

# Beam tilt studies at FLASH

FEL studies – Autumn 2007

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FLASH seminar

14<sup>th</sup> of January of 2008, Hamburg

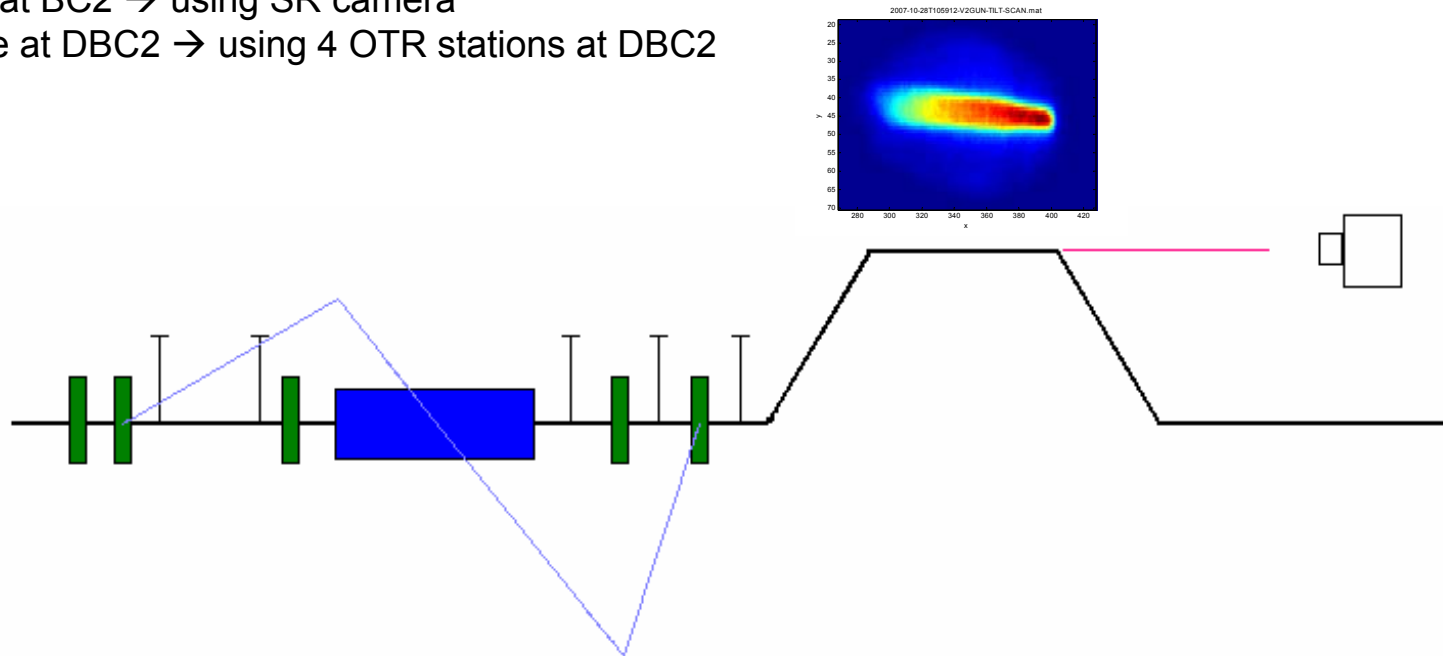
- Overview of the measurements
- Orbit response measurements
- Beam energy measurement
- Beam tilt
  - Measurements and simulations of beam tilt and emittance
  - Measured and simulated dispersion
- Summary and next steps

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

Vertical offset through ACC1 + off-crest  $\rightarrow$  dispersion +  $\Delta p$  (+ wakes)  $\rightarrow$  beam tilt,  $\uparrow$  emittance

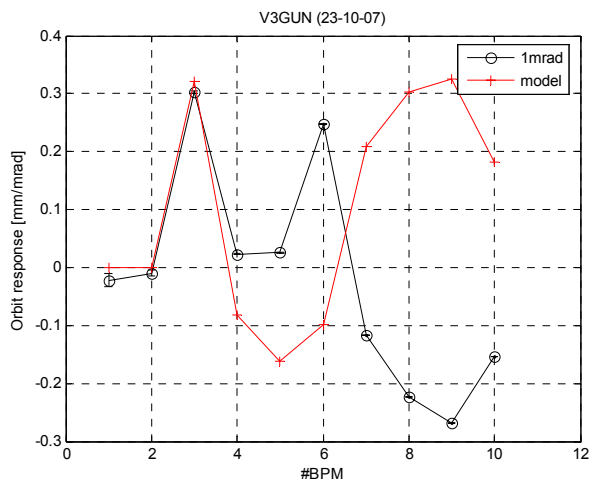
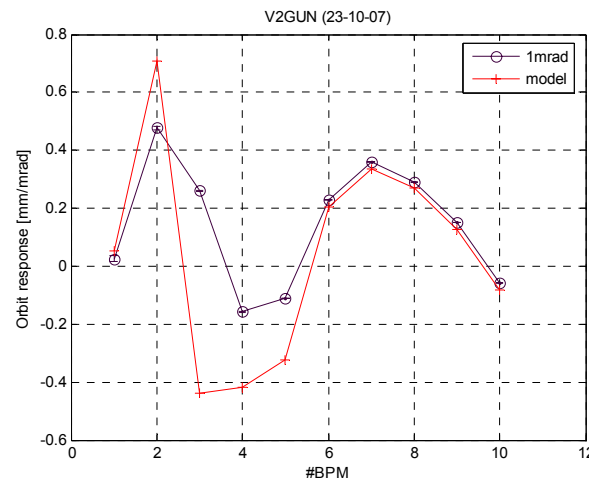
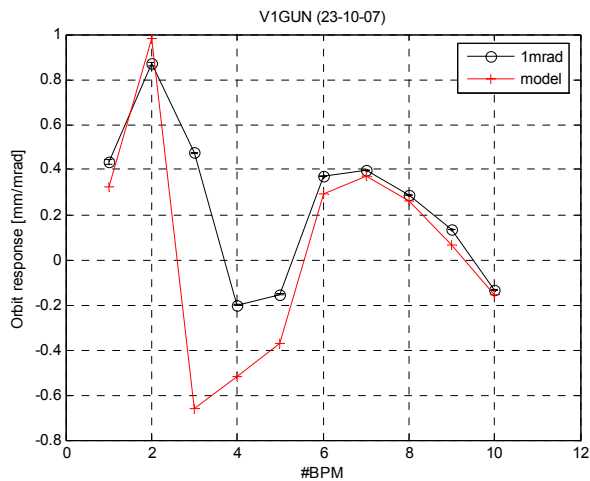
Using the gun steerers, we generated different vertical bumps at BPM9ACC1. For each bump we measured:

- Dispersion from ACC1
- Beam tilt at BC2  $\rightarrow$  using SR camera
- Emittance at DBC2  $\rightarrow$  using 4 OTR stations at DBC2

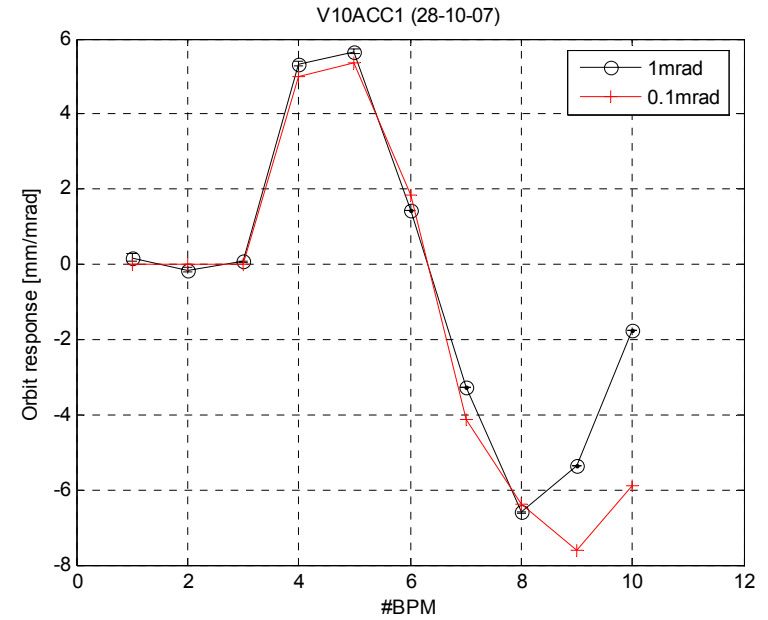
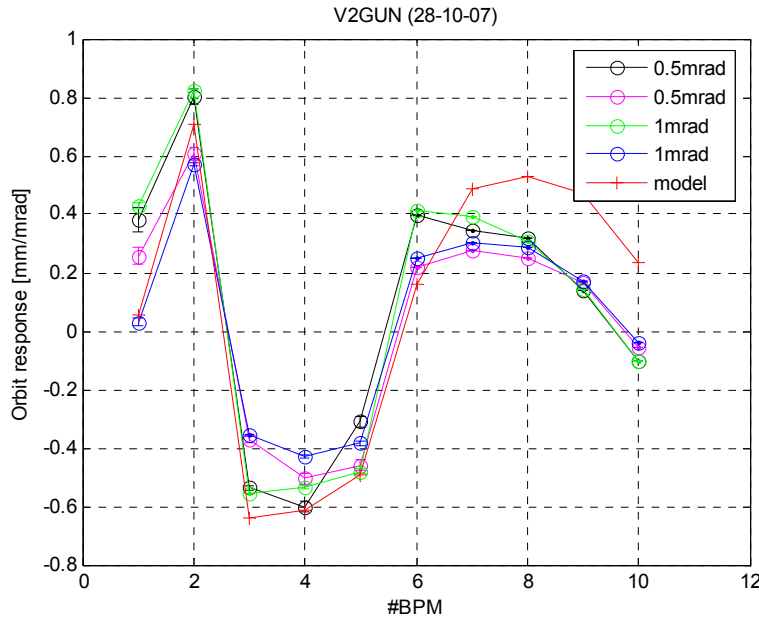


