ATF2 Alternative lattices & BBA

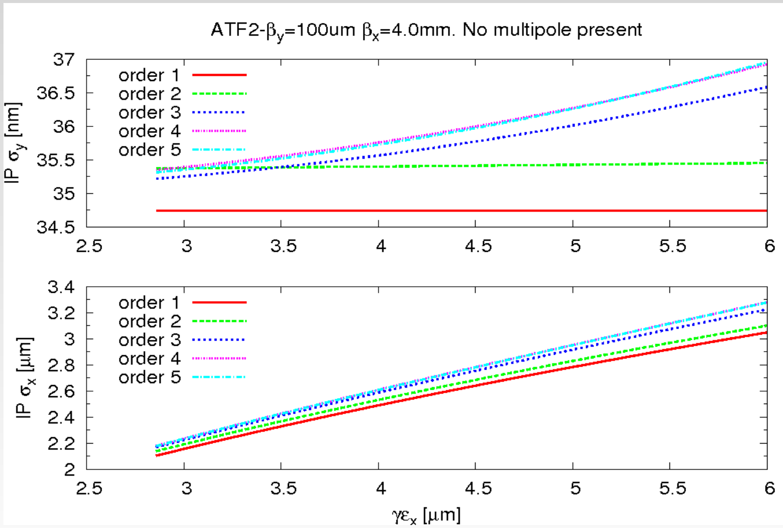
Presenter: **Edu Marin**
eduardo.marin.lacoma@cern.ch

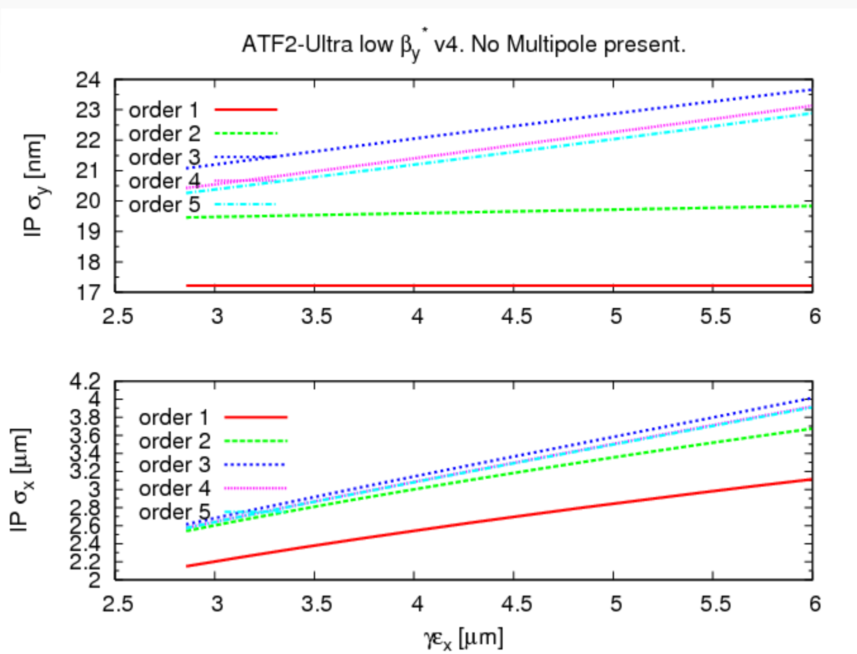
Acknowledgements : All the ATF2 Tuning team

PLAN OF THE TALK

1. The ATF2 Nominal and Ultra-Low β^* Lattice.
2. Multipoles effect
3. Possible Solutions
    1. New lattices
    2. Squeeze sequence
    3. Tuning results
4. Alternatives β_x lattices
    1. Keeping the magnets distribution
    2. Swapping the magnets
5. Quad shunting technique
6. Conclusions and Future Plans.

1. ATF2 LATTICES





ATF2 Nominal Lattice

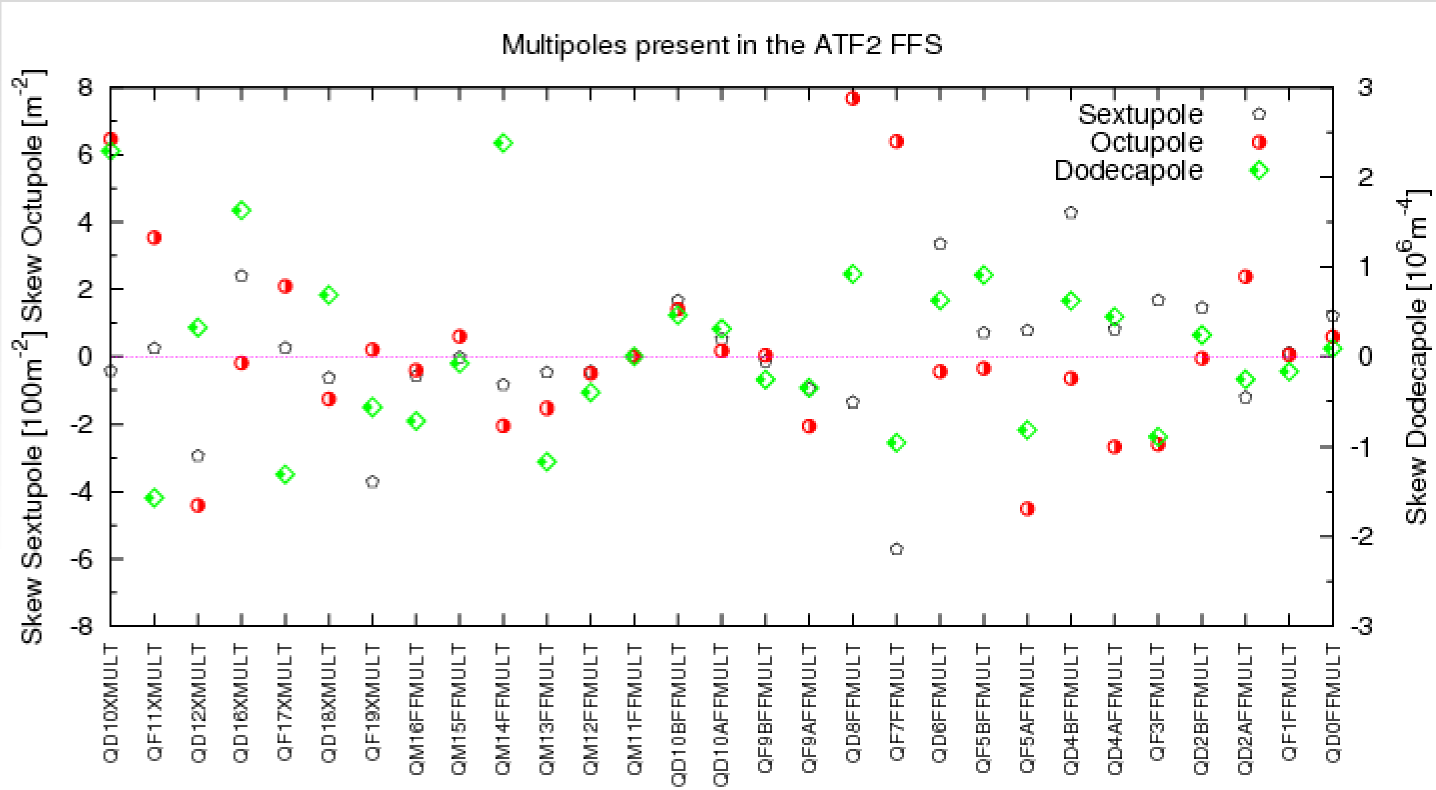
σ_x = 3.2 µm
σ_y = 37.0 nm (rms)
σ_y = 35.0 nm (core)
β_x = 3.9 mm
β_y = 0.1 mm
η_x = -2.8 µm

