Muon Threshold Optimization of A Scintillator Pixel

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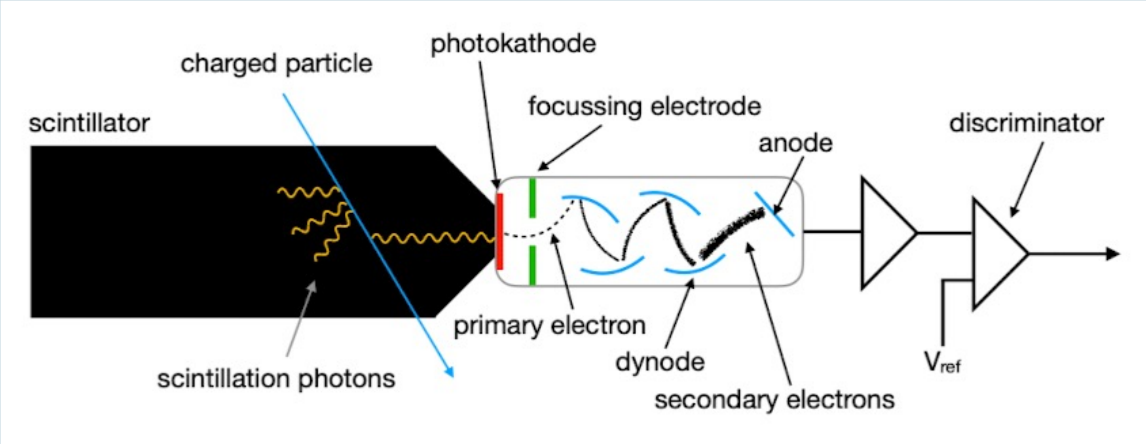
Signal Shape of a Cosmic Muon Event

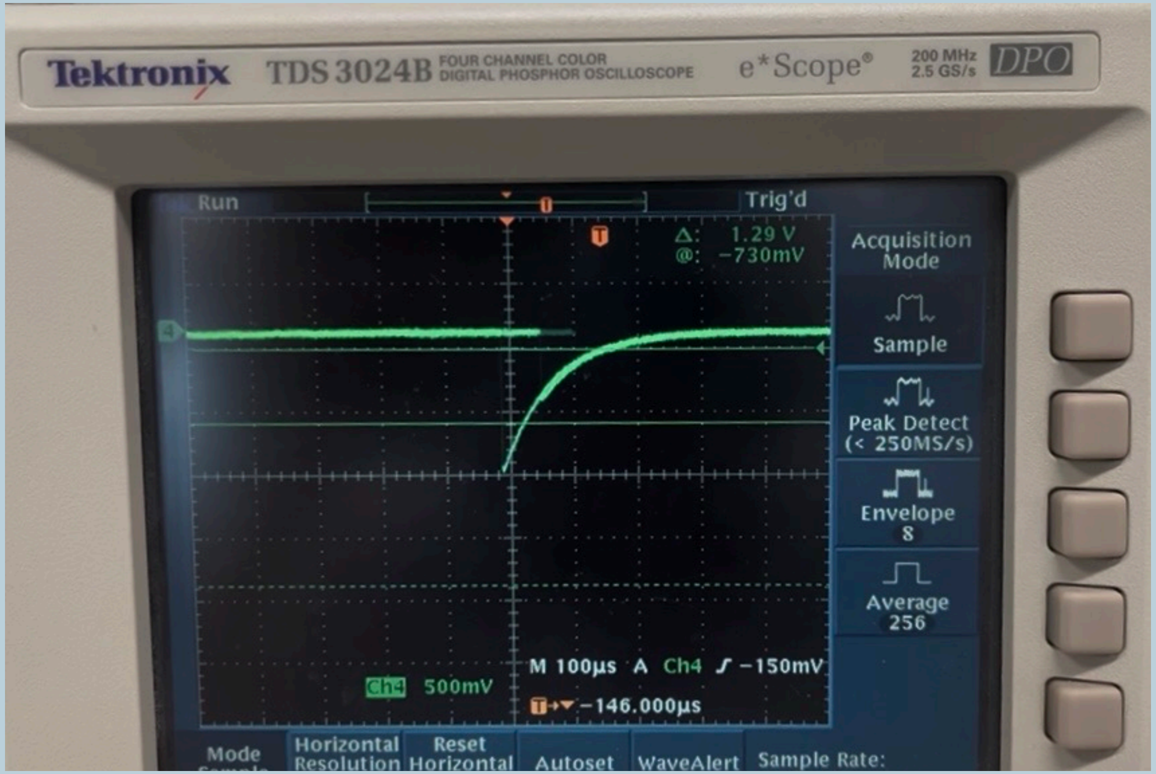


Charged muon loses energy inside the scintillator material

Signal is amplified and converted into an electrical signal inside Photo Multiplier Tube

