Electron cloud considerations

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Thanks to: G. Arduini, E. Metral, G. Rumolo

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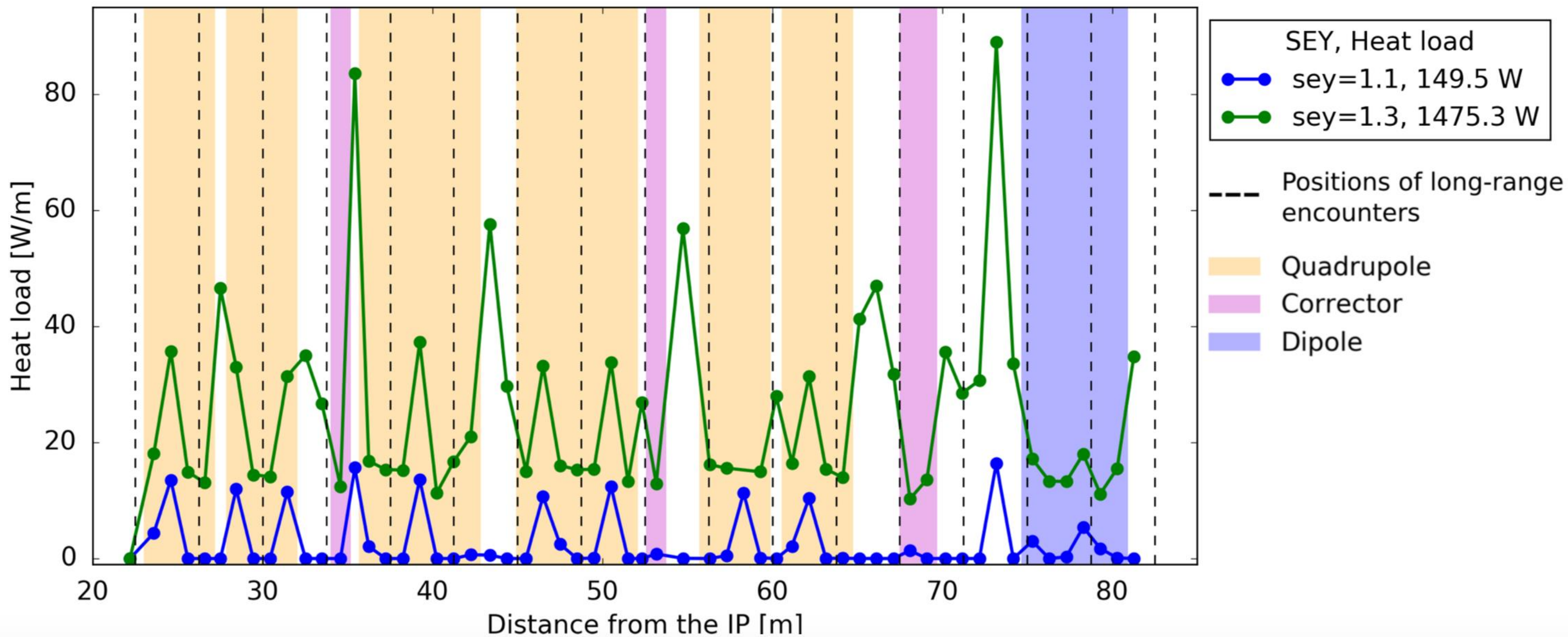
HL-LHC inner triplets: IR1 and IR5

- Simulated the **entire cryogenic length**
- Relevant **magnetic field map** is used for main dipoles and quadrupoles and for dipole correctors. Other sections (e.g. multipole correctors) are simulated as drifts
- **Conclusion: we rely on the presence of a low SEY coating** to keep heat loads on cryogenics at reasonable values
  - **SEYmax < 1.1** assumed in the estimates provided to WP9 (cryogenics)



