A Feedback/feedforward System at the TPS and Its Component Performance

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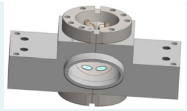
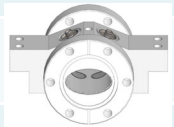
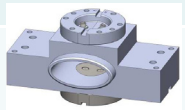
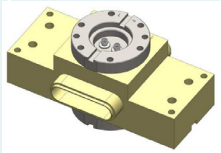
Outlines

- The components, computing module and performance of fast orbit feedback (FOFB) system
- RF adjustment
- Feedforward correction for 60 Hz beam motion
- The component performance of FOFB system
- Summary

The type of BPMs used in TPS

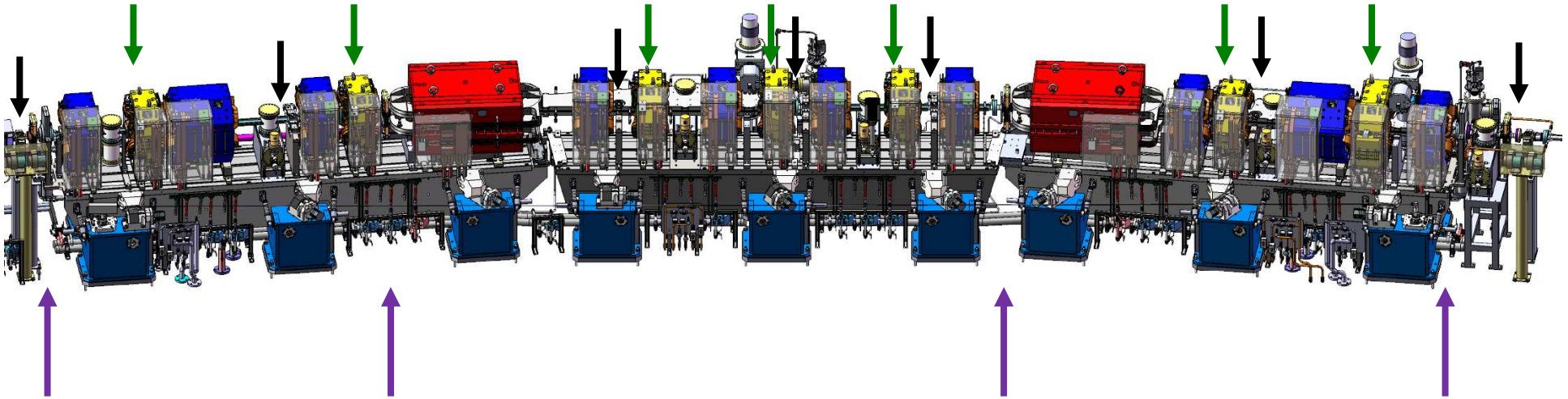
		Chamber profile	Size (mm)	ϕ button (mm)	Kx/Ky (mm)	Remarks
LTB (7)		Elliptical	56 x 28	10.2	15.20/10.95	A
Booster (60)		Elliptical	35 x 20	10.7	8.25/9.66	B
BTS (6)		Elliptical	35 x 20	10.7		A
Storage ring -Standard BPM (120 + 3)		Elliptical	68 x 30	7.4	13.8/12.73	B
Storage ring -Primary BPM (48 - 3)		Racetrack	64 x 16	7.4	6.58/8.89	B
IU22 (4 + 1)			68 x 20	7.4	8.99/9.63	B
EPU48 (1)			68 x 8	5	3/11.4	B

