Energy deposition studies for physics debris (TAXN-D2 region)

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Joint WP2-WP5 meeting & ColUSM #46, 3 October 2014
Energy deposition studies for physics debris (TAXN-D2 region)

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- Update previous simulations with the new layout
- What is the role of the D2 mask?

Joint WP2-WP5 meeting & ColUSM #46, 3 October 2014
In the past different options were explored, in particular different TCL4 settings.

Results discussed in the PDR, Chap. 10

\[ D_2 \text{ @ } L = 5 \times 10^{34} \text{ cm}^{-2}\text{s}^{-1} \]

\[ Q_4 \text{ @ } L = 5 \times 10^{34} \text{ cm}^{-2}\text{s}^{-1} \]

- 100 cm mask, TCL4@20σ
- 50 cm mask, TCL4@20σ
- 50 cm mask, TCL4@10σ
- no mask, TCL4@10σ

\[ \lesssim 40 \text{ MGy / 3000 fb}^{-1} \]

\[ \sim 20 \text{ MGy / 3000 fb}^{-1} \]
In the past different options were explored, in particular different TCL4 settings

Is the mask in front of D2 still necessary?
Present HL-LHC layout

For collimators only active length.
Mechanical assembly and interfaces to be redesigned to fit the available space

from drawing LHCLSXH_0010_1
Undergoing FLUKA studies

1st option

model according to the layout in the previous page, apart 10-cm shift toward the IP for TCLMA and TCL

Differences with last simulation (Jan 2014):
• TAN:
  • length of the separated pipes: 3.7 → **3.5 m**
  • beam separation: 148mm@IP-side; 158.6mm@non-IP-side → **149mm@IP-side; 159mm@non-IP-side**
  • aperture radius 38 → **40 mm** (aperture fixed in order to comply with different collision optics)
• TCL/TCLMA distance from D2 increased by about 50/20 cm
Undergoing FLUKA studies

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• TCL/TCLMA distance from D2 increased by about 50/20 cm

2nd option

remove TCLMA and move TCL toward D2 by 90 cm
Geometry updates

D2: aper 105 mm, octagonal bs

Q4 correctors: aper 100 mm

D2 correctors: aper 100 mm

Q4: aper 90 mm, rectellipse bs
Geometry updates

D2: aper 105 mm, octagonal bs
Before: aper 100 mm, rectellipse bs

D2 correctors: aper 100 mm
Before: same aper of D2

Q4 correctors: aper 100 mm
Before: same aper of Q4

Q4: aper 90 mm, rectellipse bs
Comparison with previous layout

D2 peak power profile

no mask @ $L = 5 \times 10^{34} \text{ cm}^{-2} \text{s}^{-1}$

HL-LHC v1.1
HL-LHC v1.0

Increase both in the D2 and the first corrector
Comparison with previous layout

D2 peak power profile

no mask @ L = $5 \times 10^{34}$ cm$^{-2}$s$^{-1}$

HL-LHC v1.1
HL-LHC v1.0

Increase both in the D2 and the first corrector

D2 corrector aperture represents a bottleneck
The role of the D2 mask

D2-Q4 peak power profile

HL-LHC v1.1 @ $L = 5 \times 10^{34} \text{ cm}^{-2} \text{s}^{-1}$
round, 50 cm mask
round, no mask

The effect of the mask is limited to the first part of D2

1st option vs 2nd option
The role of the D2 mask

The mask protects especially the inner side

peak power @ D2 longitudinal peak

$\sqrt{s} = 14$ TeV pp collisions
round, 50 cm mask
round, no mask

1st option
vs
2nd option
Peak dose

D2 peak dose profile

HL-LHC v1.1 round optics
round, w/ D2 mask
round, w/o D2 mask

1st option vs 2nd option
TAXN: energy deposition

Total power = 1150 W @ 5 × \( \mathcal{L} \)
Peak dose = 4.5 GGy @ 3000 fb\(^{-1} \)

TAXN longitudinal profile

TAXN peak fluence longitudinal profile

TAXN at longitudinal peak

TAXN at longitudinal peak

Photons
\( e^+ & e^- \)
Neutrons
Charged hadrons
Protons
Debris after the TAN

LHC
debris distribution at TCL.4R5 entrance

![LHC debris distribution at TCL.4R5 entrance](image)

HL-LHC
debris distribution at TAN.4R5 exit (truncated cone)

![HL-LHC debris distribution at TAN.4R5 exit](image)

Same number of events

For a more details, refer to L.S. Esposito at 13th HiLumi WP2 Task Leader Meeting, 13 August 2013.
Debris after the TAN

LHC

debris distribution at TCL.4R5 entrance

<table>
<thead>
<tr>
<th>x [cm]</th>
<th>y [cm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>-4</td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td>-4</td>
</tr>
</tbody>
</table>

7+7 TeV proton collisions, 142.5 µrad horizontal half-crossing angle

| Protons with $|P_T/p| < 0.05 (41\%)$ |
| Protons with $|P_T/p| > 0.05 (26\%)$ |
| Other particle species (33\%) |
| 10° outgoing beam spot |

HL-LHC

debris distribution at TAN.4R5 exit (truncated cone)

<table>
<thead>
<tr>
<th>x [cm]</th>
<th>y [cm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>-6</td>
<td>6</td>
</tr>
<tr>
<td>2</td>
<td>-6</td>
</tr>
</tbody>
</table>

7+7 TeV proton collisions, 295 µrad half-crossing angle

| Protons with $|P_T/p| < 0.05 (13\%)$ |
| Protons with $|P_T/p| > 0.05 (15\%)$ |
| Other particle species (72\%) |
| 10° outgoing beam spot |

Same number of events

jaws at 10σ

(showed only the tungsten block)

For a more details, refer to L.S. Esposito at 13th HiLumi WP2 Task Leader Meeting, 13 August 2013
Energy deposition on the TCL and TCLMA

<table>
<thead>
<tr>
<th>Power [W] 5E34 cm^-2 s^-1</th>
<th>TCL4 inner jaw</th>
<th>TCL4 outer jaw</th>
<th>TCLMA b1</th>
<th>TCLMA b2</th>
<th>D2</th>
<th>Q4</th>
</tr>
</thead>
<tbody>
<tr>
<td>w/ mask</td>
<td>175</td>
<td>99</td>
<td>7</td>
<td>1.8</td>
<td>35+4+2</td>
<td>6+3+6</td>
</tr>
<tr>
<td>w/o mask</td>
<td>170</td>
<td>102</td>
<td>-</td>
<td>-</td>
<td>52+4+2</td>
<td>6+3+6</td>
</tr>
</tbody>
</table>
Conclusions and next steps (a proposal)

• the **TCLMA** reduces the load on D2 by a factor 2

• additional protection to D2 can be provided by a **larger collimator** (or a movable TAN), thus allowing to **remove the mask**
  → **by HL-LHC annual meeting**

• **longitudinal space** should not represent a problem
  (even in the case we still go along for the mask, the TAN might be shortened and/or use W inserts inside)

• **transverse space** needs still to be addressed

• check the effectiveness of the protection for other collision optics, in particular the **flat for D2 peak load**
  → **by HL-LHC annual meeting**