

Beam jitter,

how can we estimate the position and angle jitter at IP?

Young-Im Kim

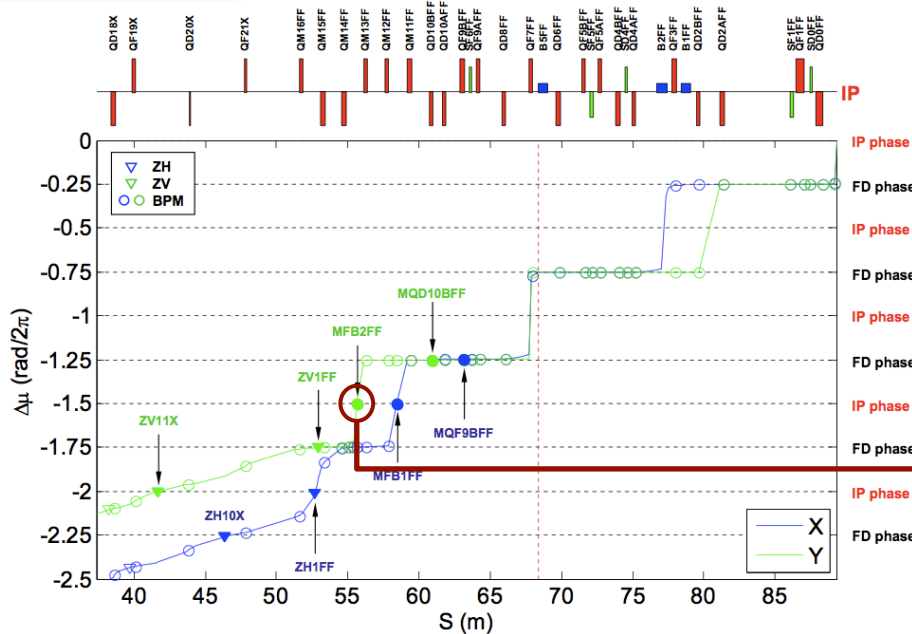
John Adams Institute - Oxford University

FONT group

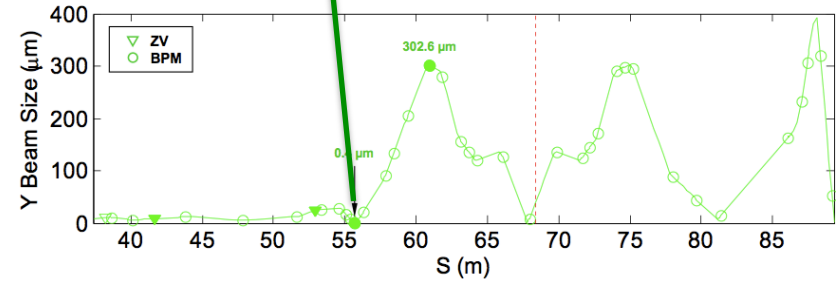
Orbit Control in FFS

ATF2

ATF2 and BDS – G. White (12 Nov 2013, LCWS 13)



$\sigma_y < 400\text{nm}$ @ IP-phase



- FFS optics requirements lead to unusual situation for beam diagnostics
- All phase changes occur inside magnetic elements, only sample FD-phase
- 1 location for IP-phase sampling at IP vertical image point (waist) with small beam size
 - Critical for FFS feedback
 - Need high-performance BPM
- Consider splitting QF7FF quad to access IP phase in x & y simultaneously?

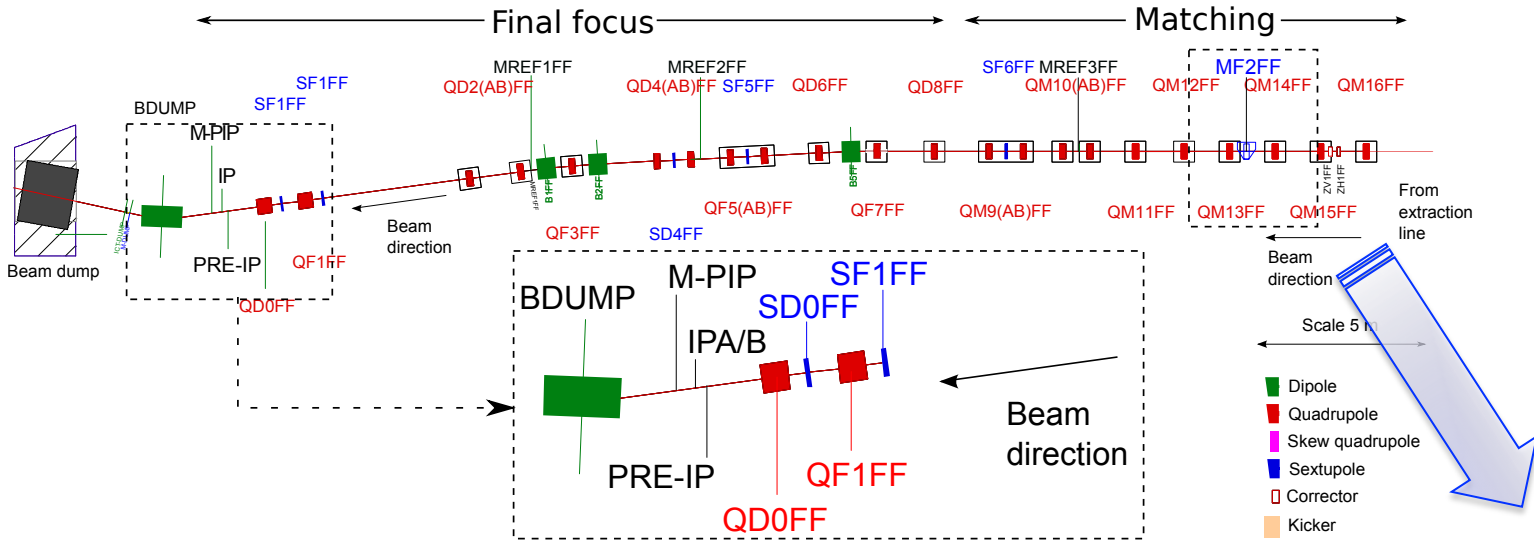
• Correct phasing and operation of 2-phase FFS feedback still to be demonstrated at ATF2

