FLUKA Energy Deposition Studies for IDS120j - Update

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Introduction

- Using Fluka 2011.2.13 for energy deposition study of IDS120j geometry
  - 100,000 simulated events: $\times 10$ trials for uncertainty estimates
- Hg jet: $r = 0.4$ cm, tilt $\theta = 97$ mr
- Gaussian proton beam $\sigma_x = \sigma_y = 0.12$ cm, KE = 8 GeV
- Corrected “P12” starting point: jet-beam intersection at $z = -37.5$ cm
  - Central proton beam trajectory goes into Hg pool, instead of shielding
  - Previous trajectory affected power deposition in SC4
- Shielding: 60% W + 40% He ($\rho_{eff} = 9.48$ g/cc)
- Proton rate = $3.125 \times 10^{15}$ s$^{-1}$ for 4 MW (8 GeV, 50 Hz)
- Multiply (average) energies by proton rate to get deposited power
Fluka model of IDS120j geometry
Removing first part of Hg pool, plot shows the trajectory of the proton beam center.
## Power deposition in SC coils

<table>
<thead>
<tr>
<th>Region</th>
<th>P (kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SC Coil 1</td>
<td>0.386 ± 0.050</td>
</tr>
<tr>
<td>SC Coil 2</td>
<td>0.082 ± 0.020</td>
</tr>
<tr>
<td>SC Coil 3</td>
<td>0.016 ± 0.008</td>
</tr>
<tr>
<td>SC Coil 4</td>
<td>0.025 ± 0.009</td>
</tr>
<tr>
<td>SC Coil 5</td>
<td>0.006 ± 0.004</td>
</tr>
<tr>
<td>SC Coil 6</td>
<td>0.002 ± 0.002</td>
</tr>
<tr>
<td>SC Coil 7</td>
<td>0.008 ± 0.007</td>
</tr>
<tr>
<td>SC Coil 8</td>
<td>0.014 ± 0.007</td>
</tr>
<tr>
<td>SC Coil 9</td>
<td>0.005 ± 0.004</td>
</tr>
<tr>
<td>SC Coil 10</td>
<td>0.061 ± 0.020</td>
</tr>
<tr>
<td>SC Coil 11</td>
<td>0.135 ± 0.027</td>
</tr>
<tr>
<td>SC Coil 12</td>
<td>0.020 ± 0.010</td>
</tr>
</tbody>
</table>

Total SC power deposition $\approx 0.8 \text{ kW}$
## Power deposition in all regions

<table>
<thead>
<tr>
<th>Region</th>
<th>P (kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SC coils 1–12</td>
<td>0.76 ± 0.07</td>
</tr>
<tr>
<td>Lower Shielding for SC1–3 ((r &lt; 50 \text{ cm}))</td>
<td>1565.5 ± 8.2</td>
</tr>
<tr>
<td>Upper Shielding for SC1–3 ((r &gt; 50 \text{ cm}))</td>
<td>53.6 ± 0.6</td>
</tr>
<tr>
<td>Shielding for SC4–6</td>
<td>35.4 ± 1.3</td>
</tr>
<tr>
<td>Shielding for SC7–9</td>
<td>11.4 ± 0.7</td>
</tr>
<tr>
<td>Shielding for SC10–12</td>
<td>6.2 ± 0.6</td>
</tr>
<tr>
<td>Beam pipe &amp; steel sh. vessels up to Be window</td>
<td>757.4 ± 6.9</td>
</tr>
<tr>
<td>Beam pipe &amp; steel sh. vessels from Be window</td>
<td>77.8 ± 1.7</td>
</tr>
<tr>
<td>Hg Pool Container Vessel</td>
<td>12.4 ± 0.5</td>
</tr>
<tr>
<td>Hg Jet</td>
<td>431.8 ± 2.9</td>
</tr>
<tr>
<td>Hg Pool</td>
<td>342.8 ± 7.3</td>
</tr>
<tr>
<td>Be Window</td>
<td>8.4 ± 0.1</td>
</tr>
<tr>
<td>Total</td>
<td>3303.5 ± 13.5</td>
</tr>
</tbody>
</table>

Total in Hg jet + pool ≈ 775 kW
SC1 power deposition

Radial $P_{\text{peak}} \approx 0.02 \text{ mW/g}$

Azimuth $P_{\text{peak}} \approx 0.01 \text{ mW/g}$
Radial energy deposition for SC2 (mW/g)

Azimuthal energy deposition for SC2 (mW/g)

SC2 power deposition

Radial $P_{peak} \approx 0.01 \text{ mW/g}$

Azimuth $P_{peak} \approx 0.03 \text{ mW/g}$
SC3 power deposition

Radial $P_{\text{peak}} \approx 0.01 \text{ mW/g}$

Azimuth $P_{\text{peak}} \approx 0.01 \text{ mW/g}$
SC4 power deposition

Radial $P_{\text{peak}} \approx 0.01 \text{ mW/g}$

Azimuth $P_{\text{peak}} \approx 0.04 \text{ mW/g}$
SC5 power deposition

Radial $P_{\text{peak}} < 0.01 \text{ mW/g}$

Azimuthal $P_{\text{peak}} < 0.01 \text{ mW/g}$
SC6 power deposition

Radial $P_{\text{peak}} \approx 0.01 \text{ mW/g}$

Azimuth $P_{\text{peak}} \approx 0.04 \text{ mW/g}$
SC7 power deposition

Radial $P_{\text{peak}} \approx 0.03 \text{ mW/g}$

Azimuth $P_{\text{peak}} \approx 0.15 \text{ mW/g}$
SC8 power deposition

Radial $P_{\text{peak}} \approx 0.02 \text{ mW/g}$

Azimuth $P_{\text{peak}} \approx 0.02 \text{ mW/g}$
SC9 power deposition

Radial $P_{\text{peak}} \approx 0.03 \text{ mW/g}$

Azimuth $P_{\text{peak}} \approx 0.09 \text{ mW/g}$
SC10 power deposition

Radial $P_{\text{peak}} \approx 0.26 \text{ mW/g}$

Azimuth $P_{\text{peak}} \approx 0.62 \text{ mW/g}$
SC11 power deposition

Radial $P_{\text{peak}} \approx 0.14 \text{ mW/g}$

Azimuth $P_{\text{peak}} \approx 0.11 \text{ mW/g}$
SC12 power deposition

Radial $P_{\text{peak}} \approx 0.10 \text{ mW/g}$

Azimuth $P_{\text{peak}} \approx 0.31 \text{ mW/g}$
Summary

• Shown Fluka energy deposition results for IDS120j geometry
  – Correction to proton trajectory: beam centre enters Hg pool

• Total power deposition in SC coils below 1 kW

• Most coils have peak energy density below 0.1 mW/g, except for:
  – SC7 has maximum azimuthal peak energy density $\approx 0.15$ mW/g
  – SC10,11,12 have very large peak energy densities, well above ITER limit

• SC4 is OK now, with correction to proton trajectory

• We need more shielding for downstream coils: 7 and 10-12.