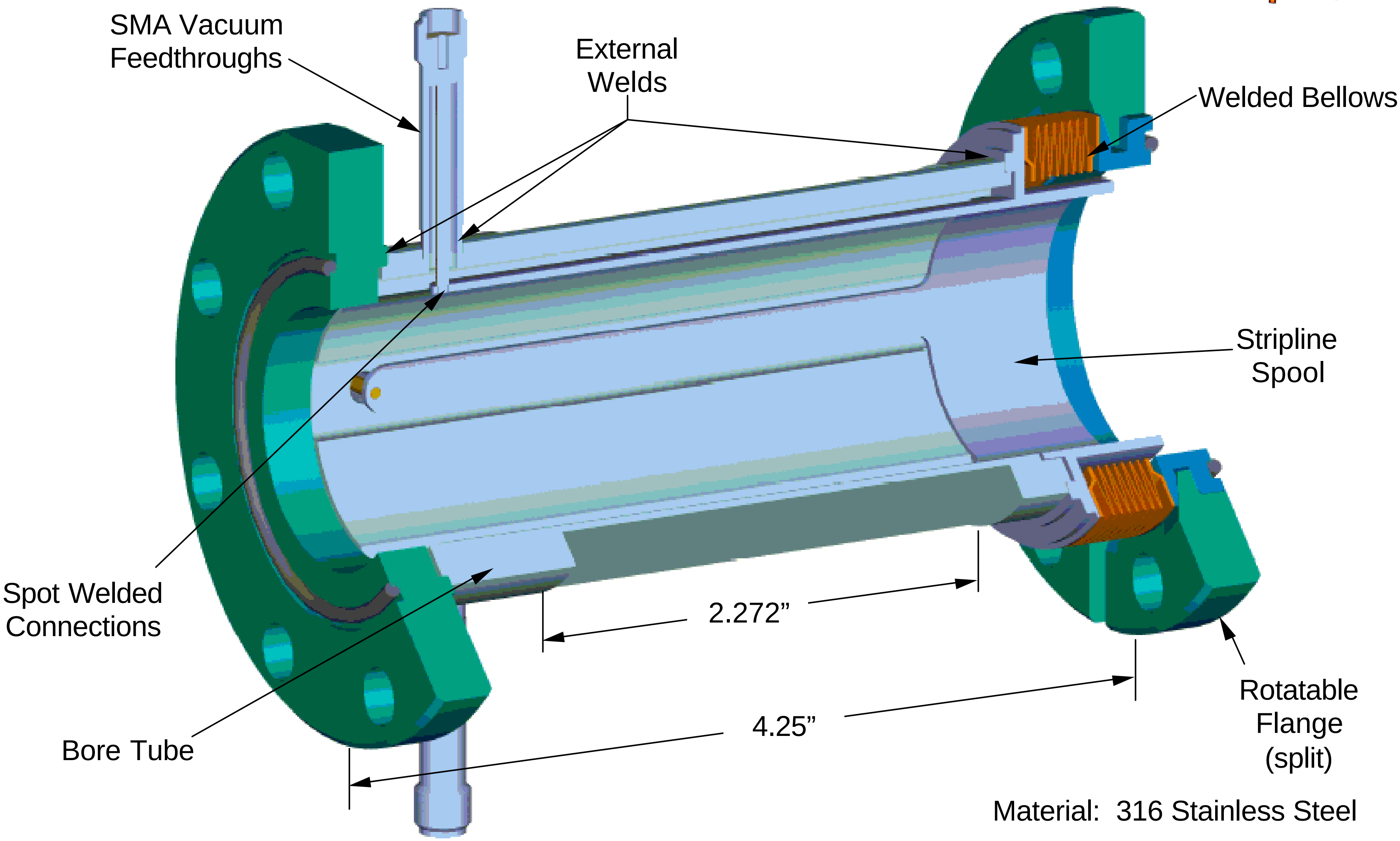
SNS Beam Position Monitor
Preliminary Design Review
February 27, 2001

