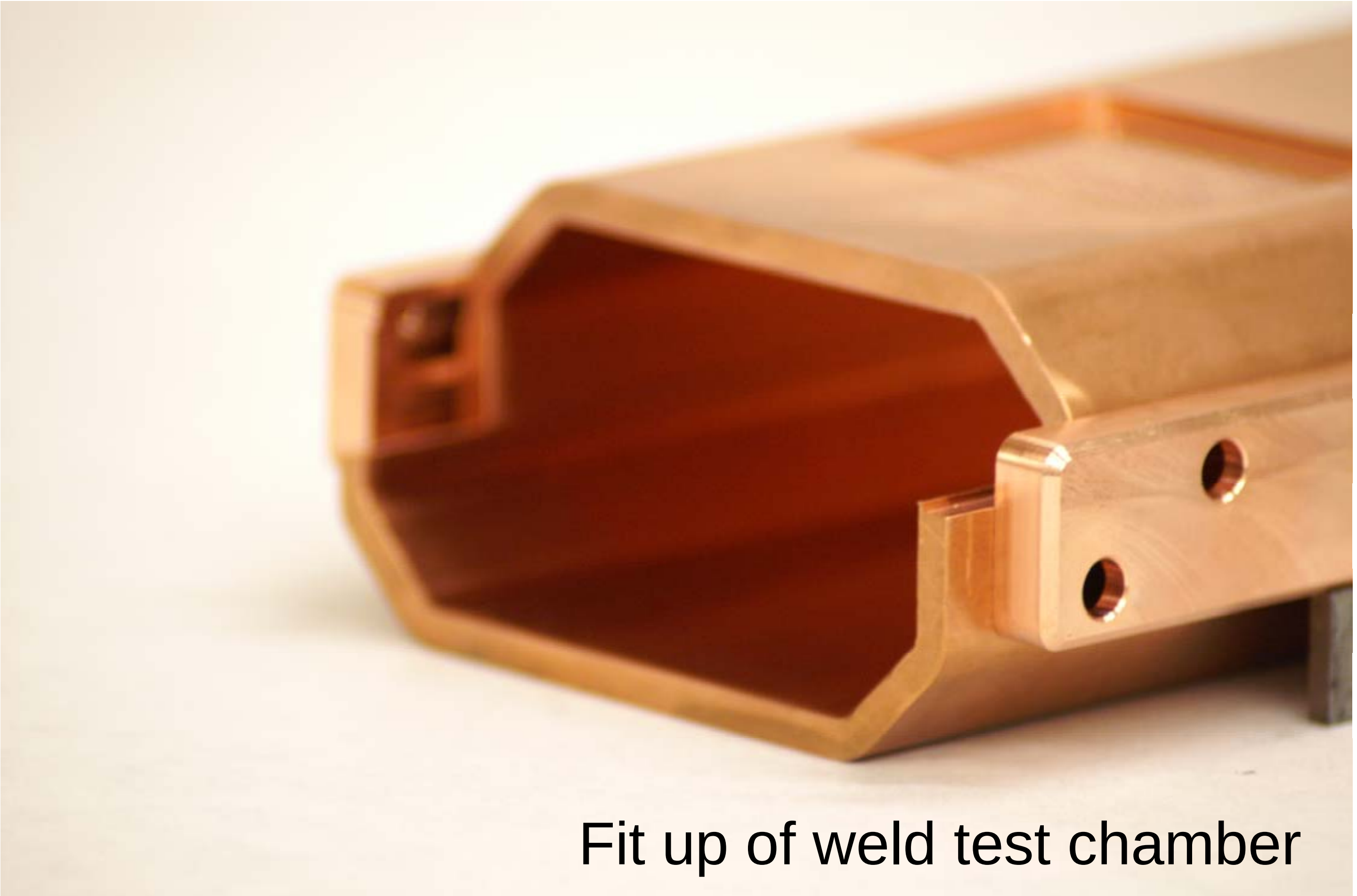
Flatness of Plane Left Side



Step 3: Electron Beam Weld Test

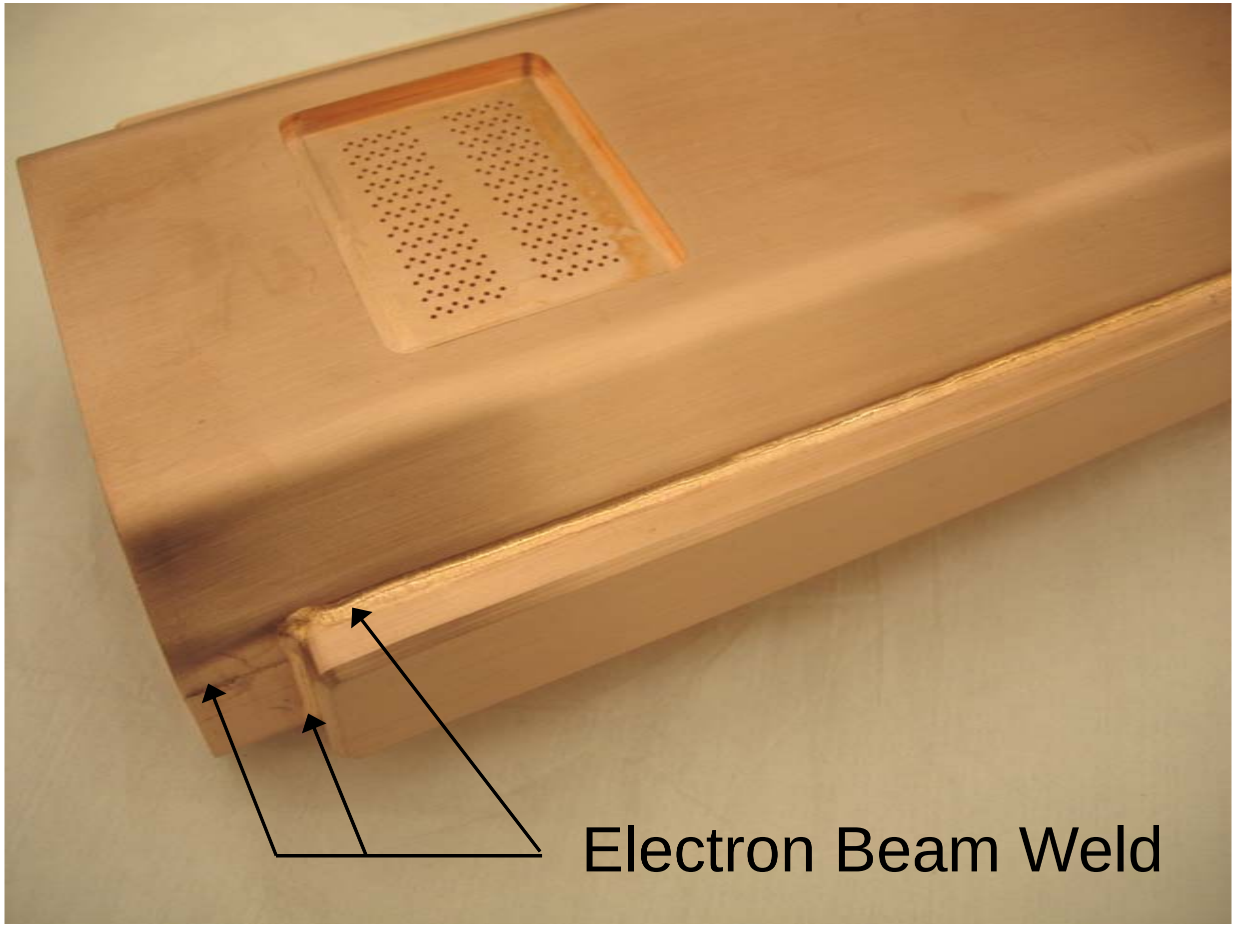
- LBNL machined, prepared and cleaned two scaled sample chambers to validate the electron beam welding process.
  - Sample chambers:
    - 10 inches in length.
    - Machined from the same extrusion material
    - Small diameter holes drilled for electronics, for proof of process
  - Water channels:
    - Scaled to match the ~ 1/7 size of the chambers
    - Copper material identical to material used for full size
    - Inlet/outlet holes for pressure testing

Step 3: Electron Beam Weld Test



Fit up of weld test chamber

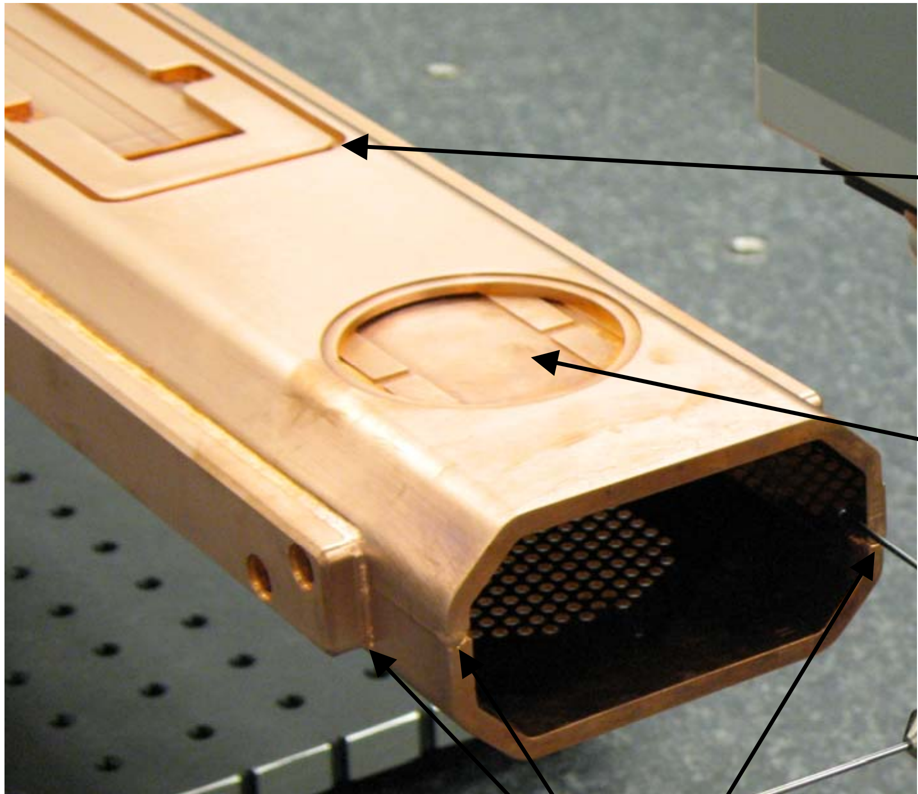
Step 3B: Electron Beam Weld Test



Step 4: Electron Beam Weld Wiggler Chambers

- All welds completed in vacuum with CNC electron beam welder.
- Chambers held in vacuum to minimize oxidation.
  - No oxidation was found.
- Electron Beam Weld Process:
  - 'Duck Under' cover welded and visually inspected by LBNL.
  - Longitudinal seam welds
  - Leak check of chamber
  - Water channel welds
  - Leak check of chamber and water channels
  - Pressure test the water channels to 90 psi

