ATF2 ultra-low betas and even more chromatic proposals

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Thanks to H. Braun, A. Jeremie, A. Latina,
D. Schulte, F. Zimmermann et al

ATF2 collaboration meeting, 2008

FFS problematics

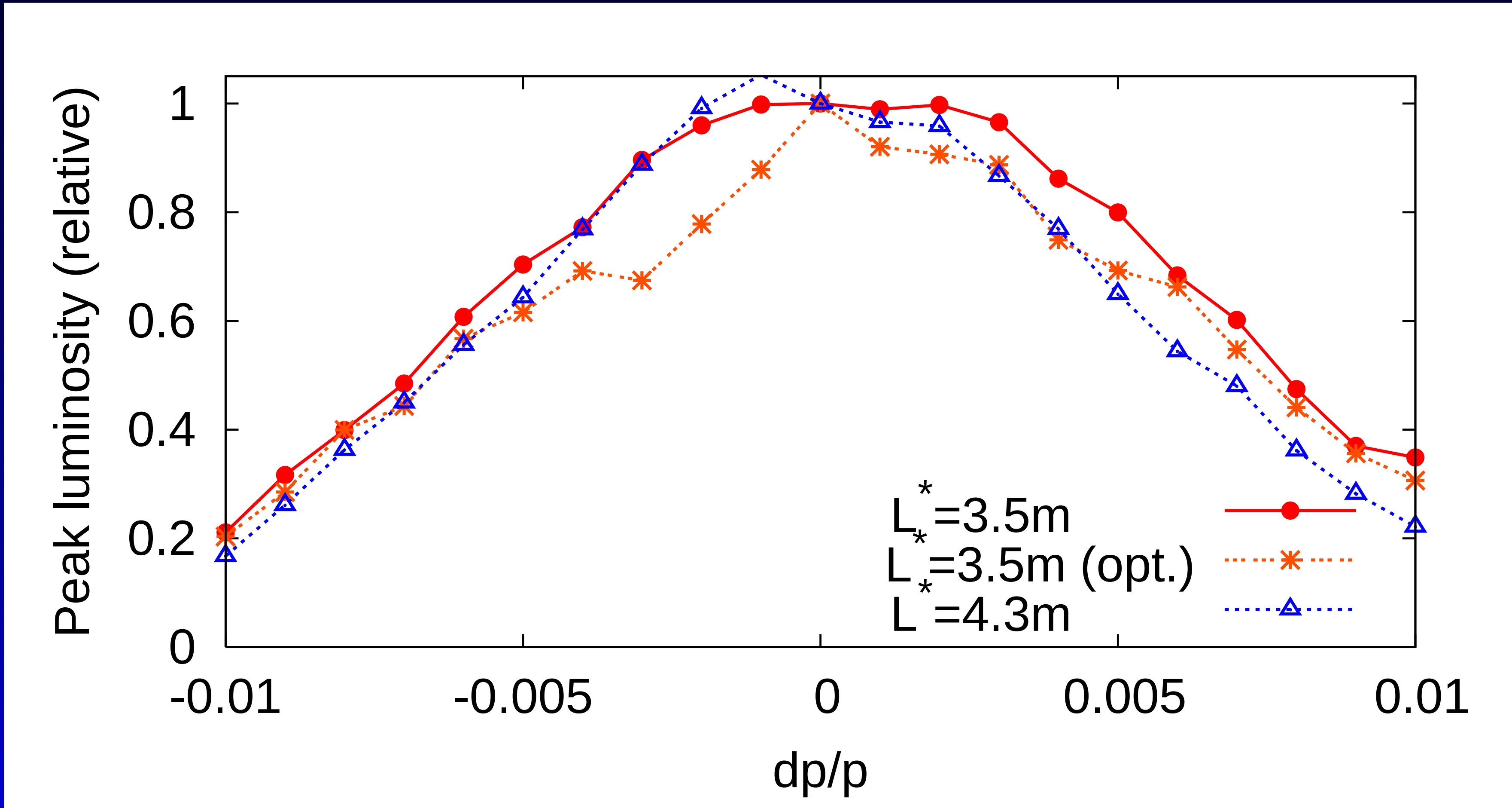
Problem	*Scales with*
Radiation	E^3
Chromaticity (ξ_y)	L^*/β^*
Imperfections, tuning time	$1/\sigma^*$?

Chromaticity

Project	Status	β^*_y [mm]	L* [m]	L^*/β^*_y	ξ_y
FFTB	Measured	0.167	0.4	2400	10000
ATF2	Design	0.1	1.0	10000	19000
ATF2 ultra-low β	Proposed	0.025	1.0	40000	76000
CLIC 3TeV	Design	0.09	3.5	39000	63000
CLIC long L*	Proposed†	0.1	8	80000	120000
ILC	Design	0.4	3.5	8750	15000
ILC pushed	Design	0.2	3.5	17500	30000

† Proposed by A. Seryi in CLIC08

CLIC FFS, 3.5m versus 4.3m L*



→ Larger peak-lumi-bandwidth for the 3.5m L* FFS

IP spot size: tuning

Project	Status	σ_y^* [nm]
FFTB	Measured	70
ATF2	Design	37
ATF2 ultra-low β	Proposed	20
ILC	Design	6
CLIC	Design	2

Does tuning *difficulty* scale as ${\sigma_y^*}^{-1}$?

ATF2 offers the unique opportunity to study tuning versus σ_y^*.

ATF2 ultra-low β proposal

EU contract number RII3-CT-2003-506395 CARE/ELAN Document-2008-002

ELAN

Exploring ultra-low β* values in ATF2
- R&D Programme proposal

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Abstract

We propose to explore the beam sizes and performance of the ATF2 Final Focus System for reduced IP beta functions up to a factor between 2 and 4 below its design. The results will demonstrate the feasibility of the system in a chromaticity regime of interest for CLIC and ILC.

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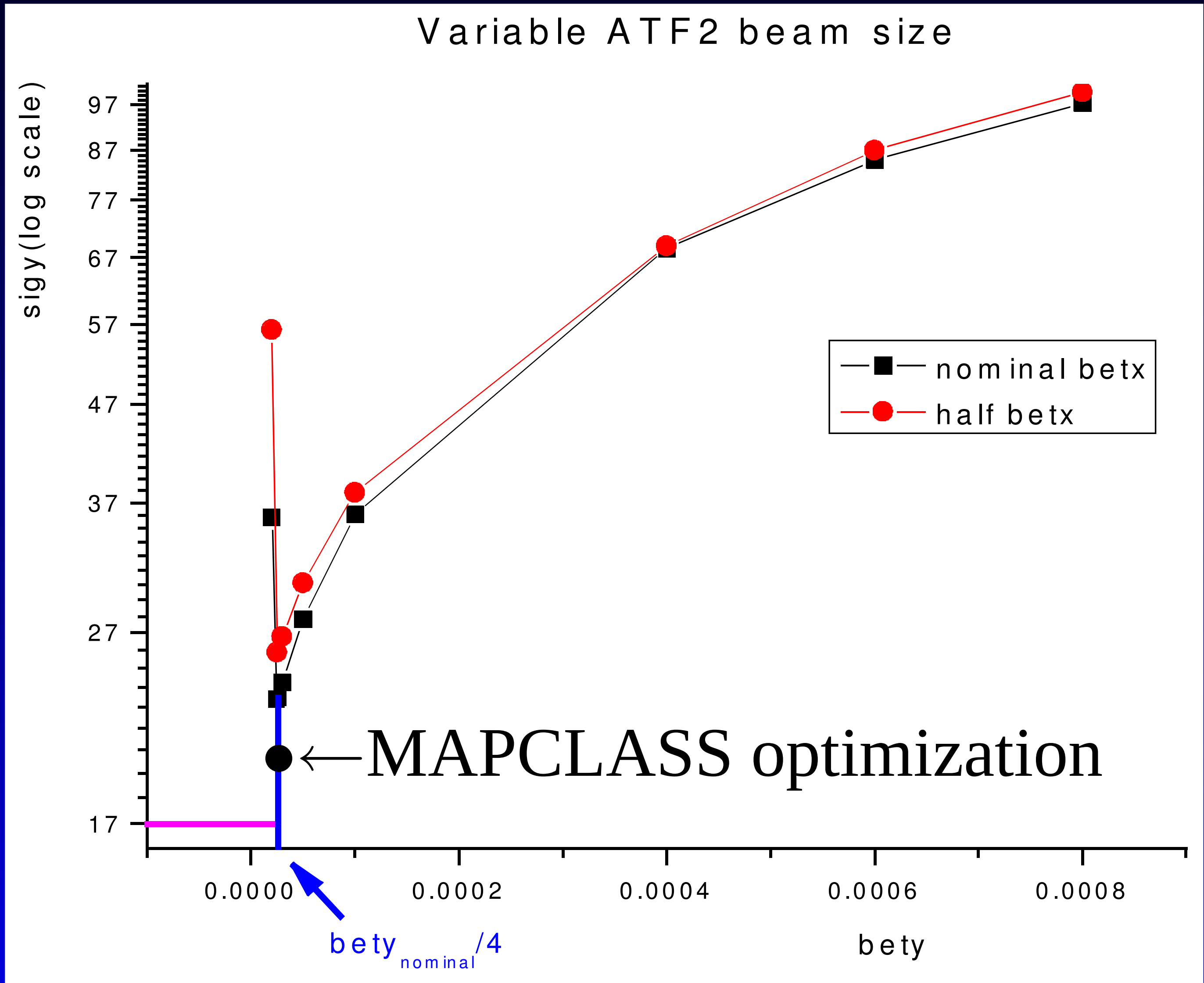
ATF2 β^* scan (S. Bai)

