MEBT BPM Stripline CDR

24 May 2017, ESS ERIC, Lund

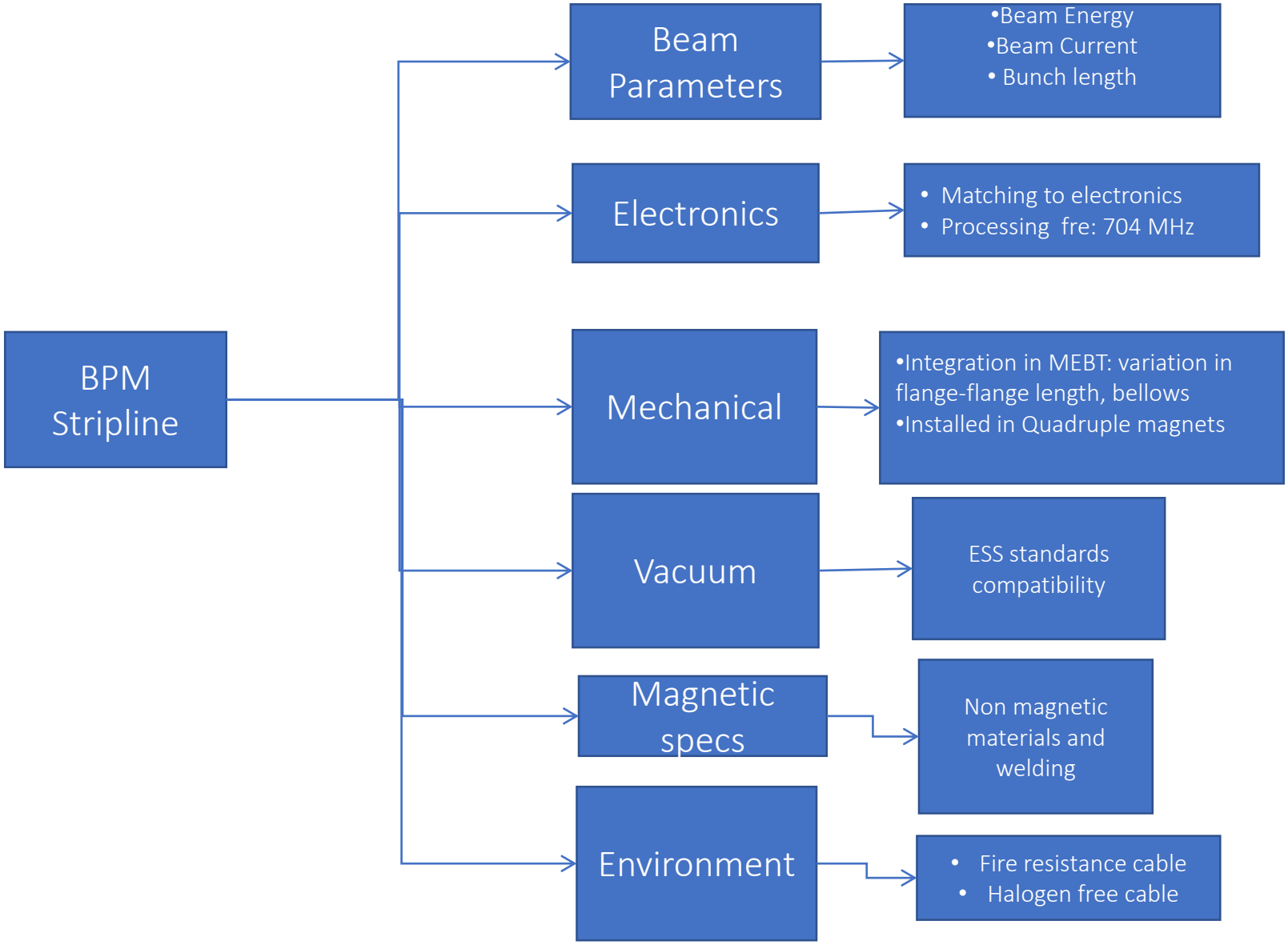
Presenter: Seadat Varnasseri, Bilbao

On behalf of the team: A. Ortega, A. Zugazaga, I. Rueda, I. Bustinduy, J. Martin, A. Conde, D. Fernandez, S. Varnasseri

Outlines:

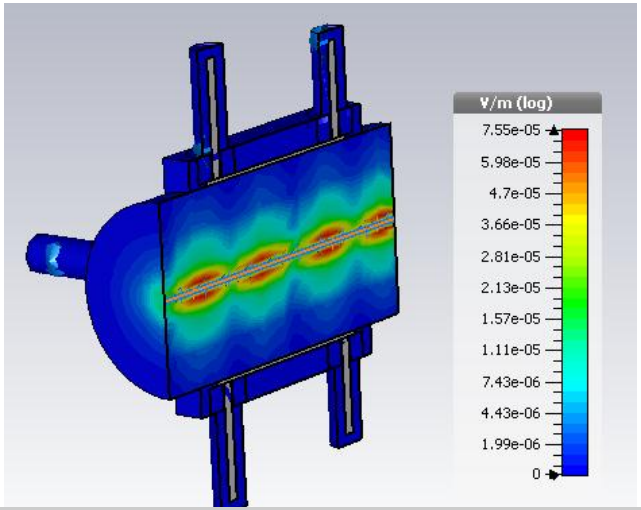
- BPM Stripline Interfaces
- Design process (History behind), 3D Low β simulations
- BPM strips expected multi-bunch voltage in time domain
- Electronics specs
- BPM various types
- Short cable to patch panel
- MEBT BPM Stripline Status
- BPM Stripline measurements
- Electrical parameters sensitivity to temperatura variation
- Verifications
- Pieces production plan
- Fabrication and delivery schedule

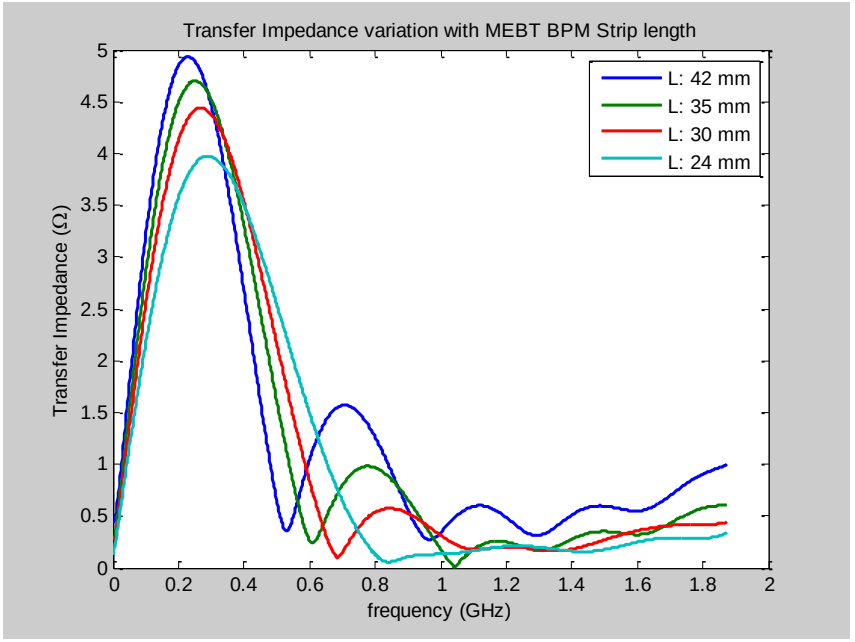
BPM Stripline Interfaces

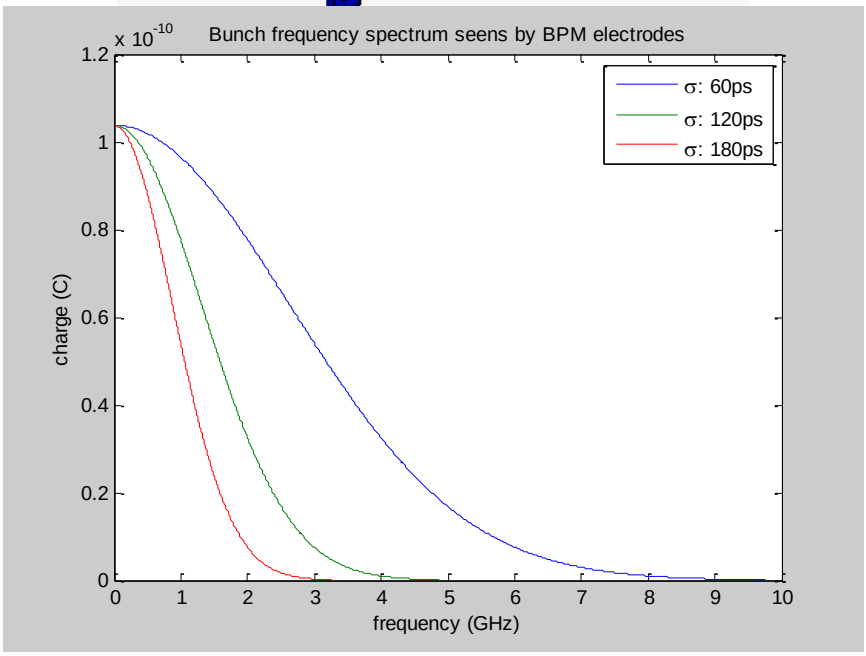


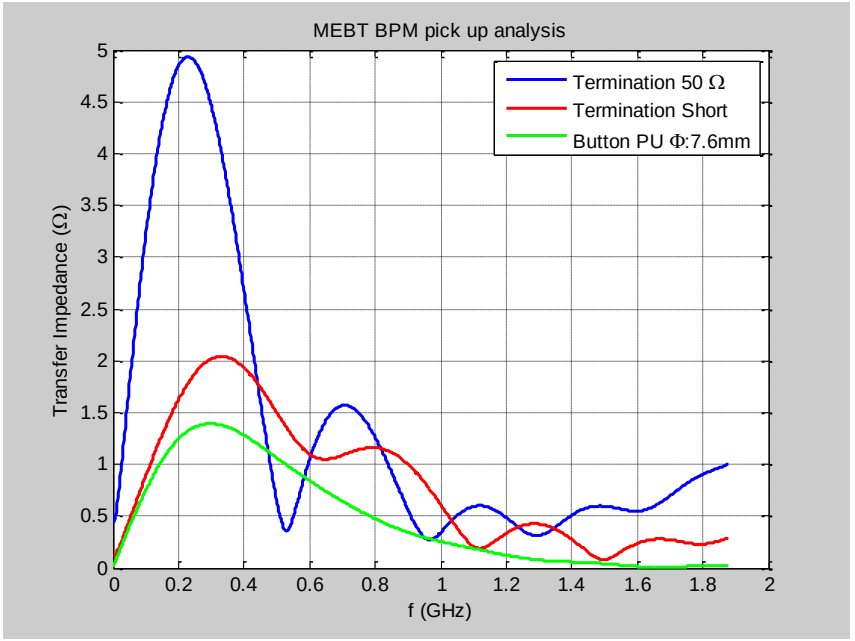
Design process (History behind)

