

# **On-crest slice emittance measurements**

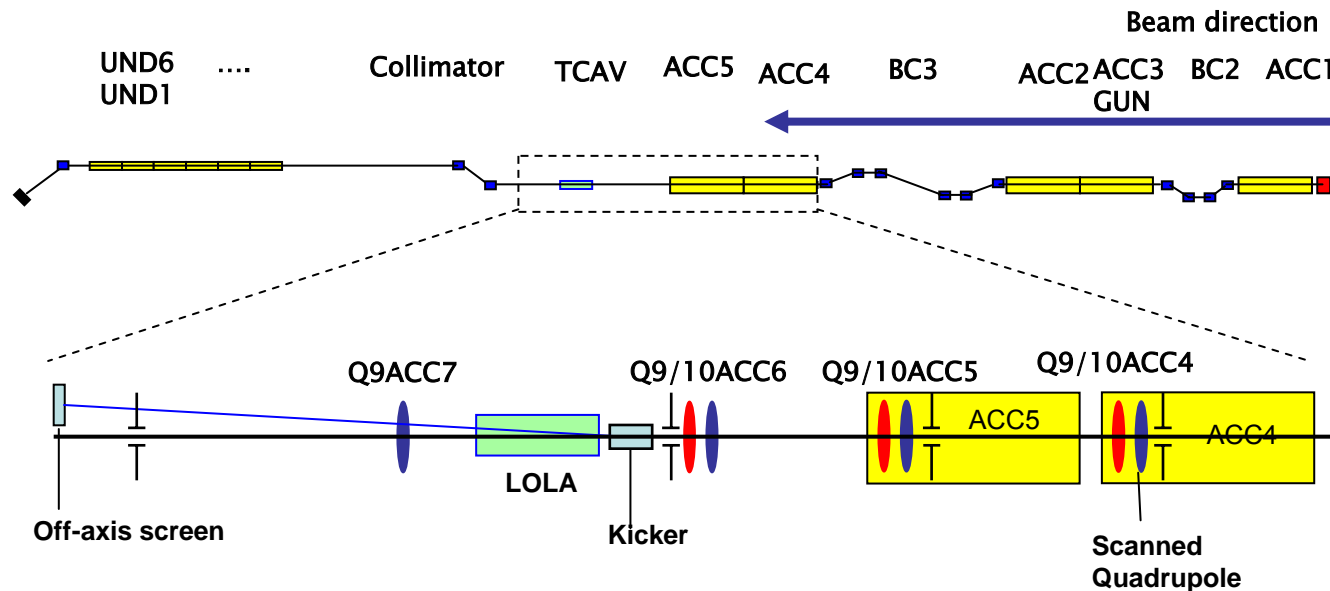
Michael Roehrs

# Outline

- Results of on-crest slice emittance measurements
- Sources of (x,z)-tilts observed with LOLA
- Effects of the tilt on slice emittance measurements
- conclusions

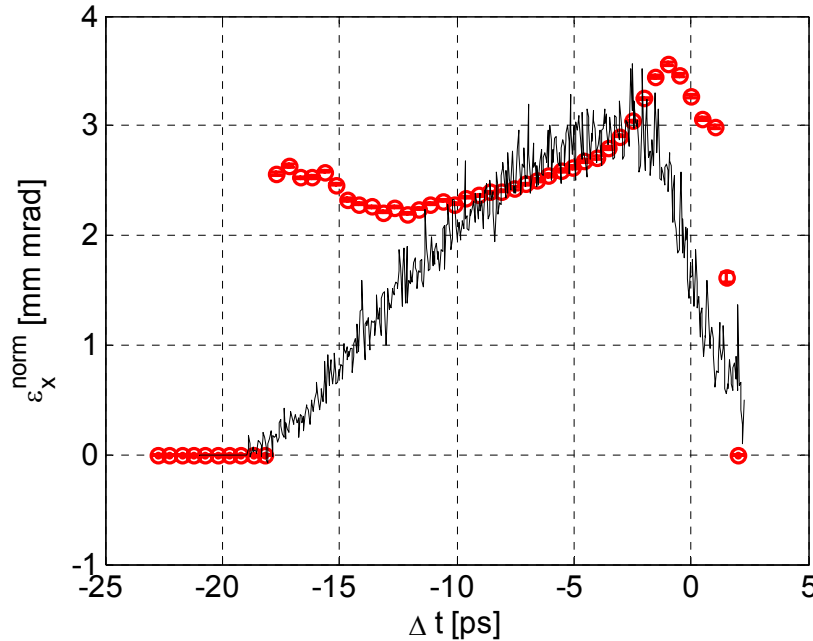
# Slice emittance measurements with different quadrupole scans (19.02.07)

- Standard method: simultaneous scan of Q9ACC4-Q10ACC6 (good long. Resolution)
- Scan of Q10ACC6 (two different optics)

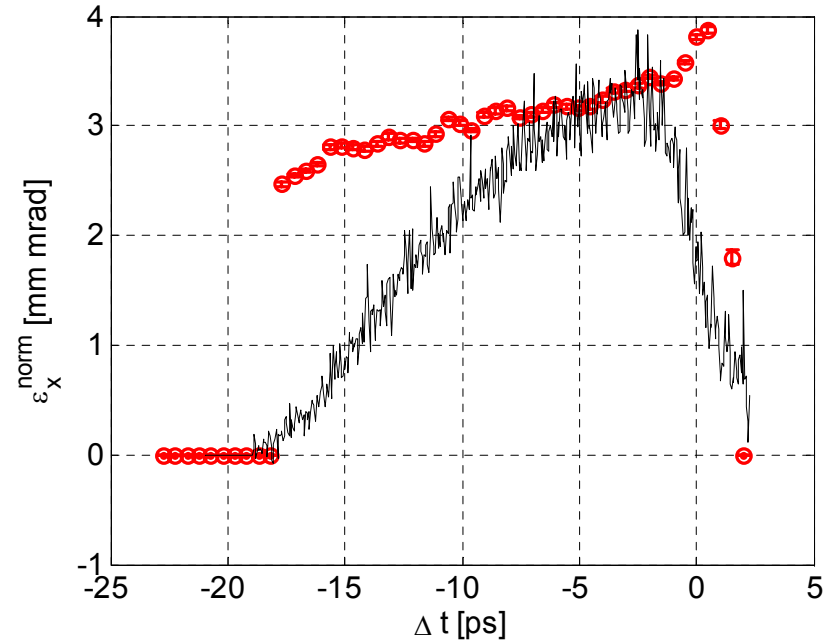


# Results: scan of Q10ACC6 (optics 1)

Gauss-fit:



Second moments:



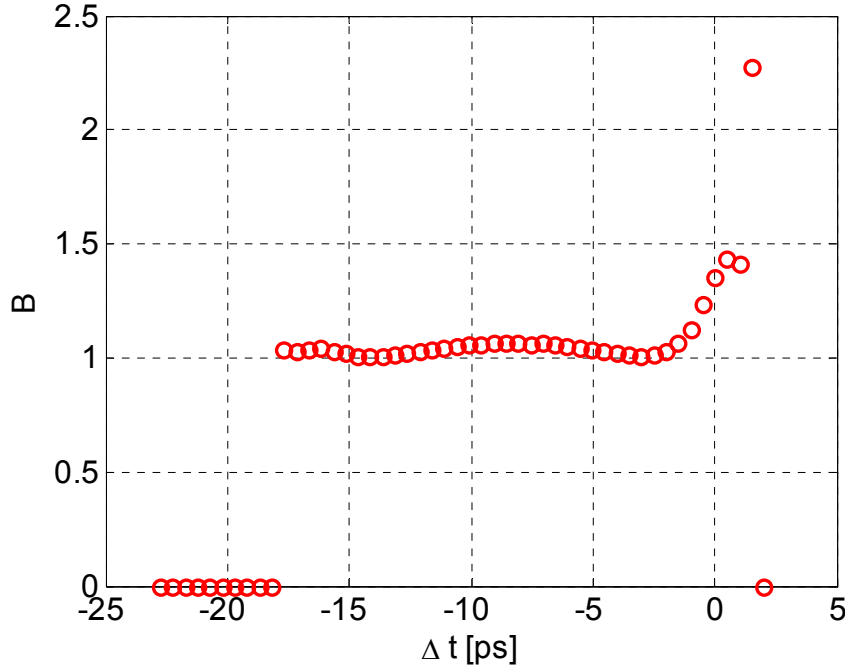
Average slice emittance: 2.7 mm mrad (gauss) / 3.1 mm mrad

Projected emittance including tilts: < 4.3 mm mrad / < 4.8 mm mrad

Projected emittance BC2-section:

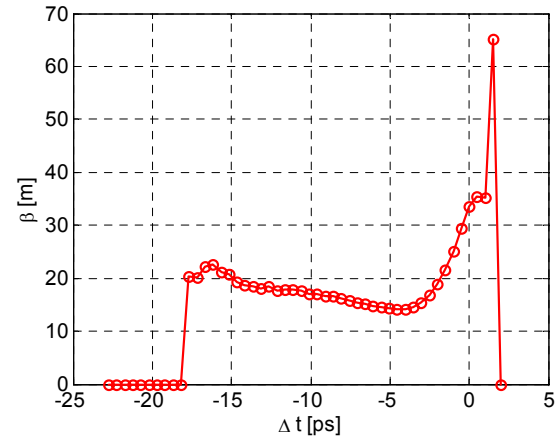
# Slice mismatch and initial Twiss parameters

Mismatch parameter with respect to projected Twiss parameters

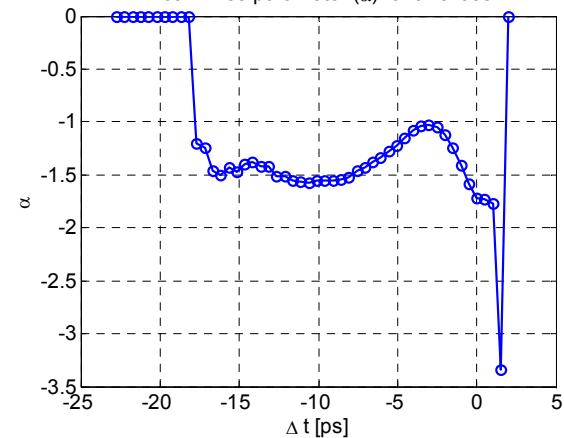


→ Correlated to energy profile ?

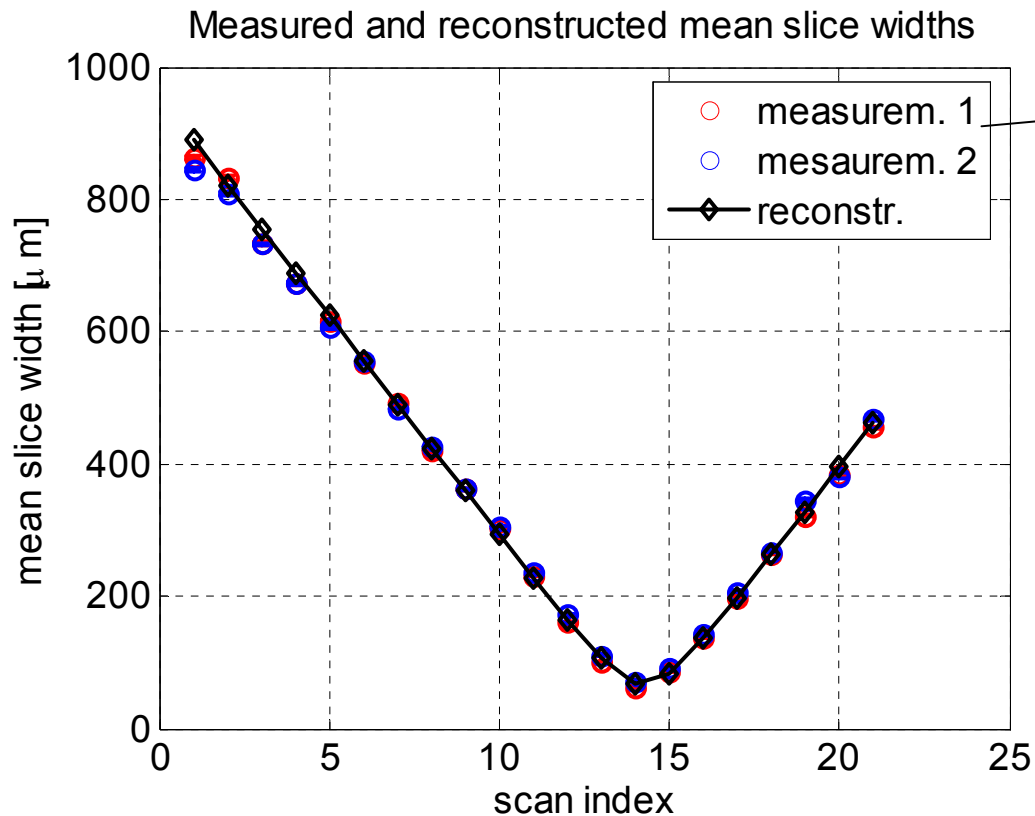
Initial beta function value for all slices



Initial Twiss parameter ( $\alpha$ ) for all slices



# Comparison of measured and calculated bunch widths



LOLA phase flipped (head deflected up- and downwards, respectively)

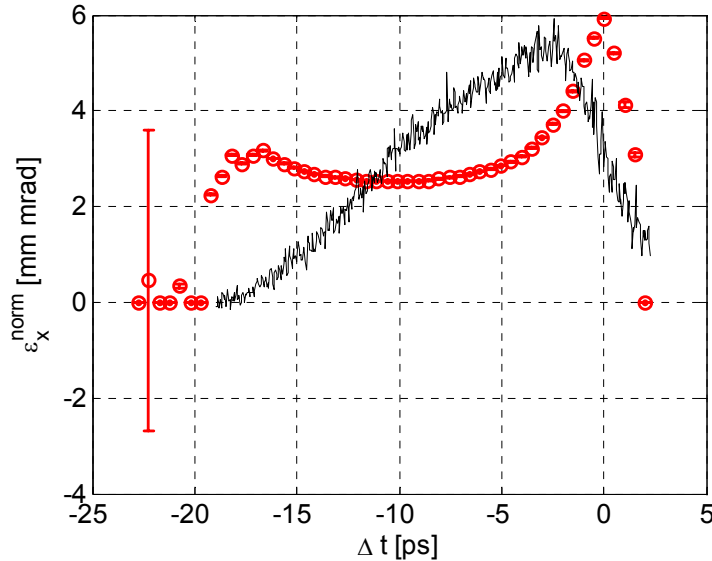
No significant errors in transfer model / of the measured beam sizes

Emittance error due to wrong k-values (5%) / energy (10%):

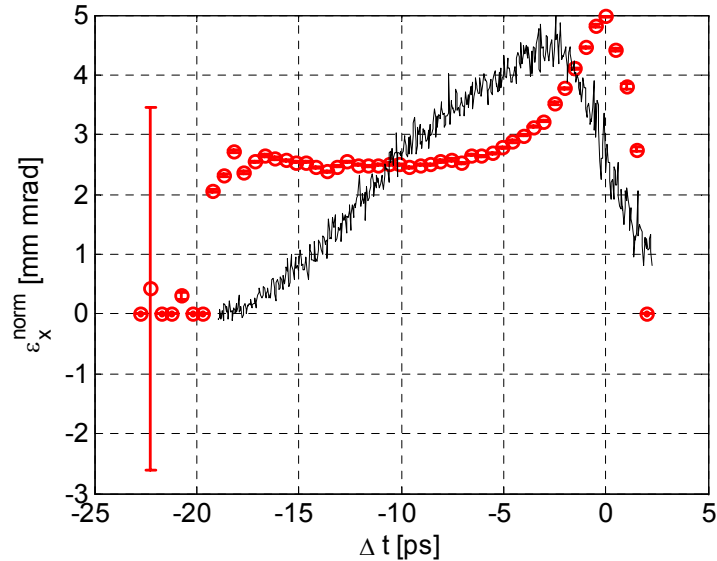
< 10%

# Scan of Q10ACC6 (optics 2)

Gauss-fit:



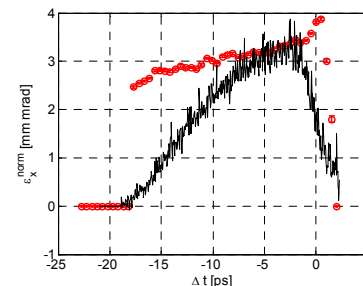
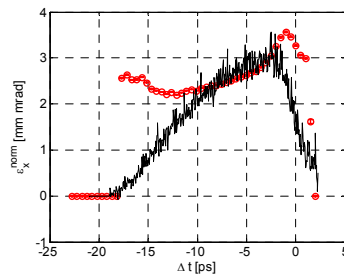
Second moments:



Average slice emittance: 3.0 mm mrad (gauss) / 3.1 mm mrad

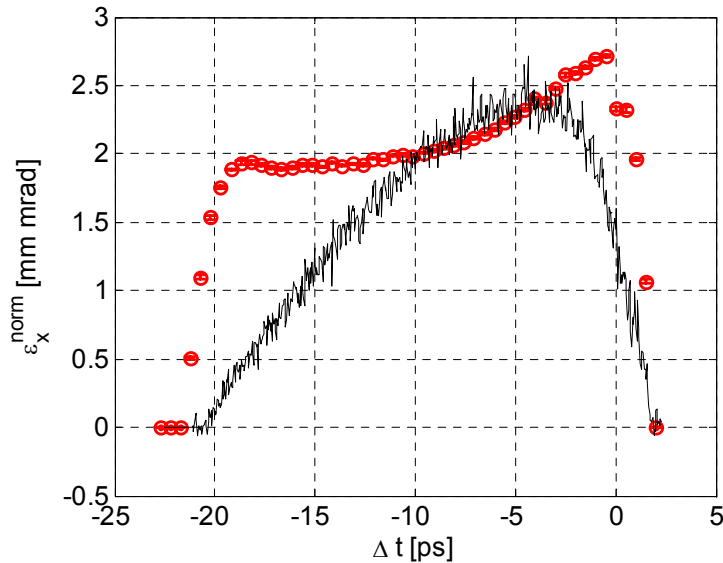
Projected emittance including (z-correlated) tilts: 4.3 mm mrad / 5.0 mm mrad

Optics 1:

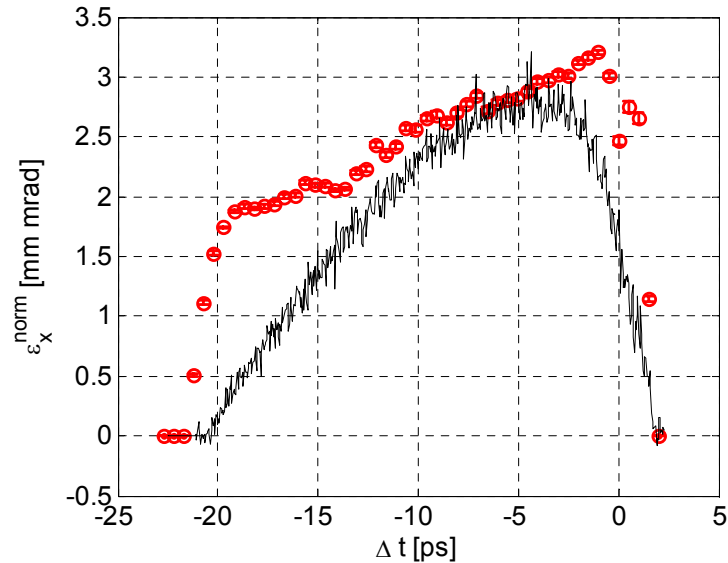


# Multi-quadrupole-scan

Gauss-fit:

