Summary of new FLASH CSR studies

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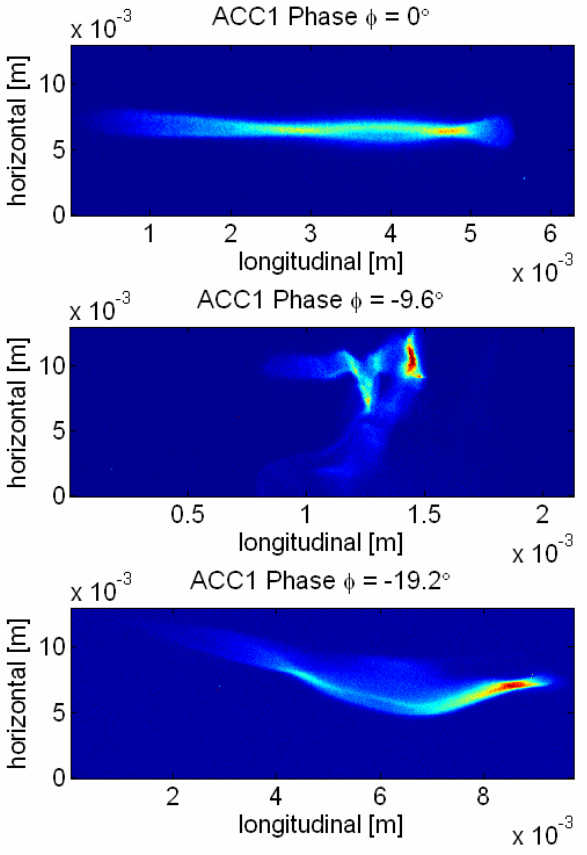
Beam Dynamics Meeting 18.9.2006

- Introduction
- Measurement Summary
  - Experimental Outline
  - What has been done?
- Analysis
  - Charge dependence
  - Beam Tilts
- Summary and Outlook

Introduction I

- Self forces on the beam distorts the beam. These distortions are observable at LOLA.
- In SASE compression scenarios beam profiles are complicated due to CSR and space charge interactions.
- Far off crest compression scenarios lead to low peak currents after BC2. Therefore only small contributions from space charge fields are expected.

