SNS LINAC
Beam Position Monitor Pickups
Final Design Review
March 12, 2002

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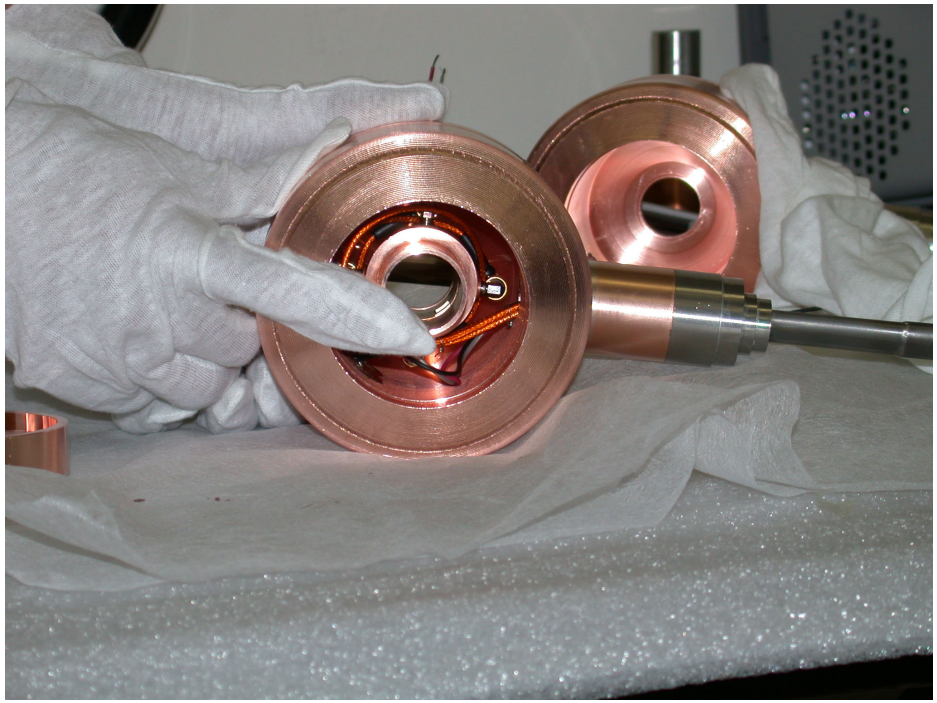
BPM Pickup Overview

- **4 Versions of BPMs: DTL, CCL, TR, & SCL.**
- **Same basic configuration, based on BNL RHIC design.**
- **Common Features include:**
  - One end is shorted.
  - 60 degree included electrode angle.
  - Electrode ID is right at the ID of the surrounding structure (beam pipe).
  - Electrical contact between electrode and feed through is due to spring force in the electrode (except the DTL BPM).

Prototype CCL BPM with Feed thru removed.

DTL BPM

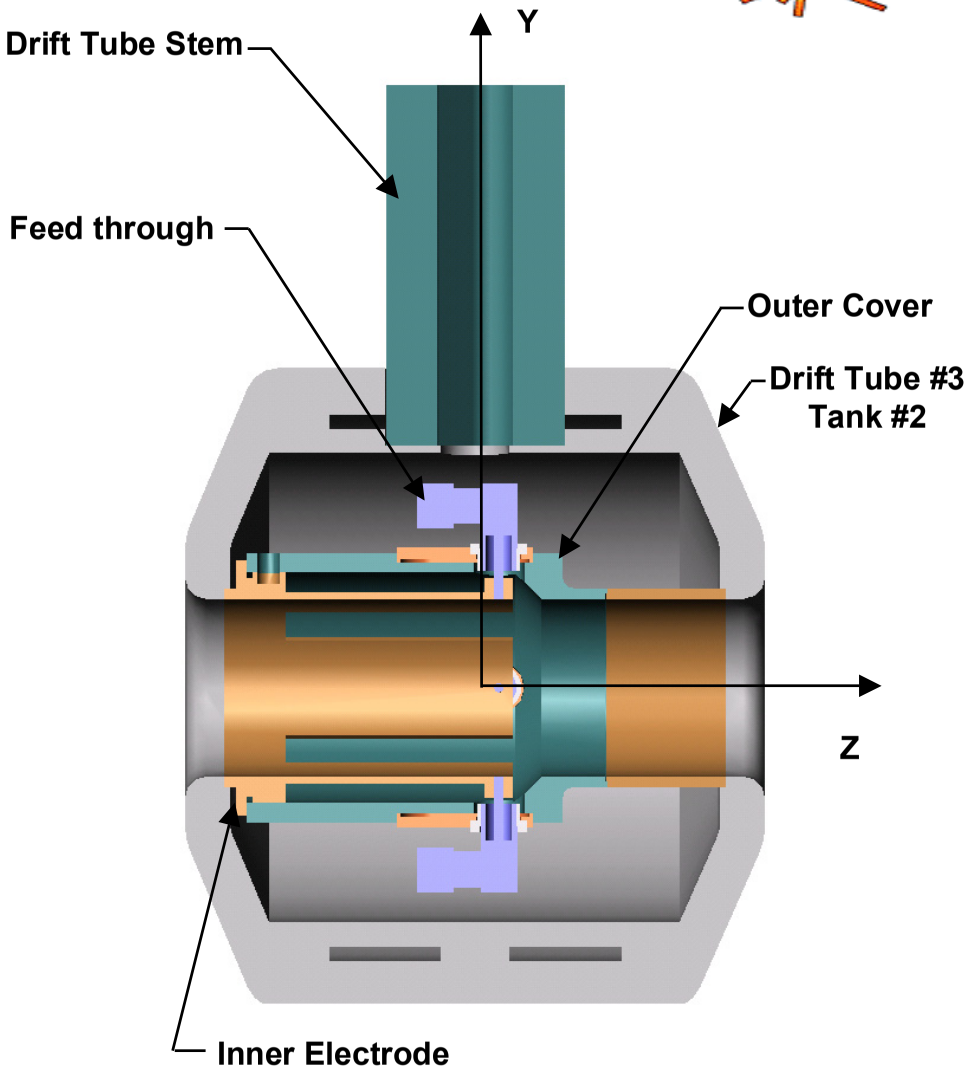
- 10 pickups required.
- 2 each in tanks #s 2, 3, 4, 5 and 6.
- BPM is built into the drift tube.
- Bore is 0.984 inches (25 mm).
- In order to meet tank #3 delivery schedule, two additional units were fabricated along with a prototype.
- A mini FDR was held for this design. Our response to the committee suggestions was included in the review information.



DTL BPM being installed in Drift Tube.

