Update on BPM development for IR1/IR5 LSS

HL-LHC WP13

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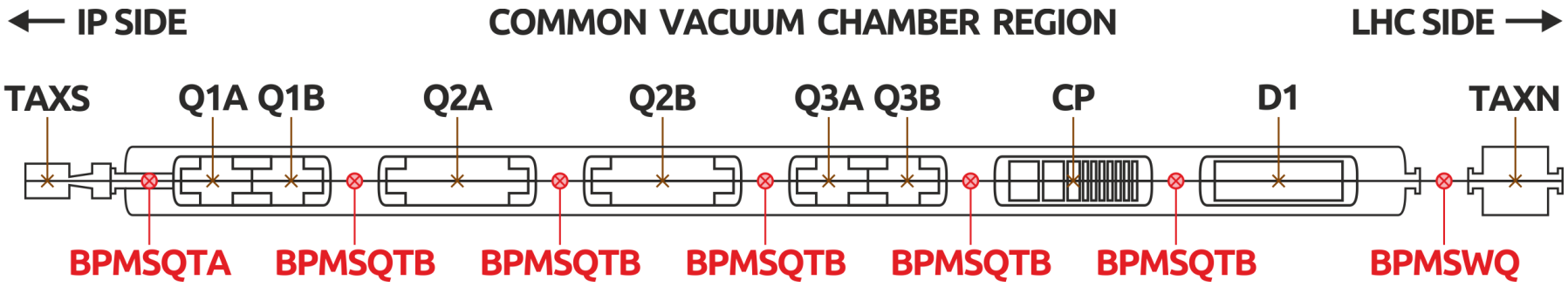
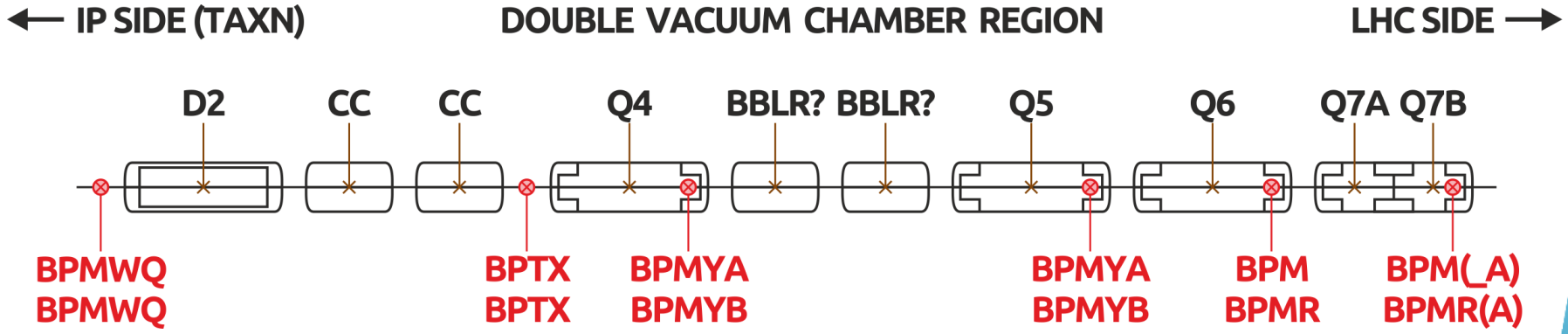
7th HL-LHC Collaboration Meeting – Madrid – 15.11.2017

Outline

- HL-LHC inner triplet BPMs
- Challenges
- Current state of the project
- String test
- Conclusions and outlook

BPMs per HL-LHC IP side





New BPMs per HL-LHC IP side

1x **BPMSQTA** cryogenic tungsten-shielded directional coupler, aperture A (small)

5x **BPMSQTB** cryogenic tungsten-shielded directional coupler, aperture B (large)

1x **BPMSWQ** warm directional coupler

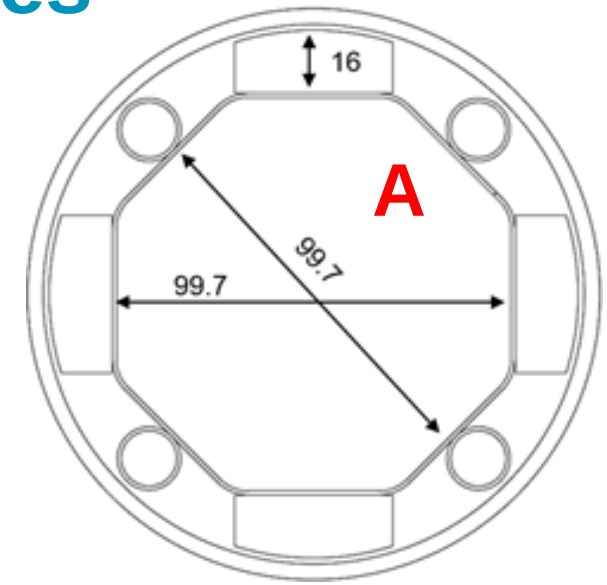
2x **BPMWQ** warm (non-directional) button

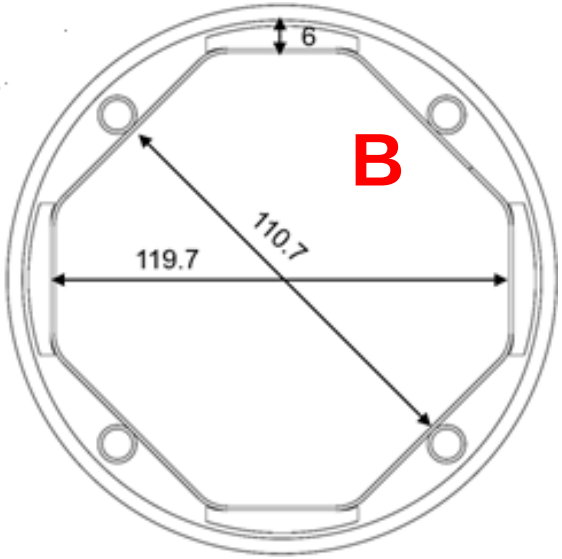
In total:

