Beam tilt studies at FLASH

FEL studies – Autumn 2007
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FEL Beam Dynamics Meeting
19th of November of 2007, Hamburg

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Overview of the measurements

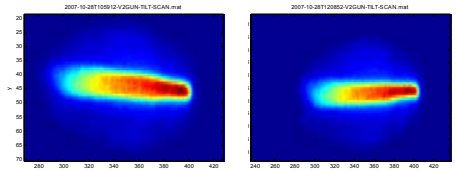
BEAM TILT MEASUREMENTS (23-10-07 & 28-10-07)

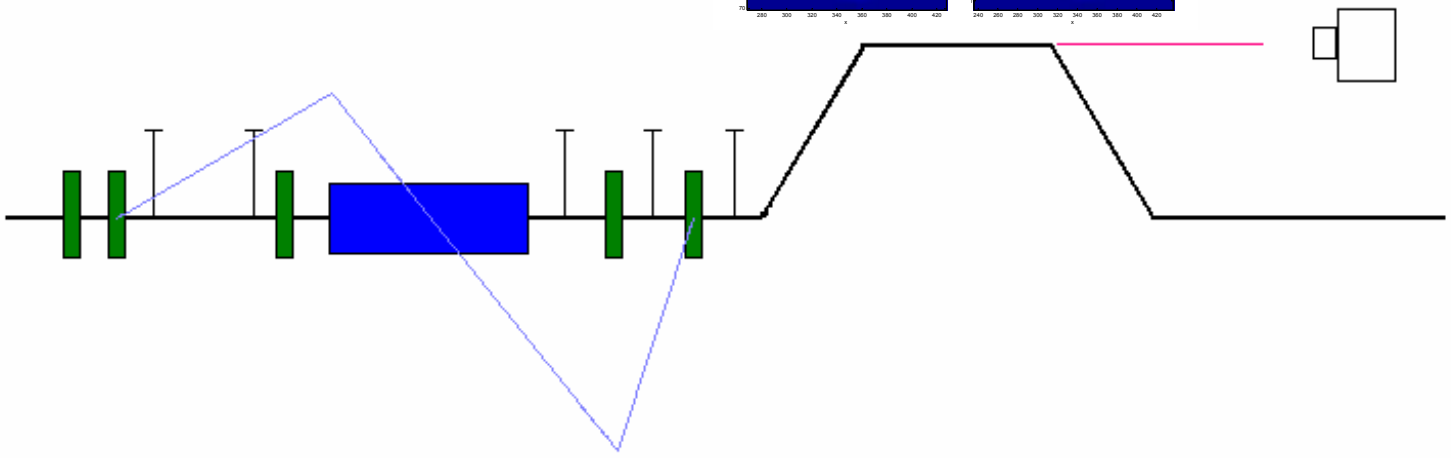
A vertical offset through ACC1 (running off-crest) tilts the beam at BC2 and generates an emittance increase.
Using the gun steerers, we generated different vertical bumps at BPM9ACC1. For each bump we measured:

-Dispersion from ACC1

-Beam tilt at BC2 → using SR camera

-Emittance at DBC2 → using 4 OTR stations at DBC2



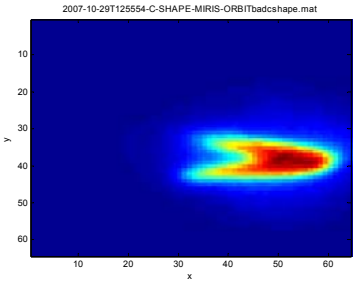


C-SHAPE MEASUREMENTS (28-10-07 & 29-10-07)

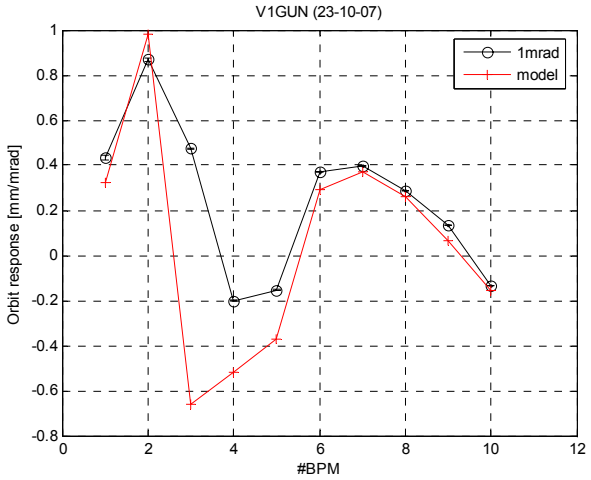
Running ACC1 on-crest, beam at BC2 can have a C-shape (for some optics and gun phase)
We have analyzed the C-shape for different iris & mirror positions and as a function of the orbit

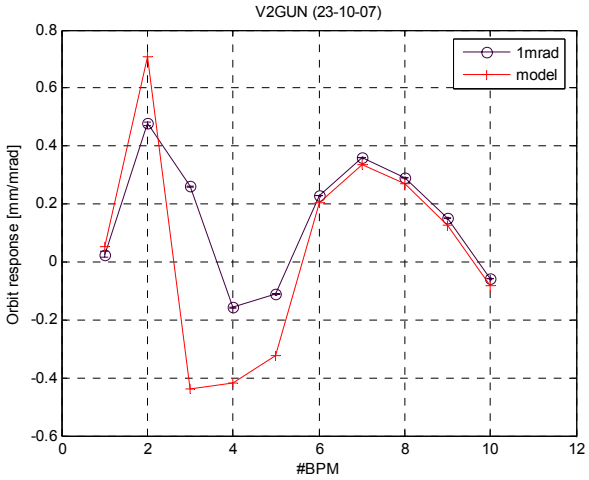
Complementary measurements

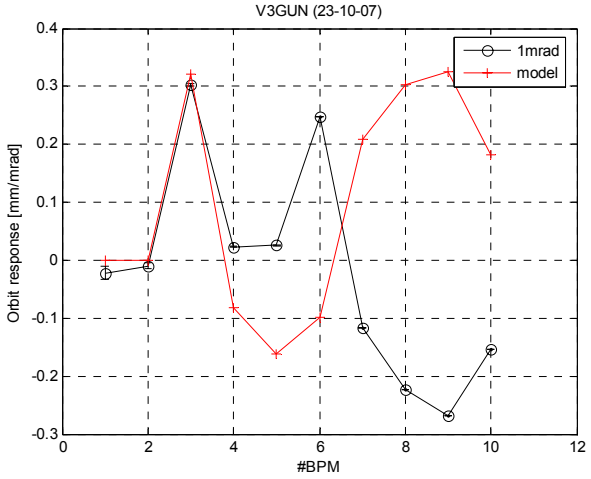
- Orbit response for gun steerers (23 & 28-10-07)
- Beam energy and energy spread after the gun (29-10-07)



