PAUL SCHERRER INSTITUT

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BPM and glass ceramic feedthrough design

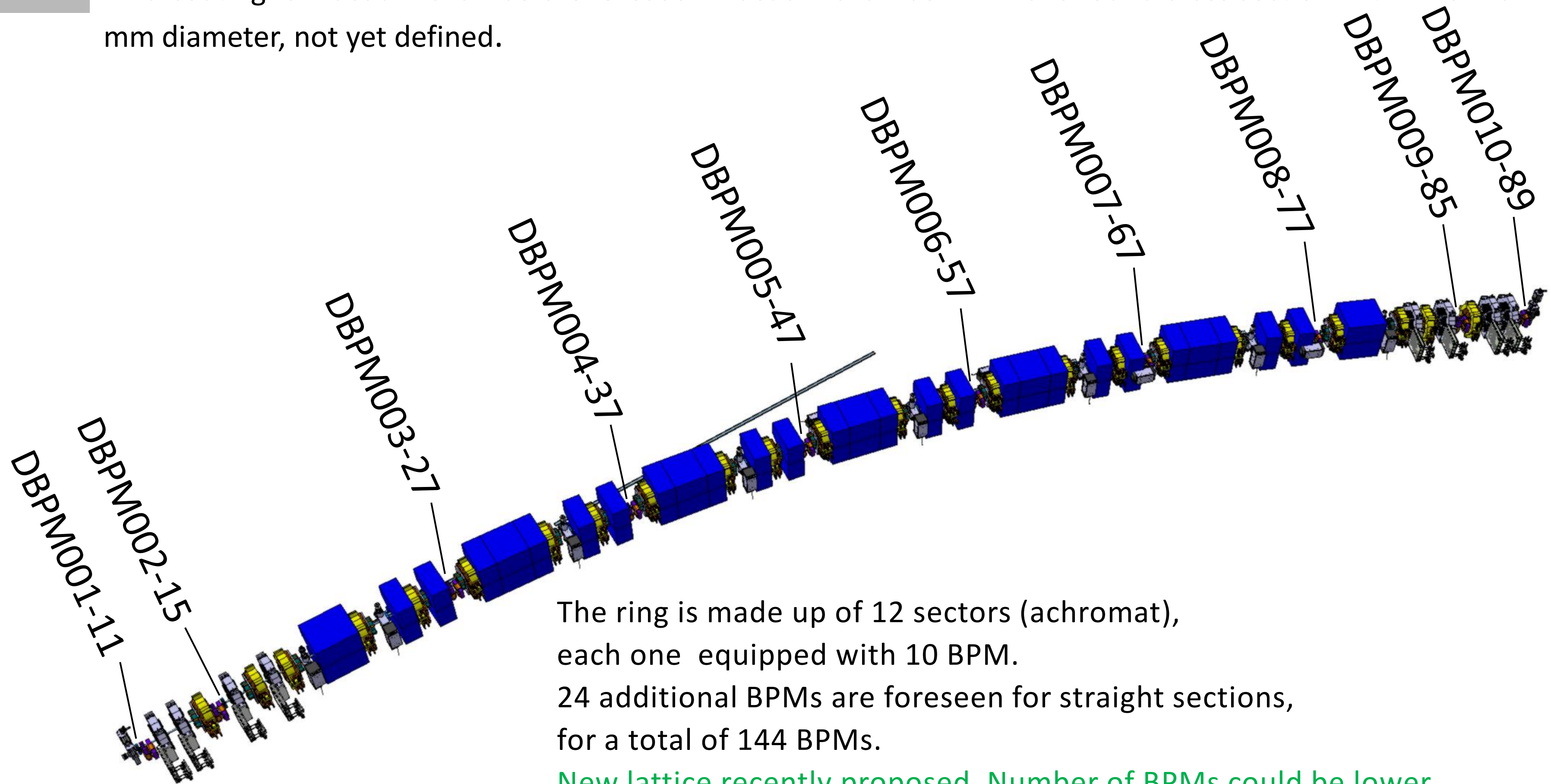
BPM button design and manufacturing workshop, Diamond Light Source, 02.05.2019

Contents

Introduction: SLS2

With respect to SLS, SLS 2 will have a new storage ring lattice. Beam energy and current will remain unchanged (2.4GeV and 400mA). The goal is to get 40-50 times lower emittance.

Re-using SLS1 linac, booster, building, but many renewals needed (most SLS1 systems, infrastructure, building nearly 20 years old ...).
NEG-coating for vacuum chambers is foreseen. Vacuum chamber will have round cross section with 17 or 20 mm diameter, not yet defined.



