Summary WP2 WP4

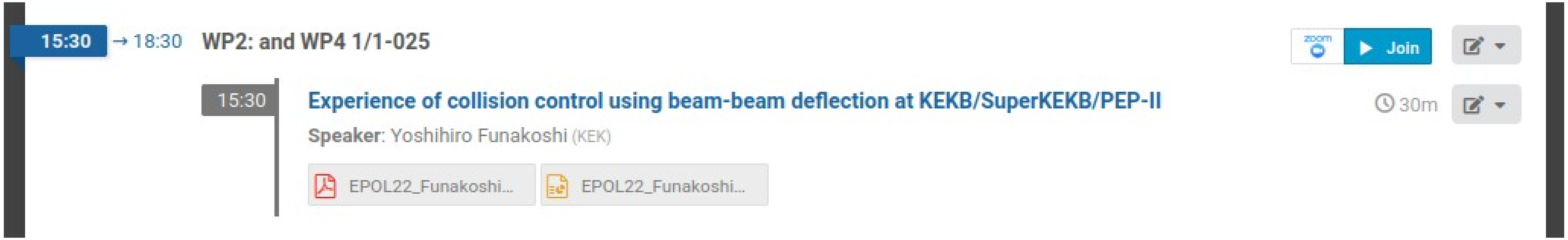
J. Keintzel, K. Oide, J. Wenninger,
For the WP2 (WP4) parallel session

2d FCC Polarization Workshop (EPOL) 2022
Joint EIC-FCC Working Meeting on e+/e- Polarization
27th September 2022

FCCIS – The Future Circular Collider Innovation Study. This INFRADEV Research and Innovation Action project receives funding from the European Union's H2020 Framework Programme under grant agreement no. 951754.

Timetable

- One joint WP2 and WP4 parallel session on Monday



BPMs for IP Orbit Feedback

BPM’s for IP orbit feedback

$$k_y = \frac{4\pi}{\beta_y^*}\xi_y$$

$$\Delta y' = -\frac{k_y}{2}\Delta y$$

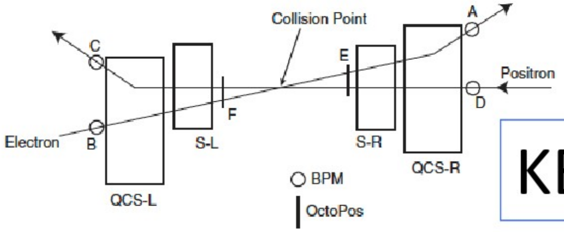
$$\Delta y = \frac{\sigma_y^*}{D} = \frac{\sqrt{\beta_y^*\varepsilon_y}}{D}$$

$$\Delta y' = -\frac{2\pi}{D}\sqrt{\frac{\varepsilon_y}{\beta_y^*}}\xi_y$$

BPMs at SuperKEKB should have higher sensitivity than KEKB.

$$\Delta y^{BPM} \approx \frac{\sqrt{\beta_y^{BPM}\beta_y^*}}{2}\Delta y'$$

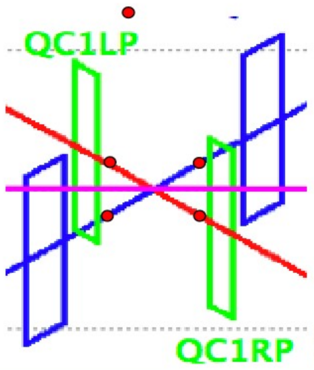
	KEKB	SuperKEKB
β_y^*	5.9mm	0.27mm
ε_y	0.15nm	8.6pm
$\sqrt{\varepsilon_y / \beta_y^*}$	1.59 x 10^{-4}	1.78 x 10^{-4}
$\sqrt{\beta_y^{BPM}\beta_y^*}$	2.0m	0.5m



KEKB

$\sqrt{\beta_y^{BPM}\beta_y^*} \approx 2.0m$ A,B,C,D: BPM ~2.4m from IP

BPM resolution: ~2μm@1.6A



BPM (l~50cm from IP)

