Beam Delivery System: status and plans of R&D until CDR

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CLIC ACE 2009

Contents

- New instrumentation: The polarimeter
- Preservation of emittances:
  - Transport aberrations
  - Failure to tune the FFS
  - ATF2
  - Collective effects $\left\{ \begin{array}{l} \text{Resistive wall} \\ \text{Fast ion instability} \\ \text{Collimator } w\text{akefields} \end{array} \right.$
- Machine protection:
  - Collimation systemm
- Plans towards CDR

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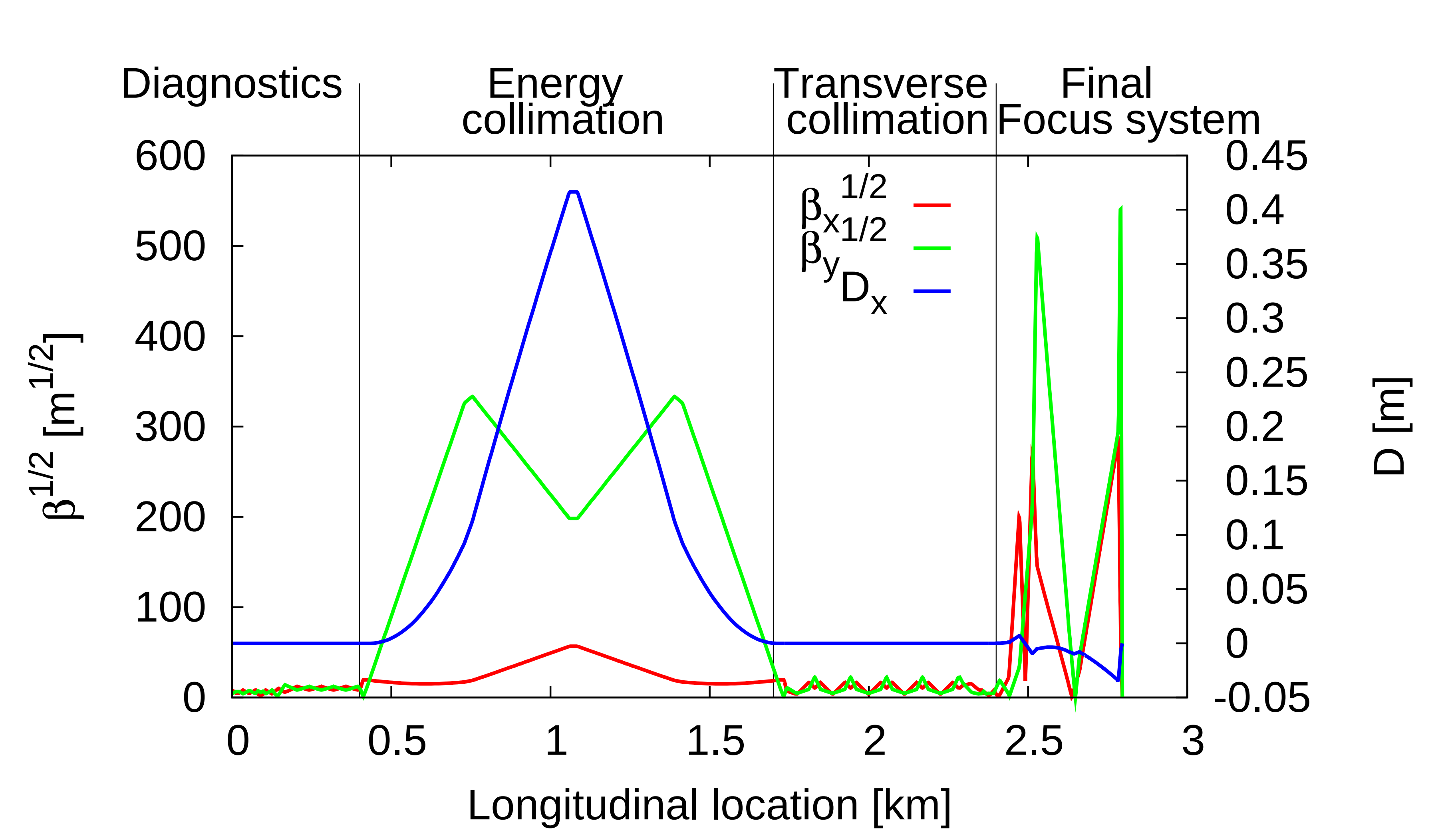
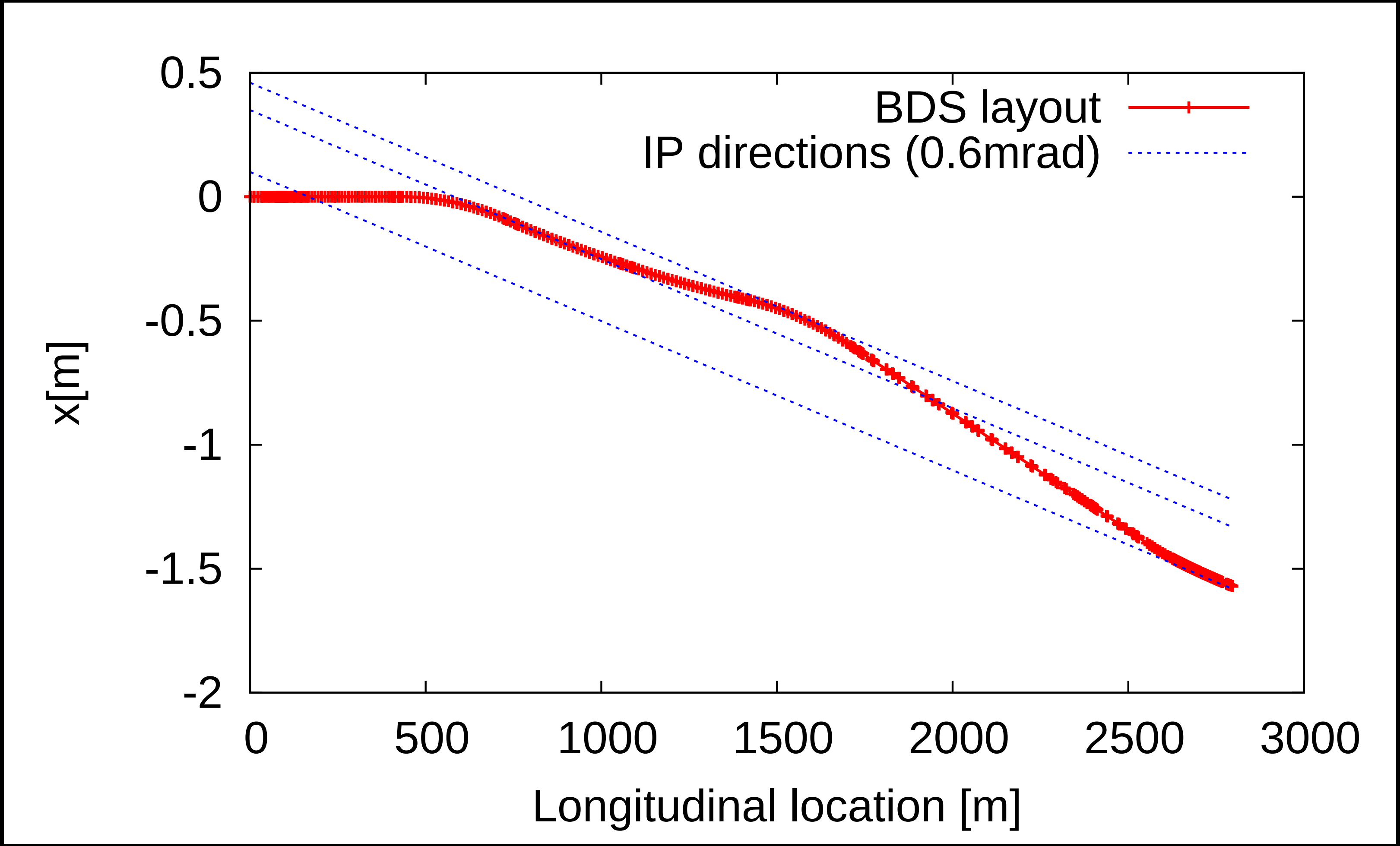
The BDS


