ATF2 EXT/FFS/IP Status

Glen White, SLAC

June 27, 2012

14th ATF2 Collaboration Meeting

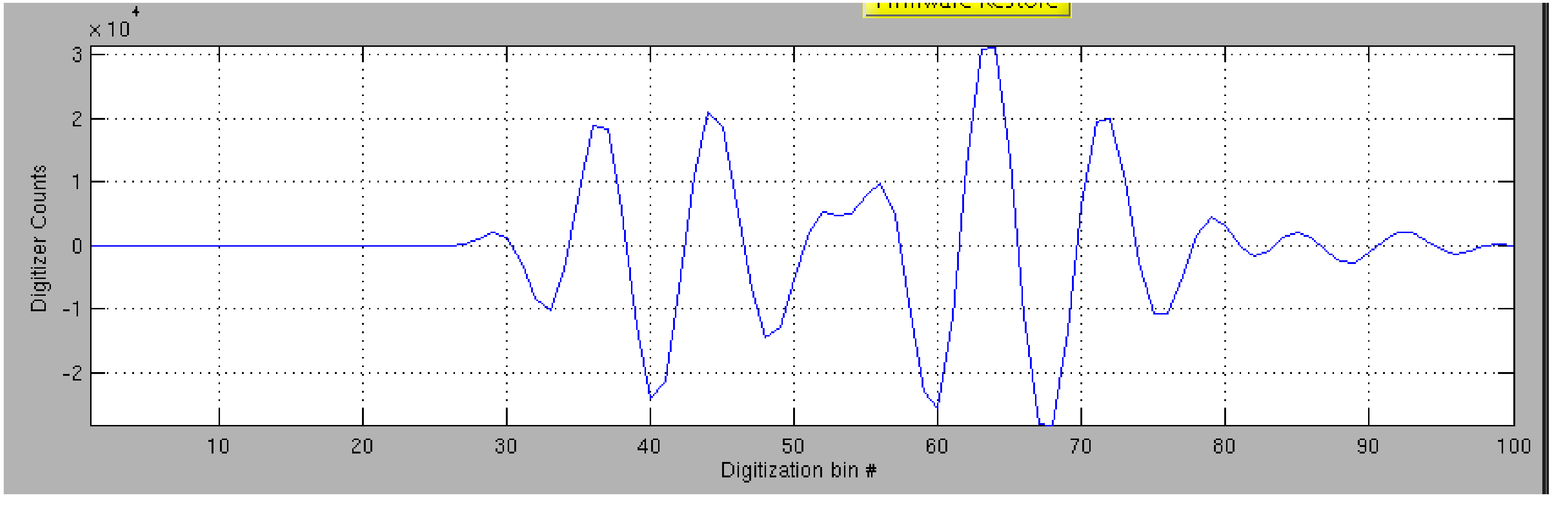
Overview

- EXT/FFS stripline BPM upgrade
- Estimate of performance of current optics
- Tuning highlights and updates
- Outstanding issues for goal 1 achievement

Upgrades to EXT BPM System

- All EXT & FFS BPMs (QF1X – MFB1FF) now converted to using SLAC digitizer system.
- Replacing Struck SIS3301's
- Better bit-depth and higher bandwidth
    - 16 bit, 120MHz
- Improved resolution (1-3 um vs. 5-10um) @5E9
- Now also have spare digitizers for backups or other uses
    - 7 SIS's & 4 SLAC digis
    - SIS's 8-ch per board, SLAC digis 4-ch per board

Multi-bunch Waveform



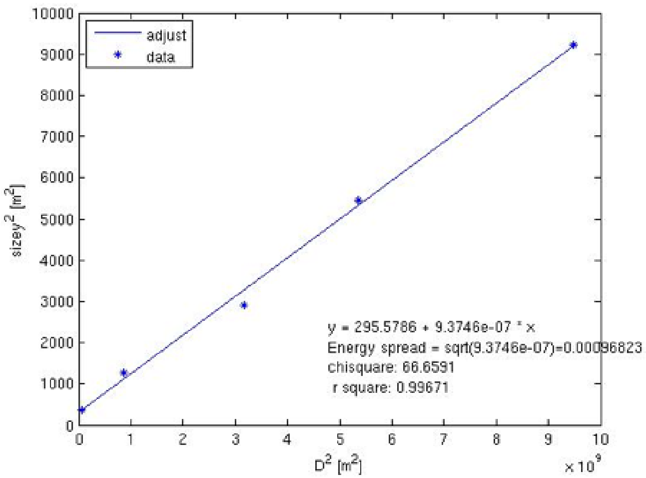
- Waveforms much clearer with new digitizer
- Looks like separation of signals from multi-bunches possible if significant temporal bunch separation.
- May need some fitting and waveform subtraction from trailing bunches for best results.
- Work with FONT group to provide multi-bunch signals to control system.

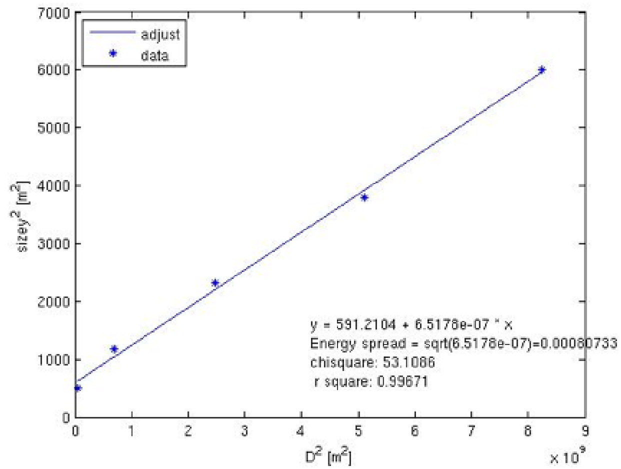
Stripline BPM Resolutions

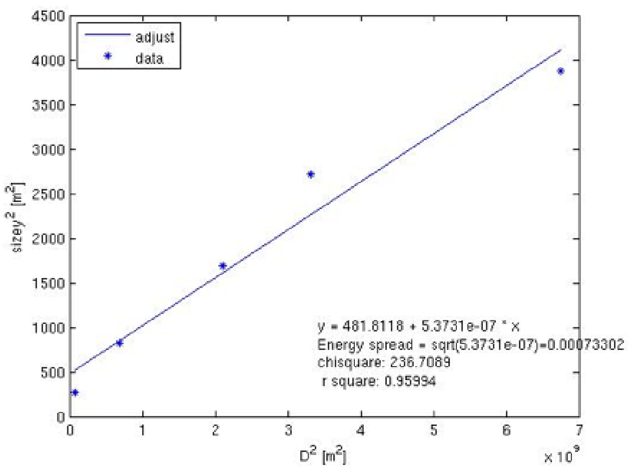
X:
MQF1X: 2.30583 um
MQD2X: 3.32814 um
MQF3X: 2.46871 um
MQF4X: 1.62131 um
MQD5X: 2.26323 um
MQF6X: 3.01951 um
MQF7X: 2.50995 um
MQD8X: 2.51684 um
MQF9X: 1.93363 um
MQF13X: 1.94521 um
MQD14X: 1.03025 um
MQF15X: 2.01426 um
~~MFB1FF: 0.00532484 um~~
Y:
MQF1X: 2.47881 um
MQD2X: 2.02744 um
MQF3X: 2.69153 um
MQF4X: 2.36792 um
MQD5X: 2.49497 um
MQF6X: 2.34505 um
MQF7X: 1.23336 um
MQD8X: 1.79747 um
MQF9X: 1.3676 um
MQF13X: 1.35898 um
MQD14X: 1.2167 um
MQF15X: 1.45859 um
~~MFB1FF: 0.00308858 um~~

- Asses stripline BPM resolution after recent installation of SLAC digitizers and processing improvements
- SVD decomposition from 500 consecutive pulses (no cuts)
- Remove top 5 correlated jitter modes
- Resolution determined from RMS of jitter subtracted remaining data.

