# *IP tuning*

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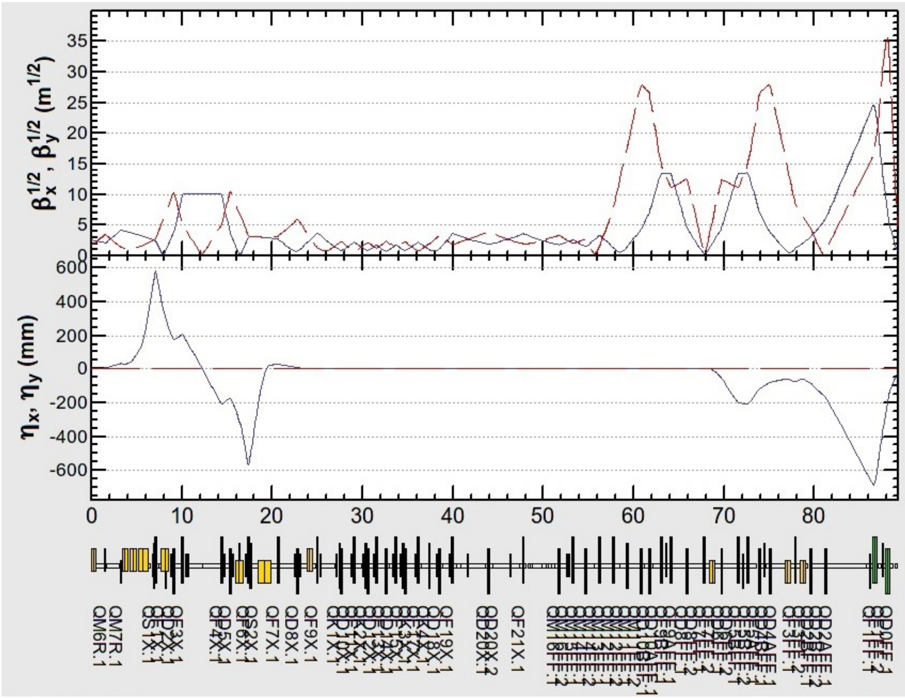
*The 13th ATF2 project meeting*

IP beam size in 2010 operation

IP beam size in 2011 operation

# *2010 May Operation*

Beam Optics was used for ***nominal FFS optics***
( $\beta x^*$ = 4cm, $\beta y^*$ = 1mm, so called “***10x10 optics***“)



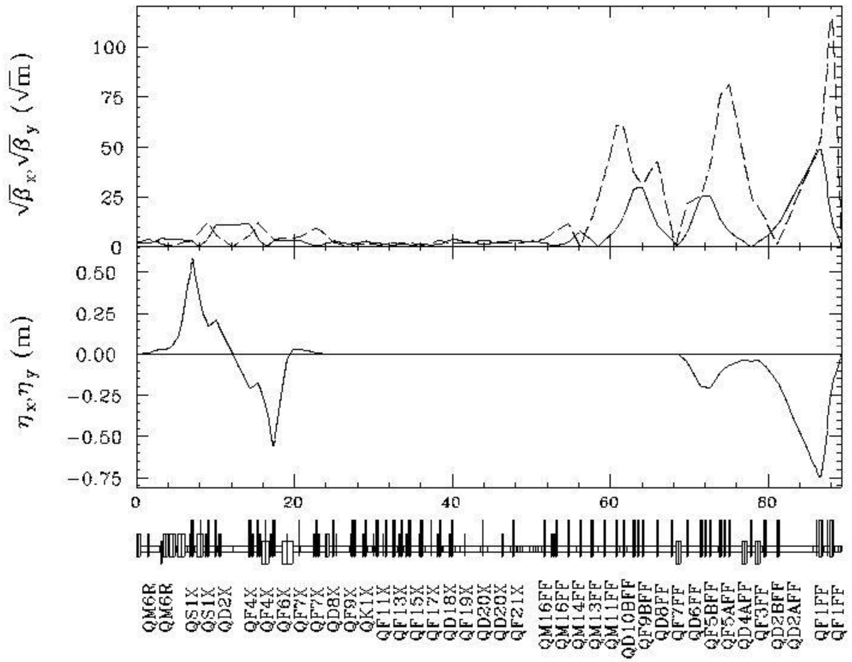

-Multi-knob ($\alpha y$, $\eta y$, <x’y>)
-Did not check the strength of sextupole magnets.

***Measured beam size was around 300nm.***

# *2010 December Operation*

Beam Optics was used for ***Edu's optimized FFS optics***

( βx* = 1cm, βy* = 0.1mm , ***βx at QF1FF was 2/3 to original*** )



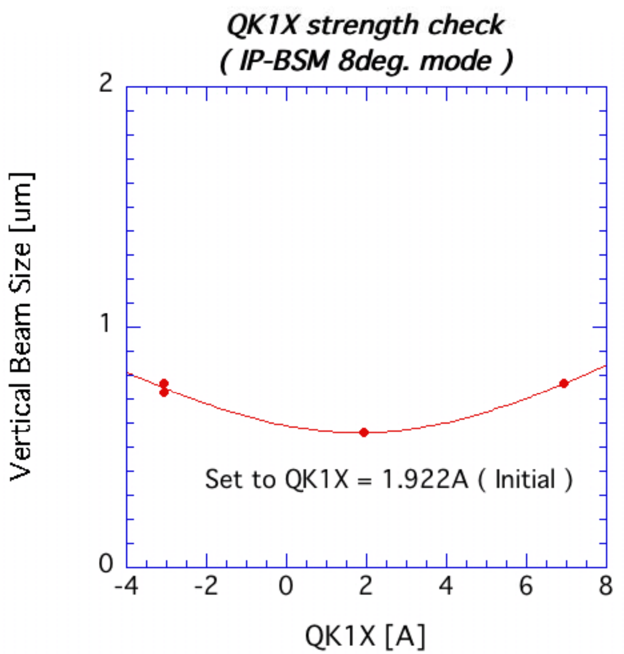

-Multi-knob (αy, ηy, <x'y>)

