Problems observed at PITZ: measurements vs. simulations

Mikhail Krasilnikov (DESY) for the PITZ Team

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Content:

- Measured and simulated emittance at PITZ:
  - vs. bunch charge
  - vs. laser transverse size
  - vs. main solenoid current
  - main components (gun, booster, cathode laser)
- Measured and simulated transverse phase space:
  - rather good agreement for 100pC
  - discrepancy for higher bunch charges
  - charge production issue
- Summary

HELMHOLTZ ASSOCIATION

PITZ Photo Injector Test Facility Zeuthen

DESY

Emittance vs. Laser Spot size for various charges

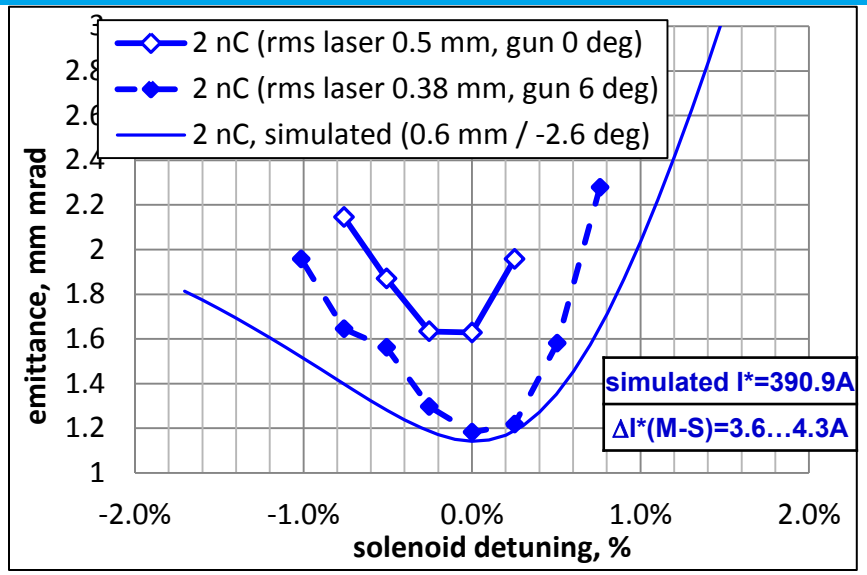
Plots - measured and simulated optimized projected emittance as a function of the rms size of the photo cathode laser spot size are not yet published – to be published soon

