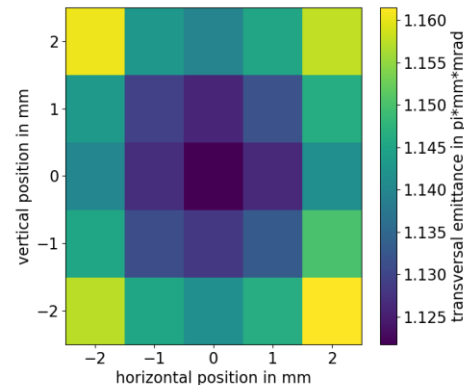
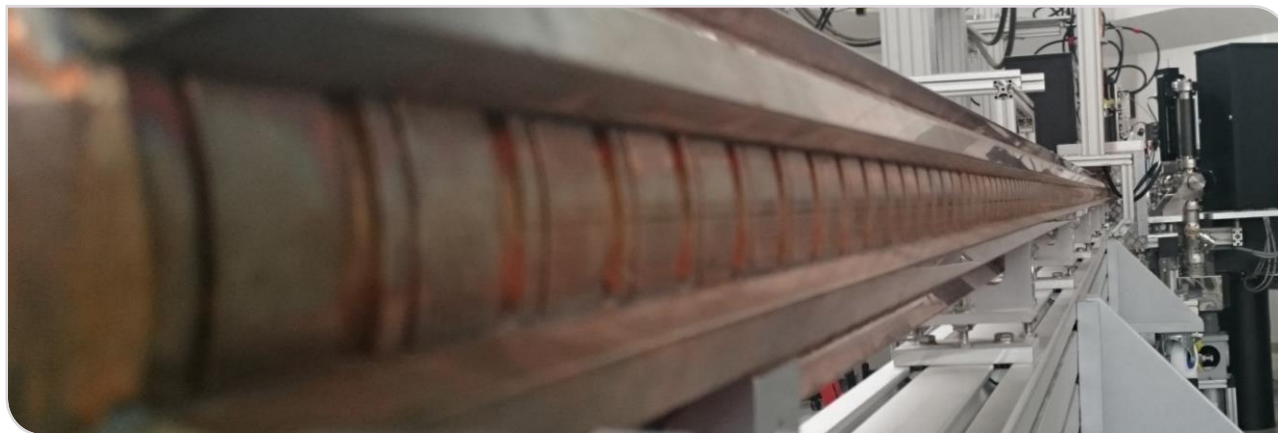


Electron Beam Characterization at the new linear accelerator FLUTE

Thiemo Schmelzer | KSETA Workshop 2021



Outline

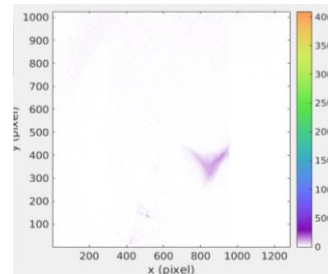
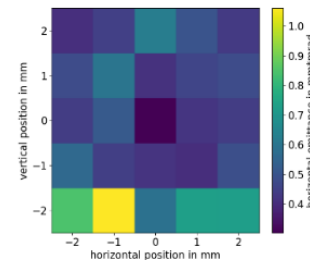
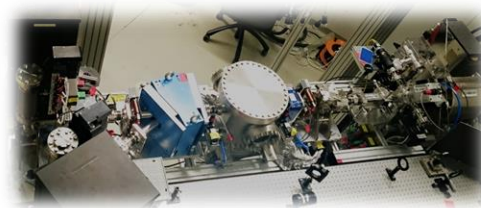
■ Accelerator at KIT: FLUTE

