ATF2 plan for Autumn-Winter run

IWLC 2010
2010 / 10 /21
Toshiyuki OKUGI, KEK

The main purpose of the ATF2 operation in 2010 autumn / 2011 winter run

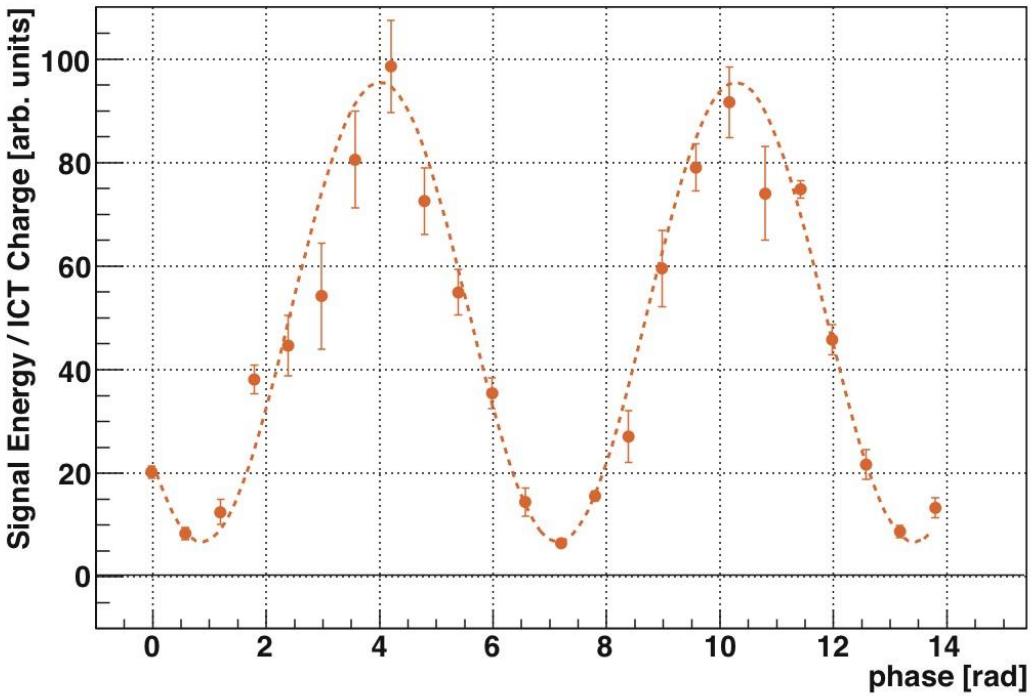
1. Investigation of the reason why the final beam size was 300nm (design 114nm) at the continuous operation in 2010 spring

2. To make small vertical beam size as small as possible.

3. Preparation of ATF2 stage 2

In 2010 spring run,

we performed 1st trial of the ATF2 continuous operation with 4cm βx and 1mm βy optics.



In the continuous operation,
we achieved the 0.87 of the modulation depth at 8.0 deg. Mode.

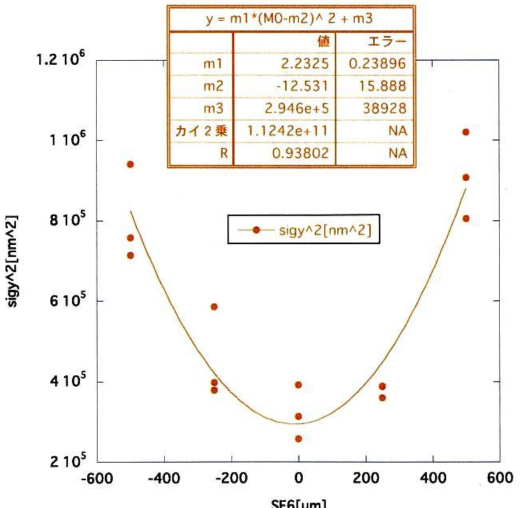
The evaluated vertical beam size is 310 +/- 30 (stat.) +0-/40 (syst.) nm.
(The design beam size is 114nm)