-*Check the <xy> by QK1X*

-*Check the strength of sextupole magnets (SD4FF, SF1FF, SD0FF).*

# <xy> correction

| QK1X[A] | QK2X[A] | QK3X[A] | QK4X[A] | C2 knob | sigma_y[um] | R31[ x 1e12] | R32 [ x 1e12] |
|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0.000 | 0.224 | 0.000 | 0.000 |
| 20 | 0 | 0 | 0 | 0.000 | 0.273 | 1.369 | 7.651 |
| 20 | 0 | 0 | 0 | 0.018 | 0.272 | 1.387 | −1.354 |
| 0 | 20 | 0 | 0 | 0.000 | 0.314 | −0.553 | 47.290 |
| 0 | 20 | 0 | 0 | 0.095 | 0.230 | −0.496 | −0.205 |
| 0 | 0 | 20 | 0 | 0.000 | 0.273 | −0.309 | 34.390 |
| 0 | 0 | 20 | 0 | 0.068 | 0.225 | −0.265 | 0.391 |
| 0 | 0 | 0 | 20 | 0.000 | 0.314 | −1.889 | −13.640 |
| 0 | 0 | 0 | 20 | −0.025 | 0.309 | −1.895 | −1.119 |

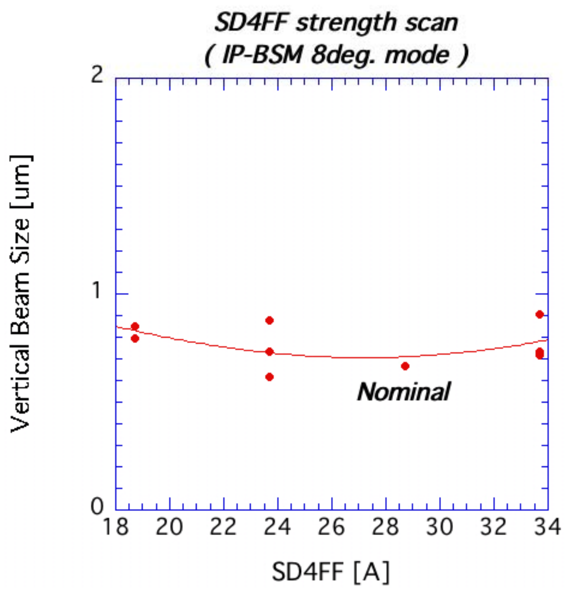


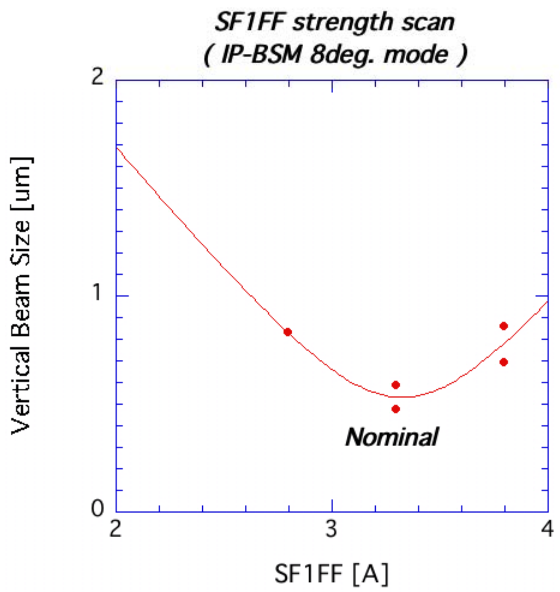

In December 2010 operation,
we checked the R31 contribution
by changing QK1X strength.

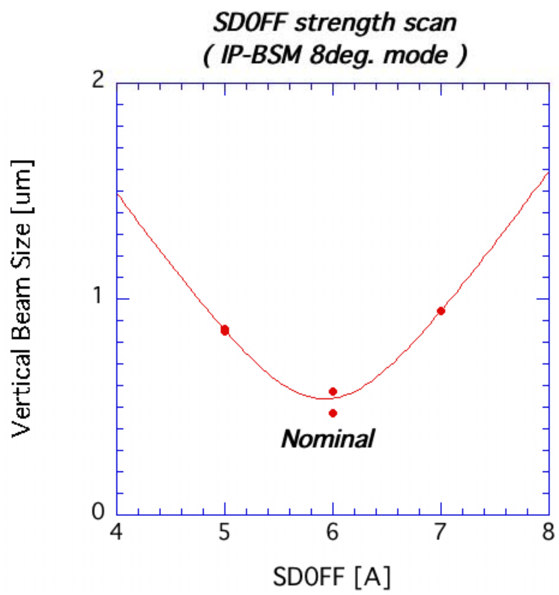
***We found the optimum QK1X setting.***
***( optimum <xy> setting )***

# Sextupole Strength Scan

We also applied the sextupole strength scan at 2010 December operation in order to check the performance of the chromaticity correction.