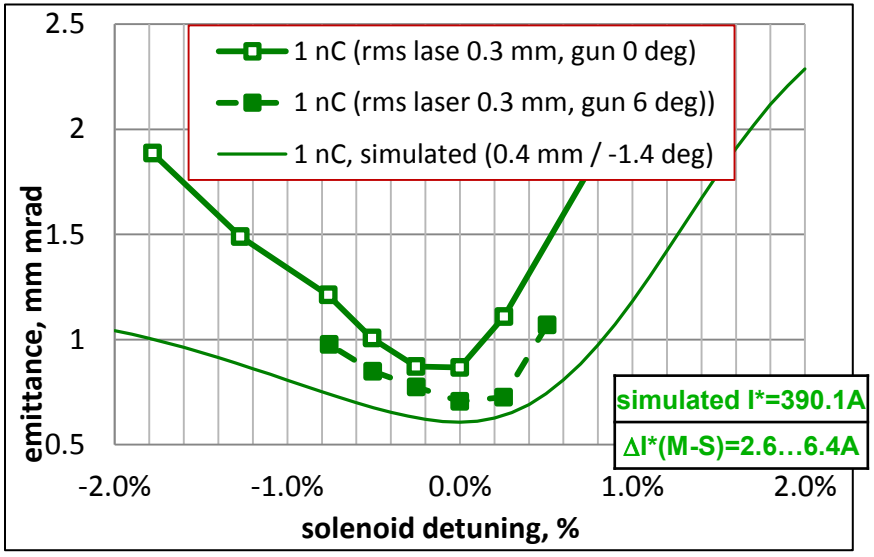
Minimum emittance

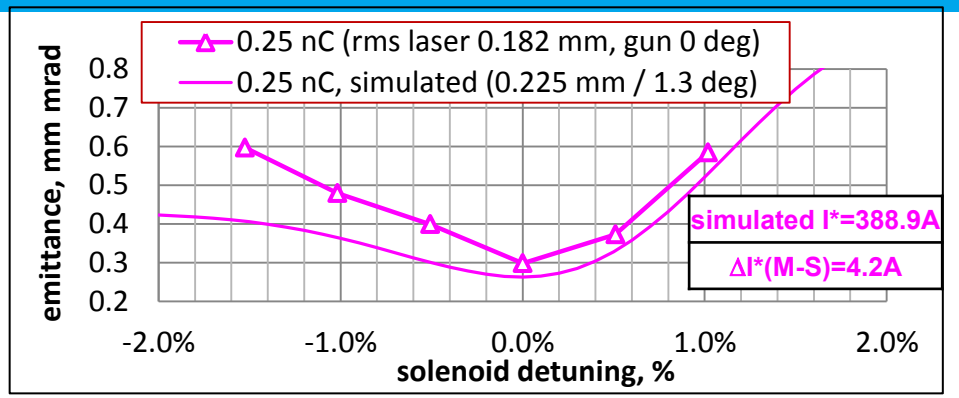
Charge, nC	Meas., mm mrad	Simul., mm mrad
2	1.25	1.14
1	0.70	0.61
0.25	0.33	0.26
0.1	0.21	0.17
0.02	0.12	0.06

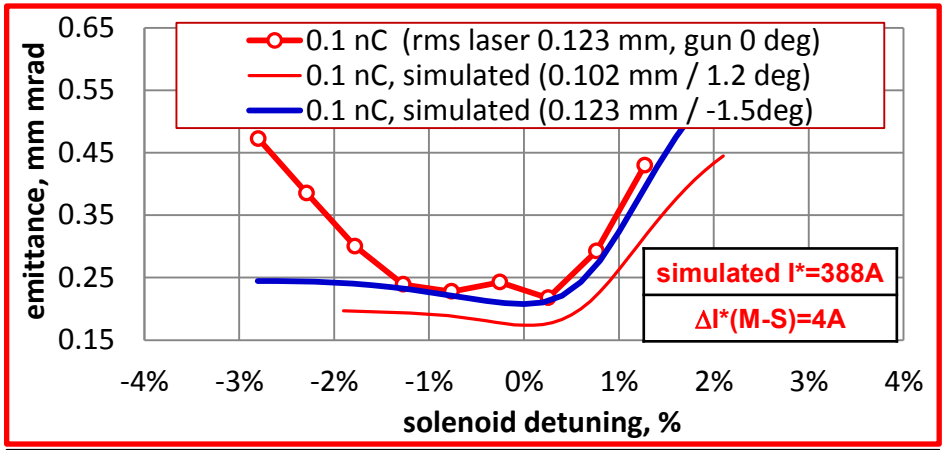
- Optimum machine parameters (laser spot size, gun phase):
  experiment ≠ simulations
- Difference in the optimum laser spot size is bigger for higher charges (~good agreement for 100pC)
- A radial homogeneous laser pulse distribution is used in simulations whereas the experimental transverse distribution is not perfect
- Artificial increase of the thermal kinetic energy at the cathode (from 0.55eV to 4eV) did not improve the understanding

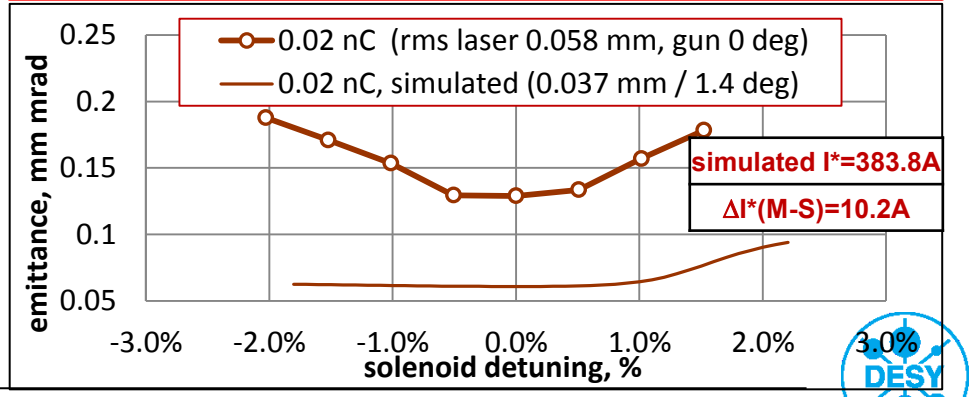
Emittance vs. (Imain/I*-1) for various bunch charges: M←→S





