Compact ERL for THz Radiation

High-rep. THz radiation facility:

- 1 to 20 THz
- Radiation with bandwidth smaller than 2%
- Single cycle emission

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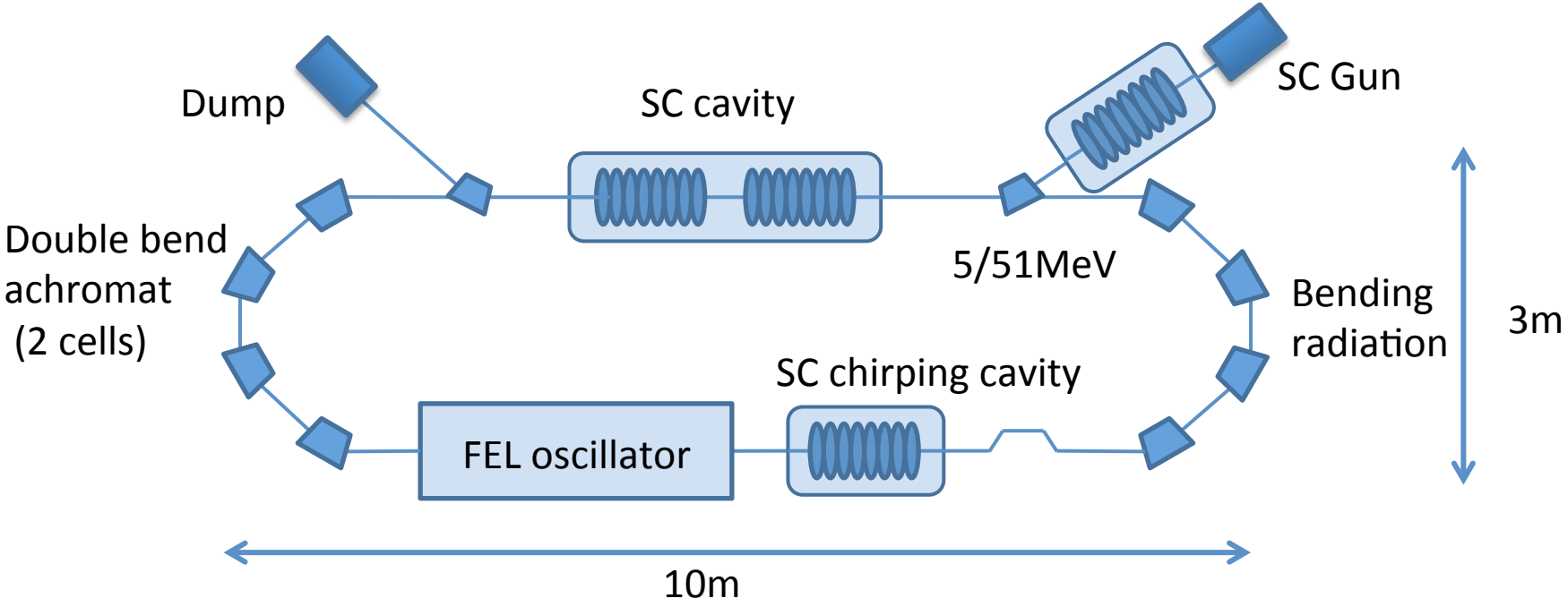
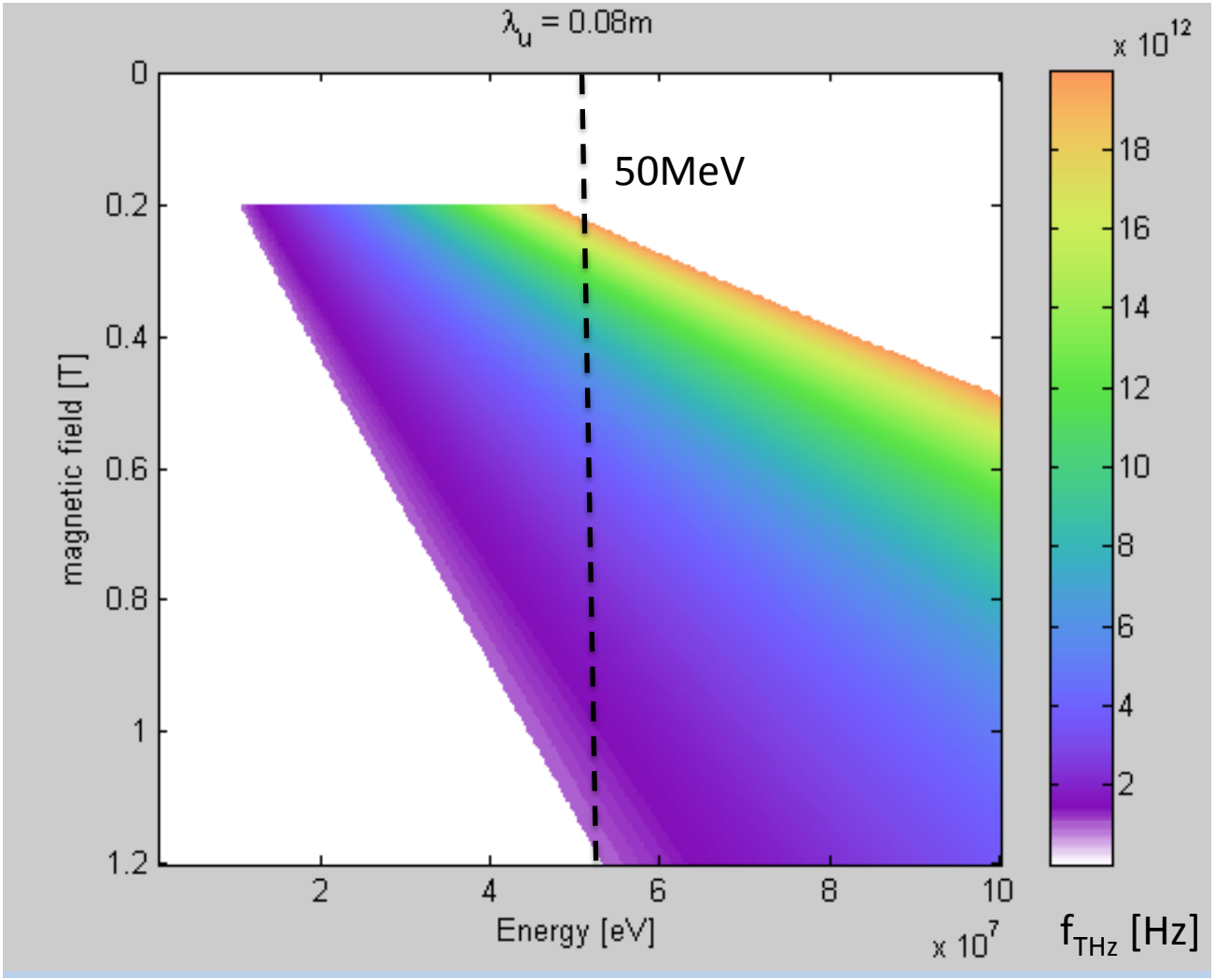
Machine layout and beam parameters

