

ATF2 Cavity BPMs

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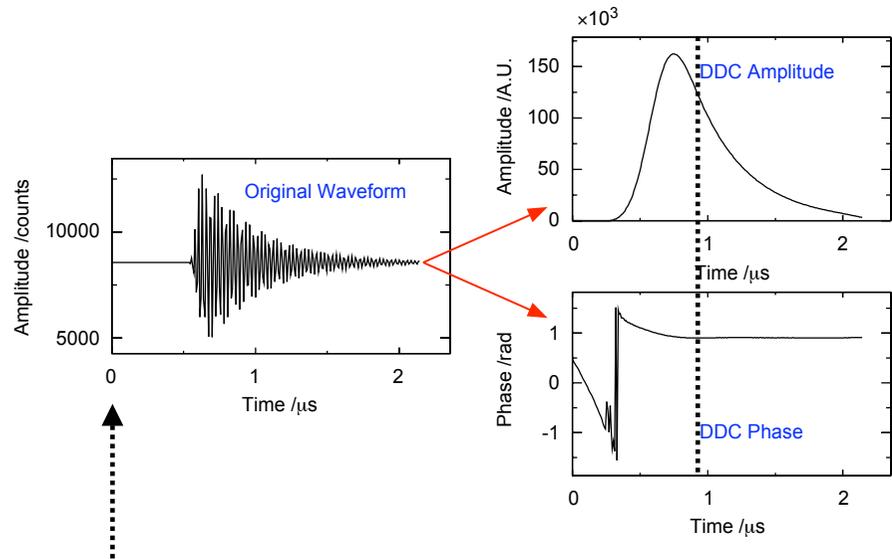
ATF Technical Board 16th December 2009
SLAC, KNU, PAL, KEK, JAI-RHUL, UCL
KEK, ATF

[https://www.pp.rhul.ac.uk/twiki/bin/view/JAI/
BeamPosition](https://www.pp.rhul.ac.uk/twiki/bin/view/JAI/BeamPosition)

Introduction

- Progress since last major report
 - Stable operation with C-band BPMs
 - Improved insensitivity to timing problems
 - C-Band and S-Band diode timing references
 - Improved amplitude extrapolation
 - Should be able to reconstruct large offsets
- Software improvements too numerous to list (all plots are online plots)
 - S-band still has some phase (but not amplitude problems)
- Full calibrate entire system, mover, non-mover, C and S band in approximately 4 hours.
 - C-band calibration stable for ~ 3 days (see White's talk)

Digital processing algorithm (DDC)



Trigger start

Extract phase and amplitude at some specific time

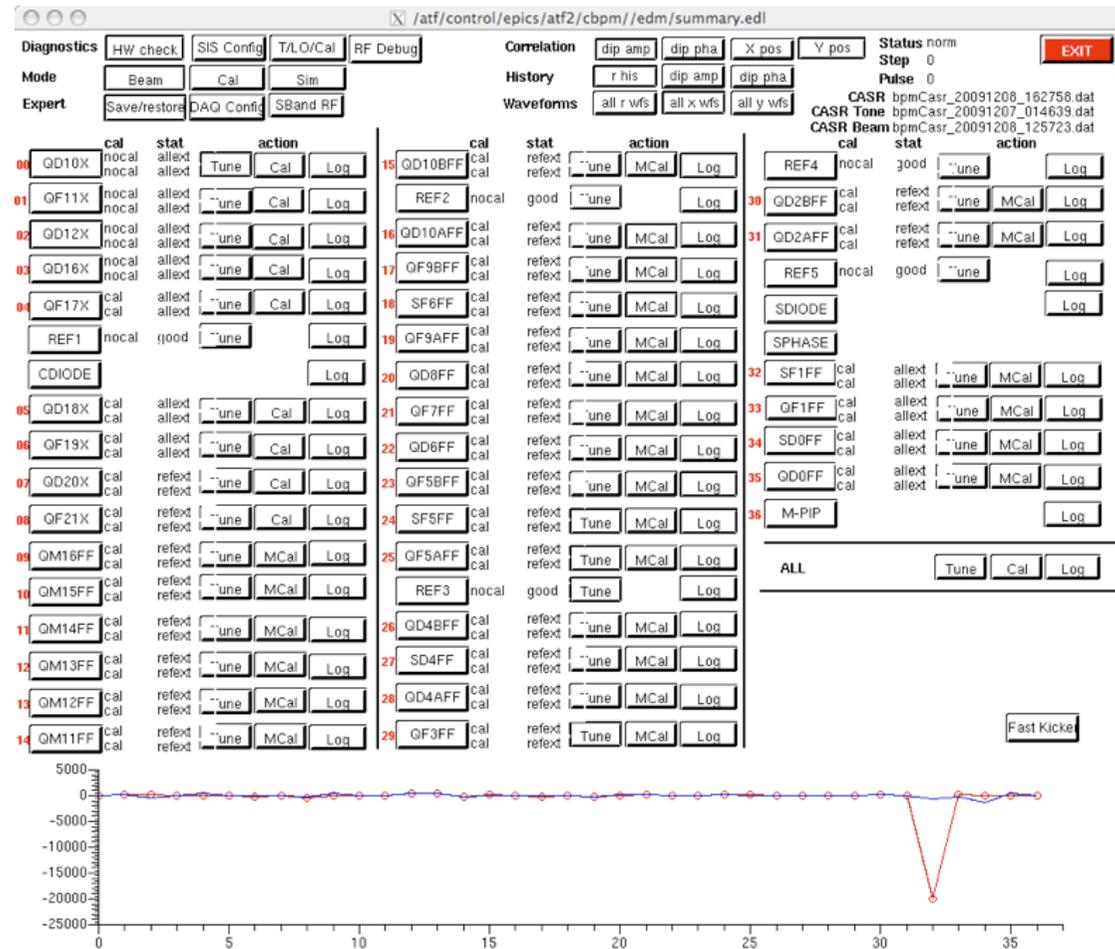
$$I = \frac{A_d}{A_r} \cos(\phi_d - \phi_r)$$

