FFS tuning overview

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Outline

- Motivation
- FFS tuning
- FFS tuning knobs (preliminary)
- Conclusions and outlooks

Emittance preservation in the CLIC BDS

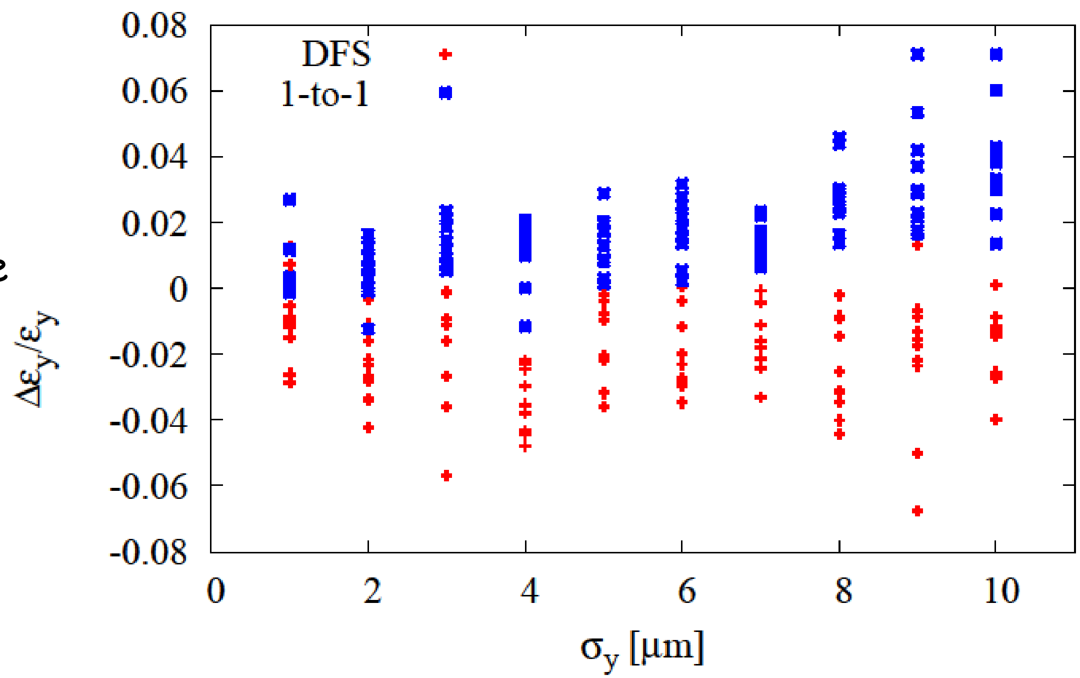
- Control beam blow-up due to static imperfections
  - so far we have dealt with magnet's displacements only
- Dispersion-free-steering algorithm works well in the Collimation section of the BDS (A.Latina et al., CLIC-Note-753)
- FFS is a highly non linear system
  - Traditional algorithms fail to preserve the emittance growth in the FFS
  - Emittance is not a good figure of merit
  - Beam sizes and luminosity are better "reference"

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

FFS tuning

Strategy

- Maximize luminosity (Simplex-Nelder algorithm)
- The positions of all magnets used as correctors (except bending magnets)
- All magnets mis-aligned (except bending magnets)

Assumptions

- Pre-alignment accuracy: 10 μm rms over all FFS
- Two identical machines in simulation
- Orbit feedback working

Results for the 3 TeV lattices

pre-alignment H&V [μm]	Relative Success rate %	Absolute Success rate %	lattice	comments
10	55	80	L* = 3.5 m	nominal
10	58	84	L* = 3.5 m	Higher energy bandwidth*
10	--	80	L* = 4.3 m	
8	81	90	L* = 6.0 m	

* by G. Zamudio

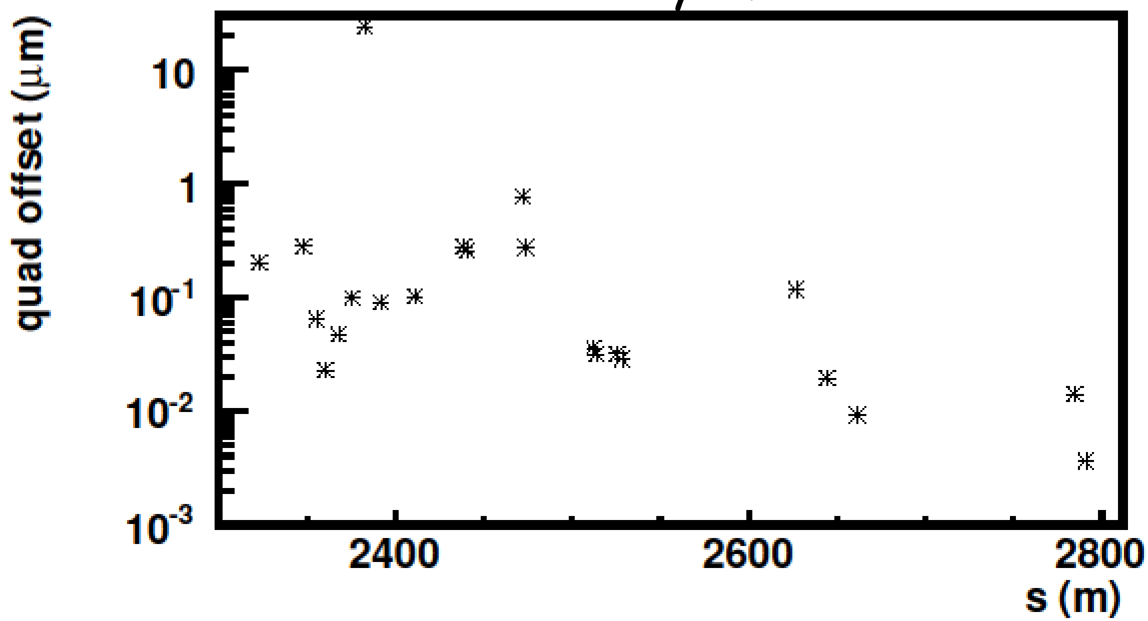
Relative success rate : normalized to the machine optimum luminosity
Absolute success rate : normalized to nominal CLIC luminosity

