Some simulation results on FF/FB system for ATF2

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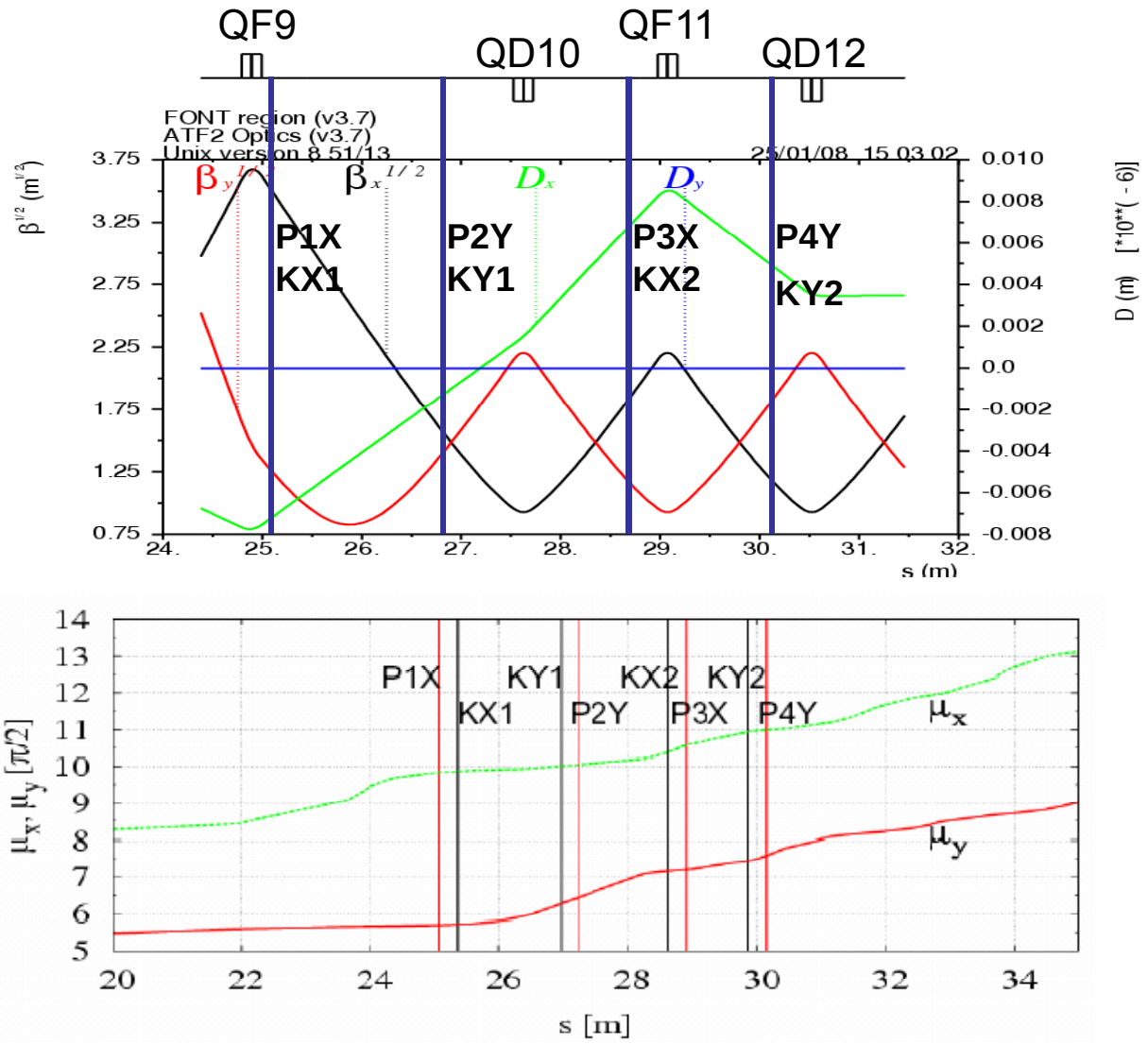
FF system scheme #2



Basic review. Feed-forward correction

Kicker strengths calculation

- Two BPMs (BPM1 & BPM2) in order to construct the response matrix
- Two kickers (K1 & K2) for vertical position (Y) and angle (Θ) correction
- Let $\begin{pmatrix} y_{K1} \\ \theta_{K1} \end{pmatrix}$ be the position and angle at K1 position before applying the correction

$$\begin{pmatrix} Y \\ \Theta \end{pmatrix} = kick2 \begin{pmatrix} R_{11} & R_{12} \\ R_{21} & R_{22} \end{pmatrix} kick1 \begin{pmatrix} y_{K1} \\ \theta_{K1} \end{pmatrix}$$

