Beam Positioning Monitors

Timothy Suzuki
Graduate Student
suzukit@frib.msu.edu

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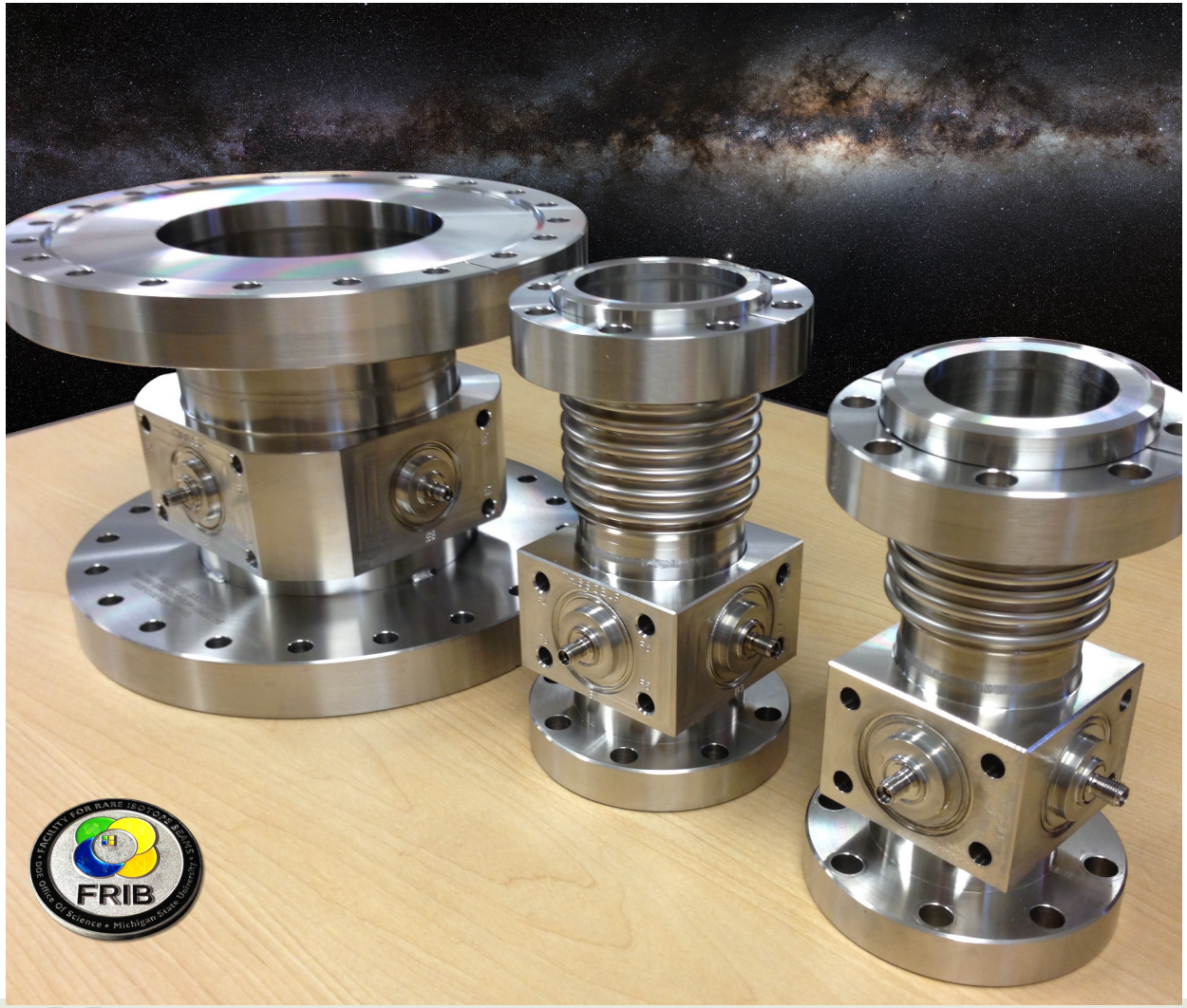
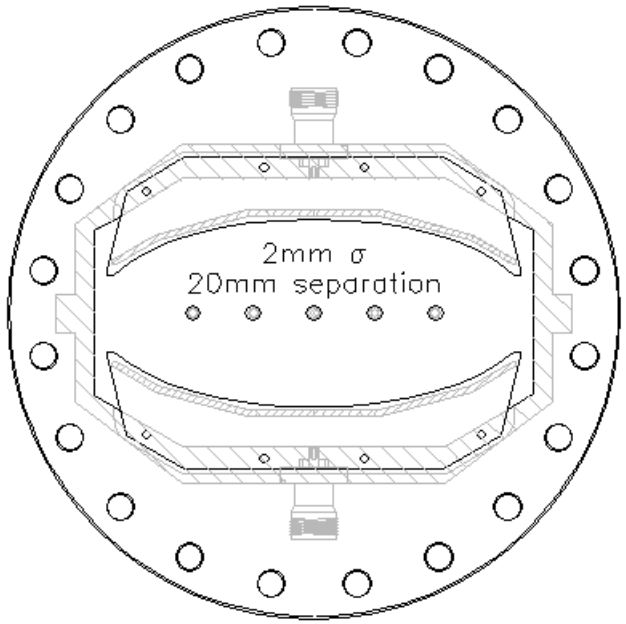
Geometry

