Status of the
ATF2 Ultra-Low β FFS.

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PLAN OF THE TALK

1. Beam size dependence on the horizontal emittance for the ATF2 Ultra-Low β Lattice.
2. Possible corrections.
    1. Insert a Dodecapole Magnet.
    2. Matching for a New ATF2 Ultra-Low βy Lattice.
        1. Properties of the New ATF2 Ultra-Low βy Lattice.
3. Misalignments
    1. Effect of Individual Misalignment.
    2. Linear regime of SD4 Misalignment.
    3. Knobs for Nominal and Ultra-Low βy Lattice.
4. Statistical Study for the first FFS Tuning.
    1. Description of the Study
    2. First FFS Tuning
    3. Results (1)
    4. Results (2)
5. Conclusions and Future Plans.

1. ATF2 ULTRA-LOW LATTICE WITHOUT MULTIPOLAR ERRORS.

BETA FUNCTIONS @IP:

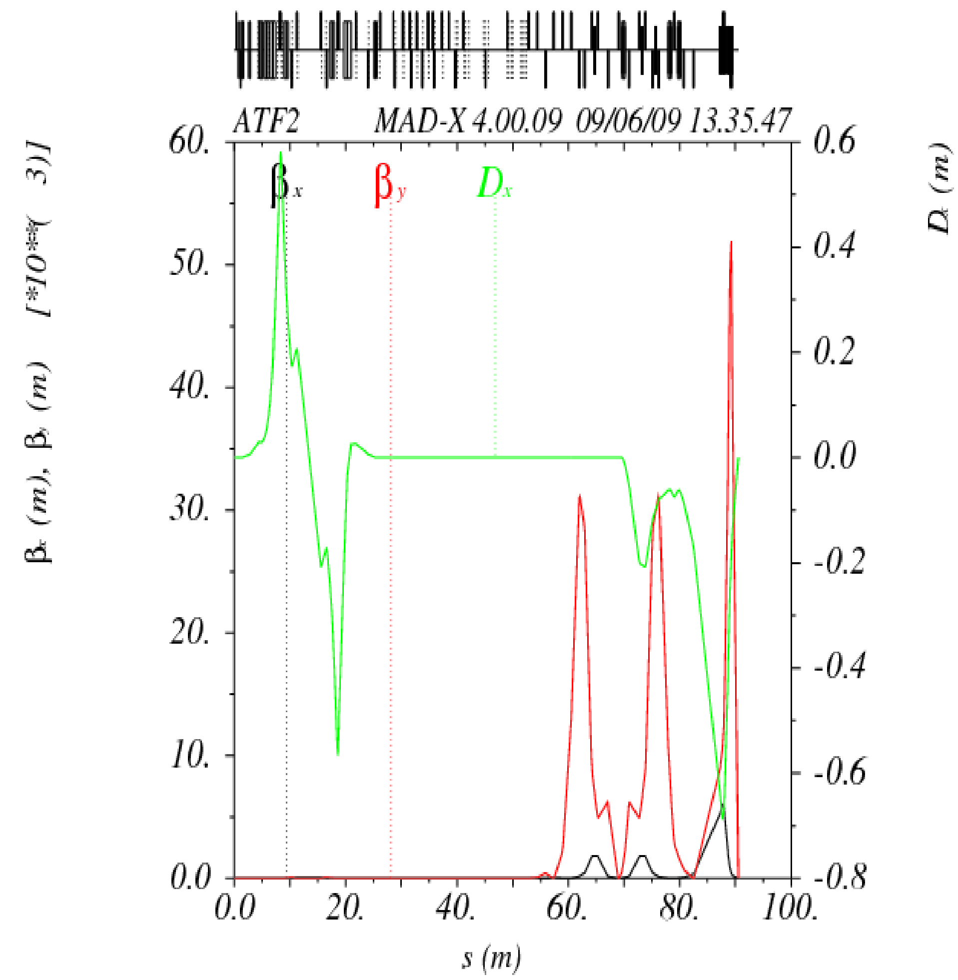
- $\beta_x = 4.0$ mm ; $\beta_y = 25.0$ µm

BEAM SIZES @IP:

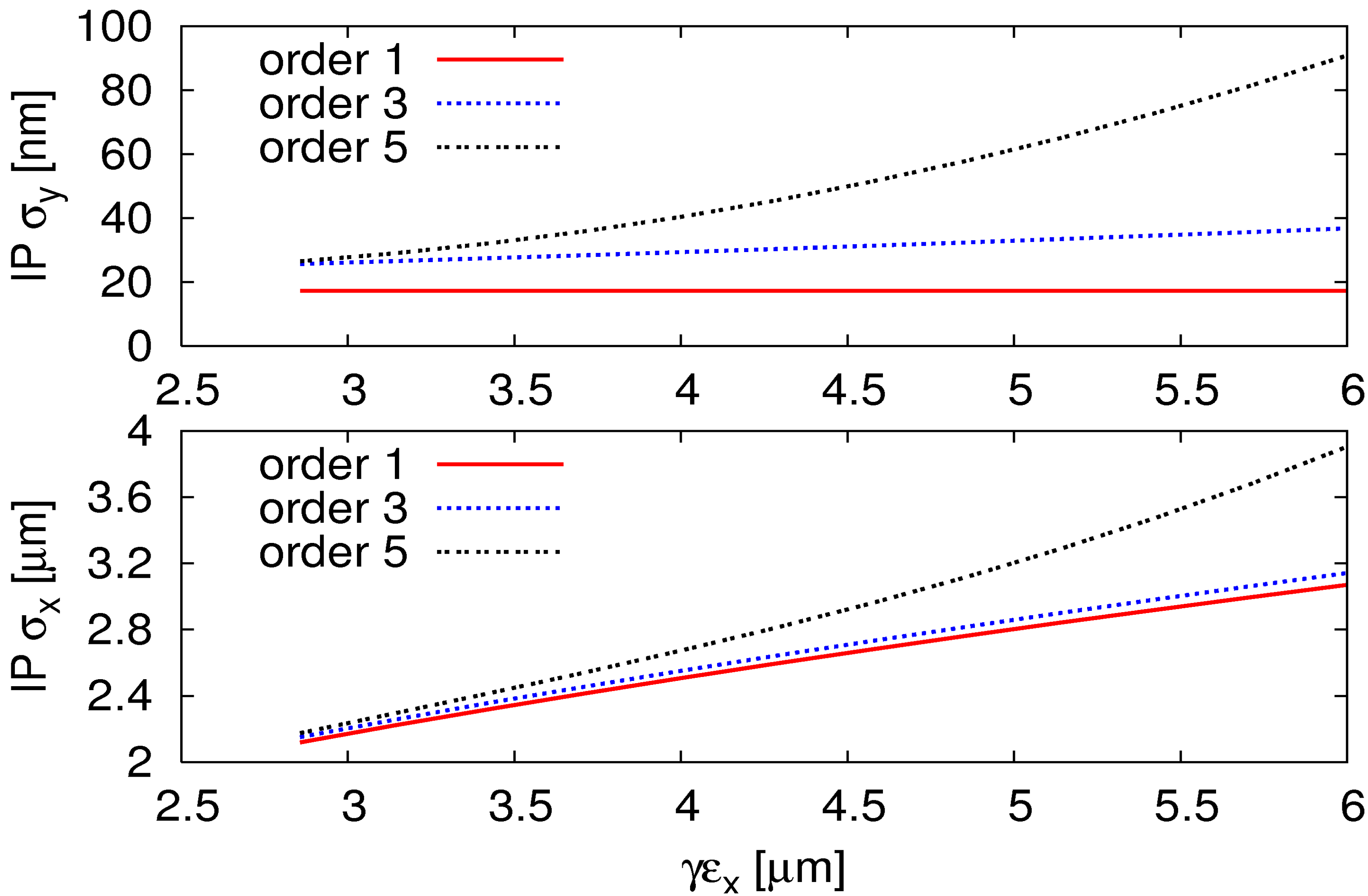
- $\sigma_x = 2.14$ µm ; $\sigma_y = 22.8$ nm