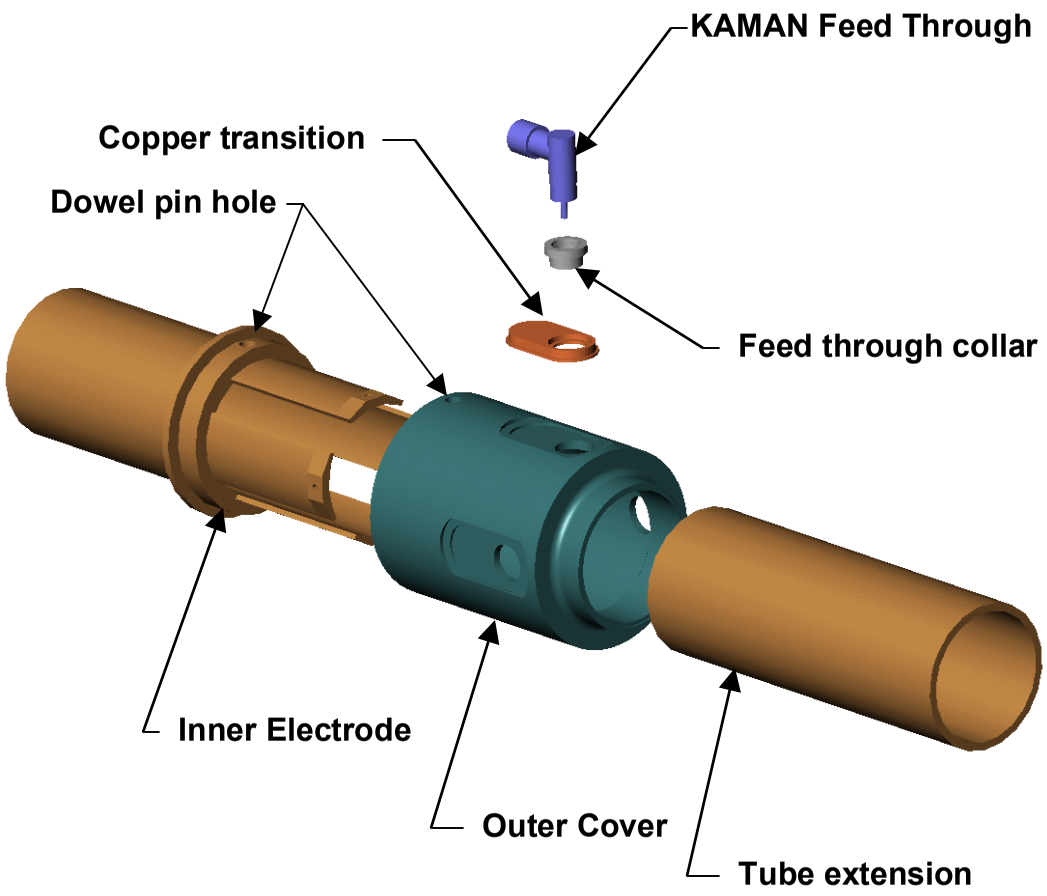
DTL BPM Design

- Beam line instrument consists of outer cover and inner electrode parts.
- Inner part has four, 60° included angle, strip-line electrodes, shorted at one end.
- Electrodes flush with drift tube ID.
- Signals from electrodes are taken through the outer cover via the feed through.
- Coaxial cable threads onto the feed through and is fed out through the center of the drift tube stem.
- SMA vacuum feed through is used to provide vacuum seal (Al_2O_3 strengthened boro-silicate seal).



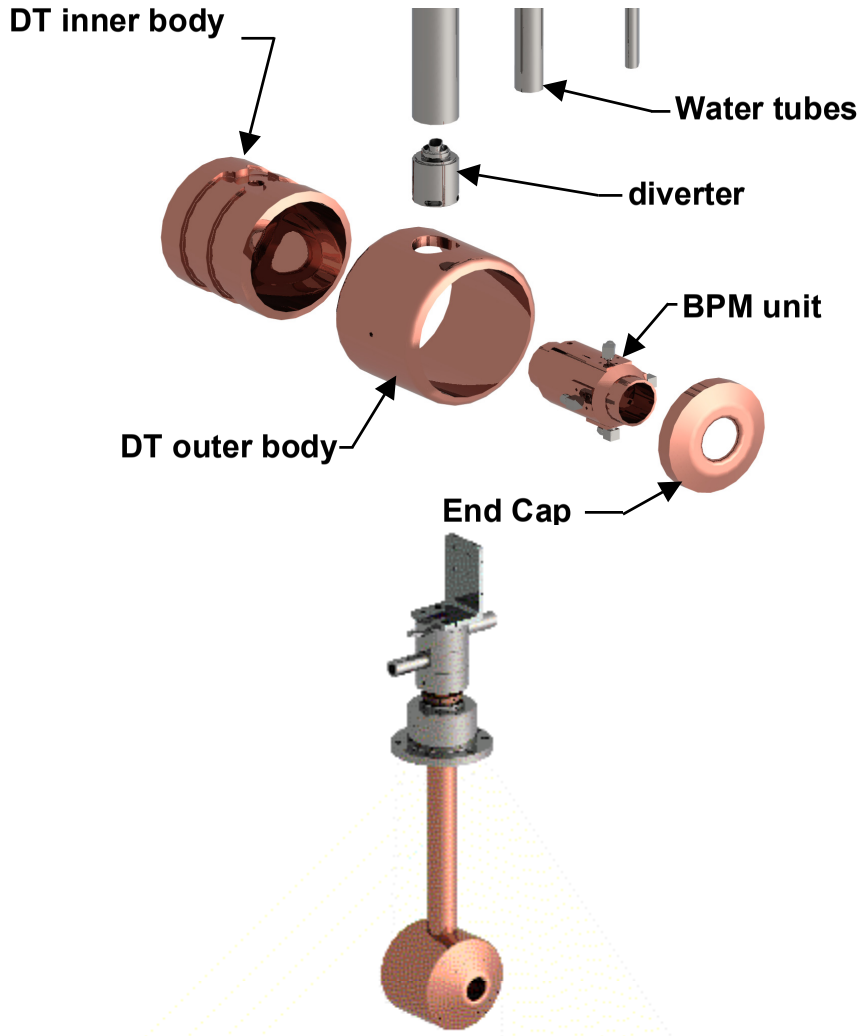
DTL BPM Fabrication

- BPM outer cover and inner electrode parts are brazed together. A dowel pin is used to correctly clock the two parts.
- Stainless collars are brazed to copper transition pieces.
- Feed through is e-beam welded to that combined ss collar and Cu transition.
- Feed though sub-assembly is welded into BPM cover.
- Electrical contact is ensured by e-beam welding feed through center pin to electrode (Cu-Cu).
- Tube extension is welded last, this allows access for e-beam of feed through center pin.



DTL BPM Installation in Drift Tube

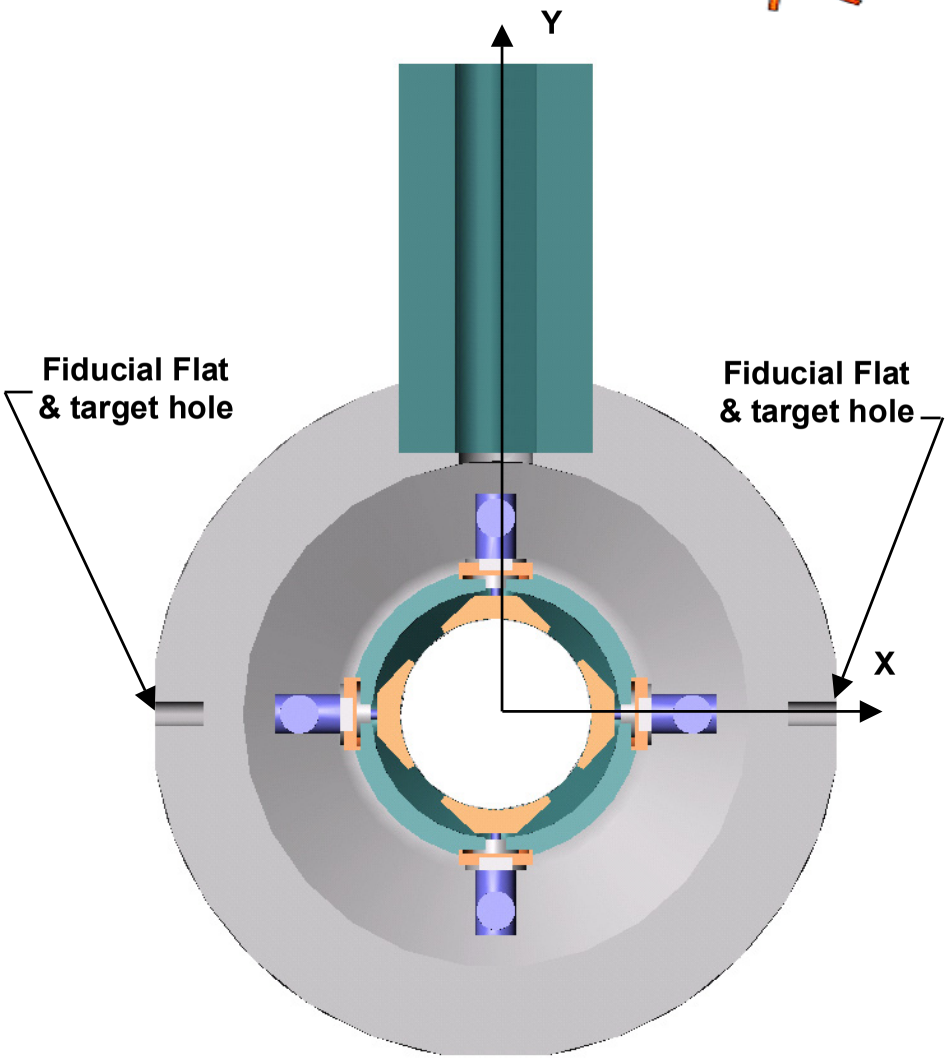
- BPM unit will be delivered to Drift Tube fabricator for installation in DT.
- Signal cables will be threaded through the center of the Drift Tube stem and connected to feed throughs.
- Thread lock will be used on the SMA connections.
- It will be necessary to leave one end of the cable un-terminated so that it will fit through the stem.
- Cable will be labeled and checked by LANL personnel prior to final welding on of the end caps.
- Once the cable is in place it's end will be terminated.
- Cables will need to be secured while drift tube undergoes final machining of the faces.



