Reconstruction of Shower Position from the Ratio of Upstream and Downstream Amplitudes

(proof of principle)

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GlueX-doc-2196

Formulas...

Assuming one-exponent attenuation (λ is attenuation length):

$$A(up)/A(down) = \exp(2 * X / \lambda)$$

Or

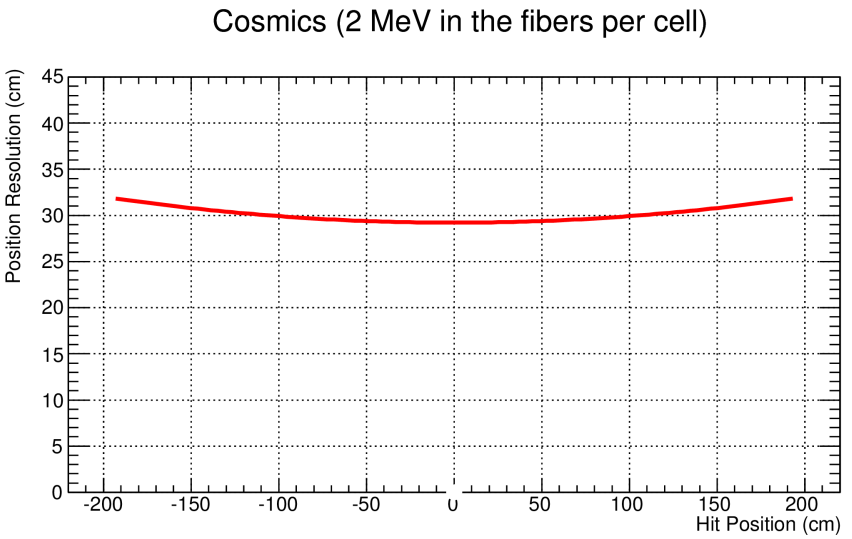
$$X = 0.5 * \lambda * \ln(A(up) / A(down))$$

Energy deposition fluctuations are calcelled in the ratio, so only photostatistics contributes to the position uncertainty (assuming we know the attenuation length):

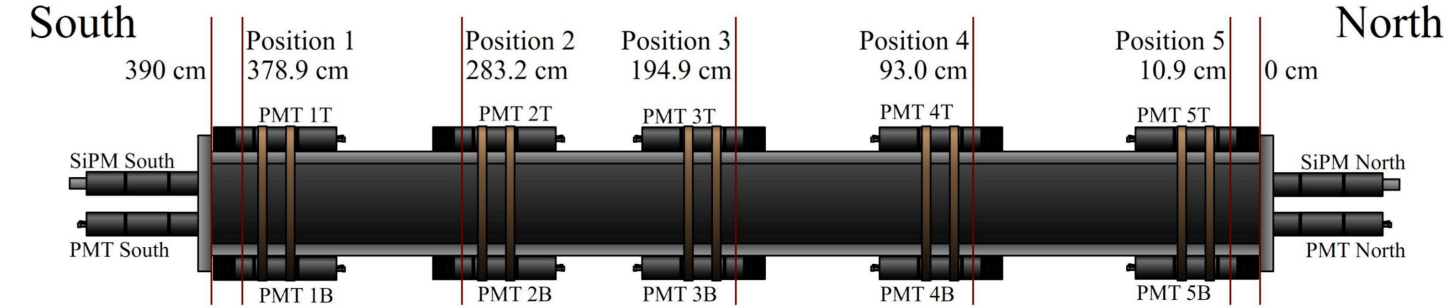
$$\delta X = 0.5 * \lambda * SQRT((\exp(-X/\lambda)+\exp(X/\lambda)) / SQRT(Npe)$$

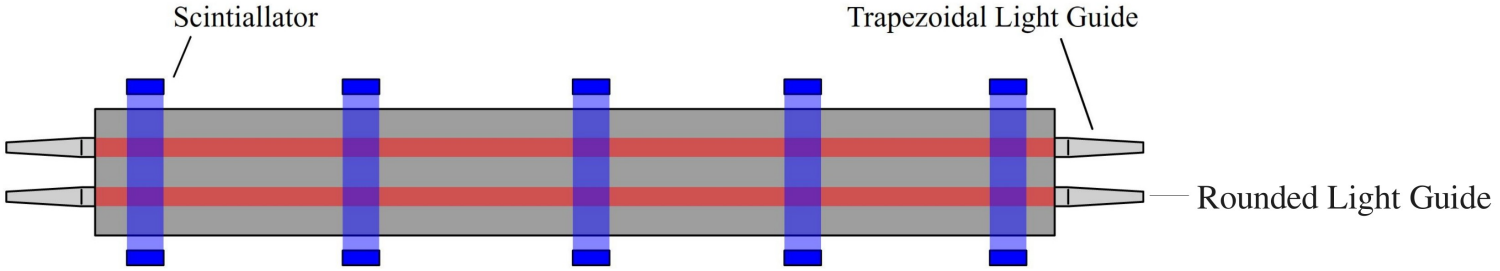
Npe ≈ 60 pe @ Bcal center for 2-MeV muons
(from GlueX-doc-1582)