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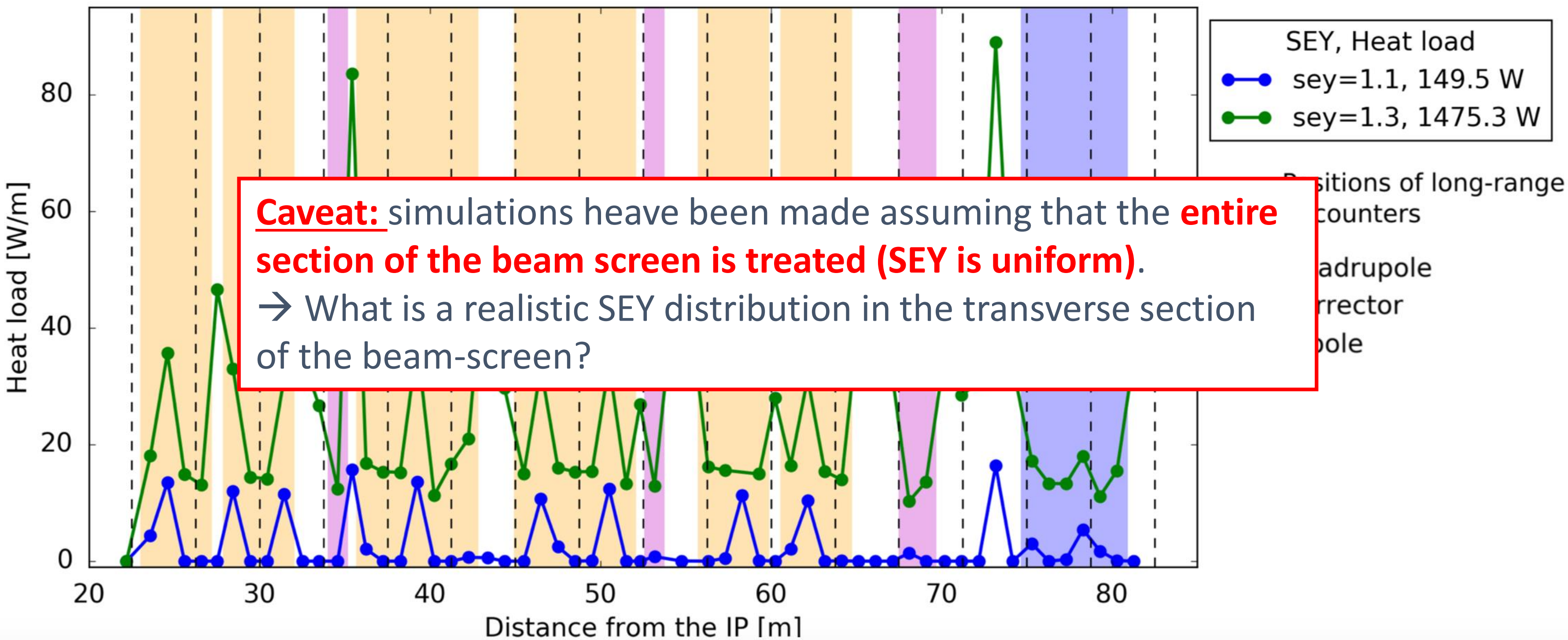
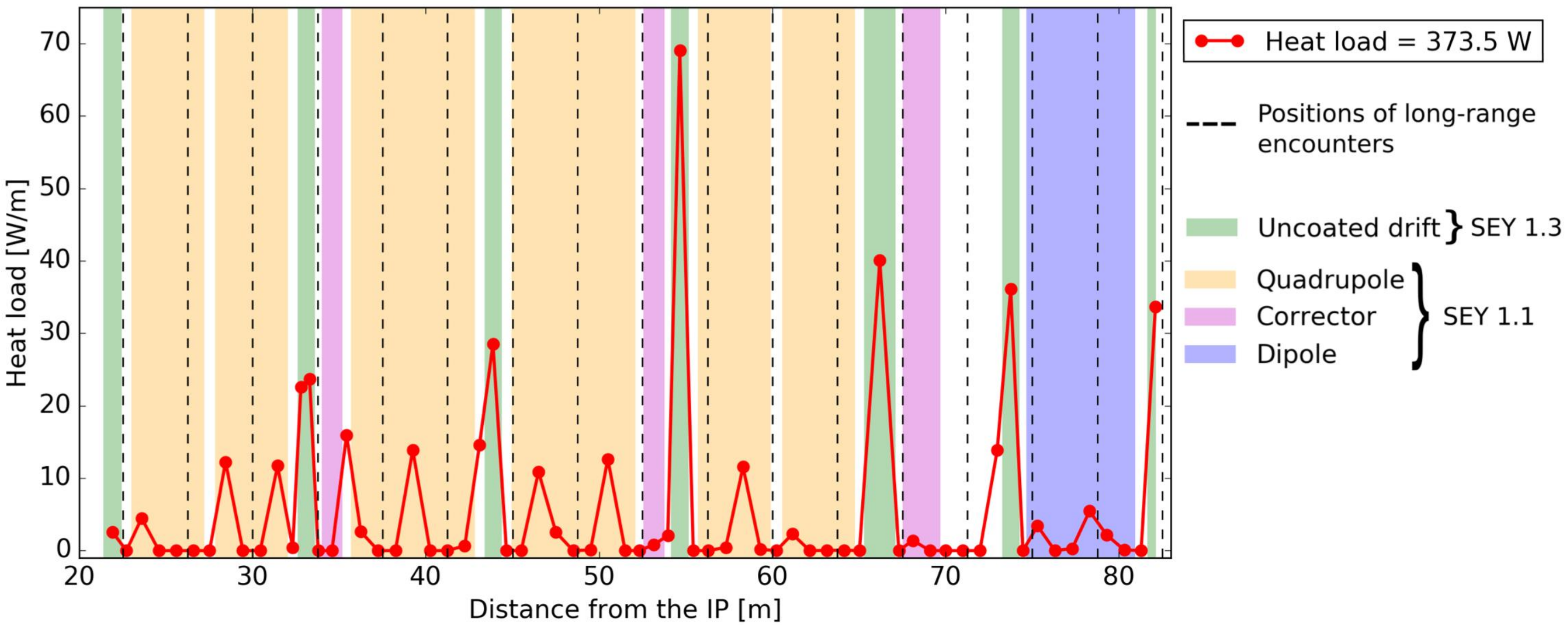


Caveat: simulations heave been made assuming that the **entire section of the beam screen is treated (SEY is uniform)**.
→ What is a realistic SEY distribution in the transverse section of the beam-screen?

