A further look into electron directionality

24/02/21

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Outline

- Comments and consideration on the angular resolution assumed in the HELLAZ proposal for solar neutrino measurements presented at last meeting

- Intrinsic limit to angular resolution for He:CF_4 at 1 bar & measured resolution by Samuele

HELLAZ proposal assumptions

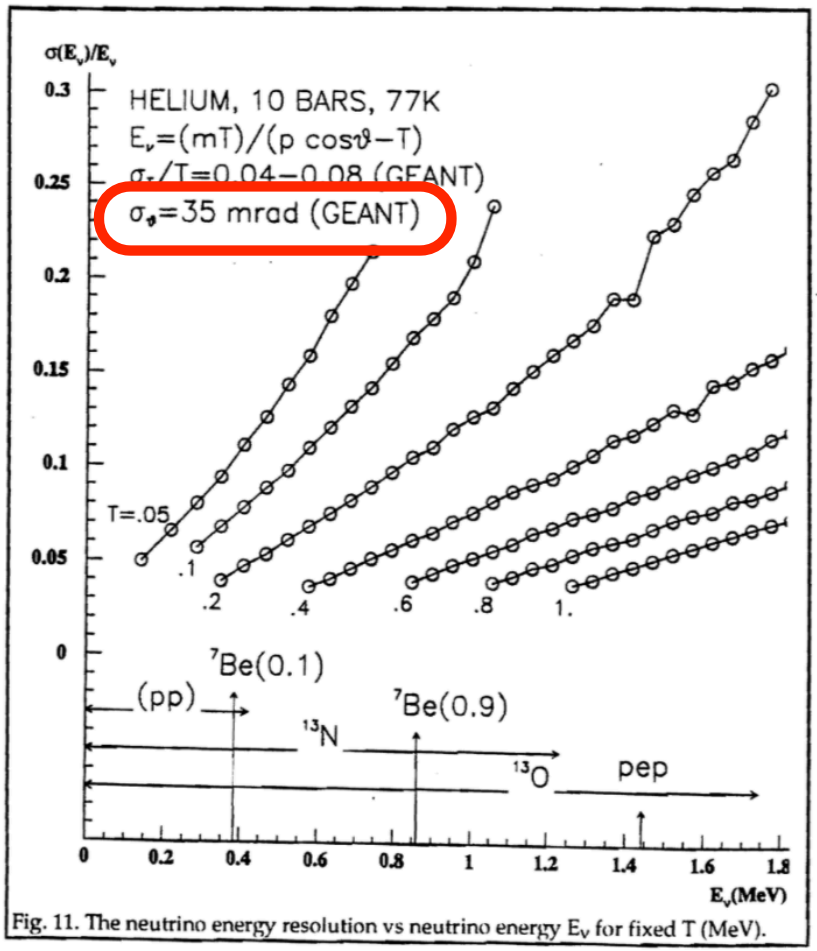


Fig. 11. The neutrino energy resolution vs neutrino energy E_ν for fixed T (MeV).

Nine 100-keV electron tracks, shown in Fig. 2, were generated along the z axis using the GEANT programme [13] to simulate the energy loss in the He gas. The variance of track directions are due only to multiple scattering in He gas and does not include drift diffusion. This would cause an additional 3D Gaussian smearing of each detected point by an amount $\sigma_x = \sigma_y = \sigma_t\sqrt{z}$ and $\sigma_z = \sigma_l\sqrt{z}$ where (σ_t, σ_l) are the (transverse, longitudinal) diffusion coefficients [14] in He gas (5 bar, 77°K, E = 20 kV/m) with z the drift length.

Note that the mean deflection in the first 10 mm is about 1 mm thus a directional error $\sigma_\theta \leq 100$ mrad may be expected if the sampling is sufficient. The purely ionization signal

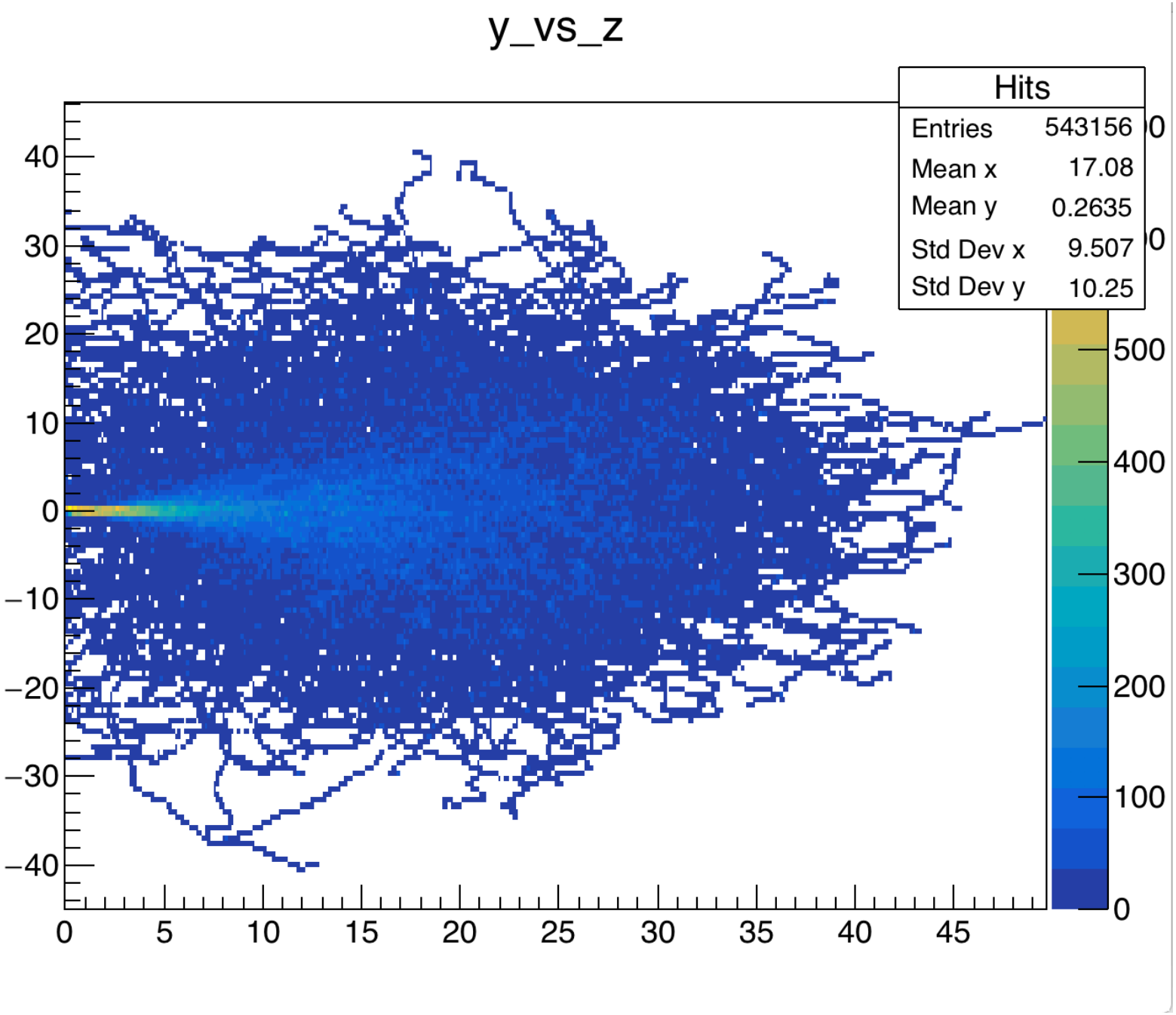
mrad. A more precise estimate for the directional error is $\sigma_\theta = (\sigma_d/\sigma_s)/\sqrt{N}$ where σ_d is the drift diffusion error ($\langle\sigma_d\rangle = 3$ mm for 10 m drift), $(s, \sigma_s = s/\sqrt{12})$ are the (real, rms) track lengths (12, 3.5 mm) with N the number of single electrons detected (400 for $s =$ 12 mm) hence $\sigma_\theta = 43$ mrad. For a straight line fit, the sampled track length s cannot be chosen much larger because the multiple scattering deflection builds up.

