Small beam size status

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ATF2 project meeting

LAL, France

Introduction

We remove many cavity BPMs in 2016 October – November in order to reduce the wake field source.

After the wake field source was removed from the beamline, the IP beam size is not squeezed less than 50 nm.

The first priority of the ATF2 small beam size tuning is to investigate the reason, and to achieve the beam size less than 40 nm.

Contents

1. *IP-BSM study (Introduction of Yasui-san's master thesis)*
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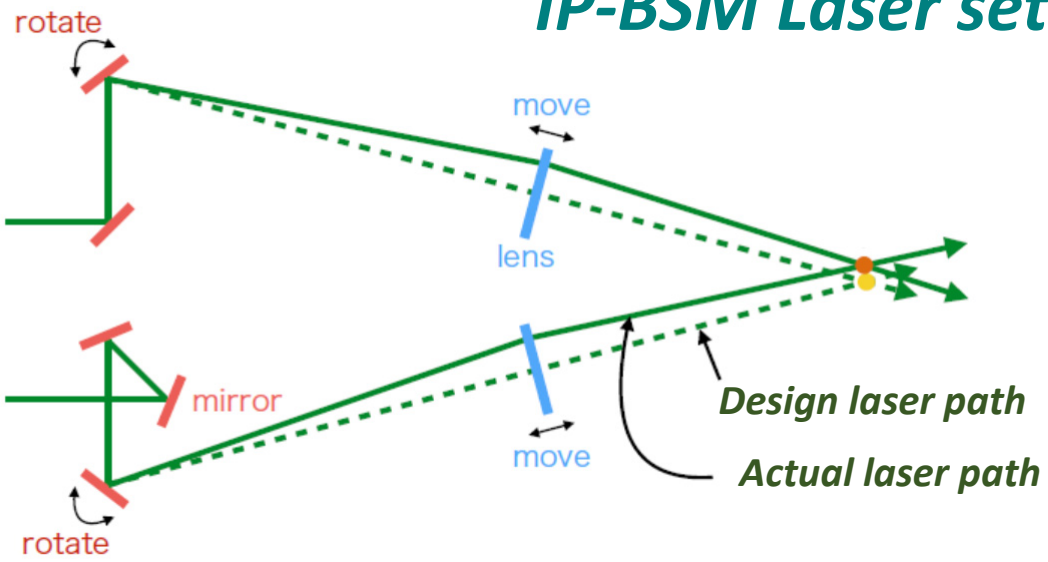
3. *IP beam size tuning status at 2018 March last operation week*

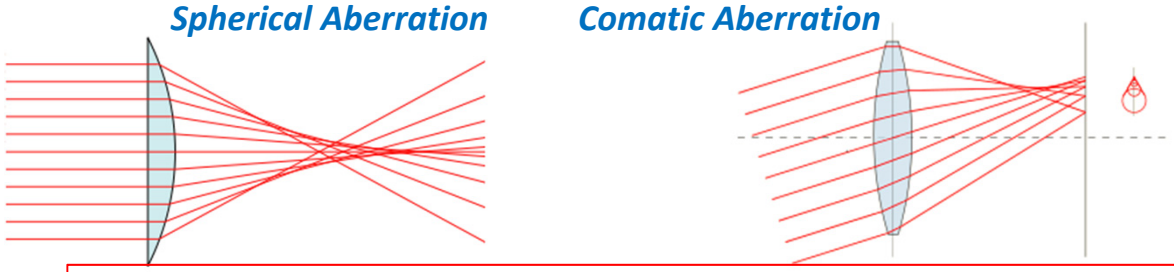
IP-BSM study

Brief Introduction of Yasui-san's Master Thesis
(The university of Tokyo, 2018)