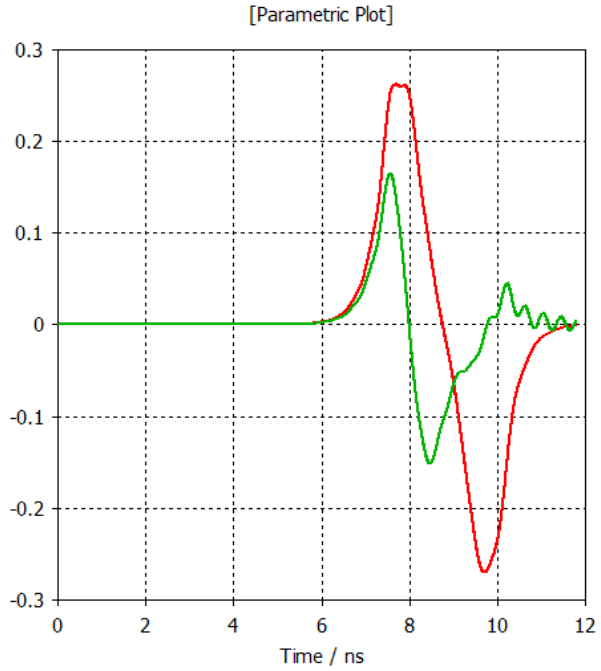
3D Low β simulations



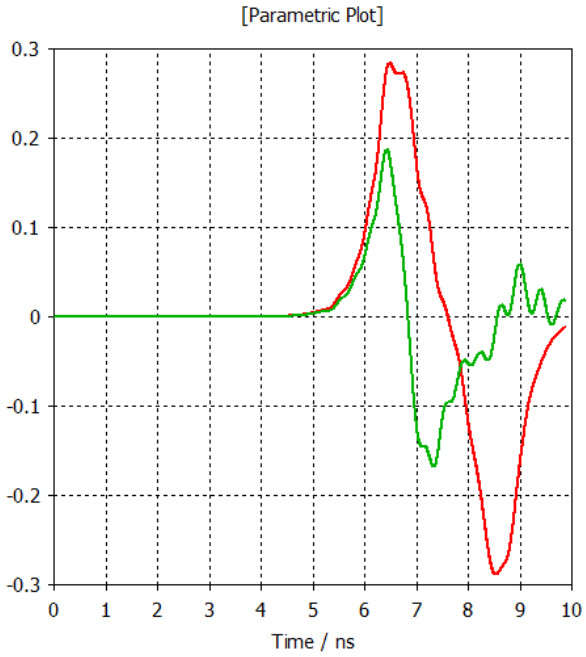






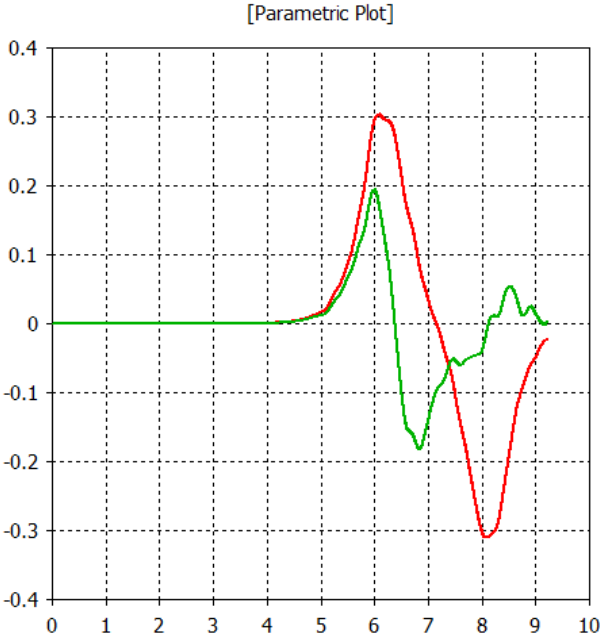


σ: 4.2 mm

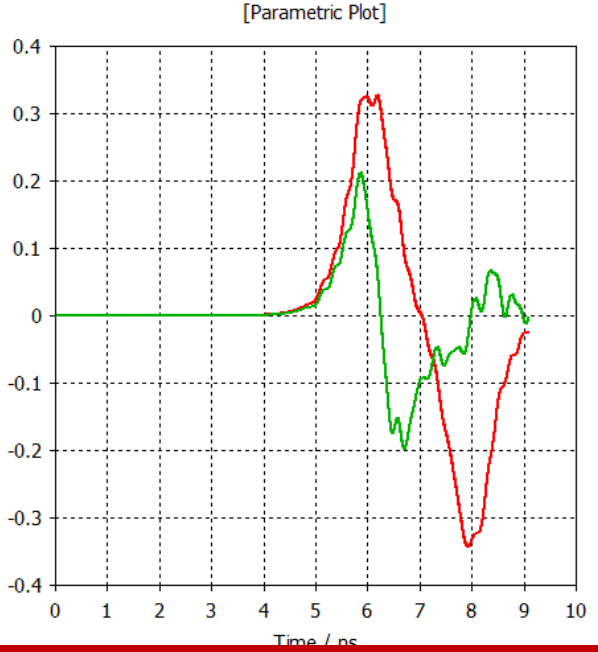


σ: 3.5 mm

Single Bunch Response

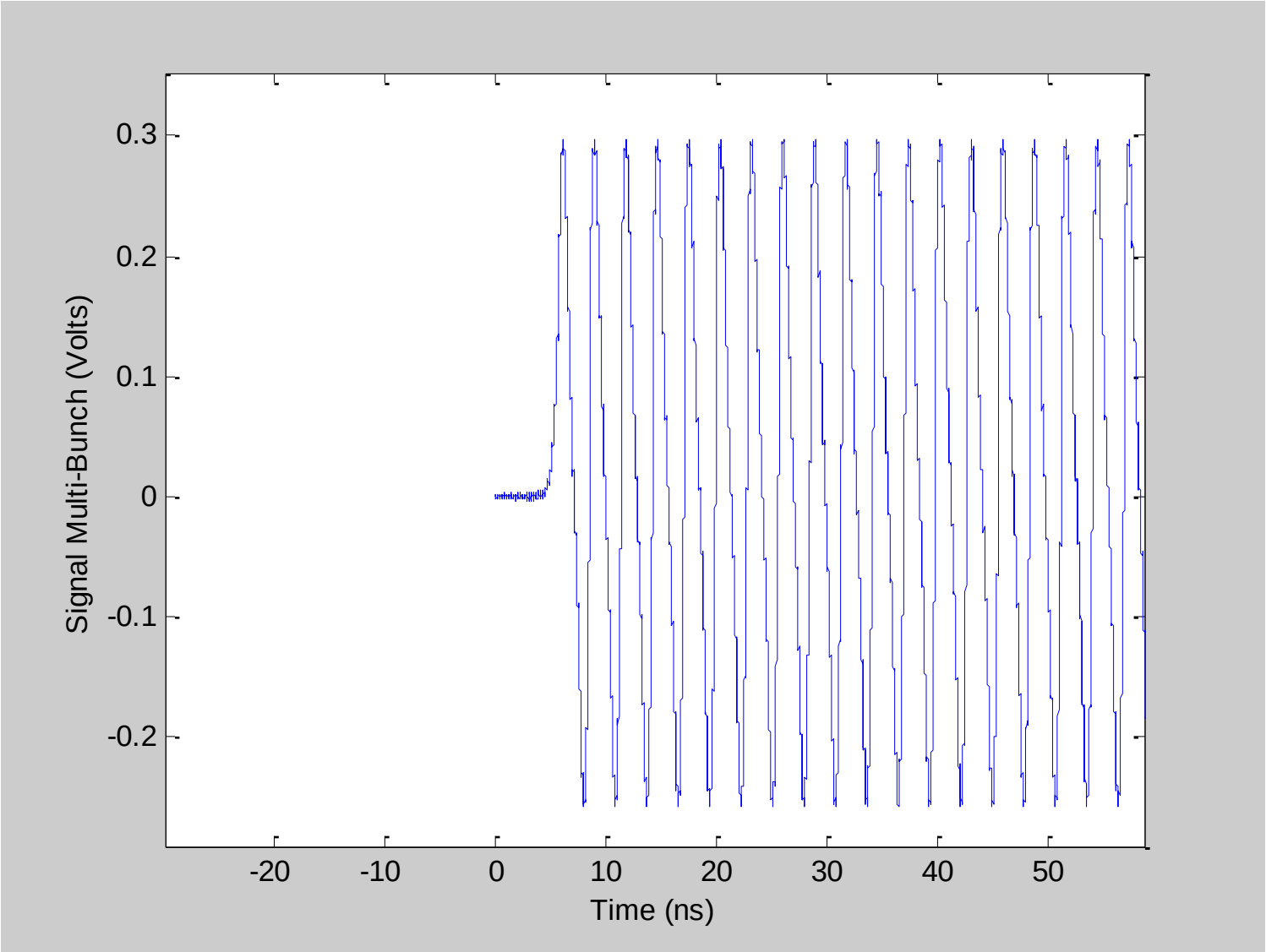


σ: 3.2 mm



σ: 2.8 mm

BPM strips expected multi-bunch voltage in time domain

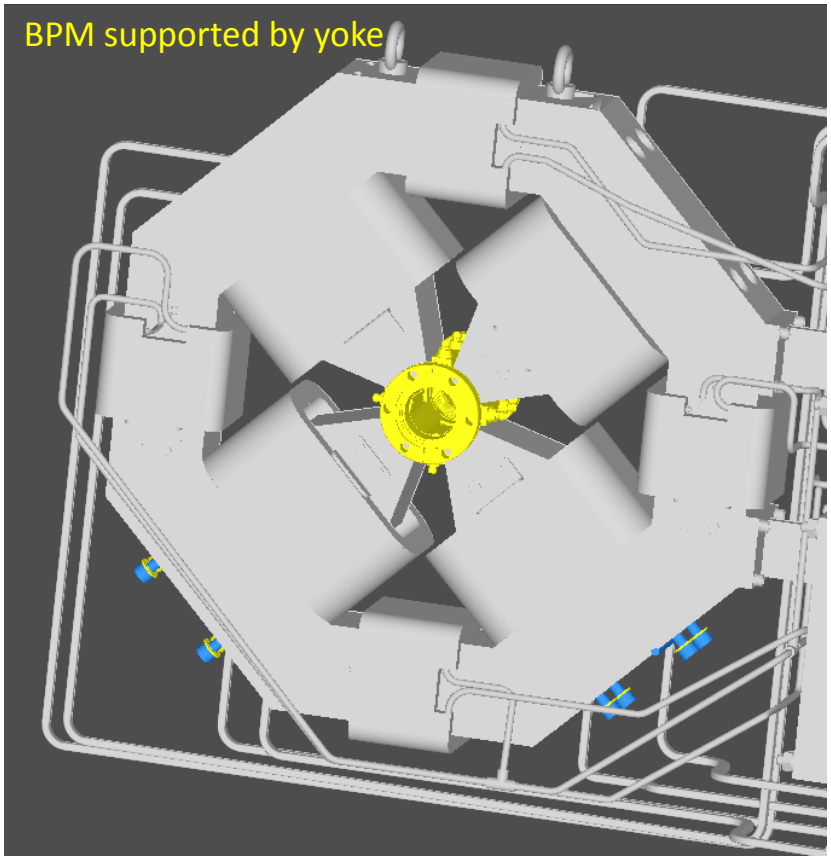


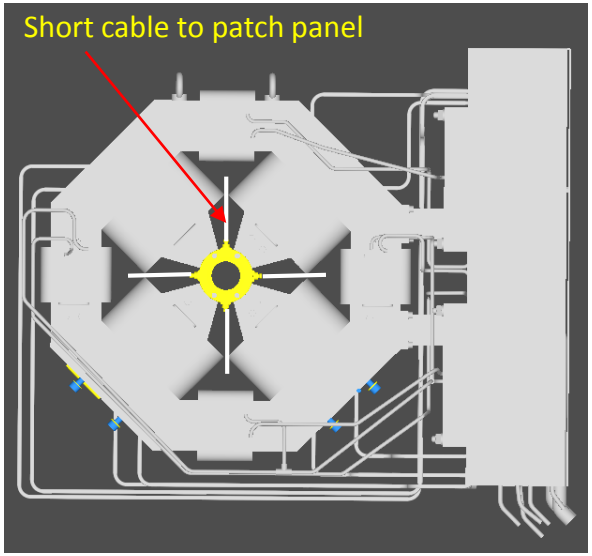
Electronics specs

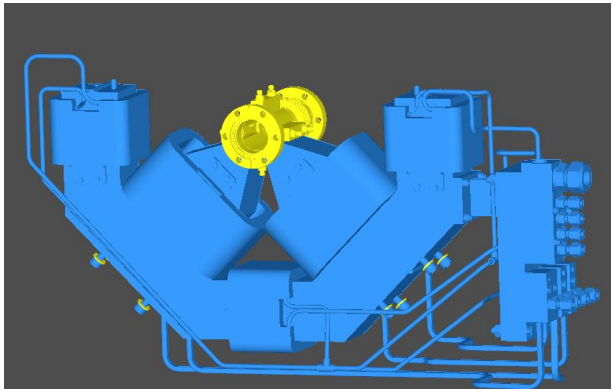
The electronics specification requirement by ESS ERIC

Parameter	Value	Comments
Max input Power	20 dBm	Input absolute limit
Center Frequency	352 / 704 MHz	Configurable
Bandwidth (3dB)	1 MHz	
