Analysis of ATF EXT/FF Orbit Intensity dependence (Data of 2014.11.18)

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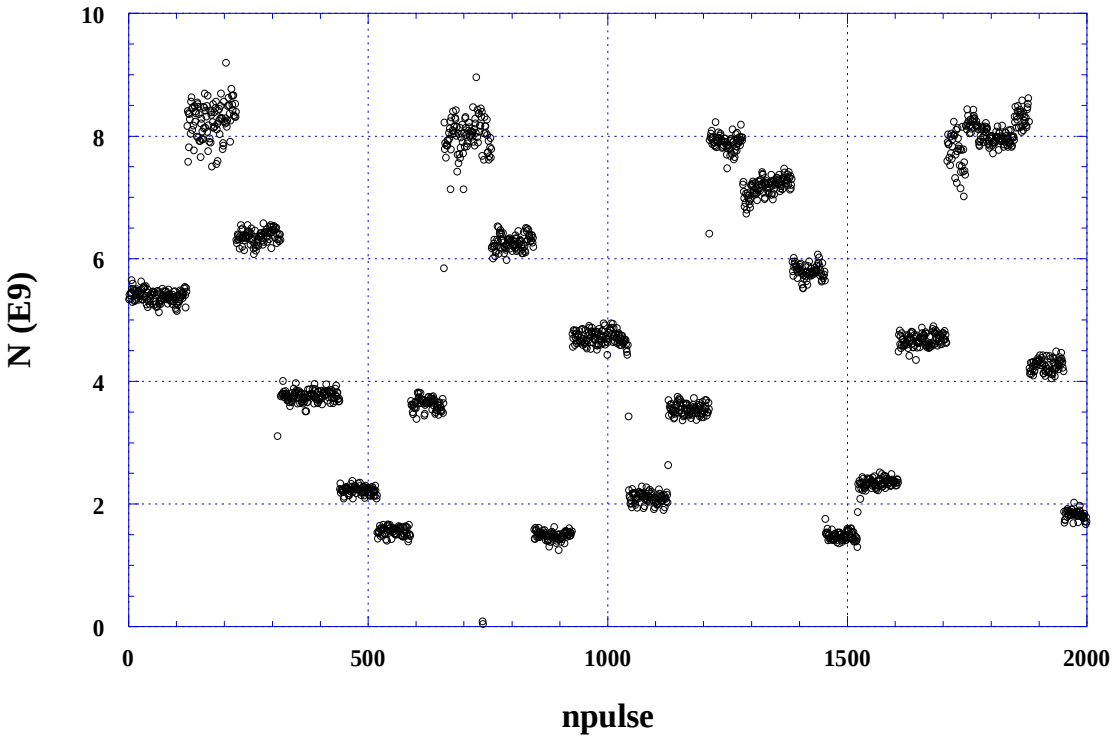
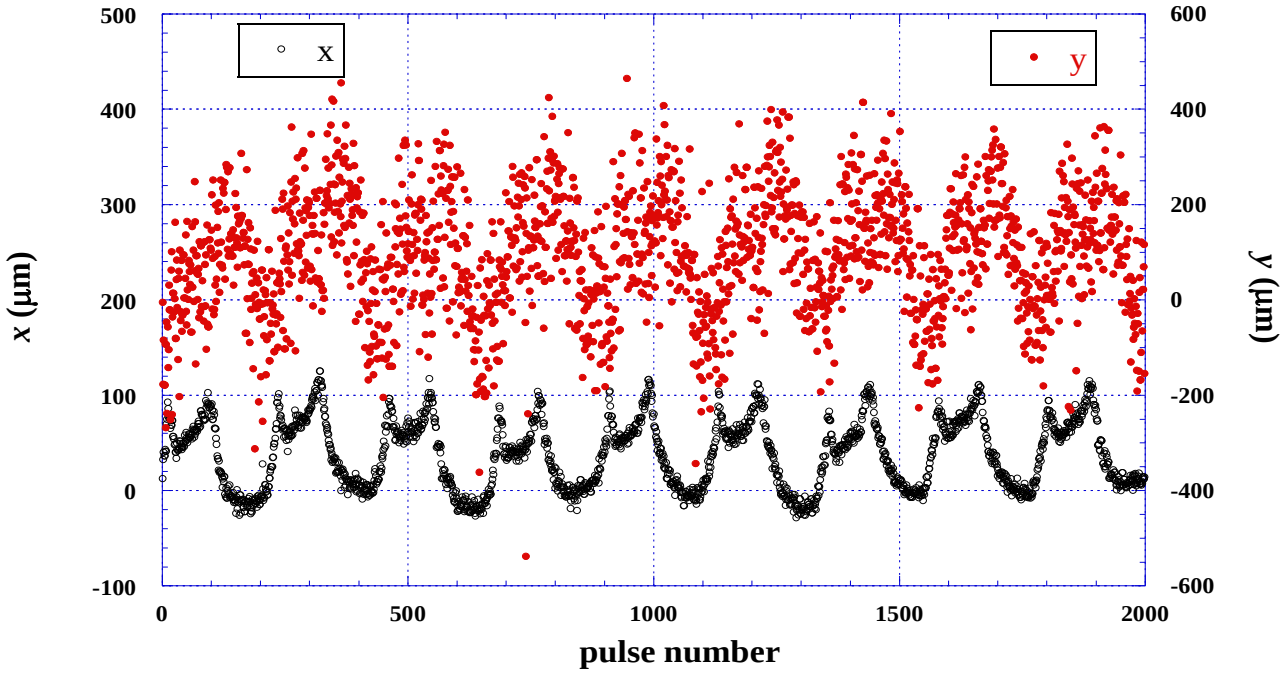
Data taking