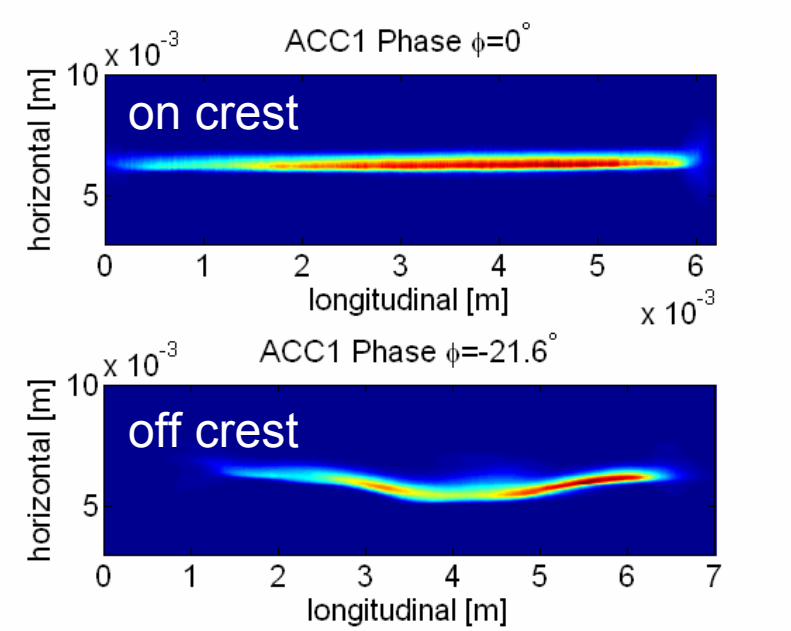


Introduction II

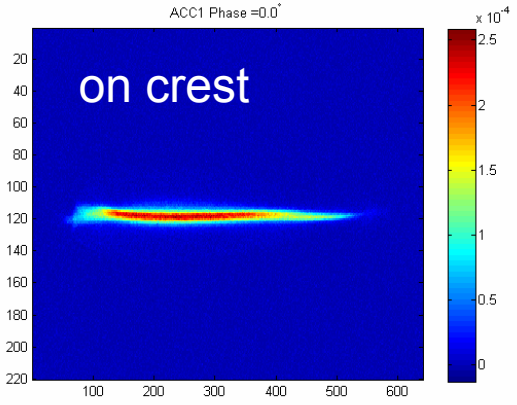
CSR induced centroid sag is predicted by simulations and observed at FLASH.

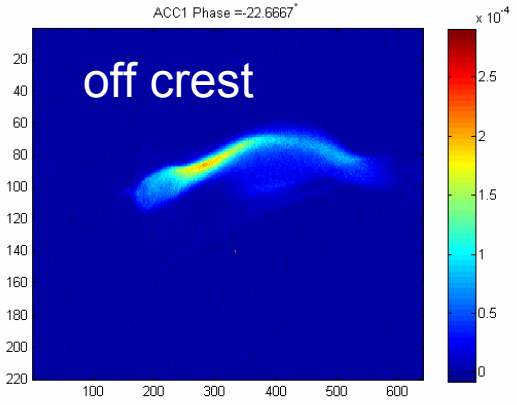
New experiments on this centroid shifts are discussed here.

