GROUP 4

Characteristics of Plastic Scintillator Detectors

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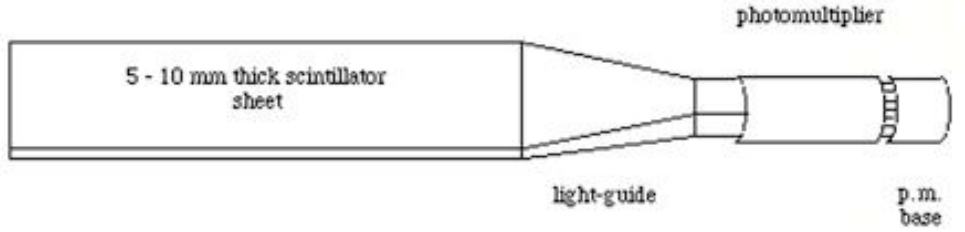
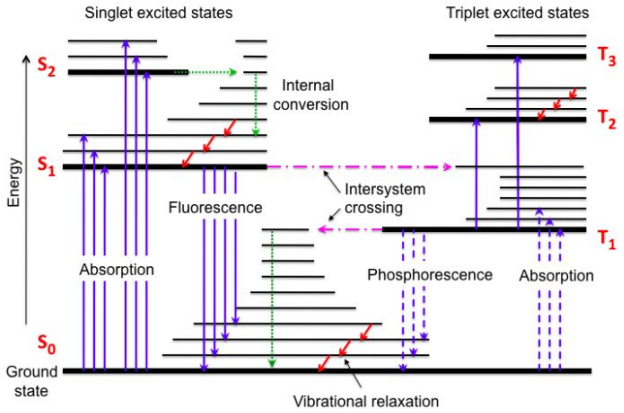
Outline

1. Introduction – **Mei Li Holmberg**
   - Scintillation materials
   - Plastic scintillators: working principle
   - PhotoMultiplier Tubes (PMTs)
2. Experimental Setup – **Deshitha Chamikara Wickramarathna**
   - Circuit Diagram
   - Coincidence Logic
   - Data acquisition system (DAQ)
3. Results and Conclusions – **Apar Agarwal**
   - Merits and Demerits
   - Takeaway

Introduction and Working principle

- Most common type of particle detectors
- Scintillator is a material that absorbs energy and re-emits light
  - **Organic scintillators** - e.g. plastic scintillators etc.
  - Inorganic scintillators e.g. NaI (Tl), $LaBr_3$ etc.
- A photodetector collects the scintillation light.
- Cover setup with Reflective paper (Tyvek) followed by Black paper (Tedlar) on the outside

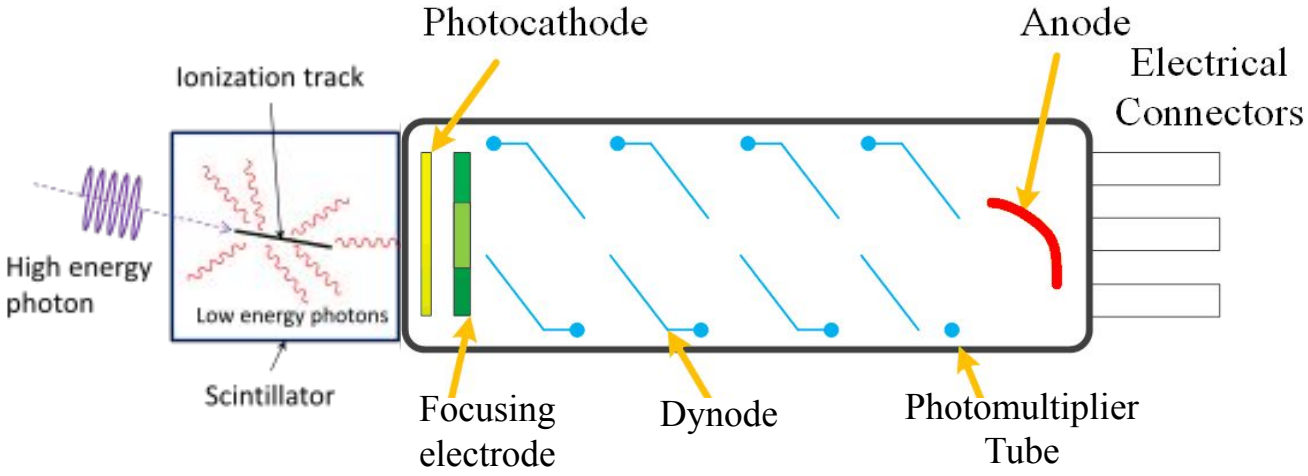




Journal of Instrumentation. 7. P02010. 10.1088/1748-0221/7/02/P02010.