FRAMEWORK:

- Beam sizes @ IP
- Implementing: MAPCLASS code (up to 5 order)
- Range values for $\gamma \cdot \varepsilon_x$ [µm] : {2.8 , 6.0}
- Value for $\gamma \cdot \varepsilon_y = 3.8$ nm



1.2 BEAM SIZE DEPENDENCE ON ε_x FOR ULTRA-LOW LATTICE.



NOTE: similar behavior as the ATF2_Nominal Lattice case.

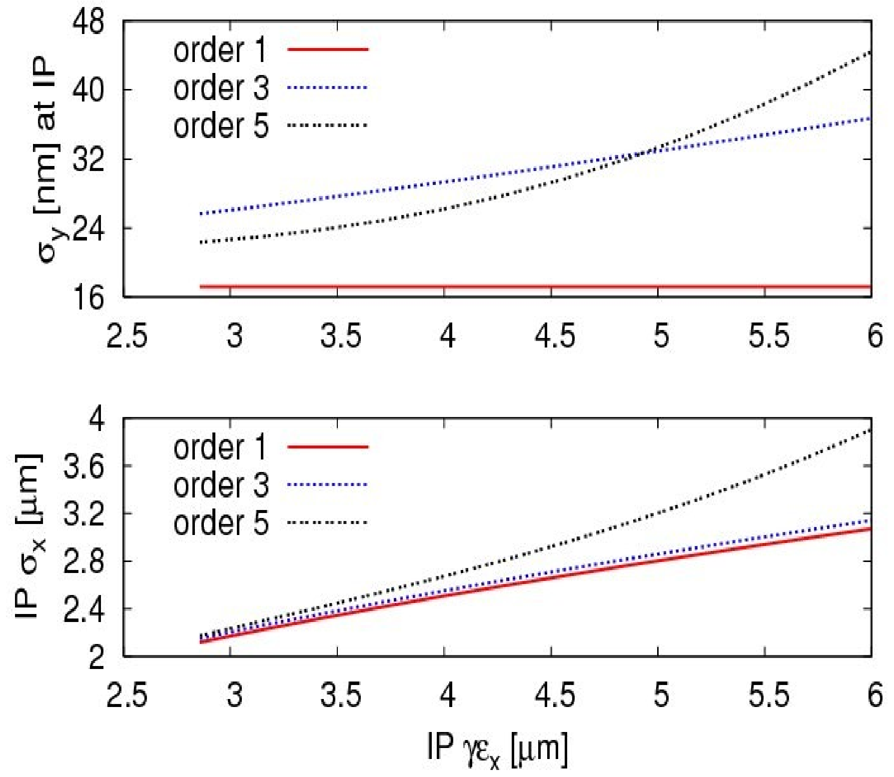
1.2 SOLUTIONS

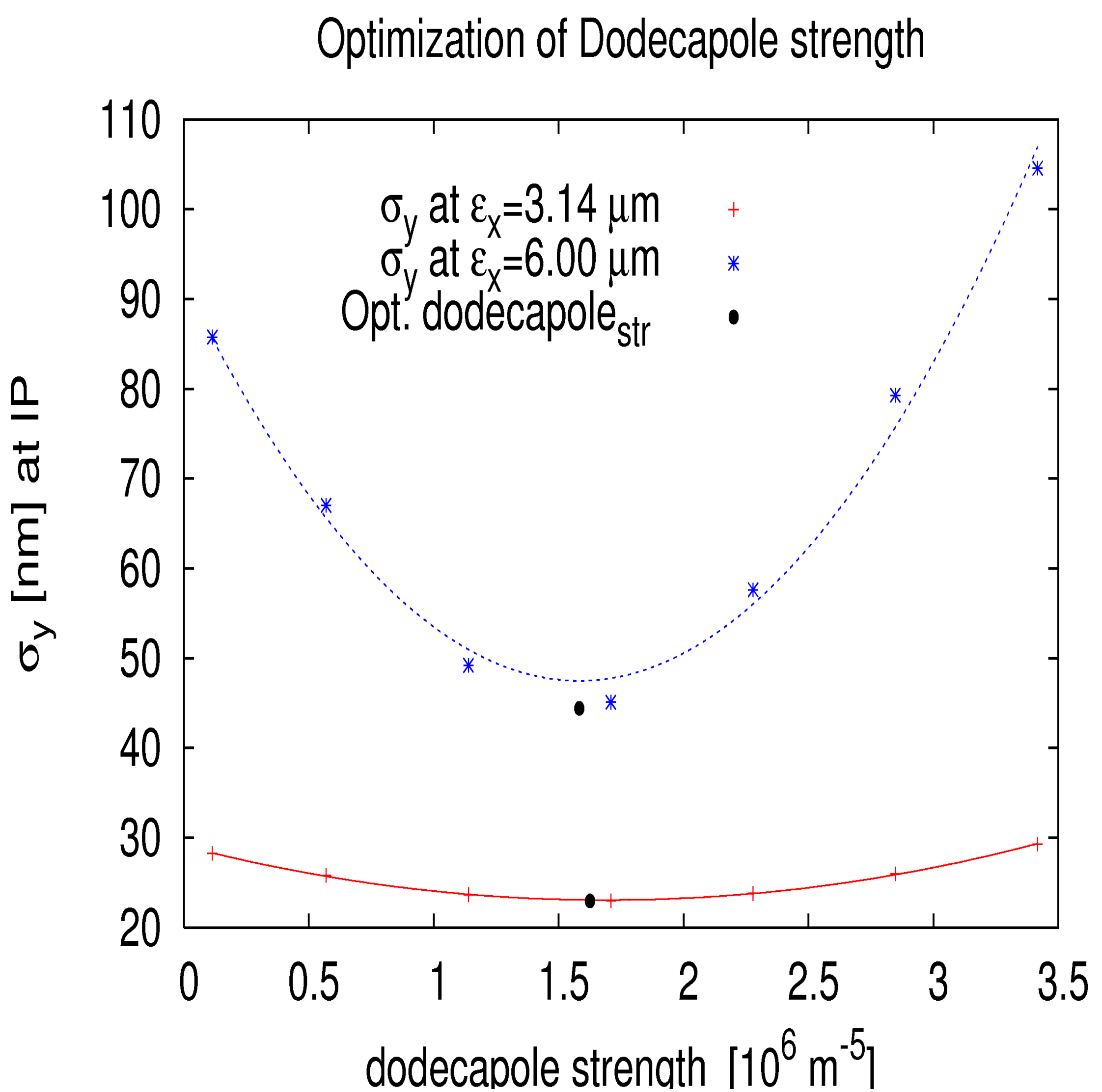
- Possible solutions...
  - Insert a Dodecapole Magnet.
  - Develop a New lattice increasing β_x.

