Paper Review

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Impact of the spatial laser distribution on photocathode gun operation

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DESY

I. Overview

- studies suggested flat-top temporal and transverse laser profile for best emittance → accomplished by means similar to PITZ
- early 2010: shortening temporal profile by one stacked laser pulse → no obvious emittance change → use of single 3 ps Gaussian pulse for LCLS user operation
- New simulations suggest better emittance with truncated Gaussian spatial distribution
- Advantages: lower emittance and larger laser transmission through BSA

II. Simulations

- Simulation done with IMPACTT
- 150 pC, 1mm diameter, 135 MeV beam energy

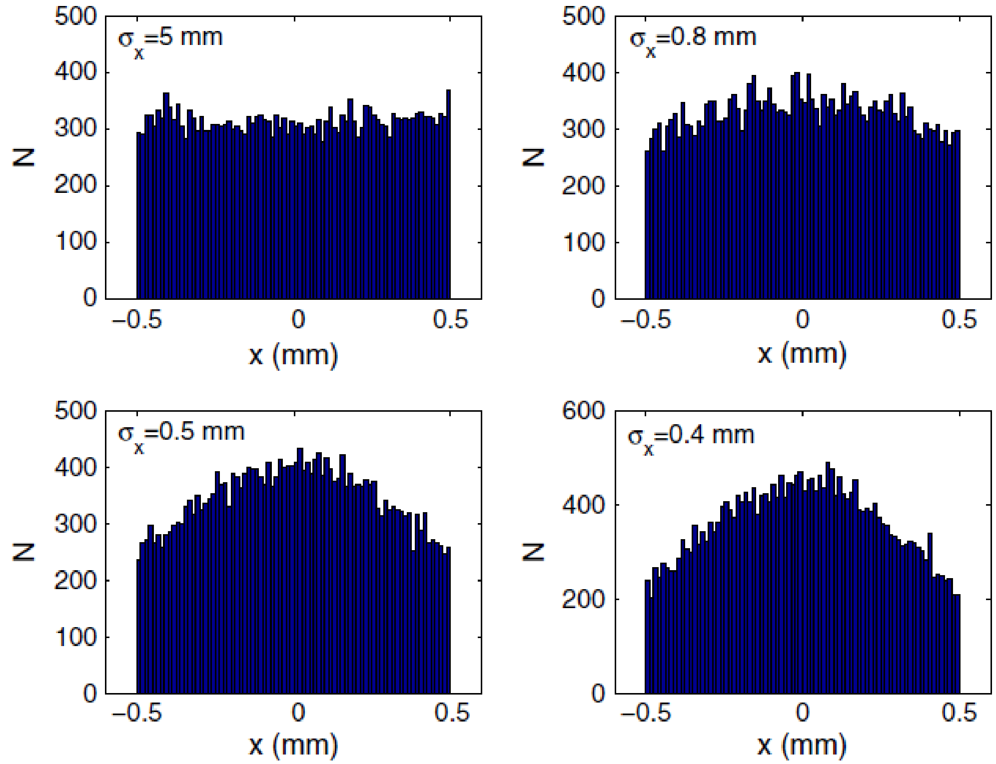
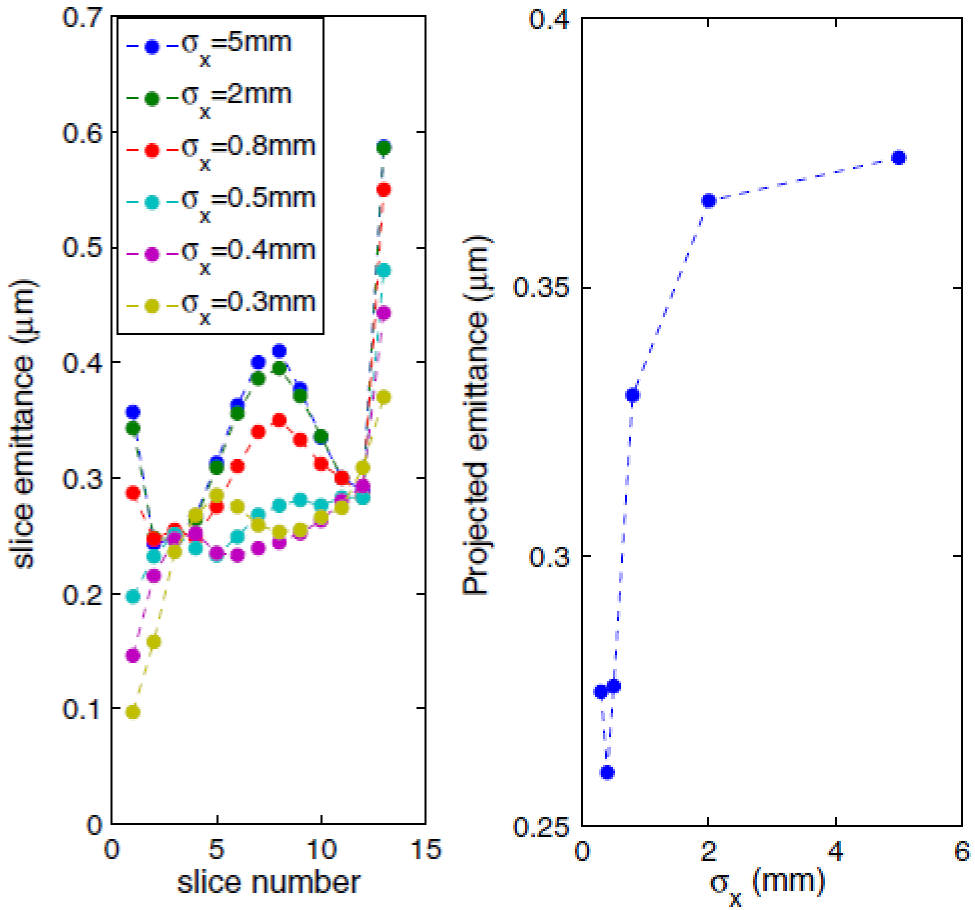


