ATF2 Alternative lattices.

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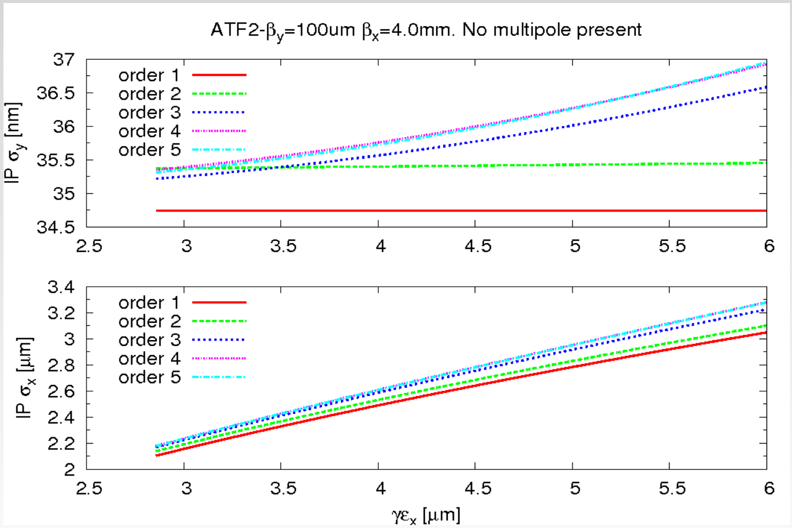
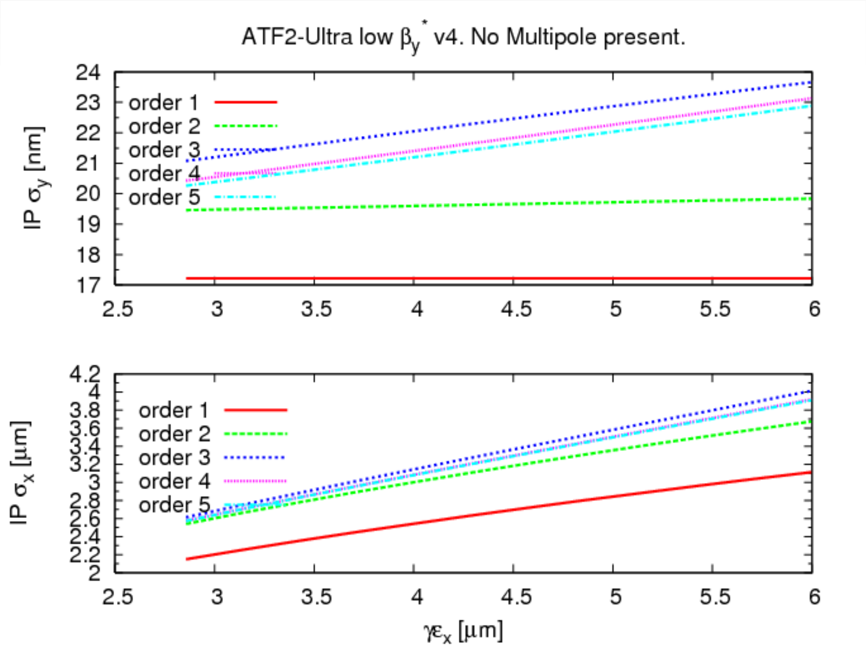
PLAN OF THE TALK

1. The ATF2 Nominal and Ultra-Low β^* Lattice.
2. Multipoles effect
3. Possible Solutions
    1. Alternative lattices
4. Squeeze sequence
5. Feasibility of the ATF2 Ultra-Low β_y^* Lattice.
    1. Beam Size and powering along the beam line.
    2. Tuning the ATF2 Ultra-Low β_y^* Lattice.
        1. Knobs for the ATF2 Intermediate lattice.
        2. Tuning results.
6. Swapping the magnets
7. Quad shunting technique
8. Conclusions and Future Plans.

1. ATF2 LATTICES





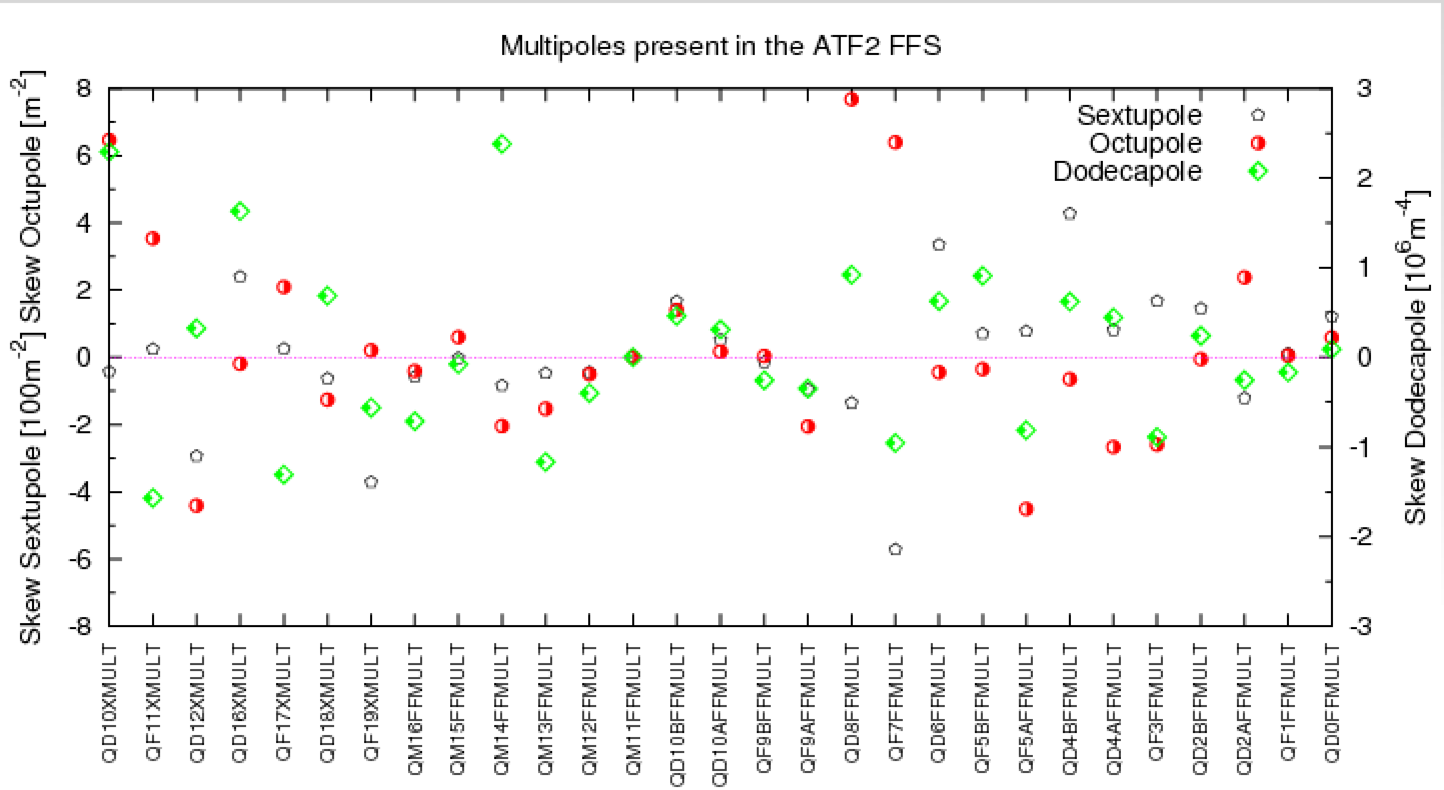
ATF2 Nominal Lattice

σ_x= 3.2 µm
σ_y= 37.0 nm (rms)
σ_y= 35.0 nm (core)
β_x= 3.9 mm
β_y= 0.1 mm
η_x= -2.8 µm

