

Numi BPM Test Stand Measurements

The Beam Position Monitors (BPMs) used for the Numi beam line incorporate one pair of "split plate" electrodes. Two sizes with a similar design are used, for the Numi beam line. A small aperture (2 in Nom) referred to as the "Numi Target BPM" and a larger (3.875 Nom), BPM referred to as the "Numi Large (M18) BPM". Both have an overall length of 8.0 in. The two port BPMs are sensitive to beam position in only one plane, and therefore require that they be installed with the mechanical orientation to match the appropriate plane. The BPMs have a thick (.375 in.) "Alignment plate" attached at both ends, which are used to align the BPM in a test stand and to provide fiducials for alignment in the beam lines. Refer to file "Numi Large BPM Data Sheet" and "Numi Target BPM Data Sheet" for more design details.

The BPM are tested on a "BPM Test Stand" for performance and as a quality control check before they are installed in the beam line. The Test Stand is a semi-automated fixture that uses an RF signal on a wire in the aperture to simulate beam. It uses stepping motor tables to move the wire through a programmed grid pattern of positions in the aperture. An HP Network Analyzer is used to measure the relative amplitude of the signal on the two ports at each grid point. A PC using LabVIEW software operates the test stand controlling the motion tables, the Network Analyzer and generating a text file of the data. In the case of the Numi BPMs an average of five measurements were performed by the network analyzer at each point. The data is then transferred to an Excel spreadsheet for analysis. BPM sensitivity (or gain) and zero offset values are produced by the spreadsheets.

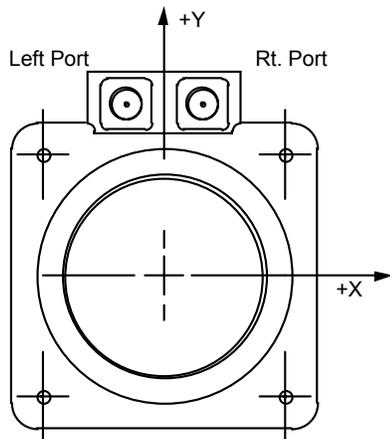
The test stand uses precision reference plates, holes and pins to locate each style of BPM. An effort is made before testing, to align the zero position of the test wire to the mechanical center of the BPM. Misalignment of the test wire or mechanical mounting deviations can be a source of offset measurement error or test stand bias. Another source of bias can be caused by an impedance mismatch between the test wire and BPM aperture. Matching transformers are used in an effort to match the 50-ohm signal cable impedance to higher wire-BPM impedance. However, as the BPMs come in various aperture sizes an optimum match is not always available. An impedance mismatch can cause RF standing waves on the test wire, which, in the case of the split plate BPM, can cause a signal "RF bias" to one side of the BPM.

In an effort to overcome possible errors produced by any "test stand bias" or an "RF bias" a routine was developed where the BPMs are measured in four orientations. The BPMs are measured in a standard orientation and then a second time rotated 180 deg. A mechanical bias caused by the test stand wire position will be a "common mode signal" and when the measurements are combined differentially, it will be canceled. The RF bias can be produced when the "split plates", which are offset axially from one another, receive a different signal from a signal on a centered wire. In this case BPM is flipped vertically, on the test stand and re-measured. The relative positions of the plates are reversed and any difference, as before, will be common mode, and when combined differentially will be canceled out. By combining all four measurements properly, the legitimate offset, the test stand bias, and the RF bias can be separated. BPMs numbered 1117, 1135, 3136, 3140, 3141, 3142, 3144, 3147, 3149, 3150, 3160, 3152, 3153, 3154, 3156, 3157, 3159, and 3160 were measured in all four orientations. BPMs numbered 3134, 3138, 3139, 3148, 3151, 3155 and 3158 were measured only in the normal orientation. The summary averages are based on the larger group, which was measured in a grid pattern, of 5 mm steps, -15 to +15 mm both axis. Refer to the files "Numi BPM Test Stand Orientations" and "Measurement Summary for more details and reference.

