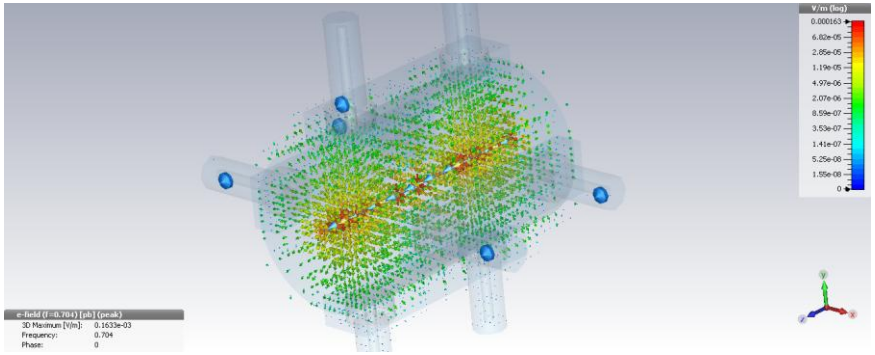
BPM & BCT design developments



Seadat Varnasseri

10-11/02/2016

ESS Beam Diagnostics Forum, ESS , Lund

BPM Design Strategy

In order to converge to the current design we needed to consider several factors:

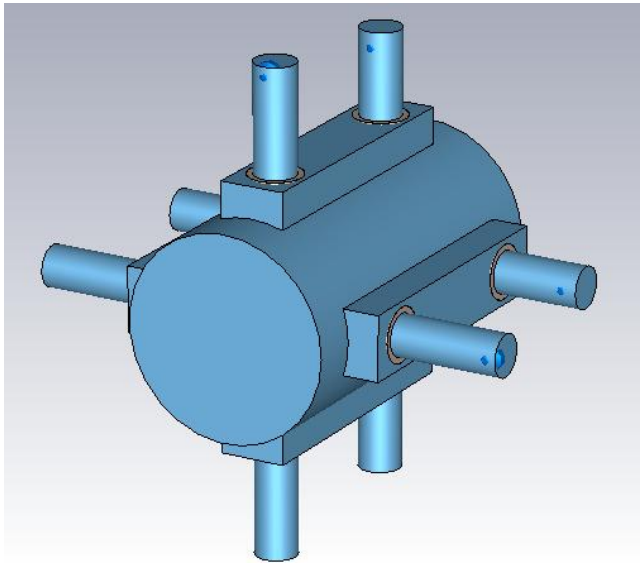
- Beam parameters and characteristics (Energy, current, bunch length,…)
- Producing enough voltage
- Matching the ports to outside cables/electronics
- Mechanical restrictions:
  - Transverse due to quadrupole pole profile
  - Longitudinal due to maximum length available

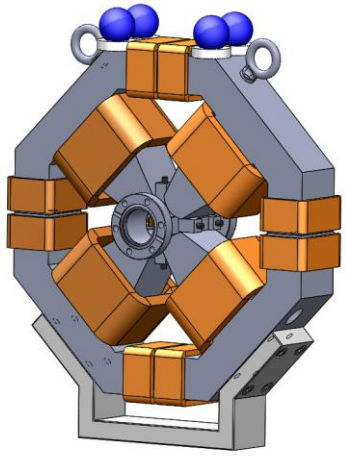
- Fabrication and alignment issues
- Other restrictions like non-magnetic material for feedthroughs or welding process in order not to produce magnetic modifications close to quadrupole magnet

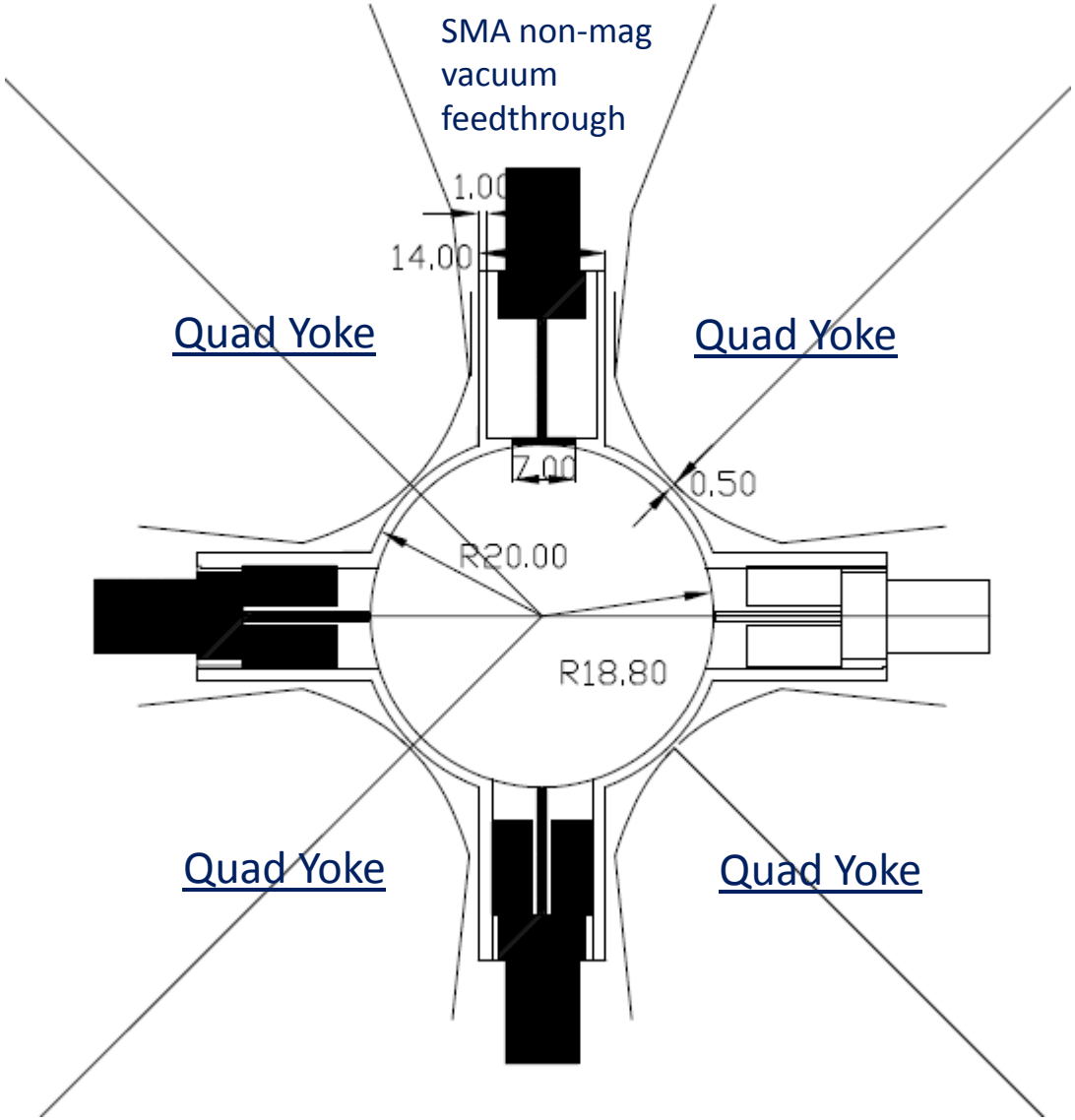
History of MEBT BPM :

- A report on the analytical analysis (2014)
- A report on frequency 352, 704 MHz
- A skype meeting for discussion (2015)

Mechanical boundaries and restrictions

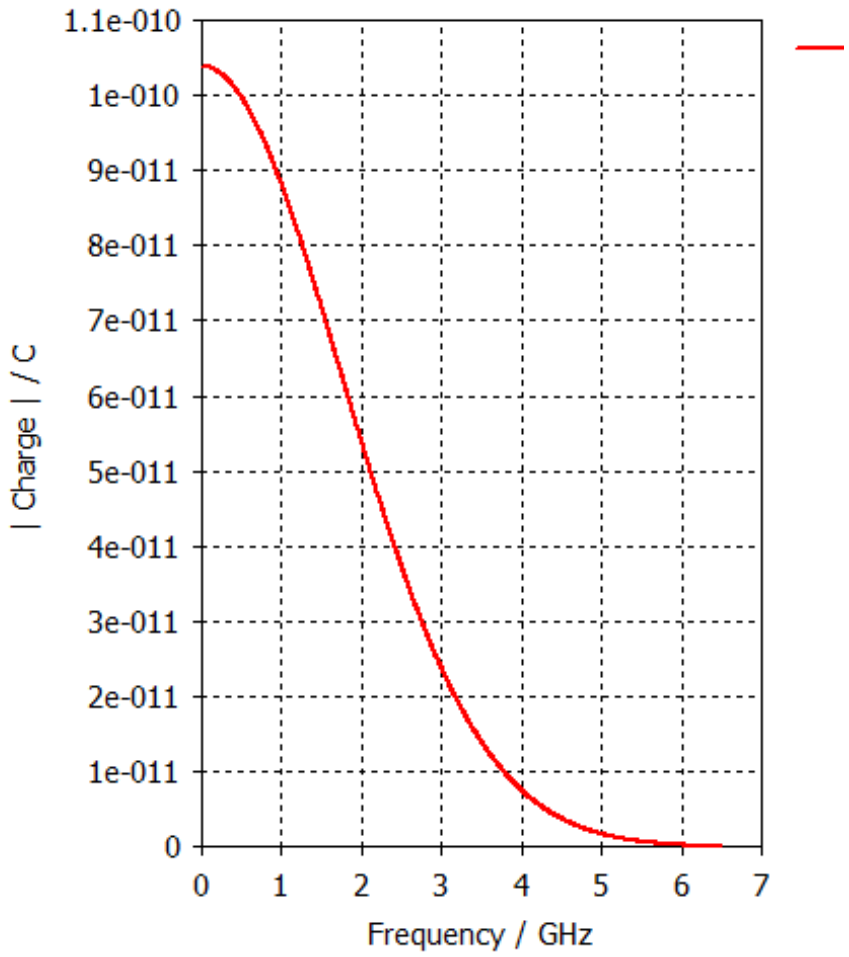




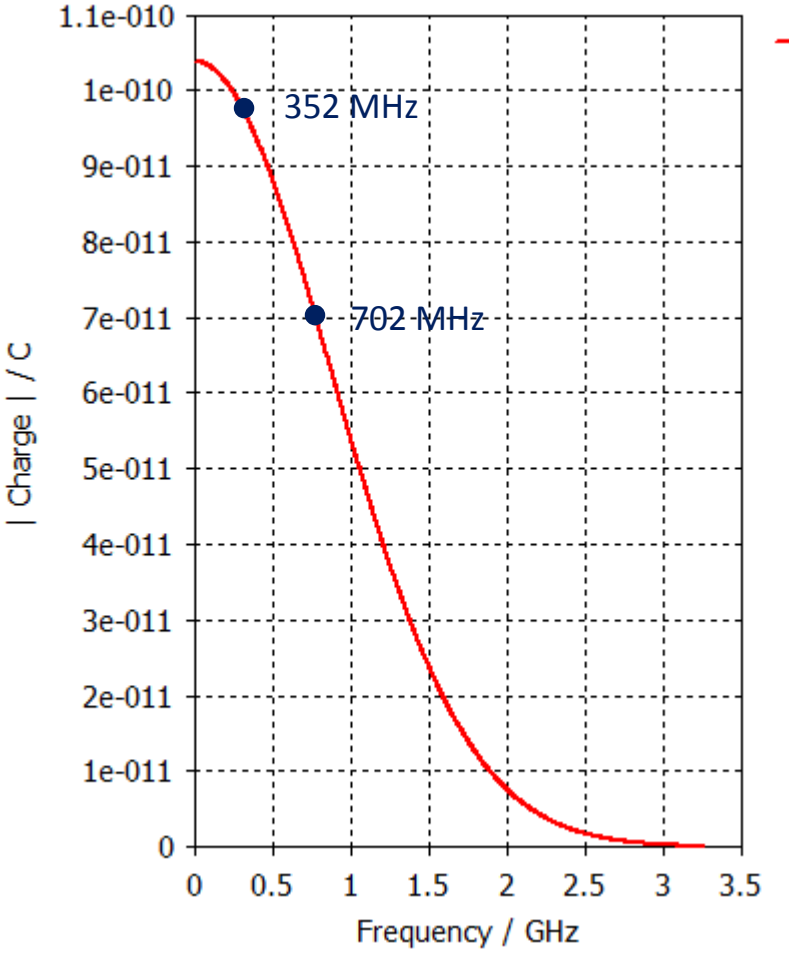


Beam bunch charge spectrums in MEBT (β=0.088)

