Energy deposition in the Matching Section (v1.2)

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ColUSM #67 – February 5, 2016
Outline

- Layout and optics
- Results for round optics, horizontal crossing with collimators in place
  - Total power
  - Peak power/dose
  - Dose map in the tunnel
- Further studies
Layout and optics
Optics

- HL-LHCV1.2 (retrieved on 13/1/2016) (R. De Maria)

- Round optics, horizontal crossing (295μrad)
Optics

- All collimators in place
  - TCLX.4R5.B1
  - TCTP.4R5.B2 (V&H)
  - TCL.5R5.B1/6R5.B1
  - No tank for the horizontal ones

- Collimator settings (R. Bruce)
  - TCLs @ 12σ
  - TCTs @ 10.9σ

- Previous reference for the D2-Q4 region:
  - L. Esposito’s talk at the 2014 Annual Meeting at KEK
    - [indico.cern.ch/event/326148/session/17/contribution/43](indico.cern.ch/event/326148/session/17/contribution/43)
Geometry

- Significant changes:
  - **Apertures**
    - TAN: 80mm → **85mm**
    - D2 correctors: 100mm → **105mm** (same as D2)
    - Q4 correctors: 100mm → **90mm** (same as Q4)
  - **Beam screen**
    - Q4 and correctors: rectellipse → **octagonal**
  - TAN length: 3.5m → **3.33m**
Comparison with survey trajectory (b1)

- Very good agreement between calculated and expected proton trajectory (Beam 1)
  - 300nm offset at exit of Q7
Results
Total power for $L = 7.5L_0 (1/2)$

- **TAXN: 1040W**
  - Will be ~20% higher in vertical crossing (IR1)

<table>
<thead>
<tr>
<th>Collimators</th>
<th>Inner/upper jaw</th>
<th>Outer/lower jaw</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCLX.4R5.B1</td>
<td>255</td>
<td>128</td>
</tr>
<tr>
<td>TCTPV.4R5.B2</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>TCTPH.4R5.B2</td>
<td>3</td>
<td>14</td>
</tr>
<tr>
<td>TCL.5R5.B1</td>
<td>22</td>
<td>124</td>
</tr>
<tr>
<td>TCL.6R5.B1</td>
<td>24</td>
<td>43</td>
</tr>
<tr>
<td>TCTV.6R5.B2</td>
<td>0.4</td>
<td>0.3</td>
</tr>
<tr>
<td>TCTH.6R5.B2</td>
<td>0.3</td>
<td>0.04</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Masks</th>
<th>Power [W]</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCLM.5R5.B1</td>
<td>16.5</td>
</tr>
<tr>
<td>TCLM.5R5.B2</td>
<td>1.0</td>
</tr>
<tr>
<td>TCLM.6R5.B1</td>
<td>5.7</td>
</tr>
<tr>
<td>TCLM.6R5.B2</td>
<td>0.1</td>
</tr>
</tbody>
</table>
- Increase of the D2 load due to the larger TAXN aperture
- Crab cavities: 140-170mW (b1), ~35-45mW (b2)
  - Dependence on the vacuum chamber profile (see later)

<table>
<thead>
<tr>
<th>Magnets</th>
<th>Magnet cold mass</th>
<th>Beam screen (b1/b2)</th>
<th>Power [W]</th>
</tr>
</thead>
<tbody>
<tr>
<td>D2</td>
<td>50</td>
<td>2.5 / 0.1</td>
<td></td>
</tr>
<tr>
<td>D2 H</td>
<td>2.2</td>
<td>0.2 / 0.005</td>
<td></td>
</tr>
<tr>
<td>D2 V</td>
<td>1.4</td>
<td>0.2 / 0.004</td>
<td></td>
</tr>
<tr>
<td>Q4 H</td>
<td>11</td>
<td>1.3 / 0.03</td>
<td></td>
</tr>
<tr>
<td>Q4 V</td>
<td>4.6</td>
<td>0.8 / 0.03</td>
<td></td>
</tr>
<tr>
<td>Q4</td>
<td>10</td>
<td>1.4 / 0.1</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
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<th>Magnet cold mass</th>
<th>Beam screen (b1/b2)</th>
<th>Power [W]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q5</td>
<td>7</td>
<td>0.1 / 0.05</td>
<td></td>
</tr>
<tr>
<td>Q5 Hb</td>
<td>0.5</td>
<td>0.01 / 0.01</td>
<td></td>
</tr>
<tr>
<td>Q5 V</td>
<td>0.4</td>
<td>0.01 / 0.01</td>
<td></td>
</tr>
<tr>
<td>Q5 Ha</td>
<td>0.3</td>
<td>0.01 / 0.01</td>
<td></td>
</tr>
</tbody>
</table>
- Peak power density below design values
- Caution: values in b2 expected to increase with vertical crossing
Peak dose ($L_{int}=4000\text{fb}^{-1}$)

- Values below 20MGy…
  - …except for the first Q4 corrector (here not evaluated), where a peak of up to ~30MGy is expected.
Peak dose for beam 2

- To be evaluated for vertical crossing
- In particular for D2 and the first Q4 corrector without TCT4

IR5 (295 urad horizontal)

*external* bore (B1)

IR1 (295 urad vertical)

*internal* bore (B2)

F. Cerutti, Aug 21, 2015, WP3 meeting
Dose per year of operation \( (L_{int}=300\text{fb}^{-1}) \)

- Relevant for vacuum and survey equipment, cabling etc.

- Averaged over ±20cm from the beam level
- RR region sensitive to the shower from TCL6
Beam pipe aperture restrictions

- Increase in the dose at the position of beam pipe restrictions indicates losses that can affect downstream elements
Beam pipe aperture restrictions

- Transitions between beam pipe sections with different apertures / axis currently simulated as smooth transitions
  - e.g. transition between D2 and crab cavities beam pipe (change in aperture and axis)

- Greater detail in the model may be required for more accuracy
Summary and further studies

- Suitability of the full protection scheme confirmed

- Integration issues in the TAN-D2 region:
  - Effect of a “thinner” TCLX
  - Removal of TCTs (with TAN displacement and aperture adjustment) in IR1 (vertical crossing)

- Later: debris losses in the Dispersion Suppressor