Bandwidth (60 dB)	35 MHz	
Crosstalk	<-60 dB	
SNR	˜ 60 dB	
Input Power range	-60 dBm to 5 dBm	
SFDR	60 dBc	
Nonlinearity	<0.1 dB	Over the Dynamic range
Noise Figure	10 dB	

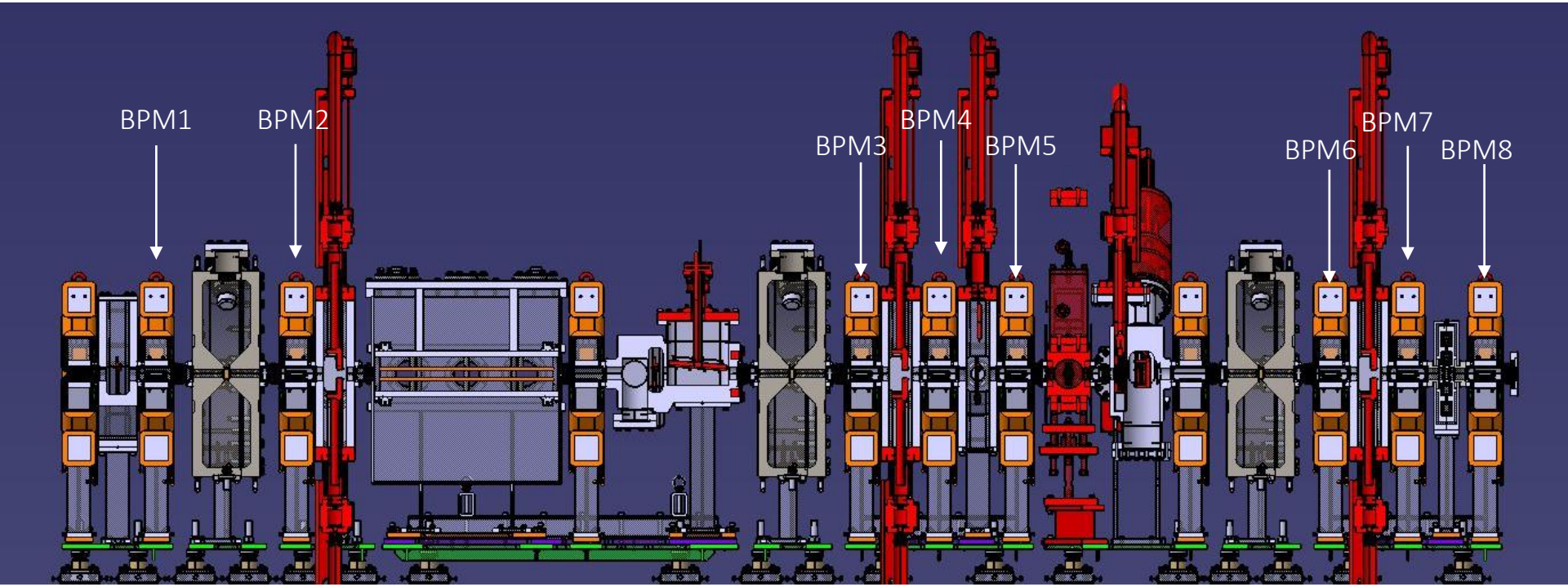
BPM Stripline location and positioning between yoke





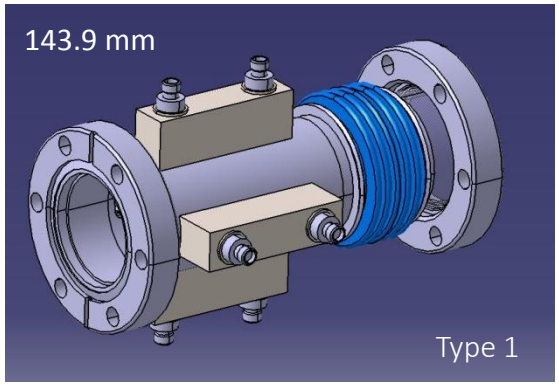


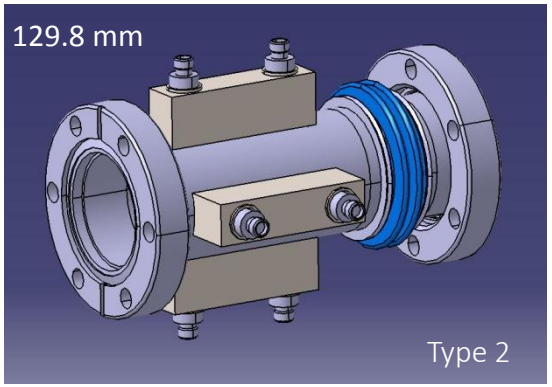
Whole MEBT and locations of 8 BPMs

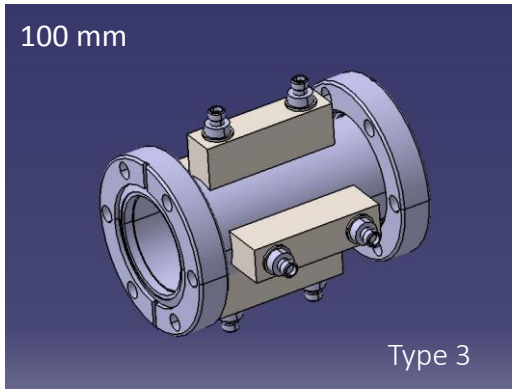


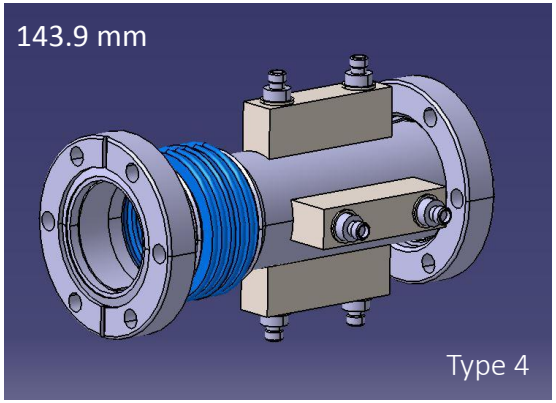
BPM various types

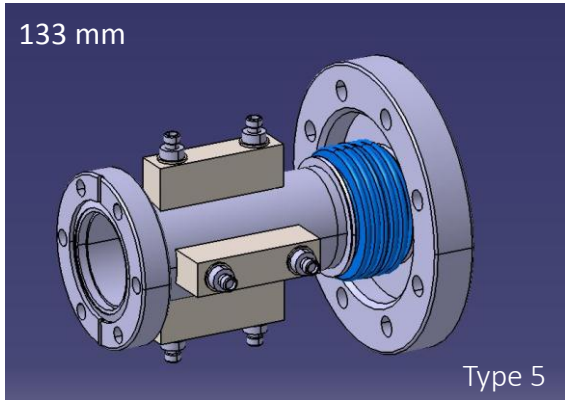
One identical BPM core design , but 5 different BPM sets based on the mechanical integration limitations (variation in tube and bellow lengths).



