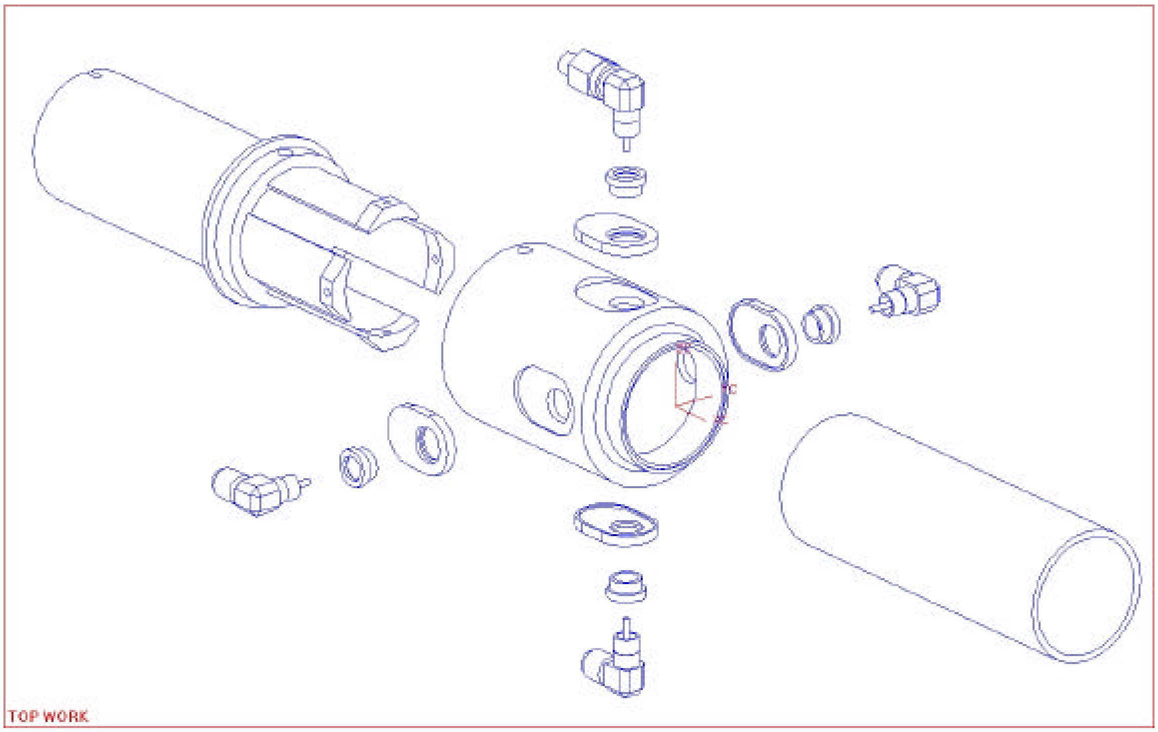
Quality Assurance Plan
for
The Spallation Neutron Source Drift Tube Linac (DTL) Beam Position Monitors (BPMs)



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1 Procure the specified materials.

Material certification shall be provided to a designated LANL representative (shop liaison or responsible engineer) for the OFE copper (ASTM F68-82, class 2 or better) and for the stainless steel (ASTM 304L).

2 Fabricate piece parts according to LANL supplied drawings and statement of work.

Fabricate BPM 12.5 mm Radius Cover Detail according to drawing number 155Y520126.
Fabricate BPM 12.5 mm Radius Electrode Detail according to drawing number 155Y520127.
Fabricate BPM 12.5 mm Radius Tube Extension according to drawing number 155Y520147.
Fabricate BPM 12.5 mm Radius Weld Interface Bracket according to drawing number 155Y520122.
Fabricate BPM 12.5 mm Radius Connector Interface Bracket according to drawing number 155Y520123.
Fabricate BPM 12.5 mm Radius Pin Detail according to drawing number 155Y520128.

For each of the above-specified parts, a dimensional inspection shall be performed in accordance with (IAW) Appendix A.

Machining and handling of the specified parts shall be IAW Appendix B.

3 LANL to procure and provide the KAMAN vacuum feed throughs.

Los Alamos will provide the specified KAMAN modified 853872-001 vacuum feed throughs. Modification refers to the custom right angle connection design.

A certificate of conformance is provide by KAMAN stating that the shipped feed throughs have passed their internal QA checks.

4 Fabricate any fixtures required for brazing.

These fixtures are provided by the vendor to facilitate brazing and post-brazing machining operations, there is no QA requirement for the fixturing.

5 Clean parts to be shipped out to the braze facility.

Parts shall be cleaned prior to brazing in accordance with standard brazing practice. The cleaning procedure shall be approved by the LANL representative prior to brazing operations.