Diagnostics
Energy collimation
Transverse collimation
Final Focus system
$\beta^{1/2}$ [$m^{1/2}$]
D [m]
$\beta_x^{1/2}$
$\beta_y^{1/2}$
D_x
600
500
400
300
200
100
0
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
0
0.5
1
1.5
2
2.5
3
Longitudinal location [km]

Polarimeter location & performance



Laser IP at 742 m and detector at 907 m. Relative polarization measurement error is 0.61% (for 1s).

BDS emittance “spoilers” by design

- CLIC BDS transport aberrations have been extensively minimized (MAPCLASS, extra non-linear elements, etc)
- Aberrations increase vertical IP beam size by 15%
- Synchrotron radiation reduces luminosity by 20%
- (in ILC these effects are below the 1%)

Vertical IP beam sizes and chromaticities

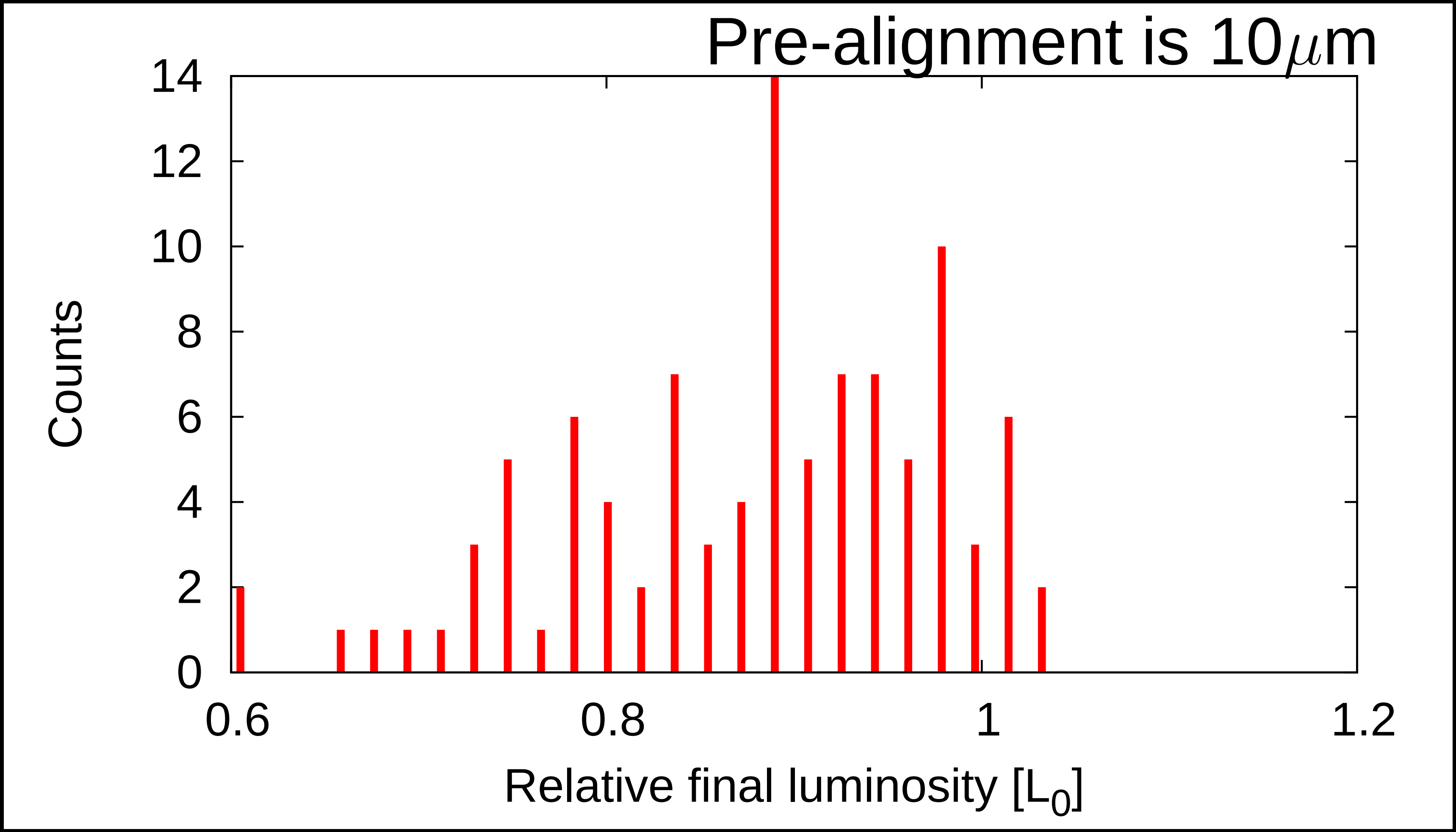
Project	Status	σ_y^* [nm]	ξ_y
FFTB	Measured	70	17000
ATF2	Commissioning	37	19000
ILC	Design	6	15000
ILC low power	Proposed	4	30000
CLIC	Design	1	63000

CLIC, the most challenging.

