

Status of very high priority beam tuning software

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on behalf of High Priority task leaders**

Status of very high priority beam tuning software

- Coupling measurement and correction in EXT line
CR, P. Bambade, JJ, S.Kuroda, T.Okugi, G. White, M. Woodley
- Dispersion measurement and correction in EXT line
J.Jones, S. Molloy, TO, MW
- EXT orbit correction *Y. Renier, PB, KK, J. Resta-Lopez, AS, GW*
- FFS orbit correction *A. Scarfe, P. Burrows, JRL, YR, GW*
- Beta matching *K. Kubo, M. Pivi*

Coupling: measurement Methods

- **Goal:** correct coupling upstream of the final focus line with available skew quads in EXT (2 then 4)
- **Possible sources of coupling:** DR, QM7 and other bending magnets, QS1X & QS2X used to correct the dispersion, roll quad errors.
- **Measurement of coupling** = measurement of the non diagonal components of sigma matrix via beam size measurements (x, y, 10 degrees)
 - **Multi (≥ 3) wire scanner positions method** \rightarrow theor. 10 sigma matrix elements. but too large error on σ_{13} , need to constraint the fit and need a good phase advance between wire scanners.
 - **Quadrupole and 2 skew quadrupole scan method wire scanners.**
 - Normal $\rightarrow \sigma_{11}, \sigma_{12}, \sigma_{22}, \sigma_{33}, \sigma_{34}, \sigma_{44}$
 - +Skew scans in x $\rightarrow \sigma_{13}, \sigma_{23}$ but experimentaly flat thus 10° is needed
 - +Skew scans in y $\rightarrow \sigma_{13}, \sigma_{14}$
 - +Skew scans in $10^\circ \rightarrow \sigma_{24}$

Coupling: correction procedures

- Use simulation to reproduce experimental measurements, assuming different sources of coupling (separately or together), and scan the 2 skew quads to find the strength couple which minimize the projected vertical emittance. Then apply it experimentally, and measure again coupling and vertical emittance (it was aimed in ATF spring 08 shifts)
 - need to be automatized (Integration to flight simulator) (Planned).
 - study if two skews are enough. (Priority)
 - study the benefit of a third skew quad and find the better position (Priority).
- Experimental method to minimize vertical emittance measured at 4 wire scanners, based on successive iterations.
- Search for a more direct coupling correction calculation with 3 or 4 skew quads using optics code, reconstructing the 4D sigma matrix and fitting it to be block diagonal →
Need to study the feasibility of this with MAD, SAD, MADX...

Dispersion measurement and correction in EXT

- **Goal:** Correction of the 1st order horizontal and vertical dispersions in the EXT line, minimising dispersions at entrance to the FF line
- 2 design algorithms for the dispersion measurement
 1. Varying the ring RF frequency
 2. Modulation of the EXT line optics to approximate an energy change
- Dispersions can be corrected by multi-knobs
 - Horizontally: QF magnets (QF1X and QF6X)
 - Vertically: Skew quads (QS1X and QS2X)

