s2e simulation of FLASH with 3\textsuperscript{rd} harm. section + coupler kicks

Igor Z.: s2e simulation of FLASH with 3\textsuperscript{rd} harm. section without coupler kicks

Simulation on the way: cpu time

Model for rf coupler kicks

Extra ASTRA loop

Simulation:
- Trajectory
- After BC3
- After DOGLEG (with 20000 particles)

Preliminary conclusion
3D simulation with space charge + cavity wakes + self fields in BCs.
8. March 2009
CPU time (mafia-2)

<table>
<thead>
<tr>
<th>L/m</th>
<th>L/m</th>
<th>L/m</th>
<th>L/m</th>
<th>L/m</th>
<th>L/m</th>
<th>L/m</th>
<th>L/m</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.6</td>
<td>11.2</td>
<td>7.3</td>
<td>6</td>
<td>42.3</td>
<td>16</td>
<td>70.5</td>
<td>9</td>
</tr>
<tr>
<td>t/h</td>
<td>t/h</td>
<td>t/h</td>
<td>t/h</td>
<td>t/h</td>
<td>t/h</td>
<td>t/h</td>
<td>t/h</td>
</tr>
<tr>
<td>0.75</td>
<td>3.33</td>
<td>1.97</td>
<td>0.02</td>
<td>12.32</td>
<td>0.04</td>
<td>22.47</td>
<td>0.12</td>
</tr>
<tr>
<td>8.52</td>
<td>10.13</td>
<td>6.13</td>
<td>0.10</td>
<td>37.58</td>
<td>0.35</td>
<td>65.36</td>
<td>39.00</td>
</tr>
<tr>
<td>(A)</td>
<td>6.27</td>
<td>31.25</td>
<td>18.55</td>
<td>0.10</td>
<td>118.28</td>
<td>0.35</td>
<td>189.9 (B - 61.5m)</td>
</tr>
</tbody>
</table>

total ASTRA cpu time

- 20000 particles with couplers: 54.09 h = 2 d 6.09 h
- 200000 particles without couplers: 166.72 h = 6 d 22.72 h = 0.99 w
- 200000 particles with couplers: 392.02 h = 16 d 8.02 h = 2.33 w

most of CPU time required for coupler kicks ?!!?
rf coupler kicks
(3.9 GHz = estimated)

generate artificial coupler fields + geometry transformations + …

extra ASTRA loop
  (autophasing & phasing)

pre processing:
  distribution = offset + slice-offset + input-distribution
  match to design optics

ASTRA processing:
  prepare ASTRA template
  extract particle # 1
  auto phasing (run ASTRA with 1 particle without space charge)
    auto phasing = off; add “auto-phases”+”set-phases”
  run ASTRA with distribution

post processing:
  manage offset and slice-offset
  add wakes
trajectory

without corrections

(without couplers)

with corrections

\[ \langle x \rangle = 0, \langle x' \rangle = 0, \langle y \rangle = 0, \langle y' \rangle = 0 \]
after BC3

**NO coupler kick**

- horizon vs. longitudinal
- vertic vs. longitudinal
- horizon-prime vs. longitudinal
- vertic-prime vs. longitudinal

**with coupler kick**

- horizon vs. longitudinal
- vertic vs. longitudinal
- horizon-prime vs. longitudinal
- vertic-prime vs. longitudinal

not quite the same plane!
after BC3

... either modified auto-phasing (ASTRA) or sensitivity to kick
after BC3

**NO coupler kick**

Projected emittance:

\[
\begin{pmatrix}
1 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 \\
0 & 0 & 1 & 0 \\
0 & 0 & 0 & \gamma_{\text{ref}}
\end{pmatrix}
\begin{pmatrix}
\alpha_x \\
\beta_x \\
\gamma_x \\
\gamma_{\text{ref}}
\end{pmatrix}
= 
\begin{pmatrix}
-0.072 \\
6.244 \\
0.161 \\
3.752 \times 10^{-6}
\end{pmatrix}
\]

Slice emittance:

Current / A:

**with coupler kick**

Projected emittance:

\[
\begin{pmatrix}
1 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 \\
0 & 0 & 1 & 0 \\
0 & 0 & 0 & \gamma_{\text{ref}}
\end{pmatrix}
\begin{pmatrix}
\alpha_y \\
\beta_y \\
\gamma_y \\
\gamma_{\text{ref}}
\end{pmatrix}
= 
\begin{pmatrix}
0.163 \\
11.240 \\
0.091 \\
1.627 \times 10^{-6}
\end{pmatrix}
\]

Slice emittance:

Current / A:
after DOGLEG

200000 particles

No coupler kick \( x_{av} = -0.406 \)

With coupler kick \( x_{av} = -0.332 \)

20000 particles → numerical \( \mu \)-bunch instability!
preliminary conclusion

weak differences (slice emittance & long. phase space) after BC2
   time dependent part of rf-kick should be negligible after BC2!

   differences even in longitudinal phase space after BC3
   possible reasons: ASTRA auto phasing;
       slightly different reference planes (more additional length
         after BCs for CSRtrack runs);
   real effect
   tuning required

rf coupler kick is not quite trivial; system is sensitive!

numerical $\mu$-bunch instability $\rightarrow$ more particles / other smoothing methods

CPU time $\rightarrow$ wait / parallel computing / no coupler kicks after BC2 /
   other model (f.i. space charge impedance instead of ASTRA)