
CERN

e-cloud heat load on IR BPMs

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Acknowledgements: Michal Krupa

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Outline

- Motivation
- Uniform SEY case
  - simulation setup
  - total e-cloud heat loads
  - e-cloud heat loads on electrodes
- Non-uniform SEY case: exposed ceramics
  - simulation setup
  - e-cloud heat loads
- Summary

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Motivation: thermomechanical simulations

Results of **e-cloud studies** for HL-LHC triplets (CERN-ACC-NOTE-2018-0009) used **for thermomechanical simulations of the BPMs in IR**:

- slices along triplet were simulated → heat loads (HL) at locations closest to BPMs are taken
- **D1 BPM** (∼73m from IP) with 20 W/m at SEY 1.1 showed **concerning thermal load on the electrodes** resulting in their significant thermal deformation

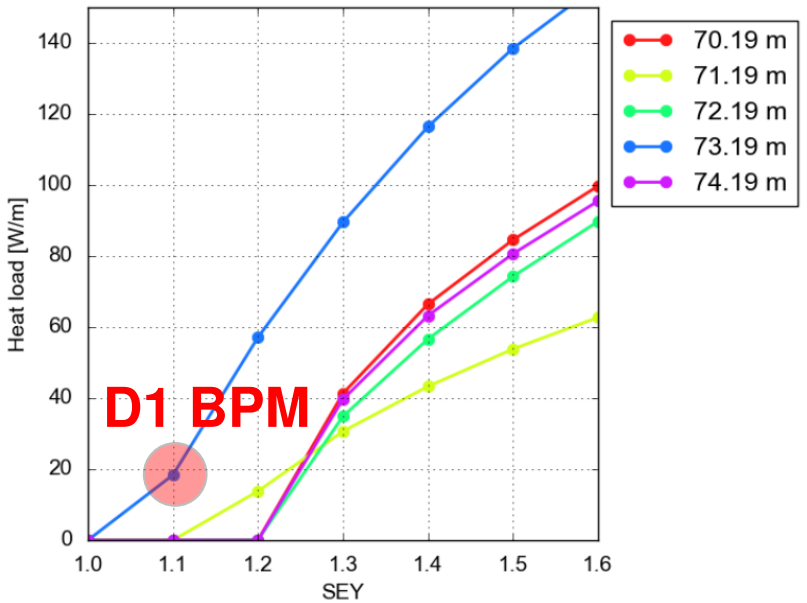
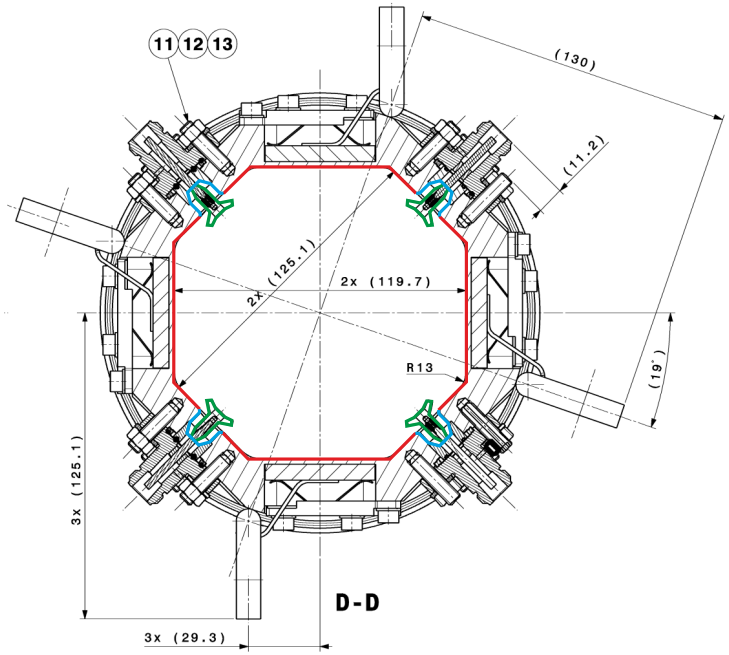


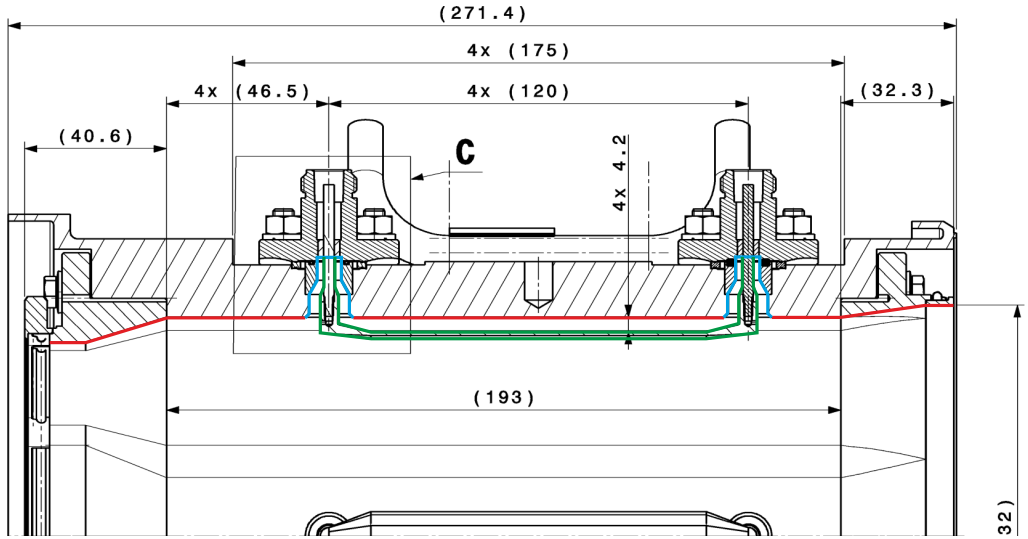
Figure B.21: Heat load as a function of the SEY at the simulated slices inside the Drift9.

Request

The e-cloud working group was requested to **simulate e-cloud heat loads for BPMs in IR**:

- at exact BPM locations
- with BPM chamber geometry
- for different coating scenarios





Surface coated with aC
Holes for contacts - aC coating needed?
Electrodes - aC coating needed?