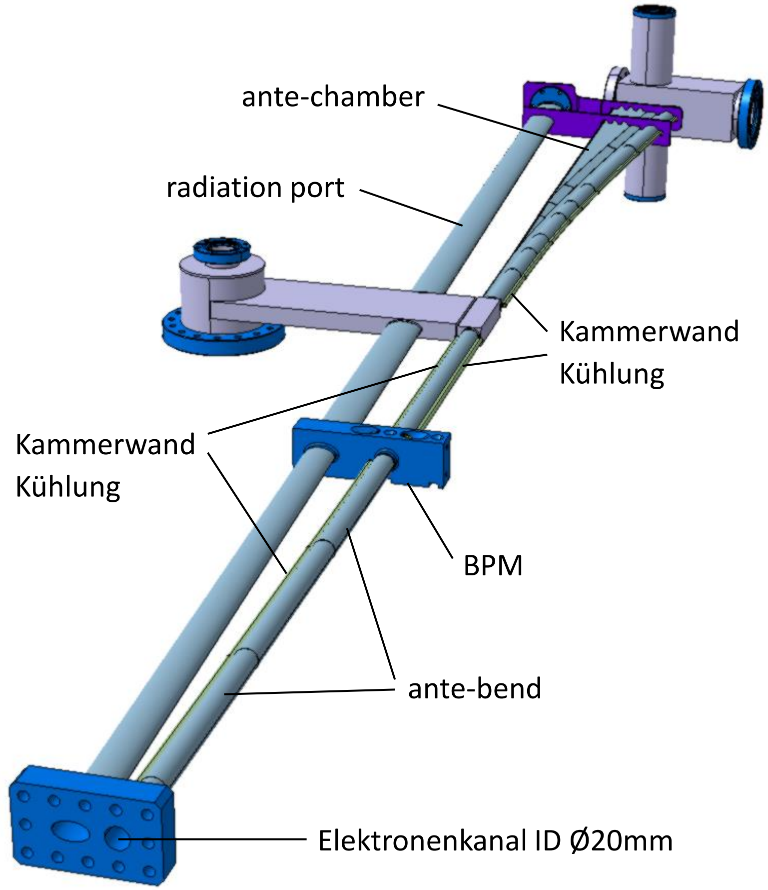
The ring is made up of 12 sectors (achromat),
each one equipped with 10 BPM.
24 additional BPMs are foreseen for straight sections,
for a total of 144 BPMs.
New lattice recently proposed. Number of BPMs could be lower.

Introduction: SLS2 Schedule

- Last SLS1 beam 3/2023
- Start of SLS2 beam commissioning Q2/2024
- SLS2 pilot experiments Q4/2024
- Rather short time for SLS2 accelerator commissioning -> aiming to test & commission critical SLS2 systems already at SLS1 where possible.

