Multipoles effect for ATF2

Dou Wang (IHEP), Edu Marin (CERN), Philip Bambade (LAL),

Glen White, Mark Woodley (SLAC),

Kiyoshi Kubo, Shigeru Kuroda, Toshiyuki Okugi (KEK)

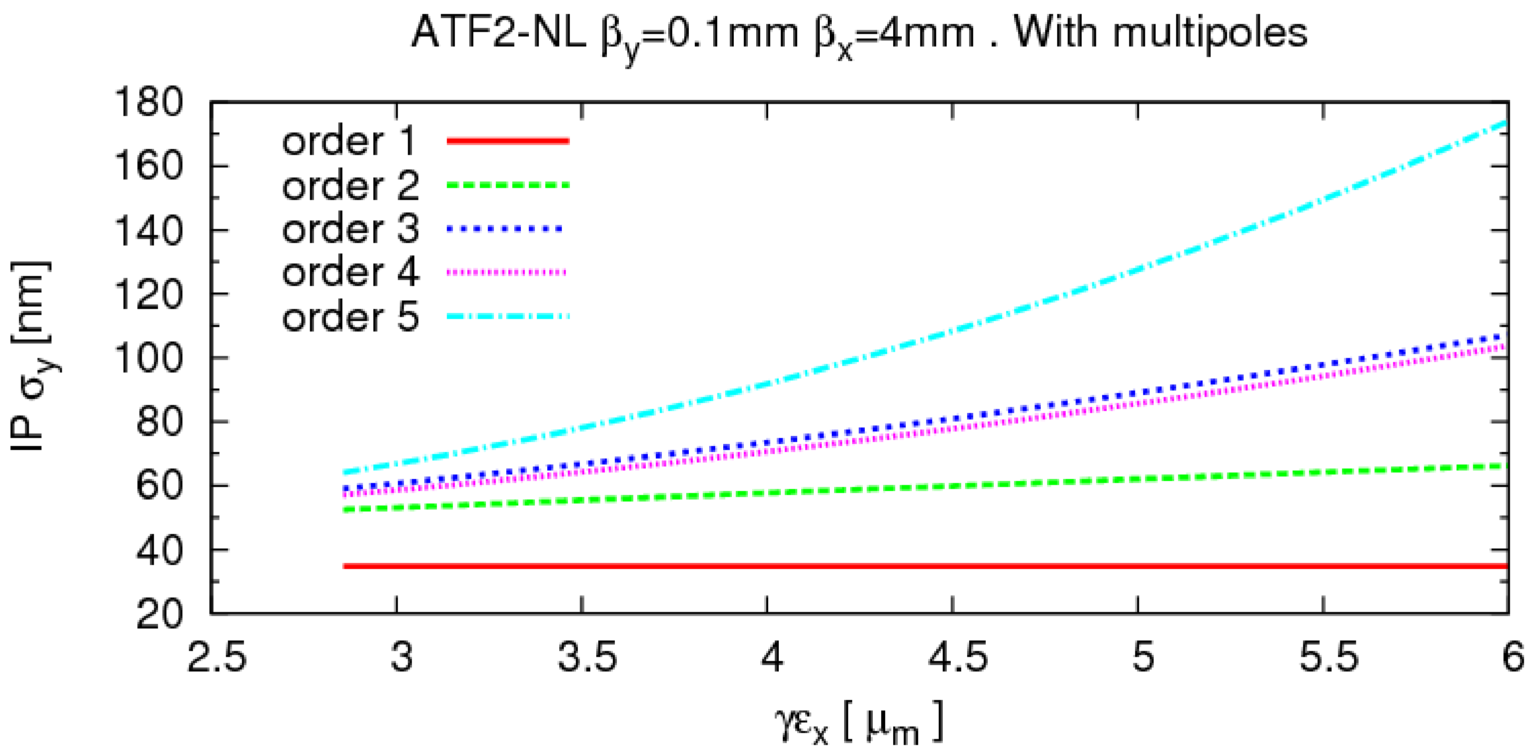
January 14, 2011

Multipoles effect on the ATF2 Nominal Lattice

ATF2 NL	MADX	SAD	Lucretia
RMS (nm)	175	278	220
Shintake (nm)	100		
Gauss Core (nm)	50	60	65

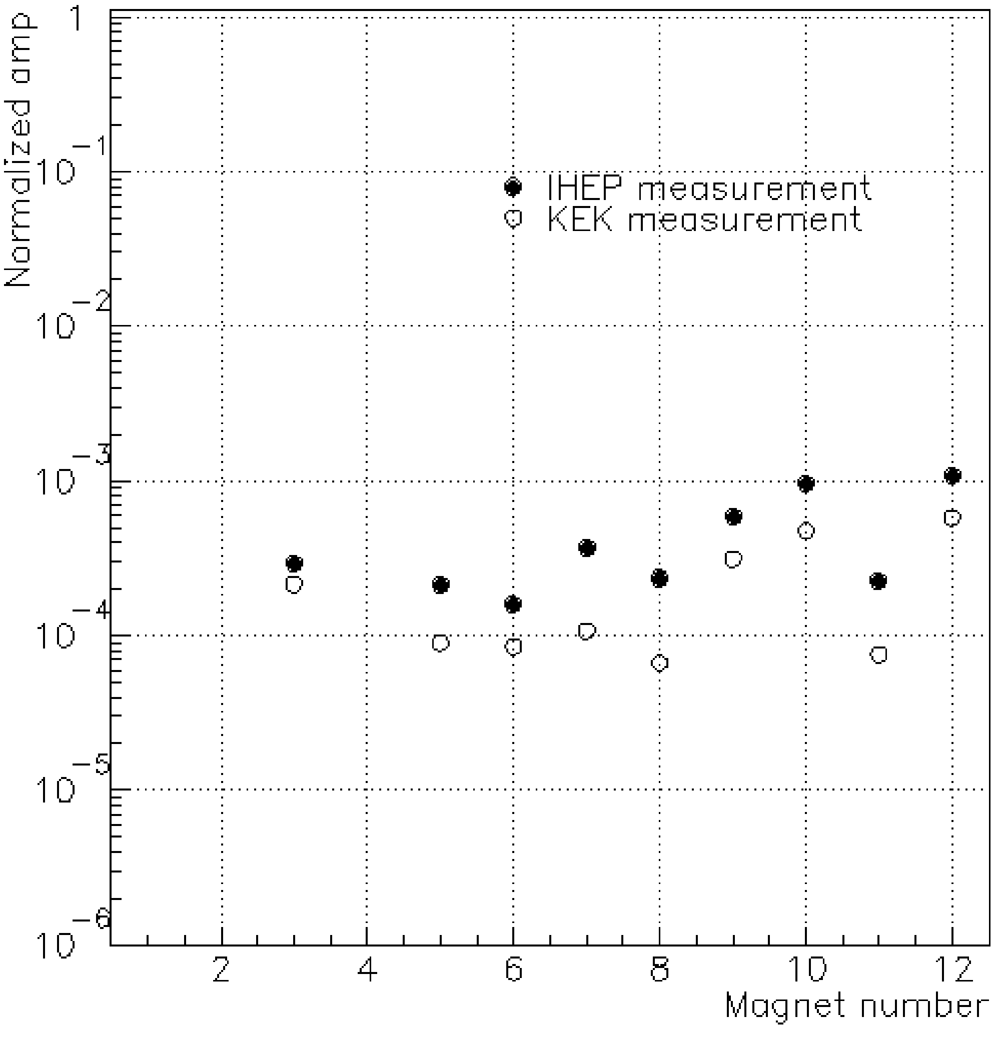
- The design RMS σ_y=36 nm
- Incorporate measured multipoles for all quads, dipoles and sextupoles into ATF2 simulation.
- The obtained beam size is much larger than the ideal one.