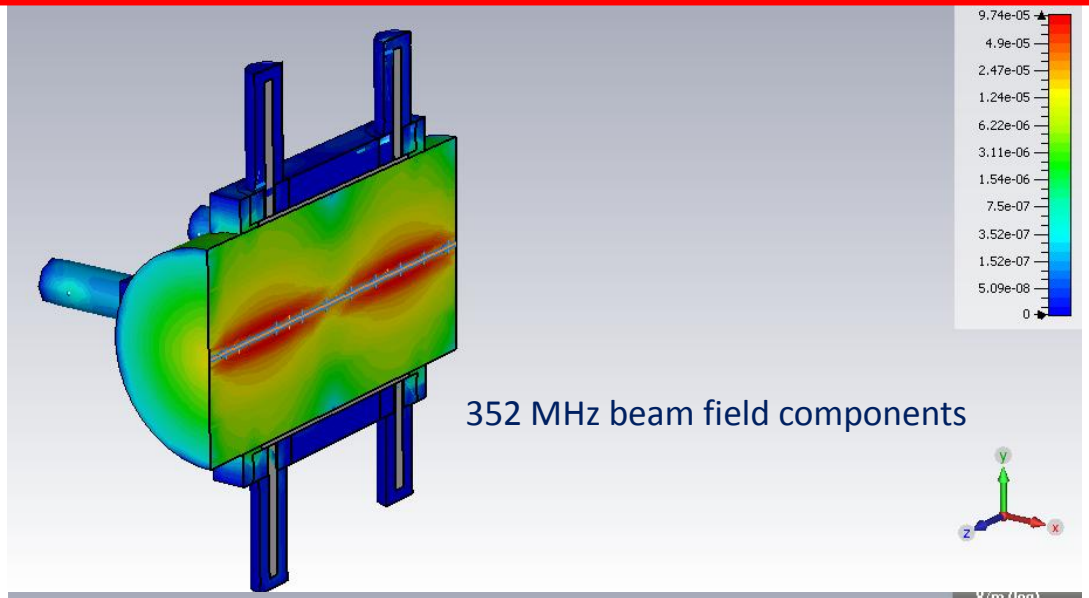
Charge spectrum at v=0.088c, σ=0.09ns



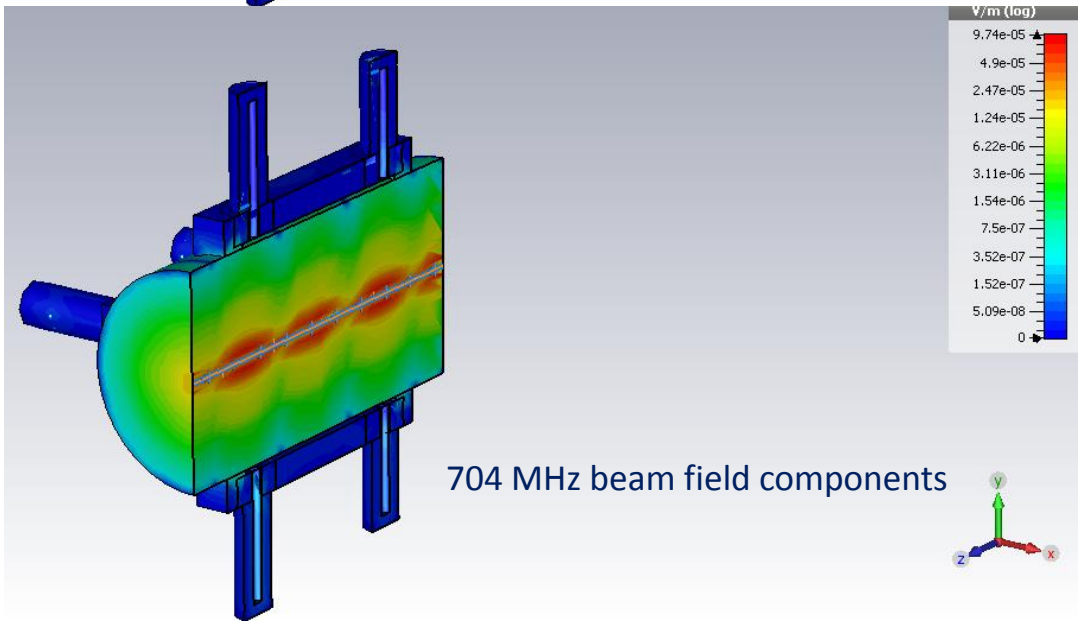
Charge spectrum at v= 0.088c, σ=0.18ns



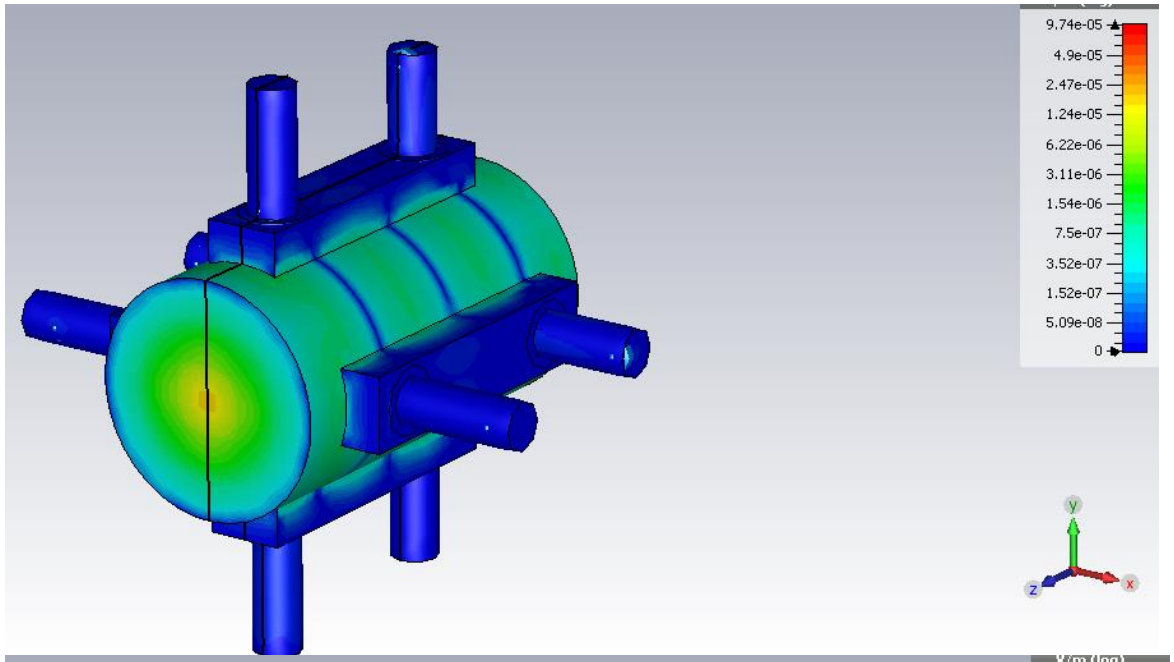
Beam components felt

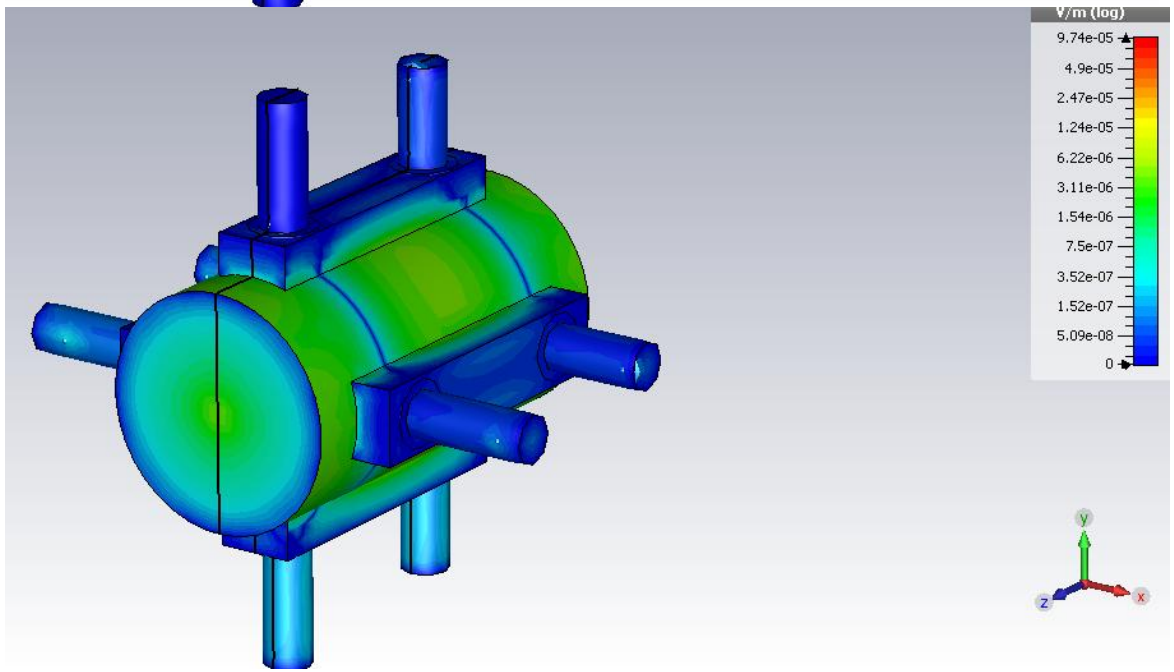


352 MHz beam field components

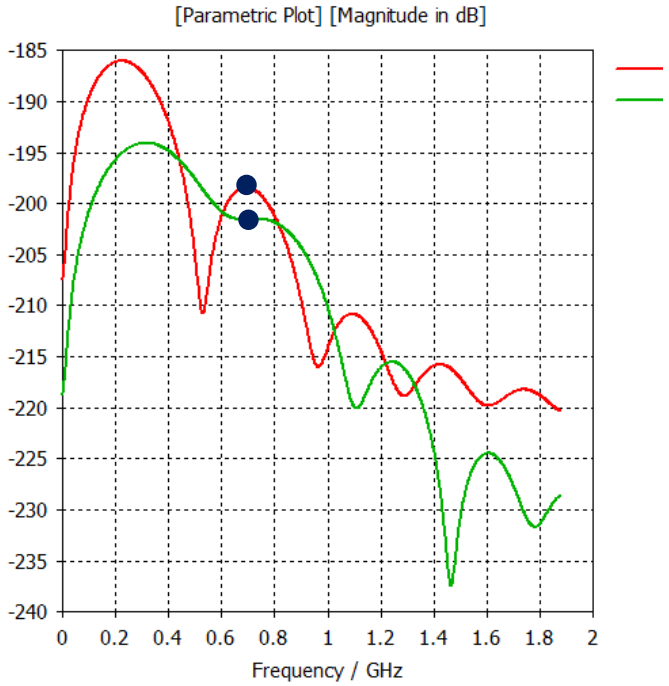


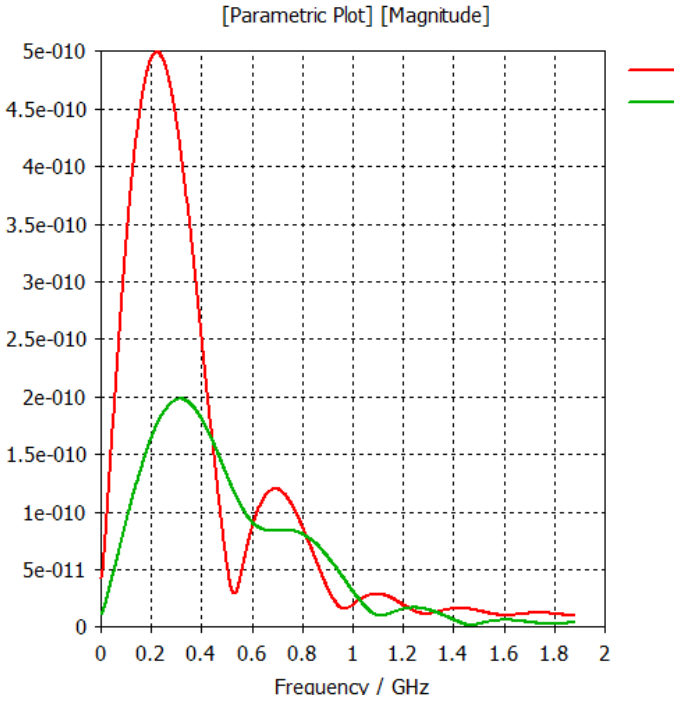
704 MHz beam field components

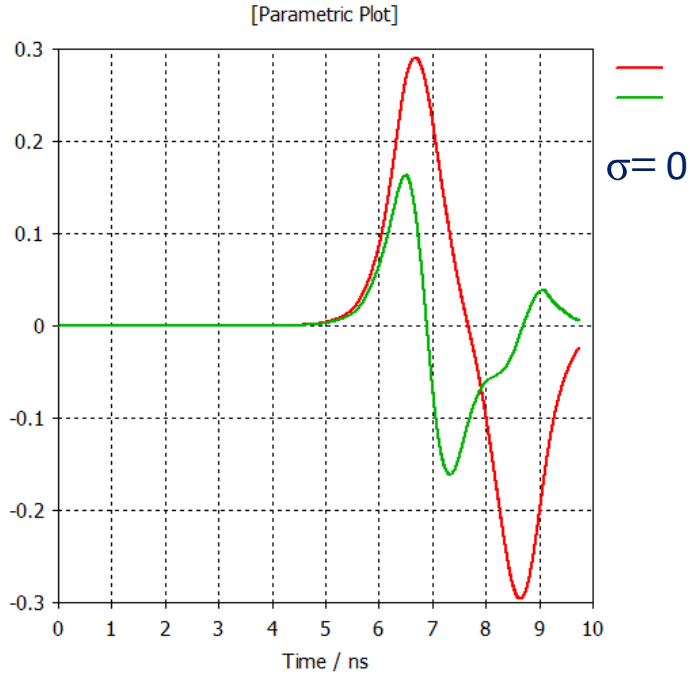




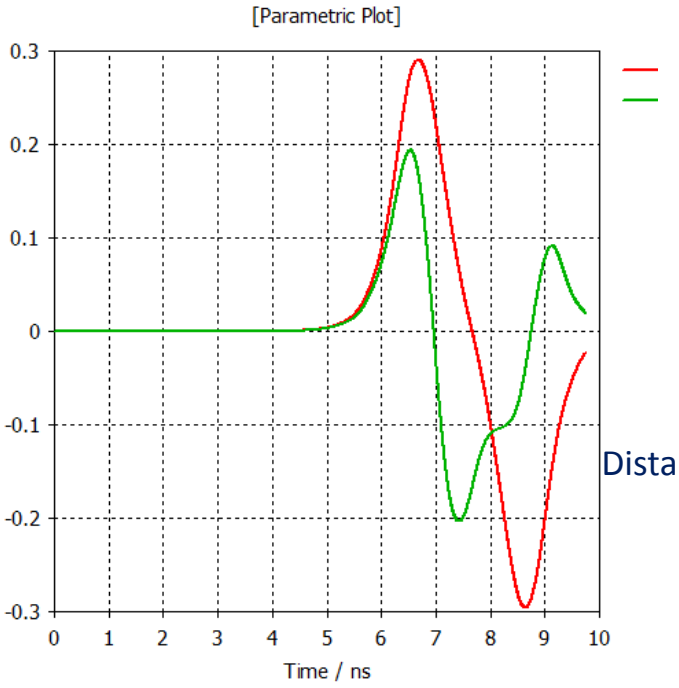
Analysis for all the beam spectrum components have been done.
The objective was the 704 MHz operation







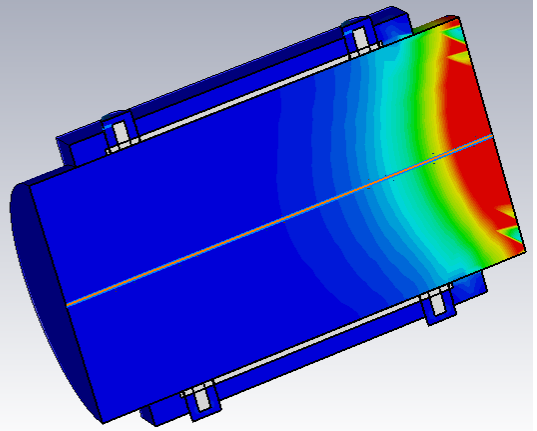
σ= 0.18 ns



Distance of 20mm

Analysis for various types and geometries of Striplines and different terminations have been realized at low energy

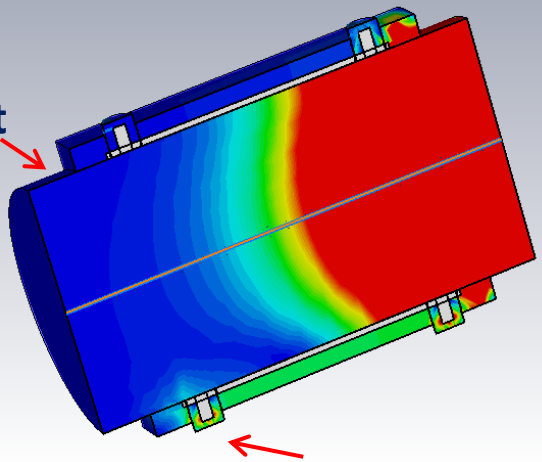
T=3.05 ns



e-field (t=0..end(0.05)) [pb]

