Passive Time-Of-Flight Measurements at FLASH

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MVP/DESY

FLASH Meeting 24.Oct.2006

1) Motivation and Principle
2) Error Sources
3) Measurements and Results
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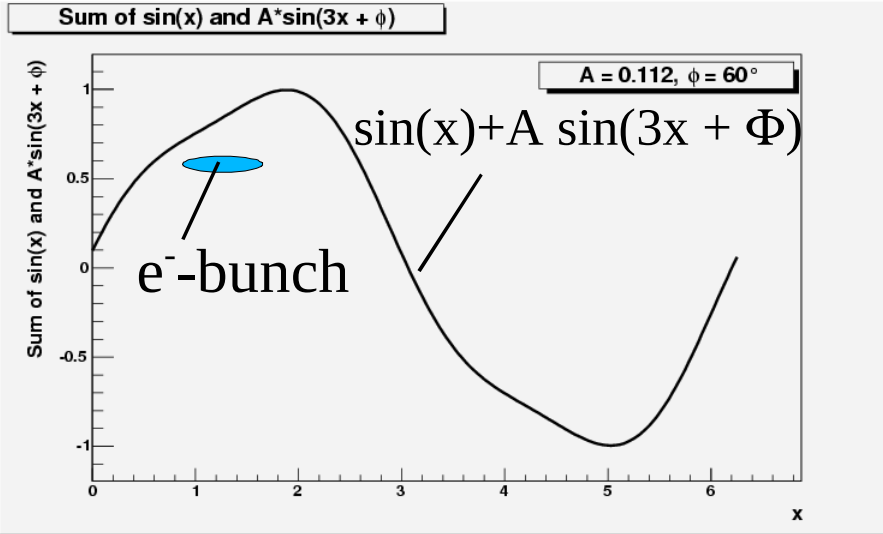
Motivation



-> Measure and optimize effect of 3rd harmonic cavity

Side effect:
-> Measure on-crest phases of modules

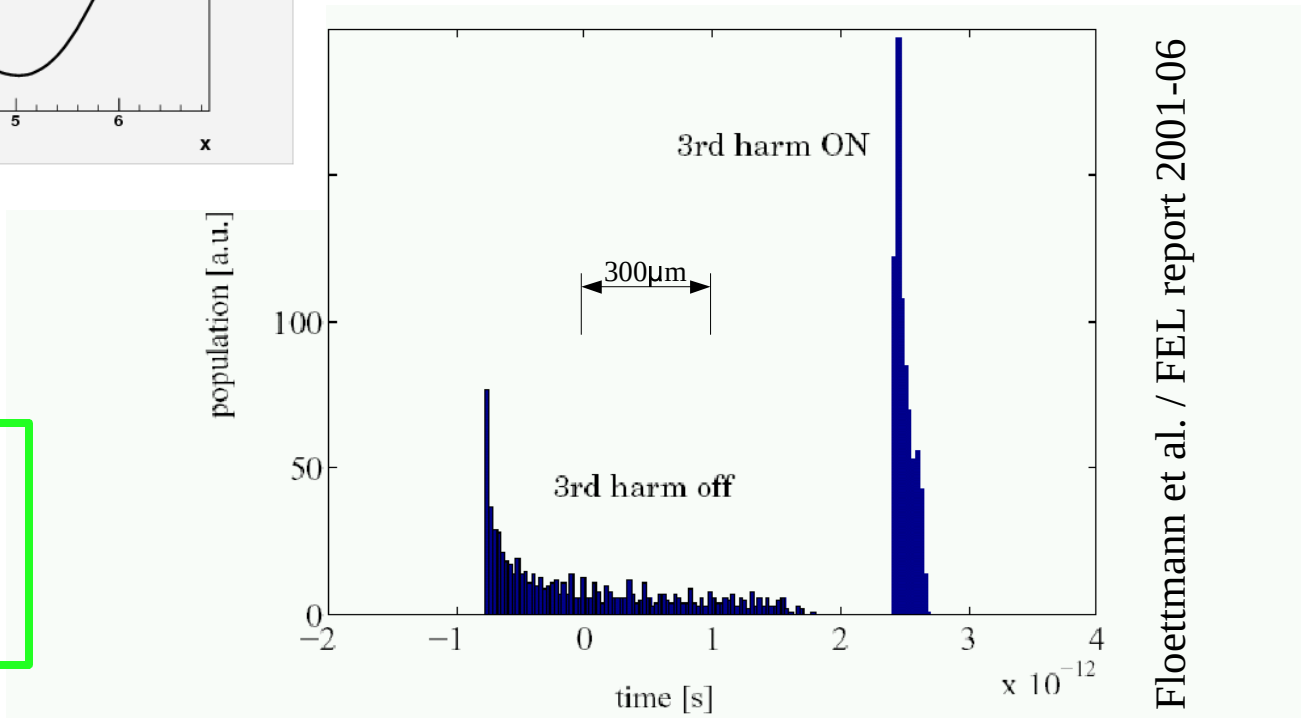


Figure 4: Comparison of the charge density profiles, downstream of the bunch compressor, when the 3^{rd} harmonic section is or not operated.