NOTE: same kind of solutions were used for the study of ATF2 Nominal Lattice with multipolar errors, with excellent results.

2.1.2 DODECAPOLE's optimization

- Optimum Dodecapole strength $=1.58 \cdot 10^{6} m^{-5}$



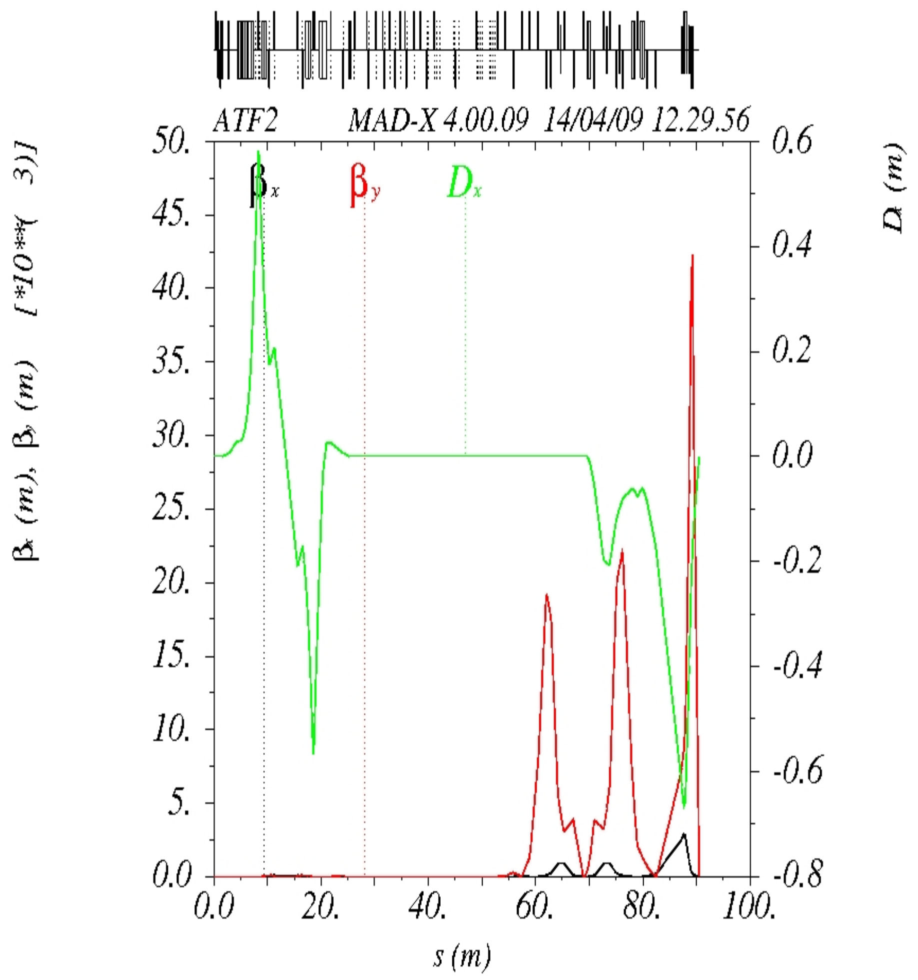


- Optimum IP beam sizes:

$\sigma_{y,\ high} = 44.4$ nm ; $\sigma_{x,\ high} = 3.9$ µm

2.2.1 Matching for a new Ultra Low β_y Lattice.

- <u>Matching via Mad-x & Mapclass</u>
  - Including Multipolar errors.
  - Constraints: increasing βx
  - Variables: Quads & Sexts strengths & SF1 SD0 Tilts