For low energy electrons, there is a large contribution coming from the scattering with atom's electrons that is not taken into account here

Such scattering can be very large and with significant change of the low energy electron direction

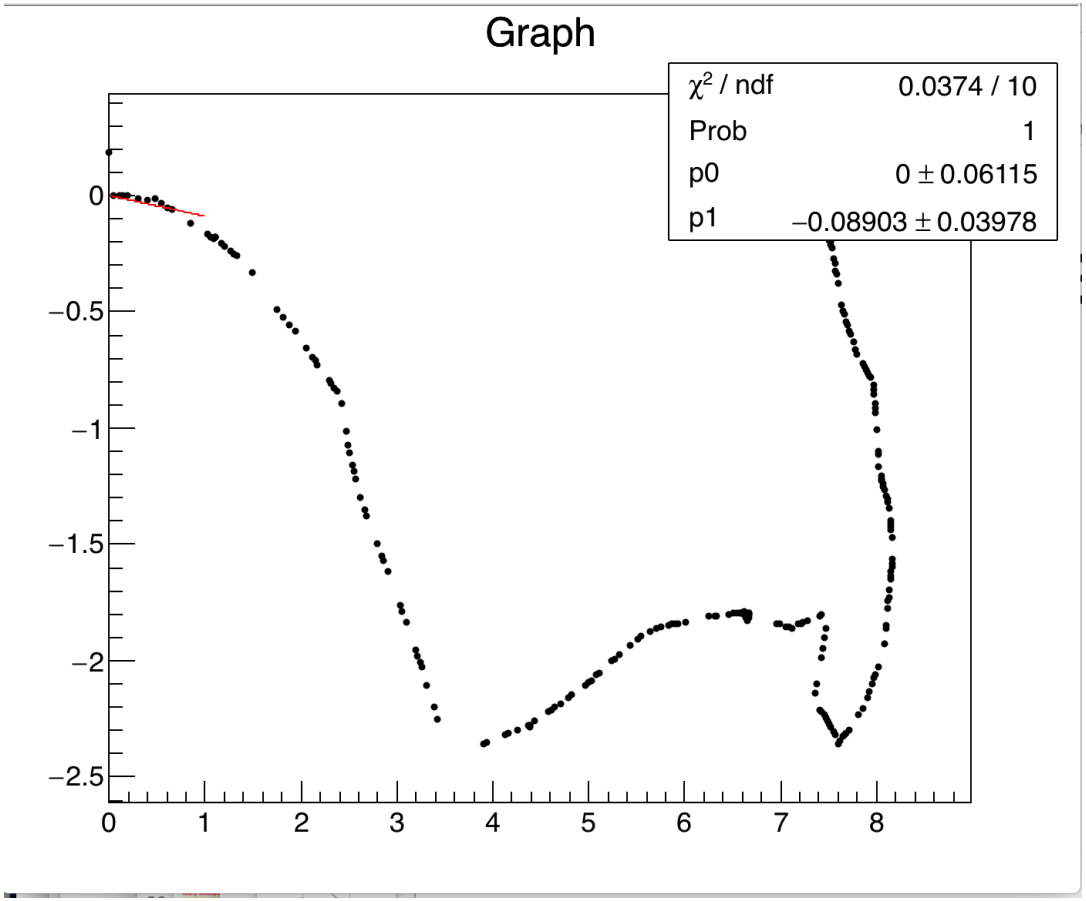
60 keV electrons from Geant4 in He:CF_4 60:40

There are tracks ending their path BEHIND the starting point here



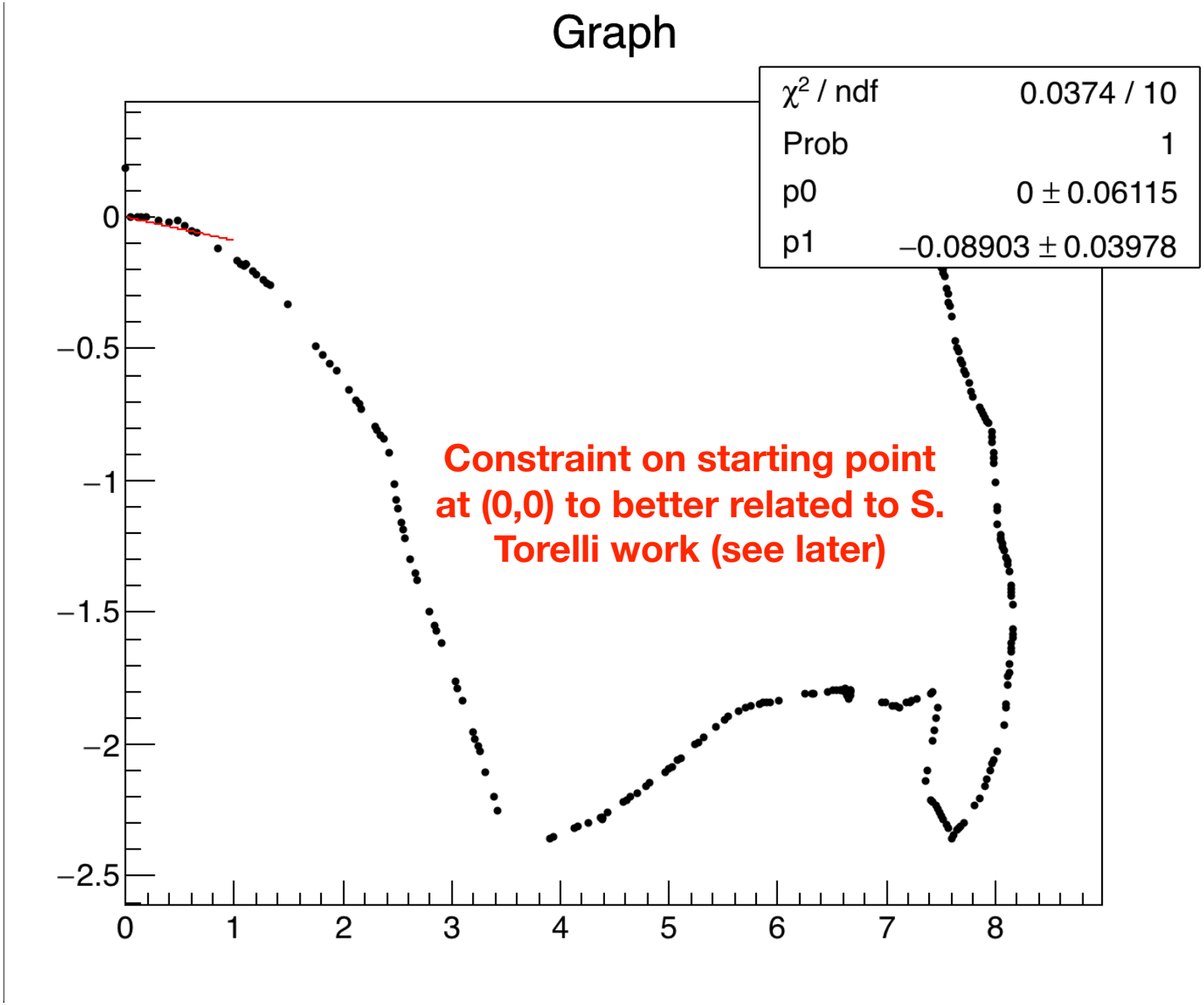
Intrinsic angular dispersion of low energy electrons

Goal: try to evaluate the intrinsic change of direction of the track fitting with a straight line the real MC true track hits (no diffusion, no readout effect) for the first XX mm

