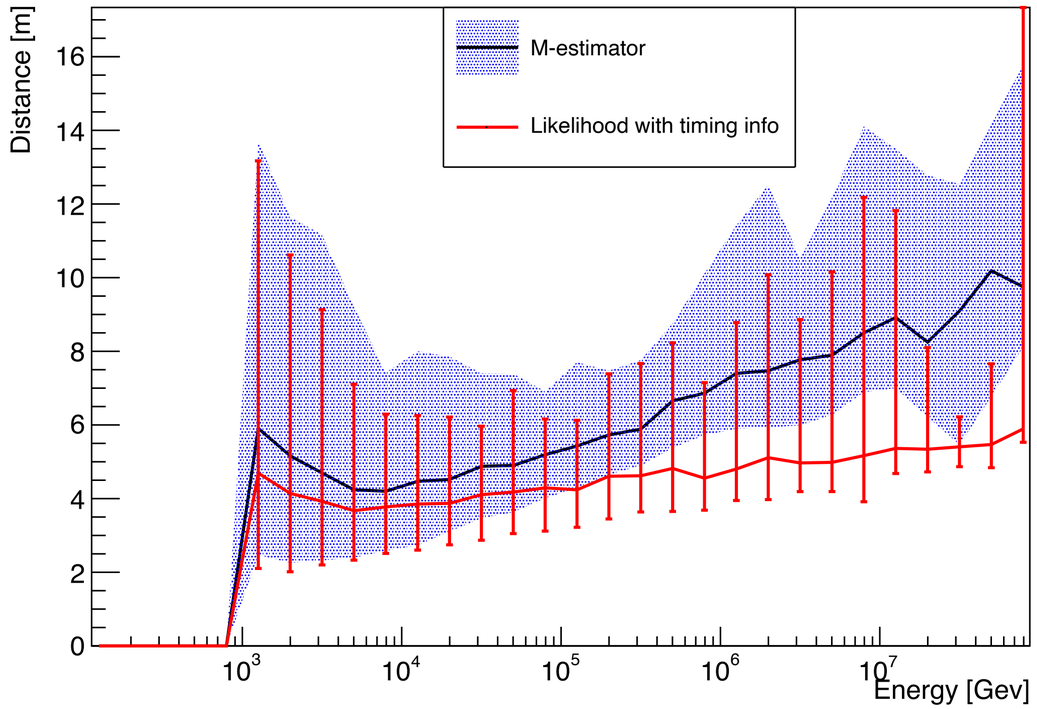
Toy MC vertex fit

Thijs van Eeden - 9th July 2020

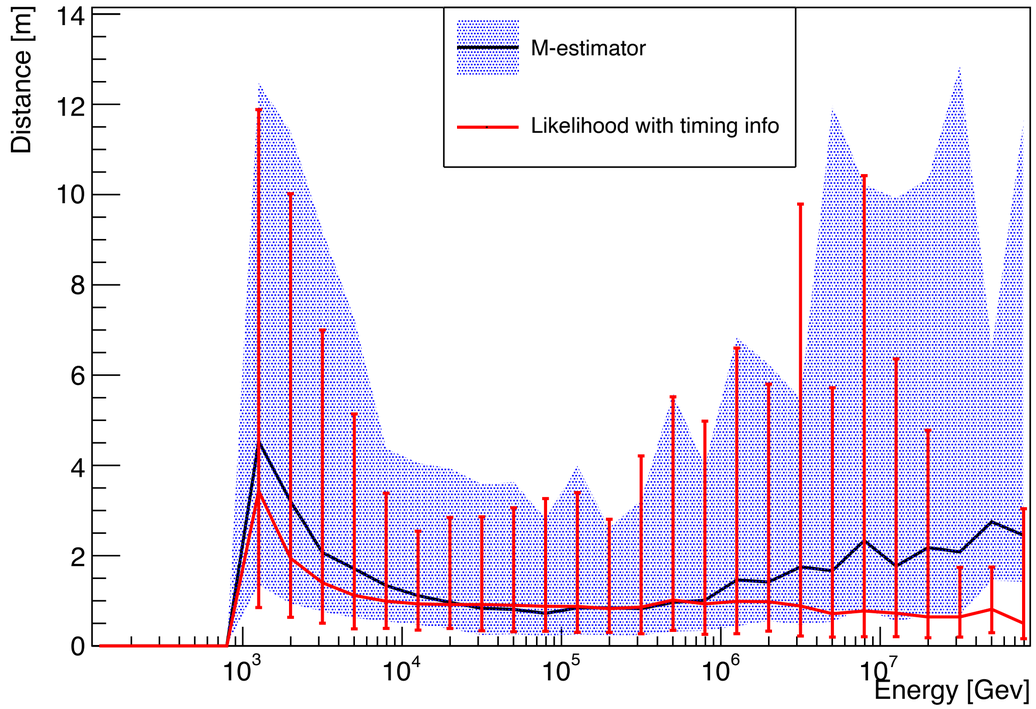
Recap: single vertex fit (nueCC)

M-estimator vs likelihood with timing information

Distance along shower axis



Distance perpendicular to shower axis

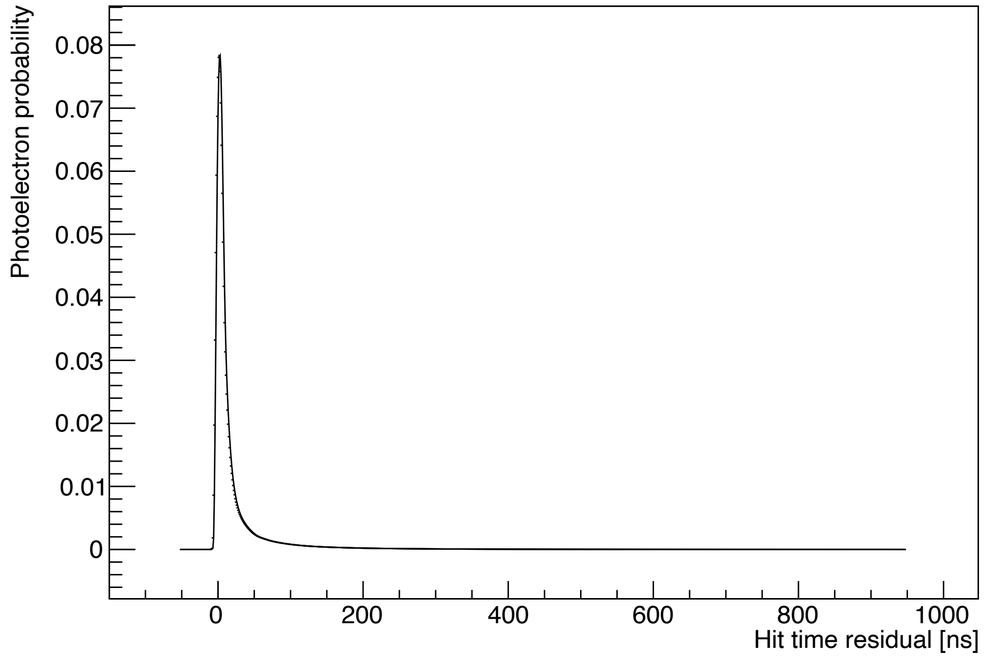


Why do we stick at 1-2 m perpendicular to the shower axis?

Nanosecond precision —> ~cm precision!

Toy experiment

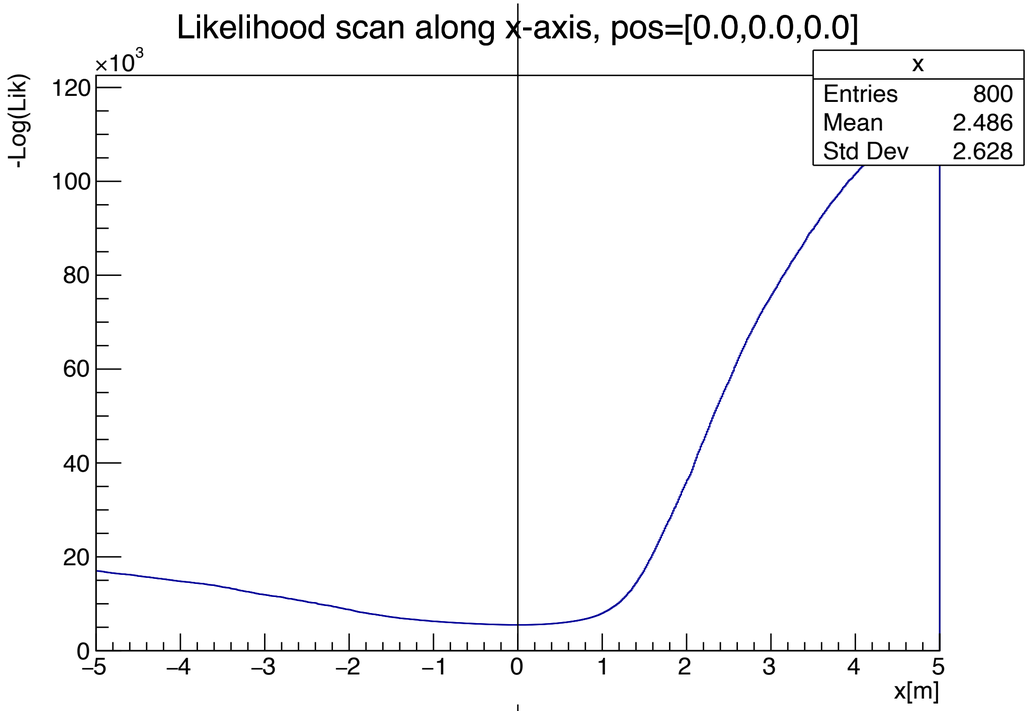
- Place a neutrino in the origin
  [0, 0, 0]
- Loop through ARCA detector file and
  generate hits by random pulling from the PDF
- Reconstruct and plot the likelihood
  and see what resolutions we get