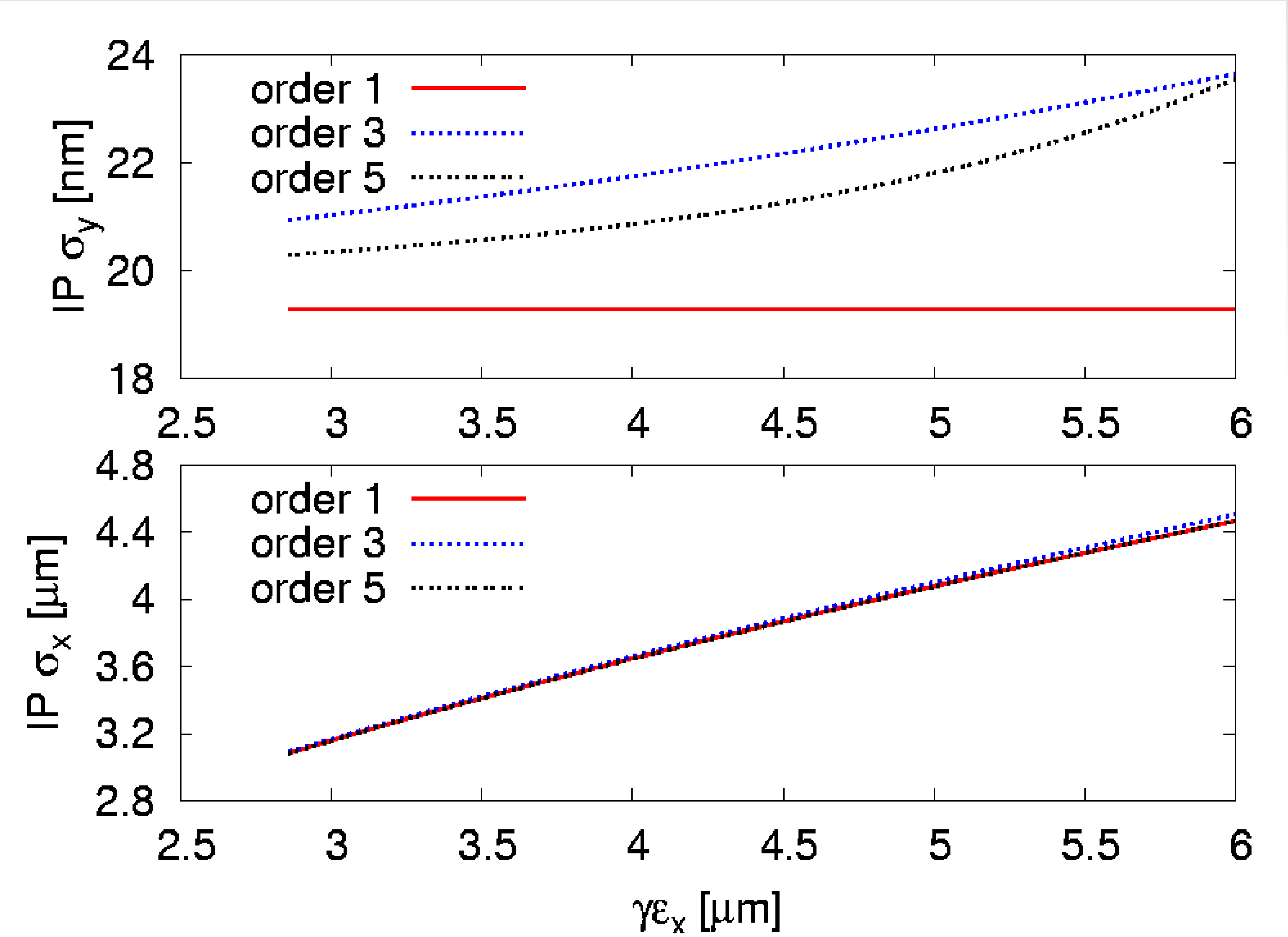


Results:

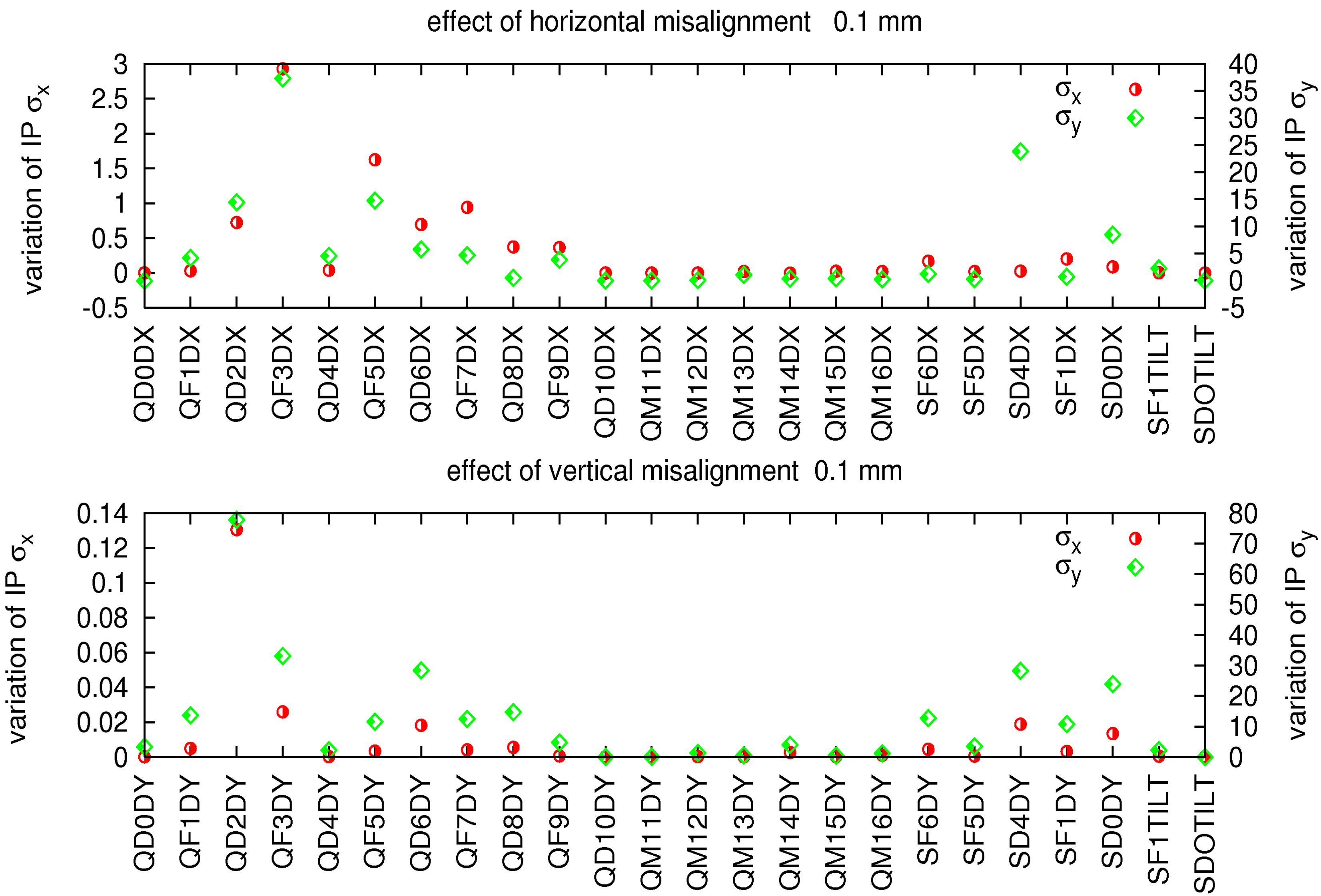
- <u>Beta functions @ IP:</u>
  - $\beta_x = 8.4608$ mm ; $\beta_y = 31.5727$ µm
- <u>Beam sizes @ IP:</u>
  - $\sigma_x = 3.08$ µm ; $\sigma_y = 20.3$ nm

2.2.2 ATF2 Ultra-Low β_y Lattice Properties.

Emittance behavior for ATF2 Ultra-Low β_{y}.