- Purpose and Goals
- Basic Parameters and Layout

■ Conditioning / Operation history

■ Parameter measurement: transverse Emittance

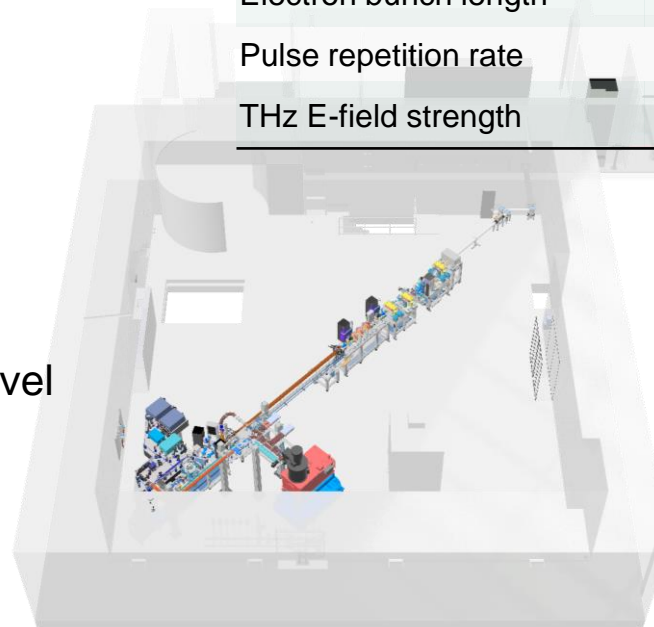
- Needed diagnostics: screen monitors
- Measurement principle: quad scan
- Results: measurement and simulation



Accelerator Overview

- Far-infrared linac and test experiment
 - Production of short THz pulses with high peak intensity
 - Generation of fs short electron pulse
- Research and Development
 - Serve as a test bench for new beam diagnostic methods and tools
 - Develop single shot fs diagnostics
 - Synchronization on a femtosecond level
 - Systematic bunch compression and THz generation studies

Final electron energy	~ 41 MeV
Electron bunch charge	1 – 3000 pC
Electron bunch length	1 – 300 fs
Pulse repetition rate	10 Hz
THz E-field strength	up to 1.2 GV/m



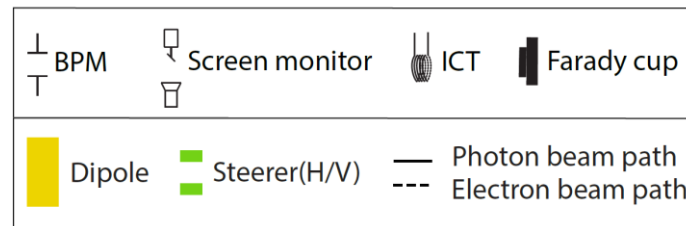
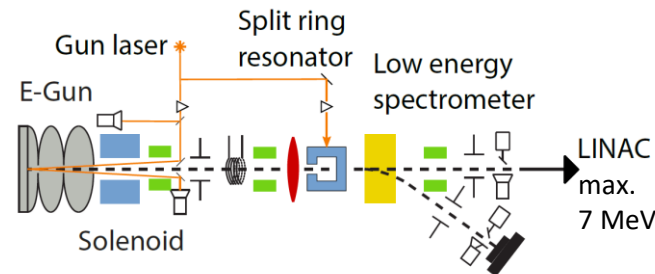
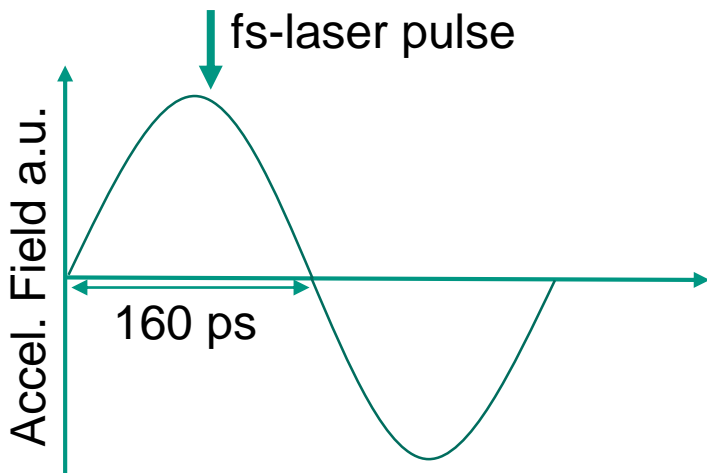
PAUL SCHERRER INSTITUT