## Complementary measurements

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

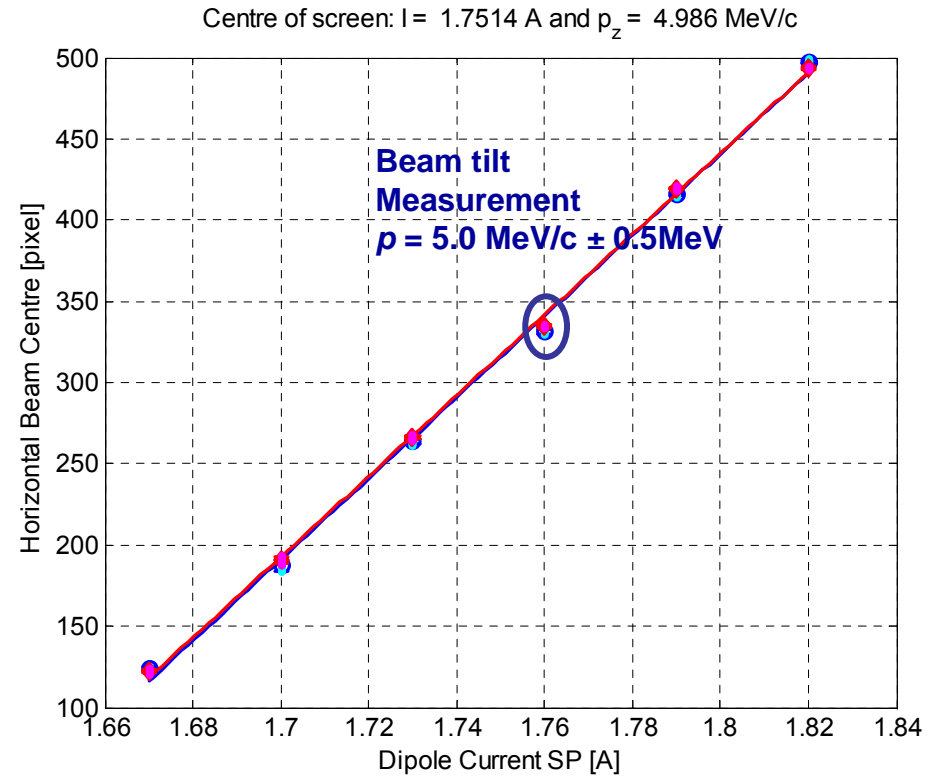
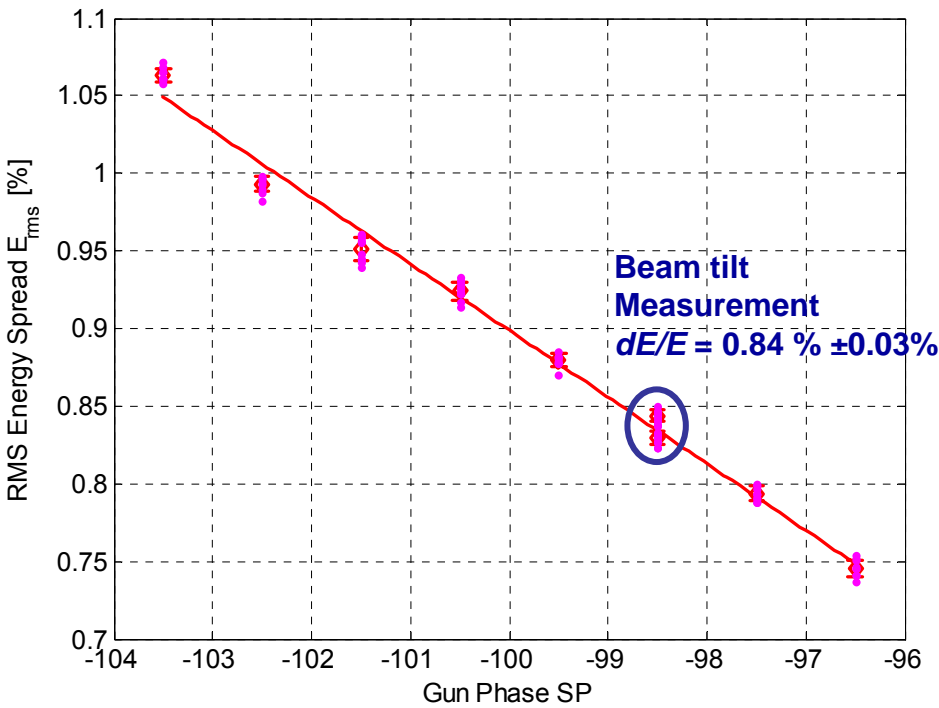


- Wrong calibration sign of BPM9ACC1 (changed)
- Wrong calibration constant of BPM1/2UBC2 (changed)
- Wrong polarity of V3GUN (changed)

