exploring ultra-low β^* values in ATF2

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CLIC'08 Workshop - BDS & MDI WG

contents

- motivation:
  - demonstrate that chromaticity levels of 500-GeV CLIC or pushed ILC are feasible
  - learn how tuning difficulty scales with σ_y
- reducing β's in ATF2
- ATF2 tuning at lower β's
- remarks on apertures, Shintake monitor etc
- time line & people
- summary

motivation I: chromaticity

project	status	β_y^* [mm]	L* [m]	L*/β_y^*	ξ_y
FFTB	design	0.1	0.4	4000	17000
FFTB	measured	0.167	0.4	2400	10000
ATF2	design	0.1	1.0	10000	19000
ATF2 pushed	proposed	0.05	1.0	20000	38000
ATF2 pushed++	proposed	0.025	1.0	40000	76000
CLIC 500 GeV	design	0.2	4.3	21500	35000
CLIC 3 TeV	design	0.09	3.5	39000	63000
ILC	design	0.4	3.5	8750	15000
ILC pushed	design	0.2	3.5	17500	30000

motivation II: tuning difficulty

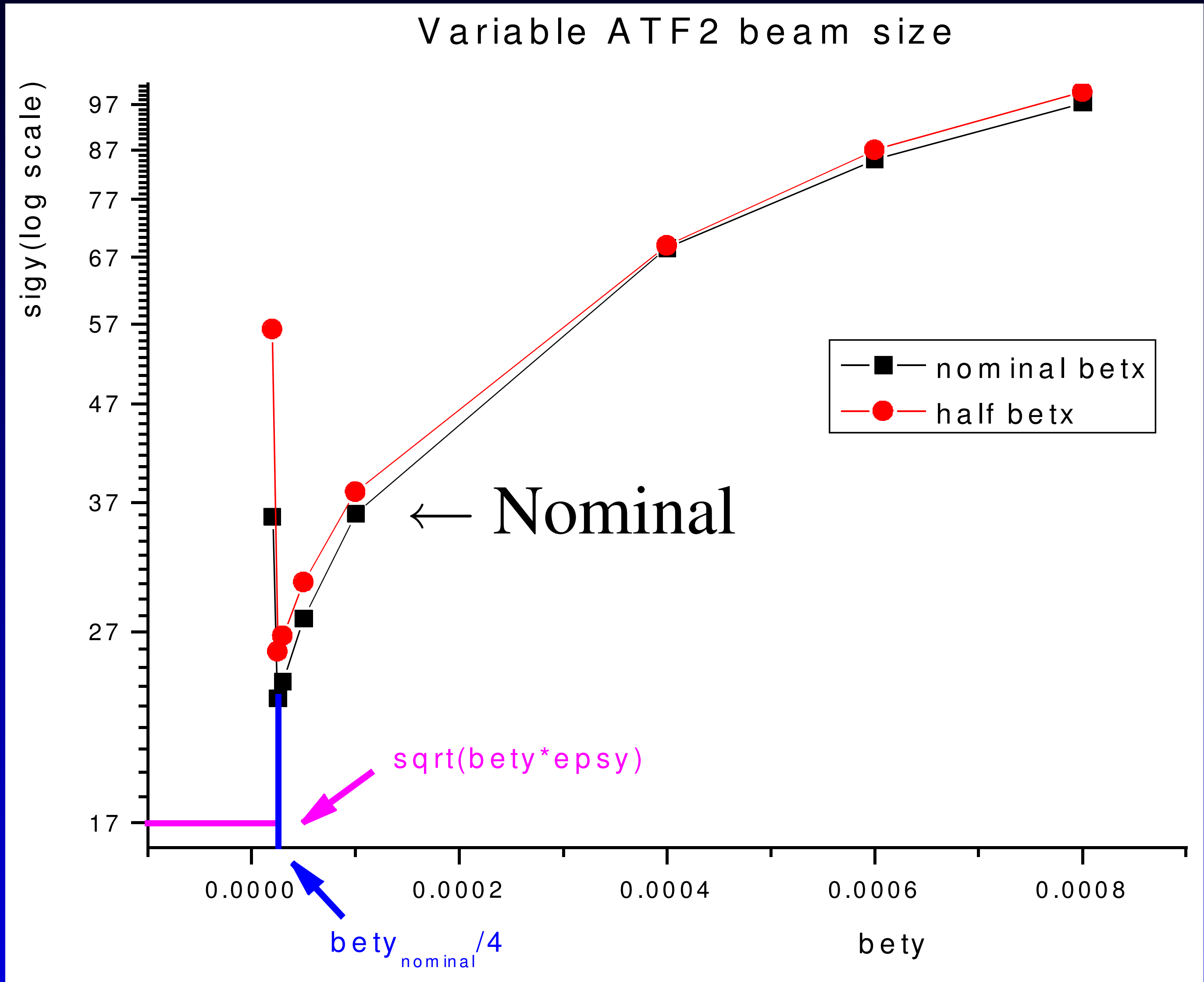
project	status	σ_y^* [nm]
FFTB	measured	70
ATF2	design	37
ATF2 pushed	proposed	<26
ATF2 pushed++	proposed	<20
ILC	design	6
CLIC 500GeV	design	3

