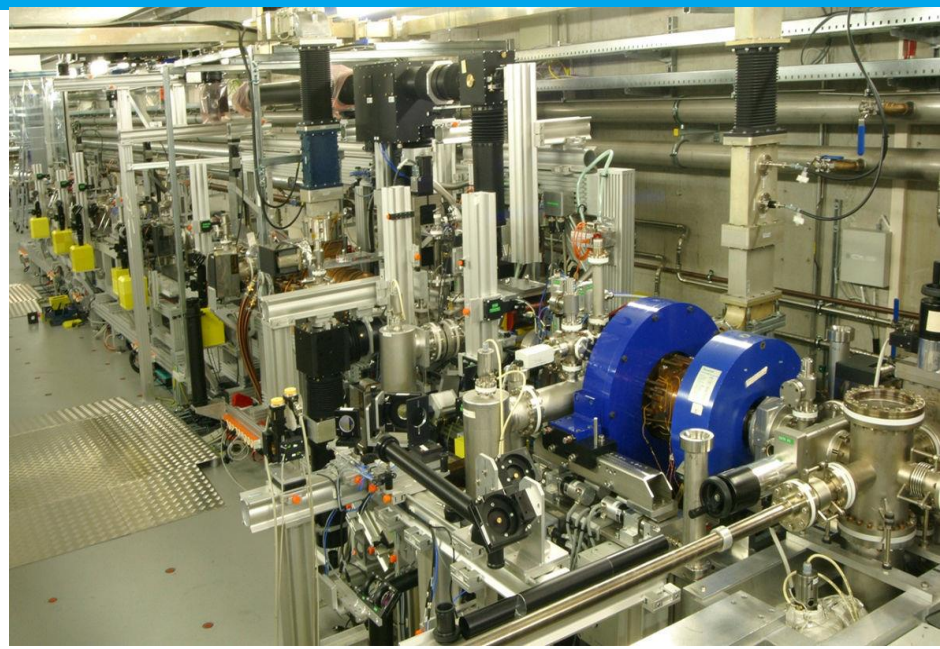
Emittance measurements of the electron beam at PITZ for the commissioning phase of the European XFEL.

- Introduction
  - PITZ setup
  - European XFEL parameters
- Measurement procedure
- Emittance measurements for E-XFEL conditions
- Summary and outlook



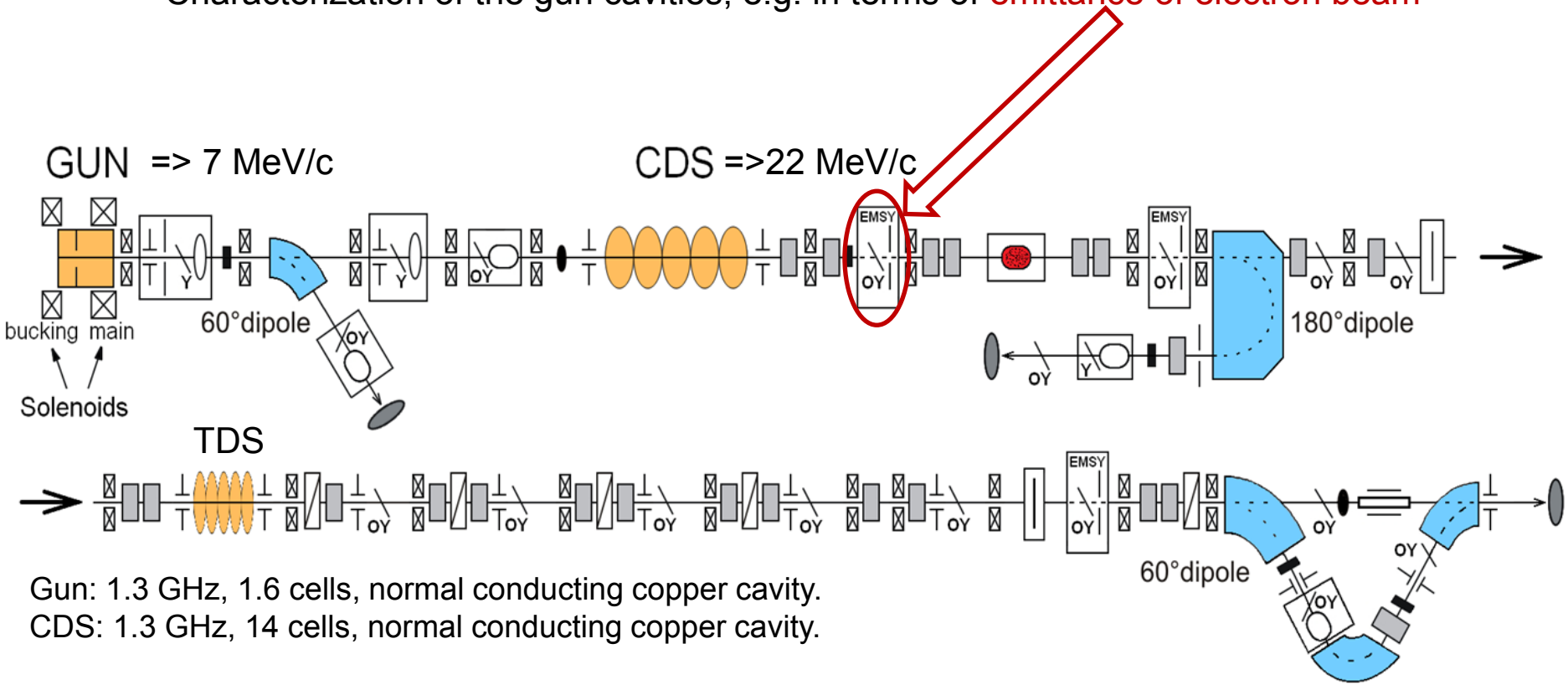
Grygorii Vashchenko
on behalf of PITZ team
FEL 2015
Daejeon, 24.08.2015