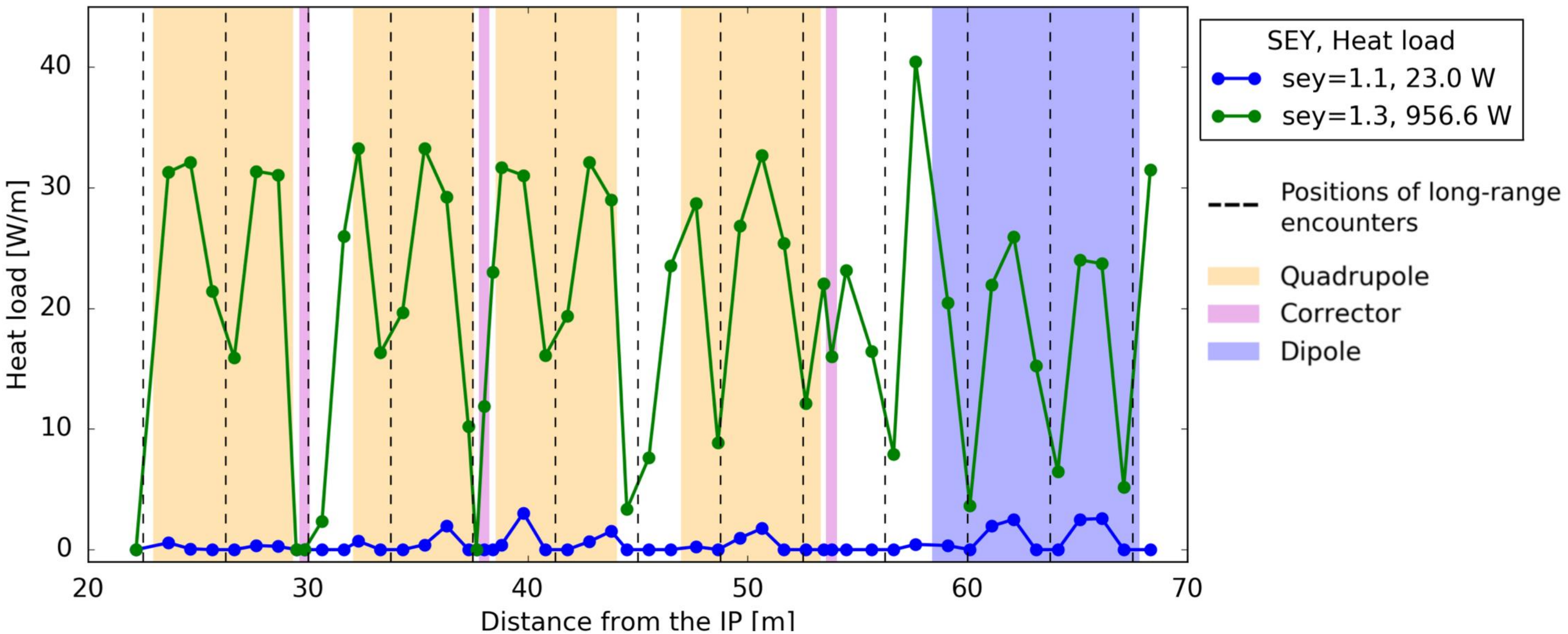
HL-LHC inner triplets: IR1 and IR5

- To asses the impact of having short uncoated sections (bellows, BPMs) we simulated the case in which **all sections outside the cold masses have SEY_{max} = 1.3**
- The heat load increases by **~220 W with respect to the fully coated case**
- Moreover, **impact on beam quality and stability needs to be assessed** as the effect on the beam is **amplified by the large beta functions**
- **Proposed strategy:**
  - Total length of **non-coated parts should be minimised** (as much as possible)
  - Once the the **"SEY profile" along the IR** is defined, we will perform detailed simulations to confirm that no problem is expected



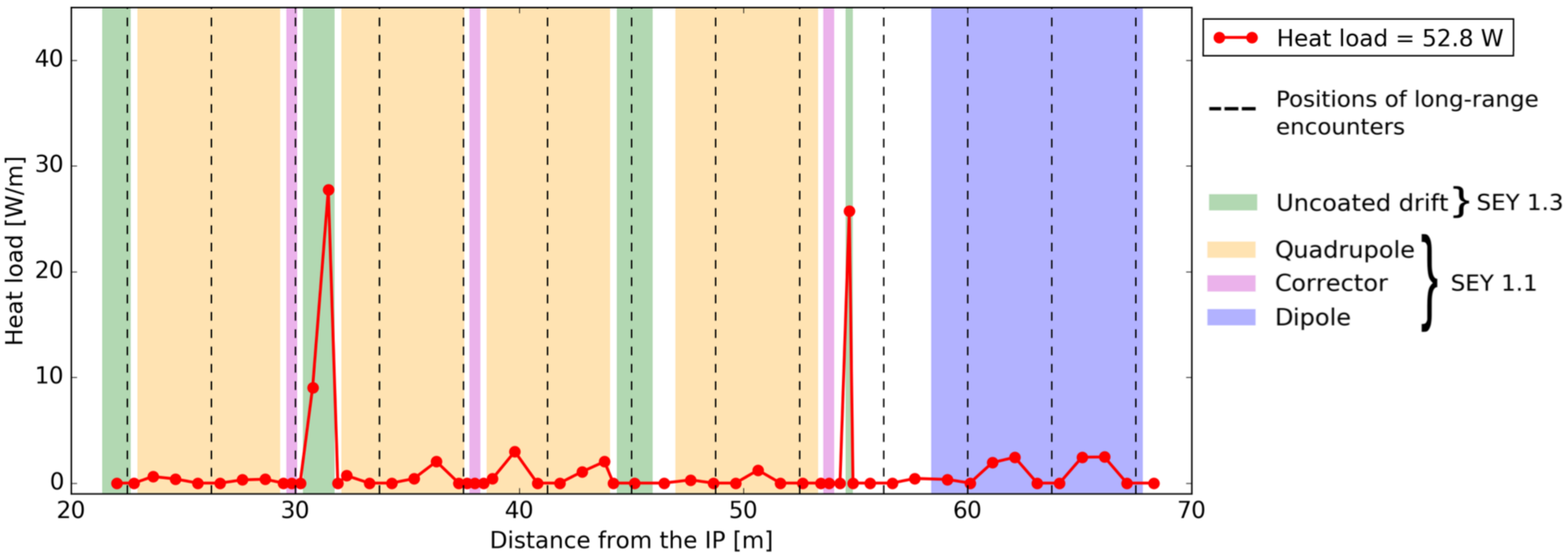
HL-LHC inner triplets: IR2 and IR8

- **Similar conclusions** as for Inner Triplets in IR1 and IR5
- We rely on the presence of a **low SEY coating** to keep heat load on cryogenics at reasonable values (here the treatment will have to be performed in situ)
  - **SEYmax < 1.1** assumed in the estimates provided to WP9 (cryogenics)



HL-LHC inner triplets: IR2 and IR8

- **Similar conclusions** as for Inner Triplets in IR1 and IR5
- We rely on the presence of a **low SEY coating** to keep heat load on cryogenics to reasonable values (here the treatment will have to be performed in situ)
  - **SEYmax < 1.1** assumed in the estimates provided to WP9 (cryogenics)
- Impact of having **non coated drifts** has been evaluated also for these devices

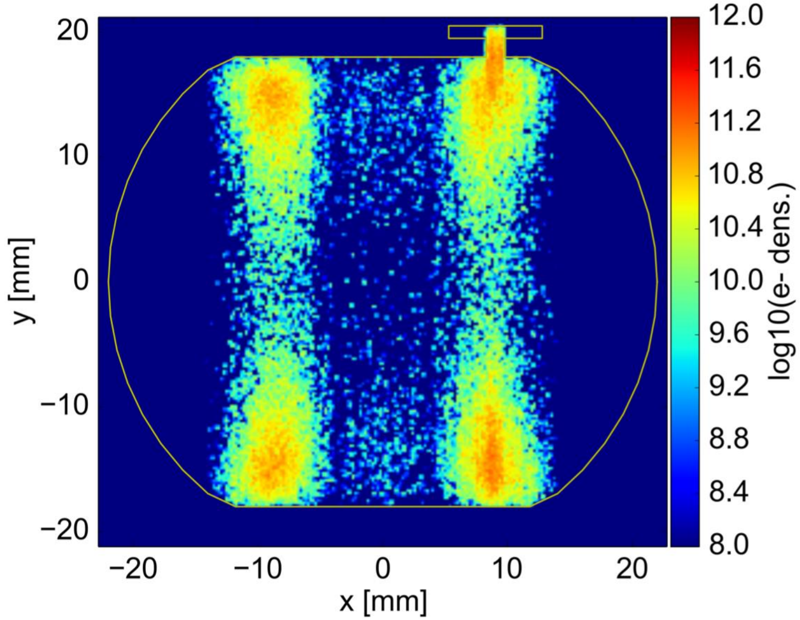


Baffle shields

- Simulations have shown that **multipacting through the pumping holes is possible**
- This was **confirmed by measurements** on the beam screen extracted from the LHC during EYETS