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

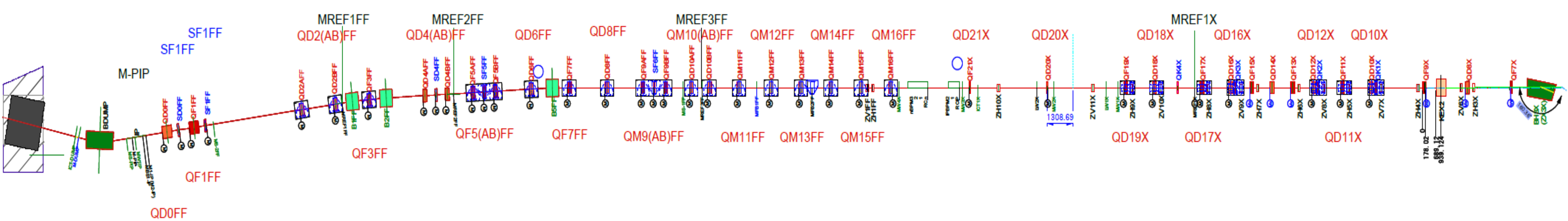
Project	L* [m]	β_y^* [µm]	ξ_y
ATF2 Nominal	1.0	100	~19000
ILC Desgin	3.5	400	~15000
ATF2 Ultra-low	1	25	~76000
CLIC 3 TeV	3.5	90	~63000

2.1. MULTIPOLES IN THE ATF2-FFS

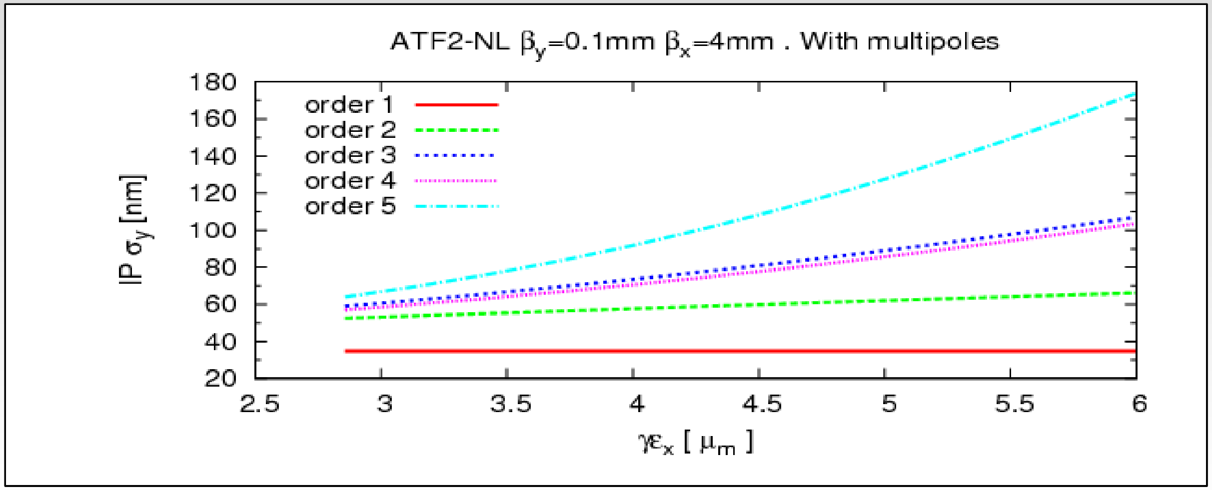


Multipoles included for:

- Kickers
- Dipoles
- Quadrupoles
- Sextupoles

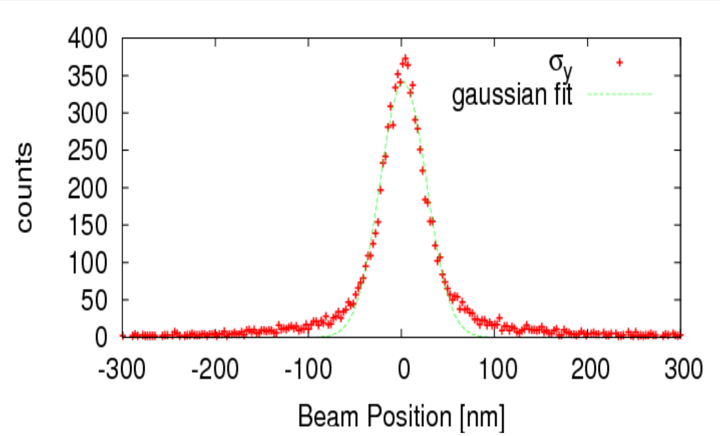


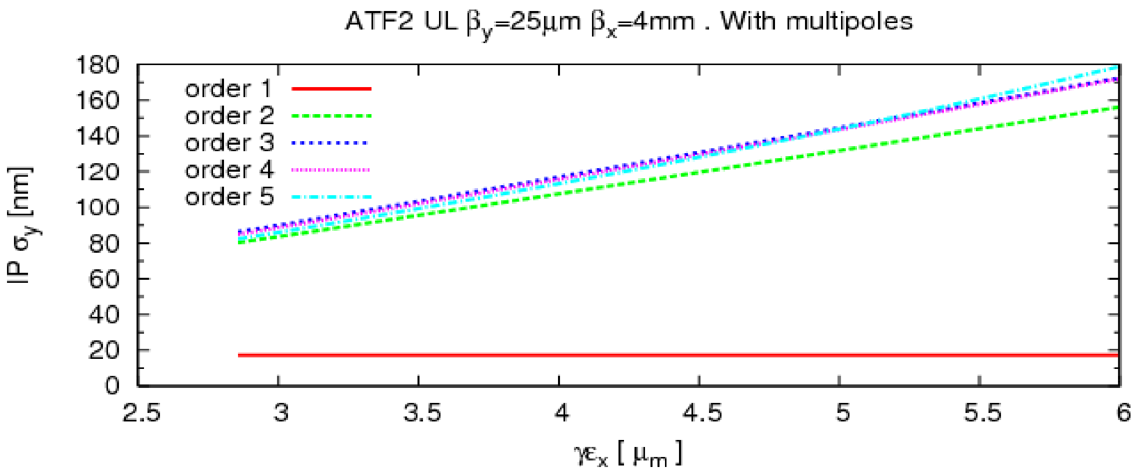
2.2. MULTIPOLES EFFECT



ATF2 Nominal Lattice

σ_x= 5.5 μm
σ_y= 174 nm (rms)
σ_y= 102 nm (Shintake)
σ_y= 51 nm (core)





ATF2 Ultra-low β* Lattice

σ_x= 4.9 μm
σ_y= 180 nm (rms)
σ_y= 70 nm (shintake)
σ_y= 48 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 detail 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. NEW LATTICES: (increase β_x^* from 4mm to 10mm)

ATF2 Nominal Lattice

σ_x = 5.3 μm
σ_y = 43.5 nm
β_x = 10 mm
β_y = 100 μm

Squeeze sequence →

ATF2 Inter 75 Lattice

σ_x = 4.9 μm
σ_y = 34.7 nm
β_x = 10 mm
β_y = 75 μm

ATF2 Inter 42 Lattice

σ_x = 4.9 μm
σ_y = 28.0 nm
β_x = 10 mm
β_y = 42 μm

ATF2 Ultra-low Lattice

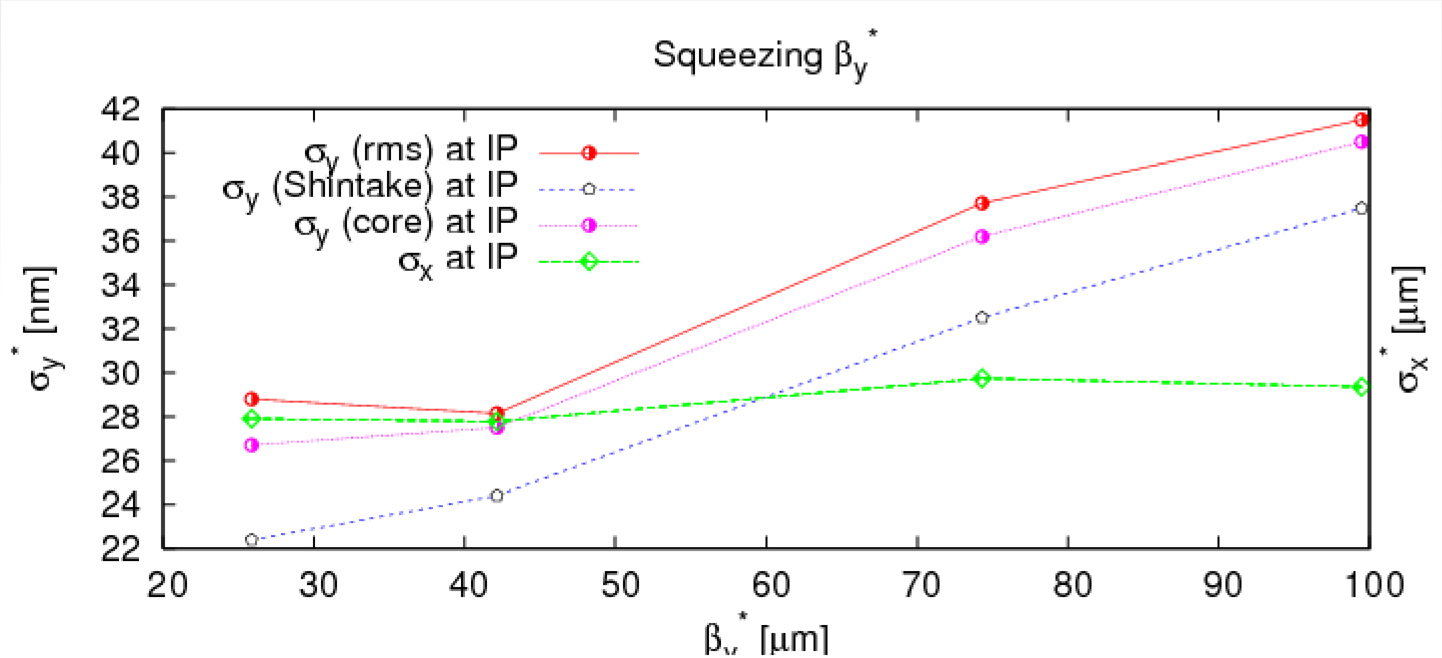
σ_x = 5.3 μm
σ_y = 28.5 nm
β_x = 10 mm
β_y = 25 μm