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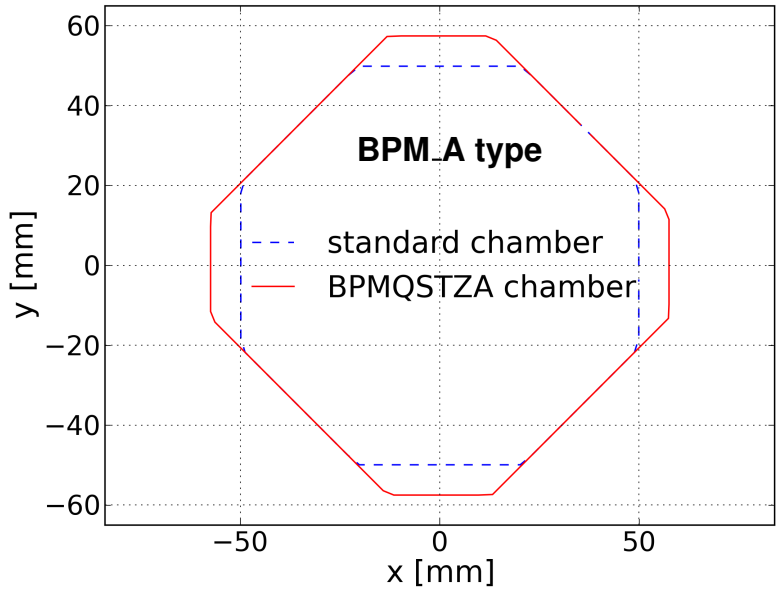
Simulation setup: uniform SEY

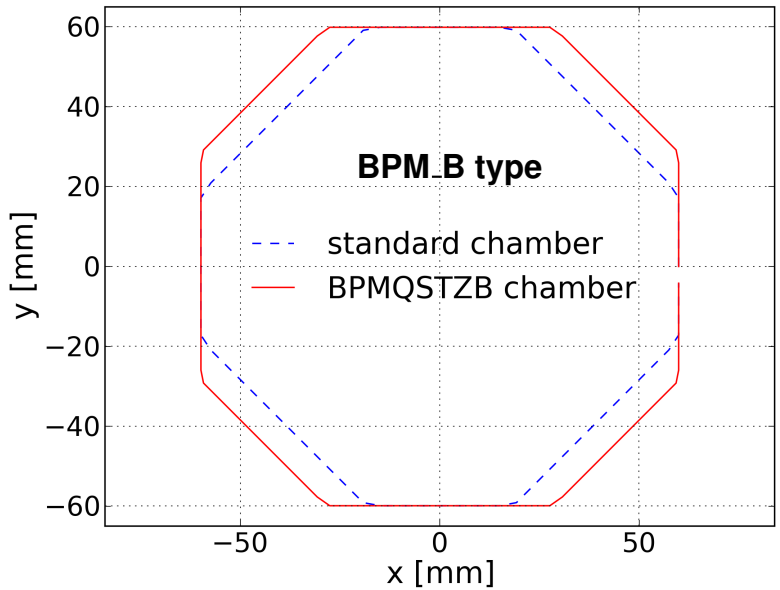
The BPM chambers:

- are larger than standard BS
- two types: one BPM_A, five BPM_B
- bodies a-C coated (SEY$\sim$1.1)

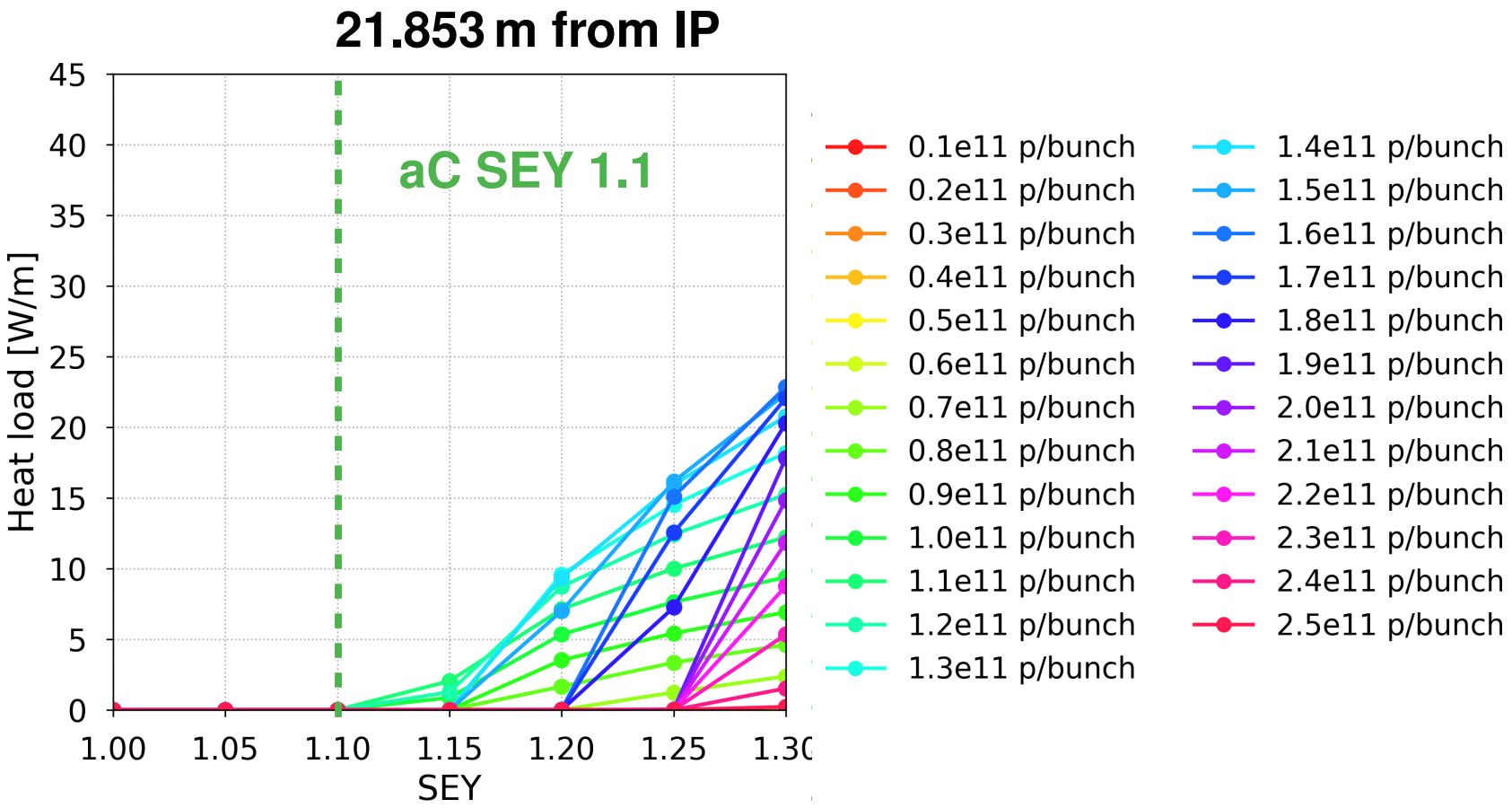
e-cloud build-up simulated at the BPM locations with:

- two beams with 24.95 ns bunch spacing
- bunch population: 1.8e11-2.5e11 p/bunch
- uniform SEY: 1.0-1.3





Heat load in BPM_A type

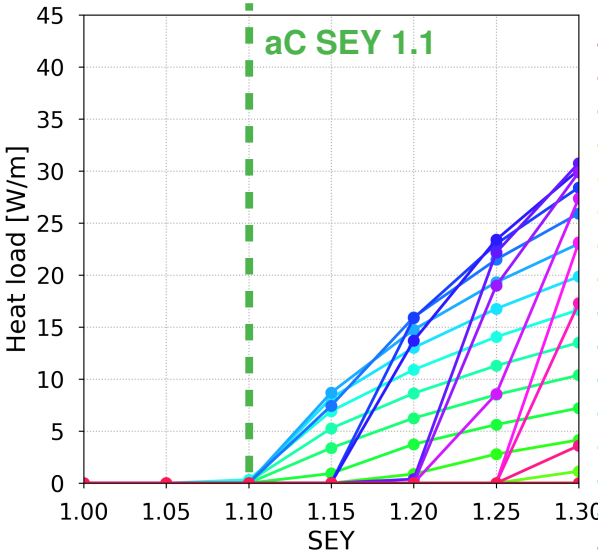


E-cloud simulations show no multipacting for $SEY < 1.25$:

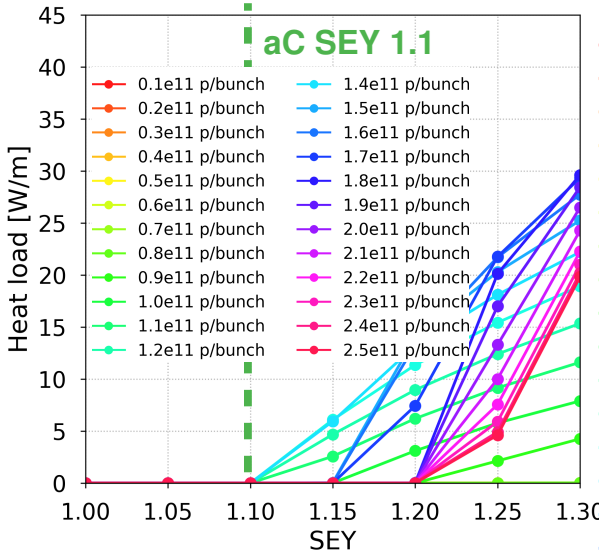
- BPM body will be coated with aC SEY 1.1 $\rightarrow$ no further investigation

