FFS Alignment and tuning

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Outline

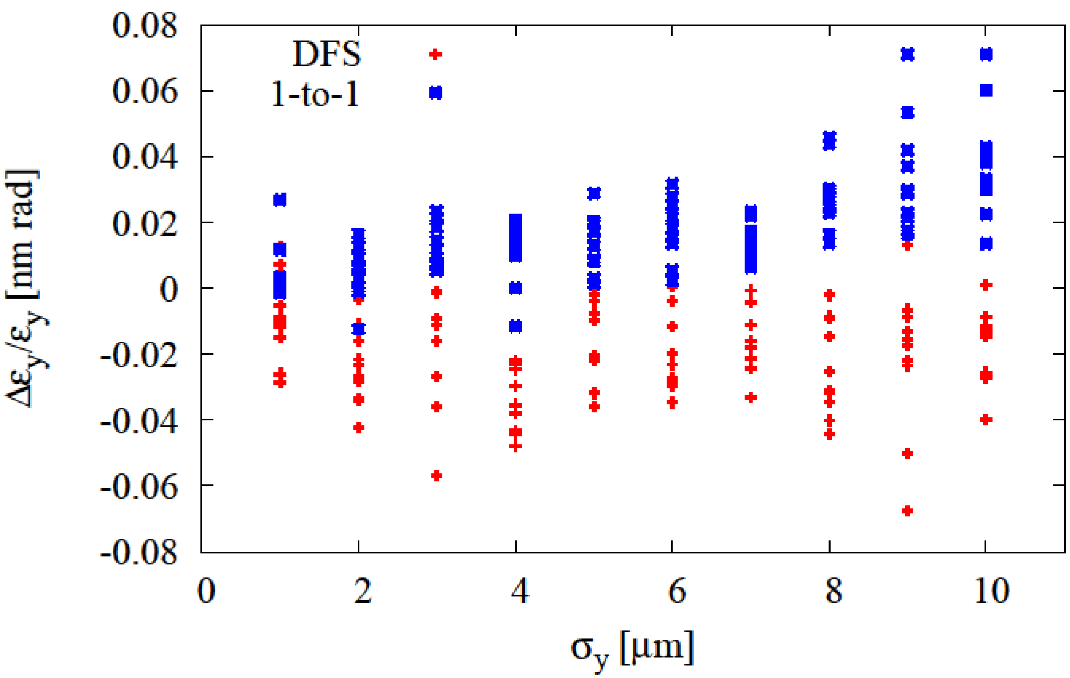
- DFS
  - focus on FFS L* = 3.5 m
- Tuning
  - Understanding the “blind” optimization
  - Comparison between lattices

Dispersion-Free-Steering in the FFS

- DFS recovers few % of the vertical emittance growth
  - nominal emittance ~90 nm rad
  - initial perturbed emittance ~[2×10^2 – 3×10^3] nm rad almost linear with misalignment

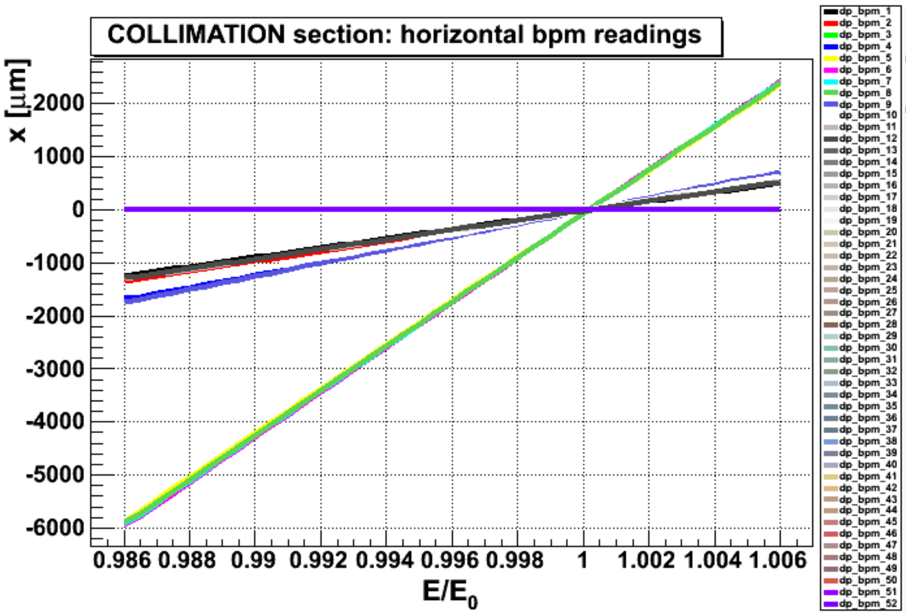
- no clear improvement with initial <rms> misalignment of the magnets

