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BGV Status 2017 and plans for 2018

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on behalf of the BGV Group

Overview

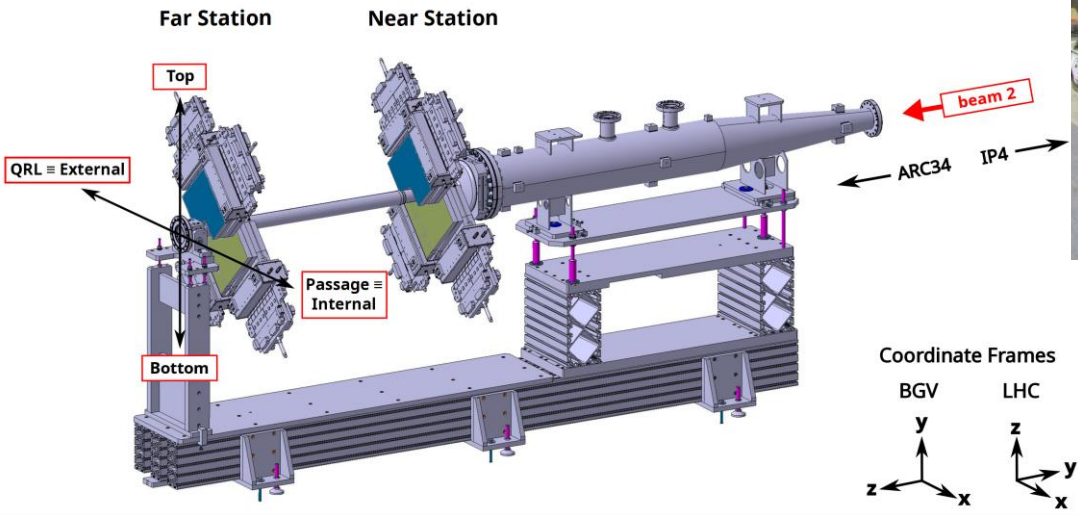
2017 Results

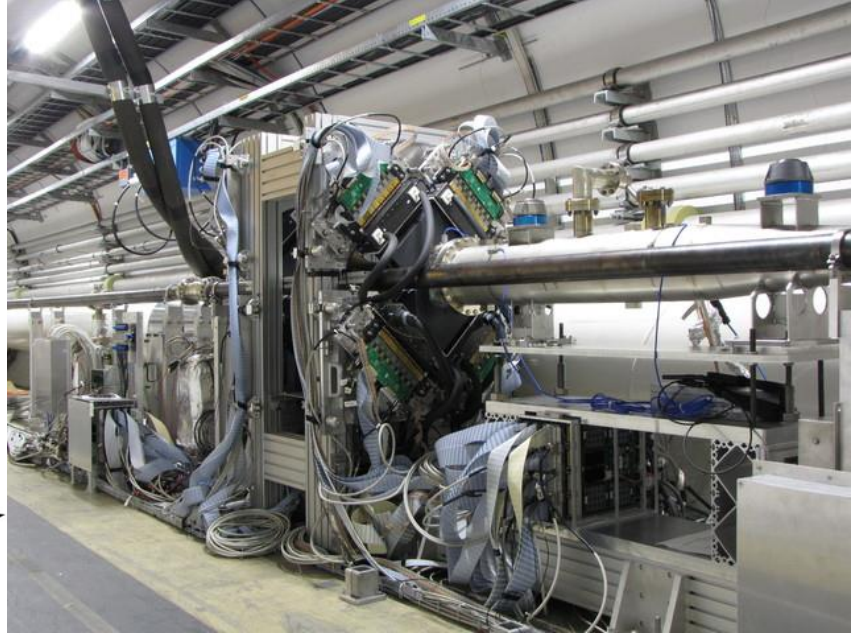
- Beam width measurement method
- Measurements and corrections
- Achievable precision

2018 BGV Status

- Trigger
- Detector status

Detector


Far Station
Near Station
Top
QRL ≡ External
Passage ≡ Internal
Bottom
beam 2
ARC34
IP4
Coordinate Frames
BGV
LHC
y
z
x
z
y
x



Beam width measurement

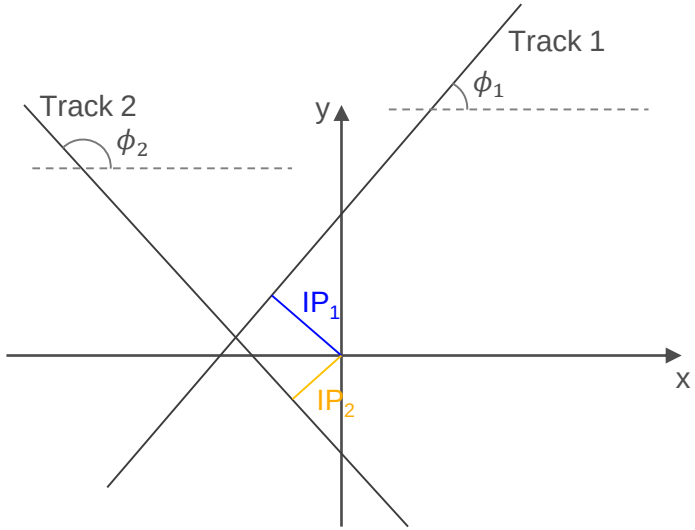
IP and ϕ (1,2) of particles from the same primary vertex are correlated as given by

$$\langle IP_1\, IP_2 \rangle = \sigma_{sum}^2 \cos(\phi_1 - \phi_2) + \sigma_{diff}^2 \cos(\phi_1 + \phi_2)$$

$\sigma_{sum}^2 = \frac{\sigma_x^2+\sigma_y^2}{2}$, $\sigma_{diff}^2 = \frac{\sigma_y^2-\sigma_x^2}{2}$

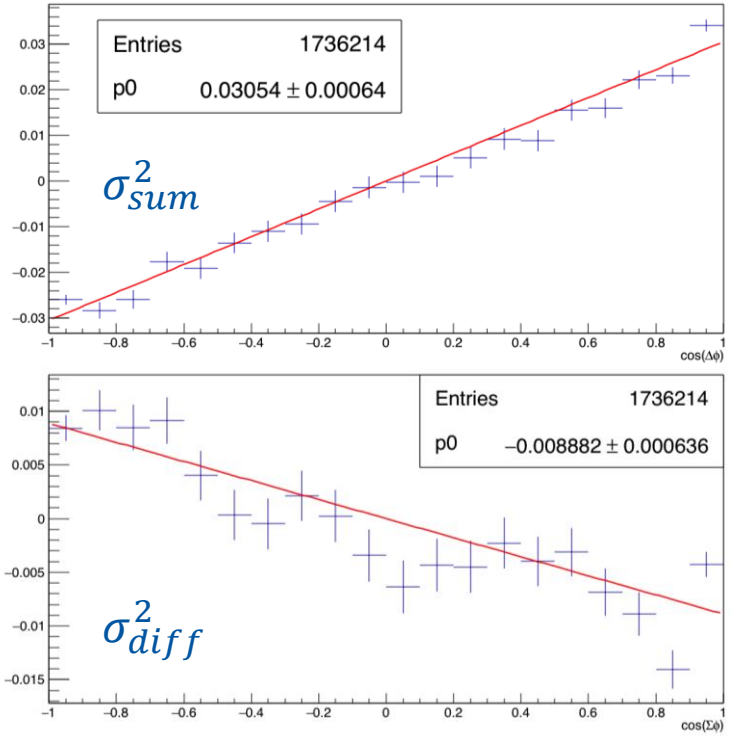
σ_x^2 (σ_y^2) being the beam spot width along x (y)