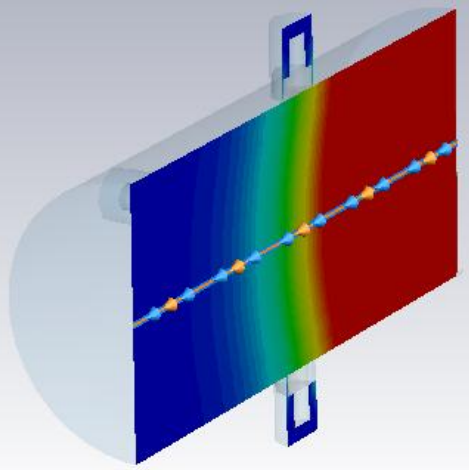
Cutplane name:	Cross Section A
Cutplane normal:	1, 0, 0
Cutplane position:	0
Component:	Abs
2D Maximum [V/m]:	6.49
Sample(173):	62
Time [ns]:	3.05

T=4 ns



e-field (t=0..end(0.05)) [pb]

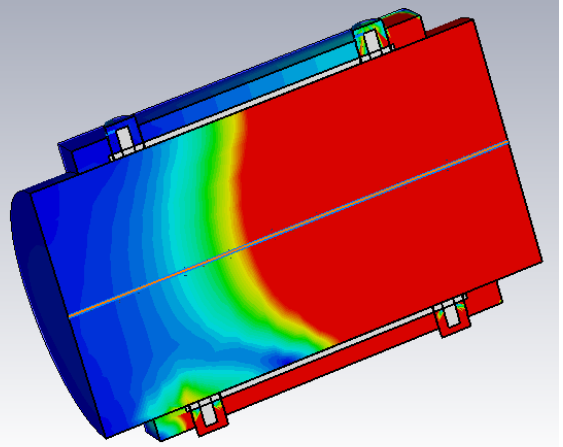
Cutplane name:	Cross Section A
Cutplane normal:	1, 0, 0
Cutplane position:	0
Component:	Abs
2D Maximum [V/m]:	151.6
Sample(173):	81
Time [ns]:	4



e-field (t=0..end(0.1))_pb (peak)

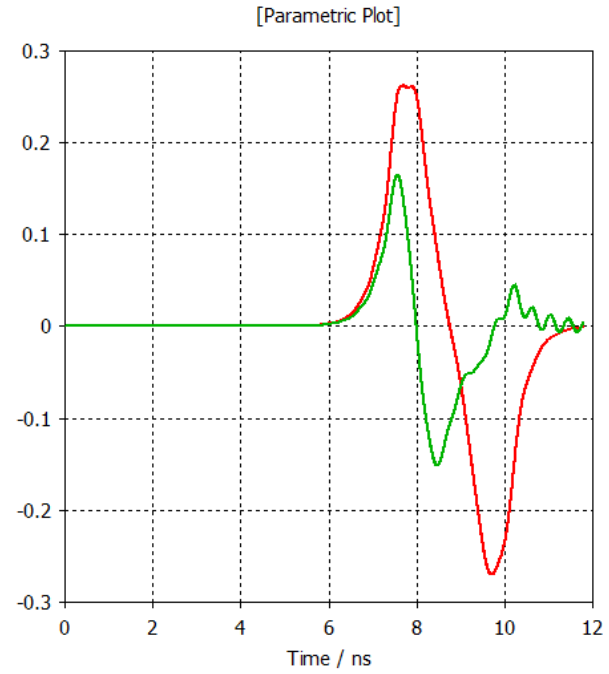
Cutplane normal:	1, 0, 0
Cutplane position:	0
Component:	Abs
2D Maximum [V/m]:	9.666e-06
Sample(106):	10
Time [ns]:	0.9

T=4.35 ns

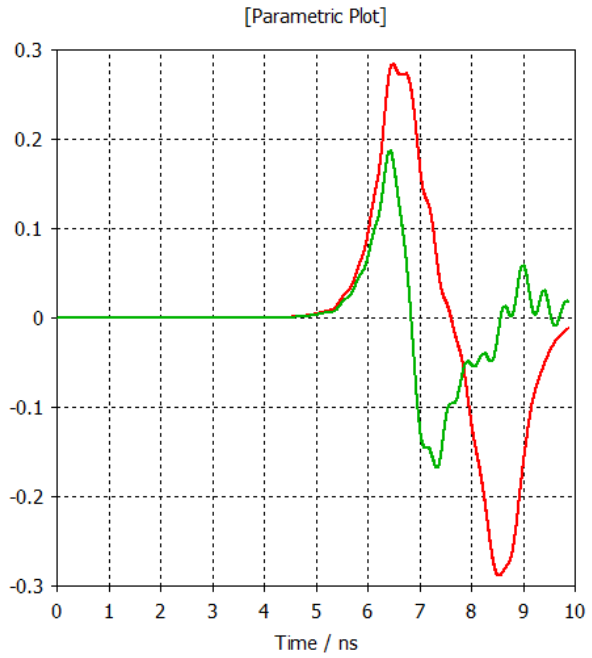


e-field (t=0..end(0.05)) [pb]

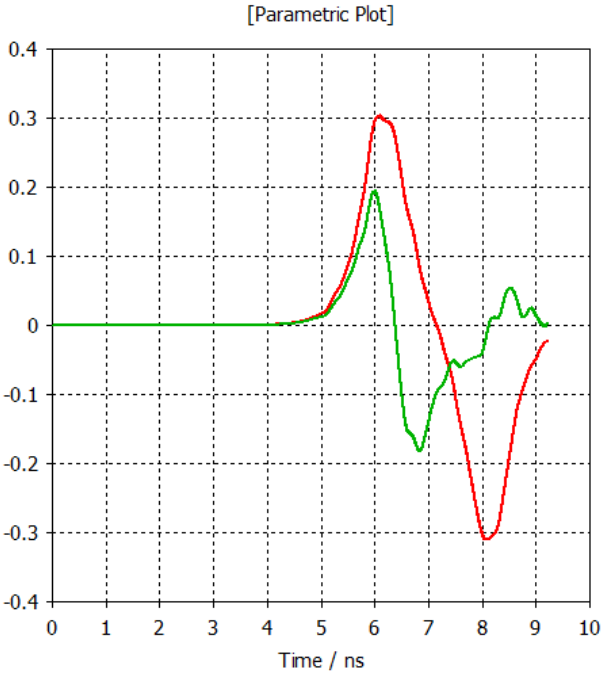
Cutplane name:	Cross Section A
Cutplane normal:	1, 0, 0
Cutplane position:	0
Component:	Abs
2D Maximum [V/m]:	490.8
Sample(173):	88
Time [ns]:	4.35



