ATF2 tuning Status

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Contents

Beam Optics in 2012 Spring Operation

Linear knob and stability

Nonlinear knob

Brief IP-BSM Status

Preliminary Beam Size Evaluation in 2012 spring operation

Beam Optics in 2012 Spring Operation

In 2012 spring operation,
- we used Glen's 2.5x1 optics in FF beamline and fixed the FF line optics,
- the beta*s were changed by changing matching quads (QM11FF-QM16FF).

as we decided in 13th ATF2 project meeting (2012 January).

FF beamline was matched to
- 10x10 beta optics ; - 2/17
- 10x 3 beta optics ; 2/20 - 2/24
- 10x 1 beta optics ; 3/05 -

Linear knob

$$\sigma^2 = \sigma_0^2 + (C_\alpha^2 Ay^2 + C_\eta^2 Ey^2 + Cc^2 Coup2^2)$$

Measured Modulation by IP-BSM

$$M = C \cos\theta \, \exp\,[-2 (k_y \sigma)^2]$$

C ; Modulation Reduction Factor (IP-BSM related)

C_α *; Effect of beam waist position (depends on vertical divergence)*

C_η *; Effect of vertical dispersion (depends on momentum spread; basically constant)*

Cc ; Effect of coupling (<x'y>) (depends on horizontal divergence)

If eachknob is not coupled,

$$M = C \cos\theta \, \exp\,[-2 (k_y \sigma_0)^2]$$ Constant for linear knob tuninig

$$\exp\,[-2 (k_y C_\alpha \, Ay)^2]$$ Effect of Ay knob

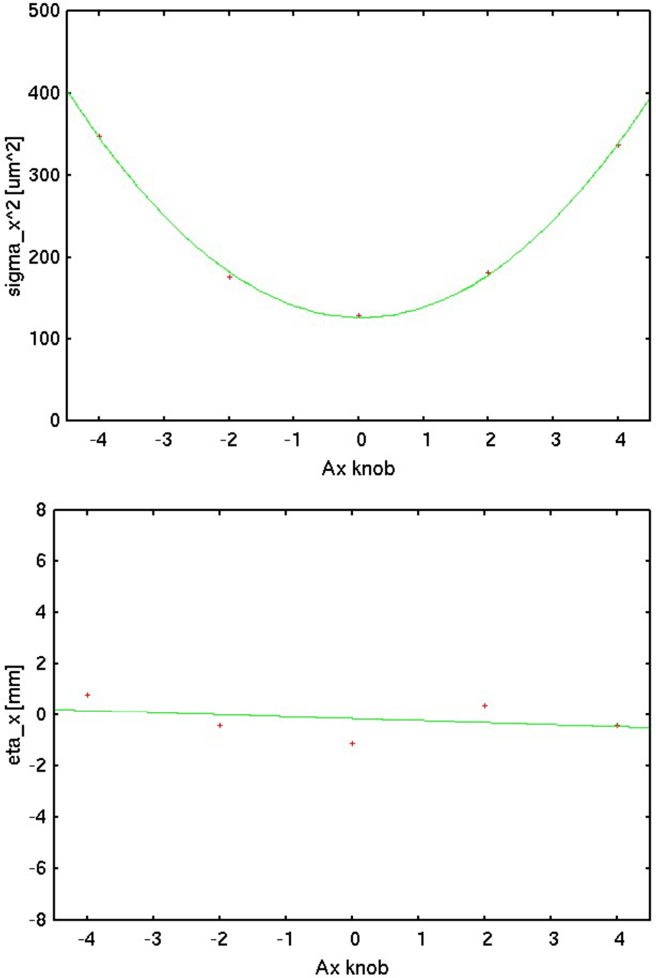
$$\exp\,[-2 (k_y C_\eta \, Ey)^2]$$ Effect of Ey knob

$$\exp\,[-2 (k \;\, Cc \, Coup2)^2]$$ Effect of Coup2 knob

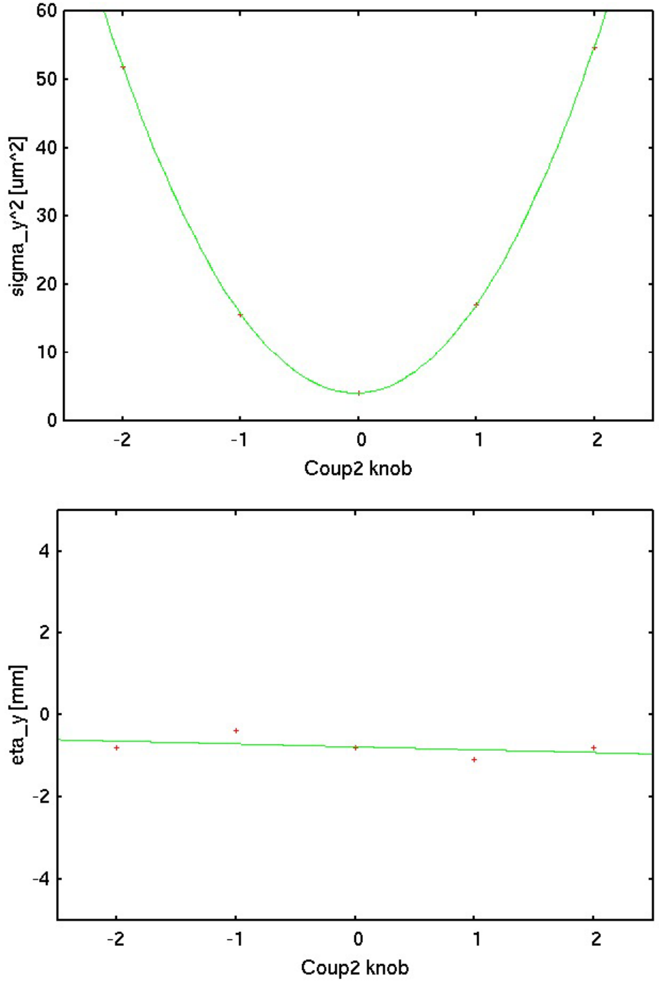
Linear Knob Independency

Measured by carbon wire scanner

Alpha X knob (horizontal movers)



Coup2 knob (vertivcal movers)



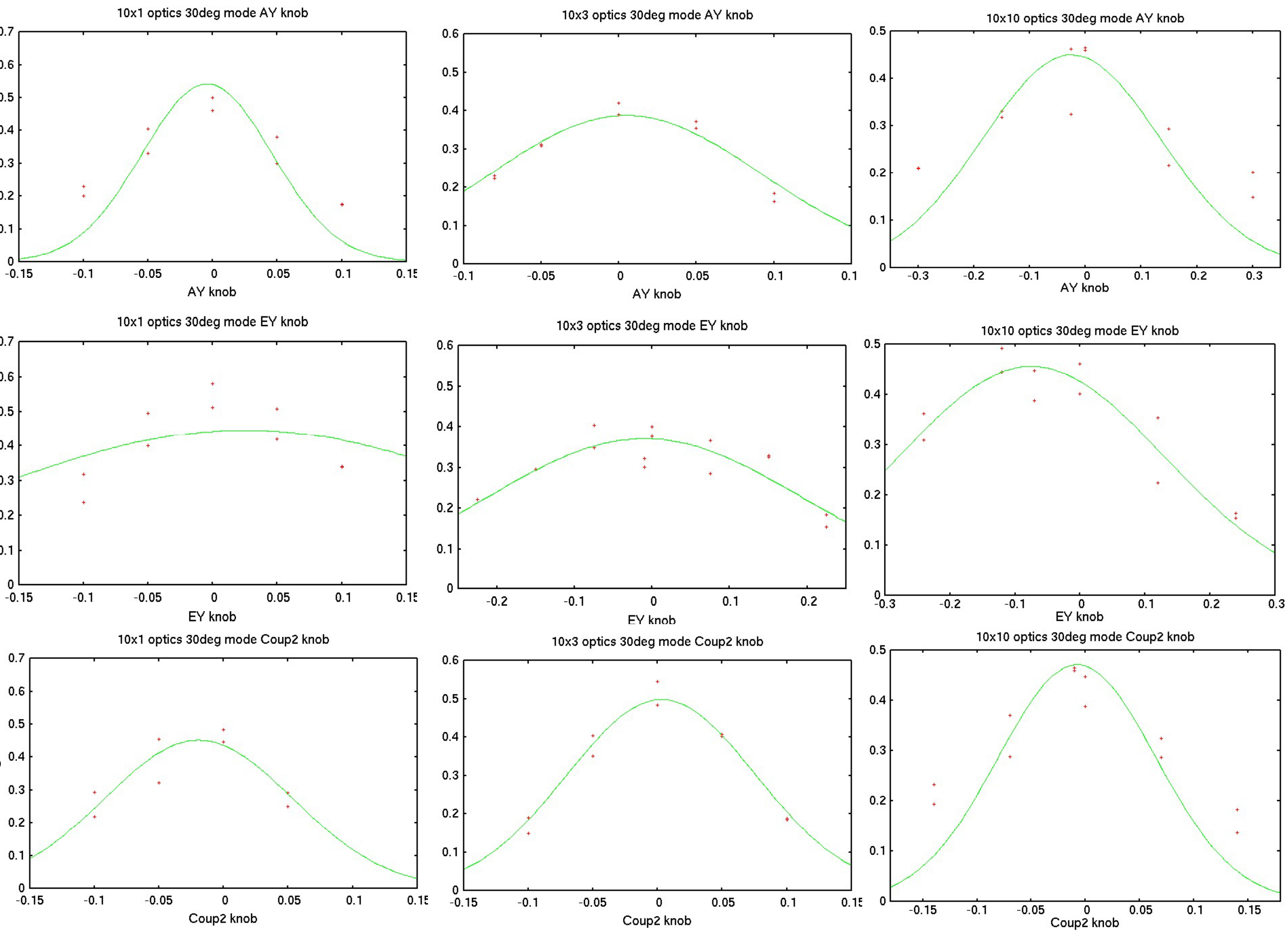
The knobs are not coupled to the dispersions.

