Emittance measurements with the gun and laser operated close to E-XFEL startup conditions.

- PITZ gun and laser operated at E-XFEL conditions
- Simulations with realistic laser transverse shape
- Emittance for E-XFEL conditions
- Emittance for various beam charges
- Summary and outlook

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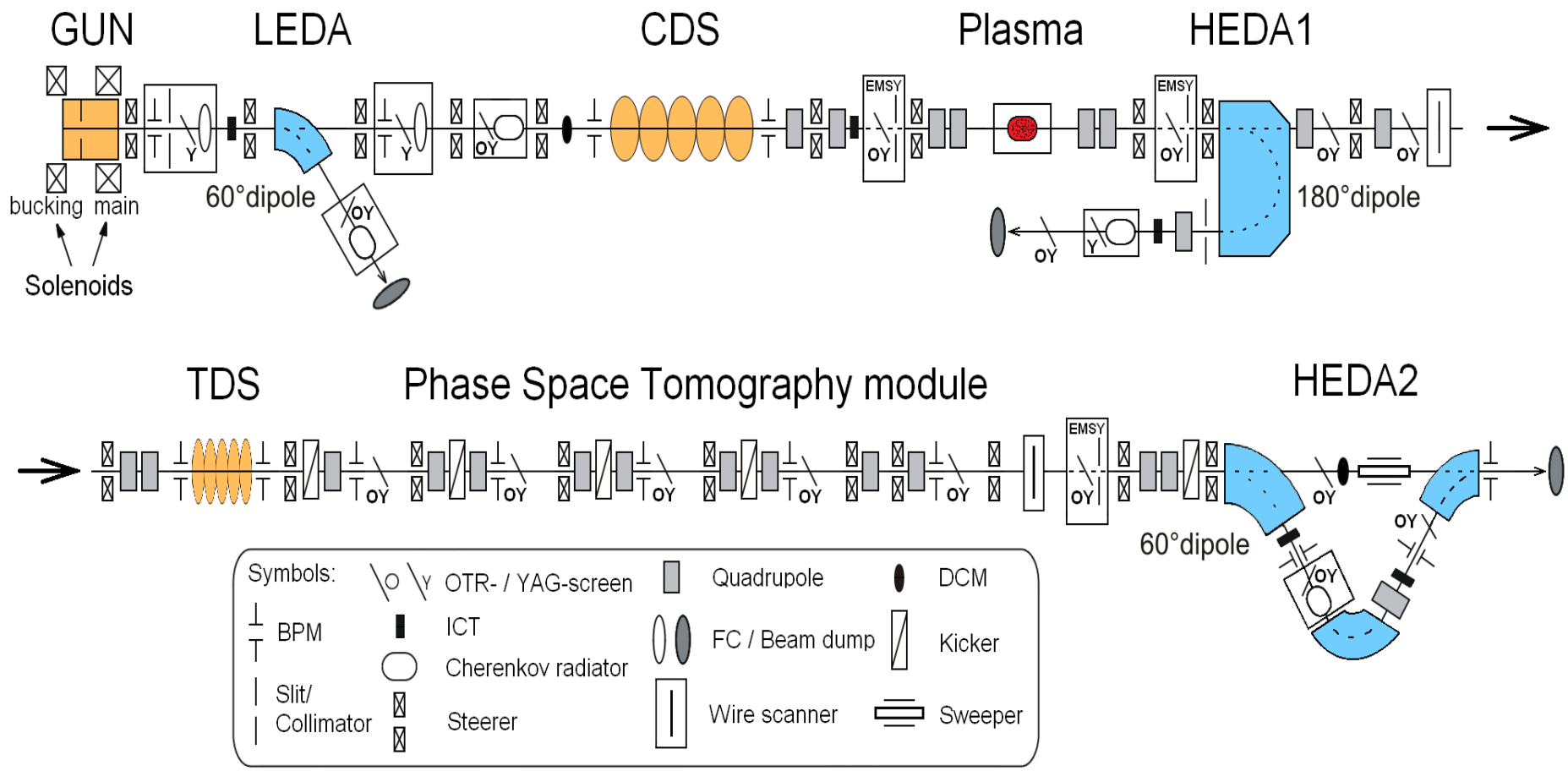
FEL 2015
Daejeon, 24.08.2015