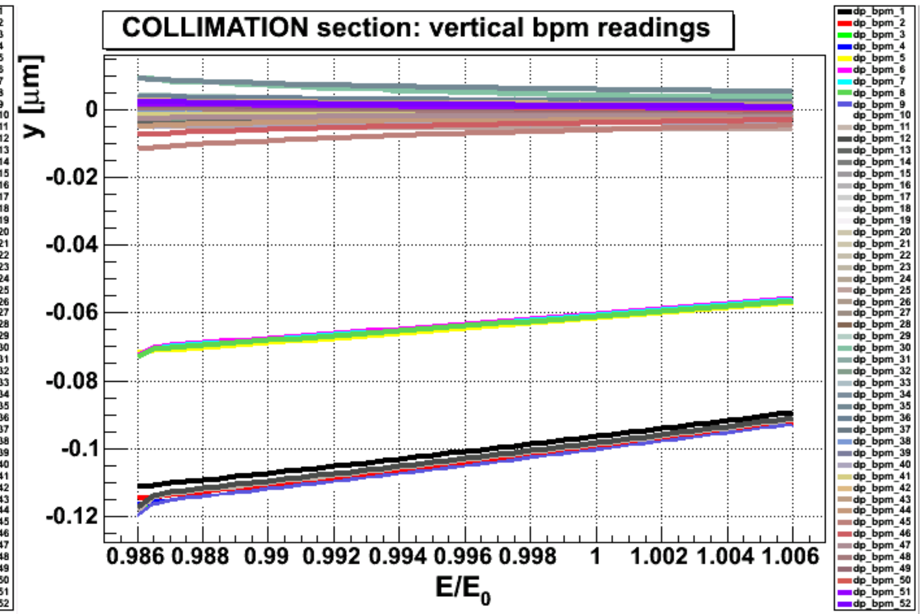
- slightly different values according to the dipole strength used in the response matrix computation

