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)

HELMHOLTZ ASSOCIATION

PITZ Photo Injector Test Facility Zeuthen

DESY

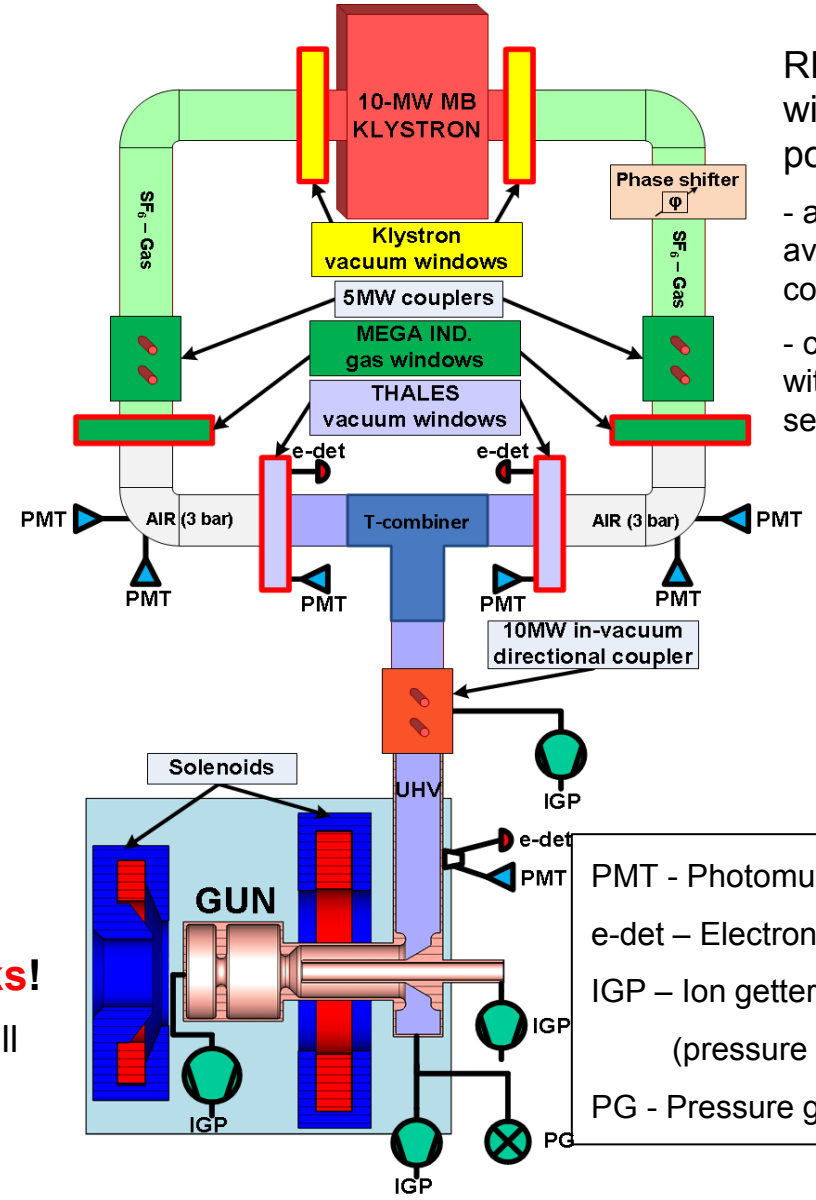
Current PITZ RF-Gun Setup and Dedicated Tasks