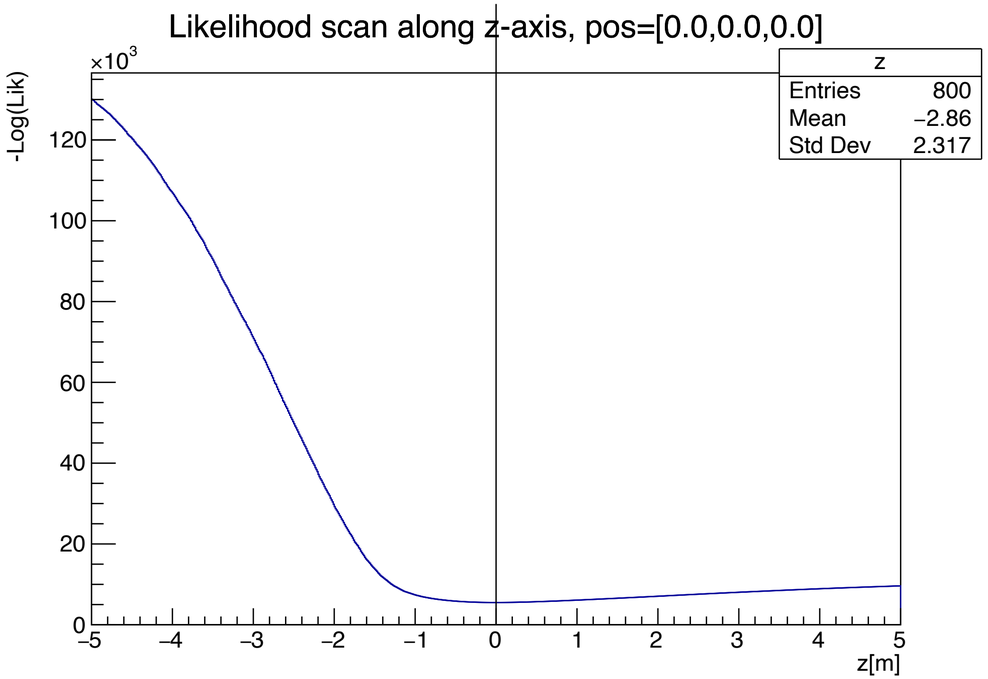


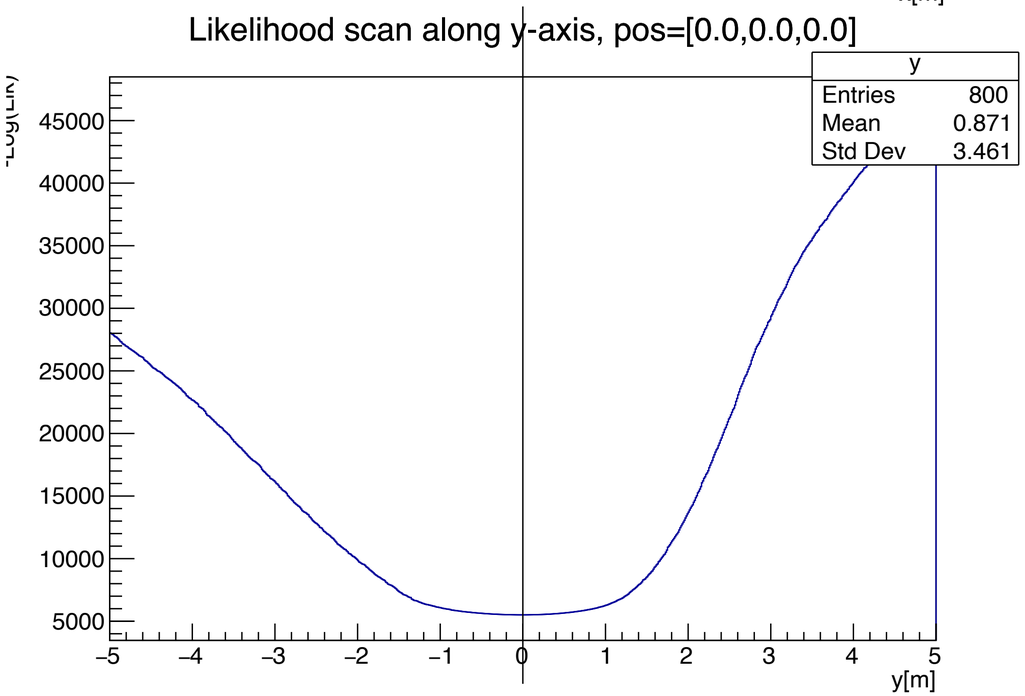
No elongation, all hits

Hits generated: 4132

- True vertex = [0 , 0 , 0], dir = [-1 ,0 ,0]
- Fit likelihood pos = [0.006, -0.006, 0.006]+-0.03
- D_along = 0.6 cm, D_perp = 0.8 cm







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- Fit likelihood pos: [0.006, -0.006, 0.006]+-0.03
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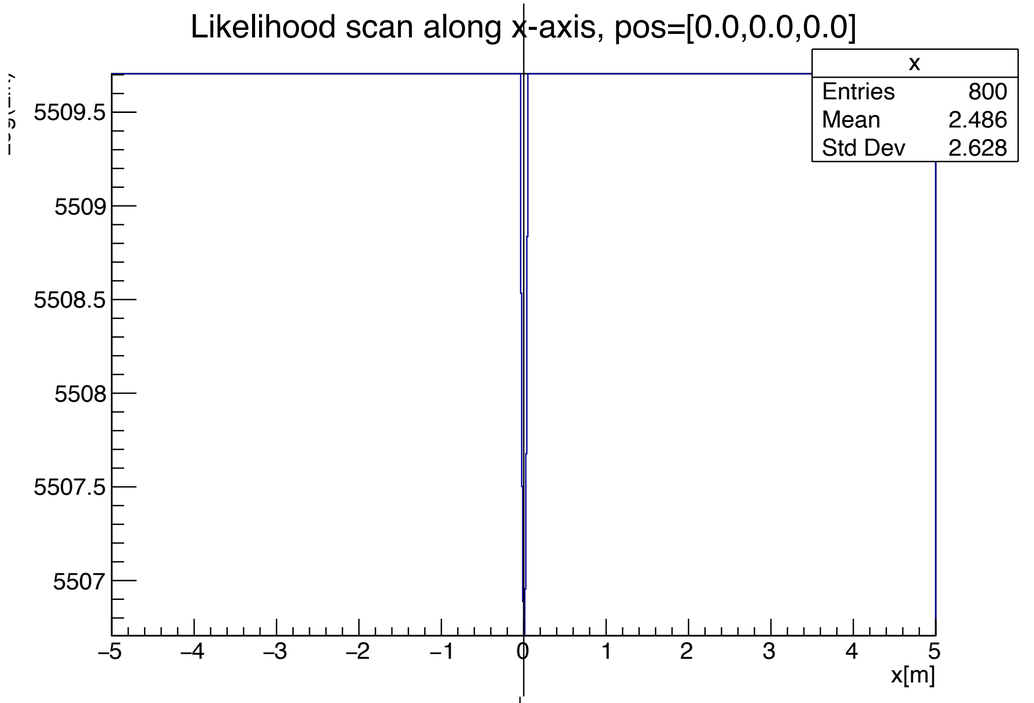
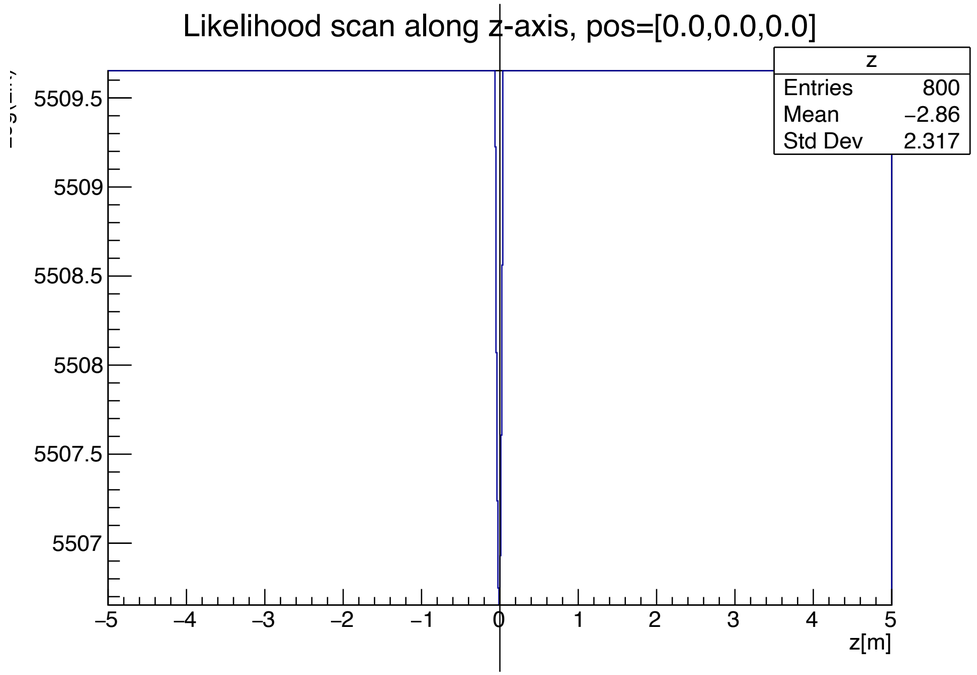
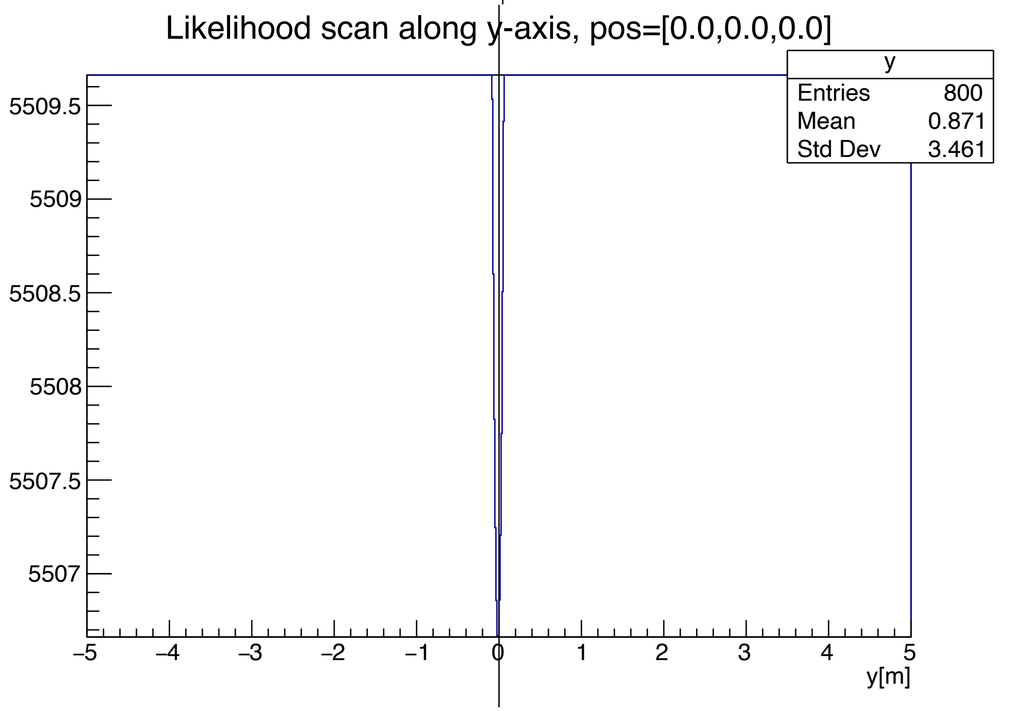


