Analysis of IP-BPM beam based alignment, sensitivity to angle

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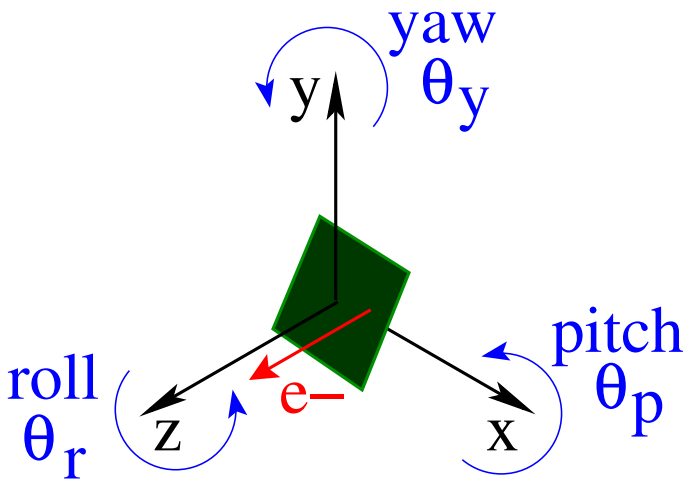
Coordinate system

Each BPM has its own coordinates with respect to a reference system centered **electrically** and aligned with the beam



Beam, BPMs

- Beam Position

  x_A, y_A, z_A

  x_B, y_B, z_B

  x_C, y_C, z_C

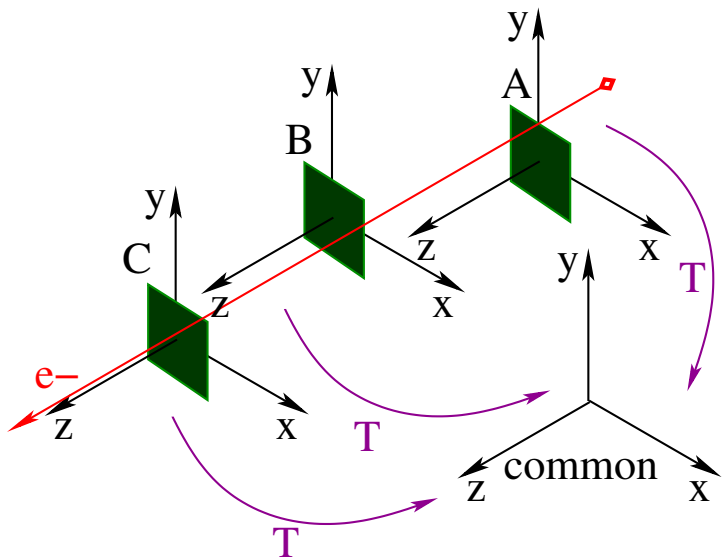
- BPM Angles respect to ref. system

  $\theta_{Ap}, \theta_{Ar}, \theta_{Ay}$

  $\theta_{Bp}, \theta_{Br}, \theta_{By}$

  $\theta_{Cp}, \theta_{Cr}, \theta_{Cy}$

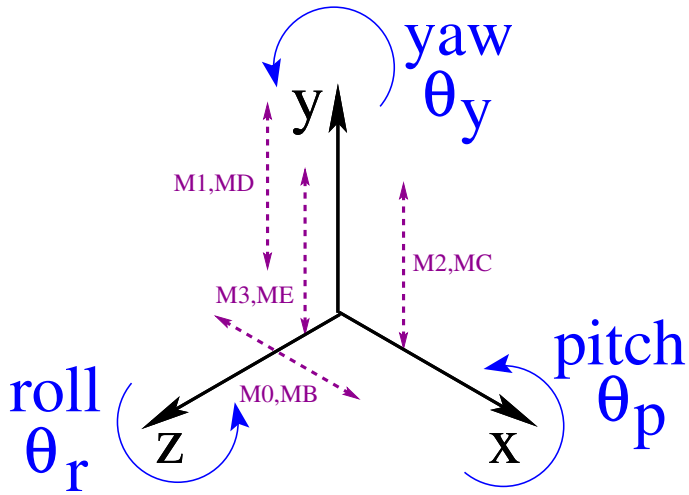
All systems relate to a common **mechanical** reference system, no rotations, just translations