Heat load in BPM_B type

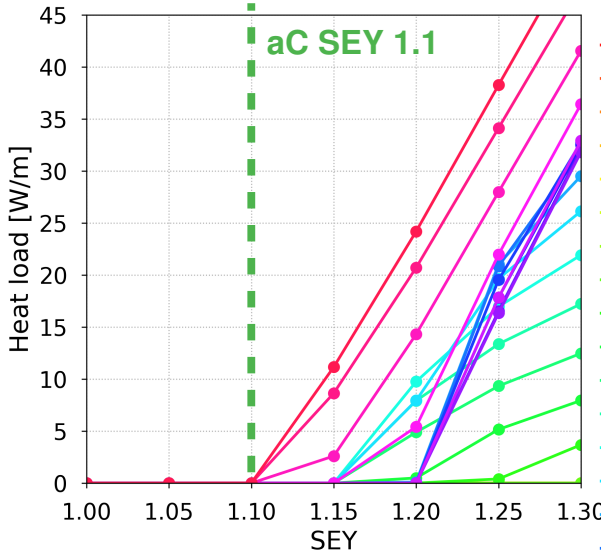
33.073 m from IP



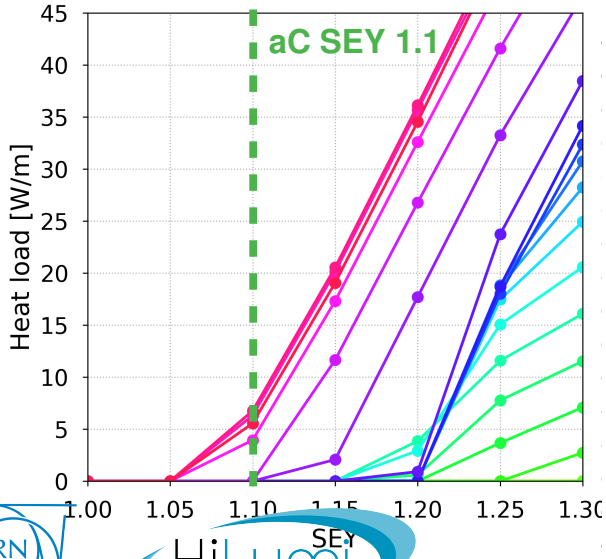
43.858 m from IP



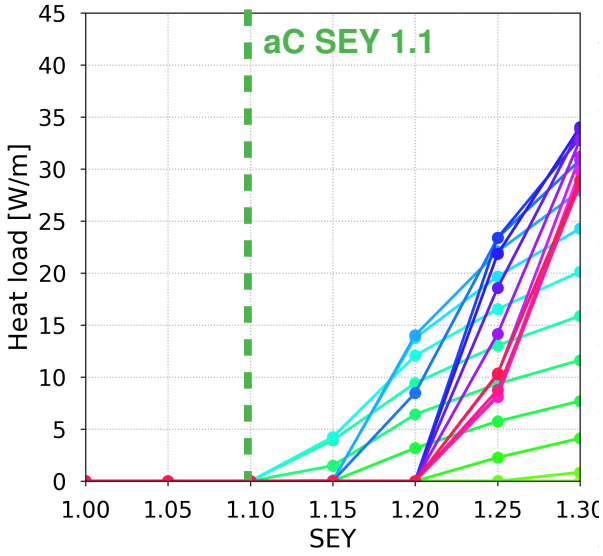
54.643 m from IP



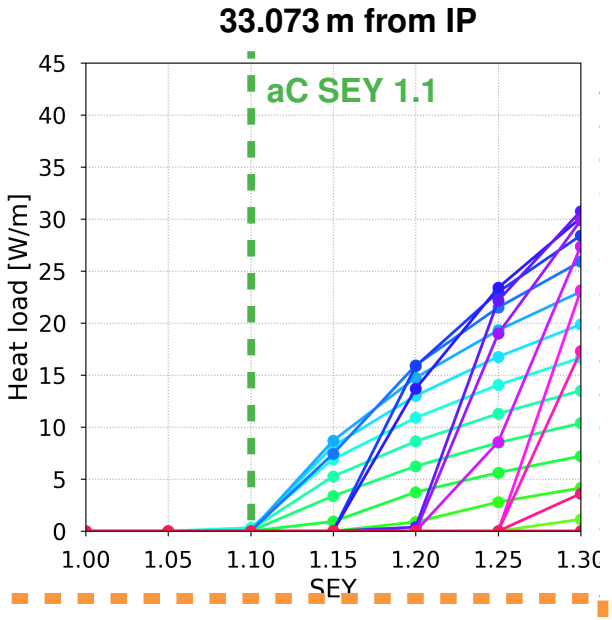
65.743 m from IP

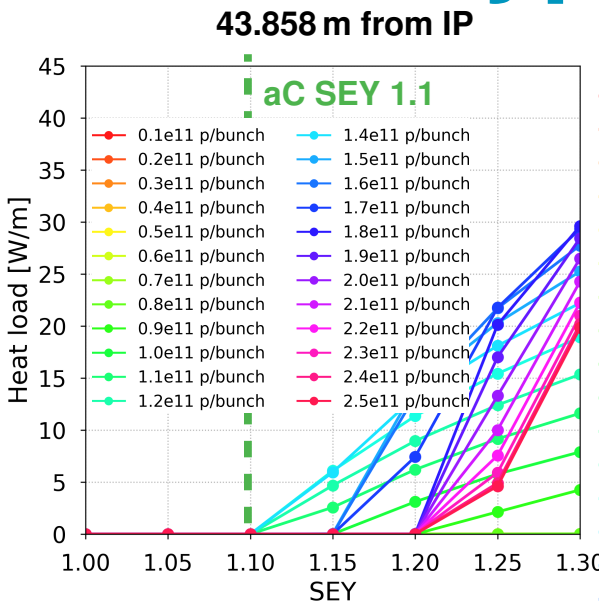


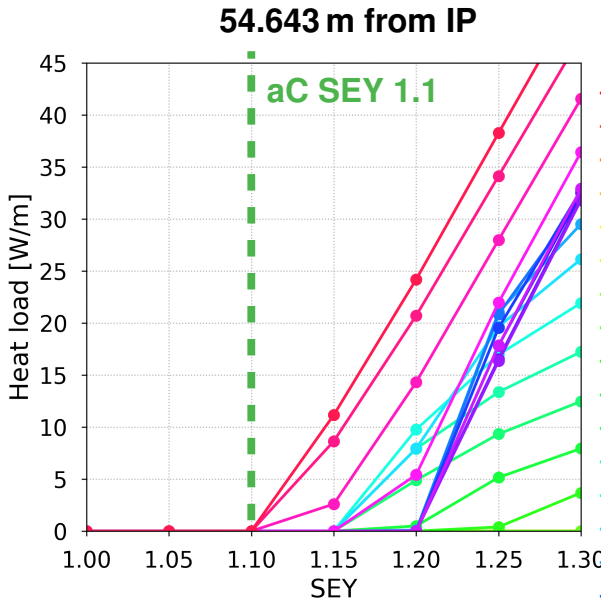
73.697 m from IP

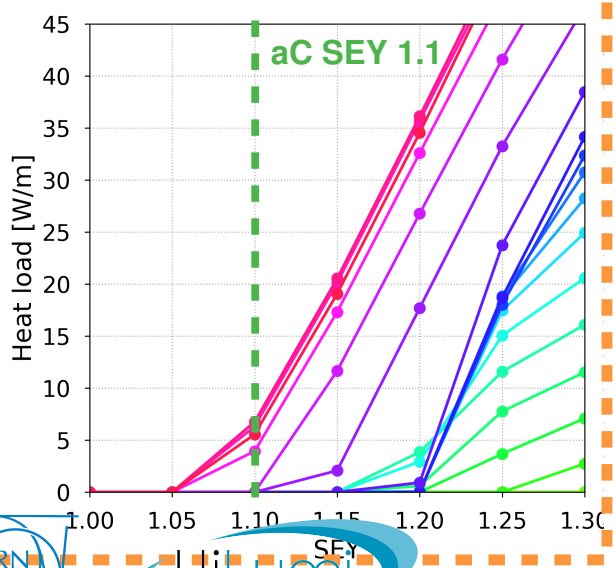


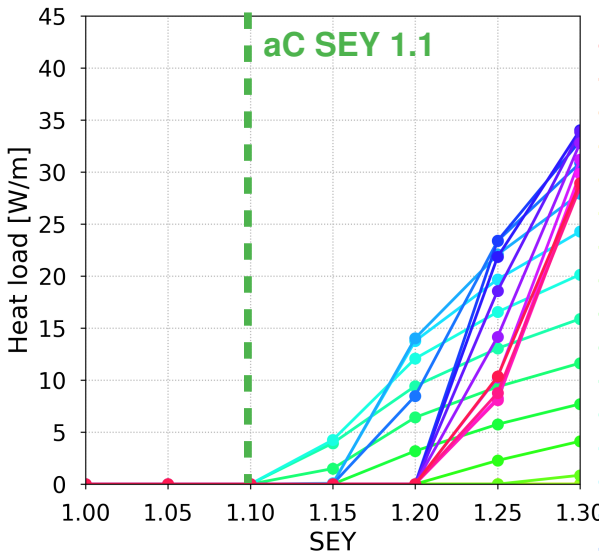
Heat load in BPM_B type







