Overview of FONT @ ATF2

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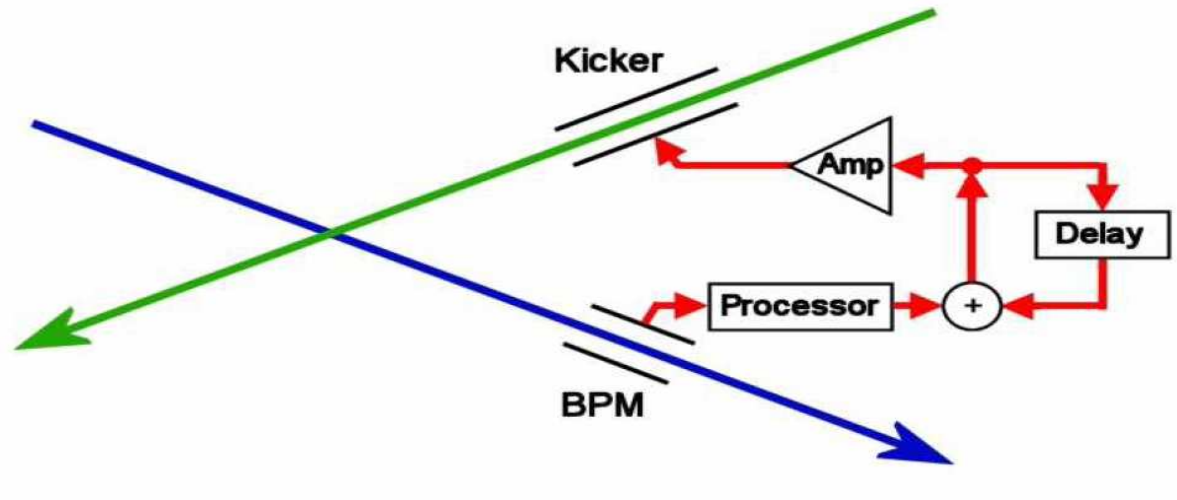
What is FONT?

- FONT: Feedback On Nano-Second Timescales
  - Removes the relative offset jitter at the IP by measuring vertical position of outgoing beam and hence the beam-beam deflection angle and steering the beams back into collision
  - Operates at high frequency and acts within a bunch train
  - Last line of defence against relative beam misalignment



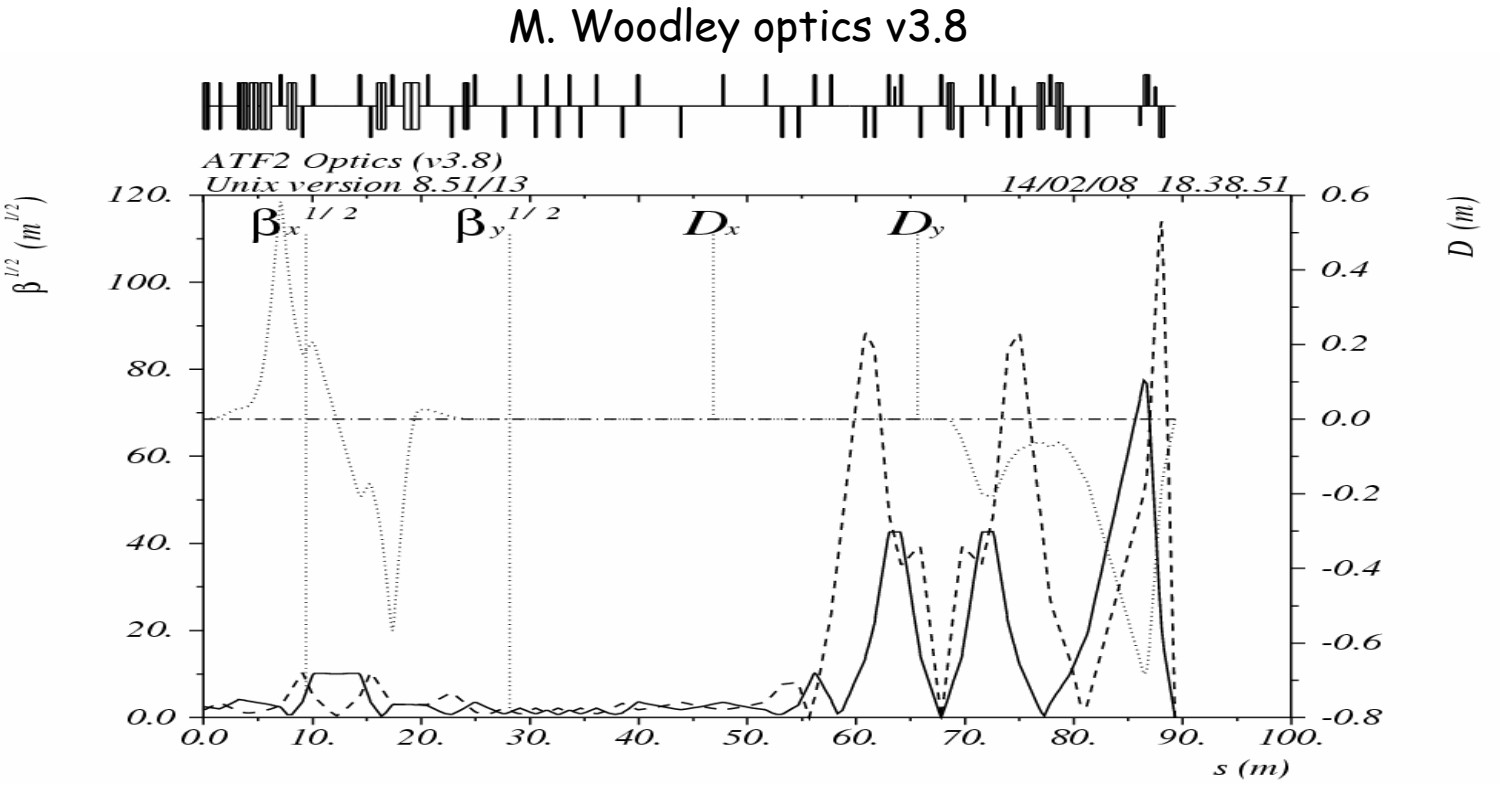
FONT4 tested at ATF2 (G. Christian et al., to be published in NIM)
FONT5 planned for ATF2