IP-BSM Laser setup

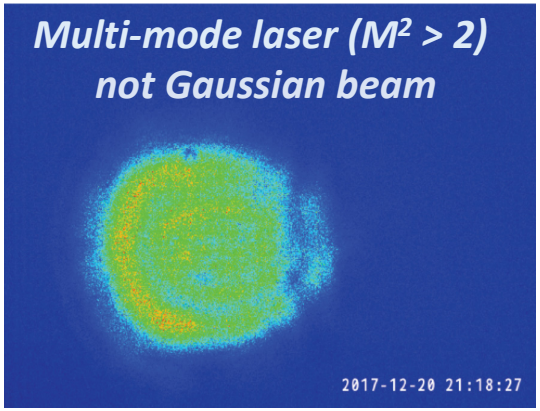


Transverse misalignment

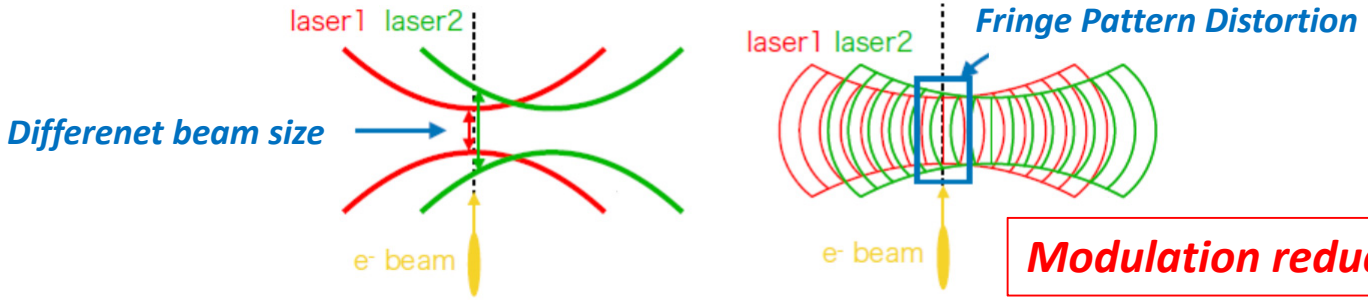


Profile overlap was not good => Modulation reduction

IP-BSM Laser profile

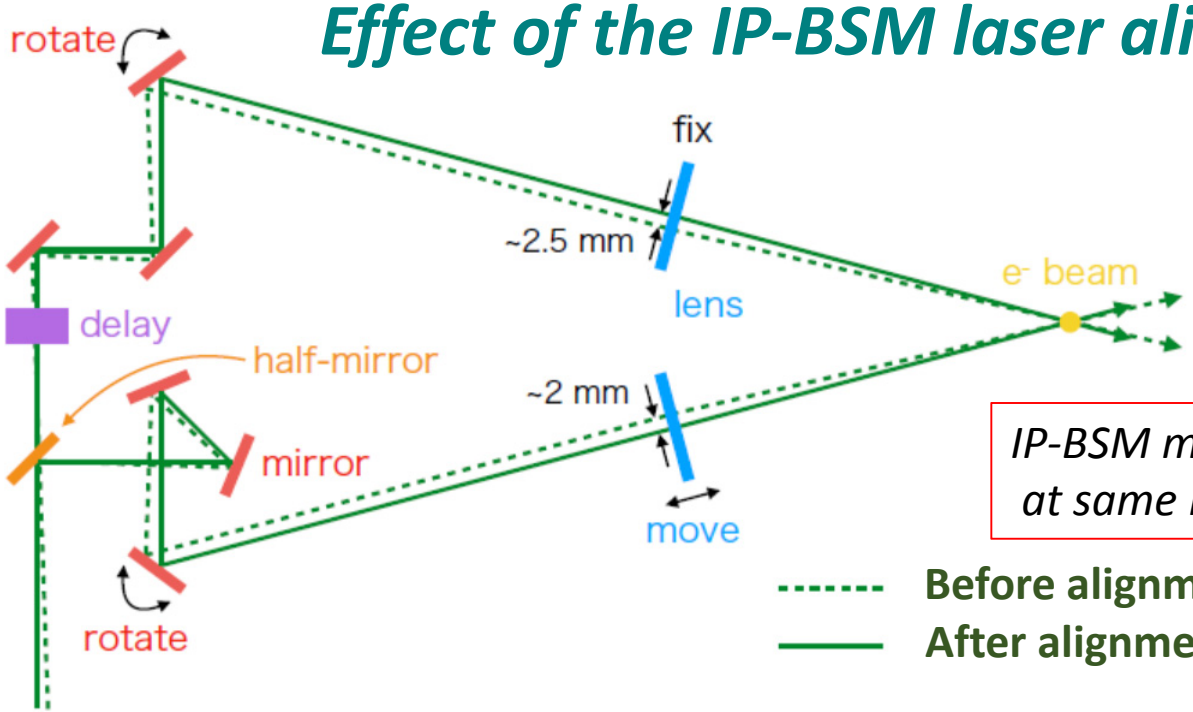


Longitudinal misalignment (Focal lens position)



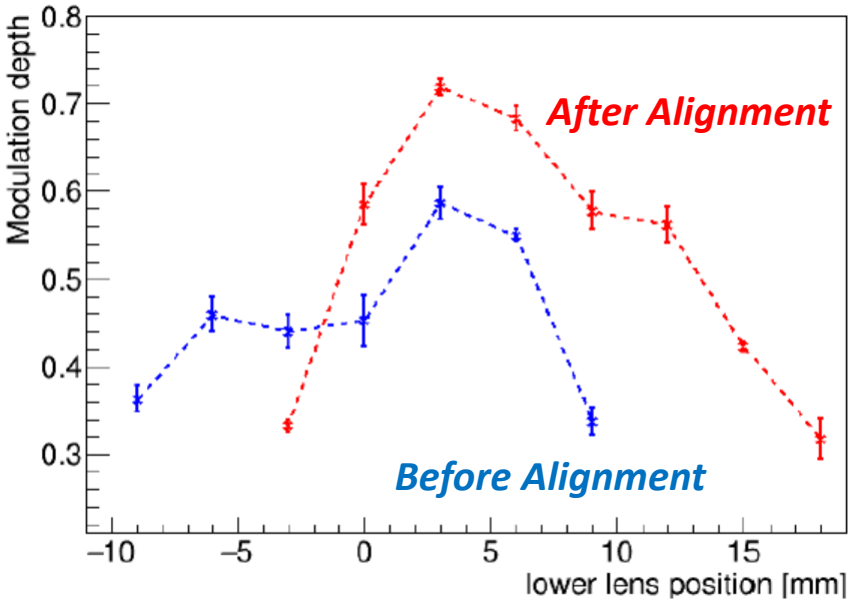
Modulation reduction

Effect of the IP-BSM laser alignment



IP-BSM modulation was measured at same beam condition.

Measured result by IP-BSM 30 degree mode

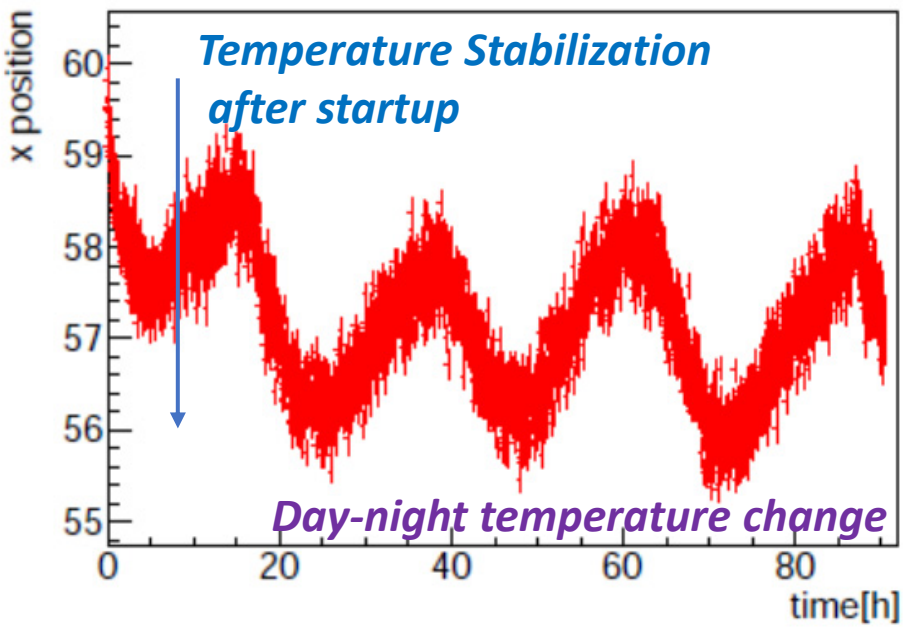


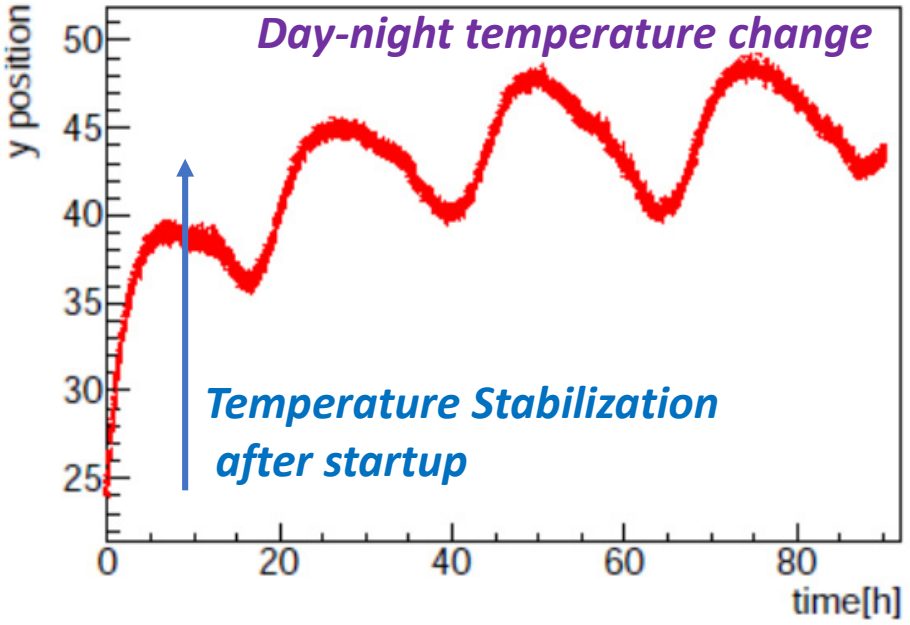
Maximum modulation is increased

- *after transverse laser path alignment*
- *after focal lens position adjustment*