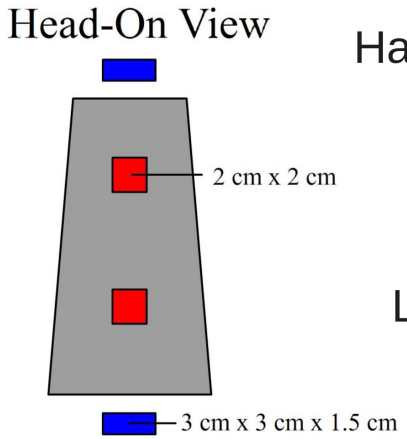
λ ≈ 320 cm with PMT
(from GlueX-doc-1582 and GlueX-doc-2249)



Setup and Geometry







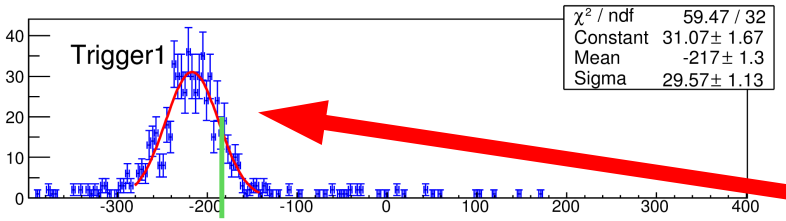
Hamamatsu R329-02 PMTs in wet contact with rounded light guides

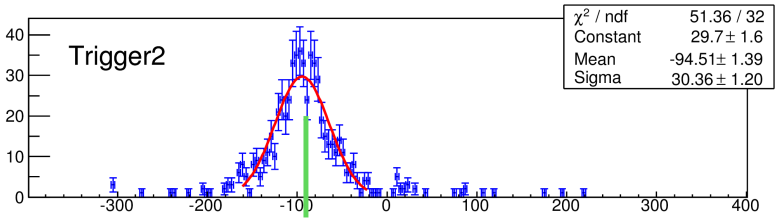
Pre-production 2010 SiPMs in dry contact with trapezoidal light guides

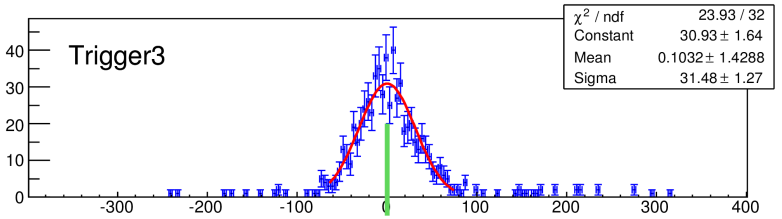
Light guides held to module face with Silicone optical Grease

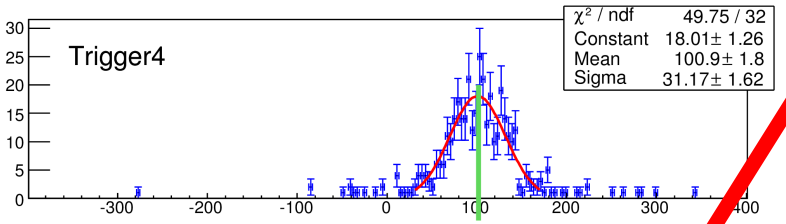
Data from Bcal test with cosmics in Regina in 2012 (GlueX-doc-2049)

