Design of a time-resolved electron diagnostics using THz fields excited in a split ring resonator at FLUTE

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Introduction

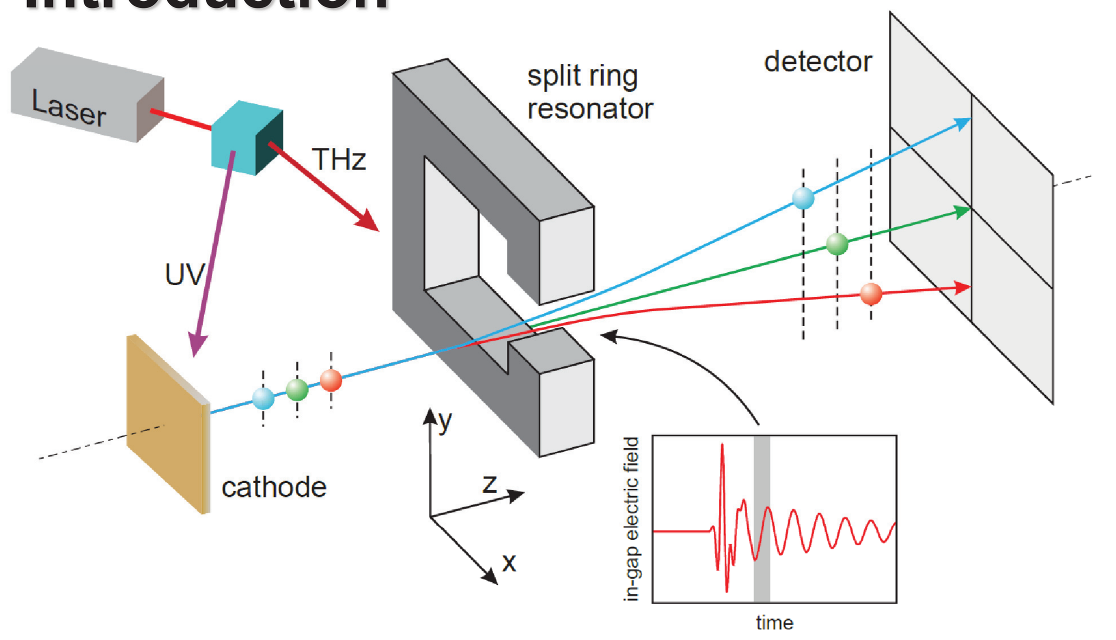

Fig.1: Principle of the SRR diagnostics [1].

A new time-resolved diagnostics using THz fields excited in a split ring resonator (SRR) has been proposed [1,2] and is being built at the test-facility FLUTE at KIT [3] as a collaboration among KIT, PSI and University of Bern. Thanks to the short pulse duration, high resonant frequency and high field enhancement of the THz pulses, such SRR diagnostics could make femtosecond resolution possible.

Analog to systems using RF deflecting structures, the SRR setup maps the longitudinal coordinate onto a transverse coordinate. A driving laser system generates intense single cycle THz pulses through optical rectification. The THz pulses are absorbed in the split ring resonator structure and lead to an electric field enhancement for the resonant frequency inside the gap [4]. The electron bunches interact with the high amplitude THz field in the gap and are deflected in the transverse direction. The longitudinal density distribution of the electron bunch is translated into a transverse density distribution, which can be measured using a transverse beam imaging screen.

Ferninfrarot Linac- und Test-Experiment (FLUTE)

