

First Characterization of 4 nC Electron Beams for THz Studies at PITZ

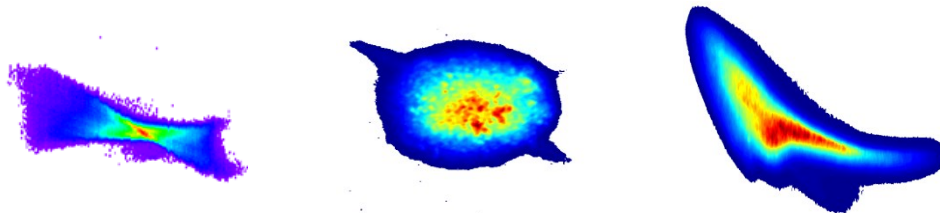
Outline

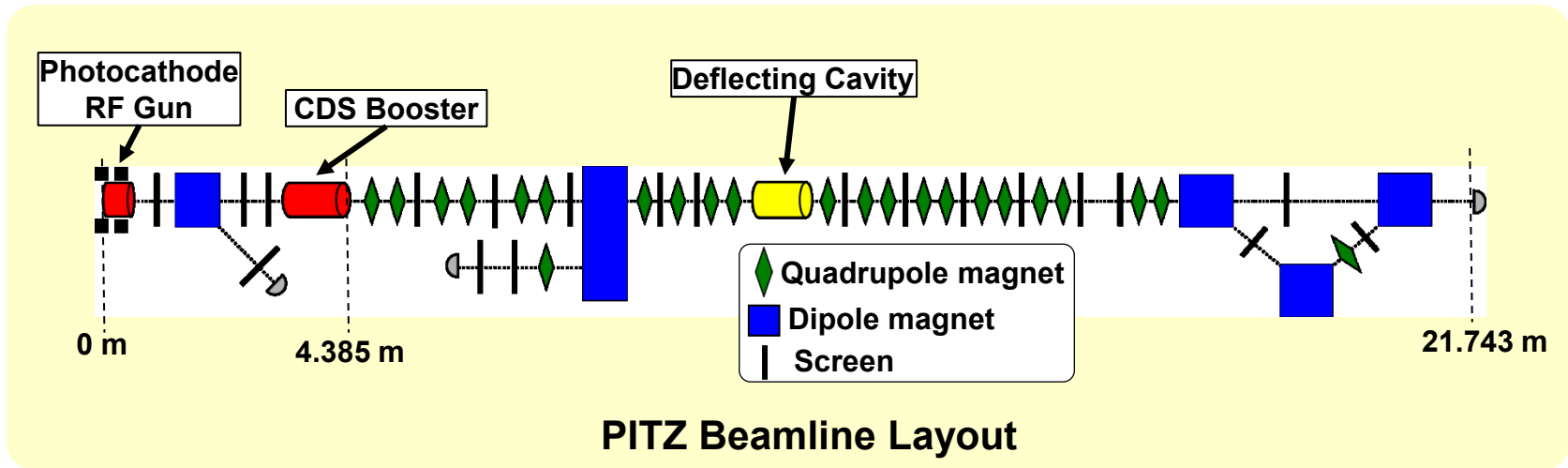
- ▶ Introduction
- ▶ Characterizations of 4 nC Beam
- ▶ Summary & Outlook

Rehearsal Talk
PITZ Physics Seminar
10.03.2016

Prach Boonpornprasert
and the PITZ team

DPG-Frühjahrstagung
TU Darmstadt, Darmstadt
14.03.2016





- ▶ The **Photo-Injector Test** facility at DESY **Zeuthen** site (**PITZ**).
- ▶ Develop, study and optimize high brightness electron sources for linac-based FELs.
- ▶ Working closely with **FLASH** and the **European XFEL**.