does tuning difficulty and tuning time scale as ${\sigma_y^*}^{-1}$?

both ILC and CLIC need ATF2 σ_y^* as low as possible!

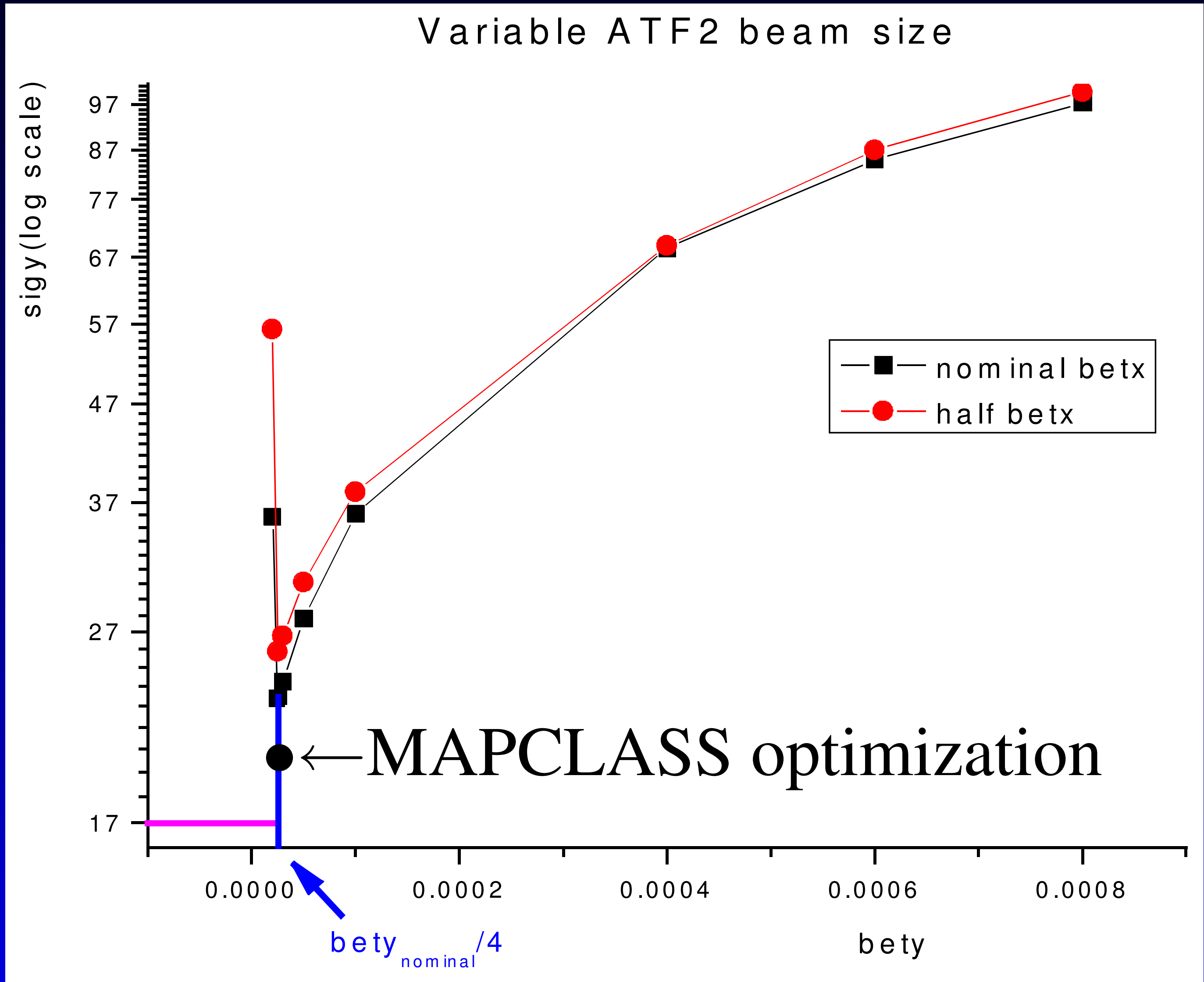
what is the minimum achievable σ_y^* in ATF2?

