ATF2 Critical Overview

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Beam Dynamics (ATF2+MDI)
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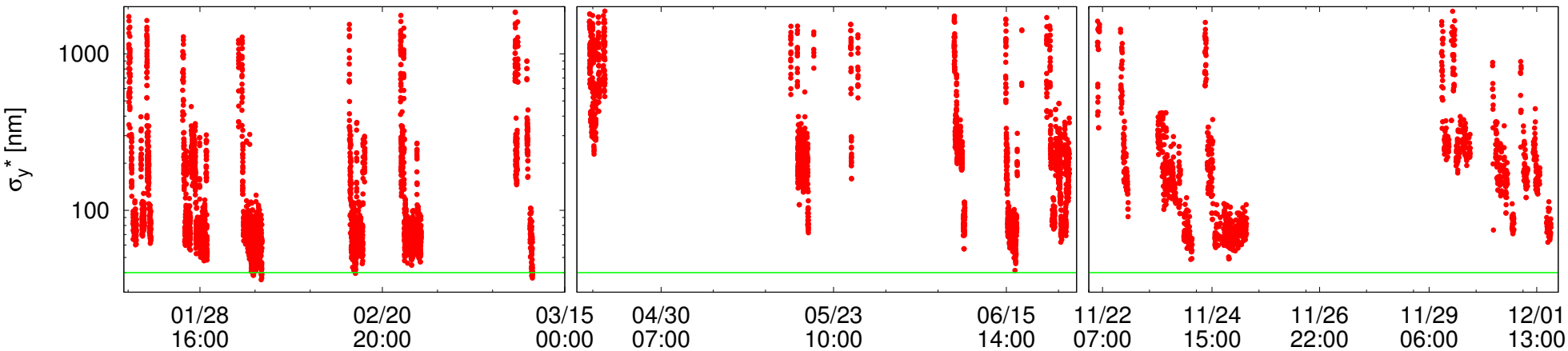
Acknowledgements: **M. Patecki, K. Kubo**

Outline

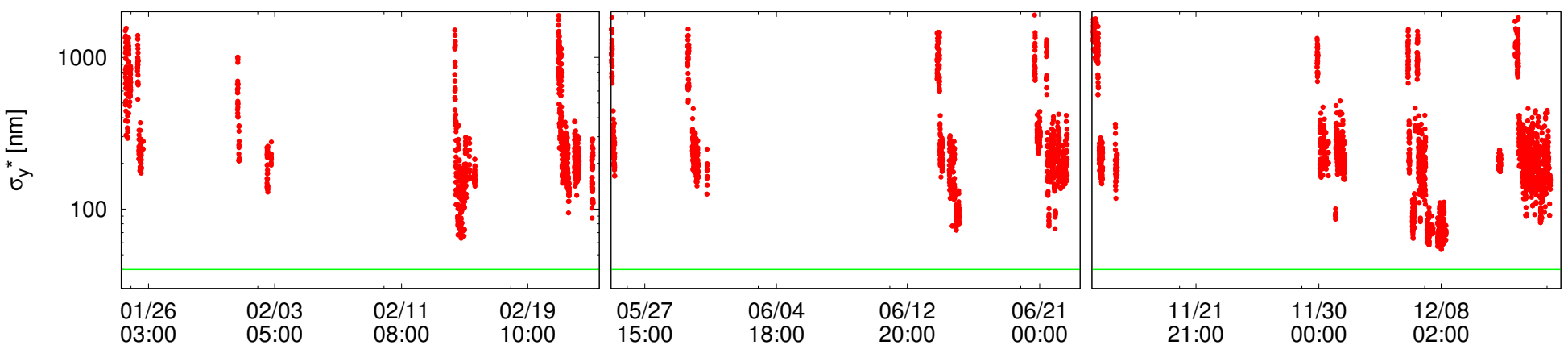
1. Operation Overview
2. Tuning Procedure
   - FF Matching
   - Jitter Orbit
   - Beam Size Error

ATF2 Operation 2016-2017

- 2016



- 2017



2016-2017 Run Operations under Study

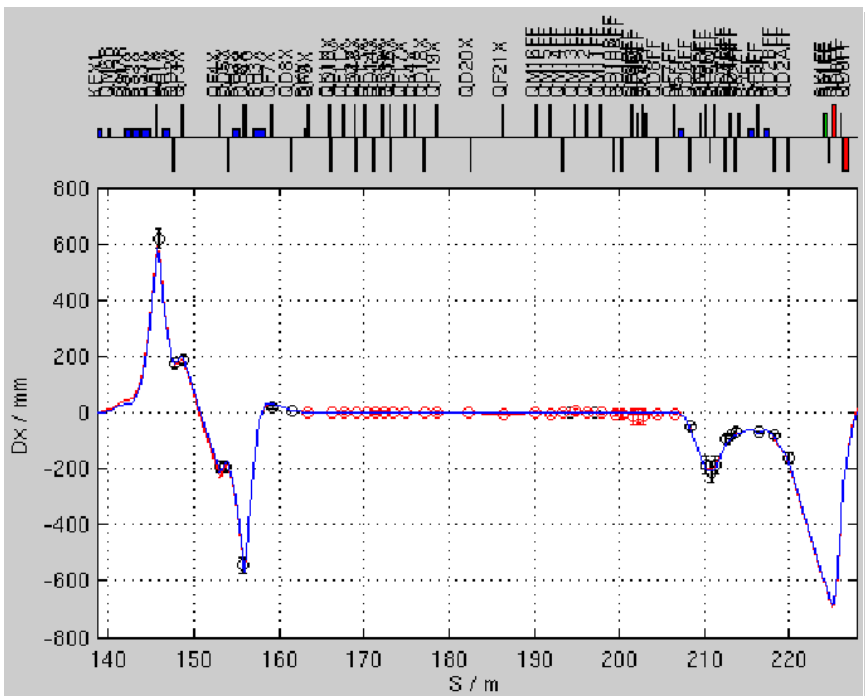
Run	Tuning Procedure	Lattice β_x^*=4mm β_y^*=0.1mm	Minimum σ_y^* [nm]	Notes
16/02/05	Standard	$10\beta_x 1\beta_y$	47±6	
16/02/24	Standard	$10\beta_x 1\beta_y$	65±8	
16/03/10	Standard	$10\beta_x 1\beta_y$	41±2	2nd Bunch
16/05/20	Standard	$10\beta_x 1\beta_y$	75±10	
16/06/16	Standard	$10\beta_x 1\beta_y$	69±5	
16/11/24	Standard	$10\beta_x 1\beta_y$	60±5	
16/12/01	Standard	$10\beta_x 1\beta_y$	74±9	
17/02/15	Standard	$10\beta_x 1\beta_y$	82±14	
17/06/15 *	Standard	$10\beta_x 1\beta_y$	89±6	
17/12/08	Standard	$10\beta_x 1\beta_y$	63±4	Sext align.
17/12/14	Standard	$20\beta_x 0.25\beta_y$	97±6	not applied