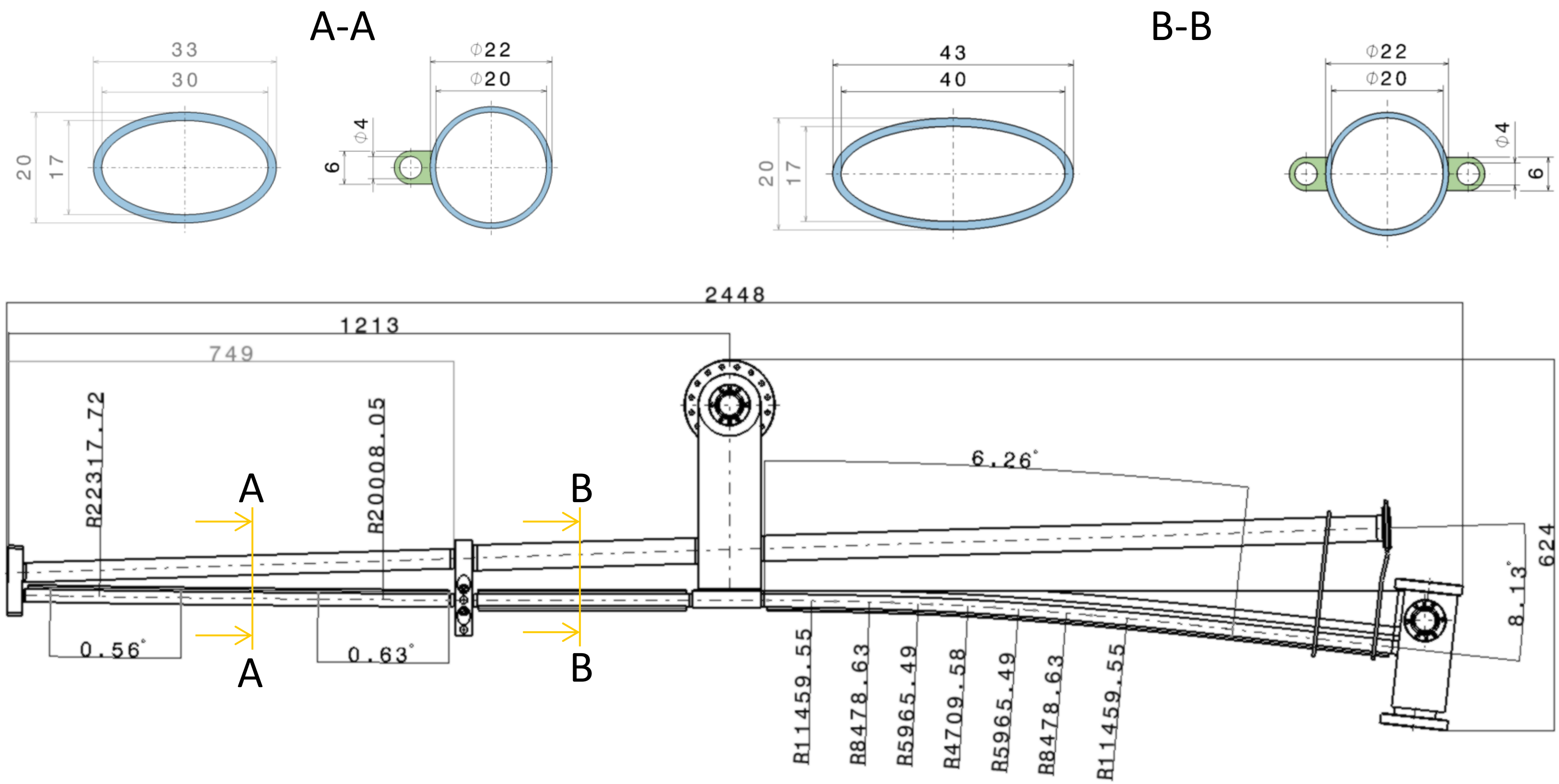
chamber geometry

- Round chamber cross section (ID Ø20mm or Ø17mm not decided yet) along the electron beam trajectory («ante-bend»!)
- Some of the synchrotron radiation power leaves the round chamber through an «ante-chamber» and is absorbed by a discreet «crotch-absorber». The rest is absorbed by «distributed –absorbers» along the round chamber wall
- The BPM is integral part of the chamber
- To let pass the synchrotron radiation to the beam lines an oval shaped «radiation port» is foreseen



Slide courtesy of Adriano Zandonella

chamber geometry



Slide courtesy of Adriano Zandonella

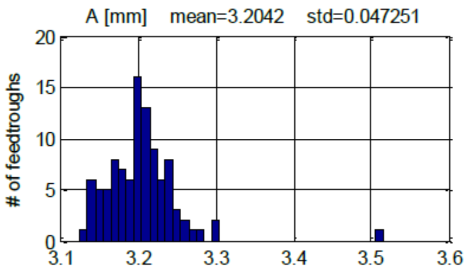
SwissFEL cavity BPM feedthroughs

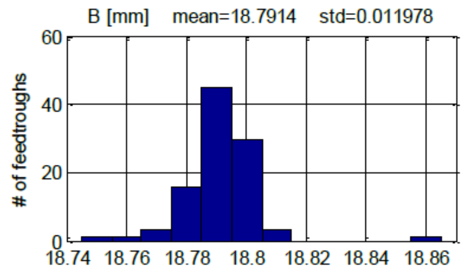
Based on PSI design, 1500 borosilicate glass feedthroughs have been produced for the cavity BPMs of the SwissFEL accelerator.

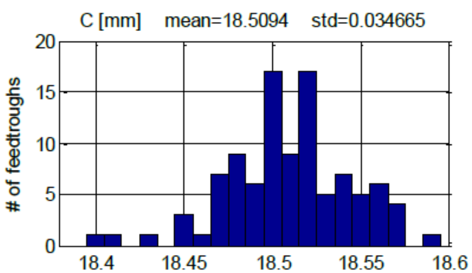
Produced by the swiss company BC Tech.

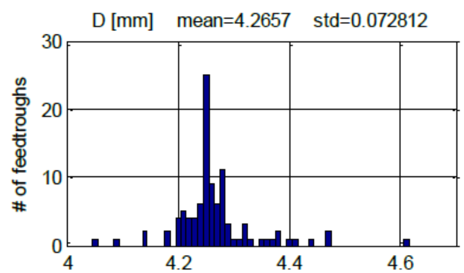
SwissFEL cavity BPM feedthroughs

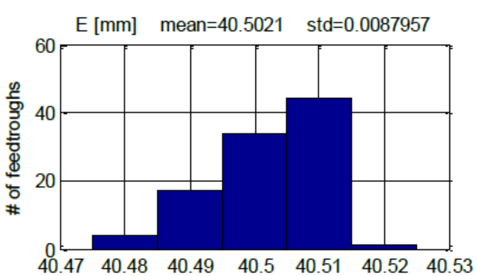
Statistics on mechanical tolerances over 100 pieces