Introduction

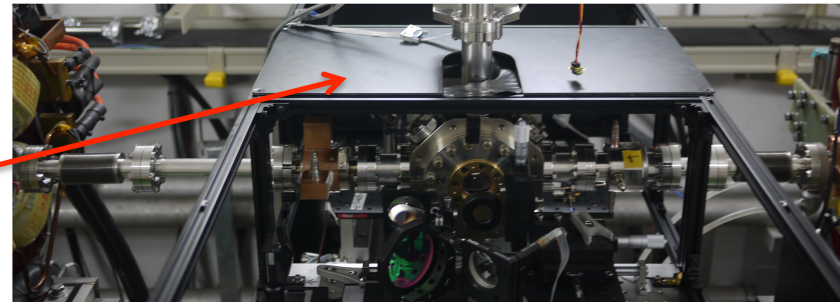
- Measurement at ATF2
 - Resolution, Jitter, correlation
- Tracking simulation
 - Calculate IP using different method
- Summary

Measurement @ ATF2

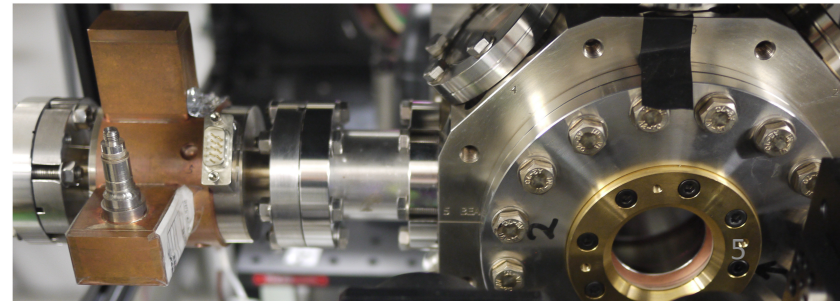
Accelerator Test Facility 2



Laser wire system

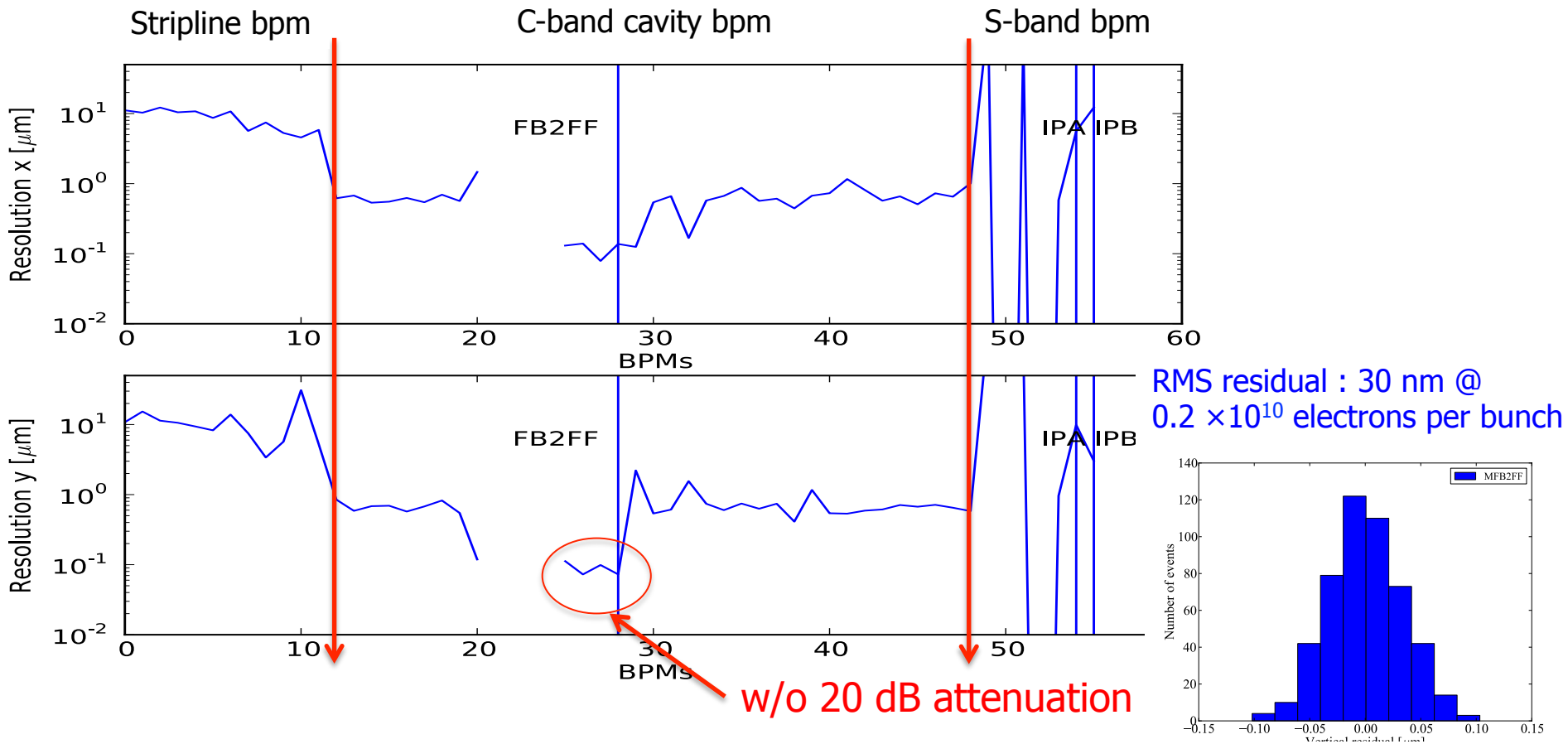


MFB2FF is mounted directly on the LW chamber and is moved by moving the entire assembly both vertically and horizontally with a total range of $\pm 250 \mu\text{m}$



