QEA Magnet Measurements at KEK and Comparison with IHEP Results

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1. Comparison of two harmonic coil systems (IHEP & KEK)

From the slides

QEA magnets

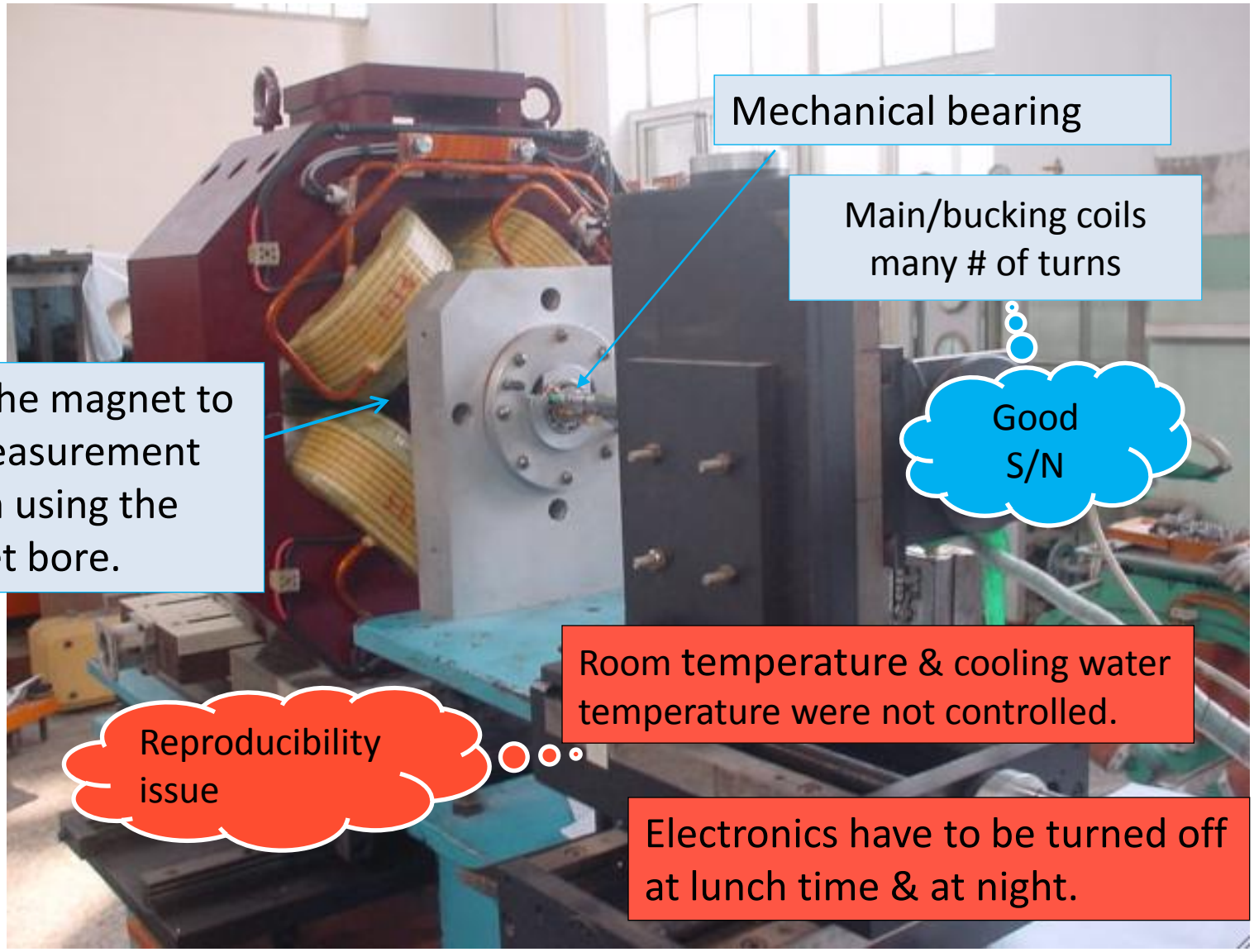
Aug.31,2006

M.Masuzawa

& Chen Wan

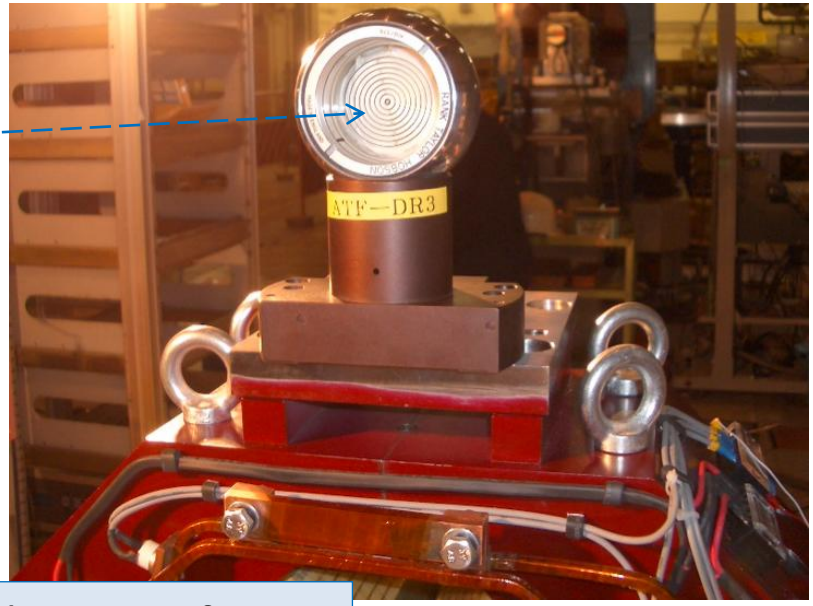
& Sun Xianjing

Measurement system at IHEP



Aug.31,2006

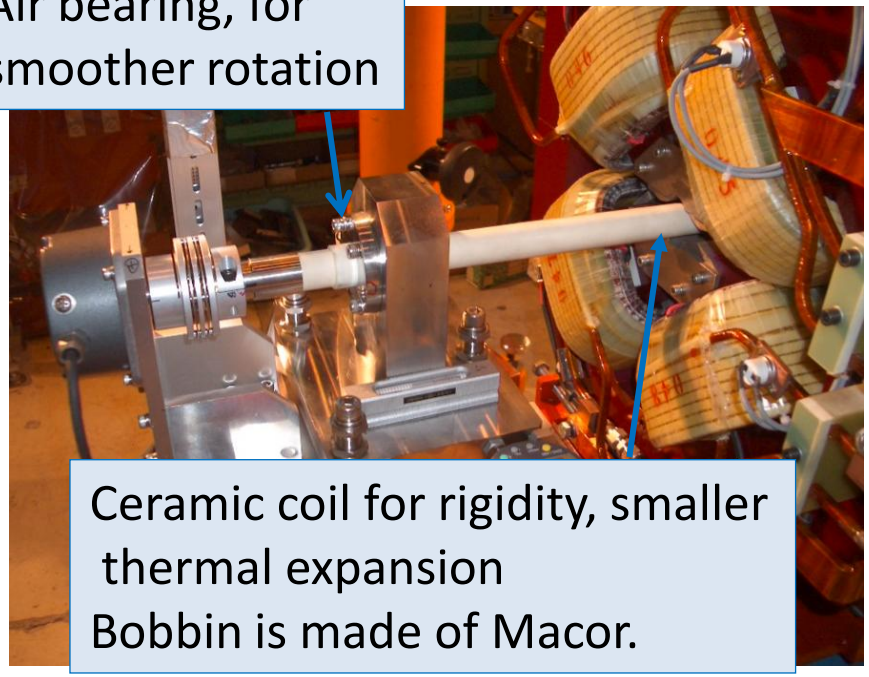
Measurement system at KEK



Harmonic coil is connected to the encoder by a coupling structure. Every time we change the magnet, we have to remove the coil from the encoder.

This coupling method guarantees the relation between the harmonic coil starting point & the encoder.

Air bearing, for smoother rotation



Ceramic coil for rigidity, smaller thermal expansion
Bobbin is made of Macor.

2. Multipole components

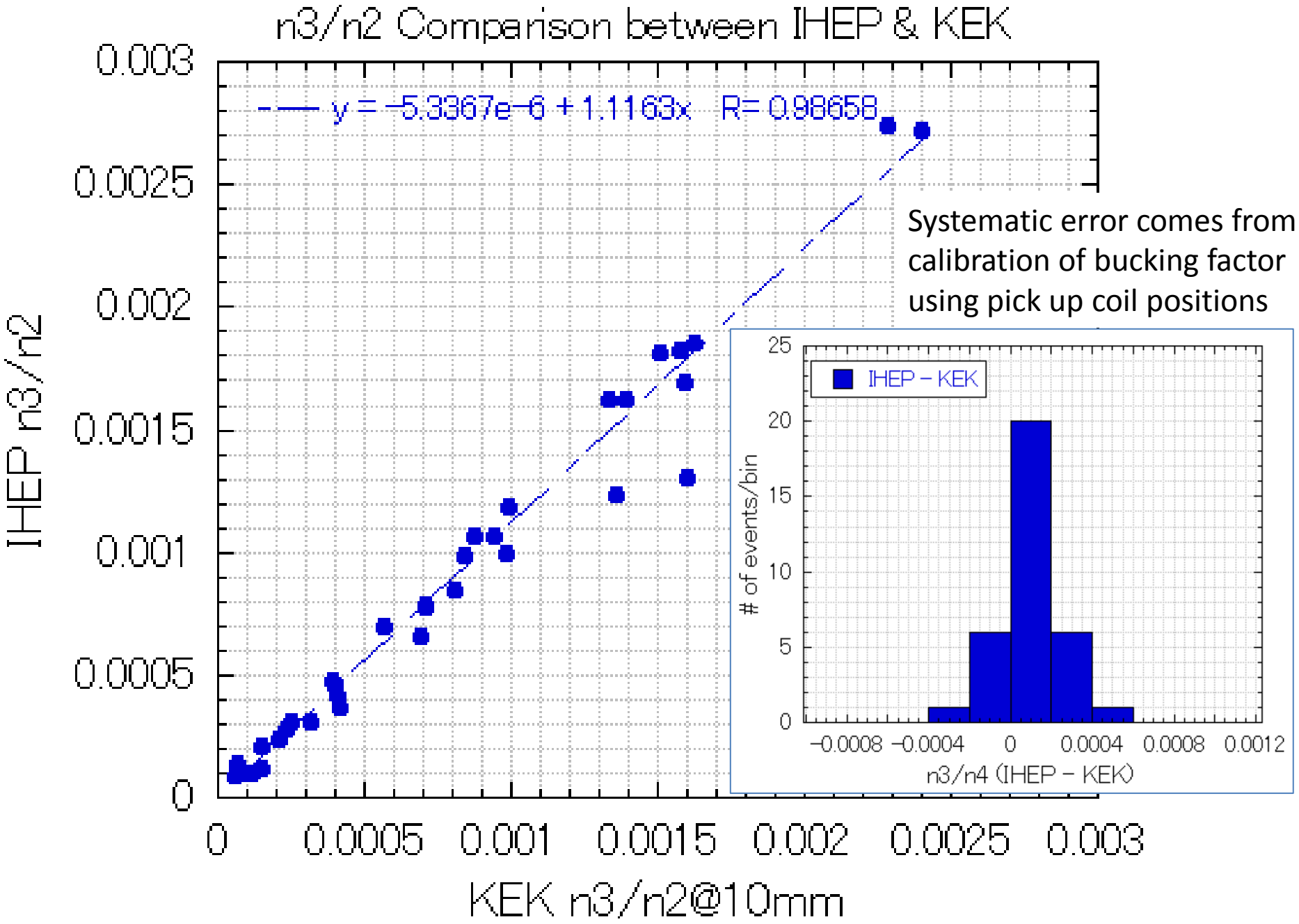
- Sextupole components n3/n2

Amplitude Abs(n3/n2)

Normal n3/n2 : Abs(n3/n2)*Cos(θ_3)