FIG. 1. Lineout intensity of the initial laser spatial distributions used in the simulations: the pure uniform laser spatial beam ($\sigma_x = 5.0$ mm), nearly uniform ($\sigma_x = 0.8$ mm), and different truncated-Gaussian laser spatial distributions ($\sigma_x = 0.4$–0.5 mm).

II. Simulations

- Result: σ_x=0.4mm shows best projected emittance



II. Simulations

- Laser transmission through iris:
- Truncated gaussian significantly loosens requirements for copper cathode quantum efficiency and laser pulse energy
- Measurement agreed very well with calculation

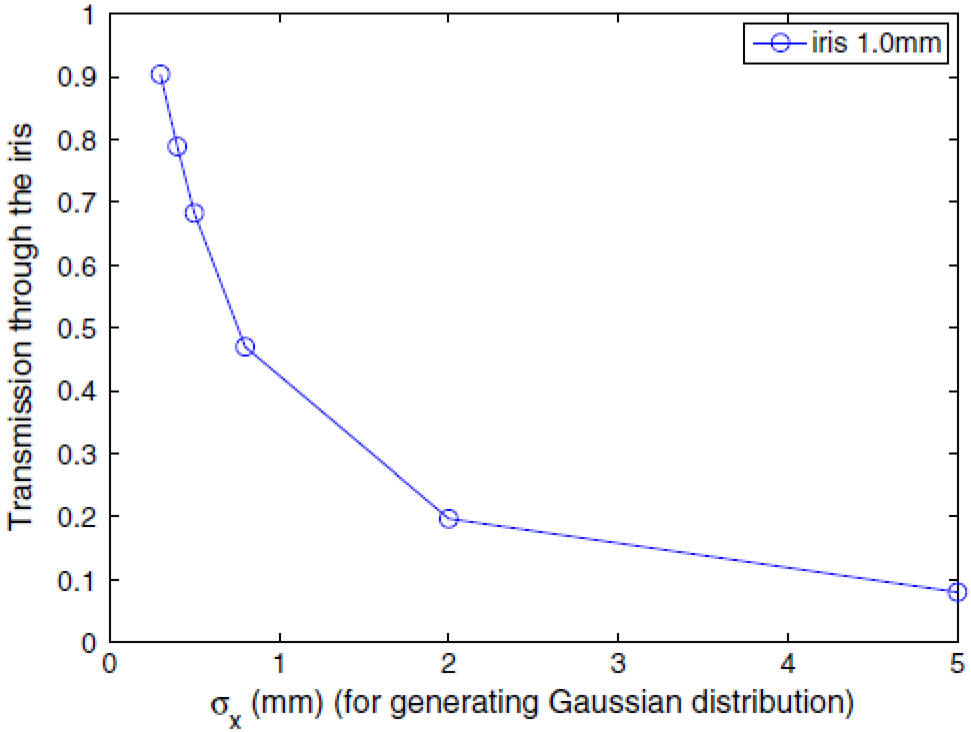


FIG. 4. Calculated laser transmission through the iris for different laser beams: the pure uniforms ($\sigma_x = 5.0$ and 2.0 mm), nearly uniform ($\sigma_x = 0.8$ mm), and different truncated-Gaussian spatial beams ($\sigma_x = 0.5$, 0.4, and 0.3 mm).

III. Measurement

- Projected emittance ≈ 0.32 µm for uniform distribution, compared to 0.23-0.24 µm for truncated Gaussian (135 MeV beam energy, 1mm BSA)