9 BPMs x 2 IPs x 2 sides = 36 new BPMs to be installed

Design priorities

- Main focus on the cryogenic directional couplers **BPMSQTA** and **BPMSQTB** which are required for string test in 2020
- Minimising differences between the two designs
- Studying possibilities of reusing parts of the design for the non-cryogenic **BPMSWQ**



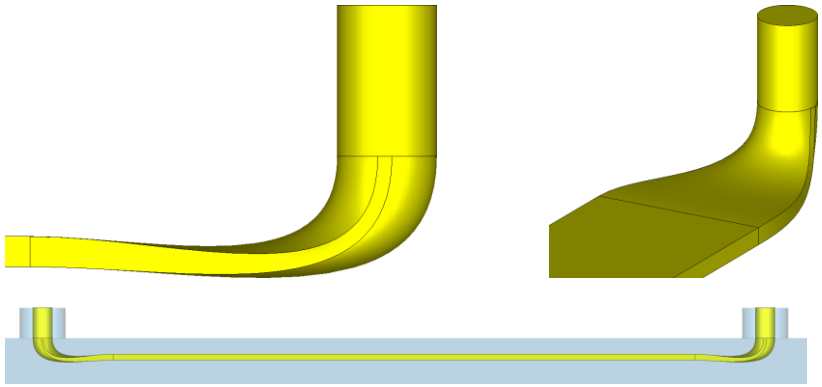


Challenges

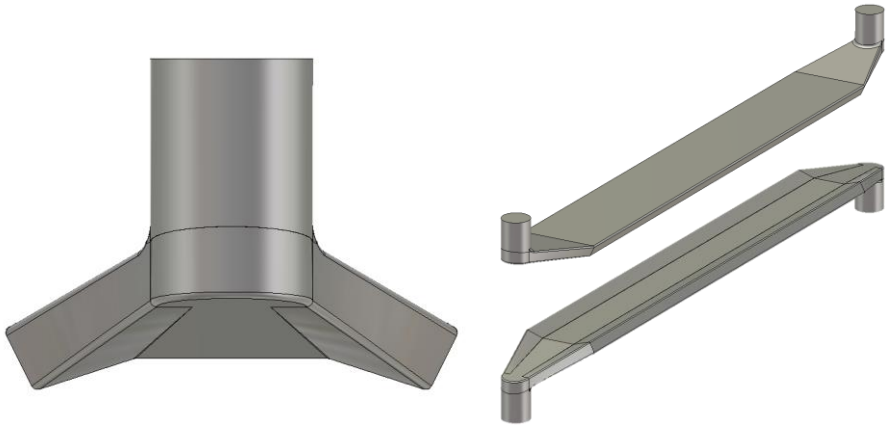
- Both beams in a single vacuum chamber
- Octagonal vacuum chamber
- Cryogenic BPMs installed in vacuum
- Tungsten blocks at H and V planes to absorb collision debris
- Heat load due to electron cloud
- Complicated integration and alignment

Electrode design

2016

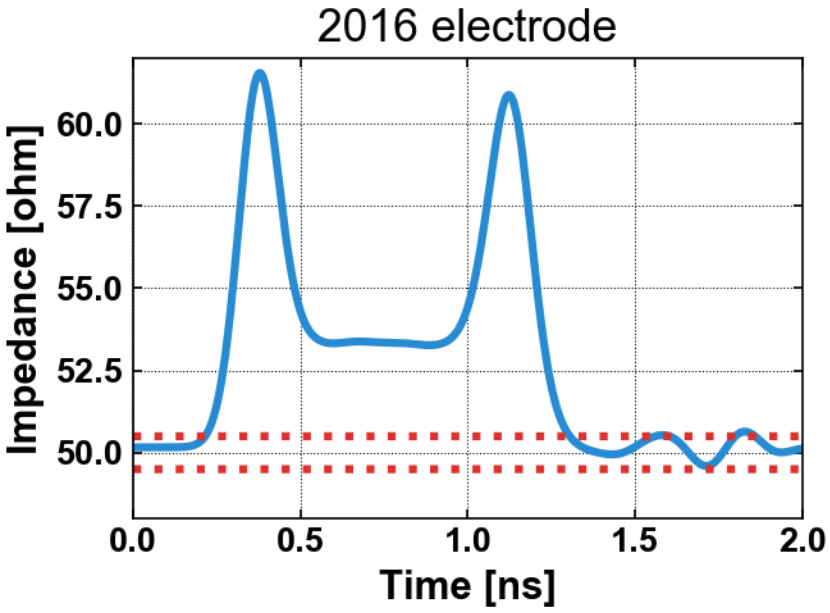


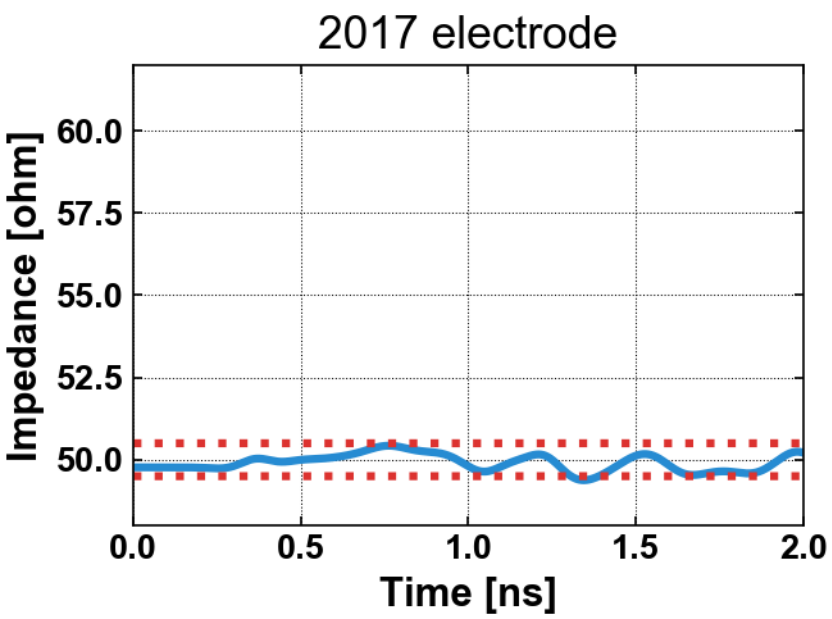
2017



3D printing of the 2016 electrode very challenging
Major simplification of the electrode shape in 2017
Additional performance improvements achieved