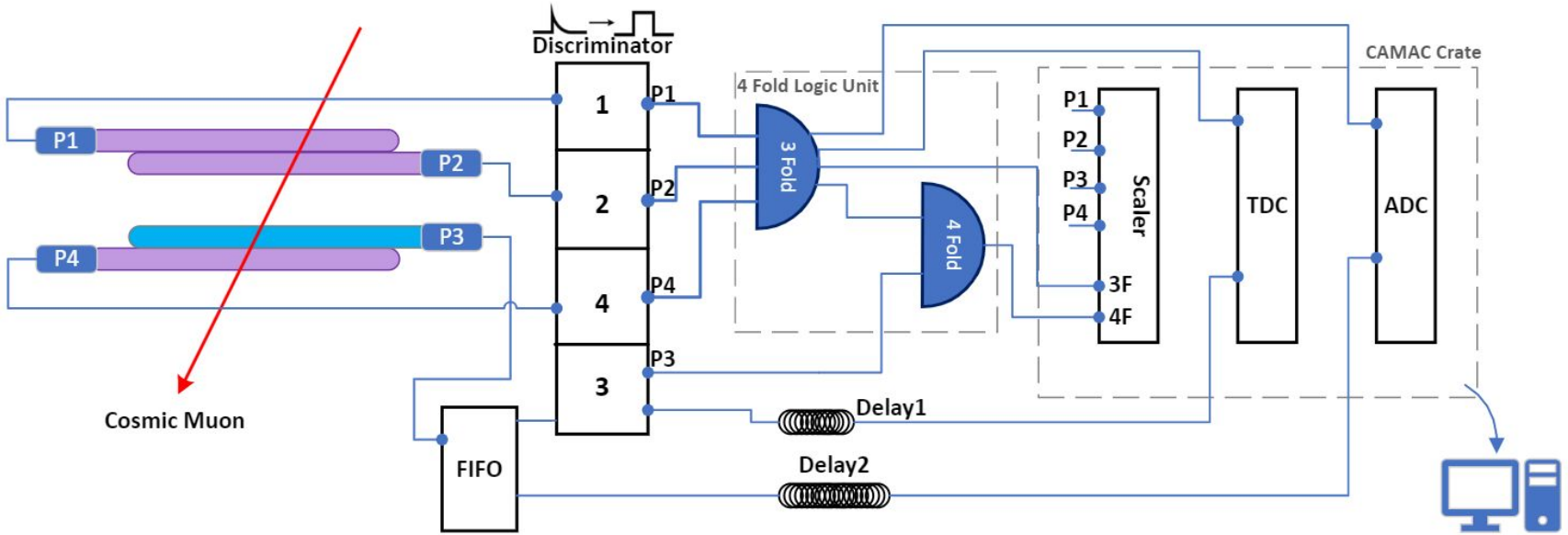
Photomultiplier Tubes

- Converts single photon into measurable electrical signal
  - Photocathode creates primary electrons
  - Dynodes create further secondary electrons
  - Anode collects the electrons

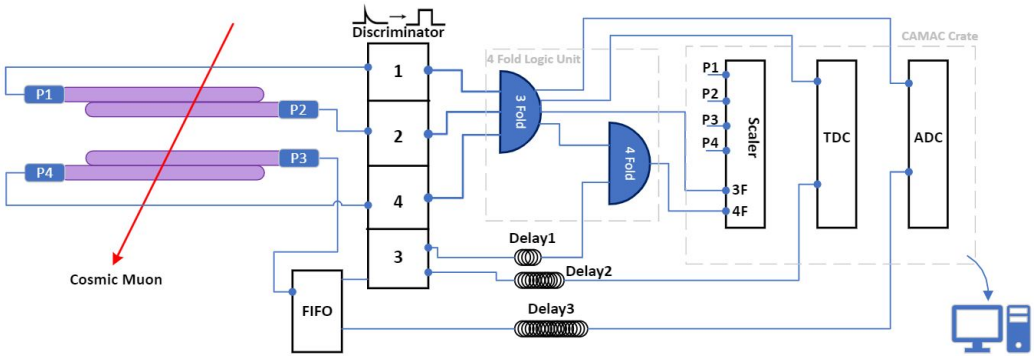


Experimental Setup

- Scaler
  - count the pulses
- TDC - Time to Digital Convertor
  - Calculate the time difference between trigger signal and test signal
- ADC - Analog to DIgital Converter
  - Get the charge of the signal



Experimental Setup (ctd.)