Target: 80% of total luminosity

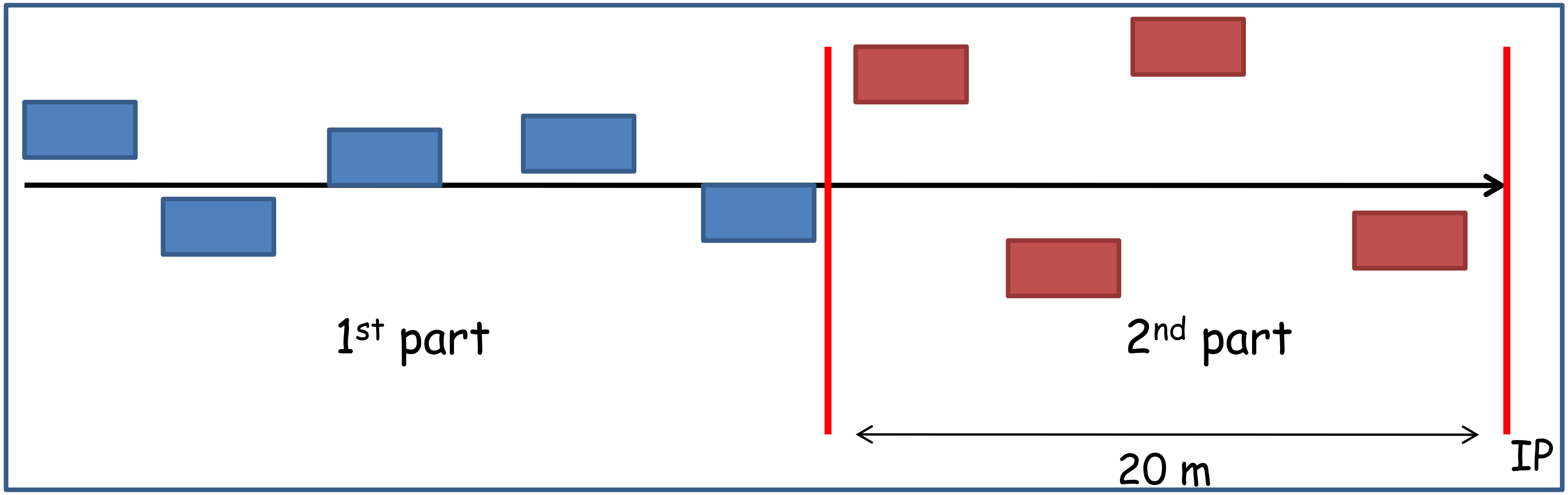
Understanding the FFS

- FFS sensitivity (defined as 2% of luminosity loss) to quadrupole vertical displacement from some μm to some nm (final doublet magnets)
- ~3 order of magnitude different sensitivity between first magnets and last 20 m of FFS

Courtesy of J. Snuverink



Tuning with different magnets displacement

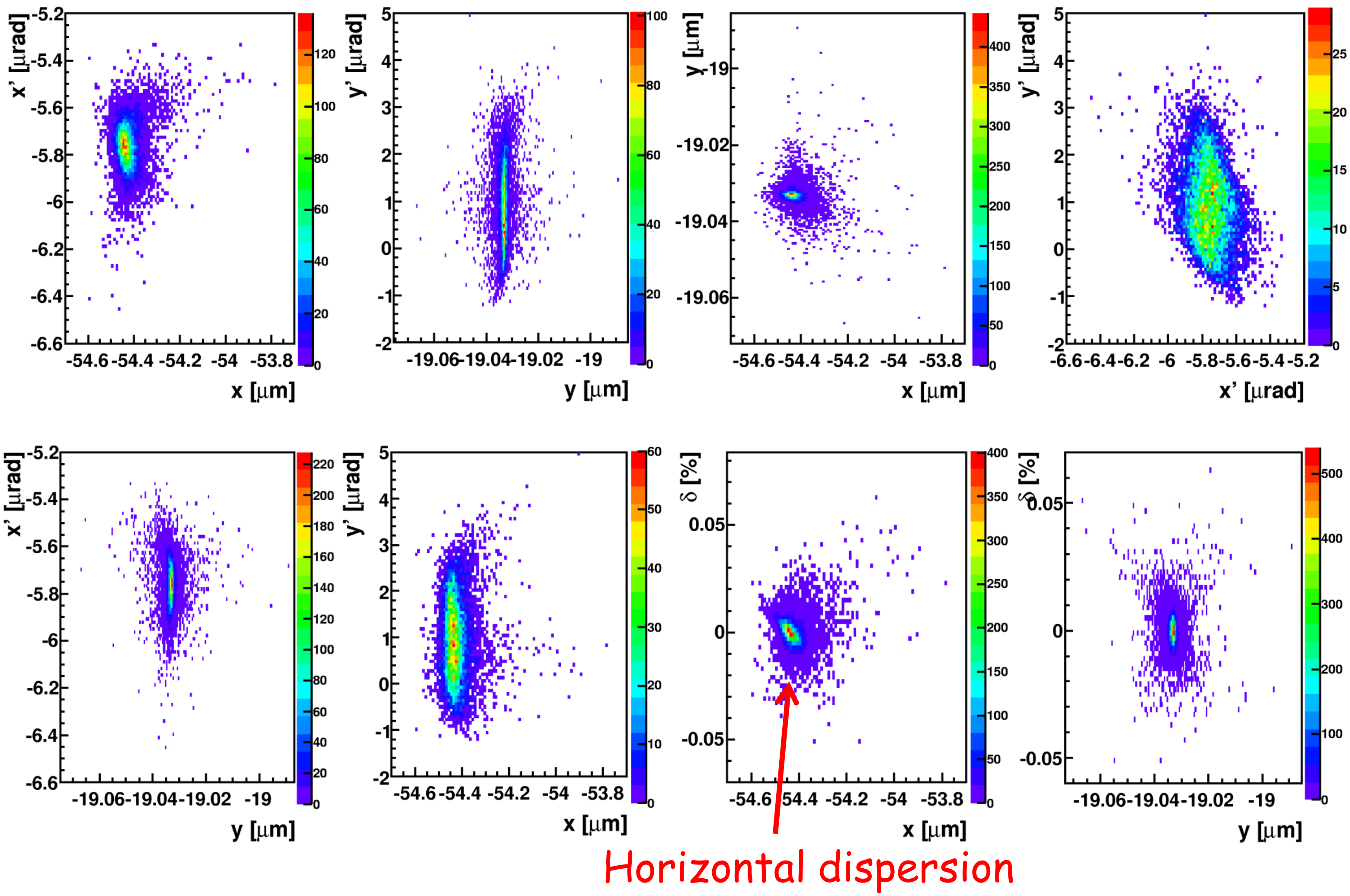


pre-alignment H&V [μm]	Relative Success rate %	Absolute Success rate %	lattice	comments
10	55	80	L* = 3.5 m	nominal
2+10	86	~100	L* = 3.5 m	
2+20	61	87	L* = 3.5 m	

10 μm rms mis-alignment in the final doublet region is recoverable!

Particle by particle correlations

One seed after tuning with less then 80 % of luminosity compared to nominal bunch