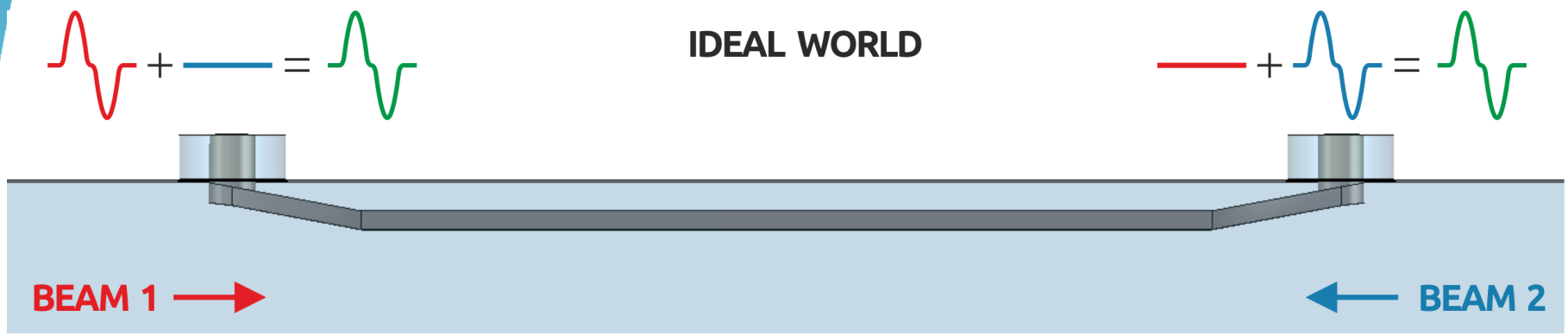
Electrode simulations - TDR

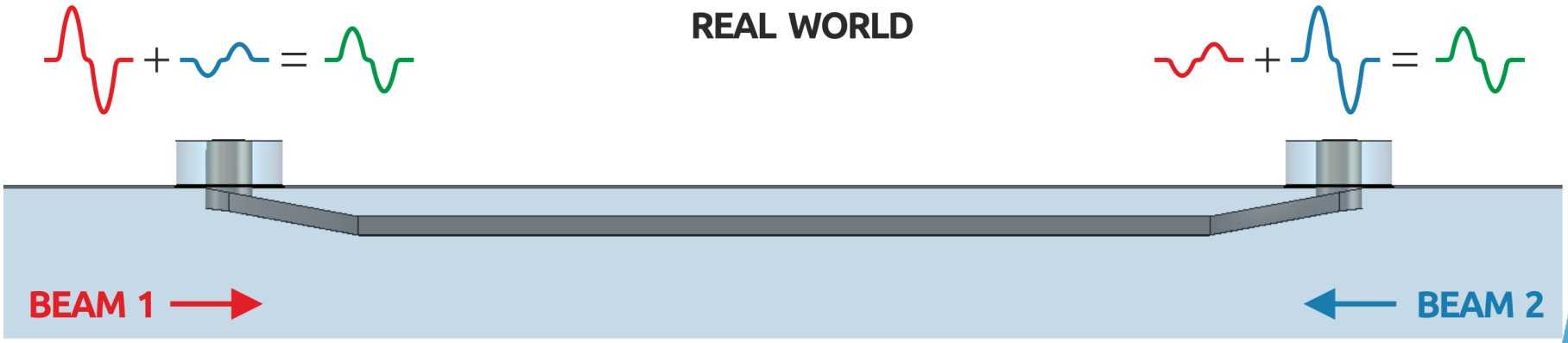




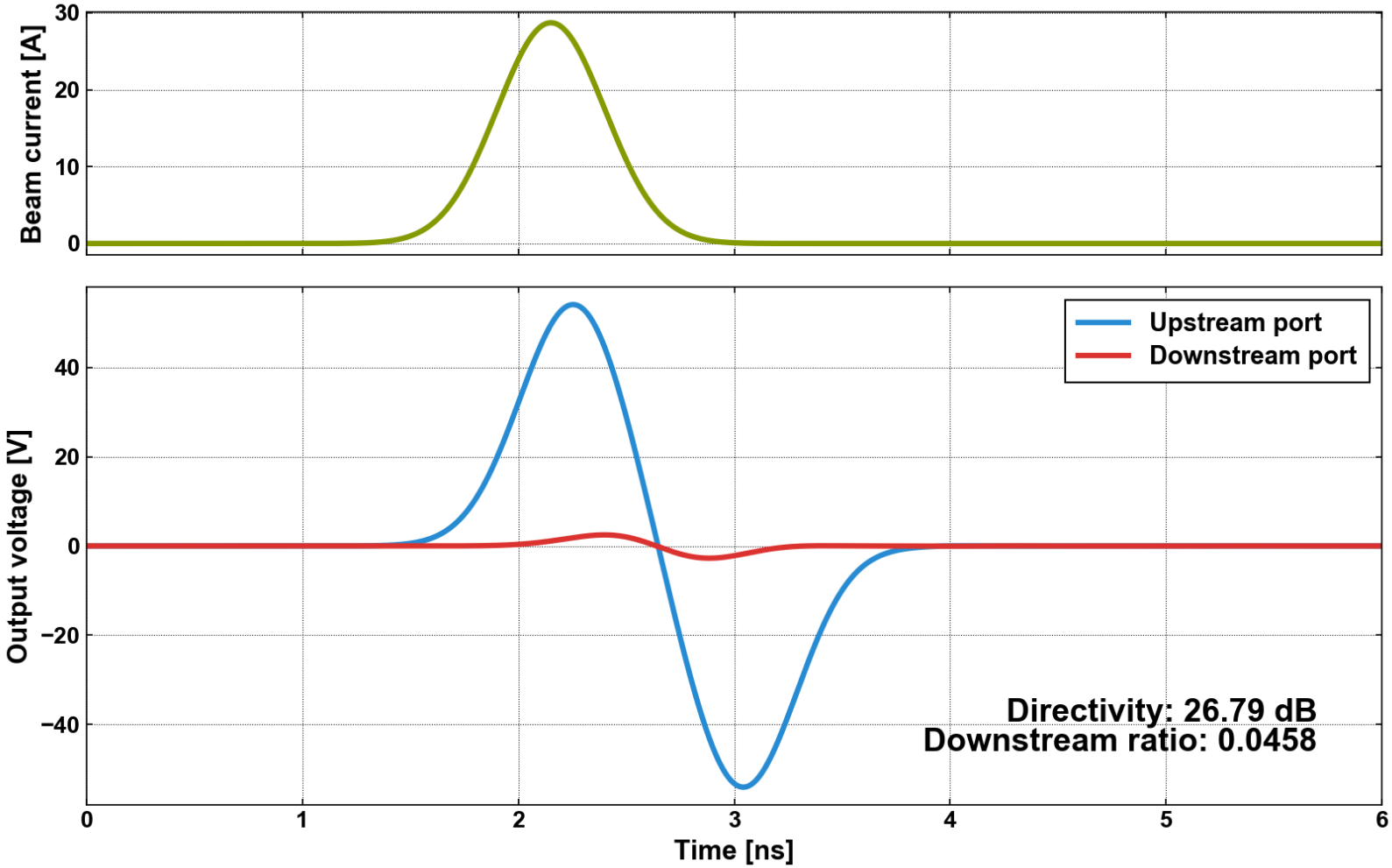
Goal: electrode impedance stable at **50 ± 0.5 Ω**