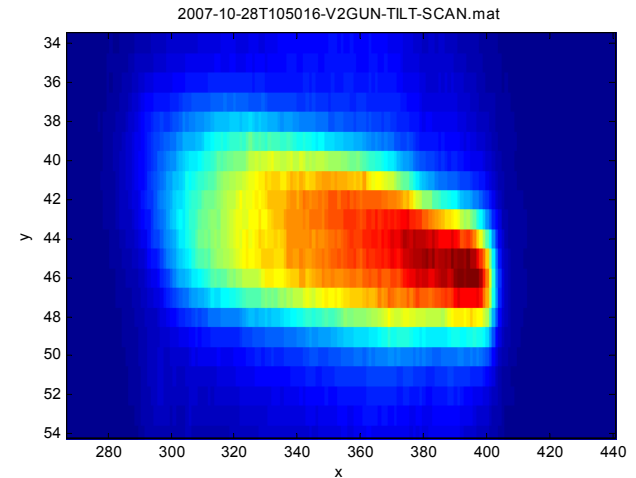
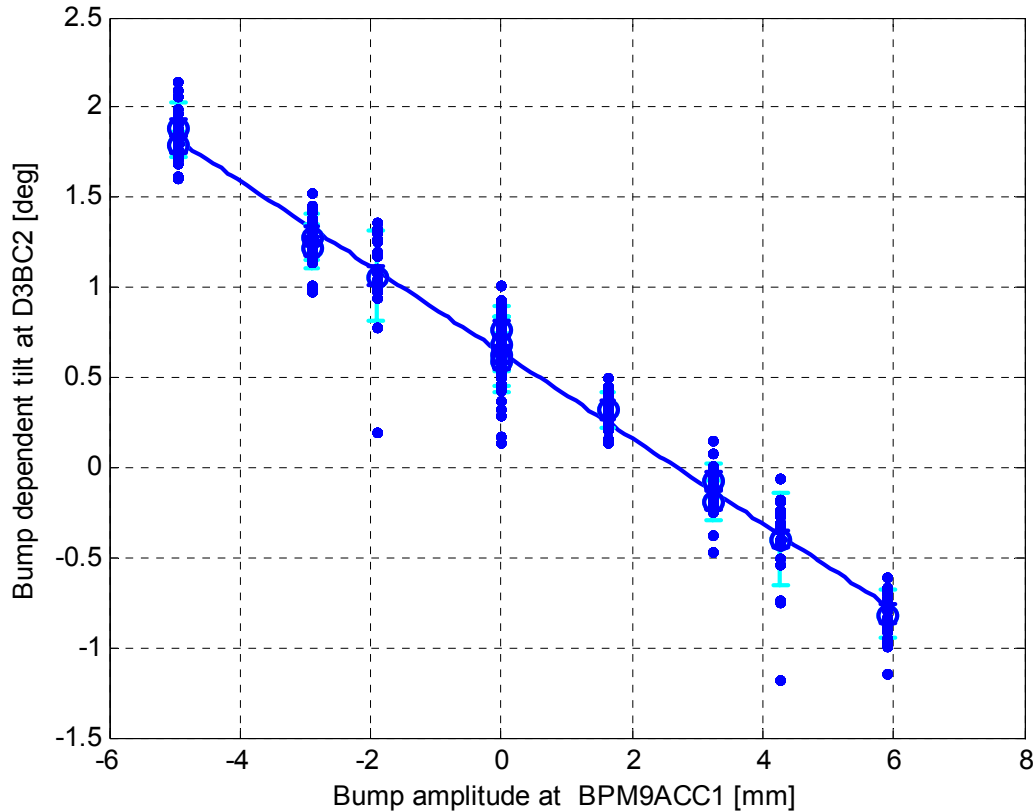


After the changes → ~ good agreement 😊 ✓

With dipole D1IDUMP and screen IDUMP



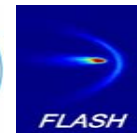
SR Camera BC2: Bunch tilt measurement 28-Oct-2007



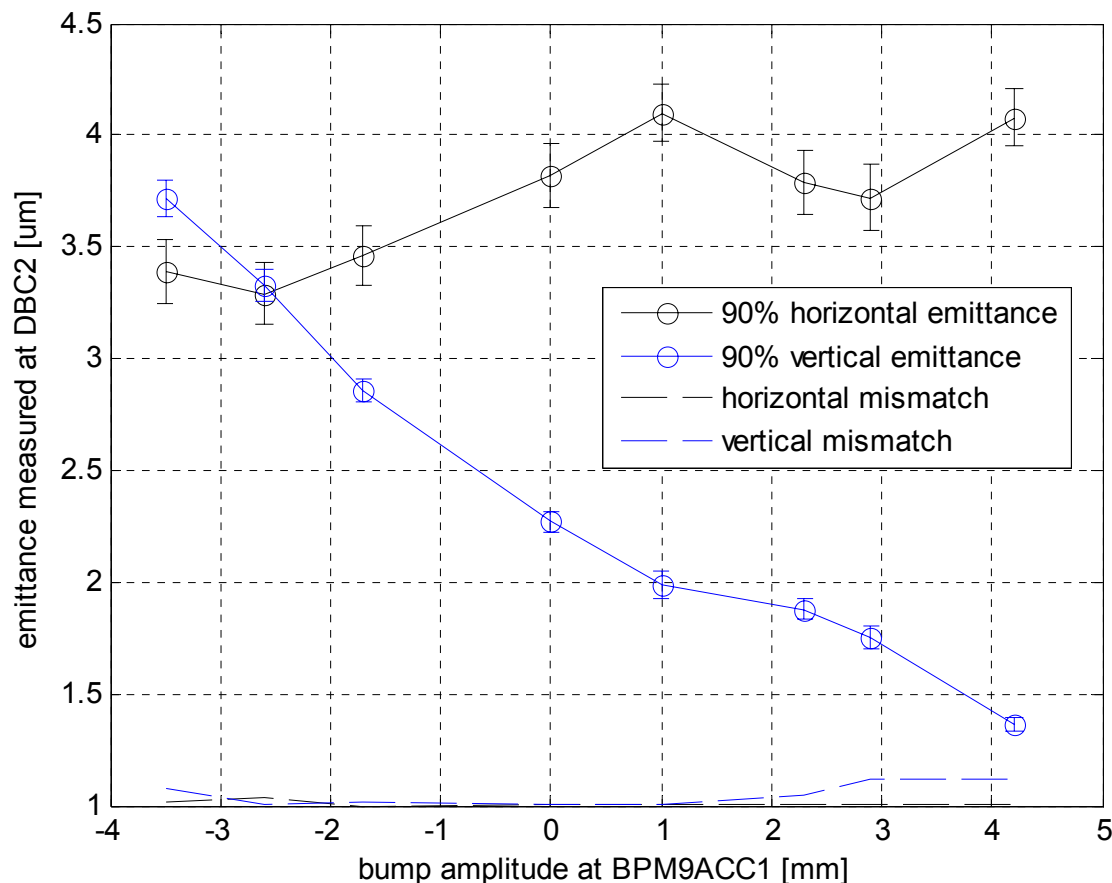
Beam tilt for no bump is  $\sim 0.7$  deg.  
 (For no bump, orbit at BM9ACC1 was  $-2.8$ mm)  
 Measurements done before the shutdown: tilt for no bump was  $\sim -0.25$  deg.  
 (and orbit at BPM9ACC1 was  $0.85$ mm)

