ATF2 Cavity BPM system

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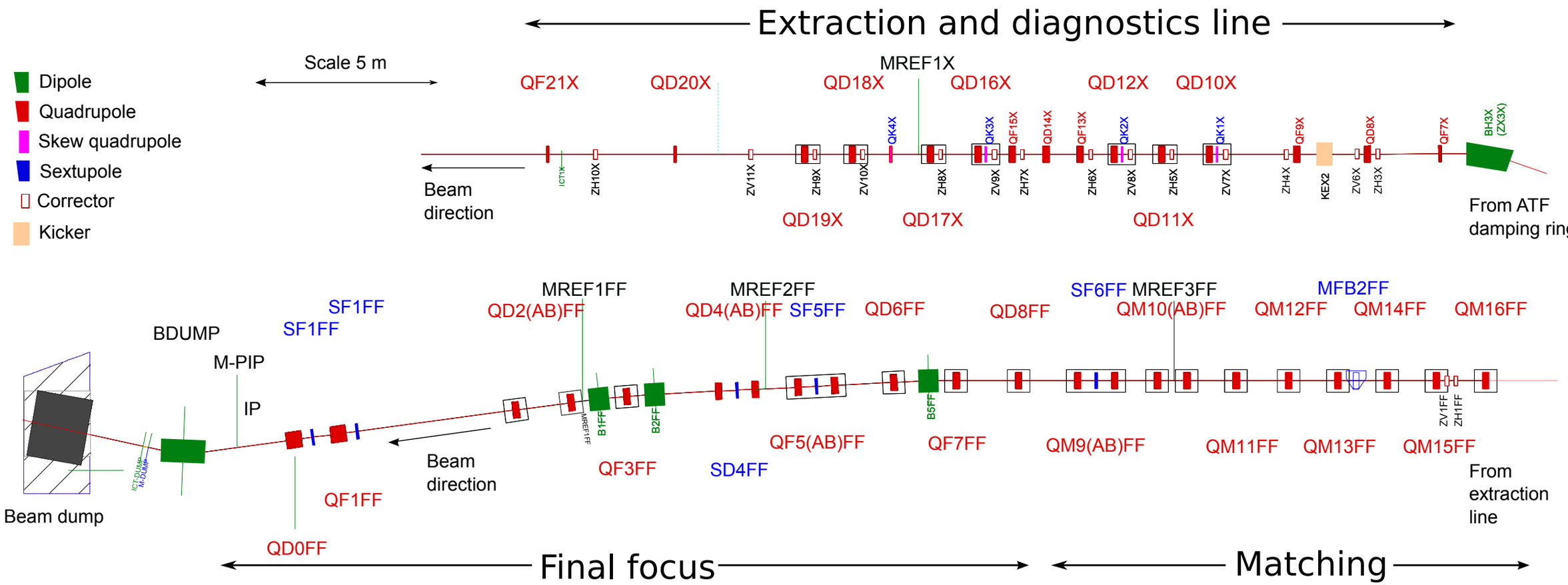
SLAC, KNU, PAL, KEK, JAI-RHUL, KEK, ATF

https://www.pp.rhul.ac.uk/twiki/bin/view/JAI/BeamPosition

Introduction

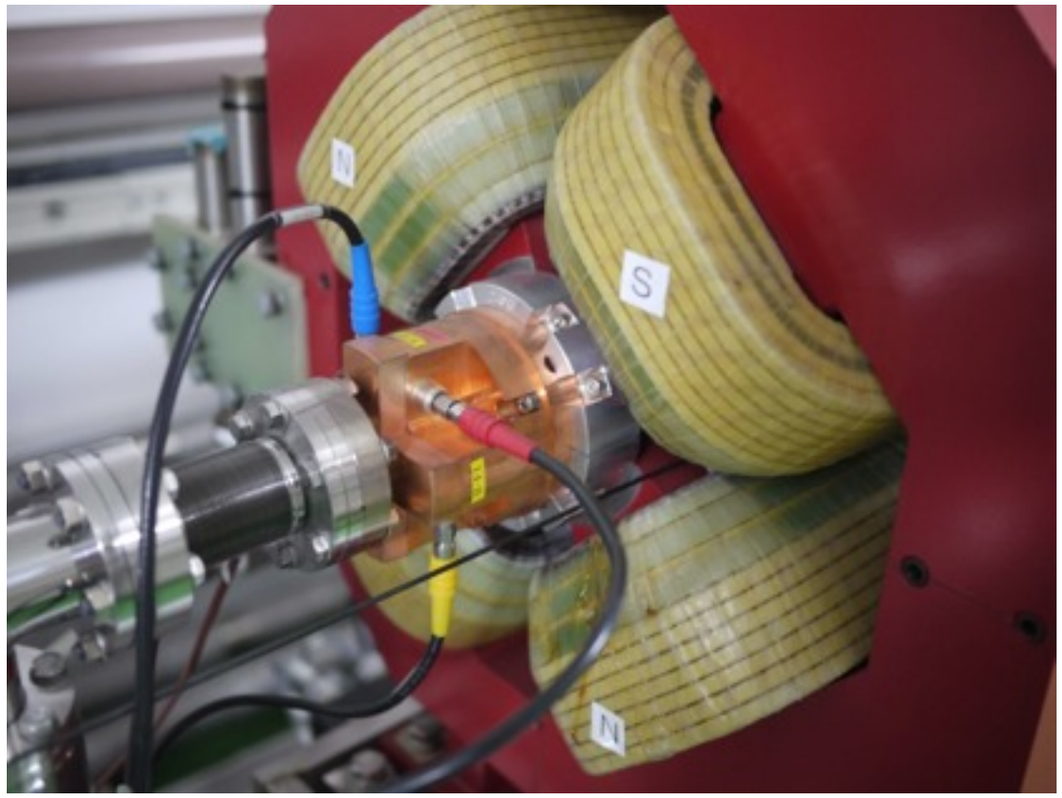
- Introduction
  - Hardware summary
  - Improvements since Summer 2011
  - Status on system performance
- Stability: Scale, IQ rotation (F. Cullinan)
- Multi-bunch operation
  - 2 and 3 bunch performance (N. Joshi)
  - Feedback and IP region with existing cavities (G. White)
- S-band problem
  - Completely understood in terms of timing uncertainty and cavity frequency difference
- Interaction point BPMs
  - Calibration in December was reasonable vertically and horizontally
- Hardware paper (almost accepted to PRSTAB)