Daryl Oshatz - LBNL

Peter Cameron - BNL

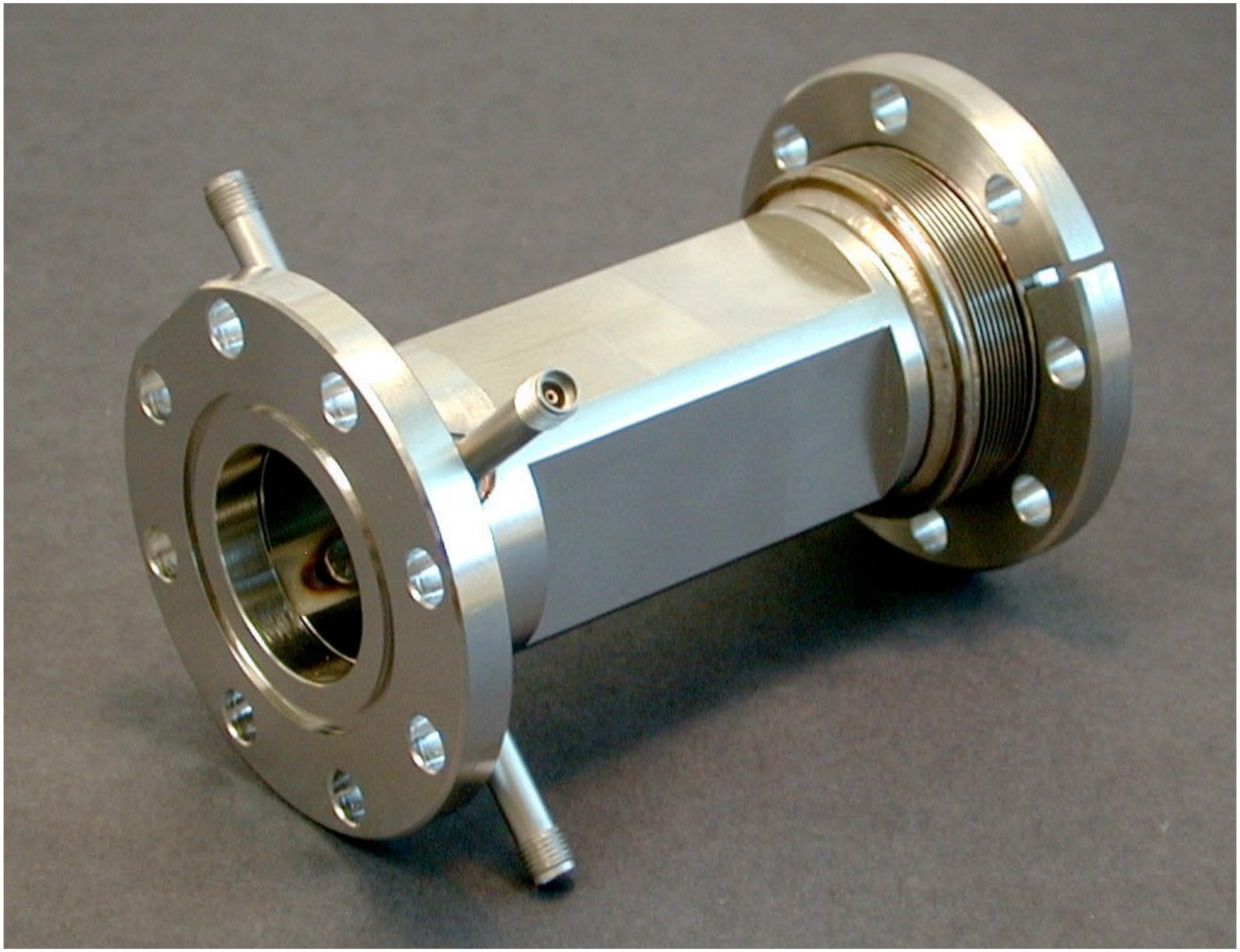
Jim O'Hara - LANL

MEBT Beam Position Monitor Overview



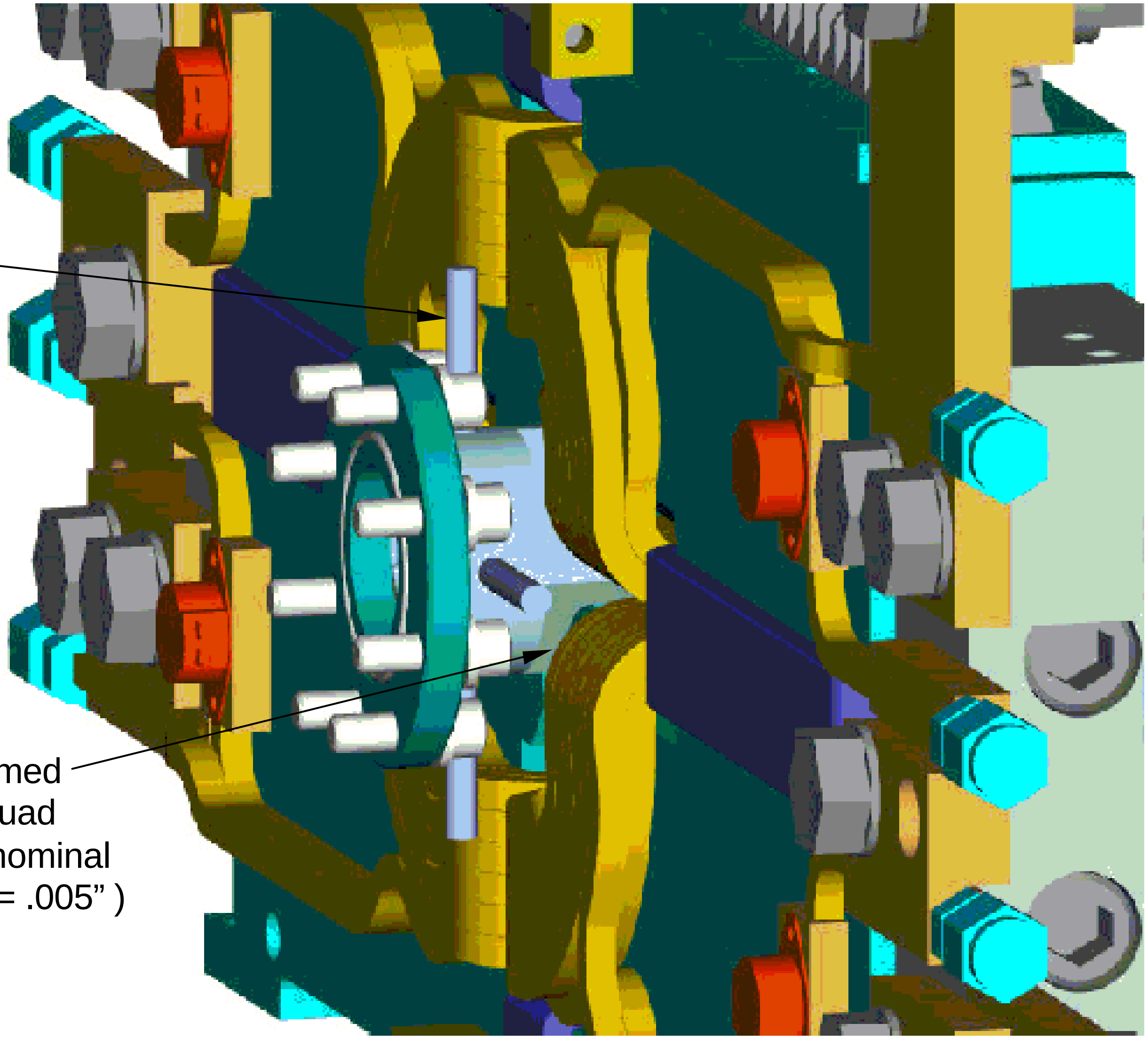
Material: 316 Stainless Steel

Completed MEBT BPM



MEBT BPM Interface with Quads

Adequate clearance is provided to connect to feedthroughs



BPM shimmed between quad pole tips (nominal clearance = .005")

MEBT BPM Welding of Stripline to Feedthrough

- **A spot welding procedure has been developed and completed on nine BPM's.**
- **Spot welding achieves a mechanical "shrink fit" of stainless steel around the Molybdenum TZM central conductor.**
- **Spot welding occurs prior to welding of the fixed end flange onto the bore tube.**
- **Of the 36 spot welds completed, none have broken during mechanical testing and normal handling.**

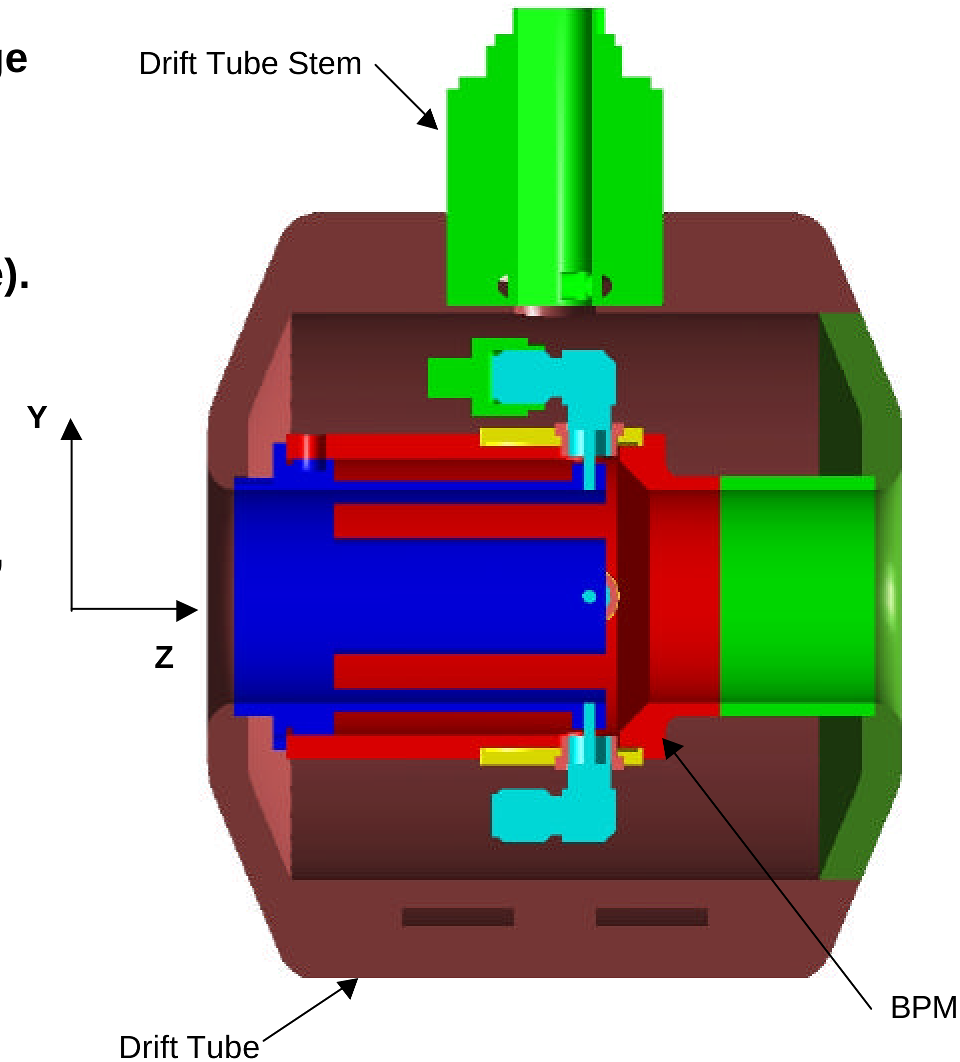
Related Documentation: LBNL Eng. Note M7857A, FES Technical Notes FE-EE-012, FE-ME-042

MEBT BPM Fabrication Status

- Eight BPM's were completed and found to have vacuum leaks in the SMA feedthrough ceramic seals. The leaks were repaired on all BPM's.
- Welded connections in the assembly were redesigned to minimize heating during welding.
- Eight more assemblies are currently being fabricated.
- The first article of the new design has been successfully completed.
- The remaining BPM's will be completed by the end of April '01.
- Estimated cost per assembly = $12,000.