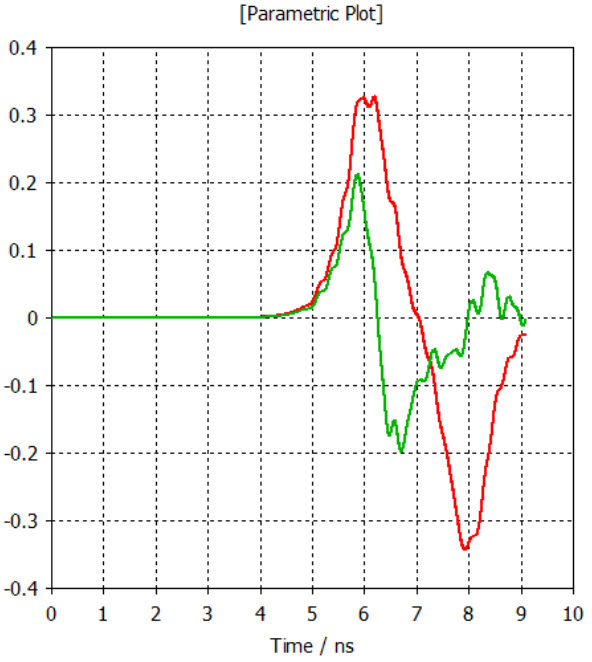
Sigma: 4.2 mm



Sigma:3.5 mm

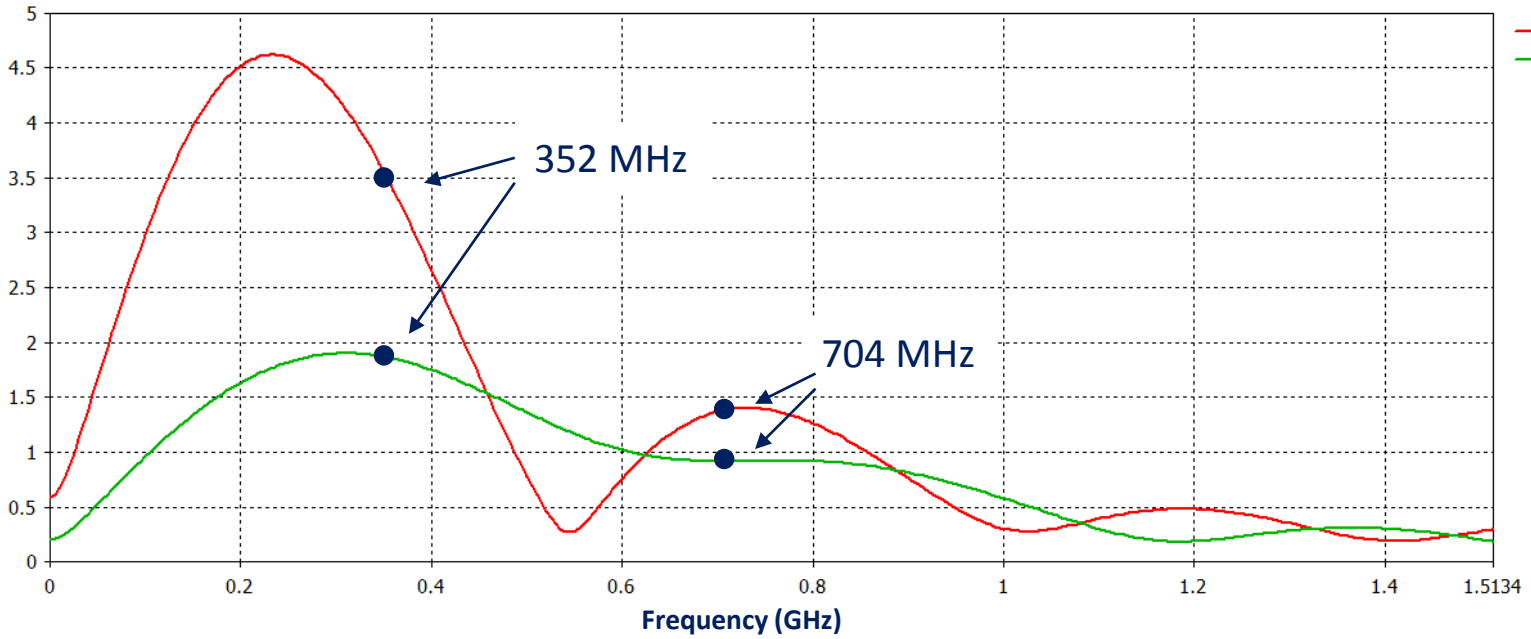


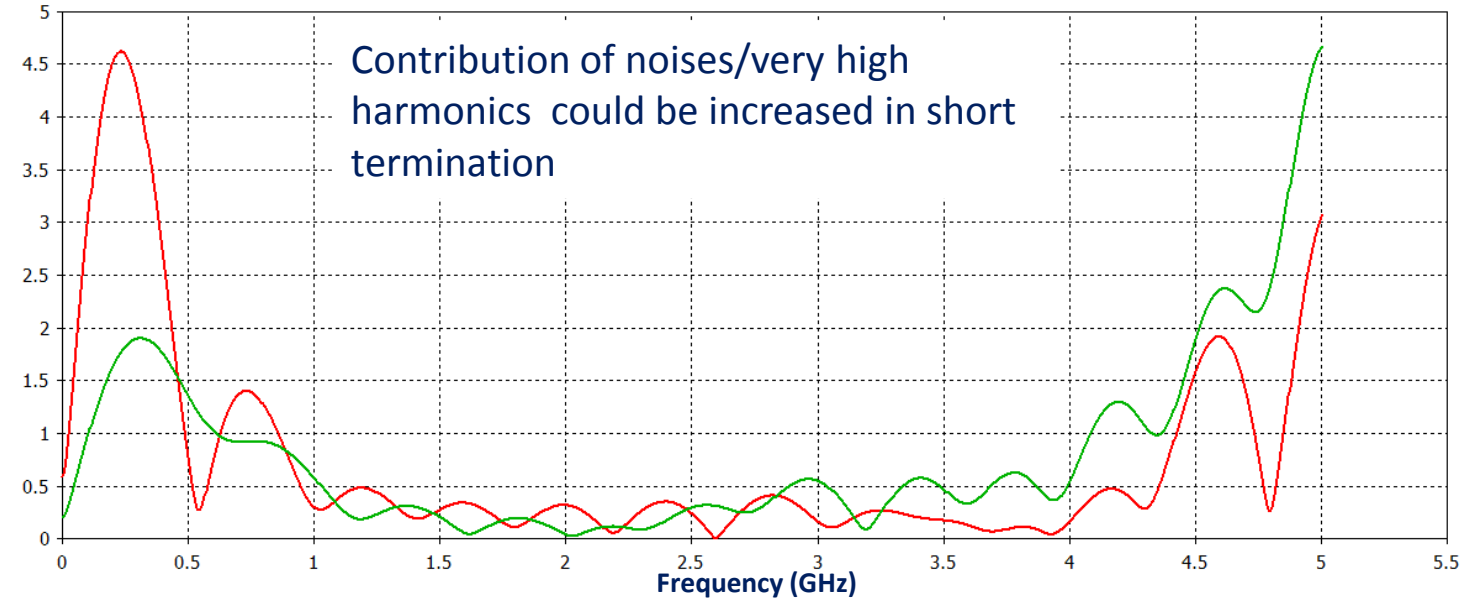
Sigma:3.2 mm

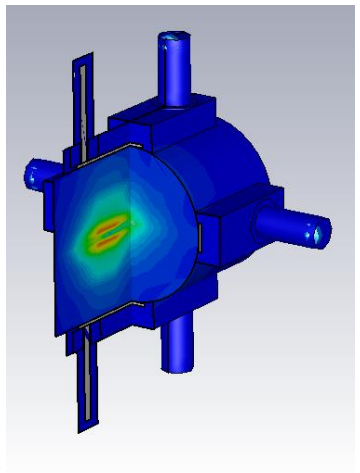


Sigma:2.8 mm

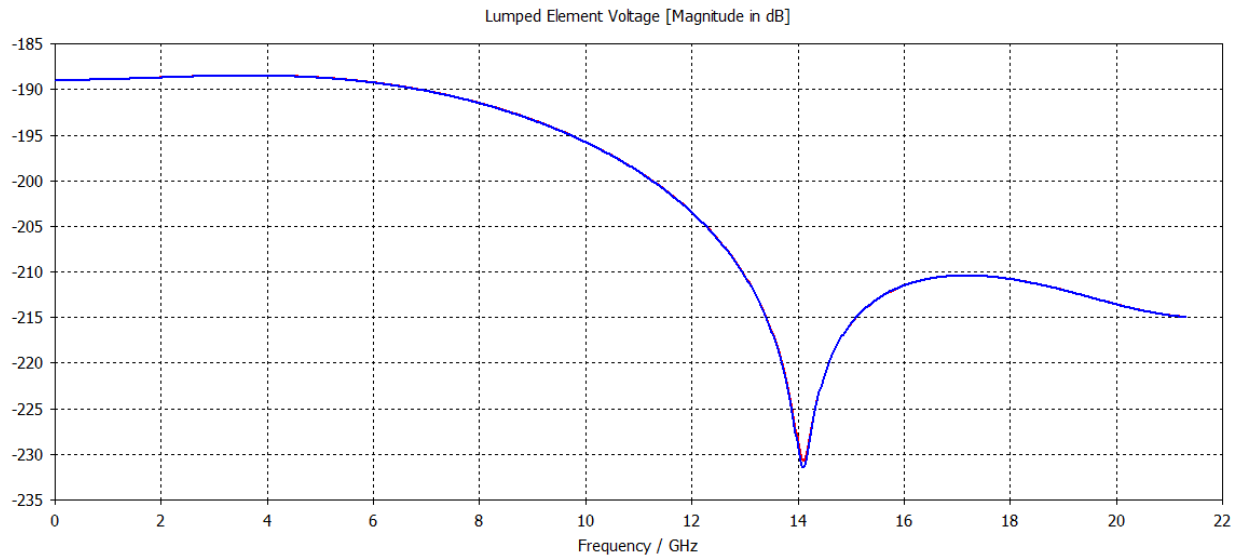
BPM Transfer functions at β=0.088





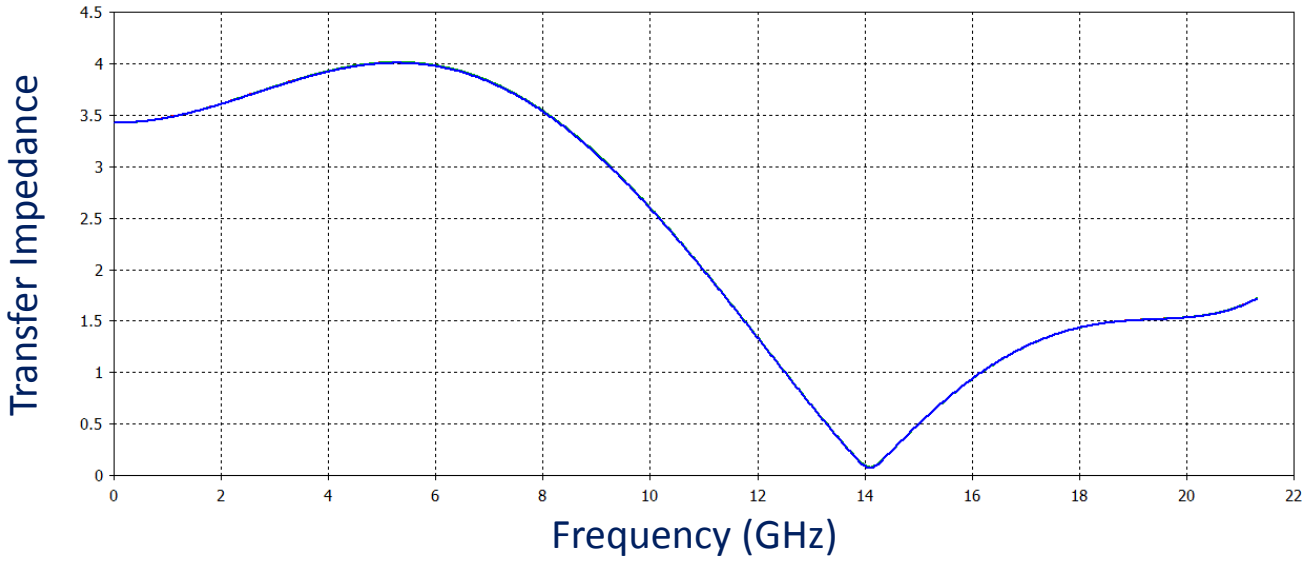


Responses at high energy β=0.999



Termination 50 Ω
Termination short

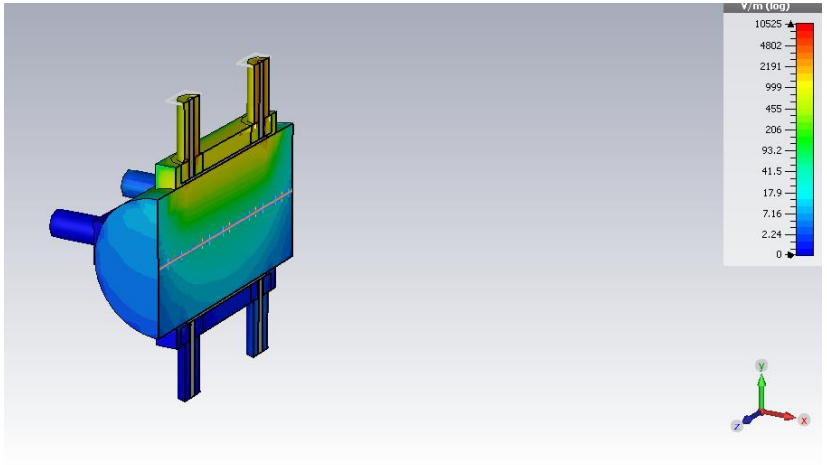
As expected at high velocity beam, unlike the low energy beam, the response for short, open and 50 ohm termination is exactly the same.