What is ATF2?

ATF2: Final focus test beam line facility at KEK

In principle the ATF2 optics design is identical to that for the ILC in spite of the two order of magnitude lower beam energy (Raimondi & Seryi final focus system)

Perfect bed to make experiments on feedback, alignment and tuning for the final focus of a linear collider



Design of FONT FF/FB system at ATF2

Goal: adaptation of upstream FONT system for ATF2

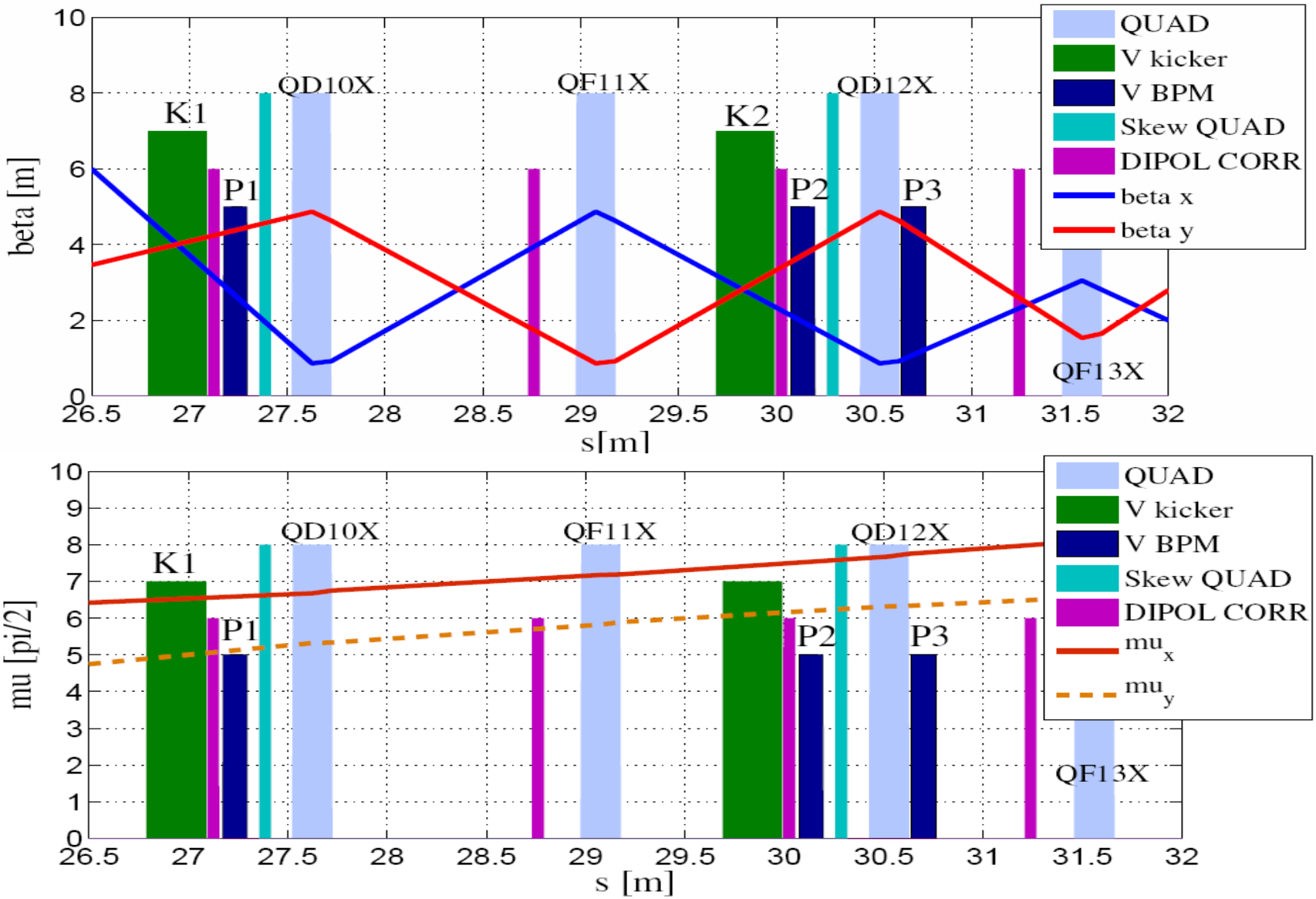
- FF+ FB systems in the ATF2 extraction line (EXT):