Drift Tube with water manifold and strain relief

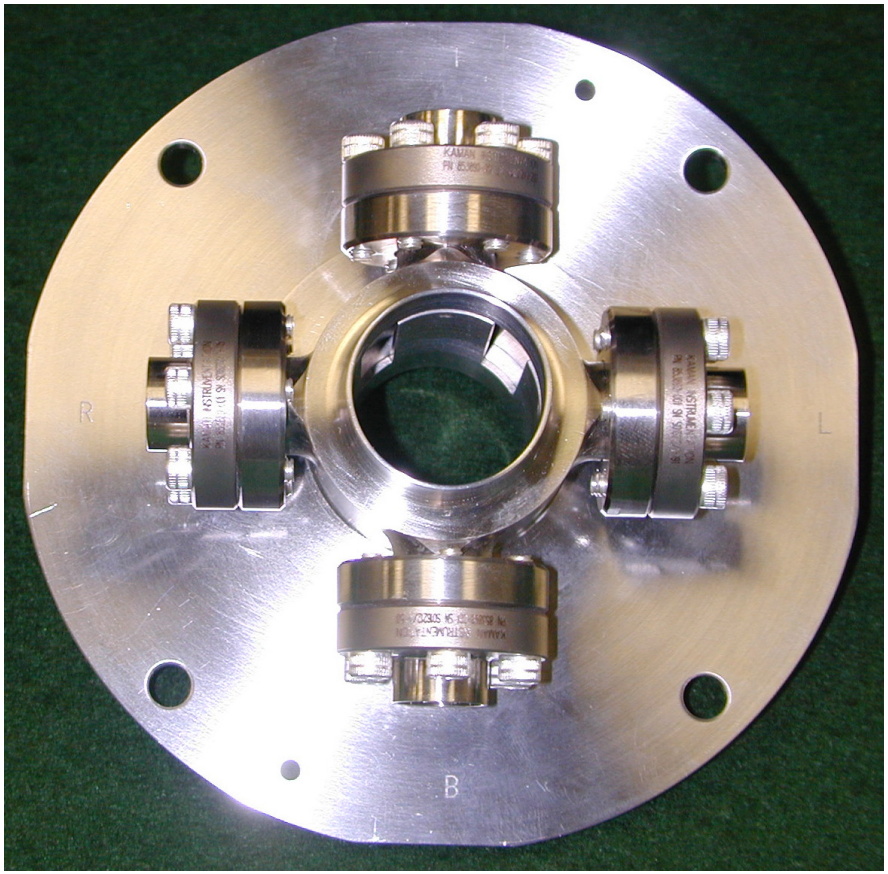
DTL BPM Alignment

- The drift tube/BPM assembly will be mapped (taut wire measurement) with reference to the fiducial features in the laboratory.
- Alignment of the drift tube/BPM assembly will be accomplished by using the two fiducial holes in the side of the drift tube.
- It will be necessary to insure the BPM is clocked in the drift tube so that the fiducial holes line up with the horizontal electrodes.
- There will be a pin in the drift tube end cap and a groove in the BPM body, so that as the two parts go together roll will be controlled.



CCL BPM Design

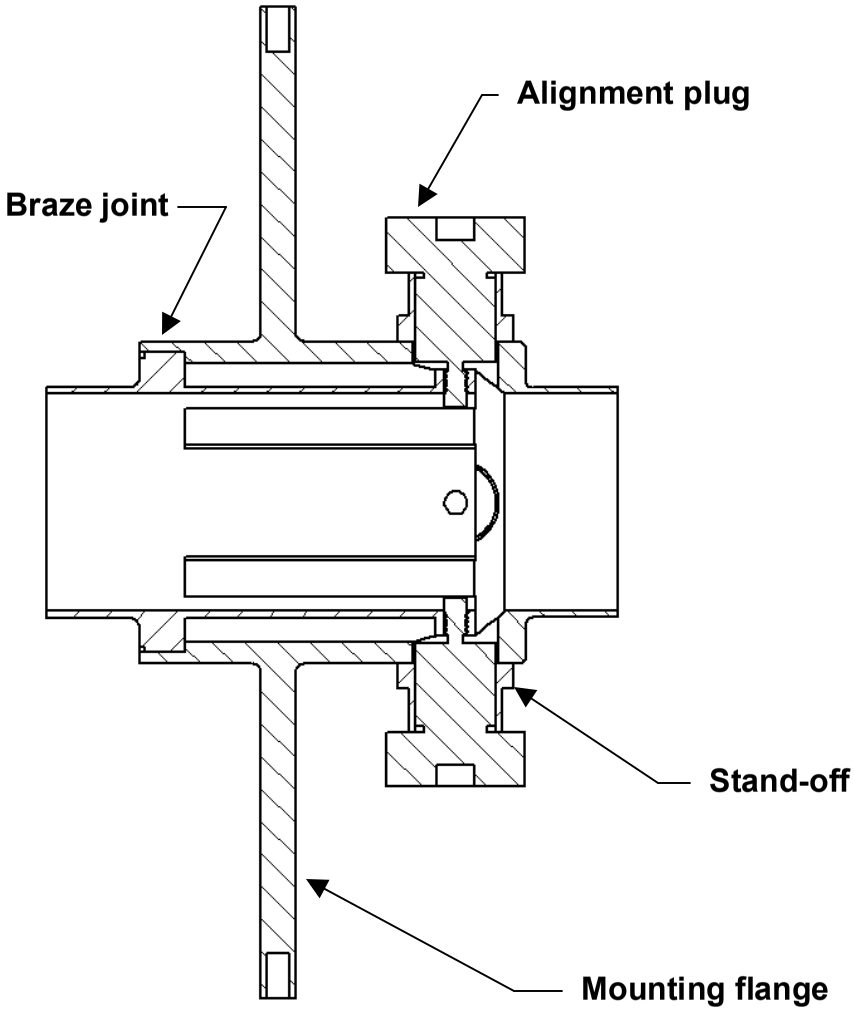
- 11 required.
- Beam line instrument consists of outer cover and inner electrode parts.
- 30 mm diameter bore (1.181”). Mates to 1.25” OD by .035” wall beam tube.
- Inner part has four, 60° included angle, strip-line electrodes, shorted at one end.
- SMA vacuum feed through built into 1.33” conflat flange is used to provide vacuum seal (Al_2O_3 strengthened boro-silicate seal).
- Contact between electrode and feed through center pin is due to spring force in electrode.
- All stainless steel construction.