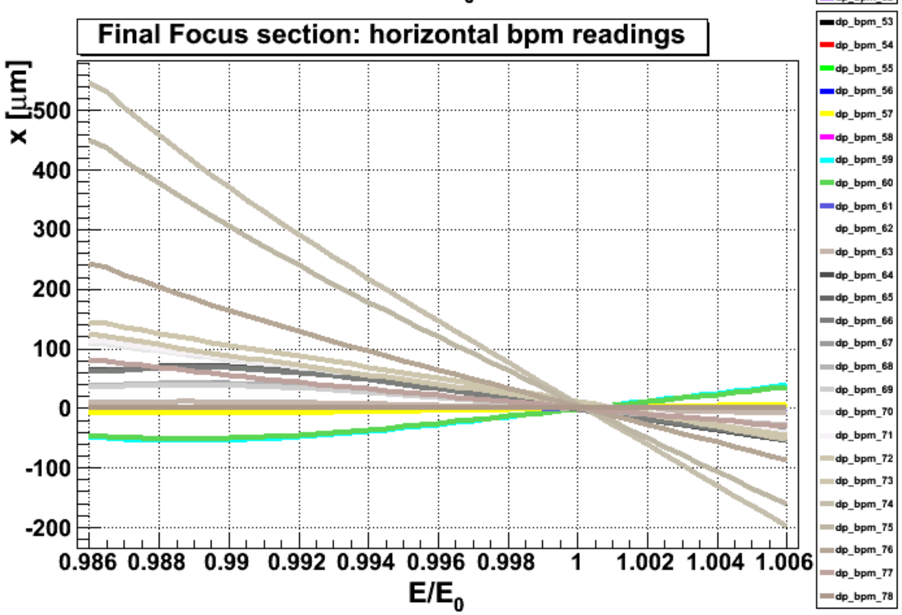


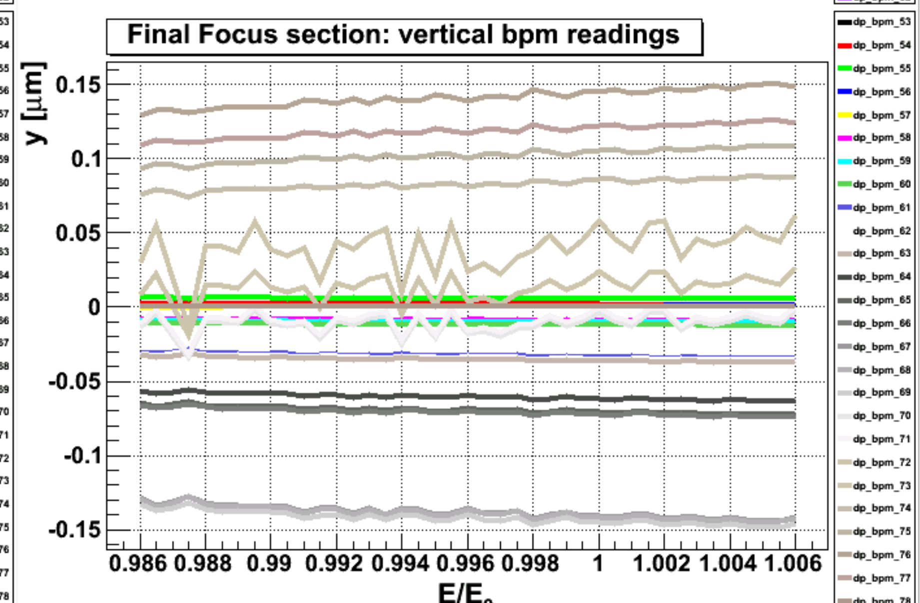
Inputs:
- Bpm resolution 25 nm
- # machines 20
- Dipole strength [0.5:10] nrad
- DFS weight 10
- DFS iter 4
- Δenergy 0.4%
- multipole on in the lattice