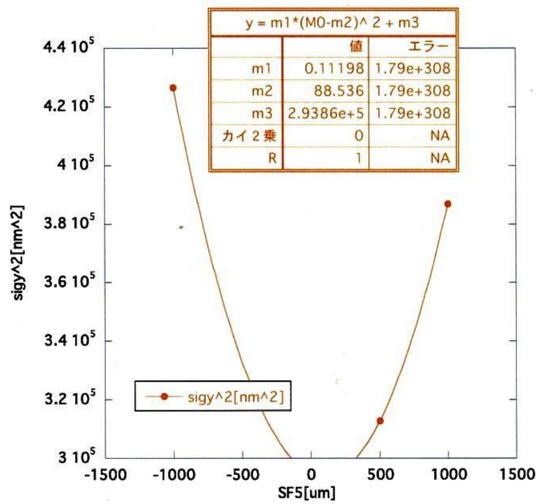
The candidate reason not to make the design beam size

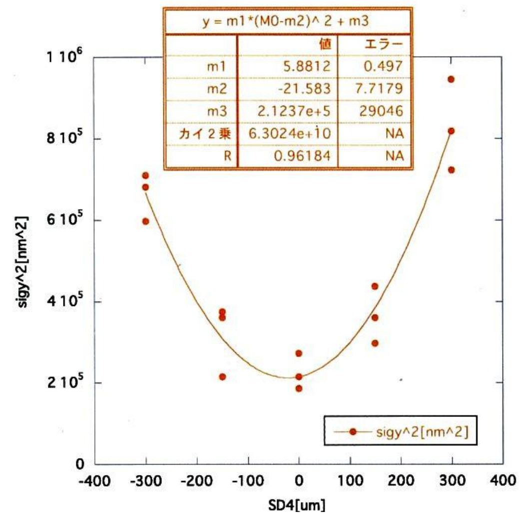
1. *Imperfect of the beam size tuning*
2. *The effect of multi-pole fields of FD magnets*
3. *The effect of the beam jitter*
   - We did not have the BPM at IP in 2010 spring run
4. *The effect of IP-BSM measurement*
   - The drift of the measured beam size was large in 2010 spring run

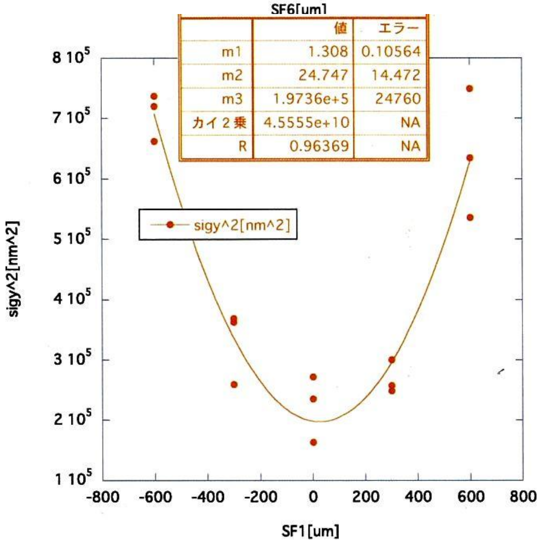
The minimum beam size was achieved after the vertical position optimization of individual FF sextupoles.