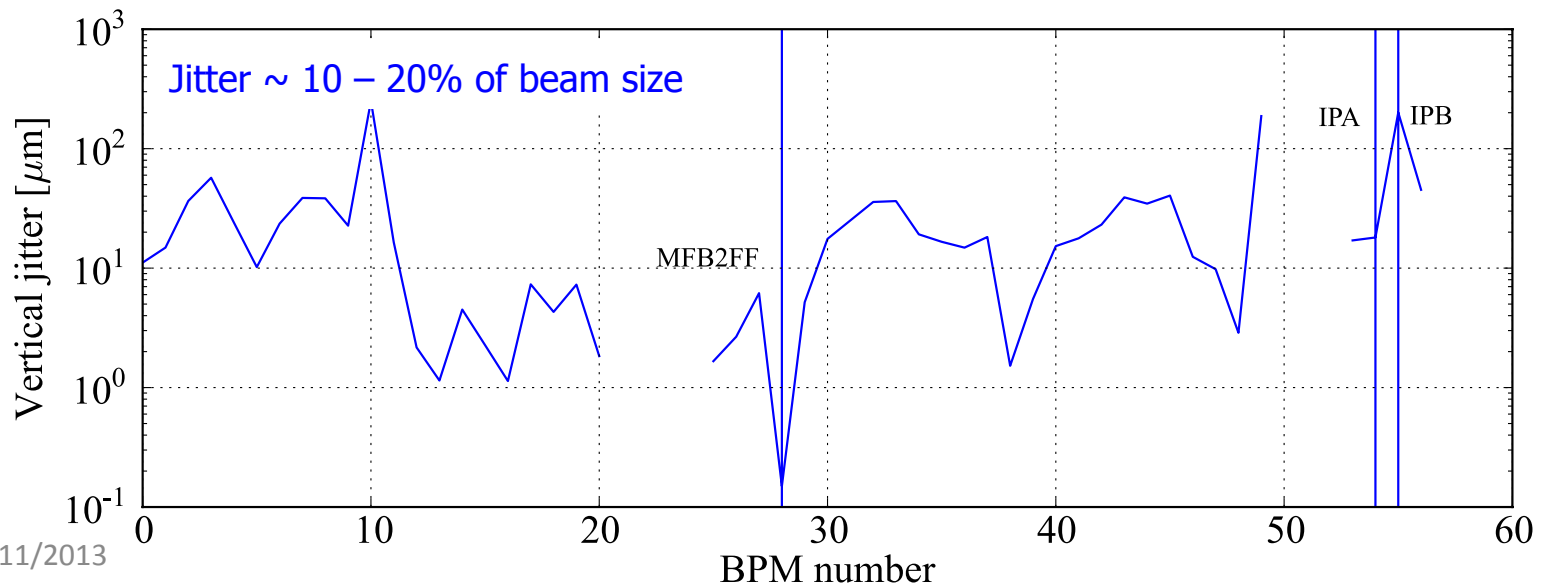
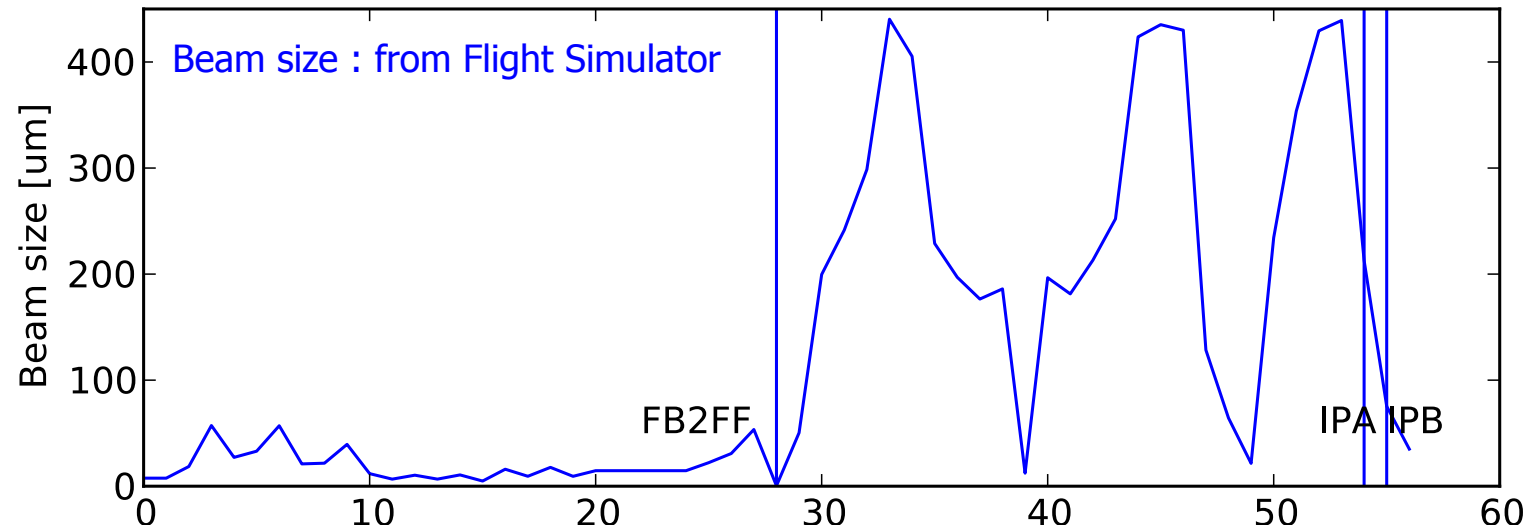
BPM Resolution (stripline + cavity)

RMS residual between the measurement provided by MFB2FF and the prediction made by spectator BPMs. Matrix inversion on measured data using SVD provided correlation coefficients for the prediction