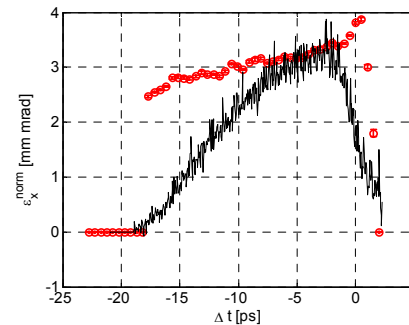
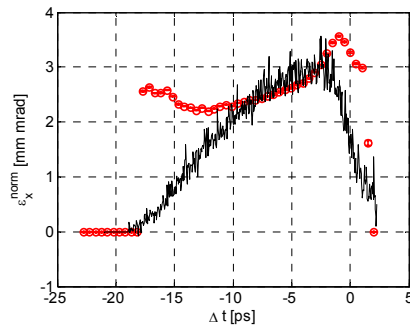


Second moments:



Average slice emittance: 2.4 mm mrad (gauss) / 2.7 mm mrad

Optics1:

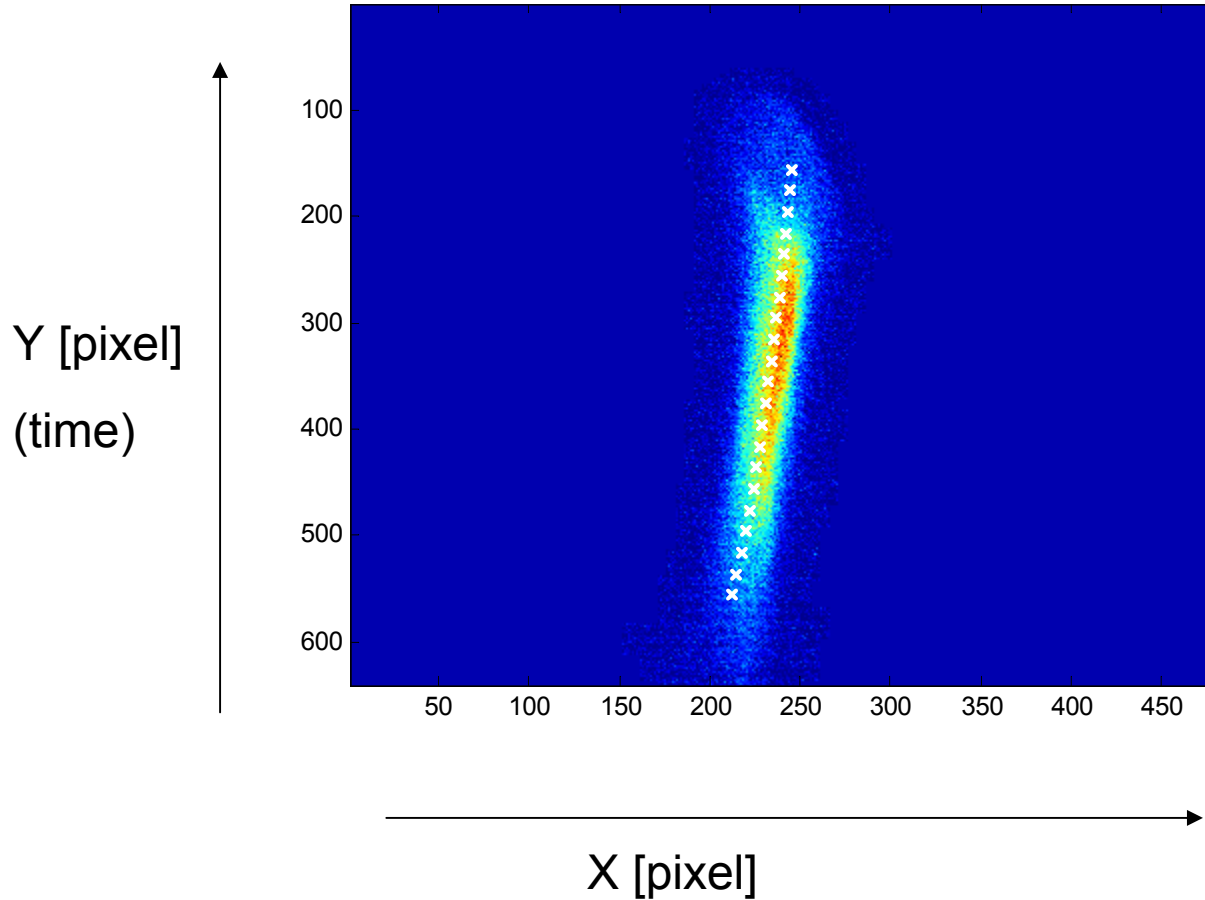


Reason for deviating slice emittance:

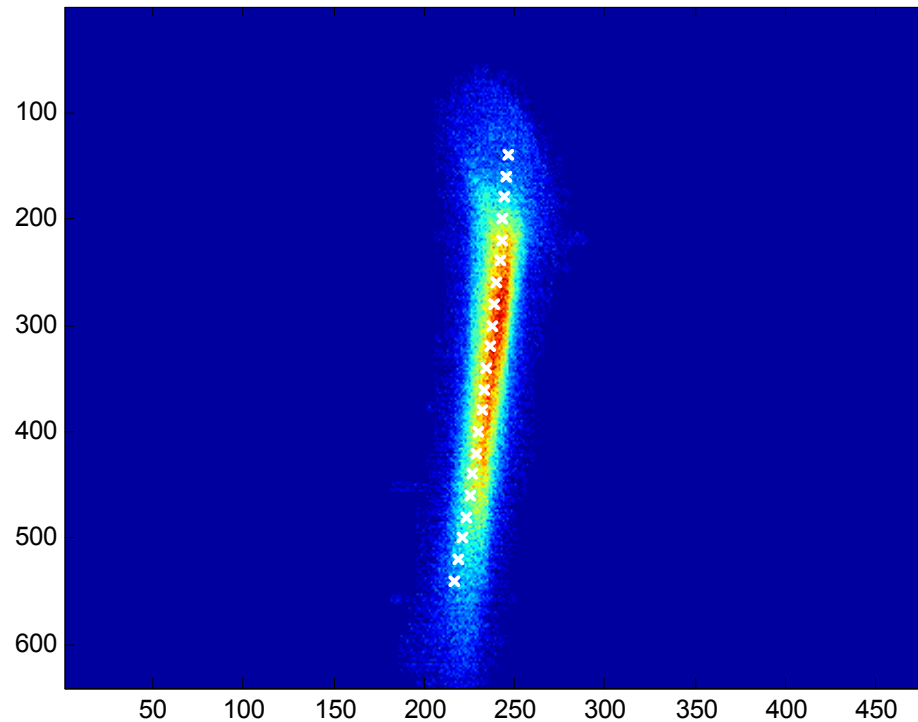
- higher resolution ?
- error in transfer matrix ?



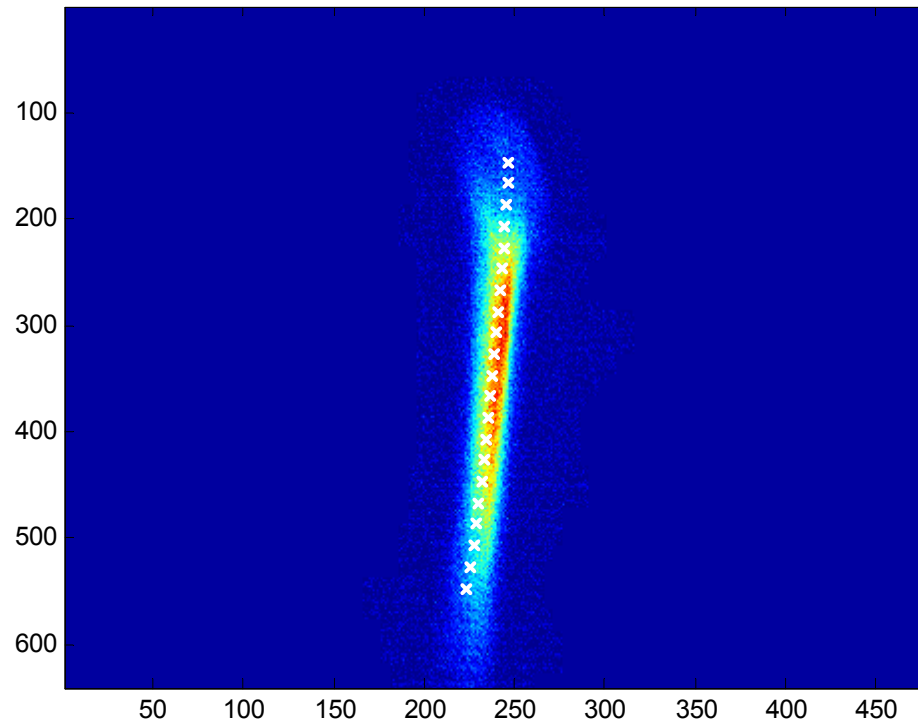
# Tilt in (x,z)-plane during a quadrupole scan (optics 2)



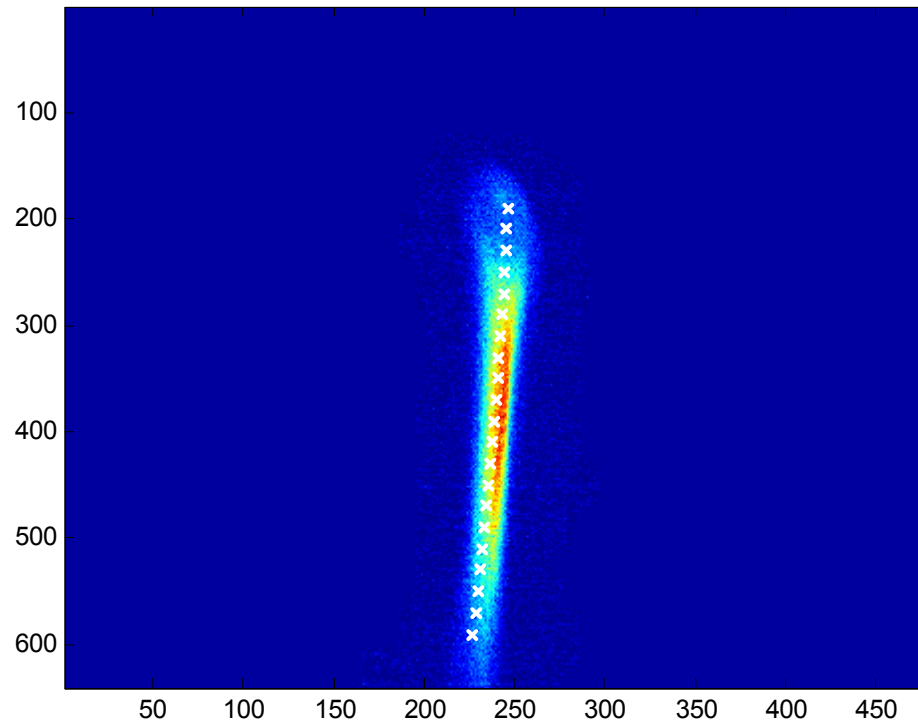
# Tilt in (x,z)-plane during a quadrupole scan (optics 2)



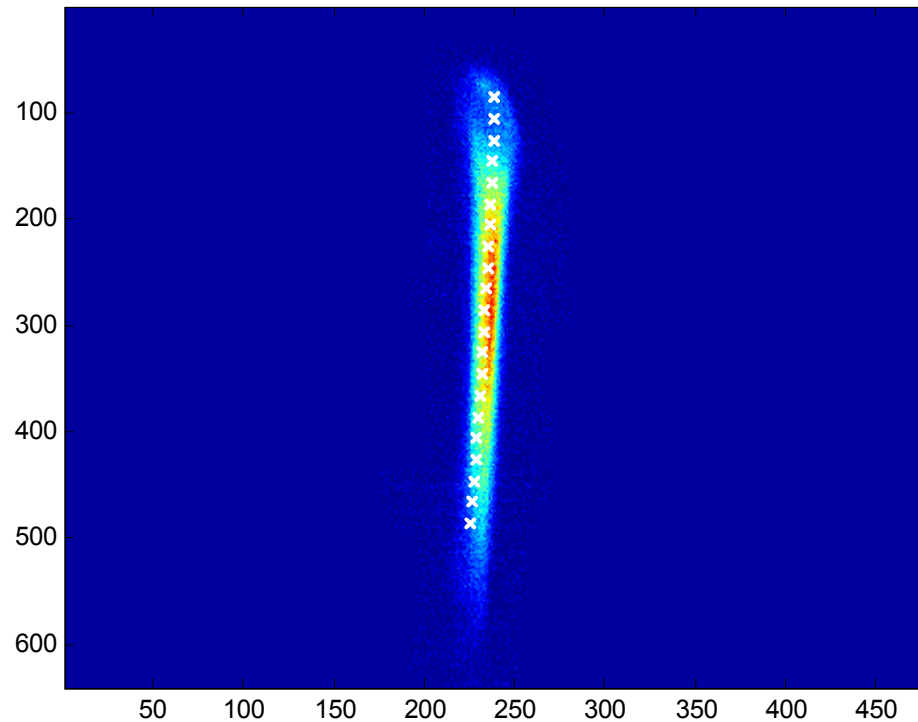
# Tilt in (x,z)-plane during a quadrupole scan (optics 2)



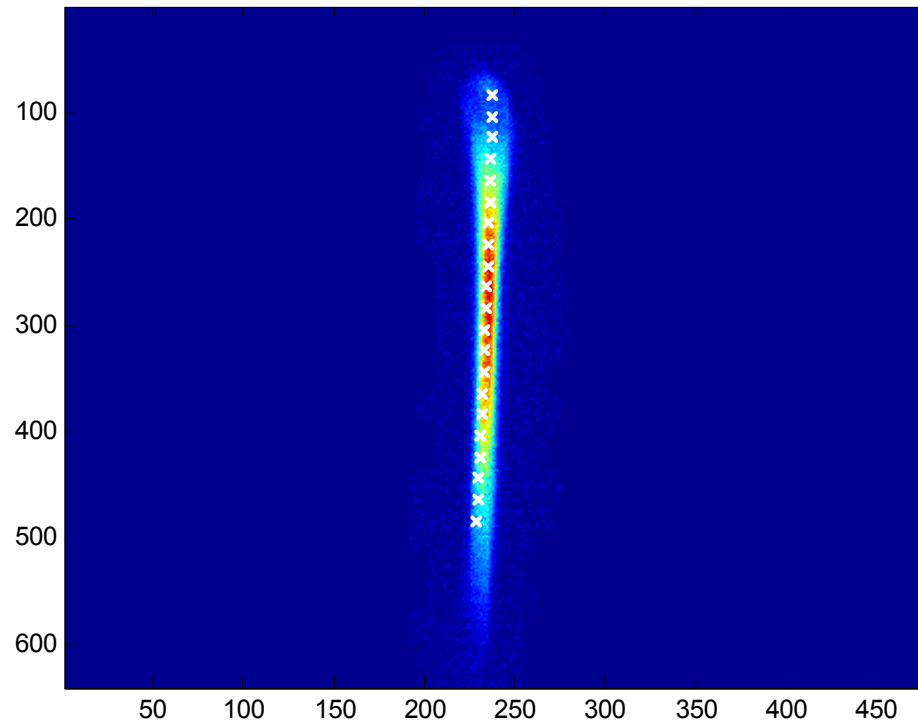
# Tilt in (x,z)-plane during a quadrupole scan (optics 2)



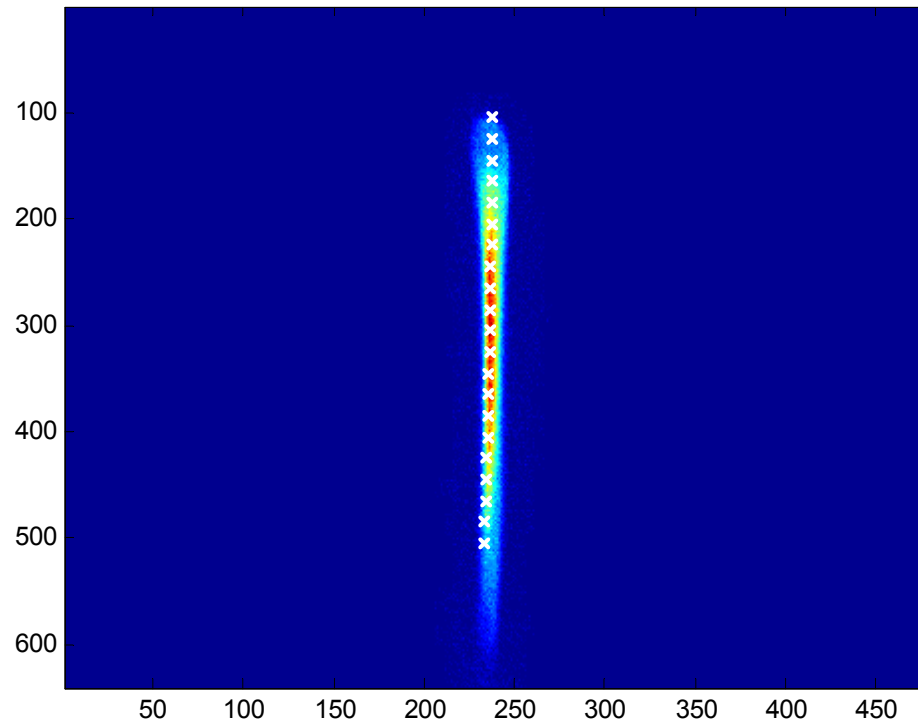
# Tilt in (x,z)-plane during a quadrupole scan (optics 2)



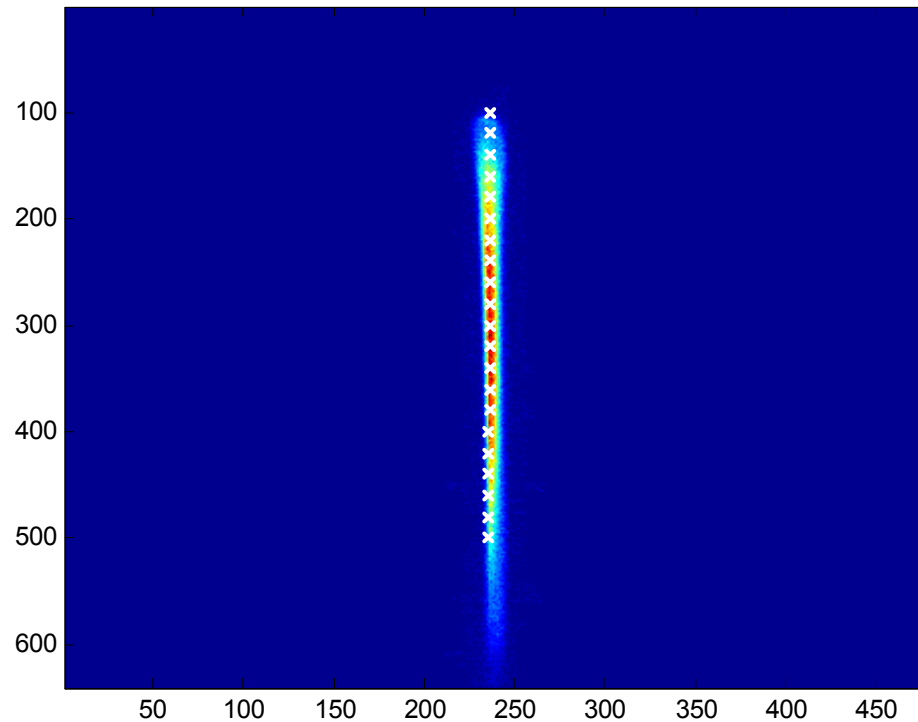
# Tilt in (x,z)-plane during a quadrupole scan (optics 2)