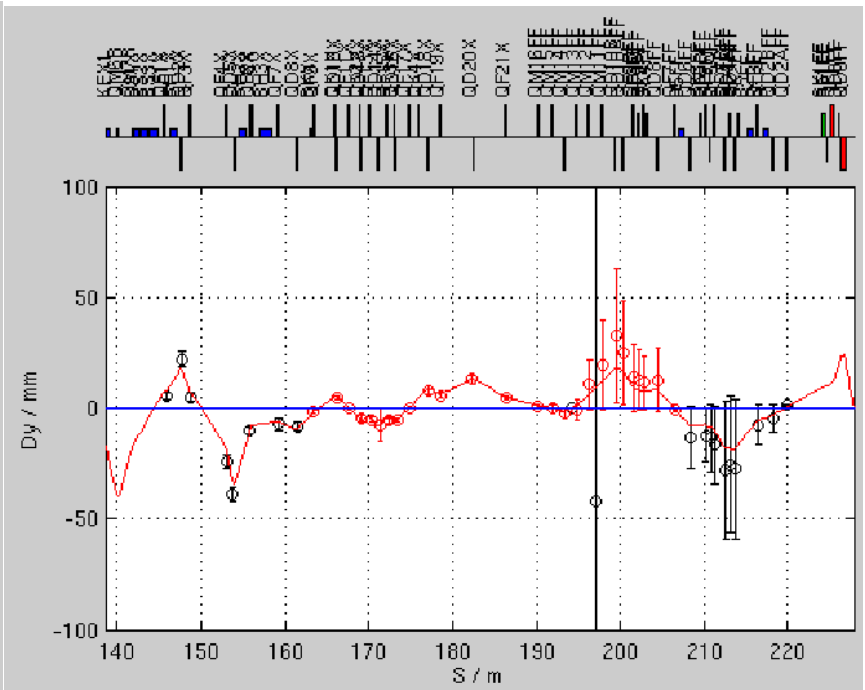
*mOTR non-operational

Standard Tuning Procedure

Dispersion + Coupling + IP Twiss + Sext Alignment IP Knobs + BSM Tuning

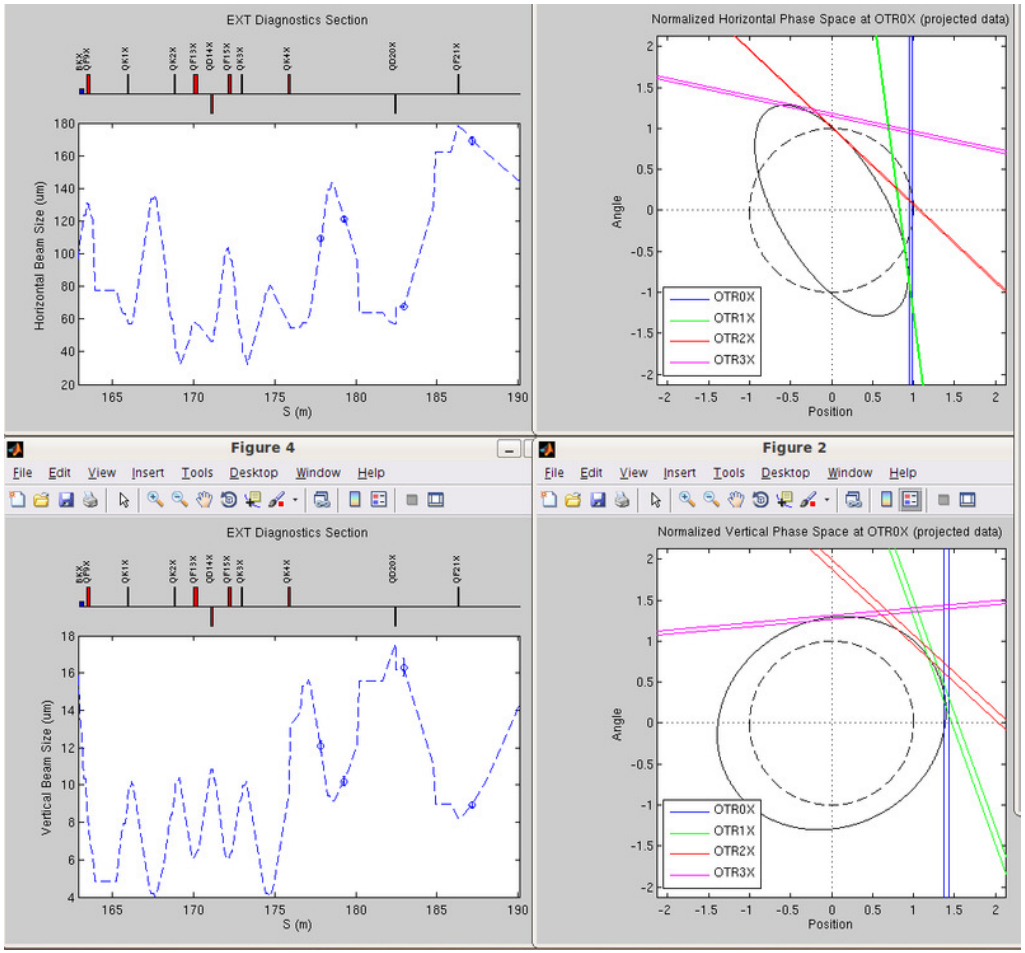
- Dispersion correction every 6-8h by using the Σ-knob





Emittance Measurement and Coupling Correction

- Coupling correction by optimization of skew quads



- Twiss measurement $\Rightarrow$ should be exploited for matching

Final Focus Matching

- mOTR provides a Twiss measurement @ OTRs
- Quadrupoles QD18X, QF19X, QD20X, QF21X + QMFFs can be rematch to IP Twiss
- Preserving the following constraints

- $\beta^*_{x,y}$
- $\alpha^*_{x,y}$=0
- $\eta^*_{x,y}$=0
- $\alpha^{\mathrm{MFB1FF}}_{x,y}$=0
- $\alpha^{\mathrm{MFB2FF}}_{x,y}$=0

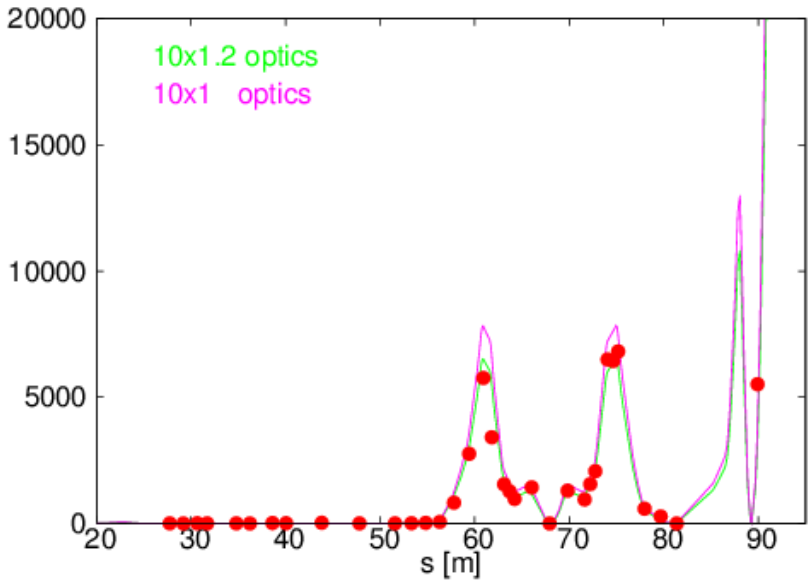
- $\Delta\phi_{MFB1FF\rightarrow IP} = n\frac{\pi}{2}$
- $\Delta\phi_{MFB2FF\rightarrow IP} = n\frac{\pi}{2}$
- $\Delta\phi_{ZH1FF\rightarrow IP} = n\frac{\pi}{2}$
- $\Delta\phi_{ZV1FF\rightarrow IP} = n\frac{\pi}{2}$

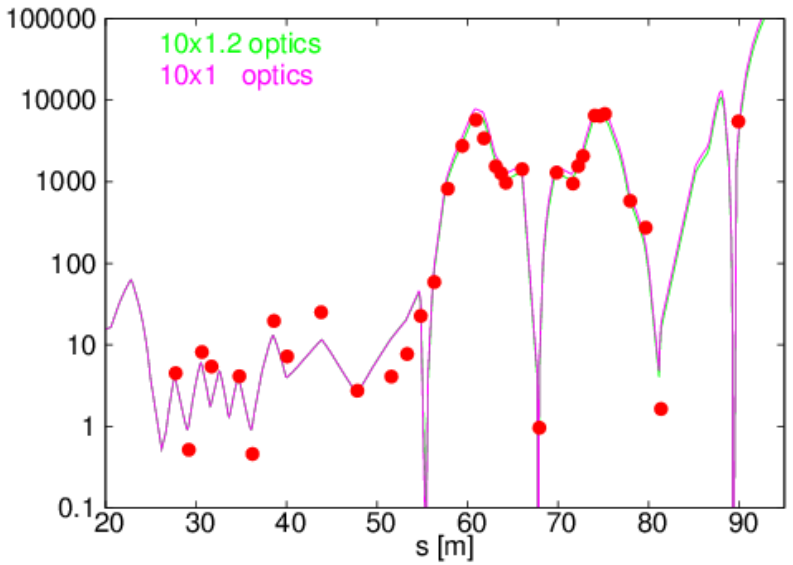
Successful attempt in Feb 2015 †

† https://agenda.linearcollider.org/event/6283/contributions/29303/attachments/24296/37607/Extraction_Status.pdf

IP Twiss Measurement

- σ_y^* (wire scanner or BSM) when scanning α-knob
- Alternative method by RND jitter sources
  - also provides information along the beamline



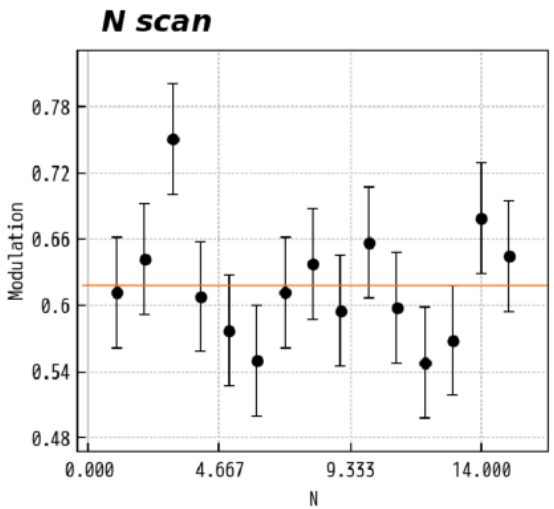


Data taken 2016/02/02 - Day Shift ‡

‡http://atf.kek.jp/twiki/bin/view/ATFlogbook/Log20160202d

IP Tuning

- Beam (various aberrations to be corrected)
- Shintake Monitor
  - various modes, laser paths, timings, waist ....
- Time consuming process
  - critical for dynamic systems
- Measurement Error
  - Correction provided by knobs is comparable to Shintake measurement error



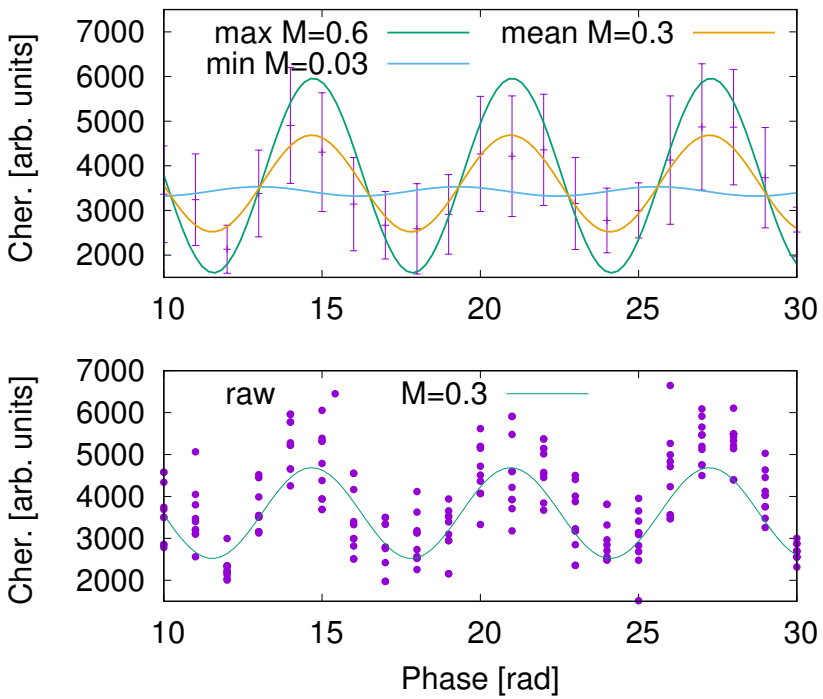
Similar error bars are obtained in other modes

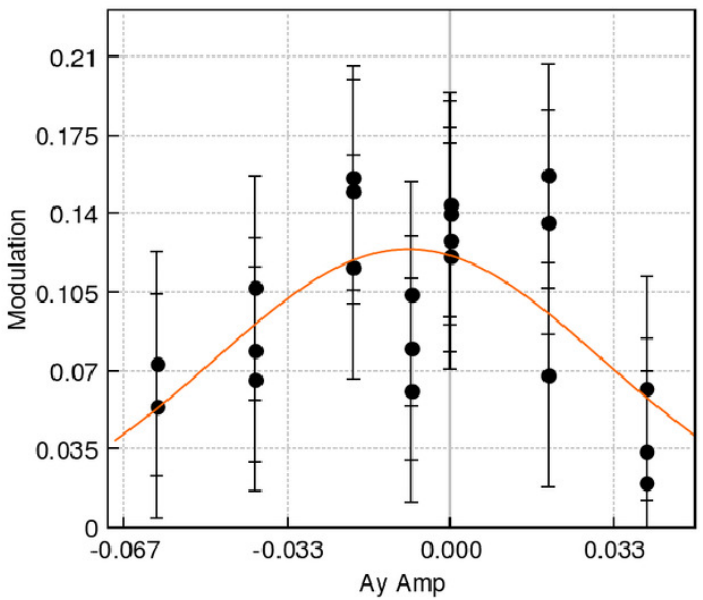
§

§Data taken 2016/02/05 - 174deg mode - Day Shift

IPBSM Error

- IPBSM modulation errors larger than few percent impact the tuning dramatically
- $Av * (1.0 + M * cos(x + Phi))$ is fitted function on (raw or statistical data)

