# DESIGN OF STRIPLINE BEAM POSITION MONITORS FOR THE ESS MEBT

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There will be overall 8 Beam Position Monitors (BPM) installed in MEBT of ESS. Seven of them will be used for the measurement of beam position, phase and intensity. One BPM will be used for the fast timing characterization of the chopped beam. The design is based on shortened stripline to accommodate the signal level for low velocity proton beam within MEBT read by electronics. Due to mechanical space limits, all the BPMs are embedded inside quadrupoles; which requires special care on the magnetic properties of the materials within BPM sets and in particular the feedthroughs. The prototype electromagnetic and mechanical design is finished and its fabrication is underway. This paper gives an overview of the electromagnetic and mechanical design and related analysis including position signal sensitivity of the BPMs.

Table 1: MEBT BPM related beam parameters

| Parameter | Value | Unit |
|---|---|---|
| Beam energy | 3.62 | MeV |
| Beam current (avg.) | 62.5 | mA |
| Particles/bunch | 1.1e9 | |
| Readout frequency | 704 | MHz |
| rf frequency | 352 | MHz |
| Bunch length | 60-180 | ps |
| Pulse length (max.) | 2.8 | ms |

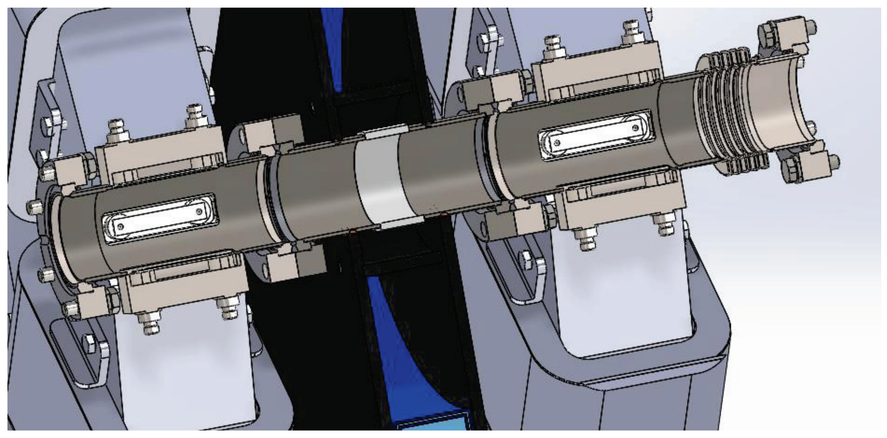

Figure 1: A CAD image of two BPM blocks embedded within two adjacent quadrupole magnets.

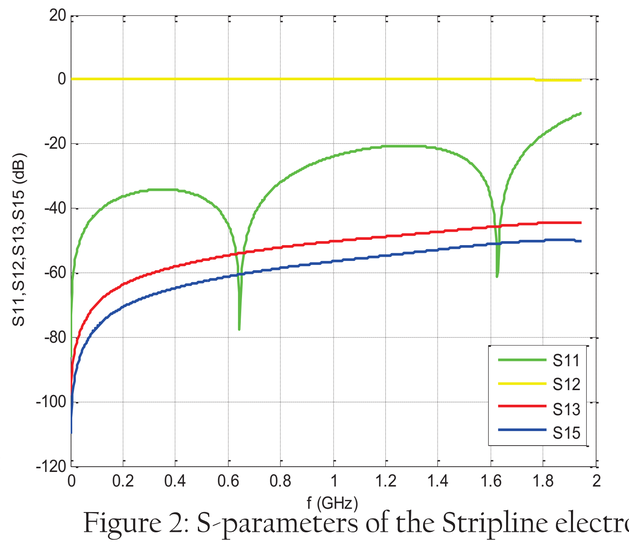


Figure 2: S-parameters of the Stripline electrode

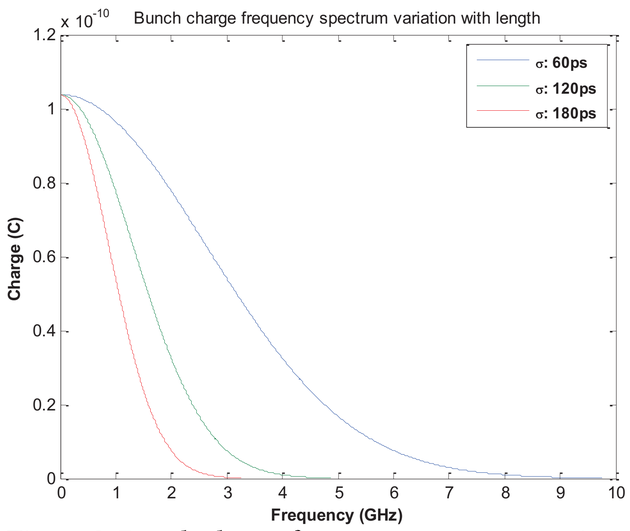


Figure 3: Bunch charge frequency spectrum variation for various bunch length in MEBT

## Linearity and displacement sensitivity

Simulation has been carried out for various scenarios of off-centre beam. The beam displacement (mm) with quanta of 1mm up to 9mm shows a linear variation of the strip voltage up to 3mm with a sensitivity of 45 mV/mm as total voltage (including all frequency components). From 3mm to 9 mm the total voltage amplitude (mV) starts to change from linear to slight quadratic fitting of $6.7x^2+29x+295$.

