Heat loads induced by collision debris

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WP10 Energy deposition & R2E

Heat Loads for HL-LHC scope (P1/P5) - Internal Review
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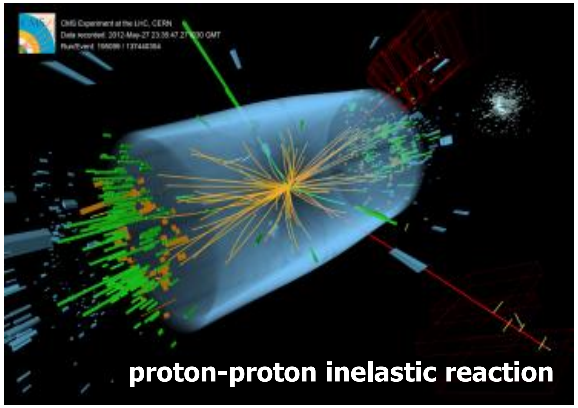
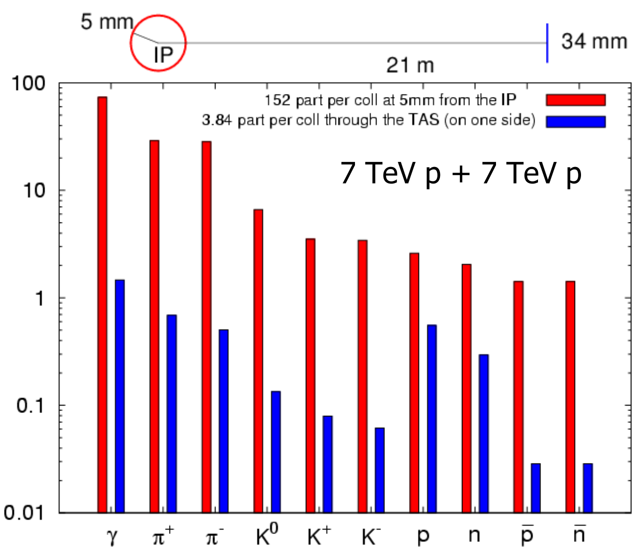
Overview

- Review of the heat loads for HL-LHC cryogenics considerations.
- The contribution to the heat leads due to collision debris in IR1 and IR5 is shown in this presentation focused on:
  - ✓ Inner triplet + D1.
  - ✓ D2.
  - ✓ The two crossing schemes are considered respectively (IR1-HC and IR5-VC) assuming 250 μrad half-crossing angle in all cases.
- The loads presented in this review refer to ultimate operation conditions, i.e., $7.5 \cdot 10^{34}$ cm^{-2} s^{-1} instantaneous luminosity.
- Simulations were performed for 7 TeV per proton beam. In case of 7.5 TeV per proton beam, a 15 % increase in the heat loads shown here is expected.

