CLIC 2 beam tuning status

Jochem Snuverink

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John Adams Institute for Accelerator Science

Royal Holloway University of London

Outline

- 2 beam tuning status
- Traditional final focus

CLIC: 1 vs 2 beam tuning

- Most efforts are on “1 beam tuning”
  - Optimise one BDS beamline from static errors
  - Collide beam with “itself” to measure luminosity
  - CPU-less intensive
  - Two methods
- 2 beam tuning will be at least twice as long (except for BBA)
  - How much longer?
  - Luminosity measurement less precise for lower luminosity
  - Additional luminosity loss is expected as self-collision is often optimal
  - After BBA, the beams need to be aligned wrt each other
    - Additional constraint on BBA
    - Final Doublets alignment of both lines needs to be good enough

Beam tuning - errors

- Misalignment in two planes:
  - 10 μm std normal distribution (CLIC prealignment) for all magnets
- BPM resolution 10 nm

Method 1: Luminosity optimisation method

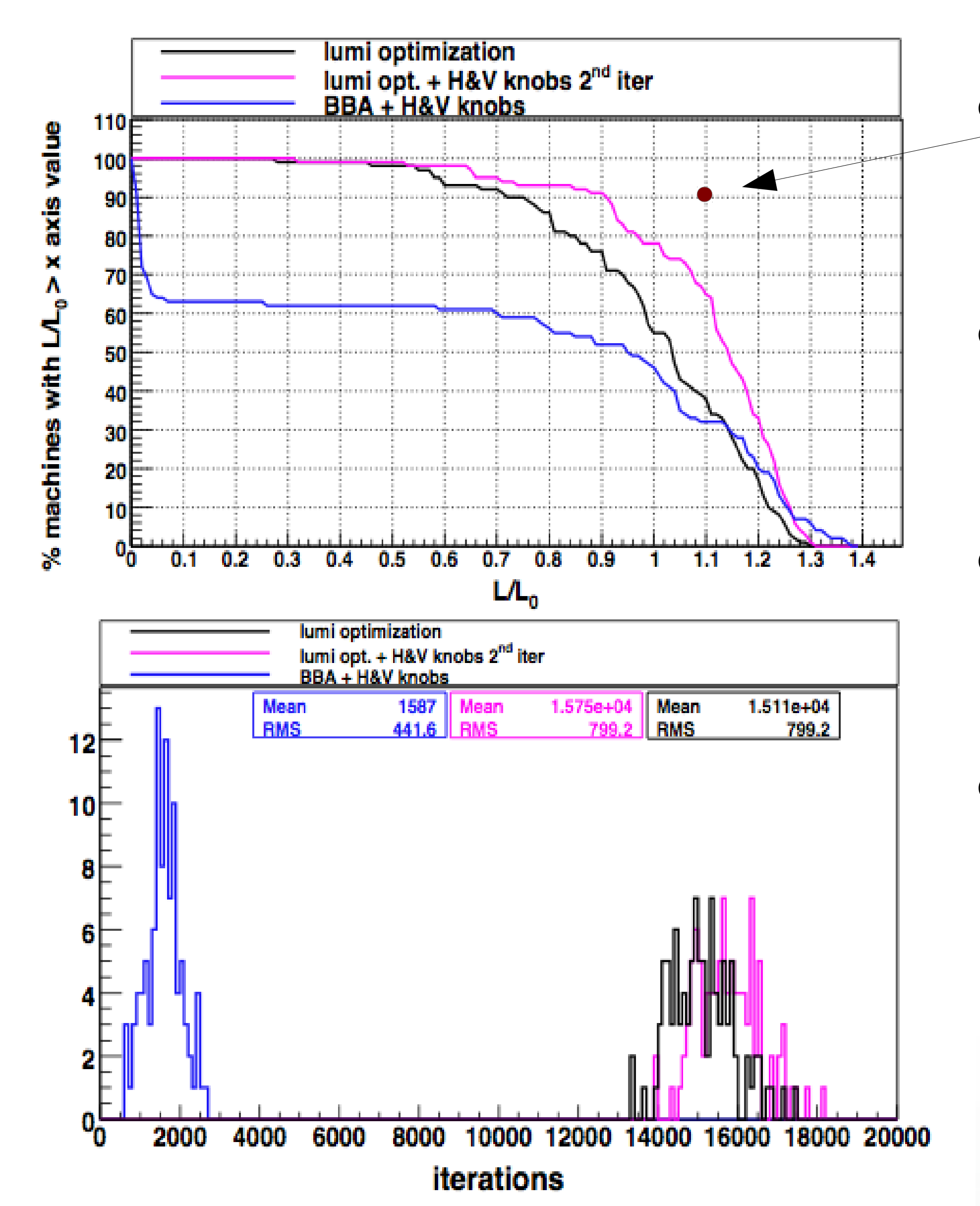
- Large optimisation with simplex method
- Move all elements of the Final Focus system
  - 2 iterations
- Can be combined with sextupole knobs afterwards
- B. Dalena et al.: http://prst-ab.aps.org/abstract/PRSTAB/v15/i5/e051006