BPM directivity



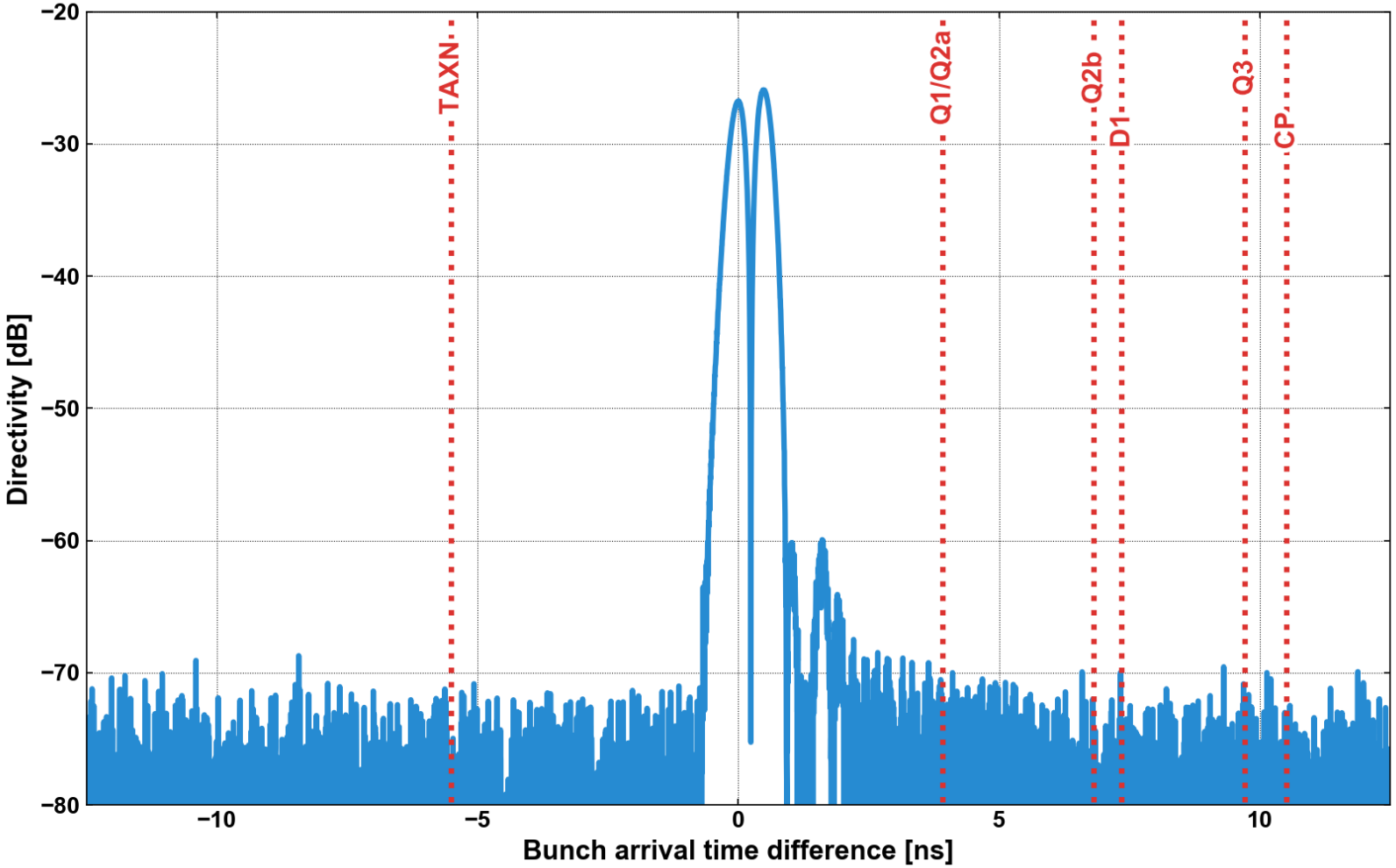


Electrode simulations - directivity



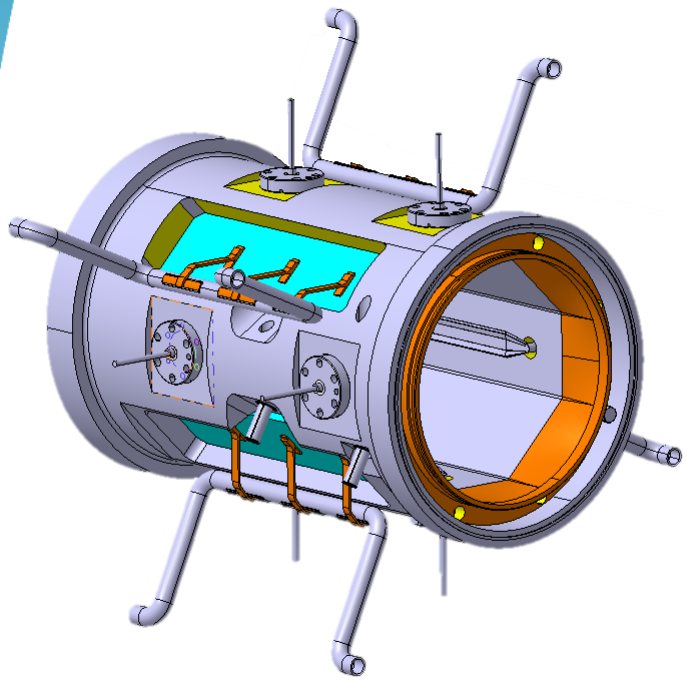
Dream: **30+ dB** directivity → 0.0316 downstream ratio

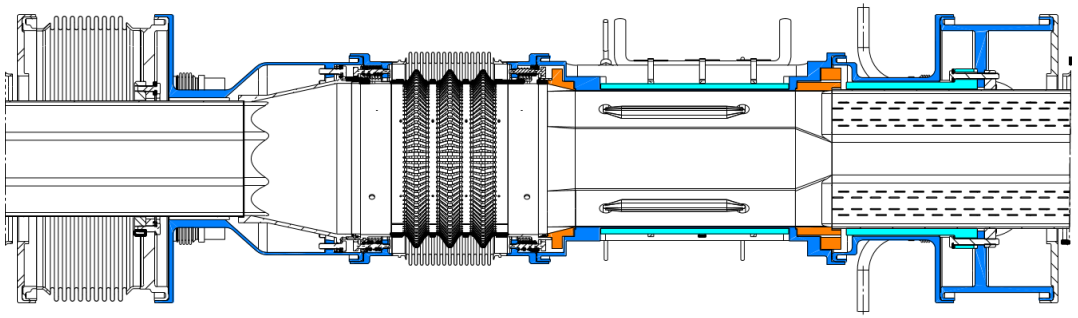
Electrode simulations - directivity



