CERN

E-cloud in Devices with Common Chamber: Inner Triplets and TDIS

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C. Bracco, R. De Maria, L. Gentini, G. Mazzacano, A. Perillo-Marcone, A. Romano, G. Rumolo, M. Taborelli

Outline

- Simulation setup
- e-cloud in inner triplets at IR1&5 and IR2&8
  - heat load estimates with and without coating
  - e-cloud in dipole, quadrupole and drift
- e-cloud in TDIS:
  - heat loads along the device
  - heat loads for different gaps

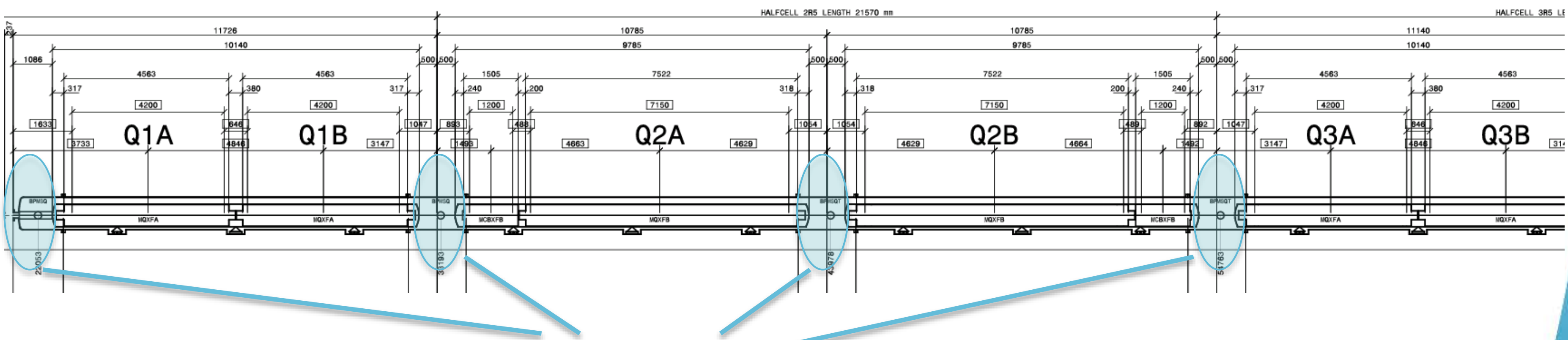
e-cloud simulations in triplets

E-cloud is simulated in main magnets, in dipole correctors and in the drifts

- With uniform SEY
- With non-uniform SEY: the drifts outside cold masses are uncoated

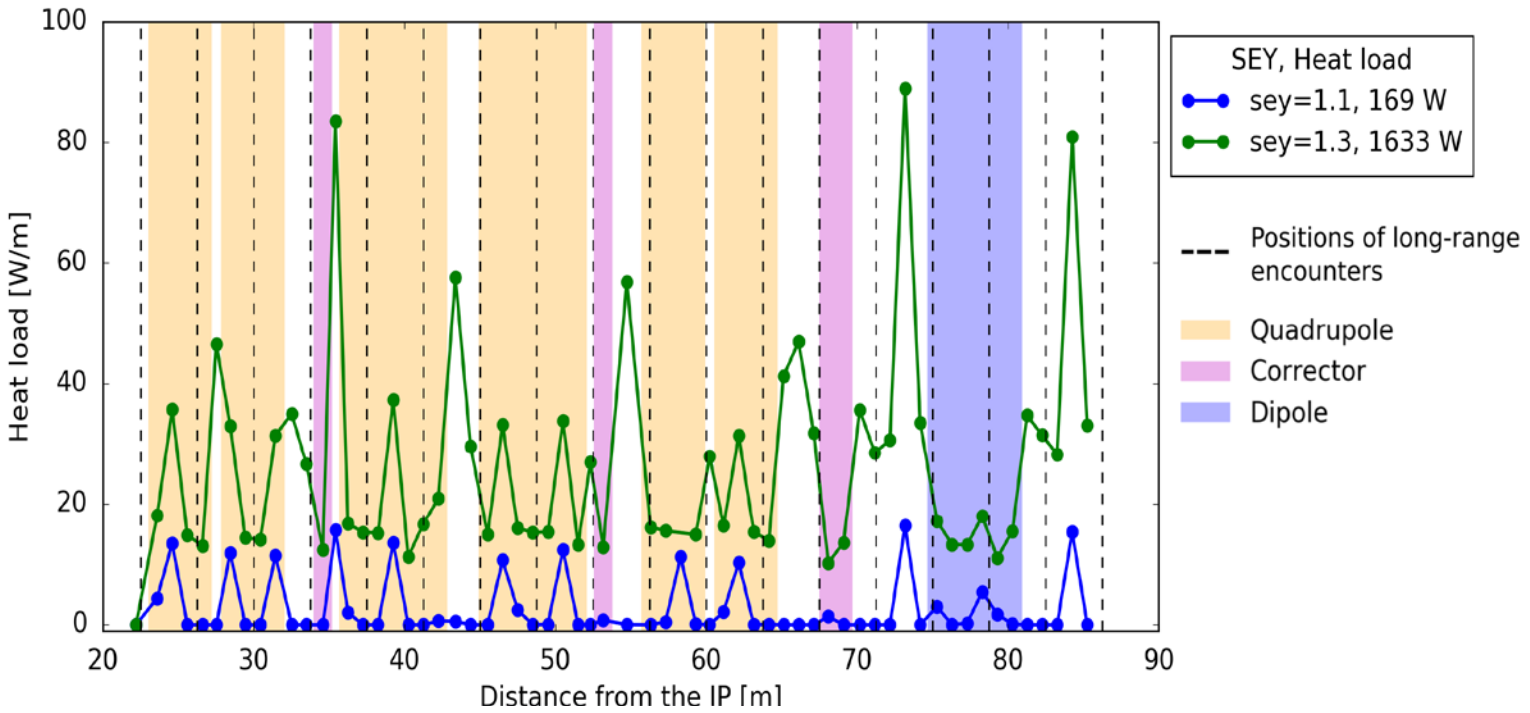
Main simulation parameters

- Beam parameters: 7 TeV, 2.2e11 p/bunch, 25 ns bunch spacing
- HL-LHC v1.2 optics
- Two counter-rotating beams: simulate different slices along triplet to account for arrival times, beam sizes and position of each beam
- SEY scan: 1.0 - 1.6
- Uncoated drifts simulated with SEY = 1.3