Step 4: Electron Beam Weld 'Duck Under' Cover, Chamber Seams and Water Channels

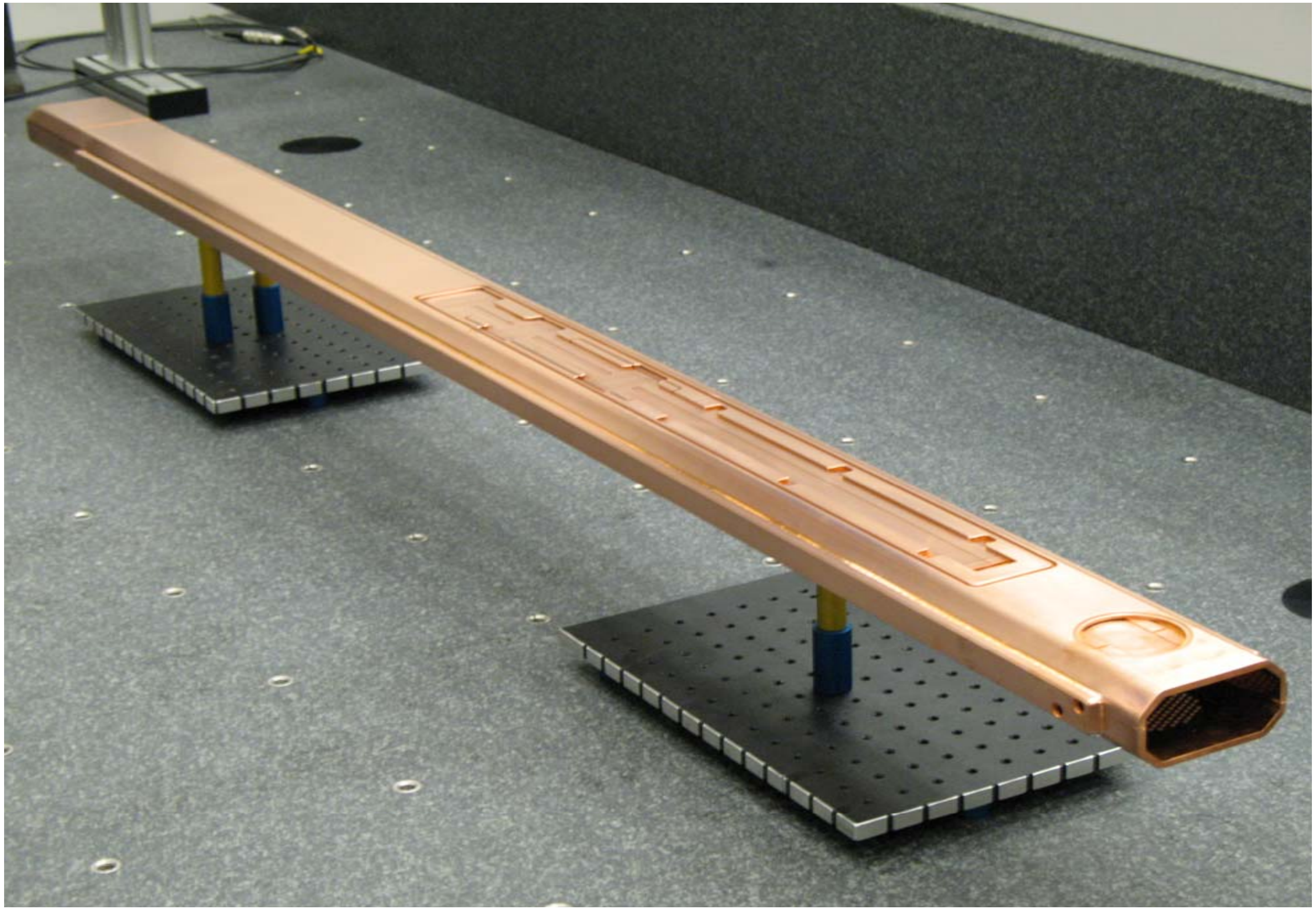


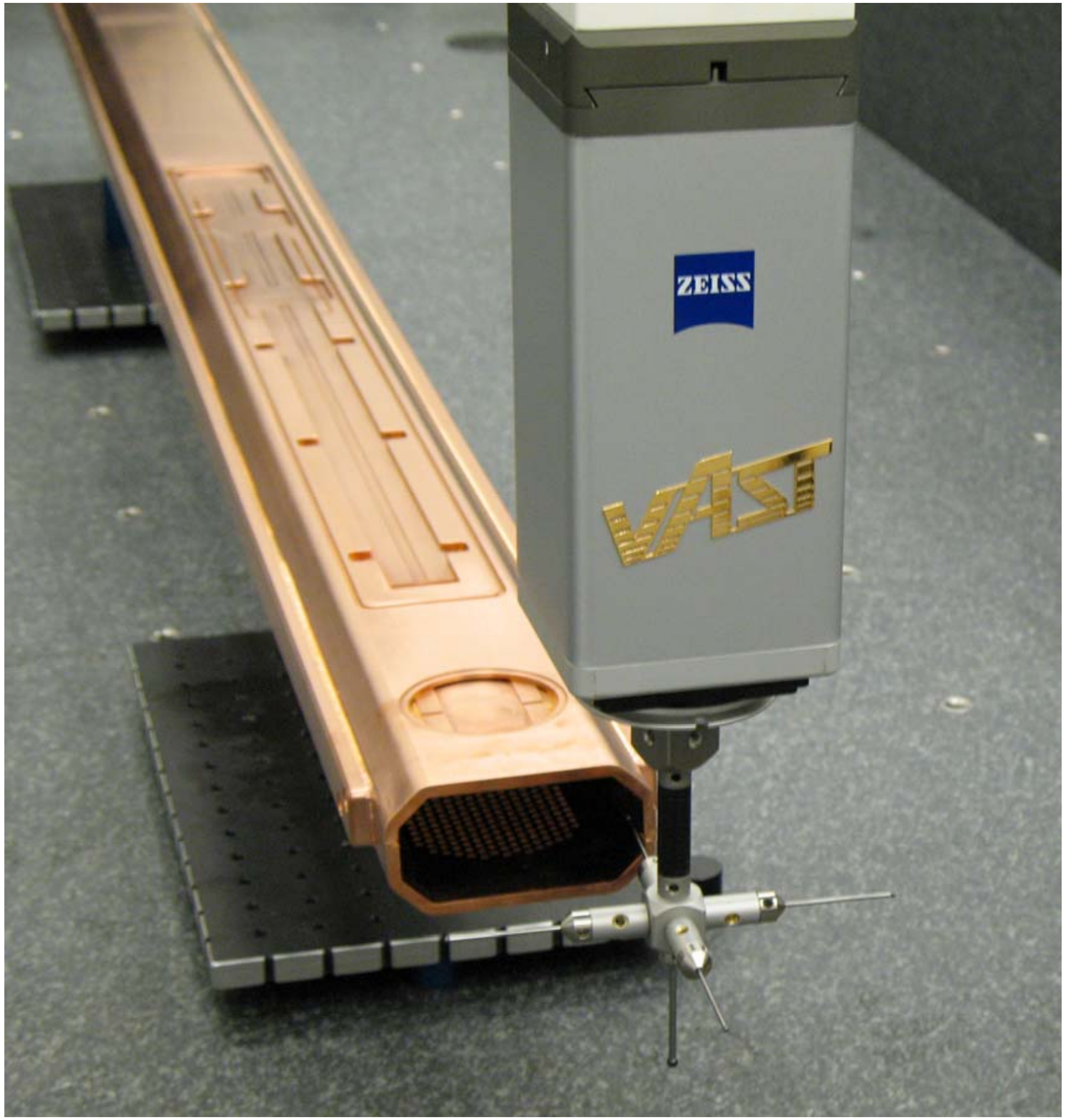
Machined detail

'Duck Under' cover, welded internally

Electron beam welded joints

Step 5: Dimensional inspection on Zeiss Coordinate Measuring Machine





Step 6: Copper to stainless transition profile cut to match the chamber profile.

Each transition is pedigreed to the chamber.

Step 7: Welding of External hardware

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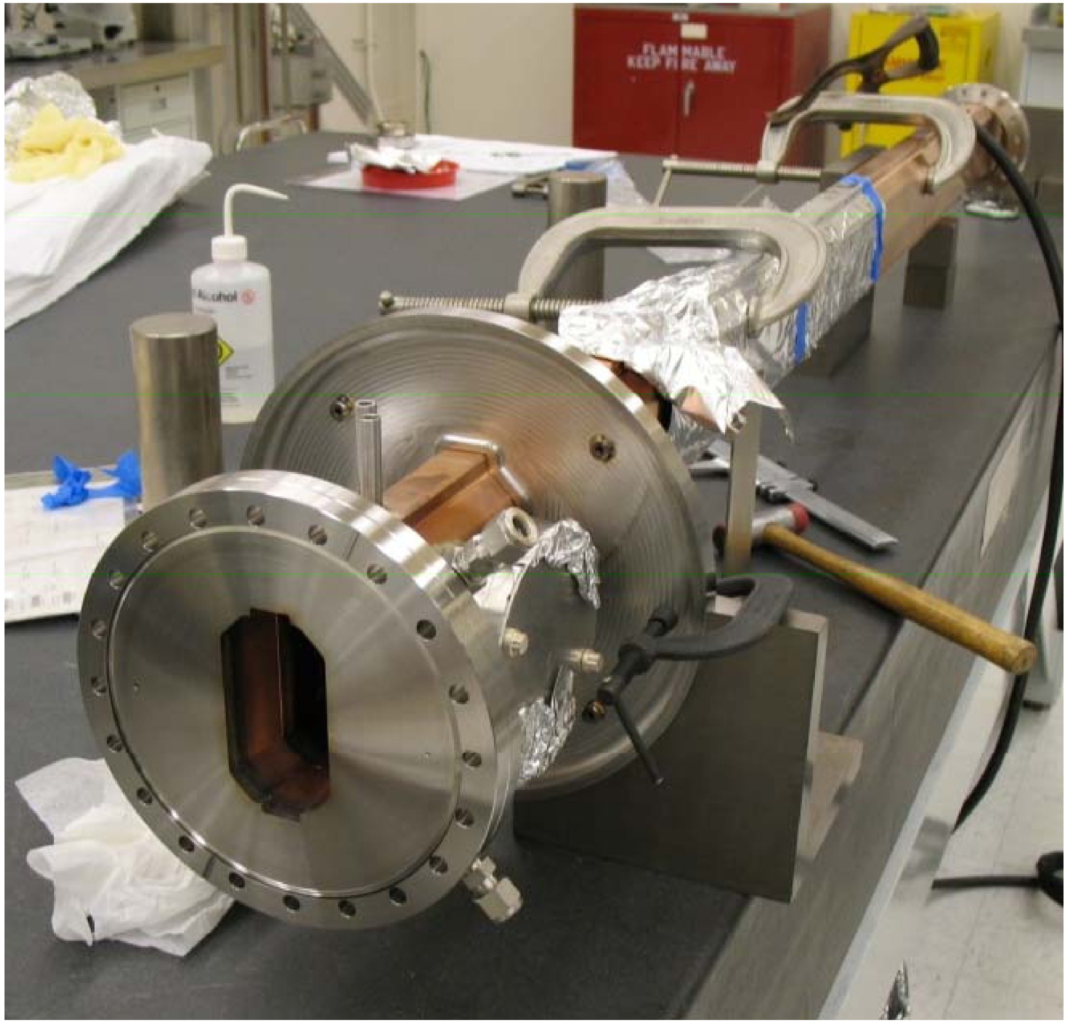
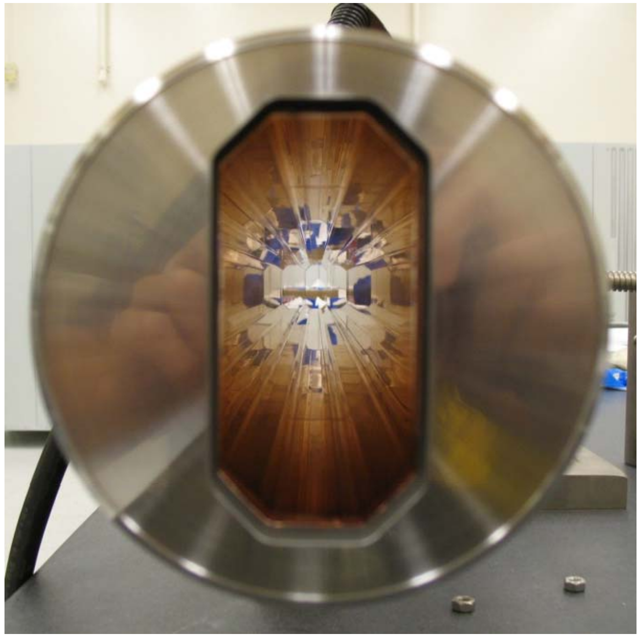


All welding was performed in an isolated environment with an Argon purge.