2 Intermediate lattices with β_y= 42 μm & β_y= 75 μm have been worked out.

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

3.2 SQUEEZE SEQUENCE

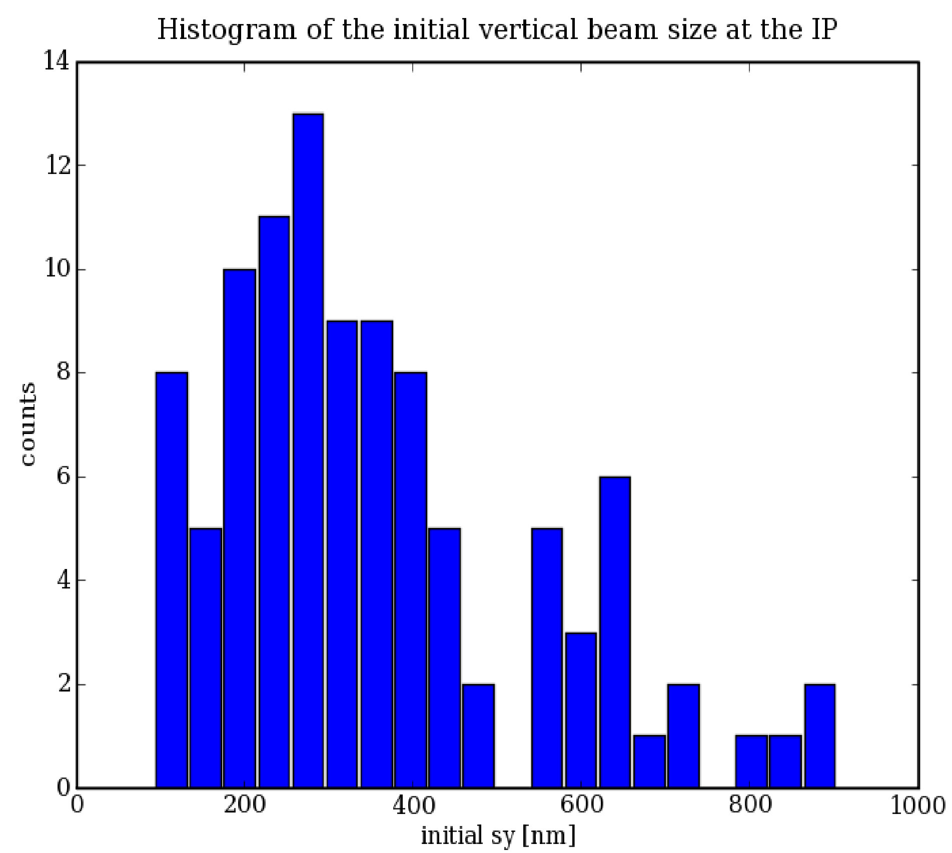
In order to improve the tuning convergence a squeeze sequence in terms of b_y is recommended to be applied



Since tuning difficulty scales as β_y therefore the ATF2 β_y= 42 µm becomes an attractive lattice.

3.3.1. TUNING INITIAL CONDITIONS

- Statistical Study formed by 100 different seeds.
- Initial σ_y [0.1 µm , 0.9 µm]
- Via MAD-X & MAPCLASS using Simplex algorithm



3.3.2 TUNING STRATEGY

The tuning includes:

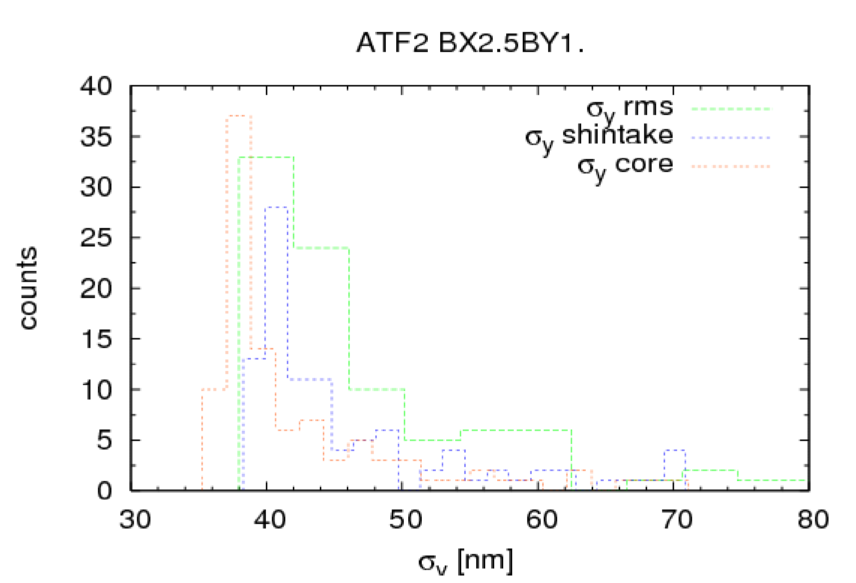
- Measurement error on σ_x, σ_y(10%)
- Magnet mispowering (10^{-4})
- Multipoles
- Transverse misalignments (30µm)
- Tilts (30µrad)