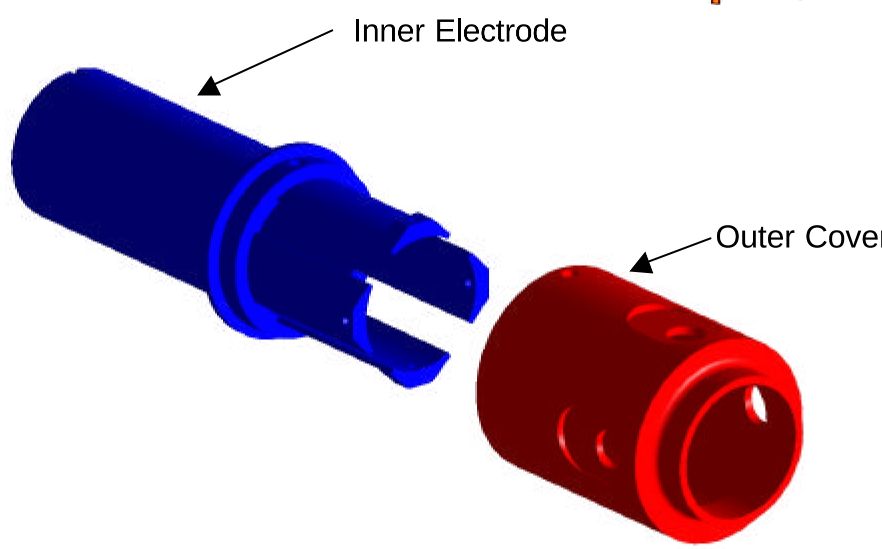
DTL Beam Position Monitor

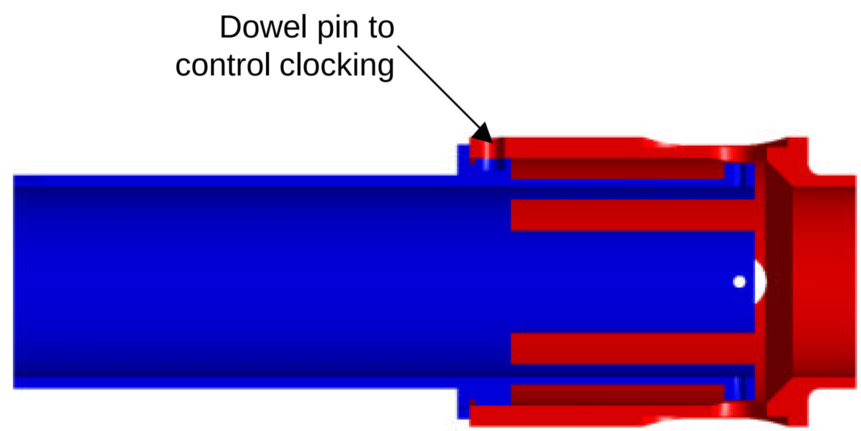
- 10 BPMs required, DT #3 and #6 of tanks 2 through 6. DT lengths change as the beam energy increases, the BPM design will not.
- The instrument is built into the drift tube, occupies DT bore (25 mm bore).
- Signal from electrodes is taken out through outer cover and drift tube stem.
- Inner electrode part has four, 60° included angle, strip-line electrodes, shorted at one end.
- Electrodes flush with drift tube ID.
- Geometry is optimized to form 50-W impedance transmission line.
- Vacuum joints are brazed or welded except for feed through.
- Internal feed through seal uses KAMAN Al_2O_3 strengthened boro-silicate seal.



DTL BPM Fabrication - Body Sub-Assembly

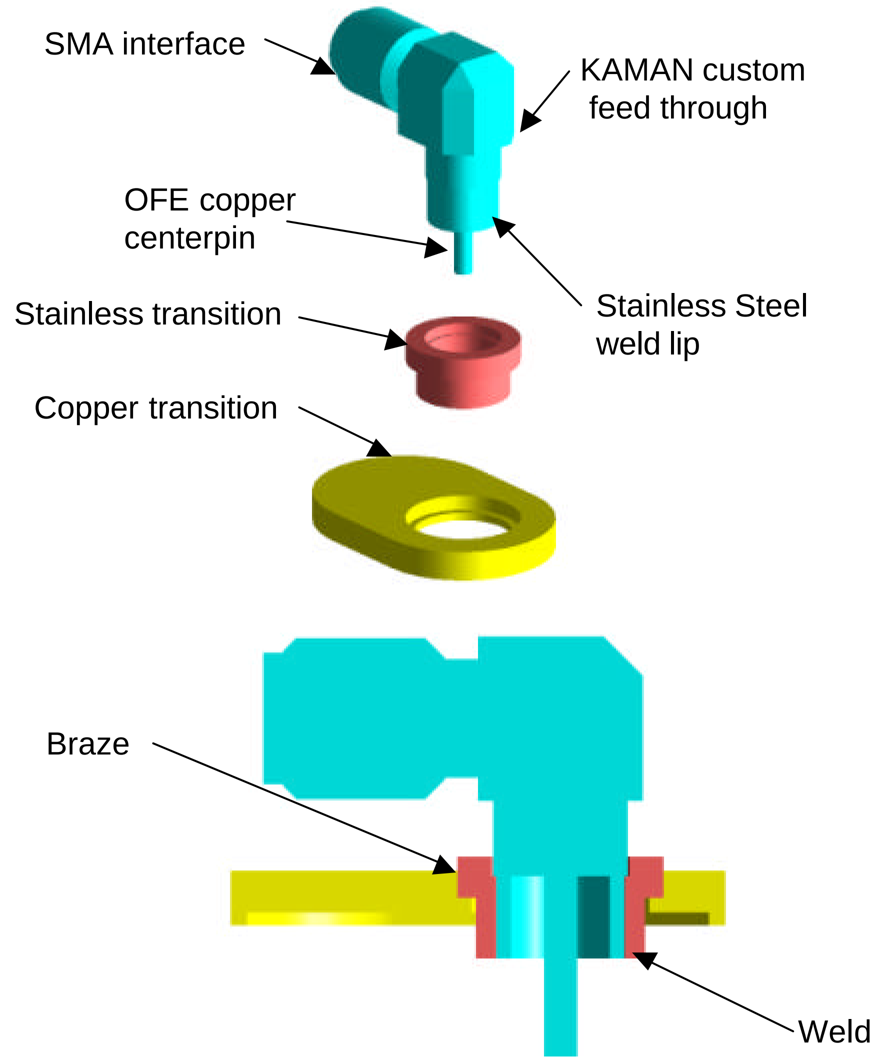
- **BPM outer cover and inner electrode parts are machined to specification.**
- **Machining of the electrodes induces internal stresses which in turn cause the electrode to move during brazing operation.**
- **To prevent electrode movement the part is annealed (stress relieved) using fixturing to hold electrodes in place.**
- **Fixturing consists of a bore sized plug to set electrodes at the proper position.**
- **Cover and electrode are then brazed together.**
- **Dowel pin is used to correctly clock the two parts.**





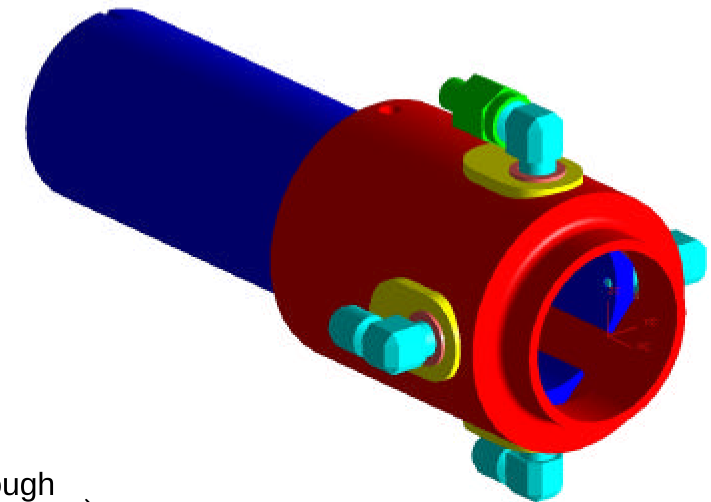
DTL BPM Fabrication - Feed Through Sub-Assembly