- Data taken in November 18 (2014) swing shift.
- After IP beam size tuning, observing modulation with IPBSM 174 degree mode. (10x1 optics)
  - Positions of the BPM reference cavity and OTR2 chanber were optimized.
- Data of EXT/FF BPM are saved with several conditions. (See Log Note)
- This report used data of
  - One file (2000 pulses) with bunch intensity intentionally changed by hand.
  - 3 files (1000 pulses), each is for fixed bunch intensity setting. (N~8.5E9, 4.9E9, 1.8E9)

Intensity vs. pulse number

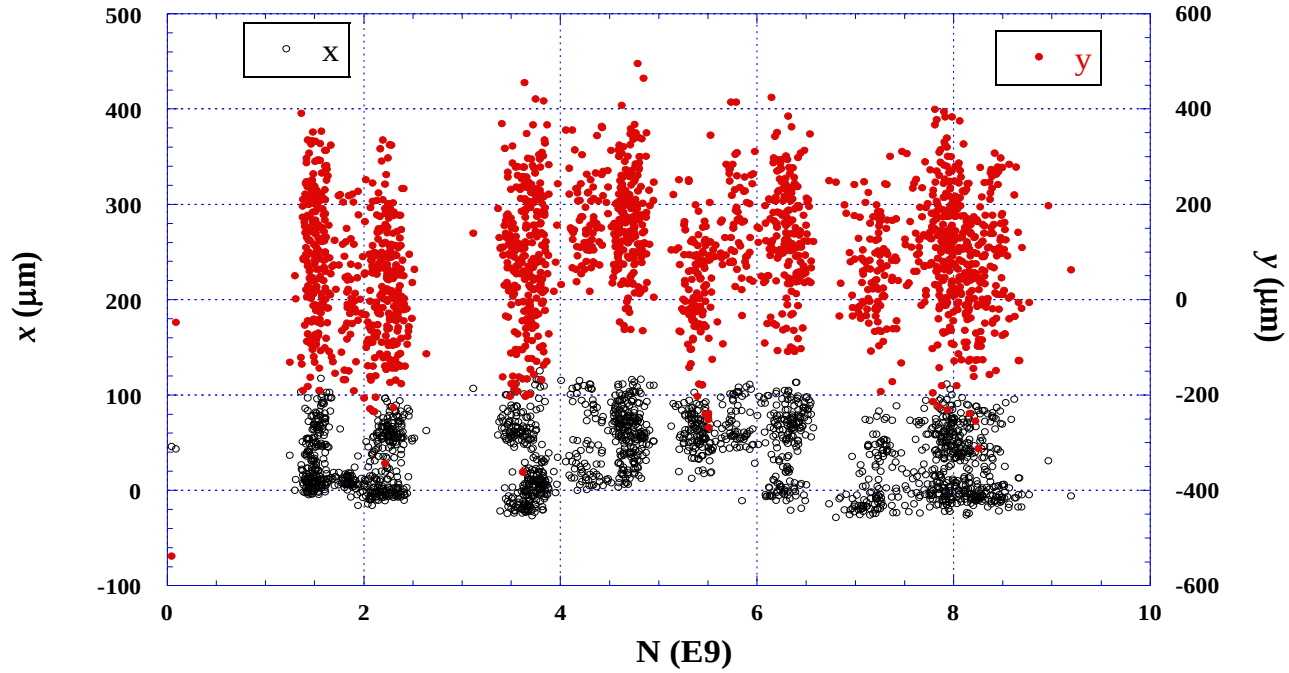


BPM reading vs, pulse number (MQD10BFF: Large beta_y)



In horizontal, drift is larger compare with pulse to pulse jitter.
In vertical, pulse to pulse jitter is more significant.
(It may be only in this particular case. (?))

Intensity dependence?