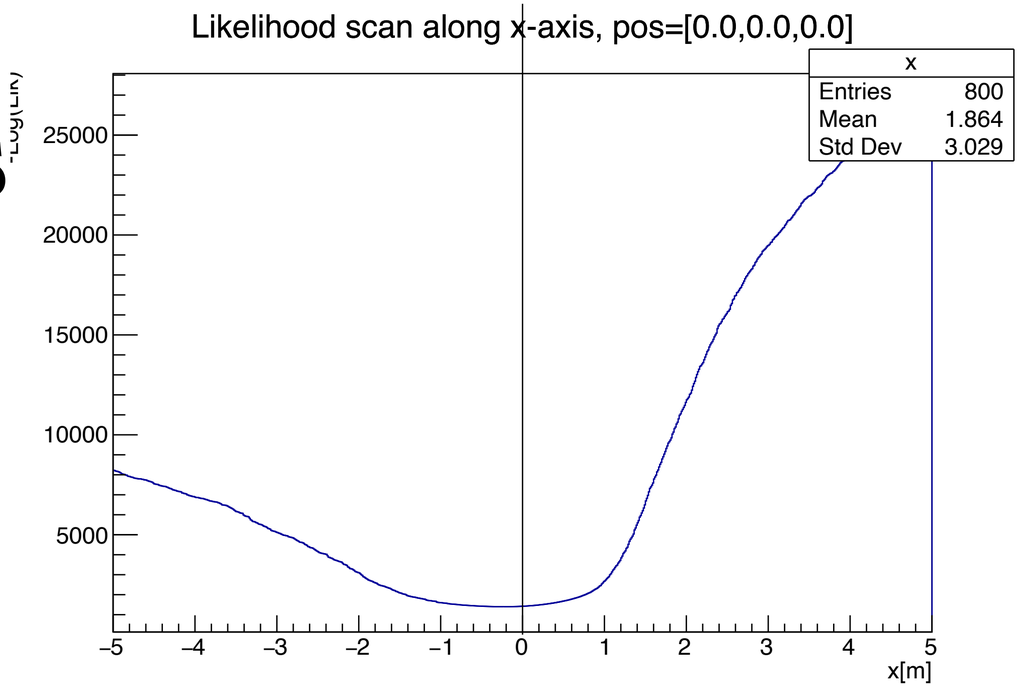


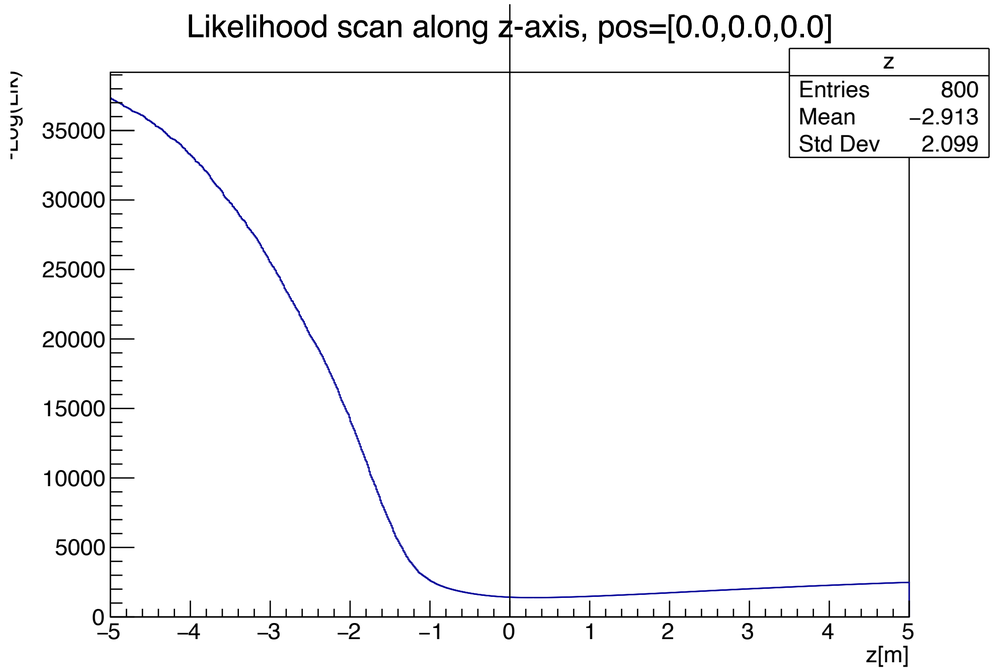


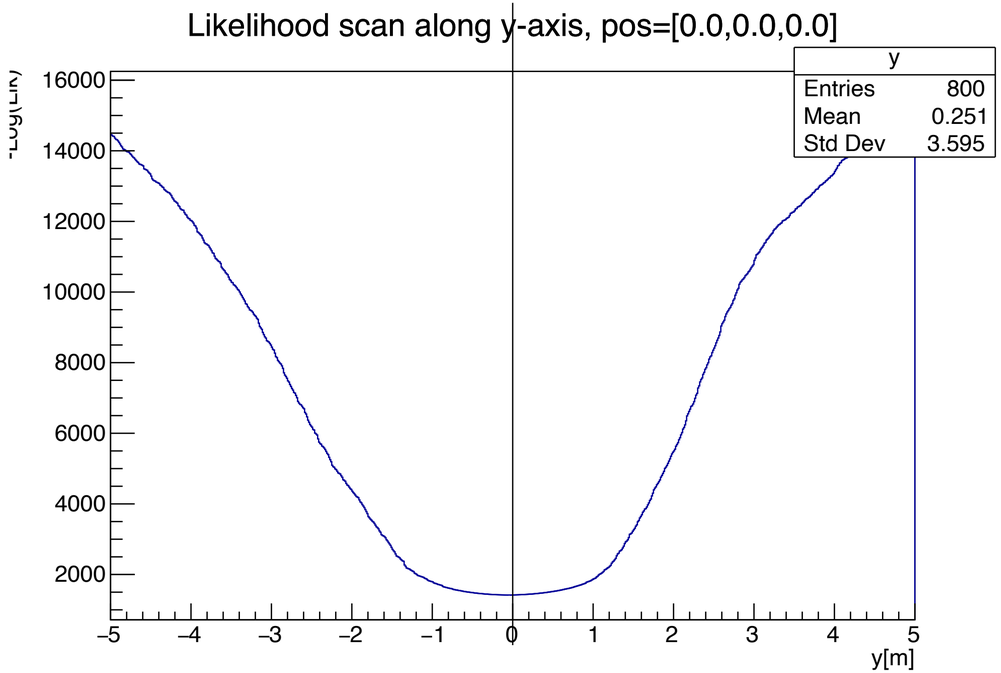
No elongation, only first hits

Hits generated: 1145

- True pos = [0, 0, 0], dir = [-1, 0, 0]
- Vertex from likelihood: [-0.23,-0.04,0.30]+-0.05
- D_along = 23 cm, D_perp = 30 cm