The fabricator shall ship the specified parts IAW Appendix D.

6 Procure the specified braze alloys.

The brazing facility shall provide certification of the brazing alloys used to the designated LANL representative (shop liaison or responsible engineer). For the brazing operation specified on “BPM 12.5 mm RADIUS Connector Interface” drawing number 155Y520121, the specified alloy is similar or equal to Wesgo Metals 50-50 (50% copper with 50% gold). For the brazing operation specified on “BPM 12.5 mm RADIUS Braze Sub-Assembly” drawing number 155Y520125, the specified alloy is similar or equal to Wesgo Metals ‘CuSil” (72% silver with 28% copper).

7 Braze outer cover to inner electrode.

Braze the parts specified on “BPM 12.5 mm Radius Braze Sub-Assembly” drawing number 155Y520125.

Brazing shall be done IAW Appendix E.

The joint produced by this operation must be tested to ensure that it is leak tight. Leak testing shall be done IAW Appendix F.

8 Braze feed through adapter to weld adapter.

Braze the parts specified on “BPM 12.5 mm Radius Connector Interface” drawing number 155Y520121.

Brazing shall be done IAW Appendix E.

The joint produced by this operation must be tested to ensure that it is leak tight. Leak testing shall be done IAW Appendix F.

9 Ship parts back to machine shop.

Shipping of the brazed parts shall be IAW appendix D.

10 Machine holes in electrode end to accept feed through center pin.

After brazing machine the holes specified on “BPM 12.5 mm Radius Braze Sub-Assembly”, drawing number 155Y201125.

For each of the above-specified parts, a dimensional inspection shall be performed in accordance with (IAW) Appendix A.

Machining and handling of the specified parts shall be IAW Appendix B.

11 Machine weld adapter to specifications to fit within slot in outer cover.

After brazing machine the holes specified on “BPM 12.5 mm Radius Connector Interface”, drawing number 155Y201121.

For each of the above-specified parts, a dimensional inspection shall be performed in accordance with (IAW) Appendix A.

Machining and handling of the specified parts shall be IAW Appendix B.

12 Ship sub-assembly parts to electron beam welder.

Shipping of the sub-assemblies shall be IAW appendix D.

13 Electron beam welder performs weld process qualification on supplied coupons.

A number of coupons for each type of weld will be provided to the electron beam welder. These coupons are for the purpose of determining the proper set-up parameters for each type of electron beam weld. After welding the sections shall be sectioned and inspected for weld joint integrity. Coupons shall be taken to an independent inspection laboratory approved by LANL for microscopic inspection.

Electron beam welding shall be IAW Appendix G.

14 Electron beam weld feed throughs to feed through adapters.

Electron beam weld the KAMAN vacuum feed through to the connector interface as specified on “BPM 12.5 mm Radius Connector Weldment”, drawing number 155Y520120. This joint must be leak tight, and also must not damage the KAMAN feed through.

This joint, in conjunction with the KAMAN vacuum feed through shall be leak checked to ensure that it is leak tight. Leak testing shall be done IAW Appendix F.

Electron beam welding shall be IAW Appendix G.

Measure the resistance of the center conductor of each feed through IAW Appendix H. The resistance should be less than 0.TBD ohms.

15 Electron beam feed through sub-assemblies to outer cover.

Four leak checked connector weldments (155Y520120) are now installed into the braze sub-assembly (155Y520125). This is another joint that must be leak tight and not damage the KAMAN feed through.

This entire sub-assembly having four KAMAN, vacuum, feed throughs installed, shall be leak checked as a unit. Leak testing shall be done IAW Appendix F.

Electron beam welding shall be IAW Appendix G.

16 Electron beam feed through center pin to electrode.

This weld is specified on “BPM 12.5 mm Radius Assembly” drawing number 155Y520124. This weld is not a vacuum tight weld, it’s purpose is to ensure permanent electrical contact between the electrode and the center pin of the feed through.

Measure the resistance of each feed through and lobe combination IAW Appendix H. The resistance should be less than 0.TBD ohms.

Electron beam welding shall be IAW Appendix G.

17 Electron beam length adapter to BPM sub-assembly.

This weld joint is specified on “BPM 12.5 mm Radius Final Assembly”, drawing number 155Y520129. This joint must also be leak tight.

This entire assembly, shall be leak checked as a unit. Leak testing shall be done IAW Appendix F.

Electron beam welding shall be IAW Appendix G.

18 Ship welded assemblies to machine shop.

Shipping of the sub-assemblies shall be IAW appendix D.