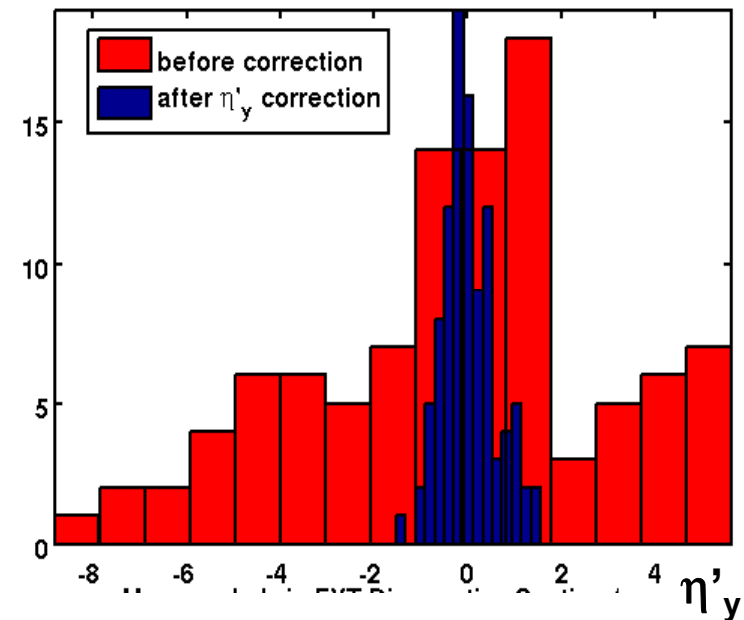
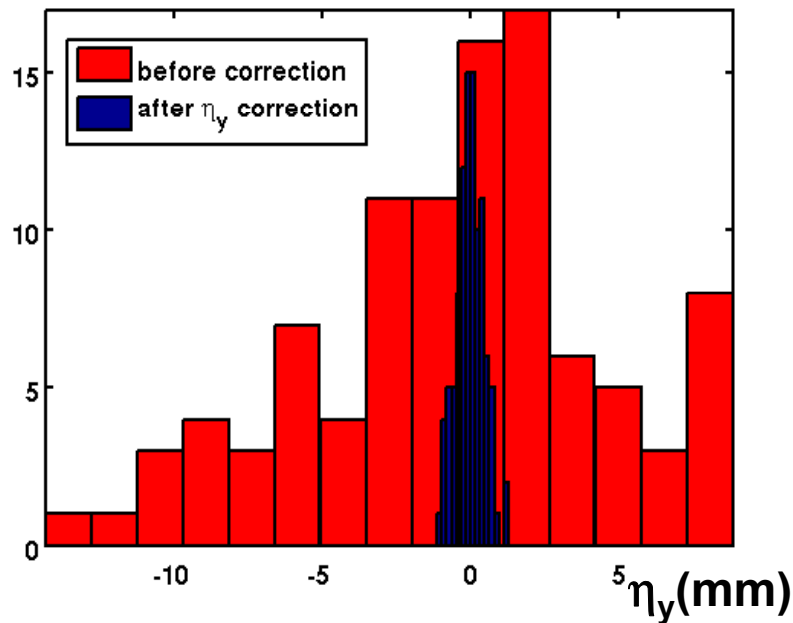
Example: Simulation Procedure (100 seeds)

- apply standard errors (EXT only)
- steer flat (EXT only)
- launch into FFS
 - use FFS feedback
- measure dispersion in diagnostic section
 - scan input beam energy
 - measure orbits
 - fit position vs energy at each BPM
- correct dispersion in diagnostic section
 - back-propagate measured η to start of diagnostic section to get η_0 and η'_0
 - use QF1X + QF6X multiknobs for η_x and η'_x
 - correct η_y and η'_y using skew quads in inflector
- correct coupling
 - scan 4 skew quadrupoles sequentially
 - deduce projected ϵ_y from wire scanner measurements
 - set each skew quad to minimize projected ϵ_y