A: Libera Single Pass Brilliance B:Libera Brilliance Plus

Position of BPMs and correctors in each cell

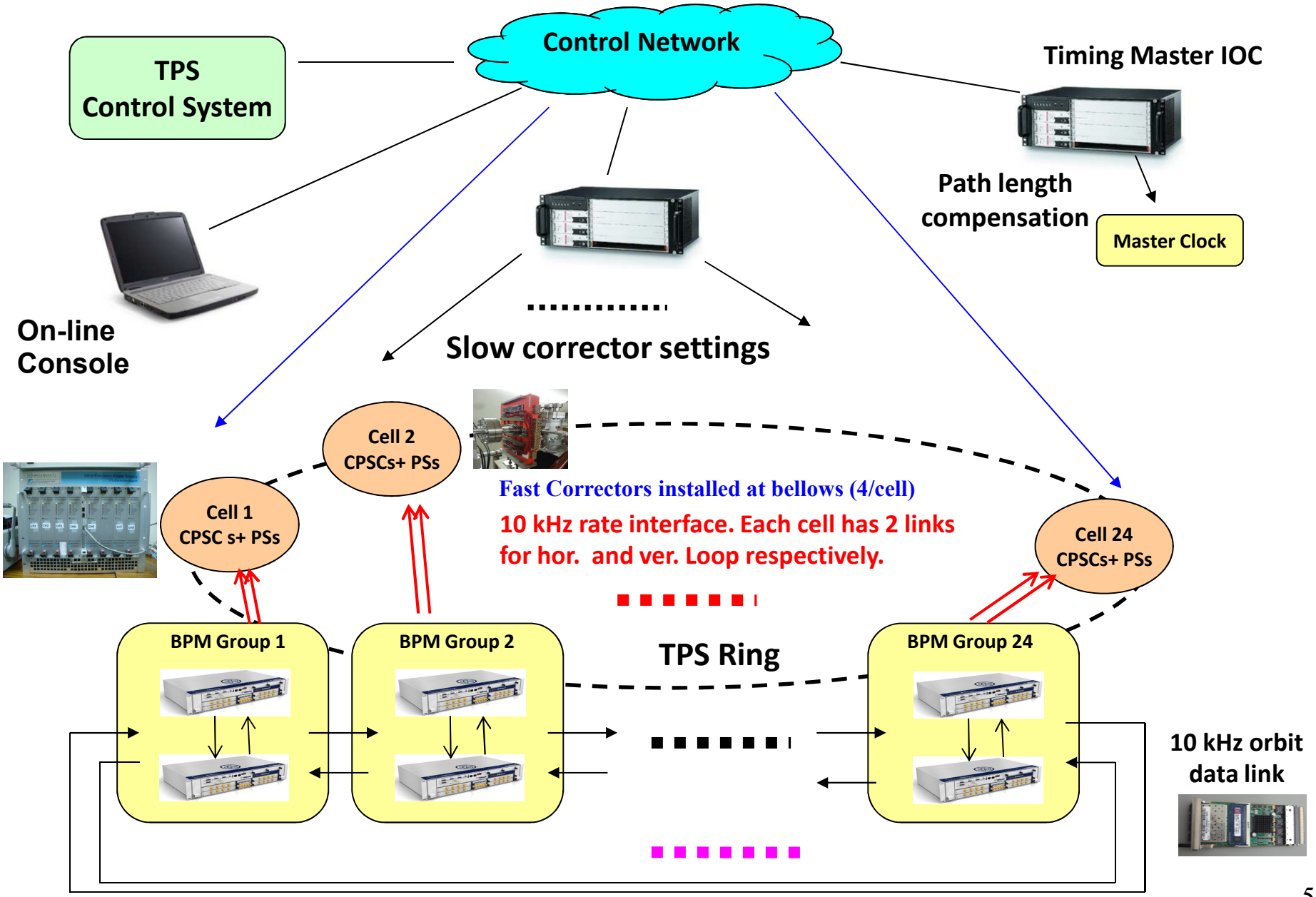
Slow corrector *7

BPM*7

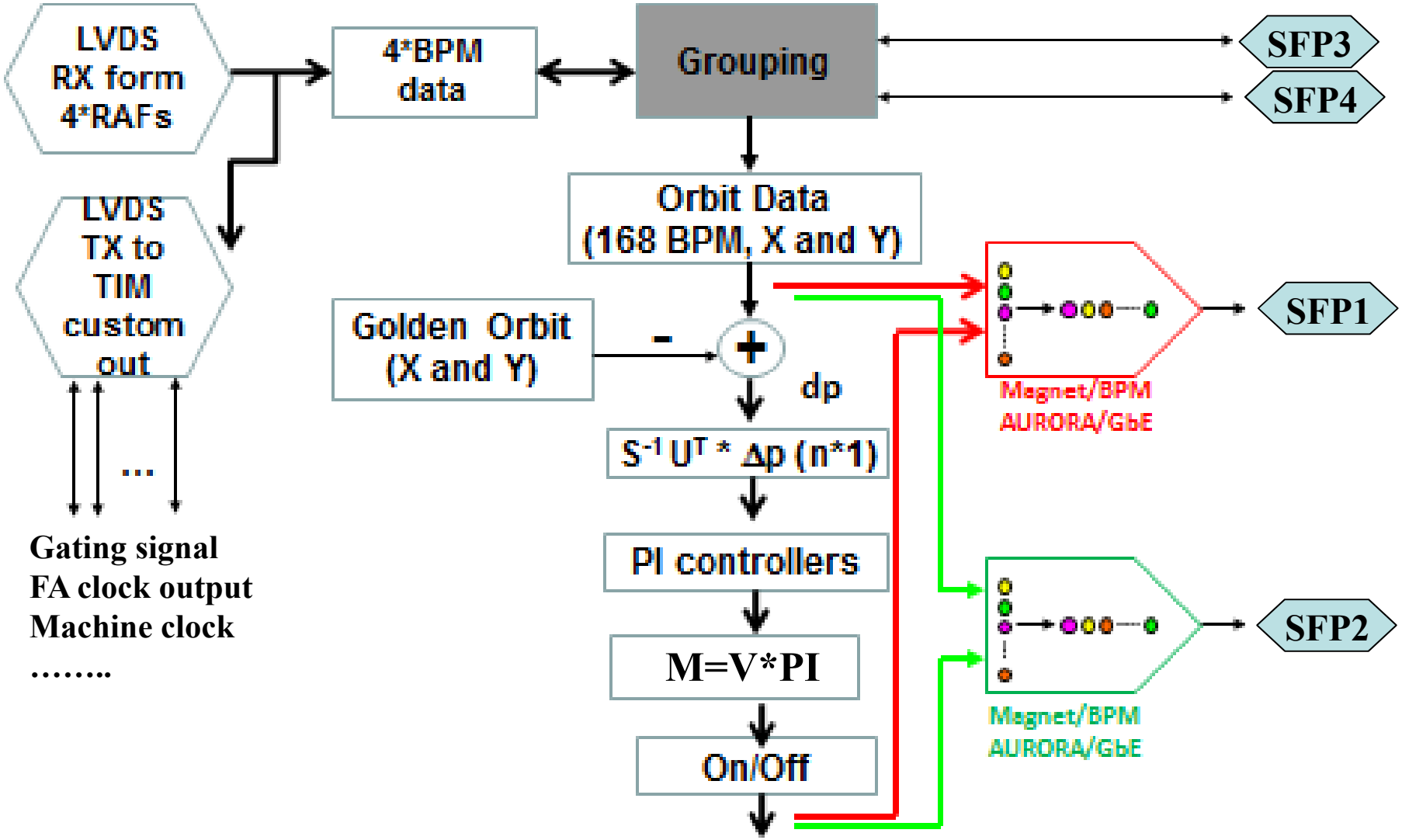


Fast corrector *4

