FONT @ ATF2

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for the FONT project group

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Introduction

- Goal: adaptation of upstream FONT system for ATF2 (see P. Burrows' presentation for R&D status)
- Beam stability by means of a combination of feed-forward (FF) correction and fast feedback (FB) stabilisation
- This system is conceived mainly for cancellation of transverse drift produced by the extraction kicker. FF + FB is most required in the vertical plane (more sensitive)
- FF+ FB systems in the ATF2 extraction line (EXT):
  - The kickers are common for FF and FB
  - A kicker in each pair has an adjacent pickup that is used for FF/FB matrix measurements
  - The FB downstream pickup pair is also used for FF residue measurement
  - Pickups (BPMs) in the ATF2 EXT are adjacent to quadrupoles

Kicker arrangement

- Single plane stripline kickers
- Locations at relatively high betatron functions (higher resolution tolerances)
- The optimal advance in a kicker pair or a pickup pair is $\pi/2$
- Suggested positions for the FONT FF/FB kickers in the extraction line. A. Kalinin schemes:

	#1 s [m]	#2 s [m]
KY1 (for y correction)	25.35	26.96
KY2 (for y' correction)	26.96	30.14
KX1 (for x correction)	21.09	25.35
KX2 (for x' correction)	23.88	28.89

(See A. Kalinin's presentation, ATF2 Weekly Meeting, July 27, 2007, & A. Kalinin' presentation in this meeting)

Kicker parameters

(Rough estimation)

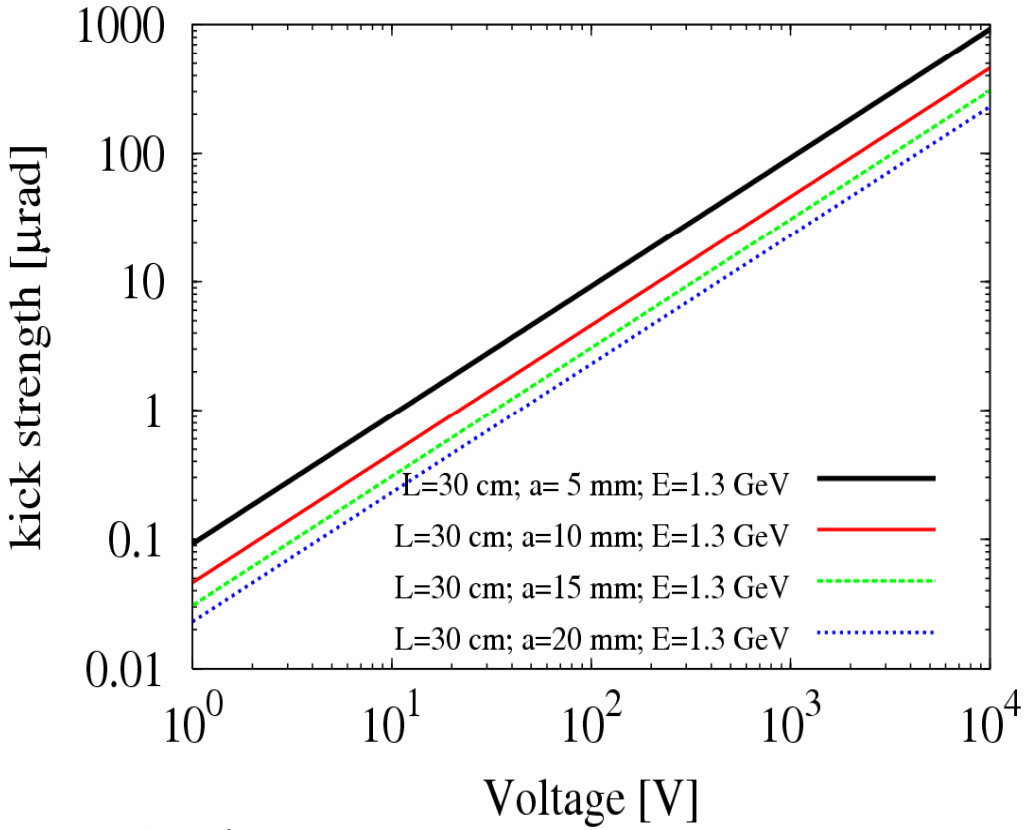
Kicker angle:

$$\Delta\theta_{x,y} = \frac{2eV}{E}\frac{L}{a}$$

The deviation at distance d from the kicker to a downstream BPM:

$$\Delta_{x,y} \approx \frac{2eV}{E}\frac{L}{a}d$$

V: voltage
E:beam energy (1.3 GeV)
L: kicker length (30 cm)
a: kicker aperture

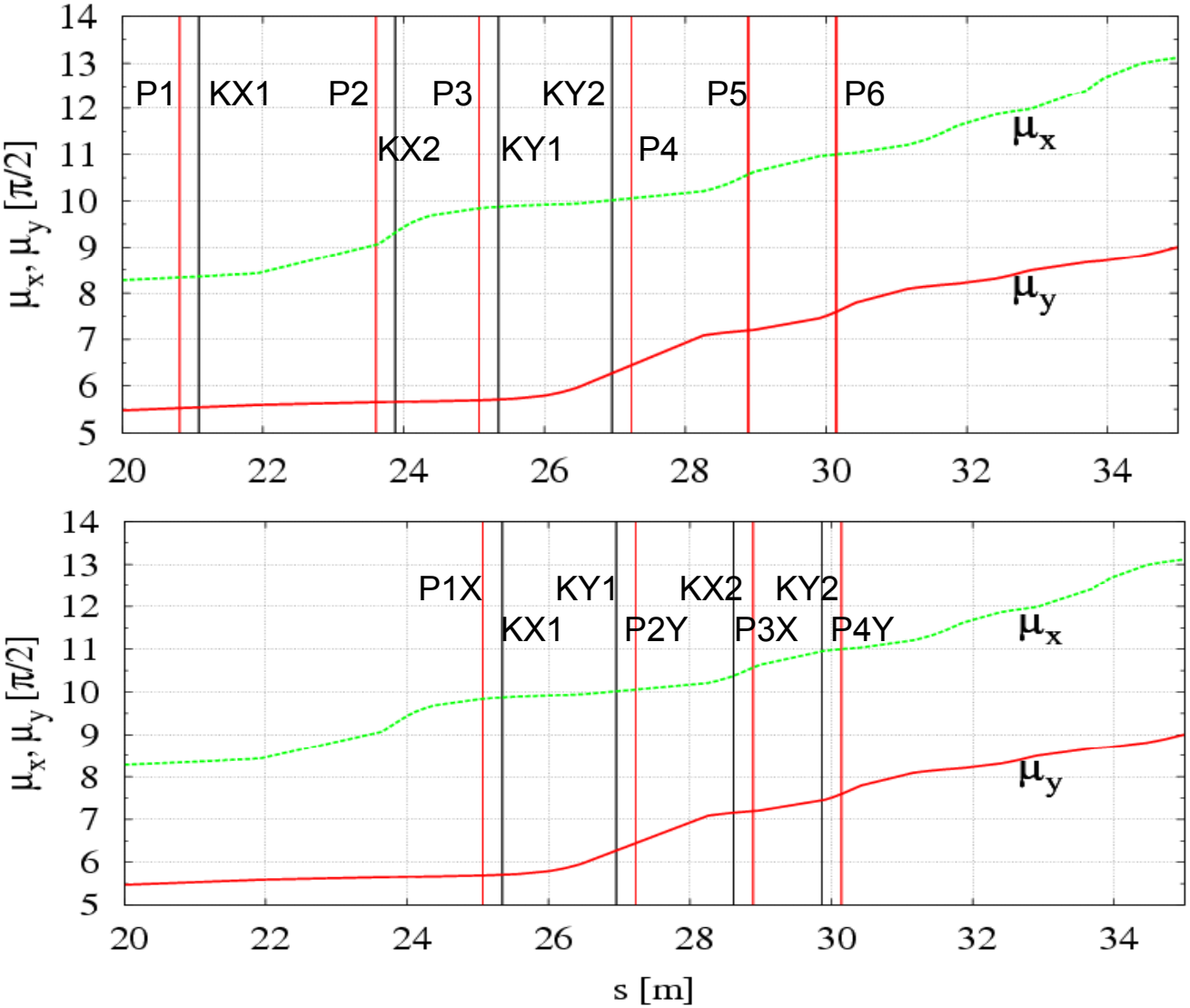


Constraint: $a < 20$ mm (beam line aperture)

