Pulse shape analysis for LAMPS neutron detector

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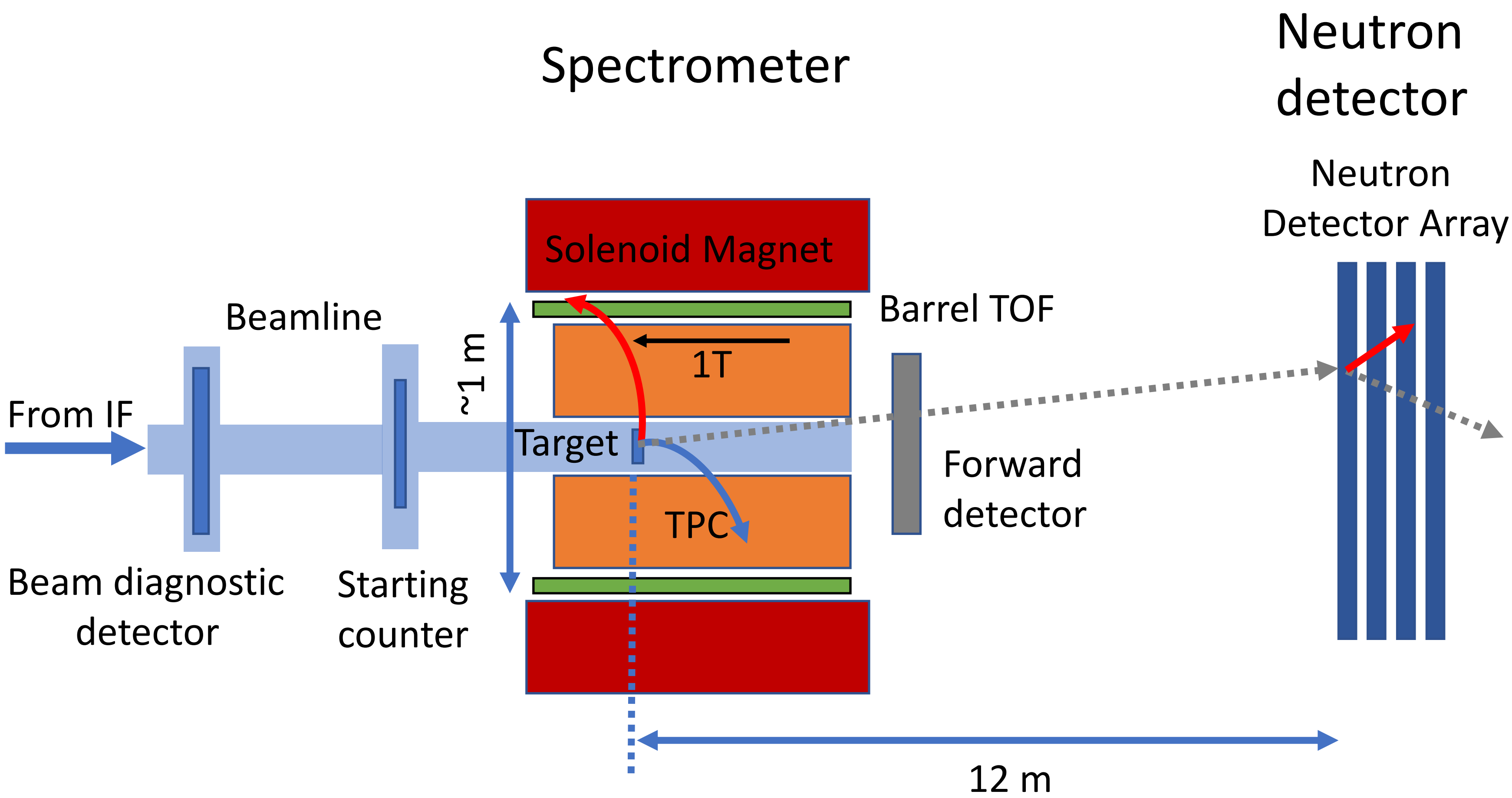
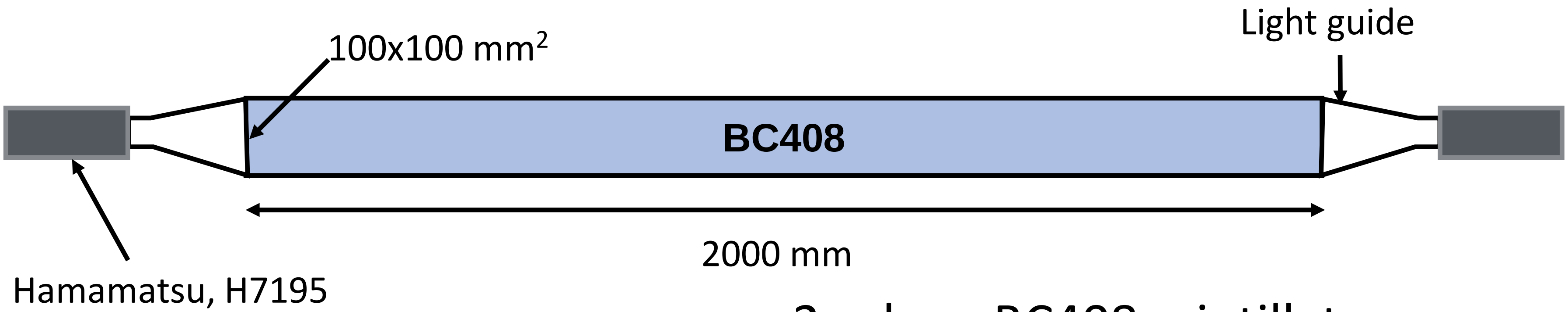
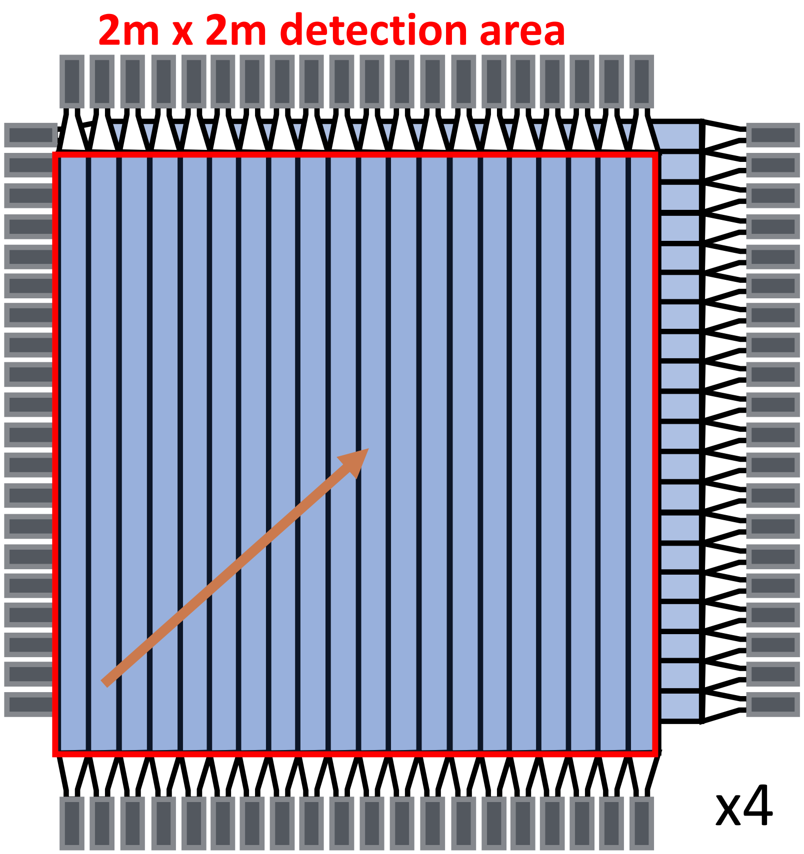
LAMPS detector system