It is very important to align the laser path in order to make the correct modulation by same electron beam size.

IP-BSM Laser Position stability

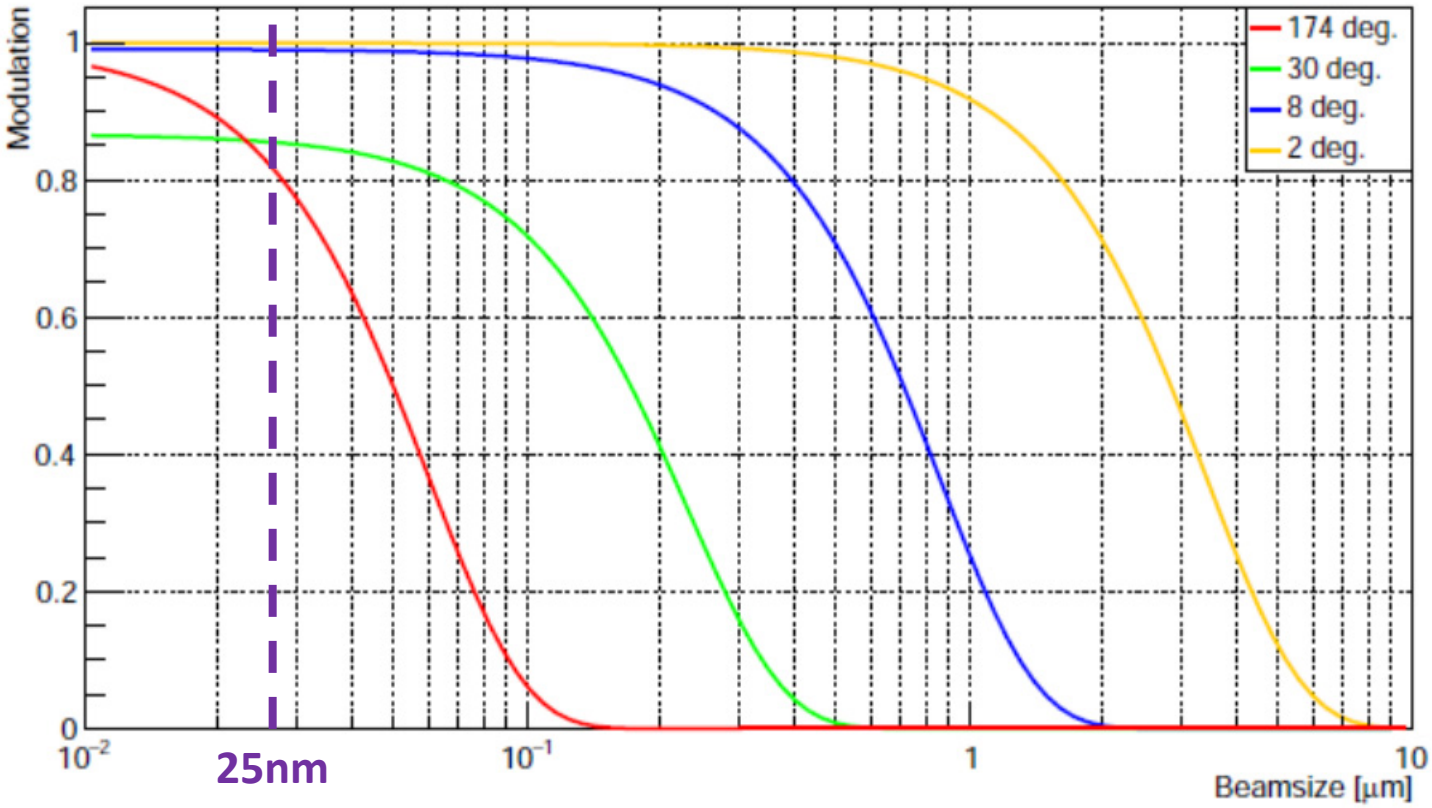




It was found that IP-BSM laser position was changed
- *by drifting to the laser temperature stabilization (1st 1 day).*
- *by oscillating by day-night temperature change (every day).*

(New laser tuning procedure)
The laser alignment is carried out at 1 day after the laser startup.

Comment for Ultra-low beta study



In order to measure the 25nm beam size,
we must achieve more than 80% modulation in IP-BSM 174 degree mode.

It is very important to reduce the modulation reduction factor.

Linear Optics Matching

2017 Autumn operation

Large nonlinear IP horizontal profile was observed
at the FF optics with small IP horizontal beta function.

We operated 20x1 optics to observed the clear IP-BSM modulation at 174degree mode.

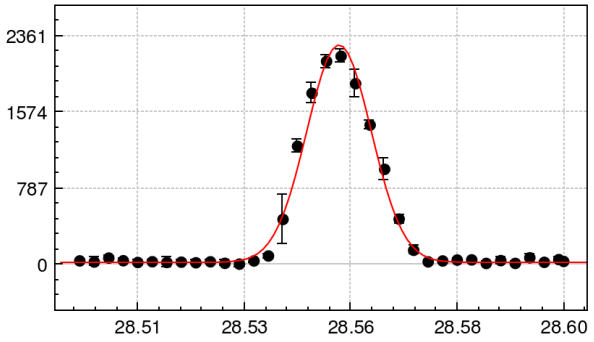
It is important to correct the 2nd order aberration.
One of the main topics in winter operation

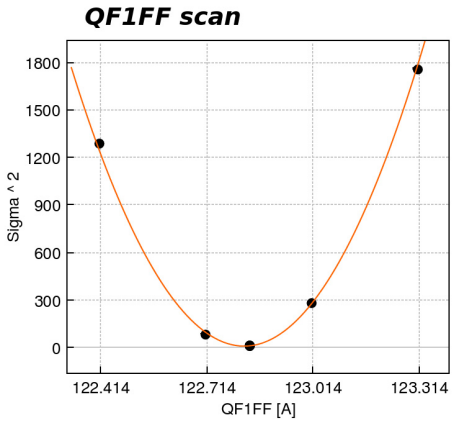
At the beginning of 2018 winter operation

Standardization of DR main magnets.
=> The beam energy at FF beamline was changed by -0.5%.
(Strength of B5FF, 2FF and B1FF was reduced by 0.5%.)