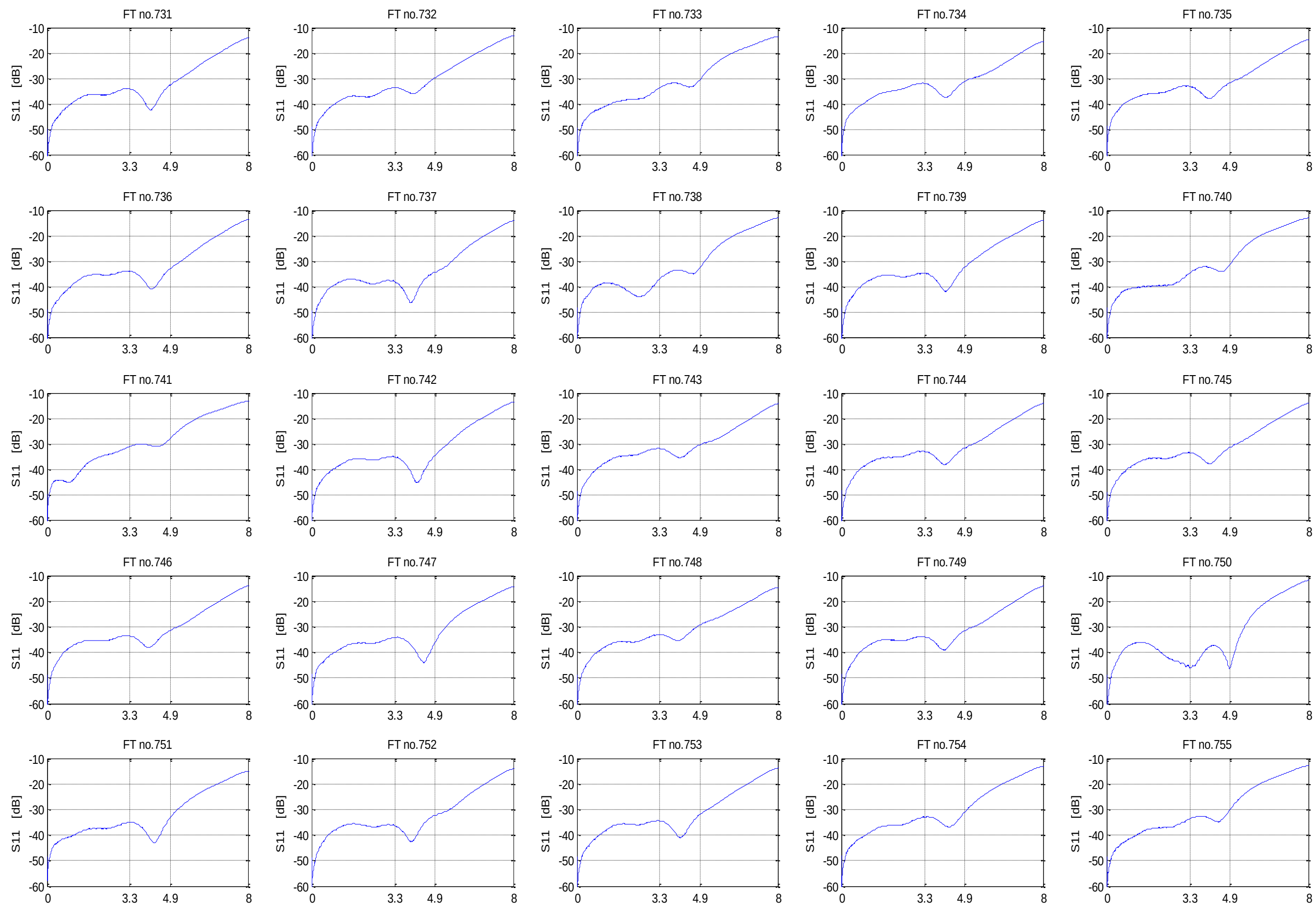




Nominal dimensions and max. allowed tolerances				
A [mm]	B [mm]	C [mm]	D [mm]	E [mm]
3.2±0.1	18.9±02	18.4±0.2	4.13±0.3	40.5±0.3

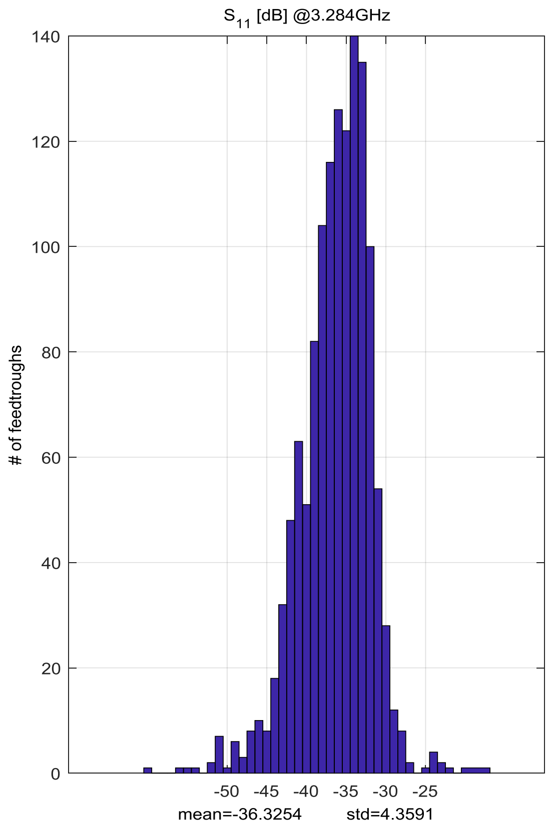
SwissFEL cavity BPM feedthroughs

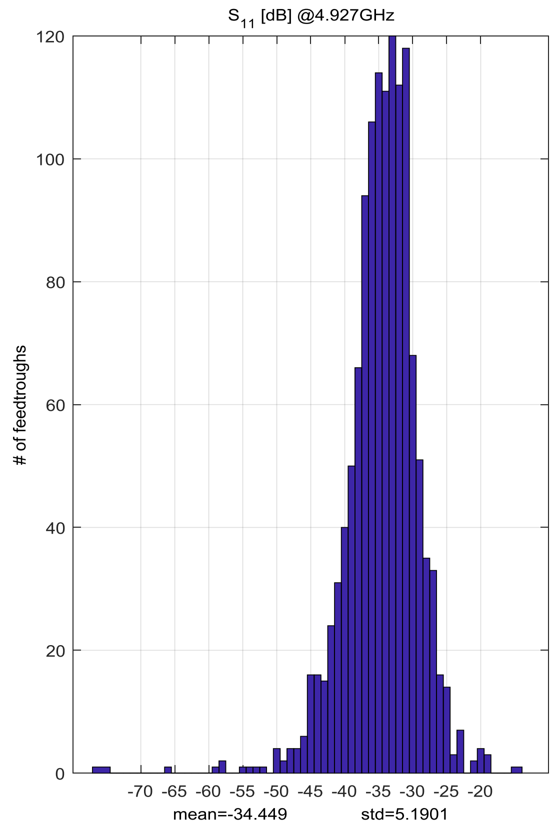
Frequency response of every single feedtrough has been measured (as an example 25 are reported here). The feedtroughs have then been sorted to equip each BPM with feedthroughs having similar reflection coefficient at the BPM working frequency (which is 3284 MHz for two types of BPM and 4927 MHz for the other two types).