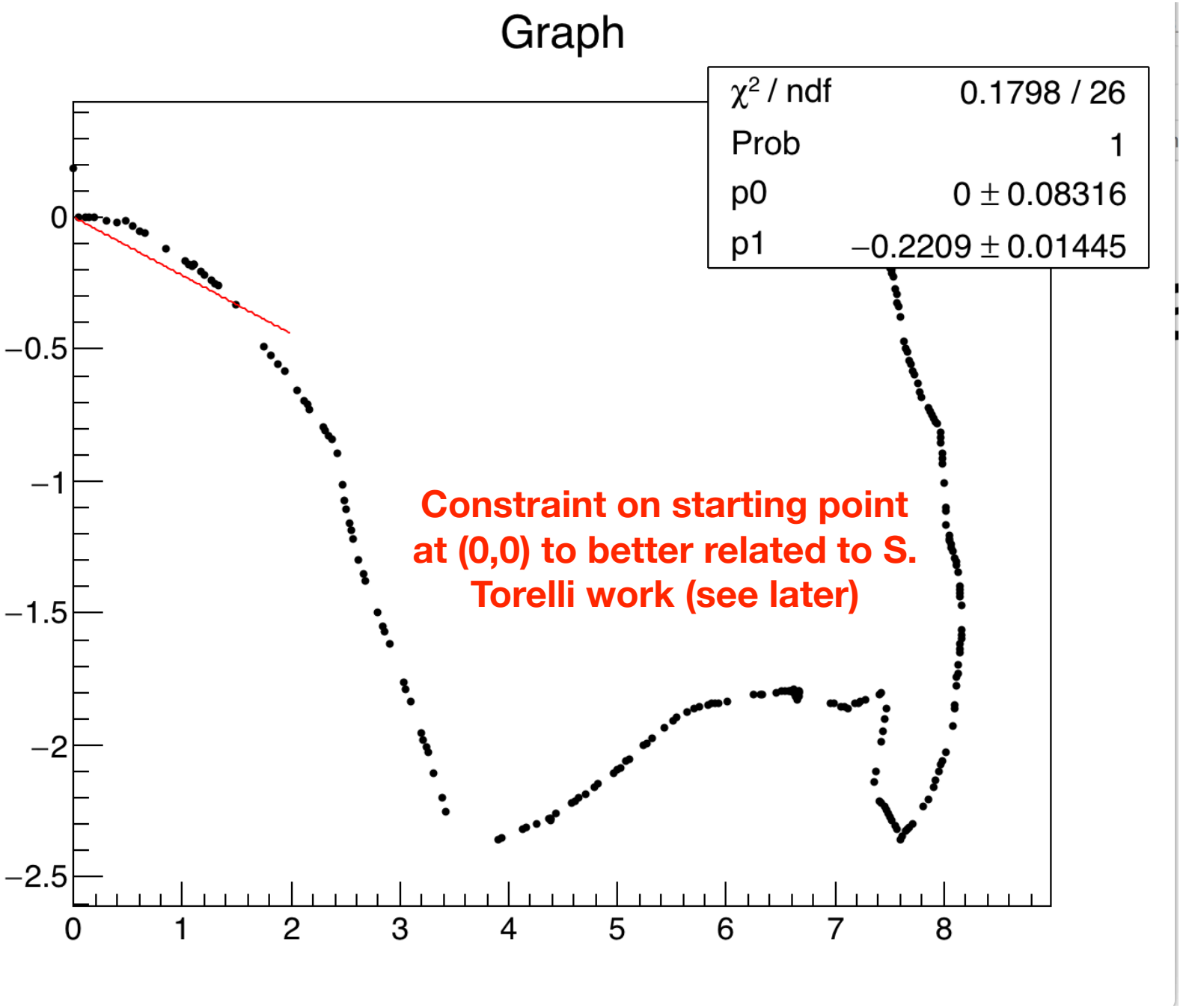


Work for the moment only the 2D projection as seen by CYGNO CMOS-camera

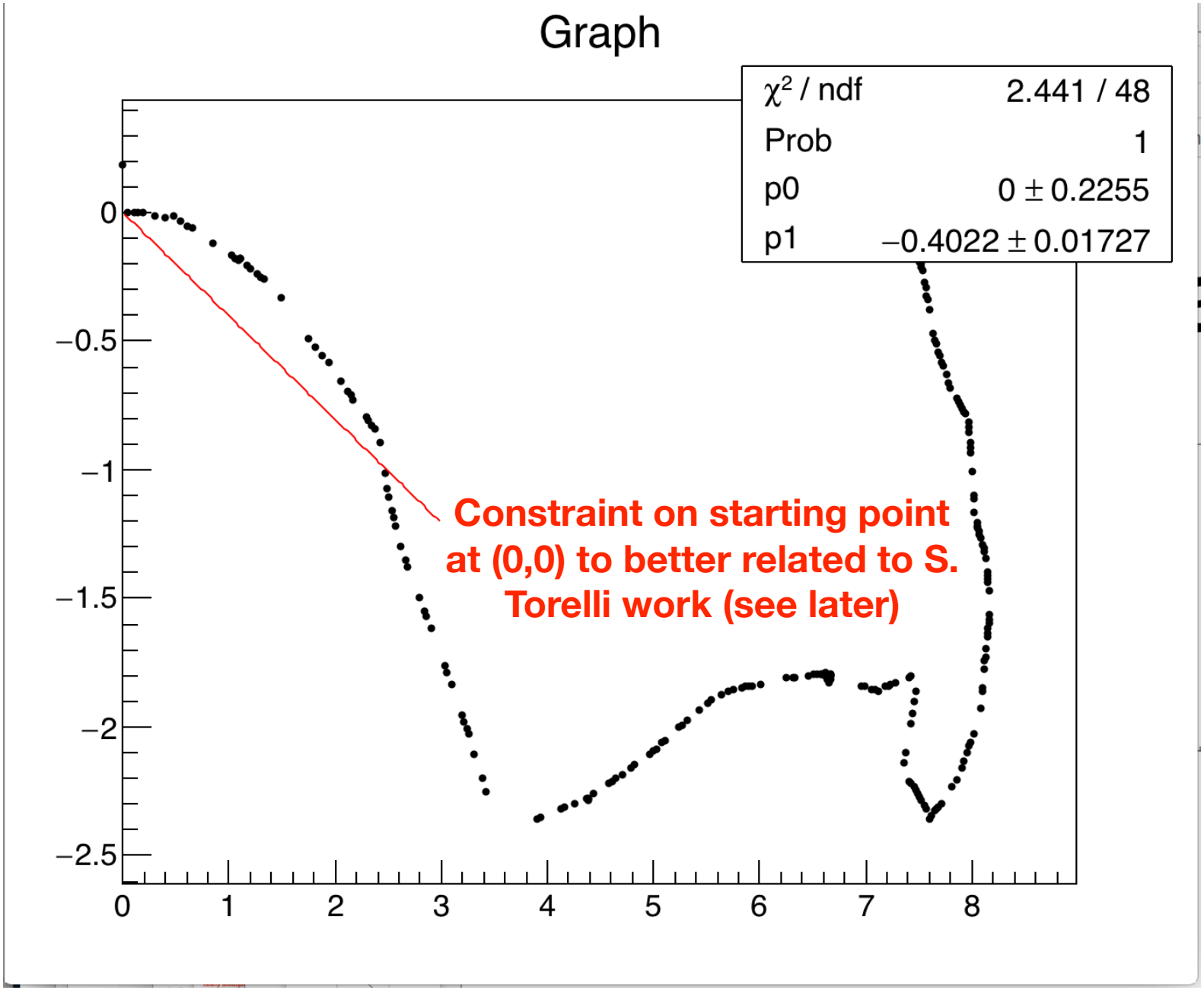
30 keV - 1mm


Graph
χ² / ndf 0.0374 / 10
Prob 1
p0 0 ± 0.06115
p1 −0.08903 ± 0.03978
Constraint on starting point at (0,0) to better related to S. Torelli work (see later)
0
−0.5
−1
−1.5
−2
−2.5
0
1
2
3
4
5
6
7
8

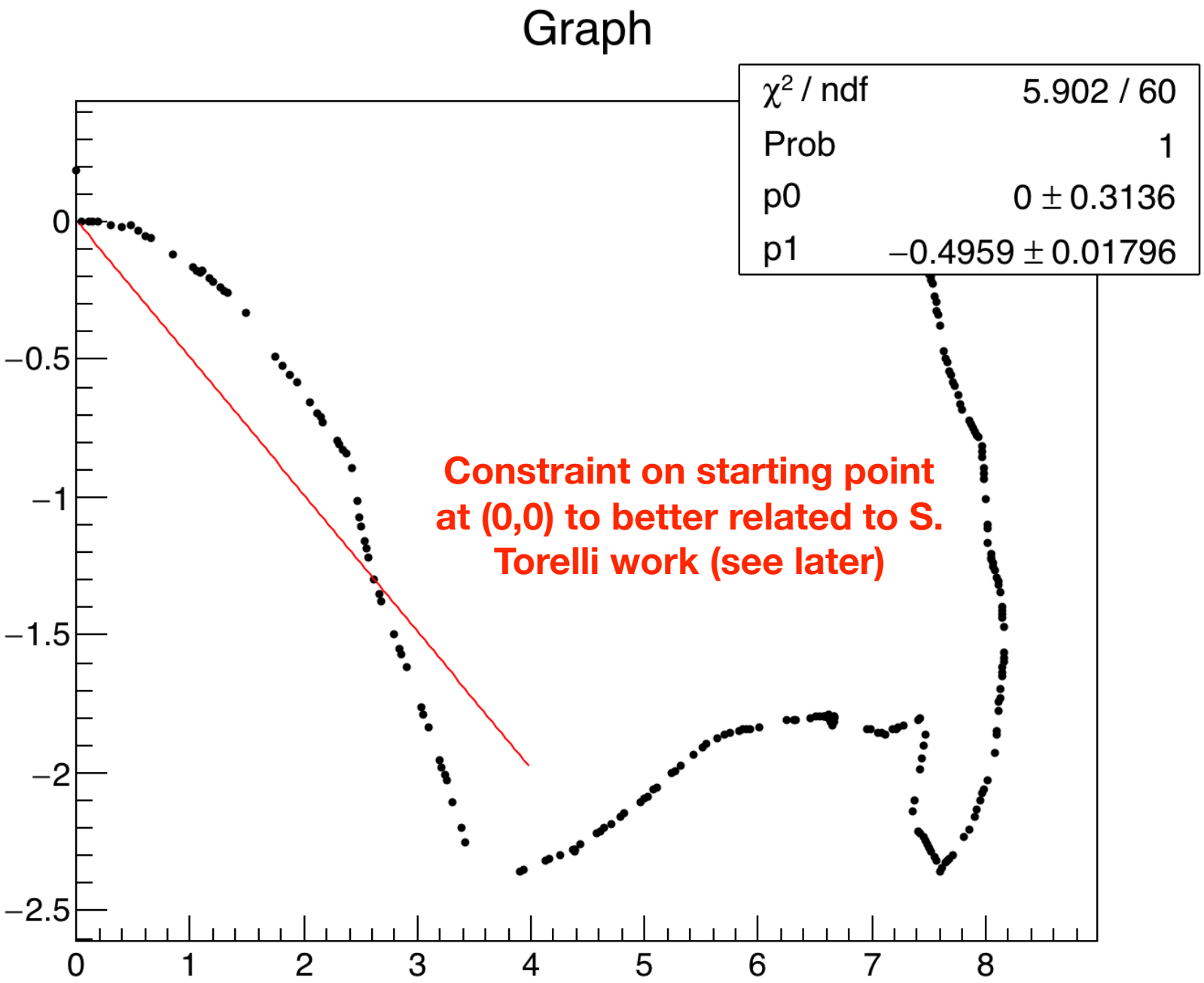
30 keV - 2 mm


Graph
χ² / ndf 0.1798 / 26
Prob 1
p0 0 ± 0.08316
p1 −0.2209 ± 0.01445
Constraint on starting point at (0,0) to better related to S. Torelli work (see later)
0
−0.5
−1
−1.5
−2
−2.5
0
1
2
3
4
5
6
7
8