- Kicker 1: $\theta_{K1} + \Delta\theta_{K1}$
- Kicker 2: $R_{21} y_{K1} + R_{22}(\theta_{K1} + \Delta\theta_{K1}) + \Delta\theta_{K2}$

$$\begin{pmatrix} Y \\ \Theta \end{pmatrix} = \begin{pmatrix} R_{11} y_{K1} + R_{12}(\theta_{K1} + \Delta\theta_{K1}) \\ R_{21} y_{K1} + R_{22}(\theta_{K1} + \Delta\theta_{K1}) + \Delta\theta_{K2} \end{pmatrix}$$

Kicks for correction:

$$\begin{pmatrix} Y \\ \Theta \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \end{pmatrix}$$

$$\Delta\theta_{K1} = -\frac{R_{11} y_{K1} + R_{12}\theta_{K1}}{R_{12}}$$

$$\Delta\theta_{K2} = \left(\frac{R_{22}R_{11}}{R_{12}} - R_{21} \right) y_{K1} + (1 - R_{22})\theta_{K1}$$

Residue propagation and constraints

- Let δy and $\delta\theta$ be the correction errors
- If we have a similar and independent system (BPM and kicker pair) for the correction of the horizontal jitter, spurious vertical kicks can be added
- The residue propagates to the IP,

$$\begin{pmatrix} \delta y_{IP} \\ \delta\theta_{IP} \end{pmatrix} = R_{IP} \begin{pmatrix} \delta y \\ \delta\theta \end{pmatrix}$$

- The tolerable error limit:

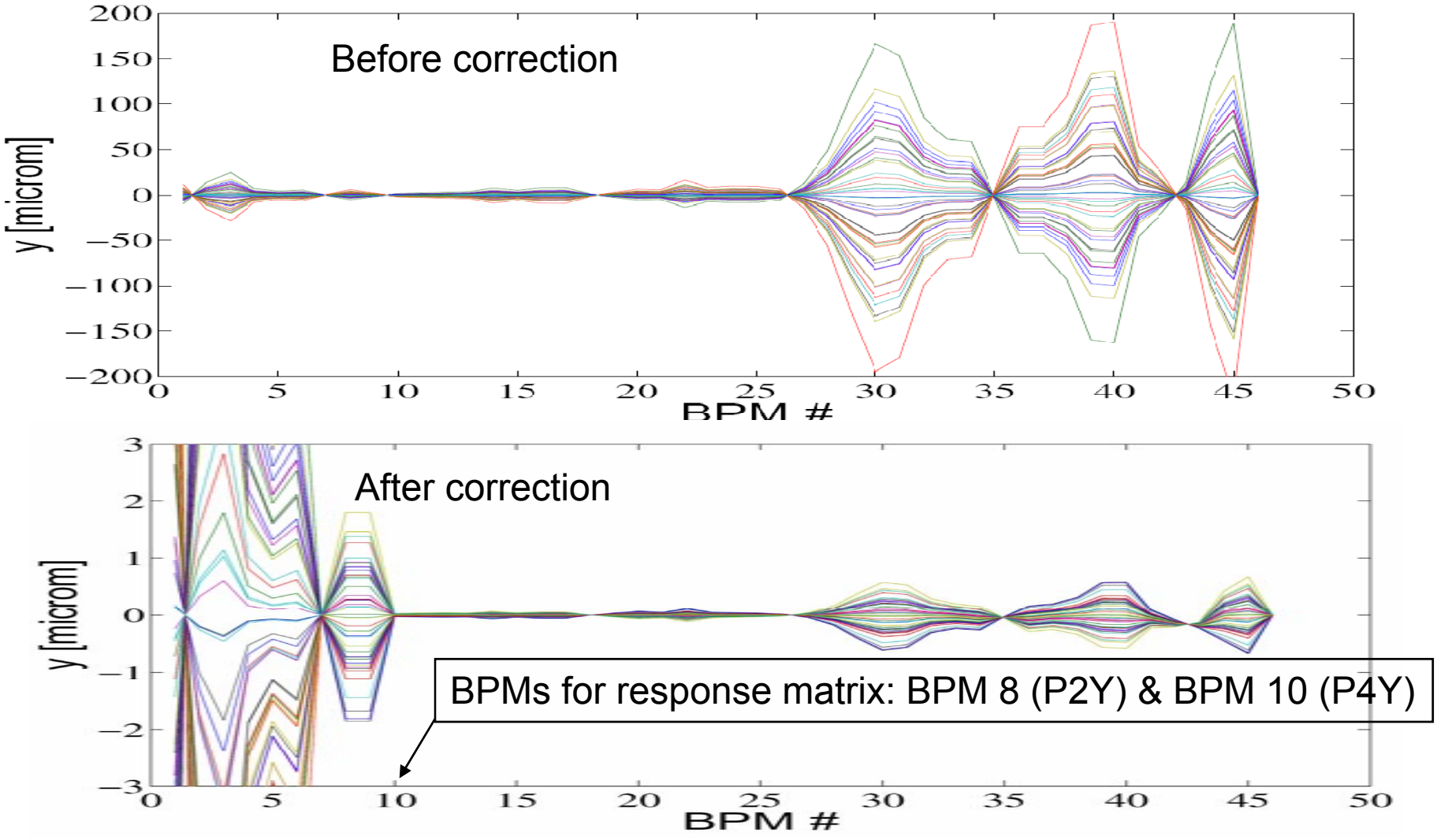
$$\delta x_{IP} \leq 0.1\sigma_x^* \approx 3\ \mu\text{m}$$
$$\delta y_{IP} \leq 0.1\sigma_y^* \approx 4\ \text{nm}$$