Order by order analysis for the Nominal Lattice



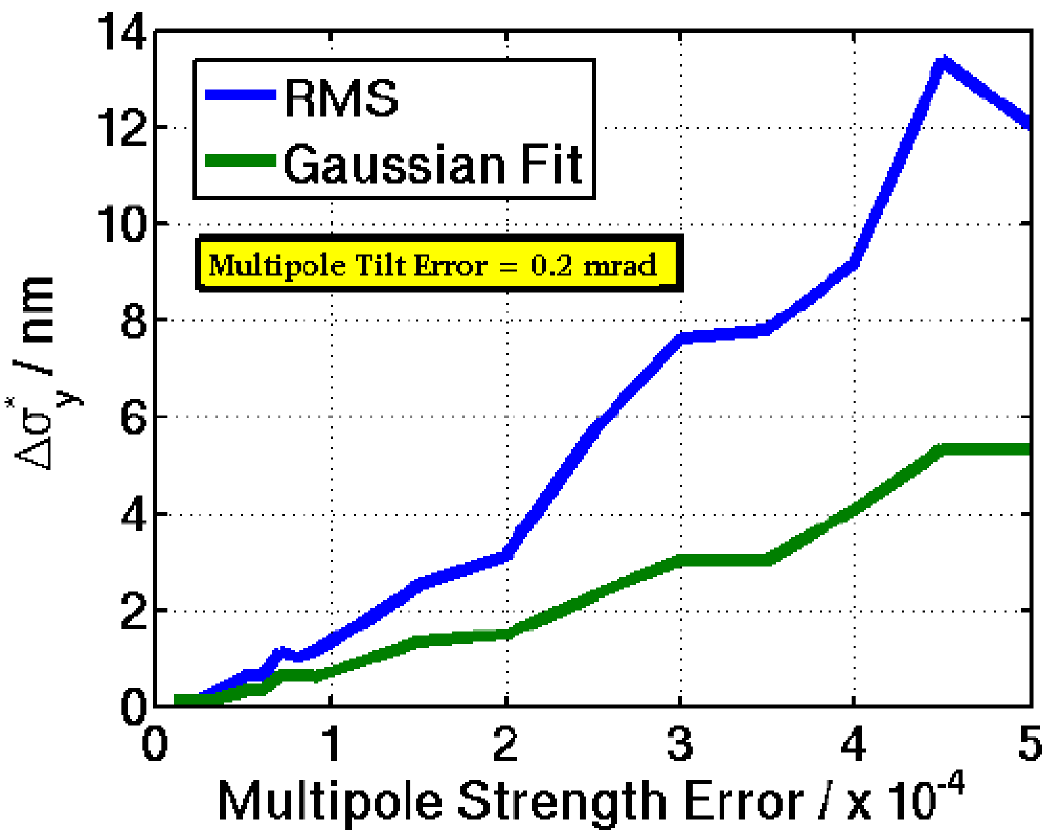
• The sextupole, octupole and dodecapole components are the main reason for the increment of σy (espetially the contributions from the skew components).

Multiupole Measurement Errors



Multipole Measurement Tolerances

- RMS error of Bn/B2: 0.1～ 5*10-4
- Assume 0.2 mrad angle error
- Errors to all multipole components for all measured magnets were set.
- Use 100 seeds of error



From Glen

Possible cures for the beam size growth

- Lattice modification (Expedient)

  - increase the IP betaX will mitigate the impact from higher order skew components