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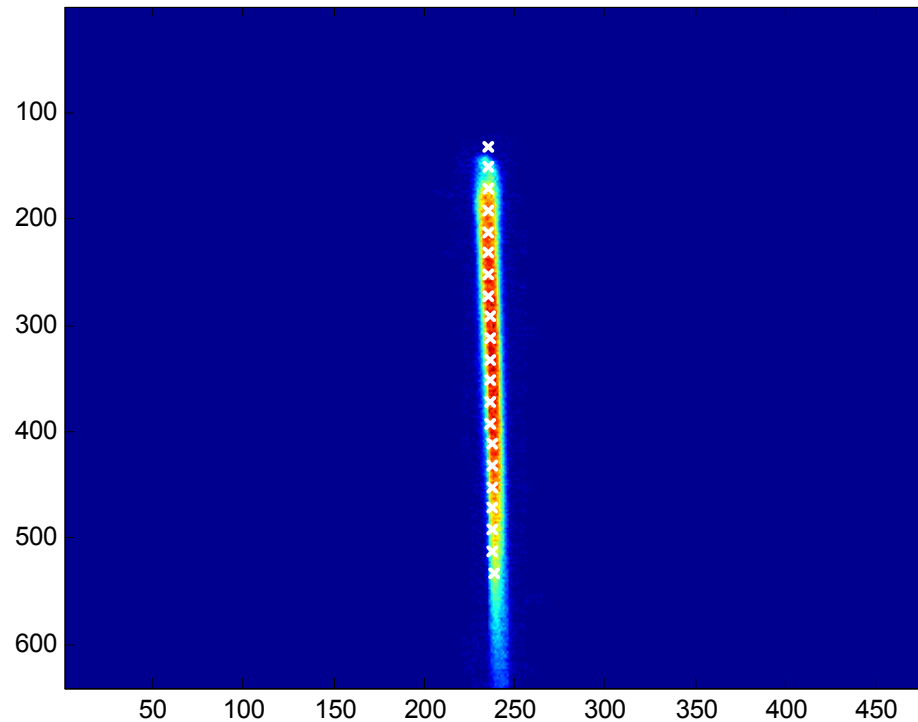


# Tilt in (x,z)-plane during a quadrupole scan (optics 2)

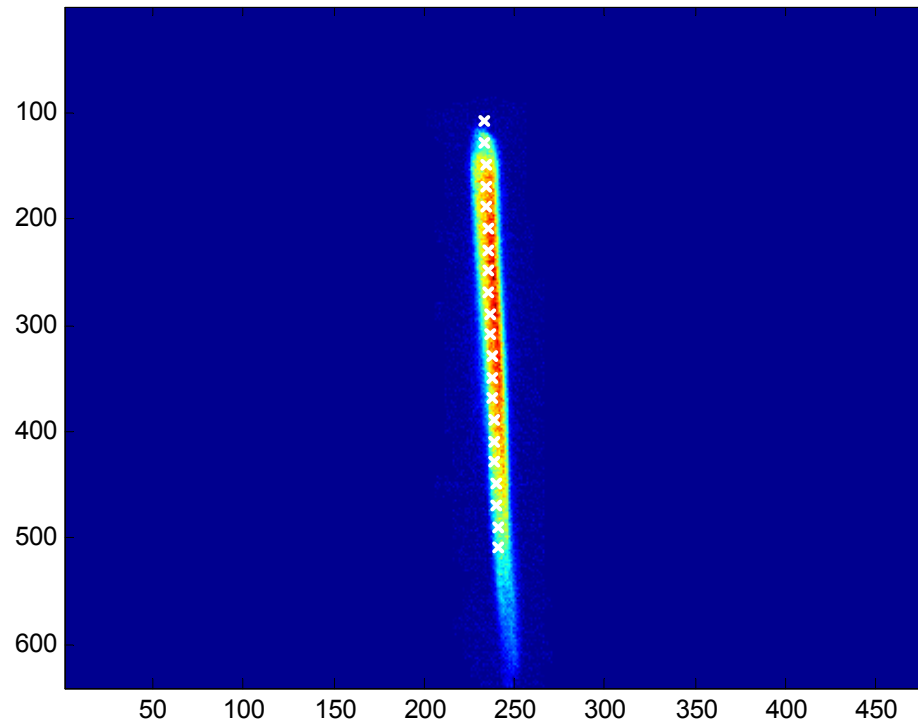




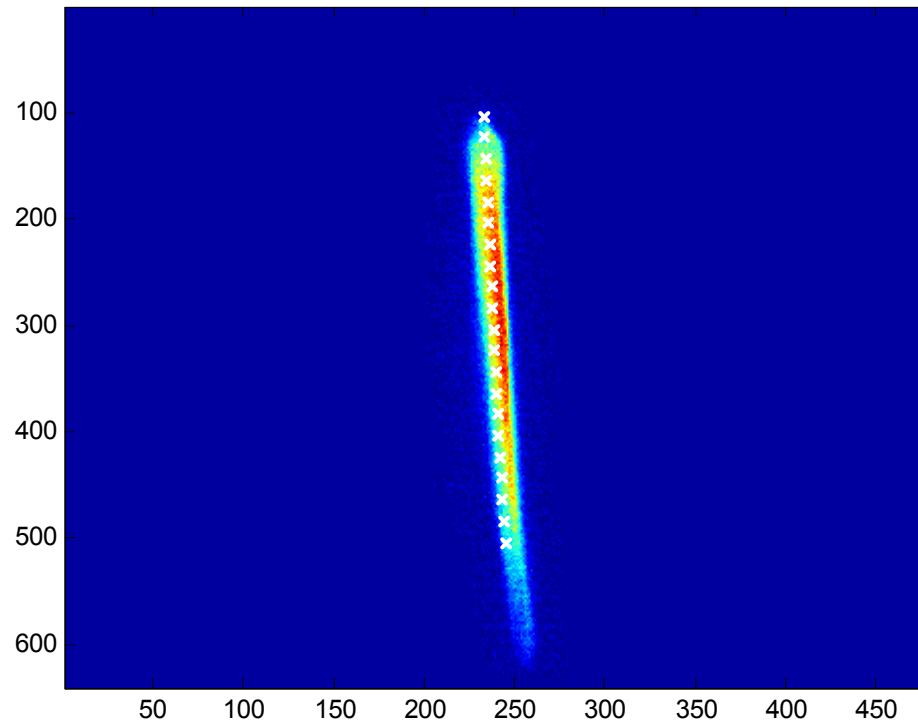
# Tilt in (x,z)-plane during a quadrupole scan (optics 2)



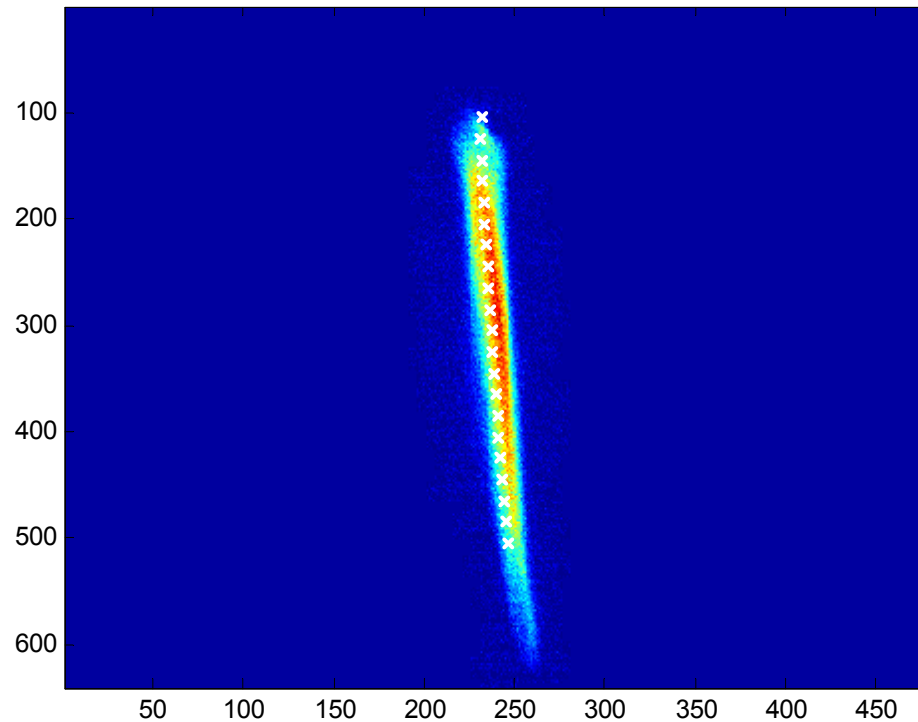
# Tilt in (x,z)-plane during a quadrupole scan (optics 2)



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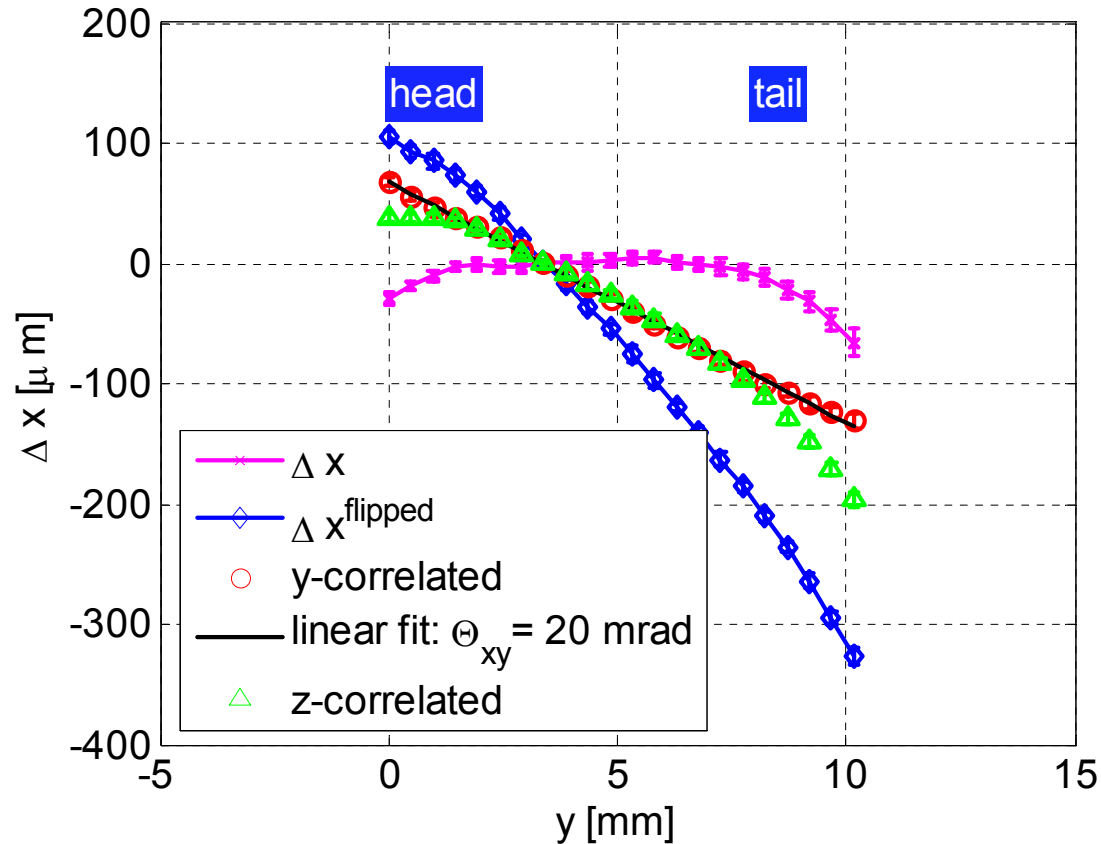
# Possible Sources for tilts measured via LOLA

- Rotation of LOLA
- ~~Rotation of Q9ACC7~~
- Rotation of the Camera-system
- XY-coupling
- ~~Sextupole components of Q9ACC7~~
- Transverse wake fields in cavities / in LOLA
- ~~Dispersion (off-crest)~~
- RF-Coupler kicks
- ~~RF-focusing (off-crest)~~
- ~~RF-Acceleration (off-crest)~~
- ~~RF fringe fields in cavities (off-crest)~~
- ~~Field errors within LOLA~~

**y-correlated  
sources**

**z-correlated  
sources**

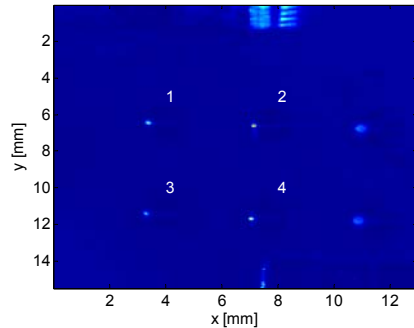
# Measurement of y- and z-correlated contributions by flipping the phase of LOLA



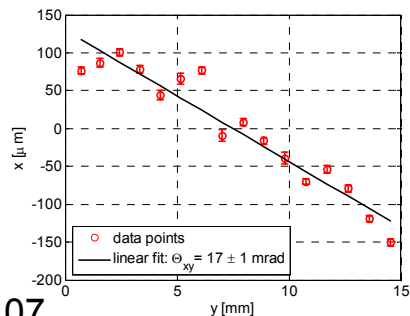
# Rotation of the camera / of LOLA

## Rotation of the camera:

- With respect to the screen holder:  
~19 mrad

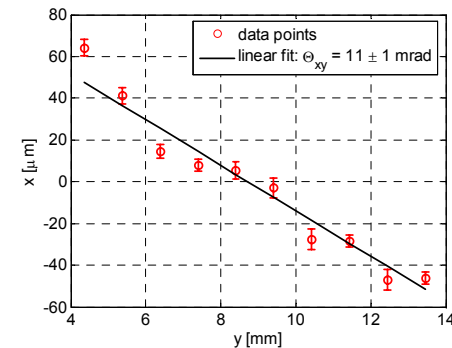


- With respect to V10ACC7 (vertical steerer): ~17 mrad



## Rotation of the camera and LOLA:

- LOLA-phase-flip: 11- 21 mrad
- Scan of LOLA-phase: 11- 17 mrad

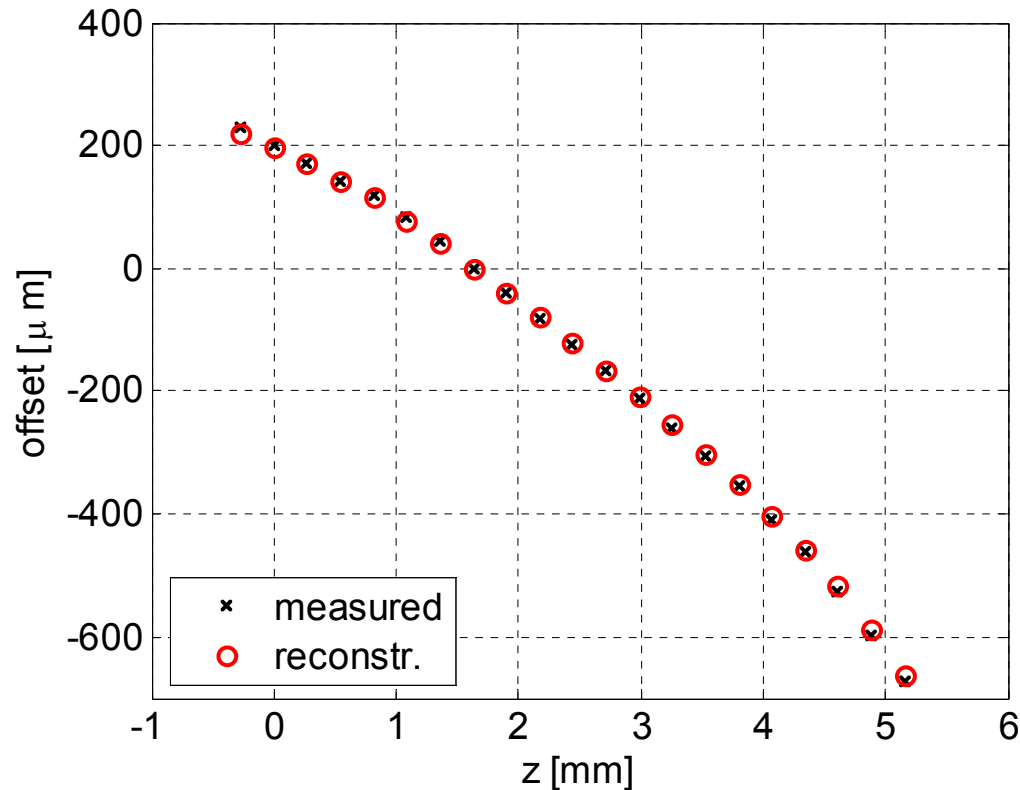


→ Rotation of the camera of ~ 1°

→ Rotation of LOLA < 10 mrad

# z-correlated tilt during a quadrupole scan

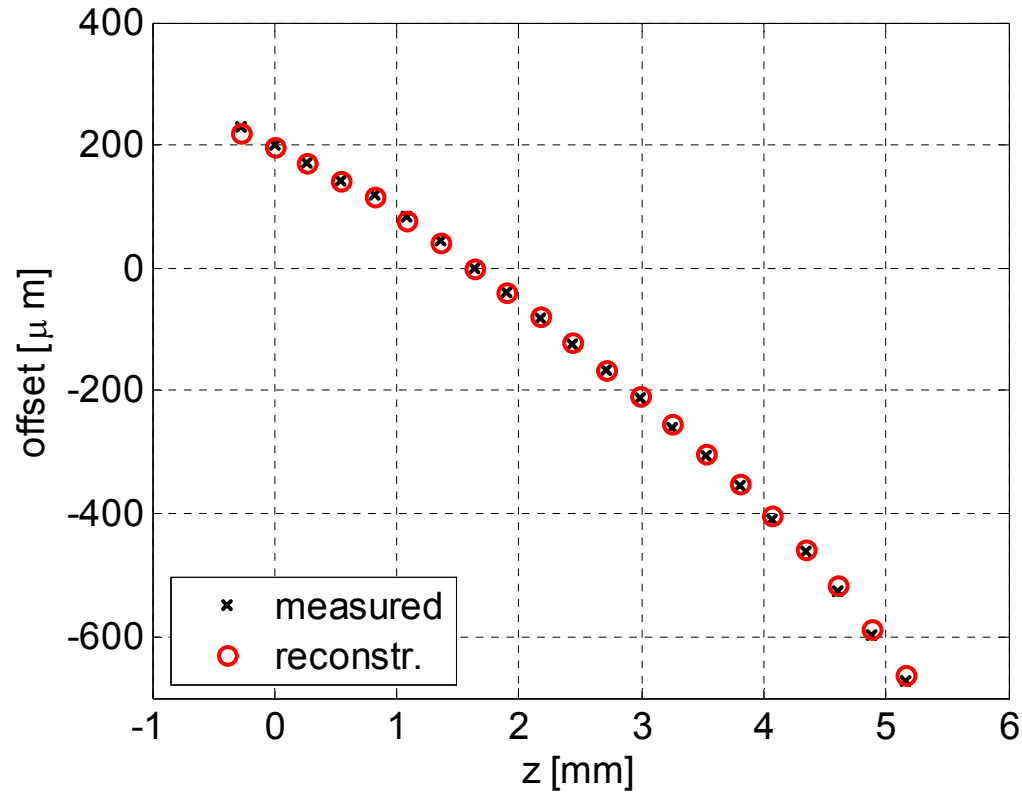
Scan of Q10ACC6 (slice emittance measurement, optics 2)



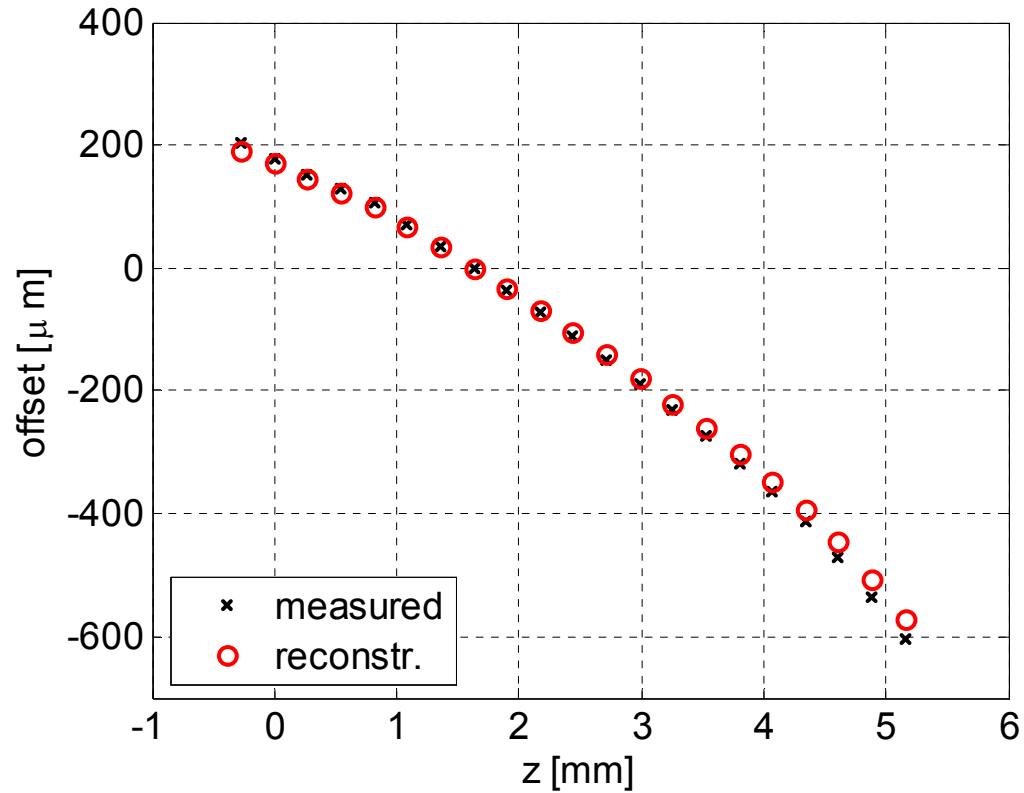
→ Tilt (in this case) generated upstream of Q10ACC6!