HELMHOLTZ GEMEINSCHAFT

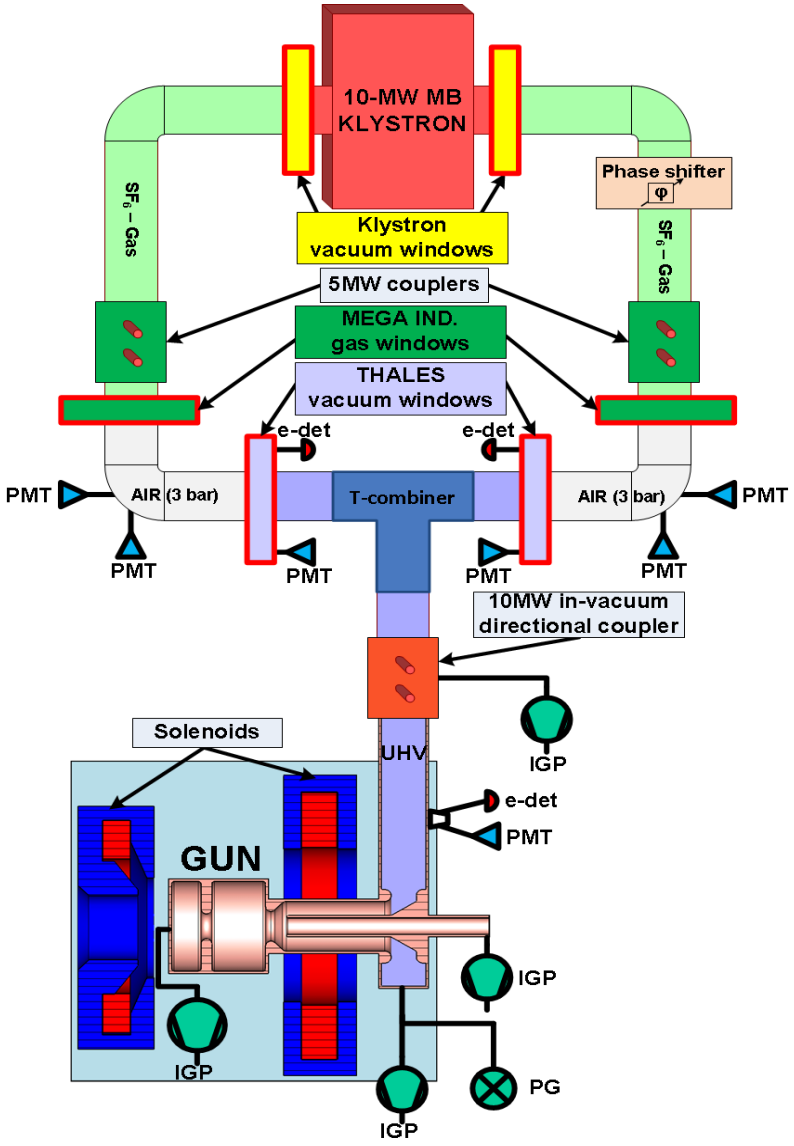
DESY

PITZ setup



Gun: 1.3 GHz, 1.6 cells, normal conducting copper cavity. Up to 7 MeV/c beam momentum.
CDS: 1.3GHz, 14 cells, normal conducting copper cavity. Up to 15 MeV energy gain.

Gun and laser setup corresponding to E-XFEL commissioning parameters

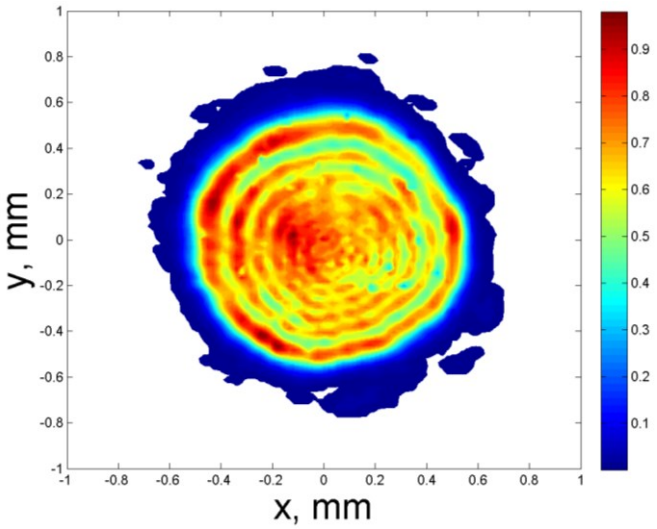


Gun setup:

- 600 us RF pulse length
- 53 MV/m on-axis peak field on the cathode
  ➔ P_z ~ 6.1 MeV/c

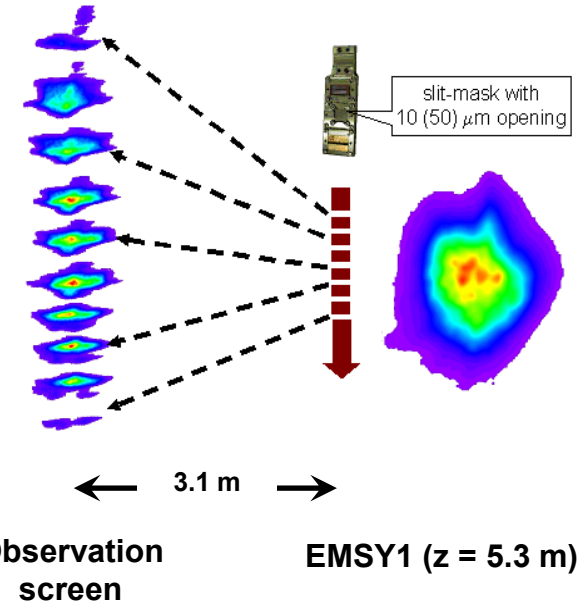
Laser setup:

- Gaussian longitudinal pulse shape with FWHM of about 12 ps ~~(estimated, no diagnostics available at the moment)~~
- Quasi-uniform transverse profile



Emittance measurements setup

- Emittance measurements for electron beams of various charges using slit scan
- Emittance as a function of main solenoid current is measured for various laser spot sizes on the cathode and gun launching phase fixed to MMMG phase
- Emittance as a function of main solenoid current is measured for various gun launching phases and fixed laser spot size on the cathode which delivers the minimum emittance as found in previous measurement.



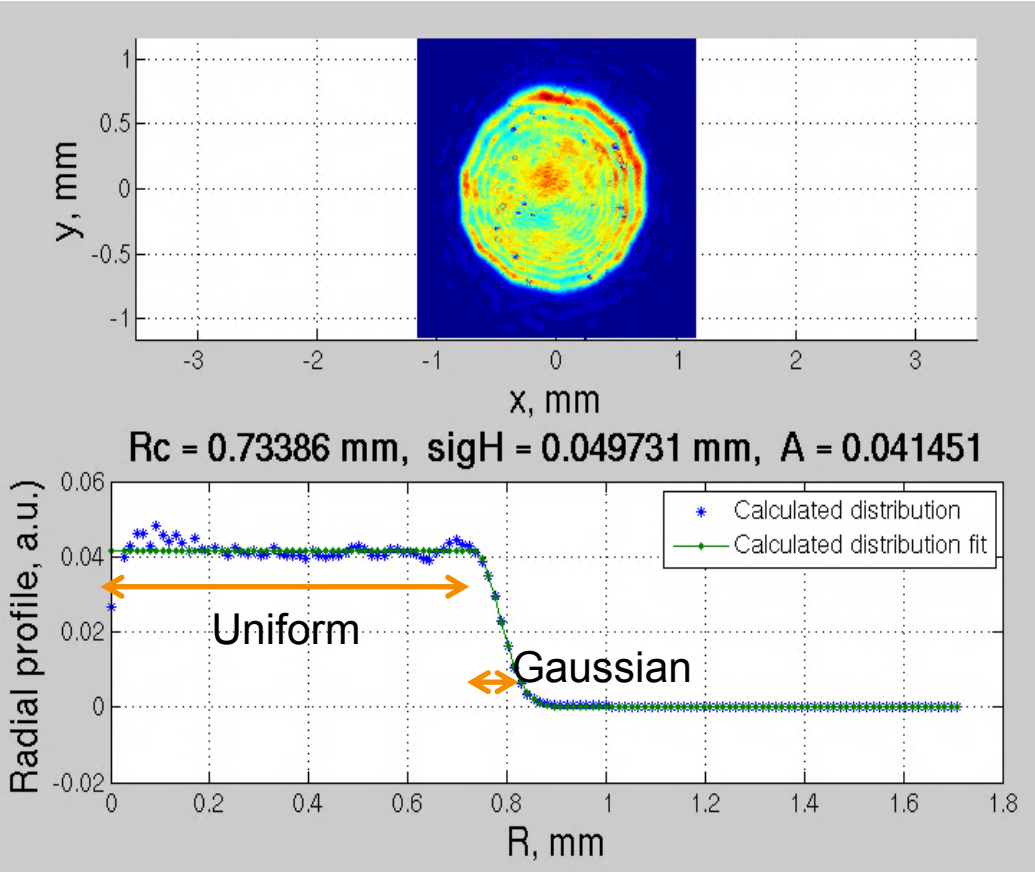
$$\varepsilon_n = \frac{\sigma_x}{\sqrt{\langle x^2 \rangle}} \beta\gamma \sqrt{\langle x^2 \rangle \cdot \langle x'^2 \rangle - \langle xx' \rangle^2}$$