Optimisation: temporal bunch separation at **BPM locations**

Mechanics, integration and alignment





Courtesy: N. Chritin

Mechanical design well advanced
Integration with the interconnects and alignment ongoing with other WPs

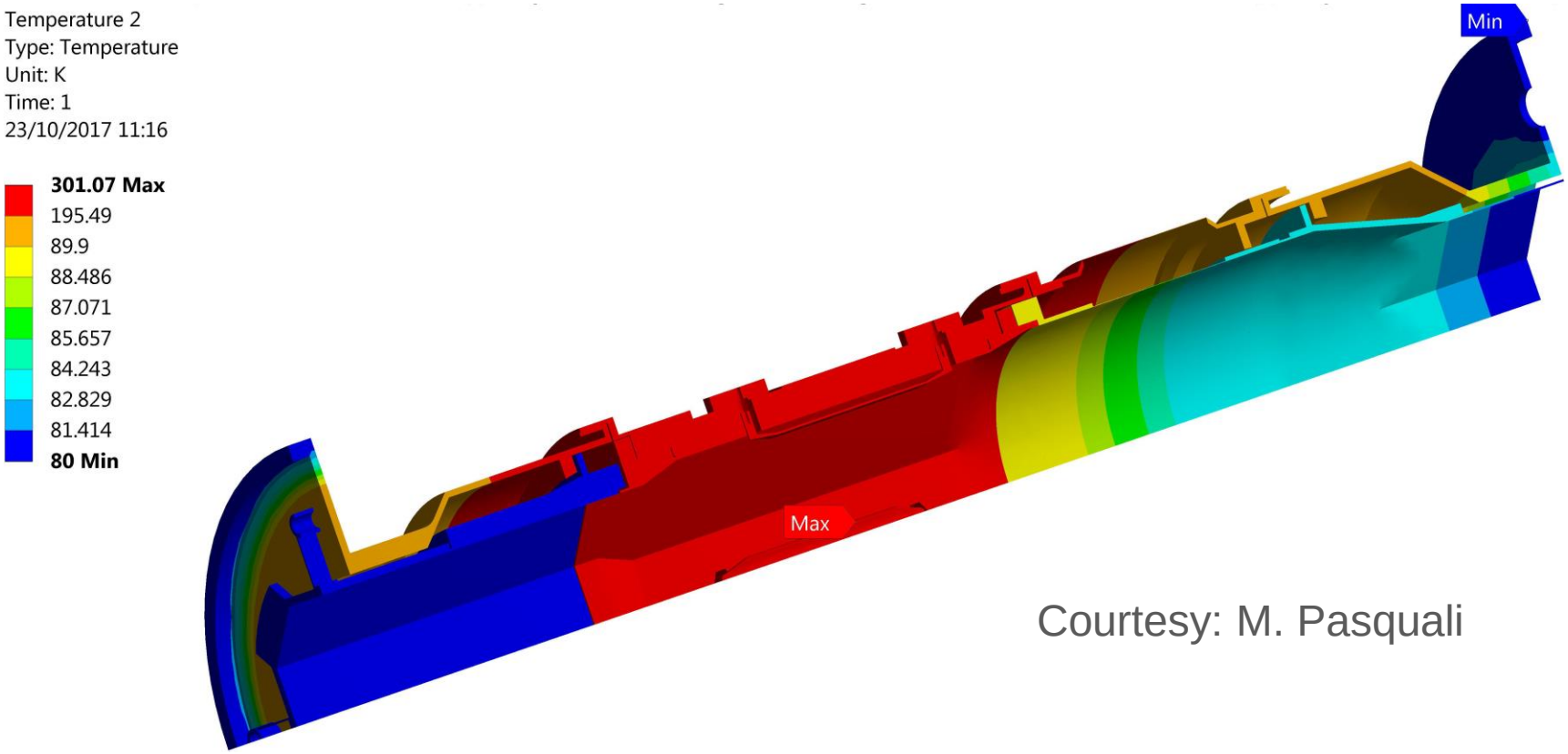
Heat load estimations

Main sources of heat load:

- Collision debris absorbed by W: 1.5 W
- Collision debris absorbed by BPM: 1 W
- Electron cloud: 2 W (20 W uncoated)
- Beam: 0.5 W
- Cables: 0.4 W

Total per BPM: **~ 6 W** (coated),
~ 24 W (uncoated)

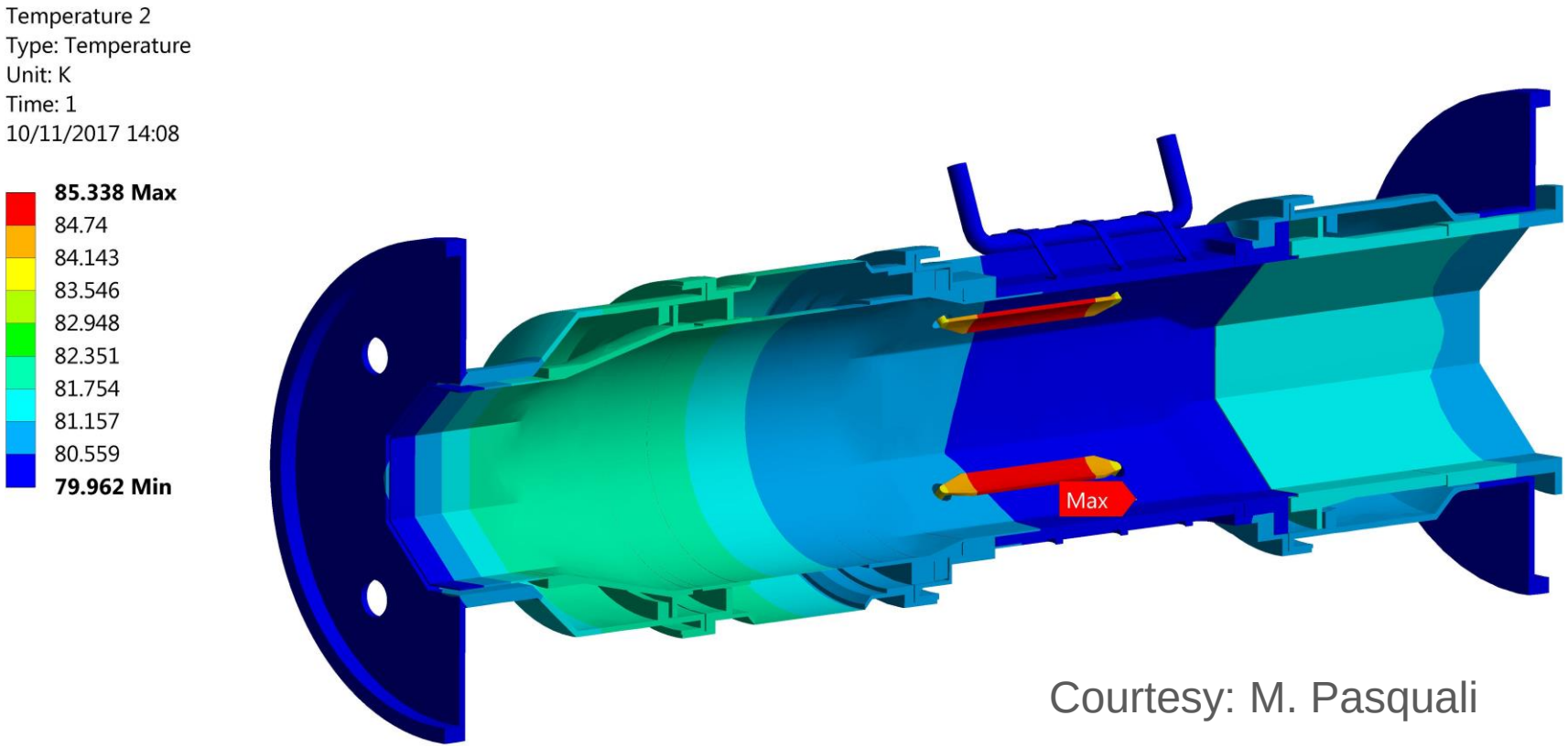
Lack of active cooling



Courtesy: M. Pasquali

BPM **220 K above** beam screen's temperature

With active cooling



Courtesy: M. Pasquali

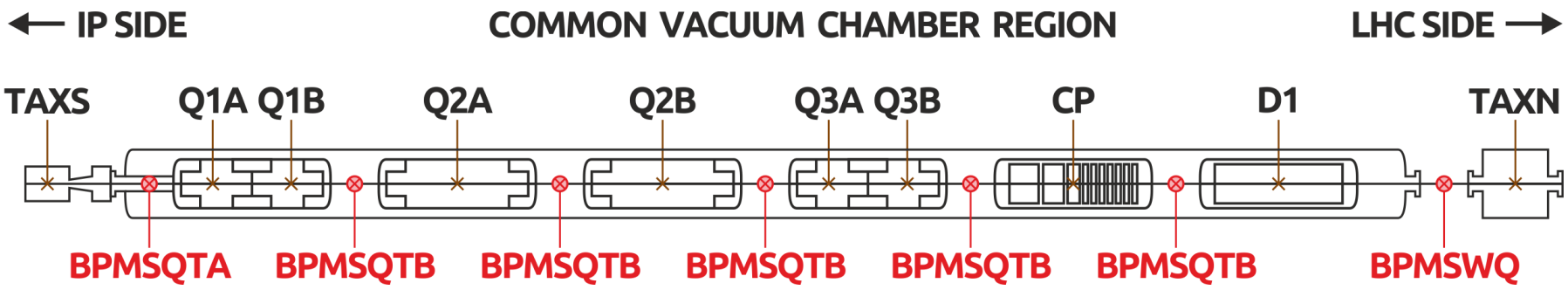
Cooling inspired by the beam screen solution