Neutron detector

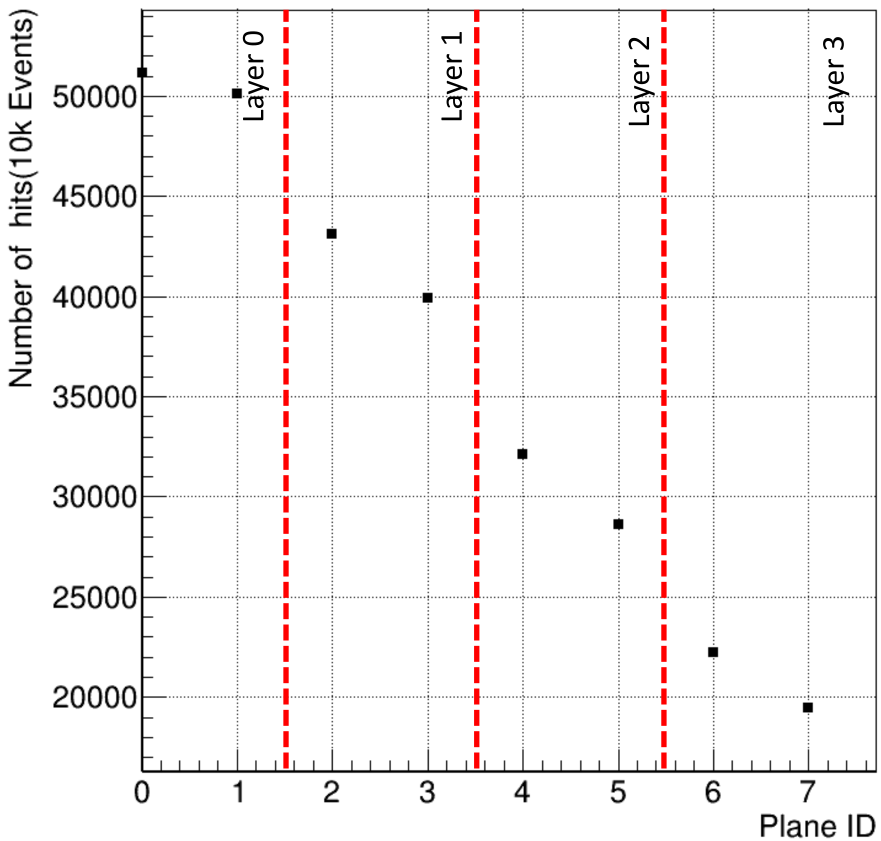




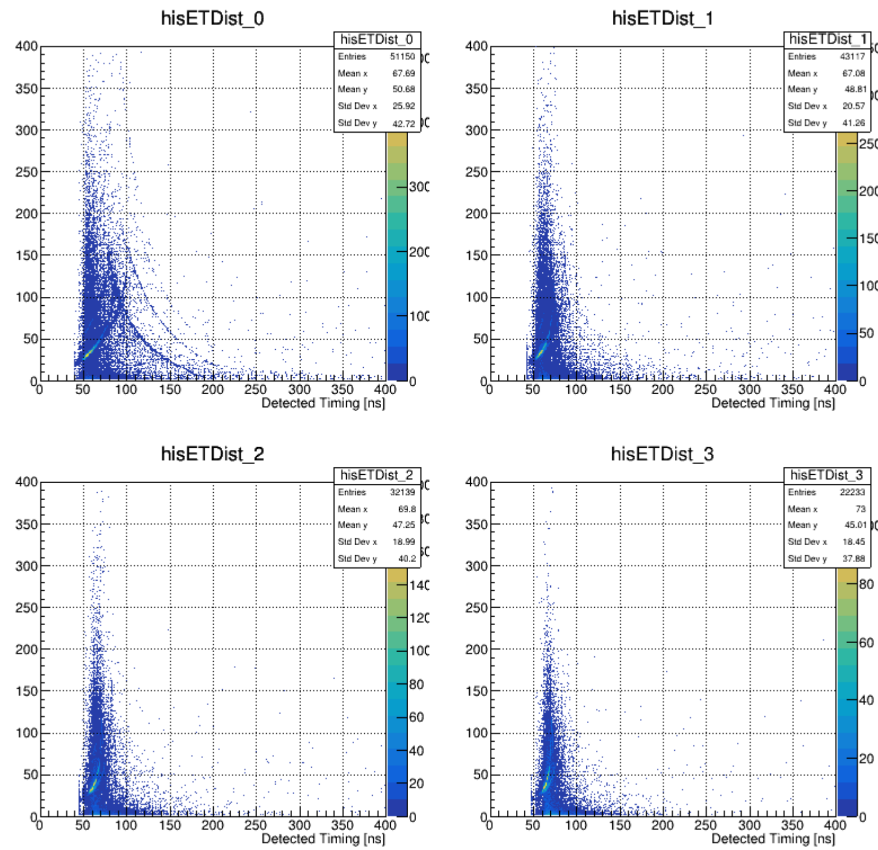
- 2m-long BC408 scintillator
- Light readout with two PMTs
- Make two 2 x 2 m^2 detection plane with 40 neutron detectors
- Two detection plane consisted single layer (4 layers in total)
- Readout : Notice 500 MHz FADC
- 20 Veto & 160 Neutron detector

