Karlsruhe Institute of Technology

seit 1558

SPONSORED BY THE

Federal Ministry of Education and Research

Design of a Diagnostic Beamline for the JETI Laser Wakefield Accelerator

Christina Widmann

Laboratory for Applications of Synchrotron Radiation (LAS)

Setup of the experiment

Synchrotron and undulator radiation can be used to characterize the electron bunches of an accelerator. This is planned to be applied to the JETI-LWFA at the university of Jena, Germany.

The size and divergence of the bunch, its temporal structure and the energy spectrum is planned to be measured in one setup .

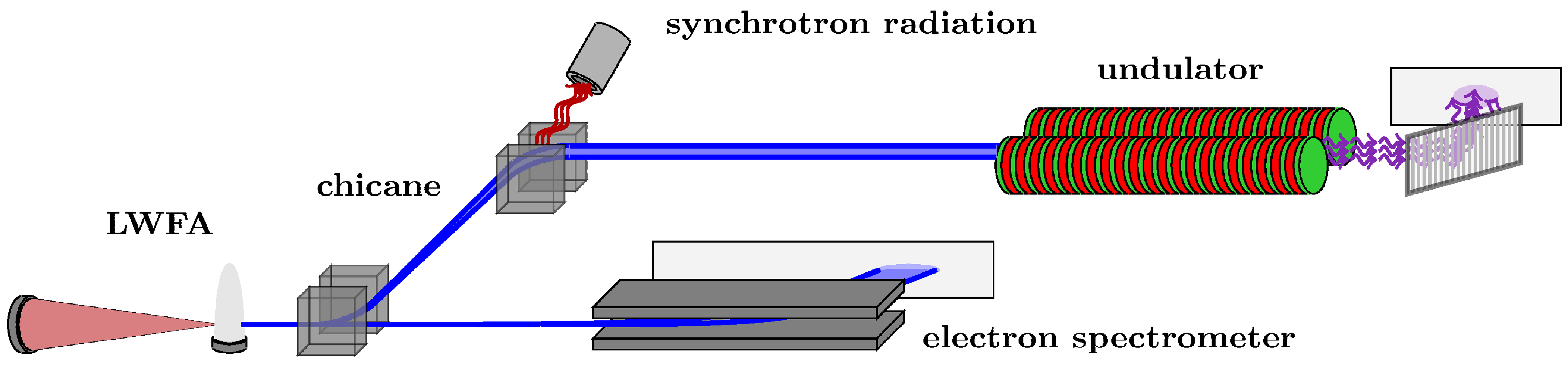

Figure 1: Sketch of the setup planned at the JETI-LWFA.

Undulator radiation

- beam size, divergence and spectrum of the undulator radiation

→ transverse electron bunch size

→ divergence of the bunch

Synchrotron radiation

- measurement of the coherent and incoherent synchrotron radiation

→ temporal structure of the bunch

Electron spectrometer

- imaging of the dispersed bunch after a dipole magnet

→ energy spectrum of the bunch

The setup is designed for the bunches of the JETI-LWFA, the parameters are listed in Tab. 1:

parameters of the LWFA	
pulse parameters	800 mJ, 27 fs, $\sim$30 TW
electrone density in plasma	$\sim 1\times10^{9}\,\mathrm{cm}^{-3}$
parameters of the bunch	
energy E	120 MeV $\pm$ 10 %
divergence of the source	$\sim$ 1 mrad
emittance	$\sim$ 25 μm mrad

Table 1: Parameters of the bunches of the JETI-LWFA.

Design of the undulator

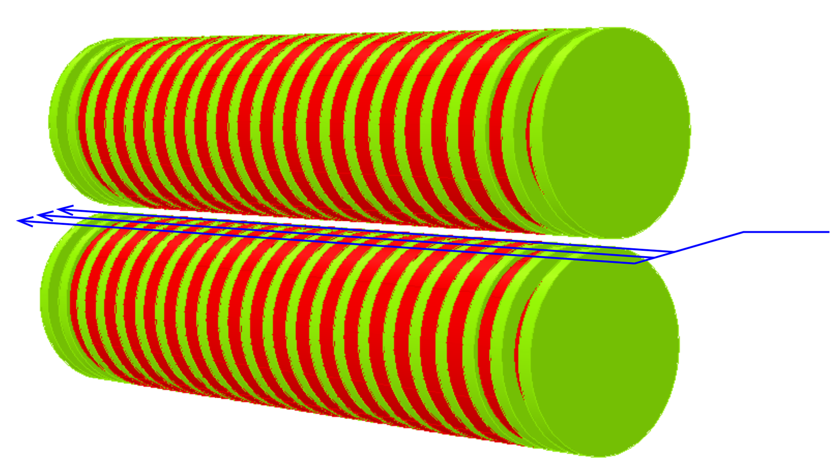

Figure 2: Design of the undulator (courtesy P. Peiffer)

A challenge to be faced is the large energy spread of the LWFA as it deteriorates the quality, increases the bandwidth and reduces the spectral brilliance of the undulator radiation, which reduces the resolution of the electron bunch diagnostic. One approach to compensate for the energy spread is to spectrally disperse the electron beam in one transversal plane and to match the resulting spacial energy distribution with the magnetic field amplitude of the undulator [1].

$$\lambda_n = \frac{\lambda_u}{2n\gamma(x)}\left(1+\frac{K(x)^2}{2}\right) \quad \text{with} \quad K = \frac{B_o e}{m_e c}\frac{\lambda_u}{2\pi}$$

Beam transport line to the undulator

A lattice of seven quadrupoles will be applied to achieve the parameters required by the undulator [2]:

- Dispersion $d\Delta x$ has to match the undulator field amplitude and D' must be zero.
- The transversal beamlet size σ_x in the deflection plane has to be small enough.
- The beta function and the beam waist in the non-deflecting plane should fulfill the usual undulator requirements.