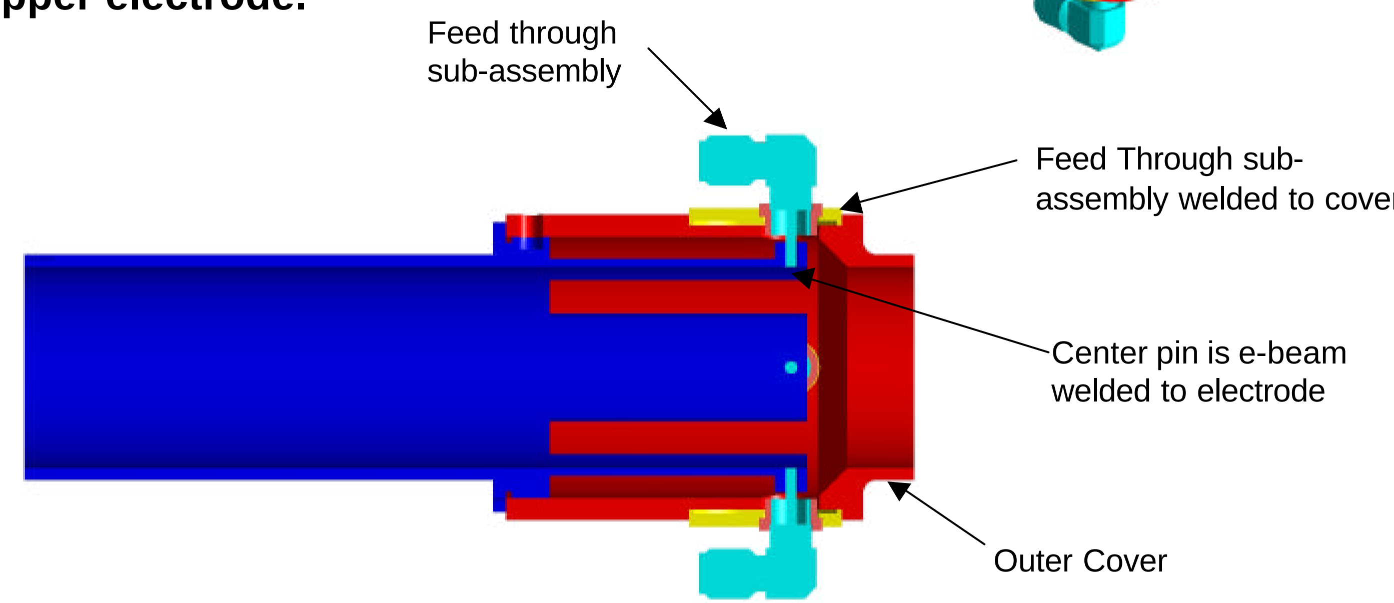
- **KAMAN will provide a custom 90° feed through.**
- **Feed through utilizes the standard TZM molybdenum pin and boro-silicate strengthened vacuum seal rearranged for 90° design.**
- **Center pin will be OFE copper.**
- **Stainless to copper transition piece is needed between feed through body and outer BPM cover.**
- **Transition piece is rough machined, brazed together, final machined, then e-beam welded to feed through.**



DTL BPM Fabrication - Feed through in body

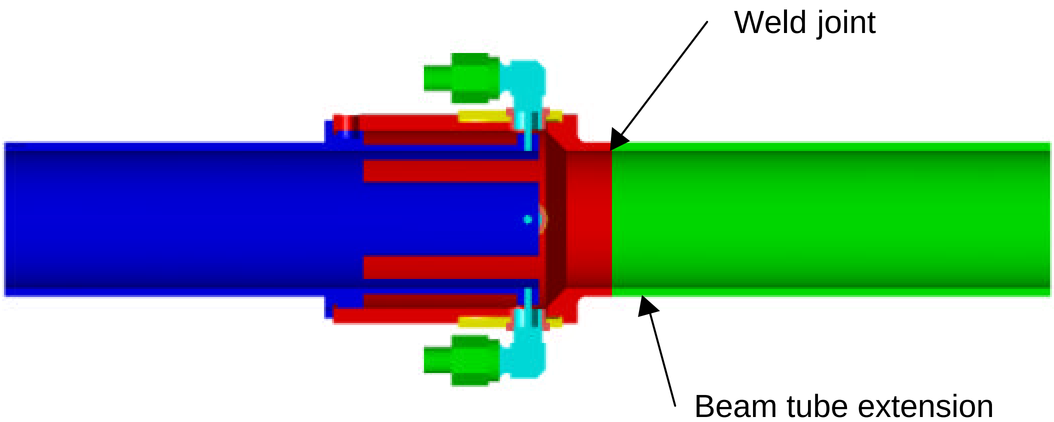
- Feed though sub-assembly is then e-beam welded into outer cover so that the plug on the center pin of the feed through fits into hole in end of the electrode.
- Electrical contact is ensured by e-beaming the copper center-pin to the copper electrode.



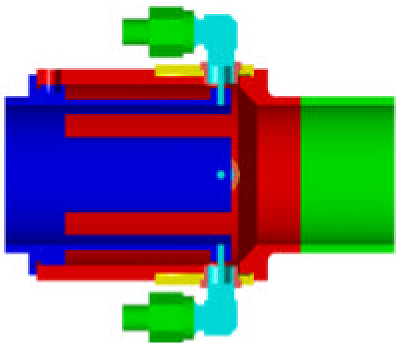


DTL BPM Fabrication - BPM Final Assembly

- In order to make the e-beam weld to the electrode, the outer cover is made in two pieces.
- A beam tube extension is welded on the assembly after center pin is welded to electrode.
- Plan is to braze and weld all BPMs at longest required length.
- Last step is to cut BPM to required length to go into appropriate drift tube.