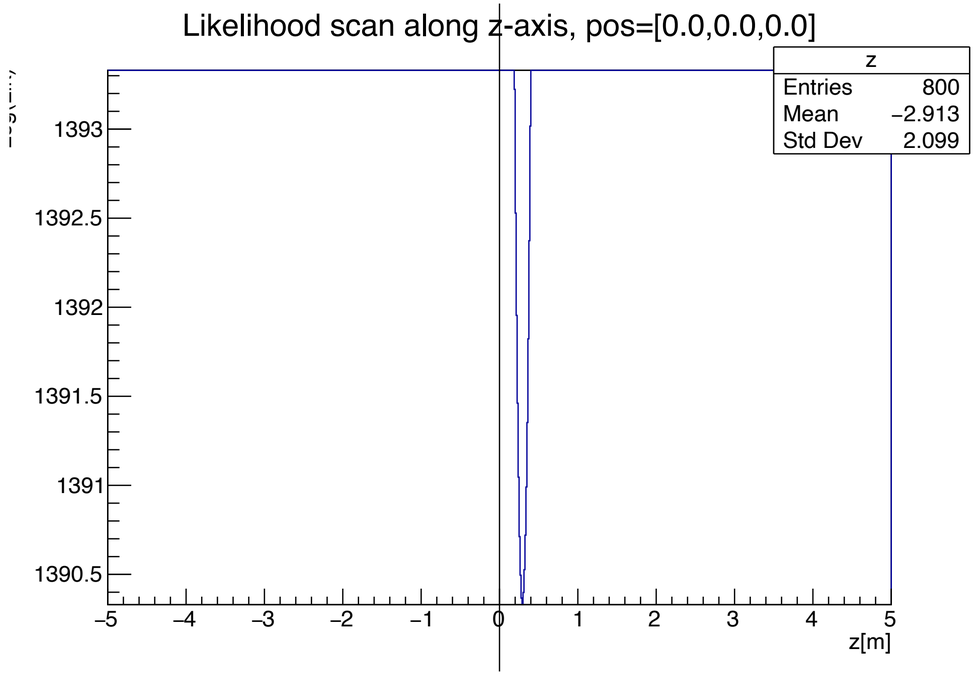


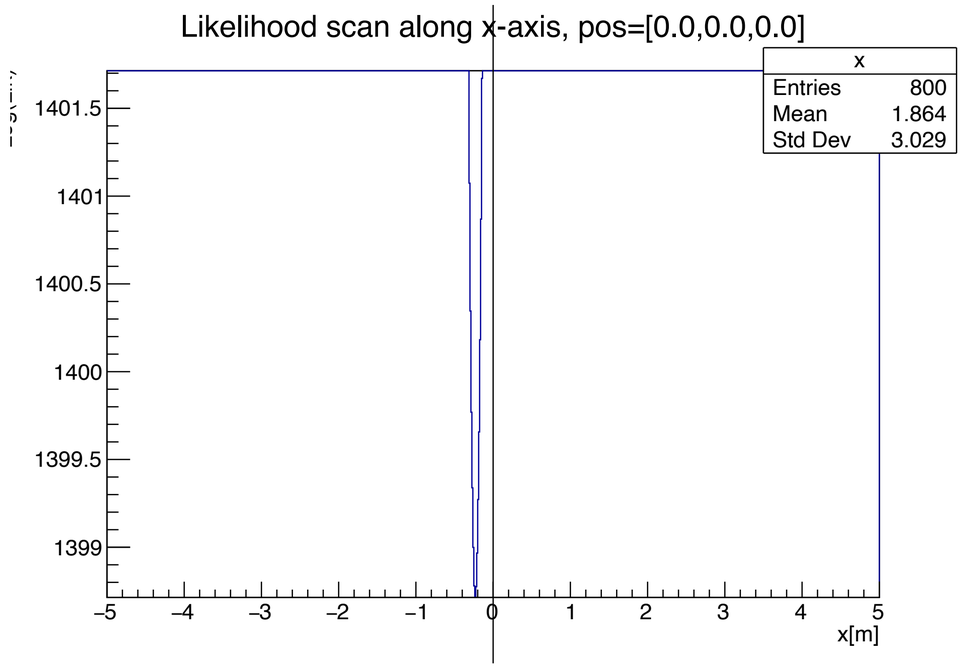


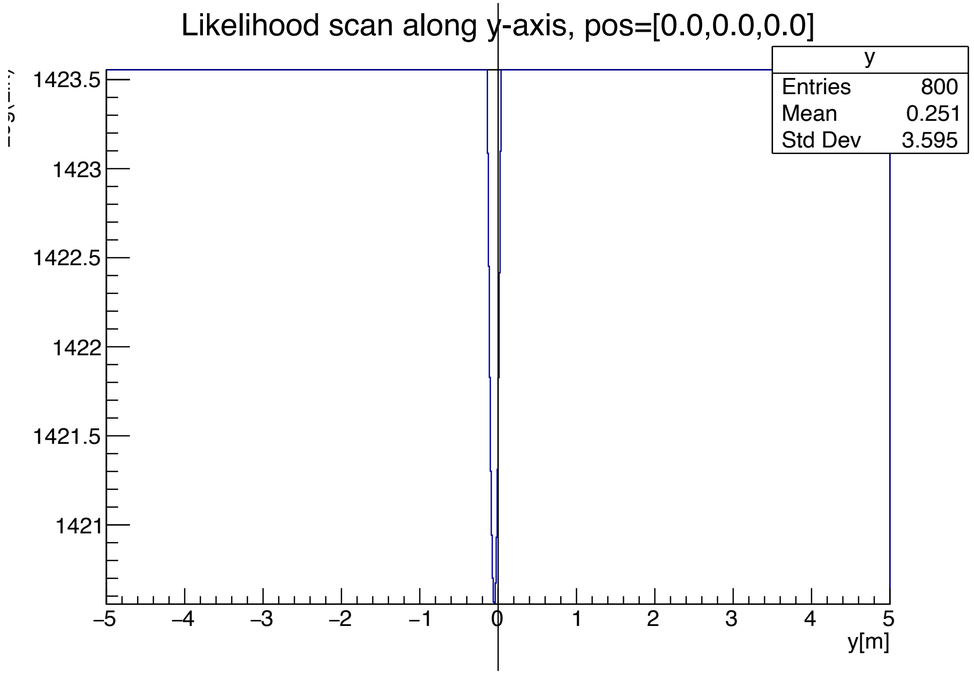
No elongation, only first hits

Hits generated: 1145

- True vertex [0, 0, 0], dir = [-1, 0, 0]
- Vertex from likelihood: [-0.23, -0.04, 0.30]+-0.04
- D_along = 23 cm, D_perp = 30 cm

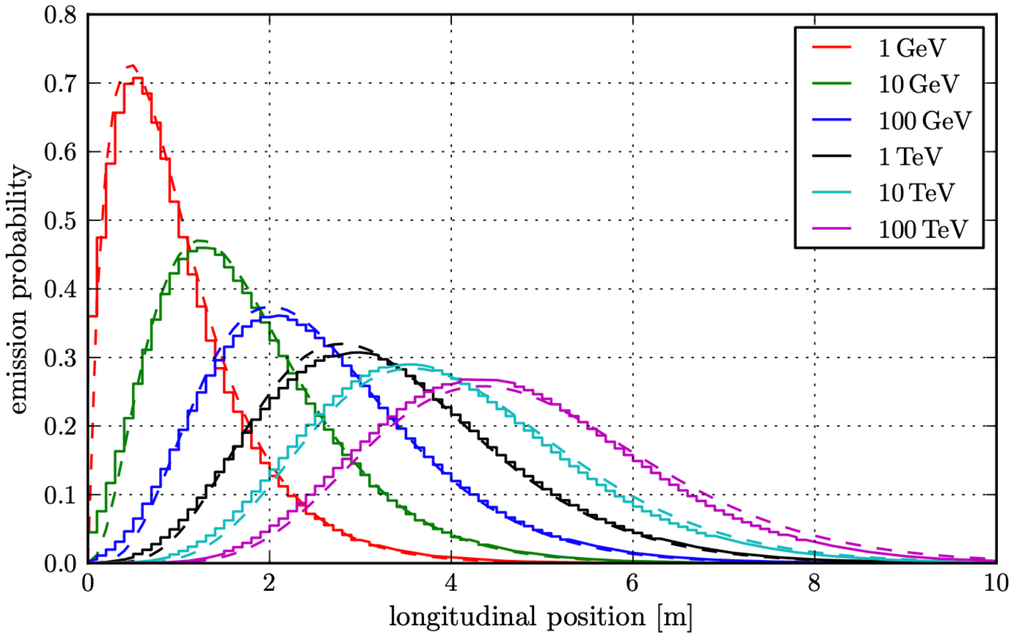






Shower elongation

- Resolutions are now in the order of cm (as expected)
- What about shower elongation?
- Vertex at [0, 0, 0,], dir = [1, 0, 0]
  - Light not emitted at vertex, but along shower axis