(detailed calculation: A. Kalinin & P. N. Burrows, "Turnaround feed-forward correction at the ILC", PAC07)

Conditions for the simulations in this work

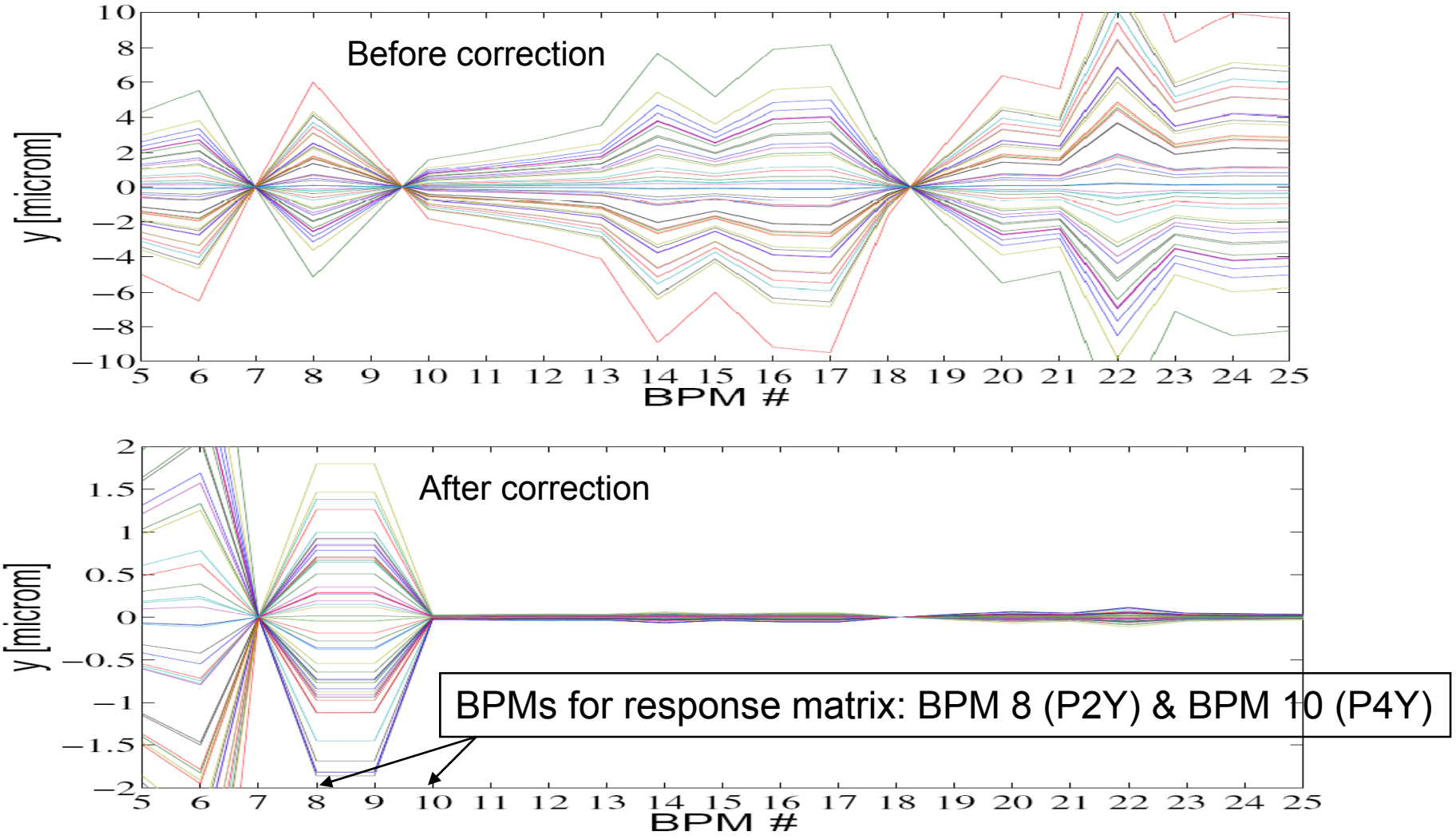
- Only considered the y, y' correction
- Added a total of 46 BPM along the ATF2 line in order to study the jitter propagation and the correction effect from the correction region to the IP
- Two kickers (KY1 & KY2) for vertical position (Y) and angle (Θ) correction
- Two pickups (P2Y & P4Y) for response matrix reconstruction
- In this work scheme #2 used for FF correction (A similar procedure will be repeated to study the performance of scheme #1)
- Normal random distribution of 100 initial vertical jitter positions with a width of +/- 40 % σ_y (initial rms beam size)
- Assuming noise in the BPMs for correction: $+/- 1\ \mu m$