Orbit response measurements 23-10-07

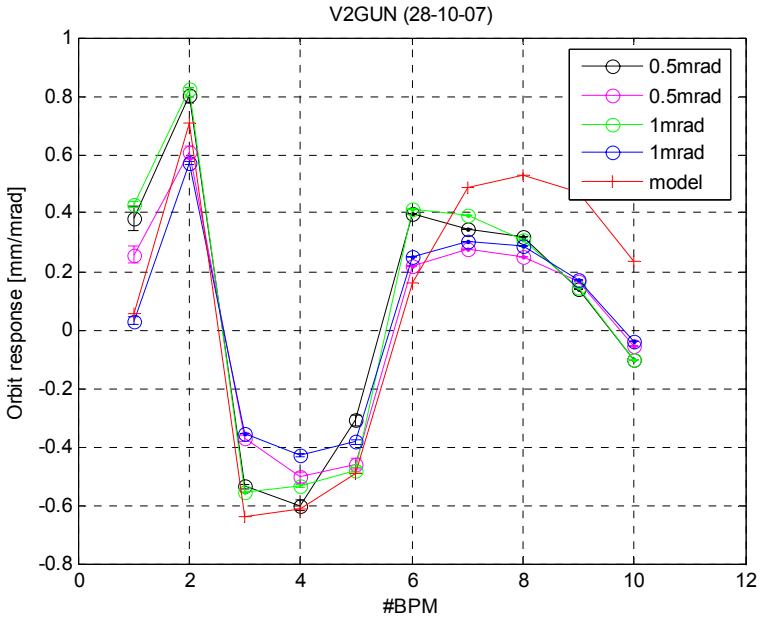


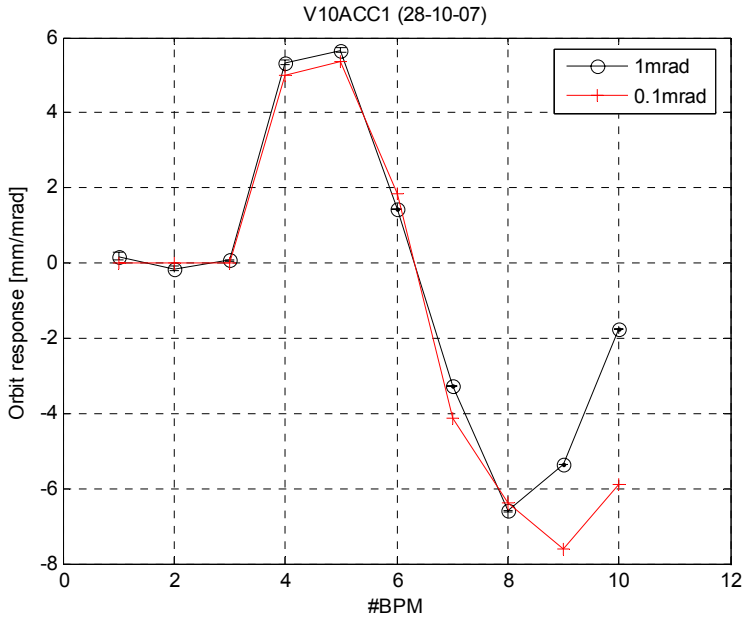




- Wrong calibration sign of BPM9ACC1 (changed)
- Wrong calibration constant of BPM1/2UBC2 (changed)
- Wrong polarity of V3GUN (changed)

