Electron Outcoupling Scheme for the Novosibirsk FEL

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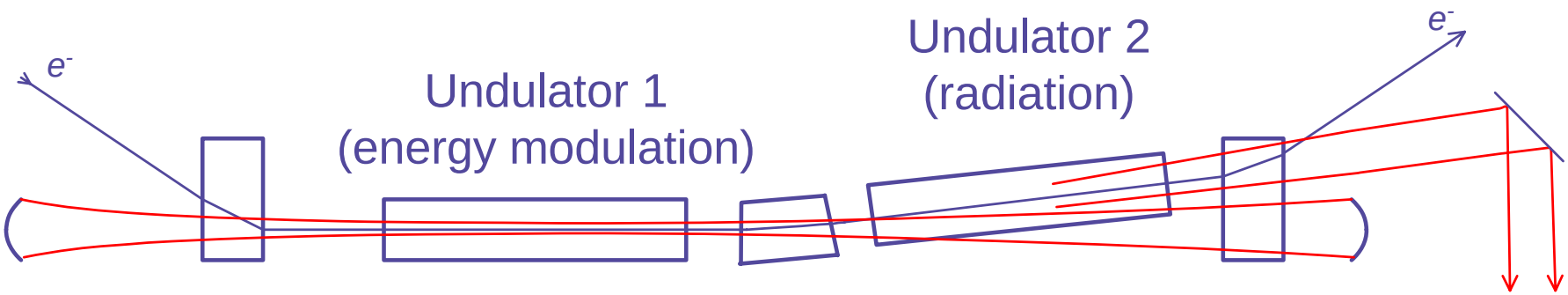
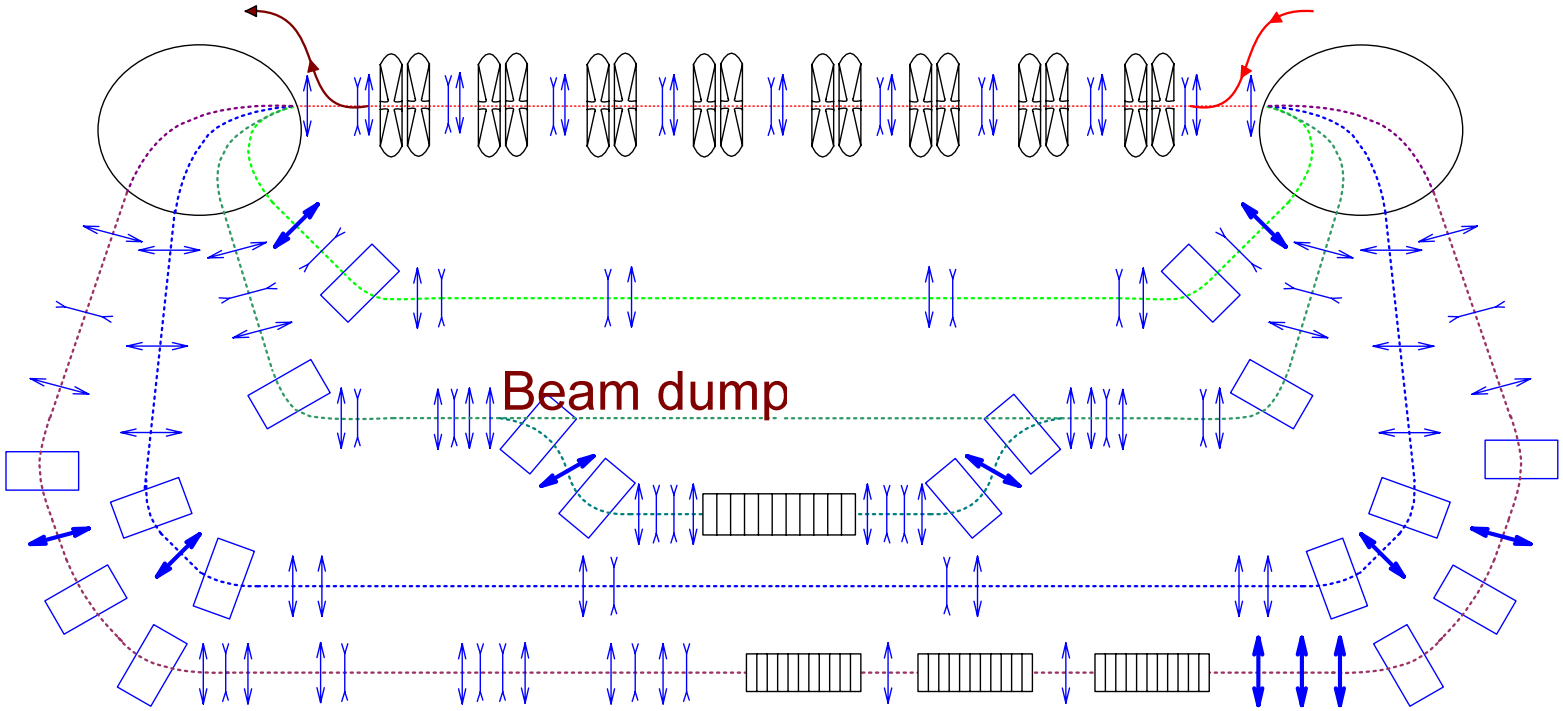
Schematic diagram of electron outcoupling



