Electron cloud estimates in the HL-LHC triplets/D1

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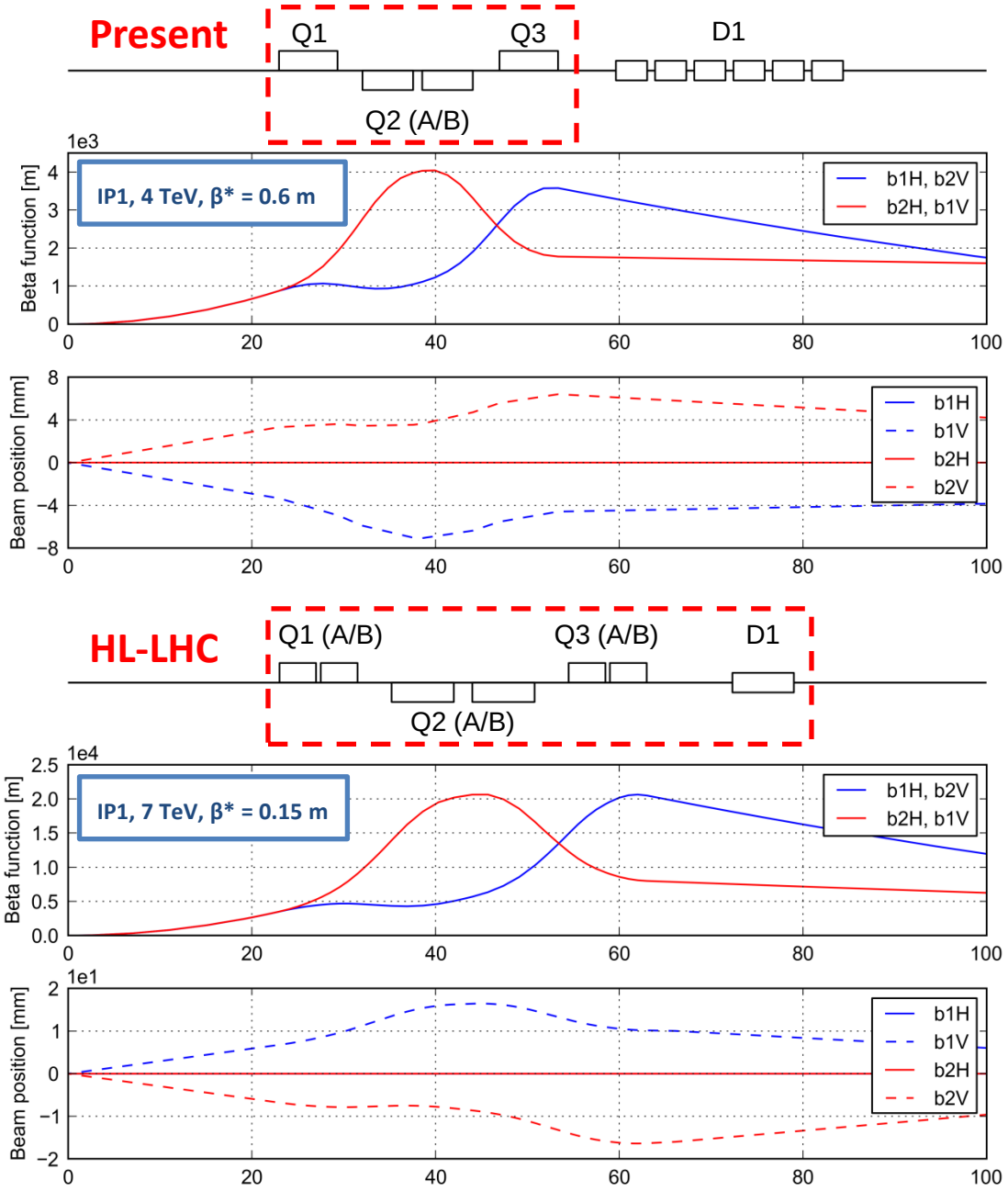
Outline

- **Introduction: the HL-LHC triplets/D1 in IP1 (IP5)**
- **Electron cloud effects in the HL-LHC inner triplets for IP1 and IP5**
  - Simulation results
  - Comparison with present triplets and mitigation
- **IP2 and IP8 triplets: observations and scaling**
- **Conclusions**

Inner triplets for HL-LHC upgrade



HL-LHC triplets in IP1 (IP5)

Main differences between present and HL-LHC (with potential impact on integrated effect of e-cloud)