OTR-Based dE/E Measurement







- Measurements by Javier^2
- OTR beamsize as a function of dispersion by changing QS2X to get dE/E
- Consistent with usual 8E-3 assumption.
  - Some variance between OTRs (+/- 1E-3) needs to be understood

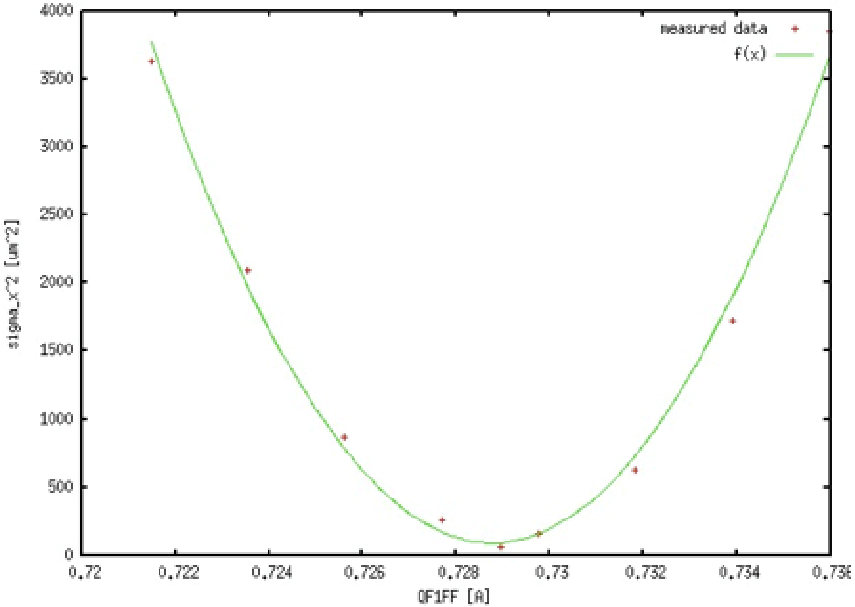
Observations on ATF2 Stability

- Improvements in controlling stability of electron beam, stability of IPBSM system
- dE/E closely monitored in DR
  - Requirement to address energy drift when exceeds ~0.2%
- Monitoring of EXT emittance
  - X emittance consistently worse than in the past (~3nm)
  - Y about 20-25 pm
  - Drifting observed, supposed from DR extraction orbit condition. Fixing by observing MB1/2X helps.
  - Setting of EXT kicker V seems important.
- Monitoring of dispersion
  - Considerable x dispersion generation from extraction orbit
  - Drifts around, can see direct correlation with IP beam sizes when in <300nm region
  - New online dispersion monitoring tool released, under test.
- IP Orbit monitoring still not possible at <um level
- Orbit
  - Feedbacks in use, EXT/FFS feedback appears to keep orbit drifts in check. Need more study as to optimal settings, impact on DR dynamics.
  - FFS orbit feedback not implemented as designed, waist not fixed at MFB1FF/MFB2FF and FFS feedback correctors non operational in feedback mode
- IPBSM stability
  - A lot of work done on understanding internals of IPBSM, identifying components which affect reproducibility and stability. Work planned for improvements over summer.
  - A lot of work done generating new software interface. Very clear and easy for non-expert use.
- Tuning
  - Work done on initial setup, getting <2um initial conditions (pre-multiknob scan)
  - Modelling of beamline seems good- propagation of OTR Twiss to IP.
  - Reproducibility of multiknob scans now a reality. Still need fairly frequent tweaks to IPBSM setup and beam properties, but now much easier to identify and perform.
  - Multiknob scans now much more systematic and faster thanks to multiple software interfaces.

Analysis of May/June Optics

- BX10BY1 optics linear Twiss rematched from BX2.5BY1 optics
- Theoretical minimum beam size at IP from tracking (3nm x 25pm emittance) [full multipole inclusive model]:
  - 11.3 um x 94 / 108 nm (RMS / Gauss fit)
  - With nominal horizontal beta, expect sigma_y 70 nm.
  - Nominal H and V beta, expect sigma_y 45 nm.
- Current IP waist offsets (from Model IP location)
  - +8.13cm / +7.2mm (x/y). ~[2*beta_x, 70*beta_y]
  - As compensated by FD settings, has small effect on vertical beta but not much (20%): beta_y = 0.12mm at waist

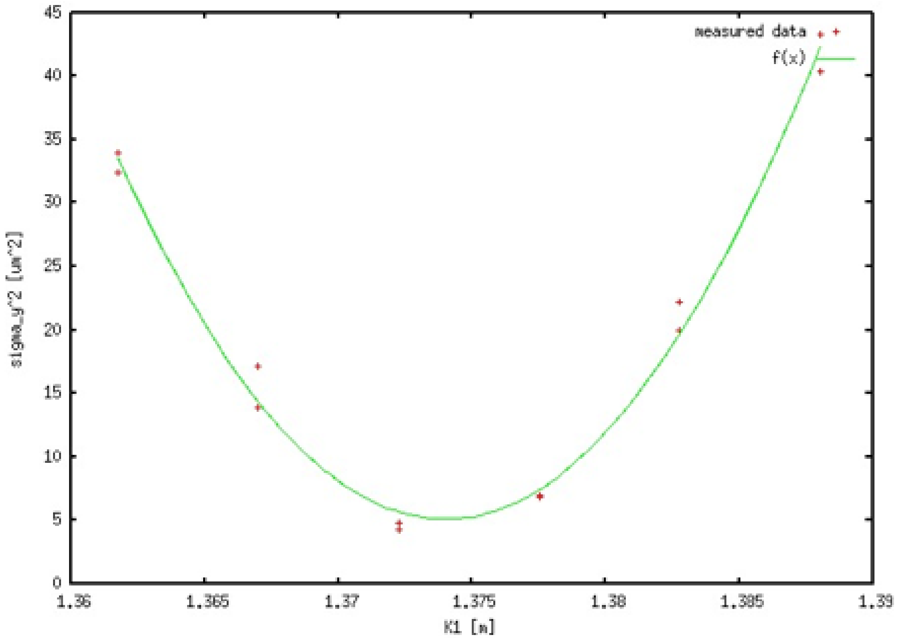
IP Emittance and Beta



0.728424, 1753.56

QF1FF scan

Horizontal emittance was evaluated.
emitx = 2.99nm
betax = 26.0mm



1.37583, 14.1210

QD0FF scan

Vertical beta function was evaluated by assuming emity=20pm.
betay = 0.16mm

5/25 H Twiss Measurements

- OTR measured
  - Beta_x = 17.8m
  - Alpha_x = -12.2
  - Emit_x = 3.8 nm
  - BMAGX = 1.6
- IP measured by quad scan against C-wire by Okugi-san
  - Assuming emit_x = 3.0nm
  - Beta_x = 25 mm
    - (If use OTR 3.8nm emittance-> 21 mm)
  - Sigma_x measured = 12 um
  - Dispersion = 10 mm
- Propogate OTR measurements to IP using live model
  - Beta_x = 21 mm
  - Sigma_x = 9 um = 12 um with 10mm dispersion

