Technical Review of Beam Position Button Design and Manufacture

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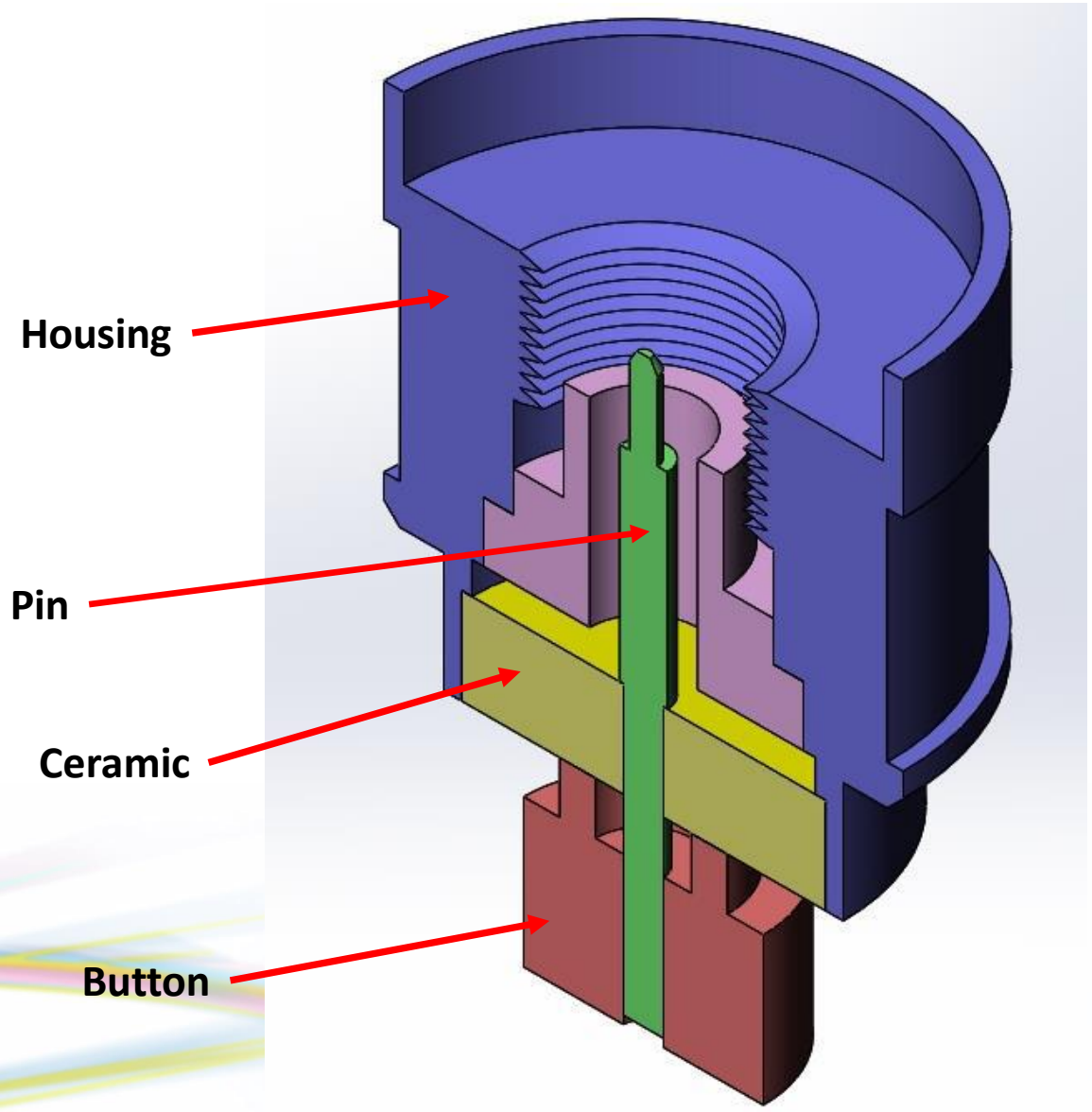
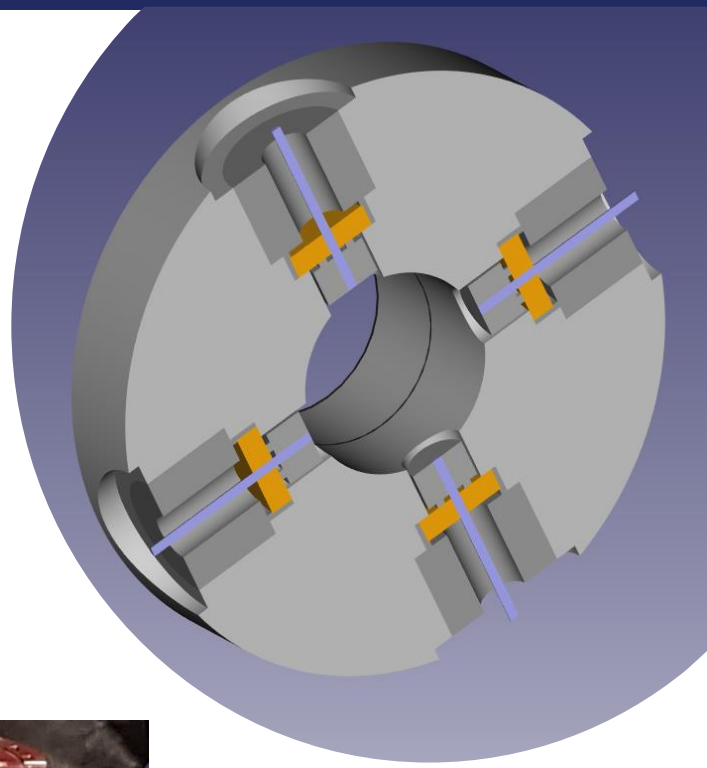
Materials and Engineering Technologies for Particle Accelerator Beam Diagnostic Instruments
21st - 23rd June 2021