The FF sextupole strength was reset to the design strength.

The nonlinear IP horizontal profile was not observed even for 2.5x1 optics.





Date: 2018/01/31 Time: 12:54:39

Fit results: A*(x-B)^2+C^2
Constant: 7359.397 +/- 13.008
X-min: 122.818 +/- 0.000
Y-min: 3.819 +/- 0.027
Chi2/ndf: 5.3491e+02 / 5

Data file:
QF1FF180131_125439.dat

betaX*= 10 mm

Xemit = 1.4 nm

Horizontal Nonliner Knob

posted at ATF Lognote 2018/01/31 Day

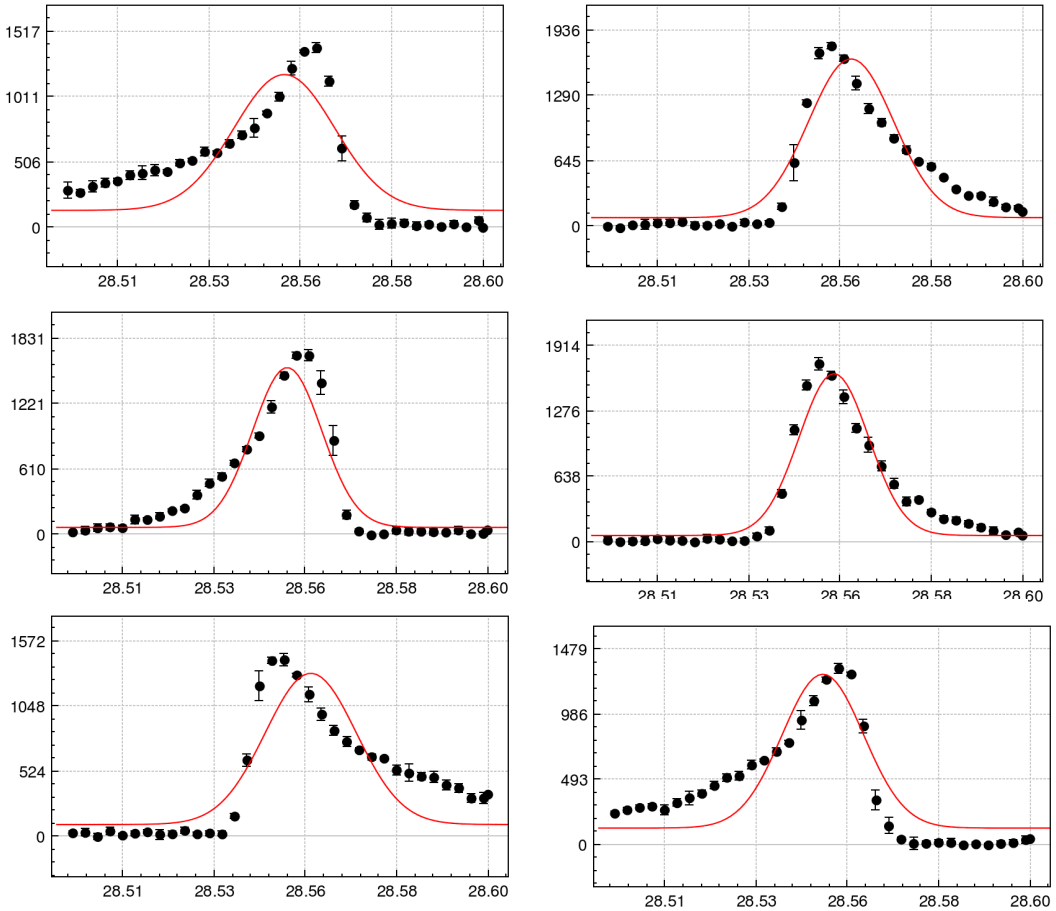
The nonlinear confirmation
was done by 2.5 x 1 optics

Nonlinear knob was calculated

	X22	X26	X66	Y24	Y46
SF6FF	-8.085	+1.925	+11.559	-4.343	+1.641
SF5FF	+4.041	+1.809	-9.015	+1.901	+1.856
SD4FF	-0.637	+1.613	-0.795	-19.121	+43.136
SF1FF	-0.221	+0.391	+0.309	+0.428	+1.889
SD0FF	+0.331	+0.045	-0.448	+3.286	+7.961

Save the nonlinear knob parameter "multiknob_init_param_180131.dat"

Horizontal IP profile by IP wire scanners



X22 = +/-0.5
Δ SF6FF = 4.0 A
Δ SF5FF = 2.0 A
Δ SD4FF = 0.3 A

X26 = +/-1.0
Δ SF6FF = 1.9 A
Δ SF5FF = 1.8 A
Δ SD4FF = 1.6 A

X66 = +/-0.5
Δ SF6FF = 5.8 A
Δ SF5FF = 4.5 A
Δ SD4FF = 0.4 A

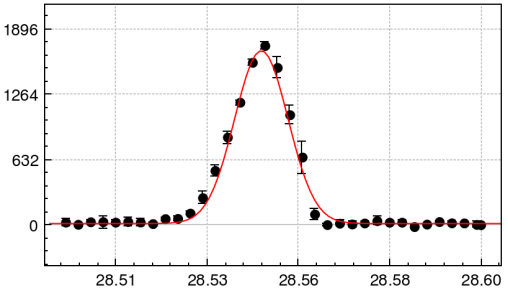
Effect to IP horizontal profile by vertical nonlinear knob

IP horizontal profile (IP wire scanner) by 2.5 x 1 optics at 2018/01/31

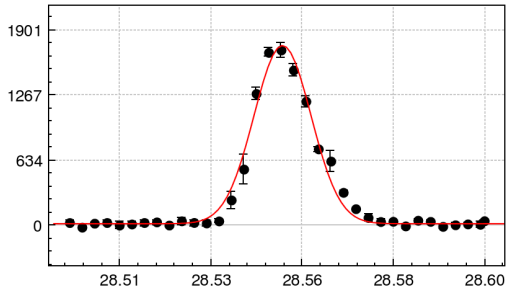
IP-BSM modulation (30 degree mode) by 10 x 1 optics at 2018/02/01