ATF2 Ultra-low β* Lattice

σ_x= 3.8 µm
σ_y= 22.9 nm (rms)
σ_y= 18.9 nm (core)
β_x= 4.0 mm
β_y= 25.1 µm
η_x= 0.01 µm

Project	L* [m]	β_y^* [µm]	ξ_y
ATF2 Nominal	1.0	100	~19000
ILC Desgin	3.5	400	~15000
ATF2 Ultra-low	1	25	~76000
CLIC 3 TeV	3.5	90	~63000


Multipoles present in the ATF2 FFS
Skew Sextupole [100m^-2] Skew Octupole [m^-2]
Skew Dodecapole [10^6 m^-4]
Sextupole
Octupole
Dodecapole
8
6
4
2
0
-2
-4
-6
-8
3
2
1
0
-1
-2
-3
QD10XMULT
QF11XMULT
QD12XMULT
QD16XMULT
QF17XMULT
QD18XMULT
QF19XMULT
QM16FFMULT
QM15FFMULT
QM14FFMULT
QM13FFMULT
QM12FFMULT
QM11FFMULT
QD10BFFMULT
QD10AFFMULT
QF9BFFMULT
QF9AFFMULT
QD8FFMULT
QF7FFMULT
QD6FFMULT
QF5BFFMULT
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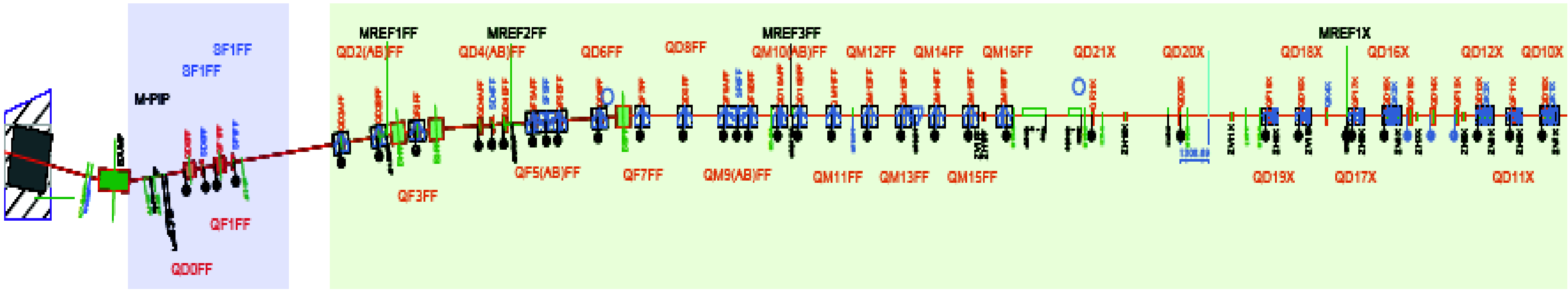
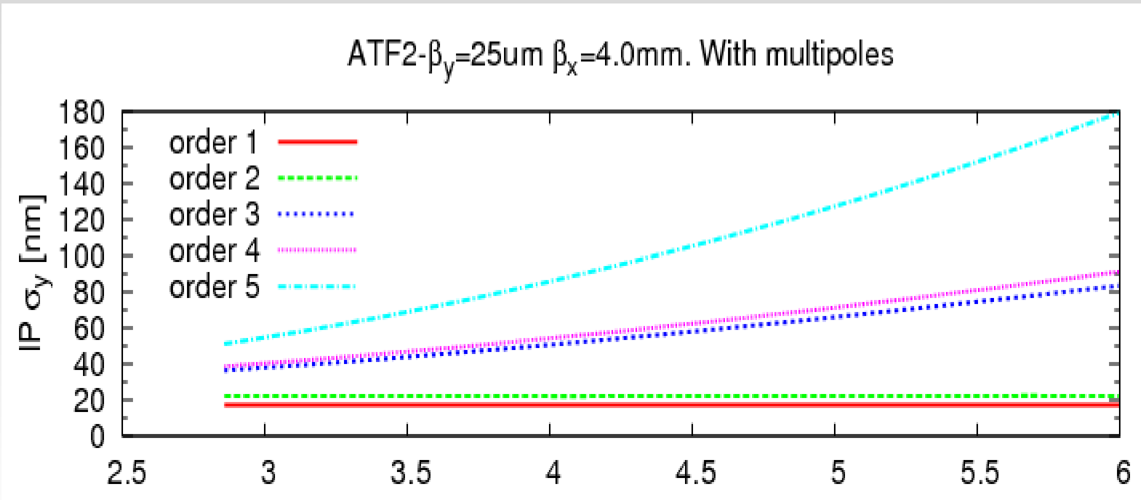
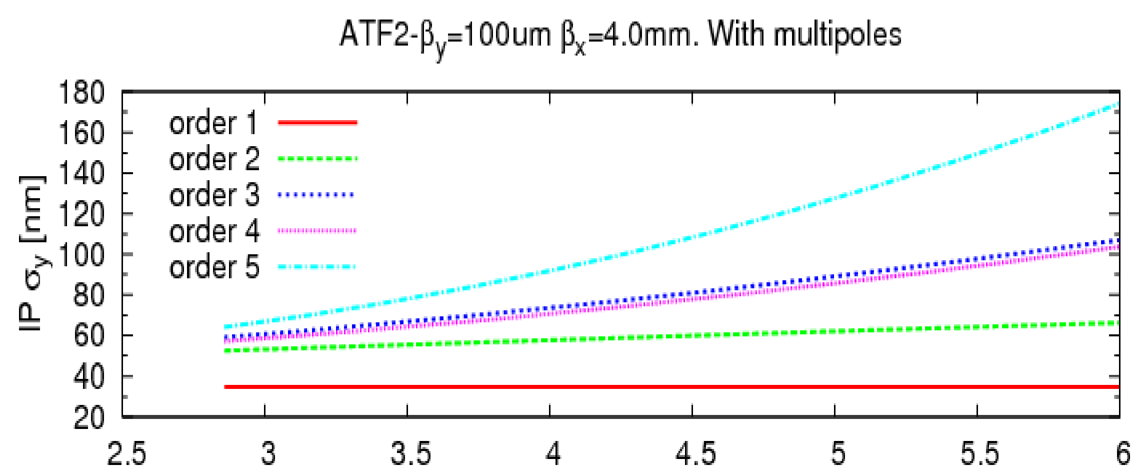
QD2AFFMULT
QF1FFMULT
QD0FFMULT