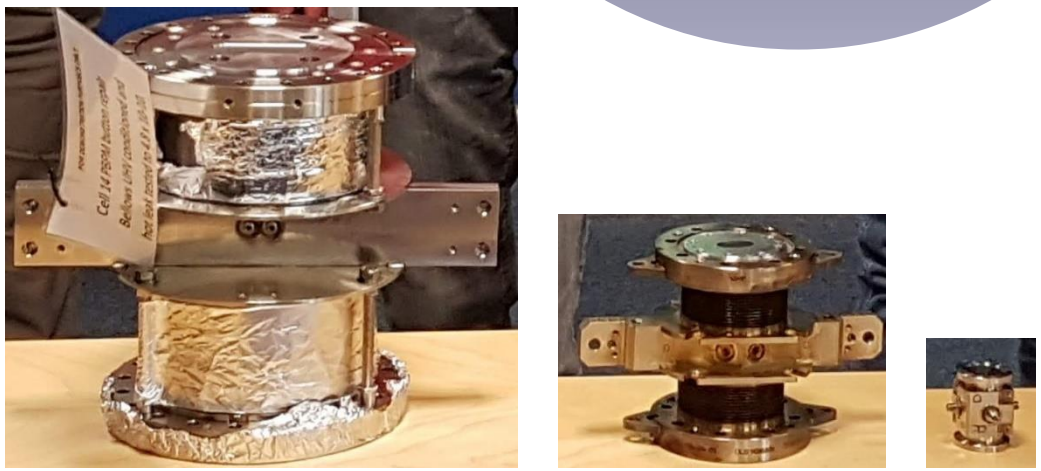
What are buttons?