  - A pair of kickers (K1 & K2) for the correction of (y,y')
  - The kickers are common for FF and FB
  - Each kicker has an adjacent pickup (P1& P2) that is used for response matrix construction
  - Downstream pickup P3 for residue measurement
  - Pickups (BPMs) in the ATF2 EXT are adjacent to quadrupoles

Location constraints:

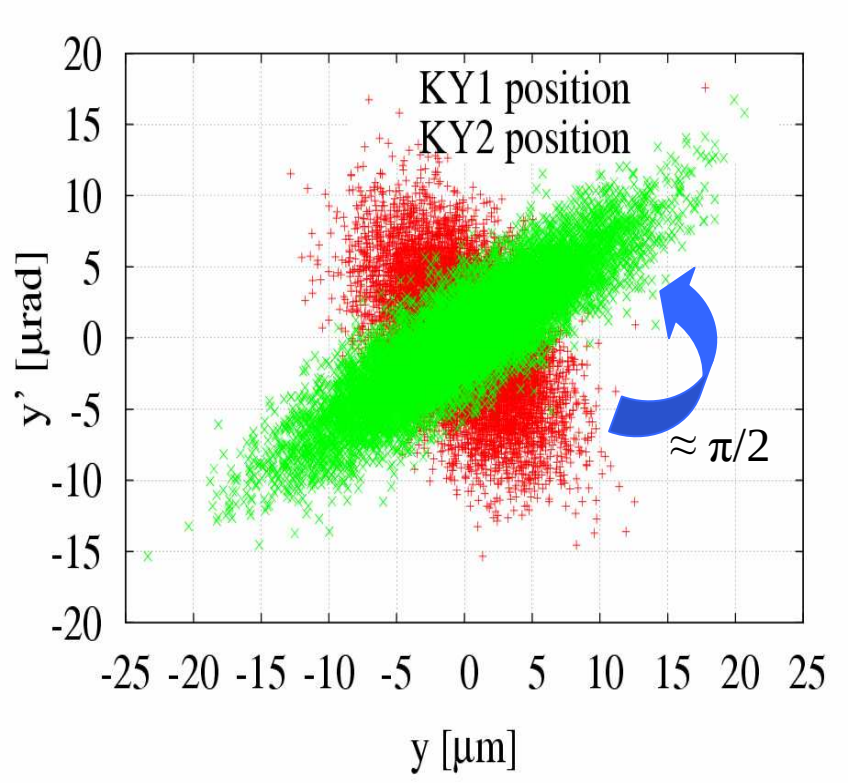
- Relatively high beta y (higher resolution tolerances)
- $\pi/2$ phase advance kicker-BPM
- Low time flight to reduce latency (the total latency goal ~ 150 ns)