Final Steps:

- Steam cleaned chambers.
- Properly packaged and wrapped both chambers.
- One was chamber sent to SLAC for TiN coating.
- Upon completion, both chambers were sent to Cornell for installation.

Special Thanks to the LBNL Main Machine Shop Personnel

Guy Pulsifer

Rick Kraft

Dan DeBoer

John Haugrud

Machinists
Brian Bentley
Mark Campagna
Kit Mui
Dave Paulson
Manny Pereira

Welding
Tim Williams
Bob Conroy

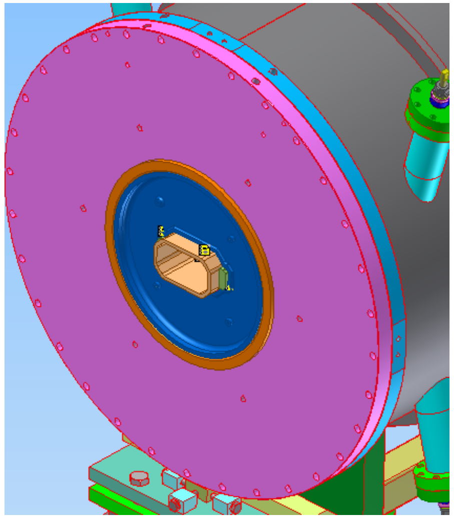
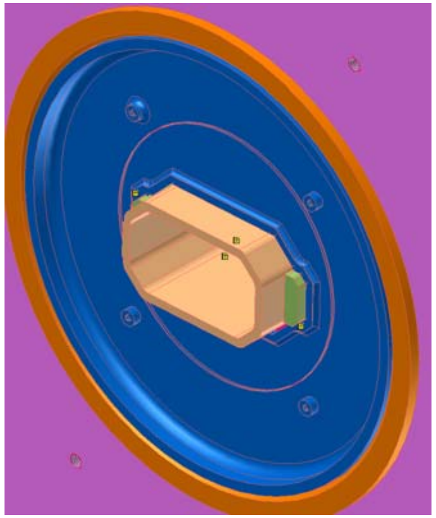
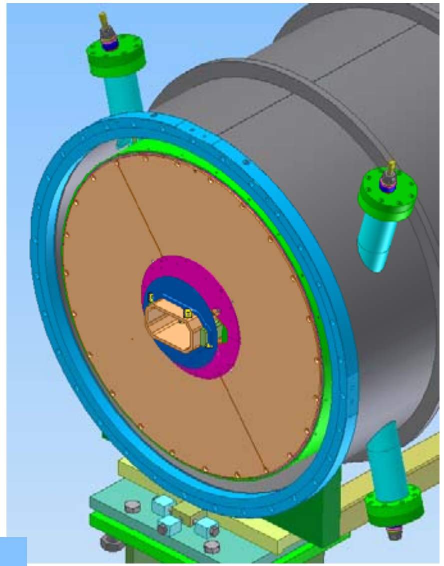
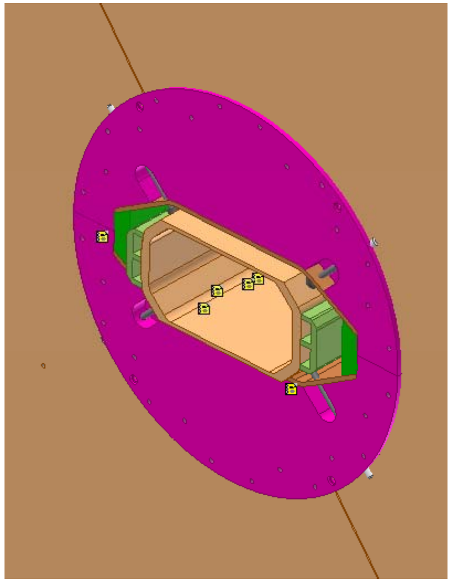
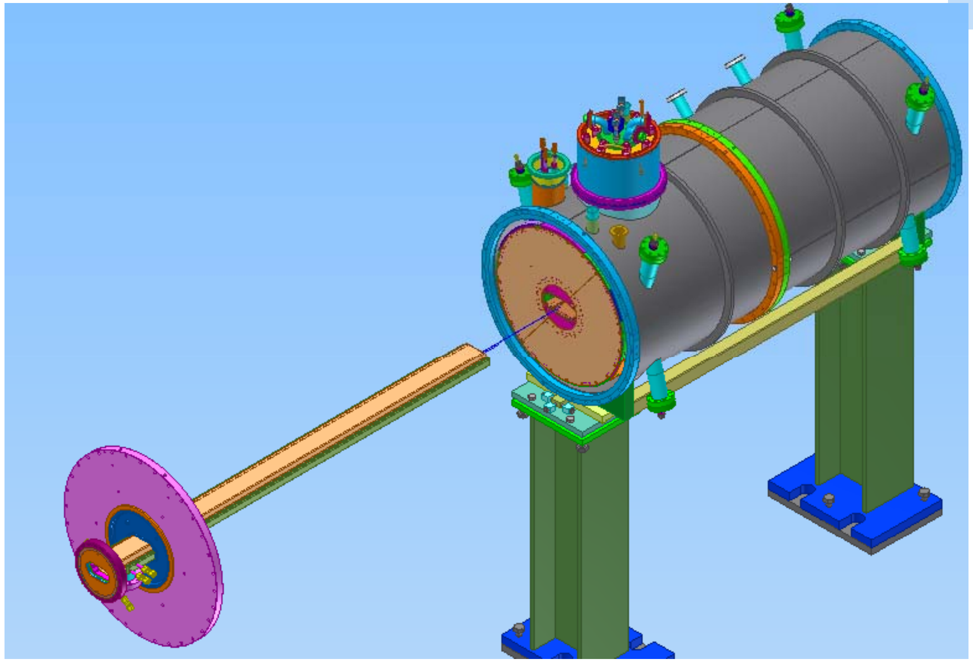
Leak Checking
Jim Dougherty
Frank Zucca
Dan Colomb

Inspection
Bob Connors

Cleaning
Chris Redding
Dennis Paiva

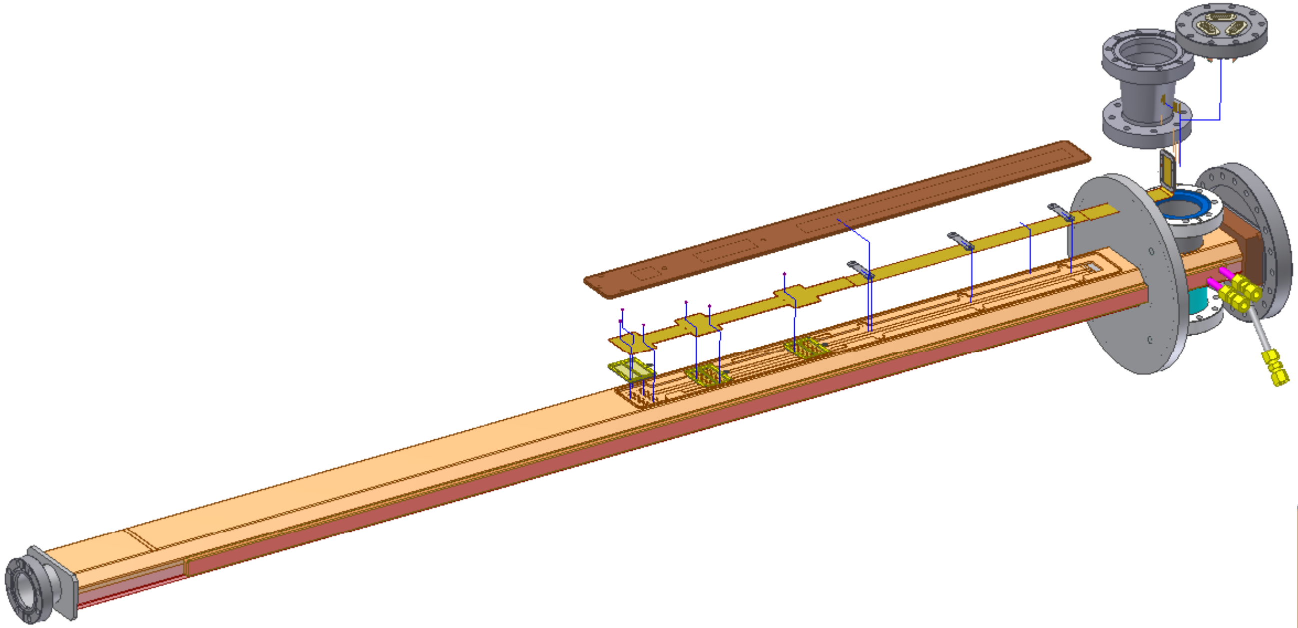
Support Hardware
Paul Knopp

Prepare the Wigglers – Extract Old Beampipe

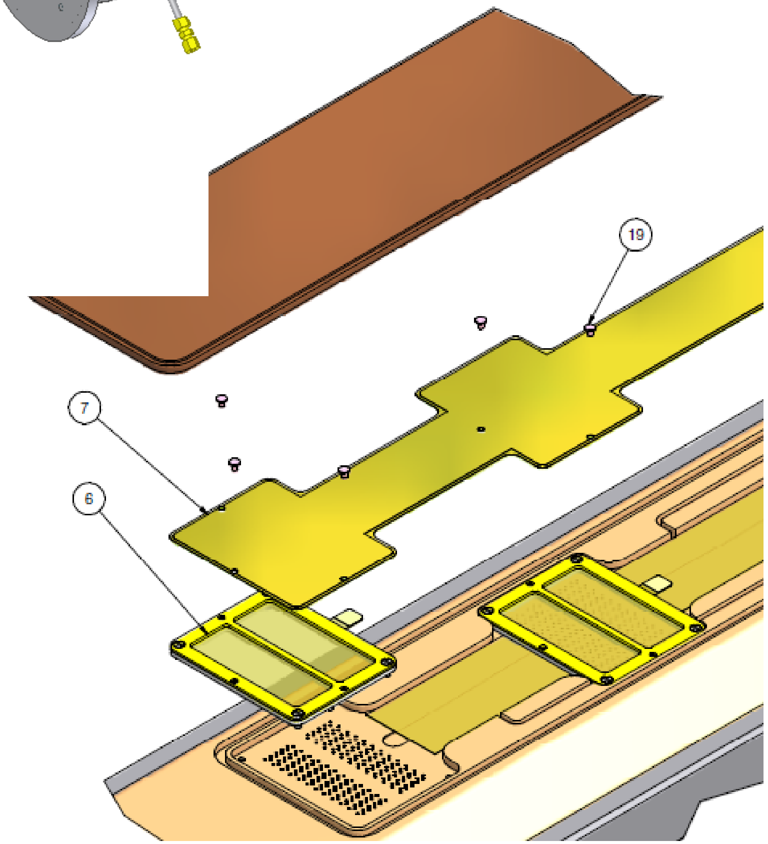






- Cut off beam pipe flange
- Cut through SST flexible disk with a hole-saw
- Remove large insulation vacuum flange
- Cut off residual flexible disk
- Pull out the remaining beampipe
- Magnet check out