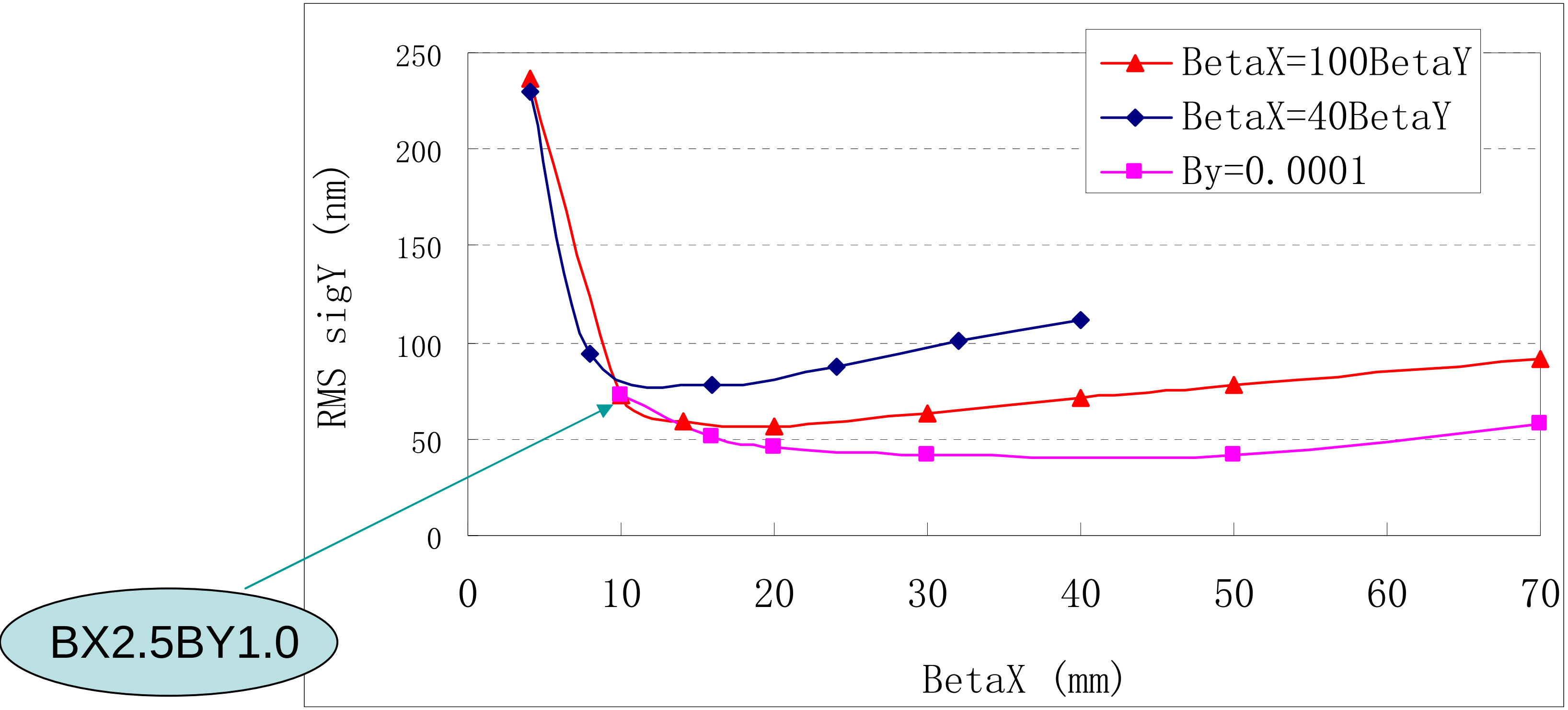
- Sextupole rotation

  - sextupoles rotations can compensate the skew sextupole component

- Add a skew sextupole

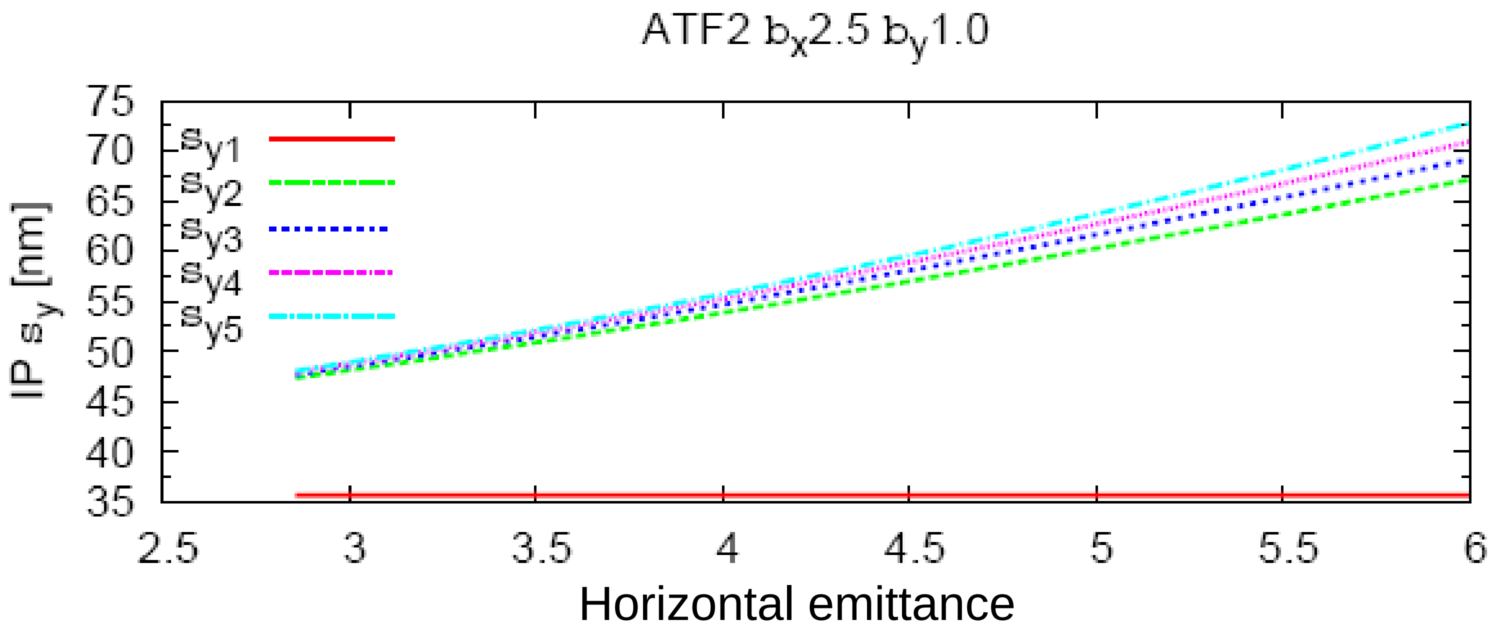
- Swap some magnets

betaX* optimization



- When betaX*>1 cm, the effect of multpoles become weaker.
- A new lattice has be designed using MADX and MAPCLASS, namely BX2.5BY1.0.