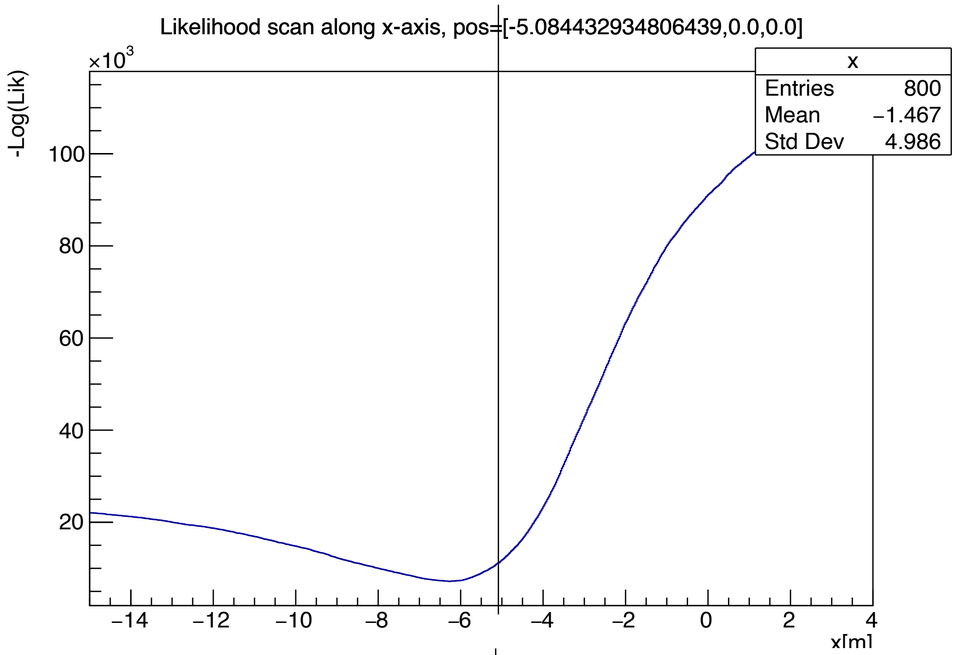


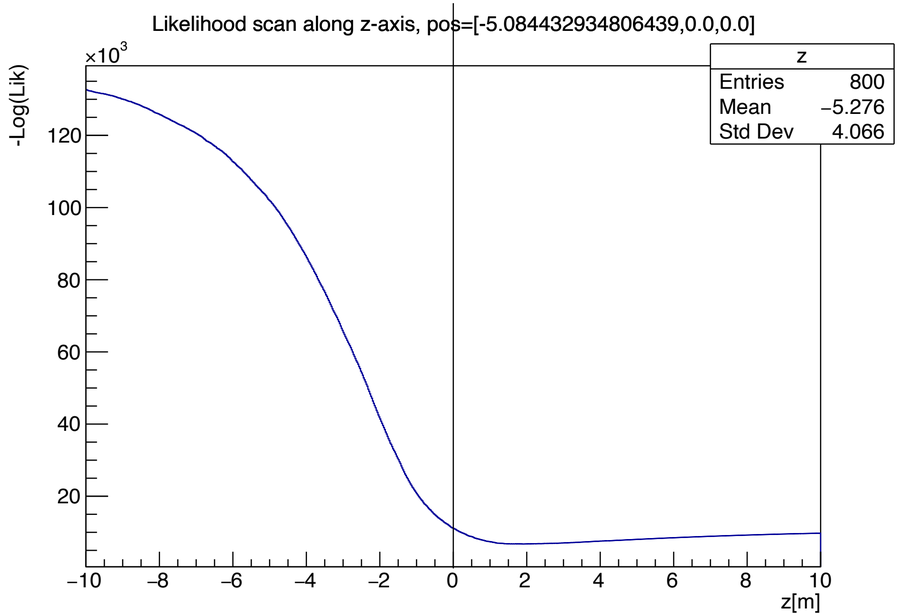
Taken from Claudio Kopper's thesis

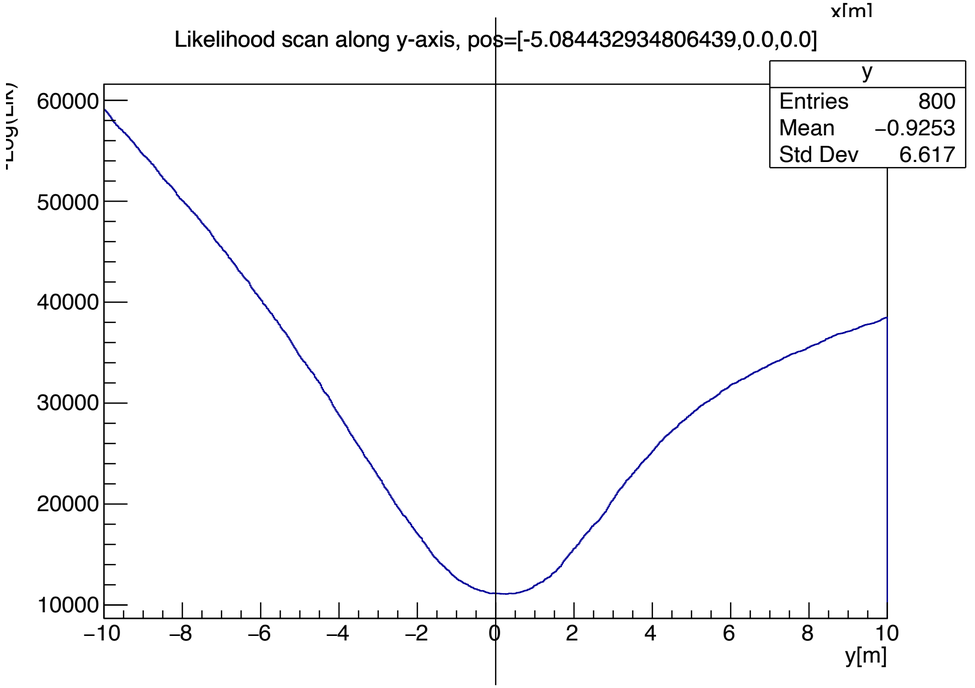
8 step elongation, all hits

Hits generated: 3451

- True pos = [0, 0, 0], dir = [-1, 0, 0]
- Expectation from shower max = [-5.08, 0, 0]



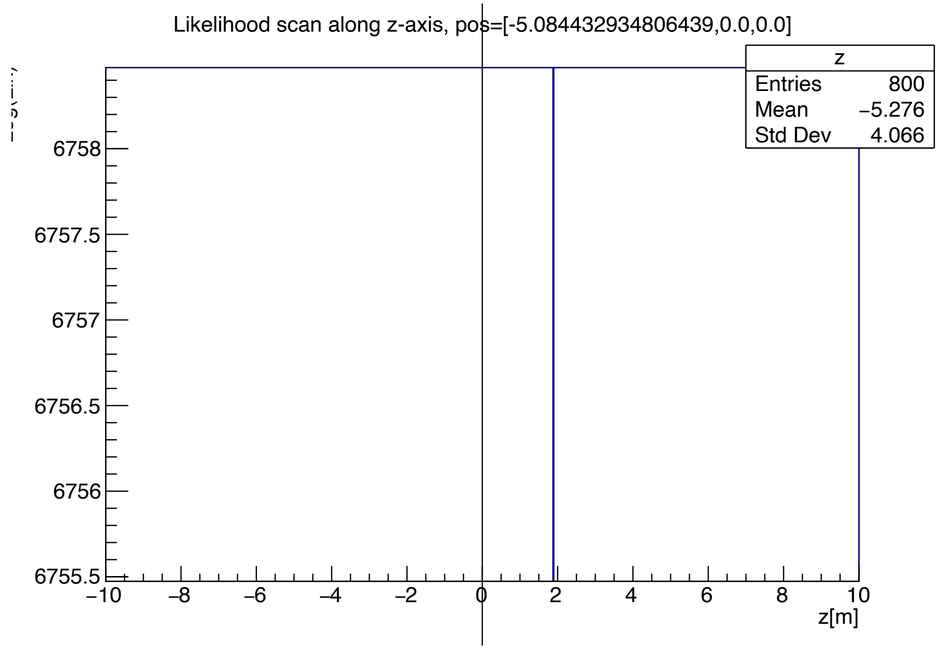


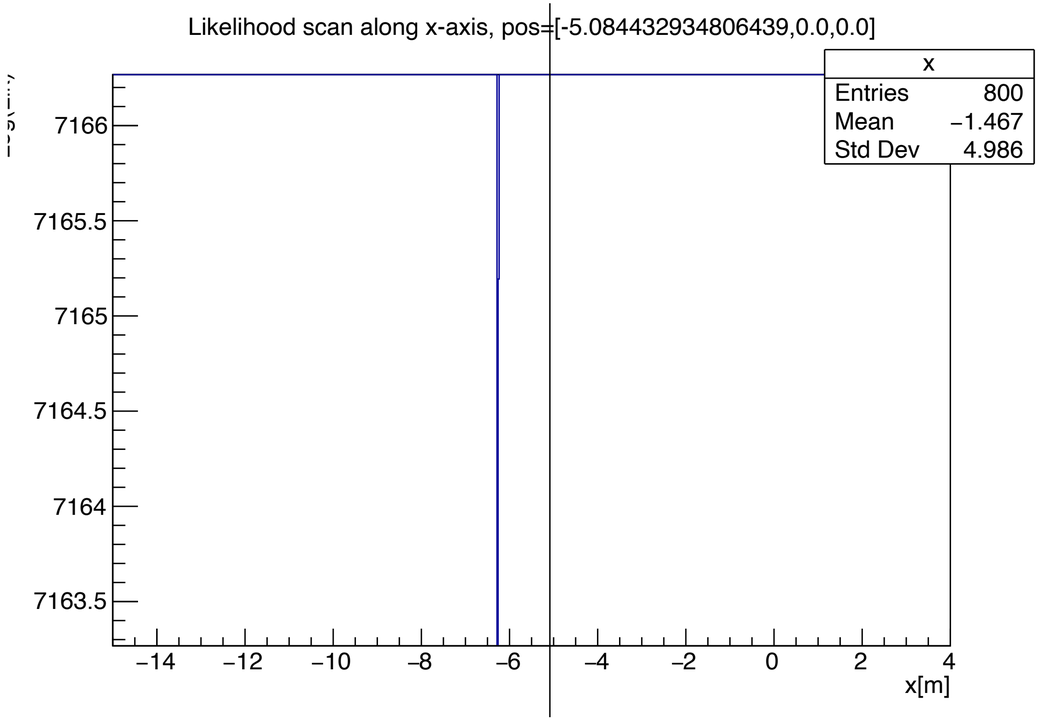


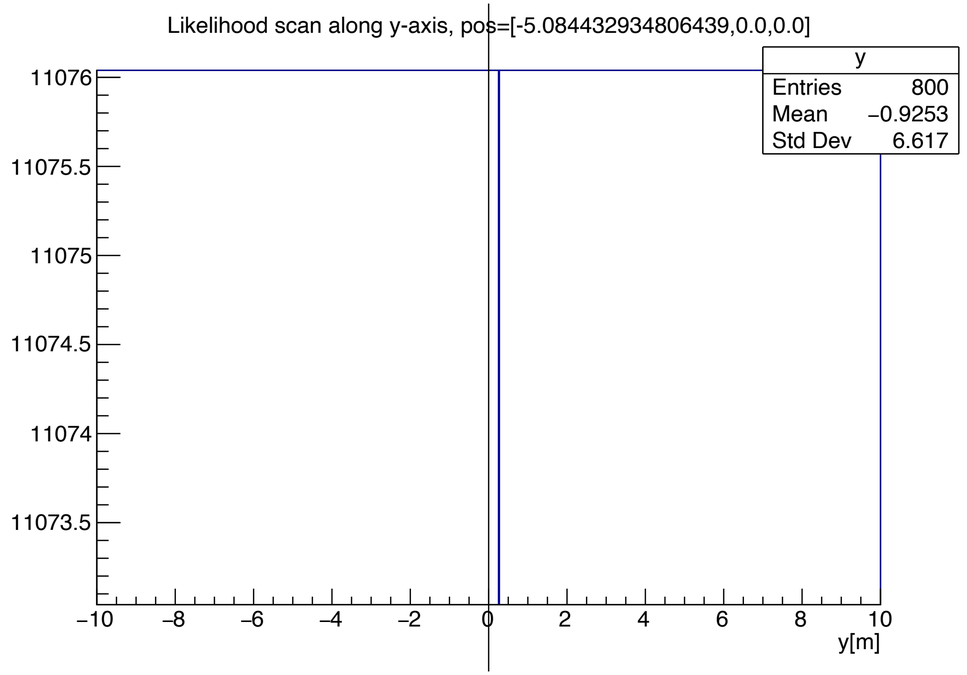
8 step elongation, all hits

Hits generated: 3451

- True pos = [0, 0, 0], dir = [-1, 0, 0]
- Expectation from shower max = [-5.08, 0, 0]
- Vertex from likelihood: [-6.27,0.26,1.89]+-0.03
- D_along = 6.27 m, D_perp = 1.90 m