This correlation is independent of the extrapolation error σ_{IP}

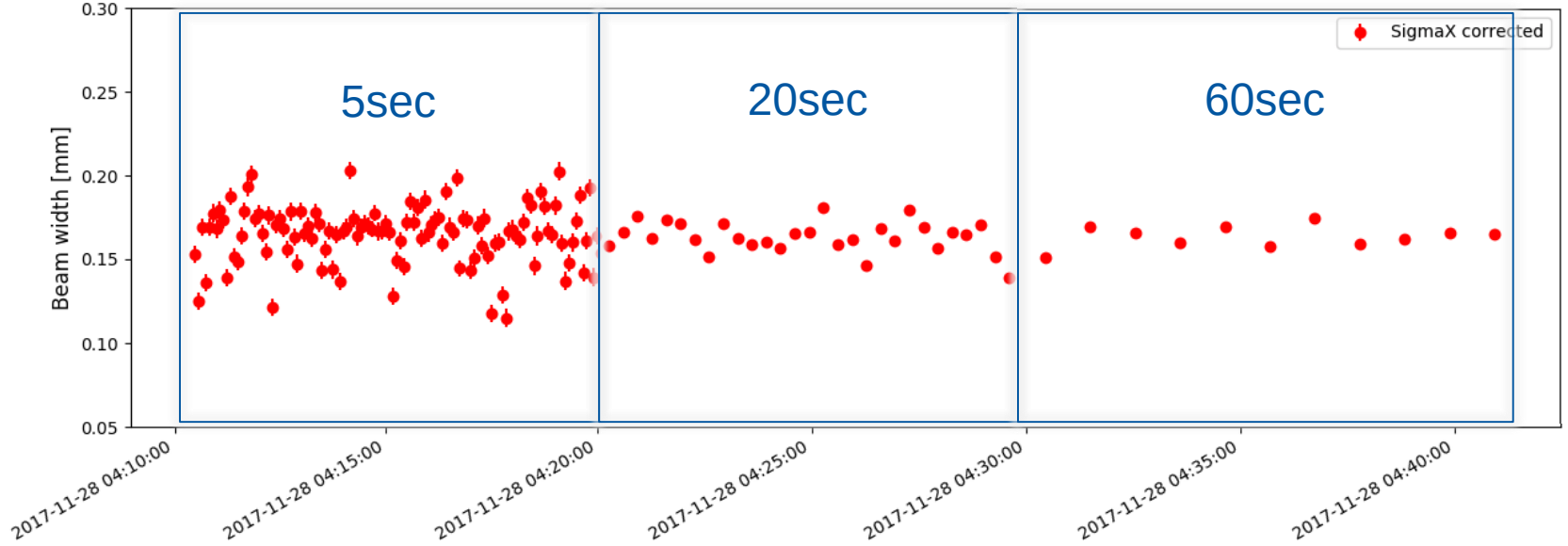


IP correlation → σ_{beam}

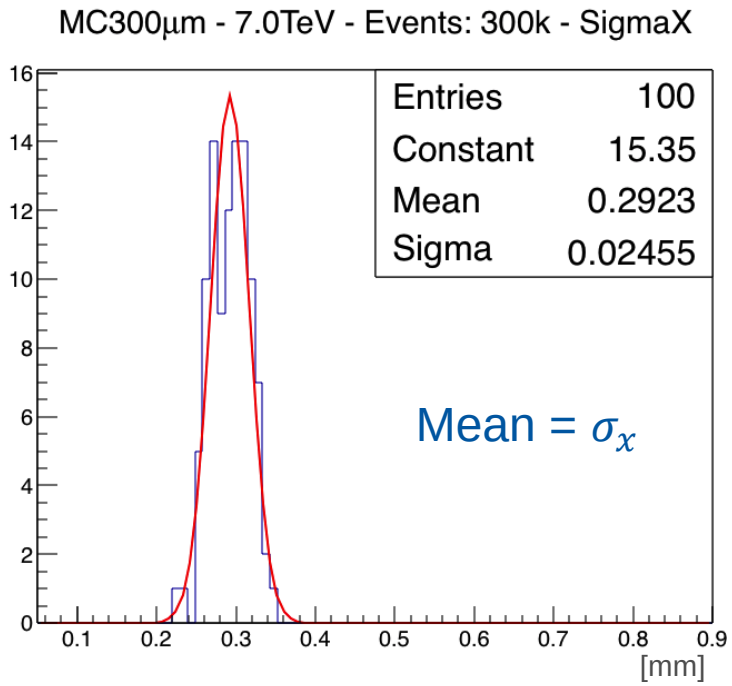
Assuming uncorrelated $\phi_1 - \phi_2$ and $\phi_1 + \phi_2$ the parameters σ^2_{sum} and σ^2_{diff} can be fit individually

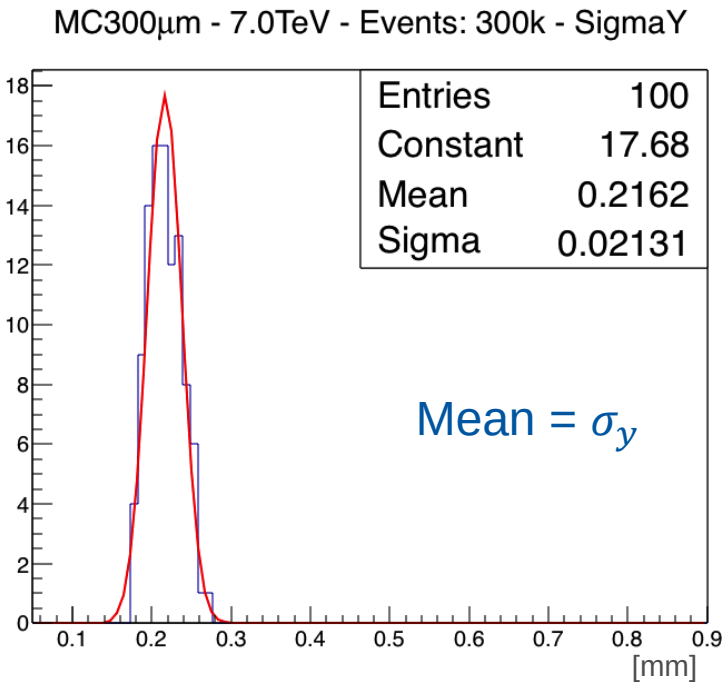


Slices in Time



Beam width


MC300µm - 7.0TeV - Events: 300k - SigmaX
Entries 100
Constant 15.35
Mean 0.2923
Sigma 0.02455
Mean = σ_x
[mm]


MC300µm - 7.0TeV - Events: 300k - SigmaY
Entries 100
Constant 17.68
Mean 0.2162
Sigma 0.02131
Mean = σ_y
[mm]

Beam width - Monte-Carlo correction

Systematic underestimation of beam width due to

- Detector geometry
- Tracking performance and combinatorics

Asymmetric behavior due to uneven detector coverage

Correction factors derived from

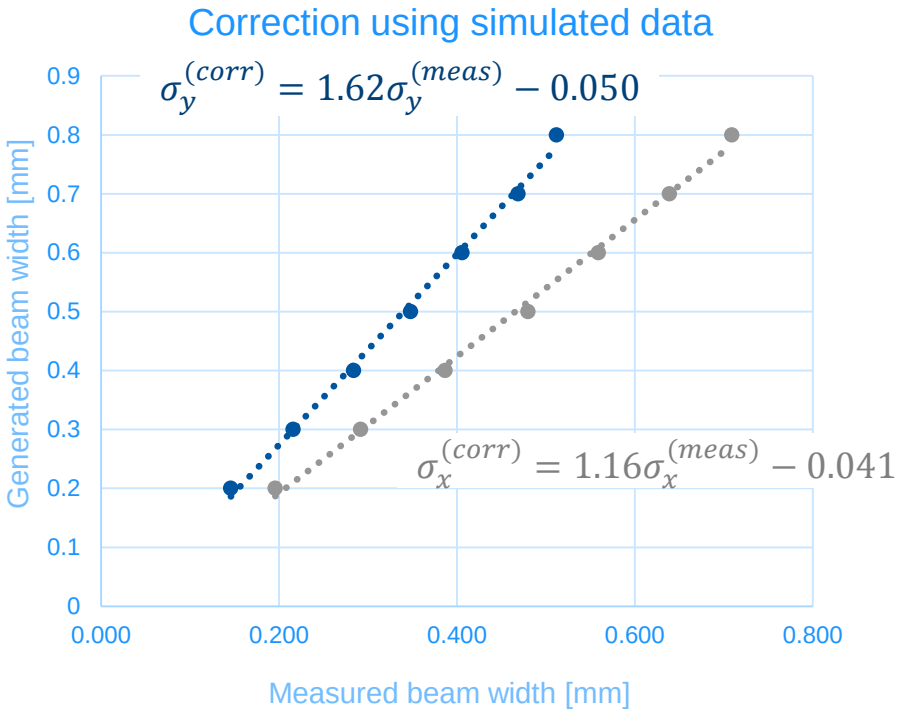
Monte-Carlo simulation, independently calculated for σ_x and σ_y

