Pulse-shape Analysis of the Prototype Neutron Detectors for LAMPS at RAON

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MULILO Benard
(Prof. B. HONG)
Korea University
Nuclear Physics Laboratory

MULILO Benard[1], LEE Jong-Won[1], SHIM Hyunah[1], AHN Jung Keun[1], MOON Dongho[2], HONG Byungsik*[1], KIM Minho[1], JO Jamin[1], KIM Young Joon[1], CHOI Wonji[1], PARK KyungHwan[2], LEE Hanseul[2]

Department of Physics Korea Univ.[1], Department of Physics Chonnam National University.[2]

1.Outline

Introduction

- ⦿ High Energy LAMPS
- ⦿ Neutron Detector Array

Data Collection

- ⌘ Experimental Set-up

Data Analysis

- ◎ Typical Pulse Shape
- ◎ Position Dependence of Pulse Shape
- ◎ Integrated ADC
- ◎ Attenuation Length from Integrated ADC

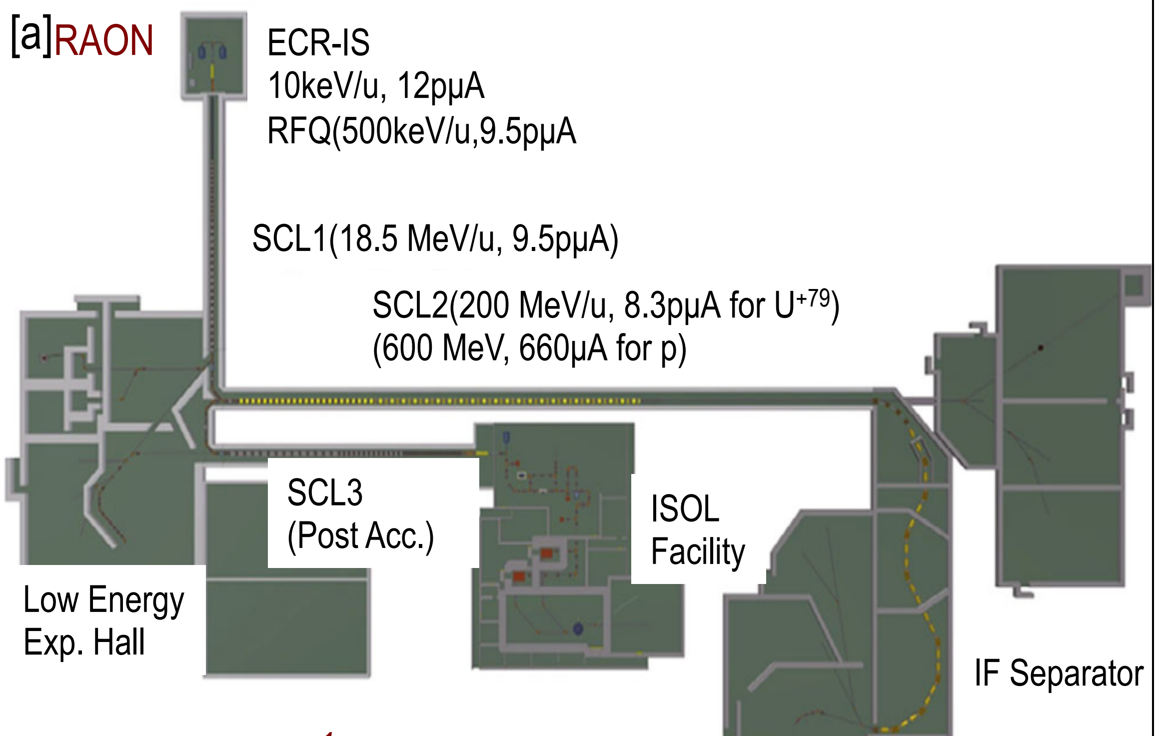
Summary & Prospect

2.Introduction

RAON →
◎ High Energy LAMPS (LAMPS-H)
◎ Neutron Detector Array (NDA)

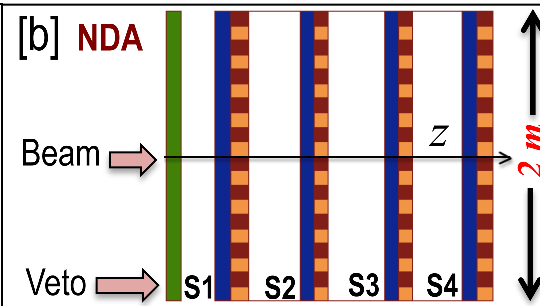
JKPS, Vol. 65, No. 7, pp 1010 ~ 1019 (2014)[1]

[a]RAON



RAON Facility Design[1]