Tuning knobs for the CLIC FFs

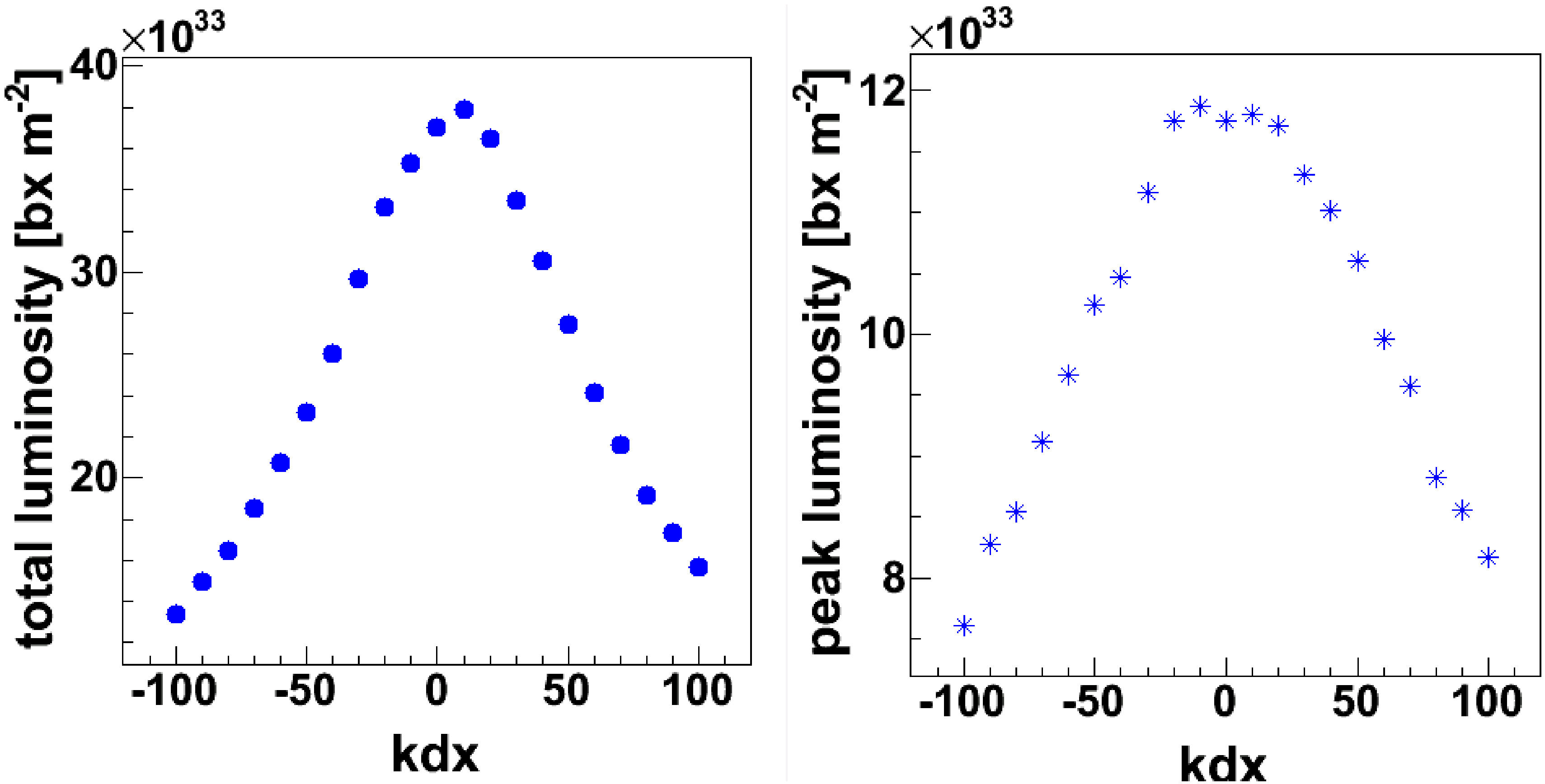
	SF6	SF5	SD4	SF1	SD0
kbx	5.0896e-08	8.3265e-08	1.9497e-08	-5.1030e-09	-8.3832e-09
kby	2.4419e-08	-4.6016e-08	-6.824e-08	2.6682e-08	4.3790e-08
kax	-7.4743e-08	-6.4241e-08	-1.1848e-08	1.0964e-08	5.0877e-09
kay	-3.7286e-08	3.7516e-08	7.4639e-08	-2.1017e-08	-3.4491e-08
kdx	-1.0938e-08	8.6757e-08	2.5068e-08	4.8439e-08	9.5420e-10

E. Marin

Procedure (preliminary):

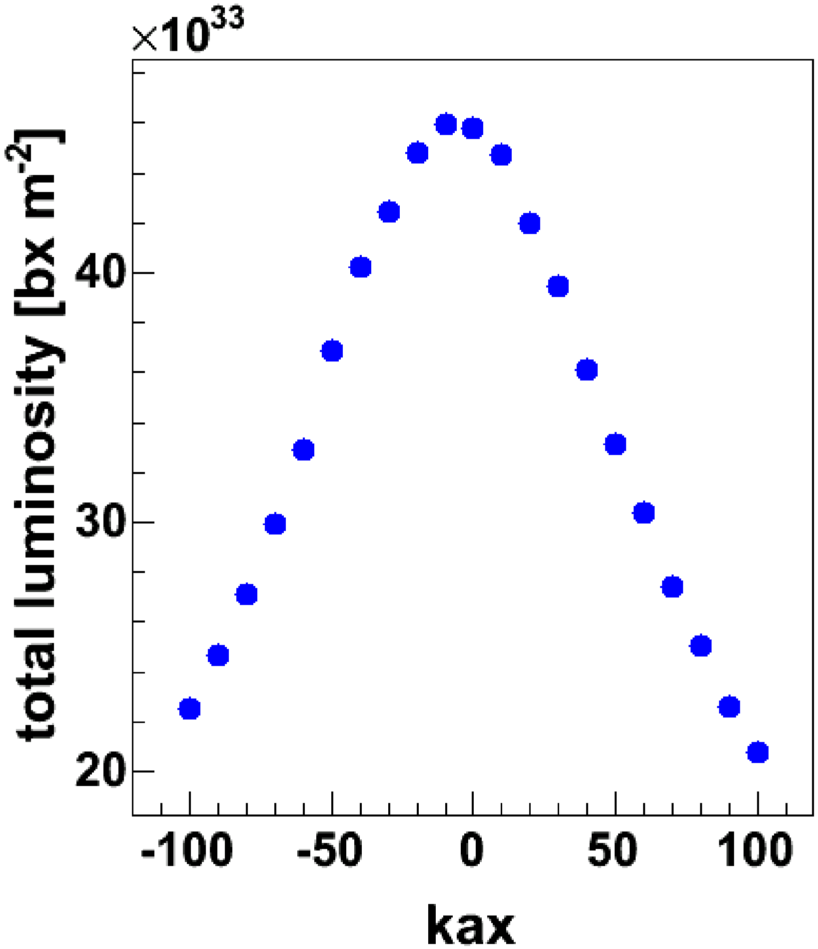
- scan of the knobs one by one starting always from the 100 different machines after tuning
- find the best knobs value for each machine
- apply the best values one by one and all together