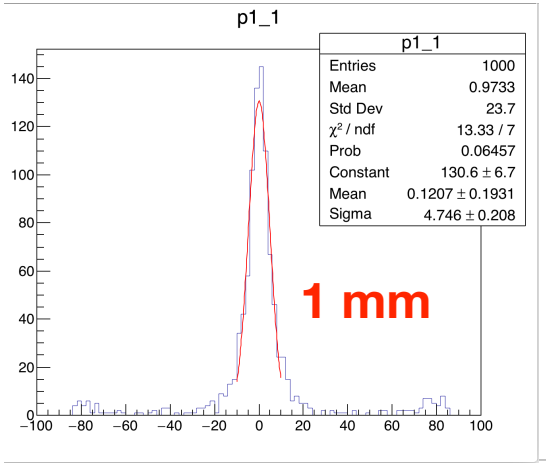
30 keV - 3 mm

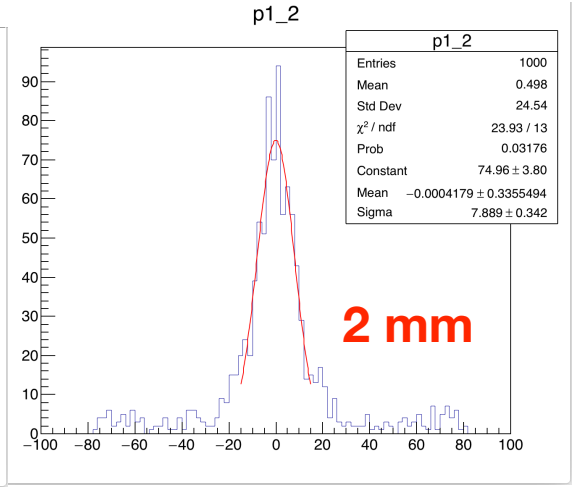

Graph
χ² / ndf 2.441 / 48
Prob 1
p0 0 ± 0.2255
p1 −0.4022 ± 0.01727
Constraint on starting point at (0,0) to better related to S. Torelli work (see later)
0
−0.5
−1
−1.5
−2
−2.5
0
1
2
3
4
5
6
7
8

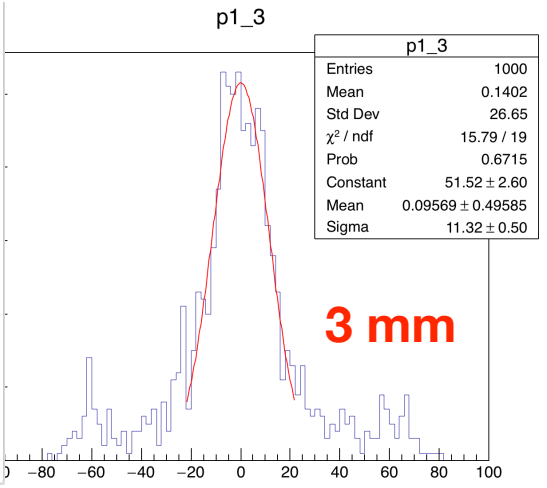
30 keV - 4 mm

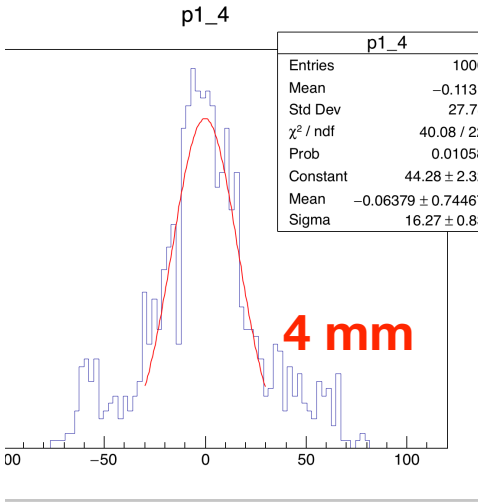

Graph
χ² / ndf 5.902 / 60
Prob 1
p0 0 ± 0.3136
p1 −0.4959 ± 0.01796
Constraint on starting point at (0,0) to better related to S. Torelli work (see later)
0
−0.5
−1
−1.5
−2
−2.5
0
1
2
3
4
5
6
7
8

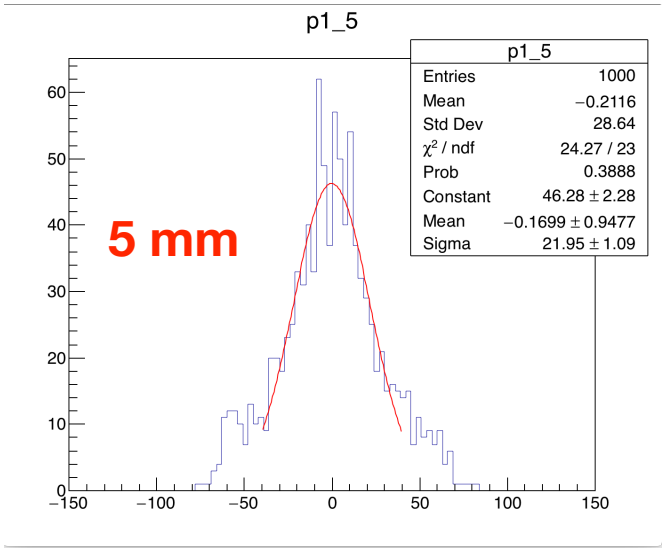
30 keV fit to first 1,2,3,4,5,10,15 mm with constraint on IP at (0,0)