Why electron outcoupling?

- lower load on optical cavity mirrors
- wavelength tunability (high power partially transparent mirrors have narrow band)

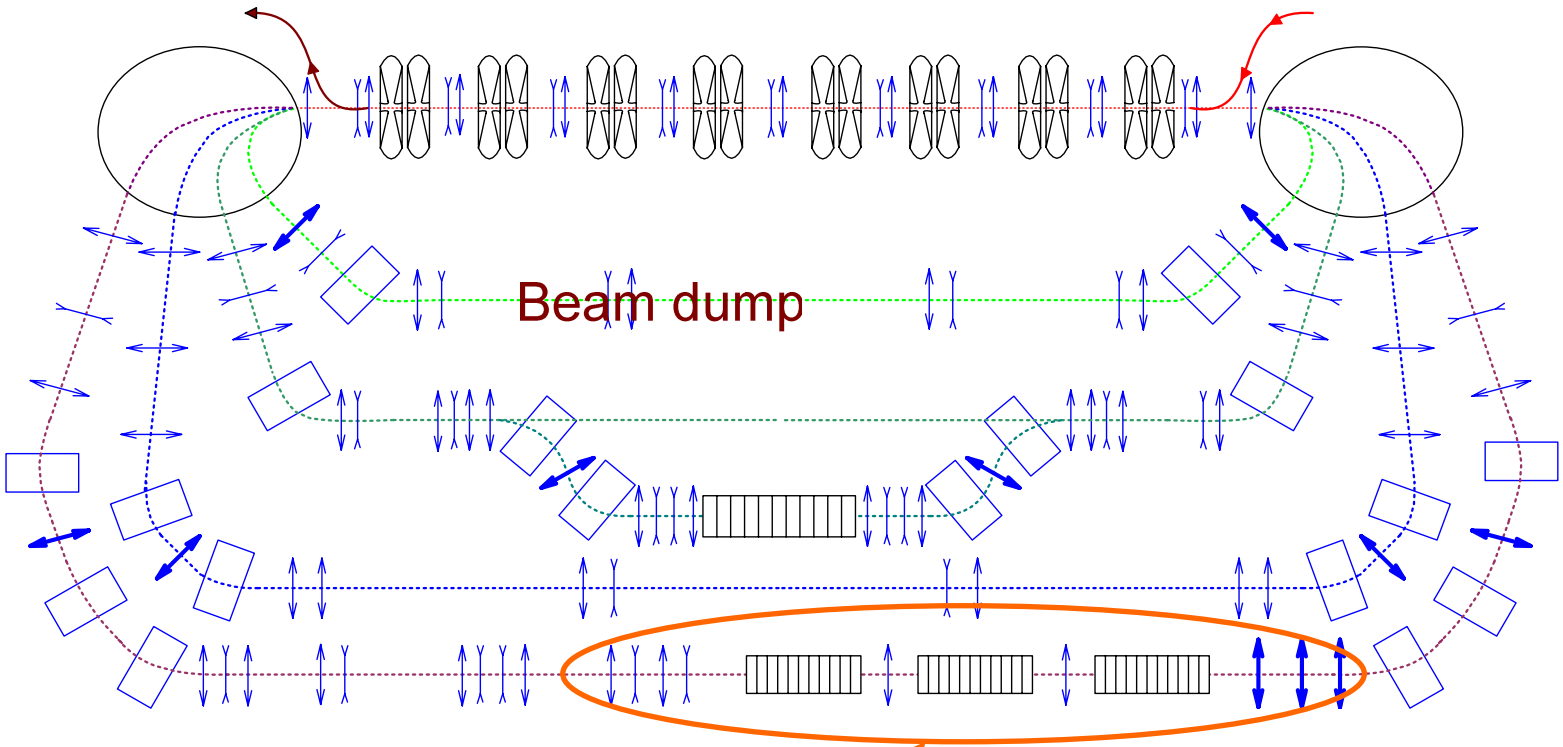
Second stage of the Novosibirsk FEL (under construction now)



