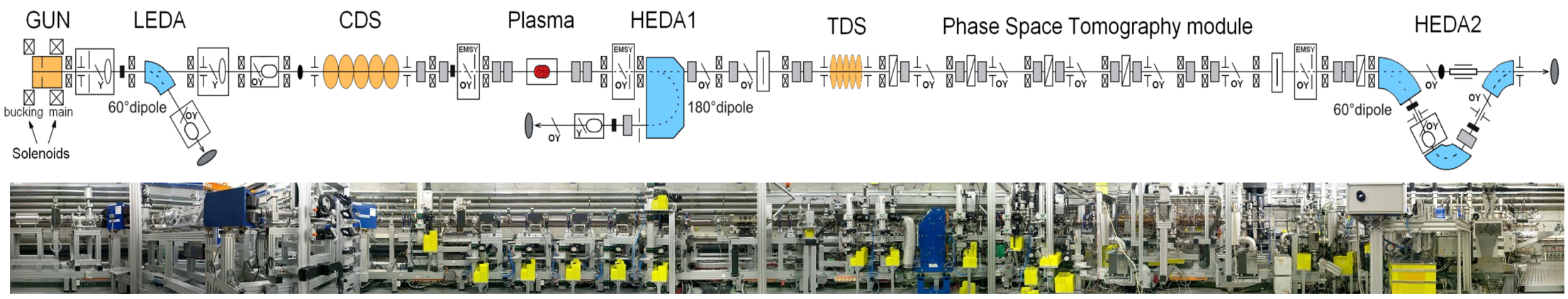
PITZ – Photo Injector Test Facility at DESY, Zeuthen Site.

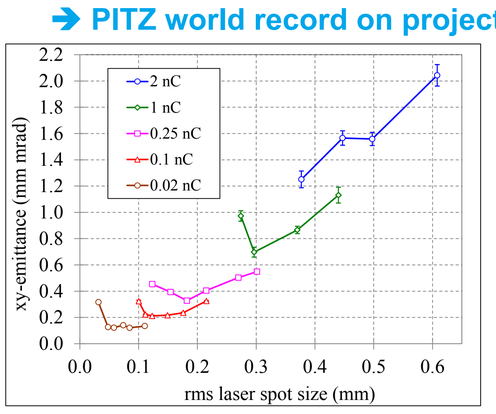
M. Krasilnikov for PITZ Collaboration

PITZ Beamline



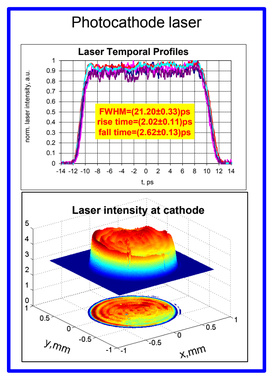
PITZ Activities for the European XFEL

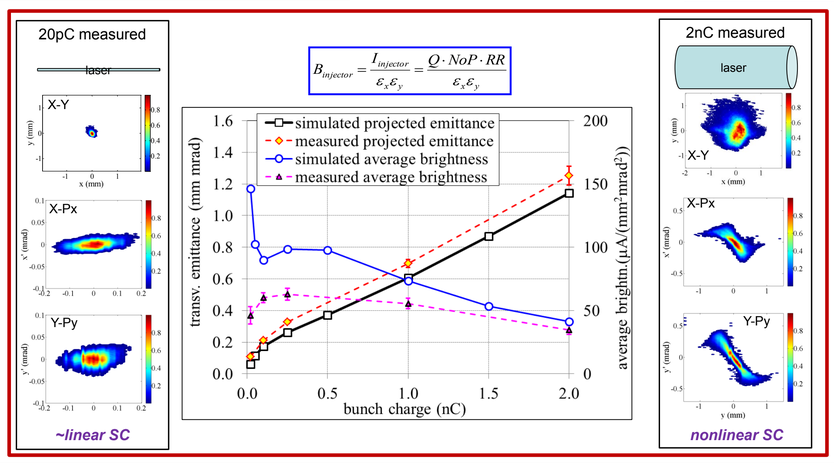
Measured (100%) rms normalized emittance
➔ PITZ world record on projected emittance in 2011 still valid



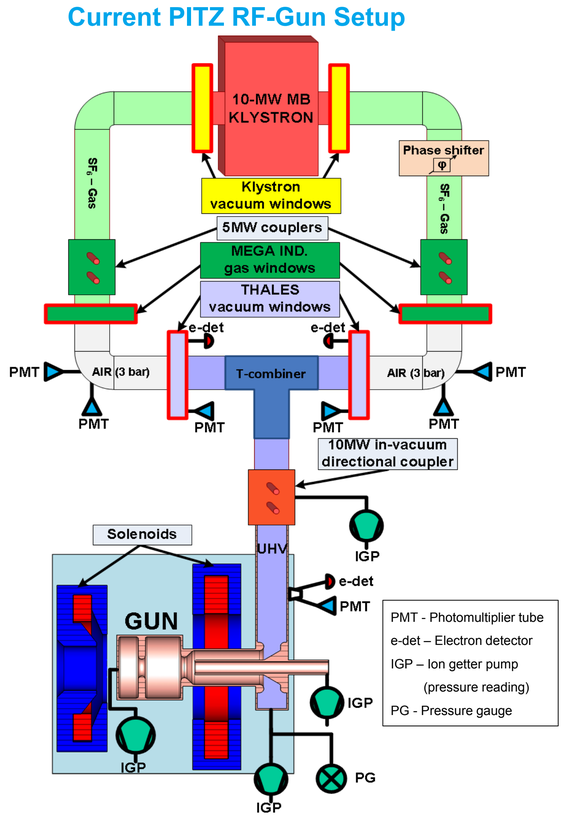
Minimum emittance ($\sqrt{\varepsilon_{n,x}\varepsilon_{n,y}}$)