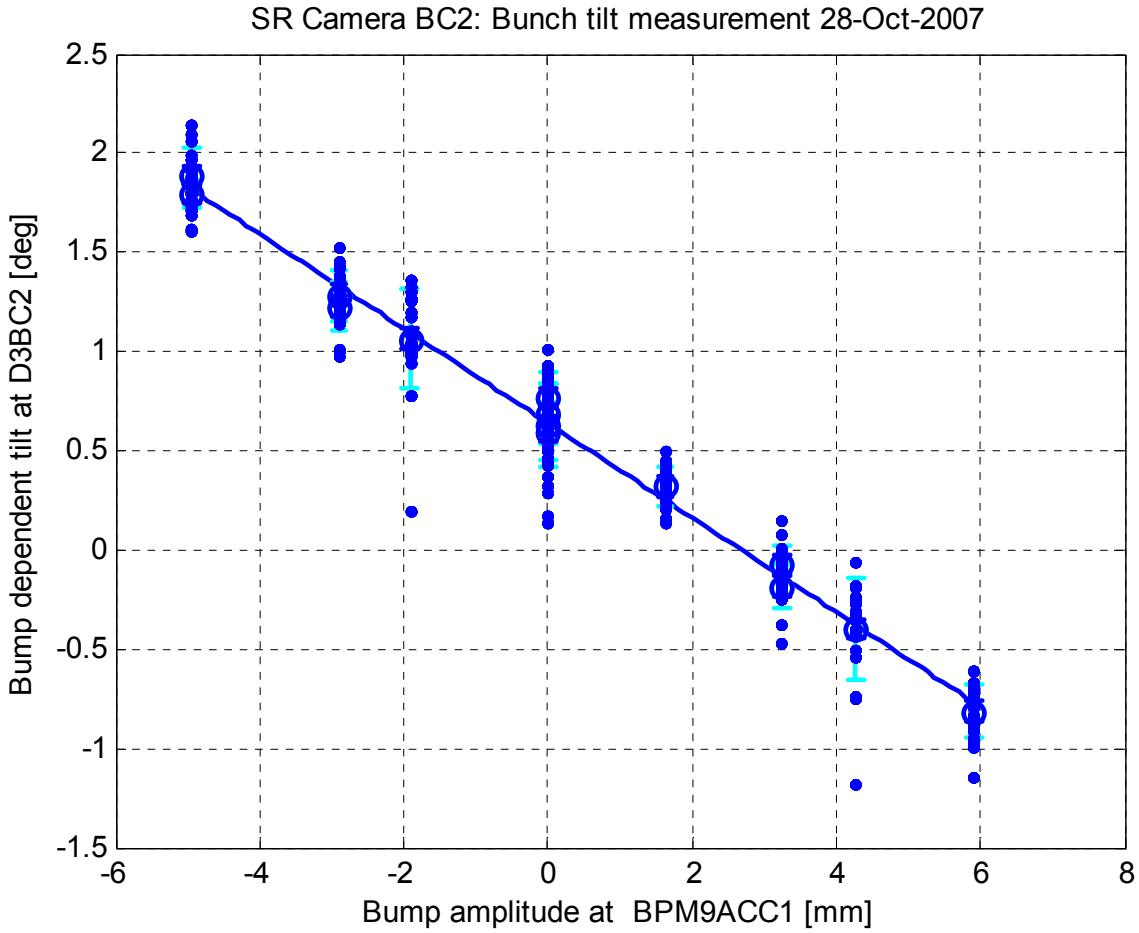
Orbit response measurements 28-10-07

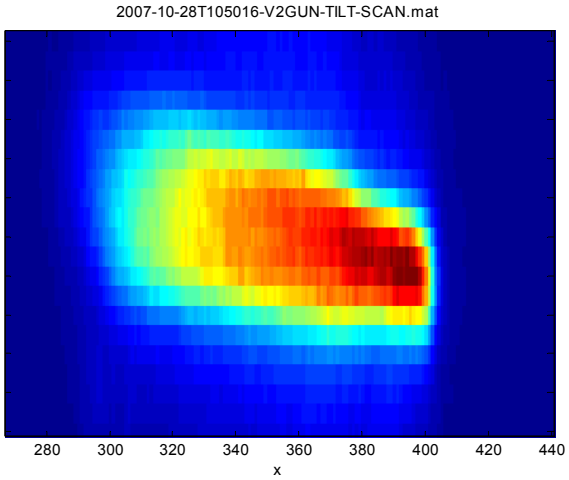




After the changes →~ good agreement ☺ ✓

Beam tilt measurements – 28-10-2007
Beam tilt

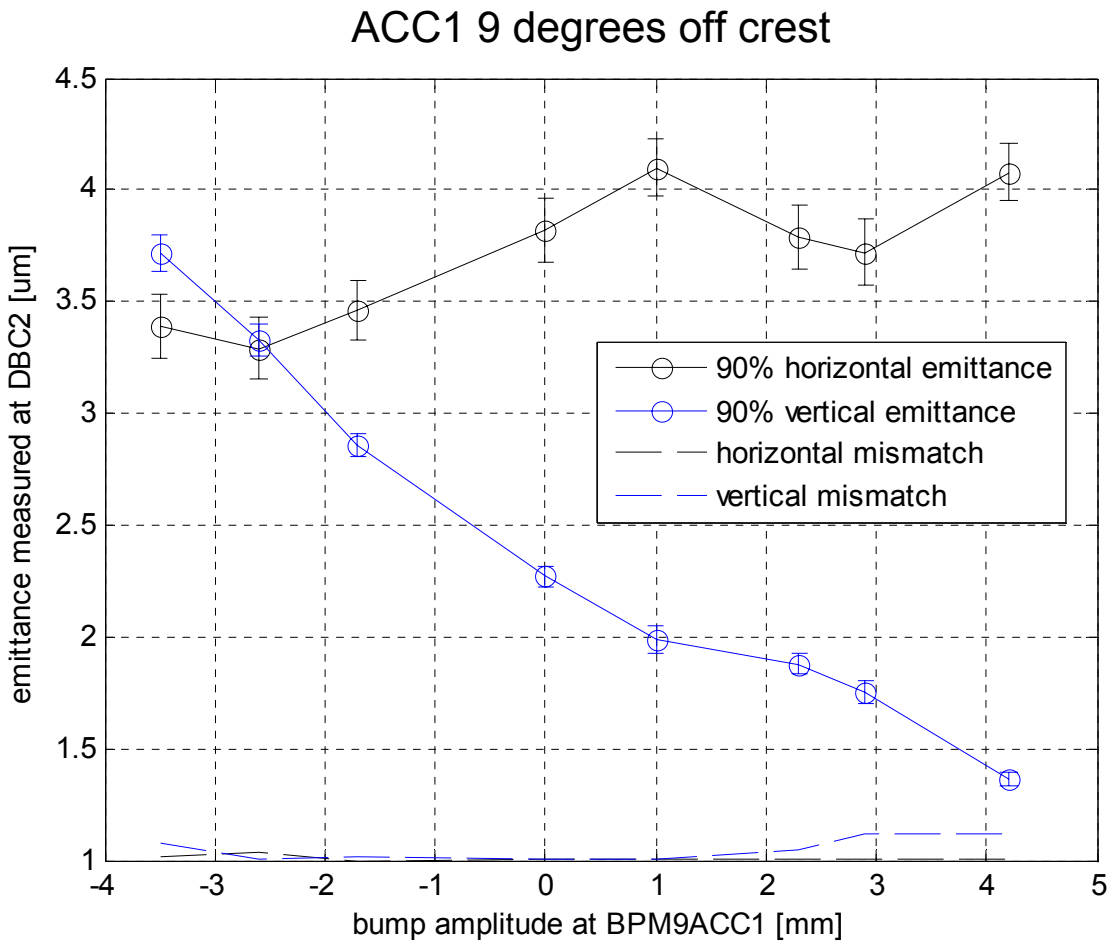




Beam tilt for no bump is not zero

(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

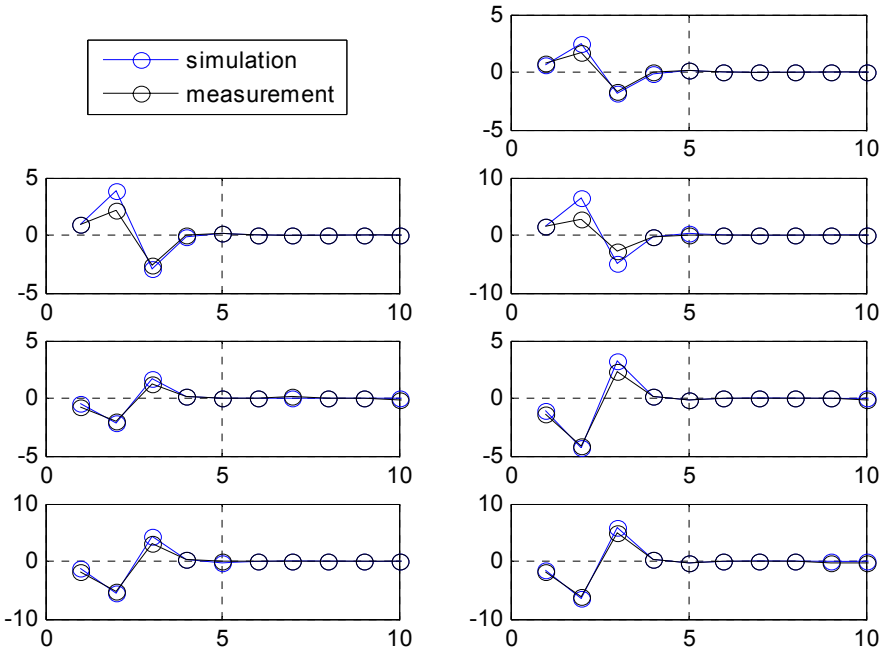
Steerer currents of the measurements for V1/2/3GUN (& bump artificially closed)

Parameters of initial distribution:

- Emittance=1.3μm
- Momentum chirp = -4%
- Bunch Length=1.7mm,
- Energy spread = 0.4%

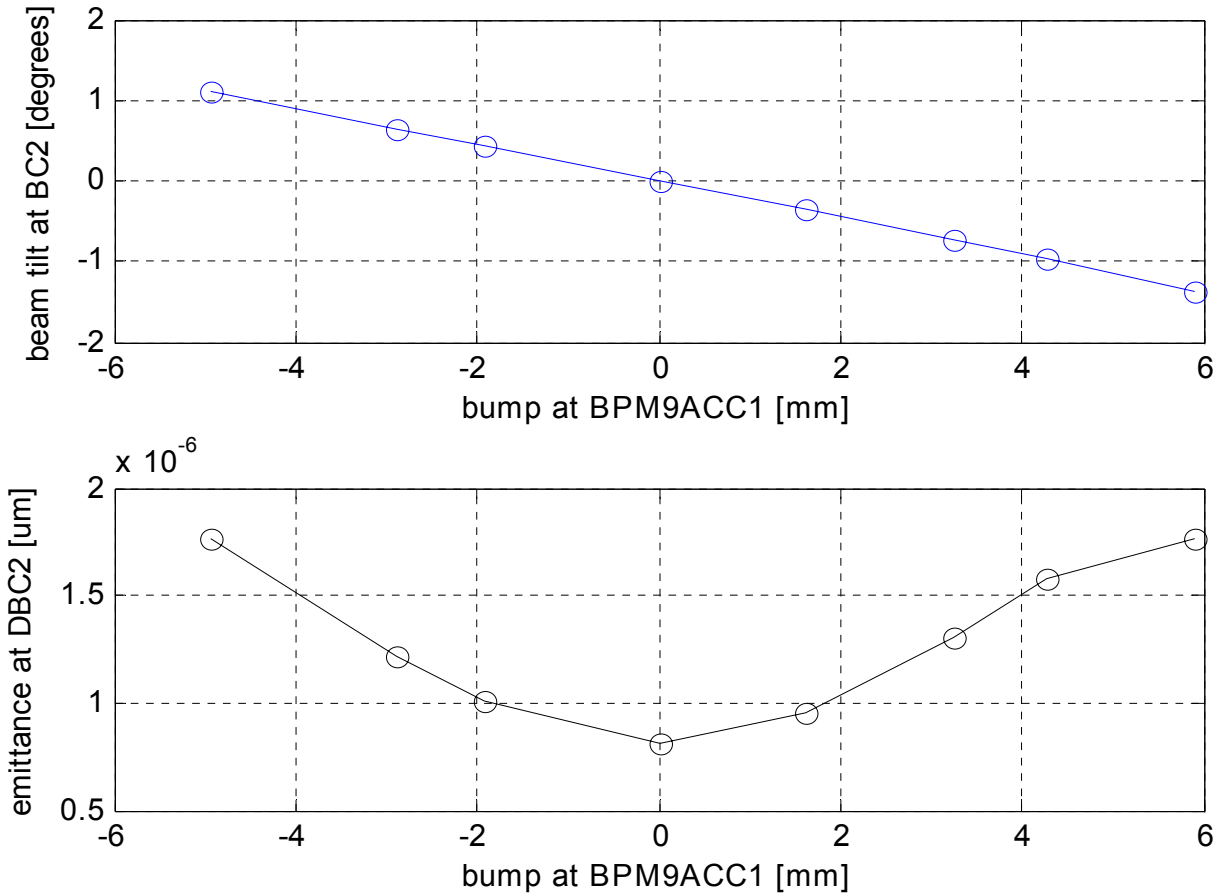
10^5 particles
Wakes included (structure and coupler)
0.62nC
9 degrees off crest at ACC1
Optics of the measurements

Simulated vs measured orbit difference [mm]



Beam tilt simulations

Basic case (zero bump = zero orbit, no wakes)