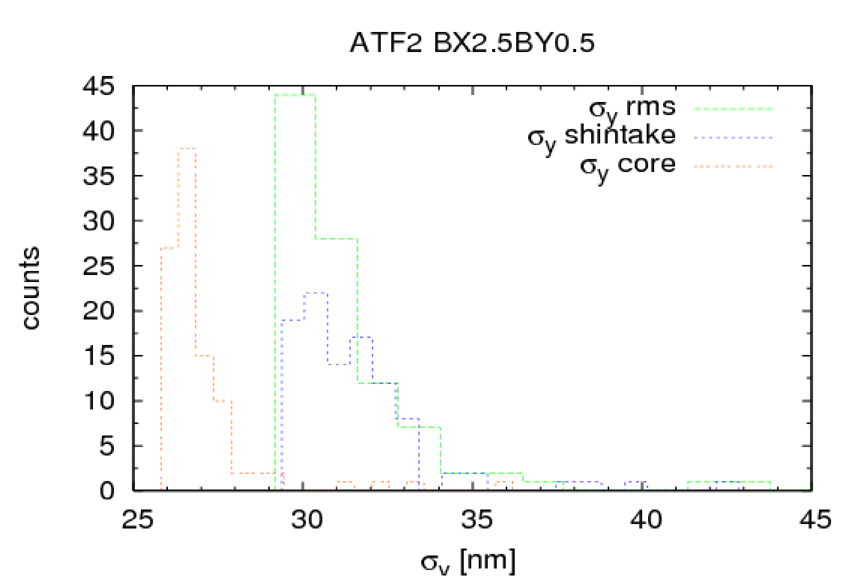
Variables:

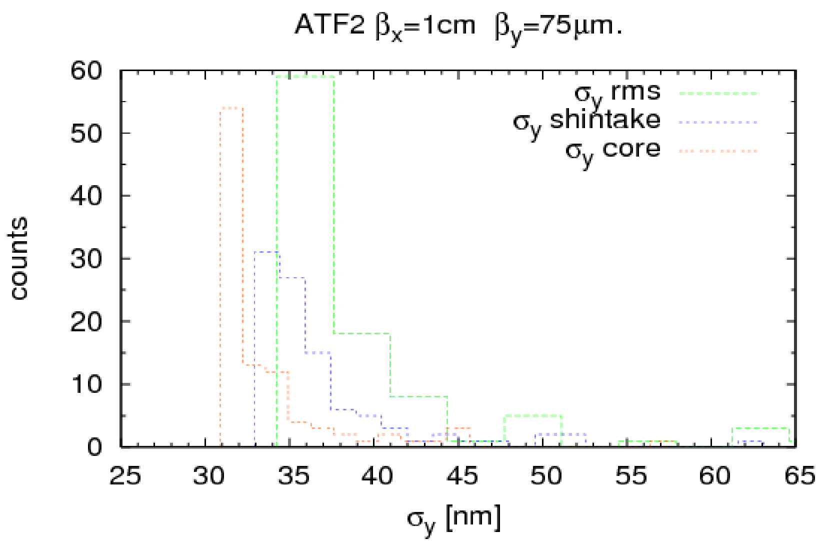
- Sextupole transversal Misalignments
- Sextupole tilts
- Magnet strengths.

- Constraint: minimize σ_y measured as the Shintake monitor does
- Tuning via Mad-x & Mapclass using the Simplex algorithm.
- Tuning in terms of knobs scan for:
  - Dispersion
  - Coupling
  - waist

3.3.3. TUNING RESULTS







Vertical beam size	ATF2 BX2.5BY1.0	ATF2 BX2.5BY0.75	ATF2 BX2.5BY0.5
RMS	72 % < 50.0 nm	87 % < 40.7 nm	84 % < 32.5 nm
SHINTAKE	68 % < 45.5 nm	87 % < 39.7 nm	84 % < 32.0 nm
CORE	68 % < 41.5 nm	85 % < 35.6 nm	90 % < 27.6 nm

4.1. ALTERNATIVES LATTICES (β_x=7mm & β_x = 8mm)

Regarding β_x, intermediate solutions have been obtained in order to preserve:

- a more suitable aspect ratio σ_y/σ_y
- To not deviate from ILC & CLIC parameters

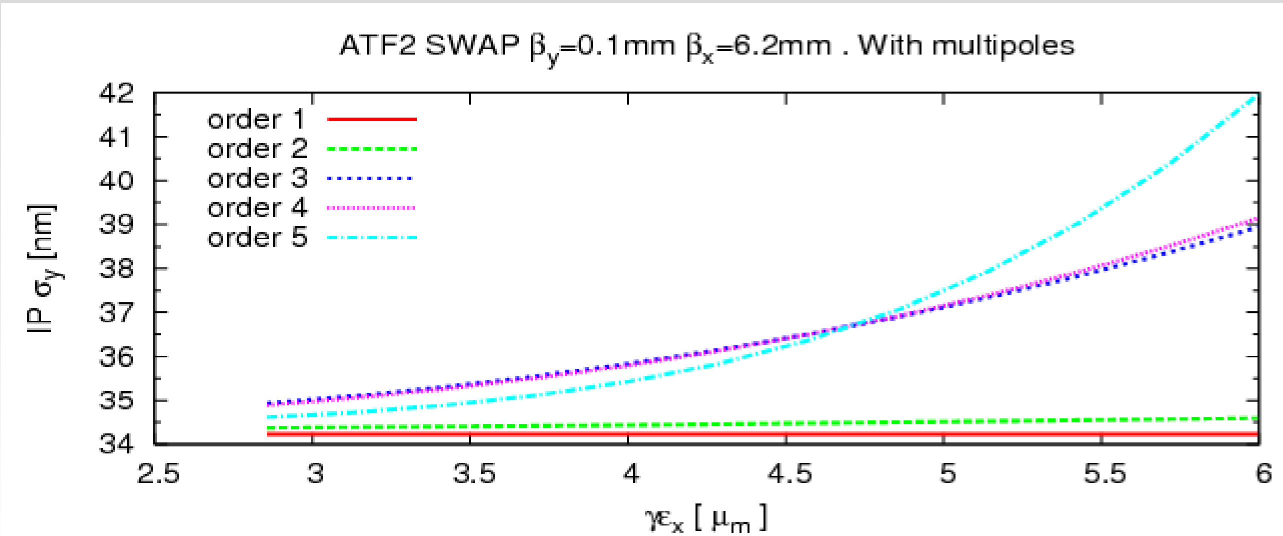
LATTICE	σ_y / σ_x [10^{-3}]		
	σ_x = 10 mm	σ_x = 8 mm	σ_x = 7 mm
NOMINAL (β_y = 100 μm)	41.5 / 5.2 ~ 8	39.0 / 4.5 ~ 8.7	40.7 / 4.0 ~ 10.1
INTER-HIGH (β_y = 75 μm)	37.7 / 5.2 ~7.2	34.4 / 4.5 ~ 7.7	37.7 / 4.2 ~ 9
INTER-LOW (β_y = 42 μm)	28 / 5.1 ~ 5.5	28 / 4.6 ~ 5.9	28.3 / 4.4 ~ 6.4

Without altering the current magnet distribution along the beam line.