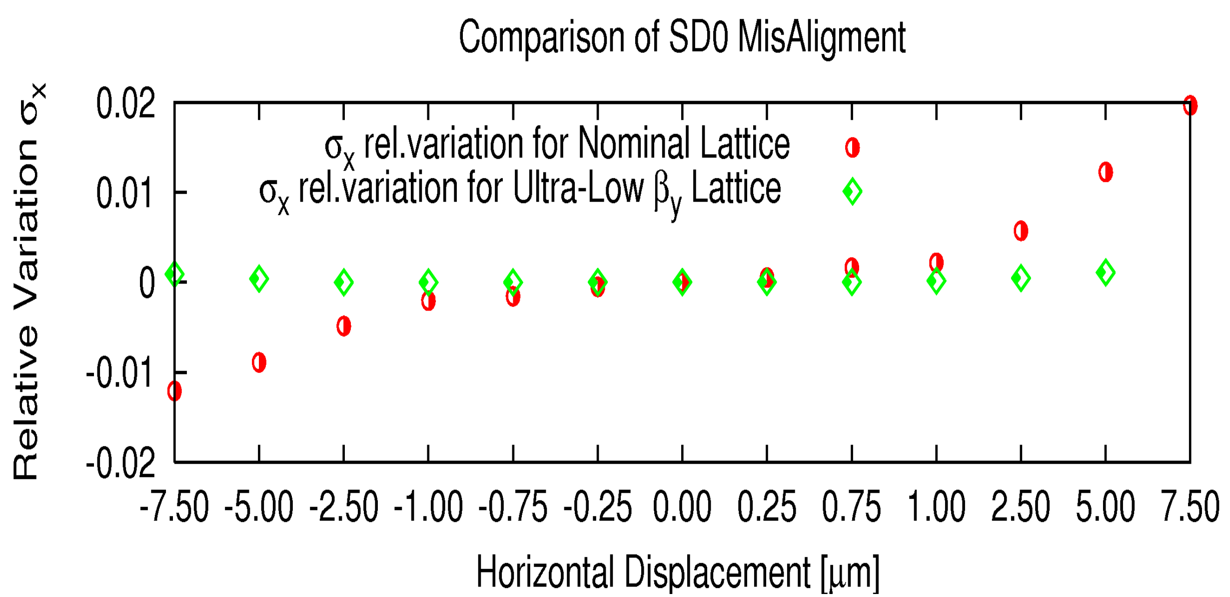
3.1 Effect of Misalignment for ATF2 Ultra-Low β_y

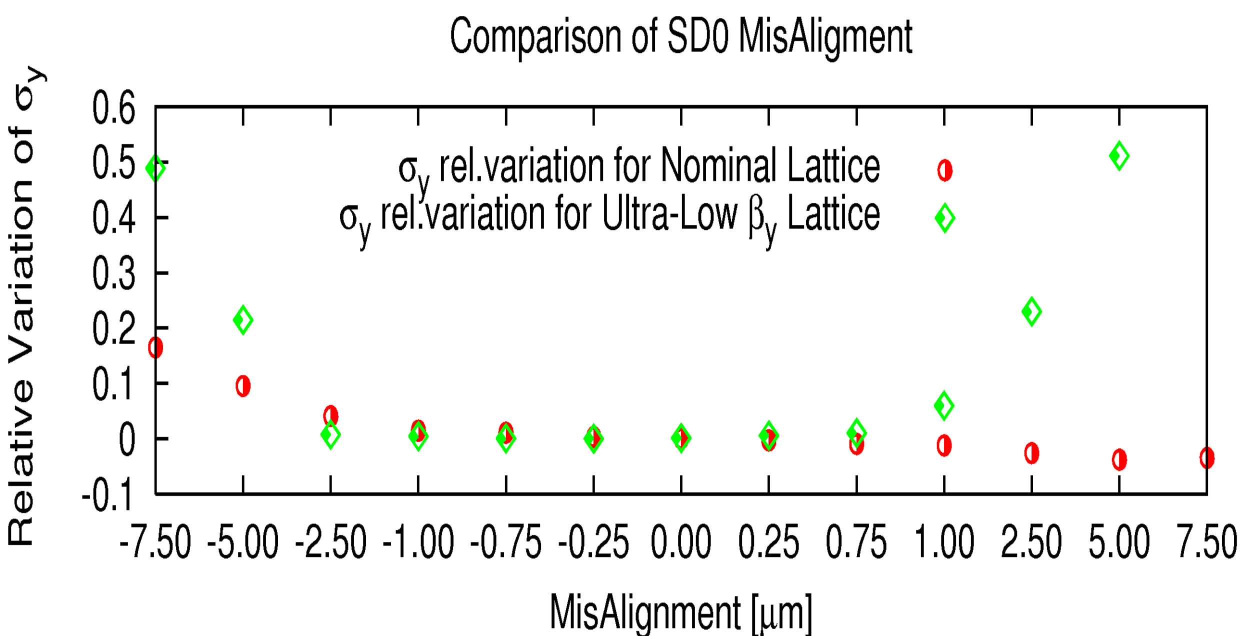


3.2. Linear regime of SD0 Misalignment.

Concerning σ_x:

A wider linear regime for SD0 horizontal displacement in the ATF2 Ultra-low βy.