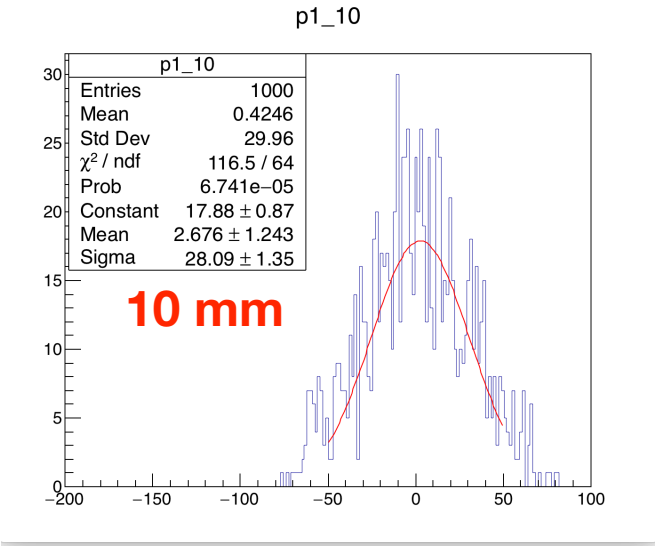


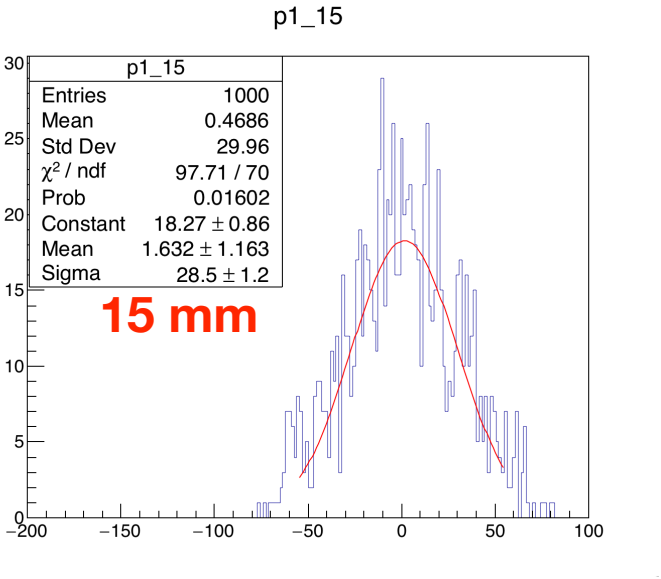




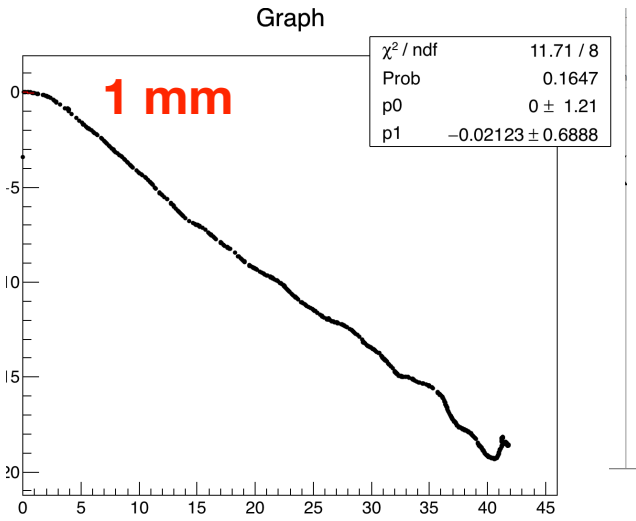


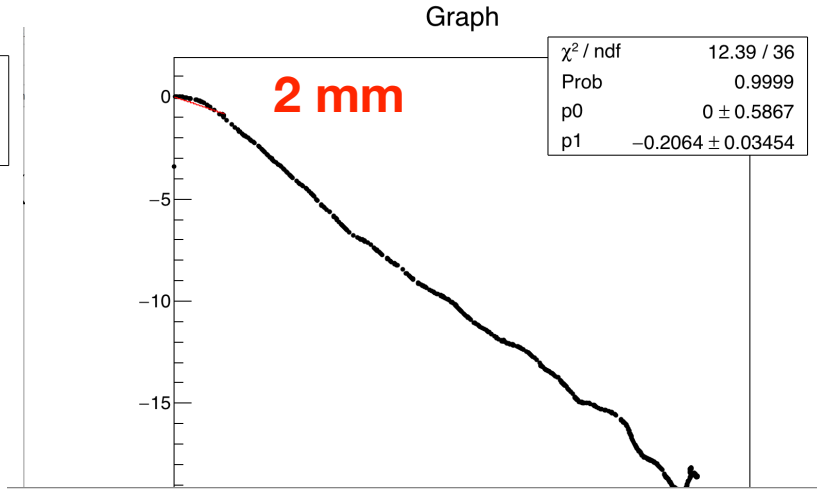


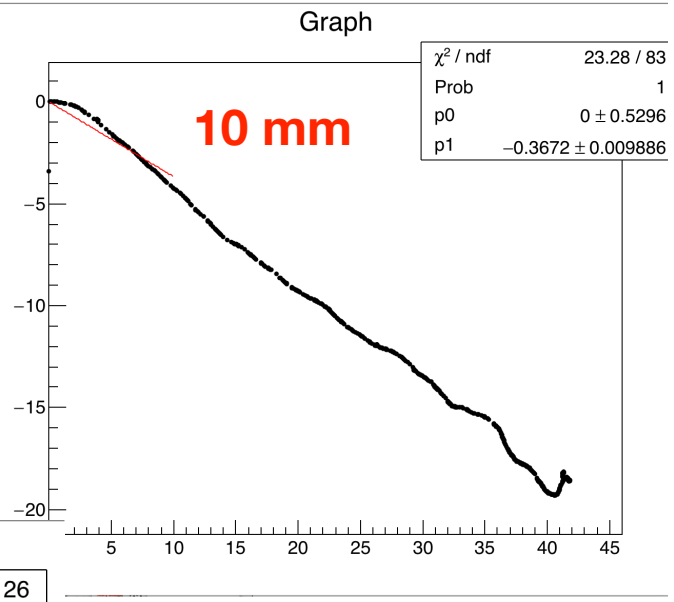


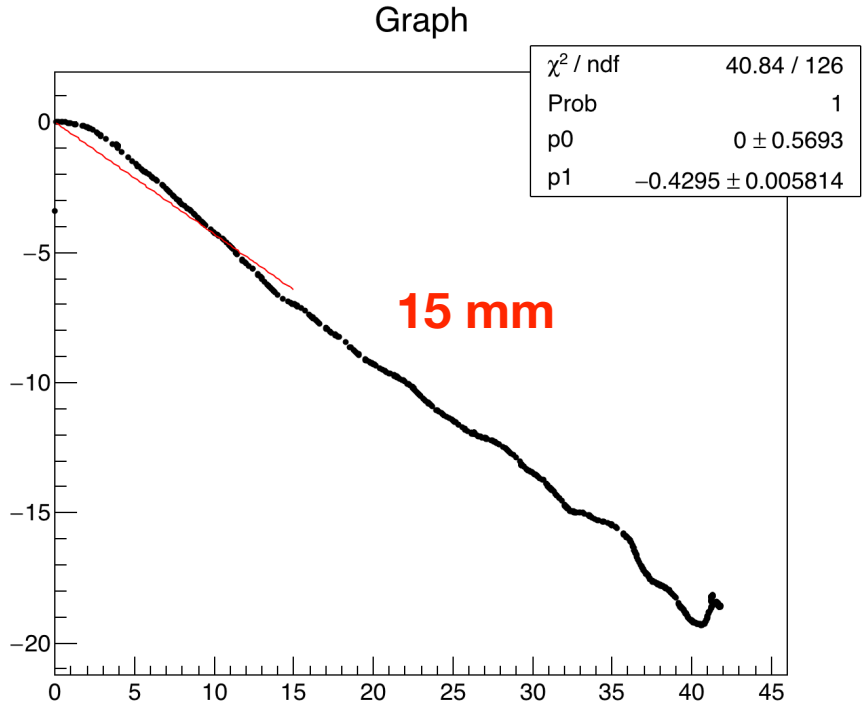


60 keV examples

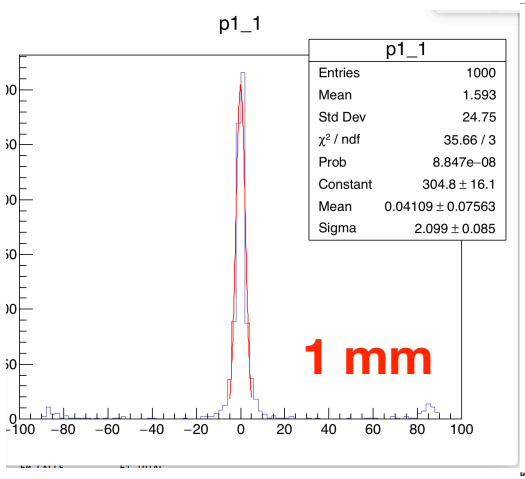


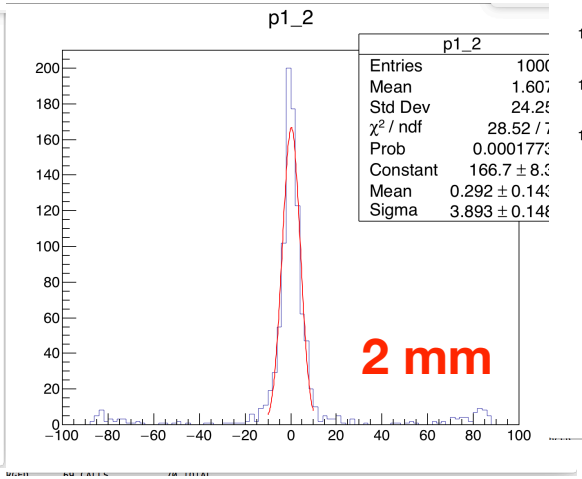


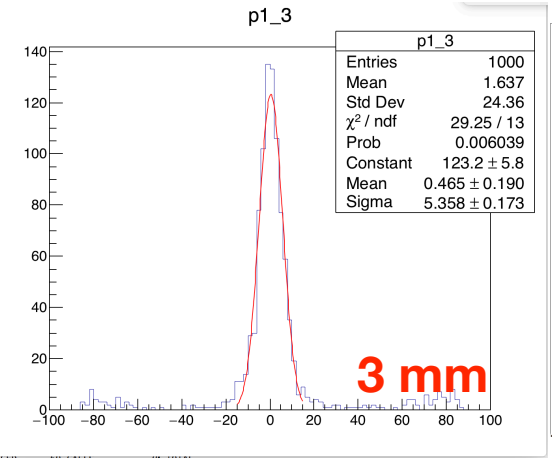


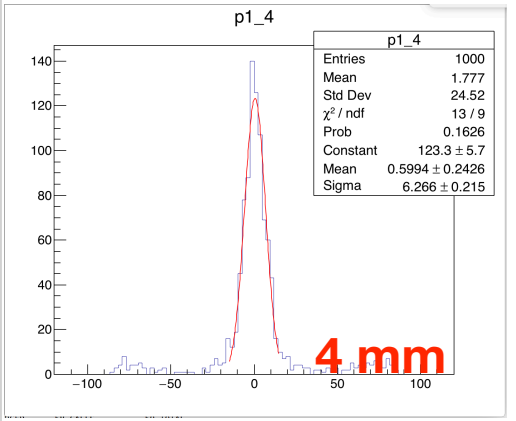


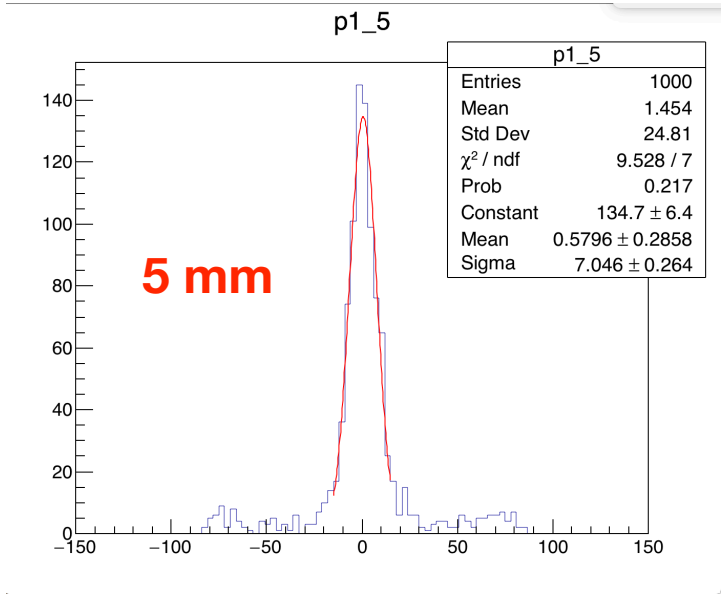
60 keV fit to first 1,2,3,4,5 mm with constraint on IP at (0,0)

