Preliminary Results of IPBPM Study at Upstream

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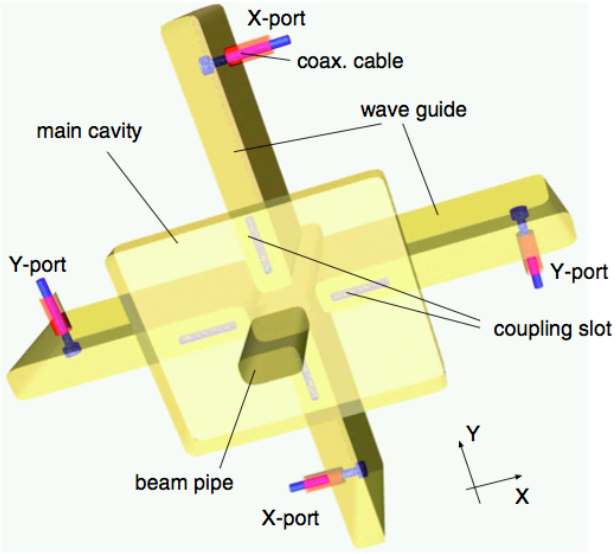
IPBPM Characteristics

- Rectangular cavity shape
  - To isolate the x and y dipole modes
    - X (5.712 GHz) / Y (6.426 GHz)
- Low angle sensitivity
  - The cavity length in the z direction L : 6 mm
- Ultra high position sensitivity
  - Expected to be large angular jitters @ the IP
  - The beam vertical divergence $\sigma_y^{*\prime}$: 345 μrad
  - The coupling constants β
    - X (1.4) / Y (2.0)

Structure of the IP BPM

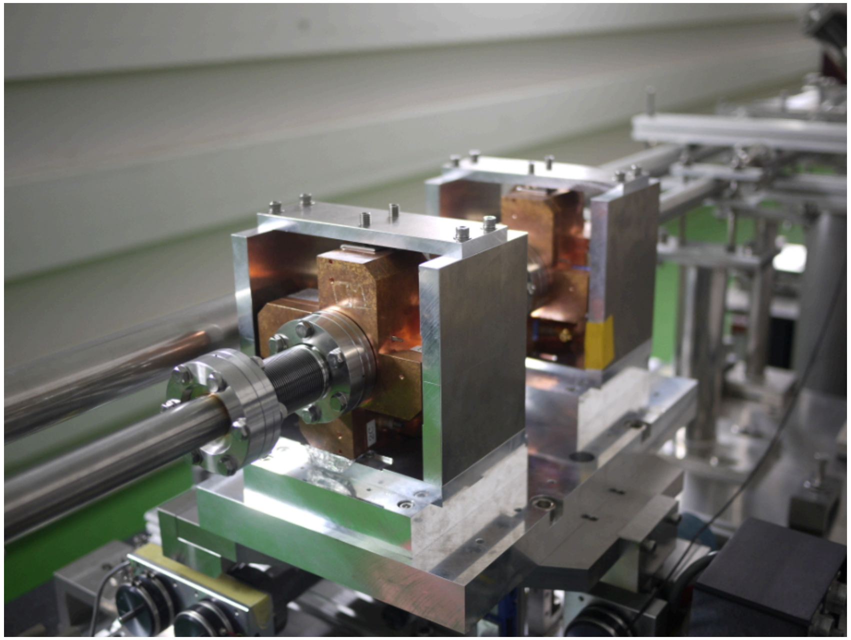


Simulated parameters of IPBPM

parameter	f_0 (GHz)	β	Q_L	Q_0	Q_{ext}	$(R/Q)_0$	τ (ns)
x	5.712	1.578	2070	5337	3382	0.549	58
y	6.426	3.154	1207	5015	1590	1.598	30