SwissFEL cavity BPM feedthroughs

Distribution of the reflection coefficient measured at the two working frequencies.

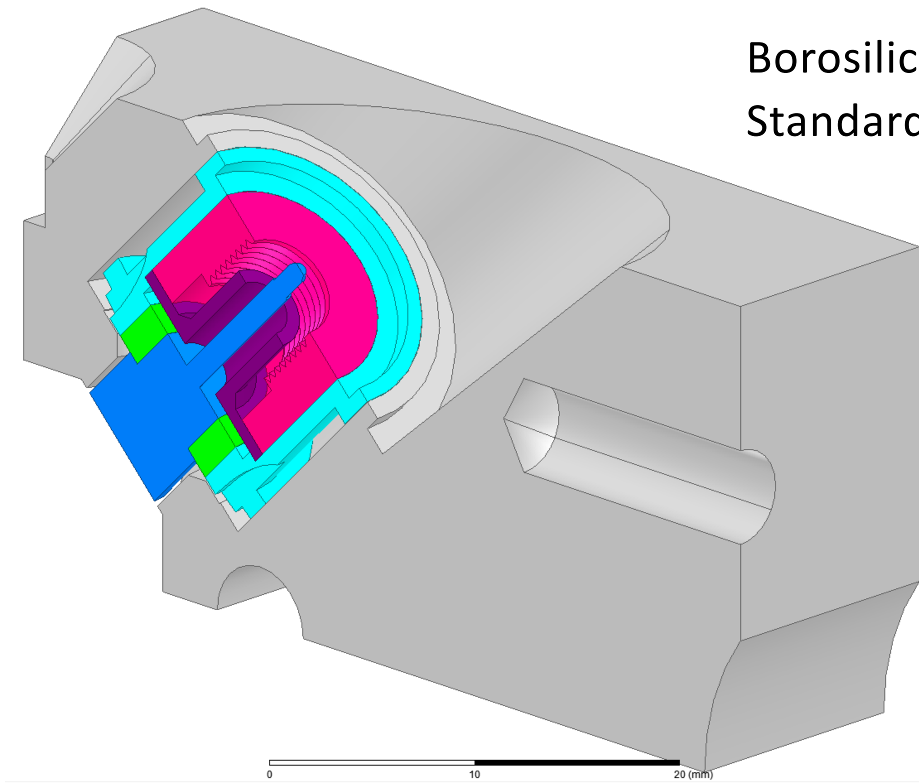




Conclusion: Good quality, cheap price.

To have an alternative option to the classical button with Al2O3, we decided to develop a button with glass feedthrough.

Button BPM with borosilicate glass as dielectric insulator

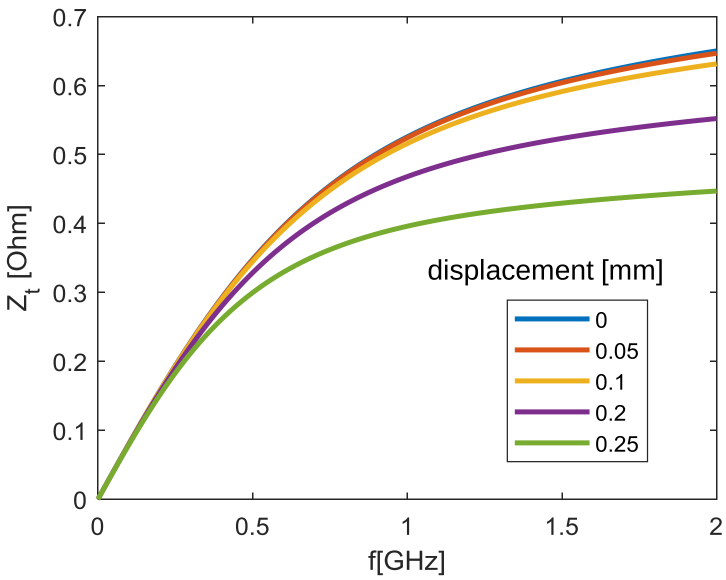


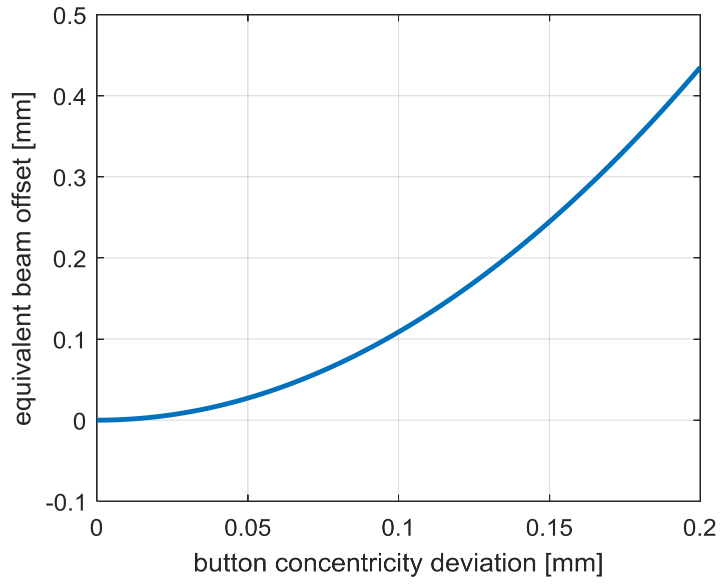
Borosilicate glass in green
Standard SMA female RF connector