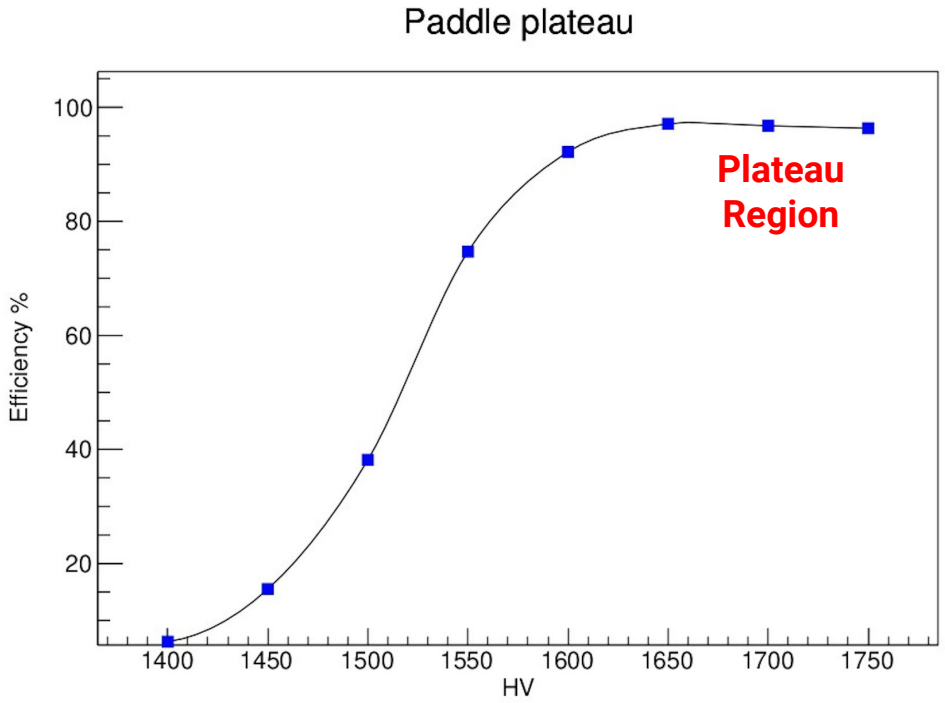
Data AcQuisition (DAQ) System

- A Nuclear Instrumentation Module (NIM) and Computer-Aided Measurement and Control (CAMAC) based DAQ setup was used to study detector characteristics.
- CAMAC module is interfaced with a local PC.
- A C++ based in-house code is used to read and analyse data from CAMAC crate.
- The DAQ allows for real time monitoring of noise rates, count rates and efficiencies.

Results - Operating Voltage and Detector Efficiency

Procedure: Increase PMT voltage for test paddle gradually and measure count rates for 10 min (each).

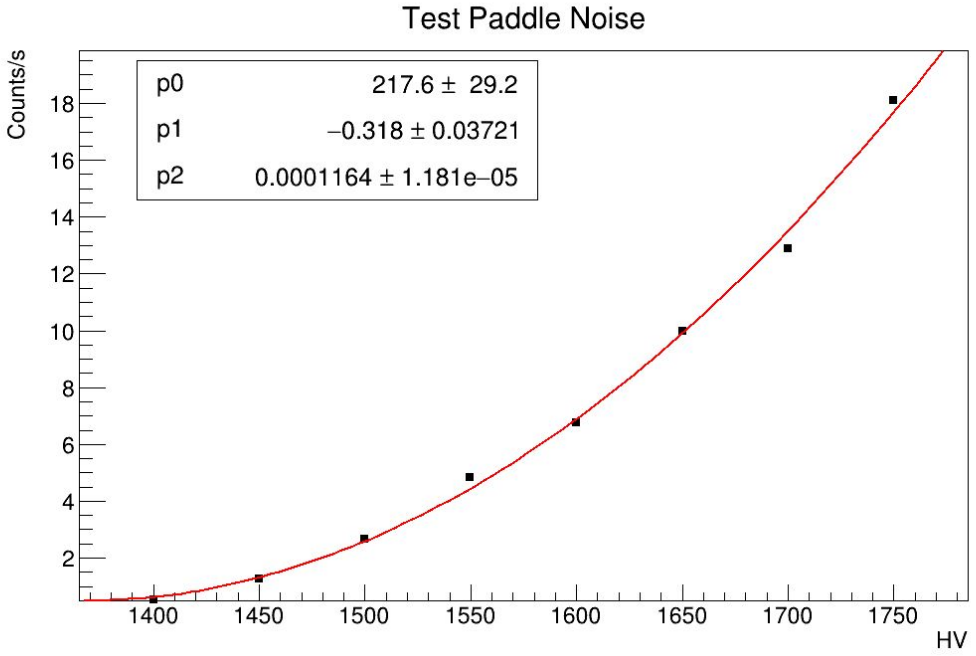
- Efficiency increases with PMT Voltage until we hit a plateau
  - At Plateau we manage to amplify nearly all the available light signal above threshold
- Operating voltage at ~1700 V
- Efficiency : ~97% Efficient