19 Cut BPM assemblies to appropriate finished lengths according to location in linac.

After welding machine the BPM Final Assemblies to the appropriate length for their position in the Drift Tube Linac. The lengths are specified on the following drawings:

Tank #2, Drift Tube #3, drawing #155Y520137
Tank #2, Drift Tube #9, drawing #155Y520138
Tank #3, Drift Tube #2, drawing #155Y520139
Tank #3, Drift Tube #8, drawing #155Y520140
Tank #4, Drift Tube #3, drawing #155Y520141
Tank #4, Drift Tube #9, drawing #155Y520142
Tank #5, Drift Tube #1, drawing #155Y520143
Tank #5, Drift Tube #7, drawing #155Y520144
Tank #6, Drift Tube #3, drawing #155Y520145
Tank #6, Drift Tube #9, drawing #155Y520146

For the above-specified parts, a dimensional inspection shall be done IAW Appendix A.

Machining and handling shall be done IAW Appendix B.

20 Machine groove for drift tube clocking pin.

For each of the completed BPM assemblies listed above a clocking groove is now machined into one end of the assembly as shown on "BPM 12.5 mm Radius Final Assembly", drawing number 155Y520129. Once the groove is cut the BPMs are complete and are ready for their final cleaning prior to being installed in a drift tube.

For the above-specified parts, a dimensional inspection shall be done IAW Appendix A.

Machining and handling shall be done IAW Appendix B.

Cleaning of the completed BPM assemblies shall be IAW Appendix C.

This entire assembly, shall be leak checked as a unit. Leak testing shall be done IAW Appendix F.

21 Ship finished BPM and drift tube assembly to electron beam welder.

Ship finished BPM and drift tube assembly to e-beam welder for installation into drift tube. Shipping of the sub-assemblies shall be IAW appendix D.

22 Install the BPM into the Drift Tube.

Procedure for installing BPM into Drift Tube

- Cut KAP50-5 cables to TBD +/- TBD length.
- Label cables using T, B, L, and R at each end for identification purposes.
- Terminate cables at one open end.
  - Verify terminations are not shorted.
  - Verify SMA pin depths are within specification.
  - Measure TDR response of each cable assembly IAW Appendix J. All cable impedances should be 50±1.8 ohms and matched to within ± 0.3 ohms within the set of four (excluding cable losses).
- Run signal cables through drift tube stem.
- Terminate cable at open ends.
  - Verify terminations are not shorted.
  - Verify SMA pin depths are within specification.
- Connect signal cables to BPM.

Use thread lock (loctite 246, high temperature, medium strength) to prevent assembly from unthreading.
Torque SMA connections to 5 in-lbfs (Reference HP Application note 326).
Inject a dc current of 5A through each cable/feed through/lobe for 5 seconds.
Measure dc resistance of each cable/feed through/lobe assembly IAW Appendix H. The resistance should be less than 0.TBD ohms.

Secure cables around BPM, making sure to prevent cables from contacting end caps during welding.
Secure opposite cable end to drift tube stem.
Measure S11 parameters of each cable/feed through/lobe assembly IAW Appendix I. S11 phases should match within ±TBD degrees at 805 MHz.
Measure TDR response of each cable/feed through/lobe assembly IAW Appendix J.

23 Electron beam weld the BPM into the Drift Tube

This weld joint is specified on the following drawings:

DTL Tank 2, Drift Tube 2-3 and 2-9 Assembly", drawing number 155Y508541
DTL Tank 3, Drift Tube 3-2 and 3-8 Assembly", drawing number 155Y508540
DTL Tank 4, Drift Tube 4-3 and 4-9 Assembly", drawing number 155Y508540
DTL Tank 5, Drift Tube 5-1 and 5-7 Assembly", drawing number 155Y508540
DTL Tank 6, Drift Tube 6-3 and 6-9 Assembly", drawing number 155Y508540

These joints must also be checked to ensure that they are leak tight. Leak checking shall be done IAW Appendix F.

Electron beam welding shall be IAW Appendix G.

24 Ship completed drift tube assembly back to machine shop.

Shipping of the drift tube/BPM assemblies shall be IAW appendix D.

25 Complete machining operation on the drift tube faces.

For each of the completed drift tube/BPM assemblies listed above a final machining operation is necessary to bring the drift tube face profile into tolerance. This operation is shown on the following drawings:

DTL Tank 2, Drift Tube 2-3 and 2-9 Assembly", drawing number 155Y508541
DTL Tank 3, Drift Tube 3-2 and 3-8 Assembly", drawing number 155Y508540
DTL Tank 4, Drift Tube 4-3 and 4-9 Assembly", drawing number 155Y508540
DTL Tank 5, Drift Tube 5-1 and 5-7 Assembly", drawing number 155Y508540
DTL Tank 6, Drift Tube 6-3 and 6-9 Assembly", drawing number 155Y508540

For the above-specified parts, a dimensional inspection shall be done IAW Appendix A.