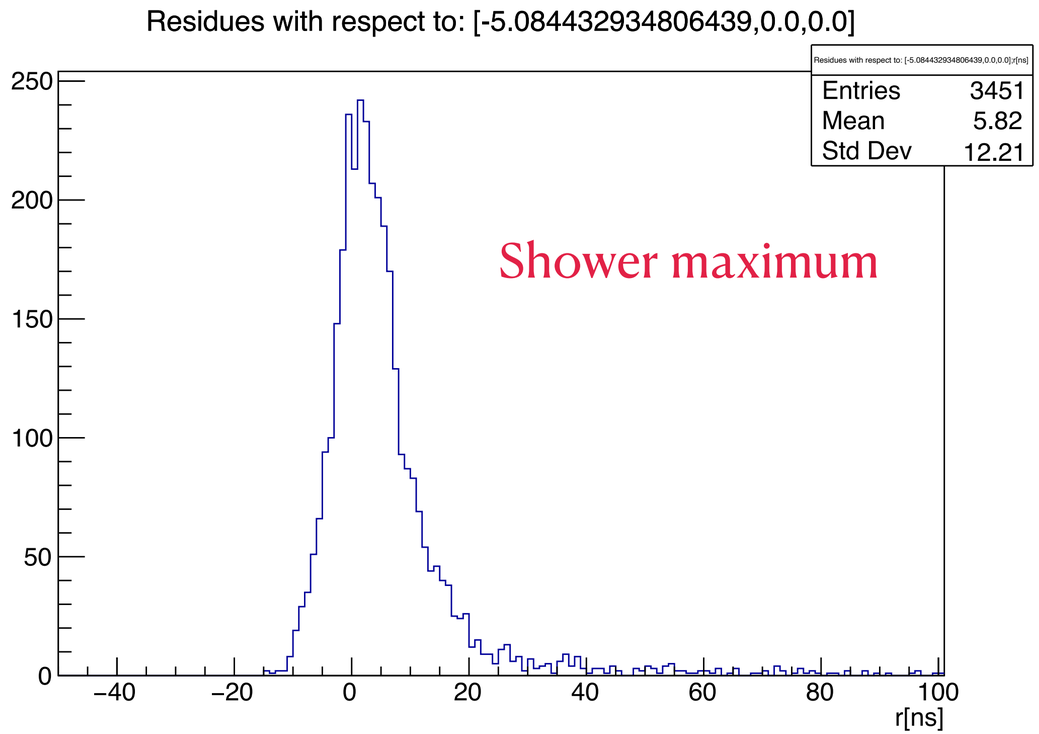


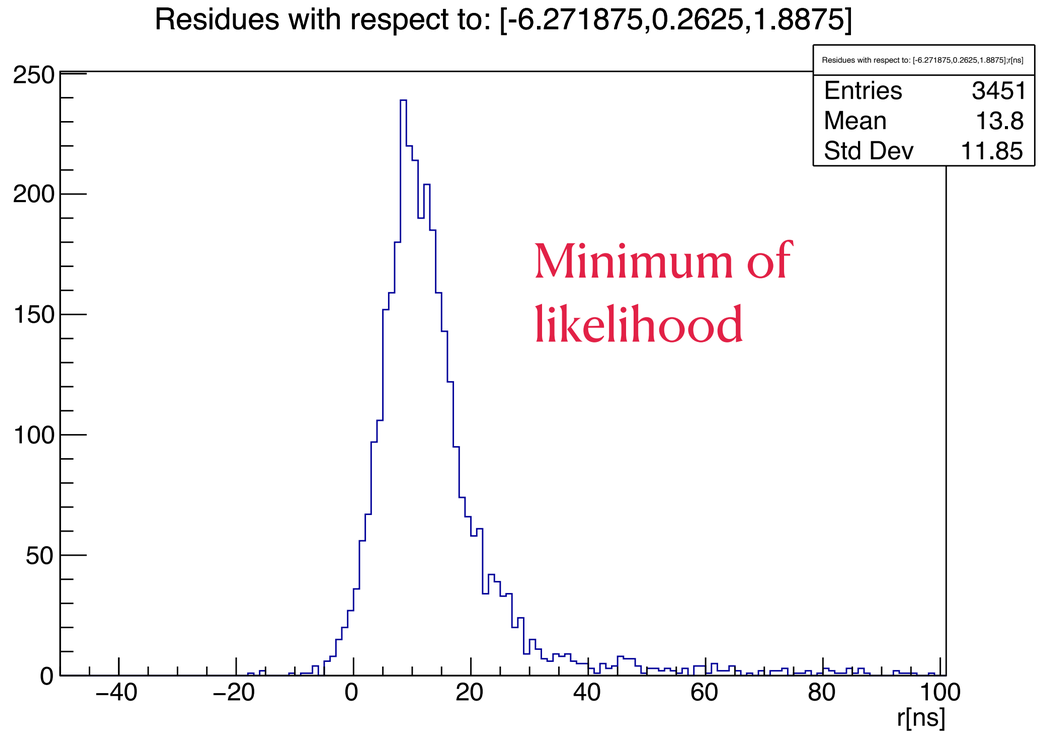




8 step elongation, all hits

Time hit residuals



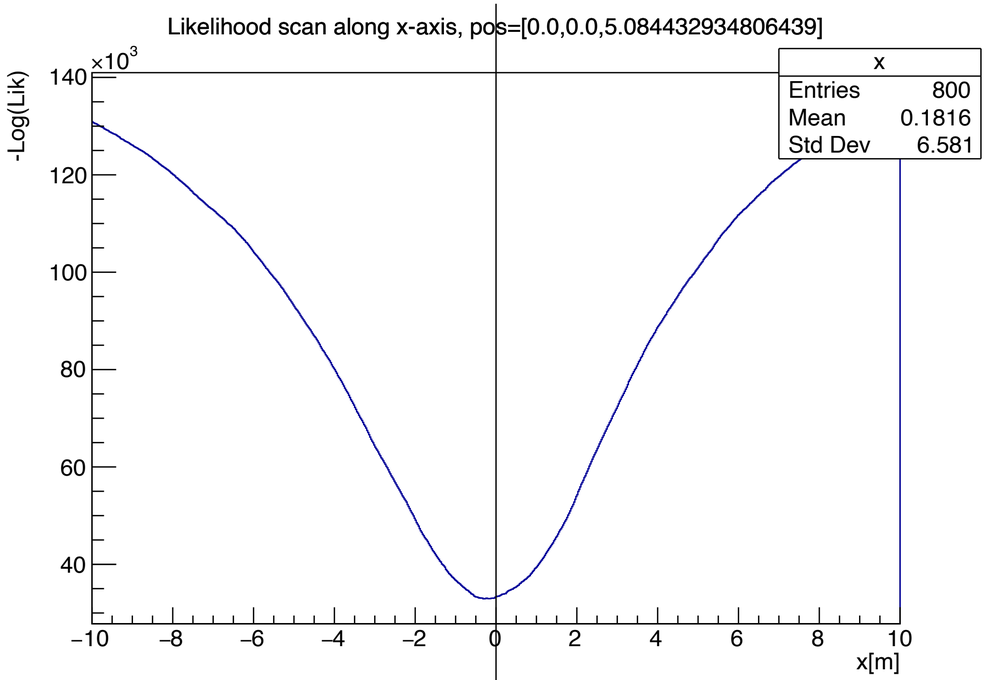


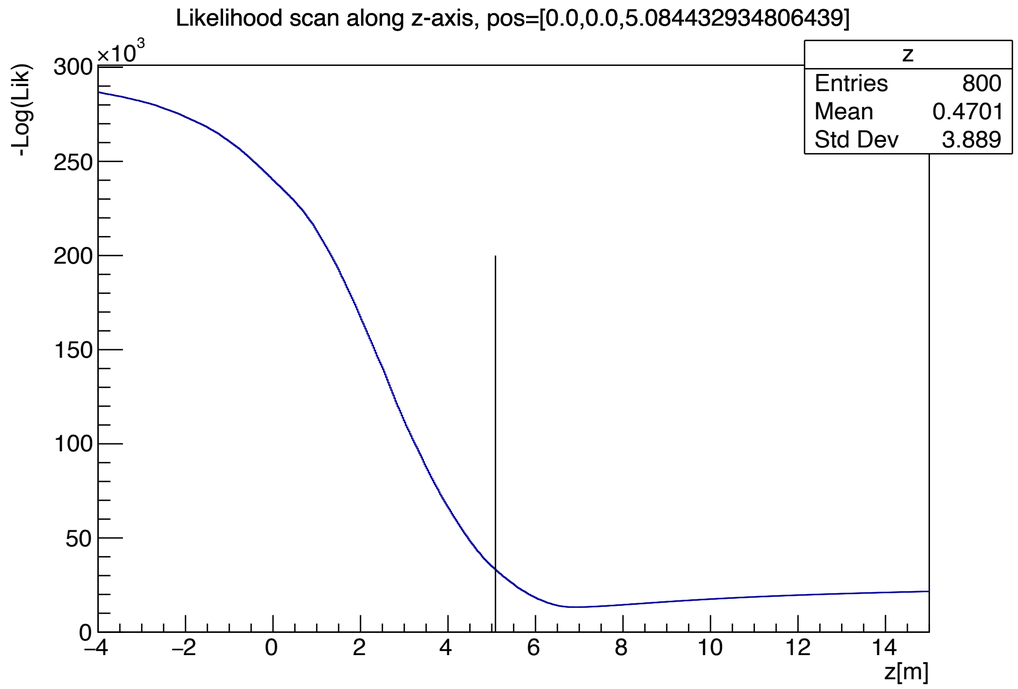
- Likelihood: very early hits are ‘impossible’
- But.. Sometimes it goes OK

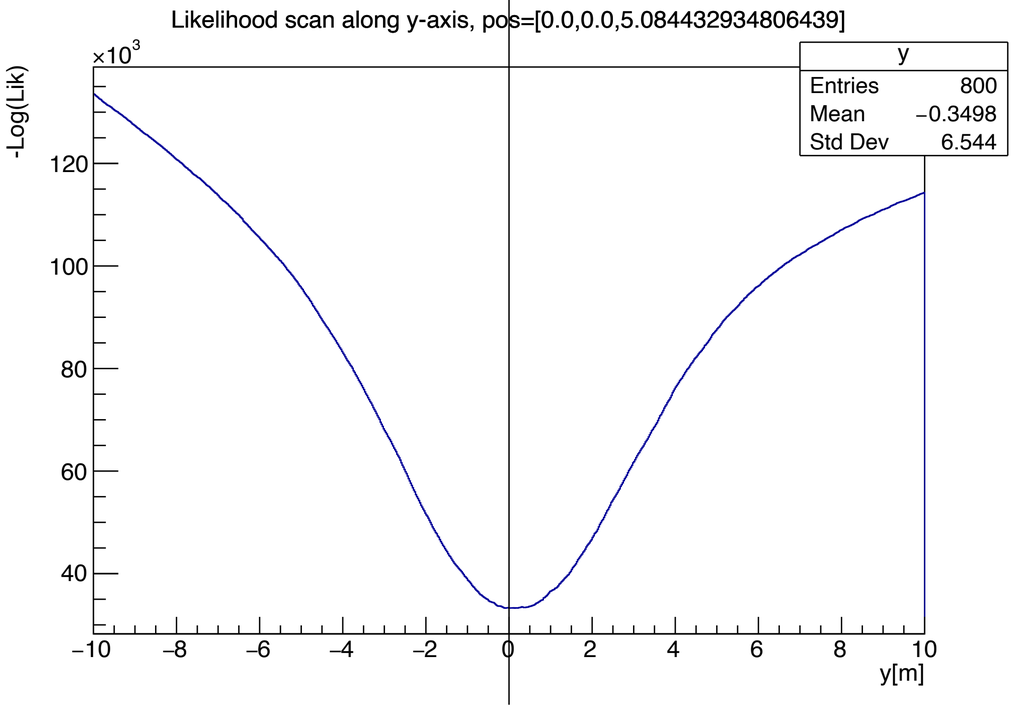
8 step elongation, all hits

Hits generated: 7404

- True pos = [0, 0, 0], dir = [0, 0, 1]
- Expectation from shower max = [0, 0, 5.08]