Ordered 8 prototypes.
The purpose is to test the manufacturing quality, mechanical tolerances and reproducibility, NEG coating, heating…

Mechanical tolerances

Effects of dimensional tolerances not yet analyzed. Useless until the vacuum pipe is not defined. However, as an example of the importance of dimensional reproducibility, button misalignment (not uniform gap around the button) has been considered.





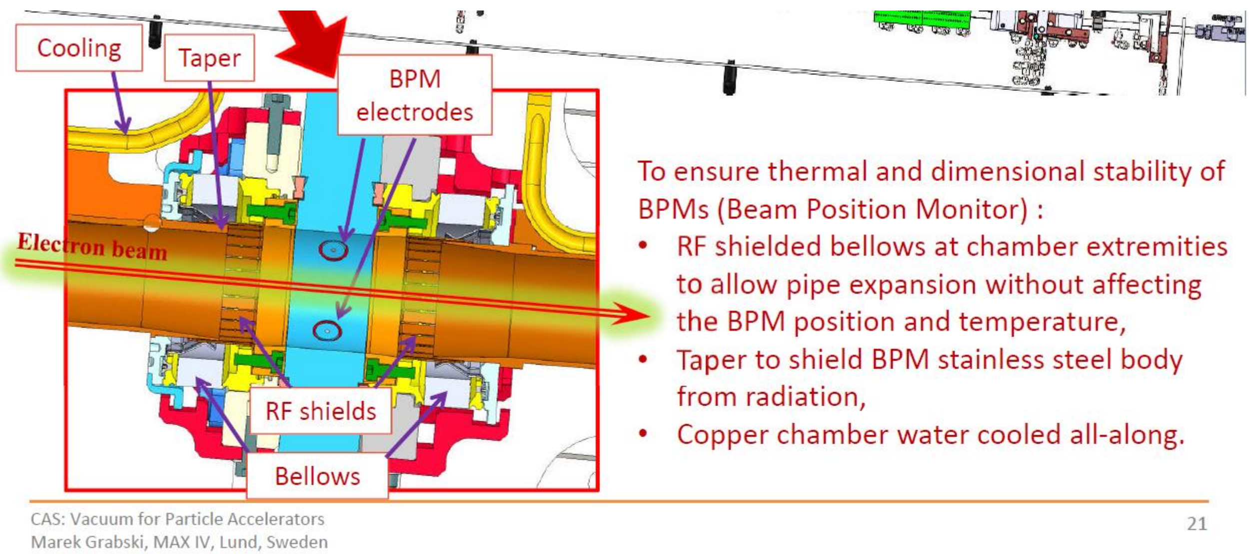
Variation of beam induced voltage in a misaligned button cannot be distinguished from variation due to beam position offset.

Some BPM design criteria

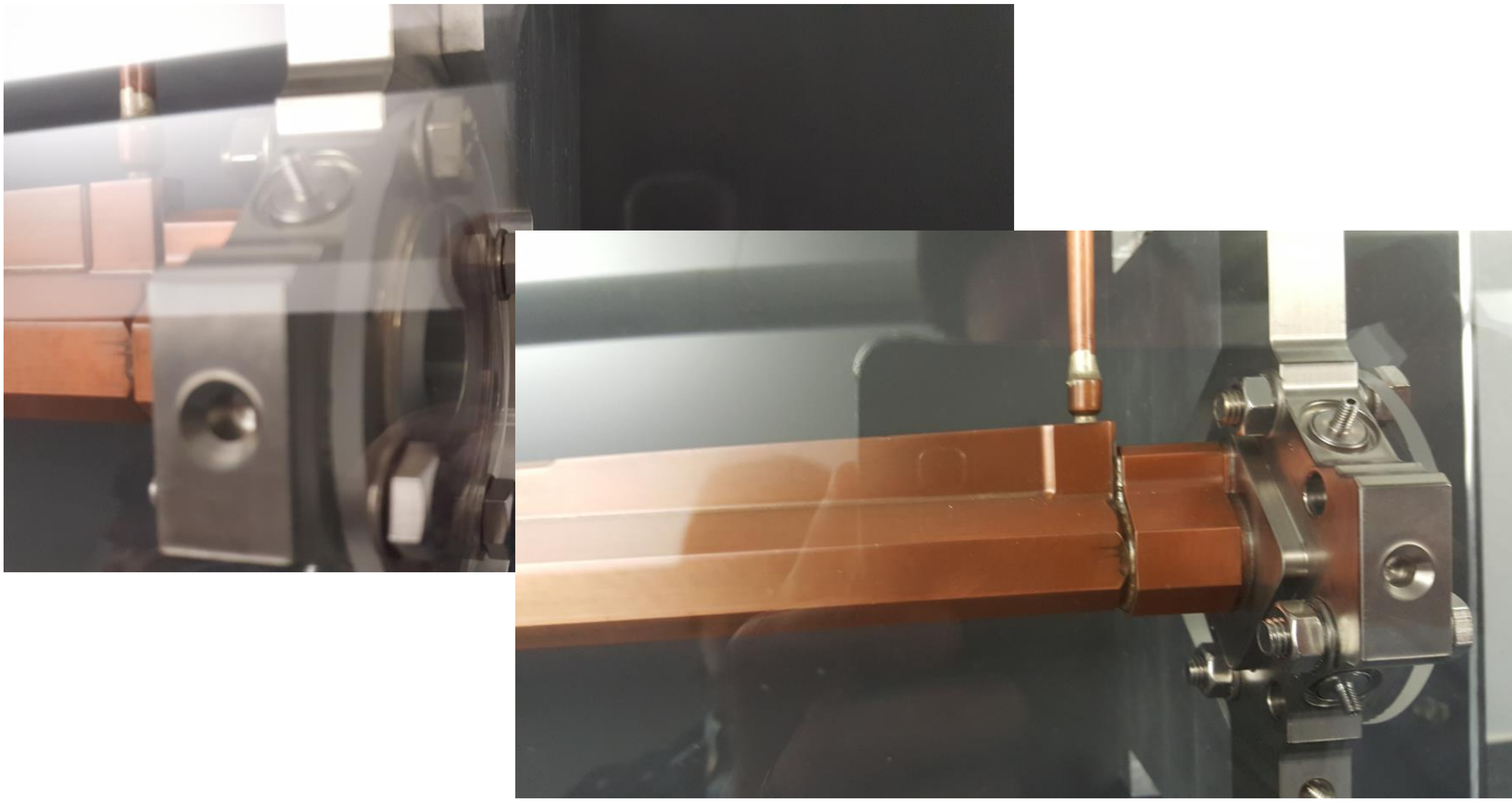
- BPM-Block milled from 1.4429 with brazed copper tube
- Button surface will have a round shape to follow the pipe curvature.