Machining and handling shall be done IAW Appendix B.

Cleaning of the completed BPM assemblies shall be IAW Appendix C.

26 Deliver drift tube/BPM assembly to LANL.

Shipping of the completed drift tube/BPM assemblies shall be IAW appendix D.

27 Map drift tube/BPM assembly at LANL.

BPMs shall be mapped and handled IAW the mapping procedure described in Appendix K.

Conduct the following electrical measurements while at LANL:

- Measure dc resistance of each cable/feed through/lobe assembly IAW Appendix H. The resistance should be less than 0.TBD ohms.
- Measure S11 parameters of each cable/feed through/lobe assembly IAW Appendix I.
- Measure TDR response of each cable/feed through/lobe assembly IAW Appendix J.

28 Deliver drift tube/BPM assembly to drift tube tank for installation in the drift tube tank.

The final leak check is to be done prior to turning over for installation in Drift Tube Tank. Leak checking shall be done IAW Appendix F.

29 Drift tube assembly is installed in the drift tube tank.

Drift tube/BPM assembly will be installed in the drift tube tank.

Visually inspect the cables and connectors for signs of damage.

30 Drift tube assembly is aligned in the drift tube tank.

Drift tube/BPM assembly is aligned in the drift tube tank.

Visually inspect the cables and connectors for signs of damage.

31 Ship drift tube tank to Oak Ridge National Laboratory.

Drift tube tank containing BPM is shipped to Oak Ridge.

32 Install drift tube tank in tunnel at Oak Ridge National Laboratory.

Drift tube tank is installed in the tunnel at Oak Ridge.

Measure dc resistance of each cable/feed through/lobe assembly IAW Appendix H. The resistance should be less than 0.TBD ohms.
Measure S11 parameters of each cable/feed through/lobe assembly IAW Appendix I.
Measure TDR response of each cable/feed through/lobe assembly IAW Appendix J.

Appendices

Appendix A – Dimensional Inspection

The fabricator shall perform a 100% dimensional inspection of the specified parts. A written report of all dimensions shall be provided. Report documents shall be produced in electronic formats such as Microsoft Word, Excel and or Adobe Acrobat PDF. Hard copies of written inspection reports shall be included with each shipment.

Appendix B – Machining and Material Handling

The fabricator shall not use Sulfur based machining fluids or oils on any parts.

The fabricator shall use polycrystalline diamond (PCD) tipped cutting tools for finish cuts on all copper parts. The use of PCD tipped tools on ferrous parts is not required. The seller shall wash all PCD inserts and tools with Acetone and rinse with isopropyl alcohol (IPA) prior to use.

All copper parts shall be protected from contact with bare hands during and after the use of PCD tipped cutting tools. Components shall be handled only with **clean white 100% cotton gloves**.

Appendix C – Cleaning

Cleaning operations on individual parts and sub-assemblies necessary for brazing or electron beam welding shall be done in accordance with standards particular to those industries. These cleaning procedures shall be submitted to and agreed upon by LANL.

After all qualification tests are performed, all surfaces of the BPM assemblies must be carefully cleaned for a high vacuum environment. Prior to packaging the BPM assemblies, they must be cleaned according to the following procedure: (Note, vinyl class 100 powder free gloves shall be worn during this entire cleaning process and all wiping will take place with 100% cotton cloth or white cleaning tissues)

1. Acetone wipe all surfaces - use a new clean cloth/tissue.
2. Isopropyl alcohol (IPA) wipe all surfaces - use a new clean cloth/tissue.
3. Acetone wipe all surfaces a second time using grade GC RESOLVE GRADE Acetone and new clean cloth/tissue.
4. Isopropyl alcohol (IPA) wipe all surfaces a second time - use a new clean cloth/tissue.
5. Change from vinyl gloves to clean white cotton gloves before handling cleaned assembly.

Any deviation in this set of cleaning steps must have prior written approval from the LANL representative. The deviation request must be accompanied with sufficient documented proof that the alternative cleaning process equals or is better than the proposed procedure.

Appendix D – Shipping

The seller shall be responsible for purchasing or fabricating shipping containers for all transportation of machined components, BPMs, subassemblies and completed assemblies during all stages of fabrication, welding, brazing, and testing. The shipping container(s) shall be designed to provide the contents protection from all damages, scratches, marks and etc. during the packaging and shipping process. Contents shall be stabilized against movement, and prevented from any mechanical or chemical damage during transportation. Wooden, hard shell plastic or metallic containers that prevent impact damage and bending shall be used. The use of any type of plastic materials in the containers requires approval of LANL due to the possible outgassing of such materials and their permanent effect on the copper components.