Important Parameters	
Beamline length	~22 m
Cathode laser pulse duration	few ps to ~22 ps (FWHM)
Electron bunch charge	sub pC to > 5 nC
Maximum electron beam momentum	~24 MeV/c

References

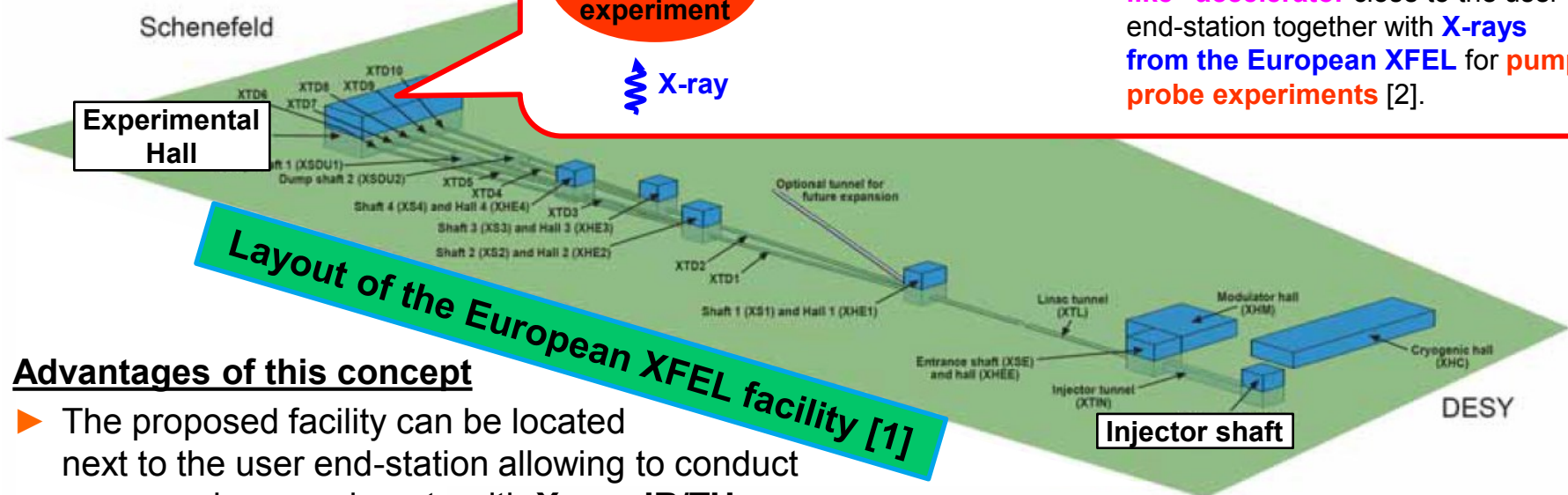
- [1] Eu XFEL Tech. Design report 2007
- [2] E.A.Schneidmiller et. al, WED55, FEL2012

Pump & Probe experiment

IR/THz

PITZ-like

There is a Proposal use **IR/THz radiation generated by a "PITZ-like" accelerator** close to the user end-station together with **X-rays from the European XFEL** for **pump-probe experiments** [2].



