3rd ARD ST3 workshop.

15-17 July 2015 KIT.

Wed 15/7
Session 1 | Facility Report and Overview
Session 2 | Beam Dynamics & Photon Sources
Poster Session: Beam Dynamics & Photon Sources
TR, PB – speed posters

Thu 16/7
Tutorial 1: CSR- & Radiation-Beam Interaction
Session 3 | Beam Diagnostics
Poster Session: Beam Diagnostics
Session 4 | Stability, Controls & Synchronization
Poster Session: Stability, Controls & Synchronization
MK – speed poster

Fri 17/7
Tutorial 2: Electromagnetic Compatibility (EMC), Distortion and Noise Reduction
Session 5 | Closing Session
Tour: ANKA | FLUTE | KMNF | Detector-Lab

HELMHOLTZ | ASSOCIATION

PITZ Photo Injector Test Facility Zeuthen

DESY

Status of PITZ.

M. Krasilnikov for the PITZ team

Content:

- Current PITZ RF-Gun Setup and conditioning results
- RF-Gun stability measurements
- Emittance results
- New developments:
  - TDS
  - 3D Elli
  - Plasma cell
  - THz studies
- Summary

parameter	XFEL injector, nominal	XFEL injector, startup
RF gun gradient (peak power)	E_{cath}=60MV/m (6.4MW)	E_{cath}=50…53MV/m (4.5…5.0MW)
RF pulse length	650us	650us
Repetition rate	10Hz	10Hz
RF gun phase stability (rms)	0.01deg	
RF gun amplitude stability (rms)	0.01%	
Cathode laser (FWHM)	Flattop (2/20\2ps)	Gaussian (~13ps FWHM)
Beam emittance (bunch charge)	< 0.9 mm mrad (1nC)	≤1 mm mrad (500pC)

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PITZ Photo Injector Test Facility Zeuthen

DESY

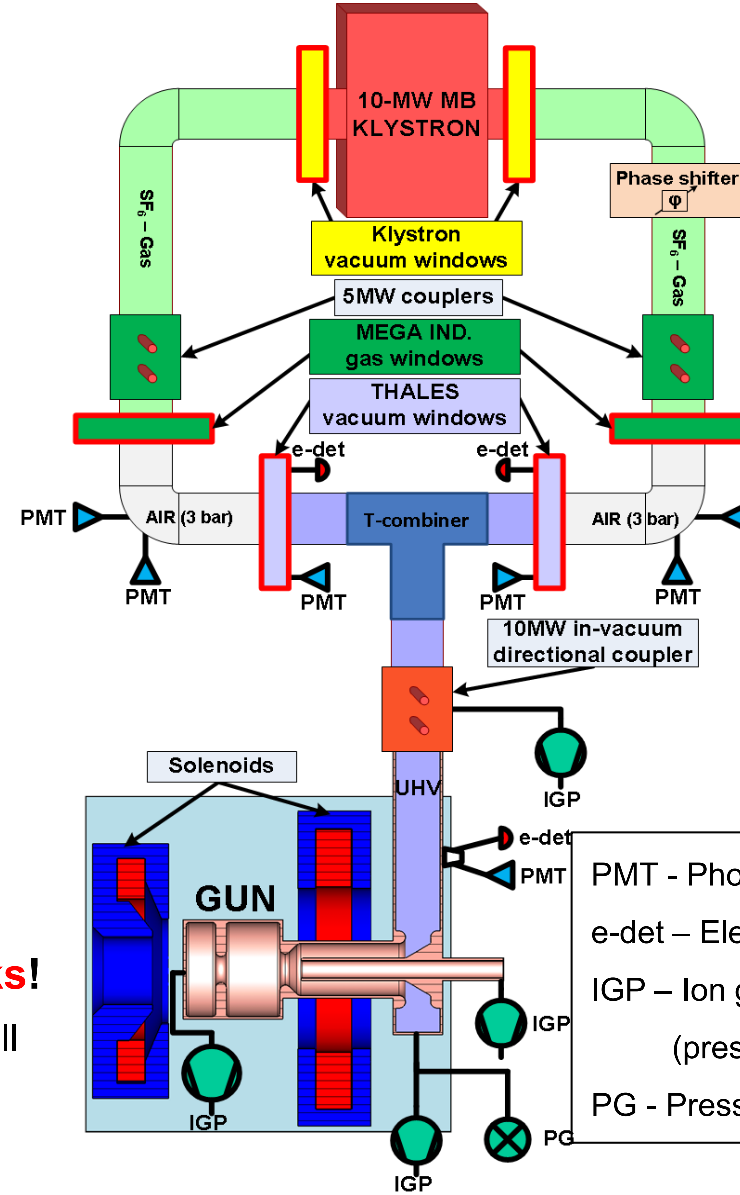
Current PITZ RF-Gun Setup and Dedicated Tasks

> **Highest priority at PITZ currently:**

Participate in the solution of the remaining problems of the RF gun for XFEL (RF windows, RF cathode contact spring, stability and long term reliability)

2 x Thales RF window solution at PITZ works!

BUT the gun-4.2 (due to its history) can not support full specifications (1 week w/o IL at 6MW, 600us, 10Hz)



RF vacuum windows position:

- adapted to available RF components
- compatible with XFEL setup

PMT - Photomultiplier tube

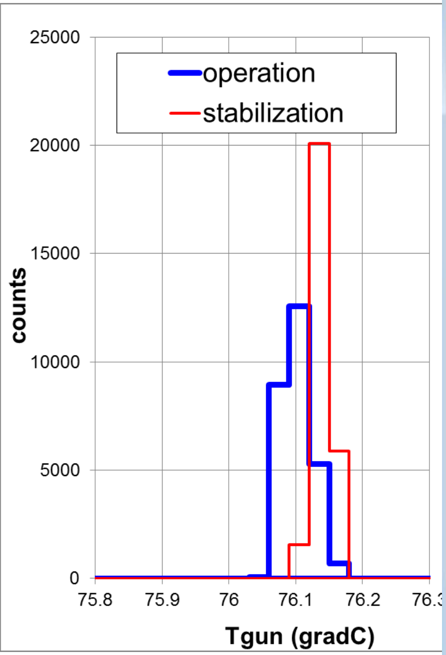
e-det – Electron detector

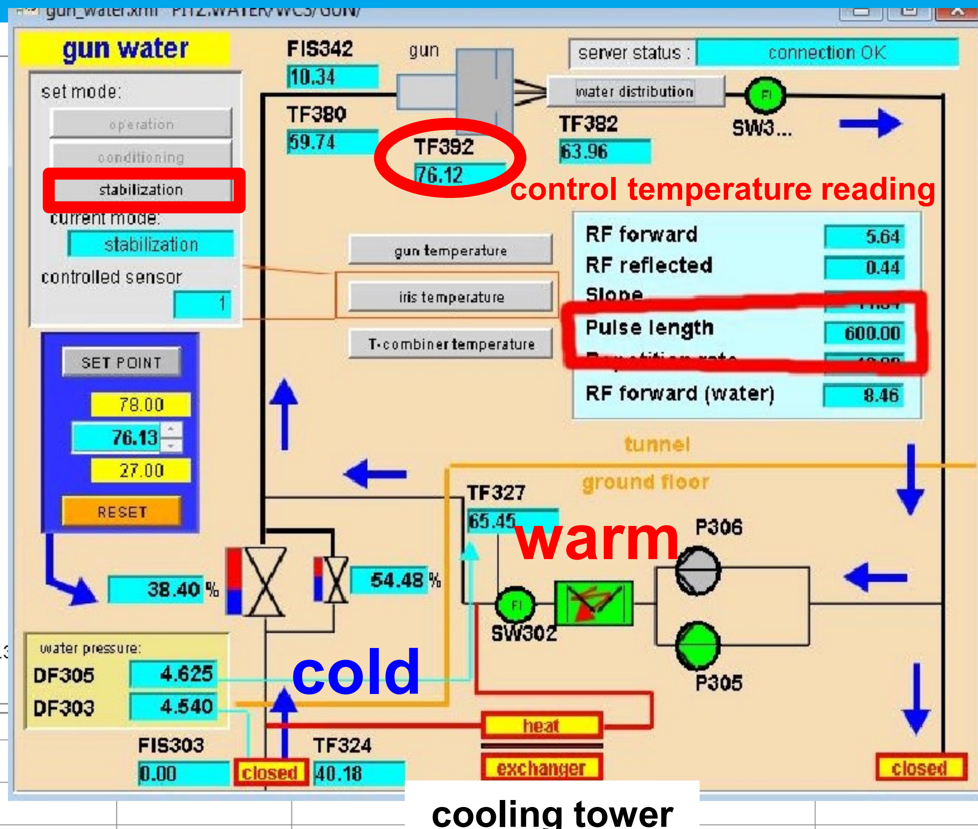
IGP – Ion getter pump (pressure reading)

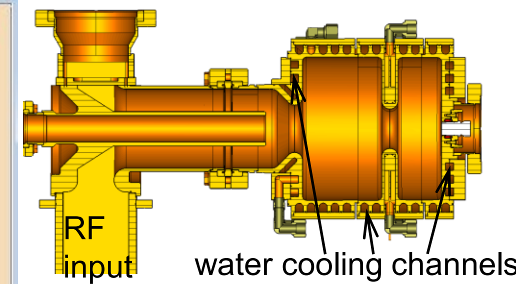
PG - Pressure gauge

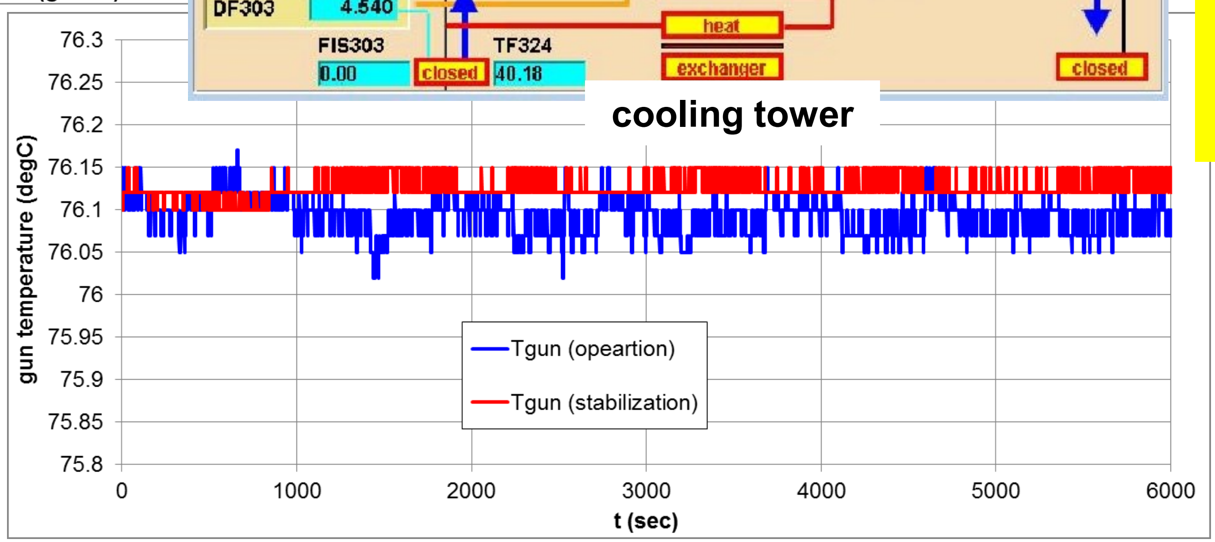
Gun RF Stability

The gun water cooling system (WCS)