> **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

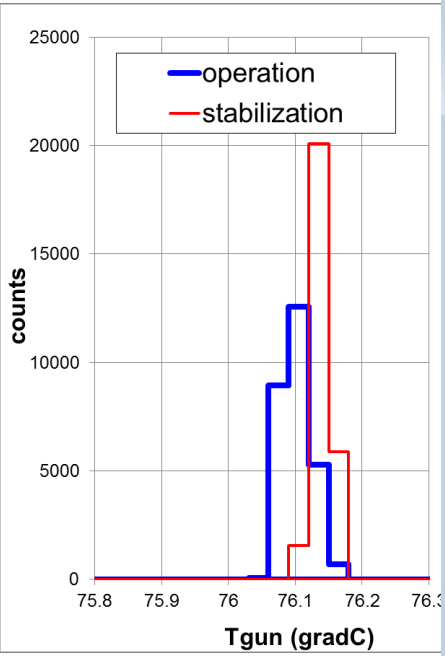
Gun RF Stability

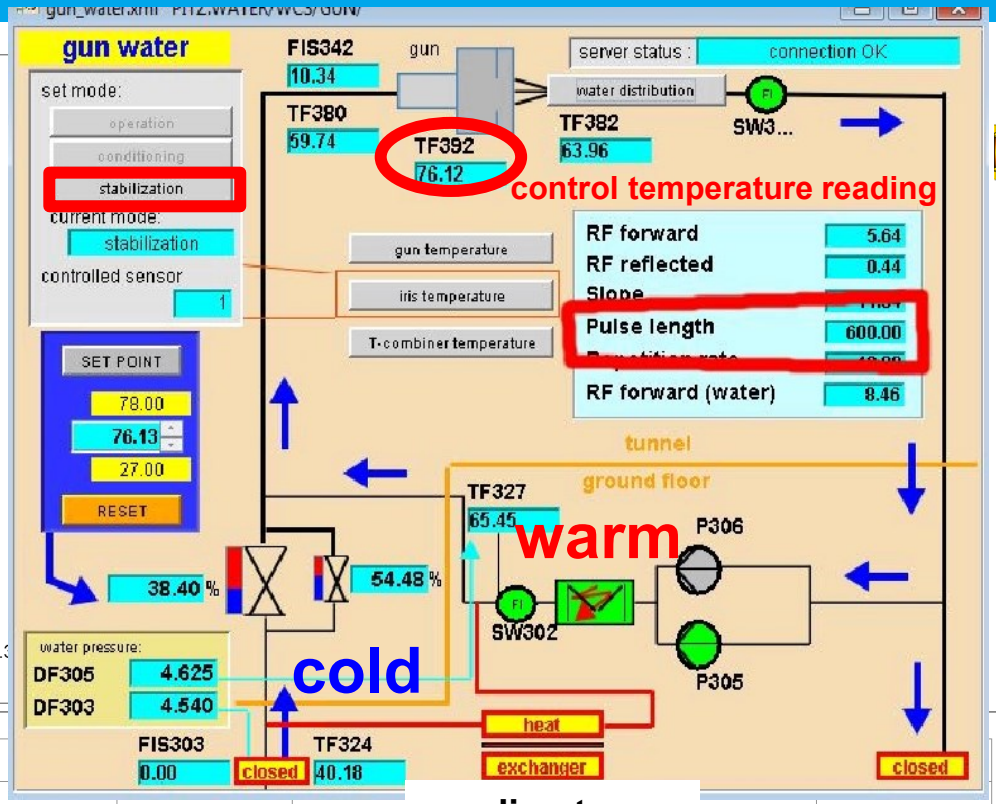
HELMHOLTZ ASSOCIATION

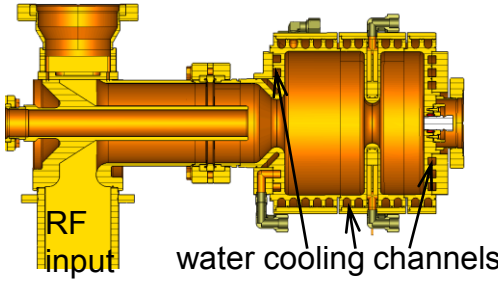
PITZ Photo Injector Test Facility Zeuthen

DESY

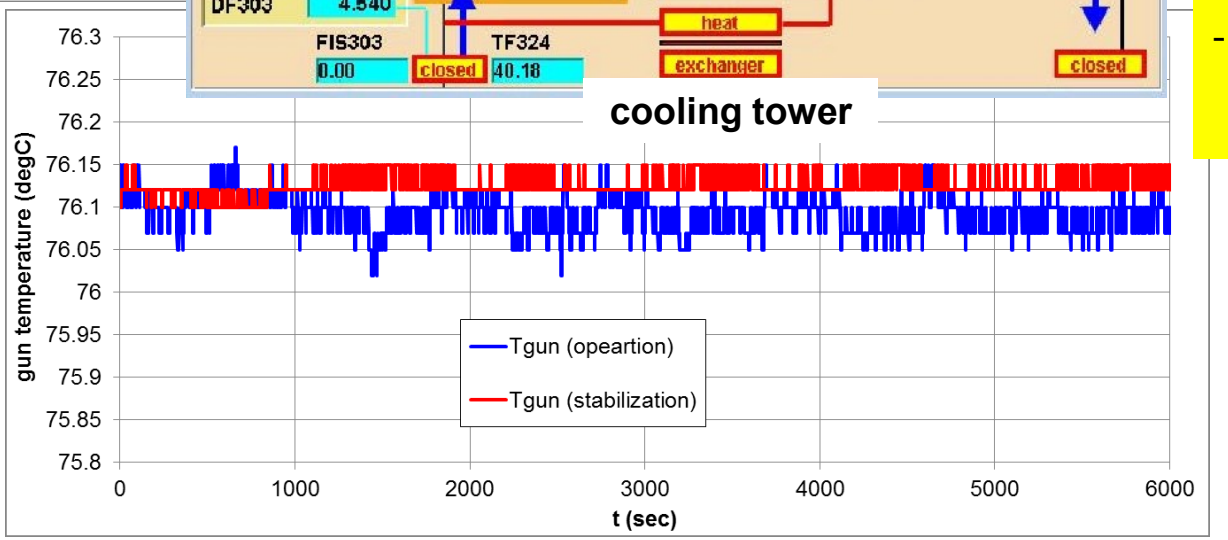
The gun water cooling system (WCS)