Advantages of this concept

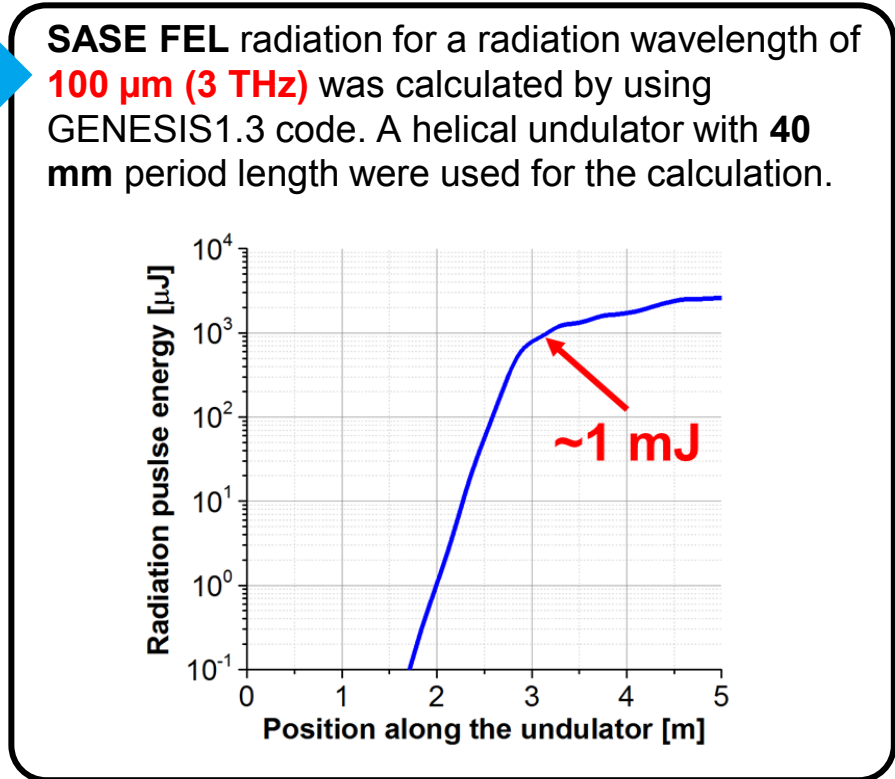
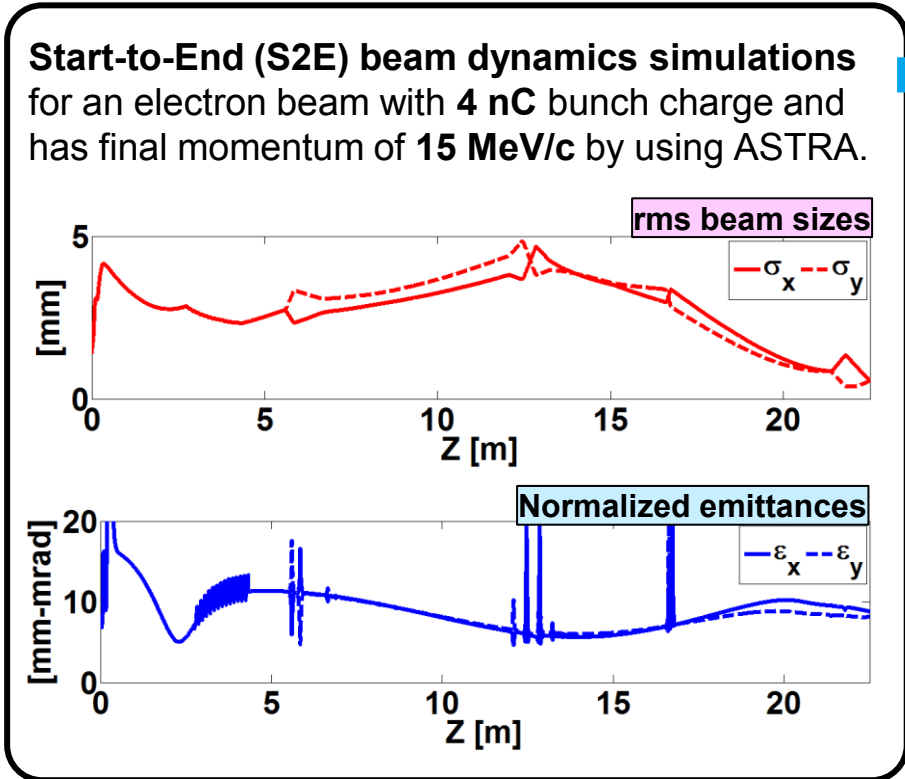
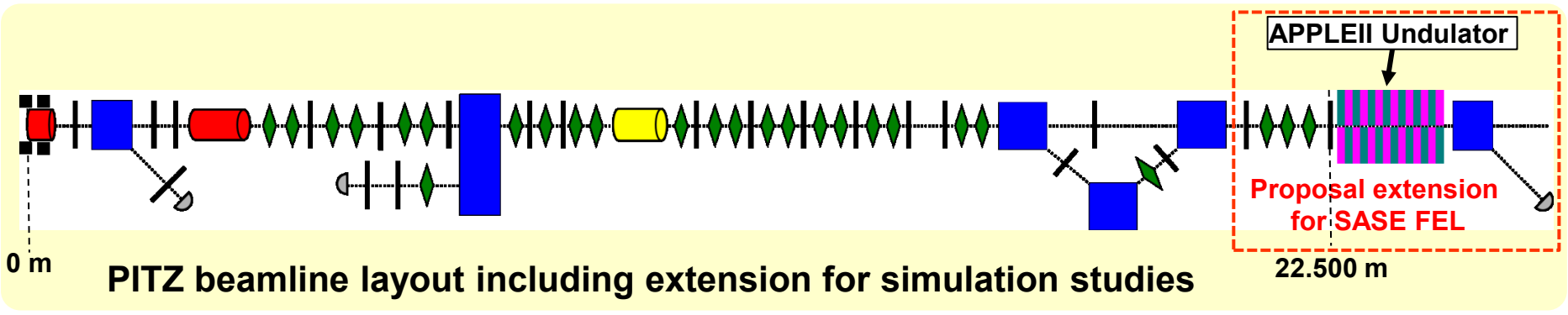
- ▶ The proposed facility can be located next to the user end-station allowing to conduct pump-probe experiments with **X-ray, IR/THz, ultra-short electron pulses** and **optical laser**.
- ▶ Time synchronization accuracy with the X-ray pulses $\sim \sigma(100 \text{ fs})$.
- ▶ Possible to generate IR/THz radiation with
 - Different methods
 - Different temporal and spectral patterns
 - Different polarizations
 - high pulse energy
 - Wide wavelength tunability