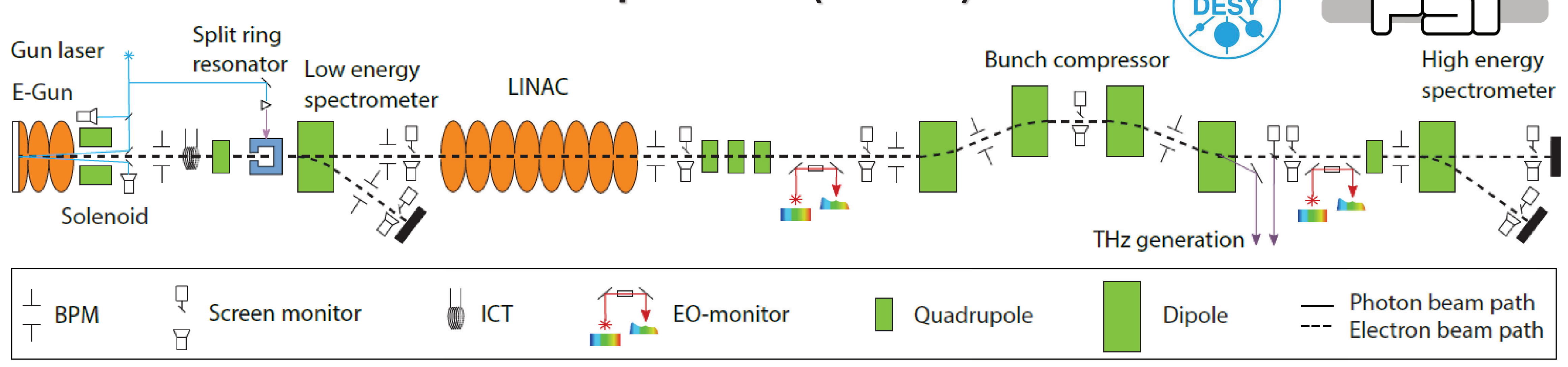

Fig.2: Schematic layout of FLUTE.

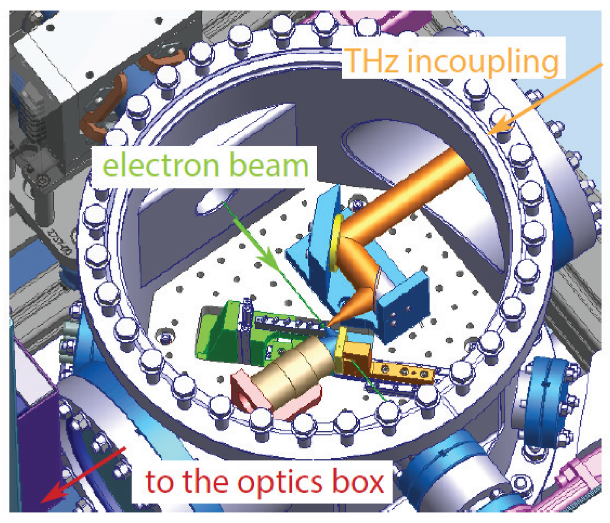

Fig.3: Experimental chamber for the proof-of-principle experiment.

Simulation Results

- ASTRA simulation with 100k macro particles
- Integration of full electric and magnetic field distribution from CST MWS simulation for the SRR structure
- Estimated temporal resolution: 18 fs

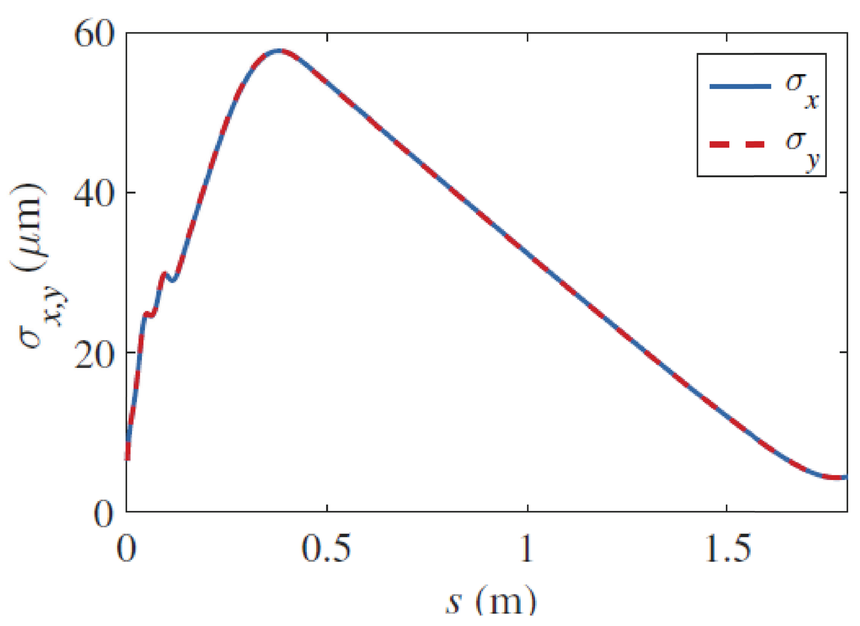

Fig.4: Transverse rms beam sizes from the cathode to the entrance of the SRR.