Bunch repetition rate	Up to 1.3GHz
Electron Peak Current	30A
RMS bunch duration	5ps (250pC)
Electron energy	51MeV
Electron energy spread	0.5%
Bending radius	16 cm



1. FEL oscillator

Choice of Undulator Parameters



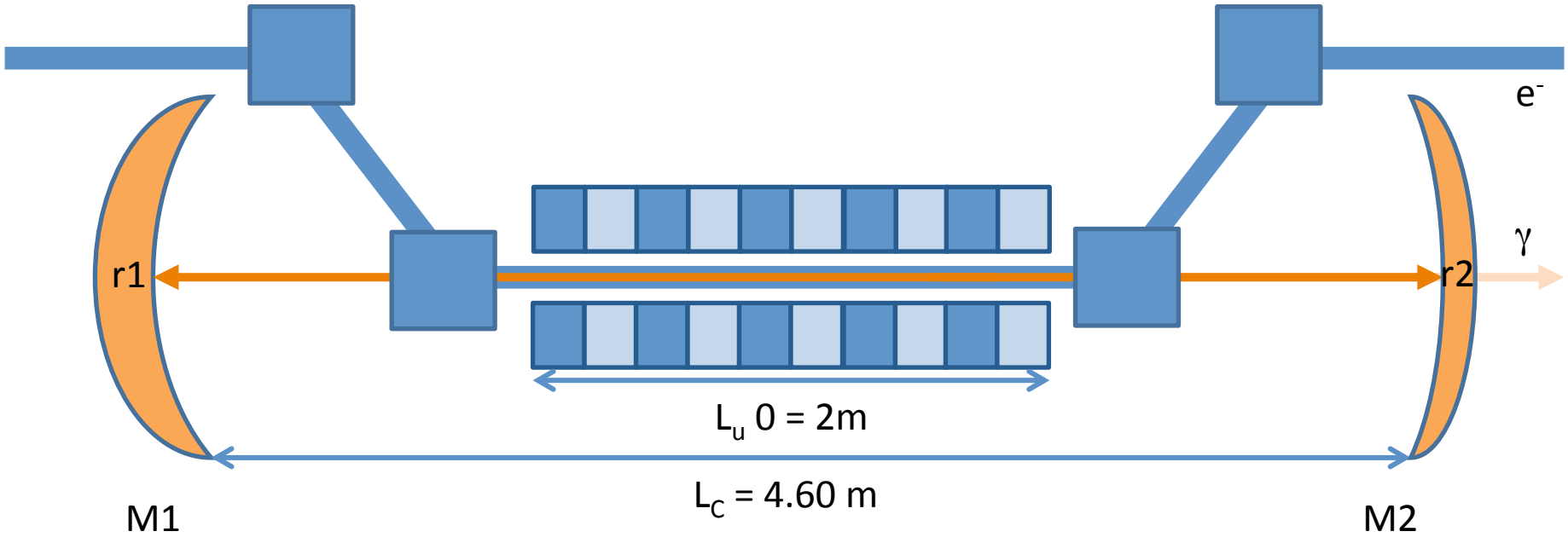
B = 0.25 - 1.2T

K = 1.86 - 8.18

For chosen λ_u, highest possible e^- energy for PM undulator.

FEL Oscillator Parameters

Undulator Parameters	Value
Period of undulator	8cm
Required maximum field strength	1.2T
Undulator length	2m
Mirror spacing	4.60m (roundtrip frequency: 32.59MHz)
Nr. of THz-pulses in oszillator	40