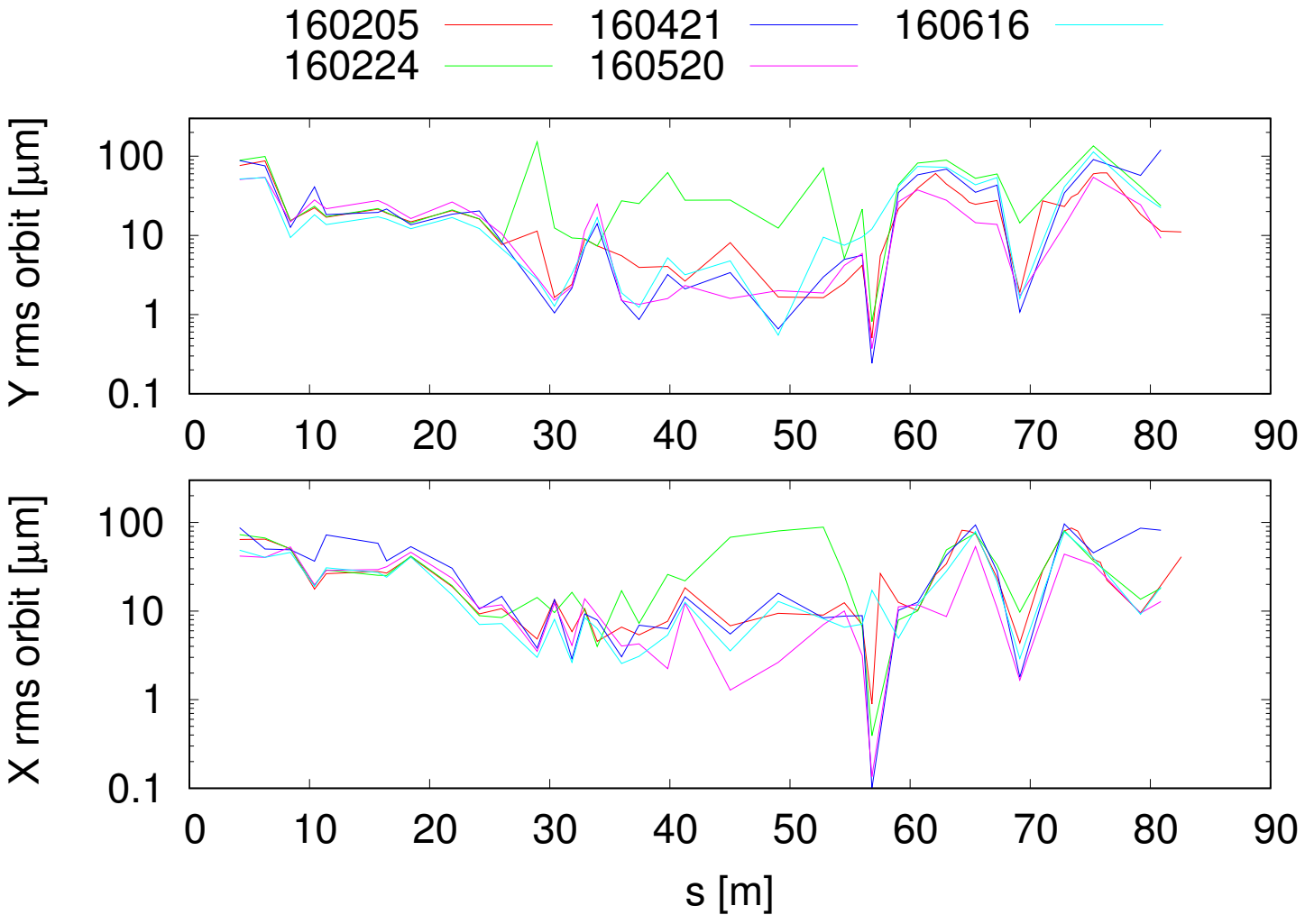




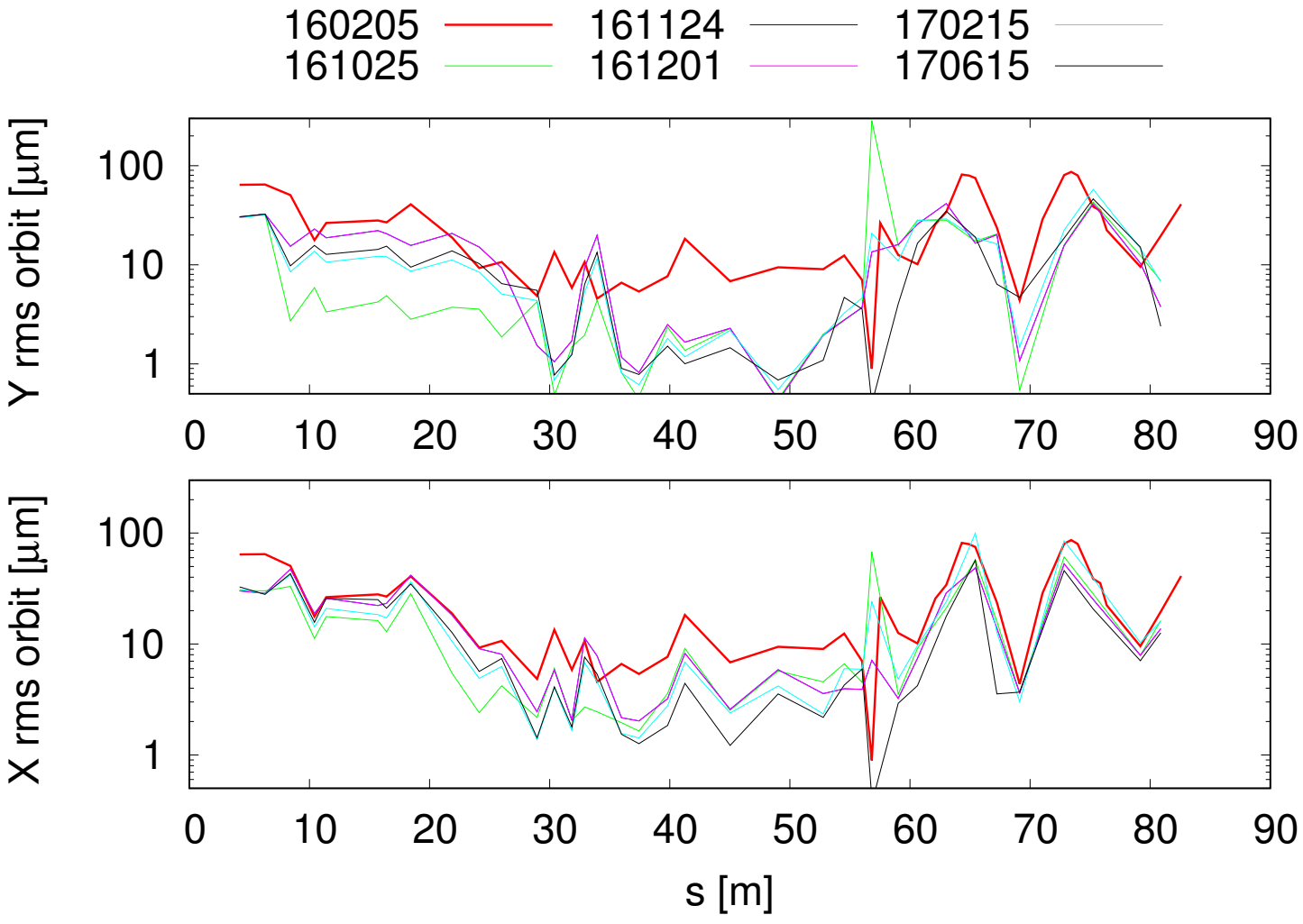
- It is crucial to minimize it as much as possible