HELMHOLTZ GEMEINSCHAFT

DESY

Photo Injector Test facility at DESY, Zeuthen site

- **Test bed for the FLASH and the European XFEL injectors:**
  - Conditioning and operation of the gun cavities
  - Characterization of the gun cavities, e.g. in terms of emittance of electron beam

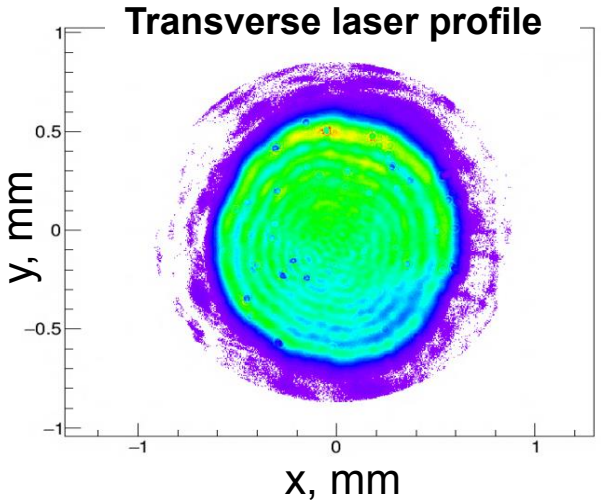


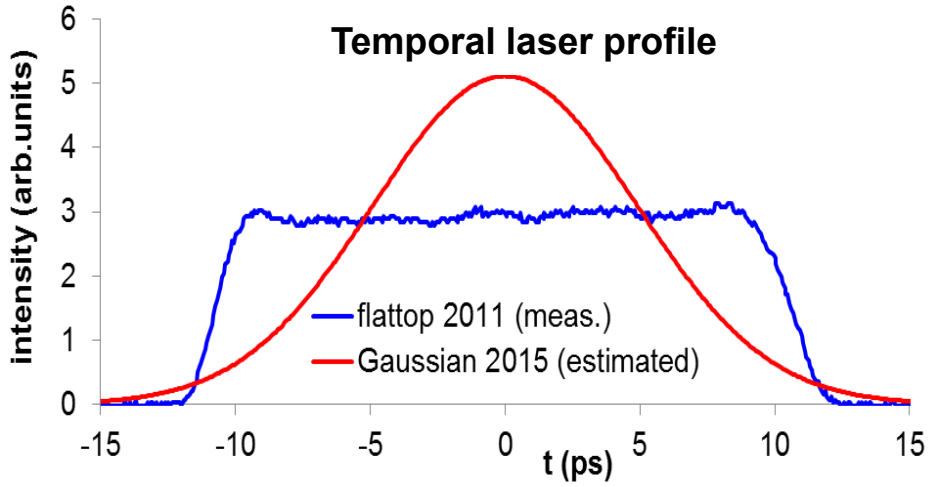
Gun: 1.3 GHz, 1.6 cells, normal conducting copper cavity.
CDS: 1.3 GHz, 14 cells, normal conducting copper cavity.

Gun and laser setup corresponding to E-XFEL commissioning parameters

Parameter	XFEL injector, nominal	XFEL, commissioning	PITZ setup
RF gun gradient Peak power	60 MV/m 6.5 MW	50…53 MV/m 4.5…5.0 MW	53 MV/m 5.0 MW
RF pulse length	650 us	650 us	~ 650 us
Repetition rate	10 Hz	10 Hz	10 Hz
Cathode laser (temporal)	Flattop (2/20\2ps)	Gaussian (~13ps FWHM)	Gaussian (~12ps FWHM)
Bunch charge Beam slice emittance (undulators)	0.02 – 1 nC 0.4 – 1 mm mrad	0.1 – 1 nC e.g. < 1 mm mrad @ 0.5 nC	0.1 – 1 nC

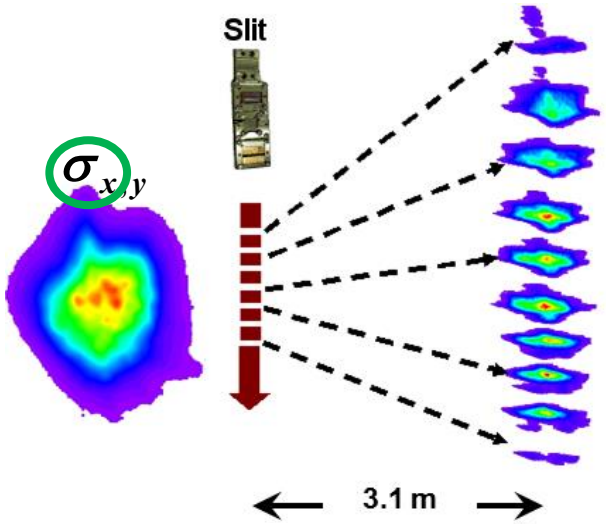
For injector startup 500 pC bunch charge was chosen and emittance requirement is < 1 mm mrad