(correction error properly propagated)

Fit parameters:

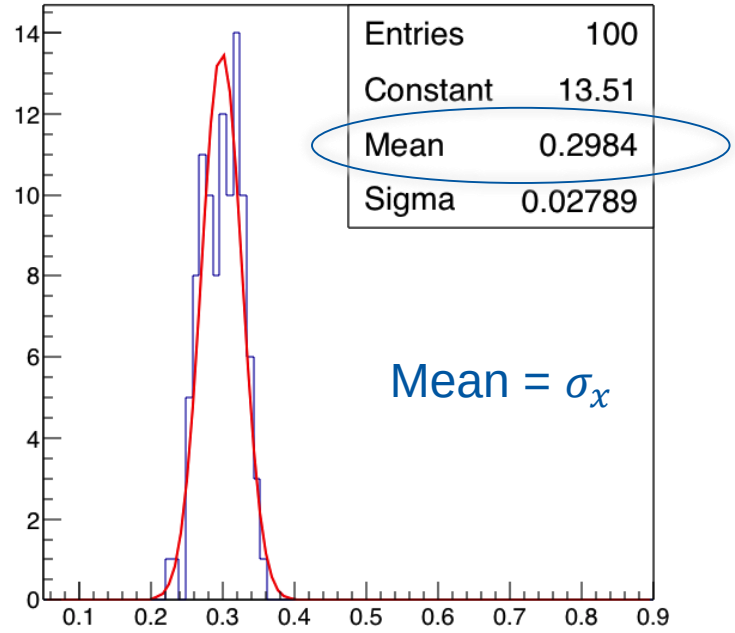
σ_x : 1.16 (±0.030), -0.041 (±0.015)

σ_y : 1.62 (±0.044), -0.050 (±0.016)

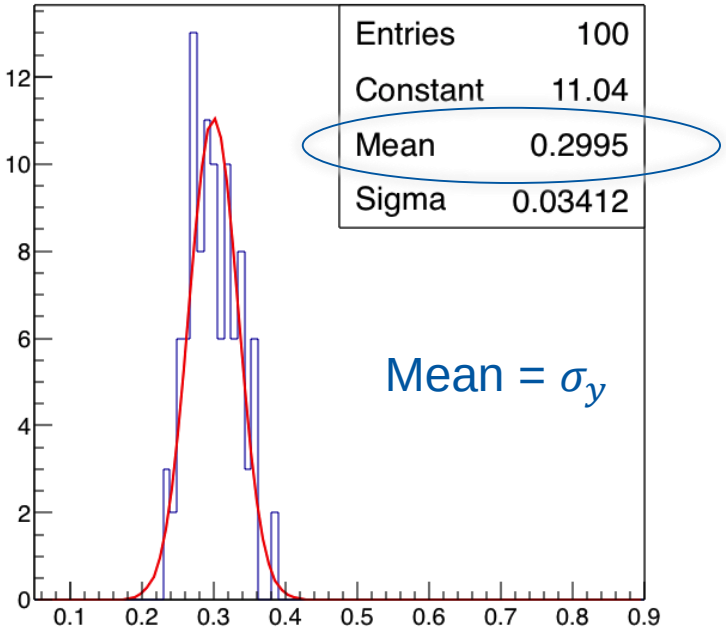


Beam width - Monte-Carlo corrected

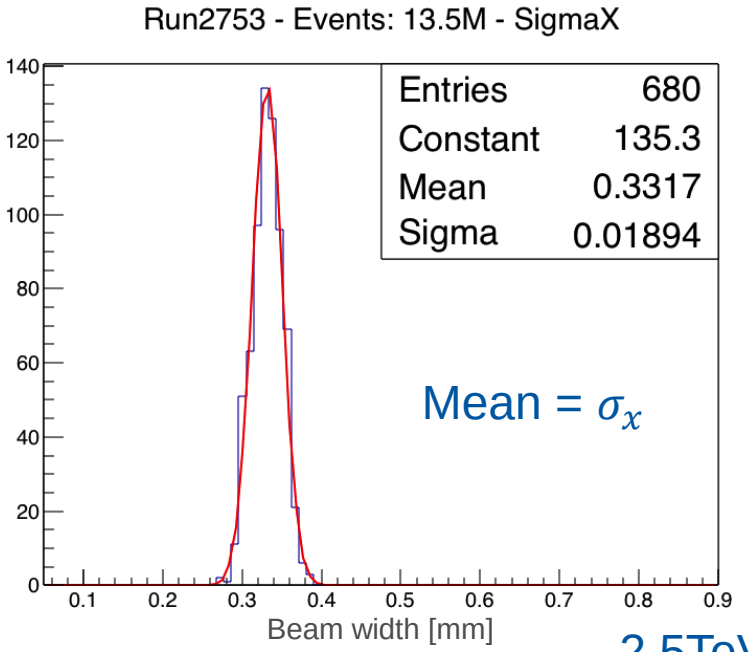
MC300µm - 7.0TeV - Events: 300k - SigmaX