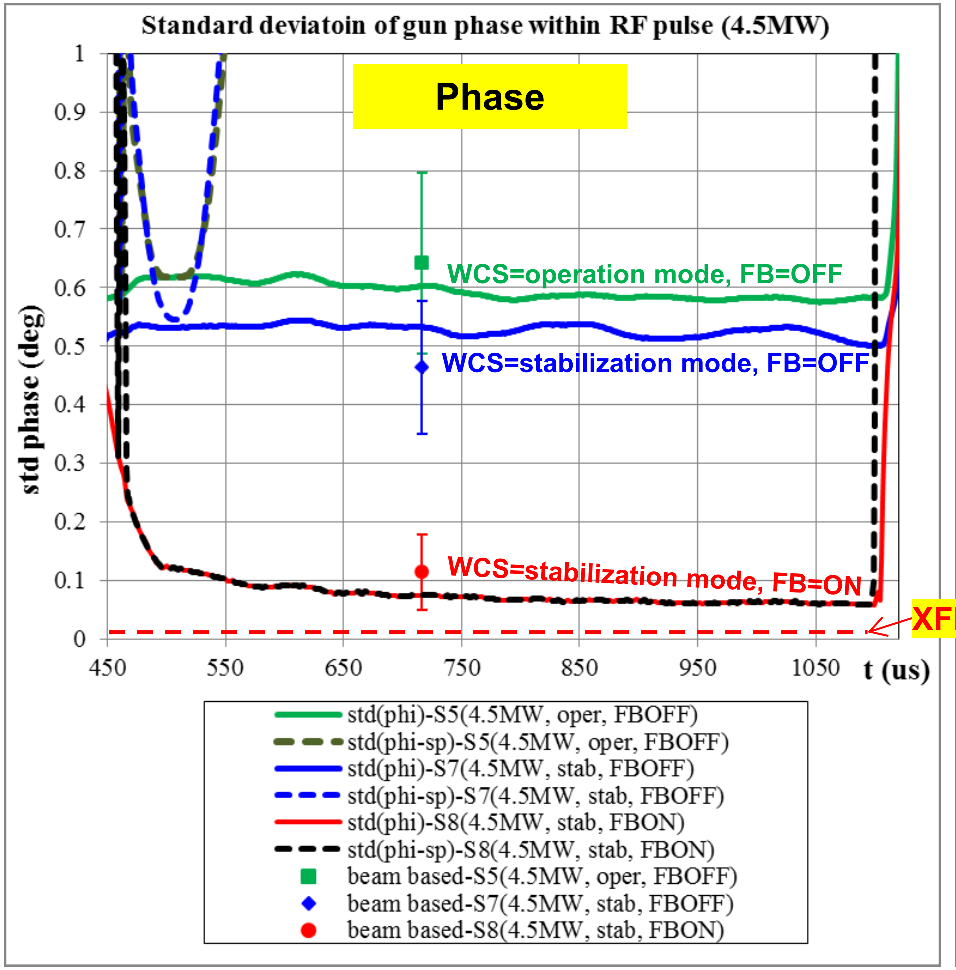


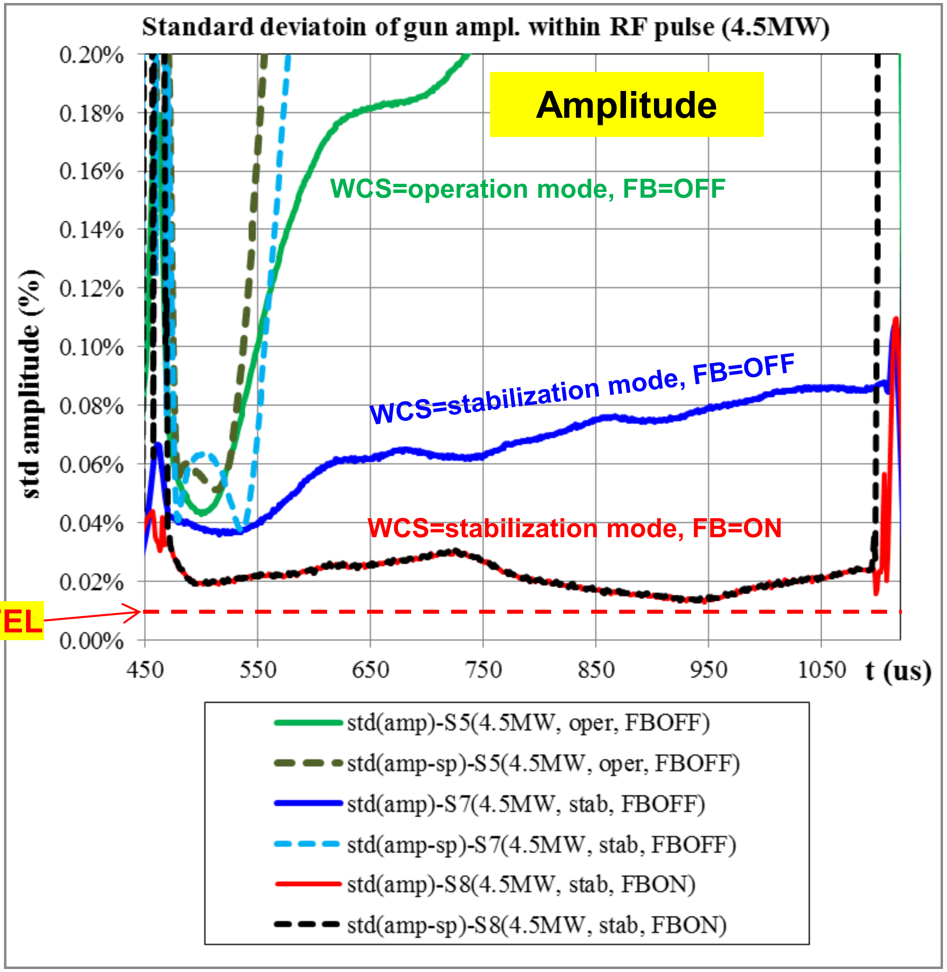




Gun WCS:
- 2 run modes
- T-readout resolution (0.025degC)→improved (new controller)

Gun RF stability at 4.5MW, 650us flat-top RF, 800 subsequent shots + Beam-based jitter measurements



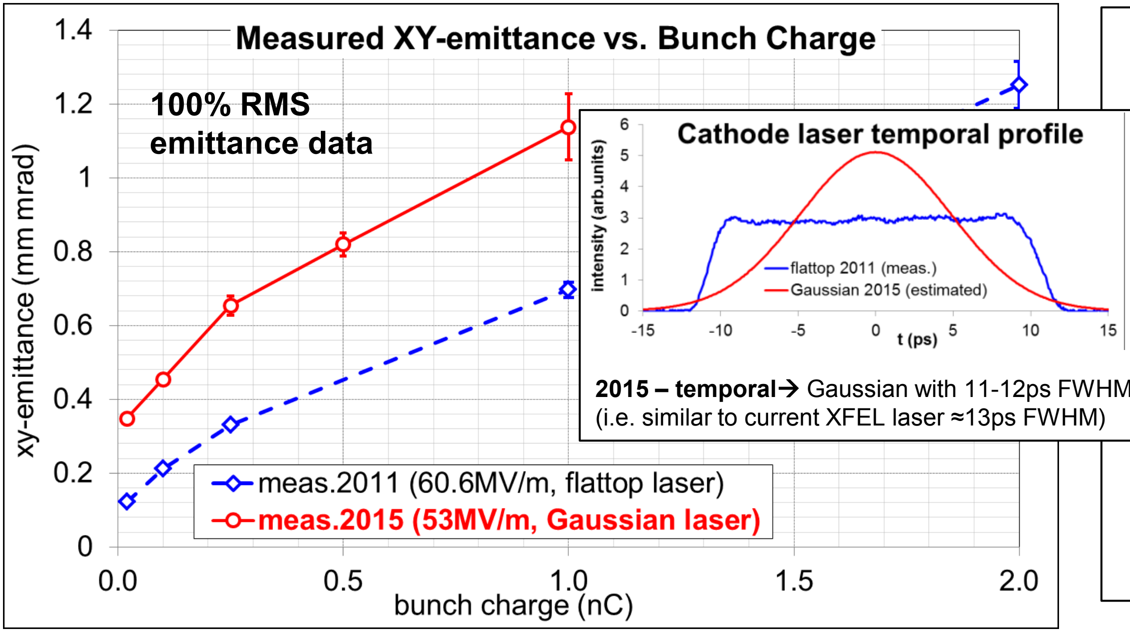


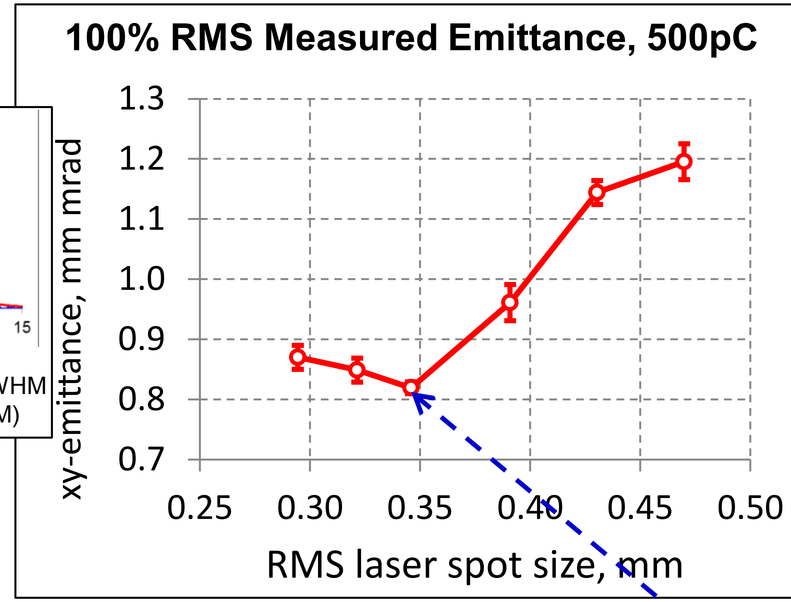
More details ➔ Speed poster: M. Krasilnikov "Improved beam-based method for RF photo gun stability measurements",

session «Stability, Controls & Synchronization»