MREF1FF
MREF2FF
MREF3FF
MREF1X
QD2(AB)FF
QD4(AB)FF
QD6FF
QD8FF
QM10(AB)FF
QM12FF
QM14FF
QM16FF
QD21X
QD20X
QD18X
QD16X
QD12X
QD10X
M-PIP
QF3FF
QF5(AB)FF
QF7FF
QM9(AB)FF
QM11FF
QM13FF
QM15FF
QD19X
QD17X
QD11X
QF1FF
QD0FF

2.2. MULTIPOLES EFFECT





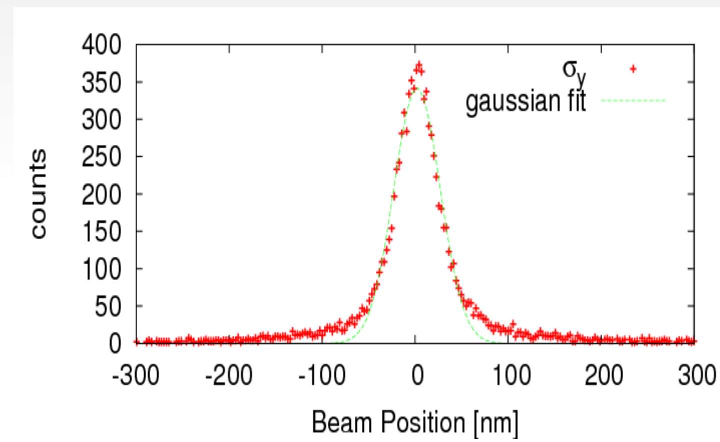
ATF2 Ultra-low β* Lattice

σ_x= 3.9 μm

σ_y= 180 nm (rms)

σ_y= 100 nm (shintake)

σ_y= 38 nm (core)



ATF2 Nominal Lattice

σ_x= 5.5 μm

σ_y= 174 nm (rms)

σ_y= 102 nm (Shintake)

σ_y= 51 nm (core)

3. POSSIBLE SOLUTIONS

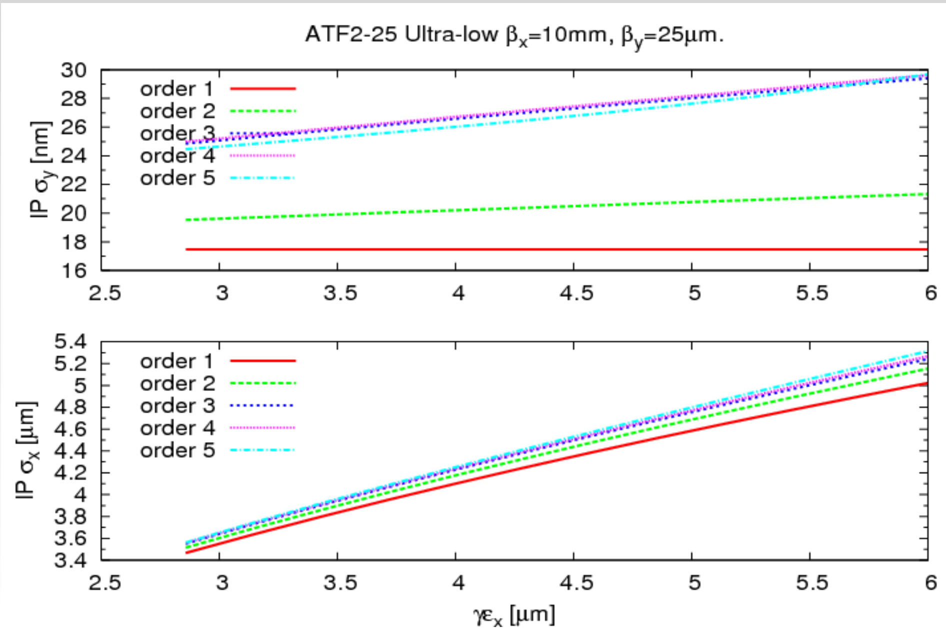
The possible cures in order to accommodate the existing multipoles could be:

- Decrease β_x at QF1FF (designing a new lattice by strengths and sextupole tilts)
- Run the machine at lower horizontal emittance
- Replace the Normal conducting QF1 by a Super conducting magnet (*)
- Swap the magnets

(*) not covered in this talk. For further details refer to the following presentation:

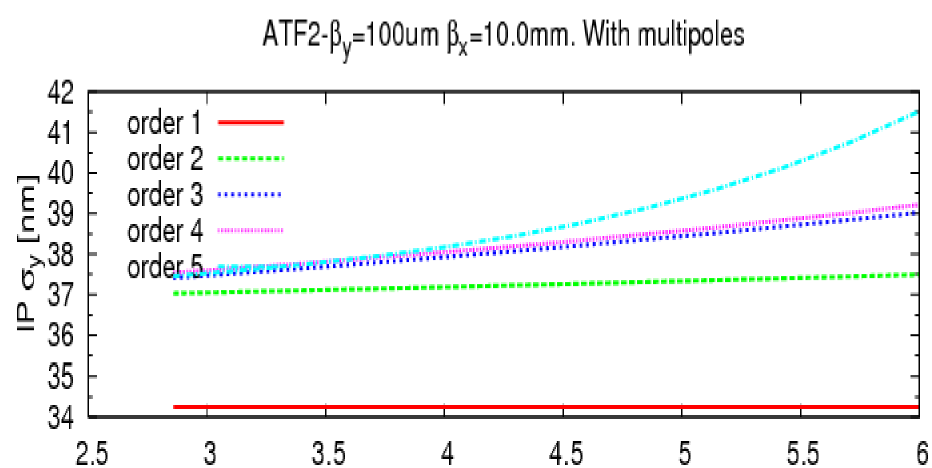
Impact on the beam size using a SC QF1 on the ATF2 Ultra-low β* lattice , during the ATF2 SC meeting in October 2009.