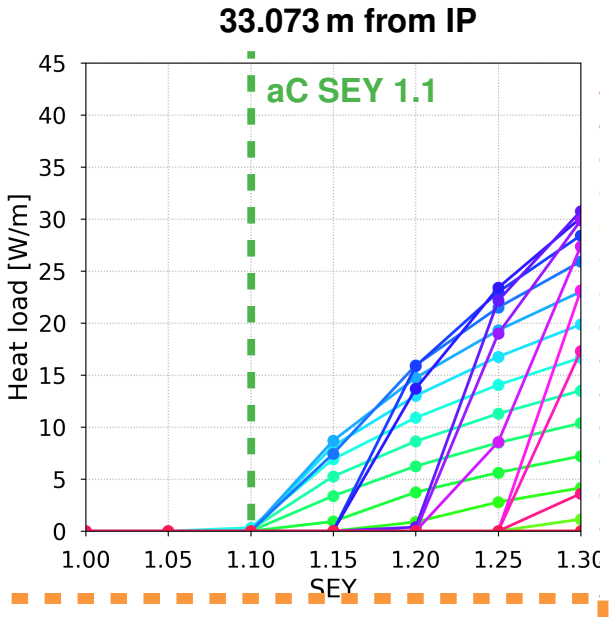


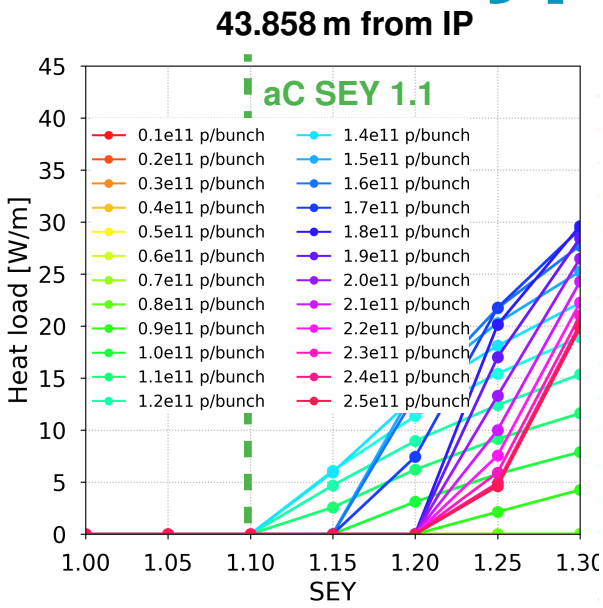


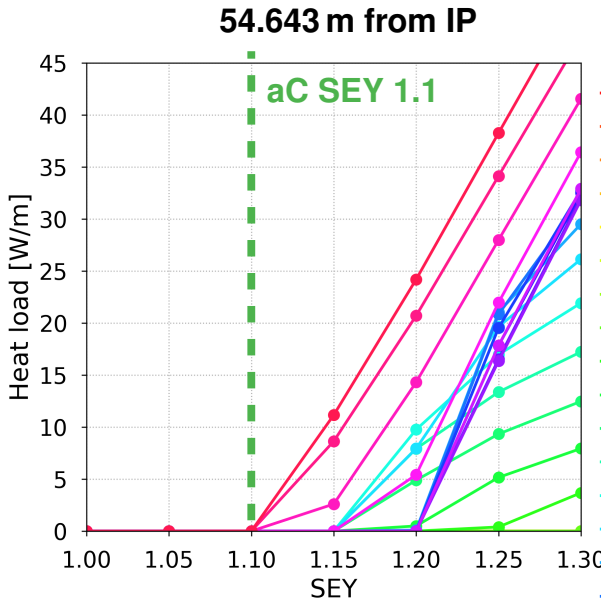
E-cloud simulations show multipacting for aC SEY 1.1 only in BPM_B at ∼65 m from IP

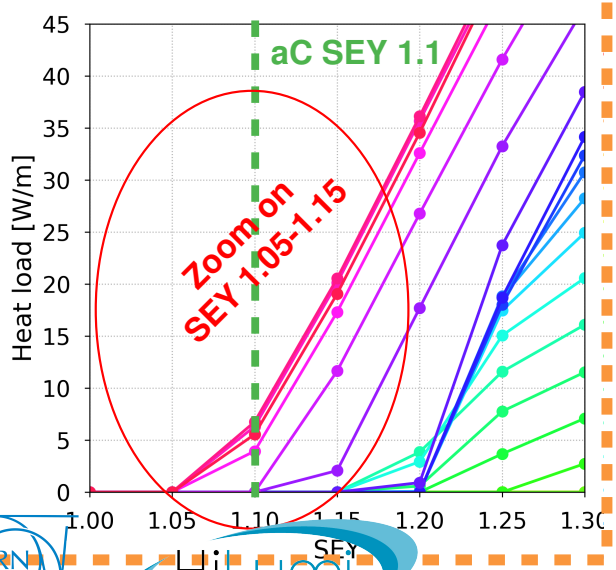
- four times lower than previous ”rough” estimation – only 5 W/m

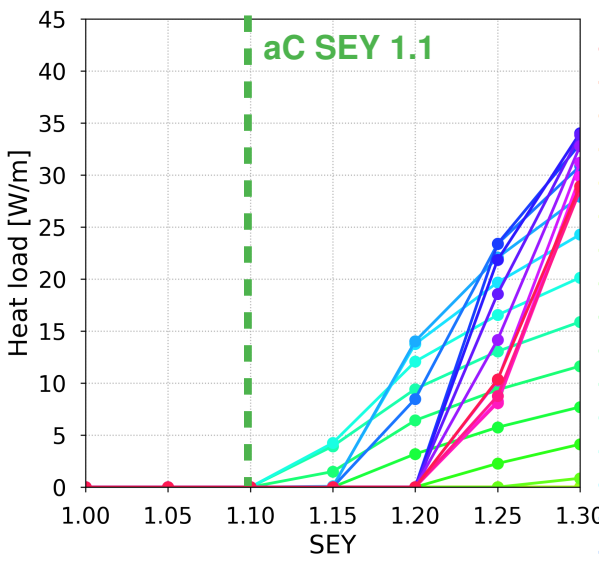
Heat load in BPM_B type







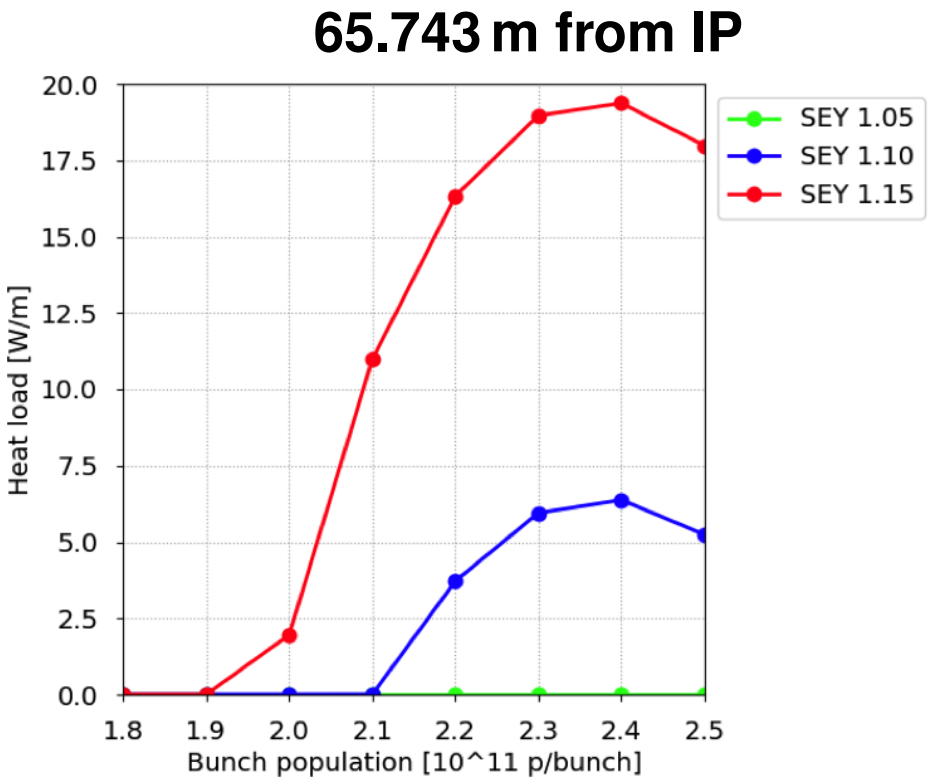




E-cloud simulations show multipacting for aC SEY 1.1 only in BPM_B at ∼65 m from IP