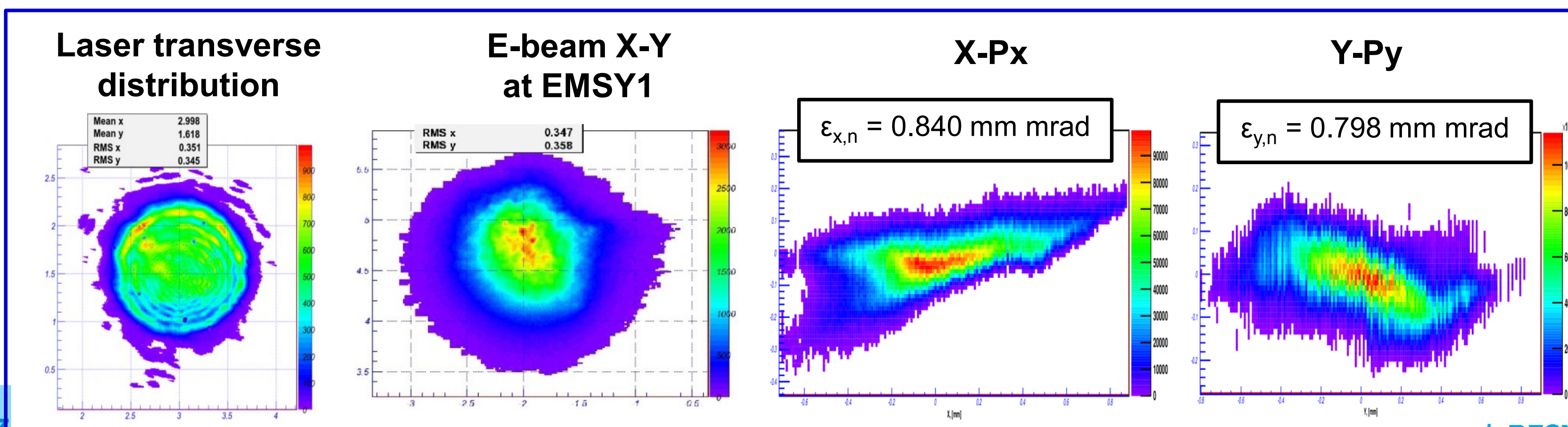
Emittance

Emittance measurements in 2015: Gun at 53 MV/m, Cathode laser → temporal Gaussian





Requirement for XFEL injector commissioning: 1 mm mrad at 500pC → **fulfilled !**



High Brightness Photo Injector for XFEL

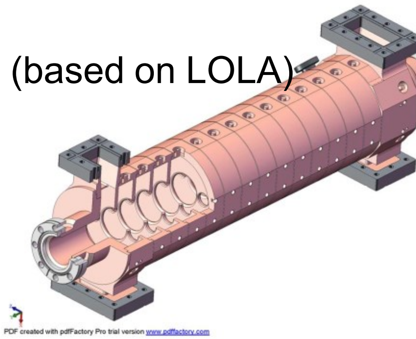
parameter	XFEL injector, nominal	XFEL injector, startup	PITZ, 2015	Remark
RF gun gradient (peak power)	E_{cath}=60MV/m (6.4MW)	E_{cath}=50…53MV/m (4.5…5.0MW)	E_{cath}=53MV/m (5MW)	
RF pulse length	650us	650us	650us	Priority w.r.t. the peak power
Repetition rate	10Hz	10Hz	10Hz	
RF gun phase stability (rms)	0.01deg		0.07deg	
RF gun amplitude stability (rms)	0.01%		0.02%	
Cathode laser (FWHM)	Flattop (2/20\2ps)	Gaussian (~13ps FWHM)	Gaussian (~11-12ps FWHM)	Pulse shaper issue
Beam emittance (bunch charge)	< 0.9 mm mrad (1nC)	≤1 mm mrad (500pC)	0.8 mm mrad (500pC)	E_{cath}=53MV/m, Gaussian laser pulse

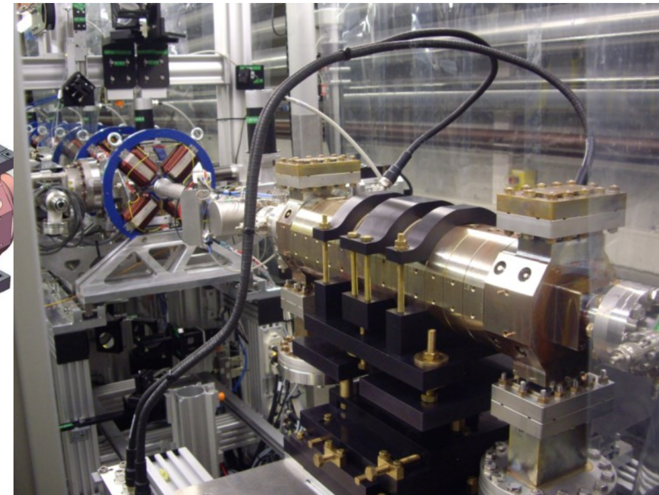
Required electron beam quality demonstrated at PITZ in 2011 with ≤200us RF pulse length

TDS

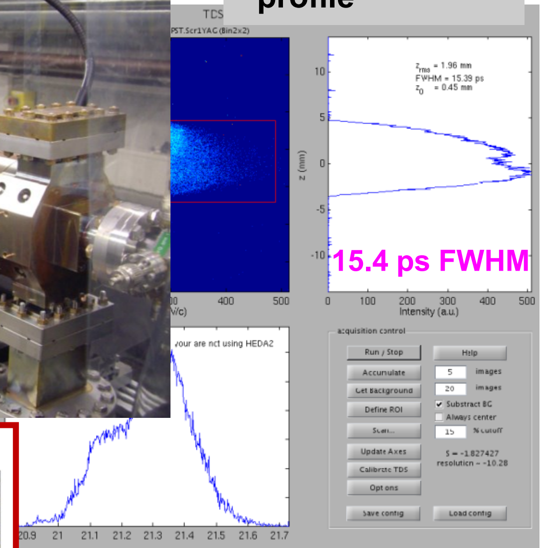
Transverse Deflecting System (TDS) status

- > Prototype for the XFEL injector
- > Designed & manufactured by INR, Troitsk, Russia
- >Travelling wave structure (based on LOLA)
- >Design parameters:
  - 1.7 MV over 0.533 m
  - 14+2 cells (2π/3)
  - 2997.2 MHz
  - Q = 11780



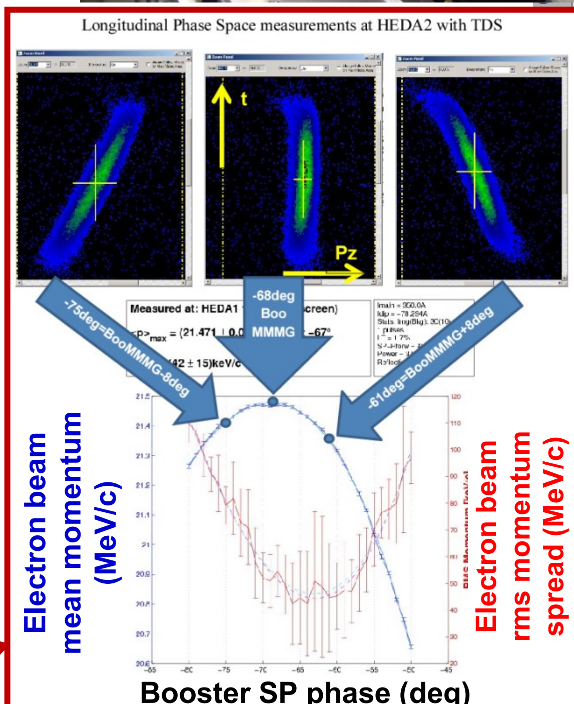


E-beam current profile



- >Expected power balance:
  - Q~88% at 45°C, 44 m WG losses…
  - 2.1 MW @structure
  - 2.7 MW @klystron

- >TDS **commissioning** started on **02.07.2015**!
  - Structure conditioned up to ~600 kW (~25% of design value).
  - **First measurements** taken:
    - Calibration of couplers vs. e-beam deflection
    - Temperature dependencies
    - Bunch length vs. charge and booster phase
    - TDS+HEDA2= single-shot images of **longitudinal phase space**

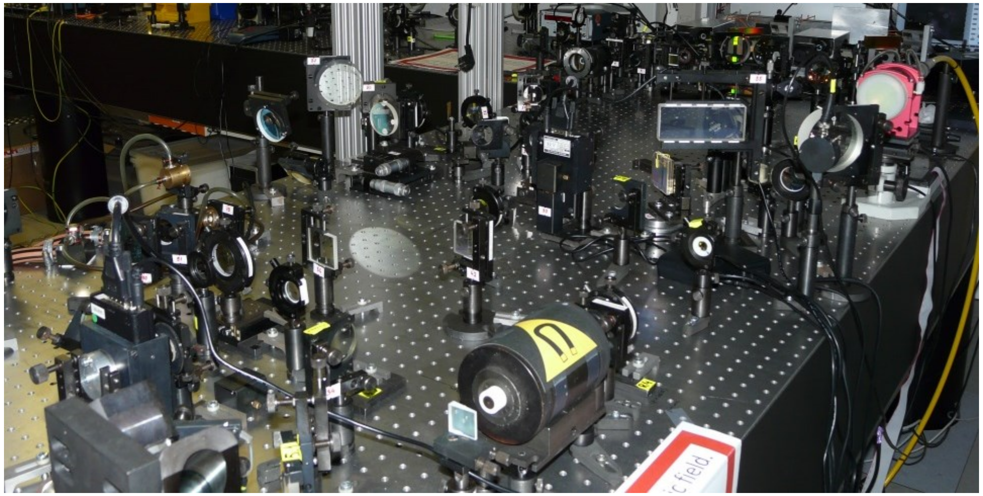


new ScandiNova modulator

3D Elli

New photocathode laser system for 3D ellipsoidal pulses

- Installation finalized 12/2014

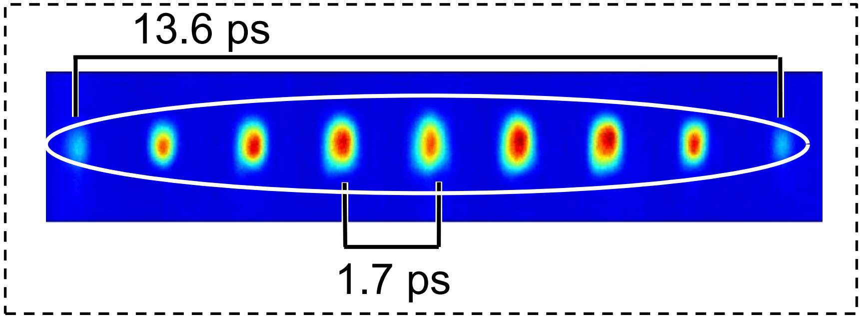


- Commissioning begun 2015
- First photoelectrons 04/2015
- Beamline finalized 04/15