Vertical position correction simulations



Vertical position correction simulations

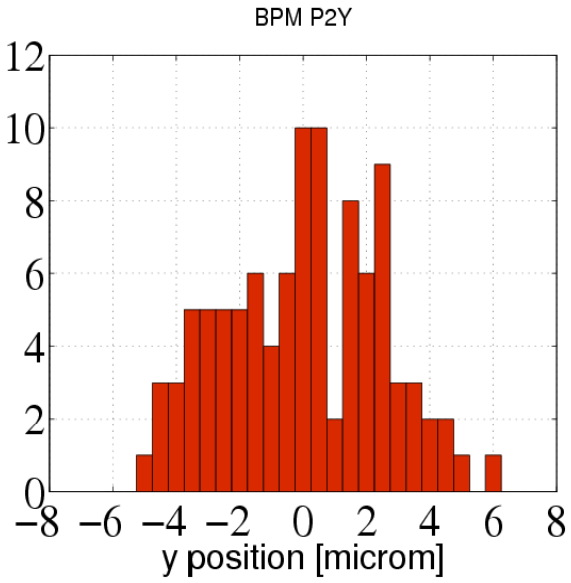
Zoom of the EXT region



BPM readings and resolution

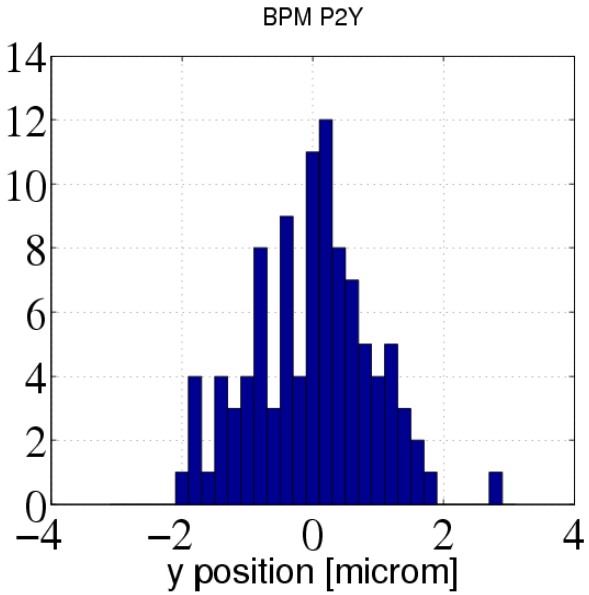
BPM P2Y

Before correction

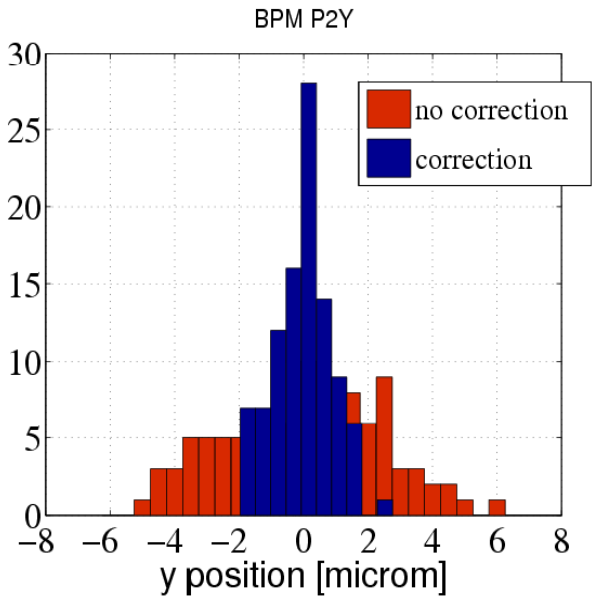


Readout ≈ [-7,+7]

After correction



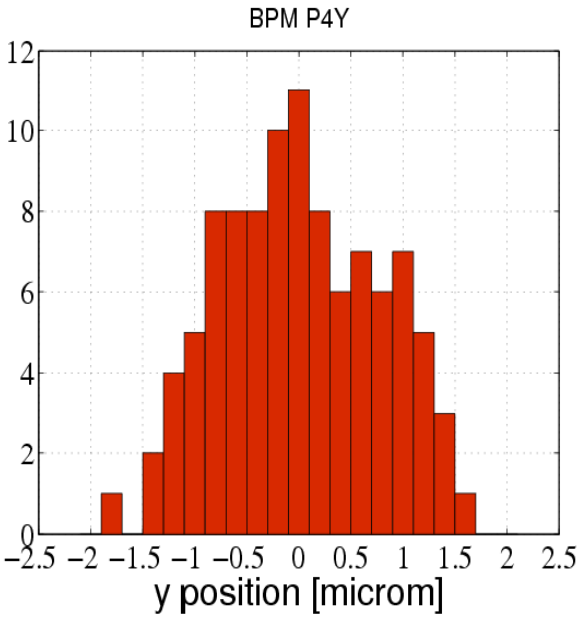
Readout ≈ [-3,+3]