BPM readings



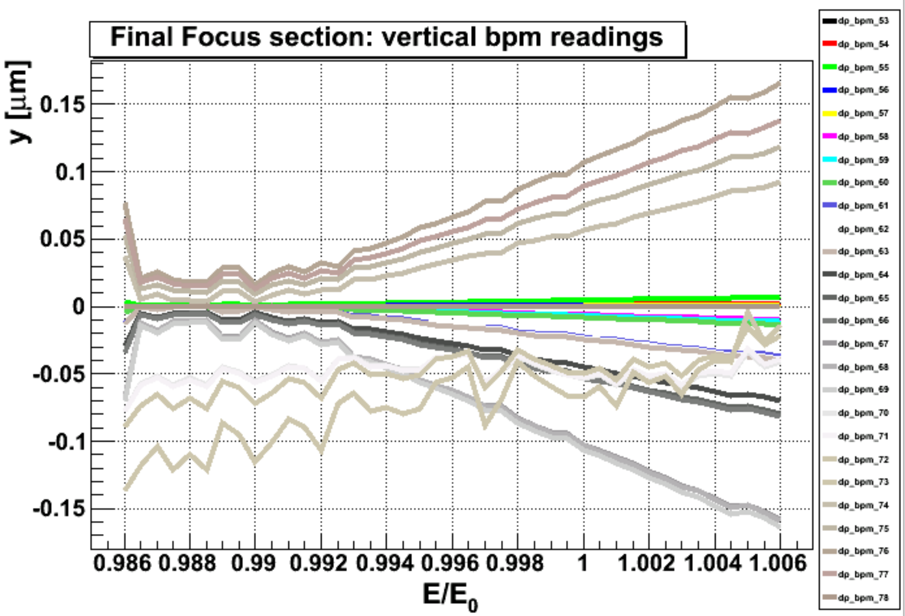




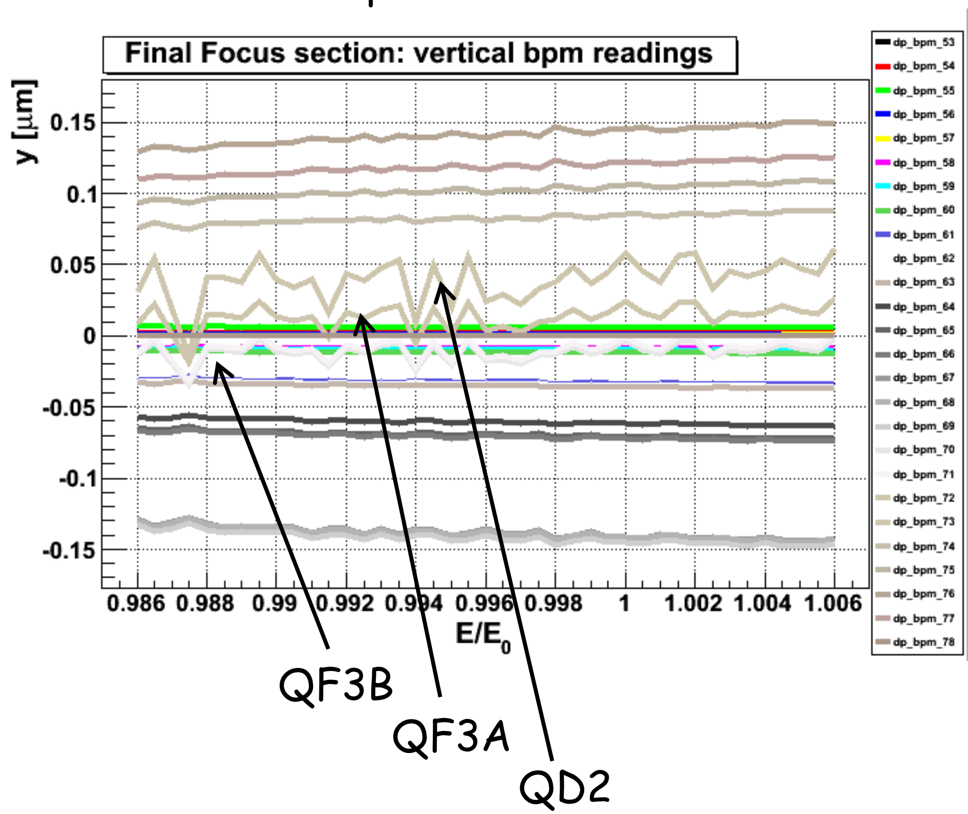


Numerical effect ?