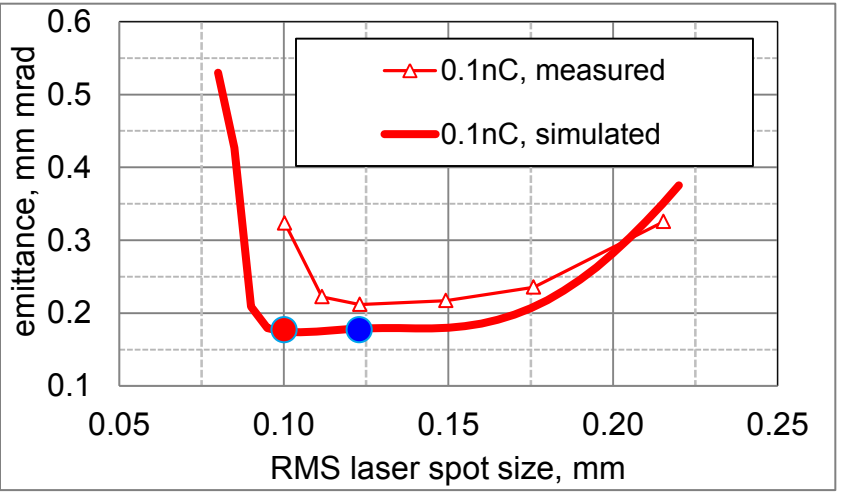


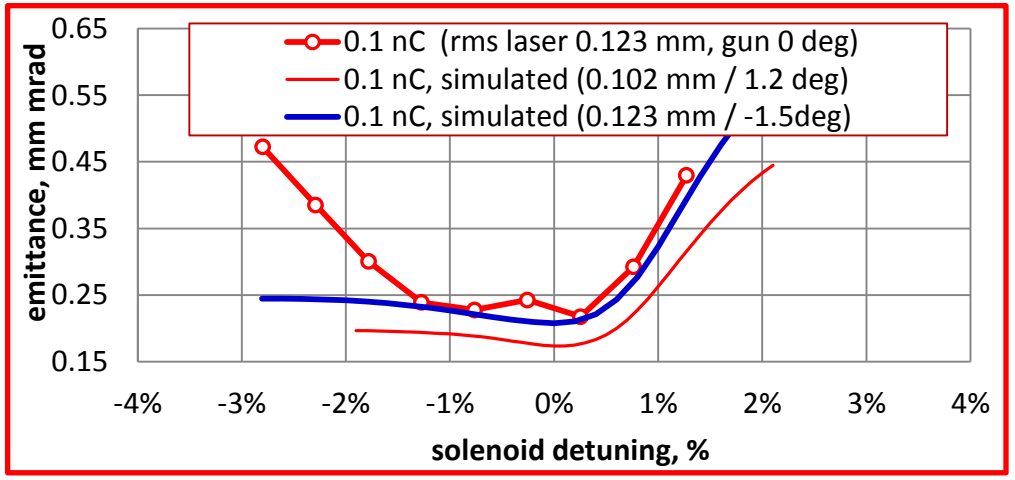




Emittance values → ~+
Optimum solenoid current ΔI(meas-sim) ~4A!