Standard Error Parameters - wiki

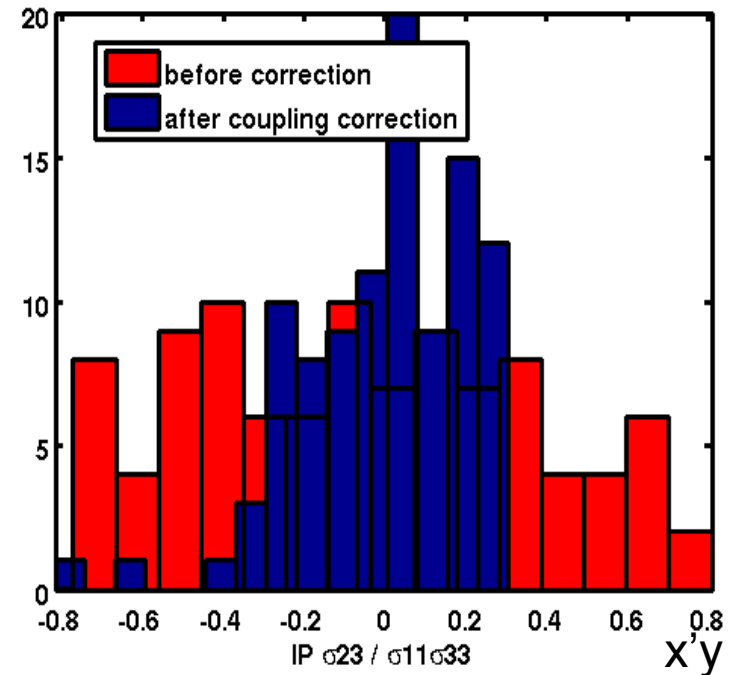
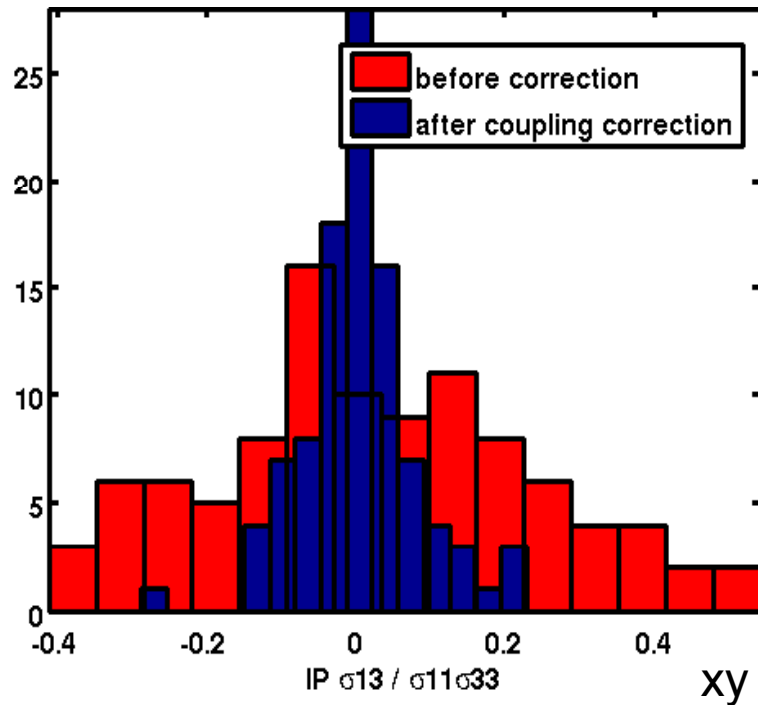
Error Parameter	Error magnitude
<i>x/y/z</i> Post-Survey	200 μm
Roll Post-Survey	300 μrad
BPM - Magnet field center alignment (initial install) (x & y)	30 μm
BPM - Magnet alignment (post-BBA, if BBA not simulated) (x & y)	10 μm
Relative Magnetic field strength (dB/B) (systematic)	1e-4
Relative Magnetic field strength (dB/B) (random)	1e-4
Magnet mover step-size (x & y / roll)	300 nm / 600 nrad
Magnet mover LVDT-based trim tolerance (x & y / roll)	1 μm / 2 μrad
C/S - band BPM nominal resolution (x & y)	100 nm
Stripline BPM nominal resolution (x & y)	10 μm
IP BPM nominal resolution (x & y)	2 nm
IP Carbon wirescanner vertical beam size resolution	2 μm
IP BSM (Shintake Monitor) vertical beam size resolution	use attached data
EXT magnet power-supply resolution	11-bit
FFS magnet power-supply resolution	20-bit
Pulse - pulse random magnetic component jitter	10 nm
Pulse - pulse relative energy jitter (dE/E)	1e-4
Pulse - pulse ring extraction jitter (x, x', y, y')	0.1 sigma
Corrector magnet pulse-pulse relative field jitter	1e-4