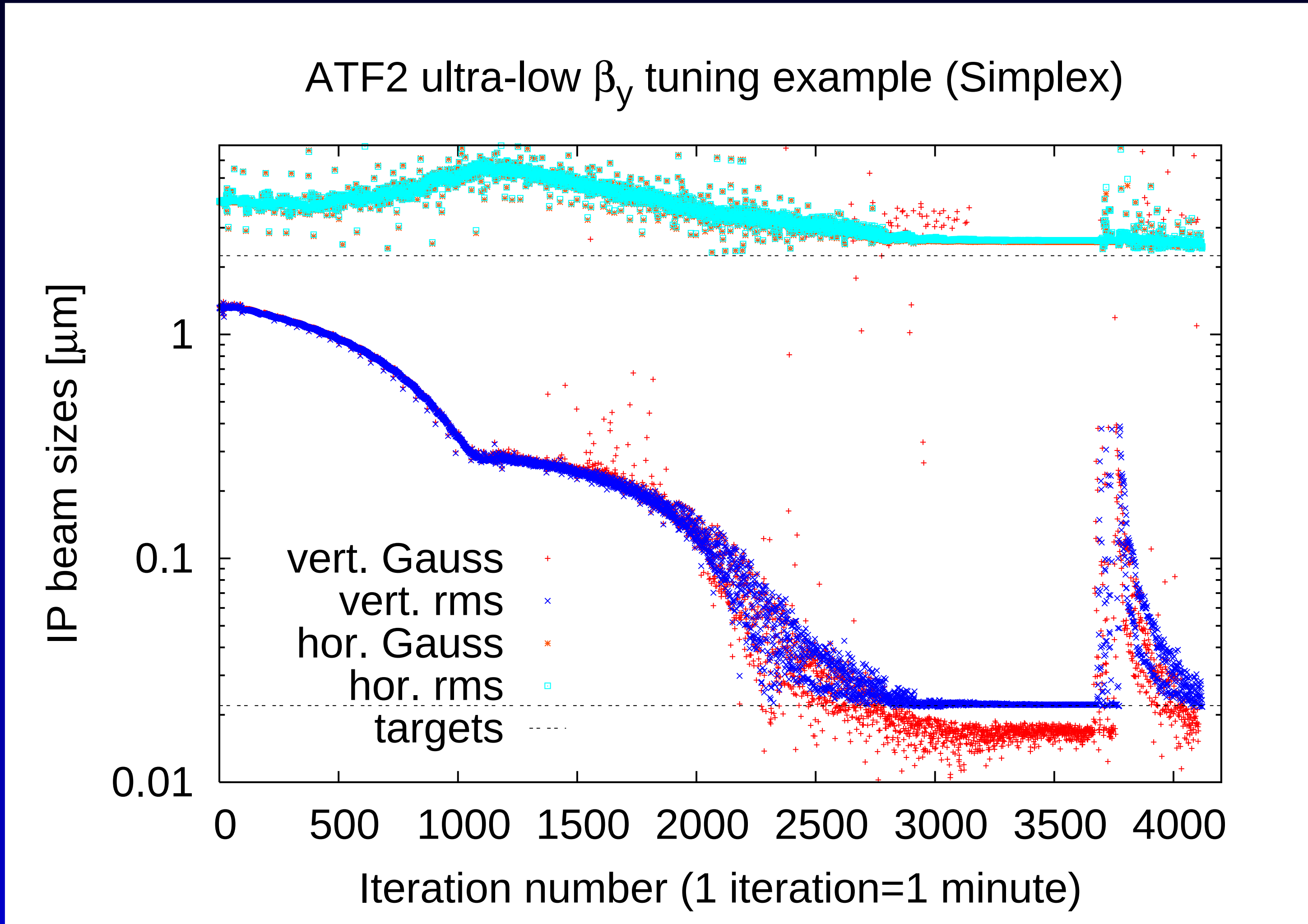


So far the minimum ATF2 σ_y^*=20nm

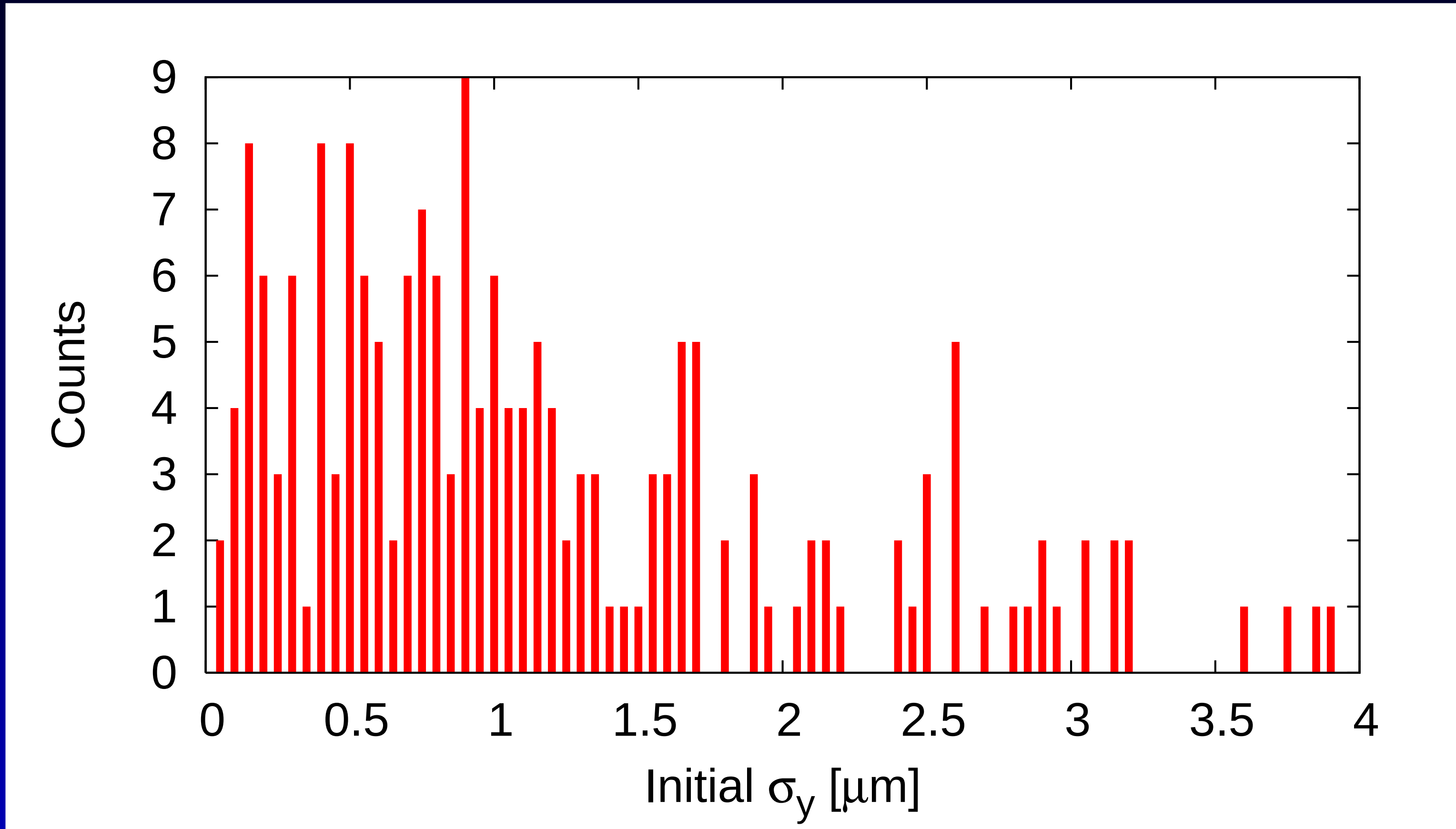
Tuning simulations

- Realistic alignment and field errors are assigned to the ideal model
- Tuning algorithm is the Simplex having: variables:x, y, roll and magnet strength observables:Luminosity (CLIC) or beam sizes (ATF2)
- Ground motion is included in the simulation