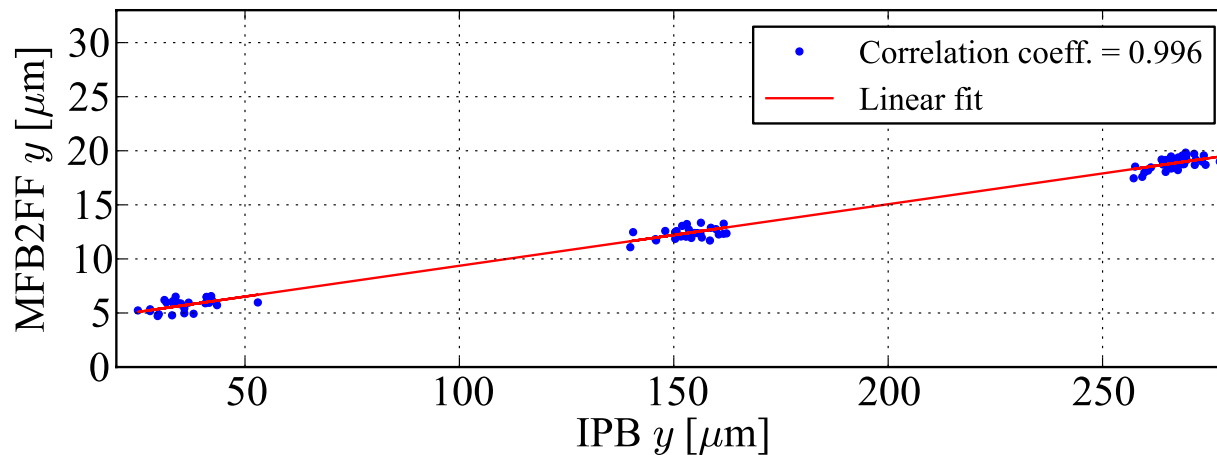
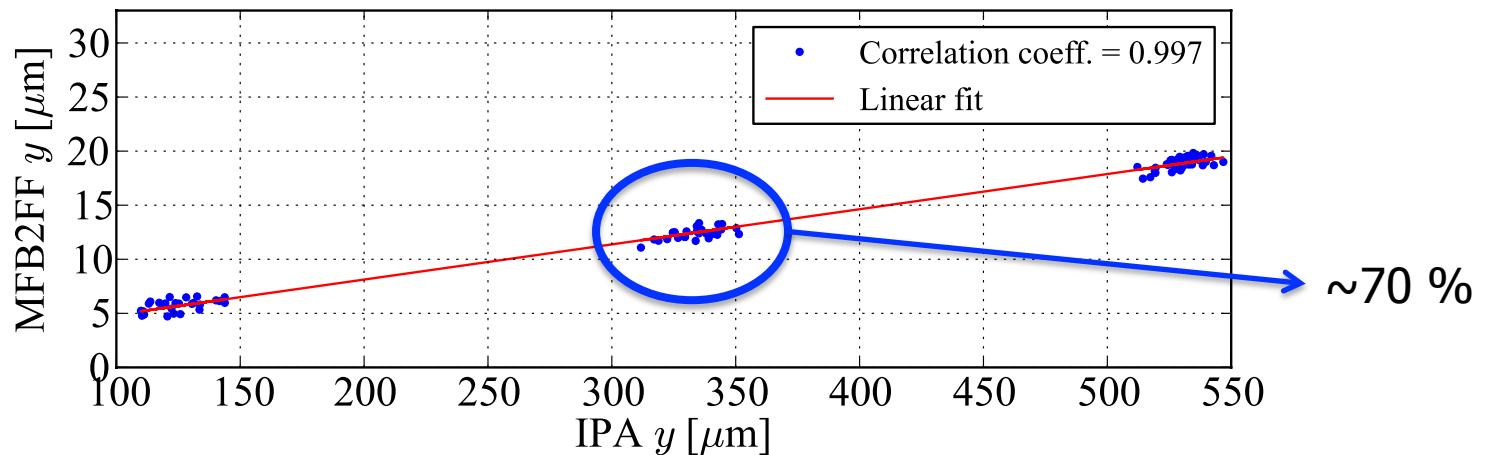
The MFB2FF resolution was measured to be continuously less than 50 nm over a period of a few days.

Jitter (Measurement)



Correlation (measurement)

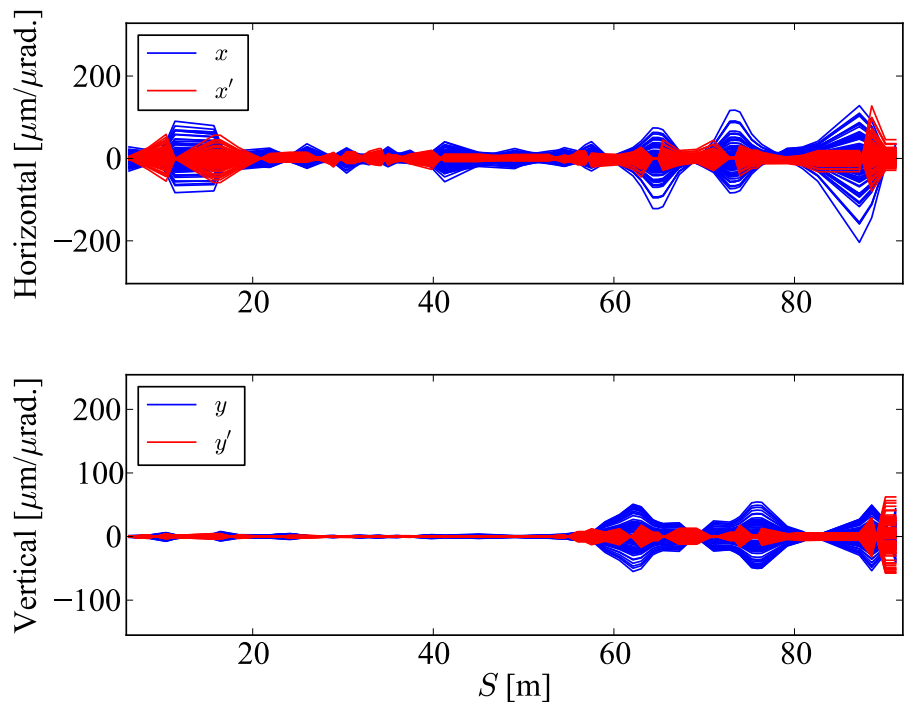
The beam was kicked using the upstream kicker K1 which is normally used as part of the Feedback On Nanosecond Timescales (FONT) feedback system



Tracking simulation

Tools

- PLACET + Octave
- ATF2 v5.1 lattice
- Perfect beamline
 - only magnet imperfection
- Jitter
 - $\sim 10\%$ emittance (after extraction kicker)



Interaction Point (IP)