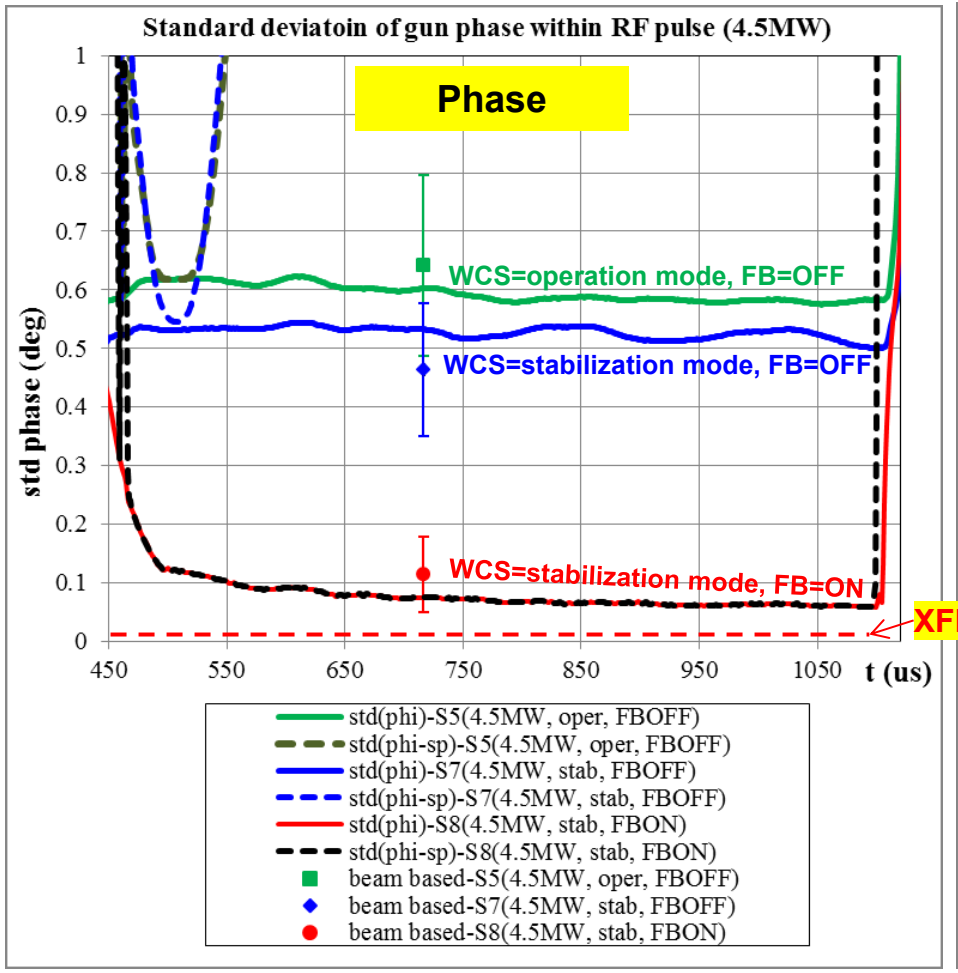


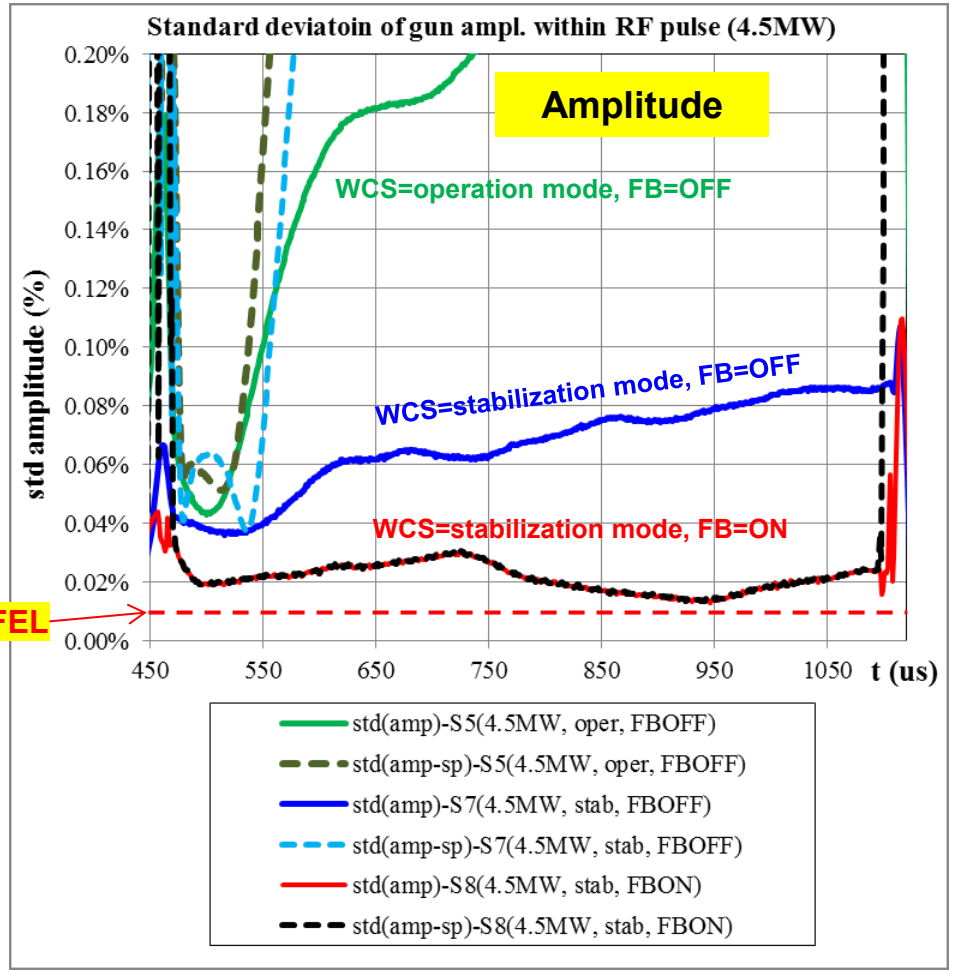


Gun WCS:
- 2 run modes
- T-readout resolution (0.025degC)→improved (new controller)