[b] NDA

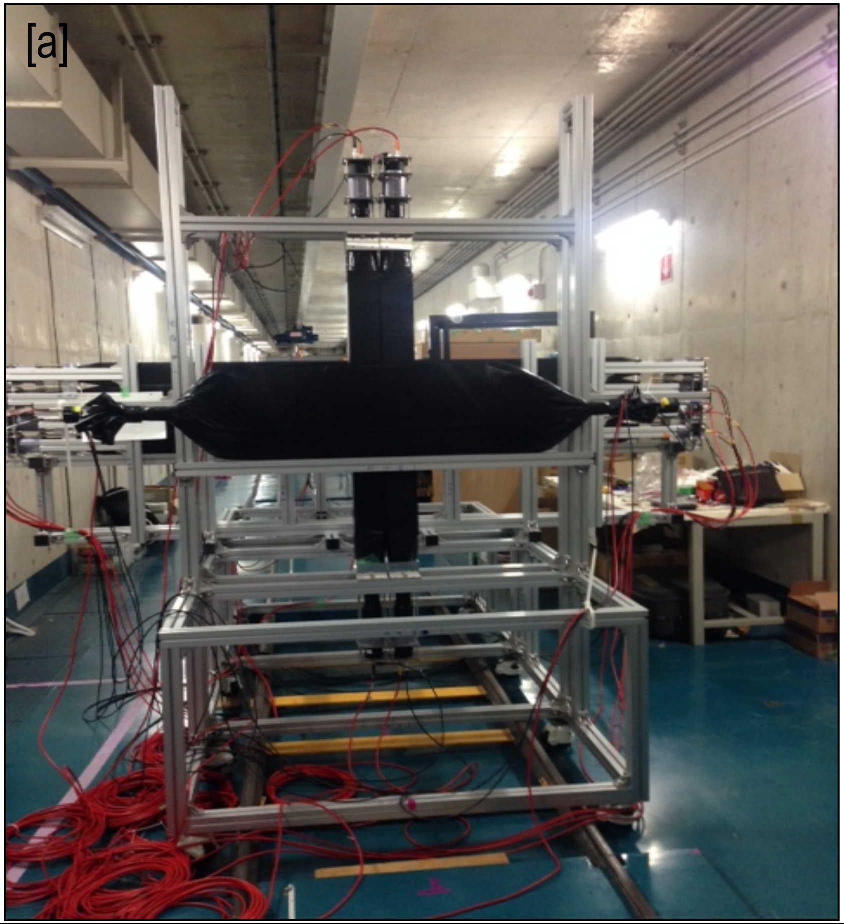


- ◎ Four stations with each station consisting of 20 horizontal and 20 vertical bars packed together.
- ◎ BC-408 plastic scintillator with each end attached to a PMT using a light guide.
- ◎ Each detector has a dimension of 0.1 x 0.1 x 2 m^3
- ◎ Veto is placed in front of S1. The information from veto is used to remove charged particles from neutrons in the offline analysis.

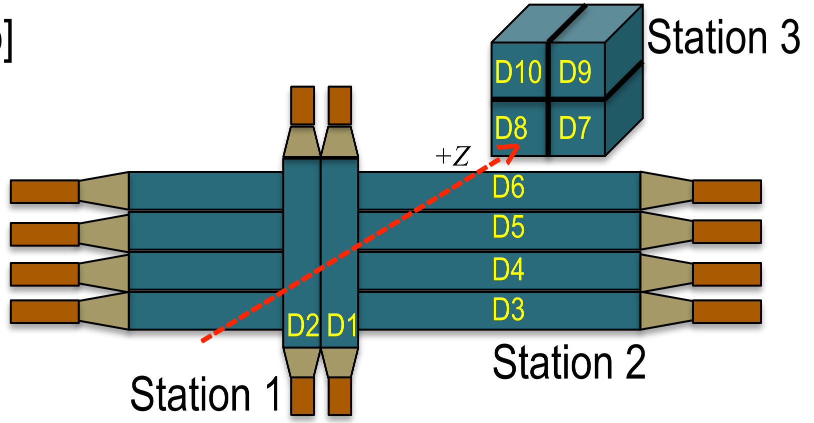
3.Data Collection

Experimental Setup

[a]



[b]