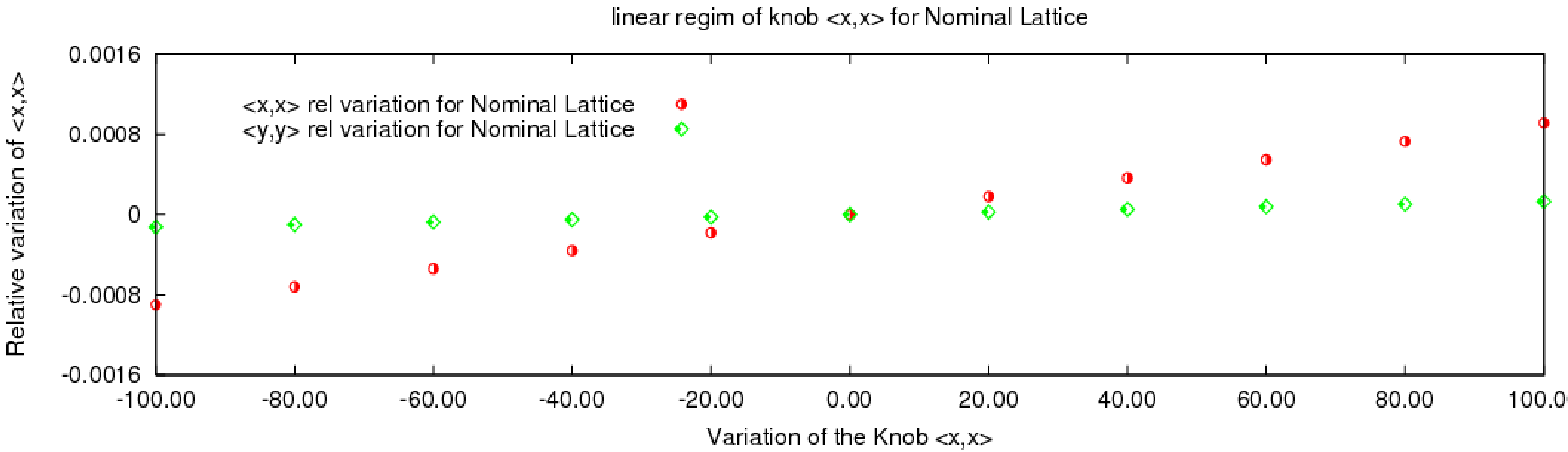


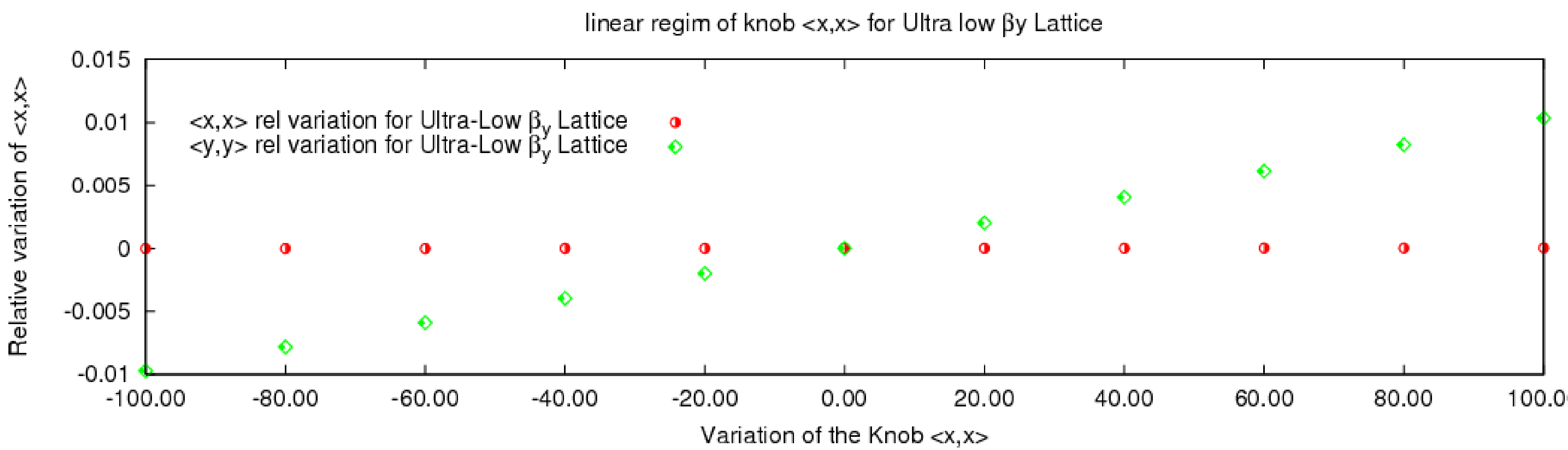


Concerning σ_y:

A short linear regime for SD0 horizontal displacement in the ATF2 Ultra-low βy.

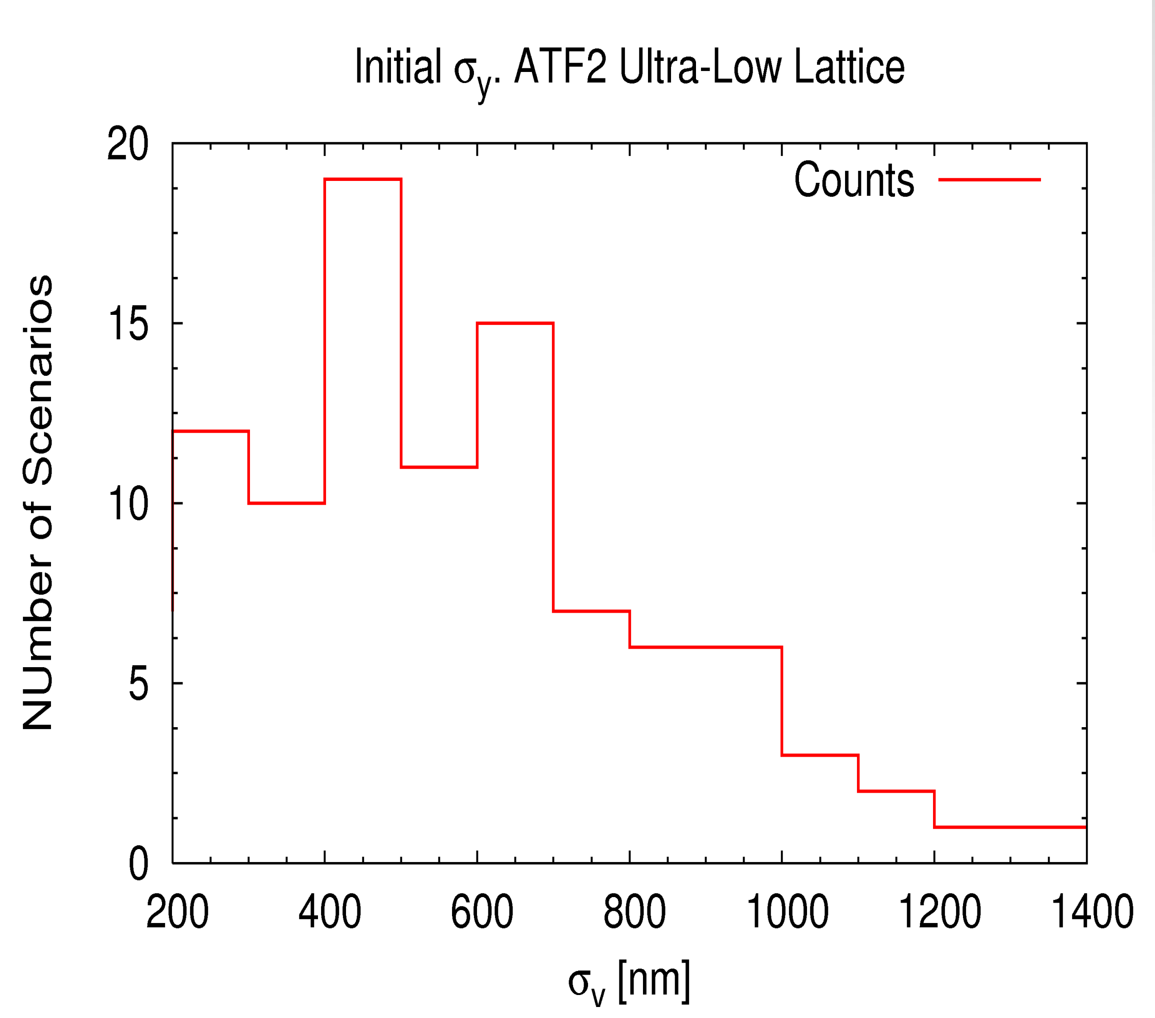
3.3. Effect of Knob (σ_x) for Nominal & Ultra-low Lattice.