- No actual bpms at IP or near IP
- Put monitor at IP
 - Only simulation
- Calculate IP using IPA and IPB reading

$$y_{IP} = y_{IPA} + \frac{L}{L_{bpm}} (y_{IPB} - y_{IPA})$$

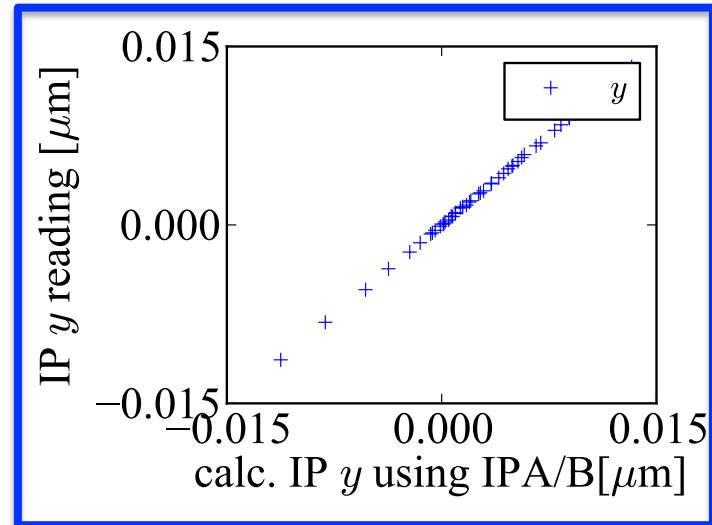
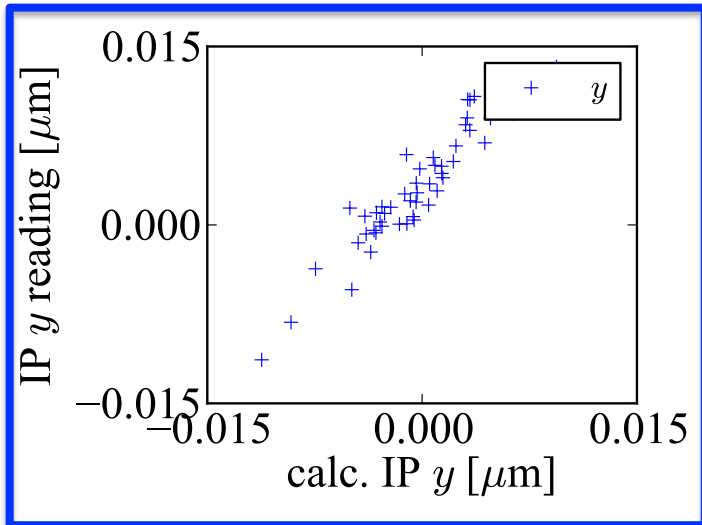
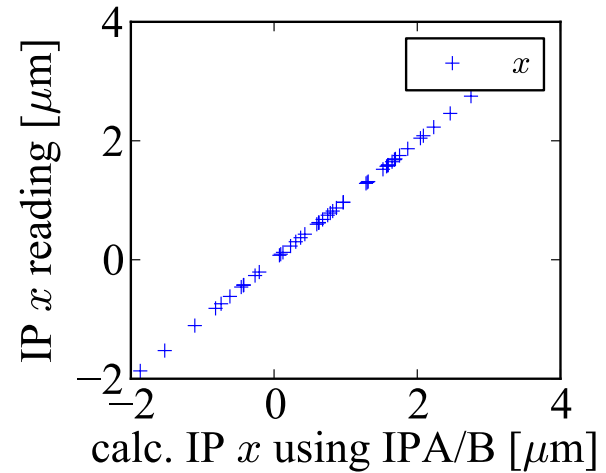
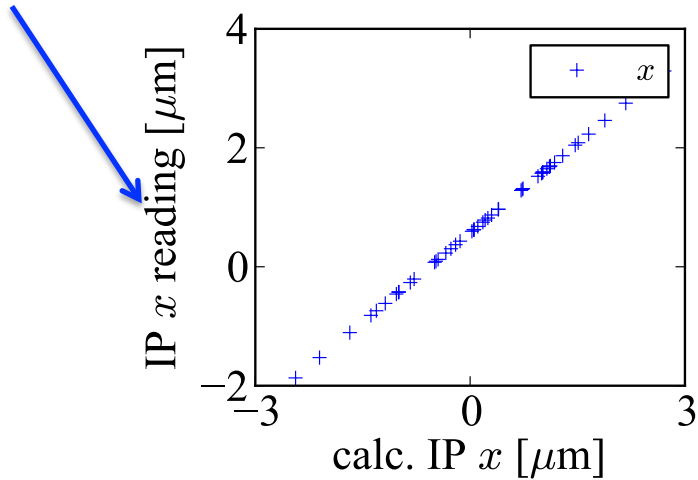
- Both simulation and measurement
- Calculate using beam transport matrix