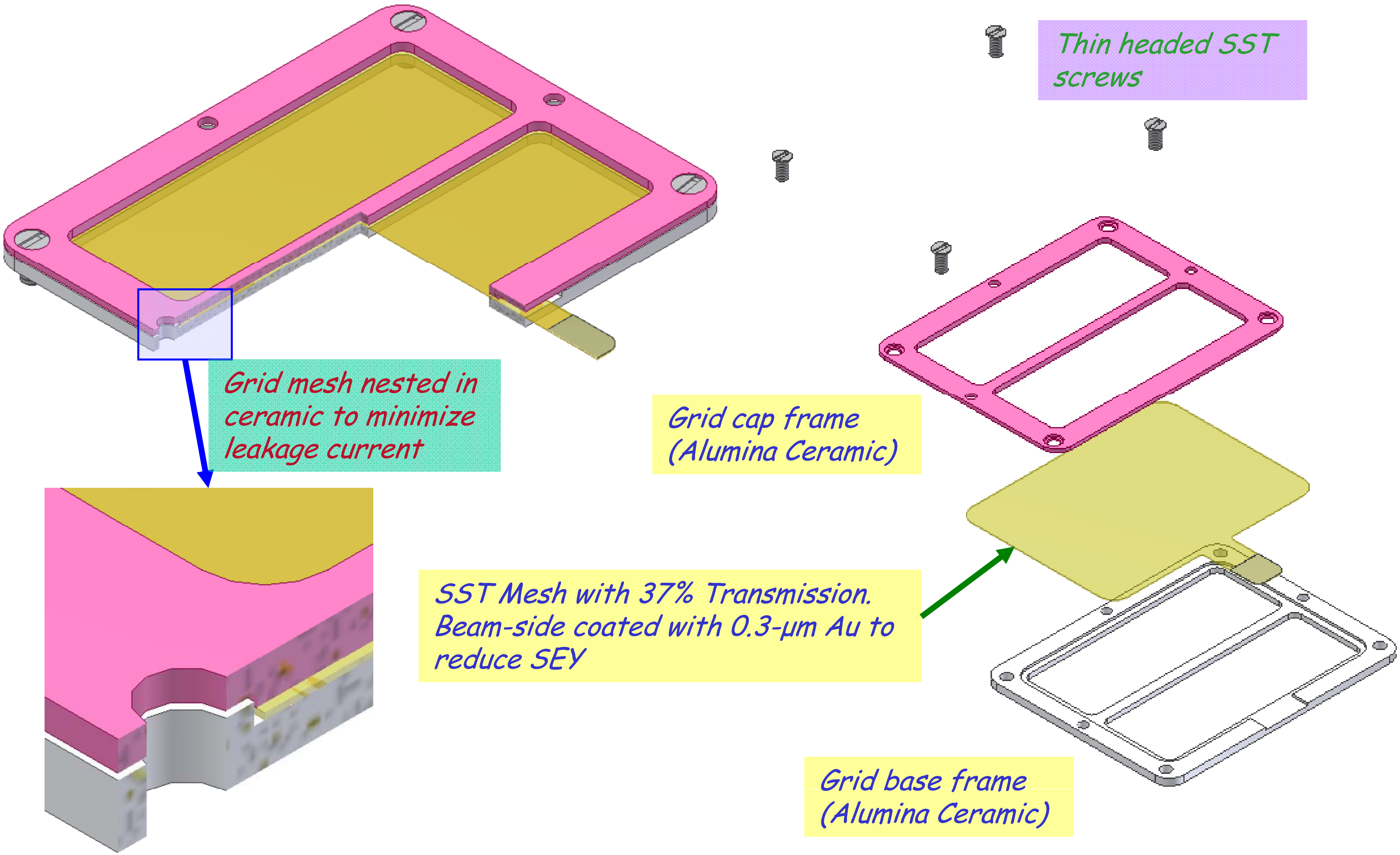
The Thin RFA Structure



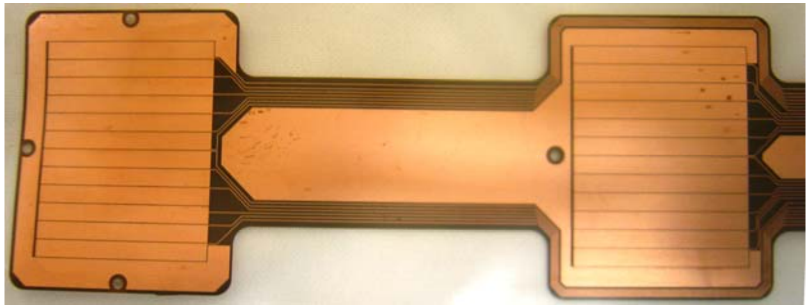
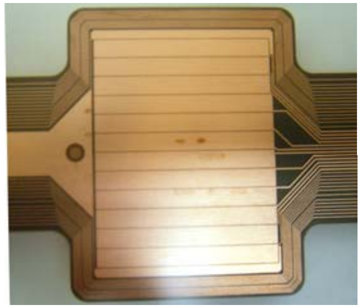
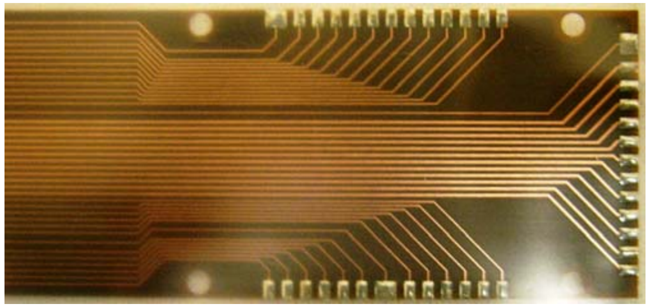
- Three RFAs at strategic wiggler field locations
- Each RFA consists of 12 'pads'
- Retarding grids bias individually
- Collector made of Cu-Kapton flexible circuit

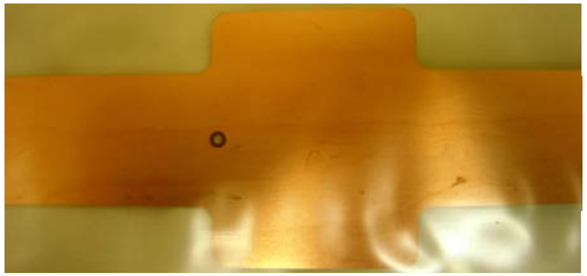


Retarding Field Grid



Flexible Circuit as Electron Detector




- 1-mil copper on both sides of 4-mil Kapton strip, 35" in length
- Minimize collect-side dielectric surface area
- Guard electrodes around collectors, biased at the same as collectors
- Locating pin-holes for precise positioning of the collector pads, w.r.t. the holes on the beam pipe

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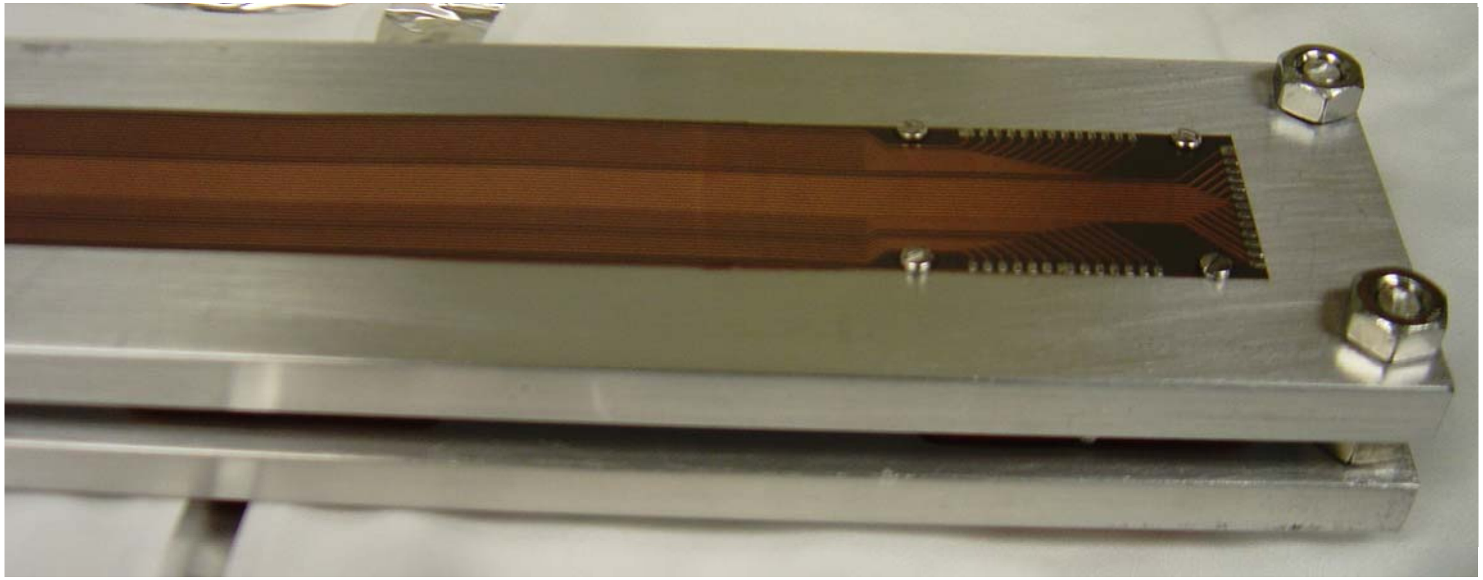
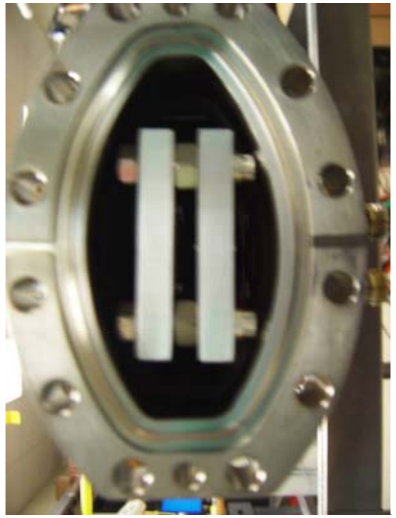
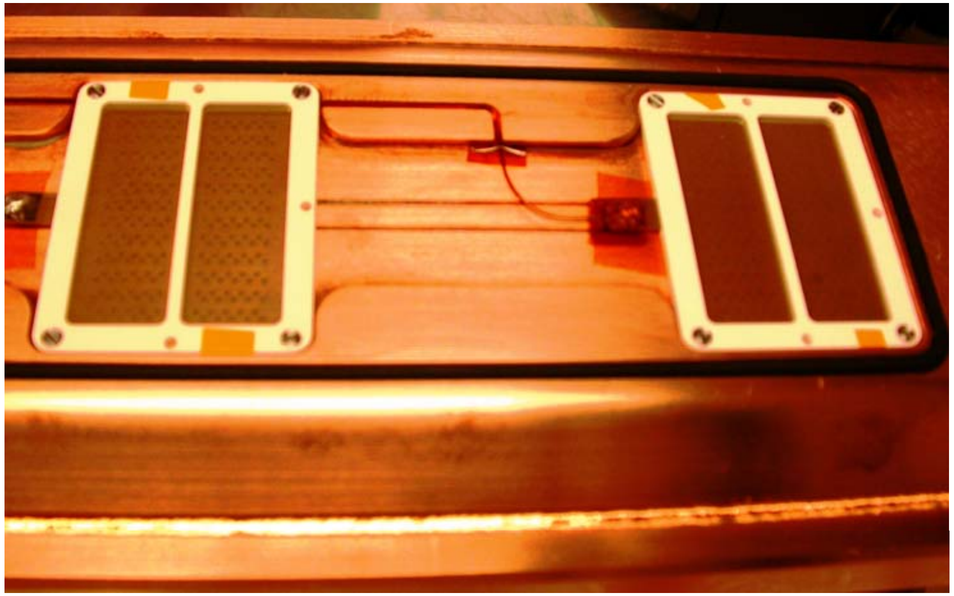
Flex-Circuit Preparations





