

***Study of multipole field  
in 2012 December Operation***

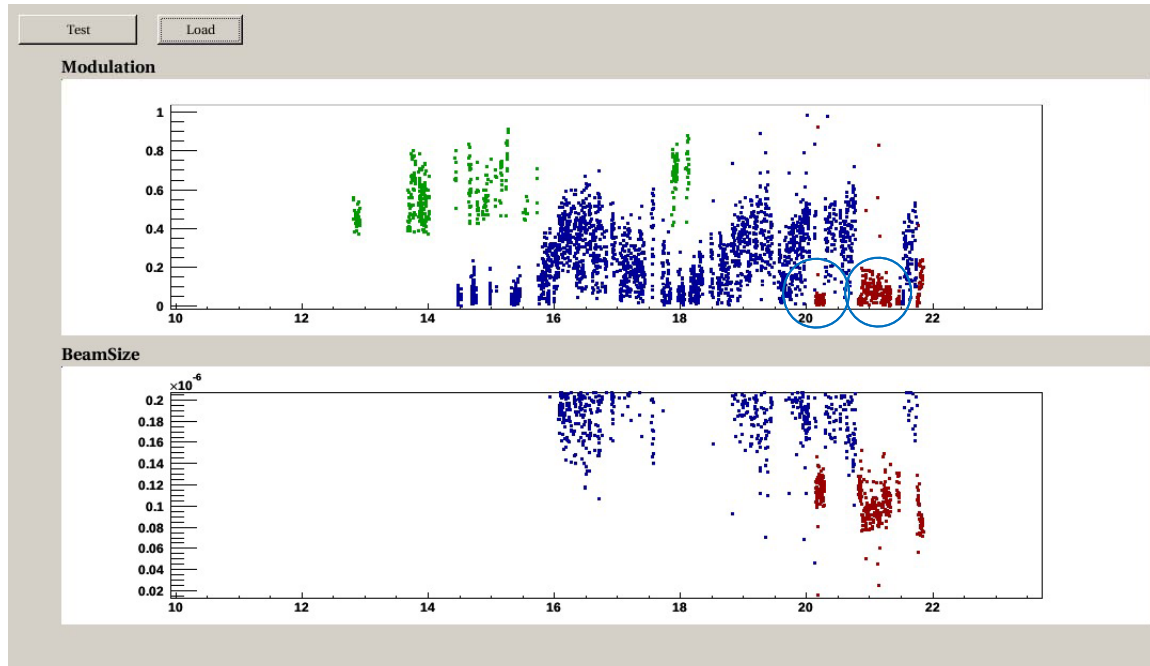
2013/ 01/ 23

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The 15<sup>th</sup> ATF2 Project Meeting  
Shokuin-kaikan, KEK

# The effect of nonlinear knobs in 2012 Dec. operation

History of last 2 weeks in 2012 Dec. operation



12/19 ; We tried the 1<sup>st</sup> 174 mode measurement, but we could not observe clear modulation.

12/20 ; We tried the 2<sup>nd</sup> 174 mode measurement, we could observe clear modulation.

The difference of the settings for 12/19 and 12/20 are the set of nonlinear knobs only.

12/19 ;  $Y_{22}=-0.6$ ,  $Y_{26}= 0.0$ ,  $Y_{44}= 0.0$

12/20 ;  $Y_{22}=-0.2$ ,  $Y_{26}=-0.2$ ,  $Y_{44}= 0.0$

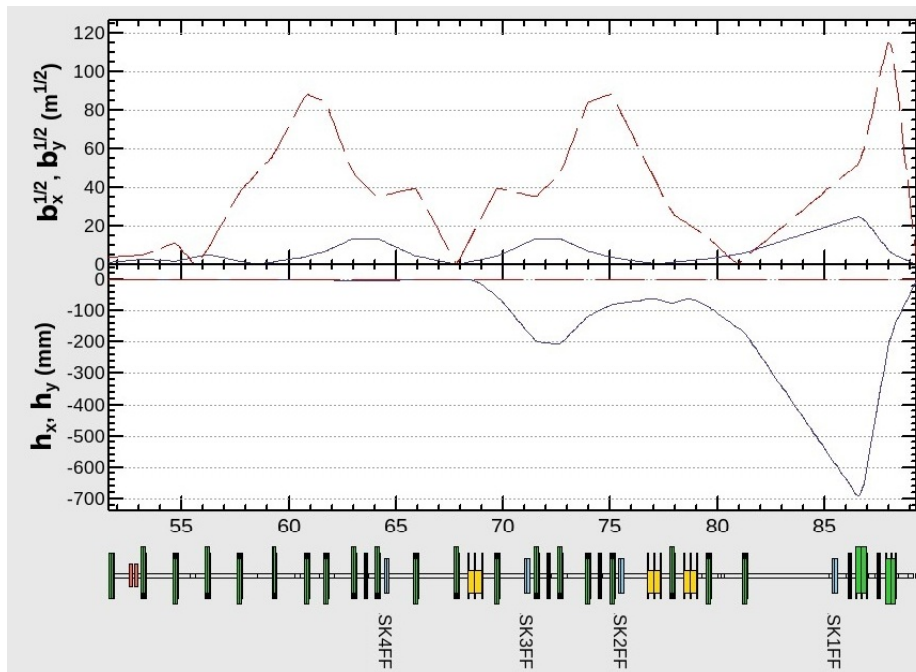
# Skew Sextupole Field Correction Knobs

**Skew sextupole field**

$$B_x = \frac{B_s^{(2)}}{2} (x^2 - y^2)$$

$$\Delta y_{IP} = \frac{R_{34} K_{2S}}{2} \left( \underbrace{\Delta x^2}_{Y_{22}} + 2 \eta \Delta x \underbrace{\frac{\Delta p}{p}}_{Y_{26}} + \eta^2 \underbrace{\frac{\Delta p^2}{p^2}}_{Y_{66}} - \Delta y^2 \right) \underbrace{\quad}_{Y_{44}}$$