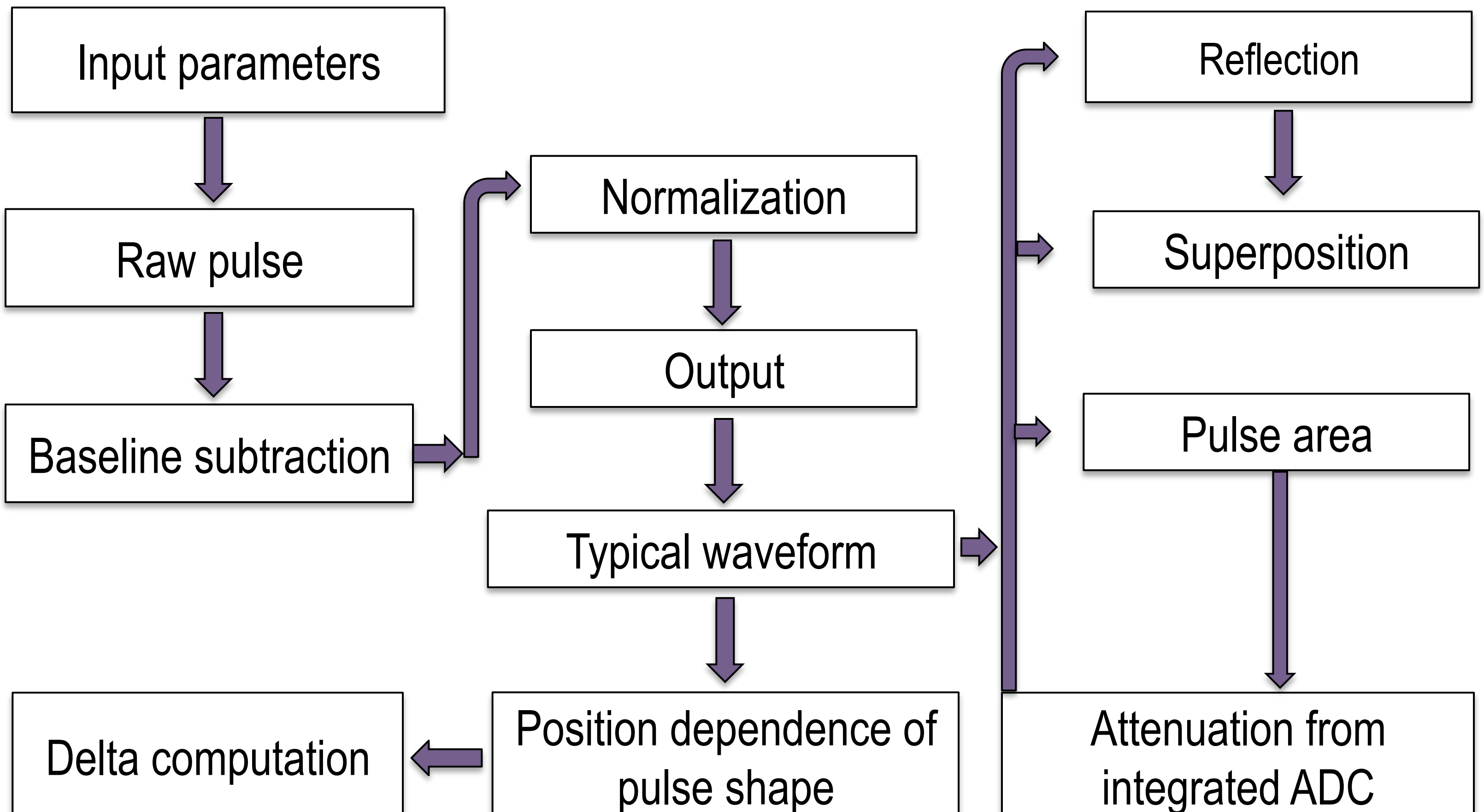


- ◎ Veto was placed horizontally in front of S1.
- ◎ 60 cm-gap between stations and distance from target to detectors was 15 m.
- ◎ Flash ADC [c] used for signal processing.

[c]

4.Data Analysis

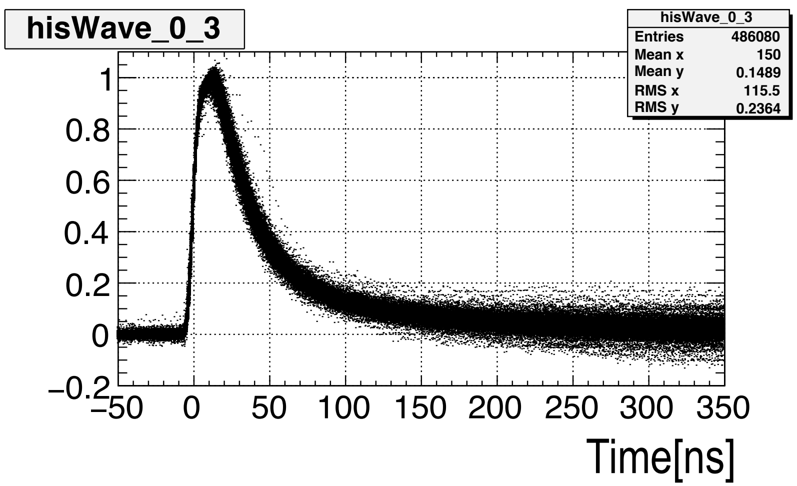
⌘Pulse Shape Analysis Routines – Program Flowchart