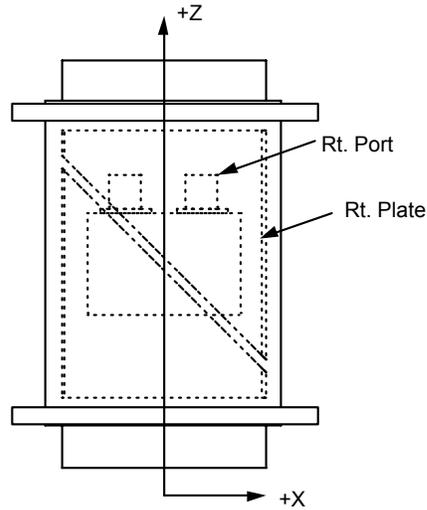
BEAM POSITION MONITOR DATA SHEET

Jim Fitzgerald
Sept. 2004

Numi Large (MI8 Style) BPM
Dwg. No. 9502.000. MB-337360



Top View as measured in test stand



Side View facing front of Test Stand

BPM Type : Split Tube, Two Electrodes, Two "N" type Ports
Overall BPM Length (Including Beam tube extensions) : 8 in.
Overall BPM Height (Including Connector Enclosure) : 7.125 in
Aperture Inside Dia. : 3.870 in., (98.290 mm)
Electrode Length : 4.5 in., (114.3) mm
Electrode Material: 4 in. OD x .065 Wall Tube, 304 S.S.
Plates Terminated : (Numi style) = 50 ohm to ground in connector housing
Housing Inside Dia.: 4.76 in.
Housing Material : 5 in. x .120 Wall Tube, 304 S.S.
Beam Tube Extensions 4 in OD x .065 Wall, 304 S.S. Tube
Alignment Hole Spacing from BPM Center Line : X Dim. = 2.375 in. , Y Dim. 2.375 in.
Alignment Hole Dia. : .2495/.2500

Test Stand Orientation Measurement Sign Convention :

The BPM was mounted on the Test Stand with orientation as shown in above "Top View" drawing, with the standard Coordinate system convention as noted.

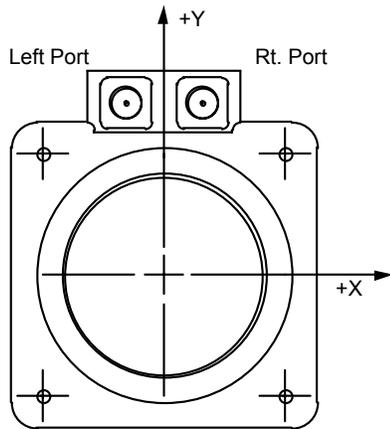
A positive value for horizontal offset indicates that the Rt. side port receives a stronger signal when the test stand wire (or Beam) is located on the BPM mechanical center as referenced by the alignment plates.

A positive value for horizontal offset value indicates that the electrical center of the BPM is actually located to the left of the mechanical center line as referenced by the alignment plate.

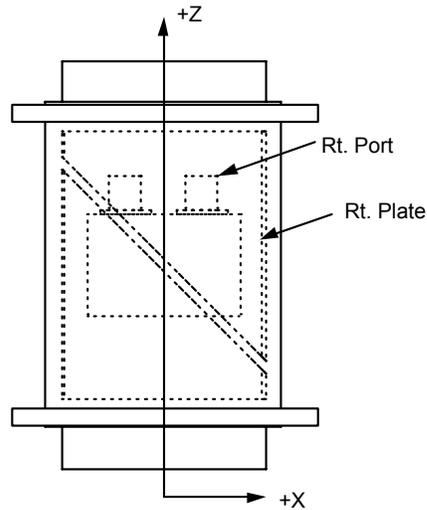
BEAM POSITION MONITOR DATA SHEET

Numi Target BPM
Dwg. No. 6755.220-MC-389238

Jim Fitzgerald
Sept. 2004



Top View as measured in test stand



Side View facing front of Test Stand

BPM Type : Split Tube, Two Electrodes, Two "N" type Ports
Overall BPM Length (Including Beam tube extensions) : 8 in.
Overall BPM Height : Including Connector Enclosure = 5.125 in
Aperture Inside Dia. : 1.995 in., (50.673 mm)
Electrode Length : 4.5 in., (114.3) mm
Electrode Material: 2.125 x .065 wall Tube, 304 S.S.
Plates Terminated : Numi style = 50 ohm to ground in connector housing
Housing Inside Dia.: 2.885 in. (73.279 mm)
Housing Material : 3.125 x .120 Wall Tube, 304 S.S.
Beam Tube Extensions : 2.125 OD x .065 Wall, 304 S.S. Tube
Alignment Hole Spacing from BPM Center Line : X Dim. = 1.6875 in., Y Dim. = 1.6875
Alignment Hole Dia. : .2495/.2500

Test Stand Orientation Measurement Sign Convention :

The BPM was mounted on the Test Stand with orientation as shown in above "Top View" drawing, with the standard Coordinate system convention as noted.