Proposed Measurement Strategy

Acceleration (ACC1 + ACC39):

$$z_m = z_i$$
$$p_m = p_i + \kappa z_i + \mu z_i^2$$

Compression (BC2):

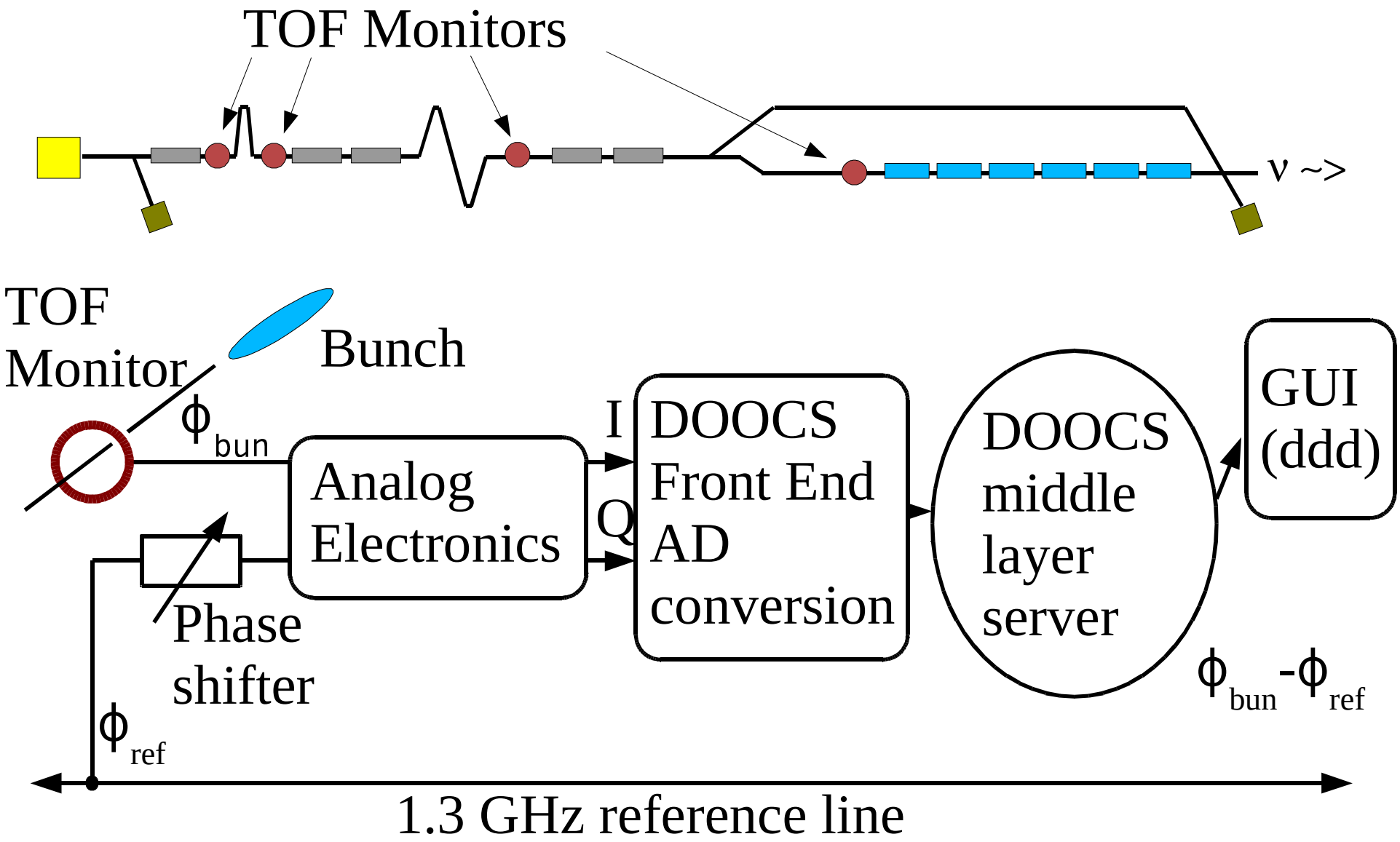
$$p_f = p_m$$
$$z_f = z_m + R_{56}\,\delta_m + T_{566}\,\delta_m^2$$

$$\delta = (p - p_0) / (p_0 + p_{Gun})$$

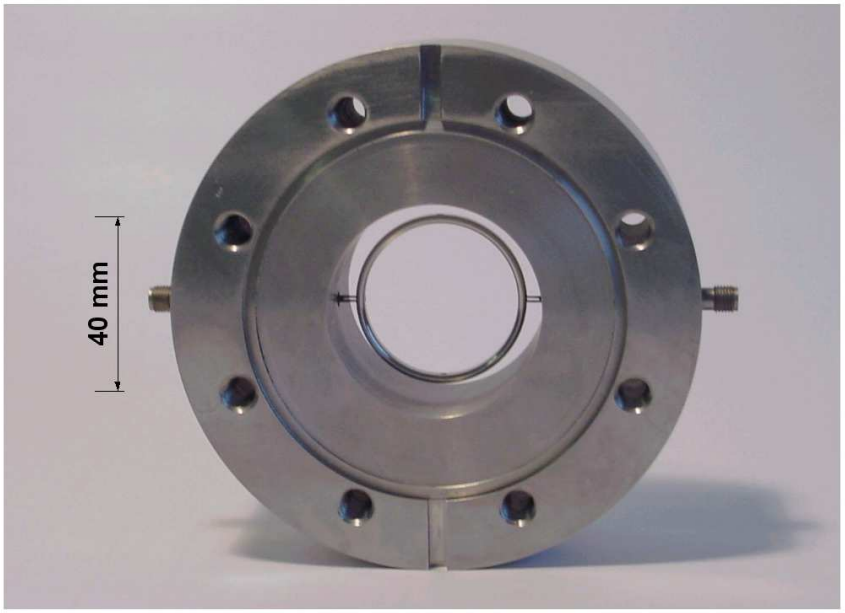
To measure: κ , μ , R_{56} and T_{566}:

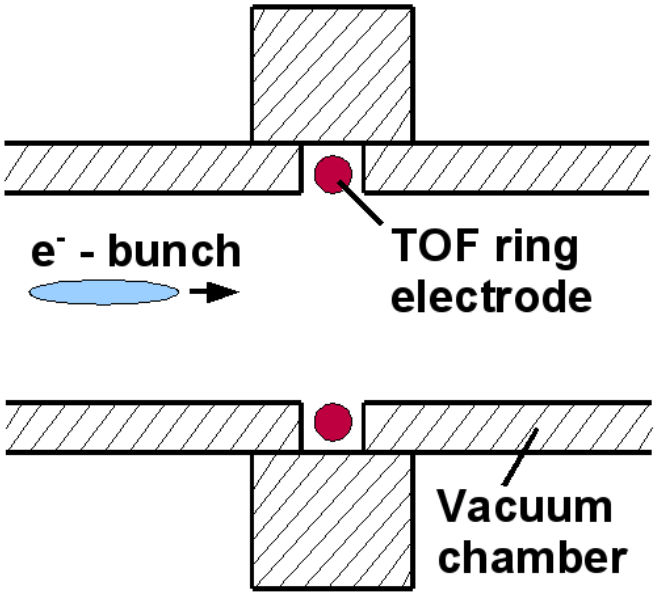
1. Measure R_{56} and T_{566} for different BC2 currents, ACC39 off, by ACC1 RF-phase scans
2. Measure κ and μ for given BC2 current, ACC39 on, by (ACC1+ACC39) RF-phase scan

Instrumentation and Signal Flow



Monitor Layout





Motivation and Principle
Summary

- Four Time-Of-Flight monitors are installed at FLASH

  -> To control and optimize operation of third harmonic cavity
  -> To control and optimize bunch charge distribution

  -> To determine ACC RF on-crest angles of dark current and beam

  -> To measure gun RF phase with respect to laser phase (?)

- Principle of Measurement

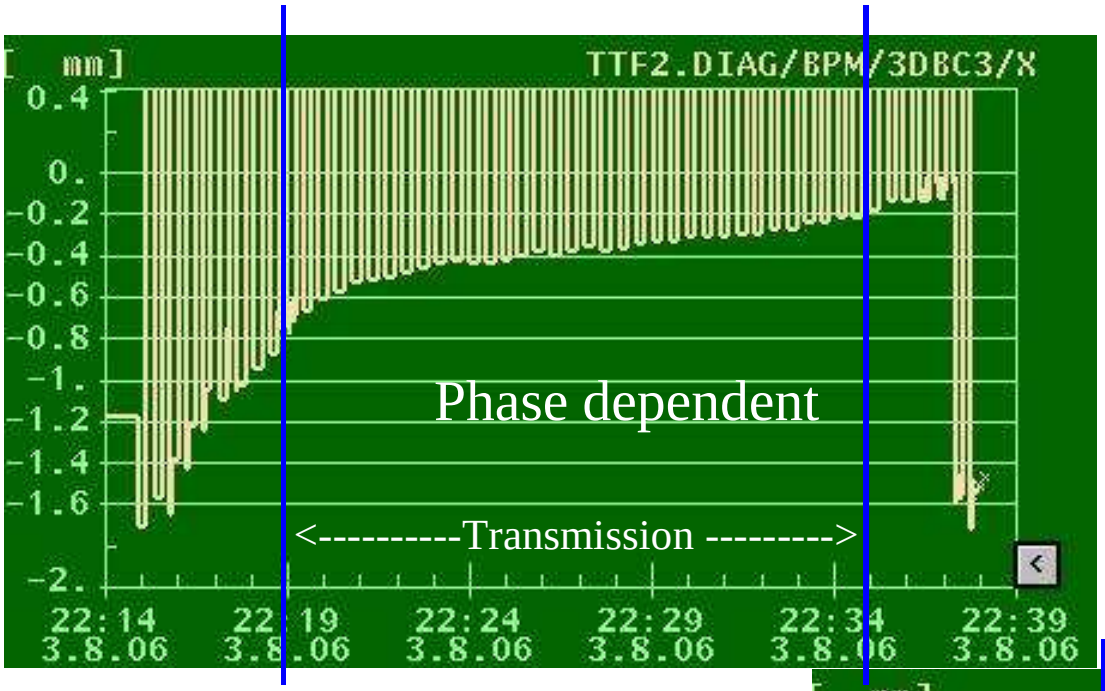
  FLASH standard signal processing, averaging over macropulses

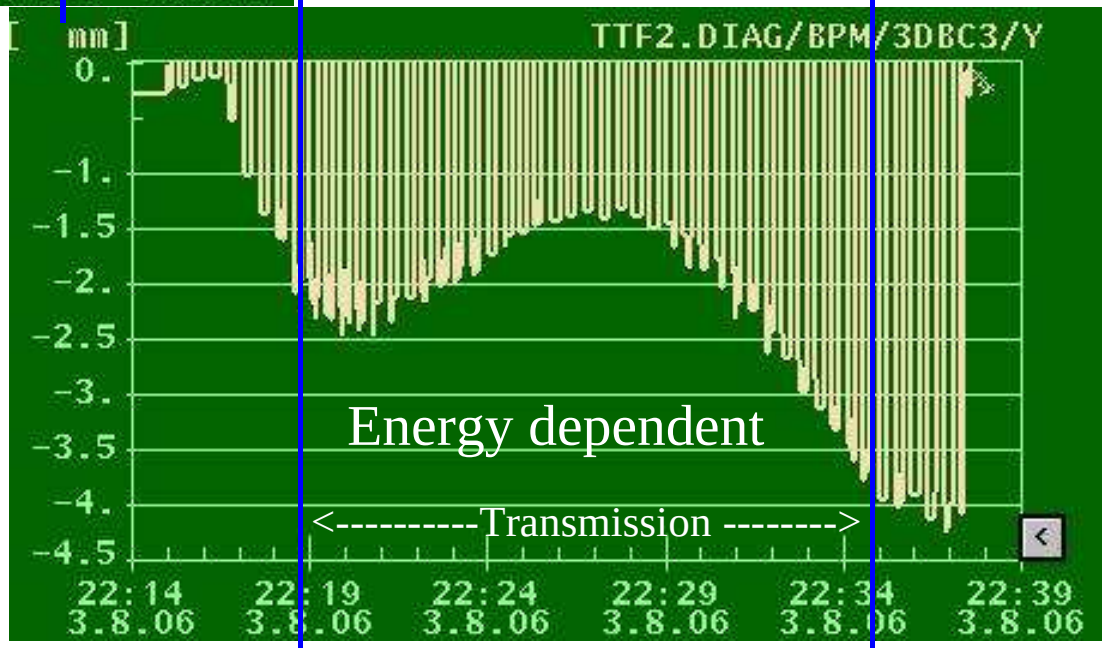
  1. Measure Longitudinal Transfer Map of Bunch Compressors
  2. Measure RF field signature of ACC1+ACC39