$$Q = \frac{A_d}{A_r} \sin(\phi_d - \phi_r)$$

- I and Q depend on
 - start trigger
 - beam arrival
 - DDC sample point
- E.g. change in trigger start, beam arrival or saturation levels causes change in I and Q and hence calibration
- Compensate for changes in code

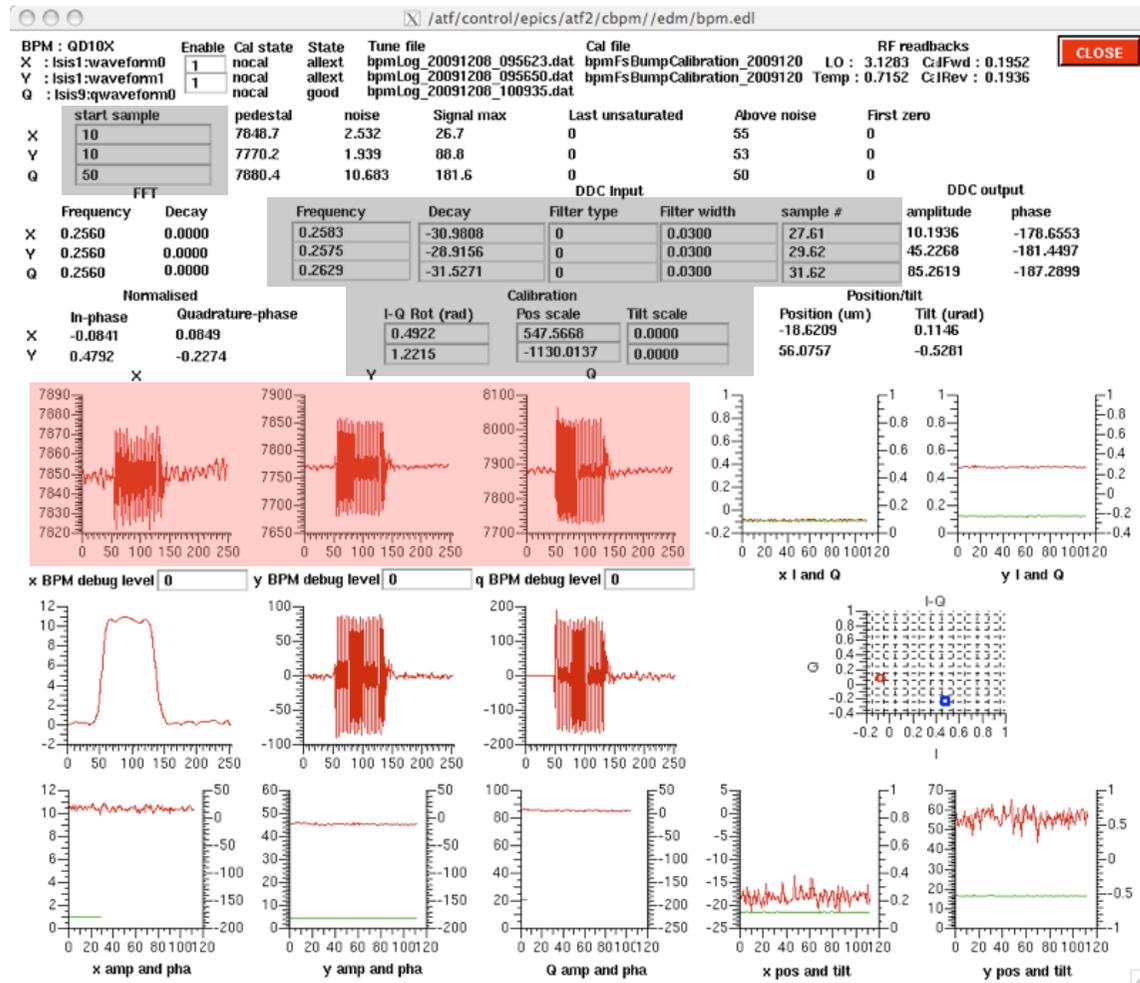
Software system

- Key element for cavity BPM usage
- Quick control of all BPM functionality and operating algorithms
- EPICS based + EDM + python + scipy + matplotlib + catools + ...
- Complete control of entire system