Appendix E – Brazing

Furnace braze shall be in accordance with ANSI/AWS C3.6-1990, Class C. Braze using CUSIL 72Ag-28Cu alloy or AWS classification BAg-8. All dimensions on LANL supplied drawings apply after brazing. Braze symbols on drawings shall be interpreted in accordance with AWS A2.4. Any conflicts or questions related to application or interpretation of weld symbols should be directed to LANL for disposition and clarification. Clean all parts prior to brazing with the accepted process. The cleaning process shall be capable of removing all oxides from the braze joints prior to brazing.

Appendix F – Leak Checking

All welded and brazed joints, subassemblies, and completed BPM assemblies (155Y520100) shall be leak checked using the following: Final assembly shall be leak tight. All leak testing shall be done using a Mass Spectrometer Leak Detector (MSLD) with a minimum sensitivity to Helium of 9×10^{-10} std cc/sec or lower. The MSLD shall be calibrated with a standard helium leak source possessing a leak rate of 10^{-9} std cc/sec or lower. The part being tested will be evacuated to a (total) pressure of not greater than 5×10^{-5} Torr before the leak testing is performed. In addition, all leak testing shall be of the Tracer Probe Type - using a Helium gas probe to introduce the Helium tracer gas to the outside surface of the item being tested. At least one of the tests must consist of placing the part inside a plastic bag with helium gas. Helium shall be introduced inside the bag so as to bathe the evacuated component in Helium. A component shall be deemed to pass testing if it exhibits **NO DETECTABLE LEAKS** at or above 2×10^{-9} std cc/sec after it has soaked in Helium for 1 minute. A certificate of compliance traceable to national standards for the equipment being used on this job must be maintained on file at the testing firm's place of business and/or at the location where the testing is being performed. These certificate(s) must be made available to LANL personnel or their representatives for inspection. The MSLD shall be calibrated before and after each series of tests. Testing shall be done in accordance to ASTM E - 1603-99. Any exceptions to these instructions must be obtained in writing from LANL.

Appendix G – Electron Beam Welding

Electron Beam (EB) welding shall be in accordance with MIL-STD-1595A. All dimensions on LANL supplied drawings shall apply after welding. Weld symbols on drawings shall be interpreted in accordance with AWS A2.4. Any conflicts or questions related to application or interpretation of weld symbols shall be directed to LANL for disposition and clarification. Clean all parts prior to welding with the industry standard process agreed to by LANL. The cleaning process shall be capable of removing all oxides from the weld joints prior to EB welding.

Appendix H – DC Resistance Measurement

All resistance measurements are to be made to an accuracy of $\pm$ 0.001 Ω or $\pm$ 5%, whichever is greater. All measurements shall be made with a calibrated voltmeter/current meter, or verified with a second measurement instrument to within $\pm$ 5%. All measurements are to be done using the 4-point measurement technique such that measurement lead contact resistances are not included in the measurements. If a resistance measurement is made with respect to the center pin of a SMA or other small connector, the correct mating pin is to be used for the connection to the center pin. This mating pin shall have two connecting points, one for the current connection and one for the sense (or voltage) connection. The sense connection shall be as close as practical to the mating portion of the pin, and the current connection should be further away. If a resistance measurement is made with respect to the ground/shield side of an SMA or other coaxial connector with a rotating nut, the measurement shall be with respect to the non-rotating body of the connector. Instrumentation calibration is not required to be traceable to NIST or other calibration laboratories as the data taken is for verification of proper assembly. This data is not intended to be used for BPM calibration purposes. The data is for verification of consistency between the four lobe circuits of each BPM.

Appendix I – S-Parameter Measurements

All S-parameter measurements shall be made with a network analyzer such as a HP 8753C or equivalent-accuracy instrument. The instrument should be calibrated using the appropriate calibration test kit (SMA or 3.5-mm) immediately priorto making the measurements. All measurements shall be at both 402.5 MHz and at 805 MHz. All data should be recorded with at least 0.01 dB and 0.01 degree resolution. Instrumentation calibration is not required to be traceable to NIST or other calibration laboratories as the data taken is for verification of proper assembly. This data is not intended to be used for BPM calibration purposes. The data is for verification of consistency between the four lobe circuits of each BPM.