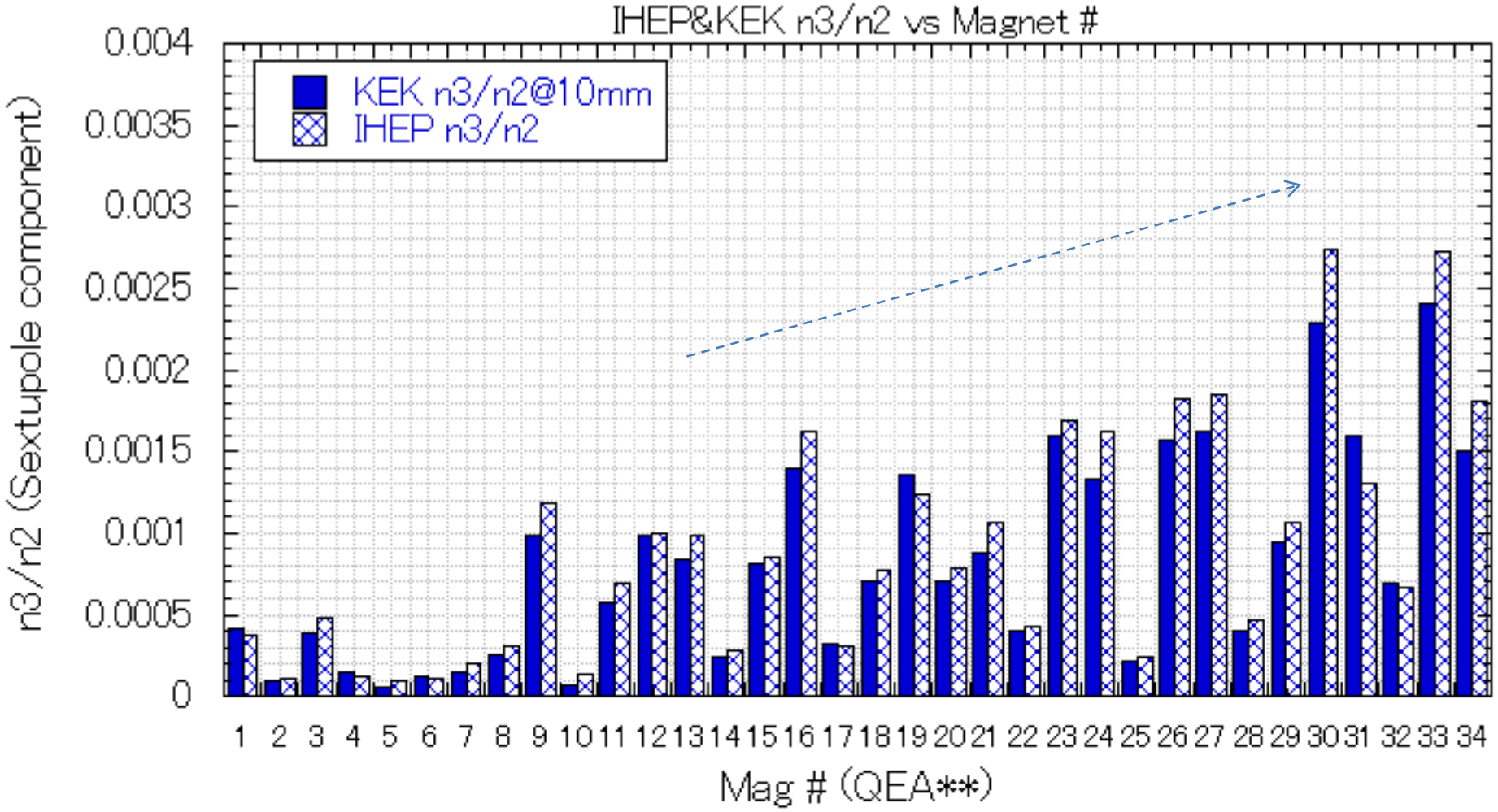
Skew n3/n2: Abs(n3/n2)*Sin(θ_3)

Amplitude Abs(n3/n2)



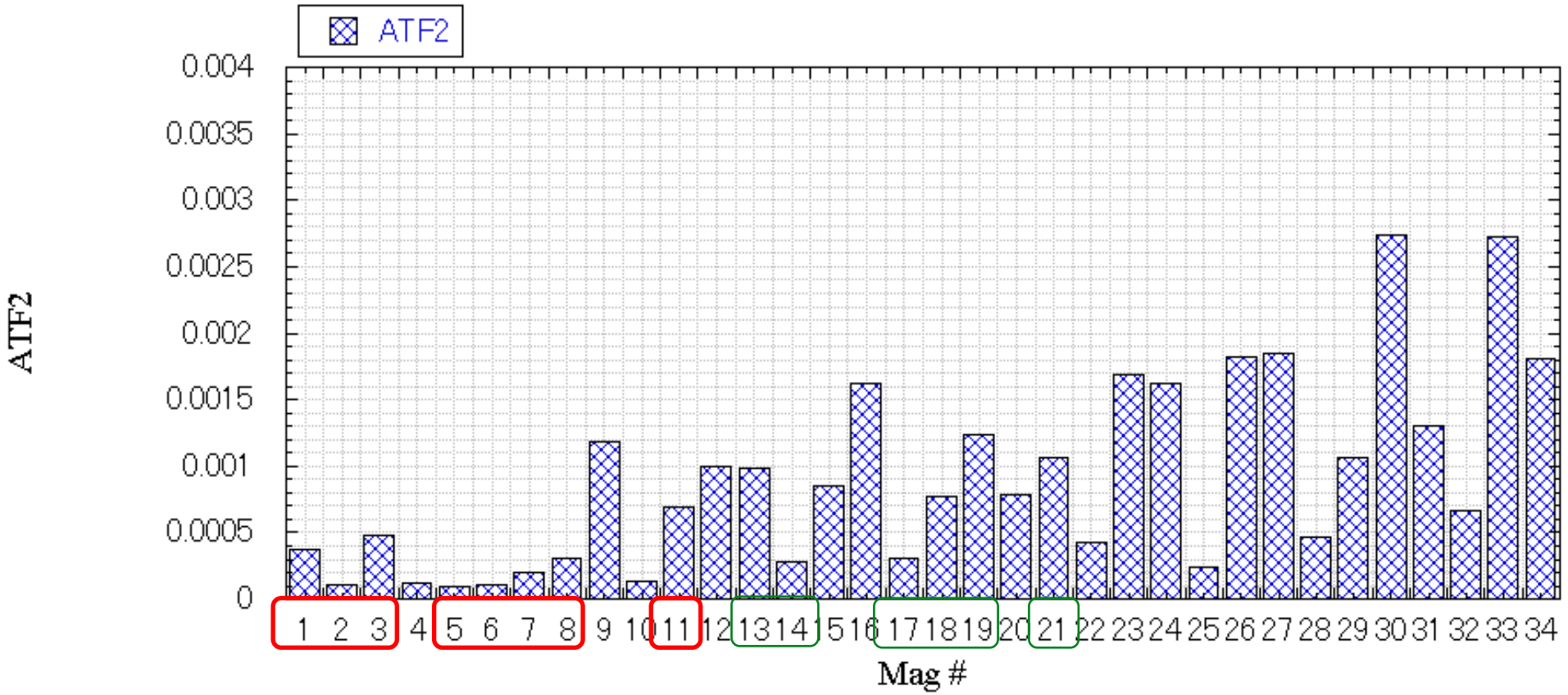
Systematic error comes from calibration of bucking factor using pick up coil positions

Amplitude Abs(n3/n2)



Amplitude Abs(n3/n2)

n3/n2 (IHEP measurements) vs Magnet # (QEA#)

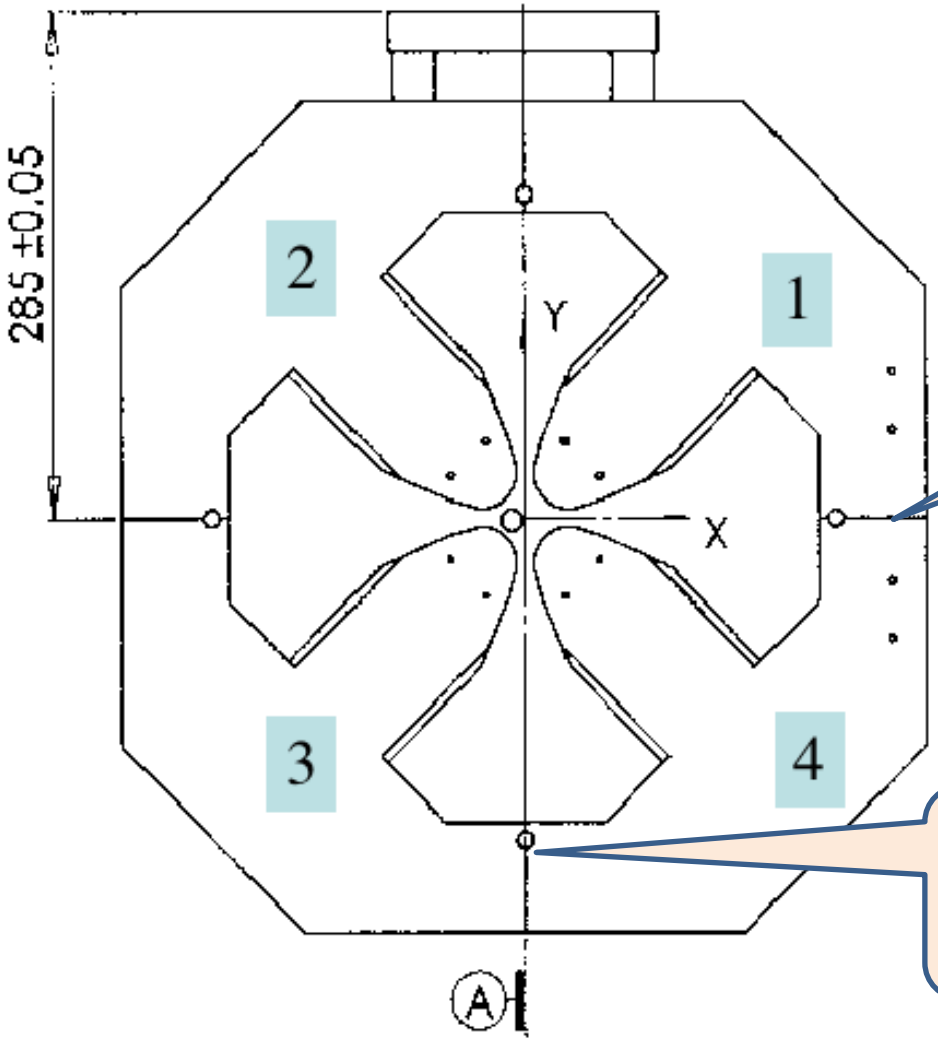


1,2,3,5,6,7,8,11 — Shim liner inserted to reduce sextpole component. Iterative process. KEK did not request any shim correction.