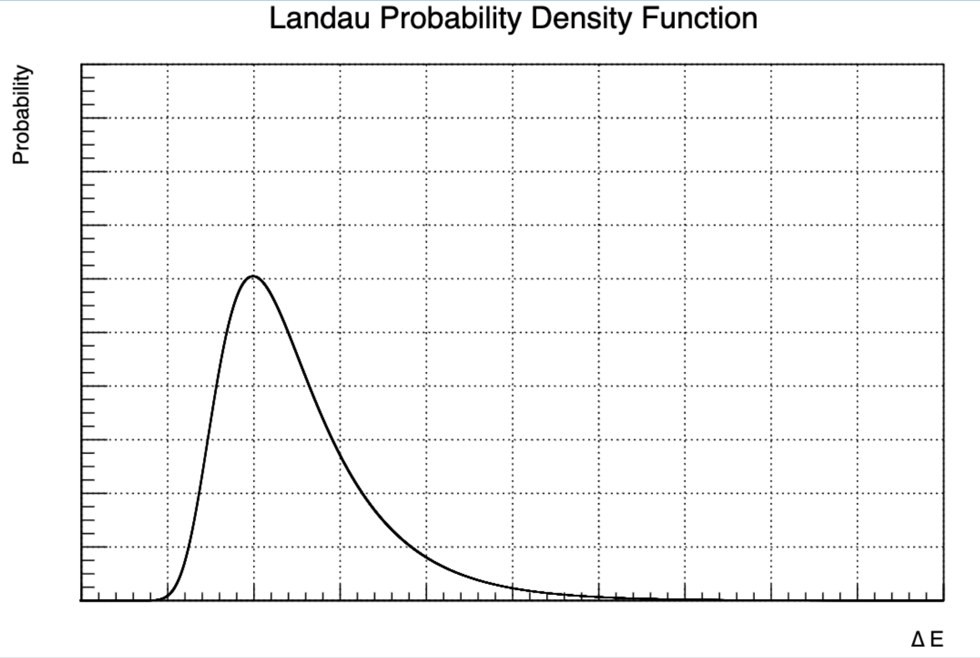
If pulse height exceeds the threshold value, discriminator records it as a muon event

Cosmic Muon Signal Monitored in Oscilloscope



Count Distribution Per Signal Height in a Fixed Time Interval

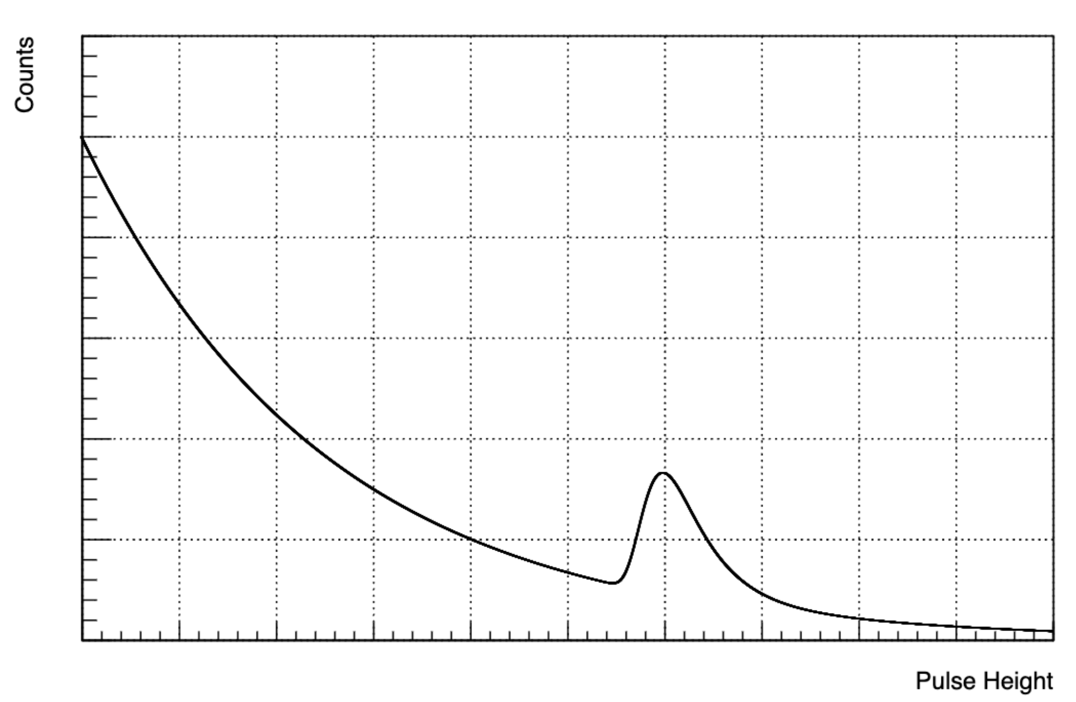
Probability Distribution of Energy Loss on a Fixed Path