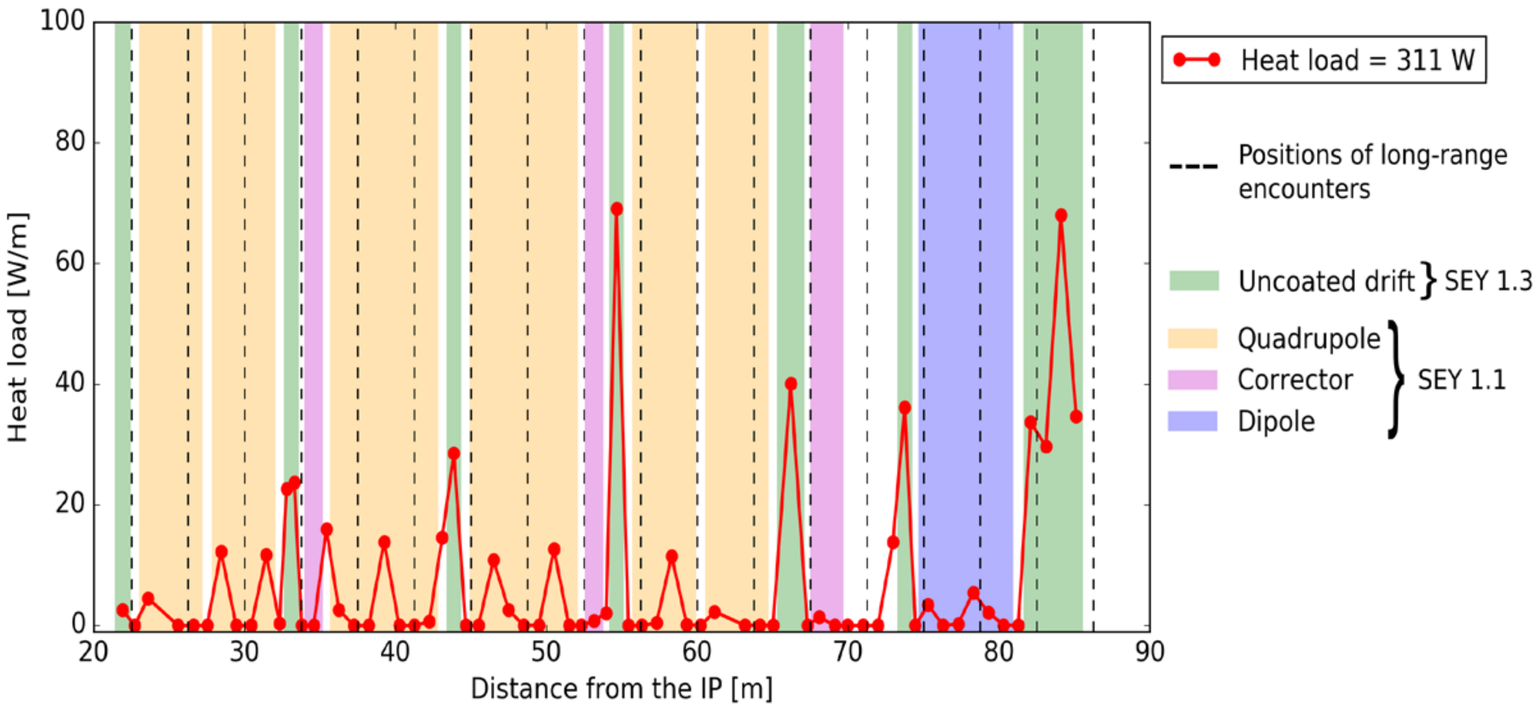
Uncoated drifts, SEY 1.3

Heat load in IR1&5: uniform SEY



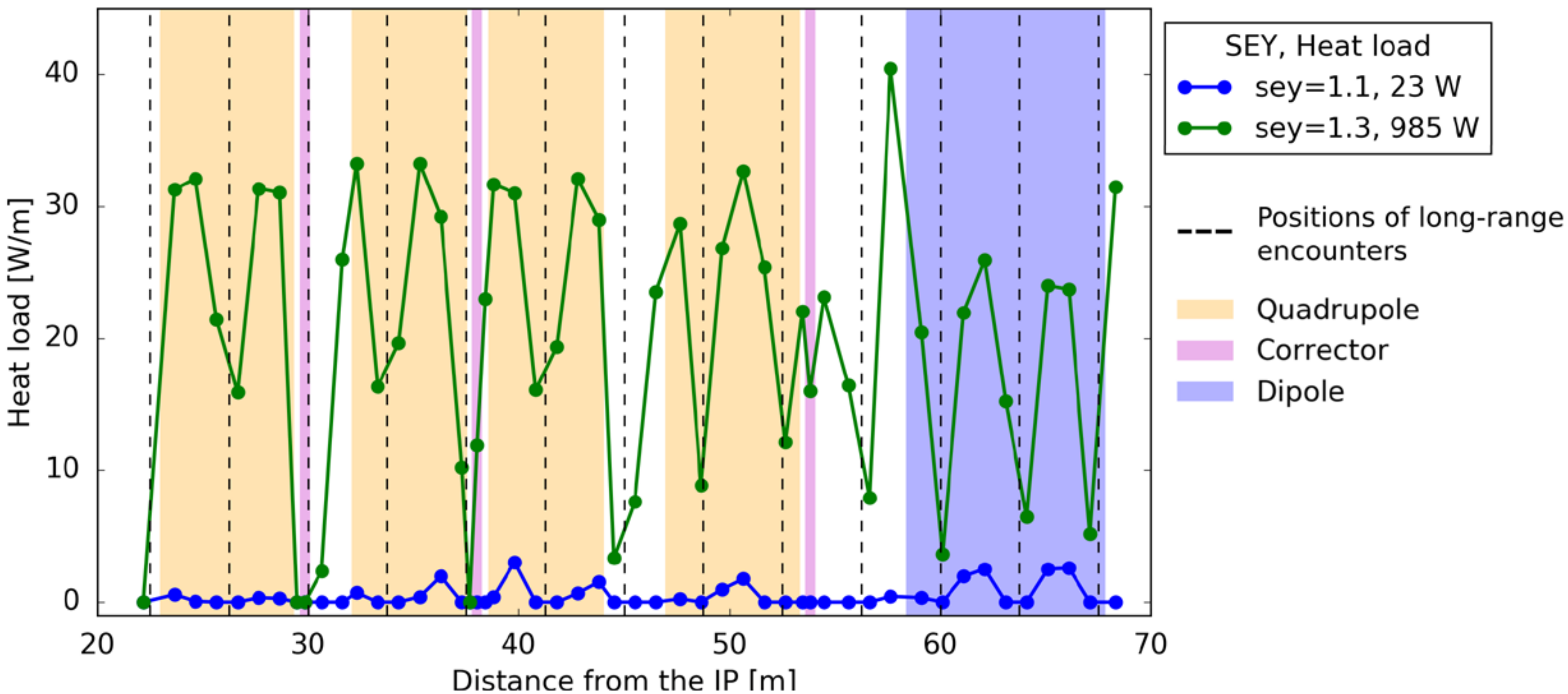
- If the whole inner triplet IR1&5 uncoated (SEY 1.3) heat load is an order of magnitude higher than in fully-coated case (SEY 1.1)
- Maximum heat load at locations between long-range encounters (beams not synchronized)

Heat load in IR1&5: uncoated drifts



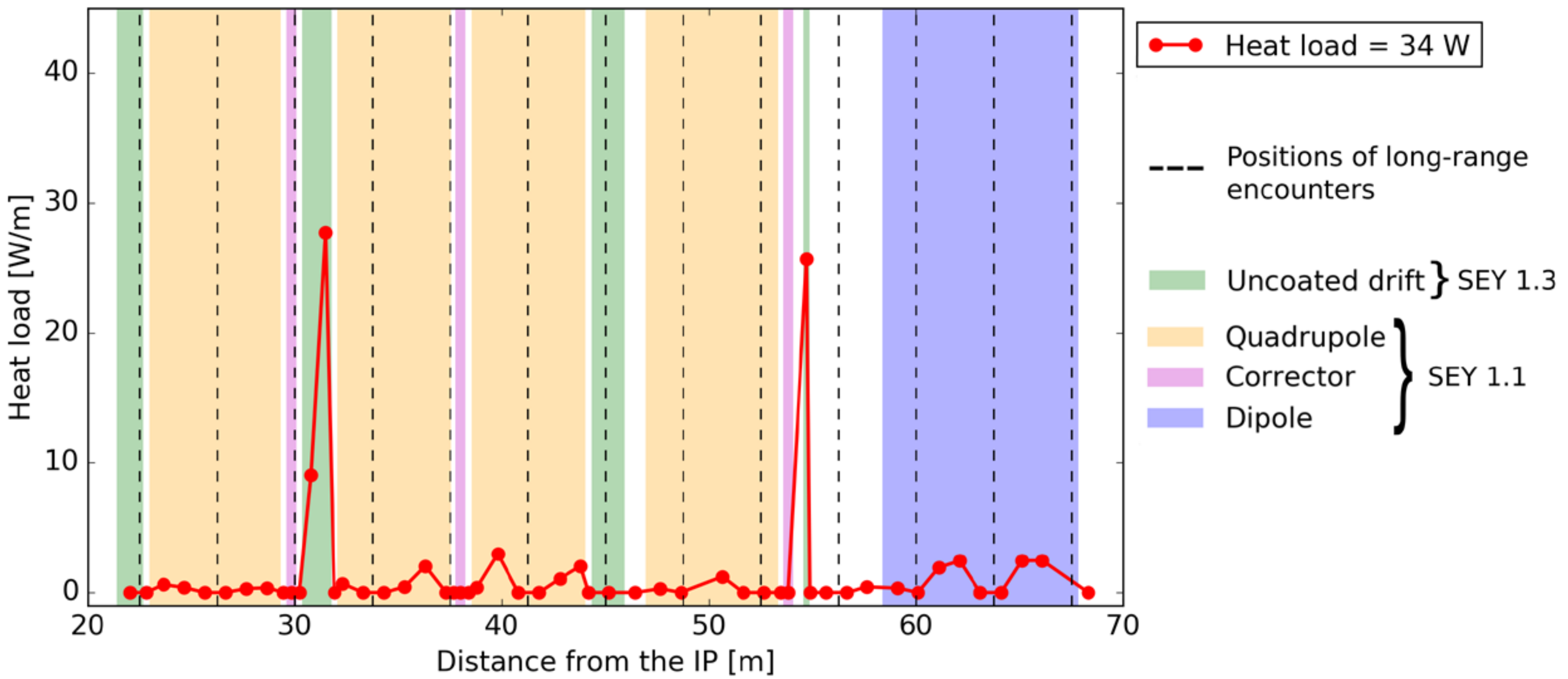
- If only the drifts outside cold masses are uncoated (SEY 1.3) and the rest of the region is coated (SEY 1.1) heat load is reduced from 1600 W to 311 W
- Contribution to the **total heat load from uncoated drifts is 265 W**

Heat load in IR2&8: uniform SEY



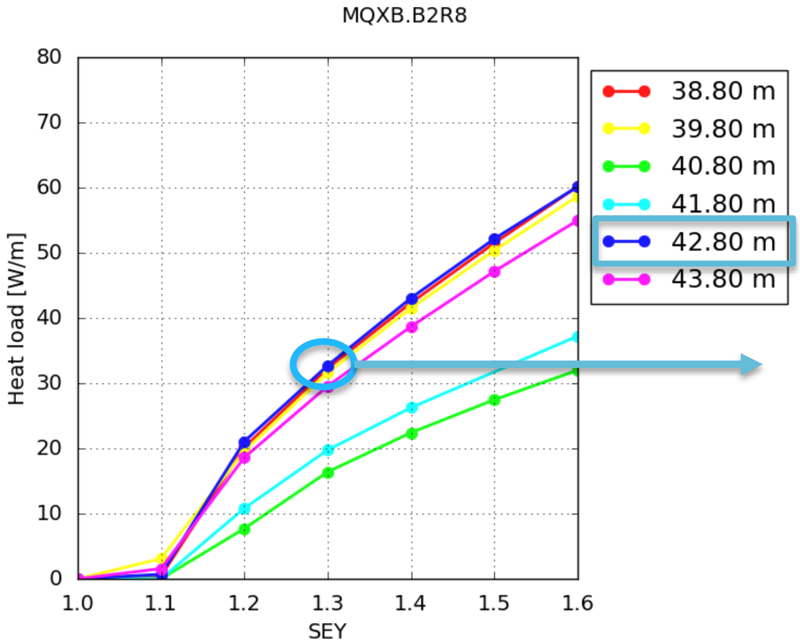
- If the whole inner triplet IR2&8 uncoated (SEY 1.3) heat load is more than one order of magnitude higher than in fully-coated case (SEY 1.1)
- Maximum heat load at the locations between long-range encounters (beams not synchronized)