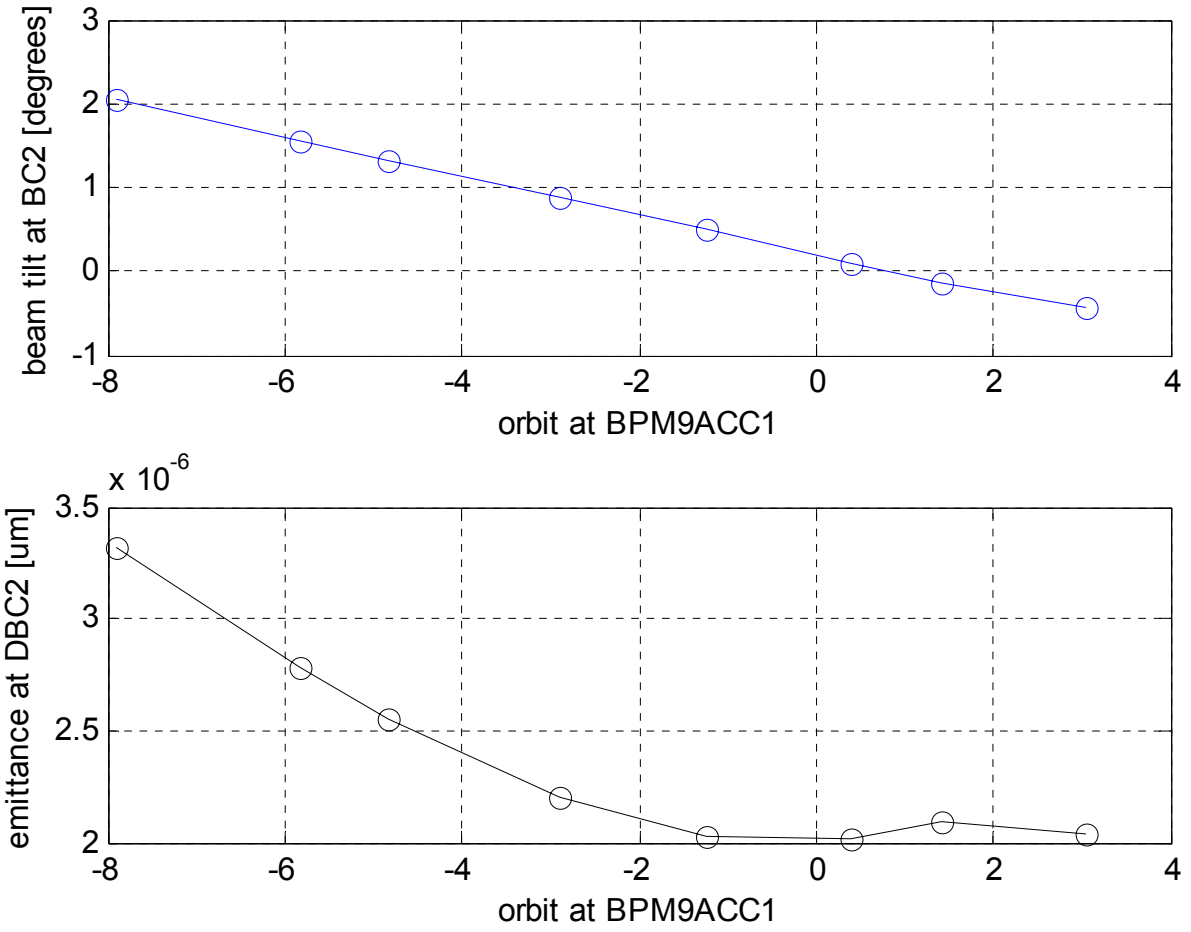


No bump corresponds to no tilt and to optimum emittance

Beam tilt simulations

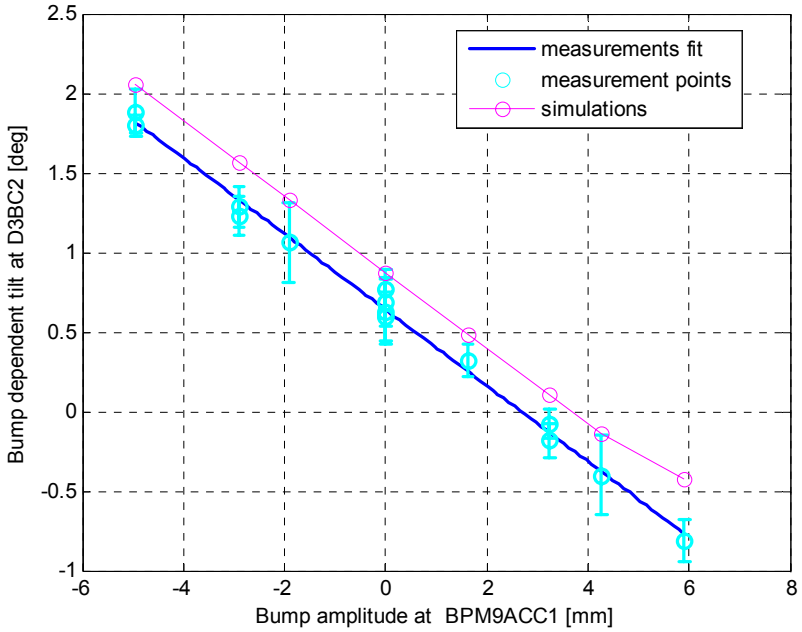
Real case (no bump=-2.8mm at BPM9ACC1)

Initial orbit misalignment of 3.5mm reproduces the initial orbit at BPM9ACC1 (-2.8mm)

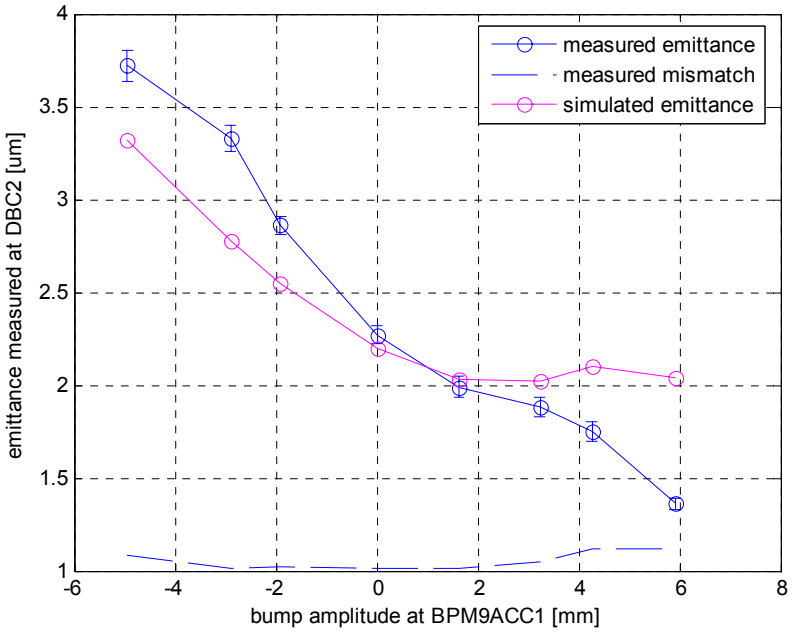


Beam tilt
Measurements vs simulations

Beam tilt

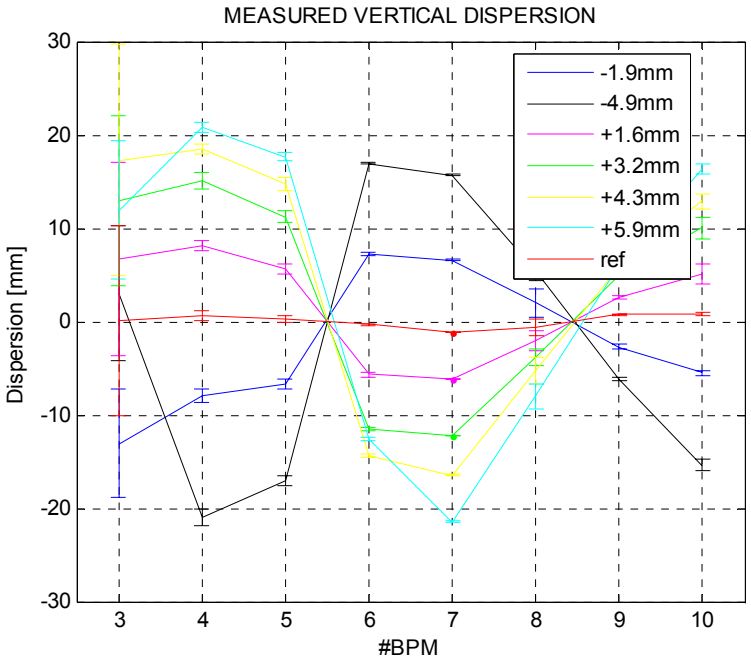


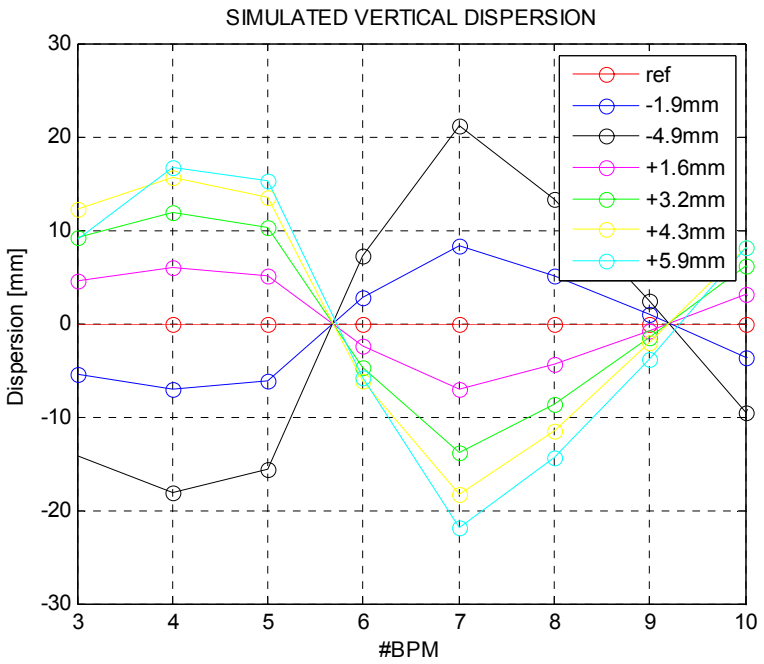
Emittance

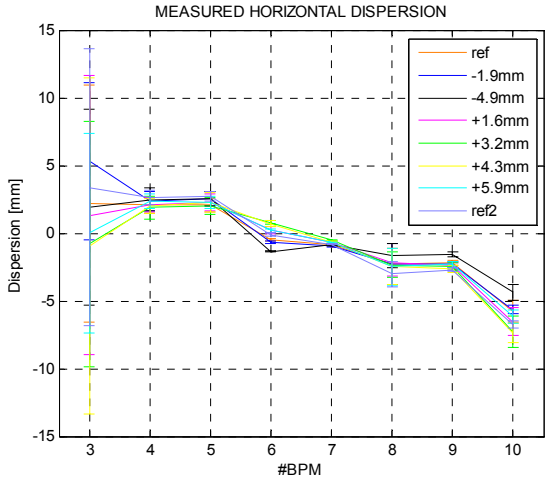


Beam tilt: if some initial offset → good agreement
Emittance: qualitative good agreement