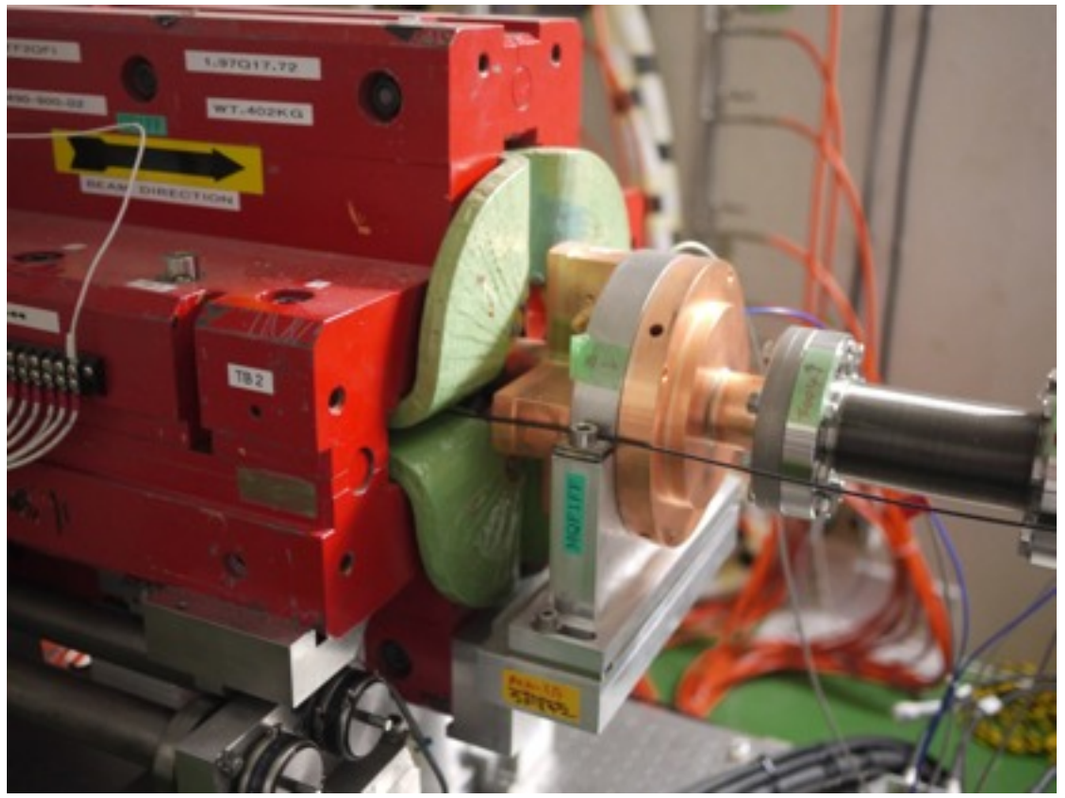
ATF2 BPM system



- 35 C-band (3 references)
  - 20 on movers 15 static
- 4 S-band (1 reference, at image frequency)
- 2 IP C-band (1 reference)

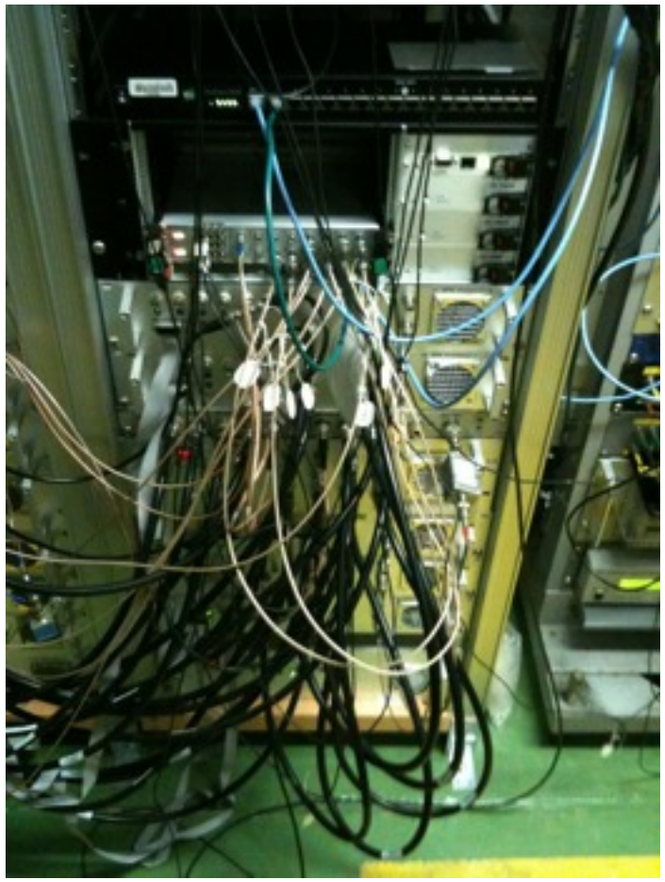
C and S-band BPMs

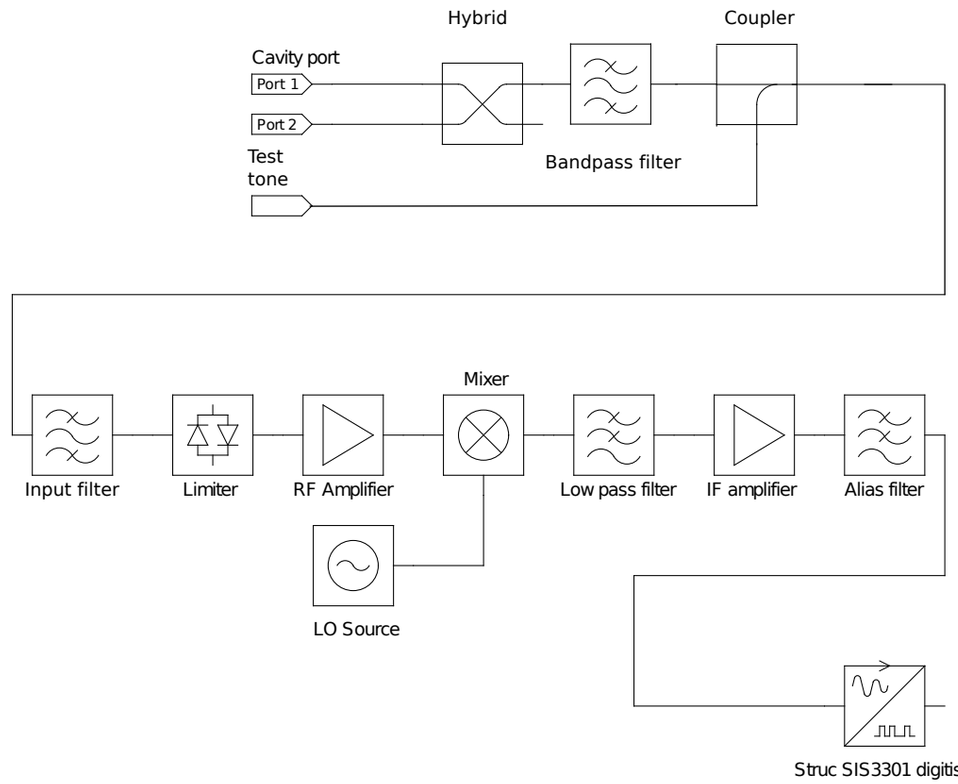




- C-band BPM
  - Dipole F : 6.426 GHz
  - Sensitivity : 0.8 V/mm/nC
- S-band BPM
  - Dipole F : 2.888 GHz
  - Sensitivity : 0.15 V/mm/nC