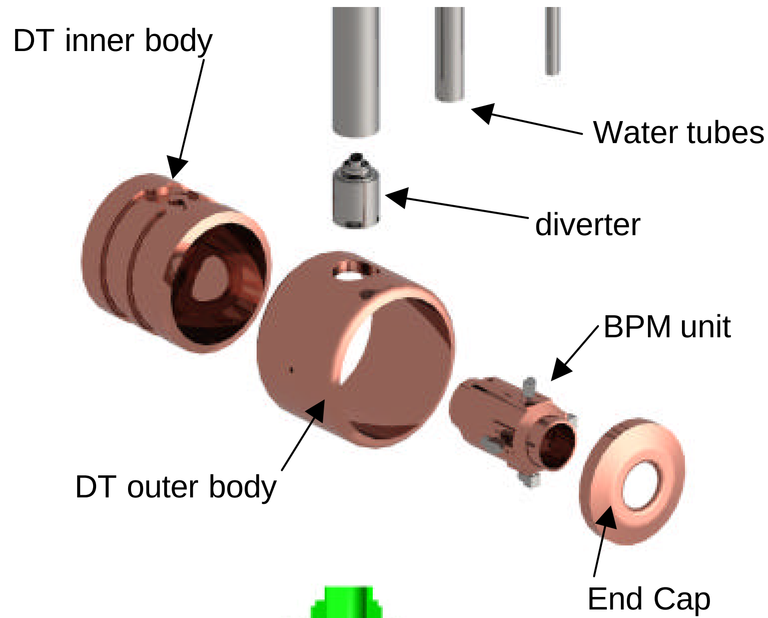
Longest required BPM, tank 6, DT #6

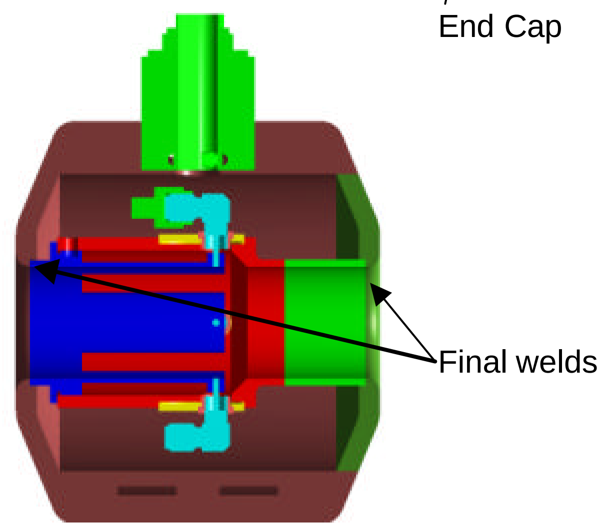


Shortest required BPM, tank 2, DT #3

DTL BPM Assembly in Drift Tube

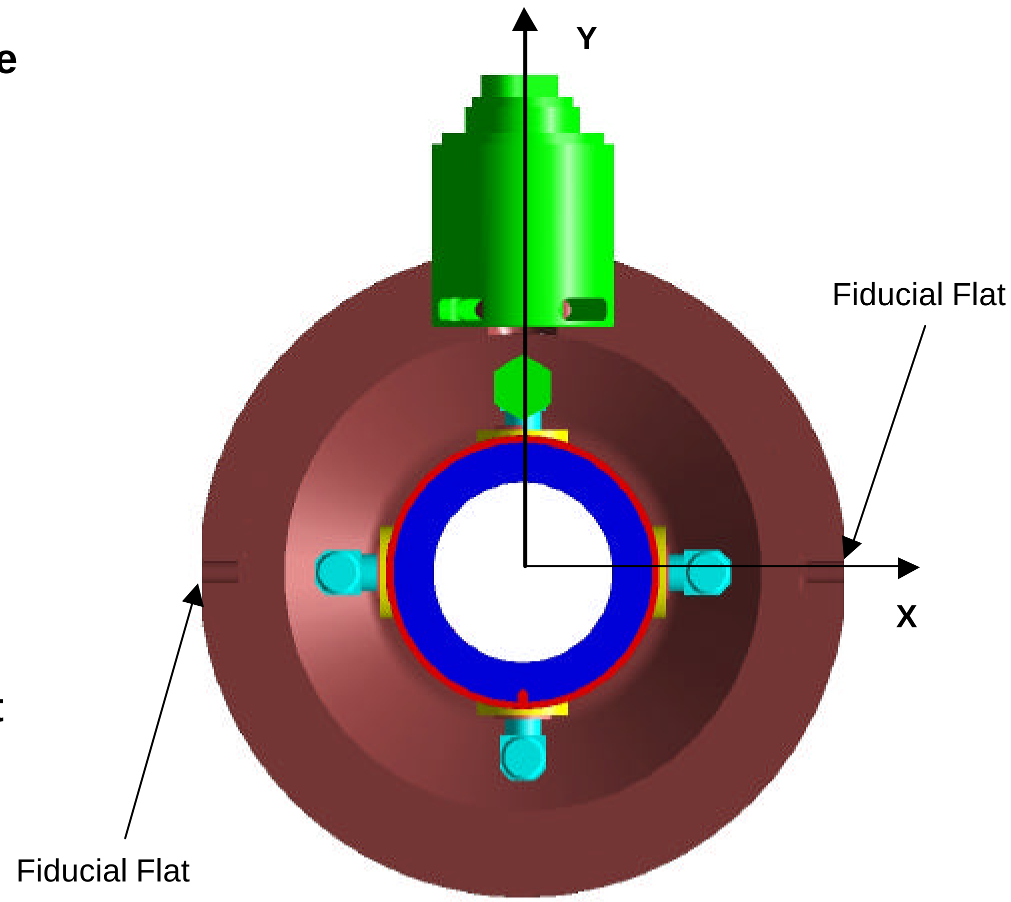
- **The complete BPM unit will be delivered to Drift Tube fabricator for installation in DT.**
- **The DT inner body, outer body, diverter tube, and water tubes (stem) will already be assembled.**
- **One end cap will not be in place yet.**
- **Signal cables will be fed down through the Drift Tube stem and threaded on to the SMA connector.**
- **BPM with cables attached is now placed in DT and will seat in installed end cap.**
- **A dowel pin design will be used to ensure proper clocking in the DT.**
- **The open end cap is then placed on the drift tube and the final sealing e-beam welds are done.**
- **BPM feed throughs are no longer accessible at this point.**
- **Final machining of DT faces is required to bring them into tolerance.**





DTL Alignment

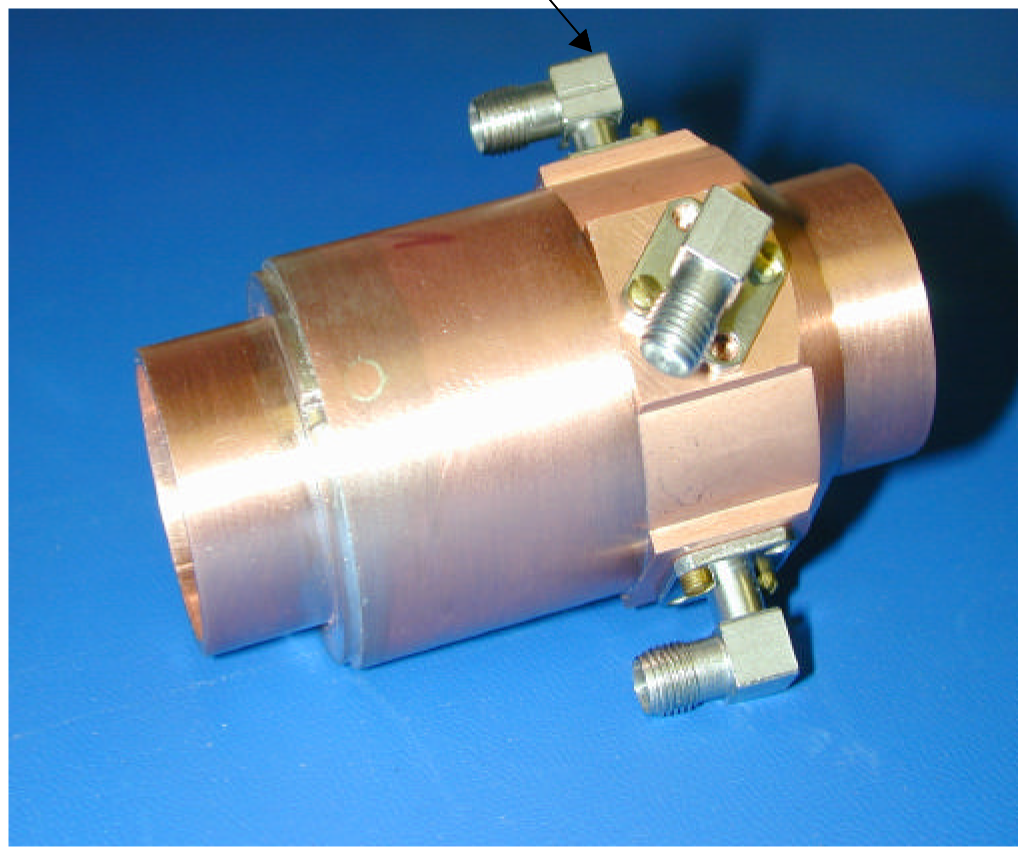
- The drift tube/BPM assembly will be mapped (taut wire measurement) with reference to the fiducial features in the lab.
- Alignment of the drift tube/BPM assembly will be accomplished by using the two fiducial holes in the side of the drift tube.
- It will be necessary to insure the BPM is clocked in the drift tube so that the fiducial holes line up with the horizontal electrodes.
- The plan is to have a pin in the drift tube end cap and a groove in the BPM body, so that when the two parts go together roll will be controlled.
- Estimated accuracy +/- 0.1 mm



DTL BPM Prototype

- **A prototype of the DTL BPM has been fabricated.**
- **Need to insure the ability to thread coax lines back through DT stem.**
- **The KAMAN feed through is a long lead item (6 month delivery expected to arrive at the end of March), so a different type of feed through was used.**
- **Helped us develop brazing process.**

Different Feed through utilized because of availability



KAMAN Feed Through - Specs

- **Advertised Specifications:**
  - **Impedance: 50** W
  - **VSWR: 1.03:1 max to 3 GHz 1.15:1 to 20 GHz**
  - **Insertion loss: .1 dB max @ 3 GHz 0.5 dB max @ 20 GHz**
  - **Insulation resistance: > 10^12 W**
  - **Voltage: 1,500 VRMS**
  - **Operating temperature: 304 ss, 77 K to 573 K; 316 ss 4 K to 573 K**
  - **Hermeticity: < 2 x 10^-10 cc/sec He**
  - **Radiation: > 200 megarads gamma**
- **BPM signal sealed at bore of Drift Tube.**
  - **minimize the volume for vacuum system to pump**
  - **no provision was made for soft vacuum in DT stem**
- **Risk - once installed in DT, seals are inaccessible and a failure will cause substantial down time to repair.**
- **Maximum calculated temperature in DT is 33 C.**