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

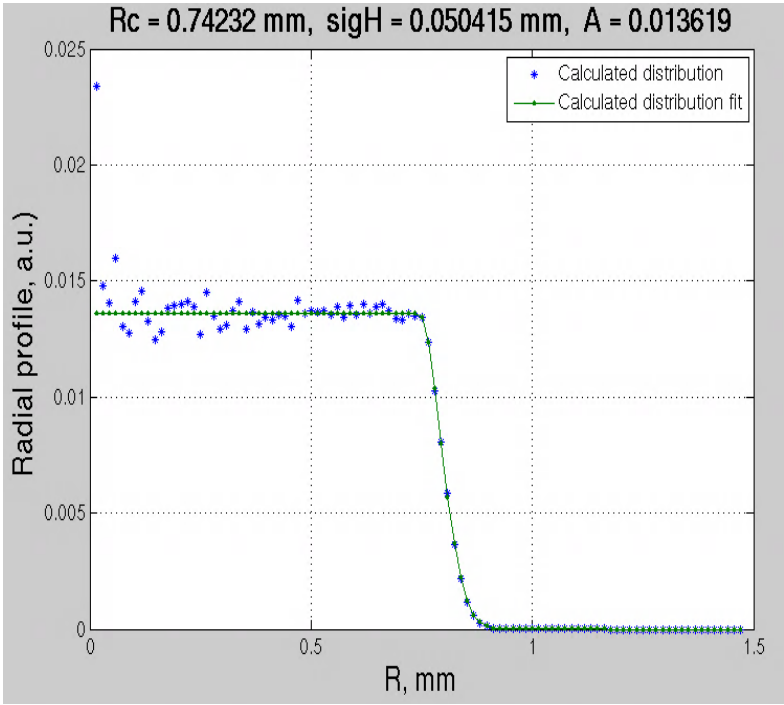
100% RMS emittance

Beam dynamics simulations with realistic transverse laser shape

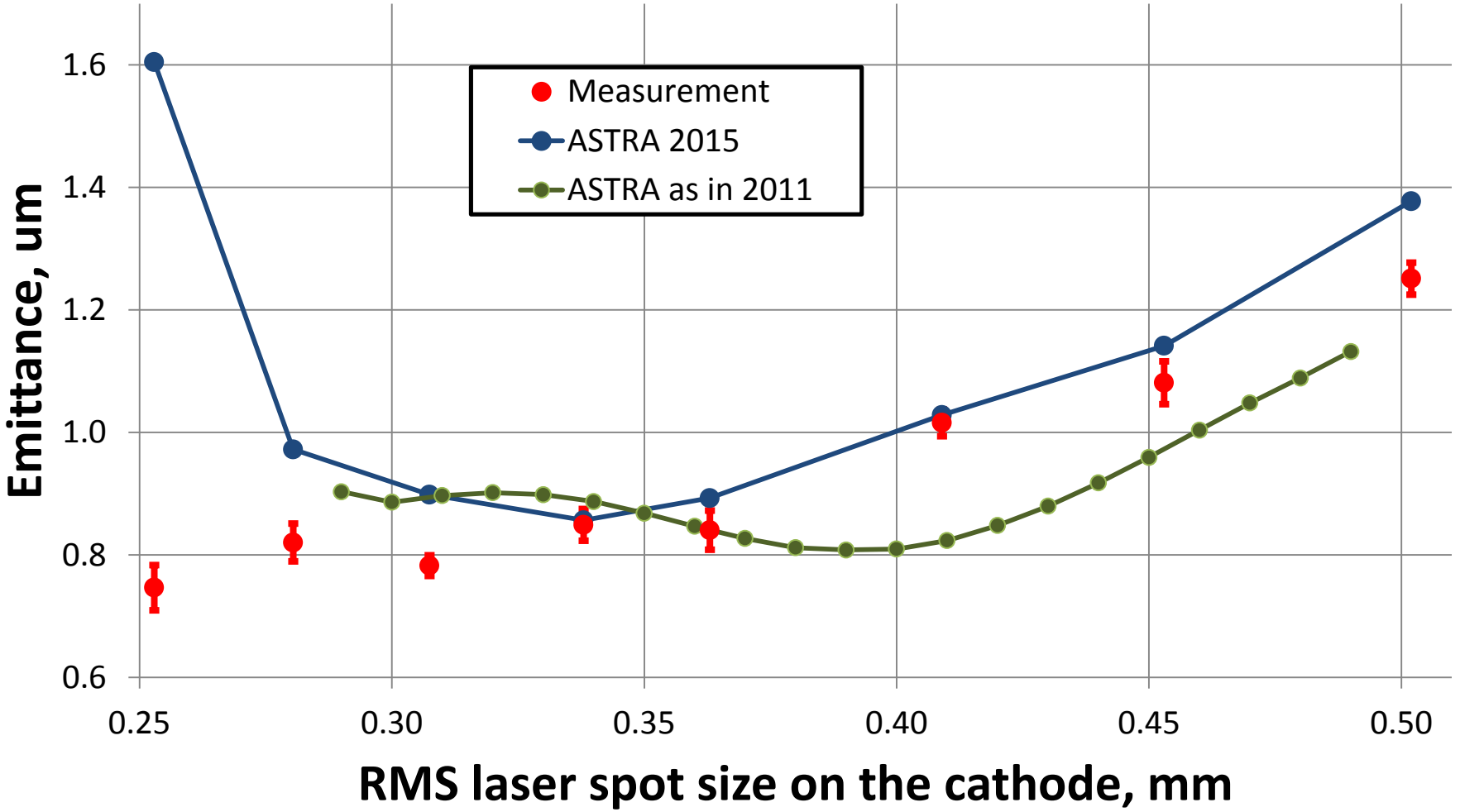
