Update on e-cloud in TDIS

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Acknowledgements:
Chiara Bracco, David Carbajo Perez, Elias Métral, Antonio Perillo Marcone, Mauro Taborelli, Christina Yin Vallgren
Outline

- e-cloud simulation setup: coating scenarios
- e-cloud depending on the TDIS gap and SEY
- e-cloud with nonuniform SEY:
  - 2 scenarios
  - contributions from chamber segments
  - beam screen coating suggestion
  - comparison of coating scenarios
Outline

- e-cloud simulation setup: coating scenarios
- e-cloud depending on the TDIS gap and SEY
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  - contributions from chamber segments
  - beam screen coating suggestion
  - comparison of coating scenarios
e-cloud simulations in TDIS

Request:
1. Apply 1.0 on the jaws for Tank 1 and 2, and 1.6 on the jaws for Tank 3, and 1.6 elsewhere for all the tanks.
2. Apply 1.0 on the jaws for Tank 1, 2 and 3; 1.6 elsewhere.

It would also be very interesting, if you can do a scan of the all the parts with 1.6 as initial value, and go down with the SEY (simulate the scrubbing effect with the beam on RF shield and the jaws) if it doesn’t take you too long time to do so.

Different SEY configurations to simulate:
- Uniform (was done before but for different geometry, TDIS Internal Review 2016)
- Nonuniform SEY:

<table>
<thead>
<tr>
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BP – back plate  
JS – side of jaws  
BS – beam screen  
J1/J2/J3 – jaws in tanks 1, 2 and 3

Main simulation parameters
- Beam parameters: 450GeV, 25 ns, 2.2e11 p/bunch
- Two counter-rotating beams (simulated different transverse slices of the device)
- Half-gap scan: 1 - 50 mm
- SEY scan: 1.0 - 1.6
Different SEY configurations simulated

- Uniform (was done before but for different geometry): **SEY scan 1.6-1.0, half-gap scan 1-50 mm**
Different SEY configurations simulated

- Uniform (was done before but for different geometry): SEY scan 1.6-1.0, half-gap scan 1-50 mm

- Nonuniform
  - **Baseline**: T1T2: graphite jaws SEY 1.0 + SEY 1.6 elsewhere; T3: SEY 1.6, half-gap scan 1-50 mm

**e-cloud simulations in TDIS**
Different SEY configurations simulated

- **Uniform** (was done before but for different geometry): SEY scan 1.6-1.0, half-gap scan 1-50 mm

- **Nonuniform**
  - **Realistic**: T1T2: graphite jaws SEY 1.0 + SEY 1.6 elsewhere; T3: SEY 1.6, half-gap scan 1-50 mm
  - **Coated 3rd jaw (Ti+Cu)**: All tanks (T1T2T3): jaws SEY 1.0 + SEY 1.6 elsewhere, half-gap scan 1-50 mm
Outline

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  - comparison of coating scenarios
Longitudinal current/heat profiles (uniform SEY)

- Multipacting is stronger at the positions where the two beams are not synchronized (12.5 ns equivalent spacing)
Longitudinal current/heat profiles (uniform SEY)

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

**Graphs:**

- **Electron current [mA/m]**
- **Heat load [W/m]**

**Legend:**

- SEY - Total
  - 1.0 - 0 mA, 0 W
  - 1.1 - 2 mA, 1 W
  - 1.2 - 106 mA, 47 W
  - 1.3 - 244 mA, 94 W
  - 1.4 - 389 mA, 135 W
  - 1.5 - 546 mA, 174 W
  - 1.6 - 717 mA, 210 W

**Note:** Positions of the long-range encounters.
Longitudinal current/heat profiles (uniform SEY)

- Multipacting is stronger at the positions where the two beams are not synchronized (12.5 ns equivalent spacing)
Longitudinal current/heat profiles (uniform SEY)

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

Longitudinal current/heat profiles (uniform SEY)

- Half gap 20.0 mm
- Positions of the long-range encounters

- SEY - Total
  - 1.0 - 0 mA, 0 W
  - 1.1 - 0 mA, 0 W
  - 1.2 - 0 mA, 0 W
  - 1.3 - 11 mA, 5 W
  - 1.4 - 127 mA, 66 W
  - 1.5 - 250 mA, 123 W
  - 1.6 - 375 mA, 170 W
Longitudinal current/heat profiles (uniform SEY)

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

![Graph showing longitudinal current and heat profiles](image-url)
Longitudinal current/heat profiles (uniform SEY)