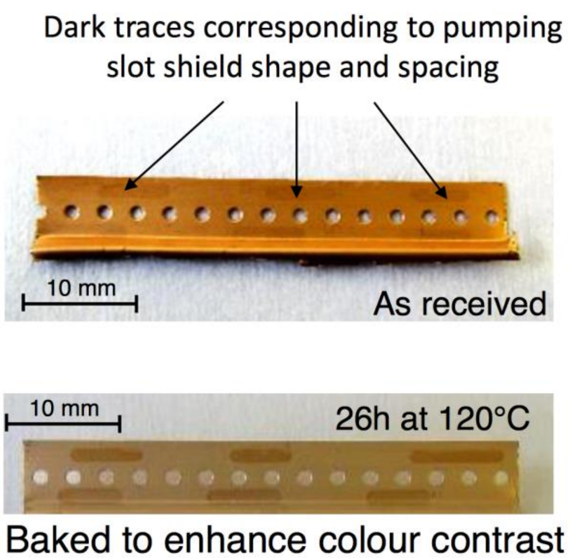
→ It is recommended to **install baffle shields behind the pumping holes for the new HL-LHC beam screens**

→ **Low SEY treatment should be applied on the shield** surface that is exposed to the beam.



For more info: A. Romano et al., "Effect of the LHC Beam Screen Baffle on the Electron Cloud Buildup", IPAC16

Lower SEY found for the parts exposed to the beam



For more info: V. Petit et al., "SEY and XPS measurements on beam screens extracted from the LHC"

Inner Triplets – summary tables

- A document has been drafted including detailed **tables for the beam induced heat loads in the different components** (simulations of the high order correctors are ongoing)
- **Impedance heating** is included assuming that **beam screens are operated at 70 K**

Inner triplets in IR1&5:

Name	Length	Field config.	Chamber	Impedance (T_BS=70 K)	e-cloud (SEY=1.1/ UncDrifts1.3)	Total
ITQ1R5	11.6 m		BSHL_Q1	5.4 W	42.6 W	48.0 W
MQXFA.A1R5	4.2 m	quad	BSHL_Q1	2.0 W	4.8 W	
MQXFA.B1R5	4.2 m	quad	BSHL_Q1	2.0 W	25.9 W	
Drifts	1.7 m	drift	BSHL_Q1	0.8 W	0.2 W	
UncoatedDrifts	1.5 m	drift	BSHL_Q1	0.7 W	11.7 W	
ITQ2Q3R5	49.1 m		BSHL_Q23	20.1 W	330.9 W	351.0 W
MQXFB.A2R5	7.2 m	quad	BSHL_Q23	3.0 W	17.1 W	
MQXFB.B2R5	7.2 m	quad	BSHL_Q23	3.0 W	25.7 W	
MQXFA.A3R5	4.2 m	quad	BSHL_Q23	1.8 W	12.0 W	
MQXFA.B3R5	4.2 m	quad	BSHL_Q23	1.8 W	2.6 W	
MBXF.4R5	6.3 m	dip	BSHL_Q23	2.6 W	11.6 W	
MCBXFBV.A2R5 MCBXFBH.A2R5	1.2 m	dip	BSHL_Q23	0.5 W	0.0 W	
MCBXFBV.B2R5 MCBXFBH.B2R5	1.2 m	dip	BSHL_Q23	0.5 W	1.0 W	
MCBXFAV.3R5 MCBXFAH.3R5	2.2 m	dip	BSHL_Q23	0.9 W	1.5 W	
Drifts	9.7 m	drift	BSHL_Q23	3.8 W	27.0 W	
UncoatedDrifts	5.9 m	drift	BSHL_Q23	2.3 W	232.5 W	
Total IT R5						**399.0 W**