It has been used all the sextupoles tilts in order to reduce the beam size.

4.2 SWAPPING THE MAGNETS

The new multipoles are scaled from the measured ones.

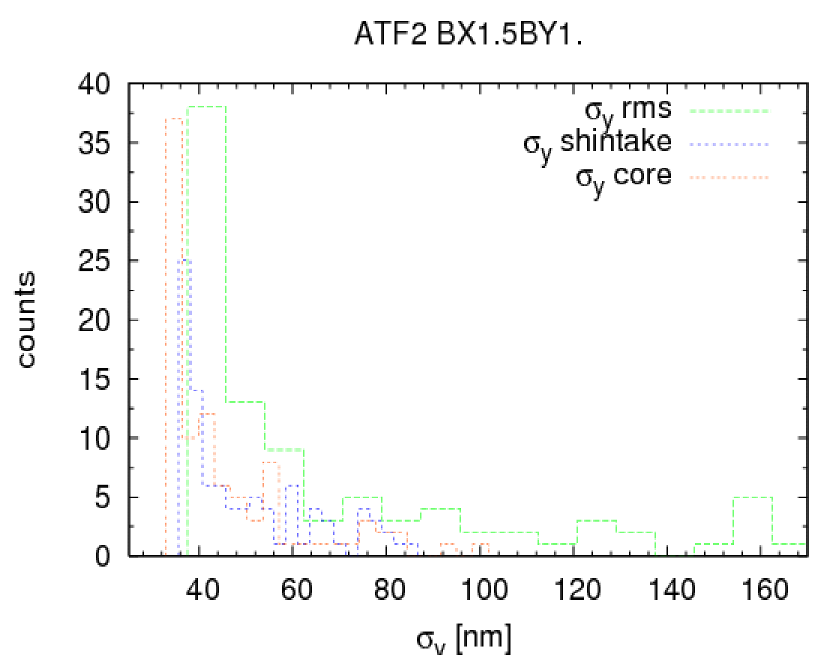


ATF2 Swap BX1.5BY1.0

σ_x = 4.0 μm
σ_y = 42.0 nm (rms)
σ_y = 38.0 nm (Shintake)
σ_y = 34.5 nm (core)
β_x = 6.2 mm
β_y = 100.0 μm

Tuning results

62 % σ_y < 48 nm (rms)
70 % σ_y < 47 nm (Shintake)
85 % σ_y < 48 nm (core)

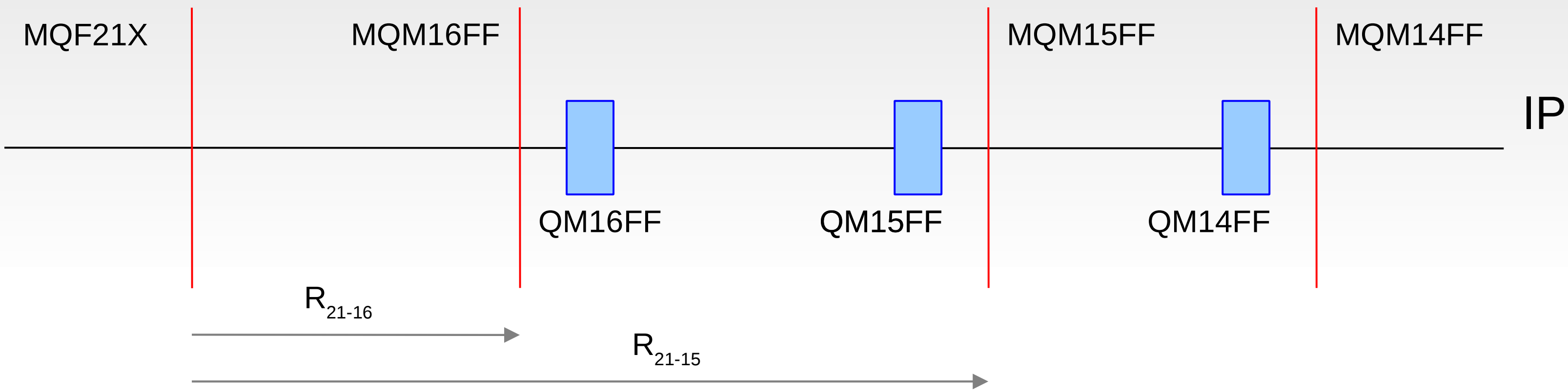


ATF2 Swap BX2.5BY1.0

σ_x = 5.0 μm
σ_y = 40.5 nm (rms)
σ_y = 40.0 nm (Shintake)
σ_y = 38.0 nm (core)
β_x = 10.0 mm
β_y = 100.0 μm