SuperKEKB

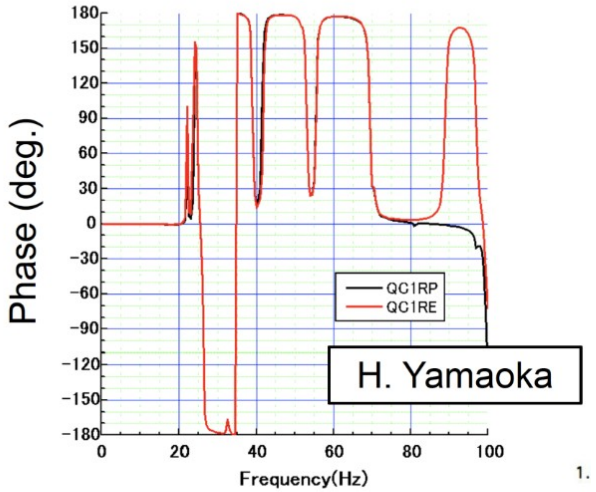
$\sqrt{\beta_y^{BPM}\beta_y^*} \approx 0.5m$

BPM resolution: ~0.2μm@3.6A

2022/September/26th EPOL 2022 SuperKEKB Y. Funakoshi 3

Which resolution for the BPMs is needed if the same orbit feedback should be used for the FCC?

Feedback Parameter



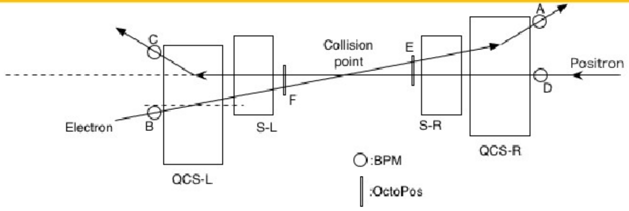
Feedback system used for e.g. vertical vibration of final focus quadrupoles

1 µm offset on QC1 leads to 0.7 µm orbit change at IP

Feedback parameter (vertical offset at IP)

$$y_e^A = m_{33}^A y_e^* + m_{34}^A y_e'^{*a}$$

$$y_e^B = m_{33}^B y_e^* + m_{34}^B y_e'^{*b}$$



y_e^* :vertical offset at IP

$y_e'^{*a}$:vertical angle at IP after collision, $y_e'^{*b}$:vertical angle at IP before collision

m^A :transfer matrix from IP to A, m^B :transfer matrix from IP to B

$$\Delta y_e'^* = y_e'^{*a} - y_e'^{*b} = \left(\frac{y_e^A}{m_{34}^A} - \frac{y_e^B}{m_{34}^B}\right) - \left(\frac{m_{33}^A}{m_{34}^A} - \frac{m_{33}^B}{m_{34}^B}\right) y_e^*$$

$\Delta y_e'^*$: vertical beam-beam kick

$$\Delta y_p'^* = y_p'^{*a} - y_p'^{*b} = \left(\frac{y_p^C}{m_{34}^C} - \frac{y_p^D}{m_{34}^D}\right) - \left(\frac{m_{33}^C}{m_{34}^C} - \frac{m_{33}^D}{m_{34}^D}\right) y_p^*$$

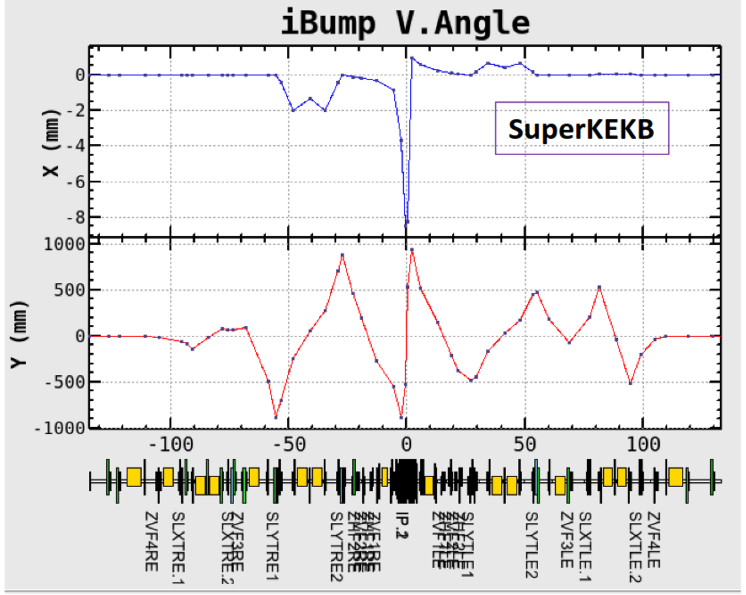
Calculated from readings of 4 BPMS

$$\Delta y'^*_{canonical} \equiv \frac{\left(\frac{y_e^A}{m_{34}^A} - \frac{y_e^B}{m_{34}^B}\right)}{\left(\frac{m_{33}^A}{m_{34}^A} - \frac{m_{33}^B}{m_{34}^B}\right)} - \frac{\left(\frac{y_p^C}{m_{34}^C} - \frac{y_p^D}{m_{34}^D}\right)}{\left(\frac{m_{33}^C}{m_{34}^C} - \frac{m_{33}^D}{m_{34}^D}\right)} = \frac{\Delta y_e'^*}{\left(\frac{m_{33}^A}{m_{34}^A} - \frac{m_{33}^B}{m_{34}^B}\right)} - \frac{\Delta y_p'^*}{\left(\frac{m_{33}^C}{m_{34}^C} - \frac{m_{33}^D}{m_{34}^D}\right)} + \left(y_e^* - y_p^*\right)$$

