Expected Dose Rates around the Collimators
What to Prepare for the upcoming LTC Meeting?

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To Clarify

- What would you like to present at the LTC
  - Locations, Plots, Values, etc…
  - Materials, Comparison?
  - Detailed Geometries

- Time Constraints
  - Stefan and Markus will not be around in June, hence everything has to be prepared until the end of this month (Stefan already leaves in one week!)

- Studies already performed
- New studies necessary?
- Anything Else? Suggestions?
Dose Rates (simplified case)

- Geometry: 10m long tunnel section including (cylindrical approximation)
  - collimator (cylinder) with 7TeV pencil proton beam hitting the center of the front face
  - beam pipe downstream of collimator, copper, 2mm thick,
  - 80 mm inner diameter
  - iron shield, cylindrical shell, 20cm thick (optional)
  - tunnel wall/floor/ceiling, cylindrical shell, 30cm thick

<table>
<thead>
<tr>
<th>collimator material</th>
<th>length (cm)</th>
<th>diameter (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CC</td>
<td>126</td>
<td>6</td>
</tr>
<tr>
<td>Be</td>
<td>135</td>
<td>6</td>
</tr>
<tr>
<td>Cu</td>
<td>50</td>
<td>6</td>
</tr>
</tbody>
</table>

- Loss assumption: $10^{16}$ protons/year, 180 days of continuous operation
- 1 hour, 1 day, 1 week, 1 month, 1 year of cooling
- Results: ambient dose equivalent rates anywhere within the 10m long tunnel section for each collimator material and two scenarios: with iron shield, w/o iron shield
e.g. Copper - Carbon

Dose Rate after one LHC year of operation: 7TeV p-beam, 1E16 protons/year
(Cu Coll Shld: Full Geometry: via full simulation (both sources))

Aisle: 2.2 – 4.5 mSv/h
Shield Outside Peak: ~20 mSv/h
Shield Inside Peak: ~200 mSv/h
Collimator Peak: > 460 mSv/h

10^{16} protons/year,
180 days irradiation
1 day of cooling

Aisle: 1.0 – 2.2 mSv/h
Shield Outside Peak: ~5 mSv/h
Shield Inside Peak: ~50 mSv/h
Collimator Peak: ~ 100 mSv/h
Copper: Shielded - Unshielded

Aisle Peak: 2.2 – ~50 mSv/h
Collimator Peak: > 460 mSv/h

10^{16} protons/year,
180 days irradiation
1 day of cooling

Shield Outside Peak: ~20 mSv/h
Shield Inside Peak: ~200 mSv/h
Collimator Peak: > 460 mSv/h
Carbon: Shielded - Unshielded

Aisle: 0.22 – 2.2 mSv/h
Collimator Peak: > 22 mSv/h

Shield Outside Peak: ~5 mSv/h
Shield Inside Peak: ~50 mSv/h
Collimator Peak: ~100 mSv/h

10^{16} protons/year,
180 days irradiation
1 day of cooling
Carbon: Contribution from the Wall

Inner Contribution (Shield, Pipe, Collimator)
Aisle: 0.5 – 1.0 mSv/h

Outer Contribution (Wall)
Aisle: 1.0 – 2.2 mSv/h

$10^{16}$ protons/year,
180 days irradiation
1 day of cooling

Dose Rate after one LHC year of operation: 7TeV p-beam, 1E16 protons/year
(CC Coll Shld: Full Geometry: via full simulation (inner sources))

Dose Rate after one LHC year of operation: 7TeV p-beam, 1E16 protons/year
(CC Coll Shld: Full Geometry: via full simulation (outer sources))
Remanent Dose Rate (Max!)

- Collimator: Shielding (ins) Shielding (out)
  - Be: 20mSv/h 40mSv/h 3mSv/h
    - Dominated by $^7$Be (53d) and $^{11}$C (20.5min)
  - C: 20mSv/h 40mSv/h 3mSv/h
    - Dominated by $^7$Be (53d), $^{11}$C (20.5min)
  - Cu: 650mSv/h 100mSv/h 6mSv/h
    - Dominated by $^{42}$K (12.4h), $^{44}$Sc (4h), $^{56}$Mn (2.6h), $^{61}$Cu (3.3h), $^{61}$Cu (12.7h)
  - W: >1Sv/h 100mSv/h 10mSv/h

- Beam pipe (Copper):
  - Be: Peak: 20mSv/h ~ 2 – 10 mSv/h within the first 10 m downstream
  - C: Peak: 20mSv/h ~ 2 – 10 mSv/h within the first 10 m downstream
  - Cu: Peak: 300mSv/h ~ 2 – 10 mSv/h within the first 10 m downstream
    - Dominated by $^{42}$K (12.4h), $^{44}$Sc (4h), $^{56}$Mn (2.6h), $^{61}$Cu (3.3h), $^{61}$Cu (12.7h)
Dose rates (more realistic case)

- Geometry: 30m long tunnel section including (realistic geometry)
  - CC collimator, 252 cm length (~two former Cu-Coll), design as used for Vacuum study
  - quadrupole magnet at ~3.5 m downstream of the collimator
  - copper beam pipe, 2 mm thick, ~40 mm inner diameter
  - various flanges
  - iron shield, 20cm thick (optional)
  - tunnel wall/floor/ceiling
- Loss assumption: $10^{16}$ protons/year, 180 days of continuous operation
- 1 hour, 1 day, 1 week, 1 month, 1 year of cooling
- Results: ambient dose equivalent rates anywhere within the 30m long tunnel section for each collimator material and two scenarios: with iron shield, w/o iron shield
More Realistic Simulation

$10^{16}$ protons/year, 180 days irradiation, 1 day of cooling

Dose Rate after one LHC year of operation: 1TeV p-beam, 1E16 part.
(Carbon Collimator Full Geometry: via full simulation)