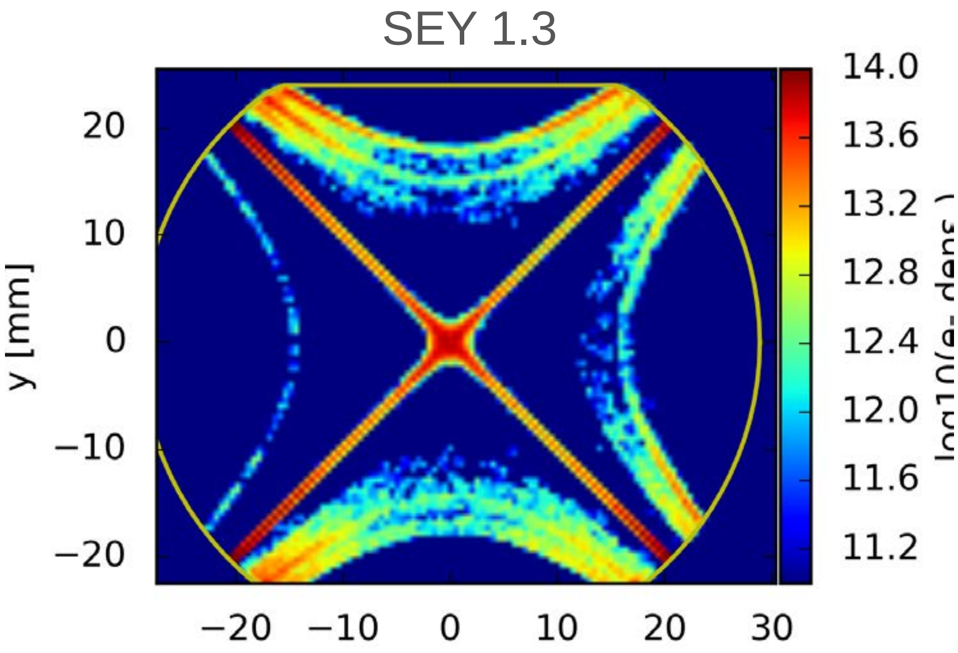
Heat load in IR2&8 : uncoated drifts



- If only the drifts outside cold masses are uncoated (SEY 1.3) and the rest of the region is (SEY 1.1) heat load is reduced from 950 W to 34 W
- Contribution to the total heat load from uncoated drifts is **31 W**

e-cloud in a IR8 quadrupole magnet

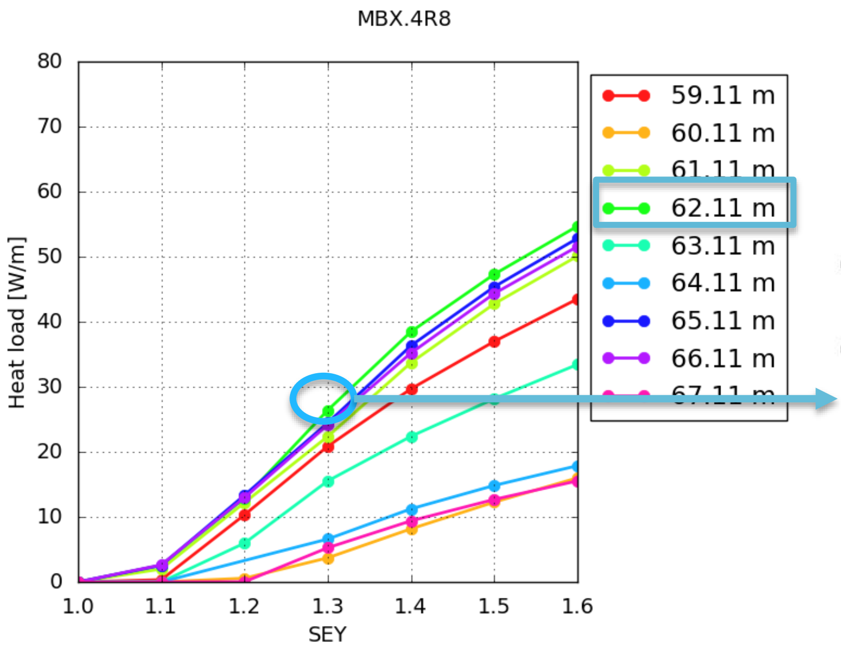


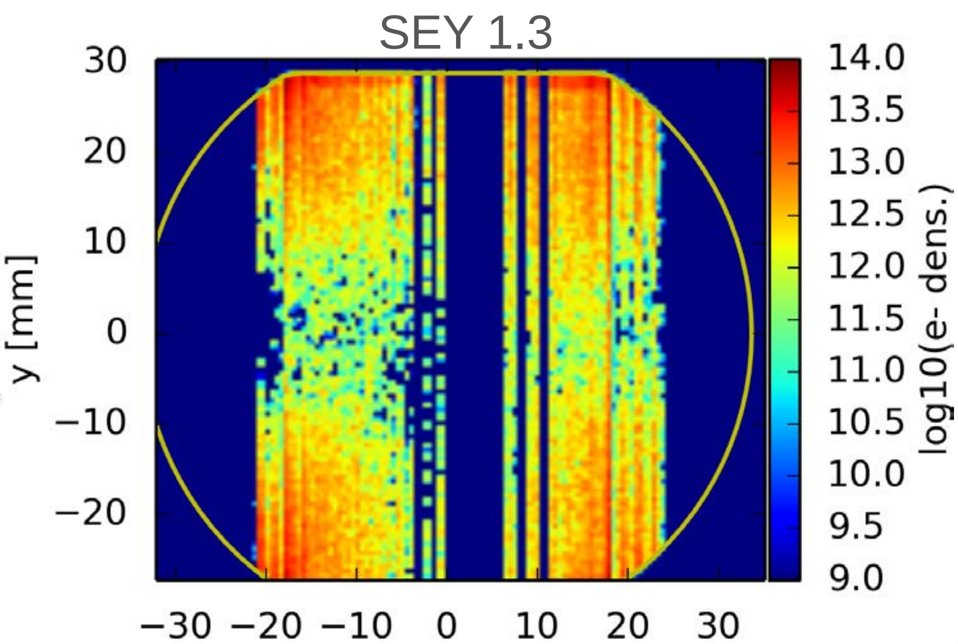


see video here

- Heat load at different longitudinal positions along the quadrupole (different delay): highest heat load at the position in between two long range encounters
- Electron distribution is mainly concentrated along the pole-to-pole lines
- Some electrons are trapped along the field lines

e-cloud in a IR8 dipole magnet

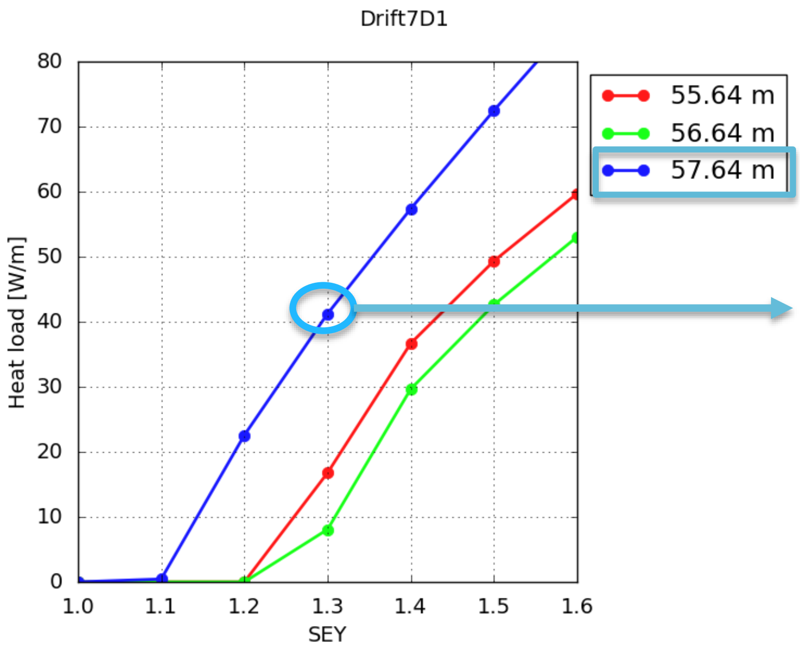


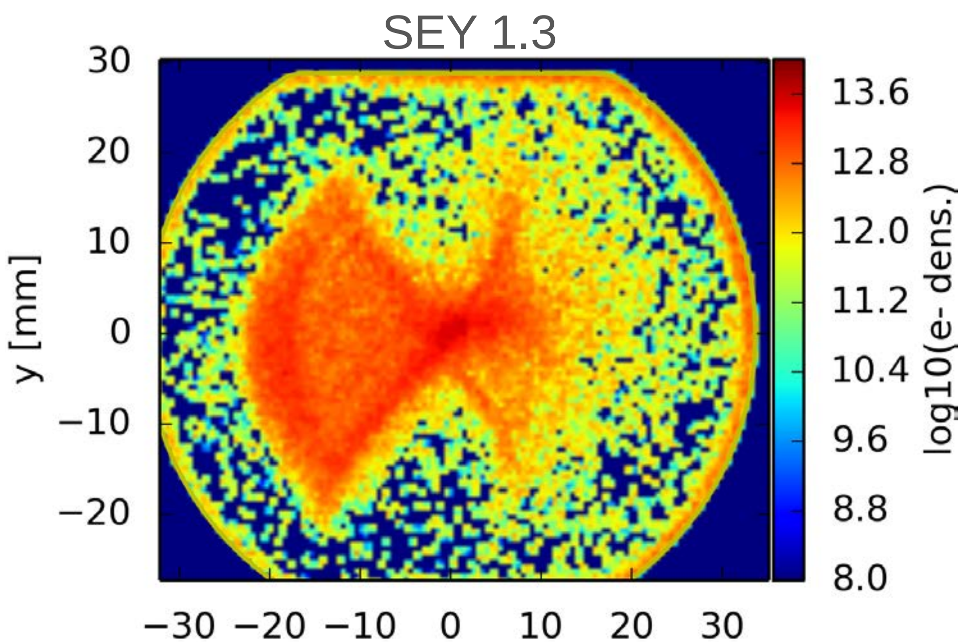


see video here

- Heat load at different longitudinal positions along the dipole (different delay): highest heat load at the position in between two long range encounters
- Electrons are located along the field lines