2022/September/26th EPOL 2022 SuperKEKB Y. Funakoshi 4

Orbit Feedback System

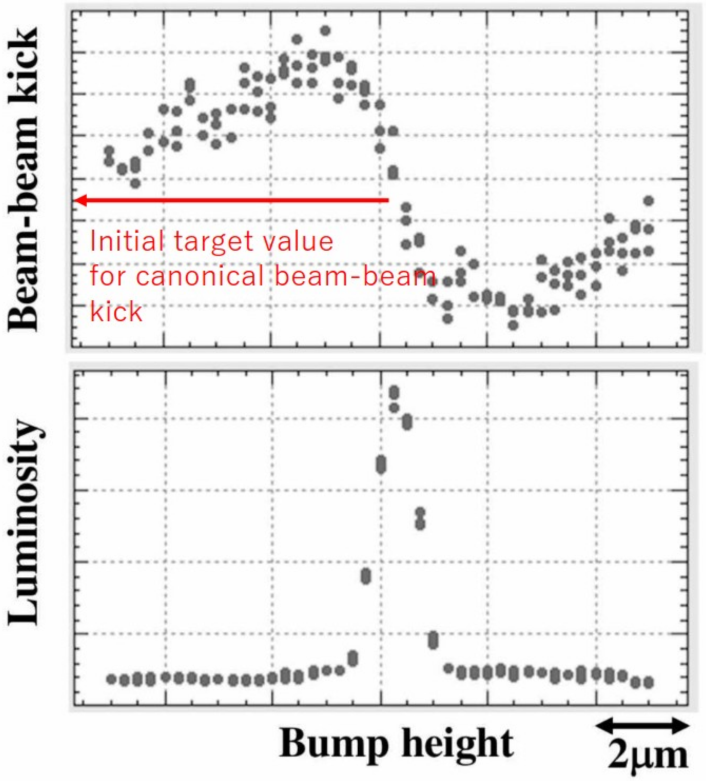
Steering magnets dedicated for orbit FB (v-angle)



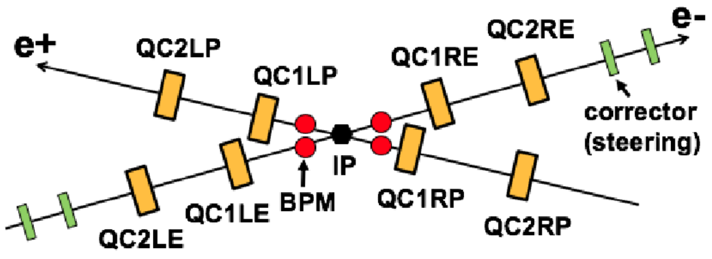
For a vertical angle bump, 8 steering magnets are used in order to close the vertical dispersion.

IP orbit feedback

	KEKB	SuperKEKB
IP vertical offset	Beam-beam deflection (used)	Beam-beam deflection (used)
IP vertical angle	used	Not used
IP horizontal offset	Beam-beam deflection (used)	Dithering (not yet used) Slow FB to maintain vertex point is used.