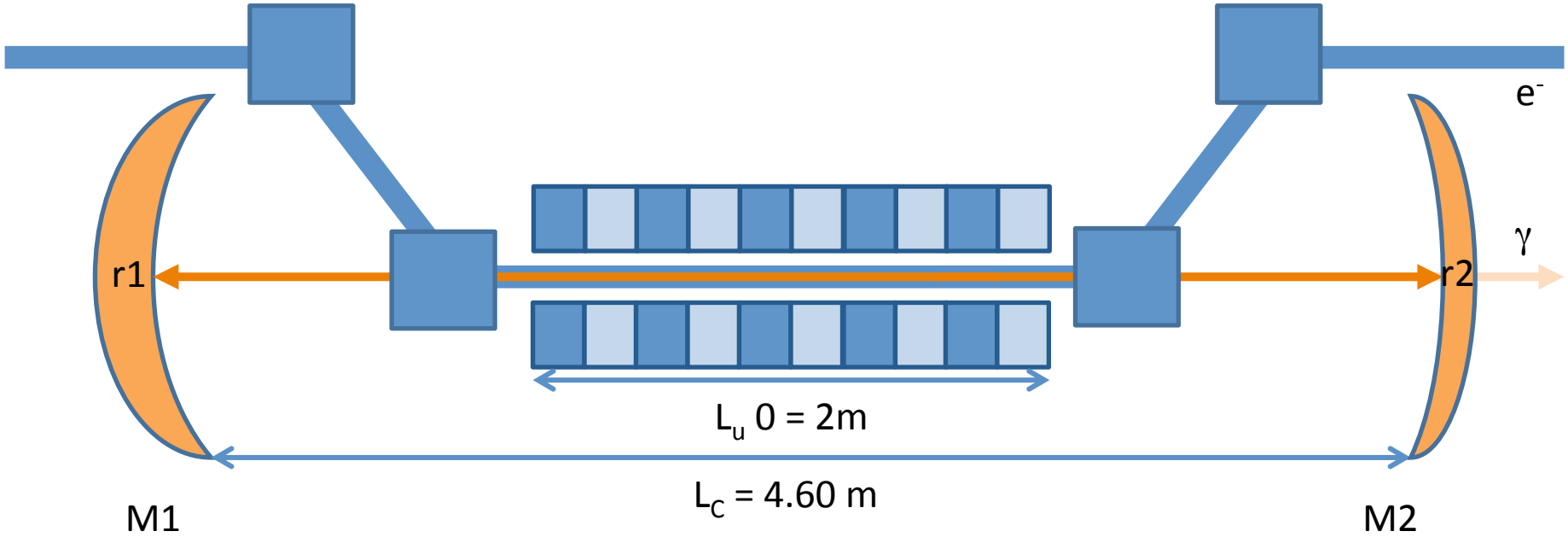


FEL Oscillator Parameters

Mirror Parameters	Value
Material	Ag 200 nm coated Cooper Crystal
Focus length f	4 m
Radius r1 = r3	8 m
Reflectivity R2	0.95
Thickness M1	5 mm
Thickness M2	2 mm

$2f = r > L_C/2$

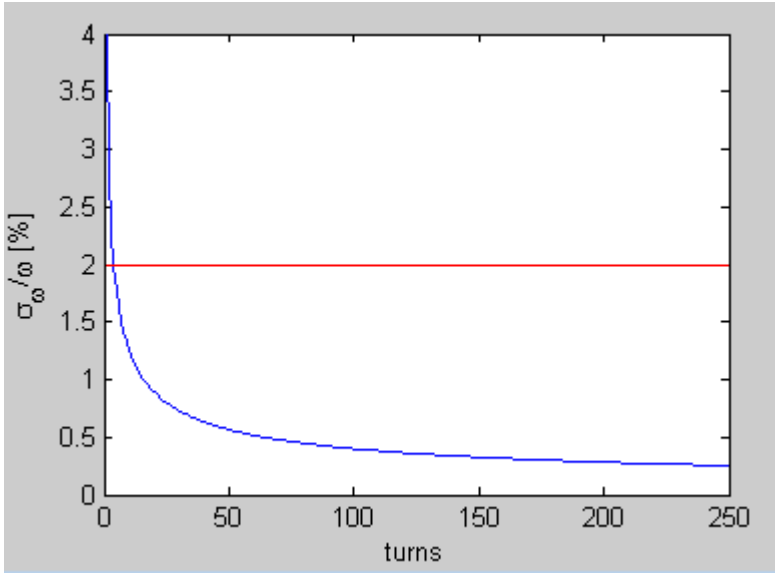
P. Tan et al. Proceedings of IPAC2012, New Orleans, TUPPP059