Prototype CCL BPM.

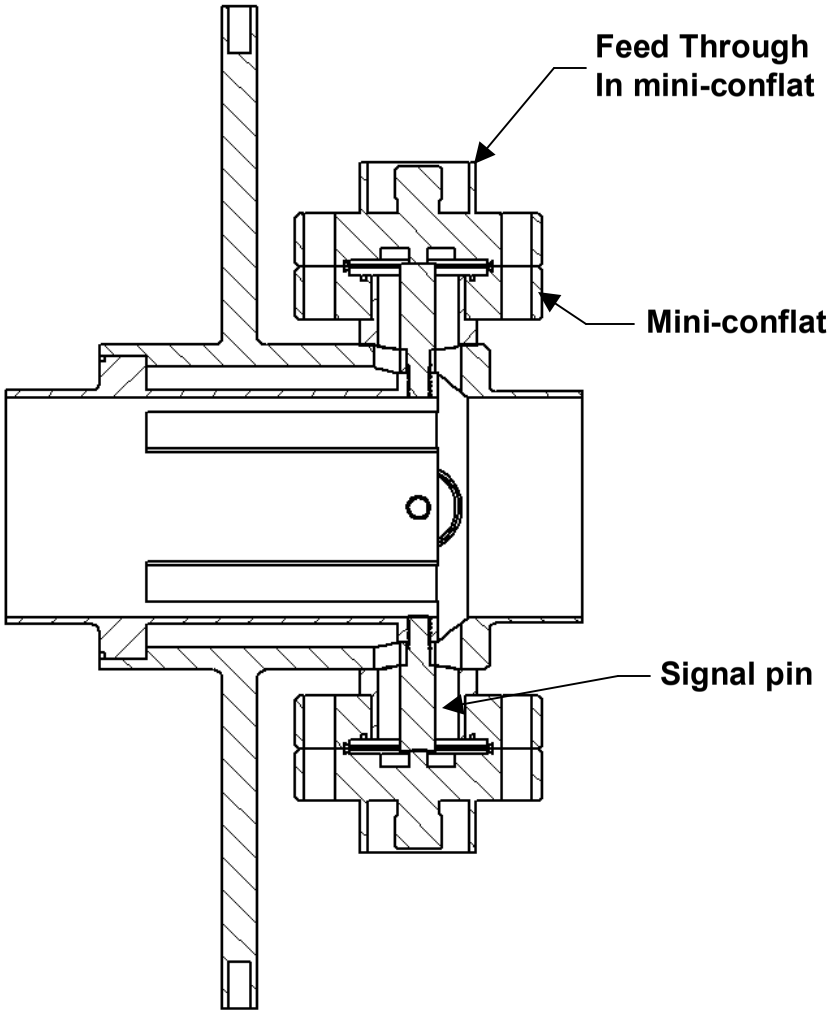
CCL BPM Fabrication Plan

- Fabrication plan as described in the CCL BPM drawings.
- Initial step is to fabricate all the piece parts to specifications.
- Assemble the inner electrode part and the outer cover part.
- Utilize the fixture plugs to align the parts and to locate the stand-offs.
- Weld the stand-offs in place.
- Use the fixture plugs to deflect the electrodes outward by the prescribed amount.
- Braze the electrode to the cover.
- The Braze temperature is high enough to re-anneal the stainless and the electrodes now have a permanent deflection.



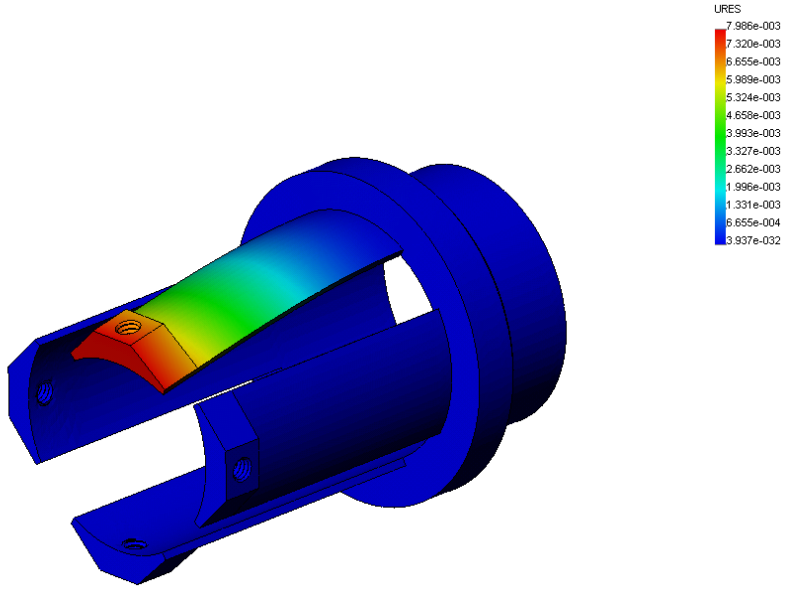
CCL BPM Fabrication Plan

- Weld on the mini-conflat.
- Install the signal pin.
- Set the min-conflat with the feed through installed in it on the signal pin and check the position of the electrode.
- Machine the length of the signal pin such that the electrode is positioned within specification.
- Specification is that the electrode edge is within –0.000 to +0.003 of the bore.
- Bolt up the conflat pairs.



CCL BPM Electrode Deflection

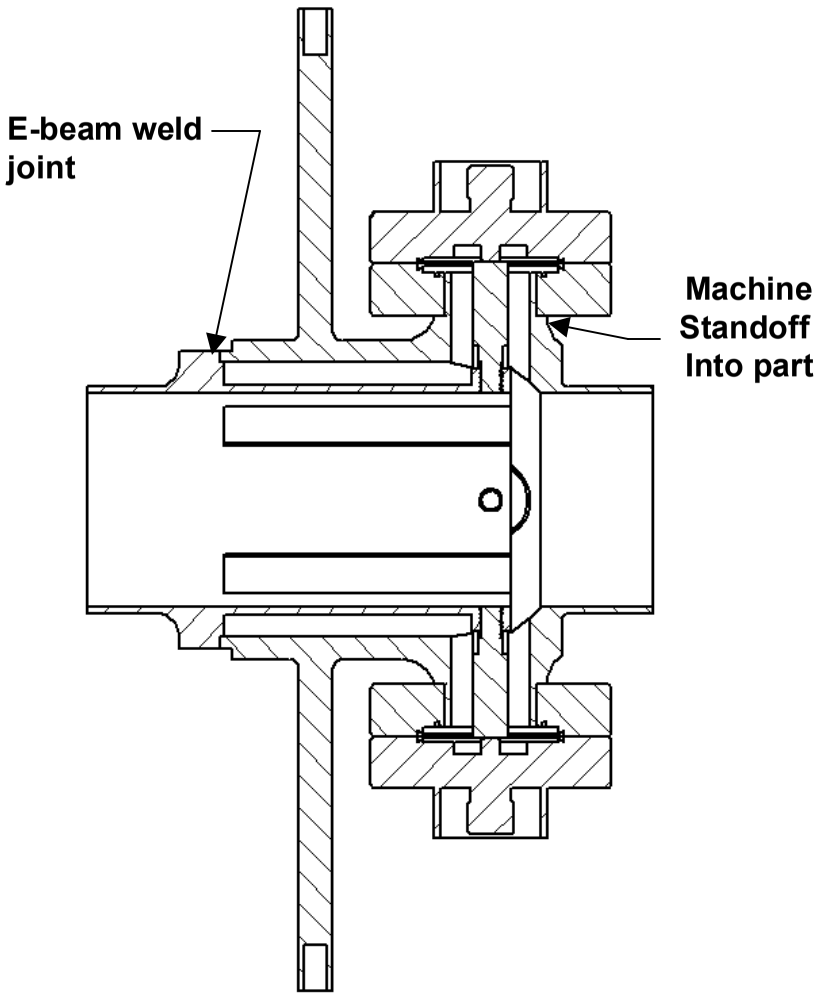
- A finite element model was used to determine the specific distance the electrode is deflected during annealing.
- Too much deflection and the electrode will yield and too little deflection and the contact force is reduced.
- For the CCL BPM an 0.008" deflection was specified. This produces approximately 3 pounds of contact force between the electrode and feed through center pin.
- The 0.008" deflection causes approximately 17,000 psi of stress in the electrode.