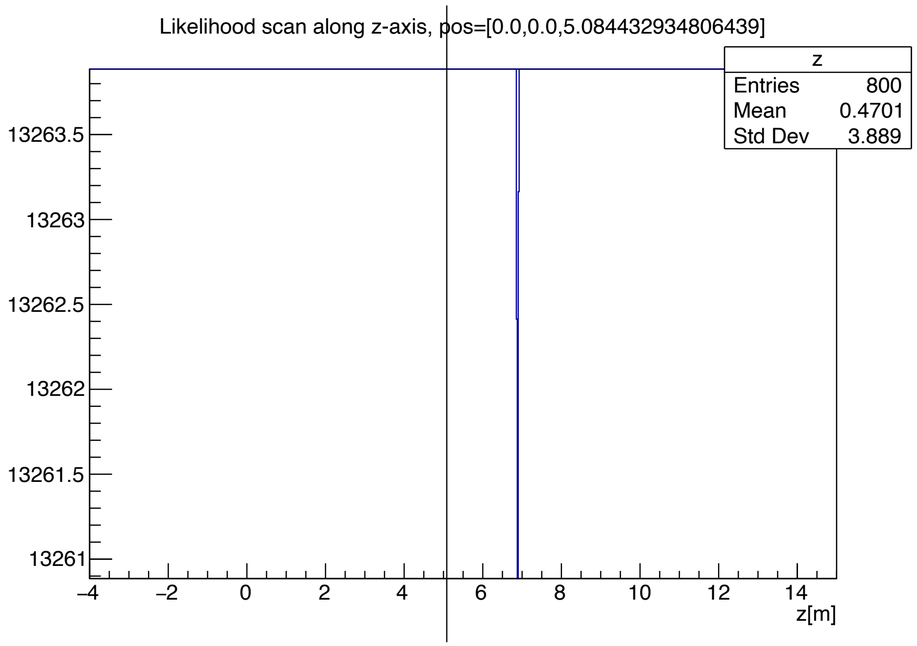


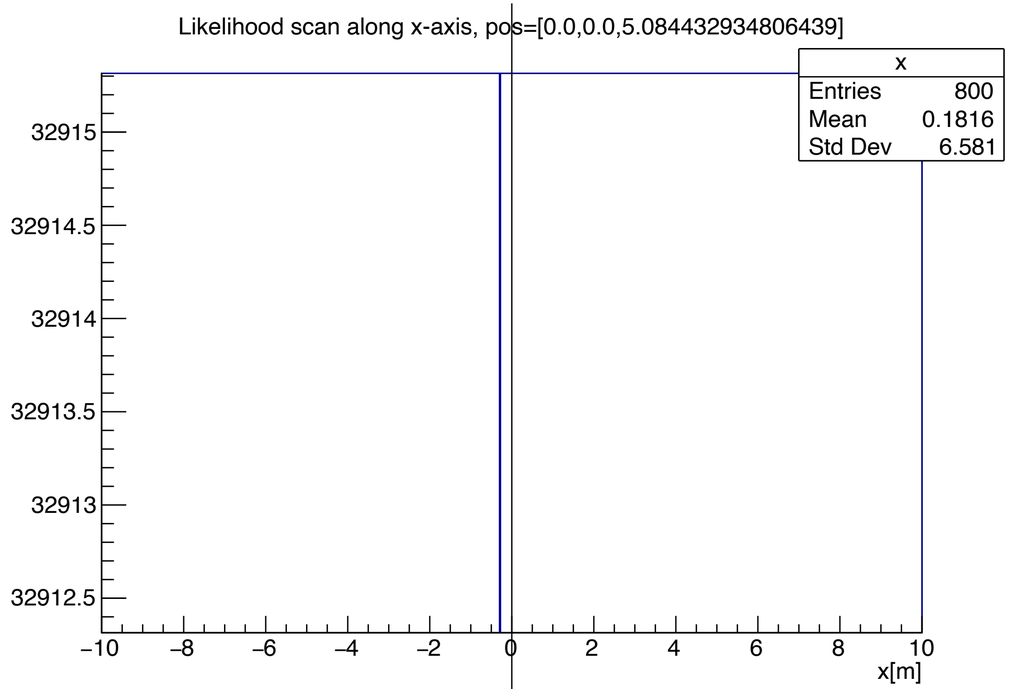


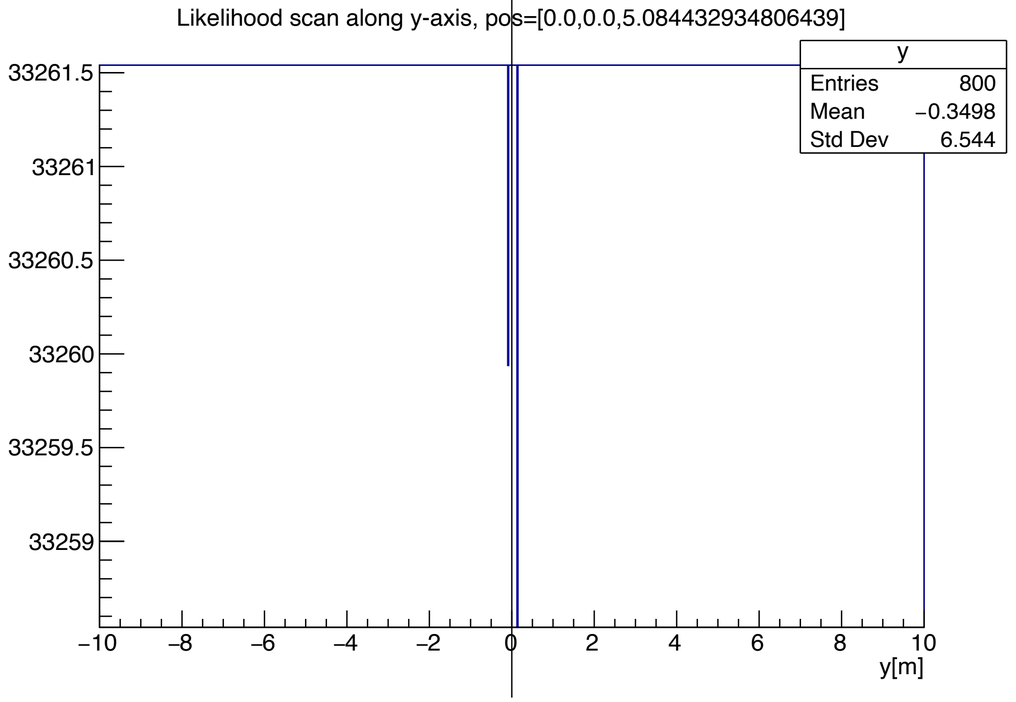
8 step elongation, all hits

Hits generated: 7404

- True pos = [0, 0, 0], dir = [0, 0, 1]
- Expectation from shower max = [0, 0, 5.08]
- Vertex from likelihood: [-0.29,0.13,6.89]+-0.03
- D_along = 6.89 m, D_perp = 0.32 m