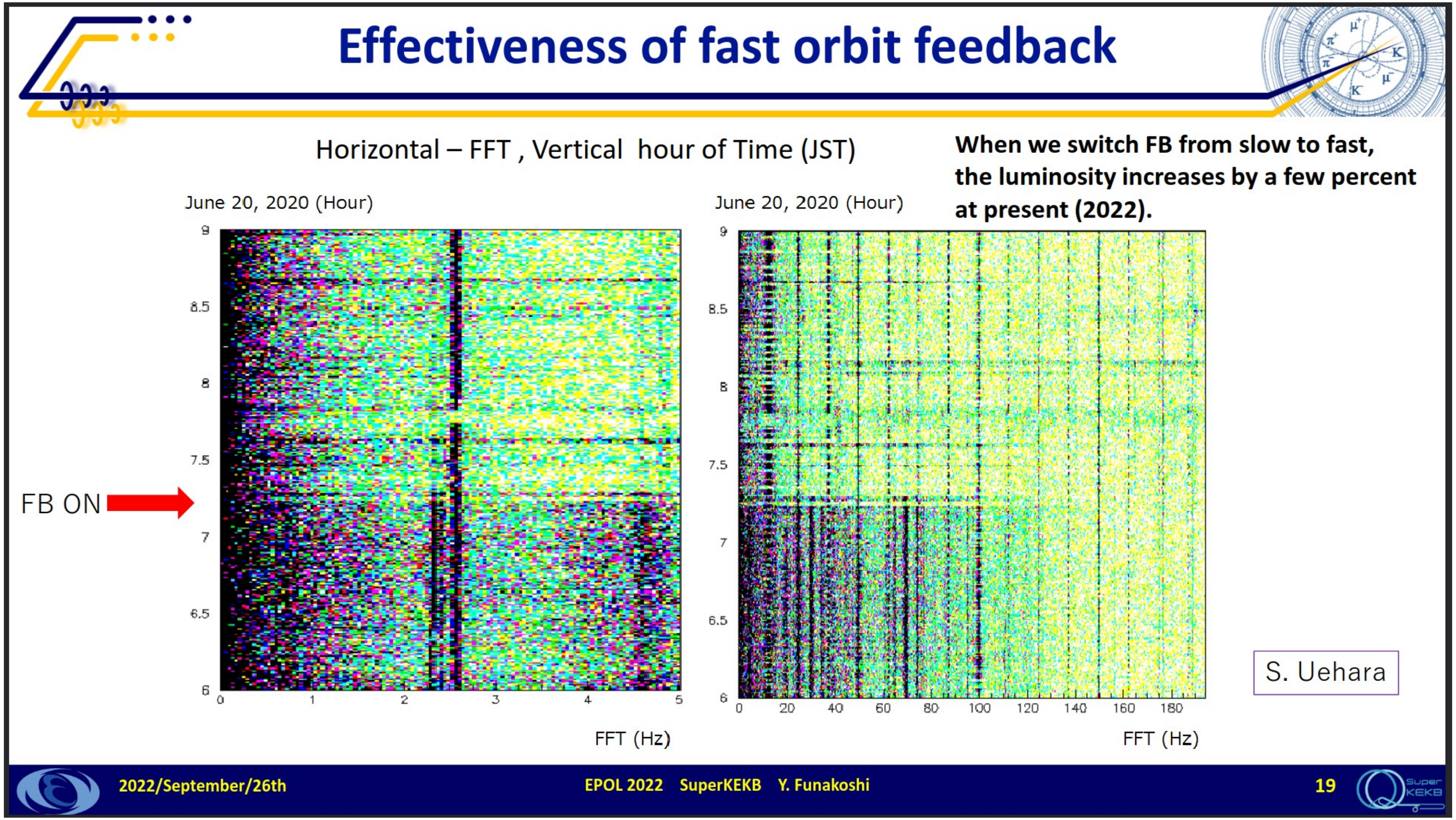
Vertical (scan vertical offset at IP)



Slow and Fast Feedback System

Since 2022 fast orbit feedback used

→ Luminosity increase



Summary

Summary

- IP orbit feedback (vertical) is indispensable to avoid a luminosity decrease.
- The beam-beam deflection method has been very successfully applied to both KEK and SuperKEKB.
- In SuperKEKB, a fast orbit feedback system has been developed and successfully used in daily physics operation.
  - At present (2022), the luminosity increases by a few percent, when we switch FB from slow to fast one.
  - When we achieve a smaller vertical emittance and/or squeeze IP β_y^* further, the fast orbit feedback may become more important.
- One of annoying issues with the orbit feedback using the beam-beam deflection method is the stability and the beam current dependence of the target value of the canonical beam-beam kick.
  - We have not yet found a method to stabilize the target value.

2022/September/26th EPOL 2022 SuperKEKB Y. Funakoshi 25

Thank you!

Energy calibration and polarization
indico.cern.ch/category/8678

J. Keintzel, K. Oide, J. Wenninger,
For the WP2 (WP4) parallel session

2d FCC Polarization Workshop (EPOL) 2022
Joint EIC-FCC Working Meeting on e+/e- Polarization
27th September 2022

FCCIS – The Future Circular Collider Innovation Study. This INFRADEV Research and Innovation Action project receives funding from the European Union's H2020 Framework Programme under grant agreement no. 951754.