Beam tilt studies at FLASH

FEL studies – Autumn 2007
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Overview of the measurements

BEAM TILT MEASUREMENTS (23-10-07 & 28-10-07)
A vertical offset through ACC1 (running off-crest) tilts the beam at BC2 and generates an emittance increase.
Using the gun steerers, we generated different vertical bumps at BPM9ACC1. For each bump we measured:
- Dispersion from ACC1
- Beam tilt at BC2 \(\rightarrow\) using SR camera
- Emittance at DBC2 \(\rightarrow\) using 4 OTR stations at DBC2

C-SHAPE MEASUREMENTS (28-10-07 & 29-10-07)
Running ACC1 on-crest, beam at BC2 can have a C-shape (for some optics and gun phase)
We have analyzed the C-shape for different iris & mirror positions and as a function of the orbit

Complementary measurements
- Orbit response for gun steerers (23 & 28-10-07)
- Beam energy and energy spread after the gun (29-10-07)

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Orbit response measurements
23-10-07

- Wrong calibration sign of BPM9ACC1 (changed)
- Wrong calibration constant of BPM1/2UBC2 (changed)
- Wrong polarity of V3GUN (changed)
Orbit response measurements
28-10-07

After the changes →~ good agreement 😊 ✔️
Beam tilt measurements – 28-10-2007

Beam tilt


Beam tilt for no bump is not zero
(For no bump, orbit at BM9ACC1 was -2.8mm)
Beam tilt measurements – 28-10-2007
Emittance at DBC2 (90% values)

Emittance is not minimum for no bump
(For no bump, orbit at BM9ACC1 was -2.8mm)
Beam tilt simulations

Steerer currents of the measurements for V1/2/3GUN (& bump artificially closed)

Parameters of initial distribution:
- Emittance = 1.3 μm
- Momentum chirp = -4%
- Bunch Length = 1.7 mm,
- Energy spread = 0.4%

10^5 particles
Wakes included (structure and coupler)
0.62 nC
9 degrees off crest at ACC1
Optics of the measurements
Beam tilt simulations
Basic case (zero bump = zero orbit, no wakes)

No bump corresponds to no tilt and to optimum emittance

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Initial orbit misalignment of 3.5mm reproduces the initial orbit at BPM9ACC1 (-2.8mm)
Beam tilt
Measurements vs simulations

Beam tilt: if some initial offset → good agreement
Emittance: qualitative good agreement
Beam tilt: Dispersion from ACC1
Measurements and simulations

MEASURED VERTICAL DISPERSION

SIMULATED VERTICAL DISPERSION

MEASURED HORIZONTAL DISPERSION
Comparison between measured and simulated dispersion for each bump

Good agreement 😊

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C-shape simulations: a possible source
Energy chirp coming from the gun + vertical dispersion

Initial kick of 20mrad compensated with V2/3GUN, E=4.5MeV
energy chirp=6%
wakes included

What can generate such a kick? **Solenoid** misalignment?
Simulations of the C-shape Moving ACC1 phase

+ 2 degrees

- 2 degrees

Same effect observed in measurements
C-shape measurements

After adjusting gun phase and optics …

… C-shape is there
Moving ACC1 phase

- Same effect observed during measurements before the shutdown
- Same effect predicted by simulations

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Pseudo solenoid misalignment

Moving both iris and mirror positions the beam is misaligned respect to the gun.
Moving vertically

↑0.85mm

2007-10-29T124226-C-SHAPE-MIRIS-up085.mat

↓0.60 mm

2007-10-29T122445-C-SHAPE-MIRIS-down06.mat

↓1.80 mm

2007-10-29T122739-C-SHAPE-MIRIS-down18.mat

C-shape does not change significantly when moving up and down

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Moving horizontally

Movement to the right enhances C-shape

\[ \rightarrow 2.00\text{mm} \]

\[ \rightarrow 0.88\text{mm} \]

Movement to the left reduces the effect

\[ \leftarrow 0.83\text{mm} \]

\[ \leftarrow 0.83\text{mm} \]
Correcting the orbit without moving iris and mirror has a similar impact to the C-shape as moving iris and mirror.
Summary

- Good agreement between model and measured orbit response for gun steerers
- **Beam tilt:**
  - Measurements of beam tilt, emittance and dispersion are in a good agreement with simulations.
  - Initial conditions (without gun steering) were not optimal.
- **C-shape:**
  - Correcting the orbit has a similar effect as moving iris and mirror positions.
  - Vertical dispersion created upstream ACC1 would generate the C-shape (simulated and ~ confirmed by measurements)

Next steps

- Analyze beam energy measurement
- Do more precise simulations (using initial distribution from ASTRA, using same way to determine beam tilt for measurements and simulations, etc.)