$$y_{IP} \approx R_{33} y_{MFB2FF} + R_{34} y'_{MFB2FF}$$

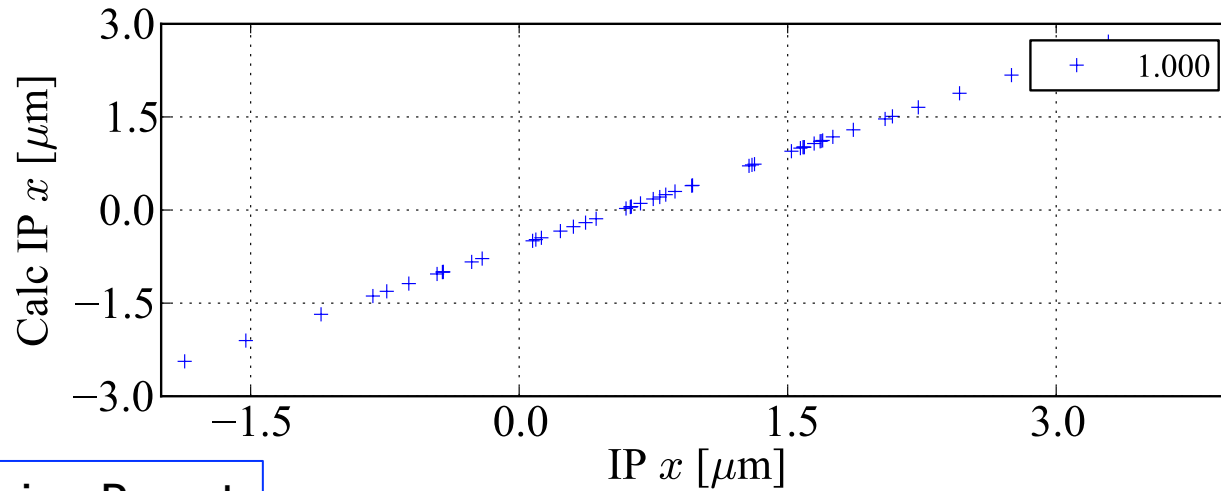
- Both simulation and measurement

IP calculation

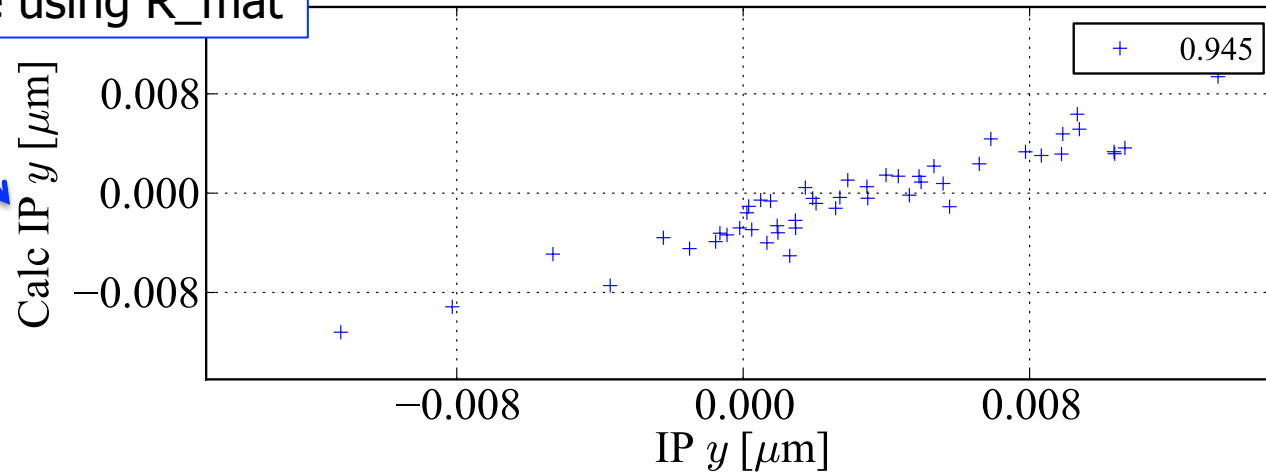
Reading from monitor at IP



Comparison

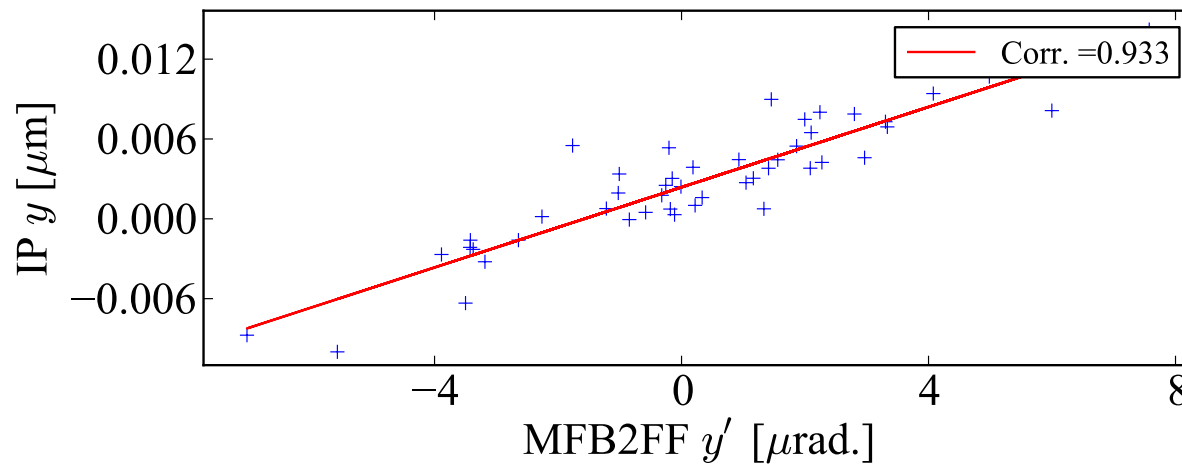
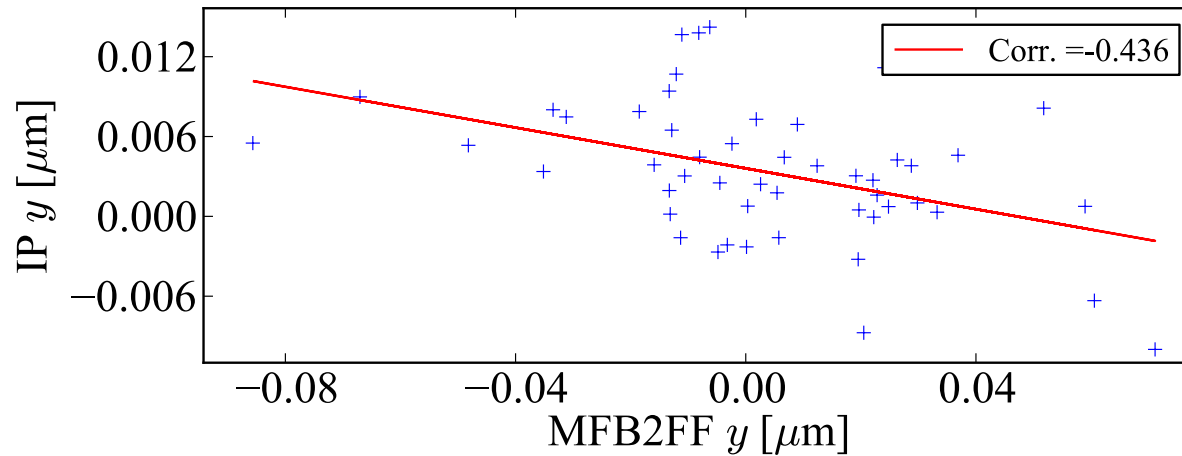