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»

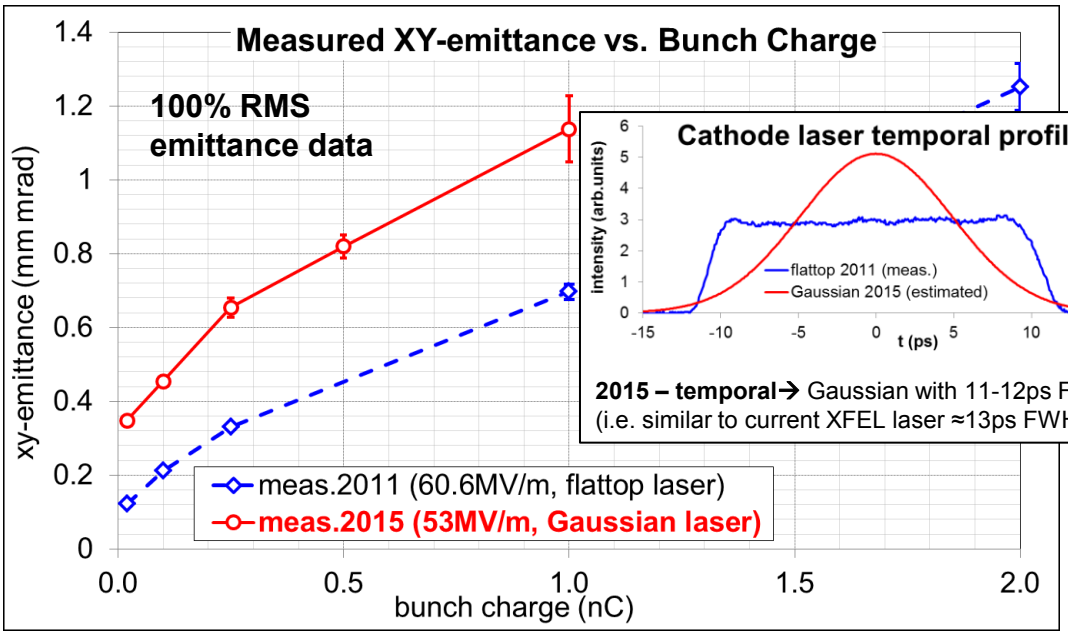
Emittance

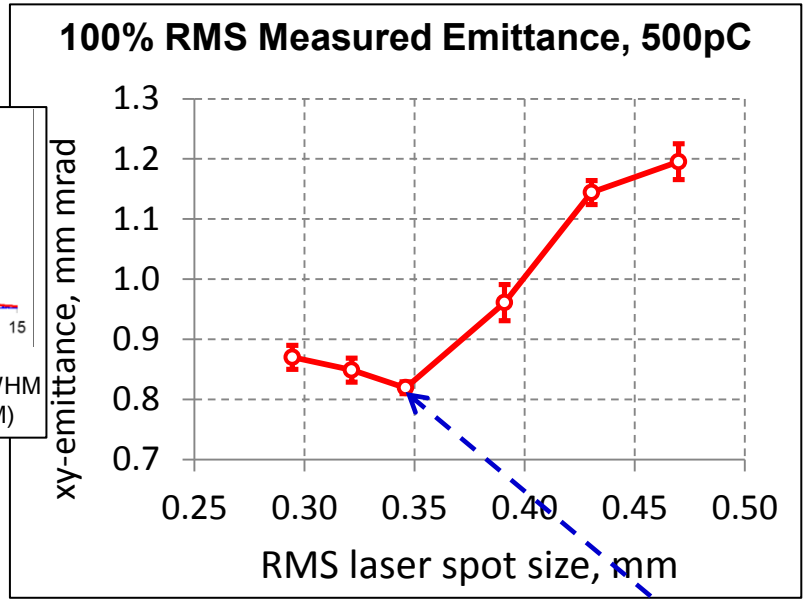
HELMHOLTZ ASSOCIATION

PITZ Photo Injector Test Facility Zeuthen

DESY

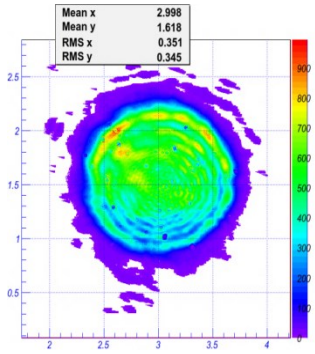
Emittance measurements in 2015: Gun at 53 MV/m, Cathode laser → temporal Gaussian



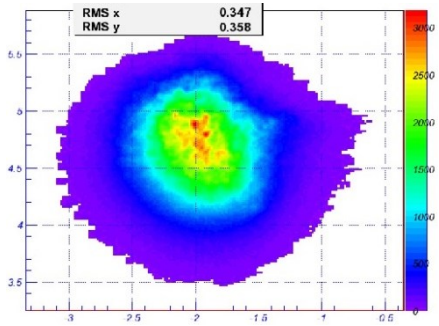


Requirement for XFEL injector commissioning: 1 mm mrad at 500pC ➔ **fulfilled !**