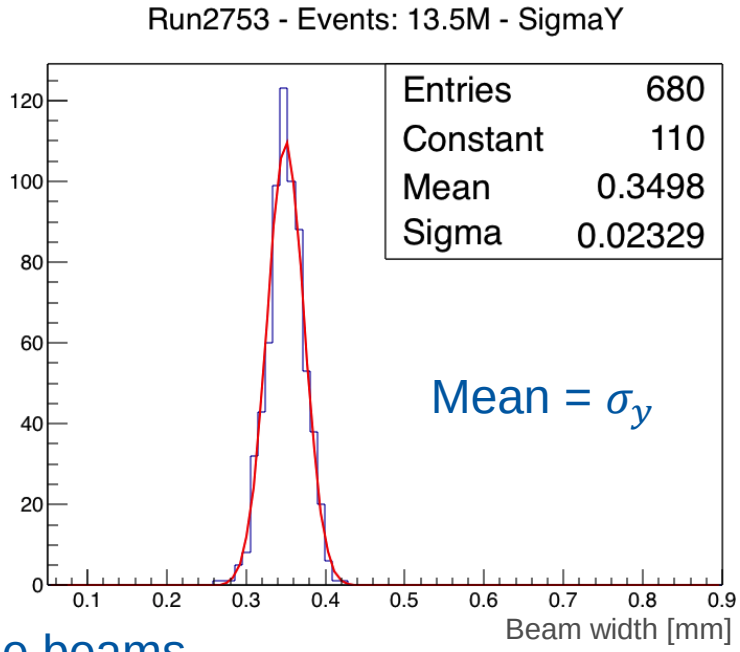


MC300µm - 7.0TeV - Events: 300k - SigmaY



Beam width - Real data corrected

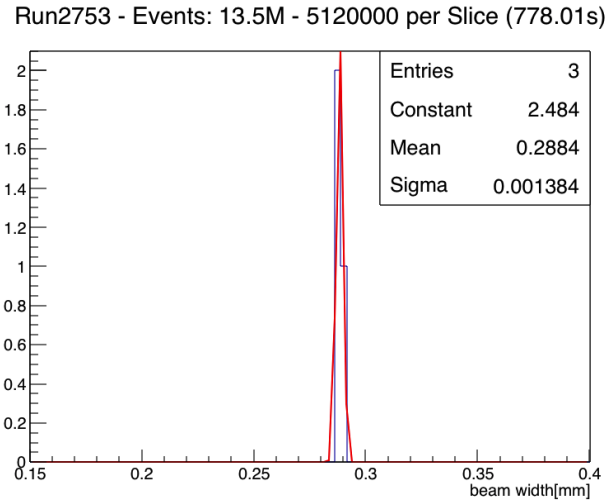


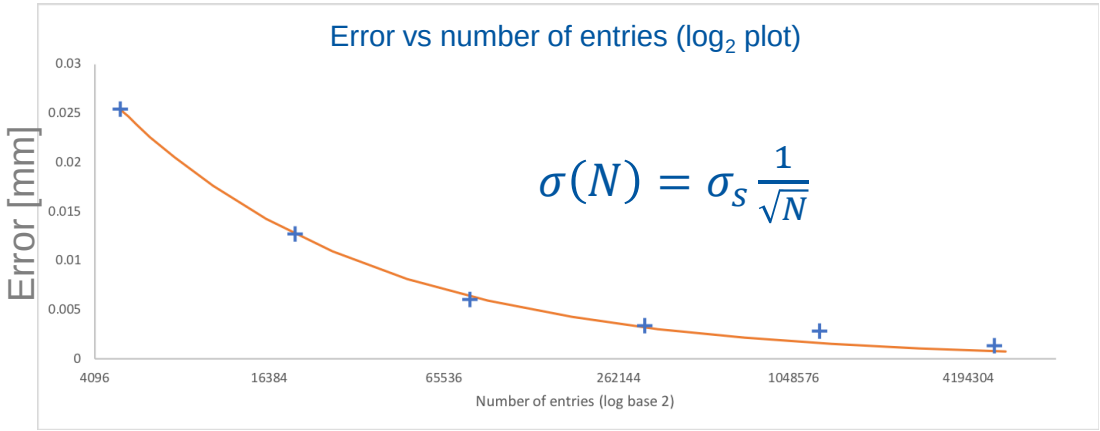


2.5TeV stable beams

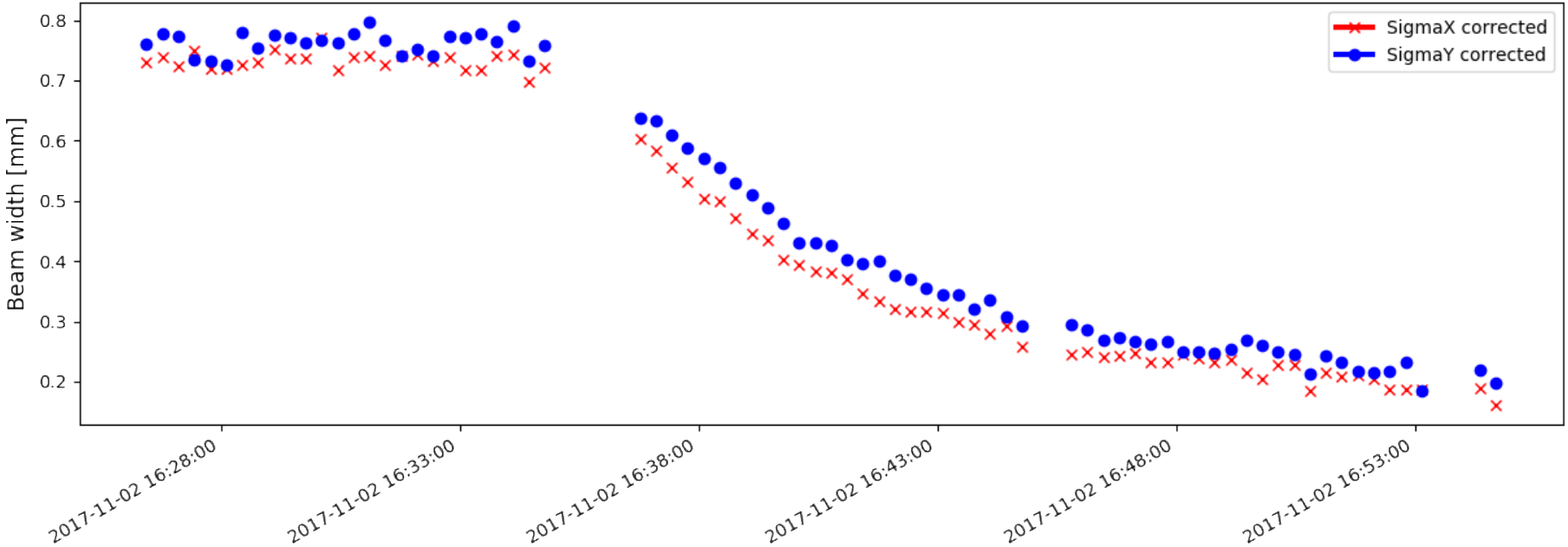
Resolution vs integration time

The longer the integration time the higher the precision (until ~3µm)