Order by order analysis for the new BX2.5BY1.0



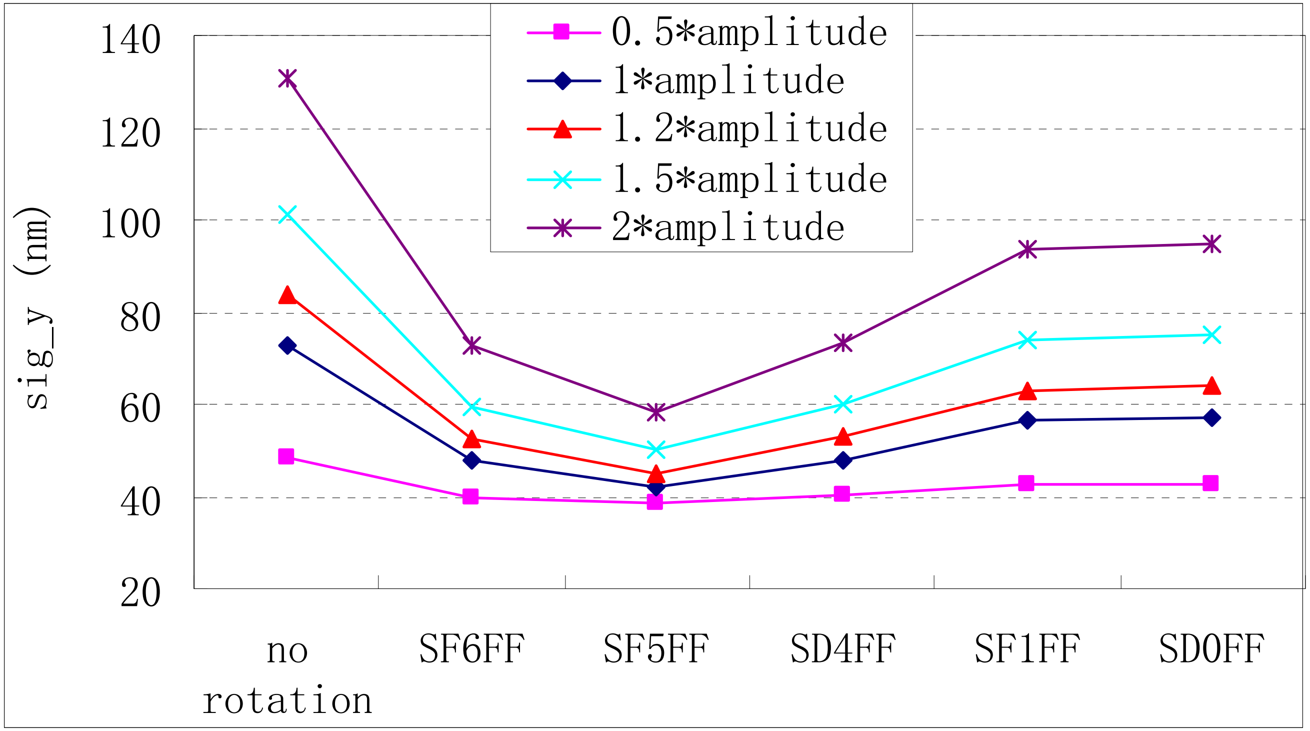
• still the skew sextupole component is present.

Sextupole rotation for the BX2.5BY1.0 Lattice

ATF2 BX2.5BY1.0	Rotation (mrad)		RMS σy (nm)	
	MADX	SAD	MADX	SAD
SF6FF	9.0	9.0	48.7	48.0
SF5FF	21.0	20.0	43.4	42.3
SD4FF	-8.0	-7.6	48.7	48.0
SF1FF	-4.0	-4.0	57.0	56.5
SD0FF	3.0	2.8	57.6	57.2

- Good consistency with MADX and SAD.
- Large rotation required by SF5FF (≈20 mrad). Mechanical alignment is needed.
- If the multipole measurements were not accurate, the optimized sextupole rotation will not work.

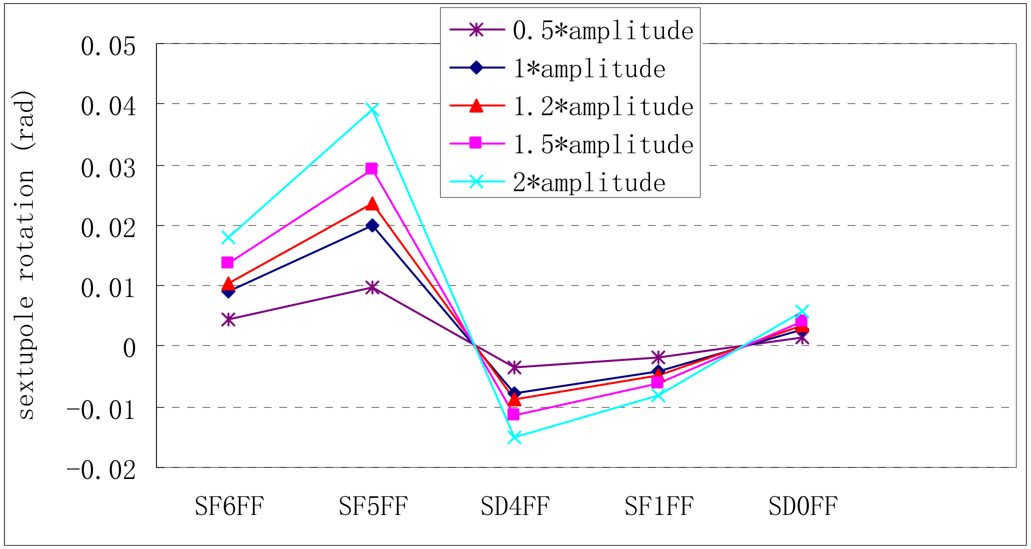
Scale up the multipole amplitude

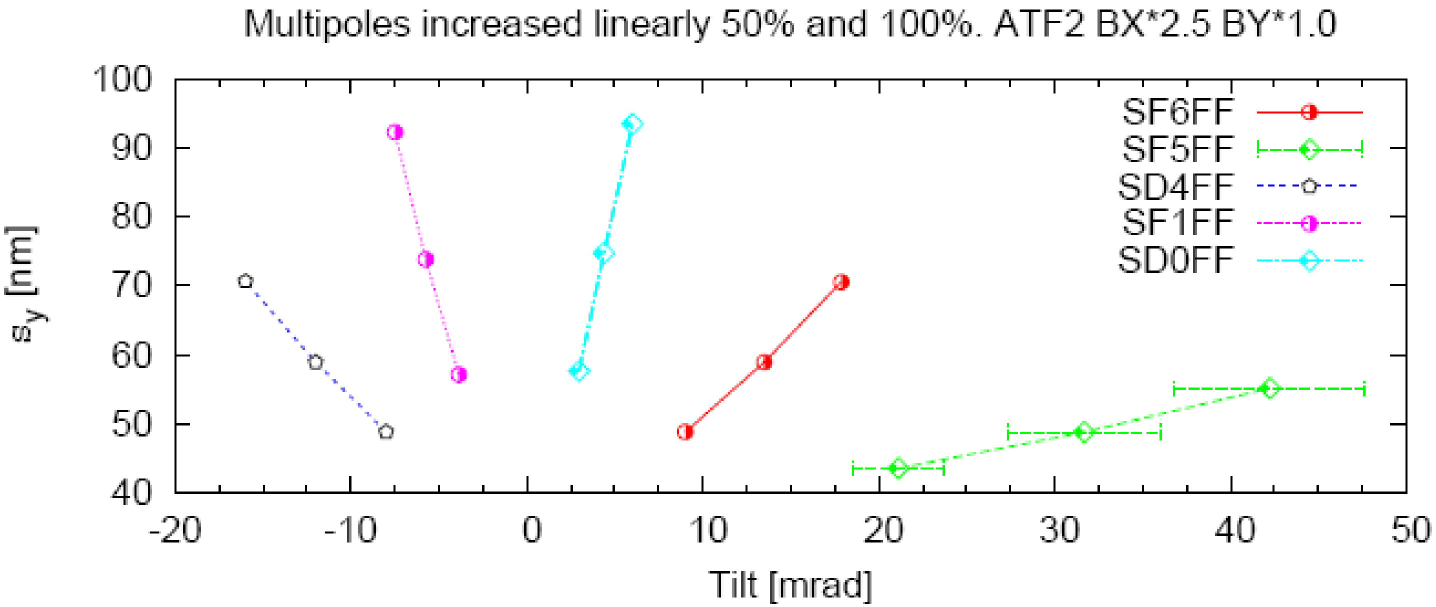


- SF5FF is always the best one!