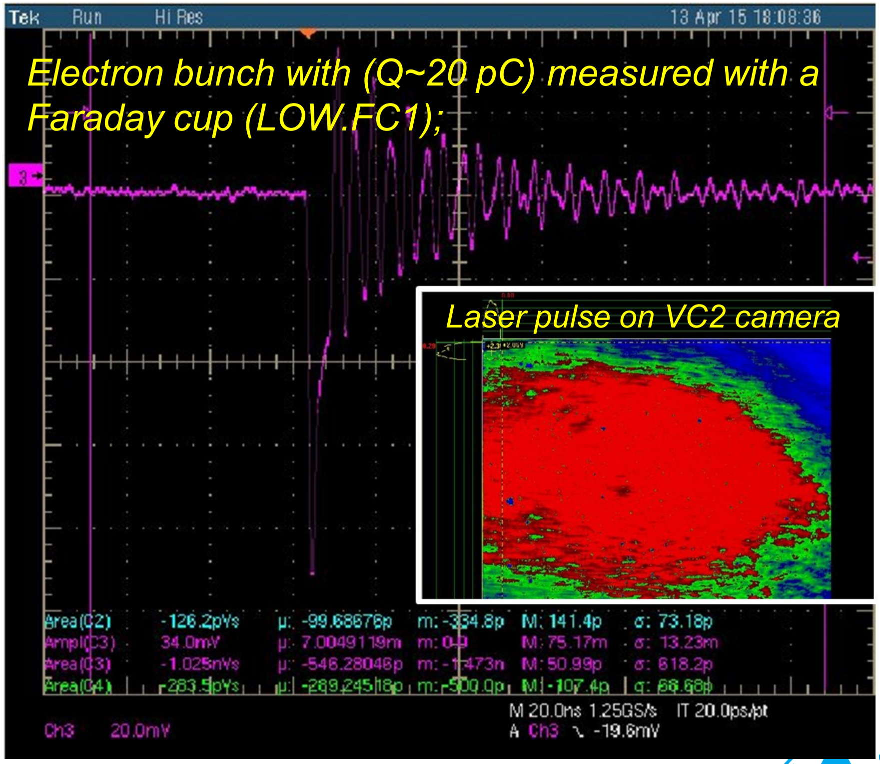
More details ➔ Speed poster:

T. Rublack “New photocathode laser system for 3D quasi-ellipsoidal pulses - first produced photoelectrons”,

session 2 «Beam Dynamics & Photon Sources»



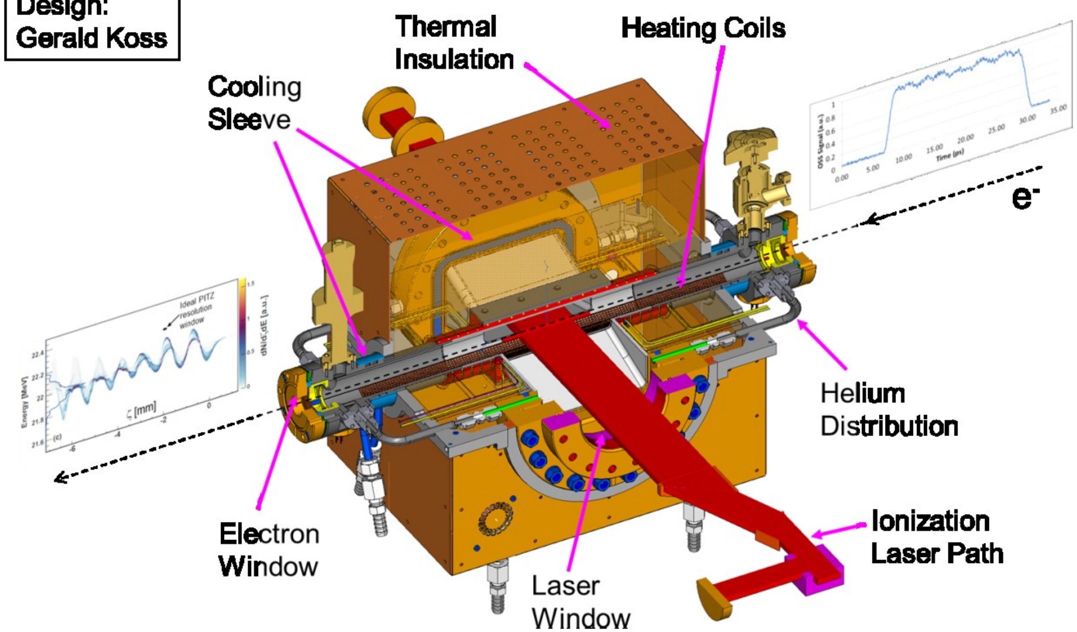
Cross-correlation measurement of pulse



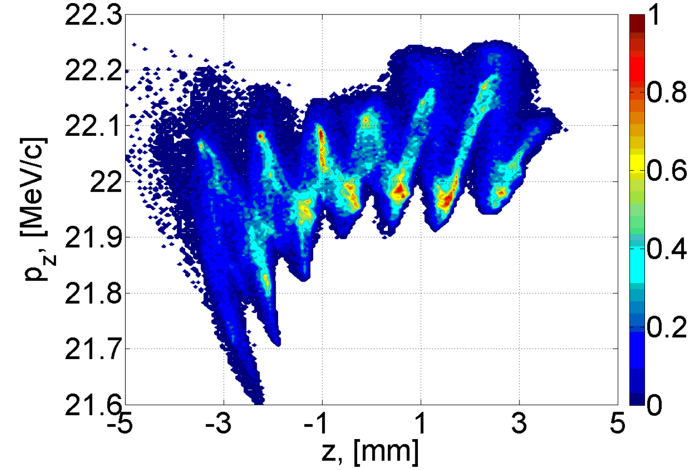
PDPWA

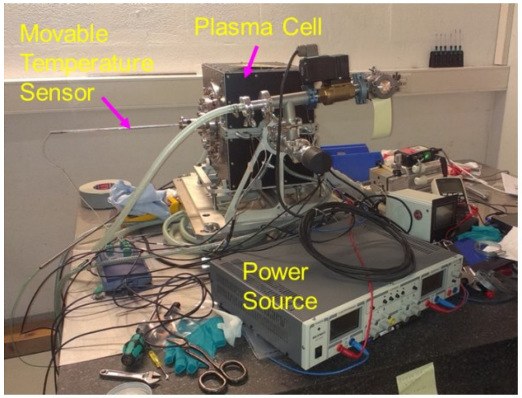
Self-modulation Experiment with long Electron Beams

Design:
Gerald Koss

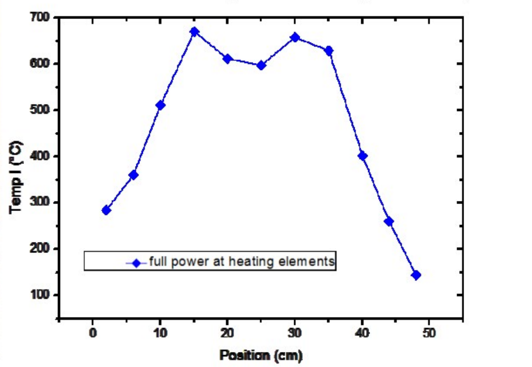


Simulation of experiment:
Expected phase space





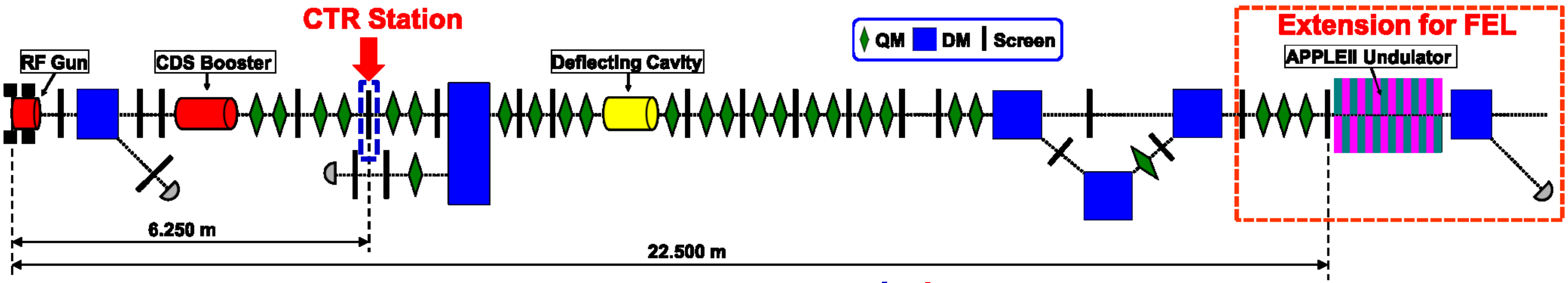
Measurement of longitudinal temperature profile



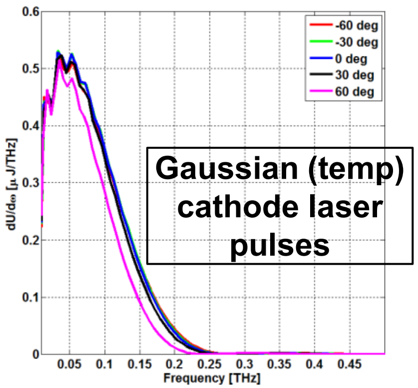
- PITZ plasma cell:
  - designed and fabricated
  - commissioning mainly done (next step: Lithium vaporization, ionization)
  - leaky plasma cell is being repaired
- PITZ beamline was remodeled
- Ionization laser is set up
- Several preparatory experiments performed:
  - <100μm focusing into plasma cell
  - 8μm Kapton foil → for first experiments, 3μm → goal for the window thickness (from BD simulations and first experiments)
- **Installation into PITZ beamline → this week**