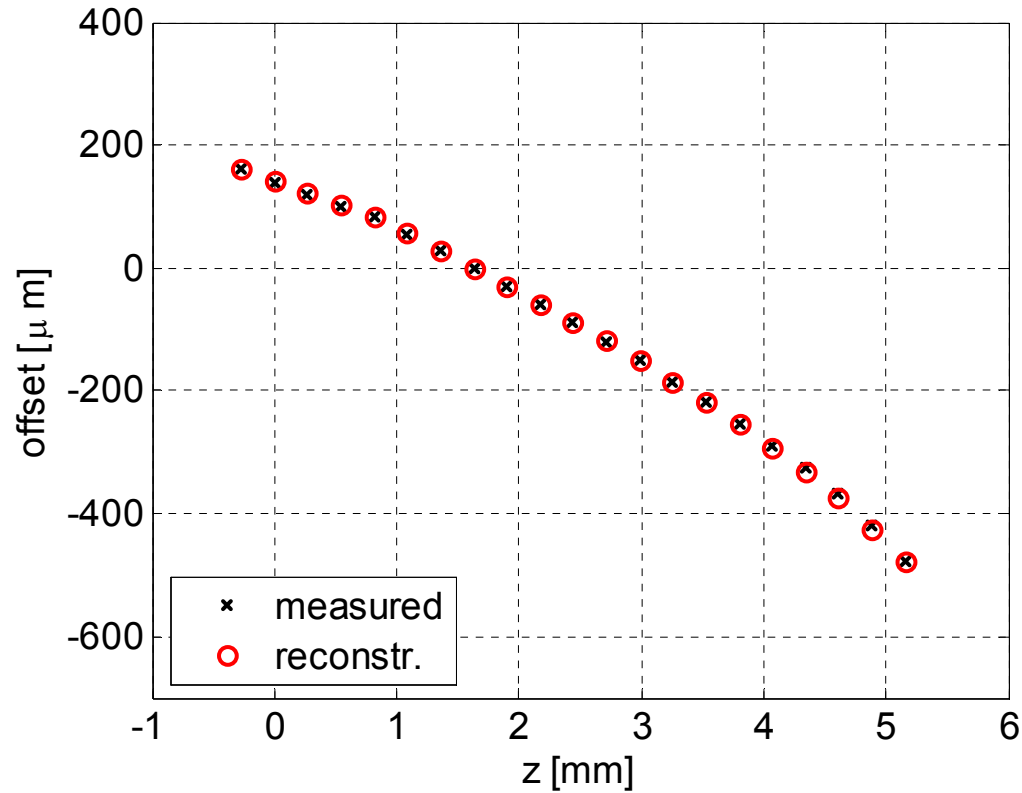
# z-correlated tilt during a quadrupole scan



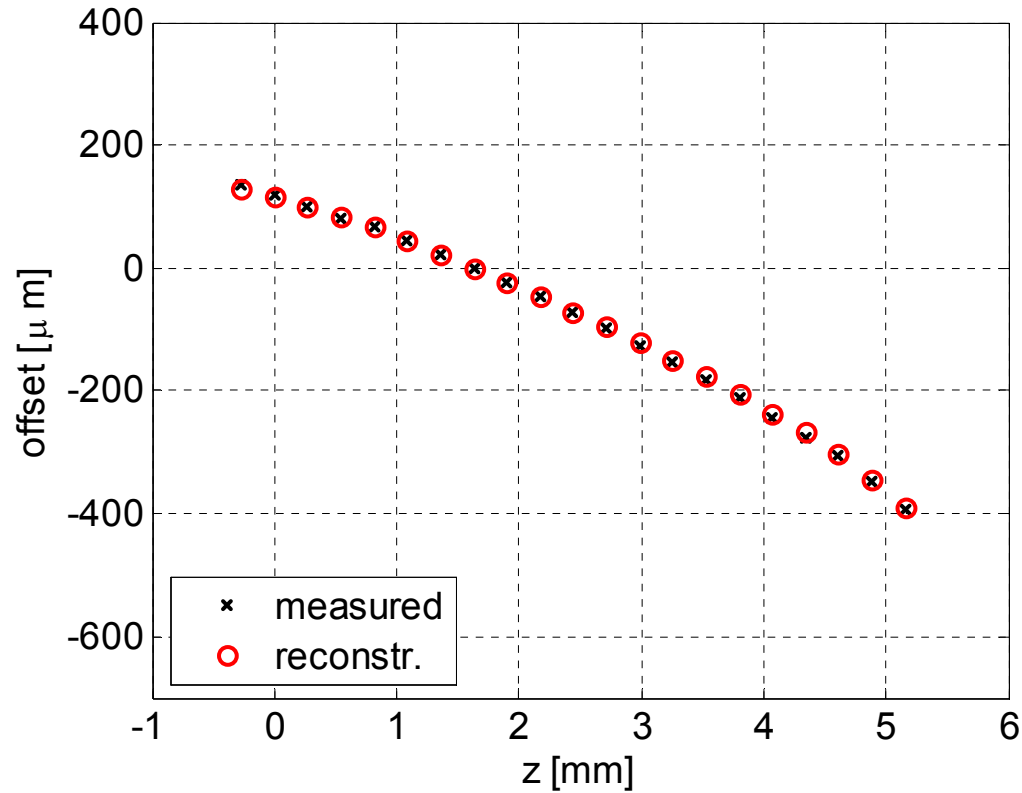
# z-correlated tilt during a quadrupole scan



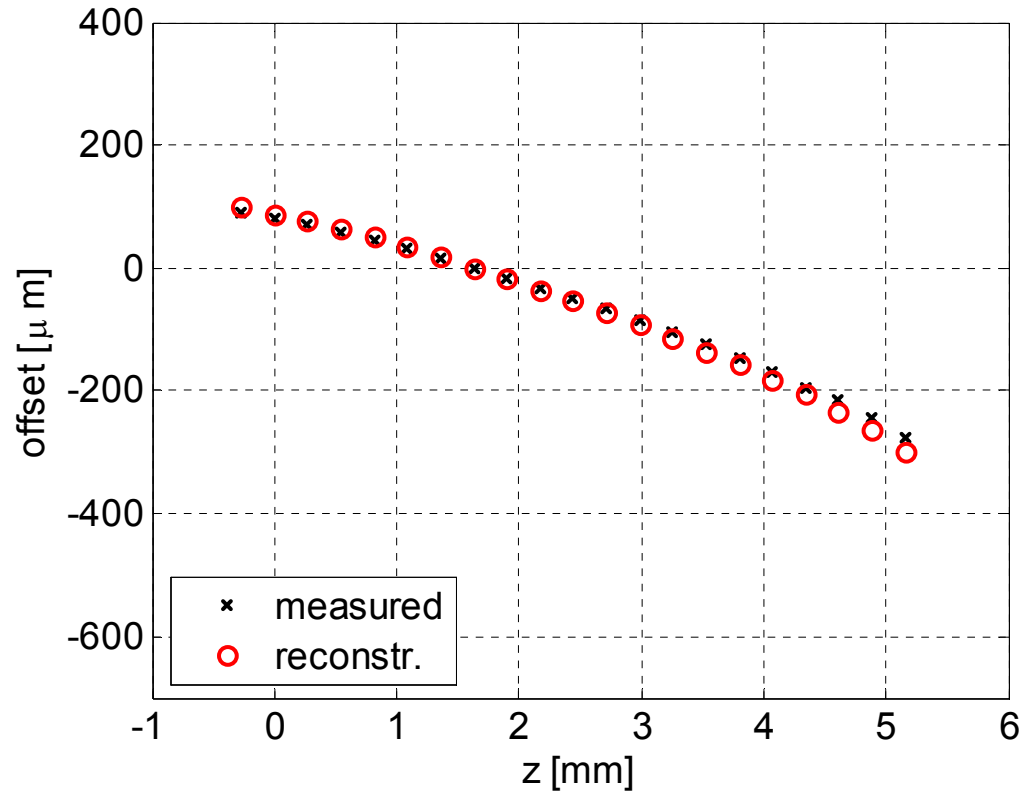
# z-correlated tilt during a quadrupole scan



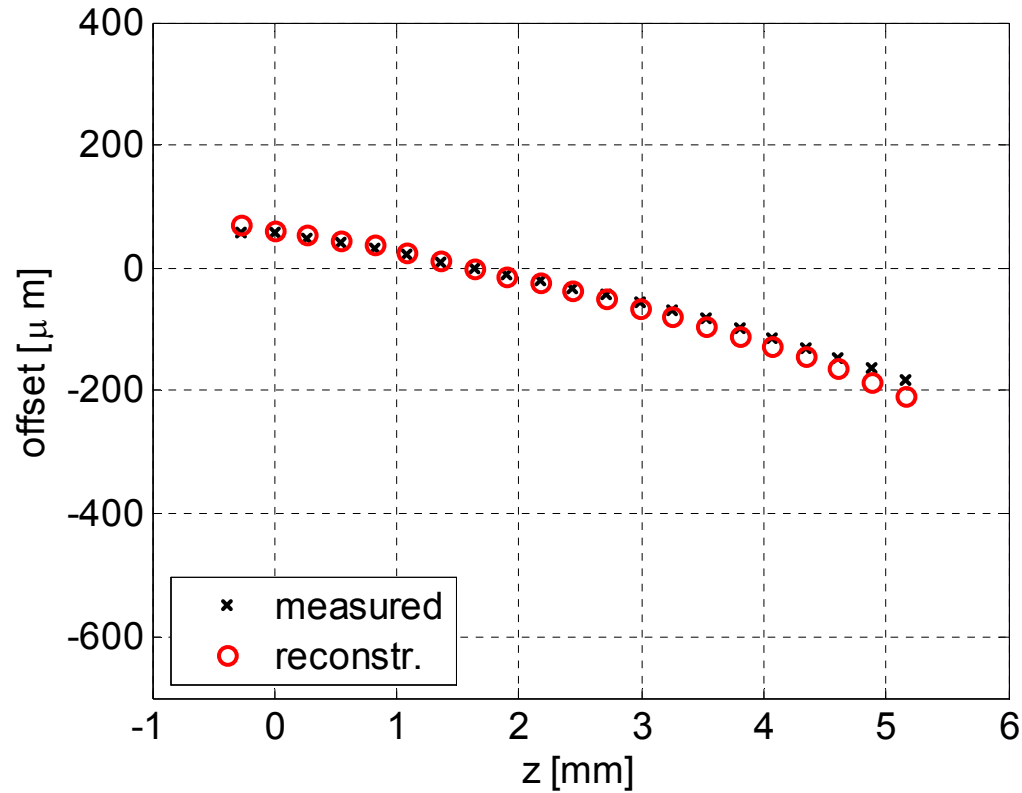
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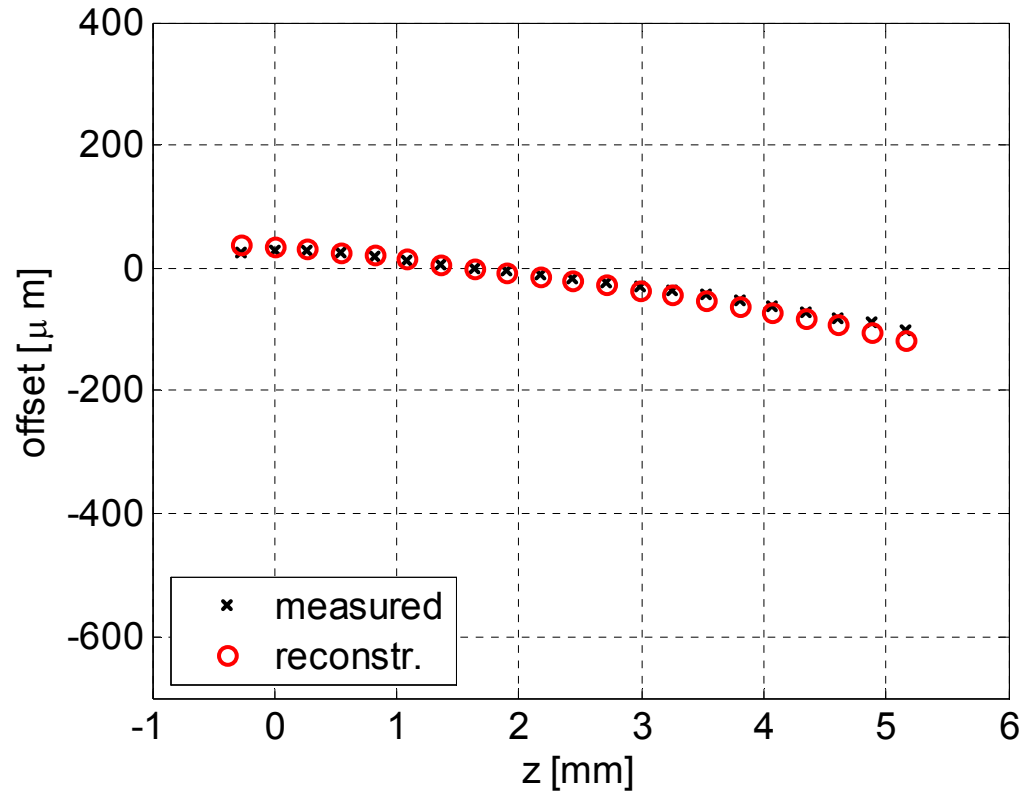
# z-correlated tilt during a quadrupole scan



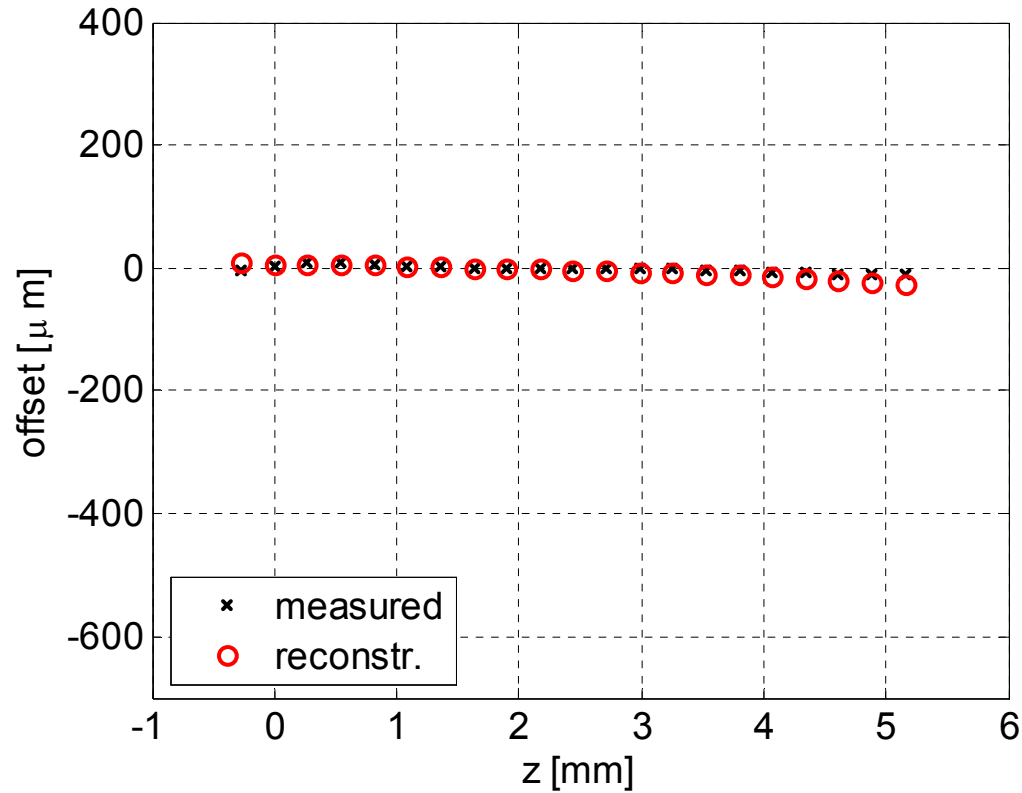
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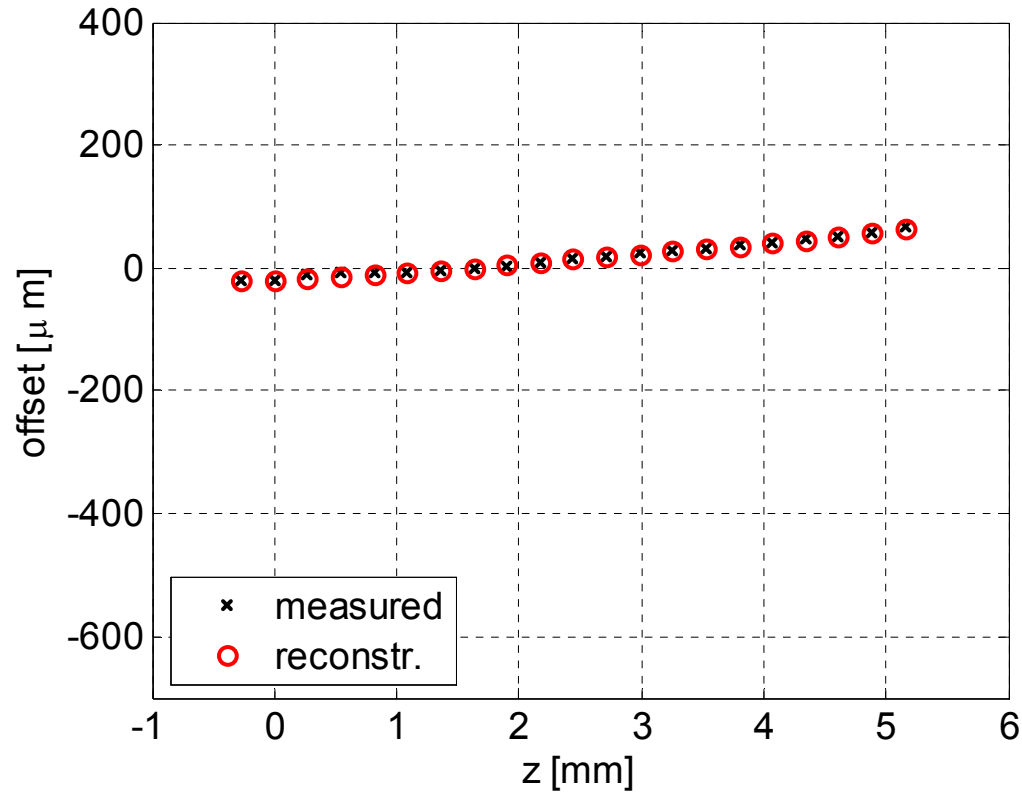


