

# Beam Position Measurement with BPMs and HOM-BPMs - Last Measurements and Status

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for the BPM and the HOM teams

- 1. Studies on FLASH BPMs
- 2. HOM-BPMs
- 3. XFEL Prototypes

# 1. FLASH BPMs

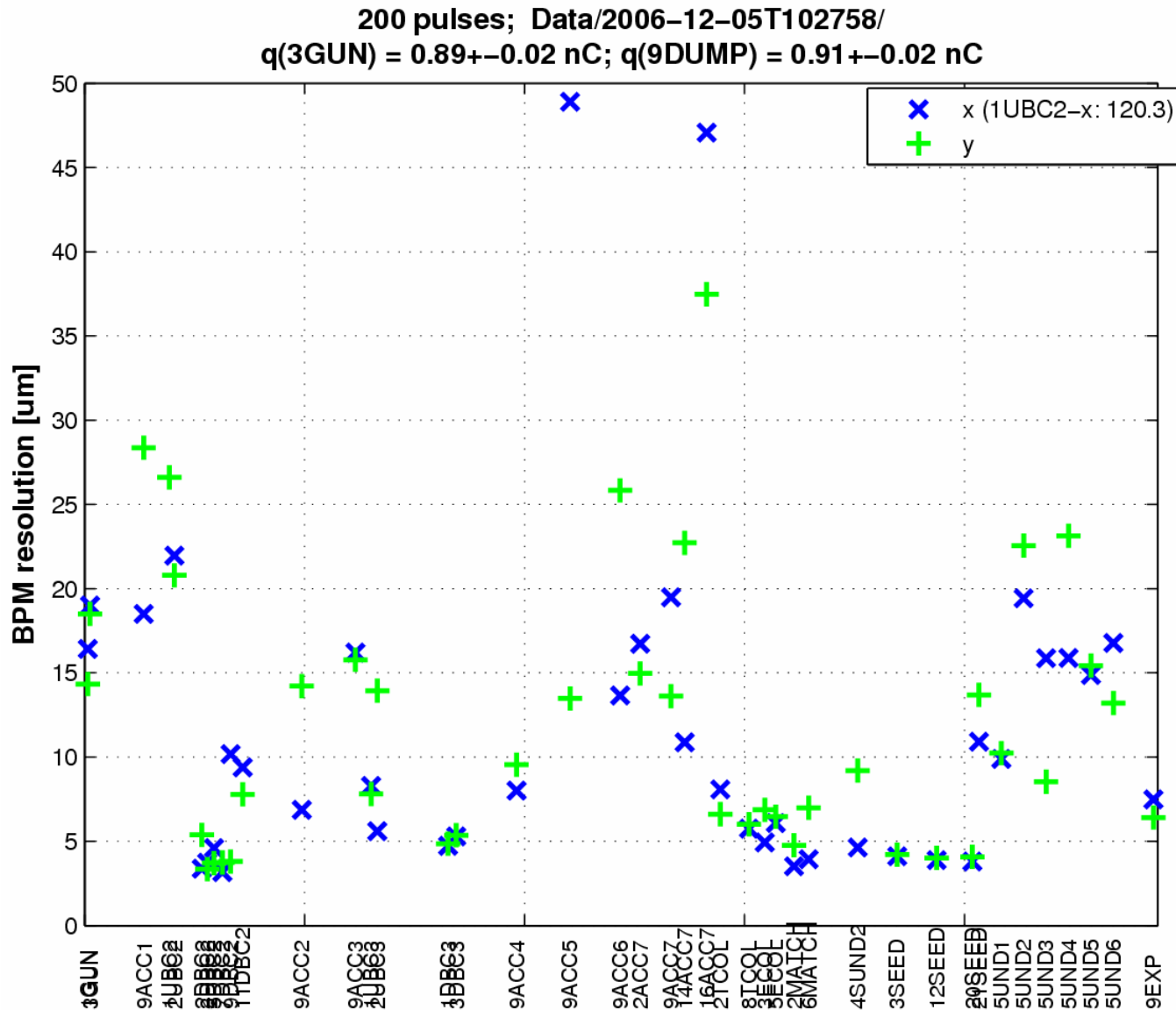
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- FLASH BPMs:
  - striplines; buttons; cavity and re-entrant cavities
- Resolution studies
  - vs. bunch charge
- Studies on BPM-electronics
  - non-linearity studies on TTF2-electronics (Wendt)
  - “Neumann” electronics at button and stripline BPMs
- T&H trigger
  - new DOOCS server (I2C); easier control and study
  - test with stabilized trigger
- Other:
  - calibration studies, charge resolution

# FLASH BPMs

BPM type	Aperture Ø [mm]	Electronics type	Linac section	Amount	Comment	
Button	34	TTF2	UBC2 IDUMP	2 1		
Button	34	TTF1	GUN	2		
Button	9	TTF2	UND diag	6	5UNDx (x=1...6)	
Button	9	Neumann	UND diag	6	21SEED	
Button - coupled	9		UND inside	12	To be commissioned	
Button	150 ?	TTF2	DUMP	2		
Stripline	34	TTF2	many	20	Almost everywhere	
Stripline	34	Neumann	2ACC7	1		
Stripline	44	TTF2	ECOL BYP	2 7		
Stripline Zeuthen	?	Frascati TTF2	ACC6&7 DUMP	2 1		
Cavity	78	Zeuthen	9ACC2..5	4		
Reentrant cavity	78	Saclay	9ACC1	1		
Total				69		

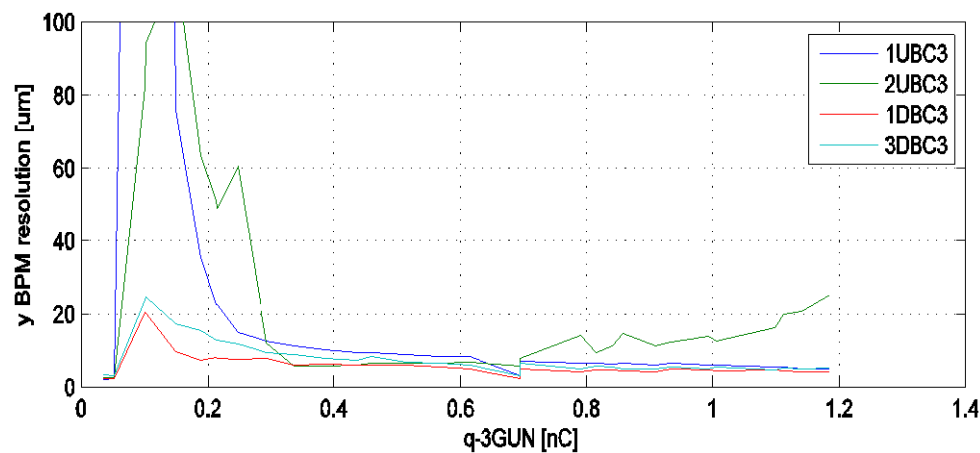
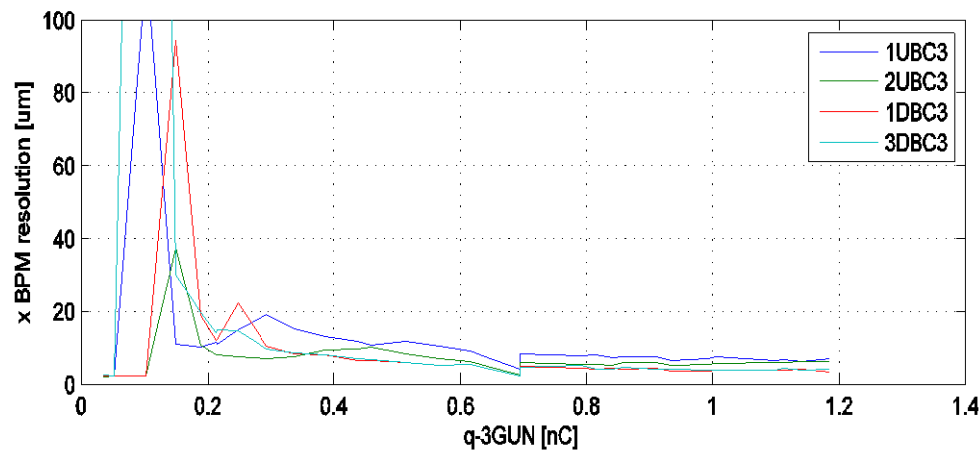
# BPM Resolution (5 Dec. 2006)