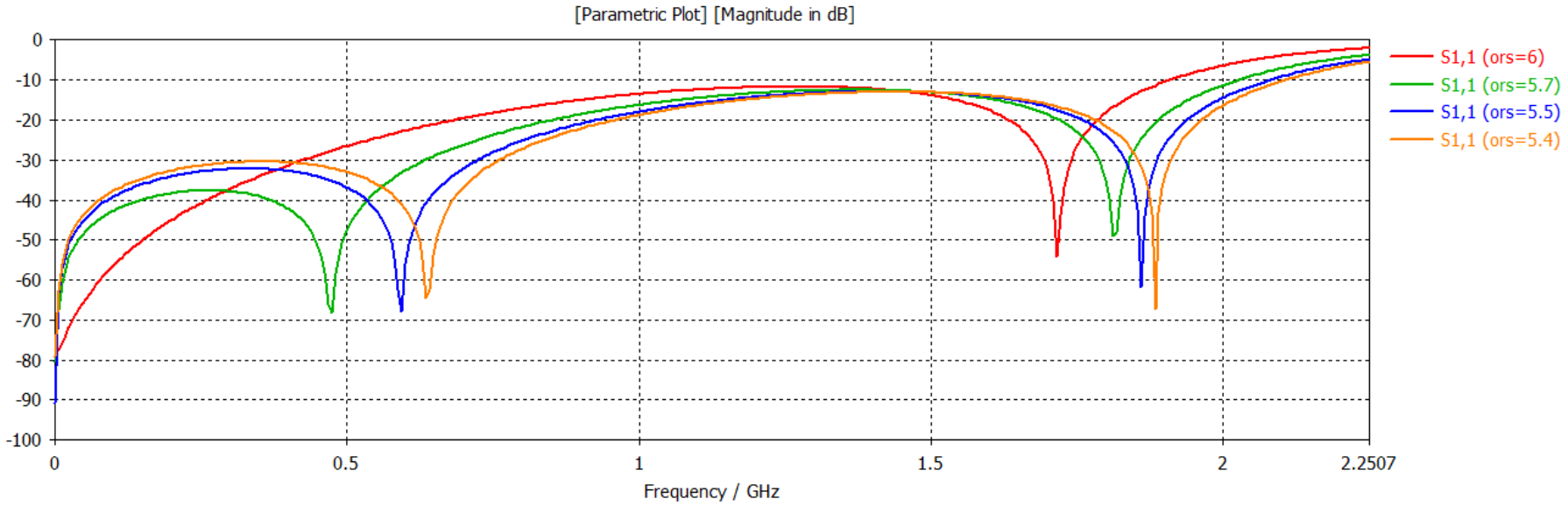
Termination 50 Ω
Termination short
Termination Open

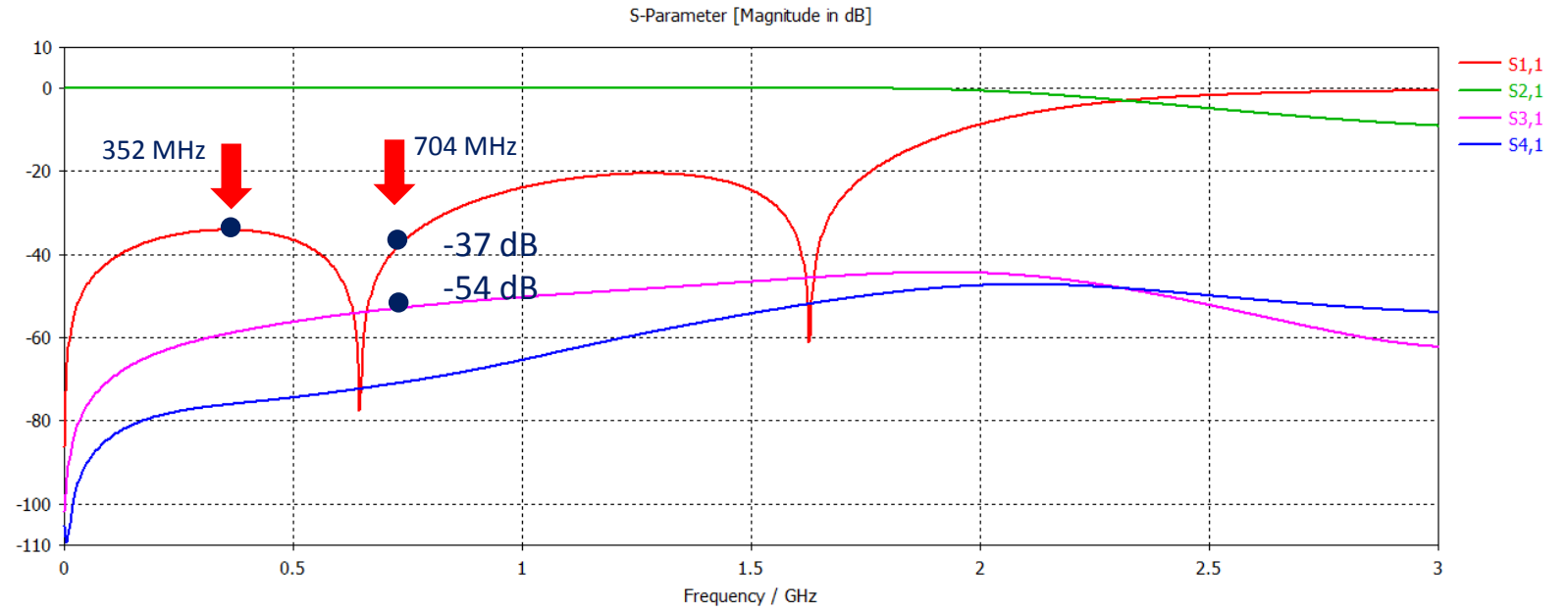
Various optimization on components geometry and materials

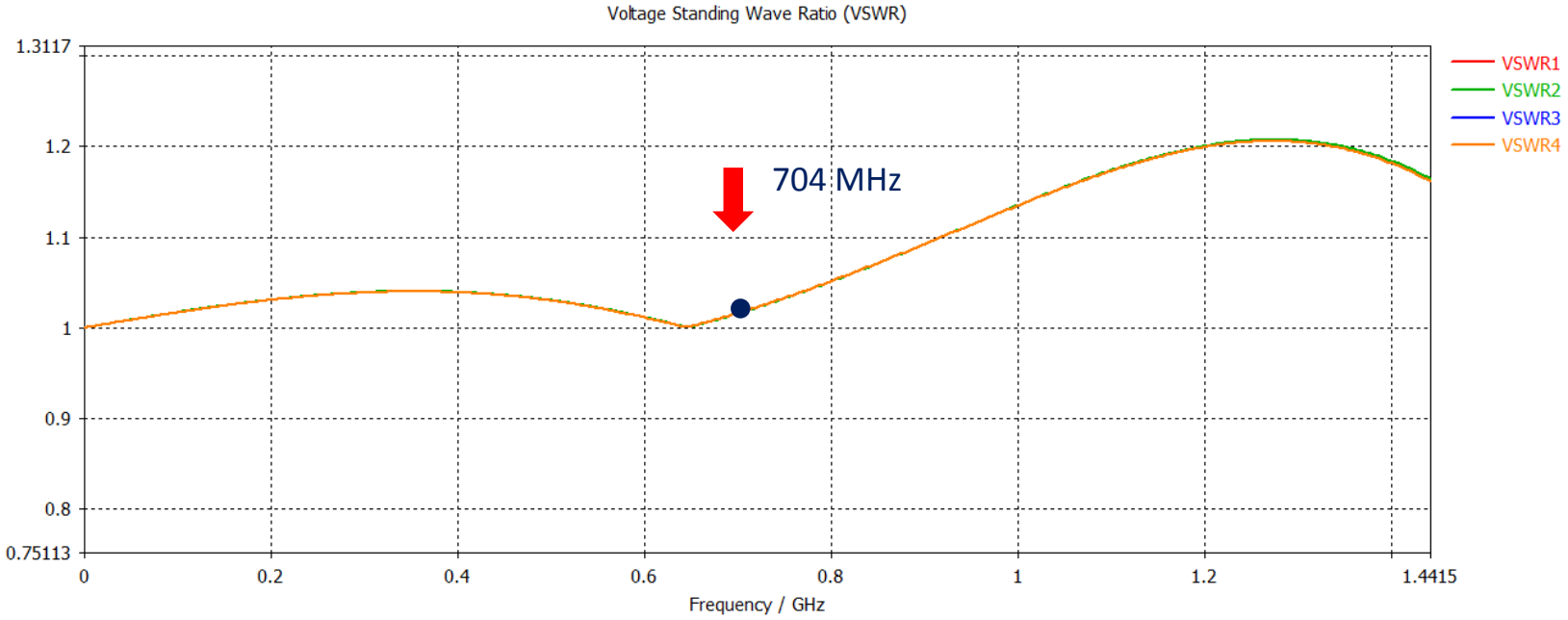
But just low β beam analysis is not enough!
The produced signals should get out and reach electronics with minimum mismatch.



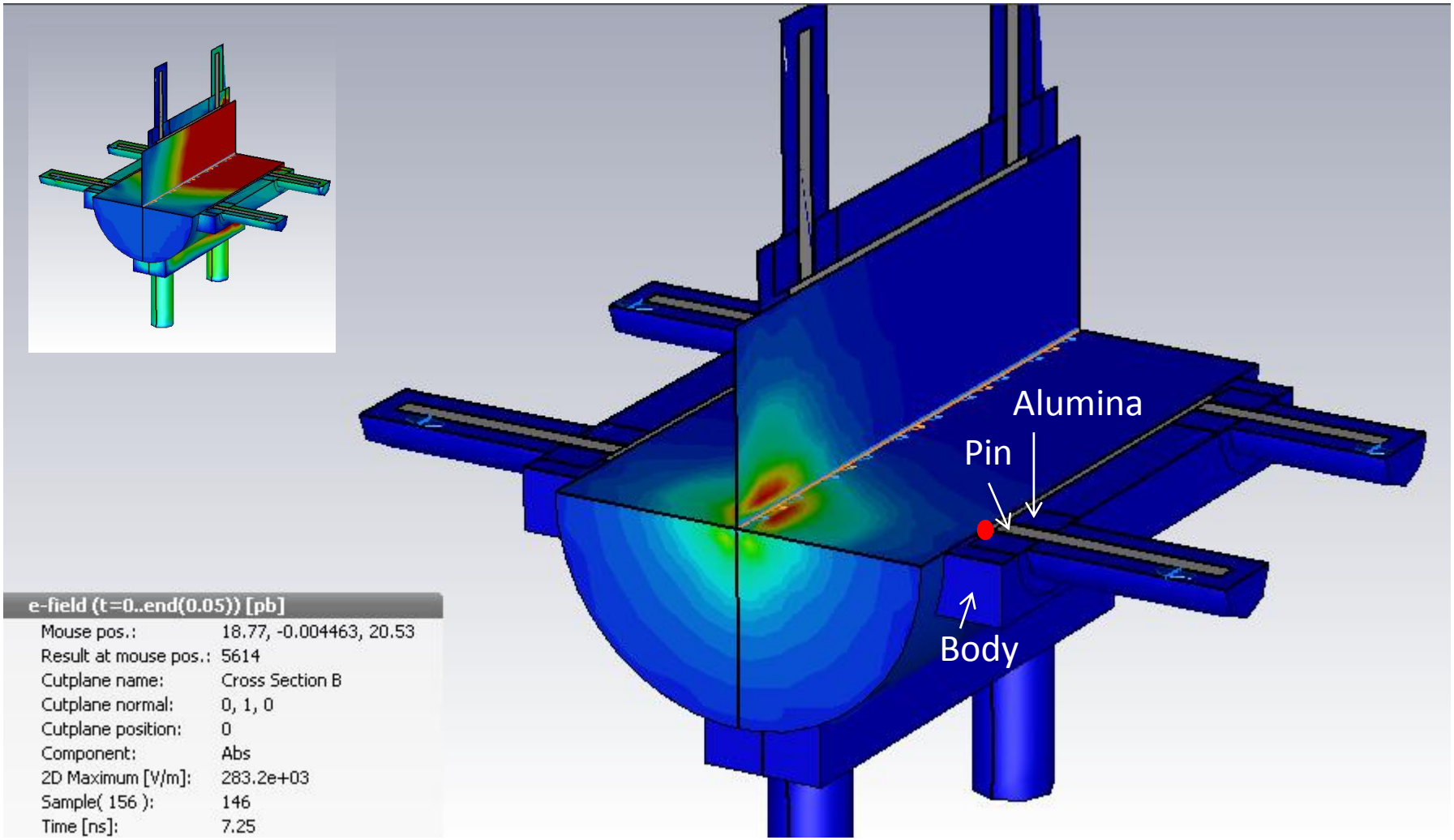
Spacer outer radius variation
Various materials like Alumina 95%, 96%, 99.5%, Macor ,… were analyzed.