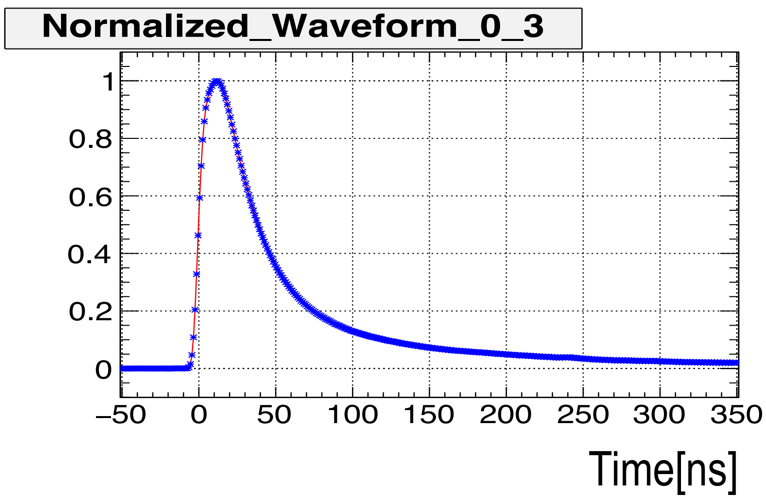
4.Data Analysis

Waveform From Cosmic Data For 1 m-Long Detector

[a] Total waveform



[b] Averaged, normalized typical waveform

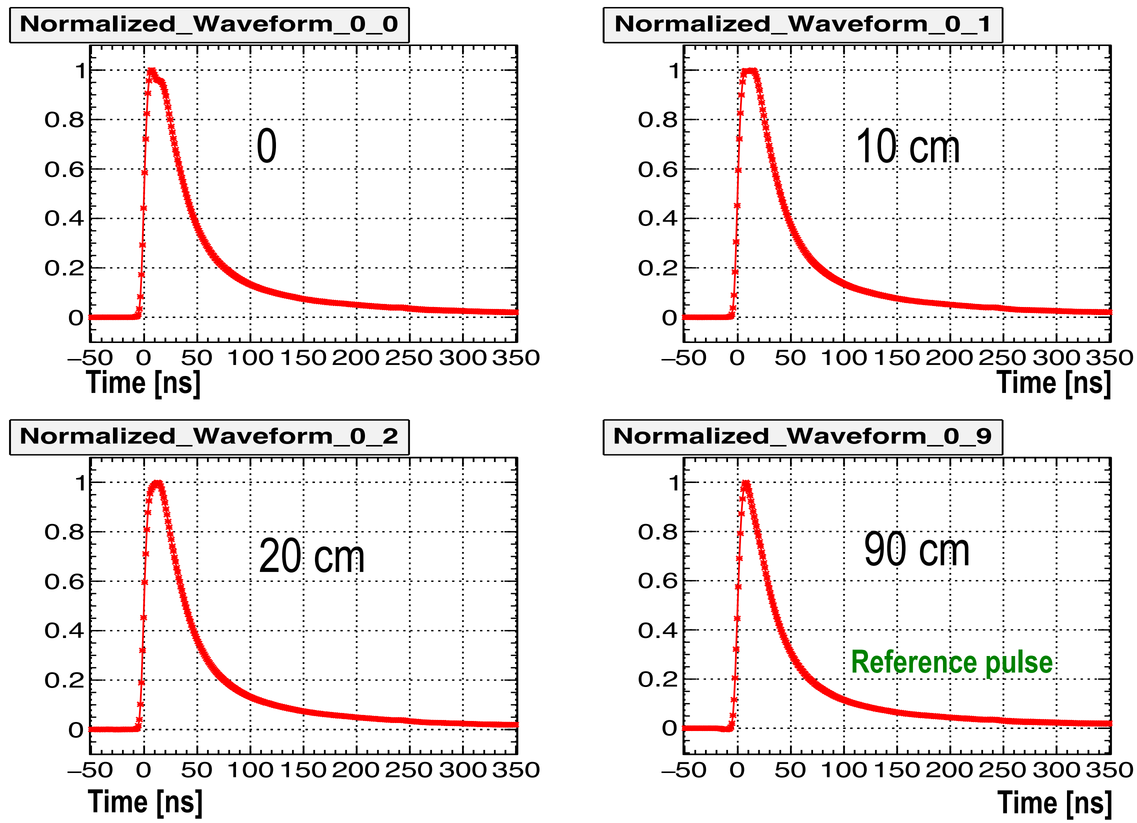


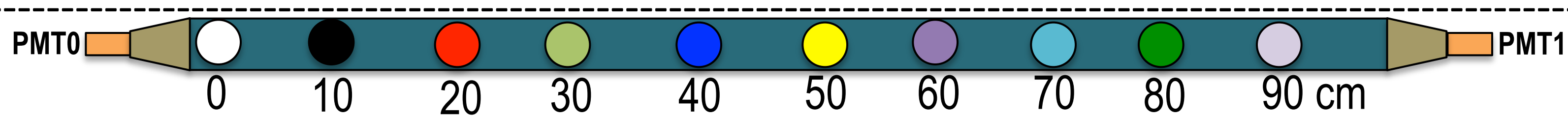
Thousands of raw pulses were processed and superimposed to obtain:

- ⊙ Total waveform in [a].
- ⊙ The total waveform was processed and an averaged, normalized, typical waveform [b] was obtained.

4.Data Analysis

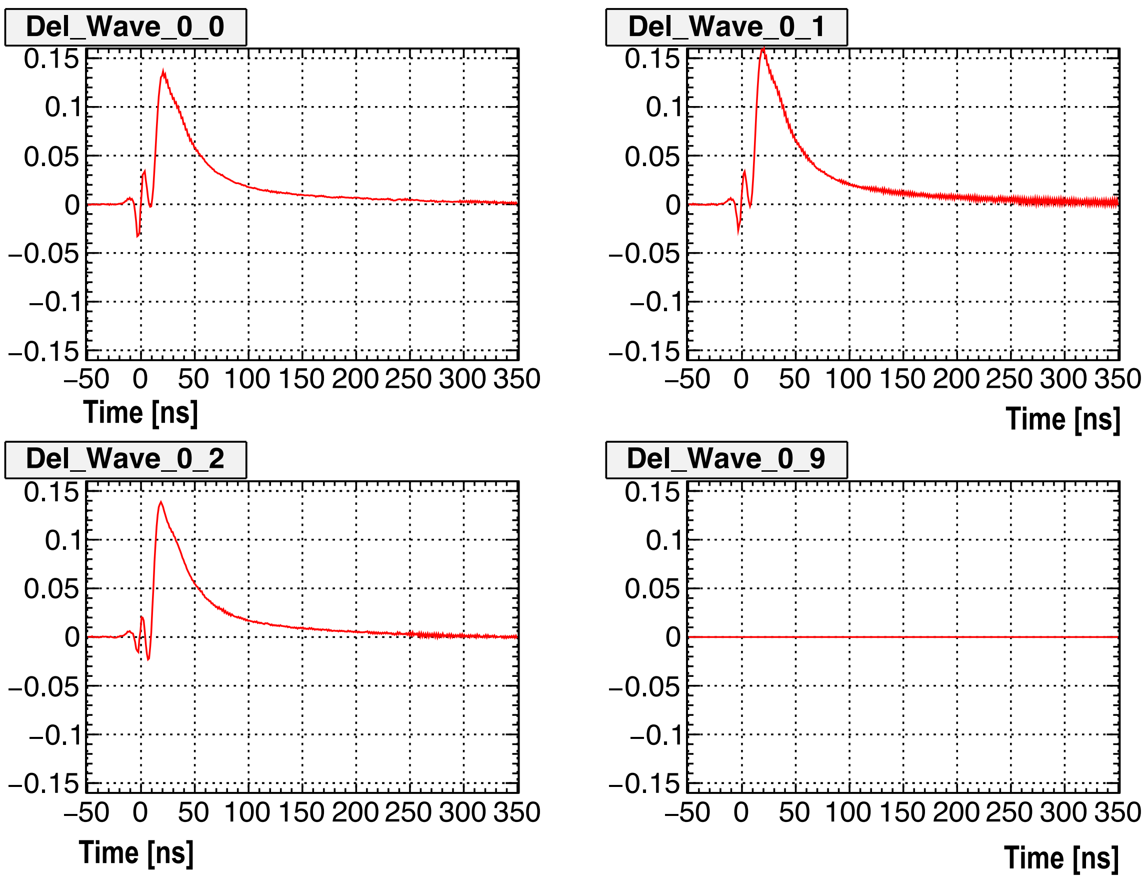
Study of Waveform by Position along the 1 m-Long Scintillator's Length