***We confirmed the optimum sextupole strengths were nominal setting in 2010 December operation.***

***However, the minimum beam size at IP was 300-400nm in 2010 beam operation.***

# *IP tuning in 2011 December Operation*

*1. First beam size measurement with IP-BSM was ready in 13$^{th}$ December 2011.*

*2. Beam size tuning with 10x10 optics (Nominal FF optics)*
*in 15$^{th}$ December 2011.*

*3. Beam size tuning with 1x2.5 and 5x2.5 optics*
*(Glen's FF optics; reduction of the effect of multipole error of QEA magnets)*
*in 16$^{th}$ December 2011.*

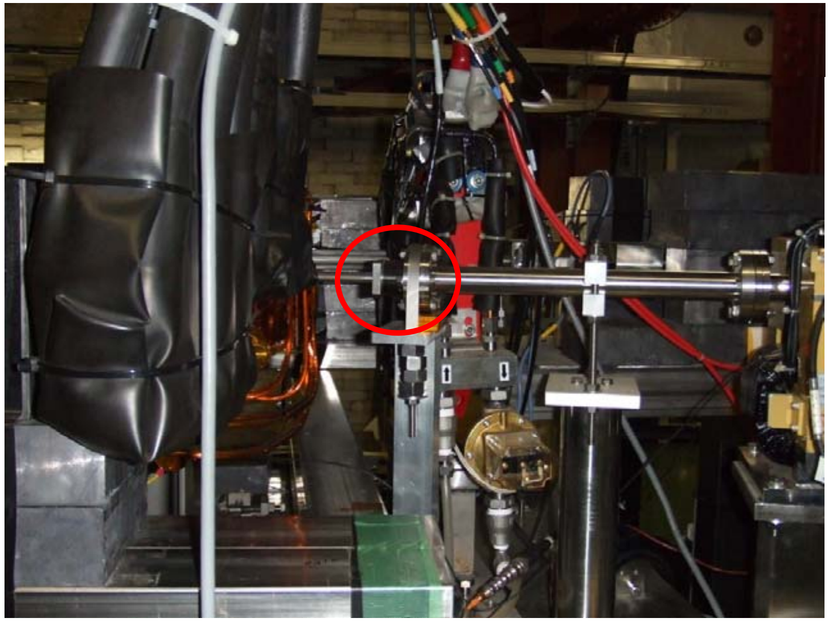
## *Comment*

In 2011 December operation,
minimum beam emittance in extraction line was huge
(~50pm after coupling correction).

*After the earthquake,*
*the beam emittance in extraction line was huge (~50pm after coupling correction).*
*the beam emittance in extraction line has large intensity dependence.*

***Large wake source ??***

***At the exit of septum magnet***



***Candidate***

Septum beam pipe is 7mm vertical gap.

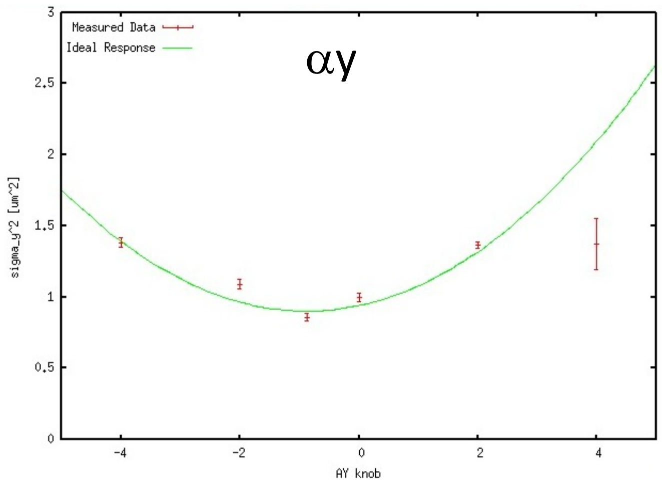
Beam pipe is 24mm diameter.

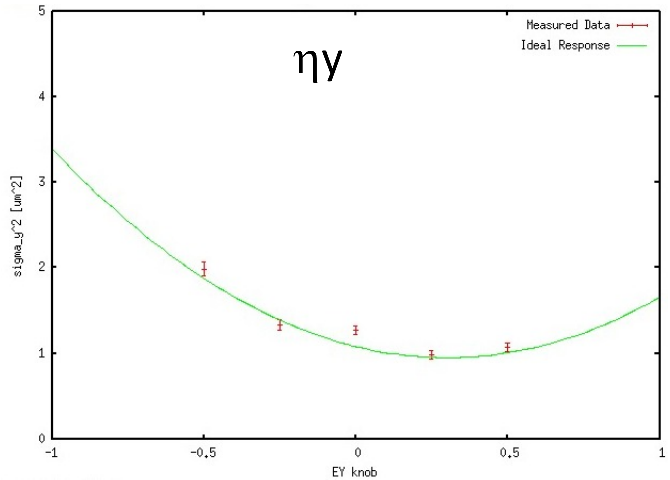
R34(BS3Xexit,IP)=-0.04 for 10x10 optics

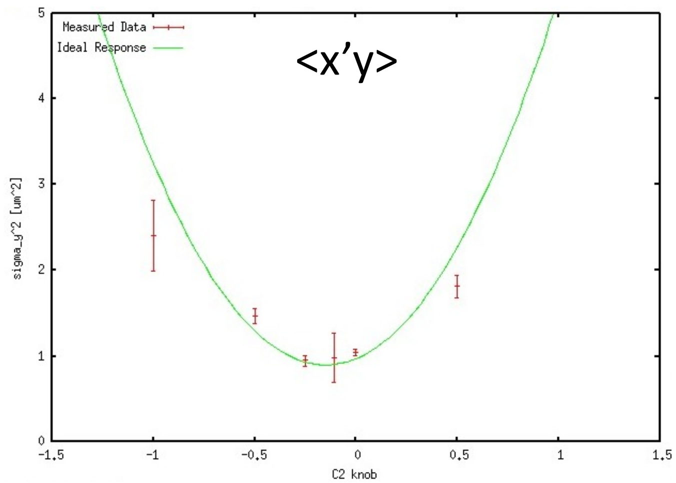
25urad(30kV) kick corresponds to 1um at IP.