# Beam tilt measurements – 28-10-2007

## Emittance at DBC2 (90% values)



ACC1 9 degrees off crest



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



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

Parameters of initial distribution:

- Emittance =  $1.3\mu\text{m}$
- Energy = 5MeV
- Bunch Length = 1.7mm,
- Energy spread = 0.7%

$10^5$  particles

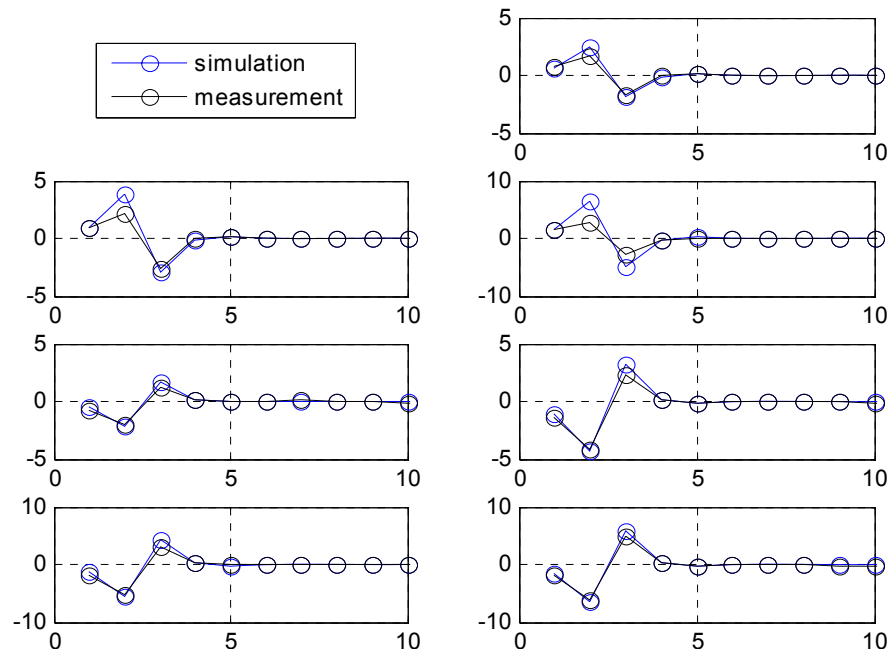
Wakes included (structure and coupler)

0.62nC

9 degrees off crest at ACC1

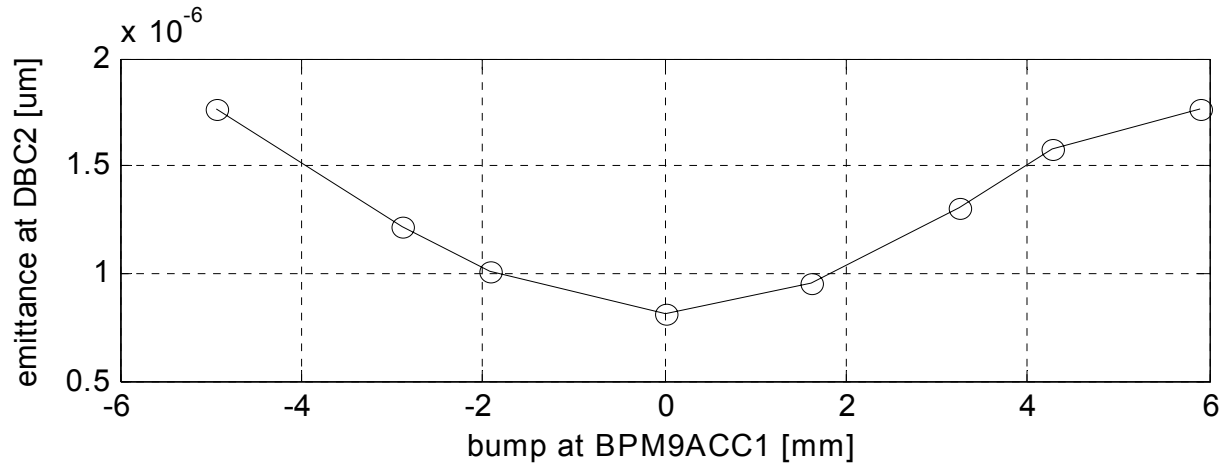
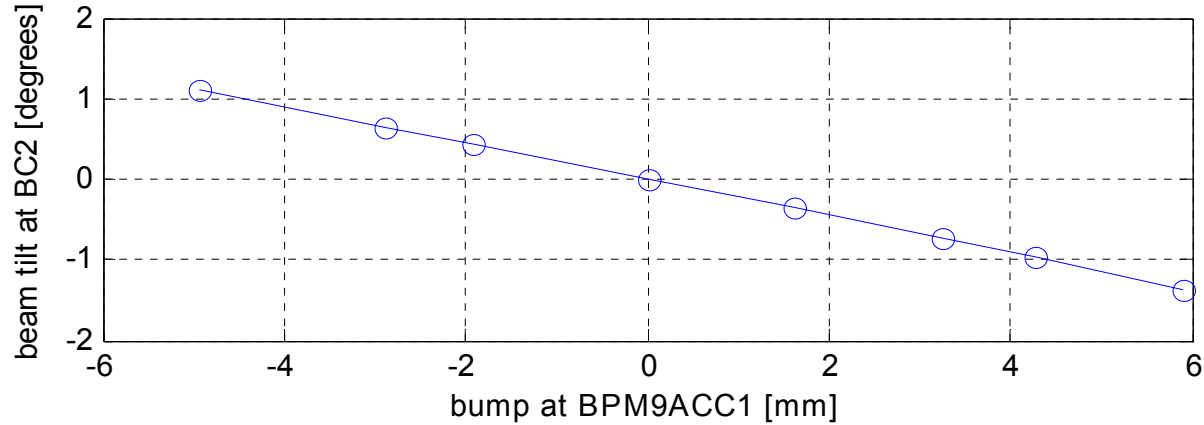
Optics of the measurements