0.008" deflection of CCL BPM due to a 3 lbf load

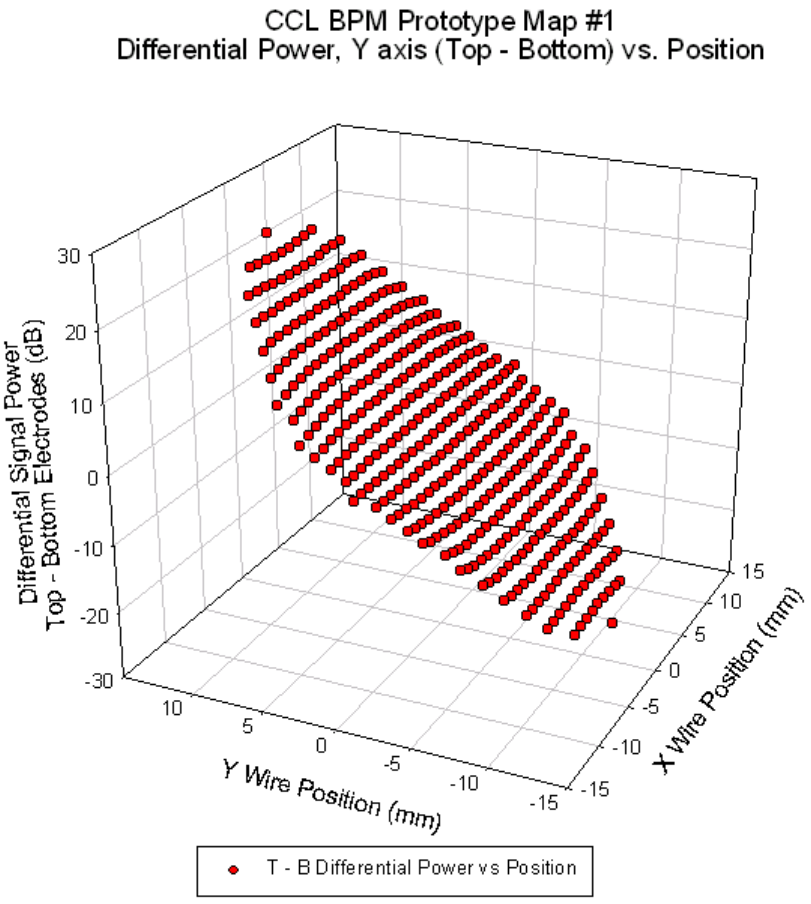
CCL BPM Vendor Fabrication Modifications

- **Bid packages went out to 5 different vendors. Each was asked to provide a manufacturing plan.**
- **The successful bidder had three modifications to the design plan:**
  - Machine the standoffs into the cover.
  - Eliminate the brazing operation and electron beam weld the joint between the electrode and the cover.
  - Anneal the electrode part separately
- **Machining the standoff into the cover improved the standoffs positional accuracy and eliminated an outside weld joint.**
- **E-beam welding the cover/electrode joint caused a concern about the ability to keep the two parts within dimensional specification.**
- **Vendor was confident they could make the weld work. With adequate inspections (pre/post weld), award was made for a CCL and SCL prototypes.**



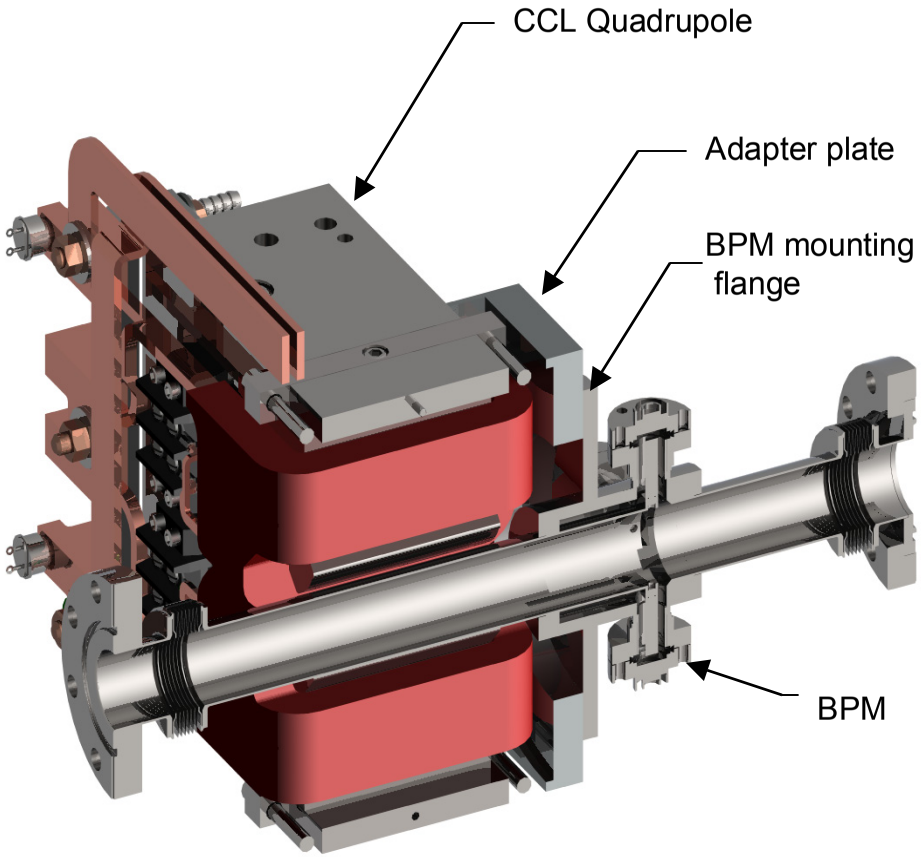
CCL BPM Prototype Results

- **Pre and post weld inspections at the vendor were passed.**
- **An additional inspection was done locally at an independent shop.**
  - Both ends of the bore were concentric to within 0.001”.
  - Some unexpected deformation of the electrode fingers. Their radius of curvature near the base had increased.
  - Measured electrode end location showed 3 of the four fingers were out of spec by a maximum of 0.003”.
- **The BPM was mapped with the following results:**
  - T-B sensitivity = 1.776 dB/mm
  - T-B offset = 0.09 dB (0.05 mm)
  - L-R sensitivity = 1.776 dB/mm
  - L-R offset = -0.197 dB (-0.11 mm)
- **Predicted sensitivity was 1.87 dB/mm.**