Introduction

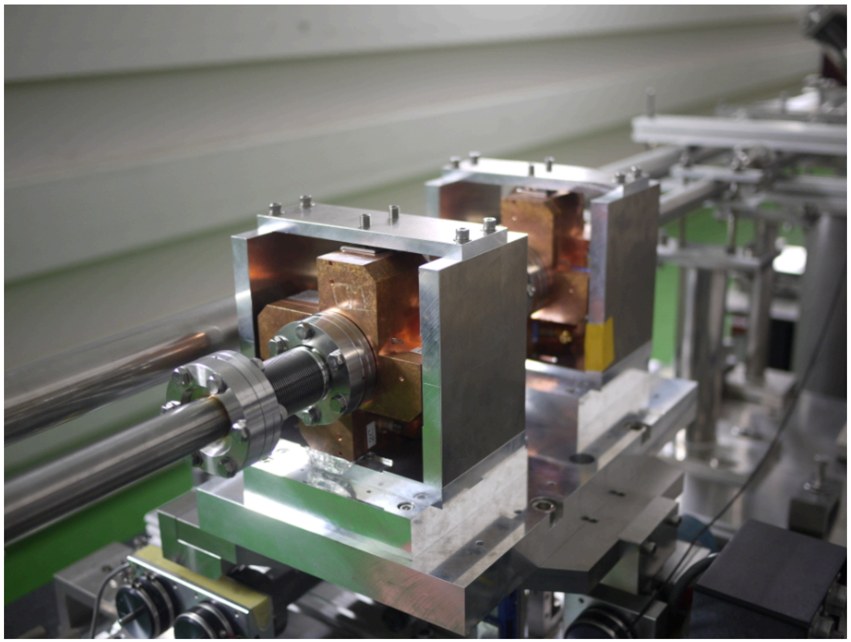
IPBPM system in the ATF2 beam line



- Two cavities were fabricated together to form an IPBPM block
- Located on one of two switchable beam lines
  - The IPBPMs installation can be quickly removed without breaking vacuum
  - The small aperture could introduce wake-fields that distort the bunch shape
- Three shifts
  - 16th November
  - 30th November
  - 8th December

Installation

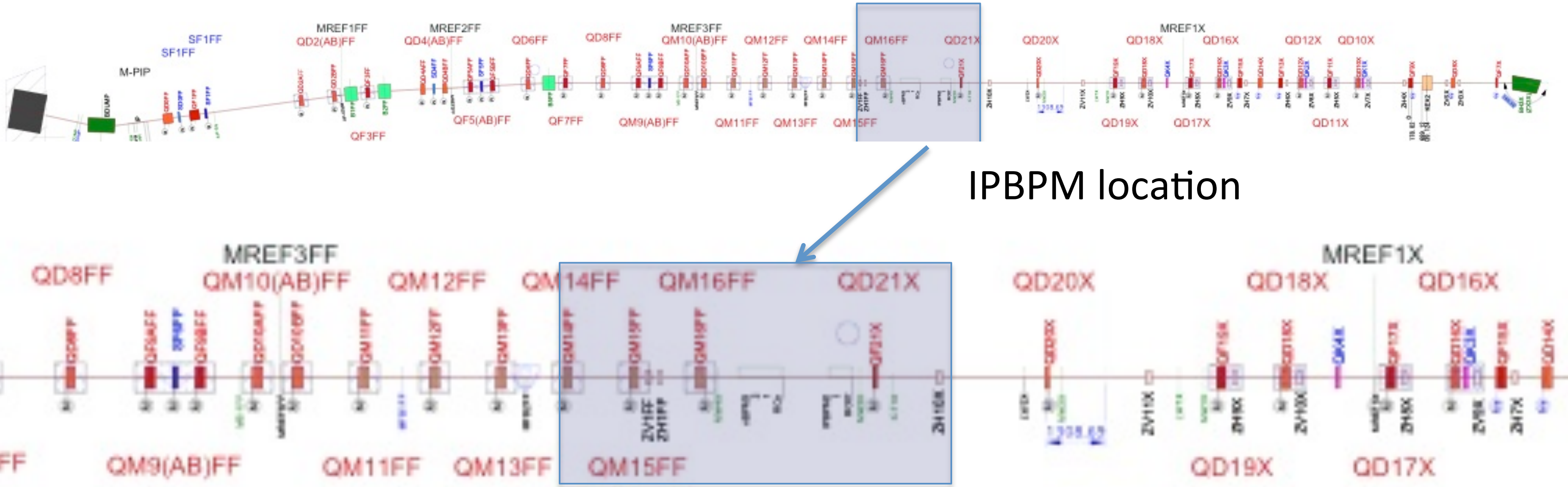
IPBPM system in the ATF2 beam line



- Two IPBPM blocks were mounted on a magnet mover system
- The mover system has three degrees of freedom, vertical, horizontal and roll
- The movement range is ±1.5 mm with approximately 1 μm accuracy
- The expected relative motion between blocks is ~ 1.4 nm at 1.56 Hz.