# z-correlated tilt during a quadrupole scan

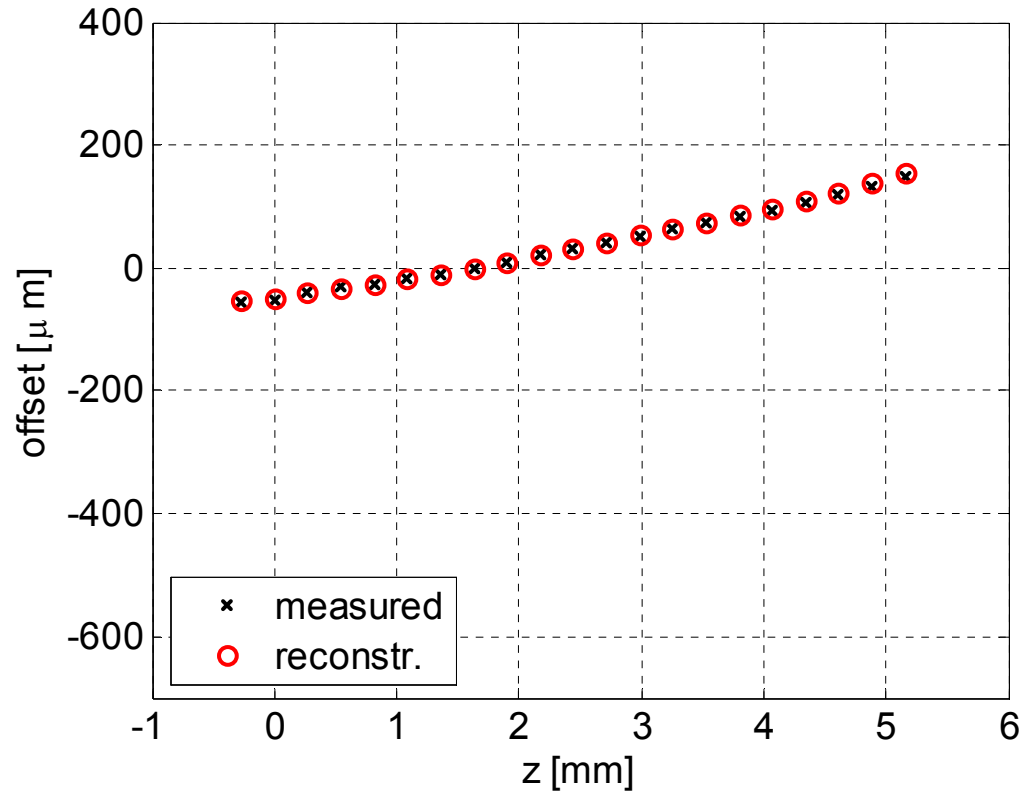




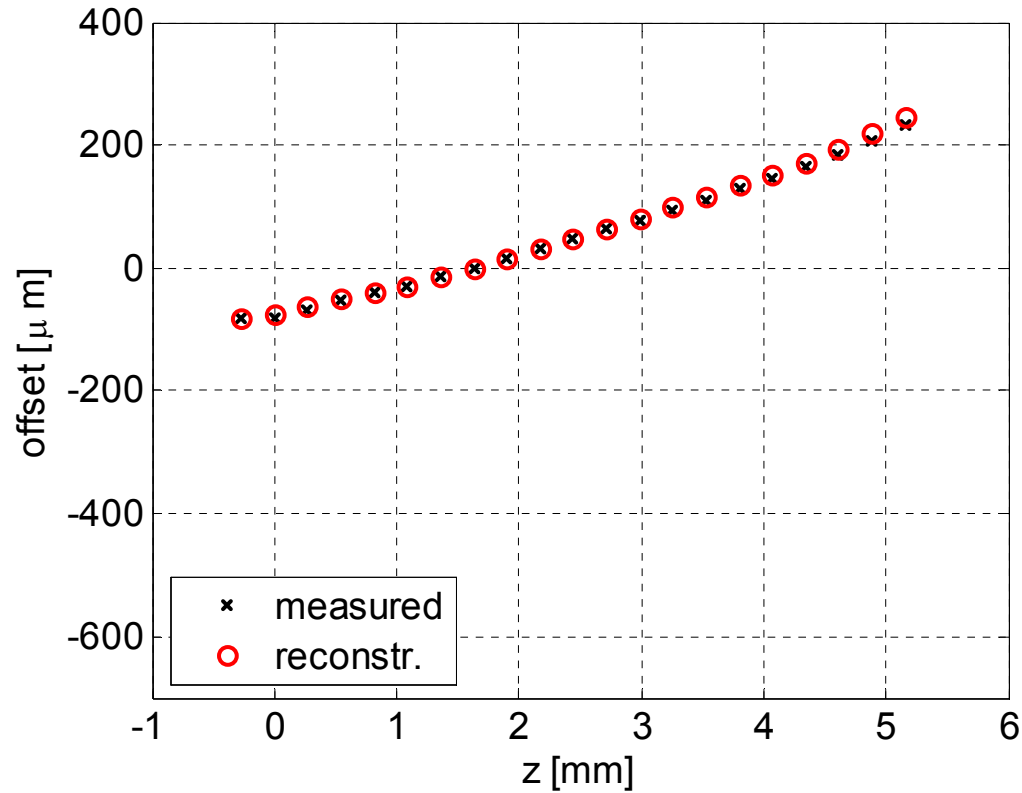
# z-correlated tilt during a quadrupole scan



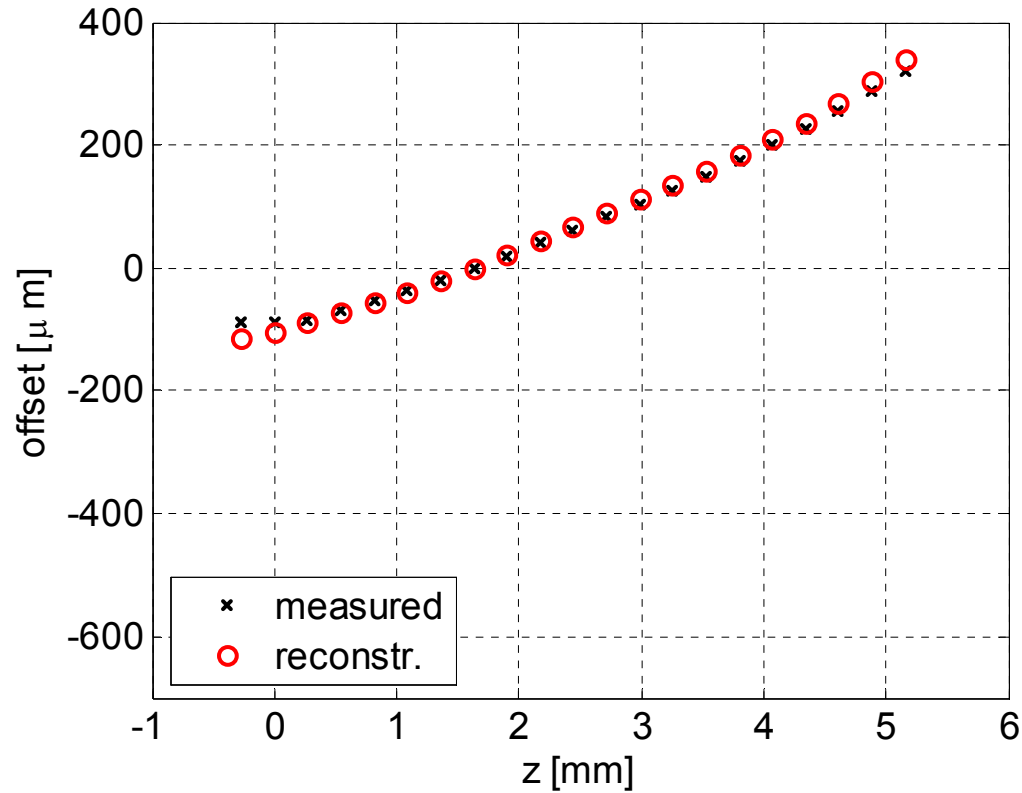
# z-correlated tilt during a quadrupole scan



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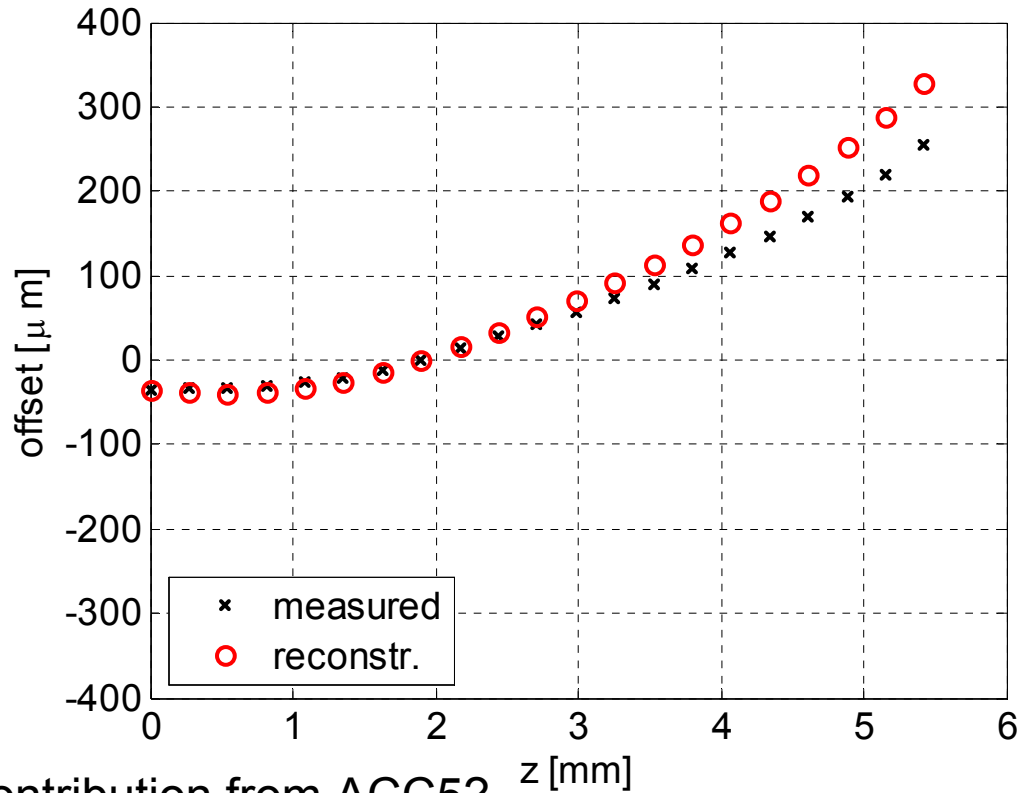


# z-correlated tilt during a quadrupole scan

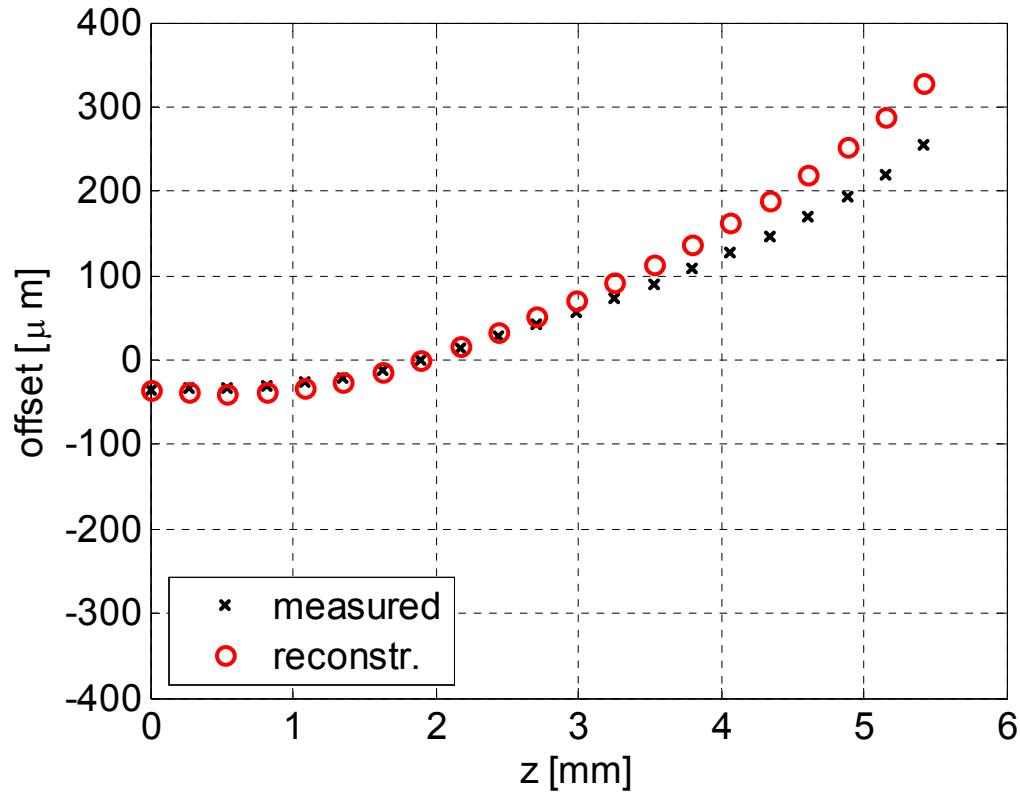


# z-correlated tilt during a multi- quadrupole-scan

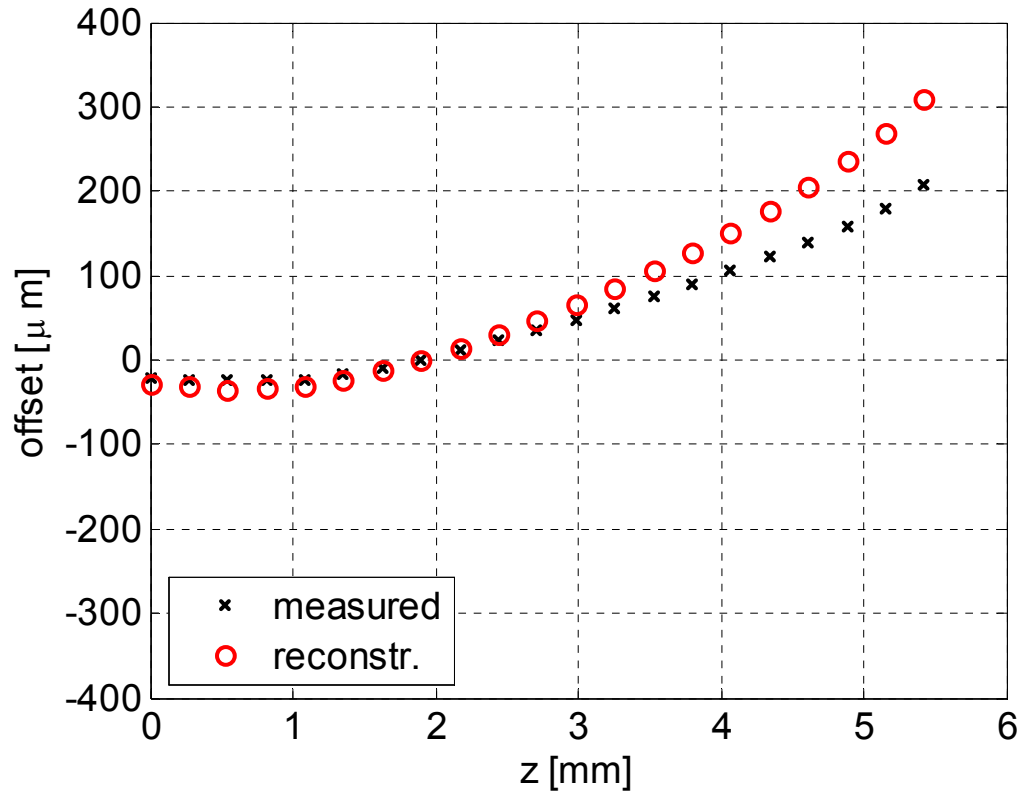
First quadrupole scanned: Q9ACC4, upstream of module ACC5!