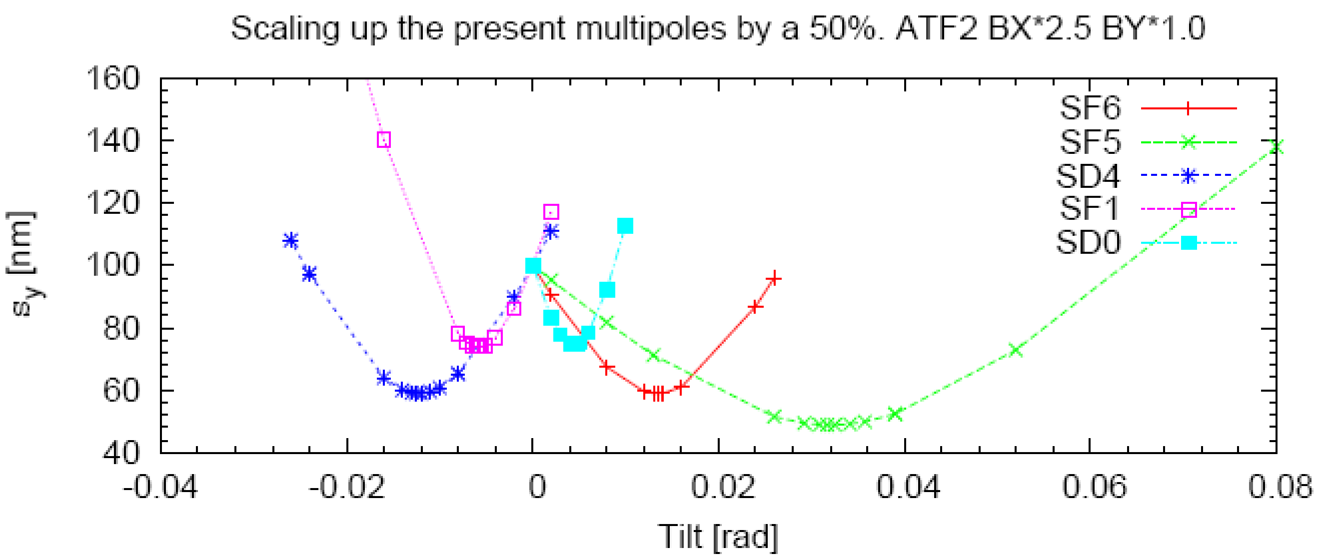
Sextupole rotations for systematic multipole measurement error