Inner Triplets – summary tables

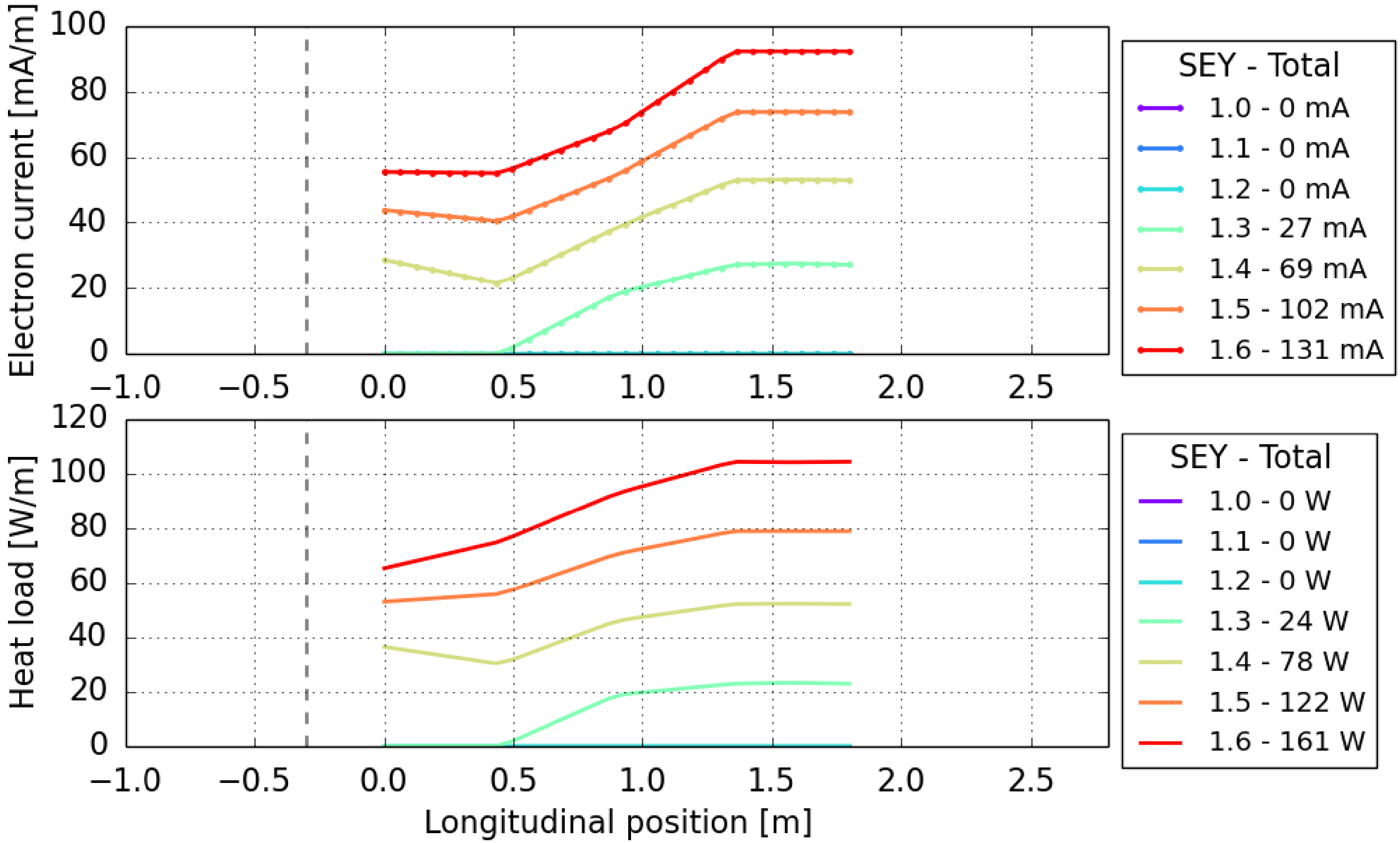
- A document has been drafted including detailed **tables for the beam induced heat loads in the different components** (simulations of the high order correctors are ongoing)
- **Impedance heating** is included assuming that beam screens **are operated at 70 K**

Inner triplets in IR2&8:

Name	Length	Field config.	Chamber	Impedance (T_BS=70 K)	e-cloud (SEY=1.1/ UncDrifts1.3)	Total
ITQ1R8	9.8 m		BSMQ_Q1-R	13.7 W	9.3 W	23.0 W
MQXA.1R8	6.4 m	quad	BSMQ_Q1-R	8.9 W	1.8 W	
MCBXH.1R8						
MCBXV.1R8	0.5 m	dip	BSMQ_Q1-R	0.7 W	0.0 W	
Drifts	0.9 m	drift	BSMQ_Q1-R	1.2 W	0.0 W	
UncoatedDrifts	2.1 m	drift	BSMQ_Q1-R	2.9 W	7.5 W	
ITQ2Q3R8	23.7 m		BSMQ_2	25.0 W	33.4 W	58.4 W
MQXB.A2R8	5.5 m	quad	BSMQ_2	5.8 W	2.9 W	
MQXB.B2R8	5.5 m	quad	BSMQ_2	5.8 W	5.8 W	
MQXA.3R8	6.4 m	quad	BSMQ_2	6.8 W	1.5 W	
MCBXH.2R8						
MCBXV.2R8	0.5 m	dip	BSMQ_2	0.5 W	0.0 W	
MCBXH.3R8						
MCBXV.3R8	0.5 m	dip	BSMQ_2	0.5 W	0.0 W	
Drifts	2.9 m	drift	BSMQ_2	3.0 W	0.0 W	
UncoatedDrifts	2.5 m	drift	BSMQ_2	2.6 W	23.1 W	
ITD1R8	13.9 m		BSMB_1	11.8 W	10.1 W	21.9 W
MBX.4R8	9.5 m	dip	BSMB_1	8.1 W	9.5 W	
Drifts	4.4 m	drift	BSMB_1	3.7 W	0.5 W	
UncoatedDrifts	0.0 m	drift	BSMB_1	0.0 W	0.0 W	
Total IT R8						**103.2 W**

- Electron cloud build-up simulations have been performed for the TAXS absorber
- **Two beam device** → multipacting **depends on the distance w.r.t. the long range encounters**

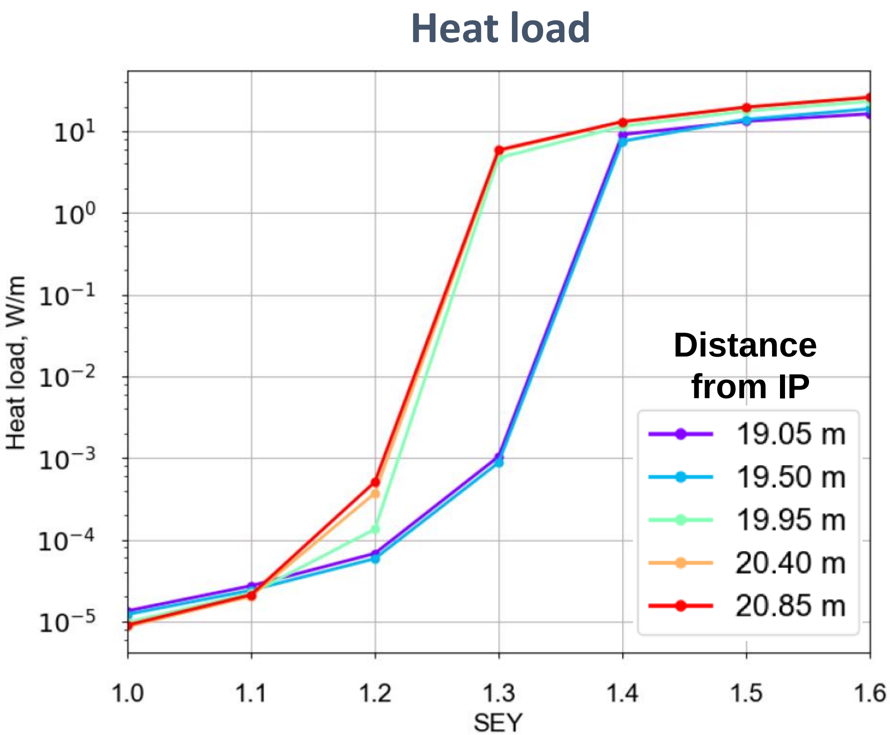
Length = 1.8 m, circular chambers, diameter = 60 mm