$\Delta E \propto PMT\ Signal\ Height$

Including Exponentially Decaying Noise

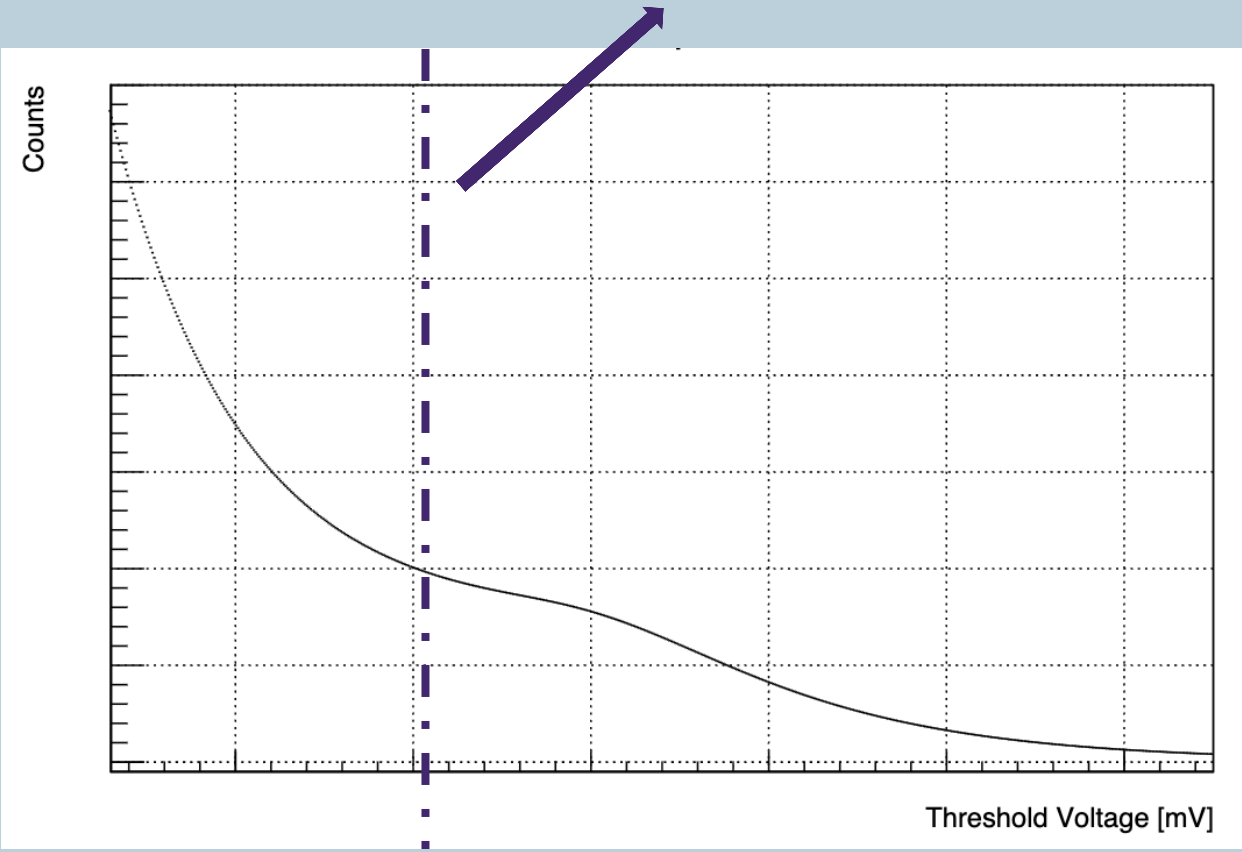
Distribution of Counts Per Pulse Height In A Fixed Time Interval



Plateau Method

Slops starts to decrease rapidly as discriminator starts to exclude muon events

- Set the discriminator threshold to a low threshold value.
- Record the number of counts above the threshold value in a fixed time interval.
- Increase the threshold in small increments and record the counts until they converge to zero.
- Do the same procedure for several fixed HV's (determines the PMT amplification)