**We will put 4 skew sextupole correctors**



SK1FF ; sensitive to Y22, Y26, Y66

SK2FF ; sensitive to Y44

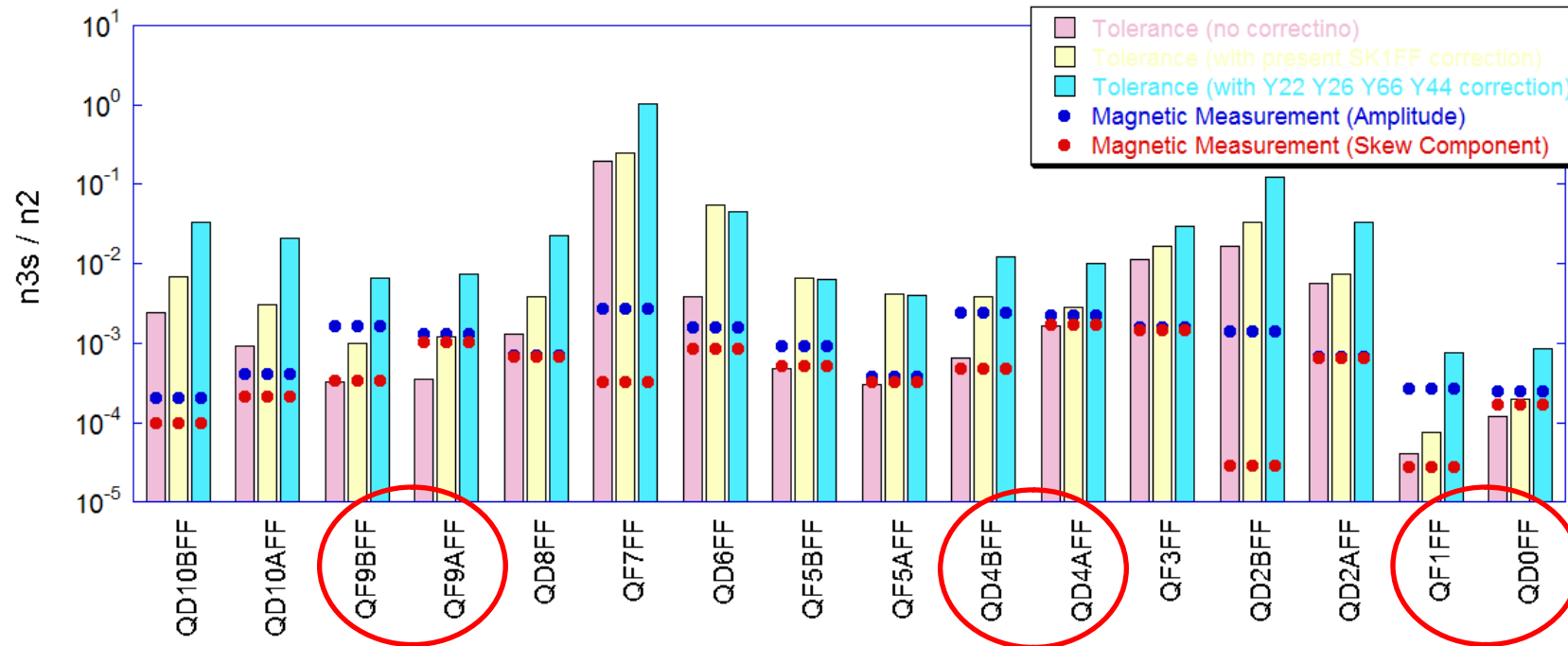
SK3FF ; sensitive to Y22, Y26, Y66

SK4FF ; sensitive to Y22

**Y22, Y26, Y66, Y44 knobs  
are calculated by the combination  
of SK1FF, SK2FF, SK3FF, SK4FF.**

# Performance of New Correction Scheme

## Tolerance of Skew Sextupole Component



*Red* ; No correction

*Yellow* ; with SK1FF correction

*Blue*; with 4 SKs correction  
( 10A maximum)

*By using 4 SKs correction,*

*-The tolerances for all quadrupoles can be increased.*

*-We can investigate the source of abnormal field.*

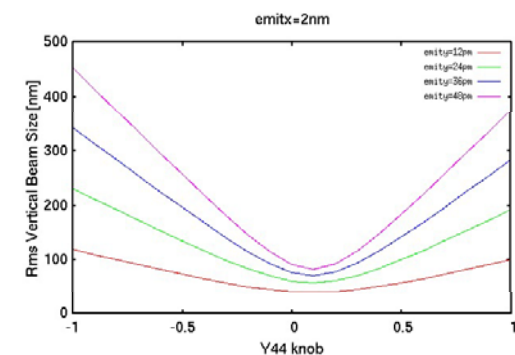
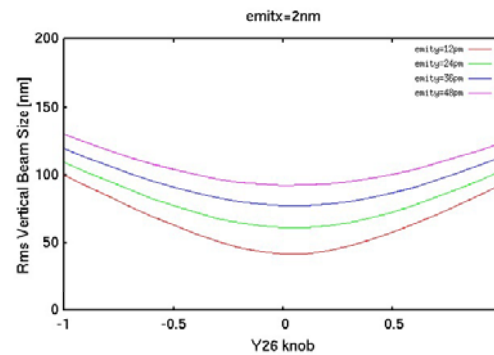
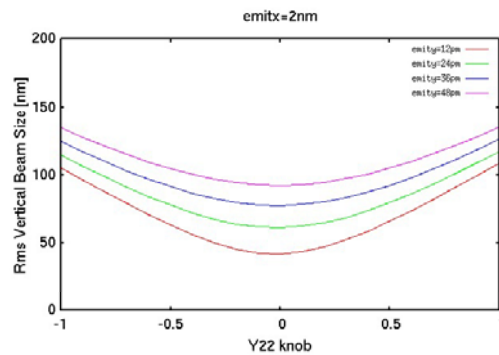
# Response for Nonlinear Knobs in 2012 Dec. operation

Nonlinear knob was designed to be increased by 100nm for (knob)=1 (emitx=2nm, emity=12pm).

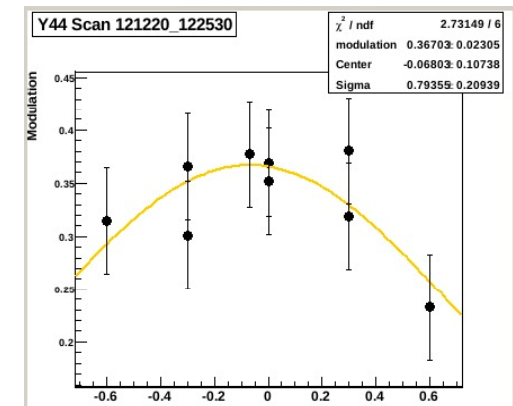
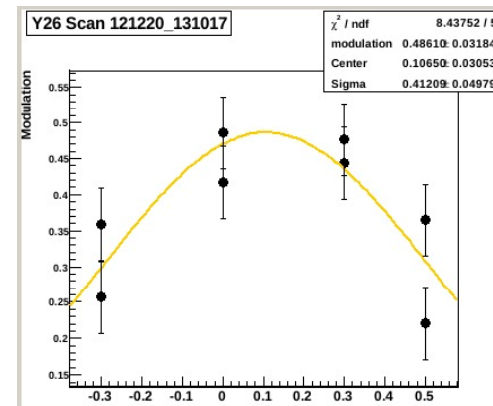
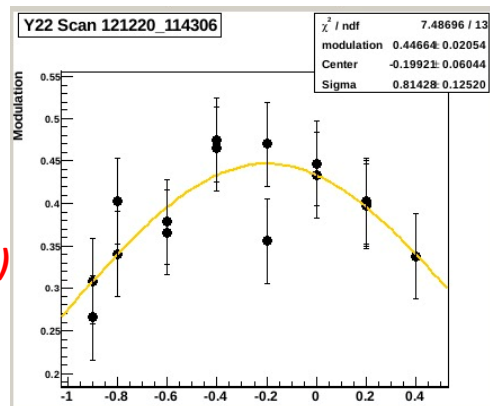
We expected the response for Y44 was larger than Y22, Y26, because the vertical emittance was larger than design.