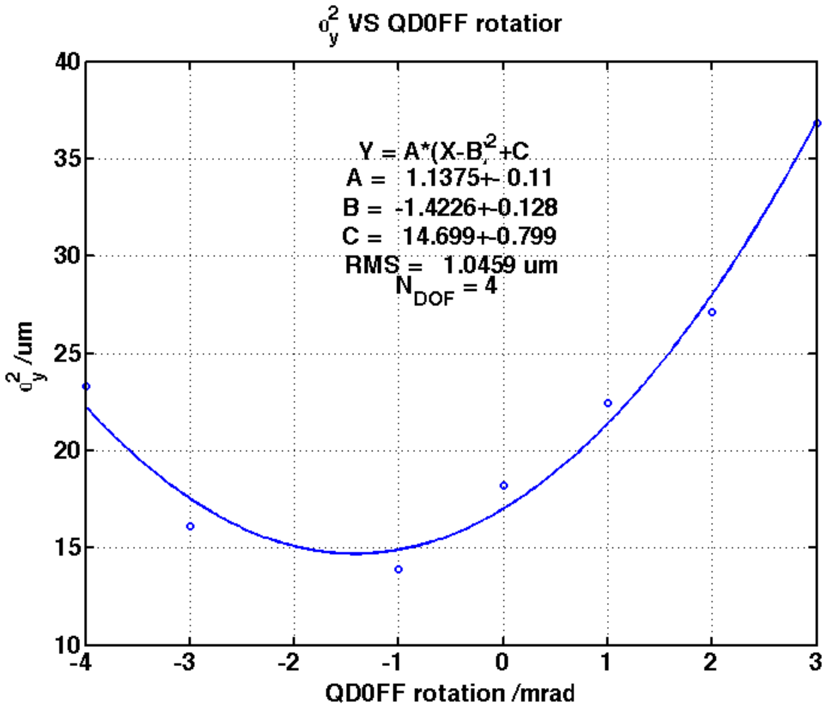
Tuning Procedure Comments

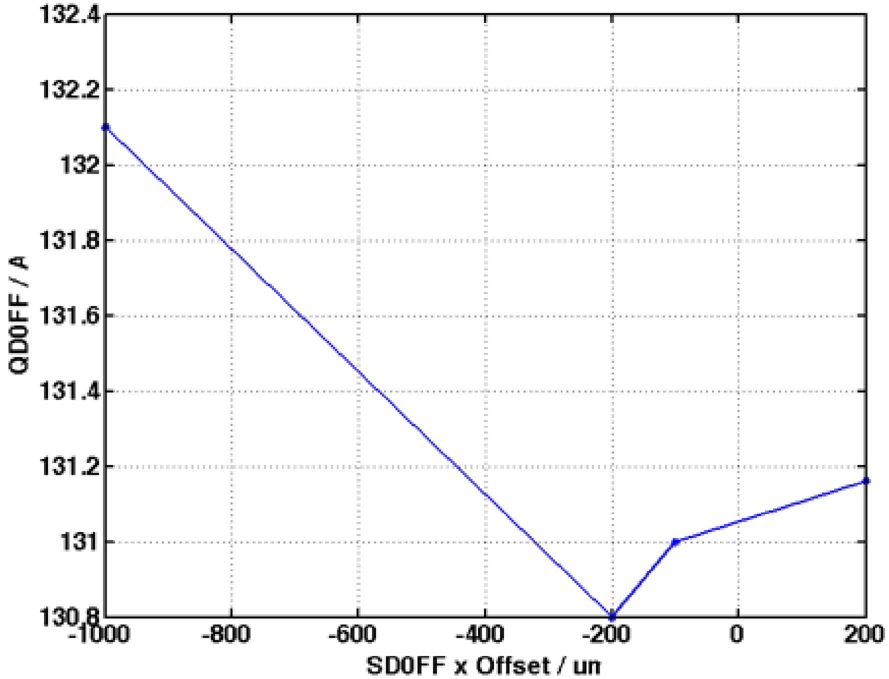
- The simulations of how the tuning procedure works that shows <40nm tuning is possible has assumptions about initial error conditions
- In simulation, the multiknob tuning procedure is shown to work only under the following initial conditions (ie after alignment, initial tuning etc):
  - Vertical beam size is reduced to <2um with the sextupoles centred on beam as much as possible with NO multiknob scans performed to get to that stage.
- Starting multiknob scans above 2um is NOT guaranteed to converge to small spot sizes, this is an unknown initial condition.

EXT/FFS Initial Setup

- Usual
  - Steering, EXT dispersion, coupling
- Turn off FFS sextupoles
- IP beam on waists with QD0/QF1
- Reduce IP vertical dispersion <0.1mm with QD0 tilt
- Minimise coupling by reduction IP sigma_y with roll optimisation of strongest FFS matching quads (QM14=600urad, QM12=300urad)
- Switch on SD0FF
- Recover 0 dispersion situation with vertical mover
  - **Large offset compared to other sextupoles (1.3mm)**
- Recover waist situation with horizontal mover and QD0 waist scans
- Slow!
- Other sextupoles brought on quickly returning to previously calculated BPM BBA offset values
- Initial vertical spot sizes 8um x 1.7um