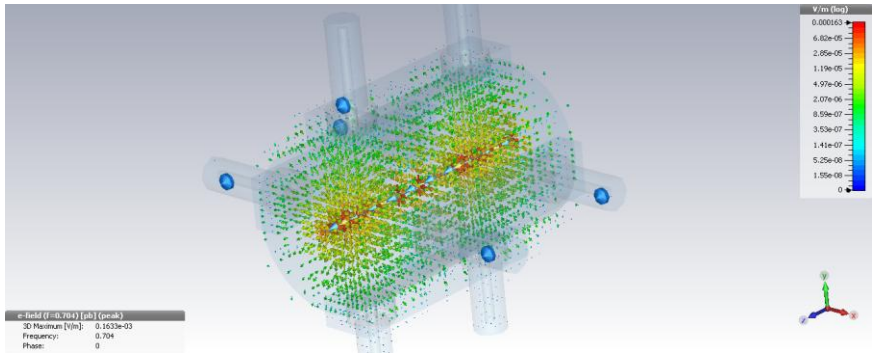

S-Parameter [Magnitude in dB]
10
0
-20
-40
-60
-80
-100
-110
0
0.5
1
1.5
2
2.5
3
Frequency / GHz
352 MHz
704 MHz
-37 dB
-54 dB
S1,1
S2,1
S3,1
S4,1

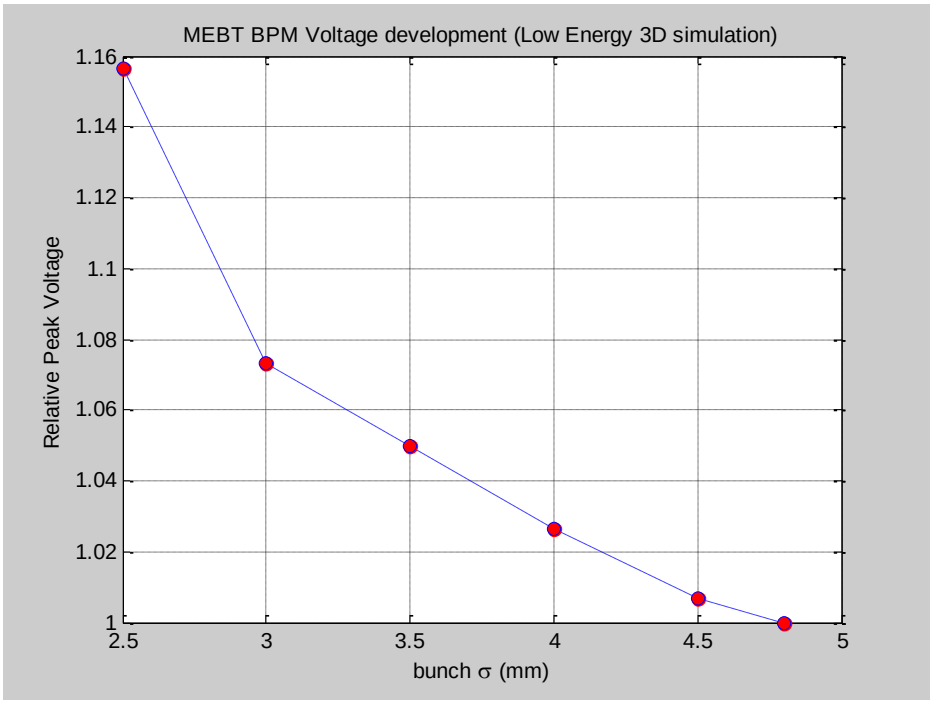

Voltage Standing Wave Ratio (VSWR)
1.3117
1.2
1.1
1
0.9
0.8
0.75113
0
0.2
0.4
0.6
0.8
1
1.2
1.4415
Frequency / GHz
704 MHz
VSWR1
VSWR2
VSWR3
VSWR4

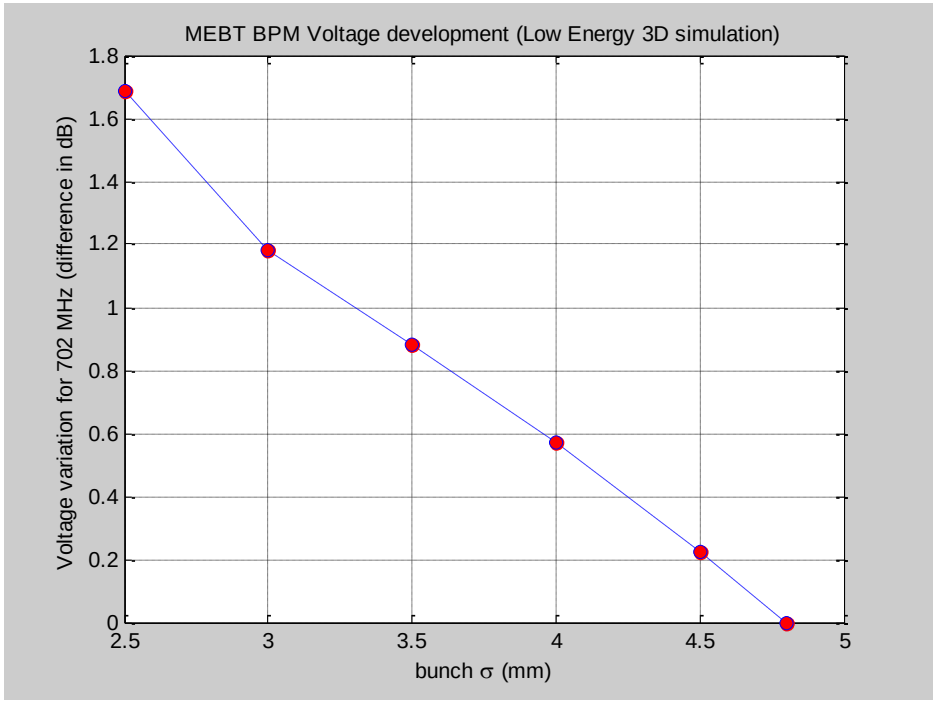
Electric field hot points analysis



Electrode voltage with bunch length variation through MEBT







This means the BPM electrode output voltage is bunch length sensitive

BPM electrode voltage changes with MEBT energy variation

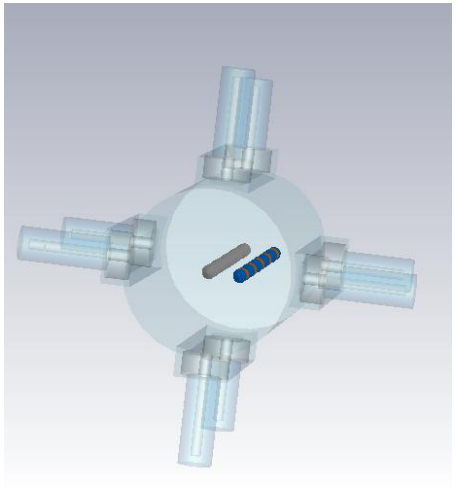
Electrode voltage will change due to energy variations. It corresponds to about 1% for 50 Ω termination electrodes and 2.5% for short termination for an energy changes of 1%.

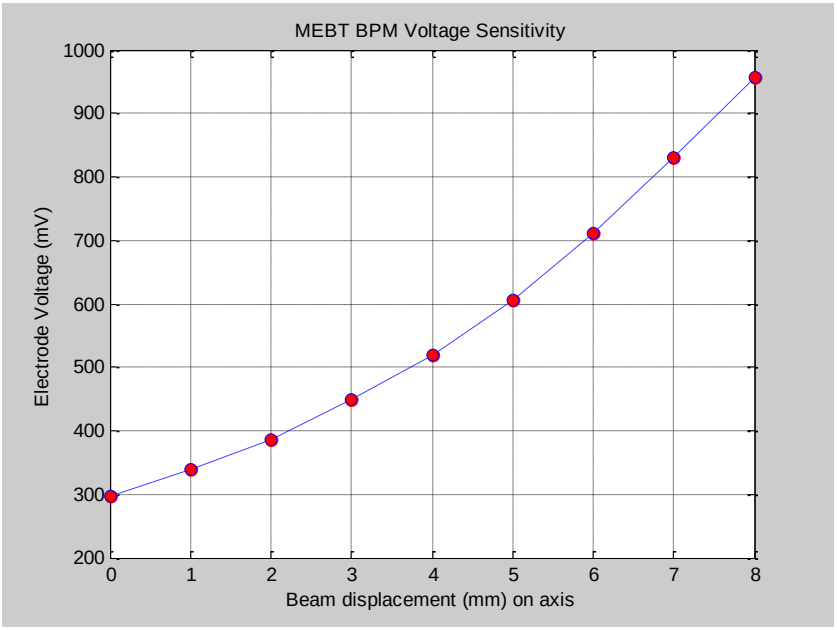
β	V (50 Ω) mV	V (Short) mV
0.088	297	160
0.089	300	164
0.0924	312	175

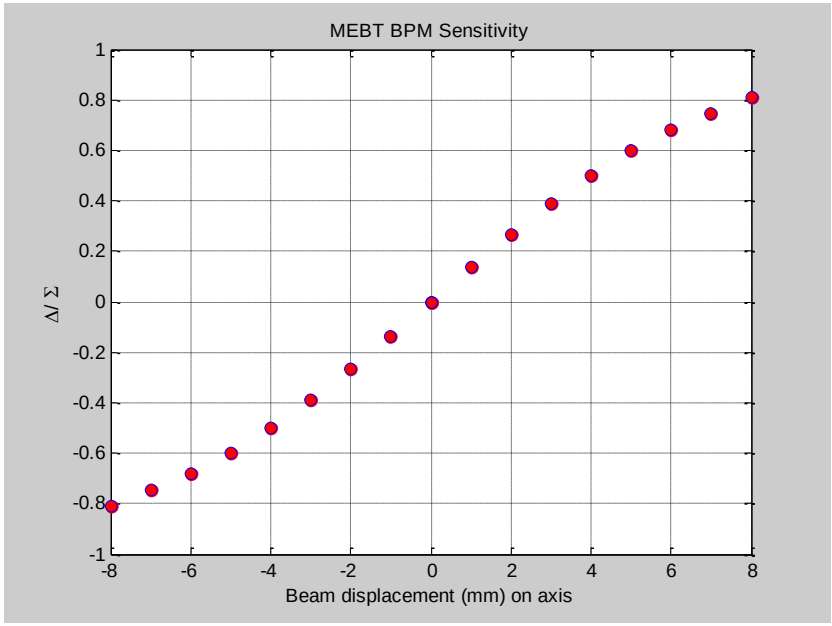
Δβ/β	ΔV/V (50Ω)	ΔV/V (Short)
1%	1%	2.5%
5%	5.2%	9.5%

BPM Sensitivity to beam displacement

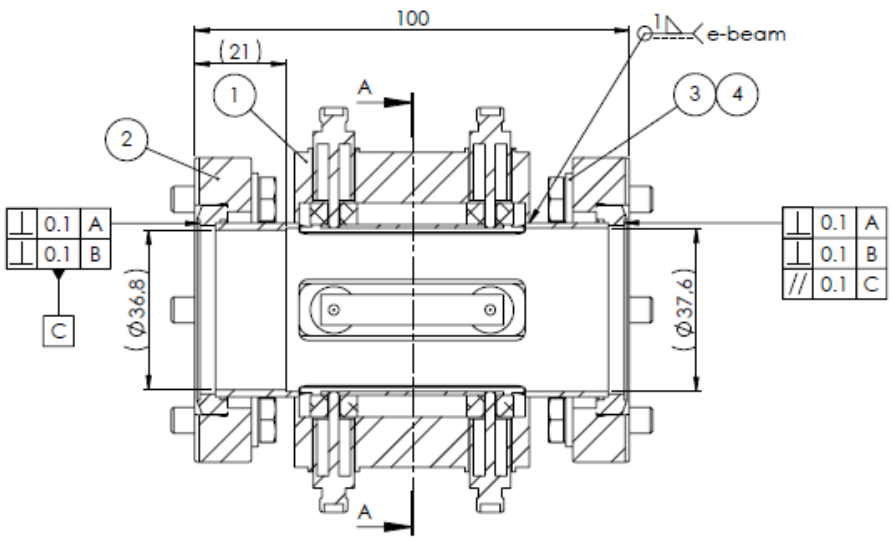
Voltage sensitivity (Oscop mode) is 45 [mV/mm] for 50Ω and 30 [mV/mm] for short termination
Delta over sigma sensitivity is 0.13 [1/mm]

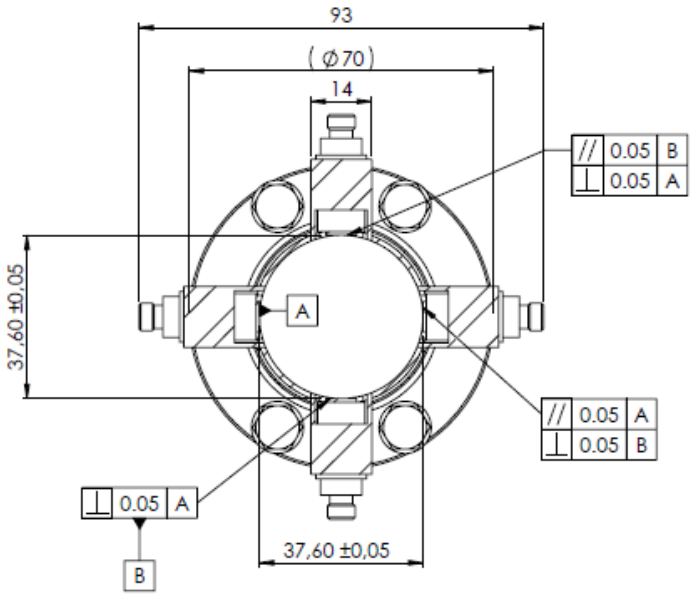




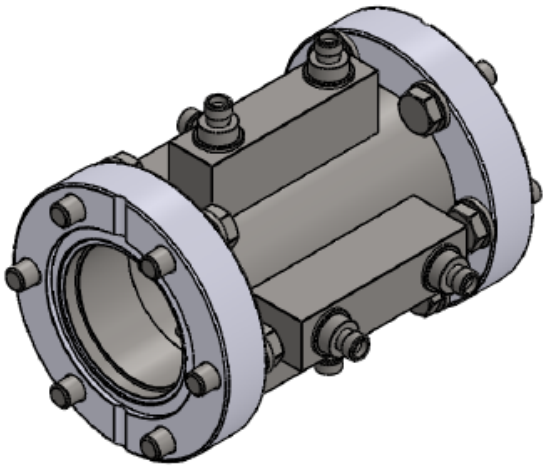


Just low ß beam analysis and signal matching analysis are not the only issues considered. They should be possible to reasnoably fabricate the device within mechanical tolerances.