- Easy to integrate new tests
- IP-BPM electronics + tilt monitor



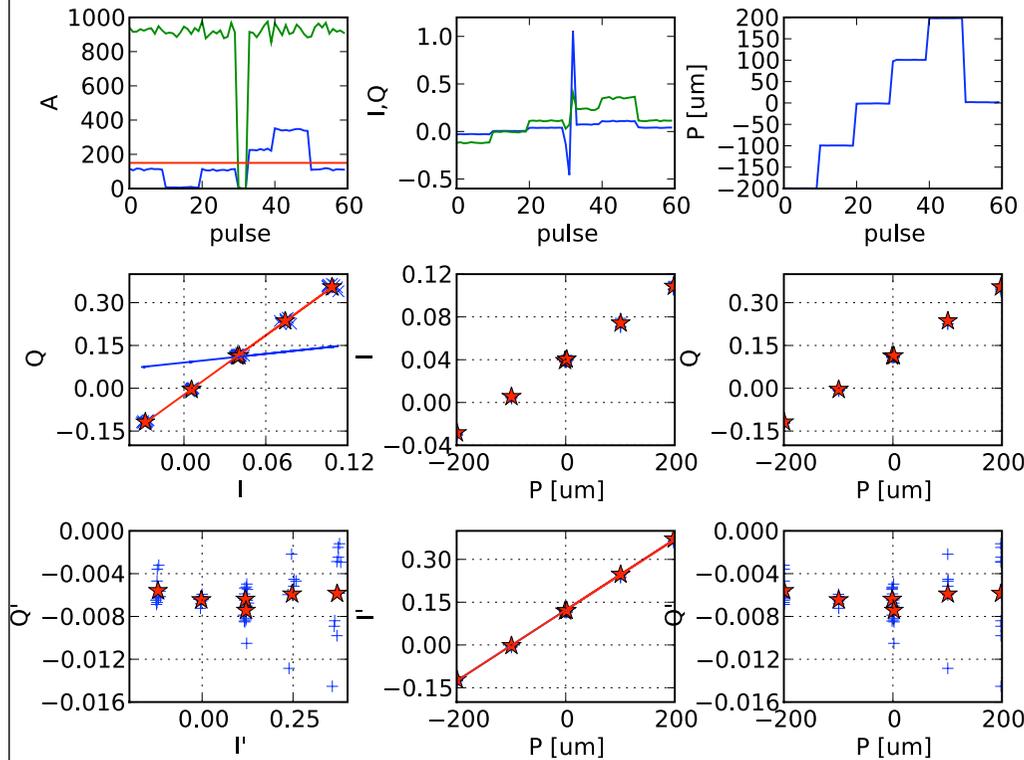
Software system

- Raw data from digitizers
- Determine parameters for BPM
- Frequency, decay time, sample time
- Displays algorithm state, input parameters, output etc



Calibration

IQ Calibration plots



Every pulse : Blue points
Average at location : Red stars

- Calibration method

- Move BPM typically +/- 200 um
- Record I-Q
- Determine I-Q rotation such that all variation is in rotated-I