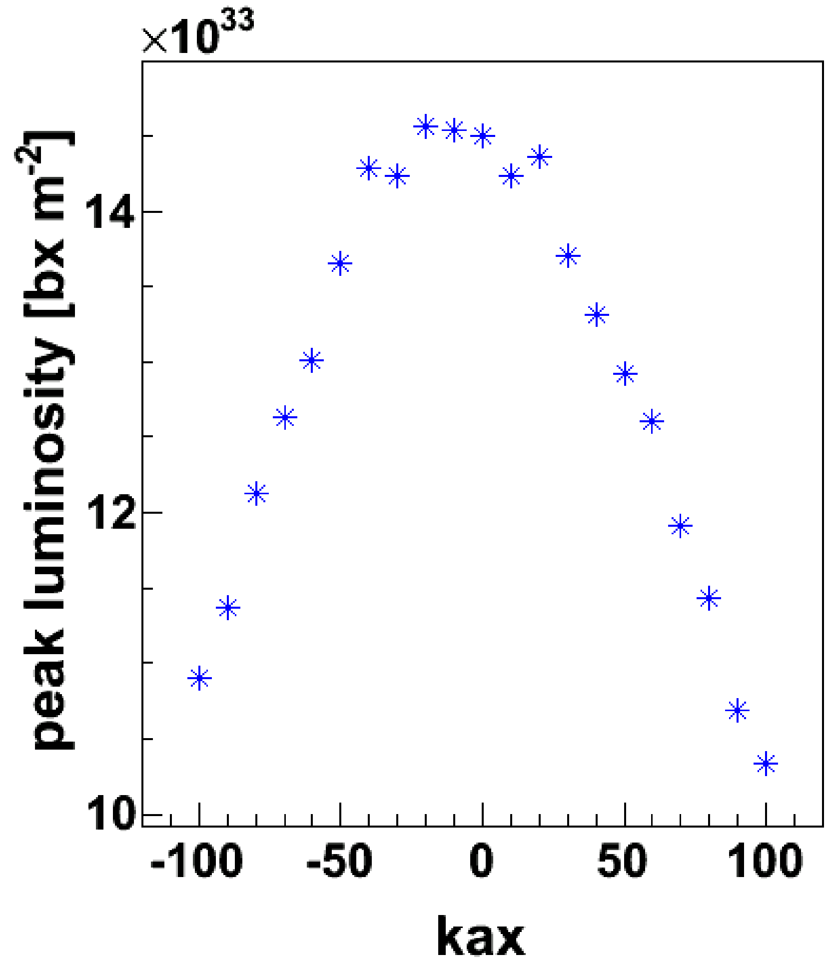
Horizontal dispersion knob scan



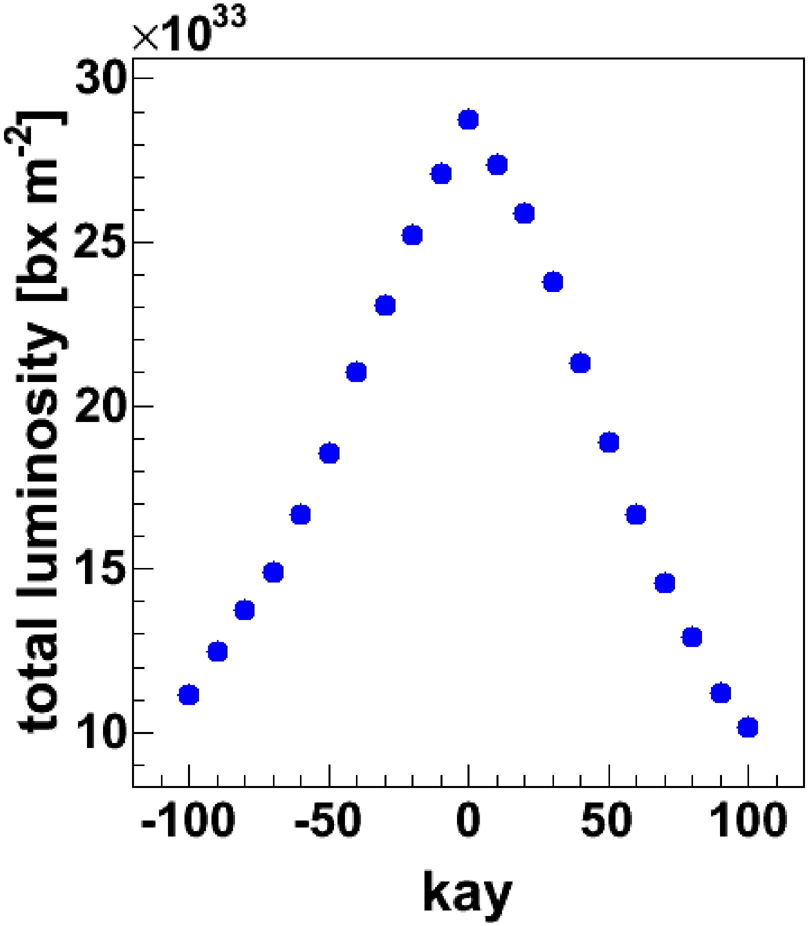
Maximum value of total luminosity taken

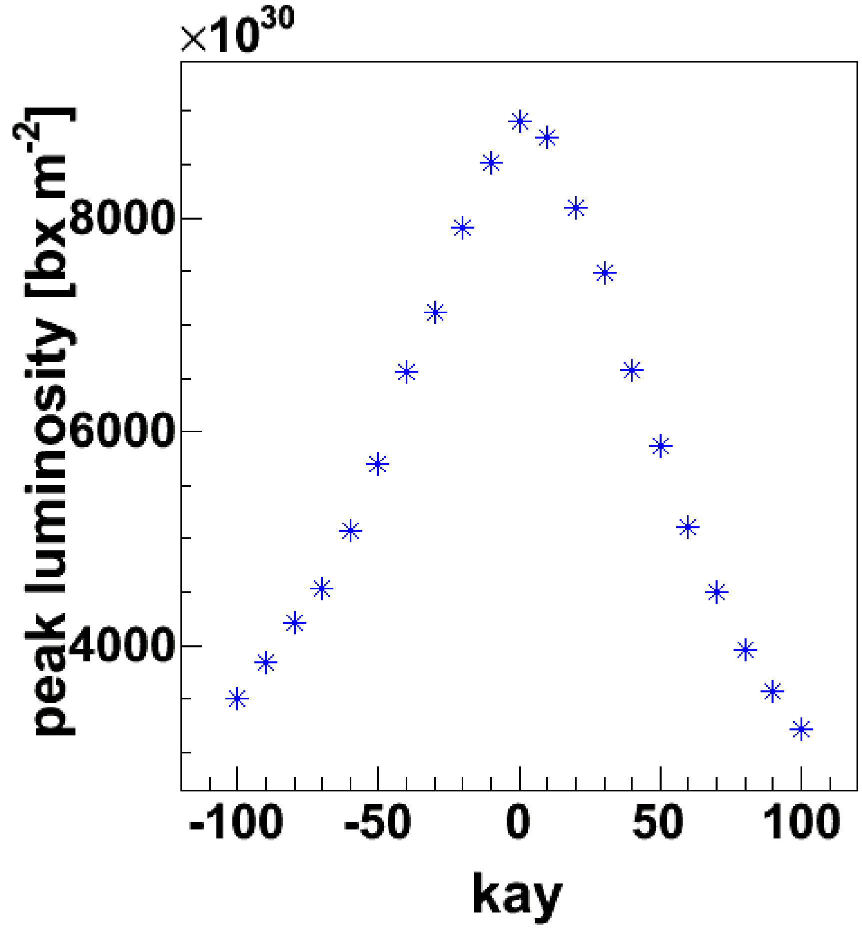
αx knob scan





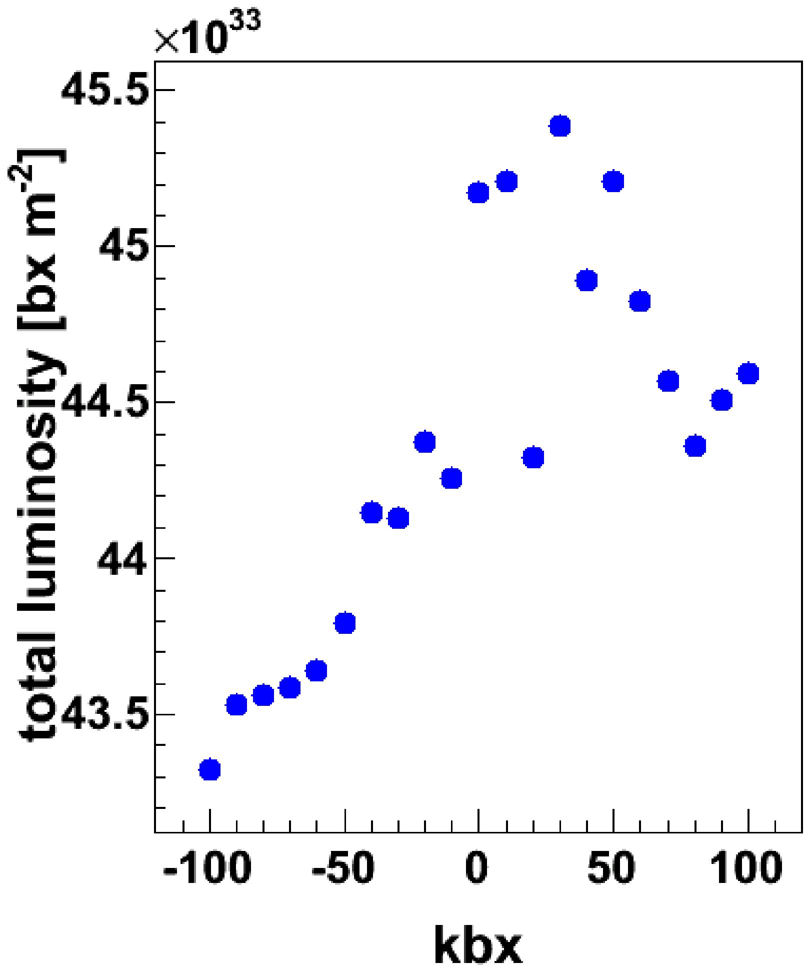
αy knob scan