The dependence for Y26 was larger than those of Y22,Y44.

**Model Response**



**Measurement (around optimum)**



The expected beam size for knob zero and optimum knob settings are almost same in simulation, but the those were quite different in experiment.

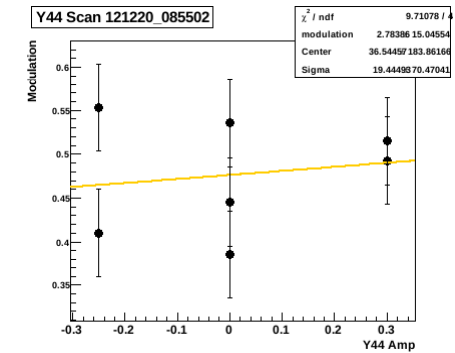
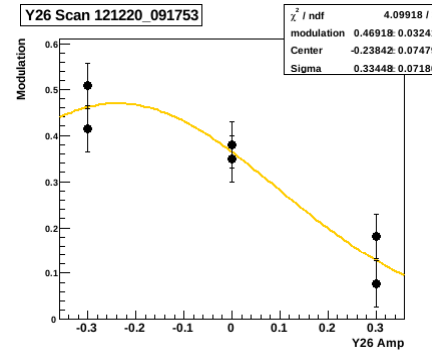
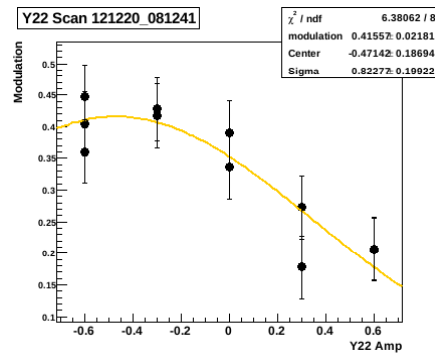
	rms beam size	core beam size
Y22, Y26=0.0	55.4nm	51.7nm
Y22,Y26=-0.2	58.3nm	54.7nm

# Error source of multipole field

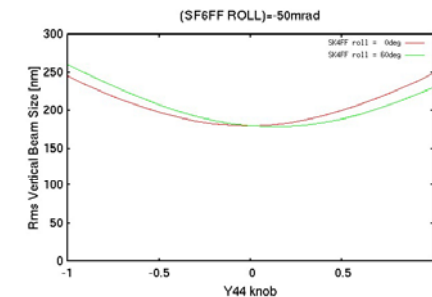
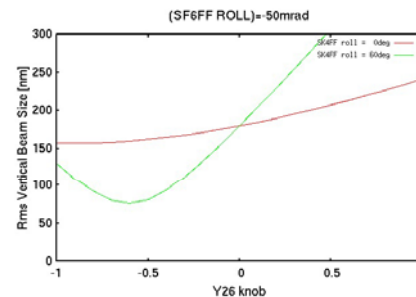
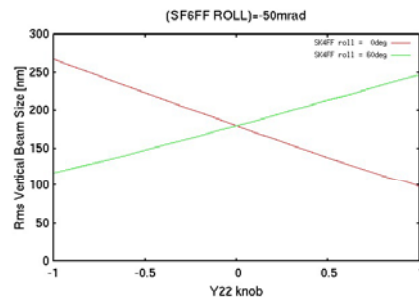
When we assumed the be large errors both for SK magnet and FF sextupoles, we could reproduce the measured IP vertical beam size in simulation.

In simulation, I assumed the roll for SF6FF by -50mrad to make a large T322.

*Measurement  
(origin is knob zero)*

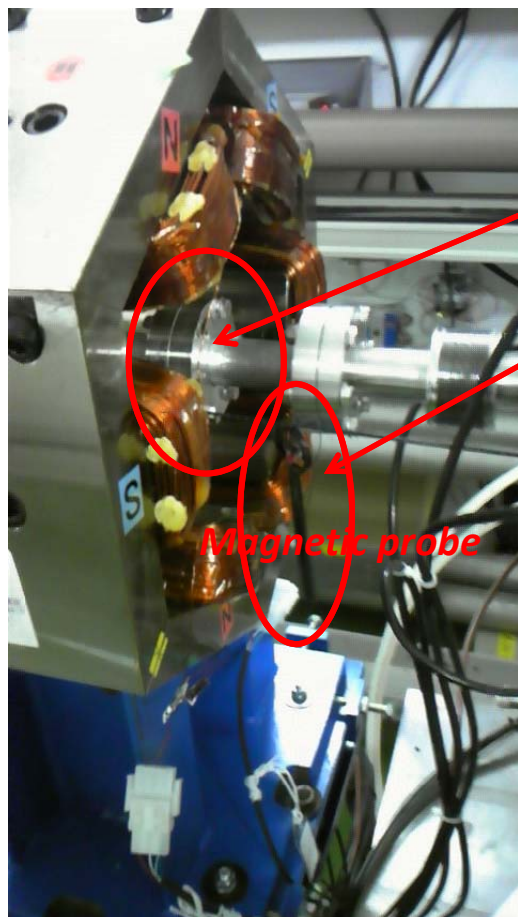


**Model  
Response  
with errors**



When we assumed the large rotation of SK4FF field, we could reproduce same response of the nonlinear knob in 2012 Dec. operation.

## *Candidate of the magnetic errors for skew sextupoles*



### *The problems for SK4FF*

- A flange was located to be inside of bore, and the bolts were a little bit magnetized.
- A nut was made by an iron. the location was closed to magnet bore.