Questions and open points:

- NEG coating of buttons: is coating of the electrodes never a problem, or are there precautions needed depending on geometry (depth & width of the slit to the dielectric, ...)
- How to avoid that synchrotron radiation hits the button: retract the button? How much? Experience? Impact on BPM signal if button is not retracted?



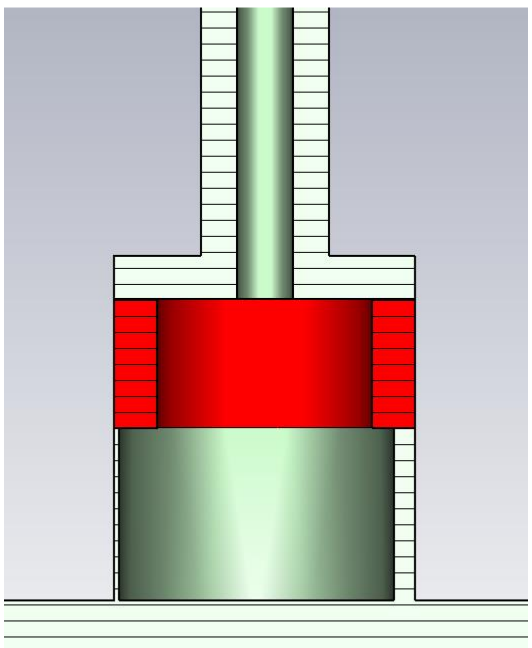
example MAXIV

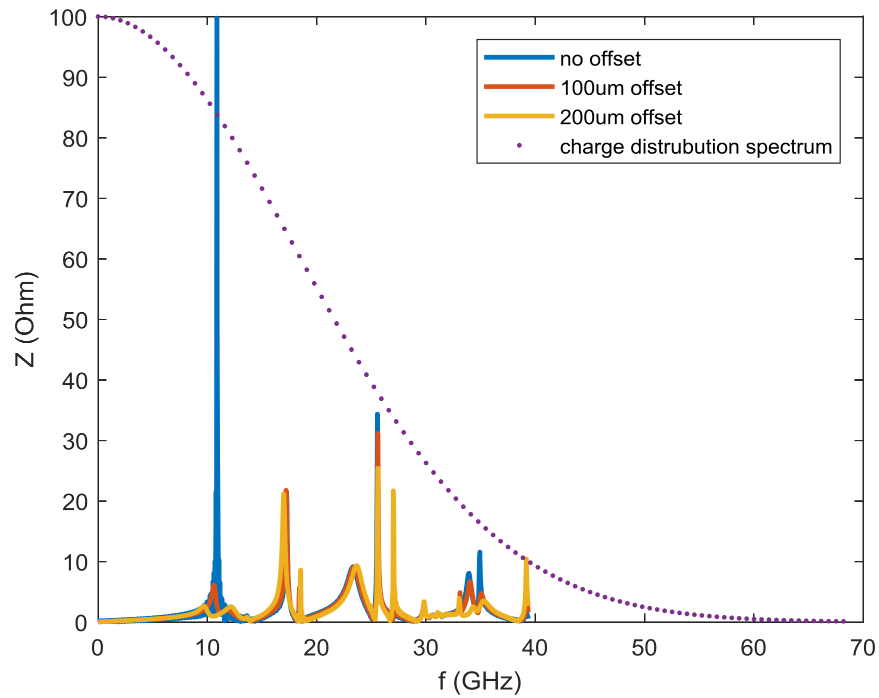


Slide courtesy of Adriano Zandonella

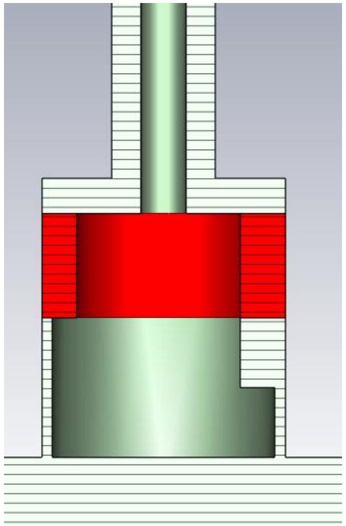
Damping of trapped HOMs

With the aim to keep as lower as possible the contribution of BPMs to the whole machine impedance, methods to damp resonant modes trapped in the button have been considered.