Collision debris

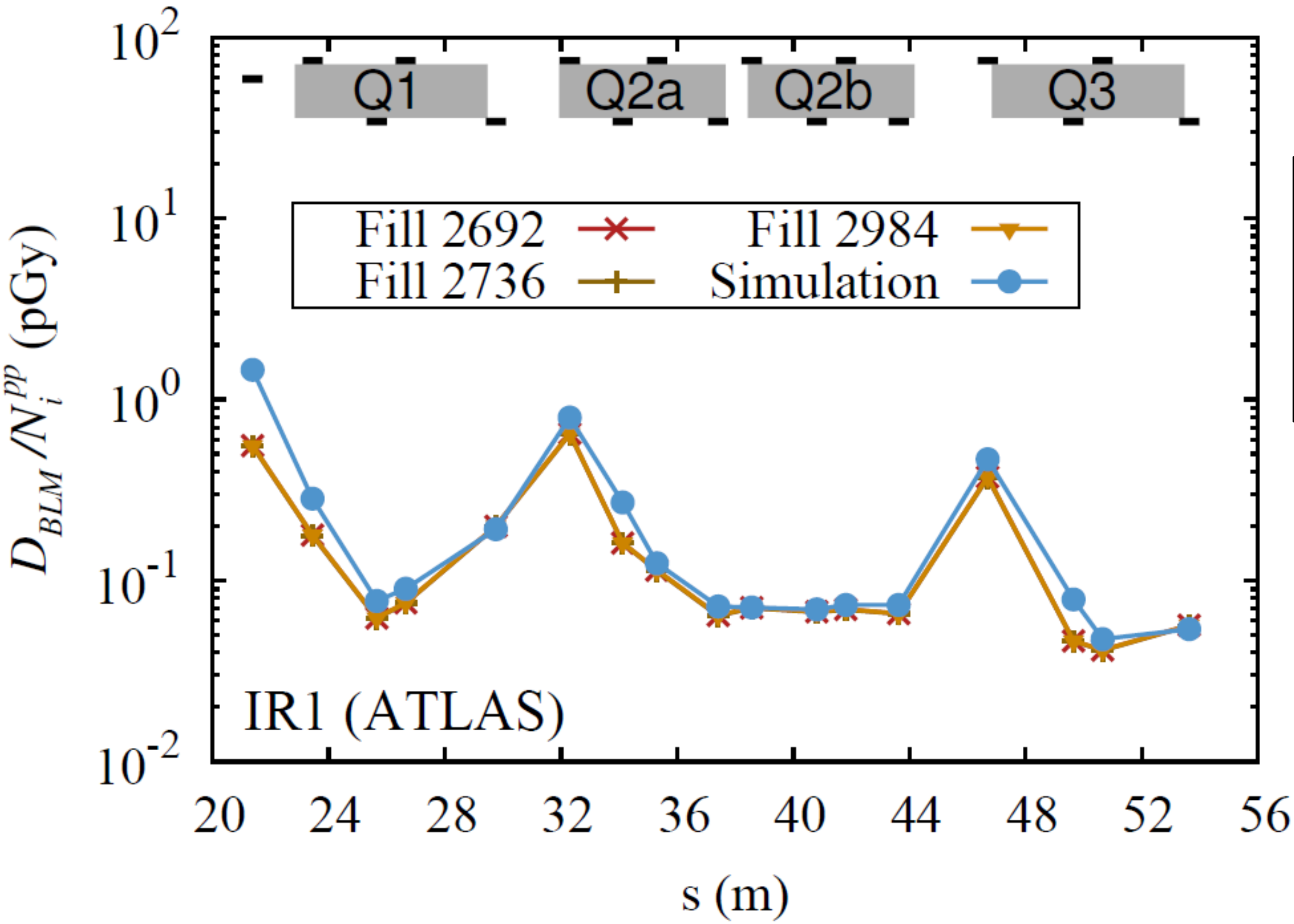




- Collision debris is emitted 4 π.
- The main detectors (ATLAS, CMS) cover the vast majority of the angular range.
- But the very forward debris will escape the cavern.

- At the LHC machine: $L_{inst} = 10^{34}$ cm^{-2} s^{-1}, the inelastic collision rate is 8.5e8 s^{-1}
- 950 W towards each side (L&R).
  - → 150 W is absorbed by the TAS.
  - → 650 W goes through the TAS out of which 150 W is absorbed in the triplet cold magnets.
- In the triplet cold mass with 6.5 TeV beams (80 mb):
  - → Prediction: ~125 W
  - → Measured by TE-CRG-OP: 115-135 W