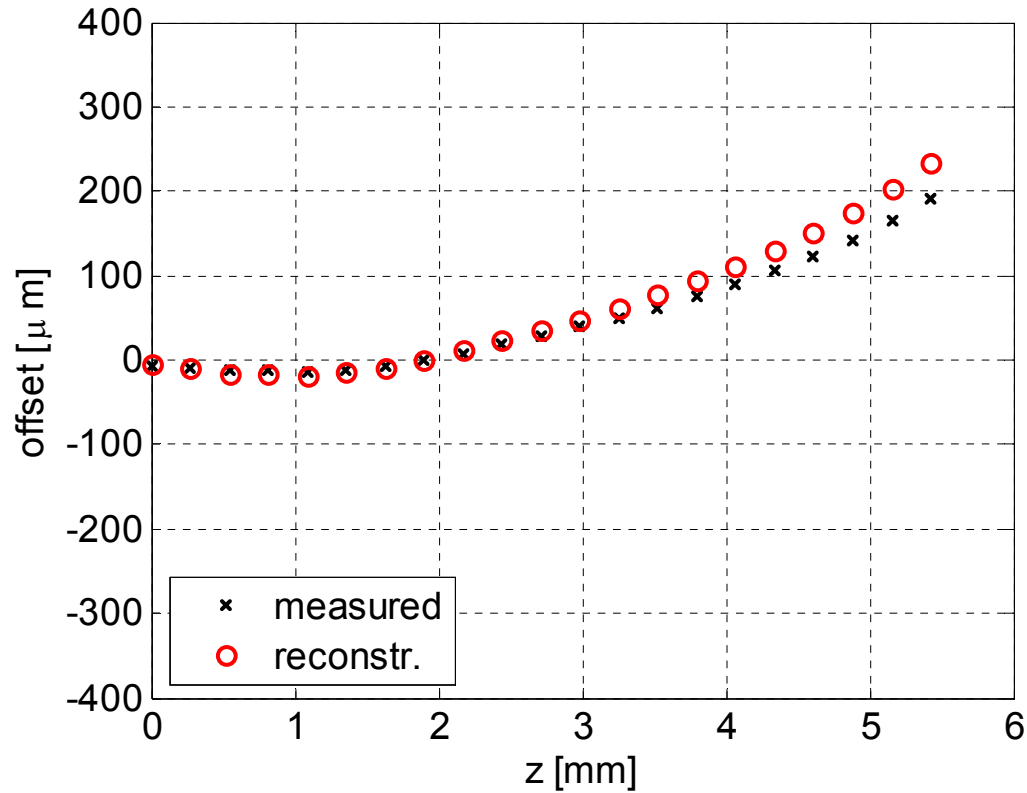
# z-correlated tilt during a multi- quadrupole-scan



# z-correlated tilt during a multi- quadrupole-scan

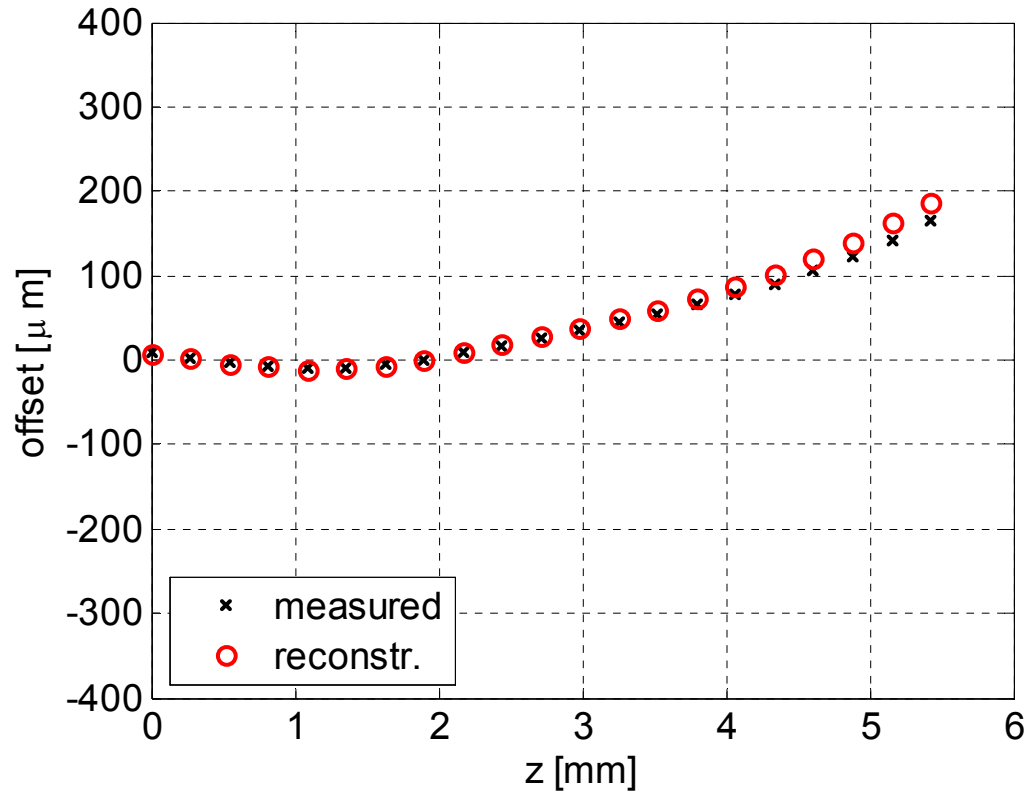


# z-correlated tilt during a multi- quadrupole-scan

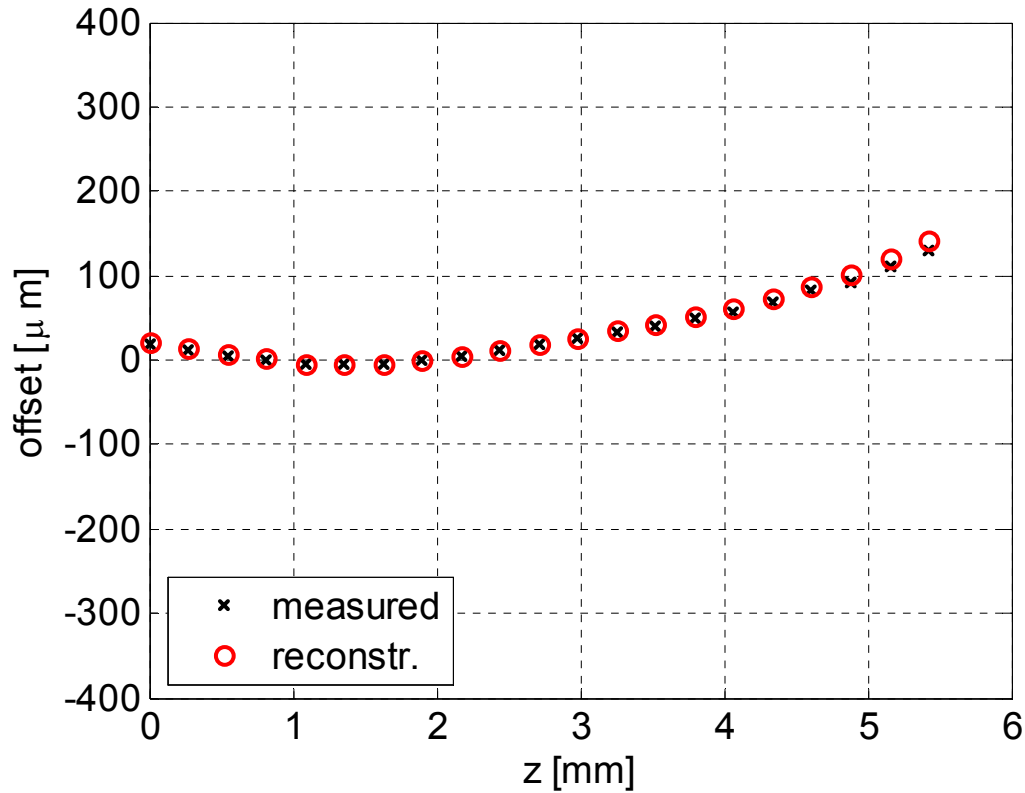




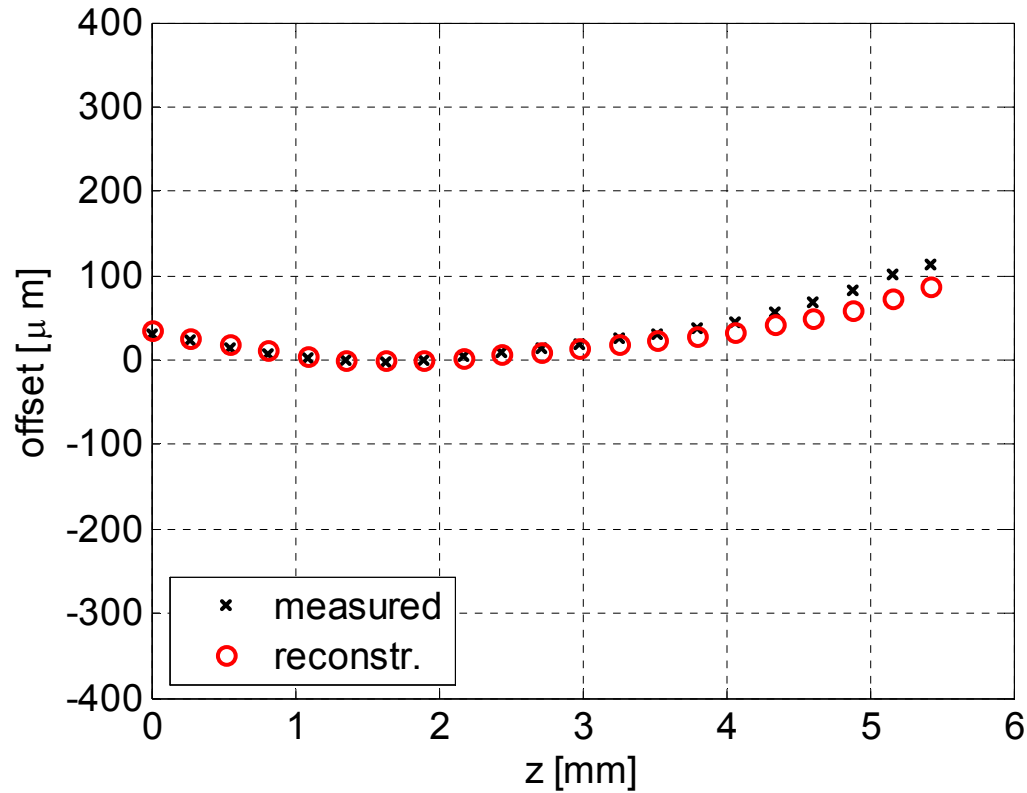
# z-correlated tilt during a multi- quadrupole-scan



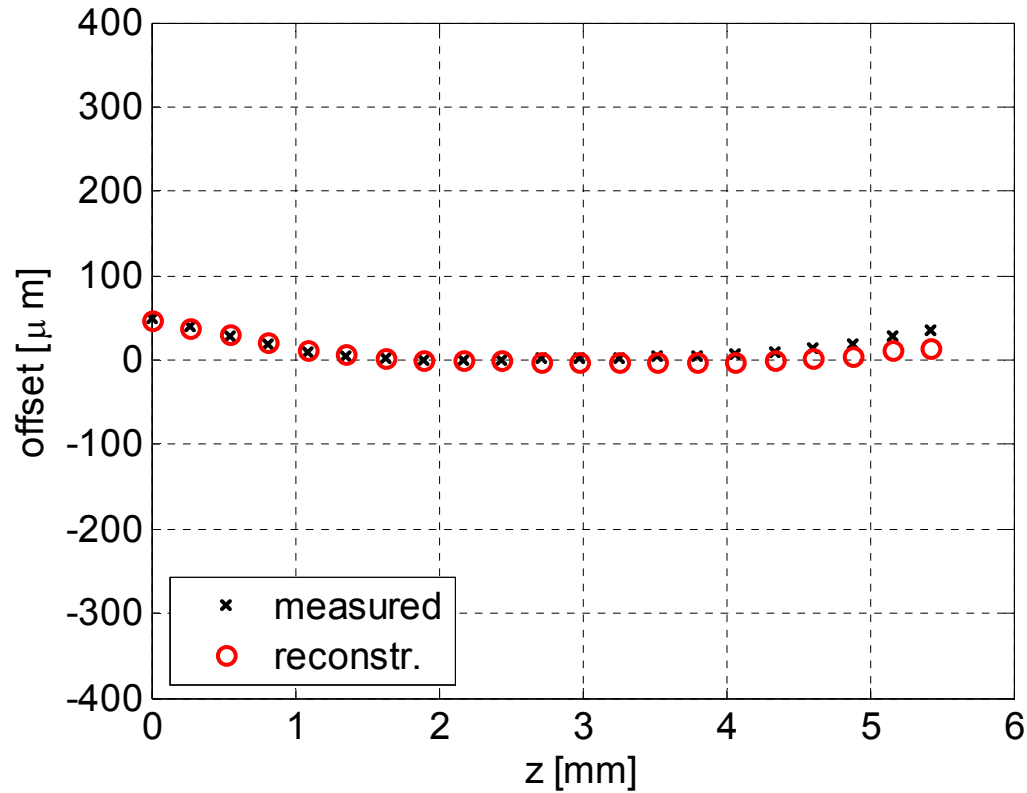
# z-correlated tilt during a multi- quadrupole-scan



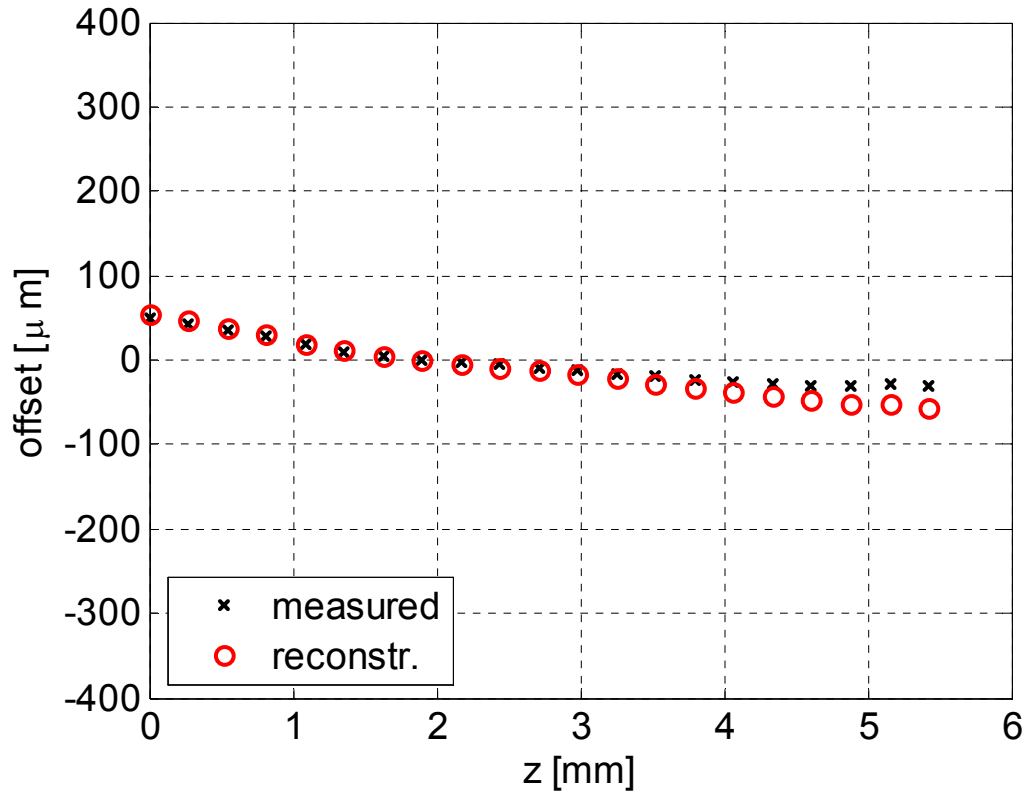
# z-correlated tilt during a multi- quadrupole-scan



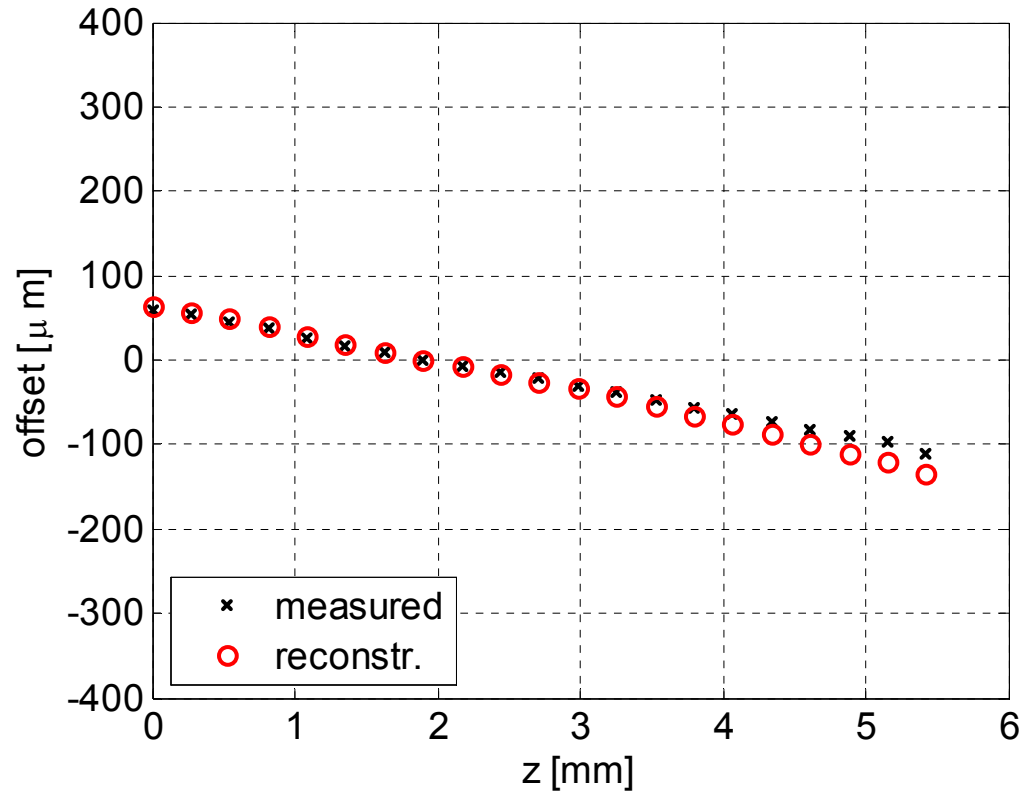
# z-correlated tilt during a multi- quadrupole-scan



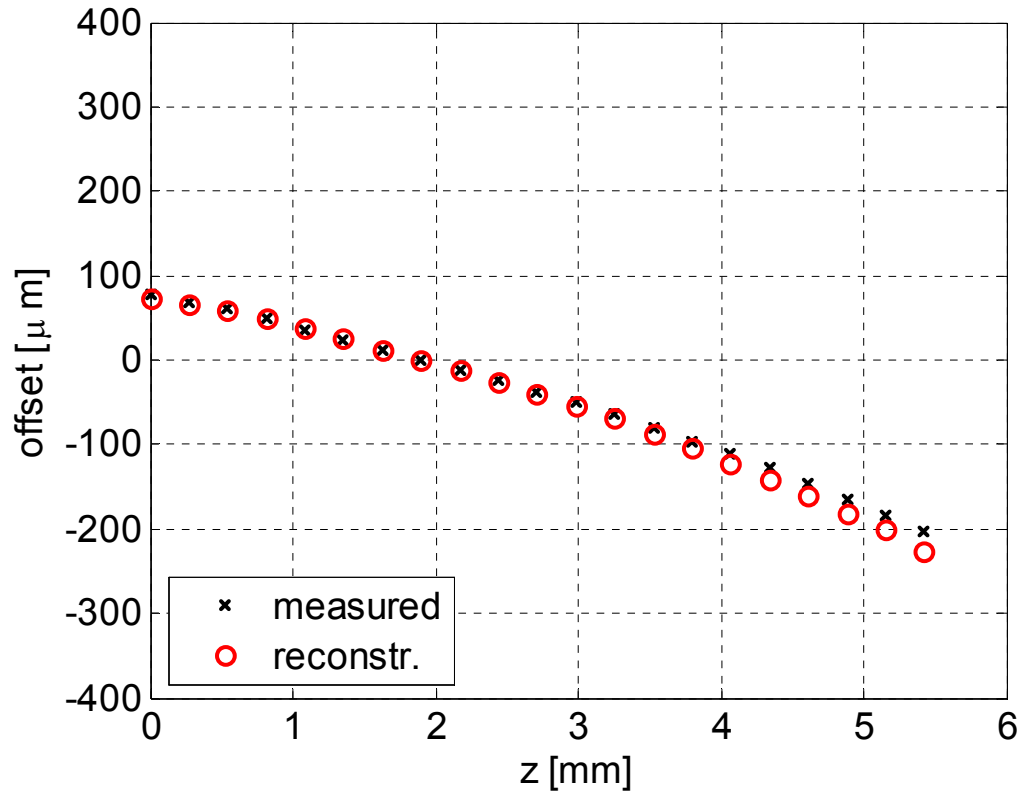
# z-correlated tilt during a multi- quadrupole-scan