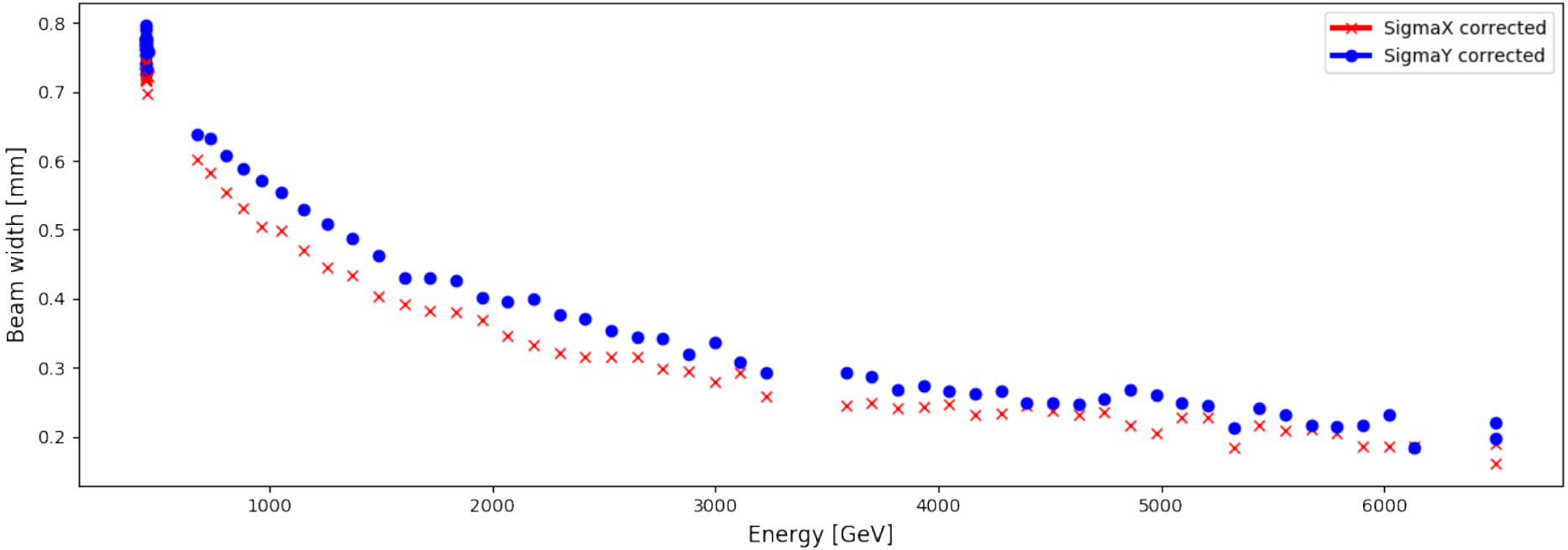


Corrected BGV beam width



Corrected BGV beam width

Time to energy conversion using loggingDB

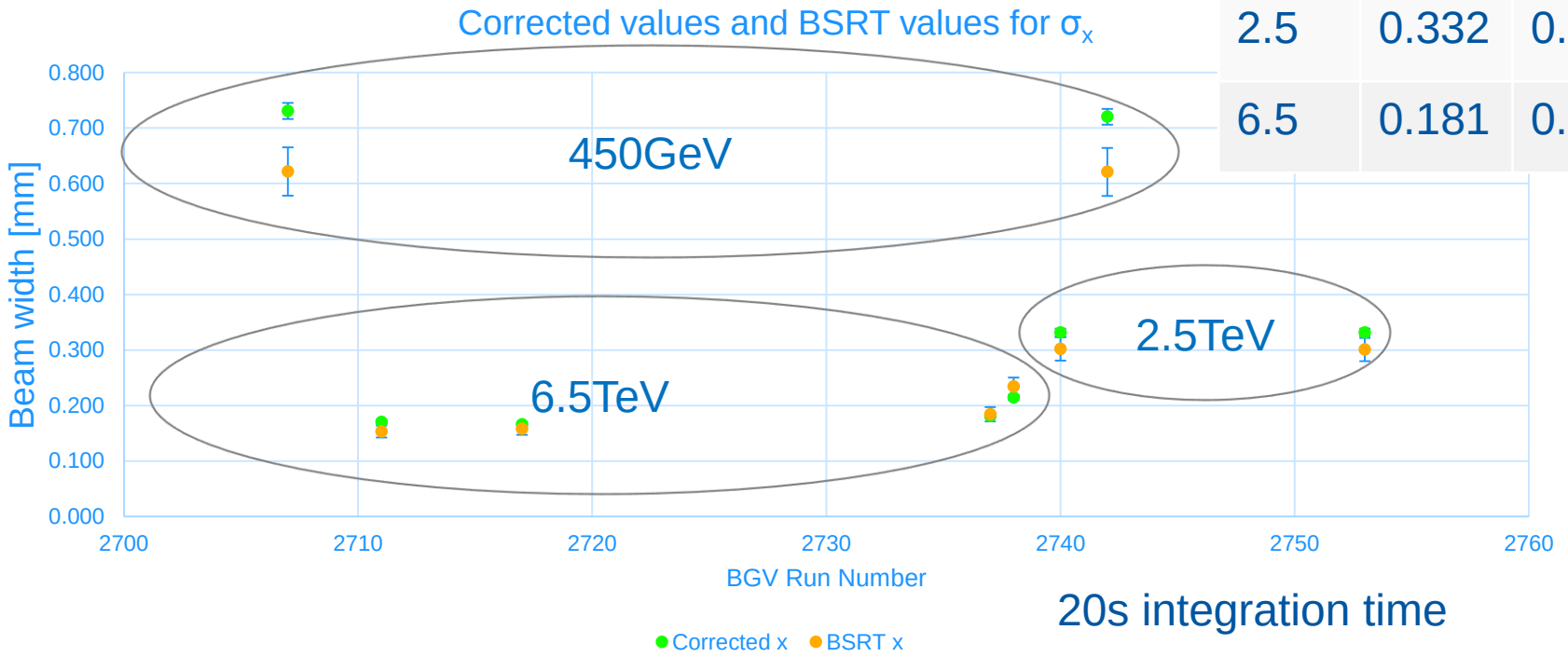


Typical BGV measurements

Fill #	Integration time (sec)	Beam width x (µm)	Beam width y (µm)	Error x (µm)	Error y (µm)	Rel. Error
6371 (6.5TeV)	3	180	215	28	34	16 %
	20	182	217	10	13	6 %
	60	182	217	6	7	3 %
6358 (450GeV)	3	731	761	31	43	5 %
	20	732	762	14	18	2 %
	60	734	764	6	14	1-2 %
6386 (2.5TeV)	20	302	325	9	11	3 %
	60	302	325	5	6	2 %
6399 (2.5TeV)	20	331	355	8	10	3 %

BGV vs BSRT

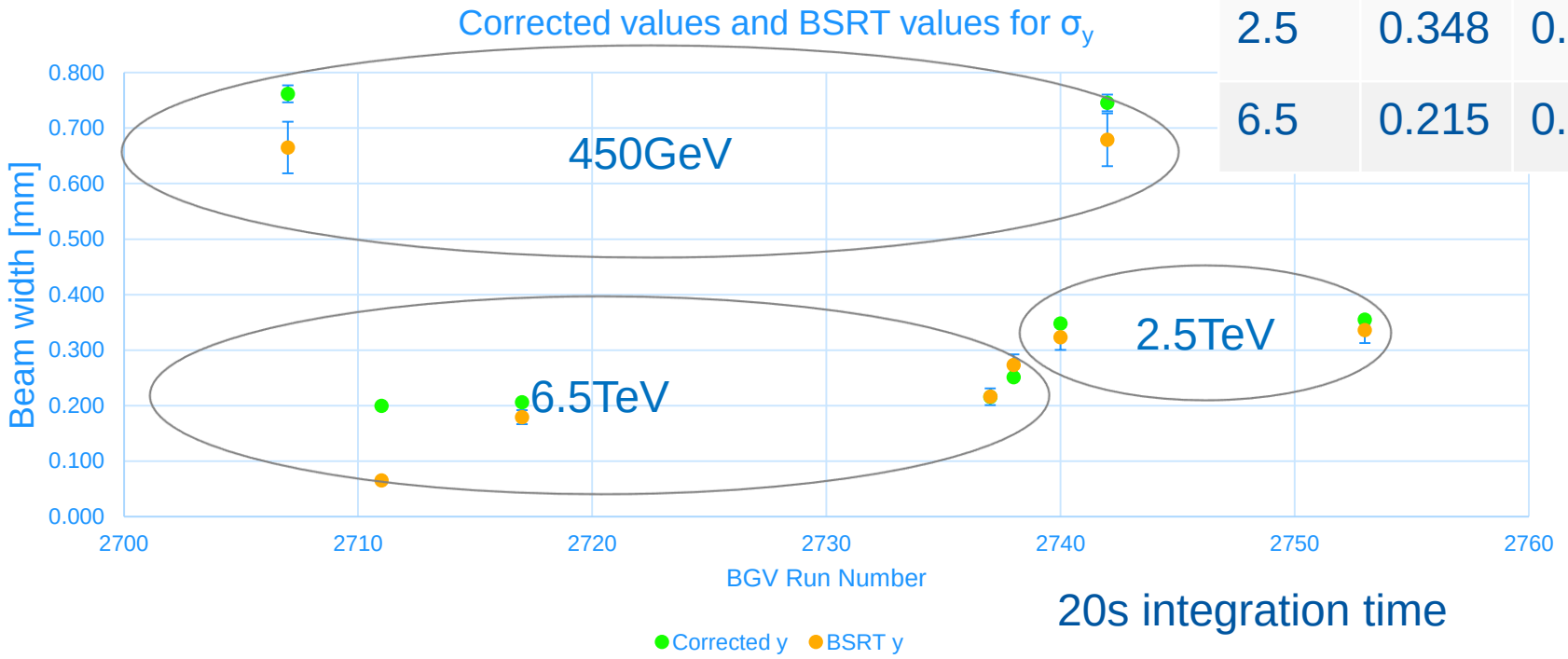
	BGV	BSRT
0.45	0.731	0.622
2.5	0.332	0.302
6.5	0.181	0.184