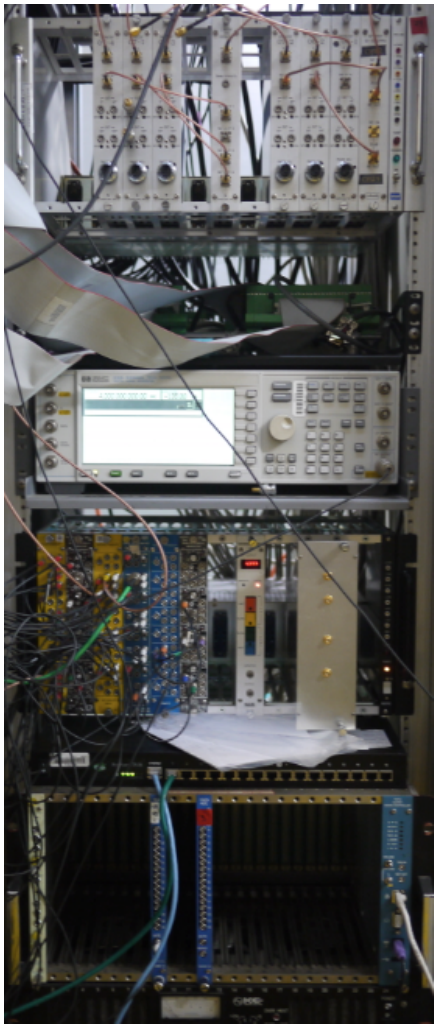
Beam line layout

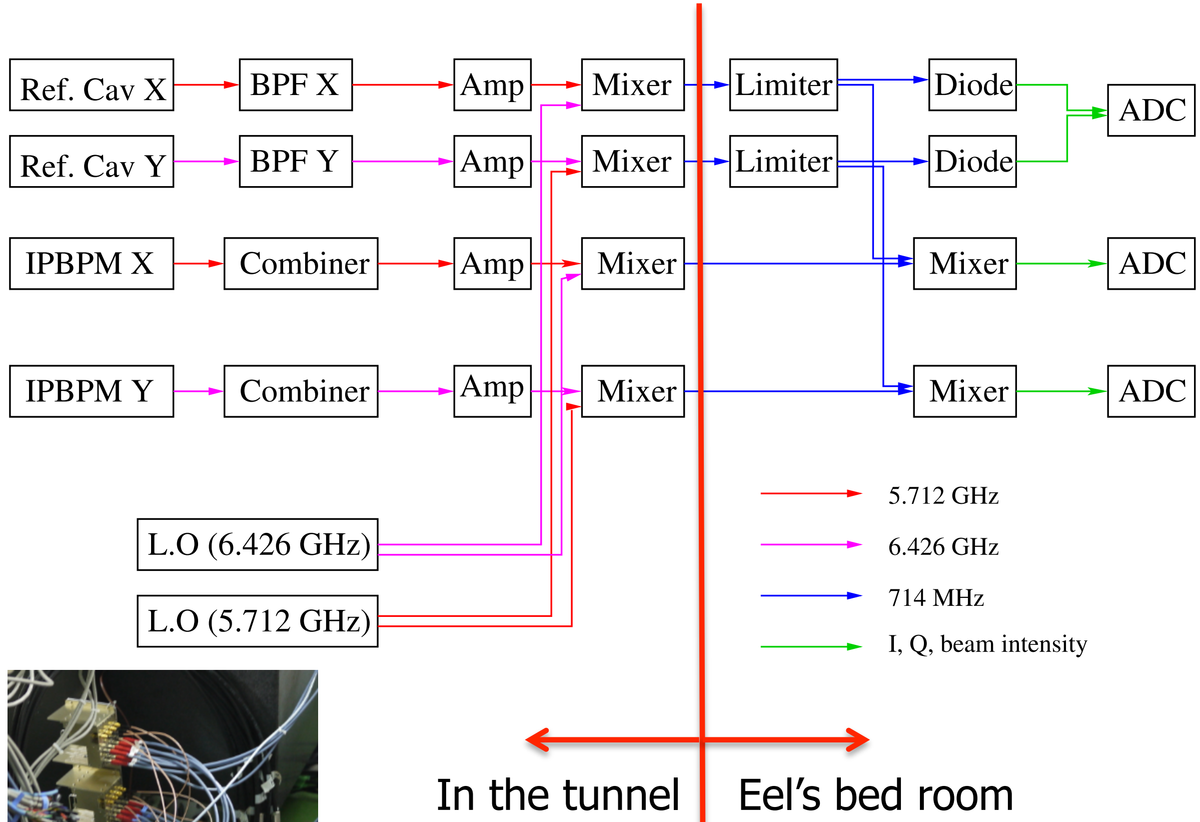
ATF2 Beam line

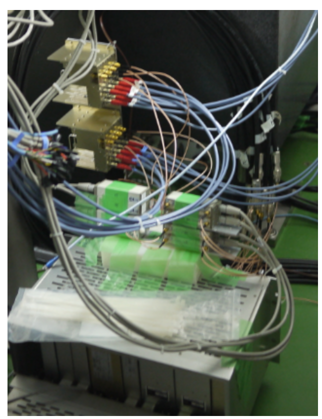


- Use normal C-band BPMs to monitor beam
  - Took entire BPM information for beam jitter study

Electronics







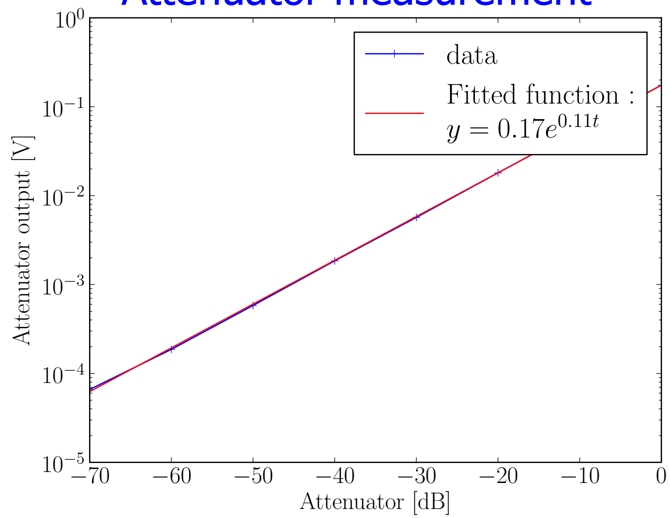
Total processing electronics gain : 40 dB
The minimum detectable signal : -95 dBm