A positive value for horizontal offset indicates that the Rt. side port receives a stronger signal when the test stand wire (or Beam) is located on the BPM mechanical center as referenced by the alignment plates.

A positive value for horizontal offset value indicates that the electrical center of the BPM is actually located to the left of the mechanical center line as referenced by the alignment plate.

BPM TEST STAND
Measurement Orientations

Jim Fitzgerald
Sept. 2004

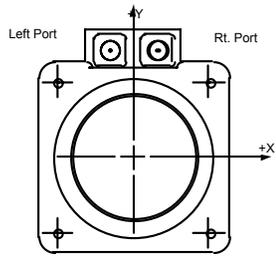
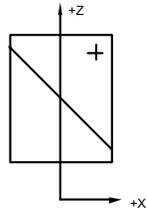
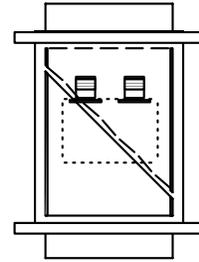


Fig. 1 GTSN
Top View as measured in Test Stand

Electrode Orientation
with sign convention



1



Side View Facing Front of Test Stand

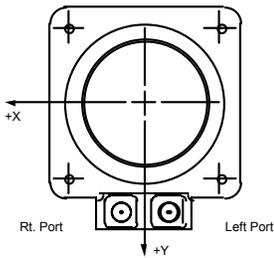
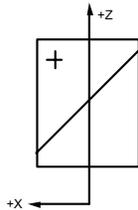


Fig. 2 GTRN



2

BPM Offset = Ave of OS (1+2+3+4)

Test Stand (wire) Bias = Ave of OS (1-2-3+4)

RF (Bias) = Ave of OS (1+2-3-4)

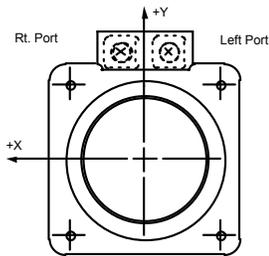
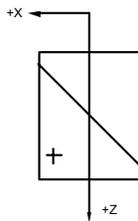


Fig. 3 GTSF



3

Legend

- G = BPM grounded with beam tube extensions
- B = Bottom feed of rf Signal to test wire
- T = Top feed of RF signal to test wire
- S = Standard, Port Housing on back side of test stand
- R = Rotated, Ports Housing of front side of test stand
- N = Normal, Connector terminals facing up
- F = Flipped, Connector terminals facing down

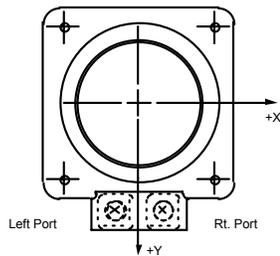
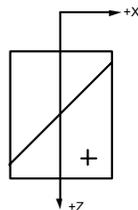