FLUKA simulations benchmark at the LHC

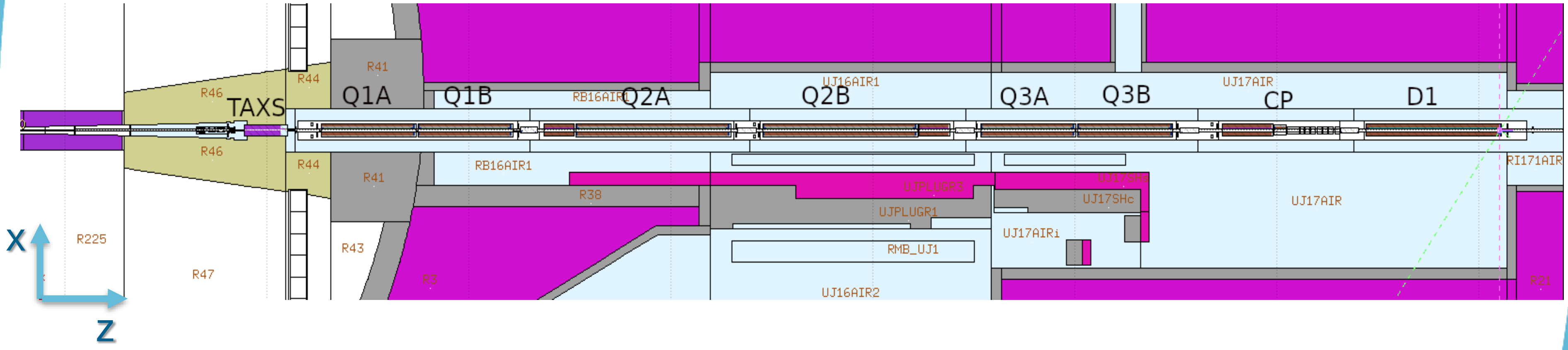


Experimental data obtained from the Beam Loss Monitors installed in the vicinity of the triplet.

Data: 2012
4 TeV beams

IT+D1 heat loads due to collision debris (I)

- Layout model of IR1 in FLUKA of the IT+D1 region:

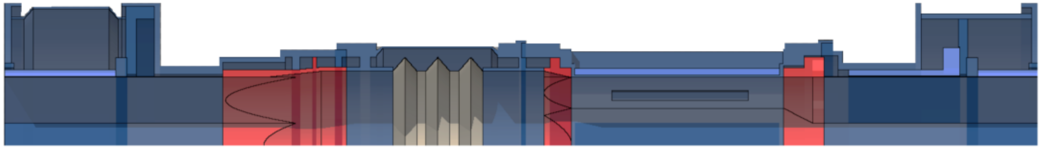


IT+D1 heat loads due to collision debris (II)

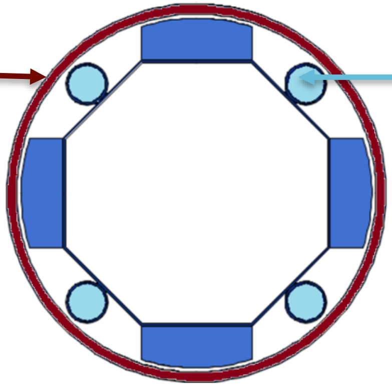
Total Power (W)	IR1	HC	IR5	VC
	cold mass	*beam screen*	*cold mass*	*beam screen*
Q1A + Q1B	165	251	171	263
Q2A + OC	147	98	152	102
Q2B + OC	201	146	185	131
Q3A + Q3B	180	104	201	120
CP – OC	69	69	98	84
D1	99	68	122	86
pipe extensions	20	75	21	87
Total	**881**	**811**	**950**	**873**
interconnects		70		77

IT+D1 heat loads due to collision debris (III)

- In previous table the contribution from the interconnects is included on top of the other contributions:

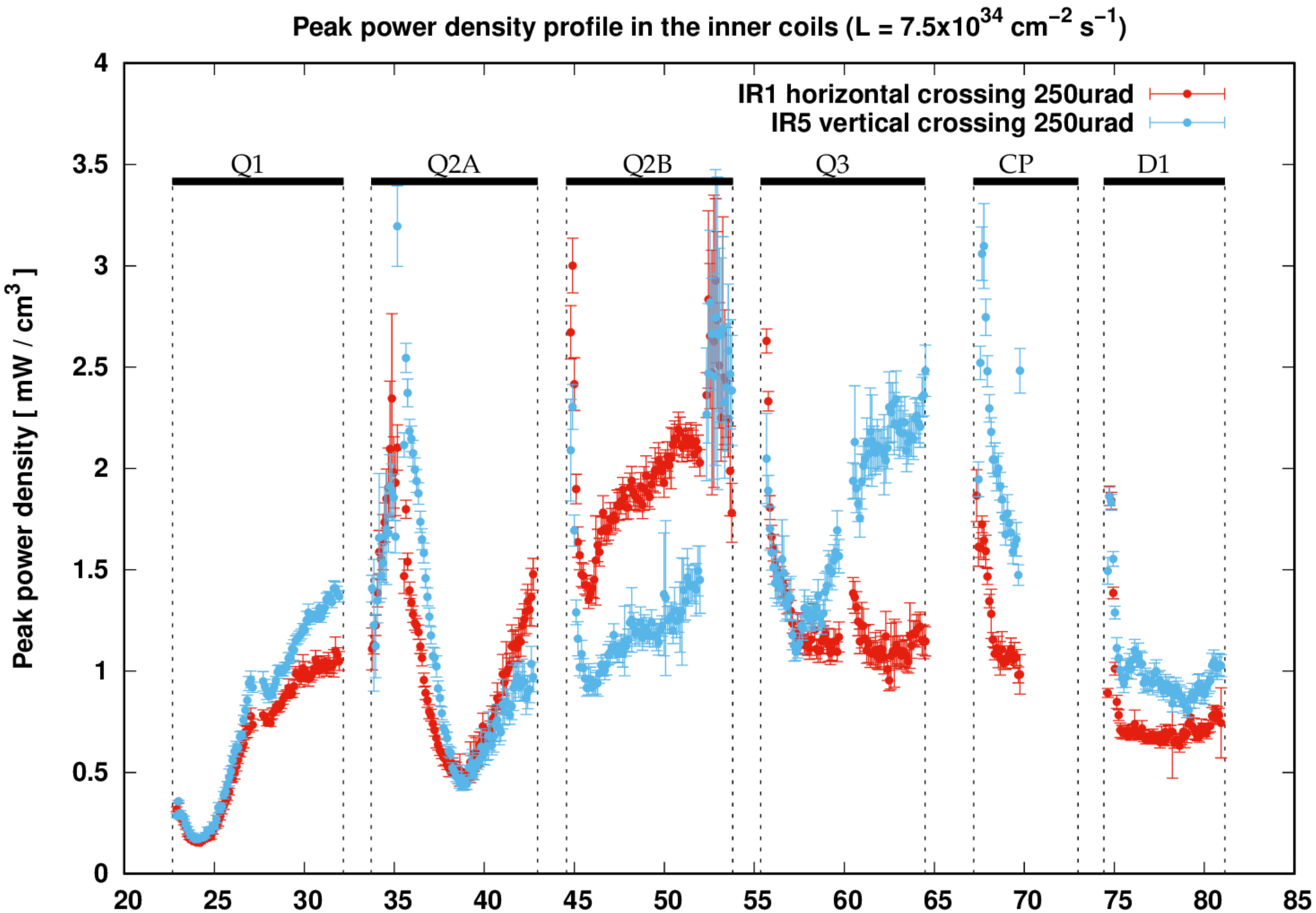


- “Pipe extensions” refers to the elements in between the magnets inside the triplet-D1 cryostat.
  - Cold mass:
  - BS:
    - Inermet shielding.
    - He-pipes.
    - Beam Screen.



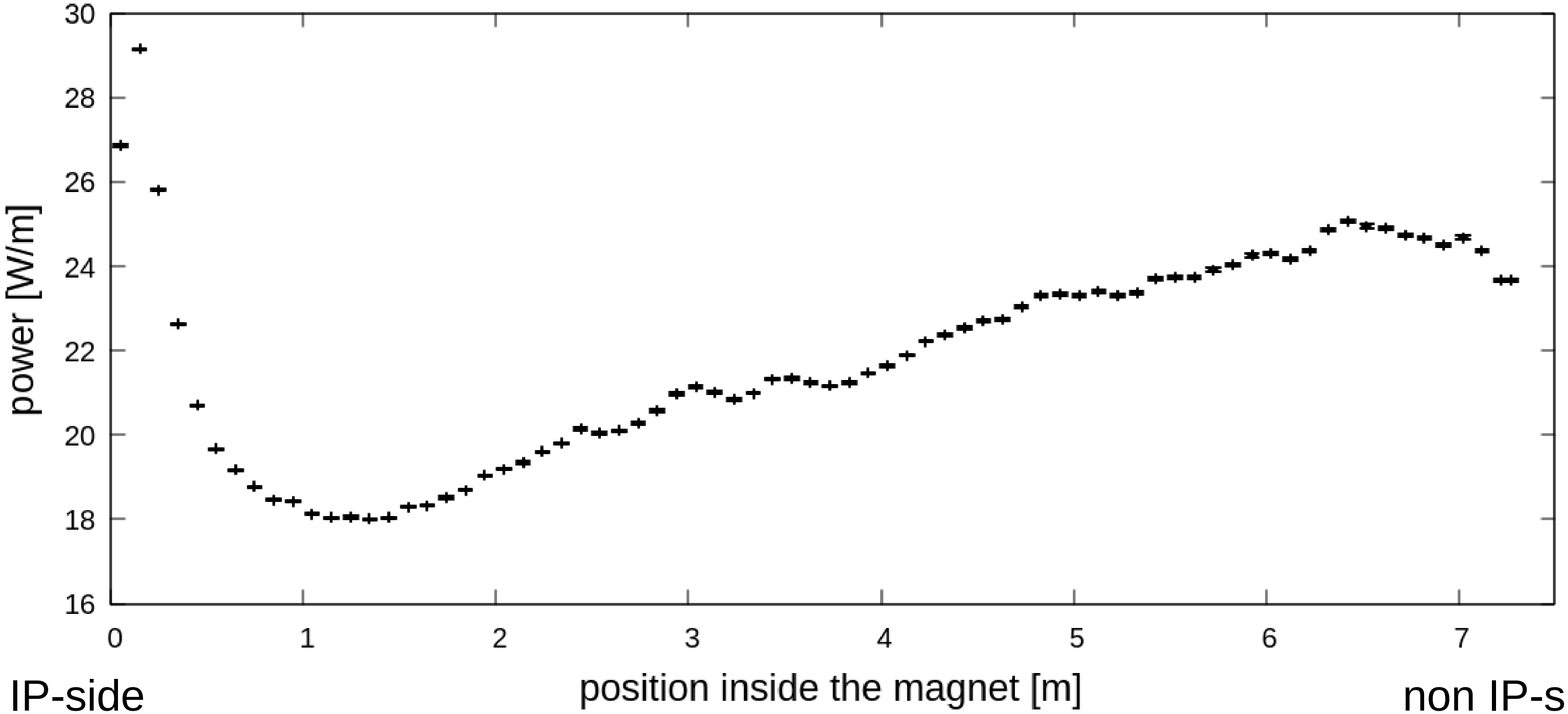
IT+D1 heat loads due to collision debris (IV)