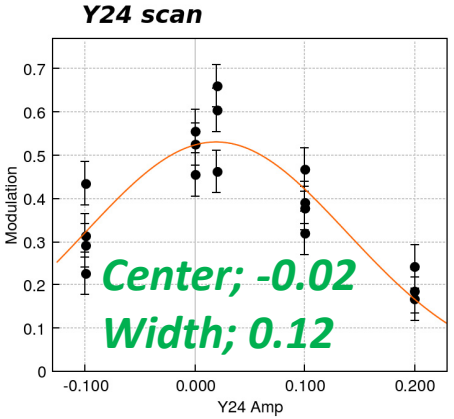
Y24 knob

Y24 = +0.2 (ΔSD4 =-3.8 A)



Y24 = -0.2 (ΔSD4 =+3.8 A)





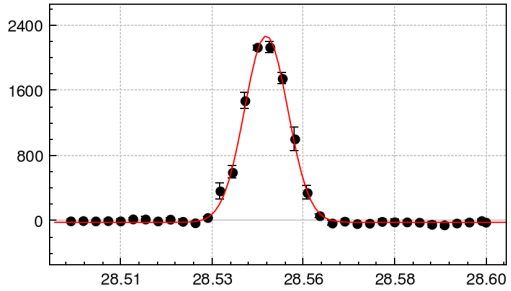
Date: 2018/02/01 Time: 06:14:30

*Fit results: A*exp(-((x-B)/C)^2/2)*
Modulation: 0.532 +/- 0.019
Center: 0.019 +/- 0.006
Sigma: 0.119 +/- 0.007
Chi2/ndf: 3.0695e+01 / 14

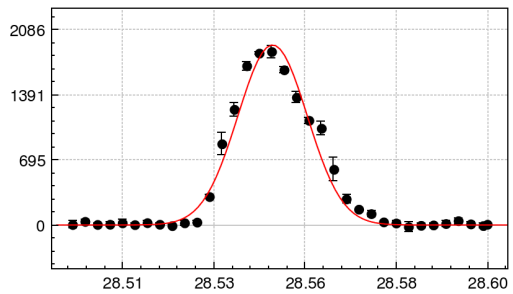
Data file:
Y24_fringe_180201_061430.dat

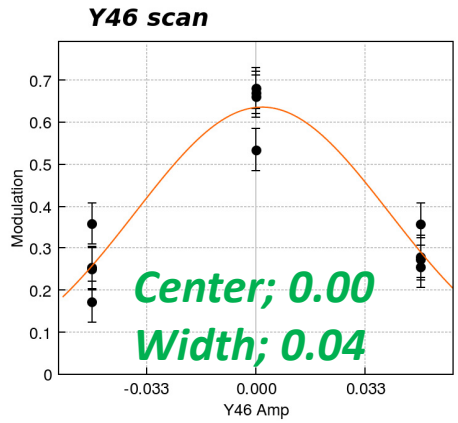
Y46 knob

Y46 = +0.1 (ΔSD4 =+4.3 A)



Y46 = -0.1 (ΔSD4 =-4.3 A)





Date: 2018/02/01 Time: 06:52:20

*Fit results: A*exp(-((x-B)/C)^2/2)*
Modulation: 0.637 +/- 0.025
Center: 0.002 +/- 0.002
Sigma: 0.039 +/- 0.002
Chi2/ndf: 1.5122e+01 / 9

Data file:
Y46_fringe_180201_065220.dat

Horizontal 2nd order aberration by Normal FF sextupoles were corrected.

It was confirmed not to affect to horizontal IP profile by changing Y24, Y46.

Summary of linear optics matching

The beam energy at FF beamline was shifted at 2017 autumn operation by +0.5%.

The beam energy was recovered after we did the standardization of DR magnets.
We skipped the standardization procedures at least 2017 autumn operation.
It is very important to standardize DR magnets every startup.

Comments;
Some DR main magnets were down at 3/13/2018 swing shift.
But, we put the original current to the troubled magnets after the standardization.
The beam condition was correctly recovered.

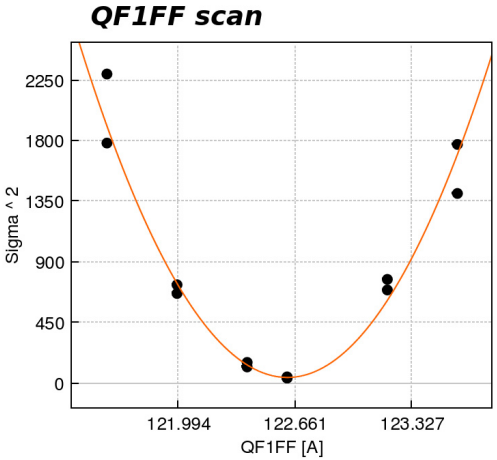
Strength of the normal sextupole magnet setting seemed to be good
for 2018 Feb-March operation.

- 2nd order aberrations for IP horizontal beam size was corrected well.

- The 2nd order correction for vertical direction was small impact to horizontal beam size within the operational range.

IP beam size tuning status at 2018 March last operation week

Beam Optics at 2018 March Operation

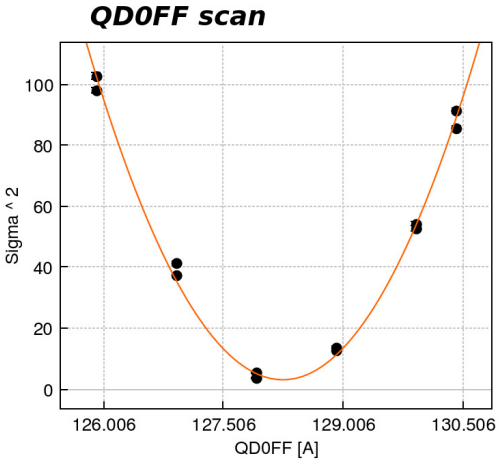


Date: 2018/03/12 Time: 14:59:55

Fit results: A*(x-B)^2+C^2
Constant: 1760.745 +/- 1.876
X-min: 122.614 +/- 0.000
Y-min: 6.675 +/- 0.021
Chi2/ndf: 1.9054e+04 / 12

Data file:
QF1FF180312_145955.dat

emittamce = 1.16843
beta = 38.1379
Data file saved: /atf/data/ipbsm/knob/QF1FF180312_145955.dat