www.ibpt.kit.edu/flute

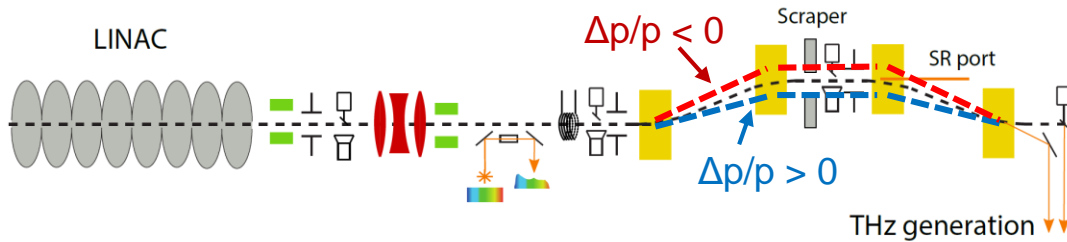
Injector Section











- Beam generation in Photo-injector
 - Combination of accelerating RF pulse and electron generating Laser pulse
 - fs-timing synchronization necessary

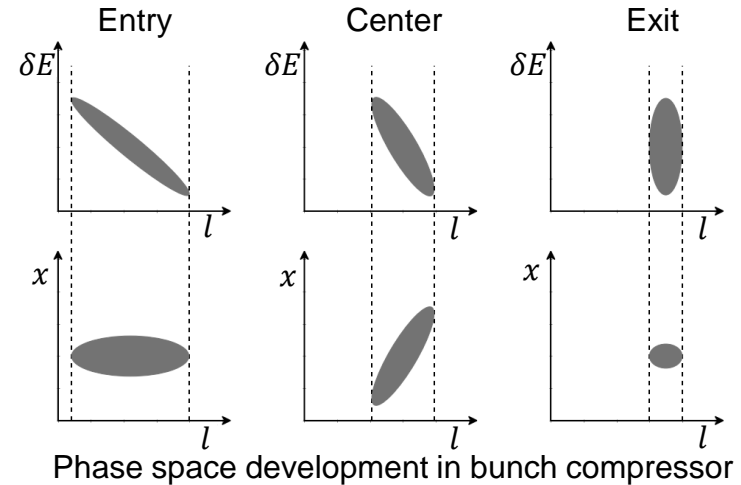


Bunch Compression

- Magnetic chicane
 - Longitudinal compression
 - Based on changing beam path lengths

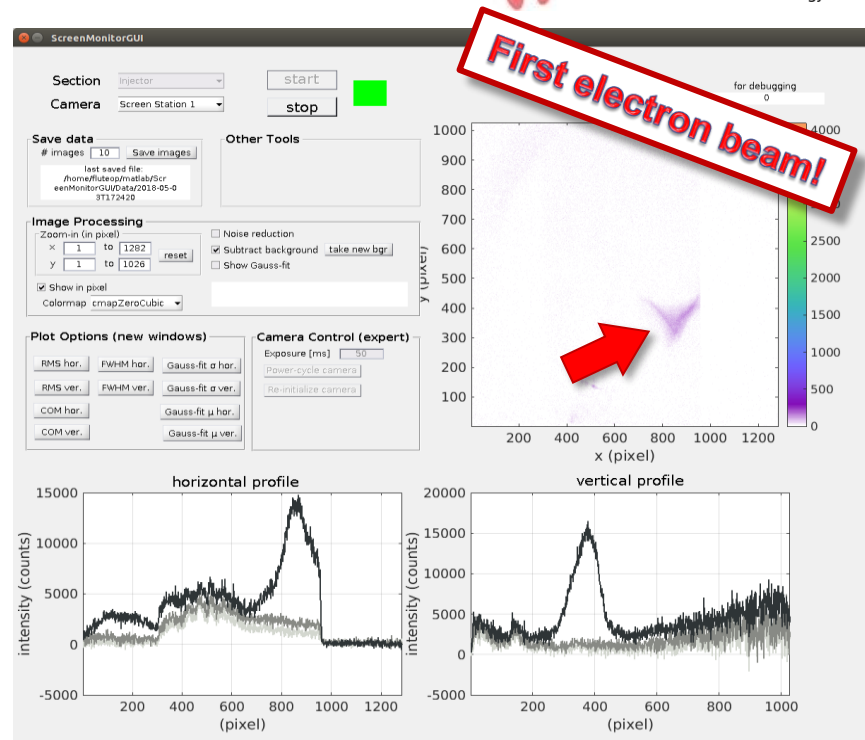


				
BPM	Screen monitor	ICT	Farady cup	EO-monitor
				Photon beam path
Quadrupole	Dipole	Steerer(H/V)		Electron beam path