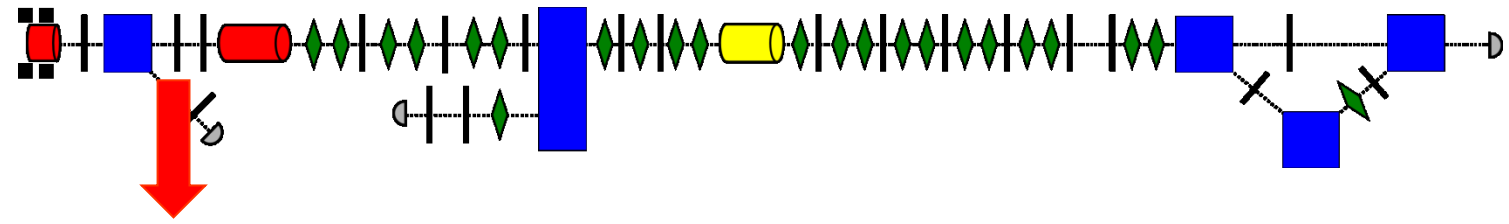
Prototype facility for the development of such IR/THz source is already existed. It is "PITZ facility".



2 options of radiation have been studied:

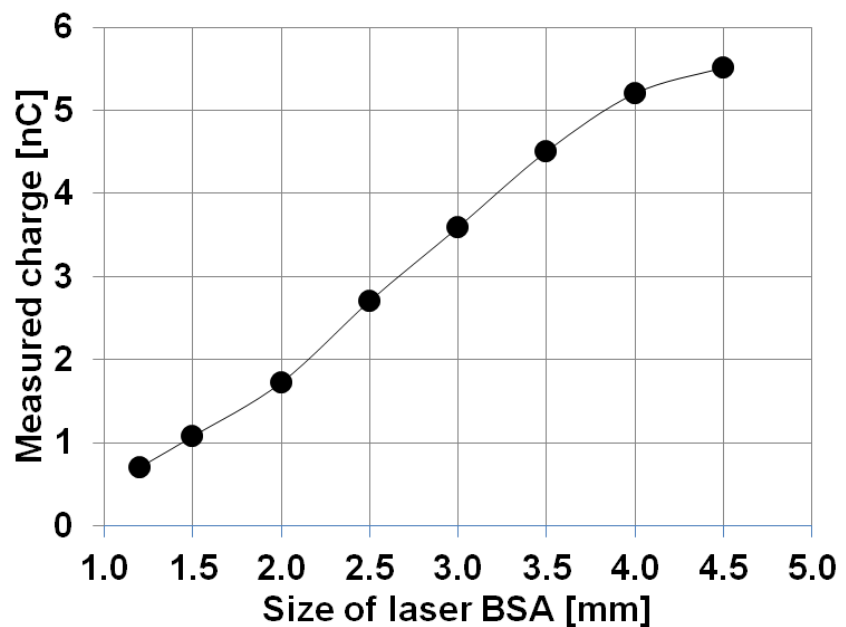
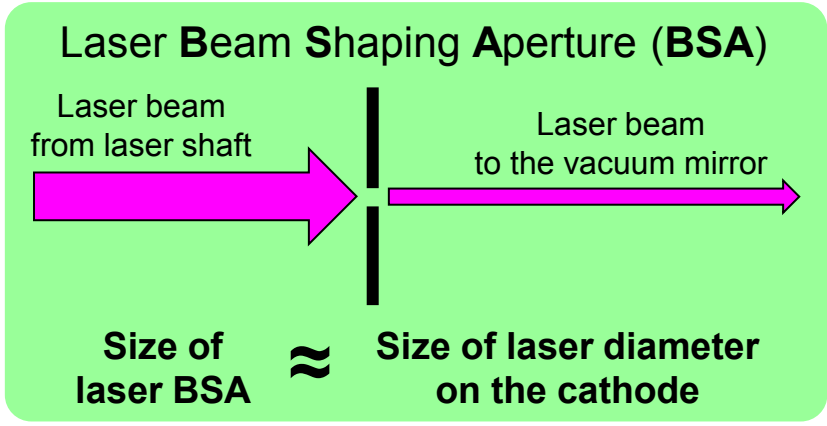
- ▶ **SASE FEL**
- ▶ **Coherent Transition Radiation (CTR)**