*Since the magnetic field at 1mm offset is less than 1gauss, it is very difficult to estimate actual field of SK4FF.*

*But, we found the SK4FF field was not ideal magnetic field.*

*SK1FF also have a flange inside of bore.*

*It is difficult to move.*

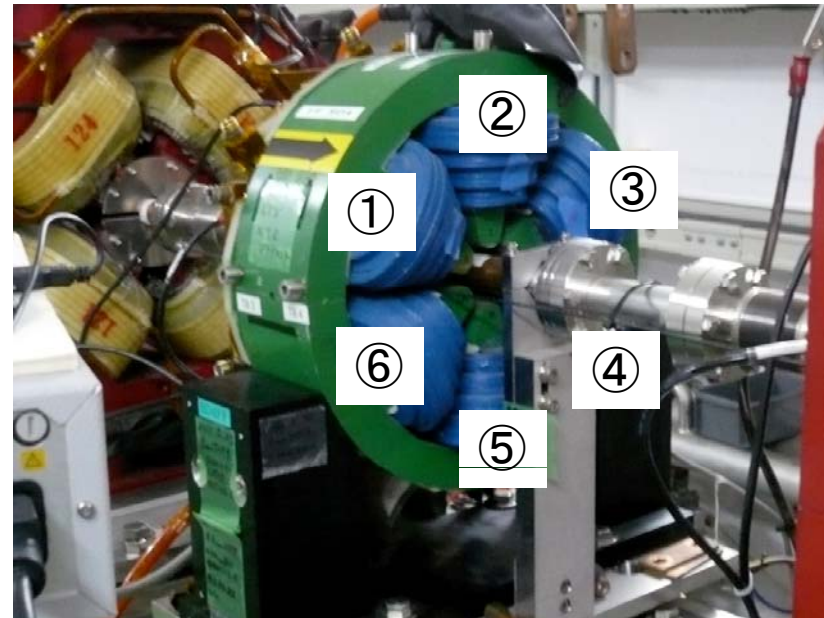
## *Impedance measurement for FF sextupoles*

*We measured the impedances of the coils for every poles for FF sextupoles.*

*The coils for every poles were separated to measure the impedances independently .*

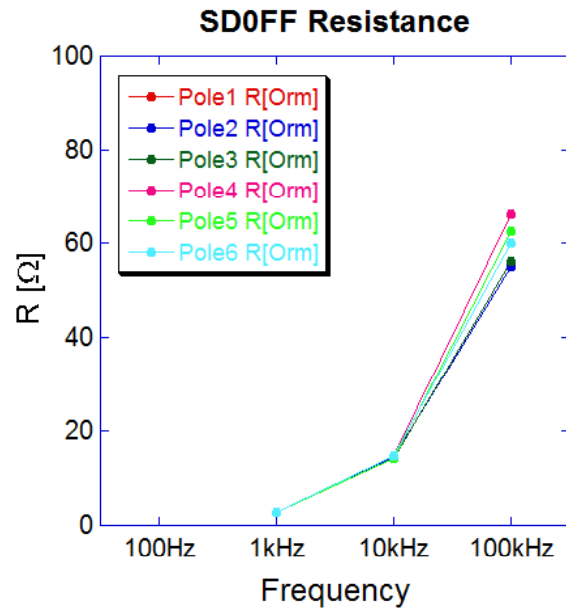
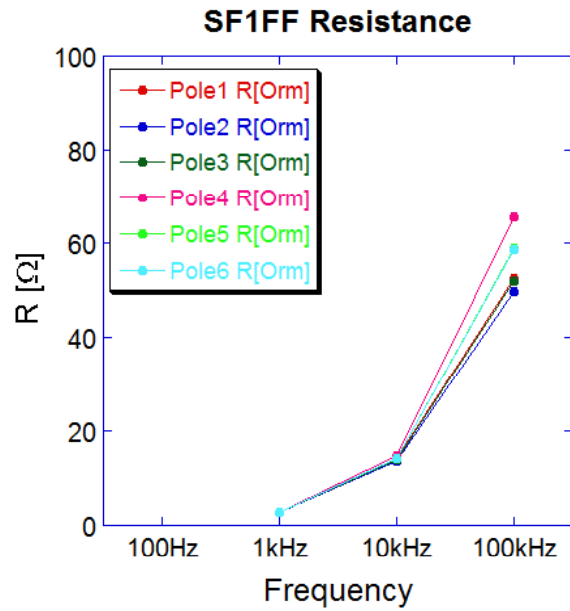
*The impedance for each coil was measured with LCR meter.*

*The numbering of the coils are shown in the right picture.*

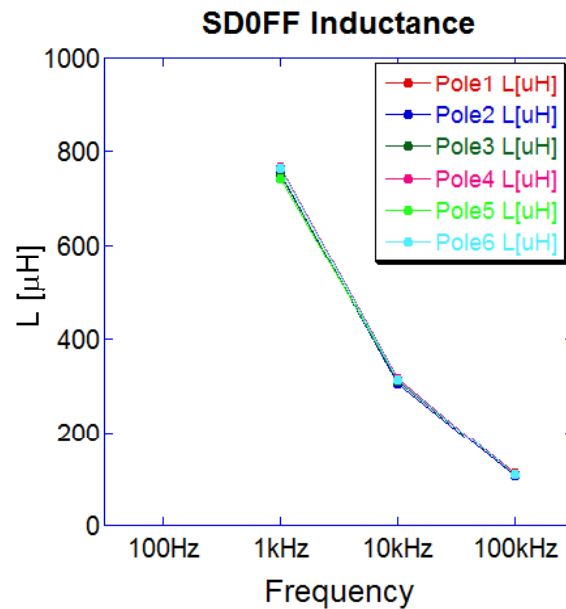
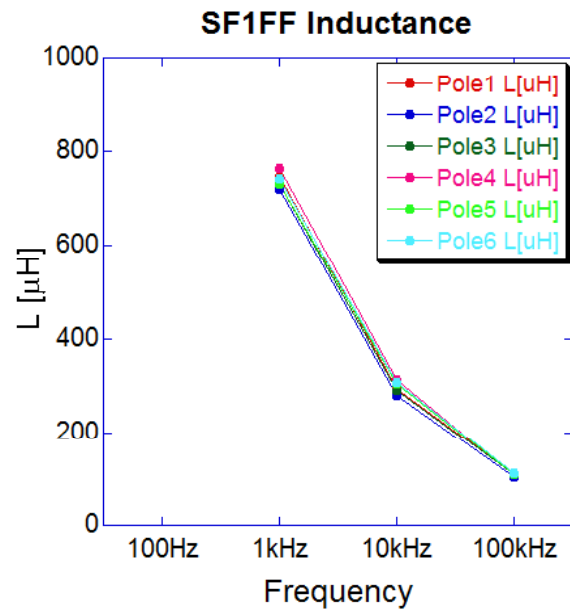