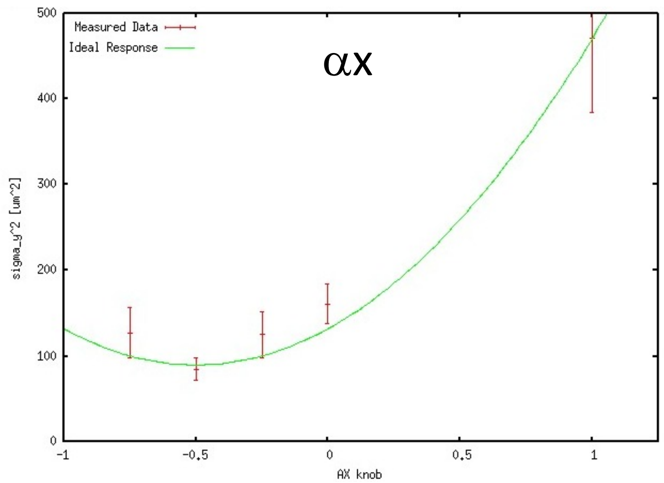
*After the earthquake,*
*-the OTR chamber was removed here.*
*-the extraction line was realign and the vertical level was 0.5mm changed with respect to the septum magnets.*

# *Beam size tuning with Multi-knob by 10x10 nominal optics*



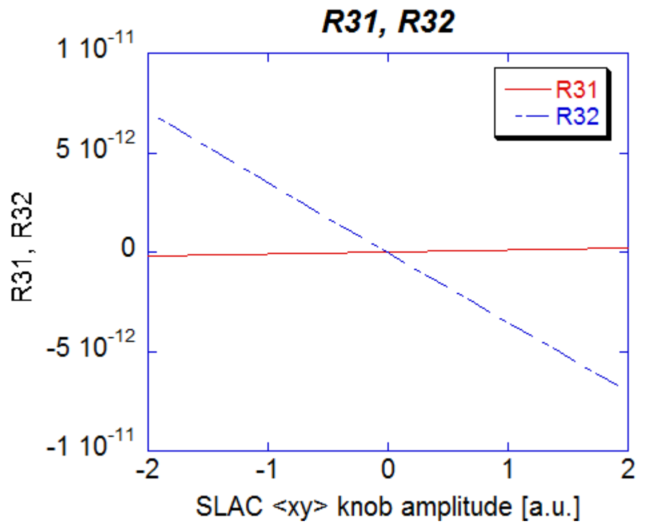

- Multi-knob worked well
- Horizontal beam size was matched to the model (9.2um).

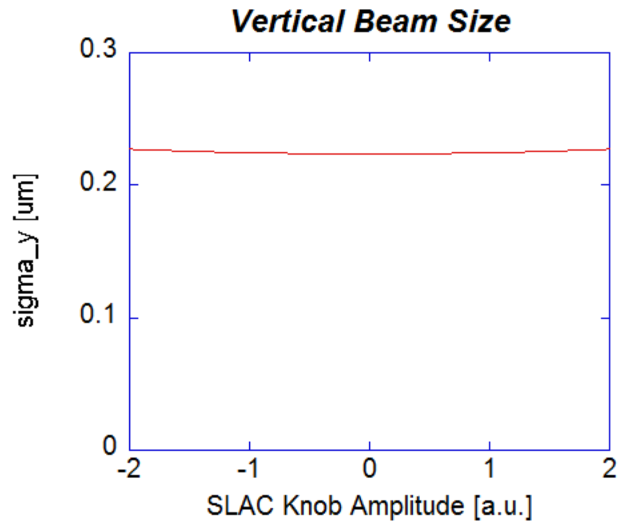
*Optics mismatch seemed to be small.*

*But, the minimum beam size was around 1um!*

# <xy> for 10x10 nominal optics

We applied single knob with QKs.
-But, the knob was <x'y> (same effect of C2 knob) and the amplitude was small.




We did not check the contribution of R31 for 10x10 nominal FF optics
in 2011 December operation.

Since the minimum beam size was larger than 2010 operation,
we should check the <xy> response in this year operation.

| QK1X[A] | QK2X[A] | QK3X[A] | QK4X[A] | C2 knob | sigma_y[um] | R31[ x 1e12] | R32 [ x 1e12] |
|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0.000 | 0.224 | 0.000 | 0.000 |
| 20 | 0 | 0 | 0 | 0.000 | 0.273 | 1.369 | 7.651 |
| 20 | 0 | 0 | 0 | 0.018 | 0.272 | 1.387 | −1.354 |
| 0 | 20 | 0 | 0 | 0.000 | 0.314 | −0.553 | 47.290 |
| 0 | 20 | 0 | 0 | 0.095 | 0.230 | −0.496 | −0.205 |
| 0 | 0 | 20 | 0 | 0.000 | 0.273 | −0.309 | 34.390 |
| 0 | 0 | 20 | 0 | 0.068 | 0.225 | −0.265 | 0.391 |
| 0 | 0 | 0 | 20 | 0.000 | 0.314 | −1.889 | −13.640 |
| 0 | 0 | 0 | 20 | −0.025 | 0.309 | −1.895 | −1.119 |

If the reason why the IP beam size was large was the effect of <xy>,
it is difficult to correct the 1um of the beam size only by QK magnets.