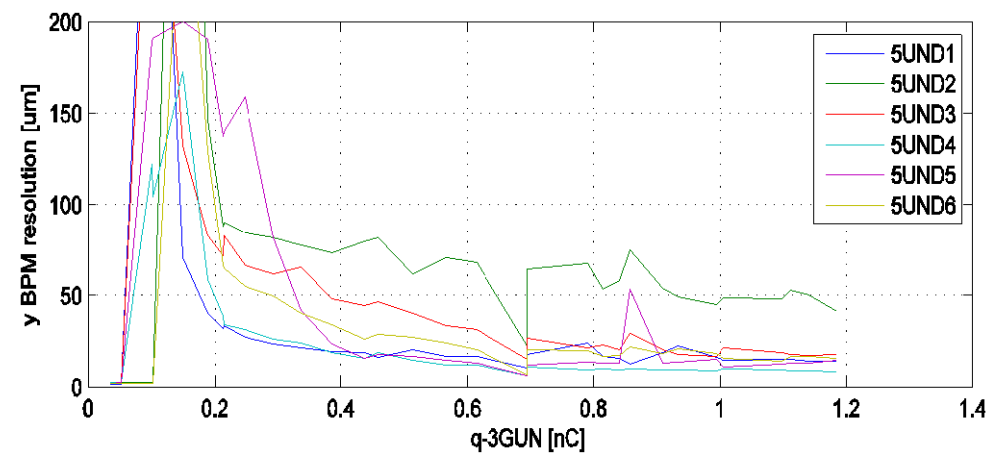
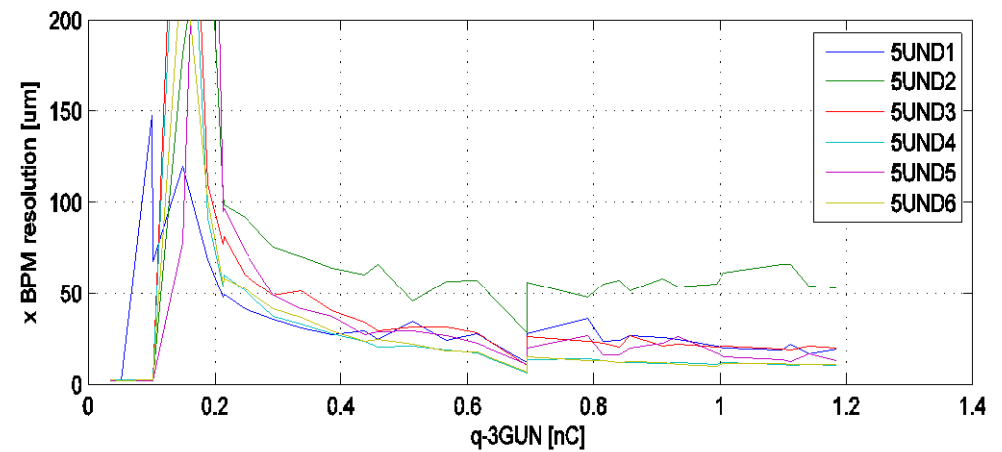
striplines:  $< 10 \mu\text{m}$   
 buttons:  $\leq 25 \mu\text{m}$