Dispersion Correction



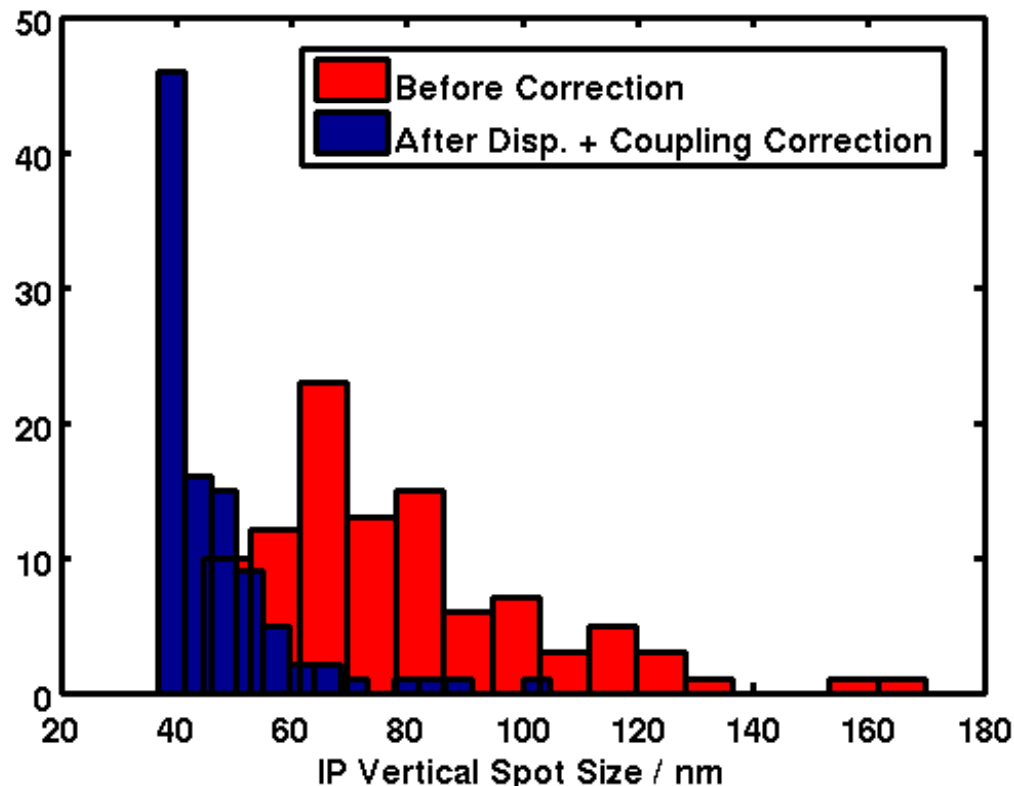
- Vertical dispersion / dispersion' as measured in EXT diagnostic section **before** and **after** dispersion correction.

Coupling Correction



- IP coupling terms **before** and **after** EXT coupling correction procedure.

Simulation Performance



- IP spot sized considerably reduced.
- Full simulation including FFS errors and tuning ok- FFS tuning removes remaining errors from EXT tuning.

Simulation Work to do

- **Wirescanner errors- roll and finite resolution**
 - Need sensible numbers to use here... ?
- **Error just internal to EXT considered here**
 - Add additional sources (from ring.. QM7...)
 - Consider mis-matches from ring
 - Include beta matching procedure in sim
- **Look further at 2 skewQ performance.**
- **Consider alternate approaches**
 - Single-step coupling correction?
 - Alternate method of dispersion measurement (without ring E-ramp)?