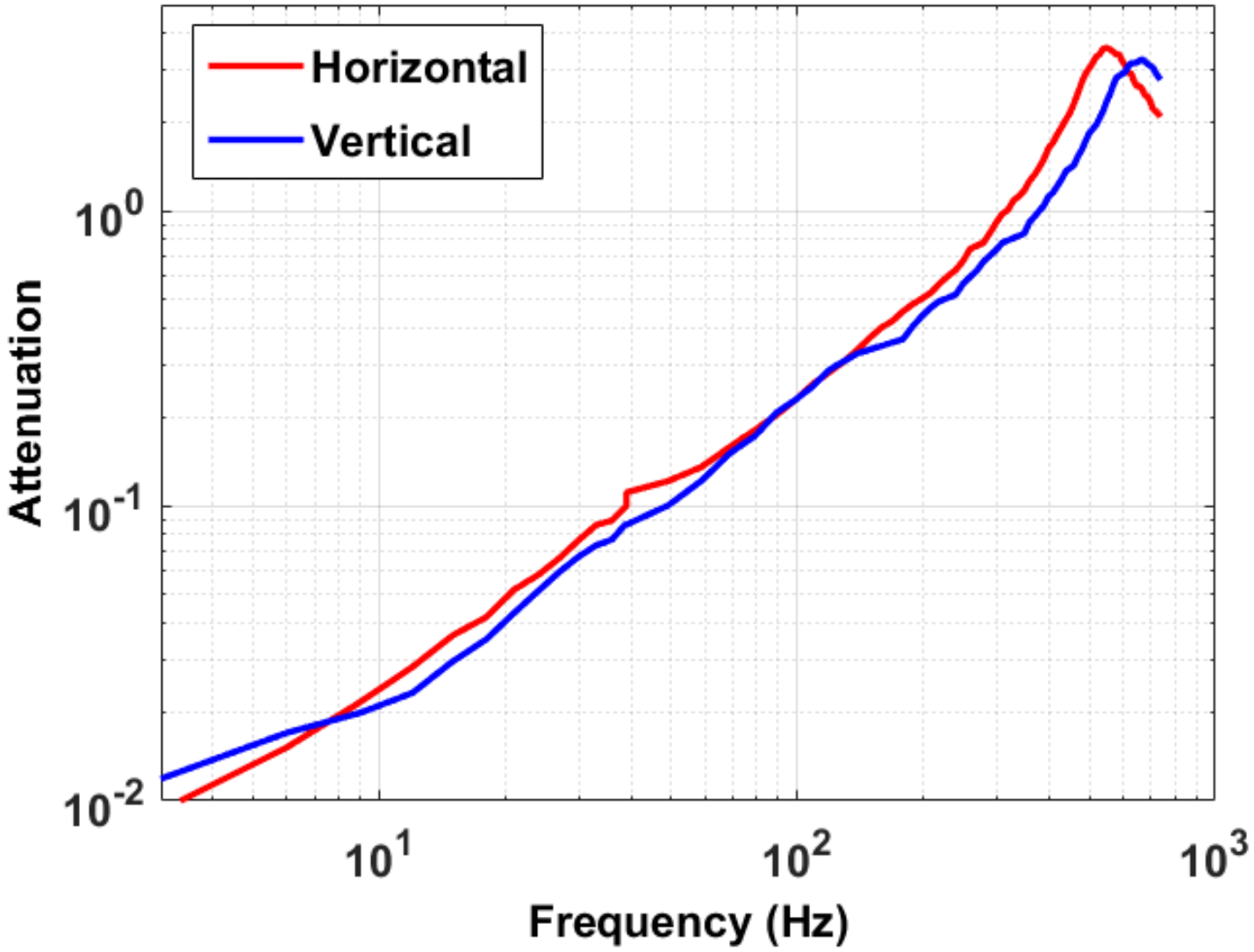
FOFB Infrastructure / BPM system



Computation module of FOFB

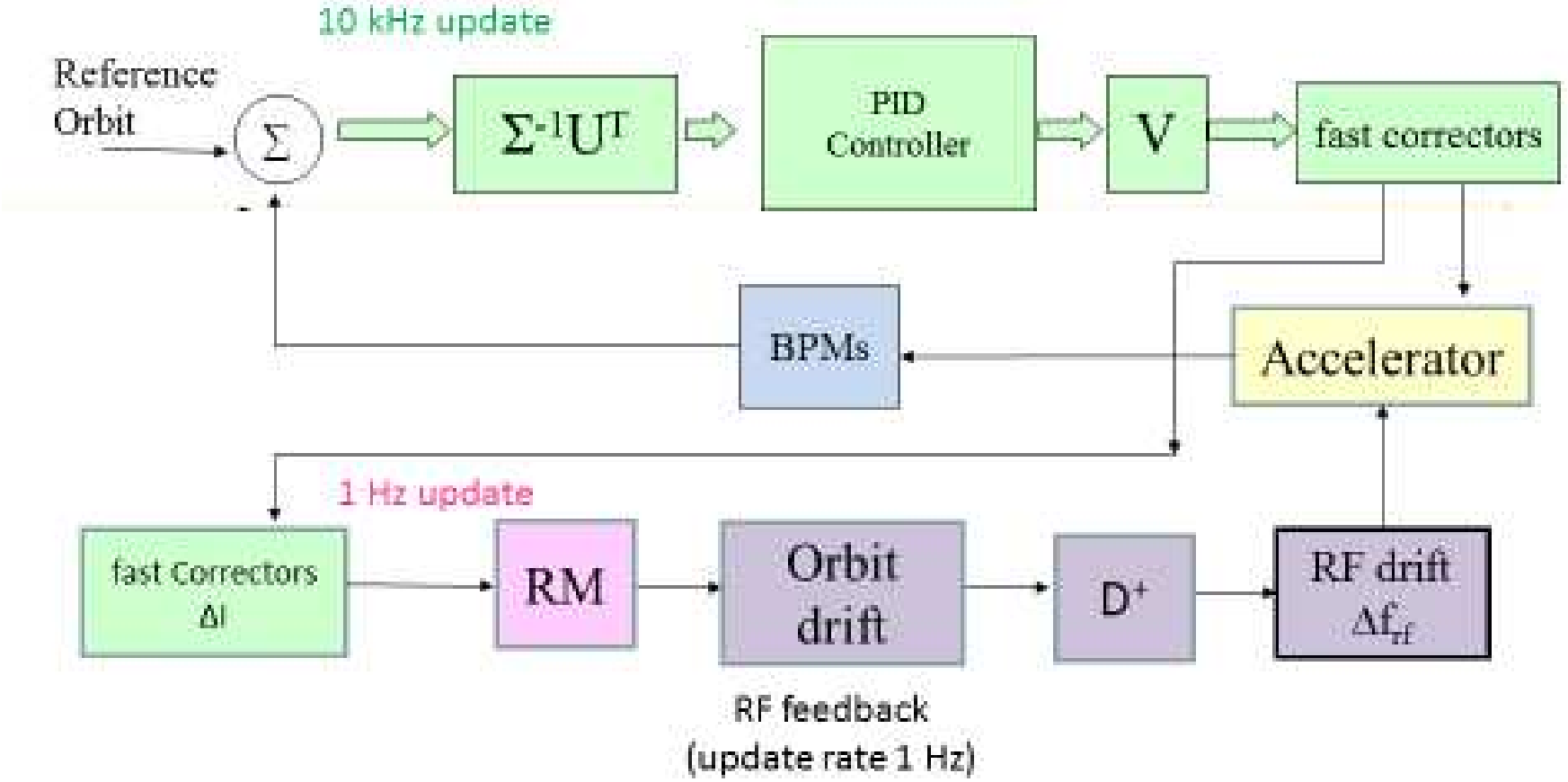


Performance of FOFB



The bandwidth of FOFB is ~ 300 Hz for both horizontal and vertical planes.