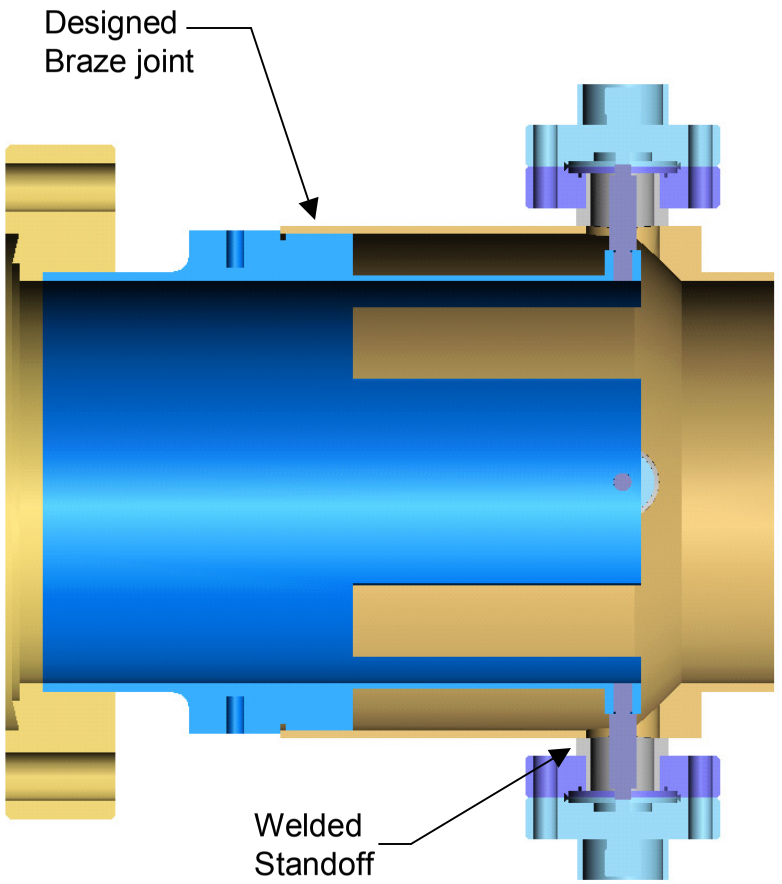
CCL BPM Installation & Alignment

- The CCL BPM will be rigidly attached to a quadrupole magnet.
- Up and downstream beam tube will be welded to BPM.
- The quadrupole magnet will have an adjustable kinematic mount.
- An adapter plate will be used to mount the BPM to the magnet.
- One side of the adapter plate will be pinned to the magnet face and the other side of the adapter plate will be pinned to the BPM mounting flange.
- Survey target holes are provided as alignment fiducials.
- Place the BPM within 1 mm and measure accurately (within 0.1 mm) where it is located.



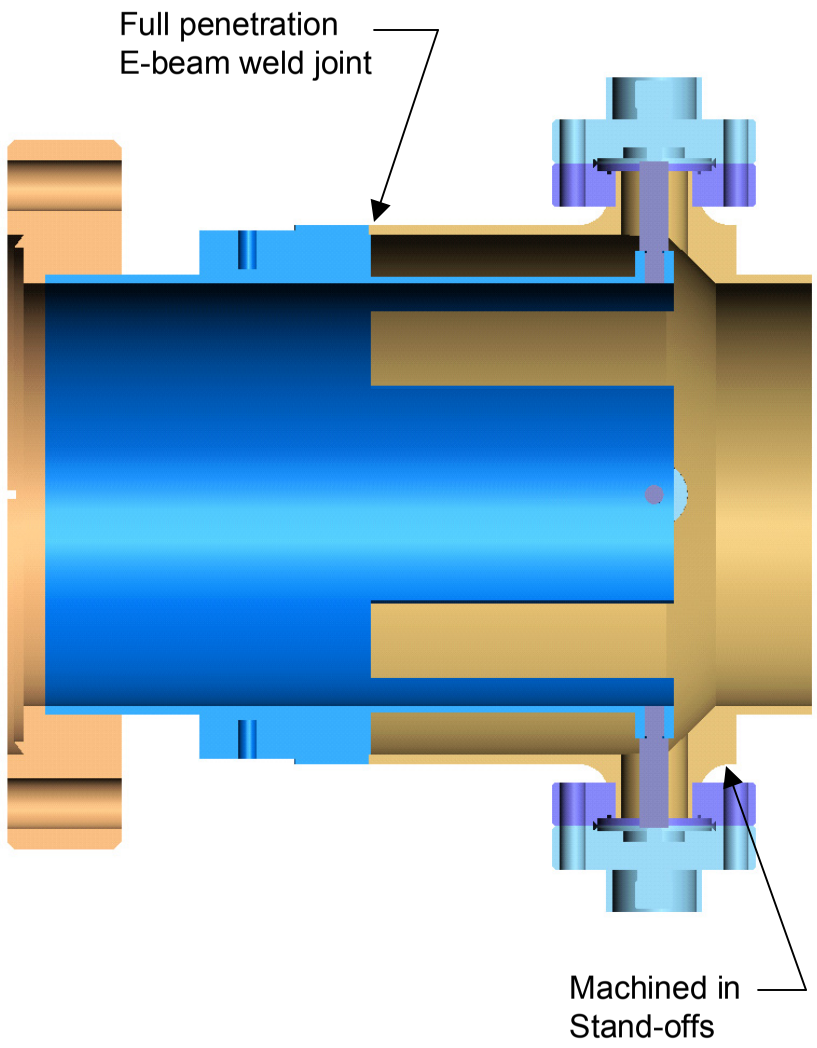
SCL BPM Design

- 32 required, located in the warm regions of the Superconducting LINAC.
- Based on BNL RHIC design.
- Beam line instrument consists of outer cover and inner electrode parts.
- 70 mm diameter bore (2.756”). Mates to 2.875” diameter by .065” wall beam tube (2.745” ID tube).
- Inner part has four, 60° included angle, strip-line electrodes, shorted at one end.
- SMA vacuum feed through built into 1.33” conflat flange is used to provide vacuum seal (Al_2O_3 strengthened boro-silicate seal).
- Contact between electrode and feed through center pin is due to spring force in electrode.
- All stainless steel construction.



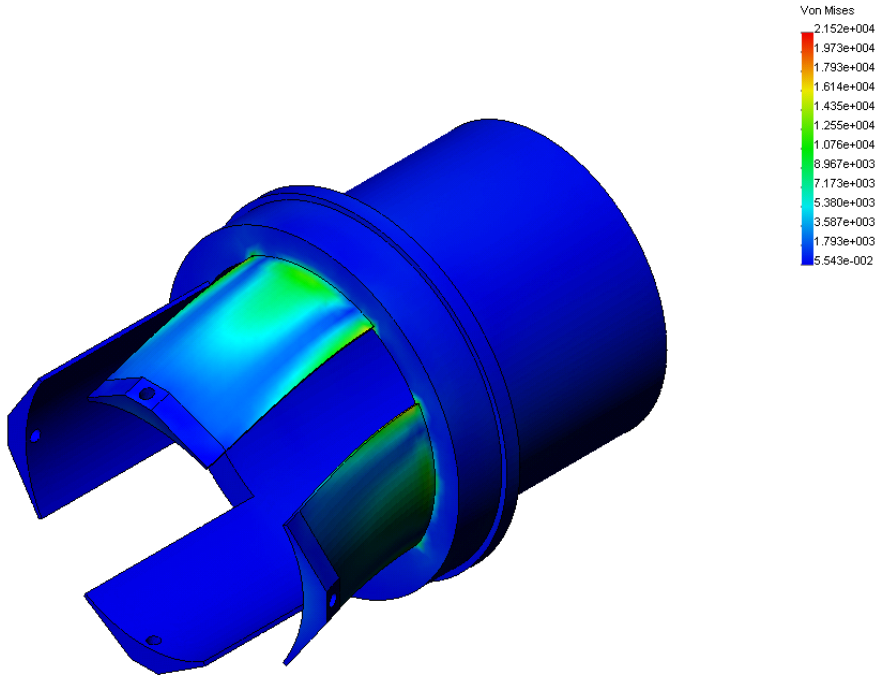
SCL BPM Fabrication

- **Fabrication Plan is essentially the same as for the CCL. The only differences are the dimensions of the parts.**
  - Fabricate piece parts.
  - Assemble cover, electrode, stand-off using fixture plug.
  - Weld stand-offs to cover.
  - Braze cover to electrode at the same time deflecting electrodes.
  - Weld on min-conflat.
  - Install pins and feed throughs.
  - Weld on 4-5/8” conflat.
- **The vendor recommended the same modifications to this design.**
  - Machine stand-offs into cover.
  - Anneal electrodes while deflecting them.
  - Electron beam weld cover to electrode.