Calibration

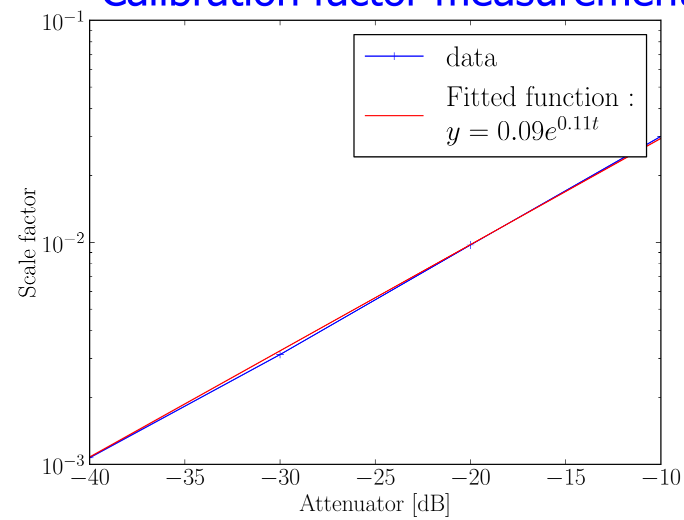
- Calibration factors needed to convert the ADC readouts to beam positions
- To estimate systematic errors in the calibration factor, the calibration procedure was repeated several times
- Used mover system for calibration
- Calibrated with 40, 30, 20 and 10 dB attenuator
- Although calibrations at attenuation settings of 0 dB was impossible due to the limited dynamic range and beam jitter but with 10 dB was done 16th of November.
- Calibration factors are extrapolated from the calibration results with 40, 30 and 20 dB attenuator

Scale factor

Attenuator measurement



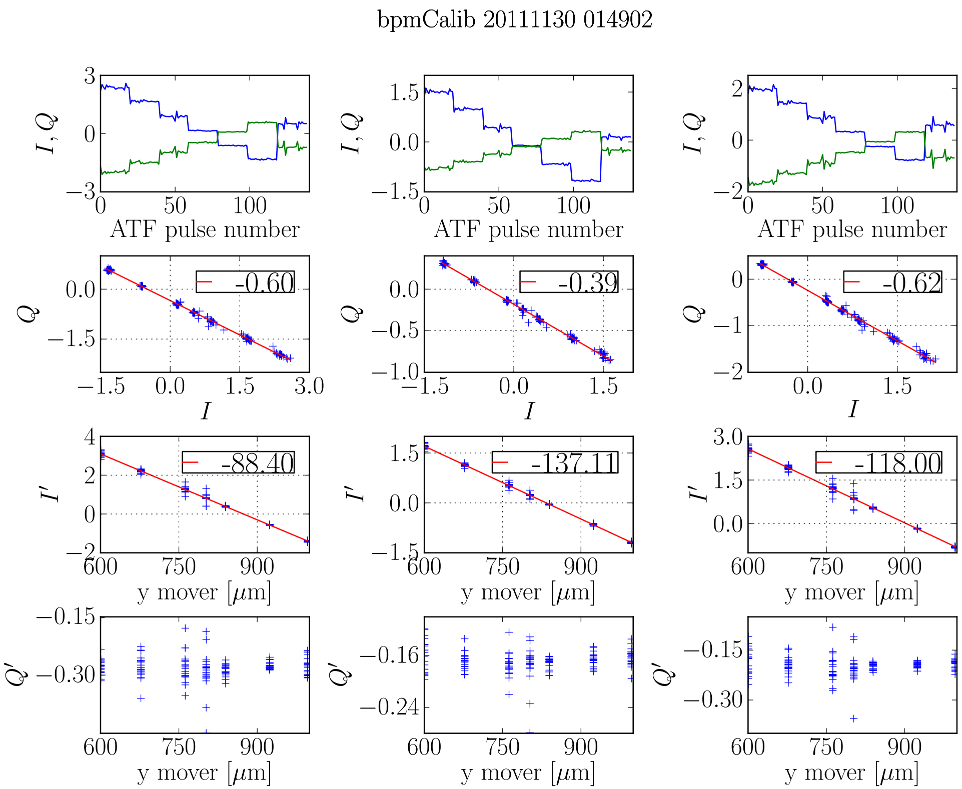
Calibration factor measurement



- Effect of attenuator is well known
- Adjust scale factor by $10^{(A/20)}$

- Cannot calibrate without attenuator due to beam jitter and narrow dynamic range
  - Beam jitter should be smaller than dynamic range

