# Beam Dynamics Simulation for the Upgraded PITZ Photo Injector applying various Photocathode Laser Pulses

- Update results
- Summery

Mahmoud Bakr
Simulation results
PITZ, 25.06.2015

HELMHOLTZ ASSOCIATION

DESY

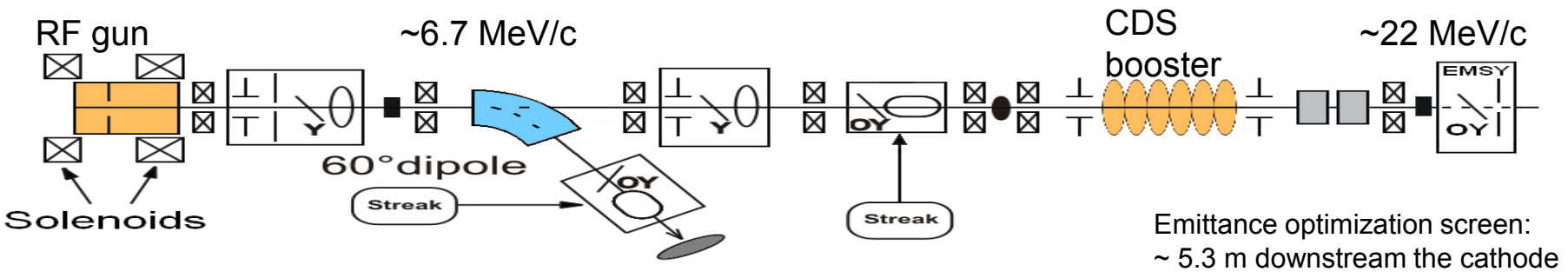
# Introduction

- **Motivation:** Answer the next question

  → Does the other charges (20 pC ~4 nC)?

- **Main idea:** The reduction of the emittance using 3D ellipsoidal laser compared to Flat top laser is not constant but depends on the charge?

PITZ setup used in the simulations



# ASTRA Simulation setup

Two different photo cathode laser shapes have been considered in beam simulations:

- Longitudinal distribution: Flattop. Transverse distribution: radial homogeneous
- Uniformly filled 3D ellipsoidal distribution

## Fixed parameters during emittance optimization

- Bunch charges: 20 pC ~ **4** nC,
- Electrons thermal kinetic energy at the cathode (0.55 eV),
- Gun gradient: 59.8 MV/m corresponding to Pz~6.7 MeV/c beam momentum after the gun
- CDS booster starting position: 2.73 m
- CDS booster gradient: 17.6 MV/m corresponding to Pz~22 MeV/c final beam momentum
- Reference point: EMSY1 (Z=5. 27 m) → best emittance for 2 profiles with the same bunch length

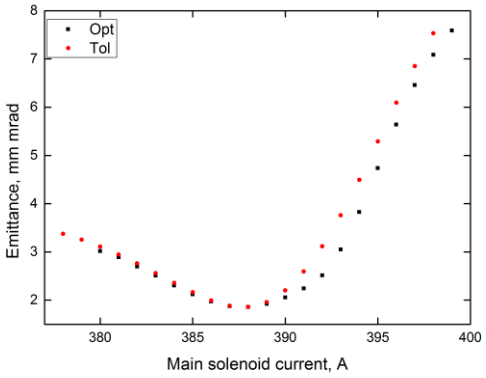
## The following parameters were optimized in the simulations:

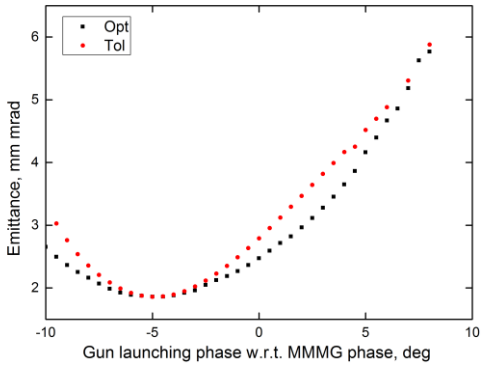
- Rms laser beam size,
- Gun Lunching phase,
- Solenoid current