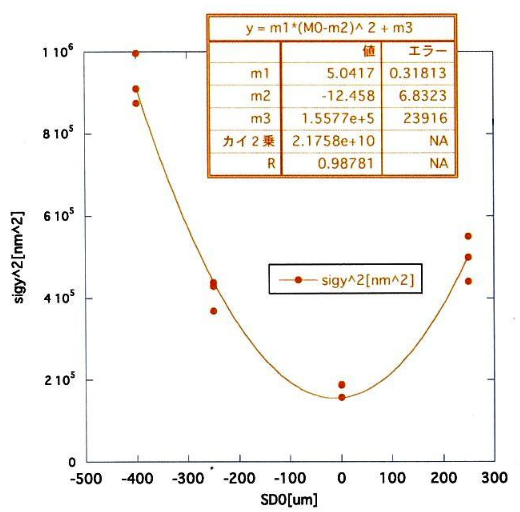
I believe the vertical position of FF sextupoles were not so bad at the continuois operation











The β* also checked to be design beta function at the beginning of the continuous operation with post-IP WS.

When Mark applied the IP beam size magnification knob, the measured beam size was not reduced.

I believe the beta matching was not main reason why the measured beam size was not so small.

However, we need to check with careful beam tuning.
(Continuous operation is important in coming beam operation period !)

However, we have never change the strength of FF sextupoles to check the chromaticity and geometric aberration.

We need to scan the strength of FF sextupoles in 2010 autumn run.

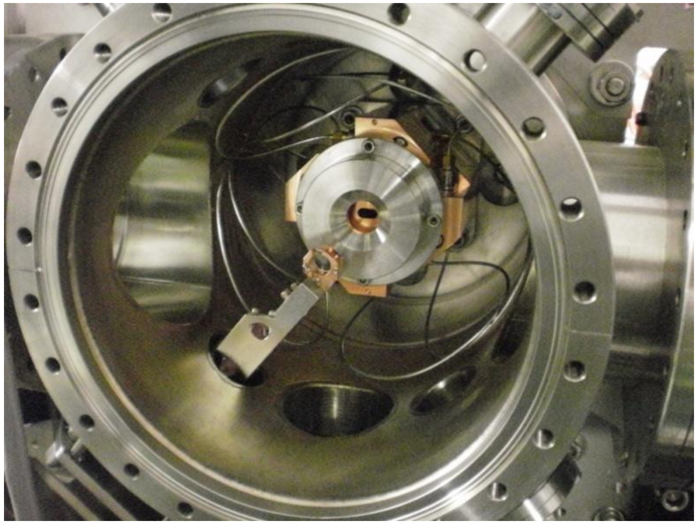
To confirm the amount of the beam jitter, we installed the IP-BPM.

Installation of IP-BPM

•IP-BPM installed

•BPM cables are connected in the cable

•Cabling work was finished



- We performed the cavity BPM with 8.7nm resolution.
- The resolution was excluded the effect of the coupling of X and off-phase(Q).
- The effect of the off-phase(Q) is large for the beam large divergence.

BPM resolution test in 2008

Presented by Y.Honda (2010 / 7 /21)

$$Y2I_{Predicted} = \frac{z_{23}}{z_{12}+z_{23}} Y1I + \frac{z_{12}}{z_{12}+z_{23}} Y3I = 0.317 * Y1I + 0.683 * Y3I,$$

$$\text{Residual} = Y2I_{measured} - Y2I_{predicted}.$$

- To prove the intrinsic resolution, we used correlations of all available information of the three BPMs.
- RMS of Residual improves as number of parameters used in the analysis.
  - ideal model: 28nm
  - with x information: 15nm
  - all information: 8.7nm
- This result is almost same as Shintake's 25nm result at FFTB. (They used only y information.)

Parameter	A	B	C	D	E	F
Y1I	0.275	0.279	0.294	0.298	0.274	0.282
Y1Q	0.039	-	-0.016	-	0.035	0.027
Y3I	0.726	0.748	0.732	0.731	0.724	0.723
Y3Q	-0.009	-	0.022	-	0.001	-
YREF	0.012	-0.055	-0.053	-0.055	-0.046	-0.070
X1I	-0.063	-	-	-0.134	-0.324	0.0367
X1Q	-0.020	-	-	-	-	-0.021
X3I	0.089	-	-	0.170	0.365	-
X3Q	-0.012	-	-	-	-	-
XREF	-0.076	-	-	-	-	-
RMS (Count)	22.02	70.11	69.08	39.15	25.63	24.32