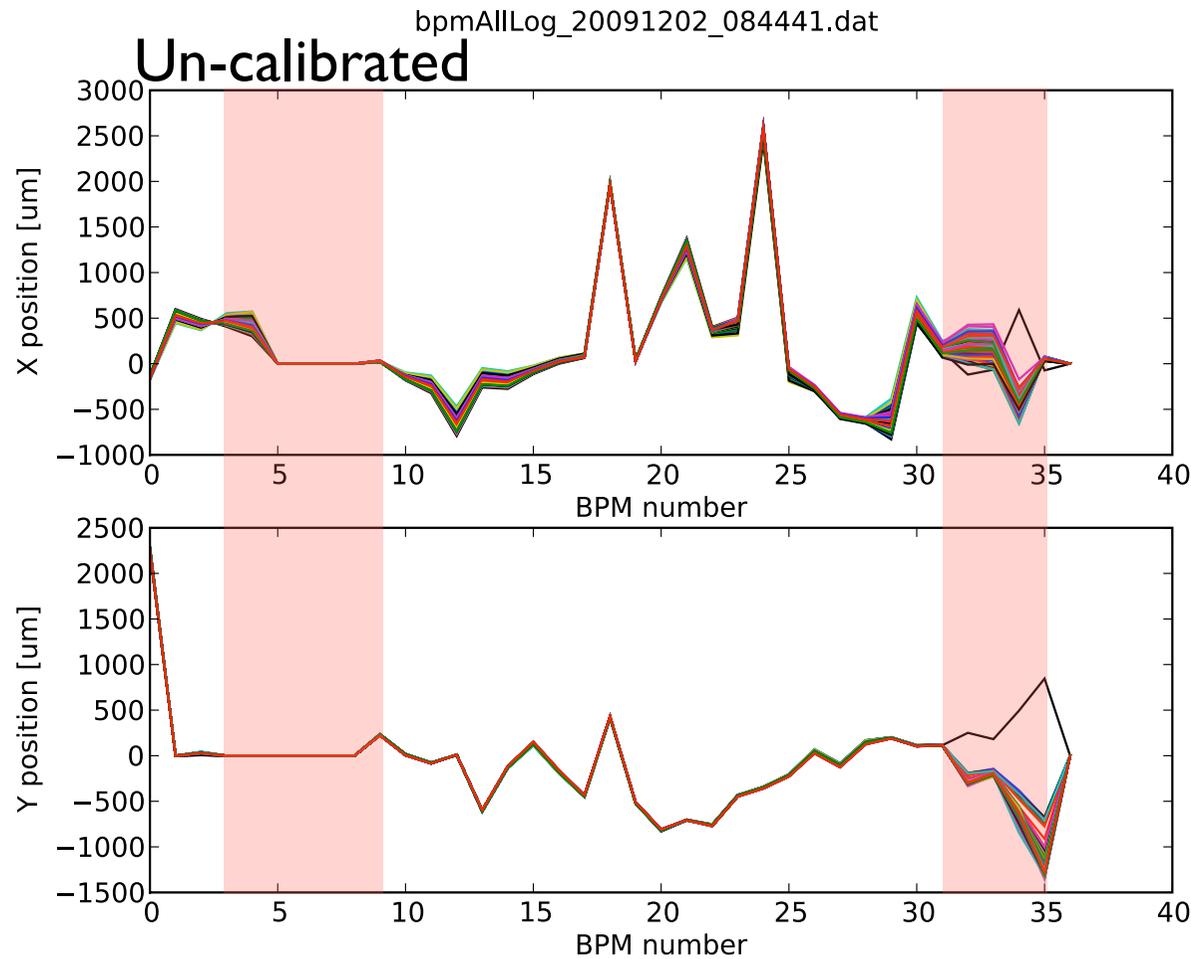
$$I' = I \cos \theta_{IQ} + Q \sin \theta_{IQ}$$