# Resolution vs. Charge

## Striplines (34mm)



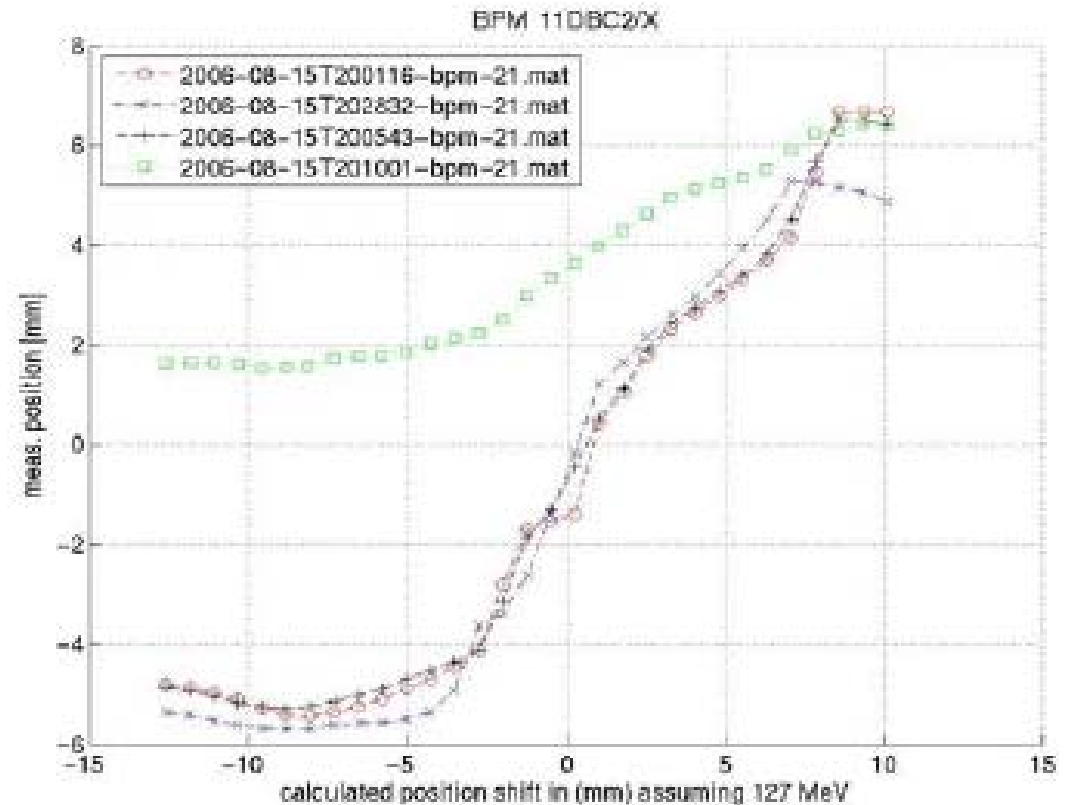
## UND – Diag. stations



# Studies on Non-Linearities (TTF2-electronics)

- Stripline BPMs

- changing electronics settings improve linearity

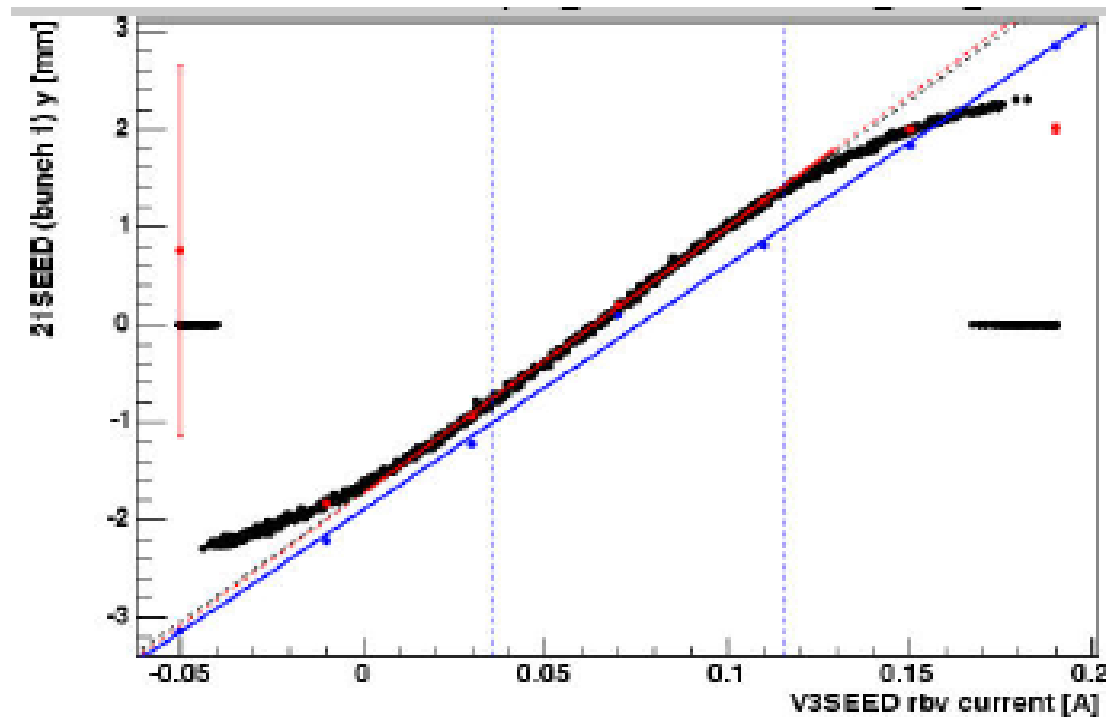


- Button BPMs

- extra-amplifiers and filter drastically improved resolutions and linearity

# Neumann Electronics

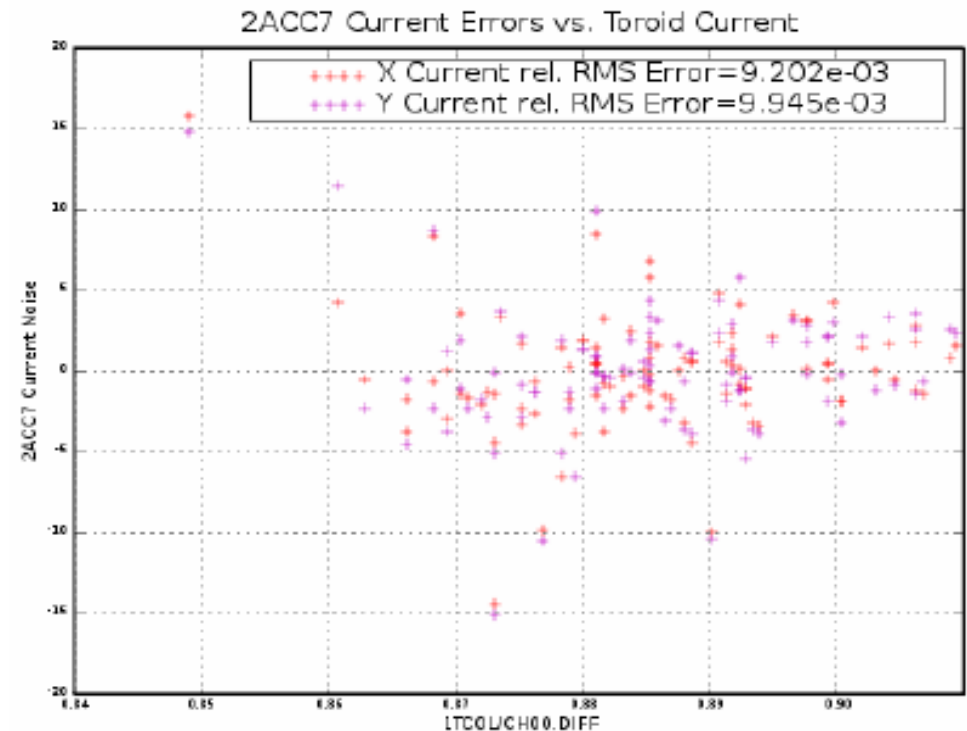
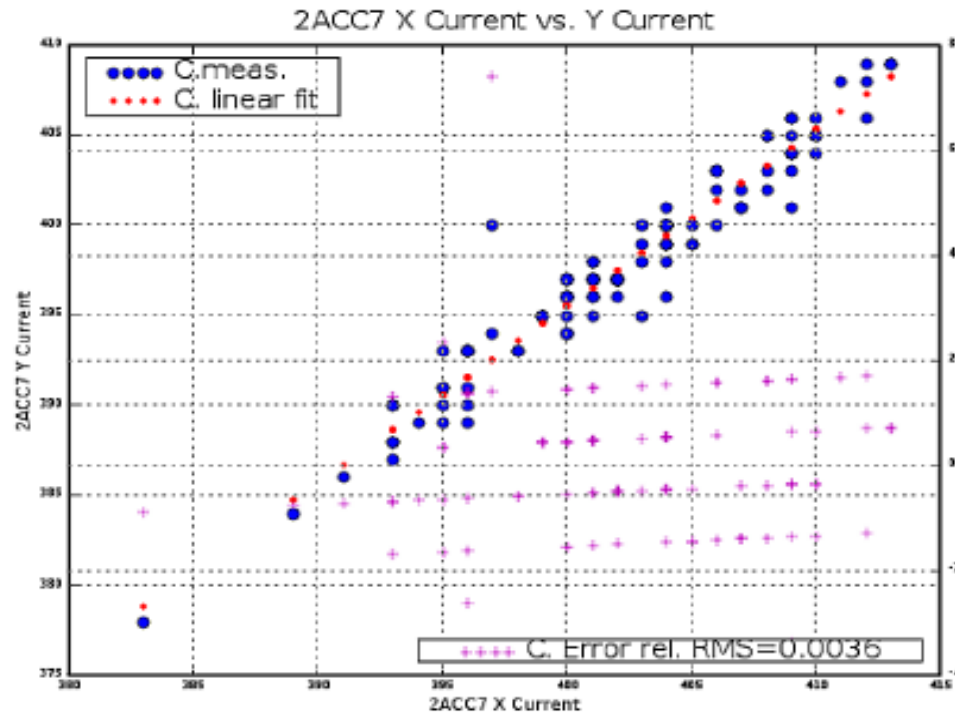
- Button BPM 21SEED
  - resolution 10-15  $\mu\text{m}$
  - good linearity



# Neumann Electronics

- Stripline BPM 2ACC7

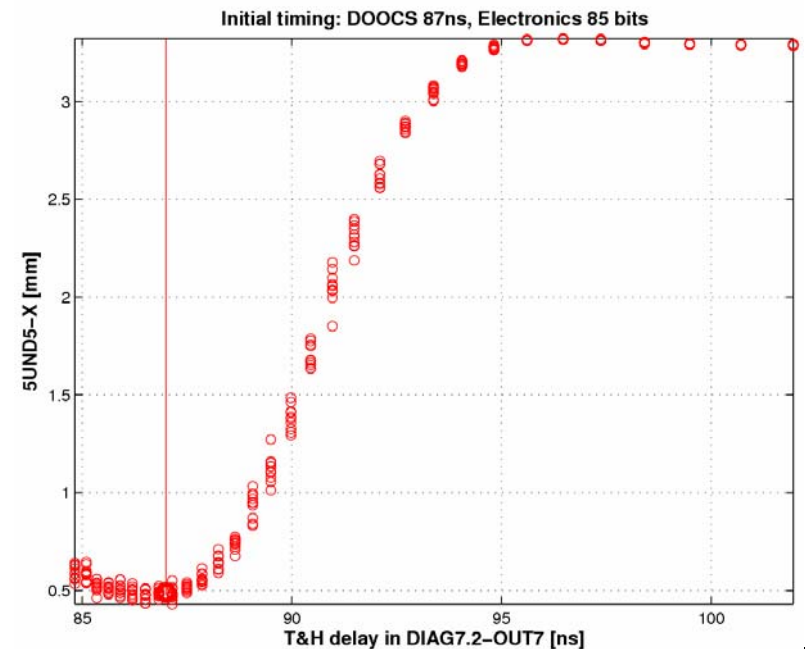
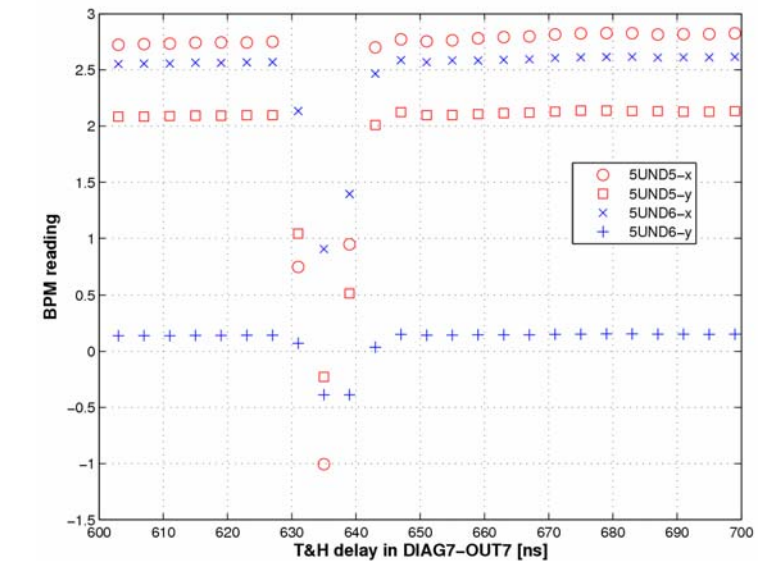
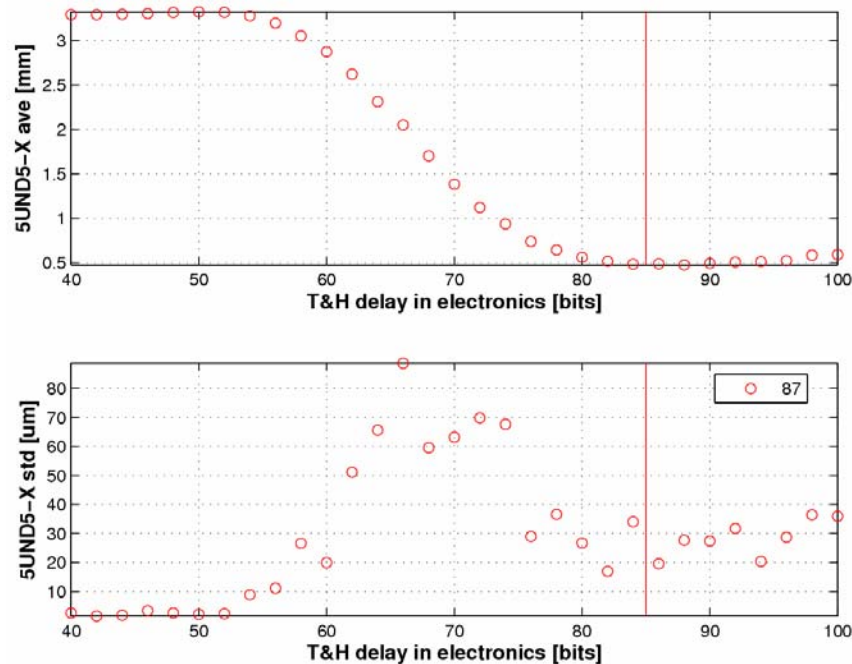
- good position linearity
- prelim: indications for good charge resolution wrt toroids





# T&H Trigger: New Electronics (I2C) Server

- better control and study of electronics
- fine adjustment of trigger timing



# T&H Trigger: Stabilized Trigger

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- **Synchronization-card**

- stabilizes the 9MHz signal by help of a 81MHz signal (from EOS hutch)
- installed in CON-32
- connected one delay card to it, and one VXI rack with BPM electronics: BPMs 5UND5 and 5UND6 (last has modified electronics also)

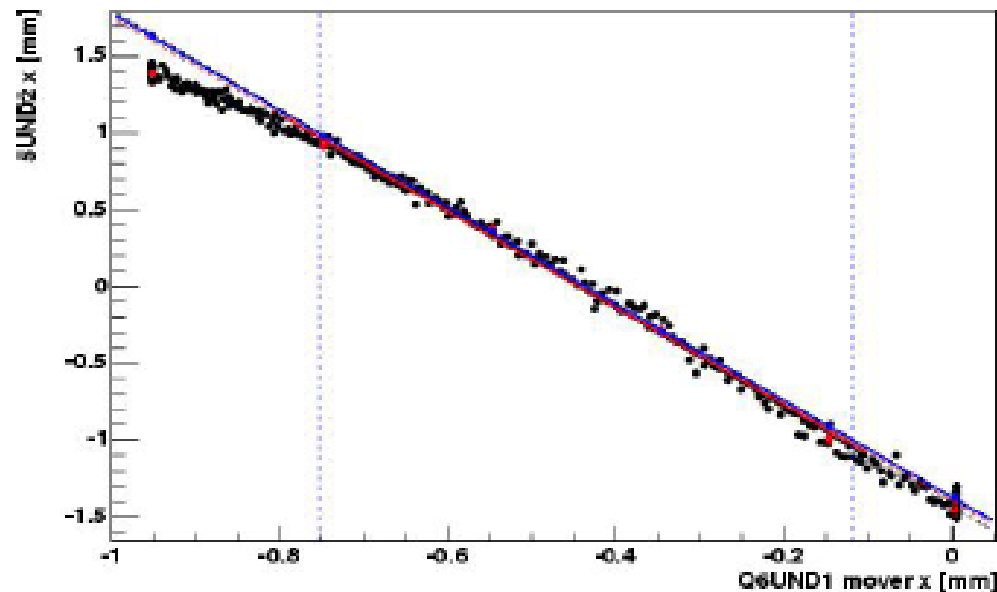
- **Tests**

- 5UND6 not calibrated (bad ADC channel → changed)
- 5UND5 seems to give better resolution, but too little statistics, also unsure timing adjustment
- Plan: connect all UND-DIAG BPMs to the stabilized timing