20s integration time

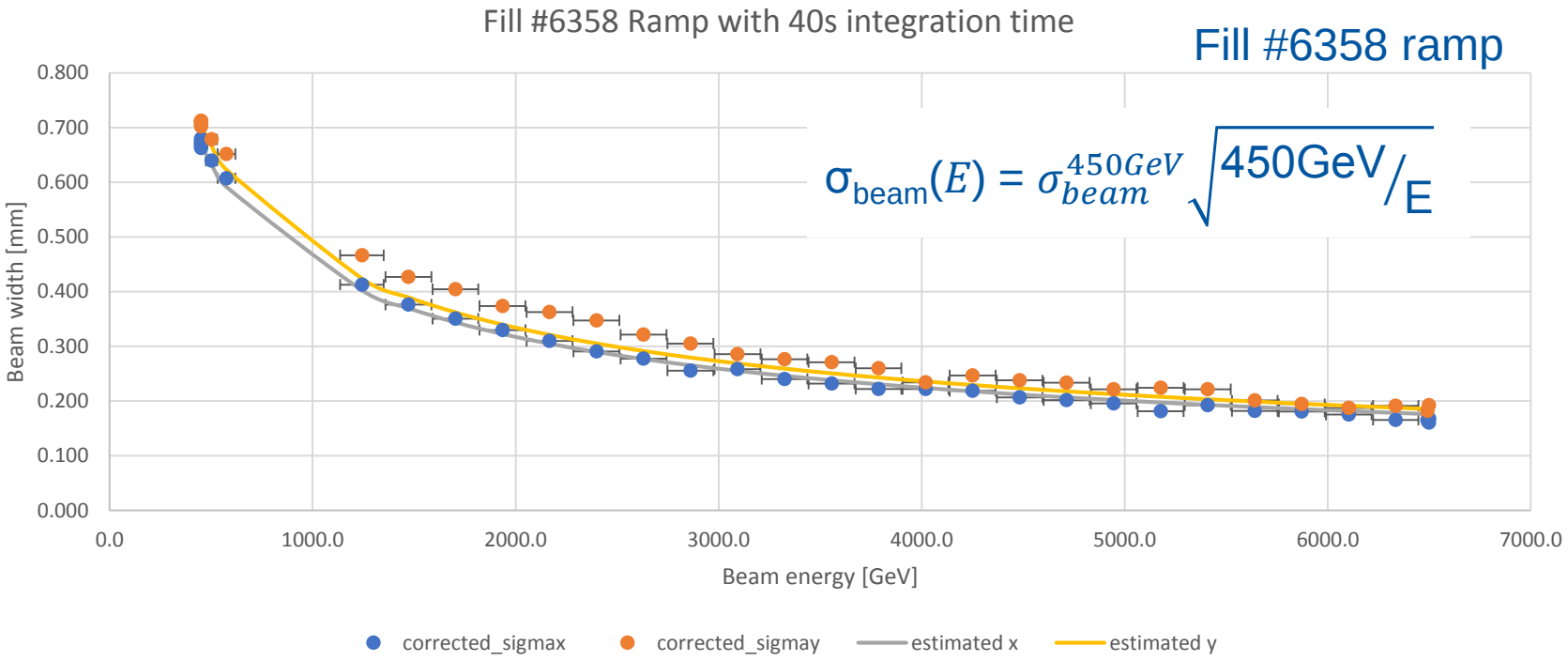
BGV vs BSRT

	BGV	BSRT
0.45	0.762	0.665
2.5	0.348	0.323
6.5	0.215	0.216

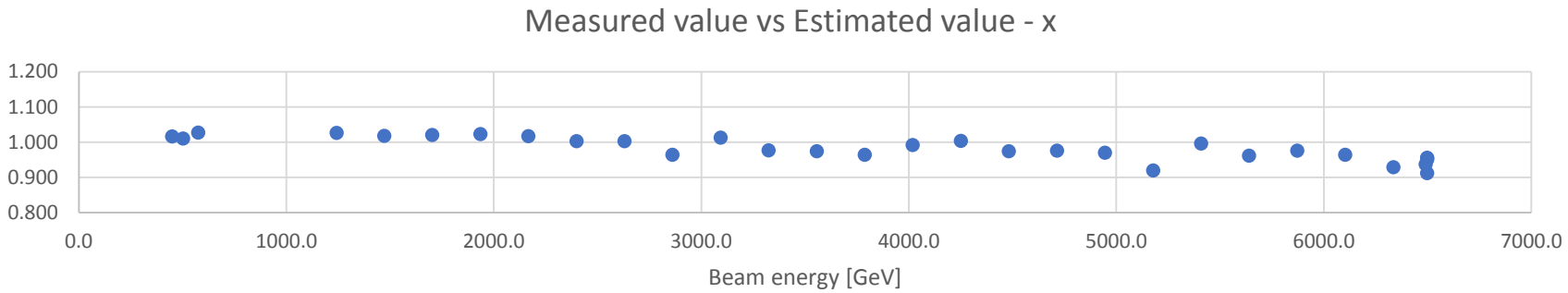


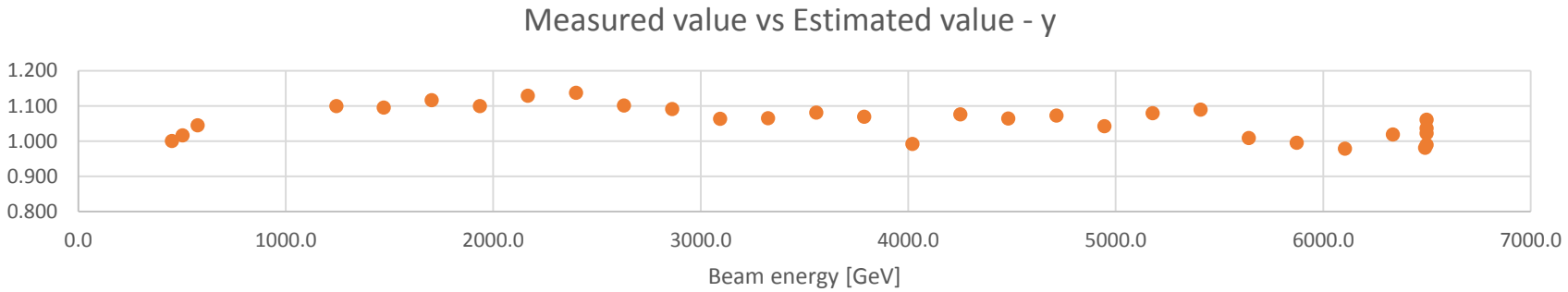
20s integration time

Beam width evolution during ramp

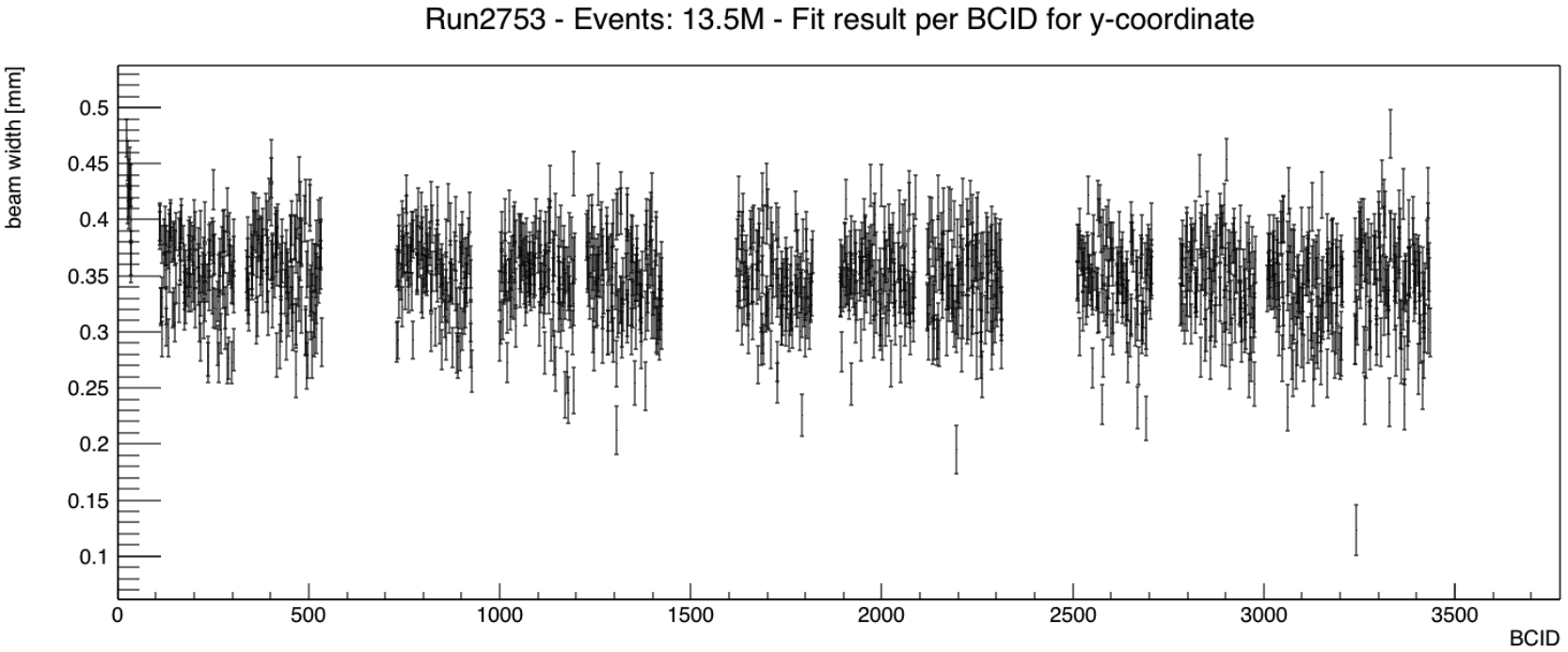


measurement/prediction





Beam width vs BCID



Expected 2018 performance

Assuming a readout rate of 10kHz (effective)

Average over all bunches

- 20 seconds of data
- 2 % precision @ 450GeV
- 6 % precision @ 6.5TeV

Per Bunch Precision

- 5 min of data
- For up to ~200 BCIDs
- 8% precision @ 6.5TeV

HL-LHC BGV target beam width resolution: 2% in 1min for 10^{11} p/bunch (average)

Updates performed for 2018

- L0 Trigger system has been upgraded
  - Constant fraction discriminator
  - Logic unit with adaptable delays
- Detector is operational
  - Two more HLT blades were added during the shutdown to increase the readout rate
  - Goal is to perform all calculations online in the service tunnel