SCL BPM Electrode Deflection

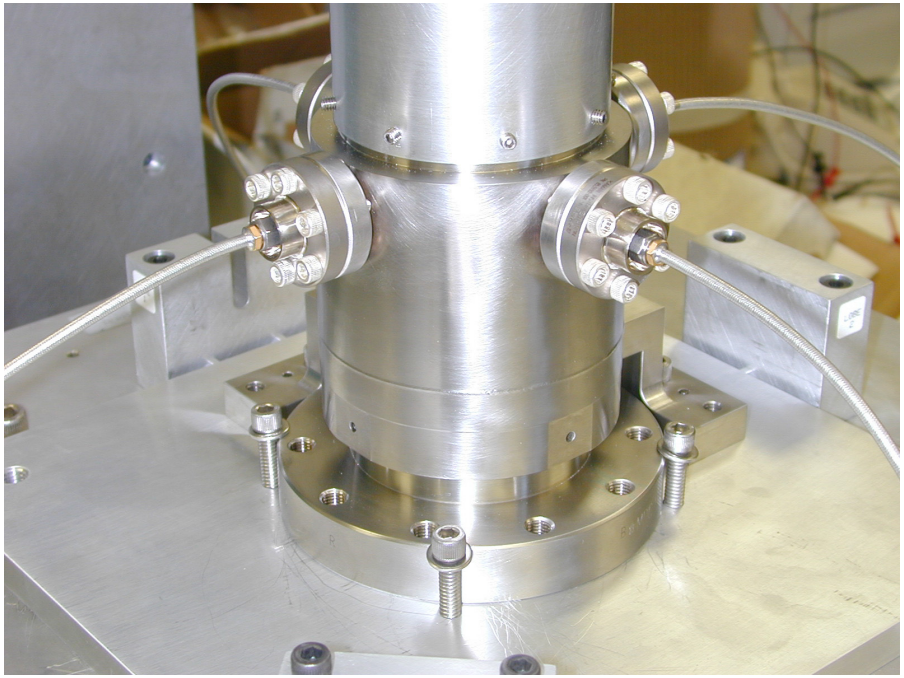
- **For the SCL BPM an 0.008” deflection was specified. This produces approximately 13 pounds of contact force between the electrode and feed through center pin.**
- **The 0.008” deflection causes approximately 21,520 psi of stress in the electrode.**
- **Yield stress for the annealed stainless is 30,000 psi.**



21,520 psi stress when electrode is deflected .008 inches

SCL BPM Prototype Results

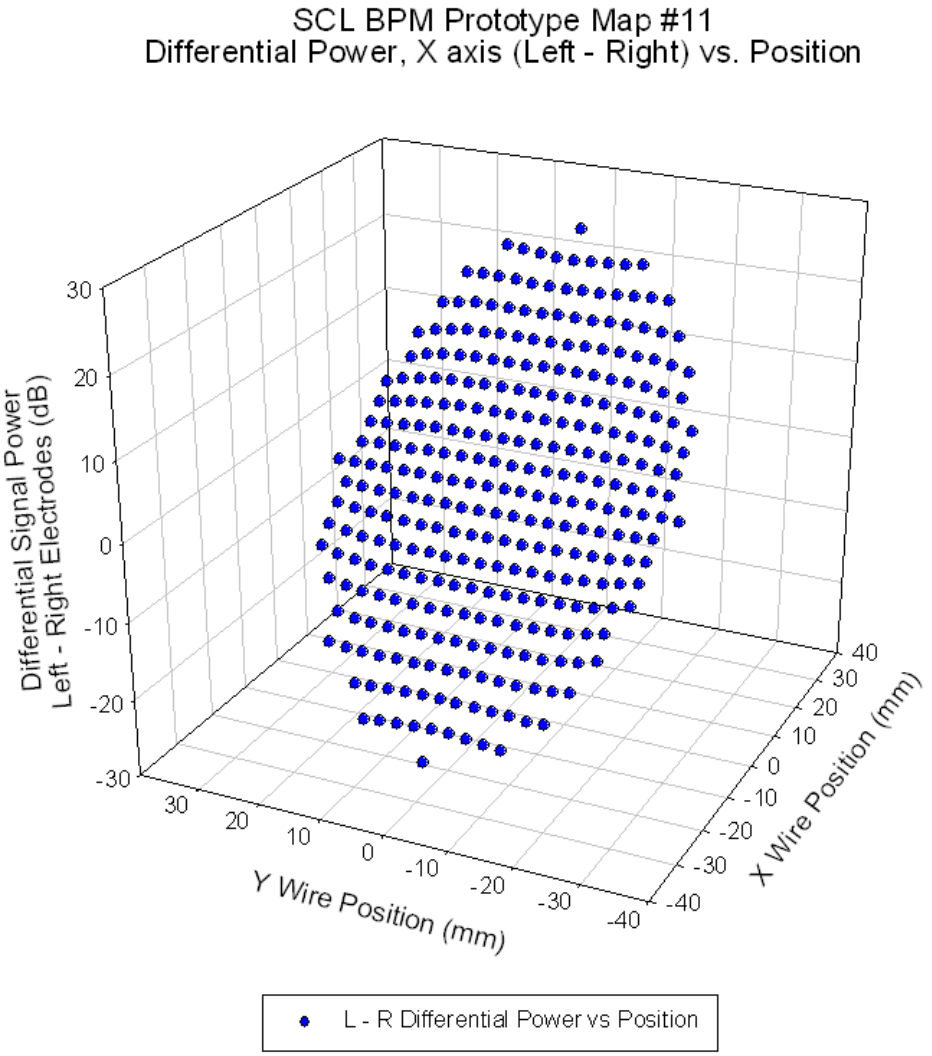
- **Pre and post weld inspections at the vendor were passed, parts were within specifications.**
- **Have yet to do an independent dimensional inspection.**
- **The prototype was shipped to TJNL for inspection.**
- **TJNL made a recommendation to vent the signal pins.**