# Re-calibration of UND BPM (Diag. Stations)

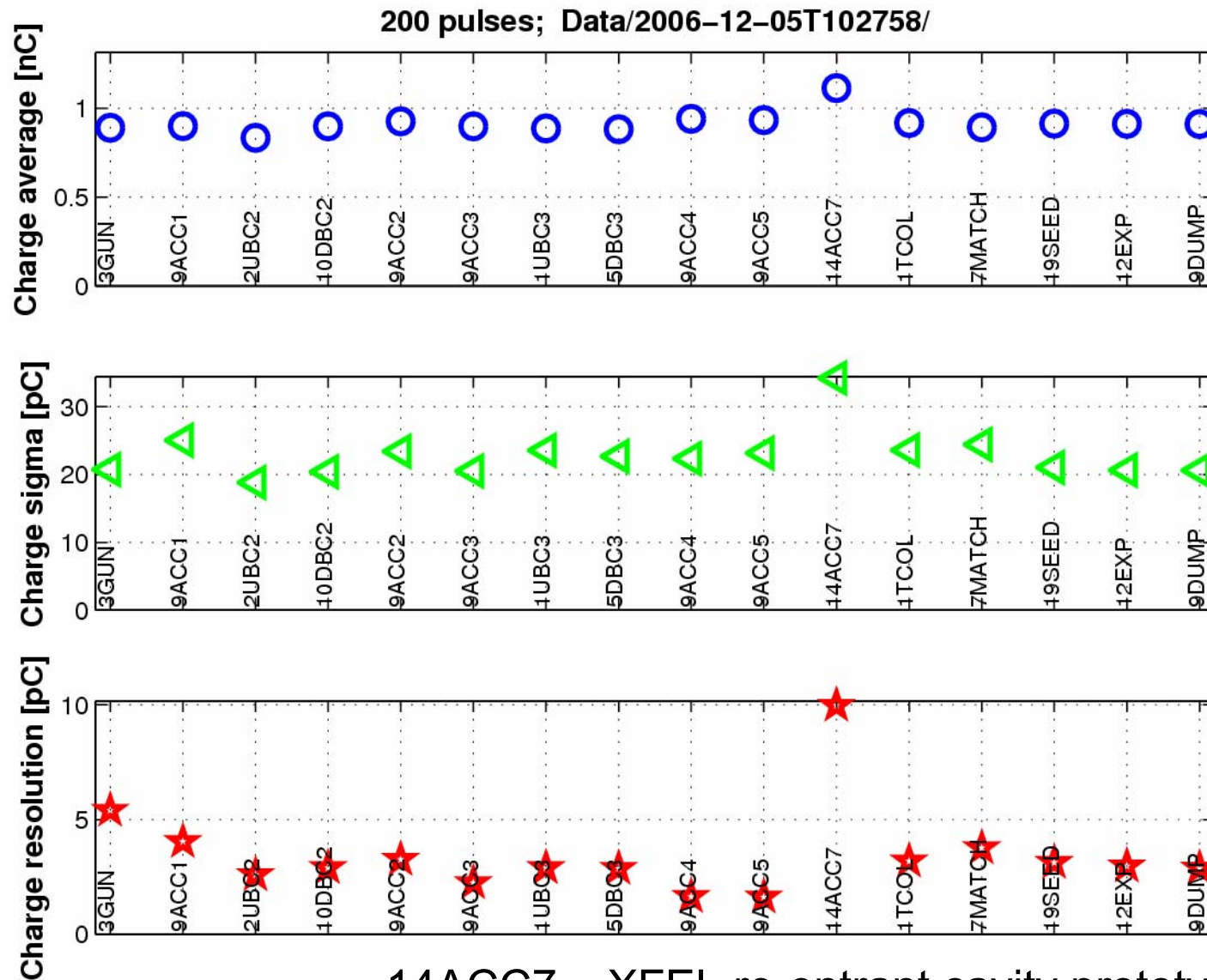
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- Checked calibration or re-calibrated UND BPMs
  - calibration is relatively stable



➤ P. Castro

# Charge Resolution (Toroids and BPMs)



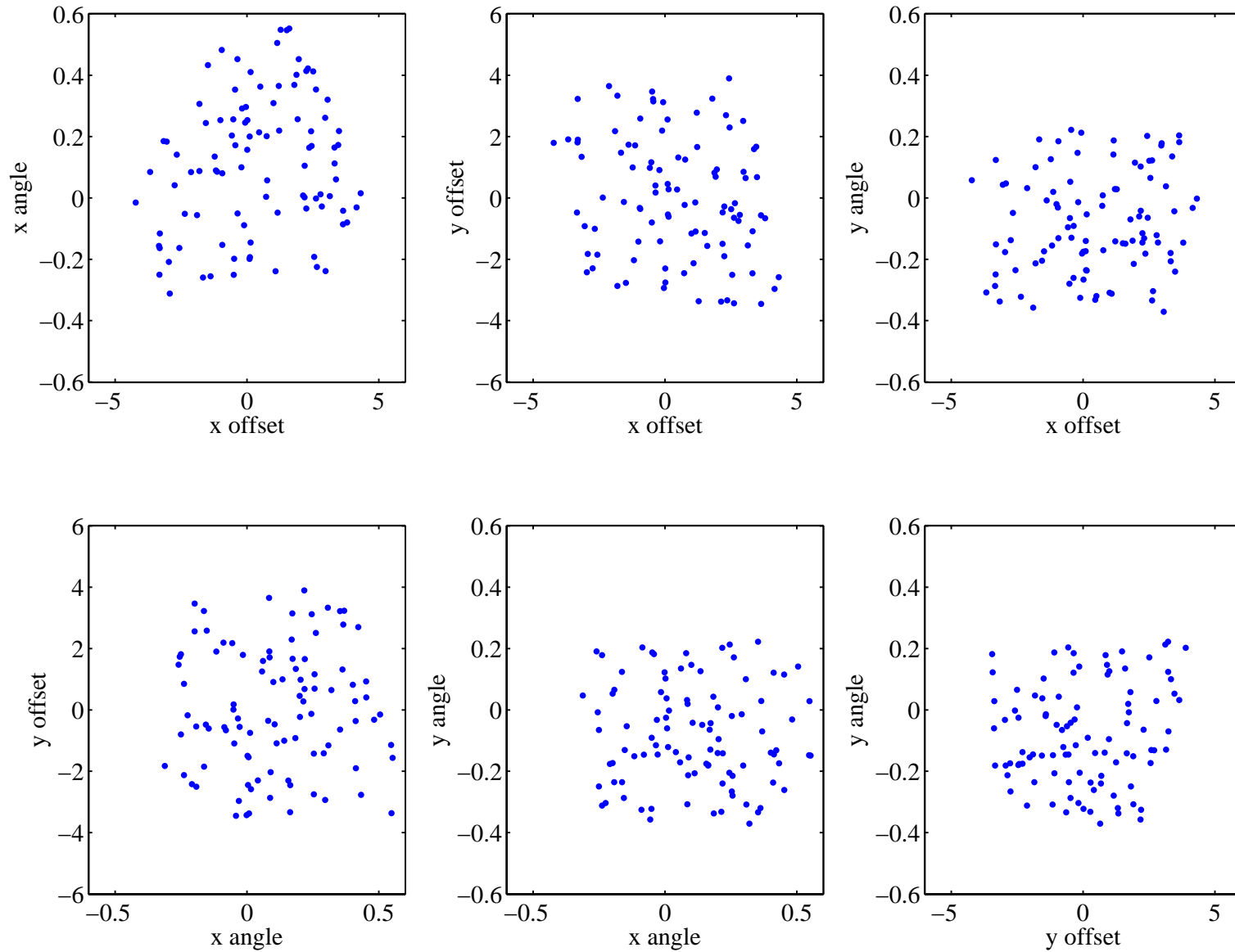
14ACC7 – XFEL re-entrant cavity prototype  
(calibration to be checked)