- ▶ Gaussian laser pulse with ~ 11 ps (FWHM) temporal length was used.
- ▶ Bunch charges were measured by a Faraday cup after the gun.
- ▶ The measurements were done for **different sizes of laser BSA**. The laser transmission was fixed at **70%**.

Machine Parameters	
Peak power of RF in the gun	6.0 MW
Photocathode laser pulse shape	Gaussian
Photocathode Laser temporal length	~ 11 ps FWHM

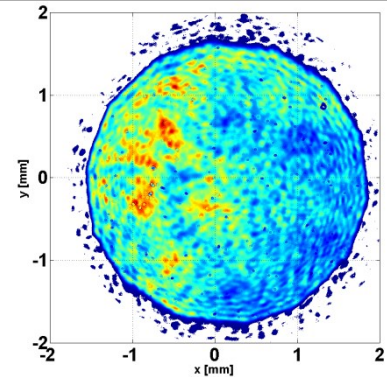


- ▶ Momentum Measurement
- ▶ Emittance Measurement
- ▶ Longitudinal Profile Measurement
- ▶ Test of Beam Transport

BSA size of 3.2 mm

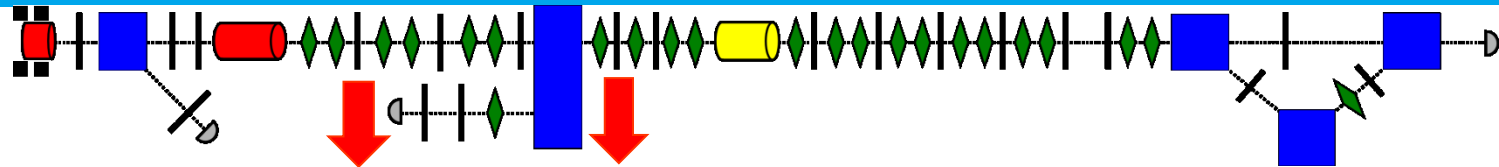
$$\sigma_x = 0.822 \text{ mm}$$

$$\sigma_y = 0.836 \text{ mm}$$

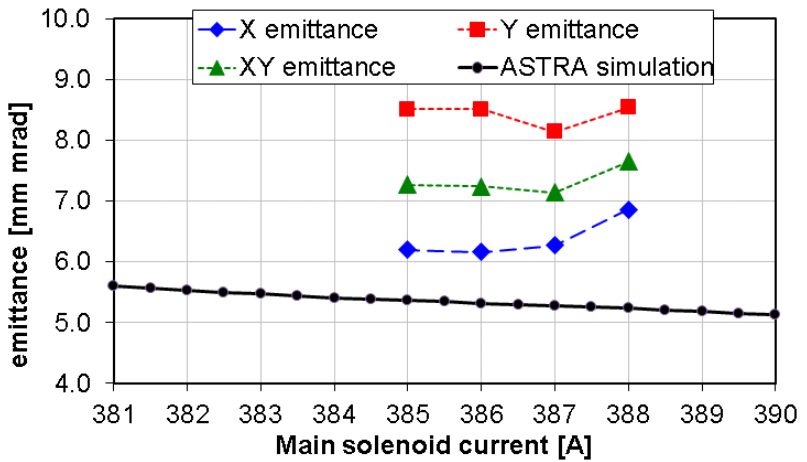


Machine Parameters	
Photocathode laser pulse shape	Gaussian
Photocathode laser temporal length	~11 ps FWHM
Photocathode laser BSA size	3.2 mm
Peak power of RF in the gun	6.0 MW
Peak power of RF in the booster	2.8 MW
Gun RF phase*	0 degree
Booster RF phase*	0 degree