- $\gamma\epsilon_x = 3\mu$m, $\epsilon_x = 1.2$nm

ATF2 ultra-low β tuning example

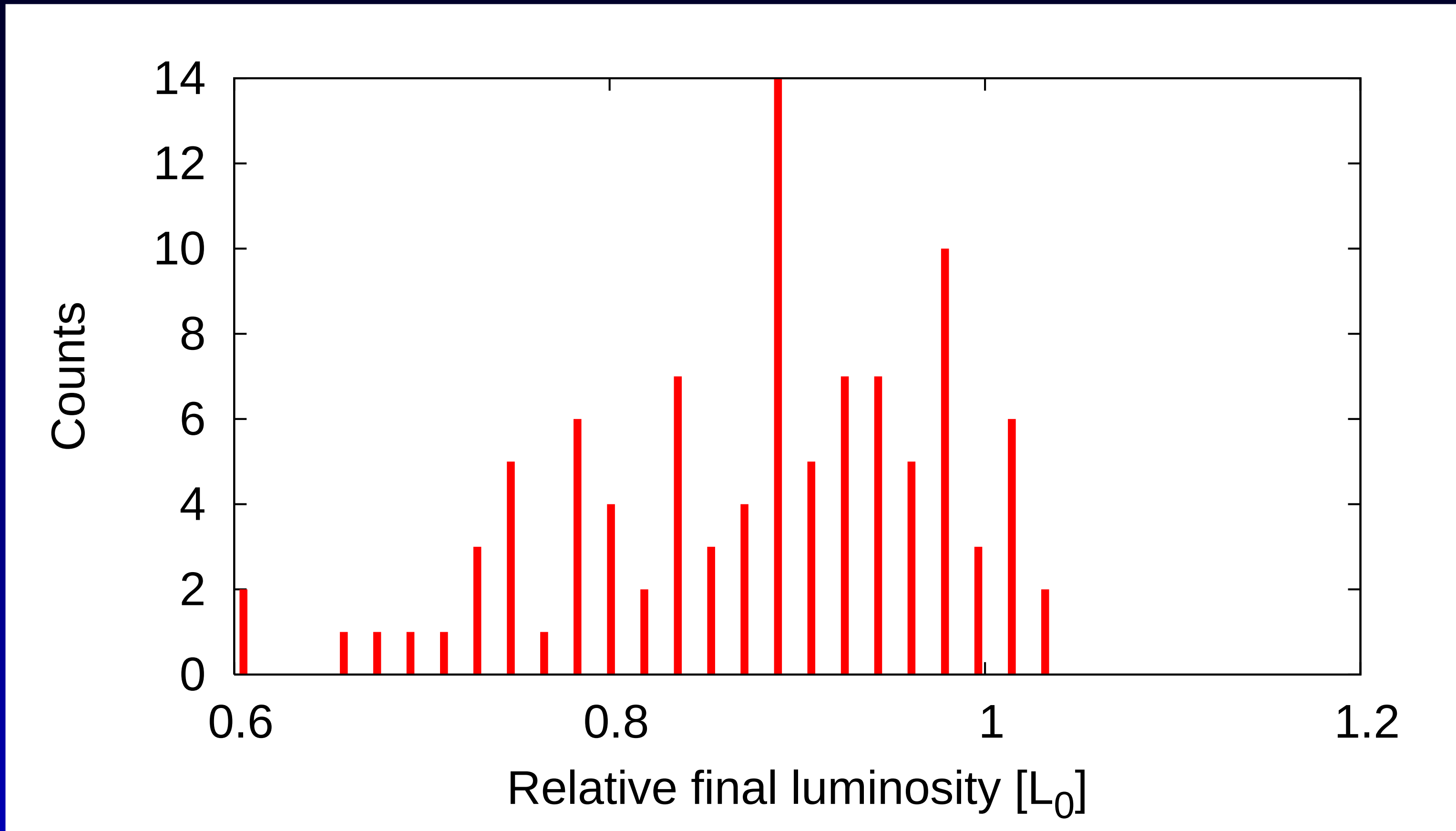


CLIC tuning: 100 perturbed machines



Initial CLIC beam sizes up to 4μm (to be tuned down to 1nm).

Luminosity after tuning

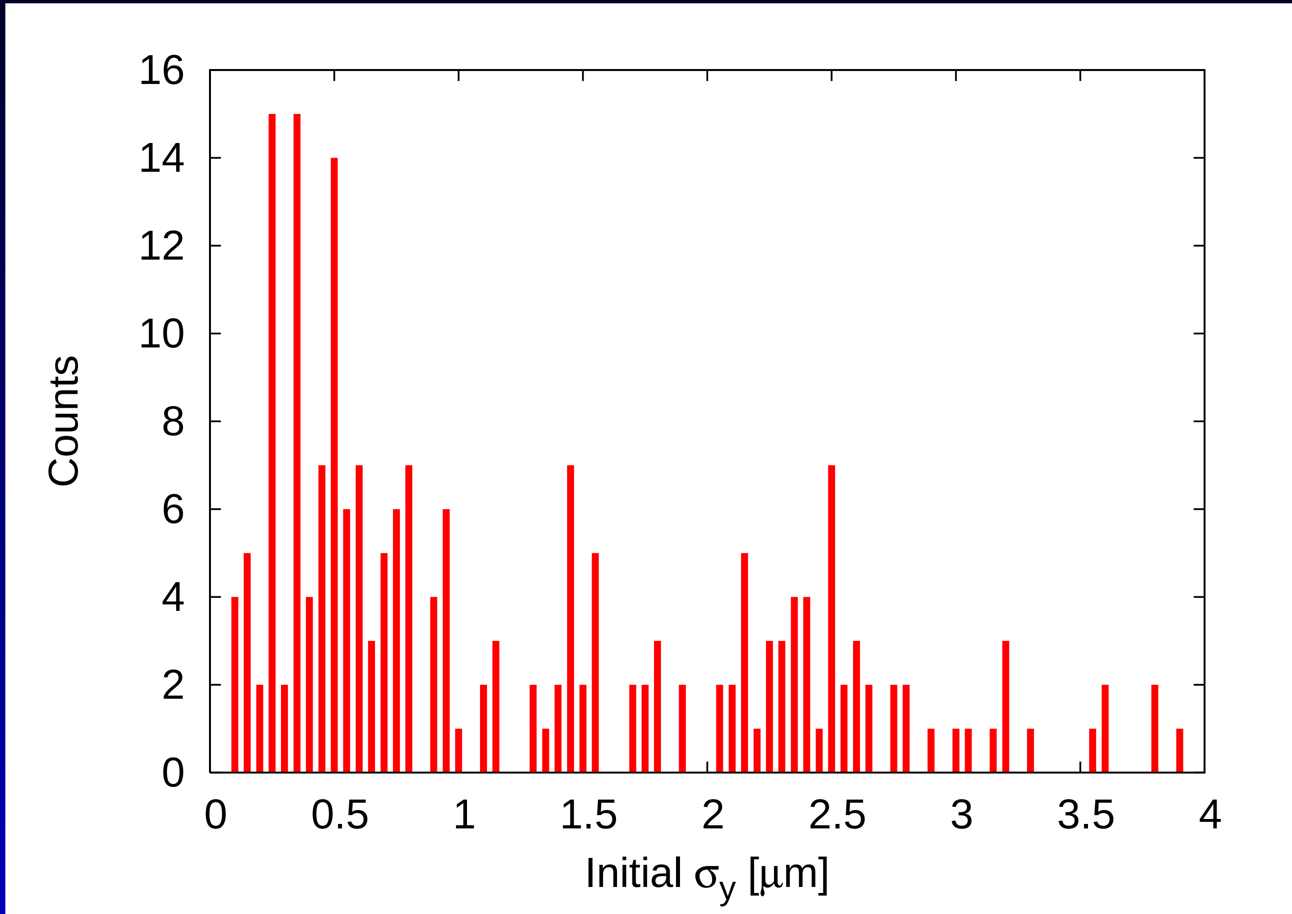


20% of the cases below 80% of the target luminosity!