- four times lower than previous ”rough” estimation – only 5 W/m

Heat load vs bunch population on BPM_B



Assuming some SEY variation on aC coating (1.05-1.15):

- SEY 1.15: max HL ~20 W/m with 2.3e11 p/bunch
- SEY 1.1: max HL ~6 W/m with 2.3e11 p/bunch

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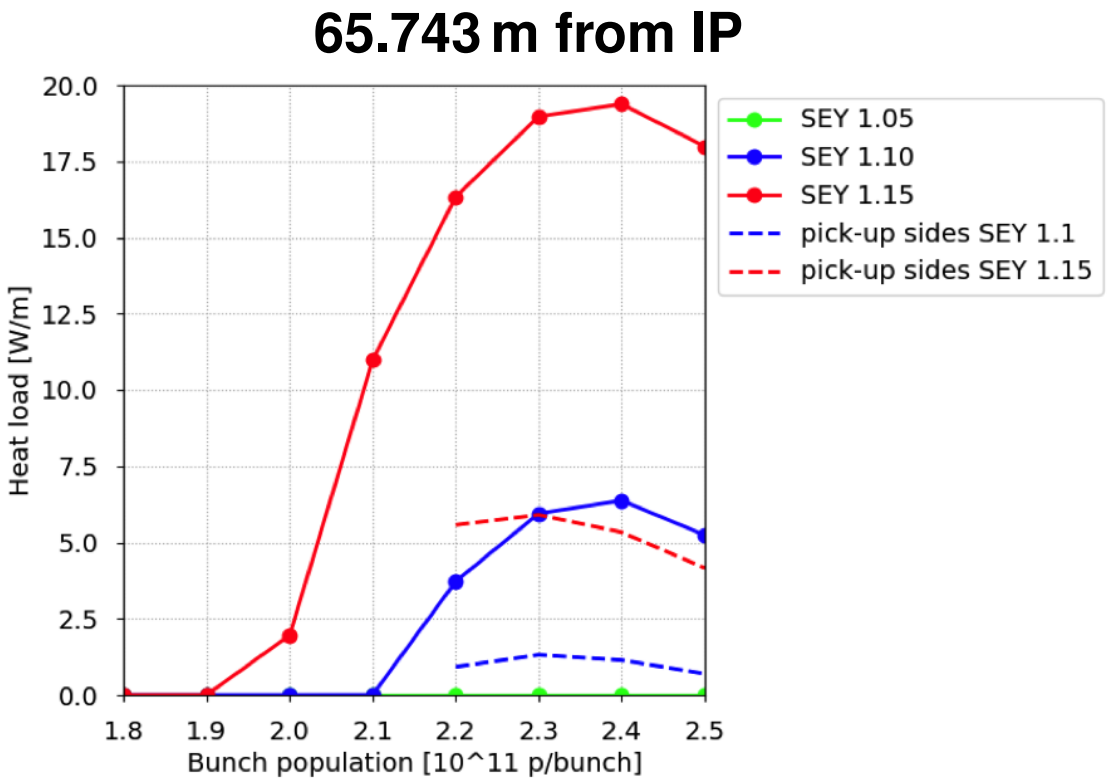
Heat load vs bunch population on BPM_B electrodes



With 2.3e11 p/bunch beam the pick-up sides get the total of:

- SEY 1.15: $\sim$6 W/m$\rightarrow$1.25 W/m/pickup side$\rightarrow$ $\sim$0.22 W/pickup* side
- SEY 1.1: $\sim$1.25$\rightarrow$ $\sim$0.3 W/m/pickup side$\rightarrow$ $\sim$0.05 W/pickup* side

* Assuming 175 mm BPM body length

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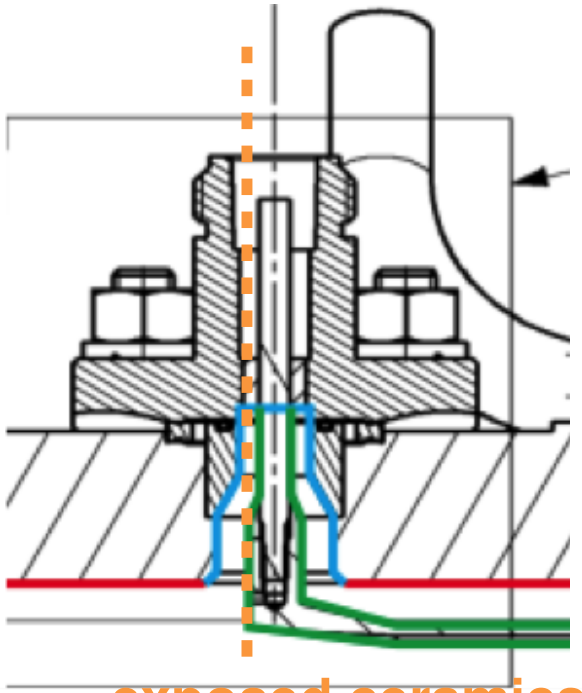
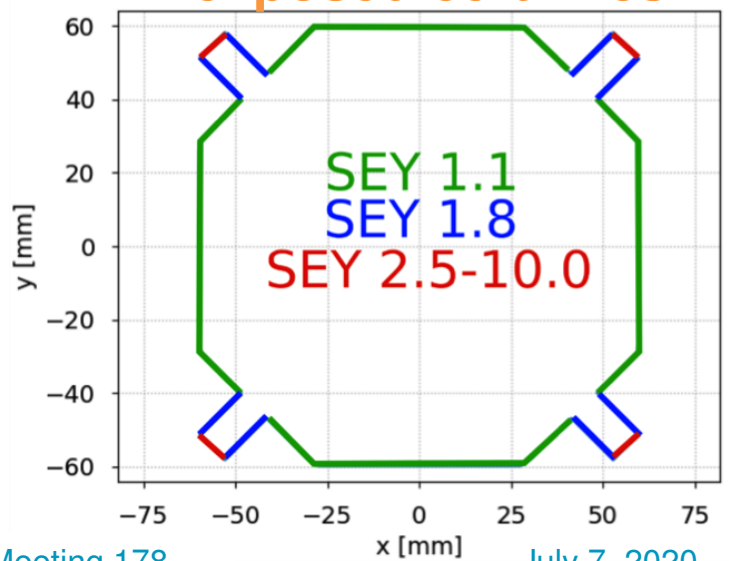
Simulation setup: nonuniform SEY