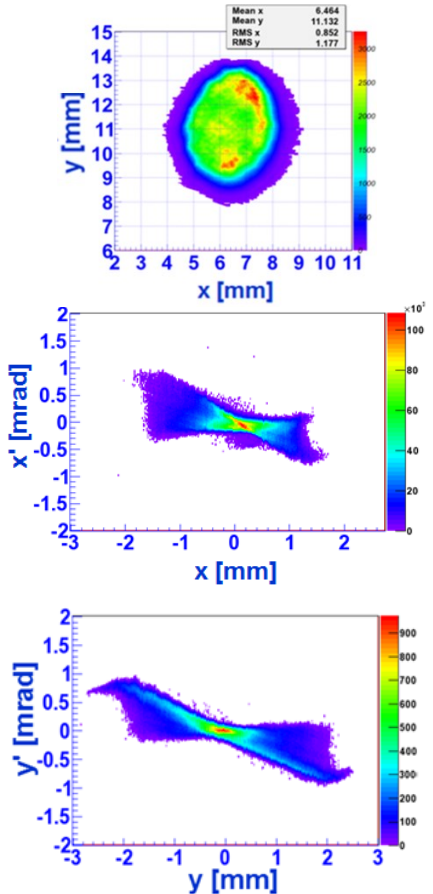
*With respect to the **Maximum Mean Momentum Gain (MMM_G)** phase



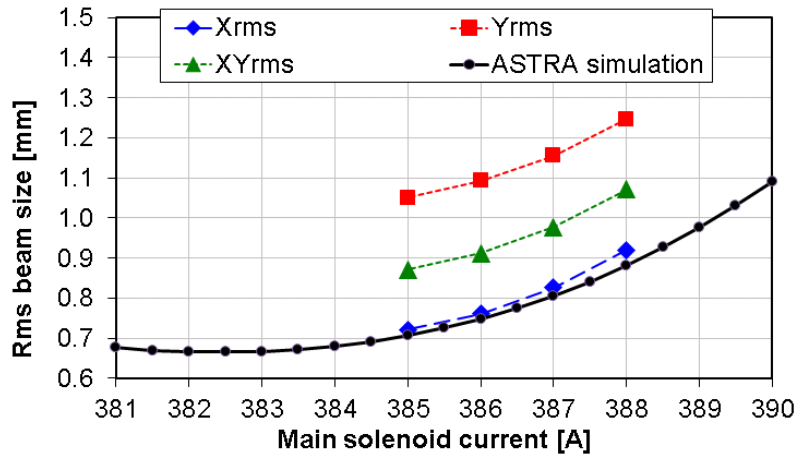
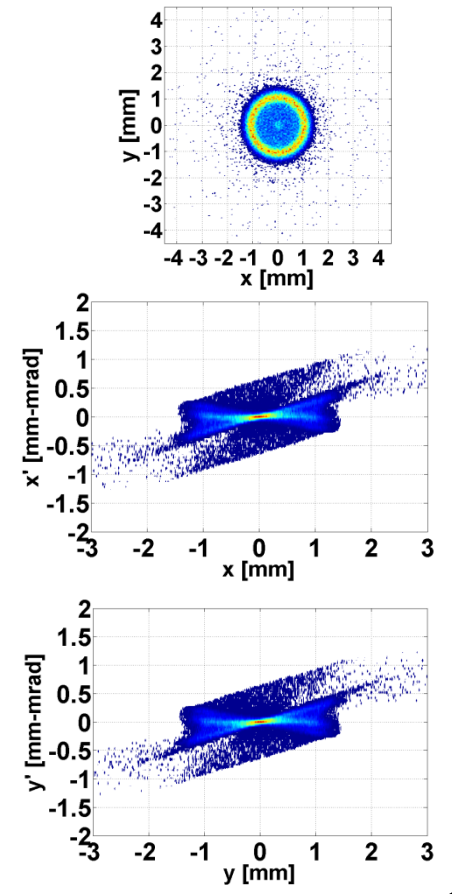
Beam Profiles with Main Solenoid Current of 387 A