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

![Graph showing electron current and heat load profiles with positions of long-range encounters indicated.](image)
Longitudinal current/heat profiles (uniform SEY)

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

Half gap 6.0 mm

- Positions of the long-range encounters

---

**SEY - Total**
- 1.0 - 0 mA, 0 W
- 1.1 - 0 mA, 0 W
- 1.2 - 0 mA, 0 W
- 1.3 - 0 mA, 0 W
- 1.4 - 0 mA, 0 W
- 1.5 - 26 mA, 13 W
- 1.6 - 104 mA, 48 W
Multipacting is stronger at the positions where the two beams are not synchronized (12.5 ns equivalent spacing).
Longitudinal current/heat profiles (uniform SEY)

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

What is it at small gaps and high SEY? Multipacting or numerical error?
Build-up at small gap and high SEY

- Simulations start with initial seed electrons
- **Multipacting on the beam screen** for small gaps and high SEY

4 mm half-gap, 12.5 ns delay
Longitudinal current/heat profiles (uniform SEY)

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

Which part of chamber contributes more? Beam screen? Jaws?
Electron flux on different segments (uniform SEY)

- **At long-range encounter**: e-cloud builds up on the flat part of beam screen
- **Between long-range encounters**: e-cloud builds up on the flat part of beam screen, jaws and on the rounded beam screen part

**Uniform SEY 1.4, half-gap 10 mm**
Electron flux on different segments (uniform SEY)

- **At long-range encounter:** e-cloud builds up on the flat part of beam screen
- **Between long-range encounters:** e-cloud builds up on the flat part of beam screen, jaws and on the rounded beam screen part

**Uniform SEY 1.4, half-gap 20 mm**
Electron flux on different segments (uniform SEY)

- **At long-range encounter**: e-cloud builds up on the flat part of beam screen
- **Between long-range encounters**: e-cloud builds up on the flat part of beam screen, jaws and on the rounded beam screen part

**Uniform SEY 1.4, half-gap 30 mm**
Electron flux on different segments (uniform SEY)

- **At long-range encounter:** e-cloud builds up on the flat part of beam screen
- **Between long-range encounters:** e-cloud builds up on the flat part of beam screen, jaws and on the rounded beam screen part

**Uniform SEY 1.4, half-gap 40 mm**

![Diagram showing electron flux on different segments.](image)
Electron flux on different segments (uniform SEY)

- **At long-range encounter:** e-cloud builds up on the flat part of beam screen
- **Between long-range encounters:** e-cloud builds up on the flat part of beam screen, jaws and on the rounded beam screen part

Uniform SEY 1.4, half-gap 45 mm

![Graphs showing electron flux on different segments](image-url)
Electron flux on different segments (uniform SEY)

- At long-range encounter: e-cloud builds up on the flat part of beam screen
- Between long-range encounters: e-cloud builds up on the flat part of beam screen, jaws and on the rounded beam screen part

Uniform SEY 1.4, half-gap 50 mm
**Electron current by segment (uniform SEY)**

- **At long-range encounter**: largest contributor is the beam screen
- **Between long-range encounters**: largest contributor are the jaws
- **Beam screen** (flat and round parts) accounts for **more than a half of the total** current
- Contribution of jaws is highly dependent on the delay

![Graph showing electron current by segment](image)

- **SEY - Total**
  - 1.6 - 748 mA
  - Round part of BS: 183 mA
  - Flat part of BS: 224 mA
  - Side of jaws: 50 mA
  - Jaws: 231 mA
  - Back plate: 60 mA

**Positions of the long-range encounters**

Half gap 40.0 mm
Electron current by segment (uniform SEY)

- Opening the gap from 40 to 50 mm half-gap reduces total current
  - lowers the contribution of jaws by 30%
  - contribution from the beam screen (round and flat parts) is roughly unchanged

![Graph showing electron current by segment](image)

Half gap 50.0 mm

SEY - Total
- 1.6 - 657 mA
- round part of BS: 109 mA
- flat part of BS: 283 mA
- side of jaws: 30 mA
- jaws: 170 mA
- back plate: 65 mA

Positions of the long-range encounters
Total electron current vs SEY (uniform SEY)

- Electron flux on the walls increases for large gaps.
- Maximum is reached at half-gap 40 mm SEY 1.6: **750 mA**
- Multipactoring threshold very high for small gaps and decreasing when the jaws are opened.