Measured and Simulated Emittance: 0.1nC

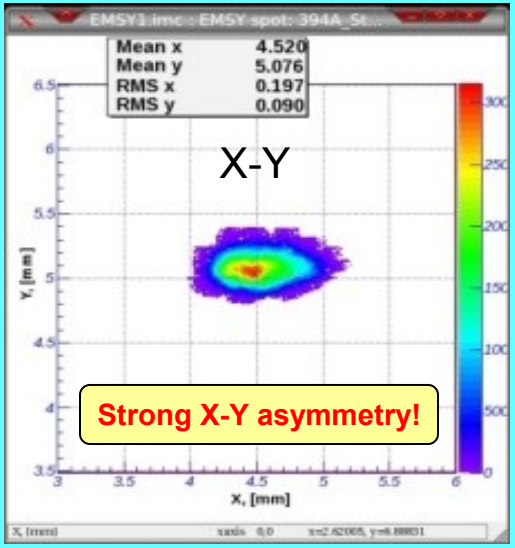


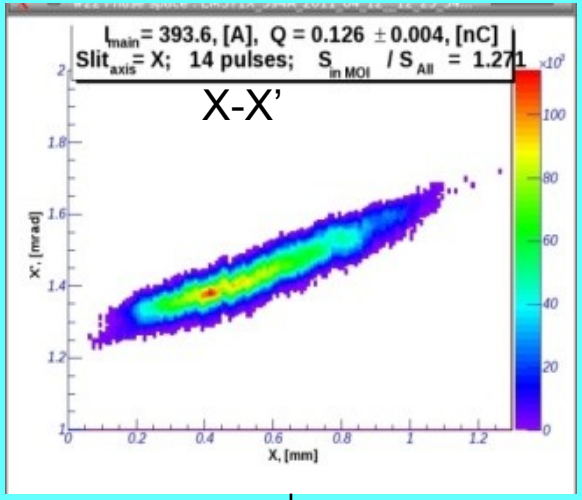


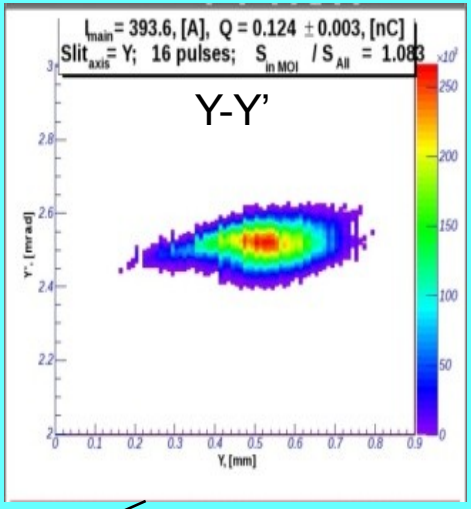
Rather good agreement in both beam rms size and emittance!