Multiplicity test (MC IQMD, Au+Au 400 AMeV)

Number of hit modules by planes (10k evt)



Deposit E vs Detected time



In case of first neutron wall layer, multiplicity is 5 in average. At least 20% of total events contains multiple hits on single module.

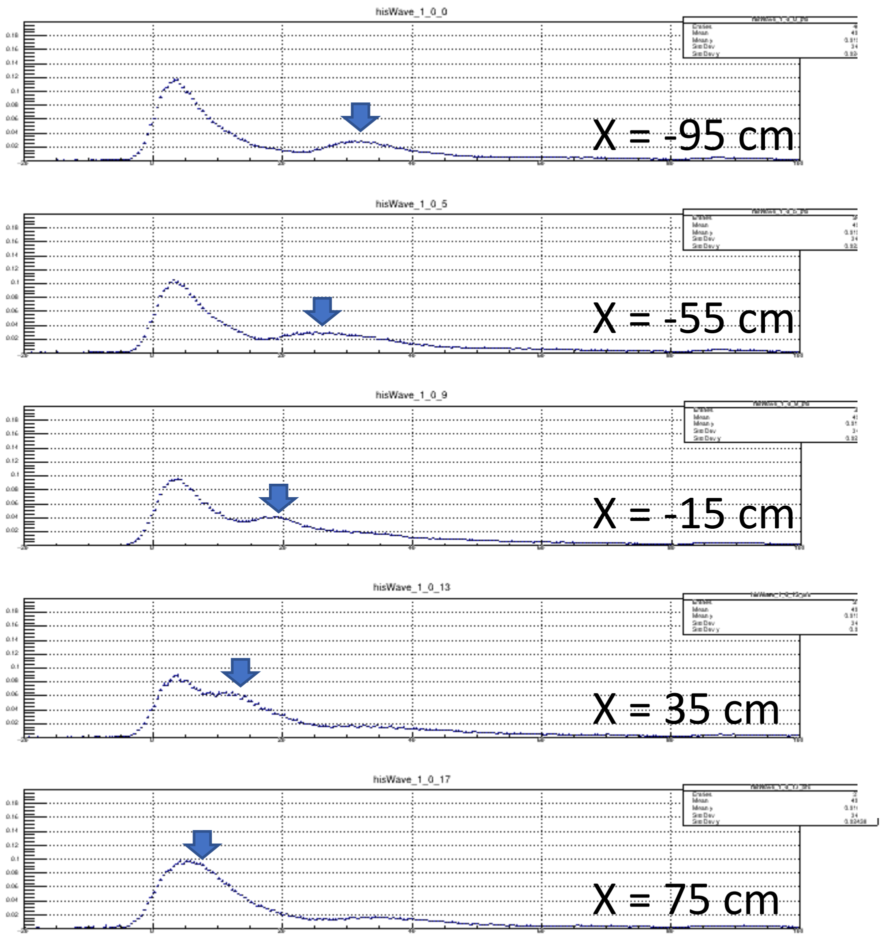
Most hits are in 50 – 100 ns
To define multi-hit events waveform analysis is required.