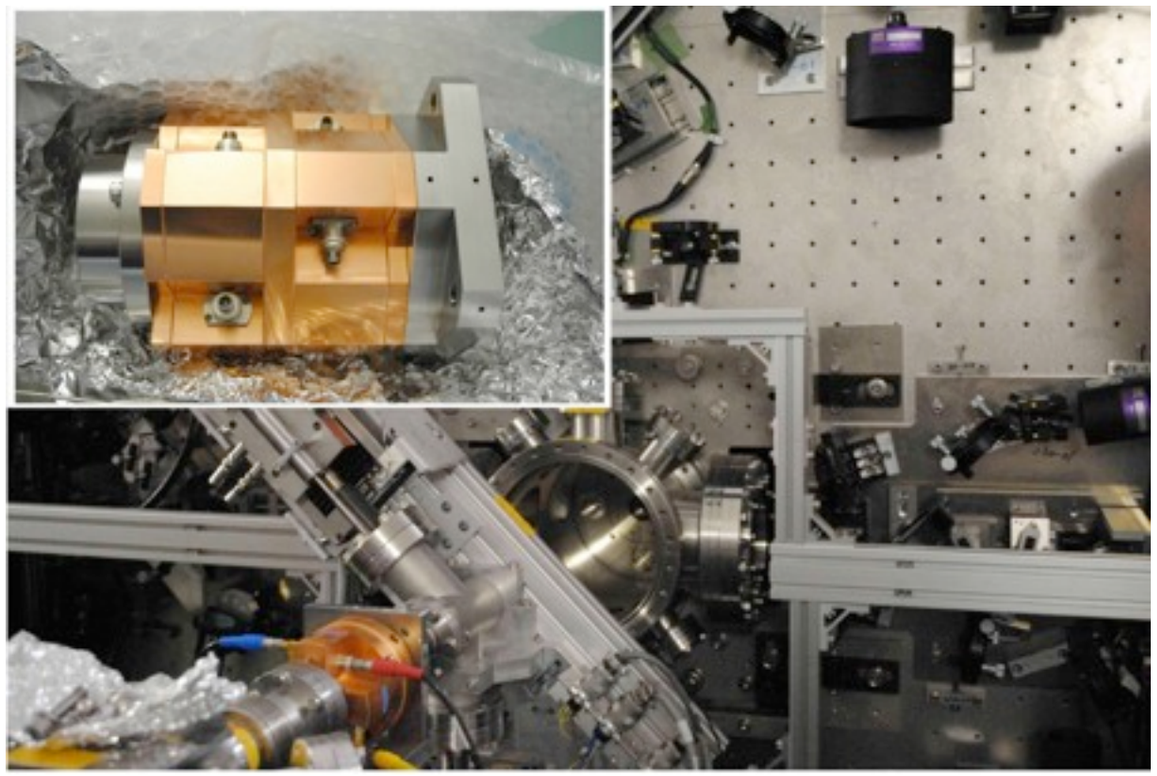
Processing RF electronics

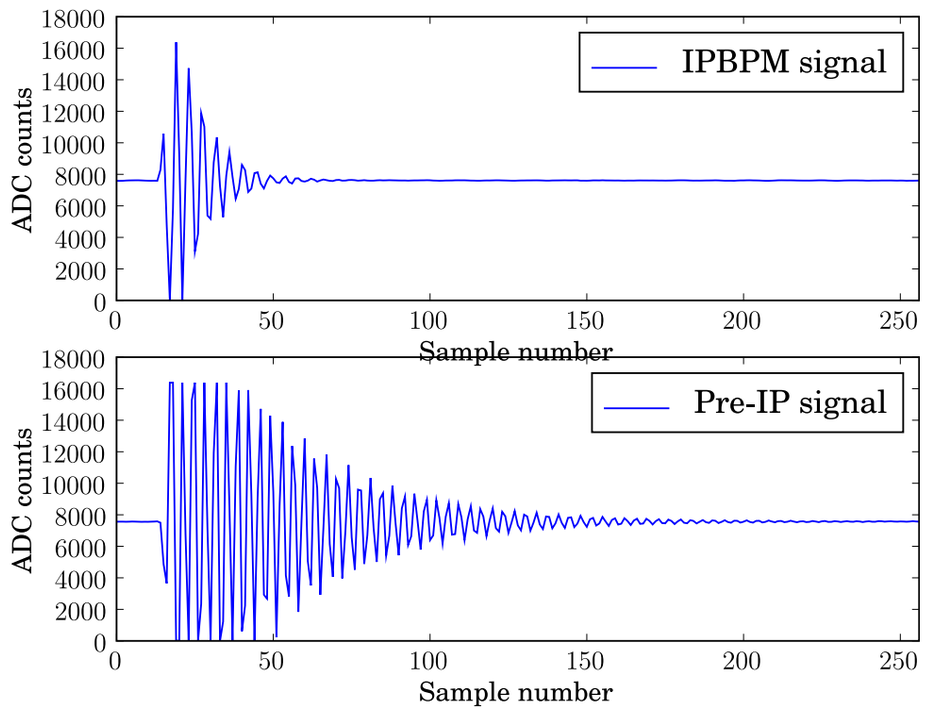




- Signal stage, image rejection down-converters/amplifiers
  - Intermediate frequency ~ 25 MHz
  - 100 MHz digitizer (14 or 16 bit)
  - C-band electronics : in tunnel
  - S-band electronics : outside shielding blocks