4. 1. Description of the Statistical Study

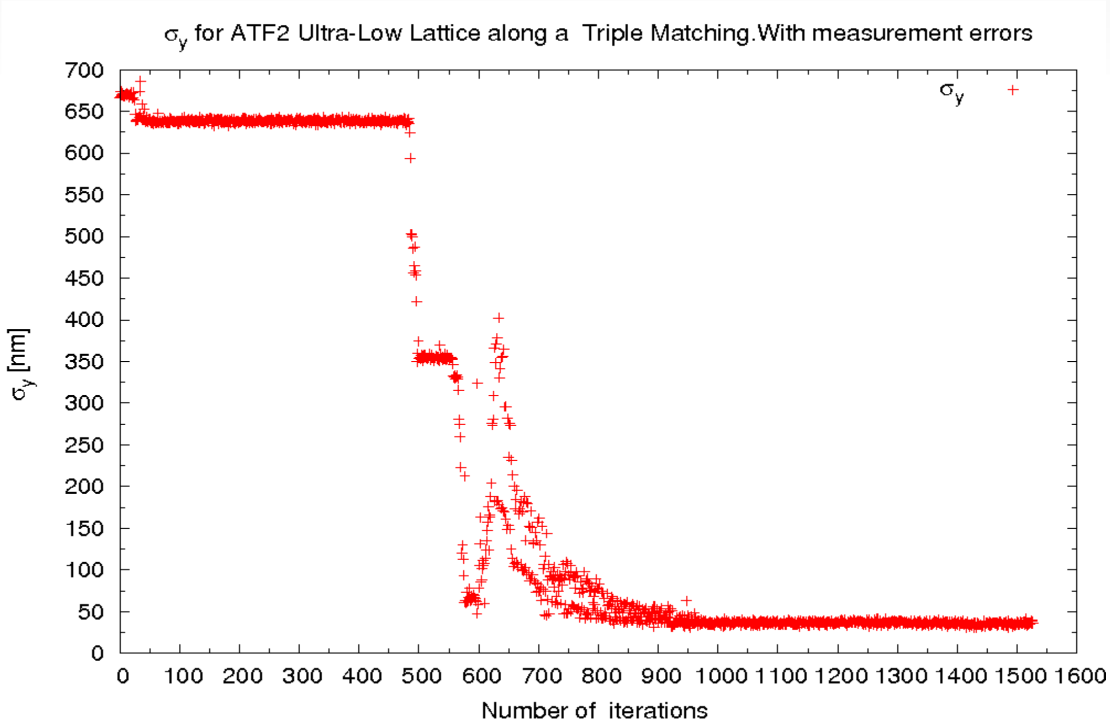
- Tuning via MAD-X & MAPCLASS using Simplex algorithm
- Initial σ_y [0.2 μm , 1.4 μm]
- 100 different seeds.
- Random initial transversal displacements of all quads & Sext: 30 μm
- Tuning by reduced sets of variables.
- Up to 3000 iterations in total.



4.2. Description of the First FFS Tuning.

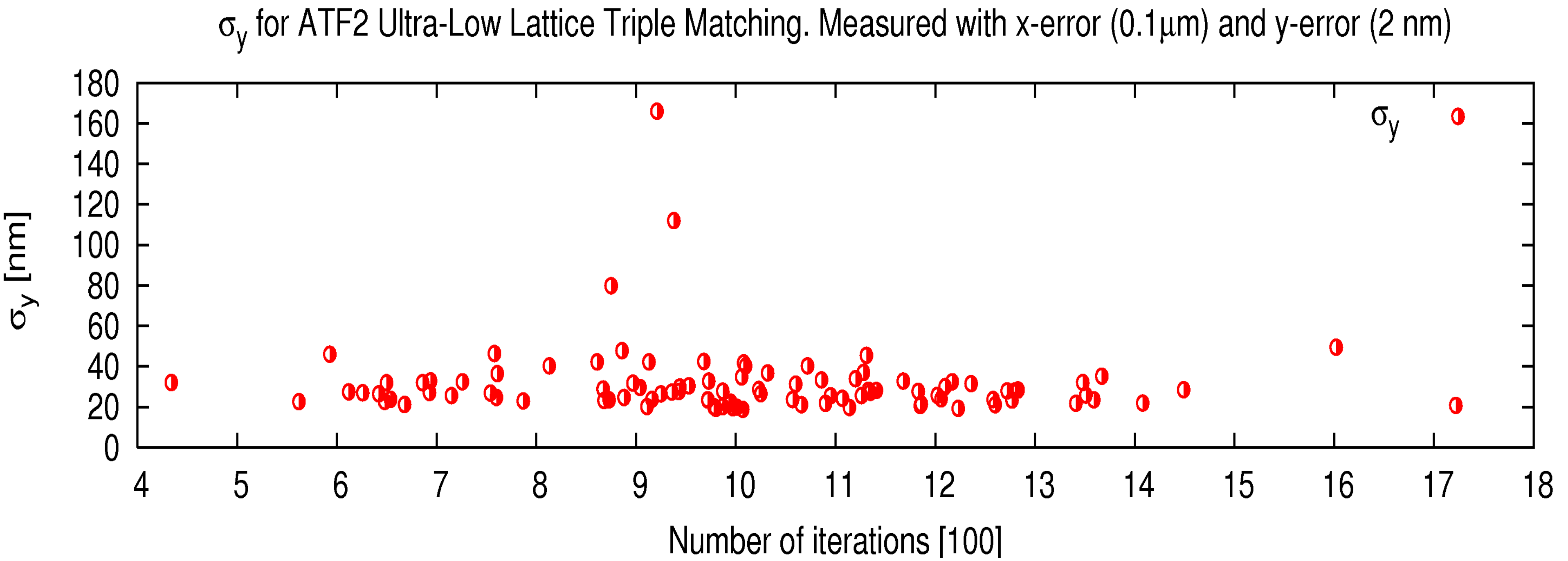
- Tuning via Mad-x & Mapclass using the Simplex algorithm in three blocks
  - Horizontal displacements of Sext. up to 500 iterations.
  - Horizontal displacements of QD0.....QF9 up to 500 iterations.
  - Horizontal and vertical displacements of all Quads & Sext. Up to 2000 iterations

- Assumptions.
  - Including:
    - Multipolar errors.
    - Measurement error: $\sigma_x(1\mu m)$, $\sigma_y(2nm)$
  - Constraint: minimizing σ_y
  - Variables: Transversal Misalignments of Quads & Sext.