→ Total length of triplets (IP1 and IP5): about 25% more quadrupole length

→ D1 sharing the same cooling circuits

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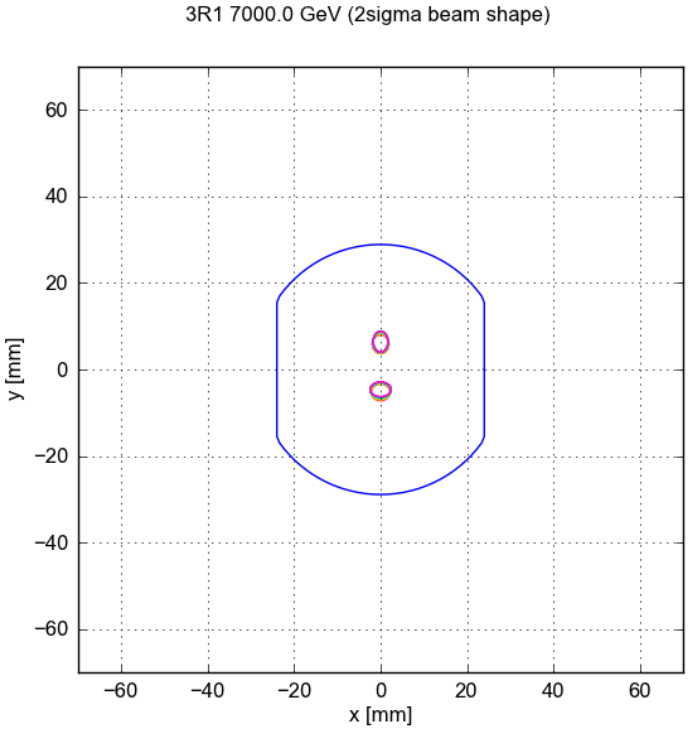

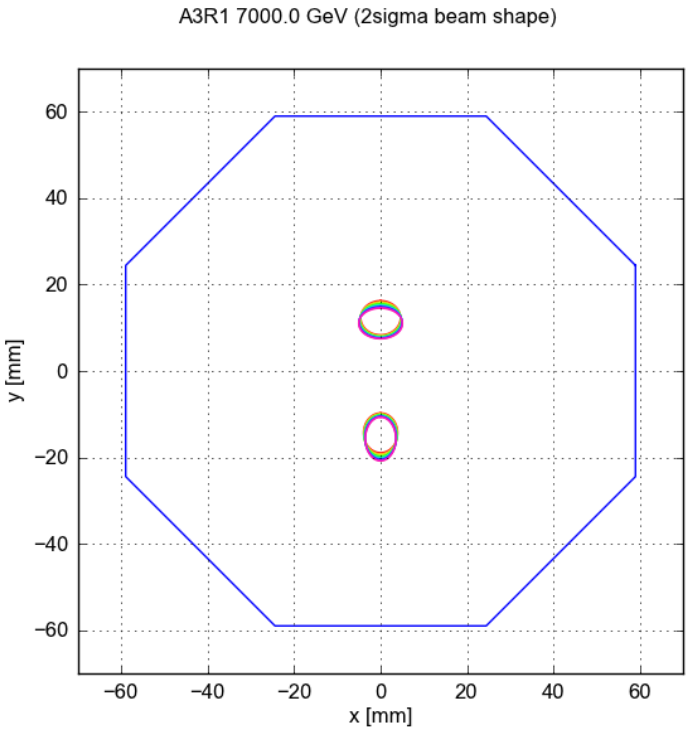

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→ Shape and size of the beam screen

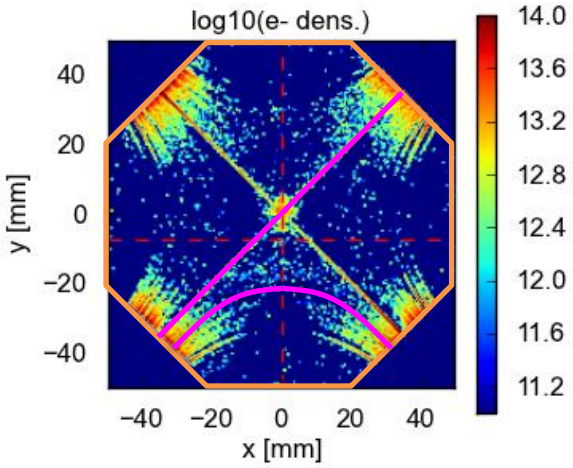
→ Beta functions (up to a factor 50) and beam positions (up to a factor 2)

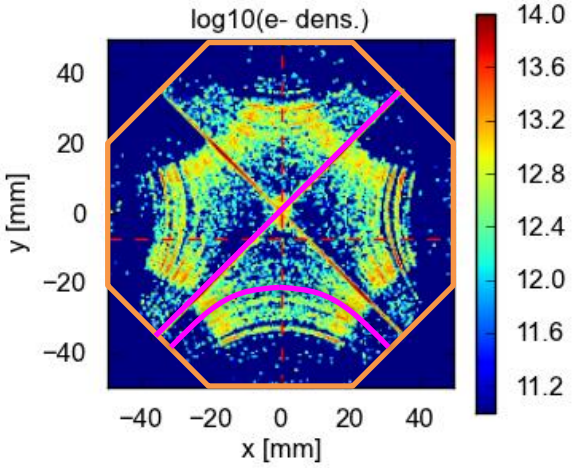
→ Bunch population (HL-LHC: 2.2 x 10^{11} ppb, nominal LHC: 1.15 x 10^{11} ppb)

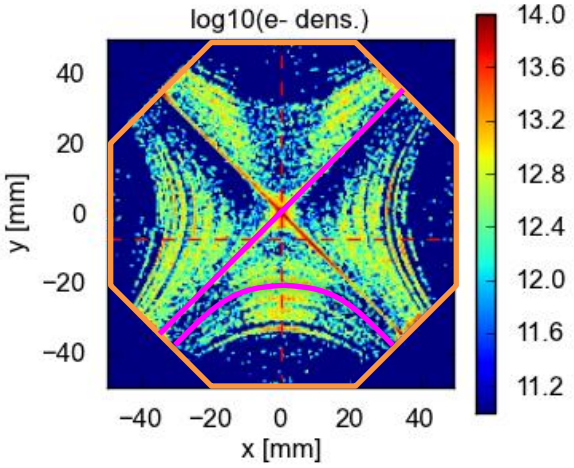
A look to the EC buildup in the quads

Few snapshots of the **electron distribution** → HL-LHC triplets develop thicker stripes along field lines farther from the center of the chamber