Interaction point region



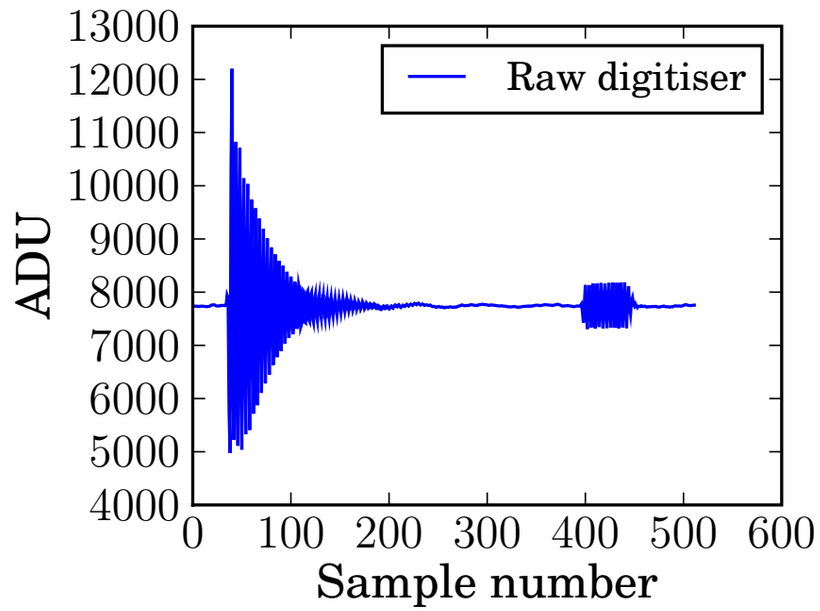


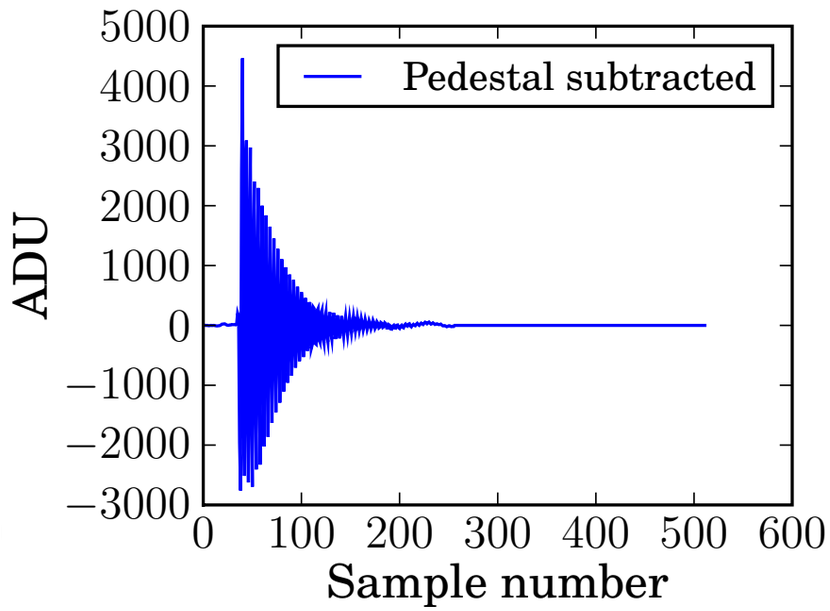
- IPBPM block 2 dipole cavities
  - Dipole F : 5.712 (6.426)
  - Sensitivity : 0.95(2.06) V/mm/nC
  - Installed in IPBSM vacuum chamber
    - No mover for calibration
    - Small dynamic range
- Electronics
  - SLAC
  - KEK homodyne

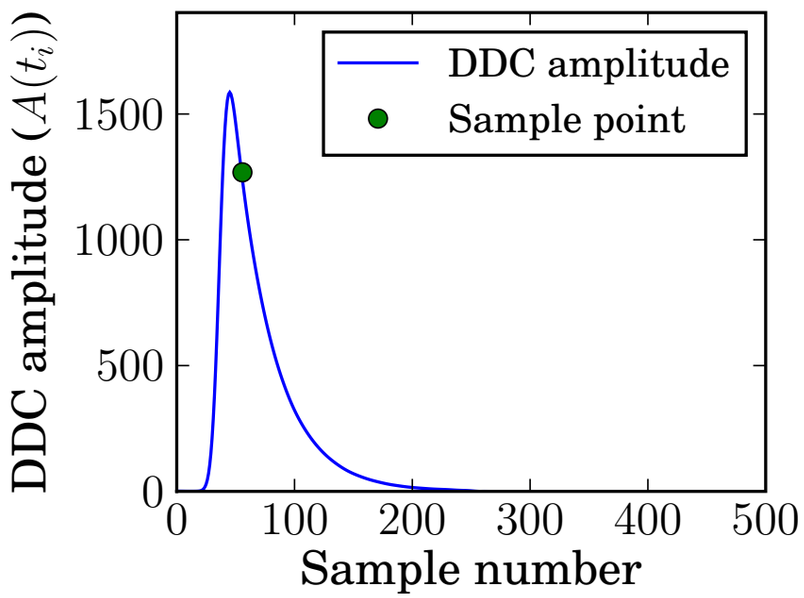
Signal processing

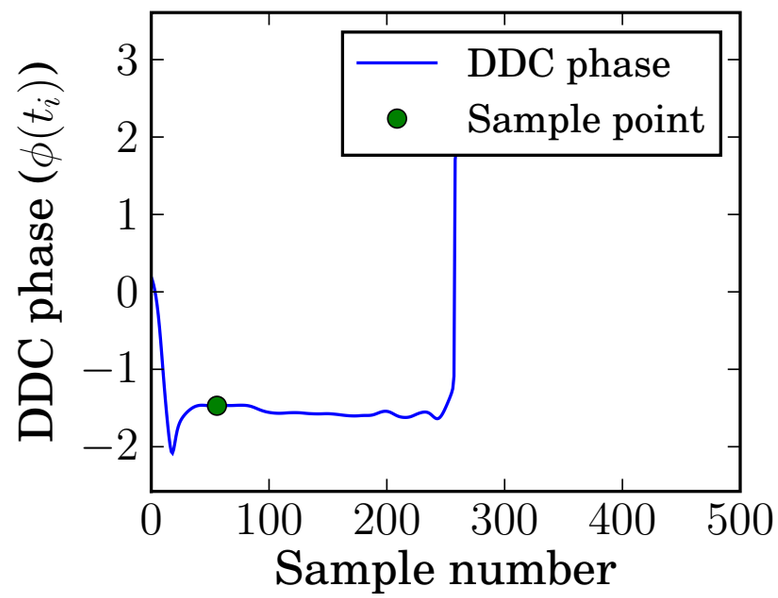
$$\tilde{V}_{\mathrm{d}} = [A_x x + jA_\theta \theta - jA_\alpha \alpha]\, q e^{-t/\tau_d} e^{j(\omega_d t + \phi_d)}$$

- Signal from electronics
  - 25 MHz decaying oscillation
  - Mixed with digital local oscillator
    - Starts at ADC trigger start
  - Measure amplitude and phase





