Energy deposition in the Triplet-D1 region (v1.2)

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Outline

• Simulation setup
  • Layout and optics
  • Geometry
• Results for round optics (V/H)
  • Total power
  • Peak power/dose
• Other optics
• Dose minimisation with alternative optics & crossing combinations
• Summary
Simulation setup
Layout and optics

- Element lengths and positions extracted from V1.2 TWISS file
  - Exception: TAS kept at V1.1 position
  - TAS aperture = 60mm
- New magnetic field map for D1
  - Special treatment necessary to remove unphysical spikes at certain boundaries
- Main scenarios studied:
  - Round optics, $\beta^*=15\text{cm}$, crossing $295\mu\text{rad}$
    - 1. Vertical crossing (IP1)
    - 2. Horizontal crossing (IP5)
Geometry upgrades & updates

- 1. Update of various layer thicknesses

- Coil aperture (cold): $R = 7.435\text{cm}$
- 250$\mu$m insulation
- 1.5mm liquid He
- 200$\mu$m insulation
- 4mm cold bore ($R_{in} = 6.84\text{cm}$)
Geometry upgrades & updates

2. Beam screen design
   - Inermet shielding extended towards the poles in “thin” BS (50% filling factor)
   - Adjustment (1.1mm radial reduction) of dimensions to adapt to change in the defined coil aperture and other layers (insulation etc.)

Q1

- $d_{max} = 16\text{mm}$
- 1.5mm clearance from cold bore
- 99.8mm

Q2 and beyond

- $d_{max} = 6\text{mm}$
- 119.8mm
- 112.4mm
- 50% filling factor
Geometry upgrades & updates

• 3. New FLUKA models of interconnect with circular BPM

BS shielding gap 70.8cm

Q1 → Q2

Q2 → Q3 and beyond

Design provided by R. Fernandez-Gomez, T. Lefevre
Results
Total power for $L=7.5L_0$

<table>
<thead>
<tr>
<th></th>
<th>Round vertical</th>
<th>Round horizontal</th>
<th>RV V1.1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Magnet cold mass</td>
<td>Beam screen</td>
<td>Magnet cold mass</td>
</tr>
<tr>
<td>Q1A + Q1B</td>
<td>167</td>
<td>251</td>
<td>176</td>
</tr>
<tr>
<td>Q2A + corr.</td>
<td>139</td>
<td>115</td>
<td>128</td>
</tr>
<tr>
<td>Q2B + corr.</td>
<td>170</td>
<td>147</td>
<td>179</td>
</tr>
<tr>
<td>Q3A + Q3B</td>
<td>186</td>
<td>154</td>
<td>161</td>
</tr>
<tr>
<td>CP</td>
<td>86</td>
<td>106</td>
<td>57</td>
</tr>
<tr>
<td>D1</td>
<td>114</td>
<td>108</td>
<td>92</td>
</tr>
<tr>
<td>TOTAL</td>
<td>862</td>
<td>881</td>
<td>793</td>
</tr>
</tbody>
</table>

- Extension of BS shielding towards poles re-balances loads between CM and BS
- Loads in horizontal crossing $\sim$10% lower with respect to vertical crossing
Peak power density \((L=7.5L_0)\)

- Values quite low overall
- There is an important effect in the IP-faces due to shielding gap in the interconnect, especially in horizontal crossing
Peak dose ($L_{int} = 4000\text{fb}^{-1}$)

Vertical crossing

Horizontal crossing

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Peak dose \( (L_{int} = 4000 fb^{-1}) \)

- The horizontal case is worse
  - Shielding gap in the interconnect creates a localised problem
Is this consistent with previous results?