10x1 optics ***10x3 optics*** ***10x10 optics***

Ay

Ey

Coup2



Beam Drift Issues

Beam drift was large in April - May

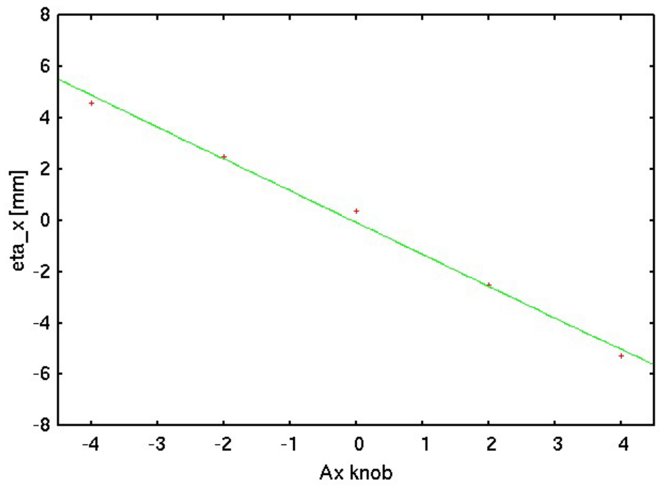
Fortunately , small drift in June (outside temperature was low and stable)

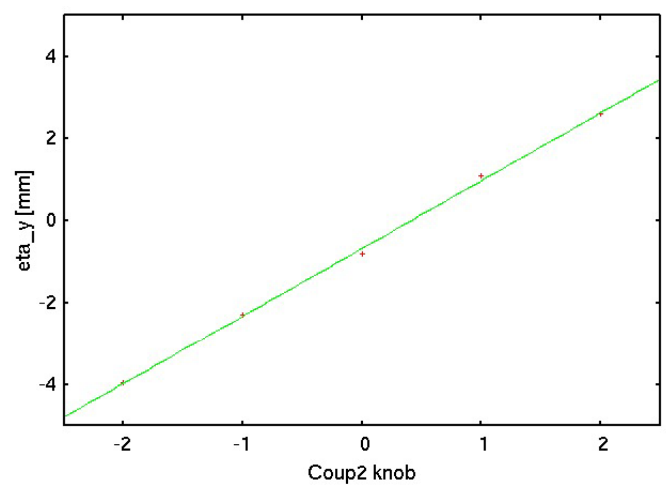
-*We applied DR and EXT orbit feedback.*

-*Energy drift was corrected by changing the rf frequency in DR sometimes (once a week)*

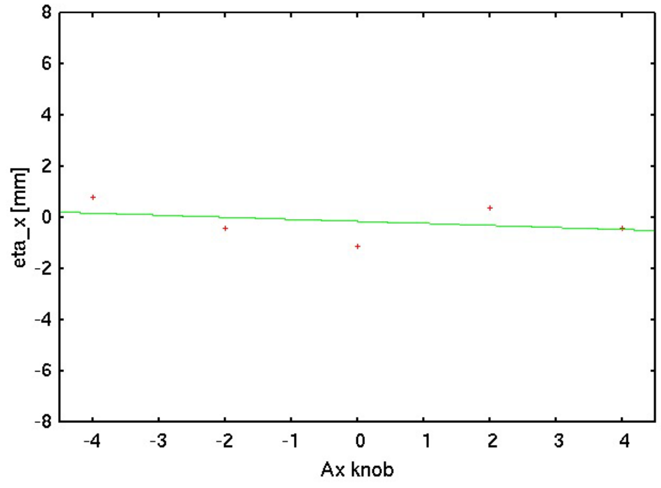
-*It is important to correct FF dispersion for IP beam size tuning.*

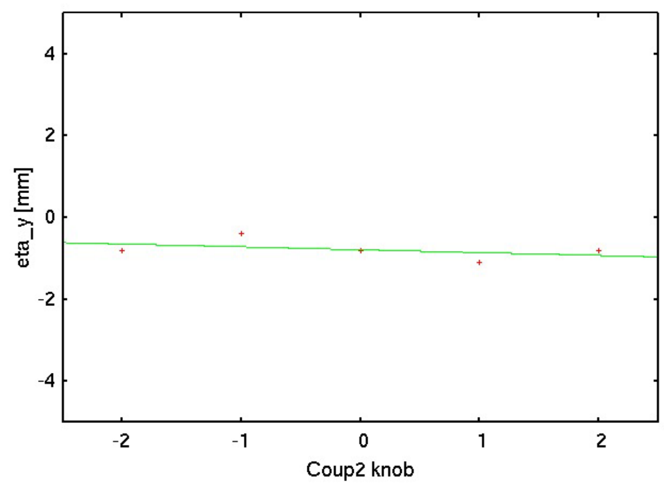
2 days after orbit and dispersion tuning in FF beam line,
the large coupling of linear knob was observed.





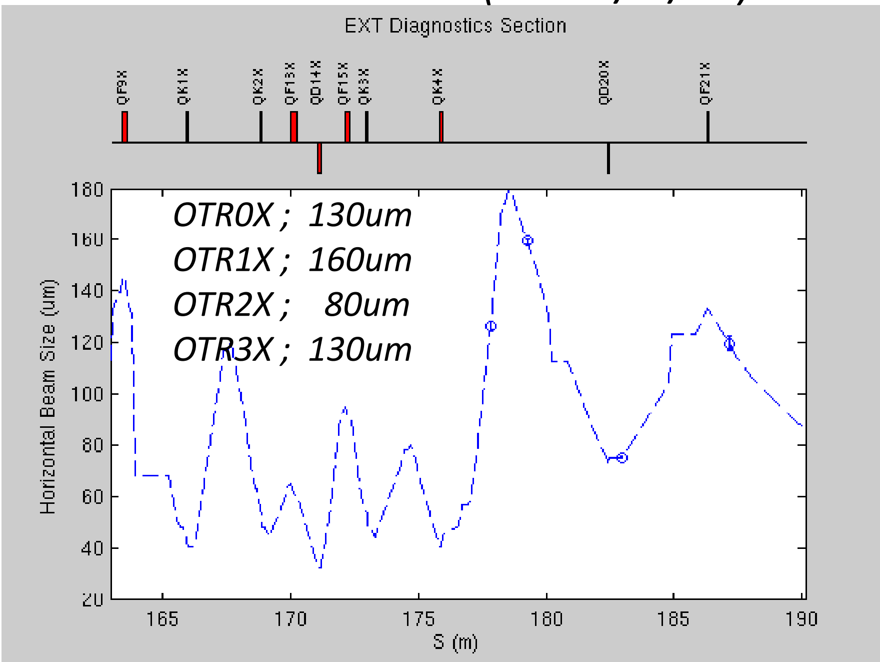
After FF dispersions were corrected,
the coupling was disappeared.





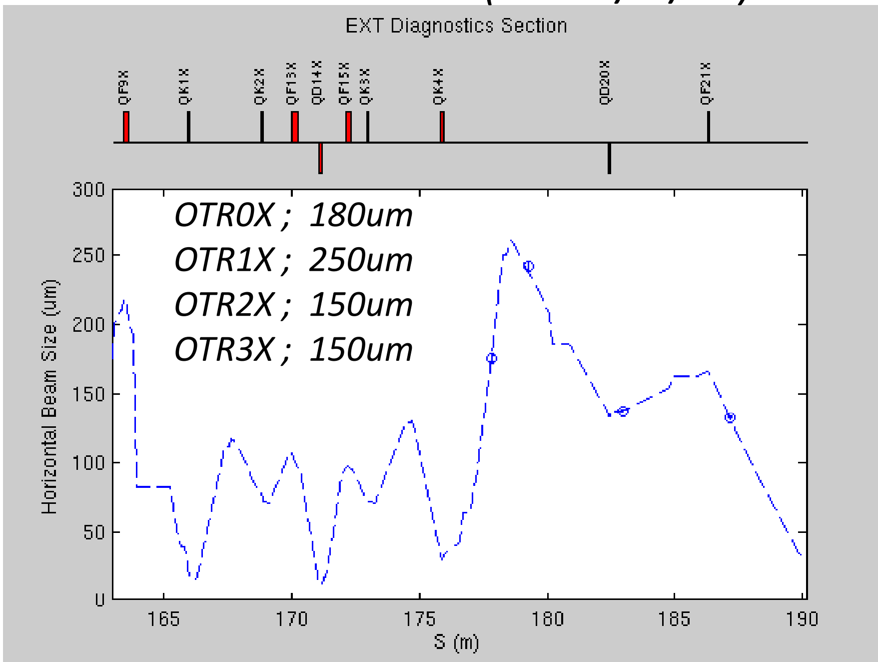
The horizontal beam size at OTRs were increased from April 2012

OTR measurement (2012 /3 /14)



Typical horizontal emittance was 1.5-2.0nm

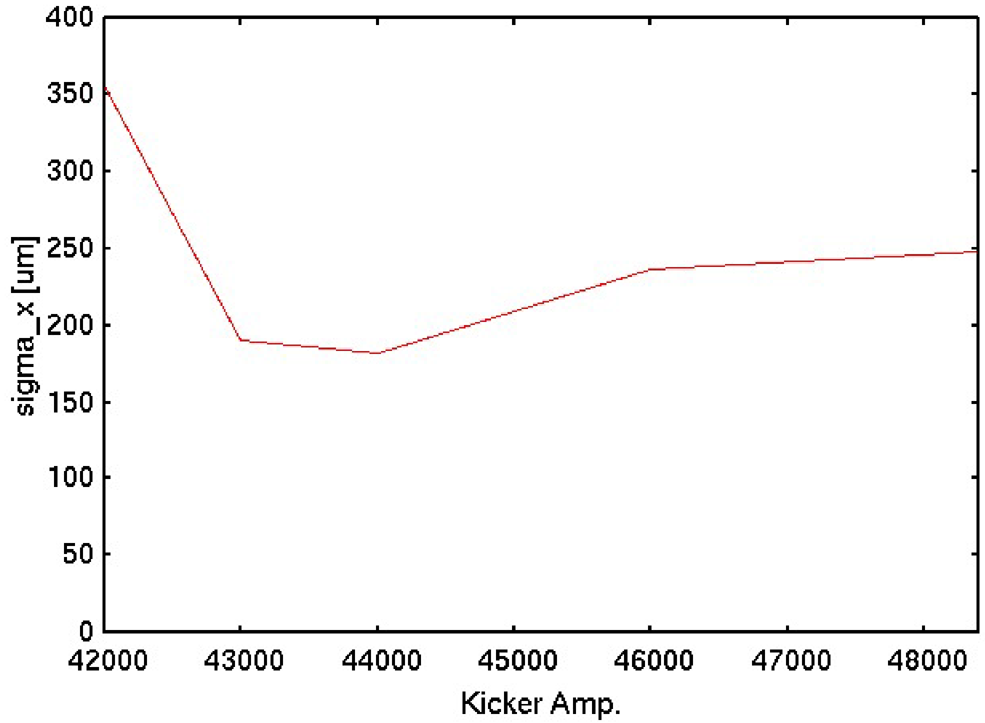
OTR measurement (2012 /6 /13)



Typical horizontal emittance was 3.0nm

Even though the fitting shows 1-2nm emittance sometimes in June operation,
- the beam size at OTRs were very large to those in Feb.-May.
- the Bmag was large for horizontal direction
- the IP emittance measurement show 3nm horizontal emittance.