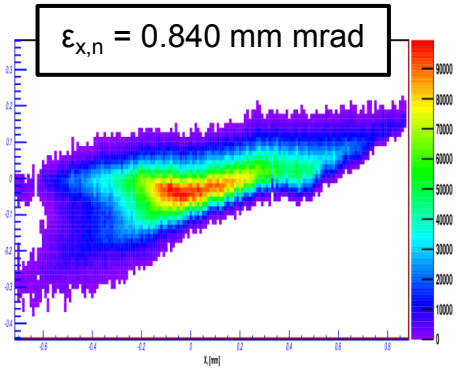
Laser transverse distribution



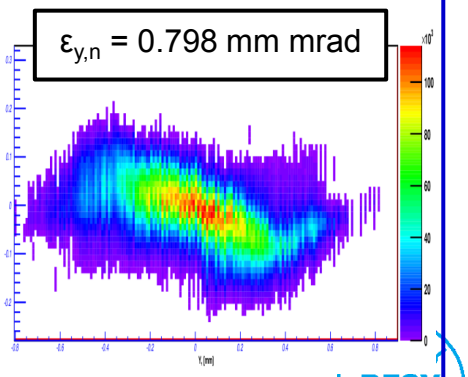
E-beam X-Y at EMSY1



X-Px



Y-Py



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

HELMHOLTZ ASSOCIATION

PITZ Photo Injector Test Facility Zeuthen

DESY

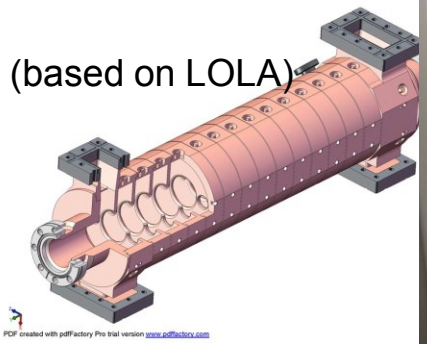
Transverse Deflecting System (TDS) status

> Prototype for the XFEL injector

> Designed & manufactured by INR, Troitsk, Russia

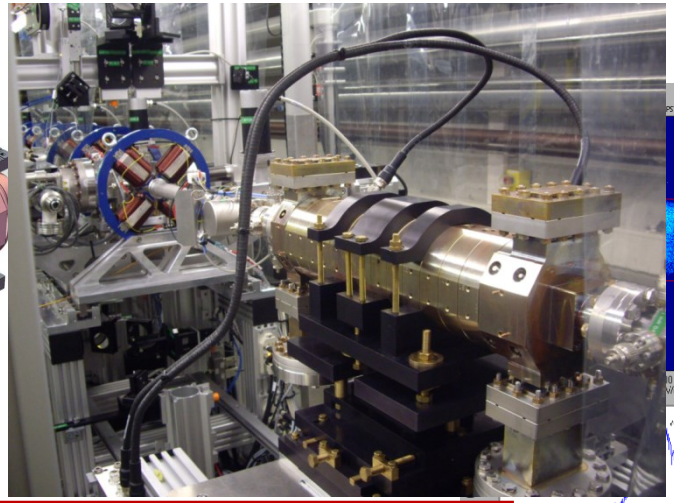
>Travelling wave structure (based on LOLA)

>Design parameters:
- 1.7 MV over 0.533 m
- 14+2 cells (2π/3)
- 2997.2 MHz
- Q = 11780

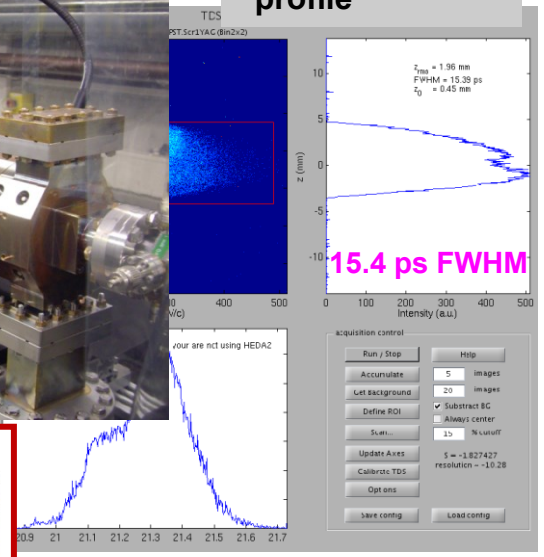


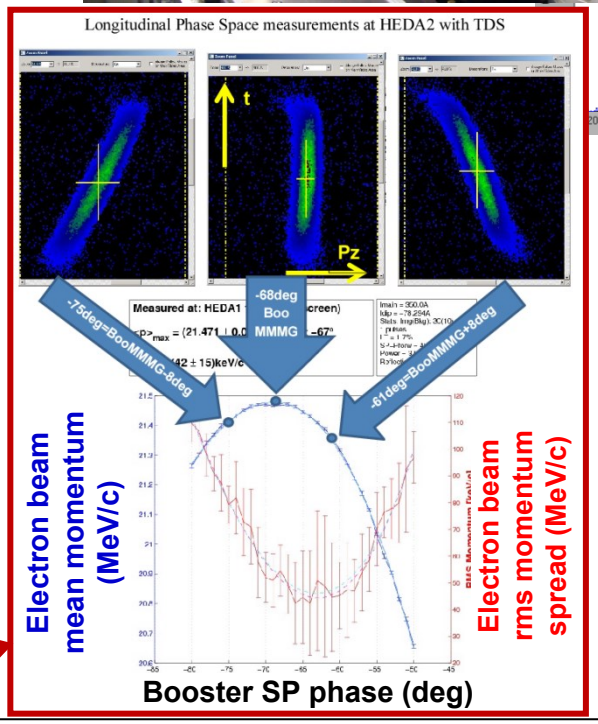
>Expected power balance:
- Q~88% at 45°C, 44 m WG losses…
- 2.1 MW @structure
- 2.7 MW @klystron