Operation Progress

- RF conditioning progressed to 3 MW
→ Beam energy ~ 1.5 MeV
- Laser transport through 3 rooms finished
- Laser and RF synchronized to 8 ns
- Repetition rate started at 1 Hz
- First diagnostic elements installed

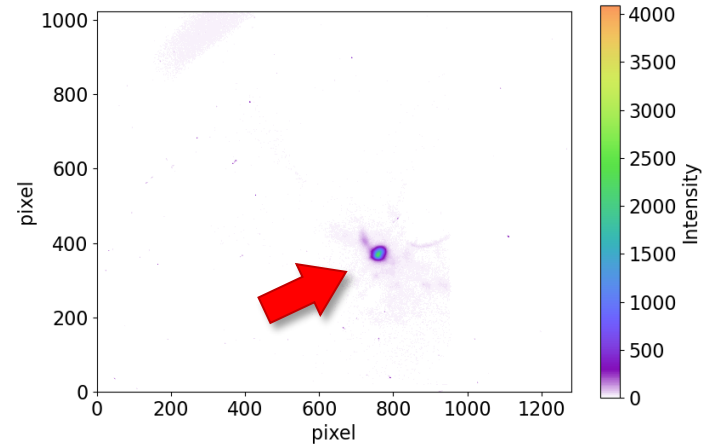


YAG screen monitor: First electrons! (2018-05-03)

Operation Progress

- RF conditioning progressed to 3 MW
→ Beam energy ~ 1.5 MeV
- RF conditioning up to 16 MW
→ Beam energy > 6 MeV
- Laser transport through 3 rooms finished
- Laser and RF synchronized to 8 ns
- Laser synchronization down to 120 fs
- Repetition rate started at 1 Hz
- Repetition rate increased factor 5
- First diagnostic elements installed
- Diagnostics commission and calibrated

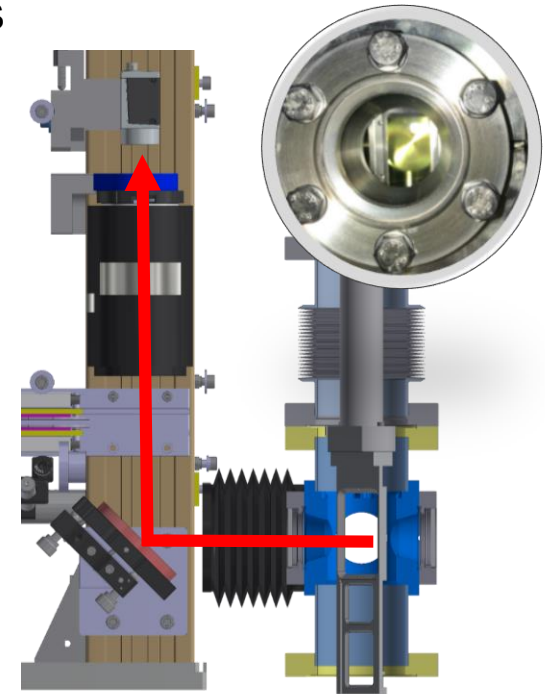
- Linac RF conditioning started



Measured electron profile, June 2021

Transverse Beam Profile

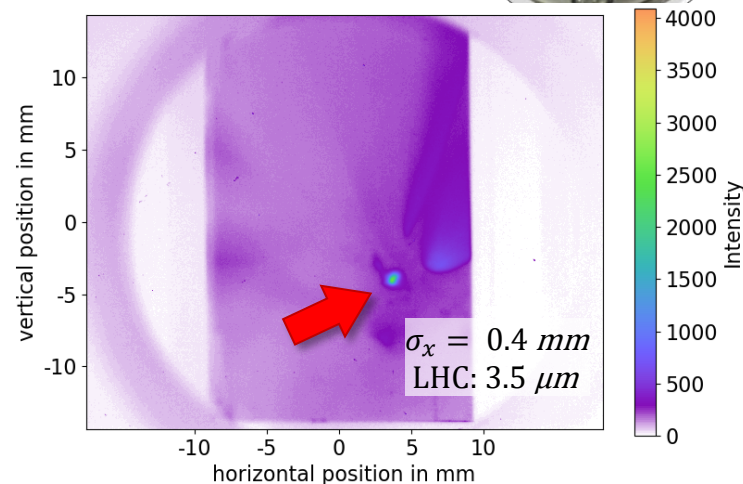
- Camera and screen stations for bunch profile diagnostics
 - Scintillation YAG screen for visualization
 - Station designed for Swissfel, PSI
- Contributions:
 - Installation of several stations
 - Calibration of cameras and lenses
- Implemented camera readout in Python
 - Direct control for operator
 - Embedded live image processing
 - Easy access to profile data