Air

Vacuum





To scale

Outline

- Design
  - Wake loss reduction
  - Resonance control
- Fabrication
  - Material quality
  - Sealing technology
  - Mechanical tolerances
  - Testing and inspection

Design (1/3)

Some BPM design considerations

- Smaller chamber dimension
  - → **small button head** : Wakefield↓ and signal ↓
- Mitigate signal inference between bunches.
  - → **Low Permittivity insulator**
- Mitigate internal reflection
  - → **Impedance matching within the button structure**
- Trapped mode in annular gap(s)
  - → **Reduce the gap**
  - → **Remove the skirt**

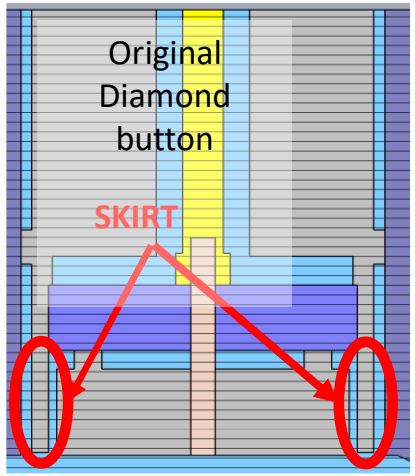
- 100µm **OK**
- 50µm **Challenging**
- 25µm **Not yet**

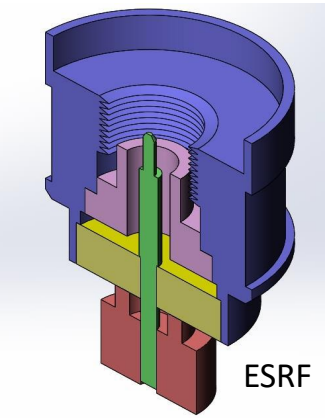
Design (2/3)

- There is a general move away from having a ‘skirt’.

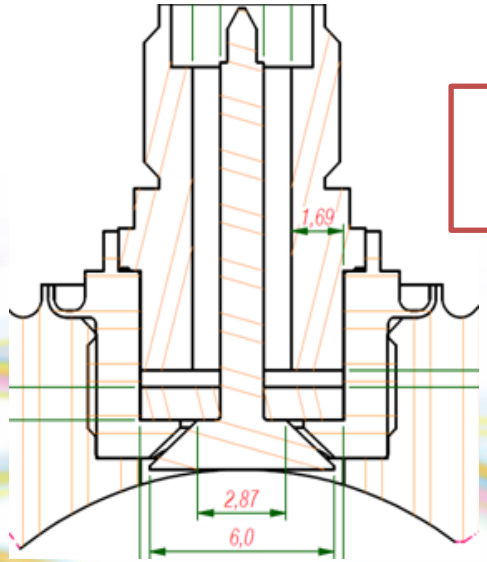
A skirt:

- Simplifies installation
- Mitigates against poor installation tolerances
- Causes additional wake loss and heating.





- **Non cylindrical button shapes** are being investigated.