Simulations



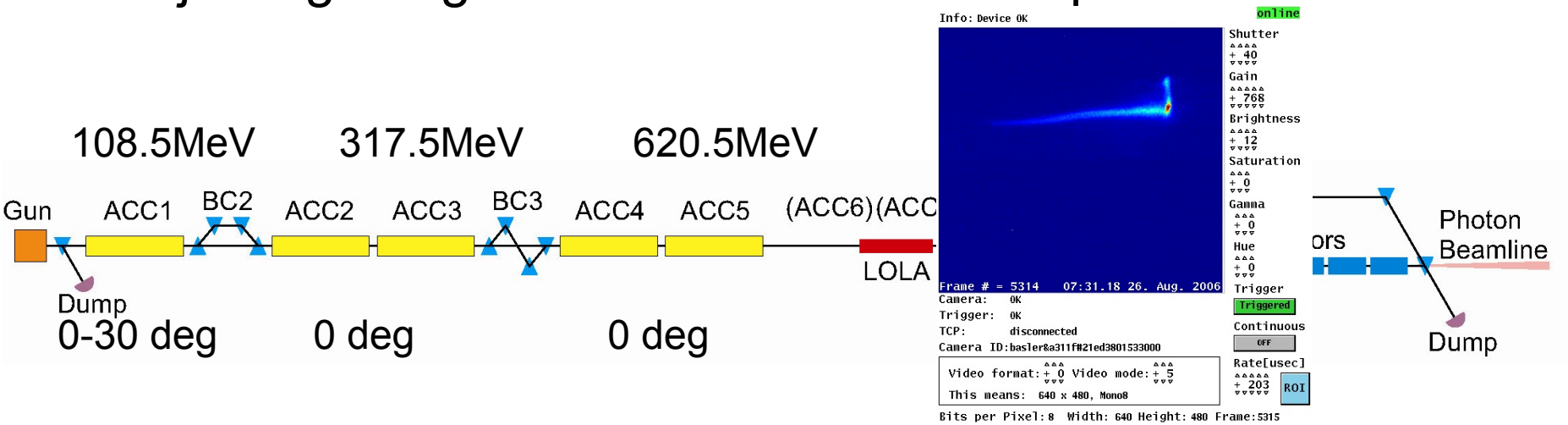
Measurements





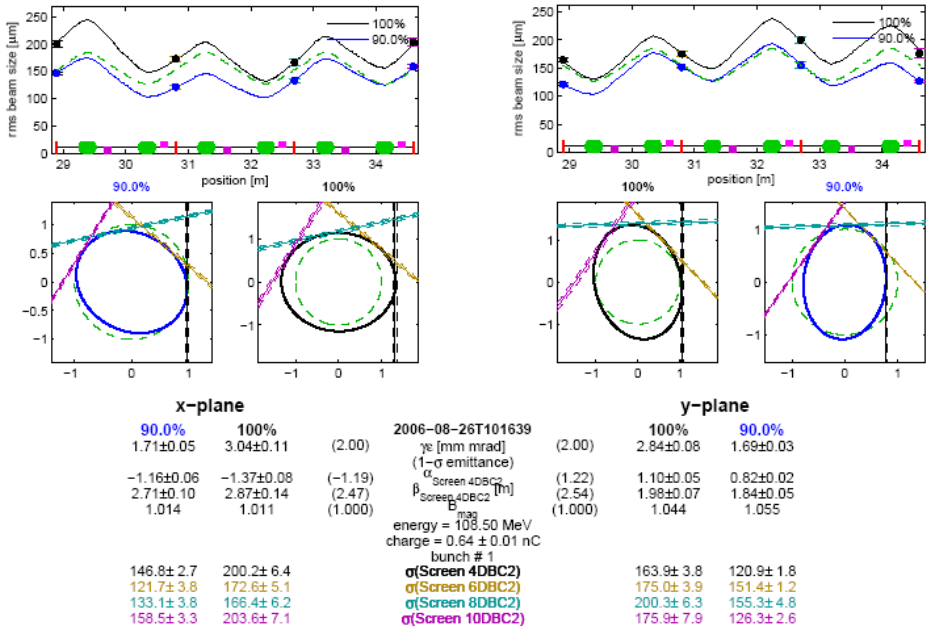
Experimental Outline

- Experiments on the 26.8.2006 - two shifts.
- Beam transport up to LOLA through ACC1, ACC23 and ACC45.
- ACC1 phase varies while ACC23 and ACC45 are on crest.
- Energy profiles along the machine is kept constant by adjusting the gradient in ACC1 with the phase.