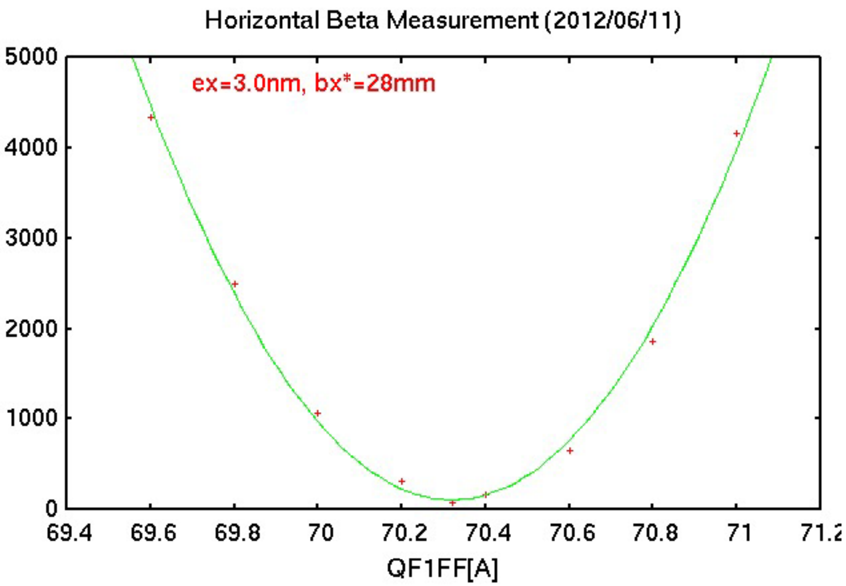
We investigated the dependence of the beam orbit at the entrance of EXT line, by changing the strength of extraction kicker.

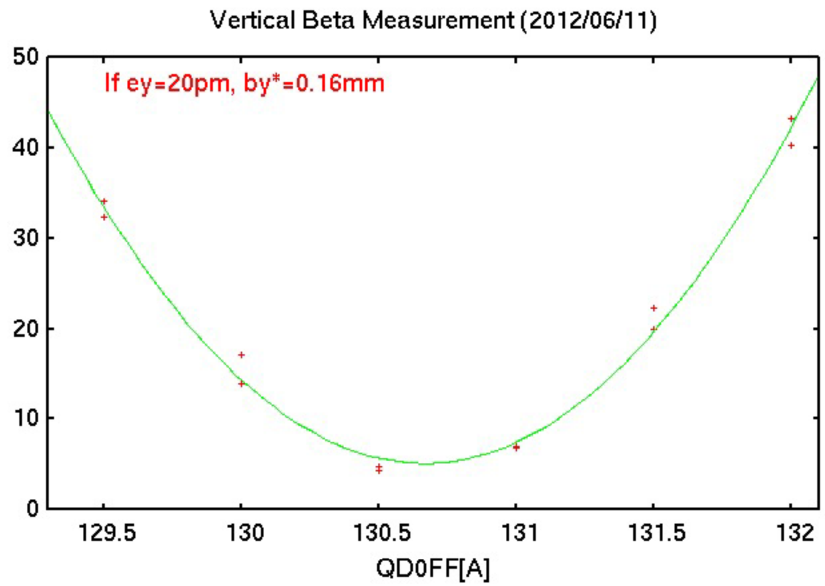


We observed clear beam size dependence at OTR1X (largest beam size), but no dependence for evaluated emittance with 4 OTRs and evaluated emittance at IP.

Kicker amplitude was sensitive to the Twiss parameters, but not sensitive to horizontal emittance.

IP beam size measurement in 11th June 2012.





ex = 3.0nm
bx = 28mm (design 40mm)

If we assumed to ey=20pm,
by=0.16mm (design 0.10mm)

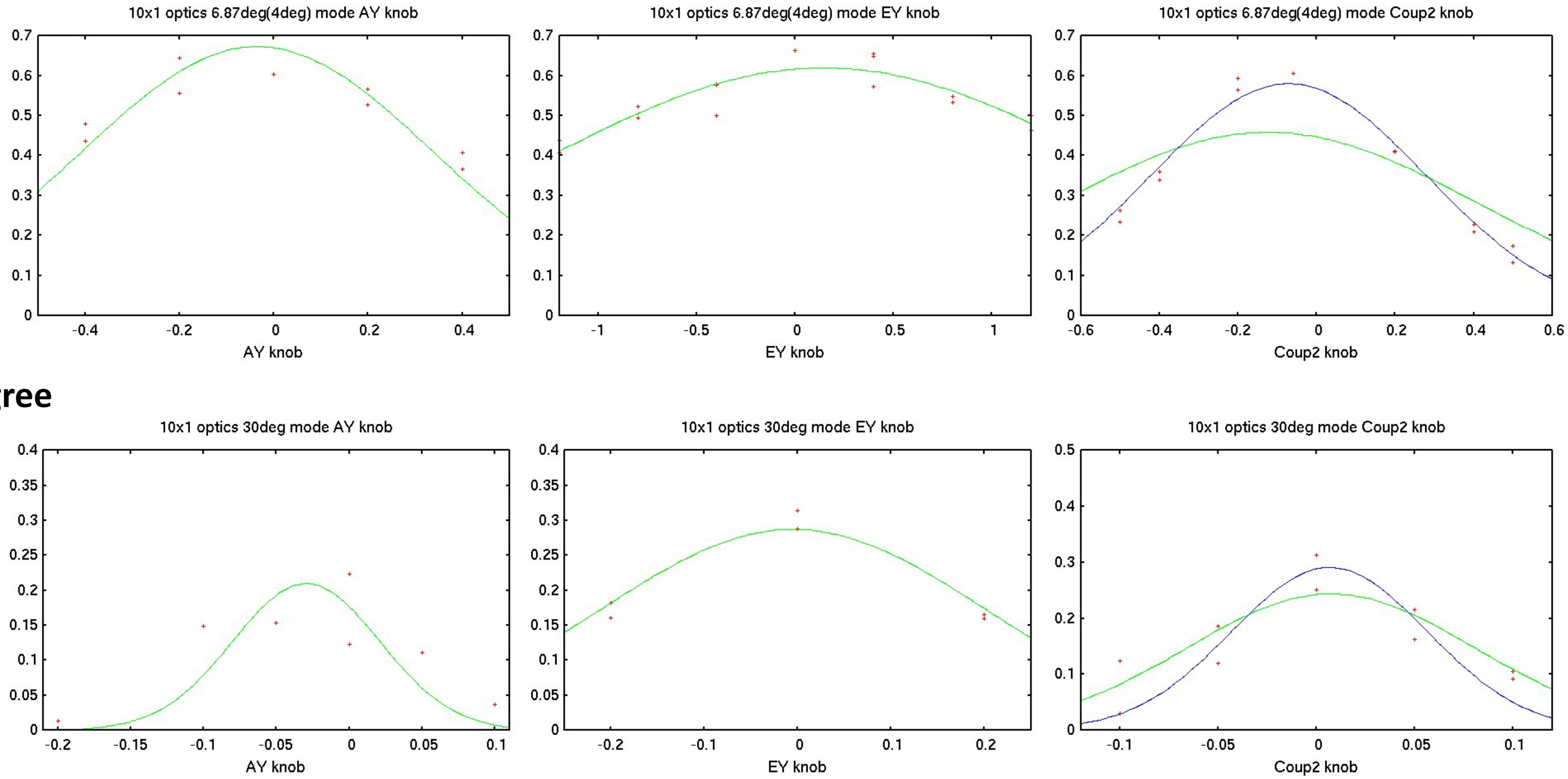
Since the betax* was small,
the IP horizontal beam size was almost same to the Feb.-March operation.

IP beam size tuning in June 2012

Ay knob | **Ey knob** | **Coup2 knob**

2-8 degree mode

30 degree mode



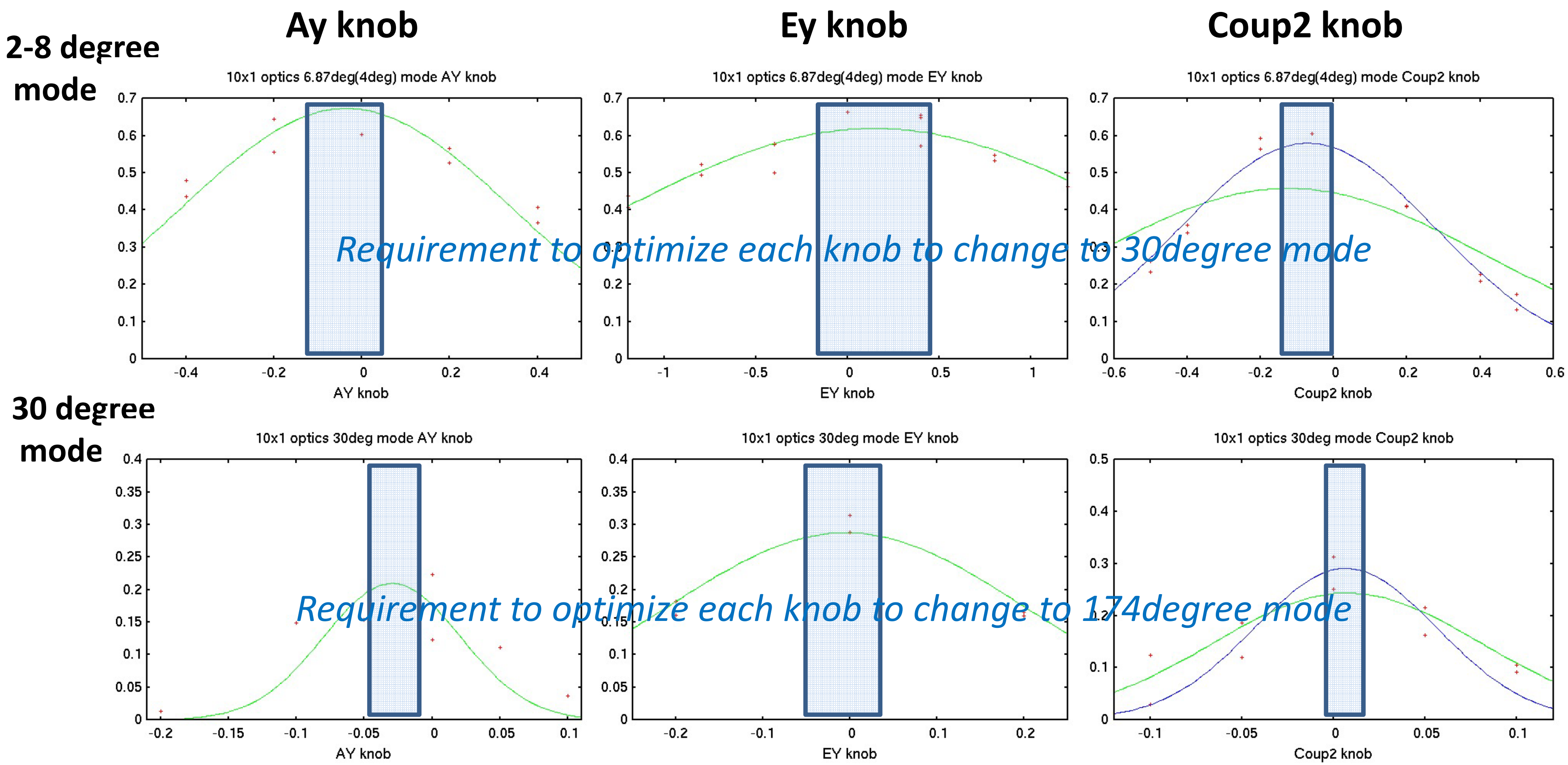
Green line ; design (ex=2nm, bx=40mm)

Blue line ; ex=3nm, bx=28mm

Response of linear knobs were consistent with the IP beta measurement.