FFS Orbit-Steering

Goal: to provide initial orbit steering in FFS and maintain with FB

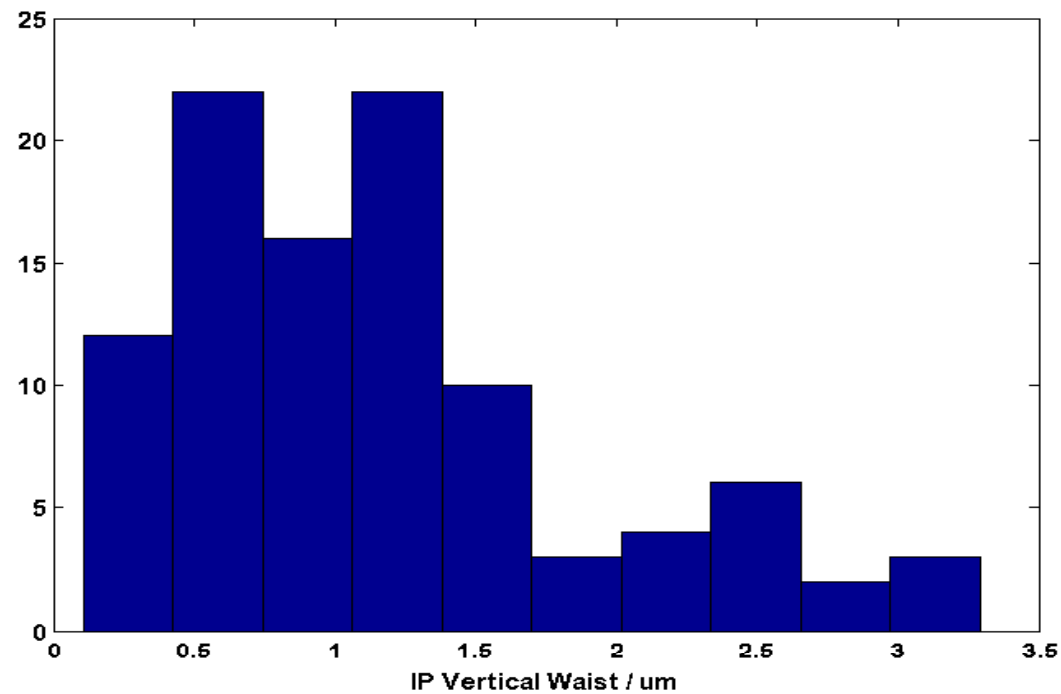
Several orbit-steering methods have been developed and are ready for comparative tests:

- Global orbit-steering using a least-squares minimiser and SVD
- 1-to-1 orbit-steering using a simplex minimiser
- dispersion free orbit steering using a simplex minimiser