Electron beam and laser radiation parameters

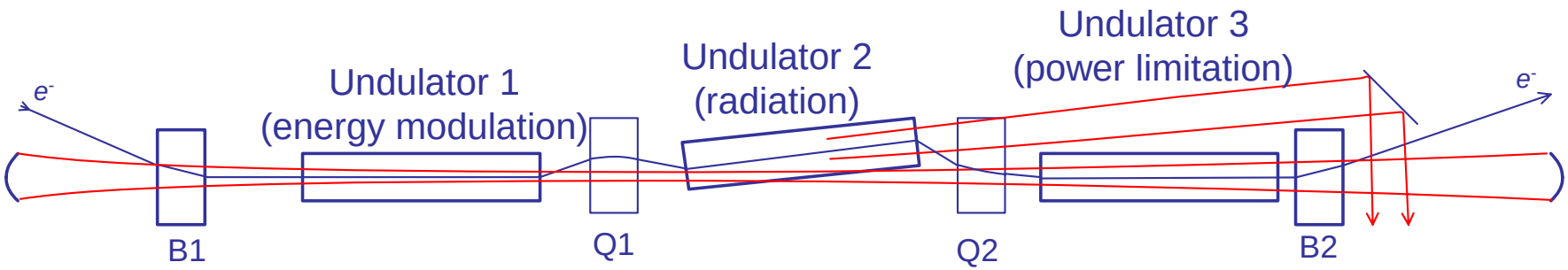
Energy, MeV	40
Peak current, A	100
Electron beam emittance (normilized), μm	20
Relative energy spread	$3 \cdot 10^{-3}$
Undulator period, cm	6
Maximum *K*	2
Number of periods in each undulator	28
Radiation wavelength, μm	15

Second stage of the Novosibirsk FEL (under construction now)