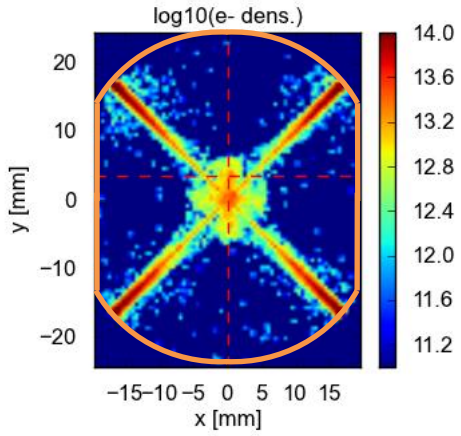
HL-LHC (2.20 x 10^{11} ppb)

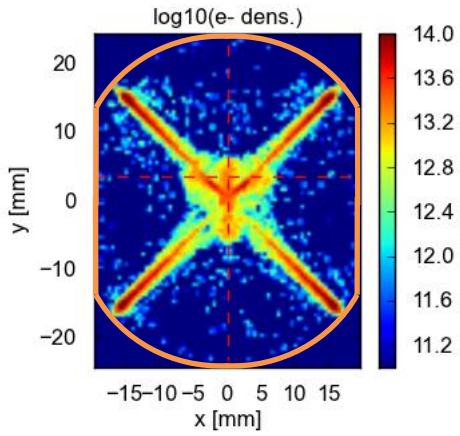


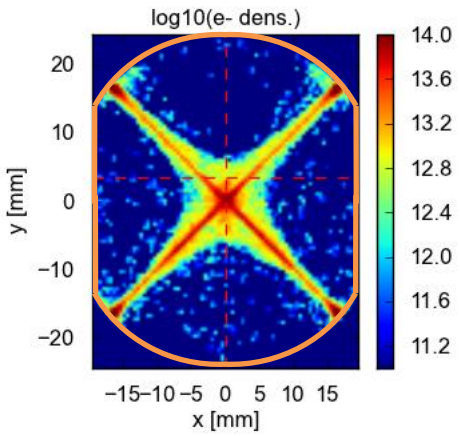




Present (1.15 x 10^{11} ppb)







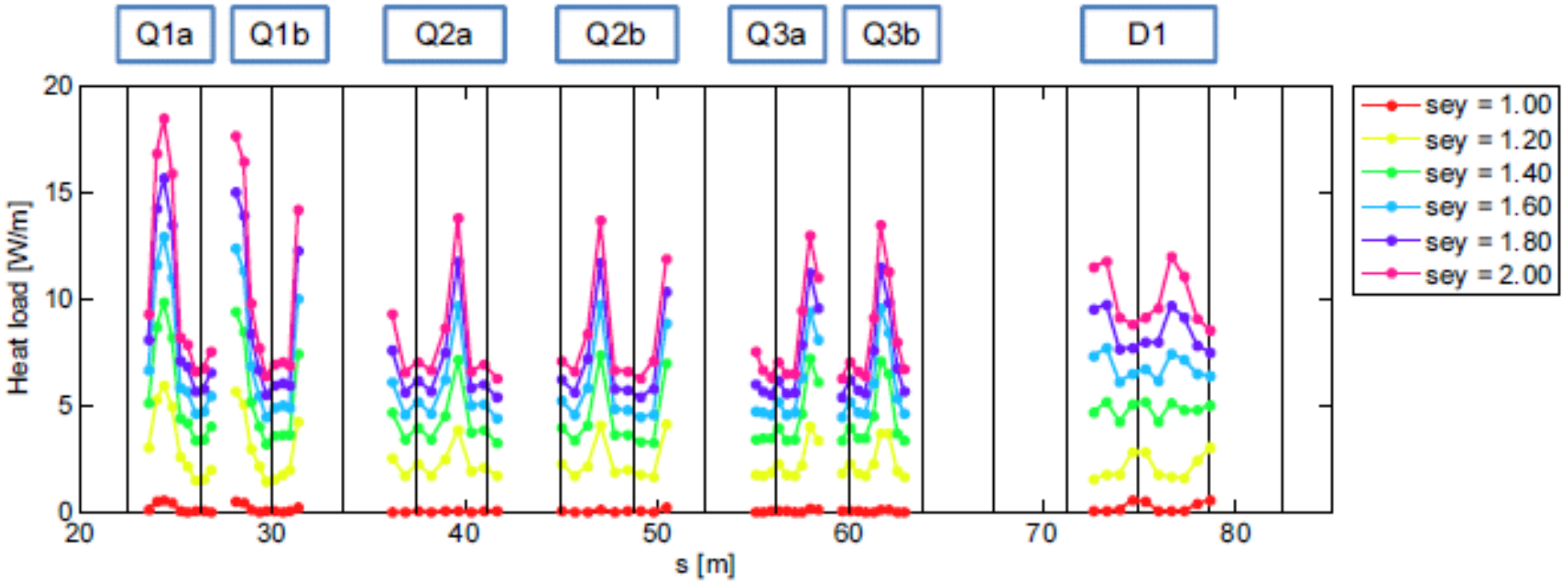
Distribution of heat load – HL-LHC triplets