Sha Bai's & Philip Bambade's first β_y scan



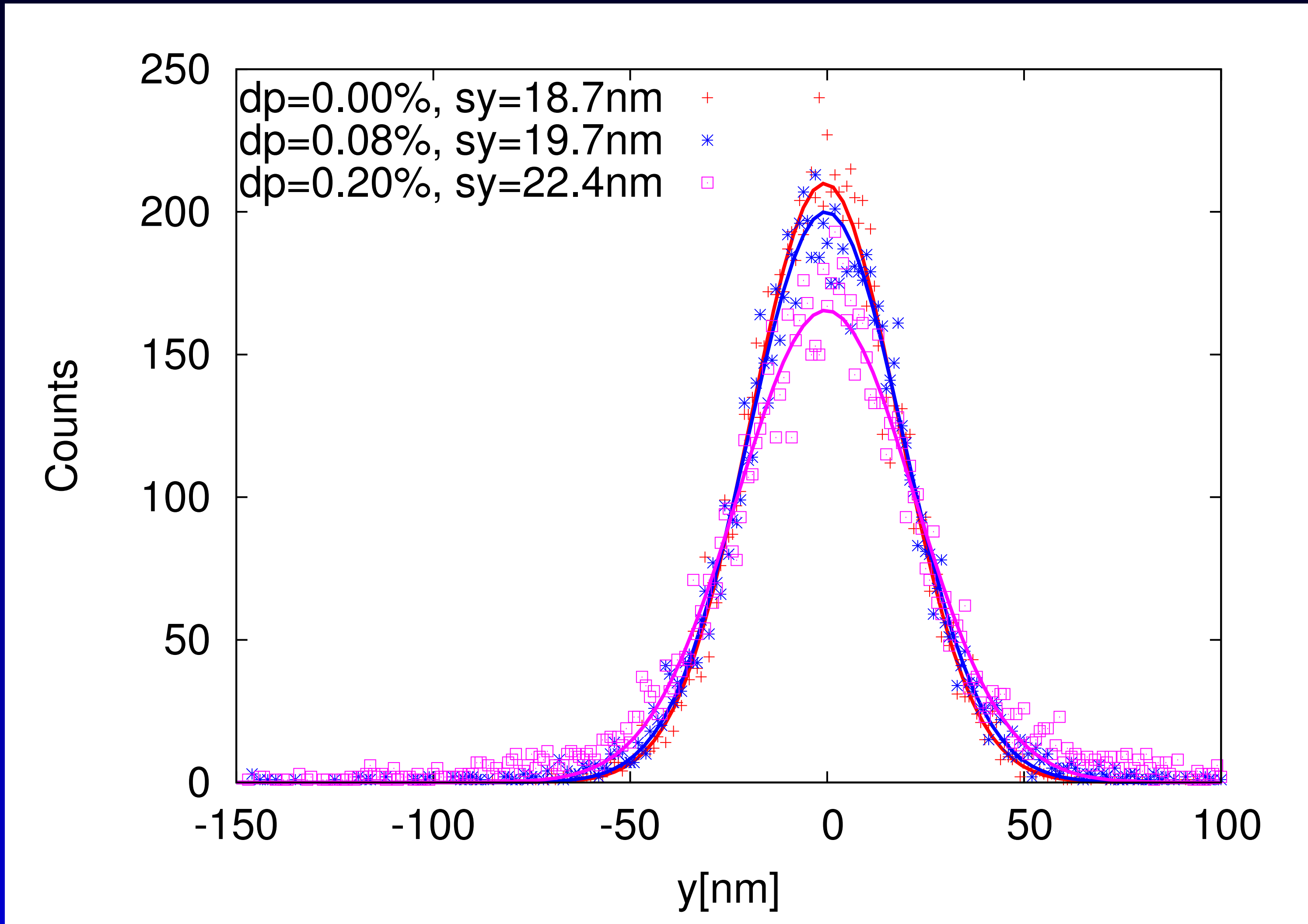
could we push a bit more?