Computation model of RF adjustment

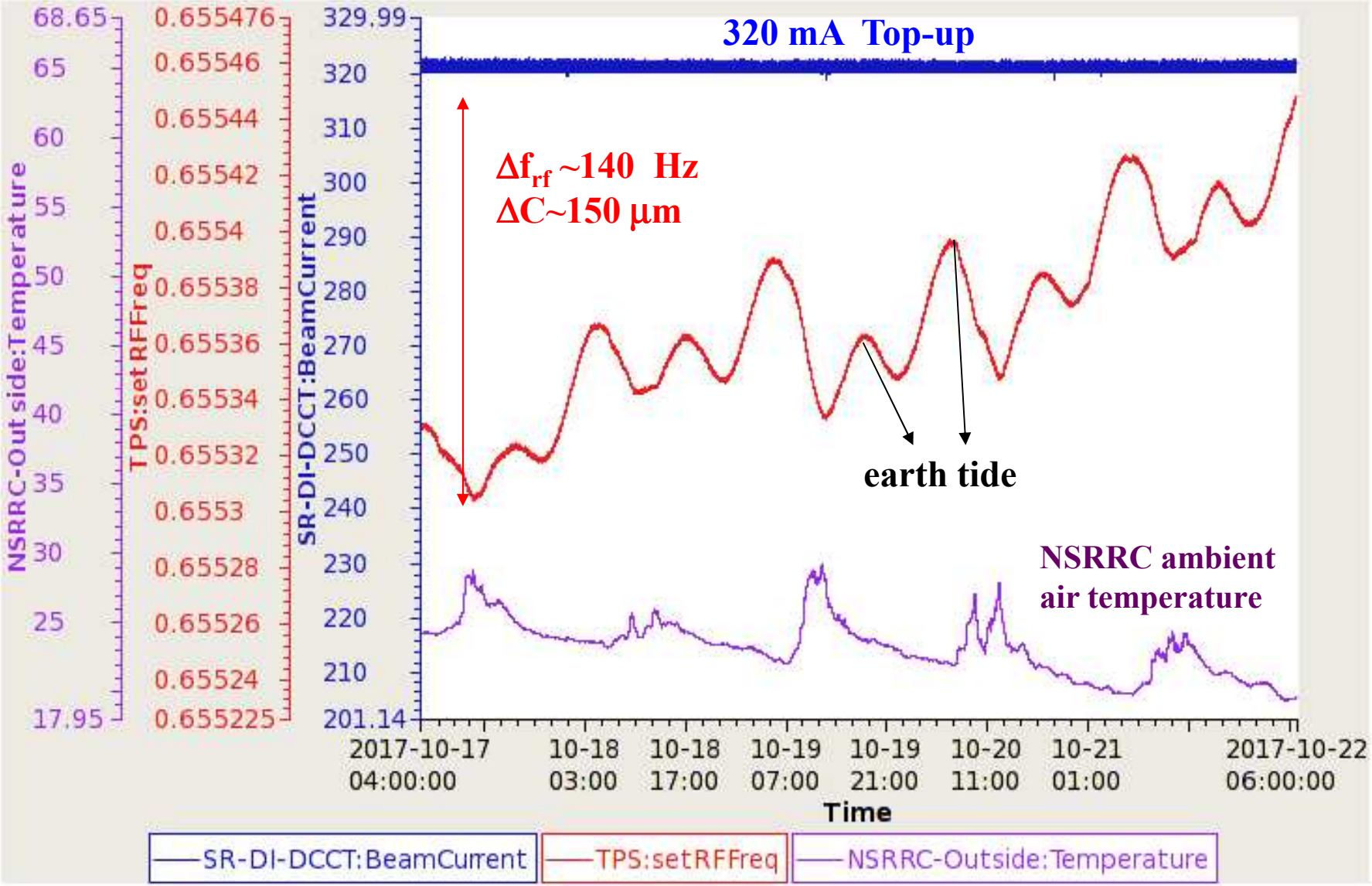


Corrector Response Matrix RM $=U\Sigma V^T$

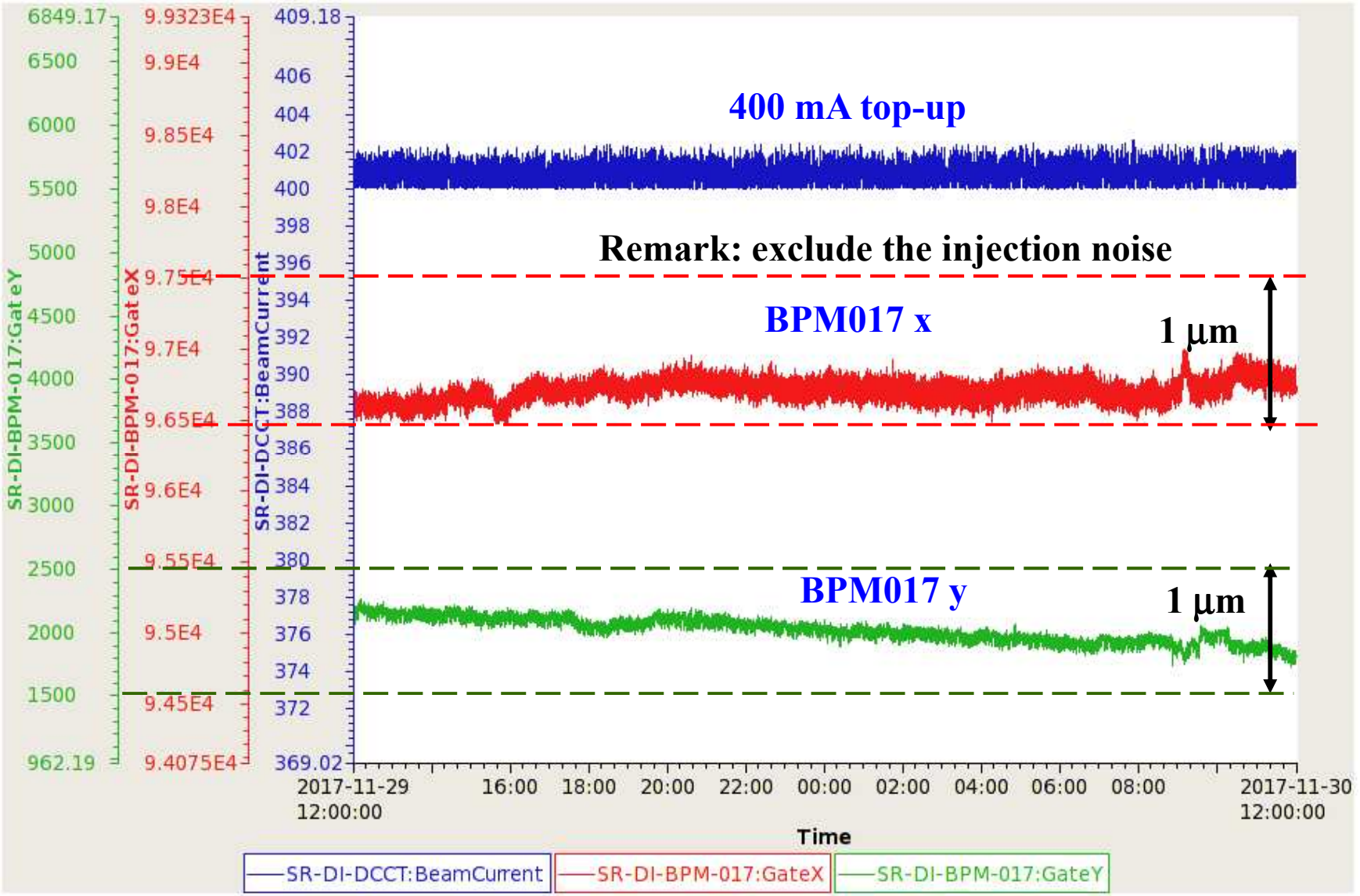
Dispersion Matrix D

Inverse Dispersion Matrix D^+

Performance of RF adjustment



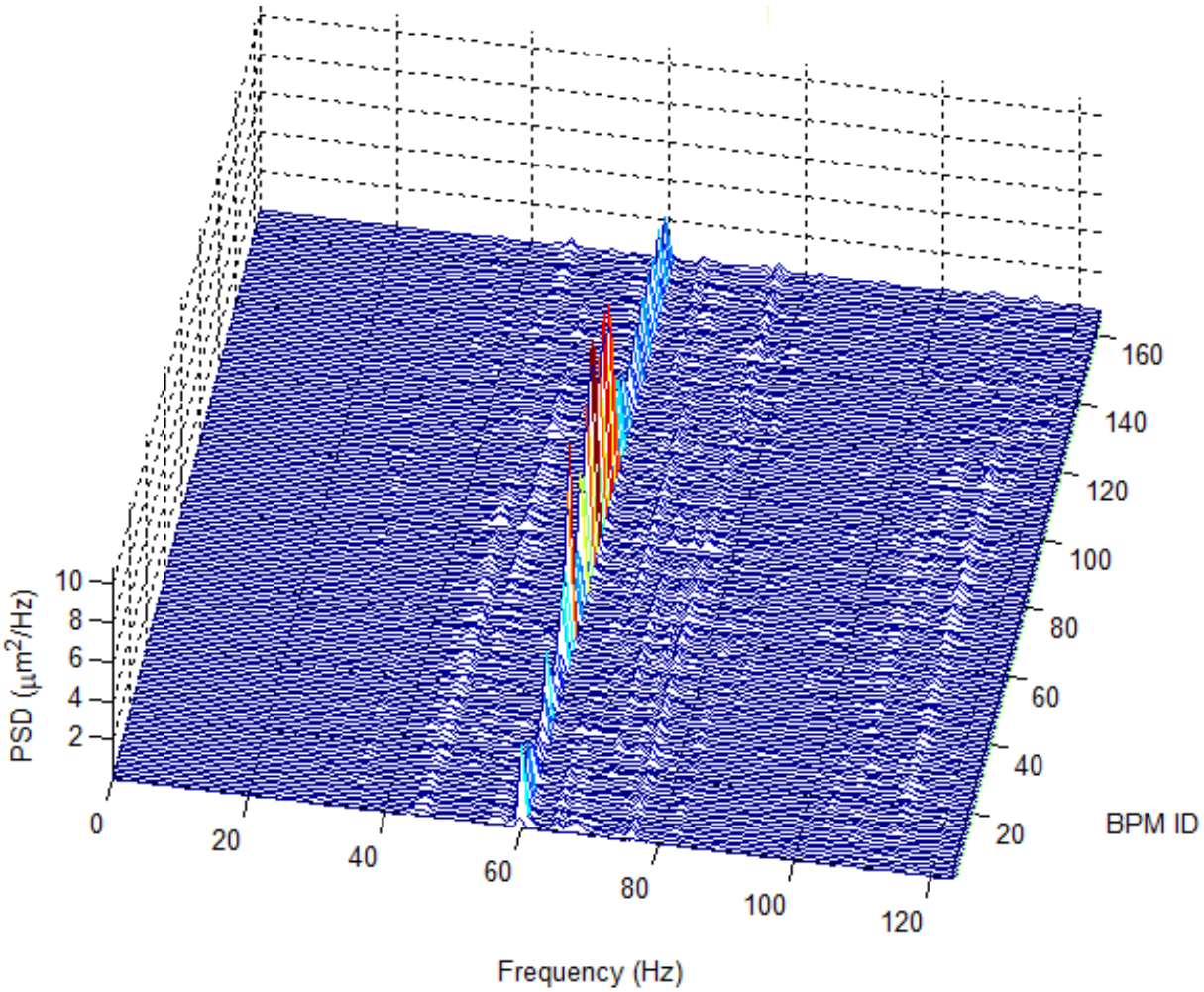
Orbit long term drift (FOFB On + RF adjustment)



Submicron beam orbit stability is achieved (BPM 10Hz rate, 1Hz archives)

