Study of the performances of a 3D printed BPM

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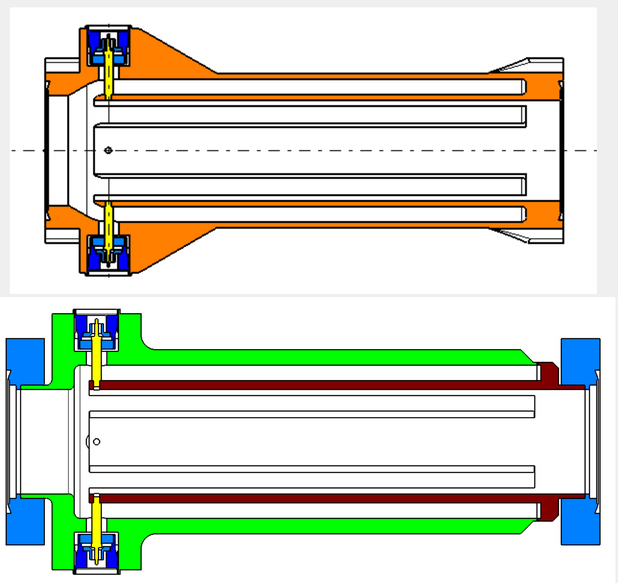
Introduction

Following previous results which have shown that some components built using additive manufacturing (3D printing) are compatible with ultra high vacuum, we have adapted the design of a stripline BPM to the requirements of additive manufacturing and built it. We report here on the design adaptation and on its mechanical and electrical performances.

Advantages of i3D manufacturing

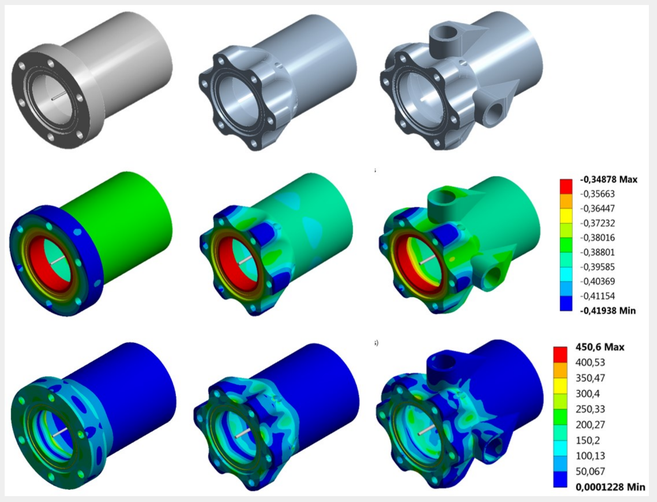


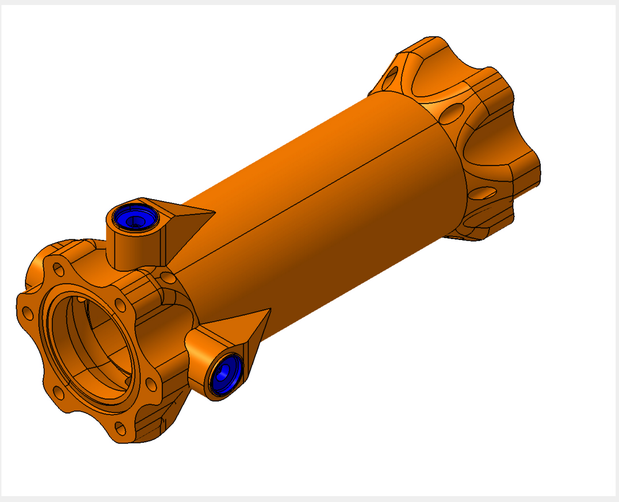
- **Topological optimisation**
  - Software INSPIRE from ALTAIR.
  - See box on the right.
- **Optimized design**
  - Printed vertically.
  - Feedthrough support.
- **Difficult shapes**
  - Thin cylindrical electrodes can be manufactured.
  - Better accuracy (better than 0.1 mm).
- **Vacuum tests**
  - Leak tested by the vacuum group. No leak found.
  - Outgassing comparable to normal BPM.
  - Paper in preparation.
- **Improved efficiency**
  - Ready in less than 2 weeks against 4 to 6 weeks.
  - Better mechanical accuracy.
  - About 3k€(50% cheaper).
  - **Surface quality may be an issue.**