Electrodes **5 K above** beam screen's temperature

Other thermomechanical considerations

- Thin skin BPM body deformation due to pressure difference – 60 μm
- Electrode-body thermal expansion differential – 100 μm (steady state)
- Electrode thermal deformation – ~10 μm
- More simulations ongoing

String test



- 6 cold BPMs required – **1 x BPMSQTA** and **5 x BPMSQTB** – verification whether full BPMs are really needed
- Possibility of including warm **BPMSWQ** under study
- The BPMs need to be ready in 2020

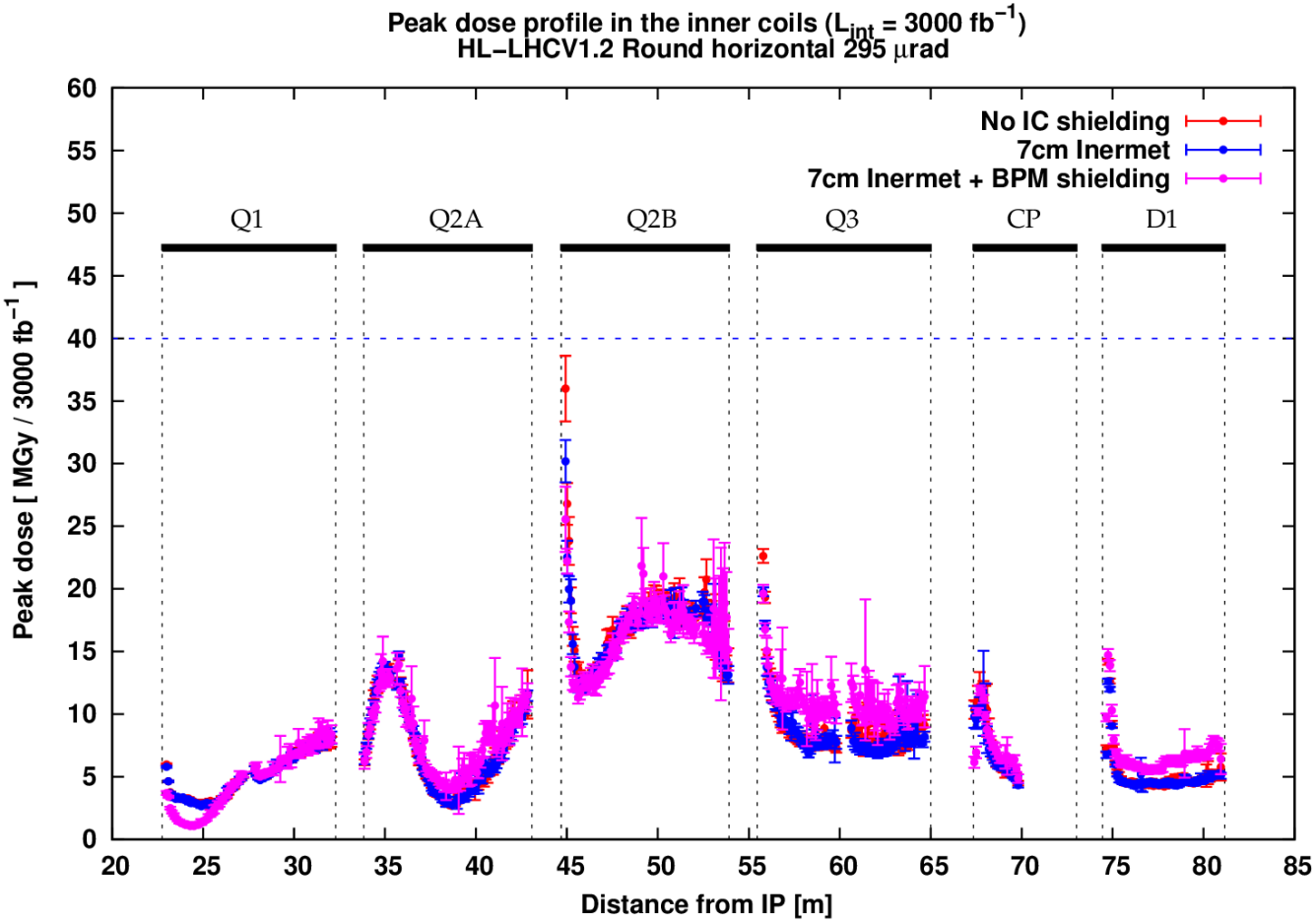
Conclusions and outlook

- Development of new HL-LHC BPMs on track
- Focus put on design of the BPMs required for the string test
- Current main activities: advanced transient thermomechanical simulations, full interconnect integration, feedthrough studies

Thank you for your attention!