13,14,17,18,19,21 — Donated to ATF ring (By Urakawa-san's request)

•Shim correction for sextupole components

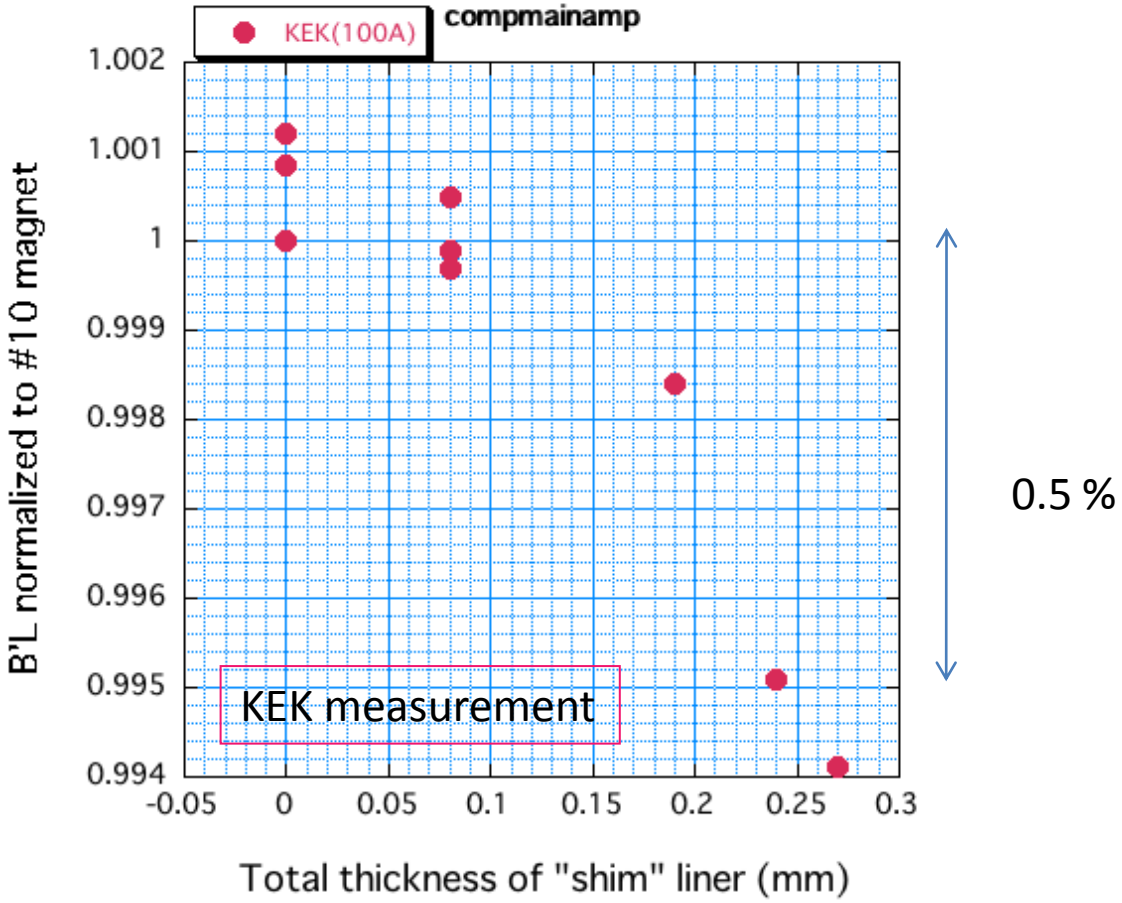
Thin liner insertion by IHEP to adjust the sextupole component (QEA07 for example)



0.16 mm shin liner Between #1 and #4 quadrants

0.11 mm shim liner between #3 and #4 quadrants.

B'L as a function of liner thickness



"Shim" liner insertion

Pros: control of sextupole components

Cons:The bore becomes larger, resulting in a weaker field.

Not optimized for other higher multipole components.

Sextupole tolerances

From EXCEL file : "ATF2 FF Q JKJ" sent out by James Jones as e-mail attachment, sent ~noon UK time 20th July 2005. This table is for "All orders 2%".

USE THE RIGHTMOST COLUMN OF THIS TABLE AS THE TOLERANCES FOR THE QEA QUADS THAT IHEP IS MAKING : note that many of the quads have loose tolerances such as 1.48E-01 and so it is OK if some quads have higher sextupole components than others.

		K2 for 2% beam size increase			Sextupole/Quad
Qname	minK2		B2@r=10mm	K1	B2/B1@r=10mm
QM16	8.52E+01	1.08E+02	1.85E-02	1.60887	2.65E-01
QM15	1.68E+02	7.24E+01	3.65E-02	2.37818	1.52E-01
QM14	1.63E+02	3.80E+02	3.53E-02	-5.5	-1.48E-01
QM13	1.27E+02	1.14E+02	2.75E-02	3.82429	1.49E-01
QM12	1.09E+01	2.38E+01	2.36E-03	3.72274	1.46E-02
QD10	4.90E-01	2.20E-01	1.06E-04	-1.56774	-7.02E-04
QD10A	3.28E-01	1.40E-01	7.11E-05	-1.56774	-4.46E-04
QF9	5.22E-01	2.33E-01	1.13E-04	1.87037	6.24E-04
QF9A	8.60E-01	4.19E-01	1.86E-04	1.87037	1.12E-03
QD8	3.81E+00	1.60E+00	8.25E-04	-2.80317	-2.85E-03
QF7	2.29E+02	7.52E+02	4.96E-02	2.99762	3.82E-01
QD6	1.85E+00	4.00E+00	4.02E-04	-2.80317	-3.31E-03
QF5	3.95E-01	6.39E-01	8.56E-05	1.87037	1.06E-03
QF5A	2.19E-01	5.22E-01	4.74E-05	1.87037	5.85E-04
QD4	1.36E-01	3.36E-01	2.94E-05	-1.56774	-4.32E-04
QD4A	2.28E-01	4.73E-01	4.95E-05	-1.56774	-7.28E-04
QD2B	7.81E+00	4.89E+00	1.69E-03	2.94454	8.31E-03
QF3	1.54E+01	1.16E+01	3.34E-03	-1.24713	-4.64E-02
QD2A	1.11E+01	3.76E+00	2.41E-03	-1.37206	-1.37E-02
QF1	8.52E-02	4.37E-02	1.85E-05	2.28379	9.56E-05
QD0	5.84E-02	3.14E-02	1.27E-05	-2.98885	-5.26E-05

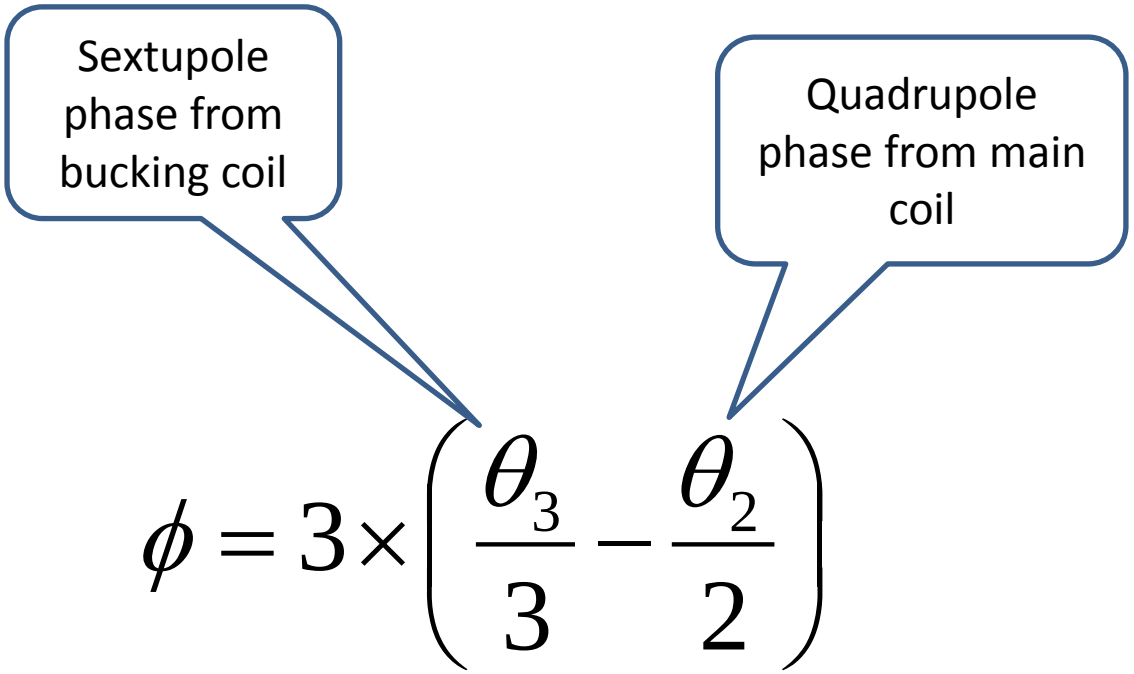
Summary

From 12/19/2008 ATF2 project meeting

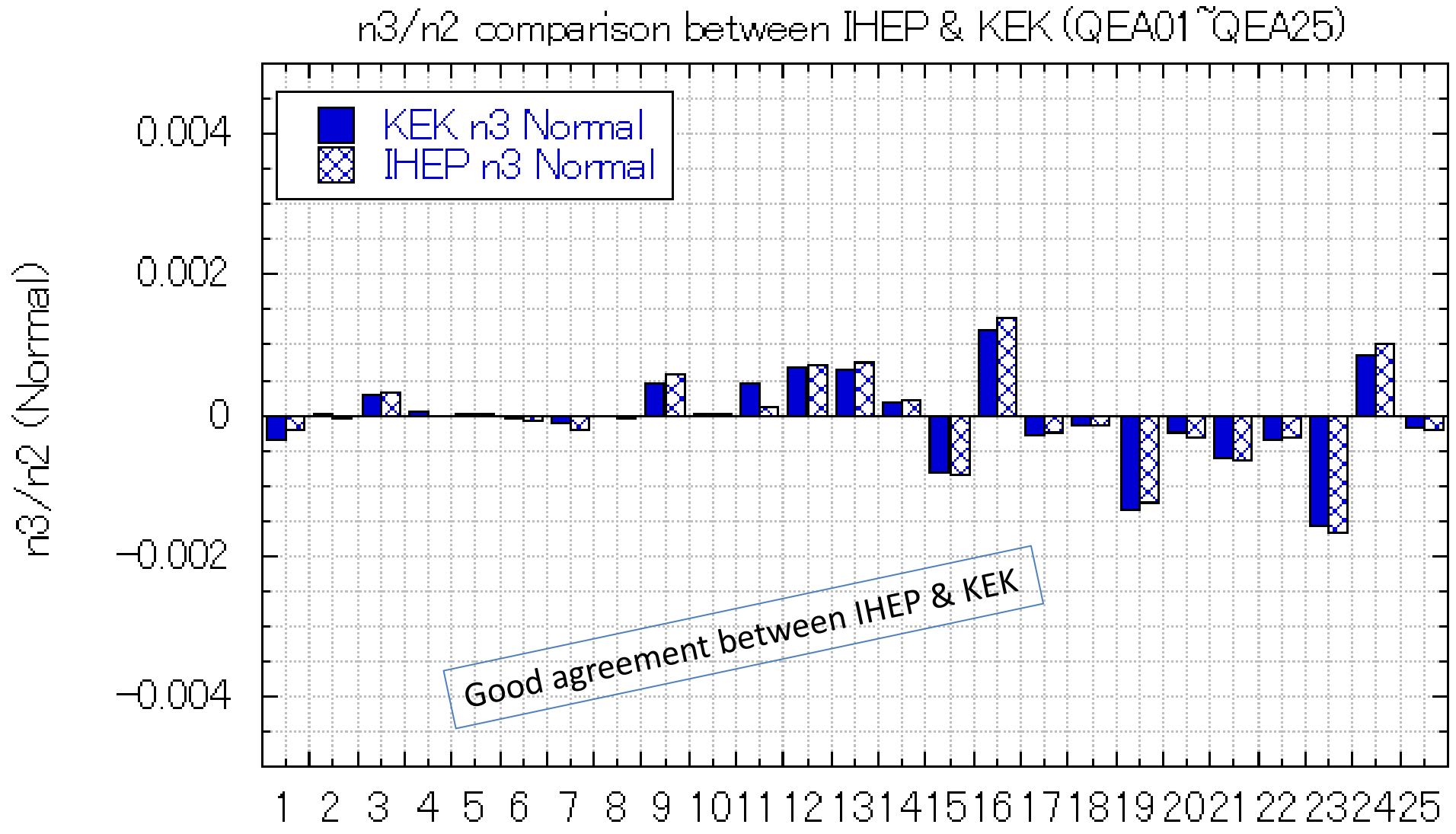
- 24 magnets were measured at both IHEP and KEK.
- KEK data will be used for generating the excitation curves, though the IHEP measurement improved for magnets in the 2nd batch.
- Large offset in the magnetic field with respect to the mechanical center was measured. Alignment people should use the field measurements result when aligning the magnets in the beam line.
- **Sextupole components seem to be small enough, or at least one can select good magnets for critical places in the beam line.**
- Trim coil data were taken. Be careful when connecting the trim coils to the power supply.
- Bad news:
  - 6 magnets in the 2nd batch were taken away by the ATF group. We only have 24 - 6 = 18 magnets left.