e-cloud in a IR8 drift

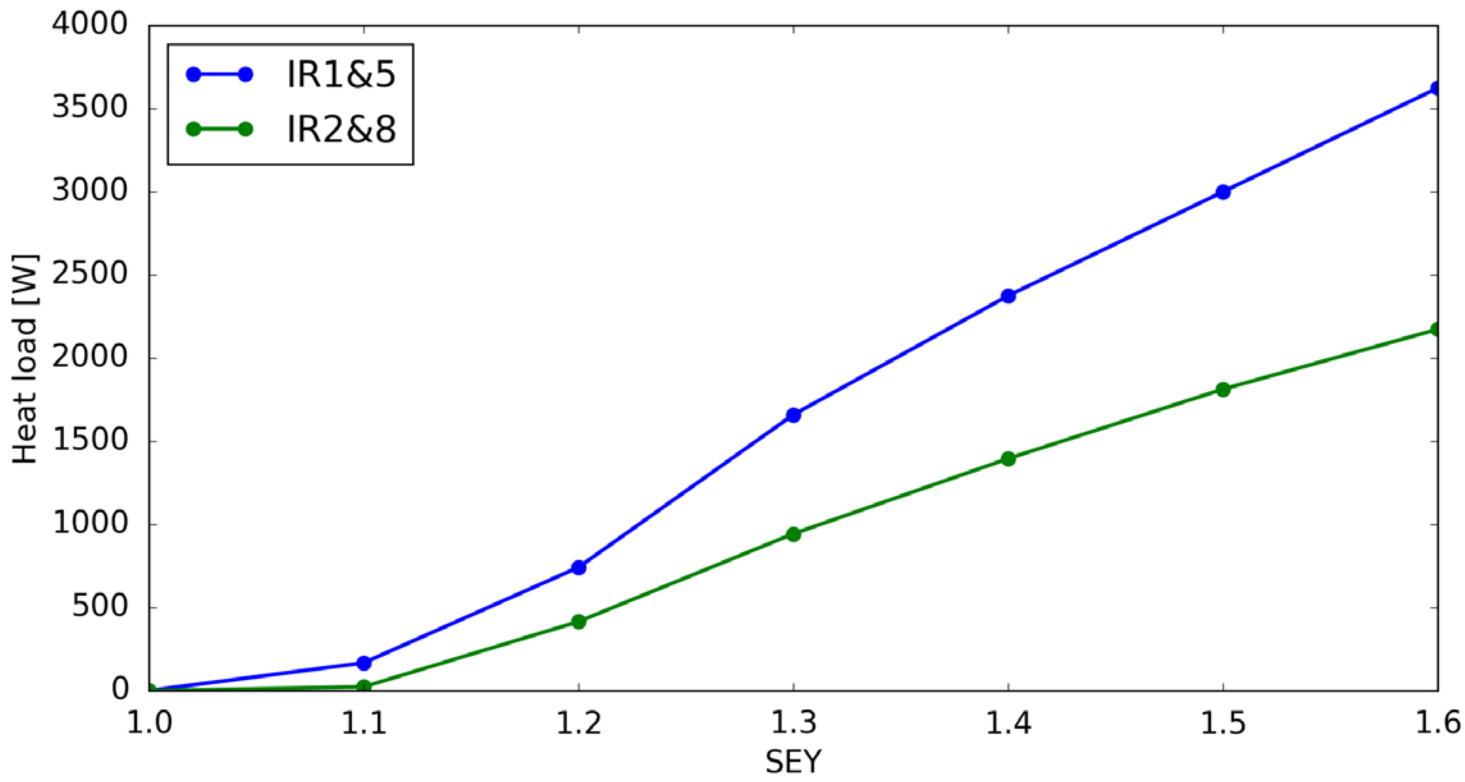




see video here

- Heat load at different longitudinal positions along the dipole (different delay): highest heat load at the position in between two long range encounters
- Electrons in the chamber get the kick from the passing beams and impact the walls

Total heat loads: IR1&5 vs IR2&8

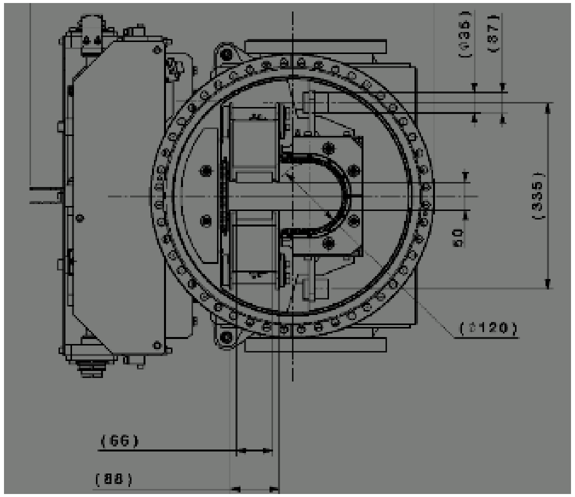


- Heat load in IR1&5 is much higher than in IR2&8
- In case of fully coated inner triplets (from SEY 1.3 to SEY 1.1) heat load can be reduced by order of magnitude

e-cloud simulations in TDIS

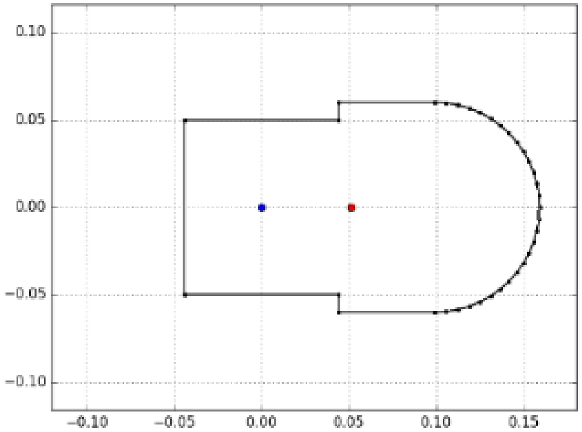
We performed a first series of simulations to identify possible critical points:

- Assumed uniform SEY for the whole profile
- SEY=1.4-1.5 (Cu-like) can be considered as a worst case scenario
- We assume that no high SEY surfaces (e.g. aluminum) are exposed to the beam



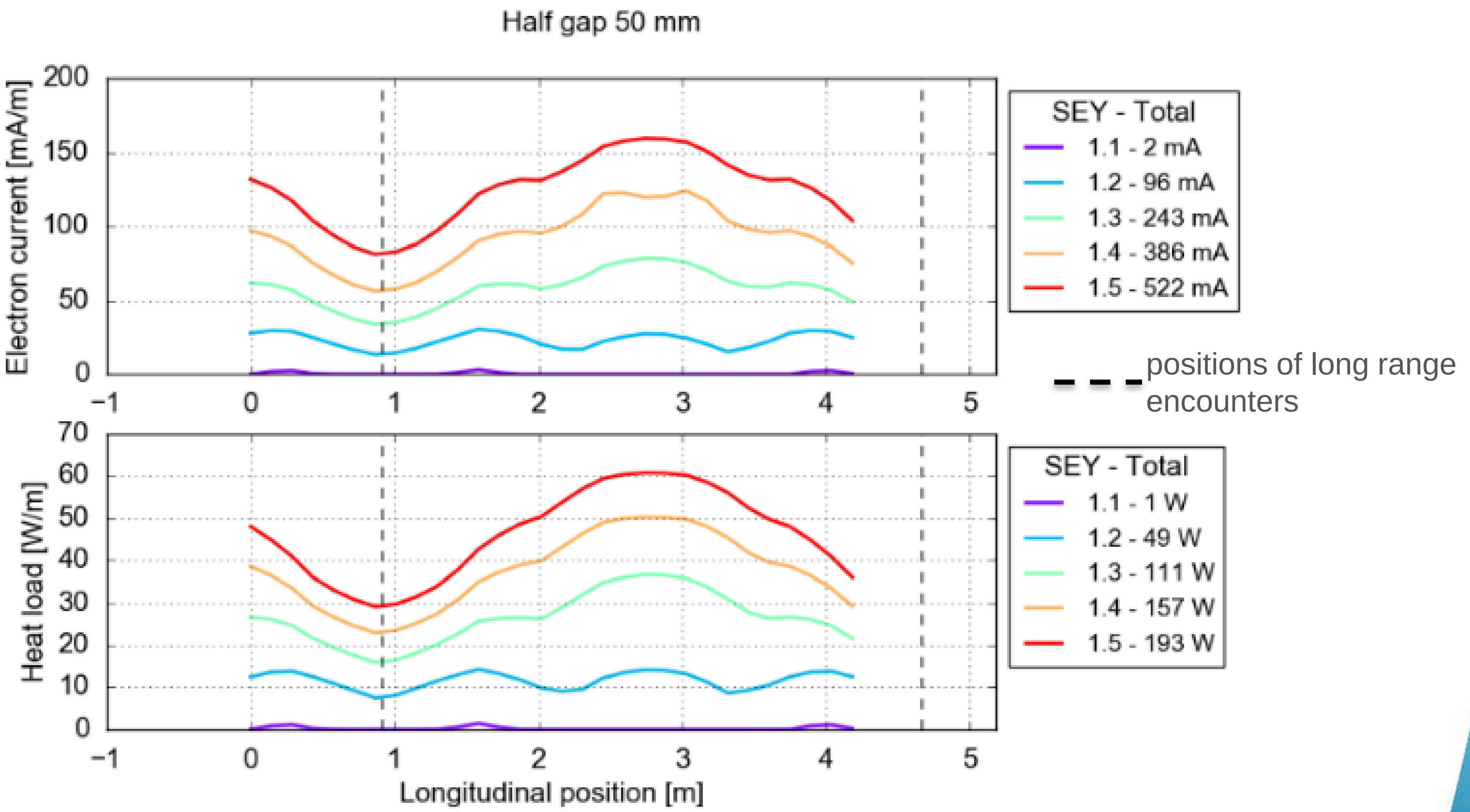
Main simulation parameters

- Beam parameters: 450 GeV, 2.2e11 p/bunch, 25 ns bunch spacing
- HL-LHC v1.2 optics
- Two counter-rotating beams: simulate different slices along TDIS to account for arrival times, beam sizes and position of each beam
- Half-gap scan: 1 - 50 mm
- SEY scan: 1.0 - 1.6