One of the BPMs reference system could be chosen to coincide with the common

Movers

There is a set of movers to control BPM position



$$x = x_0 + f_x(M_{0,B})$$

$$y = y_0 + f_y(M_{123,CDE})$$

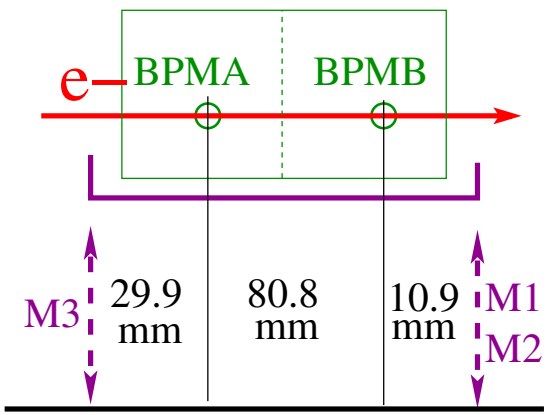
$$z = z_0$$

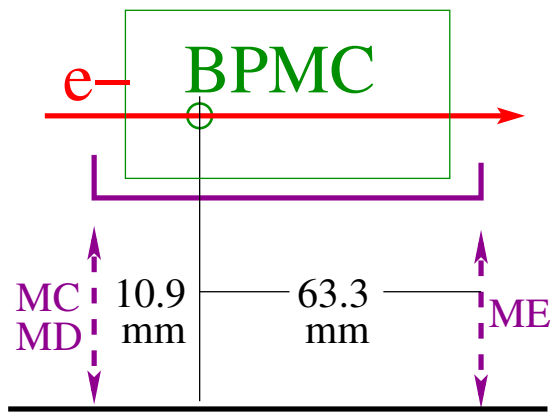
$$\theta_p = \theta_{p0} + f_p(M_{123,CDE})$$