No clear intensity dependence can be seen from direct correlation plot.
→ more detailed analysis

Analysis using SVD

$$M = \begin{pmatrix} \text{BPM1x - pulse1} & \text{BPM1y - pulse1} & \text{BPM2x - pulse1} & \cdots\cdots \\ \text{BPM1x - pulse2} & \text{BPM1y - pulse2} & \text{BPM2x - pulse2} & \cdots\cdots \\ \text{BPM1x - pulse3} & \text{BPM1y - pulse3} & \text{BPM2x - pulse3} & \cdots\cdots \\ \vdots & \vdots & \vdots & \vdots\cdots \end{pmatrix}$$

pulse

monitor

(Average is subtracted for each monitor)
(Data far from average (>5-sigma) removed. BPM noise, etc.)

$$M = UWV$$

W: Diagonal matrix of singular values

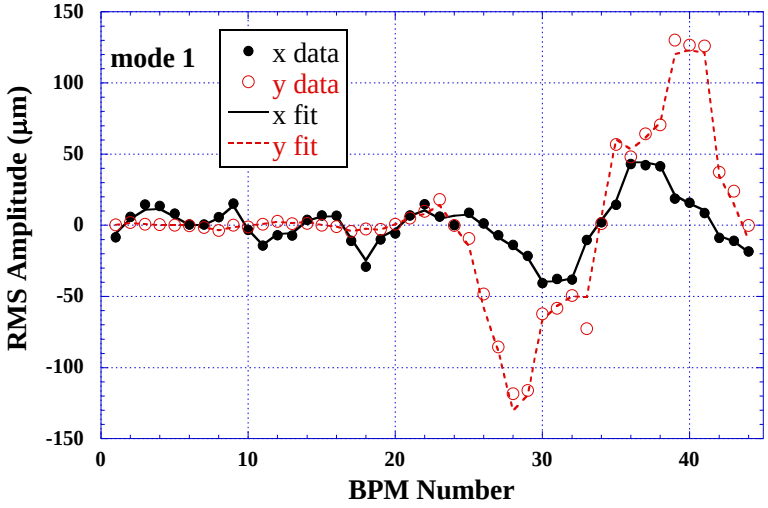
$$W = \begin{pmatrix} w_1 & 0 & 0 & \cdots \\ 0 & w_2 & 0 & \cdots \\ 0 & 0 & w_3 & \cdots \\ \vdots & \vdots & \vdots & \vdots\cdots \end{pmatrix}$$