Cosmic ray measurement

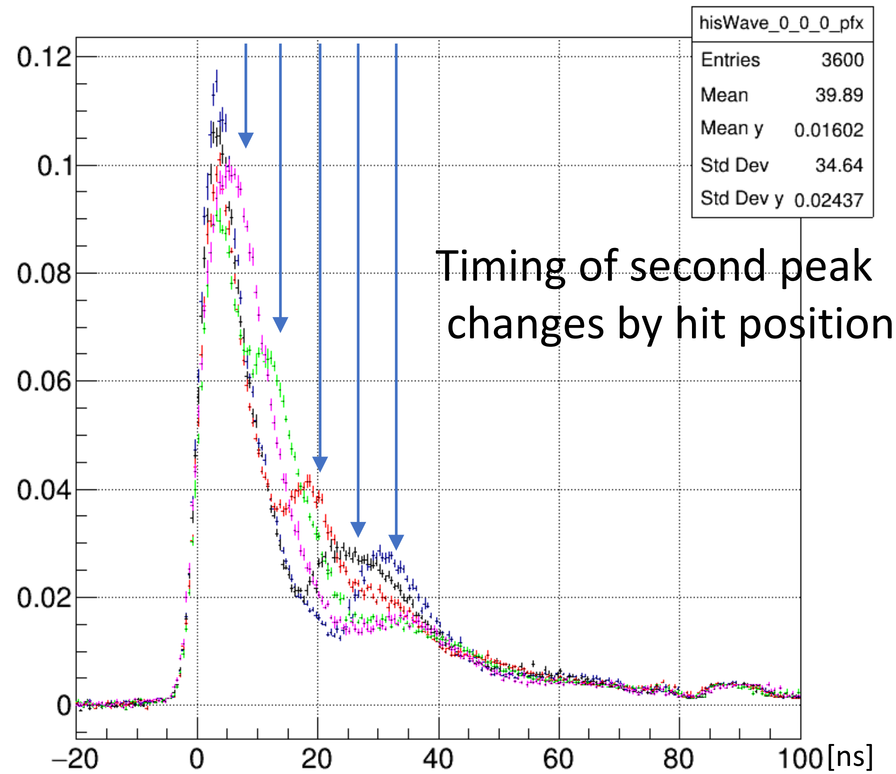
- Taking cosmic ray data for 2 months
- Total Data size : 8.4 T

Neutron detector signal shape

Changes of typical signal shape by hit position

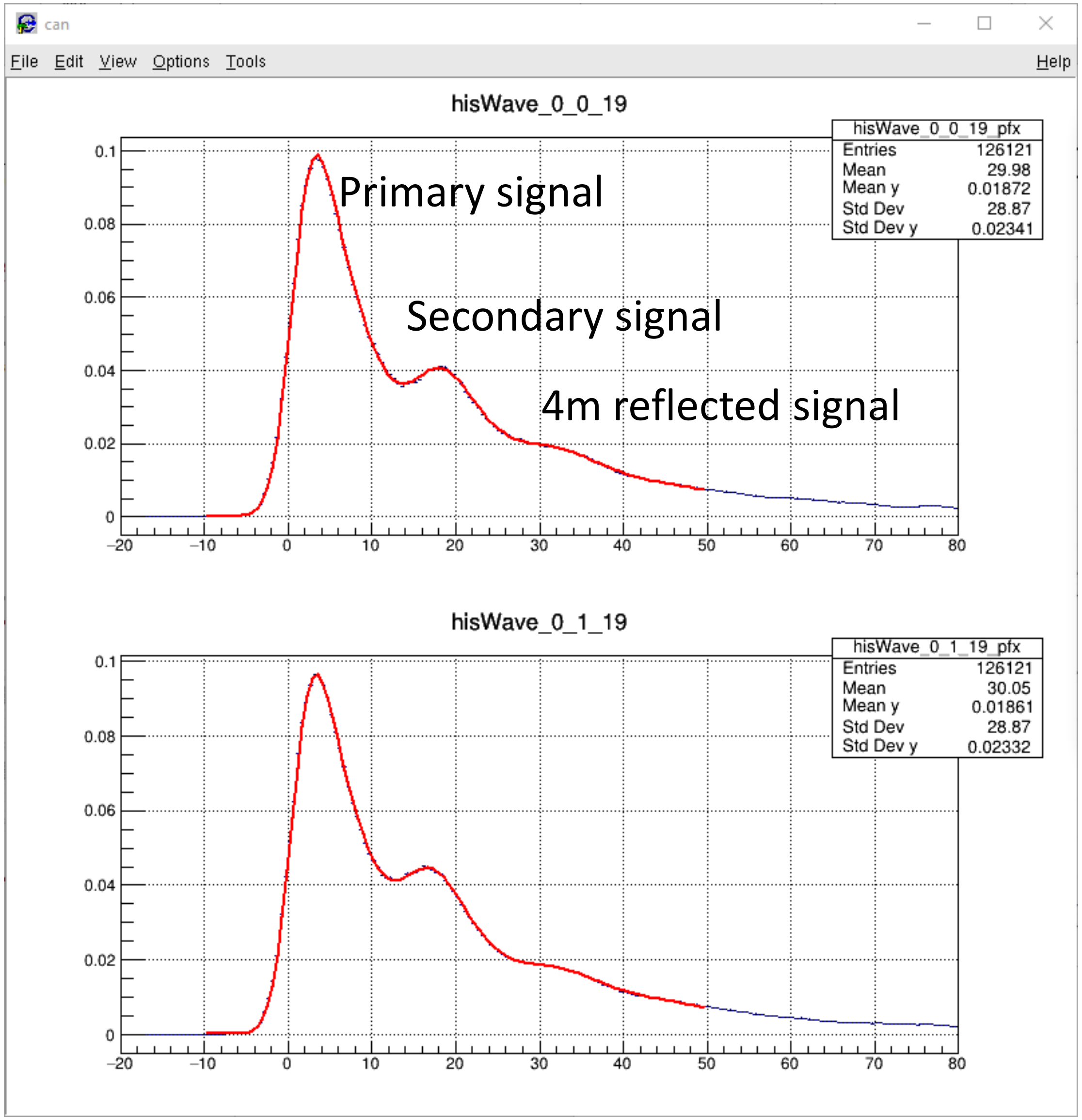


Timing of second peak



Can we describe typical signal shapes by function of hit position?