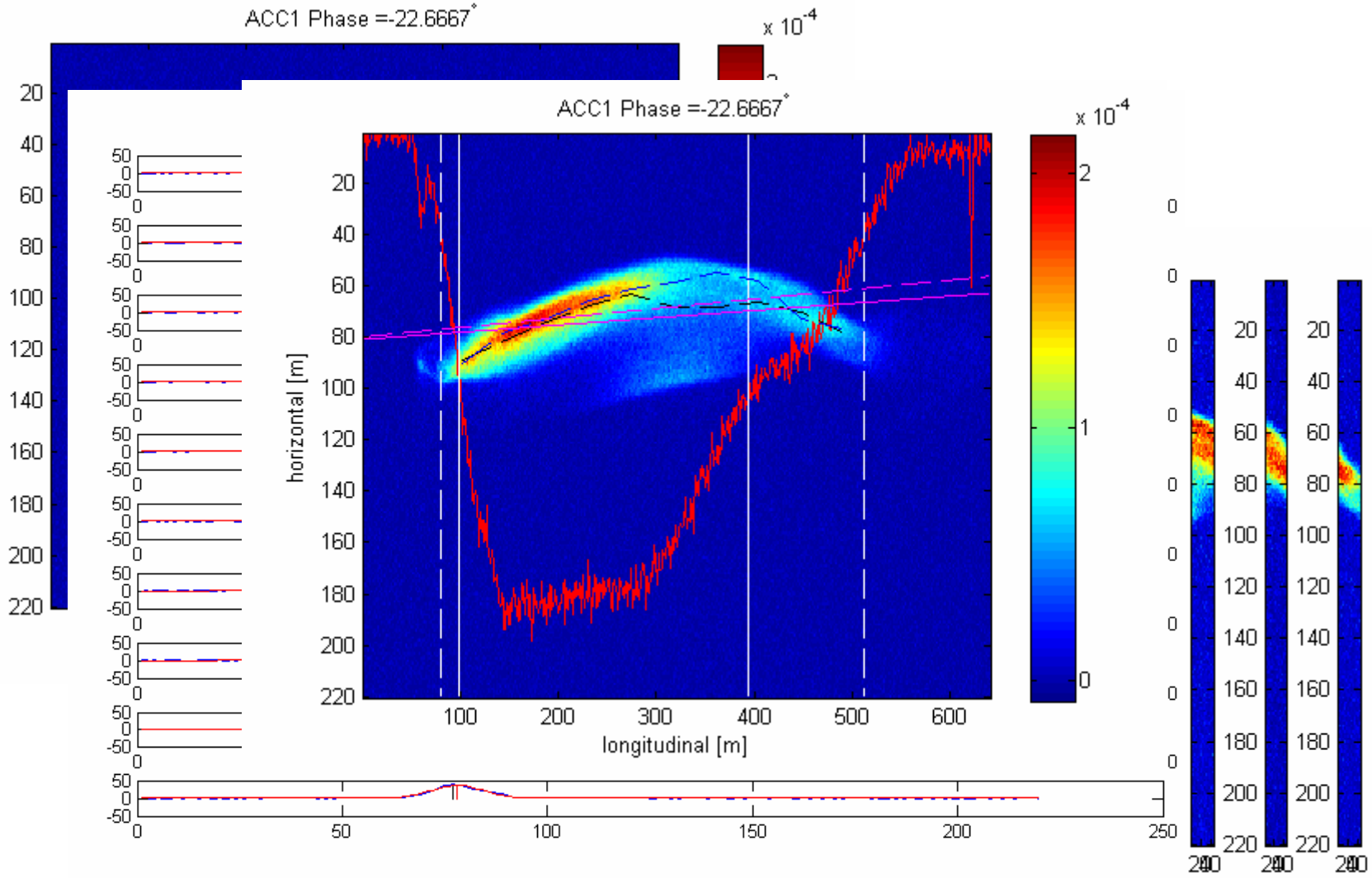


What has been done?

- The ACC1 phase scan is repeated for different bunch charges (0.4,0.65,0.8,1.0,1.2,1.4,1.6,1.8,2.0nC).
- For each charge the emittance is measured in DBC2 and matching is applied.
- In the 0.65nC case the phase advance between BC3 and LOLA has been scanned from 100 to 220 deg…..no analysis yet