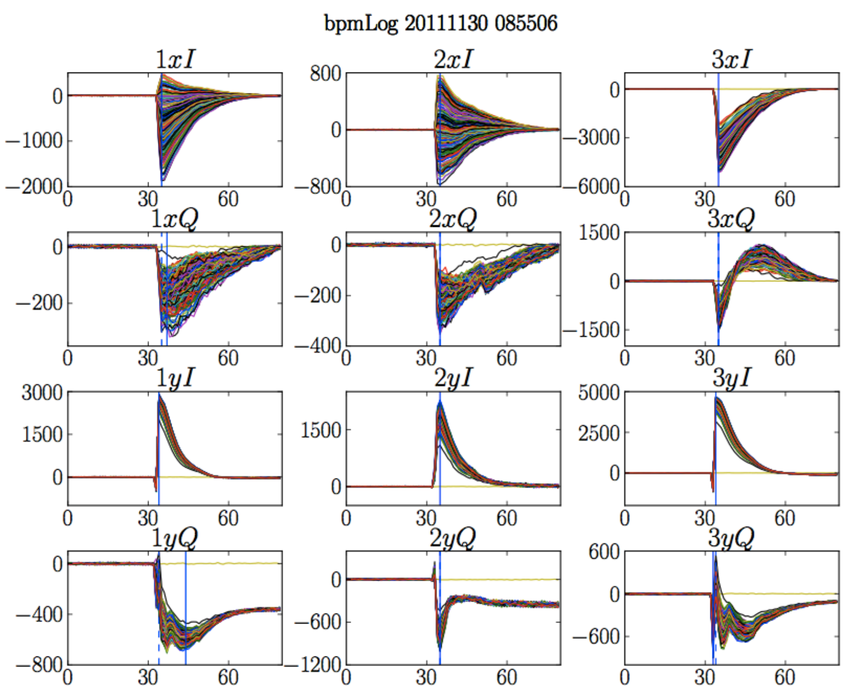
Calibration plot

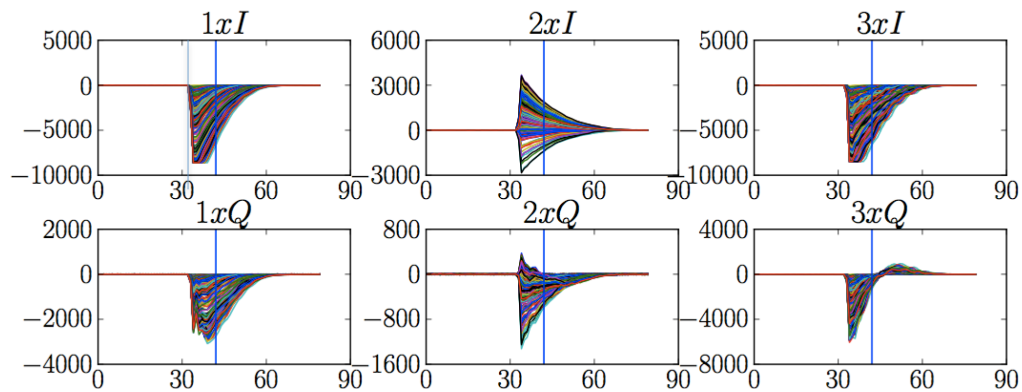


- Calibration plot
  - With attenuator
  - Horizontally, vertically
  - Tried to minimized Q using phase shifter
- Calibration factors : within 5% stability

Waveform – homodyne

Waveform data for resolution run

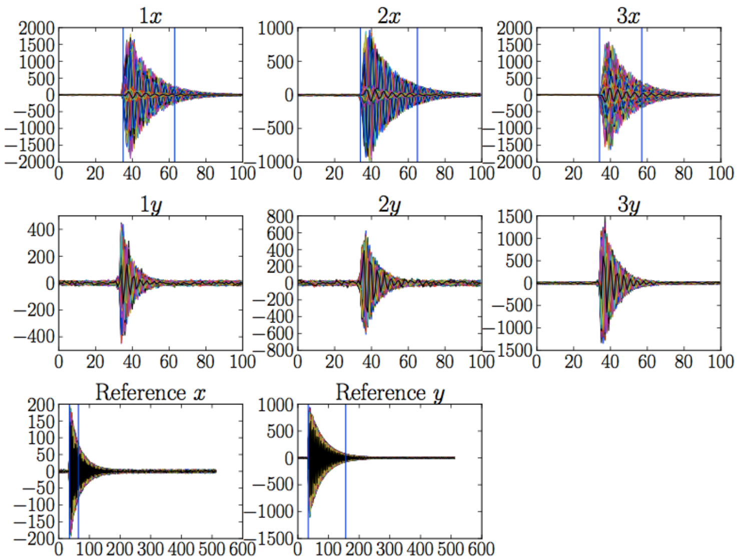




There are some saturated data.
We can use integration method.