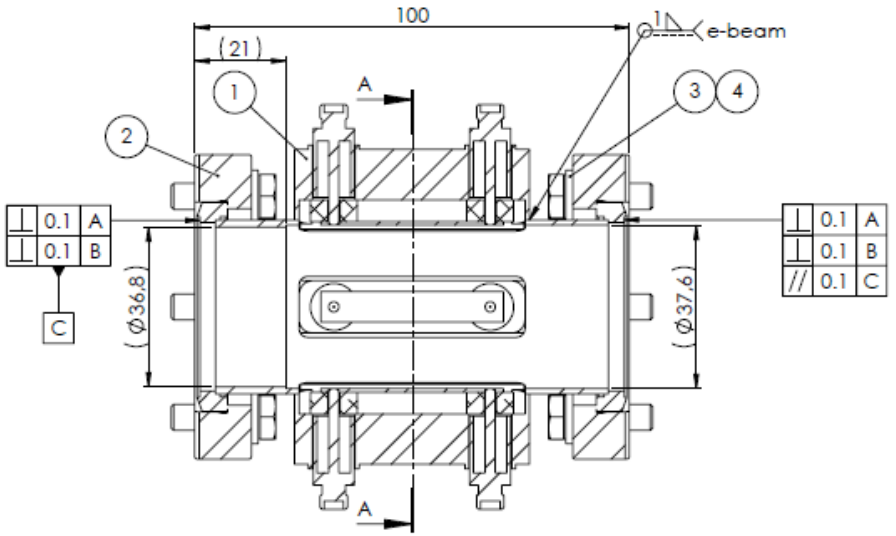


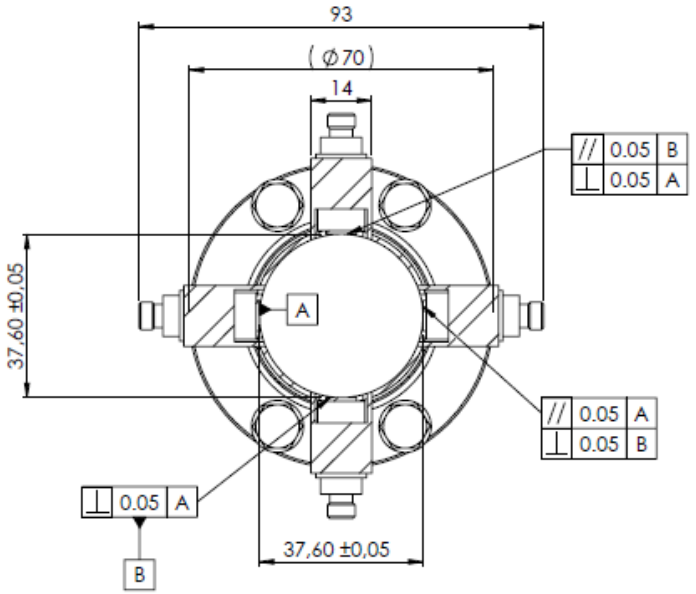




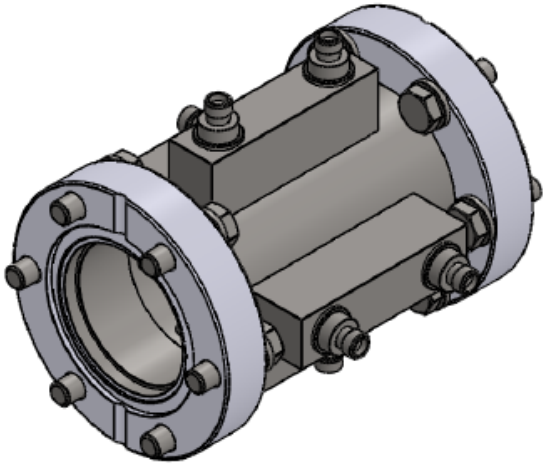


Type 3 dimensions





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

Acabado: rebarbar y romper aristas

Tolerancias generales en roscas DIN 13: 6H - 6g

Tolerancias dimensionales generales: ISO 2768 - 1(m) Lineales

ESS BILBAO
Este plano, su formato y su contenido es propiedad de ESSbilbao y para uso estrictamente confidencial. No debe copiarse o distribuirse a terceros sin el permiso escrito de ESSbilbao

	Nombre	Fecha
Diseñado	S. Varnasseri	16/09/2015
Dibujado	A. Zugasaga	26/10/2015
Verificado	I. Ruedo	
Aprobado		

NOT FOR PRODUCTION

Tolerancias geométricas generales: ISO 2768-2(K)

Medidas en milímetros

Rugosidad

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

ESCALA 1:1

HOJA 1 DE 1

1m Short cable between BPM stripline and patch panel: ECO142, fire resistant, Halogen free, Outer diameter< 5 mm

LOW LOSS FLEXIBLE CABLE 5/50 D (ECO142: alternative to RG142)

ECO-Friendly cable
Cost effective solution

P/N: C291 325 290 S+

APPLICATION NOTE

Designed by RADIALL, ECO142 is an advantageous alternative solution to RG142:

- **Advantageous in term of electrical performance:** its optimized construction allows better attenuation and screening effectiveness than RG142.
- **Advantageous in term of environmental aspect:** halogen and sulphur free, this cable does not emit any toxic substance when submitted to fire.
  The flame retardant jacket allows ECO142 to meet fire resistance standards.
- **Advantageous in term of price:** ECO142 design has integrated all RADIALL knowledge to reach the best performances with a very competitive price.
  ECO142 is UL style 1375 approved.

This cable is compatible with a large range of connector series.

CONSTRUCTION / DIMENSIONS

	material	mm	inches
center conductor	solid OFC[1] copper	0.95	0.037
dielectric	foam PE[2]	2.85	0.112
inner shield	Al[3] foil	3.10	0.122
outer shield	TC[4] braid	3.50	0.138
jacket	black LSZH PE[5]	4.50	0.177

ELECTRICAL CHARACTERISTICS

characteristic impedance	50Ω ± 2Ω	
operating frequency range	DC - 3 GHz	
shielding effectiveness	80 dB (DC - 3 GHz)	
voltage withstanding	5 000 V rms	
peak power	2.7 kW	
capacitance	87 pF / m	26.4 pF / ft
velocity of propagation	77 % (4.3 ns / m)	

MECHANICAL CHARACTERISTICS

recommended minimum bending radius	15 mm	0.590 inch
weight	36 g / m	0.0242 lbs / ft

ENVIRONMENTAL CHARACTERISTICS

operating temperature range	-40 / +85 °C	-40 / +185 °F
fire resistance	yes (UL1581 VW1 / IEC 332-1)	
halogen free	yes (IEC 754-2)	

LOW LOSS FLEXIBLE CABLE 5/50 D (ECO142X)

ECO-Friendly cable
Cost effective solution

P/N: C291 320 180

APPLICATION NOTE

Designed by RADIALL, ECO142X is an advantageous alternative solution to ECO142 when higher power level is required:

- **Advantageous in term of electrical performance:** the crosslink foam polyethylene used as dielectric material allows higher temperature level (thus power range) than ECO142.
- **Advantageous in term of environmental aspect:** halogen and sulphur free, this cable does not emit any toxic substance when submitted to fire. The flame retardant jacket allows ECO142X to meet fire resistance standards.
- **Advantageous in term of price:** ECO142X design has integrated all RADIALL knowledge to reach the best performances with a very competitive price.
  ECO142X is UL style 1375 and 3651 approved.

This cable is compatible with a large range of standard connector series.

CONSTRUCTION / DIMENSIONS

	material	mm	inches
center conductor	solid SPC[1]	0.95	0.037
dielectric	X foam PE[2]	2.98	0.117
inner shield	SPC[1] braid	3.64	0.143
outer shield	SPC[1] braid	4.30	0.169
jacket	black with blue stripe LSZH PE[3]	5.00	0.197

ELECTRICAL CHARACTERISTICS

characteristic impedance	50Ω ± 2Ω	
operating frequency range	DC - 6 GHz	
shielding effectiveness	75 dB (DC - 5 GHz)	
voltage withstanding	5 000 V rms	
capacitance	94.5 pF / m	28.7 pF / ft
velocity of propagation	71 % (4.7 ns / m)	

MECHANICAL CHARACTERISTICS

recommended minimum bending radius	30 mm	118 inch
weight	60 g / m	0.0433 lbs / ft

ENVIRONMENTAL CHARACTERISTICS

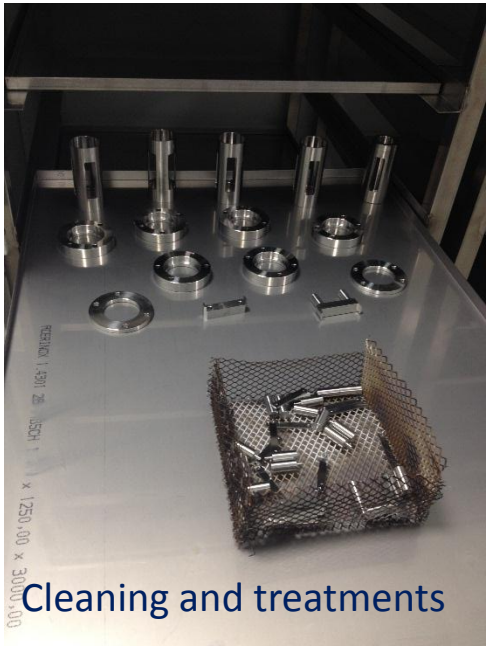
operating temperature range	-40 / +105 °C	-40 / +221 °F
fire resistance	yes (UL1581 VW1 / IEC 332-1)	
halogen free	yes (IEC 754-2)	

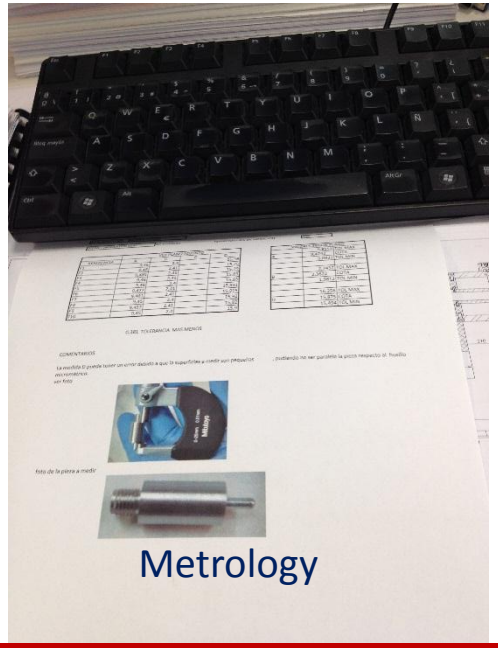
MEBT BPM Stripline Status

- ✓ 3D Electromagnetic and mechanical Design: Finished February 2016
- ✓ Prototype fabrication process started: April 2016
- ✓ Finished first prototype: April 2017
- ✓ RF measurements of prototype finished: April 2017
- ✓ Magnetic checks finished: May 2017
- ➢ Mechanical needs some improvements in the welding auxiliaries.