- Example Tuning history:
  - 1st Tuning stops at iteration 227.
  - 2nd Tuning stops at iteration 471.
  - 3rd Tuning stops at 1527.

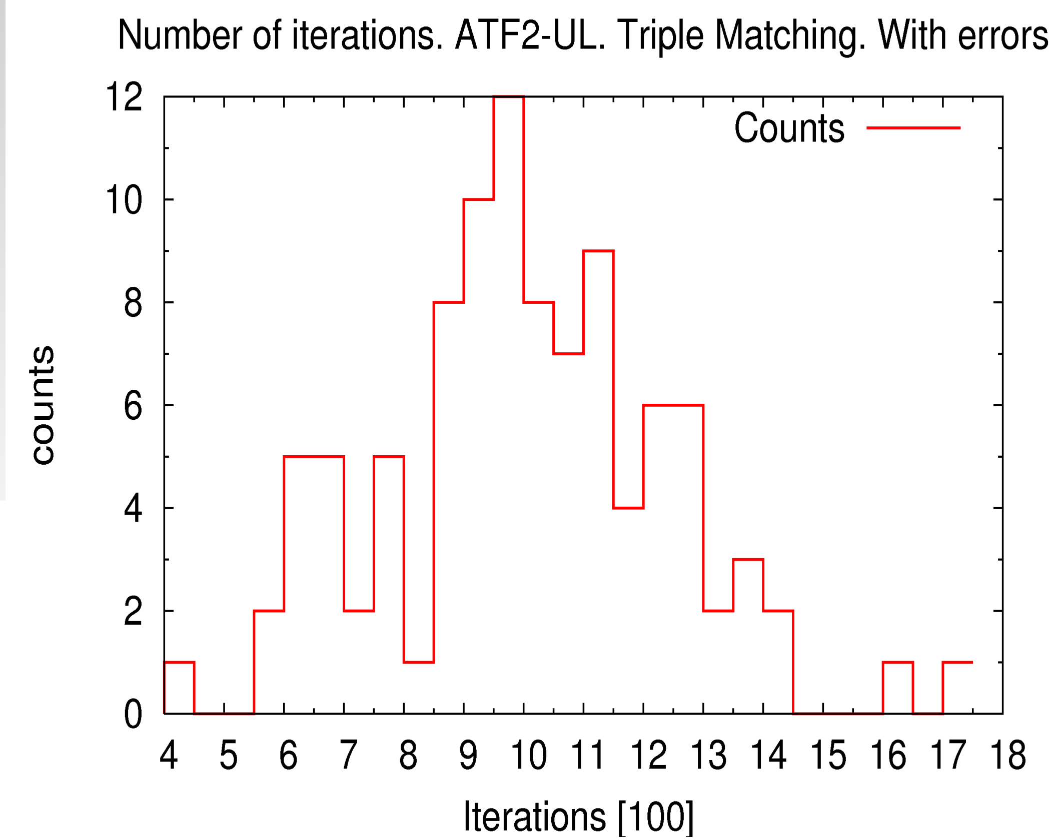
4.3. Results (1).

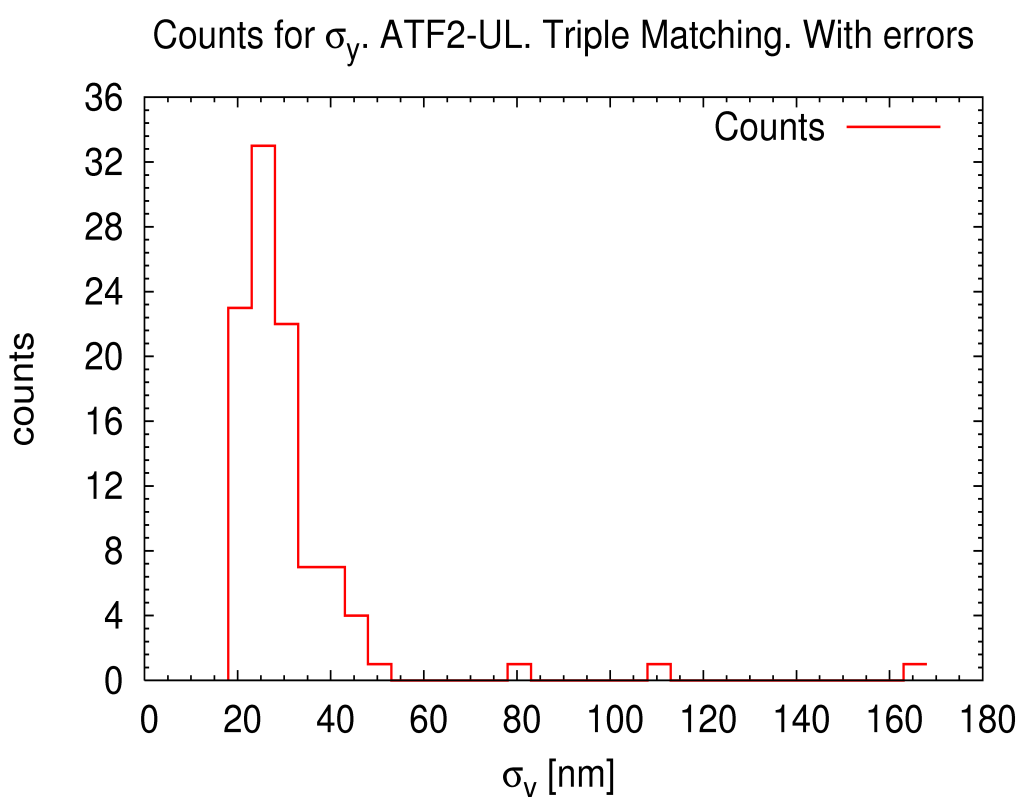


How it can be improved ?

4.4. Results (2).

- Number of iterations needed for convergence around 1000.





- 80% of the scenarios have a final $\sigma_y < 33$ nm

5. CONCLUSIONS & FUTURE PLANS

- The Dodecapole magnet alone solution is not sufficient.
- The ATF2 Ultra-Low β_y Lattice including multipolar errors and Misalignments has been obtained with a final σ_y =23.8 nm.
- Knob generation under development.
- Statistical Tuning Study shows that a reduced Tuning improves the results bringing the 80% of the seeds from 39 nm down to 33nm.

To be done...

- Obtaining valid Knobs for ATF2 Ultra-Low β_y Lattice.
- Improve the matching to obtain the 90% of the seeds close to 20nm.
- Realistic tuning performance with and without knobs.