How to fix this?

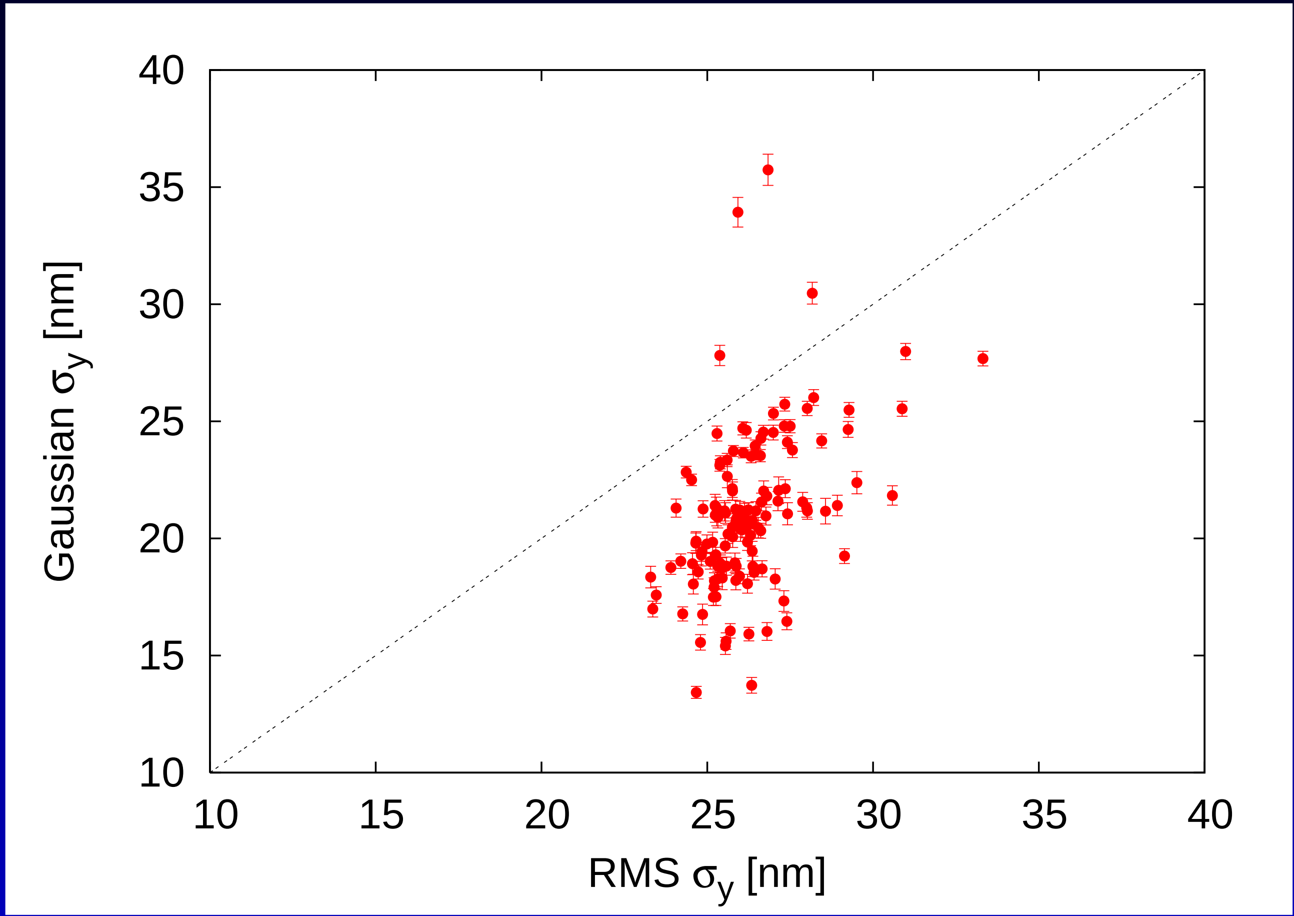
- *Join the ATF2 collaboration*

ATF Initial σ_y for 150 seeds



Up to 4μm of initial σ_y (same as CLIC!).

ATF2 β_y^*=0.025mm



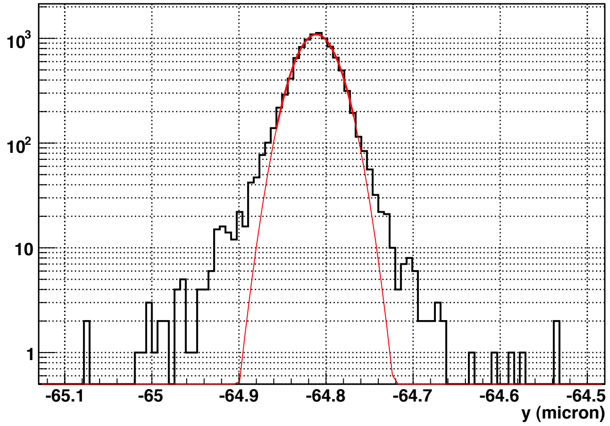
Rising discrepancy between rms and Gaussian fit, what does the Shintake monitor do?