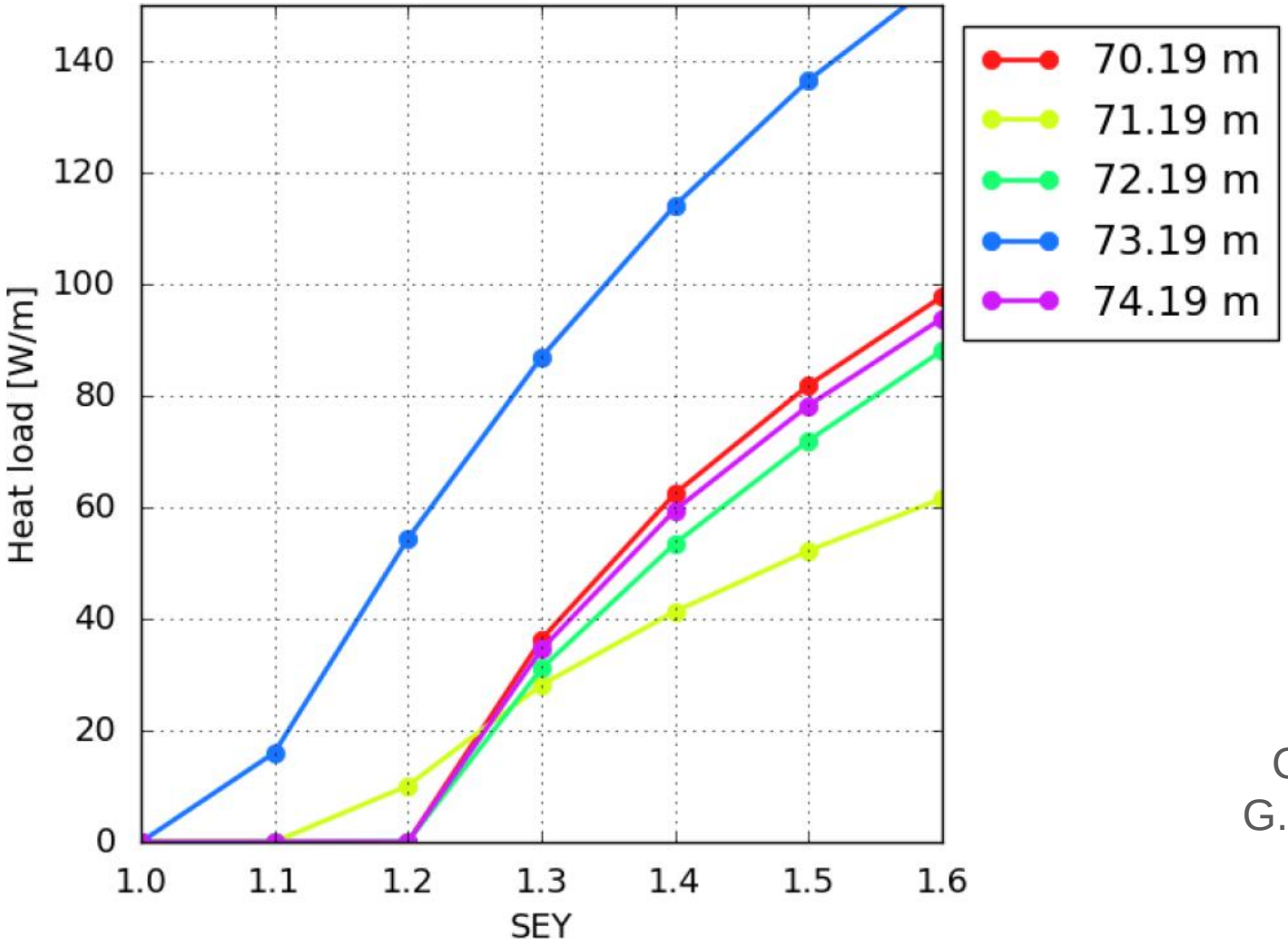
Acknowledgements: A. Demougeot, D. Draskovic, D. Duarte Ramos, R. Fernandez Gomez, G. Iadarola, R. Jones, M. Pasquali

Back up: Tungsten shielding



Courtesy: A. Tsinganis, F. Cerutti

Back up: Heat load

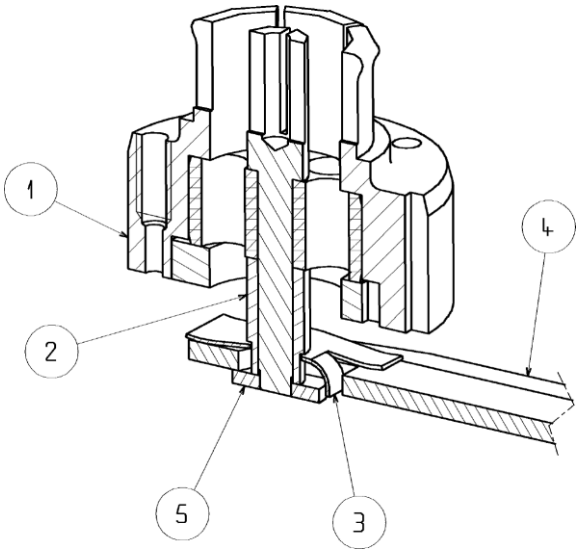


Courtesy:
G. Iadarola

Back up: Locations

Number	1	2	3	4	5	6	7
Type	BPMSTQA	BPMSTQB	BPMSTQB	BPMSTQB	BPMSTQB	BPMSTQB	BPMSQW
Distance from IP [mm]	21853	33073	43858	54643	65743	73697	86846
Location comments	Between TAXS and Q1A	Between Q1B and Q2A	Between Q2A and Q2B	Between Q2B and Q3A	Between Q3B and CP	Between CP and D1	After D1, WARM
N Periodicity number	5.34	8.34	11.23	14.11	17.08	19.21	22.72
Preceding ideal position [mm] N = floor(N)	20,570	31,790	43,010	54,230	65,450	72,930	84,150
Succeeding ideal position [mm] N = ceil(N)	24,310	35,530	46,750	57,970	69,190	76,670	87,890
Distance from ideal position [mm] Towards the IP. Negative number means it's too far from the IP	-1,283	-1,283	-848	-413	-293	-767	1,044
TOF from ideal position [ns] Towards the IP. Negative number means it's too far from the IP	-4.28	-4.28	-2.83	-1.38	-0.98	-2.56	3.48
Bunch arrival time difference [ns] Negative numbers mean the bunch going towards the IP arrives first	3.92	3.92	6.82	9.72	10.52	7.36	-5.51

Back up: LHC electrodes



Courtesy: C. Boccard, P. Clergue