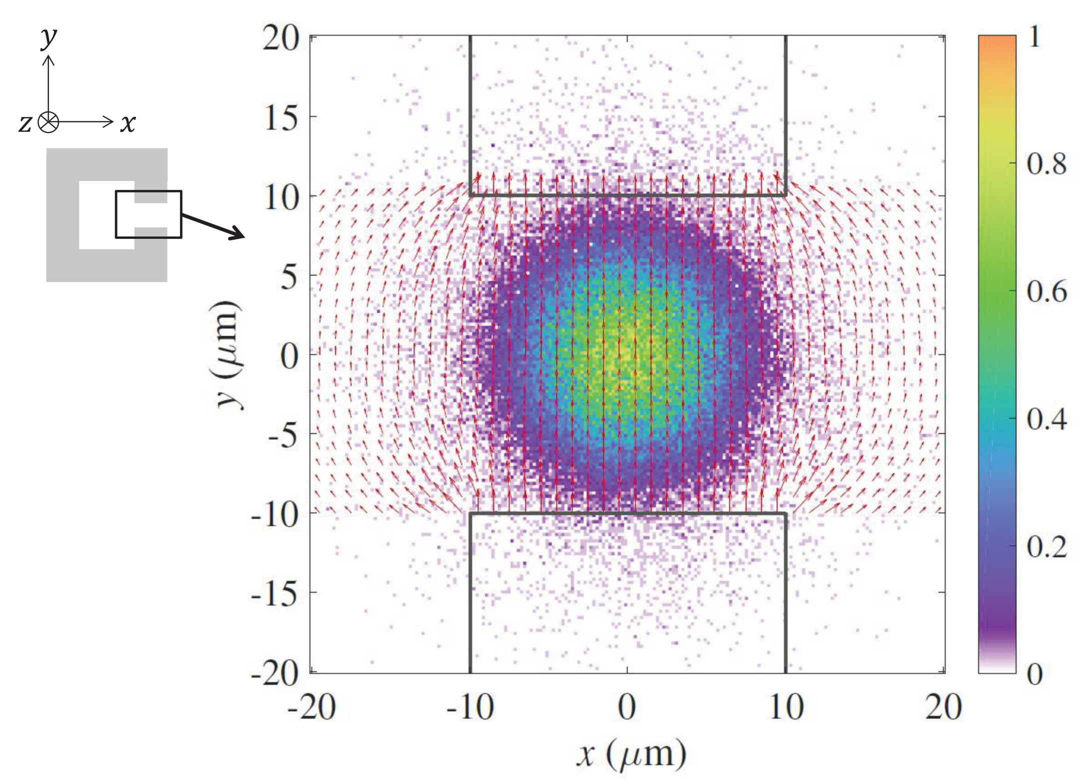

Fig.5: Transverse particle distribution (in color code) and transverse electric field (red arrows) at the entrance of the SRR.

Table: Accelerator settings

Laser rms pulse length	2 ps
Laser rms transverse size	5 μm
Bunch charge	50 fC
Gun gradient	120 MV/m
Gun phase	0 degree
Solenoid magnetic field	0.24 T
Bunch energy	7 MeV
Normalized rms transverse emittance	2.7nm

Table: SRR parameters

Gap size in x	20 μm
Gap size in y	20 μm
Gap width in z	10 μm
Resonant frequency	300 GHz
Peak electric field	500 MV/m
Integrated field	10kV