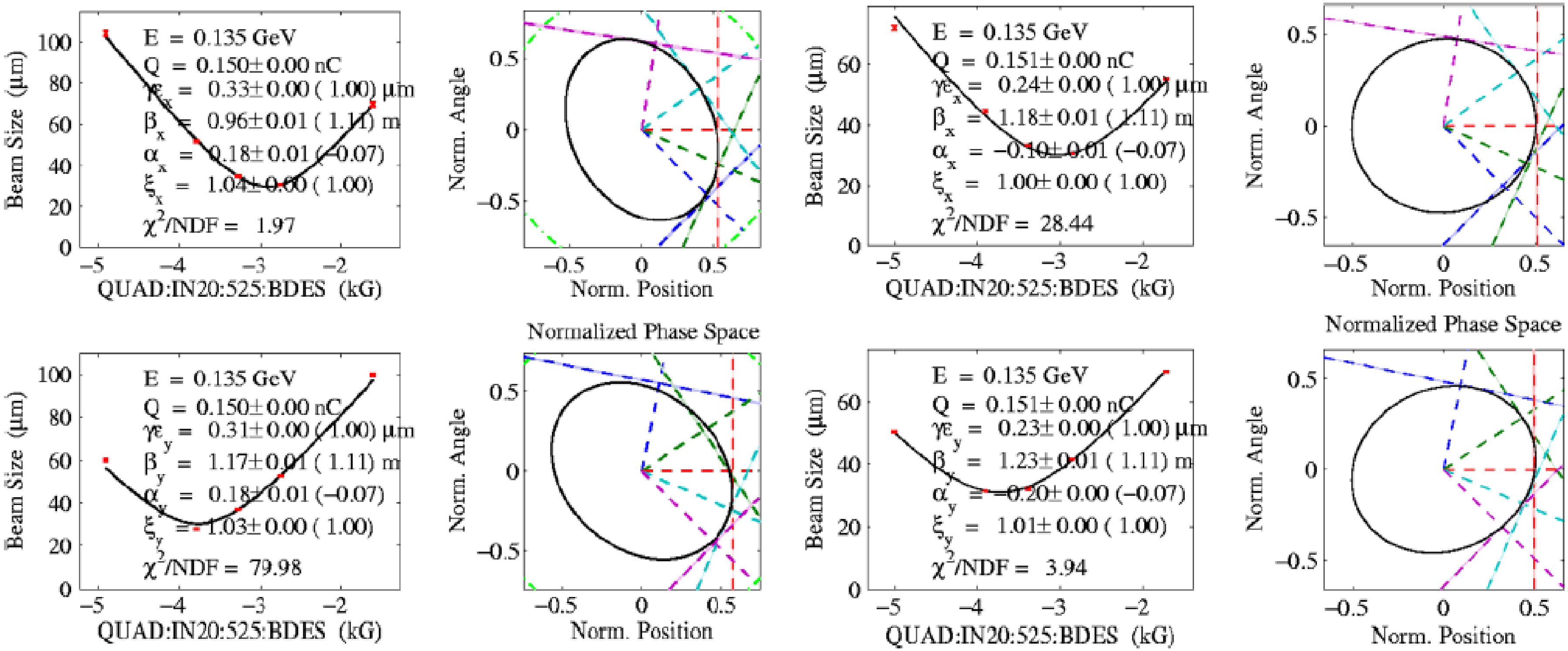


FIG. 6. Measured projected emittance at the LCLS injector with 150 pC: regular nearly uniform (left) and truncated-Gaussian (right) laser spatial distributions at the photocathode. Note that 5% of particles in the tails are excluded in the beam size measurements.

III. Measurement

> User Operation with truncated Gaussian laser profile

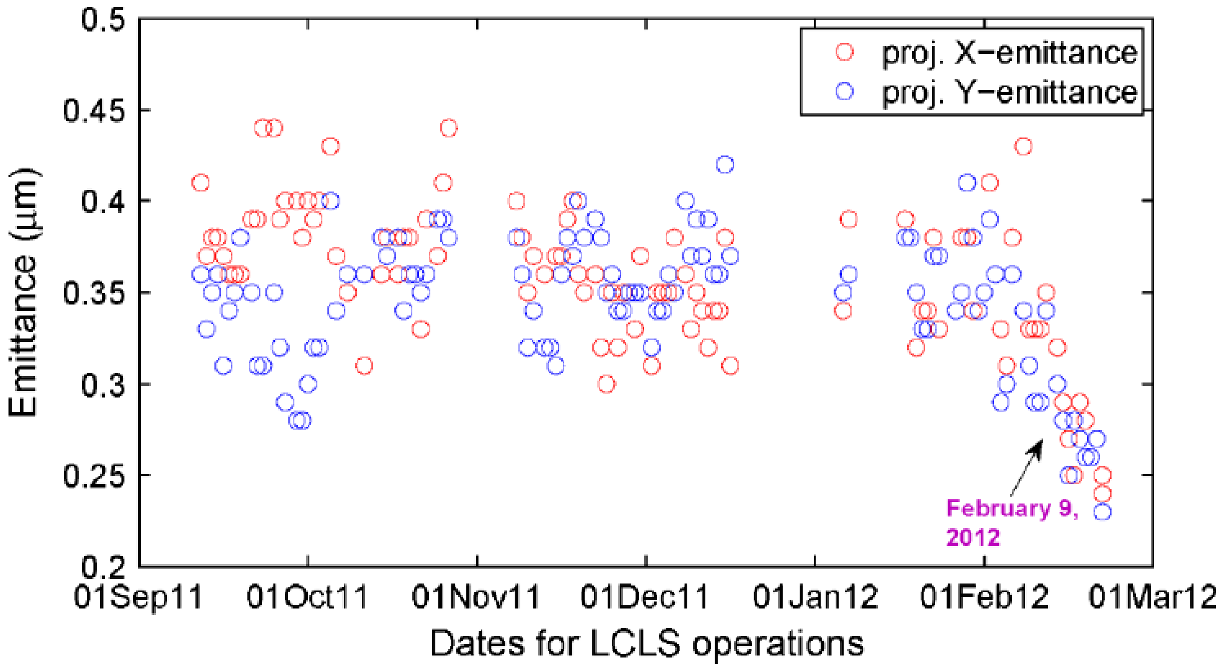


FIG. 7. The LCLS injector emittance (150 pC) evolution during regular user operations for six months. Emittance of nearly uniform laser spatial (before February 9) and truncated-Gaussian profiles (after February 9).

IV. Summary

- LCLS running their copper cathode now with Gaussian temporal profile (3 ps) and truncated Gaussian spatial profile without loss in FEL power (“at least the same”)
- Temporal profile: laser system simplified → more reliable
- Transmission: lower requirements for cathode and laser system
- Emittance reduced by ~ 25%