For example: a=10 mm; kick of 10 μm ✹ 🕓 0.3 kV
a=10 mm; kick of 100 μm ✹ 🕓 2.0 kV

Optimal phase advance positions

From M. Woodley's ATF2 lattice v3.7



Scheme #1:

BPMs in the lattice:
P1 (ML7X)
P2 (ML8X)
P3 (ML9X)
P4
P5
P6

Scheme #2:

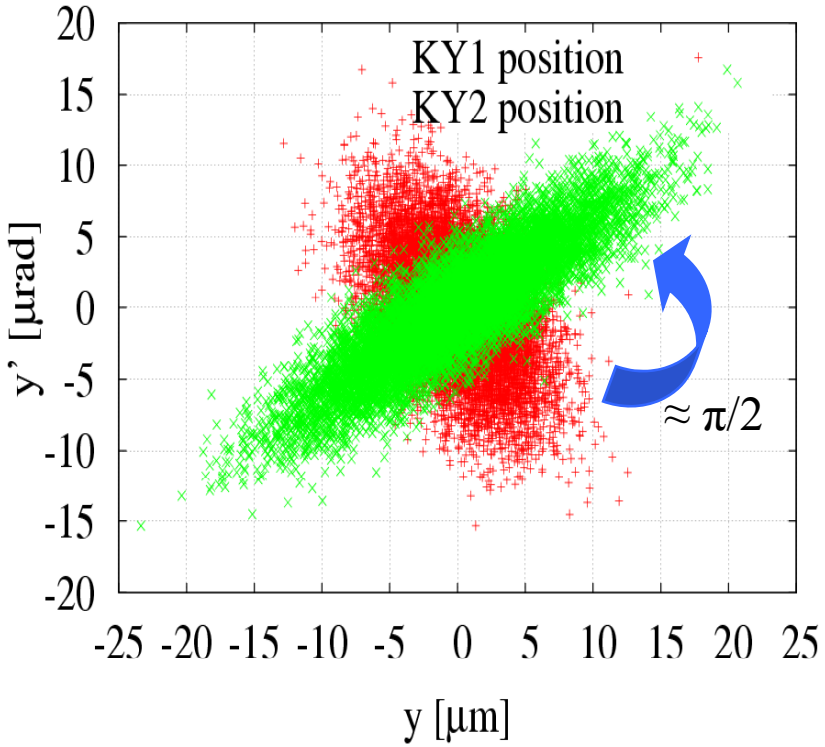
BPMs in the lattice:
P1X → P3
P3X → P5
P2Y → P4
P4Y → P6