Calculate using R_mat

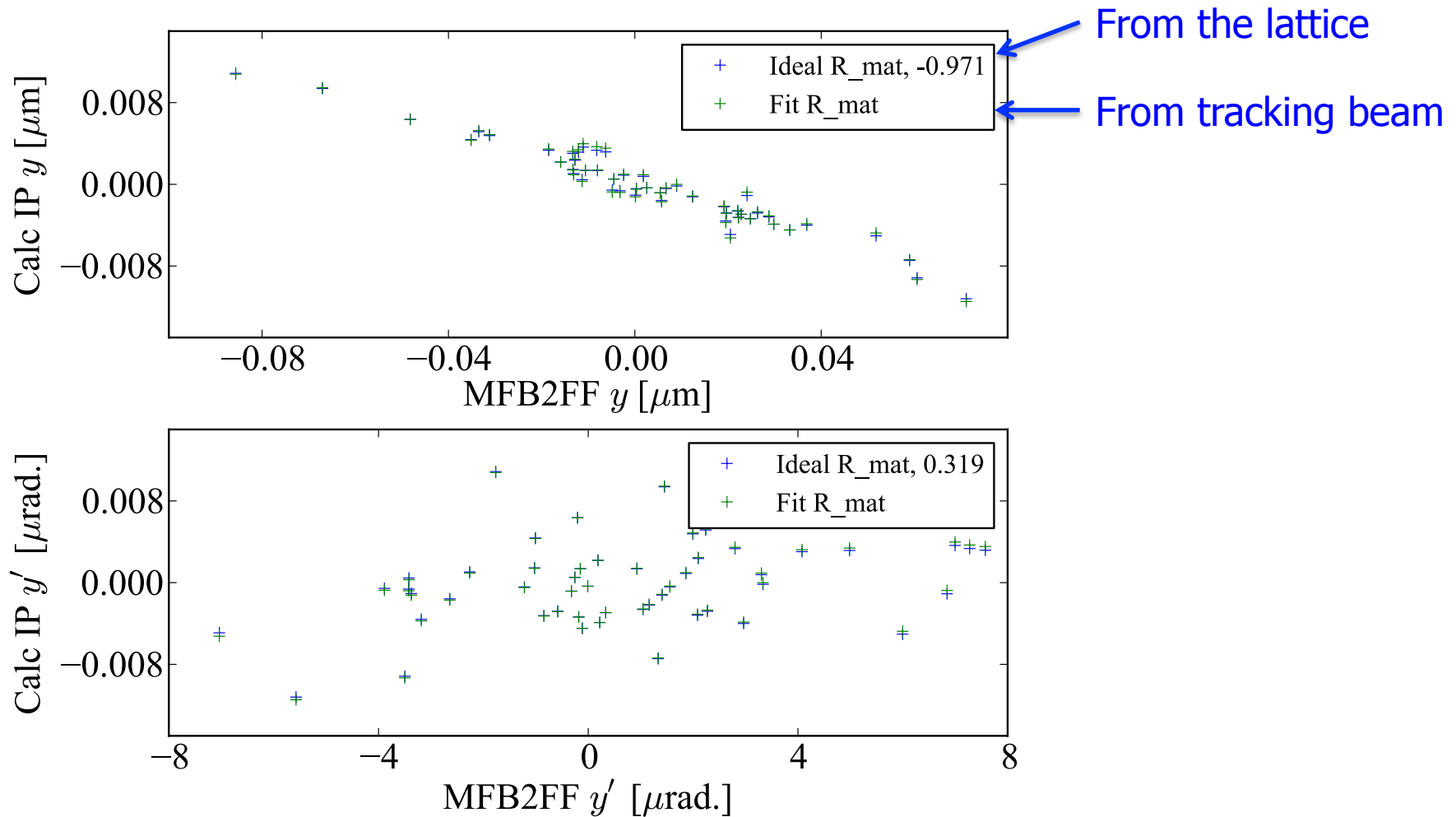


Calculate using IPA and IPB

w/o BPM, 10% jitter (IPA/IPB)



w/o BPM, 10% jitter (R_mat)



Tried to get the second order matrix but it wasn't conclusive

Summary

w/o BPM

Jitter	Y residual [nm]	Yp residual [nm]	FB2FFy & IP y %	FB2FFyp & IP y %
10%	2.72	3.9	-43.60	93.28
20%	9.35	3.73	-43.44	93.32
30%	14.07	5.58	-43.25	93.38

Jitter is important that one cannot predict from just the MFB2FF position or MFB2FF angle alone the IP position

w/ BPM

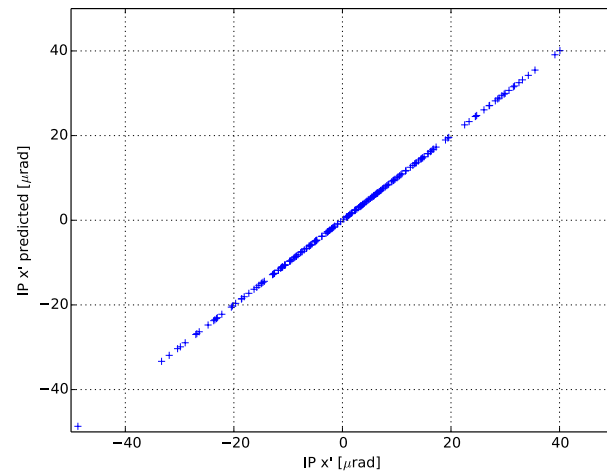
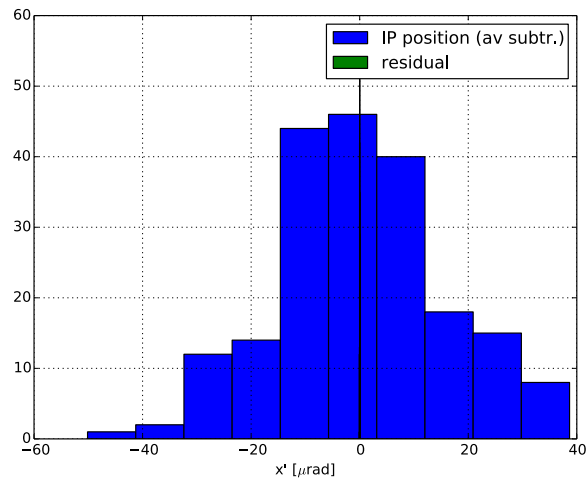
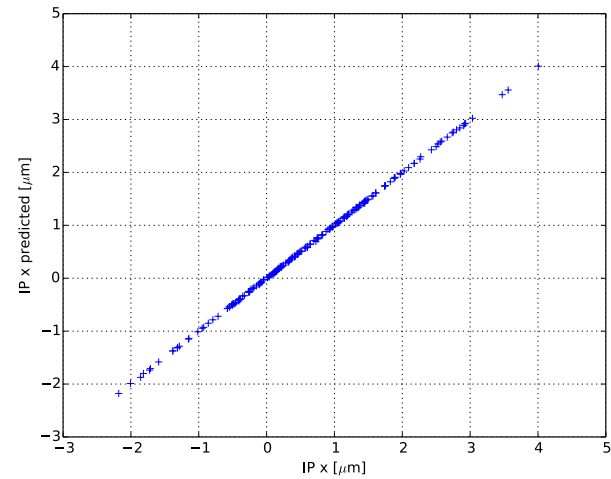
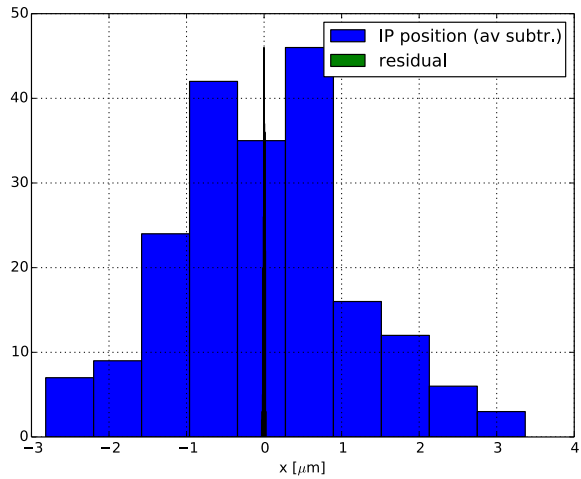
Jitter	Y residual [nm]	Yp residual [nm]	FB2FFy & IP y %	FB2FFyp & IP y %
10%	200.55	195.36	7.32	-23.69
20%	199.48	195.26	1.57	-20.53
30%	198.73	195.52	-3.01	-18.14