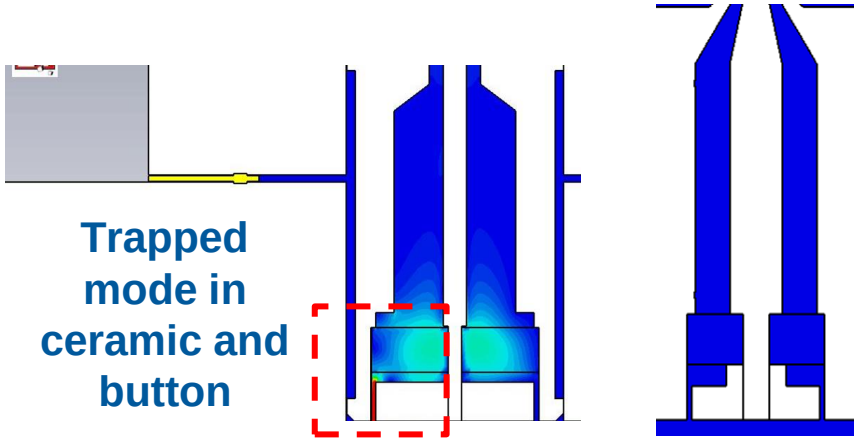


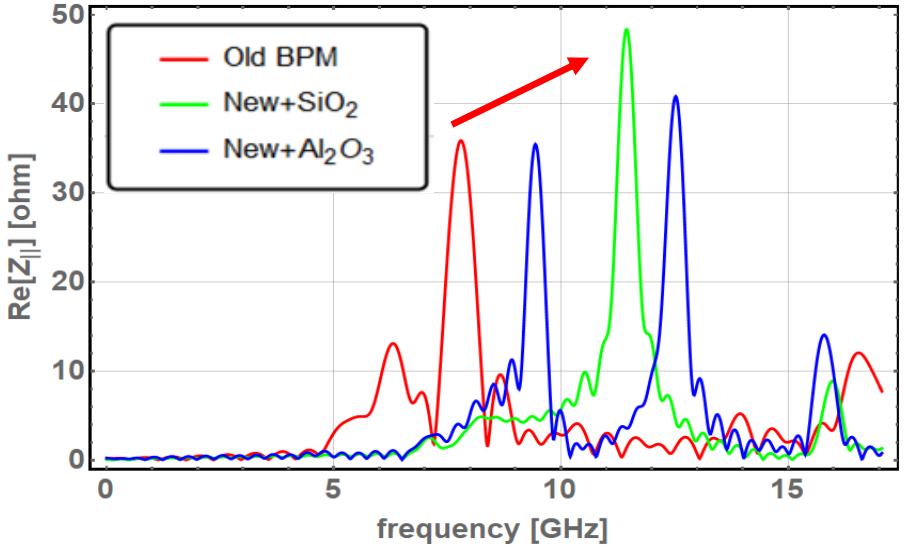
Conical profile shifts the HOMs to higher frequencies

50% wake loss reduction compared to step shaped buttons

Courtesy of Henrique de Oliveira Caiafa Duarte

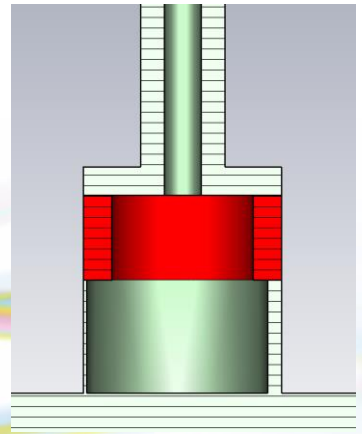
Design (3/3)

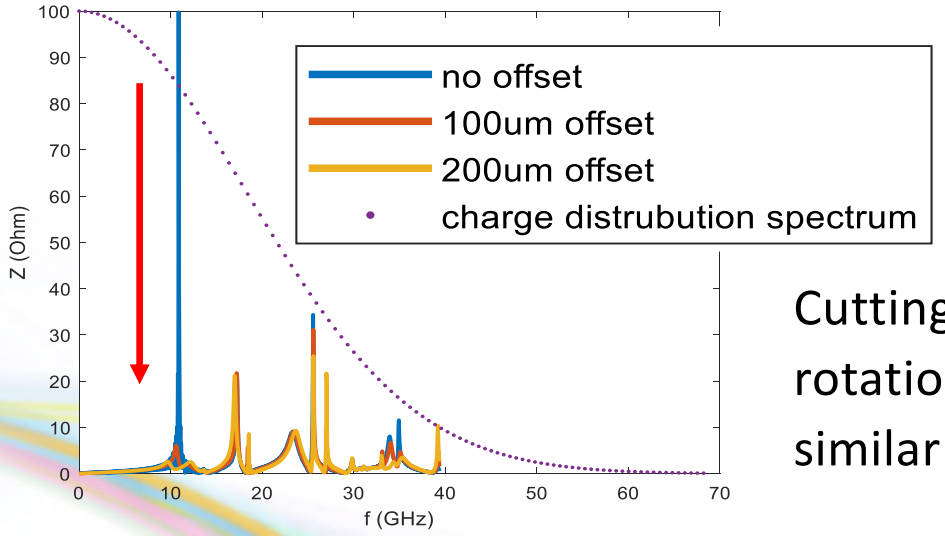




Courtesy of A. Schälicke, J.-G. Hwang

Button non centered in the vacuum chamber housing.