Requirement of the accuracy of knob center search

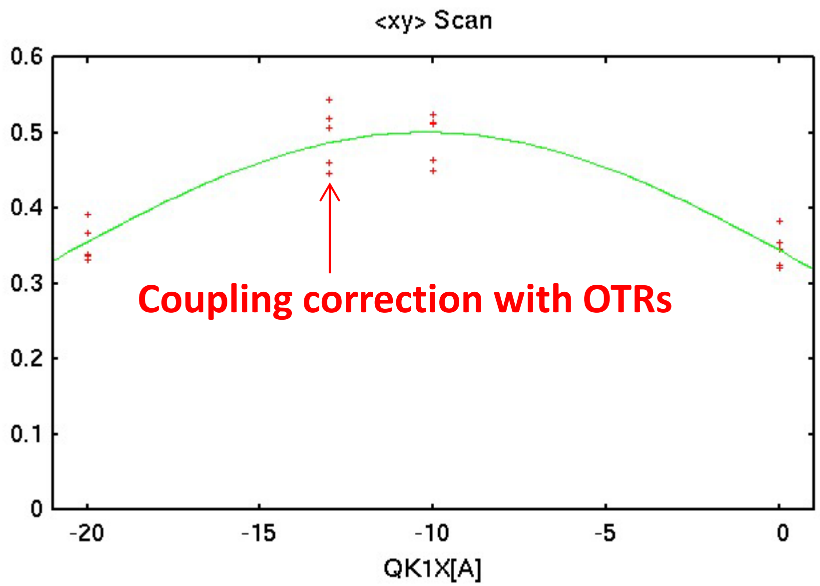
Modulation reduction factor is not important for IP beam size tuning, but important for the stability of the measurement.



The fluctuation of the modulation measurement was too large to optimize the knob for 30degree mode.

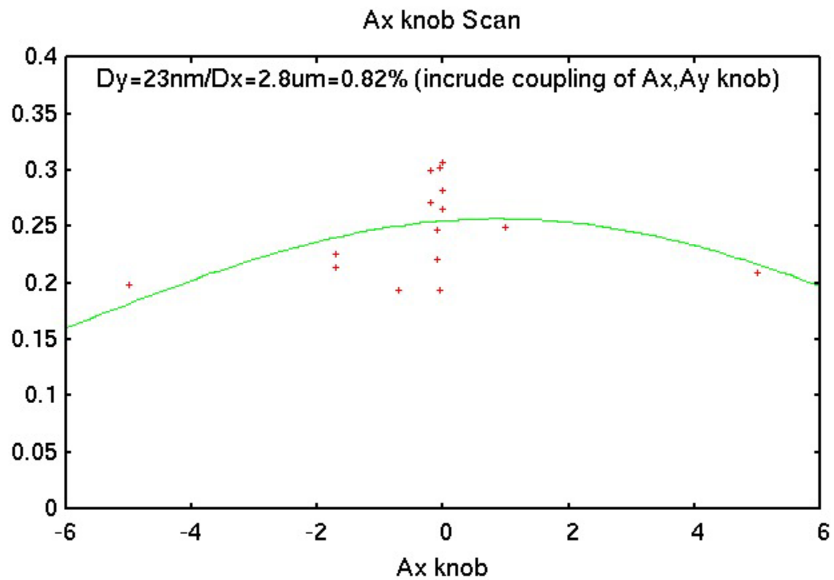
Effect of beam tilt

2012 February



Optimum <xy> was not so far from the coupling correction in EXT.

2012 June



The beam tilt angle was less than 8.2mrad.
(include of the coupling of Ax and Ay for Ax knob)

Nonlinear knobs

When the strength of sextupoles are changed,
the chromaticity, geometrical aberration, 2nd order dispersion are changed.

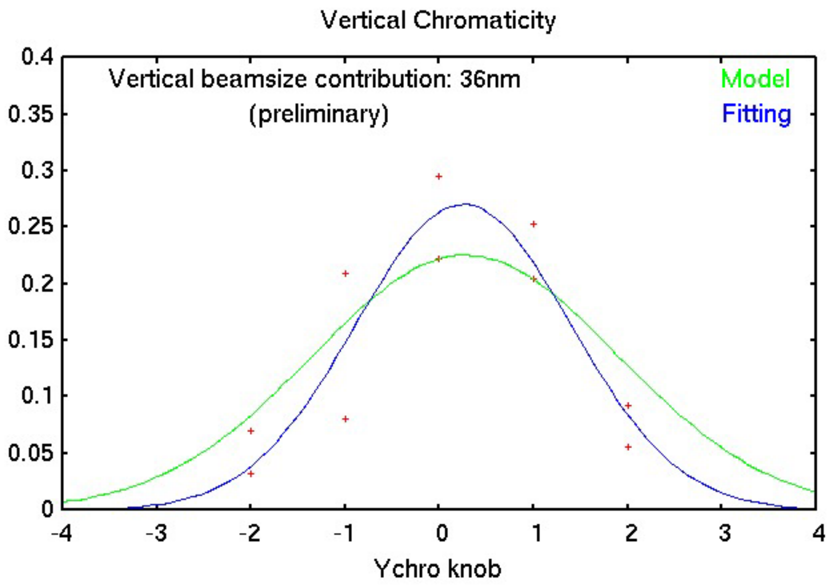
Therefore, we prepare the nonlinear knob to change the nonlinear effect independently.

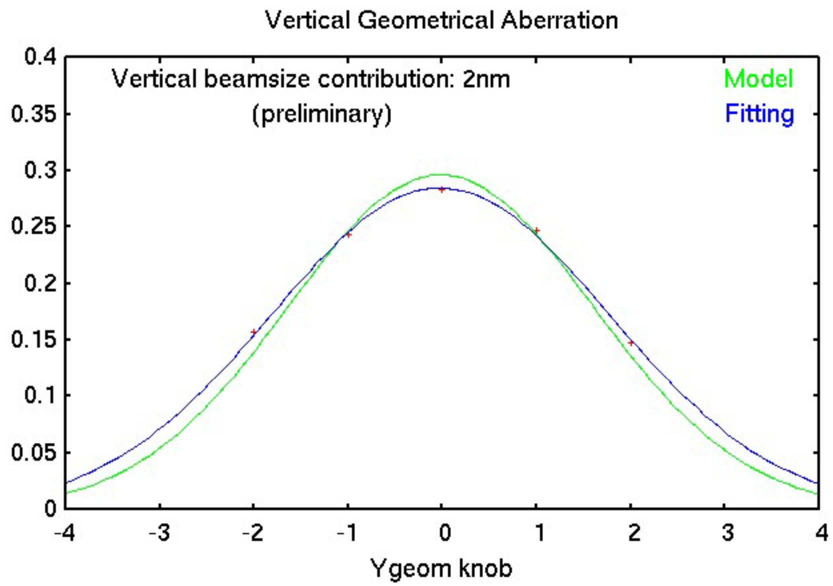
The nonlinear knobs are orthogonal to

- horizontal chromaticity
- vertical chromaticity
- horizontal geometrical aberration
- vertical geometrical aberration
- 2nd order dispersion

We use the vertical chromaticity knob (Ychro)
and the vertical geometrical aberration (Ygeom) for IP beam size tuning.

Nonlinear knob test



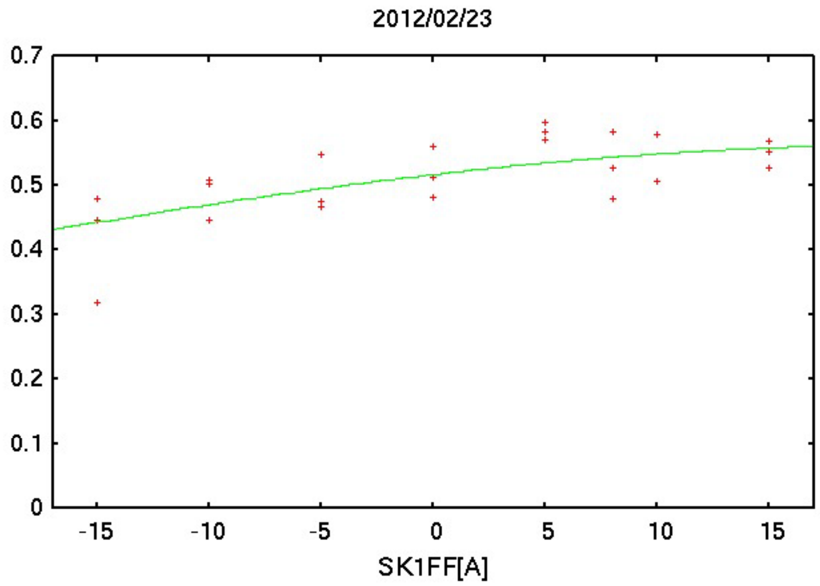


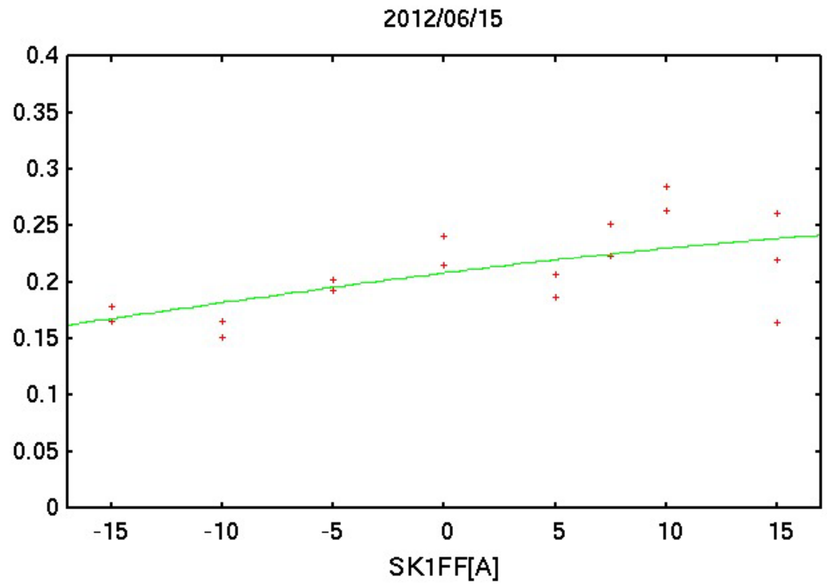
Model was calculated when the beam passed through the center of sextupole magnet.
(No effect of linear knob, when we changed the strength of sextupole)

The effect of the nonlinear knobs were a few 10nm in June operation.