¶Data taken 2017/12/14 - 174deg mode - Day Shift

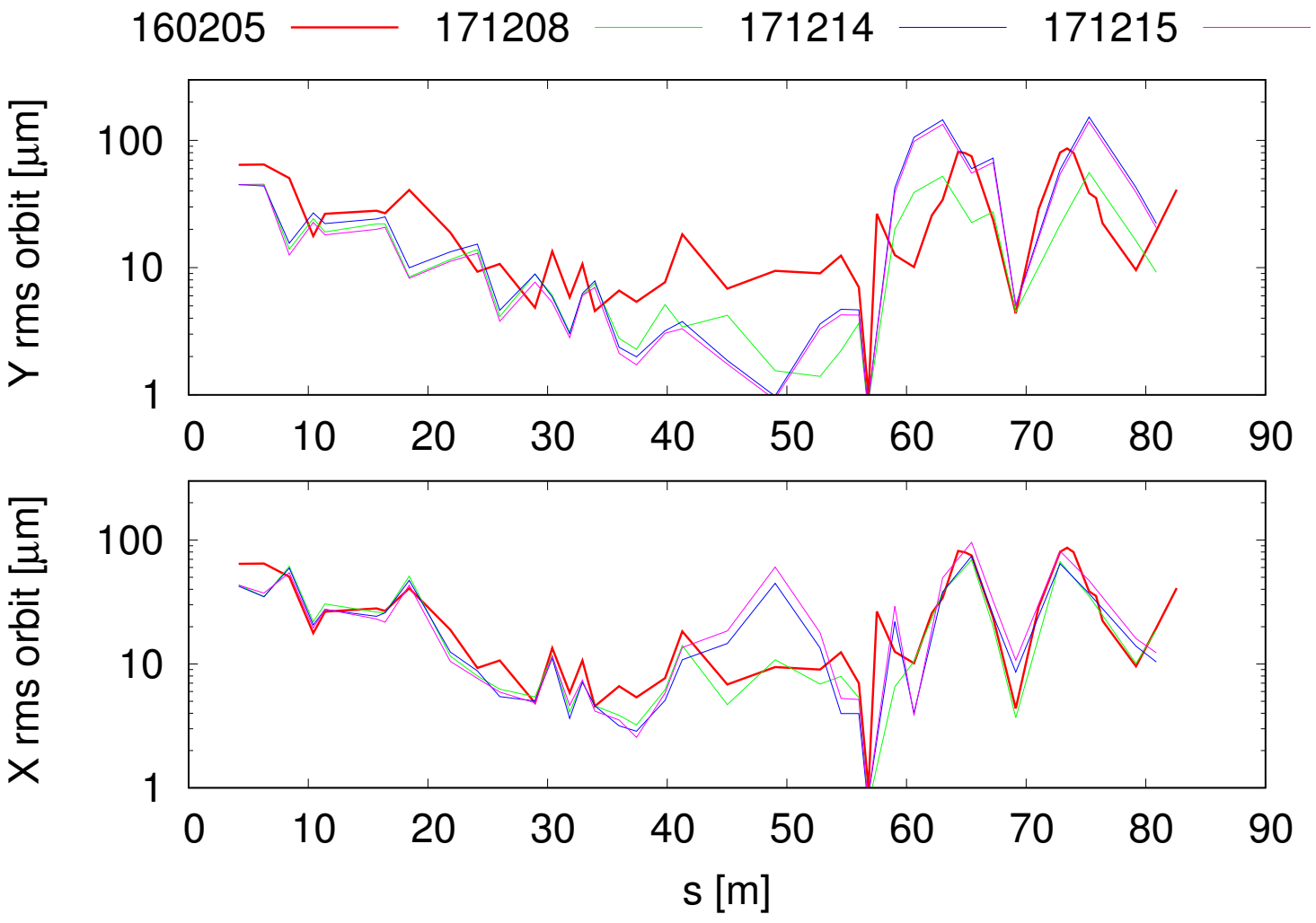
Jitter Conditions I



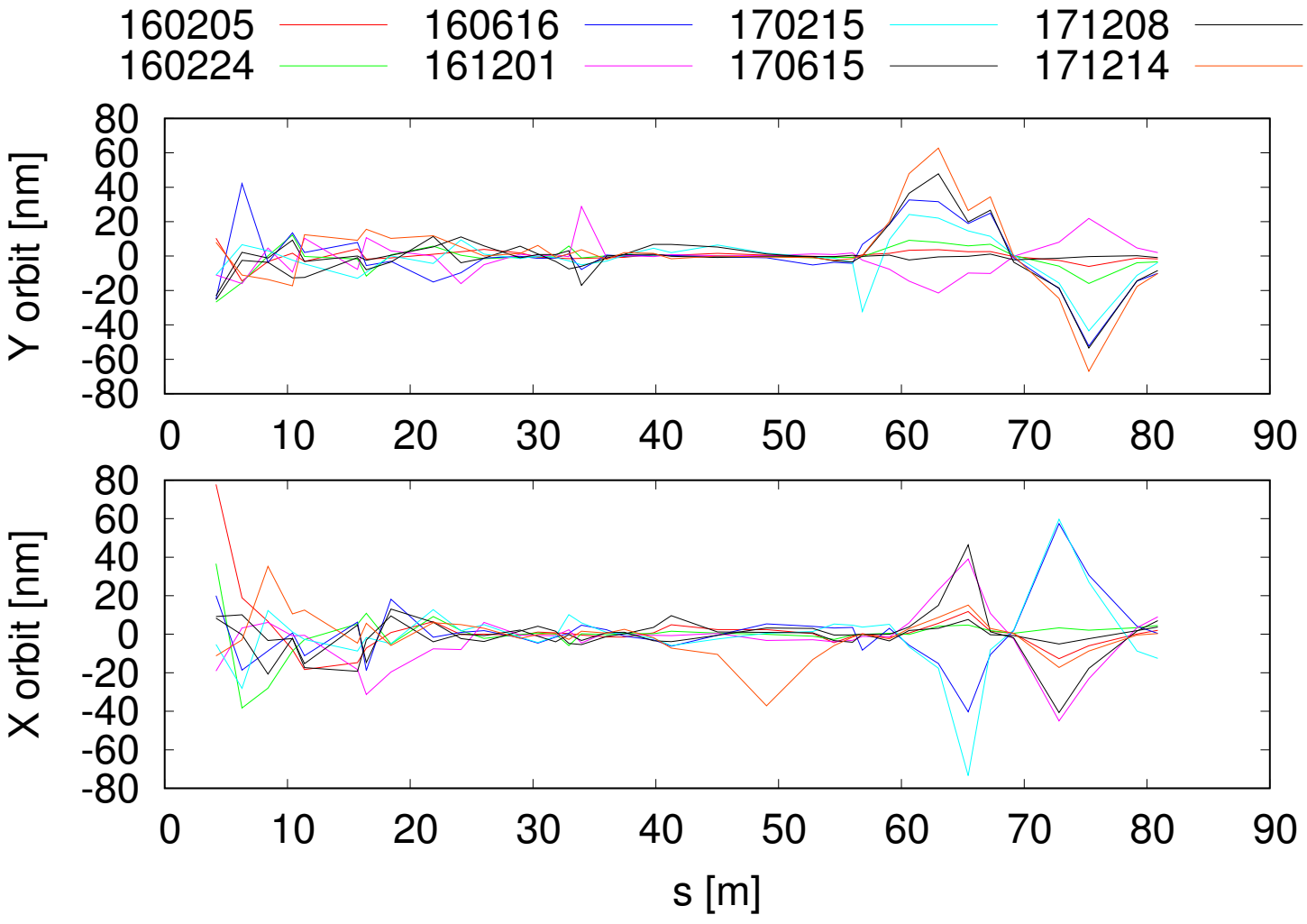
Jitter Conditions II



Jitter Conditions III



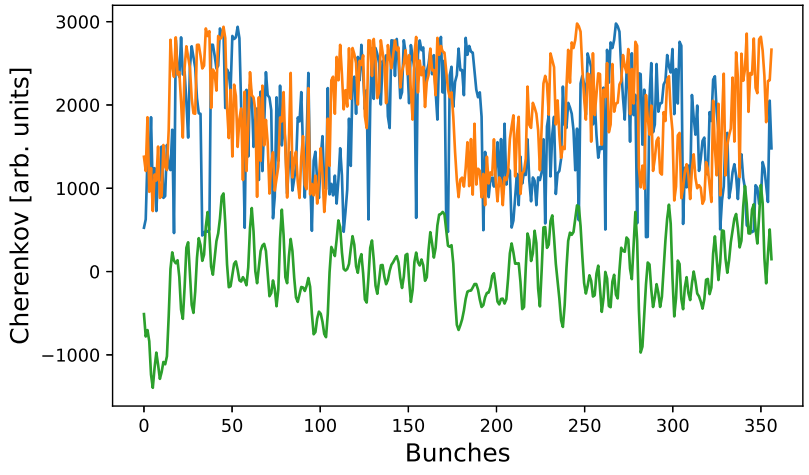
Orbit Conditions



Modulation Signal

Is the modulation obtained by Shintake monitor correlated with beam orbit?

- Low frequency removed by FFT from Cherenkov signal

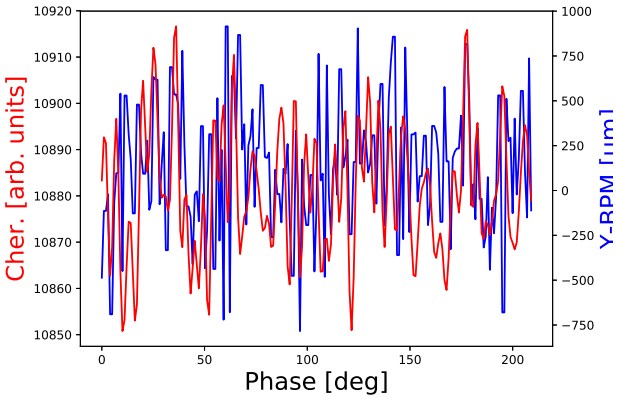


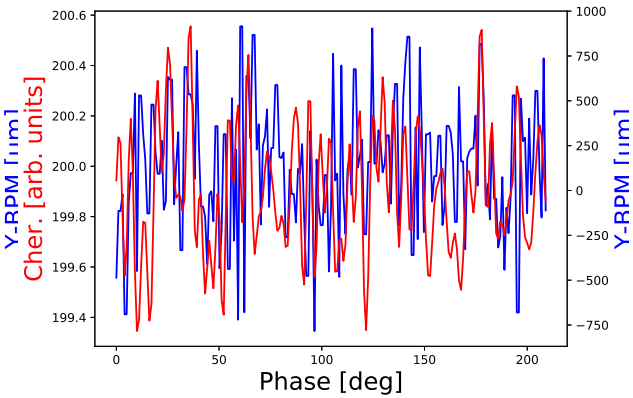
- Orbit data also treated by SVD

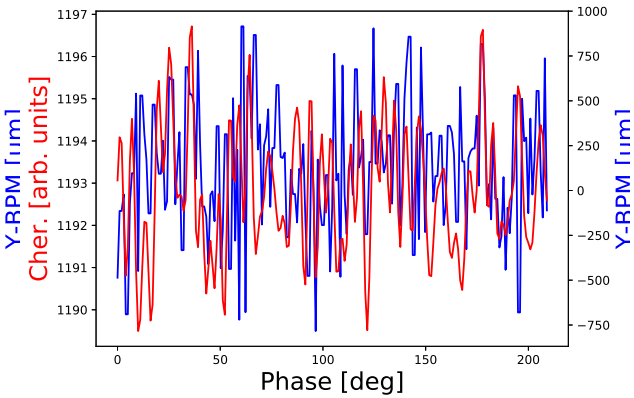
Modulation Signal vs Beam Jitter @ BPMs

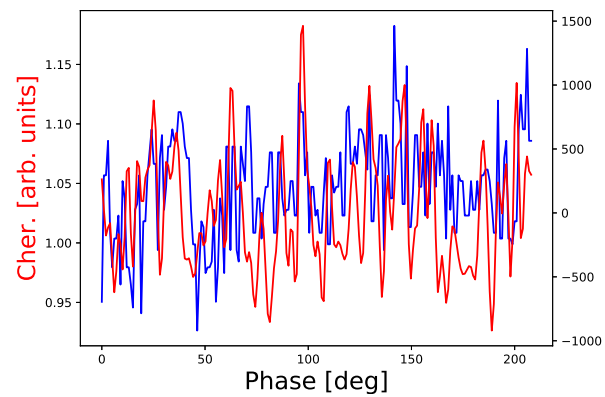
BPMs used in the study:

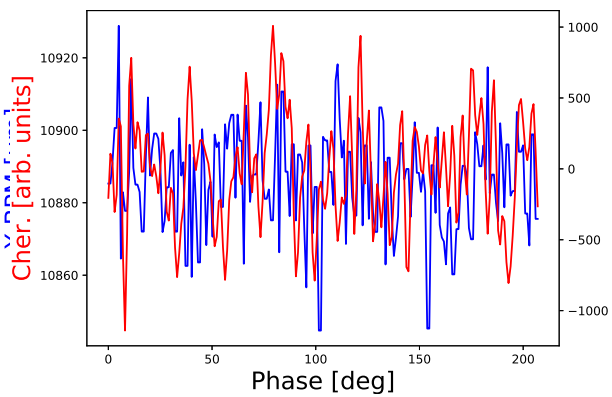
- MQM13FF
- MQM12FF
- MFB1FF
- MQF9AFF
- MQD8FF
- MQF7FF
- MQD4BFF

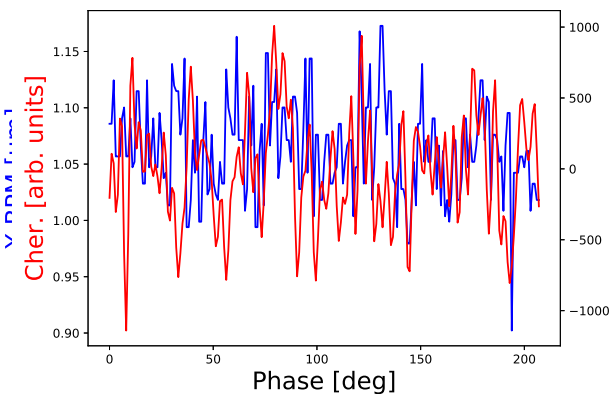






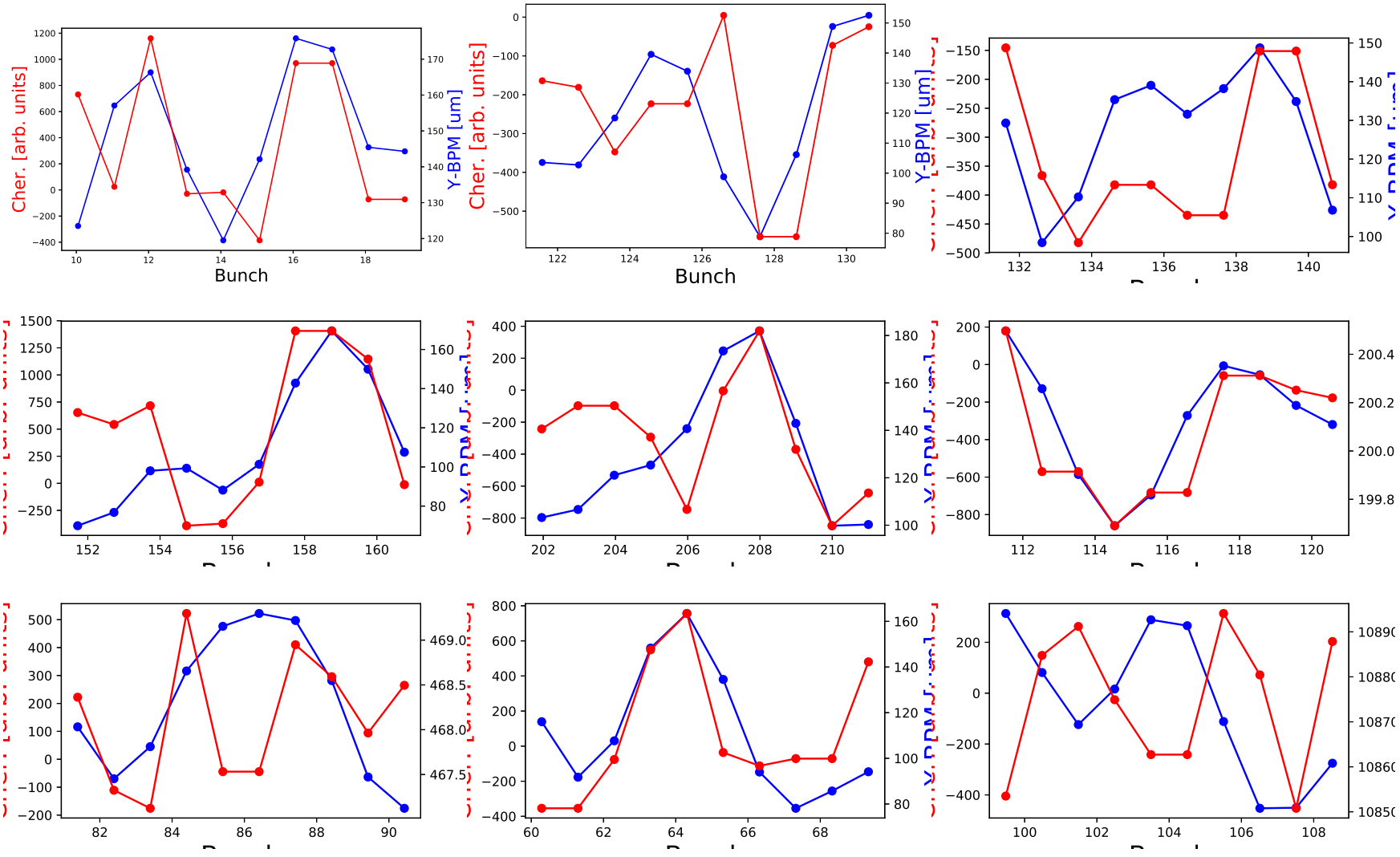






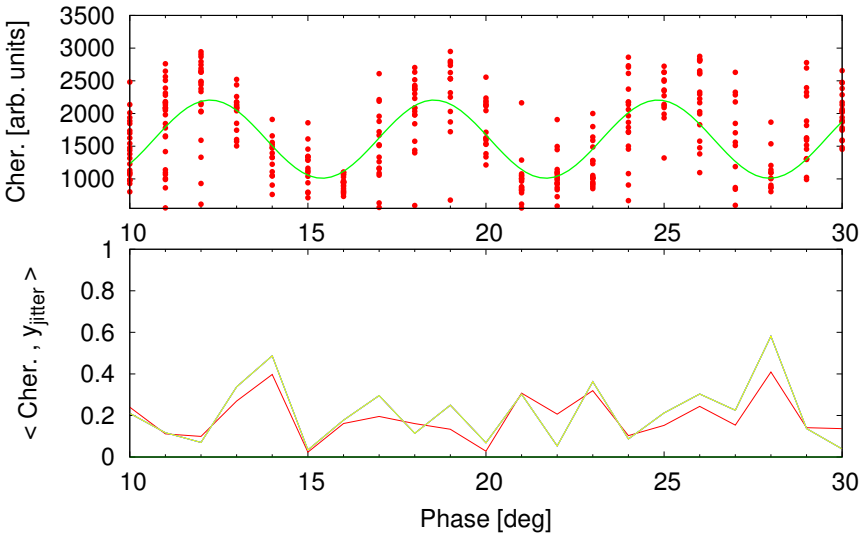
Beam Size Error

Modulation Error vs Beam Jitter @ single phase

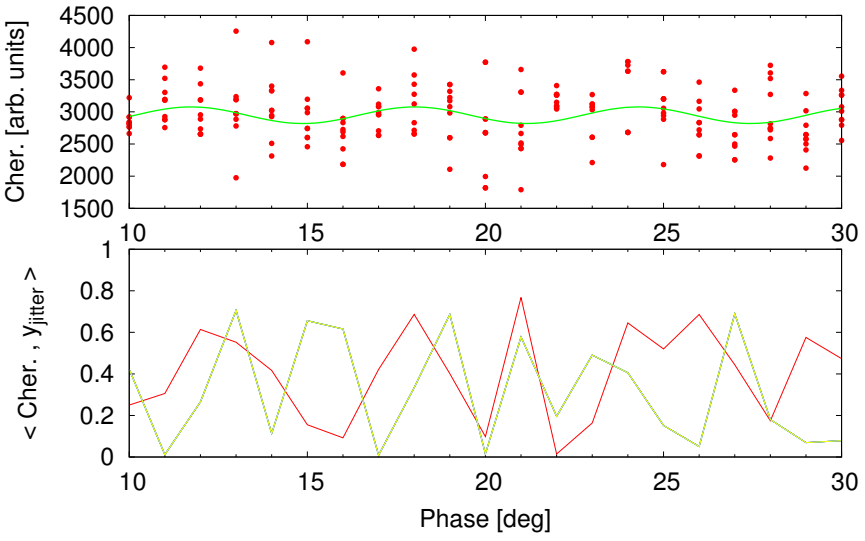


Correlation Coefficients