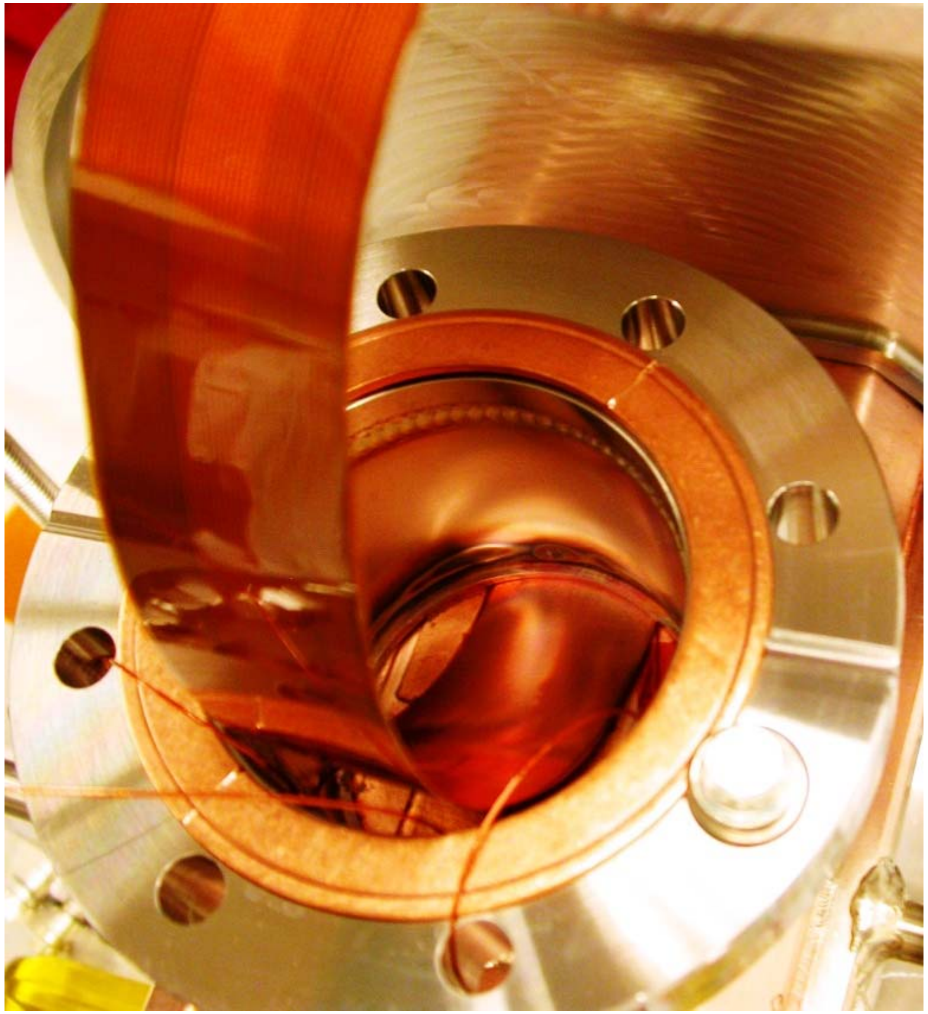
- *Having lots of problems with Au-based UHV solder. End up using Sn63Pb37 Flux cored solder. (Vacuum tests were done to confirm its UHV compatibility.)*
- *Circuit connect pads (and all wires) were tinned, and solvent cleaned, then followed by 150°C-24hr bakeout in vacuum.*
- *The fully prep-ed circuits were taped with UHV Kapton tapes (with silicone adhesives) , with only collector pads exposed, to prevent electric shorts. Carefully 'roll' out all air bubbles under the tapes.*

Install the grids



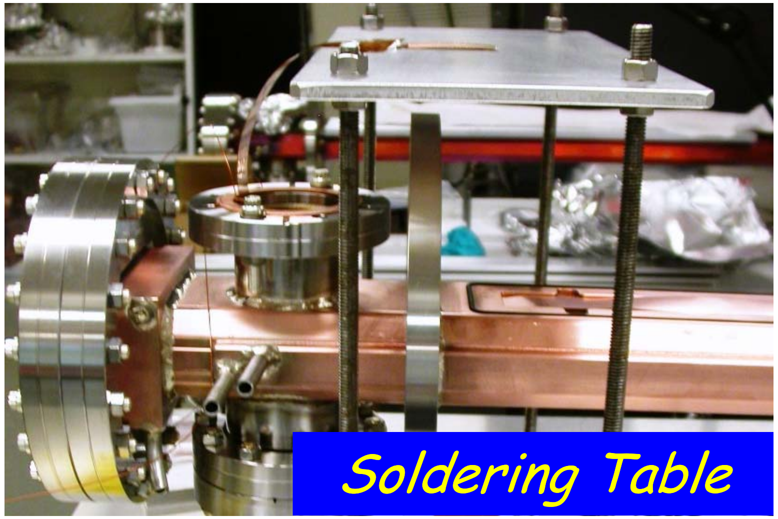
- Small Ni-pads were spot-welded to the Au-coated SST grids, and tinned, cleaned
- The sandwiched gird assemblies were screwed to the chamber
- Three grids were individually connected using Kapton coated wires, soldered to the Ni-pads

Insert the collector Flex-Circuit



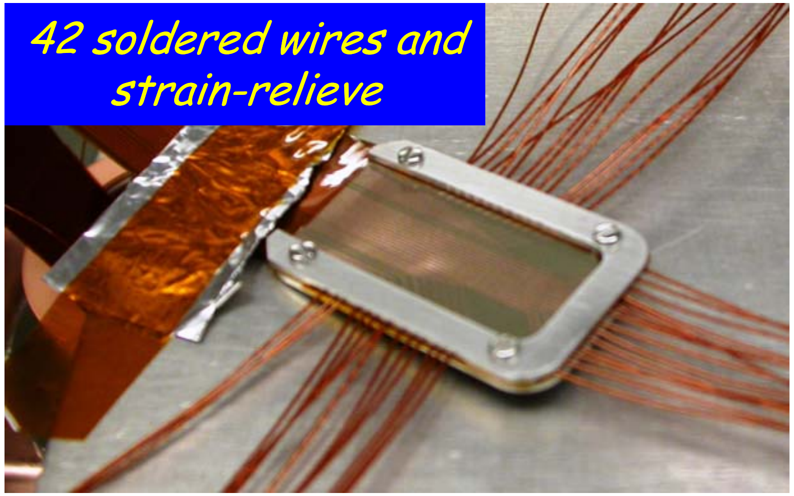
Through the "Tunnel"