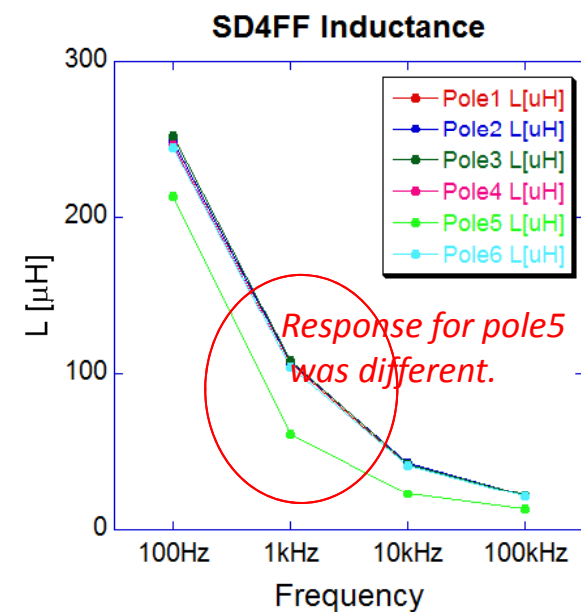
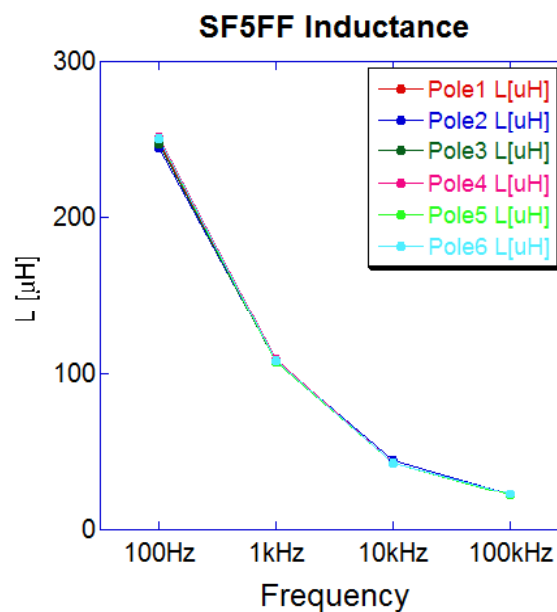
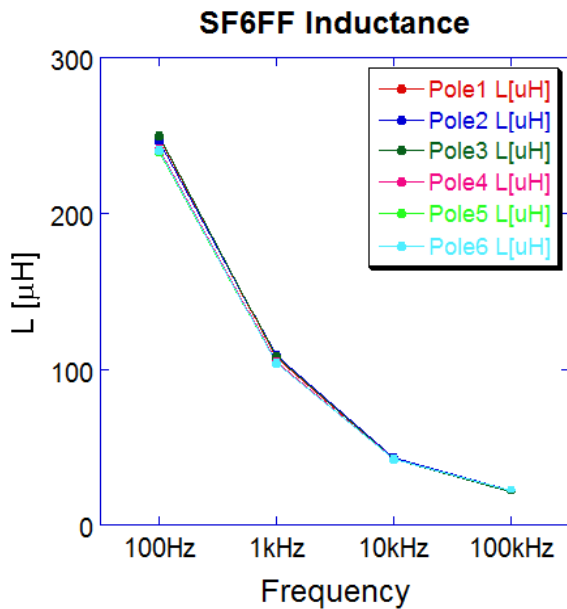
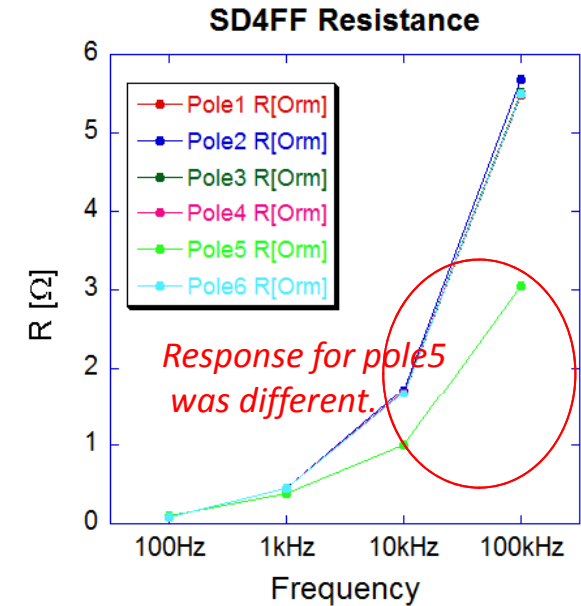
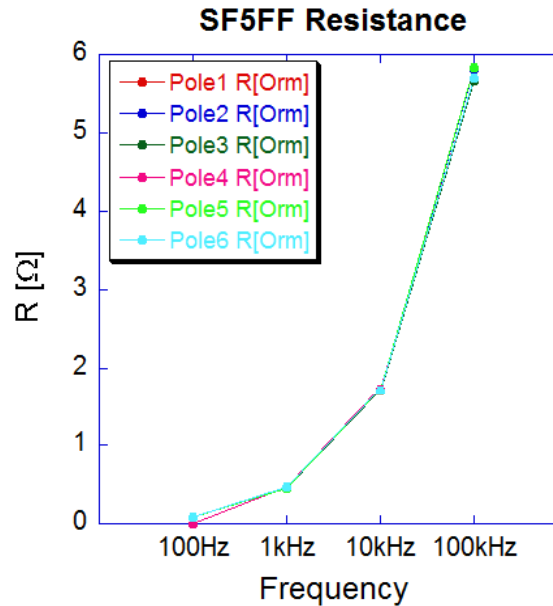
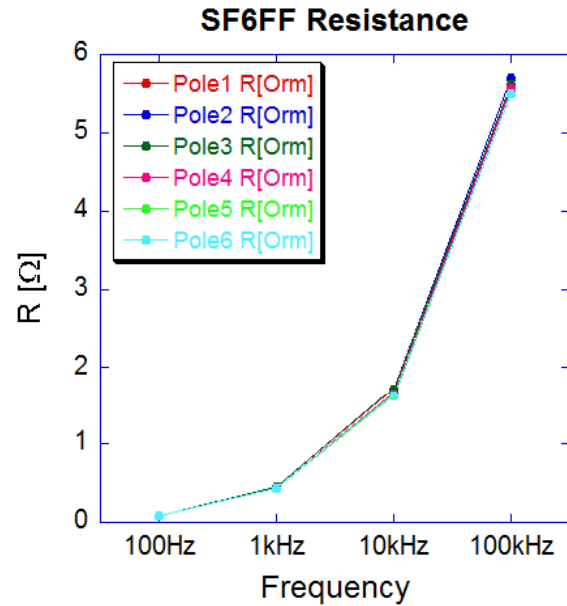
# FF sextupoles with large bores