Electron outcoupling scheme is used here

Electron outcoupling scheme of Novosibirsk FEL

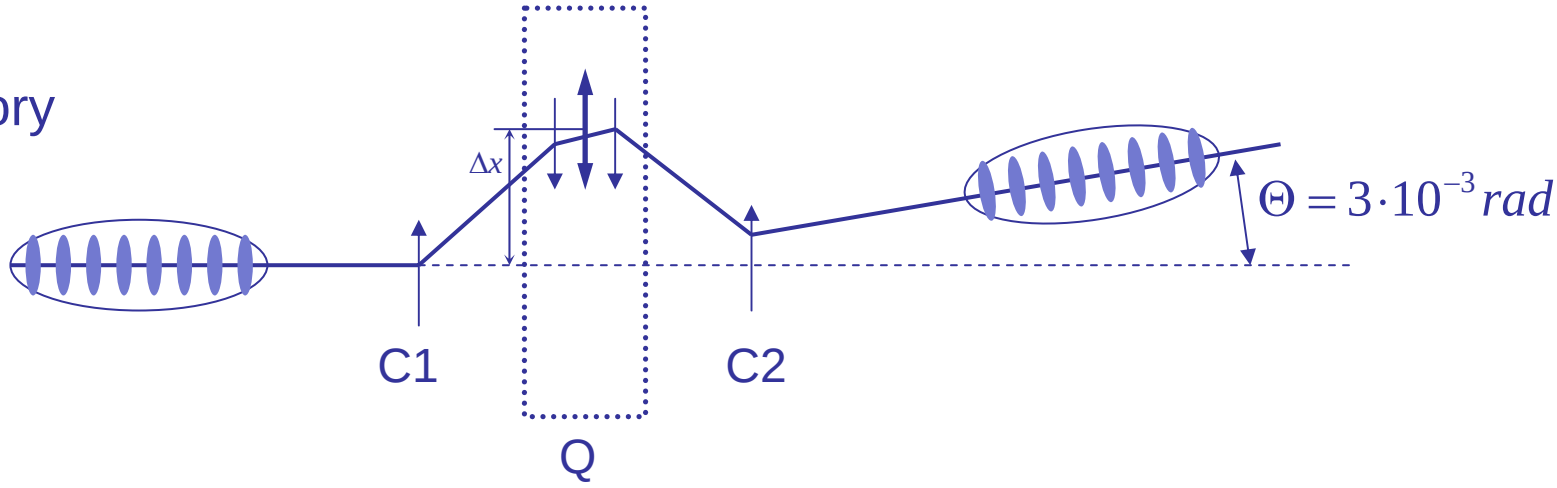


Features

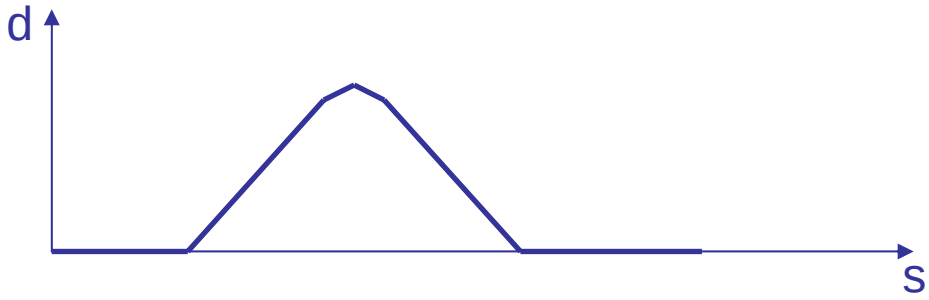
- Three undulators
- Achromatic bend
- Strong focusing in undulators