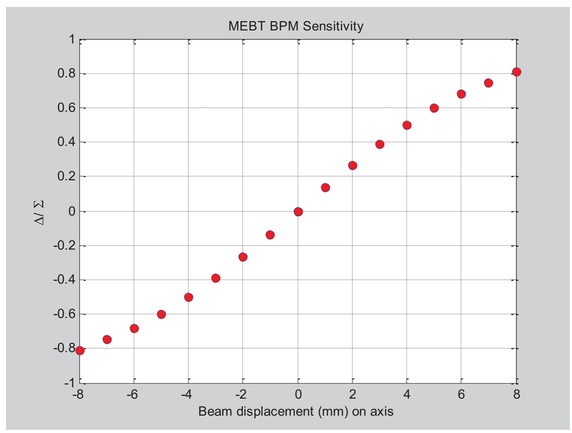


Figure 4: Delta over sigma

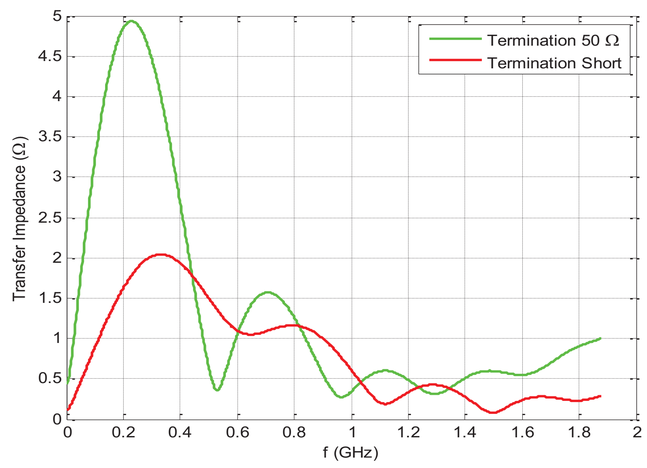


Figure 5: Transfer impedance for 50Ω (green) and short termination (red) vs. frequency component of bunch. Strip length pp: 36 mm

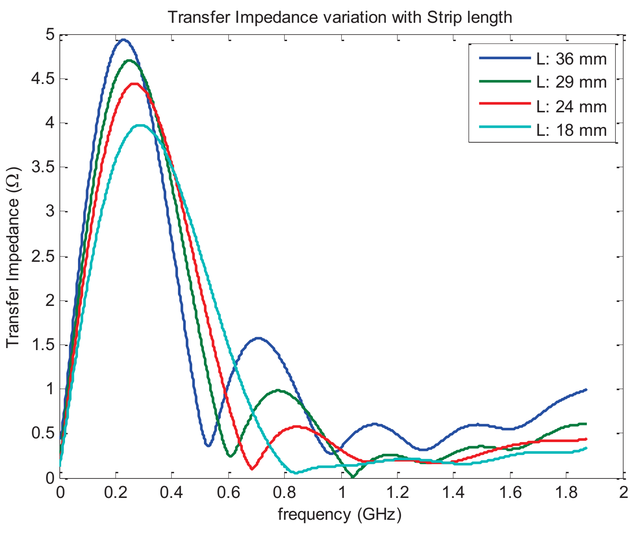


Figure 6: Transfer impedance for 50Ω termination vs. frequency for various lengths of strip

Table 2: Stripline voltage amplitude variation with bunch length at 3.62 MeV

| Bunch length (σ) | Voltage pk |
|---|---|
| 180 ps | 295 mV |
| 150 ps | 302 mV |
| 120 ps | 308 mV |
| 105 ps | 320 mV |
| 60 ps | 340 mV |