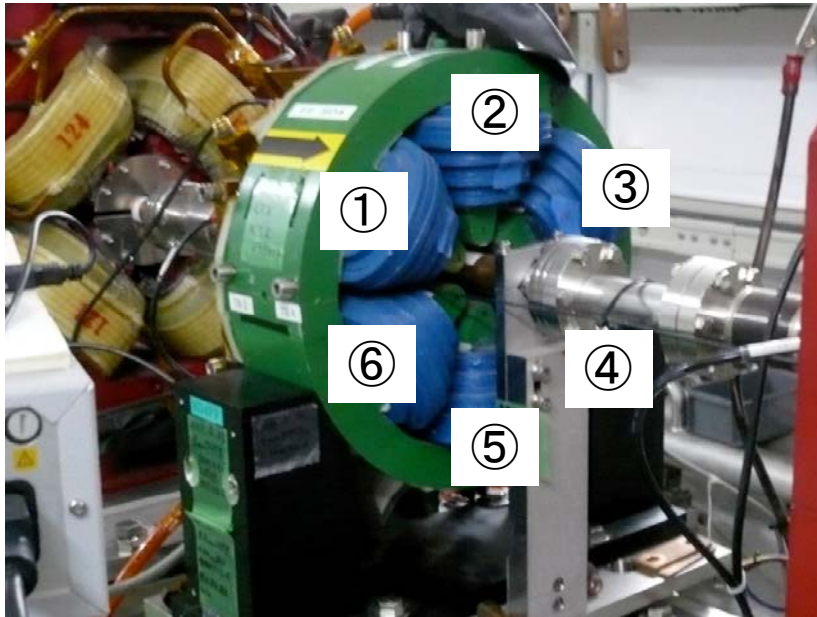
*We could not observe clear difference for SF1FF and SD0FF*



# FF sextupoles with small bores



## *The effect of the small current of pole5 for SD4FF*



*When the current of pole5 was smaller than those of others,*

- Generate the horizontal kick*
- Generate **the skew quadrupole field***
- Reduce the sextupole field*
- Generate the higher multipole fields.*

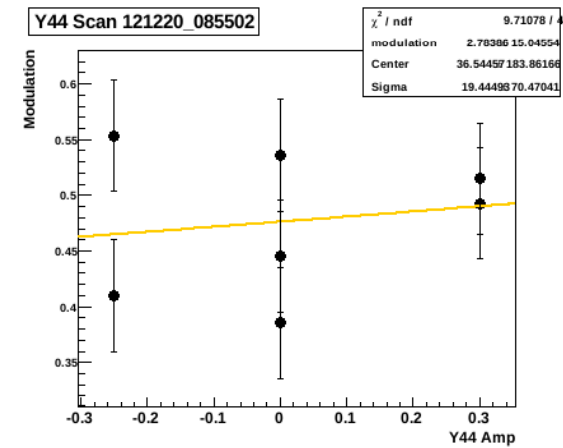
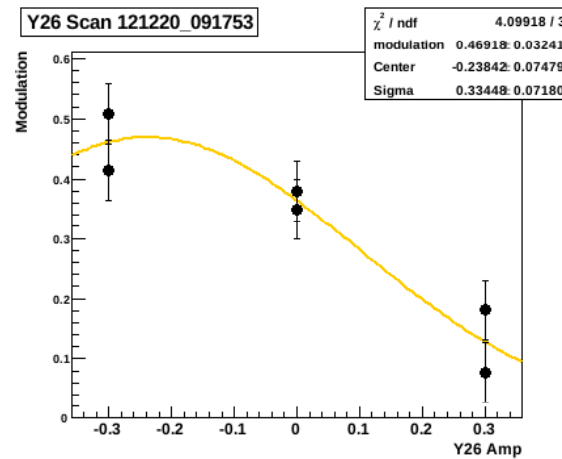
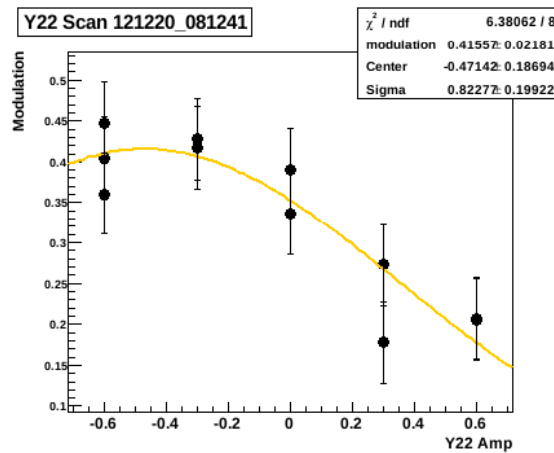
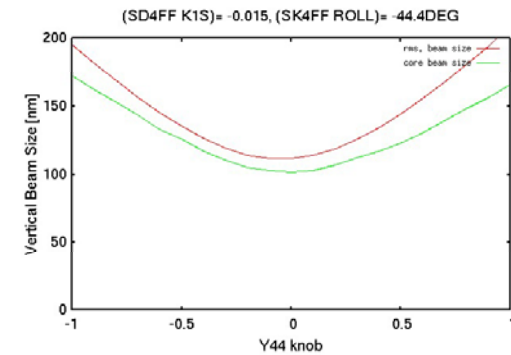
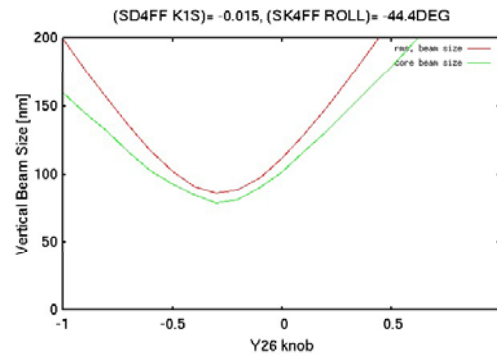
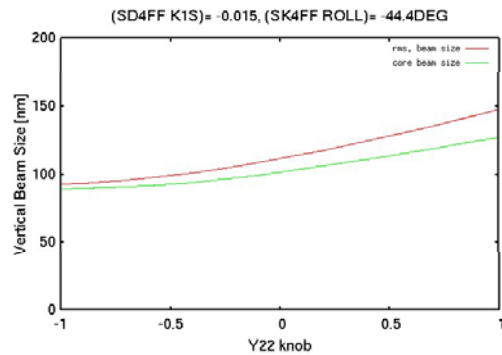
## *The effect of the skew quadrupole field of SD4FF*