Screen Station Layout, courtesy S. Schott

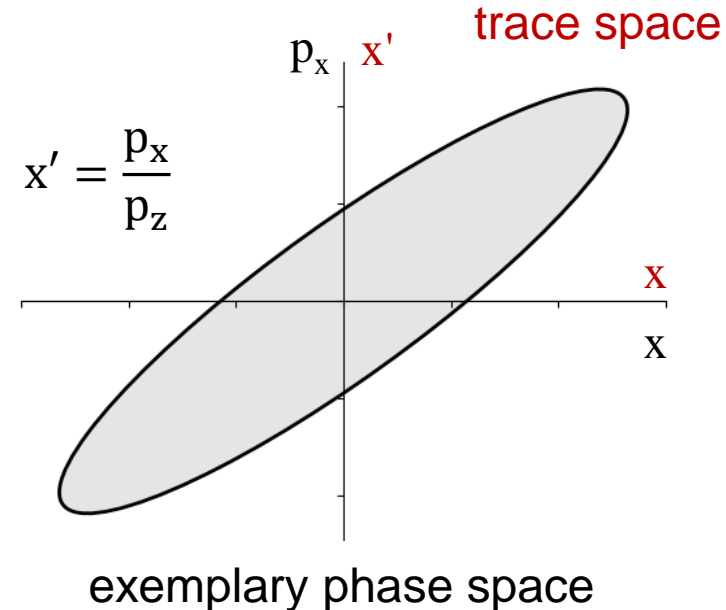
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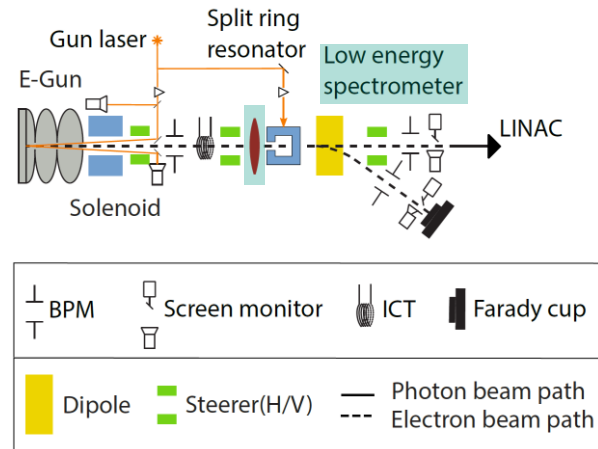
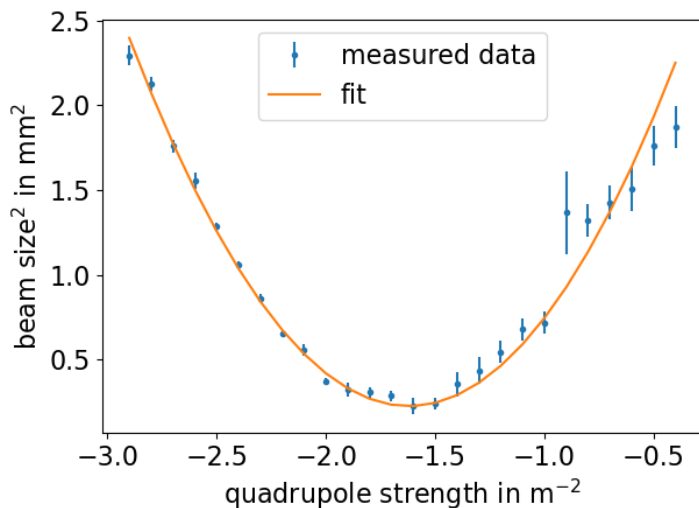
Beam Emittance