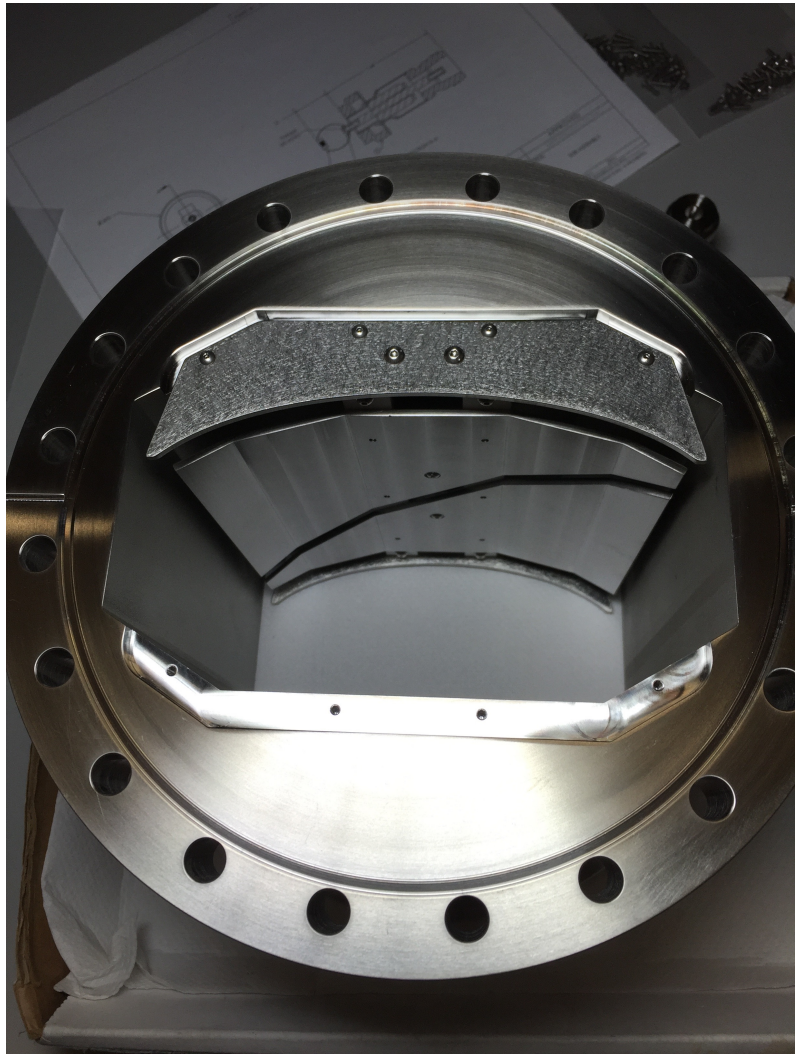


- 20 mm diameter buttons
- Left to right
  - 98.3 mm ID
  - 47.6 mm ID
  - 41.3 mm ID
- Not in picture
  - 71.2 mm ID

Elliptical

- Split plate



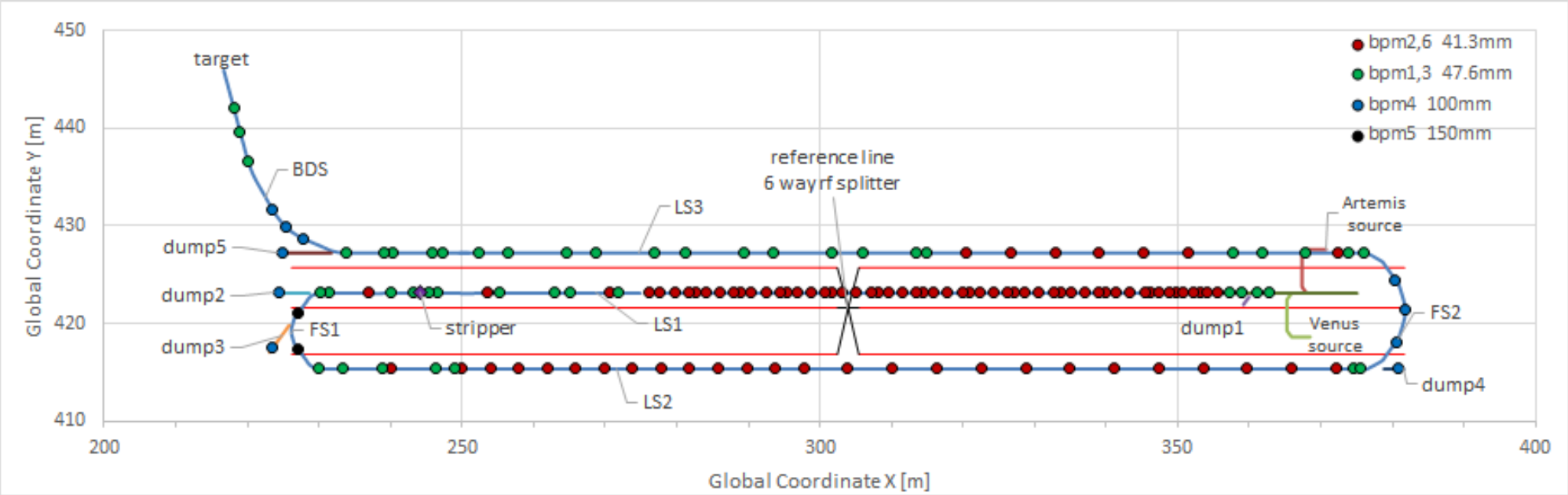


Types, Locations

Type	Diameter	Count
bpm2/6	41.3	89
bpm1/3	47.6	48
bpm4	98.3	11
bpm5	62x145	2
bpm7	71.2	2
Total		152