$$\begin{aligned} Y2I_{predicted} &= \alpha_0 + \alpha_{Y1I} * Y1I + \alpha_{Y1Q} * Y1Q + \alpha_{Y3I} * Y3I \\ &+ \alpha_{Y3Q} * Y3Q + \alpha_{Yref} * YREF + \alpha_{X1I} * X1I + \alpha_{X1Q} * X1Q \\ &+ \alpha_{X3I} * X3I + \alpha_{X3Q} * X3Q + \alpha_{Xref} * XREF. \end{aligned}$$

Result of 2008 and rough estimation of the online resolution

Presented by Y.Honda 2010 / 7 /21

- Summary and Discussion
  - Intrinsic resolution 8.7nm has been measured.
  - Y information of single cavity can predict 28nm beam position.
  - With X information this can be improved
    - Roll misalignment of 1mrad between cavities can produce ~10nm residual if x beam jitter is 10um.
    - At IP, x jitter must be smaller. This situation might be improved.
  - Phase error (Q) contributed ~10nm .
    - Beam orbit angle signal can contaminate.
      - At IP angle jitter will be much bigger.
      - At FFTB, 25nm resolution has never achieved at the IP. They suspect beam angular divergence (jitter?).
  - Situation at strongly focused point. Bunch length stabilization becomes important.
    - Bunch tilt can produce position signal
    - Bunch length or tilt change look like a beam position jitter.

from FFTB paper

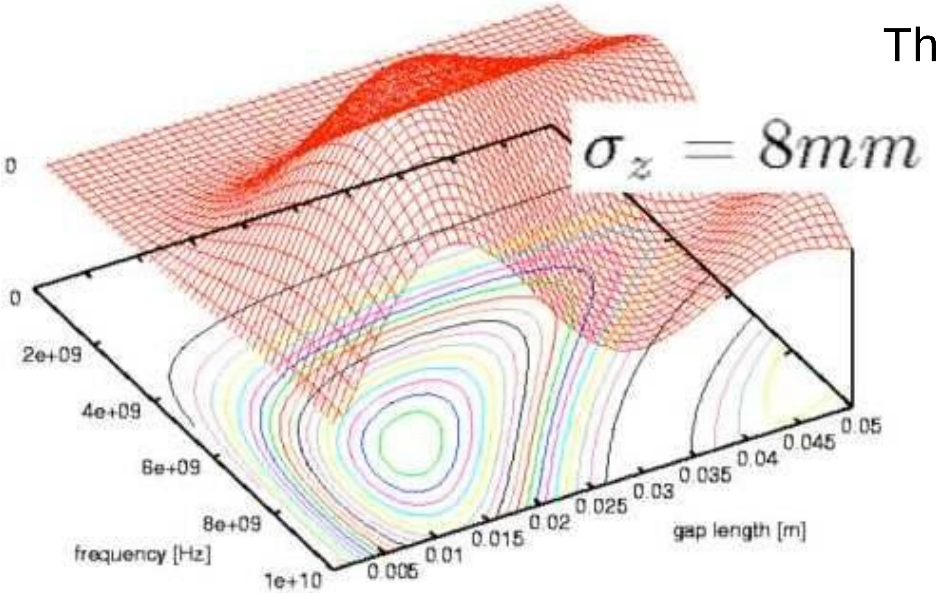
5 DISCUSSION AND CONCLUSION

Although the resolution of approximately 25 nm was measured for the RF-BPMs from the triplet set, the measured resolution of the RF-BPM at the FFP was around 80 nm. This is attributed to the beam's large angular divergence (460 μrad) and is not completely understood. Even though the FFP BPM was not able to measure beam motion below 80 nm, it was very efficient in minimizing beam aberrations before using the KEK BSM.