BPM readings and resolution

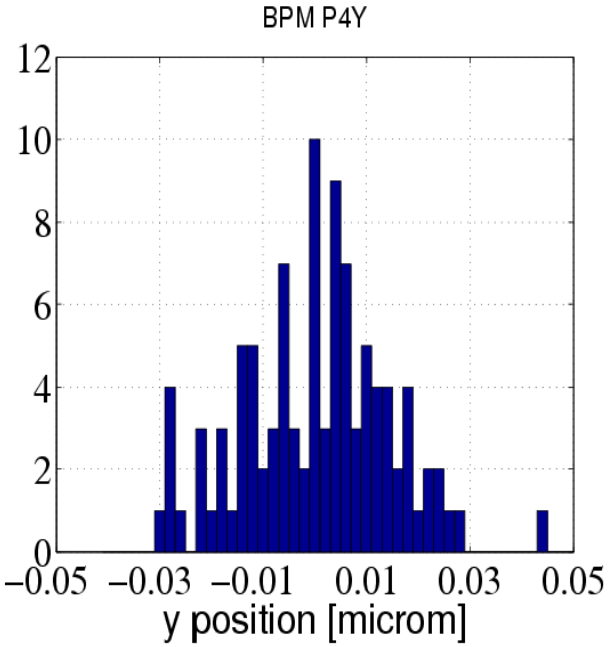
BPM P4Y

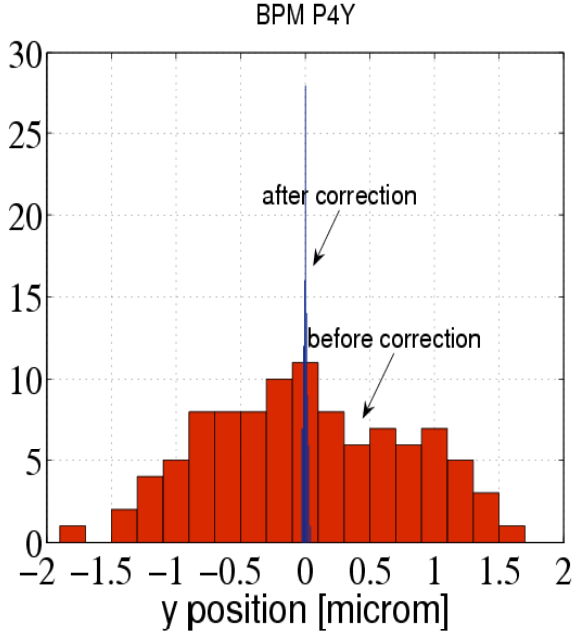
Before correction



Readout ≈ [-2,+2] μm

After correction





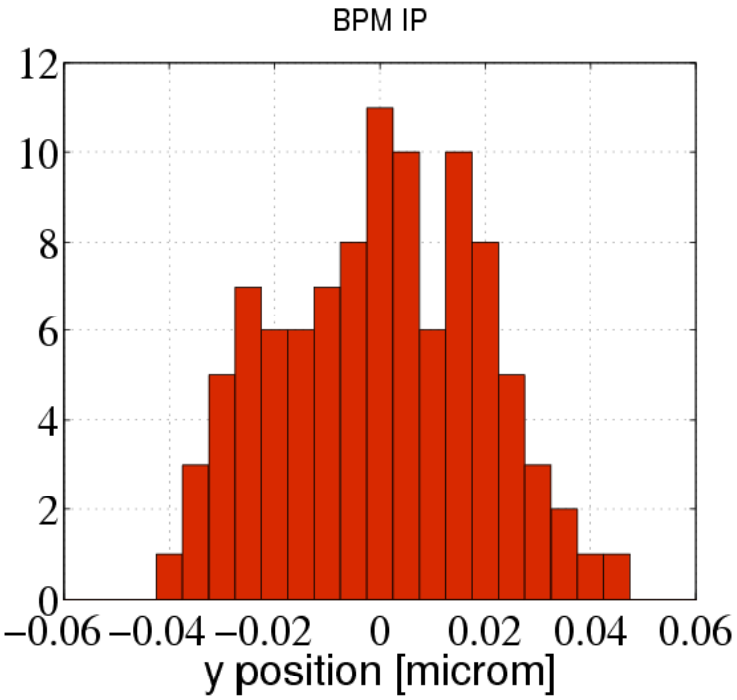
Readout ≈ [-0.05,+0.05] μm

About 2 orders of magnitude smaller than before correction ! ?

BPM readings and resolution

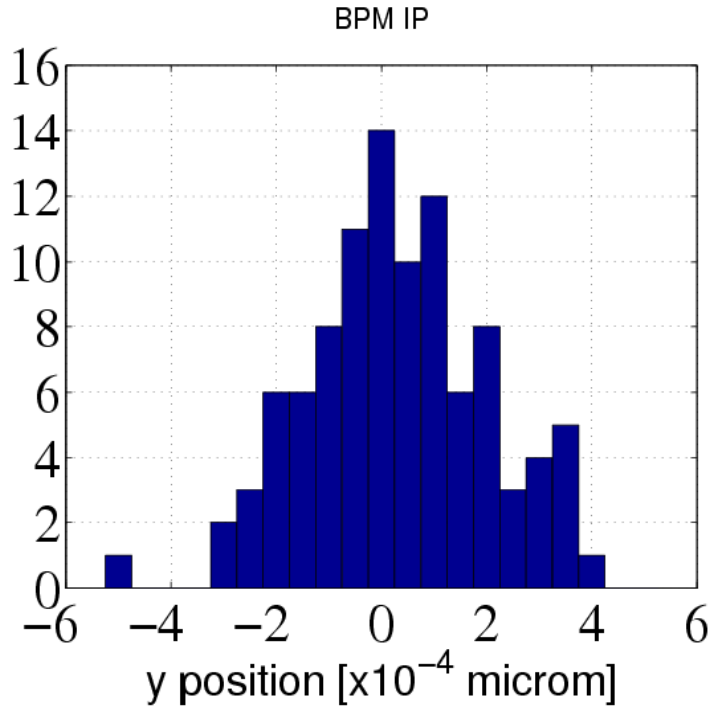
IP position reading

Before correction



max $\delta y_{IP} \approx 50$ nm

After correction



max $\delta y_{IP} \approx 0.5$ nm

Much smaller than the required superior limit $0.1\sigma^*_y \approx 4$ nm

Some thoughts on the FF/FB system

(To be discussed)

- Matrix construction with the BPM pair with the pass of the first bunch. FF correction applied (1st bunch)
- For the rest of the train FB system correction, using the 2nd BPM of the pair.
- The signal from the first bunch after the FF correction is taken as initial reference for the FB stabilization of the following bunches in the train