4.Data Analysis

Waveform Delta between two pulses along 1 m-Long Scintillator's Length



Del_Wave_0_0:
is the difference between the pulse at 0 position and the reference pulse at 90 cm.

Del_Wave_0_9:
is the reference pulse. Therefore, delta is zero, that is a flat distribution.

Distortion from reflections[2]
in interconnecting cables is one of the causes of wave delta.

William R. Leo, Techniques for Nuclear and Particle Physics Experiments, p244 (1987)[2]

4.Data Analysis

Attenuation Length, λ For 2 m-Long Prototypes

- ❑ Attenuation length, λ is understood as the distance (cm) in the material where the intensity of the beam has dropped to 1/e, or about 63% of the particles have been stopped.

- ❑ This is the Beer-Lambert's law:

$$P(x) = P_o e^{-x/\lambda}$$

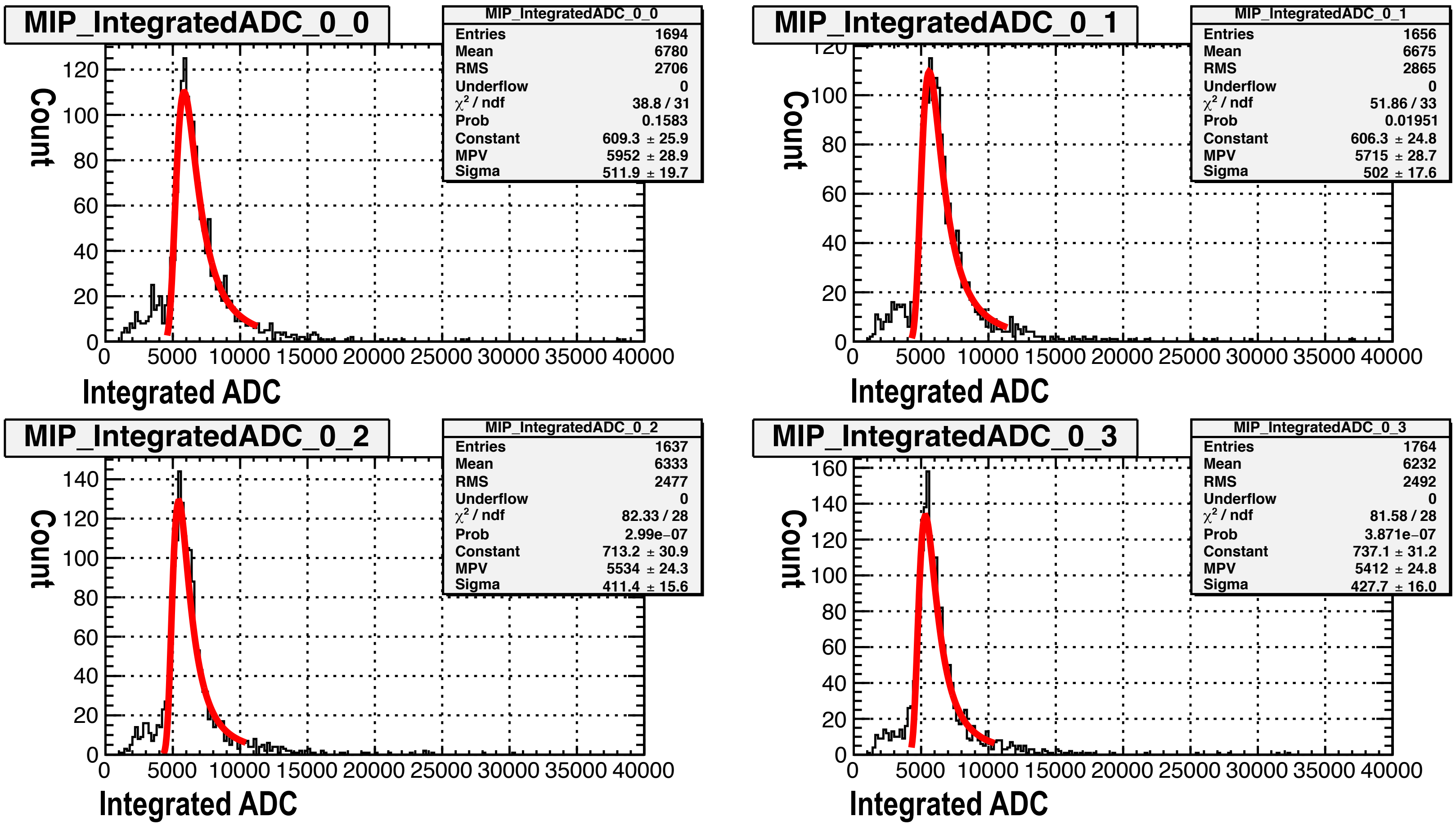
Where;