>TDS **commissioning** started on **02.07.2015**!
- Structure conditioned up to ~500 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**



E-beam current profile





new ScandiNova modulator

3D Elli

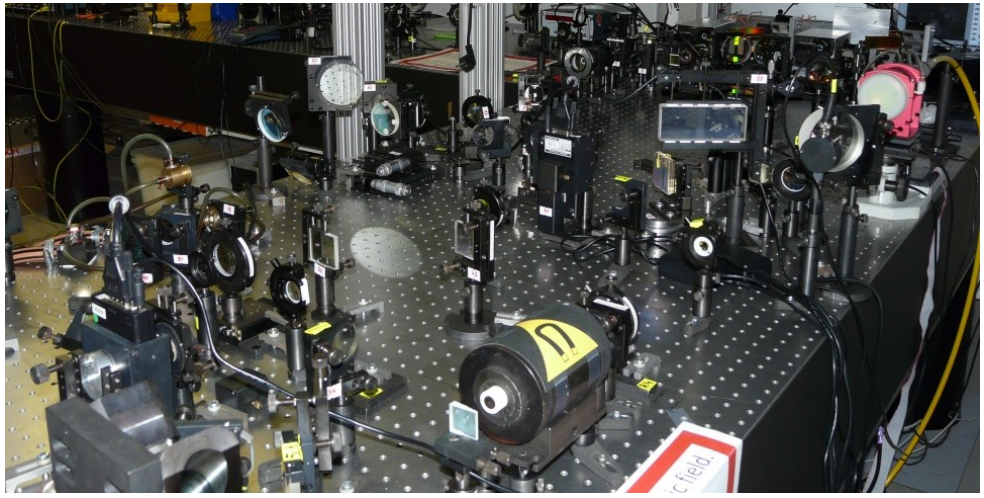
HELMHOLTZ ASSOCIATION

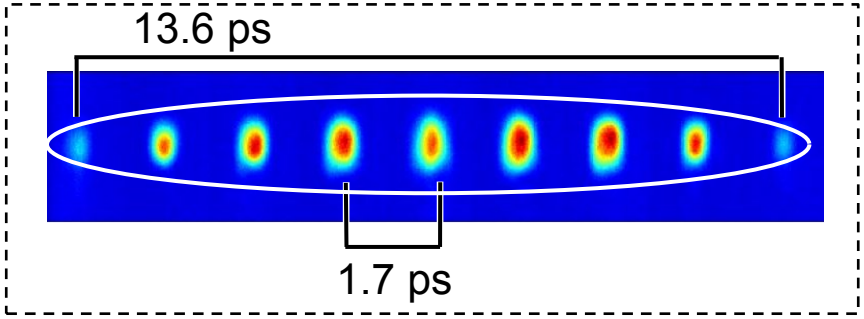
PITZ Photo Injector Test Facility Zeuthen

DESY

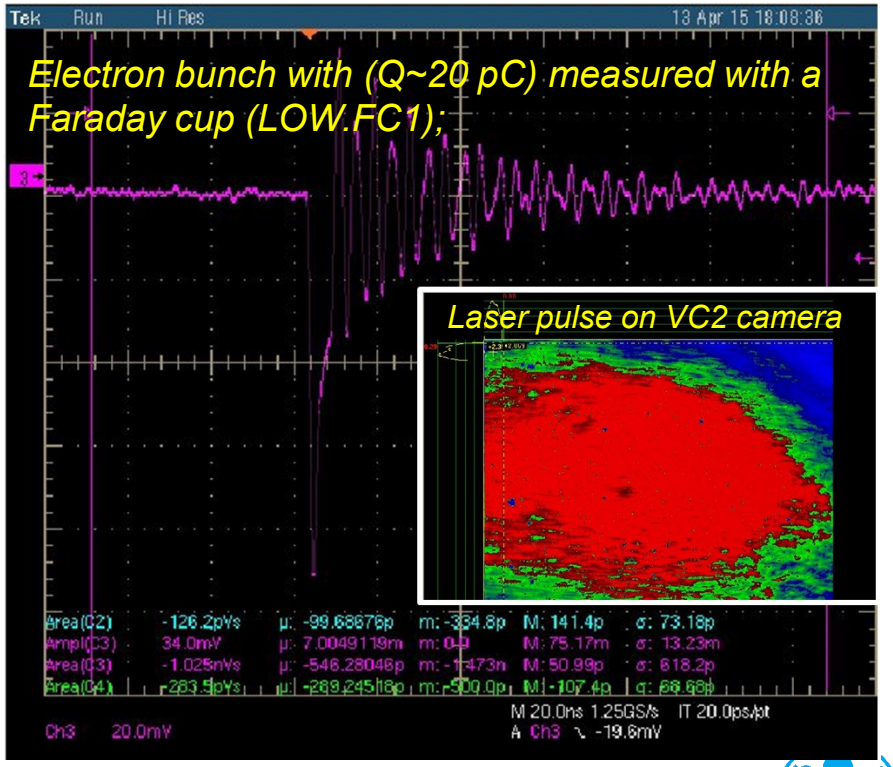
New photocathode laser system for 3D ellipsoidal pulses