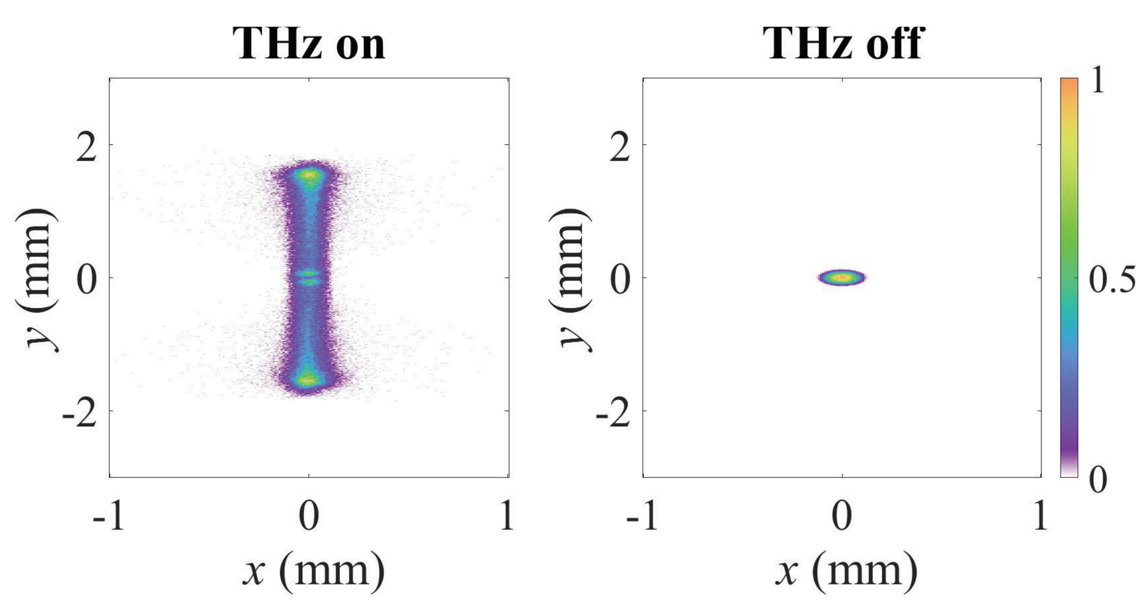

Fig.7: Simulated image at the screen in the straight section. Clear streaking effect can be seen.