Heat load distribution along HL-LHC triplets + D1

→ Build up more or less efficient at different locations mainly due to the different hybrid bunch spacings

→ The least efficient build up, i.e. lower heat load, at the locations of the long-range encounters (vertical dashed lines)

→ Values in D1 are comparable or higher than values in the quads

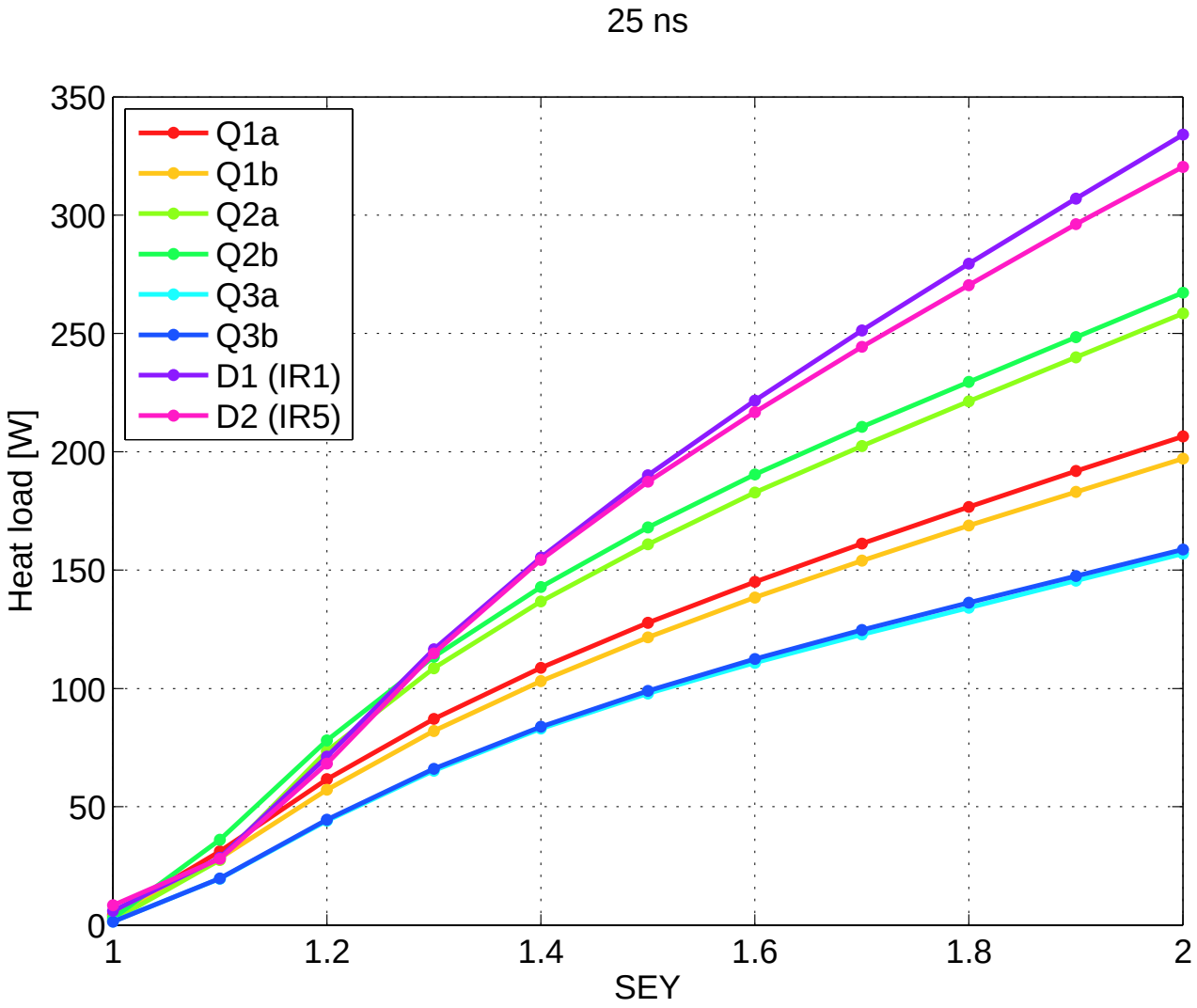


Total heat load per element – HL-LHC triplets

Total heat load per element in HL-LHC triplets + D1

→ Similar thresholds for quads and D1