Steering effects during RF phase scans

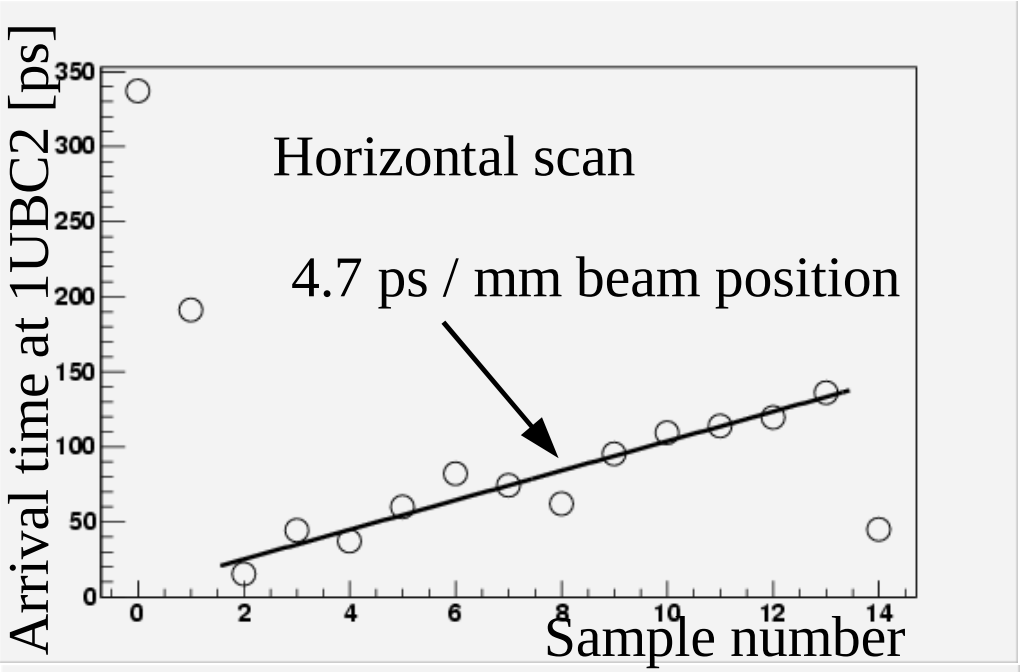
ACC23 RF phase scan
(90° around on-crest phase):

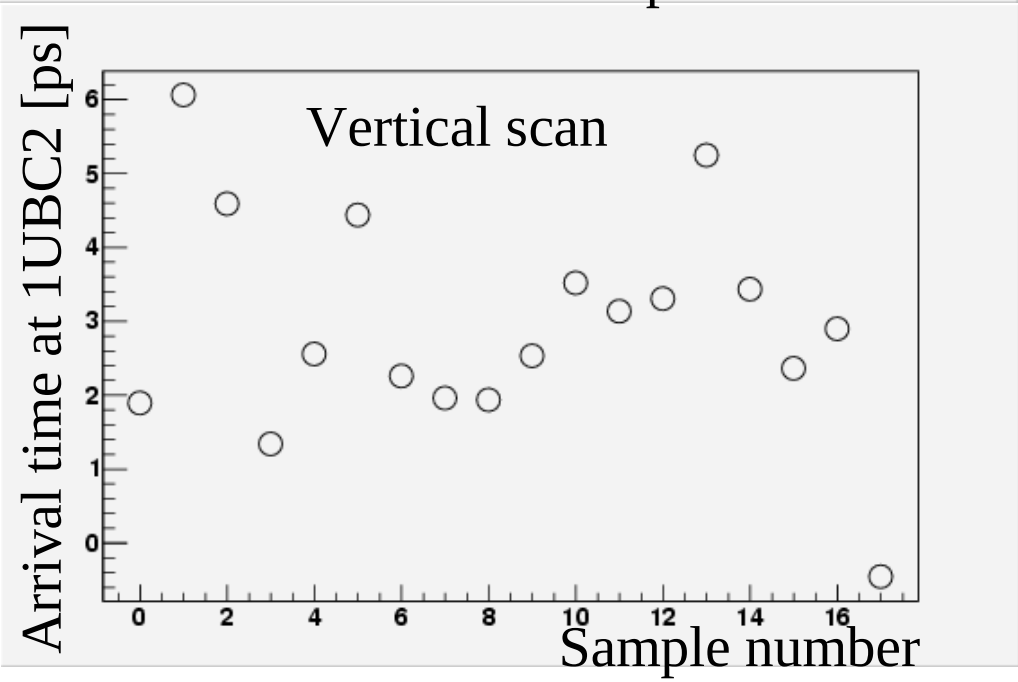
Distance BPM – Module: 23m





(Measurements at late shift 03.Aug.2006)