SCL BPM in mapping fixture

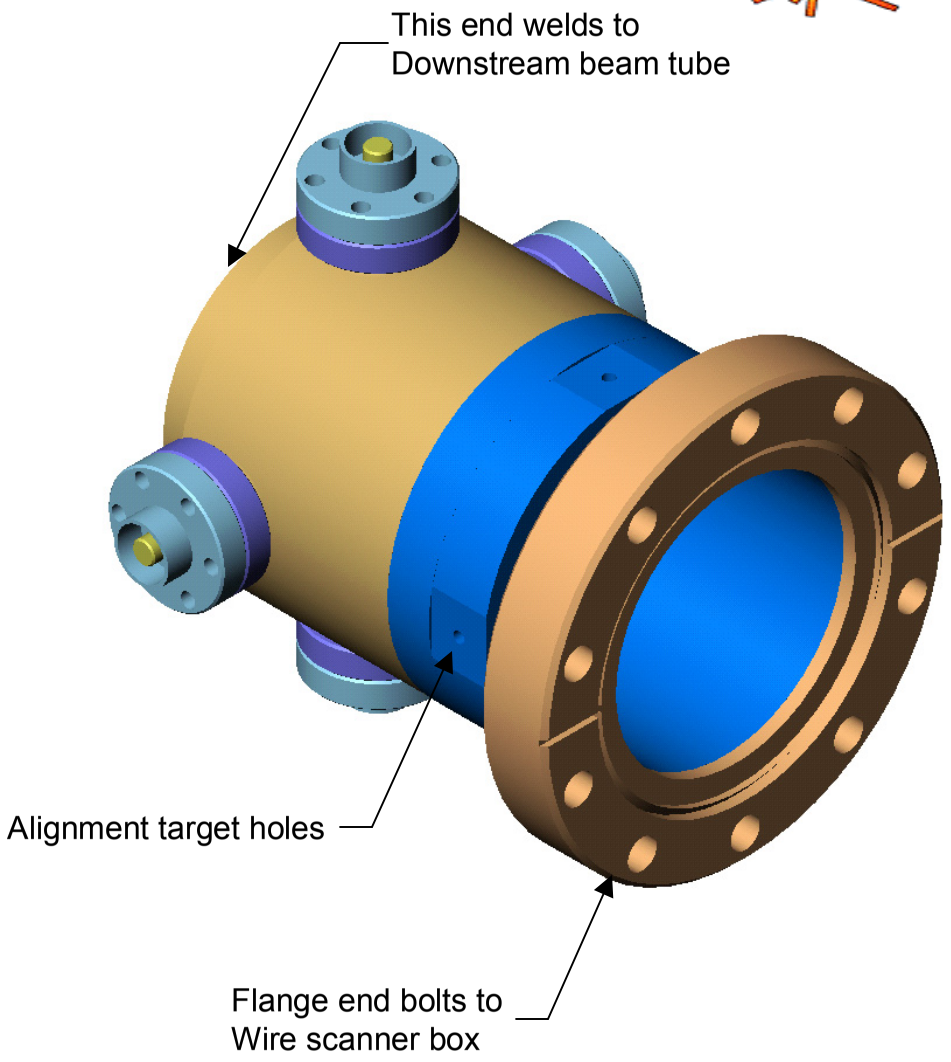
SCL BPM Prototype Results

- **The BPM was mapped with the following results:**
  - T-B sensitivity = 0.804 dB/mm
  - T-B offset = 0.367 dB (0.46 mm)
  - L-R sensitivity = 0.804 dB/mm
  - L-R offset = -0.144 dB (-0.18 mm)
- **Predicted sensitivity was 0.79 dB/mm.**



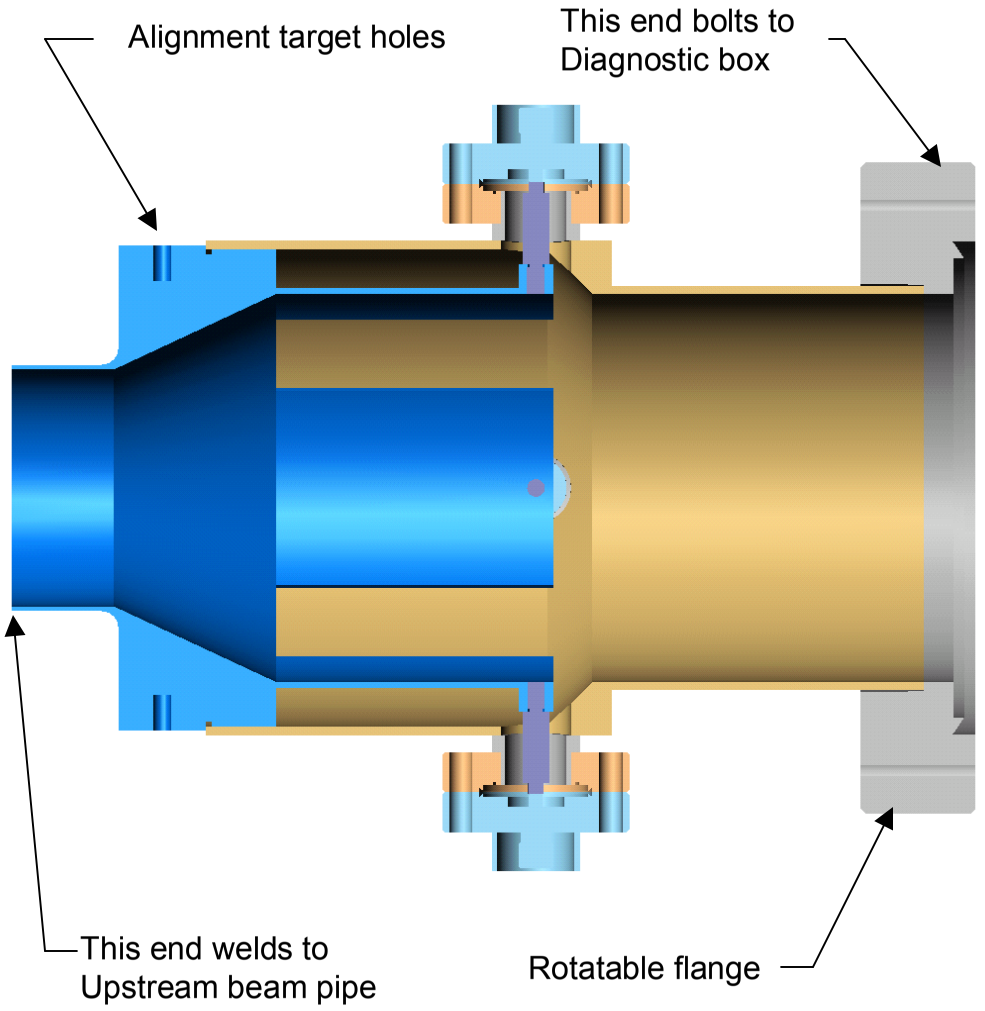
SCL BPM Installation & Alignment

- **SCL BPM was designed to be bolted to the SCL wire scanner box, which was to be alignable.**
- **Beam tube was to be welded to the opposite end.**
- **Alignment of the BPM is based on the four fiducial target holes provided.**
- **Place the BPM within 1 mm and measure accurately (within 0.1 mm) where it is located.**



Transition Region BPM Design

- 1 Required in the region between the end of the CCL and the start of theSCL.
- TR BPM is essentially an SCL BPM (70 mm diameter bore (2.756")). that has been modified to mate to a 1.75" OD beam tube (.035" wall, 1.680 ID).
- Did not prototype this BPM. There is only one needed and it was very similar to SCL BPM.
- Alignment issues are the same as for the SCL BPM.



Summary

- **DTL BPMs**
  - Order was placed to fabricate the remaining 8 BPMs.
  - 2 units to be delivered at the end of April.
  - Remaining 6 delivery is end of June.
  - Cost $30,000 for fabrication and $32,000 for feed throughs.
- **CCL BPMs**
  - Contingent upon acceptance of prototypes.
  - 11 CCL BPMs to be delivered 5 weeks ARO.
  - Cost $10,725 for fabrication and $13,948 for feed throughs.
- **SCL BPMs**
  - Contingent upon acceptance of prototypes.
  - 32 SCL BPMs to be delivered 5 weeks ARO.
  - Cost $28,064 for fabrication and $40,576 for feed throughs.
- **TR BPM**
  - 1 TR BPMs to be delivered 5 weeks ARO.
  - Cost $3,532 and $1,268 for feed throughs.