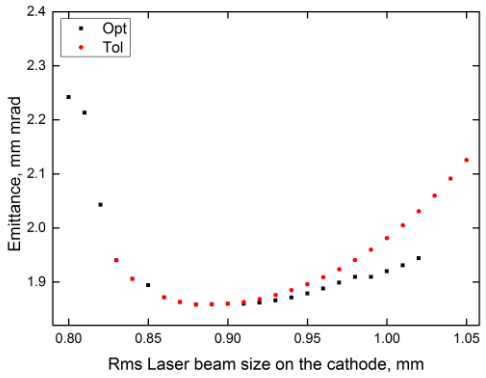
# Results for 4 nC

## flat-top laser

Opt. emittance 1.862

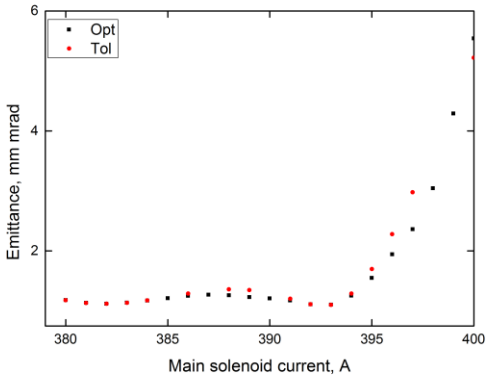


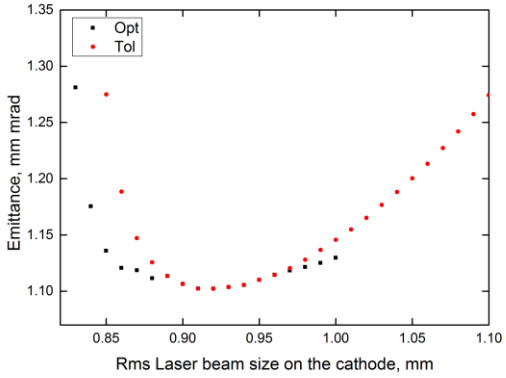



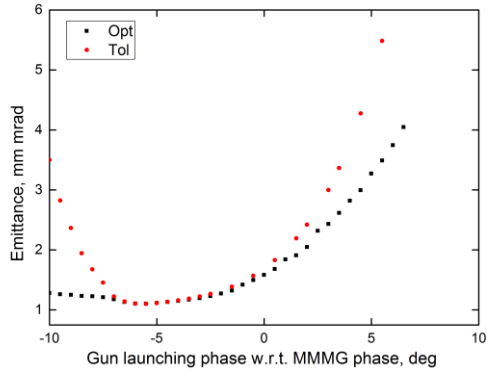




## 3D Ellipsoidal laser

Opt. emittance 1.1012



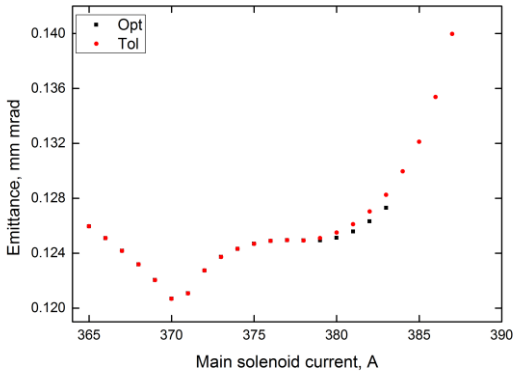



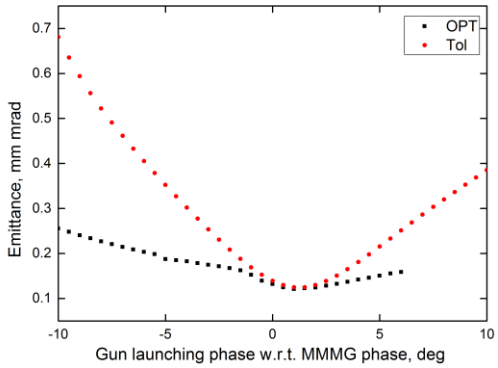