Method 2:
“BBA” method

1. Multipoles off, Beam Based Alignment
   1. 1-1 correction
   2. “Target Dispersion Steering” (DFS-like method)
2. Multipole shunting:
   1. vary position to centre the multipoles
3. Multipole knobs
4. Target Dispersion Steering
5. Multipole knobs

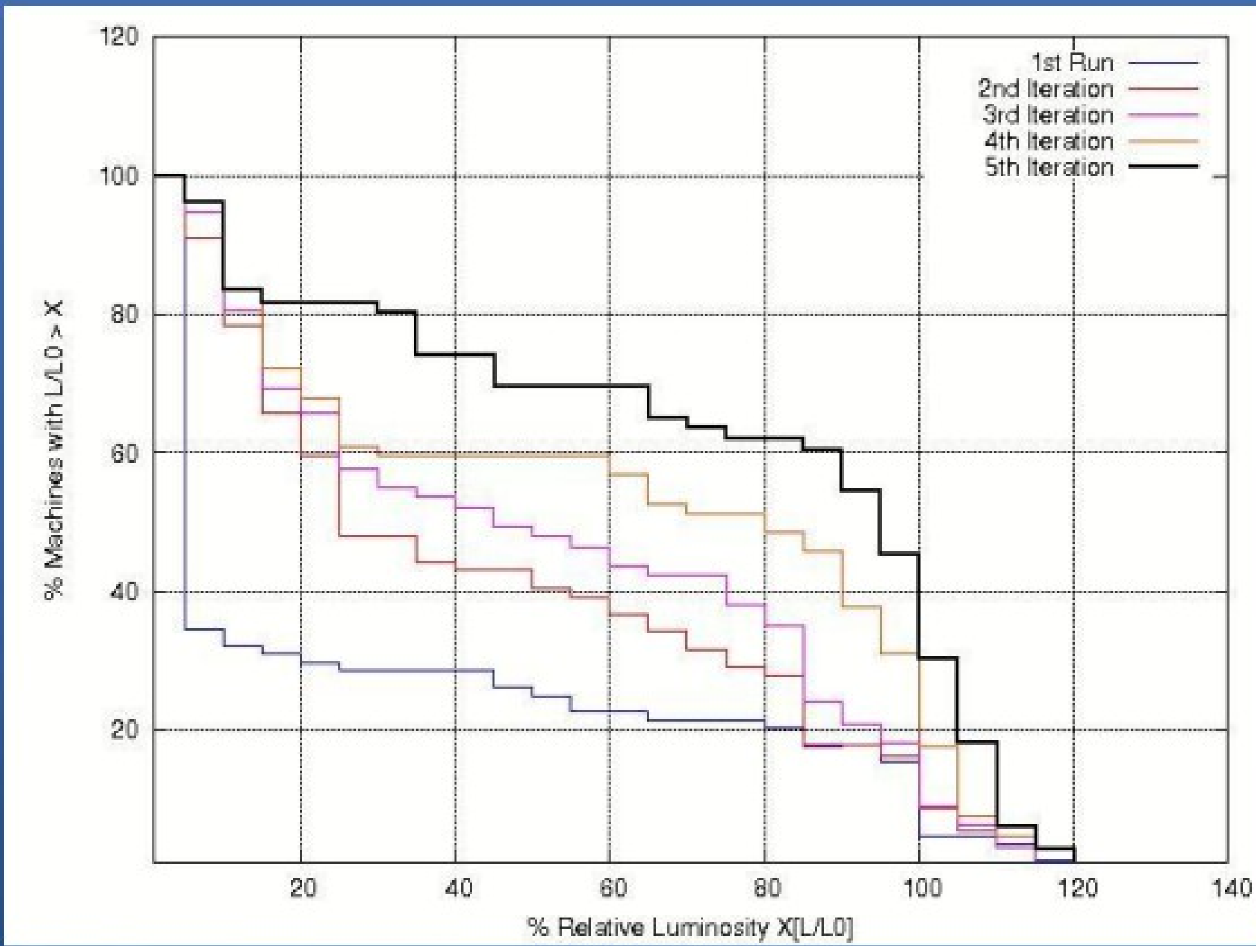
A. Latina, P. Raimondi:
http://accelconf.web.cern.ch/AccelConf/LINAC2010/papers/mop026.pdf