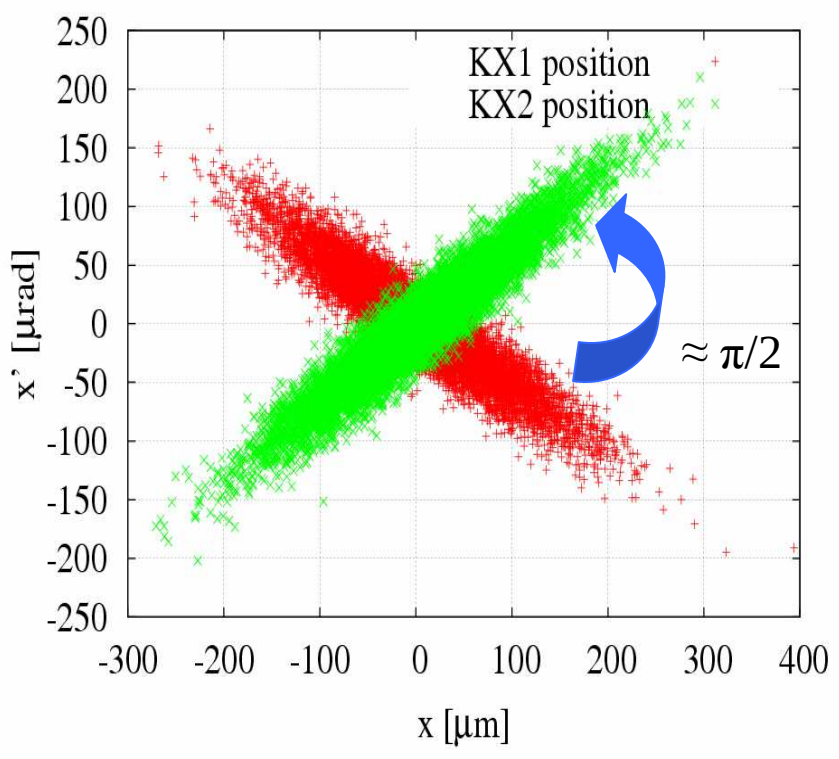
Pay much more attention on the latency constraint!
Relaxed attention on the phase advance condition between kicker & BPM!

Design of FONT at ATF2



Phase advance between kickers





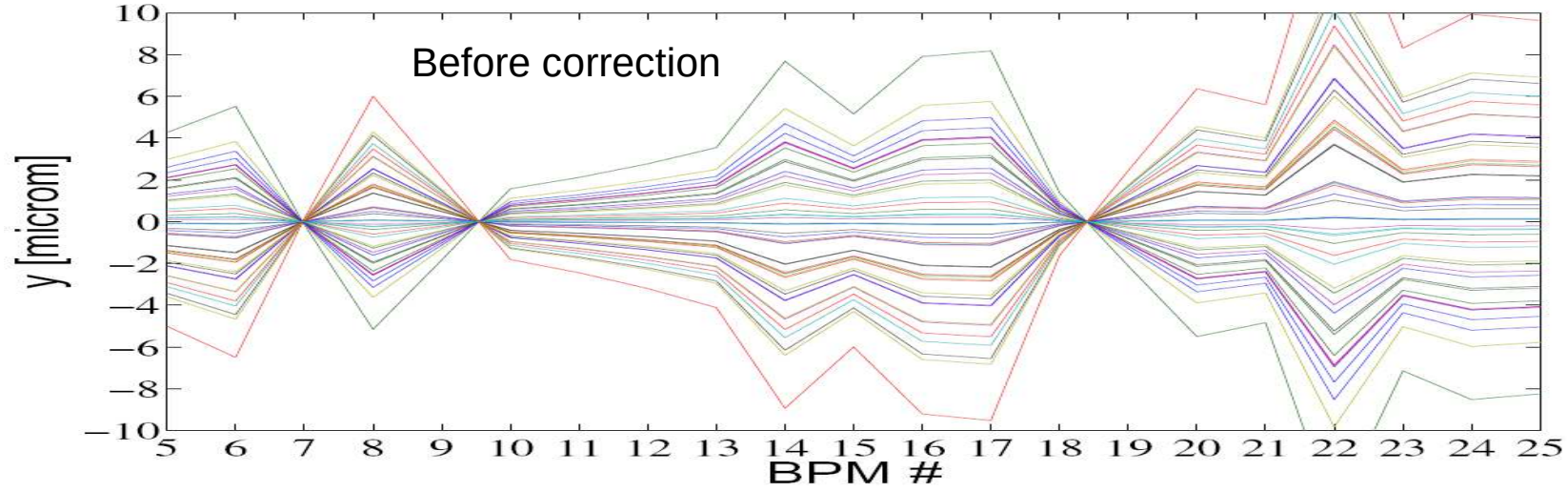
Phase advance between kicker pairs of ≈ π/2