$$Q' = -I \sin \theta_{IQ} + Q \cos \theta_{IQ}$$

- Scale

$$x = S_x I'$$

Charge dependance



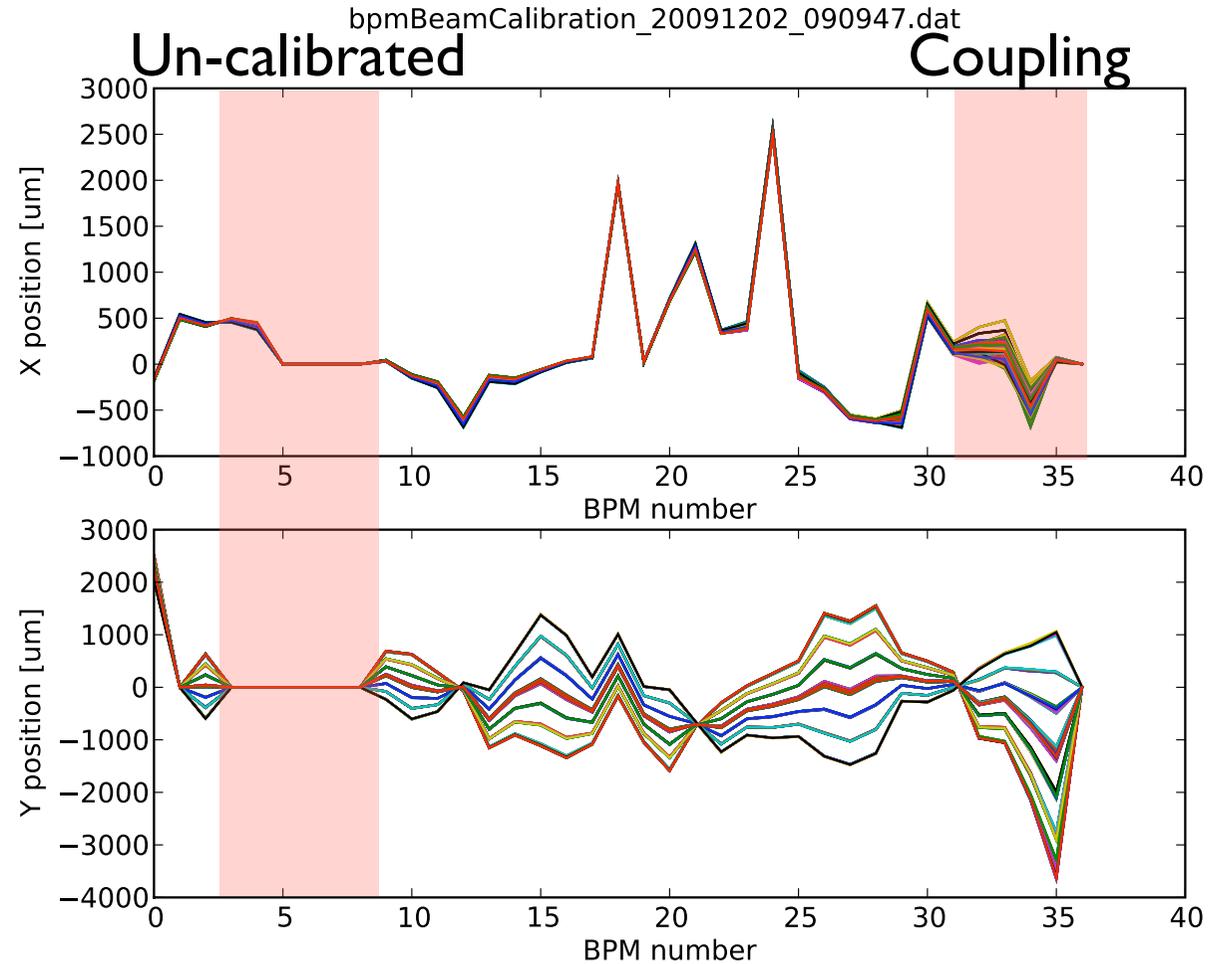
Horizontal orbit jittery due to dispersion

S-band BPMs more noisy

- Similar orbit for charge between 0.1 to 0.5×10^{10}

Linearity at large offset

Vertical corrector
scan ZV7X



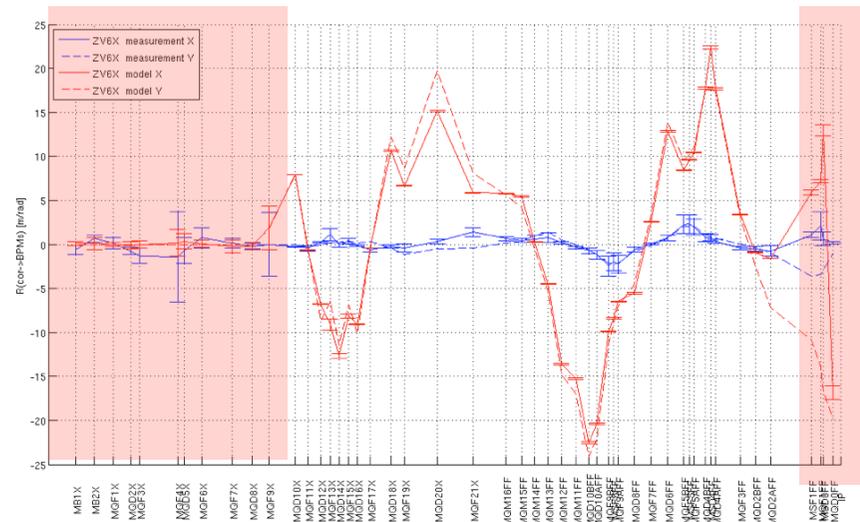
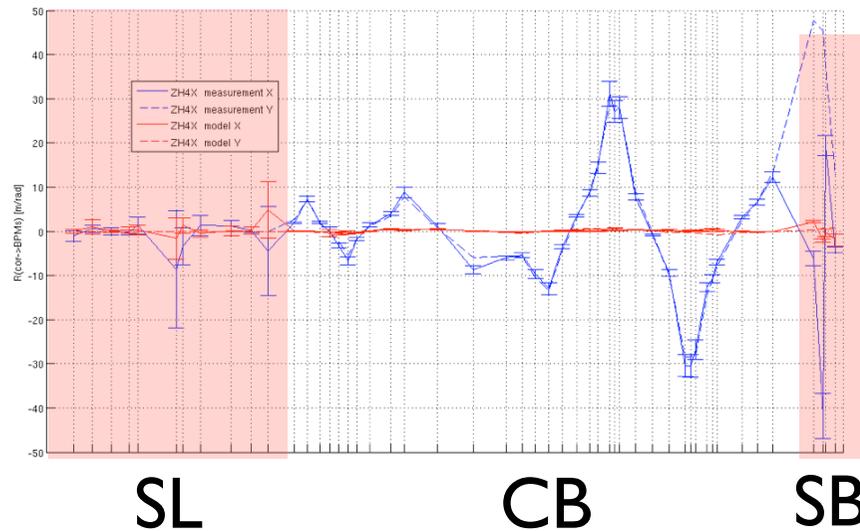
- Good linear dependance!