![Graph showing electron current vs SEY for different half-gaps.](image)
Total electron current vs SEY (uniform SEY)

- Electron flux on the walls increases for large gaps
- Maximum is reached at half-gap 40 mm SEY 1.6: 750 mA
- Multipacting threshold very high for small gaps and decreasing when the jaws are opened

With old geometry ~680mA
Outline

- e-cloud simulation setup: coating scenarios
- e-cloud depending on the TDIS gap and SEY
- e-cloud with nonuniform SEY
  - 2 scenarios
  - contributions from chamber segments
  - beam screen coating suggestion
  - comparison of coating scenarios
Nonuniform SEY: jaws in tanks 1,2 SEY 1.0
SEY 1.6 elsewhere (BASELINE no coating J3)

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<td>1.6</td>
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BP – back plate
JS – side of jaws
BS – beam screen
J1/J2/J3 – jaws in tanks 1,2 and 3
Longitudinal current/heat profiles (nonuniform SEY: jaws 1.0 T1T2)

- Maximum reached for gaps ~40 mm: total \(514\, \text{mA}\) e-current
Nonuniform SEY: Coated jaws in tank 3 SEY 1.0

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<tr>
<td>Coat J3</td>
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BP – back plate
JS – side of jaws
BS – beam screen
J1/J2/J3 – jaws in tanks 1,2 and 3
Longitudinal current/heat profiles (nonuniform SEY: jaws 1.0 T1T2T3)

- Maximum reached for gaps ~40 mm: total **457 mA** e-current

![Graph showing longitudinal current and heat profiles](image)

**Jaws SEY 1.0 and the rest SEY 1.6 (T1T2T3)**

**Half-gap, Total**
- 4.0 mm, 85 mA, 43 W
- 6.0 mm, 81 mA, 39 W
- 8.0 mm, 83 mA, 39 W
- 10.0 mm, 89 mA, 42 W
- 20.0 mm, 183 mA, 85 W
- 30.0 mm, 335 mA, 127 W
- 40.0 mm, 457 mA, 145 W
- 50.0 mm, 423 mA, 137 W

**Positions of the long-range encounters**
Outline

- e-cloud simulation setup: coating scenarios
- e-cloud depending on the TDIS gap and SEY
- e-cloud with nonuniform SEY
  - 2 scenarios
  - contributions from chamber segments
  - beam screen coating suggestion
  - comparison of coating scenarios
From Uniform to Baseline SEY distribution

Half-gap 40 mm

SEY - Total
- 1.6 - 748 mA
- round part of BS: 183 mA
- flat part of BS: 224 mA
- side of jaws: 50 mA
- jaws: 231 mA
- back plate: 60 mA

Positions of the long-range encounters

Half-gap 50 mm

SEY - Total
- 1.6 - 657 mA
- round part of BS: 109 mA
- flat part of BS: 283 mA
- side of jaws: 30 mA
- jaws: 170 mA
- back plate: 65 mA
From Uniform to Baseline SEY distribution

Significantly reduced contribution from jaws
From Baseline to Coated J3

Half-gap 40 mm

Half-gap 50 mm

SEY - Total
- 40.0 mm, 514 mA, 162 W
- 50.0 mm, 492 mA, 154 W

T112
- round part of BS: 84 mA
- flat part of BS: 115 mA
- side of jaws: 25 mA
- jaws: 72 mA
- back plate: 25 mA

T3
- round part of BS: 44 mA
- flat part of BS: 72 mA
- side of jaws: 16 mA
- jaws: 49 mA
- back plate: 12 mA

SEY - Total
- 40.0 mm, 457 mA, 146 W
- 50.0 mm, 423 mA, 137 W

T112
- round part of BS: 84 mA
- flat part of BS: 115 mA
- side of jaws: 25 mA
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- round part of BS: 44 mA
- flat part of BS: 72 mA
- side of jaws: 16 mA
- jaws: 49 mA
- back plate: 12 mA

117th HiLumi WP2 Meeting
From Baseline to Coated J3

Reduction of contribution from jaws
From Baseline to Coated J3

Half-gap 40 mm

SEY - Total
- 40.0 mm, 514 mA, 162 W
- T112
- round part of BS: 84 mA
- flat part of BS: 115 mA
- side of jaws: 25 mA
- jaws: 72 mA
- back plate: 25 mA
- T3
- round part of BS: 44 mA
- flat part of BS: 72 mA
- side of jaws: 16 mA
- jaws: 49 mA
- back plate: 12 mA