- Generate the vertical dispersion ( can be corrected with Ey knob )*
- Generate the  $\langle x'y \rangle$  ( can be corrected with Coup2 knob )*
- Converted T122 from SF6FF to the IP vertical beam size*
  - > generate T322*
  - > **almost same effect to the roll of SF6FF***

# The effect of skew quadrupole field of SD4FF

## Simulation

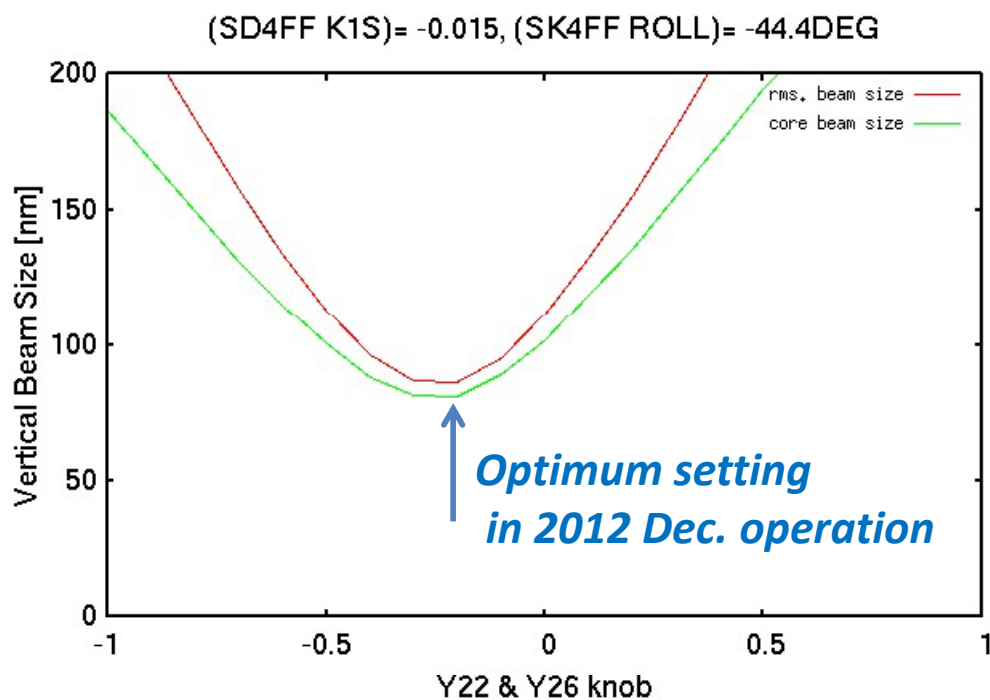
- Put  $K1S=-0.015$  at SD4FF
- Rotate the SK4FF by  $-44.4$  deg.
- Optimize the linear knobs ( $A_y$ ,  $E_y$ ,  $Coup2$ )
- Evaluate the nonlinear knob response



Same response to the measurement

## Simulation Results ( $emitx=2nm$ , $emity=20pm$ )

	rms beam size	core beam size	
No errors	55.4nm	51.7nm	
With errors, linear knob	111.1nm	101.5nm	
Y22=-0.6, Y26= 0.0	96.4nm	91.1nm	<b>12/19 setting</b>
Y22=-0.2, Y26=-0.2	71.1nm	67.0nm	<b>12/20 setting</b>

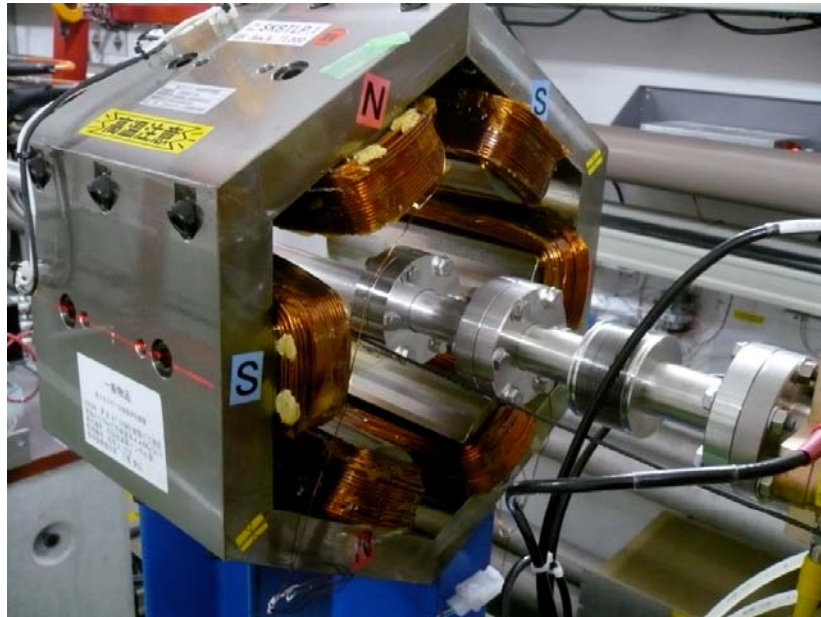


*There is a clear difference between the setting of 12/19 and 12/20.*

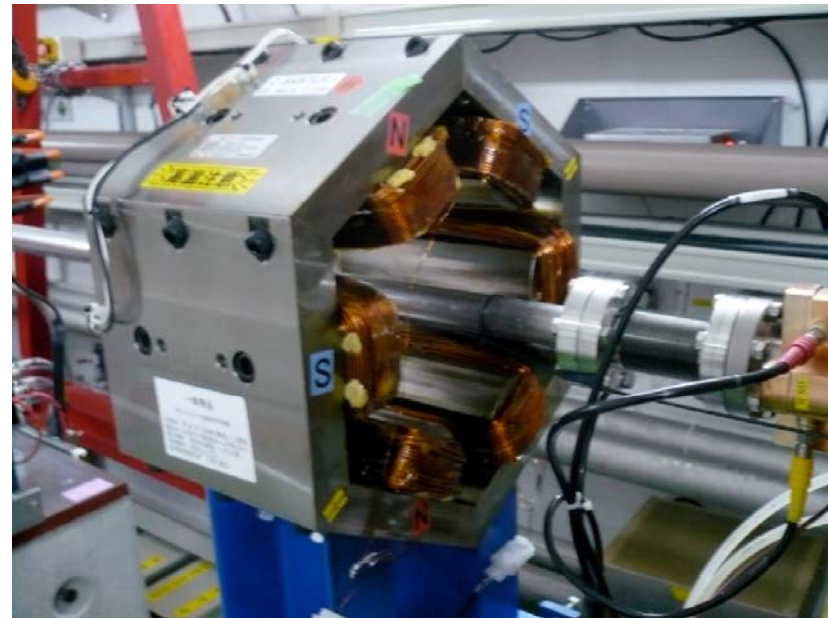
*The estimated beam size on 12/20 setting was smaller than that of no correction, but larger than that of no multipole errors.*