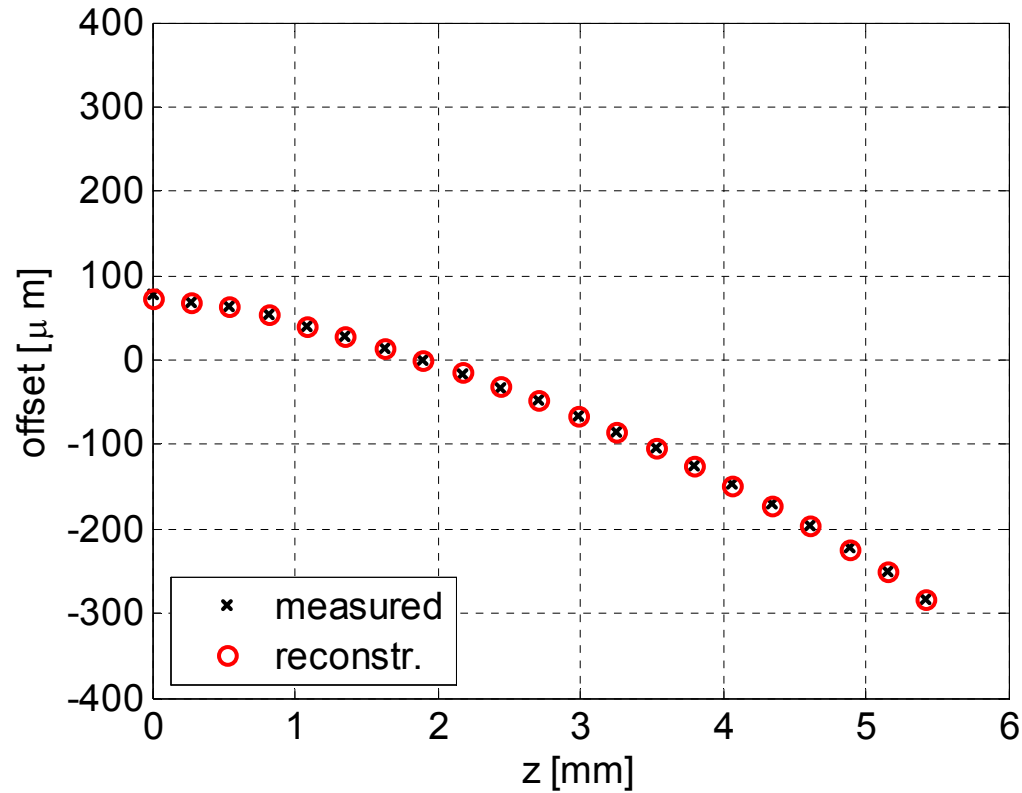
# z-correlated tilt during a multi- quadrupole-scan



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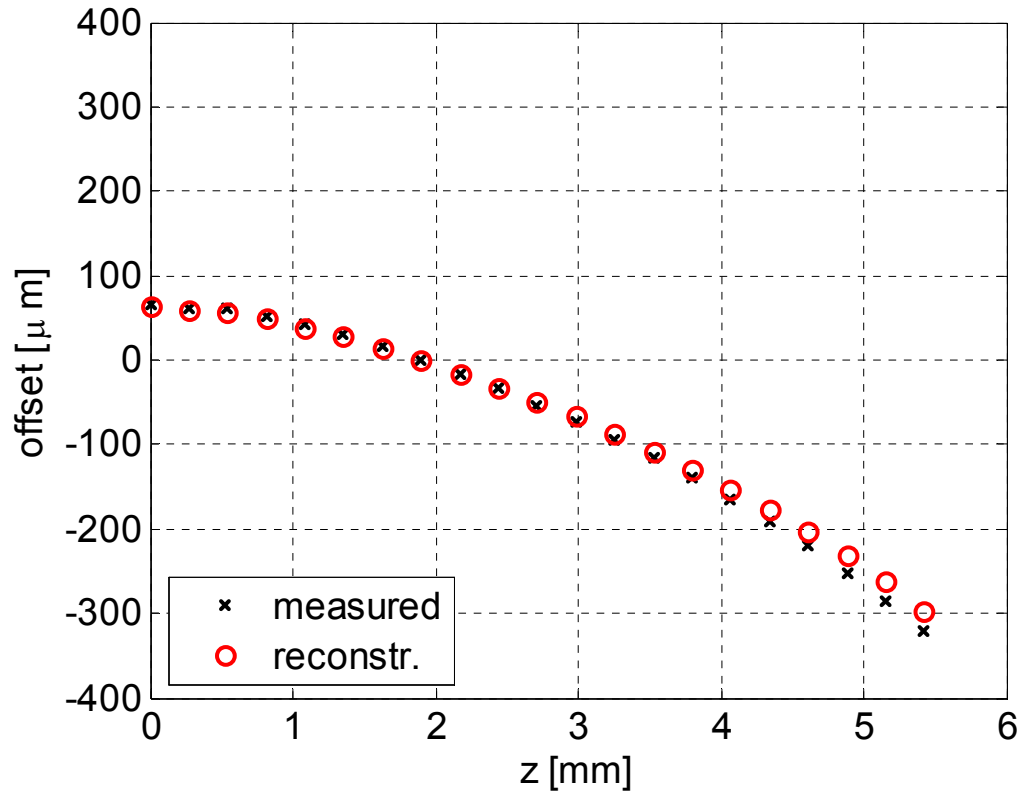


# z-correlated tilt during a multi- quadrupole-scan

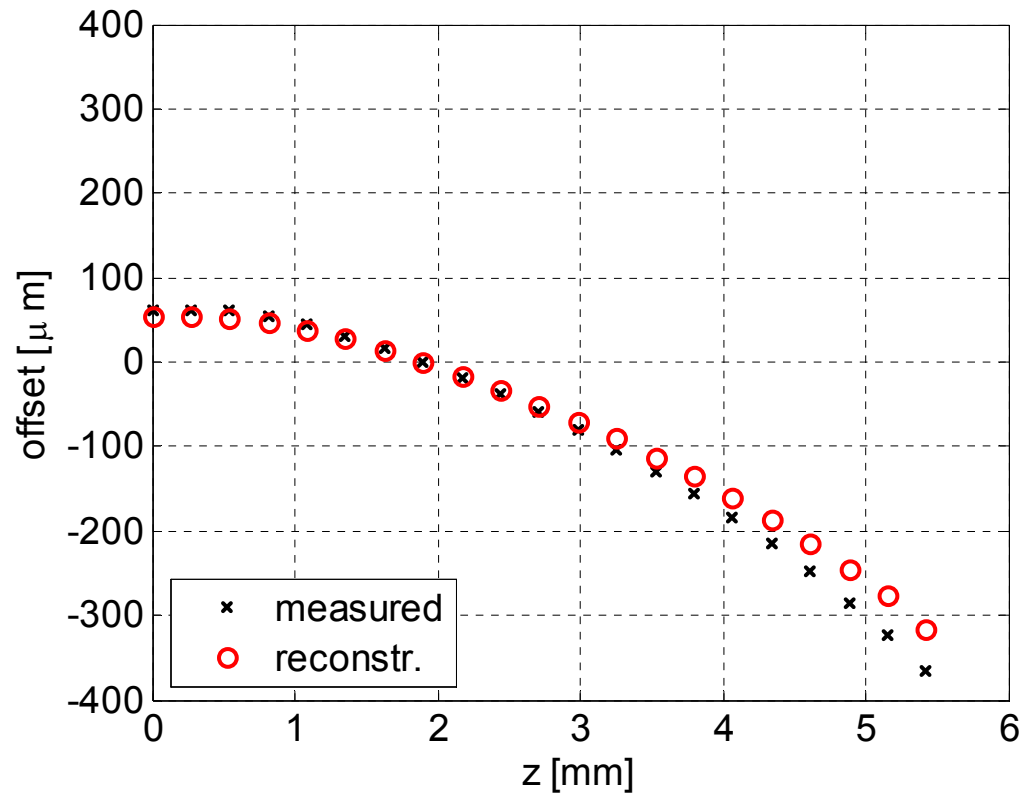




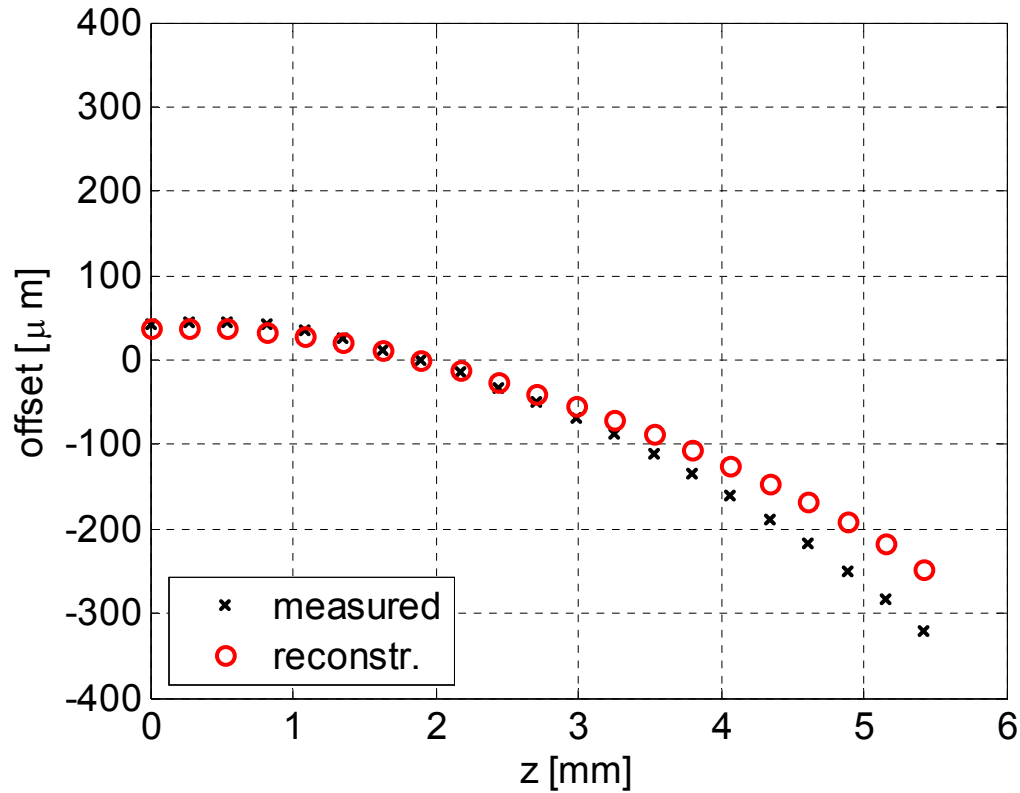
# z-correlated tilt during a multi- quadrupole-scan



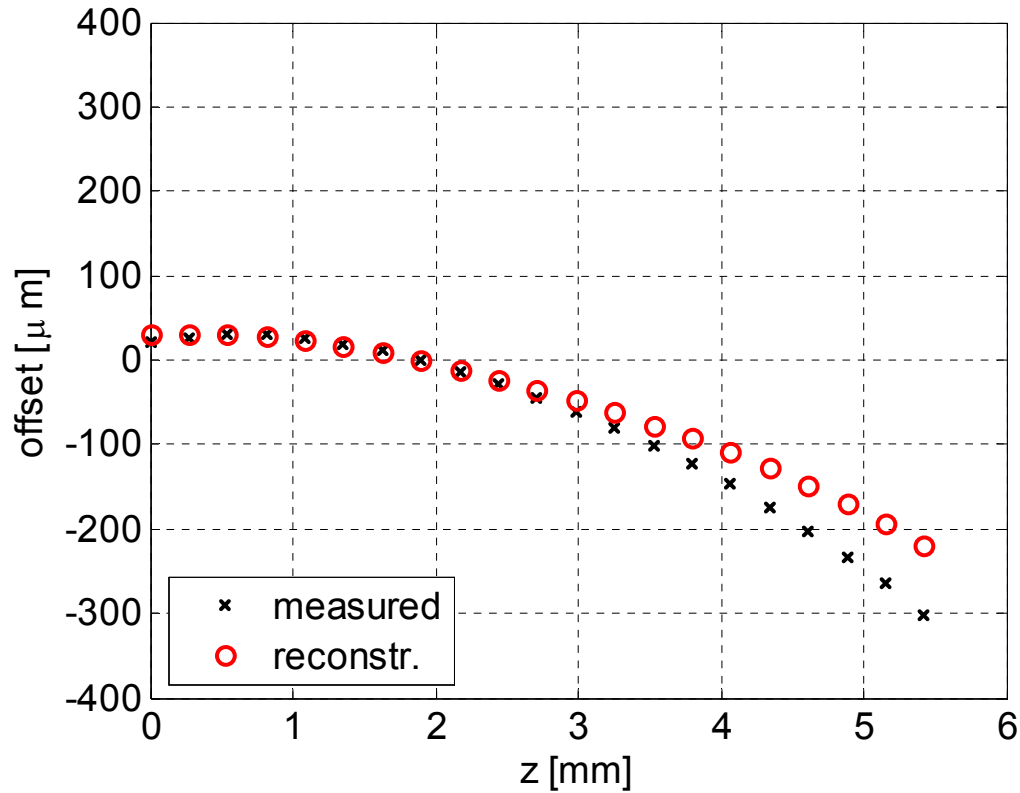
# z-correlated tilt during a multi- quadrupole-scan



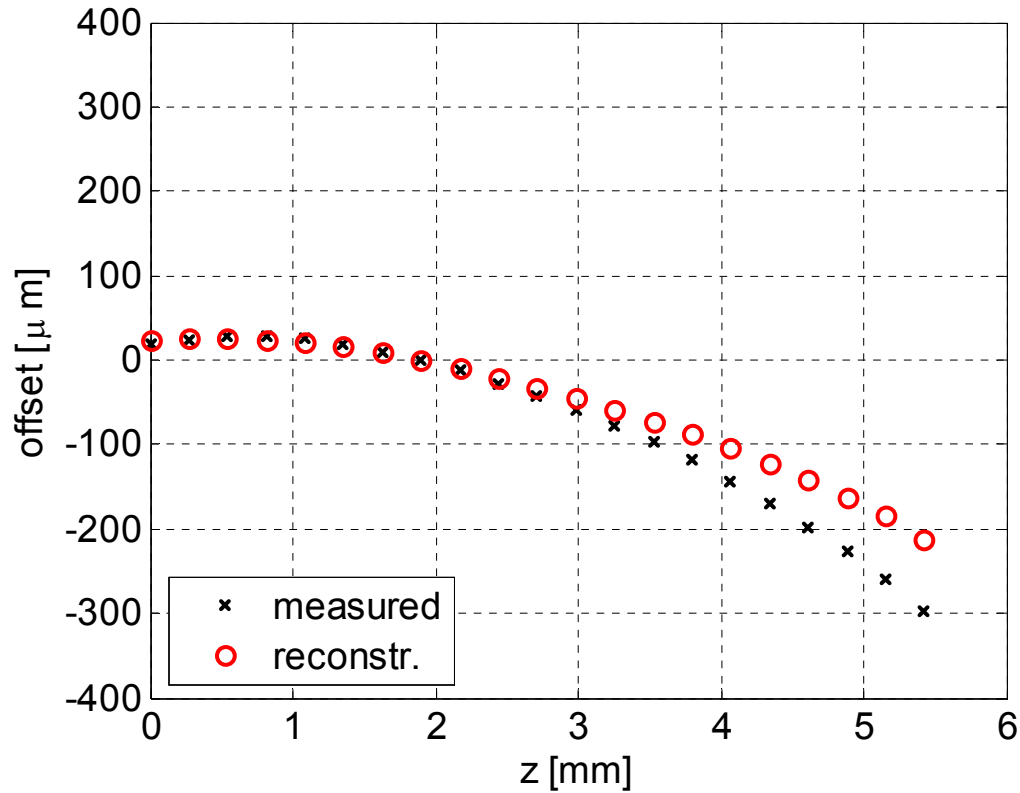
# z-correlated tilt during a multi- quadrupole-scan



# z-correlated tilt during a multi- quadrupole-scan

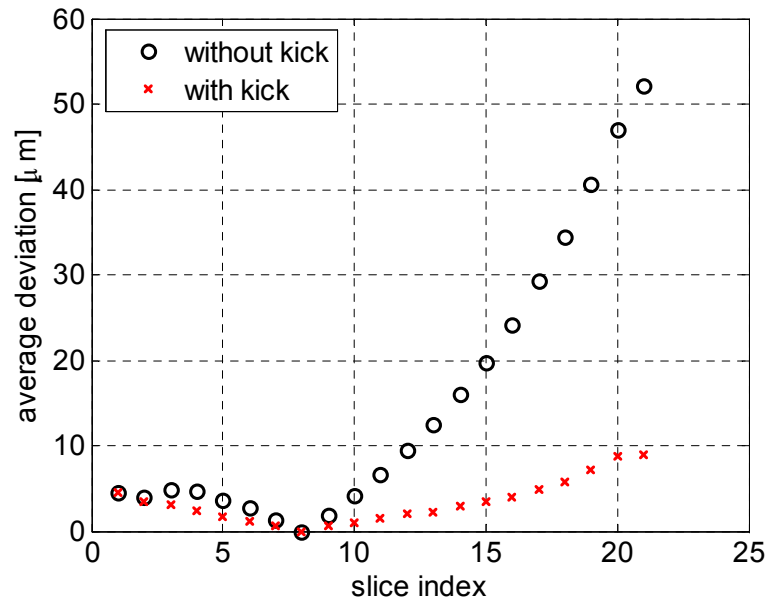


# z-correlated tilt during a multi- quadrupole-scan

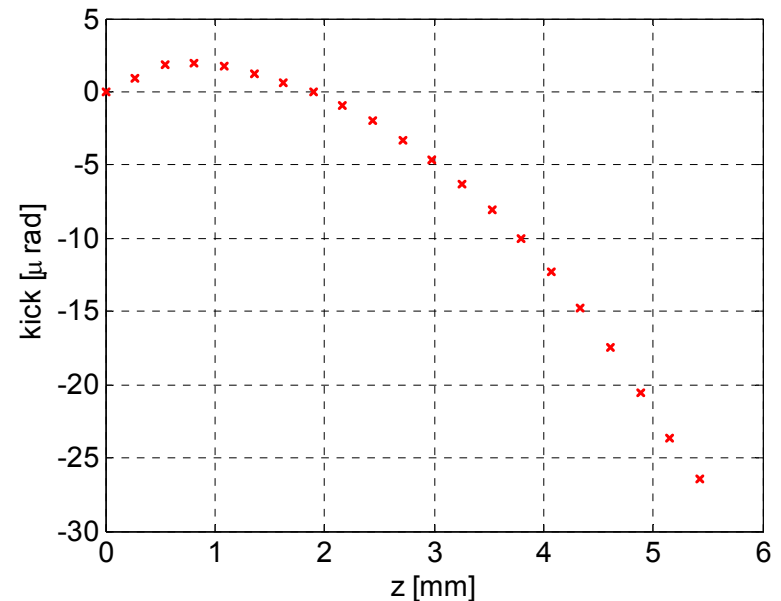


# z-correlated tilt during a multi- quadrupole-scan

Deviation between measured  
and fitted centroid offsets:



Time-dependend kick added in the  
center of ACC5:

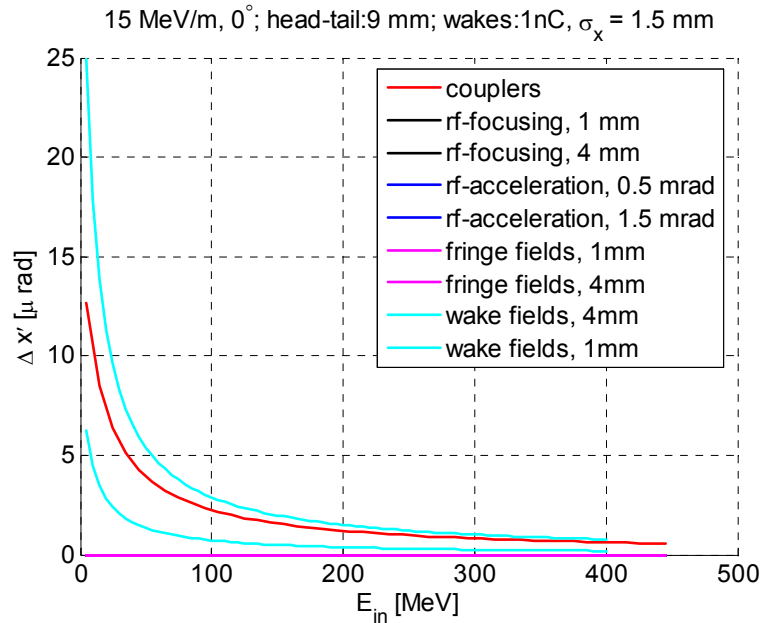


→ Contributions from wake fields in ACC5?