- 2016/02/05

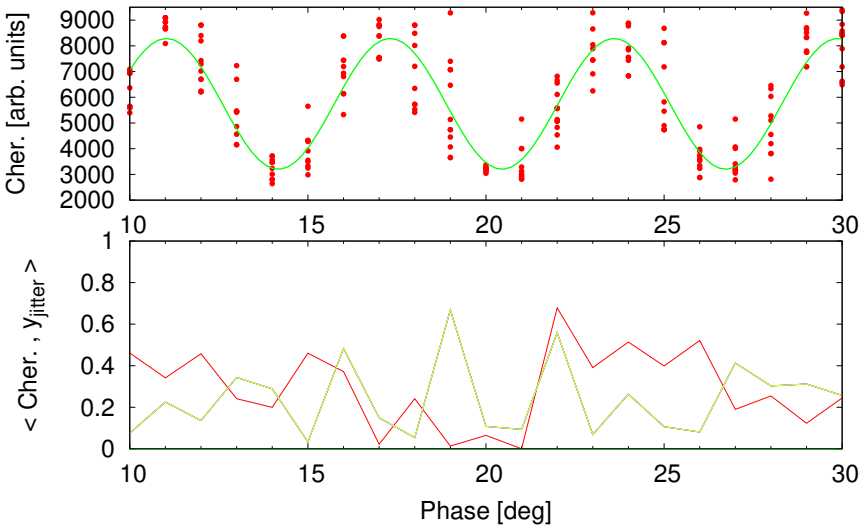


- 2017/12/14

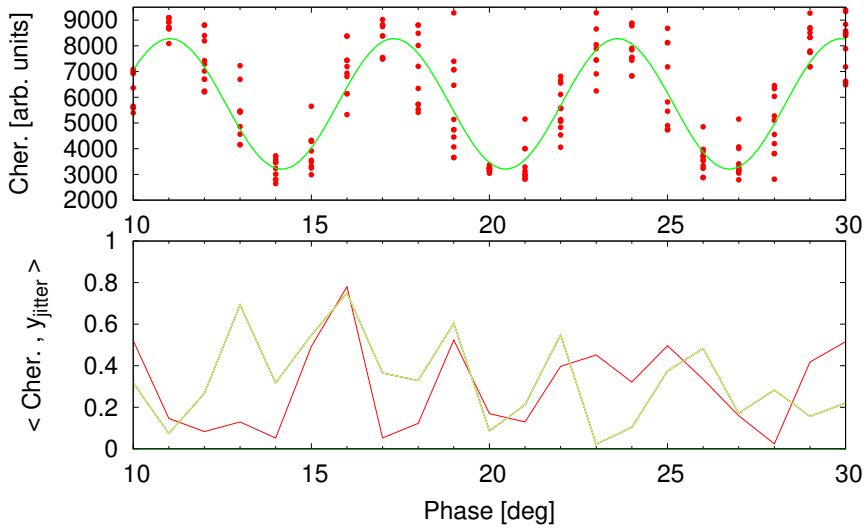


Correlation Coefficients-II

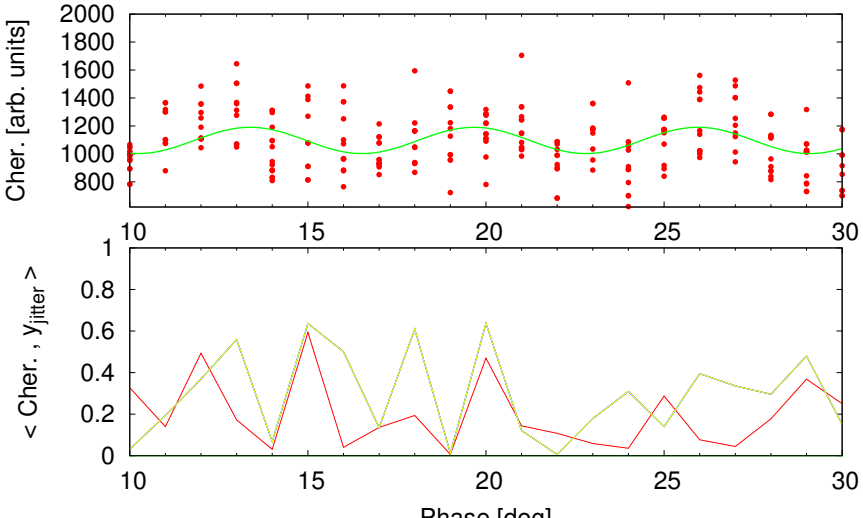
- 2016/10/25 (SVD)



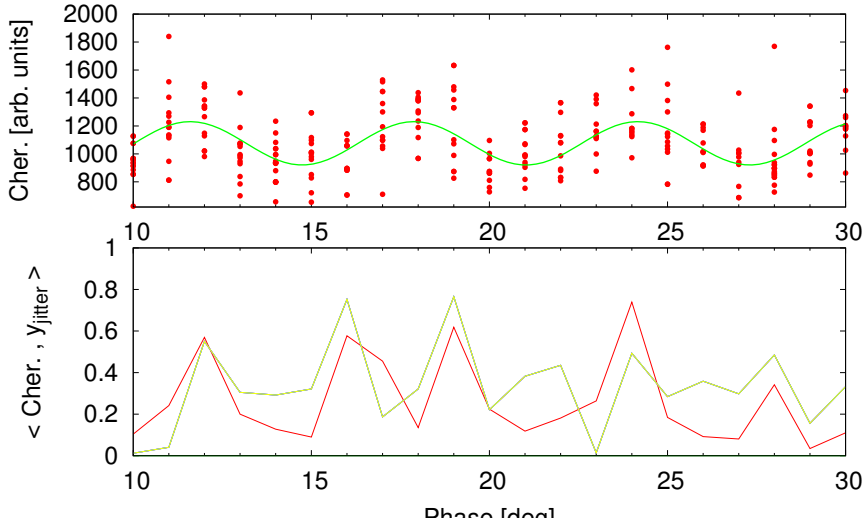
- 2016/10/25 (NO SVD)



- 2016/12/01 (SVD)



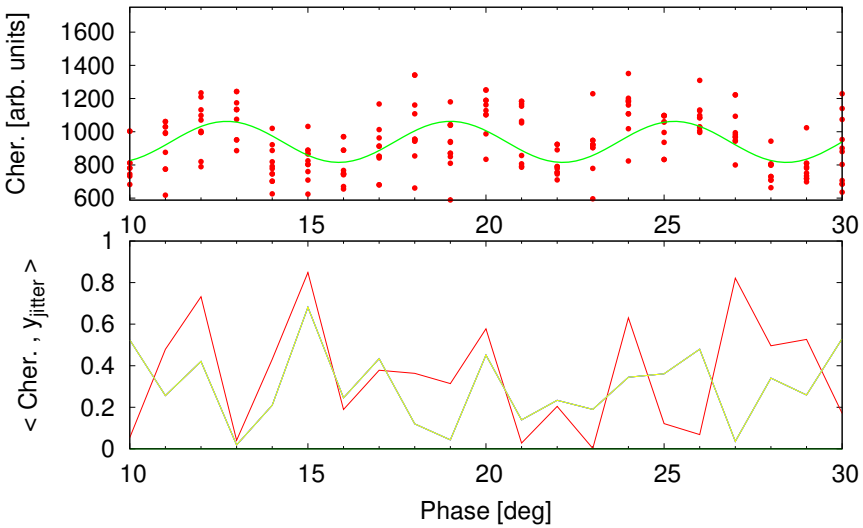
- 2016/12/01 (NOSVD)



