some tools for longitudinal phase space

LiTrack

random distributions $\rightarrow$ uncorrelated energy spread but with noise
rf, BCs, cavity wakes, non linear effects
MATLAB

improvements:
S.Lange & M.Clemens, HSU
GUI, optimizer (genetic alg.), ‘knobs’
wish list: SC wakes, search insensitive working points, …

recursive $\mu$-bunch analysis

SC impedance, linear working point, periodic boundary conditions
systematic distributions; energy profiles of laser heater
$\rightarrow$ gain curves
MathCAD

non linear effects without over-compression (MathCAD)

a) working point sensitivity without wakes; (polynomials)
b) shape sensitivity with cavity wakes and SC effects; (syst. distr.)
recursive μ-bunch analysis

\[ S = S(s, \delta E) = \frac{s}{\Pi_c} + \text{Re}\{a \cdot e^{ik_s}\} + c \delta E \quad a = a(\delta E) \]

\[ E = E(s, \delta E) = E_0 + E'_0 \frac{s}{\Pi_c} + \text{Re}\{b \cdot e^{ik_s}\} + d \delta E \quad b = b(\delta E) \]

<table>
<thead>
<tr>
<th>BC</th>
<th>RF</th>
<th>impedance</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \tilde{S} = S - r_{56} (E - E'_0)/E_0 )</td>
<td>( \tilde{S} = S )</td>
<td>( \tilde{S} = S )</td>
</tr>
<tr>
<td>( \tilde{E} = E )</td>
<td>( \tilde{E} = E + \Delta E + \Delta E'S )</td>
<td>( \tilde{E} = E + \text{Re}{ge^{ik\Pi_cS}} )</td>
</tr>
<tr>
<td>( \tilde{E}_0 = E_0 )</td>
<td>( \tilde{E}_0 = E_0 + \Delta E )</td>
<td>( \tilde{E}_0 = E_0 )</td>
</tr>
<tr>
<td>( \tilde{E}'_0 = CE'_0 )</td>
<td>( \tilde{E}'_0 = E'_0 + \Delta E' )</td>
<td>( \tilde{E}'_0 = E'_0 )</td>
</tr>
<tr>
<td>( \tilde{\Pi}_c = \Pi_c C )</td>
<td>( \tilde{\Pi}_c = \Pi_c )</td>
<td>( \tilde{\Pi}_c = \Pi_c )</td>
</tr>
<tr>
<td>( \tilde{a} = a - \frac{r_{56}}{E_0} b )</td>
<td>( \tilde{a} = a )</td>
<td>( \tilde{a} = a )</td>
</tr>
<tr>
<td>( \tilde{b} = b )</td>
<td>( \tilde{b} = a\Delta E' + b )</td>
<td>( \tilde{b} = b + ge^{ik\Pi_c\delta E} )</td>
</tr>
<tr>
<td>( \tilde{c} = c - \frac{r_{56}}{E_0} d )</td>
<td>( \tilde{c} = c )</td>
<td>( \tilde{c} = c )</td>
</tr>
<tr>
<td>( \tilde{d} = d )</td>
<td>( \tilde{d} = c\Delta E' + d )</td>
<td>( \tilde{d} = d )</td>
</tr>
</tbody>
</table>
uncorrelated energy spread

\[ E_{\text{rms}} = 10 \text{ keV} \]

\[ P(\delta E) \]

\[ \begin{align*}
\text{gaussian} \\
\text{real LH}
\end{align*} \]

\[
I_{\text{noise, rms}} \approx \sqrt{\frac{e \lambda}{\pi \omega}} \int_{\omega > 0} |G|^2 d\omega
\approx 210 \text{ A}
\]

\[
G = \frac{1}{C_x} \frac{I_{\text{mod, x}}}{I_{\text{mod, 0}}}
\]

after dogleg
(r56=0.84mm)

after BC2
(C2=5,
r56=-20.7mm)

after BC1
(C1=20,
r56=-103mm)
shape sensitivity

from Kirsten Hacker

Coaxial cable impedance matching model
Tapered to SMA connector to maximize bandwidth of output

signal analysis (zero crossing)
→ center of mass of bunch with very high resolution
design

\[
\frac{I}{A}
\]

\begin{align*}
\text{initial current (100 x scaled)} \\
\text{current after BC1 (5 x scaled)} \\
\text{current after BC2}
\end{align*}

\[
\frac{c \cdot t}{mm}
\]
bunch charge reduced by 5%

- initial current (100 x scaled)
- current after BC1 (5 x scaled)
- current after BC2
no laser heater!

0.5% modulation at $\lambda = 0.6$ mm

gain without/with LH = 390 / 19
"dip"

initial current (100 x scaled)
current after BC1 (5 x scaled)
current after BC2

no laser heater!
gain at $\lambda = 1$ mm
without/with LH = 39 / 18