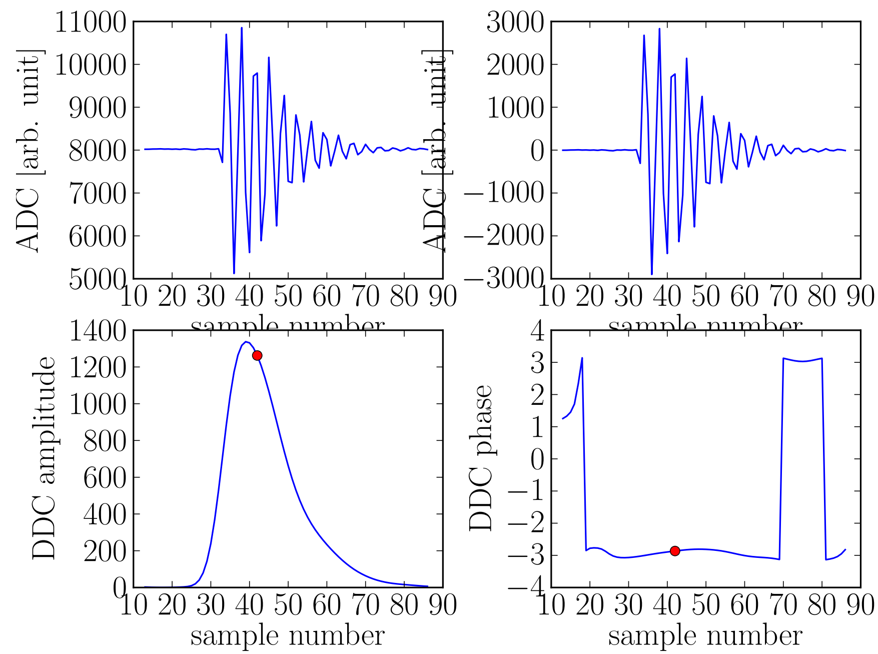
Waveform - heterodyne

Waveform data for calibration horizontally

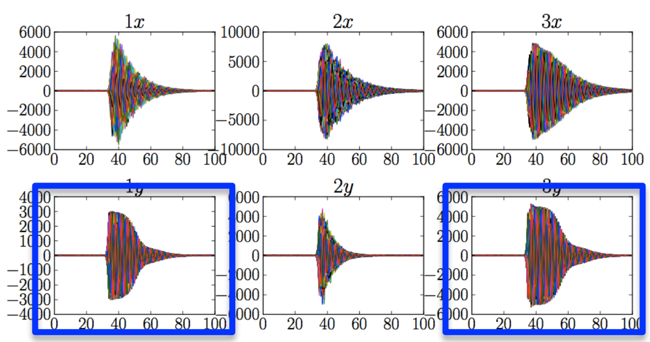


25 MHz IF

Example of Digital Down Conversion



Waveform data for resolution



Electronics saturation?
Decreased the resolution. How to deal?

Resolution - Homodyne

Vertical

Charge : 0.5 ~0.6 x 10^{10} , Unit [nm]

	40 dB	30 dB	20 dB
One point	10.0	15.0	16.0
Filter	6.90	8.12	9.05
Integration	6.73	7.55	10.09

Horizontal

	40 dB	30 dB	20 dB
One point	20.0	39.0	72.0
Filter	14.52	26.14	50.08
Integration	16.50	23.91	35.00

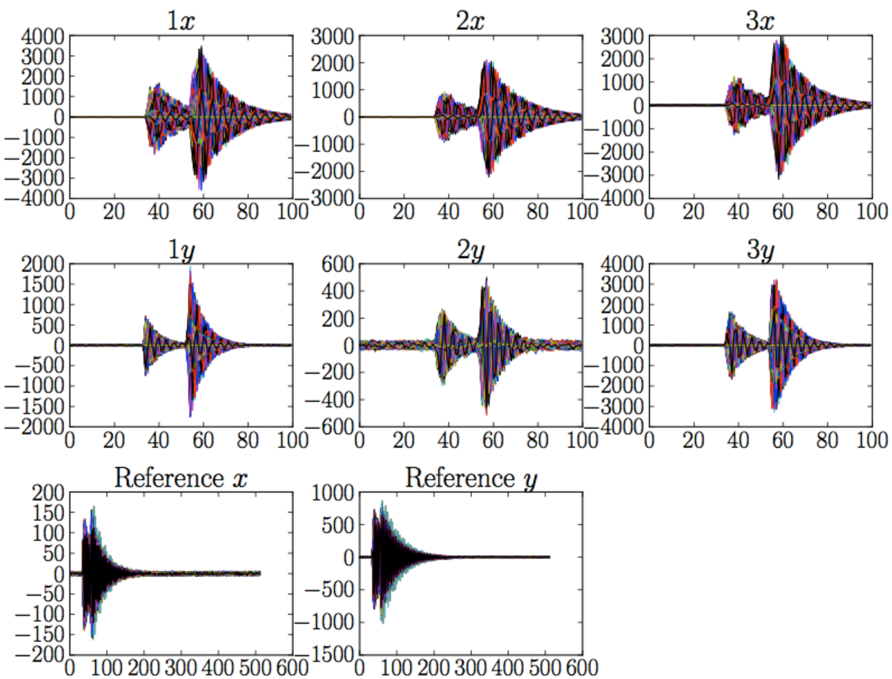
- SVD Residual
- Charge normalized
- Working on heterodyne data