Dependence on transversal beam position

of TOF monitor '1UBC2'

Independent measurements by K. Hacker & Fl. Loehl:

2.8 ps/mm – 4.4 ps/mm

Model calculations by K. Hacker:

3.8 ps/mm – 5.5 ps/mm

Error Sources

Summary

- Temperature effects

  are long term – but measurements are short term

- Charge per bunch sensitivity

  eliminated by differential measurements

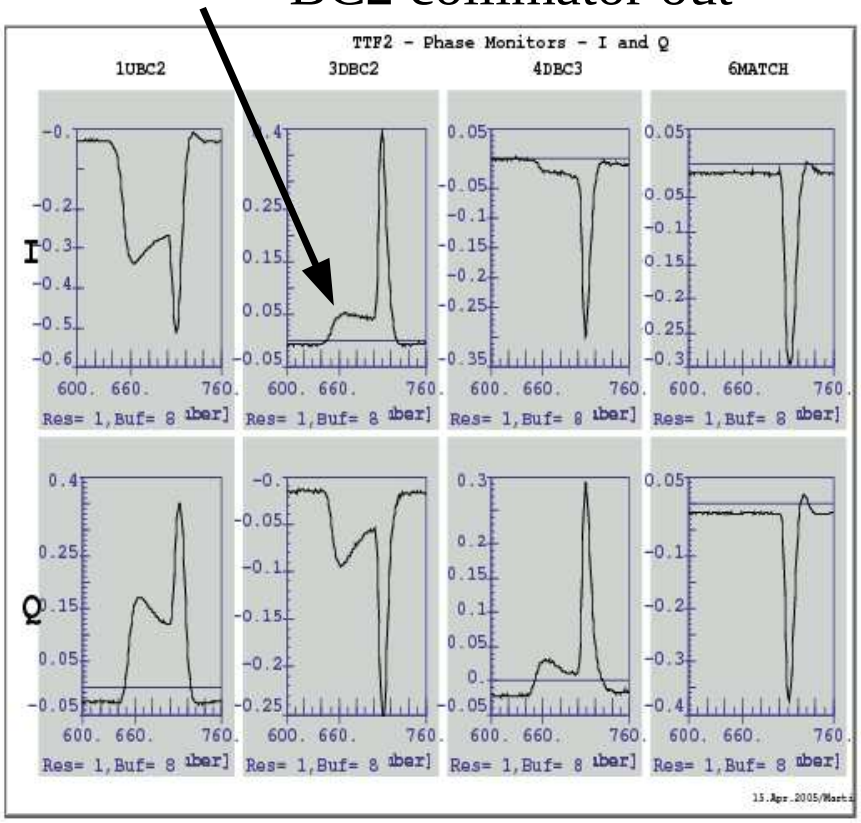
- Beam horizontal position influence

  compensation by 'cold-combiner' under development

Dark current signal

12.May.2005

BC2 collimator out



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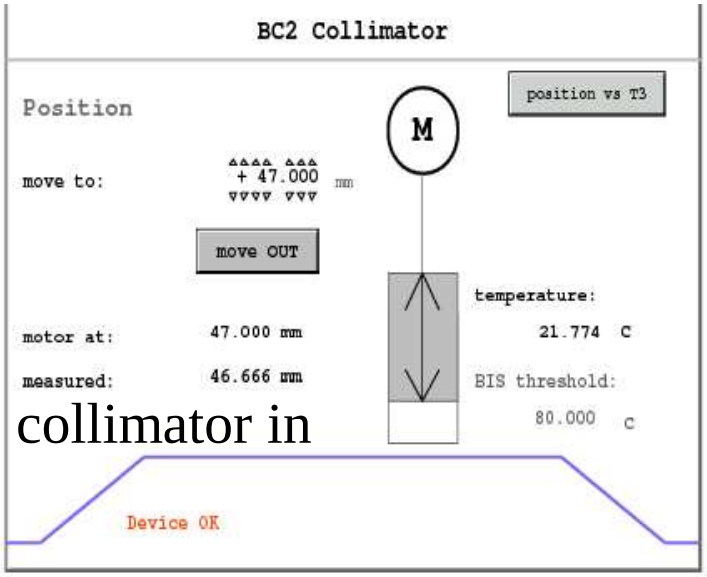
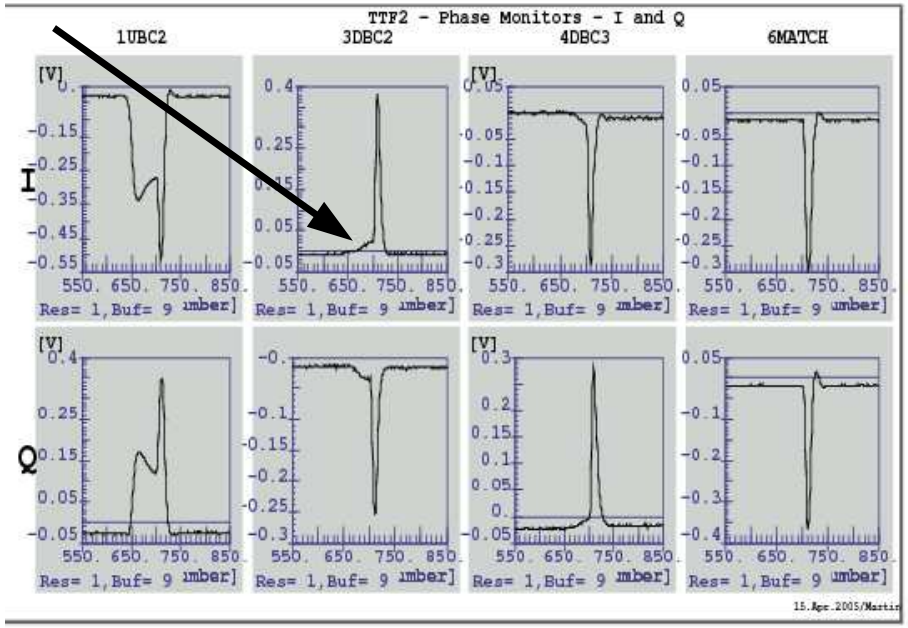
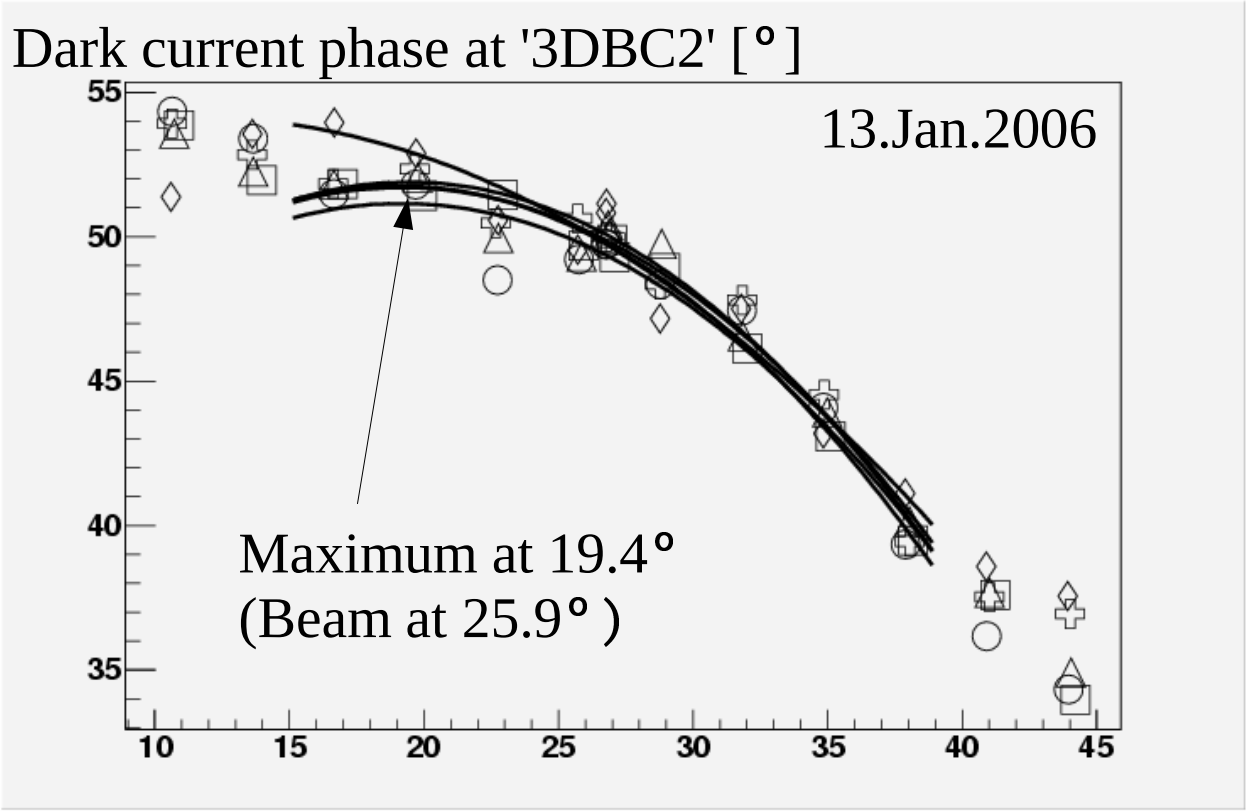
BC2 collimator in