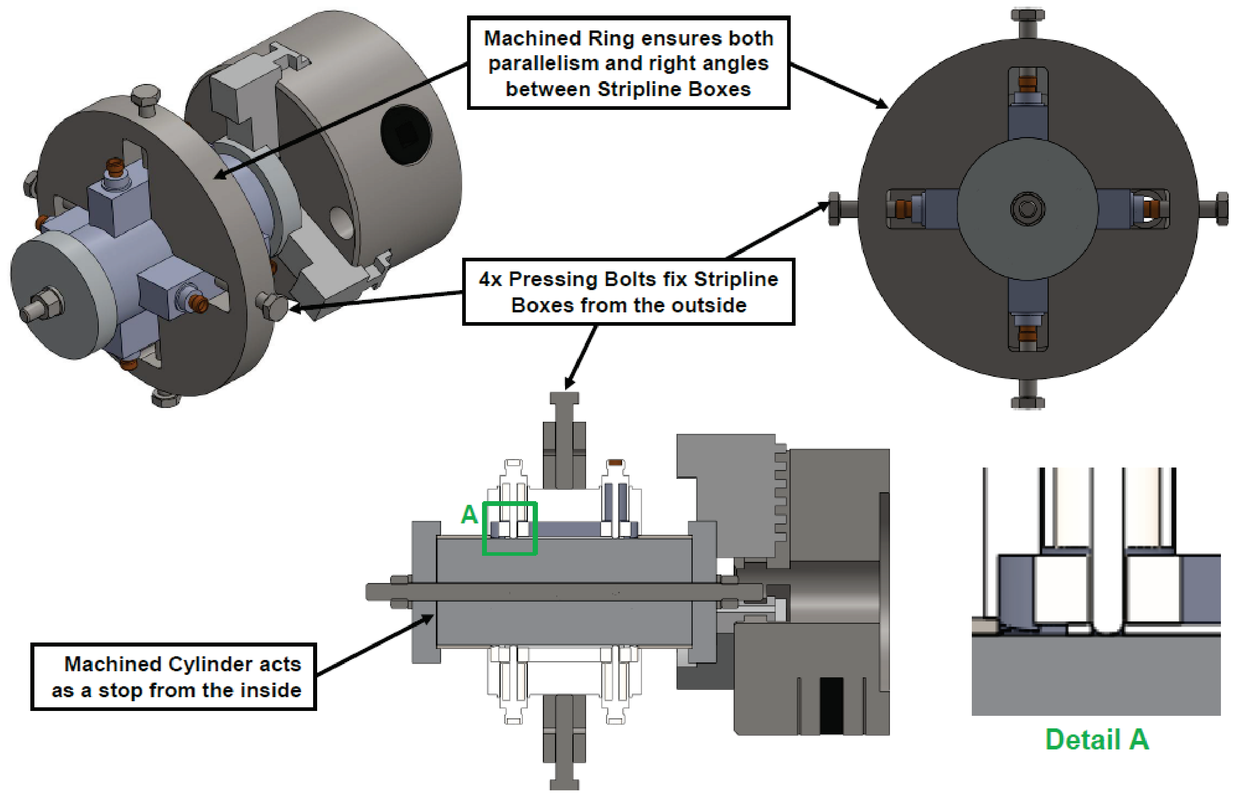


Figure 7 : Fabrication tools for linear and angular alignment/welding.

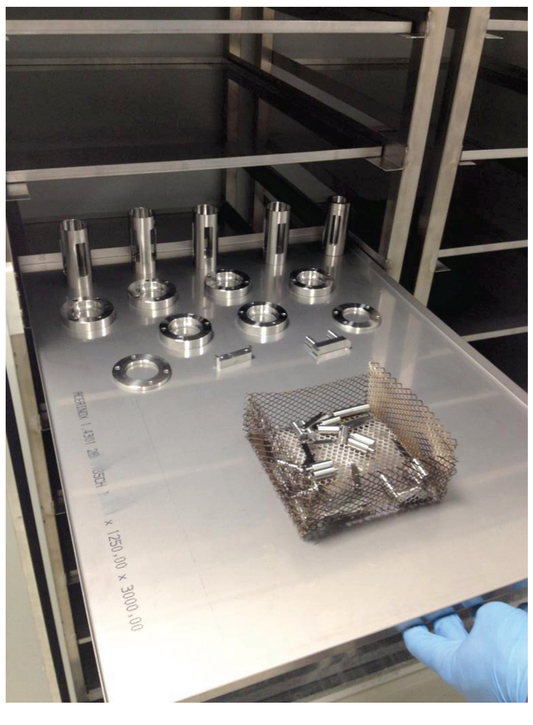

Figure 8: Vacuum cleaning and treatment of BPM components in Oven before welding

## MECHANICAL PROTOTYPE

A mechanical prototype is under fabrication at ESS-Bilbao. Several issues are investigated during the production, including the magnetic properties of materials after welding process, RF parameters of the ports, mechanical tolerances, vacuum leakage, e-beam welding process of the pieces, fabrication alignment, temperature stability and other related electrical measurements. The feedthrough, strips and body material is stainless steel and all the welding is based on e-beam. The tolerances vary between 5 µm of the ceramic spacer to 20 µm of the body outer diameter. The tight tolerances help to minimize possible errors from the fabrication part on the overall performance of the BPM blocks. Due to tight mechanical integration of MEBT components, the rotatable CF flanges on both sides of the block has been foreseen, which eases the screwing of the BPM blocks to upstream and downstream components.