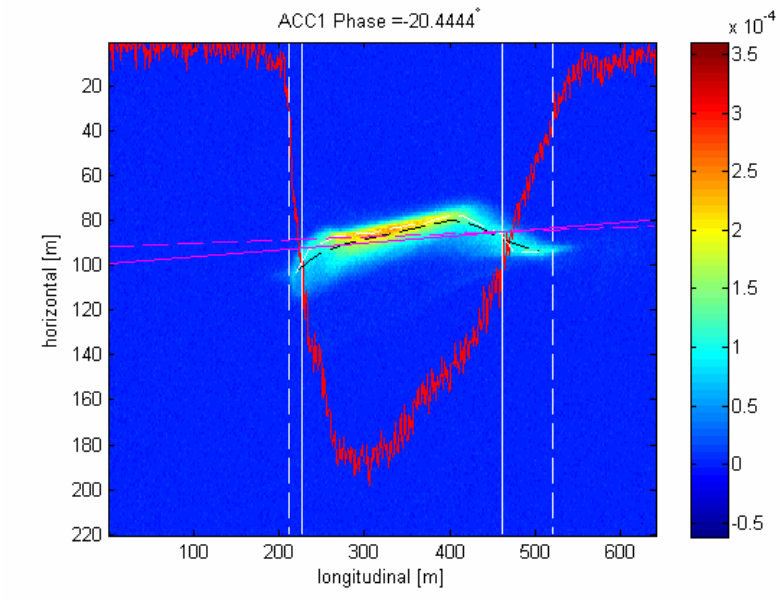


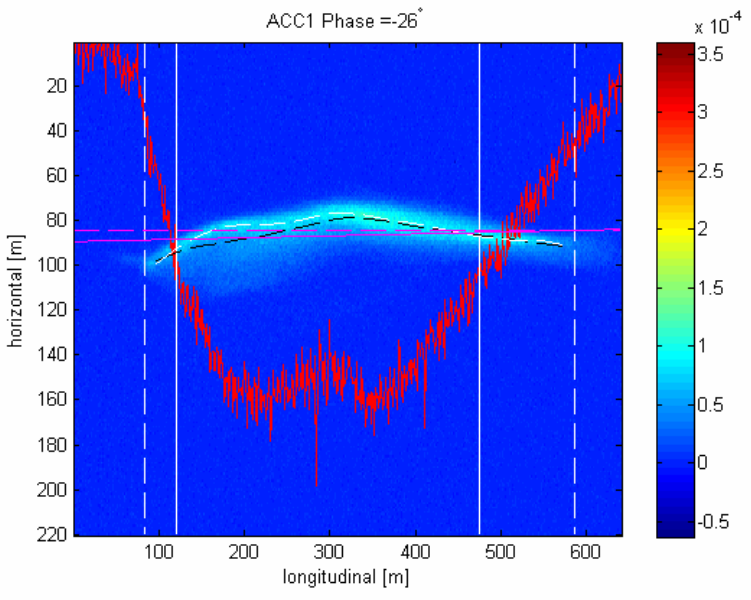
Analysis I


ACC1 Phase =-22.6667°
x 10^-4
ACC1 Phase =-22.6667°
x 10^-4
horizontal [m]
longitudinal [m]

Analysis II

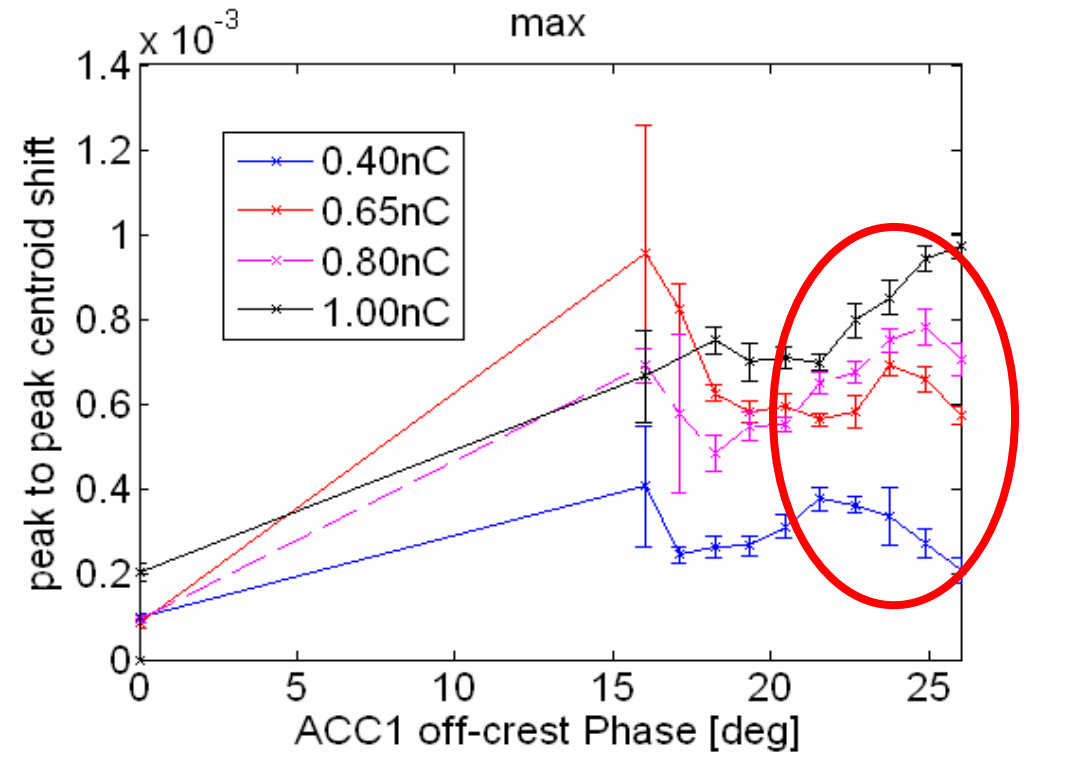
- Centroid curves has been extracted from the pictures.
- The linear correlation is detemined from this curve
- Subtraction of linear correlation
- From the corrected centroid curve the peak to peak spread is calculated