50000 "macroparticles" in the bunch



150000 "macroparticles" in the bunch

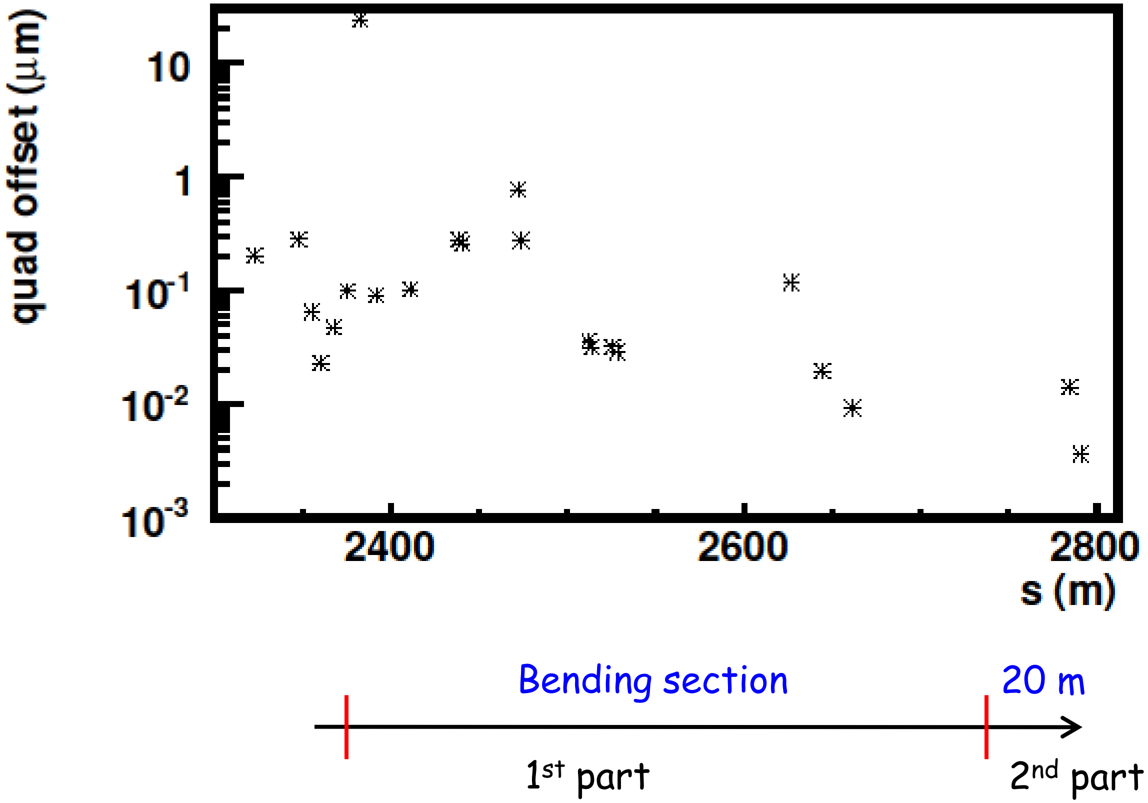


Ideal BPMs

- particles loss ~3% both cases
- 3 noisy BPMs vertical excursion: ~93 nm (150000 mp) ~134 nm (50000 mp)

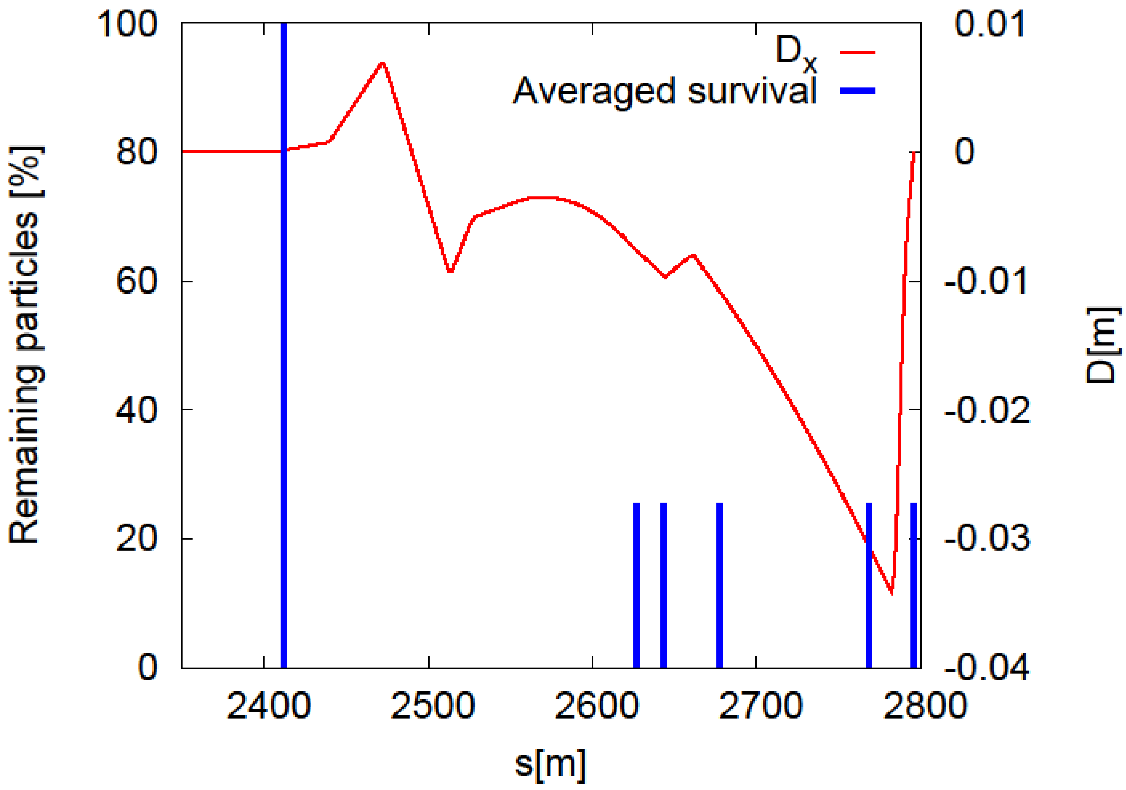
FFS sensitivity

- Vertical offset corresponding to 2% luminosity loss for each single quadrupole of the FFS
- Most sensitive quadrupoles are the last ones