Simulated vs measured orbit difference [mm]



# Beam tilt simulations

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

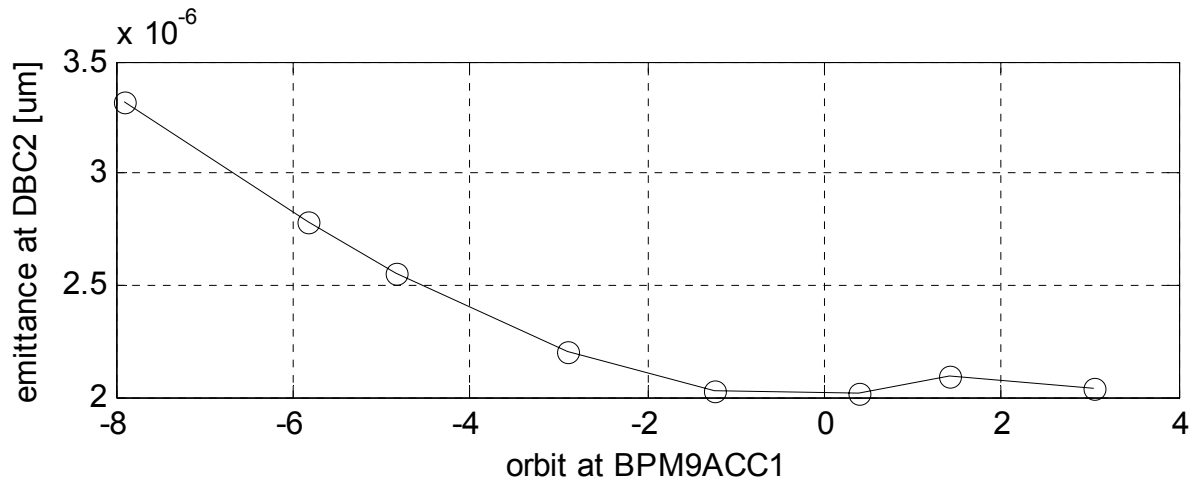
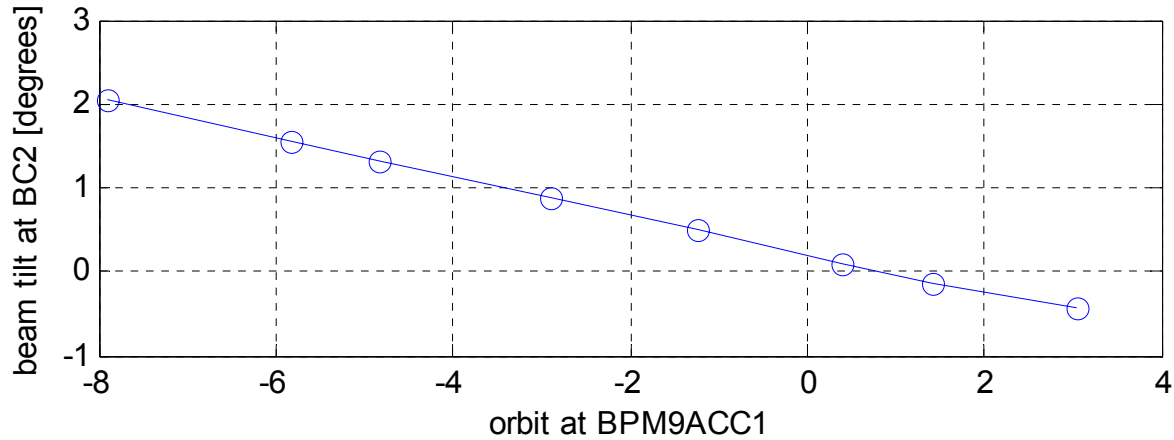