• YES
  • An increase in the peak dose in Q2B is expected going from vertical to horizontal crossing
  • A longer gap (from 10 to 50cm) in the BS shielding was shown to lead to significantly higher peak dose values in the IP-faces (especially in Q2B)
    • REMINDER: Gap is now ~71cm

\[ L_{int} = 3000 \text{fb}^{-1} \]

See F. Cerutti, 5th PLC Meeting, July 2, 2013
Further studies: flat optics

- Two flat optics scenarios were also studied for both vertical and horizontal crossing
  - 150 μrad half-crossing angle, $\beta^*_x / \beta^*_y = 40 / 10$ cm
  - 210 μrad half-crossing angle, $\beta^*_x / \beta^*_y = 40 / 10$ cm
- Sensitivity of results to changes in bunch length and beam divergence is limited
- On the contrary, the crossing angle plays an important role
  - Lower dose for lower crossing angle
Peak dose minimisation with alternative optics & crossing combinations

In collaboration with S. Fartoukh (BE/ABP)
Peak dose minimisation scenarios

• Different combinations of optics and crossing can reduce peak dose values
• The flexibility of such combinations depends on various constraints e.g.:
  • Possibility of exchange of crossing planes between IP1 and IP5 (HV $\rightarrow$ VH)
  • Possibility of running with the same crossing plane in IP1 and IP5 (HH or VV)
• Four scenarios considered, with decreasing constraints:
  • 1. Baseline scenario: 50% vertical up (V$^+$) / 50% vertical down (V$^-$) in IP1, 100% horizontal (H) in IP5 with round optics
  • 2. Crossing plane exchange between the two IPs: 50% H, 25% V$^+$, 25% V$^-$ with round optics
  • 3. Crossing plane exchange between the two IPs: 50% H, 25% V$^+$, 25% V$^-$ with flat optics (150μrad)
  • 4. No constraints: 50% V$^+$ / 50% V$^-$ with flat optics (150μrad) in both IPs, which is better than 100% H
Peak dose minimisation scenarios

1. Baseline scenario:
   - 50% vertical up ($V^+$) / 50% vertical down ($V^-$) in IP1
   - 100% horizontal (H) in IP5 with round optics
   - Important reduction in IP1 (from 35 to 25MGy)
   - **BUT**, we remain exposed to the high peak value in IP5
     - If the local problem is cured, peak values would be below 30MGy.

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**IP1**

Peak dose profile in the inner coils ($L_{int} = 4000 \text{ fb}^{-1}$)

**IP5**

Peak dose profile in the inner coils ($L_{int} = 4000 \text{ fb}^{-1}$)
Peak dose minimisation scenarios

- 2. Crossing plane exchange between the two IPs
  - 50% H, 25% $V^+$, 25% $V^-$ with round optics in both IPs

![Graph showing peak dose profile in the inner coils (L_{int} = 4000 fb^{-1})]
Peak dose minimisation scenarios

- 3. Crossing plane exchange between the two IPs
  - 50% H, 25% V⁺, 25% V⁻ with flat optics (150μrad)

![Peak dose profile in the inner coils (L_{int} = 4000 fb⁻¹)](image)
Peak dose minimisation scenarios

- 4. No constraints
  - 50% $V^+$ / 50% $V^-$ with flat optics (150μrad) in both IPs
Peak dose minimisation scenarios

• Comparison of three mixed scenarios:

- Energy deposition in the Triplet-D1 region

Peak dose profile in the inner coils ($L_{int} = 4000 \, fb^{-1}$)

- Mixed scenario $RV^+\cdot RV^-\cdot RH \ 25:25:50 \ (295 \ \mu rad)$
- Mixed scenario $FV^+\cdot FV^-\cdot FH \ 25:25:50 \ (150 \ \mu rad)$
- Mixed scenario $FV^+\cdot FV^- \ 50:50 \ (150 \ \mu rad)$
Possible improvement

- Octagonal shielded BPM
  - Shielding gap reduction to ~57cm (instead of 71cm with circular BPM)
  - The shorter gap would surely lead to a reduction of peak dose values
  - **BUT** the gap is still quite long (more than the 50cm studied in the past)
  - This solution is not expected to cure the problem
Summary

• Simulation parameters updated to V1.2
• Various geometry updates (magnet aperture, BS designs)
• New models added: interconnects with circular BPM
• Peak dose estimates show challenging localised problem in IP-face of Q2B, especially for horizontal crossing
• Flat optics scenarios show improvements attributable to the lower crossing angle
• Different optics and crossing combinations (depending on hardware options) could significantly reduce peak dose values

• *Study will be extended to the matching section*
Extra slides
D1 magnetic field map

- Unphysical field values at certain boundaries
  - Due to numerical issues in Roxie?
- A routine was written to detect these spikes and replace them with the average of neighbouring values (excluding neighbouring spikes)
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