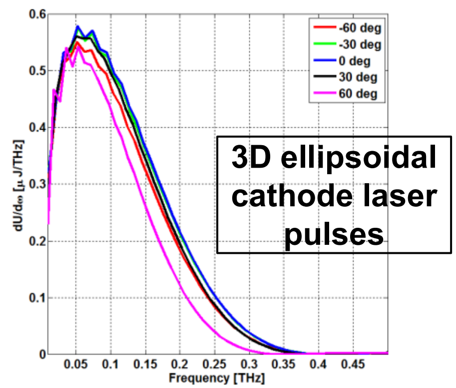
Studies on THz option at PITZ

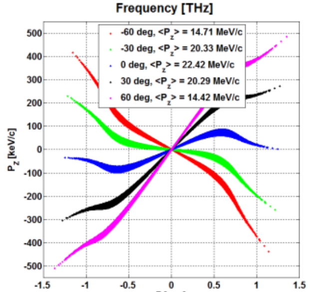
Simulations of the IR/THz Options at PITZ (High-gain FEL and CTR)



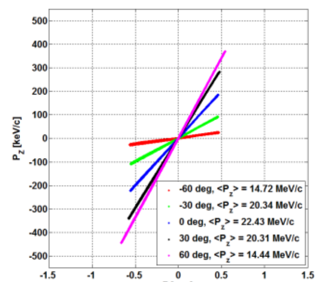
CTR Radiation Calculations (Generalized Ginzburg-Frank Formula)







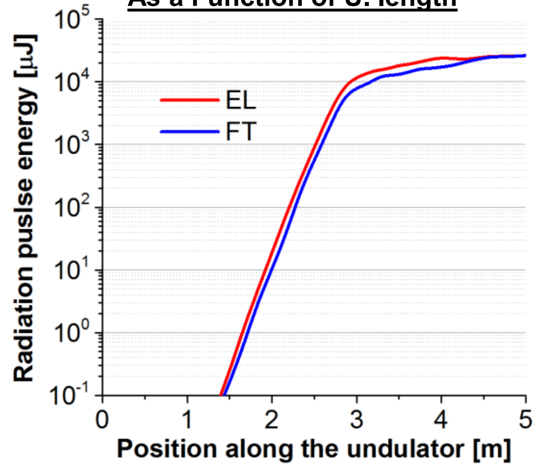
Long. Ph. Spaces (Gaussian)



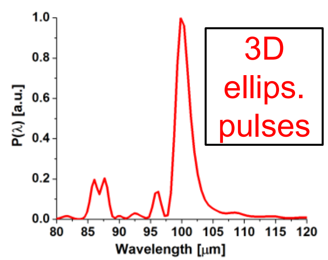
Long. Ph. Spaces (3D-Ellipsoidal)

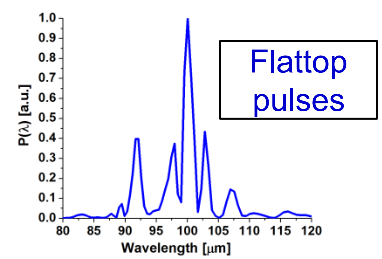
SASE FEL Calculations (GENESIS 1.3 code)

Energy in the Radiation Pulse As a Function of U. length



Spectral Profile of Radiation Pulseat the Saturation





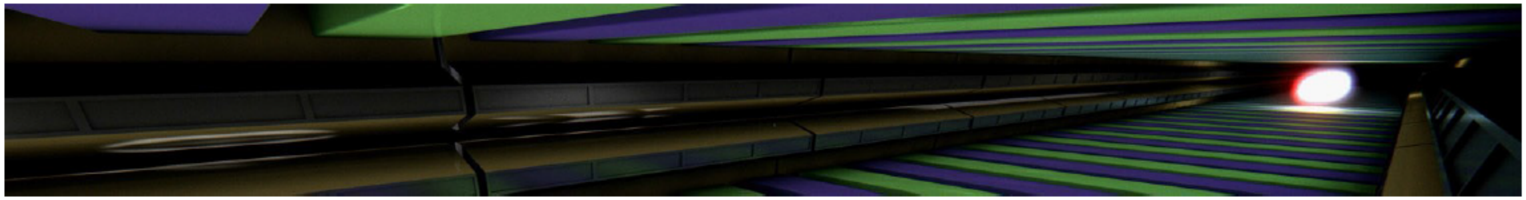
More details ➔ Speed poster: P. Boonpornprasert "Simulations of the IR/THz Options at PITZ (High-gain FEL and CTR)",

session 2 «Beam Dynamics & Photon Sources»

Summary and Outlook

- **2 x Thales RF window** solution at PITZ **works**!
- **Gun RF stability** at PITZ is comparable to FLASH results → improvements still required to reach the XFEL specs (phase jitter x 5; amplitude jitter x 2)
- **Emittance requirements** for XFEL injector commissioning were **demonstrated experimentally**.
- **New developments** at PITZ:
  - **TDS**: commissioning is ongoing, first measurements done
  - **3D ellipsoidal laser**: first photoelectron produced
  - **Plasma acceleration** experiment: Self-modulation experiments are in preparation
  - Simulations of the **IR/THz** options at PITZ (High-gain FEL and CTR) → case studies

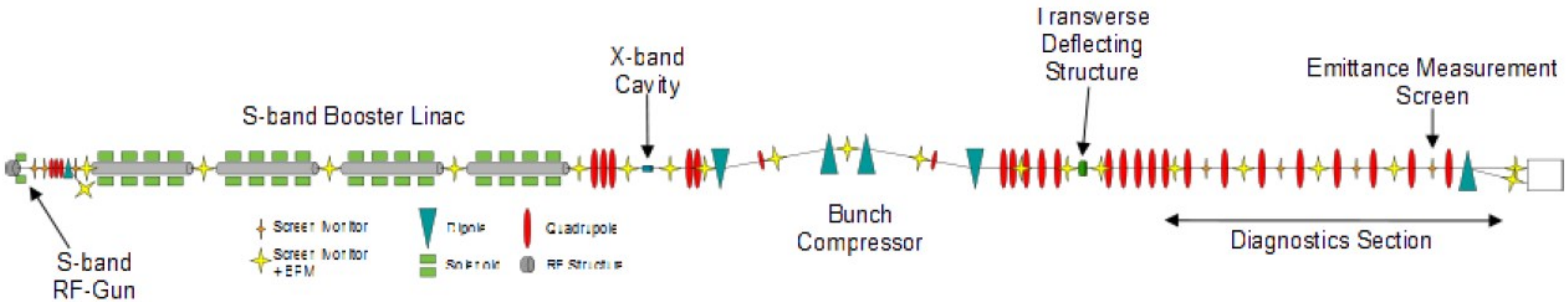
Other contributions

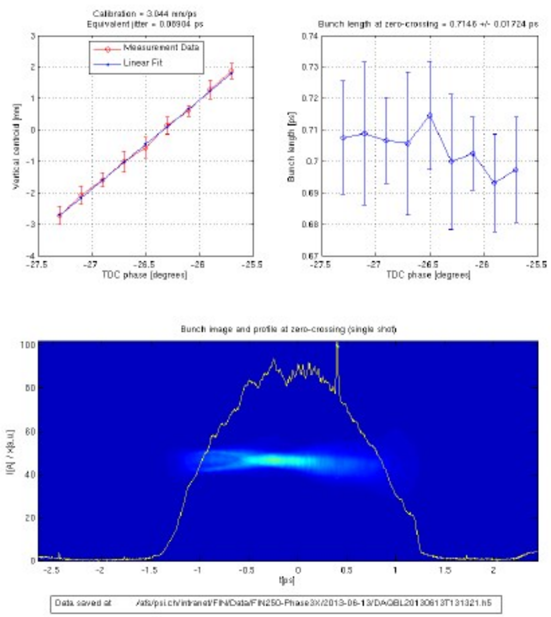


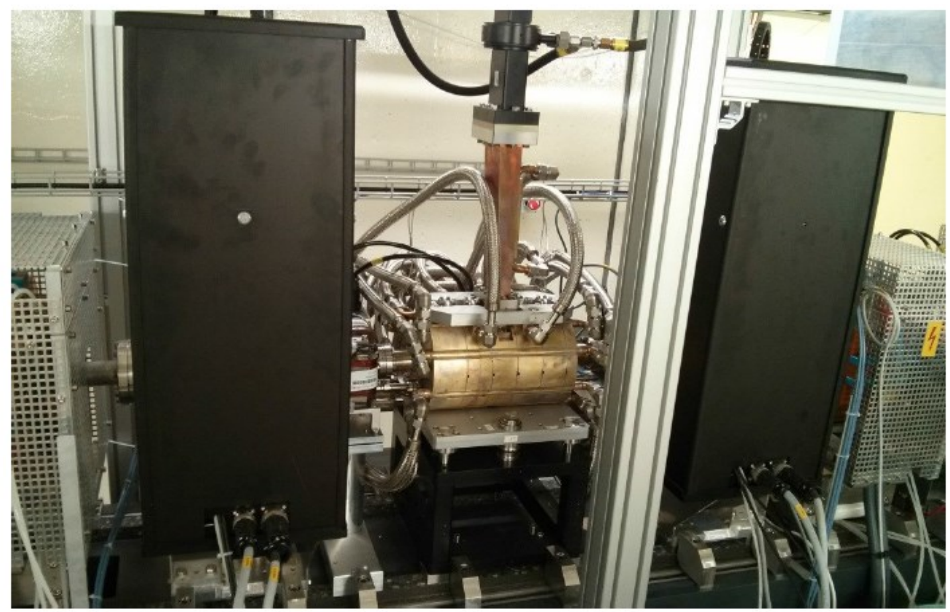
Experience from TDS Measurements at the SwissFEL Injector Test Facility

Bolko Beutner, for the SwissFEL Injector Team
DESY Hamburg / formerly Paul Scherrer Institute