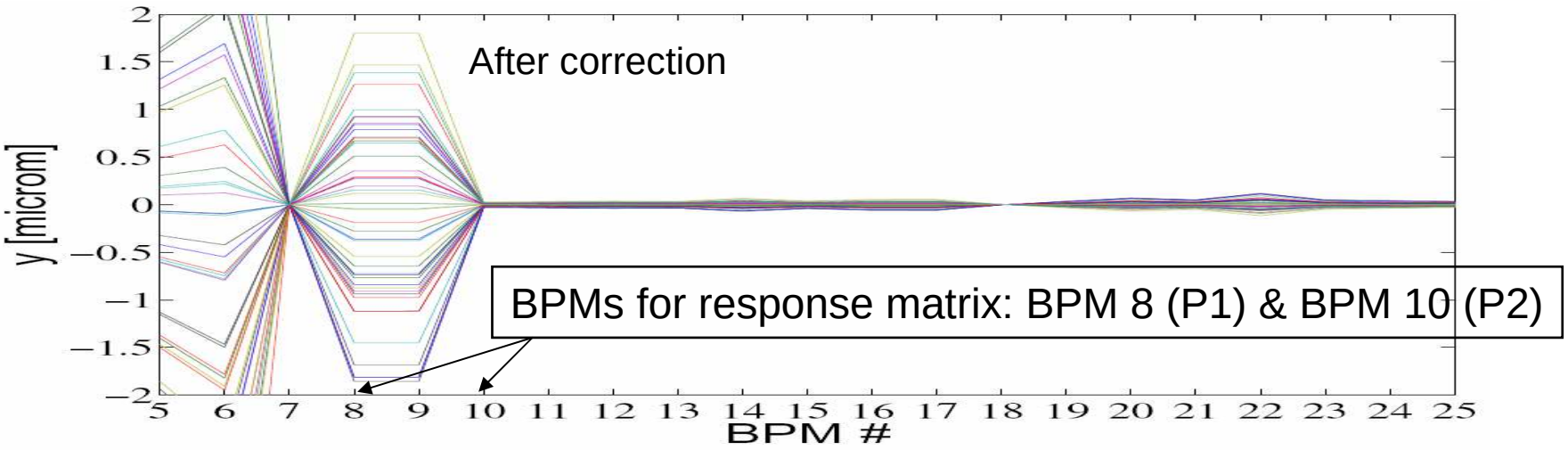
Conditions for the simulations in this work

- 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 (K1 & K2) for vertical position (Y) and angle (Θ) correction
- Two pickups (P1 & P2) for response matrix reconstruction
- 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: $+/- 1\ \mu m$
- Placet-octave tracking and correction simulations