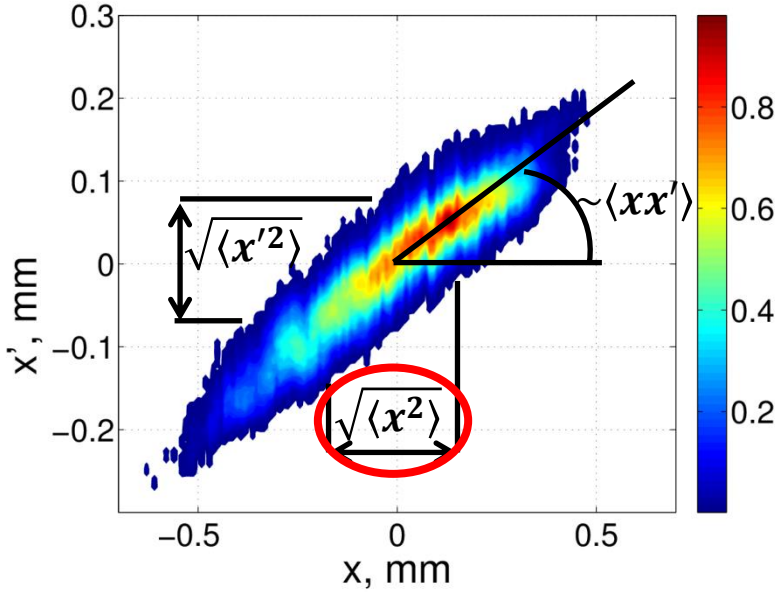


Emittance measurements setup at PITZ

Normalized projected emittance is measured using single slit scan technique



EMSY1 (z = 5.3 m) Beamlet collector screen



Optimization loops:

- Emittance vs. charge
  - Emittance vs. laser spot size
  - Emittance vs. gun phase
    - Emittance vs. main solenoid current

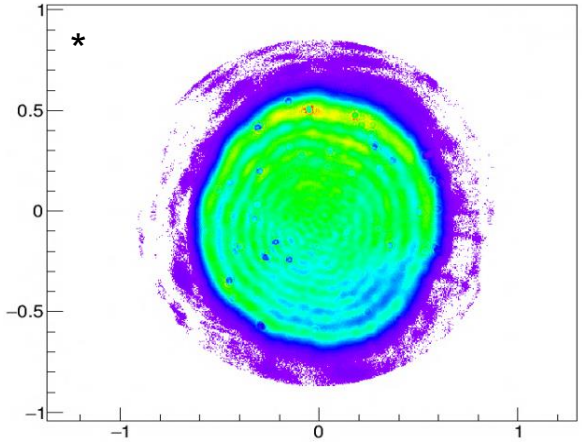
$$\varepsilon_n = \frac{\sigma_x}{\sqrt{\langle x^2 \rangle}} \beta\gamma \sqrt{\langle x^2 \rangle \cdot \langle x'^2 \rangle - \langle xx' \rangle^2}$$

correction factor (>1) introduced to correct for low intensity losses from beamlet measurements => **conservative estimation**