on-going optimization with MAPCLASS



Sha is still looking into further improvements...

some tracking for β_y=0.025mm



rms spot sizes below 20 nm within reach
($\gamma\epsilon_x = 3\ \mu$m, $\gamma\epsilon_y = 30$ nm [10$\times$ ATF '09 goal!?])

tuning versus β_y

0-th order tuning algorithm based on Simplex:

- observables: σ_x and σ_y at IP
- 100–150 variables: magnet strengths, tilts, x and y displacements
- code: PLACET-Octave
- ingredients:
  - realistic errors
  - ground motion (PLACET model)
  - convergence “reached” when $\sigma_y < 1.1\sigma_{y0}$ for 3 measurements, or maximum number of iterations
- we try this on the nominal & $\beta_y/2$ case

simulation ingredients

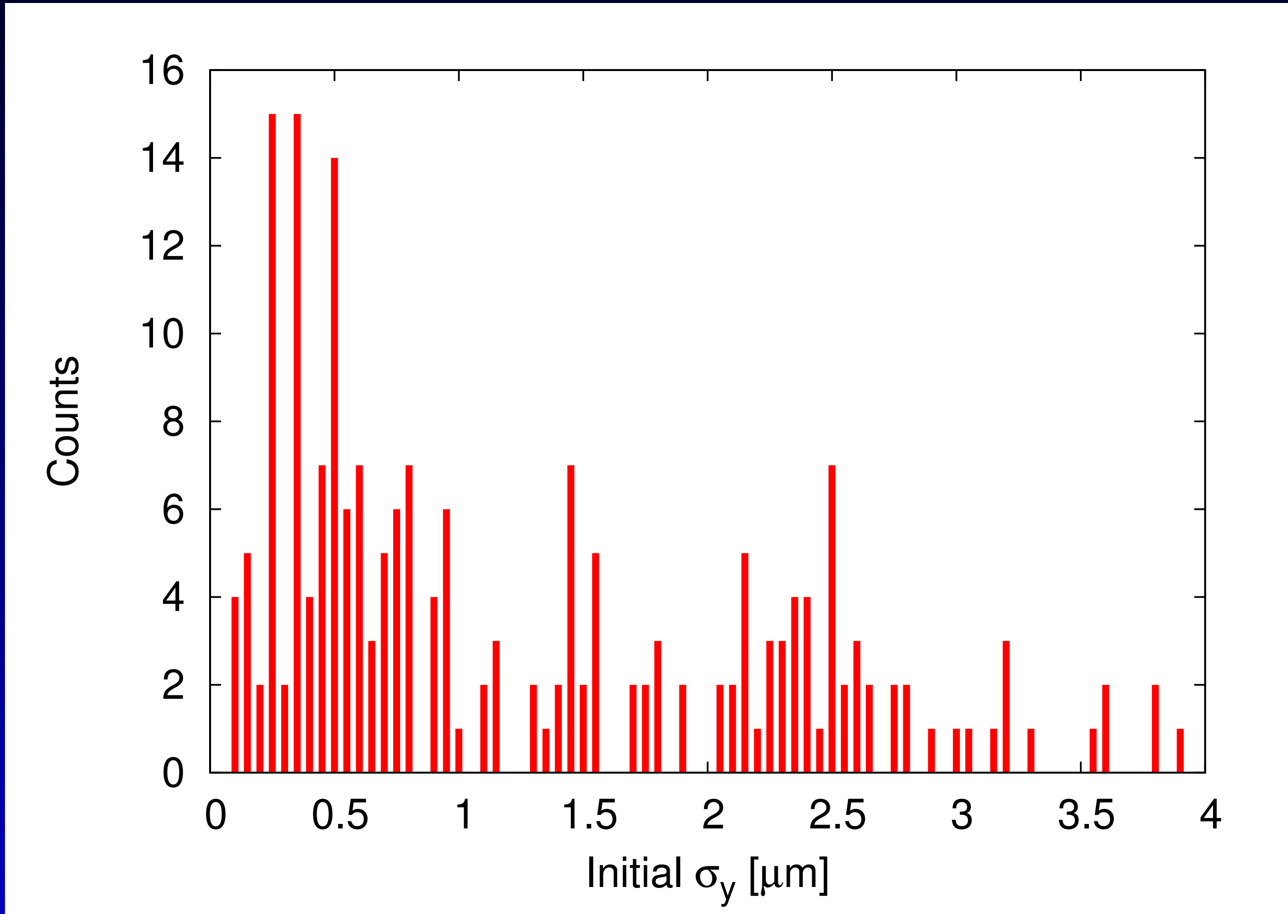
errors:

- H & V misalignments with $\sigma = 30\ \mu$m
- transverse roll with $\sigma = 30\ \mu$rad (too low?!)
- relative strength error with $\sigma = 10^{-4}$
- measurement error of σ_y, σ=2 nm

missing ingredients:

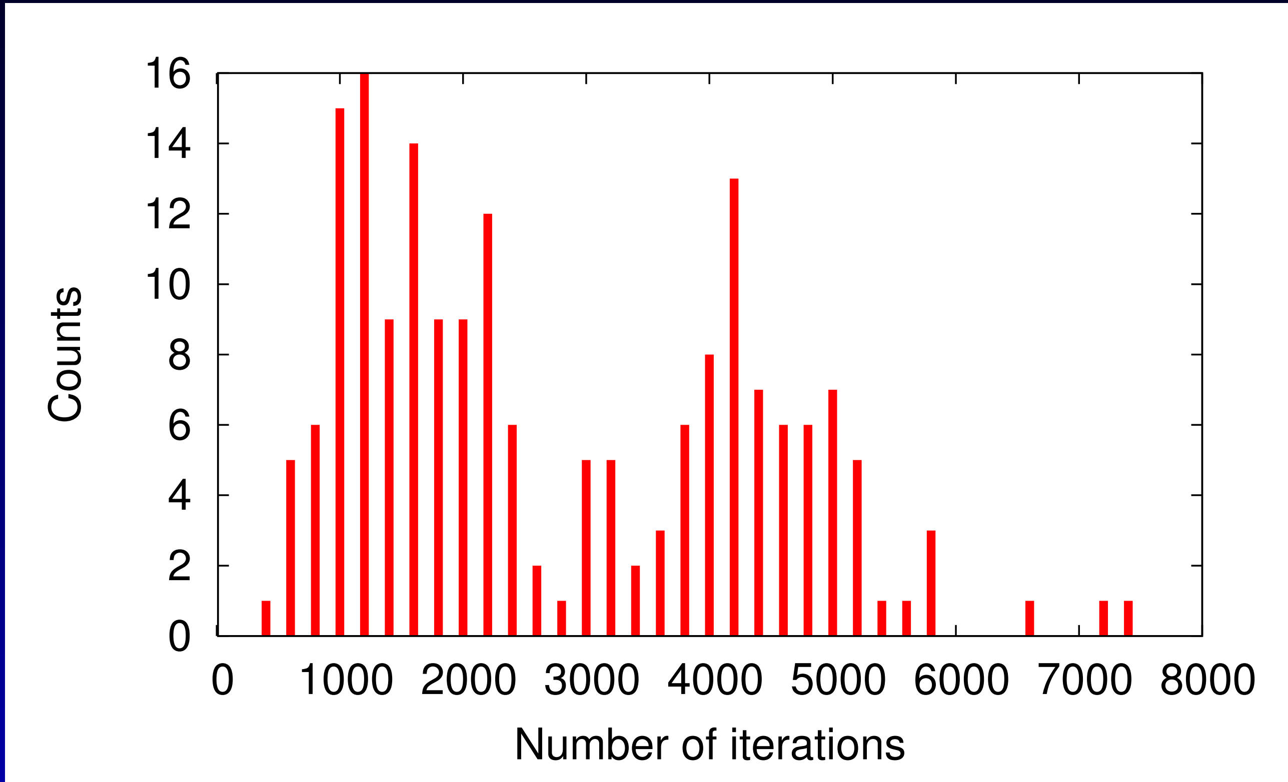
- beam jitter
- mover step size
- (which could become the limiting factors!)