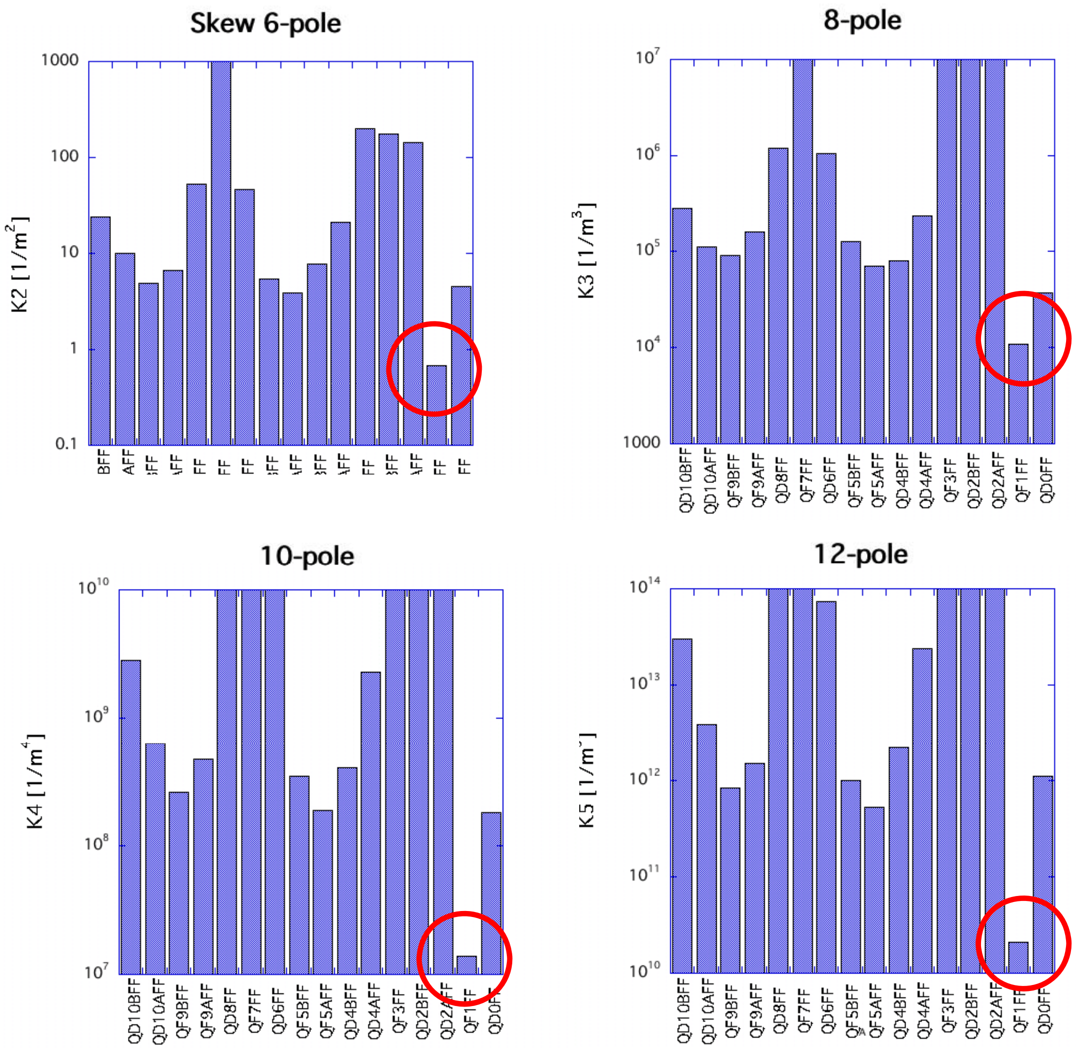
However, we should check whether the reason was <xy> or not.

# *Sextupole Strength Scan for 10x10 nominal optics*

We should check the sextupole strength check in this year operation.

# *The sensitivity of the multipole fields*

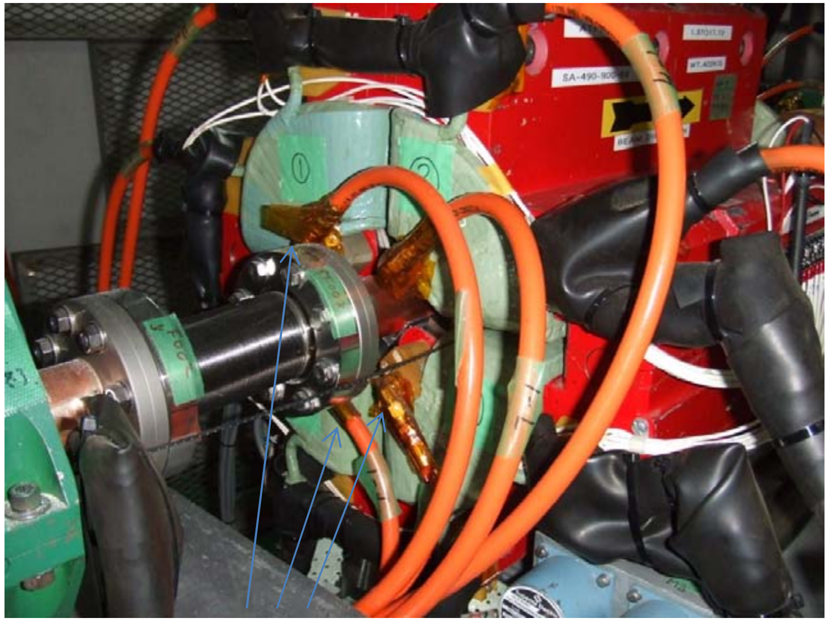
The amount of the multi-pole fields to increase the vertical beam size to 300nm for the beam with1nm horizontal emittance and10pm vertical emittance