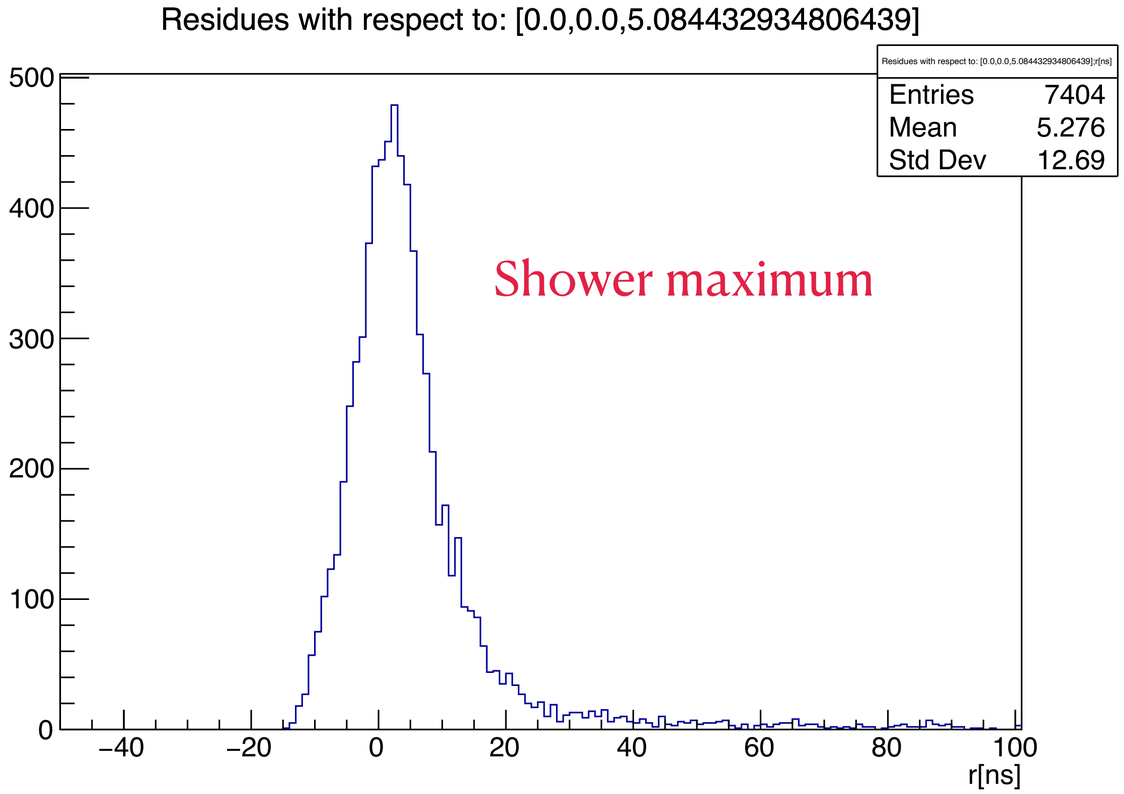


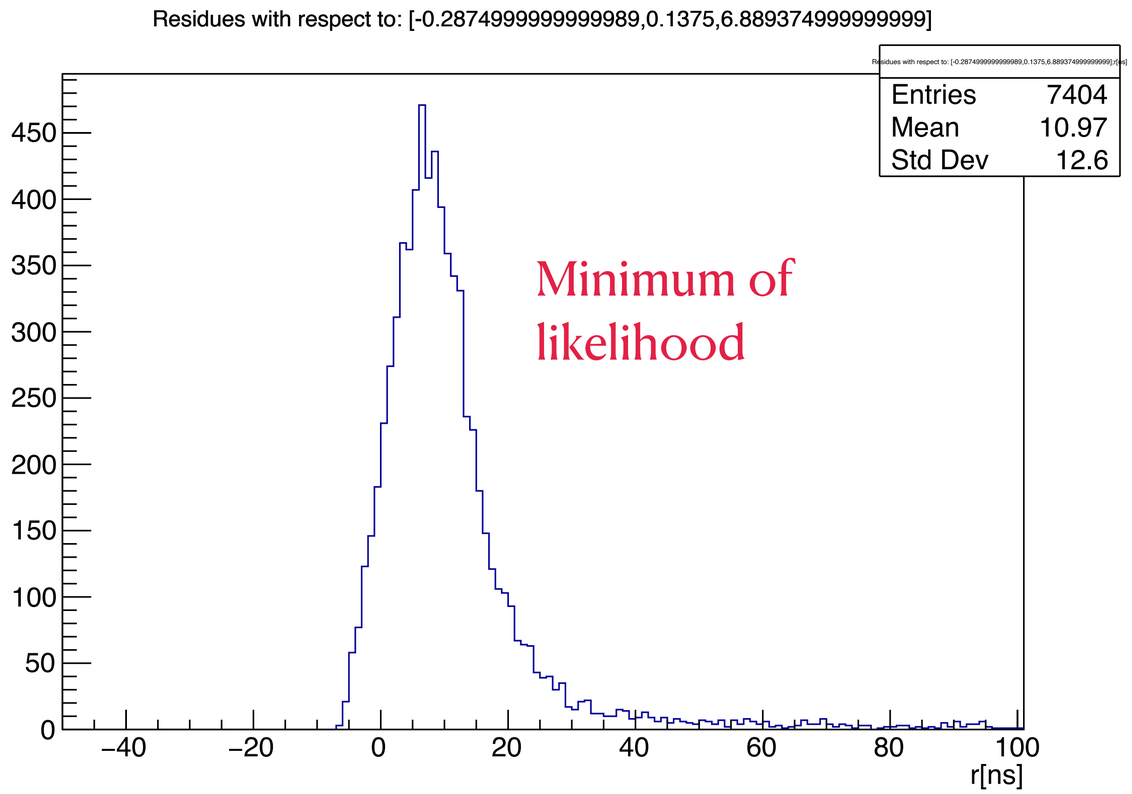




8 step elongation, all hits

Hit time residuals





- This one looks better

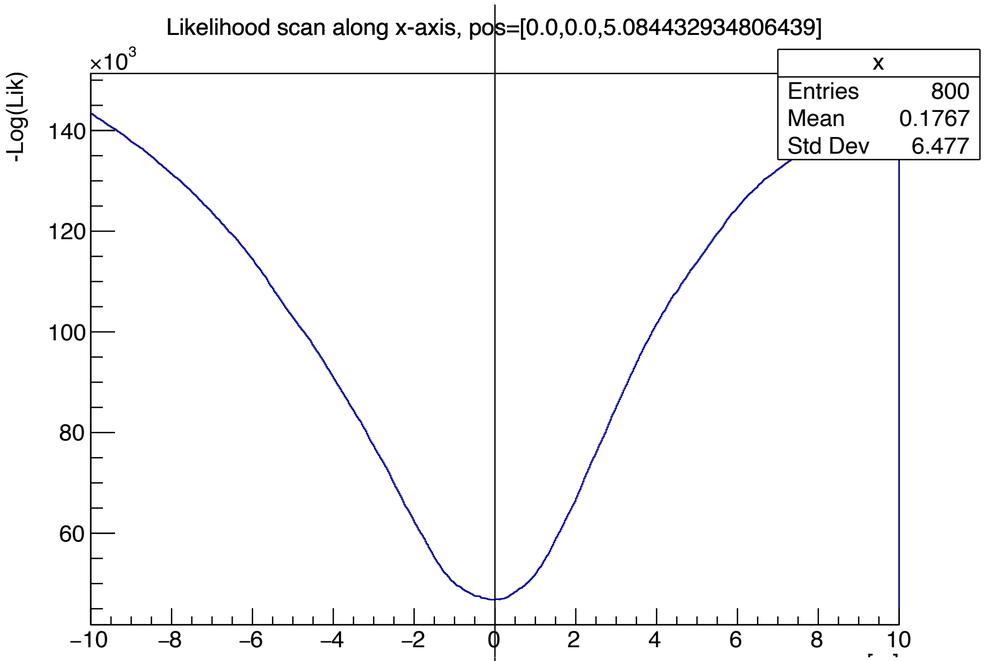
Next step

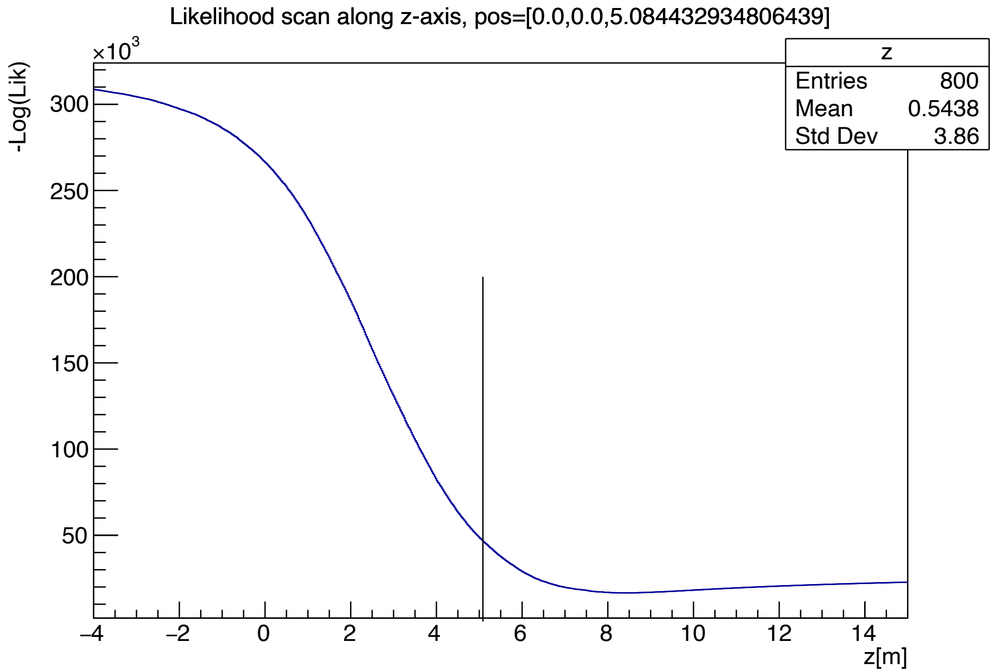
- Shower elongation generally messes up the position fit
- Include shower elongation in reconstruction
- Hopefully that increases the resolution

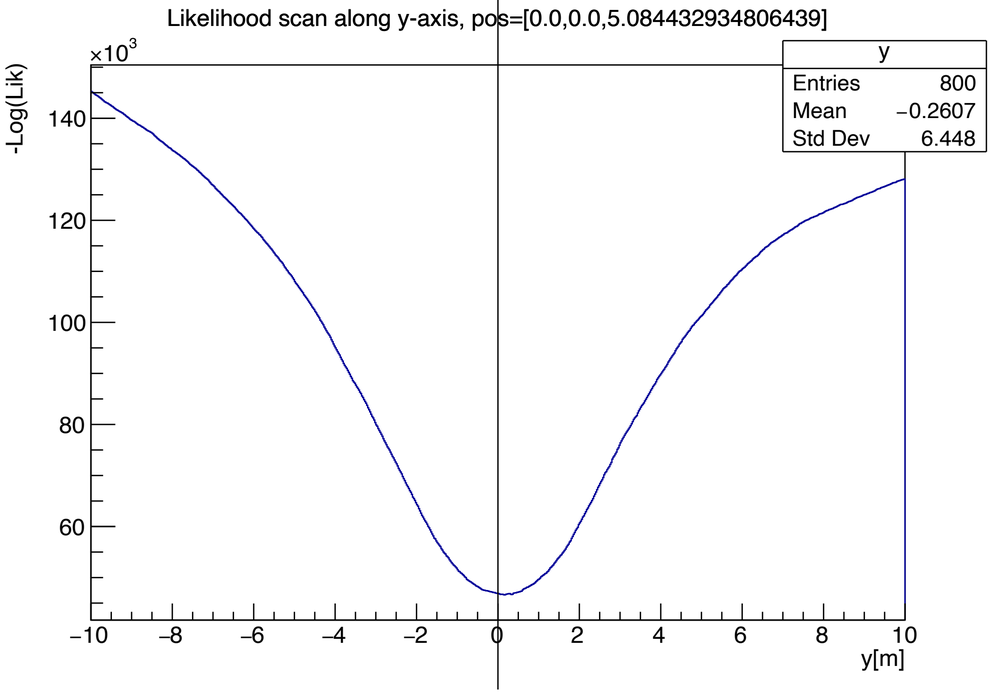
100 step elongation, all hits

Hits generated: 7888

- True pos = [0, 0, 0], dir = [0, 0, 1]
- Expectation from shower max = [0, 0, 5.08]







100 step elongation, all hits

Hits generated: 7888

- True pos = [0, 0, 0], dir = [0, 0, 1]
- Expectation from shower max = [0, 0, 5.08]
- Vertex from likelihood: [-0.01, 0.16, 8.36]+-0.03
- D_along = 8.36 m, D_perp = 0.16 m