Fig. 4 GTRF



4

BPM TEST STAND DATA Numi Large (MI8) BPMs				Jim Fitzgerald Sept. 2004			
Average of 17 BPMS measured in four orientations	Ave. Sen.	Ave. Sen.		Ave. BPM	Ave. Table	Ave RF	
	db/mm	(mm/db)		Offset	Bias	Bias	
	0.245	4.088	Ave dB =	-0.005	-0.001	-0.036	
			Ave mm =	-0.021	-0.005	-0.145	
BPM No.	Sensitivity	Sensitivity	Raw Meas	BPM OS	Wire OS	RF Bias	
N-MI8 3140	(dB/mm)	(mm/dB)	dB	No chg	Chg mid 2	Chg bot 2	
3140GTSN	0.245	4.082	-0.067	-0.067	-0.067	-0.067	
3140GTRN	0.245	4.082	-0.047	-0.047	0.047	-0.047	
3140GTSF	0.245	4.082	0.013	0.013	-0.013	-0.013	
3140GTRF	0.245	4.082	-0.016	-0.016	-0.016	0.016	
	Ave 4	0.245	4.082	Ave dB	-0.029	-0.012	-0.028
				Ave mm	-0.119	-0.050	-0.113
3141GTSN	0.245	4.082	-0.015	-0.015	-0.015	-0.015	
3141GTRN	0.245	4.082	-0.009	-0.009	0.009	-0.009	
3141GTSF	0.245	4.082	0.053	0.053	-0.053	-0.053	
3141GTRF	0.245	4.082	0.048	0.048	0.048	-0.048	
	Ave 4	0.245	4.082	Ave dB	0.019	-0.003	-0.031
				Ave mm	0.079	-0.011	-0.128
3142GTSN	0.245	4.082	-0.041	-0.041	-0.041	-0.041	
3142GTRN	0.246	4.065	-0.040	-0.040	0.040	-0.040	
3142GTSF	0.245	4.082	0.024	0.024	-0.024	-0.024	
3142GTRF	0.245	4.082	0.028	0.028	0.028	-0.028	
	Ave 4	0.245	4.076	Ave dB	-0.007	0.001	-0.033
				Ave mm	-0.030	0.003	-0.136
3144GTSN	0.247	4.049	-0.049	-0.049	-0.049	-0.049	
3144GTRN	0.247	4.049	-0.070	-0.070	0.070	-0.070	
3144GTSF	0.246	4.065	0.042	0.042	-0.042	-0.042	
3144GTRF	0.246	4.065	0.058	0.058	0.058	-0.058	
	Ave 4	0.247	4.057	Ave dB	-0.005	0.009	-0.055
				Ave mm	-0.019	0.038	-0.222
3147GTSN	0.245	4.082	-0.057	-0.057	-0.057	-0.057	
3147GTRN	0.246	4.065	-0.046	-0.046	0.046	-0.046	
3147GTSF	0.245	4.082	0.027	0.027	-0.027	-0.027	
3147GTRF	0.246	4.065	-0.002	-0.002	-0.002	0.002	
	Ave 4	0.246	4.073	Ave dB	-0.020	-0.010	-0.032
				Ave mm	-0.079	-0.041	-0.130
3149GTSN	0.243	4.115	-0.042	-0.042	-0.042	-0.042	
3149GTRN	0.243	4.115	-0.048	-0.048	0.048	-0.048	
3149GTSF	0.243	4.115	0.330	0.330	-0.330	-0.330	
3149GTRF	0.244	4.098	0.040	0.040	0.040	-0.040	
	Ave 4	0.243	4.111	Ave dB	0.070	-0.071	-0.115
				Ave mm	0.288	-0.292	-0.473

