

Status of the THz-Streaking Experiment with Split Ring Resonators at FLUTE

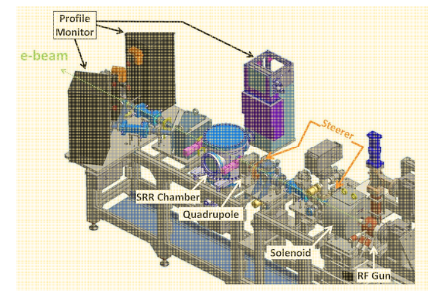
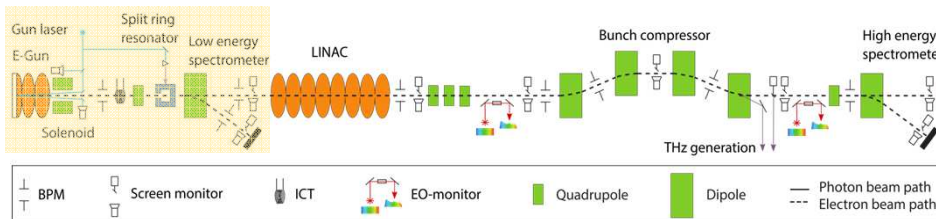
V. Schlott¹, M. Dehler¹, R. Ischebeck¹, M. Moser¹, T. Feuer², M. Hayati², Z. Ollmann², R. Tarkeshian², E. Bründermann³, S. Funkner³, A.-S. Müller³, M.J. Nasse³, G. Niehues³, R. Ruprecht³, T. Schmelzer³, M. Schuh³, M. Schwarz³, M. Yan³

¹ Paul Scherrer Institut (PSI), Diagnostics Section, CH-5232 Villigen PSI, Switzerland

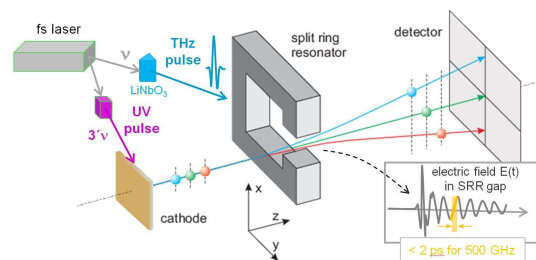
² Institute of Applied Physics (IAP), University of Berne, Sidlerstrasse 5, CH-3012 Berne, Switzerland

³ Karlsruhe Institute of Technology, Laboratorium für Applikationen der Synchrotronstrahlung, KIT Campus Süd, Kaiserstrasse 12, D-76131 Karlsruhe, Germany

The SRR Experiment at the FLUTE Test Facility



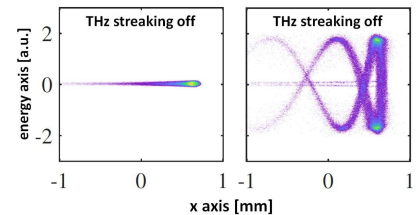
Principle of THz-Streaking with Split Ring Resonators



Temporal Resolution (similar to RF deflectors)

$$\frac{\sigma_{y0}}{cS} = \frac{\sqrt{\epsilon_y}}{\beta(s_0) \sin(\Delta\psi_{s_0 \rightarrow s_1})} \frac{1}{eV} \frac{E}{2\pi f} \rightarrow \frac{\sigma_{y0}}{cS} \sim 2 \text{ fs}$$

- FLUTE beam energy: $E = 7 \text{ MeV}$
- SRR gap (deflecting) voltage: $V = 12 \text{ kV}$
- SRR resonance frequency: $f = 300 \text{ GHz}$
- β -function (@ SRR): $\beta(s_0) = 1 \text{ m}$
- bunch charge: $Q = 50 \text{ fC}$
- emittance: $\epsilon_y = 3 \text{ nm}$
- phase advance SRR / screen: 90°



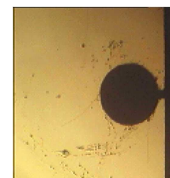
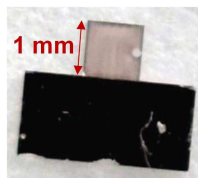
Split Ring Resonator Design Optimization



“classical SRR”
20 μm x 20 μm x 20 μm
gap dimensions



“manufacturing SRR design”
20 μm x 20 μm x 80 μm gap dimensions
milled and drilled out of a solid plate
increased interaction region for larger kick strength



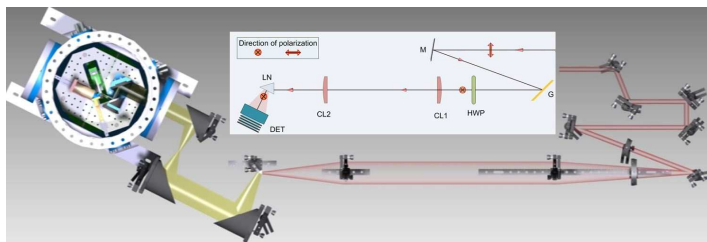
images of SRR for FLUTE experiment
manufactured from glass with gold coating
avoids charging up and heating by halo electrons or
accidental hit by main beam

ASTRA Simulations

for conservatively assumed kick strength of 5keV/c
(considering e.g. losses in the THz beam transport)
clearly visible streaking image on FLUTE low energy
spectrometer screen (FLUTE bunch length is 2 ps)

THz Pulse Generation and Characterization

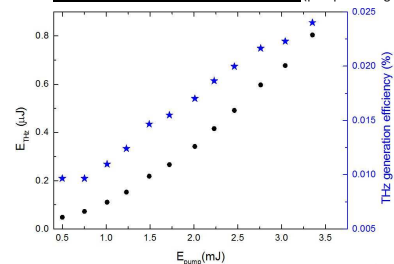
Layout of the THz Pulse Generation (red beam path) and THz Beam Transport to SRR in Vacuum Chamber (yellow beam path)



Legend of symbols: M: dielectric mirror; G: reflection grating; HWP: 1/2 retardation plate; CL1: plane convex cylindrical lens ($f = 421 \text{ mm}$); CL2: plane convex cylindrical lens ($f = 250 \text{ mm}$); LN: MgO doped stoichiometric LiNbO₃ prism

- Optical rectification in LiNbO₃ crystal with FLUTE gun laser pulses (6mJ @ 800 nm, 35 fs (FWHM) @ 1 kHz)
- Conversion efficiency of 0.024% results in maximum THz pulse energy of 80 μJ for 3.35 mJ pump laser energy
- 4f imaging system provides THz spot dimensions of 0.92 mm (horizontal) and 1.15 mm (vertical)
- Maximum THz field strength of 14 MV/m can be reached at the location of the SRR in the experimental chamber

THz Pulse Energy and Conversion Efficiency (pump: FLUTE gun laser)



Pyro-Electric Camera Image of THz Beam Profile