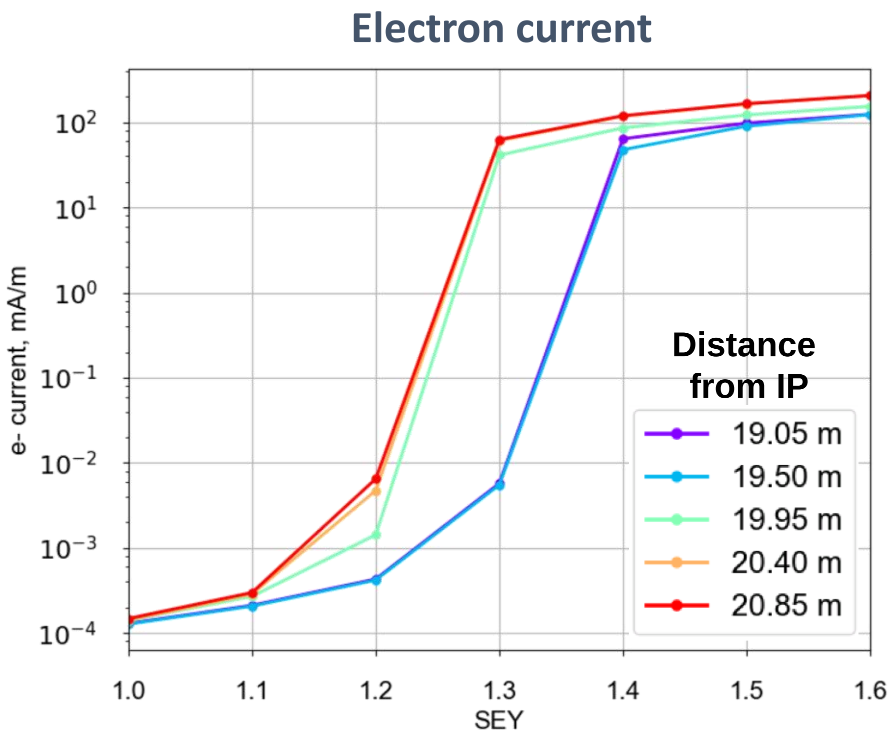


TAXS absorber

- Electron cloud build-up simulations have been performed for the TAXS absorber
- **Two beam device** → multipacting **depends on the distance w.r.t. the long range encounters**
- Multipacting thresholds are above $SEY_{max} = 1.2$
- **Is NEG or aC coating foreseen** for the TAXS chambers?