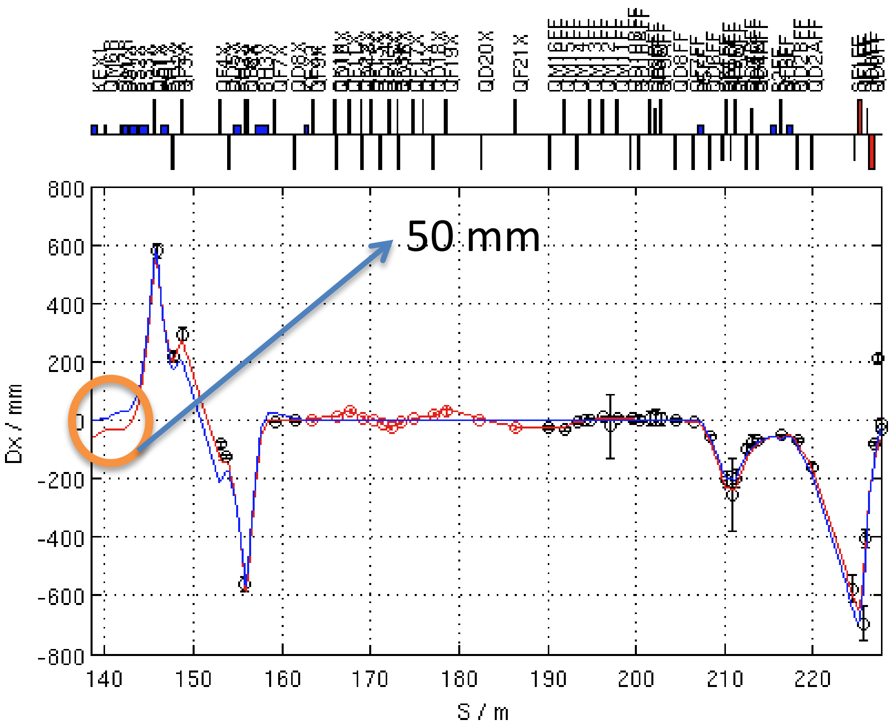
Initial Setup

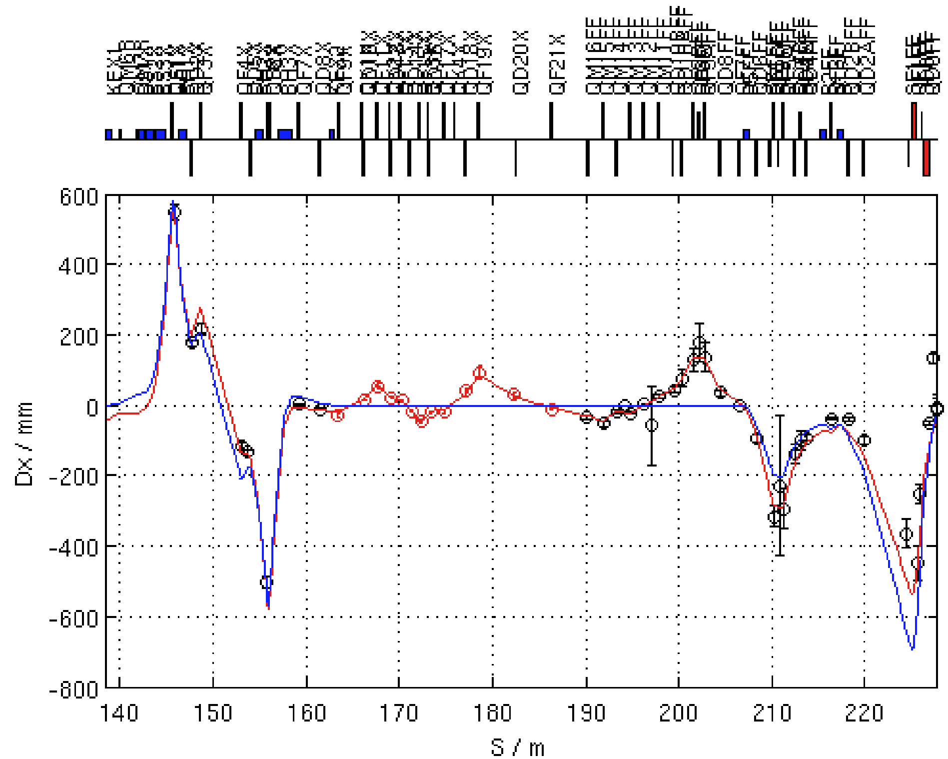




- IP vertical dispersion with QD0 roll
  - Min dispersion at -1mrad
- SD0FF x positioning by waist measurements with QD0 waist scans