3.1 ALTERNATIVE LATTICES: DECREASE β_x at QF1



ATF2 Ultra-low Lattice

σ_x = 5.3 µm
σ_y = 29.0 nm
β_x = 10 mm
β_y = 25 µm



ATF2 Nominal Lattice

σ_x = 5.3 µm	σ_x = 4.5 µm
σ_y = 41.5 nm	σ_y = 41.7 nm
β_x = 10 mm	β_x = 8 mm

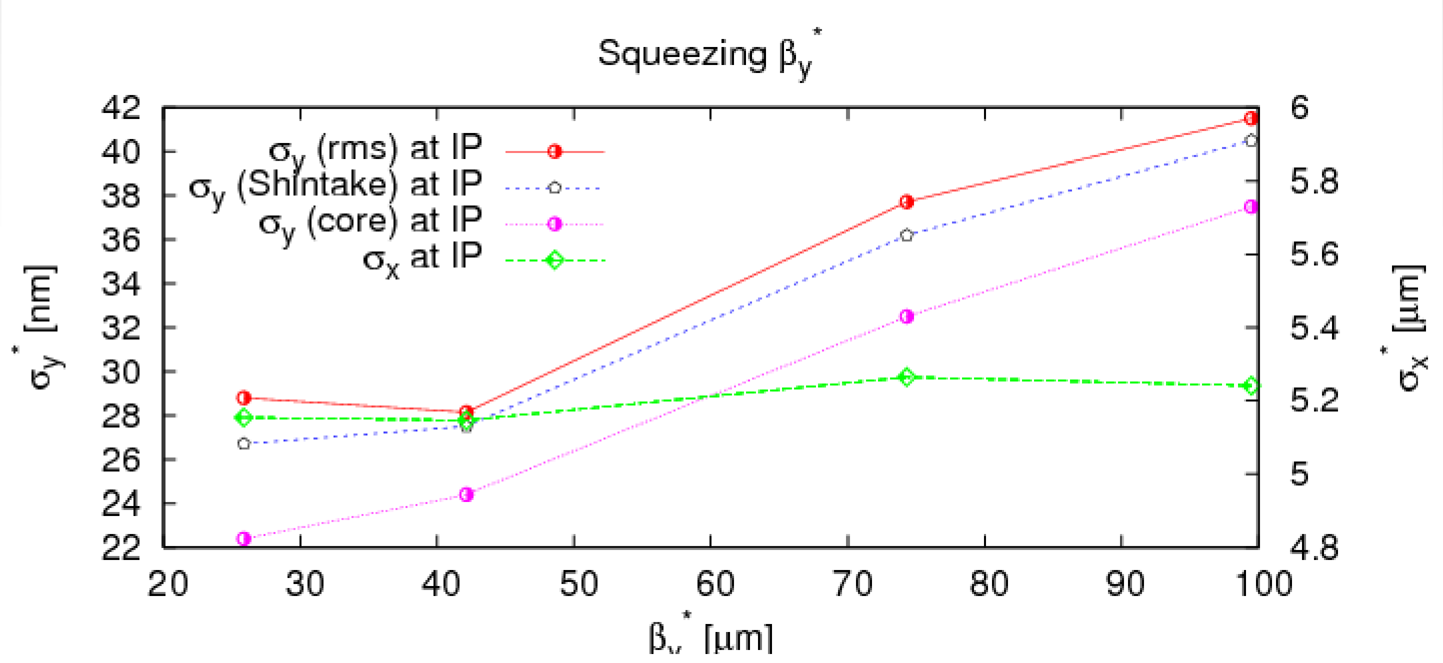
β_y = 100 µm

All these lattices are available at: http://clicr.web.cern.ch/CLICr/ATF2/New_Multipoles/

4. SQUEEZE SEQUENCE

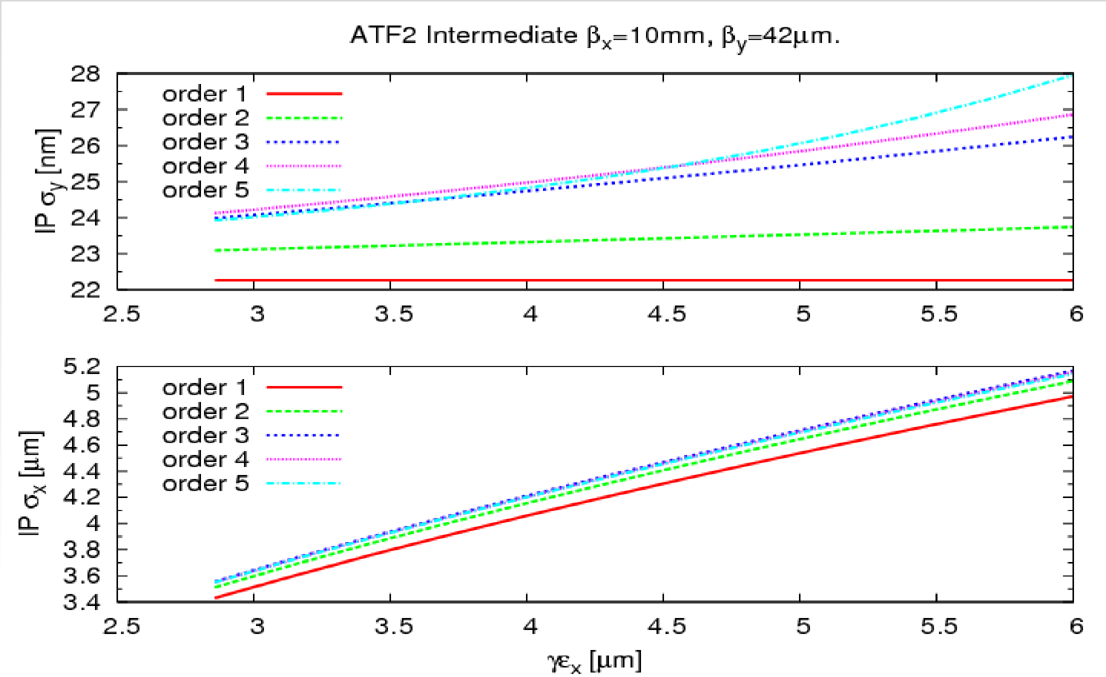
To reach a successful tuning for the Ultra low lattice is recommended to follow a squeeze sequence.

In these sense, 2 Intermediate lattices (β_y= 42 µm & β_y= 75 µm) have been worked out.



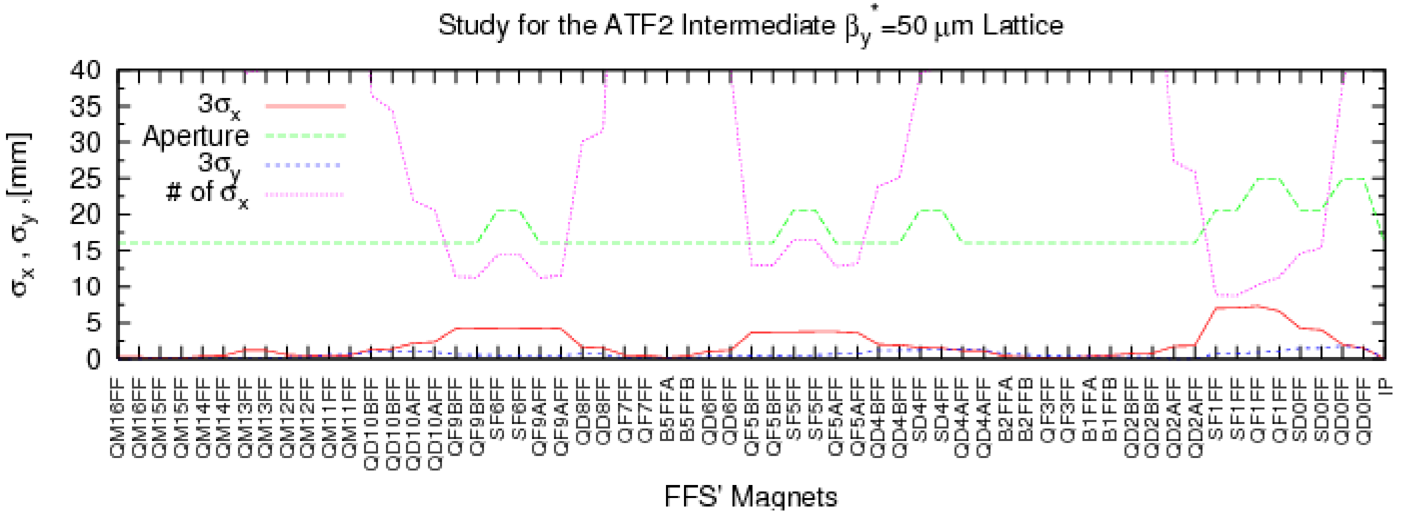
Since the tuning difficulty scales as ≈$(\beta_y)^{-½}$ → unfortunately the ATF2 β_y= 42µm becomes the proper lattice.