No bump corresponds to no tilt and to optimum emittance

# Beam tilt simulations

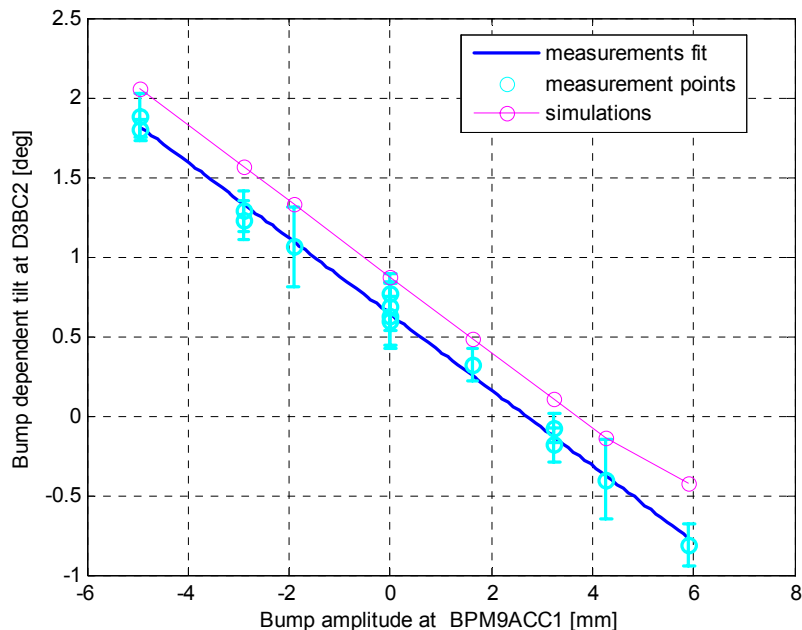
## Real case (no bump=-2.8mm at BPM9ACC1)

An initial orbit offset of 3.5mm reproduces the initial orbit at BPM9ACC1 (-2.8mm)

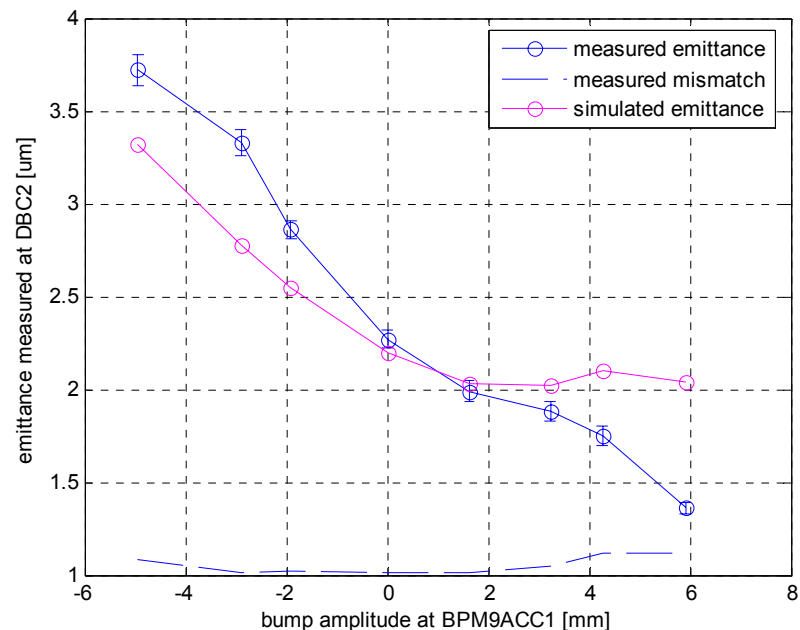


# Beam tilt Measurements vs simulations

## Beam tilt

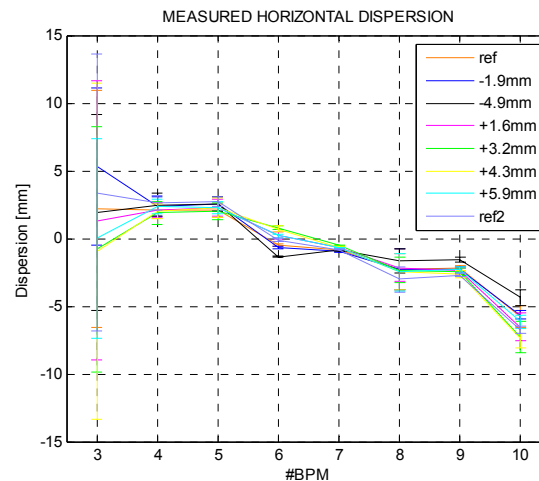
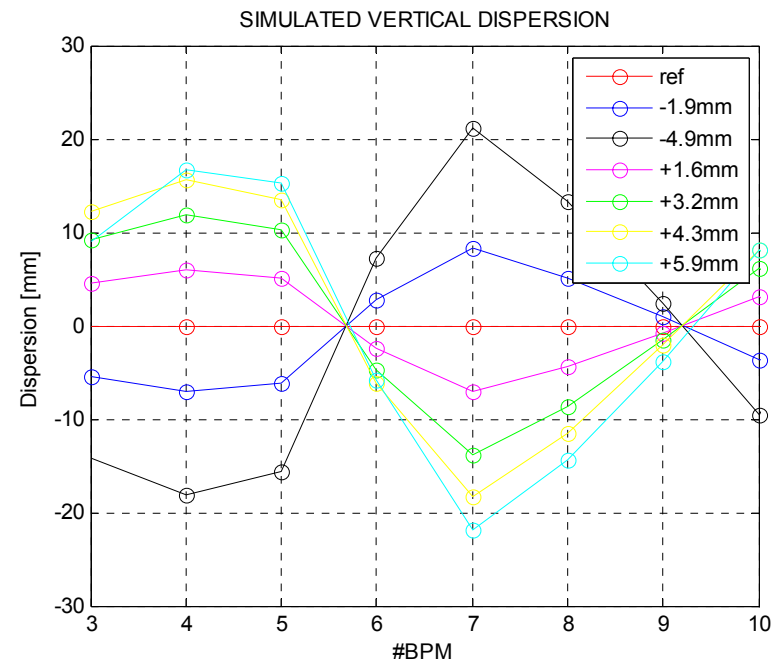
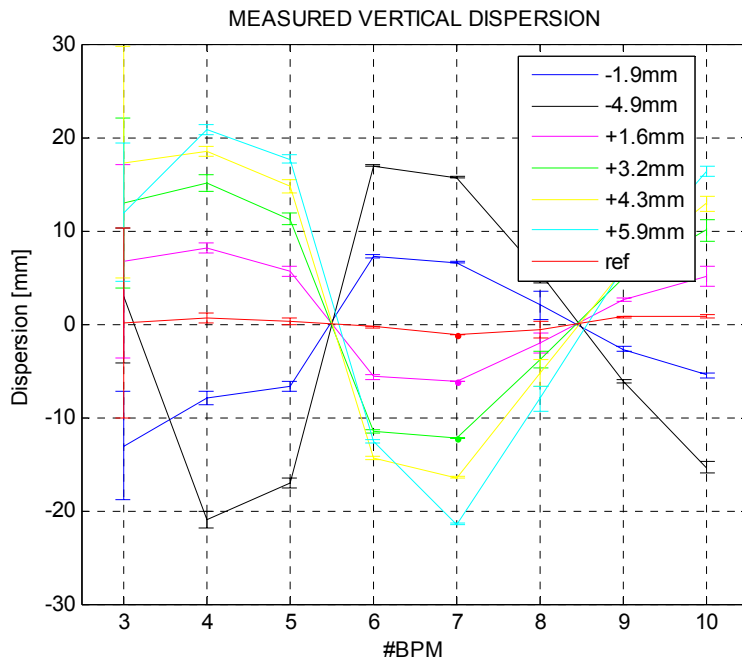