- ⊙ $P(x)$ is the number of incident radiation.
- ⊙ P_o is the number of photons reaching the PMT (ADC value)
- ⊙ x is the path length of the scintillating material.
- ⊙ λ is the attenuation length and depends on the material and energy.

- ❑ The integrated ADC method was applied in understanding the attenuation length, λ of the current 2 m-long prototypes.

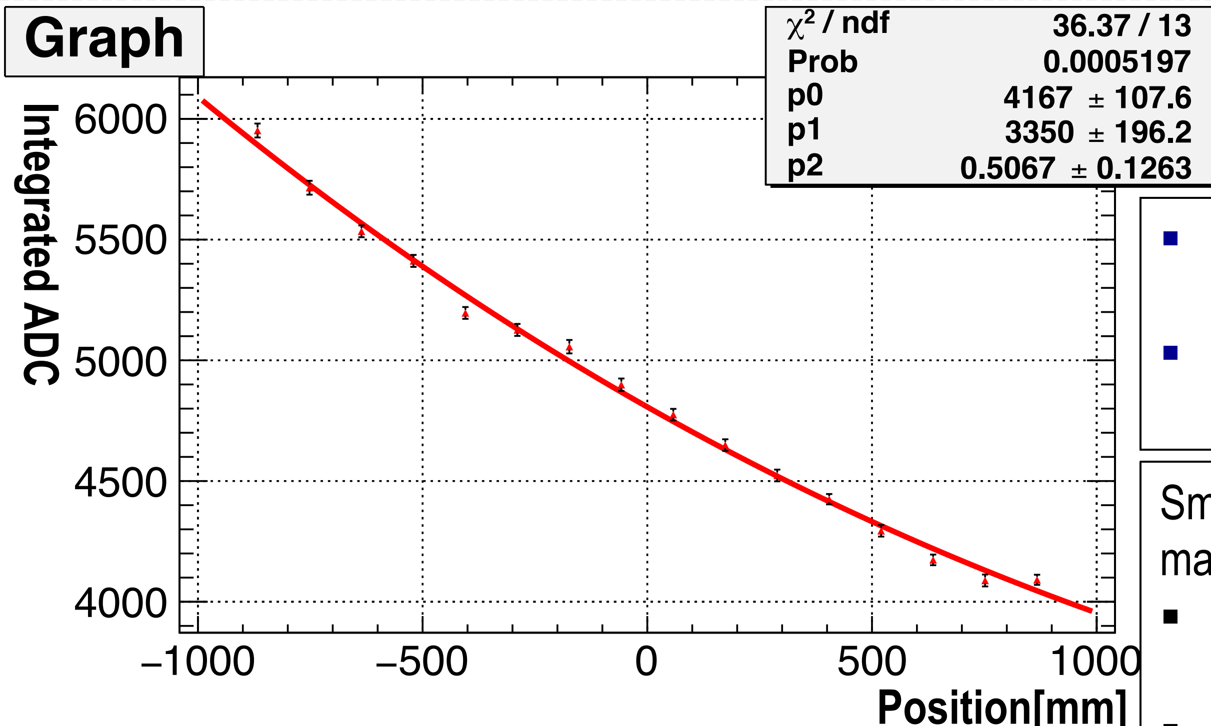
4.Data Analysis

Integrated ADC From Cosmic Muons For 2 m – Long Prototypes



4.Data Analysis

Attenuation (λ) From Integrated ADC Using Cosmic Data – 2 m Prototype



$$P = P_0\left[e^{-\frac{x}{P_1}} + P_2 e^{-\left(\frac{2L-x}{P_1}\right)}\right]$$

Fitting function for integrated ADC

- Po = PMT photons
- P1 = Attenuation Length
- P2 = Reflectivity

Comparison of λ to the BC-408 Manufacturer’s value

- Expt. Value = 335 cm
  Dim. [10 x 10 x 200] cm^3
- Th. Value = 210 cm
  Dim. [1 x 20 x 200] cm^3

Smaller attenuation length by manufacturer is due to:

- The smaller dimension of the detector.
- The detector’s polished edges.
- The limit in the signal cable interconnections.

5.Summary & Prospect

Summary

◎ Waveform changes by position as pulse traverses the scintillating material from the interaction point to the photomultiplier tubes.

◎ Attenuation length for 2 m-long prototypes computed using the integrated ADC method is 335 cm and is of the order of the detector's length.