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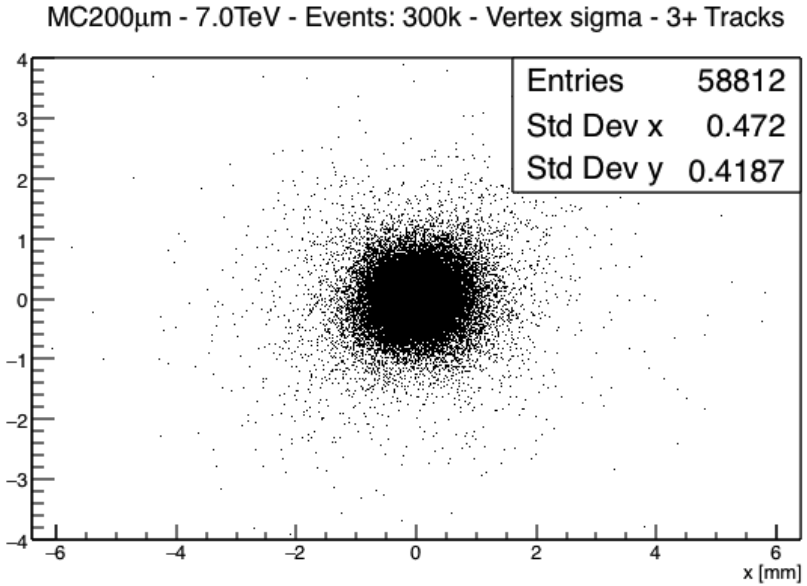
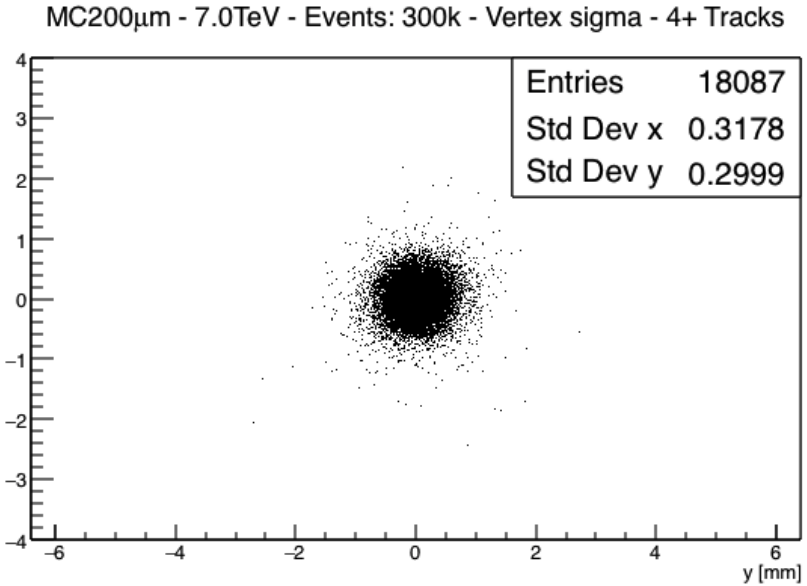
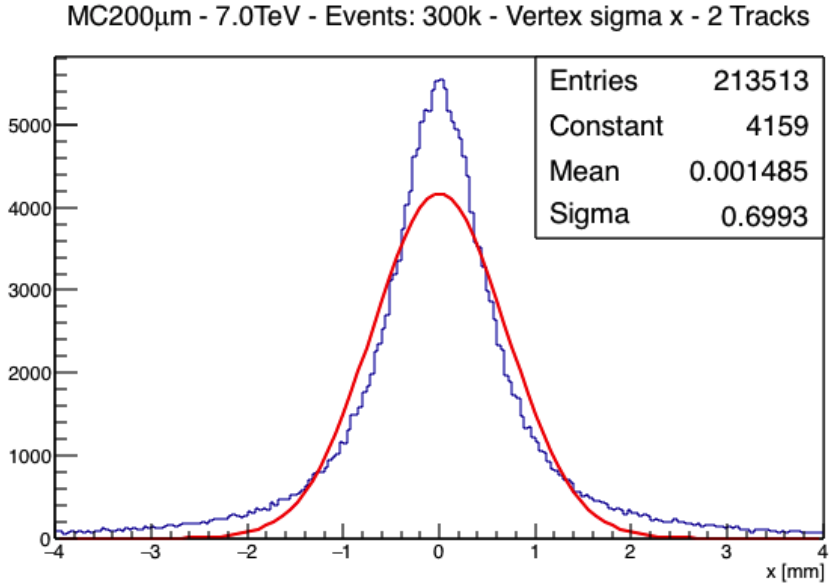
Backup

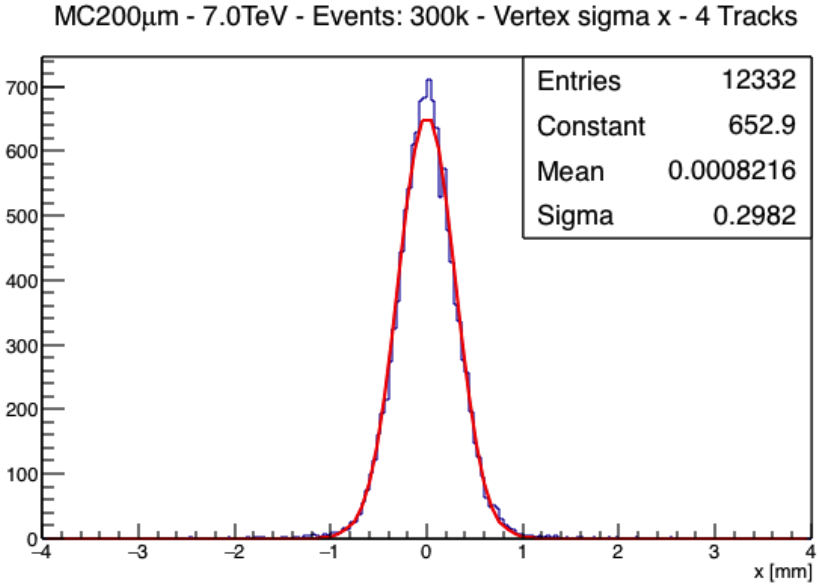
Vertex reconstruction





Vertex reconstruction

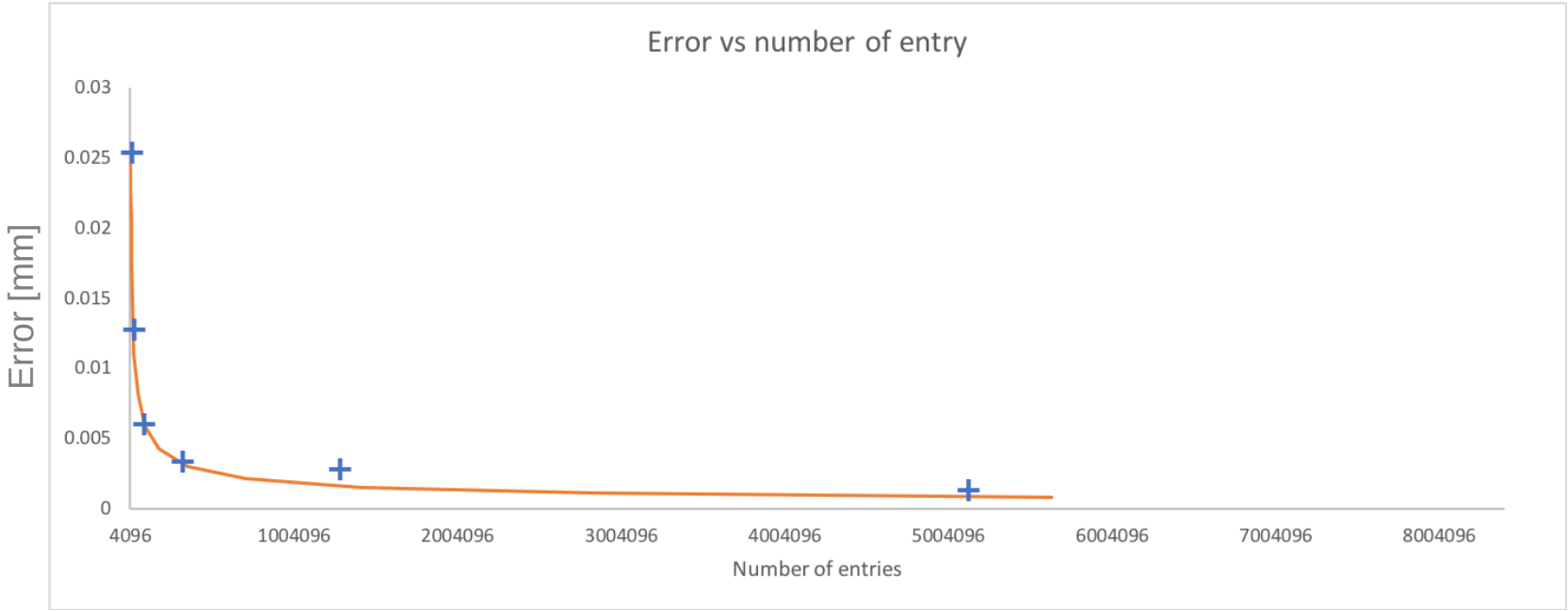




The Sigma of the vertex is a convolution of the measurement error and the actual beam width: $\sigma_{vertex} = \sqrt{\sigma_{beam}^2 + \sigma_{error}^2}$ which for these values gives $\sigma_{error} = 0.221$

