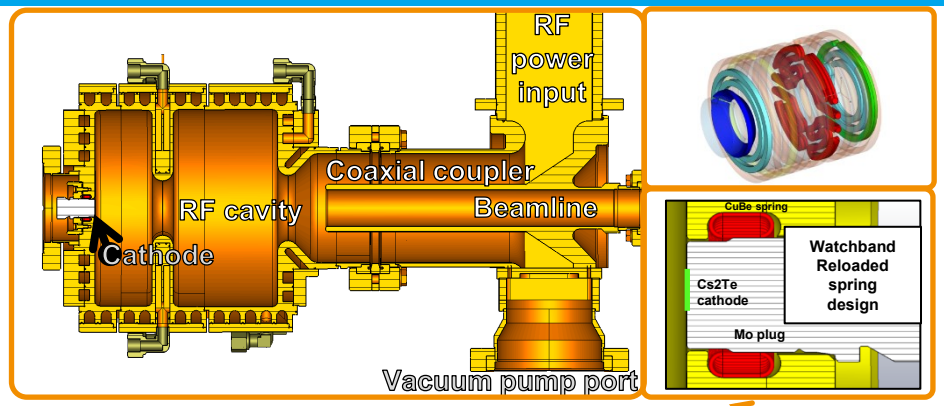
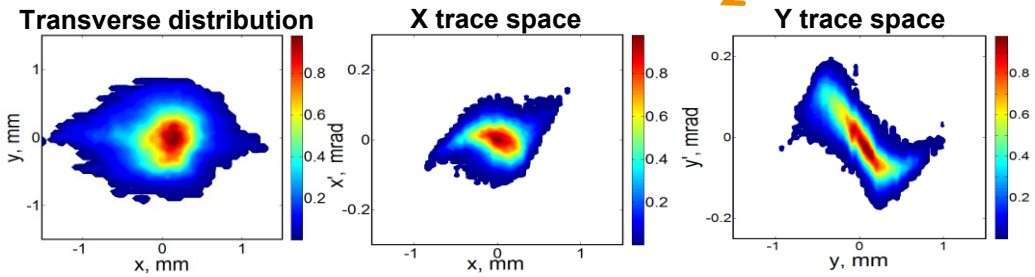
Photoelectron beam asymmetry studies at PITZ. Motivation and simulations.



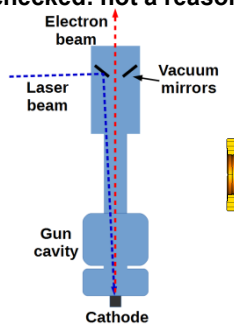
Parameter	Value
Max. accelerating gradient at the cathode, MV/m	**60**
Frequency, MHz	**1300**
Unloaded quality factor	~20000
Beam momentum after gun, MeV/c	7
RF peak power, MW	**6.5**
RF pulse duration, μs	**≤650**
Repetition rate, Hz	10

The photoelectron gun designed to be rotationally symmetric but the observed beam has azimuthal asymmetry:



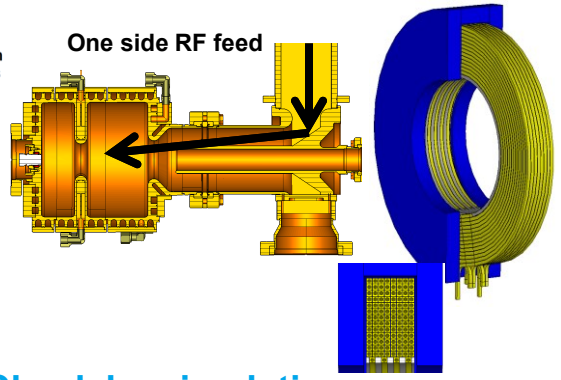
Possible origins of e-beam asymmetry

Vacuum mirror (checked: not a reason)



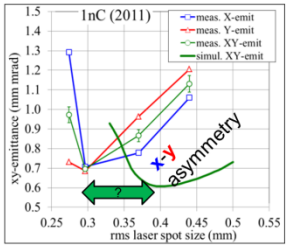
One side RF feed

Solenoid imperfections

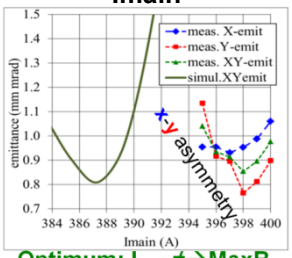


Also there was found that the simulated optimum machine parameters do not coincide with experimental data:

Emittance vs. laser XYrms

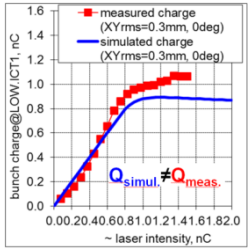


Emittance vs. Imain



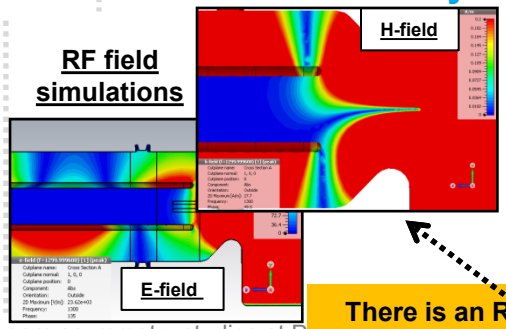
Optimum: $I_{main} \neq \rightarrow MaxB$

Bunch charge vs. laser energy

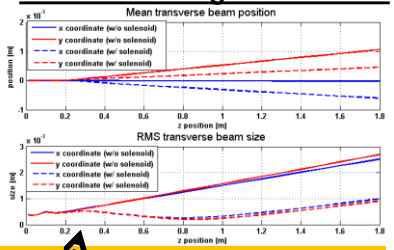


Check by simulations

RF field simulations



Particle tracking simulations:

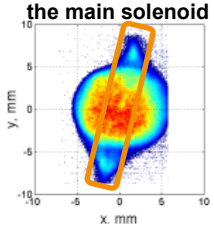


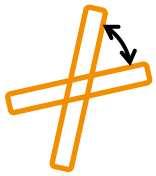
There is an RF field asymmetry and is has an influence on the beam

Gun quadrupoles

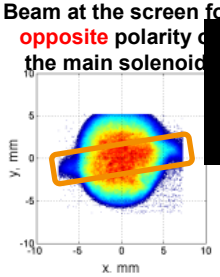
Experiment with two main solenoid polarities (Larmor angle experiment)

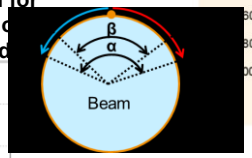
Beam at the screen for **normal** polarity of the main solenoid

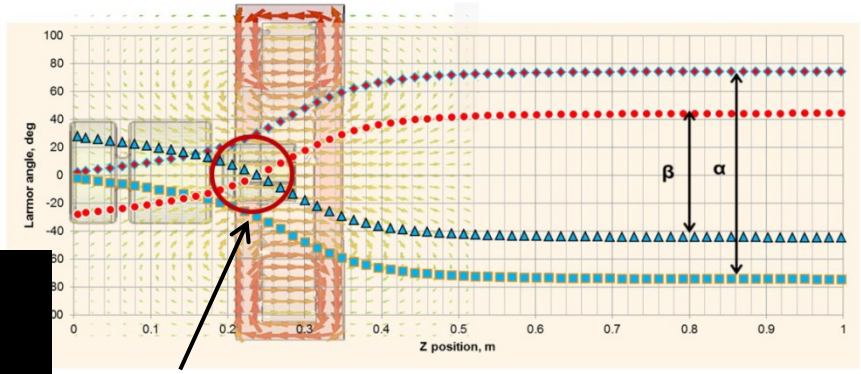




Beam at the screen for **opposite** polarity of the main solenoid







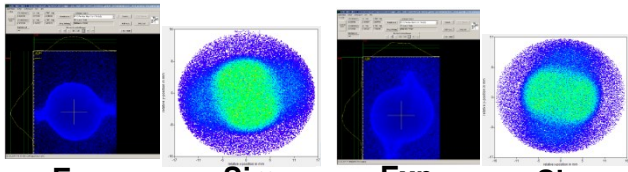
The most probable place of the beam asymmetry origin

α – beam Larmor angle without beam distortion
β – Larmor angle of the distorted beam

Beam shape simulations by a rotational quadrupole

1. the kick optics can be **modeled as a rotated quadrupole**
2. a rotated quadrupole near the coupler is effective at compensating for the kick, cancelling both the coupler emittance and the astigmatic focusing.

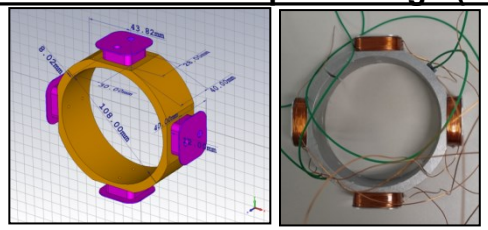
I main = -361A **I main = +361A**



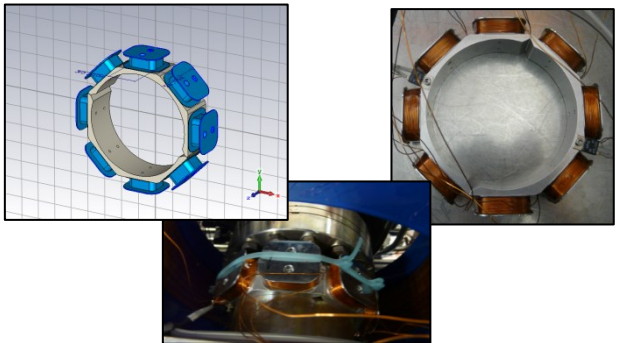
Exp. **Sim.** **Exp.** **Sim.**

Gun quad design

1st iteration of the quad design (4 coils)



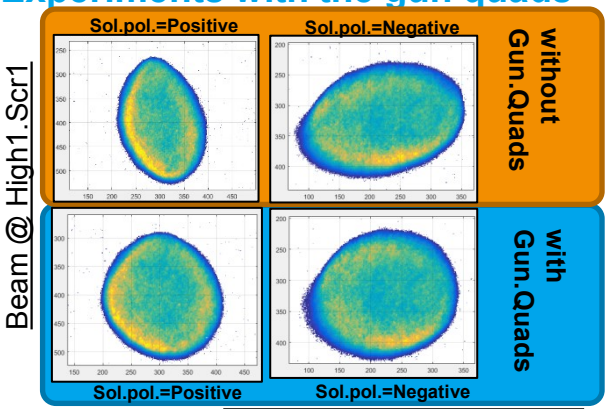
2nd design of the quad (8 coils)



Parameters of the 2nd quad design:

- **Combination of a normal and a skew quads:**
  - **Gun.Q1 is the normal quad**
  - **Gun.Q2 is the skew quad**
- **Aluminum frame**
- **0.56 mm copper cable**
- **140 windings per coil**
- **2 thermal switchers (80 degC max)**
- **Non-magnetic screws**
- **Fixed by radiation-hard cable tie**
- **Q_grad = 0.0117 T/m @ 1A**

Experiments with the gun quads



Emittance measurements with Gun Quads:
Gun Q1 = -0.6A
Gun.Q2 = -0.5A