The nonlinear knobs were now on ready for beam size tuning.

Correction of Skew Sextupole Field





We measured same response of SK1FF strength scan in Feb. and June 2012.
(Minimum SK1FF was around 20A ; design was 5A)

We set to SK1FF=8-10A for the current limit of SK1FF,
the residual contribution from fit was 20nm.

Had we better to replace the SK1FF to stronger one ??

IP-BSM Status in 2012 Spring Operation

The maximum modulation of IP-BSM in 2-8degree mode

The maximum modulation for 2-8 degree mode
was changed from 60-80% to 50% from end of March.

In March 2012, we replaced the rear-mirror of IP-BSM laser.
After that the laser spot size was increased twice at the exit of laser.

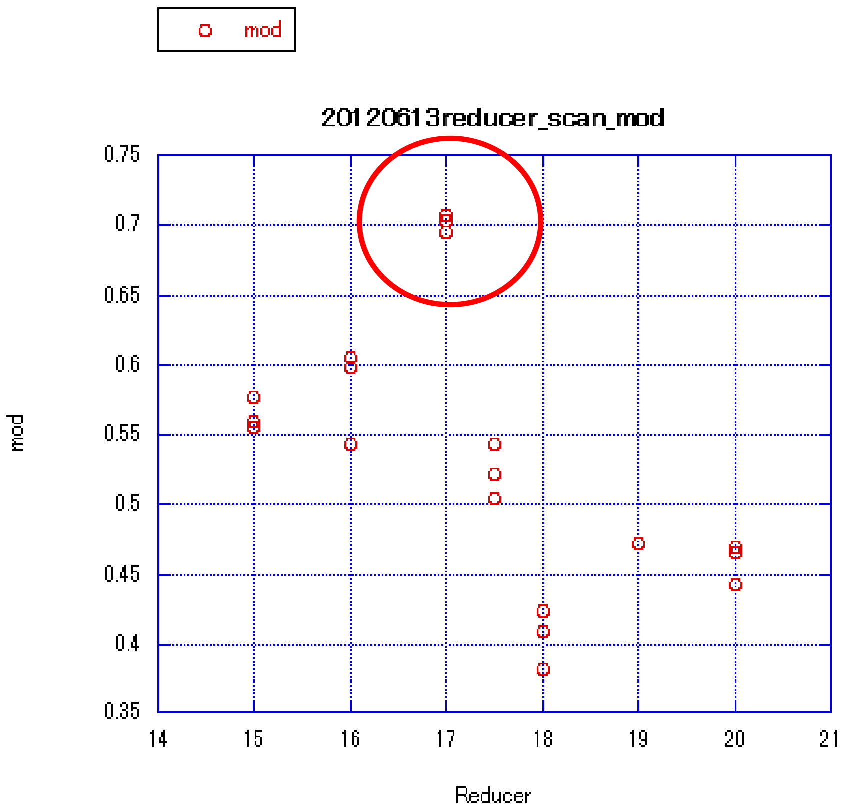
From the middle of March, we had measured 3times more than 60% modulations.

1. 80%(04/26) ; half of the lower path laser light did not go to IP by drift.
   After the realignment of laser path, the modulation was decreased to less than 60%.

2. 83% (06/06) ; only the laser path of 2-8degree mode was made.
   After making 30 degree mode (laser path for 2-8 degree mode also changed),
   the modulation was decreased to less than 60%.

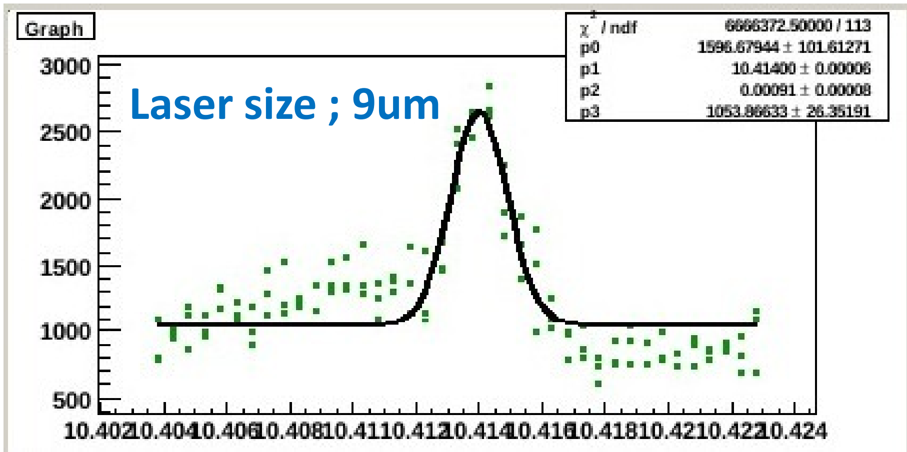
3. 80%(6.3degree mode), 90%(4.0degree mode) 6/13-6/14

IP-BSM setting in 6/13-6/14

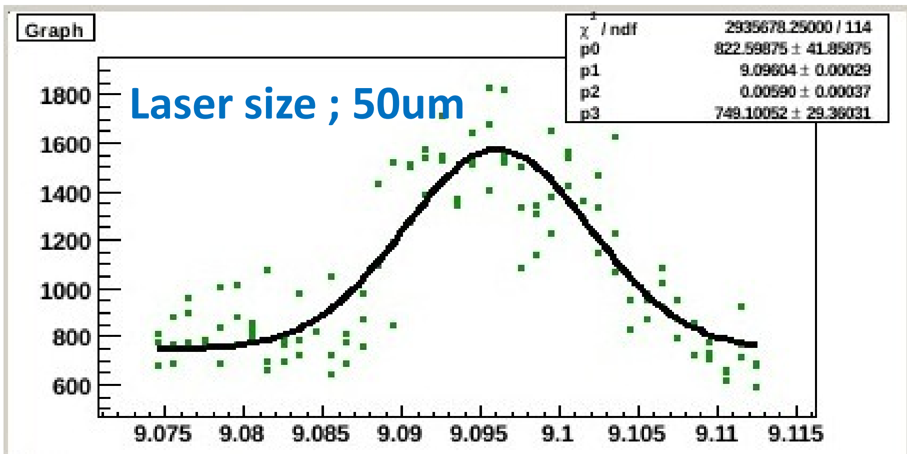


Very narrow optimum setting

Beam profile of upper path



Beam profile of lower path



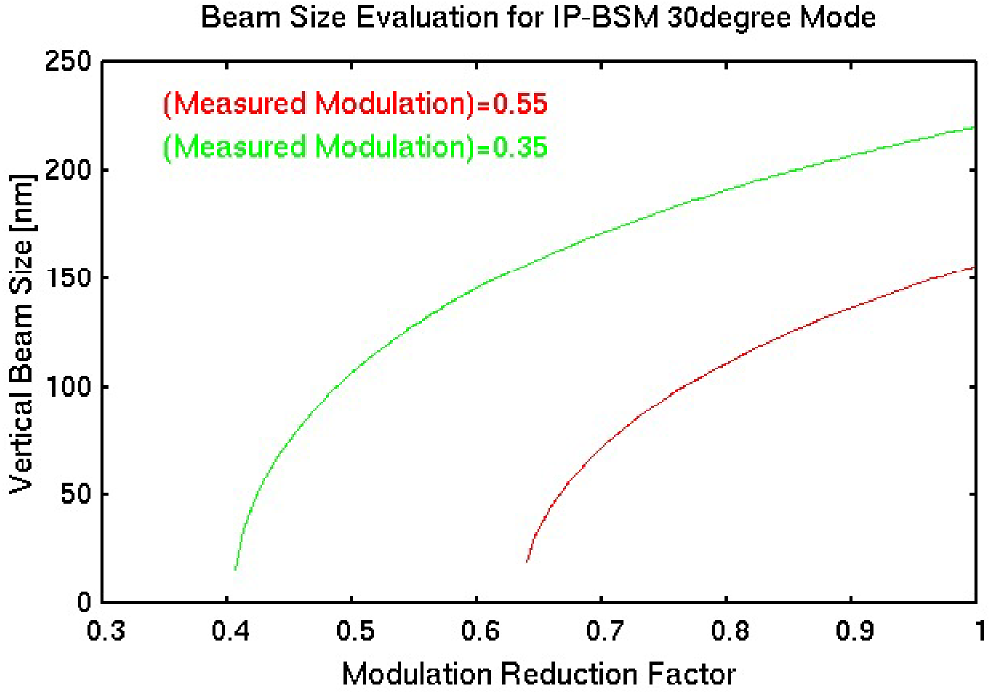
Very large unbalance of laser pfofile at this setting.

We did not understand how to optimize the setting of IP-BSM

The achieved beam size in 2012 spring operation (preliminary)

Maximum modulation of 30degree mode

10x10 optics	(the week of 2/13-2/17) ;	0.45
10x 3 optics	(the week of 2/20-2/24) ;	0.55
10x 1 optics	(the week of 3/05-3/09) ;	0.55
After middle of March ;		0.35



Typical modulation of 2-8degree mode

Before middle of March ; 0.6-0.8

After middle of March ; 0.4-0.6

$$\sigma = \frac{1}{k_y}\sqrt{\frac{1}{2}\ln\frac{C\cos\theta}{M}}$$

C ; Modulation Reduction Factor (IP-BSM related)

Modulation reduction factor is important to evaluate the IP beam size.