→ Values in D1 higher than values in the quads for high SEY values



Total heat load on the triplet beam screen

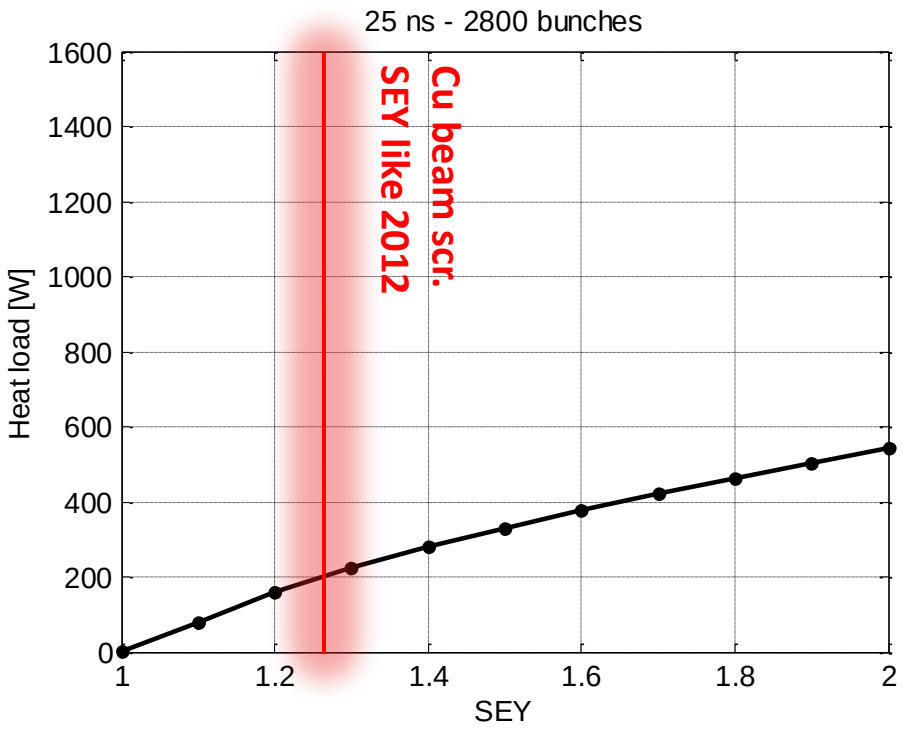
Effect of larger bunch population and chamber size. For the **same SEY**:

- Similar energy, but significantly larger number, of impacting electrons

⇒ Total **heat load about x2-3 larger**

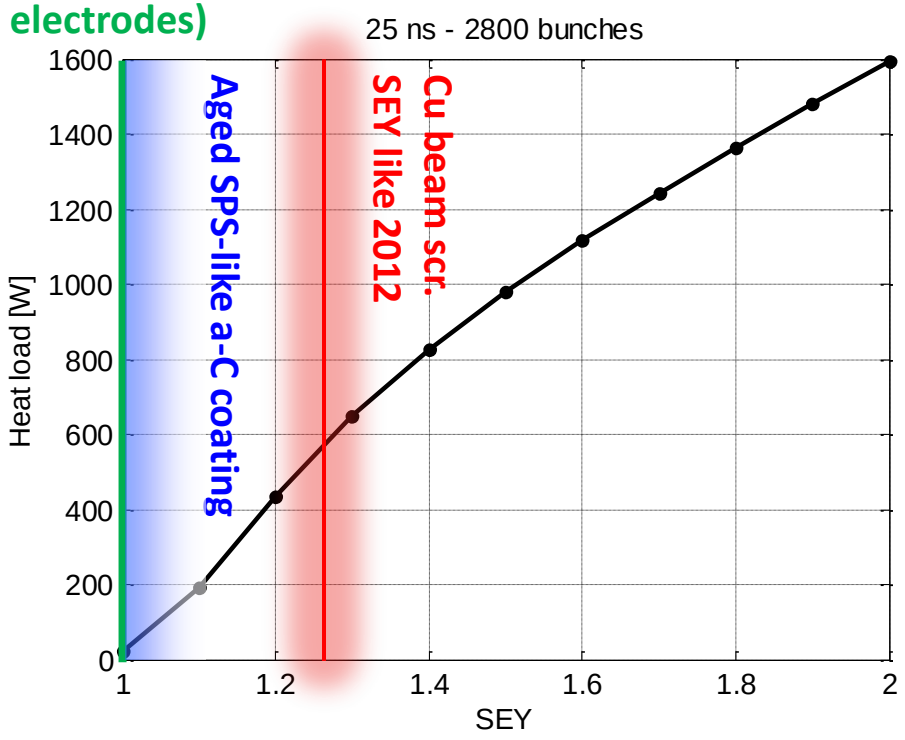
E-cloud suppression can be obtained using **low SEY coatings (studies already ongoing → COLDEX)** and/or **clearing electrodes (low impedance design needed)**

Present triplets
(1.15 x 10^{11} ppb)