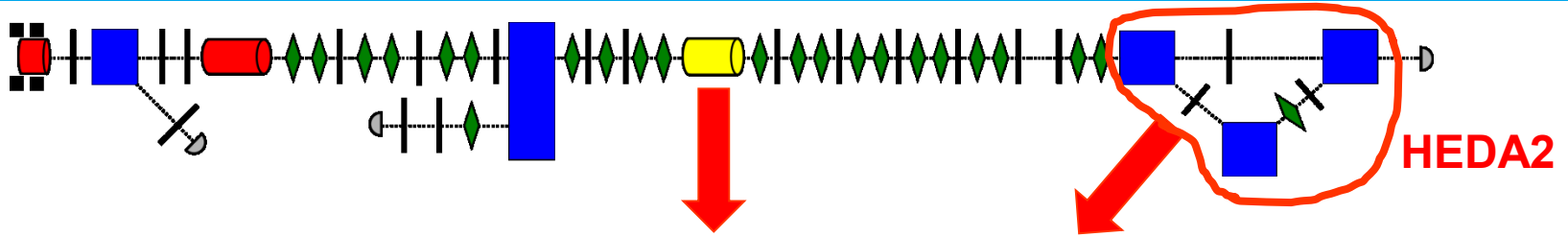


Measurement



ASTRA Simulation





- ▶ The bunch length of 4nC bunch charge was measured by using the **deflecting cavity**.
- ▶ The longitudinal phase space was measured by **transport the streaked beam to HEDA2**.

Measurement

FWHM bunch length = 24.67 ps

Long. bunch profile

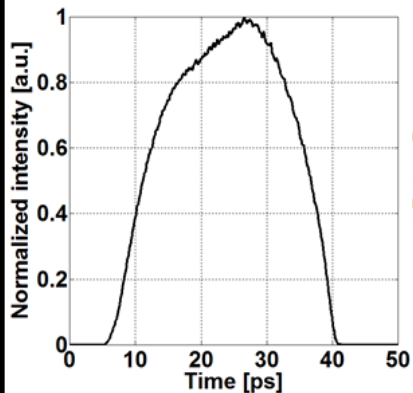
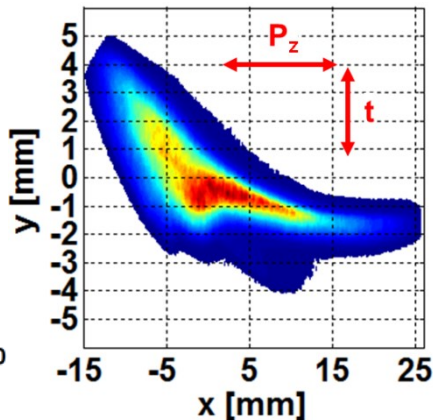


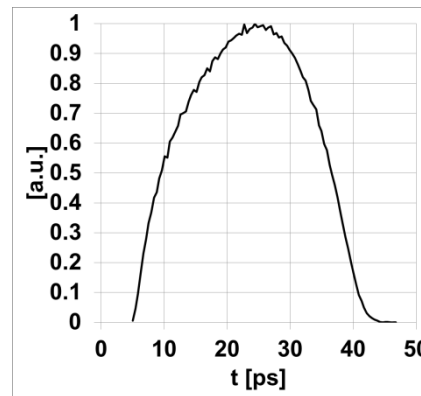
image of the streaked beam in HEDA2 section