Beam Tuning Method

$$M = C \cos\theta \, \exp\left[-2\,(k_y \sigma)^2\right]$$

C ; Modulation Reduction Factor
(IP-BSM related)

$$\sigma^2 = \beta\varepsilon + (C_\alpha^2 Ax^2 + C_\eta^2 Ey^2 + C_c^2\, Coup2^2) + Ct\, \langle xy \rangle^2$$

Correct with linear knobs **Correct with QKs**

$$+ (C_{geom}^2 Y_{geom}^2 + C_{chro}^2 Y_{chro}^2) + C_{SK}^2\, SK1FF^2$$

Correct with nonlinear knobs **Correct with SK1FF**

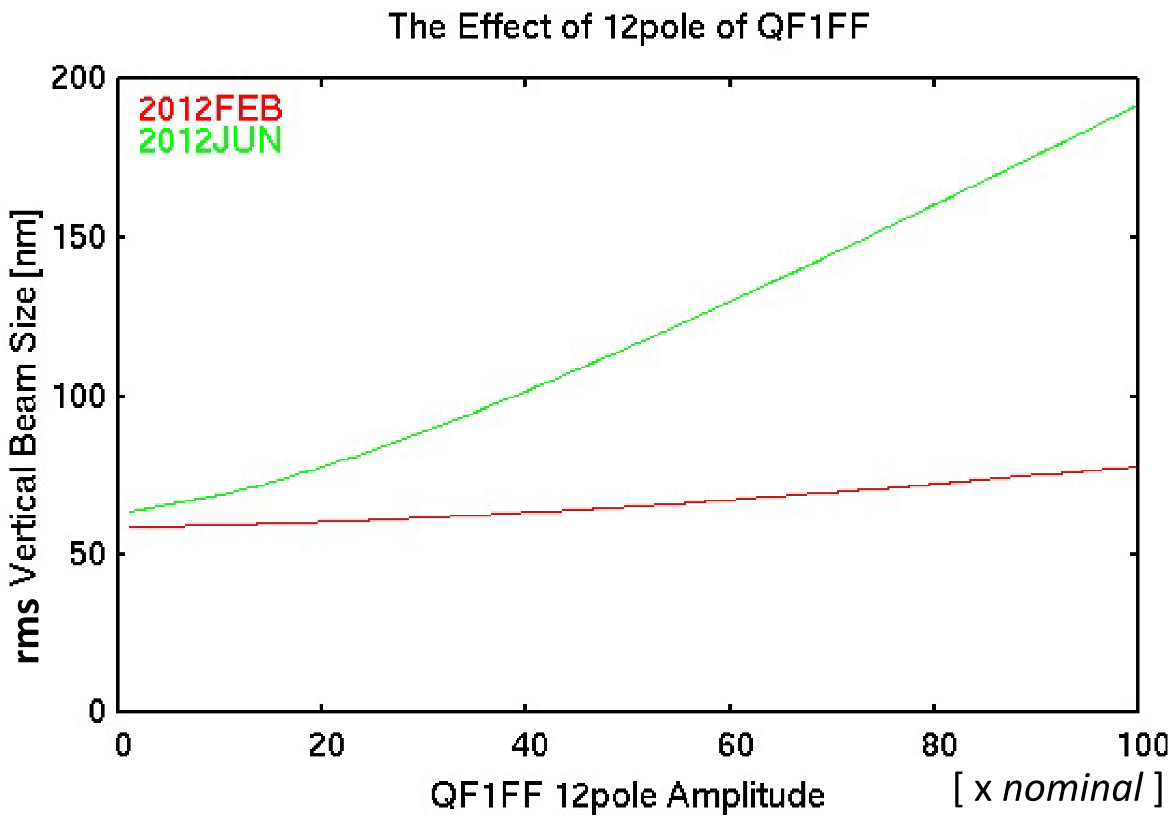
$$+ \sigma_{8pole}^2 + \sigma_{10pole}^2 + \sigma_{12pole}^2 + \ldots\ldots$$

-***can not correct with any tuning knobs***
-***But, since the effect strongly depend on the beam size at quads,***
we can control the effect by changing $\sigma_{x'}^*$;

If the beam size was reached to the limit, we should increase the betax.*

The Effect of Multipole Error

Example ; 12pole of QF1FF



Summary

- In 2012 spring operation, we used Glen's 2.5x1 optics in FF beamline.

-FF beamline was matched to

10x10 optics ; - 2/17
10x 3 optics ; 2/20 - 2/24
10x 1 optics ; 3/05 -

- Linear and Nonlinear knobs were worked well.

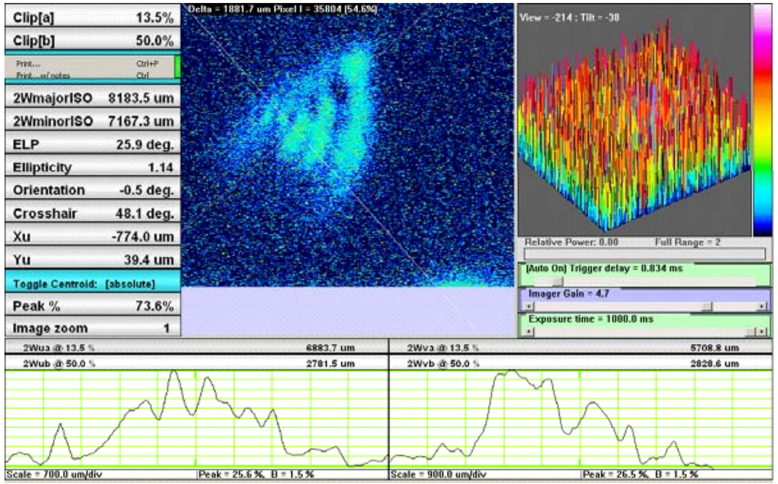
- We succeeded the modulation measurement with IP-BSM 30 degree mode.

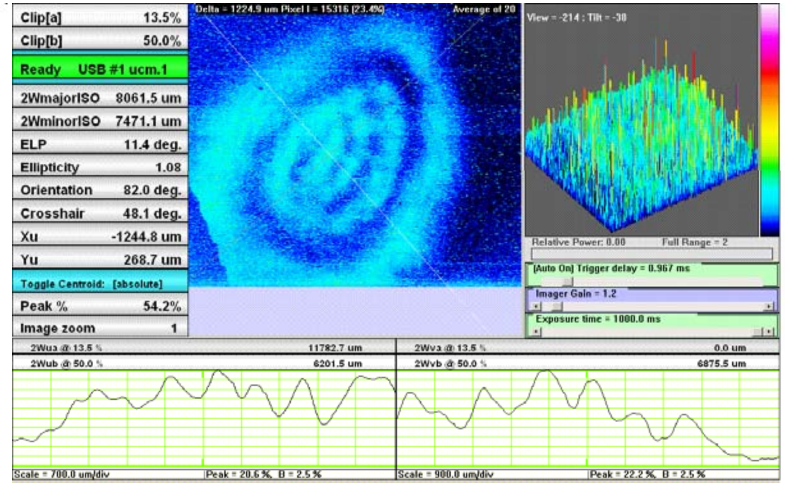
- Maximum modulation of 30degree mode was

10x10 optics (the week of 2/13-2/17) ; 0.45
10x 3 optics (the week of 2/20-2/24) ; 0.55
10x 1 optics (the week of 3/05-3/09) ; 0.55
After middle of March ; 0.35

Backup

Laser Profile of IP-BSM laser





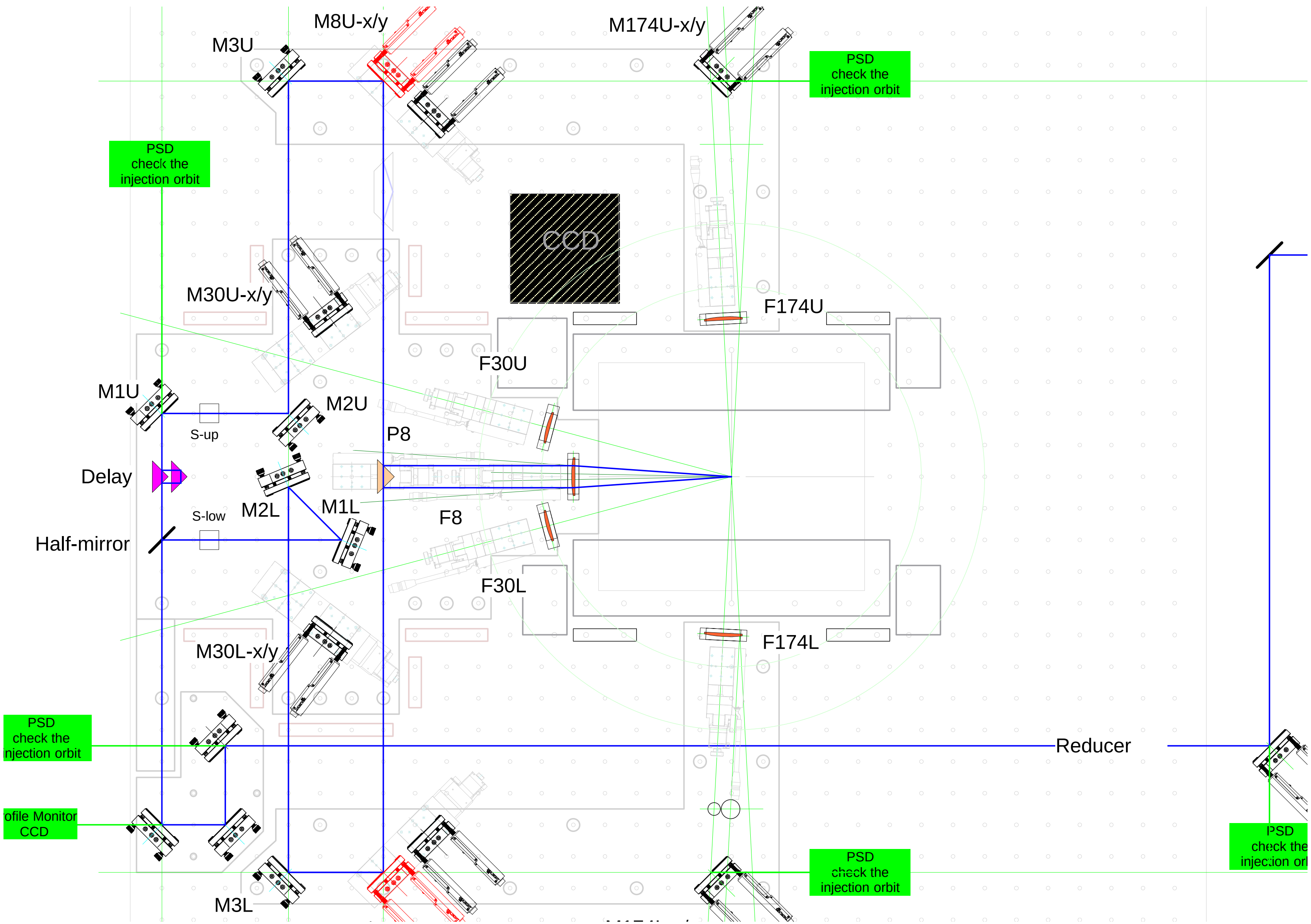
Before rear mirror replacement

After rear mirror replacement

Optical components were broken
by sharp peak of laser profule.