5.1 FEASIBILITY OF THE INTERMEDIATE LATTICE



ATF2 Intermediate Lattice

σ_x= 5.15 μm
σ_y= 28.0 nm
β_x= 10.0 mm
β_y= 42.0 μm



Radius of magnets:

Quads: 16mm.

Sexts: 20.6mm.

FD: 25mm.

5.2. TUNING CONDITIONS

- Statistical Study formed by 100 different seeds.
- All Quads & Sex. are misaligned according to a random Gaussian distribution within 30 μm
- All Quads & Sext are tilted according to a random Gaussian distribution within 300 μmrad
- Initial $\sigma_y < 900$ nm
- Tuning via MAD-X & MAPCLASS using Simplex algorithm

The variables are:

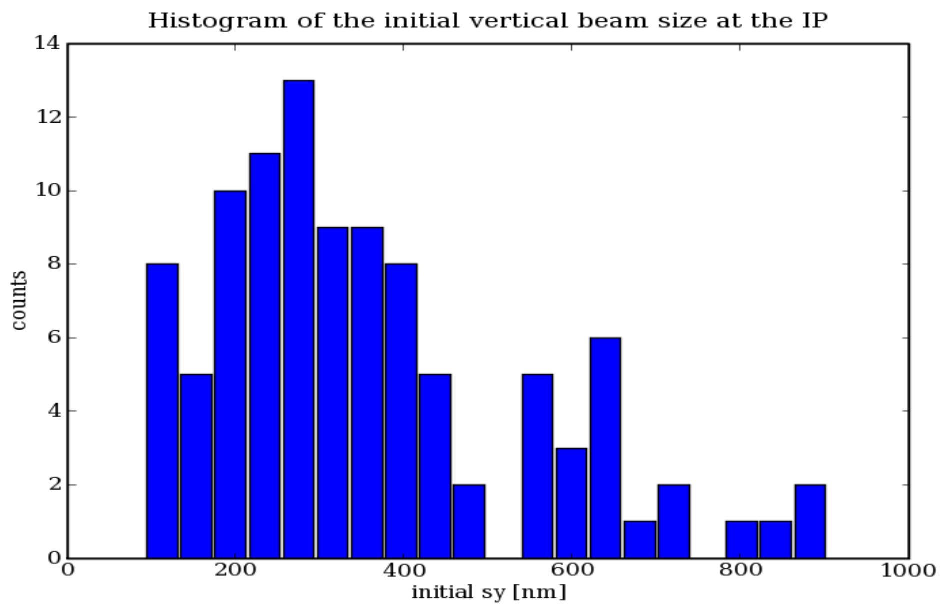
- Misalignments
- Tilts
- Magnet Strengths

The tuning process includes:

- Measurement error: 10%
- Magnets mispowerings (10^{-4})
- Multipoles

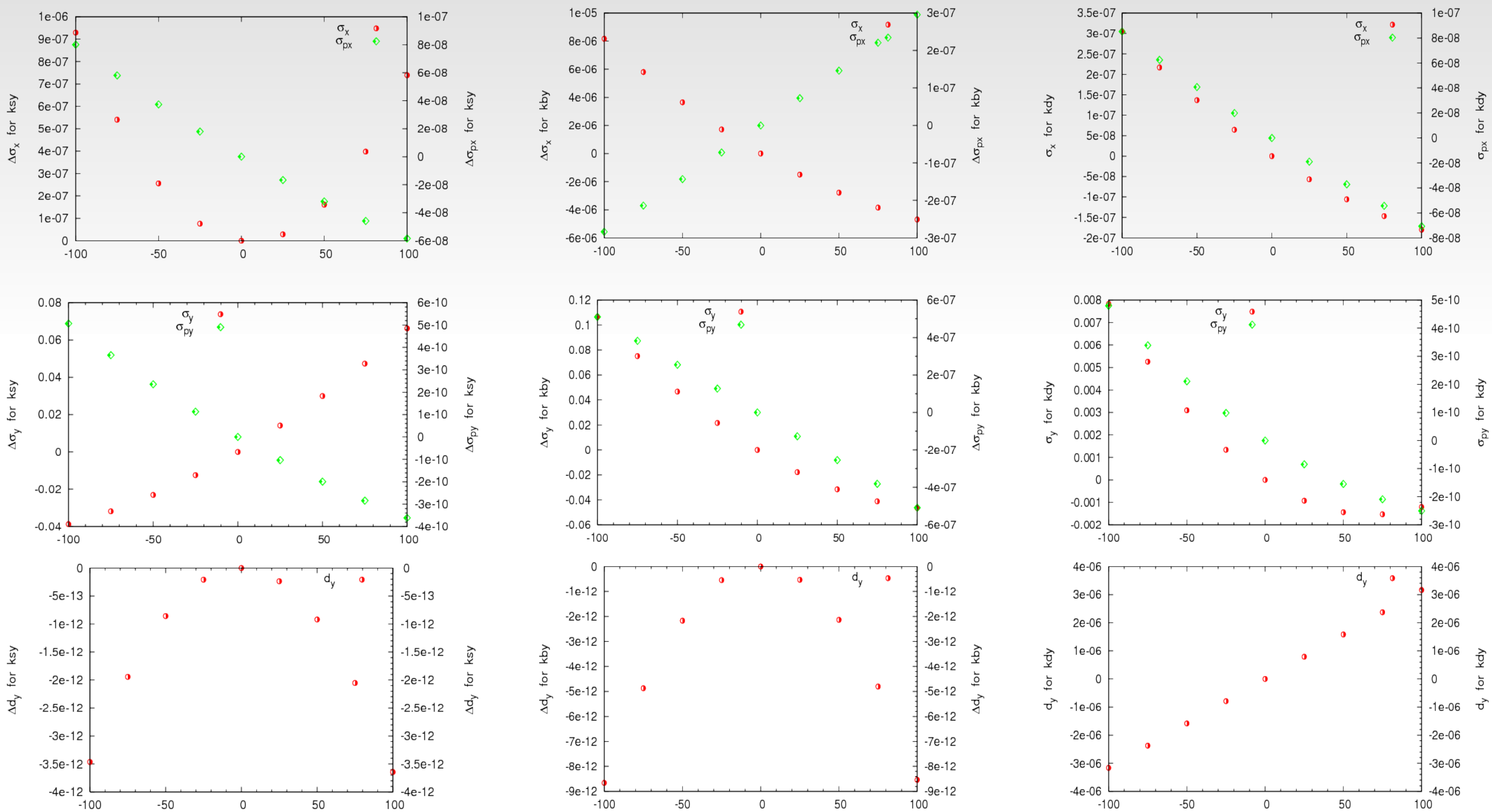
Constraint:

<u>minimize σ_y evaluated as the BSM does</u>

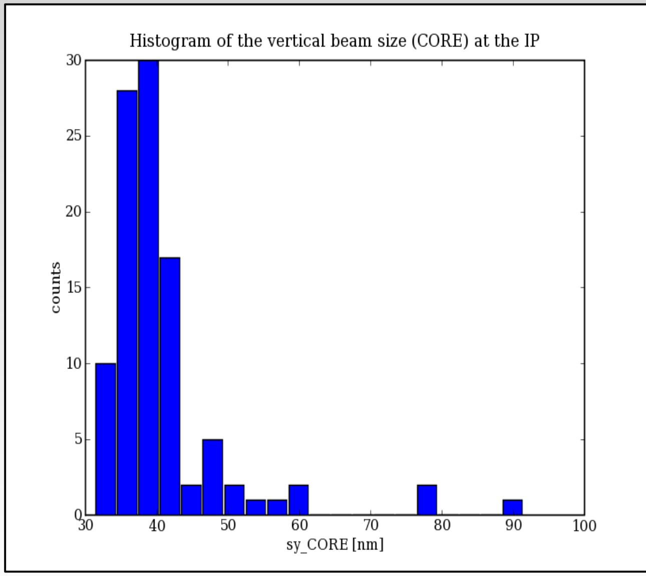


5.2.1 Knobs for the β-functions, dispersion and beam size

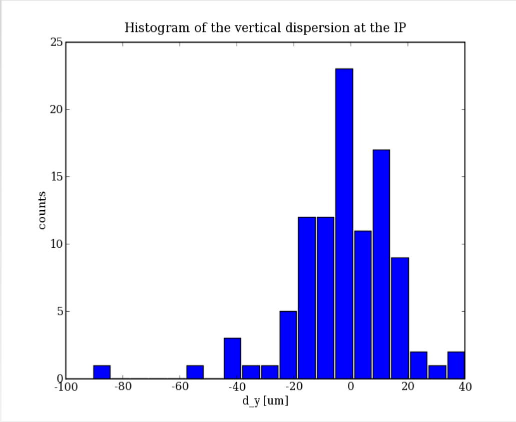
Displacing sextupoles in the vertical direction, a set of knobs have been obtained, with the aim to control the twiss functions and the beam sizes.