There is a window where ceramics is exposed to the beam:

- window is ∼2mm at each feedthrough
- ceramics SEY can be very high

e-cloud build-up simulated for the BPM_B type with non-uniform SEY





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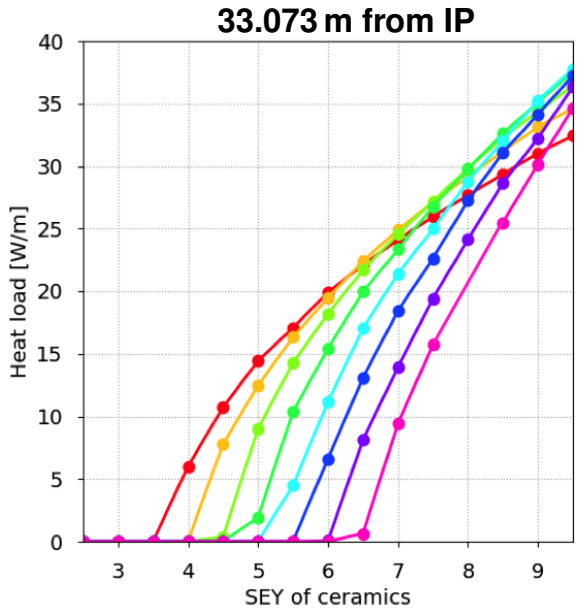
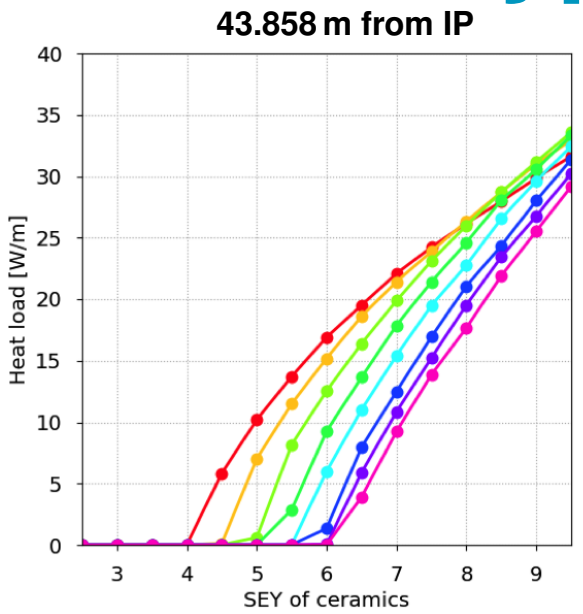
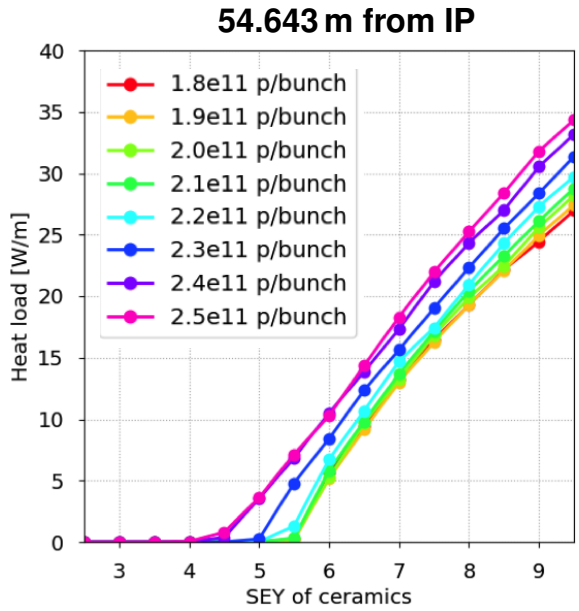
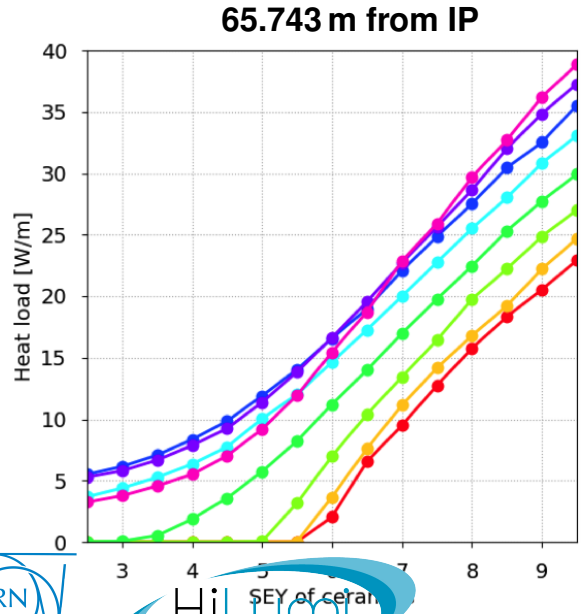
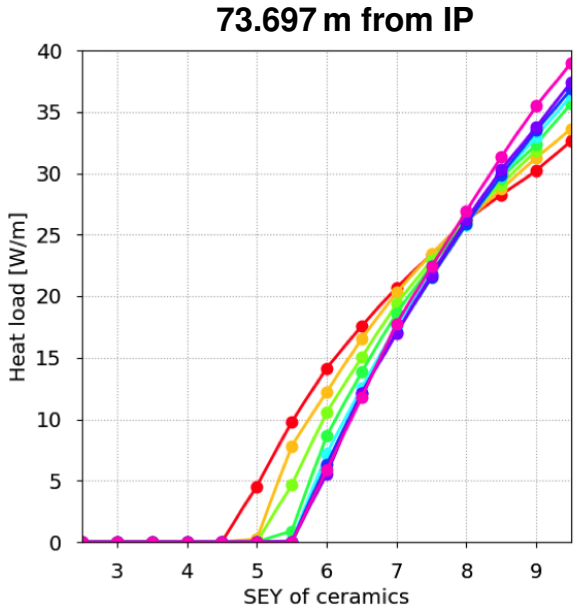