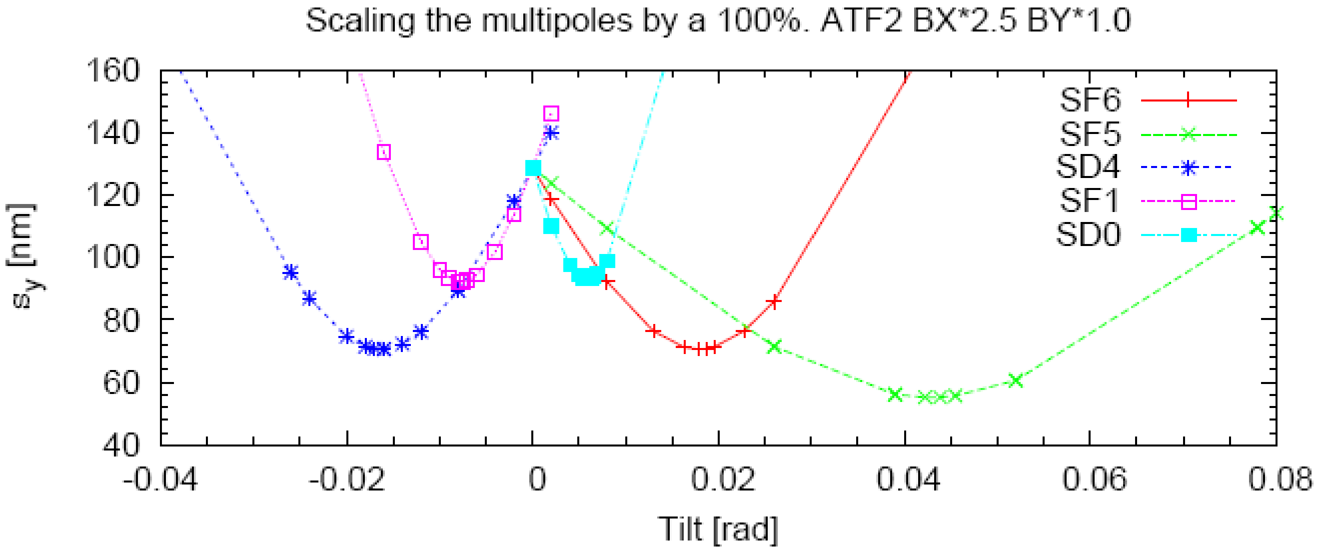
SF5FF rotation: 10～40 mrad



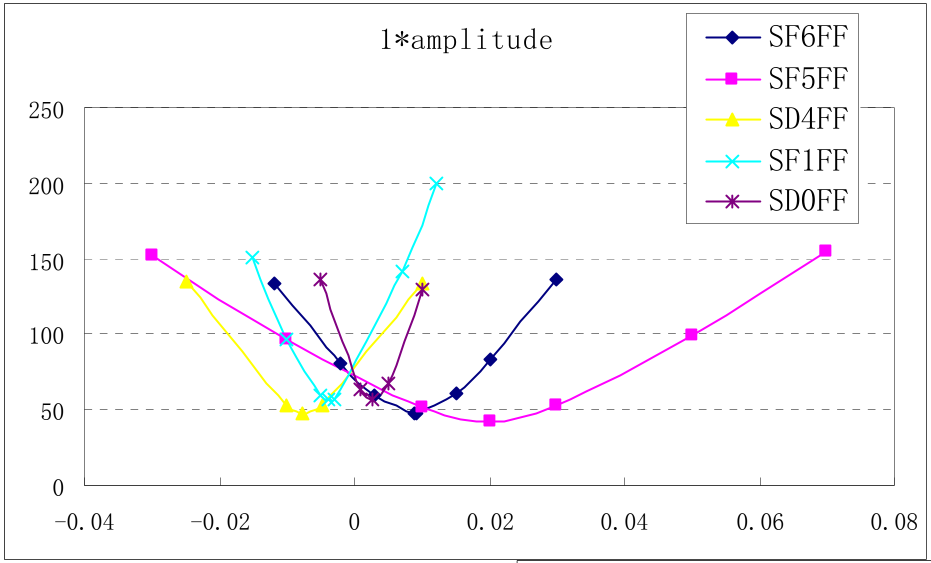


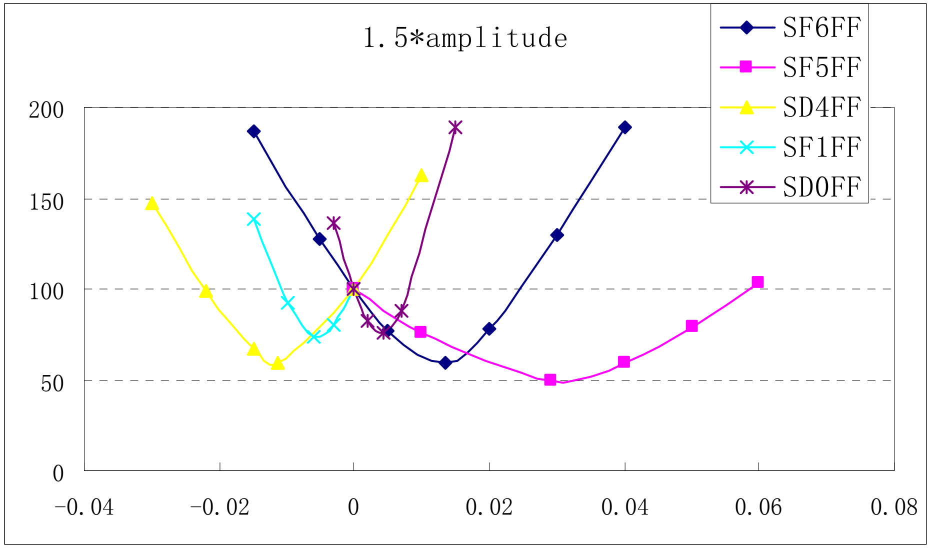
Sensitivity of the sextupole rotation -MADX

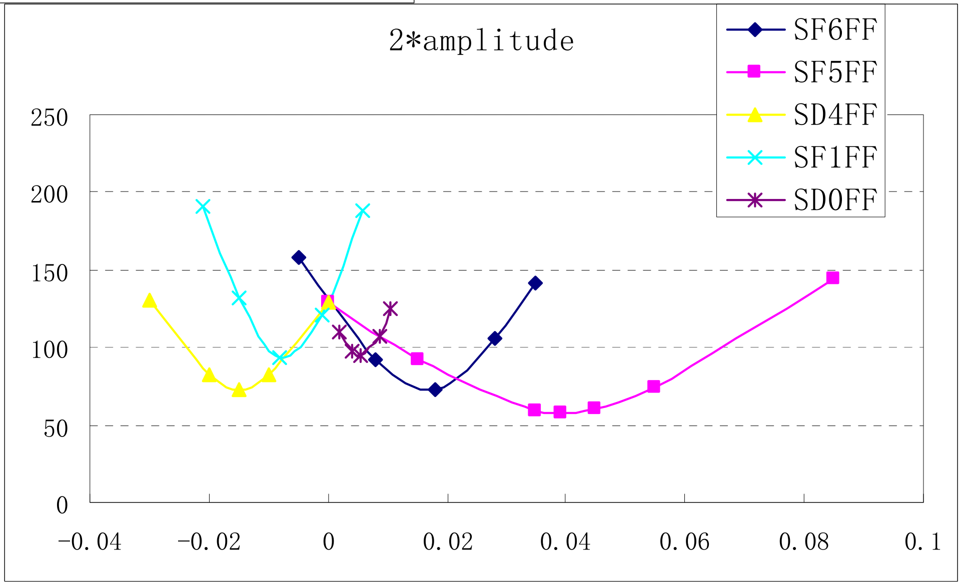




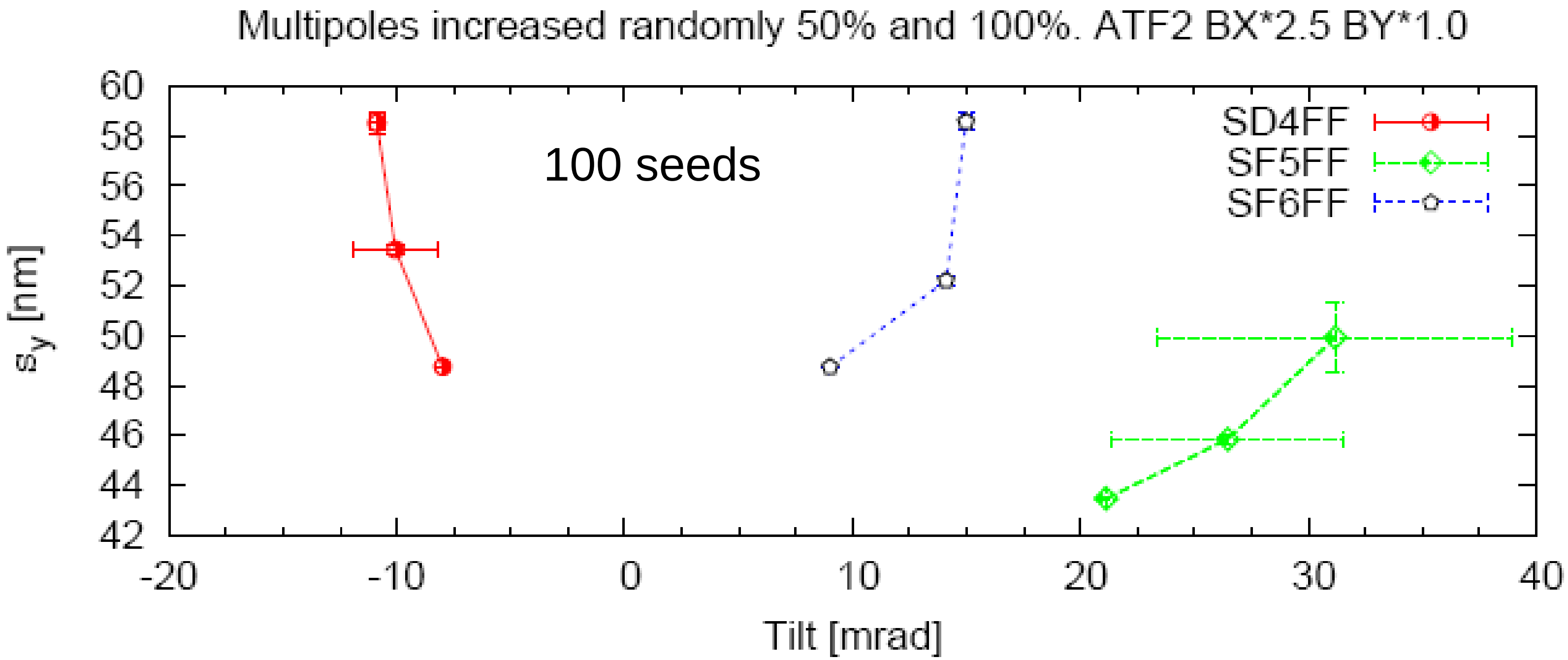
Sensitivity of the sextupole rotation -SAD