Vertical position correction simulations

Zoom of the EXT region





Residual 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,

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

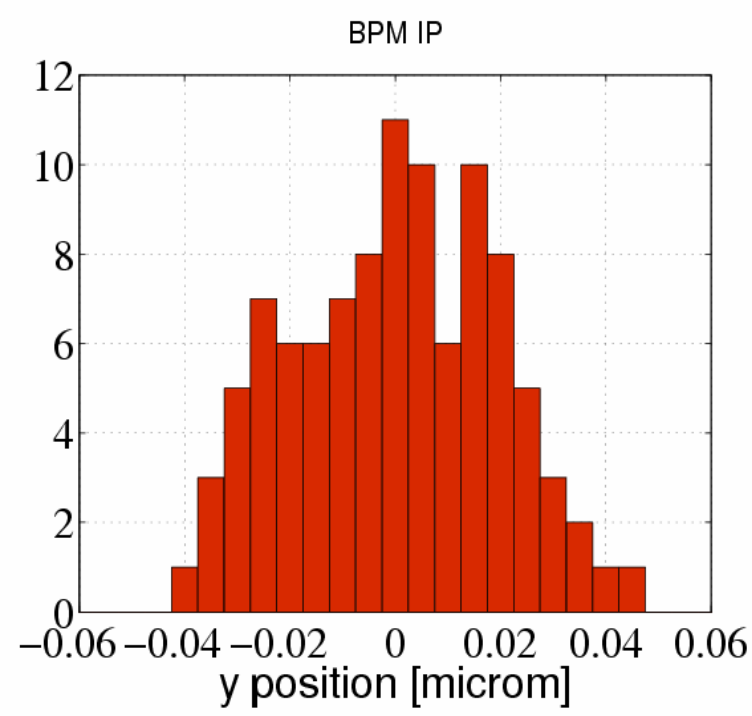
- The tolerable error limit:

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

$$\delta y_{IP} \leq 0.1\sigma_y^* \approx 4\ \text{nm}$$

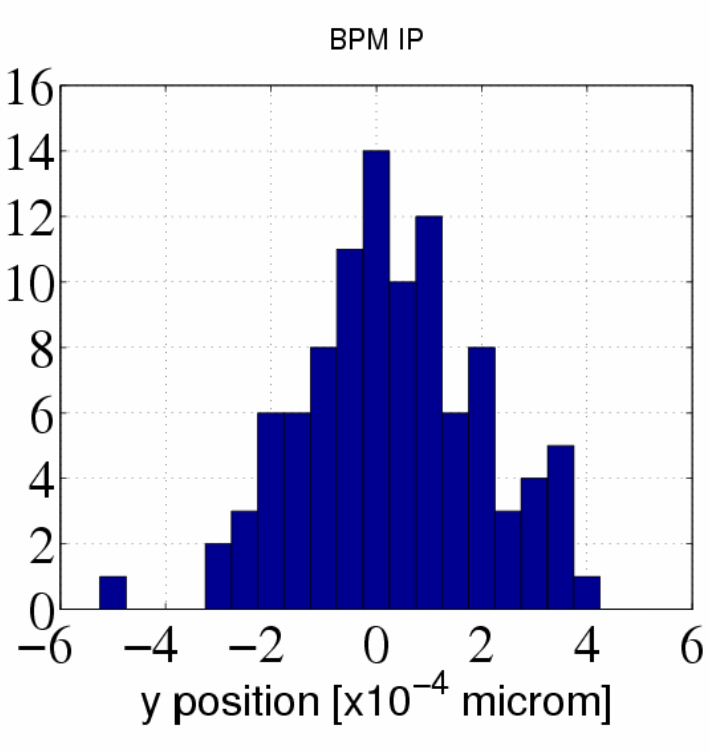
BPM readings at IP

Before correction



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

After correction



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

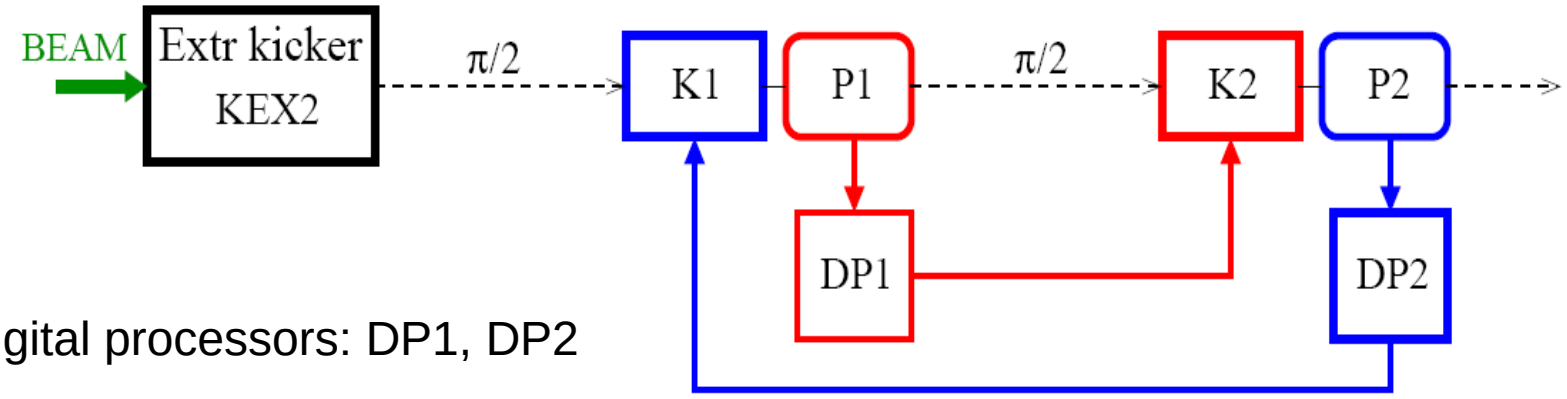
Much smaller than the required superior limit $0.1\sigma^*_y \approx 4$ nm

