COLLISION DEBRIS
ON THE TRIPLET QUADRUPOLES

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optics input by R. Martin and R. Tomas

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BUILDING UPON WASHINGTON

- the final focus triplet magnets are mainly impacted by pions captured by the quadrupole field

- several factors (in particular the crossing angle/plane and the coil aperture) determine the peak energy deposition profile in the superconducting coils

- a continuous shielding liner inside the aperture, absorbing a power of a few kW at 5L₀, represents an essential protection solution, weakened by the interconnection gaps

- the challenge concerns especially the magnet lifetime (cumulated dose) rather than their operation conditions (steady power density)
L* = 45m LAYOUT

89 urad half crossing angle
50 mm ID TAS aperture

15 mm tungsten shielding

107 T/m 205 mm
89-86 T/m 248 mm
COMPARISON WITH PREVIOUS LAYOUTS ($L^*$)

the difference is made by the considerably larger coil aperture (>200mm) wrt $L^*$=36m (100mm) and $L^*$=61m (140mm)
HORIZONTAL vs VERTICAL CROSSING

well localized hot spots, reflecting the interplay of crossing plane and magnetic configuration
CROSSING POLARITY & PLANE ALTERNATION

idea by S. Farthouk (CERN BE-ABP)

equalizing the dose in three spots, a reduction of more than 35% can be achieved on the maximum dose, i.e. a 60% lifetime increase
**OPTIMIZED Q1 SPLITTING**

Idea by R. Martin (CERN BE-ABP)

<table>
<thead>
<tr>
<th>L$^* =$36m</th>
<th>length [m]</th>
<th>gradient [T/m]</th>
<th>coil ID [mm]</th>
<th>W thick. [mm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1A</td>
<td>10</td>
<td>239</td>
<td>92</td>
<td>21</td>
</tr>
<tr>
<td>Q1B</td>
<td>10</td>
<td>200</td>
<td>110</td>
<td>24</td>
</tr>
<tr>
<td>Q2A&amp;B</td>
<td>17.5</td>
<td>189</td>
<td>115</td>
<td>15</td>
</tr>
<tr>
<td>Q3</td>
<td>20</td>
<td>191</td>
<td>115</td>
<td>15</td>
</tr>
</tbody>
</table>

The maximum dose at the Q1 (non-IP) end is counteracted by increasing in Q1b the coil aperture and the absorber thickness, thanks to relaxed beam aperture requirements in Q1. Q1a provides strength compensation.

The lifetime gets limited by downstream lower maxima.
L* = 45m LAYOUT WITH SPECTROMETER

-60 urad horizontal kick (on the incoming beam)
+42 urad hor. kick (on the inc. beam)
detector spectrometer
dipole compensator

1.5 T
-110 urad half horizontal crossing angle
(-18 internal -92 external)
intended to mimic the real case of +110
(+18+92, same sign i.e. worse combination)

the detector spectrometer alters the peak dose profile in the triplet, inducing a significant increase of the maximum dose
the alternate case (in reality - internal + external) features a smaller crossing angle at the IP, pointing to 0 (x>0) as well, but through an opposite spectrometer polarity.
VERTICAL CROSSING [I]

+85 urad half vertical crossing angle
(internal horizontal angle fully compensated by external correction)

the detector spectrometer alters the peak dose profile in the triplet, without a significant increase of the maximum dose
VERTICAL CROSSING [II]

Three degrees of freedom:
- opposite spectrometer polarity moves the $\pi$ peak to 0
- external angle inversion moves the $\pi/2$ peak to $-\pi/2$
- triplet polarity inversion (FDDF into DFFD)

-60 urad horizontal spectrometer kick (on the incoming beam)
CONCLUSIONS

The $L^*=45m$ layout benefits from a very large coil aperture, keeping the maximum dose at $40 \text{ MGy per } 5\text{ab}^{-1}$ with 15mm tungsten shielding (at 33 MGy for horizontal crossing), provided a suitable extension of the absorber in the interconnections is guaranteed.

Regular crossing plane and vertical angle polarity alternation would allow to go down to 25 MGy per 5ab$^{-1}$ in both high luminosity insertions, yielding a 60% lifetime increase for the triplet (Q1).

The detector spectrometer changes (worsens) the picture, but not drastically, opening to the possible exploitation of several degrees of freedom (internal and external angle polarities and triplet polarity).