5.1. QUAD SHUNTING TECHNIQUE

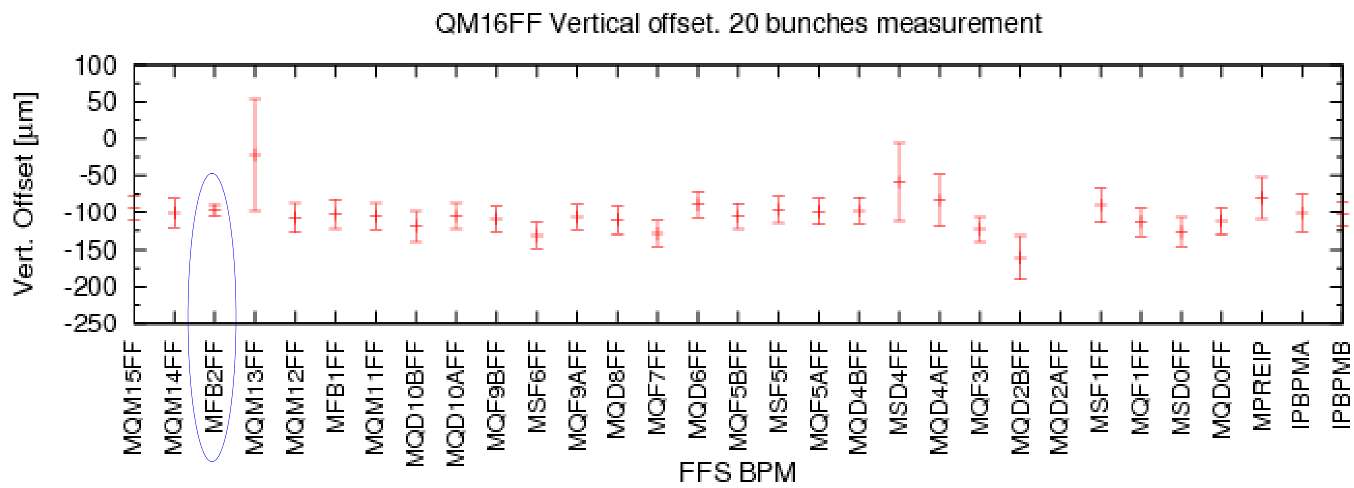
- The measurement consists on shunting and moving the QM16FF quadrupole

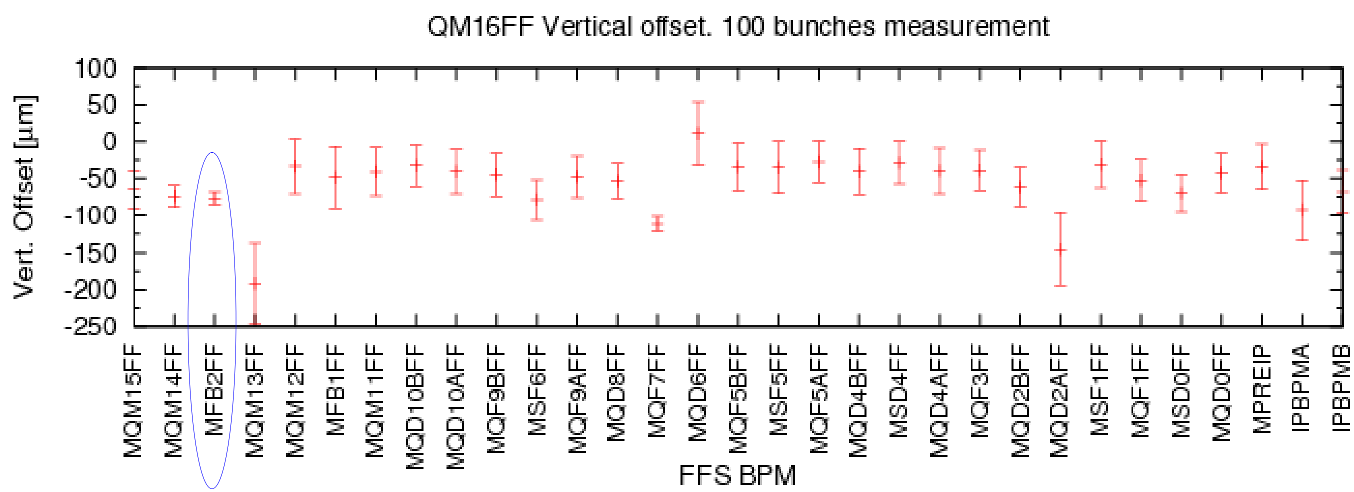


- The drift between the first 2 BPMs allows to measure the incoming angle precisely
- Knowing the R-matrices from QM16 to the downstream BPMs the angle jitter can be propagated for a later subtraction

5.2. QUAD SHUNTING TECHNIQUE

- Comparison of the two different set of measurements:

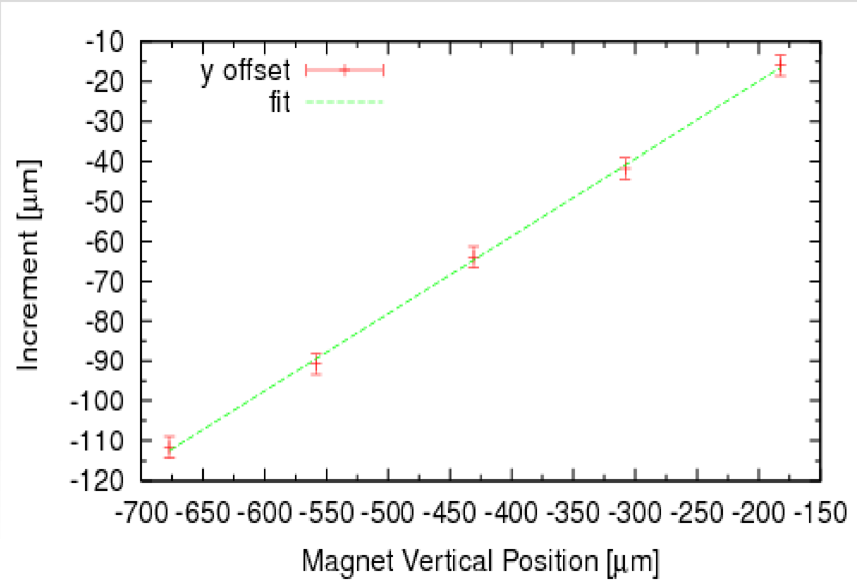




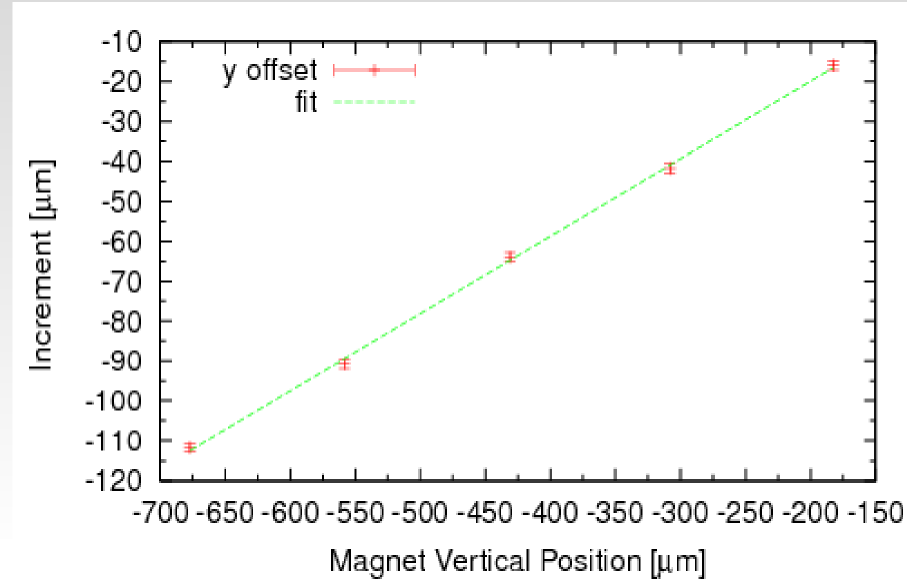
Dec. Measure	20 bunches	
QM16FF [µm]	Jitter Out -97 ± 8 (MFB2FF)	Jitter In -104 ± 13 (MFB2FF)
	100 bunches	
QM16FF [µm]	Jitter Out -77 ± 10 (MFB2FF)	Jitter In -70 ± 20 (MFB2FF)

5.2. QUAD SHUNTING TECHNIQUE

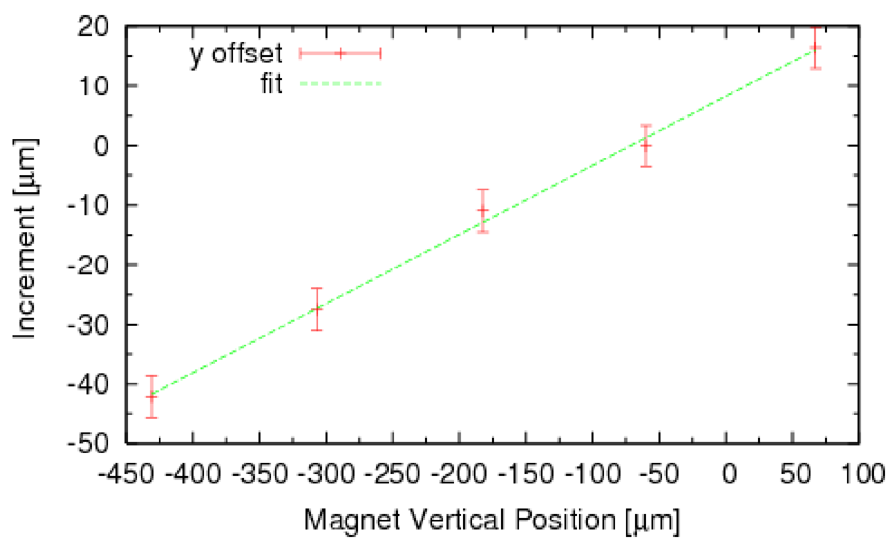
- Comparison of the measurements:



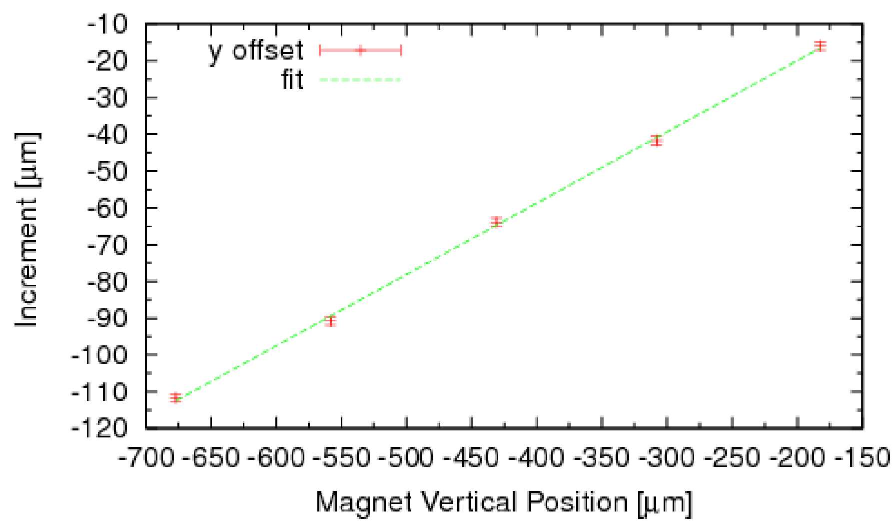
20 bunches MFB2FF



Removing the jitter



100 bunches MFB2FF



6. CONCLUSIONS & FUTURE PLANS

- A new version of the ATF2 Nominal and Ultra-low lattices have been obtained. Considering all the multipoles present in the FFS magnets.
- The statistical tuning study shows
  - Nominal lattice: 68 % of the seeds reach σ_y < 45.5 nm (Shintake).
  - Interm. β_y=75μm lattice: 87% of the seeds reach σ_y < 39.7 nm (Shintake)
  - "Ultra-low" β_y=42μm lattice: 84 % of the seeds reach σ_y < 32.0 nm (Shintake).
- Ordering the magnets according to their quality would improve the aspect ratio σ_y / σ_y . The statistical tuning study for the ATF2BX1.5BY1 shows:
  - 70 % of the seeds reach σ_y < 47 nm (Shintake).
- A beam based alignment resolution below 10 μm was reached.

To be done...

- Design a feasible ATF2 Ultra-low β_y from the ATF2 Swap lattice
- Implement the squeeze tuning technique as a unique process, implementing the already installed skew sextupole magnet