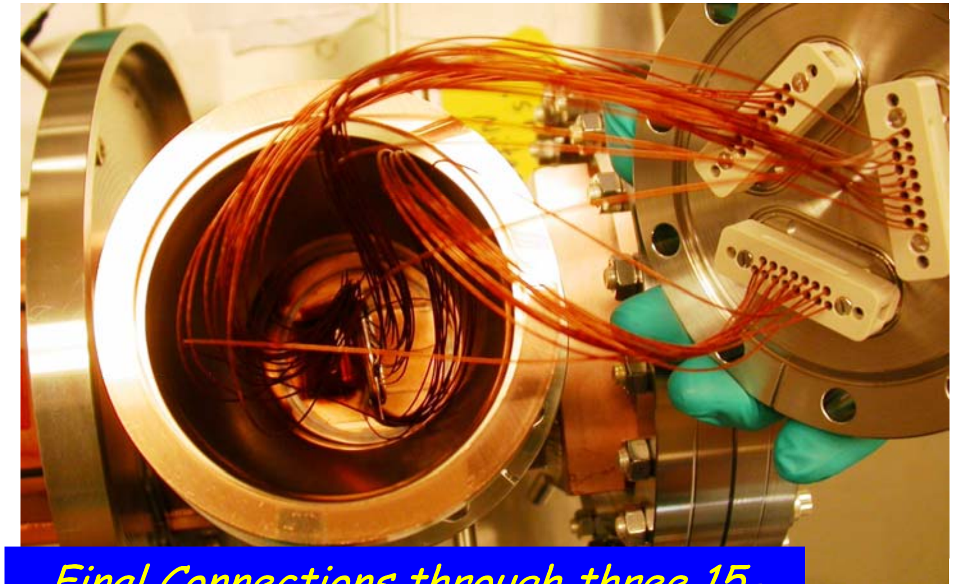
RFA Connections



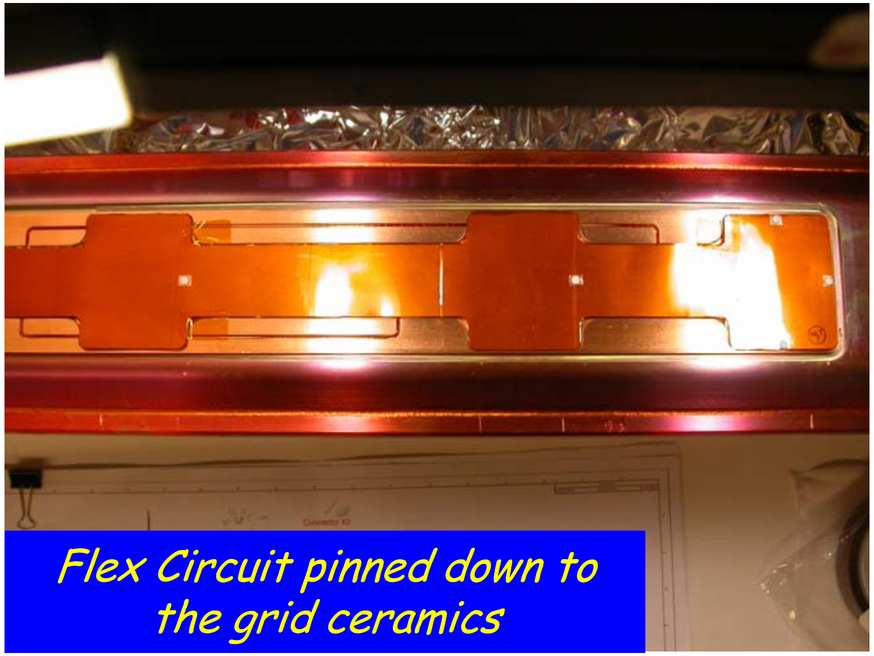
Soldering Table

42 soldered wires and strain-relieve





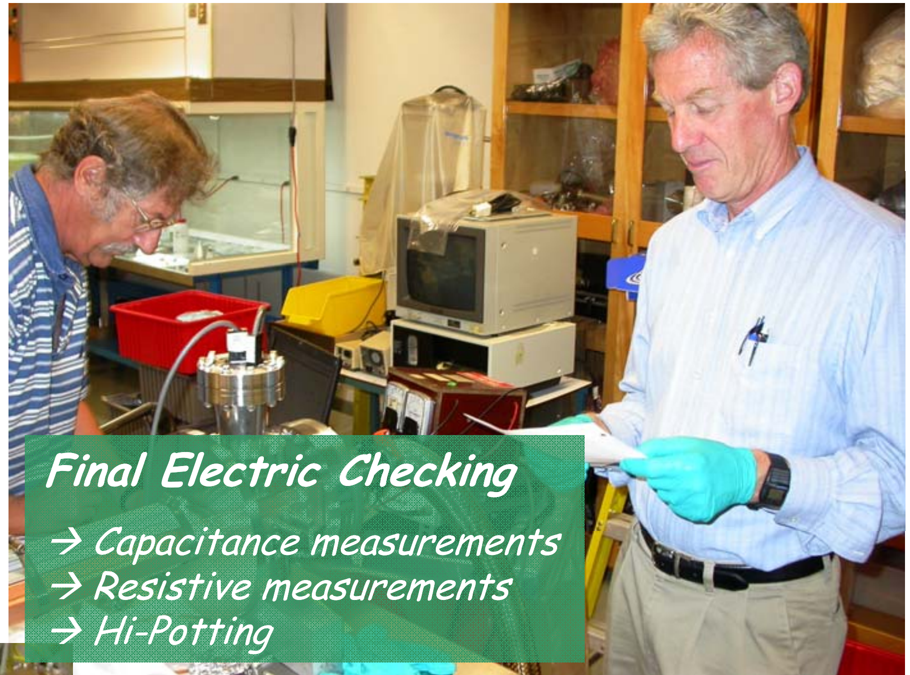
Final Connections through three 15-pin D-type vacuum feedthroughs



Flex Circuit pinned down to the grid ceramics

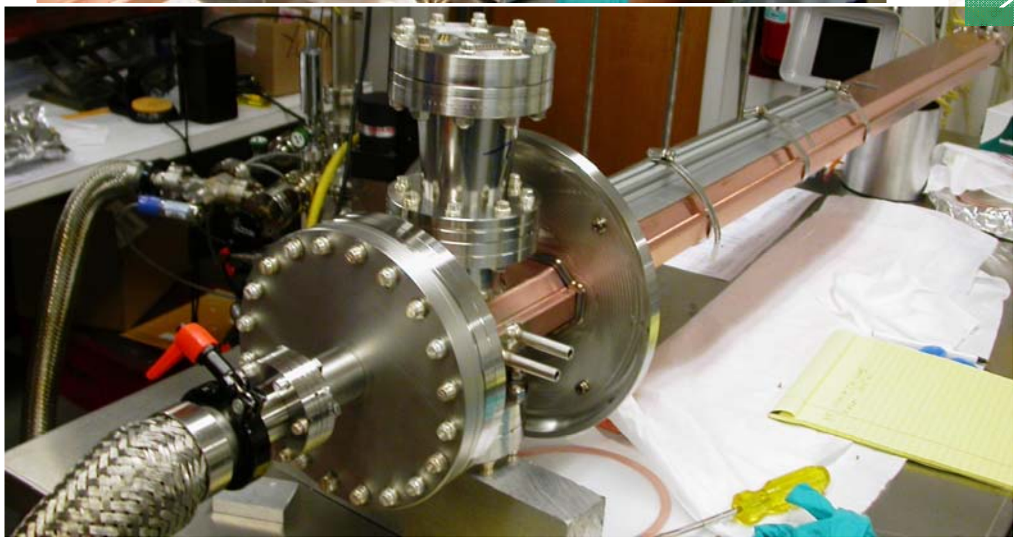
Checking, Checking and Checking

Pin-to-pad checking



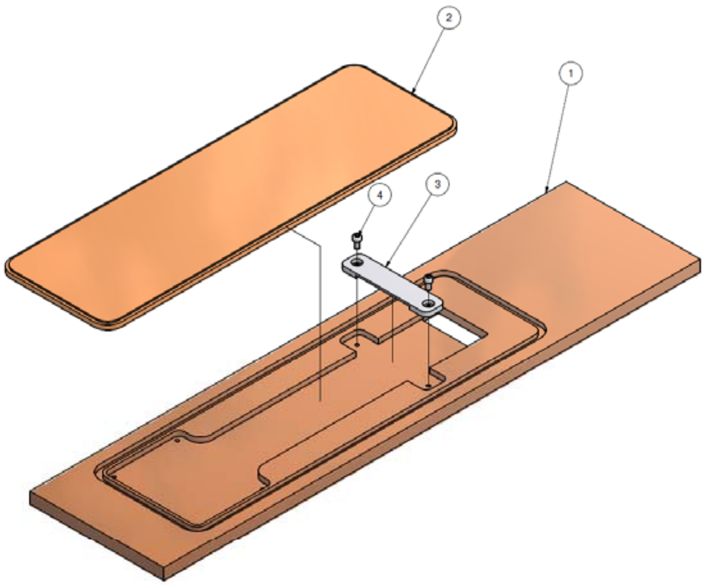
Final Electric Checking

→ Capacitance measurements
→ Resistive measurements
→ Hi-Potting

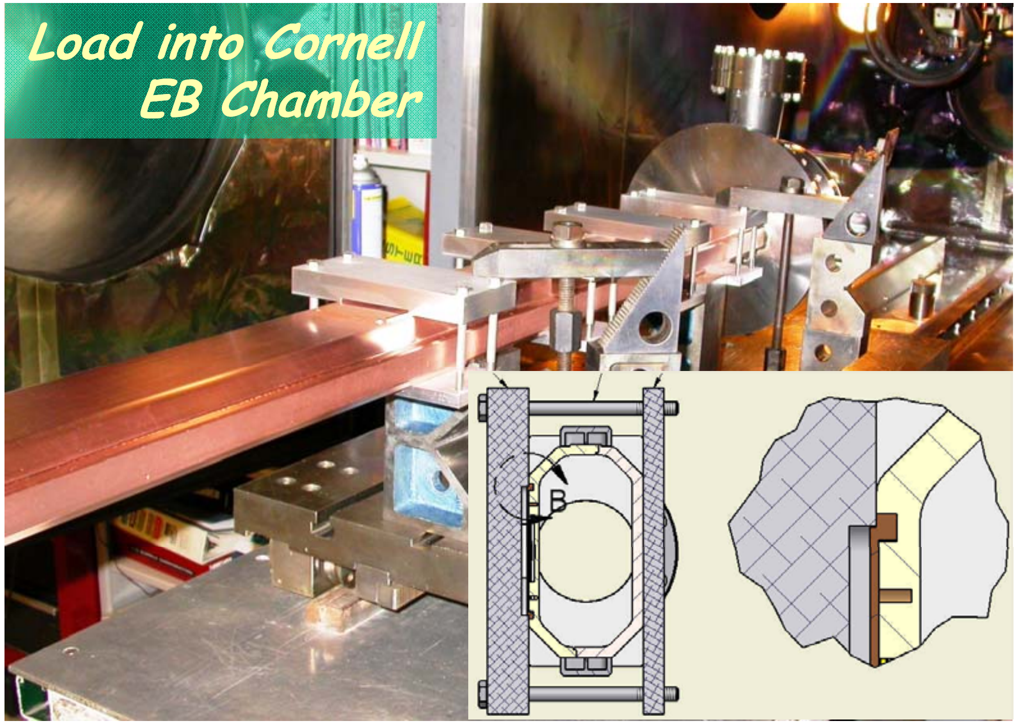


Leak checking before EB-Weld

RFA Vacuum Cover EB-Welding

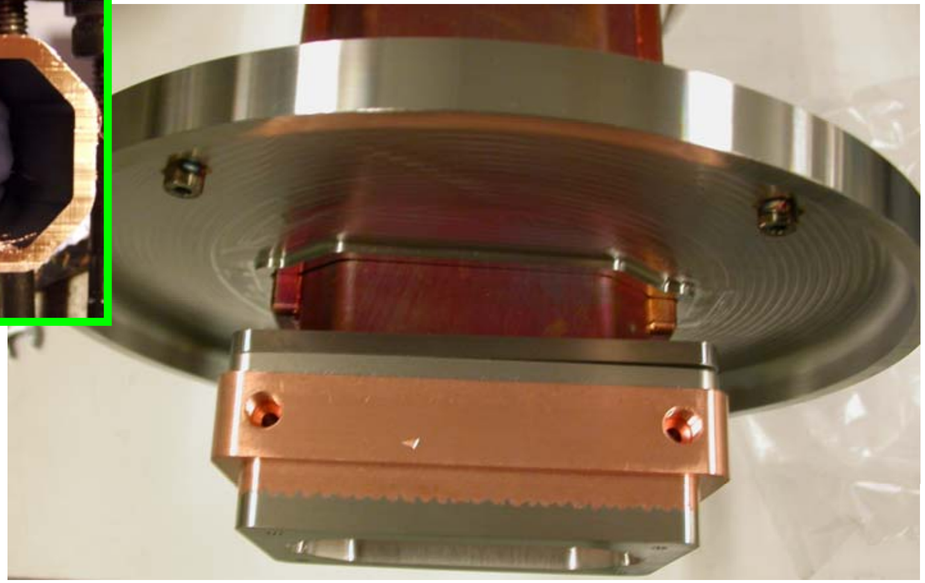


Test welds for E-beam parameters and temperature control



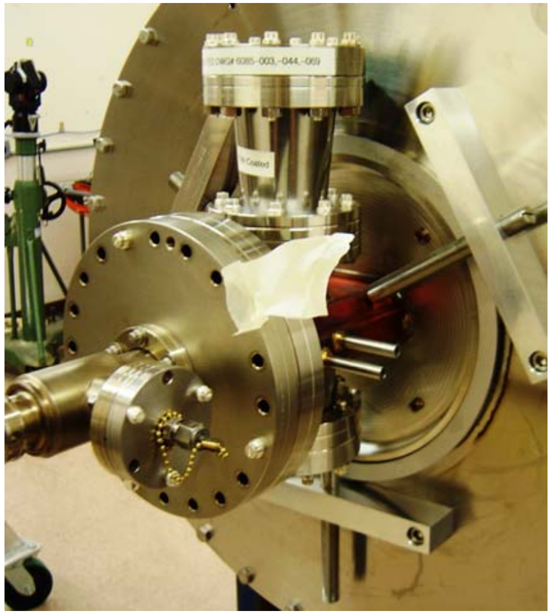
- *RFA vacuum cover thickness was increased at Cornell to increase safety factor*
- *EB-weld parameters: 35 mA (Sharp focusing ~0.5 mm beam spot) @ 30 IPM; 1-mm penetration*
- *T_{max} < 100°C during E-beam welding*