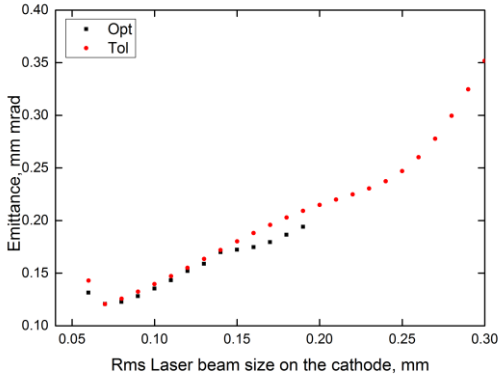
# Results for 50 pC

## flat-top laser

Opt. emittance 0.1249

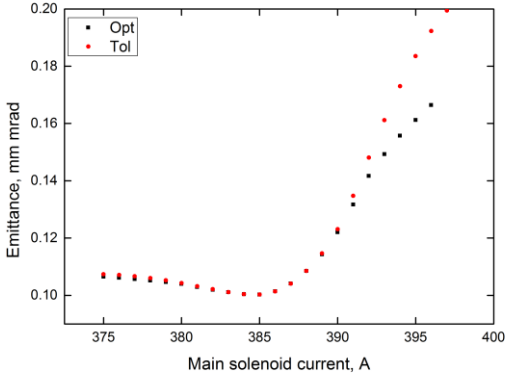


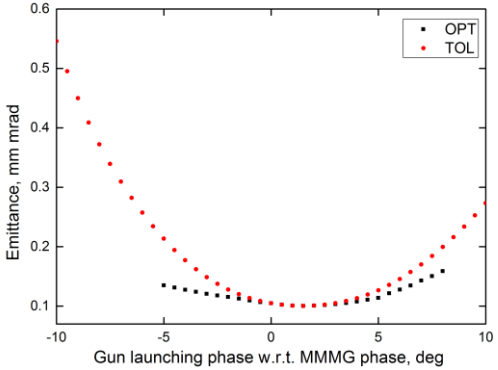



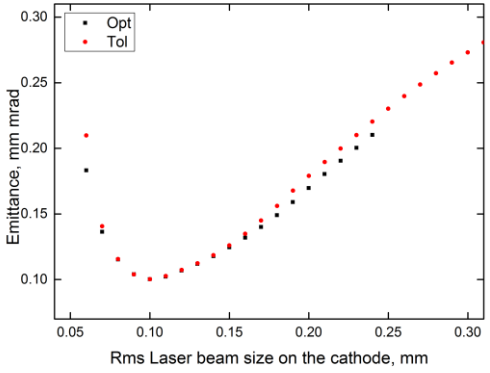




## 3D Ellipsoidal laser

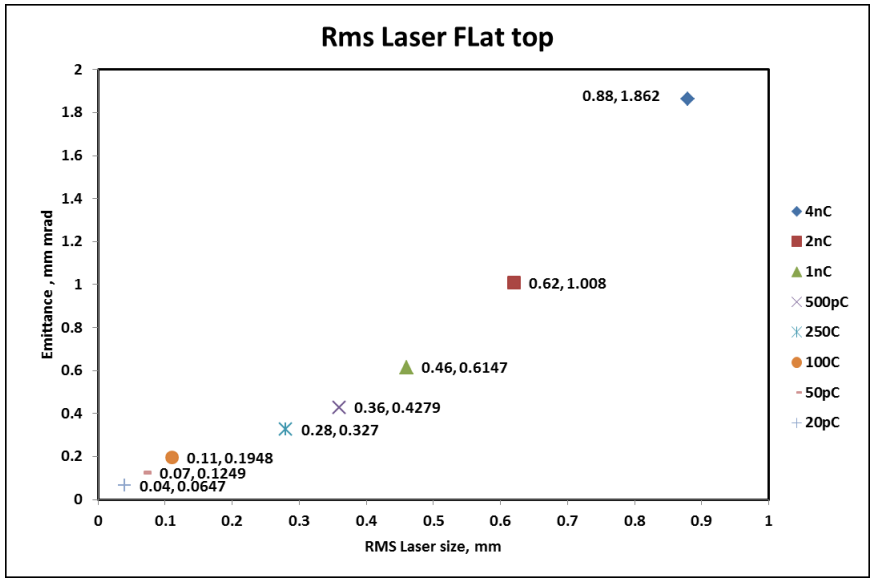
Opt. emittance 0.1001