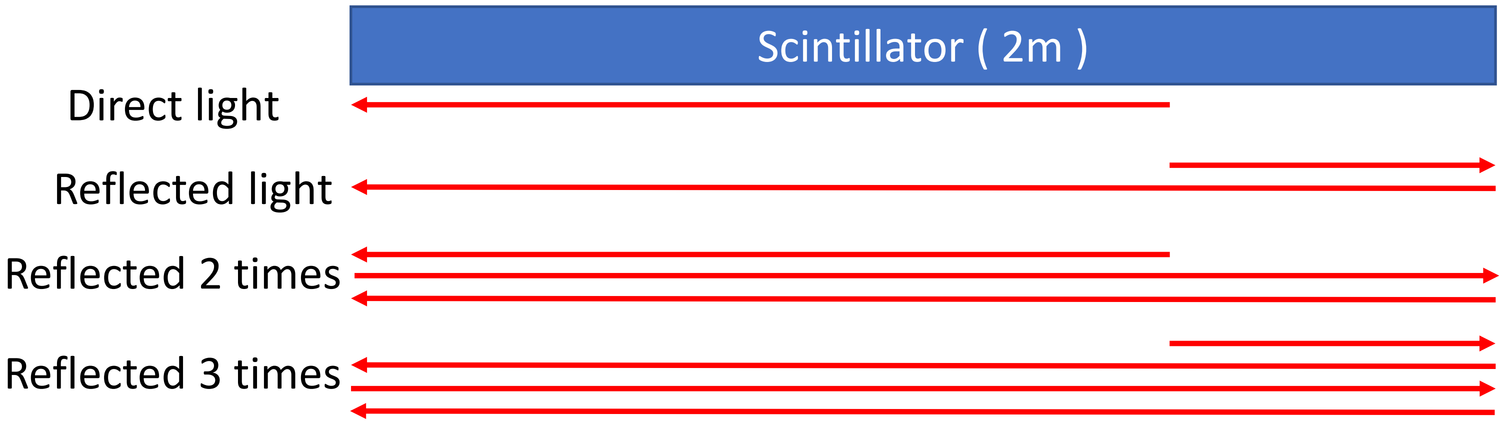
Typical signal shape



Fitting function

$$f(t, t_s, \sigma_r, \sigma_d) \coloneqq \left(1 + \mathrm{erf}\left(\frac{t - t_s}{\sigma_r}\right)\right) \exp(-\frac{t - t_s}{\sigma_d})$$

t_s: *signal timing*
σ_r: *rising slope*
σ_d: *falling slope*



$$F(t, t_s, H, \sigma_r, \sigma_d) = H \times \left\{ \begin{array}{c} f(t, t_s, \sigma_r, \sigma_d) \\ + \mathrm{R} \times \exp\left(-\frac{t_d}{L/v}\right) f(t, t_s + t_d, \sigma_r', \sigma_d') \\ + R^2 \exp\left(-\frac{t_4}{L/v}\right) f(t, t_s + t_4, \sigma_r'', \sigma_d'') \\ + \mathrm{R}^3 \exp\left(-\frac{t_d + t_4}{L/v}\right) f(t, t_s + t_d + t_4, \sigma'''_r, \sigma'''_d) \end{array} \right\}$$

Parameters for fitting

$$F(t, t_s, H, \sigma_r, \sigma_d) = H \times \left\{ \begin{array}{c} f(t, t_s, \sigma_r, \sigma_d) \\ +\mathrm{R} \exp\left(-\frac{t_d}{L/v} \right) f(t, t_s + t_d, \sigma_r', \sigma_d') \\ +R^2 \exp\left(-\frac{t_4}{L/v} \right) f(t, t_s + t_4, \sigma_r'', \sigma_d'') \\ +\mathrm{R}^3 \exp\left(-\frac{t_d + t_4}{L/v} \right) f(t, t_s + t_d + t_4, \sigma'''_r, \sigma'''_d) \end{array} \right\}$$