## 2. HOM-BPMs

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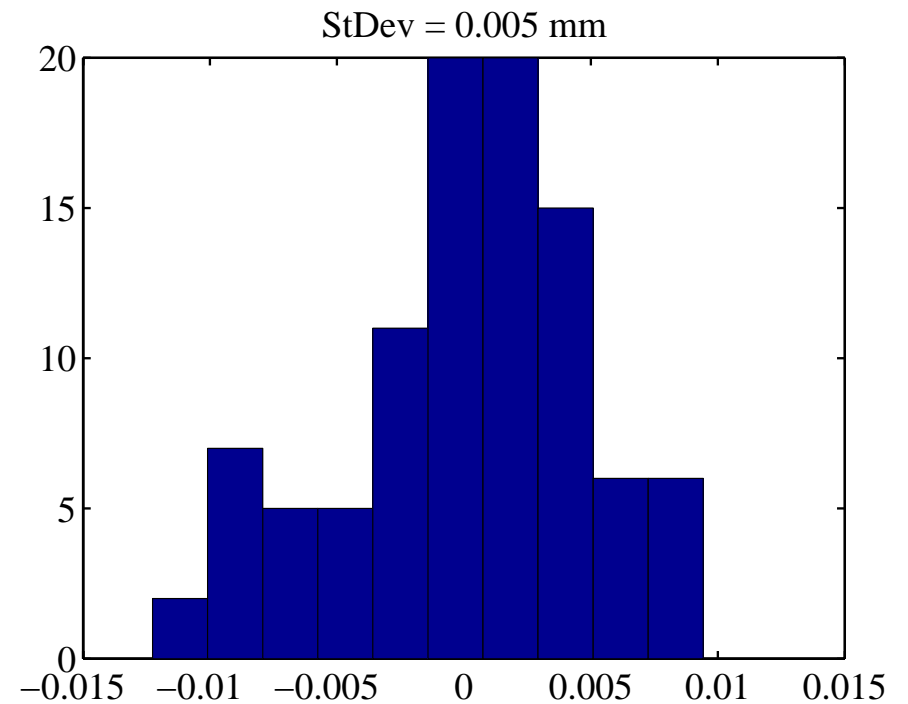
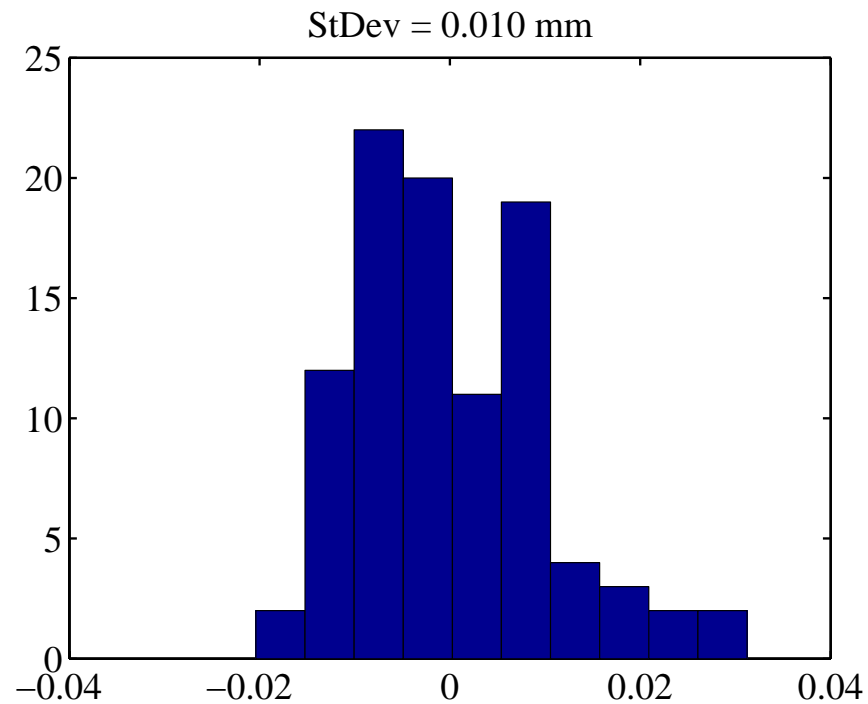
- Large crew: SLAC, FNAL, KEK, DESY
- Purpose
  - calibrate HOM signals into BPM-like signals
  - single bunch for now
  - include into control system
  - beam phase measurement
- Measurements
  - refined earlier calibration measurements
    - cover better the 2D scans
    - go through minimum signal in all 4D space
  - tested FPGA board
  - beam phase measurement
    - simultaneous for all modules (one cavity per module)

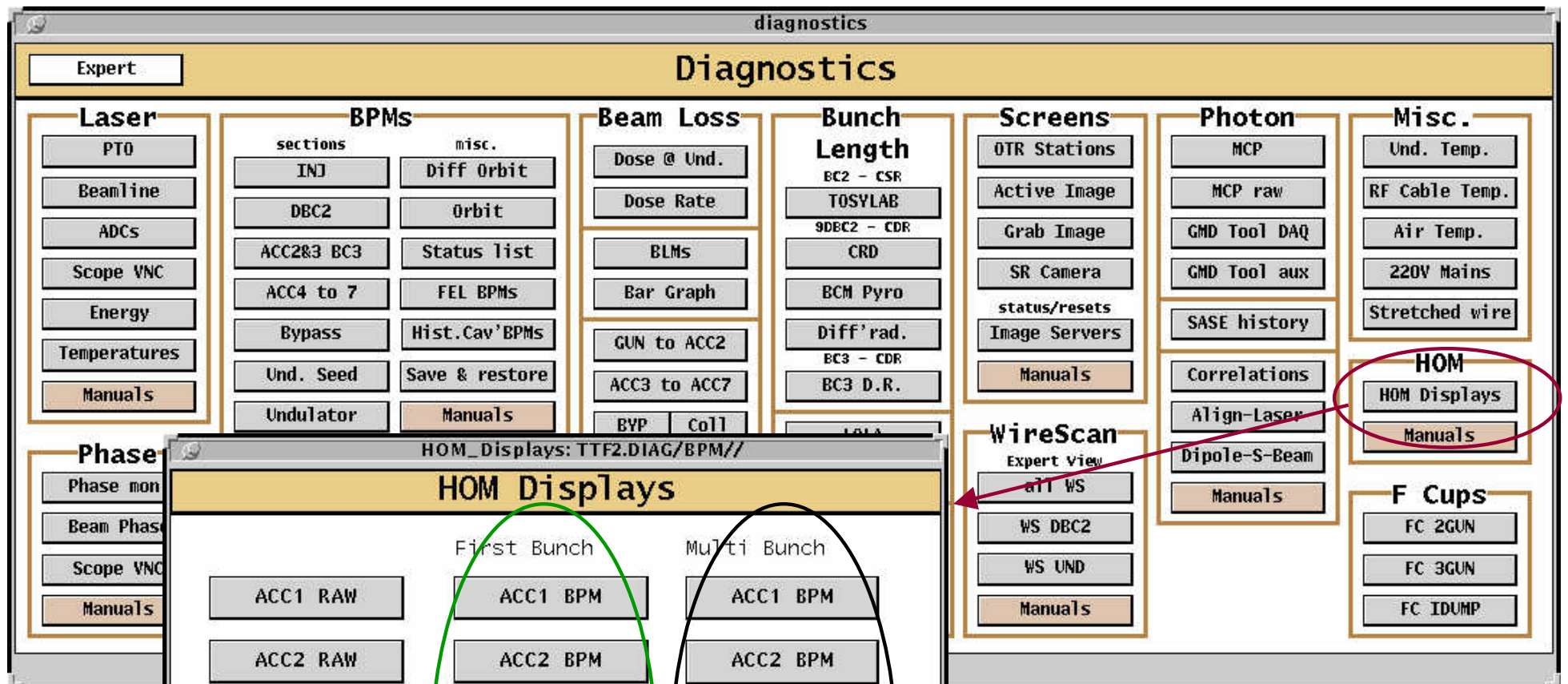
# 2D Scans



# Position measurement resolution

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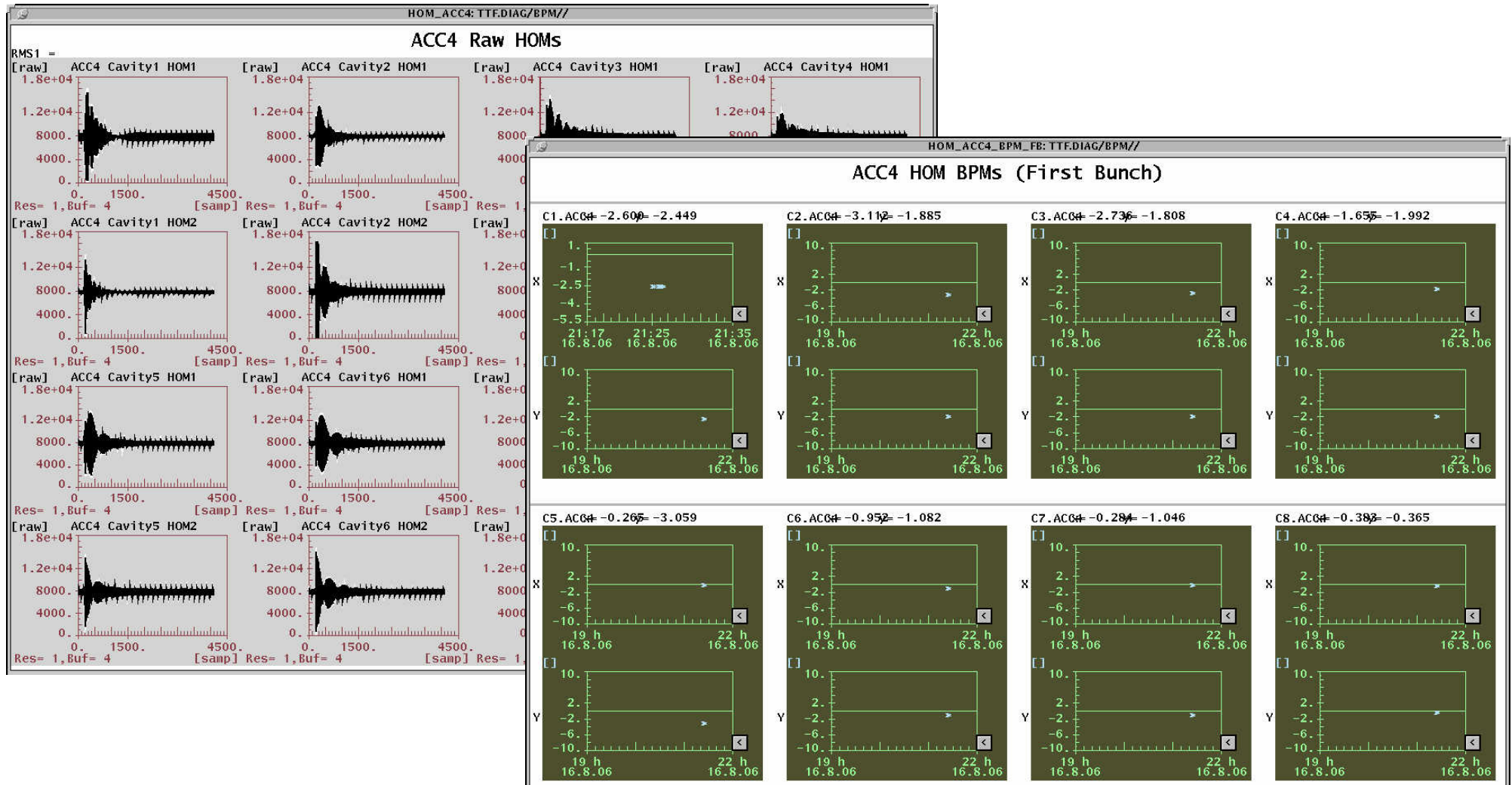