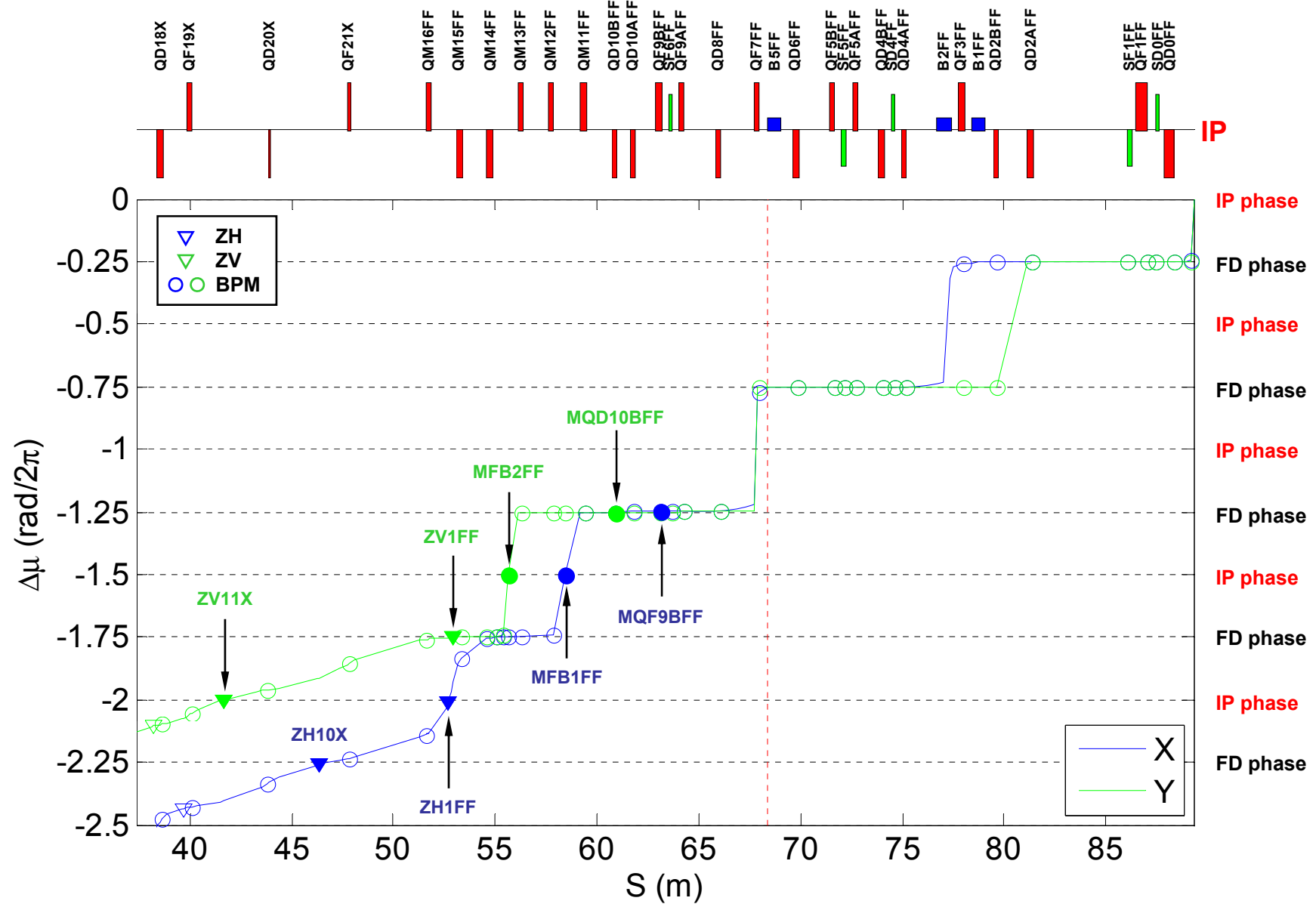
Comparative Criteria

- Beam size jitter
- IP position jitter
- Average orbit size and jitter
- Max mover moves
- Sensitivity to BPM resolution
- Sensitivity to BPM - magnet alignment
- Sensitivity to corrector/mover errors/resolution