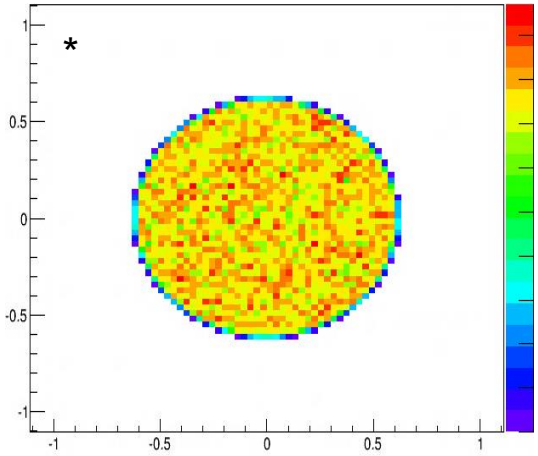
100% RMS emittance

More realistic beam dynamics simulations

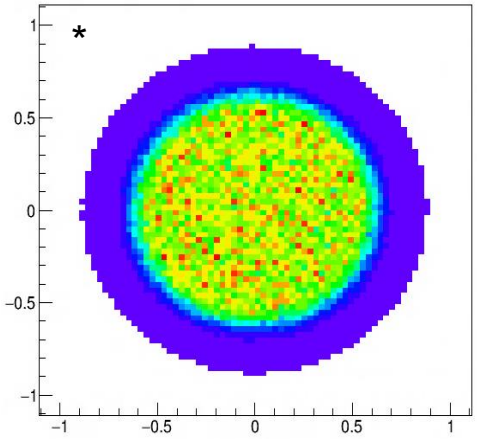
Measured laser transverse distribution



Uniform laser distribution for simulations until now

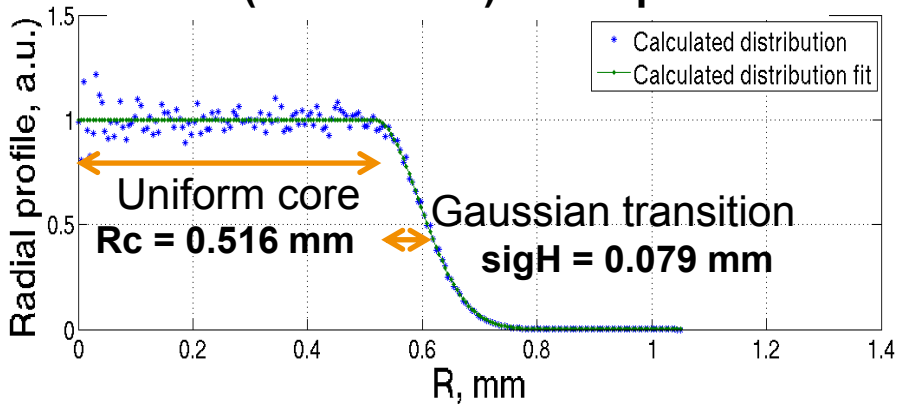


New approach: Core + Halo generation for simulations



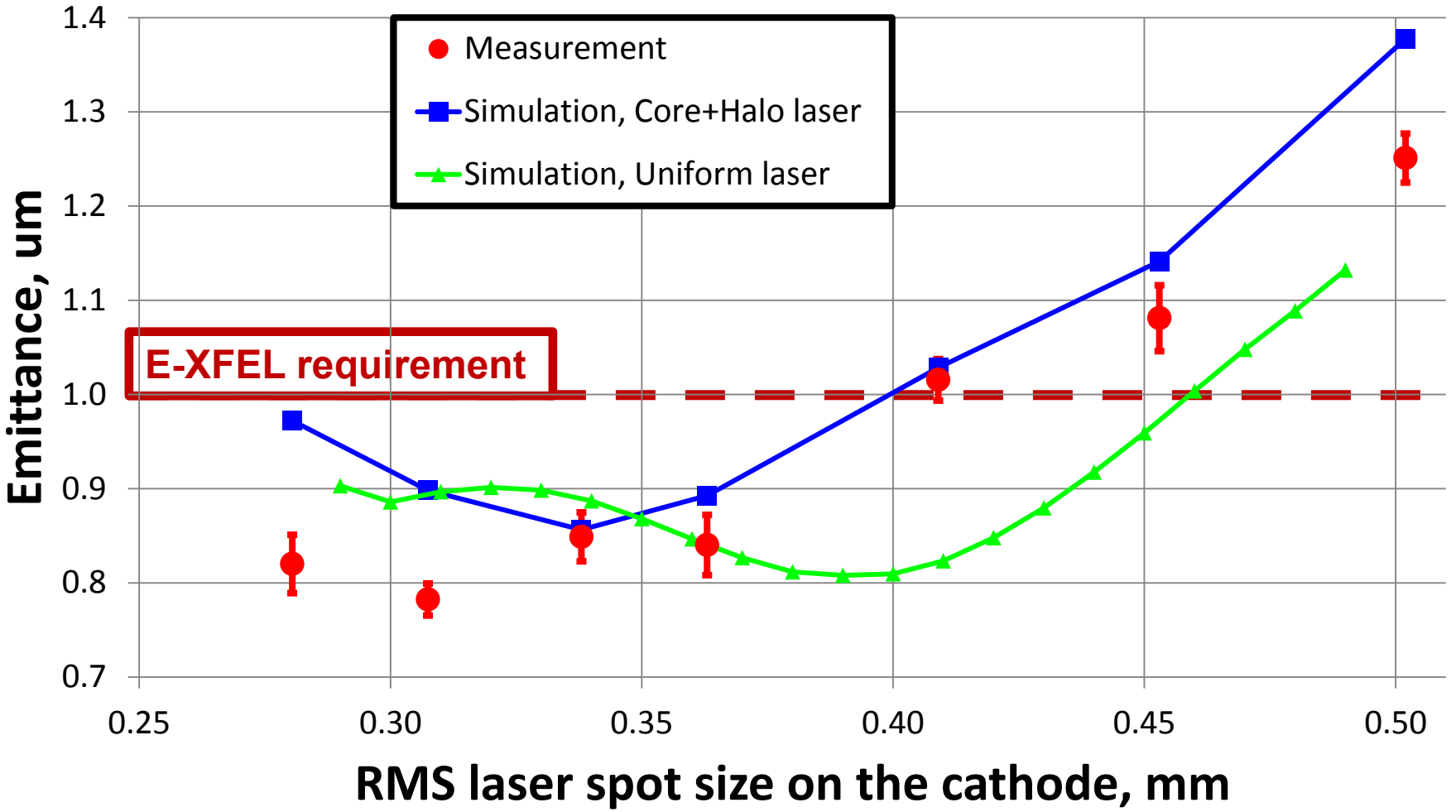
*All axes are in mm, range [-1.1;1.1]