Results CDR



- Goal: 90% of machines to reach 110% luminosity
- Remaining 10% for dynamic imperfections
- 16,000 lumi. meas. for method 1
- 2,000 for method 2

BBA + Knobs at 3 TeV



- Optimization still in progress
- Results from 5 iterations
- Next: apply Simplex
- We can see improvements through the five iterations

Strategy

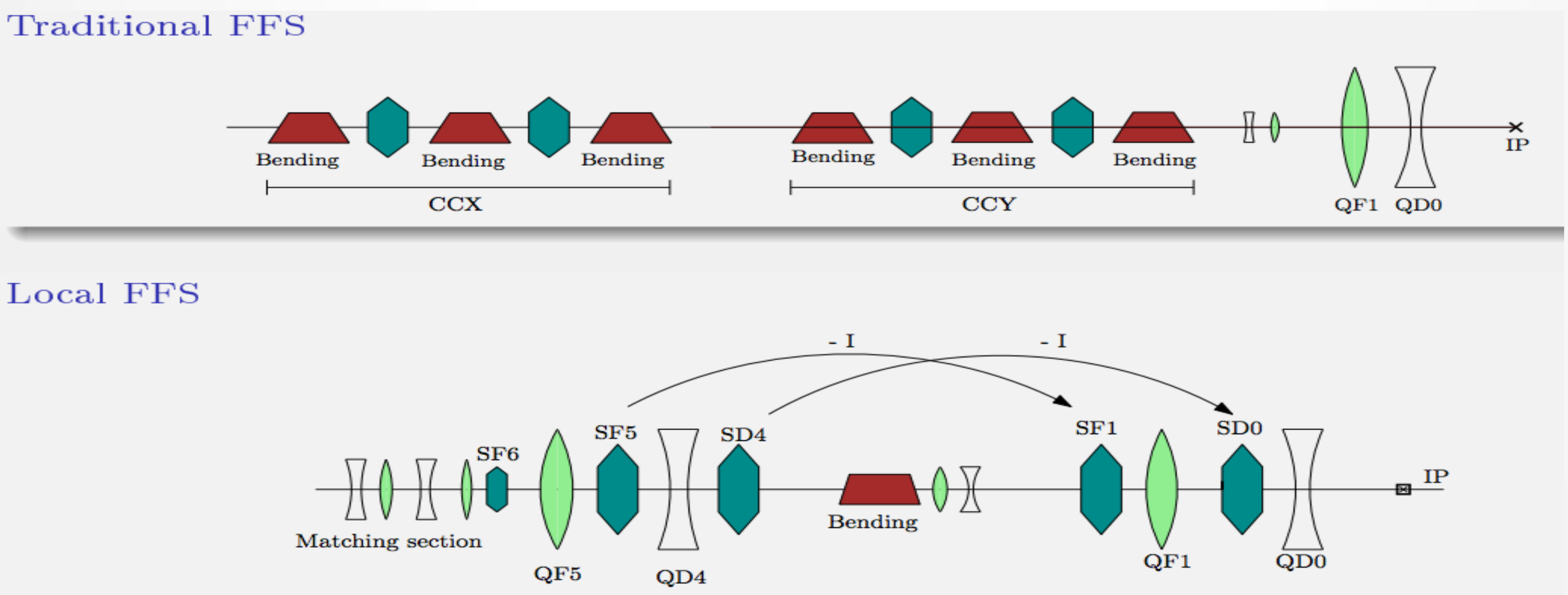
- Apply current 1 beam tuning with the current setup for two beams
  - Beam based alignment (ala Latina-Raimondi)
  - Sextupole knobs
    - Including automatic centering of beams ("almost ideal IP feedback") for now to speed up tuning
    - Alternate beamlines after each knob
  - Add additional methods from ILC experience (TODO)
    - Quadrupole shunting
    - Add mover minimisation in BBA
    - Higher order knobs corrections

Tuning

- 100 seeds (200 machines) taken and BBA applied
- Successful BBA seeds taken and one round (crude) of sextupole knobs was performed
  - Not all seeds make progress or converge
- Best seeds reach about 60% of nominal luminosity so far
- 2^{nd} and further iterations with finer range to be done
  - Seems essential from ILC experience