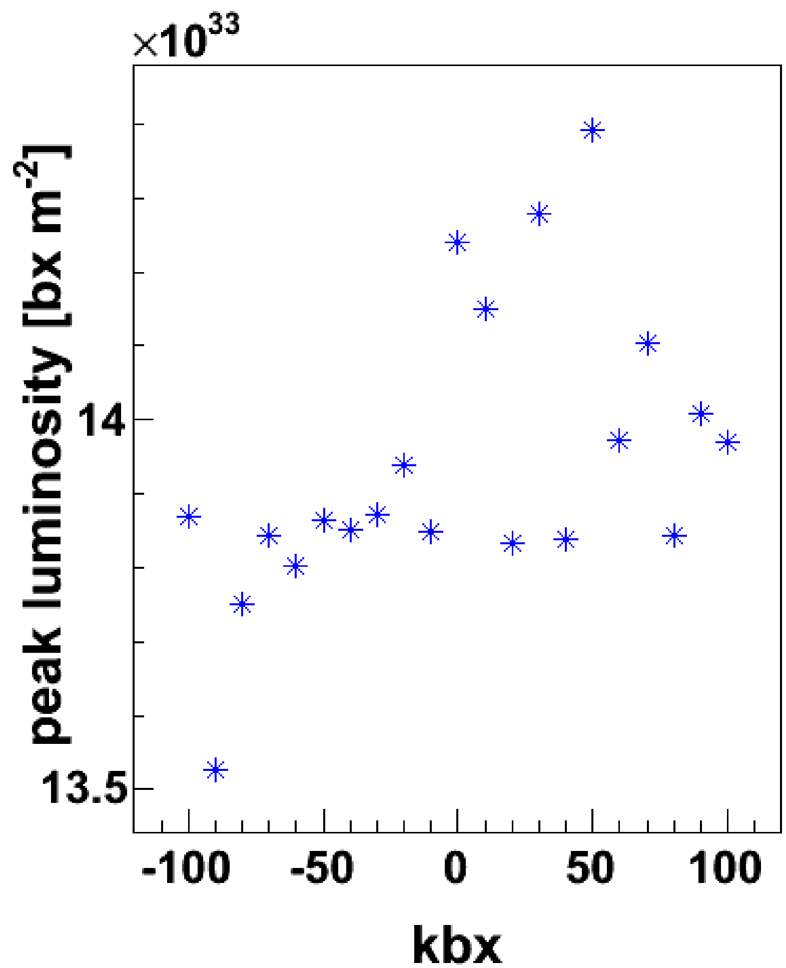




Almost all the seed are well centered at 0

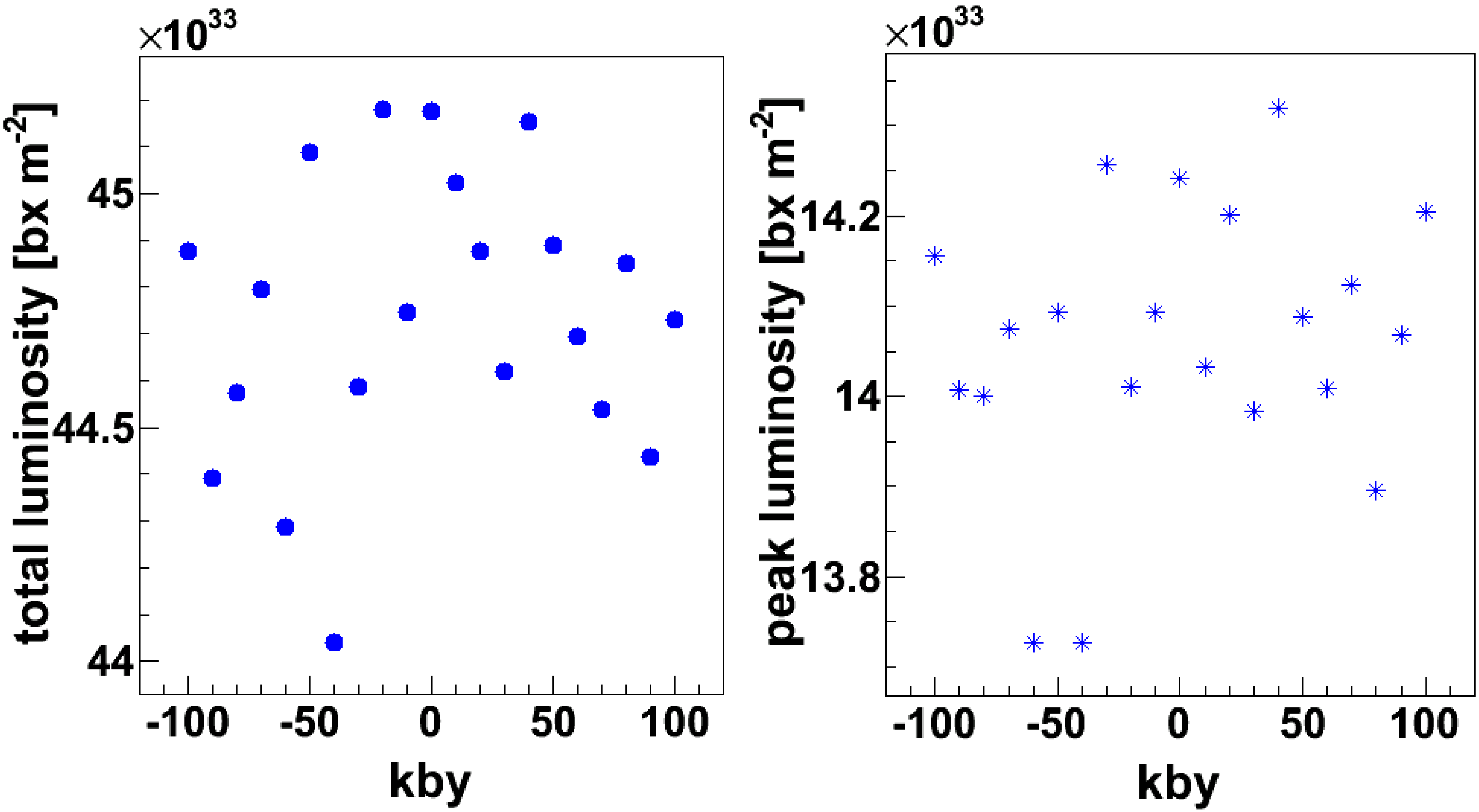
βx knob scan





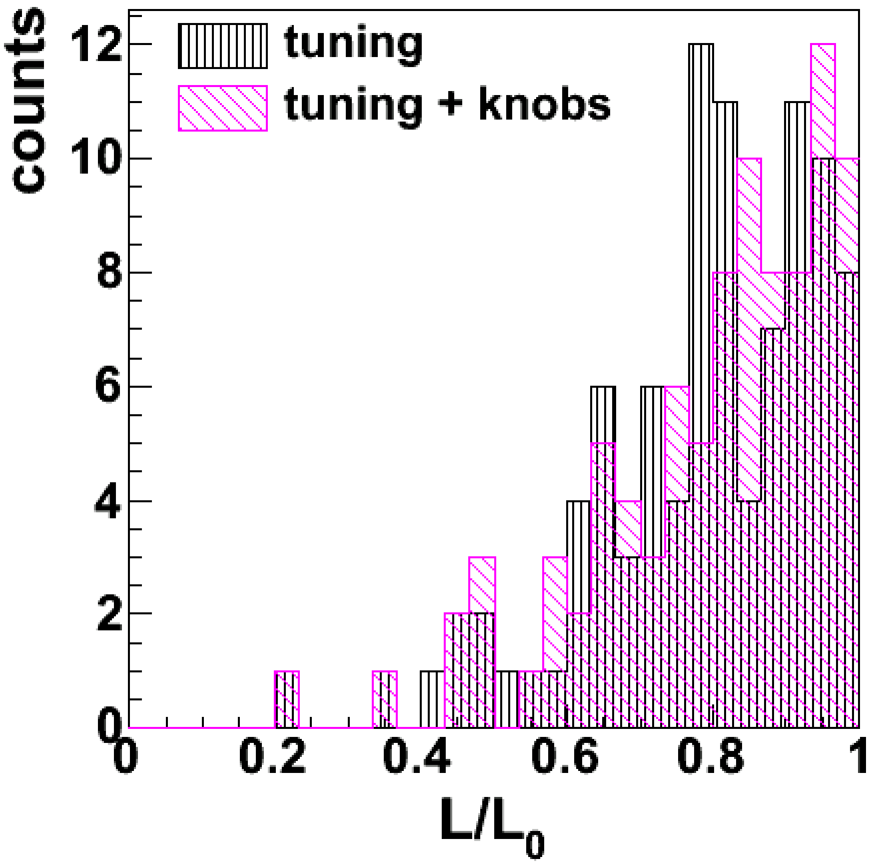
For some seed the trend with luminosity is not so clear…
Some other need to wide the knobs scan range