C-band calibration

		08/12/2009 AM		09/12/200 9 AM	
		θ	S	θ	S
QM13FF	x	-0.4429	730.6016	-0.4344	766.3729
	y	-0.5583	572.9346	-0.55217	538.1593
QM11FF	x	-1.0601	723.4036	-1.07427	733.3487
	y	-1.0132	590.5859	-1.01145	571.2461
QD10AFF	x	-1.1935	-599.1746	-1.19559	-579.5771
	y	-0.5458	732.6153	-0.5535	747.6142
QF7FF	x	-1.1745	-649.7678	-1.17508	-764.88304
	y	0.1271	637.3934	0.11279	633.4649
SF5FF	x	-0.1483	-733.4521	-0.20396	-721.3833
	y	0.2932	-616.1576	0.29688	-613.8675
SD4FF	x	0.2479	634.7448	0.24642	737.3457
	y	-0.3946	-669.6132	-0.38895	-672.46778
QD2BFF	x	0.6555	-514.9741	0.6606	-496.1783
	y	0.5636	-615.7744	0.5793	-594.6615

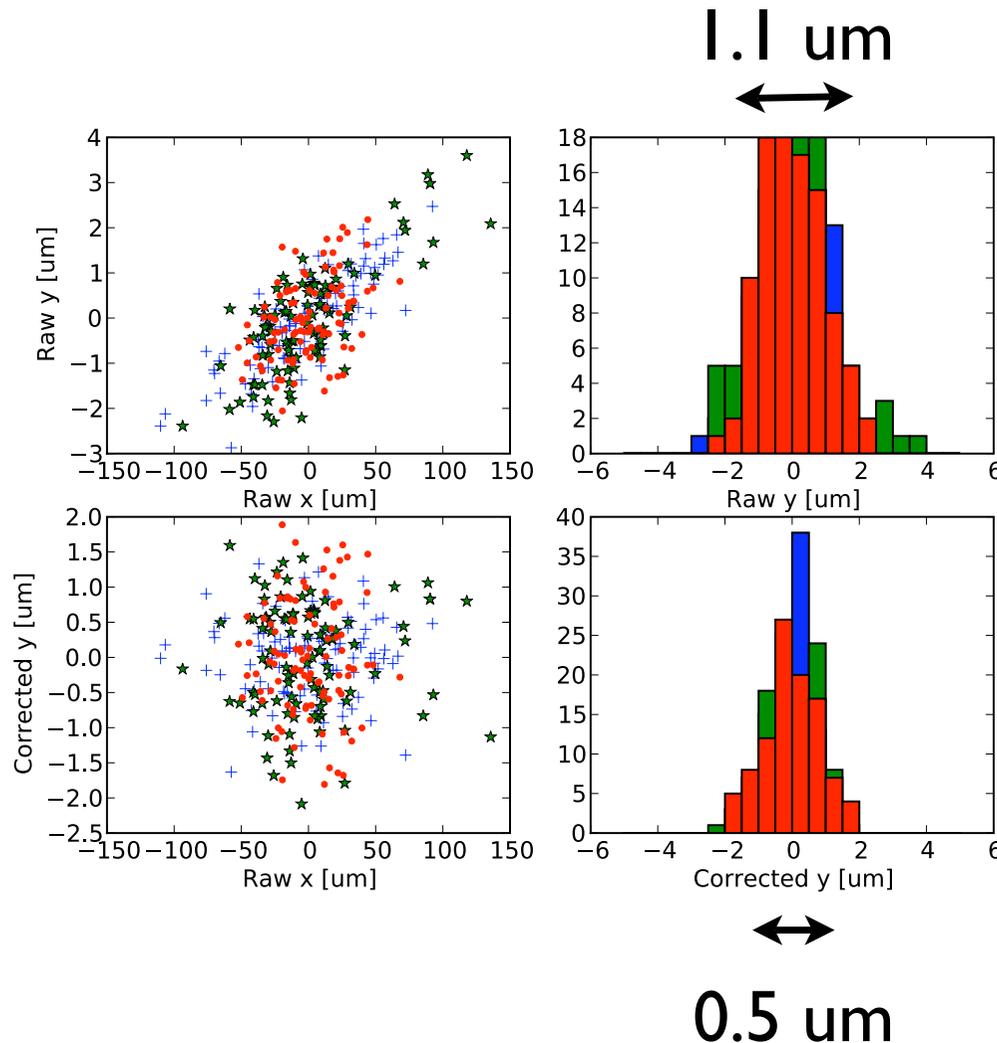
- Excellent calibration for most of operation week
- Phase shifts 0.01 or less at C-band
- Amplitude variation of order 5 to 10 %
- Need calibration tone to correct final scale problems