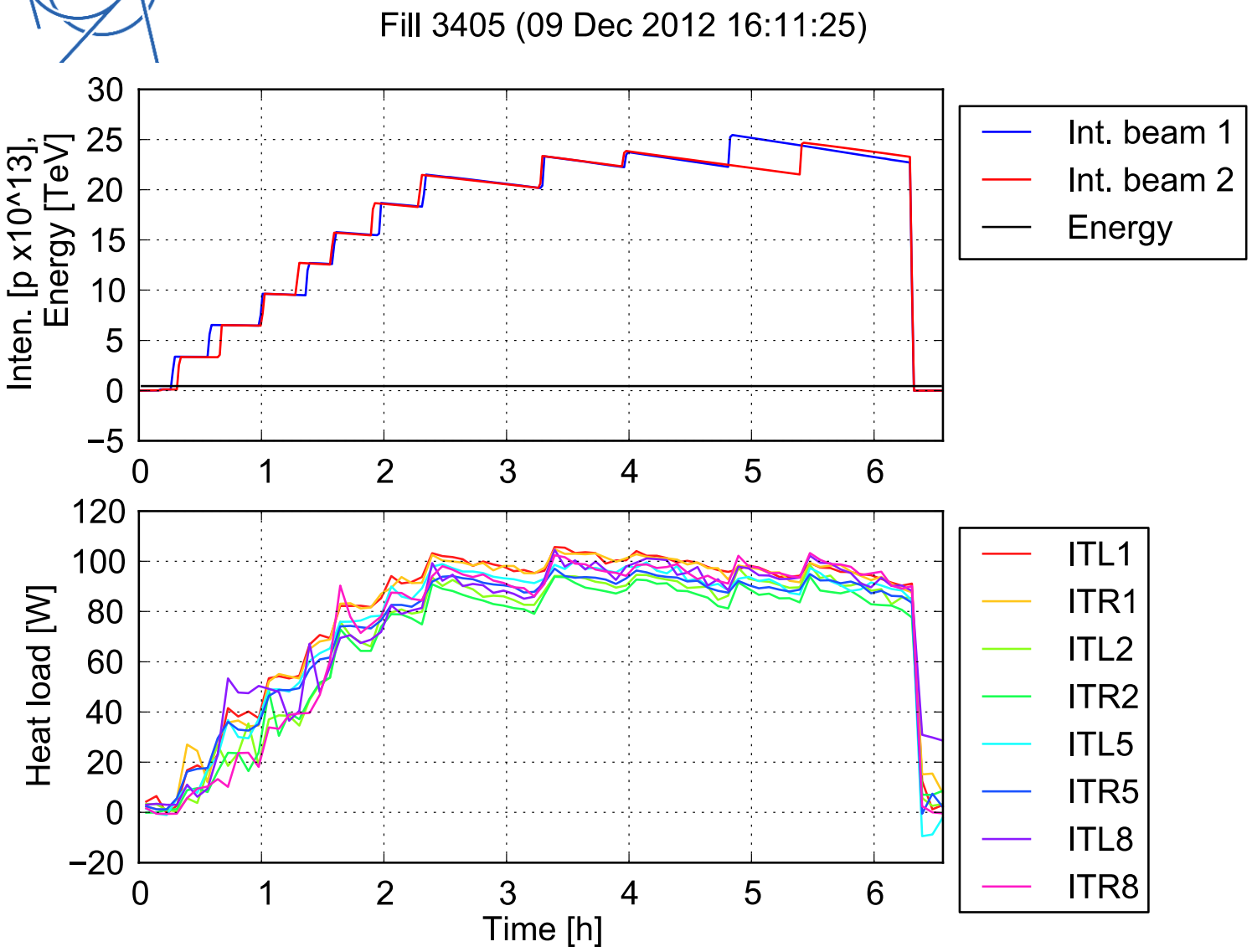


Full suppression (SEY≈1 or clearing electrodes)

HL-LHC triplets
(2.20 x 10^{11} ppb)



Measured heat load (25ns) – IP2 and IP8



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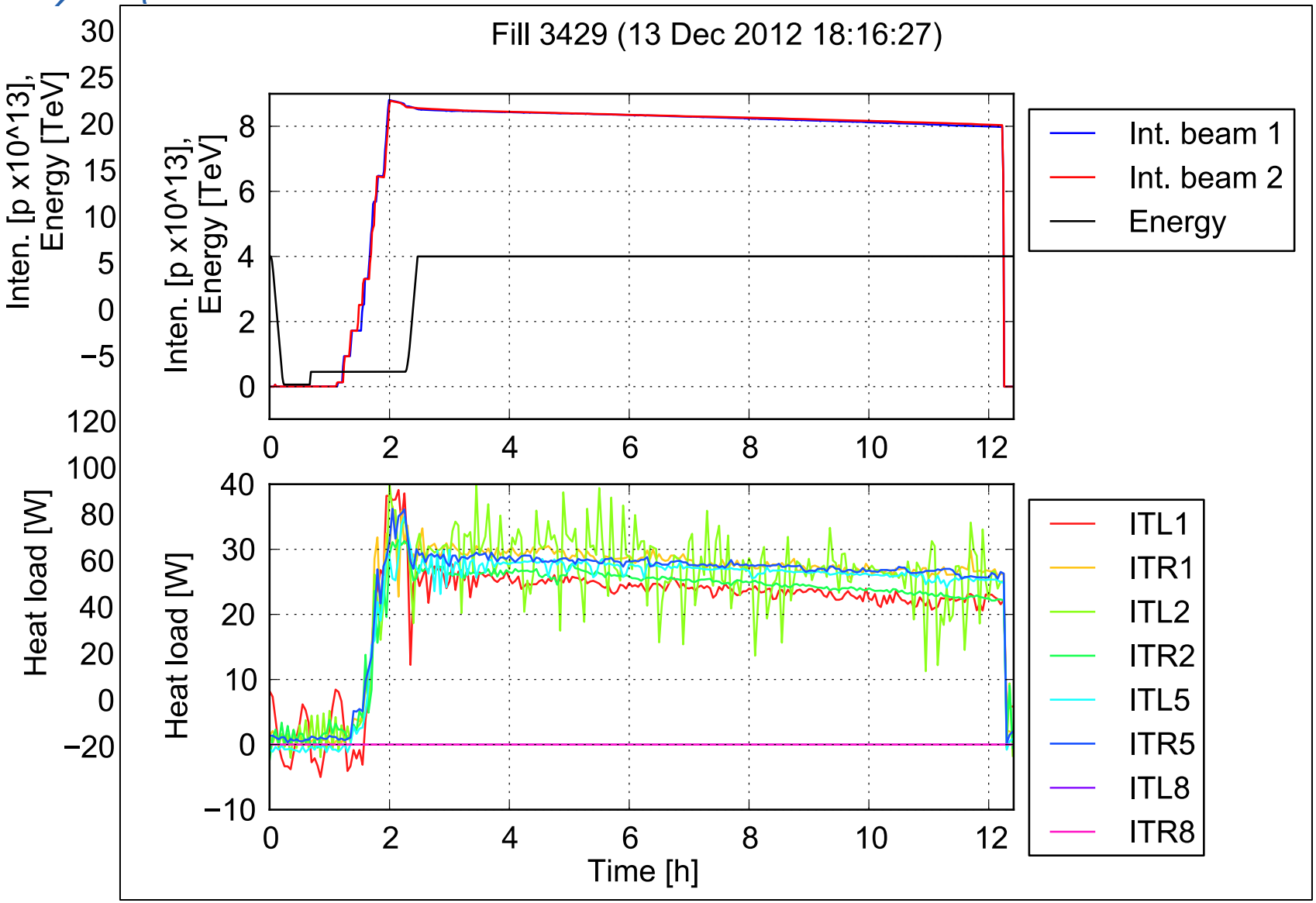