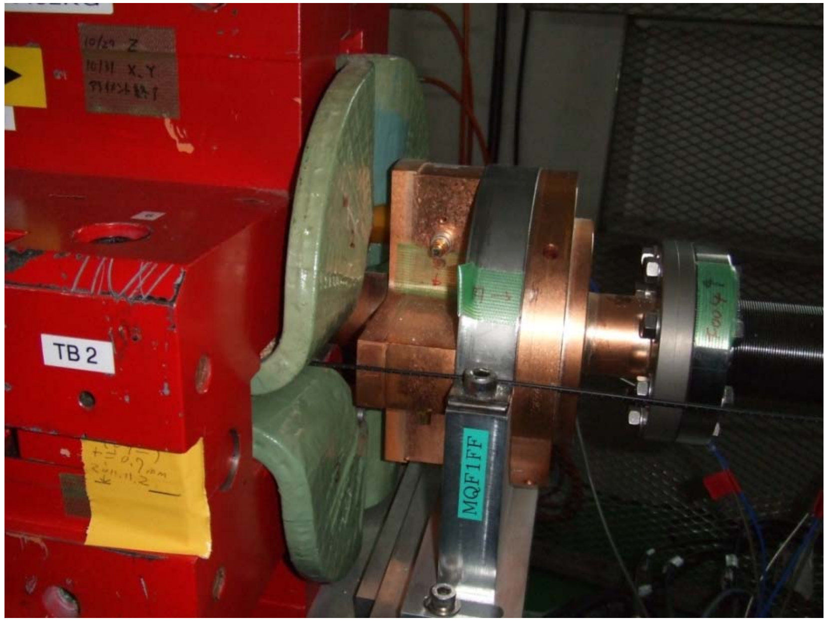

QF1FF is the most sensitive for all of the multi-pole fields.

QD0FF is comparable to the other FF quads.

# *Magnetic Material around Final Doublet*



Connector of cooling water
(magnetic material)




Feed through of S-band BPM
(Kovar)

| | *Magnetic Field* |
|---|---|
| *QF1FF* | *150-200Gauss* |
| *QD0FF* | *300-350Gauss* |

There is a possibility to make a multipole error for these component,
but there component was not changed from 2010.

# *Summary of 10x10 nominal optics*

The vertical beam size was reached to 300-400nm only with multi-knob tuning in 2010.

But, the munimum beam size was around 1um in 2011 December operation.

What is difference ??

- Large wake ??
- <xy> contribution ??

  *This contributions was small in 2011 December operation.*
- Imperfection of chromaticity and 2$^{nd}$ order dispersion correction ??

  *This contributions was small in 2011 December operation.*
- Higher multipole effects ??

  *This effect was not yet checked from 2010.*

# *Beam size at MSPIP for 2.5x1.0 Glen's Optics*

QK1X = -9A
476um

QK1X = -17A
298um

Theoretical Calculation (εx=2nm, εy=50pm)

| QK1X [A] | σy at IP [nm] | σy at MSPIP [um] |
|---|---|---|
| 0 | 71 | 582 |
| 20 | 132 | 606 |

Beam divergence at IP was not sensitive to the expectation.
Beam size at MSPIP was too small to the model expectation.

***Large optics mismatch!***

# *Beam size at MSPIP for 2.5x5.0 Glen's Optics*

This optics also had the large beam size dependence for QK magnets,
even though the model shows the QK1X strength is insensitive to the MSPIP beam size.

| QK1X [A] | $\sigma$y at IP [nm] | $\sigma$y at MSPIP [um] |
|---|---|---|
| 0 | 158 | 260 |
| 20 | 193 | 306 |

However, we could make the beam size at MSPIP small by changing the QKs
and adjusted the beam orbit in FF beamline.

We could reduce
- <x'y'> by QKs and FF orbit
- <x'y> by multi-knob

↓

<xy> could be small ??

We did the beam size tuning in this condition
at the end of 2011 December beam operation

# *Final Beam Size in 2011 December Operation*

***Beam Size, tuned with IP C-wire ; 1.1um***

After several tuning with IP-BSM (only 1.5 hours remained) ->


We took the large statistic data twice
at the end of beam operation,
the both of measured beam sizes were ~ 850nm.

***The final beam size was smaller then 10x10 optics,***
***but was larger then 2010 operation.***

# *Summary*

In2010 operation, the minimum beam size was around 300nm
with both 10x10 nominal optics and 1x2.5 Edu's optics.

In 2010 December, we checked <xy> and sextupole strengths.

In 2011 December, the extraction emittance was increased
and the minimum beam size at IP also increased to be around 1um.