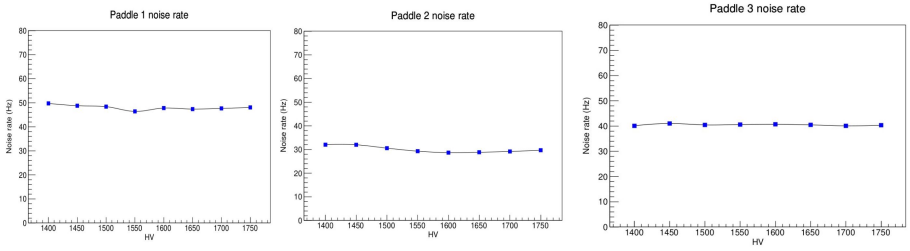


Results - Noise Rate

Procedure: Increase PMT voltage for test paddle gradually and measure noise rates (Total Counts - Coincidence logic) for 10 min (each)

- Noise rates for Test paddle increase with applied voltage
- Noise rates for Rest of the Paddles remains constant as expected.

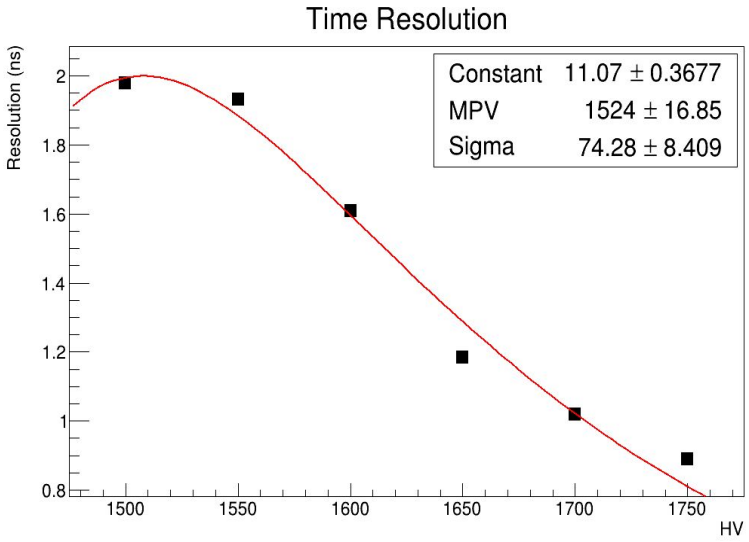


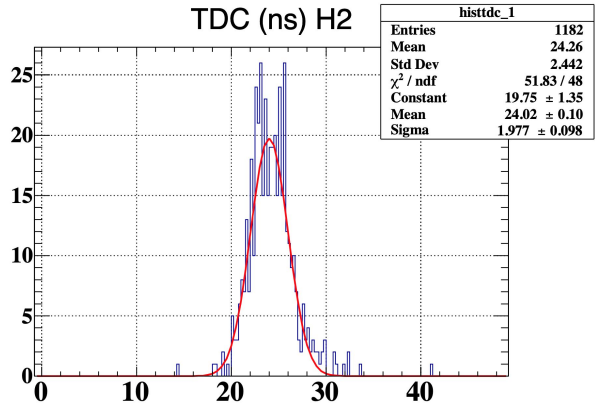


Results - Time Resolution

Procedure: Increase PMT voltage for test paddle gradually and measure delay between trigger logic and 4 fold coincidence logic for 10 min (each)

- We obtain a gaussian distribution for the time difference.
- The x position of peak gives us the mean delay of signal from trigger.
- The Standard deviation (σ) of the distribution gives us the timing resolution of our detection system.