SwissFEL Injector Test Facility





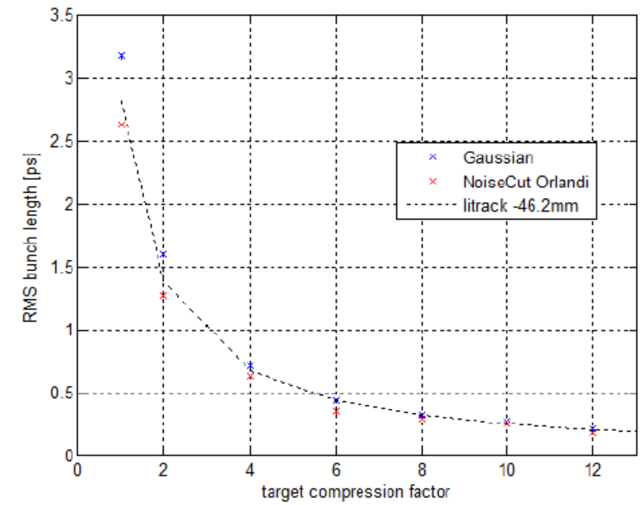


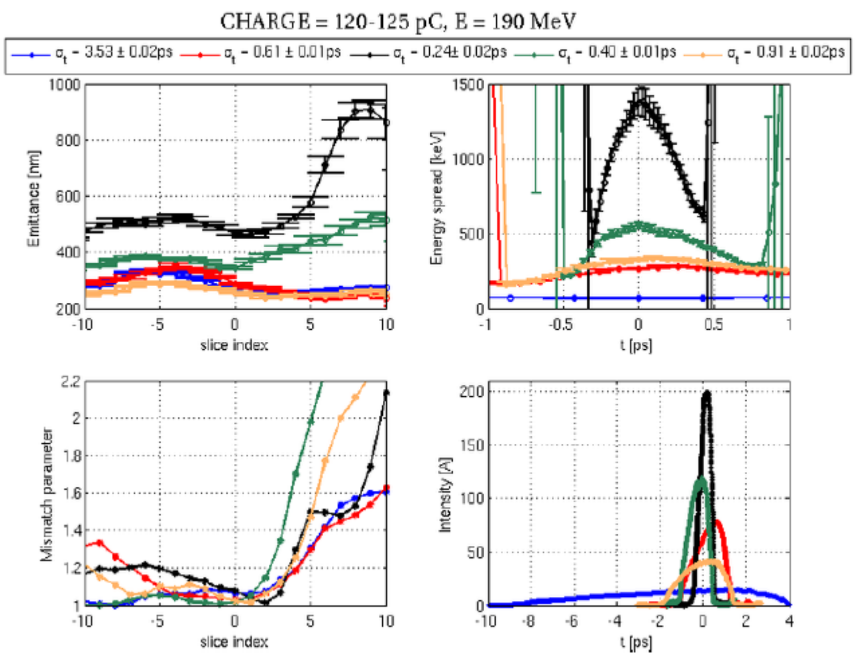
European XFEL

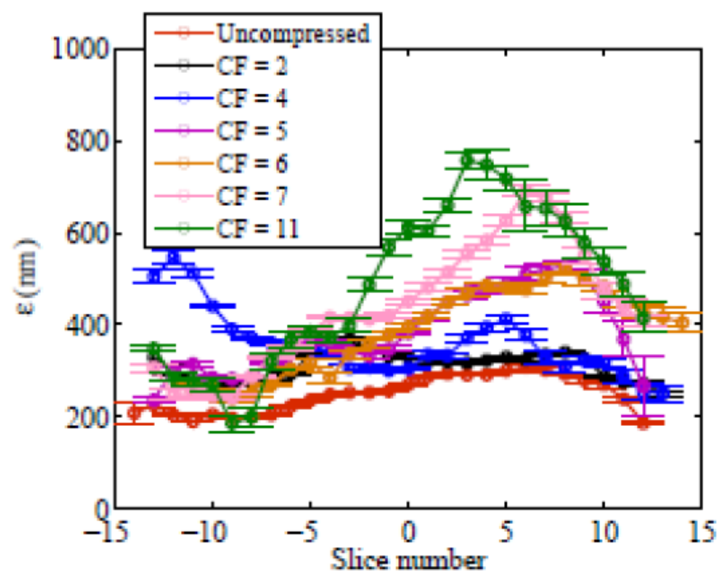
TDS Studies

- Bunch Length agrees very well with Expectations
- Slice energy spread and slice emittance increases more than expected for compression factors above 5-6
  - Effects are understood

=> see you at the Poster







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Online diagnostics of time-resolved electron beam parameters with TDS at the European XFEL

Minjie Yan (DESY)

3rd ARD ST3 Workshop
KIT, 15. July. 2015

- 3 sections with Transverse Deflecting Structures (TDS) @ European XFEL
- Future upgrade to online longitudinal phase space measurement:
  TDS + kicker magnet+ septum magnet

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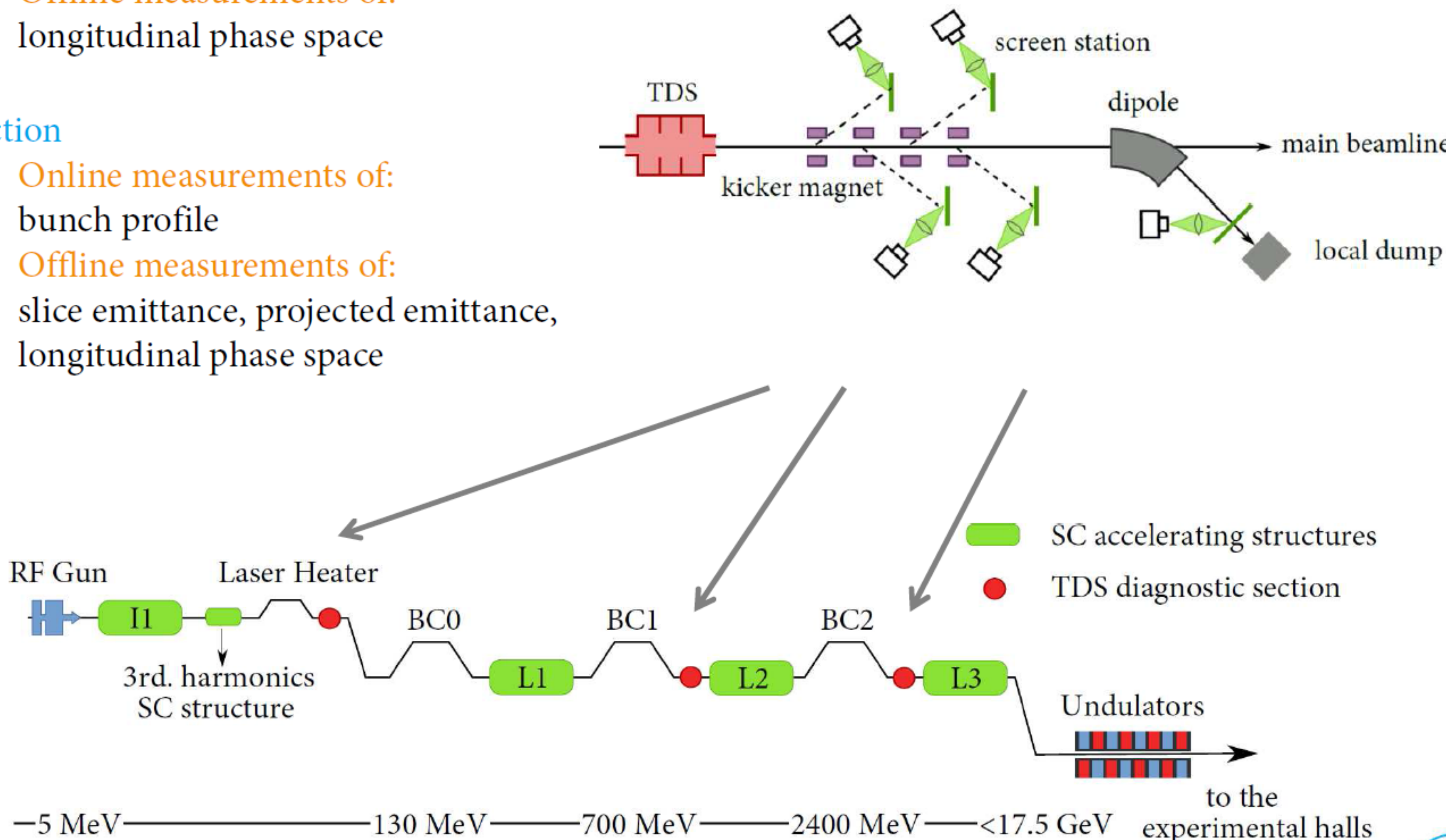
Longitudinal diagnostics with TDS @ European XFEL

Injector and BC1 section

- Online measurements of:
  bunch profile, slice emittance, projected emittance
- Offline measurements of:
  longitudinal phase space

BC2 section

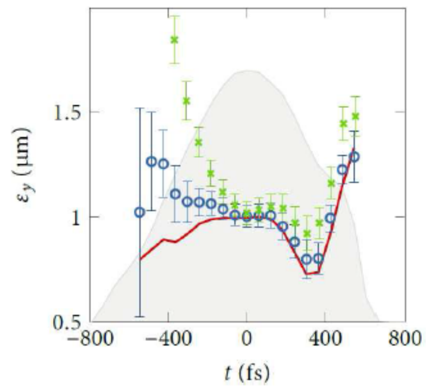
- Online measurements of:
  bunch profile
- Offline measurements of:
  slice emittance, projected emittance, longitudinal phase space

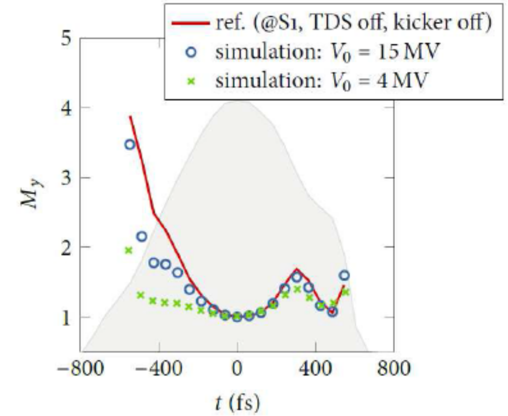


elegant simulation with S2E bunch: example shown for BC1 section

Slice emittance

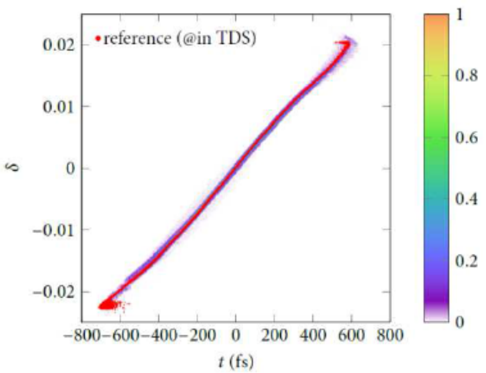
- With longitudinal resolution of ~10fs.
- At the matched optics:
  statistical error: ~5%
  systematic error: ~5%

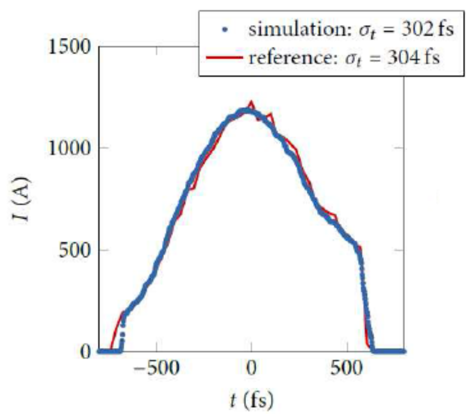


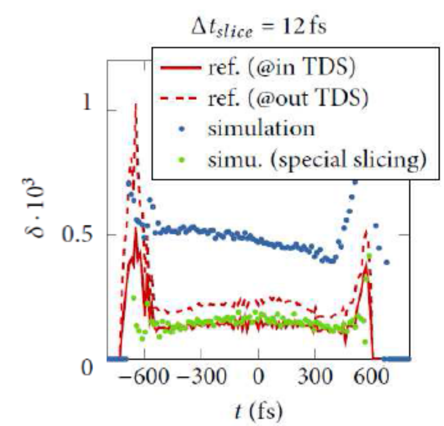


Longitudinal phase space

- Longitudinal resolution: ~10fs
- Energy resolution: ~8 $\cdot 10^{-5}$ (~57keV@beam energy of 700MeV)
- Induced energy spread from the TDS: ~2 $\cdot 10^{-4}$ (~144keV@beam energy of 700MeV)