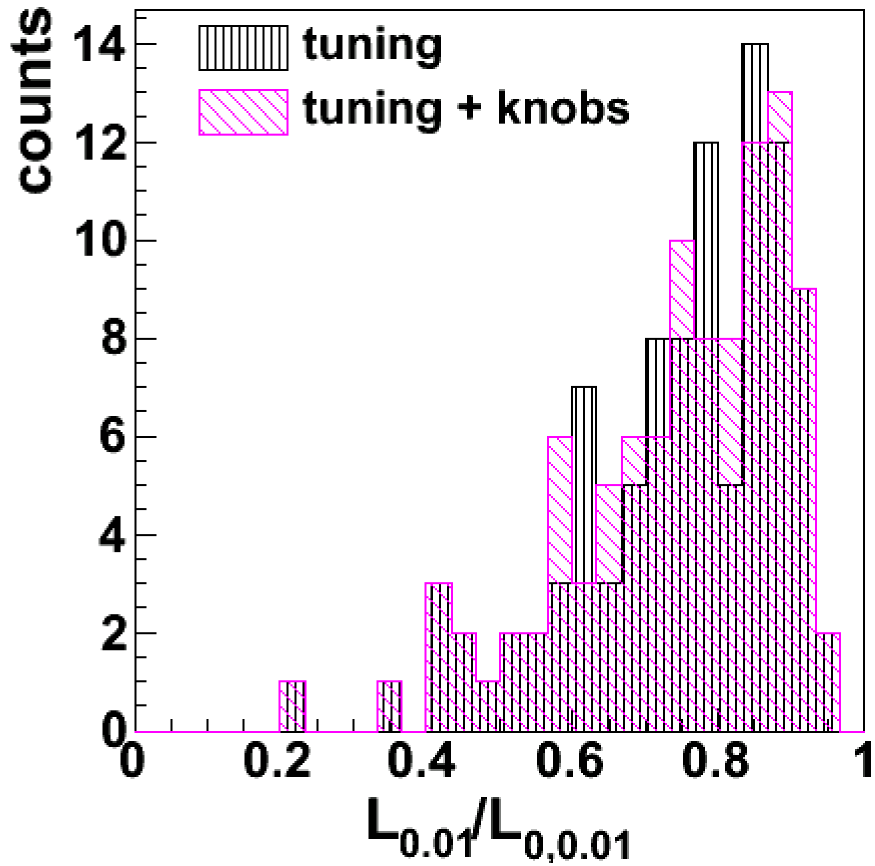
βy knob scan



Very hard to find any trend with luminosity…

Overall luminosity gain





all best values of knobs applied

Summary

pre-alignment H&V [μm]	Relative Success rate %	Absolute Success rate %	lattice	comments
10	55	80	L* = 3.5 m	nominal
10	58	84	L* = 3.5 m	Higher energy bandwidth
10	65	87	L* = 3.5 m	Tuning + horizontal knobs

Design and tuning knobs improve the FFS performances

Conclusion

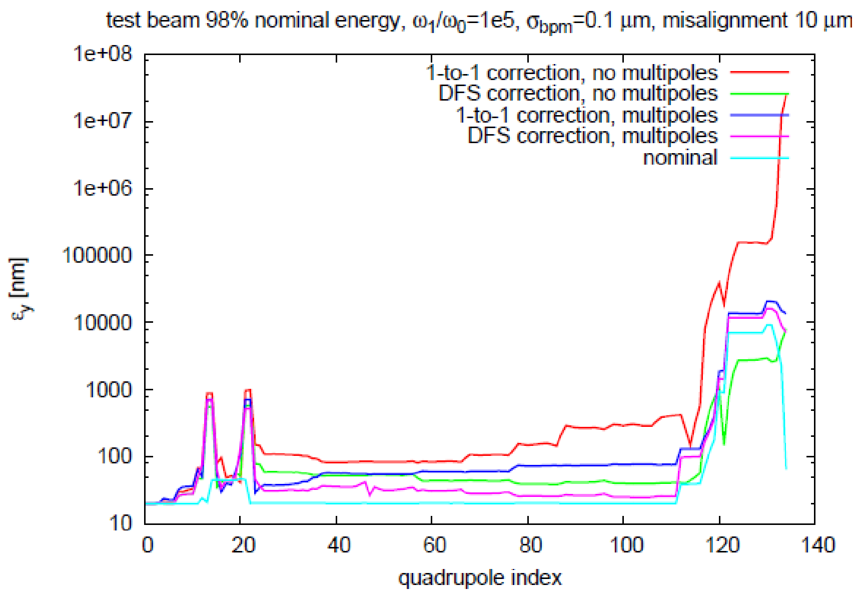
- Tuning the CLIC-FFS using luminosity recover **80%** of the machines to 80% of nominal CLIC luminosity
- New lattice with higher energy bandwidth ($\pm$ 1.5%) performs better: **84%** of the seed reach 80% of luminosity
- First implementation of tuning knobs improves tuning results: **87%** of the seed reach 80% of luminosity

…and outlook

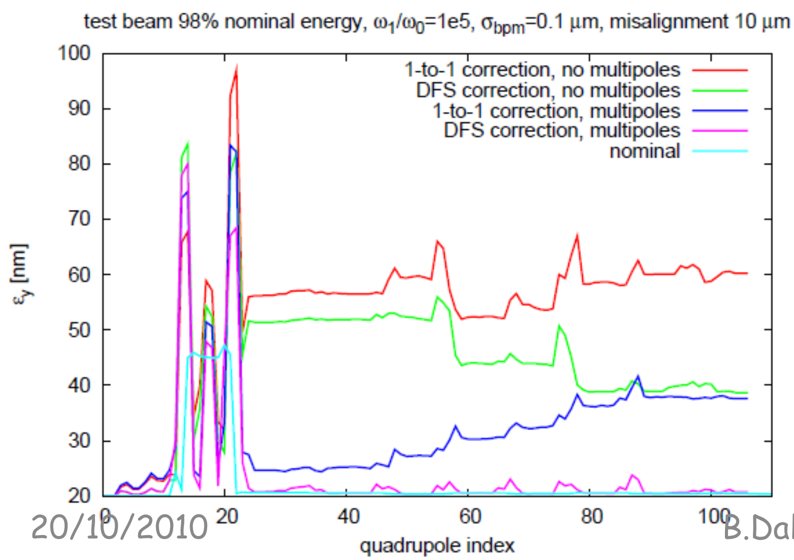
- Improve the scan of the knobs procedure
- Alternate luminosity tuning with knobs
- Alternate Andrea's method (see next talk) with luminosity tuning and with knobs