CH (core + halo) radial profile



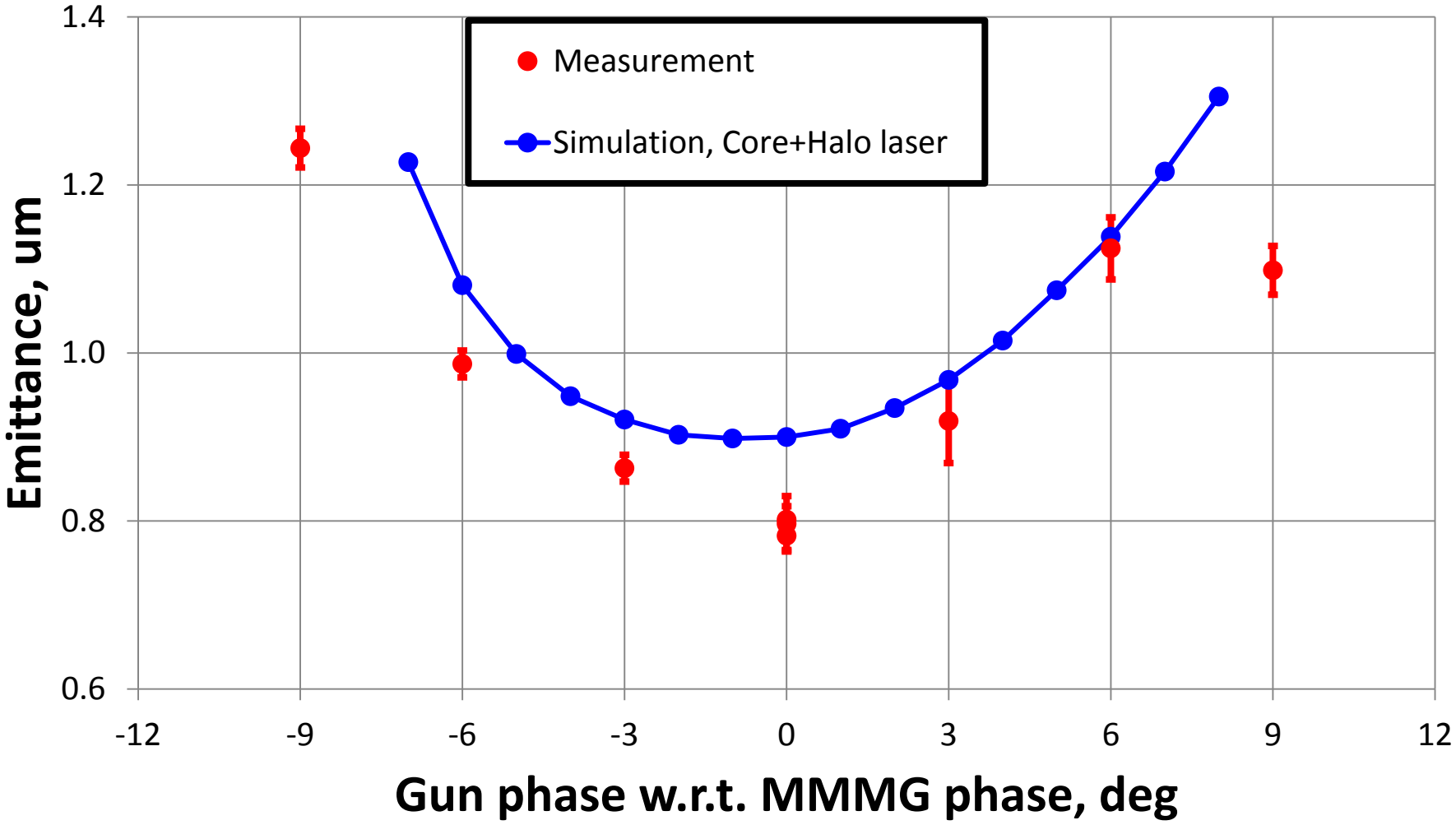
- Better modeling but keeping 2D symmetry as required by simulation tool
- Directly plug in measured transverse profile into simulations