history of first bunch  
(under commissioning)

useful for multi-bunch;  
does not work yet

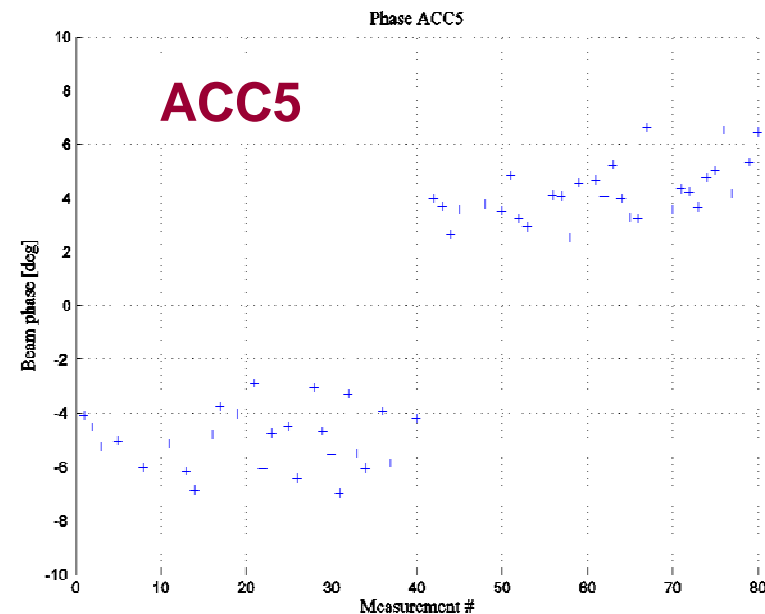
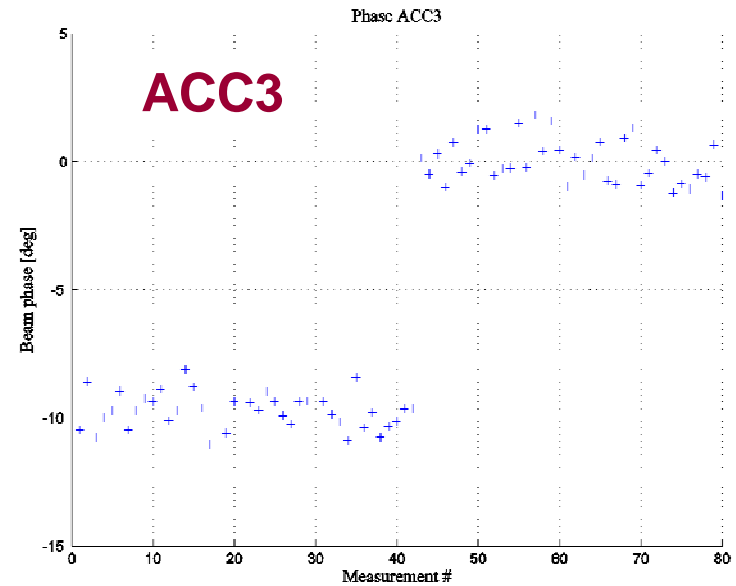
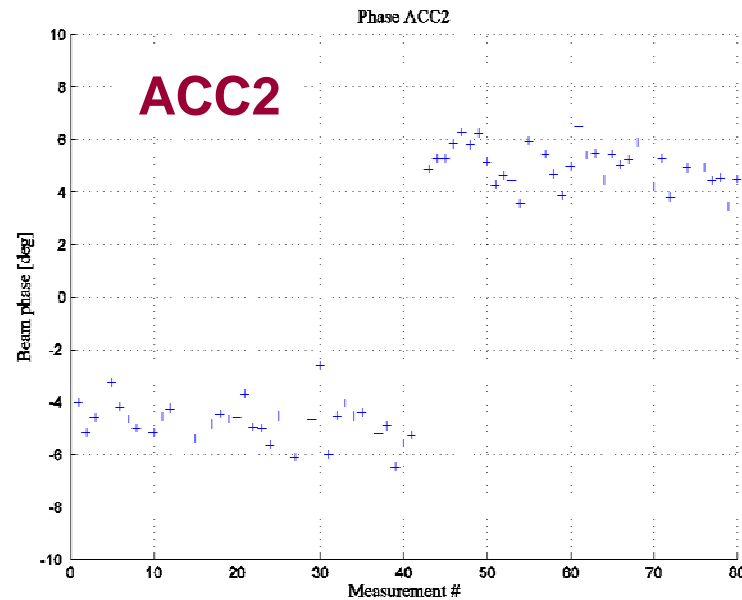


# HOM-BPMs



- calibration needs to be checked (don't use yet!)
- eventually will provide also beam angle

# Beam phase w.r.t. RF: 10deg phase change



- similar for ACC1
- did not work for ACC4, reason not understood
- expert system for now, based on scopes

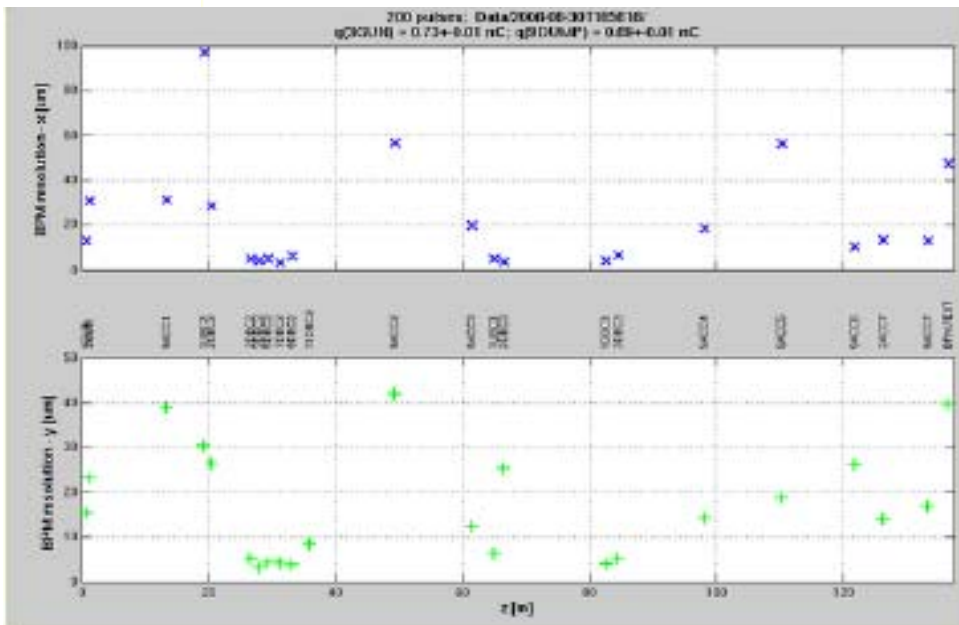
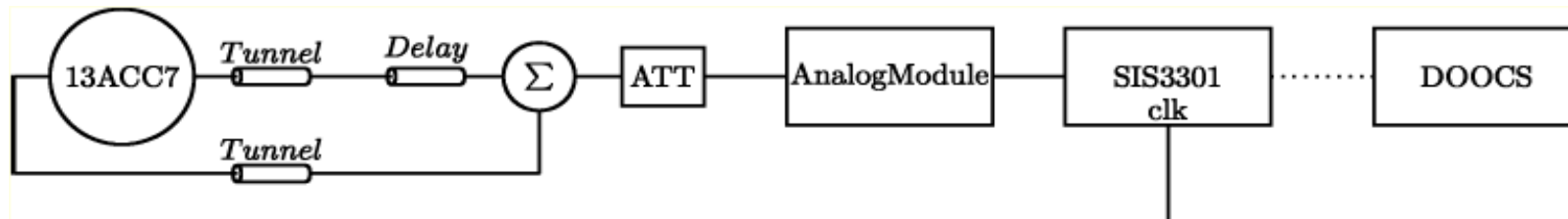
### 3. XFEL prototypes

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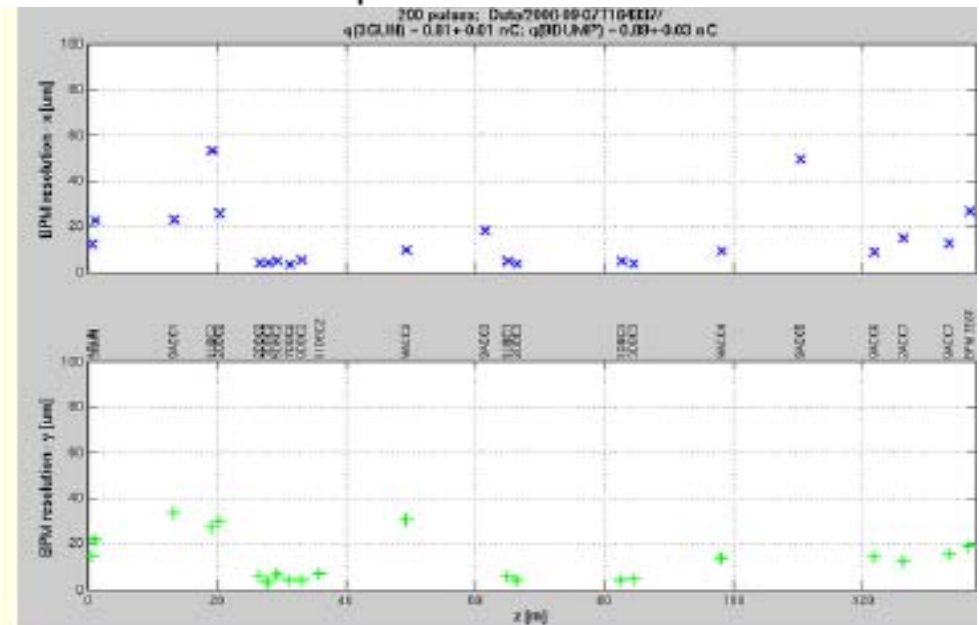
- 3a. Button 13ACC7
- 3b. Re-entrant cavity 14ACC7 (name to be changed)
- 3c. PSI resonant stripline BPMs
  - built in Oct.