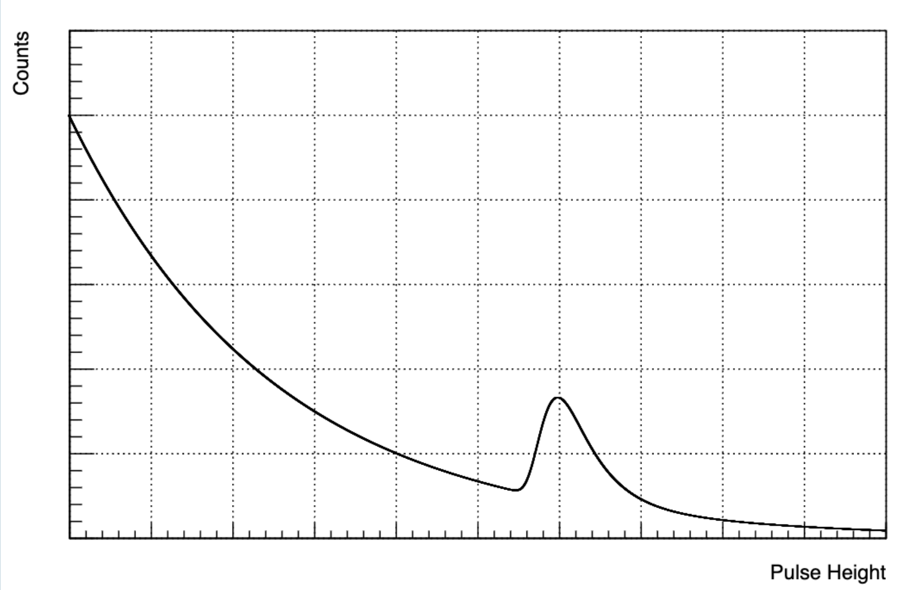


- Data is measured using 1.5 kV and 1.6 kV as PMT HV.
- The threshold was increased in 10 mV steps.
- 2 minutes of data were collected for each threshold value.

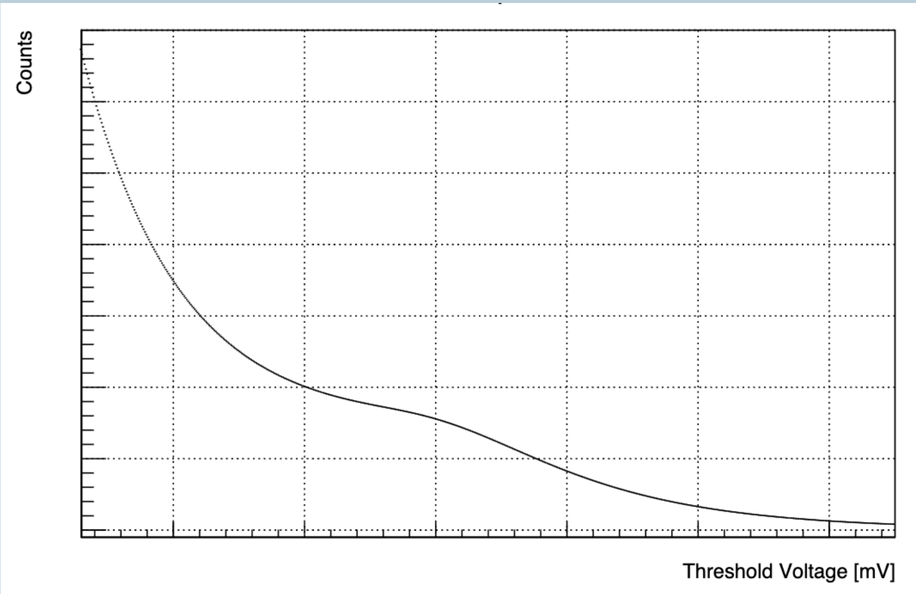
Fitting Function

Event distribution can be estimated by sum of an exponential and a landau distribution. Landau distribution is usually approximated by a distribution called Moyal distribution.