H : Signal height

σ_r : 2 . 7

σ_d: 7.1

σ' : $\sigma + \mathrm{a} \times propagation\ Length$

R : Reflectivity, 0.5

t_s: Half height time

t_4: 30 ns, Fixed

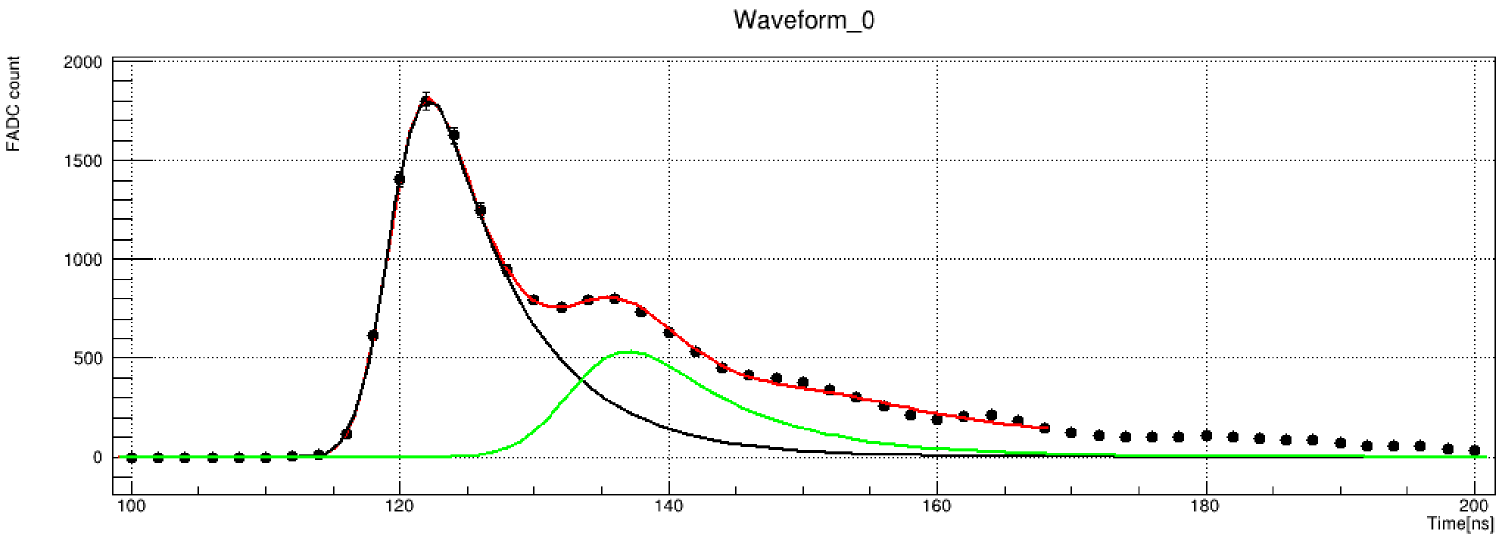
t_d: $\frac{2(1 \pm x) + 0.4}{0.158} \pm 4$ ns

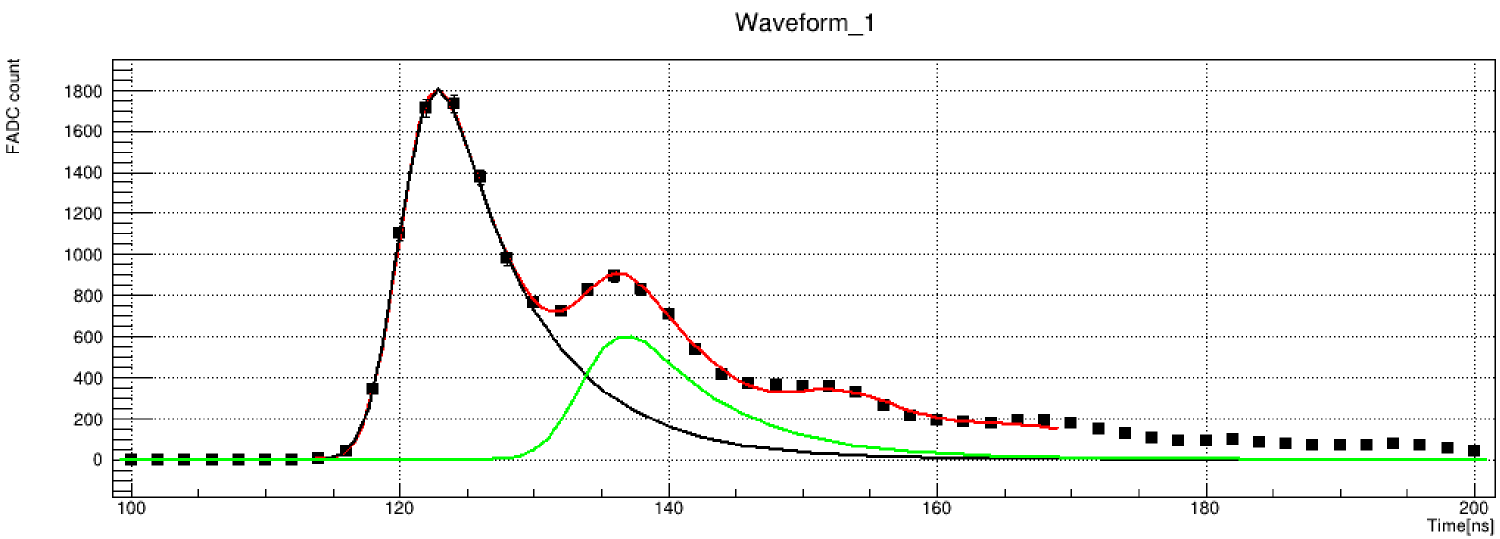
L : Attenuation Length (2.6 m)

v : speed of light in scintillator (158 mm /ns)