- One point
  - Choose one sample point
- Filter
  - Use gaussian filter for removing noise on the homodyne signal
  - Choose one sample point
- Integration
  - Integrated few sample point
  - Same as charge ADC

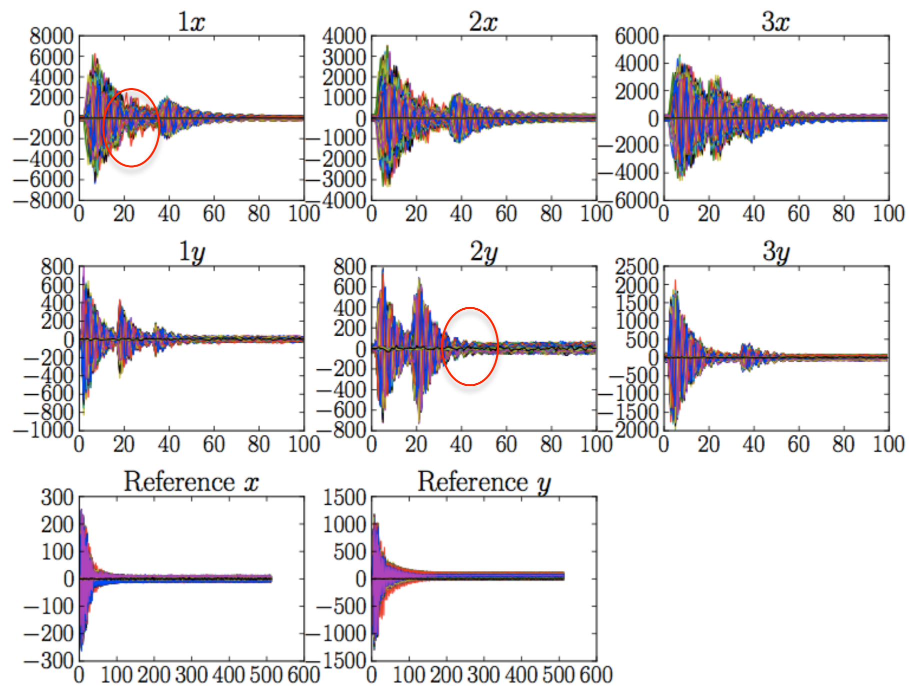
- Did few scans for finding filter width, sample point and integration width

Waveform – heterodyne (multi bunch)

Two bunch waveform (187.6 ns bunch spacing)



Three bunch waveform (150 ns bunch spacing)



We can see clearly the bunch separation.

But, how can we use reference information for charge normalization??

Summary & Plan

- Before install measured mechanical vibration
  - The expected relative motion between blocks is ~ 1.4 nm at 1.56 Hz
- Took three shifts for IPBPM study at upstream
  - 16^{th}, 30^{th} Nov. 8^{th} Dec.
- Calibration factors are extrapolated from the calibration results with 40, 30 and 20 dB attenuator
- SVD residual is below 10 nm which means below 7.99 nm
  - Geometrical factor : 0.799
- Should be careful to deal with saturated data
  - Digitizer saturation, electronics saturation