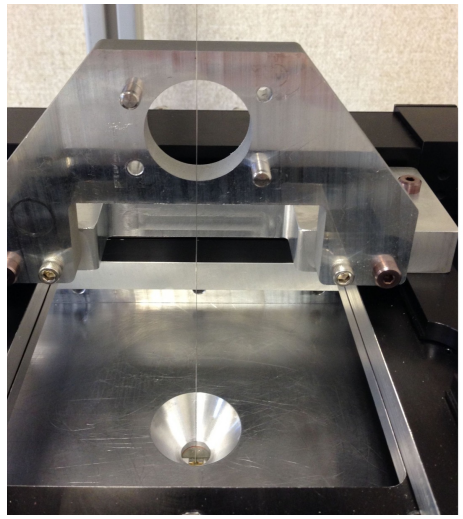
Button

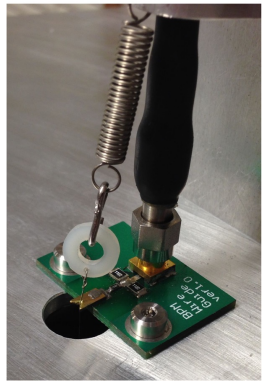
Elliptical

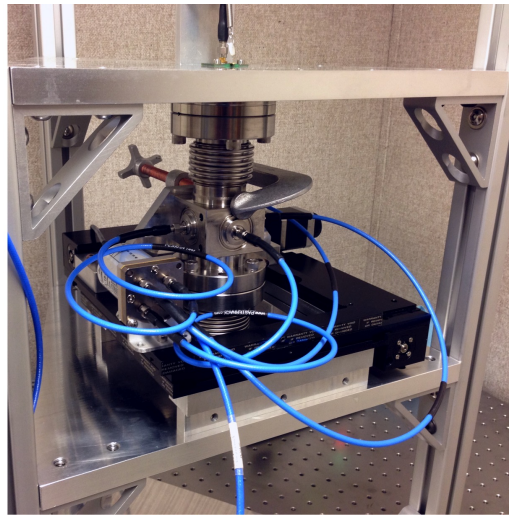


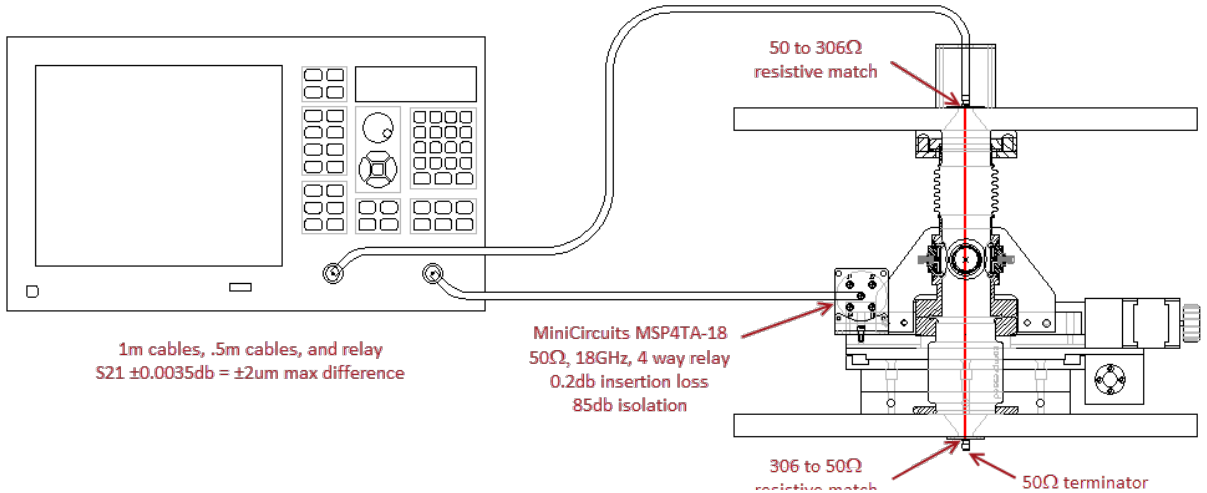
Test Stand

- Current through the wire simulates beam
- Table moves BPM to predetermined positions based on BPM ID
- At each position, each button measures a signal in units of dB
- Signal data is sent to network analyzer through SMA cables and recorded in MATLAB