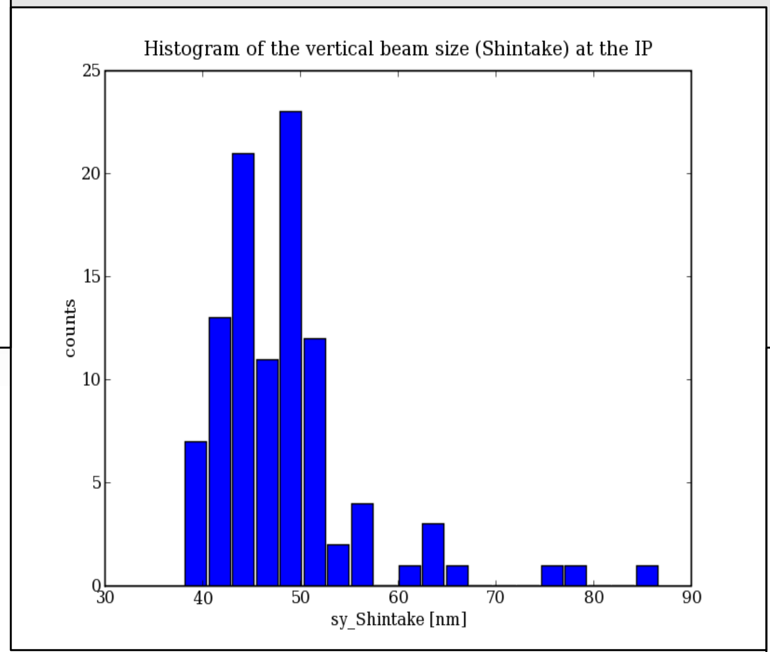


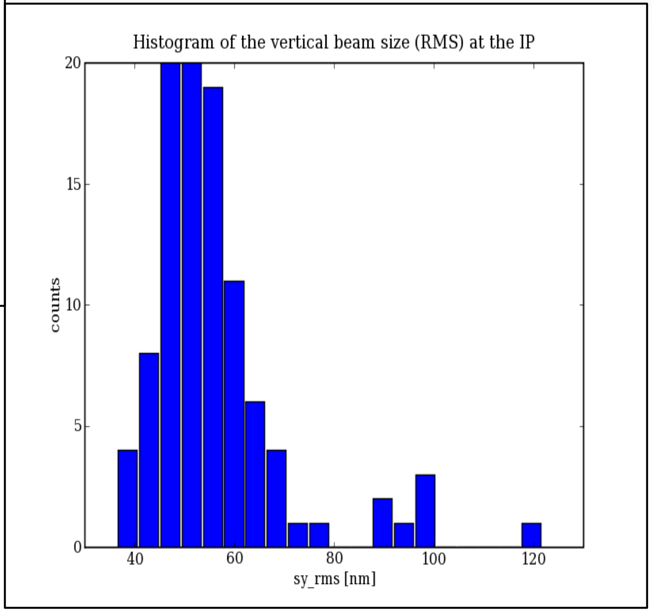
5.2.2. TUNING RESULTS

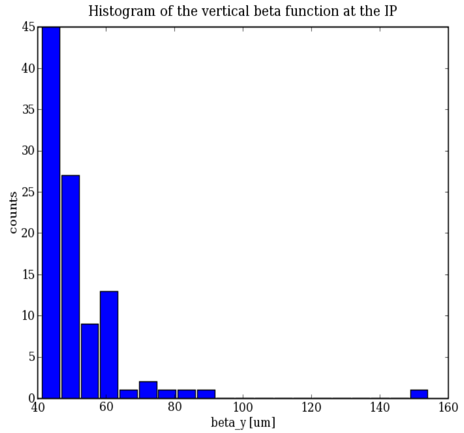


75% seeds reach a σ_y (BSM) < **50 nm**





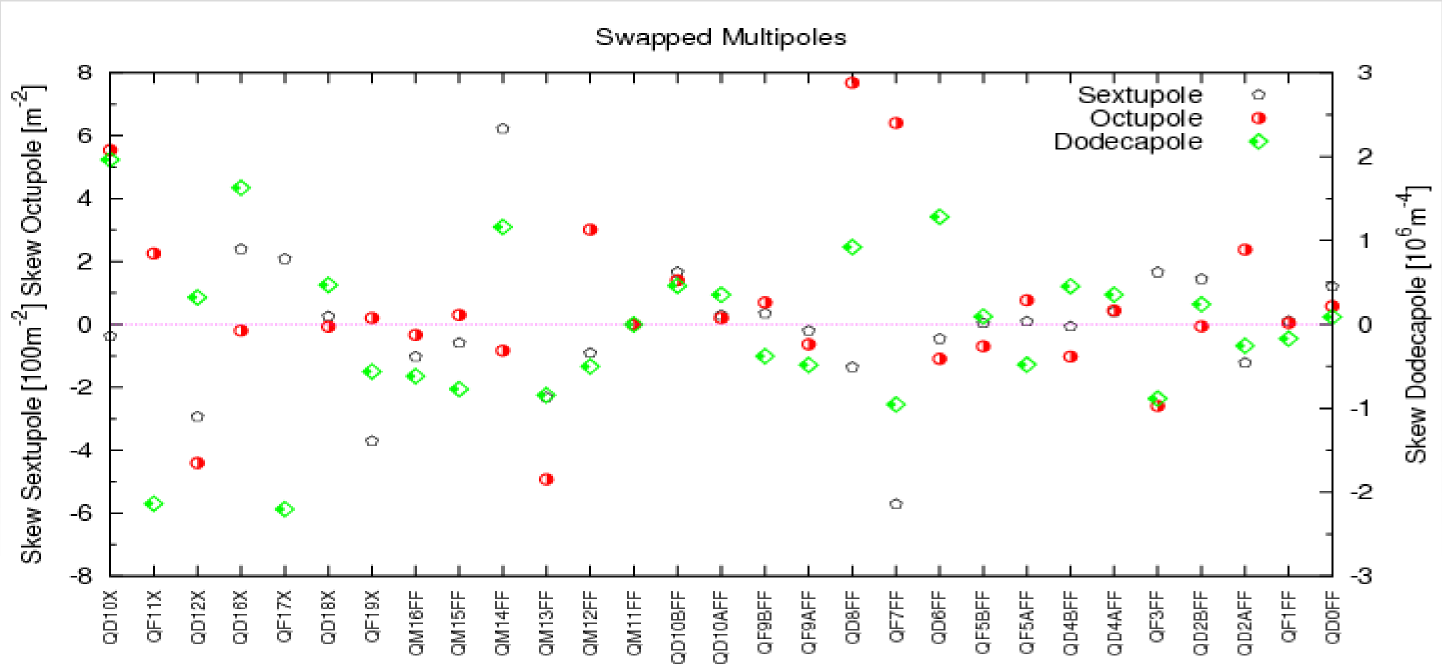




Still missing:

- Coupling correction
- Knob for the horizontal dispersion

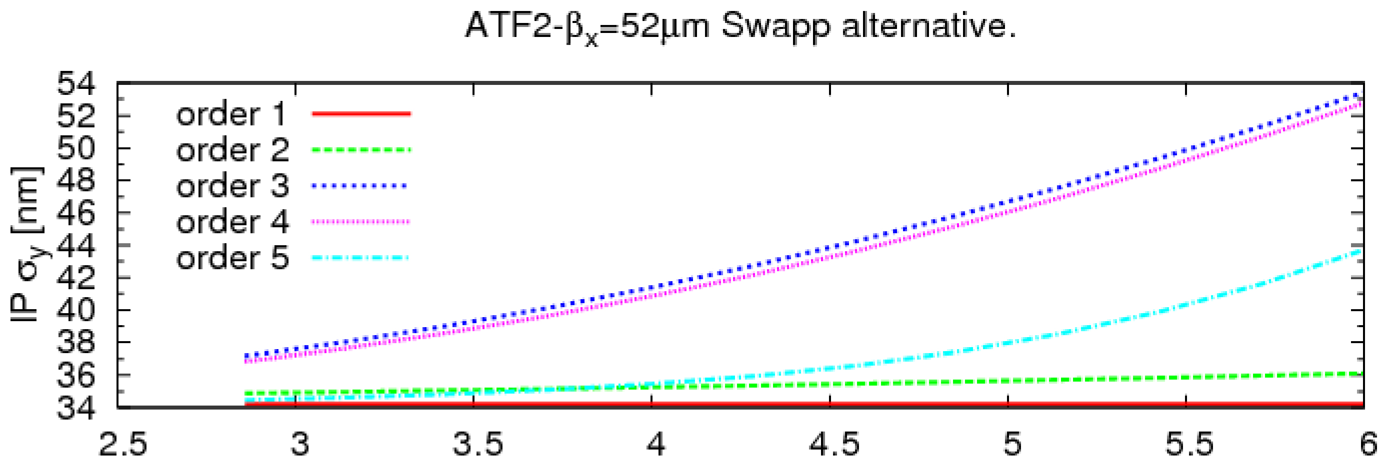
6. SWAPPING THE MAGNETS



The new multipoles are scaled from the measured ones.

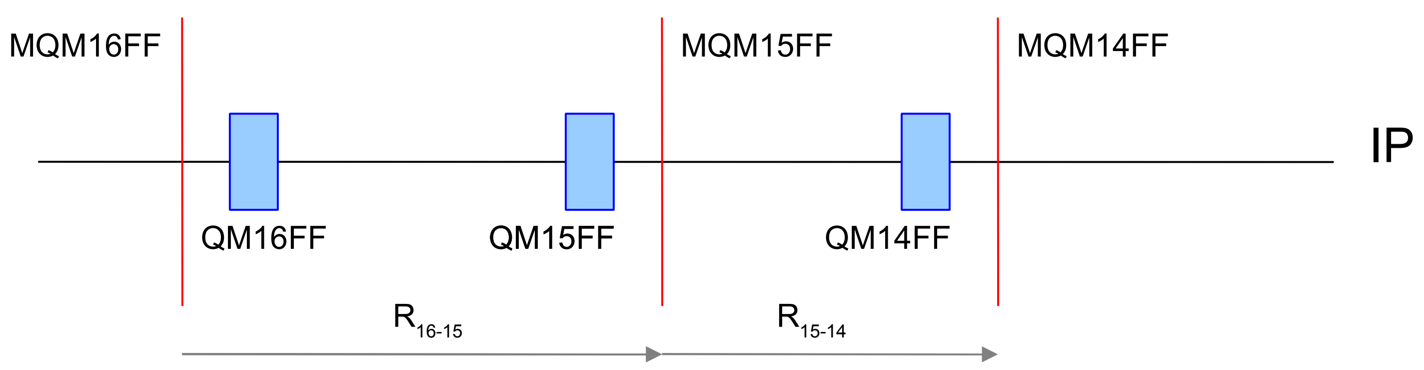
ATF2 Swap option

σ_x = 3.85 µm
σ_y = 44.0 nm (rms)
σ_y = 37.0 nm (Shintake)
σ_y = 35.0 nm (core)
β_x = 5.2 mm
β_y = 100.0 µm