TDIS: longitudinal current/heat profiles

- Multipacting is stronger at the positions where the two beams are not synchronized (12.5 ns equivalent spacing)



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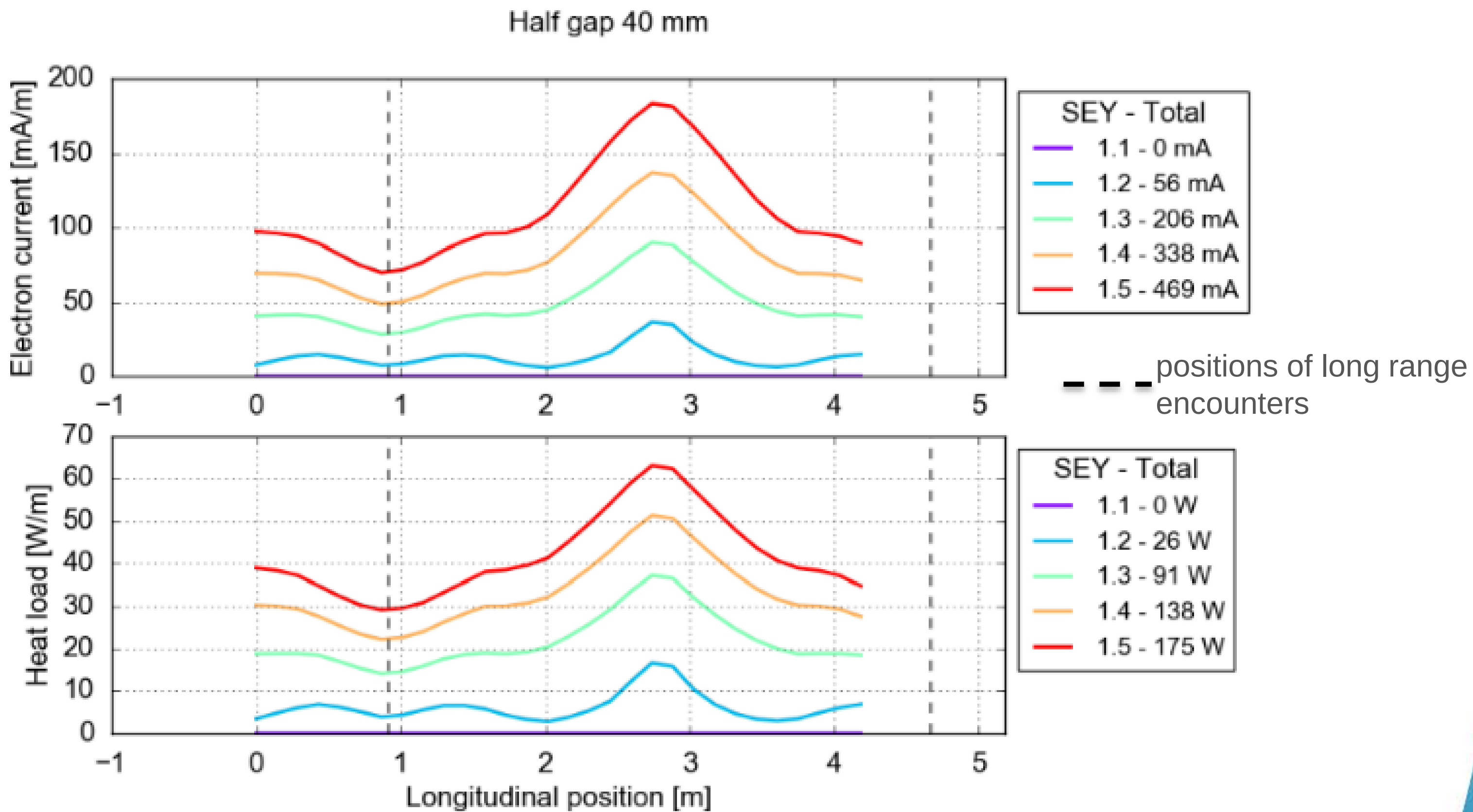

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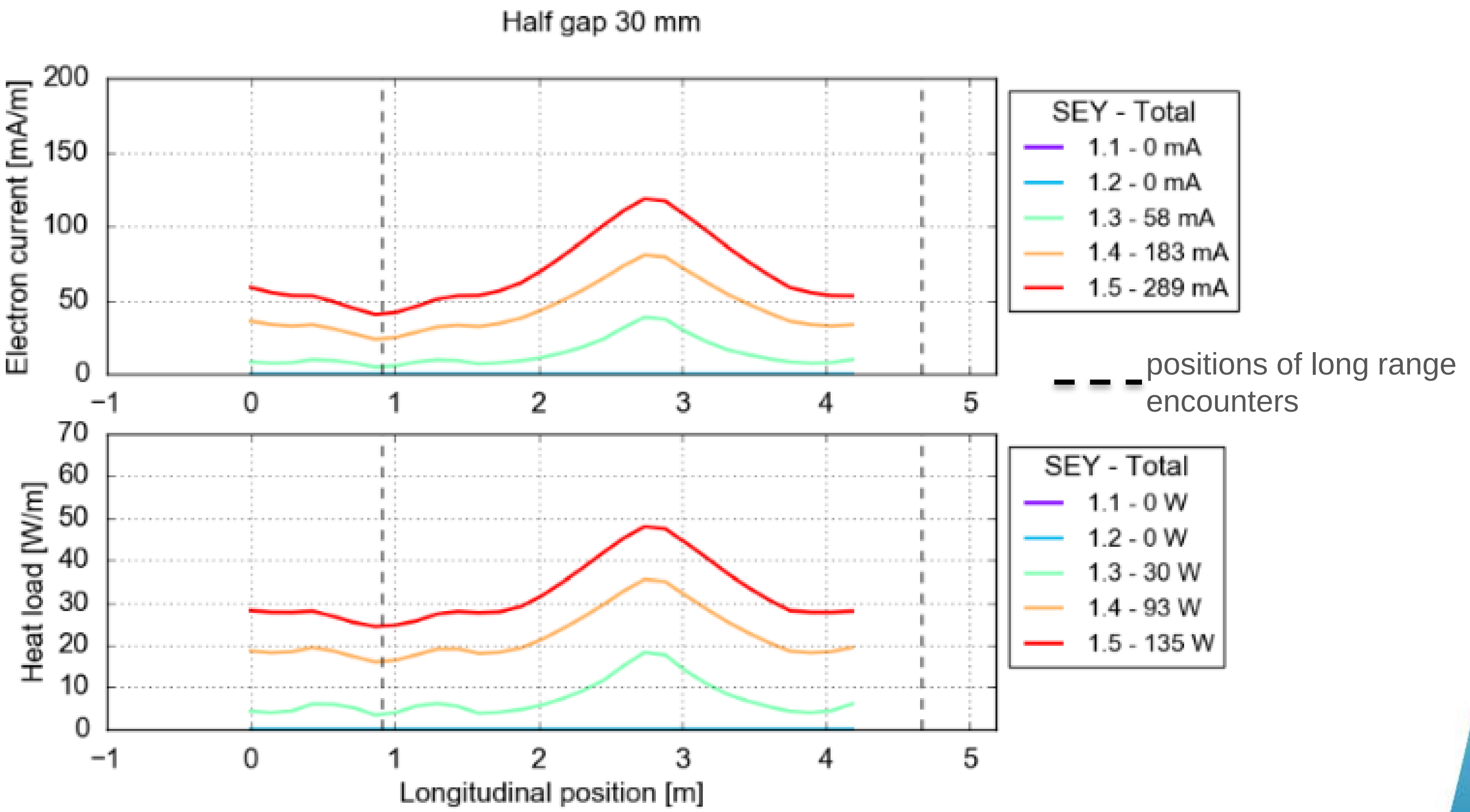