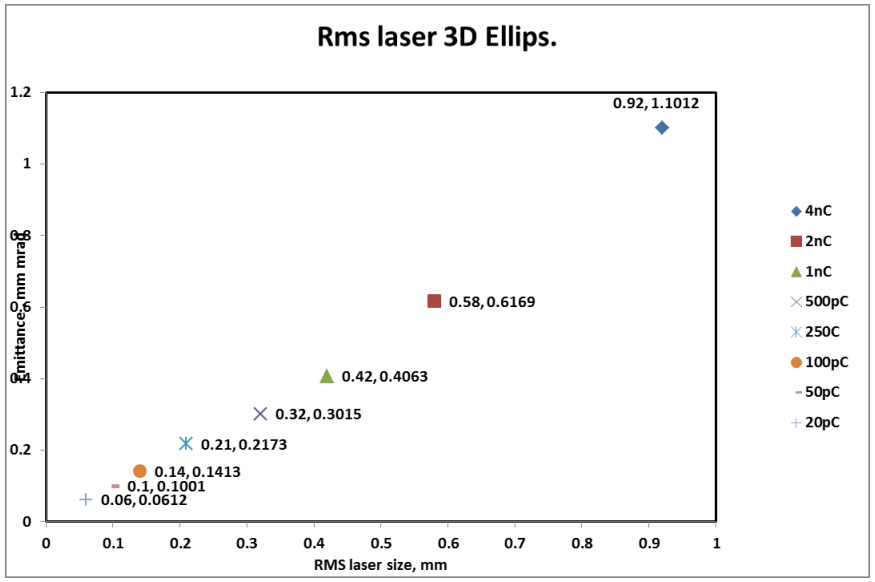


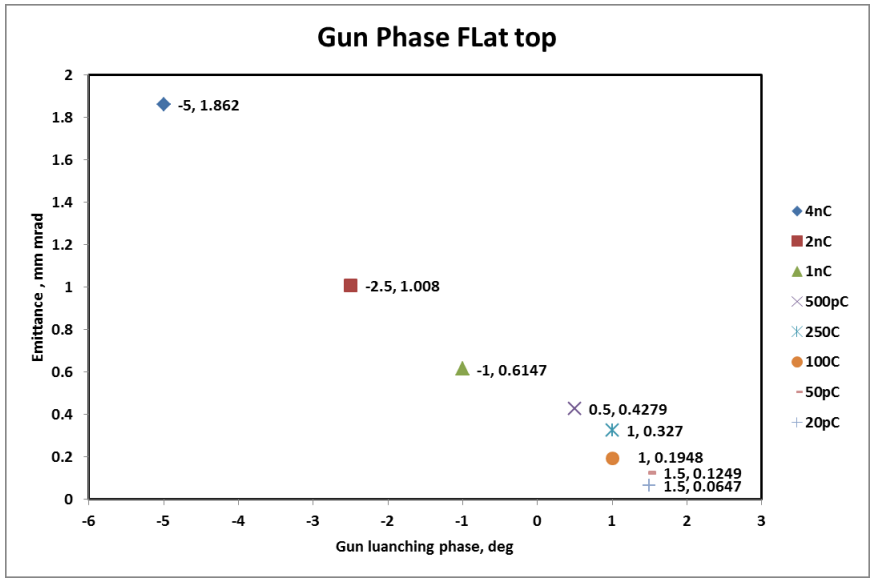



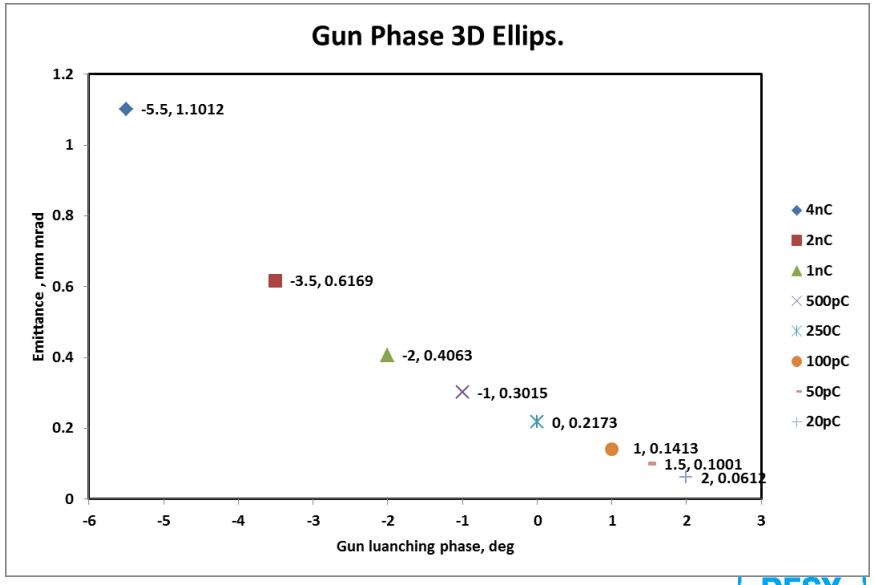



# General conclusions



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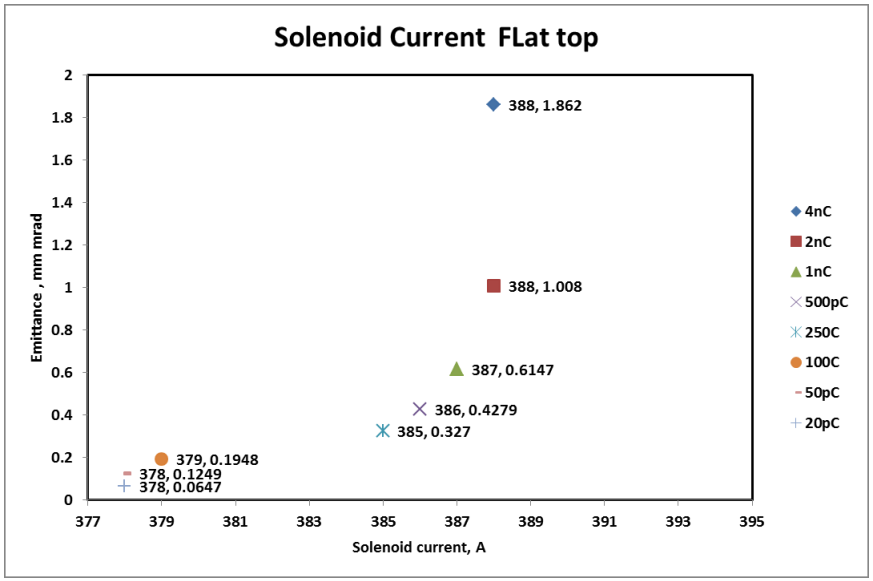
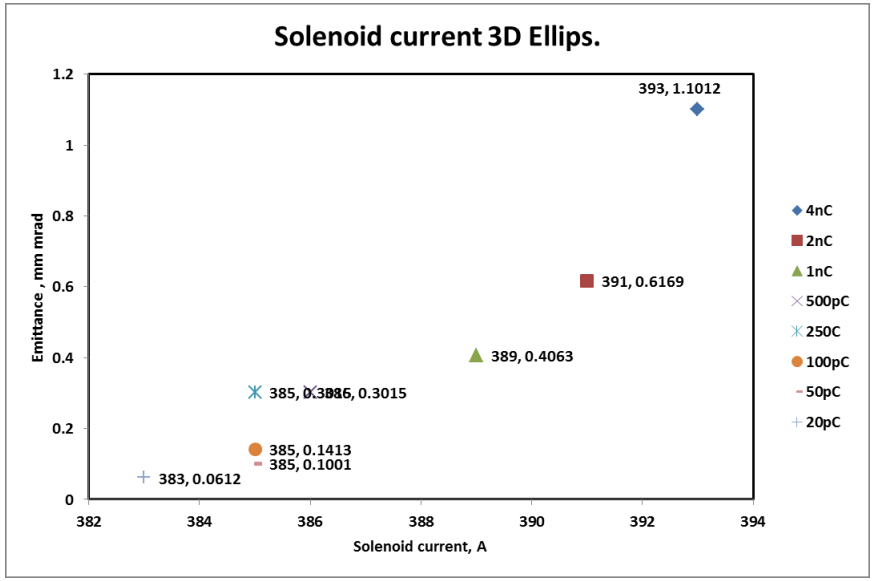
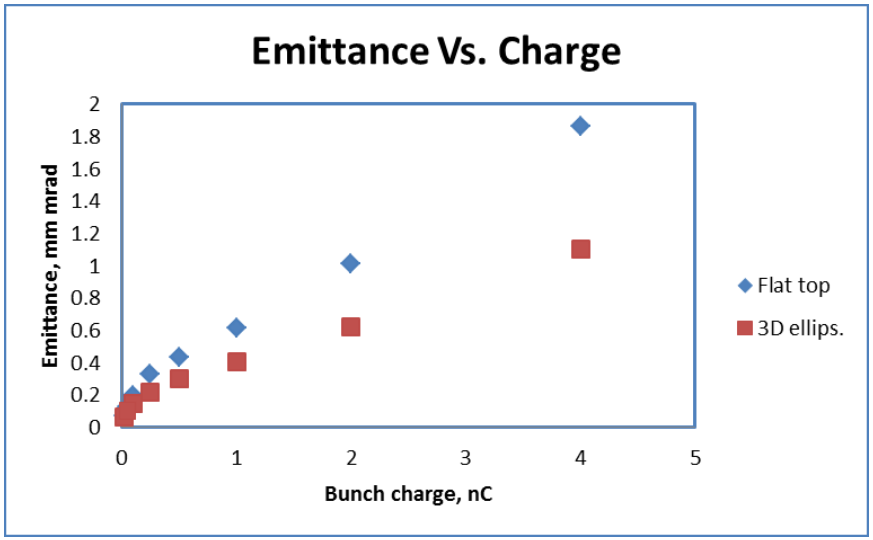
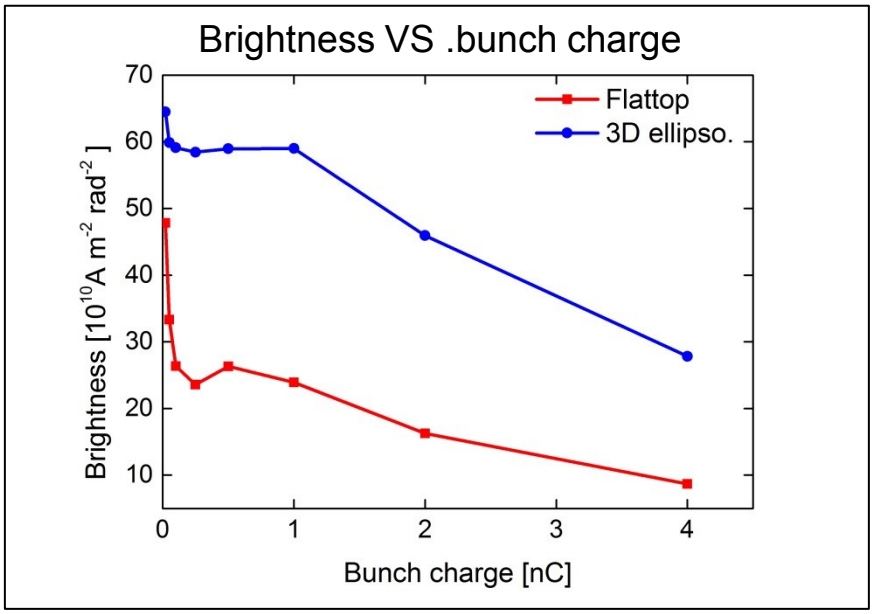