KAMAN Feed Through - Risk

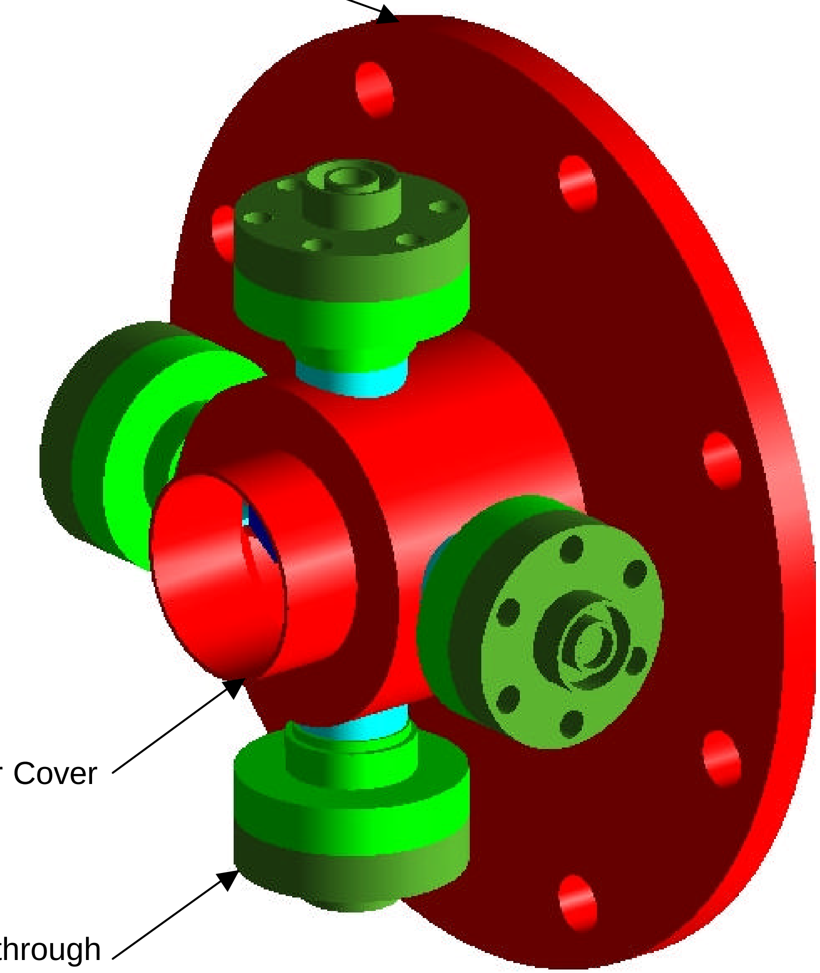
- Failure modes
  - Exceed specified temperature
  - Damage due to handling
  - Radiation
- Effort required to repair vacuum leak.
  - The problem DT needs to be identified.
  - DT is removed through slug tuner ports and access ports in bottom of tank.
  - May require several DT's to be removed to get to problem one.
  - Once DT is replaced all affected DT's must be re-aligned using laser tracker system.
  - Re-alignment plan calls for on-line system using mirrors, does not require removal of the tank.
- Down-time will depend upon state of preparedness.
  - Spare BPMs available?
  - Spare DT available?

KAMAN Feed Through - Experience

- **CERN, LHC project, 5 K operation (type N), cycle 10x liquid N2 to 200 C without failures. - *Jean-Pierre Papis***
- **SLAC, PEP II - 1000 installed, Spear 3 - 500 installed, no problems - *Steve Smith***
- **DESY, Tesla Test Facility, 80 room temperature installations, 2 years, no problems - *Manfred Wendt***
- **BNL, RHIC - 1400 installed, Qualification was 5x liquid N2 heat gun to room temperature followed by 200 C bake. No failures during testing and none in 3 years operation. - *Pete Cameron***
- **LANL, LEDA - 40 installed, room temperature application, no failures in 3 year operation. Initial problems with welding operations did cause seal failures. HALO - 80 installed, room temperature application, no failures in 6 month operation. Some seals were damaged during installation. - *Jim O'Hara***
- **TRW, thermal shock test, 15x 0 C to 100 C, transfer time < 10 s, followed by a 84 psi leak test (5.7 x atm). 10 cable assembly units tested, all passed (leak rate 5 x 10^-9 cc/sec).**

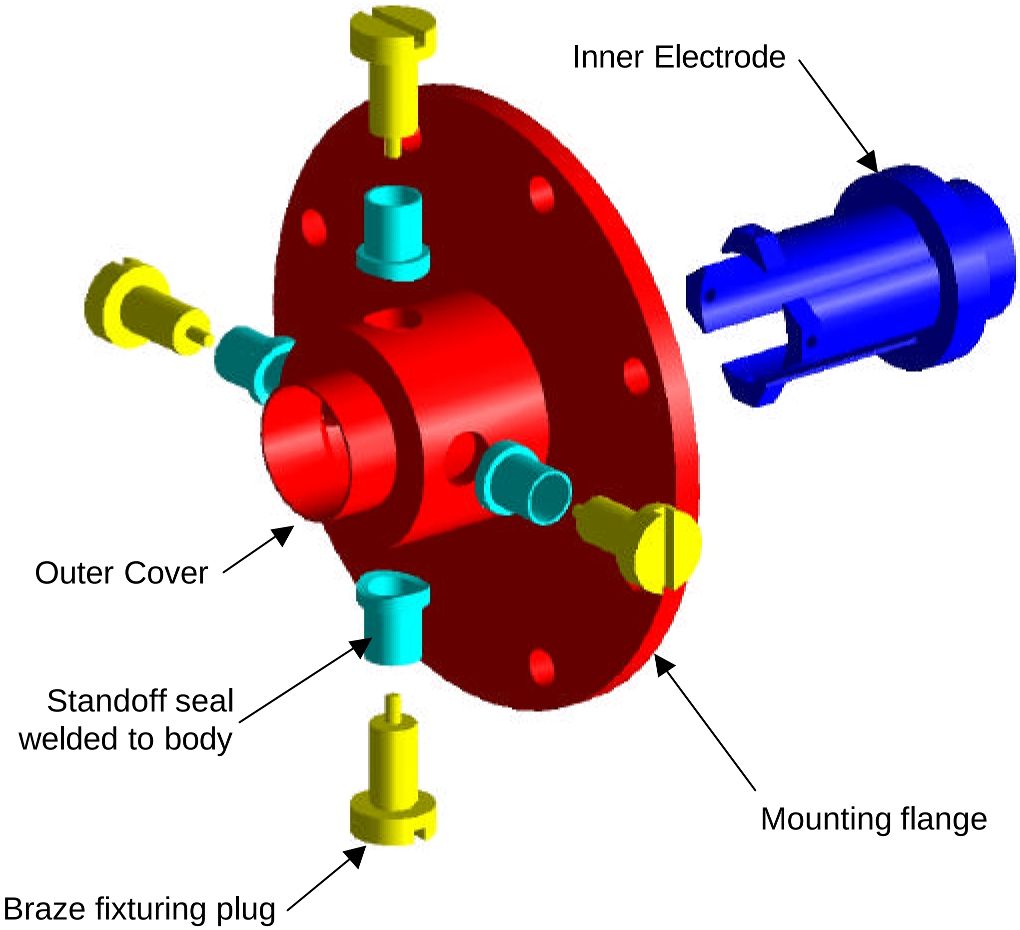
CCL Beam Position Monitor

- **15 Required**
- **Based on BNL RHIC design.**
- **Beam line instrument consists of outer cover and inner electrode parts (30 mm bore).**
- **Inner part has four, 60° included angle, strip-line electrodes, shorted at one end.**
- **Geometry is optimized to form 50-W impedance transmission line.**
- **SMA vacuum feed through built into 1.33” conflat flange is used to provide vacuum seal (Al_2O_3 strengthened boro-silicate seal).**
- **All stainless steel construction.**