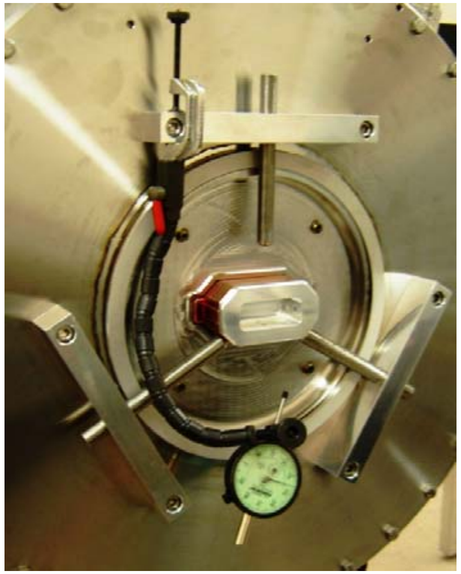
Final Trimming to Length



- After successful RFA vacuum cover EB-weld, both beampipes were leak checked and followed by 120°C/48hr bakeout to degas from the RFA components
- The beam pipes were then trimmed to their final length for insertion into the SCW magnets. Large flow of dry N_2 to keep pipe clean, and clean lint-free clothes were used to stop metal shavings
- Final parts dry-fit and adjustment before insertion into the SCWs

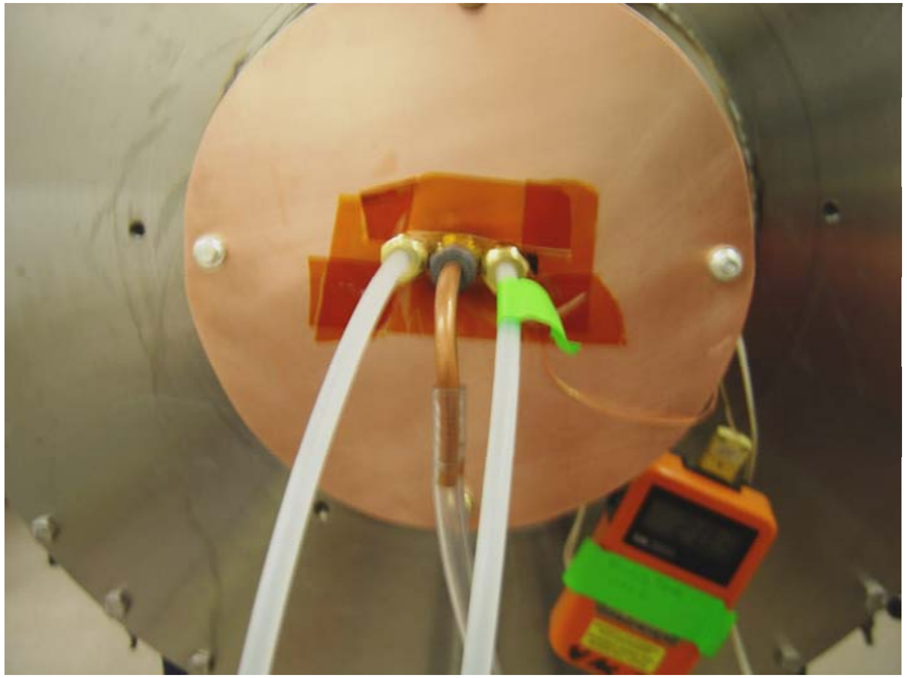
Beampipe Insertion and Survey

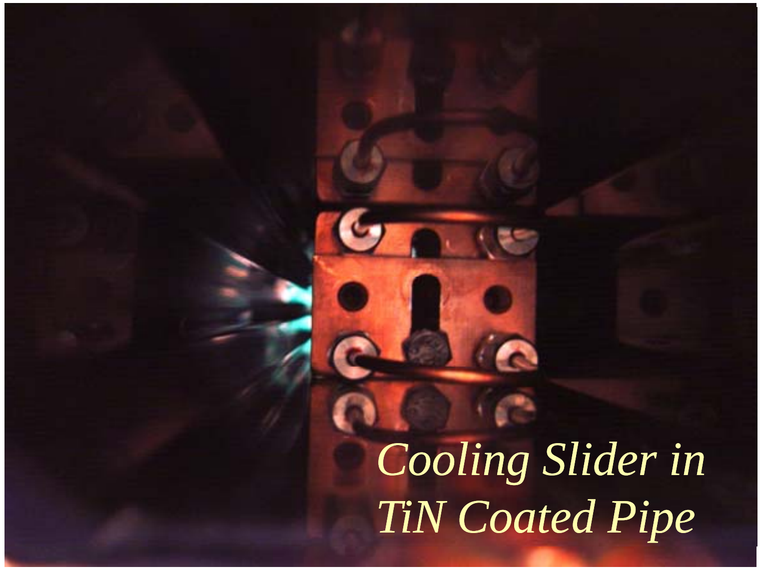




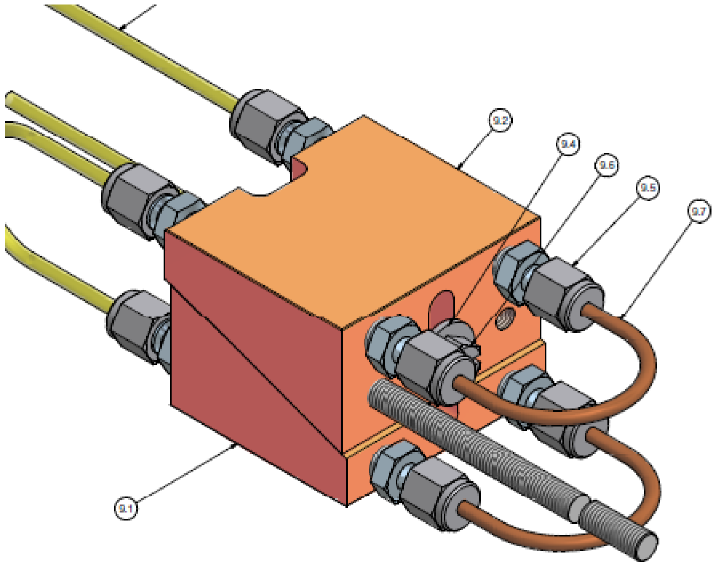
- *Trimmed beampipe was wrapped with super-insulation, and insert into the warm-bore of the wiggler magnet*
- *And the beam pipe was adjusted and locked at desired position w.r.t. the wiggler magnet by the survey screw*