initial σ_y for 150 seeds



initial σ_y up to 4 μm

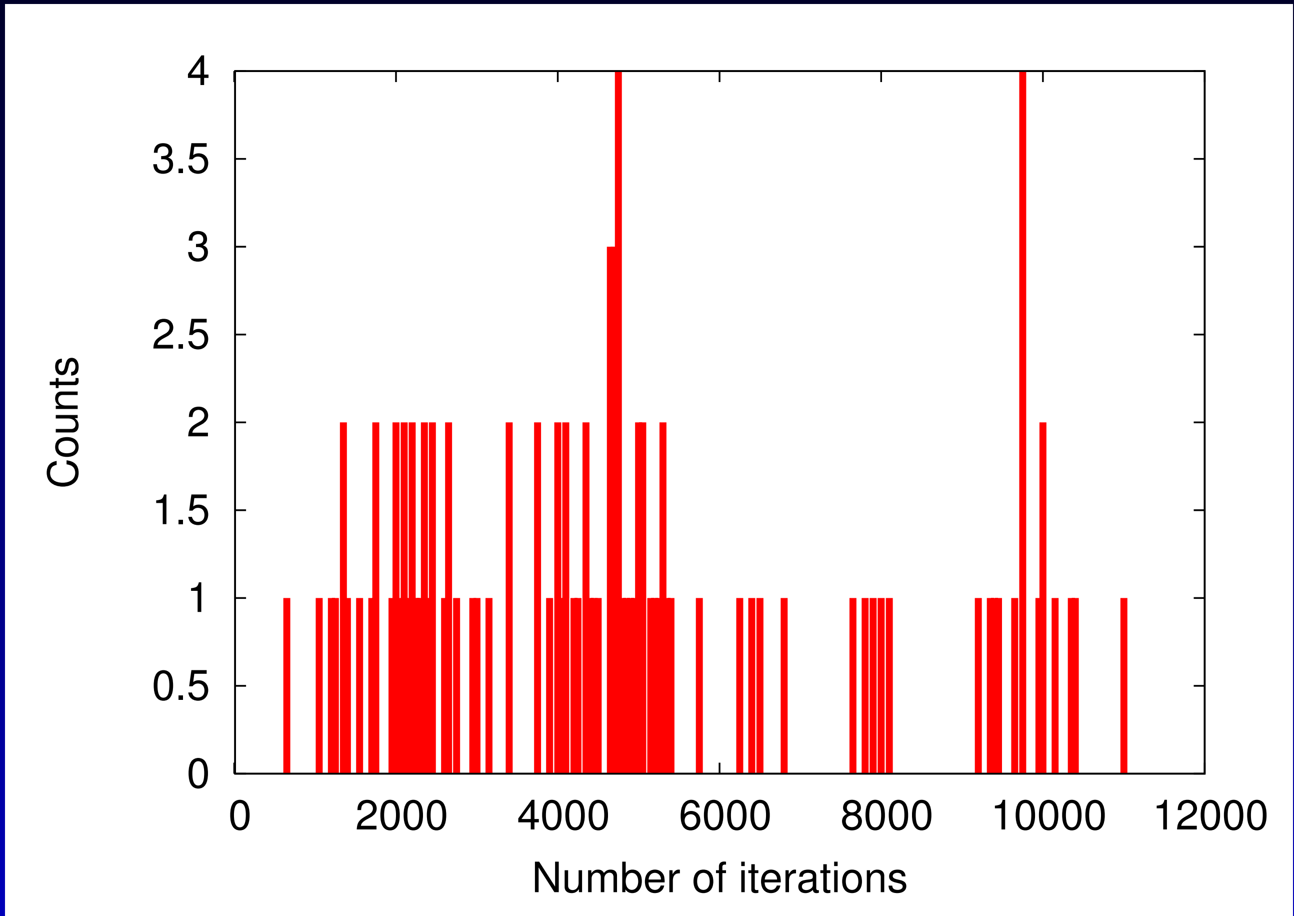
number of iterations for β_y=0.1 mm



less than 8000 iterations required;