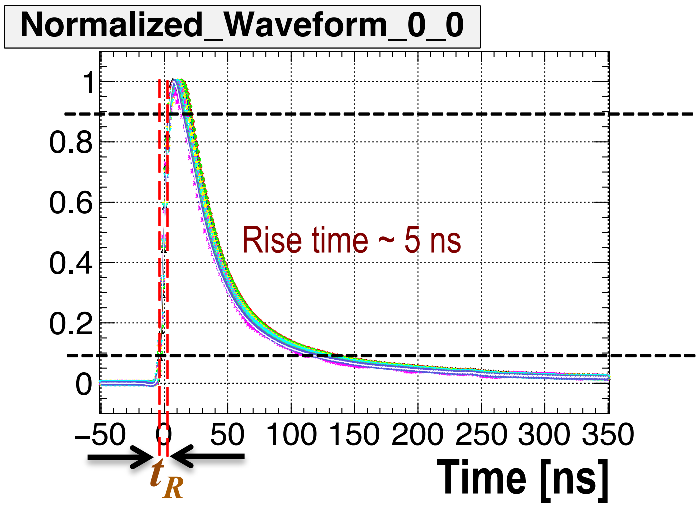
◎ Prototypes are suitable for ToF experiment since radiation can be stopped within the active volume.

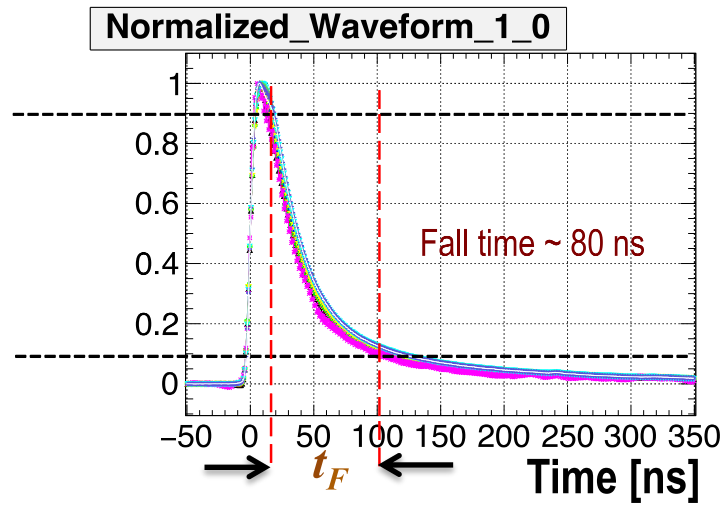
Prospect

⌘ Determine the attenuation length from the pulse height method by utilizing a user defined function to fit the pulse height MPV data points and compare the two methods.

⌘ Study reflection further as reflected pulses distort the amplitude of the pulse thereby affecting actual pulse characteristics.

6.BACKUP[1]