- Parameters measurement: transverse Emittance
 - Definition as area of ellipse
 - Comprised of particle position and momentum
- Diagnostic limitation: momentum measurement
- Trace space combines divergence and position
- Various approaches for measurement



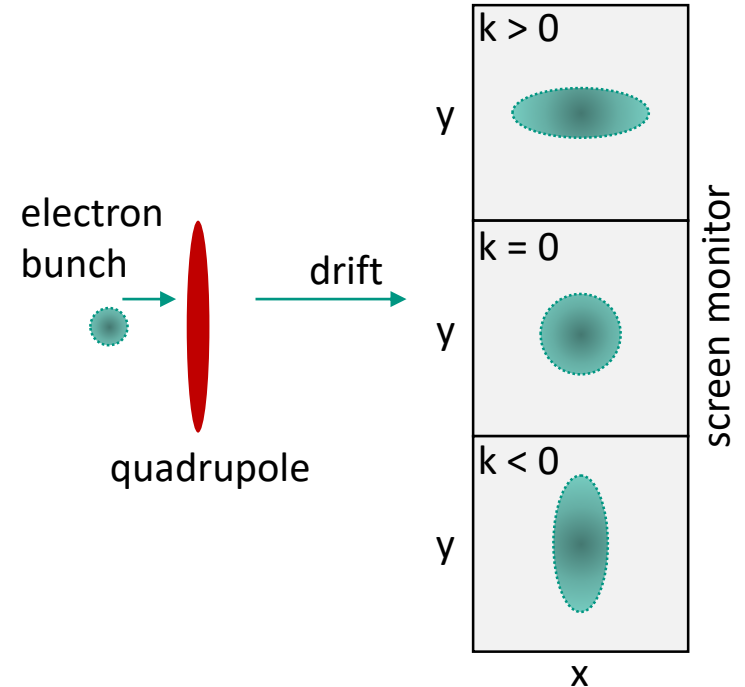
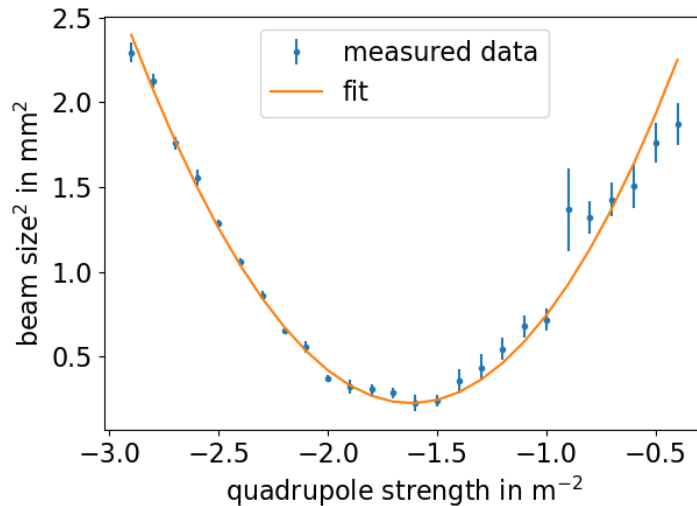
Measurement Setup

- Quadrupole-Scan method
 - Measurement of beam size in dependence of quadrupole strength
 - Initial beam size and divergence reconstructed with fit parameters



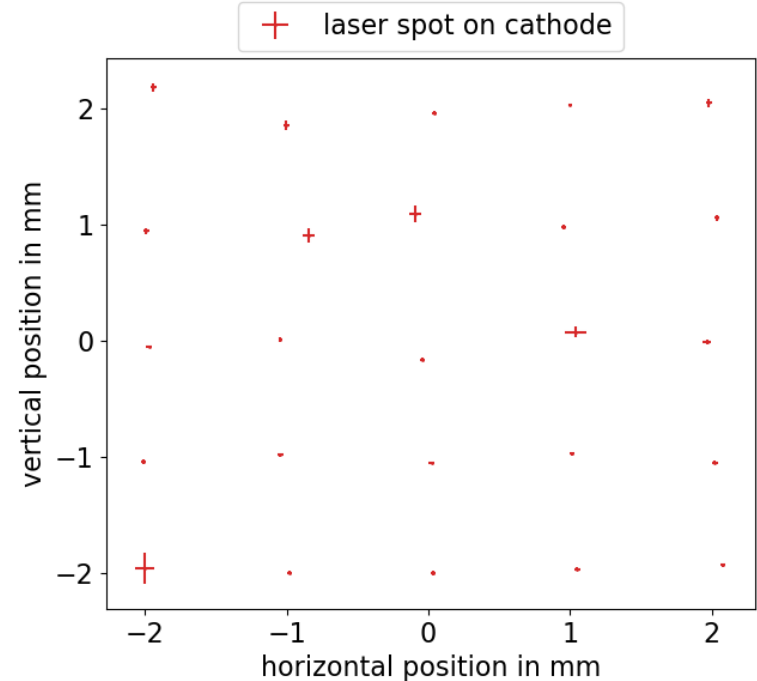
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Systematic Parameter Study