# 3a. Button XFEL prototype 13ACC7

- Neumann electronics with high resolution ADC (Struck)



Att. = 10dB



Att. = 1dB

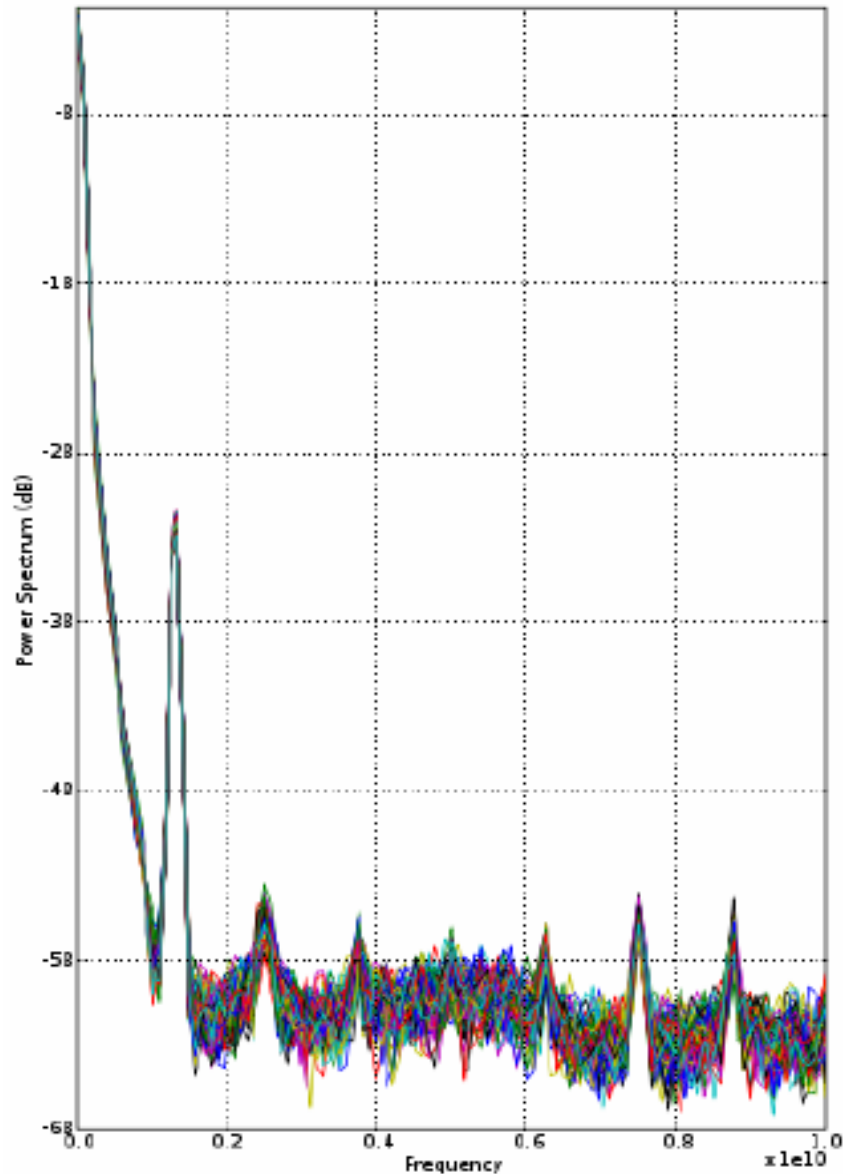
improved resolution with reduced gain (and removed atten.)

Resolution is limited by S/N ratio

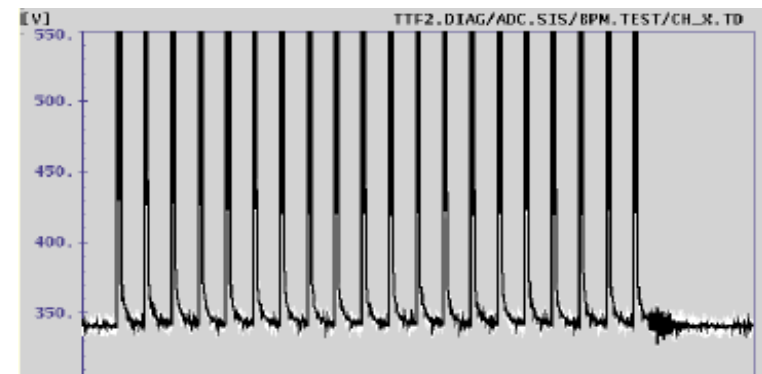
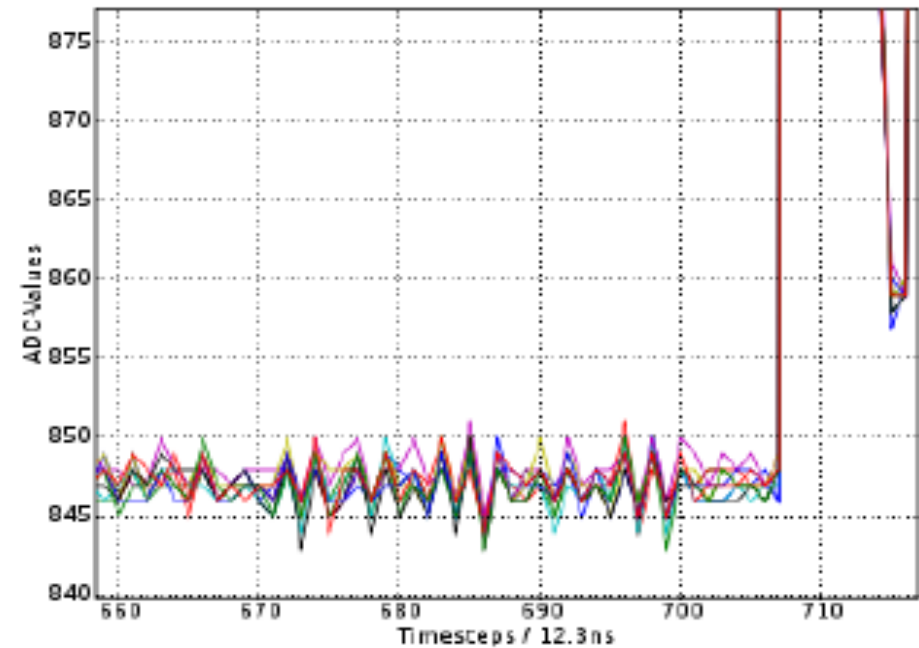
Indications for good charge resolution

# Button XFEL prototype 13ACC7

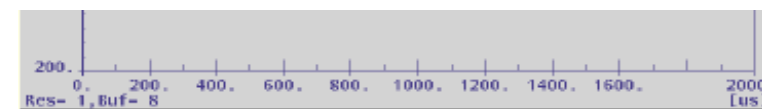
Spektrum des Monitorausgangs am 21SEED  
ueber 1h im Minutenabstand



Lange Delayline  
RS-ATT = 2 dB

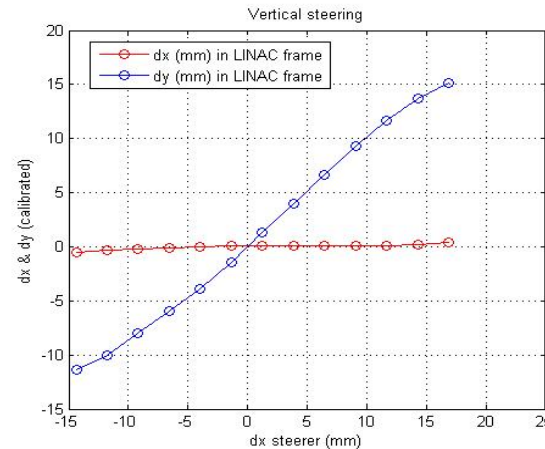
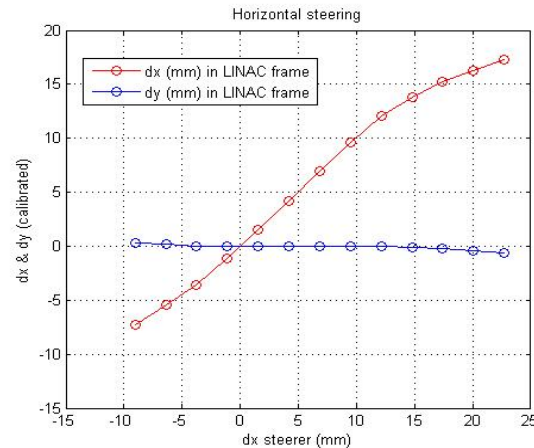


random signal after bunch train?