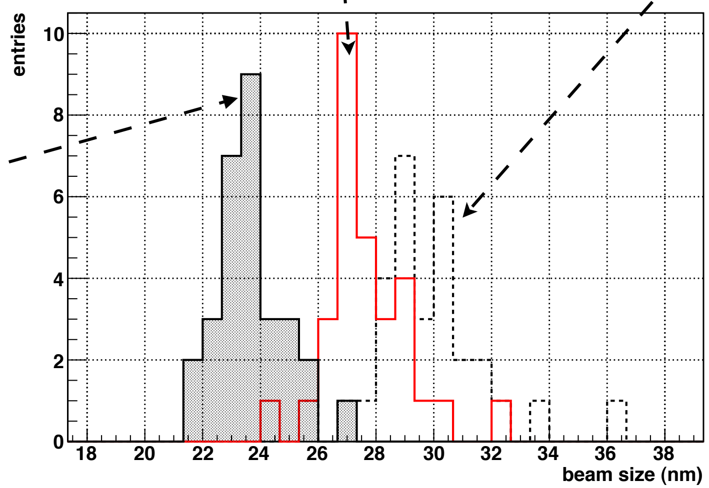
ATF2 β_y^*=0.025: Shintake monitor

Y. Kamiya

For beams with larger deviation from Gaussian made by Rogelio

beam profile



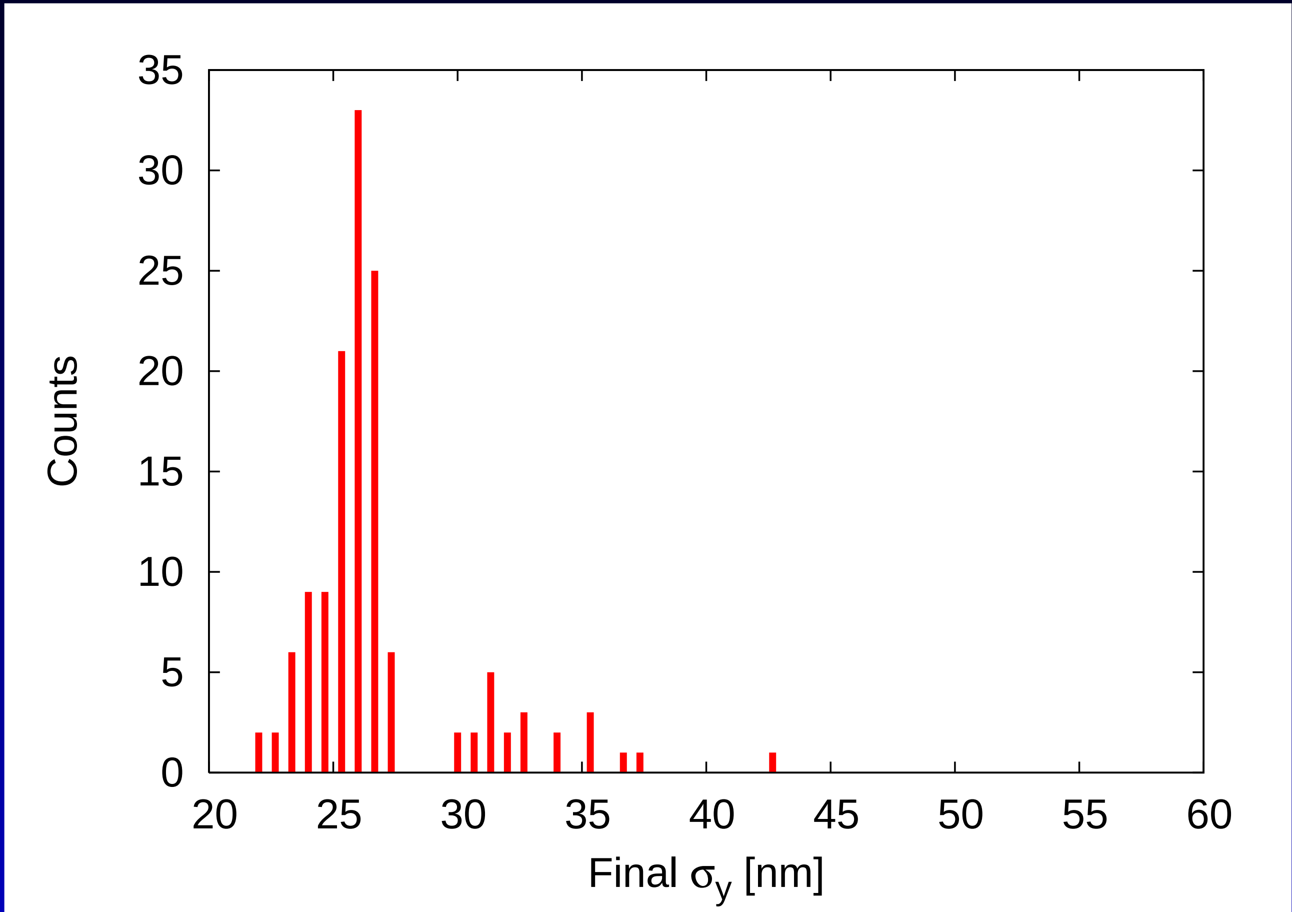


The larger deviation cause bigger difference

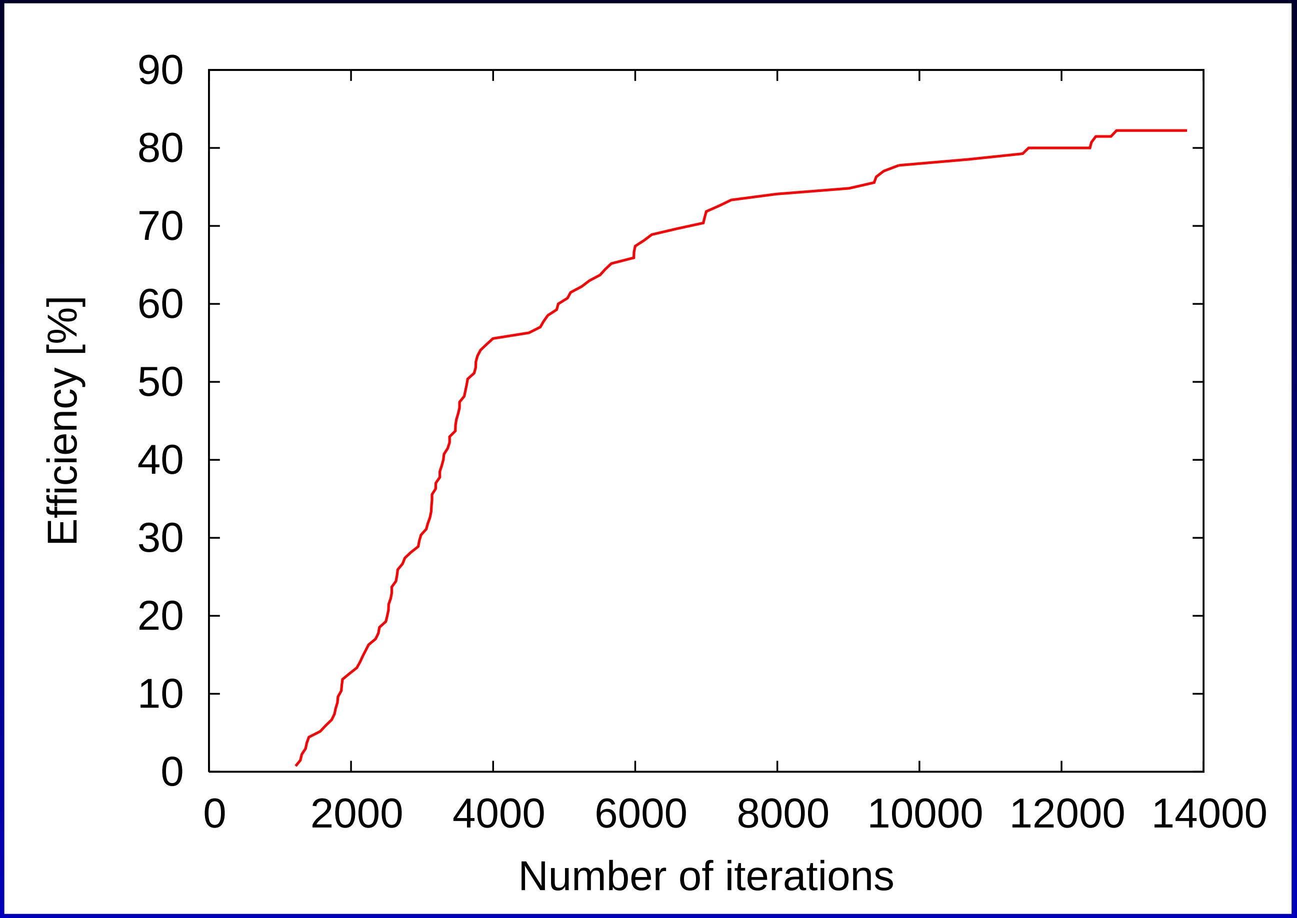
Measured size is between the core size and the RMS size