FEL Oscillator Performance

$$P_{sat} = \frac{P_{beam}}{2N_u(1-R)} = 600MW$$

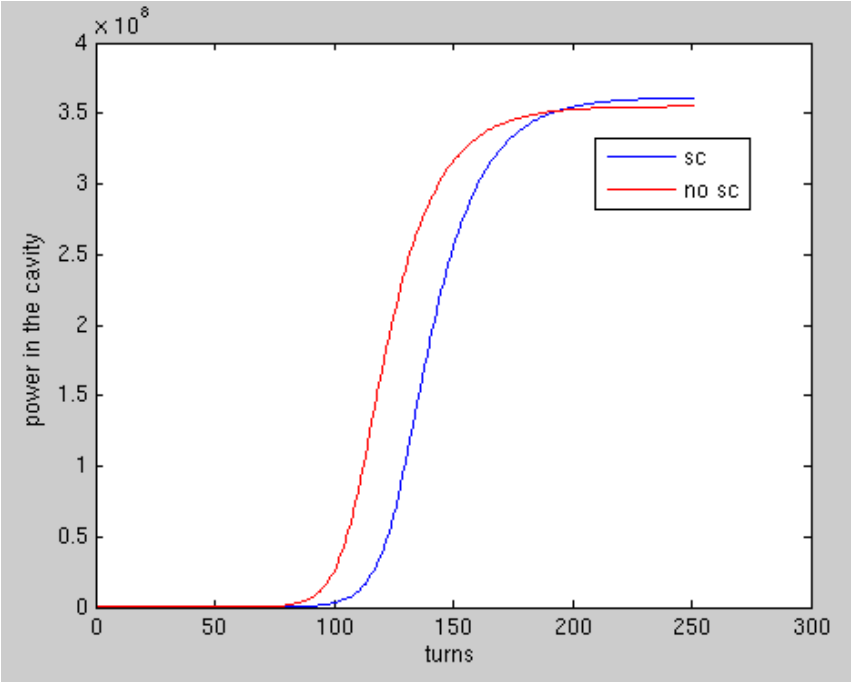
$$P_{out} = 30MW \qquad E \approx P\Delta t \approx 300\mu J$$



$$\left(\frac{\sigma_\omega}{\omega}\right) = \frac{\lambda}{4\pi\sigma_z}$$

Wavelength	bunch length	FEL energy	Avg P
1 – 20 THz	5ps	300uJ	400kW

FEL Oscillator Performance



- GENESIS 1.3 steady state simulation shows 350MW peak power in the cavity.
- Less power because of 3D effects.

Wavelength	bunch length	FEL energy	Avg P
1 – 20 THz	5ps	175uJ	230kW

2. Bunch compression

FEL wants a couple of tens of Amperes for the space charge to have a small effect.

$$I \approx 30\text{A} \qquad \sigma_t > 5\text{ps}$$

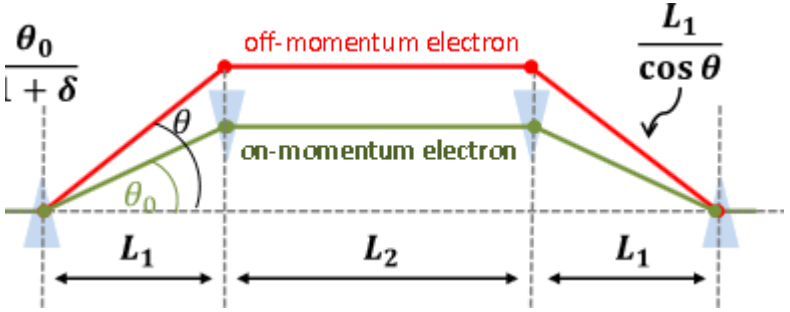
For CSR we need small bunch length to radiate coherently, high charge for high power:

$$I \approx 200\text{A} - 5\text{kA} \qquad \sigma_t < 50\text{fs}$$

Bunch compressor (assuming compression from 5 ps to 50 fs (but for factor 200 designed))

$$B_{dipole} \approx 0.05\text{T}, L_{dipole} = 0.5\text{m}, L_1 = 0.8\text{m}, L_2 = 1\text{m}, \sigma_\delta = 0.05$$

R_{56} = 5cm



Cavity

$$V_0 = 12.6\text{MV}, f_{rf} = 3.9\text{GHz}$$

3. THz single cycle using CSR

$$\sigma_z \approx c/\omega \qquad P_{csr} = N^2 x \frac{e^2 c}{\varepsilon_0} \frac{1}{\rho^{2/3} \sigma_z^{4/3}} \qquad E \approx \frac{P}{2f}$$

For E = 1uJ and B = 1T

P_{avg} = 1.3kW @ 1.3GHz

f [THz]	σ_z [fs]	Q [pC]	compression factor
1	150	1050	35
2	80	936	60
3	53	875	100
10	16	717	300