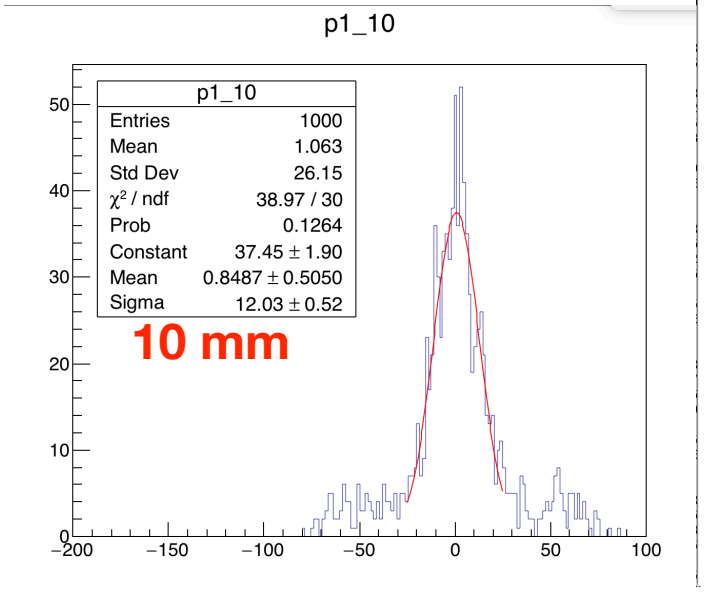


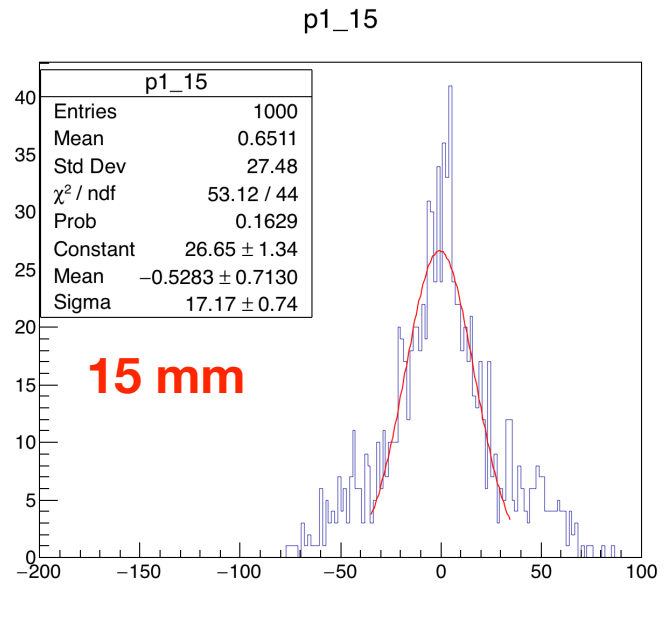




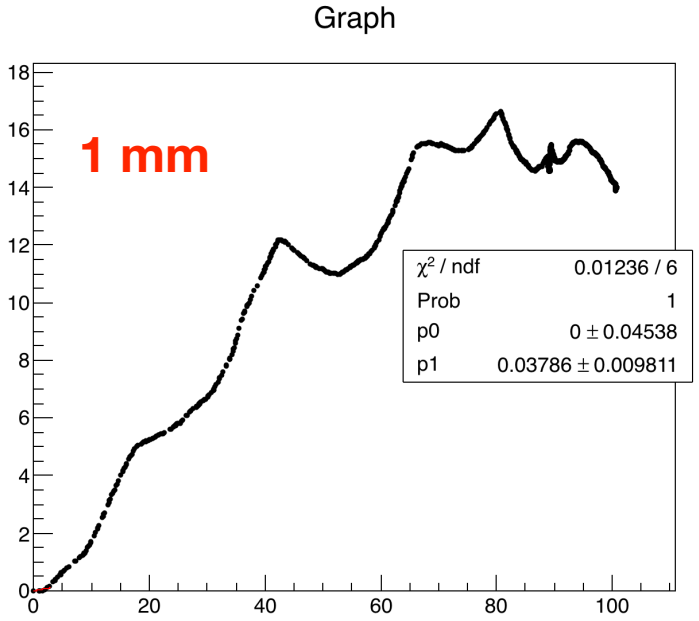


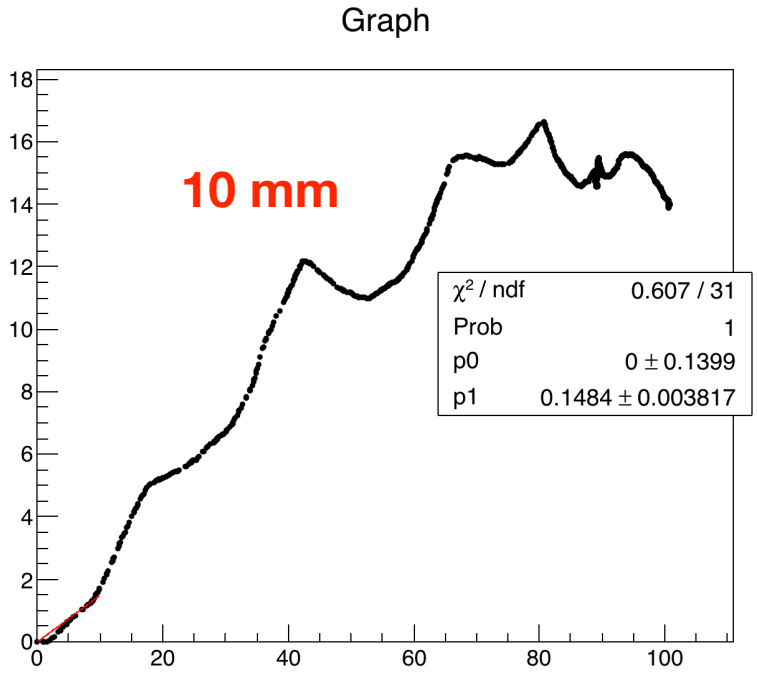


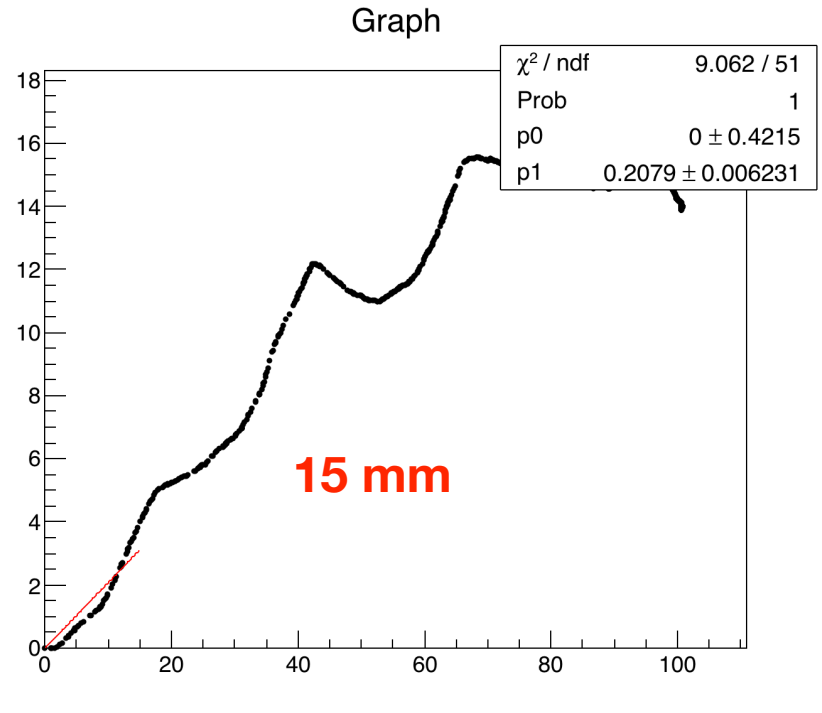




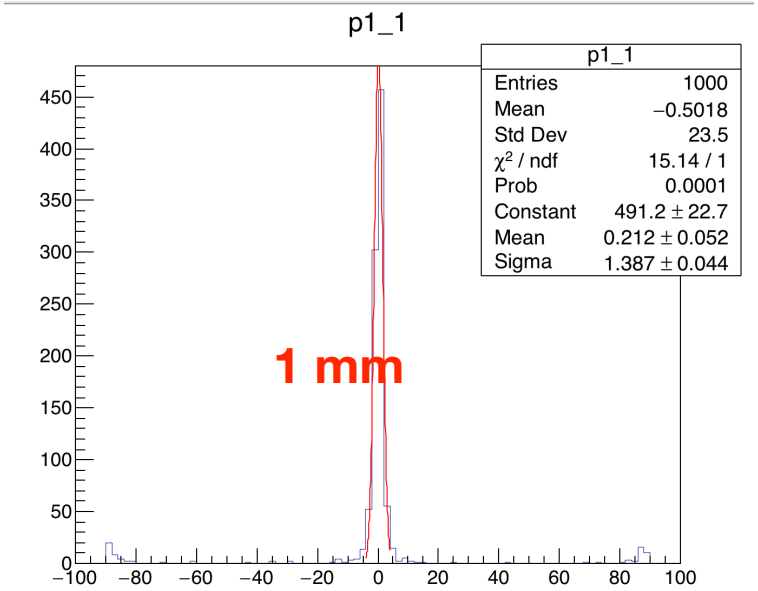