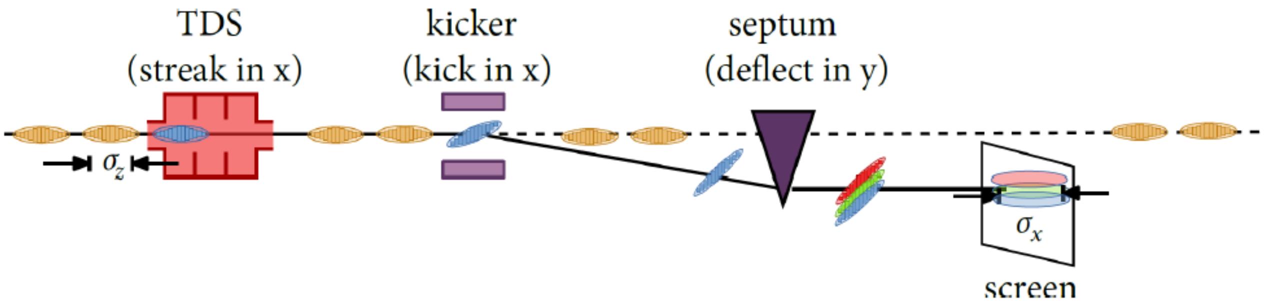




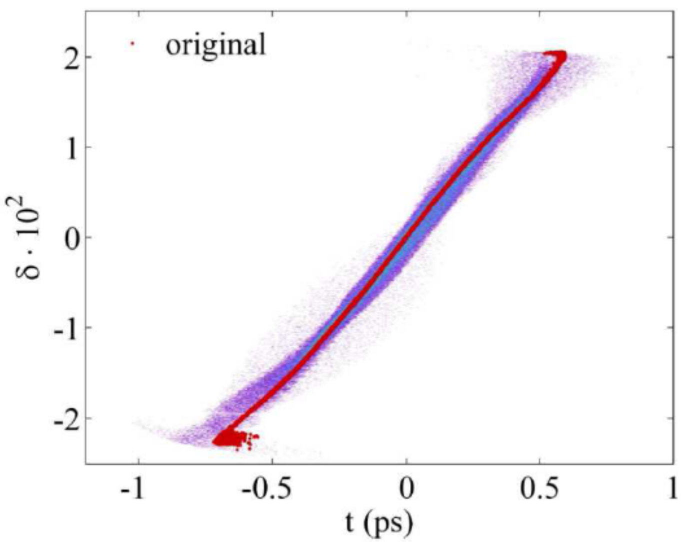
Future upgrade to online longitudinal phase space measurements

TDS + fast kicker magnet + septum magnet

- Pulse-stealing mode (lost one bunch in the bunch train)



- elegant simulation with S2E bunch:



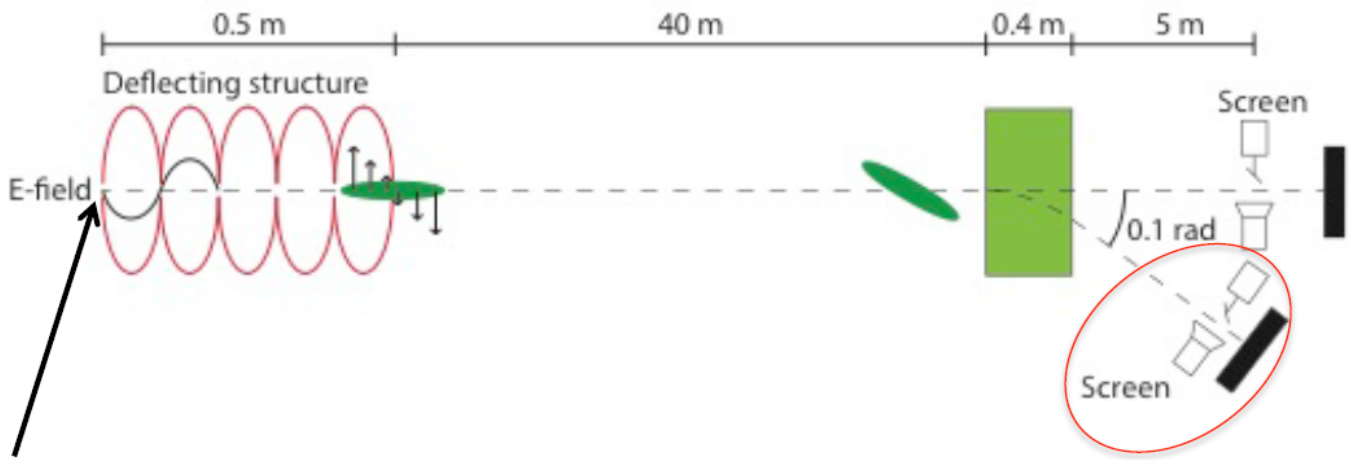
Karlsruhe Institute of Technology

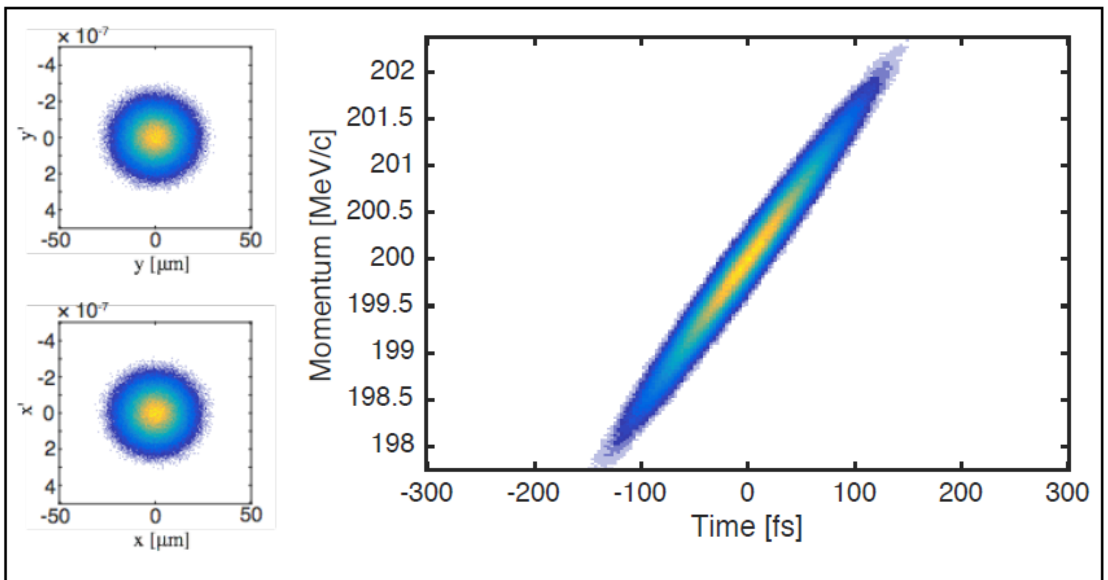
FLUTE

Bunch Length Measurement of Femtosecond Electron Bunches using a Transverse Deflecting Structure and a Magnetic Spectrometer

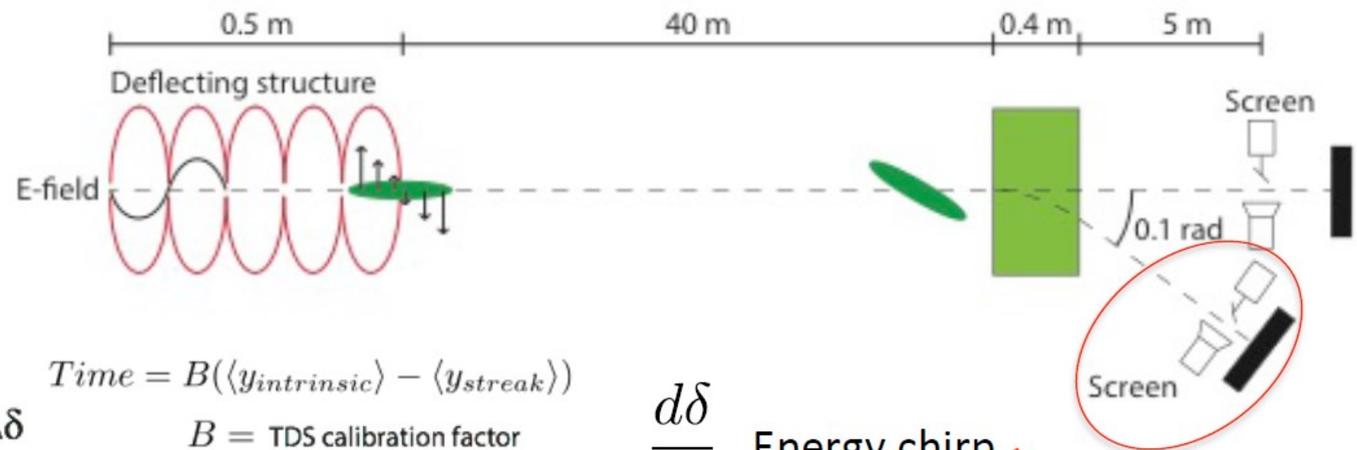
B. Smit, V. Schlott, M. Yan, E. Prat, and R. Ischebeck