Beam profile was increased
No sharp peak

Difficulties	Solutions
Reproducibility of a laser path: A Laser is not well adjusted to the design path because there is no reference to guide it. A laser travels 10cm high from the vertical table. Non-negligible mismatch toward the IP happens very often after the adjustment of the laser orbit.	**Well defined references near the optical elements:** Put reference lines on the base plates, pedestals etc., to enable the alignment of optical element and traveling laser.
Significant spot size difference at IP between upper and lower lasers. Path length is not same because of the chicane for fringe phase control. It introduces the different waist position; i.e., no ideal crossing.	**Match the path length of upper and lower lasers.** It will be done by adding a drift space that created by an image flopping mirrors.
Concern on the small beam tuning: Changing the crossing angle was done by two sets of rotatable stage and mirror on it. Searching a beam (laser wire, z scan) is done by adjusting the angle of this mirror. Sharing this mirror for different crossing mode lead a retuning every time because it was changed during the previous mode.	**Change the crossing-angle handling concept.** • Remove the rotator and introduce a mirror on a linear mover to select the crossing mode. • Independent mirror adjustment for each crossing mode. • Fixed reducer setting. • Introduce focal lens movers.

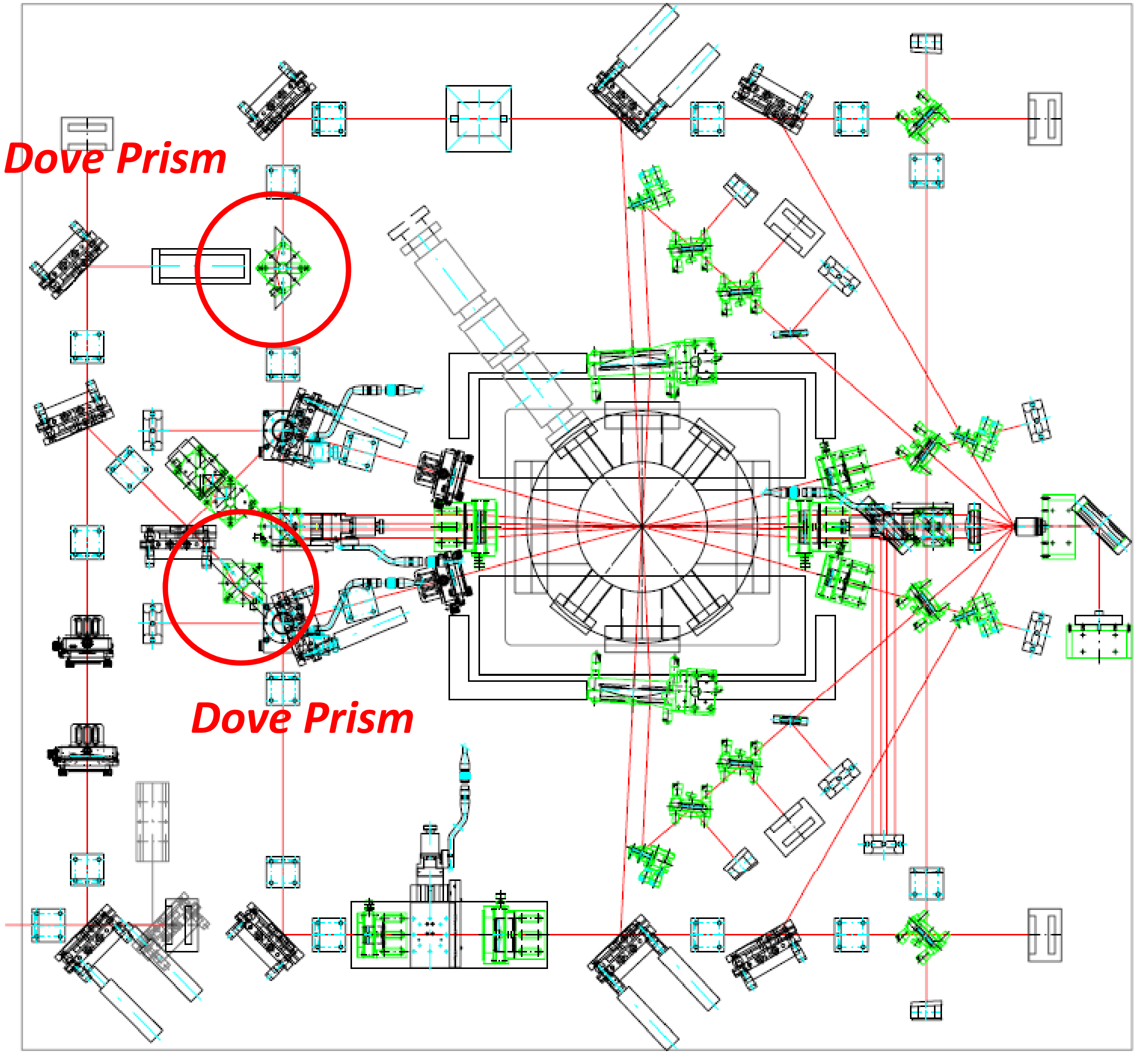

M8U-x/y
M3U
M174U-x/y
PSD
check the
injection orbit
PSD
check the
injection orbit
CCD
M30U-x/y
F174U
F30U
M1U
M2U
S-up
P8
Delay
M2L
M1L
F8
S-low
Half-mirror
F30L
M30L-x/y
F174L
PSD
check the
injection orbit
Reducer
ofile Monitor
CCD
M3L
PSD
check the
injection orbit

Other problems of IP-BSM

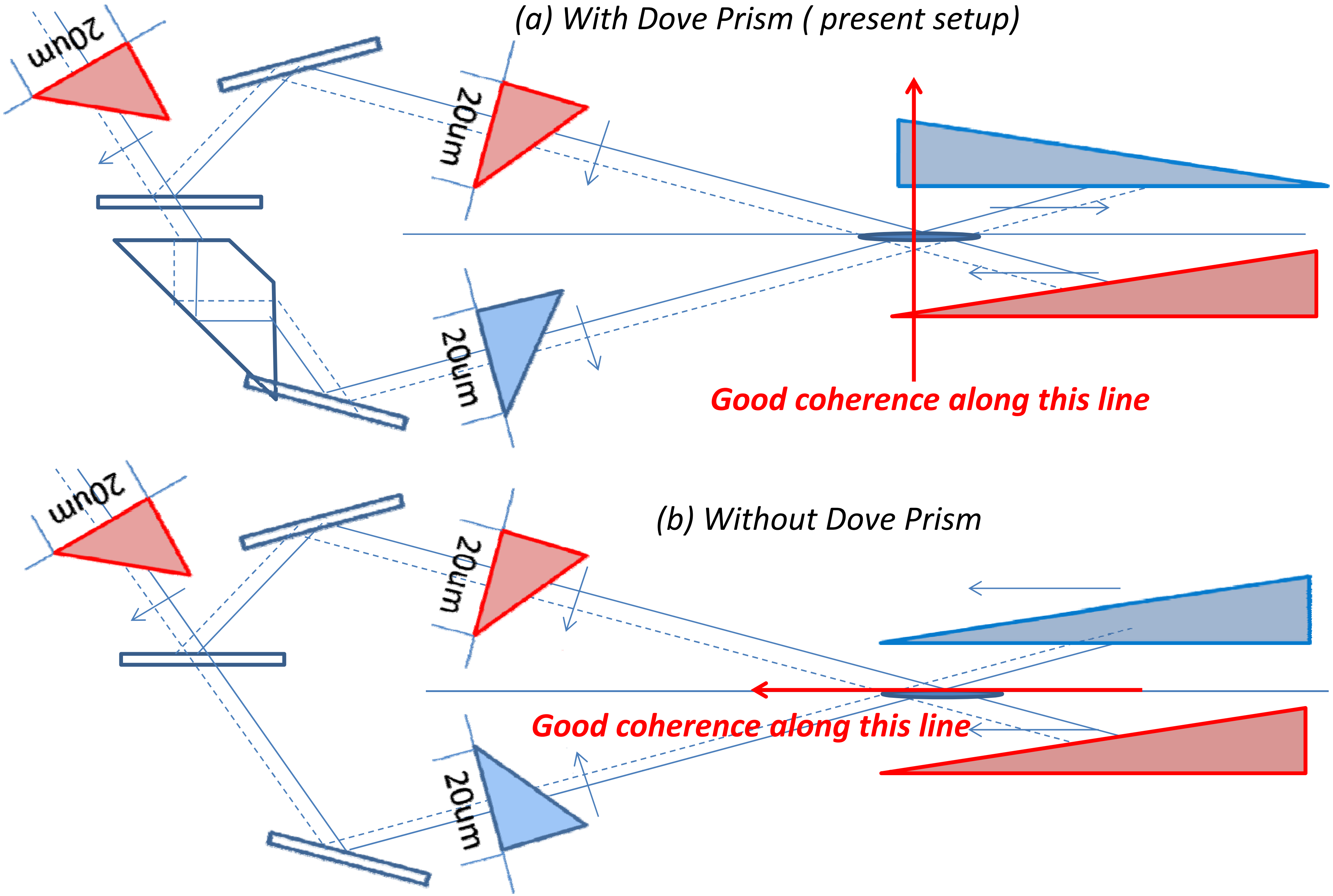
Most of the problems were already presented yesterday, and we will discuss in tomorrow discussion session

1. Alignment of optical components on the vertical table are different from the design.
   - Laser injection angle is different from 2-8degree mode and 30degree mode.
   - When the rotator is rotated, the laser position at the mirror on the rotator is change.
   - Upper path for 174degree mode is not seen in the screen of 2-30degree mode.