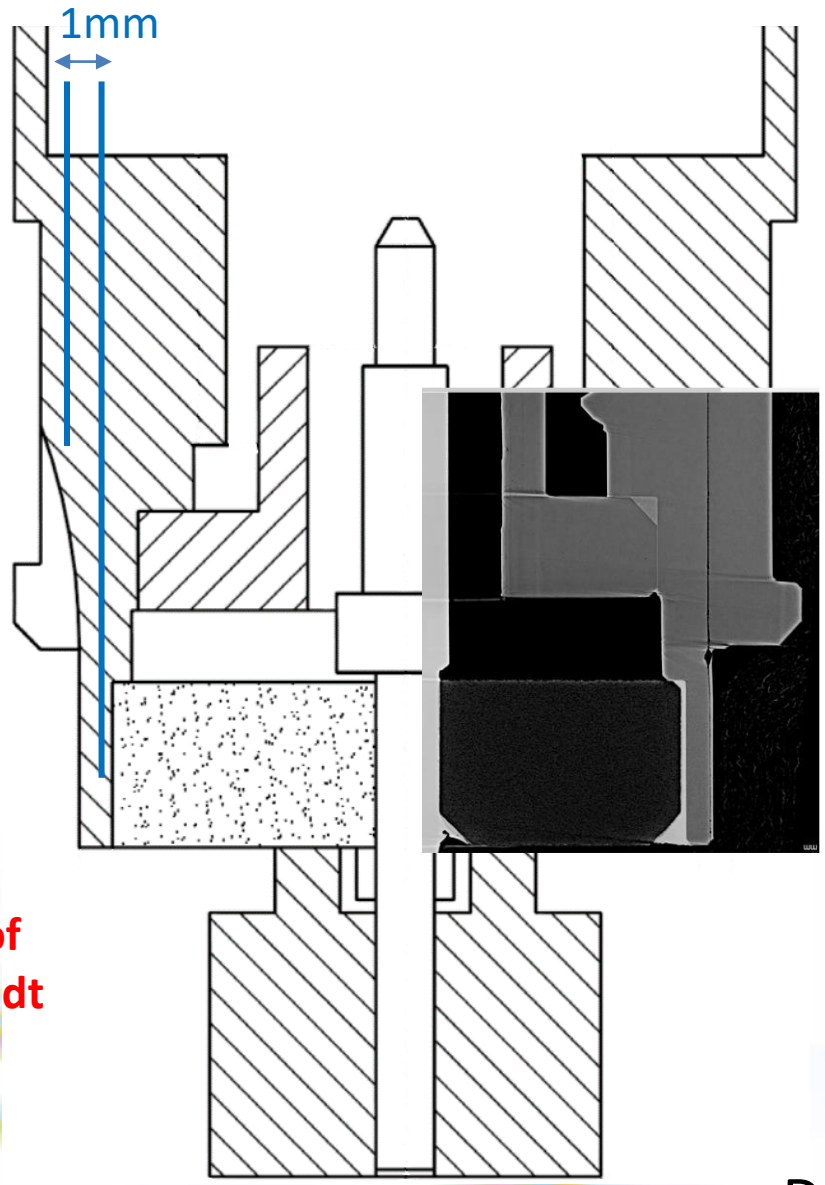


11GHz resonance strongly damped for all geometries

Cutting the button along the rotation axis produces a similar beneficial effect.