Simulations



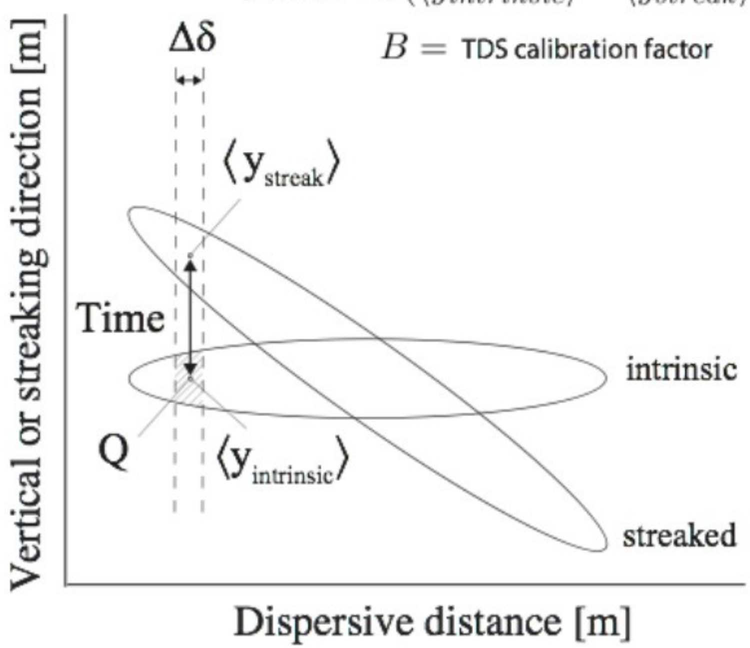


Proposal



$$Time = B(\langle y_{intrinsic} \rangle - \langle y_{streak} \rangle)$$

$B =$ TDS calibration factor



$\frac{d\delta}{dt}$ Energy chirp

$\frac{Q}{d\delta}$ Energy spread

Current profile $\frac{Q}{dt}$

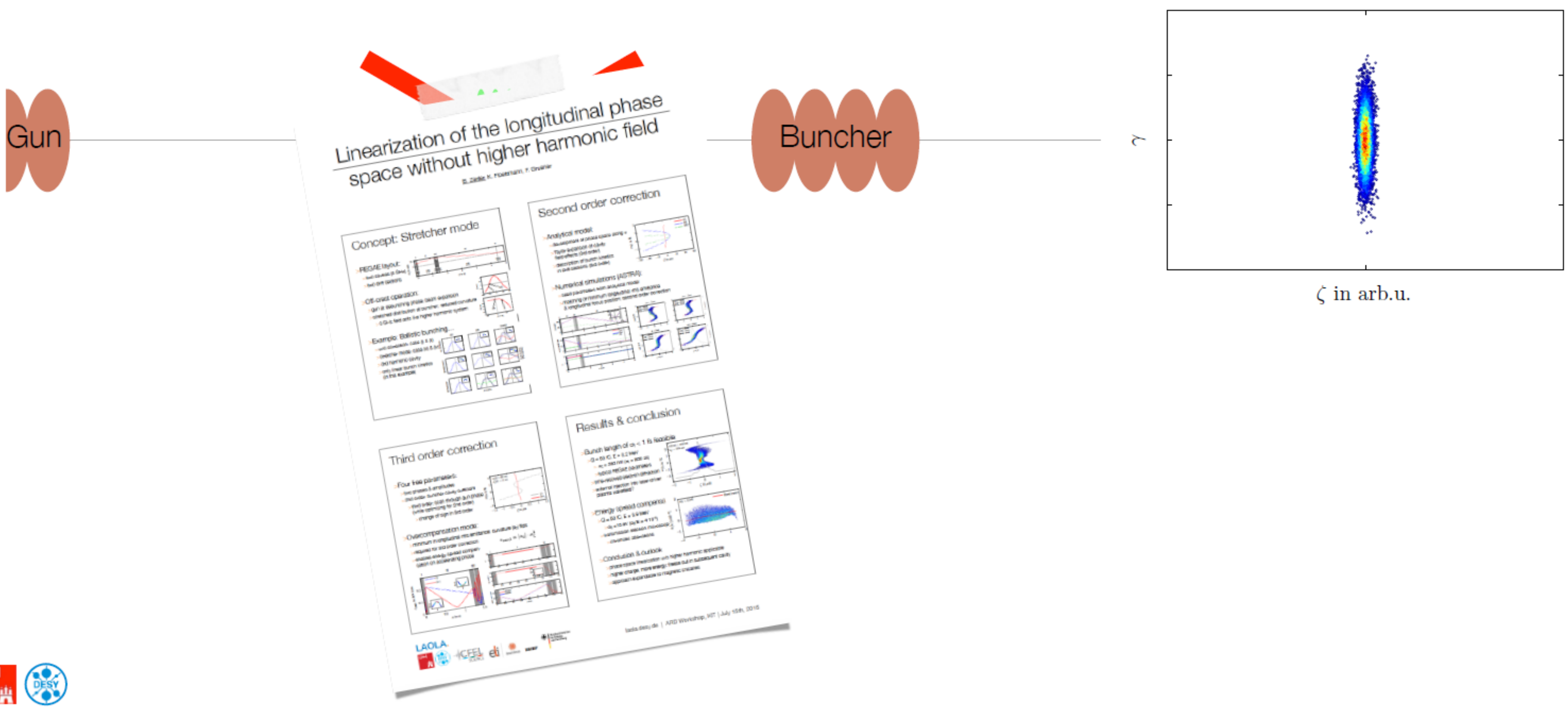
Linearization of the longitudinal phase space without higher harmonic field

Benno Zeitler
CFEL, UHH, LAOLA.
laola.desy.de

CFEL SCIENCE

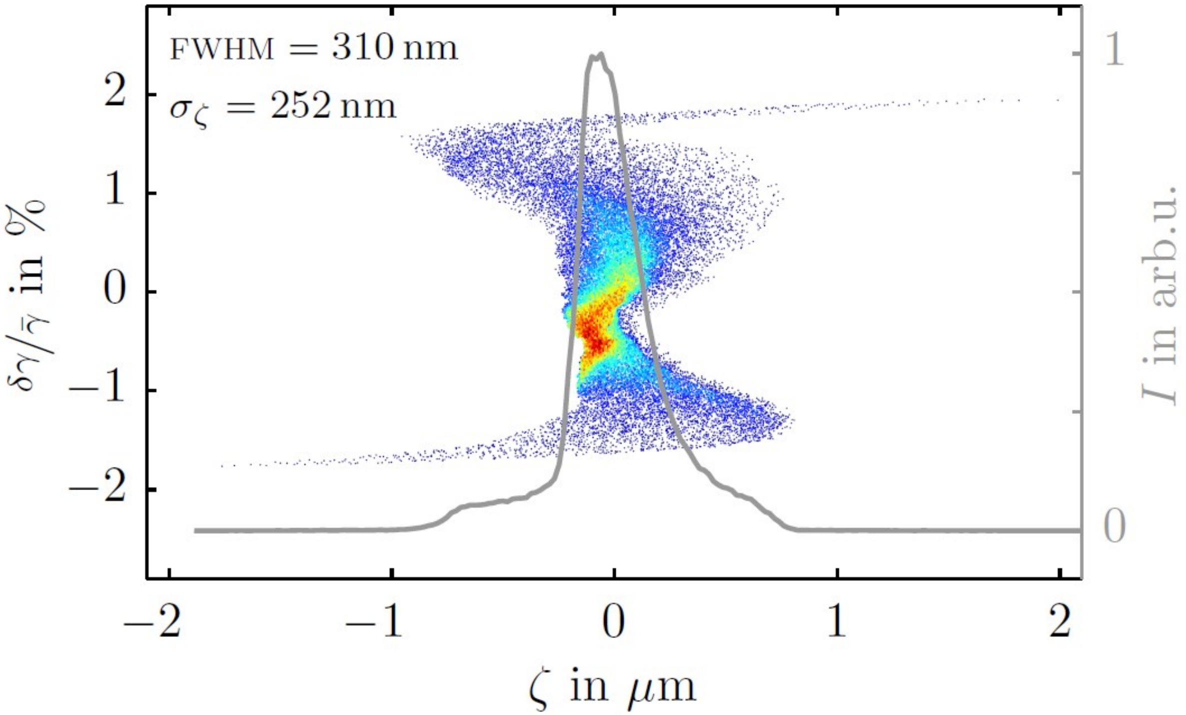
LAOLA. is a collaboration of UHH DESY

Phase space linearization



LAOLA.

Bunch compression



LAOLA.

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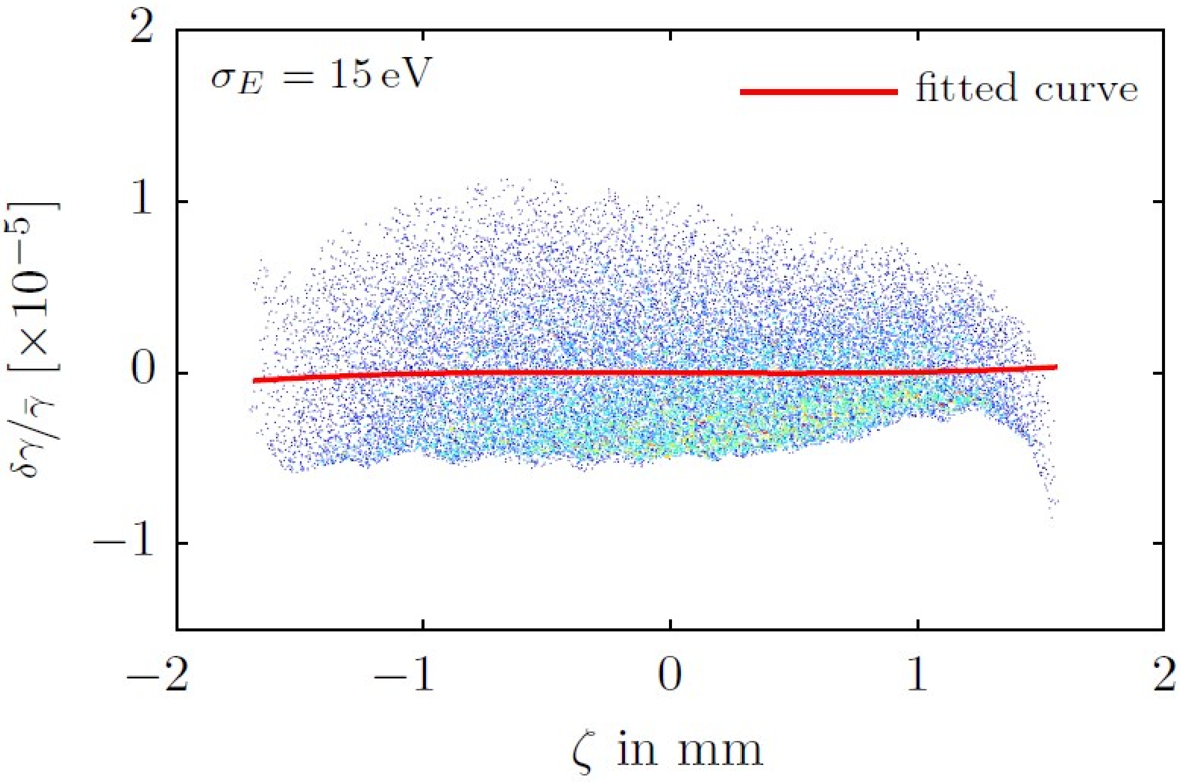
Energy spread compensation



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3rd ARD ST3 workshop.