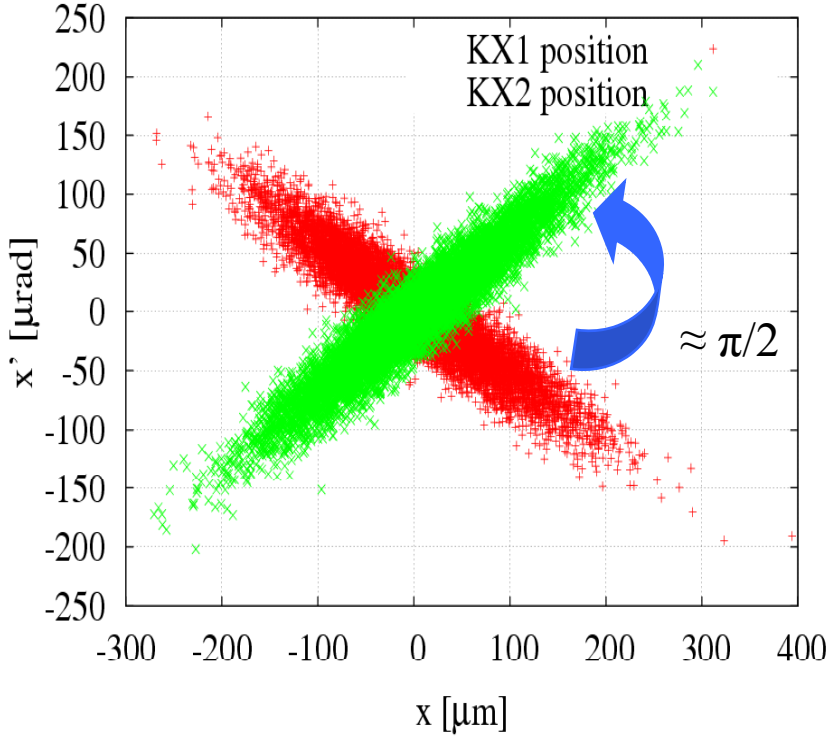
Placet based model for ATF2

- Tracking of initial transverse gaussian distribution of 10000 macro-particles
  - 0.08 % energy spread
  - Nominal energy E_0=1.3 GeV
  - Vertical normalised nominal emittance $\gamma\varepsilon_y$=3 x 10^{-8} m·rad
  - Horizontal normalised nominal emittance $\gamma\varepsilon_y$=3 x 10^{-6} m·rad
- In Placet the correctors are represented as dipoles
- Study of jitter propagation, kicker response in the downstream BPMs
- Possibility to apply ground motion effects (Andrei Seryi's models) and dynamics corrections
- Steering FF/FB corrections using the FONT kickers and BPMs in progress

Phase advance between kickers

(#1 scheme)





Phase advance between kicker pairs of $\approx \pi/2$

Orbit jitters in the EXT line

Main sources: extraction kicker errors, energy jitter in DR and residual dispersion in the EXT line, …

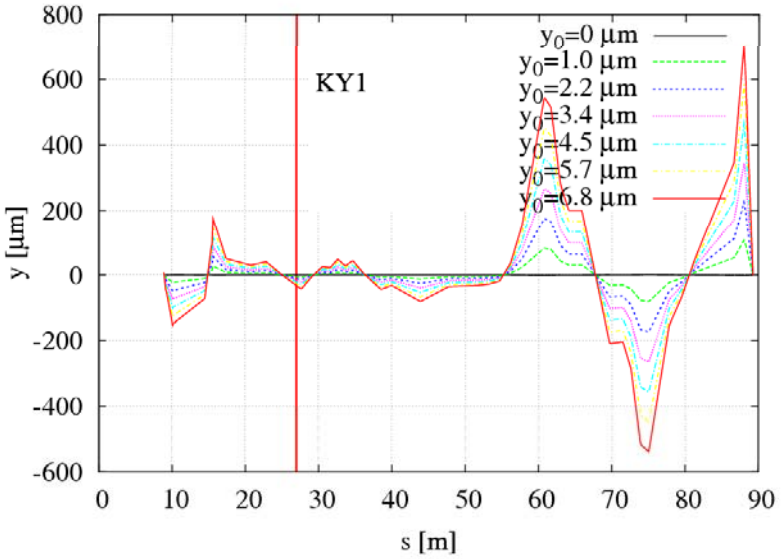
Estimated from measurements in ATF [ATF2 Proposal, Volume 1, pg. 41; M. Ross et al., ATF-04-05, 2004]:

- x jitter 20 μm (~20 % of the beam size)
- y jitter 2-3.5 μm (~40 % of the beam size)
- x' jitter 1.0 mrad (? Too big!)
- y' jitter 2 μrad