Measured and Simulated Phase Space at EMSY1: 0.1nC

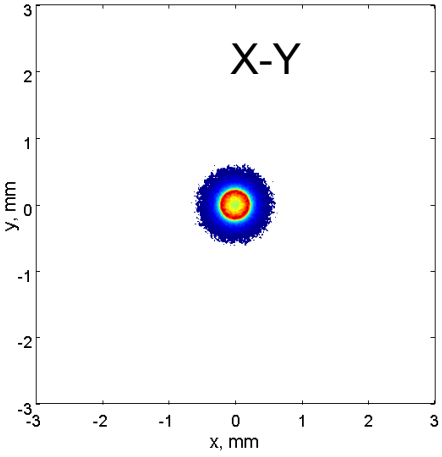
Measured

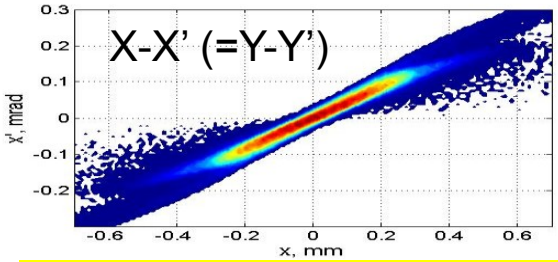


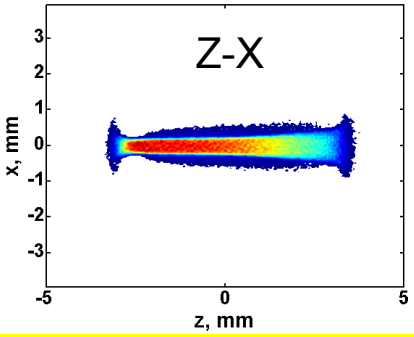




Simulated

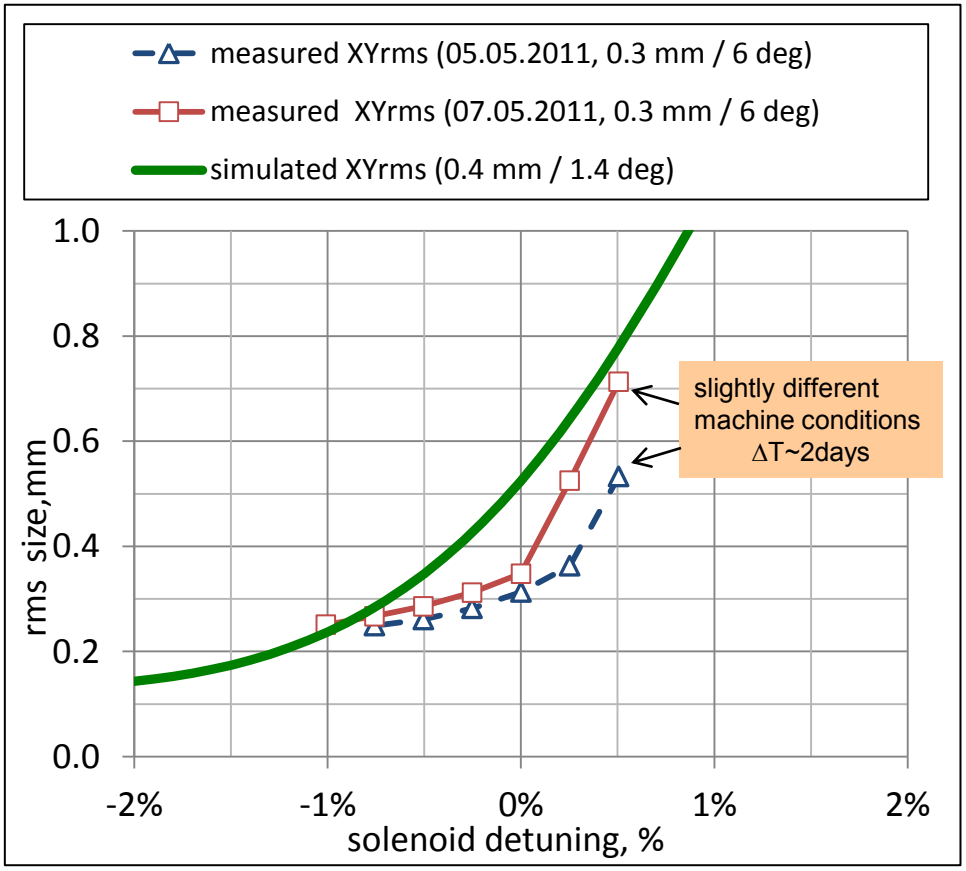




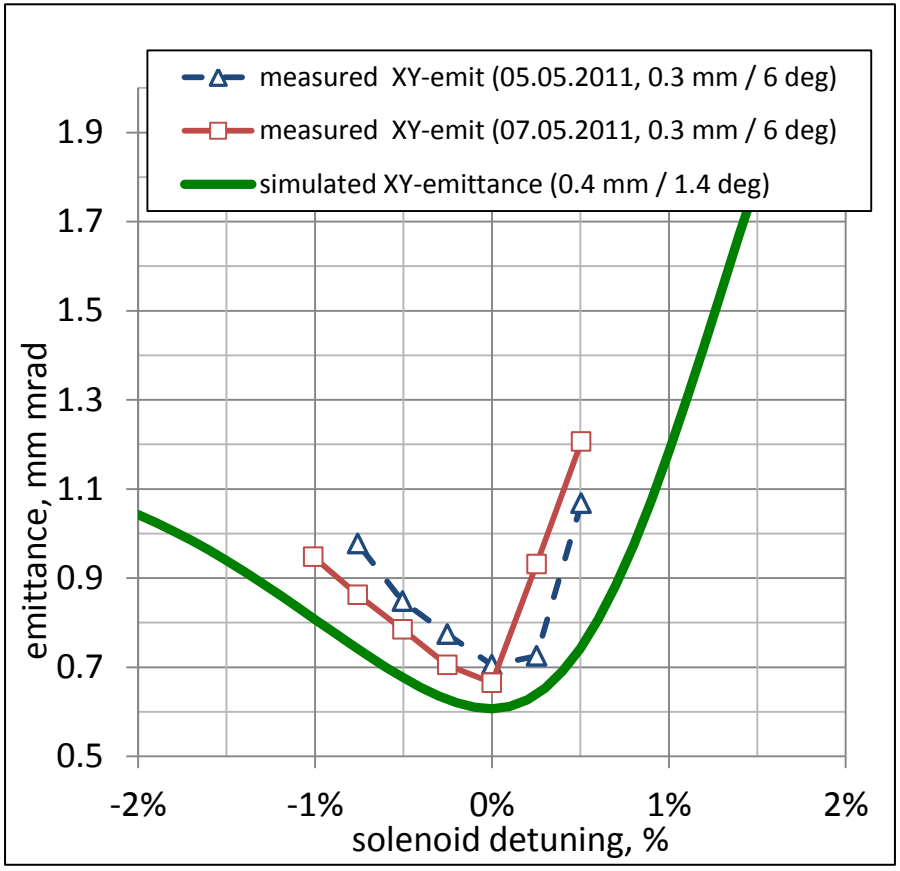


Measured and Simulated Emittance: 1nC

Electron beam **size** at EMSY1



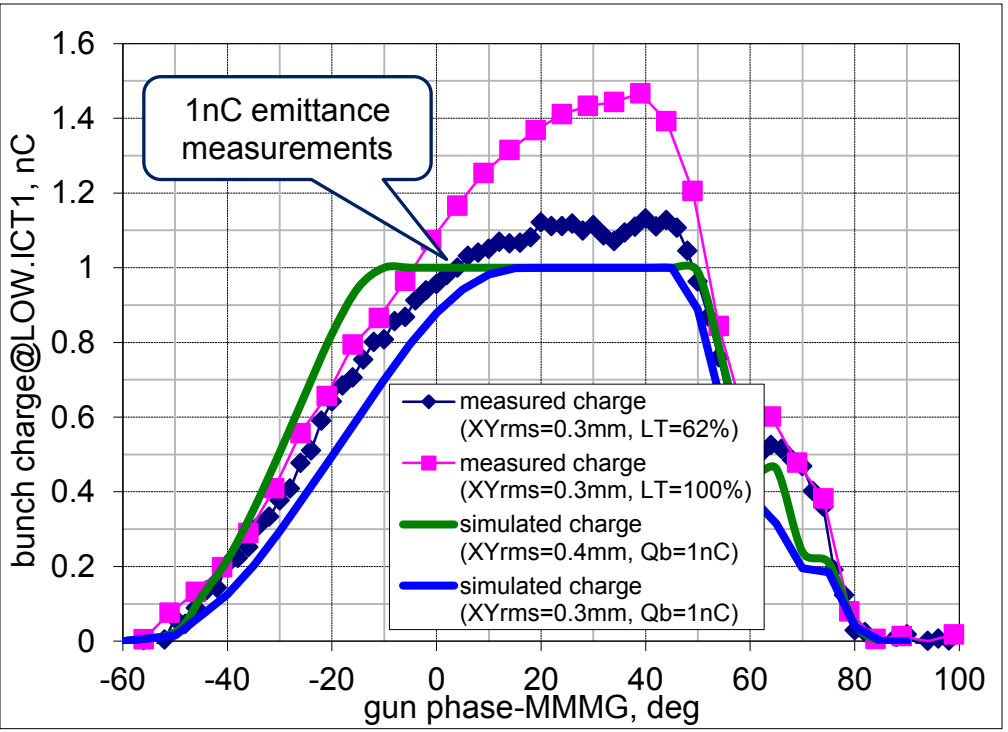
Electron beam **emittance** at EMSY1



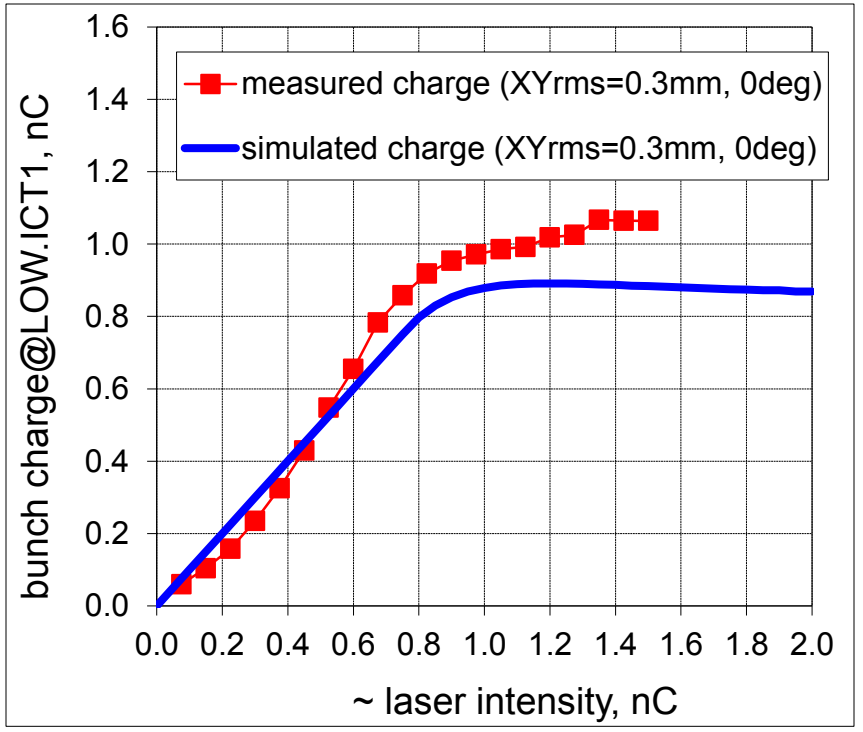
- Optimum laser rms spot sizes:
  - **Experimental** XYrms=0.30mm (BSA=1.2mm)
  - XYrms=0.4mm → from **simulations**
- Simulated electron beam size at EMSY1 is still larger than the measured one
- Applying 0.3 mm laser spot to the simulation – it is impossible to produce **1nC**!