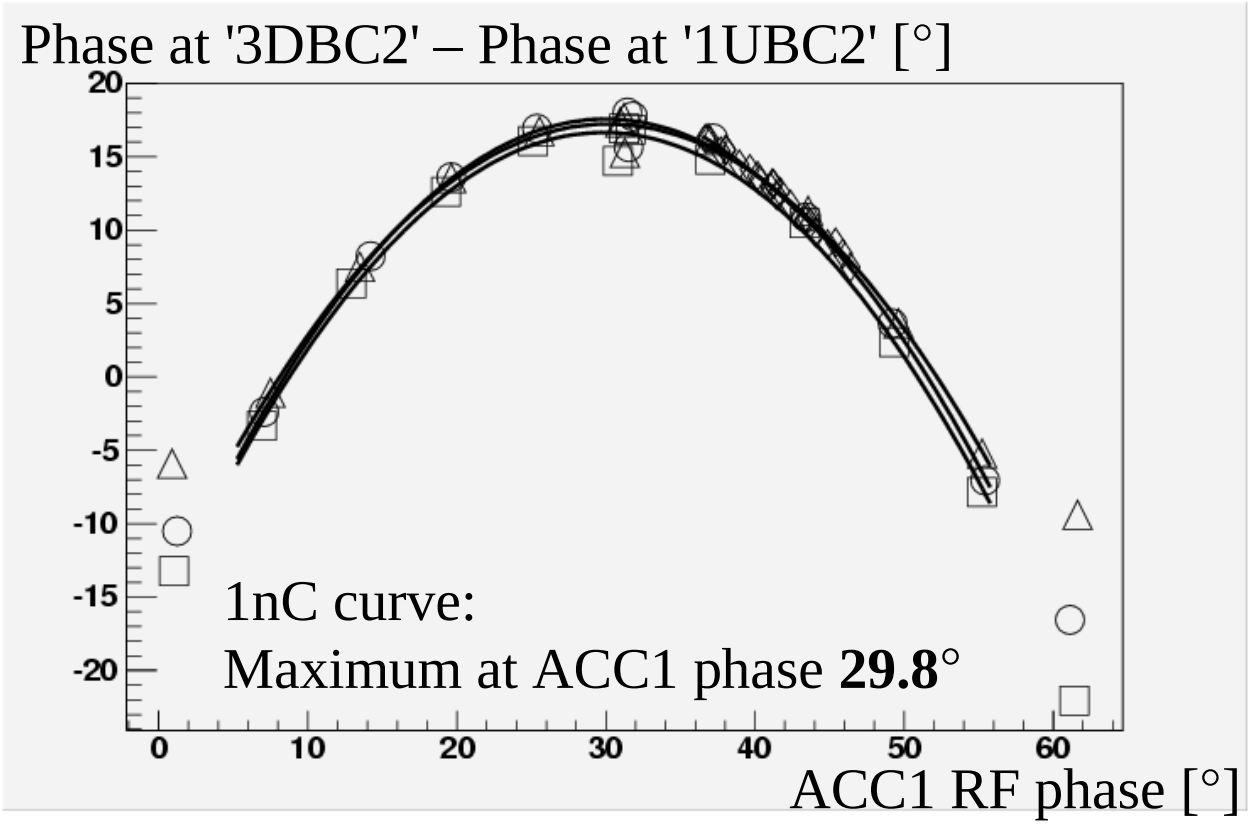


12.May.05 16:50.02

On crest phase determination
- 1. Dark current -



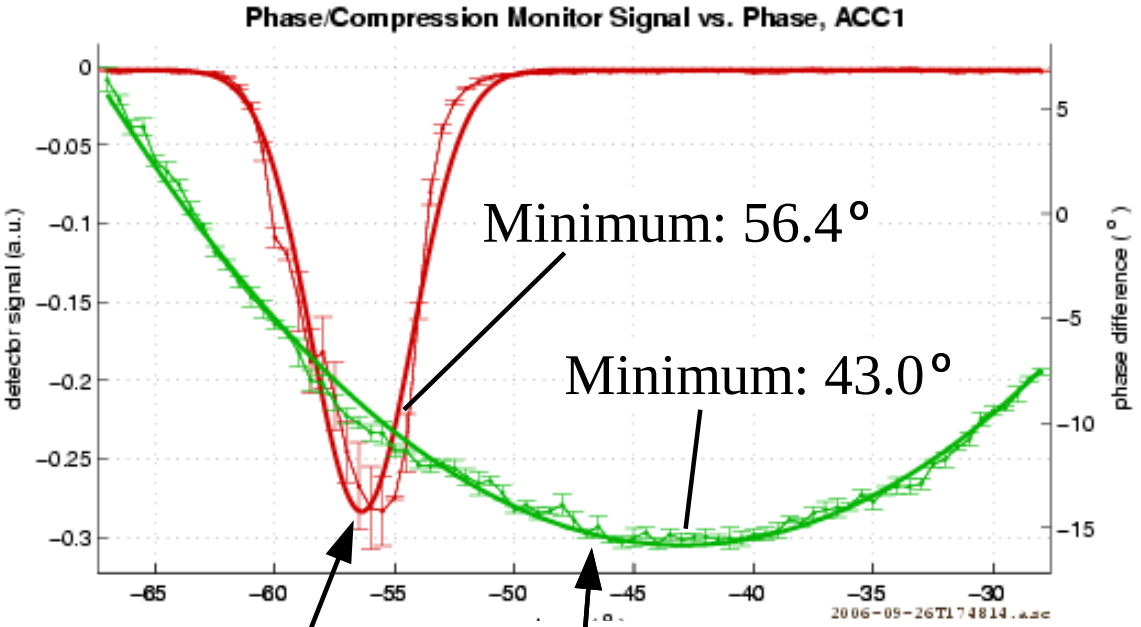
On crest phase determination - 2. Beam -



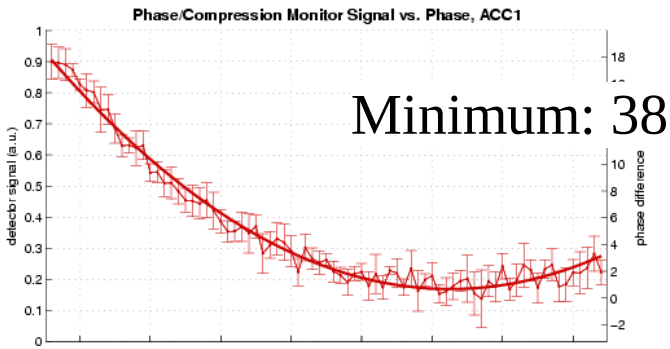
- On-crest phase by eye
  (minimum energy spread on screen 3DBC2): **31.5**°
- Pyro-detector maximum signal ('maximum compression') at **42.5**°