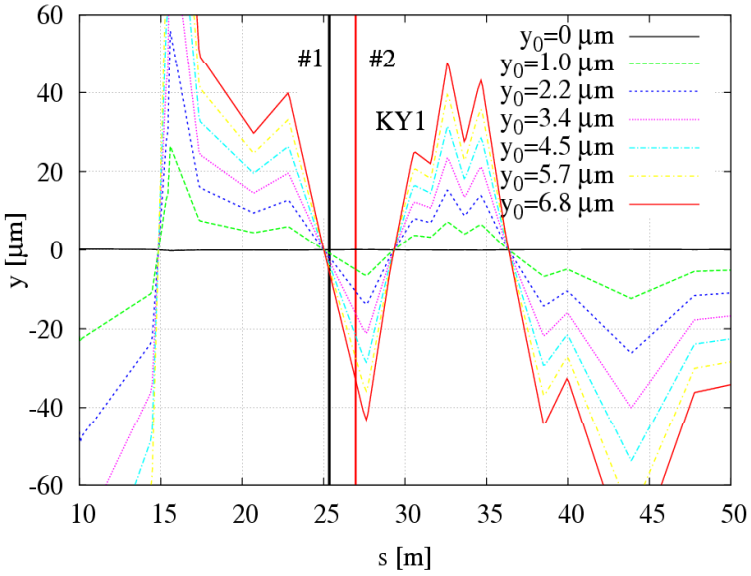
Should we use this values as a reference for the ATF2 beam dynamics simulations ?

Initial jitter propagation

Beam centroid trajectory <y>:

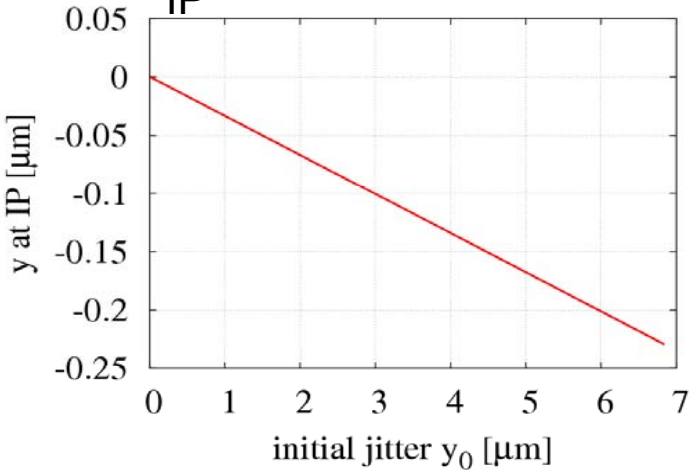


Extraction line



Example of a study of the effect of an initial vertical jitter in the range [0-7] µm and its transport to the IP