- Peak power distribution along the IT-D1 region:



IT+D1 heat loads due to collision debris (V)

- The most exposed magnet in the IT+D1 region for IR1-HC is Q2B where the power distribution along the magnet is:

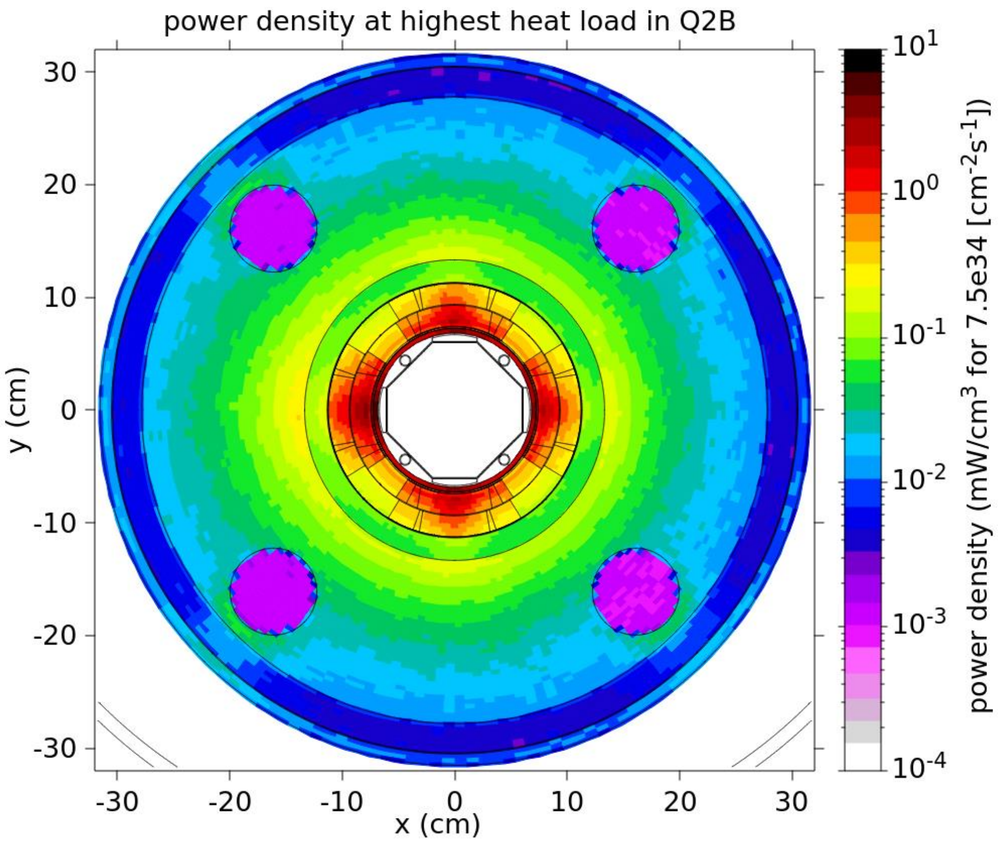


IP-side

non IP-side

IT+D1 heat loads due to collision debris (VI)