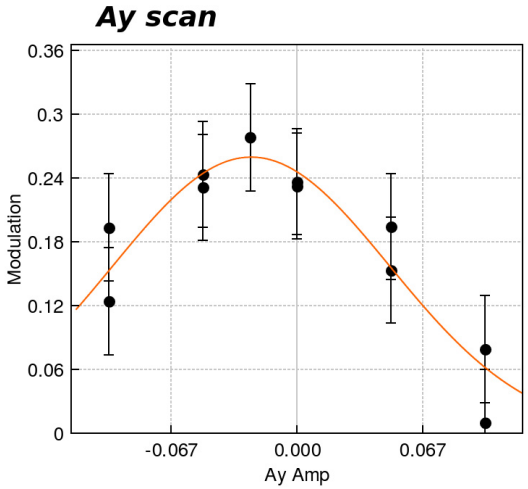
Date: 2018/03/12 Time: 15:17:59

Fit results: A*(x-B)^2+C^2
Constant: 18.294 +/- 0.092
X-min: 128.244 +/- 0.004
Y-min: 1.808 +/- 0.037
Chi2/ndf: 2.4803e+02 / 9

Data file:
QD0FF180312_151759.dat

emittance[nm] / beta*[mm] = 0.109761
Data file saved: /atf/data/ipbsm/knob/QD0FF180312_151759.dat

When emitY=12pm, BetaY*=0.11mm.
=> SigmaY*=36 nm



Date: 2018/03/13 Time: 18:00:37

Fit results: A*exp(-((x-B)/C)^2/2)
Modulation: 0.260 +/- 0.024
Center: -0.025 +/- 0.010
Sigma: 0.074 +/- 0.011
Chi2/ndf: 3.0867e+00 / 8

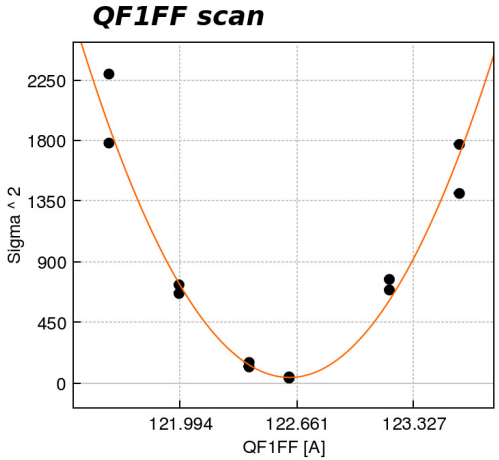
Data file:
Ay_fringe_180313_180037.dat

Minimum beam size was 70 nm.
IP-BSM modulation was reducing
M=0.25 => 0.15 in the IP beam size tuning.

Emittance was larger than design ??
Then, beam optics was rematched.

Beam size measured by ODR
also suggested larger beam size ??

Optics Matching (03/14/2018)



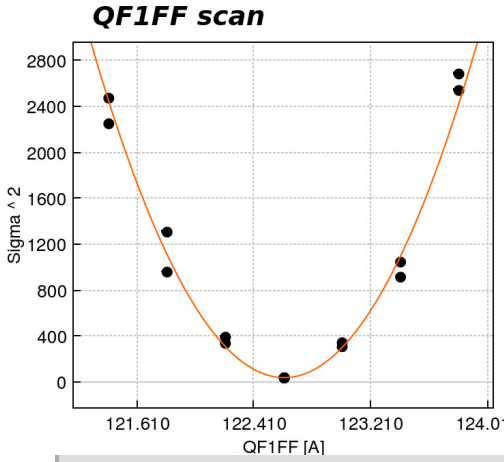
Date: 2018/03/12 Time: 14:59:55

Fit results: A*(x-B)^2+C^2
Constant: 1760.745 +/- 1.876
X-min: 122.614 +/- 0.000
Y-min: 6.675 +/- 0.021
Chi2/ndf: 1.9054e+04 / 12

Data file:
QF1FF180312_145955.dat

emittamce = 1.16843
beta = 38.1379
Data file saved: /atf/data/ipbsm/knob/QF1FF180312_145955.dat

Optics Matching (03/14)

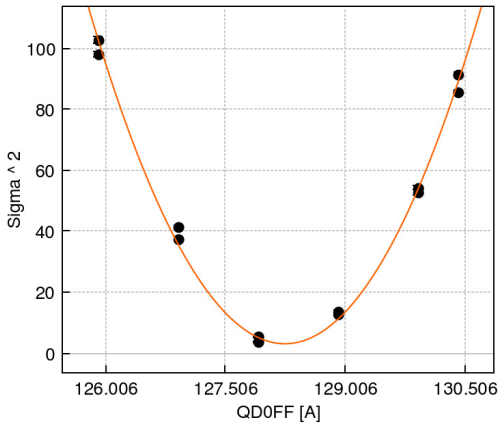


Date: 2018/03/14 Time: 10:10:31

Fit results: A*(x-B)^2+C^2
Constant: 1663.982 +/- 1.427
X-min: 122.614 +/- 0.000
Y-min: 6.470 +/- 0.021
Chi2/ndf: 1.6582e+04 / 14

Data file:
QF1FF180314_101031.dat

emittamce = 1.10086
beta = 38.0218
Data file saved: /atf/data/ipbsm/knob/QF1FF180314_101031.dat

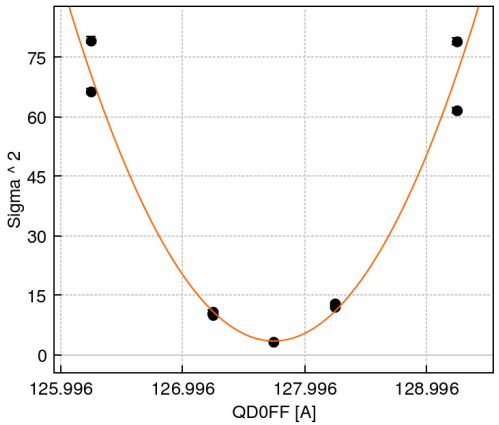


Date: 2018/03/12 Time: 15:17:59

Fit results: A*(x-B)^2+C^2
Constant: 18.294 +/- 0.092
X-min: 128.244 +/- 0.004
Y-min: 1.808 +/- 0.037
Chi2/ndf: 2.4803e+02 / 9

Data file:
QD0FF180312_151759.dat

emittance[nm] / beta*[mm] = 0.109761
Data file saved: /atf/data/ipbsm/knob/QD0FF180312_151759.dat



Date: 2018/03/14 Time: 10:26:12

Fit results: A*(x-B)^2+C^2
Constant: 29.923 +/- 0.203
X-min: 127.740 +/- 0.004
Y-min: 1.901 +/- 0.035
Chi2/ndf: 3.8867e+02 / 6

Data file:
QD0FF180314_102612.dat

emittance[nm] / beta*[mm] = 0.17954
Data file saved: /atf/data/ipbsm/knob/QD0FF180314_102612.dat