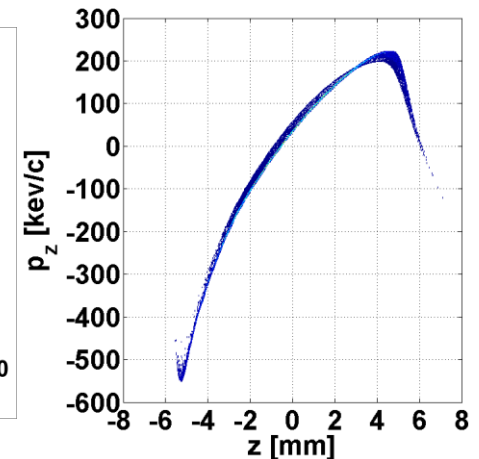
ASTRA Simulation

FWHM bunch length = 27.01 ps

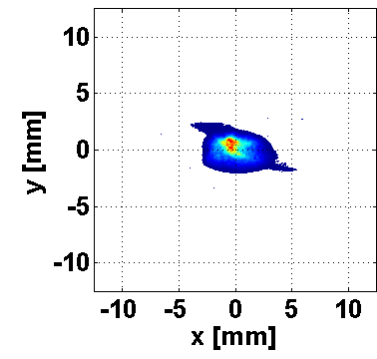
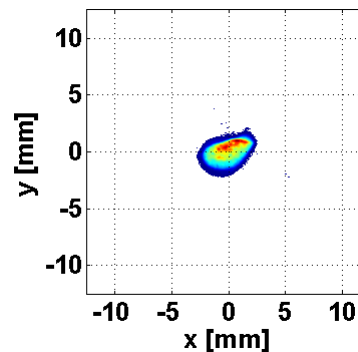
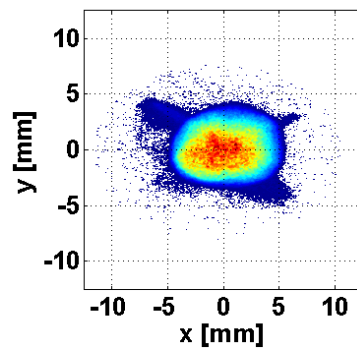
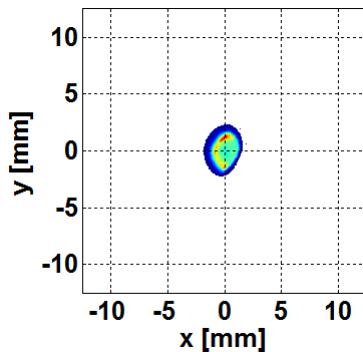
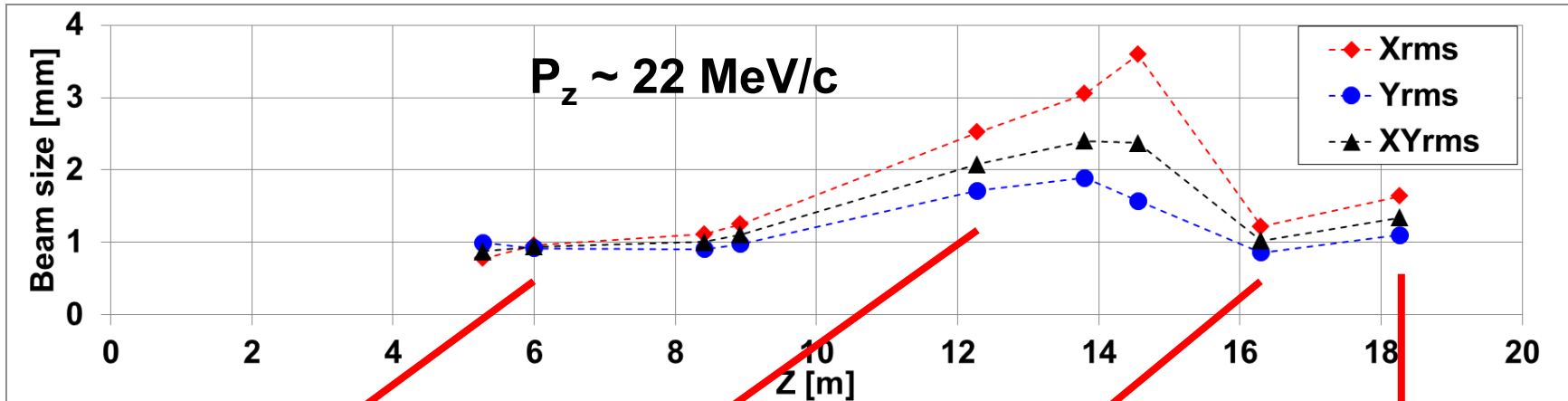
Long. bunch profile



Long. phase space



- ▶ The 4nC beam was transported from cathode ($Z = 0$) to the last screen ($Z = 18.262$ m).
- ▶ Just test of beam transport and focusing. No specific beam matching strategy.



Summary

- ▶ First experimental characterizations of 4 nC bunch charge and corresponding beam dynamics simulations were done.
- ▶ Experiences from these measurements are very useful for preparation of the experiment plan in the next measurement period.

Outlook

- ▶ More consistent between simulation and measurement results.
- ▶ More emittance measurement stations for beam matching studies.
- ▶ Slice emittance and energy spread measurements. → more realistic FEL calculations.
- ▶ Next experiments with 4 nC beam are planned to take place this year

Other talks from PITZ on Thursday:

AKBP15.1 Gregor Loisch
 AKBP15.2 Osip Lishilin
 AKBP15.3 Gaurav Pathak

Activities on plasma
 acceleration experiments
 at PITZ