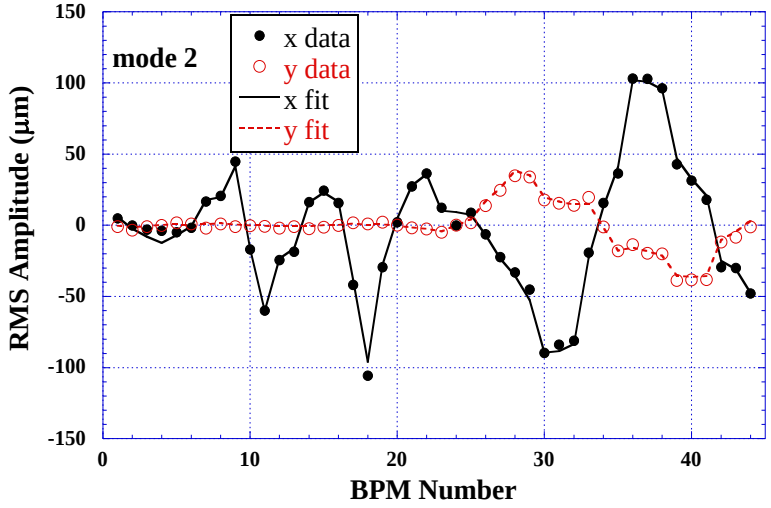
U_ij represents amplitude of mode *j* in pulse *i*

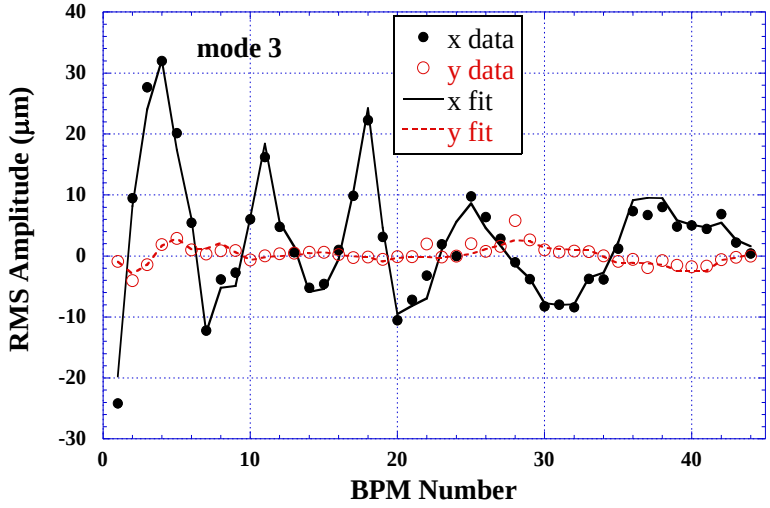
V_kl represents response of monitor *l* to mode *k*

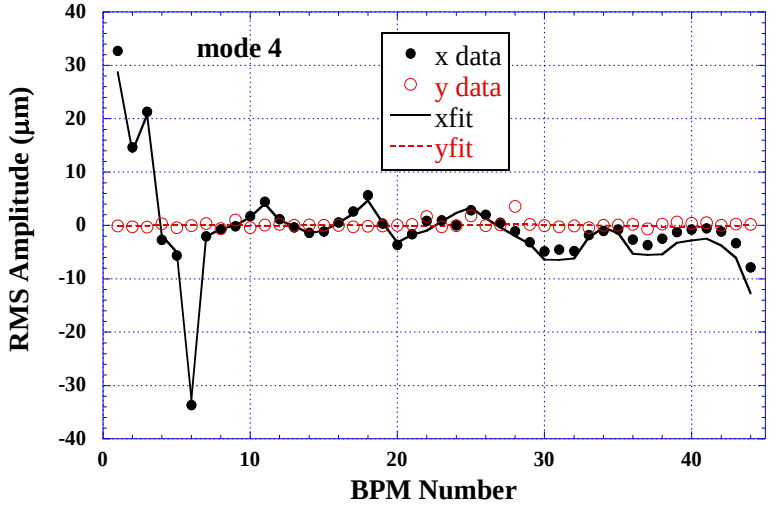
Result of SVD: First 4 modes vs. BPM x,y

Circles: amplitude at each BPM, Lines: Fitting by injection orbit + dispersion (model)