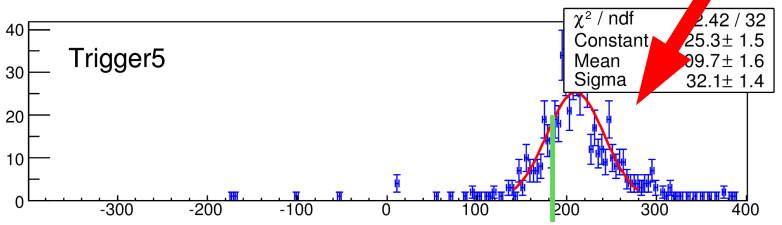
Results from 2012 Cosmics Test





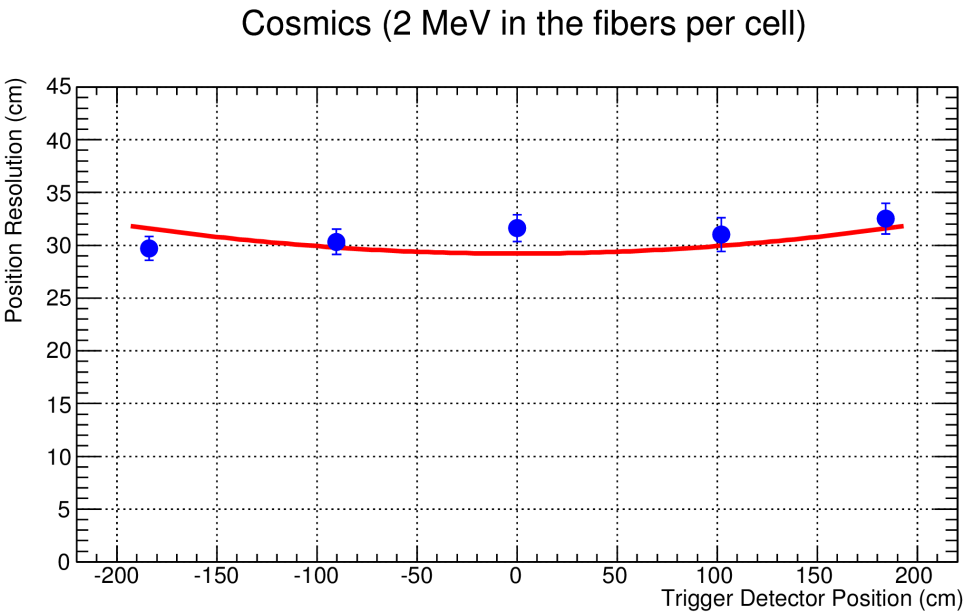




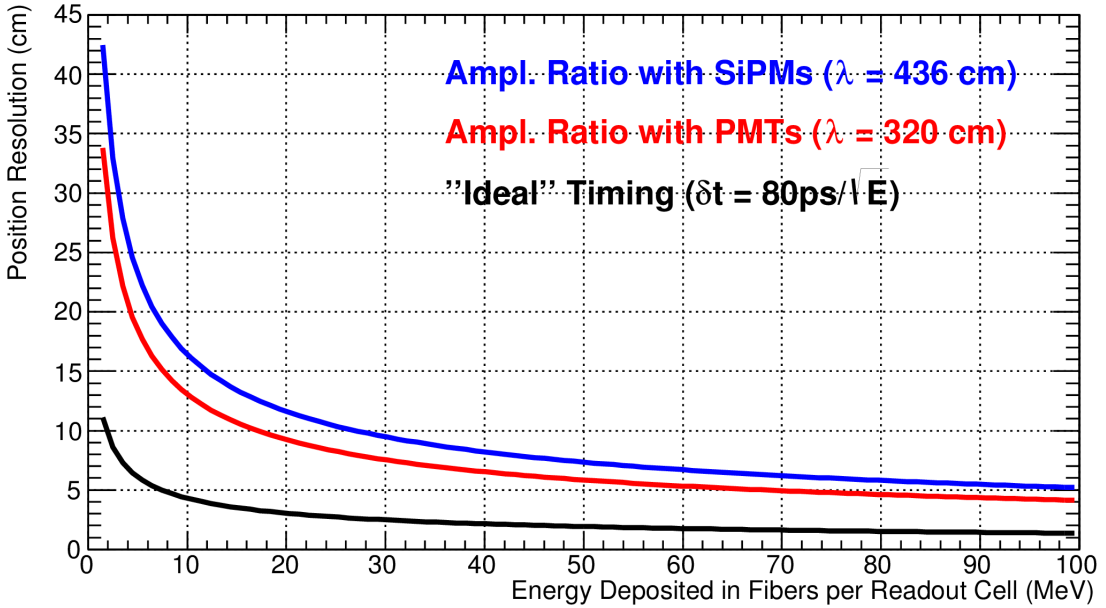


* Trigger detector positions are shown with green tics

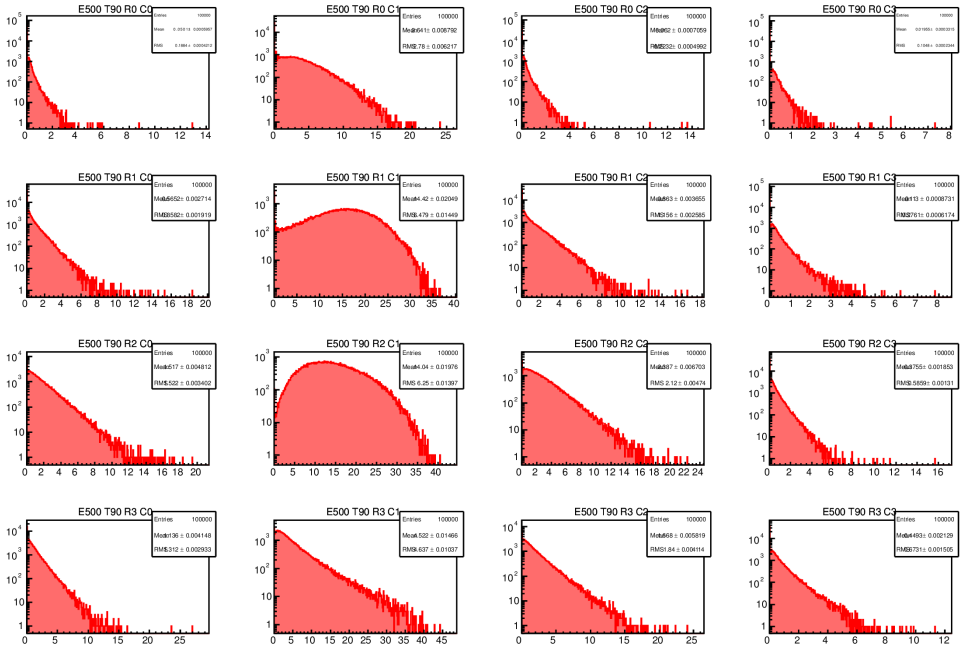
* Distortions near the module edges are caused by the “second” short-attenuation exponent contribution



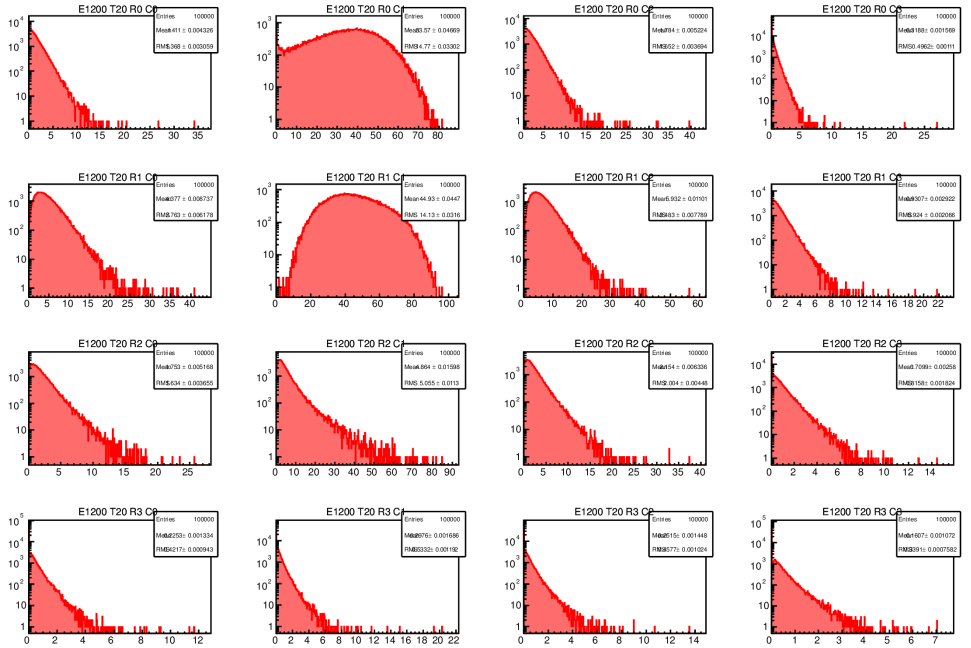
Expected Position Resolution



E=500 MeV @ 90 deg



E=1200 MeV @ 20 deg



Conclusions:

* With the ratio-of-amplitudes method, we can reach the position resolution better than 10 cm for high-energy-deposition readout cells and of the order of 10-20 cm for low-energy-deposition cells

* Though the reachable position resolution is no so good as expected for one-photon-hit with high-resolution TOF, the proposed technique should be used to improve position reconstruction (in addition to the timing methods) and to resolve ambiguous multihit situations.