Charge, nC	Measured, mm mrad
2	1.25±0.06
1	0.70±0.02
0.25	0.33±0.01
0.1	0.21±0.01
0.02	0.121±0.001





Current PITZ RF-Gun Setup



Highest priority at PITZ currently
→Participate in the solution of the remaining problems of the RF gun for XFEL:

- check the principle of operation with 2 RF windows
- RF spring
- stability and long term reliability

RF-Guns, conditioned and characterized at PITZ

→ European XFEL

→ FLASH

3D quasi ellipsoidal cathode laser pulses

Work supported by the German Federal Ministry of education and Research, project 05K10CHE "Development and experimental test of a laser system for producing quasi 3D ellipsoidal laser pulses" , Helmholtz Joint Research Groups, project HRJRG-400 and RFBR grant 13-02-91323.

Main idea: minimize the impact of the space charge on the transverse emittance.

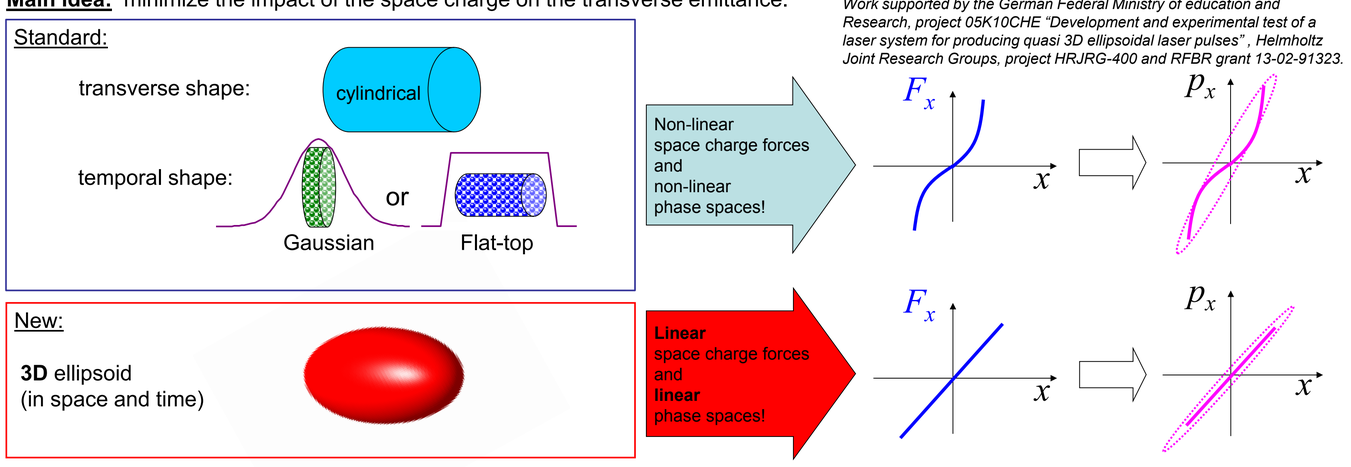
Standard:

transverse shape: cylindrical

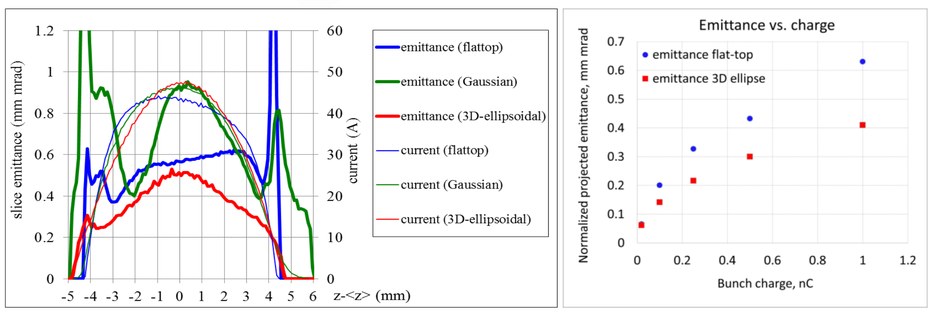
temporal shape: Gaussian or Flat-top

New:

3D ellipsoid
(in space and time)