29th Oct. 2008 ATF2 Weekly meeting 9/16

Final spot size for β_y=0.025mm



Success versus time, β_y=0.025mm



Summary table

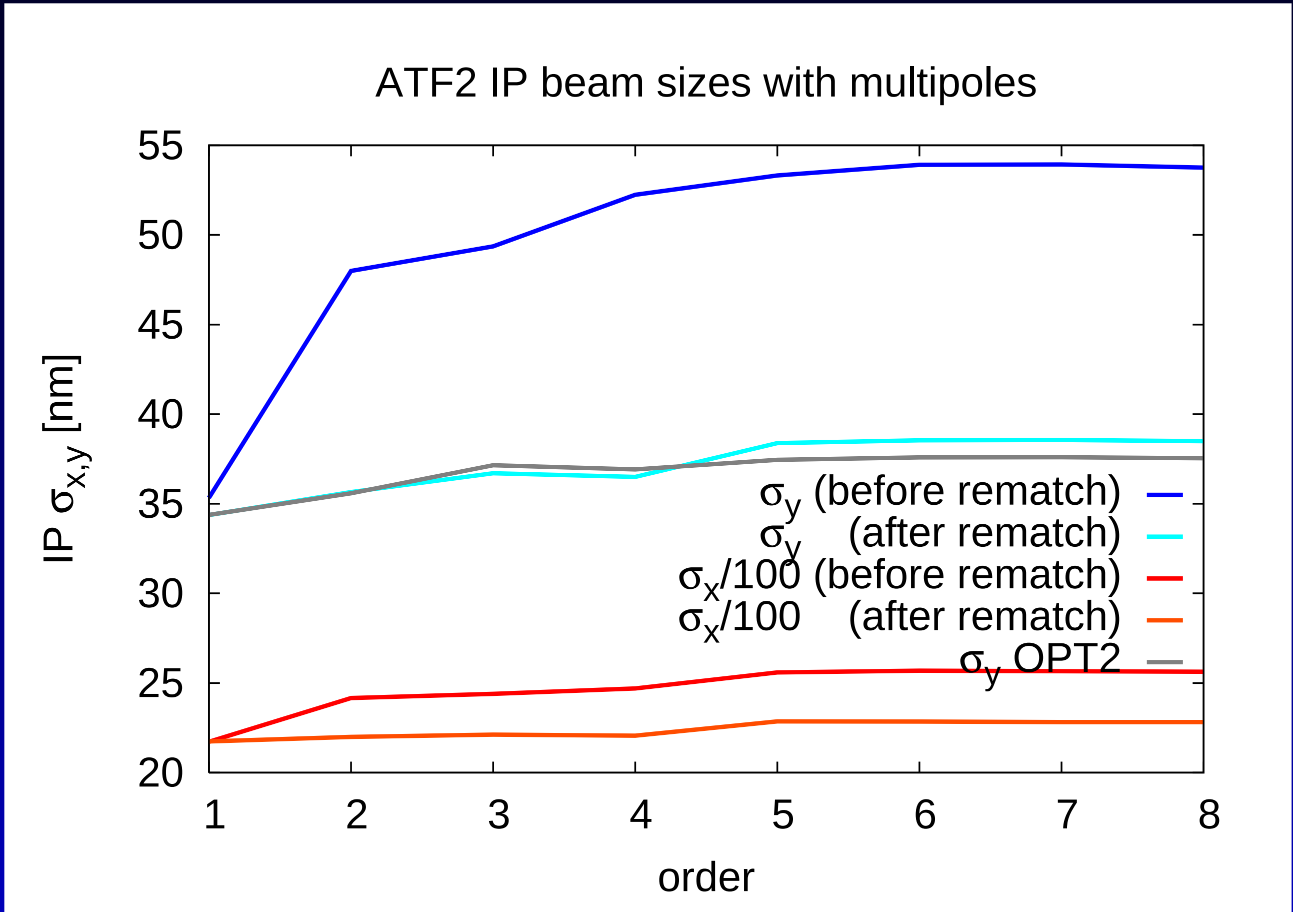
case	Max. tuning time	Ratio of success
β_y=0.1mm	5.5 days	100%
β_y=0.05mm	8 days	90%
β_y=0.025mm	10 days	80%

Tuning time roughly scales with β_y^{-2} or σ_y^{-1}

The magnetic error crisis

- C. Spencer's magnetic measurements.
- Impact on beam sizes for the nominal ATF2:
  - Lucretia, σ_y =100nm
  - SAD, σ_y =90nm
  - MADX, σ_y =55nm
- Discrepancies among the codes for multipoles above the sextupole.
- IP spot sizes no longer 37nm!
- Then? Rematch and fix bugs $\longrightarrow$ ϵ_x

Rematching with MAPCLASS

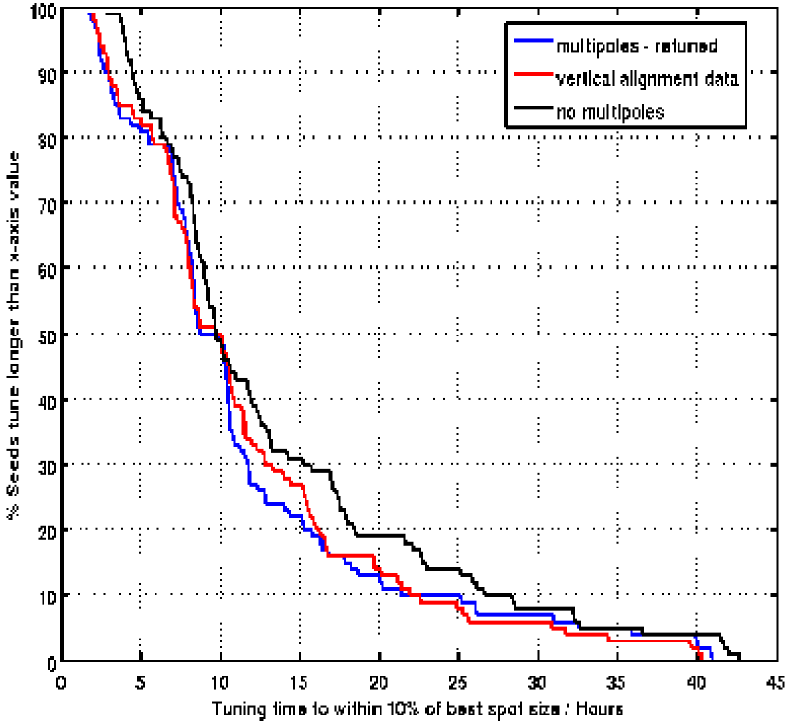


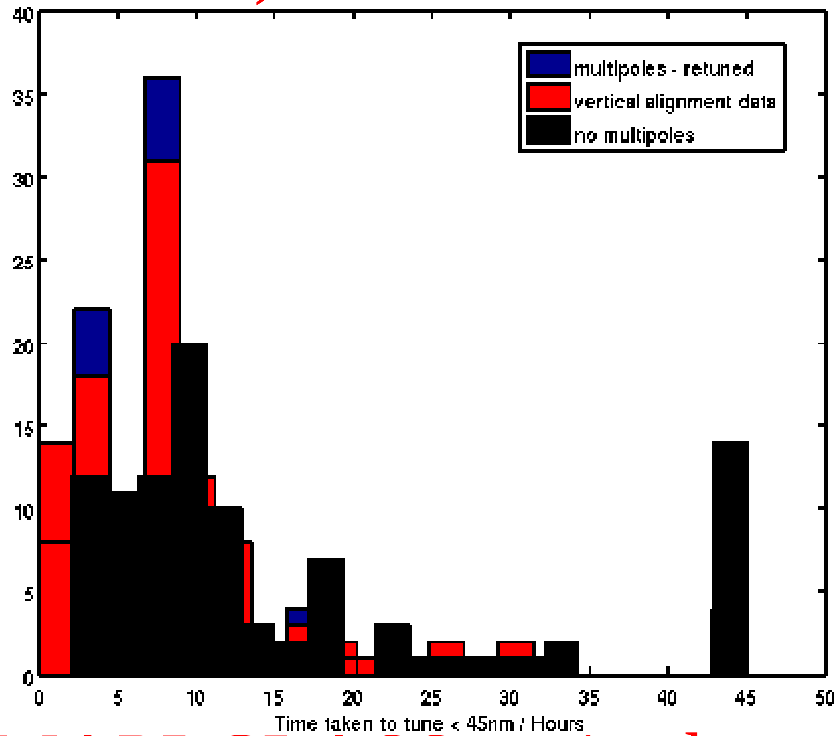
MAPCLASS manages to restore the effect of the multipoles for the nominal ATF2 ($\epsilon_x = 1.2$nm).