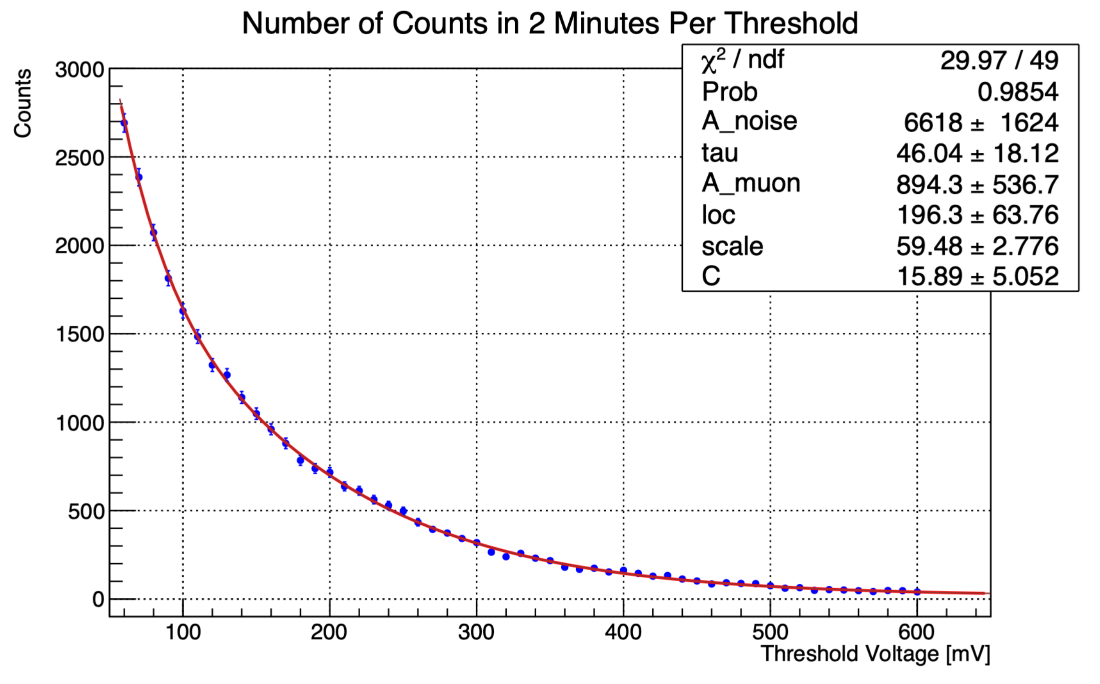
$$f(x) = \overbrace{A_{noise}}^{\text{Total \# of Noise Counts}} \cdot \underbrace{\frac{e^{-x/\tau}}{\tau}}_{\text{Exponential PDF}} + \overbrace{A_{muon}}^{\text{Total \# of Muon Counts}} \cdot \underbrace{f_{MoyalPDF}(x, \mu, \sigma)}_{\text{Moyal PDF}}$$

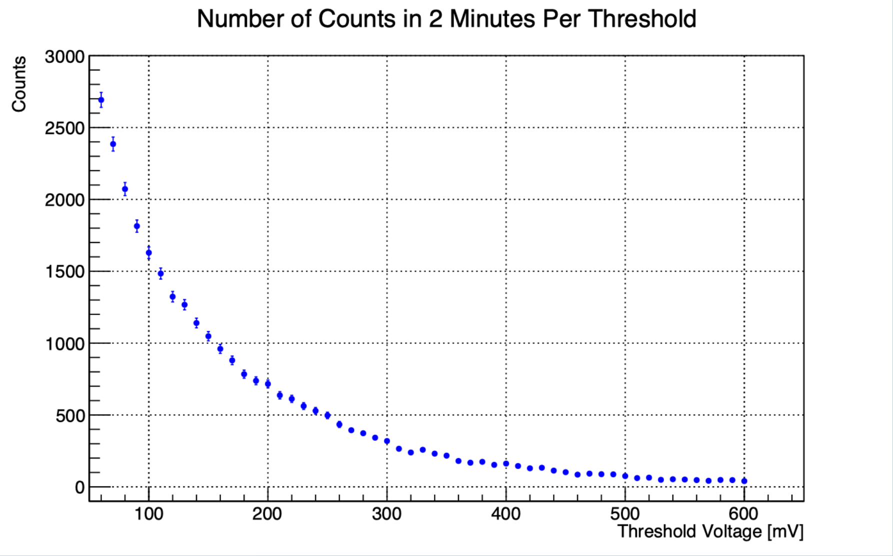


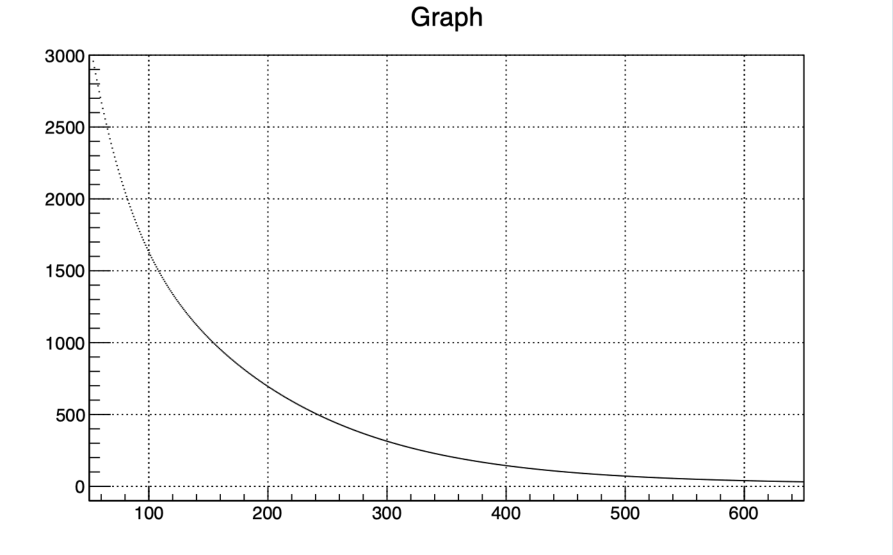
$$f_{Fit}(x) = A_{noise} \cdot e^{-x/\tau} + A_{muon} \cdot f_{MoyalSF}(x, \mu, \sigma) + C$$