Vacuum tests


Magnetic
permeability tests

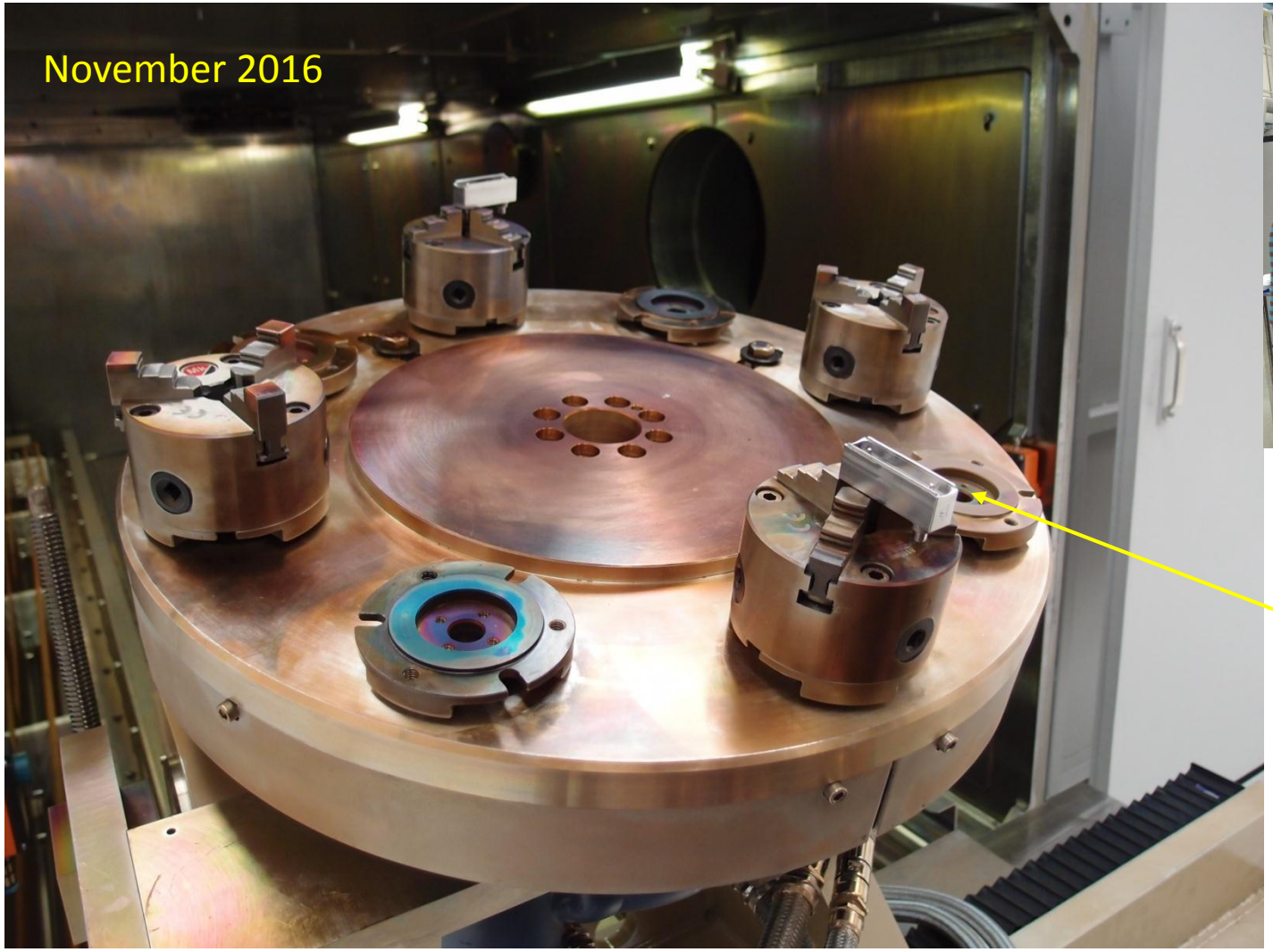

Cleaning and treatments

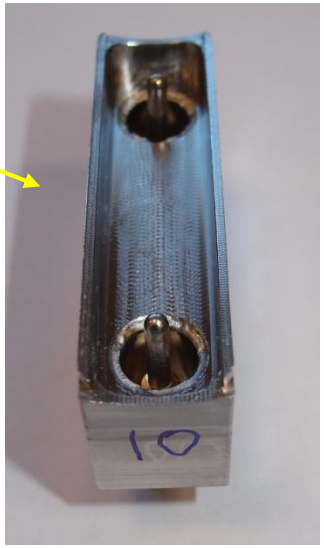

Metrology


Fabrication pieces

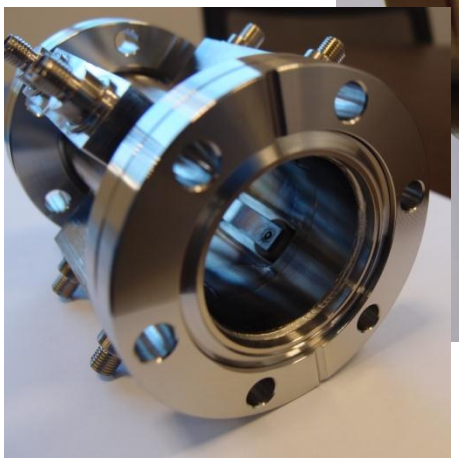

Failures!!

Fabrication process: e-beam welding



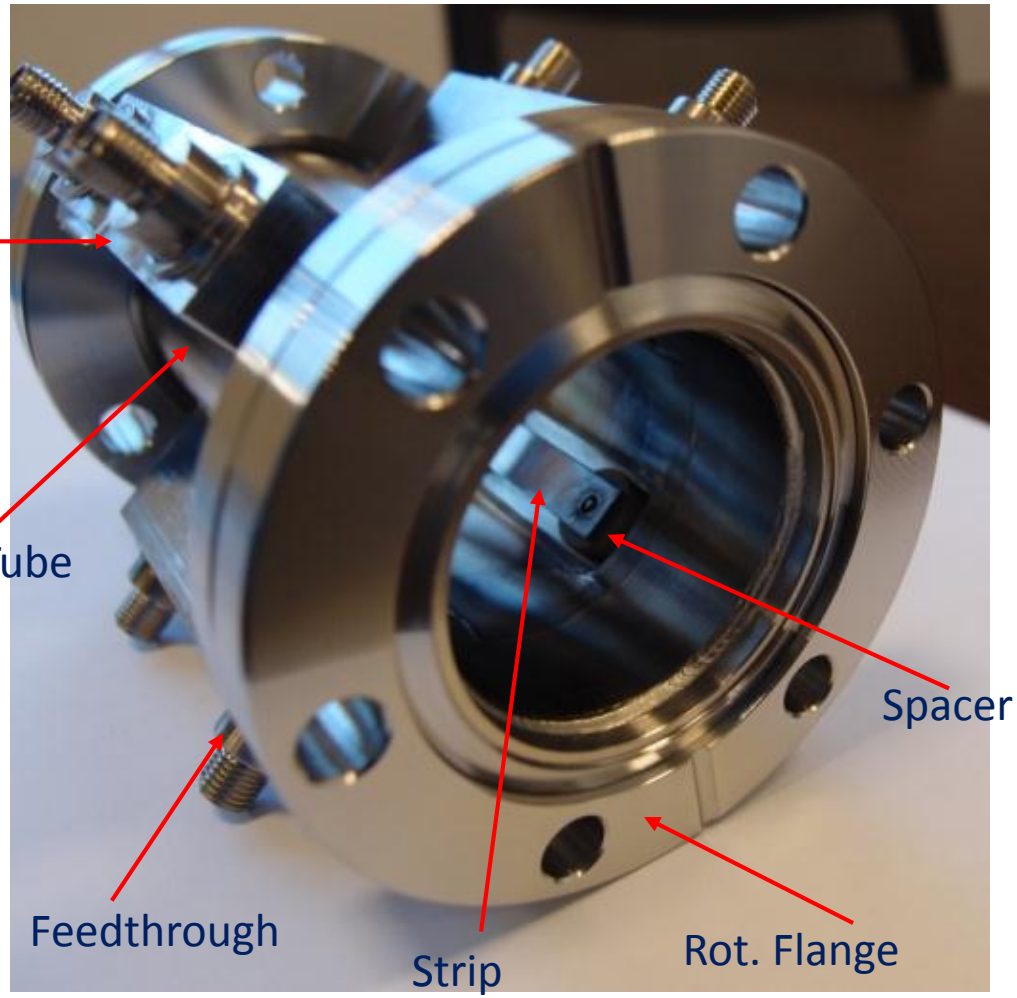


MEBT BPM prototype, April 2017



Various parts:

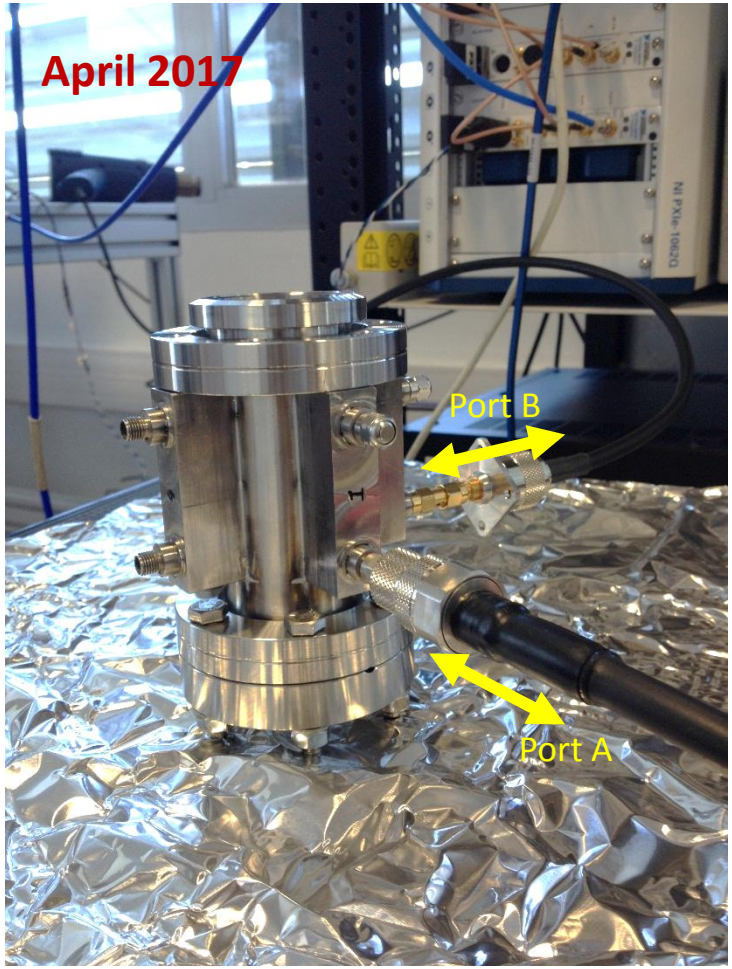
- SL Box (8x4)
- SL Tube
- Feedthrough (8x8)
- Strip (8x4)
- Spacer (8x8)
- Rot. Flange

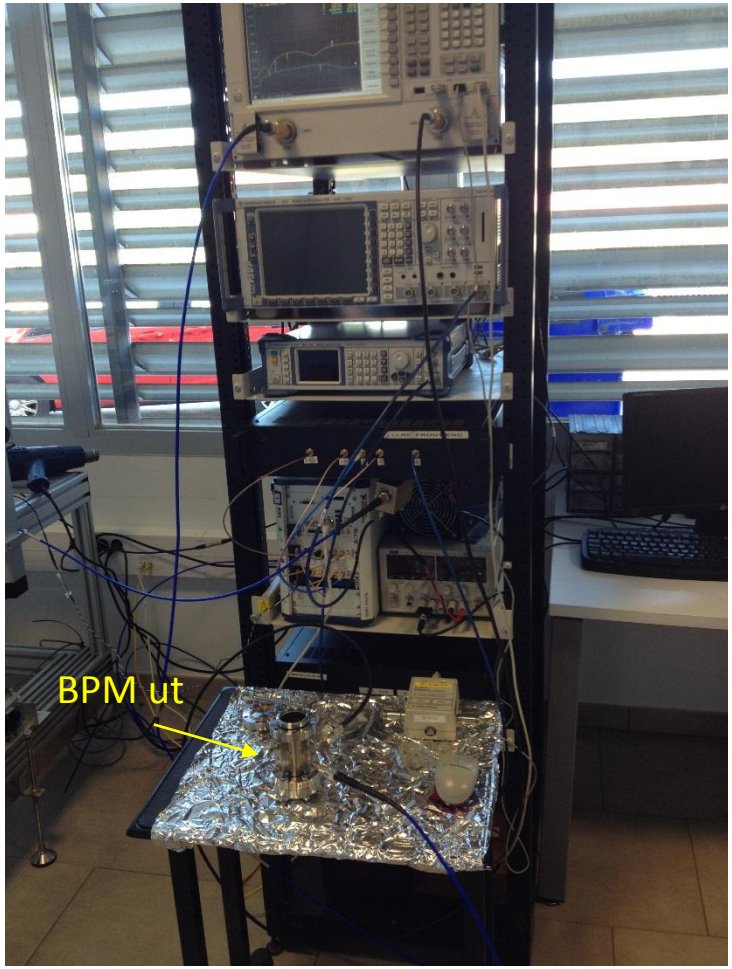


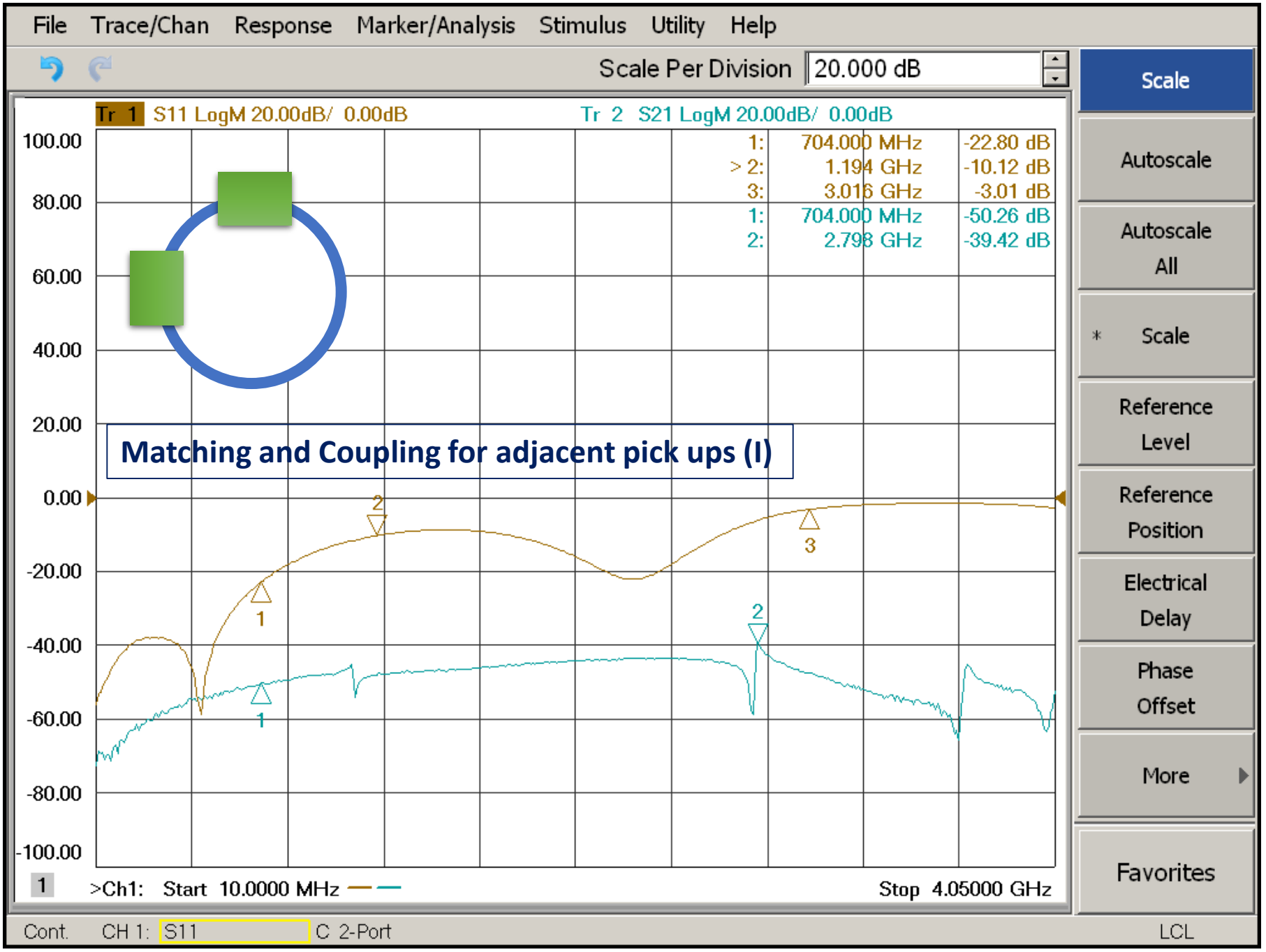
BPM Stripline measurements

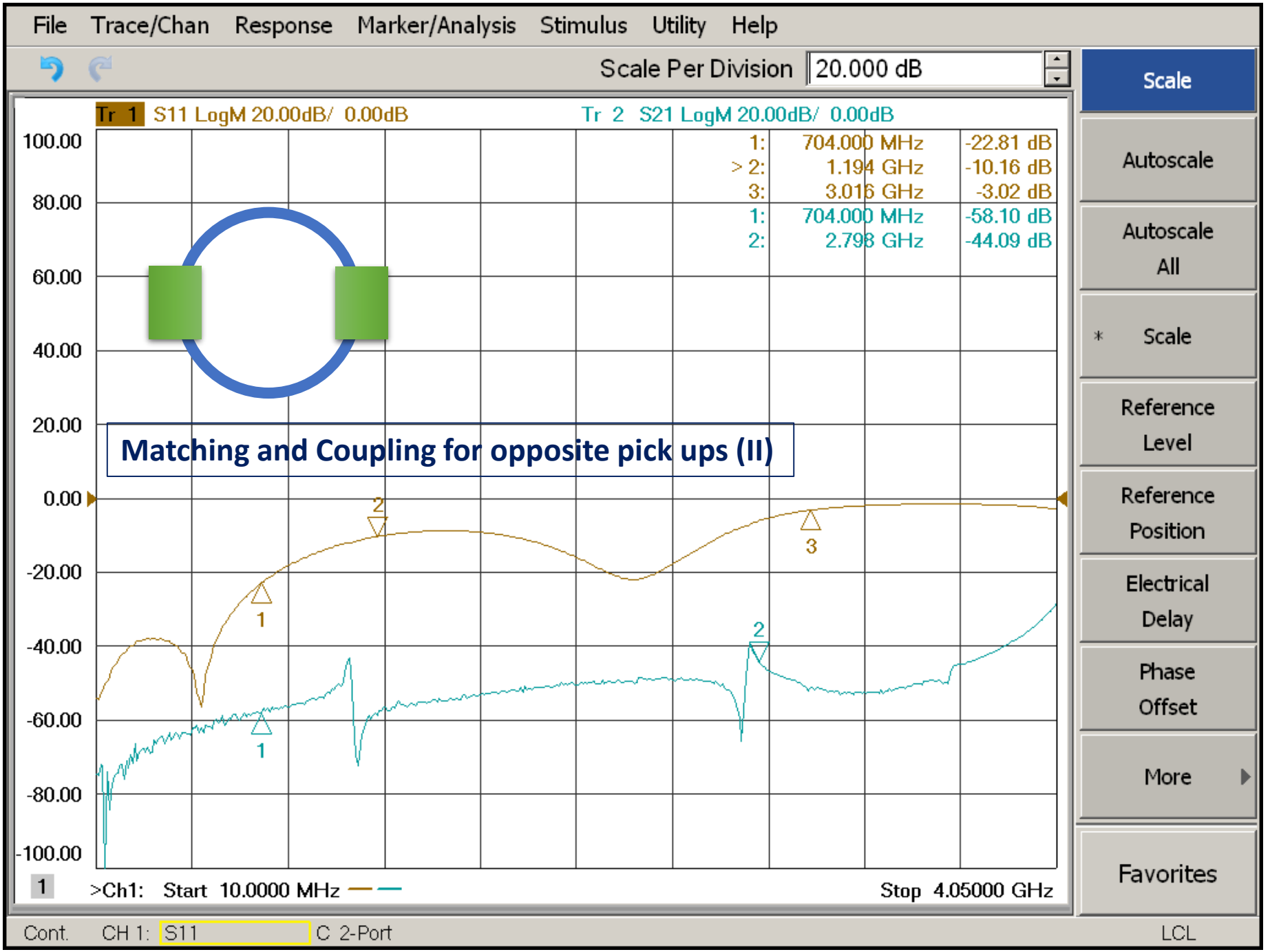
- Signal transmission and matching to electronics
- Coupling between electrodes