Glen’s simulation with MAPCLASS optics

Tuning Results - Time

(ϵ_x =1.2nm)

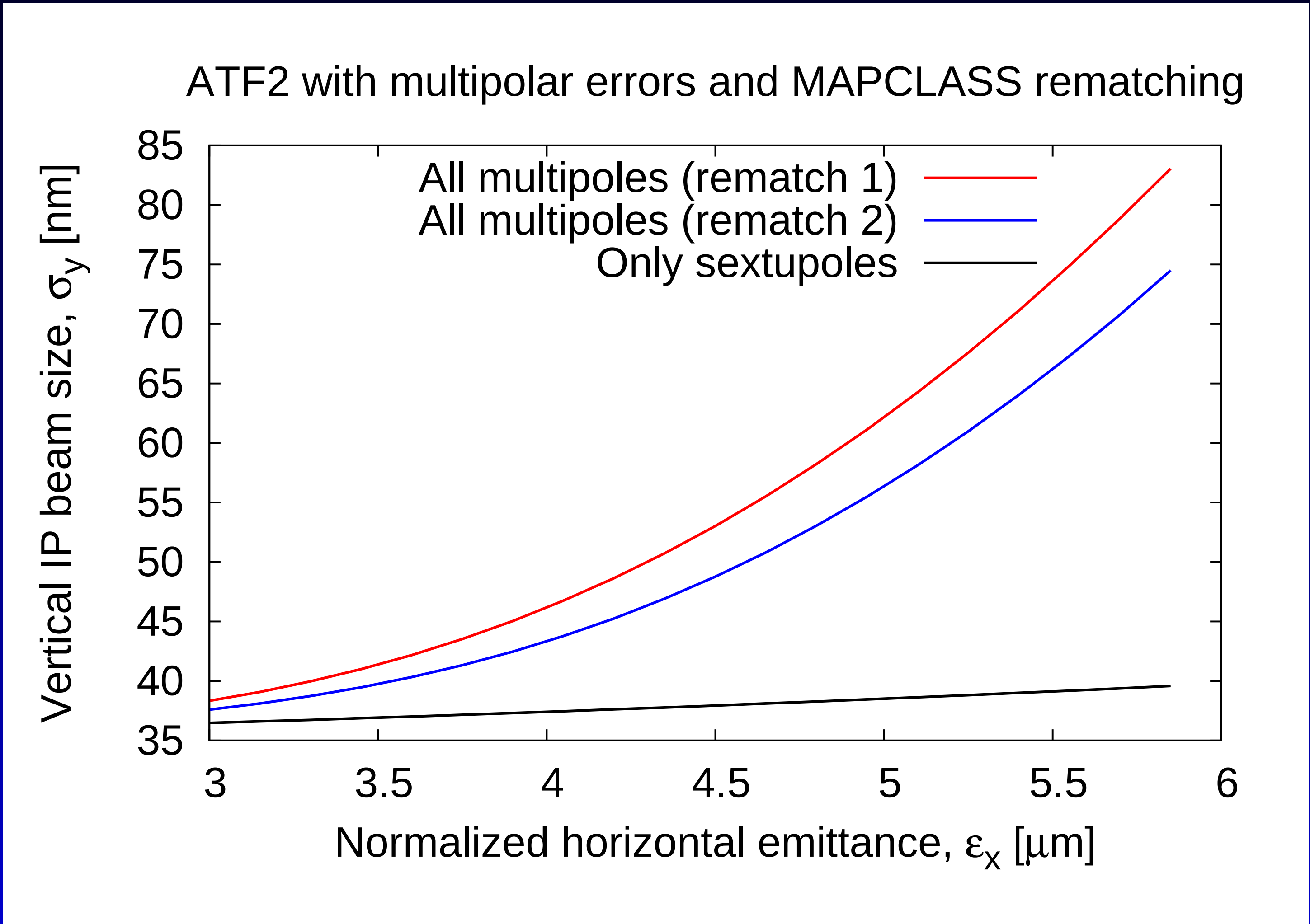




MAPLCLASS optics better than ideal!

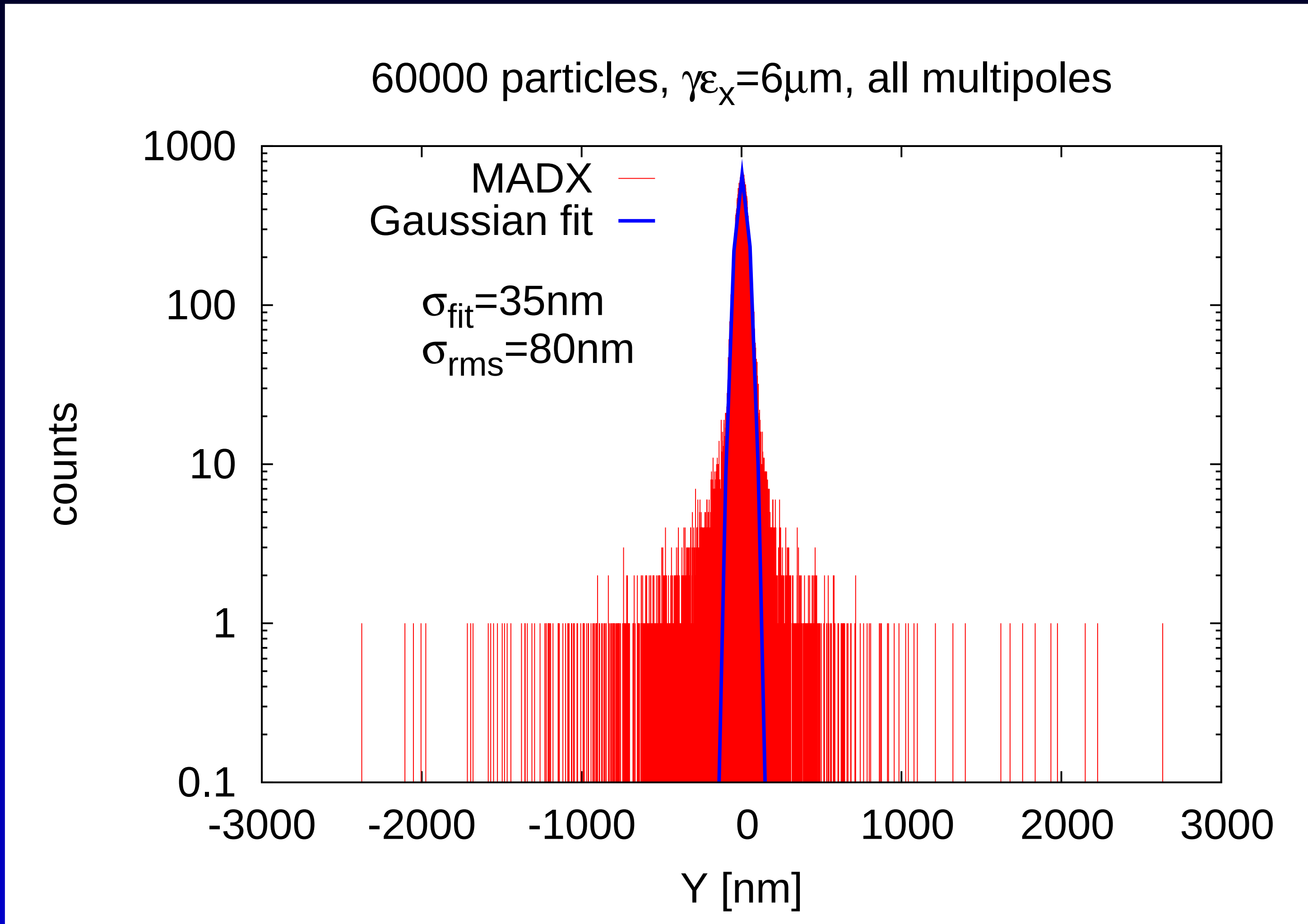
- 90% Seeds tune < 1 day
- All results similar- <45nm results noticeably better after MAPCLASS rematching