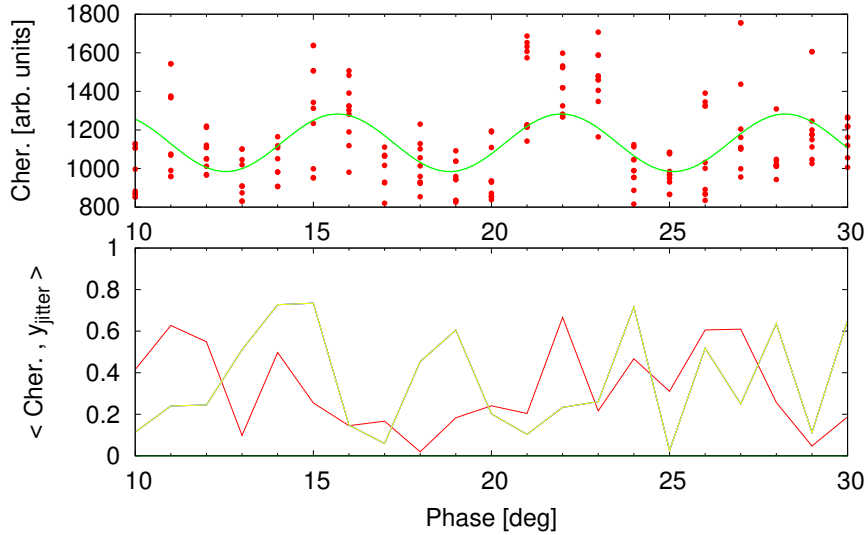
Beam Size Error

Correlation Coefficients-III

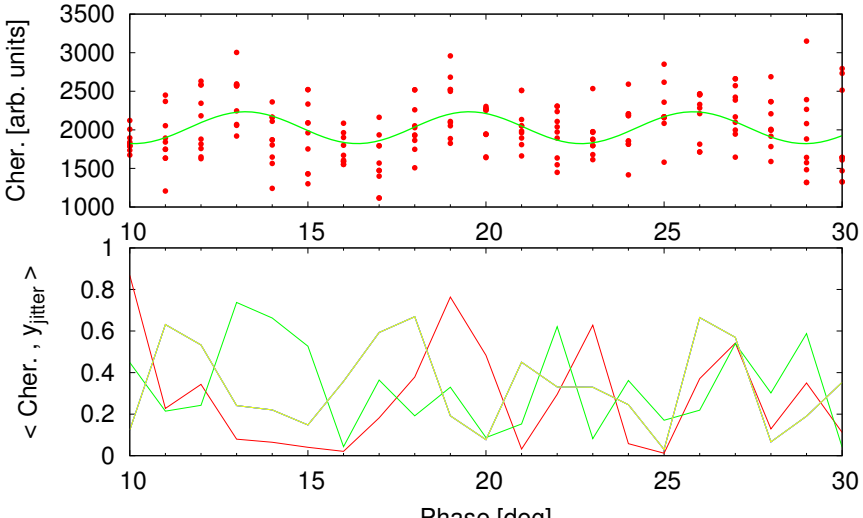
- 2016/11/24



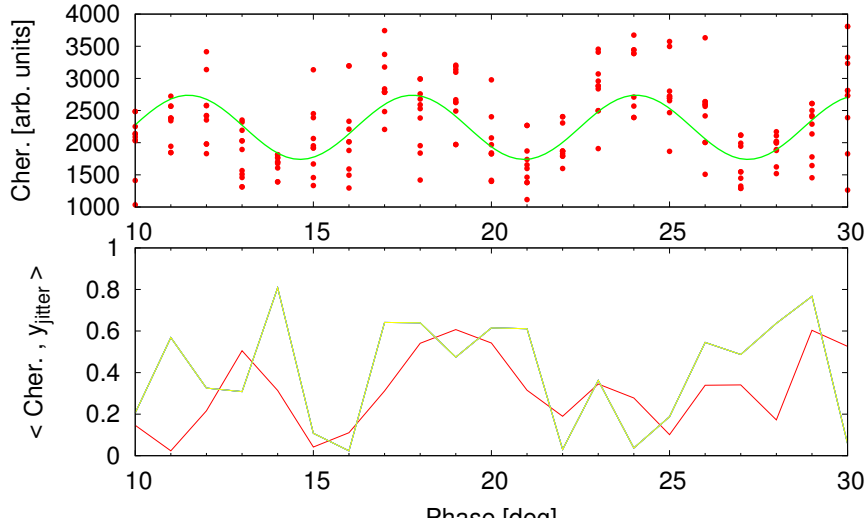
- 2017/02/15



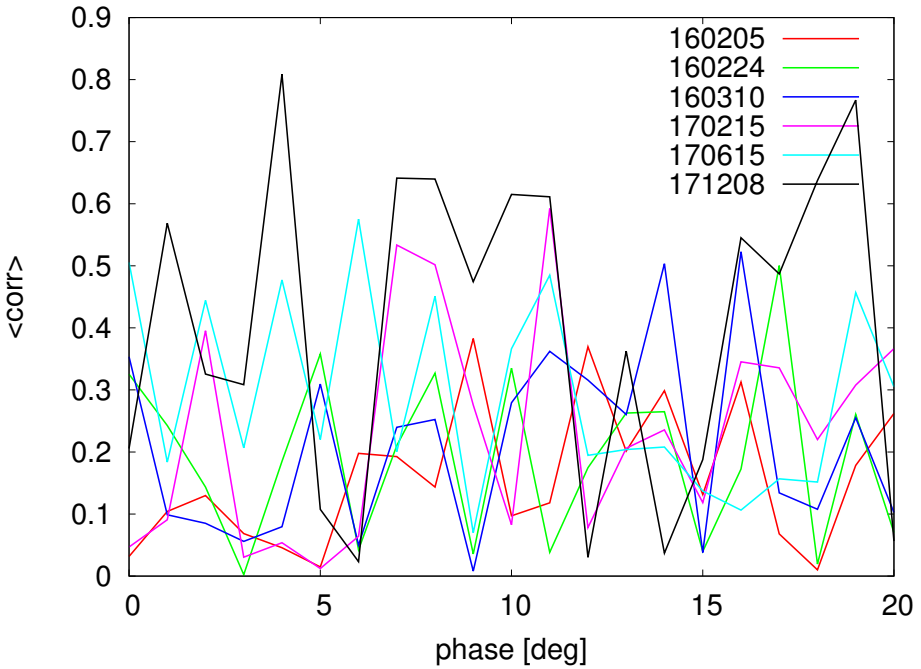
- 2017/06/15



- 2017/12/08

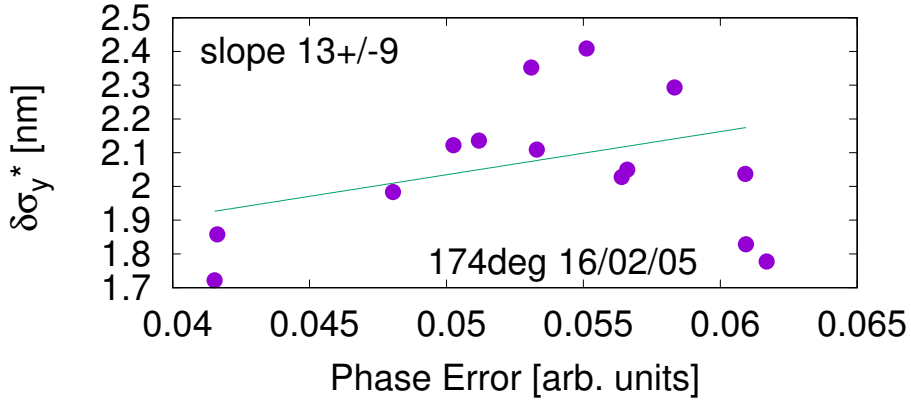


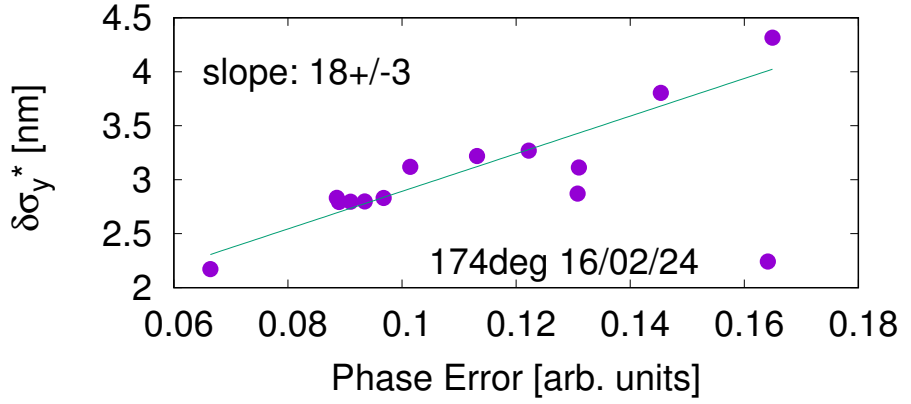
Correlation Coefficients Summary

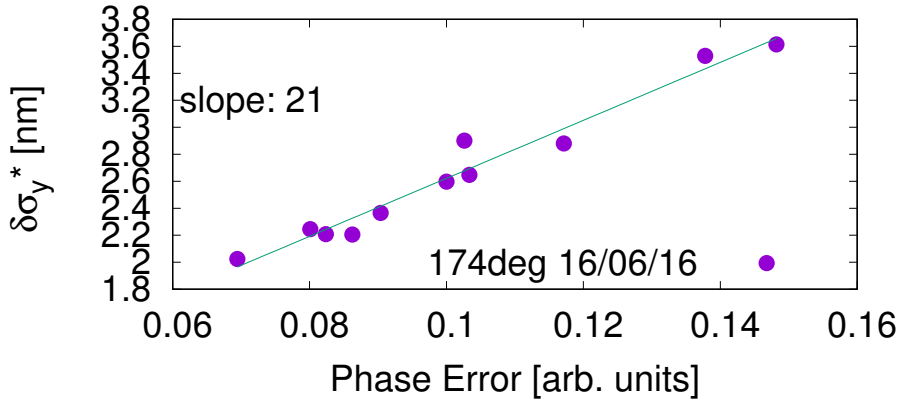


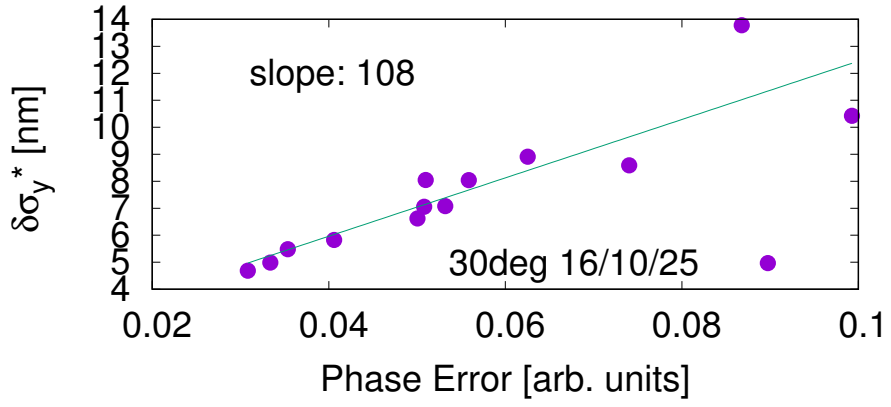
- Low correlations are observed for 2016/02 and 2016/03 runs
- Higher correlations are observed for 2017/02, 2017/06 and 2017/12 runs