Beam tilt: Dispersion from ACC1
Measurements and simulations

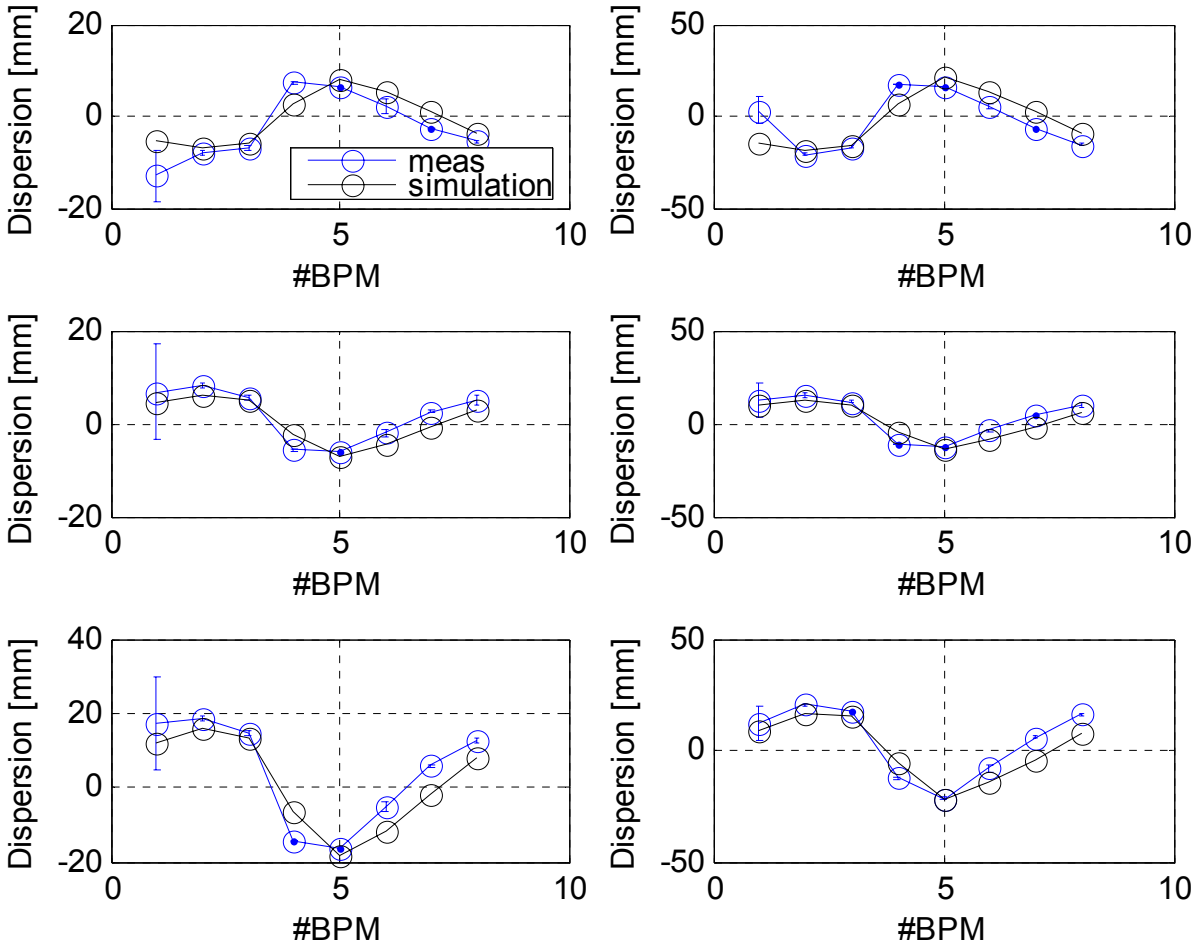






Eduard Prat, DESY

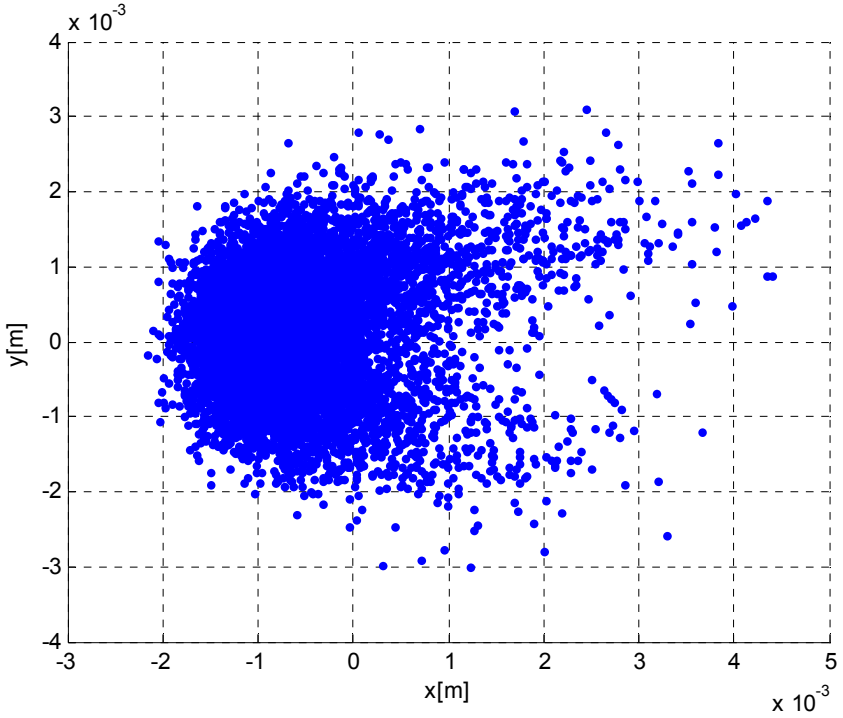
Comparison between measured and simulated dispersion for each bump