Yp residual : residual of IPy using the angle at FB2FF

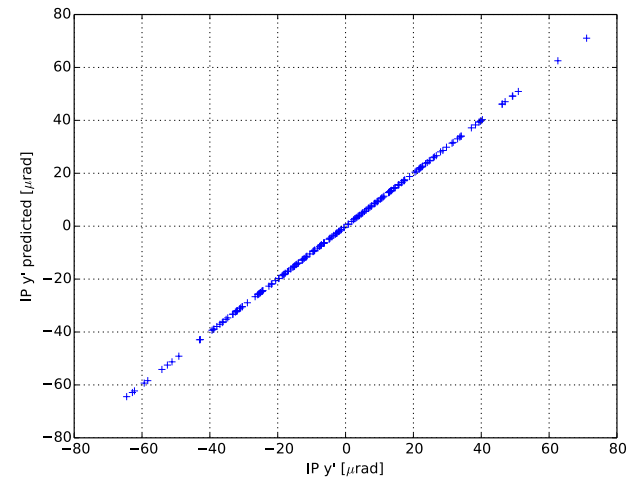
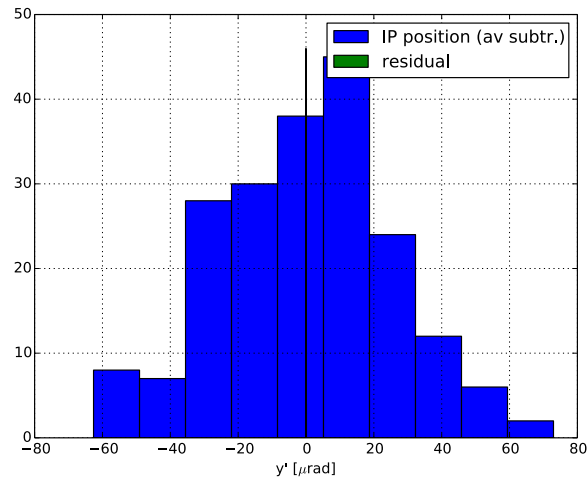
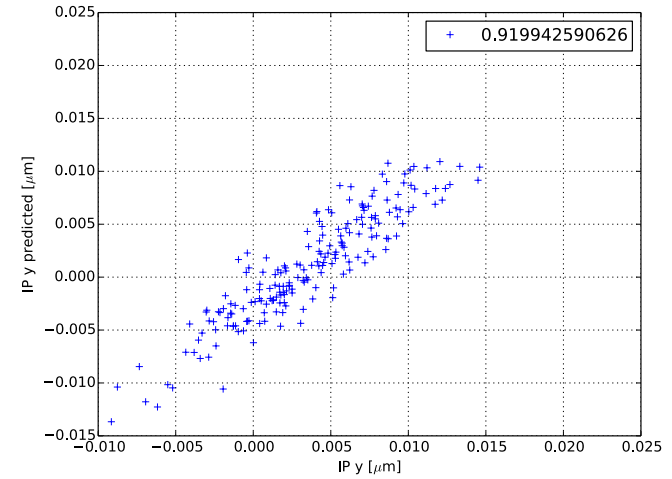
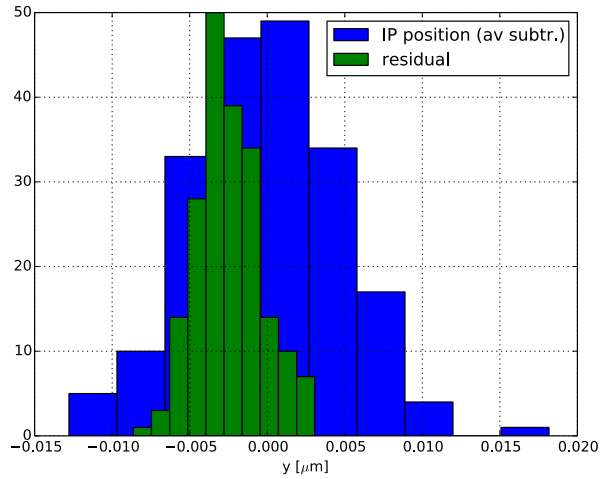
SVD prediction

- Singular Value Decomposition (SVD)
- Use all BPMs information
 - Excluded pre-IP, IPA, IPB, post-IP BPMs
 - SVD matrix determined with different simulation seed as IP prediction
 - BPM resolution on (in both seeds)
 - find correlations matrix X between BPM readings A and IP (position and angle) B : $A X = B$
 - find matrix X with simulation and invert matrix A with SVD method: $X = A^{-1} * B$
 - simulation with different seed is used to predict IP position with the found matrix X
 - it could be difficult to find a good matrix X in real as good IP information is needed
 - therefore results need to be read with caution

SVD prediction



SVD prediction



Summary

- 1 location for IP-phase sampling at IP vertical image point (waist) with small beam size
- Measured the correlation between MFB2FF and IPBPMs
- Measured MFB2FF resolution and jitter
- Calculated IP position and angle with:
 - transport matrix (using MFB2FF)
 - IPA and IPB
 - SVD (using all BPMs)
- x , x' and y' are possible to estimate, but not easy to estimate IP y
- More studies can be done