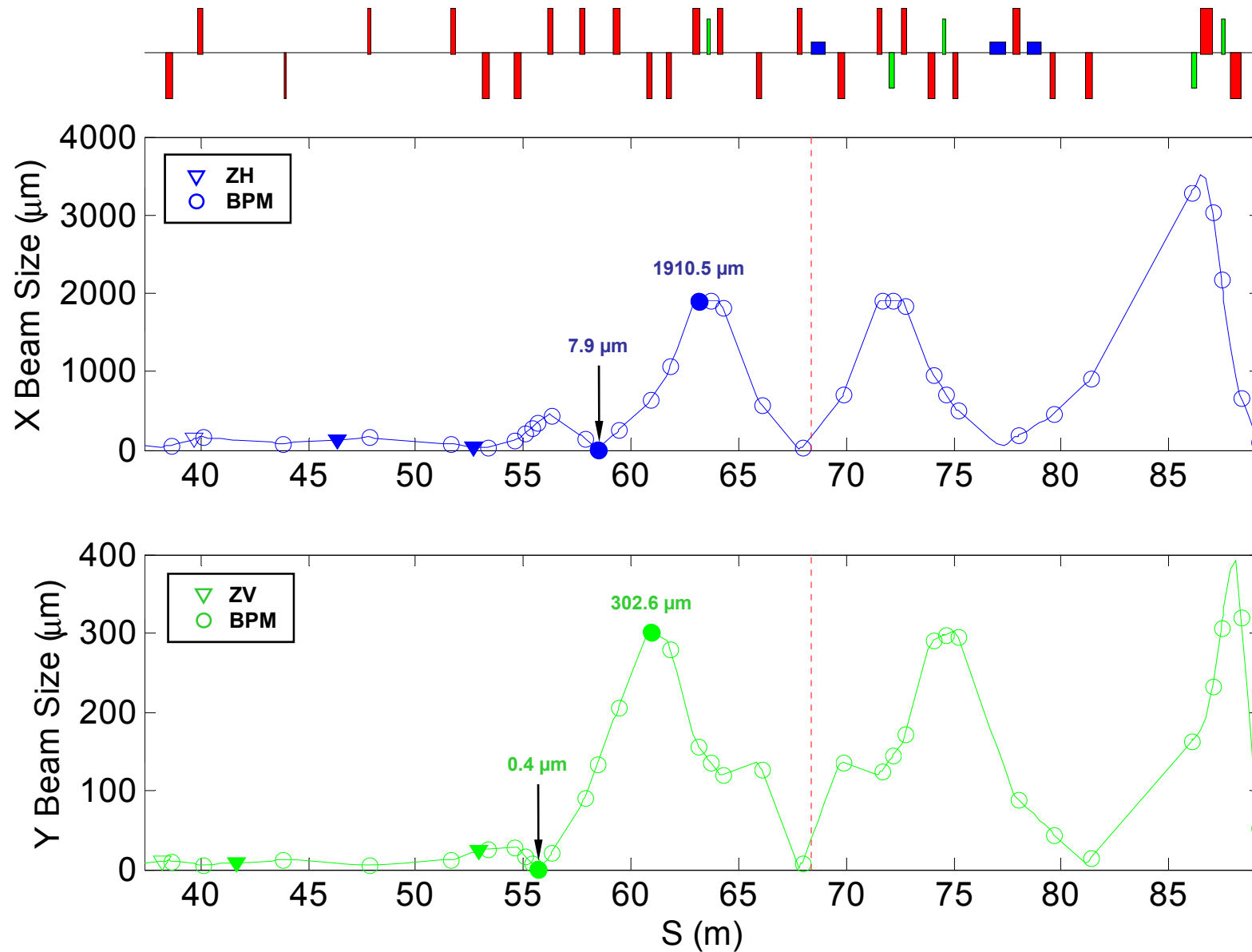
Beamsize after Steering/alignment + EXT disp/coupling correction (100 seeds)



ATF2 pulse-to-pulse feedback devices (v4.0)



ATF2 pulse-to-pulse feedback devices (v4.0)



Feedback Plans

- Use mover based 1-1 steering for initial steering of beam
- Maintain orbit with FFS pulse-pulse feedback devices (2 orthogonal stripline kicker-bpm pairs in each plane)
 - Feedback with low gain (approx 50-pulse step-response convergence time) to deal with slow drifts and avoid amplifying fast jitter
 - Simple integral feedback system used
 - Open question: how critical is getting correct phase at 1st vertical bpm fb location? Phase changes fast there- may have to be condition of beta-match?...