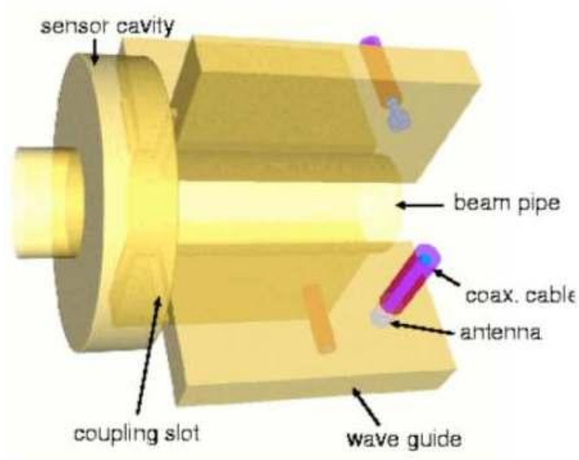
Beam divergence ; 460 urad
-> resolution is increased 25nm -> 80nm

Beam divergence at ATF2 design optics
εy=20pm -> $\sigma y'$=450urad

KEK IP-BPM



Thinner gap than FFTB cavity BPM



We expect the effect of the beam divergence is smaller then FFTB cavity BPM.

We expected 30nm (no divergence effect) - 80nm (same to FFTB) resolution, including the effect of coupling of X and off-phase(Q).

It is enough to use for 100nm beam.

The resolution study at large divergence beam (i.e. ATF2 IP) is important to measure the fine beam position at ATF2 IP for the design beta_y optics.

Improvement of IP-BSM

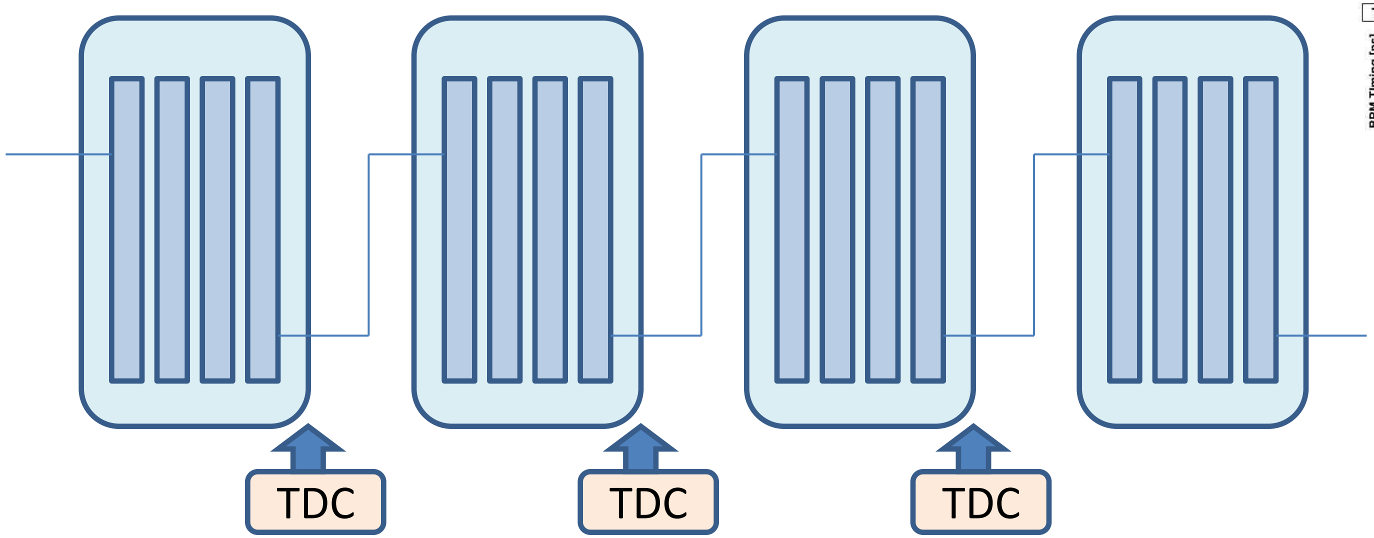
1. Installation of the phase jitter monitor for the IP-BSM laser