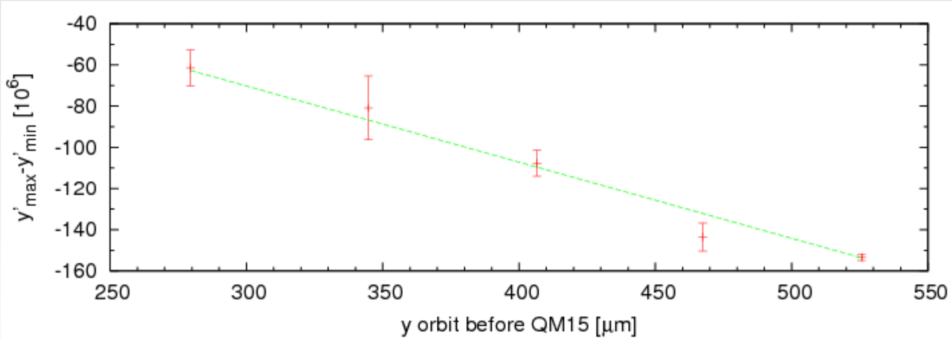
7.1. QUAD SHUNTING TECHNIQUE

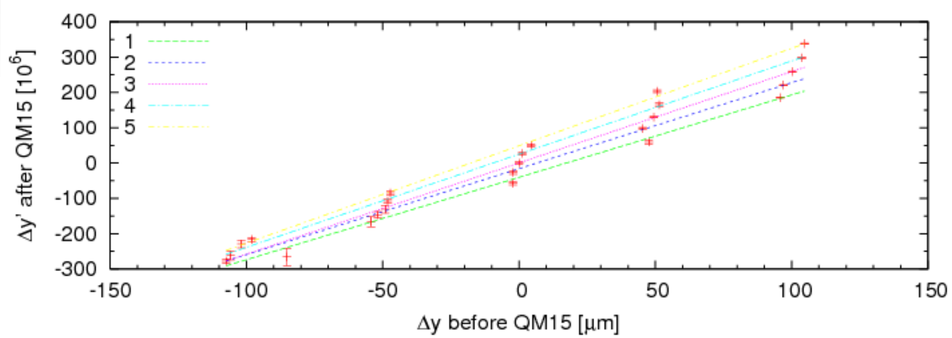
- Two sets of measurements were applied as an alignment technique:
  - Shunting 2 quadrupoles
  - Shunting and moving only 1quadrupole
- Measurement description:

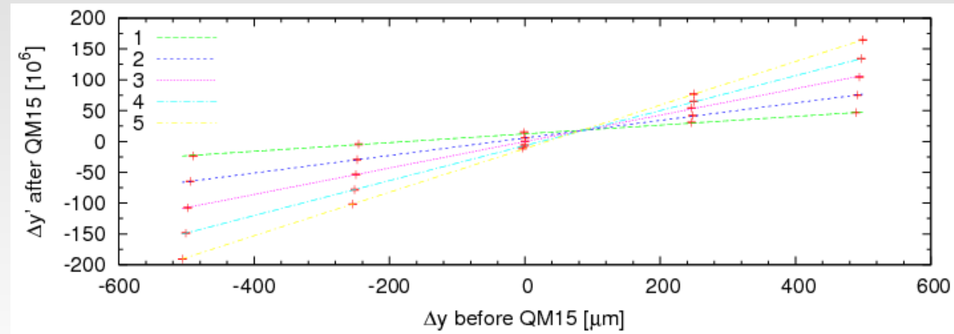


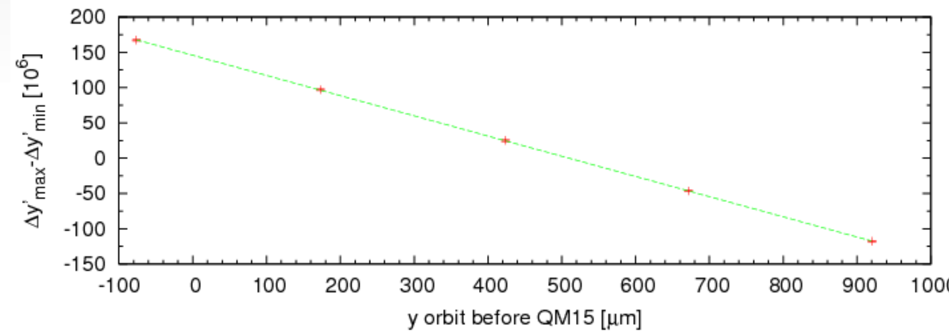
7.2. QUAD SHUNTING TECHNIQUE

- Comparison of the two different kind of measurements:





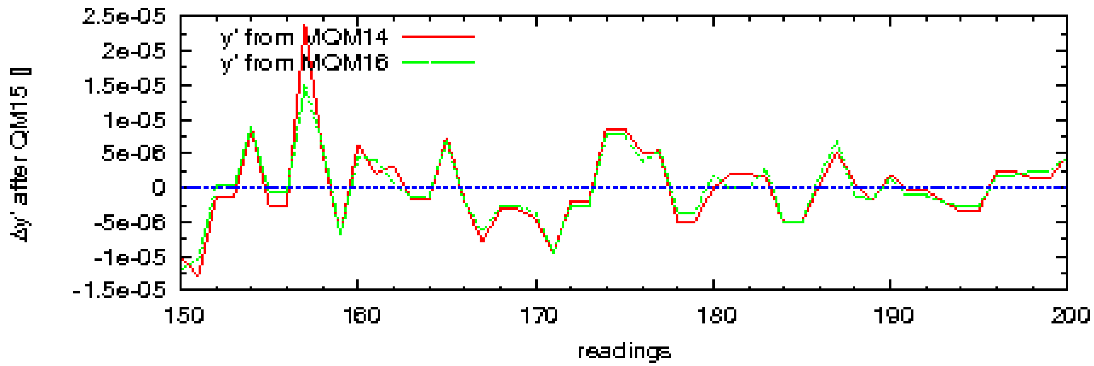


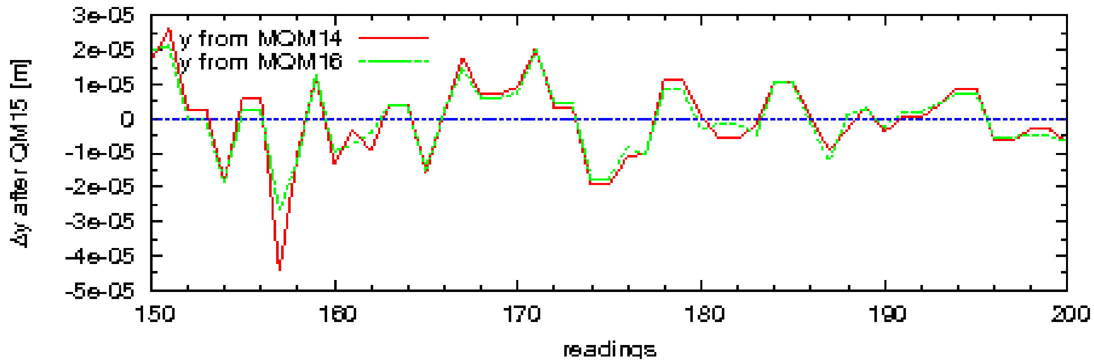


	1st Measurement Type 1	2nd Measurement Type 1*	3dt Measurement Type 2	4th Measurement Type 2
Offset [µm]	110 ± 40	135 ± 86	114 ± 18	510 ± 1.6

7.3. QUAD SHUNTING TECHNIQUE

- Data analysis:





8. CONCLUSIONS & FUTURE PLANS

- All the multipoles of each single magnet in the FFS are introduced into the model.
- A new Nominal and Ultra-low lattices have been obtained. Still work ongoing for improvements
- A first statistical tuning study shows that 75% of the seeds reach a final σ_y <50 nm.
- The moving alignment technique reaches a better precision.

To be done...

- Concerning the lattices, try to decrease β_x at the IP, with the objective to obtain a more suitable ratio σ_y/σ_x
- Implement the squeeze tuning technique
- Obtain the coupling knobs.
- Understand the discrepancies between the alignment measurements