Imperfections as emittance “spoilers”

- 10μm transverse misalignments can decrease lumi by 10^{-6}
- 10^{-5} relative gradient error in QD0 decreases lumi by 0.94
- Tuning algorithms are fundamental!
- Can we tune the FFS using the Simplex to maximize lumi?

Current status of FFS tuning

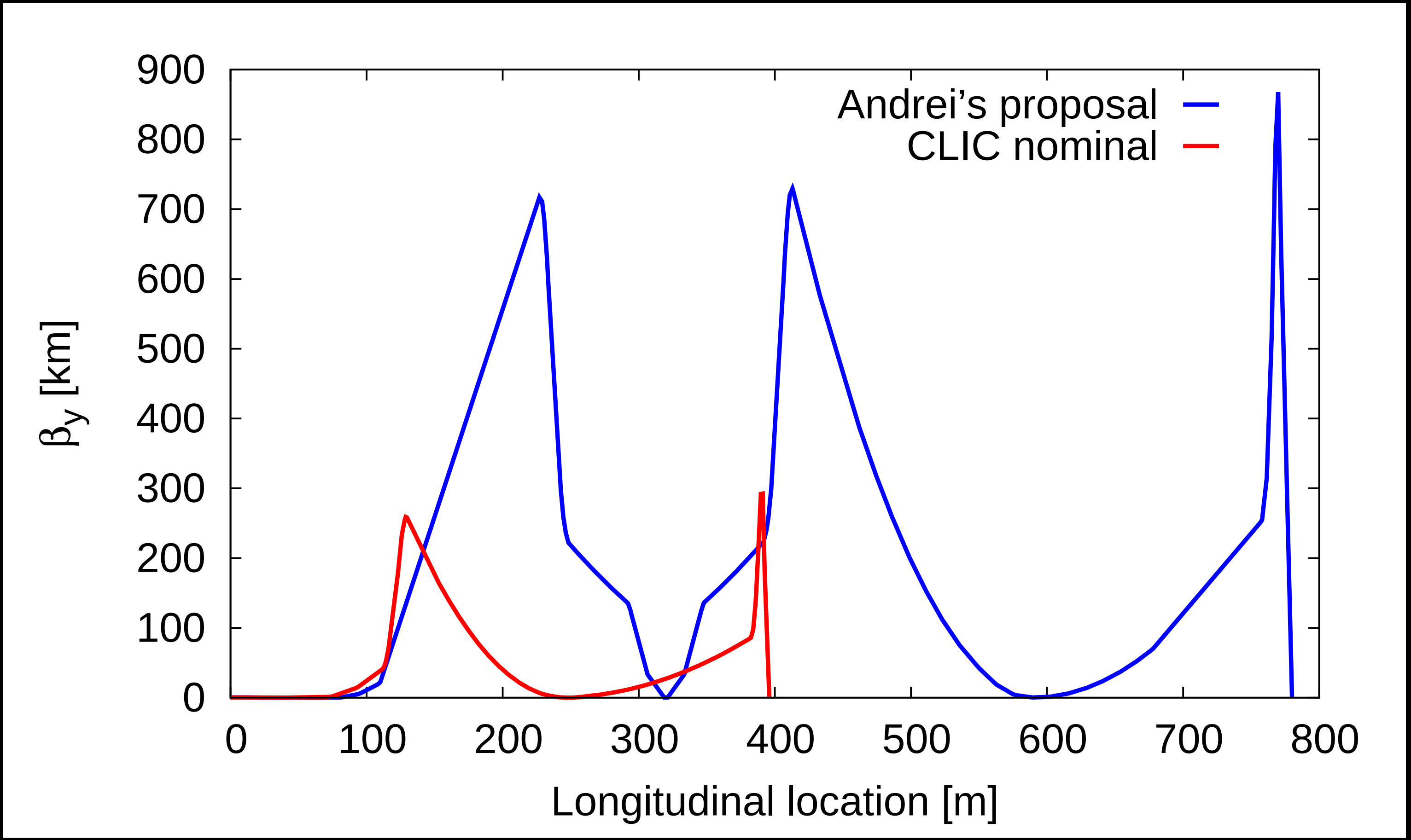


80% of the cases reach 80% of the lumi in 18000 iterations.

How to improve tuning performance?

- Use of more clever algorithms than the Simplex (presently on-going)
- Tune in a beta-squeeze sequence (like colliders)
- Relax the optics
- Andrei Seryi proposed a new optics with double L* to ease QD0 stabilization, let's see what happens

