Electron cloud considerations

G. Iadarola, G. Skripka

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

HLLHC-WP2 Meeting, 27 June 2017
• 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)
• 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
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**Caveat:** simulations have 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?
To assess the impact of having short uncoated sections (bellows, BPMs) we simulated the case in which all sections outside the cold masses have SEY\textsubscript{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 "SEY profile" along the IR is defined, we will perform detailed simulations to confirm that no problem is expected.
• **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
• 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

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**

<table>
<thead>
<tr>
<th>Name</th>
<th>Length</th>
<th>Field config.</th>
<th>Chamber</th>
<th>Impedance (T_BS=70 K)</th>
<th>e-cloud (SEY=1.1/ UncDrifts1.3)</th>
<th>Total</th>
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</table>
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:

<table>
<thead>
<tr>
<th>Name</th>
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<th>Total</th>
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<td>Drifts</td>
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</table>
• Electron cloud build-up simulations have been performed for the TAXS absorber
• Two beam device $\rightarrow$ multipacting depends on the distance w.r.t. the long range encounters

Length = 1.8 m, circular chambers, diameter = 60 mm
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• Two beam device $\rightarrow$ multipacting depends on the distance w.r.t. the long range encounters
• Multipacting thresholds are above $SEY_{\text{max}} = 1.2$
• Is NEG or aC coating foreseen for the TAXS chambers?

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

**Diagram:**

- **Maximum allowed by cryogenics**
- **Margin**
  - LHC 2016: ~7 kW
  - HL-LHC: ~4 kW
- **Heat load per arc [kW]**
  - LHC 2016:
    - 2200b
    - 1.1e11 p/bunch
    - 6.5 TeV
  - HL-LHC:
    - 2748b
    - 2.2e11 p/bunch
    - 7 TeV
- **e-cloud load**
  - 2016:
    - ~5.5 kW
    - (S12 and S81)
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
• Heat loads in the **Inner Triplets** have been estimated IR1&5 and for IR2&8
  → We rely on low SEY surface treatments ($\text{SEY}_{\text{max}} < 1.1$) 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\text{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\text{max}**. Is aC or NEG coating foreseen?
• More in general it would good to define the **“SEY\text{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**
  o **Experimental IRs are by far the most critical**
  o In particular the **heat load in the stand-alone magnets in IR2 and IR8 affects the cooling capacity in the neighboring arcs**
  o 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