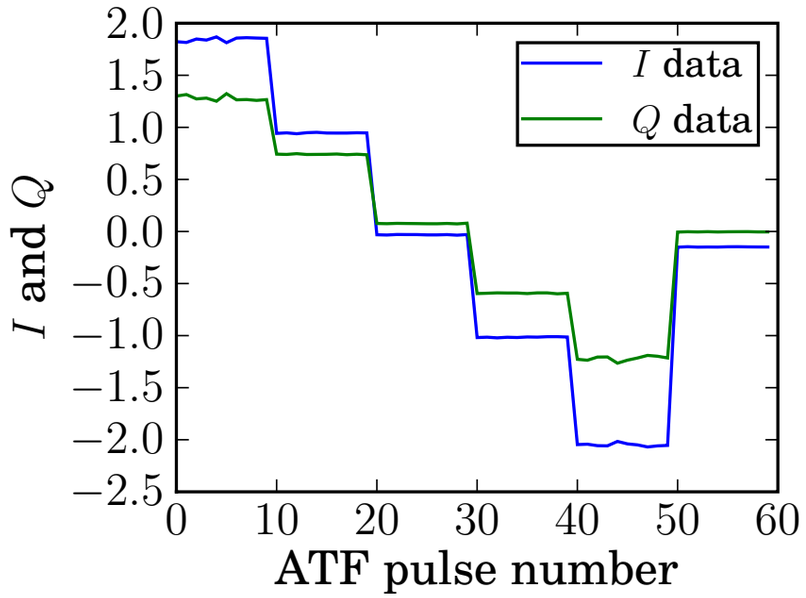


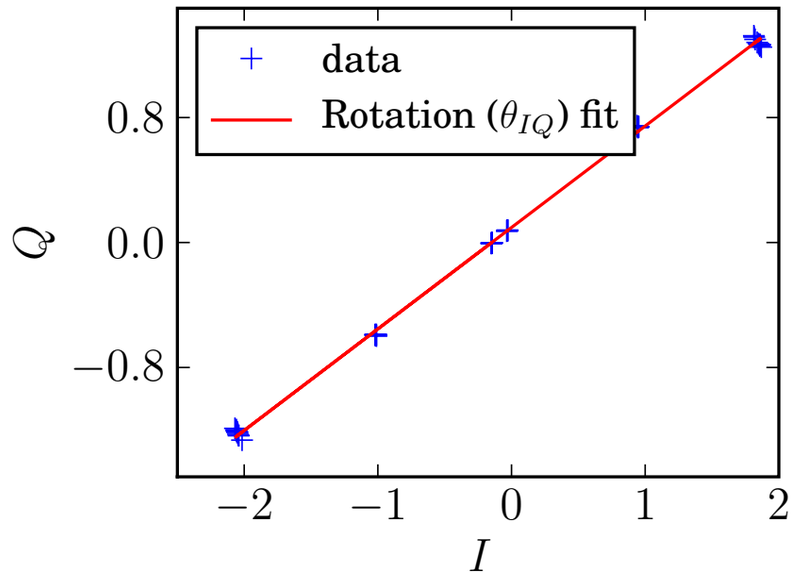


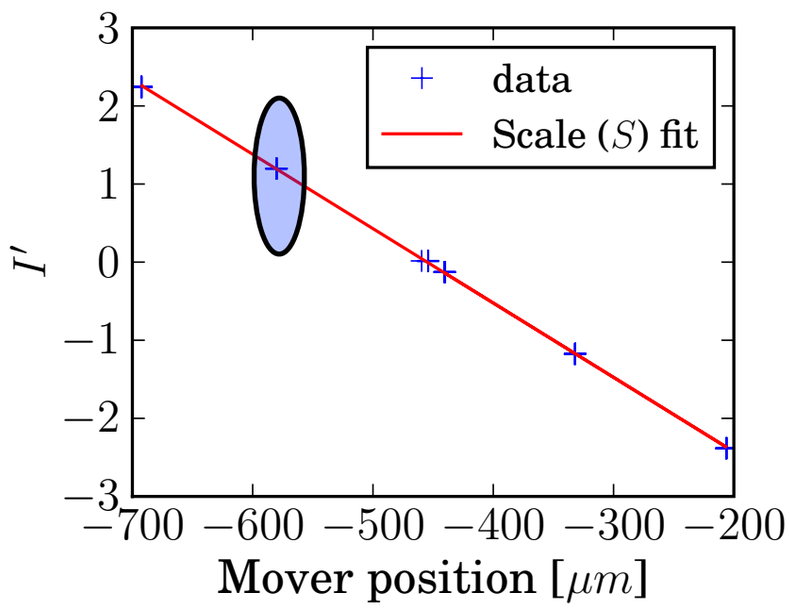
ATF2 BPM calibration

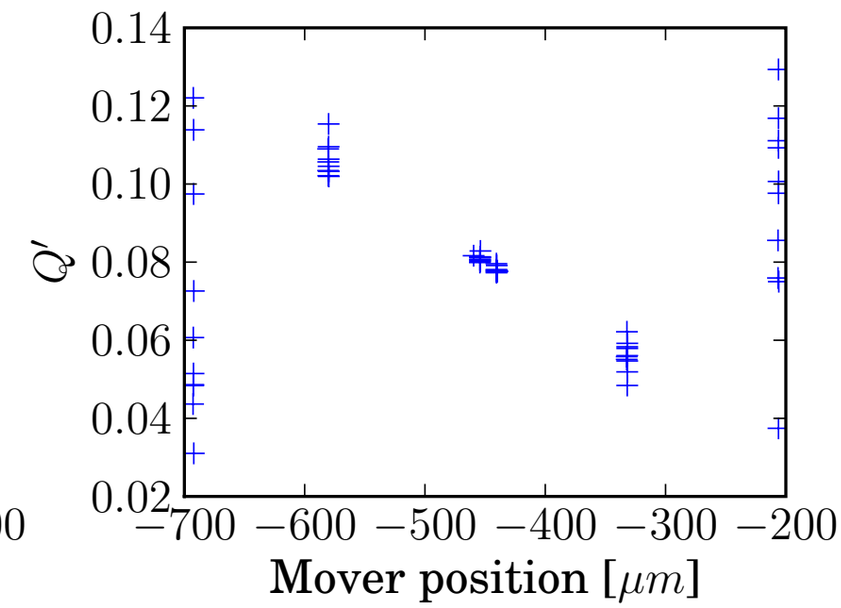
- Move BPM order 100s of um
- Measure I and Q
  - Angle of I-Q line is rotation
- Slope of rotated I is scale

Example has low beam jitter









$$d = Se^{i\theta_{IQ}}\sqrt{I^2+Q^2}e^{j\tan^{-1}Q/I}$$

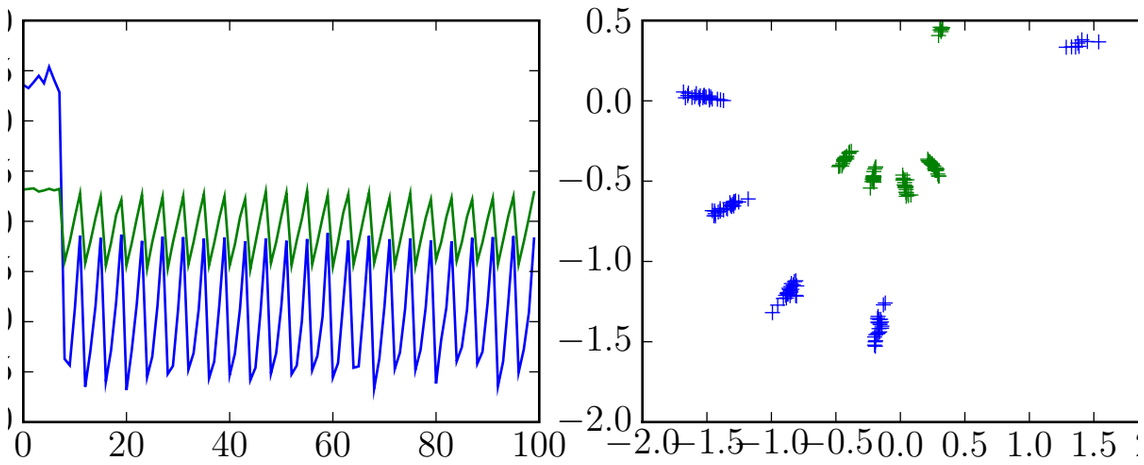
Summary of current status

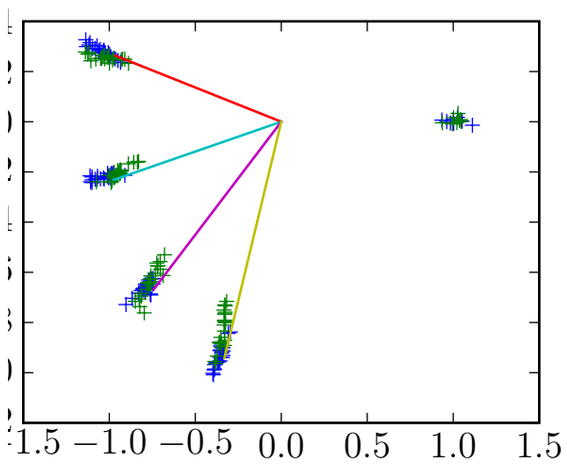
- Complete jitter subtracted calibration on BPM system during December operation
  - No dedicated BPM shifts
  - No recalibration over three weeks
  - Stable signs for calibration constants
  - Stable calibration of S-band BPMs
- Reasonable stable calibration of IP region BPMs
  - Cable ambiguity (will it be possible to access the IPBPM chamber before spring)