Vertical beam motion for 60 Hz

Power spectral density of vertical beam motion



Source hunting

Beam position for each BPM $B_i(t)$

↓ Fourier Transform

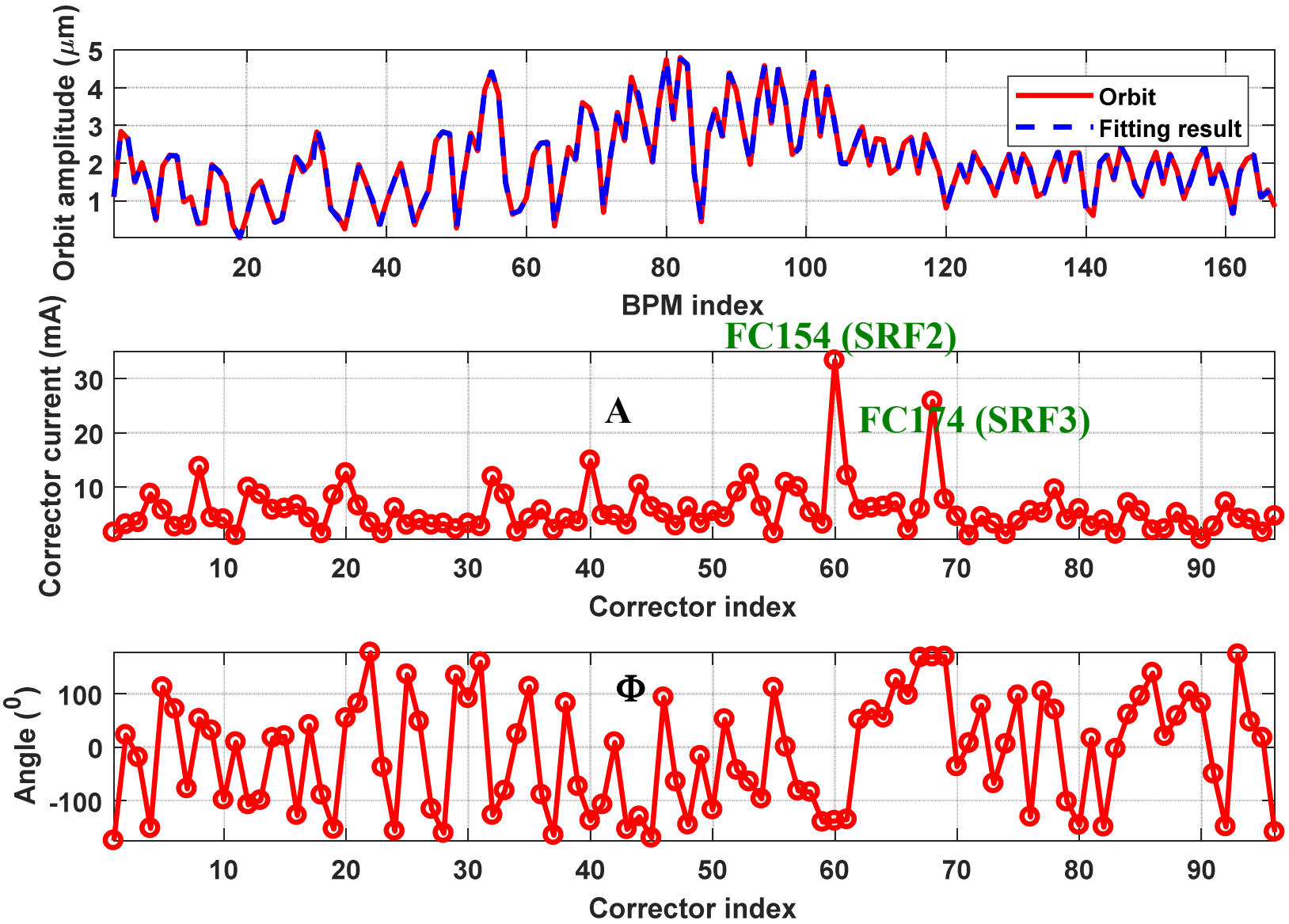
$B_i(f)$

↓ $\mathbf{C(60)=R^{-1}B(60)}$

R: response matrix

Corrector strength $C_i(60)$

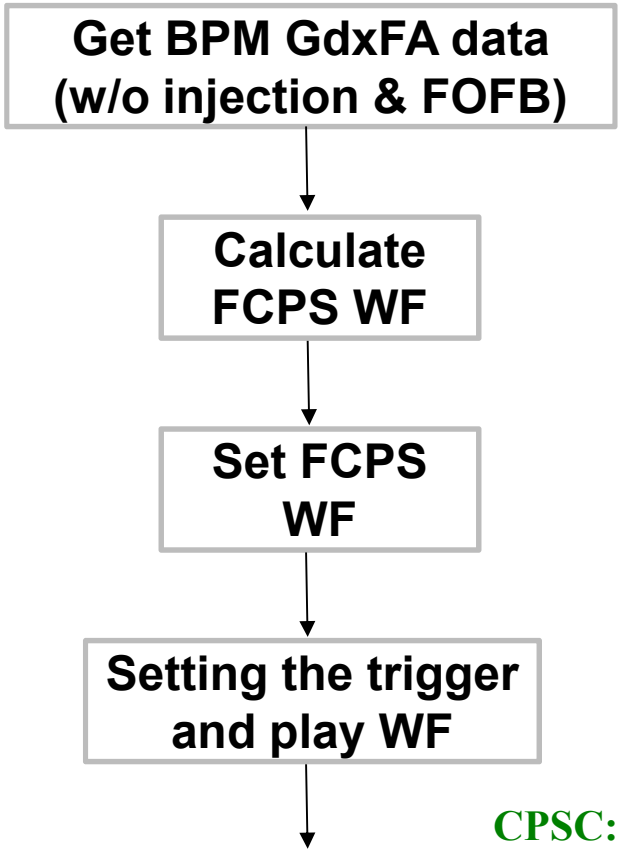
Source hunting for 60 Hz



$-A*\cos(2\pi*60*t+\Phi)$

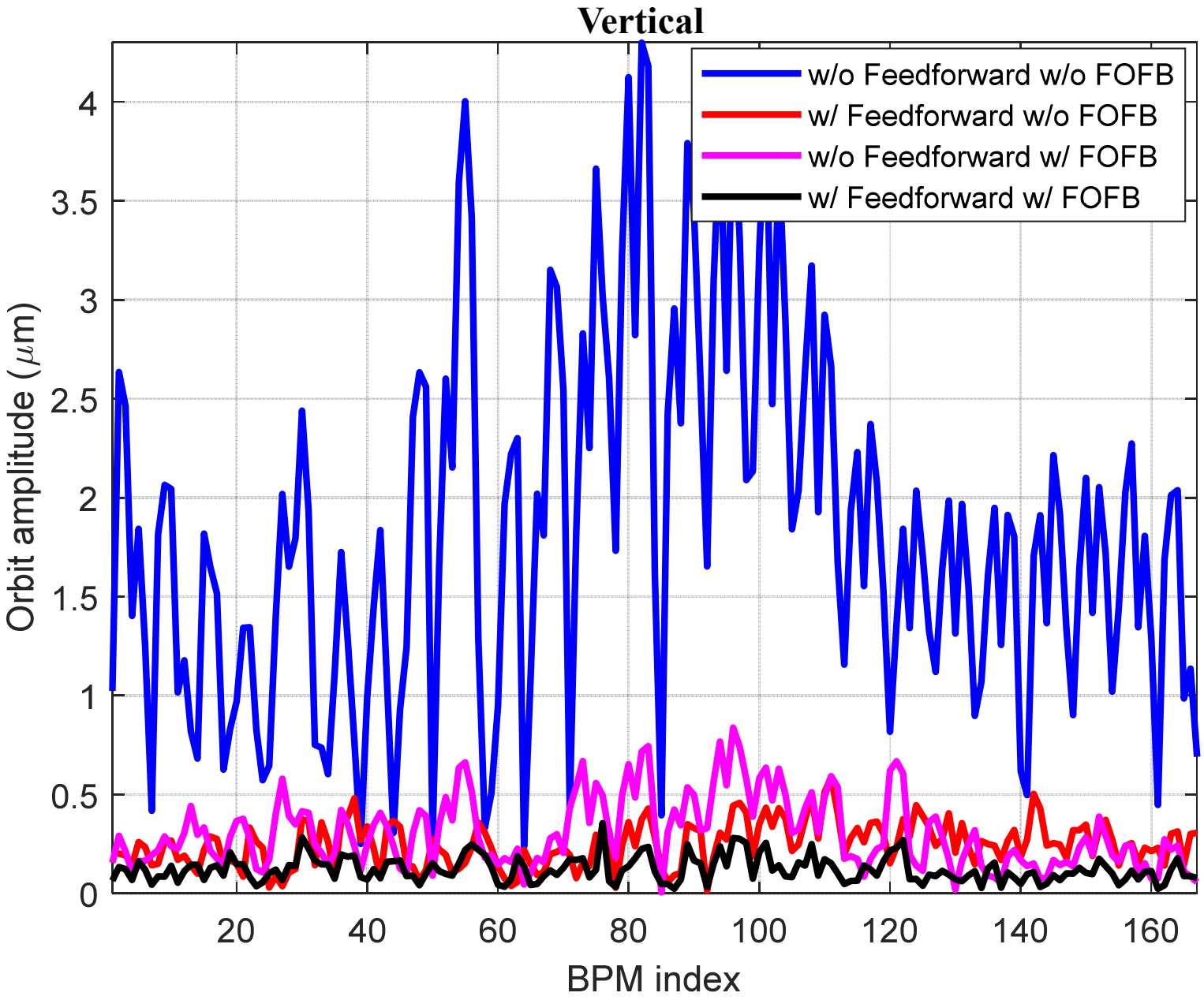
Feedforward correcting for 60 Hz beam motion

- 4*24 fast correctors are used.
- CPSC : Current output = slow setting + FOFB + WF
- Trigger locked with the phase of the mains.