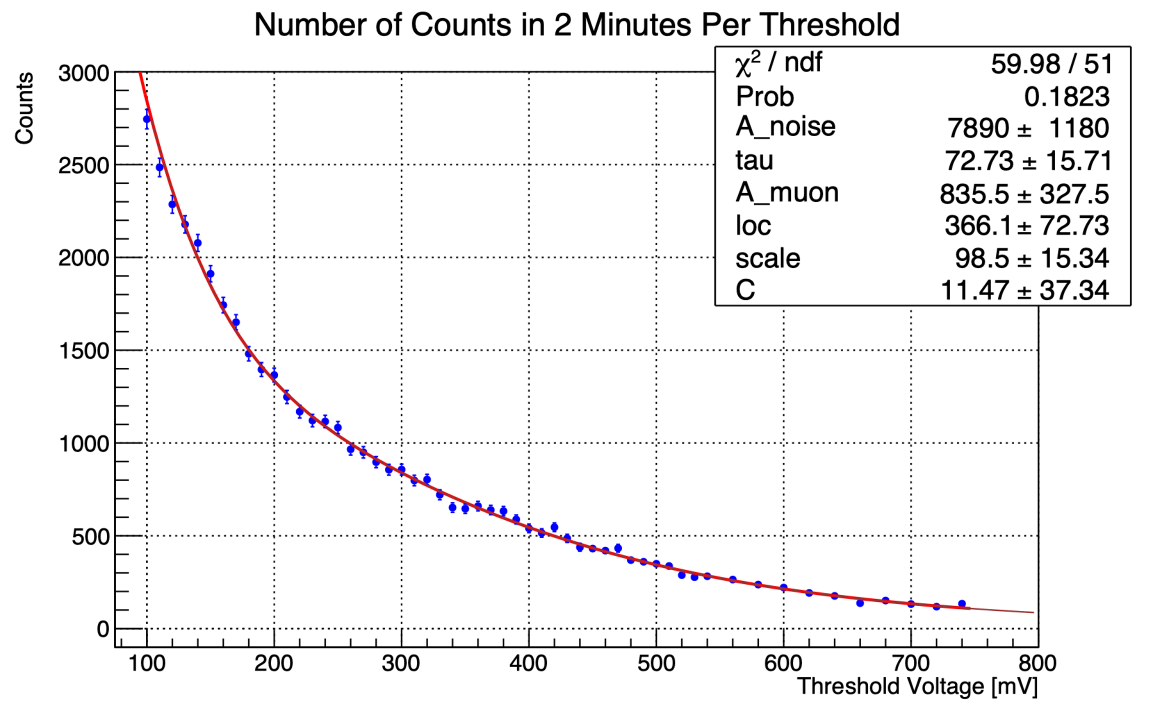
1500 HV Plots

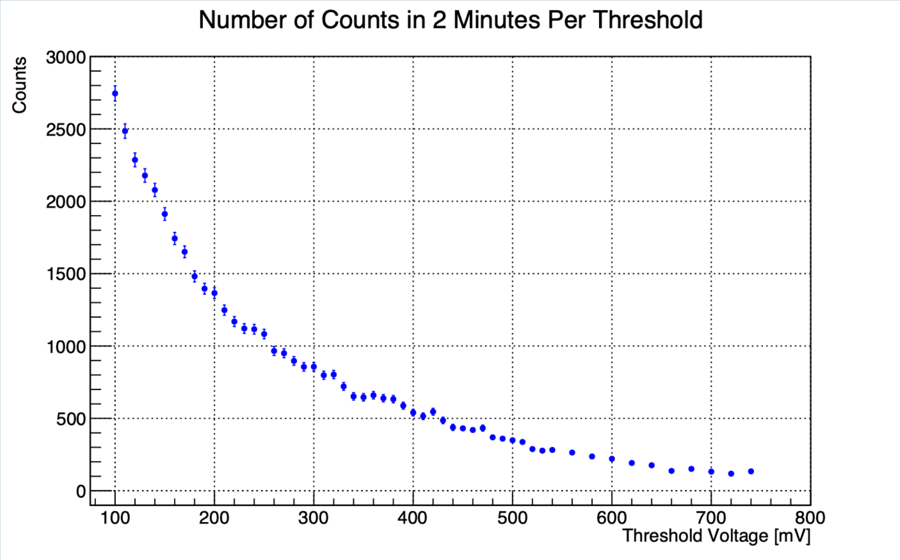


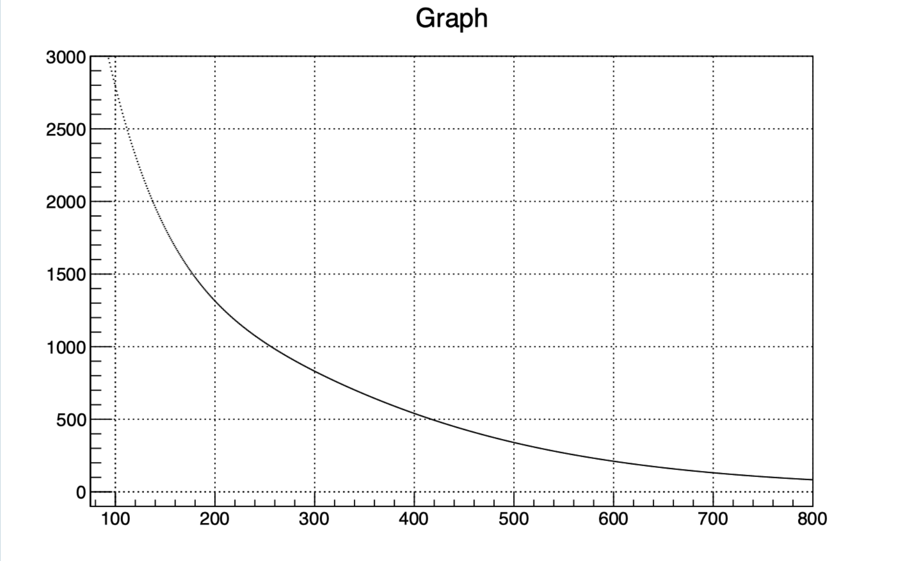




1600 HV Plots

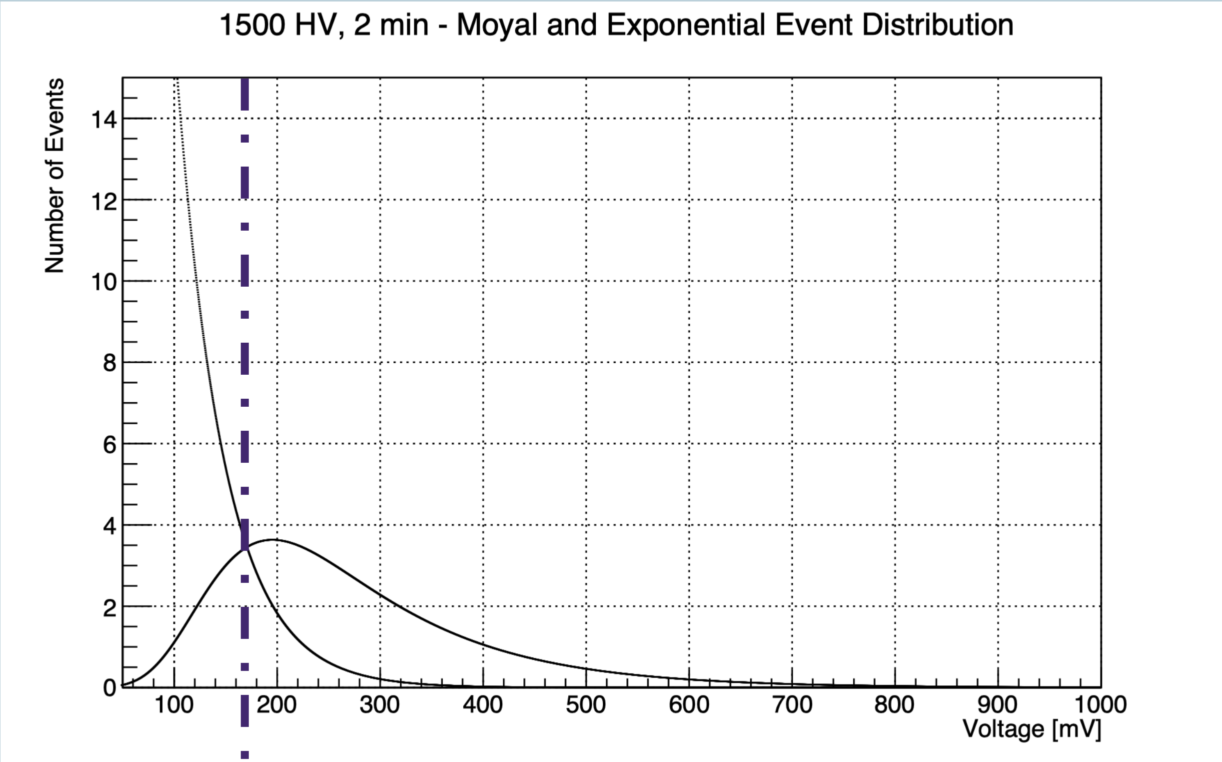






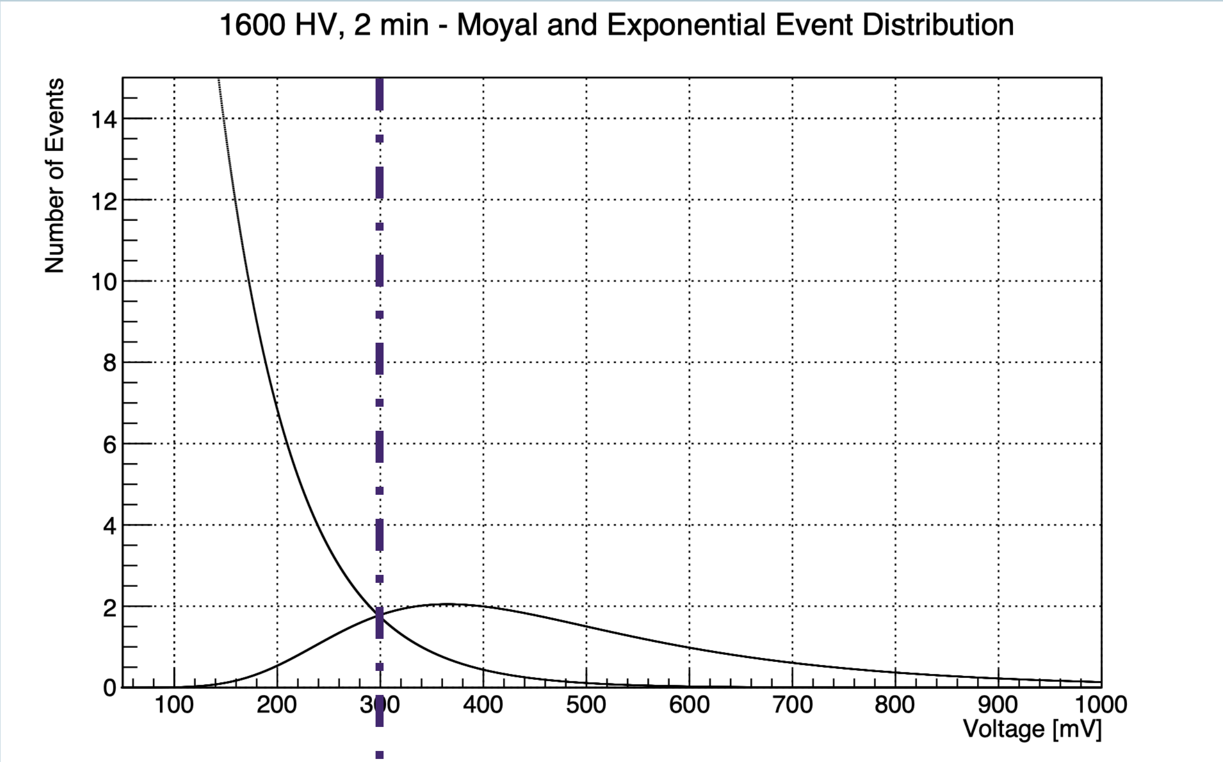
Reconstructed Event Distributions

1500 HV



Optimum Threshold is chosen as 170 mV

1600 HV



Optimum Threshold is chosen as 300 mV

Testing Optimum Thresholds

Horizontal Area of The Scintillator : 42.5 cm x 10.5 cm

Muon Count Rate Per Area : 0.89 $\text{min}^{-1} \cdot \text{cm}^{-2}$

Expected Muon Count Rate: 0.89 x (42.5 x 10.5) = $\boxed{397.16 \ \text{min}^{-1}}$

Count Rate estimated by the fitting function of 1600 HV for 300 mV threshold : $\boxed{420 \ \text{min}^{-1}}$

Count Rate computed in test measurement for 300 mV : $\boxed{431 \ \text{min}^{-1}}$

Count Rate computed in test measurement in basement for 300 mV : $\boxed{177 \ \text{min}^{-1}}$

Count Rate estimated by the fitting function of 1500 HV for 170 mV threshold : $\boxed{442. \ \text{min}^{-1}}$

Count Rate computed in test measurement for 170 mV : $\boxed{453 \ \text{min}^{-1}}$

Count Rate computed in test measurement in basement for 170 mV $\boxed{191 \ \text{min}^{-1}}$

Future Work

- Use of larger time intervals to obtain better fits.
- Optimization of another scintillator
- Coincidence method analysis of the two scintillators