SECCIÓN A-A



N.º DE ELEMENTO	N.º DE PIEZA	Material	CANTIDAD
1	MEBT-BP-0100-ESS.00-PCK	AISI 316L	4
2	MEBT-BP-1100-ESS.01-PCK	AISI 316L	1
3	Washer ISO 7089 - 6	AISI 316	12
4	ISO 4017 - M6 x 20-N	AISI 316	12

ESS bilbao
P.T. Zamudio
c/ Laida Bidea 201, Pab 4
48170 ZAMUDIO (Bizkaia)
tel: 946076855
www.essbilbao.org

MATERIAL:
PESO (g): 477.09

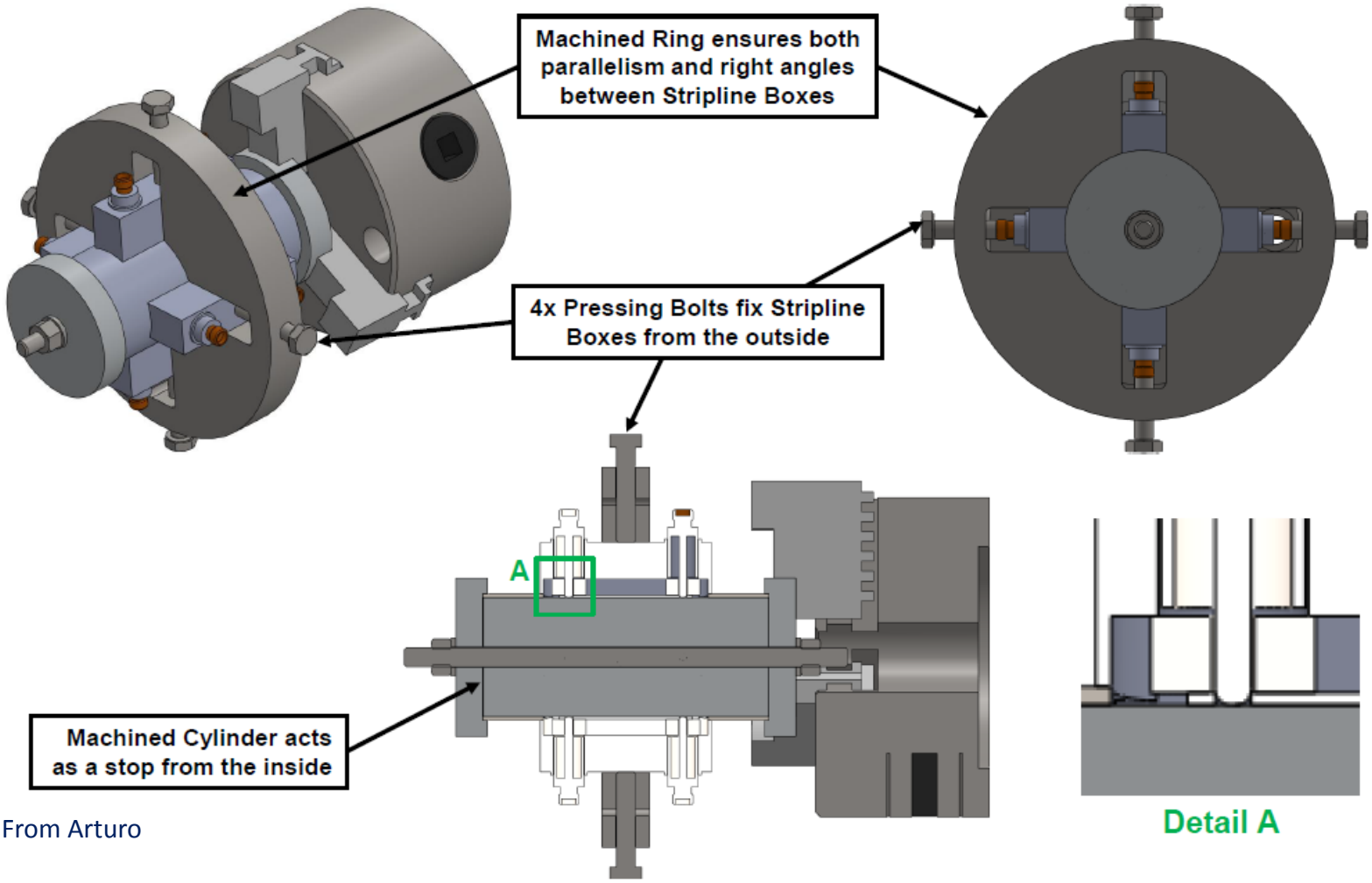
TÍTULO: Section 2 - BPM

Nº DE DIBUJO: MEBT-BP-1000-ESS.01-PCK
A3

NOT FOR PRODUCTION

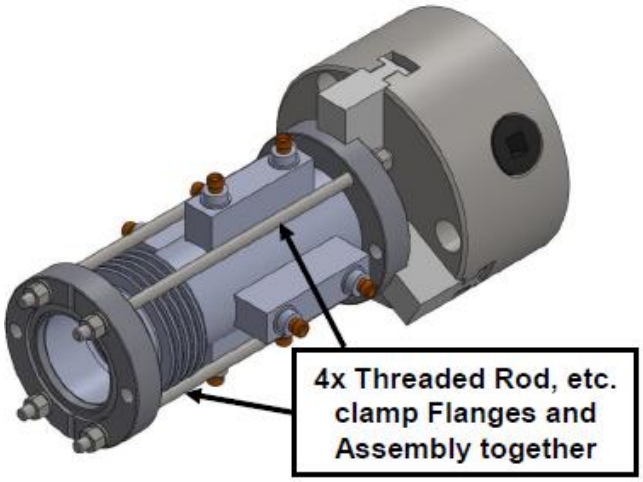
More details later with mechanical/vacuum group

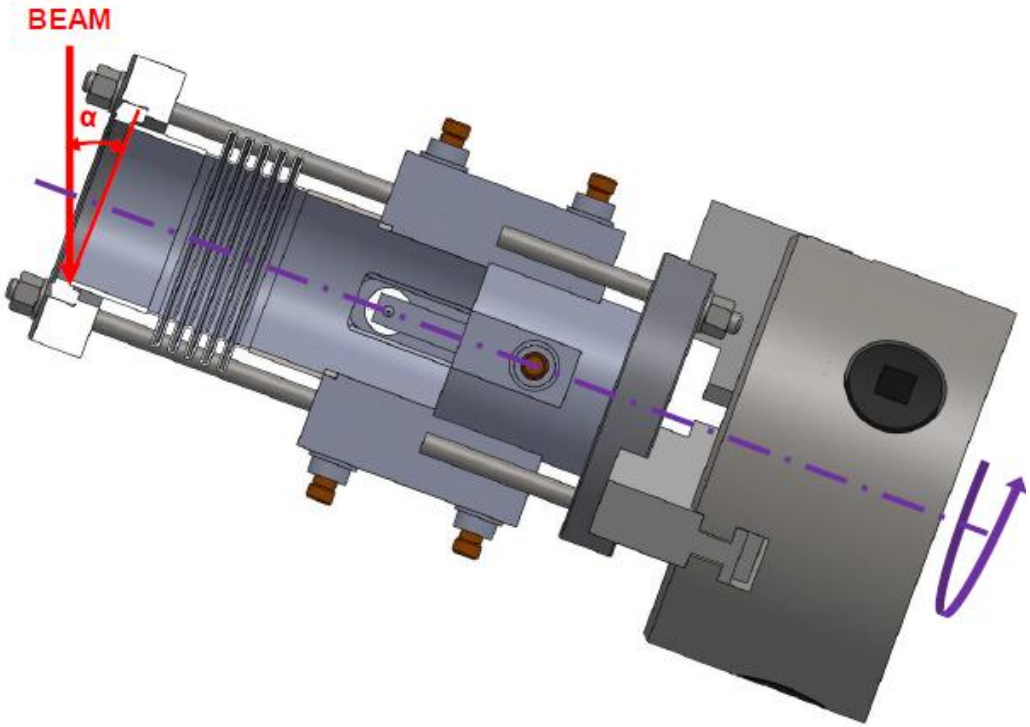
W#3.1: Stripline Box to Tube (Tack Pass: Layout)

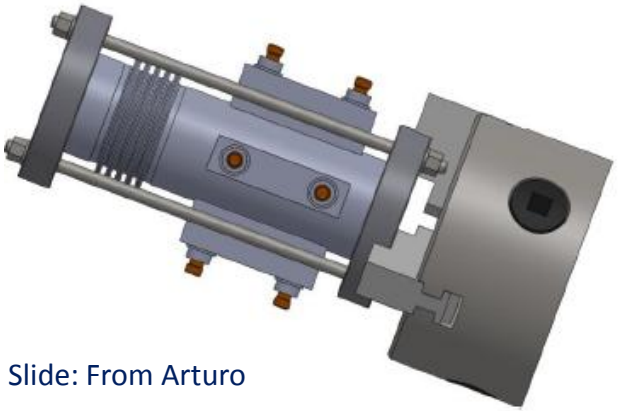


Slide: From Arturo

W#6: Flange to Assembly







Weld Procedure:
- 2 flanges = 2 welds/BPM
- Assembly rotation wrt tube
- Box tilted wrt to beam (rotation wrt 'y'axis)

Slide: From Arturo

The BPM finished/undergoing tasks

- Analysis and studies for the type of Pickup based on the MEBT beam parameters and electronic freq.
- Electromagnetic analysis
- Interfaces with quadrupole magnets
- High frequency analysis
- Low energy analysis
- Beam voltage sensitivity analysis
- Fabrication studies
- Pieces manufacturing and their EM effects studies
- Mechanical detailed designs
- Launch the first prototype

Future remained tasks

- Observation of the fabrication process
- Mechanical measurement and tolerances
- Assembly of the BPM set
- Signal transmission
- Tests of the response of the strips
- Measurements on the impedance matching
- Characterization of the BPM sets based on test bench measurement
- Launching the BPM sets (if every thing is successful)
- Electrical/mechanical tests with/without uTCA electronics
- Delivery to Lund

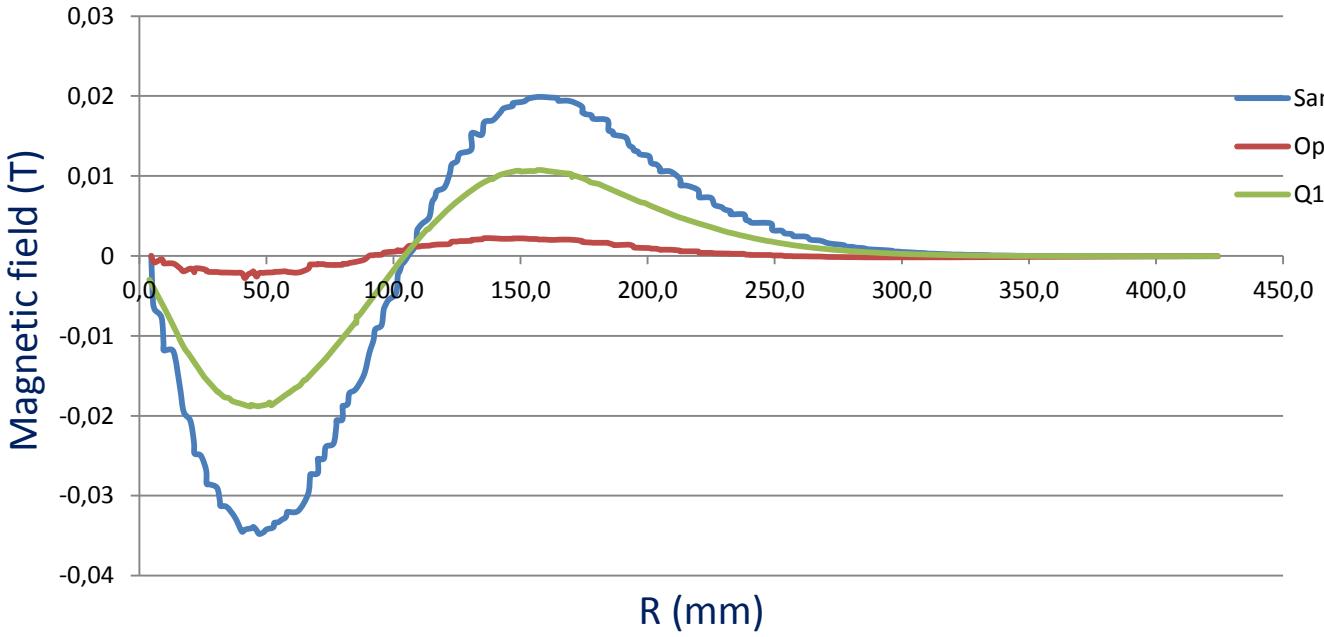
MEBT Beam Current Transformers

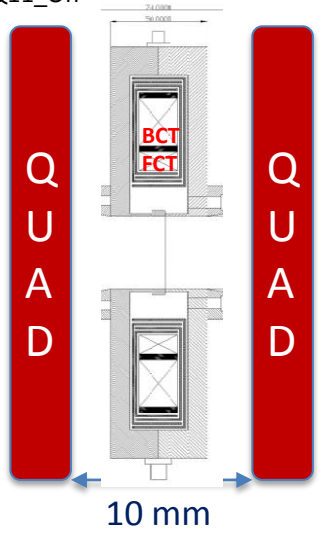
There will be two types of beam current transformers in the MEBT:

- Slow current transformer to measure the current in time scale of us
- Fast current transformer to measure in time scale of ns

They require to be magnetically shielded against the external magnetic fields

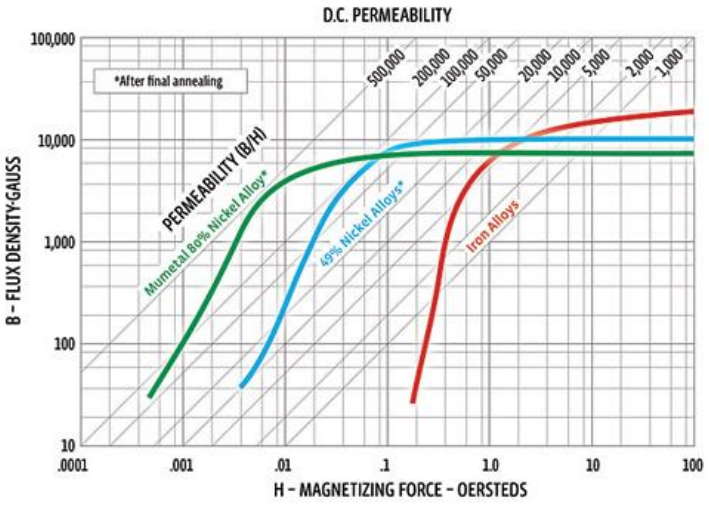
Magnetic field in the location of toroids

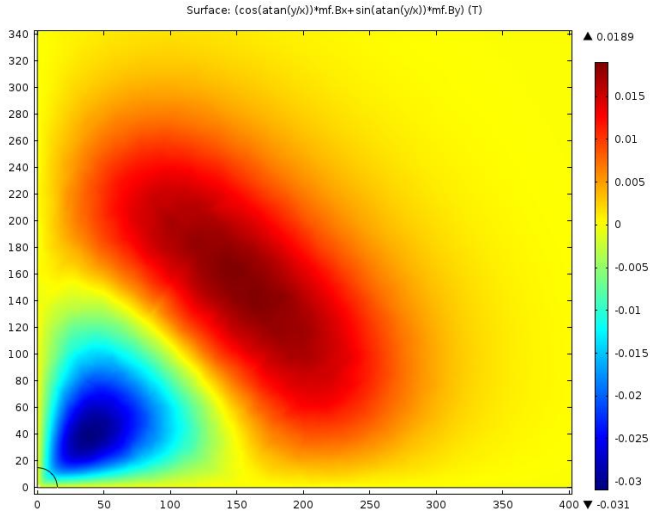




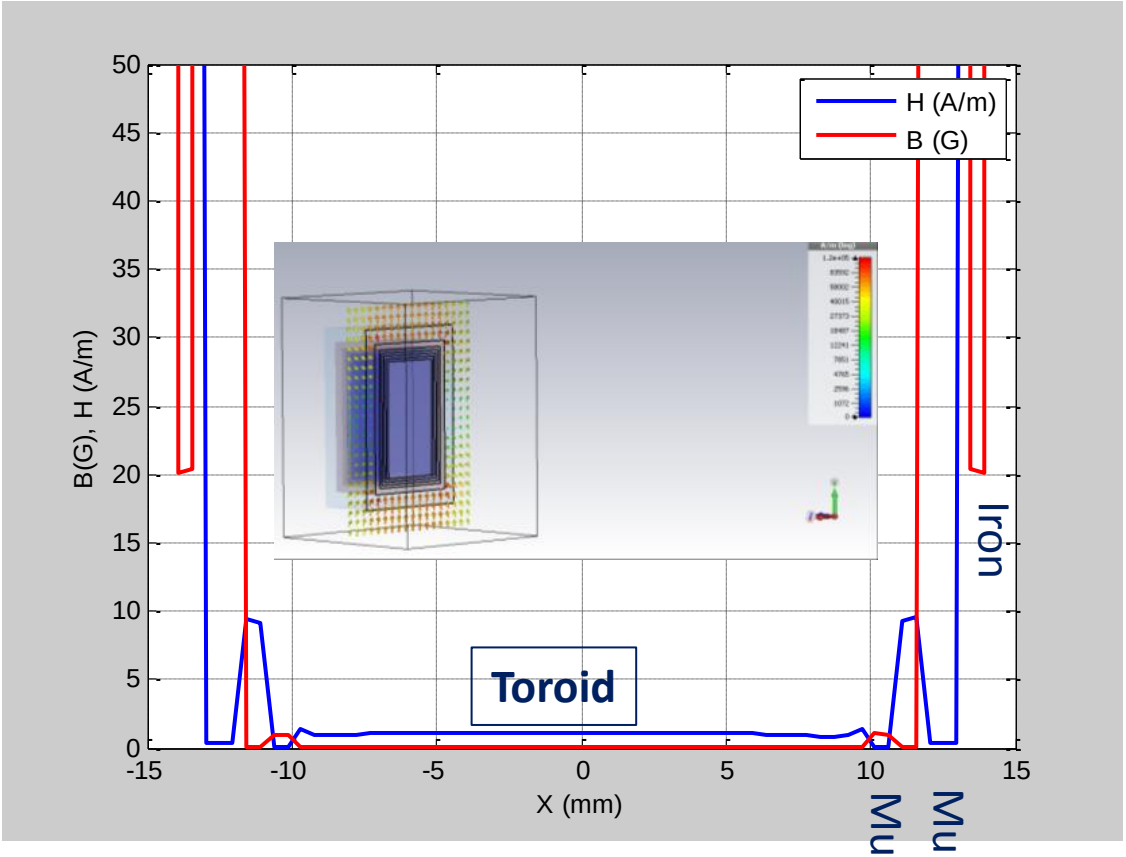
Knowing the field intensity imposed by the adjacent quadrupoles in the location of toroids, one can estimate the sheilding layers requirement in order to attenuate the magnetic fields.

Magnetic field intensity within shielding layers

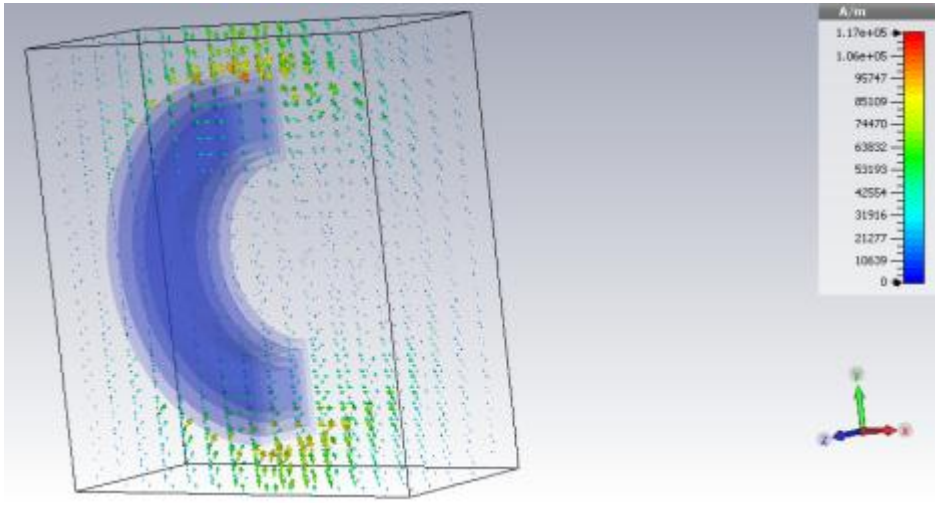


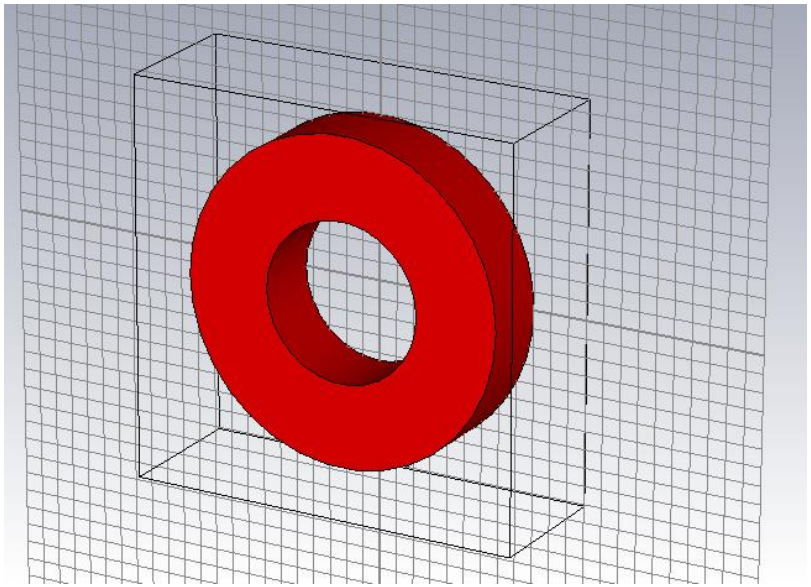


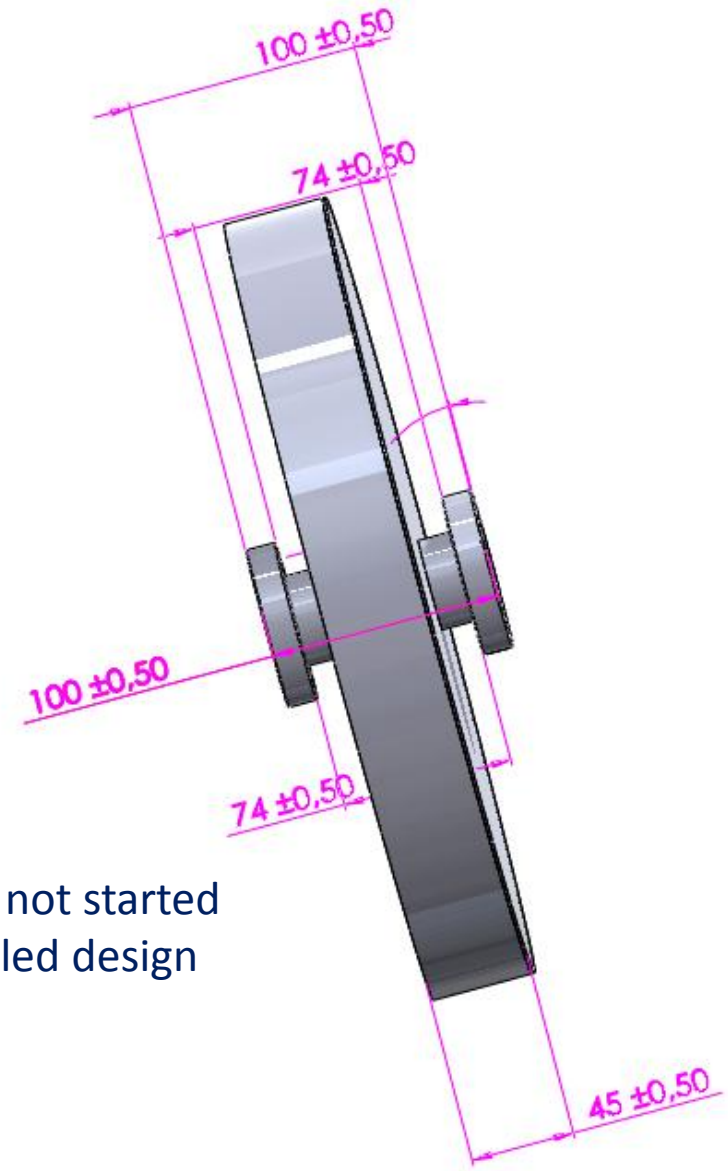
Magnetic field intensity attenuation due to shielding layers



We have started the primary analysis on magnetic shielding







We have not started the detailed design yet.

BCT tasks

- The primary studies and anlysis for the shielding, materials, approximate volume, Toroids,… is done
- A combined design of both slow and fast BCTs in the same shielding will be implemented
- The shielding and bypass wall and toroids will be in air
- The detailed design and analysis of shielding will be started as soon as the quadrupole integrated field profile and mechanical spaces are freezed
- The toroids from Bergoz (1MHz, >700MHz)will be used
- The insulated tube and ceramic gap will be implemented