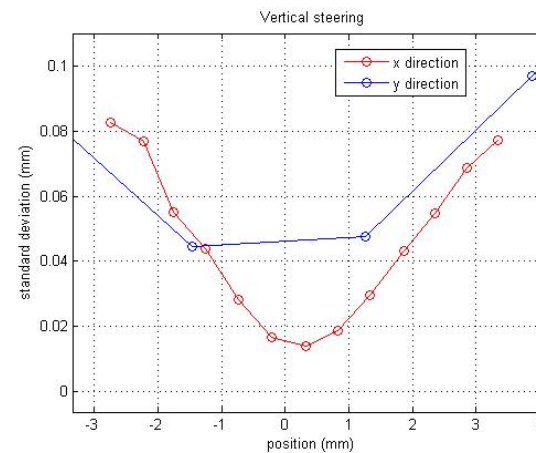
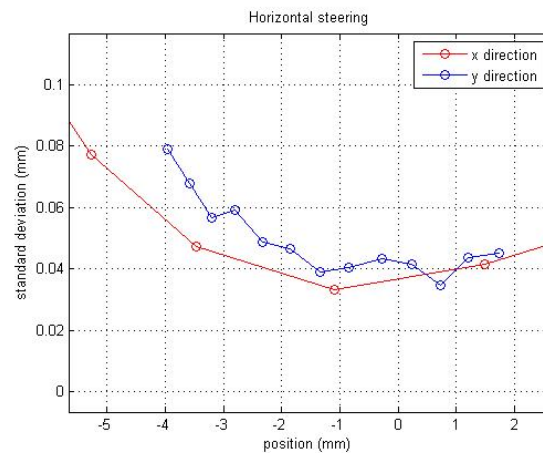


## 3b. Re-entrant Cavity Prototype 14ACC7 - First Beam tests

- Summer 2006, the first beam tests were carried out (at room temperature).
- The BPM was calibrated to have a good measurement dynamics.



*Calibration results in LINAC frame from horizontal (left) and vertical (right) steering*



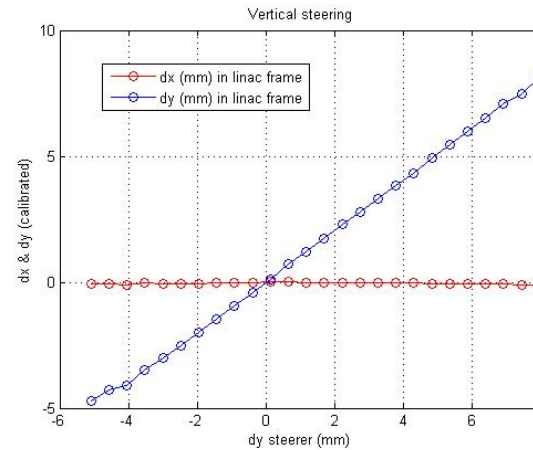
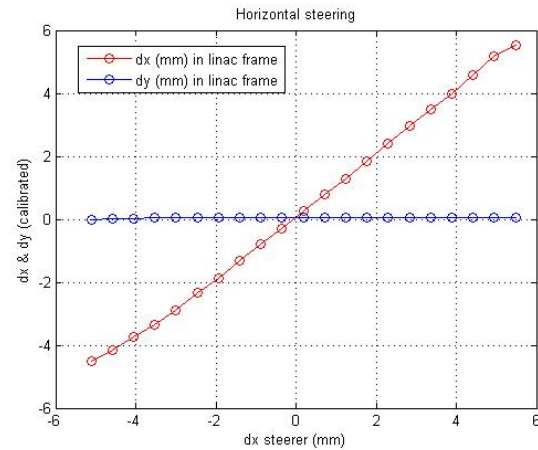
*Standard deviation of the position measurement (calibrated)*

- Good linearity in a range **+/-5 mm**
- RMS resolution **<40  $\mu\text{m}$**  with beam jitter

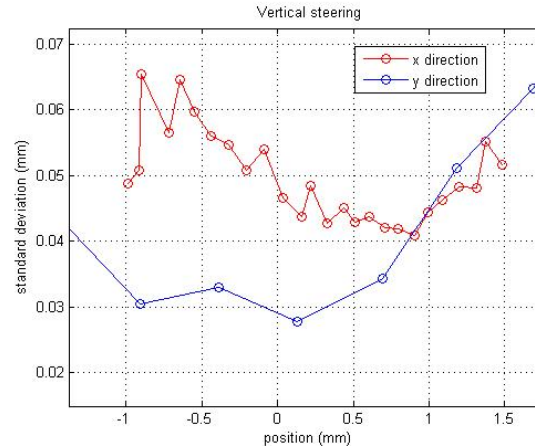
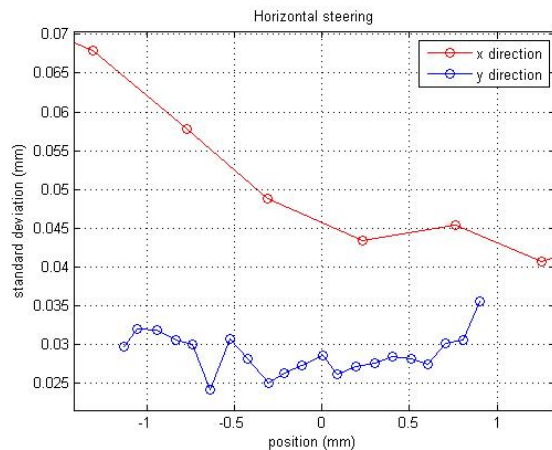


# First Beam tests on 14 ACC7 BPM system

- A second test period was necessary to validate the first results: the same steerers were used, the deviation range was limited to  $\pm 4$  mm for a more accurate calibration



*Calibration results in LINAC frame from horizontal (left) and vertical (right) steering*



*Standard deviation of the position measurement (calibrated)*

- This second measurement corroborates the first calibration.
- Linearity in this calibration range is good for both channels.
- Minimum standard deviation of the measurements at the BPM center is around 40  $\mu\text{m}$  for X channel and around 30  $\mu\text{m}$  for Y channel.

# Next BPM studies

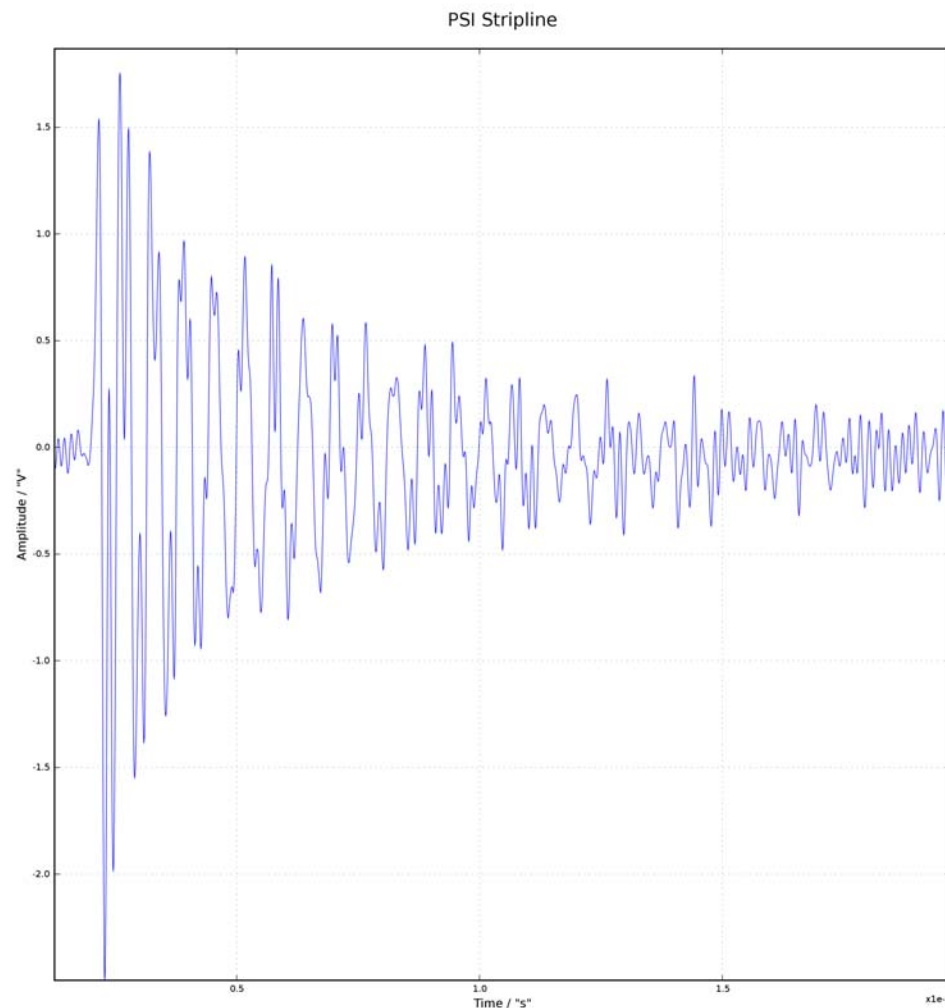
- Resolution studies of the 14ACC7 BPM
  - first measurements indicate resolution below 20 $\mu$ m
- Mixer will be modified and attenuators will be removed to improve the resolution.
- Calibration of the 14 ACC7 BPM with this new layout.
- Calibration of the 9ACC1 BPM



# 3c. PSI Resonant Stripline

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➤ very strong signals



with 20dB attenuators