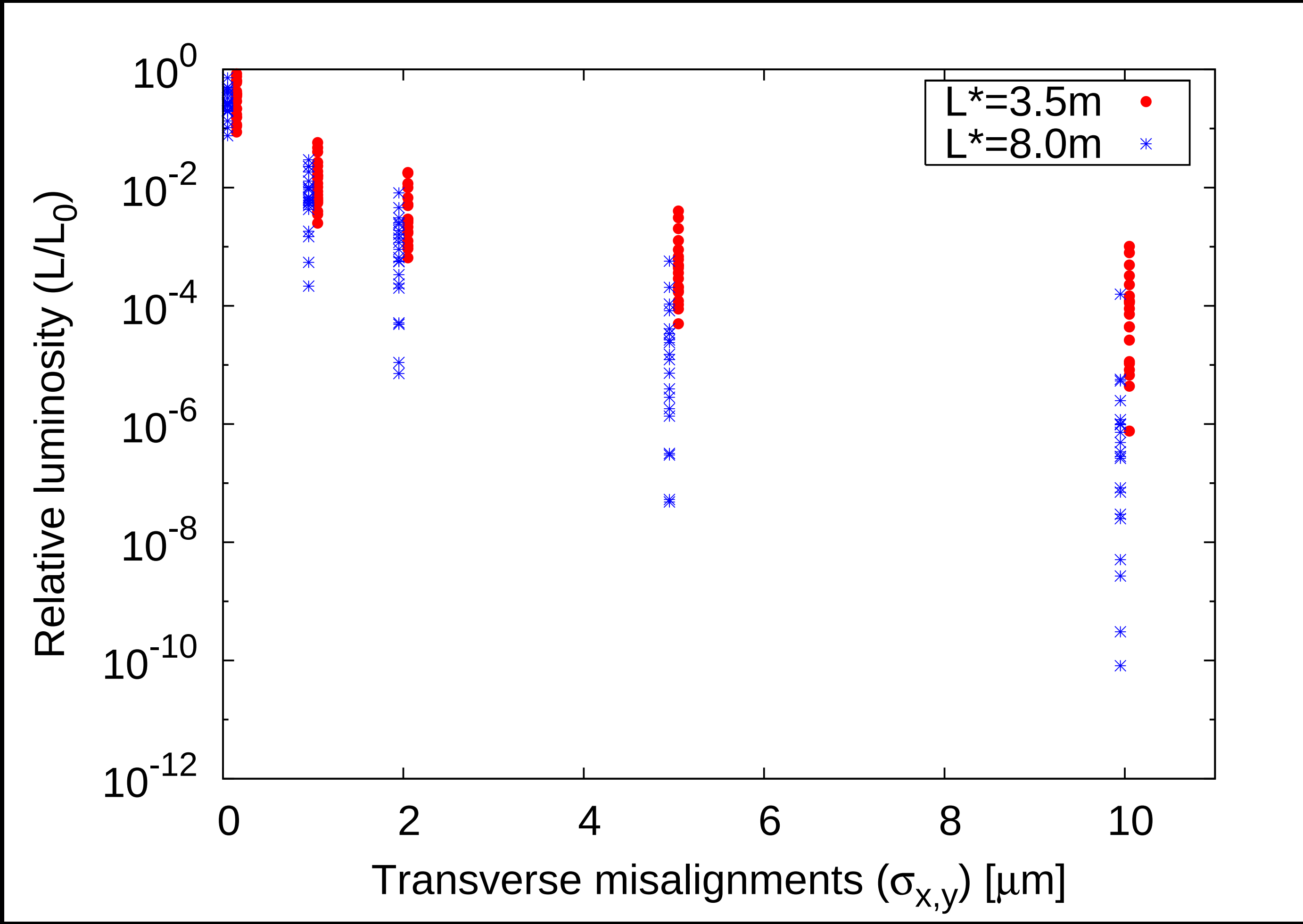
Comparing Andrei's FFS to CLIC nominal



Andrei's prop: L*=8.0m, β_y^*=0.10mm

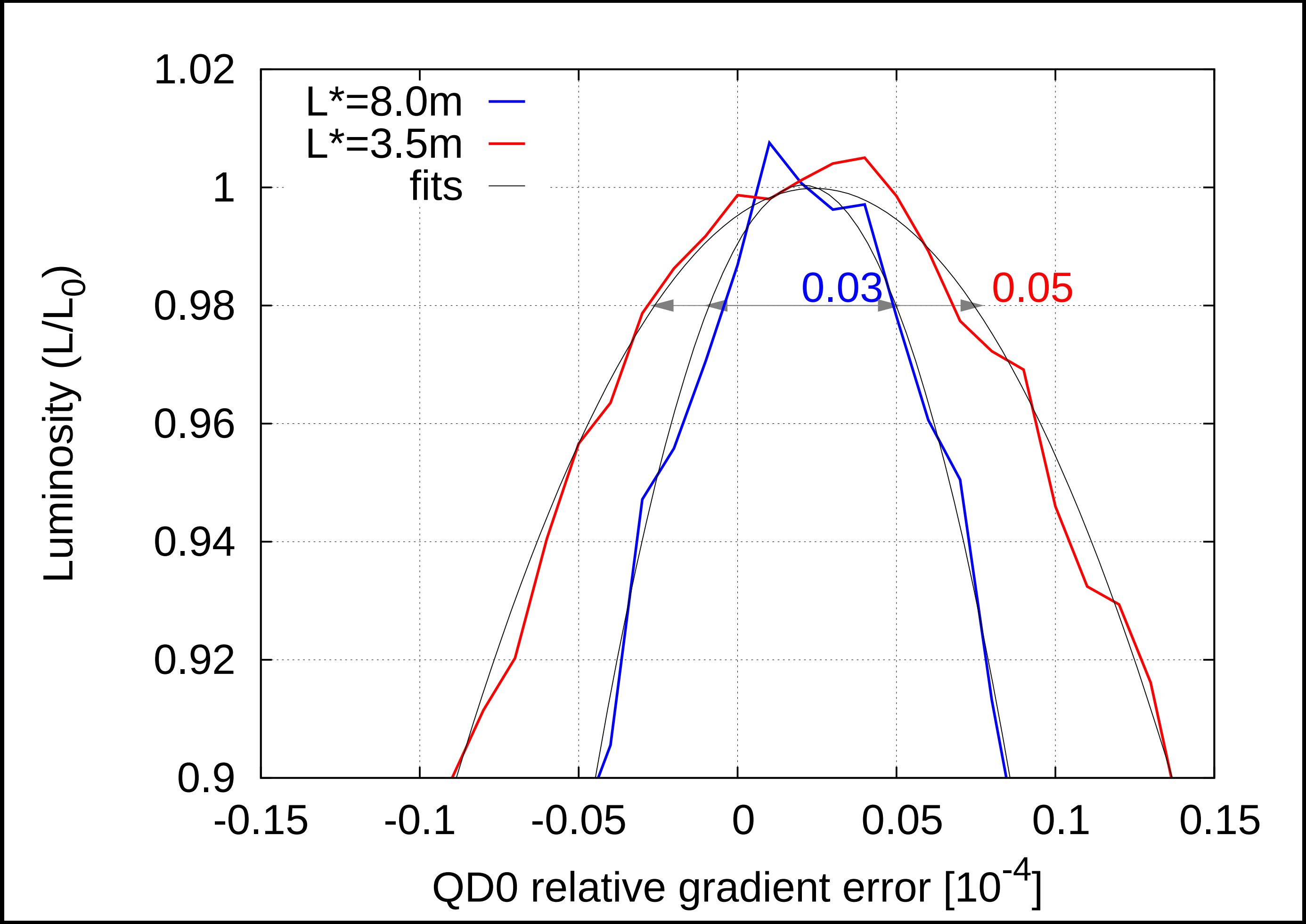
CLIC nominal: L*=3.5m, β_y^*=0.07mm

Sensitivity to misalignments



Doubling L* increases sensitivity to misalignments by a factor of 4

Sensitivity to QD0 gradient error



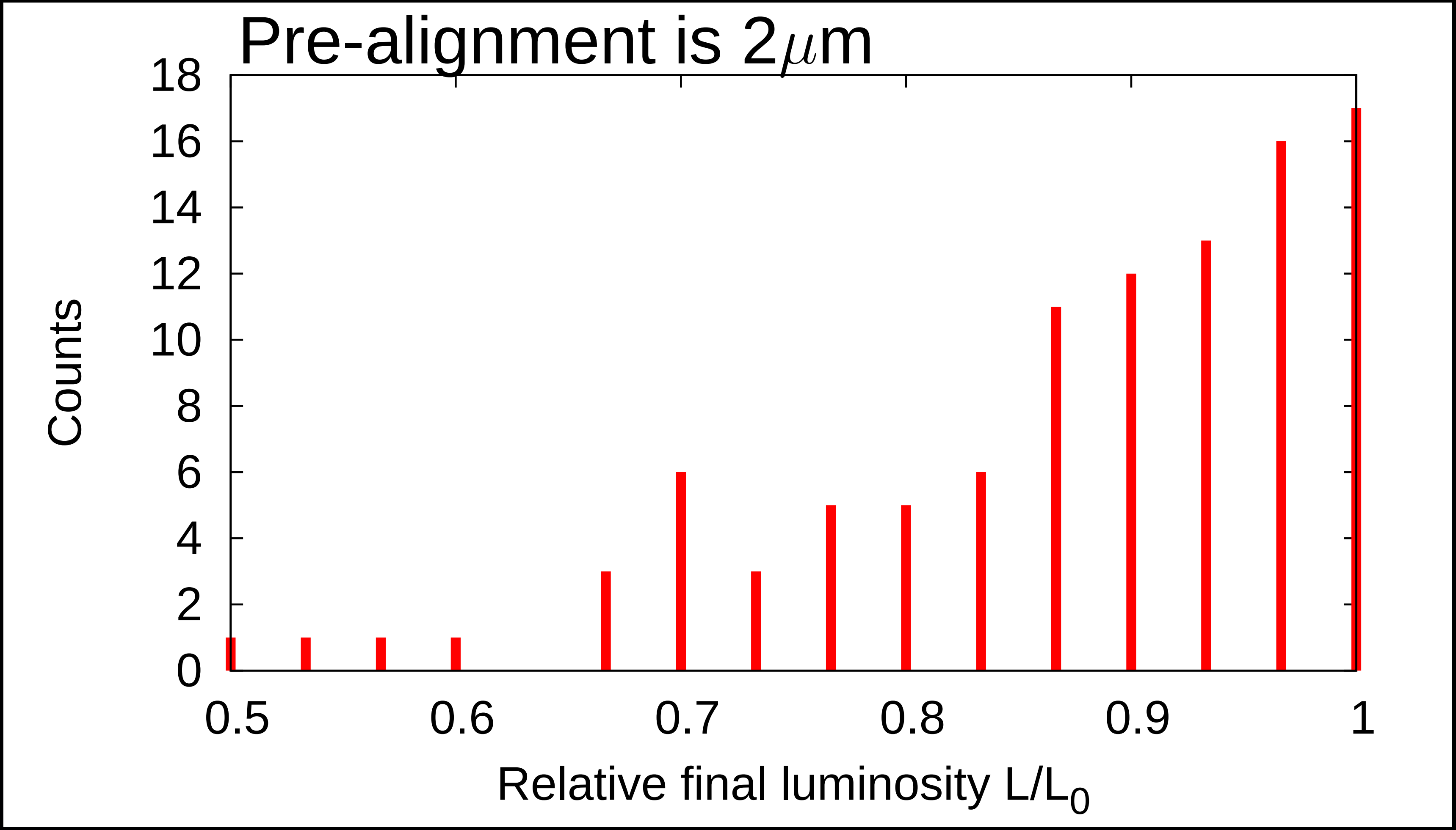
Doubling L* increases sensitivity to gradient error by a factor of 2

QD0 specifications

	L*=3.5m	L*=8.0m
Gradient	575T/m	211T/m
Aperture (radius)	3.5mm	8.5mm
Outer radius	35mm	70mm
QD0 jitter	0.15nm	0.18nm
QD0 support	detector	ground
QD0 technology	PM	PM
QD0 grad tol.	5×10^{-6}	3×10^{-6}

A superconducting QD0 adds the extra challenge of stabilizing coils.