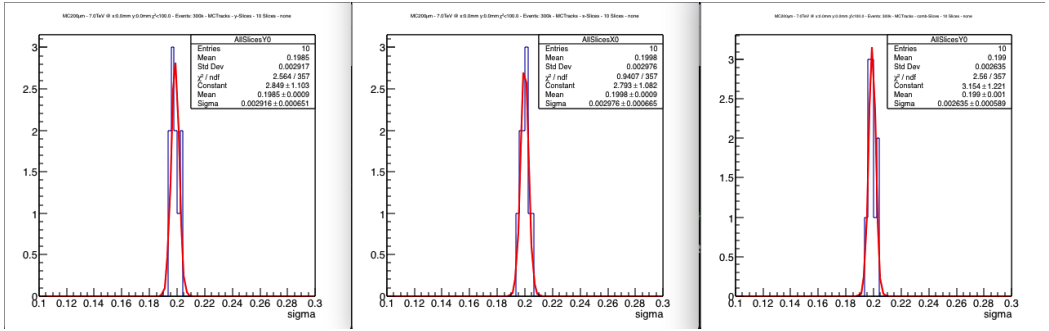
Resolution vs integration time

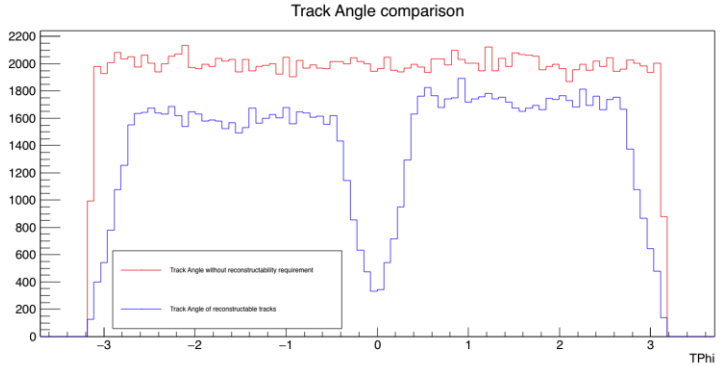
The longer the integration time the higher the precision until ~3µm



All Tracks from the MC primary vertex

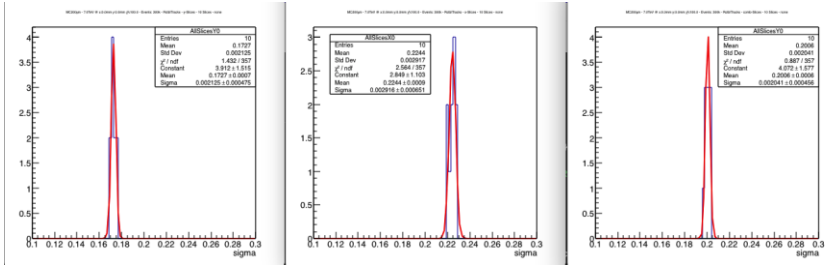
- No selection applied (except the PV flag)
- Should give a round beam and a flat tPhi distribution
  - Effectively gives 0.199 ± 0.003 mm beam size

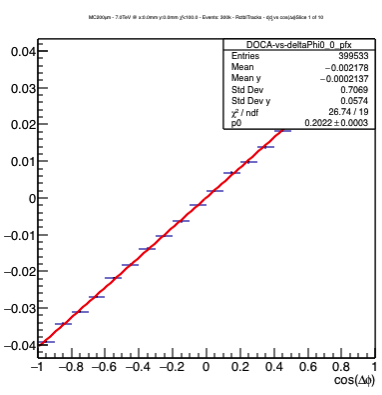


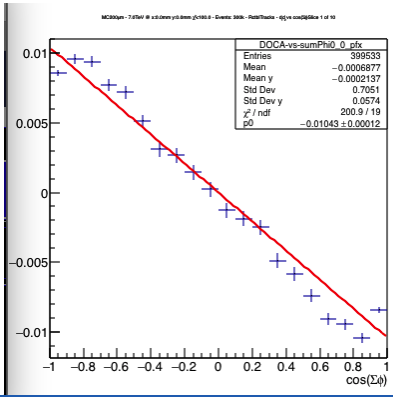


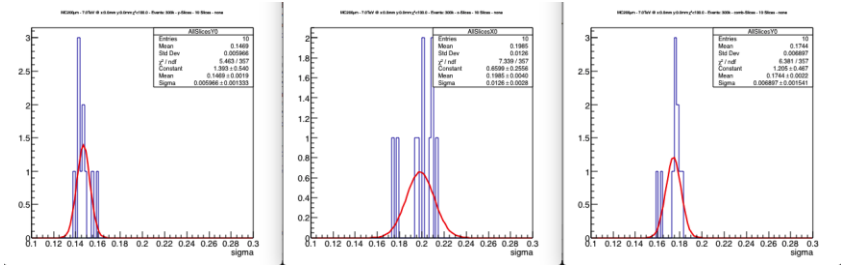
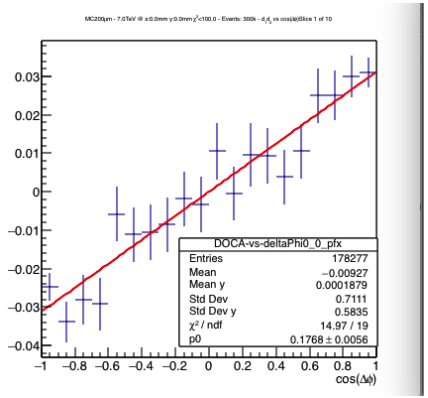
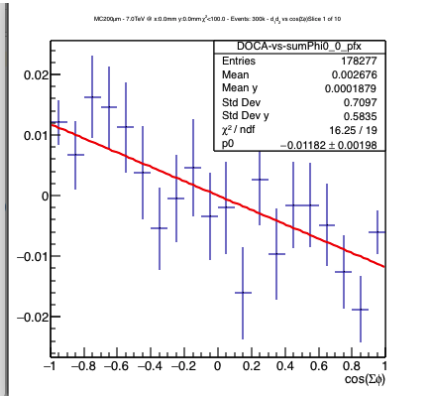
Reconstructable tracks (4+ clusters each in NEAR and FAR)

- Geometry selection applied, theoretical limit of detector (coverage)
- Shows the effect of the geometry on the reconstructed values, if the beam is not round here anymore the geometry influences the result even in MC.
- Results:
  - Fit x: 0.224 ± 0.003
  - Fit y: 0.173 ± 0.002
  - Fit comb: 0.201 ± 0.002
- Shows that there's a geometric effect since the beam is not perceived round anymore (but the average actually is)
- The fit quality is actually very nice so it's not a fit artifact
- The tracks are taken from the truth values so there are no fitting errors either







All Reconstructed tracks (measurement)

- Geometry and reconstruction limitations applied
- Gives a value below the expected and different values for x and y beam width
- Results:
  - Fit x: 0.199 ± 0.013
  - Fit y: 0.147 ± 0.006
  - Fit comb: 0.174 ± 0.007
- Uses reconstructed track information
- The fit quality resembles the common one for reconstructed data
- The results for x and y differ more dramatically now and the combination fit is not the correct value anymore