FFS Tuning with apertures

- particles lost in the bending magnets
  ➔ tight horizontal angle acceptance

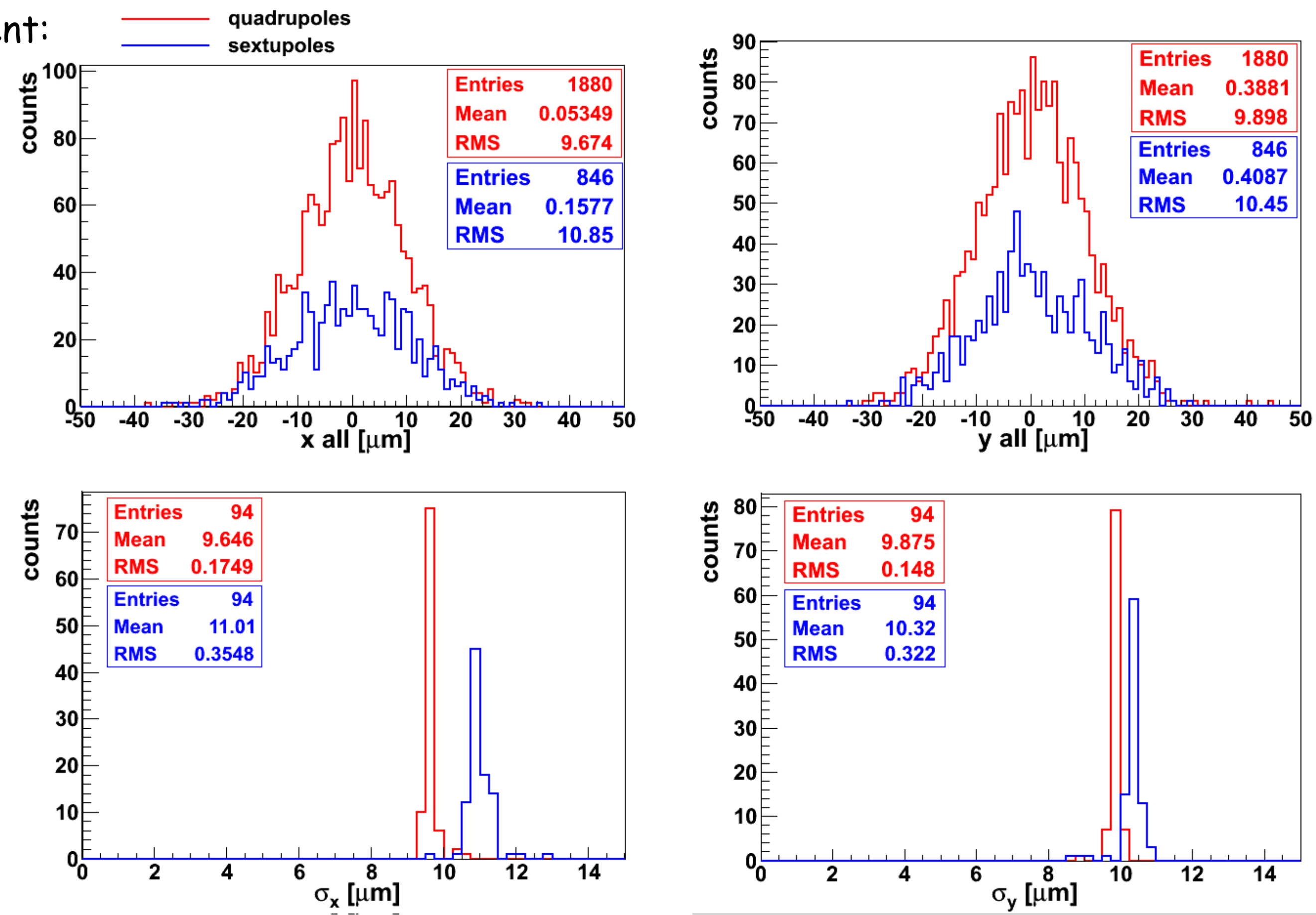


Particles loss minimization

"Level 0" tuning implemented in PLACET (octave interface):

- 🙂 100% particles recovered
- 🙁 luminosity success rate very low (due to huge beam angles at IP)

Final misalignment:



FFS Tuning L* = 3.5 m

split elements

Initial misalignment H 1st and 2nd part [μm]	Initial misalignment V 1st and 2nd part [μm]	Success rate %	comments
10 + 10	10 + 10	57.1	wrong octupole strength ➔ can be slightly better
2 + 10	2 + 10	97.7	wrong octupole strength
2 + 10	10 + 10	52.0	