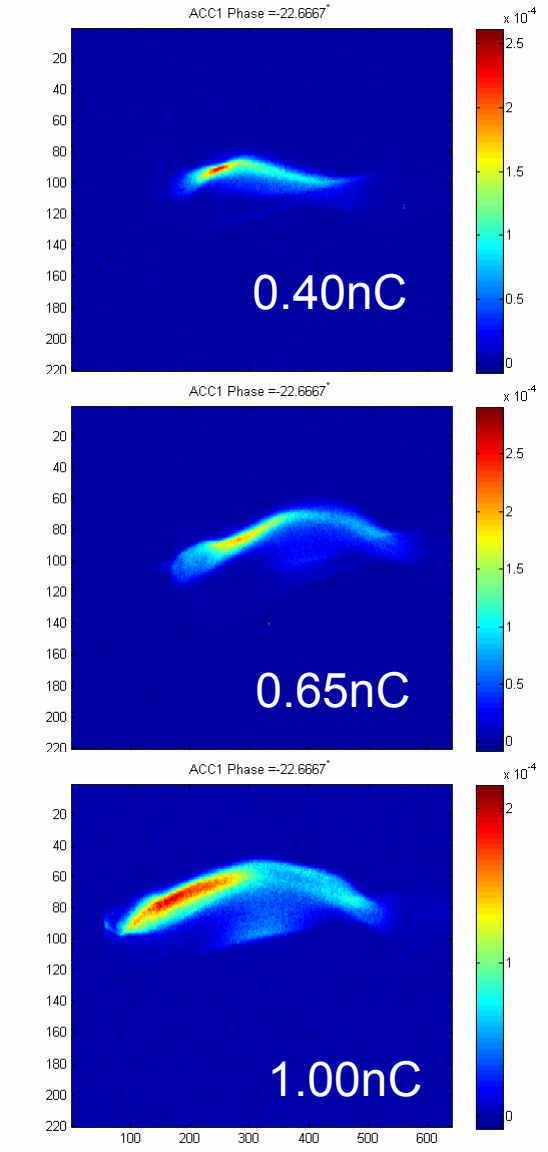




Charge dependence I

- In the strong over compression range a clear charge dependence is observable for charges between 0.4 and 1.0nC