Small angle achromatic bend

Trajectory

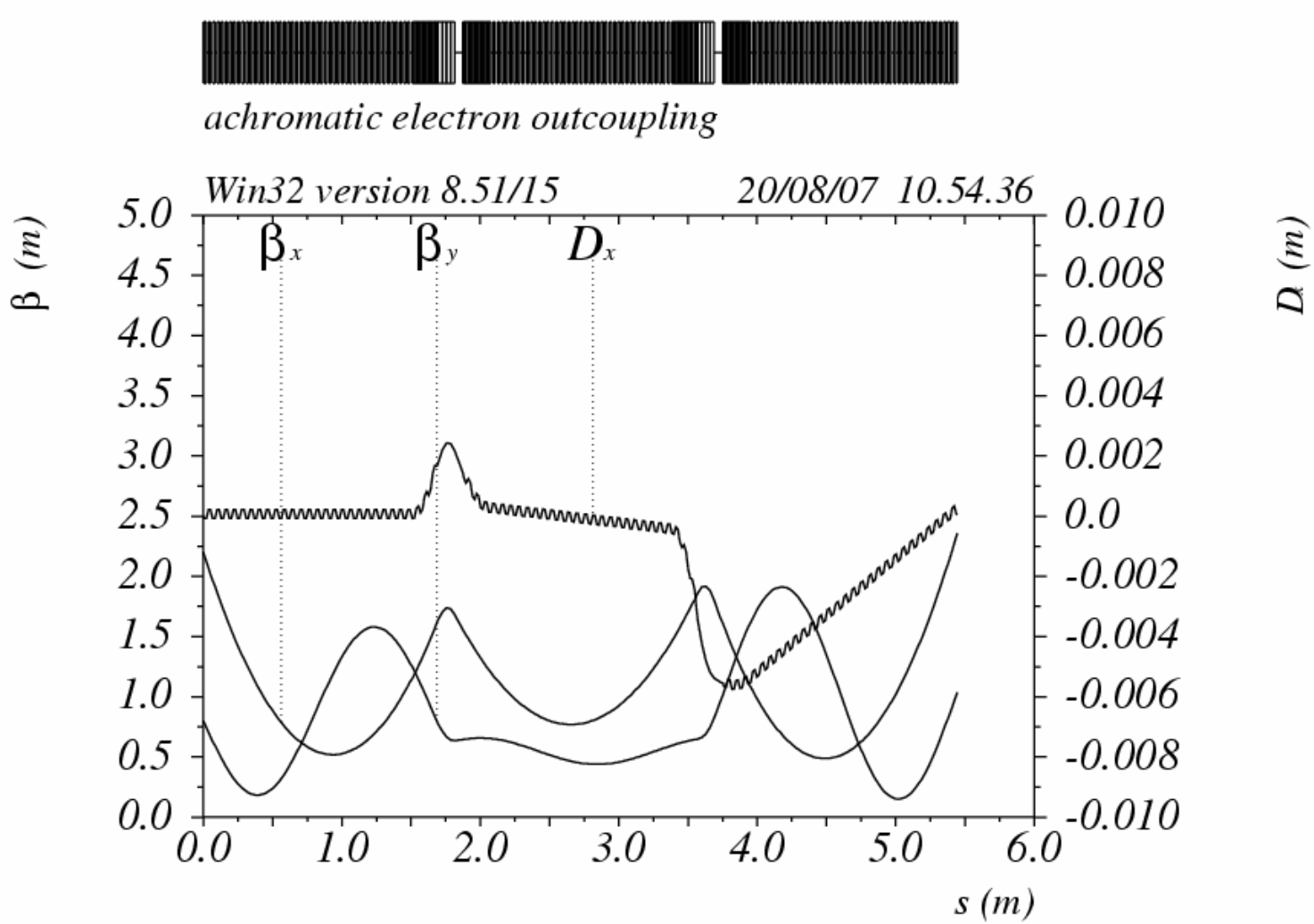


Dispersion



$$\left.\begin{aligned} R_{16} &= 0 \\ R_{26} &= 0 \end{aligned}\right\} \Leftrightarrow \begin{cases} R_{51} = 0 \\ R_{52} = 0 \end{cases} \qquad F = \frac{\Delta x}{\Theta}$$