Emittance vs. laser spot size for 500 pC beams



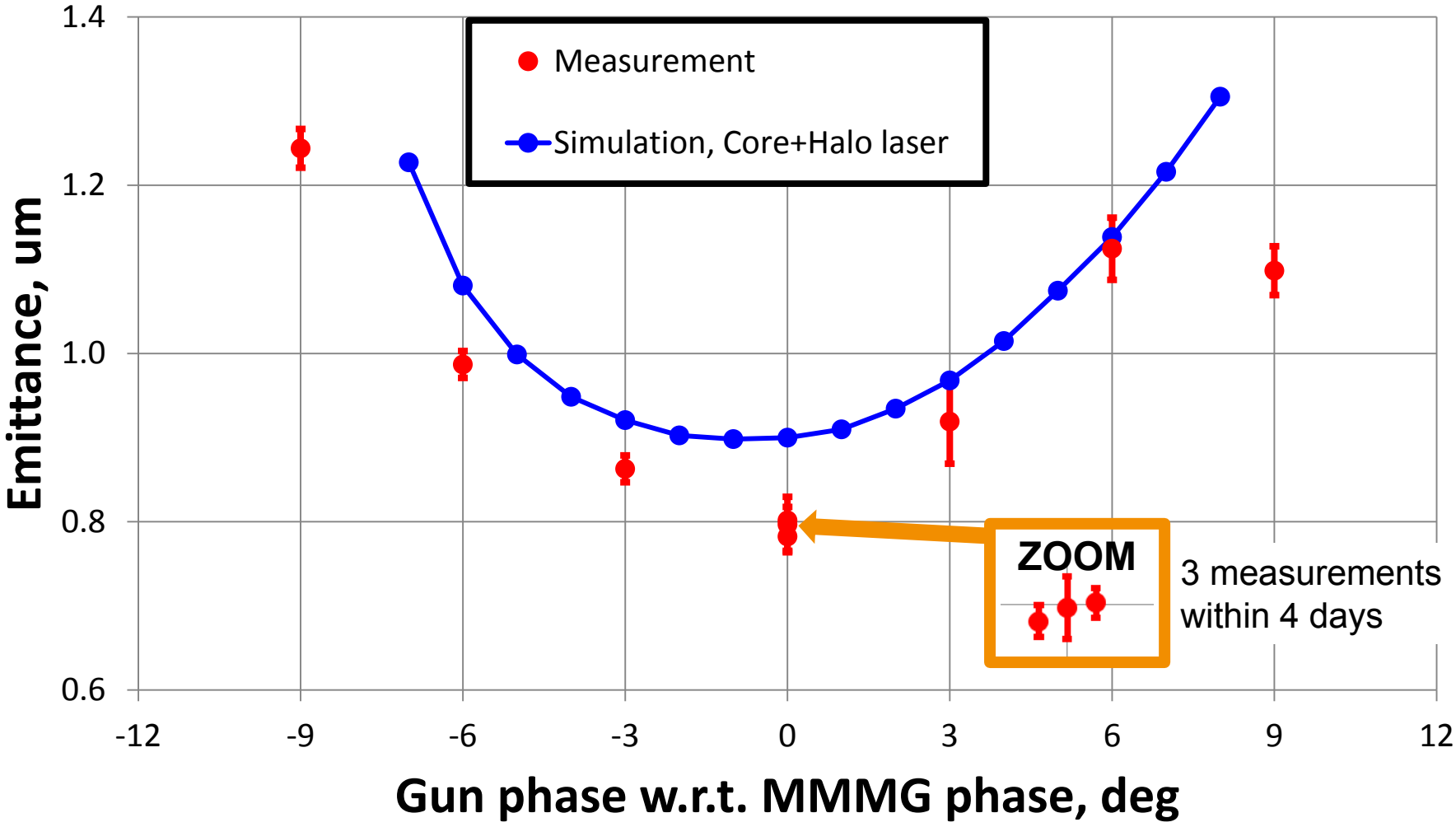
European XFEL commissioning phase requirements on emittance are fulfilled.