$$\theta_r = \theta_{r0}$$

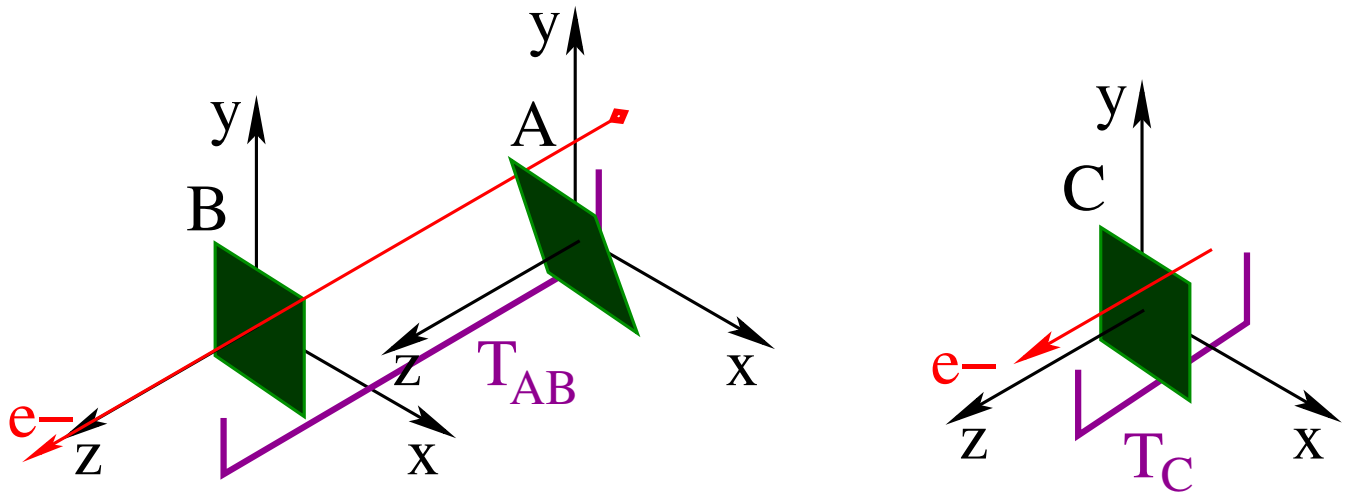
$$\theta_y = \theta_{y0}$$

All initial values are set during the IP BPMs installation





Block AB and C Alignment



Using BPMB as reference, $1000\beta_y$ optics

	Beam test 1		Beam test 2
	B	A	C
x_0 [μm]	0 ± 5	53 ± 5	$180? \pm ?$
y_0 [μm]	0 ± 3	$\mathbf{-34 \pm 3}$	$\mathbf{-55 \pm 23}$
z_0 [mm]	not meas.	not meas.	not meas.
θ_{p0} [mrad]	0 ± 0.1	$\mathbf{1.6 \pm 0.1}$	$\mathbf{< 1.6}$
θ_{r0} [mrad]	not meas.	not meas.	not meas.
θ_{y0} [mrad]	not meas.	not meas.	not meas.

Block AB and C Adjustment

$$M_{0123} = \frac{3 - V_{0123}[\mathrm{V}]}{4} \qquad M_{BCDE} = \frac{V_{BCDE}[\mathrm{V}] - 5}{5} \tag{1}$$

	Adjustment (if BPM B is reference and centered)		
	B	A	C
$x[\mu\mathrm{m}]$	$125M_0$	$53 + 125M_0$	$180 + 150M_B$
$y[\mu\mathrm{m}]$	$94.8M_{1,2} + 30.2M_3$	$-34 + 11.2M_{1,2} + 113.8M_3$	$-55 + 128.0M_{CD} + 22.0M_E$
z[mm]	not meas.	not meas.	not meas.
θ_p[mrad]	$1.03(M_3 - M_{1,2})$	$1.6 + 1.03(M_3 - M_{1,2})$	$1.6 + 2.02(M_{DC} - M_E)$
θ_r[mrad]	not meas.	not meas.	not meas.
θ_y[mrad]	not meas.	not meas.	not meas.

$$M_{0123,BCDE} \in [-1, 1], \Delta M_{0123,BCDE} \geq 1.25 \times 10^{-2}$$

Using BPMB as reference, $1000\beta_y$ optics

Block AB and C Adjustment (cont.)

Using BPMB as reference, 1000β_y optics

	Adjustment (if BPM B is reference and centered)		
	B	A	C
y[μm]	$94.8M_{1,2} + 30.2M_3$	$-34 + 11.2M_{1,2} + 113.8M_3$	$-55 + 128.0M_{CD} + 22.0M_E$
θ_p[mrad]	$1.03(M_3 - M_{1,2})$	$1.6 + 1.03(M_3 - M_{1,2})$	$1.6 + 2.02(M_{DC} - M_E)$

POSSIBLE CORRECTIONS

Horizontal position seems to be possible to correct.

Vertical correction at least to μm precision is possible between:

- A and C
- B and C.

V: $y_B = 0\mu$m, $\theta_{Bp} =$ **0mrad**, $y_A = -34\mu$m, $\theta_{Bp} = 1.6$mrad