unsplit elements

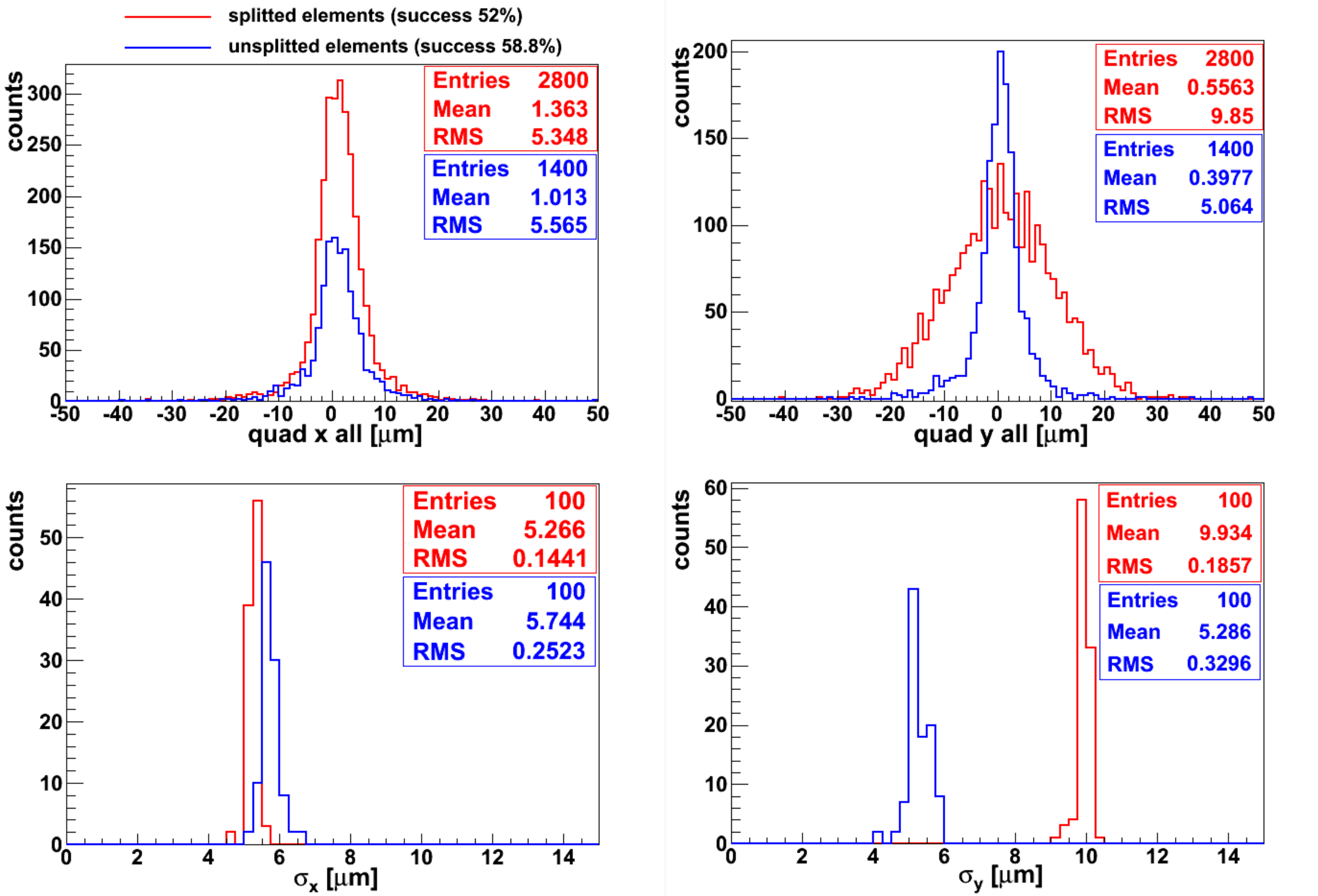
Initial misalignment H 1st and 2nd part [μm]	Initial misalignment V 1st and 2nd part [μm]	Success rate %	comments
10 + 10	10 + 10	52.0	w apertures
2 + 10	2 + 10	86.0*	w/w o apertures
2 + 10	10 + 10	58.8	