The values achieved are listed below, a plot of the beta function and the dispersion is shown in Fig. 3.

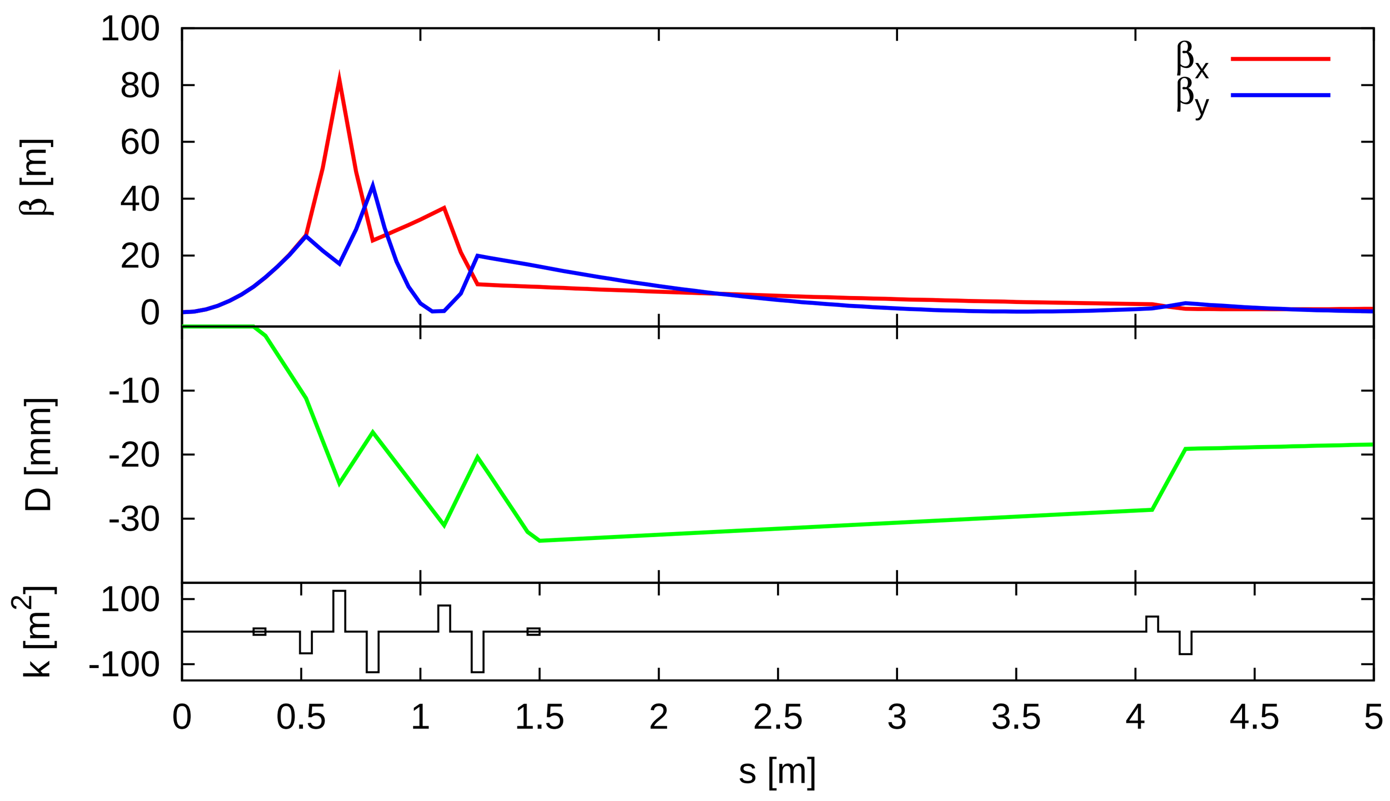

Figure 3: Plot of beta functions and dispersion.

beam parameters	achieved	target parameters
dispersion $d\Delta x$	3.8 mm	4.0 mm
D'	0	0
beam size σ_x	0.15 mm	0.09 mm
$\alpha_{x,y}$	-0.39, 0.39	0
β_y	0.08 m	0.5 m

Table 2: Parameters required and parameters achieved.

Acknowledgements

Special thanks to V. Afonso Rodriquez, A. Bernhard, M. Kaluza, M. Nicolai, P. Peiffer and R. Rossmanith.

References

[1] G. Fuchert et al., WEPC06, FEL2009, p. 507 (2009).

[2] V. Afonso Rodriguez et al., IPAC'11, TUPO005 (2011).