Reduce number of parameters from 16 to 10

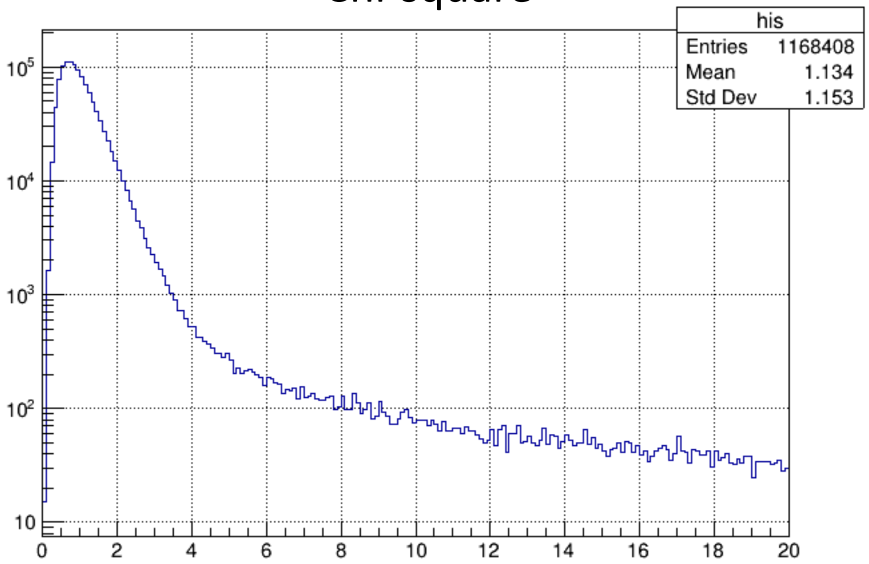
Fitting results



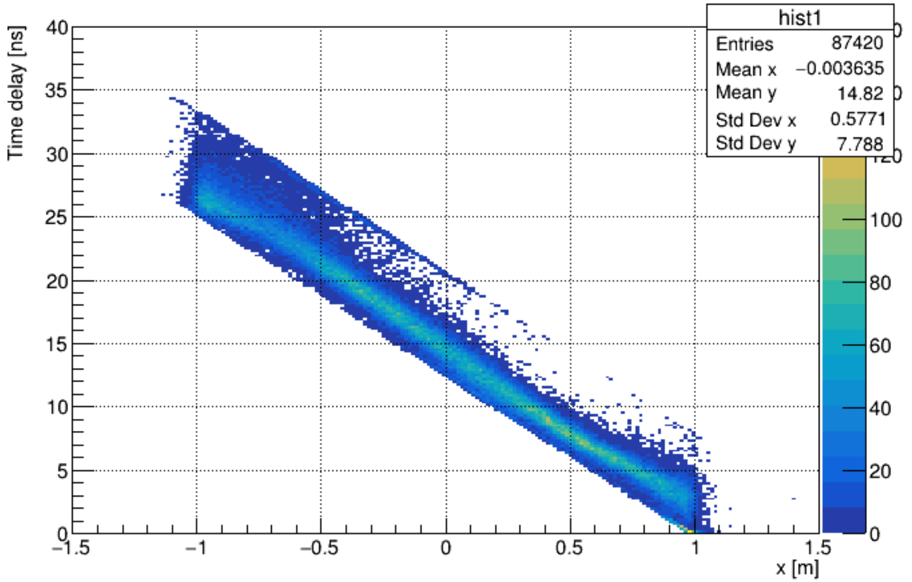


Fitting results

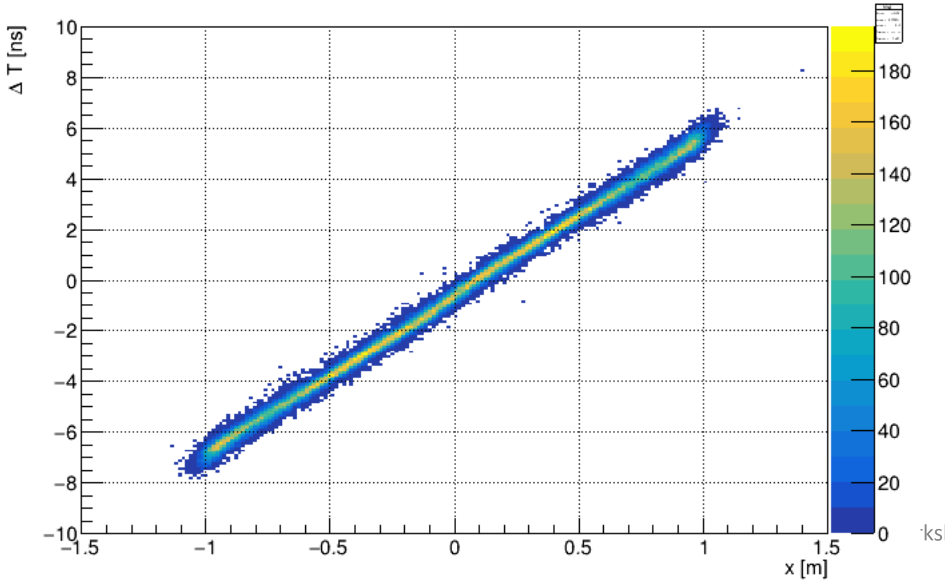
Chi-square



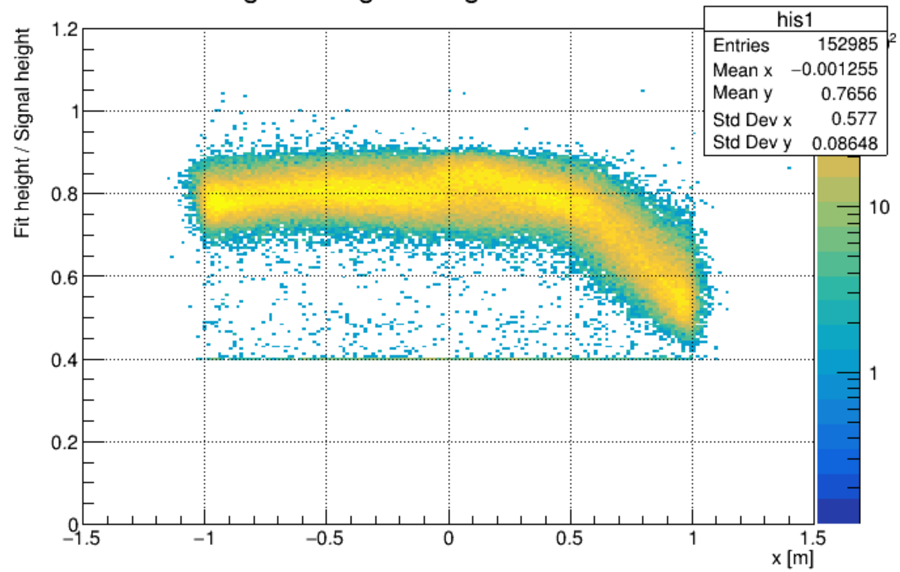
Reflected signal time delay vs x



Δ T vs Hit position

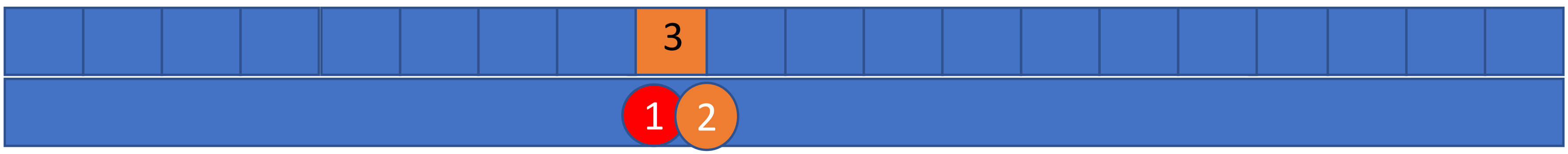


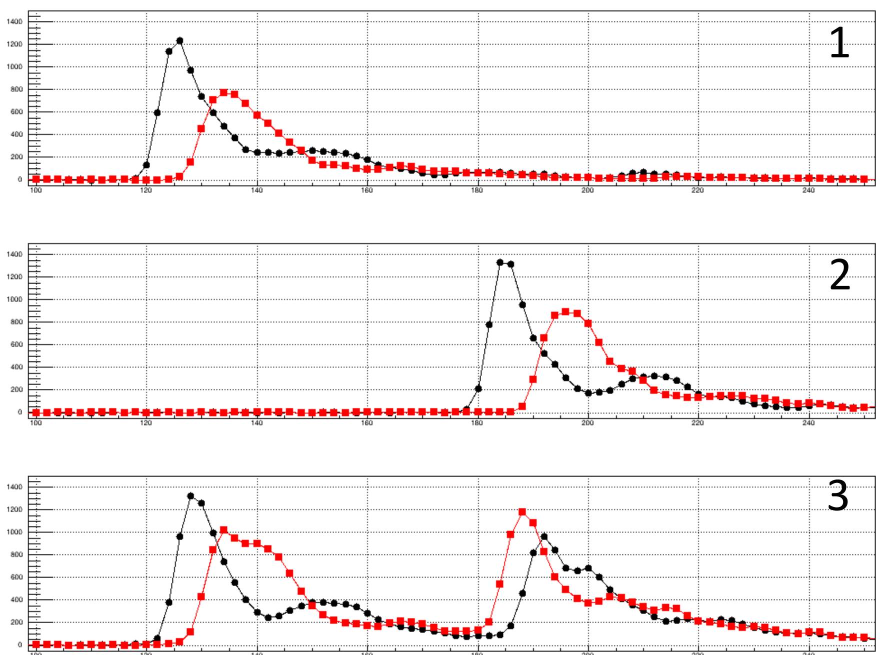
Fit height vs Signal height

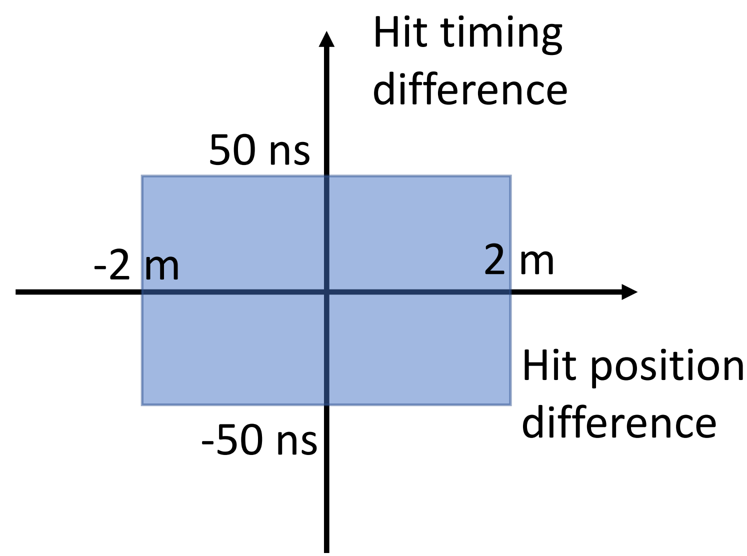


Search for multiple hits at single module

Select events two particle maybe penetrated single module
-Single hits on upper plane
-Two hits on lower plane
-Hit positions on lower plane are placed under the upper hit module







Fitting performance will be checked for hit timings and hit positions

Summary

- Neutron multiplicity on the neutron detector array with MC.
- To analysis multi-hit event, I designed fitting function for neutron detector.
- Fitting result was reasonable for -20 ns to 50 ns.
- Fitting test for multi-hit events will be tested not so far future.

Thanks!