Fix bugs and rematch and rematch

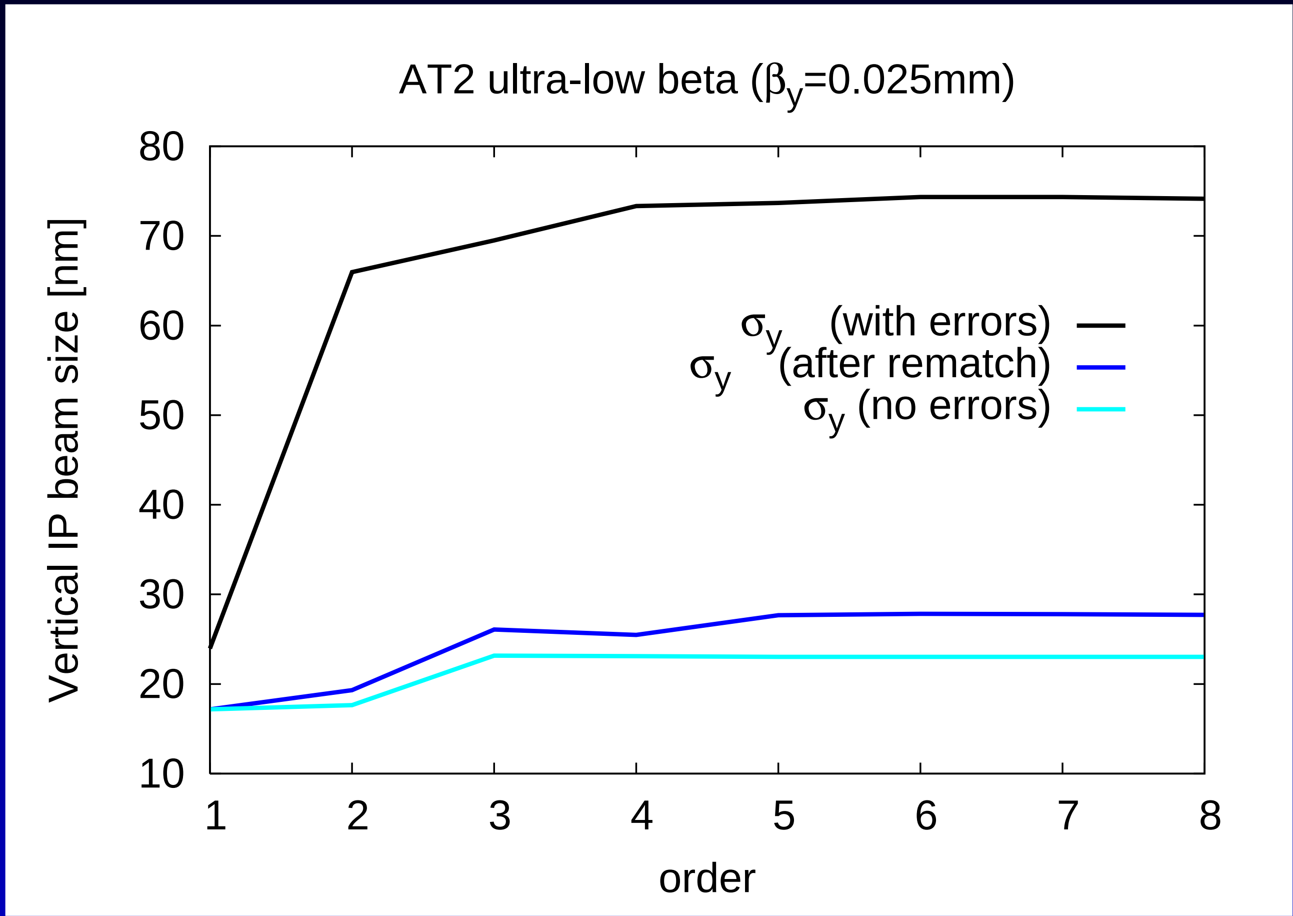


Need N more rematching to obtain: $\lim_{N\rightarrow\infty} \sigma_y$

Particle distribution at $\gamma\epsilon_x = 6\mu$m



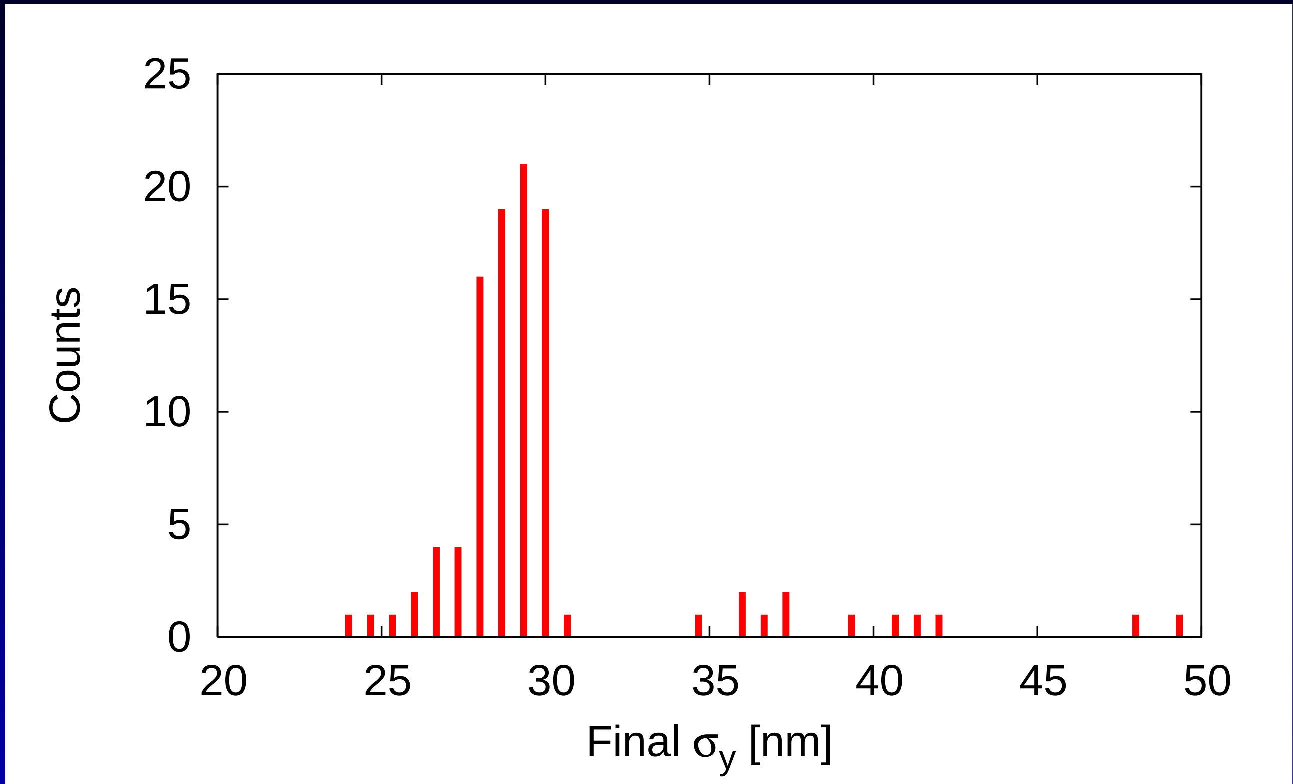
Impact on ATF2 ultra-low β



So far, minimum beam size with multipoles 27nm ($\epsilon_x = 1.2\mathrm{nm}$).

What about tuning?

Impact on ATF2 ultra-low β



Maximum tuning time 10 days

Ratio of success 70%

Most likely σ_y=29nm

$(\epsilon_x = 1.2\text{nm})$

Summary table

case	Max. tuning time	Success	$\langle\sigma_y\rangle$
β_y=0.1mm	5.5 days	100%	43nm
β_y=0.05mm	8 days	90%	33nm
β_y=0.025mm	10 days	80%	26nm

including multipoles

β_y=0.025mm	10 days	70%	29nm

$$(\epsilon_x = 1.2\text{nm})$$

Andrei's proposal for CLIC: double L^*

Advantages of moving QD0 out of detector:

- Easier design
- Easier stabilization
- Less or zero interplay with solenoid

Disadvantages:

- Higher chromaticity $\rightarrow$ tuning difficulty?
- ...

ATF2 tests for long L*?

- Could ATF2 β_y be further reduced to prove larger chromaticity?
- Present limitation is aberrations, could octupoles/decapoles be introduced in ATF2 lattice to compensate for them?
- Seems that tuning time scales with $1/\sigma_y$, what about L*?
- Could L* be increased in ATF2 by displacing the Shintake monitor? Synergy with ground motion correlation studies (A. Jeremie, B. Bolzon)

Summary & outlook

- CLIC and ATF2 have many similarities:
  - Same initial distorted $\sigma_y \approx 4\mu m$
  - Same chromatic level (ATF2 ultra-low β)
  - Similar tuning failure using the Simplex
- Magnetic errors crisis. Solutions: change optics? add dodecapoles? low ϵ_x operation? Superconducting QF1?
- More *colorful* proposals to come
- Lots of work for 2009: CERN hired a PhD to work ≈80% on ATF2

Thanks!