Real laser transverse profile



Generated laser profile with fit parameters for simulations

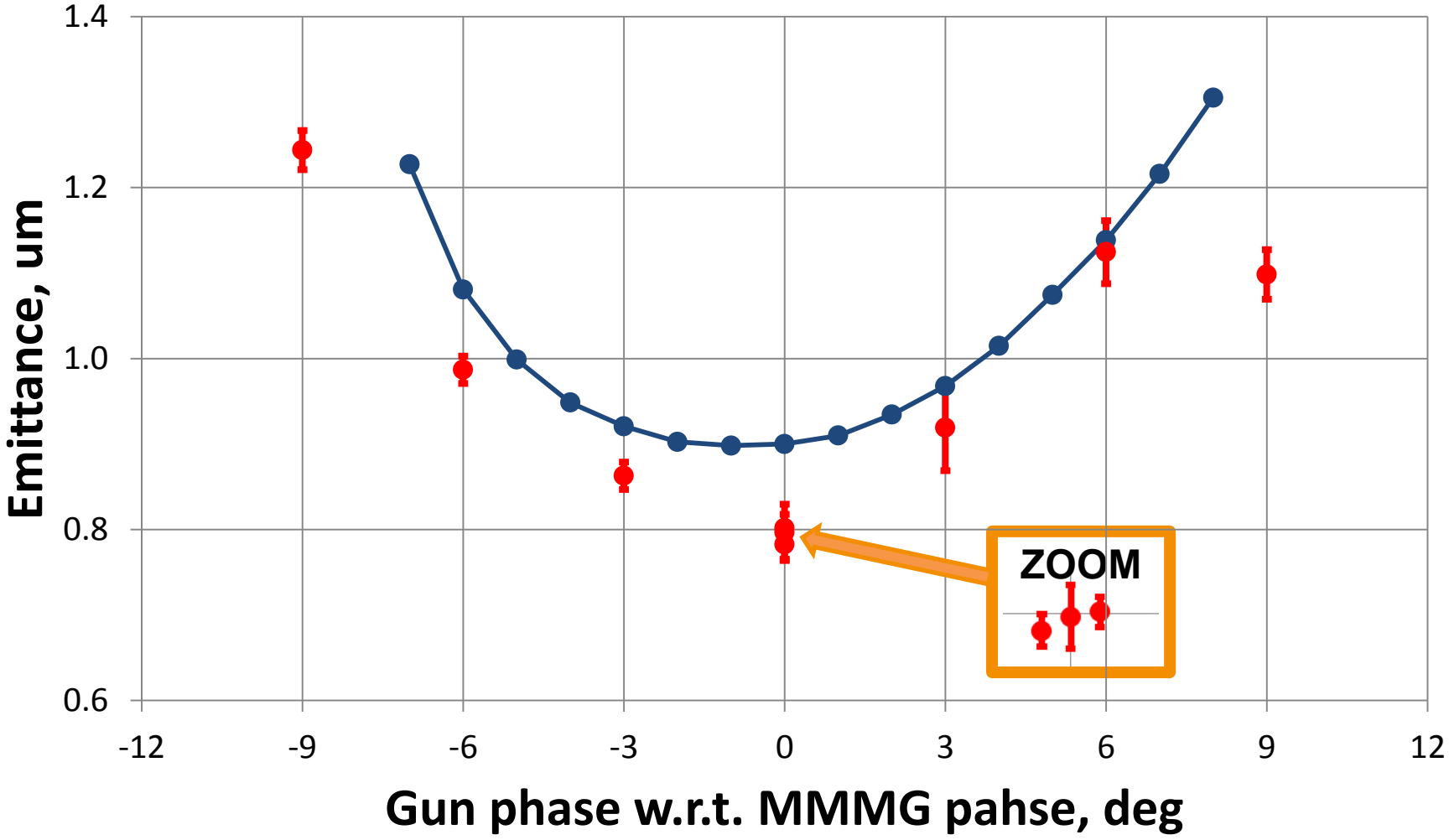


Emittance measurements for 500 pC, MMMG gun phase, laser spot size scan