- Installation finalized 12/2014





Cross-correlation measurement of pulse



- Commissioning begun 2015
- First photoelectrons 03/2015
- Beamline finalized 04/15

More details ➔ Speed poster:

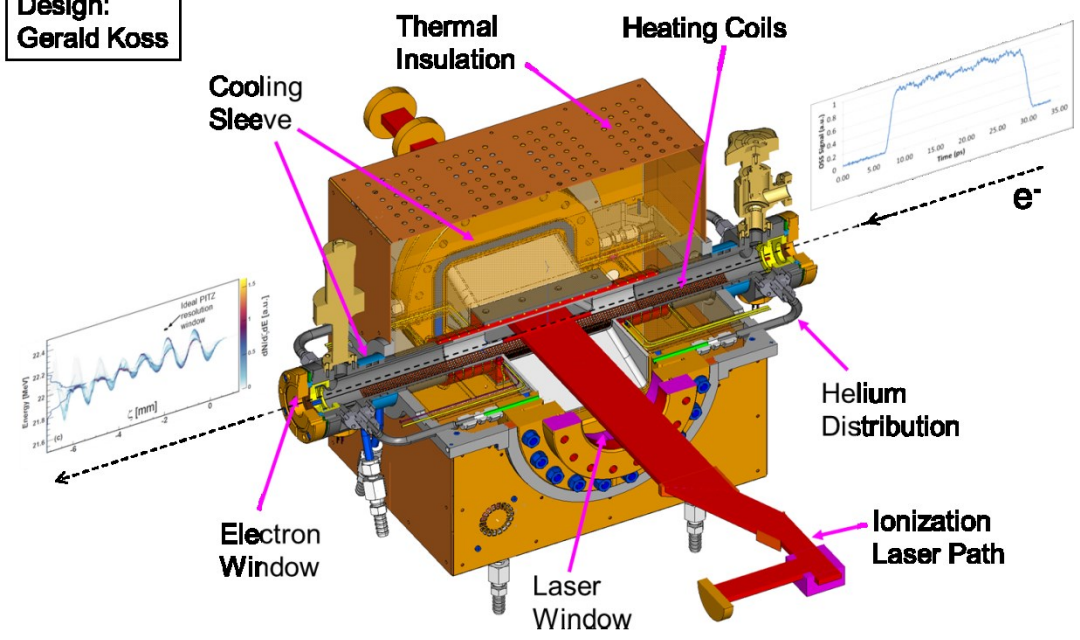
T. Rublack “New photocathode laser system for 3D quasi-ellipsoidal pulses - first produced photoelectrons”,

session 2 «Beam Dynamics & Photon Sources»

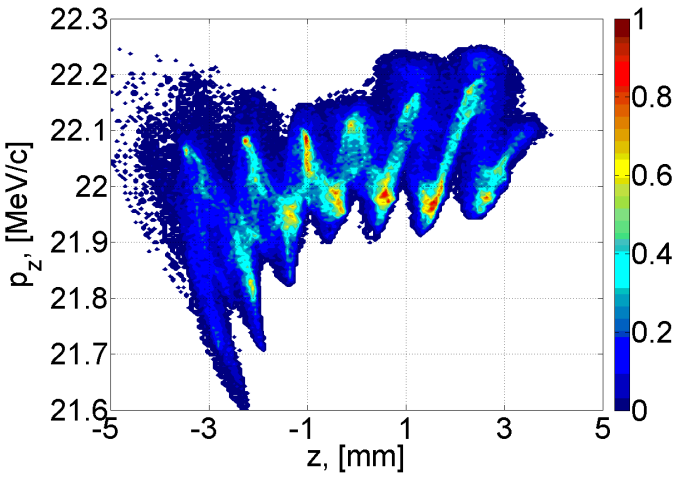
PDPWA

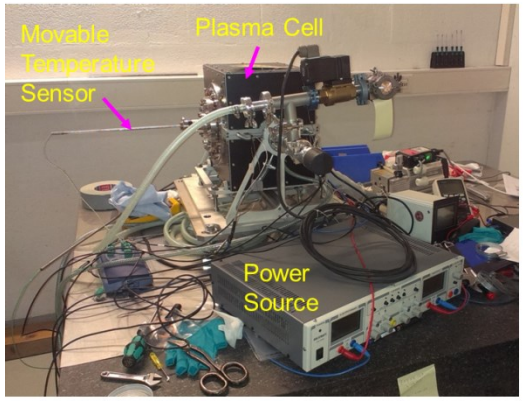
Self-modulation Experiment with long Electron Beams