Contribution from the beam screen is large. Coating?
Outline

- e-cloud simulation setup: coating scenarios
- e-cloud depending on the TDIS gap and SEY
- e-cloud with nonuniform SEY
  - 2 scenarios
  - contributions from chamber segments
  - beam screen coating suggestion
  - comparison of coating scenarios
Nonuniform SEY: coated beam screen SEY 1.0

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<tr>
<td>Baseline and BS</td>
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BP – back plate
JS – side of jaws
BS – beam screen
J1/J2/J3 – jaws in tanks 1, 2 and 3
Baseline with coated beam screen

- **Half-gap 40 mm**
  - SEY - Total
    - T12: 40 mm, 514 mA, 162 W
    - round part of BS: 84 mA
    - flat part of BS: 115 mA
    - side of jaws: 25 mA
    - jaws: 72 mA
    - back plate: 25 mA
  - T3: 44 mA
  - round part of BS: 44 mA
  - flat part of BS: 72 mA
  - side of jaws: 16 mA
  - jaws: 49 mA
  - back plate: 12 mA

- **Half-gap 50 mm**
  - SEY - Total
    - T12: 50 mm, 492 mA, 154 W
    - round part of BS: 57 mA
    - flat part of BS: 155 mA
    - side of jaws: 14 mA
    - jaws: 55 mA
    - back plate: 33 mA
  - T3: 21 W
  - round part of BS: 5 mA
  - flat part of BS: 14 mA
  - side of jaws: 2 mA
  - jaws: 18 mA
  - back plate: 5 mA
Baseline with coated beam screen

Almost no electron current left
Beam screen and jaws SEY 1.0 in all tanks

If both beam screen and jaws in T3 are coated with SEY 1.0:

NO e-CURRENT
Outline

- e-cloud simulation setup: coating scenarios
- e-cloud depending on the TDIS gap and SEY
- e-cloud with nonuniform SEY
  - 3 scenarios
  - contributions from chamber segments
  - beam screen coating suggestion
  - comparison of coating scenarios
Total electron current vs half-gap

- Electron flux on the walls increases for large gaps
- Maximum is reached at half-gaps ~40 mm
- Coating the jaws in tank 3 allows gaining ~30% (50 mm half-gap)
- Coating the beam screen lowers the current by one order of magnitude and kills multipactoring at small gaps

**SEY table**

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BP – back plate
JS – side of jaws
BS – beam screen
J1/J2/J3 – jaws in tanks 1,2,3

**SEY**
- Uniform SEY 1.6
- Baseline
- Coated 3d jaw
- Coated beam screen
- Coated beam screen and jaws

**Graphs**

- Electron current vs half-gap
- Max value, mA
- At 50 mm
  - Half-gap, mA
- Baseline
- Coated BS+J3
- Coated BS
- Coated J3
- Uniform SEY 1.6
Summary

We simulated the e-cloud in the presence of both beams in the TDIS assuming:
- Different gaps: 1-50 mm
- Uniform SEY: 1.0-1.6

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 at locations where two beams are not synchronized
- In between LREs the back plate, side of the jaws and round part of the beam screen also contribute to e-cloud build-up
- Multipacting threshold very high for small gaps and decreasing when the jaws are opened

With nonuniform SEY:
- Simulating realistic Graphite jaws showed that the current on the jaws is 30% smaller than in the uniform 1.6 SEY case
- If coating the Cu+Ti jaws in the 3d tank the electron current is reduced by 15% at half-gap of 50 mm
- Coating the beam screen lowers the total current and heat load by order of magnitude where Cu-Ti jaws become the largest contributor
- **Coating both the beam screen and the Cu+Ti jaws brings electron current to zero**
New beam screen geometry
Longer flat part of beam screen

Flat part of BS: 38 mm → 61 mm

Reduced set of simulations
- Beam parameters: 450GeV, 25 ns, 2.2e11 p/bunch
- Two counter-rotating beams (simulated different transverse slices of the device)
  - reduced number of points along the device
- Half-gap scan: 1 - 50 mm
  - reduced number of gaps
- SEY scan: 1.0 – 1.6 with 0.2 step
Longitudinal current/heat profiles (uniform SEY)

- Less than 5% difference in current and heat load

Half gap 50.0 mm
Longitudinal current/heat profiles (uniform SEY)

- Less than 5% difference in current and heat load

Half gap 40.0 mm