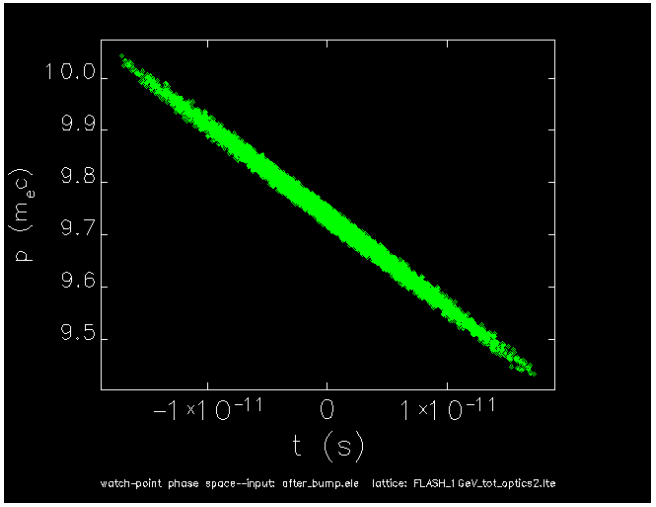


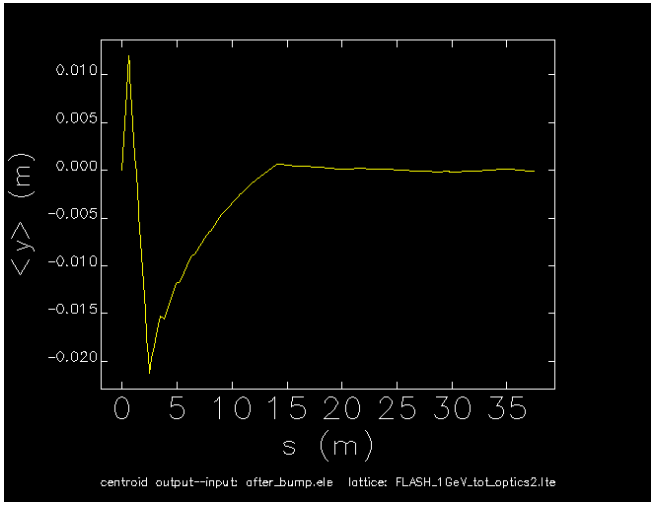
Good agreement ☺

C-shape simulations: a possible source

Energy chirp coming from the gun + vertical dispersion





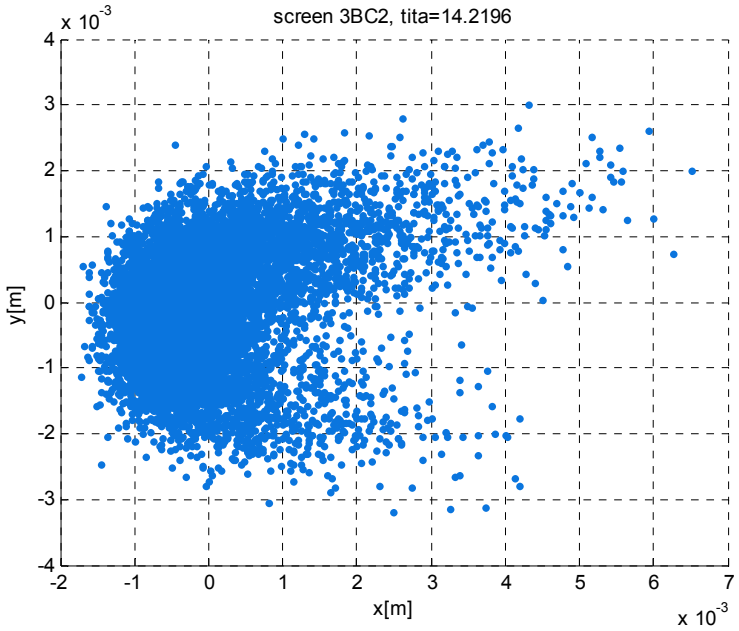


Initial kick of 20mrad compensated with V2/3GUN,
E=4.5MeV
energy chirp=6%
wakes included

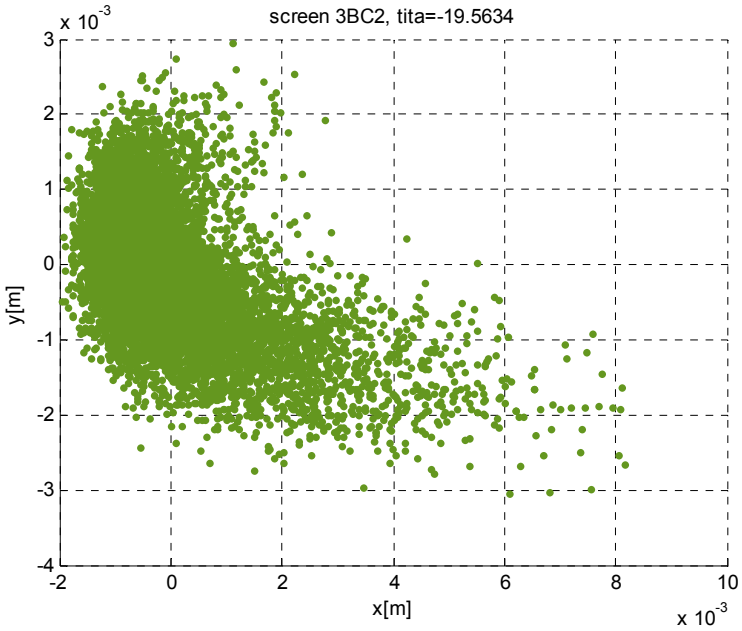
What can generate such a kick? Solenoid misalignment?