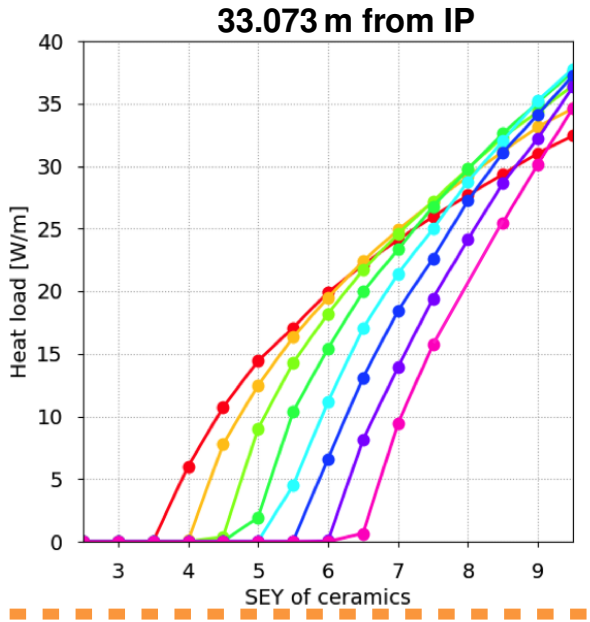


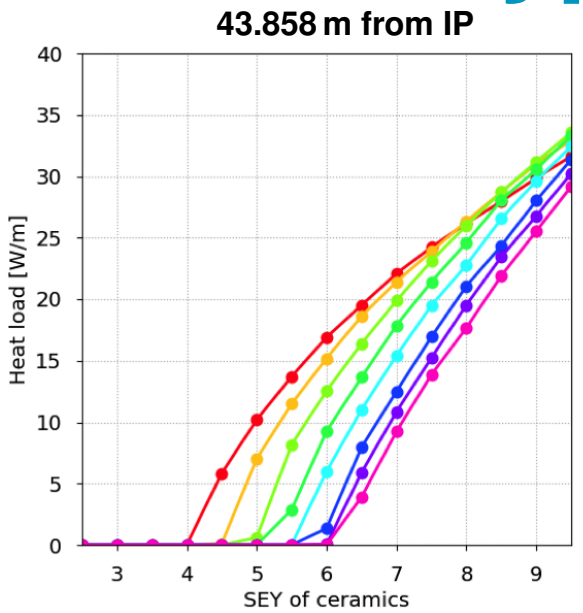


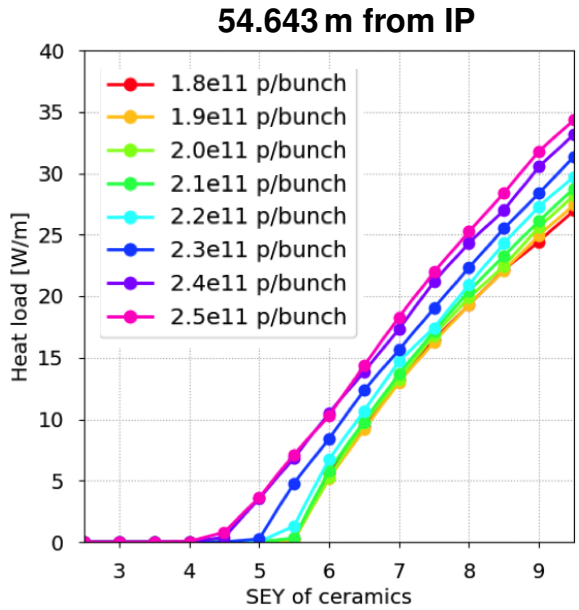


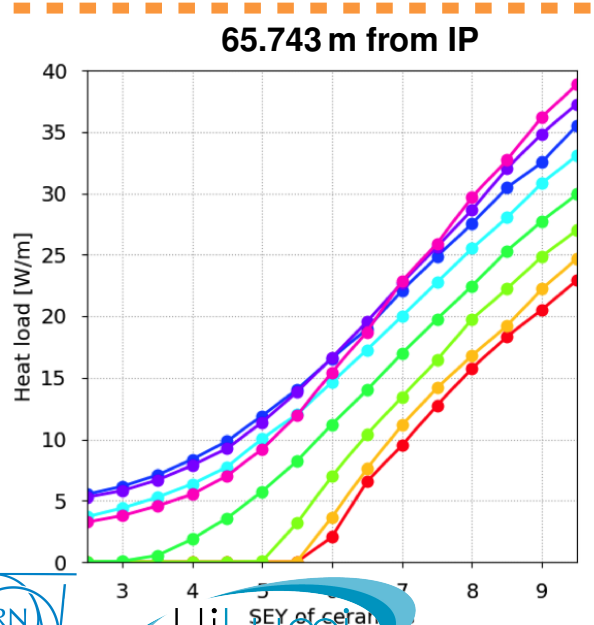


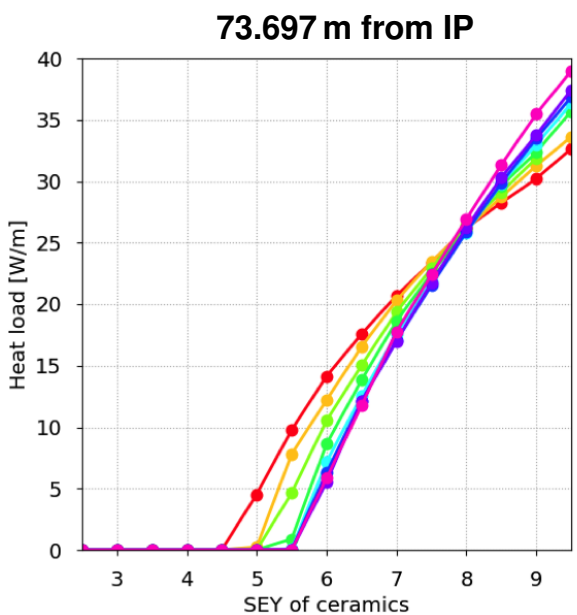
Heat load in BPM_B type











E-cloud simulations show multipacting for low SEY of ceramics in BPM_B at ∼65 m from IP

- assuming 2 mm opening at start and end of a pickup→ 40 W/m translates to ∼0.16 W on a BPM

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Summary

Electron cloud build-up in the HL-LHC BPMs in IR5 was simulated accounting for:

- correct BPM chamber geometry
- exact locations of BPMs with corresponding delays in the arrival of the two beams

The BPM chamber is expected to be coated with aC SEY of 1.1. For this value no or not significant heat loads are expected from e-cloud

- $<$1.25 W/m/electrode side in case of SEY 1.15
- $<$0.3 W/m/electrode side for SEY 1.1

The heat load increases at feedthroughs (exposed ceramics):

- heat load 7-40 W/m depending on SEY of ceramics
- the total heat load is $<$0.16 W (exposed ceramics window is very short)