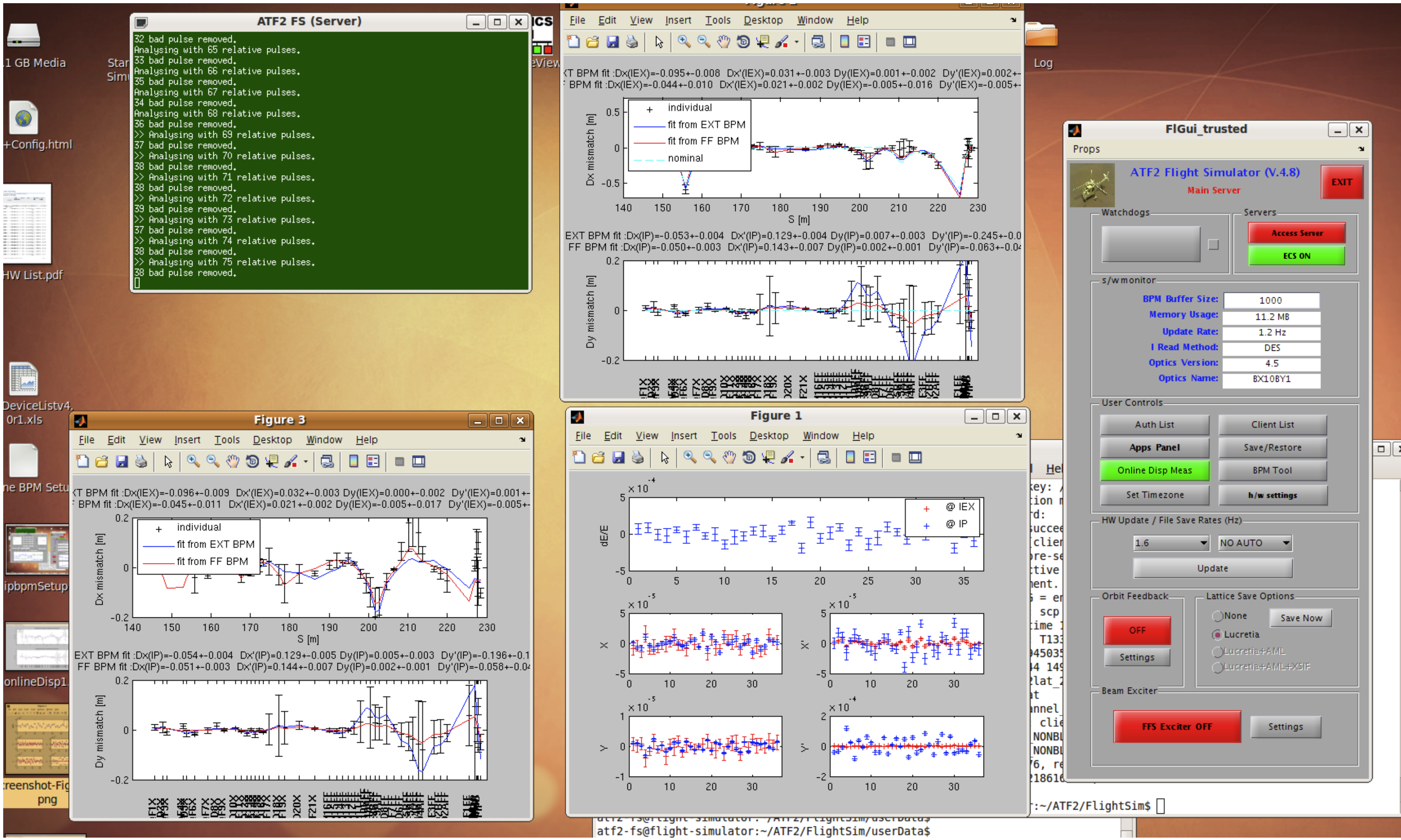
Dispersion Drifts



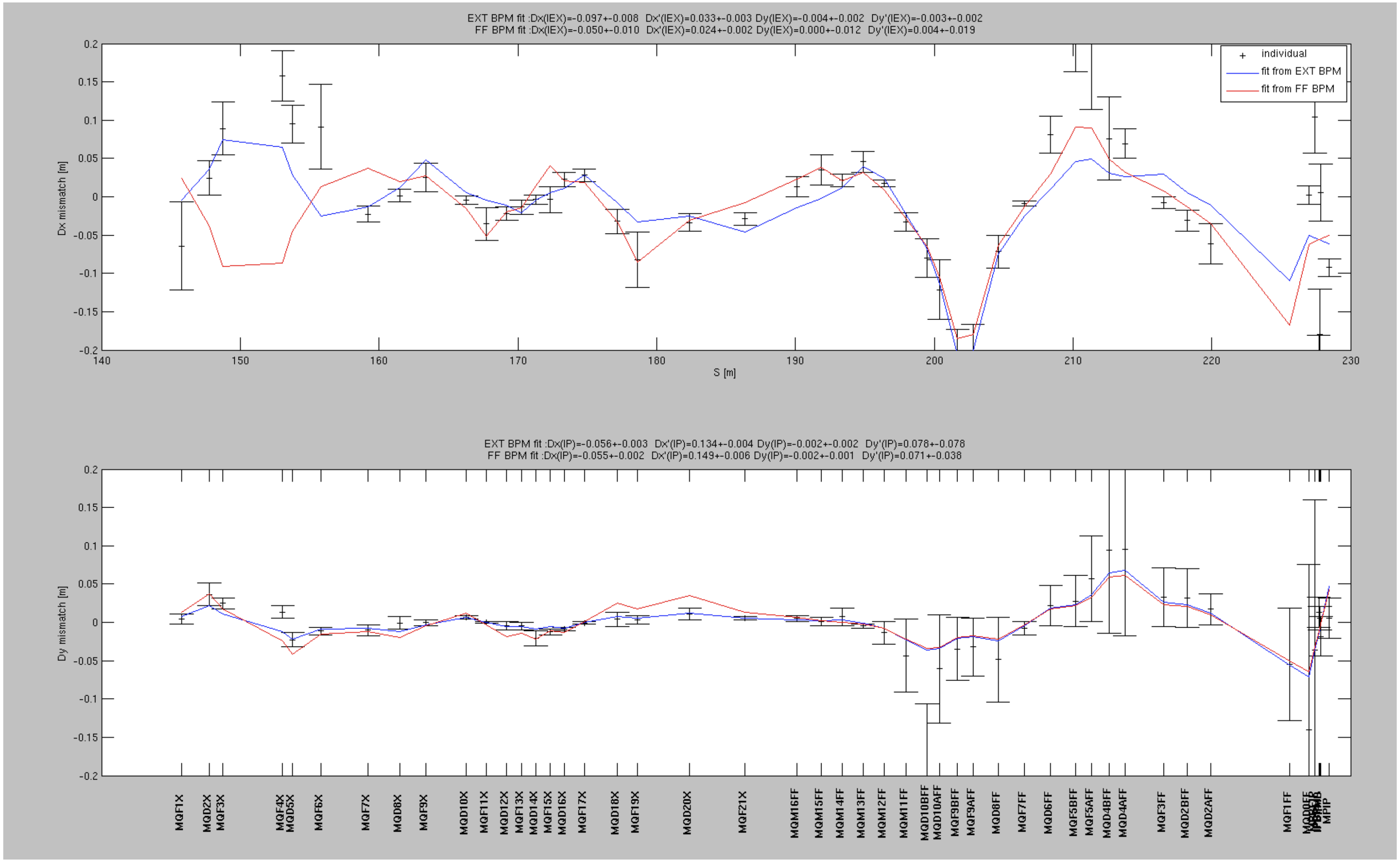


- Frequently see X dispersion drifting around with above signature both in DR freq ramp measurements and online measurements.
- Also see slower drifts in FD phase vertical dispersion. This often corresponds to degraded IP spot sizes. Fixing with QS1X/QS2X observed to correct IP situation even though drift seen in FD phase.

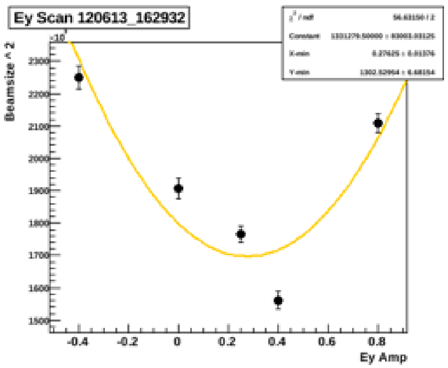
Online Dispersion Monitoring



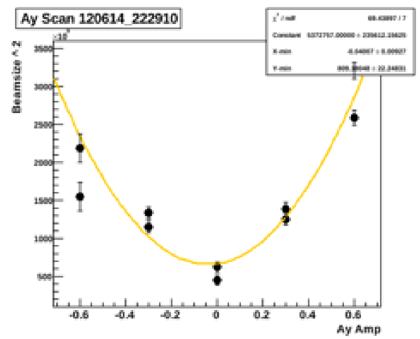
Online Dispersion

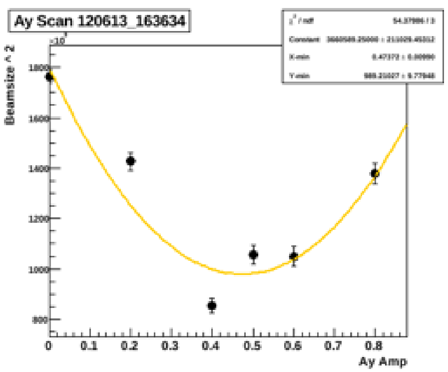


MultiKnob Scans 2-8 Degree Mode



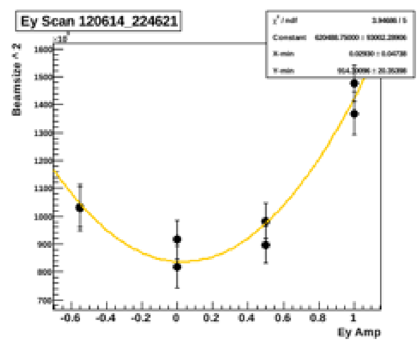
Ay knob : set to -0.04

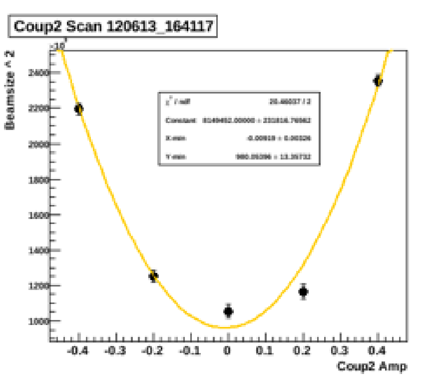




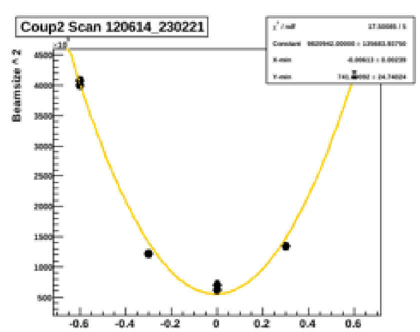
Ey knob scan; set to 0.029

for Ey, mover hit limit easily on negative side (~ 0.55)



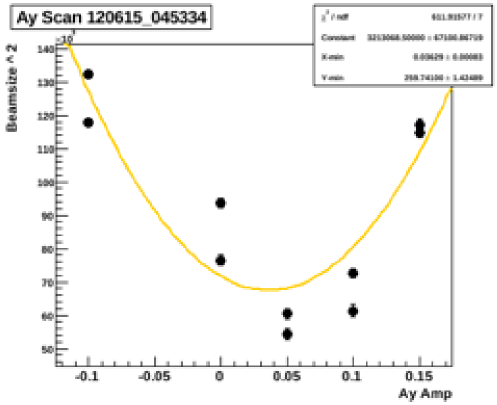


Coup2 knob scan: set to -0.006

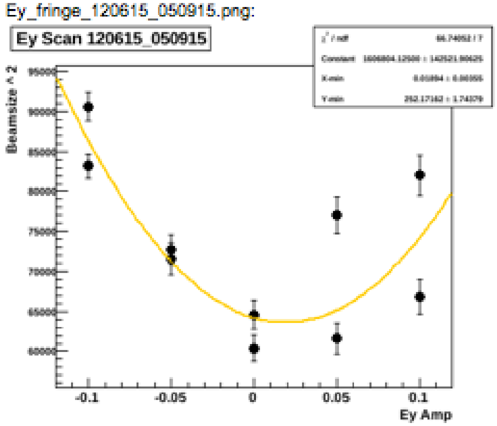


- Minima seem reproducible
- Second iteration scan around zero
  - Good orthogonality
- Not always- see later slides on scan quality

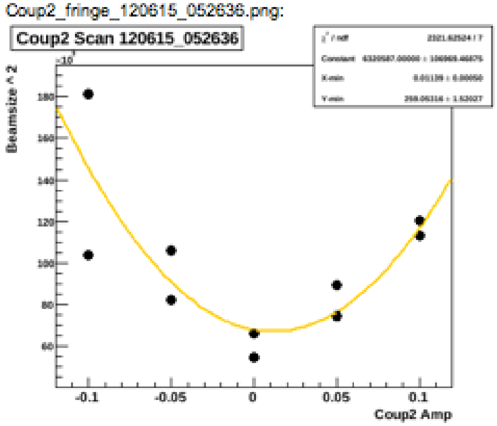
- Ay_fringe_120615_045334.png:



- Set alpha_y -> 0.05
- Ey_fringe_120615_050915.png:



- Set Ey -> 0.019
- Coup2_fringe_120615_052636.png:

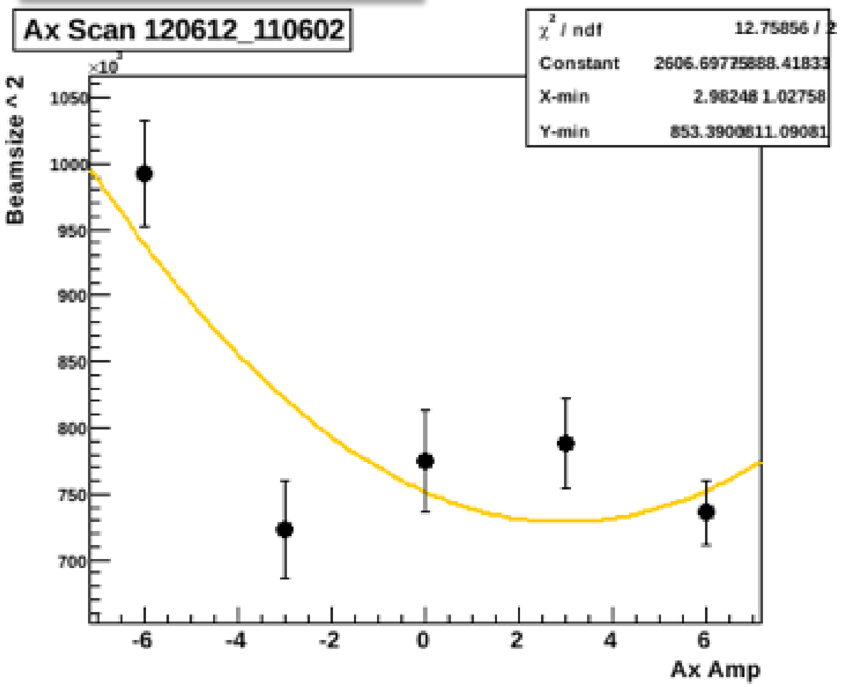


30-degree mode scans

- Same points show quite large variation often
- Re-optimisation of IPBSM (LW, timing, Z scans) or correction of dispersion required every few hours
  - Is obvious when minima not reproduce
- Reproducibility of data point measurements not good enough to progress
- Need to understand and fix nature of large jumps beyond expected statistical errors of measurements

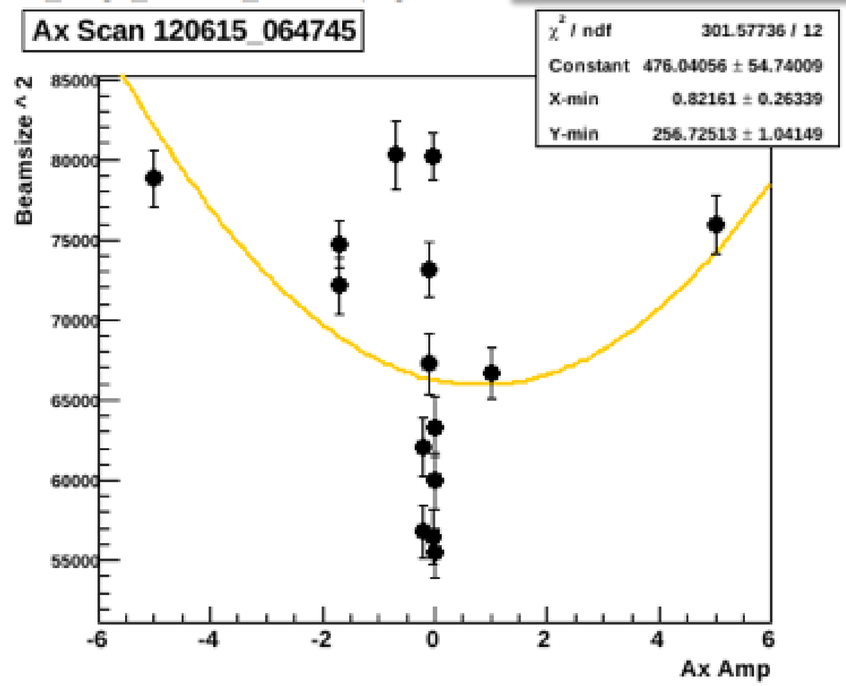
Alpha_x vs. Sigma_y

6-degree mode



- Ax_fringe_120615_064745.png:

30-degree mode



- No clear correlation with horizontal alpha scan for vertical beam size
- Started to try 2-d QK4X - <x'y> vs. sigma_y scans.
  - Not much change with QK4X = +5A
  - Very slow set of scans, situation drifted out under us during attempt and moved on to other items