Simulations of the C-shape Moving ACC1 phase

+ 2 degrees



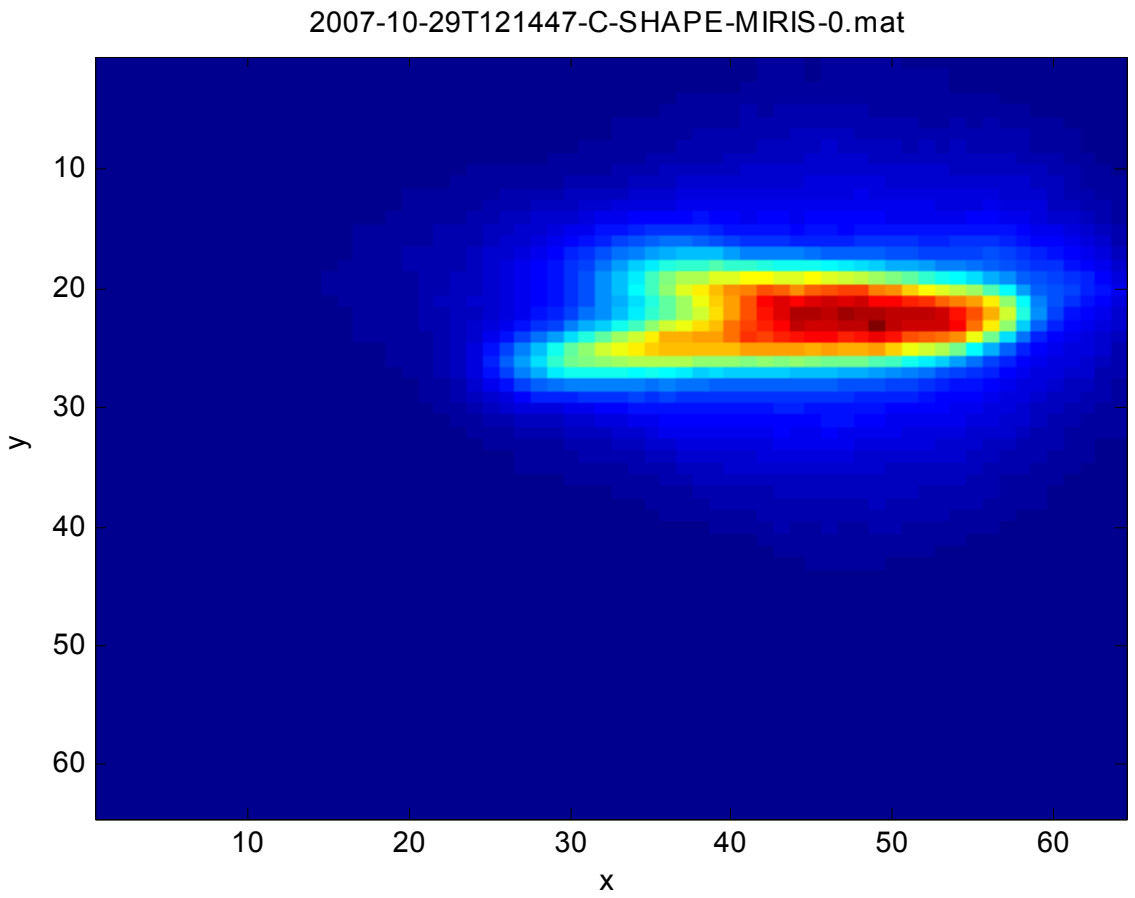
- 2 degrees



Same effect observed in measurements

C-shape measurements

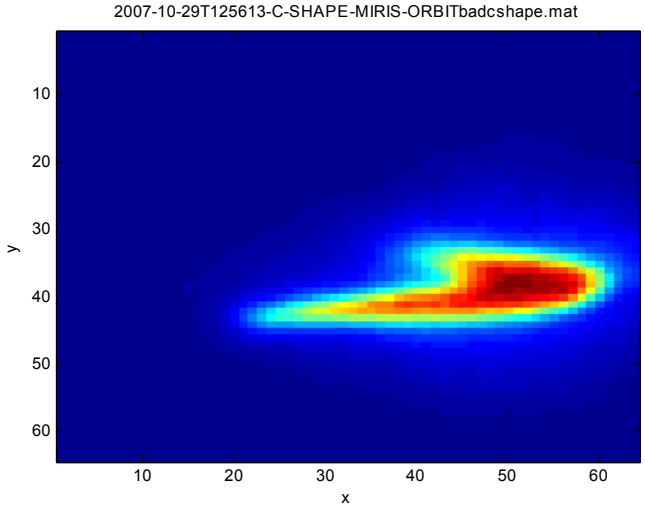
After adjusting gun phase and optics …



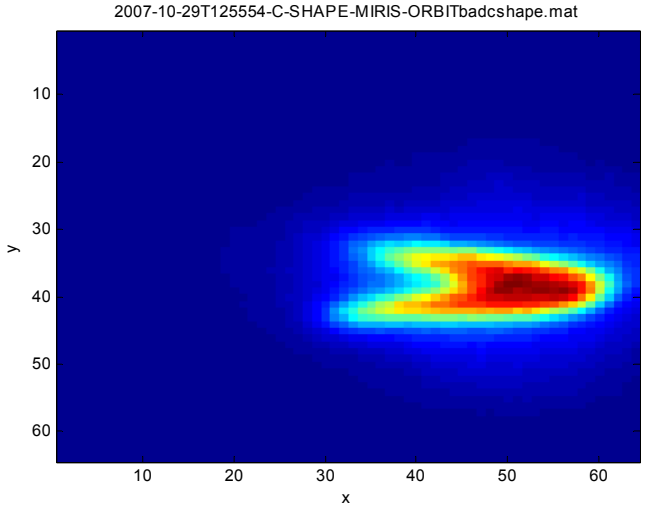
… C-shape is there

Moving ACC1 phase

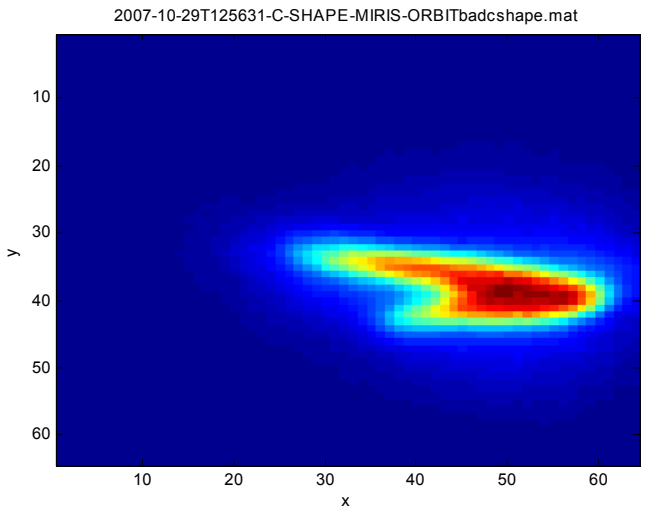
+ 1 degree



reference



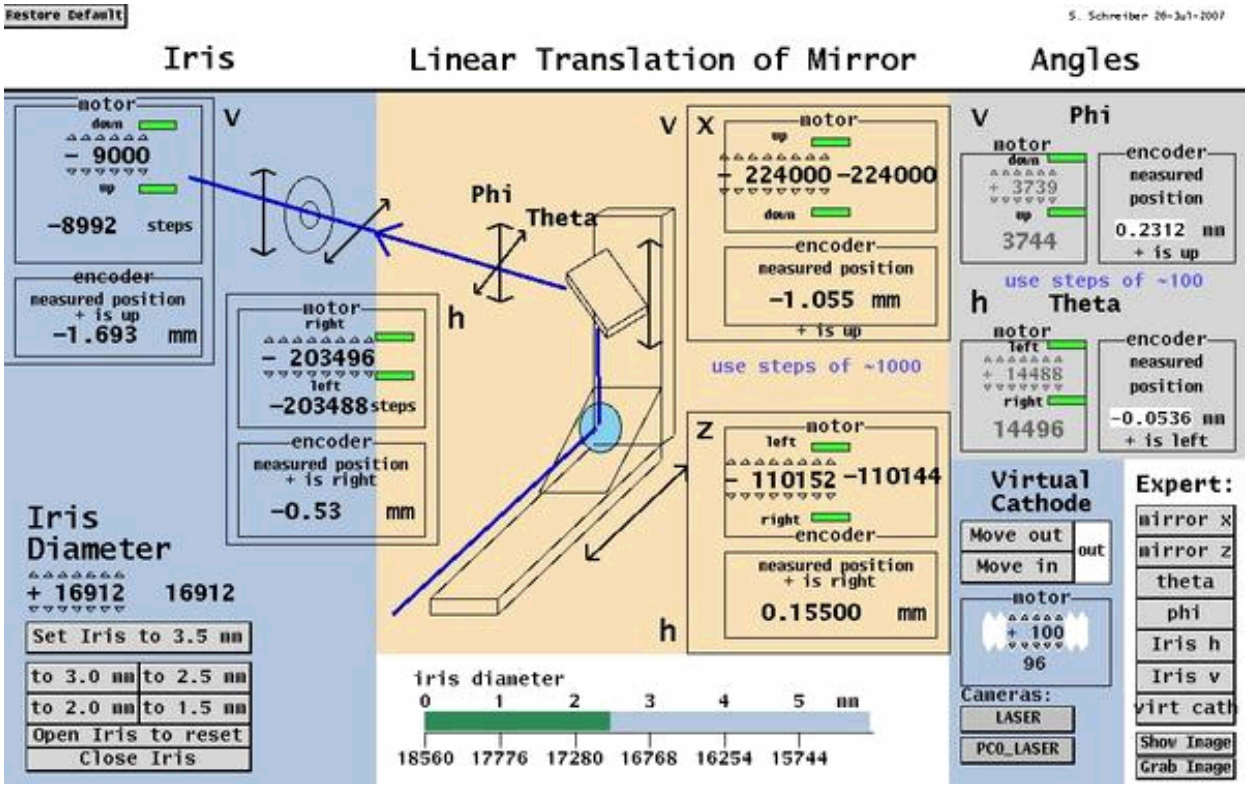
-1 degree



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

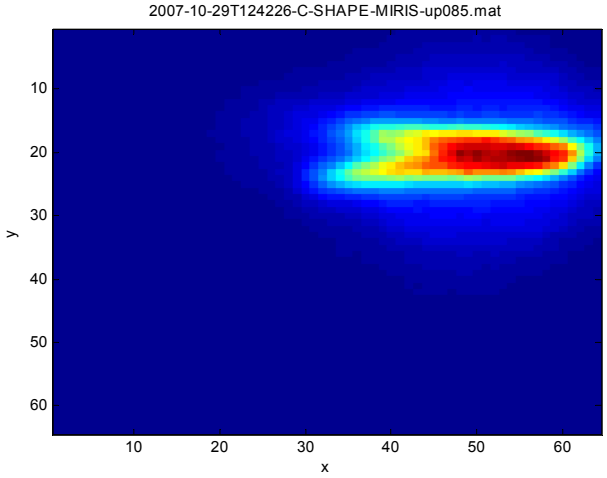
Pseudo solenoid misalignment

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



Moving vertically

↑0.85mm



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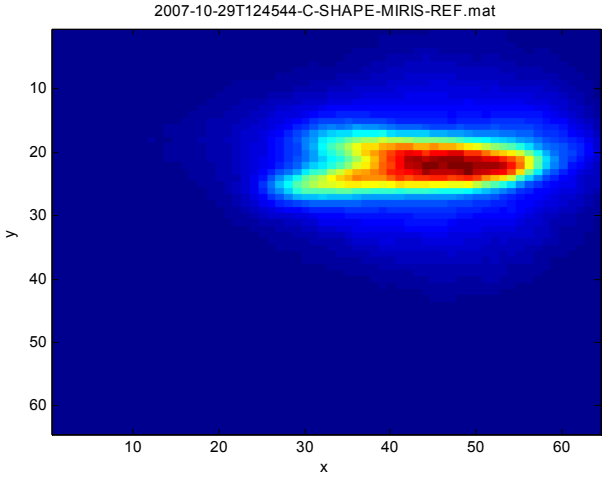
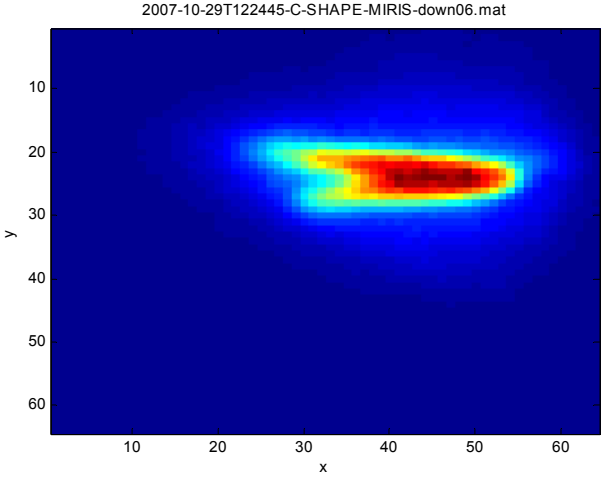
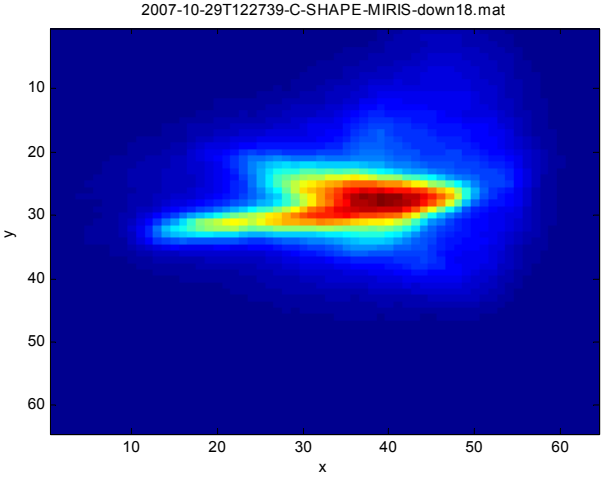