IP

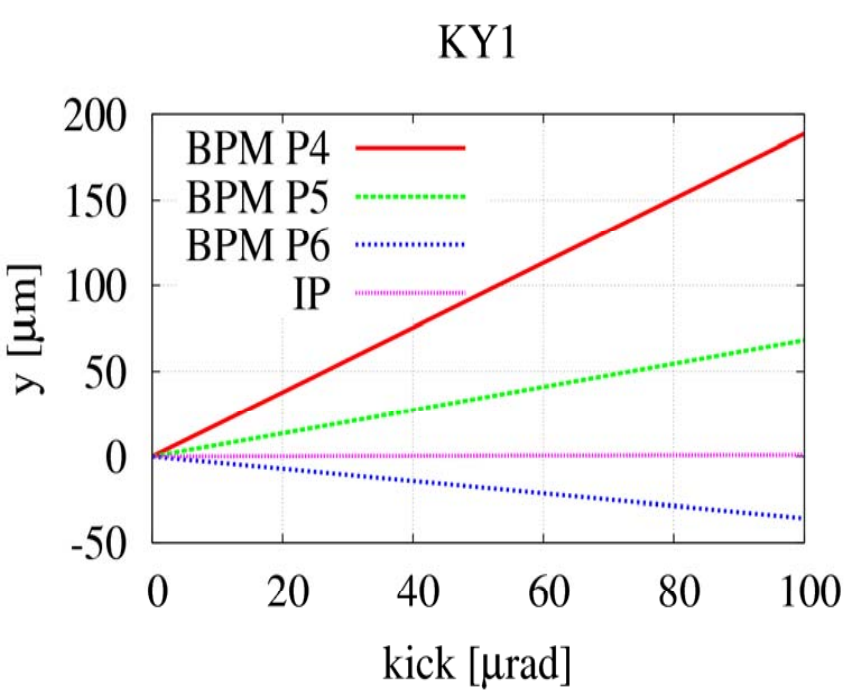


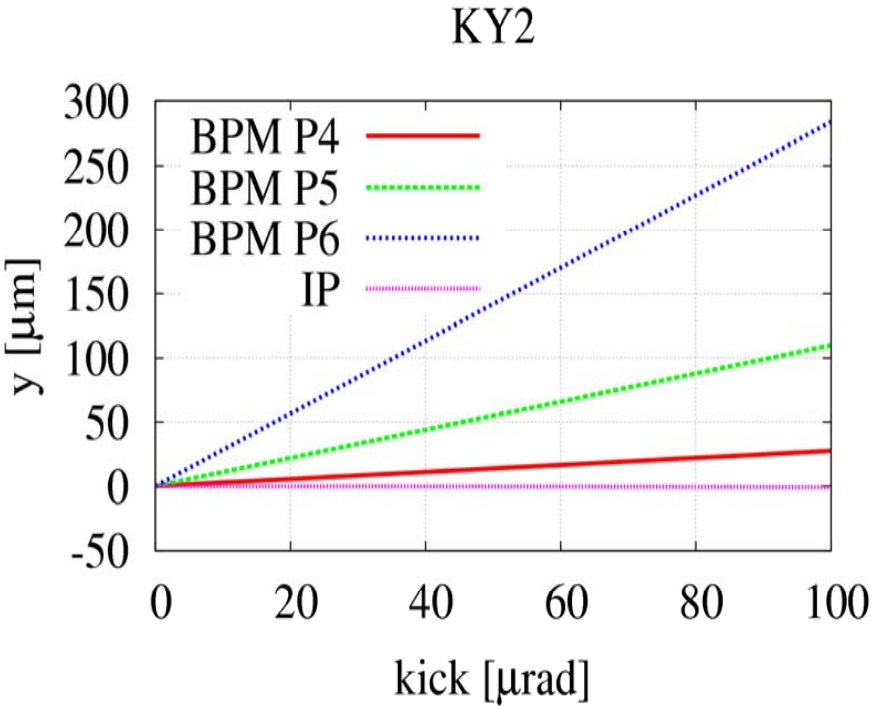
Kicker response in the downstream BPMs

Vertical kickers

Checking the linearity of the kicking strength for each kicker versus the orbit response

(#1 scheme)





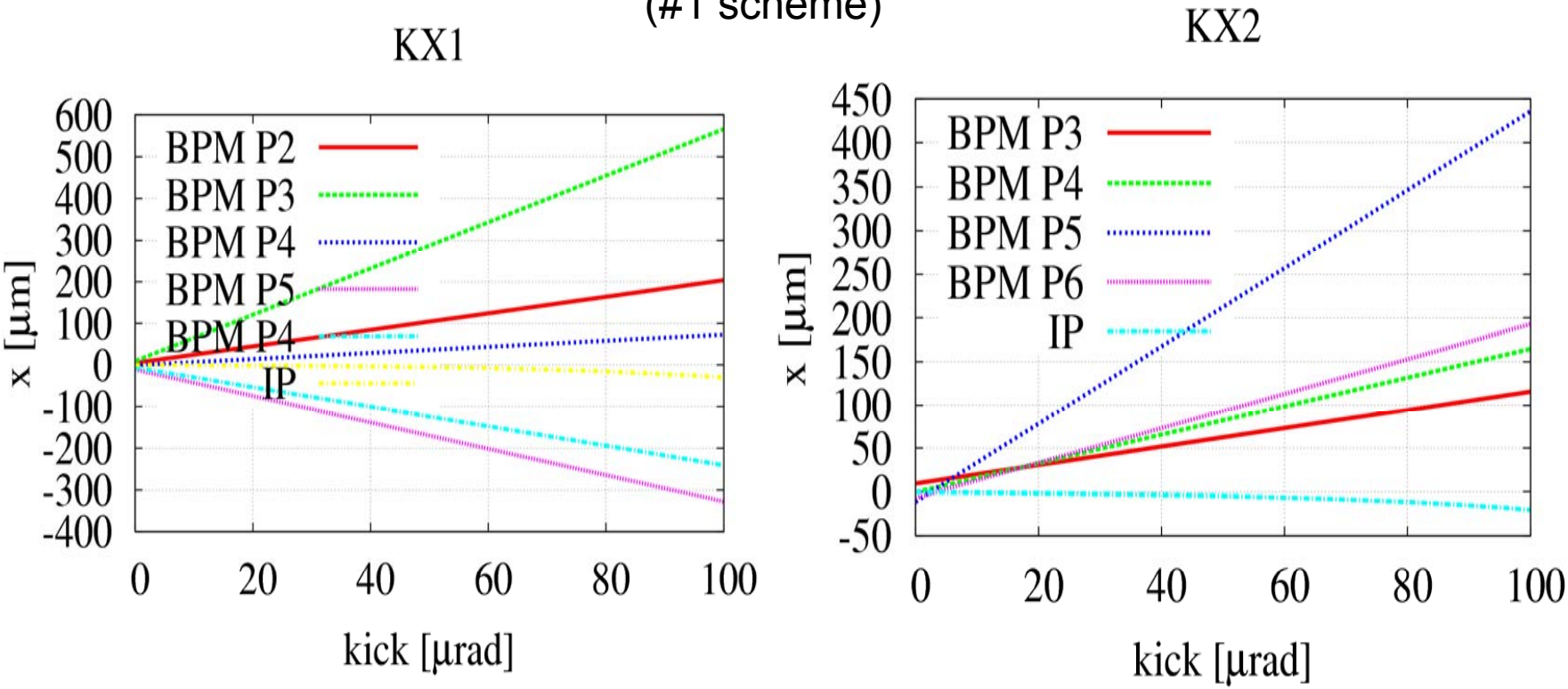
For kicks in the range of interest (≤ 100 μrad) the transport is basically linear