On crest phase determination
- 2. Beam -

Measurements by
L. Froehlich, Chr. Gerth
Late shift 26.Sep.2006



TOF through BC2 [a.u.]
Dark current only



RF On-Crest Phase Measurements

Summary

- RF On-Crest Phase Determination Operative

  - for dark current
  - for beam
  - averages over macropulses

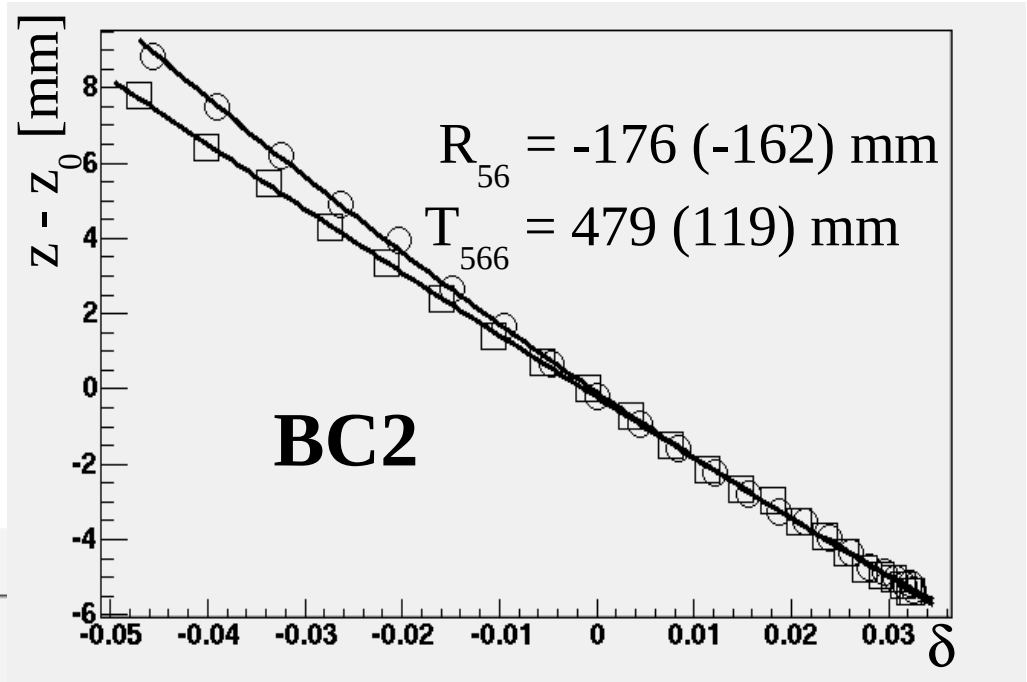
- Tested and used for ACC1 and ACC23

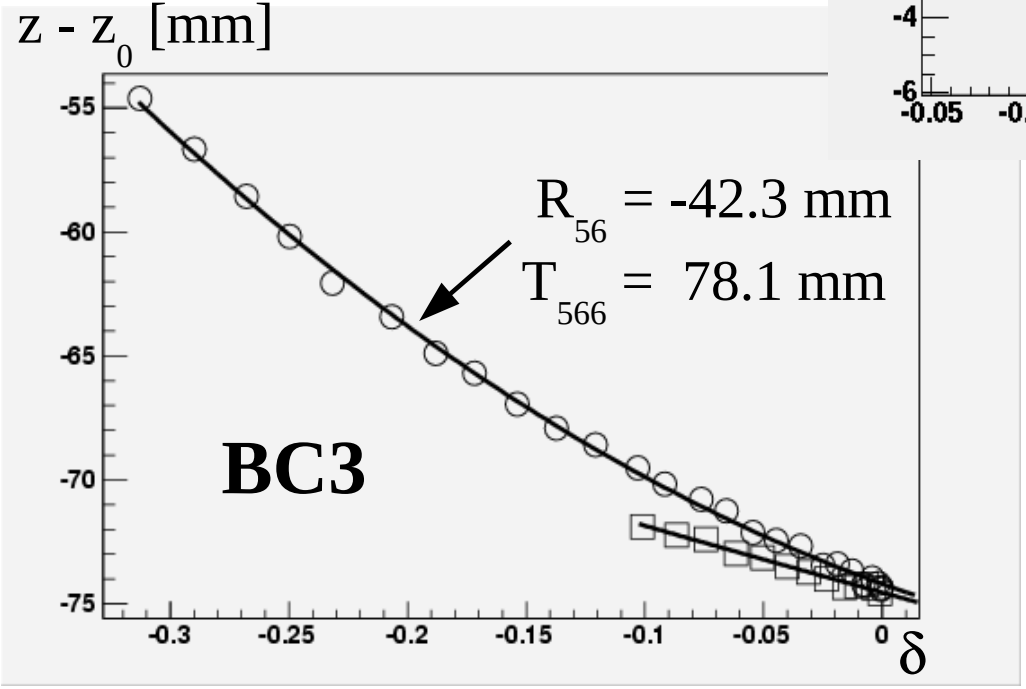
- To be tested for ACC45

Longitudinal Transfer Map Coefficients

$$z = z_0 + R_{56}\,\delta + T_{566}\,\delta^2$$

$$\delta = (p - p_0)/(p_0 + p_{Gun})$$





Design values:

BC2[1)] R_{56} = -181 mm

T_{566} = 295 mm

BC3[2)] R_{56} = -49 mm

T_{566} = 75 mm

[1)]TESLA-FEL 2002-01 [2)]Limberg et al. EPAC2002

Longitudinal Transfer Map Measurements

Summary

- First measurements of R_{56} and T_{566} done for BC2 and BC3

  beam steering effects during module RF scans
  improvement of measurement accuracy required

- R_{56} and T_{566} measurements to be done for collimator section

Conclusion

- A TOF Monitor System is installed at Flash
  to optimize the operation of the coming 3rd harmonic cavity

- In addition it is used/can be used to measure dark current
  and beam on-crest phases of all module(-groups)

- First measurements of R_{56} and T_{566} of BC2 and BC3
  have been done as part of the development
  of the 3rd harmonic cavity operation procedure

Detailed information in TTF logbook directory
doc/SubSystems/Time-Of-Flight