Optical functions in undulators

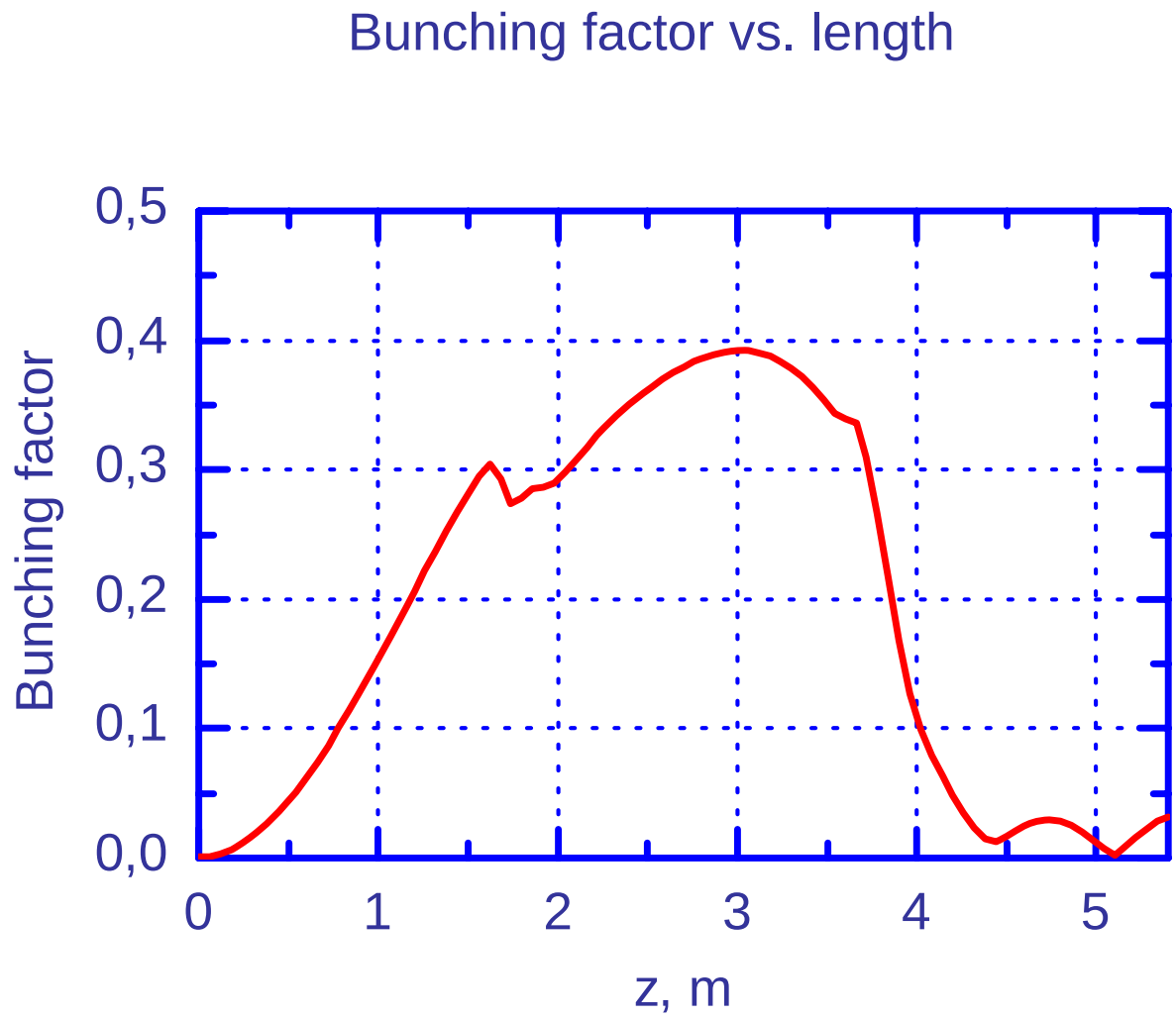


Modelling

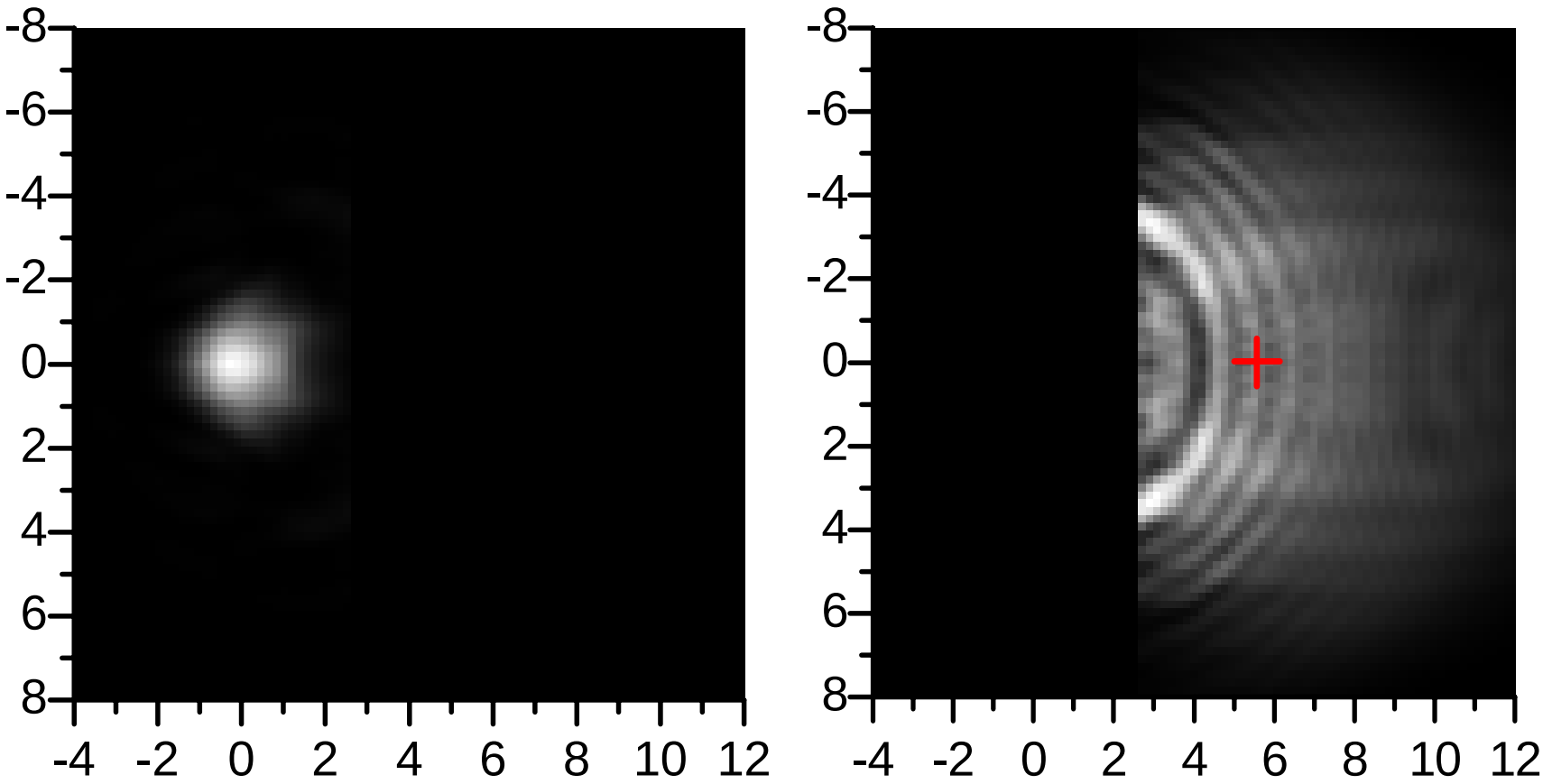
- GENESIS code (by S. Reiche) is used to simulate the operation of FEL and electron outcoupling itself
- OPC code (by J.G. Karssenberg, P.J.M. van der Slot) is used to propagate radiation field in the optical cavity

Energy, MeV	40
Peak current, A	100
Relative energy spread	$3 \cdot 10^{-3}$
Maximum K	2
Undulator period, cm	6
Number of periods in each undulator	28
Deflection angle in second undulator, mrad	3