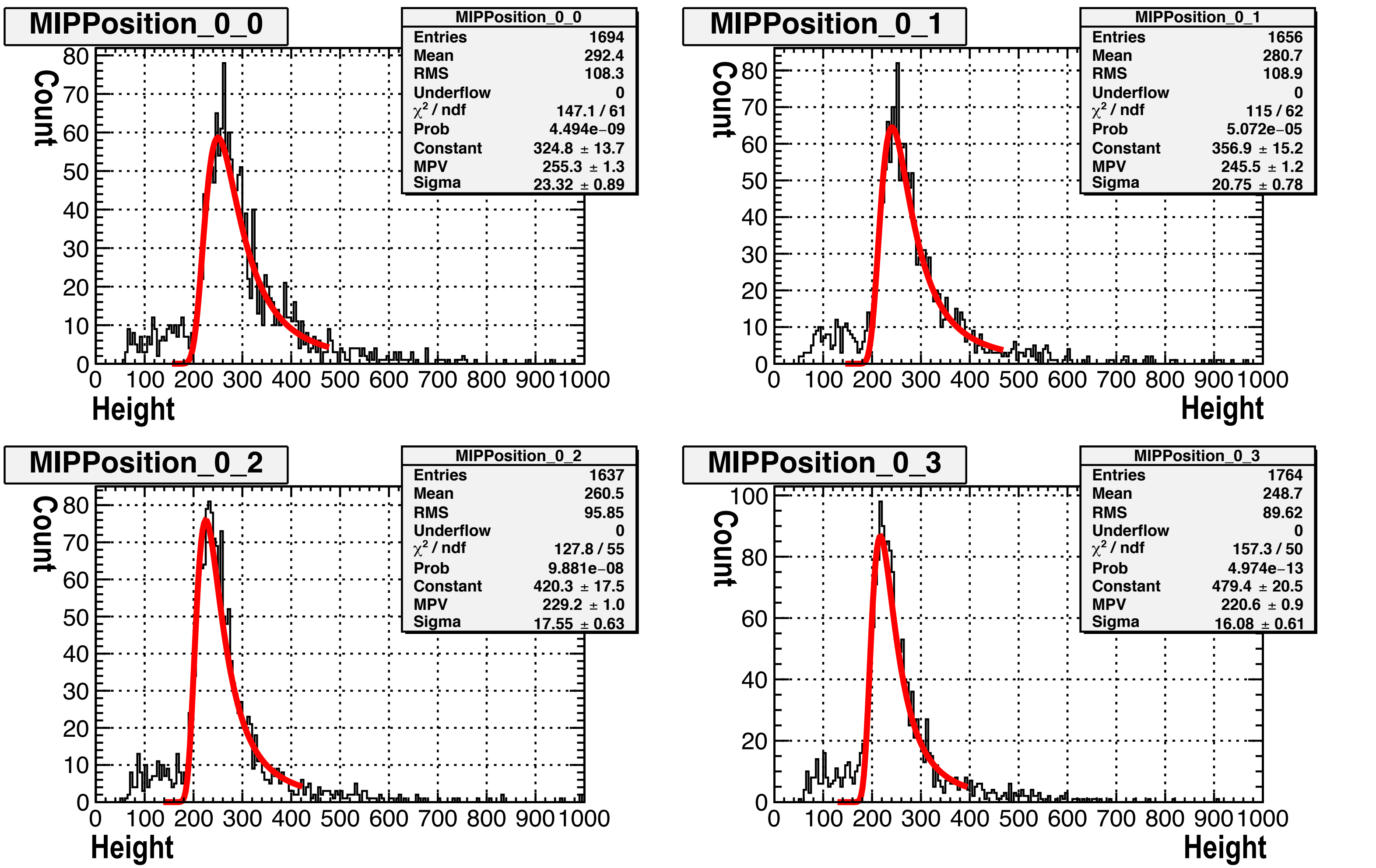
PW_{FWHM} ~ 30 ns

Rise Time (t_R) and Fall time (t_F)

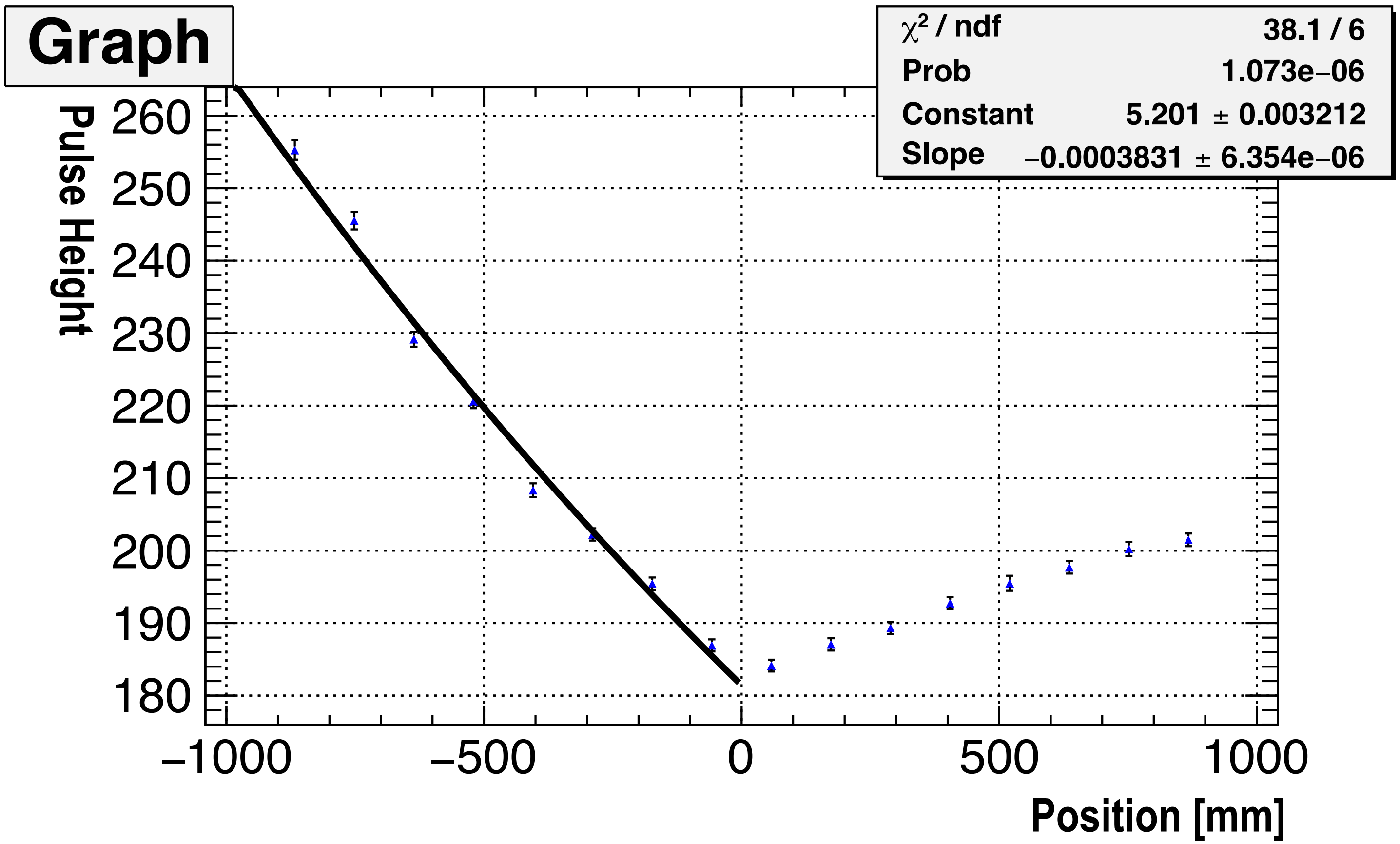
- Rise time is time required for a signal to rise from 10% to 100% of the height of the signal.
- Fall time is the time needed for the signal to fall from 90% to 10% of the maximum height.

6.BACKUP^2

Pulse Height From Cosmic Muons



6.BACKUP[3]



Exponential fit function with λ = 1/slope = 1/0.0003831 = 261 cm = attenuation length