Tuning longer L* with better pre-alignment

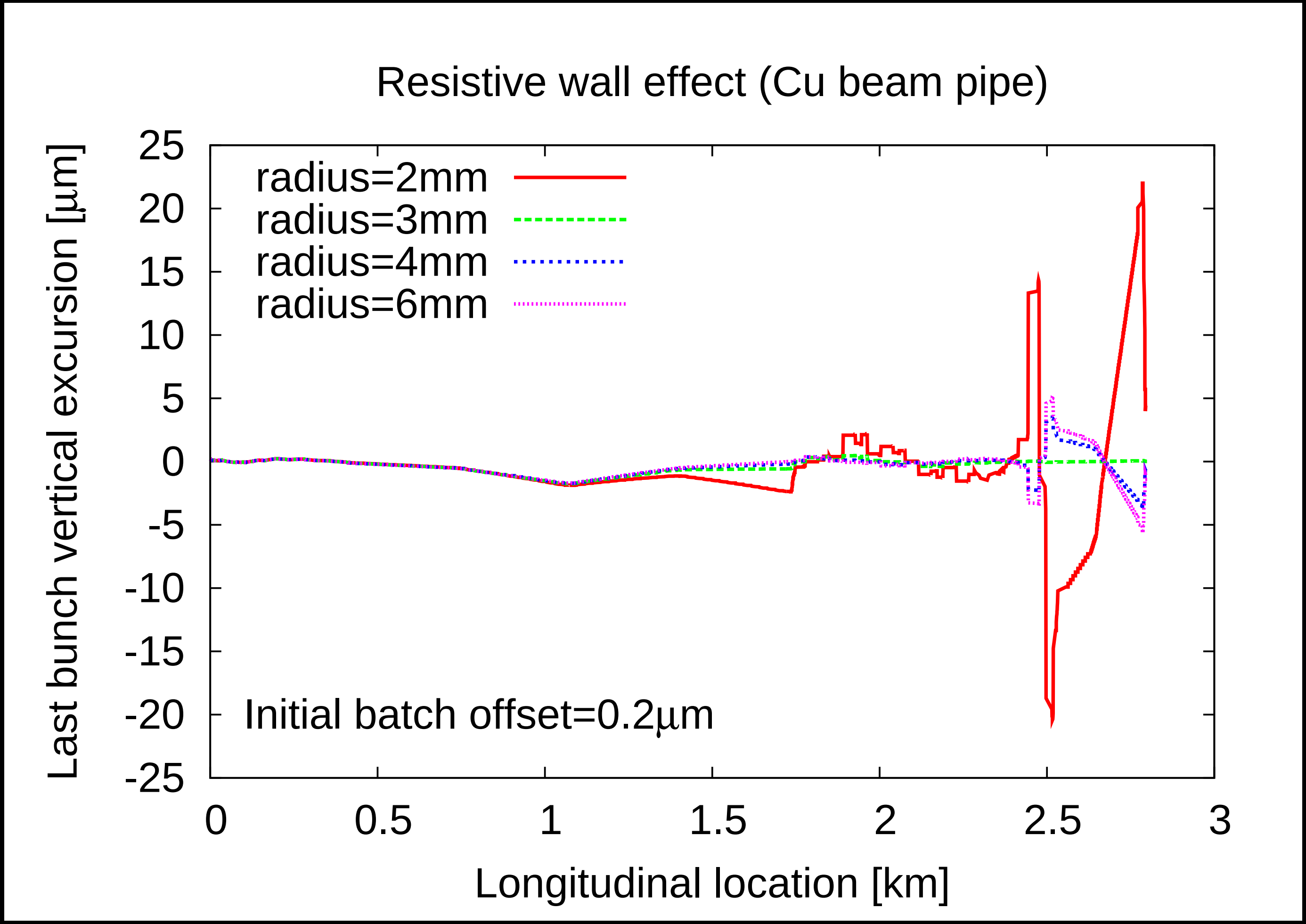


Same tuning performance as for nominal by re-ducing pre-alignment a factor 5

ATF2 ultra-low β proposal

- CARE/ELAN-2008-002 proposed a squeeze of the ATF2 IP β-functions by a factor of 4
- $\sigma_y \approx$20 nm, $\xi_y \approx$76000
- ATF2 ultra-low β will experimentally prove CLIC-like aberrations and tuning algorithms.
- Beneficial for the ILC project, more in particular for the ILC low power option.
- This proposal was accepted
- Presently a CERN PhD working on this

Collective effects: Resistive wall



8mm Cu beam-pipe is enough to neglect resistive wall. Only QD0 has a smaller aperture.

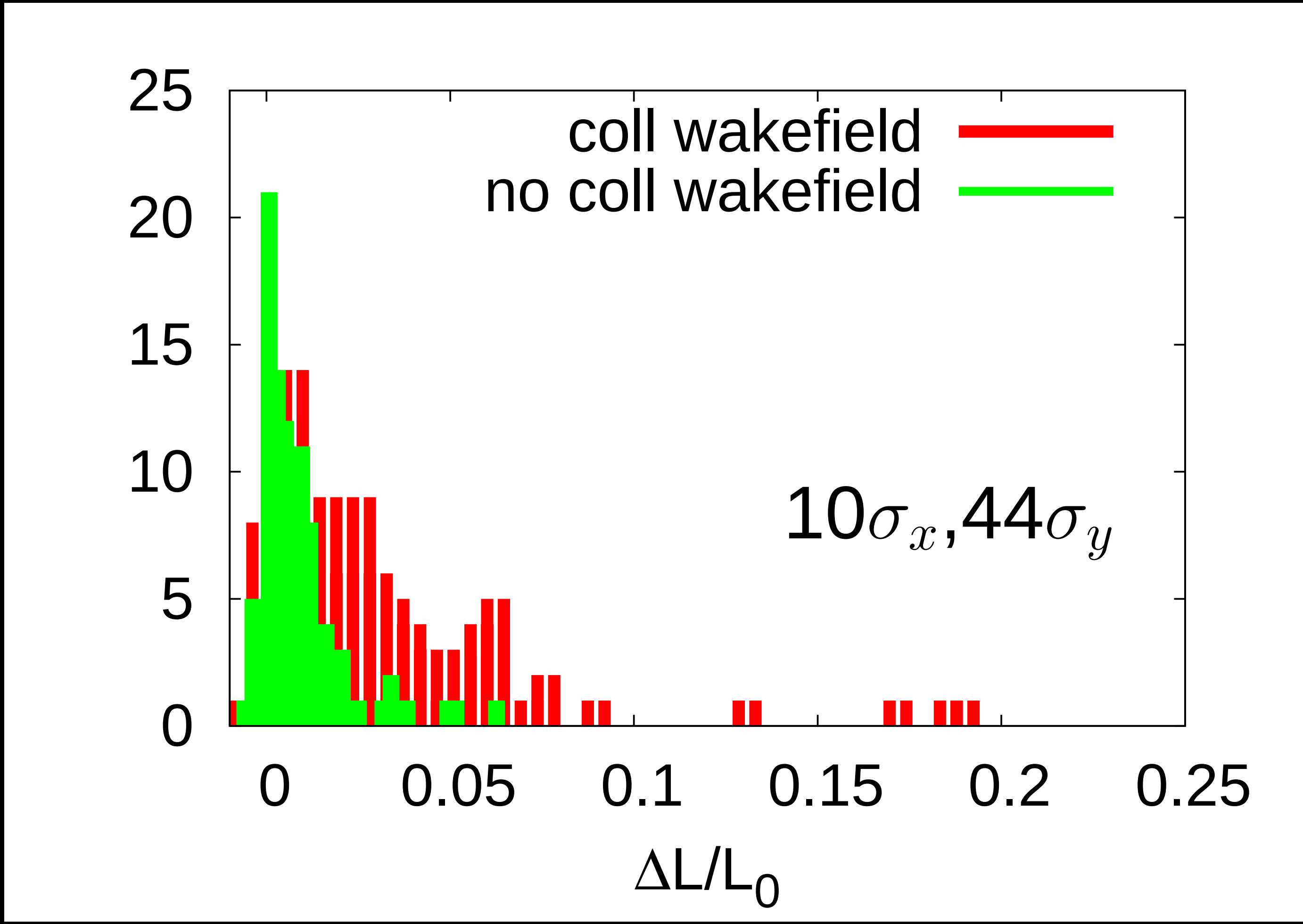
Collective effects: Fast ion

Two sources:

- Scattering ionization
- Field ionization

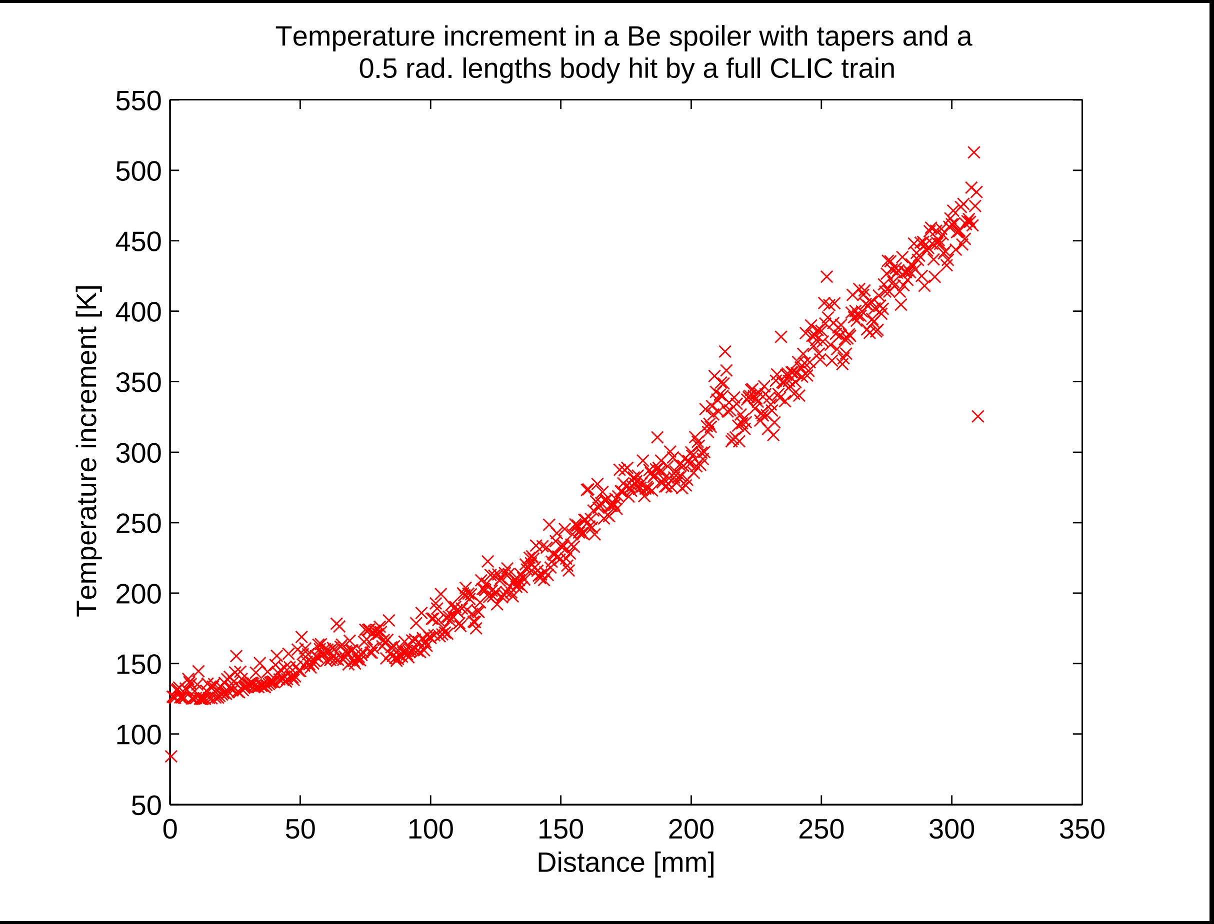
10 nTorr seem enough to avoid fast ion instabilities.

Collective effects: Collimator wakefields



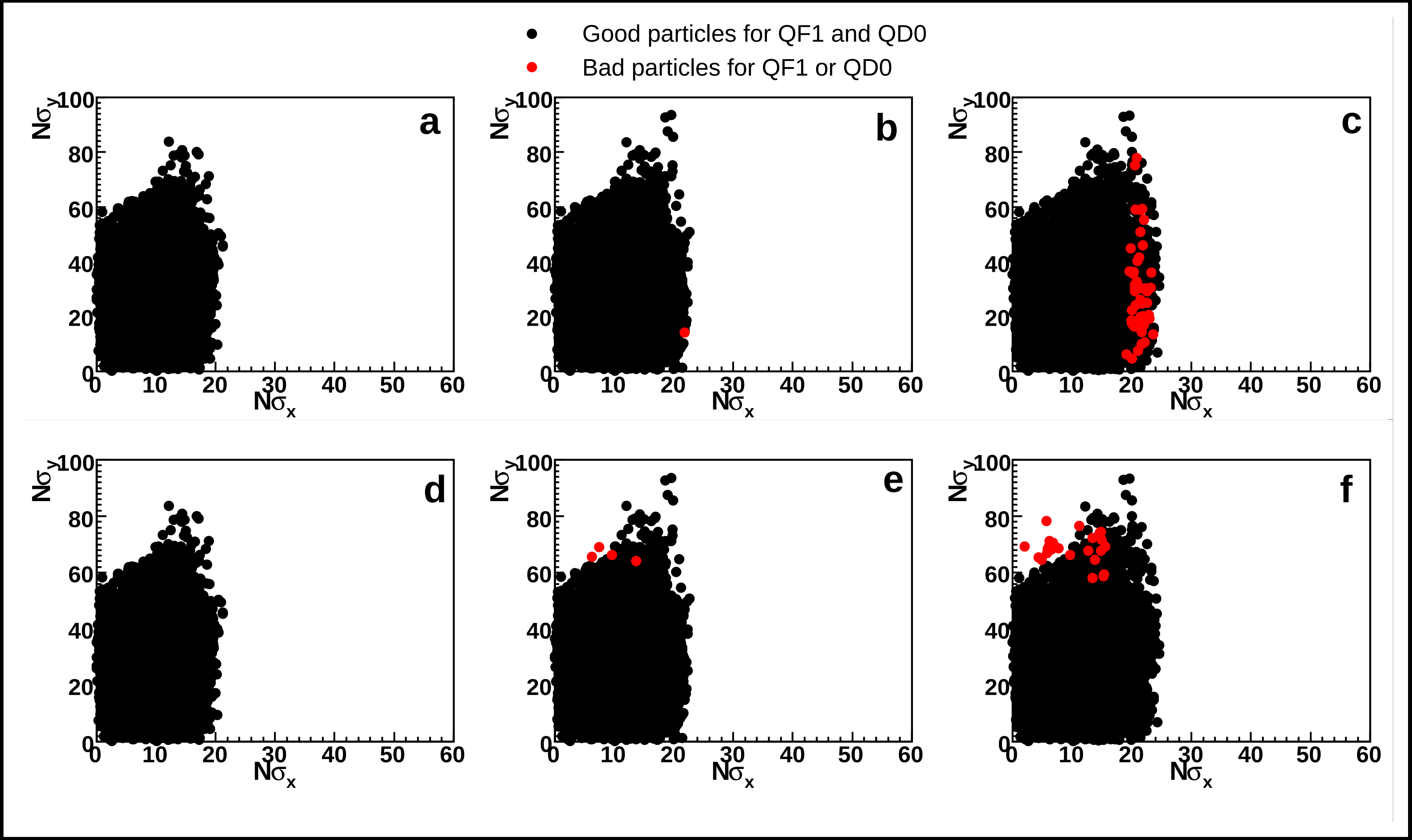
Assuming an initial jitter of 0.2σ wakefields peak lumi reduction is 20%. Open the collimator gaps?