BPM No.		Sensitivity (dB/mm)	Sensitivity (mm/dB)	Offset (dB)	BPM OS No chg	Wire OS Chg mid 2	RF Bias Chg bot 2
3150GTSN		0.246	4.065	-0.029	-0.029	-0.029	-0.029
3150GTRN		0.246	4.065	-0.043	-0.043	0.043	-0.043
3150GTSF		0.246	4.065	0.048	0.048	-0.048	-0.048
3150GTRF		0.246	4.065	0.060	0.060	0.060	-0.060
	Ave 4	0.246	4.065	Ave dB	0.009	0.007	-0.045
				Ave mm	0.037	0.026	-0.183
3152GTSN		0.245	4.082	-0.047	-0.047	-0.047	-0.047
3152GTRN		0.245	4.082	-0.290	-0.290	0.290	-0.290
3152GTSF		0.245	4.082	0.087	0.087	-0.087	-0.087
3152GTRF		0.245	4.082	0.071	0.071	0.071	-0.071
	Ave 4	0.245	4.082	Ave dB	-0.045	0.057	-0.124
				Ave mm	-0.183	0.232	-0.505
3153GTSN		0.244	4.098	-0.054	-0.054	-0.054	-0.054
3153GTRN		0.245	4.082	-0.042	-0.042	0.042	-0.042
3153GTSF		0.245	4.082	0.016	0.016	-0.016	-0.016
3153GTRF		0.244	4.098	0.004	0.004	0.004	-0.004
	Ave 4	0.245	4.087	Ave dB	-0.019	-0.006	-0.029
				Ave mm	-0.078	-0.025	-0.119
3154GTSN		0.245	4.082	-0.044	-0.044	-0.044	-0.044
3154GTRN		0.245	4.082	-0.036	-0.036	0.036	-0.036
3154GTSF		0.245	4.082	0.035	0.035	-0.035	-0.035
3154GTRF		0.245	4.082	0.030	0.030	0.030	-0.030
	Ave 4	0.245	4.082	Ave dB	-0.004	-0.003	-0.036
				Ave mm	-0.015	-0.013	-0.148
3157GTSN		0.246	4.065	-0.056	-0.056	-0.056	-0.056
3157GTRN		0.246	4.065	-0.066	-0.066	0.066	-0.066
3157GTSF		0.246	4.065	0.012	0.012	-0.012	-0.012
3157GTRF		0.246	4.065	0.009	0.009	0.009	-0.009
	Ave 4	0.246	4.065	Ave dB	-0.025	0.002	-0.036
				Ave mm	-0.103	0.007	-0.145
3159GTSN		0.244	4.098	-0.024	-0.024	-0.024	-0.024
3159GTRN		0.244	4.098	-0.035	-0.035	0.035	-0.035
3159GTSF		0.244	4.098	0.043	0.043	-0.043	-0.043
3159GTRF		0.244	4.098	0.051	0.051	0.051	-0.051
	Ave 4	0.244	4.098	Ave dB	0.009	0.005	-0.038
				Ave mm	0.036	0.019	-0.157
3160GTSN		0.246	4.065	-0.028	-0.028	-0.028	-0.028
3160GTRN		0.246	4.065	-0.009	-0.009	0.009	-0.009
3160GTSF		0.246	4.065	0.058	0.058	-0.058	-0.058
3160GTRF		0.246	4.065	0.042	0.042	0.042	-0.042
	Ave 4	0.246	4.065	Ave dB	0.016	-0.009	-0.034
				Ave mm	0.064	-0.036	-0.139

BPM No.		Sensitivity (dB/mm)	Sensitivity (mm/dB)	Offset (dB)	BPM OS No chg	Wire OS Chg mid 2	RF Bias Chg bot 2
1117GTSN		0.244	4.098	0.033	0.033	0.033	0.033
1117GTRN		0.244	4.098	0.024	0.024	-0.024	0.024
1117GTSF		0.244	4.098	-0.045	-0.045	0.045	0.045
1117GTRF		0.244	4.098	-0.036	-0.036	-0.036	0.036
	Ave 4	0.244	4.098	Ave dB	-0.006	0.005	0.035
				Ave mm	-0.025	0.018	0.141
		(dB/mm)	(mm/dB)	(dB)	No chg	Chg mid 2	Chg bot 2
3136GTSN		0.244	4.098	-0.081	-0.081	-0.081	-0.081
3136GTRN		0.244	4.098	-0.105	-0.105	0.105	-0.105
3136GTSF		0.244	4.098	-0.004	-0.004	0.004	0.004
3136GTRF		0.244	4.098	-0.007	-0.007	-0.007	0.007
	Ave 4	0.244	4.098	Ave dB	-0.049	0.005	-0.044
				Ave mm	-0.202	0.022	-0.179
3156GTSN		0.244	4.098	-0.025	-0.025	-0.025	-0.025
3156GTRN		0.245	4.082	-0.038	-0.038	0.038	-0.038
3156GTSF		0.245	4.082	0.036	0.036	-0.036	-0.036
3156GTRF		0.245	4.082	0.019	0.019	0.019	-0.019
	Ave 4	0.245	4.086	Ave dB	-0.002	-0.001	-0.030
				Ave mm	-0.008	-0.004	-0.121
3135GTSN		0.244	4.098	0.033	0.033	0.033	0.033
3135GTRN		0.244	4.098	0.024	0.024	-0.024	0.024
3135GTSF		0.244	4.098	-0.045	-0.045	0.045	0.045
3135GTRF		0.244	4.098	-0.036	-0.036	-0.036	0.036
	Ave 4	0.244	4.098	Ave dB	-0.006	0.005	0.035
				Ave mm	-0.025	0.018	0.141
1135GTSN		0.238	4.202	-0.951	-0.951	-0.951	-0.951
1135GTRN		0.240	4.167	-0.278	-0.278	0.278	-0.278
1135GTSF		0.239	4.184	-0.856	-0.856	0.856	0.856
1135GTRF		0.240	4.167	-0.826	-0.826	-0.826	0.826
Rejected	Ave 4	0.240	4.172	Ave dB	-0.728	-0.161	0.113
				Ave mm	-3.037	-0.671	0.473