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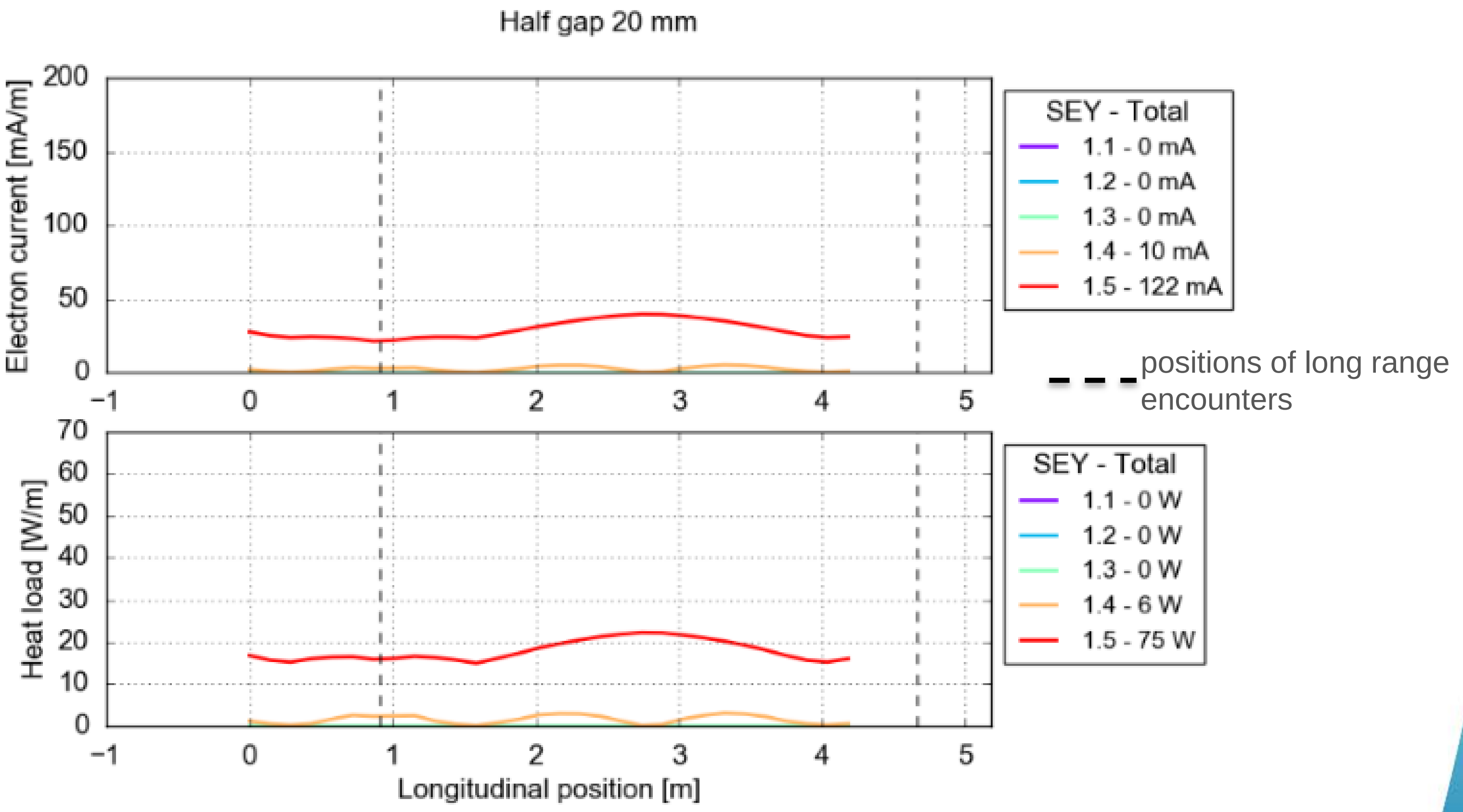

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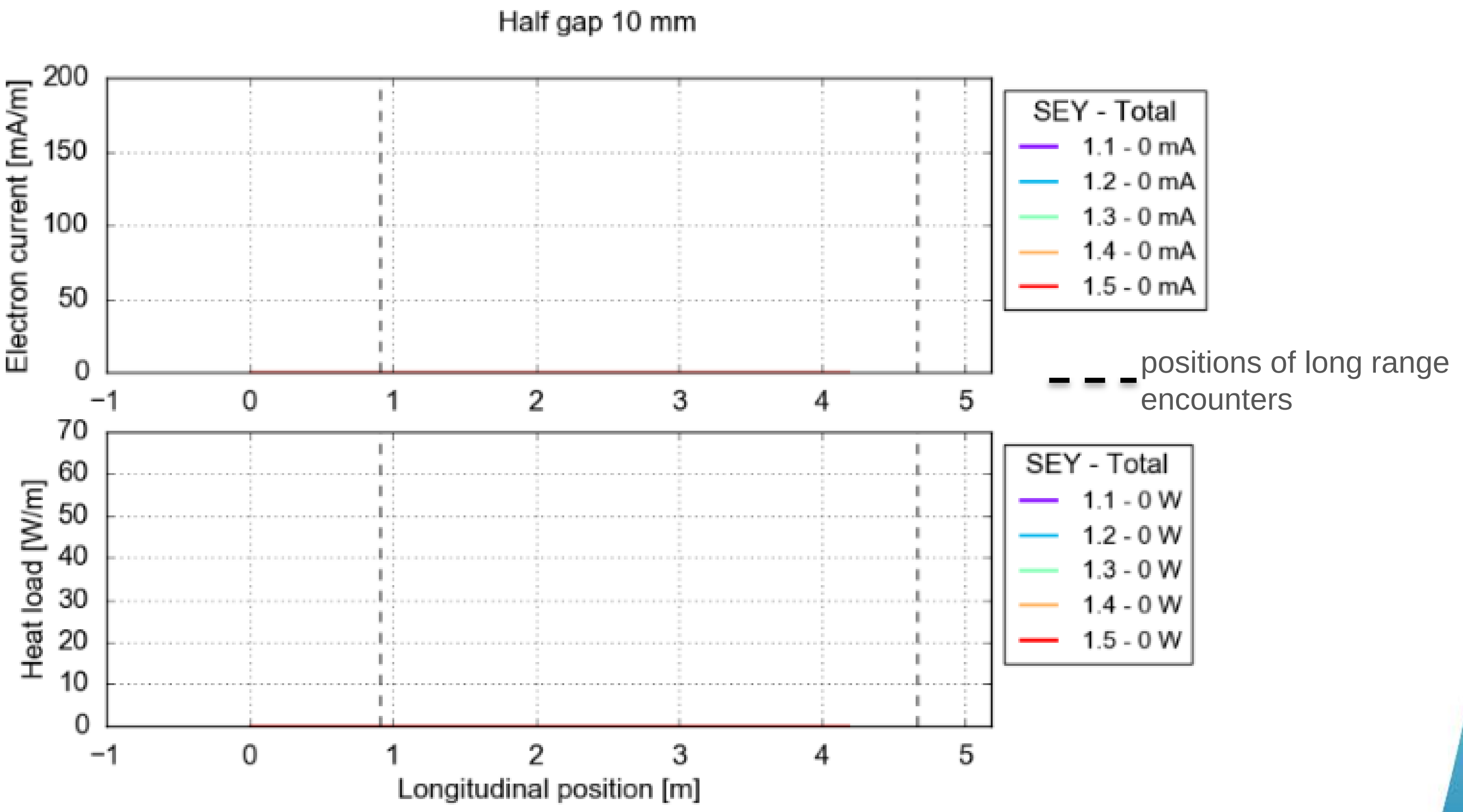

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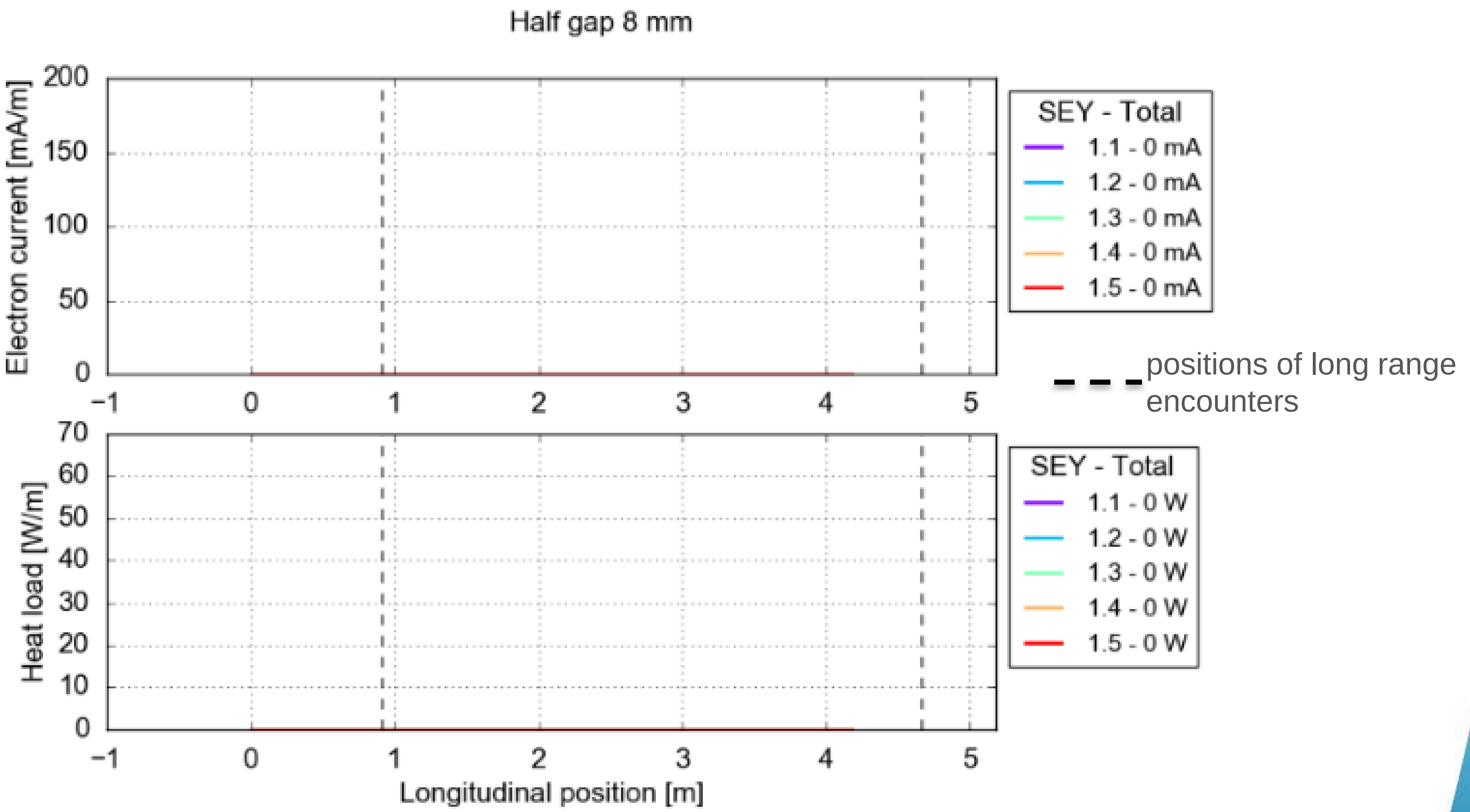