Appendix J – TDR Measurements

All measurements shall be made with a TDR with a rise time of either =50 ps, or as short as possible if the combined cable/lobe length is too long for this resolution. If possible, the TDR instrument should be calibrated and normalized data traces recorded. The data should be averaged by a factor of at least 256. Vertical resolution shall be =0.1 ohms. Cable impedance measurements should be made over the first 1- to 2-ns of cable length from the TDR calibration point, due to the relatively high series loss component of the KAP50-5 cable. Instrumentation calibration is not required to be traceable to NIST or other calibration laboratories as the data taken is for verification of proper assembly. This data is not intended to be used for BPM calibration purposes. The data is for verification of consistency between the four lobe circuits of each BPM.

Appendix K – DTL BPM Mapping Procedure

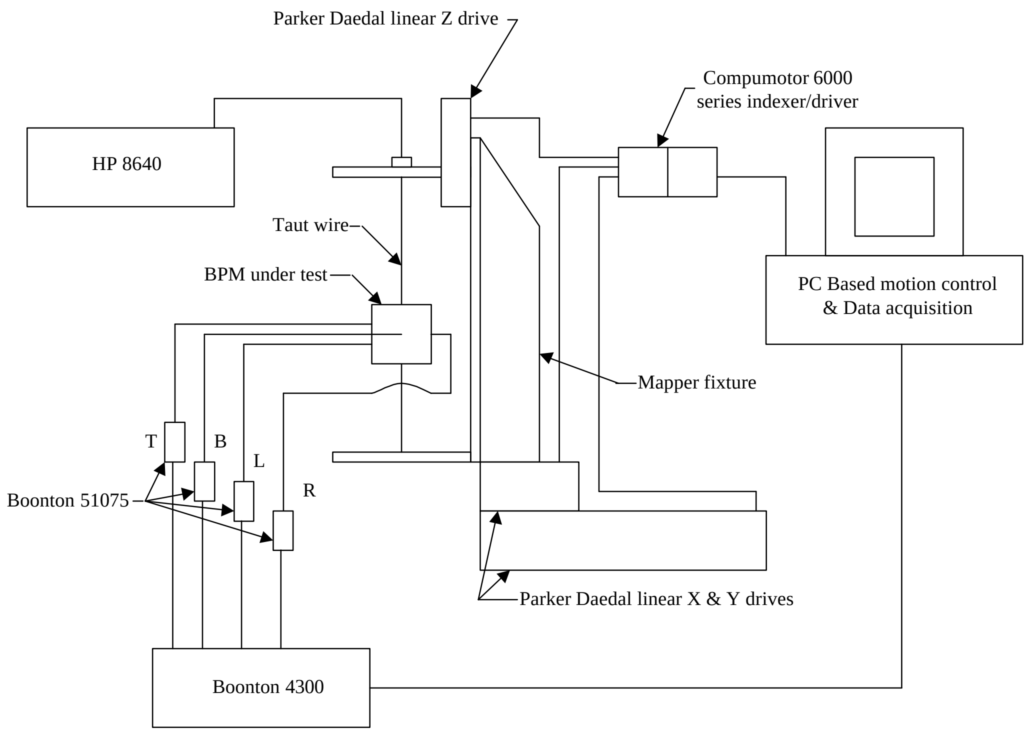
DTL BPM Mapping Procedure

Description

The BPM will be mapped using the LANSCE-1 BPM mapping station. A schematic of the mapping station is shown below. The station consists of the following equipment:

Hewlett Packard model 8640B signal (This instrument shall have an up to date calibration sticker or certificate).
Boonton 4300 RF Power meter (This instrument shall have an up to date calibration sticker or certificate).
4 Boonton 51075 Power sensors (These devices shall have an up to date calibration sticker or certificate).
Mapping fixture hardware
0.004 inch diameter stainless steel wire (antenna)
2, 8 inch travel, Parker Daedal precision linear bearing tables model number 406008LN
1, 4 inch travel, Parker Daedal precision linear bearing table model number

3 Compumotor 6000 series indexer/driver motor controllers
PC based motion control using LabVIEW software
PC based data acquisition using PCI card running LabVIEW software



Schematic of Mapper System

An RF signal either 402.5 or 805 MHz is generated by the HP 8640. This signal is transmitted to the taut wire running through the BPM. The RF signal on the wire is detected by the Boonton 51075 power sensors connected to each electrode (T, B, L, R) of the BPM. The power on the electrode is detected at the sensors and is read out at the Boonton 4300 power meter. This reading is acquired by the data acquisition card on the PC under the control of National Instruments LabVIEW software. The PC based motion control will position the wire at numerous places within the bore of the BPM and a reading is taken at each position. The positioning of the wire is also accomplished using a LabVIEW program which commands the Compumotor indexer/driver. The indexer/driver sends electric pulses to the stepper motors, which drive the Parker/Daedal precision linear bearing tables. The stepper motor positioning system utilizes linear encoders to provide feedback to the Compumotor controller. All of this functionality has been wrapped up into a single program that automates the data acquisition process.