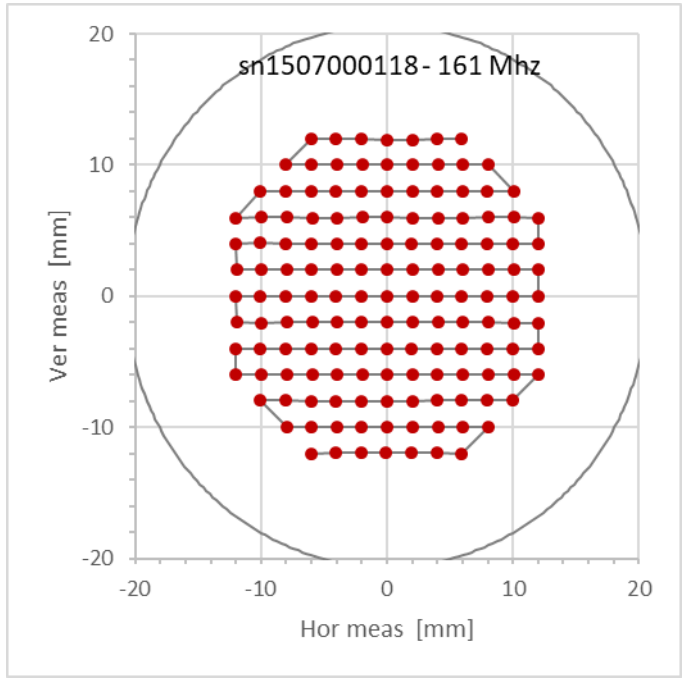


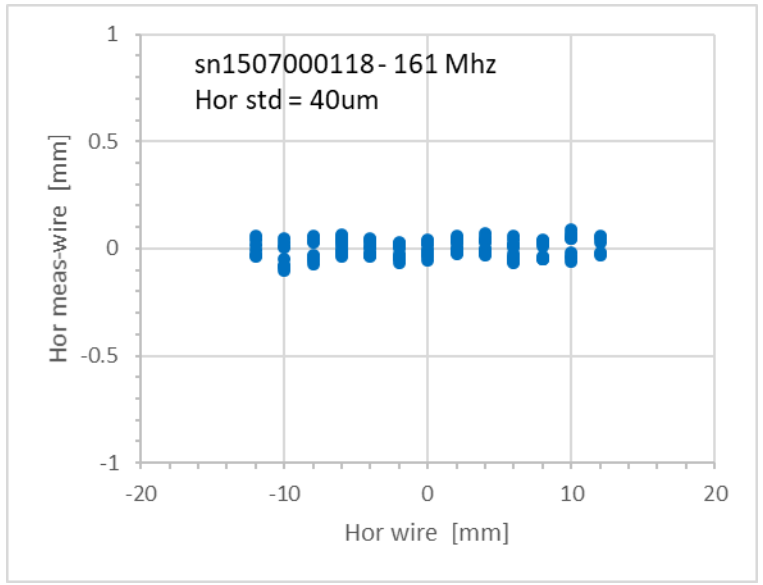


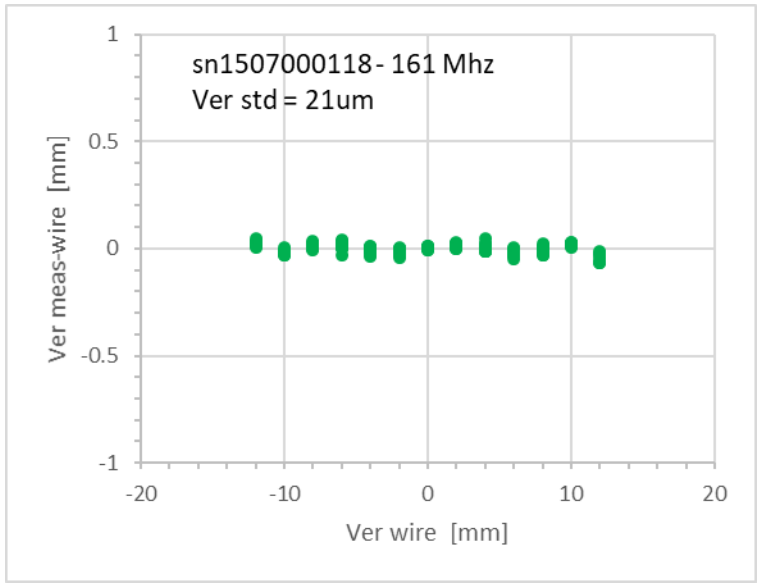


BPM Scan Example

- 41.3 mm ID
- 161 MHz