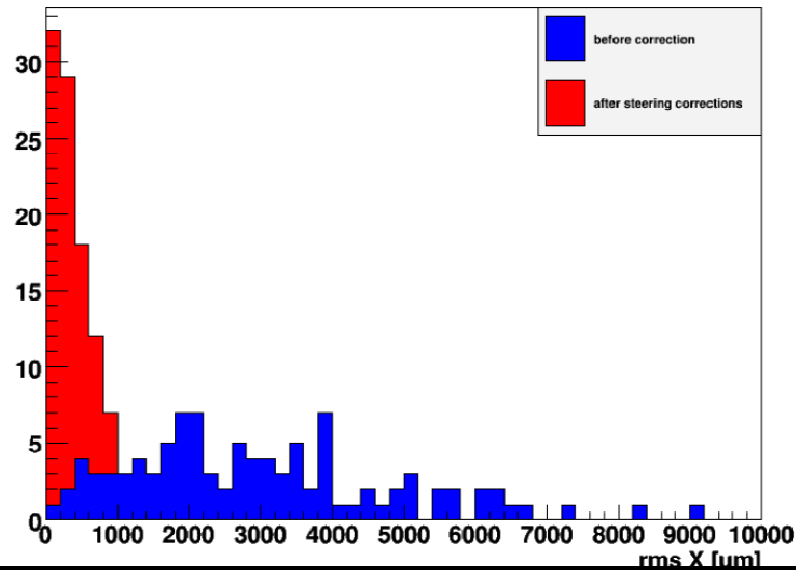
EXT Orbit Corrections

- **Goal:** to provide initial orbit steering in EXT and maintain with FB
- Simulate ATF2 with agreed errors (e.g. wiki list).
- Analyze the effects on the stability and the size of the beam.
- Development of several algorithms (e.g. "1 to 1", "dispersion free").
- Compare the results of all.
- Implement the best ones in the Flight Simulator.
- Explicit reconstruction and control of the orbit (specially in QM7)
- Make Graphical User Interface and User's guide.
- Study the EXT FB implementation, interactions with other FBs.

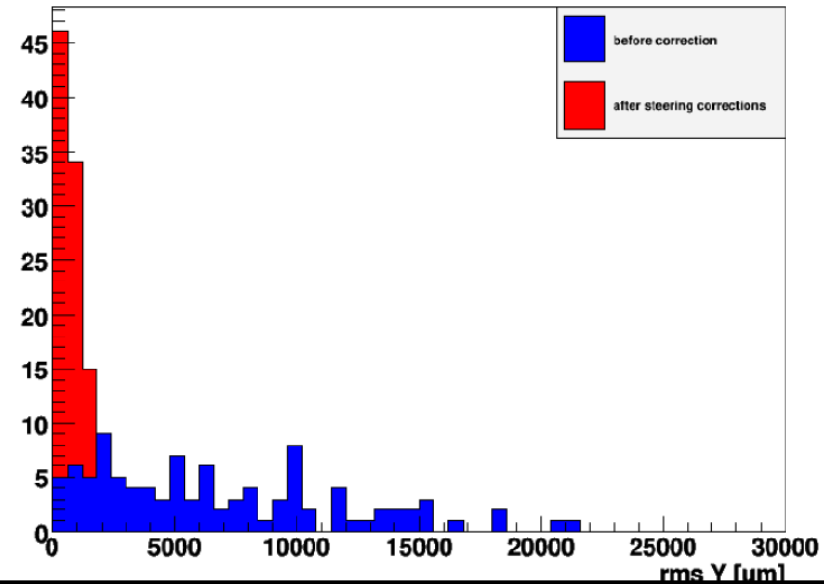
Simulation of EXT Orbit Corrections

- static magnets' misalignment and rolls and BPMs' resolution.
- 11 bits corrector power supplies.
- implementation of "1 to 1" method using SVD for EXT+FF.
- include correction moving quadrupoles in FF.
- specific treatment of correctors' saturation.
- attempt to make orbit reconstruction and control in QM7(ATF).

rms X bpm readings before and after 1-to-1 correction



rms Y bpm readings before and after 1-to-1 correction



EXT Orbit Correction plans

Soon :

chose the 1 or 2 best algorithms.

implementation in the Flight Simulator (if cavity BPMs available).

Optimisation :

Interaction with other feedback (as soon as others are available in FS).

Handle errors (e.g. Missing BPMs).

Orbit reconstruction and control.

Compare expected correction and experimental one.

Beta matching in EXT

Goal: To set correct (designed) Twiss parameters at the exit of EXT (entrance of FF).

1. Measure Twiss parameters around the extraction kicker in DR. : Measurement of tunes changing quad strengths around the kicker.
2. Calculate a proper setting of quads in the EXT to match input twiss param. We need to decide which magnets should be changed. Strength of off-center QM7R (?).
3. Measure emittance and Twiss parameters in the EXT using Multi-wire and/or Quad scan methods.
4. Calculate a proper setting of quads in EXT to match into the FFS.
5. Perform 3 again to confirm the matching.
6. Iterate 4 and 5 if necessary.

Procedure needs to be incorporated into tuning simulations.

Controls Implementation

- Code in Flight Simulator environment.
- Write GUI's
- Currently need to program breaks for user input to perform E scan and wirescans.
- Investigate inclusion of EPICS/FS links to wirescanner / E ramp processes.