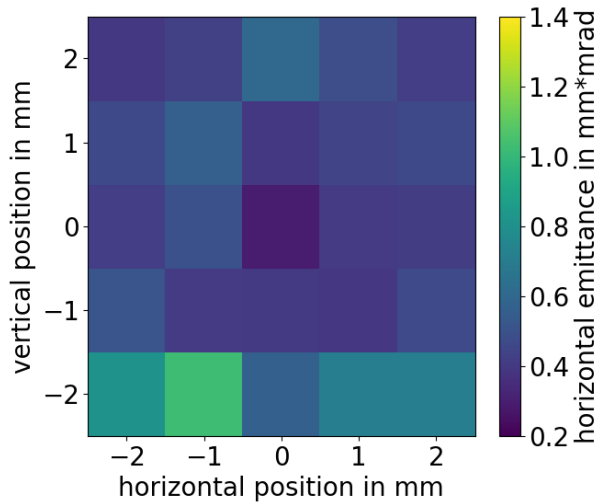
- Influence of Laser spot position on cathode
- 5x5 grid with 1 mm spacing
- Quadrupole scan with 60 steps per position (0.1 A steps)
- RF power + Laser power fixed
→ electron energy at 5.81 MeV
- Bunch charge varying from 15 pC – 30 pC
→ cathode surface effect