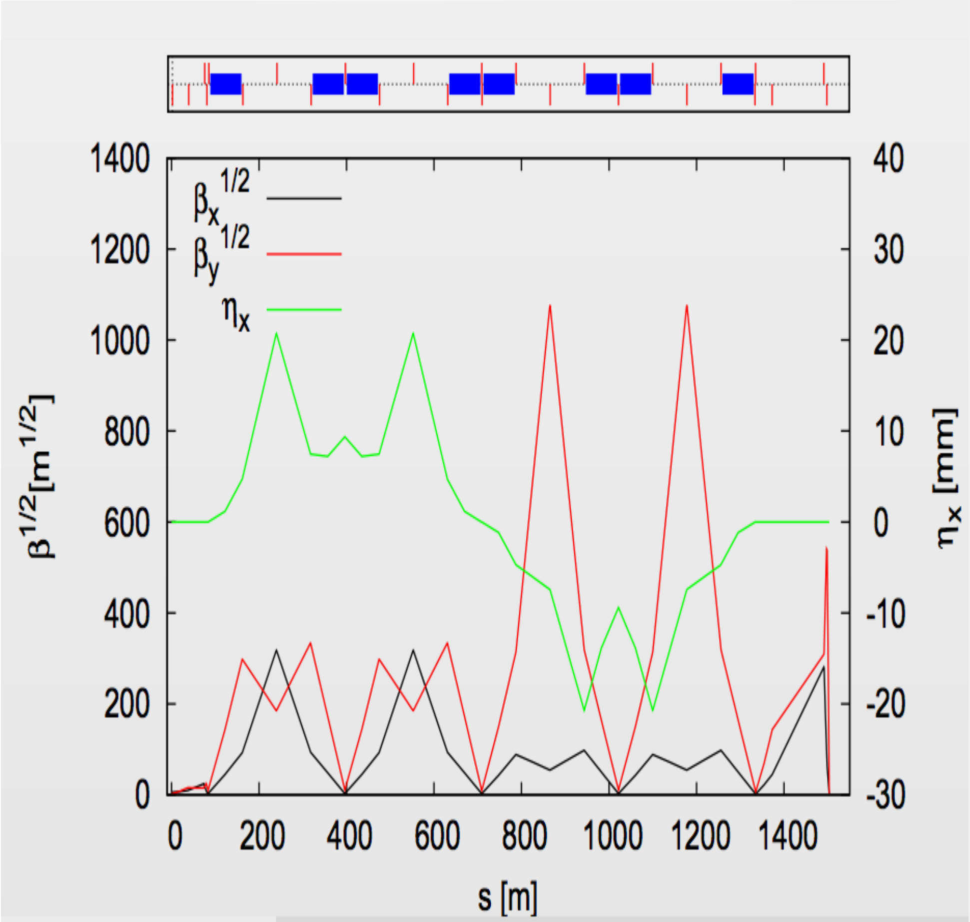
Traditional Final Focus

- Two separate sections for chromaticity correction
- Lattice by Hector Garcia, see e.g. his talk at CLIC WS 2014
- Relatively simple system for design and analysis