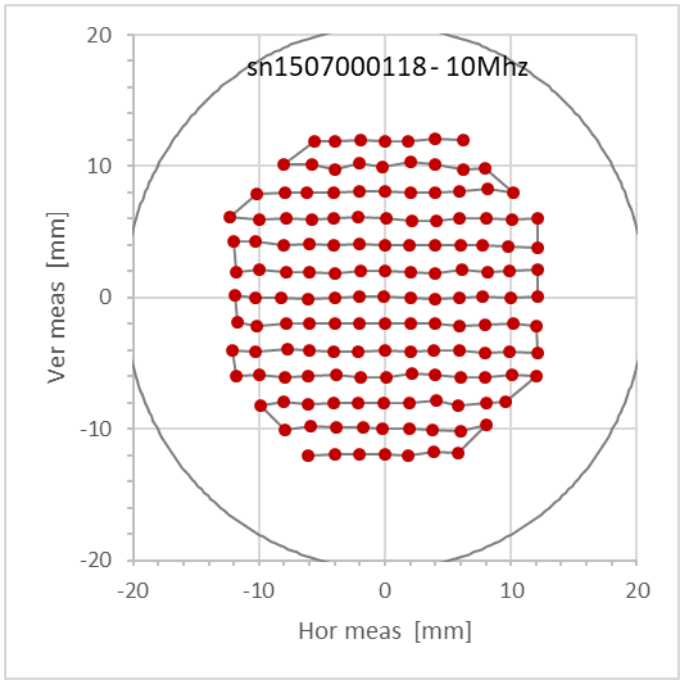


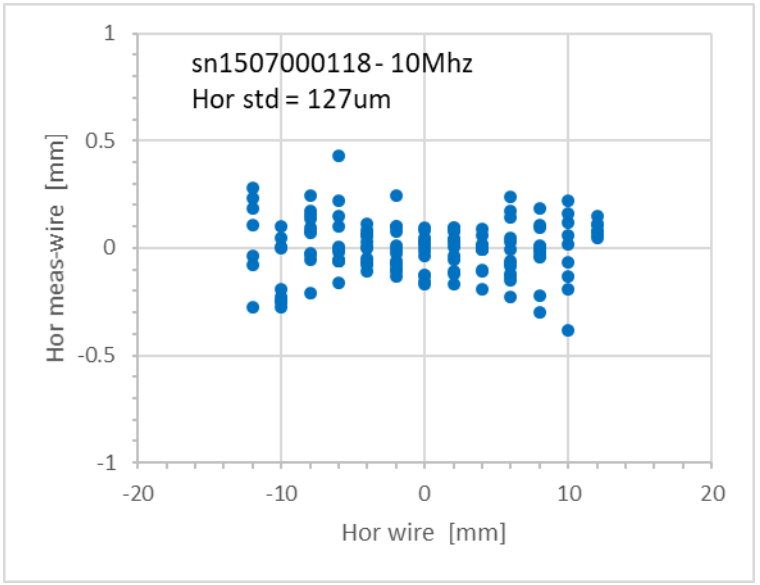


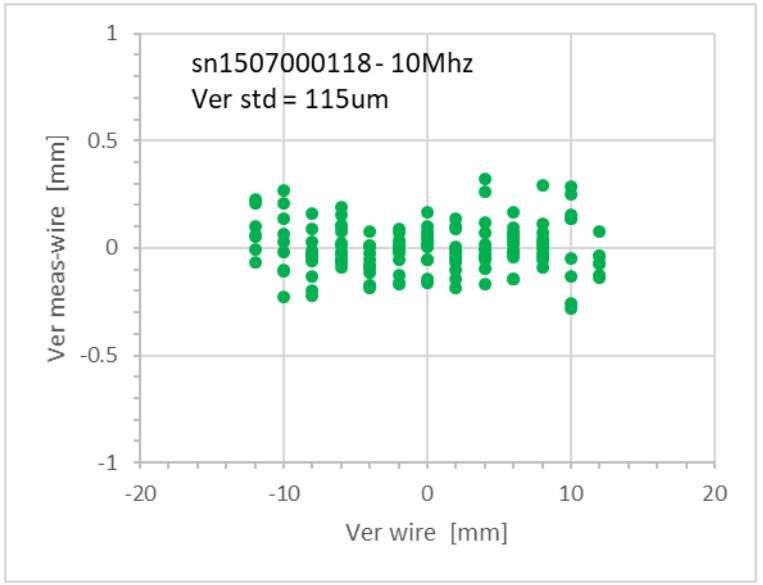


Low Frequency BPM Scan

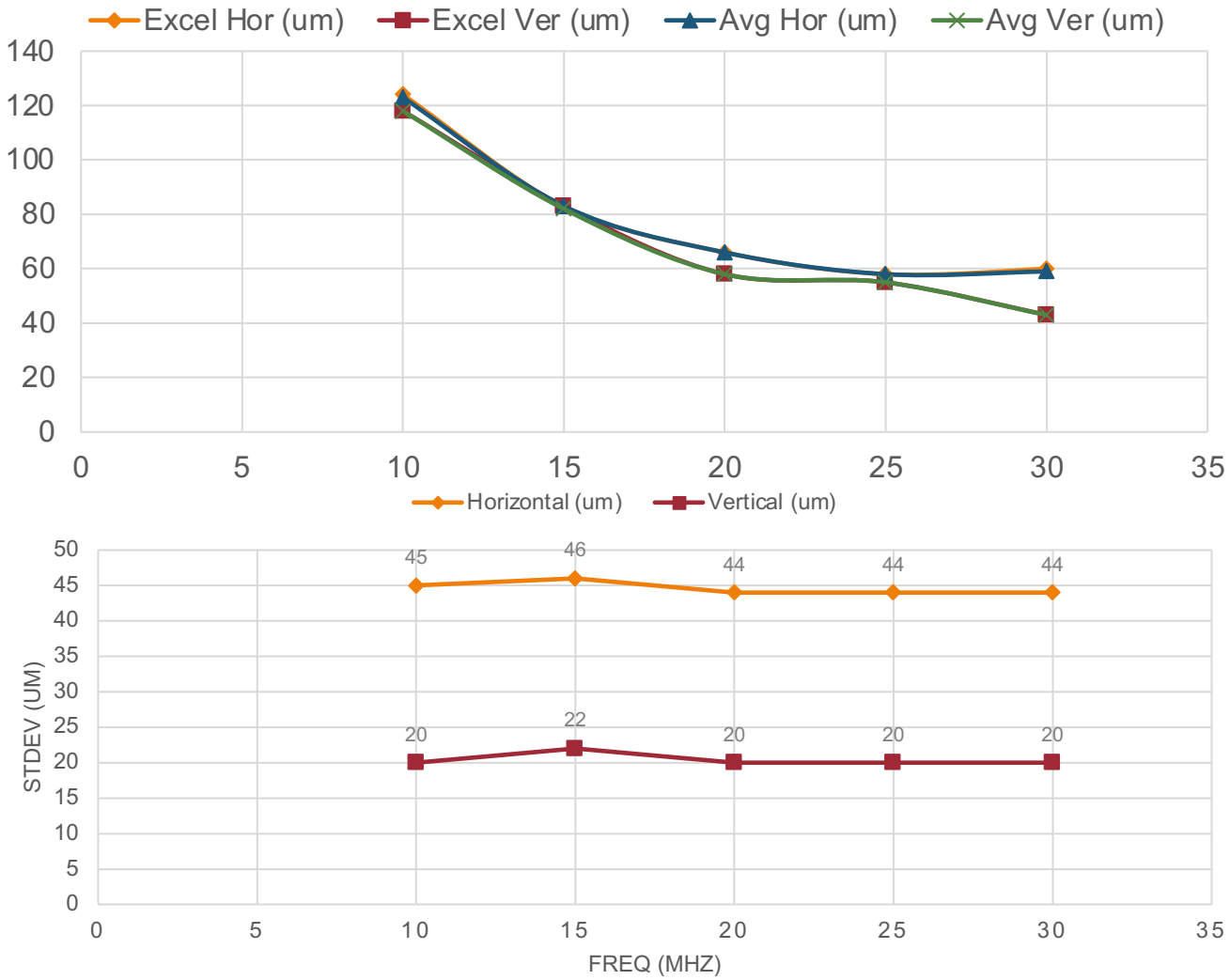