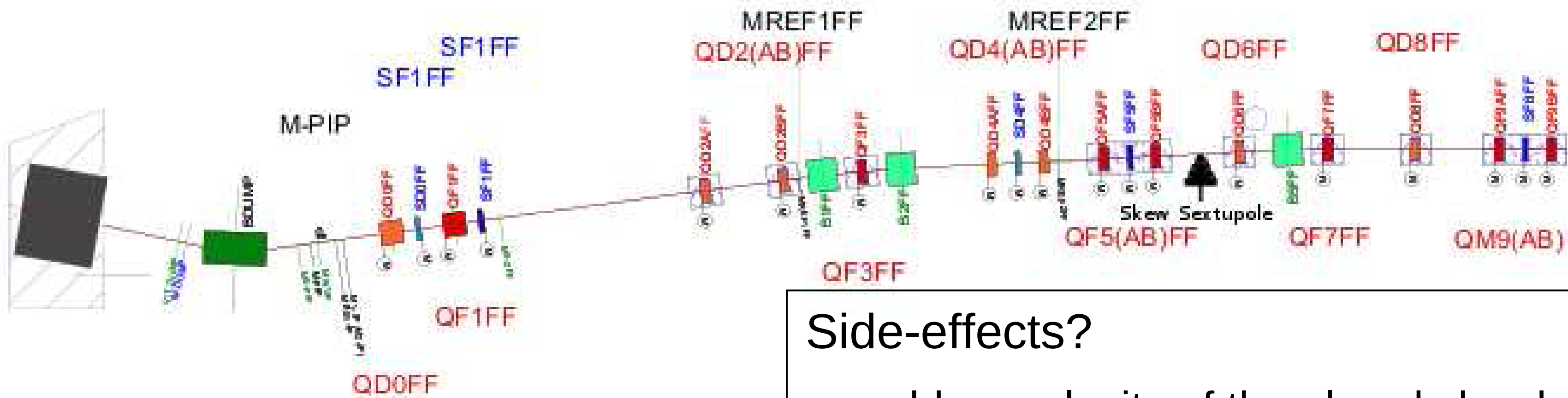
Sextupole rotations for random multipole measurement error



SF5FF rotation: 20～32 mrad

Insertion and Optimization of a Skew Sextupole

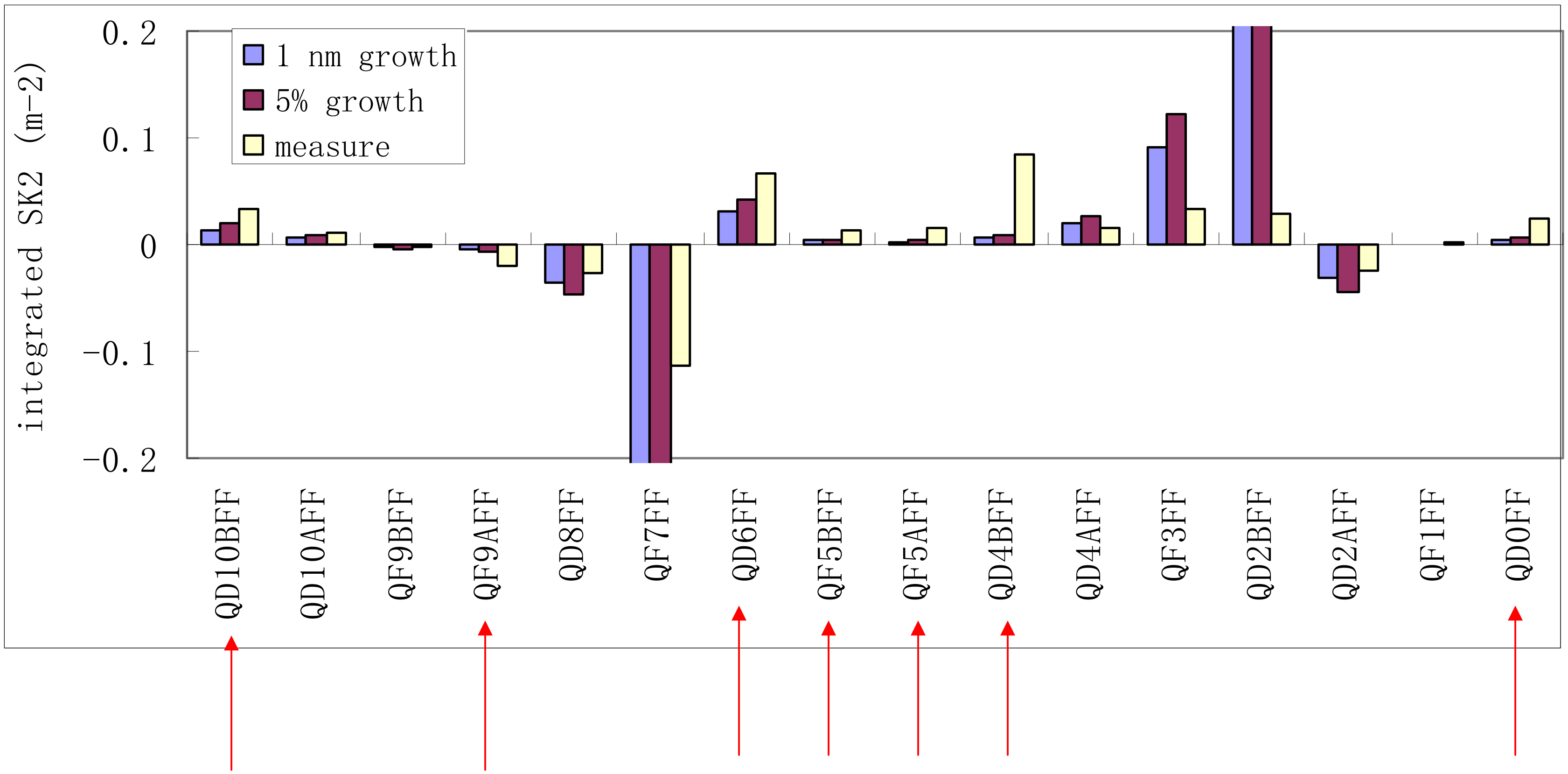
- Edu studied the possibility of adding a Skew Sextupole.
- Location : between QD6FF and QF5BFF
- σy=43.5 nm after optimization of the skew sextupole strength