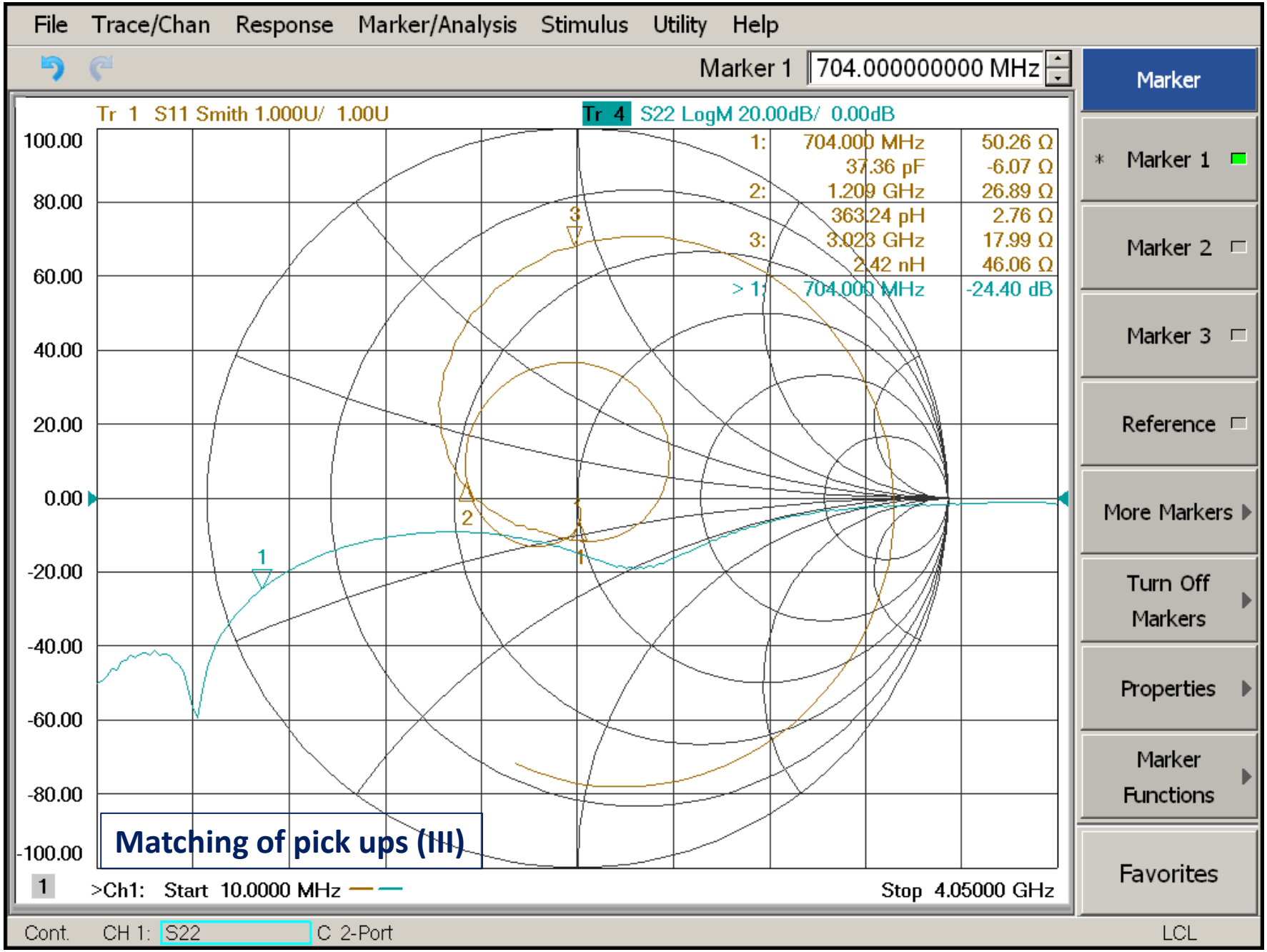
Measurement setup for high frequency checks
Transmission and reflection : Reflection < -20 dB, Transmission> -0.5 dB



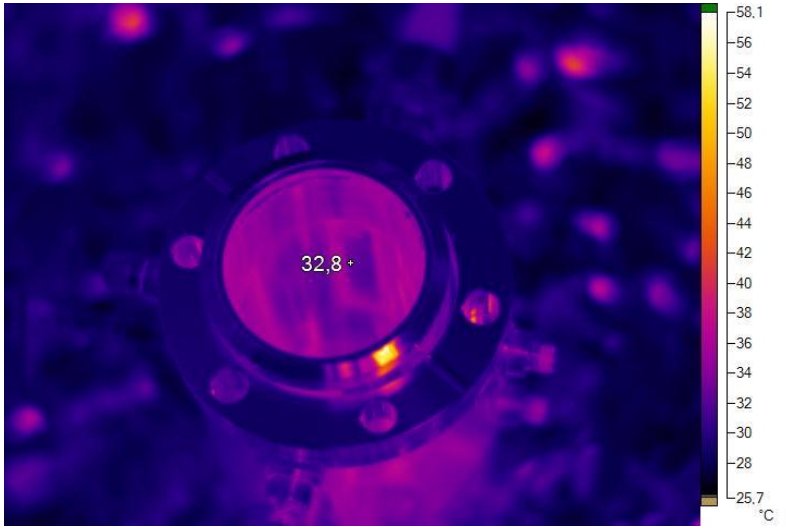


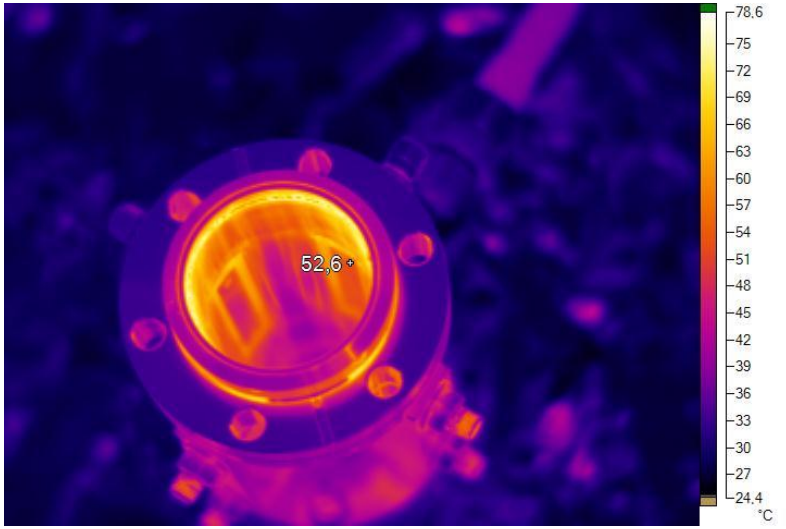

File
Trace/Chan
Response
Marker/Analysis
Stimulus
Utility
Help
Scale Per Division
20.000 dB
Scale
Autoscale
Autoscale All
Scale
Reference Level
Reference Position
Electrical Delay
Phase Offset
More
Favorites
Tr 1 S11 LogM 20.00dB/ 0.00dB
Tr 2 S21 LogM 20.00dB/ 0.00dB
1: 704.000 MHz -22.80 dB
> 2: 1.194 GHz -10.12 dB
3: 3.016 GHz -3.01 dB
1: 704.000 MHz -50.26 dB
2: 2.798 GHz -39.42 dB
100.00
80.00
60.00
40.00
20.00
0.00
-20.00
-40.00
-60.00
-80.00
-100.00
Matching and Coupling for adjacent pick ups (I)
>Ch1: Start 10.0000 MHz
Stop 4.05000 GHz
Cont.
CH 1: S11
C 2-Port
LCL

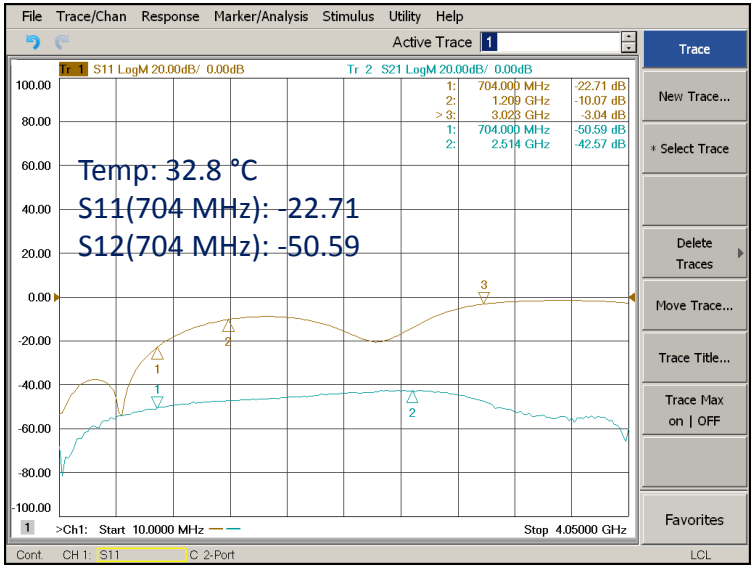

File
Trace/Chan
Response
Marker/Analysis
Stimulus
Utility
Help
Scale Per Division
20.000 dB
Scale
Autoscale
Autoscale All
Scale
Reference Level
Reference Position
Electrical Delay
Phase Offset
More
Favorites
Tr 1 S11 LogM 20.00dB/ 0.00dB
Tr 2 S21 LogM 20.00dB/ 0.00dB
1: 704.000 MHz -22.81 dB
> 2: 1.194 GHz -10.16 dB
3: 3.016 GHz -3.02 dB
1: 704.000 MHz -58.10 dB
2: 2.798 GHz -44.09 dB
100.00
80.00
60.00
40.00
20.00
0.00
-20.00
-40.00
-60.00
-80.00
-100.00
Matching and Coupling for opposite pick ups (II)
1
2
3
1
2
1
>Ch1: Start 10.0000 MHz
Stop 4.05000 GHz
Cont.
CH 1: S11
C 2-Port
LCL