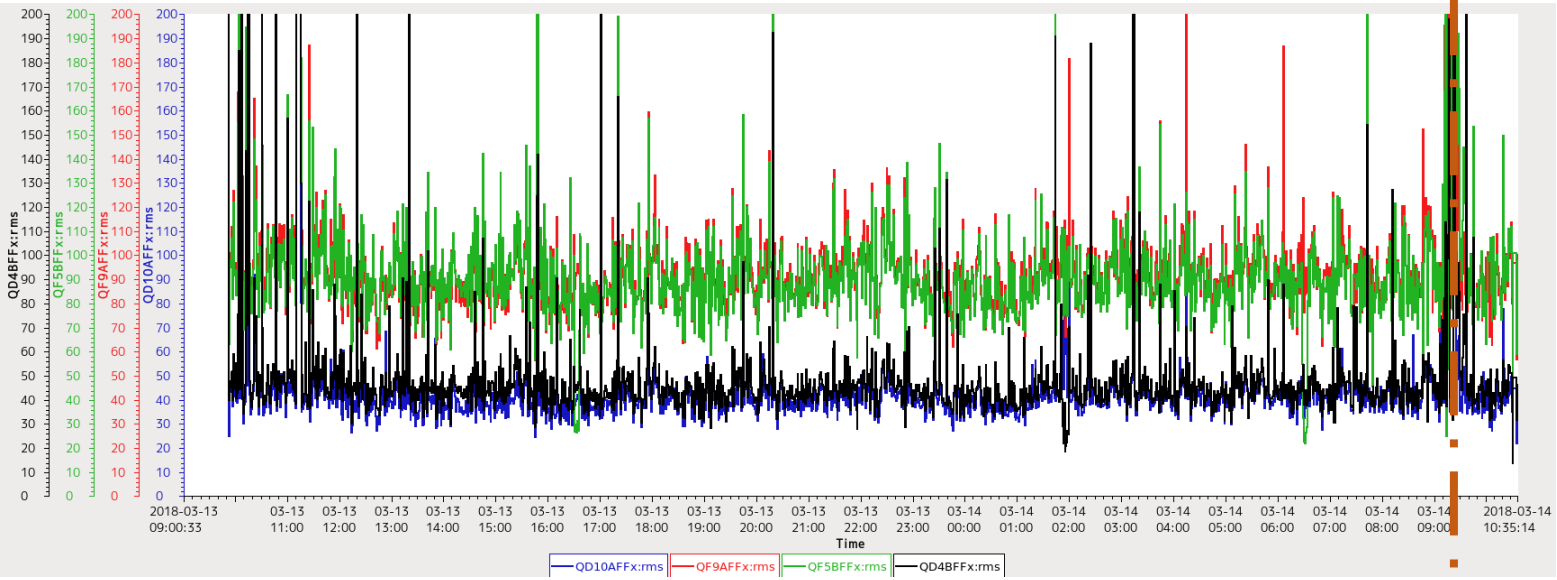
When emitY=20pm, BetaY*=0.18mm.
=> SigmaY*=60 nm

