Longitudinal SC Amplifier

s2e seminar, NOV. 2012: still not on homepage

BC-chicanes in FODO structure

long. phase-sp.  
$\Delta\mathcal{E}/\text{MeV}$

$\rightarrow s/\mu\text{m}$

$-10 \rightarrow 10$

$\rightarrow s/\mu\text{m}$

$-10 \rightarrow 10$

$\rightarrow I/\text{A}$

$\rightarrow s/\mu\text{m}$

$\rightarrow I/\text{A}$

$\rightarrow \lambda/\mu\text{m}$

$F(\omega)$

$F(0)$

$-10 \rightarrow 10$

$-10 \rightarrow 10$

$z = 1.3 \text{ m}$ after stage 1

$z = 2.5 \text{ m}$ after stage 2

$z = 3.7 \text{ m}$ after stage 3

$z = 4.9 \text{ m}$ after stage 4

$z = 6.1 \text{ m}$ after stage 5

$z = 7.3 \text{ m}$ after stage 6
Parameters
(after discussion with Florian Grüner)

particles: \[ q = 40 \text{ pC} \]
\[ \sigma_{\parallel} = 1.5 \text{ \mu m} \]
\[ E_{\text{av}} = 300 \text{ MeV} \]
\[ E_{\text{rms}} = 0.6 \text{ MeV} \]
\[ \epsilon_n = 0.2 \text{ \mu m} \]
\[ \sigma_x = \sigma_y \approx 0.5 \text{ \mu m} \]

250E6 electrons \[ \hat{I} = 3.2 \text{ kA} \]

slice energy spread

waist \[ \rightarrow \alpha = 0, \beta = 0.7 \text{ mm} \]

correlated spread is neglected in the following (small compared to SC induced correlation)

matching to FODO:

to be investigated !!!

example (without SC):
\[ \alpha_x = \alpha_y = 0 \]
\[ \beta_x = \beta_y = 0.7 \text{ mm} \]

to FODO lattice with
\[ L_p = 1 \text{ m} \]
\[ \varphi = 71 \text{ deg} \]
calculation with 100E6 particles for 40 pC
first test run; 3D SC solver; resolution 5.8 μm transverse, 10 nm longitudinal (= cell size);
lattice: FODO, period = 60 cm, phase advance 90 deg; BC 4 magnet chicane, r56 = 10.8 μm
total length = 11.05 m

bunch: normalized emittance 0.2 μm; approximately matched to lattice (with s.c.)

calculation: step width 2cm (or smaller); no self effects in bending magnets;
total cpu time 150 000 sec; sc-step 250 sec; on MPY28MAFIA4
amplitude/(arb. units) vs. lambda
EM Field for some (predefined) Source Fields

field 2d object: solve 2d integral

a) stiff 2d object f.i. disc

b) time dependent 2d object

extreme ratio:

Flash: 1.2 GeV, $\varepsilon_n \approx 1 \, \mu m$, $\beta \approx 5 \, m$
$\rightarrow \sigma_r \approx 50 \, \mu m$, $\lambda_{ph} \approx 5 \, \text{nm}$
ratio $1\text{E}4 : 1$

XFEL: 15 GeV, $\varepsilon_n \approx 1 \, \mu m$, $\beta \approx 5 \, m$
$\rightarrow \sigma_r \approx 10 \, \mu m$, $\lambda_{ph} \approx 0.1 \, \text{nm}$
ratio $1\text{E}5 : 1$

SC ampl.: 300 MeV, $\varepsilon_n \approx 0.2 \, \mu m$, $\beta \approx 0.5 \, m$
$\rightarrow \sigma_r \approx 10 \, \mu m$, $\lambda_{ph} \approx 100 \, \text{nm}$
ratio $100 : 1$