LHC WITH LONG RANGE COMPENSATION

Ulrich Dorda

SLAC, LARP Mini-Workshop on Beam-Beam Compensation 2007
Outline

1 MODELL etc
2 NOMINAL LHC
3 PACMAN
4 UPGRADE
BBTrack: weak-strong tracking code
Linear Transfer matrices between nonlinear elements
Stability defined by Liapunov criterion (300,000 turns)

Tunes (tune diffusion) with help of sussix (incorporated in BBTrack)
IP1 & IP5 only
Position: 104m from IP (reserved), defined by equal $\beta$ functions (or ratio corresponding to the average beam-beam encounter).

- Required wire - current: 81Am
- Average beam-beam separation: $9.5\sigma \rightarrow$ enough for the compensation to work and for the wire to be in the shade of the collimators.
- $\beta_{wire} \approx 1800 \rightarrow$ enough to place a wire with finite extensions.
NOMINAL LHC II

Uncompensated

- $Q_x$ range: 0.290 to 0.330
- $Q_y$ range: 0.300 to 0.325
- Color scale from 1 to 10

Graph shows the compensated and uncompensated regions in the $Q_x-Q_y$ plane.
NOMINAL LHC II

Uncompensated

Wire-compensated
Uncompensated

\[
DA = 5.4\sigma
\]

The color indicates the tune diffusion.
Uncompensated

$DA = 5.4\sigma$

Wire-compensated

$DA = 7.2\sigma$

The color indicates the tune diffusion. Lower amplitude particles are also “stabilized”.
The color indicates the DA.
It works for all Phaseadvances (overall tune constant).
Color = Tune diffusion
DC CURRENT: PACMAN vs. NOMINAL BUNCH

![Graph showing DC current comparison between PACMAN and nominal bunch]

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### 3 Alterantives are studied

<table>
<thead>
<tr>
<th>variable</th>
<th>nominal N</th>
<th>low $\beta$</th>
<th>Compact</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta_\star$ [m]</td>
<td>0.55</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>particles/bunch [$10^{11}$]</td>
<td>1.5</td>
<td>1.15</td>
<td>1.15</td>
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<tr>
<td>#LRBBBs</td>
<td>15</td>
<td>17</td>
<td>21</td>
</tr>
<tr>
<td>wire position [m]</td>
<td>104</td>
<td>136</td>
<td>170</td>
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<tr>
<td>$\beta_{\text{wire}}$ [m]</td>
<td>1780</td>
<td>3299</td>
<td>2272</td>
</tr>
</tbody>
</table>

![Graph showing data distribution](image-url)
UPGRADE I - INCREASE N

Uncompensated

Wire-compensated

$DA = 4.33$

$DA = 6.33$
Uncompensated

$DA = 5.16$

Wire-compensated

$DA = 7.1$
UPGRADE III - COMPACT

Uncompensated

Wire-compensated

$DA = 4$

$DA = 5.2$
CONCLUSIONS

- Wire compensation works
- Wire compensation should become part of the 'official' roadmap phase 1 upgrade
- Low $\beta$-max optics is the better one.