FB correction algorithms

FF and FB using the same kicker and BPM pairs. Interesting test option!

Pilot bunch algorithm: all bunches in a train are corrected using the same FB signal obtained from the first, pilot bunch

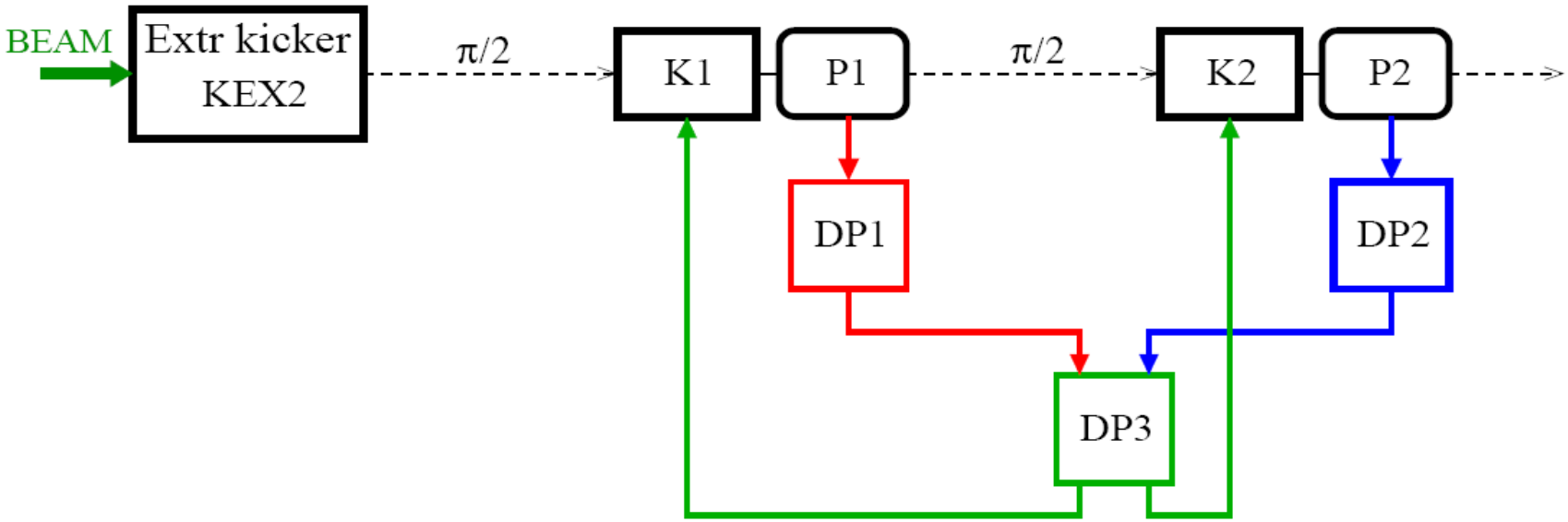
Two parallel FB systems for independent correction for angle and position