S-band problem introduction

- Problem for both C and S band systems, root is
  - Dipole and reference cavity frequencies not the same
    - Time of signal arrival in digitisers is not constant
      - Digitisers are locked to 714 MHz
    - Problem with DR-RF ramp

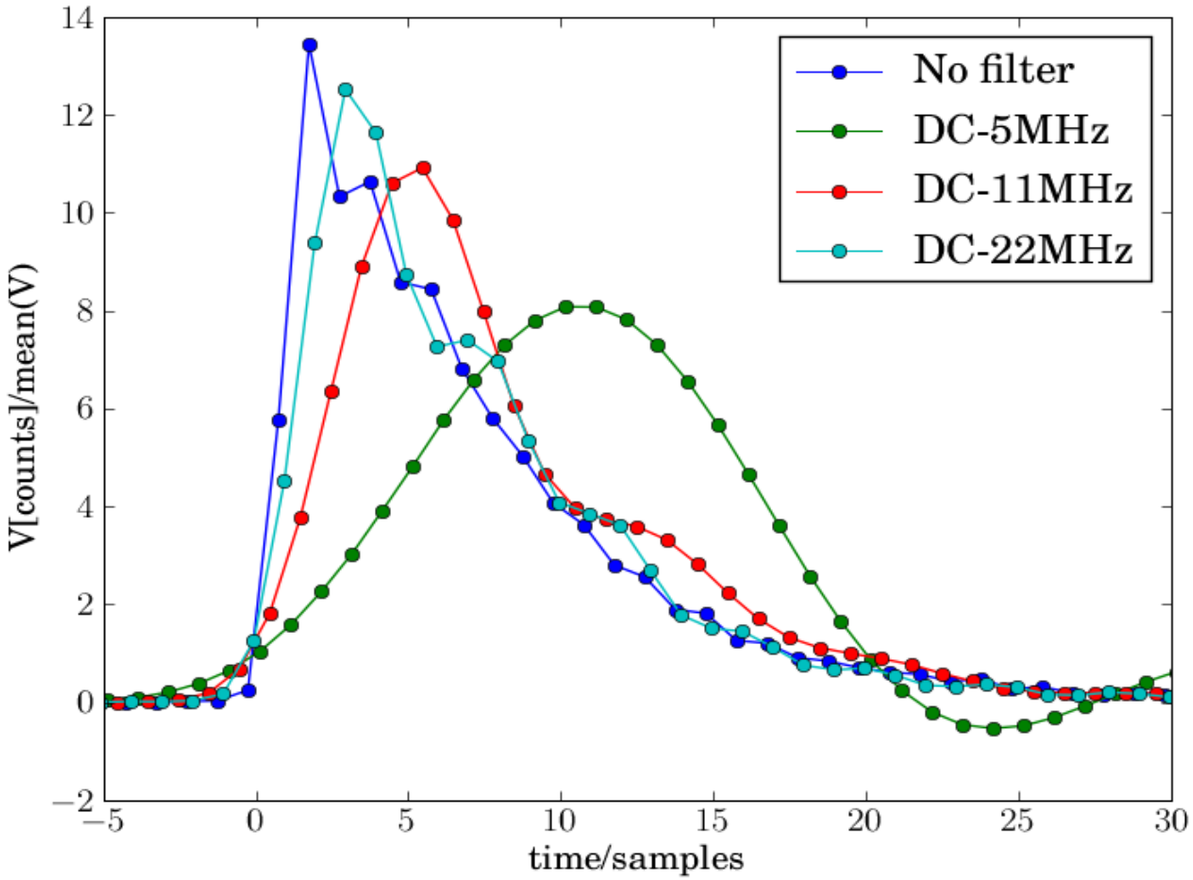
$$\frac{V_p}{V_r} = \frac{A_p}{A_r} e^{-\Delta\Gamma(t_s - t_0)} e^{j\Delta\omega(t_s - t_0)}$$





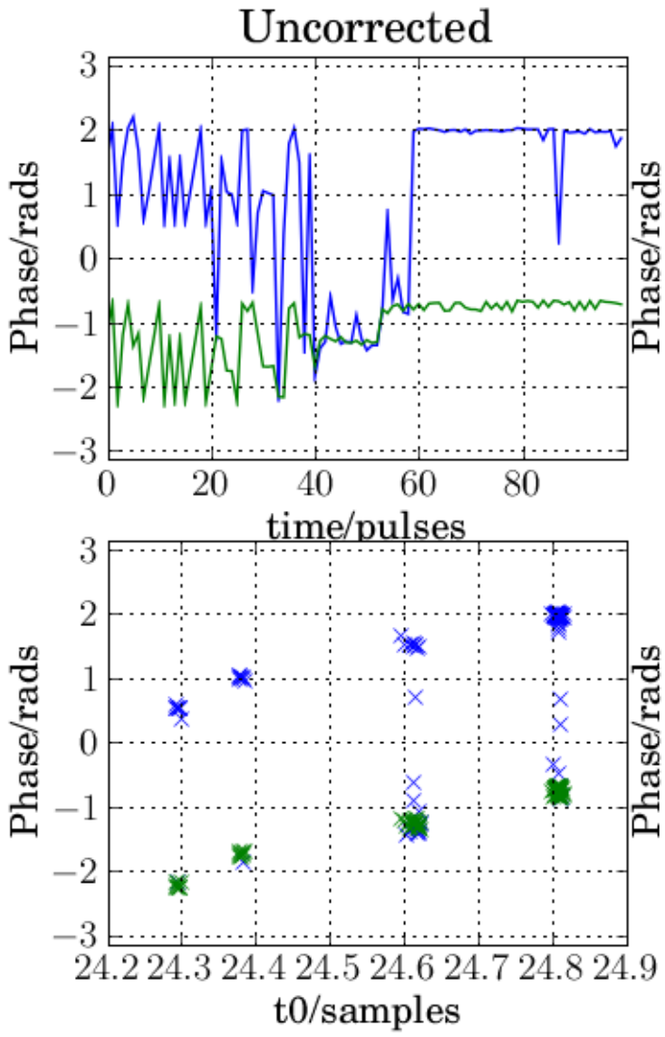
S-band problem measurements

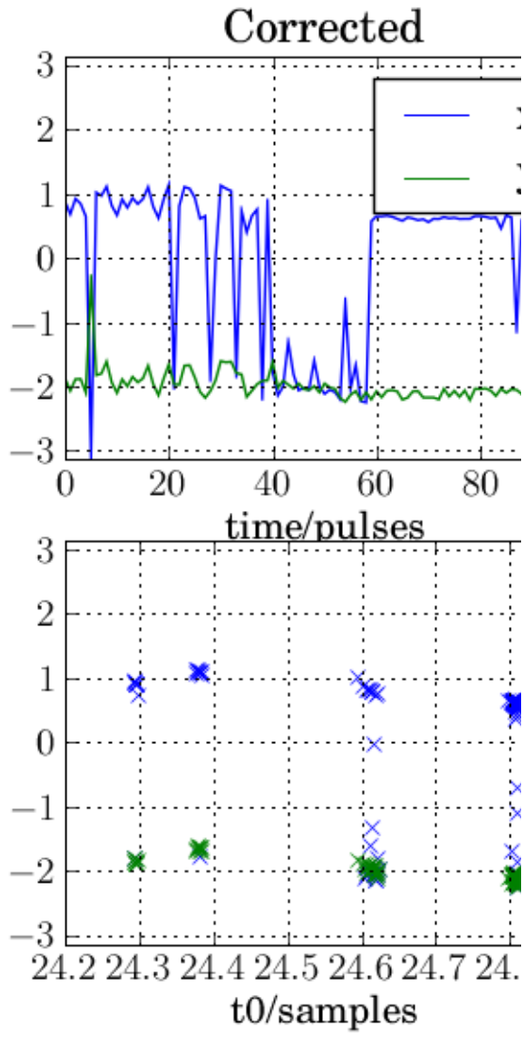
- Used S-band diode (C-band reference diode was being used) to investigate effect
  - Changed filter to change rise time
    - Need 2-3 points on linear rising edge to extract time
- No filtering rises too quickly
  - Need to optimise filter