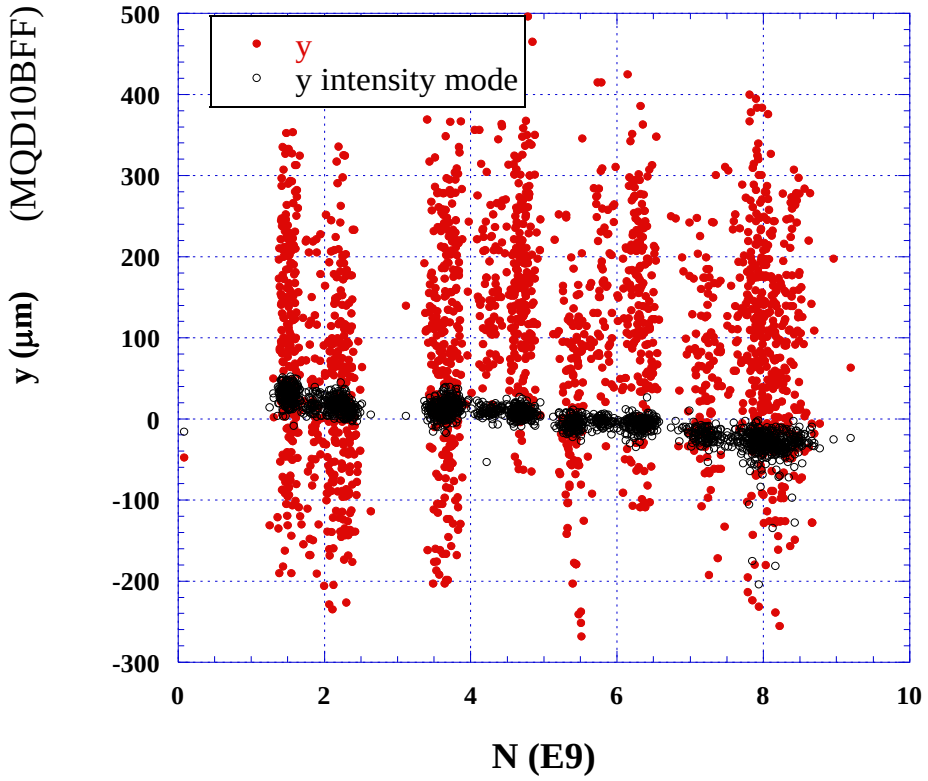






Result of SVD: mode 5, intensity dependent mode

Measured y and y of mode 5 at MQD10BFF vs. Intensity



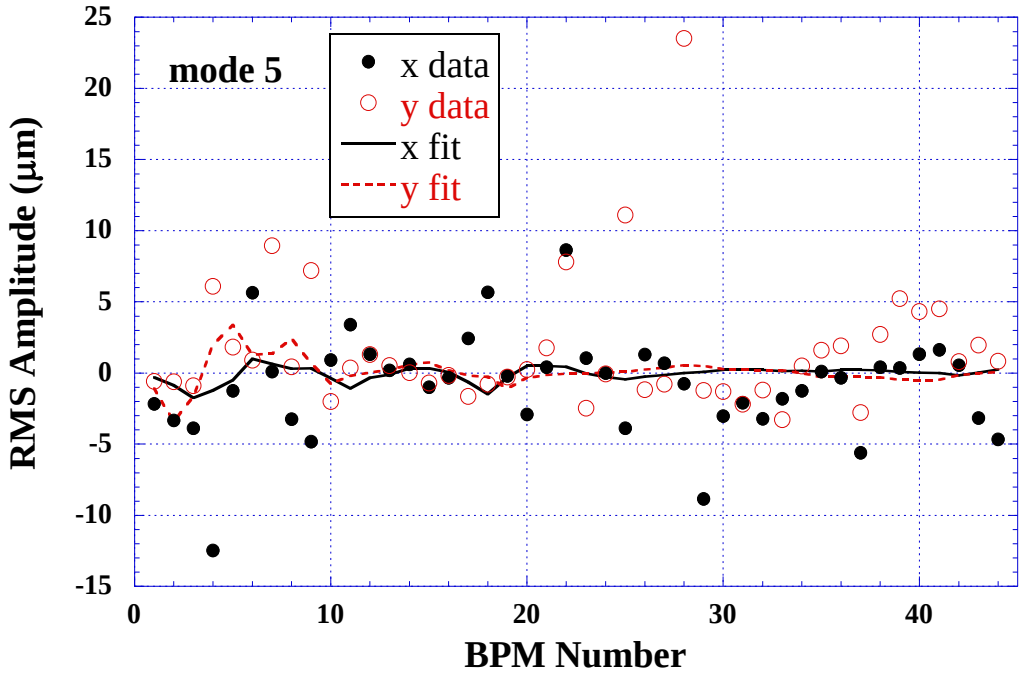
Red: y

Black: offset and jitter of other modes subtracted

Correlation = 0.83

Result of SVD: mode 5, intensity dependent mode

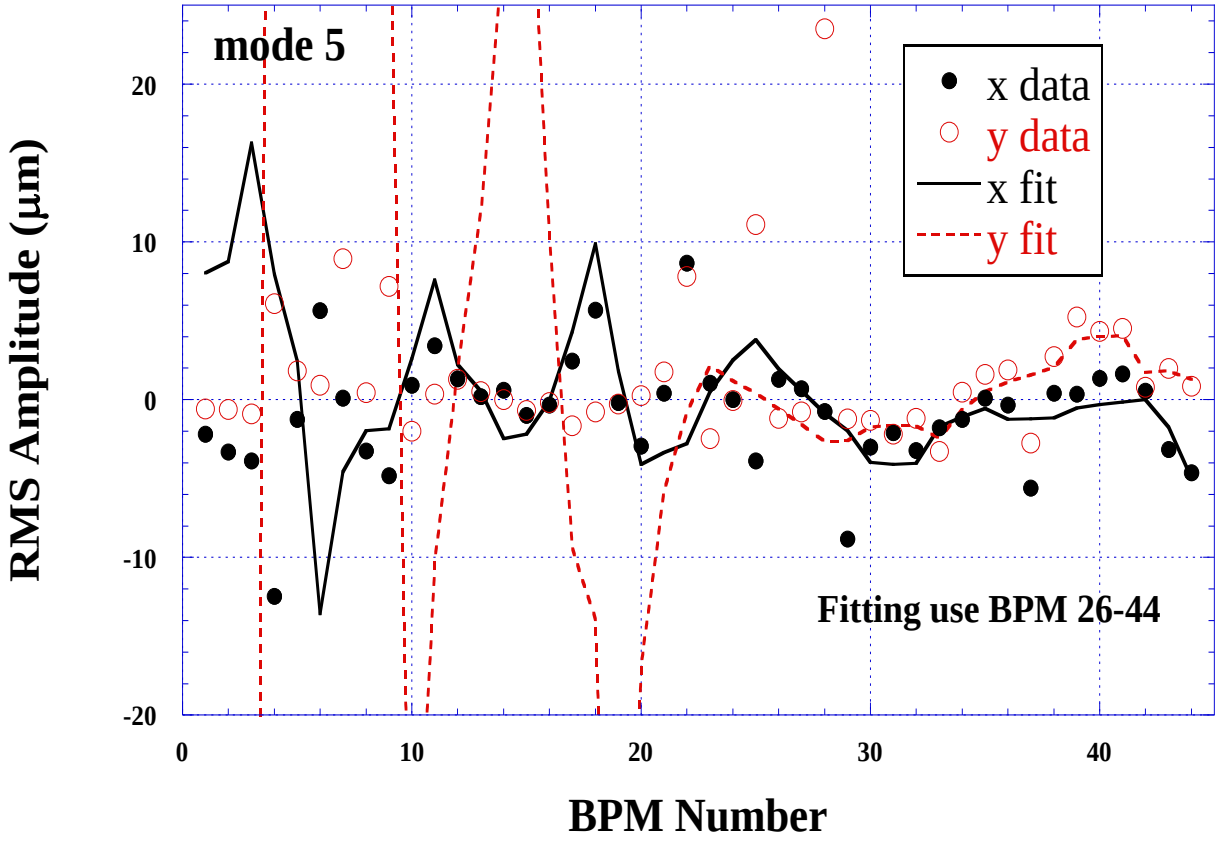
Circles: amplitude at each BPM, Lines: Fitting by injection orbit + dispersion (model)



This mode is not from injection.
Created in the middle of the beam line?
BPM calibration error depending on intensity?
Study to be continued.

Max. 24 um at QD10BFF
: < 0.1 of beam size
for intensity fluctuation of
2.3E9 (standard dev.)

Fit only downstream part BPM intensity dependent mode



May be real orbit, may not be. It is hard to decide from these data.