When emitY=20pm, BetaY*=0.11mm.
=> SigmaY*=47 nm

Beam jitter history

Horizontal Orbit Jitter

Optics rematched

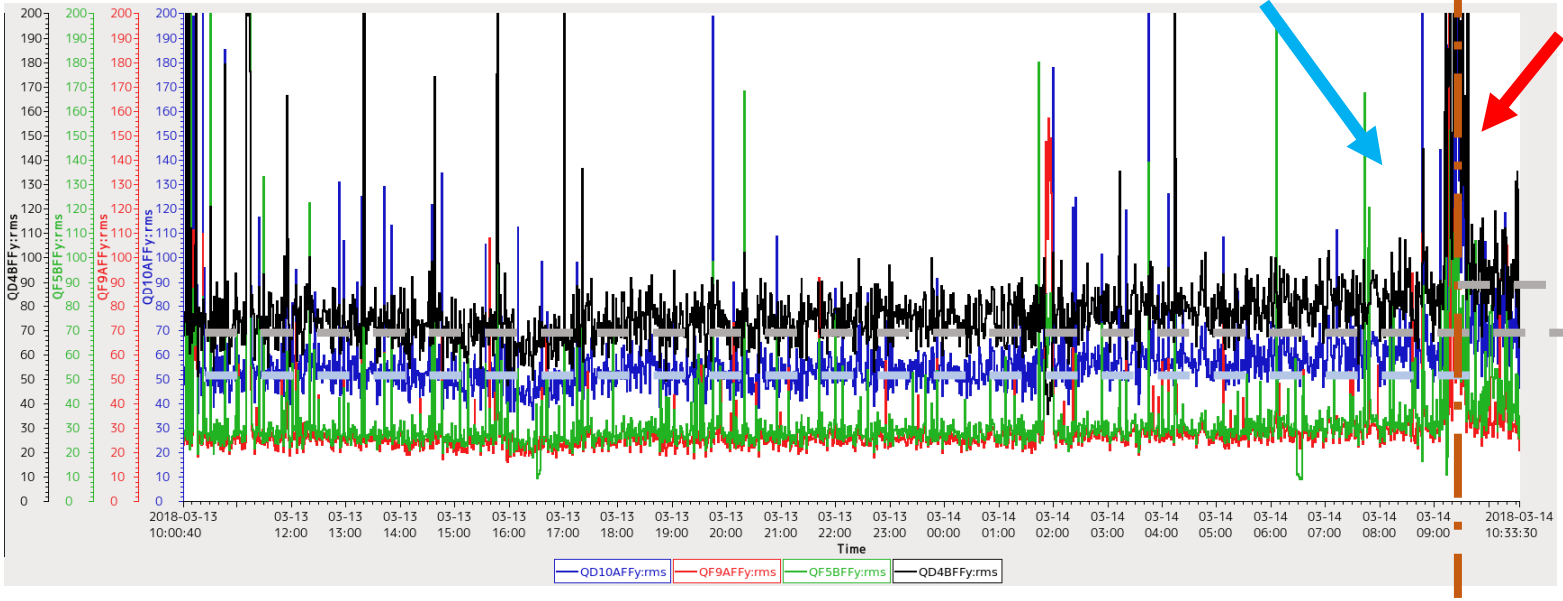


Vertical Orbit Jitter

Vertical dispersion at QD10/QD4 was 0.5m

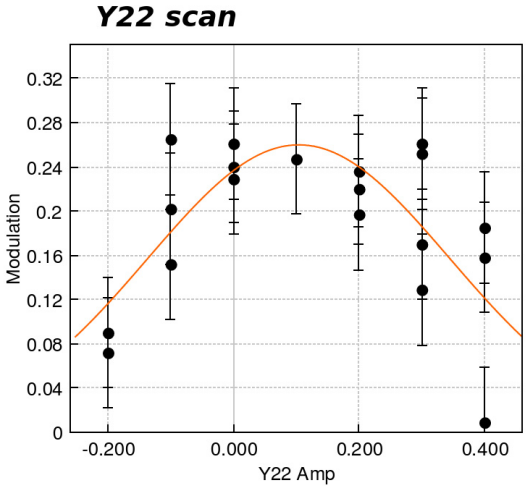
Vertical dispersion correction

Jitter difference by optics



Vertical jitter was increasing …

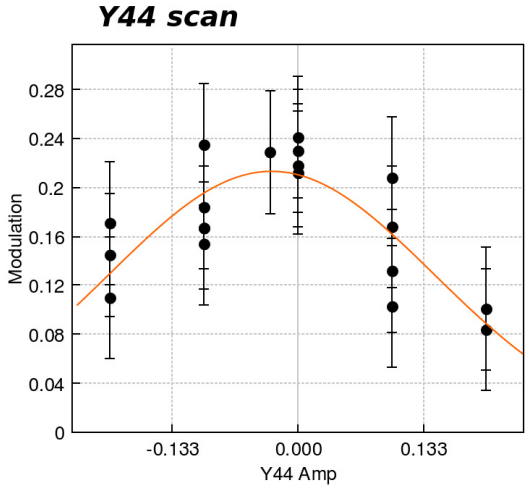
Final beam size in 2018 March Operation



Date: 2018/03/15 Time: 23:53:25

Fit results: A*exp(-((x-B)/C)^2/2)
Modulation: 0.261 +/- 0.022
Center: 0.103 +/- 0.021
Sigma: 0.240 +/- 0.031
Chi2/ndf: 1.8224e+01 / 16

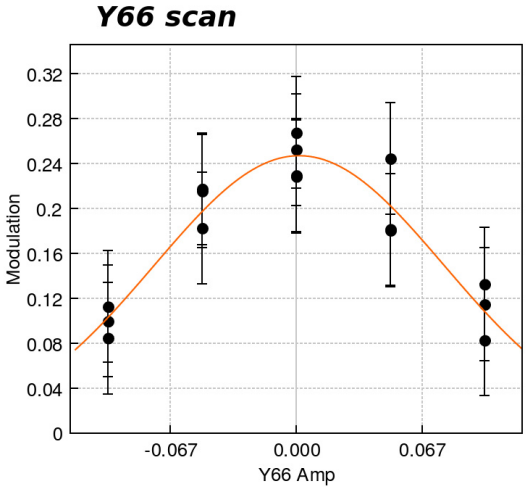
Data file:
Y22_fringe_180315_235325.dat



Date: 2018/03/15 Time: 22:47:28

Fit results: A*exp(-((x-B)/C)^2/2)
Modulation: 0.214 +/- 0.018
Center: -0.029 +/- 0.021
Sigma: 0.173 +/- 0.031
Chi2/ndf: 6.2690e+00 / 16

Data file:
Y44_fringe_180315_224728.dat



Date: 2018/03/15 Time: 21:28:07

Fit results: A*exp(-((x-B)/C)^2/2)
Modulation: 0.248 +/- 0.021
Center: 0.001 +/- 0.008
Sigma: 0.077 +/- 0.010
Chi2/ndf: 2.5900e+00 / 13

Data file:
Y66_fringe_180315_212807.dat

No time to apply Y26 knob,
but the beam size was still about 70 nm.

No time to optimize the IP-BSM lens position.

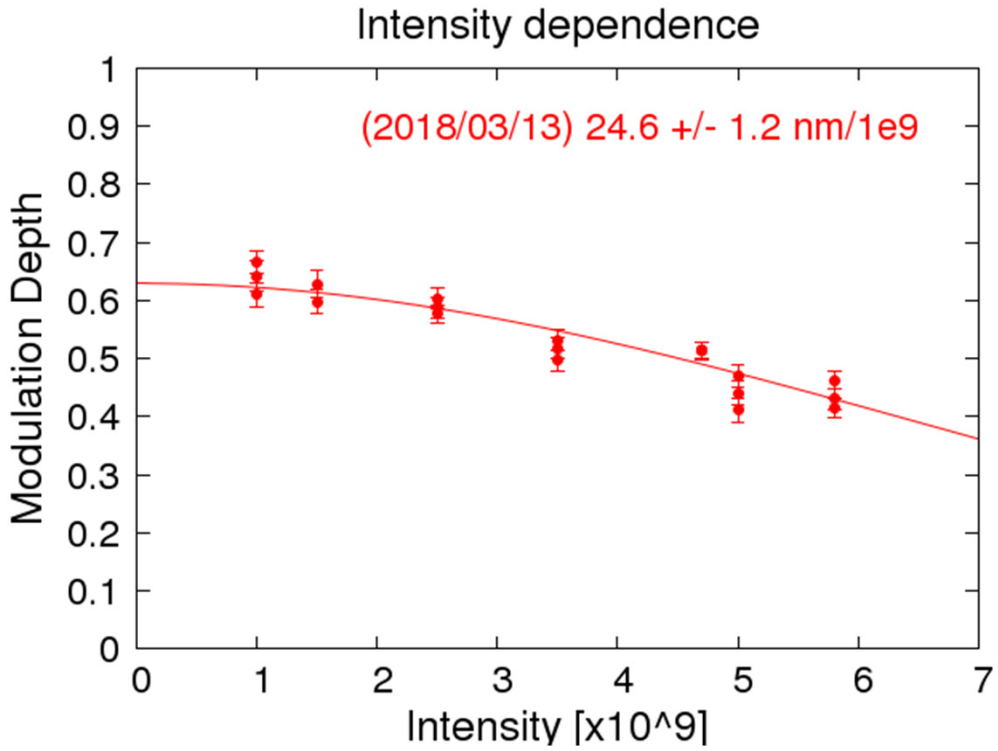
If the modulation reduction factor is
80% ; 70 nm => 65 nm
70% ; 70 nm => 61 nm

The IP-BSM optimization is important to evaluate the IP beam size.

Intensity dependence

No time to reduce the intensity dependence by wake field source scan (reference cavity).

The intensity dependence in March 2018 was large.



(Beam intensity for IP beam size tuning) = 1.0-1.2e9

(Effect of intensity dependence)
70 nm => 65 nm

Intensity dependence also affect to evaluate the IP beam size.

Summary of IP beam size tuning

We measured the IP beam with 2 set of ATF2 optics.
One optics is EmitY/betaY=0.11, and another is EmitY/BetaY*=0.18.*
IP beam sizes for both optics were 65-70 nm (still larger than 50nm).
=> We should do the coupling correction with multi-OTR.

The measured beam size was included the systematic error of IP-BSM monitor.
=> We should tune the IP-BSM monitor itself.

The intensity dependence was larger than last week,
but the contribution was 25nm/1e9.
=> We should reduce the intensity dependence by reference cavity scan.

Furthermore, we need to take care of the dispersion drift within the knob scan,
especially the day with large temperature variation.