Kicker response in the downstream BPMs

Horizontal kickers

Checking the linearity of the kicking strength for each kicker versus the orbit response

(#1 scheme)



Feed-forward correction

Kicker strengths calculation

- Two BPMs (BPM1 & BPM2 separated by a distance L) in order to measure position y_{BPM1} and angle $\theta_{BPM1}=(x_{BPM2}-x_{BPM1})/L$
- Two kickers (K1 & K2) distanced by a drift space of length L_k
- Let $R^{BPM1 \to K1}$ be the transfer matrix between BPM1 and kicker 1,

$$\begin{pmatrix} y_{K1} \\ \theta_{K1} \end{pmatrix} = R^{BPM1 \to K1} \begin{pmatrix} y_{BPM1} \\ \theta_{BPM1} \end{pmatrix}$$

$$\begin{pmatrix} Y \\ \Theta \end{pmatrix} = kick2 \begin{pmatrix} 1 & L_k \\ 0 & 1 \end{pmatrix} kick1 \begin{pmatrix} y_{K1} \\ \theta_{K1} \end{pmatrix}$$

- Kicker 1: $\theta_{K1} + \Delta\theta_{K1}$
- Kicker 2: $\theta_{K1} + \Delta\theta_{K1} + \Delta\theta_{K2}$

$$\begin{pmatrix} Y \\ \Theta \end{pmatrix} = \begin{pmatrix} y_{K1} + L_K(\theta_{K1} + \Delta\theta_{K1}) \\ \theta_{K1} + \Delta\theta_{K1} + \Delta\theta_{K2} \end{pmatrix}$$

Kicks for correction:

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

$$\Delta\theta_{K1} = -\frac{y_{K1} + L_K\theta_{K1}}{L_K}$$

$$\Delta\theta_{K2} = -(\theta_{K1} + \Delta\theta_{K1})$$

Residue propagation and constraints

- Let δy and $\delta\theta$ 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:

$$\delta x_{IP} \leq 0.1\sigma_x^*$$
$$\delta y_{IP} \leq 0.1\sigma_y^*$$

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

Summary and ongoing studies

- Optimal locations have been chosen for the kicker and BPM pairs of the FONT FF/FB system
- The required FONT kicker performance is being studied in order to define a complete mechanical model
- Placet based beam dynamics simulations using a single bunch has been performed: initial jitter propagation, kicker response, residue propagation
- In the kick range [0-100] μm the (x,x') and (y,y') transports are practically linear
- Multibunch tracking simulation studies are planned to study the performance of the FF/FB system for 20 bunches
- Steering correction simulations using Placet for the FONT at ATF2 in progress