# Summery




| Charge nC | Flat top | 3D ellips. | Reduction |
|---|---|---|---|
| 4 | 1.862 | 1.1012 | 41% |
| 2 | 1.008 | 0.6169 | 39% |
| 1 | 0.6147 | 0.4063 | 34% |
| 0.5 | 0.4279 | 0.3015 | 30% |
| 0.25 | 0.327 | 0.2173 | 34% |
| 0.1 | 0.1948 | 0.1413 | 27% |
| 0.05 | 0.1249 | 0.1001 | 20% |
| 0.02 | 0.0647 | 0.0612 | 5% |




**Using 3D ellipsoidal laser profile leads 20 pC→ 4nC :**

**a. T. emittance for charges > 0.25 nC → 34-42% reduction**

**b. T. emittance for charges < 100 pC → 5-27 % reduction**

To be done soon:

1- Precise simulations for < 100 pC

2- FEL paper

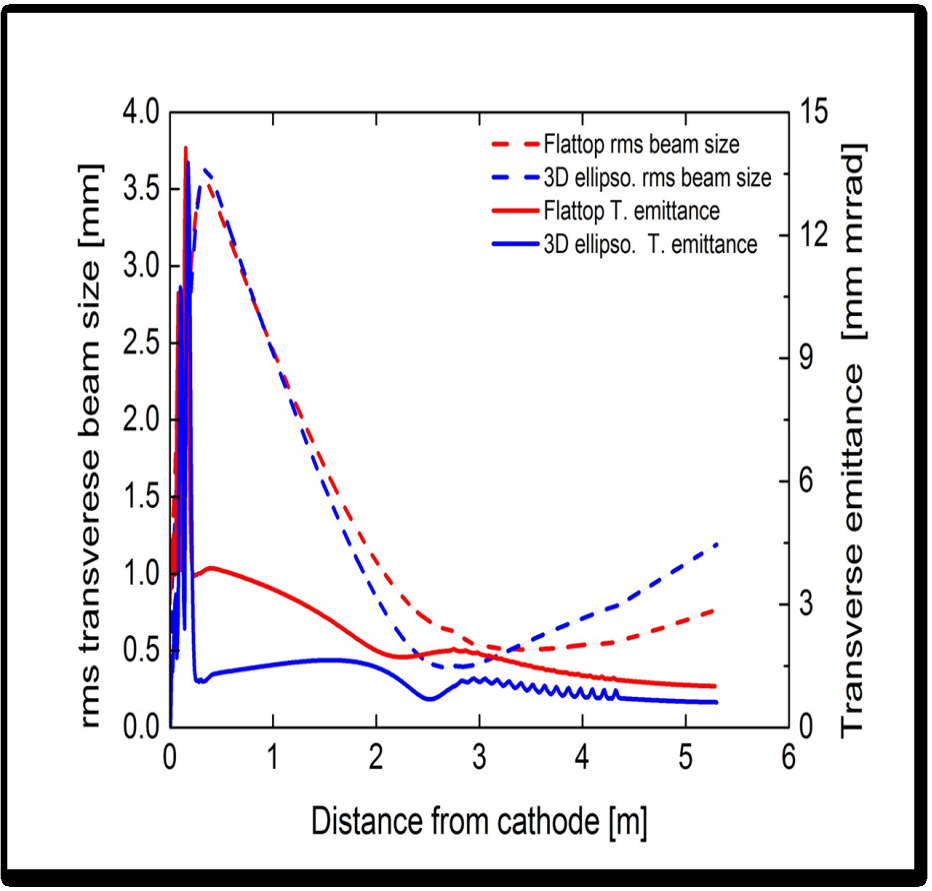