100 keV examples

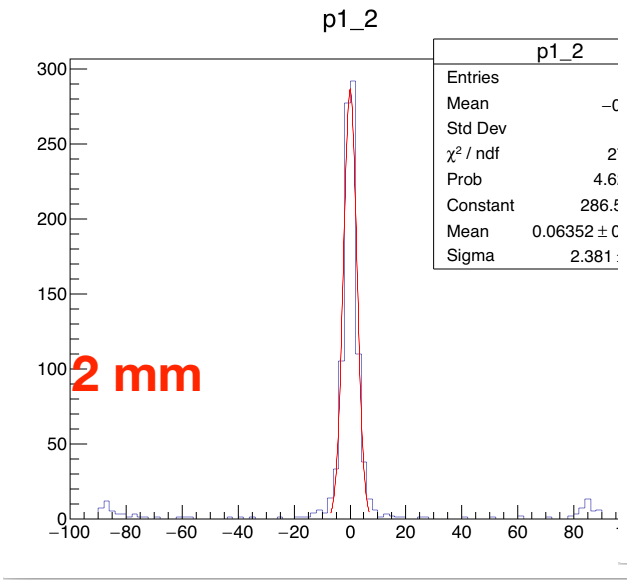


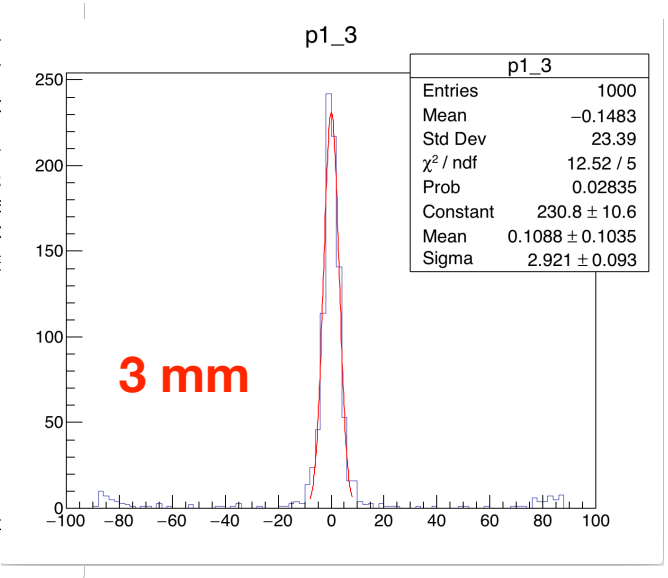


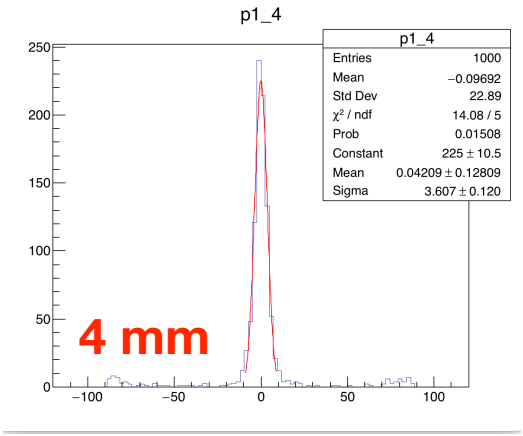


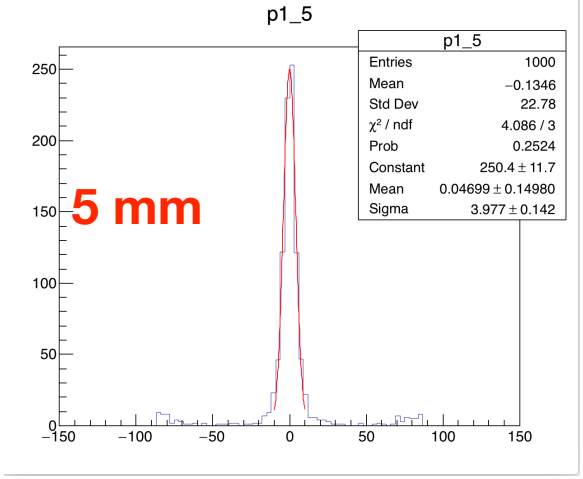
100 keV fit to first 1,2,3,4,5 mm with constraint on IP at (0,0)