- 41.3 mm ID
- 10 MHz



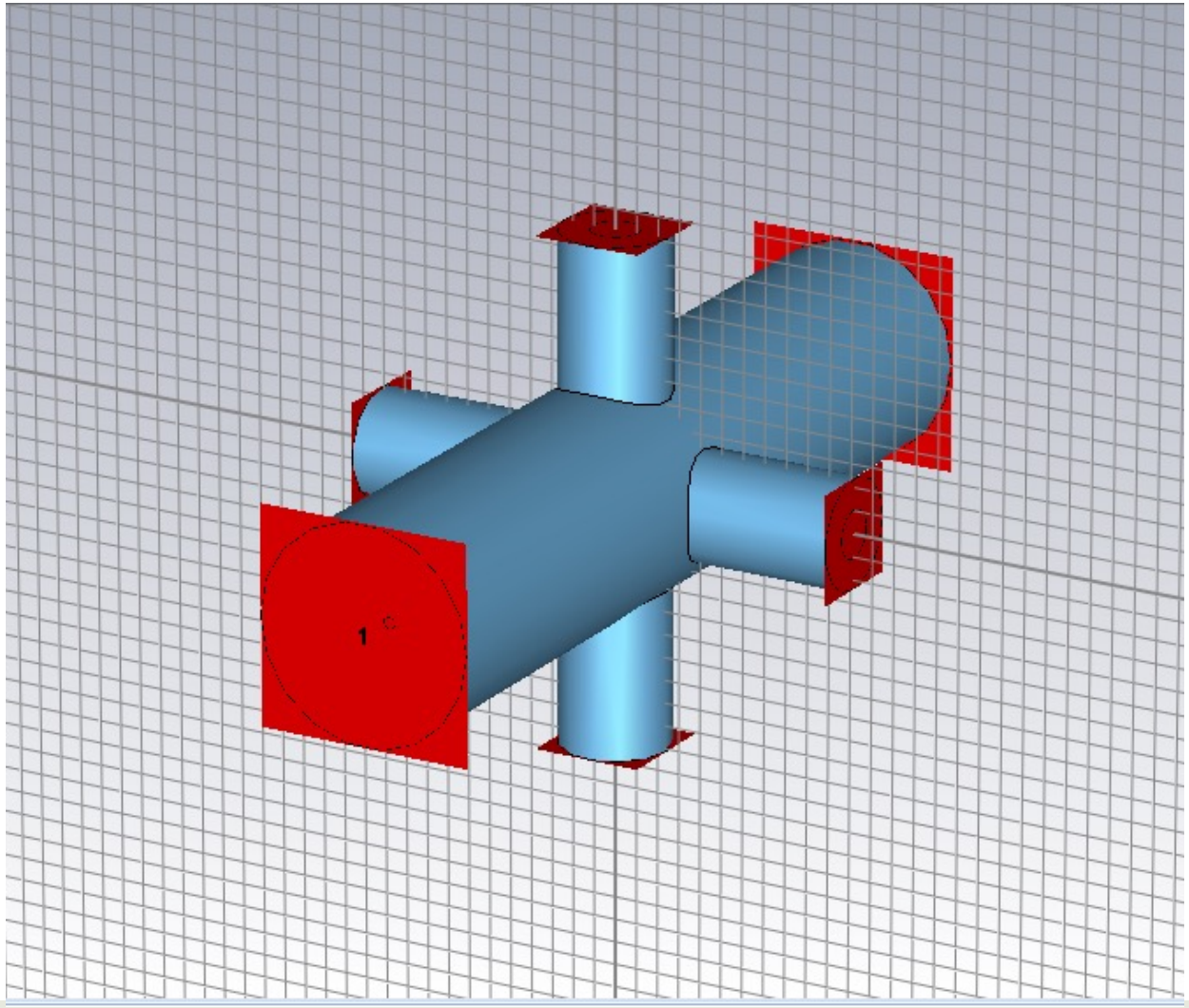


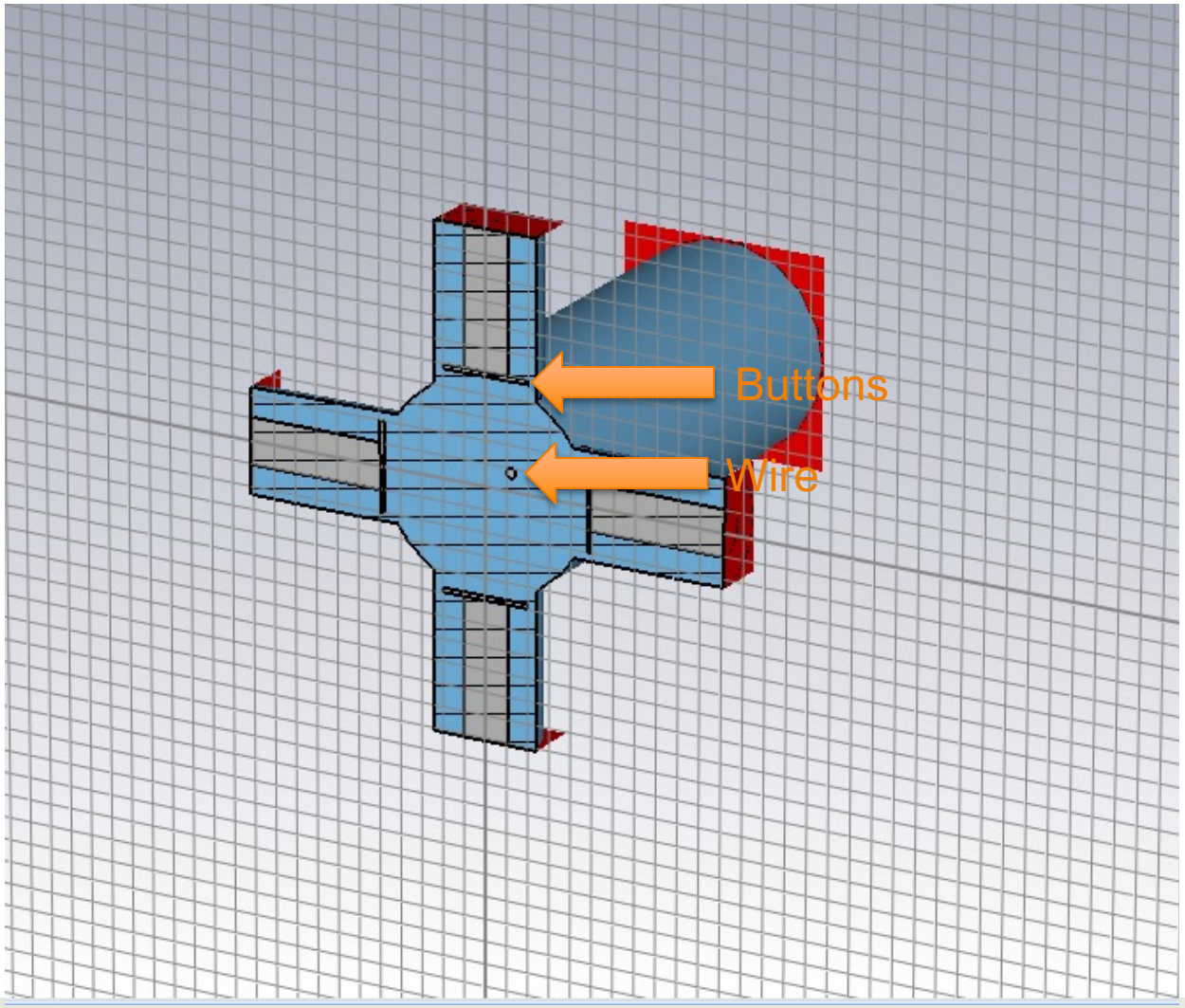


Signal Amplification

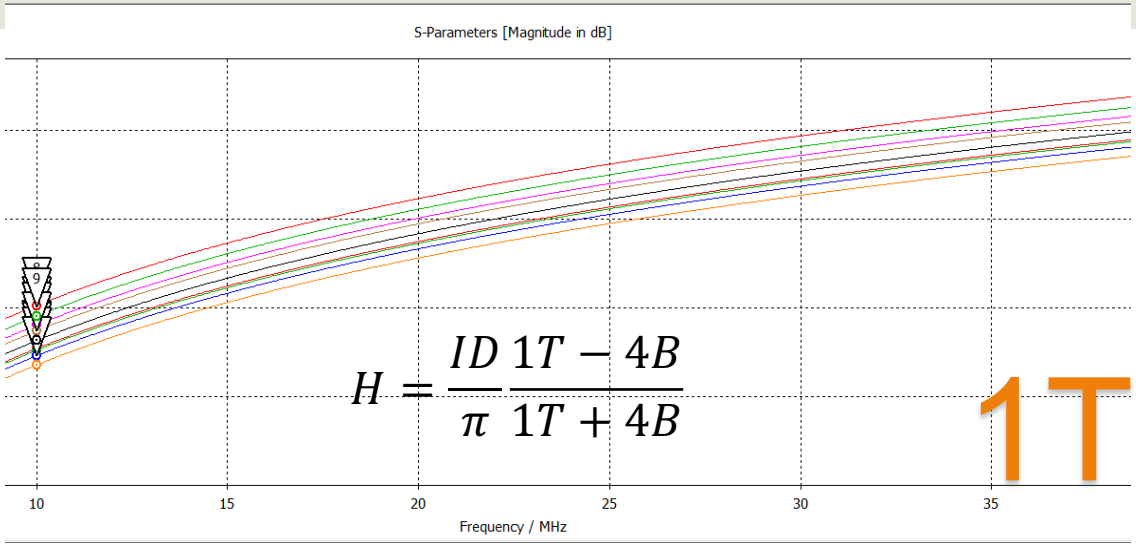