References

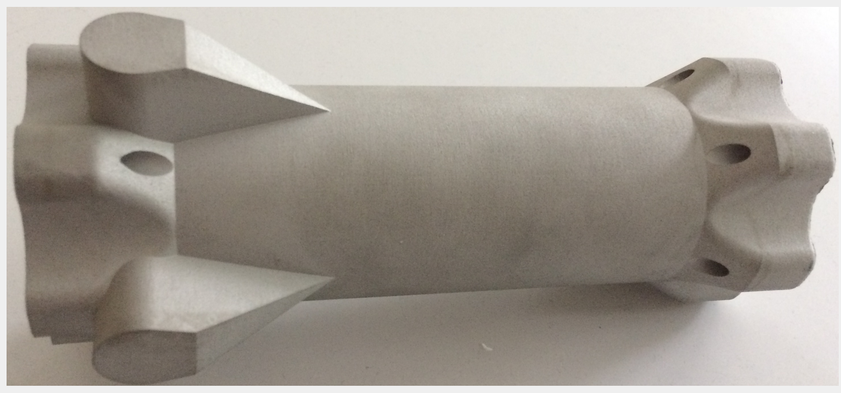
— IPAC'17 WEPVA043
Study of the suitability of 3D printing for Ultra-High Vacuum applications
— IPAC'14 WEPRO052 The ThomX Project Status
— Offset calibration of the beam position monitor using external means
doi: 10.1063/1.42118
— Measurements and Calibration of the Stripline BPM [...], IBIC 2015, TUPB048
— PHIL Photoinjector `http://stacks.iop.org/1748-0221/8/i=01/a=T01001`

Topological optimisation

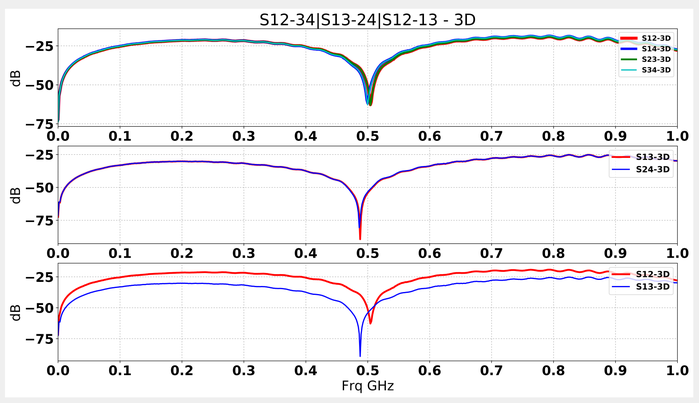


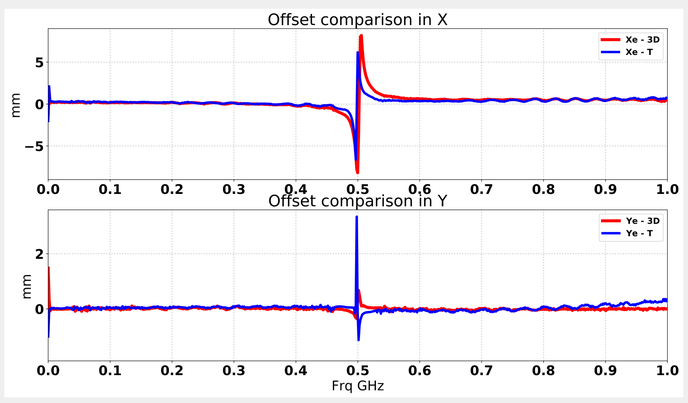


Left: Topological optimisation of the BPM. The left column correspond to the original BPM, the center column to the end of the i3D BPM not on the feedthrough side and the right column the i3D BPM on the feedthrough side. The top line shows a view of the CAD model, the middle line show the stress induced displacement in millimeters when the BPM is bolted and the bottom line the Von Mises strains in MPa*.*
Right: CAD 3D view.
Some features: optimized flange, about 60% of the original weight, no welding (shorter)....



Electrical tests (Lambertson method)

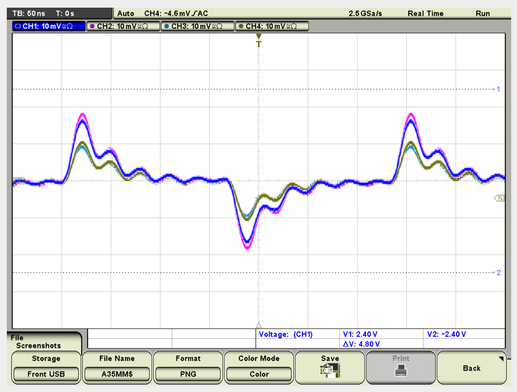




	X		Y	
	20 MHz to 200 MHz	20 MHz to 400 MHz	20 MHz to 200 MHz	20 MHz to 400 MHz
Trad. manuf. (raw value)	17 ± 3	11 ± 3	3 ± 2	4 ± 2
i3D (raw value)	13 ± 2	8 ± 3	1 ± 2	1 ± 2
Trad. manuf. (k=14 mm)	238(36) µm	154(44) µm	36(26) µm	51(24) µm
i3D (k=14 mm)	178(30) µm	107(48) µm	36(26) µm	20(31) µm

*Measured average electrical offset between the electrodes. The top two lines of values are raw value and the bottom two lines assume a linear calibration coefficient k=*14 mm*.*

Stretched wire



Conclusion

- Better mechanical precision on i3D BPM confirmed by electrical measurements.
- Stretched wire method in progress.
- Beam tests in preparation.
- No impedance measurements.
- Surface quality is very different.

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