Electron beam asymmetry compensation with gun quadrupoles at PITZ.


Abstract

The electron beam asymmetry observed at the Photo Injector Test Facility at DESY in Zeuthen (PITZ) was traced back to multiple kicks in the gun section, namely around the location of the coastal power coupler and the main solenoid. Several dedicated studies have been performed to quantify the kick location and strength. Based on these studies, two designs of compensating quadrupole coils were proposed. The coils were fabricated and tested with an electron beam. The second updated design implies a twin quadrupole setup on the same frame nested around the gun coastal coupler close to the main solenoid centre location. Skew and normal quadrupole magnets are powered independently, enabling the flexibility in electron beam manipulations. By means of this setup, a symmetric beam is achieved, and an electron beam with low asymmetry is measured. Simulation results show that measured horizontal and vertical phase-space and to even simulate overall emittance values. Some details of the gun quadrupole designs, magnetic measurements, and results of electron beam measurements including emittance optimization will be reported.

Motivation: asymmetric electron beam in a rotationally symmetric RF-gun:

- Beam-symmetric
- RF coupler field asymmetry → post- WEP02, Y. Chen et al. "Coastal Coupler RF Kick in the PIZT RF Gun"
- Solenoid imperfections (anomalous quadrupole fields) → post- WEP01, Q. Zhao "Beam Asymmetry Studies with Quadrupole Field Errors in the PIZT Gun Section"

Possible sources of the beam asymmetry:

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Design of compensating gun quadrupoles

1st Design (4 coils)

Parameters:
- Aluminum frame
- 0.56 mm copper cable
- 180 windings per coil
- 2 thermal switches (80 deg C max)
- Non-magnetic screws
- Fixed by radiation-hard cable tie
- Use with 3A power supply
- Q, grad = 0.0207 Tm @ 1A

2nd Design (8 coils)

Parameters:
- Combination of a normal (Gun.Quad1) and a skew (Gun.Quad2) quads
- Aluminum frame
- 0.56 mm copper cable
- 140 windings per coil
- 2 thermal switches (80 deg C max)
- Non-magnetic screws
- Fixed by radiation-hard cable tie
- Q, grad = 0.0117 Tm @ 1A

Photo Injector Test facility at DESY, Zeuthen site (PITZ)

"Larmor angle" Experiment

Main idea: Test beam electron beam asymmetry was observed at high1.Scr2 for beam asymmetry studies, sources and operation of trapped beam.

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First tests with electron beam

Machine parameters:
- \( P_{\text{peak}} = 6.6 \text{MW}, \ \text{MMRM} \rightarrow P_{\text{peak}} = 6.5 \text{MeV} / c \)
- \( P_{\text{peak}} = 2 \text{MW} = 22.5 \text{MeV} / c \)
- Photocathode laser (11.5ps FWHM, \( 0.3 \text{mm} \))
- Bunch charge - 0.5 nC

Electron beam measurements without gun quadrupoles \( f_{\text{rms}} = 3.1 \text{mm}, \ f_{\text{rms}} = 3.6 \text{mm} \)

Electron beam measurements with gun quadrupoles \( f_{\text{rms}} = 2.3 \text{mm}, \ f_{\text{rms}} = 0.5 \text{mrad} \)