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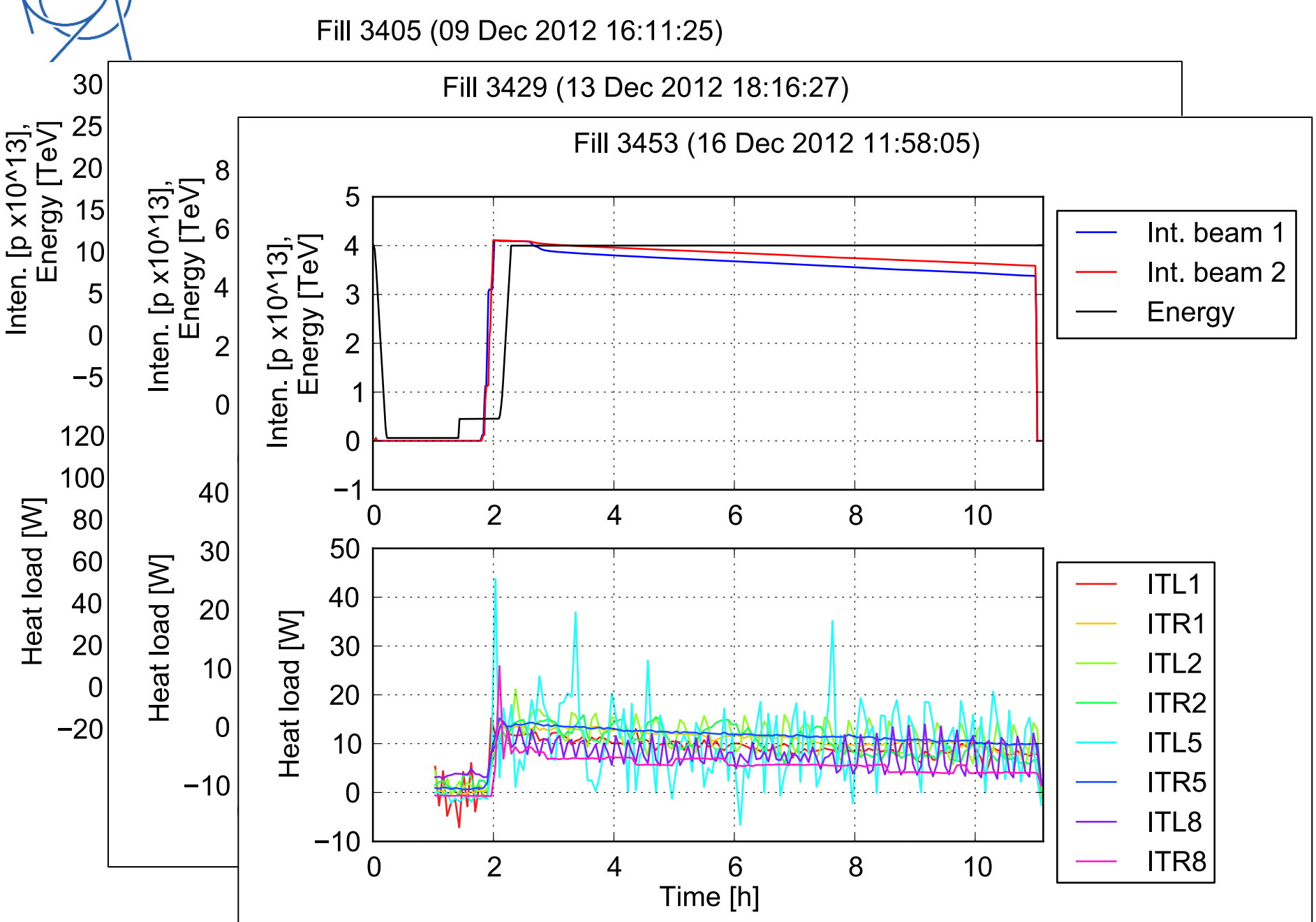
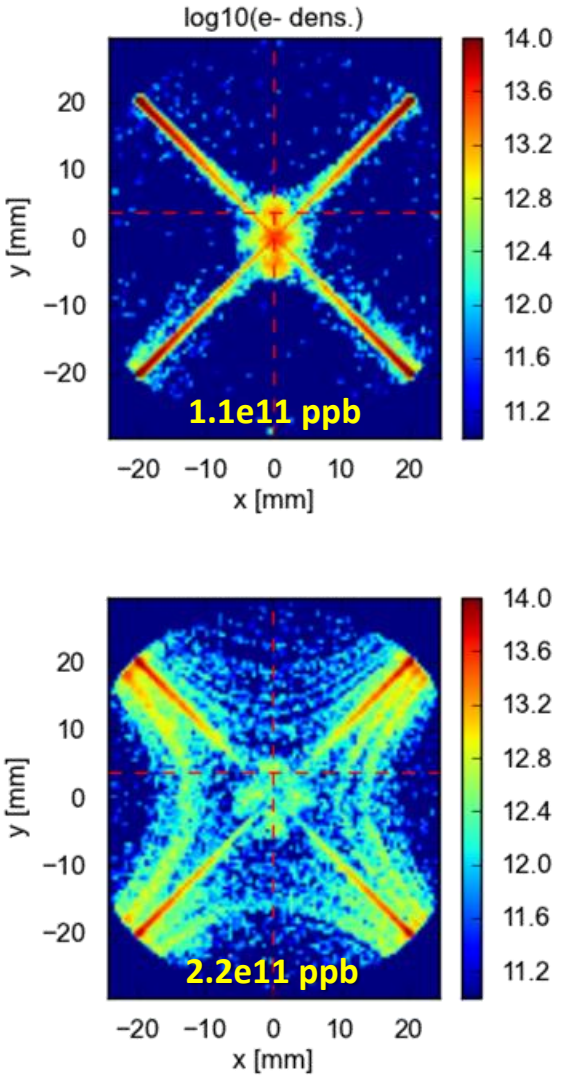
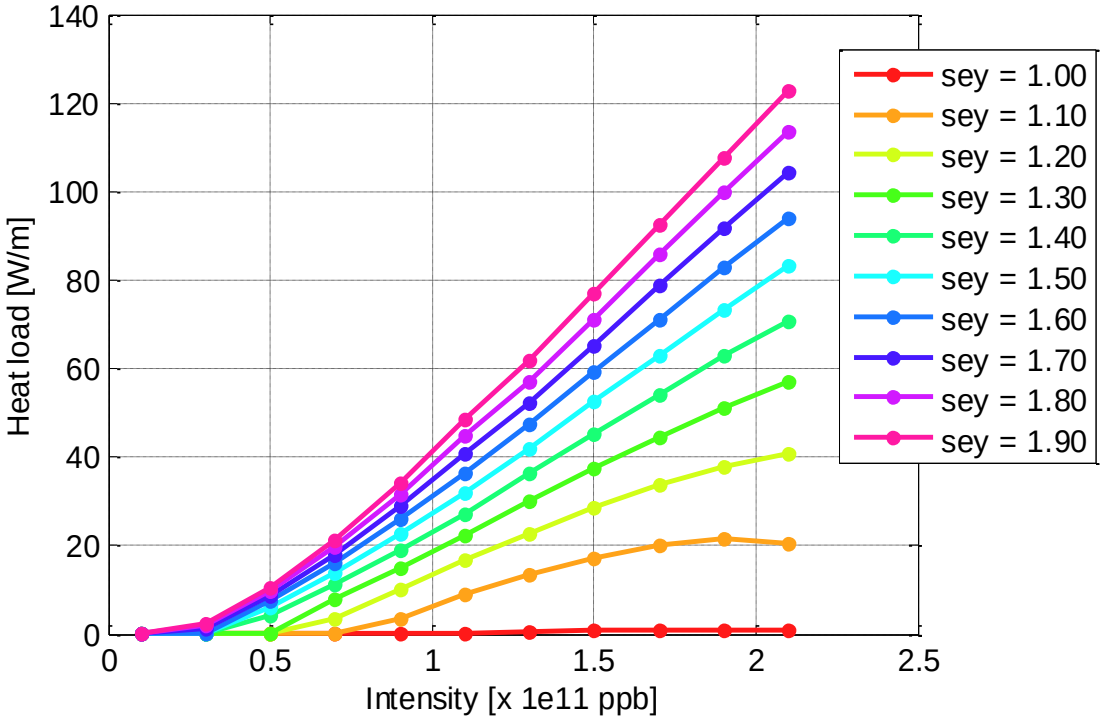


Scaling with bunch population - IP2 and IP8



Scaling heat load in present inner triplets with bunch population:

- Doubling bunch population leads to about **x2-3 larger heat load**
- e-cloud **suppression strategies needed** also in IP2 and IP8



Summary

- **HL-LHC Inner triplets IP1 and IP5 + D1**:
  - Expected values of heat load on the beam screens about **a factor 3 larger** than with present triplets
  - **Suppression measures** (like low SEY coating or clearing electrodes) necessary to keep **heat loads within cooling capacity**

- **Inner triplets IP2 and IP8 + D1**
  - Data from 2012 show **similar behaviour to IP1 and 5**
  - **Pure scaling with bunch population** indicates that HL-LHC beams will lead to threefold heat load in the beam screen of IP2 and IP8 triplets