●QEA n3 normal & skew

definition of relative sextupole angle ϕ w.r.t. quadrupole

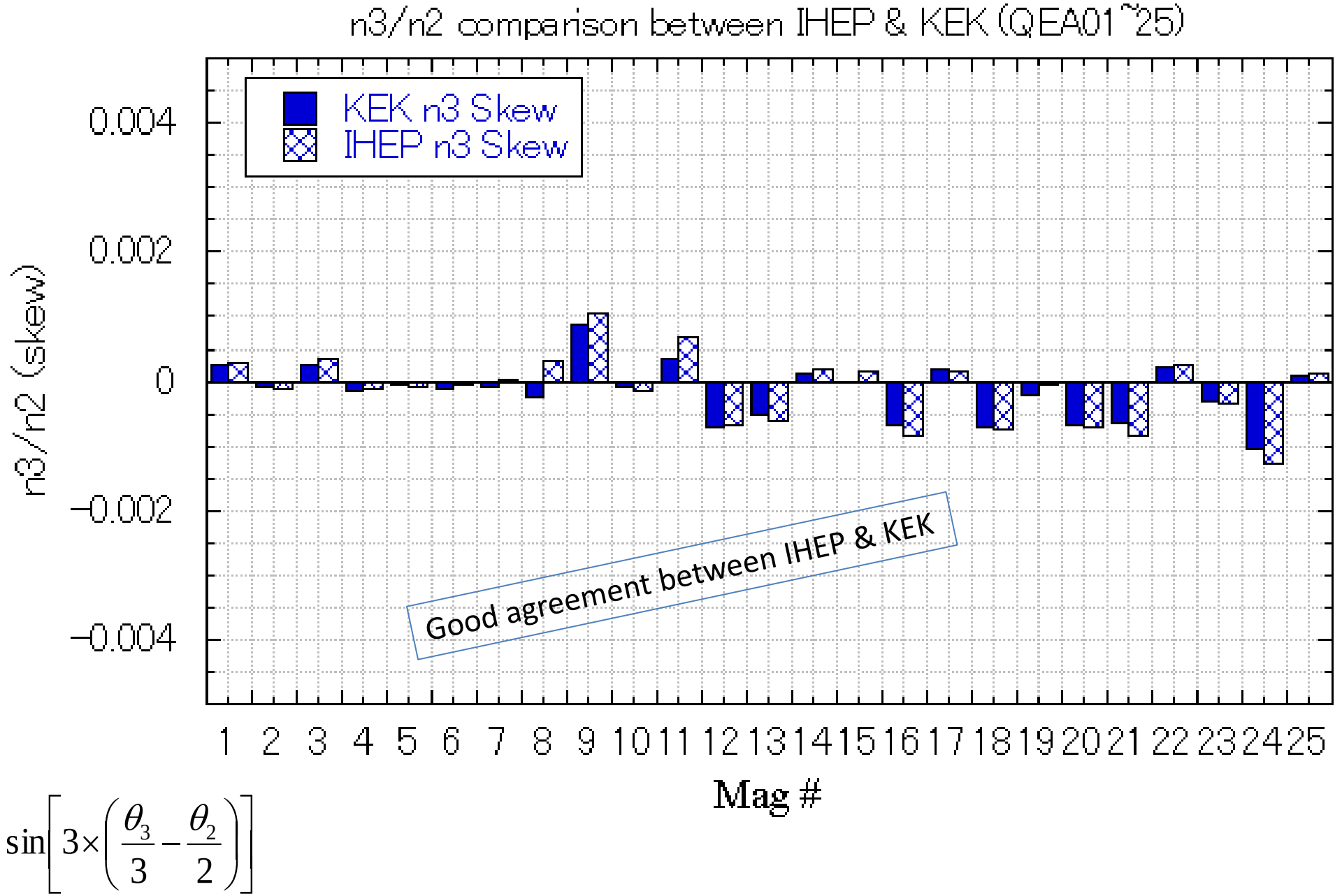


QEA n3 normal

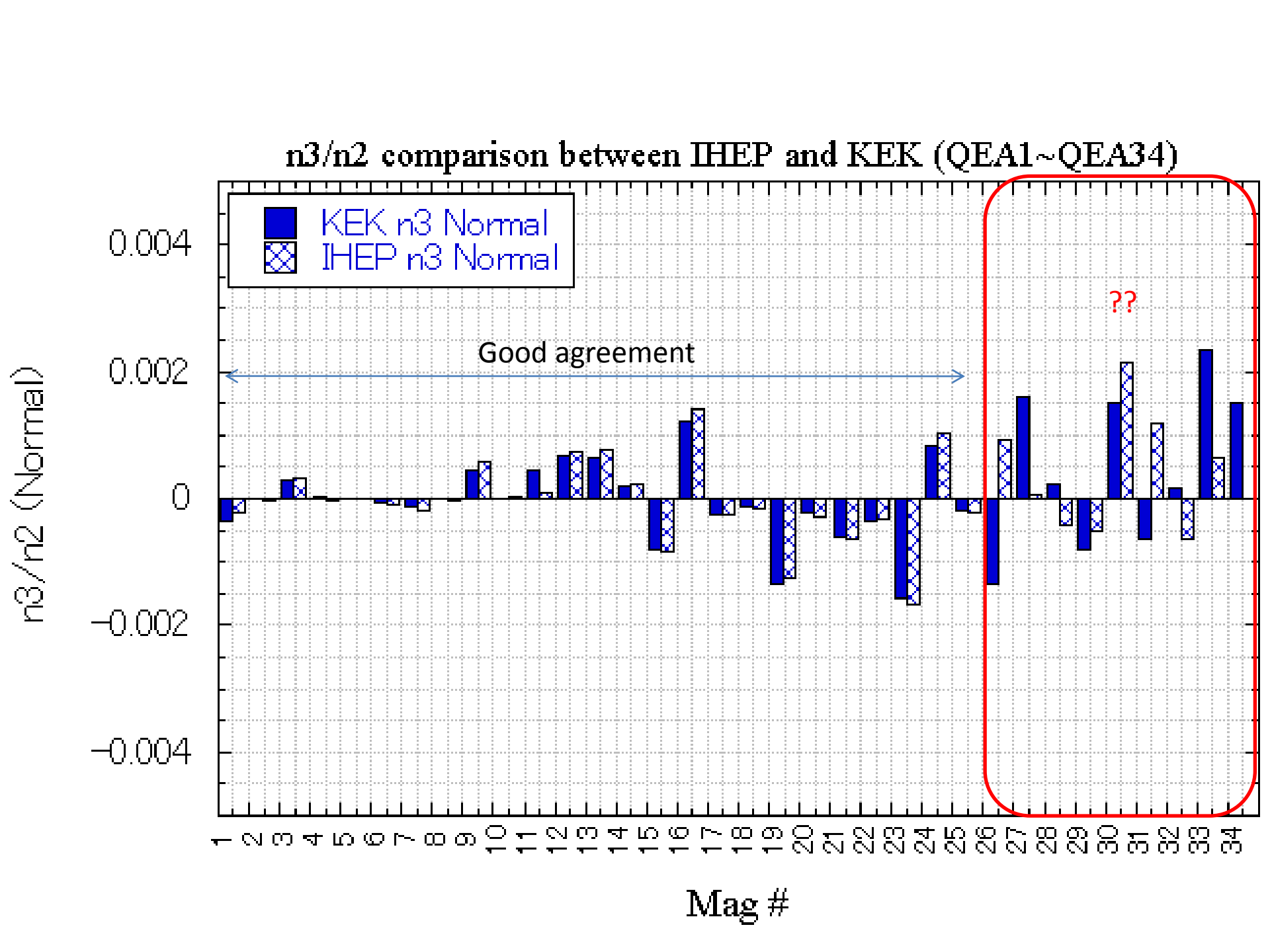


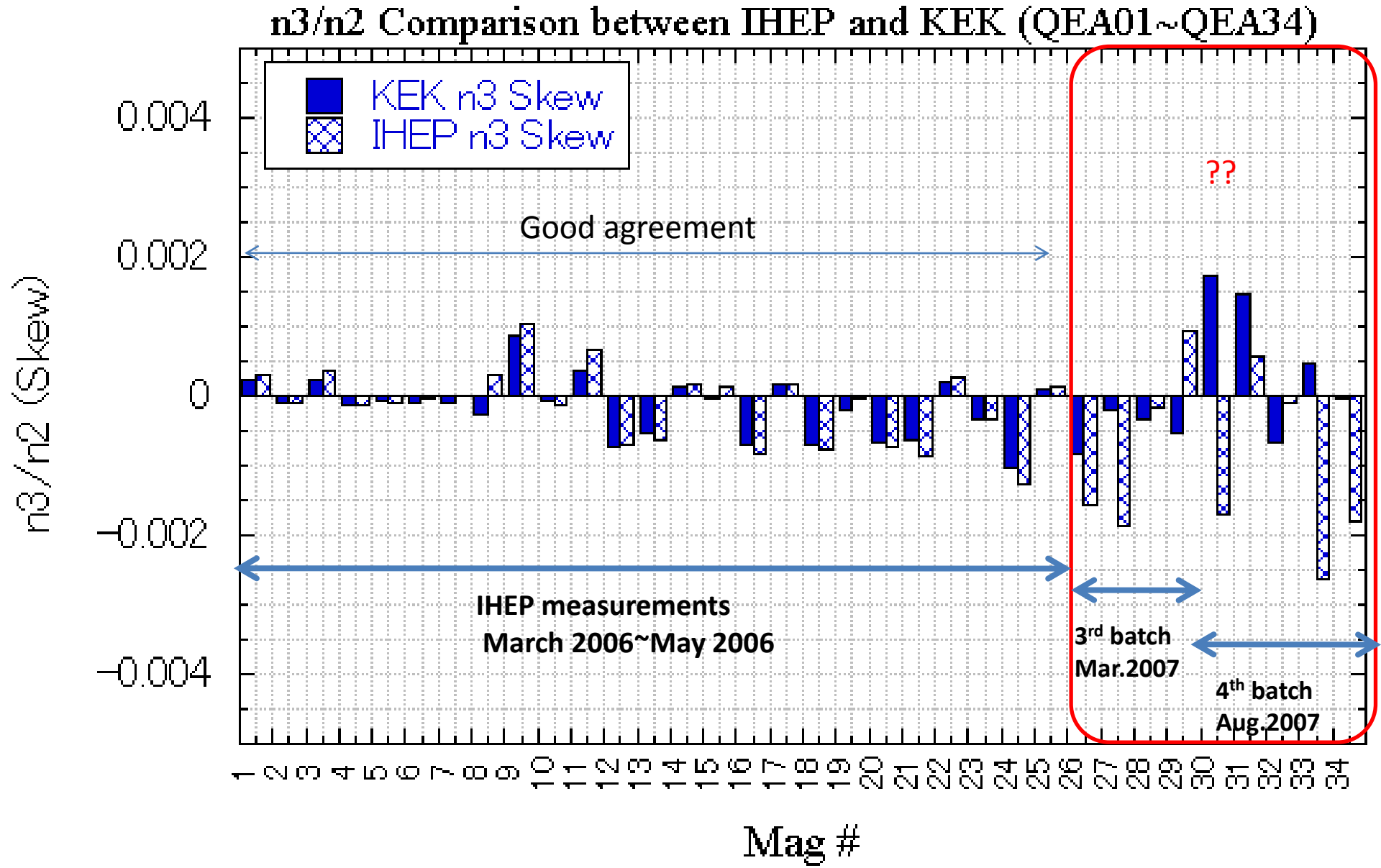
$$\cos\left[3\times\left(\frac{\theta_3}{3}-\frac{\theta_2}{2}\right)\right]$$