Summary on intensity dependence of orbit

- One intensity dependent mode was found from SVD.
  - Not from the beginning of EXT line
  - Created in the middle of the beam line? (wakefield source there)
  - Or may be just BPM calibration error depending on intensity?

- It is difficult to tell if the dependence affected measured beam size at IP.

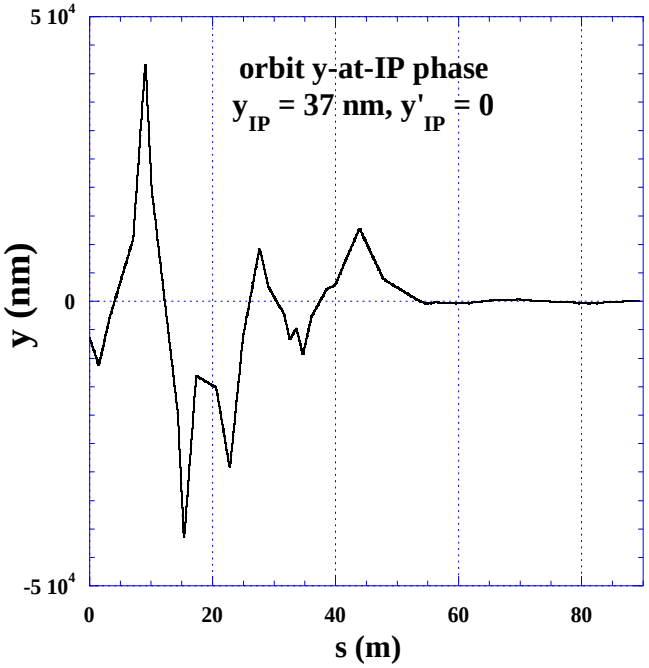
Effect to IP position of first 10 modes

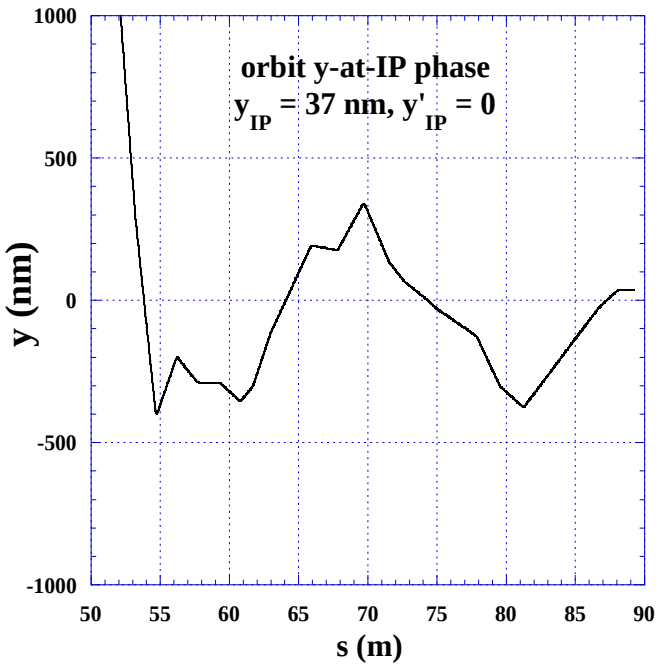
- From response of BPM to each mode, contribution to jitter at IP can be evaluated from the fitting. (Extrapolation to IP.)

Mode	Vertical Jitter at IP (nm)
1 (injection)	16.9
2 (injection)	5.8
3 (injection)	3.0
4 (dispersion)	0.1
5 (intensity)	3.2
6	0.0
7	2.1
8	1.9
9 (injection)	6.1
10	2.9
total	19.9

All BPMs in EXT-FF used

NOTE: BPMs in downstream FF line is not so sensitive to Position-at-IP phase orbit





Using IPBPM will be probably necessary for reliable estimation of orbit difference induced in the FF line.

SUMMARY

- Data of EXT/FF BPM taken in November 18 (2014) swing shift were analyzed using Singular Value Decomposition method.
- One intensity dependent mode was found.
  - No significant intensity dependence of injection orbit observed.
  - No evidence of intensity dependent orbit induced in beam line.
    - But, it cannot be excluded.
- Using IPBPM is simple and essential for reliable estimation of position jitter at IP and intensity dependence of position at IP.