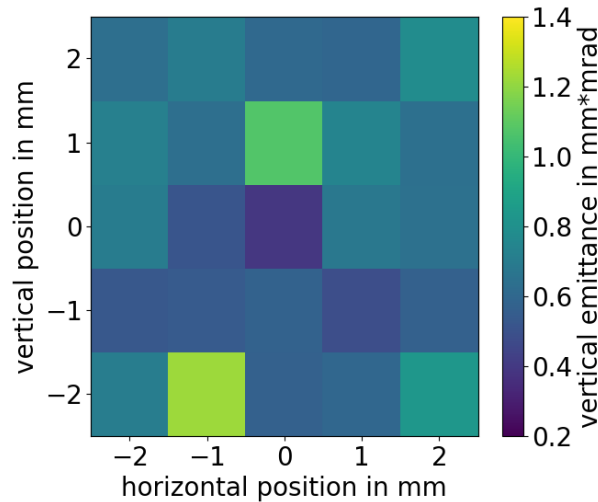
Measurement Results

- Emittance calculated separately

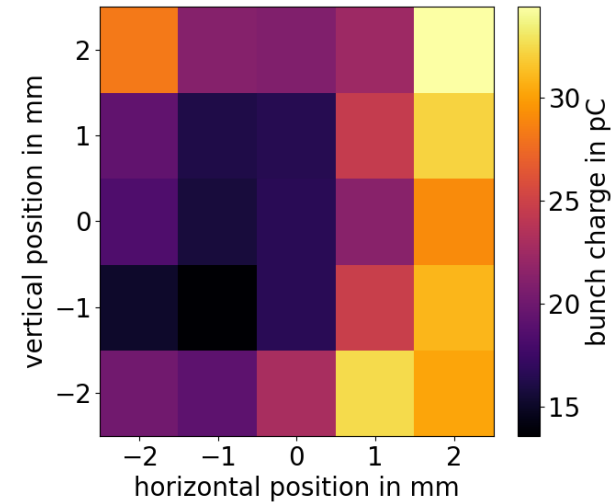
horizontal



vertical



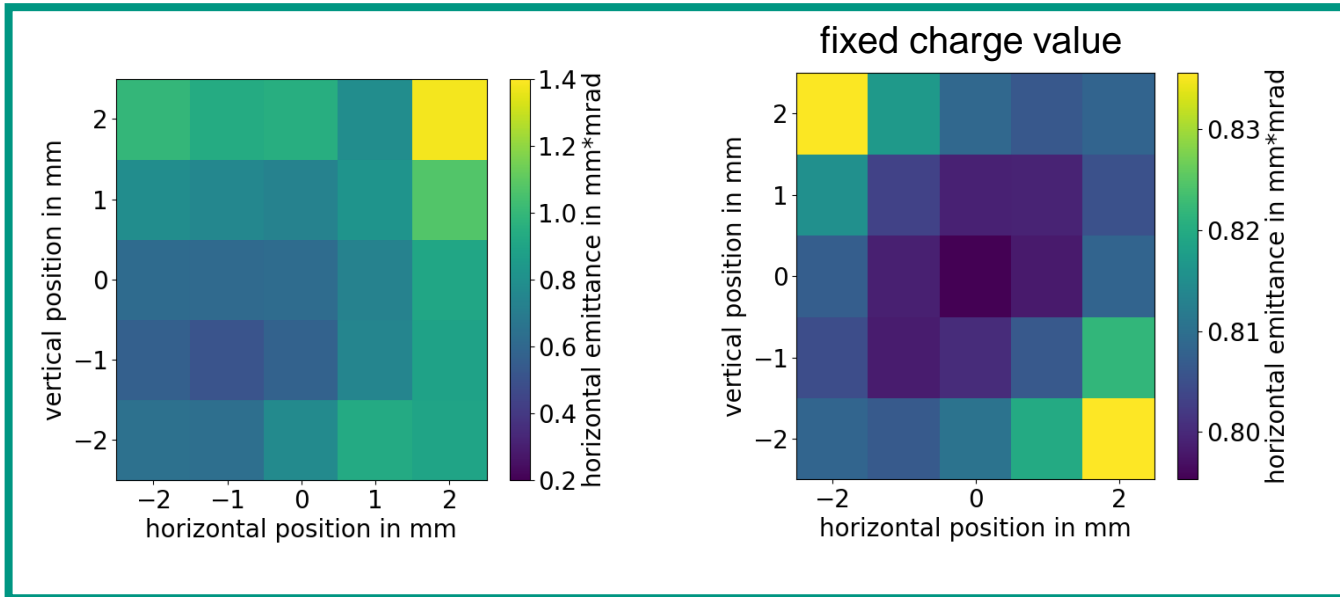
bunch charge



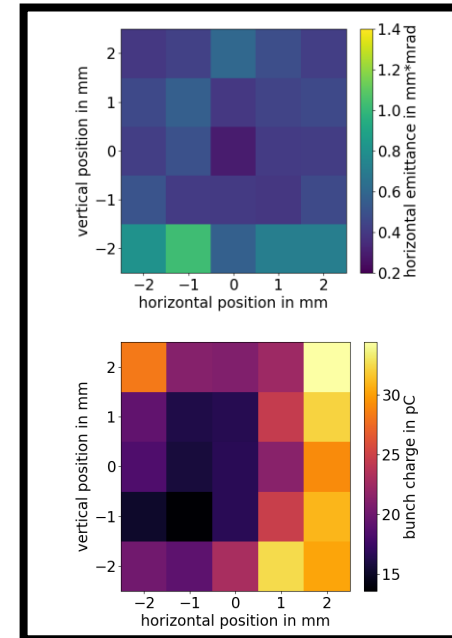
Comparison to Simulations

- ASTRA simulation: particle tracking with included space charge
- Emittance grow dominated by charge variation

Simulation



Measurement



Summary

- New linear accelerator at KIT: FLUTE
 - Purpose of generating and investigating short electron and THz pulses
 - Operation and diagnostics of electrons established
 - Electron beam parameters investigated
- Comparison with ASTRA simulation model
 - Improved model with measurement data
 - Deviations from symmetry assumption
- Outlook
 - Connection of linac imminent
 - Experiments for new short-pulse diagnostics in preparation

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Thank you for your attention