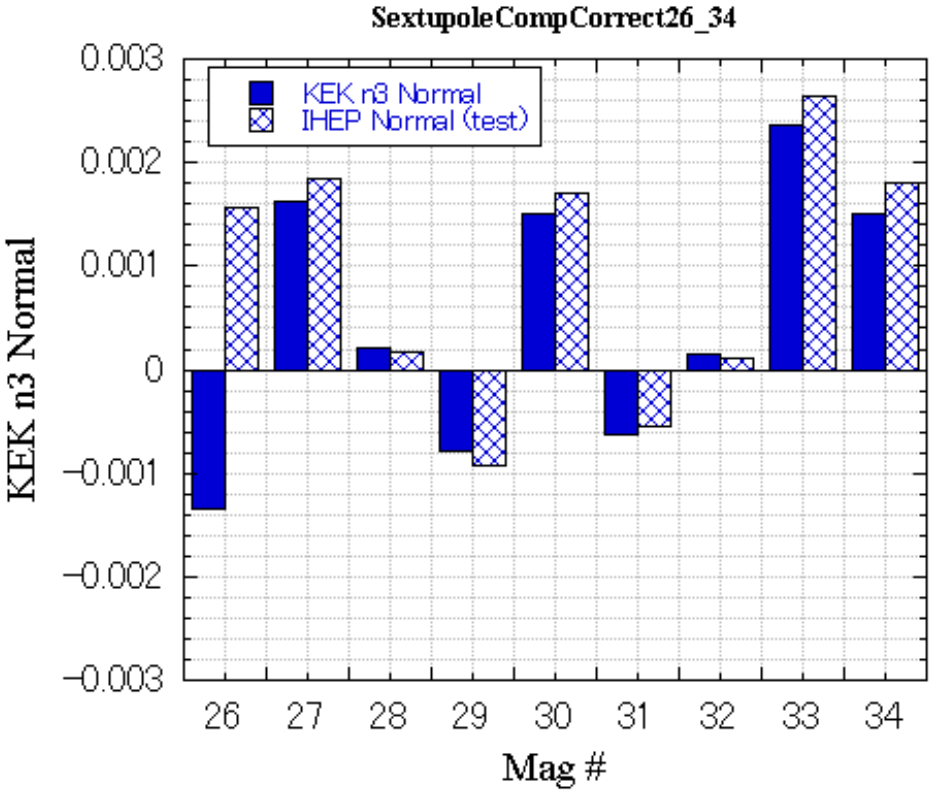
QEA n3 skew

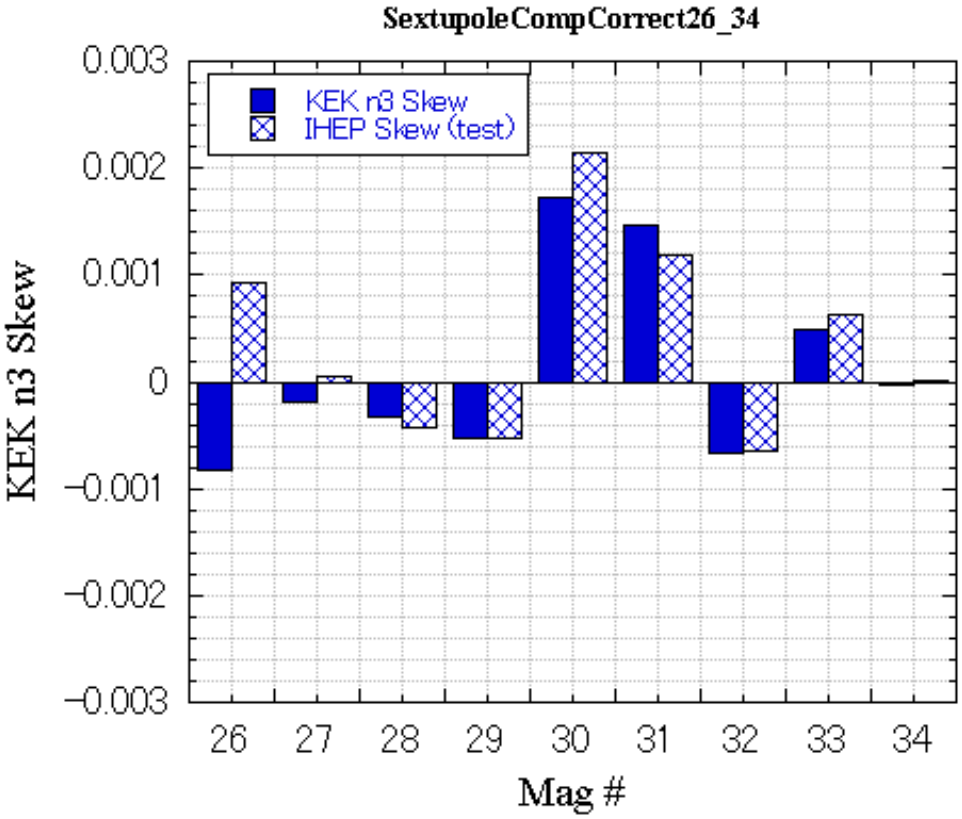


$$\sin\left[3\times\left(\frac{\theta_3}{3}-\frac{\theta_2}{2}\right)\right]$$


n3/n2 comparison between IHEP and KEK (QEA1~QEA34)
KEK n3 Normal
IHEP n3 Normal
Good agreement
??
n3/n2 (Normal)
0.004
0.002
0
-0.002
-0.004
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34
Mag #


n3/n2 Comparison between IHEP and KEK (QEA01~QEA34)
KEK n3 Skew
IHEP n3 Skew
??
Good agreement
0.004
0.002
0
-0.002
-0.004
n3/n2 (Skew)
IHEP measurements
March 2006~May 2006
3rd batch
Mar.2007
4th batch
Aug.2007
Mag #





If quad main phase is 180 degree off for the 2007 measurements at IHEP, QEA27-QEA34 agree well.

Wild guess : FD swap or pick up coil connection swap could explain.

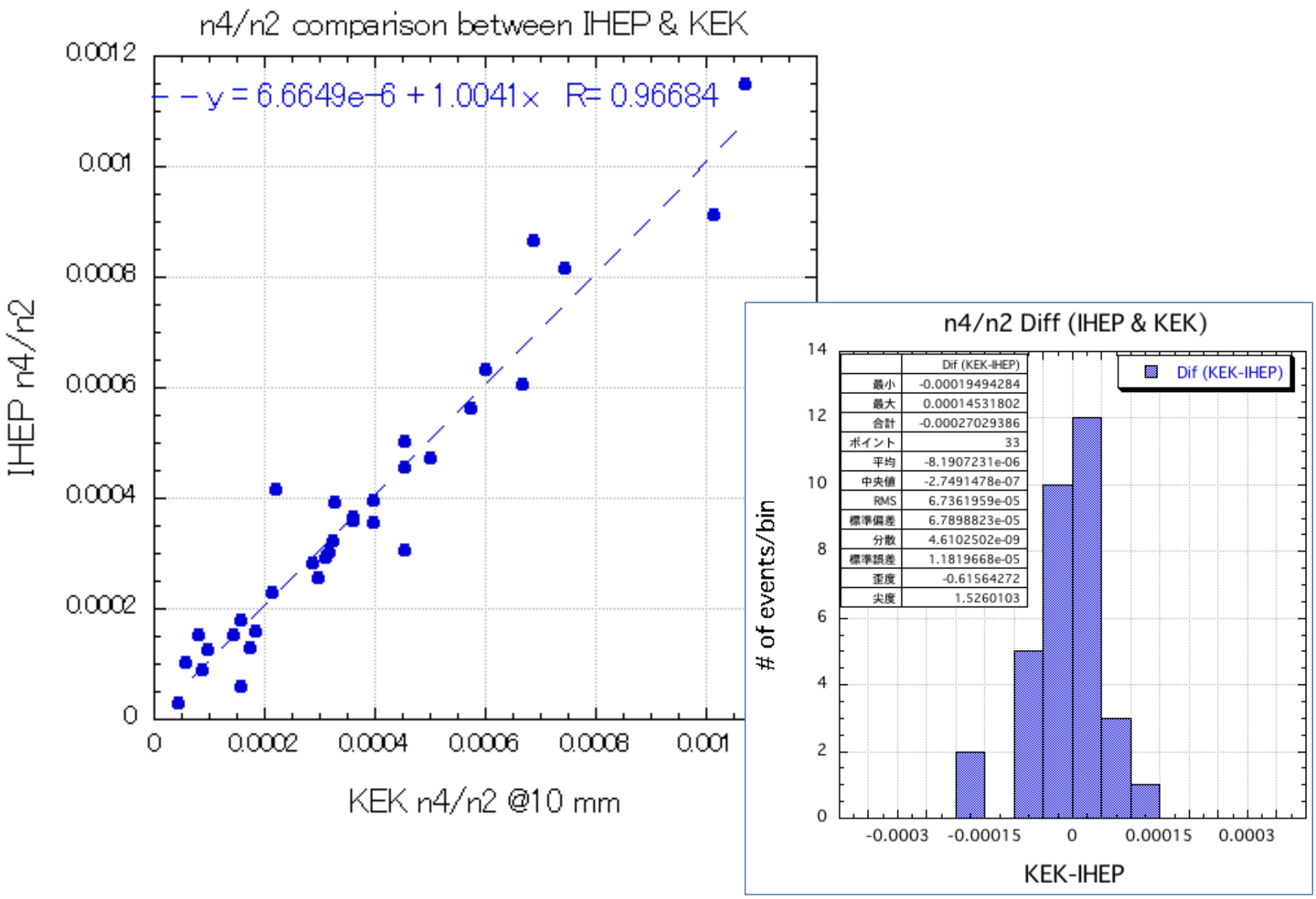
Unfortunately, #28 and #29 are on the swapping list.

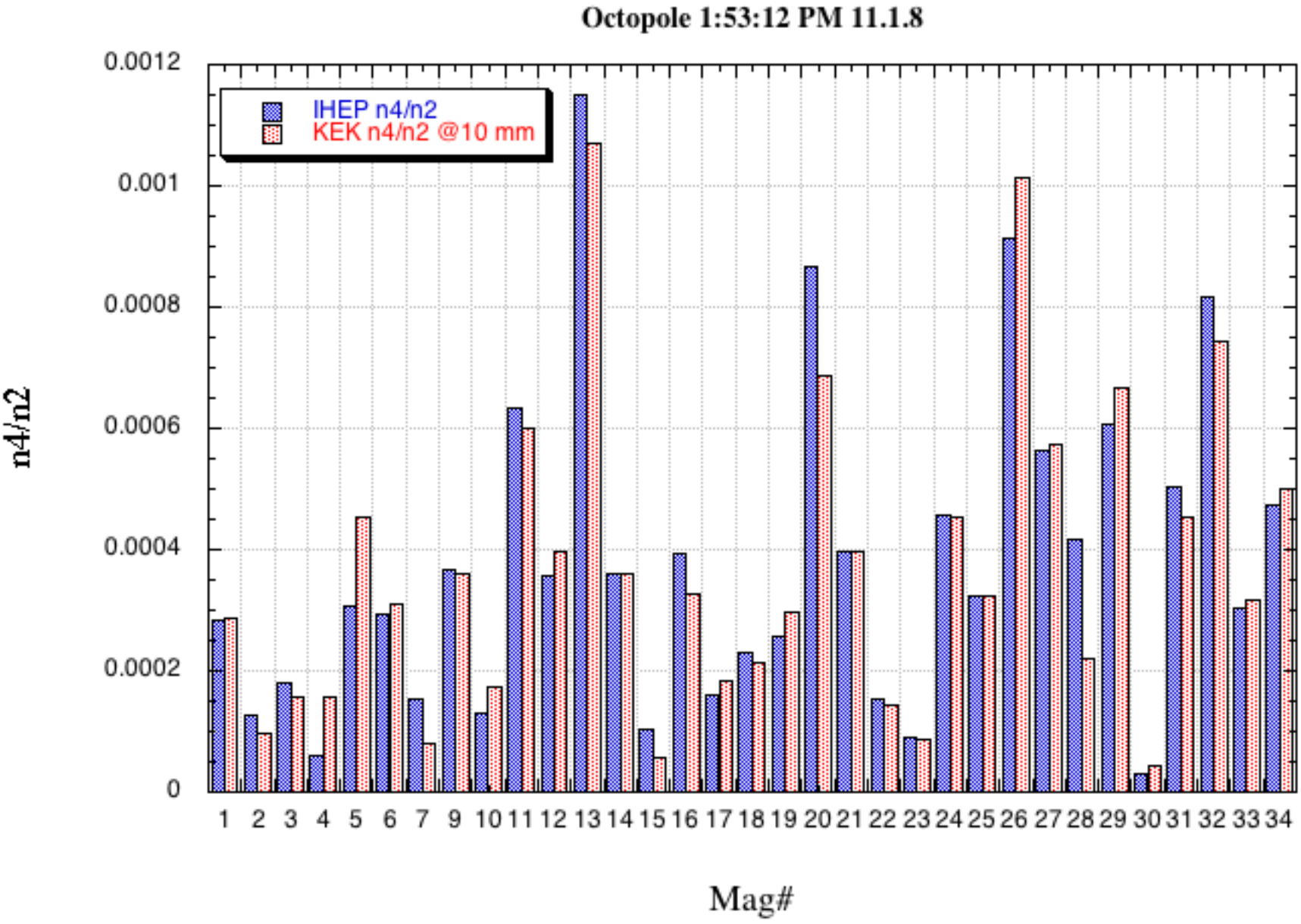
What about QEA26 ?