The BPMs listed below were measured only in the normal orientation					
BPM No.		Sensitivity (dB/mm)	Sensitivity (mm/dB)	BPM Offset (dB)	Rot Deg.
3148		0.247	4.049	-0.016	-0.180
3138		0.245	4.082	-0.011	-0.420
3139		0.247	4.049	0.014	-0.034
3158		0.244	4.098	0.012	0.900
3155		0.248	4.032	0.012	-0.920
3151		0.244	4.098	0.001	-0.500
3134		0.244	4.098	0.044	-0.500

BPM TEST STAND DATA					Jim Fitzgerald		
Numi Target BPMs					Sept. 2004		
Ave. of 5 Target BPMs measured in four orientations	Ave. Sen.	Ave. Sen.		Ave. OS	Ave. OS	Ave. OS	
	db/mm	(mm/dB)		(dB)	(mm)	(mm)	
	0.558	1.792	Ave dB	0.000	-0.007	0.034	
			Ave mm	0.000	-0.013	0.061	
BPM No.	Sensitivity	Sensitivity	Raw Meas	BPM OS	Wire OS	RF Bias	
	(dB/mm)	(mm/dB)	dB	No chg	Chg mid 2	Chg bot 2	
111GTSN	0.556	1.799	0.045	0.045	0.045	0.045	
111GTRN	0.556	1.799	0.048	0.048	-0.048	0.048	
111GTSF	0.556	1.799	-0.011	-0.011	0.011	0.011	
111GTRF	0.555	1.802	-0.013	-0.013	-0.013	0.013	
	Ave 4	0.556	1.799	Ave dB	0.017	-0.001	0.029
				Ave mm	0.031	-0.002	0.053
112GTSN	0.557	1.792	-0.005	-0.005	-0.005	-0.005	
112GTRN	0.558	1.799	-0.001	-0.001	0.001	-0.001	
112GTSF	0.556	1.795	-0.050	-0.050	0.050	0.050	
112GTRF	0.557	1.795	-0.081	-0.081	-0.081	0.081	
	Ave 4	0.557	1.795	Ave dB	-0.034	-0.009	0.031
				Ave mm	-0.061	-0.016	0.056
113GTSN	0.557	1.795	0.069	0.069	0.069	0.069	
113GTRN	0.557	1.795	0.085	0.085	-0.085	0.085	
113GTSF	0.557	1.795	0.000	0.000	0.000	0.000	
113GTRF	0.556	1.799	-0.013	-0.013	-0.013	0.013	
	Ave 4	0.557	1.796	Ave dB	0.035	-0.007	0.042
				Ave mm	0.063	-0.013	0.075
114GTSN	0.564	1.773	0.027	0.027	0.027	0.027	
114GTRN	0.564	1.773	0.066	0.066	-0.066	0.066	
114GTSF	0.564	1.773	-0.022	-0.022	0.022	0.022	
114GTRF	0.563	1.776	-0.054	-0.054	-0.054	0.054	
	Ave 4	0.564	1.774	Ave dB	0.004	-0.018	0.042
				Ave mm	0.008	-0.031	0.075
115GTSN	0.554	1.805	0.004	0.004	0.004	0.004	
115GTRN	0.554	1.805	0.000	0.000	0.000	0.000	
115GTSF	0.555	1.802	-0.044	-0.044	0.044	0.044	
115GTRF	0.563	1.776	-0.054	-0.054	-0.054	0.054	
	Ave 4	0.557	1.797	Ave dB	-0.024	-0.002	0.026
				Ave mm	-0.042	-0.003	0.046
BPM No.	Sensitivity	Sensitivity	Raw Meas	BPM OS	Wire OS	RF Bias	
	(dB/mm)	(mm/dB)					