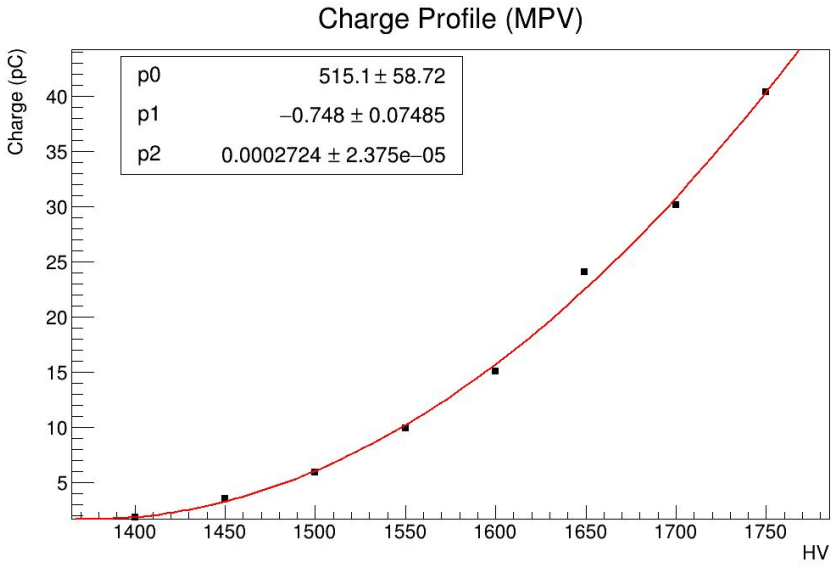


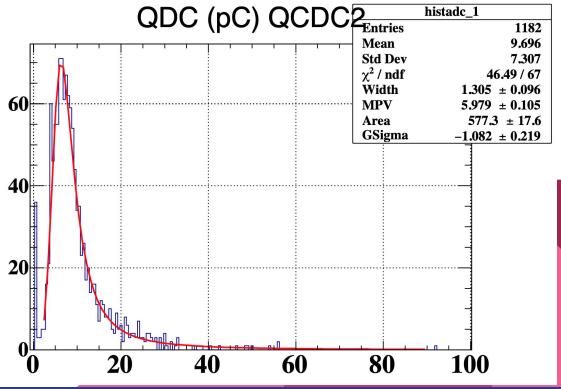


Results - Charge profile

Procedure: Increase PMT voltage for test paddle gradually and measure the charge collected from PMT triggered by 3 fold coincidence for 10 min (each)

- The charge of the signal increases with High Voltage





Conclusion

- Operating voltage 1650-1750 V
- Efficiency >97% at operating voltage
- Time resolution ~1.2 ns at operating voltage
- Noise increased with voltage

Takeaway

Go for Plastic scintillators is you want to just count charge particles like muons etc. or use them as a trigger!

Merits

- Excellent charge detection efficiency
- Fast signal response
- Cover large area for its cost

Demerits

- Poor energy and position resolution (relatively!)
- Poor detection efficiency for gammas.

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Tack!
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Thank you!

Backup

Experimental Data

Test Paddle Voltage (V)	Noise Rate (Hz)				Effeciency = (3 Fold Rate/4 Fold Rate) * 100 (%)			Time resolution (ns)	Mean Shift (ns)	Charge (pC)
	Paddle 1	Paddle 2	Paddle 3	Test Paddle	3 Fold	4 Fold	Effeciency (%)			
1400	49.75	32.04	40.10	0.54	0.16	2.55	6.27	1.98	26.2	1.877
1450	48.78	32.01	41.03	1.28	0.4	2.58	15.50	1.568	25.37	3.541
1500	48.44	30.57	40.46	2.68	1.0	2.62	38.16	1.977	24.26	5.979
1550	46.42	29.3	40.61	4.8	1.92	2.57	74.7	1.931	23.09	9.978
1600	47.81	28.68	40.72	6.76	2.36	2.56	92.18	1.609	21.14	15.11
1650	47.38	28.84	40.49	9.99	2.41	2.48	97.1	1.185	19.27	24.04
1700	47.67	29.18	40.10	12.88	2.39	2.47	96.76	1.019	18.53	30.22

Results - Time Shift