2. Multipole components

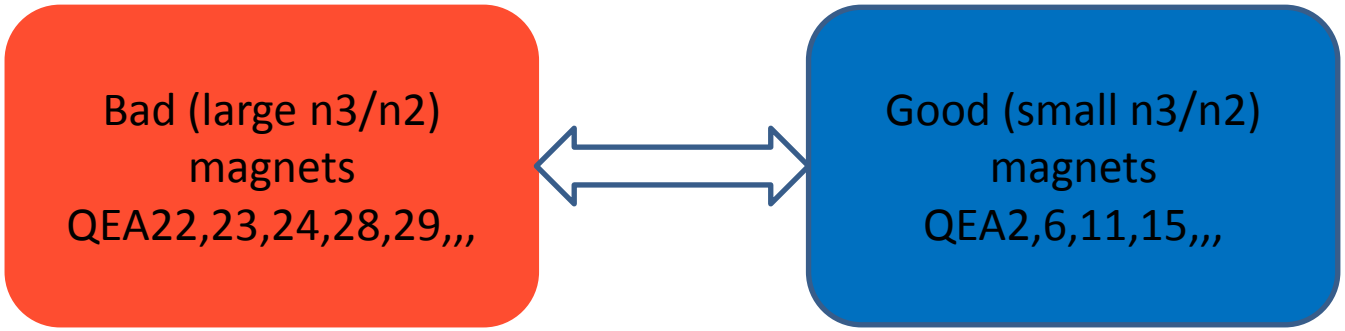
- Octupole components

Amplitude Abs(n4/n2)




Octopole 1:53:12 PM 11.1.8
IHEP n4/n2
KEK n4/n2 @10 mm
n4/n2
0.0012
0.001
0.0008
0.0006
0.0004
0.0002
0
1 2 3 4 5 6 7 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34
Mag#

3. Comments on swapping magnets

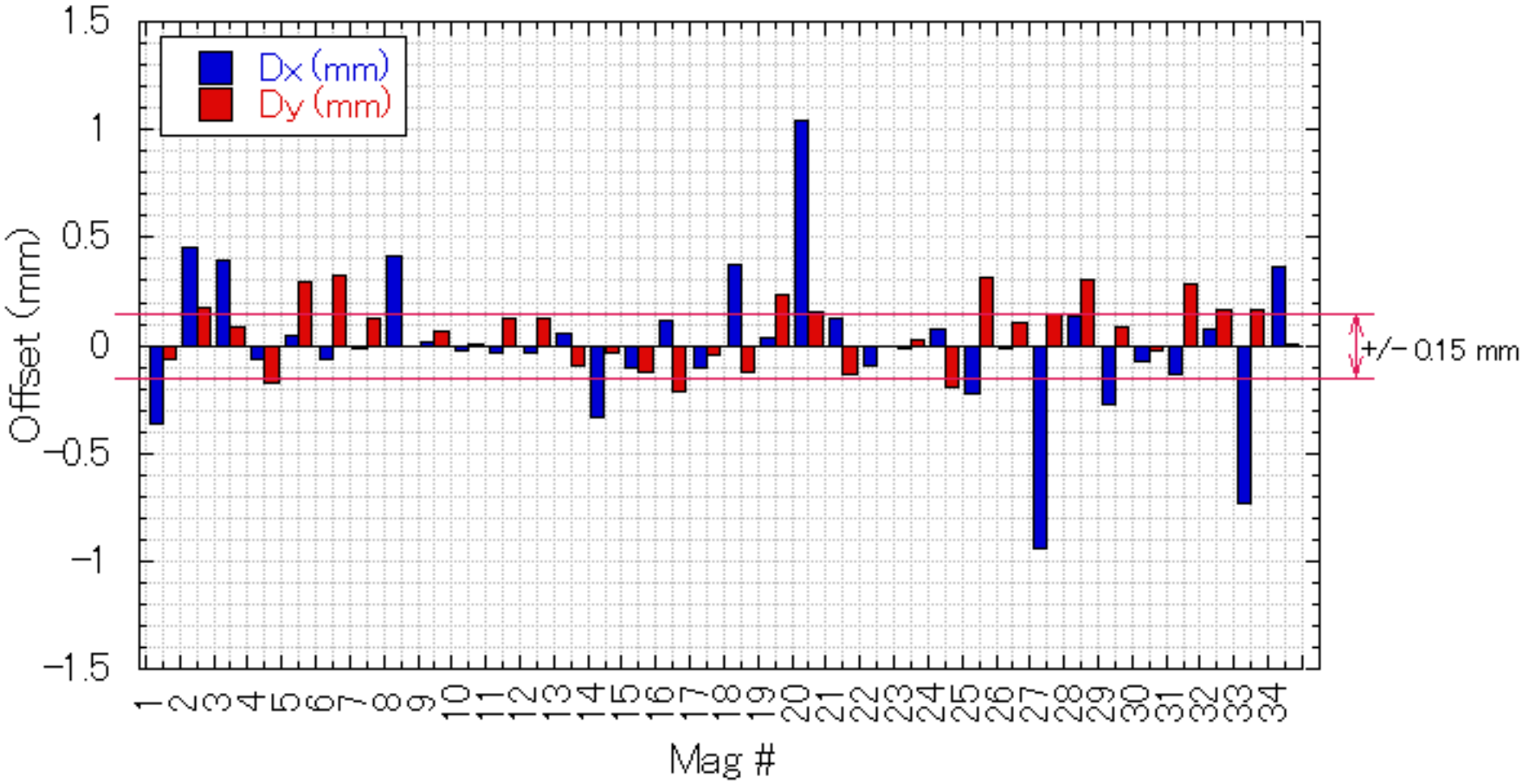


☆IHEP & KEK measurements agree at the level of what I have presented today.

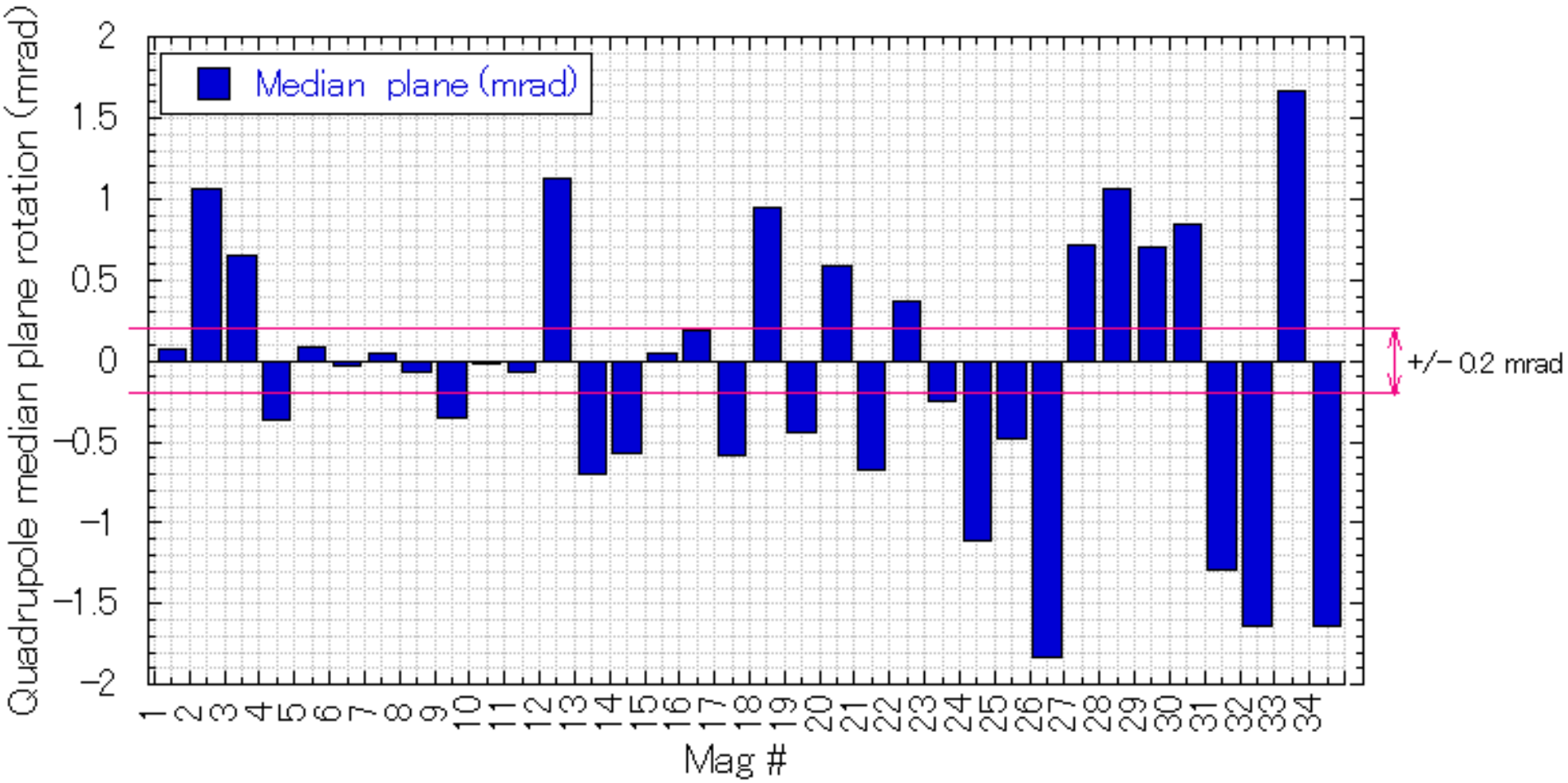
- Make sure that the definition of angles are the same as our measurements.

- When a decision to swap magnets is made, please remember that
  - Alignment needs to be done carefully to cancel the large offsets of the magnetic center and the large rotation of the quadrupole plane.
  - Excitation curve needs to be swapped, as the strength of the magnets vary quite a bit.
    - Some magnets were only ramped and measured up to 50A.
    - It is recommended to measure the magnets up to 150A but…

QEA magnet offsets (horizontal & vertical)



QEA magnet median plane



3. Comments on swapping magnets

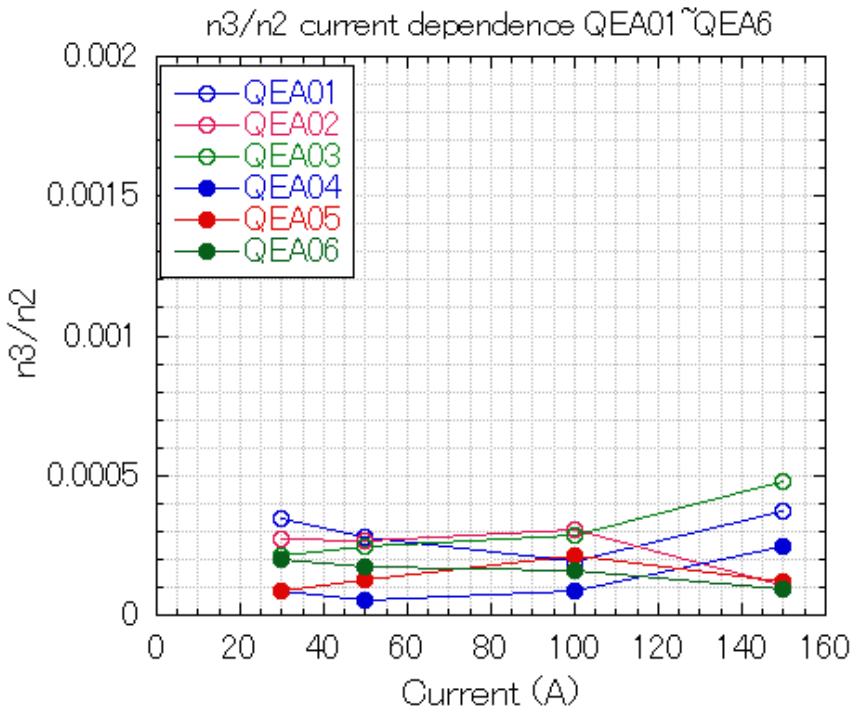
More things that you might want to pay attention to:

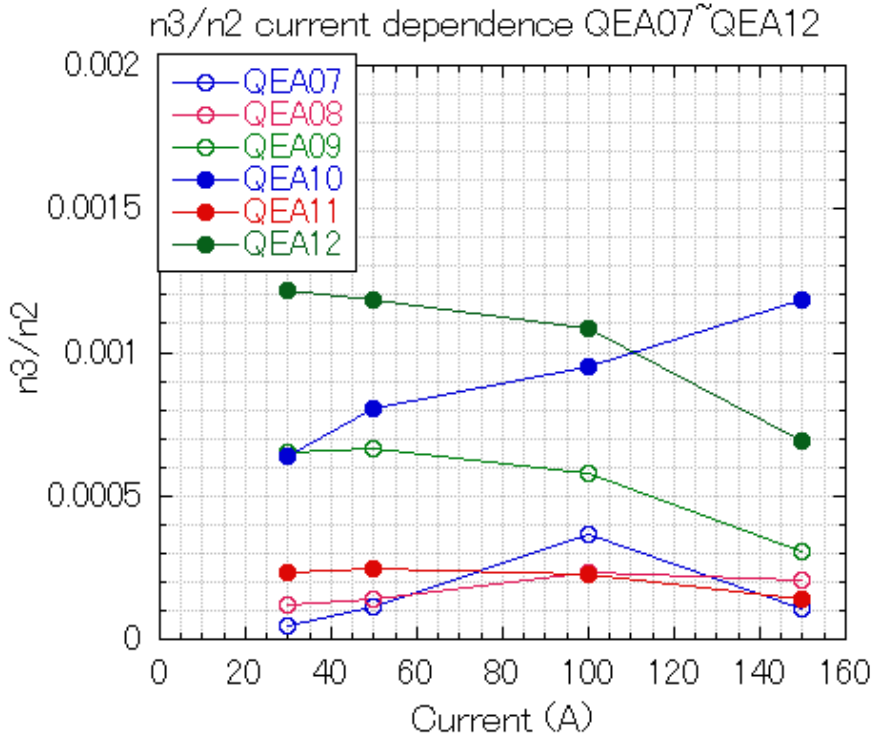
•n3/n2 current dependence data shown today are taken at the max. current, either 50A or 150A.