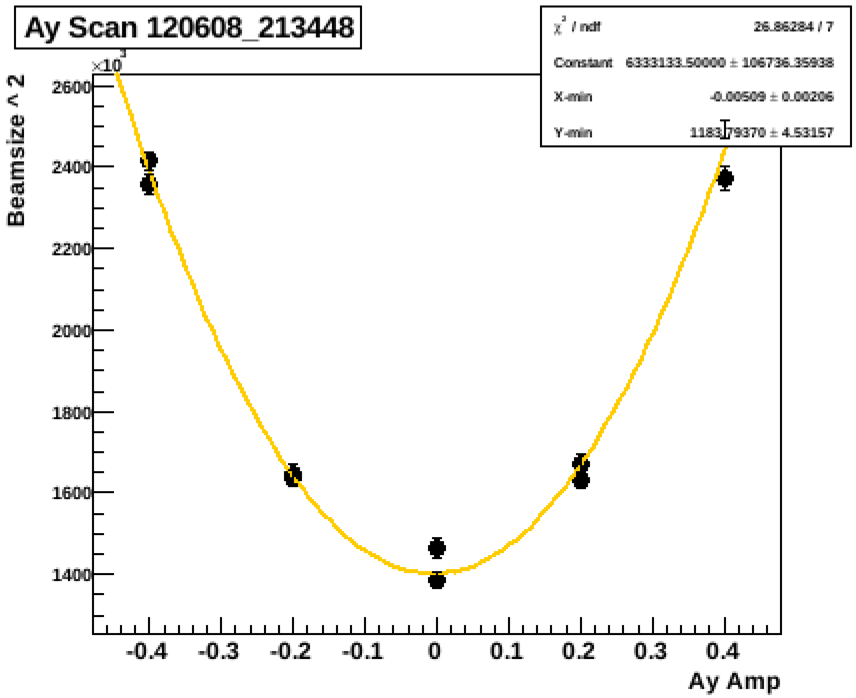
IP Multiknob Scans Stats

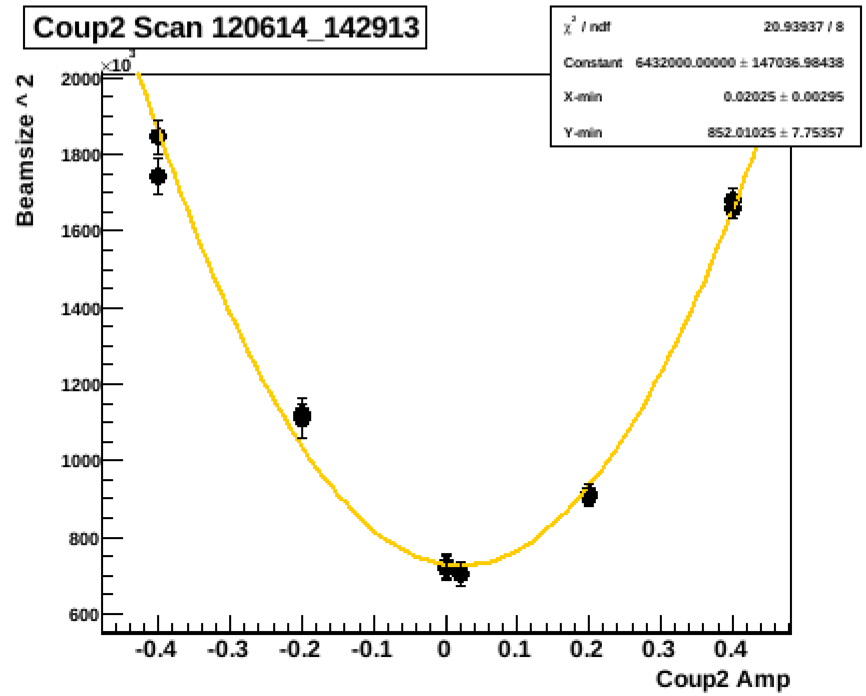
- 7-day period 6/8 through 6/14
- >100 parabolic multiknob scans
- 8 “individual tuning attempts”
  - 2 times converged to using 30-degree mode and <500nm beam sizes
- 1 failure of Sext mover system
  - Implemented position readback cross-check in software
- 11 recorded instances of IPBSM drift interrupting scanning
- 5 recorded instances of beam condition drifts
  - EXT emittance growth
  - Dispersion drift
  - DR E drift

Example Tuning Episode

- 6/14 Day & Swing shifts
  - EXT setup, IP C-wire 8.7um x **1.8**um
  - IPBSM (6.3 degree) **836** nm
  - Alpha_y - 0.014
  - Eta_y -0.31
  - <x'y> +0.014
  - Sigma_y -> **741**nm, then **593**nm no further tuning
  - IPBSM (30 degree) **219** nm
  - No further useful tuning, but beamsize maintained for multiple hours of scanning by careful monitoring of beam size and IPBSM conditions
- Only significant change in multiknobs was eta_y which should have subtracted just 240nm in quadrature with final setting.
  - **Does not explain 1800 -> 219 nm tuning!**
- Non-overlap of measured beam sizes between modes?