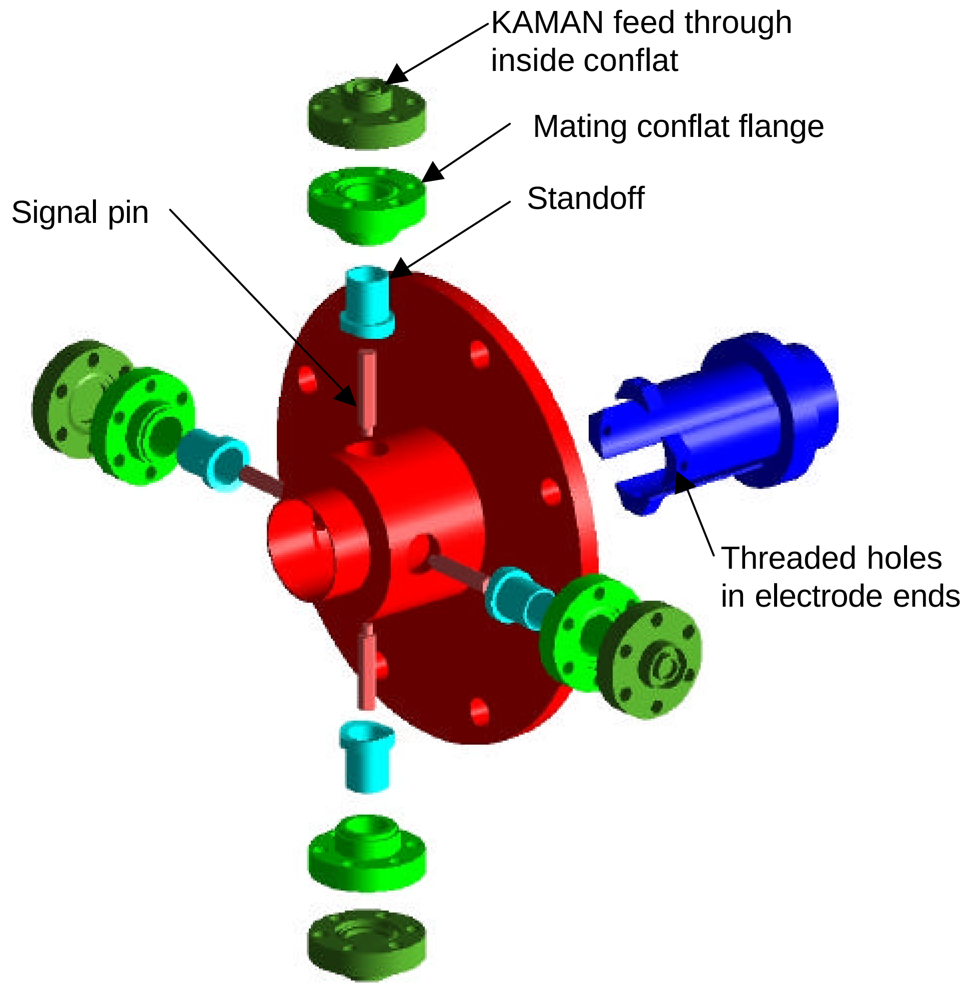
CCL BPM Fabrication and Assembly

- **BPM outer cover and inner electrode parts are brazed together.**
- **Fixturing plug is used to hold different pieces in place during assembly.**
- **Plug threads into the electrode and holds pipe standoff in place during welding.**
- **Then parts go into furnace and outer cover and inner electrode pieces are brazed together.**
- **Fixturing plugs are removed.**



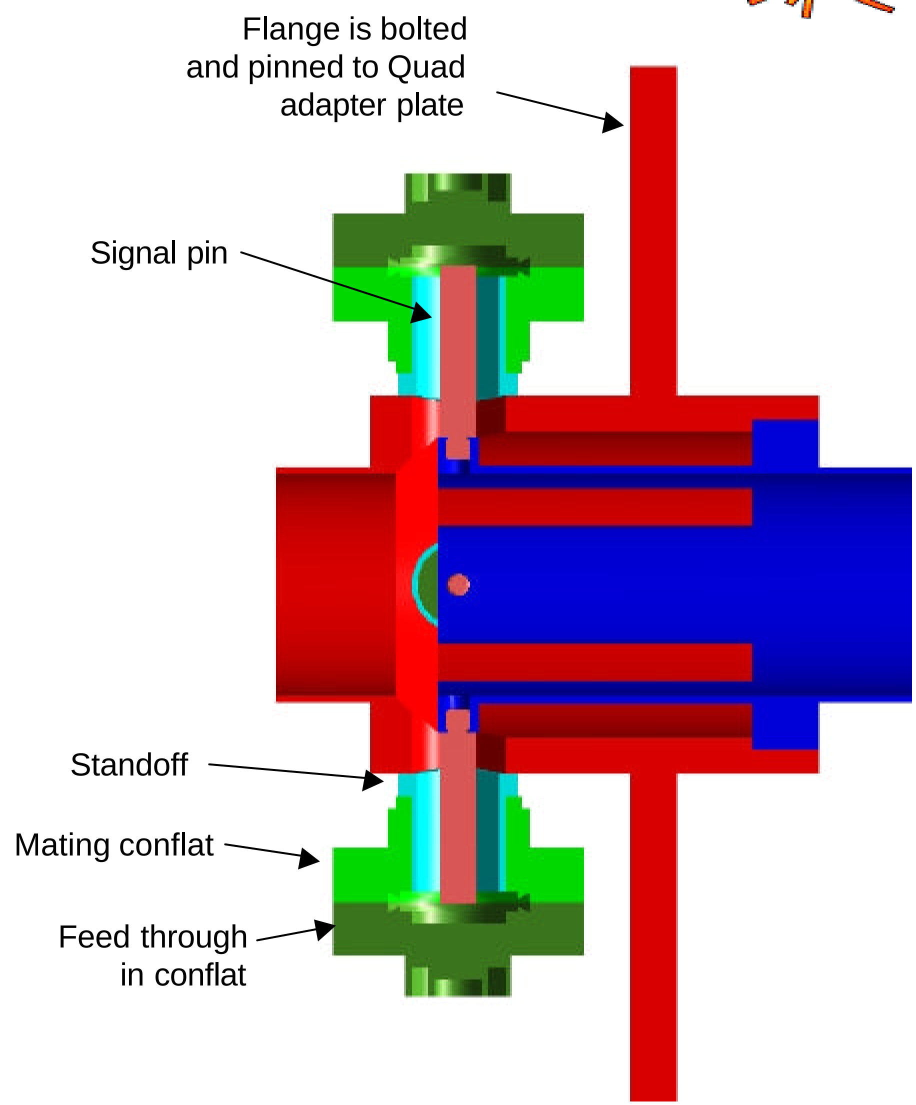
CCL BPM Fabrication and Assembly

- **Conflat flange is welded to standoff.**
- **Signal pins are threaded into the end of the electrode.**
- **Contact pressure between the feed through center-pin and the pin threaded into end of electrode provide electrical connection.**
- **By varying the length of the pin the offset of the BPM can be tweaked**
- **The feed through imbedded in the conflat allows removal and replacement if necessary.**



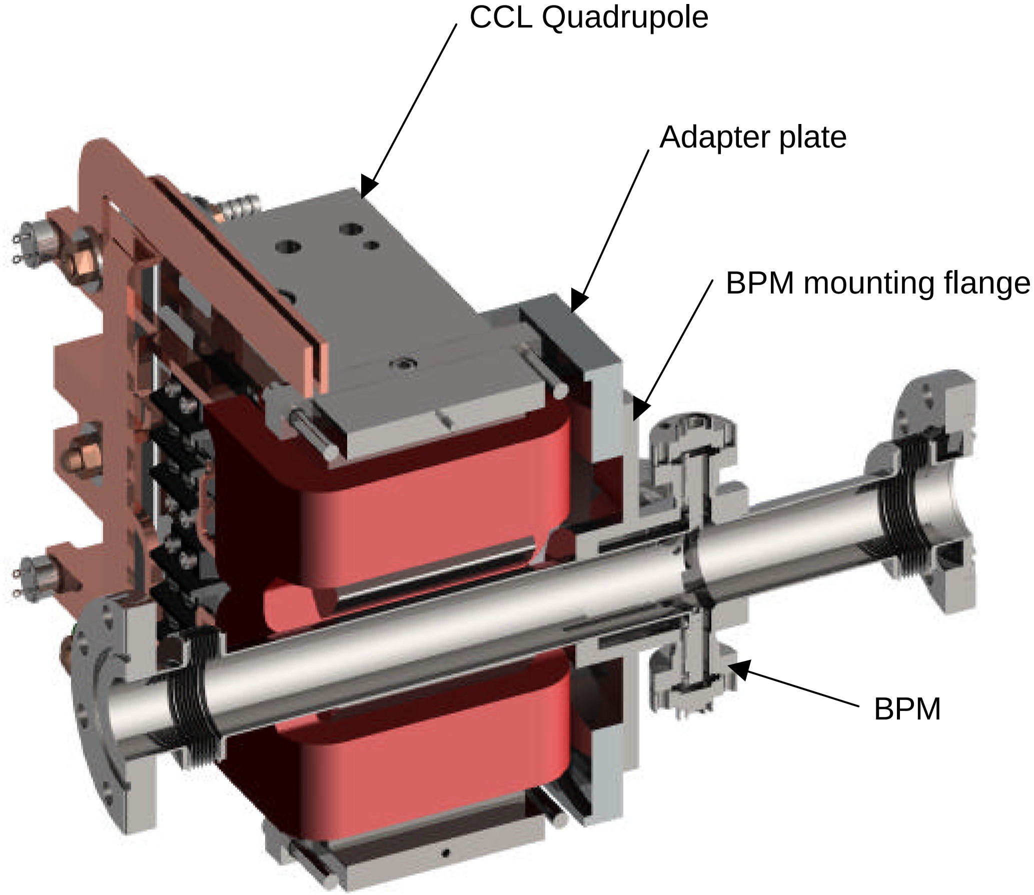
CCL BPM Fabrication and Assembly

- **Conflat flange is welded to standoff.**
- **Standoff supports mating conflat during welding.**
- **Beam tube extensions and bellows attached last.**