CST Studio



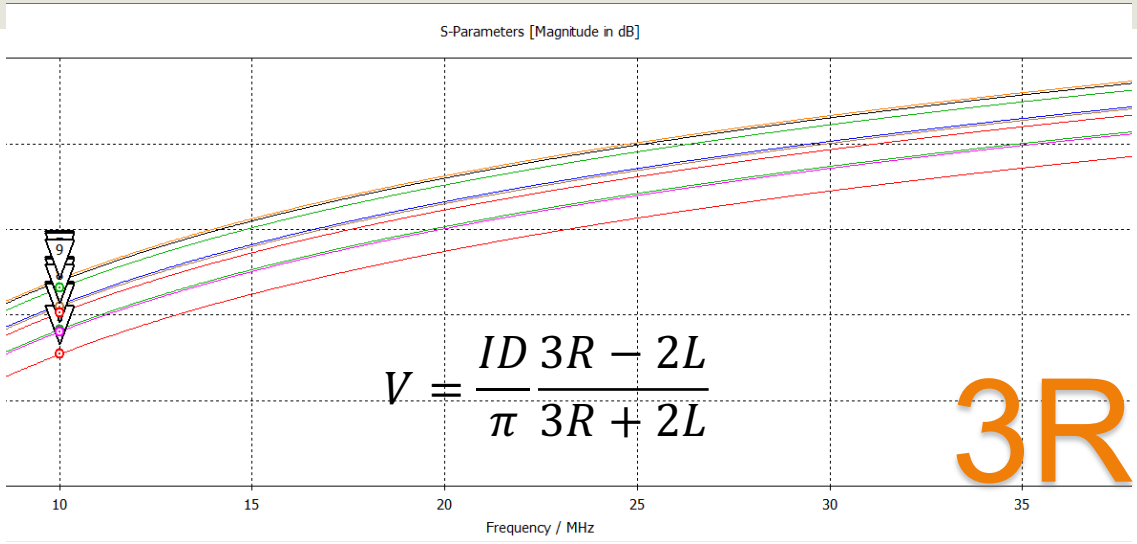


CST Studio 2



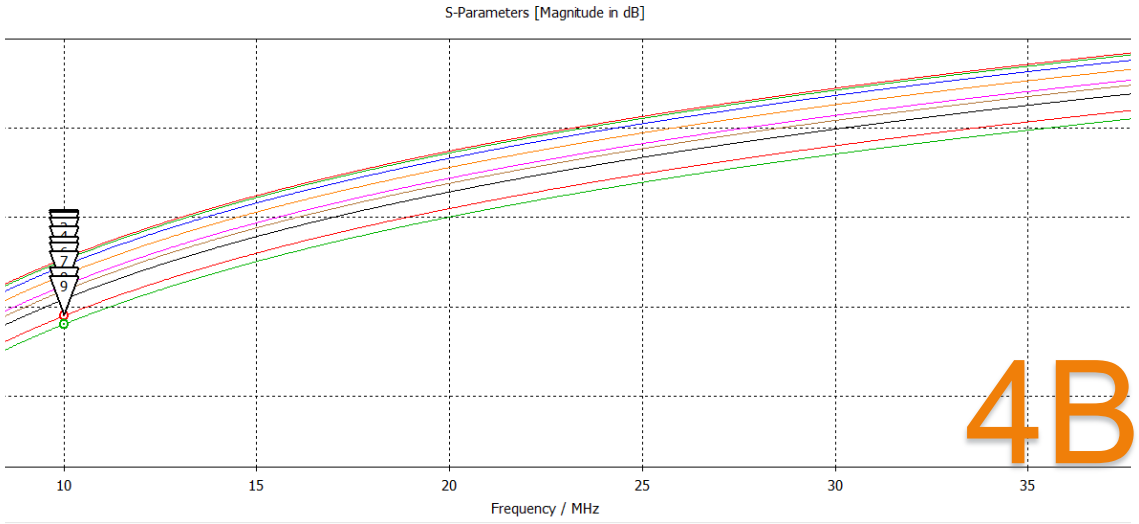
$$H = \frac{ID}{\pi}\frac{1T - 4B}{1T + 4B}$$