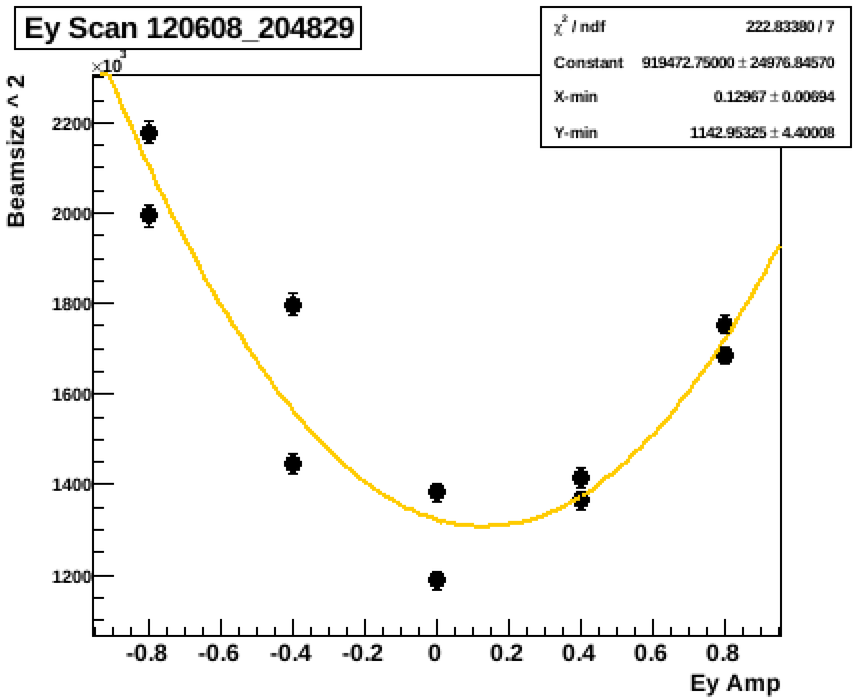
Scan Examples – The Good

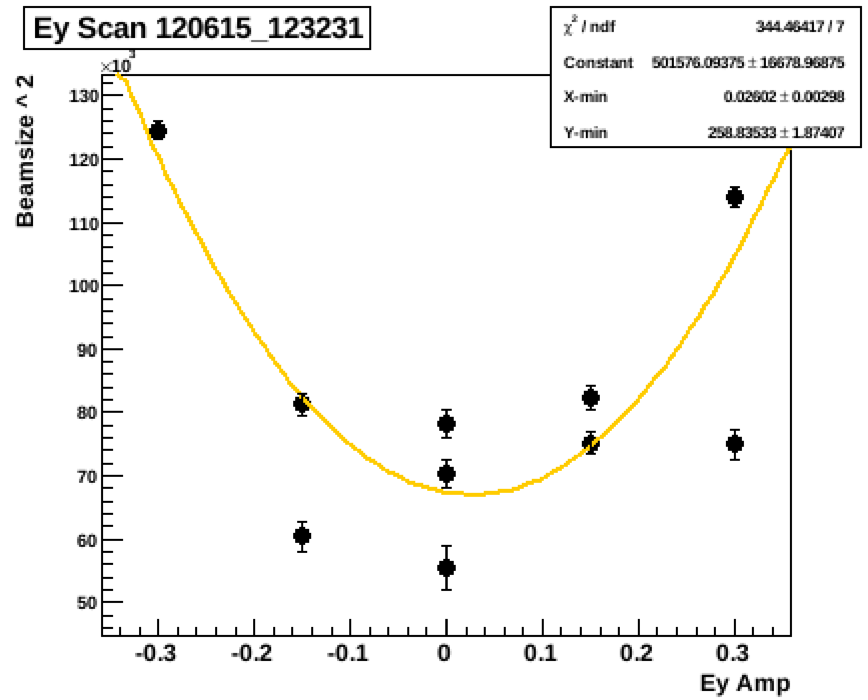




- Some good quality scans
- Reproducible scan points within error bars

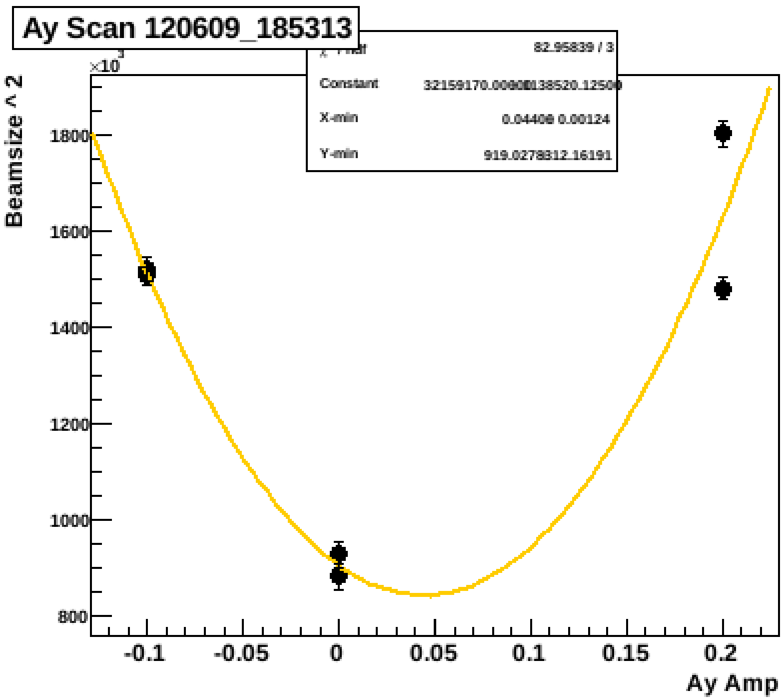
Scan Examples – The Bad

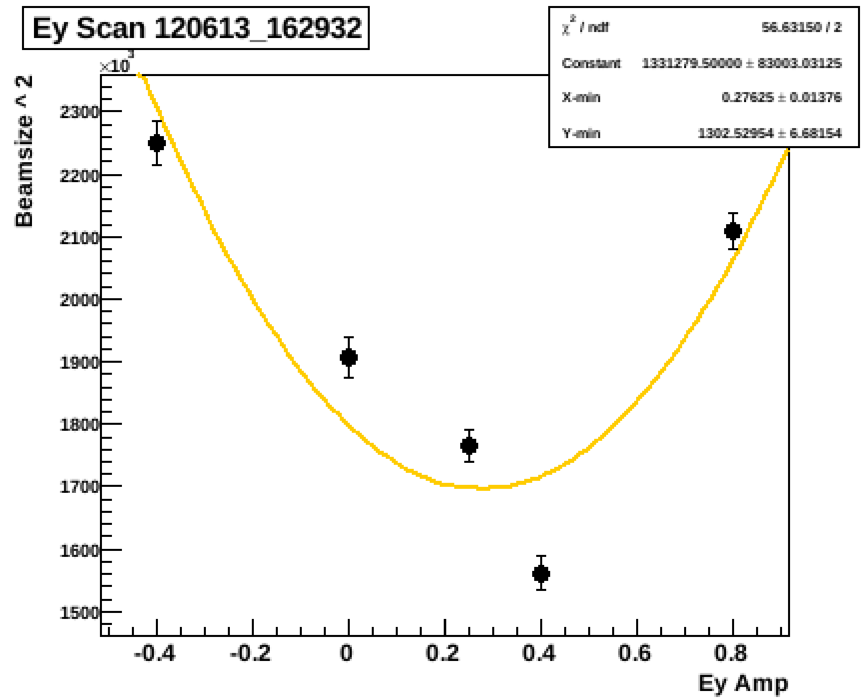




- Scans like these lead to erroneous multiknob settings which are later reversed in subsequent scans
- These should be discounted

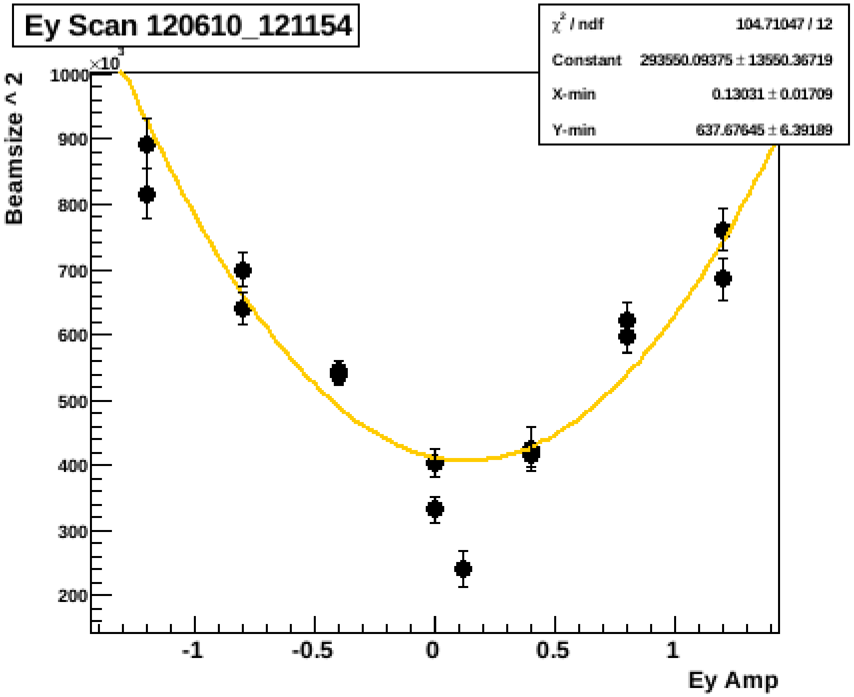
Scan Examples – The Ugly

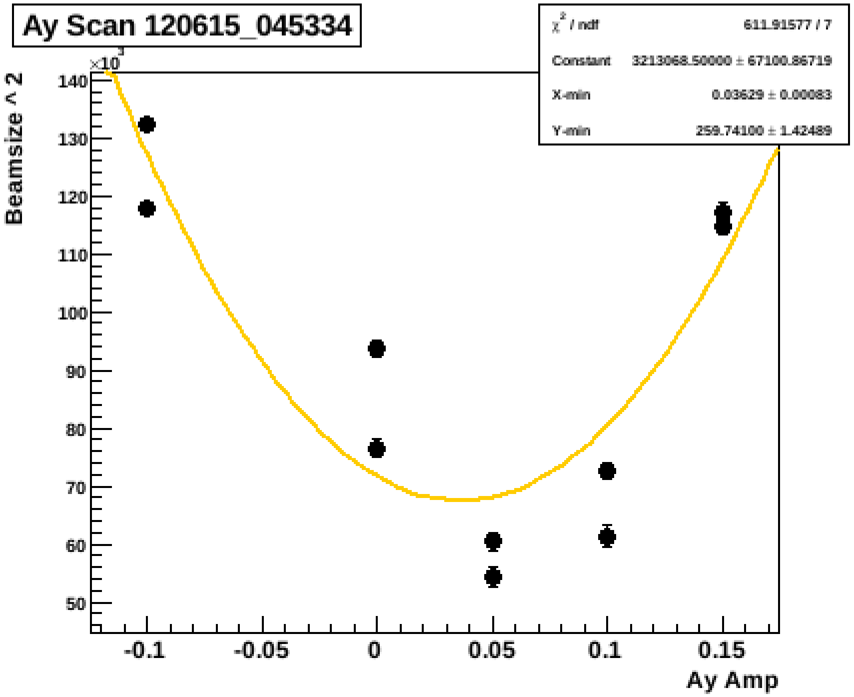




- 3-point parabolic fits? Really? Yuck…
- Should always average points, more than 2 if non-overlapping

Scan Examples – Non-Parabolic





- Some scans seem to indicate local minima near center of parabolic fit but not at parabola minima
- Also seen in simulation
- Can use more advanced 1-d minimisation algorithms. E.g. “golden-search + parabolic fit” method worked well in simulation (Matlab “fminbnd”).

Good Scanning Techniques to Consider

- Only use scans with reproducible points.
- Use at least 5 points per scan.
- Average as many times as reasonable per point.
  - Depends upon beam stability
- Use more advanced 1-d minimiser technique
- Automate scans to speed up
- Check EXT emittance, dispersion and IPBSM conditions **EVERY** time previous minimum not reproduced
- Only need 1 or maybe 2 iterations of ay, eta_y, <x'y> per IPBSM mode down to ~100nm
  - If not, something is wrong. Stop and rethink!

Most Important Outstanding Issues for Goal A

- EXT horizontal emittance
- Optics that take into account multipoles
  - It is not sufficient to simply re-match using linear Twiss parameters, you HAVE to take multipoles into consideration to reach <40nm
- EXT vertical emittance
- Stability of emittance
  - Find extracted orbit which is insensitive to small changes and MAINTAIN
  - MB1X/MB2X critical for this but currently only useable by analysis of scope traces
- IPBSM stability, reproducibility
- Agreement with overlap regions between C-wire and IPBSM modes and understand beam tuning with respect to expected effect of changes applied
  - **Otherwise, nobody should or will believe any results!**
- IP beta-matching
- Use good scanning techiniques
- Implementation and FOLLOWING of pre-defined tuning plan
- <um monitoring of IP orbit
- Setup of "golden" BBA orbit through FD system coupled with IPBSM detectors?