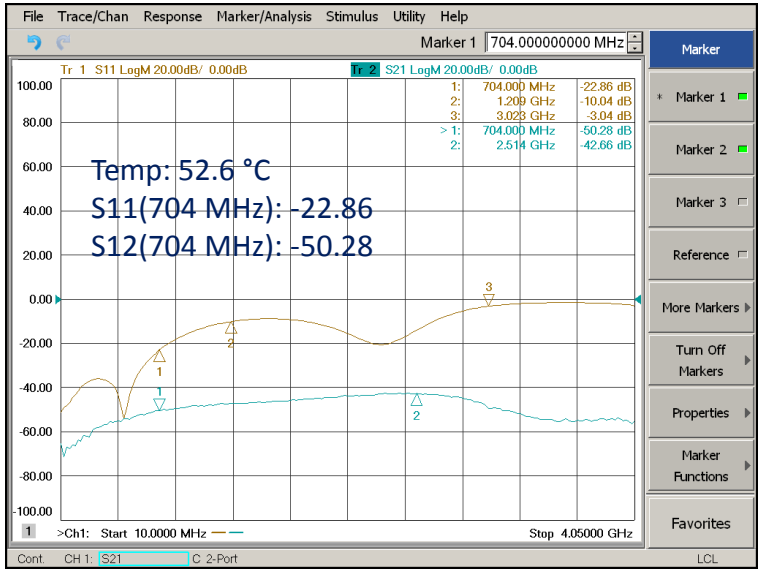

File Trace/Chan Response Marker/Analysis Stimulus Utility Help
Marker 1 704.000000000 MHz
Tr 1 S11 Smith 1.000U/ 1.00U
Tr 4 S22 LogM 20.00dB/ 0.00dB
1: 704.000 MHz 50.26 Ω
37.36 pF -6.07 Ω
2: 1.209 GHz 26.89 Ω
363.24 pH 2.76 Ω
3: 3.023 GHz 17.99 Ω
2.42 nH 46.06 Ω
> 1: 704.000 MHz -24.40 dB
100.00
80.00
60.00
40.00
20.00
0.00
-20.00
-40.00
-60.00
-80.00
-100.00
Matching of pick ups (III)
1 >Ch1: Start 10.0000 MHz
Stop 4.05000 GHz
Cont. CH 1: S22 C 2-Port
LCL
Marker
Marker 1
Marker 2
Marker 3
Reference
More Markers
Turn Off Markers
Properties
Marker Functions
Favorites

Thermal effects on BPM HF characteristics









Coupling and temperature sensitivity checks

Measured strips coupling

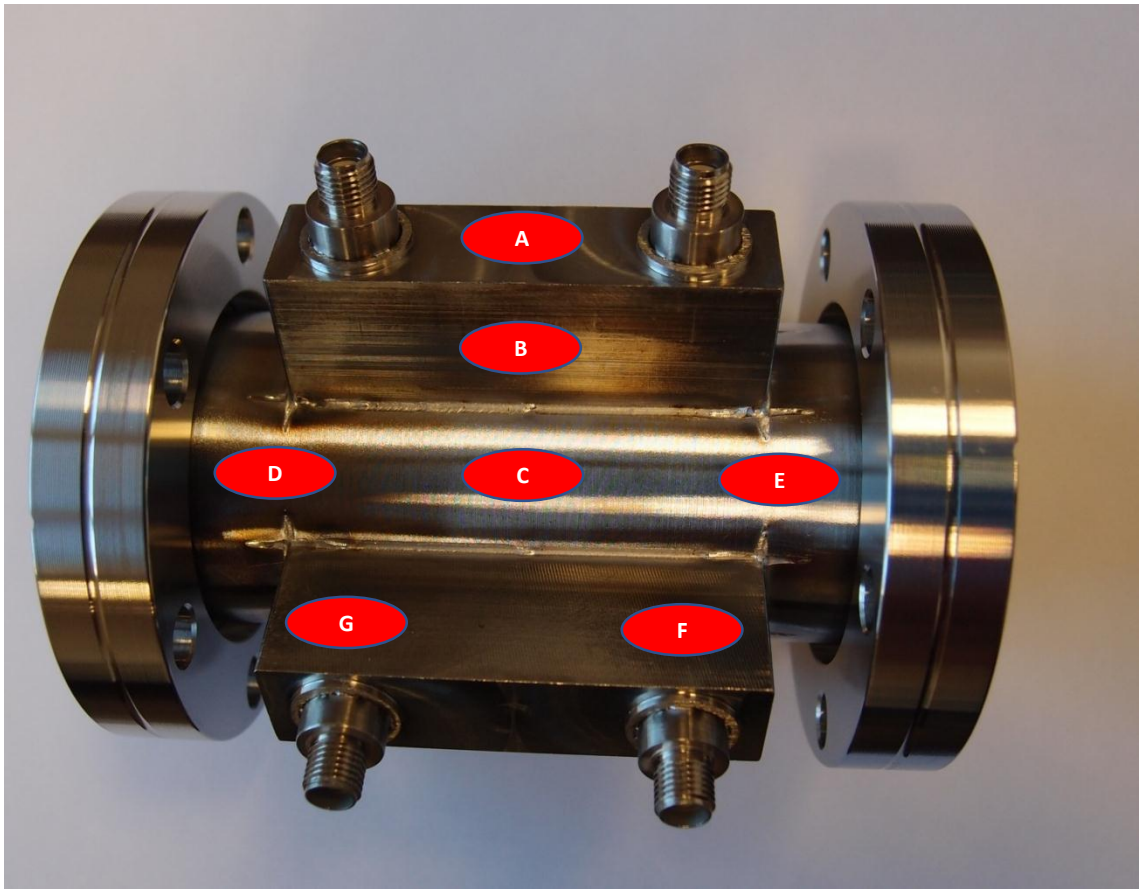
Strips	S21
Adjacent Strips (Strip1, Strip2)	-50.26
Opposite Strips (Strip1, Strip3)	-58.10

Measured temperature sensitivity

	T: 32.8 °C	T: 52.6 °C	~Δ/°C
S11 (@704 MHz)	-22.71	-22.86	-0.0075 dB/°C
Coupling adjacent (@704 MHz)	-50.59	-50.28	0.0156 dB/°C

Measured Magnetic permeability values (μr< 1.1)

Points	μr
A	1.02
B	1.05
C	1.02
D	1.01
E	1.01
F,G	1.05



Verifications (prototype):

Pieces verification
- ✓ Metrology
- ✓ Magnetic properties

Fabrication process verifications
- ✓ Metrology
- ✓ Vacuum leakage tests
- ✓ rf measurements

Acceptance tests
- ✓ rf measurements
- ✓ Magnetic permeability
- ⏻ Metrology
- ⏻ Vacuum leakage tests

❑ Lesson learnt: Needs improvement in welding auxiliaries

Verifications (series 8 BPMs):

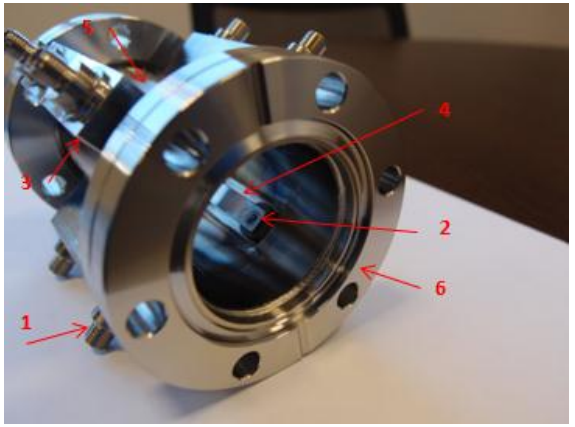
Pieces verification
- Metrology
- Magnetic properties

Fabrication process verifications
- Metrology
- Vacuum leakage tests
- rf measurements

Acceptance tests
- rf measurements
- Magnetic permeability
- Metrology
- Vacuum leakage tests

Pieces production plan

Before welding process



	BPM required pieces to fabricate/order						
	Piece	Absolute Quantity	Ordering Quantity	BPM nº	Lead time	Recieve Periority	Start order 2017
1	Feedthrough SMA, W-NM	64	75	1-8	~2.5 Months	High (Aug-17)	May
2	MEBT-BP-0102-ESS.00-MEC	64	75	1-8	~ 2 Months	High(Aug-17)	May
3	MEBT-BP-0101-ESS.03-MEC	32	40	1-8	~ 3 Months	High(Aug-17)	May
4	MEBT-BP-0103-ESS.02-MEC	32	50	1-8	~ 3 months	High(Aug-17)	May
5	MEBT-BP-0201-ESS.03-MEC	is in progress MI	is in progress MI	1-8	~ 3 Months	High(Sep-17)	June
6	Rotating CF Flange	16	20	1-8	~ 2 Months	Medium(Oct-17)	June
7	Bellow type1 (short)	1		5	~ 2 Months	Medium(Nov-17)	July
8	Bellow type2 (long)	5		1,2,3,6,8	~2 Months	Medium(Nov-17)	July

BPM provisional schedule

- **April- 2016**: Finish design (electromagnetic and mechanical)
- **April- 2017**: First prortotype ready
- **June- 2017**: Long lead components production to be started (see previous page)
- **June-2017**: Verification tests of BPM#P finished
- **Sep-2017**: Series production ready to start (BPM#1-8)
- **Nov-2017**: Main rf checks
- **March-2018**: BPM#1-8 production finished
- **May- 2018**: BPM#1-8 Measurements and Verifications finished