Energy collimator (Be) survivability



Temperature raise after impact of a full train below melting level. (*different philosophy than ILC*)

Collimator gap scan



Acceptable collimation depths are between 10-15σ_x and 44-55σ_y.

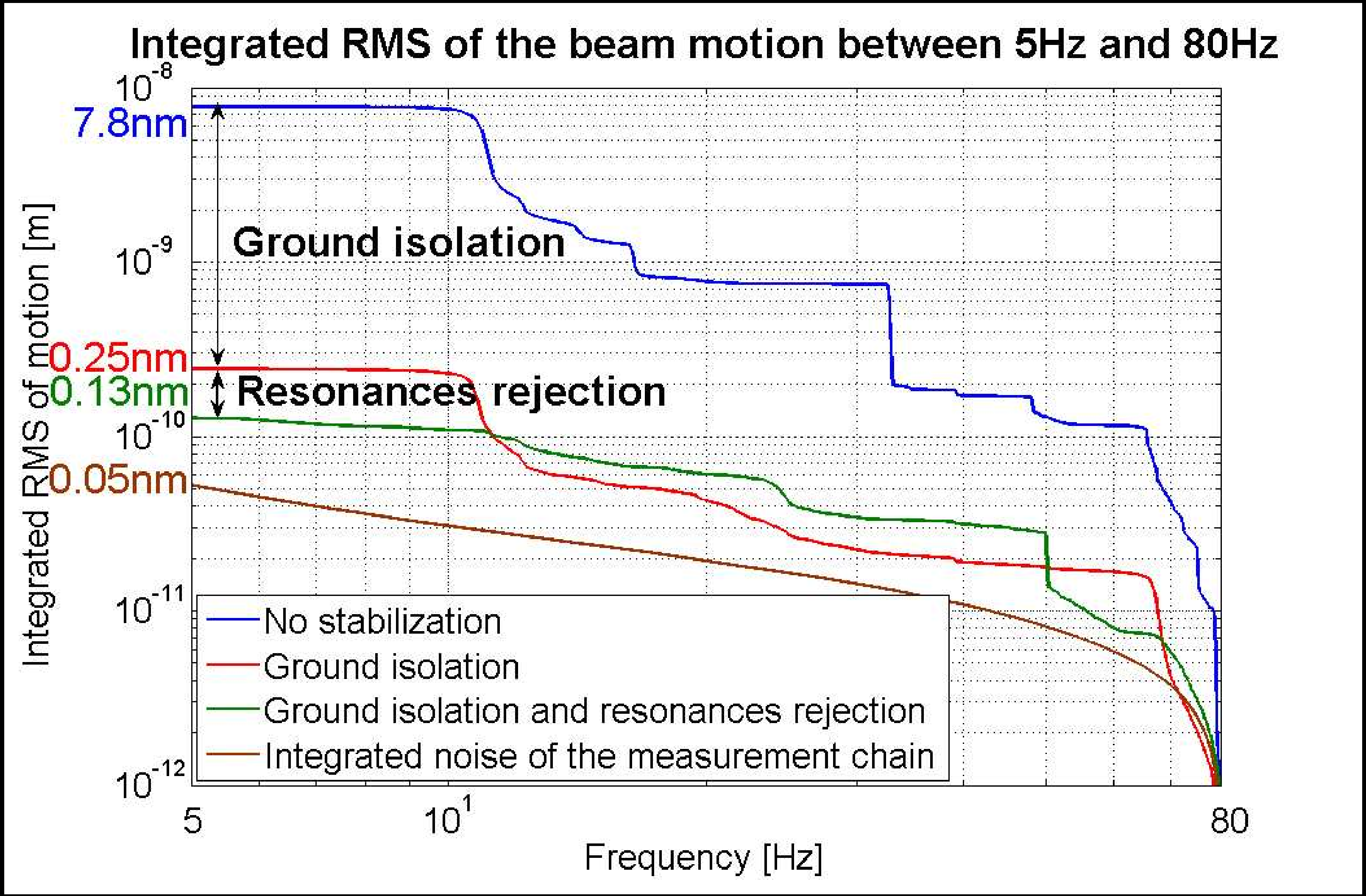
Plans towards CDR

- CLIC 500 GeV lattice optimization (new CERN student on August)
- New tuning algorithms and knobs (help from SLAC, LAL, ATF2...)
- ATF2 ultra-low β progress (new CERN PhD since March and ILC)
- Review and optimization of collimation:
  - wakefields with new parameters (UK)
  - simulations including secondaries (UK)
- QD0 review (Detlef)
- Global feedback studies (new CERN fellow since May)

Some bonus points

- Luminosity measurement, fast and precise (?)
- Crab cavity phase specifications review (0.025° for 12 GHz) (A. Dexter ?)
- Post-IP polarization measurement (help from ILC?)
- 15mW beam dump (help from ILC?)

Stabilization to the 0.13nm



Ground isolation and resonance rejection works.