Digital processors: DP1, DP2

FB correction algorithms

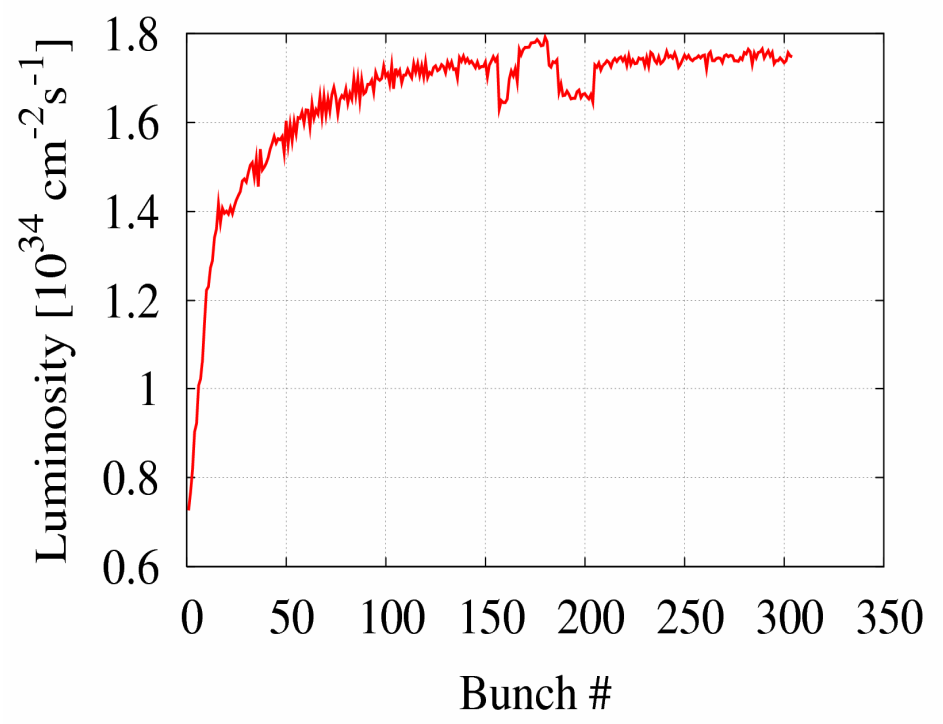
Schematic for coupled angle and position correction



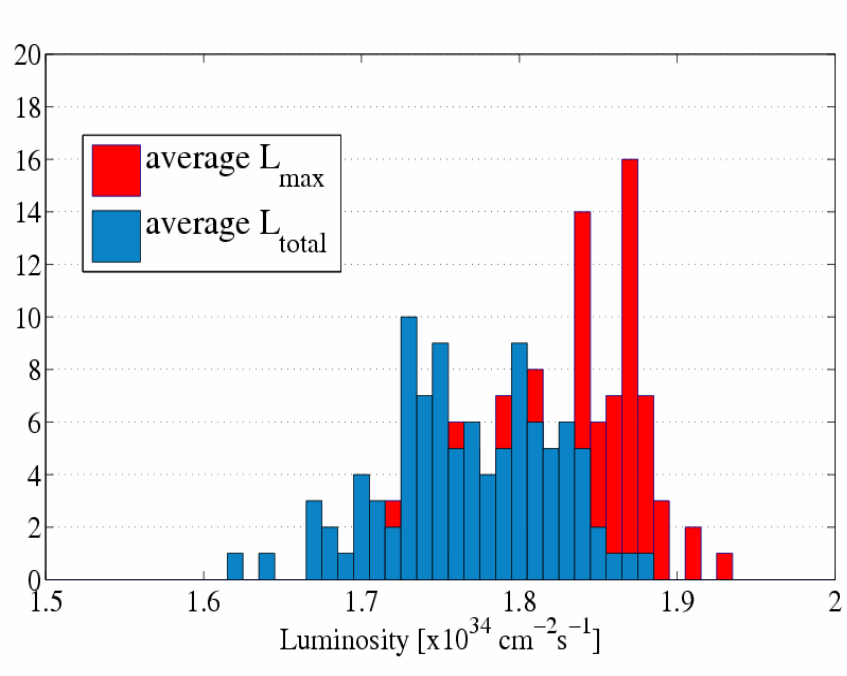
Adding different weights for simultaneous angle and position correction

Simulation example of a fast intra-train FB for the ILC

Example for 1 single random seed



Example of 100 random seeds GM model C



Mean value=1.7698 +/- 0.0539
(88.5 % of the nominal Luminosity)

Discussions during this visit at CERN

ATF2 based issues:

- Make a realistic model of the machine: introducing quadrupole and sextupole jitter, quadrupole strength errors, …
- Apply beam alignment algorithm with Placet-Octave (Andrea & Rogelio)
- Introducing ground motion misalignment (ATL model K)
- Then apply FONT steering correction
- Is this model enough?

ILC based issues:

Study of the coupling from the different FB systems: upstream slow FB system,
IP position fast FB, …

LET studies in the Main Linac: real model of the undulator alignment? (who is working in this issue?)