Side-effects?

- add complexity of the already hard tuning procedure
- required good BBA
- linear coupling
- …

Comparison of skew sextupole measurements and sensitivities for FFS quadrupoles

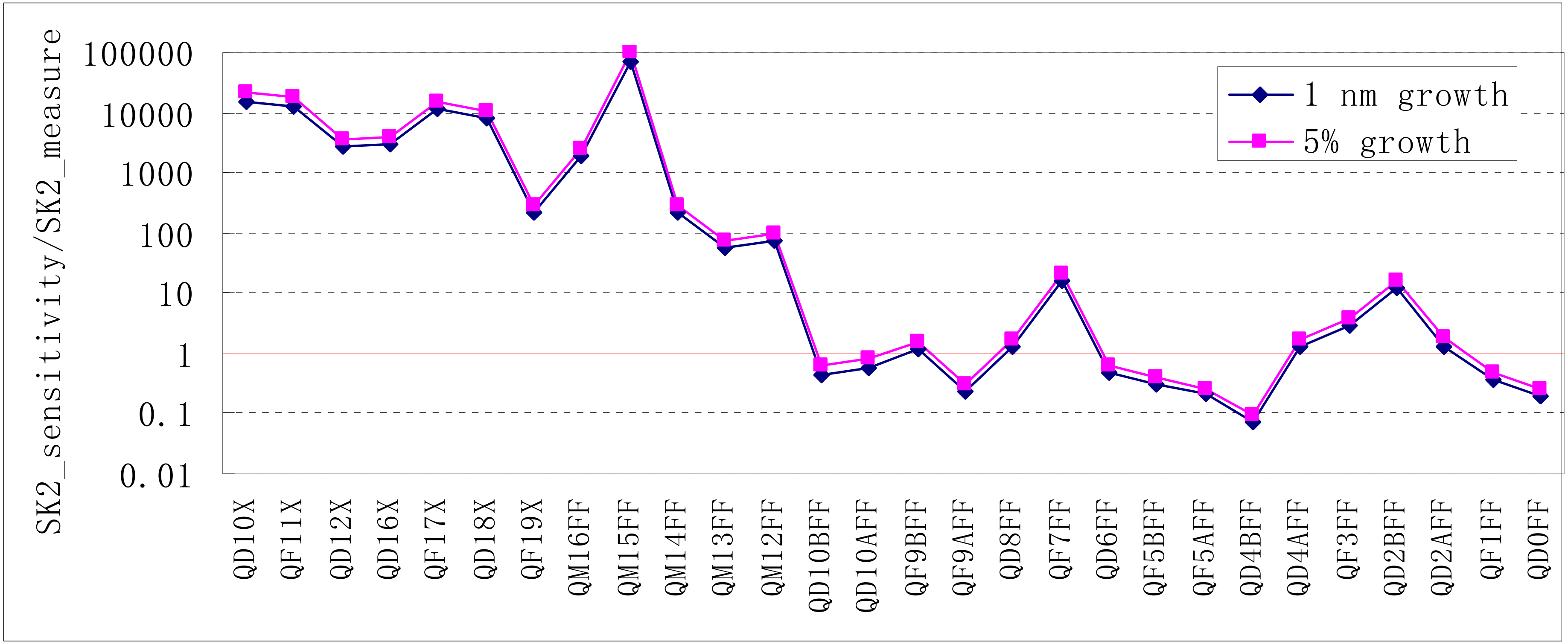


This suggest how the swapping should be made.

skew sextupole tolerance compared to the measurement for the quadrupoles

Best quadrupoles: QM15FF, QD10X, QF11X, QF17X, QD18X, …

Worst quadrupoles:QD4BFF, QD0FF, QF5AFF, QF9AFF, QF5BFF, …



How to get the multipole angle from IHEP measurements?

- Three possible calculations

  (1) take the angle directly as listed for each multipole

  (2) subtract the angle in the first line for the main quadrupole (n=2)

  (3) subtract the angle in the second line for main quadrupole (n=2)

- The angle reference for all the multipoles in IHEP measurements was the start position of the rotating coil and all the measurements assumed the magnetic center plane and the mechanical center plane are at the same position.

- Using (2), we can get the multipole angle relative to the main component. The formula should be **ANG[n]/n-ANG[2]/2** (Mark used ANG[n]-ANG[2]??). But we can't know the absolute multipole angle relative to mechanical center.

- The angles for high order multipoles have included the correction of bucking coils. So (3) is not needed.

summary

- The measured multipole fields for all quads, bends and sextupoles were included in our simulations. The vertical beam size will increase from 36 nm to about 220 nm(RMS)/60 nm(Gauss fit).
- Possible cures:

  -increase IP σx (expedient)

  -rotate sextupoles (complex mechanical alignment)

  -add a skew sextupole (harder tuning procedure, good BBA, linear coupling, …?)

  -swap some quadrupoles

- Precise cures rely on precise multpoles magnitude and angle.
- The angle reference for all the IHEP measurements is the start position of rotating coil. It seems that method (2) is the best one. (assesment for the difference of ANG[n]/n-ANG[2]/2 and ANG[n]-ANG[2]?)