1T

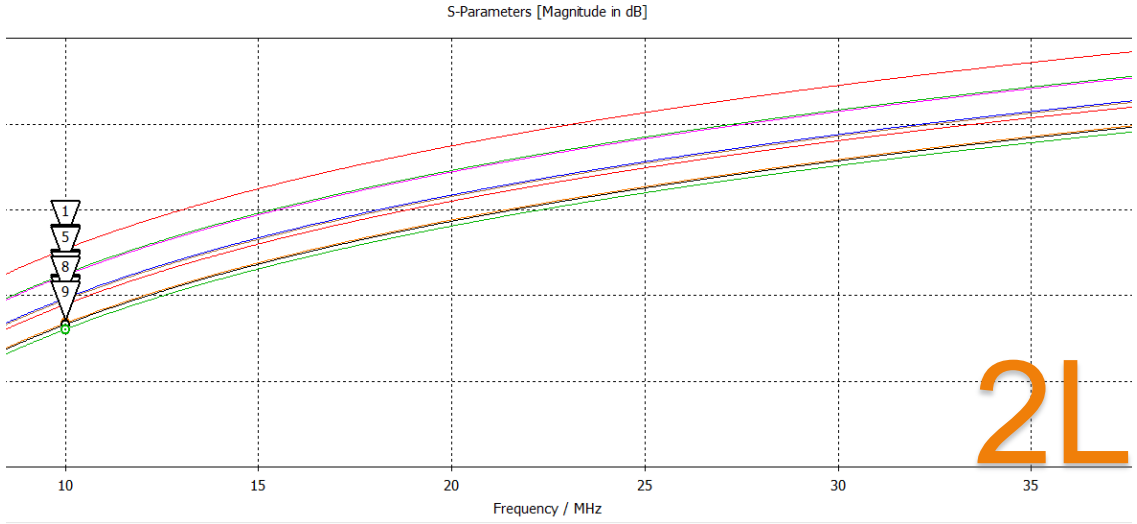


$$V = \frac{ID}{\pi}\frac{3R - 2L}{3R + 2L}$$

3R



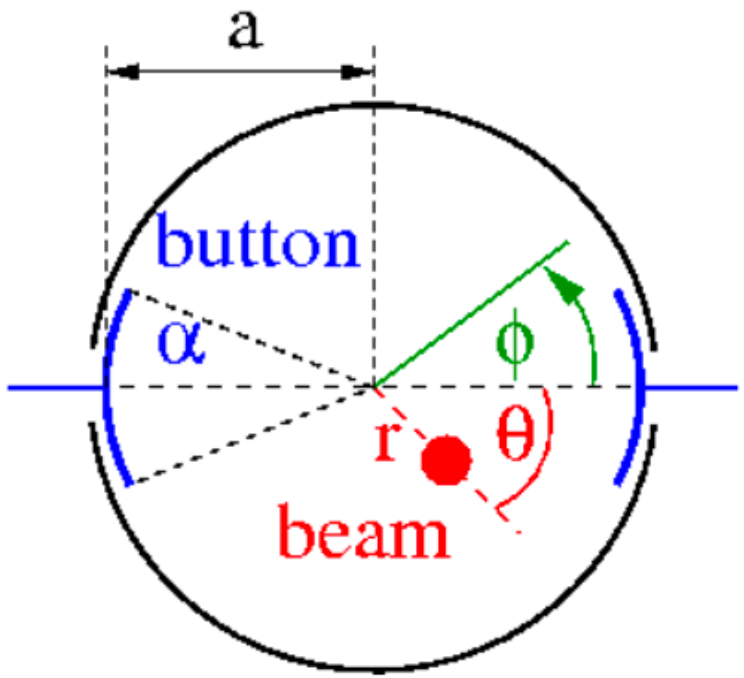
4B



2L

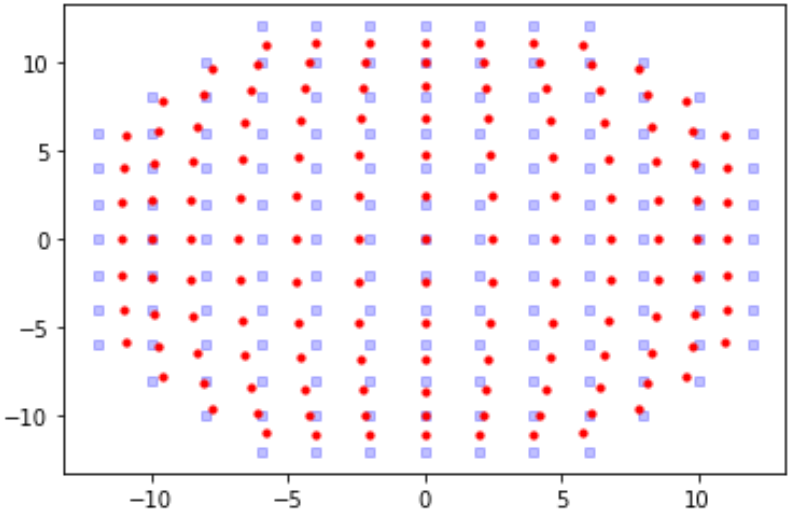
Analytical Model

- Calculate image current on the buttons
  - $j_{im} = \frac{I_{beam}}{2\pi a}\left(\frac{a^2-r^2}{a^2+r^2-2racos(\phi-\theta)}\right)$
  - $I_{im} = \int_{-\alpha/2}^{\alpha/2} a j_{im} d\phi$
- Model BPM as a circuit and calculate the voltage signal
  - $Re[V] = \frac{I_{im}R}{1+(\omega RC)^2}$
  - $H = \frac{ID}{\pi}\frac{1T-4B}{1T+4B}$
  - $V = \frac{ID}{\pi}\frac{3R-2L}{3R+2L}$

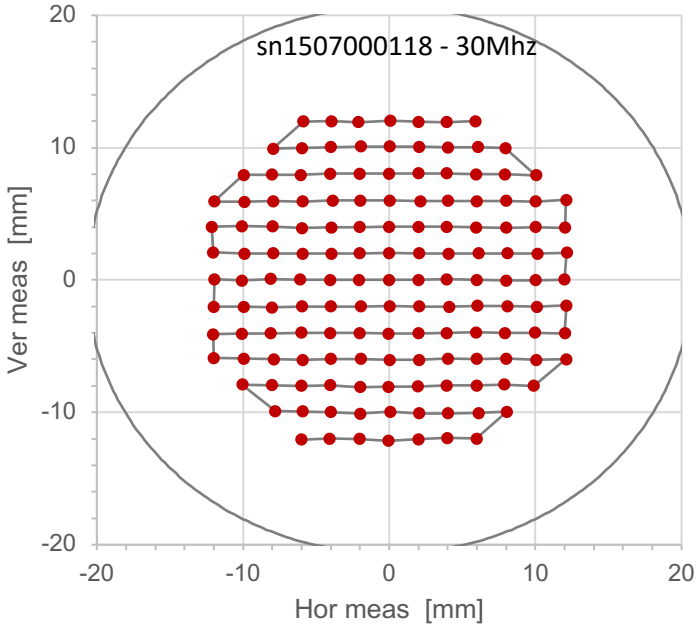


Summary

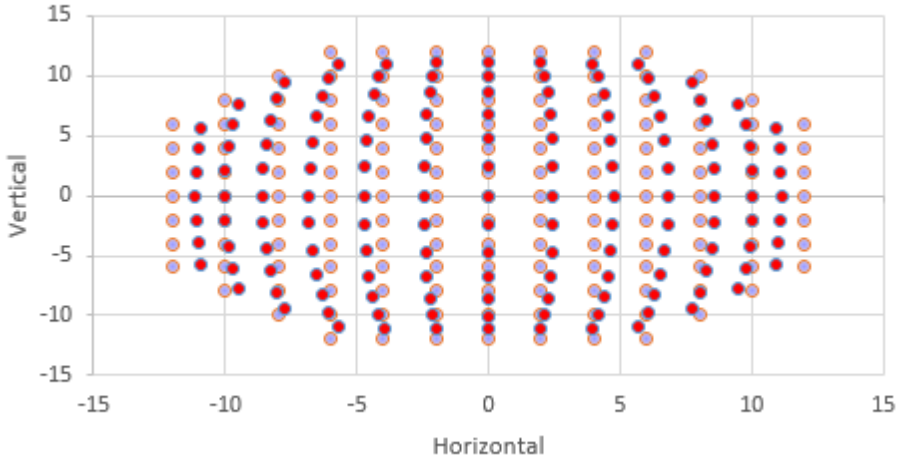
Analytical Calculation



Test Stand Measurement



CST Simulation



References

- Specification for FRIB BPM Button Electrode Assemblies FRIB-T31203-SP-000155
- FRIB Primary Beam Diagnostics Requirements FRIB-T31201-SP-000021
- FRIB BPM System Functional Requirements FRIB-T31203-SP-000239
- Cold Beam Position Monitor Installation, Integration, and Validation Plan
- FRIB Cold BPM Prototype Test Plan FRIB-T31203-SP-000182
- SOW for Steel Jacketed Cables for Cold BPMs FRIB-T30601-PD-000597
- bpms_ap PowerPoint