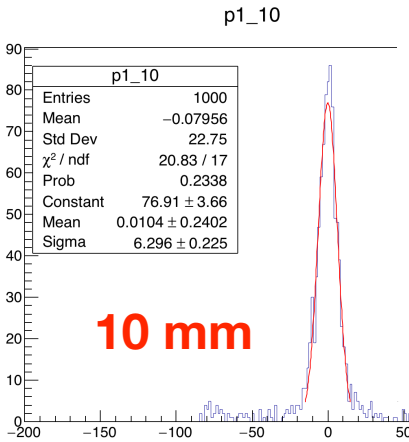


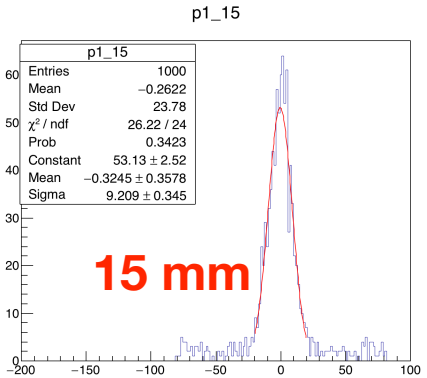




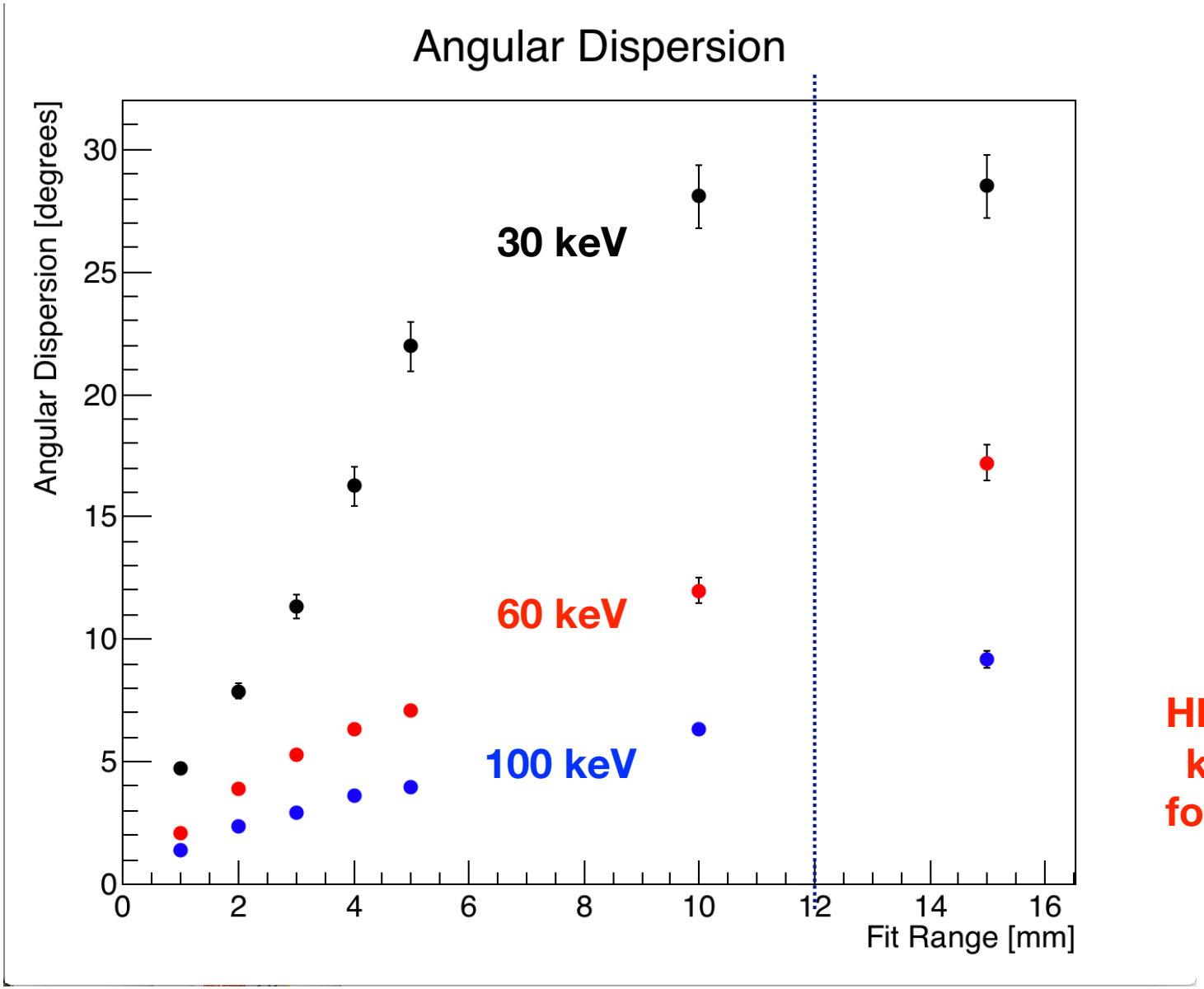








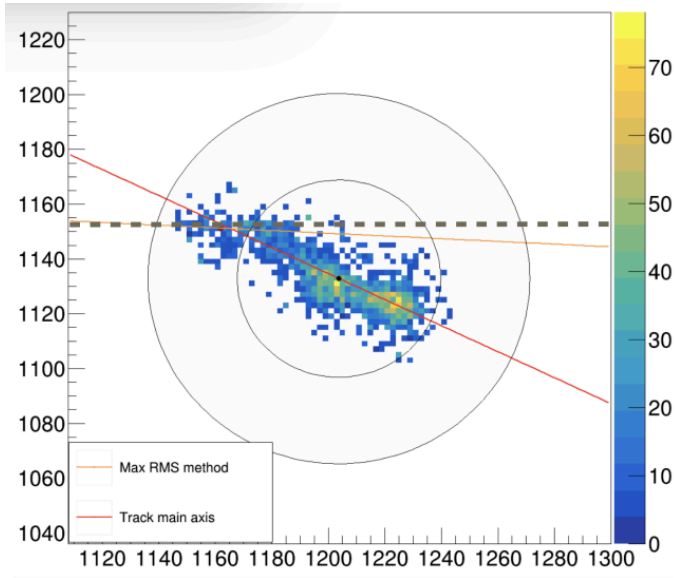
“Intrinsic” low energy electrons angular dispersion in He:CF_4 60:40 @ 1 bar



HELLAZ claims 2º for 100 keV in pure He @ 10 bar for 12 mm track sampling

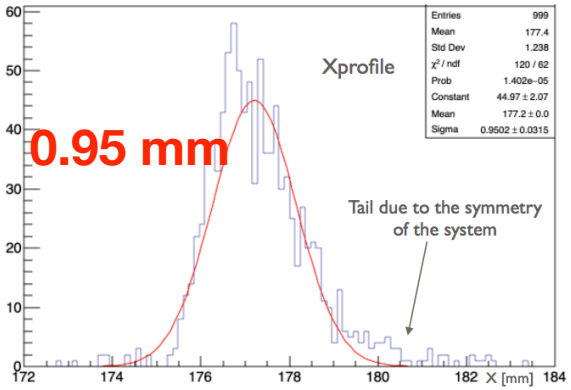
S. Torelli results on 30 keV ER

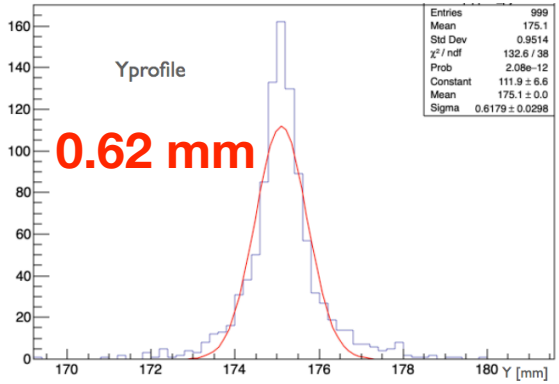
Distance from the GEM of 20cm



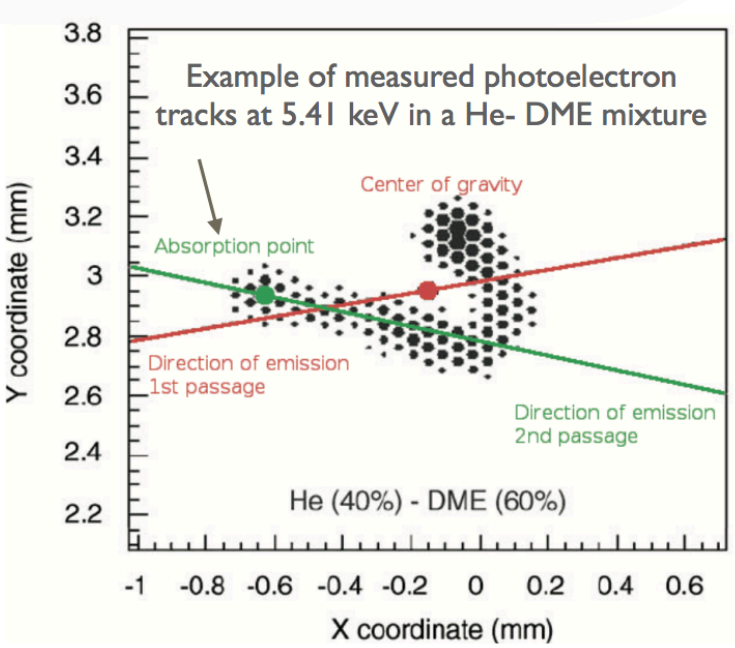
Algorithm: Astronomical X–Ray Polarimetry - pag. 130

Impact point resolution

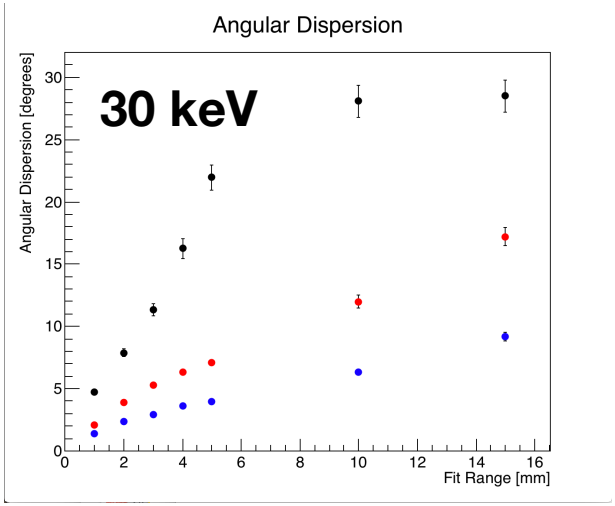




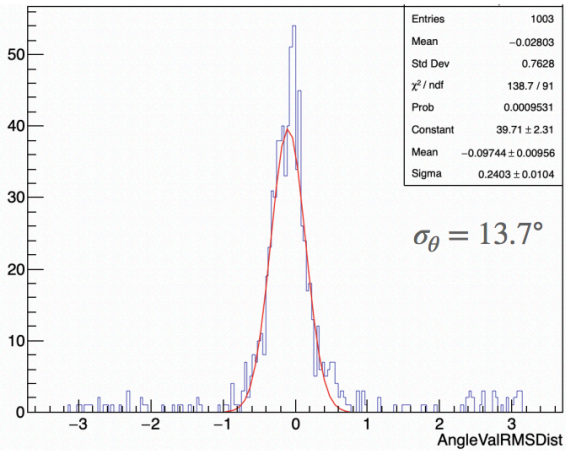
Intrinsic angular dispersion



Measured angular resolution



For 3 mm (20 px) fit range is 11.3°



Angular resolution from algorithm 7.7°