**Photoelectron beam asymmetry studies at PITZ.**

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### Motivation

The PITZ facility experience with the RF photoinjector gun operation revealed new problems which have to be solved:

- Optimization of photoinjector parameters: experiments and simulations

- Beam asymmetry modeling by a rotational quadrupole

### Electromagnetic fields and particle tracking simulations

Airfield simulations for the full gun geometry (the gun cavity with an RF coupler) show that the field asymmetry at the gun exit is caused by the presence of the solenoid magnetic field. The asymmetry can propagate to the electron beam motion place through the transverse resonances of the bunching process.

Particle tracking simulations showed that the RF field asymmetry has an influence on the electron beam distribution.

### Beam asymmetry modeling by a rotational quadrupole

**Larmor angle experiment**

The rotation of the main solenoid polarity switcher allows to perform an experiment on the beam asymmetry. The Larmor angle experiment revealed the 2-pole position of the electron beam asymmetry source.

**Quadrupole modeling (Q. Zhao)**

Modeling by a rotational quadrupole:

- **Strategy**: Use rotational quadrupole model in ASTRA simulation by scanning the rotation angle and a set of different parameters in order to reproduce the beam asymmetry features.
- **Find the parameters for beam image at high1-Screen1**
- **20-D space change used in ASTRA simulation: c = +5A, f = 5A**

### Design of compensating quadrupoles for the gun

The transverse asymmetry of the beam can be reduced by a rotational quadrupole located after a gun to design and produce compensating gun quadrupoles.

**The first design (5 coils)**

- **Parameters**:
  - 1.5 m copper cable
  - 2 thermal switches (80 mm diameter)
  - 2 thermal switches (100 mm diameter)
  - Fixed by thin metal cable tie

**The second design (2 coils)**

- **Parameters**:
  - 2 m thermocable
  - 2 thermal switches (20 mm diameter)
  - Gun: 0.5 m separation of the gun and the first quadrupole

### Experiments with the gun quadrupole (with the 2nd design of the quadrupole)

**Transverse beam asymmetry compensation**

The usage of the normal and skew quadrupoles in combination allows to make much better beam transverse distribution.

**Beam angle at High1 Screen1**

- **Beam angle at High1 Screen1**
  - X (Beam direction) = ±0.2 mrad
  - Y (Beam direction) = ±0.3 mrad

**Experiment on beam #5 (θ = 0.5 mrad)**

The observed tilt of the beam in the X-Z plane is caused by the lesion quadrupole and can be compensated by either GQ1 or GQ2.

**Xrms values**

- Xrms before solenoid: 0.32 mm
  - Xrms after solenoid: 0.37 mm

**Xrms values**

- Xrms before solenoid: 0.32 mm
  - Xrms after solenoid: 0.37 mm

**Yrms values**

- Yrms before solenoid: 0.24 mm
  - Yrms after solenoid: 0.30 mm

**Pitch values**

- Pitch before solenoid: 0.27 mrad
  - Pitch after solenoid: 0.38 mrad

**Roll values**

- Roll before solenoid: 0.27 mrad
  - Roll after solenoid: 0.38 mrad

### Other experiments

- **Experiment on the main solenoid**
  - The idea is to check whether the beam stage depends on the main solenoid polarity.

- **Experiment on the main solenoid (in)***
  - The idea is to check whether the beam stage depends on the main solenoid polarity.

- **Experiment on the main solenoid (out)**
  - The idea is to check whether the beam stage depends on the main solenoid polarity.

### Possible origins of e-beam asymmetry

- A) Incorrect input parameters between Horizontal (1 mm) and vertical (2 mm) separations
- B) RF coupler field asymmetry
- C) Solenoid misalignment