Charge dependence II

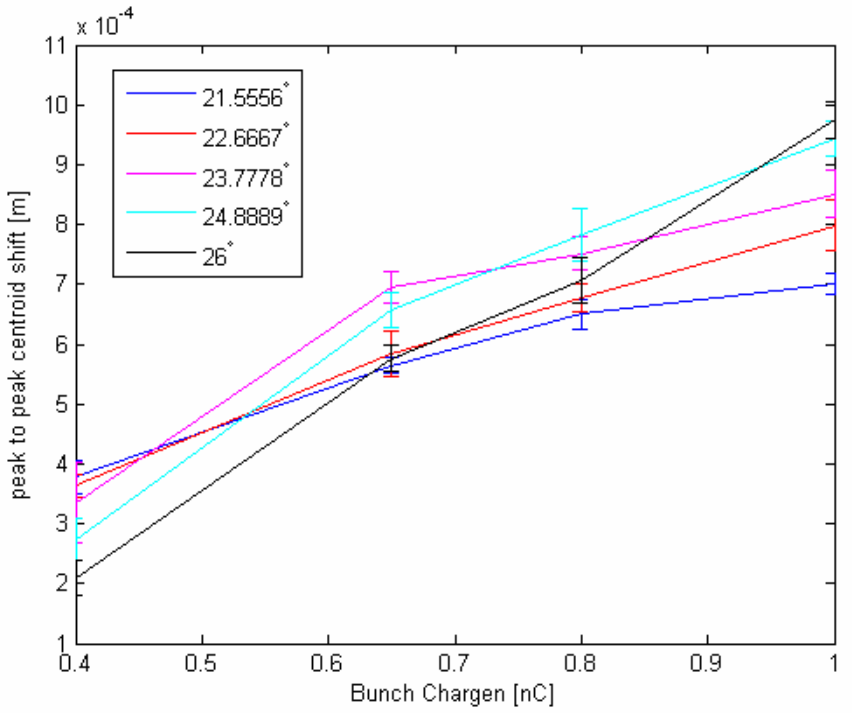
One would expect a linear dependence on the charge by naive considerations.

$$\frac{dE(s,\rho)}{c\,dt} = -\frac{2N_e e_0^2}{4\pi\epsilon_0\sqrt{2\pi}3^{1/3}R^{2/3}\sigma_s^{4/3}}F_0(s/\sigma_s,\rho)$$

$$F_0(x,\rho) = \rho^{-1/3}\left(e^{-(x-\rho)^2/2} - e^{-(x-4\rho)^2/2}\right) + \int_{x-\rho}^{x}\frac{-x'e^{-x'^2/2}}{(x-x')^{1/3}}dx'$$

In strong over compression (~26deg) the dependence is roughly linear. For shorter bunch length the charge dependence is somehow "damped".