A possible solution is to introduce some asymmetries in the button geometry.
For example placing the button non centered in ist vacuum chamber housing.
TE11 mode @ ~11GHz results strongly damped.

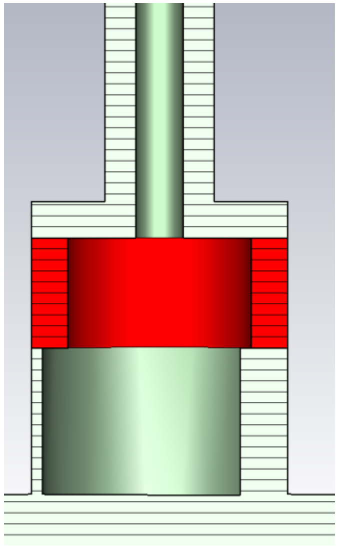


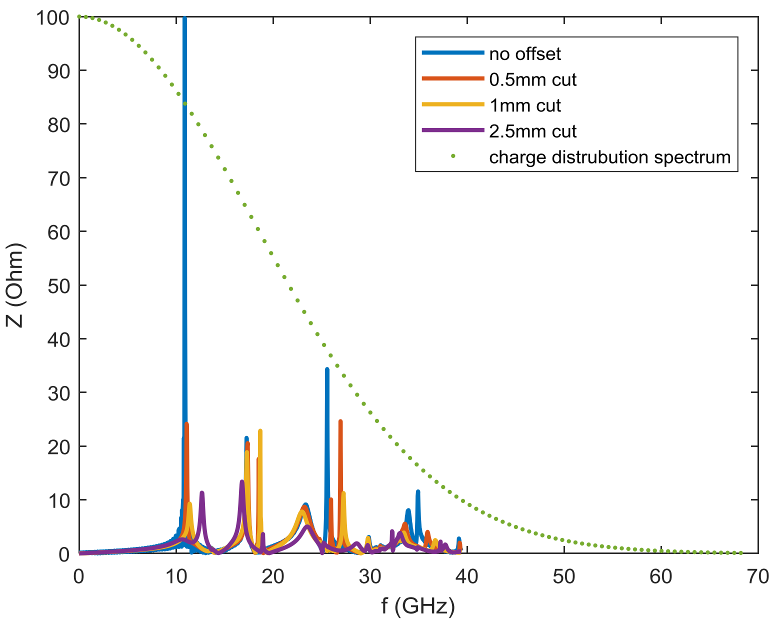


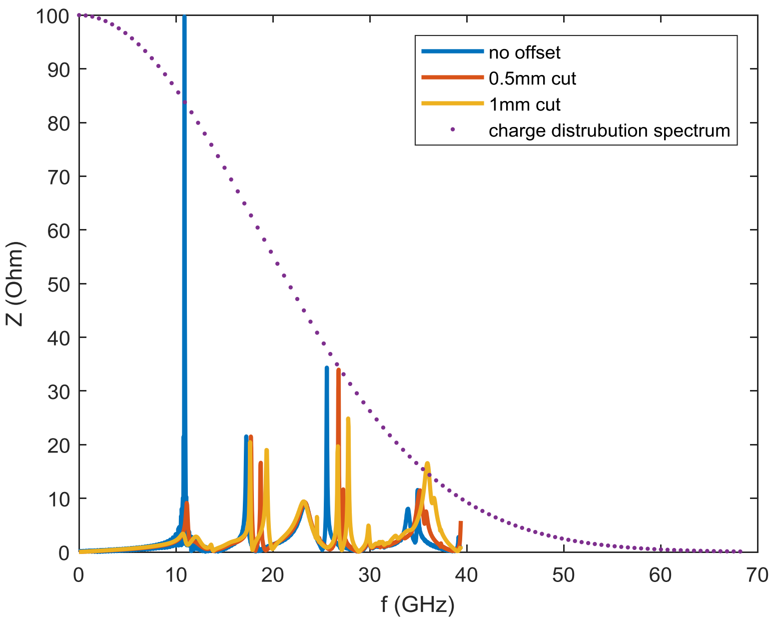
Damping of trapped HOMs



Also cutting the button along ist rotation axis produces a similar beneficial effect.







Until the vacuum chamber size is not defined, cannot be finalized. However we have designed a glass button prototype as an alternative to the more conventional ceramic option.

Many questions are still open and this workshop gives the opportunity to discuss them with a community of experts and manufacturers.

Thank you for the attention!