3- FEL poster

4- THz simulation during my staying in japan

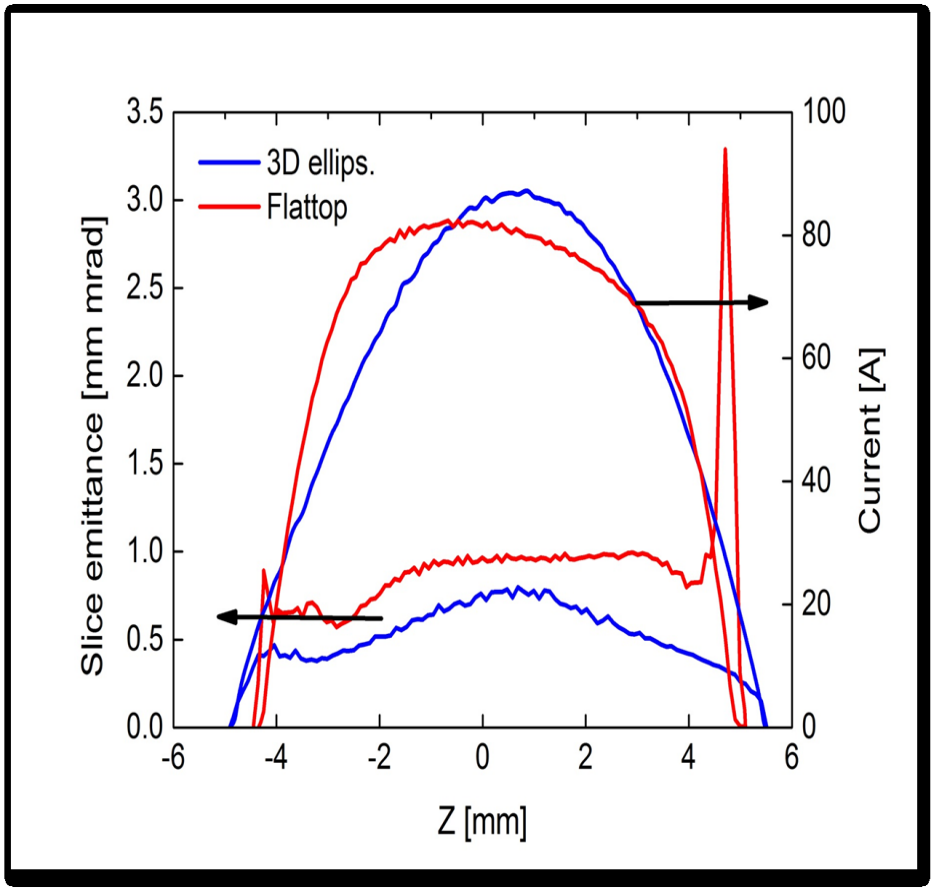
**Thanks**
**see you next year**

# Comparison for 2 nC

**Transverse projected rms emittance and rms beam size along the PITZ beamline at the emittance optimization screen.**




**Beam current and transverse emittance distribution in the bunch at the emittance optimization screen**



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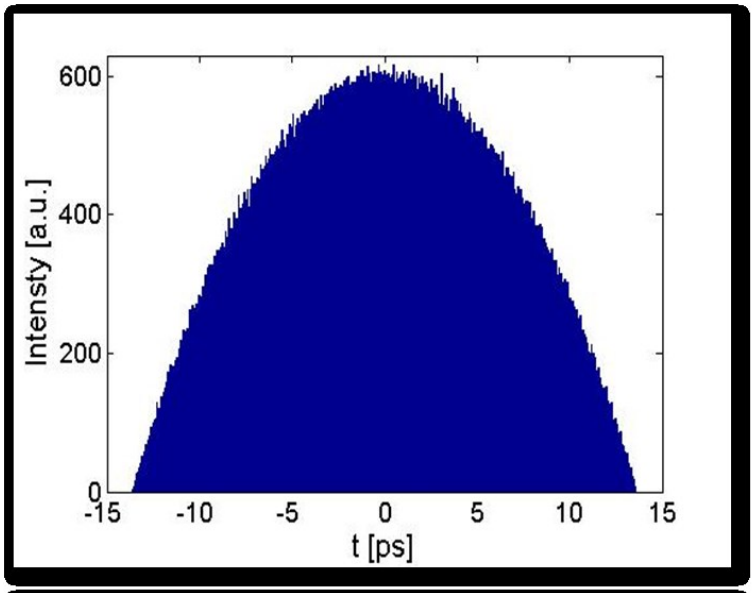
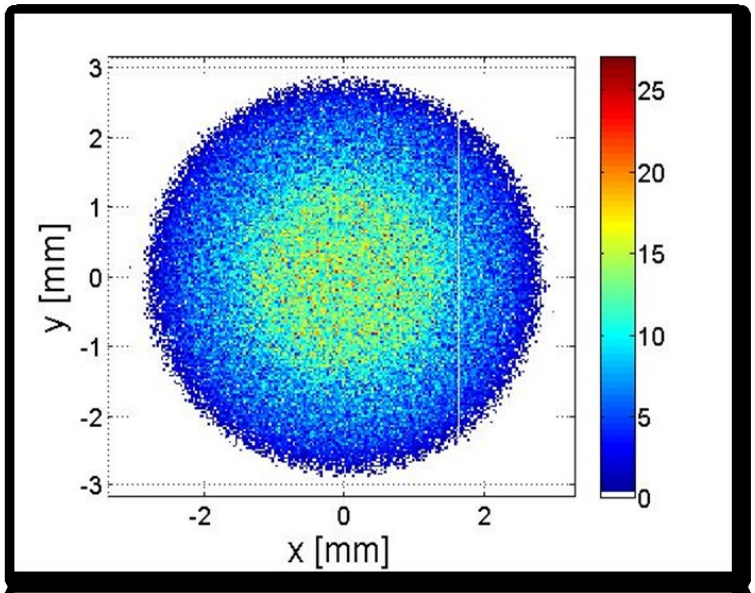
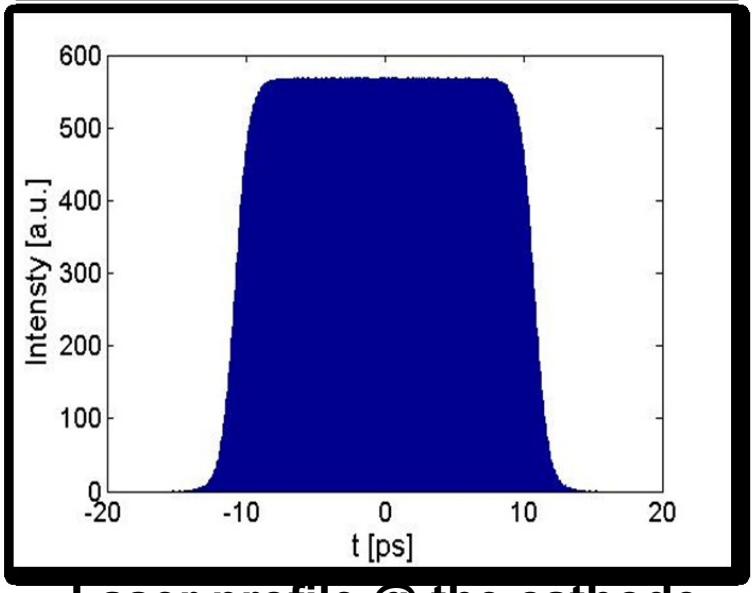
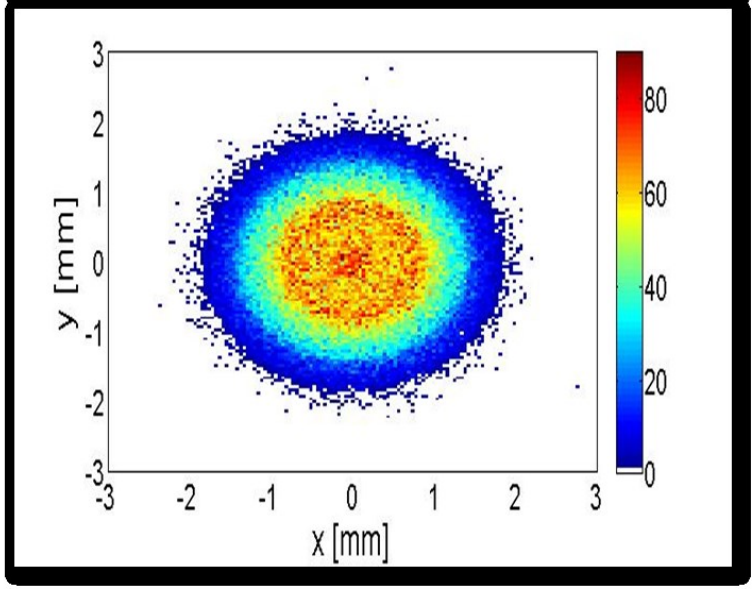