## *Improvement in 2013 Jan. operation*

*Vacuum chambers were rearranged around SK4FF*

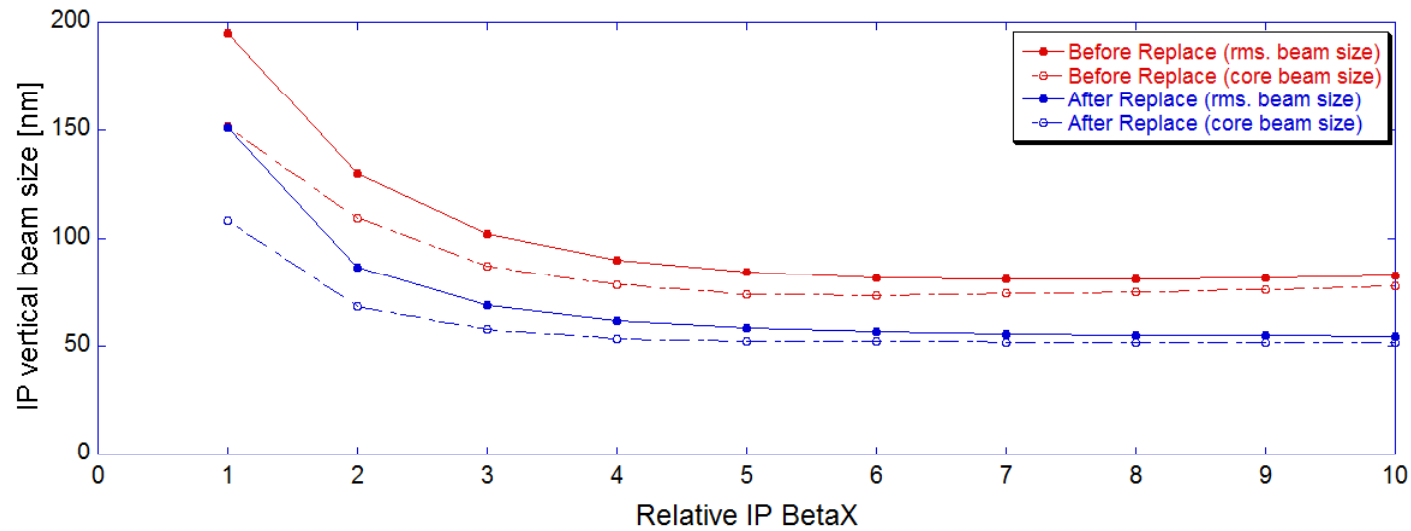
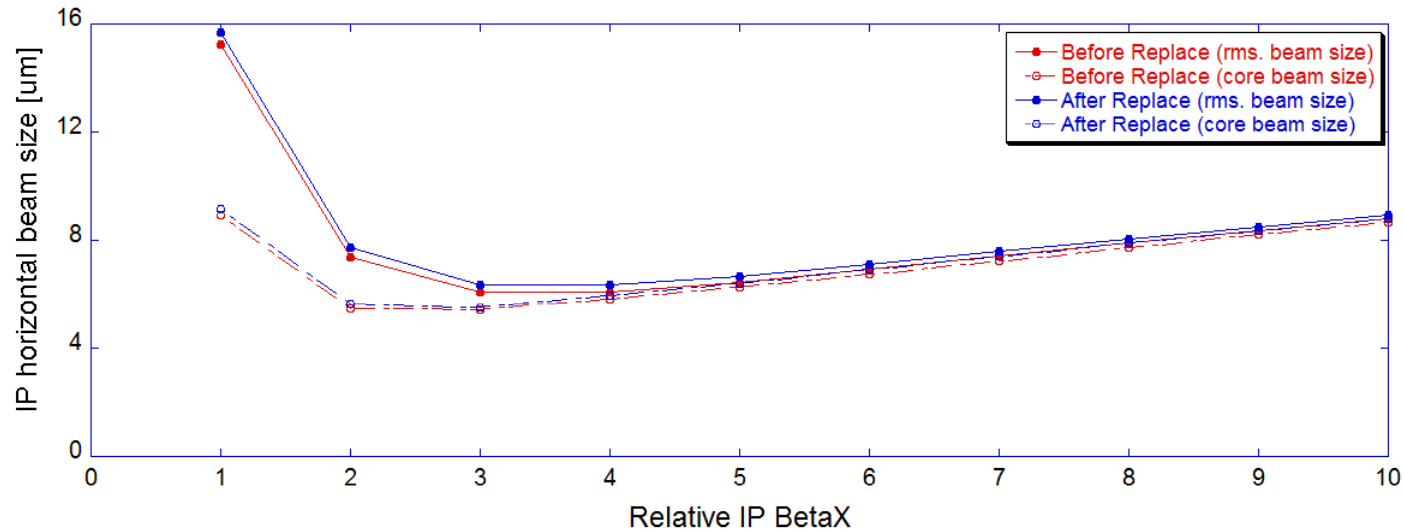


- Removed the flanged inside of bore
- Changed a nut to stainless steel



*SD4FF and SF5FF were replaced, because the field of SF5FF was small*

# *IP beam size simulation after magnet replacement*



## Summary

*We could observe clear modulation at 12/20 , but we could not at 12/19.  
The difference of the settings are only the set of nonlinear knobs.*

*When we assumed the be large errors both for SK magnet and FF sextupoles,  
we could reproduce the measured IP vertical beam size in simulation.*

*We examine the FF sextupoles and skew sextupoles, and we found the errors*  
*- an iron nut was used at the bore of SK4FF*  
*- a coil of SD4FF was short, it makes the skew quadrupole field.*

*When we assumed the large errors for SK4FF and SD4FF,  
the responses for nonlinear knobs can be explained.*

*We changed the camber arrangement around SK4FF,  
and replaced SF5FF and SD4FF to reduce the effect of abnormal field.*