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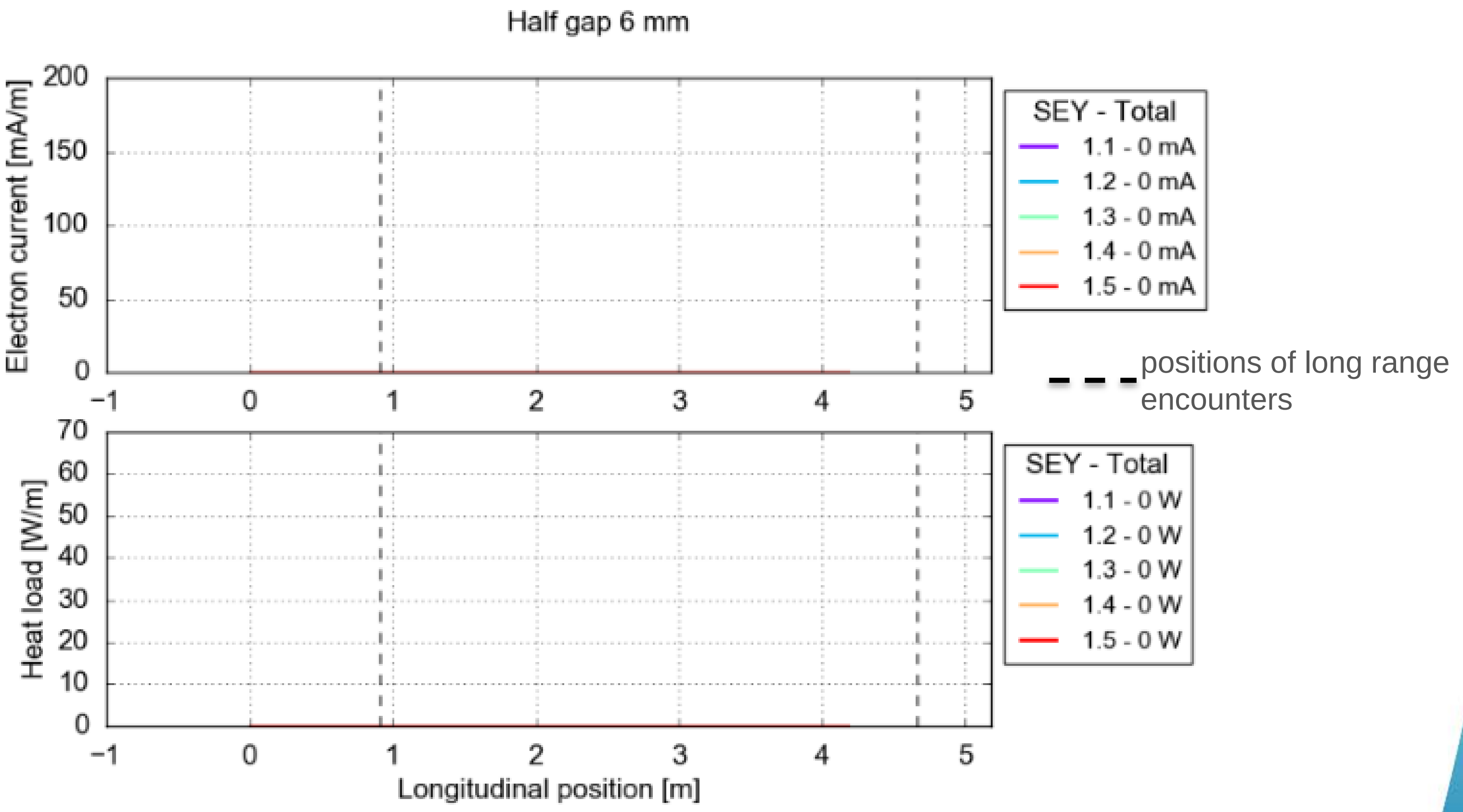

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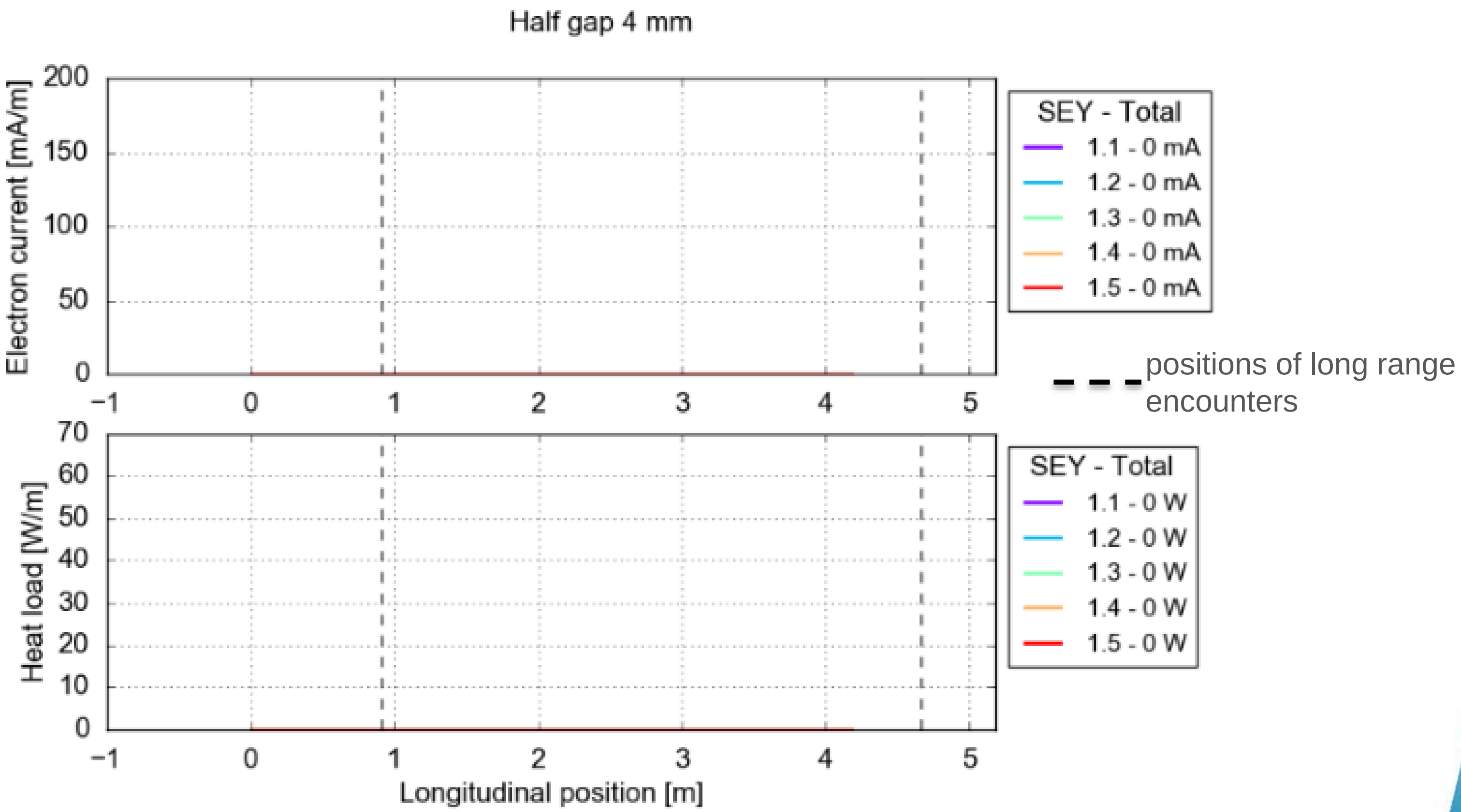
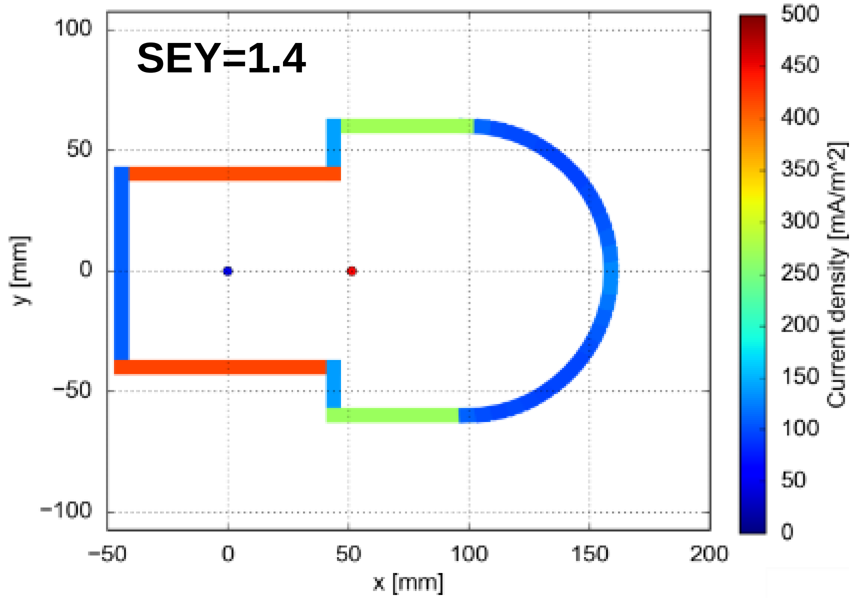
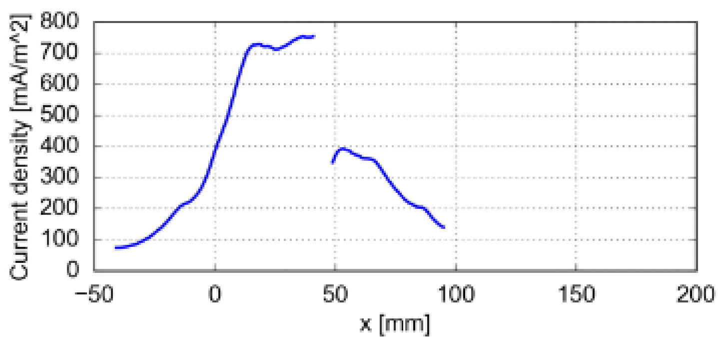