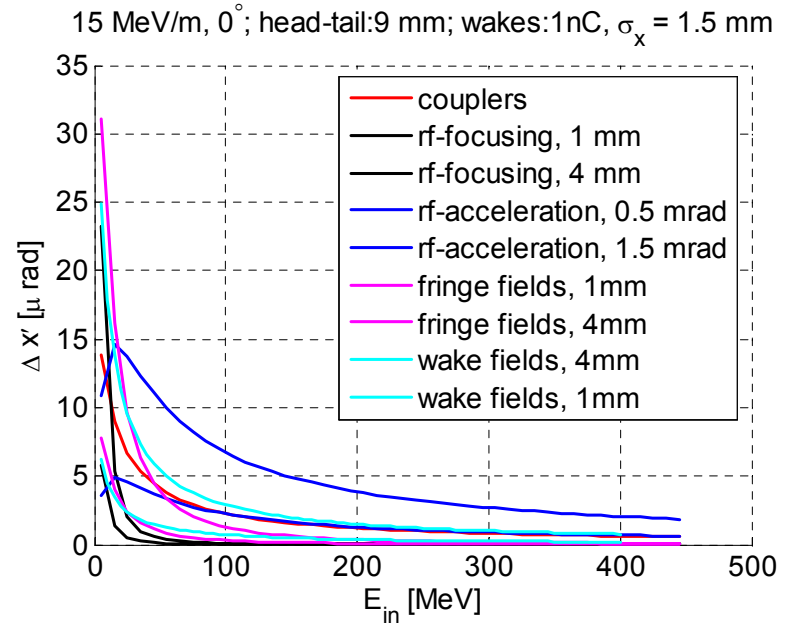
# z-correlated tilt sources in cavities

Kick difference  $\Delta x'$  between head and tail per cavity :

On-crest:



Off-crest:



Emittance growth  $\ll 10\%$  !

Wake functions: I. Zagorodnov, T.Weiland: TESLA Report 2003-19;

Coupler Kicks: Presentation of M. Dohlus

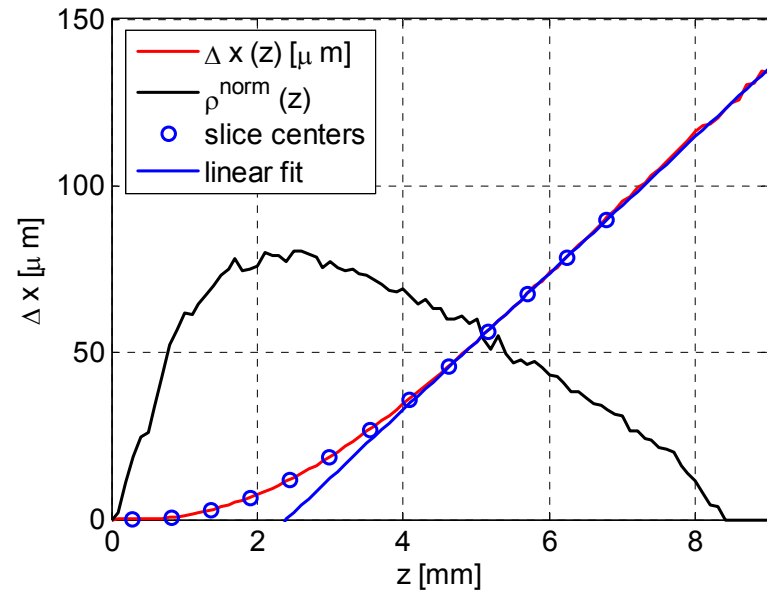
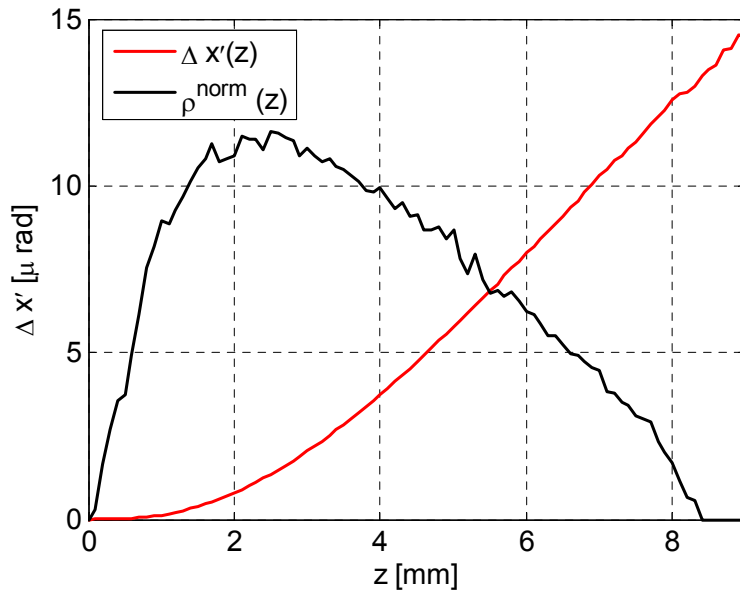
# LOLA: transverse wake fields

Time-dependend kick in LOLA:

Resulting centroid offset on the screen:

Wake field effects:  $r_{\text{LOLA}} = 5 \text{ mm}$ ,  $Q = 0.67 \text{ nC}$ ,  $E = 490 \text{ MeV}$

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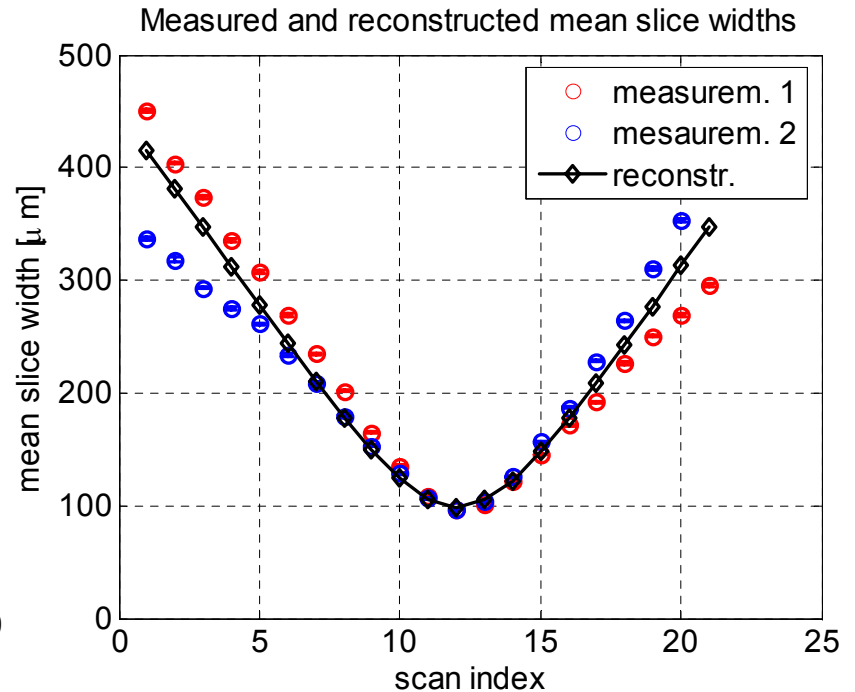
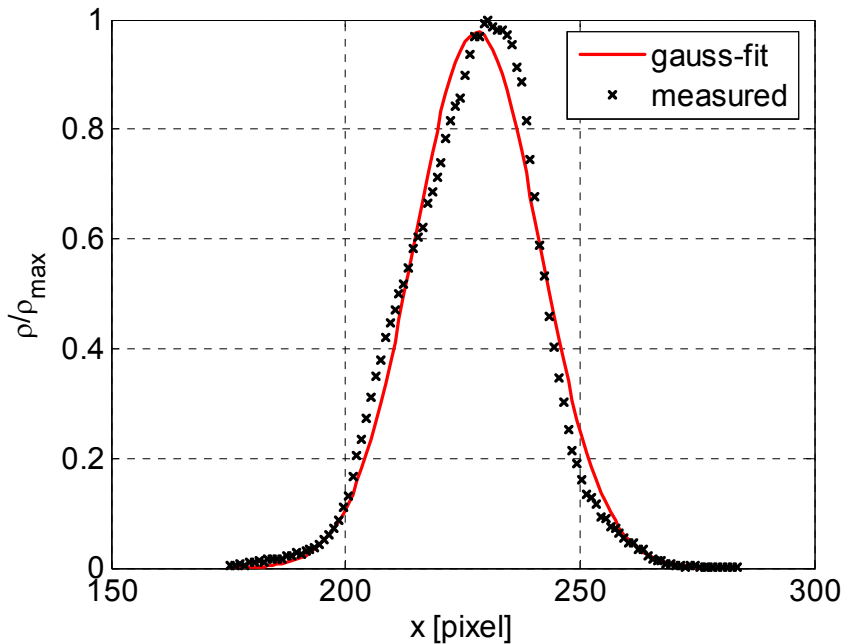
Aperture of LOLA scanned -> no significant offset of the structure!

Wake functions : I. Zagorodnov, T.Weiland: TESLA Report 2004-01



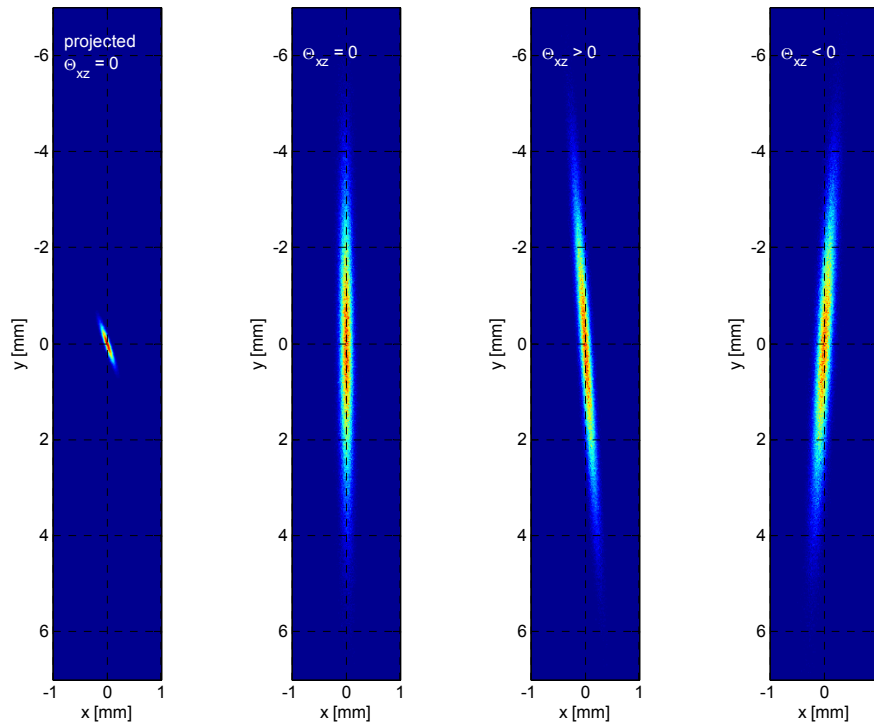
# Effects of the tilt on slice emittance measurements

- Non-gaussian profiles caused by tilts?
- Dependence of measured slice widths on the LOLA-phase:

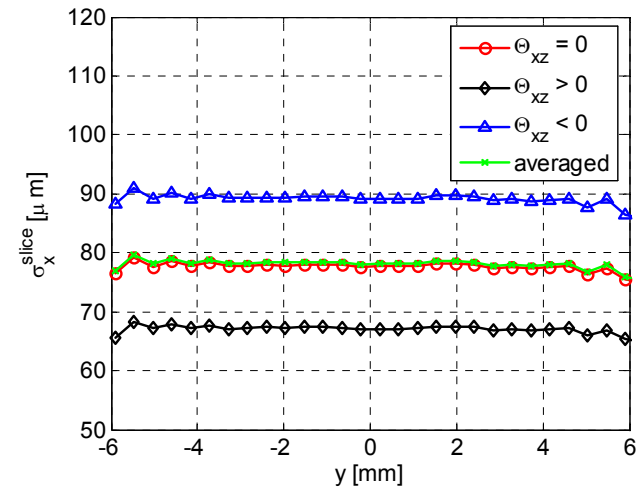


# XY-coupling in combination with an (x,z)-tilt

Simulation:



Slice widths :

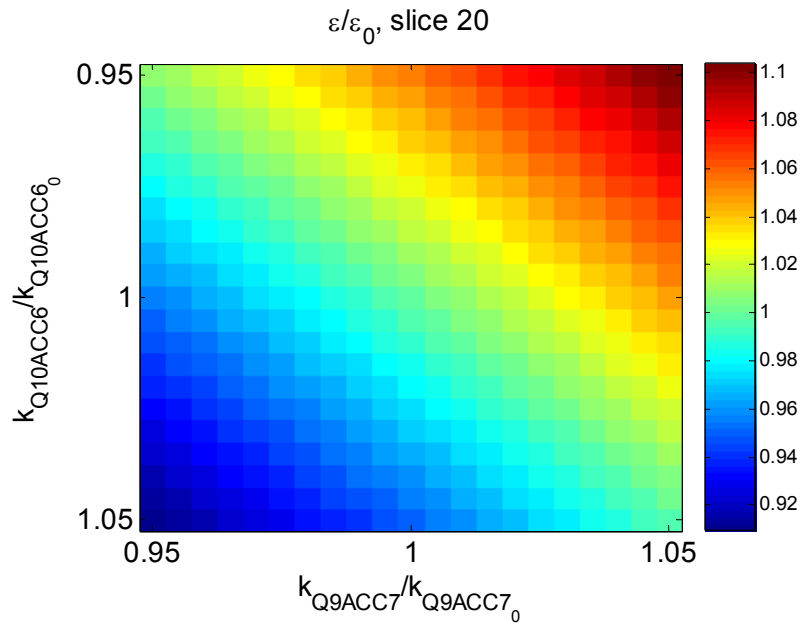


# Conclusions

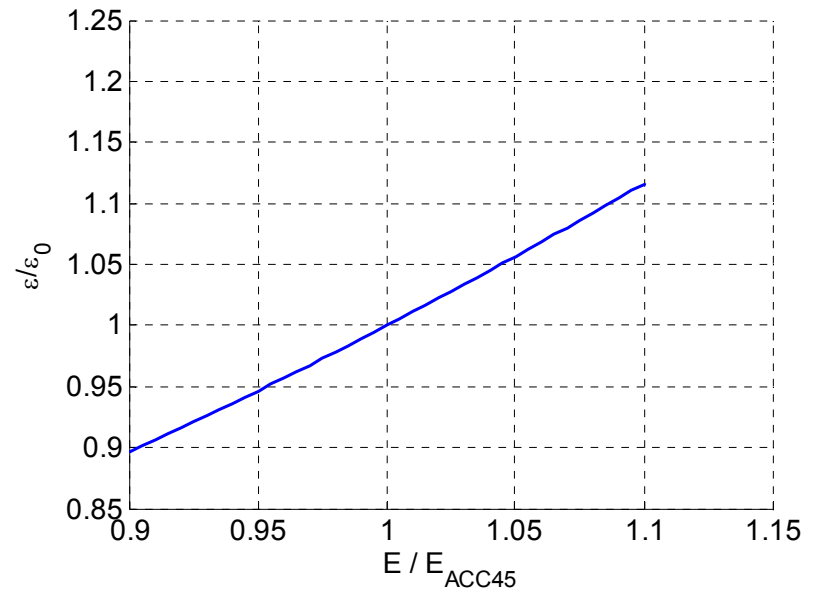
- The measured slice emittance ranges from  $\sim 2$  mm mrad to  $\sim 3$  mm mrad in the center
- It is not in contradiction to measured projected emittance values
- z-correlated tilts are mainly generated upstream of LOLA, most likely in the accelerating modules

# Errors due to erroneous transfer matrices

Deviations of k-values:



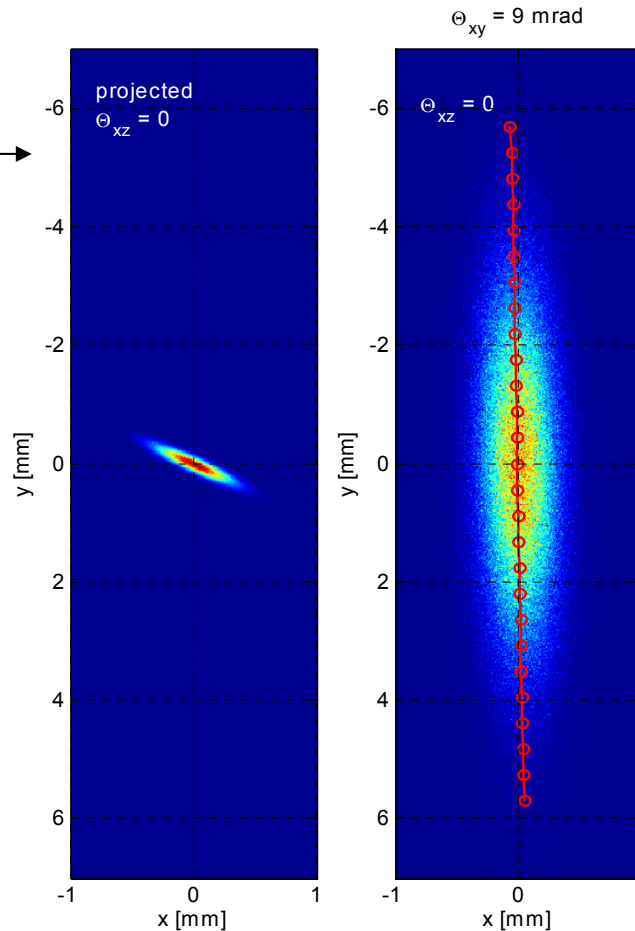
Deviation of the energy:



→ Emittance error due to erroneous transfer matrices < 10%

# Tilt from xy-coupling: simulation

Projected transverse distribution with strong xy-coupling



Tranverse distribution after passing LOLA: A tilt of 9 mrad remains from xy-coupling

# Emittance growth due to linear tilts

Gaussian bunch

$\sigma_z = 1.5 \text{ mm}$ ,  $E = 130 \text{ MeV}$