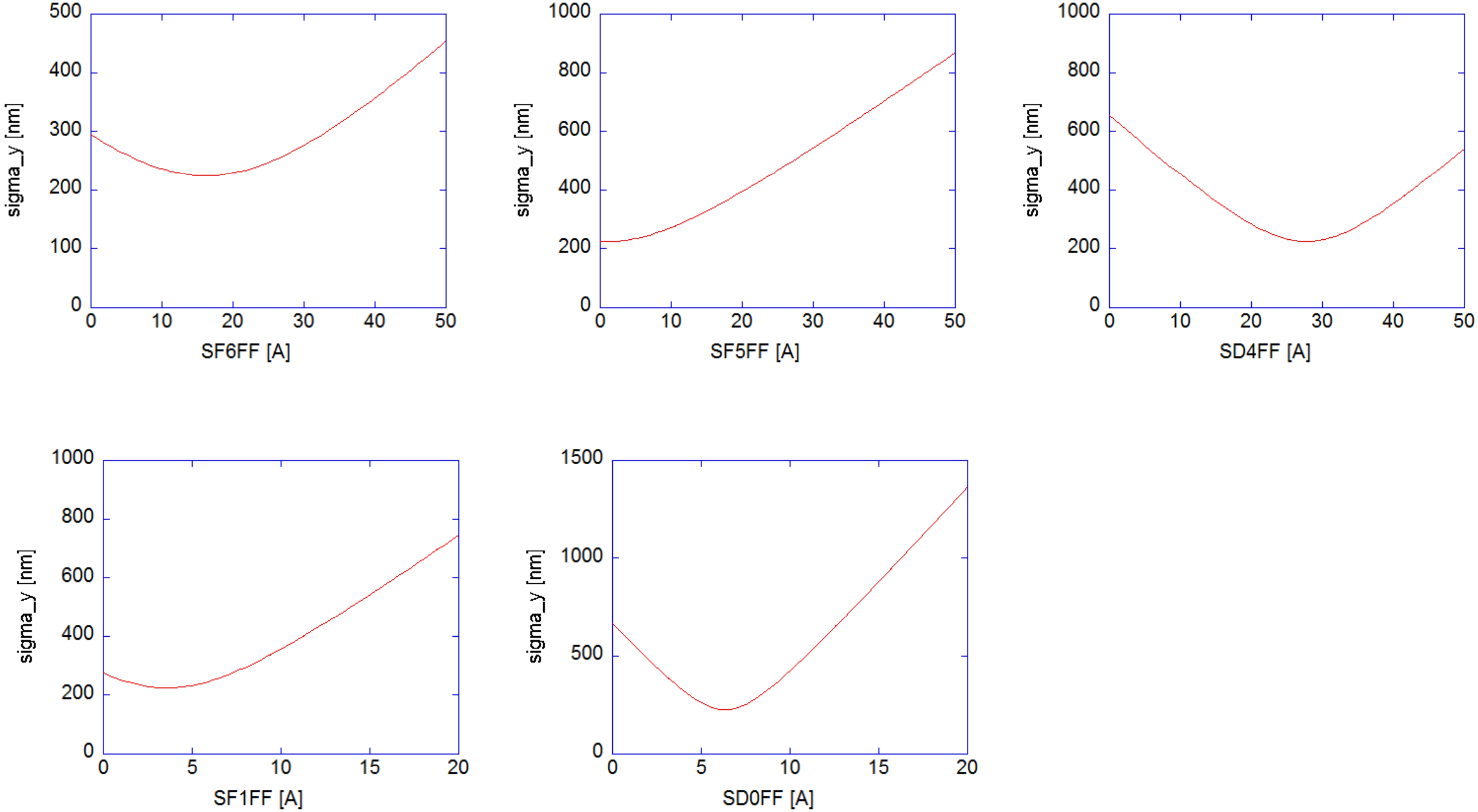
We must understand

- reason why the present IP beam size was limited to be 1um.
  ( difference from 2010 operation)

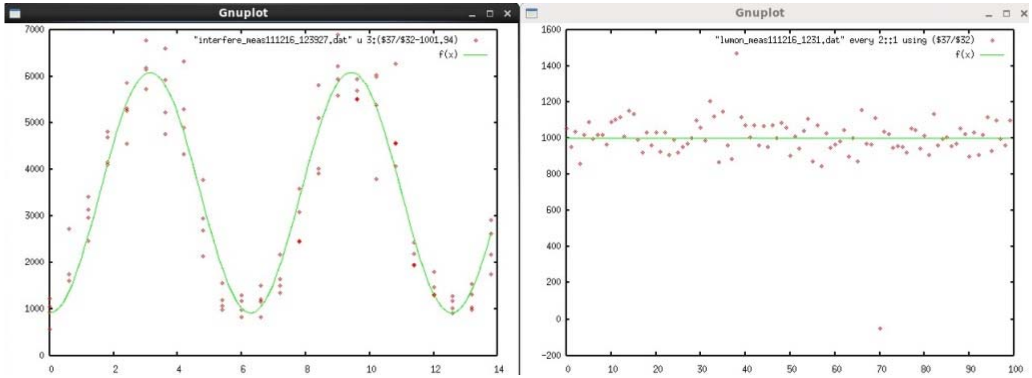
- reason why the 2010 IP beam size was limited to be 300nm.