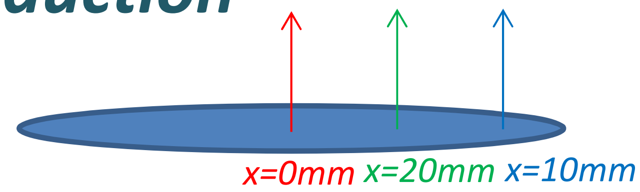
   (no reference line to put the optical components)
2. The focal points for upper path and lower path are different.
3. The collision angle is different from design.
   - Laser is not on the center of lens for 30degree mode.
4. The laser paths for lower angle mode are not kept in higher angle mode measurement.
5. Rotator move unexpected direction sometimes.
6. The effect of Dove Prism
   - If the injected laser has divergence, the focal point is shifted.
   - If the injected laser has angle, the image is rotated.
   - The reduction of maximum modulation


Dove Prism
Dove Prism

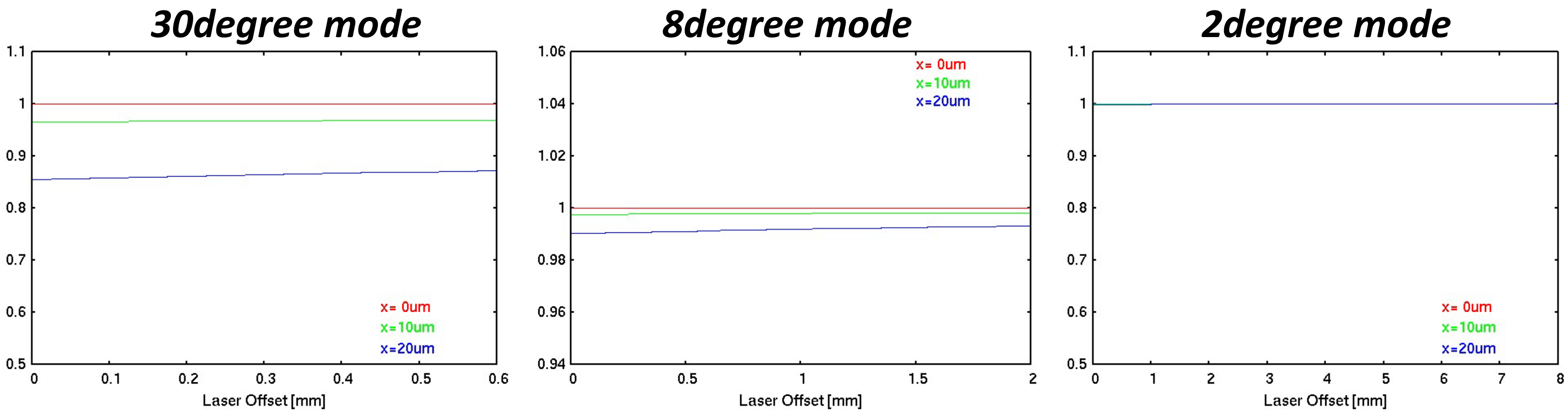
Schematic Layout of 30 degree mode collision



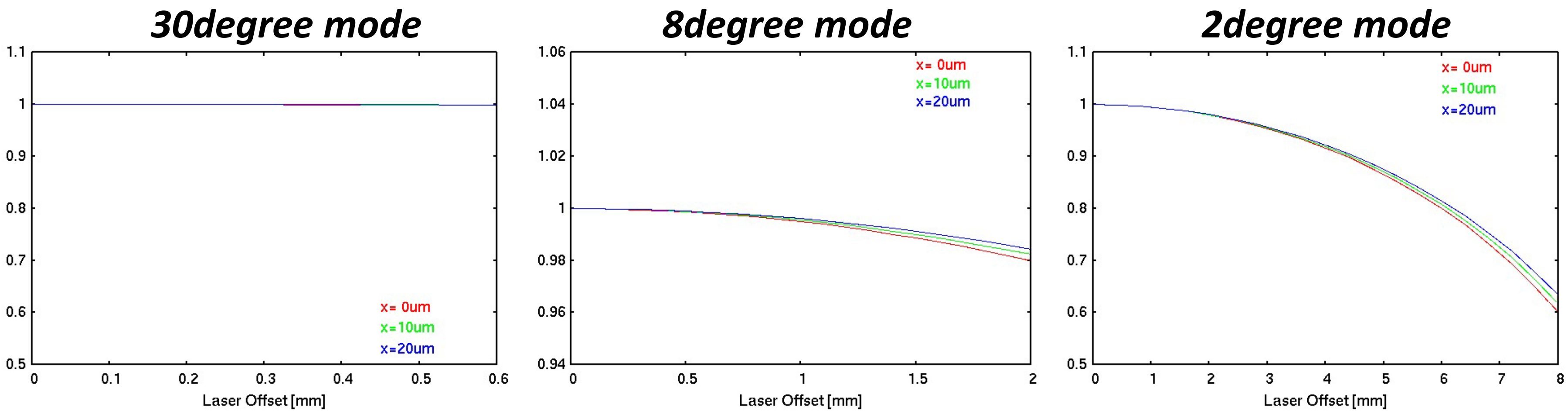
Modulation Reduction



(a) With Dove Prism (present setup)



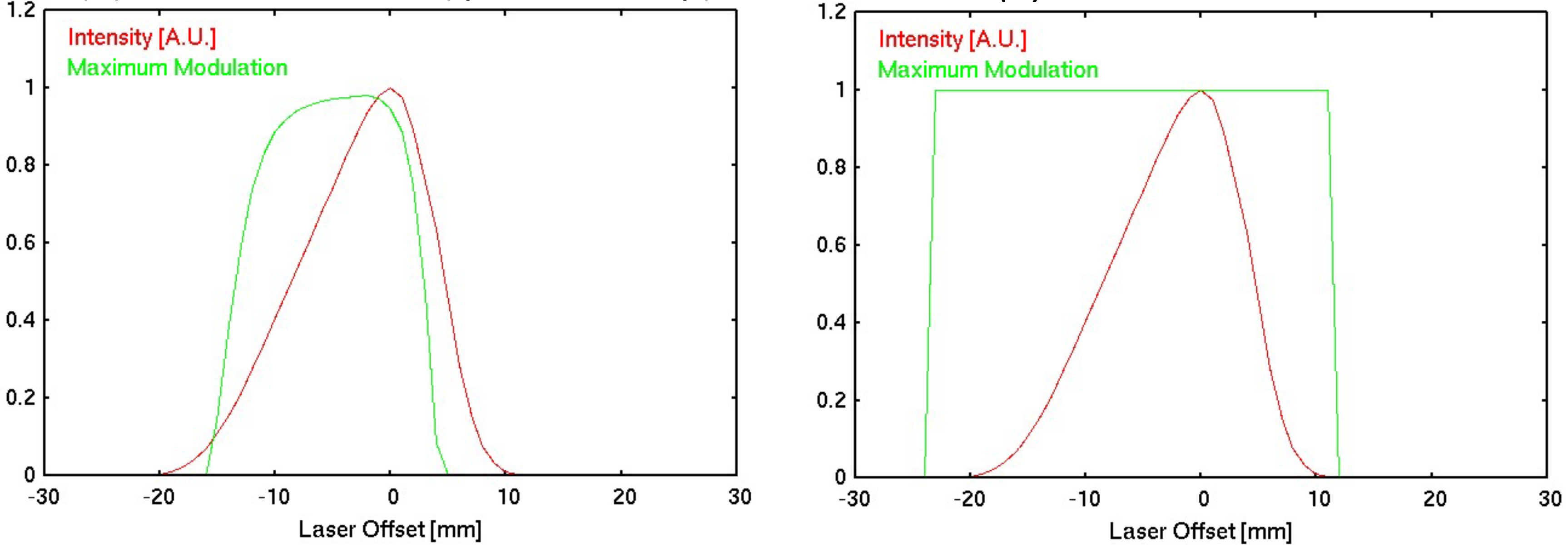
(b) Without Dove Prism



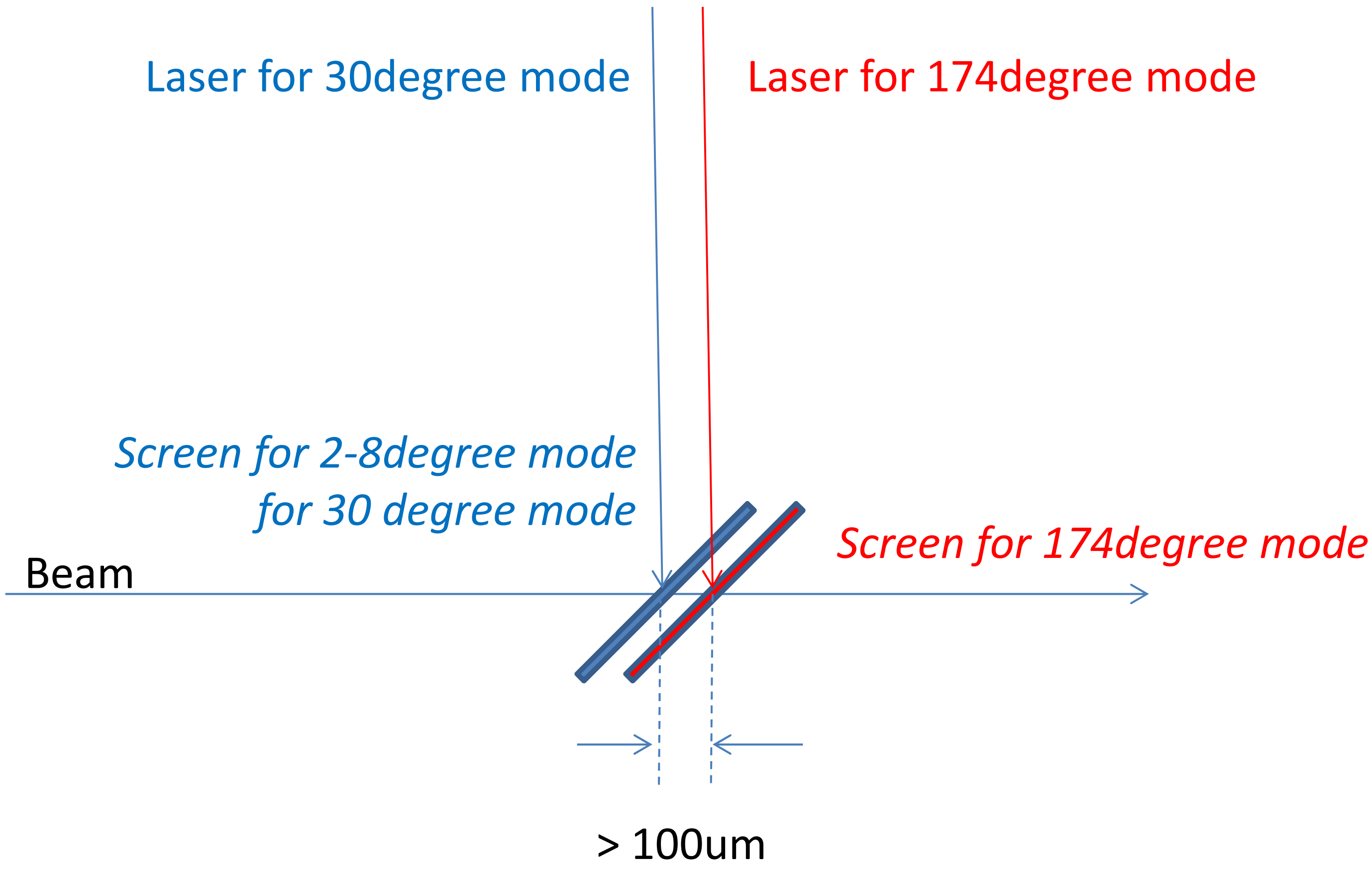
Calculation of Modulation Reduction by Comboluted the Beam Profile for 30degree mode

-Laser position is fixed to intensity maximum.
-Laser full width is assumed 20um.
-Horizontal beam size is assumed to 10um rms.
-Calculate the response to shift the injected laser position

(a) With Dove Prism (present setup) *(b) Without Dove Prism*



We'd better to remove the Dove prism for 30degree mode.



We can not see every laser paths with same screen.

Therefore, we prepare to 2 screens (for 2-30degree mode and 174degree mode)

Upper path for 174 degree mode is design to see 30 degree mode screen