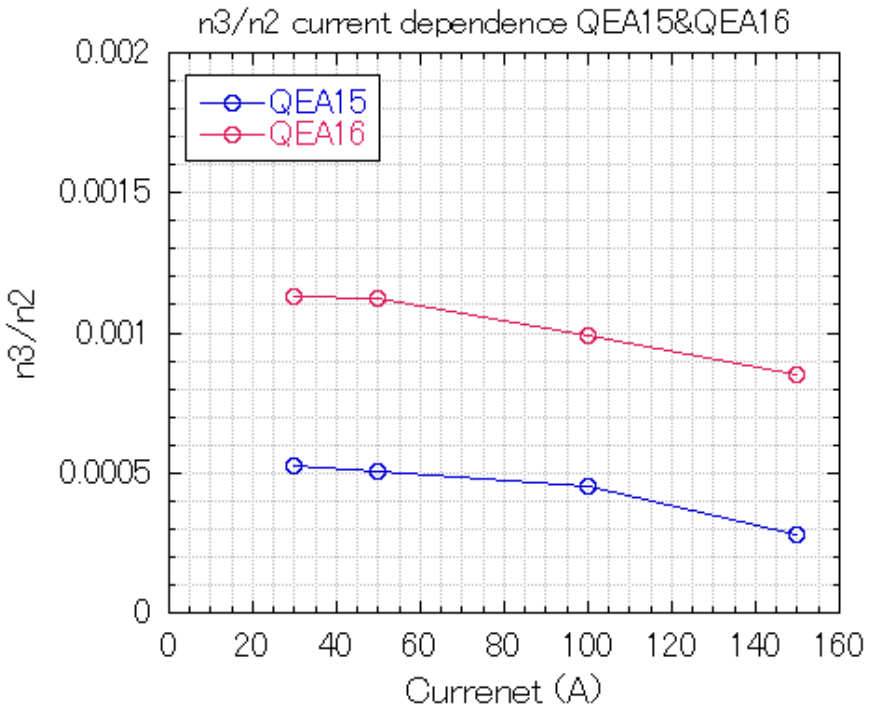
Is there a current dependence?
→Yes.
Will it get worse at higher currents?
→Yes and no.
→It depends on each magnet…

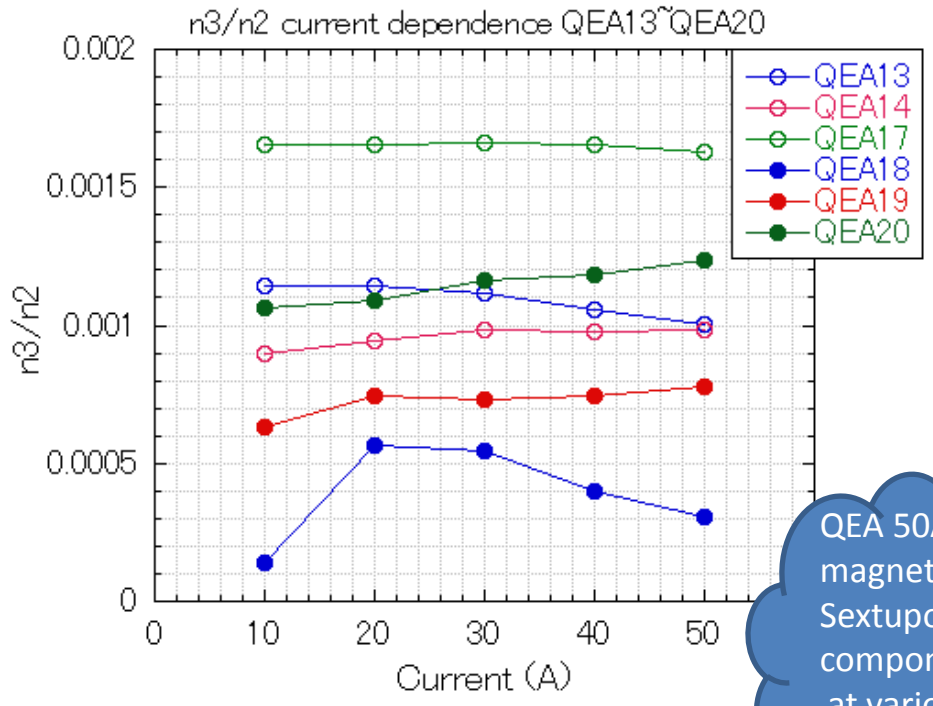
•Does n4/n2 need to be small for magnets at “critical” locations?

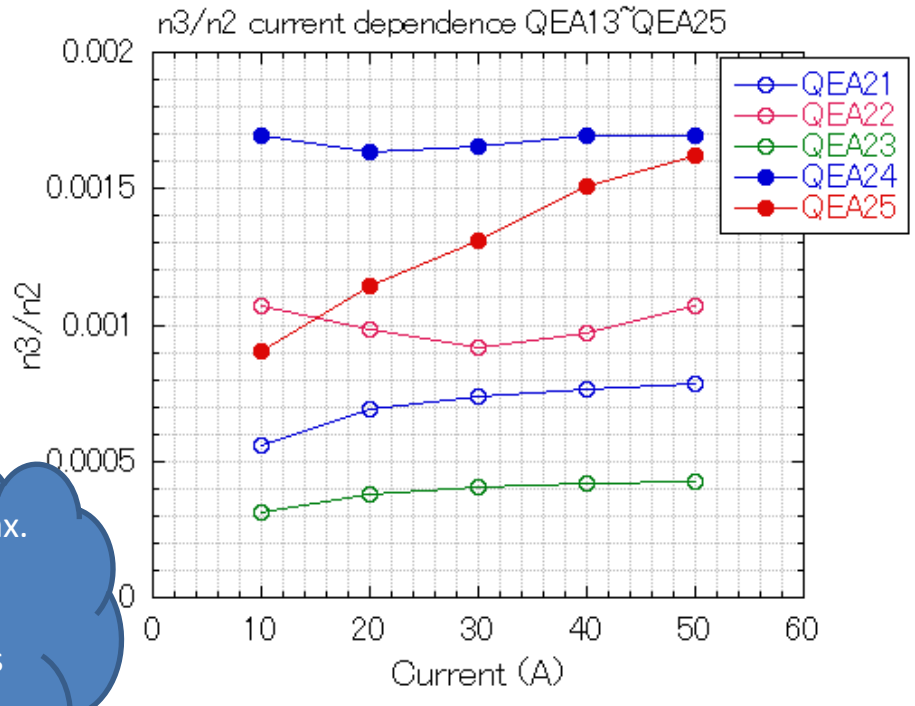
QEA 150A max.
magnets
Sextupole components
at various currents.