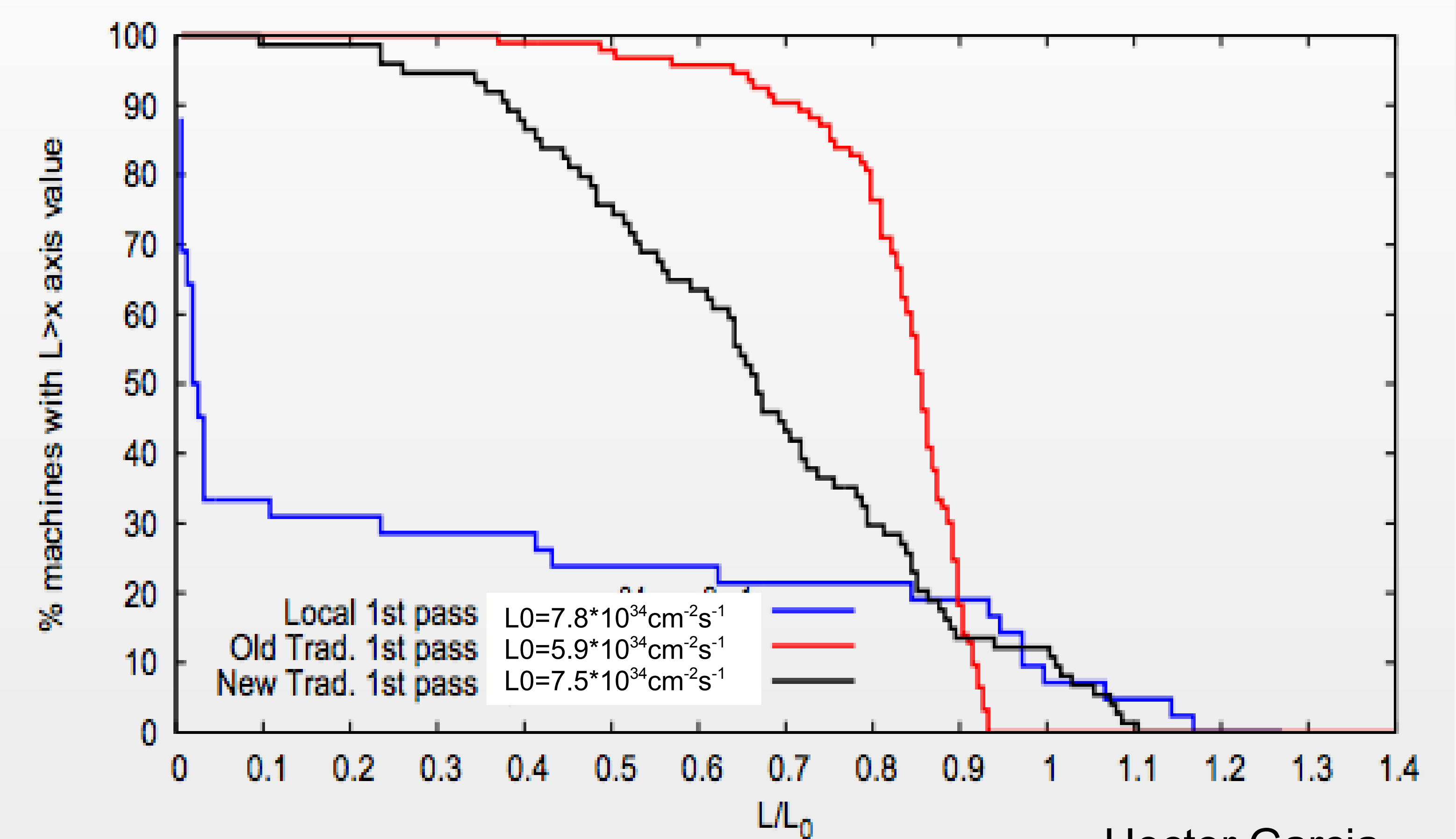
Traditional Final Focus

Parameter	Unit	Traditional	Local
Length	m	1460	450
Total Lumi	$cm^{-2}s^{-1}$	$7.5 * 10^{34}$	$7.8 * 10^{34}$
Peak Lumi (1%)	$cm^{-2}s^{-1}$	$2.4 * 10^{34}$	$2.4 * 10^{34}$



Optimised lattice achieves similar luminosity as local scheme

Tuning results 1 beam BBA+knobs 1 iteration



Hector Garcia

Traditional Final Focus seems more easy to tune than local scheme, also after optimisation

Traditional FF - 2 beam tuning

- Logical to try 2 beam tuning to traditional scheme first
  - Compare with local scheme
  - Sorry no results for this yet
- In addition, with help of Hector 2^{nd} and 3^{rd} iteration of 1 beam tuning is planned for the traditional scheme
- In parallel do add a 2^{nd} and 3^{rd} iteration to 2 beam tuning of local scheme

Conclusions

- Two beam tuning on local scheme underway
  - Needs more iterations
  - Individual seeds need to be looked at
- Traditional Final Focus seems easier to tune
  - Two beam tuning studies should reconfirm this

Backup

Old Traditional Final Focus Parameters

Parameter [Units]	3 TeV	500 GeV
Center of mass energy E_{CM}, [GeV]	3000	500
Repetition rate f_{rep}, [Hz]	50	50
Bunch population N_e [10^9]	3.72	6.8
Number of bunches n_b	312	354
Bunch separation Δt_b, [ns]	0.5	0.5
Accelerating gradient G, [MV/m]	100	80
Bunch length σ_z, [μm]	44	72
IP beam size σ_x^*/σ_y^*, [nm]	40/1	200/2.26
Beta function (IP) β_x^*/β_y^*, [mm]	10/0.07	8/0.1
Norm. emittance (IP) ϵ_x/ϵ_y, [nm]	660/20	2400/25
Energy spread σ_δ, [%]	1.0	1.0
Luminosity $\mathcal{L}_T$ [10^{34}cm$^{-2}s^{-1}$]	5.9	2.3
Power consumption P_{wall}, [MW]	589	272
Site length, [km]	48.3	13.0

Hector Garcia