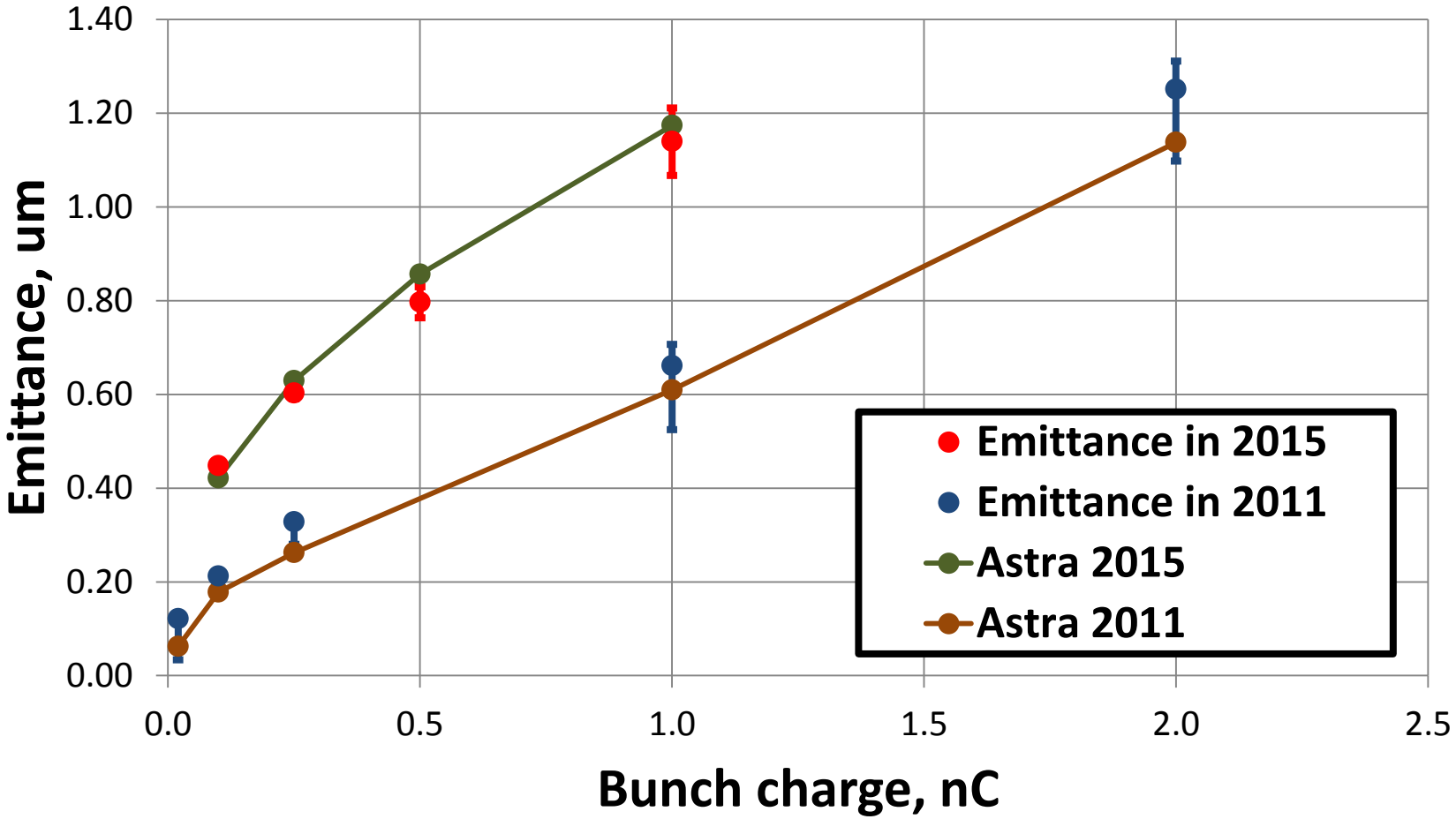


European X-FEL commissioning phase requirement on emittance is fulfilled

Emittance measurements for 500 nC, rms laser spot size of 0.3 mm, gun phase scan



Emittance for different charges



Emittance measurements in 2011 were performed for the gun on-axis peak field of 60 MV/m (53MV/m in 2015) and flat-top laser pulse shape with FWHM of 21.5 ps (Gaussian with 11-12 ps FWHM in 2015)