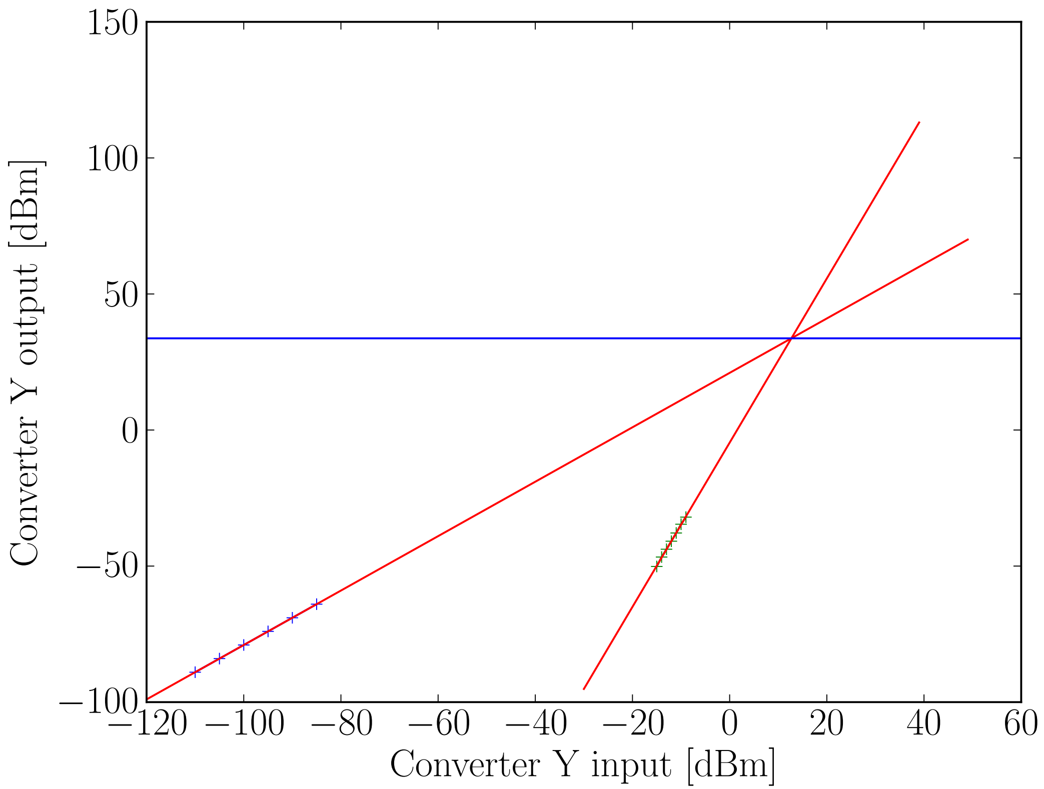
- Non-linearity study

- Charge scan
- Bunch length scan
- Multi bunch
- Cavity system simulation has been developed. I will check and compare some effect to do simulation

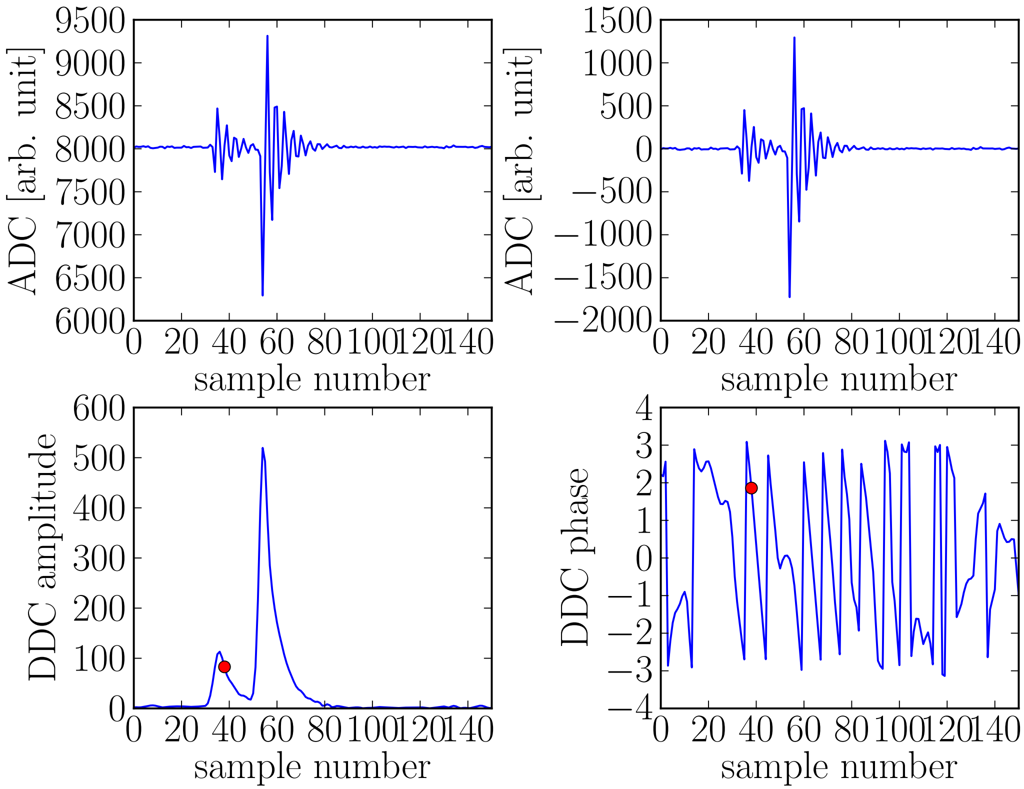
Backup

Electronics non-linearity

- IP3 measurement
- IP3 : 43 dB

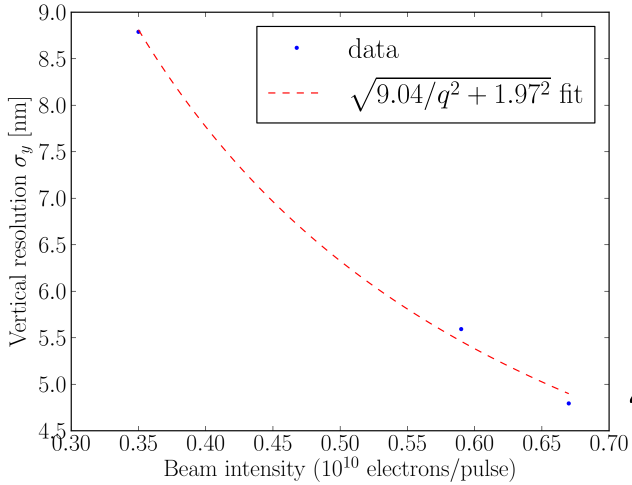


Digital Down Conversion



Charge scan

November 16th, 2011



4.79 nm

- SVD method for analysis
- Try to take data at higher intensity?
  - Less than one hour?