Radiation wavelength, μm	15
Optical cavity length, m	40
Optical cavity fundamental frequency, MHz	3.76
Mirror radius of curvature, m	25
Mirror reflectivity, %	90
Optical cavity β on mirrors, m	50
Optical cavity β_0 (Raleigh length), m	10

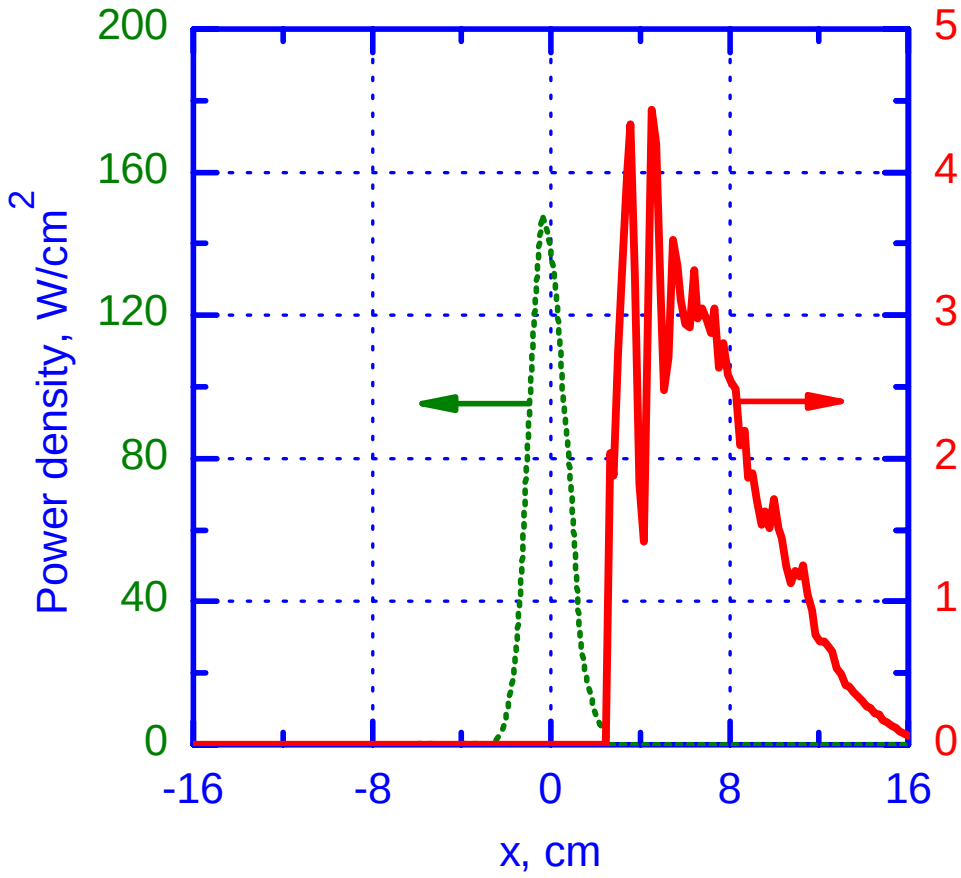

Bunching factor vs. length
Bunching factor
0,5
0,4
0,3
0,2
0,1
0,0
0
1
2
3
4
5
z, m

Power distribution on the forward optical cavity mirror surface (left) and on the outcoupling mirror surface (right).



Total average power on the cavity mirror, W	990	at	f = 3.76 MHz, I = 6 mA
Total outcoupled power, W	260		
Max. intensity on the cavity mirror, W/cm^2	170		
Max. intensity on the outcoupling mirror, W/cm^2	5		

Intensity profiles
on the forward optical cavity mirror surface (green, left axis) and on the outcoupling mirror surface (red, right axis).



Conclusion

• Electron outcoupling scheme with trajectory deflection in the second undulator (radiator) is considered.

• The scheme with deflection in the third undulator was also simulated, but the FEL output power was less for our beam parameters.

• The results of calculations look reasonable and show that the chosen parameters of FEL magnetic system are close to optimal.

Thank you!