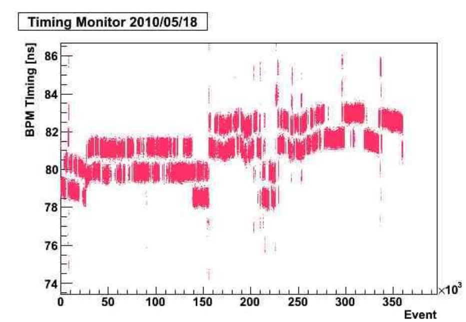
We will be able to monitor the drift of the IP-BSM laser position.

2. Improvement of timing jitter monitor of the IP-BSM laser trigger

When the trigger timing is jumped by 1count (2.8ns),
the gamma-ray signal was reduced to be 70% of the peak signal.

GUN station **DRstation** **Kicker station** **IP-BSM station**





Several TDCs will be installed and be monitored in the beam size measurement in order to identify the module with the timing jump.

Beam Optics Optimization

We must fix the beam optics by the following criteria

1. Background condition to IP-BSM detector
2. Effect of multipole error for QEA magnets

Optimisation of Optics Including Multipole Data

- **MAPCLASS used to rematch and optimise lattice including multipole fields to try and recover nominal IP vertical beam size.**
- **Quantities on the right are re-matched values different from initial nominal lattice. *Note the inclusion of design sextupole rolls.***
- **The vertical beta function was left unchanged at 0.1mm, but horizontal had to be increased by a factor of 2.5 to 1cm.**

```
ksf6ff =      45.02265407 ;
ksf5ff =      -26.9434435 ;
ksd4ff =      152.5391892 ;
ksf1ff =     -22.38137452 ;
ksd0ff =      41.20558391 ;
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sf1tilt =   -0.04258038011 ;
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kqm14ff =     -4.768046545 ;
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kqd4ff =     -1.555892097 ;
kqf3ff =      2.830240649 ;
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kqd2bff =     -1.369873894 ;
kqf1ff =      1.566624722 ;
kqd0ff =      -2.87401948 ;
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Presented by G.White at ATF2 meeting (10/06/2010)