* It was 80% with wrong octupole strength

Quad misalignment

Initial misalignment: 2 μm H /10 μm V first part, 10 μm H & V second part

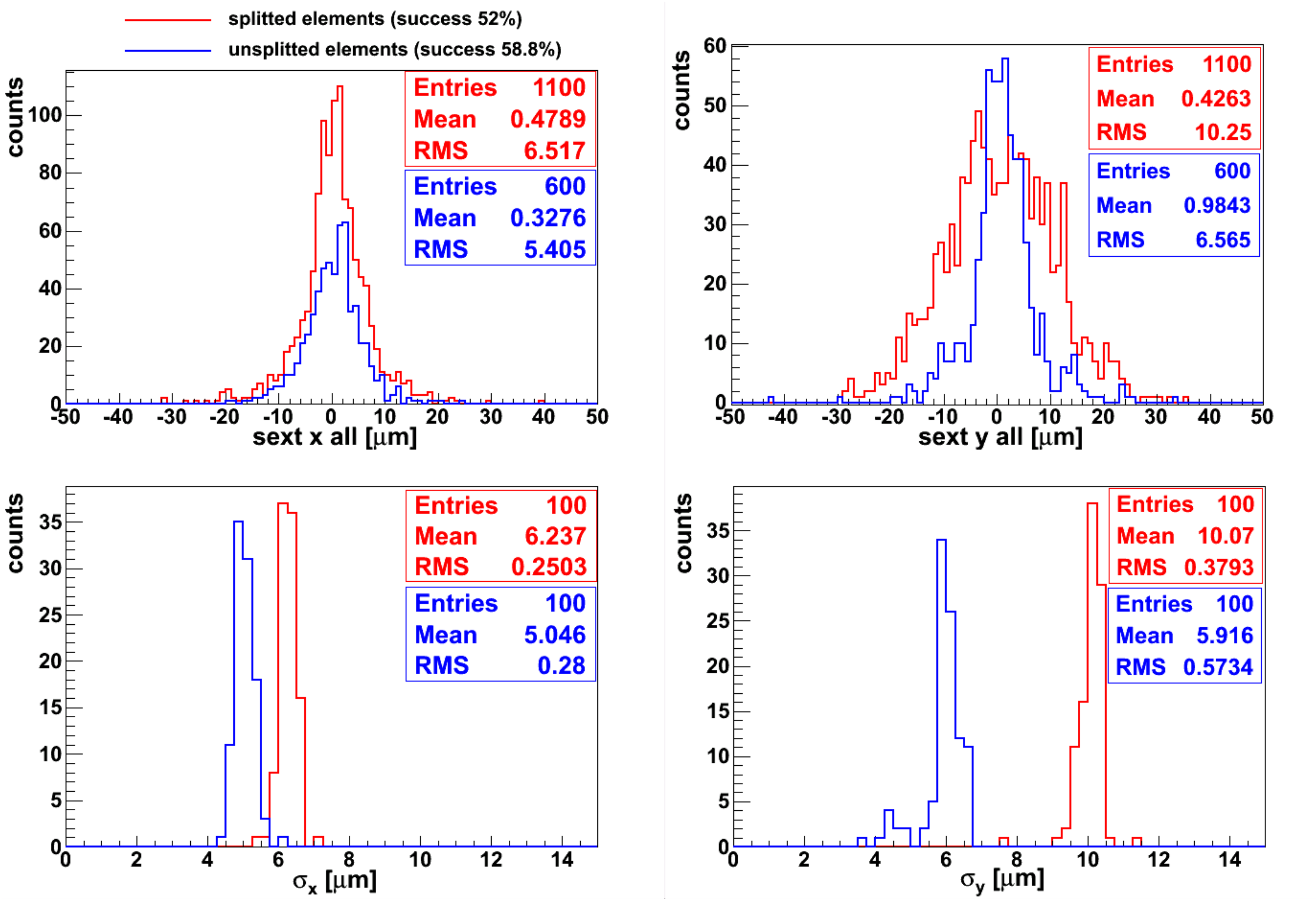
Final misalignment:



Sext misalignment

Initial misalignment: 2 μm H 10 μm V 1st part, 10 μm H & V 2nd part

Final misalignment:



FFSs performance comparison

Initial misalignment H [μm]	Initial misalignment V [μm]	Success rate %	lattice
10	10	52.0*	L* = 3.5 m
10	10	80.0	L* = 4.3 m
8	8	81.6	L* = 6.0 m

* ≅ 80% if normalized to CLIC nominal luminosity

Conclusions

- Simulations of bpm readings based techniques not trivial for the CLIC FFS (due to noise)
- Blind luminosity tuning promising
- L* =3.5 m lattice gives the highest luminosity but is less performing than 4.3 m
- Split elements may help to reduce the sensitivity to misalignments

Next steps

- intermediate matching points
- ballistic alignment ?
- quad shunting
- more complex techniques