While it is expected that the mapping system will use the equipment described herein, it is acceptable to substitute different instruments as long as the absolute accuracy and performance of these are at least as good as that of the original equipment.

Calibration

There are two items to calibrate during the BPM mapping process. The first is the Boonton power meter and the second is the wire positioning system.

Calibrating the Boonton 4300 RF Power Meter

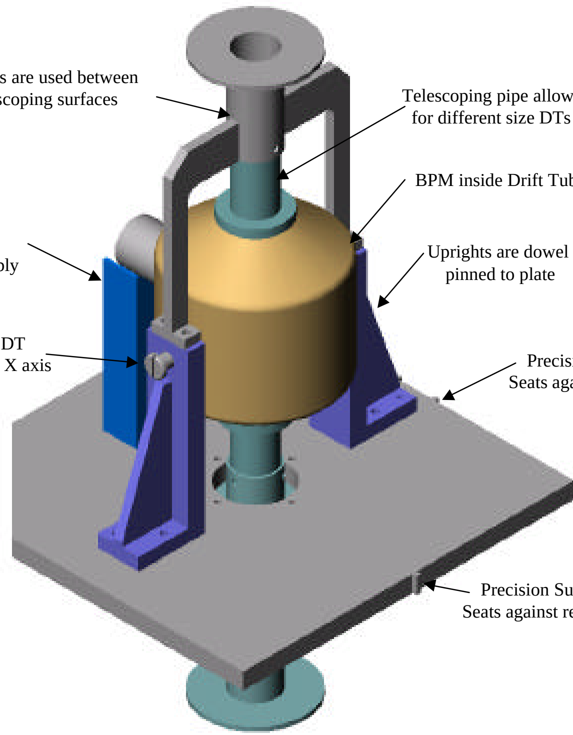
The power meter comes with an internal calibration system. You simply set the desired channel to calibrate and connect the calibration line to that channel's power sensor. The power meter sends out a series of signals of known power and the sensor's reading is compared/calibrated to the known value. The power sensors are calibrated over a range of –75 dB to 0 dB. Each sensor is in turn calibrated. This is done once a day prior to the first map.

Calibrating the wire positioning system

The mapping fixture has two blocks that have been set square in relation to the motion of the precision linear positioning tables. These blocks define the X and Y axes of the system. A precision made standard is used to locate a pin an equal (+/- .0005") distance from each of the blocks. This pin defines the coordinates (0,0) of the positioning system. Two sets of Keyence lasers, aligned with each axis, are used to measure the position of this pin. The laser system is independent of the positioning system. Once the laser system reads the pin's position the value is set to zero. With the laser system now set to zero the standard is removed and the wire is placed into the fixture. Again using the LabVIEW program the wire can be placed at the same location as the standard pin was (0,0) and the positioning system is now set to zero. This calibration can be done as often as desired. Generally it is done three times for a set of 10 maps. This gives the operator some sense of the repeatability of the set up.

BPM support

The BPM support system is shown in the following figure.



BPM Mechanical Support

The BPM is supported by the fiducials provided in the drift tube body. Two 1/8" diameter holes are placed on each side of the drift tube centered on the Y=0 plane of the beam line. These holes establish the X axis of the Drift Tube coordinate system. A V-block is used to stop the rotation (about the X axis) of the Drift Tube. The stem will have been brazed onto the drift tube body so it will need to be supported. By supporting the Drift Tube stem in the V-block, the pitch of the Drift Tube is controlled. Even though there is no upstream and downstream beam pipe before or after the Drift Tube, telescoping pieces of tubing are used to contain the RF energy. RF seals are used between the telescoping surfaces of the beam pipe and between the nose of the Drift Tube and the pipe flange.

Mapping the BPM

The procedure for mapping a DTL BPM is as follows:

Calibrate the Boonton RF Power meter as described above.
Calibrate the wire positioning system as described above.
Remove the wire from the mapper.
Install the DTL mechanical support equipment.
Install the DTL BPM, observing any handling requirements prescribed by the Drift Tube team. Such as handling the Drift Tube with cotton gloves, etc.
Install the wire into the mapper.
Connect the cable from the HP 8640B Signal Generator to the wire.
Connect the signal cables from the BPM to the Boonton 51075 Power sensors, taking care to connect the Top, Bottom, Left, and Right electrode cables to the appropriate power sensor.
Set up the data acquisition program by typing in:

The file path/name.
The number of maps to run.
The ID of the BPM.
The current map number.
The number of data points to be taken (size of the positional step).
Select the write to file button.
Select the four data point button.
The diameter of the BPM (use 90% of the BPM bore).
The delay time (time the wire sits at position for acquisition).
Any comments appropriate may be entered as well.
Turn on the RF from the signal generator.
Run the VI.