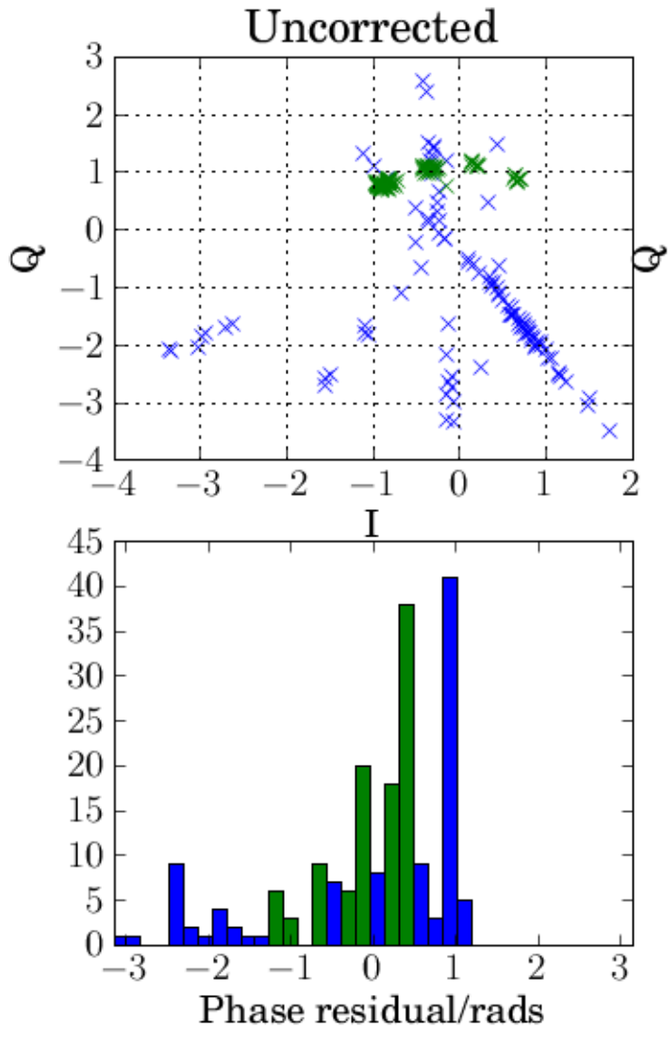


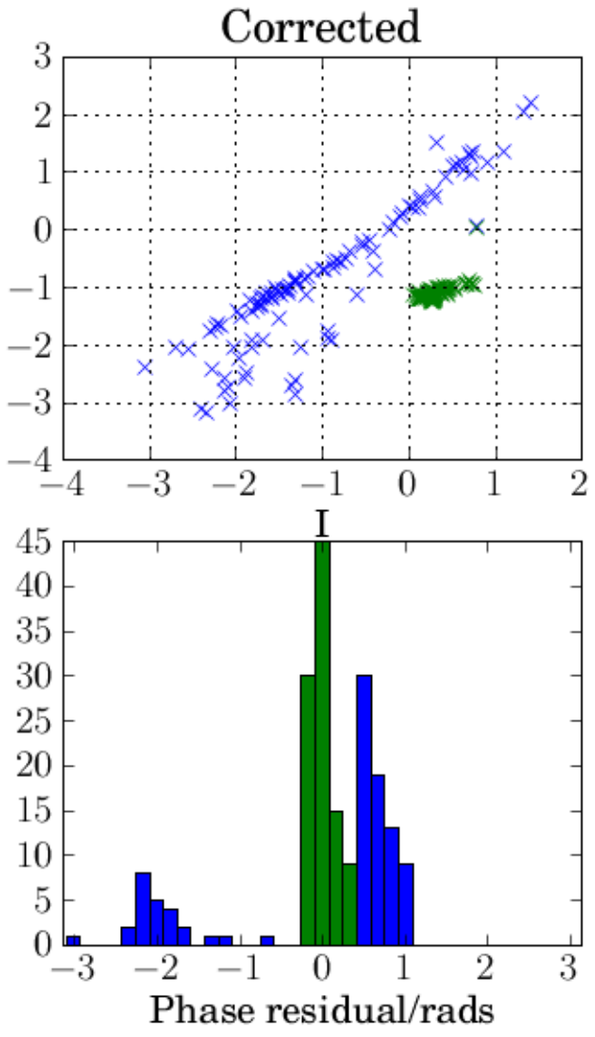
S-band problem cont.

- Significant improvement when correction is applied correctly
  - Still some residual effect, but smaller