SPARES

DFS in the BDS: reminder



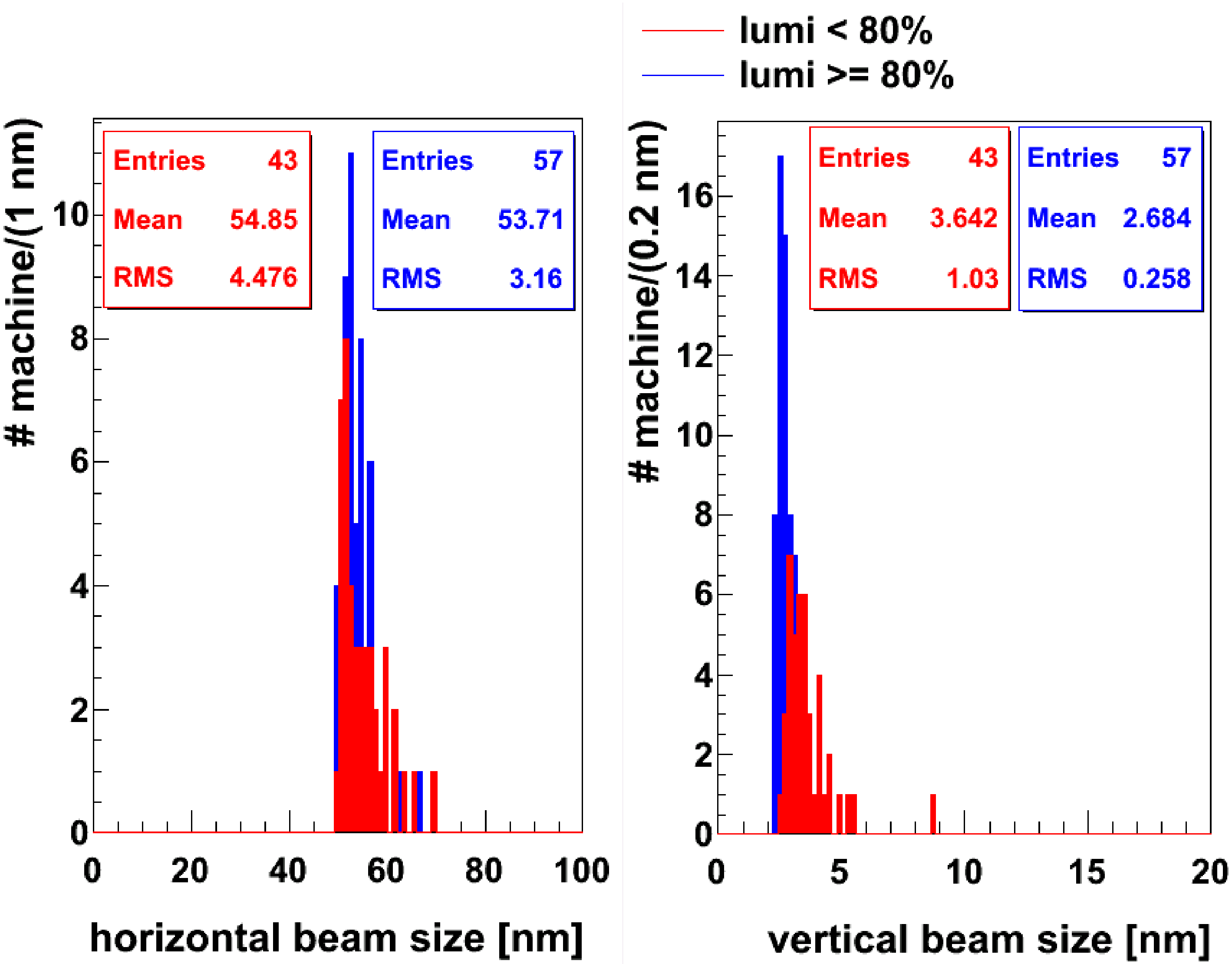
DFS in all the BDS (Collimation + Final Focus section) gives a huge final vertical emittance …



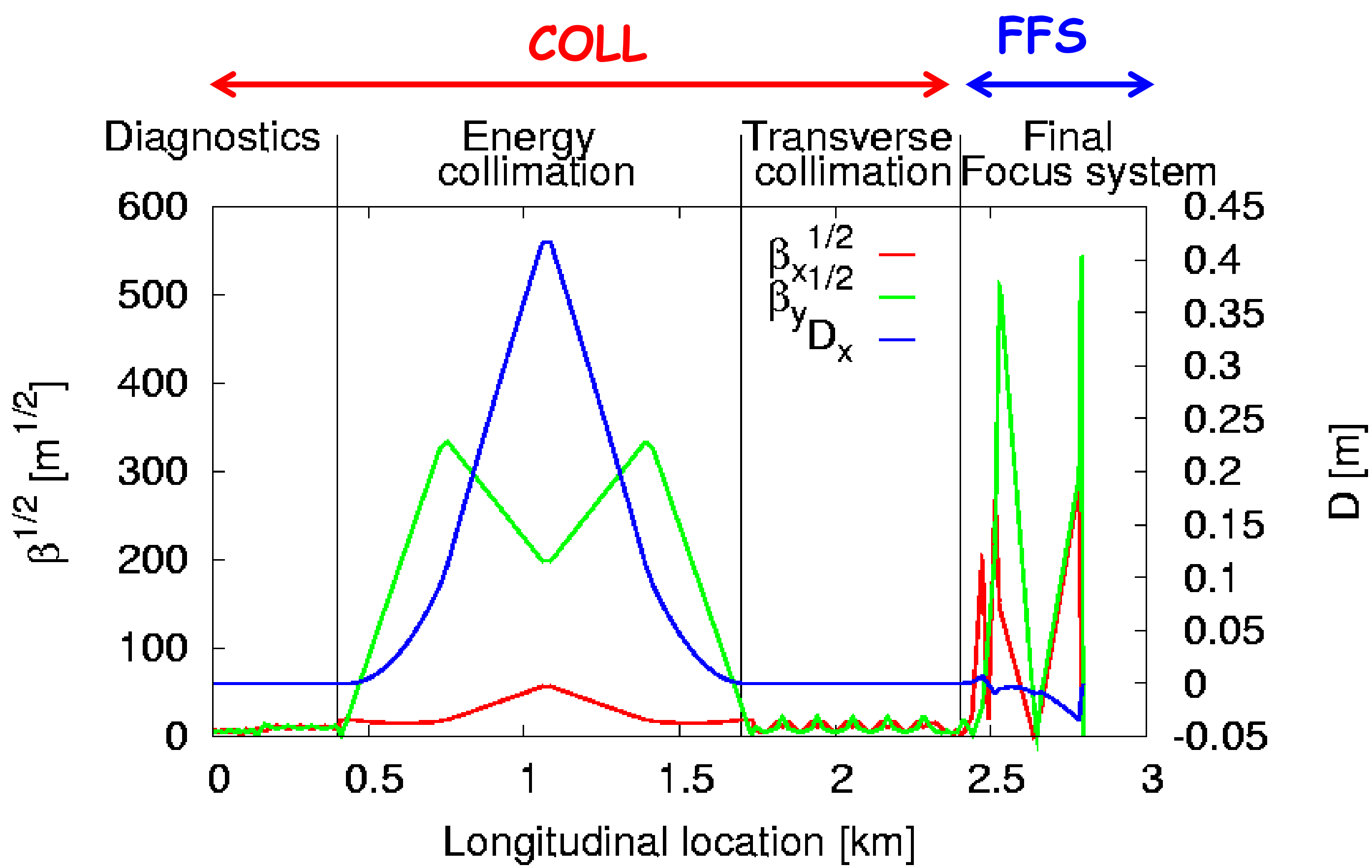
DFS in the Collimation section gives a final vertical emittance $\Delta\varepsilon_y$ = 0.7 nm