BPM system performance



- Kick beam using correctors
- ZH4X
- ZH6X
- Compare
 - Optics model (R matrices)
 - Orbit response with BPM measurements normalised by kick strength

Best resolution (MFB2FF)



- Sub-micron “resolution” confirmed
- MFB2FF at waist, so beam jitter low
- BPM rolled
- Beam size $\sim 3 \mu\text{m}$
- RMS $\sim 0.5 \mu\text{m}$
- Includes beam drift and jitter
- Will correct for this effect this evening (see later)

S-band phase problem

BPM		08/12/2009 AM		09/12/200 9 AM	
		θ	S	θ	S
SF1FF	x	-0.7064	2337.6932	-1.297	1370.8098
	y	0.1932	5573.9676	-0.3856	5606.9855
QF1FF	x	0.0656	-4206.818	-0.5275	-6115.9601
	y	-1.4801	3038.1829	1.0234	-3038.7735
SD0FF	x	0.9269	3593.66	-0.6671	3922.61
	y	-0.213	62200	-0.807	57386.7
QD0FF	x	0.3181	-1862.4049	-0.3421	-1891.254
	y	-1.3504	-6065.5702	1.10605	5687.257

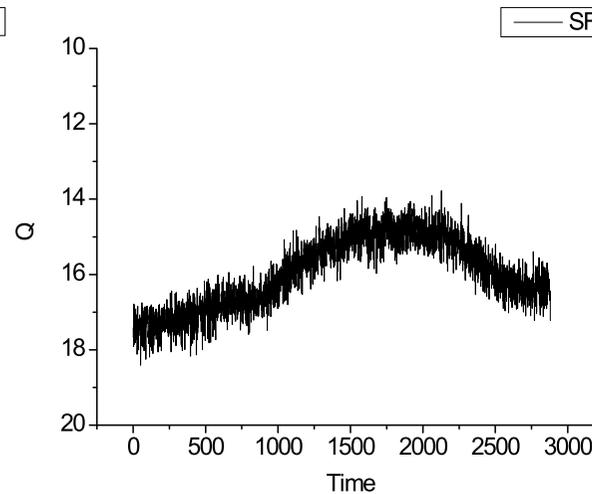
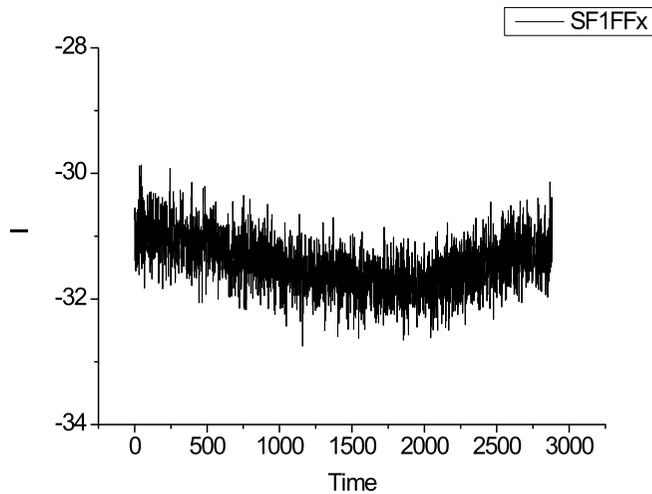
- S-Band BPMs have not had as much attention
- BPM crew has been joined by two student from Kyungpook National University (Aeyoung Heo, Youngim Kim)
- Plus Professor HyangKyu Park
- Calibration, stability and performance study of S-band system