Final Welding – Temperature Control

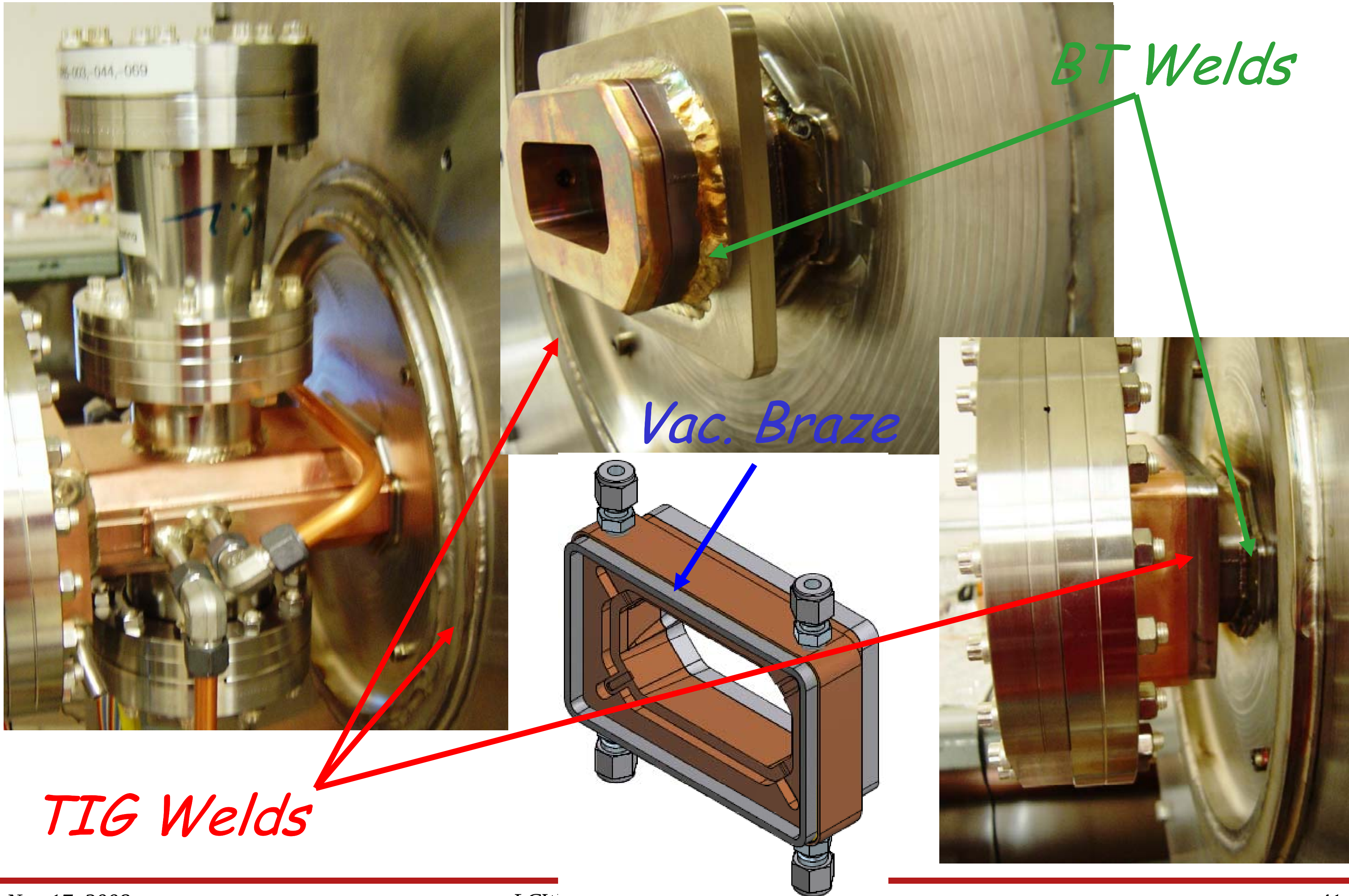




Heat control and N2 purge throughout many steps of welding

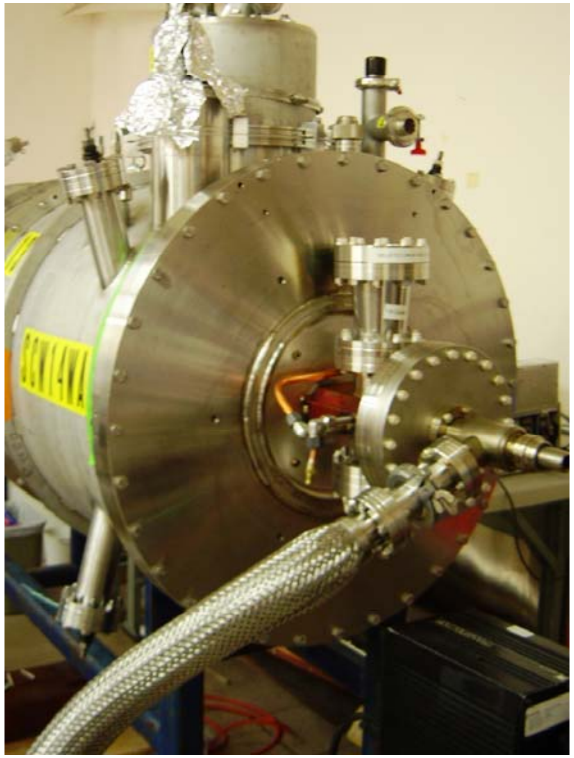


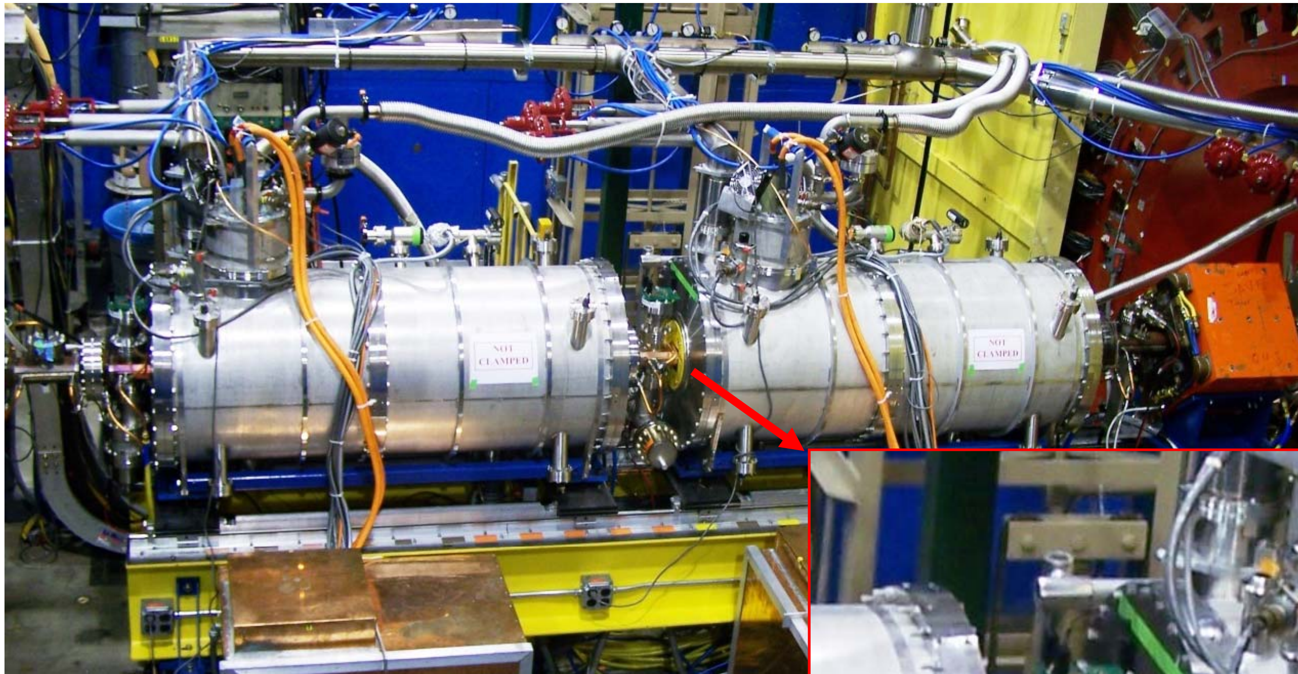
Cryo-Insulation & Beampipe Welding

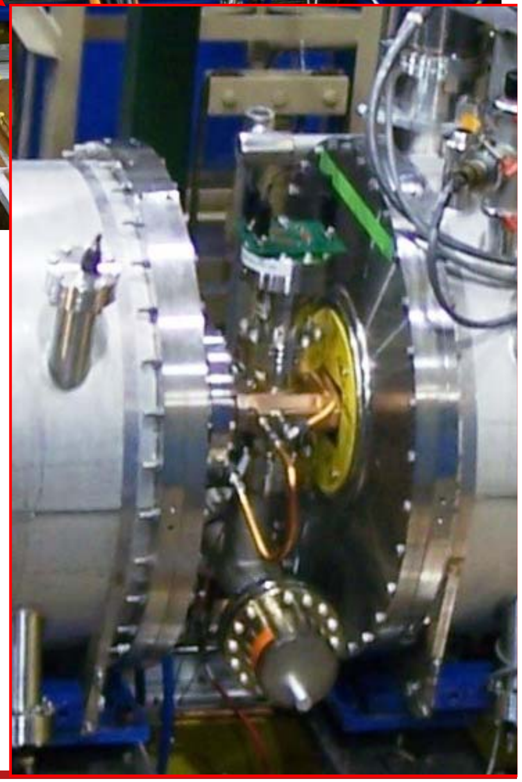


Finally Done

Final Leak checking and hot-water bake on 10/22



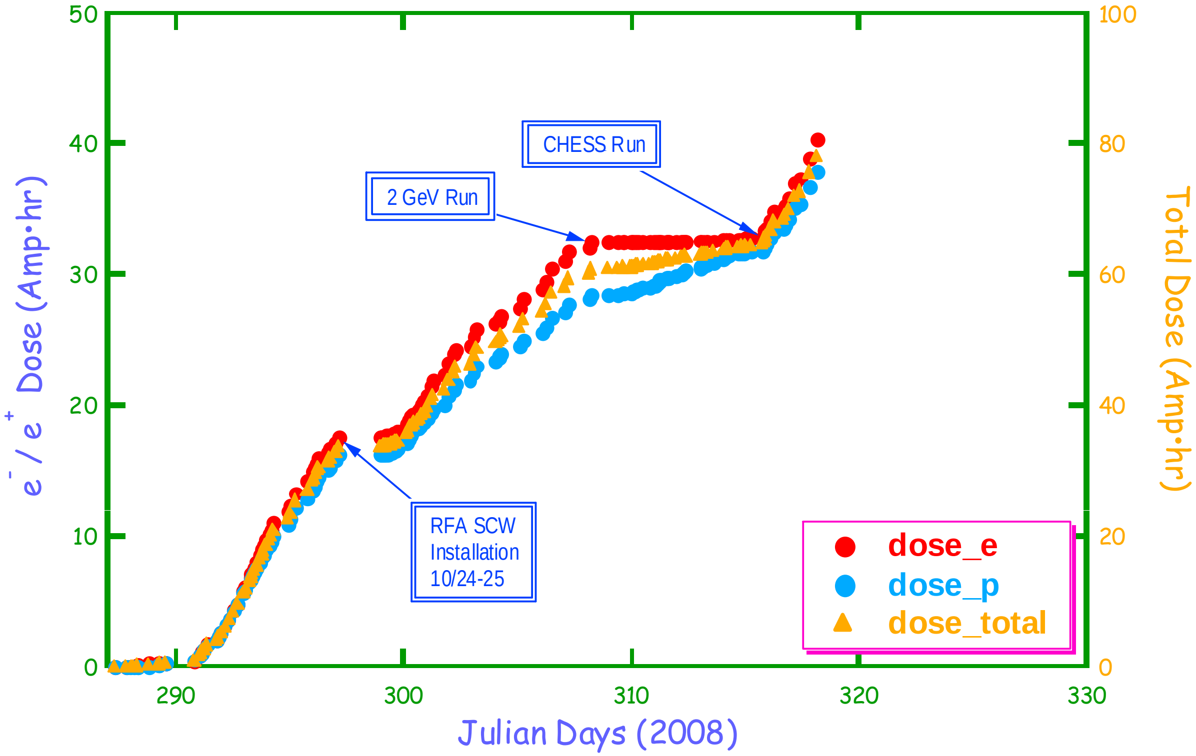


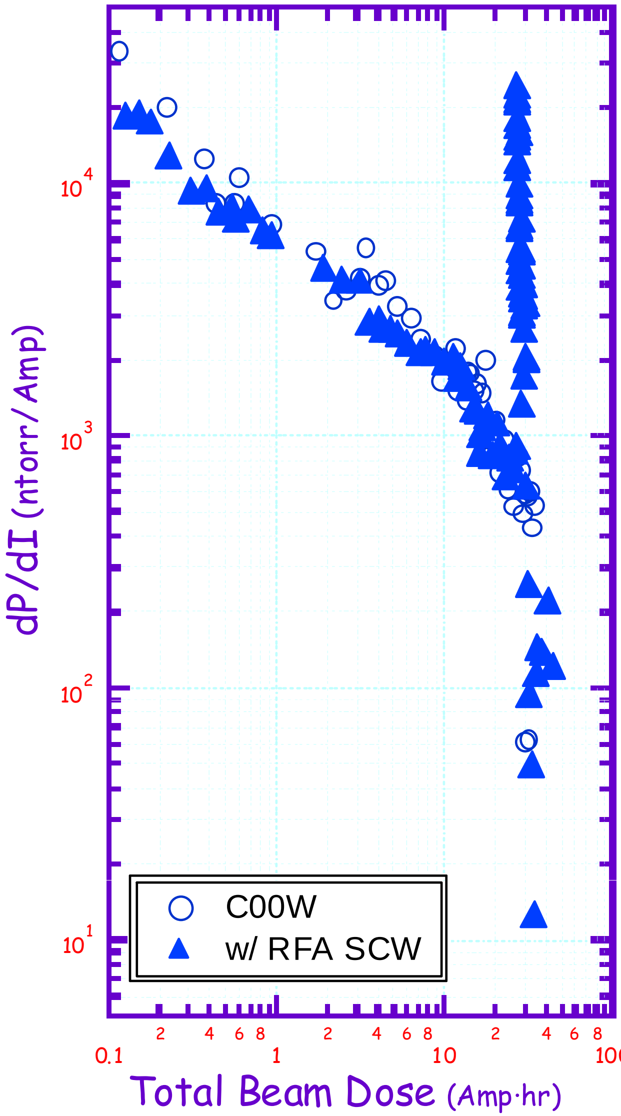


Swapped wigglers on 10/24

Both RFA wigglers were reached full field (@140 Amp) with only a few 'training'

Vacuum Performance in CESR





→ *Vacuum beam conditioning similar for the RFA wiggler chamber to the 'regular' wiggler chamber*

→ *All RFA devices are working*

- *Many thanks to the LBNL team for fabrication of two chambers, on schedule*
- *The project is also a results of dedicated work by a Cornell Team, including*

  → *Brian Clasby – All the welding (EB, TIG, BT)*
  → *M. Carrier – RFA Electric work*
  → *Eric Smith – Wiggler preparation, final assembling*
  → *J. Sikora, S. Greenward – RFA Assembling*
  → *Tobey Moore – Vacuum support, and last-minute modifications*
  → *Newman Machine Shop – Specially N. Alexander*
  → *And many other technical supports*