Data Products

The data acquired by the system is the detected power level at each sensor. For each X, Y position there are four data points taken, corresponding to Top, Bottom, Left, and Right electrodes. The program will also calculate the differences between opposing electrodes as appropriate for the coordinate system being used. For example Top-Bottom (Y axis) and Left-Right (X axis) would be used for a right-handed coordinate system. The raw data file will contain the readings from all four sensors as well as the two subtracted values.

Generally ten raw data files are taken for each BPM. Past practice has been to set up the mapper by following the steps outlined above, run three maps, break down the system, start over with step 1 from above, run three more maps, break down the system a second time, start over with step 1 again, and finally run the final four maps. This allows for better statistical analysis and also highlights the repeatability of the system.

Each raw data set is then evaluated separately using the X and Y position data along with the differentiated power data along the X and Y axes, Rx and Ry. Two different types of 3rd order polynomial fits are done to the data sets. The first type is a fit done using the X and Y positions to fit the power data in terms of Rx or Ry (forward fit). The second type of fit uses the X and Y power data to fit to the X or Y position data (reverse fit). Each of these fits can be done using either 4 coefficients or 10 coefficient functions. The following table summarizes the different fits used to analyze the data.

Data Product Table		
Input	Data to fit	Result
X and Y position	Rx differentiated power	4 coefficient polynomial fit (A_0 – A_3)
		10 coefficient polynomial fit (A_0 – A_9)
X and Y position	Ry differentiated power	4 coefficient polynomial fit (B_0 – B_3)
		10 coefficient polynomial fit (B_0 – B_9)
Rx and Ry diff power	X position	4 coefficient polynomial fit (C_0 – C_3)
		10 coefficient polynomial fit (C_0 – C_9)
Rx and Ry diff power	Y position	4 coefficient polynomial fit (D_0 – D_3)
		10 coefficient polynomial fit (D_0 – D_9)

Appendix L Check off sheet for DTL BPM

BPM serial number _______________:

Item	Item description	Testing to be done	Date Complete	Initials
1	Material certification	Certification		
2	Fabricate piece part 155Y520126	Dim Inspection		
	Fabricate piece part 155Y520127	Dim Inspection		
	Fabricate piece part 155Y520147	Dim Inspection		
	Fabricate piece part 155Y520122	Dim Inspection		
	Fabricate piece part 155Y520123	Dim Inspection		
	Fabricate piece part 155Y520128	Dim Inspection		
3	KAMAN feed through	QA certification (from KAMAN)		
4	Brazing fixtures	N/A		
5	Clean parts	Verify		
6	Braze alloy material certification	Certification		
7	Braze outer cover to inner electrode	Vacuum Leak Check		
8	Braze feed through adapter to weld adapter	Vacuum Leak Check		
9	Ship parts to machine shop	N/A		
10	Machine hole in electrode	Dim Inspection		
11	Machine weld adapter to specification	Dim Inspection		
12	Ship sub-assembly to e-beam welder	N/A		
13	Welding qualification (applicable to prototype only)	Welding shop analysis		
14	Weld feed throughs to adapters	Vacuum Leak Check		
		DC resistance		
15	E-beam feed through sub-assy to cover	Vacuum Leak Check		
16	E-beam feed through center pin to electrode	DC resistance		
17	E-beam length adapter to BPM sub-assy	Vacuum Leak Check		
18	Ship assemblies to machine shop	N/A		
19	Cut BPM assembly to length based on location in Linac (serial number)	Dim Inspection		
20	Machine groove for drift tube clocking pin	Dim Inspection		
		Clean for vacuum		
21	Finished BPM and Drift Tube ship to welder	N/A		
22	Install BPM in drift tube	Verify terminations are not shorted		
		Verify SMA pin depths		
		TDR response		
		Verify terminations are not shorted		
		Verify SMA pin depths		
		Thread lock on SMA connector		
		DC resistance		
		S11 parameters		
		TDR response		
23	Weld BPM into drift tube	Vacuum Leak Check		
24	Ship assembly to machine shop	N/A		
25	Complete machine operation on drift tube	Dim Inspection		
		Vacuum cleaning		
26	Ship BPM to LANL	N/A		
27	Map assembly	Data from mapping		
		DC resistance		
		S11 parameters		
		TDR response		
28	Deliver assembly for installation in tank	N/A		
29	Install in tank	Visually inspect cables		
30	Align BPM drift tube	Offset data from alignment		
31	Ship tank to Oak Ridge	N/A		
32	Install tank in tunnel	DC resistance		
		S11 parameters		
		TDR response		