Simulated slice emittance for 1 nC bunches



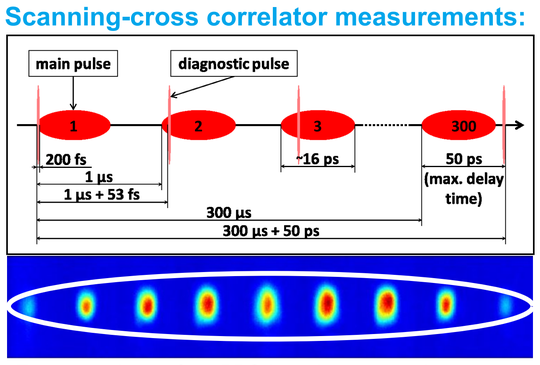
➢ **30-50% lower av. slice emittance**
➢ better longitudinal compression
➢ reduced beam halo

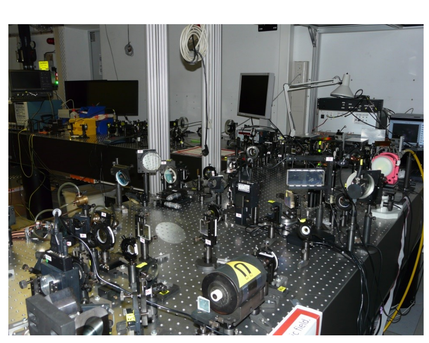
Laser system parameters

parameter	value	unit	remark
wavelength	258	nm	1030 nm fundamental
micropulse energy	15	μJ	for 1 nC bunch production from Cs_2Te photo cathodes
pulse train frequency	1	MHz	4.5 MHz→in future
pulse train length	0.3	ms	0.6 ms→in future
pulse train rep.rate	10	Hz	1,2,5 Hz as an option
micropulse rms duration	6±2	ps	**3D quasi ellipsoidal distribution**
transverse rms size	0.5±0.25	mm	

First Experimental Results

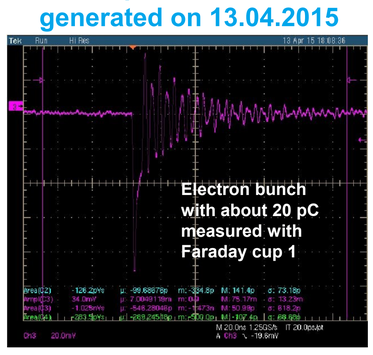
Scanning-cross correlator measurements:





Transverse image from BBO-based cross-correlator (IRxIR), here 1.7 ps delay between two neighboring shots

First photo electrons generated on 13.04.2015



PDWA Experiments at PITZ

LAOLA Laboratory for Laser- and beam-driven plasma Acceleration

> Background: proton driven PWFA experiment at CERN (AWAKE collaboration) plans to utilize beam-plasma instability for **self modulation**

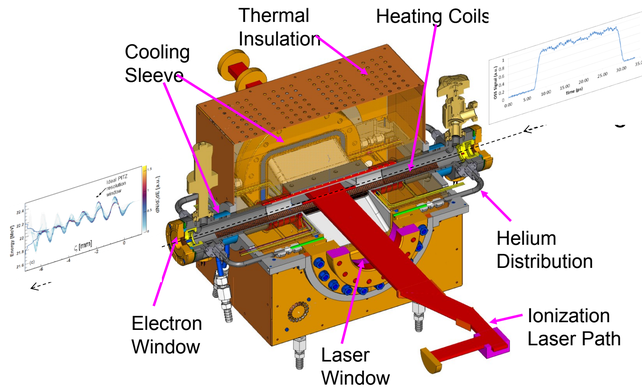
- Use high energy proton beam from SPS to drive wake and convert the **proton beam** energy into **electron beam** energy in a **single** stage
- Problem: Caldwell et al., Nature Physics (2009):

$$E_{z,max} = 240(MV\ m^{-1})\left(\frac{N}{4x10^{10}}\right)\left(\frac{0.6}{\sigma_z(mm)}\right)^2$$

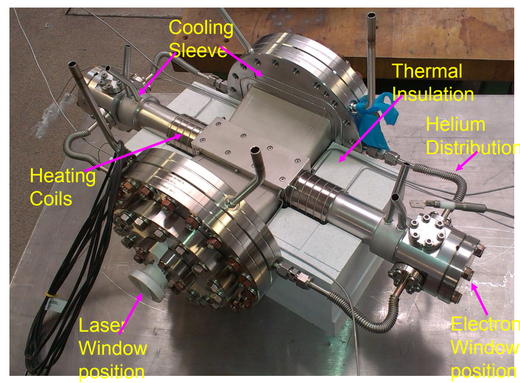
  - **short** bunches (σ_z < 100 μm) needed
  - SPS delivers $\sigma_z \approx$ 10 cm
- Solution: use beam-plasma instability to **modulate the beam at the plasma wavelength**, driving strong plasma waves for acceleration
- But: so far simulations only (no direct experimental evidence)

> Goal: detect and characterize **self modulation of electron beams** in PITZ beam line to gain critical insights into **relevant physics** (dephasing, hose instability etc.)

Plasma Cell Design



Assembled Plasma Cell



Further plasma experiments at PITZ:

- High transformer ratio (factor up to 8 possible)
- Case studies: astrophysics in the lab