Length = 1.8 m, circular chambers, diameter = 60 mm





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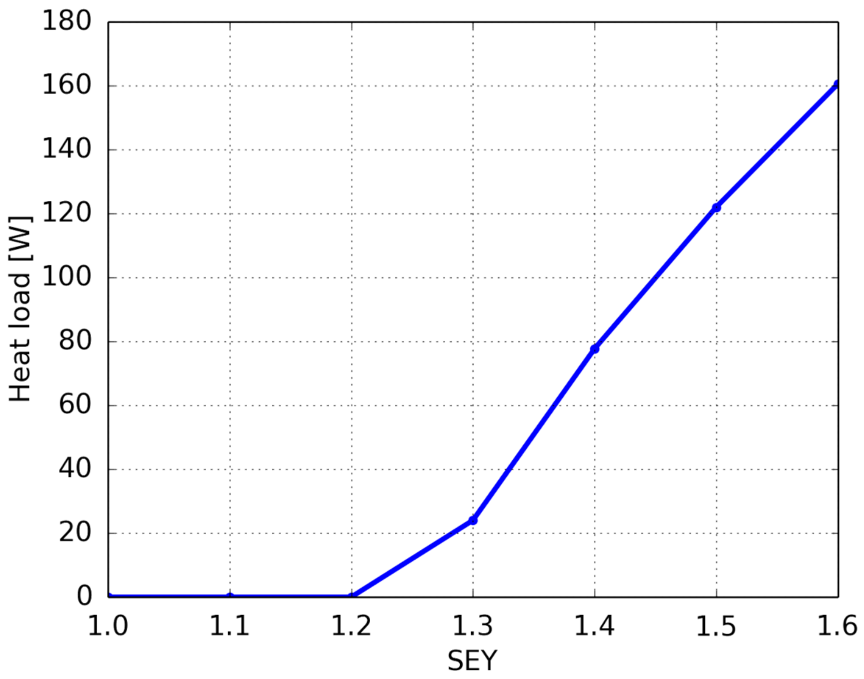
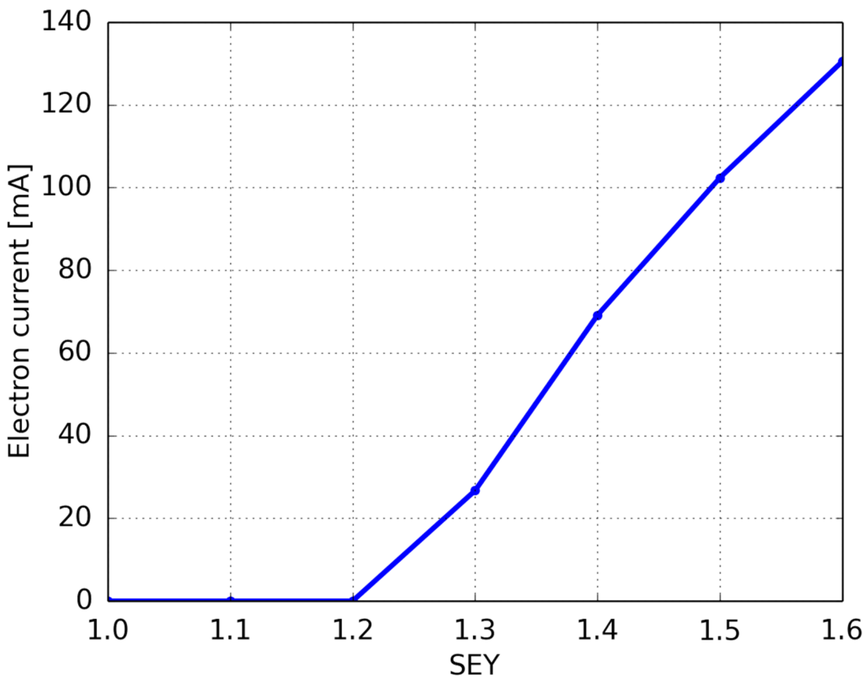
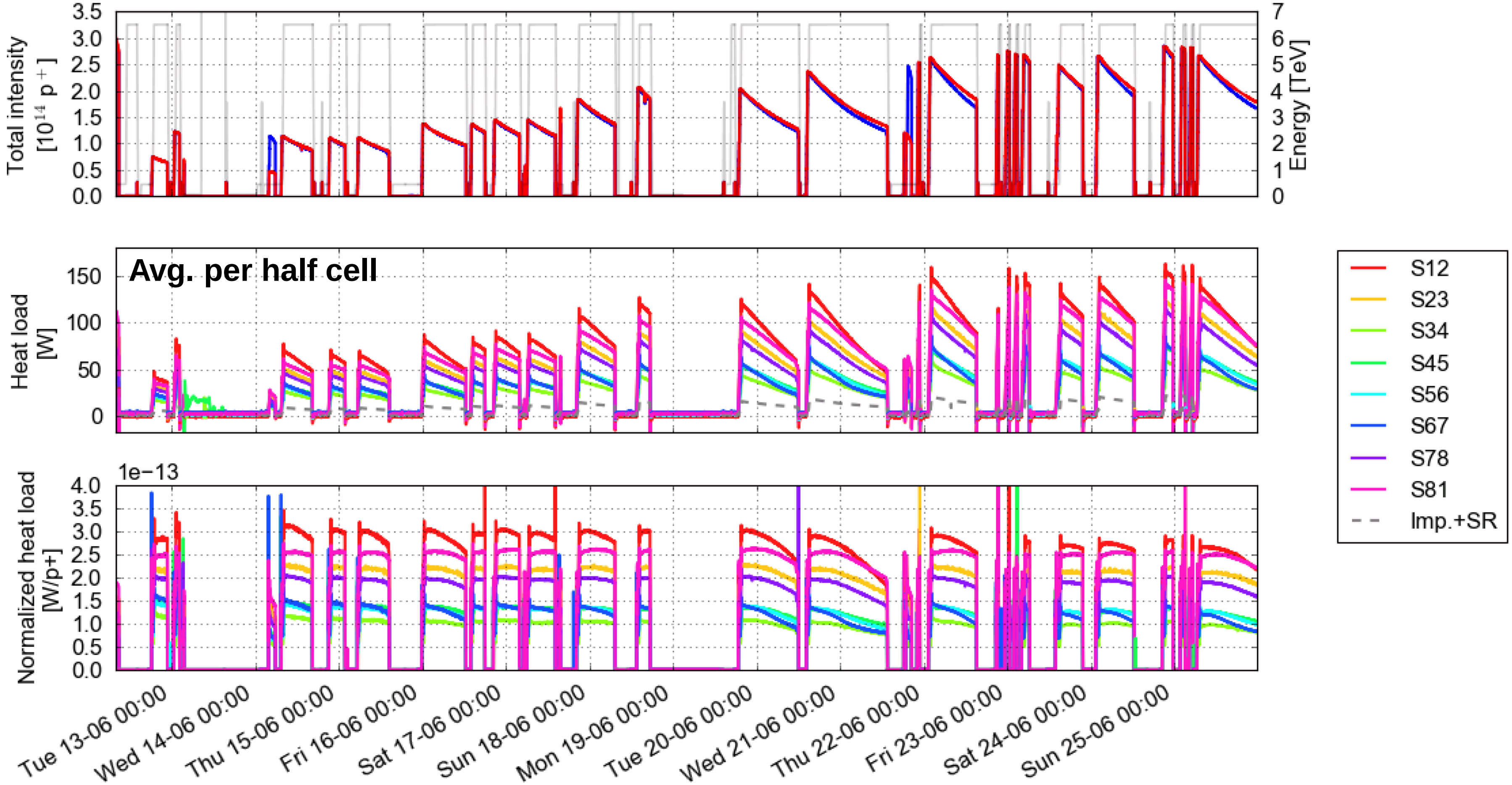




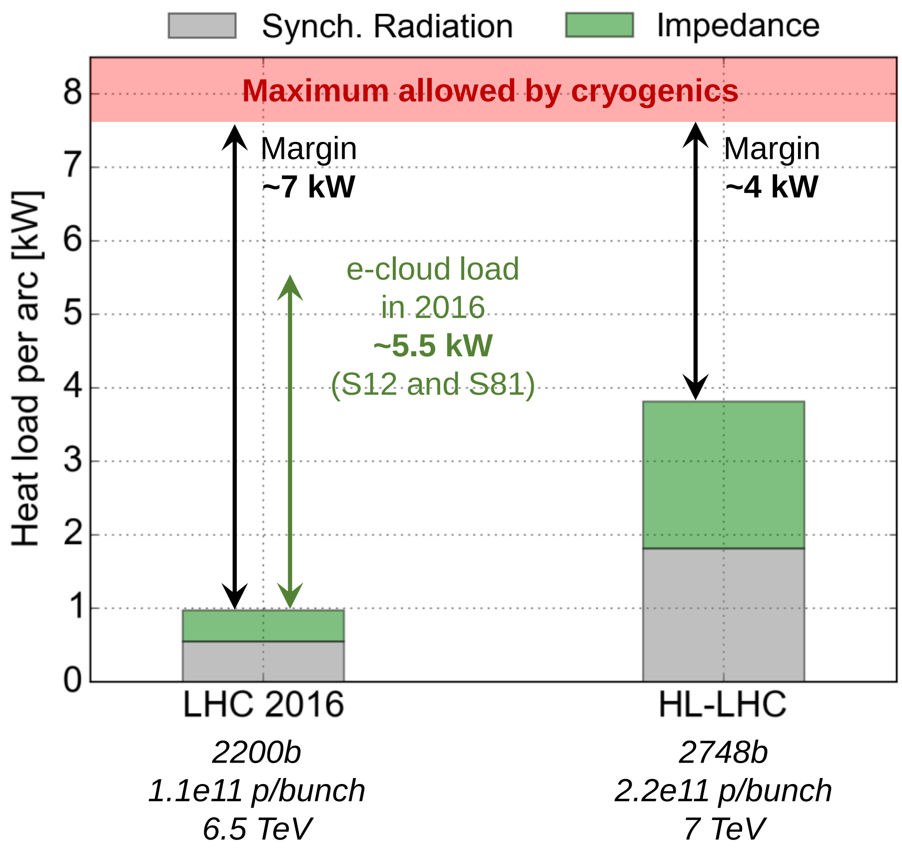
Other considerations

- Presently a **large difference beam induced heat load** is observed on the beam screen of some of the arcs
- The source of this extra heat load (presently unknown) **needs to be identified and suppressed** in order to reach the target HL-LHC performance