- The most exposed magnet in the IT+D1 region for IR1-HC is Q2B. At the peak, the power density distribution is as follow:



D2 heat loads due to collision debris

- According to the latest design of the TAXN, the aperture of the twin chamber is 88 mm.

- **Total power (W) in D2**:

		Cold Mass	Beam Screen
IR1 – HC	D2	35	2
	D2-correctors	3	0.5
IR5 - VC	D2	17	1
	D2-correctors	2	0.3

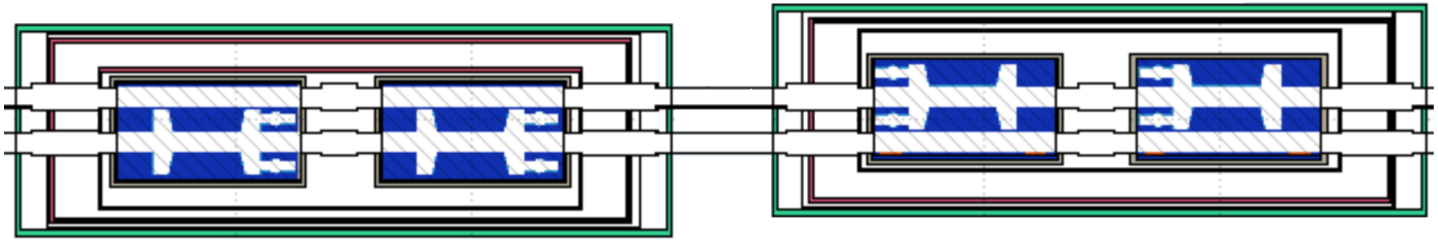
- The power is not distributed uniformly along the magnet length. The IP-side of the D2 is the most exposed region.

- The peak power density slightly exceed 1 mW/cm^3 in the D2-assembly.

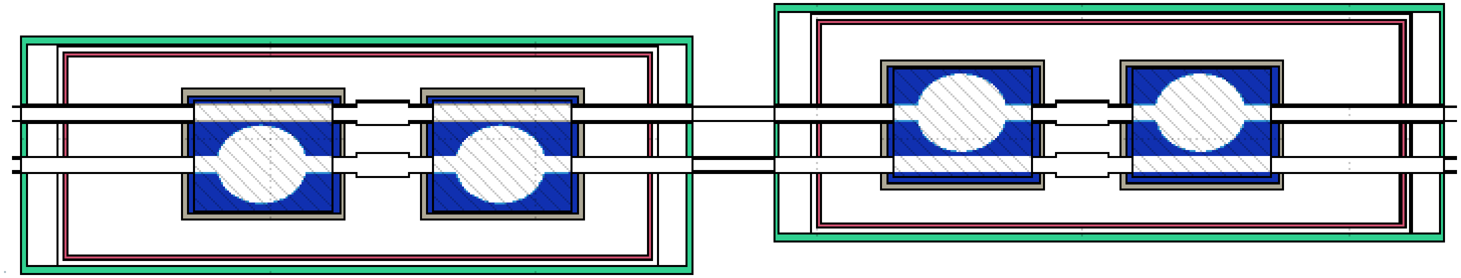
Thank you for your attention

Crab cavities

IR1 (RFD) right side



IR5 (DQW) right side



Crab cavities (II)

Total Power (W)	cavity	cavity wall	He tank (1.9 k)	BS on the other beam
RFD – IR1	C1-B2	0.20	0.23	0.9
	C2-B2	0.16	0.14	0.3
	C1-B1	0.22	0.04	< 0.01
	C2-B1	0.14	0.02	< 0.01
DQW – IR5	C1-B2	0.05	0.04	0.04
	C2-B2	0.03	0.03	0.02
	C1-B1	0.05	0.01	< 0.01
	C2-B1	0.03	0.01	< 0.01