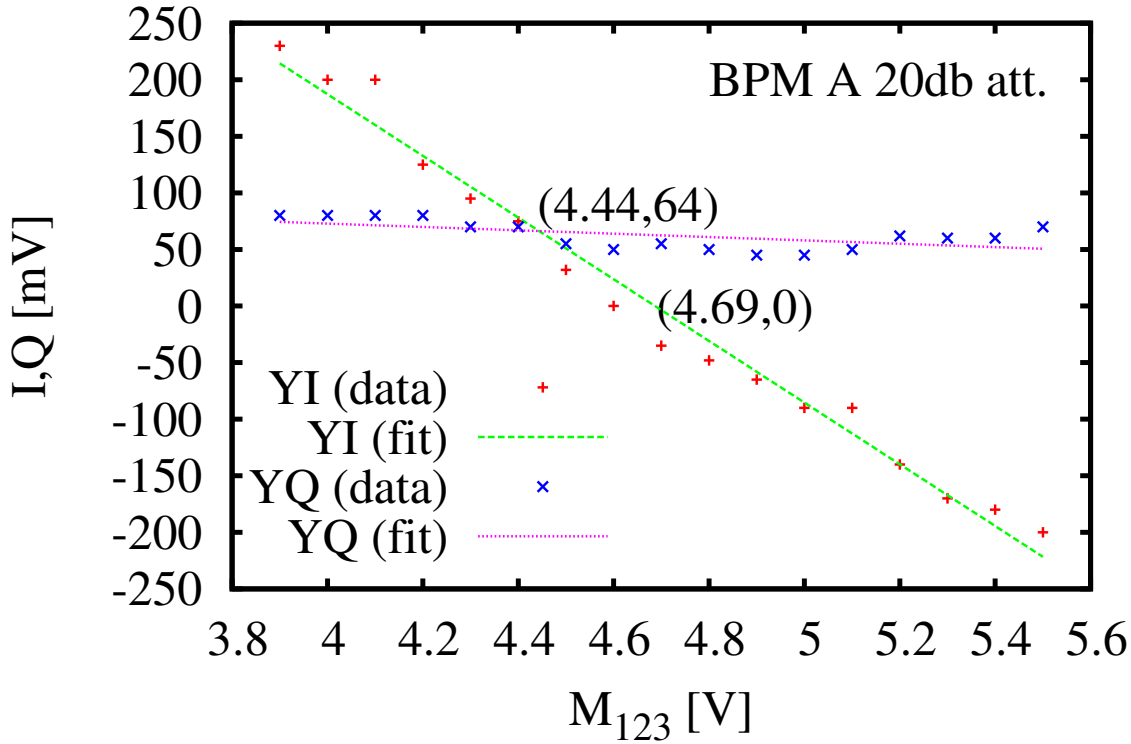
$y_B =$ **0μm**, $\theta_{Bp} = 0.4$mrad, $y_A =$ **0μm** , $\theta_{Bp} = 2.0$mrad

$y_B = 0\mu$m, $\theta_{Bp} =$ **$-$0.8mrad**, $y_A = -64.9\mu$m, $\theta_{Bp} =$ **0.8mrad**

$y_B = 21.9\mu$m, $\theta_{Bp} = -1.6$mrad, $y_A = -107.64\mu$m, $\theta_{Bp} =$ **0mrad**

Sensitivity to angle (BPMA)

1000β_y optics. 51 bunches recorded per each mover position. Maximum IQ value was picked each time.



$$(4.69[\mathrm{V}] - 4.44[\mathrm{V}]) \left(\frac{250[\mu\mathrm{m}]}{8[\mathrm{V}]}\right) \left(\frac{1}{1.6[\mathrm{mrad}]}\right) = 4.9 \left[\frac{\mu\mathrm{m}}{\mathrm{mrad}}\right] \quad (2)$$

Conclusions

- Block AB and C vertical misalignment is corrected by movers, and seems to be the case also for horizontal.
- Upper limit estimation for BPMA angle sensitivity is $4.9\mu\text{m}/\text{mrad}$.
- Movers could minimize signals I_y, Q_y on either A or B but not all at same time.

I THANK YOU ALL!

Open Questions

- Required alignment precision $(x_0, y_0, z_0, \theta_{p0}, \theta_{r0}, \theta_{y0})$ in order to check during munufacturing and assembly.
  What to check? How to check?

Support slides