Reasons of discrepancy for high Q? → Emission from the cathode?

Measured and simulated Schottky scans (1nC)



Measured and simulated laser energy scan (1nC)



- Direct plug-un machine settings into ASTRA does not produce 1nC at the gun operation phase (+6deg), whereas 1nC and even higher charge (~1.2nC) are experimentally detected
- Simulated (ASTRA) phase scans w/o Schottky effects (solid thick lines) have different shapes than the experimentally measured (thin lines with markers)

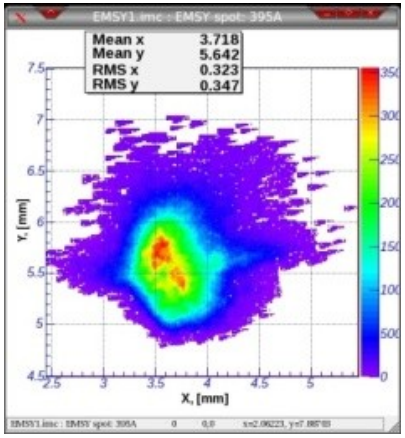
- Laser intensity (LT) scan at the MMMG phase (red curve with markers) shows higher saturation level, whereas the simulated charge even goes slightly down while the laser intensity (Qbunch) increases

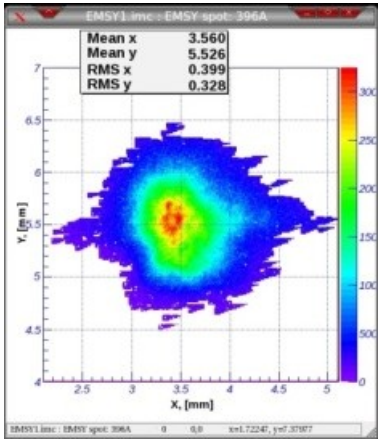
Possible reasons:

- Field enhancement of the photo emission (**Schottky-like effect**) should be taken into account
- Laser imperfections (transverse **halo** and temporal **tails**) could contribute at high charge densities
- …

Summary

- Simulated optimum machine parameters (laser spot size and RF gun phase) ≠ to those obtained experimentally
- Photo emission (bunch charge) needs more detailed modeling in simulations
- Tails (~horizontal) in the beam distribution:
  - X-Y asymmetry
  - Horizontal beam tails (beamlets from tails are not detectable)





??Reasons:

- Remaining magnetizable components
- Vacuum mirror
- Solenoid imperfection
- Stray fields from IGPs
- …