CCL BPM 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.**
- **We also intend to provide target holes for alignment fiducials.**
- **Estimated accuracy is +/- 0.2 mm.**

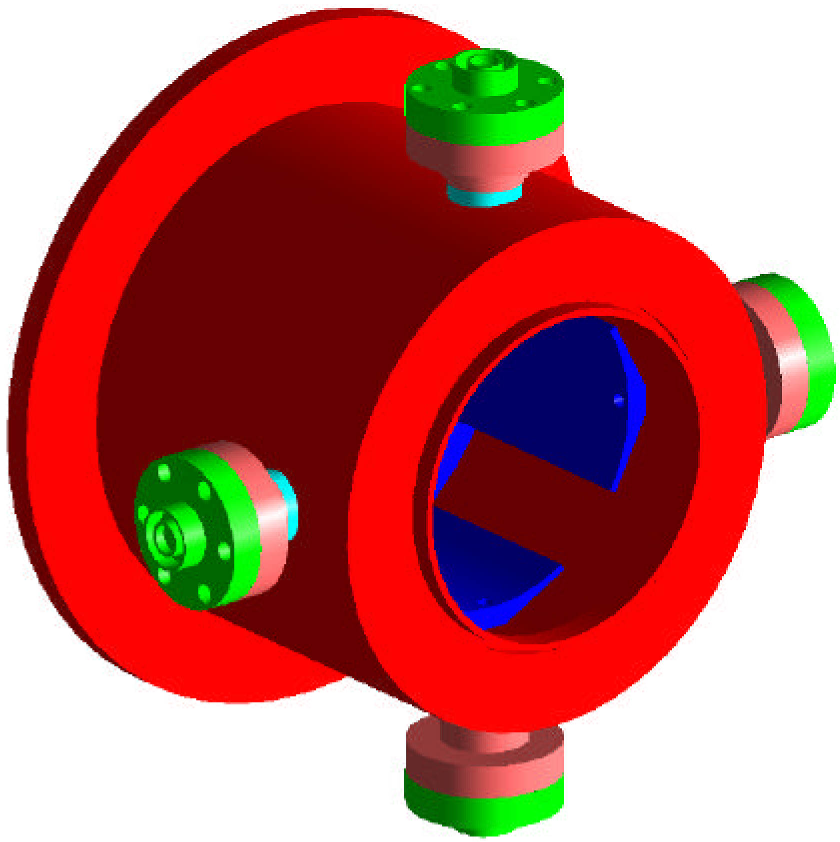


CCL BPM Prototype

- **A prototype of the CCL BPM has been fabricated By BNL.**
- **Current status: drawings under development.**

SCL Beam Position Monitor

- 31 Required
- Same basic design as the CCL BPM.
- Bore diameter is 2.874 inches (73 mm).
- Will reside in the warm section of beam line between cryo-modules.
- Plan is to also mount the BPM to quadrupole magnets, still under development.



HEBT Beam Position Monitor

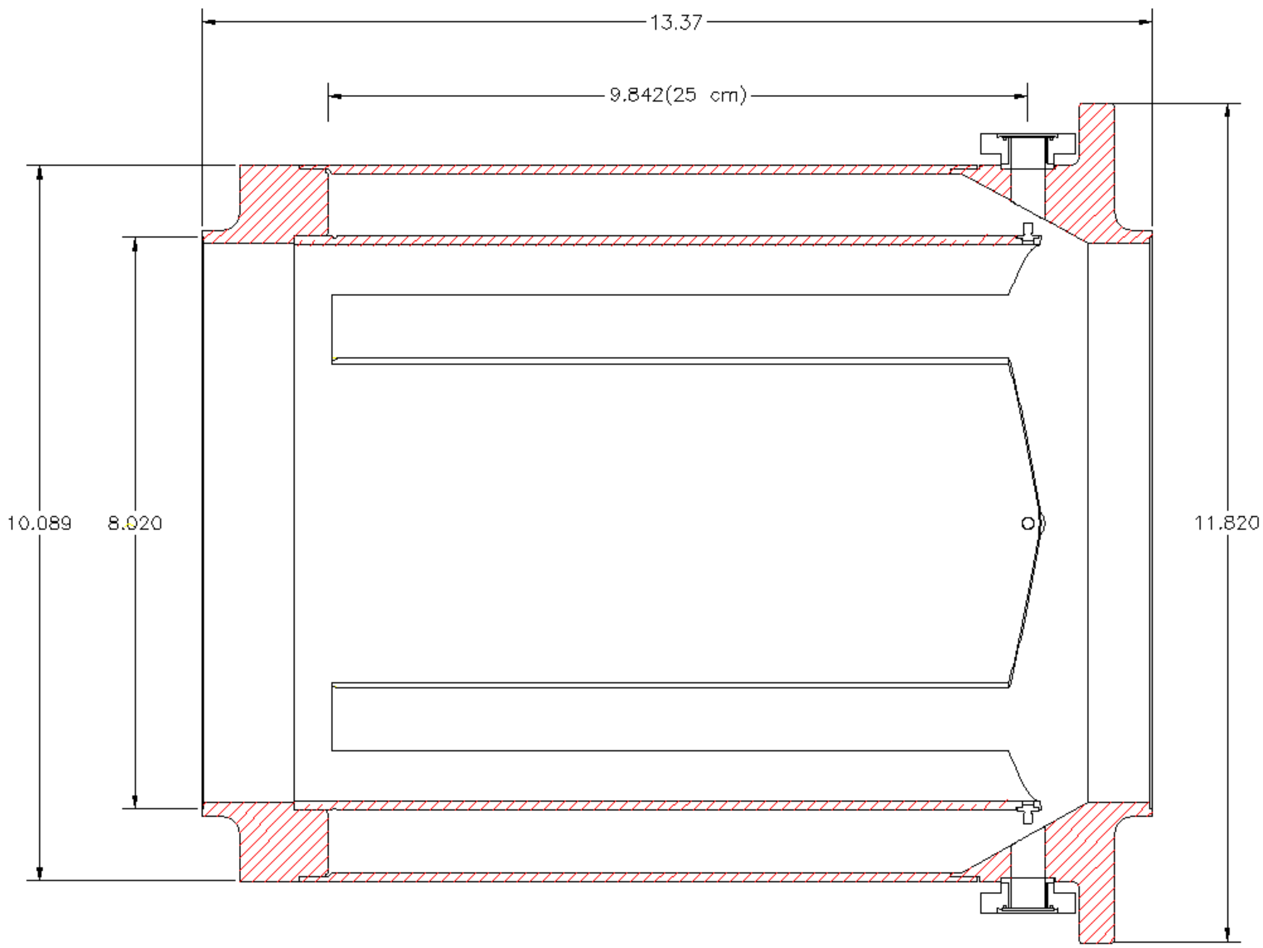
- Expected accuracy of HEBT BPM: +/- .62 mm
- Assembly method: Copper brazing
- Current status

  21 cm BPM: Fabricating 2 prototypes in shop

  12 cm BPM: Finished design drawings

HEBT Beam Position Monitor

21cm HEBT BPM



HEBT Beam Position Monitor

12cm HEBT BPM