TDIS: electron flux on the different surfaces



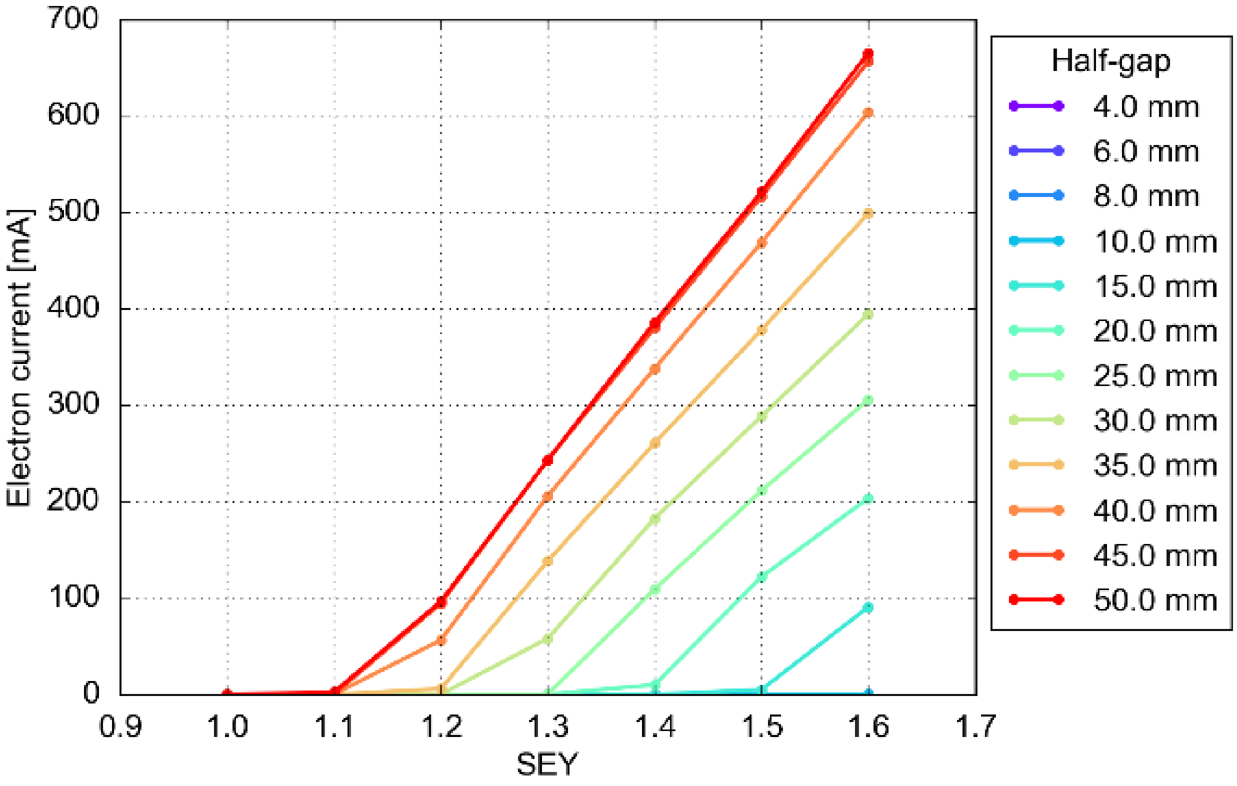
Section in between two long range encounters



- At large gaps e-cloud starts to buildup on the surface of the jaws and on the flat parts of the beam screen

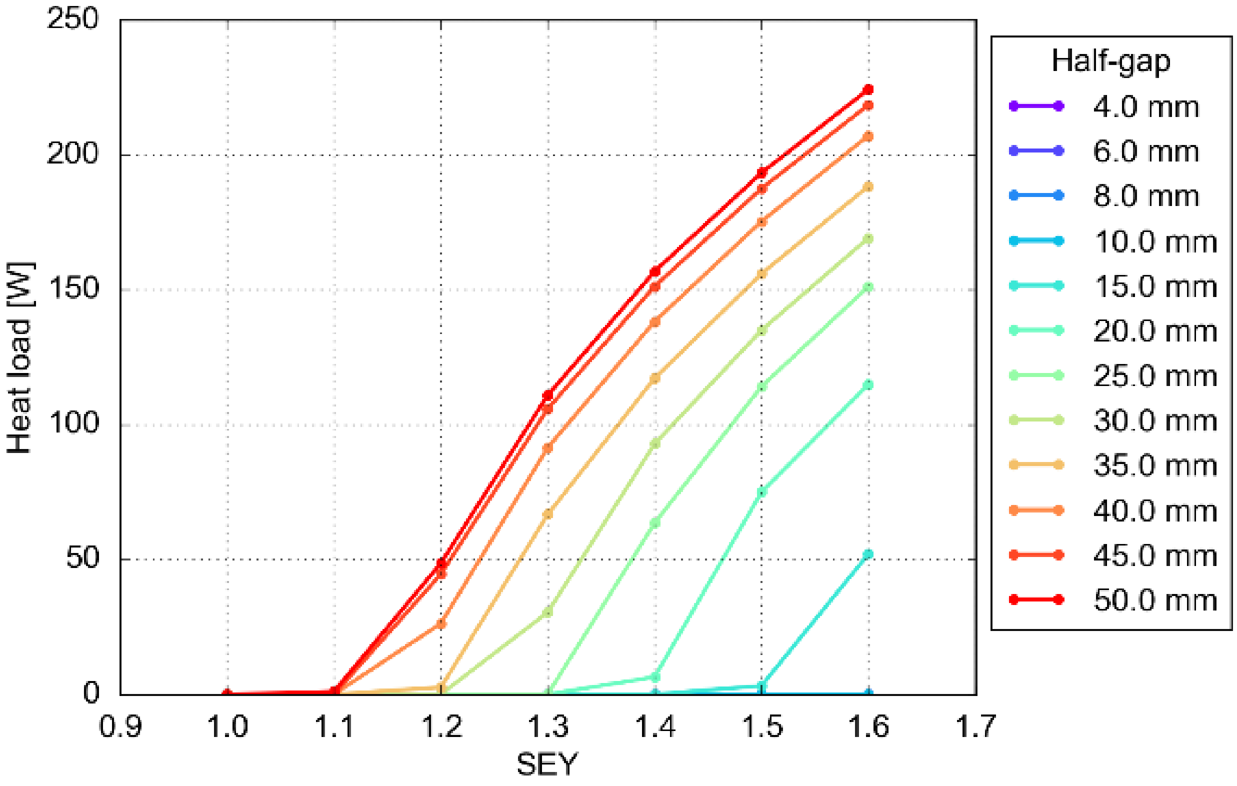
TDIS: total electron flux

- Electron flux on the walls increases for large gaps
- Multipacting threshold very high for small gaps and decreasing when the jaws are opened
- Situation tends to saturate for half-gaps larger than 40 mm



TDIS: heat deposition from the e-cloud

- Even for the worst half-gap (50 mm) and for high SEY the heat load on the whole device does not reach 250 W



Summary

We simulated the e-cloud in the presence of both beams in the Inner triplet and TDIS assuming:

- SEY scan: 1.0-1.6. Uncoated drifts in inner triplets
- Uniform SEY scan: 1.0-1.6. Gap scan in TDIS

In Inner Triplets:

- Heat load is more than an order of magnitude higher for the uncoated case (SEY 1.3) than for the fully coated (SEY 1.1)
  - IR1&5: reduced from 1633 W t o169 W
  - IR2&8: reduced from 943 W to 23W
- If only drifts outside cold masses are uncoated (SEY 1.3):
  - IR1&5 heat load is 311 W where 265 W is the contribution of the uncoated drifts
  - IR2&8 heat load is 34 W where 30 W is the contribution of the uncoated drifts
- Heat load in IR1&8 is much higher than in IR 2&8

In TDIS:

- Electron flux on the walls increases for large gaps:
  - e-cloud builds up mainly from the surface of the jaws and on the flat parts of the beam screen
  - Multipacting threshold very high for small gaps and decreasing when the jaws are opened
  - Electron flux and heat-load tend to saturate for half-gaps larger than 40 mm
- Heat load from e-cloud on the whole device does not reach 250 W even for large gaps