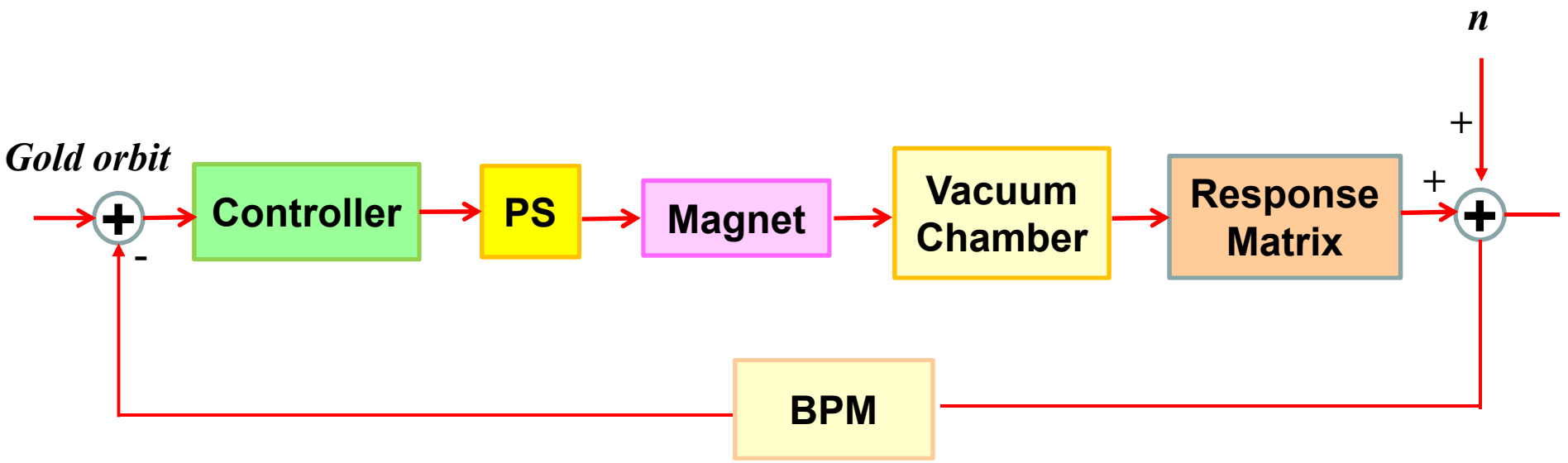


CPSC: corrector power supply controller

Feedforward and feedback to correct 60 Hz beam motion

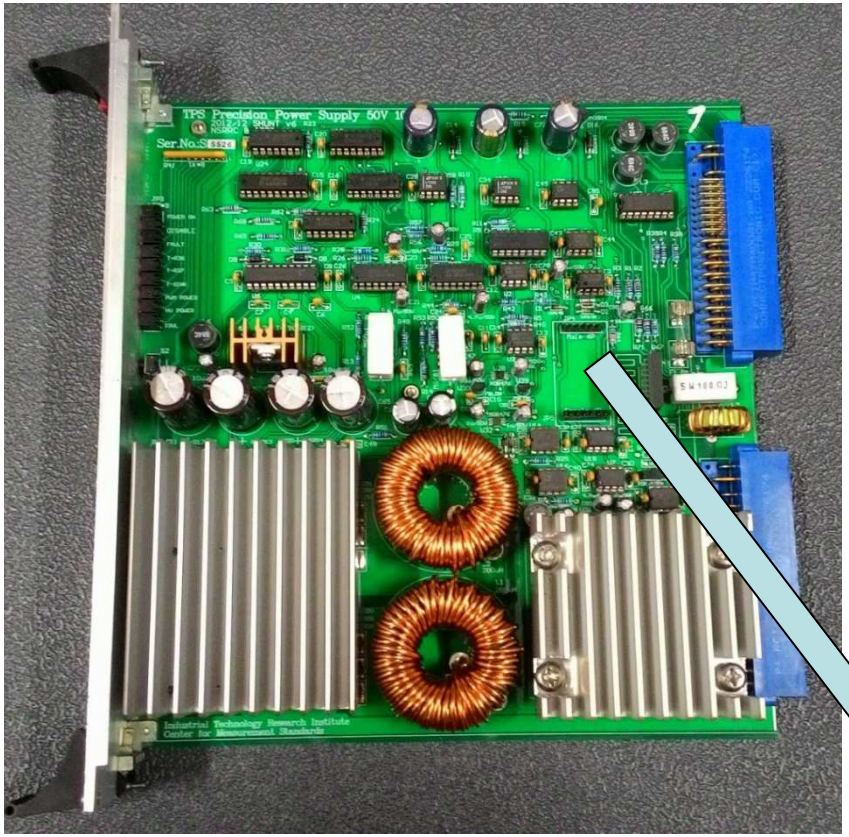


FOFB diagram



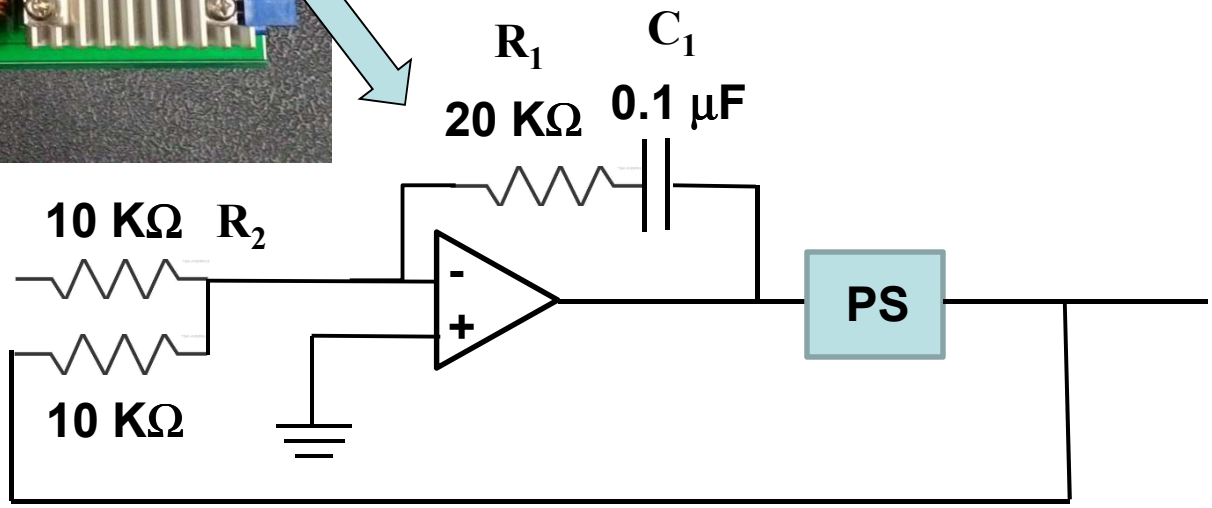
Key components: Power supply (PS)
Magnet
Vacuum chamber
Beam position monitor (BPM)
Controller (BPM platform, corrector power supply controller)