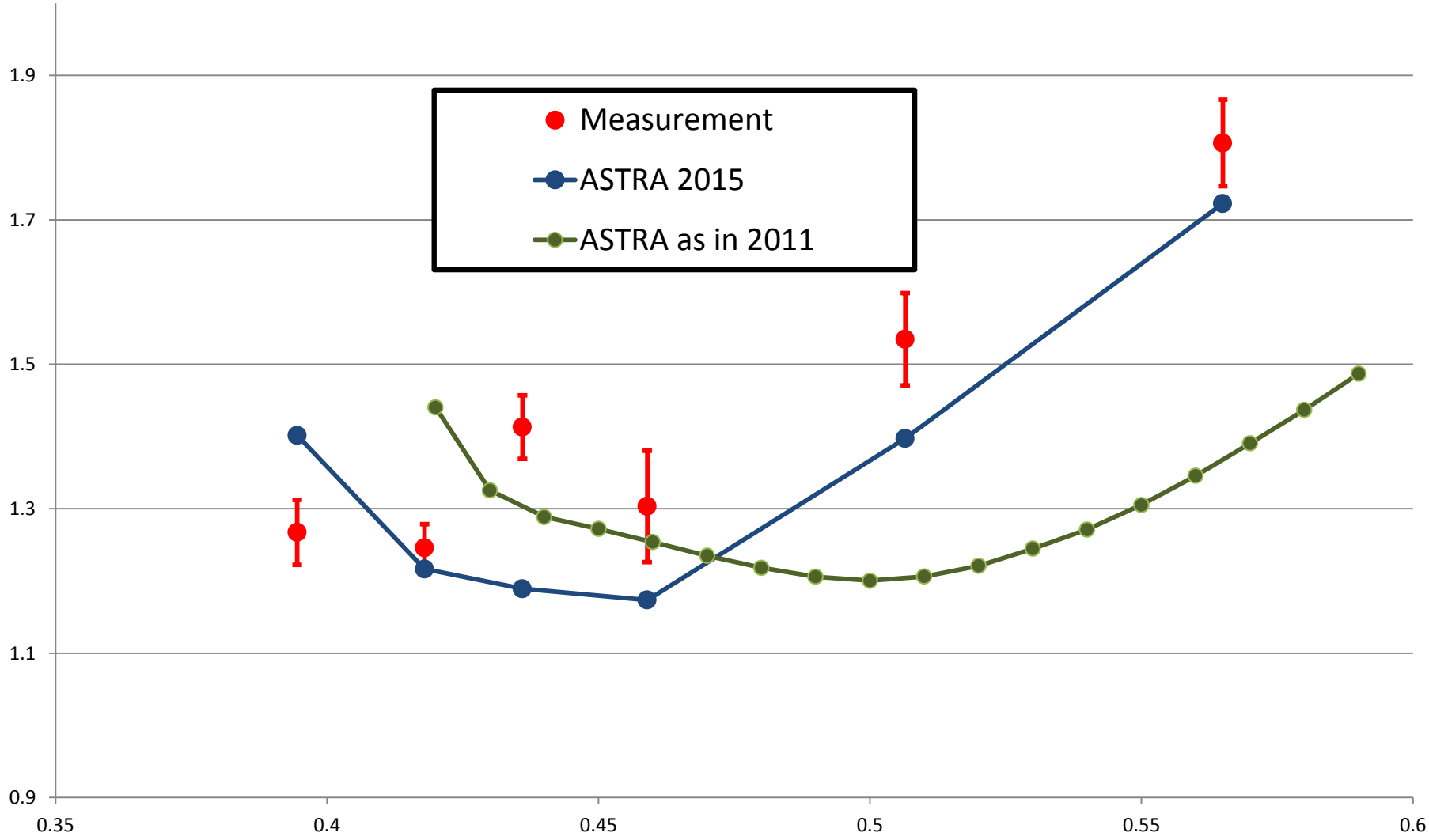
Summary and outlook

- **European X-FEL commissioning phase requirement on emittance is fulfilled**
- Emittance for electron beam charges of 100, 250, 500 and 1 nC, gun operated at 53 MV/m on-axis peak field and Gaussian laser temporal profile with FWHM of 11-12 ps was measured.

Emittance in 2015			Emittance in 2011		
Charge, nC	Emittance, um	Error, um	Charge, nC	Emittance, um	Error, um
1	1.139	0.07	2	1.251	0.06
0.5	0.797	0.03	1	0.661	0.05
0.25	0.603	0.01	0.25	0.328	0.01
0.1	0.448	0.01	0.1	0.212	0.01
			0.02	0.121	0.01

Thank you for attention!

Emittance measurements for 1 nC, MMMG gun phase, BSA scan



Emittance measurements for 250 pC, MMMG gun phase, BSA scan