Emittance vs. gun launching phase for 500 pC beams



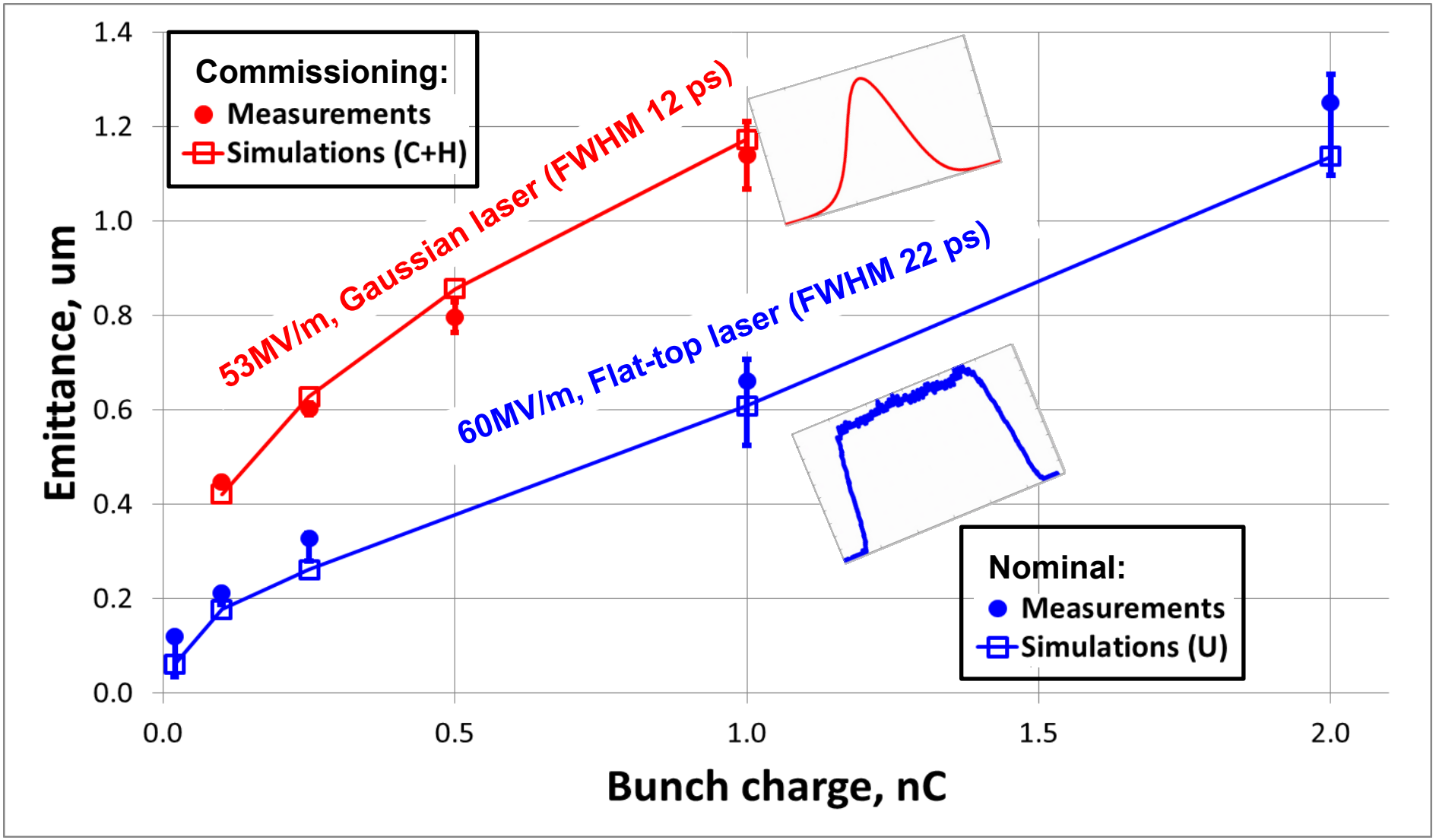
*MMMG – Maximum Mean Momentum Gain

Emittance vs. gun launching phase for 500 pC beams



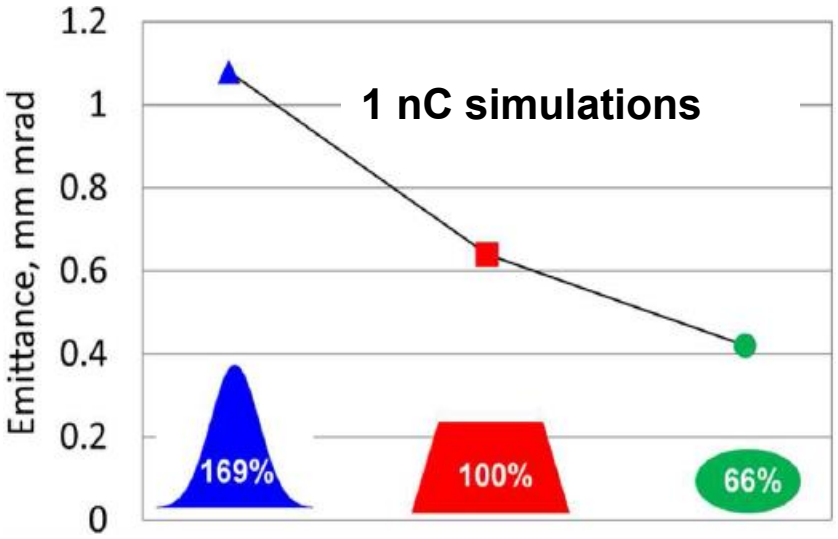
*MMMG – Maximum Mean Momentum Gain

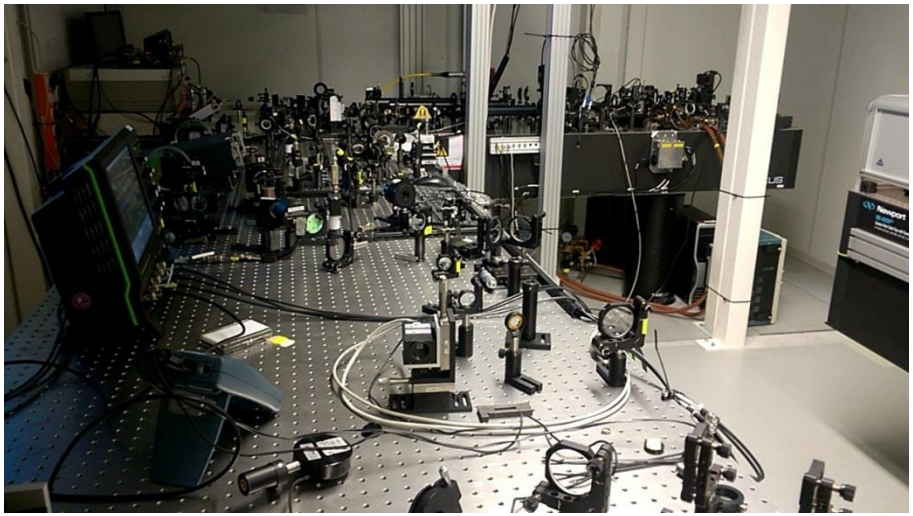
Emittance for different charges



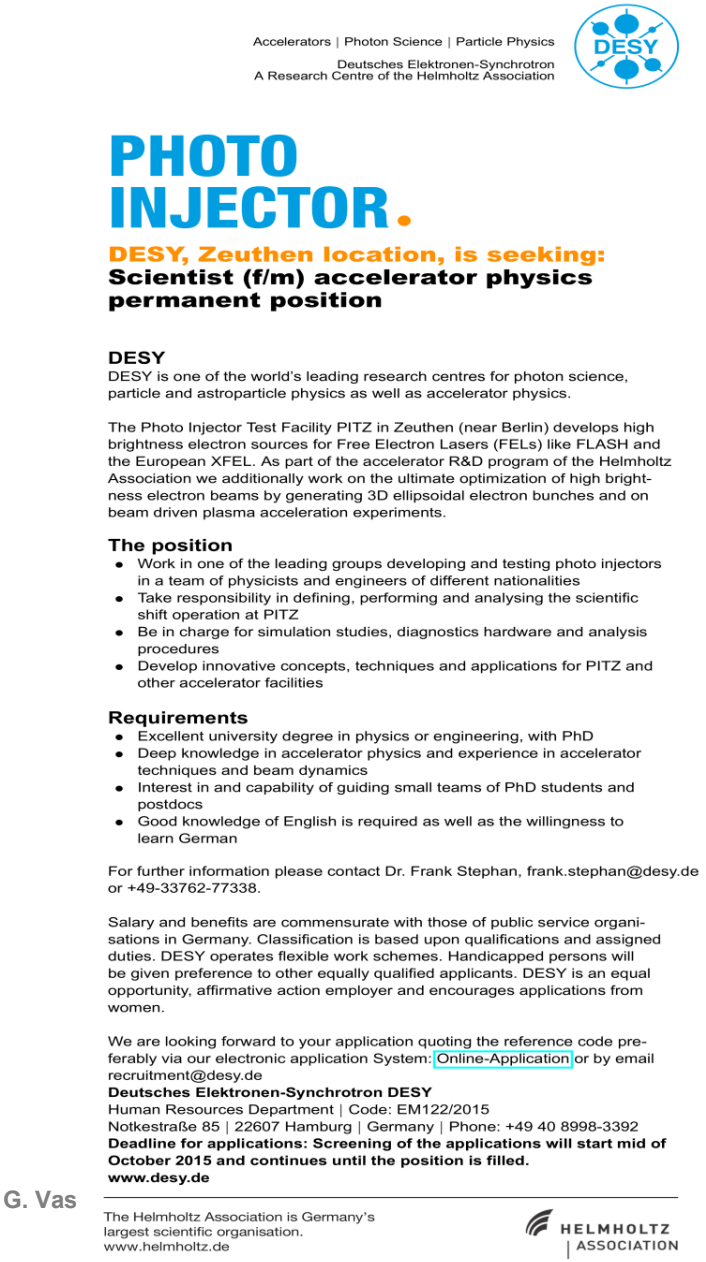
Summary and outlook

- **European XFEL commissioning requirement on emittance is fulfilled**
- Emittance measured for **various bunch charges**, gun operated at 53 MV/m, Gaussian laser temporal profile with FWHM of 11-12 ps
- **More realistic beam dynamics simulations**: transverse laser shape modeling using **core + halo → better agreement** between measurements and simulations
- **Ongoing development** beyond the European XFEL specifications: photocathode laser system which will be able to generate **3D-ellipsoidal laser pulses** → first photo electrons produced.





Thank you for attention!



Accelerators | Photon Science | Particle Physics

Deutsches Elektronen-Synchrotron
A Research Centre of the Helmholtz Association

DESY

PHOTO INJECTOR.

DESY, Zeuthen location, is seeking:
Scientist (f/m) accelerator physics permanent position

DESY
DESY is one of the world's leading research centres for photon science, particle and astroparticle physics as well as accelerator physics.

The Photo Injector Test Facility PITZ in Zeuthen (near Berlin) develops high brightness electron sources for Free Electron Lasers (FELs) like FLASH and the European XFEL. As part of the accelerator R&D program of the Helmholtz Association we additionally work on the ultimate optimization of high brightness electron beams by generating 3D ellipsoidal electron bunches and on beam driven plasma acceleration experiments.

The position
- Work in one of the leading groups developing and testing photo injectors in a team of physicists and engineers of different nationalities
- Take responsibility in defining, performing and analysing the scientific shift operation at PITZ