=> tracking calculations are required…

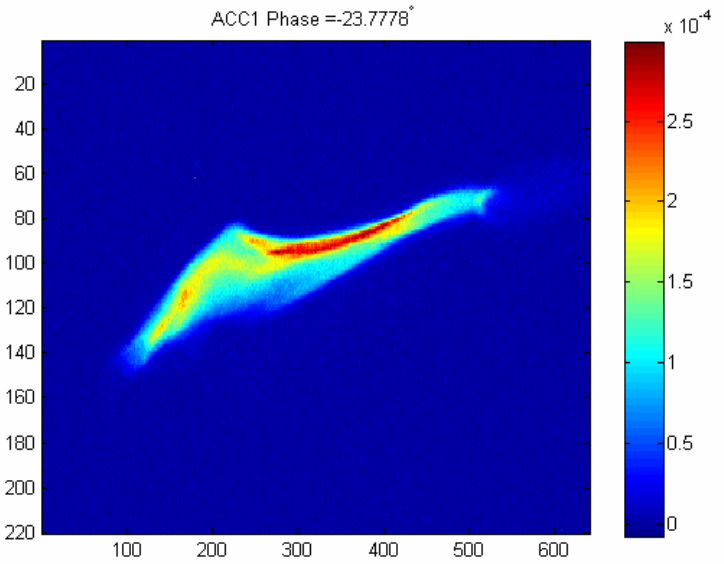


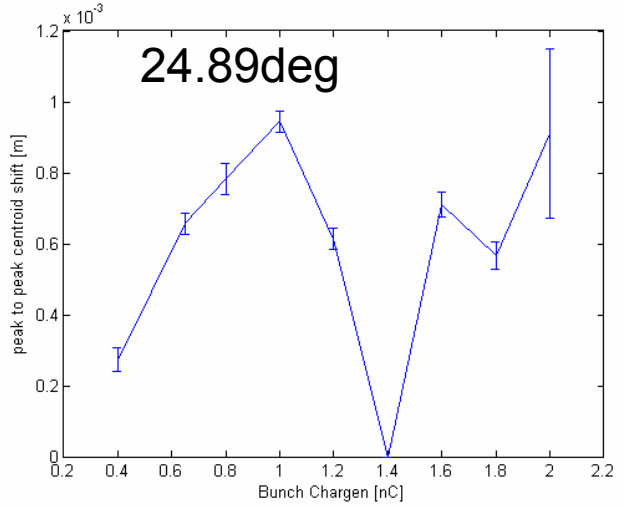
Beam Tilts I

Strong beam tilt for high bunch charges (>1nC) makes an analysis of the centroid sag difficult.

Possible reasons:

- Charge dependence of beam tilts might be induced by orbit changes due to matching (off-axis quadrupole orbits).
- Dispersion
- Wake fields
- ……



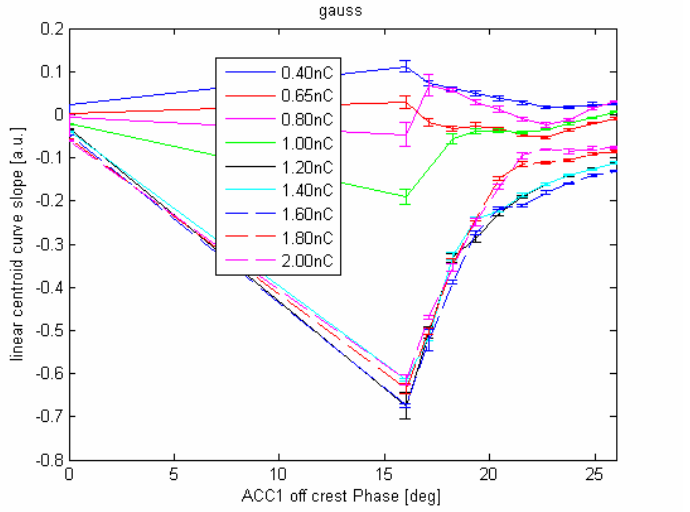


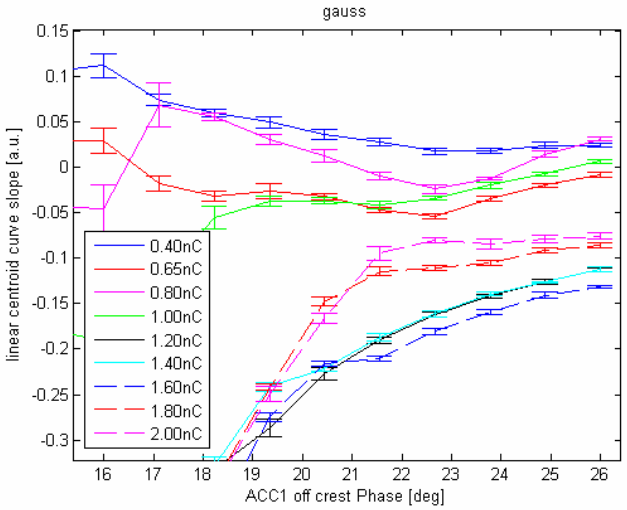
Beam Tilts II

Linear correlation of centroid curve for different charges shows no simple scaling with bunch charge. Which exclude naive wake field effects.

The on crest slope is in general smaller than the strong off crest slope, therefore dispersion might be the explanation.

Orbit was not corrected after matching of the optics in DBC2. Orbit effects cannot be excluded.





Summary and Outlook

- Charge dependence of CSR induced centroid shifts were observed between 0.4 and 1.0nC.
- Problems with higher charges => beam tilts

Next Steps:

- Slice width and the phase advance scan data will be analysed => slice emittance
- Quantitative comparison with tracking calculations
- Further investigation on beam tilts

Thank You!