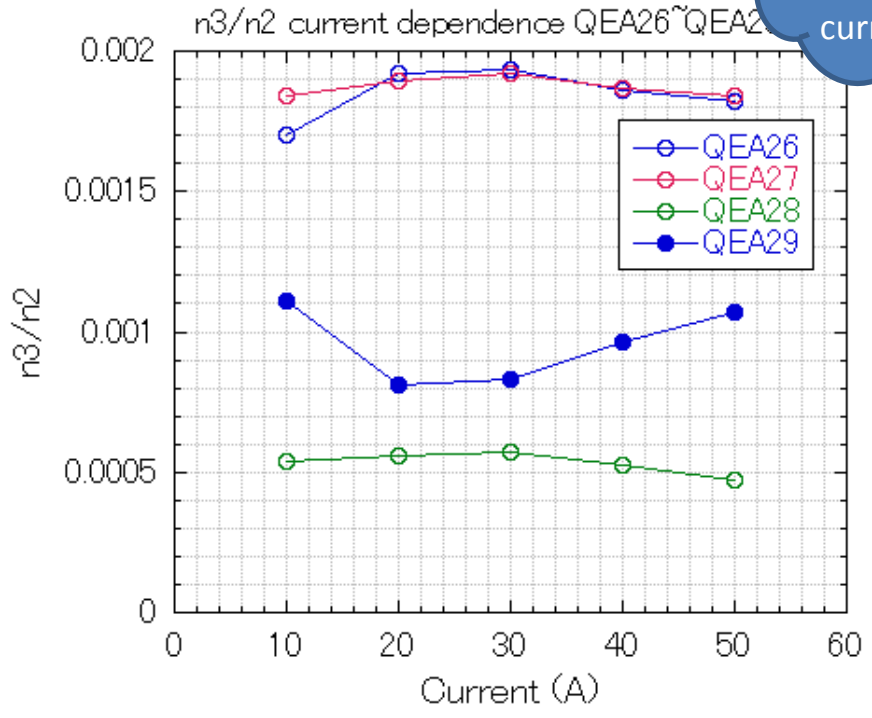


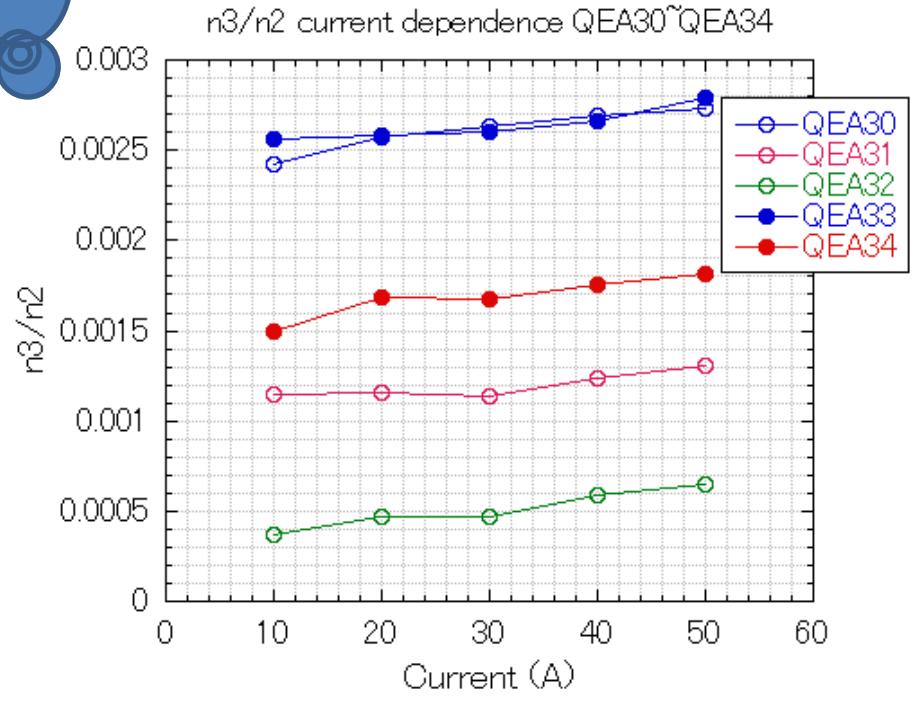




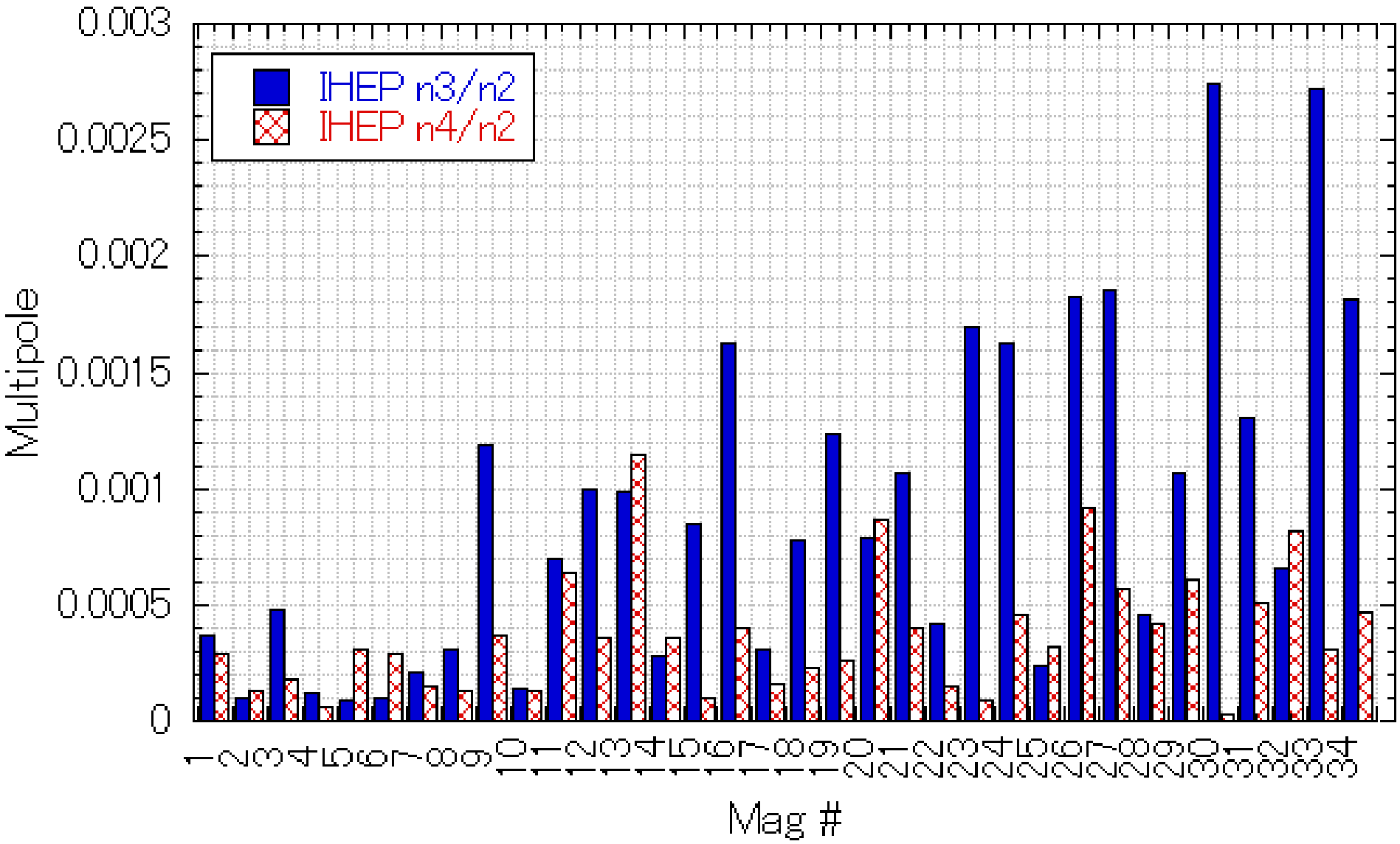


QEA 50A max. magnets Sextupole components at various currents.





Sextupole & octopole components plotted together vs Magnet#



4. Summary

Comparison between IHEP & KEK sextupole & octopole components :

☆IHEP & KEK measurements agree at the level of what I have presented today.

- Sextupole amplitude (Abs(n3/n2))
  Good correlation between IHEP & KEK
  KEK results are ~10 % smaller than IHEP, which probably comes from the error in calibrating the coil positions.
  At this point, I do not know which one is more correct.
- Normal sextupole components (QEA01-QEA25)→agree
- Skew sextupole components(QEA01-QEA25) →agree

4. Summary

☆Normal sextupole components (QEA26-QEA34)
do not agree well at all
☆Skew sextupole components(QEA26-QEA34)
do not agree well at all

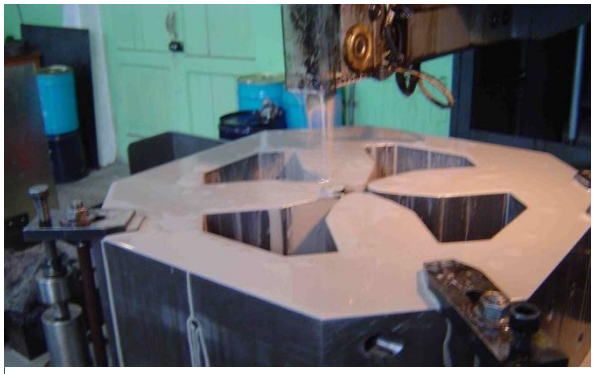
→FD swap or pick up coil connection swap could explain.

☆Octopole amplitude (Abs(n4/n2)) →agree

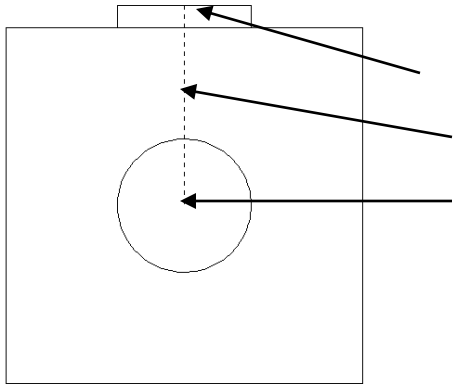
☆When swapping , pay attention to
sextupole phase in simulation
Alignment (horizontal and vertical offsets, roll)
Excitation curve
n4/n2, if this also matters

Spare

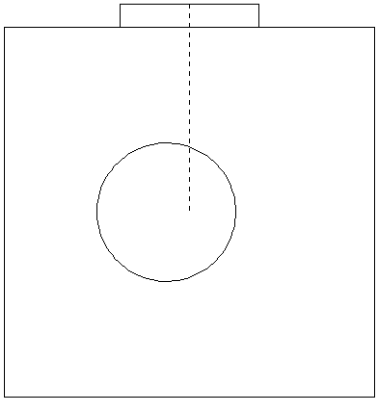
Problems with magnet & alignment base machining : 3 cases



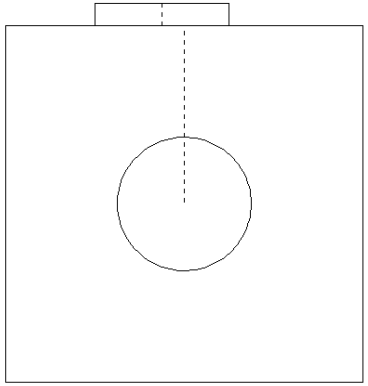
Problem with reference on EDM process??



Correct case
Alignment base center
Split line between the cores
Bore center
Must be aligned.

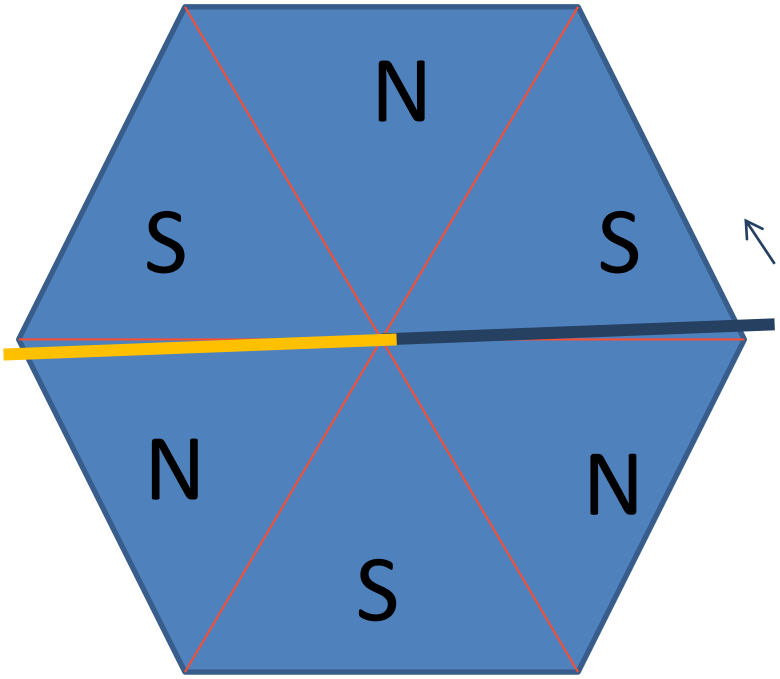


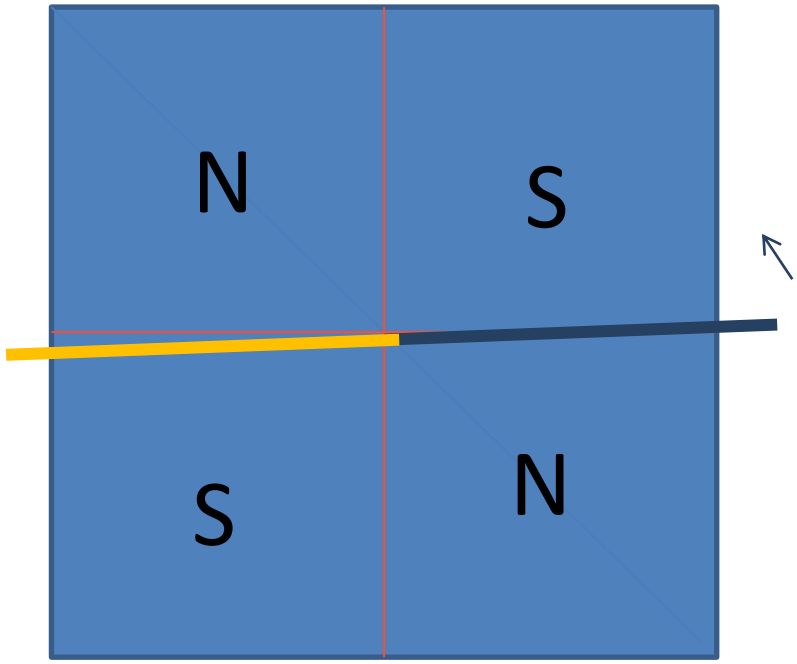
(1) Magnet bore is not aligned.
How could this happen??
EDM process???

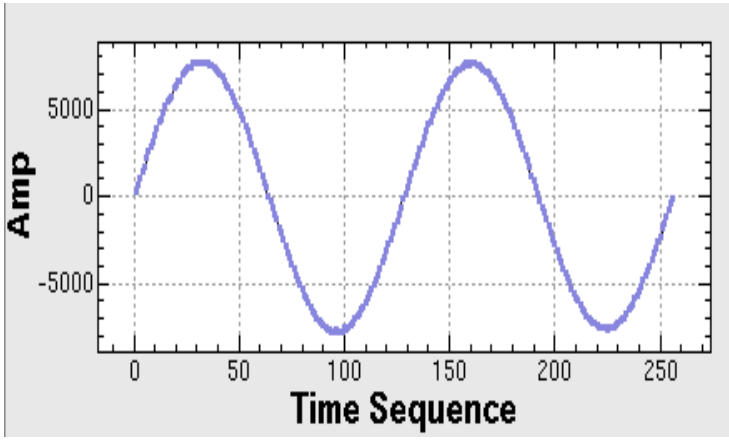


(2) Alignment base is not aligned.

(3) (1)&(2) mixed.


N
S
S
N
N
S


N
S
S
N


5000
0
-5000
Amp
0
50
100
150
200
250
Time Sequence