A. Latina et al. CLIC-Note-753

Final distribution of beam sizes at the IP

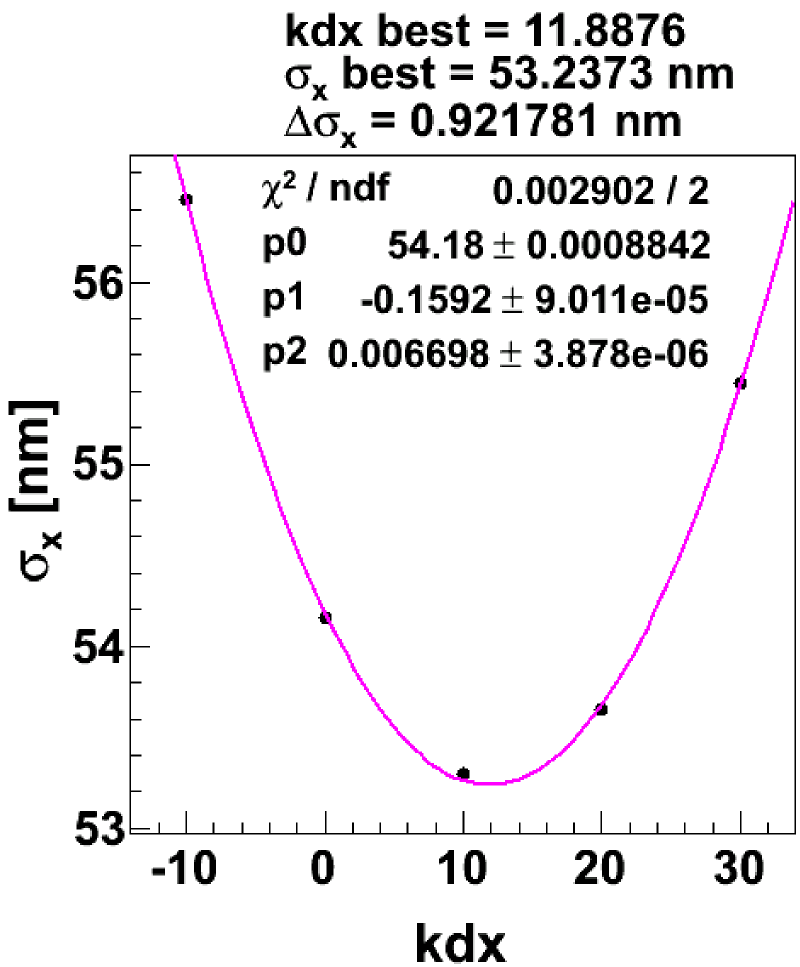


CLIC BDS lattice @ 3 TeV

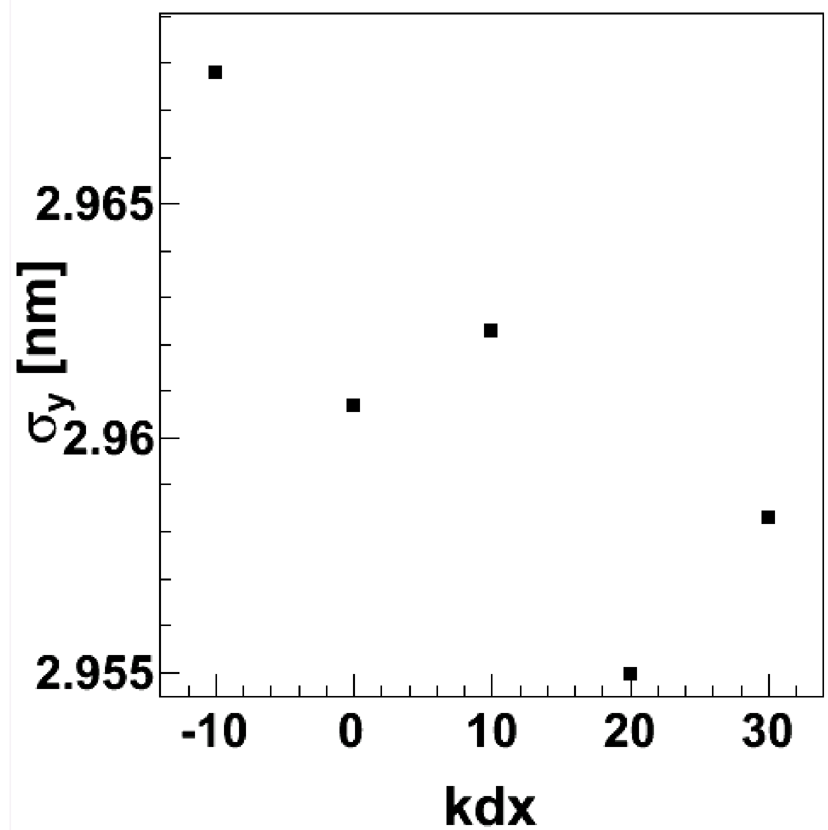


L* = 3.5 m lattice

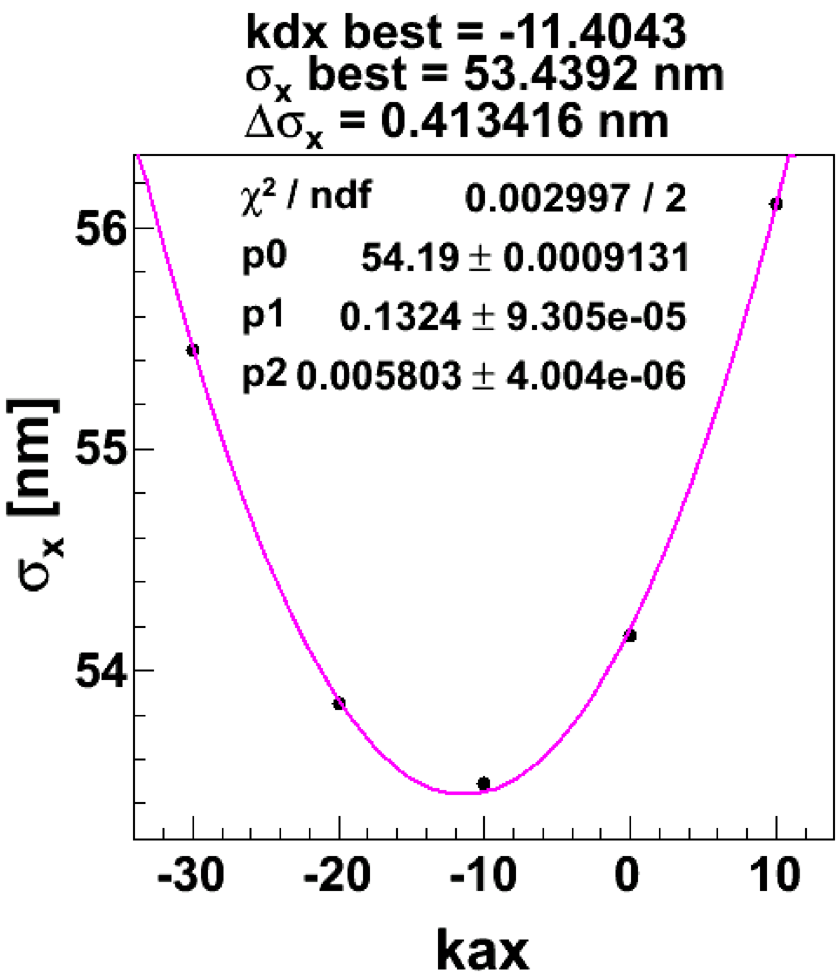
Dispersion knob scan only



Mettere luminosity



αx knob scan only



Mettere luminosity