<u>Lucretia Tracking IP sizes</u>

σ_x = 4.5um (RMS) 4.4um (Fit)
σ_y = 44nm (RMS) 42nm (Fit)

-Large beta_x (1cm) optics

-Reoptimized sextupole strength

Plan of 2010 autumn / 2010 winter run for ATF2 stage1

2010 autumn

1. Initial commissioning of IP-BPM (30-80nm resolution)
2. Background study of nominal beta_y optics
3. Define the beam optics in the 2010 autumn operation and later
4. Investigation of the reason why the final beam size was larger than the design beam size at the continuous operation in 2010 spring
5. Squeeze the beam size as small as possible

2011 spring

1. IP-BPM resolution study for large divergence beam
2. Concentrate to squeeze the beam size to design beam size

Plan of 2010 autumn / 2010 winter run to ATF2 stage2

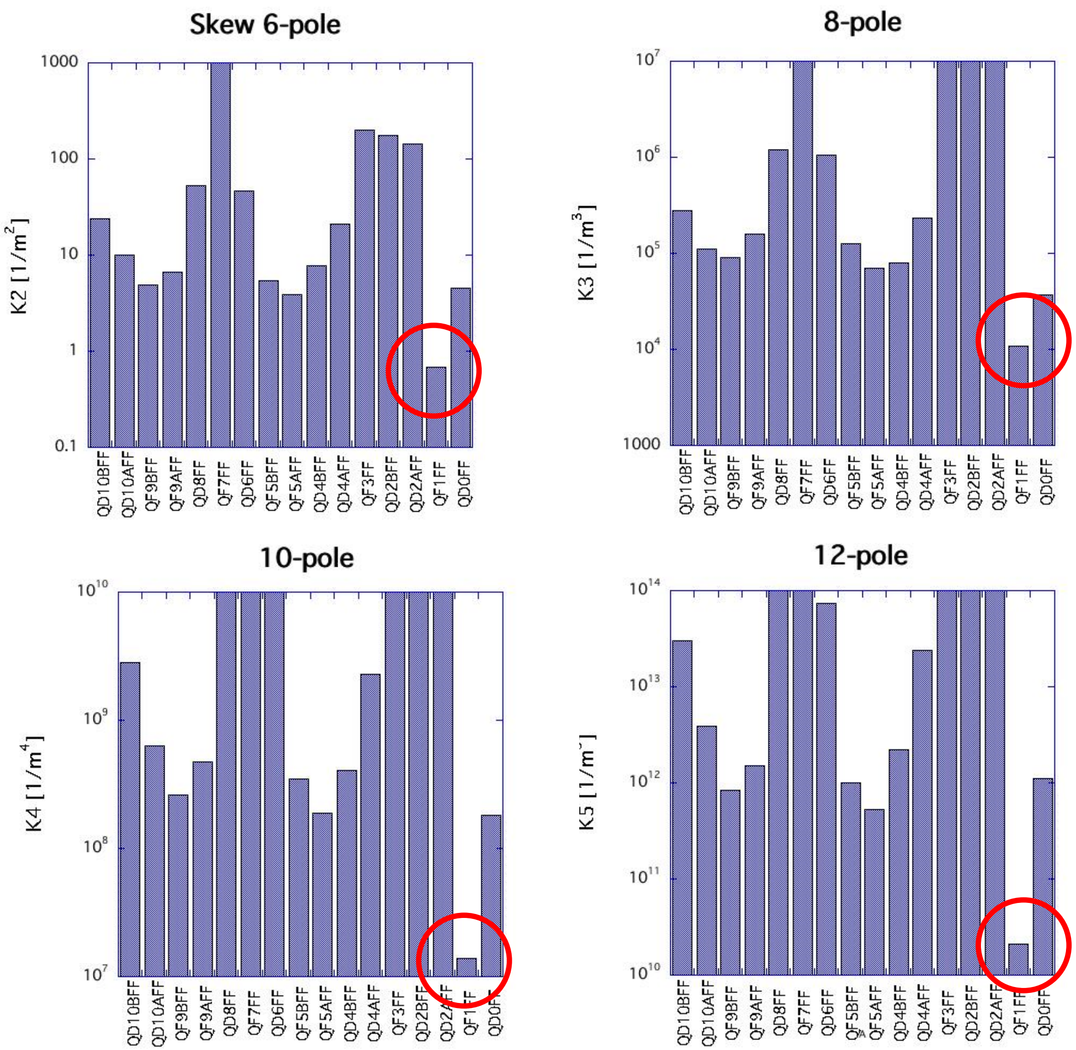
We will have to perform the following study item as preparation of ATF2 stage 2 as well as the small beam size generation.

1. Establishment of the stable multibunch beam generation
2. Establishment of the stable multibunch beam extraction (Fast Kicker)
3. Establishment of the technology of intra-train feedback (FONT)

Backup

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.

Remeasurement of FD magnet

We could not measure the multipole errors for FD magnet, because we don't have an appropriate rotating coil in KEK.

Therefore, we perform the following measurement

1.Resistance check of all coils to check the shortage of the coils

We could not find any coil shortage in this measurement.

2. Geometrical measurement of FD magnet pole

QF1 rotations are -6.25mrad at E-end (upstream) and -4.09mrad at W-end.
Average is -5.17mrad. -> Twisted !

QD0 rotations are +2.69mrad at E-end (upstream) and +2.79mrad at W-end.
Average is +2.74mrad.