S-band phase problem

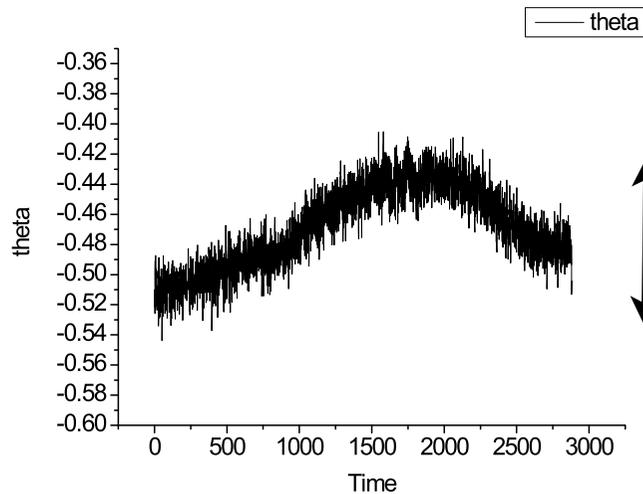
BPM	Amplitude (beam)	Phase (beam, rad)	Amplitude (cal)	Phase (cal, rad)
SF1FF x	0.322	0.292	0.296	0.010
SF1FF y	0.023	0.356	0.154	0.010
QF1FF x	0.014	0.209	0.275	0.010
QF1FF y	0.002	0.153	0.218	0.010
SD0FF x	0.125	0.562	0.240	0.014
SD0FF y	0.006	0.366	0.244	0.010
QD0FF x	0.023	0.773	0.240	0.010
QD0FF y	0.117	0.373	0.244	0.010

- Beam (05/12/09 1:30 am)
- Calibration tone (05/12/09 2:00 am)
 - Inject directly to electronics in Eel's bedroom

S-band phase problem



Thermal drift (period ~24H)

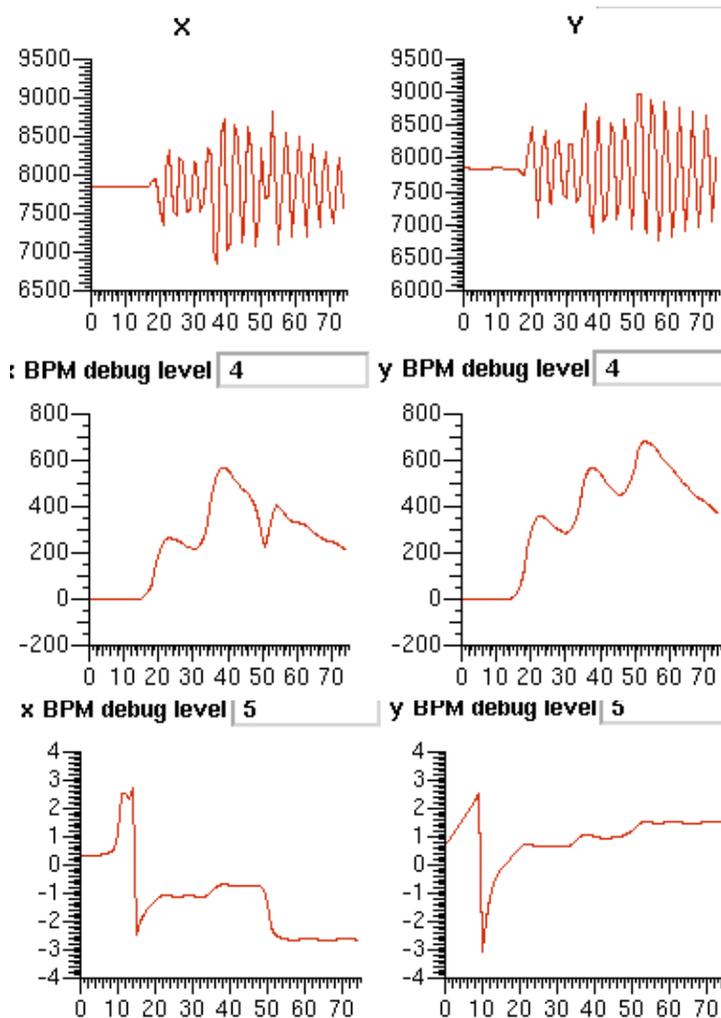


0.13

- Carefully checked one S-band BPM
- Calibration source in tunnel
- Maximum variation

Multi train mode

151 ns bunch separation



- Preparation for new extraction scheme
 - Modify trigger time by -200 ns
 - Change digital filter parameters
 - DDC filter 3 MHz to 10 MHz
 - Clear amplitude and phase changes
- Possible to extract position

Required upgrades

- Calibration tone (rather low signal)
 - Software needs lots of work
- BBA stability
 - Connection between optics and BBA corrected positions done
- Commission M-PIP (must be connected)
 - IP-BSM orbit)
- S-band system
 - RF phase instability
 - Cable routing, signal size

Summary

- C-band system looks excellent
 - Easy to calibrate and use
 - Stable within 5% (calibration tone)
- S-band still has a little way to go, but progress is being made
 - Need to improve S-band cable plant
 - Possible software problem for S-band calculations
 - Cables + electronics seem good
 - Problems will be resolved this week
- High resolution mode being tested now (no attn)
- 300 ns separation readout possible (resolution?)