1 iteration $\sim$ 1 minute; 4000 iterations $\sim$ 3 days

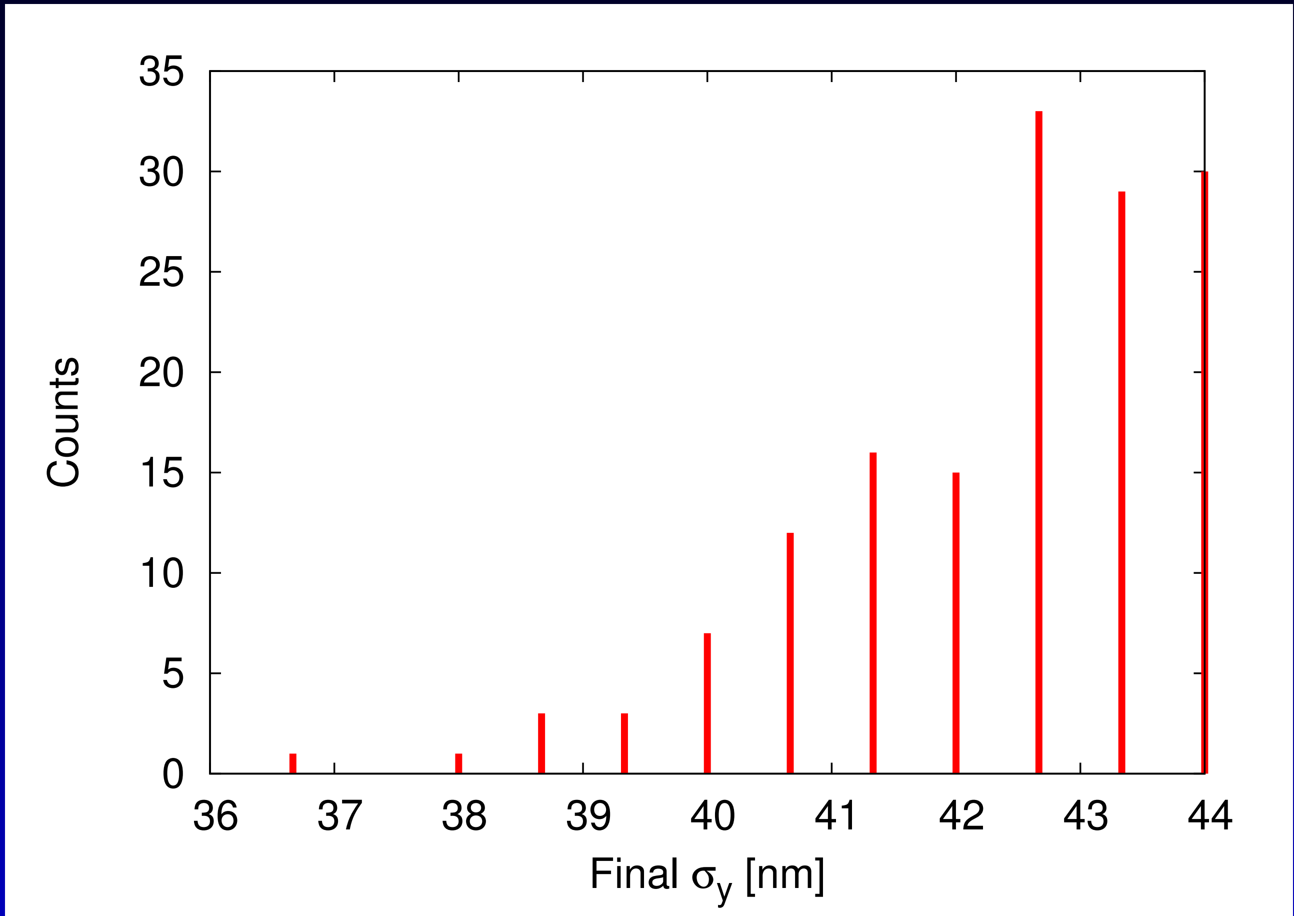
number of iterations for β_y=0.05 mm



less than 12000 iterations required but maximum is hit in some cases

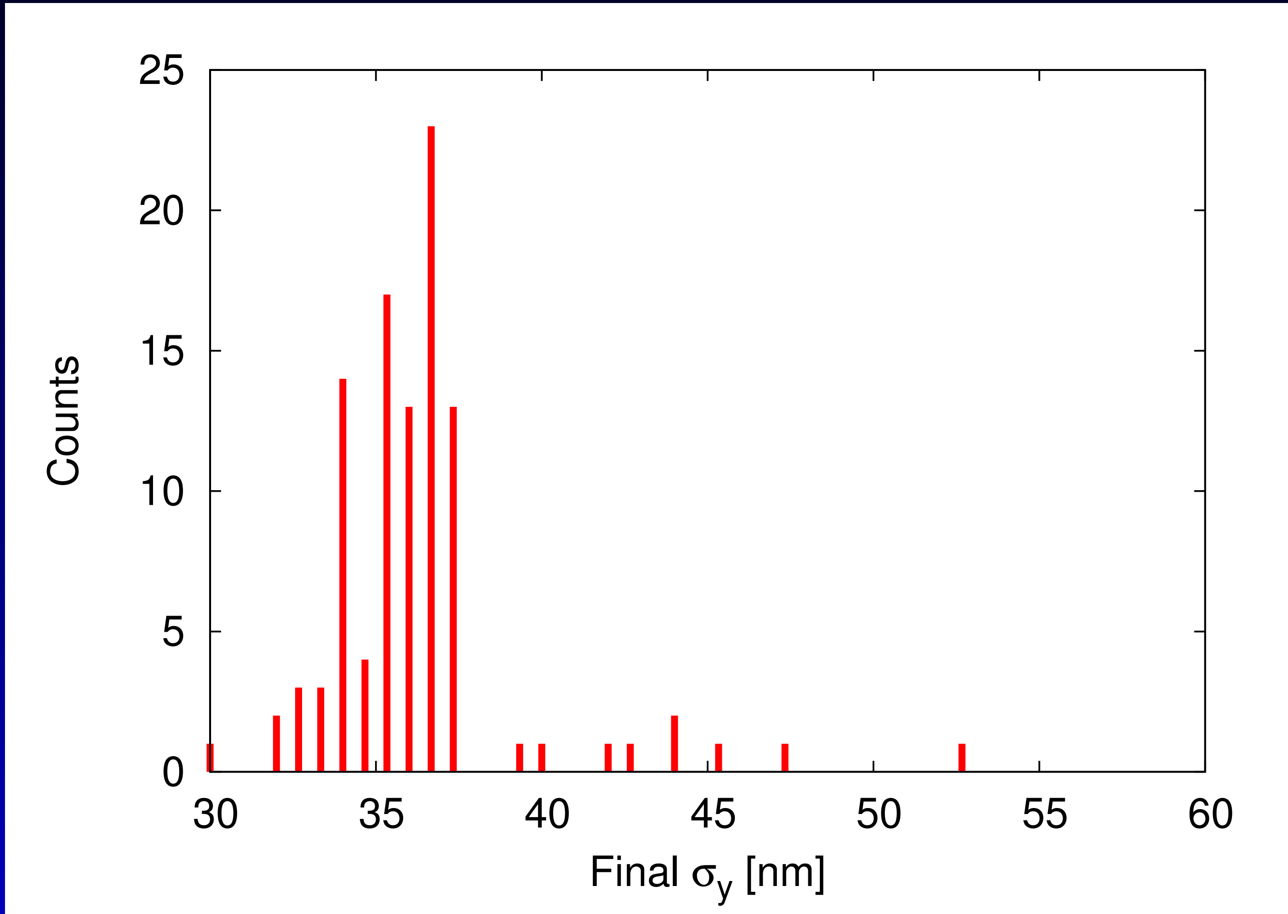
more iterations required for lower β!

final σ_y for β_y=0.1 mm



final σ_y between 37 and 44 nm

final σ_y for β_y=0.05 mm



some seeds fail to finish between 30 and 37 nm; one seed even stops at 53nm!!

lower β requires more sophisticated tuning algorithms

remarks

- $\sigma_y \approx 20$ nm was reached in simulations with $\beta_y^* = 0.025$ mm respecting ATF2 powering & aperture constraints
- Shintake monitor measuring range is between 20 nm and 5 μm: perfect!
- reducing β_x might increase background at Shintake monitor; possible solutions: new larger superconducting quadrupoles, or upstream beam collimation
- further studies are required, e.g. for $\beta_y = 0.025$ mm (tuning convergence, rms vs. Gaussian fit, Shintake monitor response, ...)

time line

- after successful operation of nominal ATF2 (2010–2011?)
- ATF2 continuous operation at lower β values for period long enough to prove operation and assess tuning difficulty
  (to be re-assessed in view of ATF2 experience)

people

- 21 people from 6 labs expressed support (directly or indirectly)

summary

- pushing the limits of ATF2, exploring uncharted chromatic territory, and reaching spot sizes below 20 nm has raised worldwide interest!
- this push will prove beneficial for ILC and CLIC
- $\sigma_y \approx 20$ nm should be the ultimate ATF2 goal
- at this stage it requires systematic studies on:
  - design and optimization
  - tuning simulations
  - halo & background simulations for Shintake monitor performance
- ATF2 low-β collaboration is open to everybody
- web page: http://flc.web.lal.in2p3.fr/atf2/lowbeta/

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