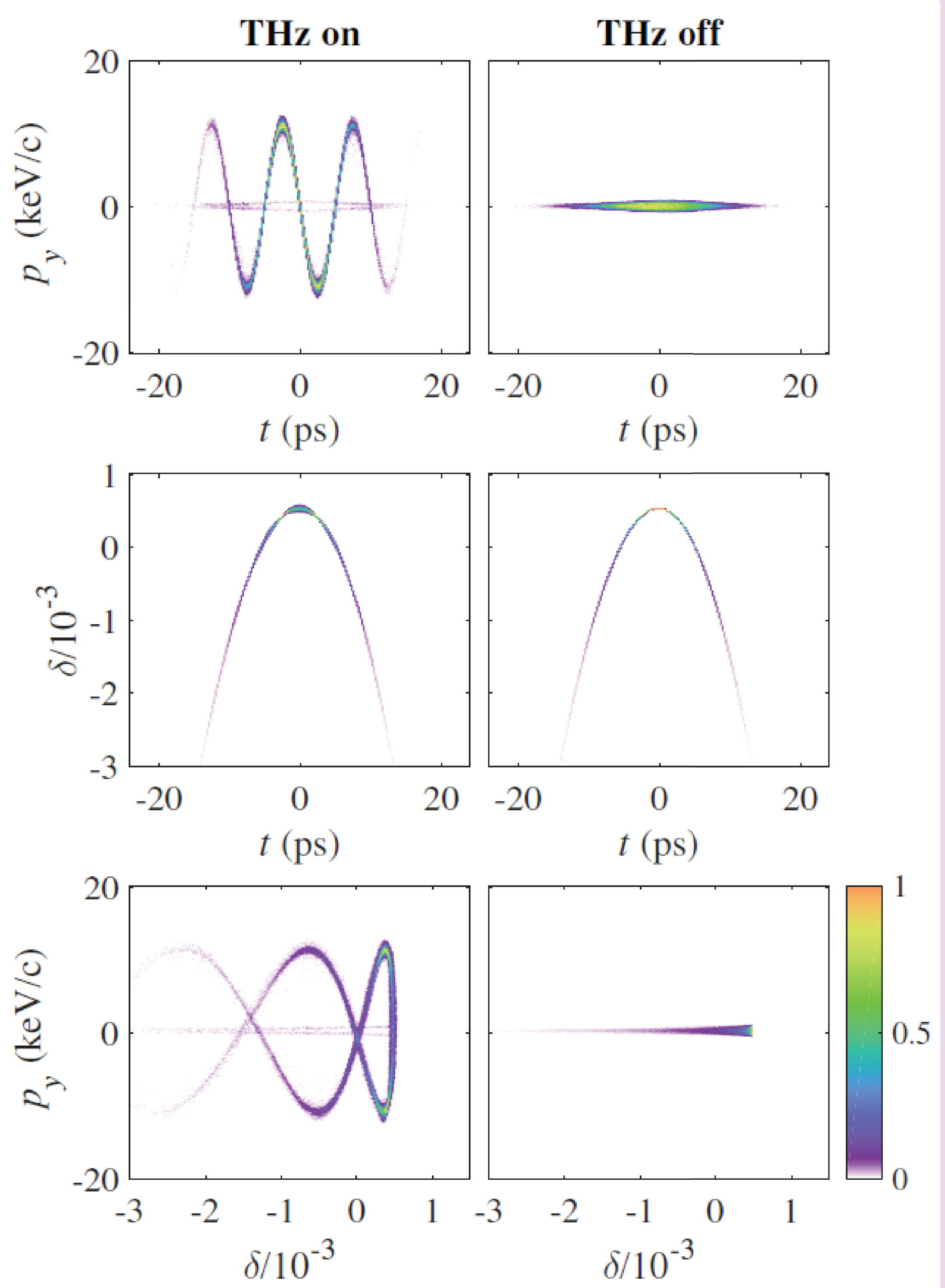

Fig.6: Particle distribution at the exit of the SRR.

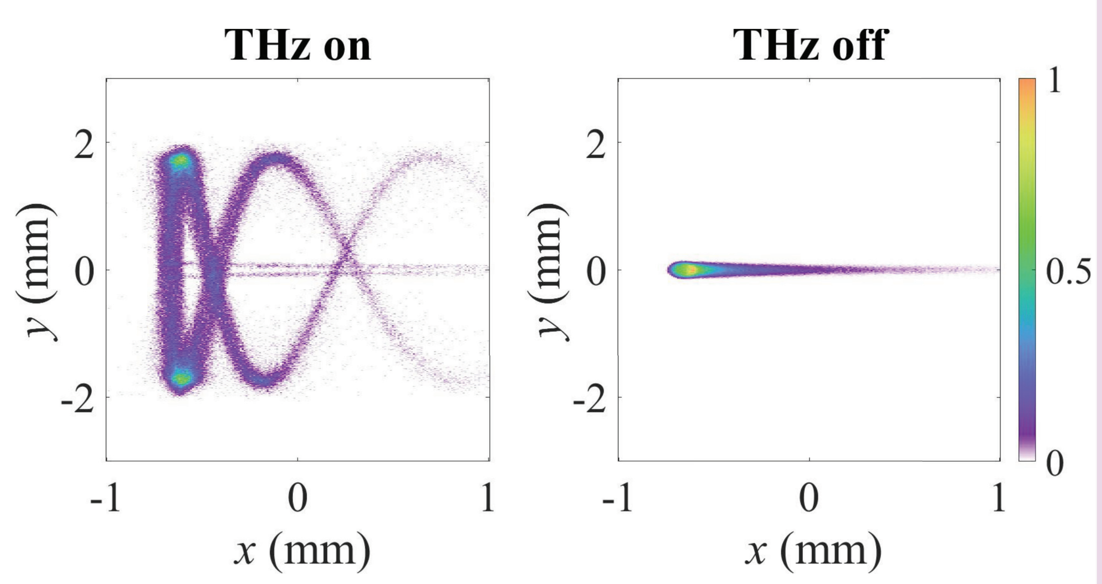

Fig.8: Simulated image at the screen in the dispersive section. The correlation between p_y and δ is in good agreement with that expected from Fig. 6.

References

[1] J. Fabianska *et al.*, Scientific Reports 4, 5645 (2014)
[2] M. Dehler *et al.*, IBIC'15, MOPB048 (2015)
[3] M. J. Nasse *et al.*, Rev. of Sci. Instrum. 84, 022705 (2013)
[4] S. Bagiante *et al.*, Scientific Reports 5, 8051 (2014)