## Emittance

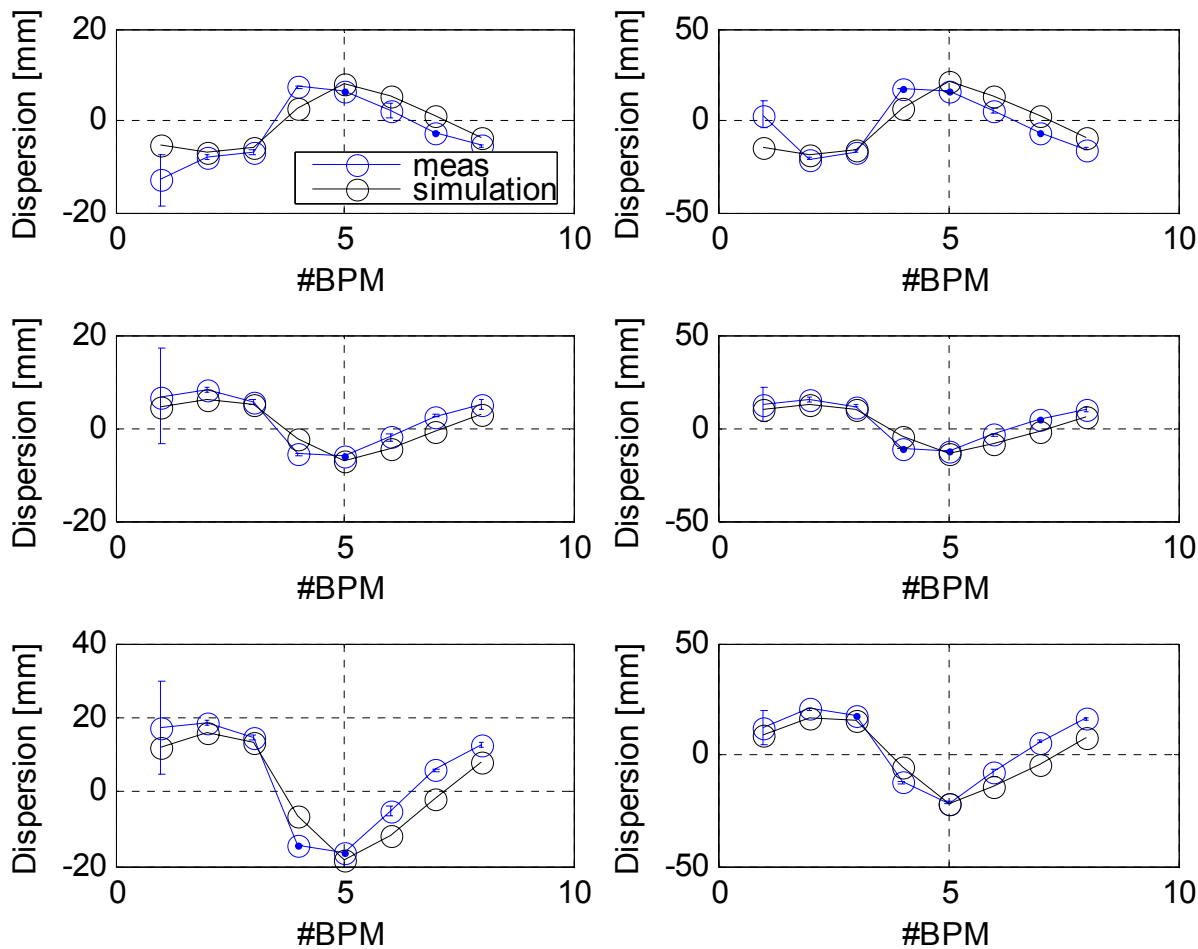


Beam tilt: if some initial offset  $\rightarrow$  perfect agreement  
 Emittance: qualitative good agreement

# Beam tilt: Dispersion from ACC1 Measurements and simulations



# Comparison between measured and simulated dispersion for each bump



Good agreement 😊

## 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) not optimal. Worse situation than before the shutdown.

## Next steps

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