- Be in charge for simulation studies, diagnostics hardware and analysis procedures
- Develop innovative concepts, techniques and applications for PITZ and other accelerator facilities

Requirements
- Excellent university degree in physics or engineering, with PhD
- Deep knowledge in accelerator physics and experience in accelerator techniques and beam dynamics
- Interest in and capability of guiding small teams of PhD students and postdocs
- Good knowledge of English is required as well as the willingness to learn German

For further information please contact Dr. Frank Stephan, frank.stephan@desy.de or +49-33762-77338.

Salary and benefits are commensurate with those of public service organisations in Germany. Classification is based upon qualifications and assigned duties. DESY operates flexible work schemes. Handicapped persons will be given preference to other equally qualified applicants. DESY is an equal opportunity, affirmative action employer and encourages applications from women.

We are looking forward to your application quoting the reference code preferably via our electronic application System: Online-Application or by email recruitment@desy.de
Deutsches Elektronen-Synchrotron DESY
Human Resources Department | Code: EM122/2015
Notkestraße 85 | 22607 Hamburg | Germany | Phone: +49 40 8998-3392
Deadline for applications: Screening of the applications will start mid of October 2015 and continues until the position is filled.
www.desy.de

The Helmholtz Association is Germany's largest scientific organisation.
www.helmholtz.de

HELMHOLTZ ASSOCIATION

Interesting posters of PITZ group:

- H. Huck "First Results of Commissioning of the PITZ **Transverse Deflecting Structure**" **MOP039**
- J. Good "New **Ellipsoidal Laser** at the Upgraded PITZ Facility" **TUP034**
- M. Bakr "Beam Dynamics **Simulations for the Upgraded PITZ** Photo Injector Applying Various Photocathode Laser Pulse Shapes" **TUP065**
- P. Boonpornprasert "Numerical Simulations of a ***Sub-THz Coherent Transition Radiation Source*** at PITZ" **MOP033**