Beam Size Error vs Phase Error I

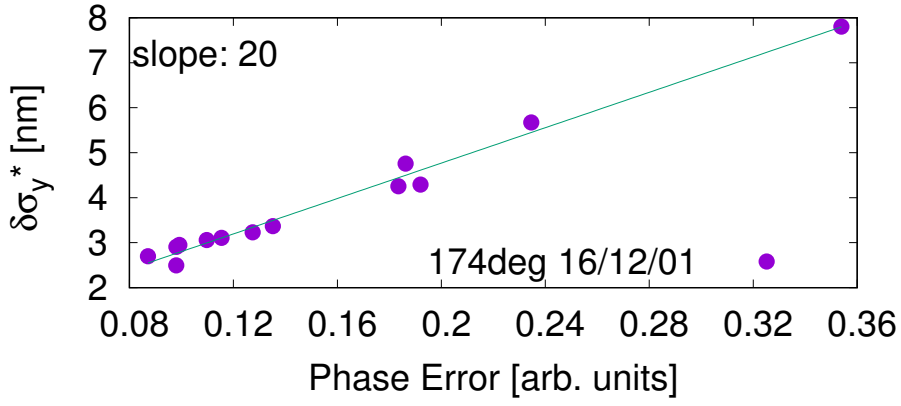


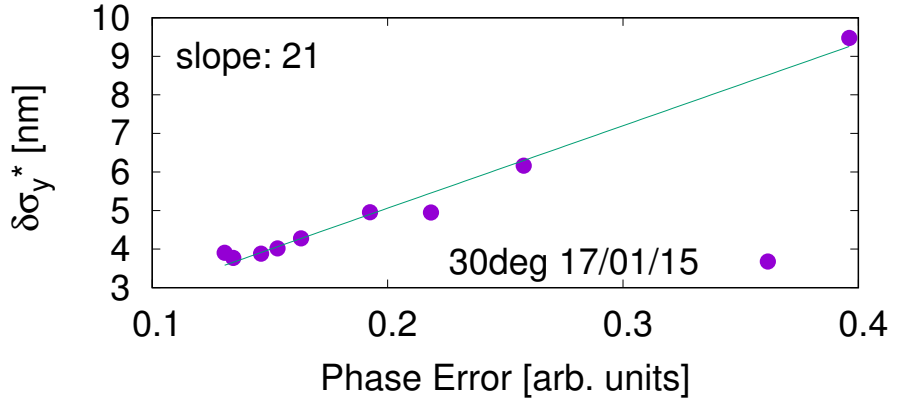


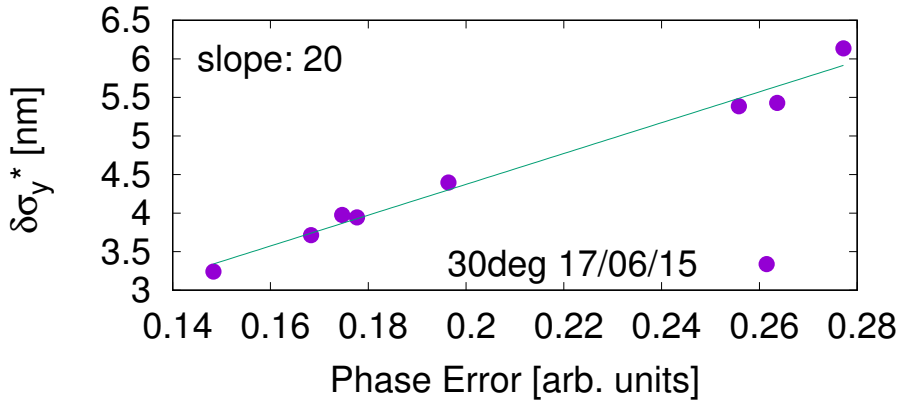


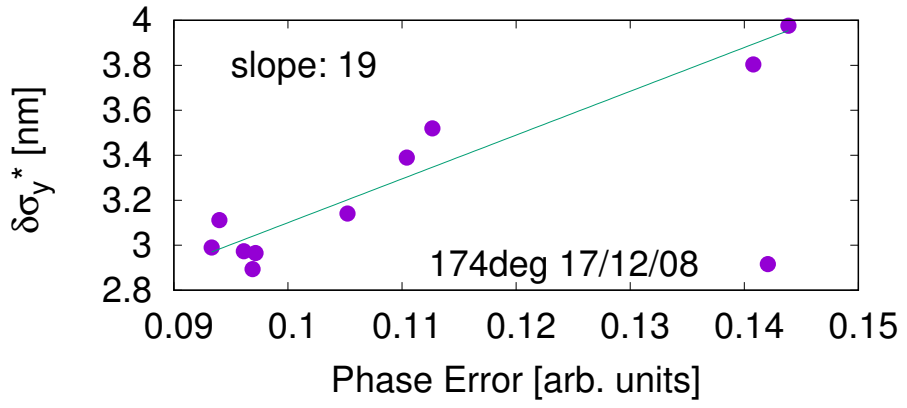


Beam Size Error vs Phase Error II

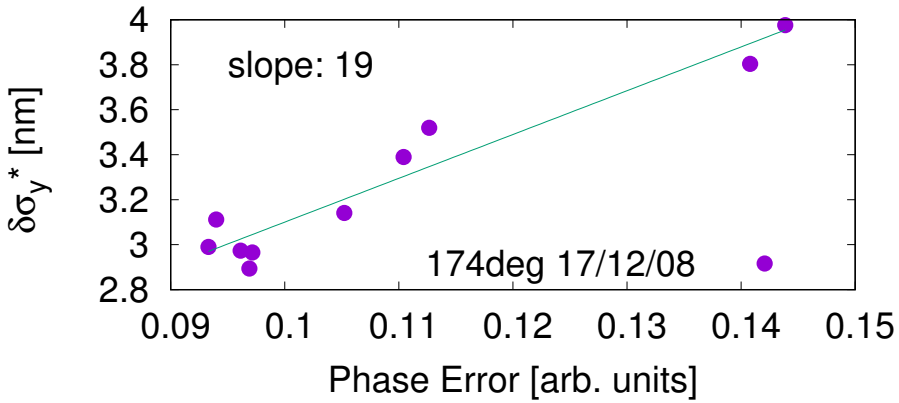


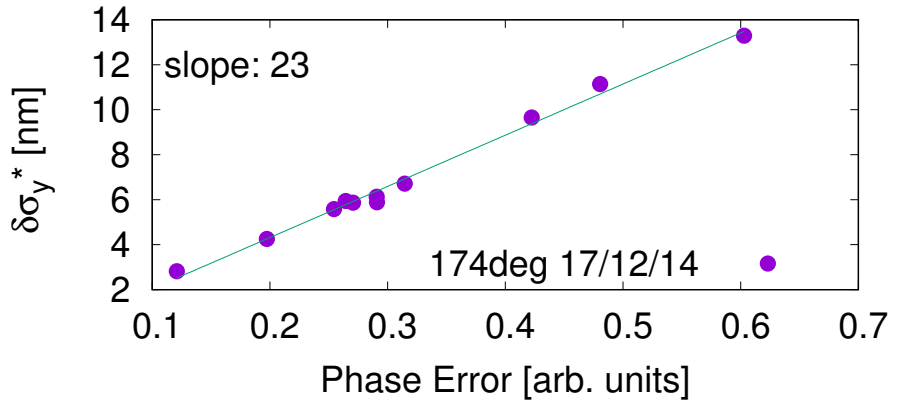


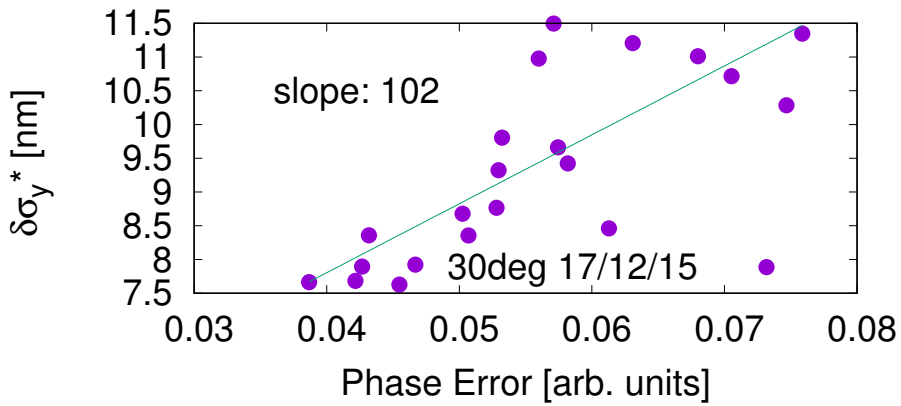




Beam Size Error vs Phase Error III







Conclusions & Recommendations

- Standard tuning procedure has been proven to work (*Initial 2016 runs*
  - mOTR (emittance, coupling, matching)
  - Sextupole alignment
- Other variables into play: jitter, orbit, Shintake, ...?
  - Jitter conditions seems to be equivalent
  - Orbit condition is difficult to assess
- Beam size error should be reduced
  - Correlation coefficient explain modulation fluctuations intermittently and mostly between high and low modulation phases
    Other hidden variables?

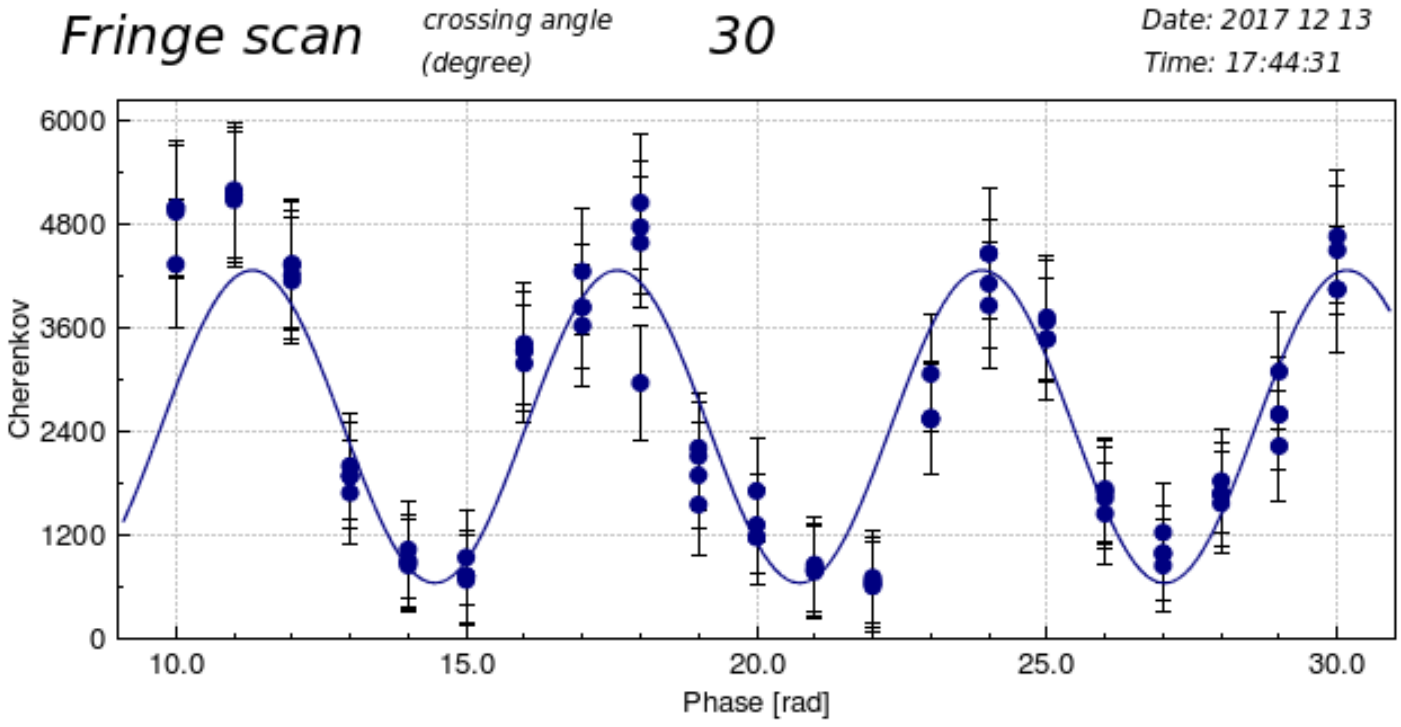
Additional Suggestions:

- Scan knobs obtained for the current lattice
- Monitoring the jitter at IP
- 2-Bunch operation mode?
- Weighted fit on peaks and valleys to determine modulation

BACK UP

Beam Size Error

Fringe Scan



Dataset: base171213_174431.binary

Fit results: Av*(1.0+M*cos(x+Ph)) CONVERGED

Event selection
Point/step: 10 Data: Cherenkov
Intensity cut* [e9]: 1.40 < I < 1.70
Phase scan direction: Positive

Modulation: 0.738 +/- 0.042
Beam Size: 92.5 + 15.8 -17.9 nm
Average: 2459.624 +/- 70.225
Phase: 1.249 +/- 0.054
Chi2/ndf: 9.5960e+01 / 81

F30U 5.0 F30L 2.0 Prism 12.00 Lambda/2 0.00
M30UX 10.2545, M30LX 10.9143, M3LX 10.7300, Mirror4X 4.9770, Mirror8X 9.0436, Mirror7X 9.7750,
M30UY 9.8980, M30LY 10.2786, M3LY 10.4900, Mirror4Y 9.5730, Mirror8Y 8.3650, Mirror7Y 6.6100,