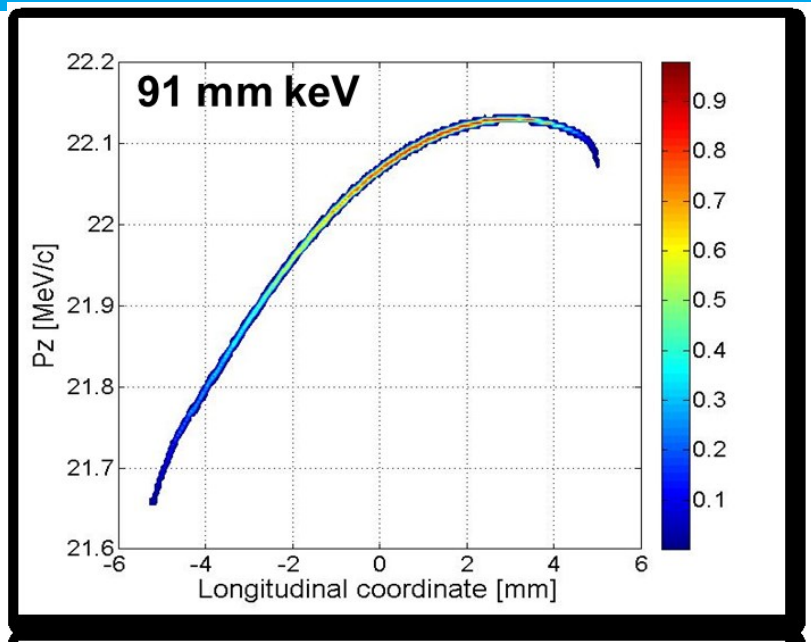



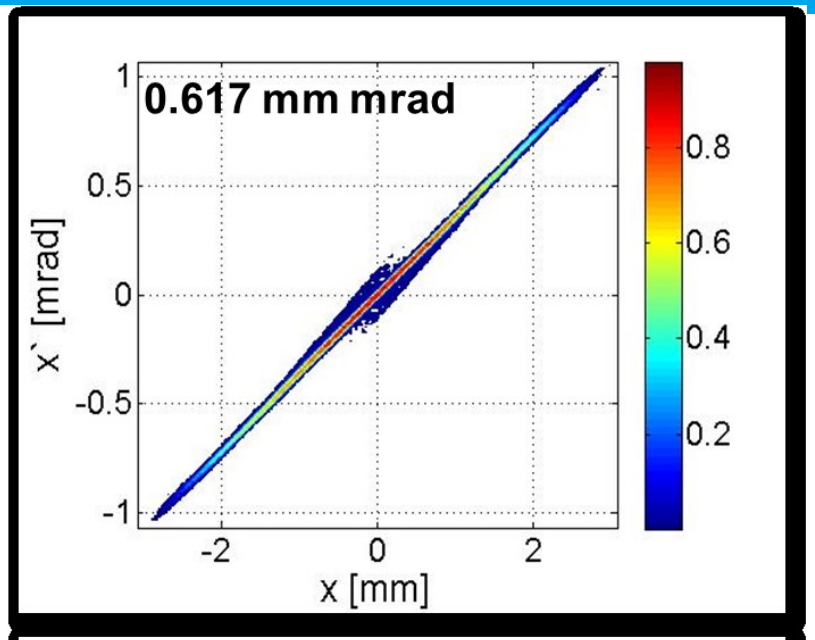



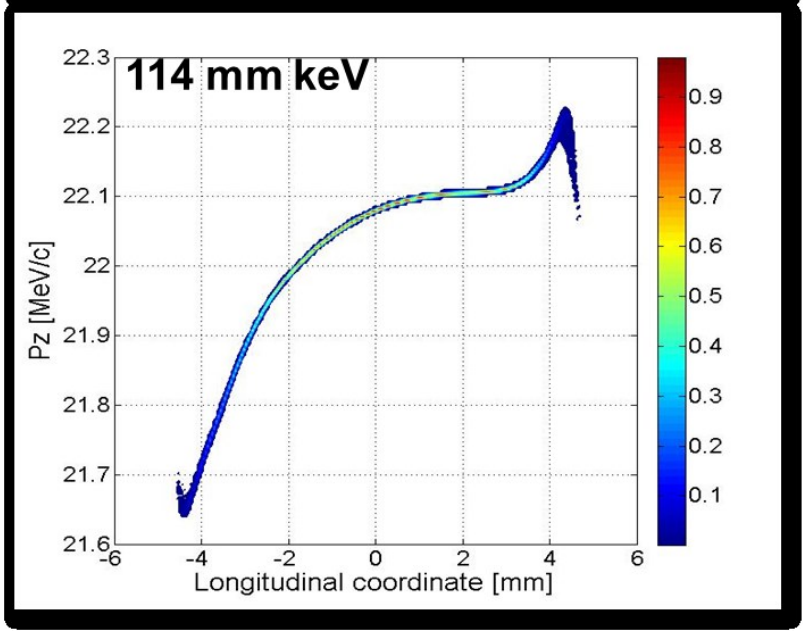



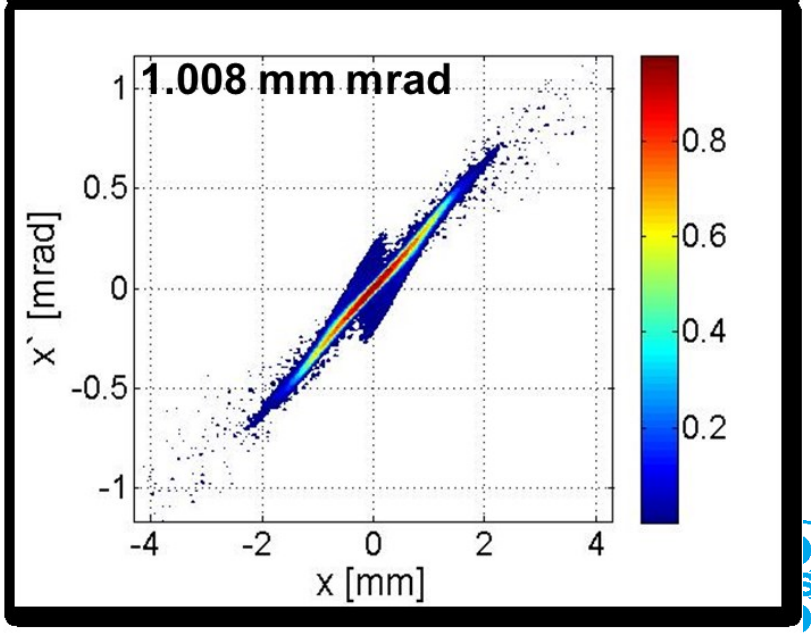

**Laser profile @ the cathode**

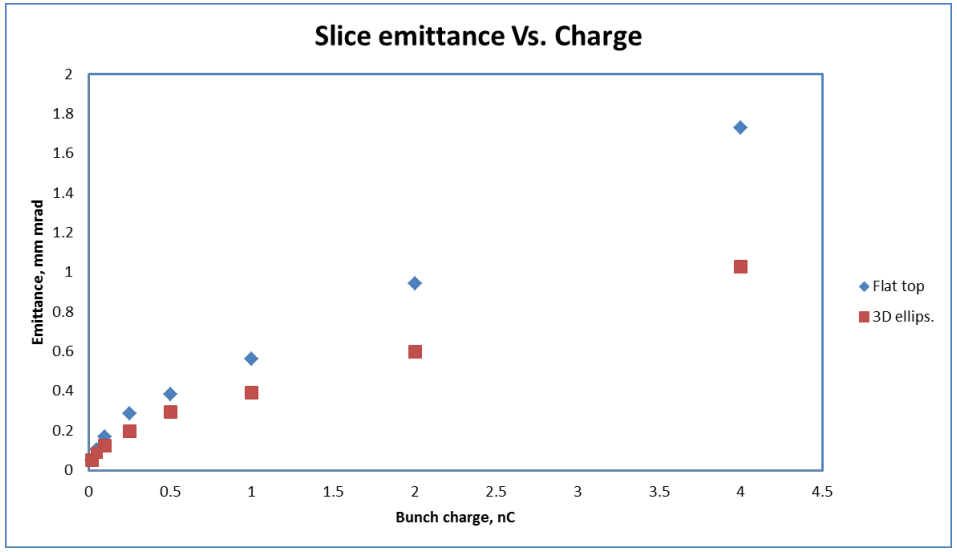
# Electron beam transverse and longitudinal phase spaces at EMSY for flattop and 3D ellipsoidal laser profiles.






| | | Bunch length mm | | |
|---|---|---|---|---|
| nC | Flattop | 3D ellipsoidal | | diffe |
| 4 | 2.454 | 2.461 | | 0.007 |
| 2 | 2.226 | 2.241 | | 0.015 |
| 1 | 2.02 | 2.041 | | 0.021 |
| 0.5 | 1.878 | 1.861 | | -0.017 |
| 0.25 | 1.788 | 1.8 | | 0.012 |
| 0.1 | 1.807 | 1.708 | | -0.099 |
| 0.05 | 1.763 | 1.671 | | -0.092 |
| 0.02 | 1.734 | 1.645 | | -0.089 |