Design:
Gerald Koss

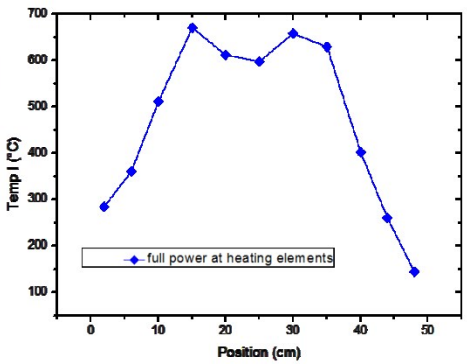


Simulation of experiment:
Expected phase space





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**

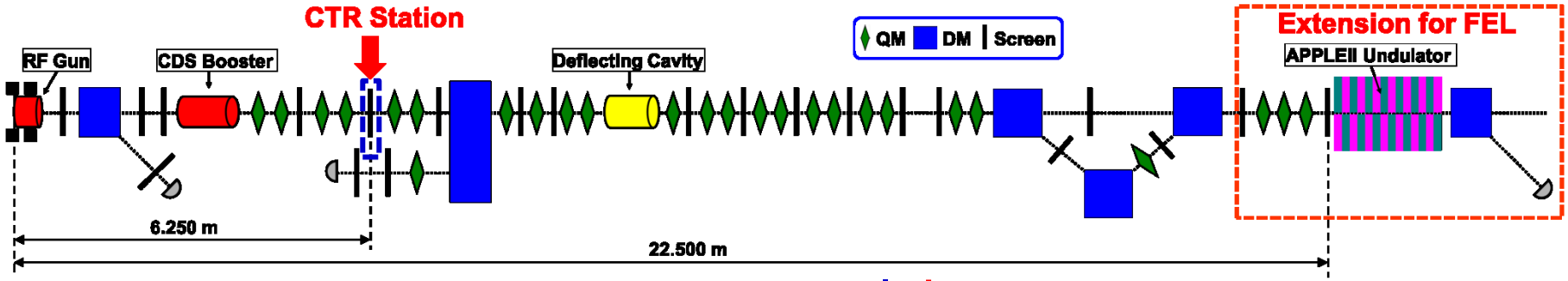
Studies on THz option at PITZ

HELMHOLTZ ASSOCIATION

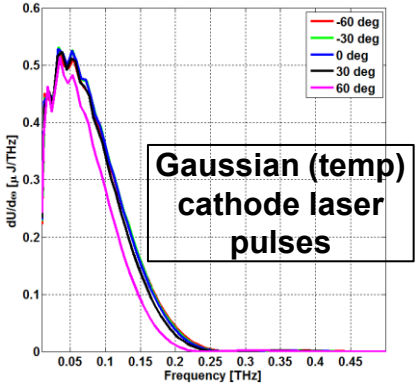
PITZ Photo Injector Test Facility Zeuthen

DESY

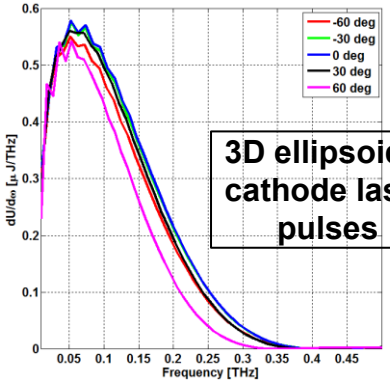
Simulations of the IR/THz Options at PITZ (High-gain FEL and CTR)



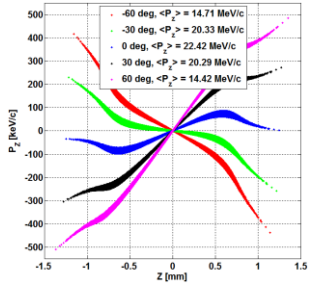
CTR Radiation Calculations (Generalized Ginzburg-Frank Formula)



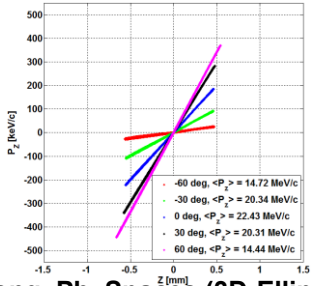
Gaussian (temp) cathode laser pulses



3D ellipsoidal cathode laser pulses



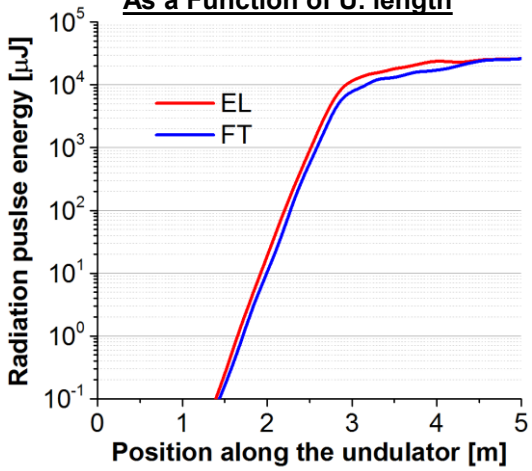
Long. Ph. Spaces (Gaussian)



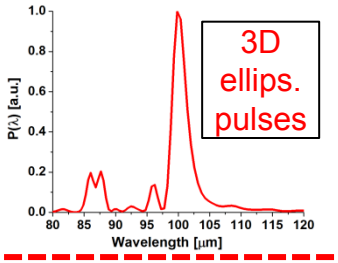
Long. Ph. Spaces (3D-Ellipsoidal)

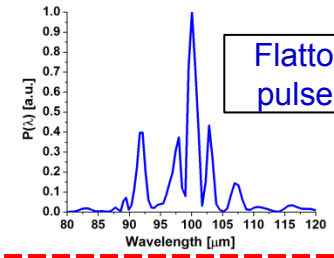
SASE FEL Calculations (GENESIS 1.3 code)

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