backup

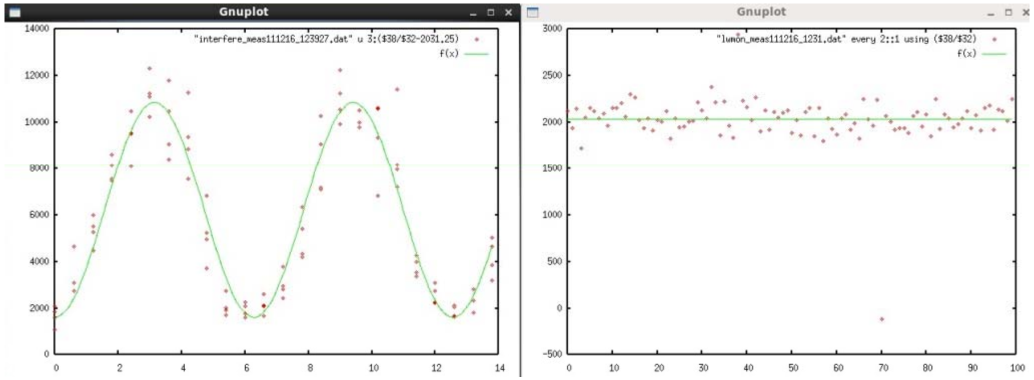
# Sextupole Response



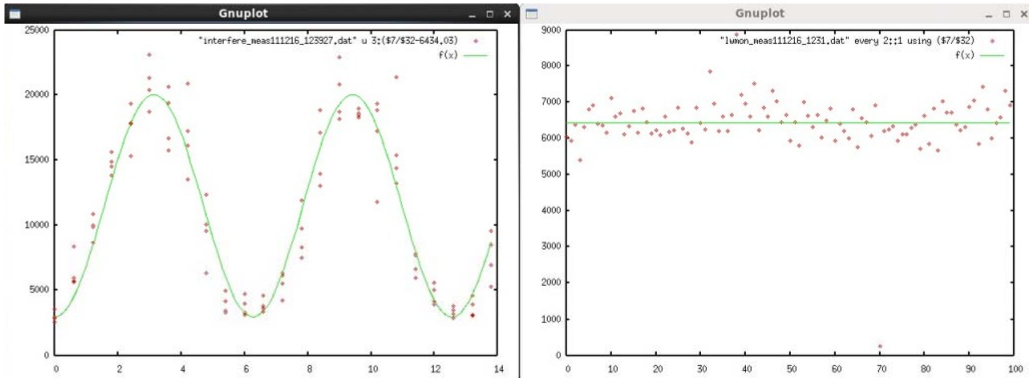
## layer 2 only




## Sum of layer 1-4



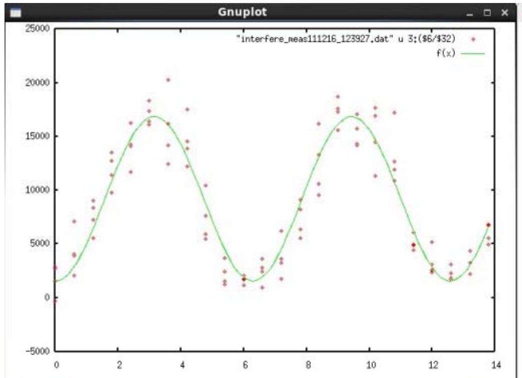

## Sum of layer 1-5



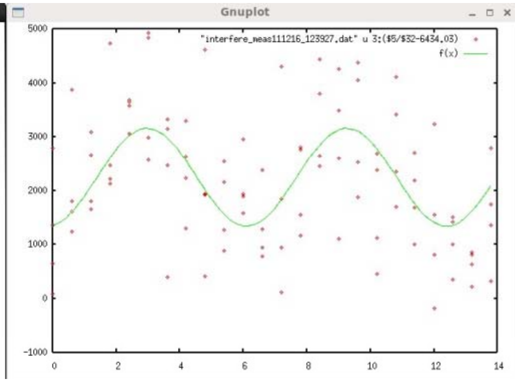

| | Background | Average | Modulation | S/N |
|---|---|---|---|---|
| Layer2 only | 1001.94 | 3504.62 | 0.740 | 3.50 |
| 1-4 layers | 2031.25 | 6239.79 | 0.741 | 3.07 |
| 1-5 layers | 6434.03 | 11495.70 | 0.743 | 1.79 |
| Fitted Method | | 9235.64 | 0.828 | |

Background data : lwmon_meas111216_1231.dat
Signal data : interfere_meas111216_123927.dat

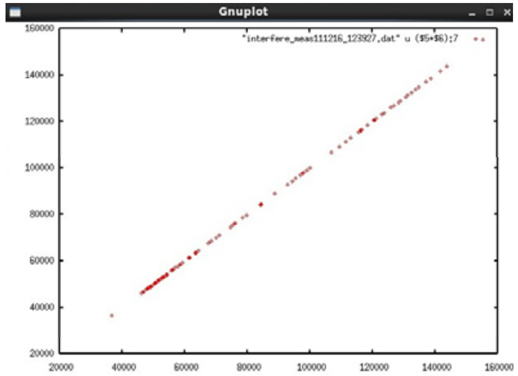
(Fitted signal)




(Fitted background) – (Background)




Fitted signal + Fitted background
vs.
Total Energy




| | Average | Modulation |
|---|---|---|
| Signal | 9235.64 | 0.828 |
| Background | 2253.05 | 0.404 |

（確認）
シャワー発展でFitされた信号とバックグラウンドは全エネルギーになっている。

まとめ

1. 全層使ったものが最も信号量が大きく、2層目だけつかったものが最も信号量は少ない。
2. 2層目だけを使ったものが最もS/Nが高く、全層使ったものがS/Nが最も悪い。
3. それぞれの解析で Modulation に大きな差は無かった。

4. Shower発展で計算されたModulation は他の解析と大きく違った値を示した。
5. Shower発展でバックグラウンドと評価されたものの平均は実際のバックグラウンドより高い。
6. Shower発展でバックグラウンドと評価されたものModulationは信号と同位相で小さい値。
7. これらから、Shower 発展のバックグラウンドの差っ引きでは、
信号のConstant 部分を余計に引いてしまっていることが分かる。