↓0.60 mm



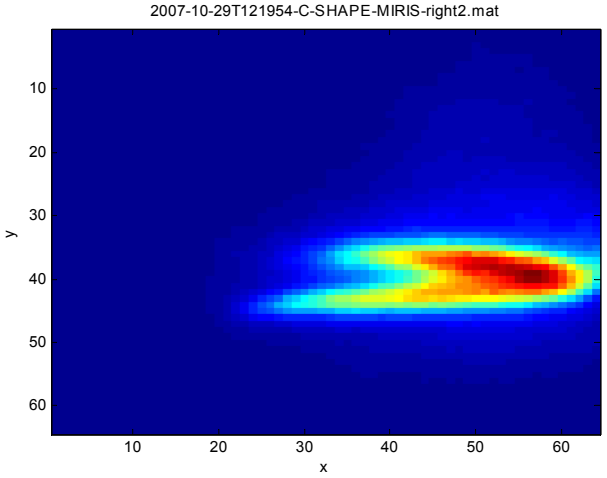
↓1.80 mm



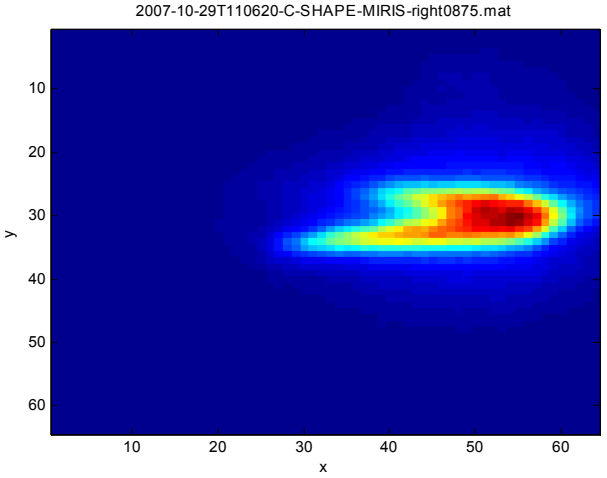
C-shape does not change significantly when moving up and down

Moving horizontally

→2.00mm



→0.88mm



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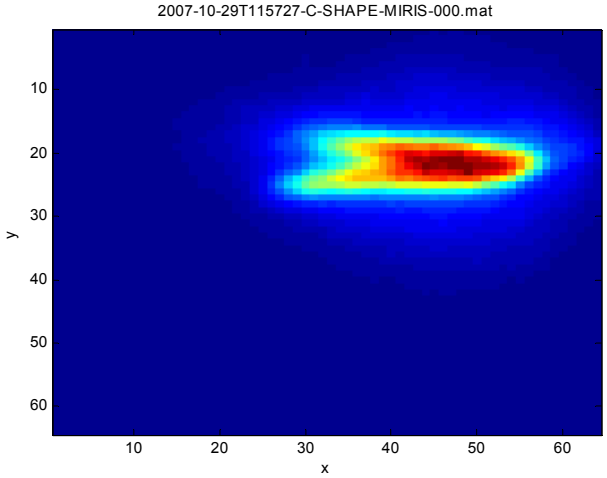
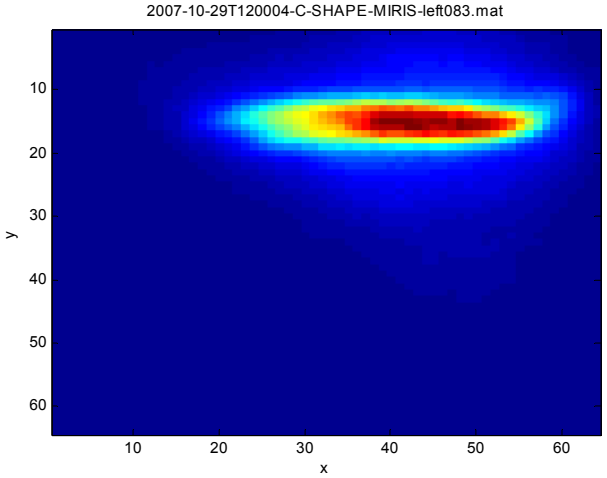


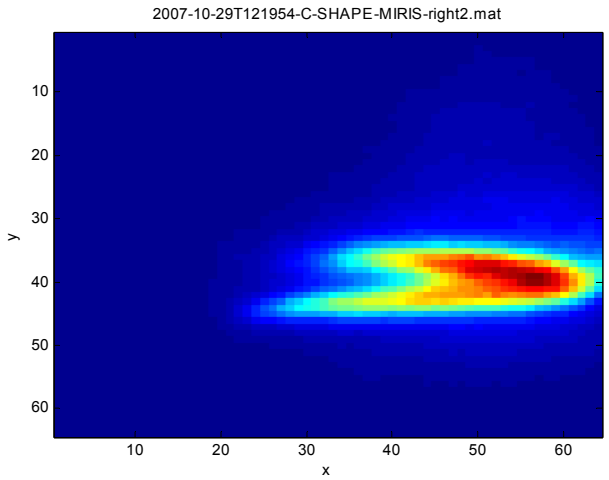
←0.83mm



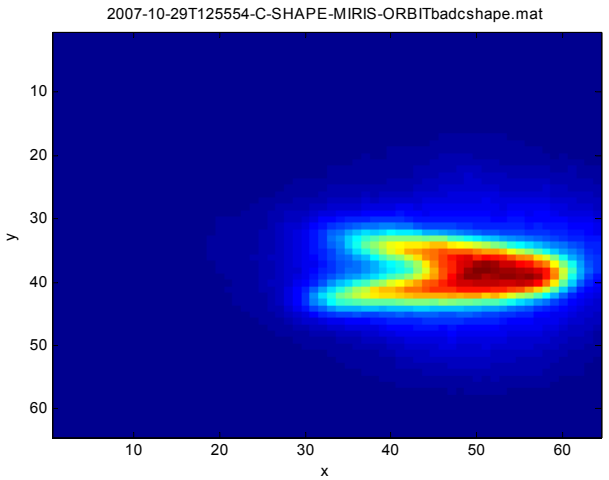
Movement to the right enhances C-shape
Movement to the left reduces the effect

Orbit correction

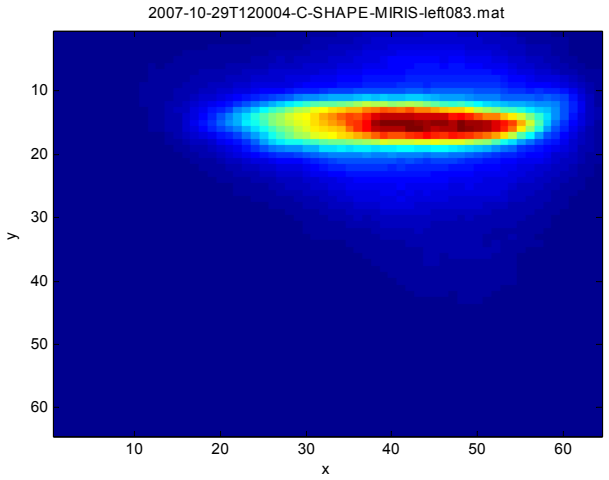
→2.00mm



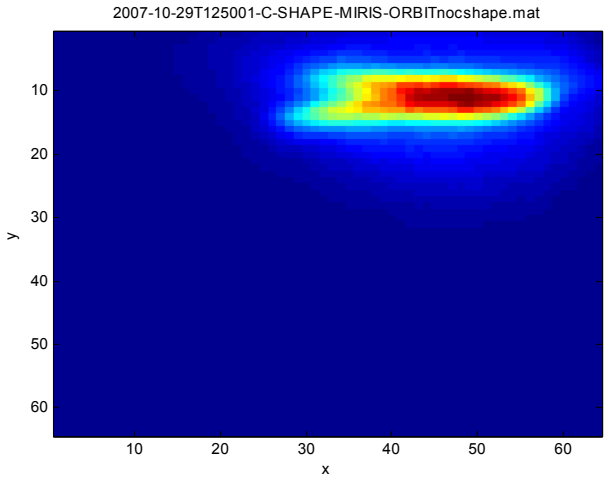
Orbit as →2.00mm



←0.83mm



Orbit as ←0.83mm



Correcting the orbit without moving iris and mirror has a similar impact to the C-shape as moving iris and mirror

Summary and next steps

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.)