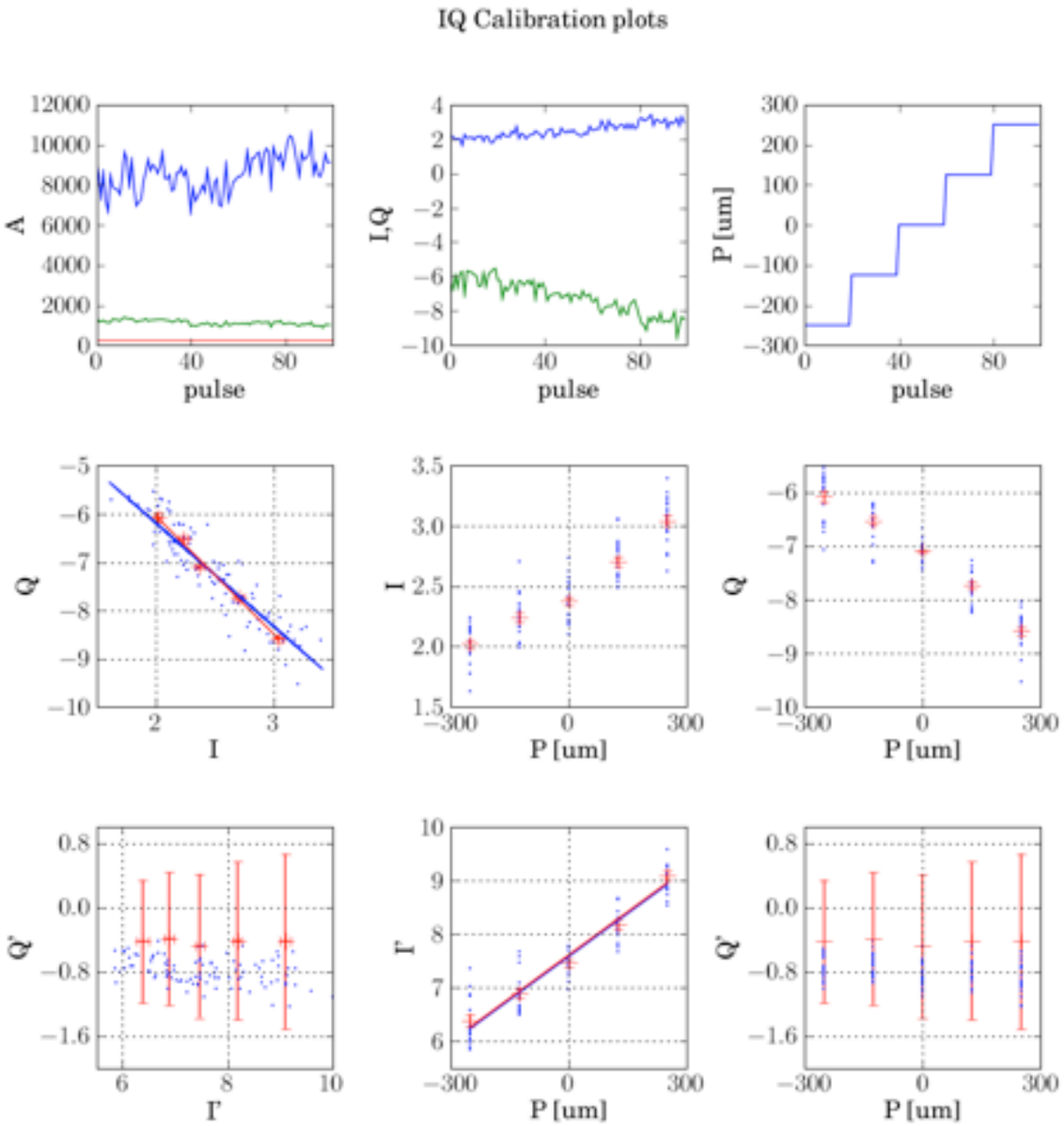


S-band solutions

- Possible solutions
  - Build new S-band refernce (should have done a while ago)
  - Or unlock entire system with a synthesised 714MHz signal independent of DR-RF
    - EXT line trigger will always shift with DR-RF clocks, so will always be a problem
- Dispersion measurements will be improved for C and S band systems if signal arrival time in the digitiser is better monitored
  - So new S-band monopole is not the entire solution

IP BPM calibration

- IPBPMs calibrated using orbit bump
  - Precision ~5%, jitter subtraction still needed

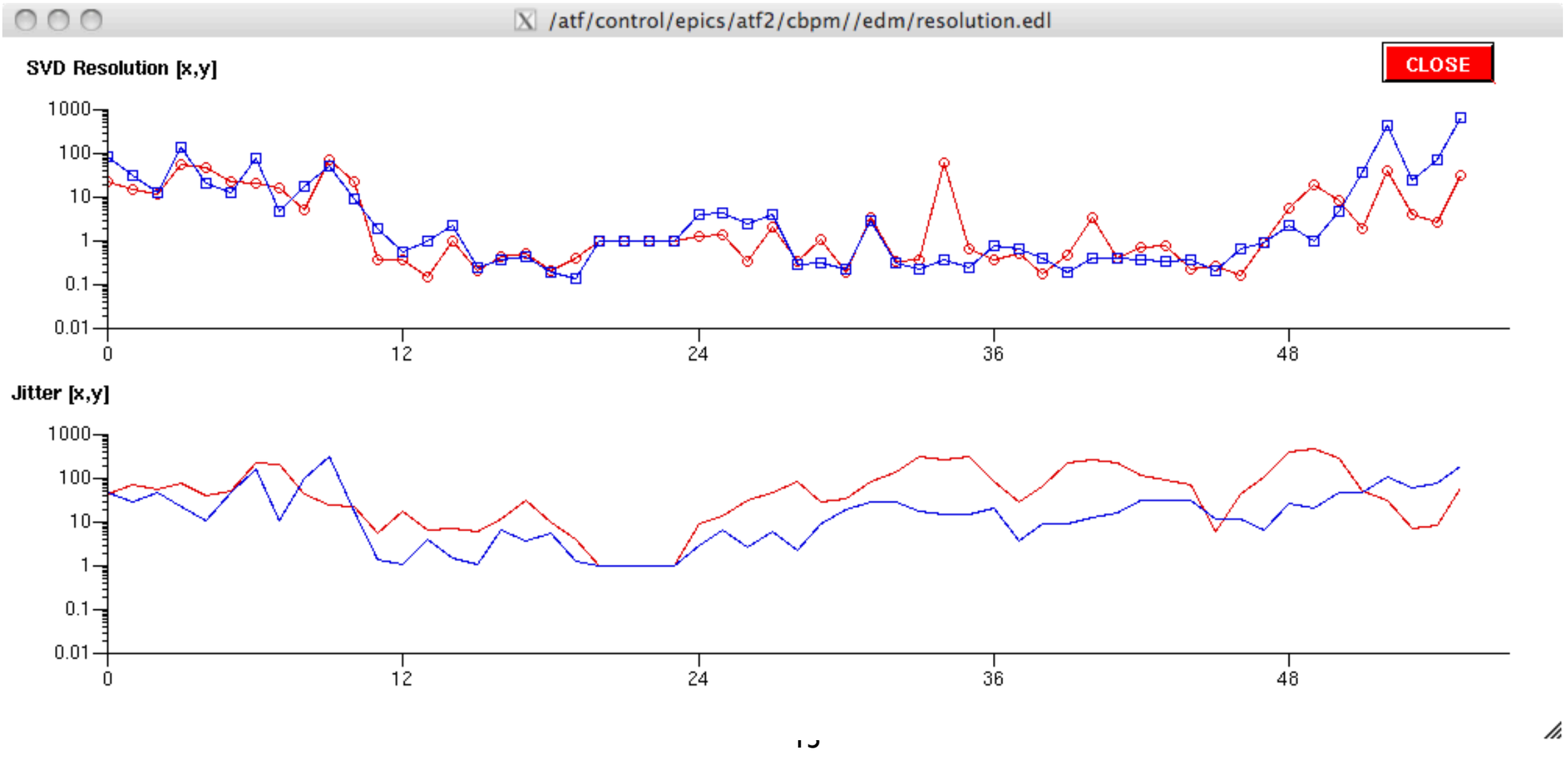


- Calibration repeated in same shift
- Consistent calibrations

BPM	Scale		IQ rotation angle	
	1	2	1	2
IPAx	185.7	181.7	-1.184	-1.155
IPBx	-174.8	-195.3	-0.743	-0.668
IPAy	51.46	49.68	-0.580	-0.584
IPBy	30.78	34.79	-1.528	-1.532

Complete operating system

- All BPMs, C-band, S-band, IP
  - Calibrated, returning position etc
  - Online jitter and resolution plot, published to EPICS



Summary and conclusions

- System stable, calibrations were performed during DR tuning, so lots of beam motion
- S-band problem completely understood if not resolved
  - Need to have excellent phase detector so system will work during DR-RF ramp.
- IP BPMs seemed to calibrate well in December in both X and Y directions
  - Need further work to keep these BPMs unsaturated to realise the required resolution
- Complete system fully commissioned and now move on to maintenance mode