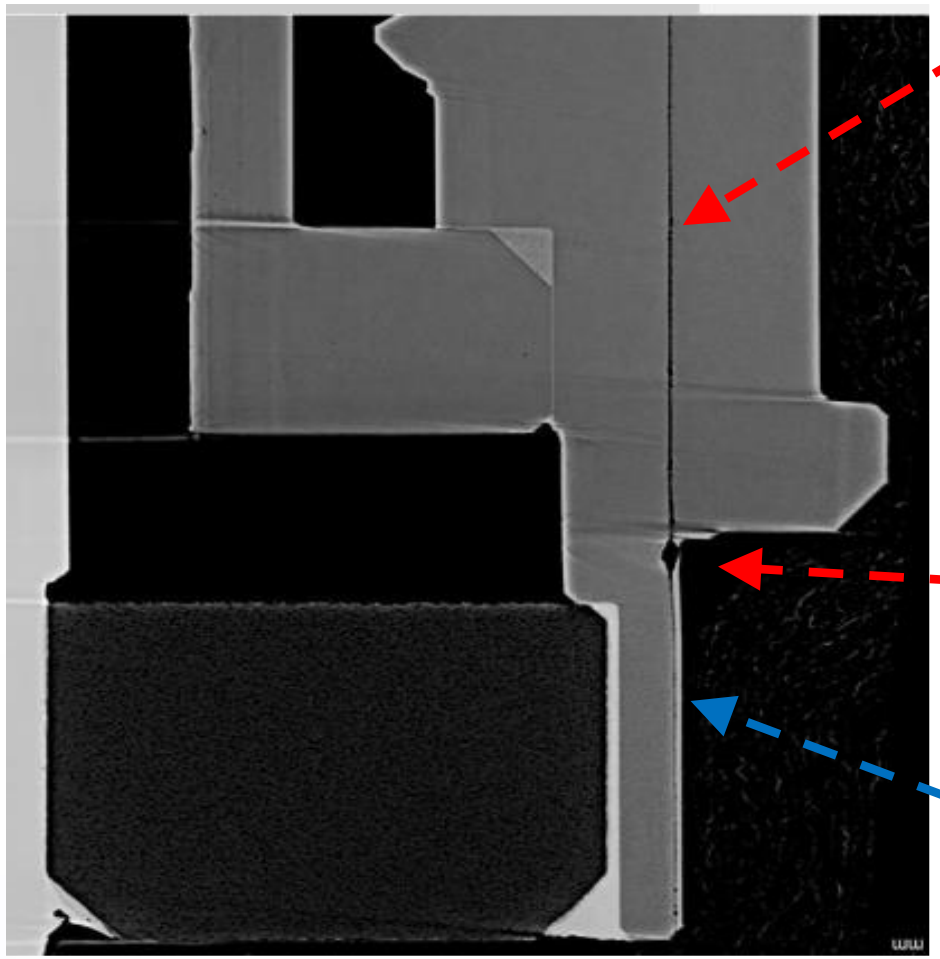
Courtesy of F. Marcellini

Fabrication - ESRF button failures.



Courtesy of
Kees Scheidt

The crack/pipe/channel traverses the full depth of the steel outer-body



Big cavity

The crack changes angle/orientation after the cavity

Due to micro channel defects in the bulk.

Fabrication - Material quality

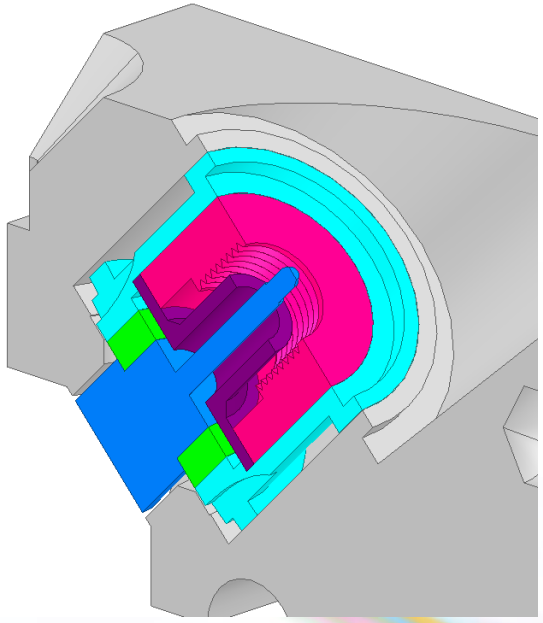
- Changes in the steel market
  - What does todays certification mean compared to 10 years ago.
- Facilities
  - now need to take more care in specifying the grade of material. **Certain steel qualities are not as good as they were in the past. Users have examine the specs & certificates**
  - need to **investigate the melting and extrusion techniques used to form the starting block** as these can interact to cause a problem while each step alone is benign.