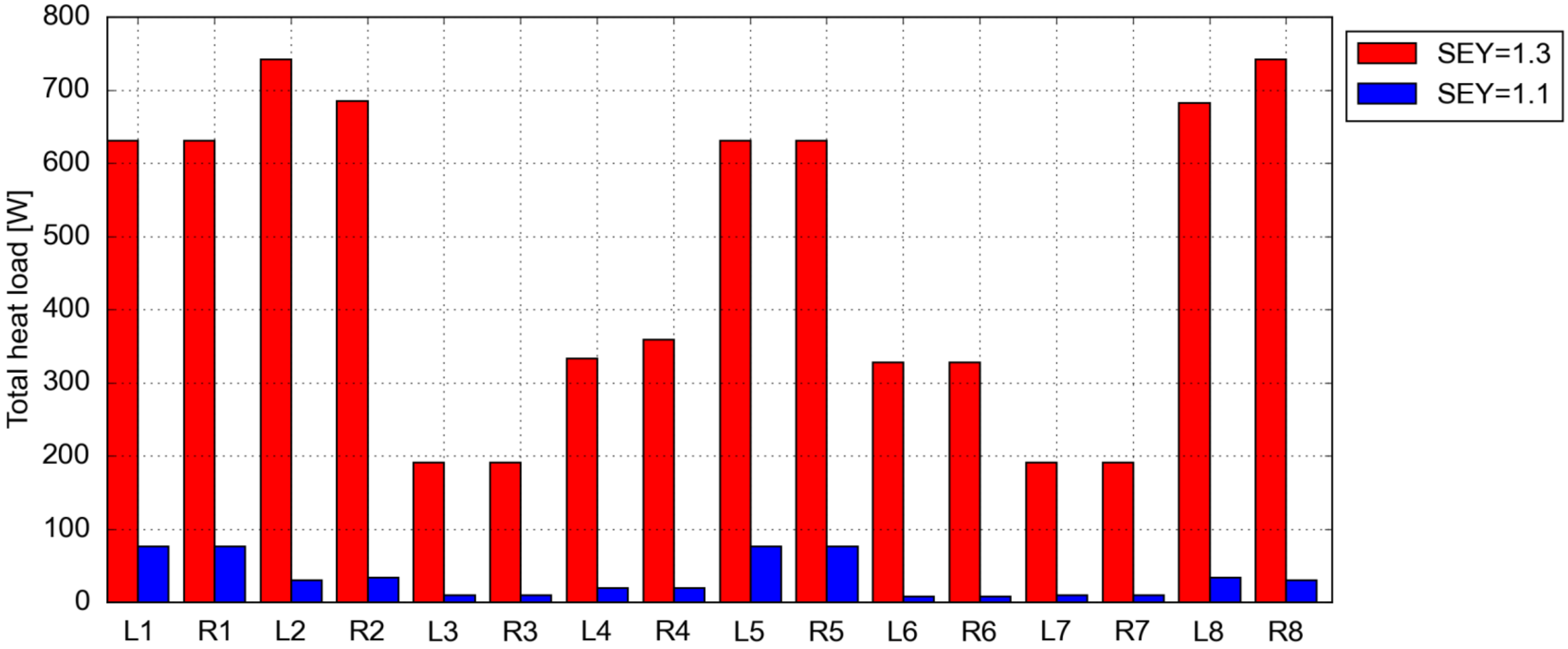
Other considerations

- The situation for HL-LHC will be **more critical as other heat load sources will be larger**
- Dedicated cryoplants will be installed for IR1 and IR5 while **IR2 and IR8 will continue sharing the cryogenics capacity with the neighbouring arcs**



Other considerations

- Detailed heat load estimations have been made for twin-bore magnets all IRs. Results have been published in https://cds.cern.ch/record/2217217?ln=en



- Only **experimental IRs have a significant impact**
- In particular **S78 and S23 are the most critical** as they are cooled by less powerful cryoplants (ex-LEP)
- Additional margin for these arcs can be gained by **coating the beams screens in the adjacent matching sections (i.e. L8 and R2)**

For more info: S. Claudet and G. Iadarola @ 6th HL-LHC Collaboration Meeting, Paris

Summary

- Heat loads in the **Inner Triplets** have been estimated **IR1&5** and for **IR2&8**
  - → We **rely on low SEY surface treatments (SEY_{max}<1.1)** to have reasonable heat loads on cryogenics
  - → **Baffle plates (with low SEY treatment)** should be installed behind the pumping slots to avoid multipacting on the cold bore
  - → A first analysis of the **impact of having un-coated drift sections** outside the cold masses has been performed. The next step is to perform refined simulations using the **realistic SEY_{max} vs *s* distribution** once available
- Build-up simulations have been performed also for the **TAXS absorber**. To evaluate heat load and electron flux we need and **input on the expected SEY_{max}**. **Is aC or NEG coating foreseen?**
- More in general it would good to define the **"SEY_{max} vs s profile"** along the IRs in order to make precise estimates of the integrated electron density in the high beta region
- Heat loads have been estimated also for **all the twin-bore magnets in all IRs**
  - ○ **Experimental IRs are by far the most critical**
  - ○ In particular the **heat load in the stand-alone magnets in IR2 and IR8 affects the cooling capacity in the neighboring arcs**
  - ○ For this reason the **coating of stand-alone magnets in IR2 and IR8 is recommended**, with priority to L8 and R2 (cooled by ex-LEP cryoplants)

Thanks for your attention