Controller of the fast corrector power supply

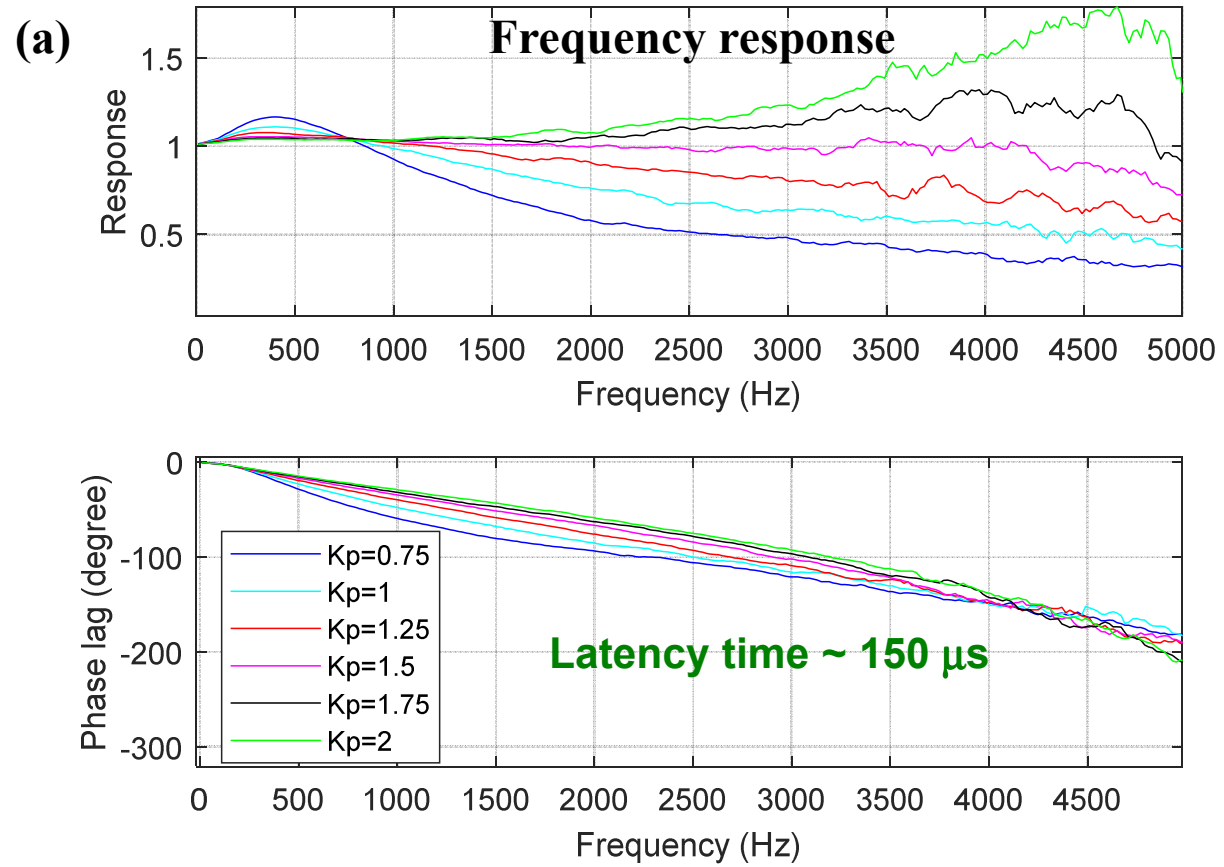


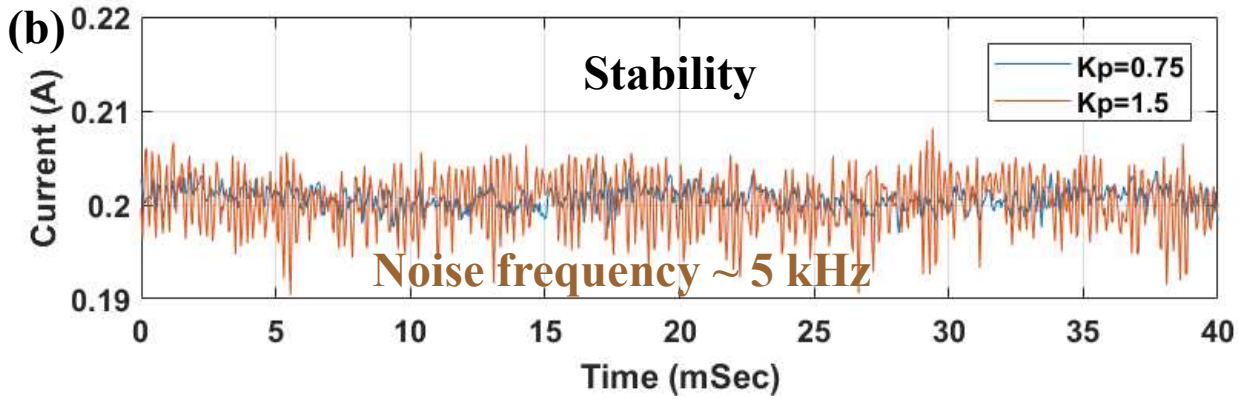
$K_p = R_1/R_2$

$K_i = 1/(C_1 * R_1)$

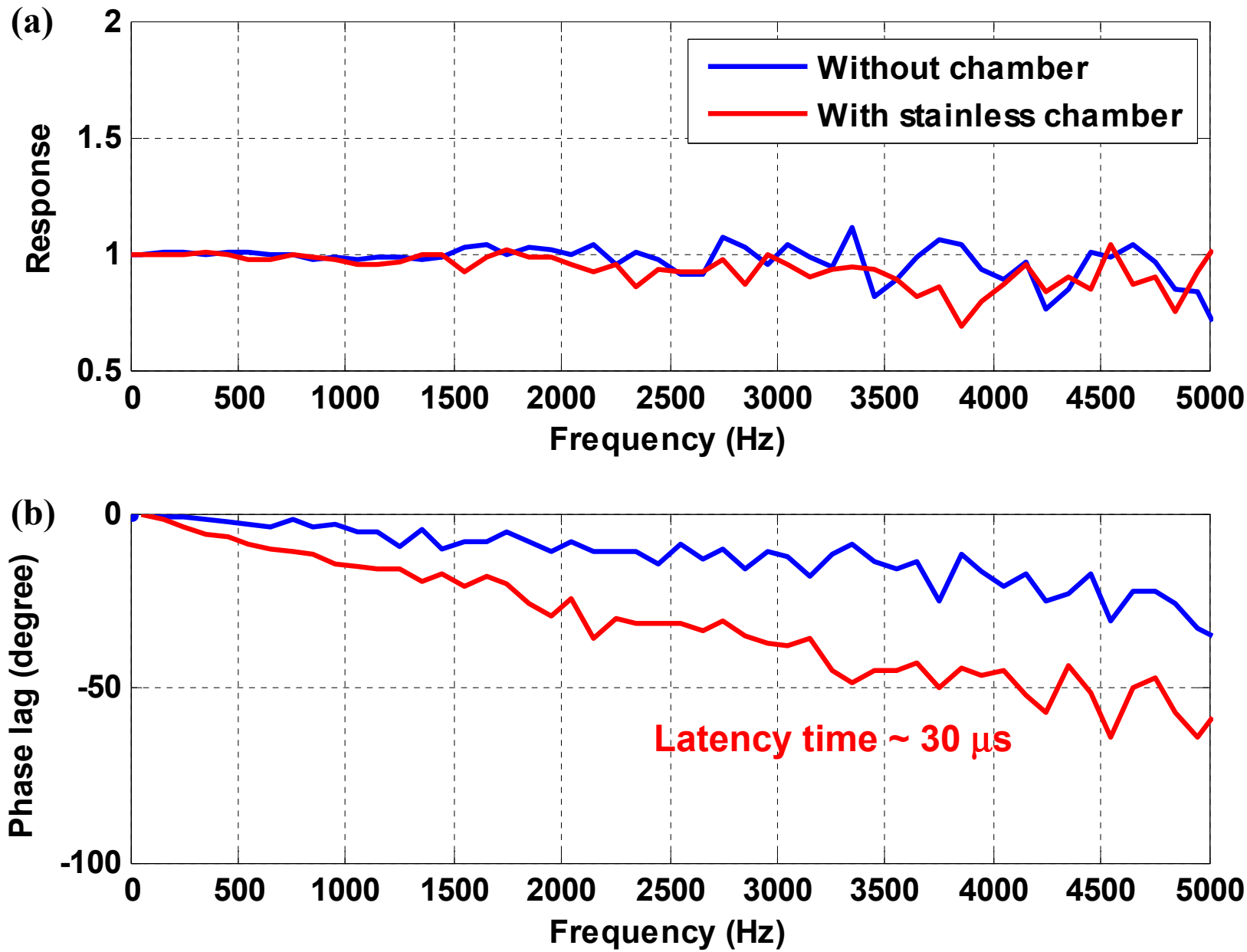


The performance of power supply at different K_p



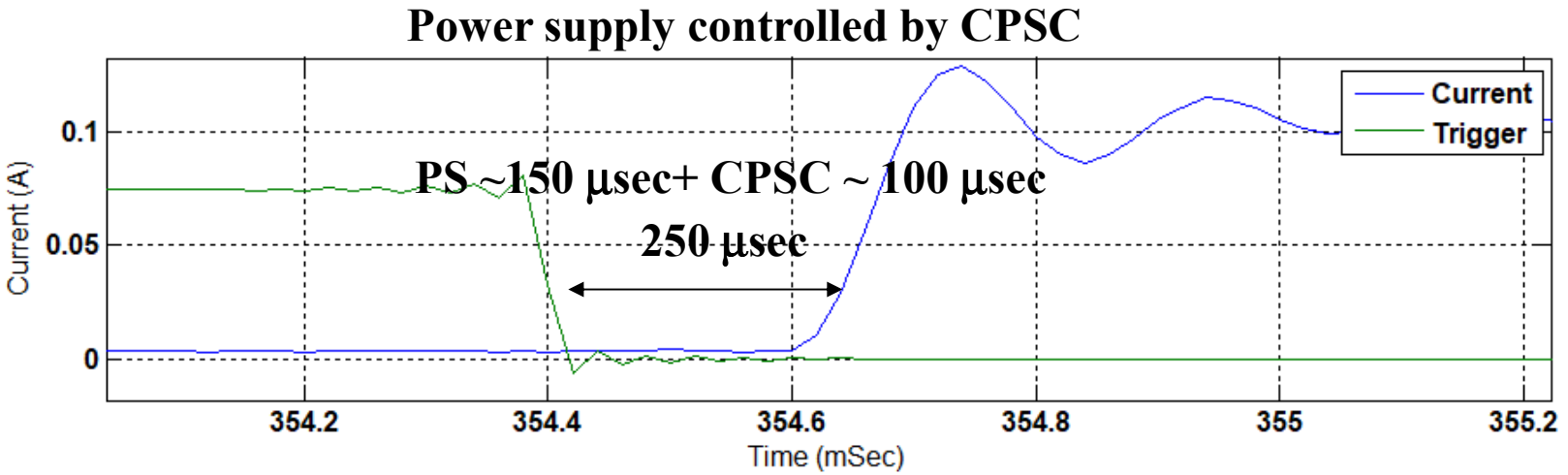


The performance of magnet & vacuum chamber

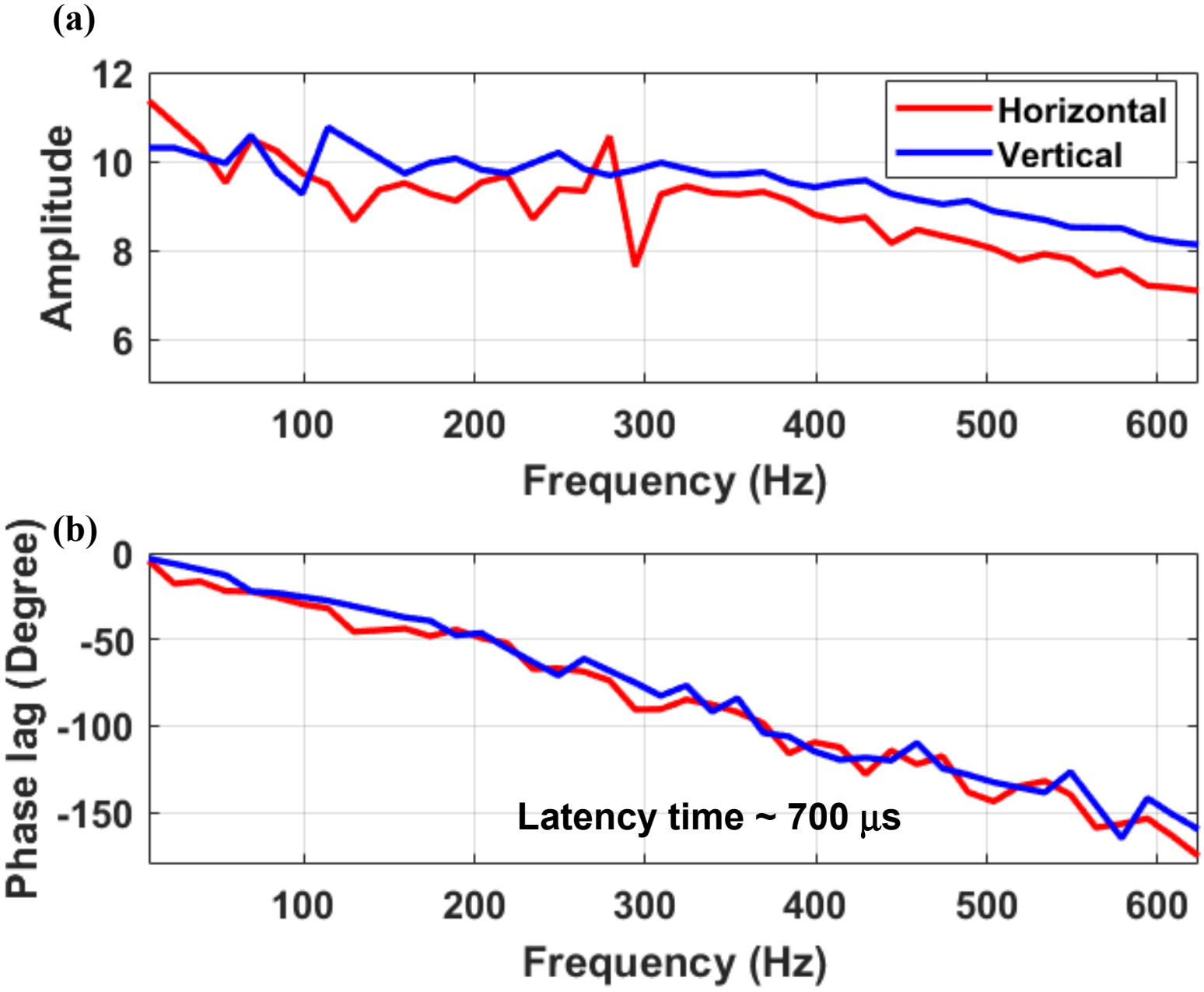


Performance of BPM electronics & CPSC

- From the manual of the BPM electronics, the latency time is ~ 300 μsec with 2 kHz bandwidth.
- The latency time of the grouping ~ 100 μsec.
- The latency time of the corrector power supply controller (CPSC) is ~ 100 μsec.
- The latency time of the corrector power supply ~ 150 μsec.
- The latency time of vacuum chamber ~ 30 μsec.



Beam response to the fast corrector power supply



Summary

- 7 BPMs and 4 correctors are used for fast orbit feedback (FOFB) in each cell.
- The bandwidth of FOFB is ~ 300 Hz in both horizontal and vertical planes now.
- RF adjustment is used to compensate the circumference change due to the earth tide and temperature variation.
- Feedforward are used to depress the 60 Hz beam motion.
- The total latency time of the components should be the main issue to limit the bandwidth of FOFB.
- Increasing the correcting rate of FOFB is ongoing to try to improve the bandwidth of FOFB.

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Thanks for your kind attention.