Fabrication - Glass ceramic buttons

Button BPM's @ PETRA III

Courtesy of Silke Vilcins

Borosilicate glass in green



8 prototypes

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

Courtesy of F. Marcellini

How to get the tolerances we need?

- **Continuous communication**.
- Make sure that the company you're working with *really* understands what you want.
- Make sure that all subgroups *really* understand what you want.
- Detailed reporting combined with in-house testing.

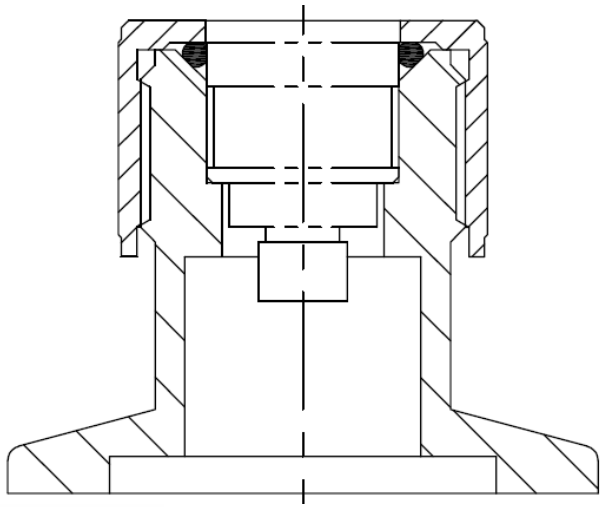
In house testing

- **“Any specifications placed on the drawings, need to be able to be measured.”**
  - Facilities need to have robust in house testing capability.

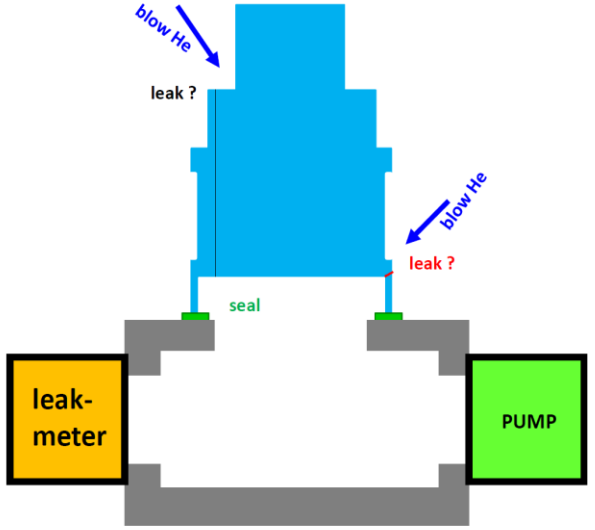
Each button needs to have a unique identifier.

- Laser marking

Leak check individual buttons.



Diamond button leak testing setup



ESRF button leak testing setup

Conclusion

- There are several different threads of design which are coming through which are independently improving things, but could also be combined for further benefits.
- Glass sealing technology is of increasing interest for new machines. Especially as buttons are getting smaller.
- Take great care over **material quality specification**.
- **Continuous communication with suppliers** give the best chance to achieve the required tolerances.
- However **in-house testing capability** is still strongly advised.
- **Each button needs to be traceable** through the entire process.

Thank you to all the participants of the workshop

And to you for your attention

https://www.diamond.ac.uk/Home/Events/2019/BPM-button-design-and-manufacturing-workshop.html
https://accelconf.web.cern.ch/ibic2019/talks/weao01_talk.pdf
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