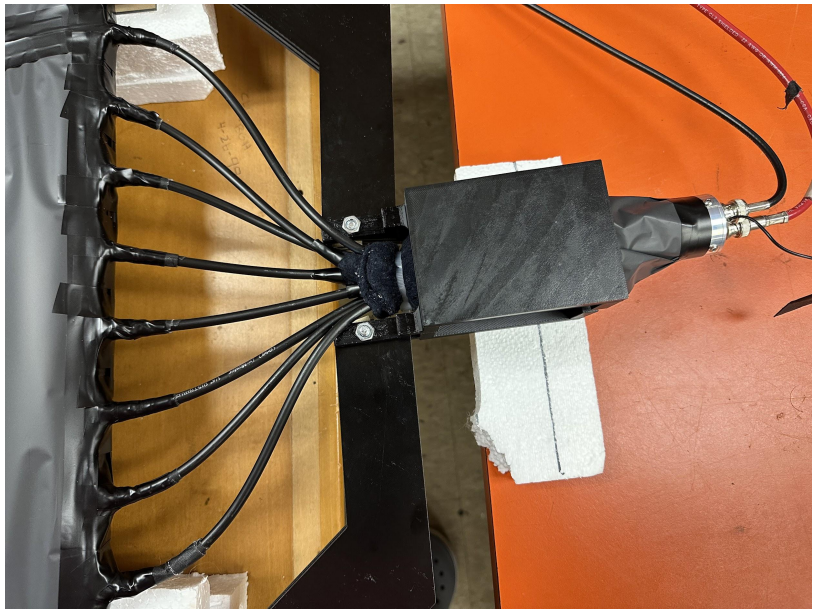
Trigger Scintillator Status

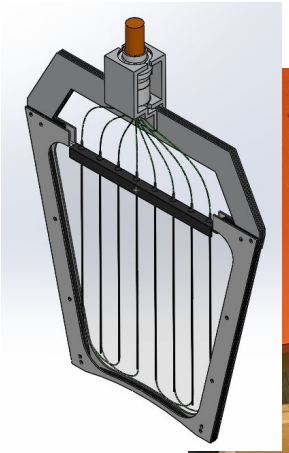
MOLLER Collaboration Meeting 2025

Rakitha Beminiwattha, Lasitha Weliyanga, Shashini Chandrasena, and Afeez Yusuff
Louisiana Tech

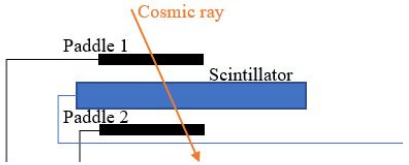
First Prototype Mounted to Final Production Frame



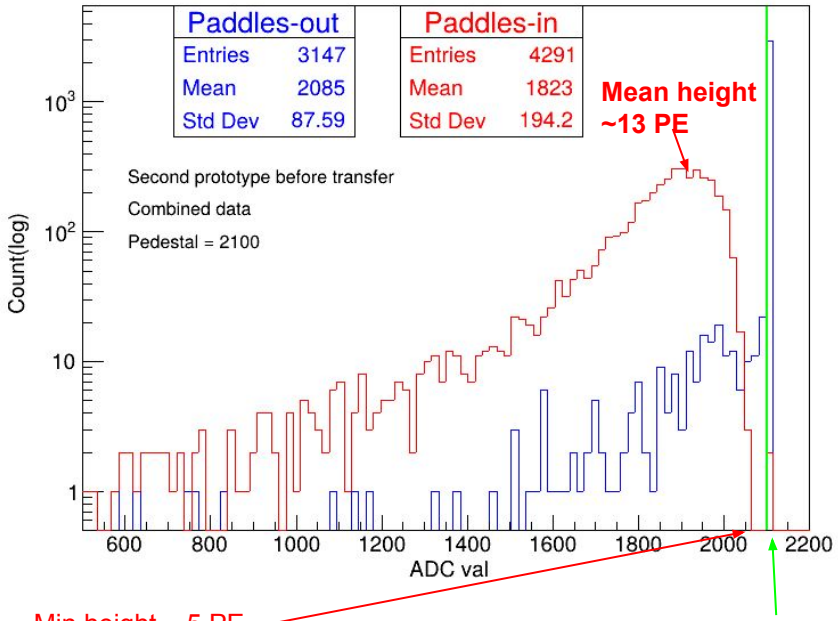
First Prototype Mounted to Final Production Module



Cosmic pulse height and Hit Timing



Min ADC value variation for all events

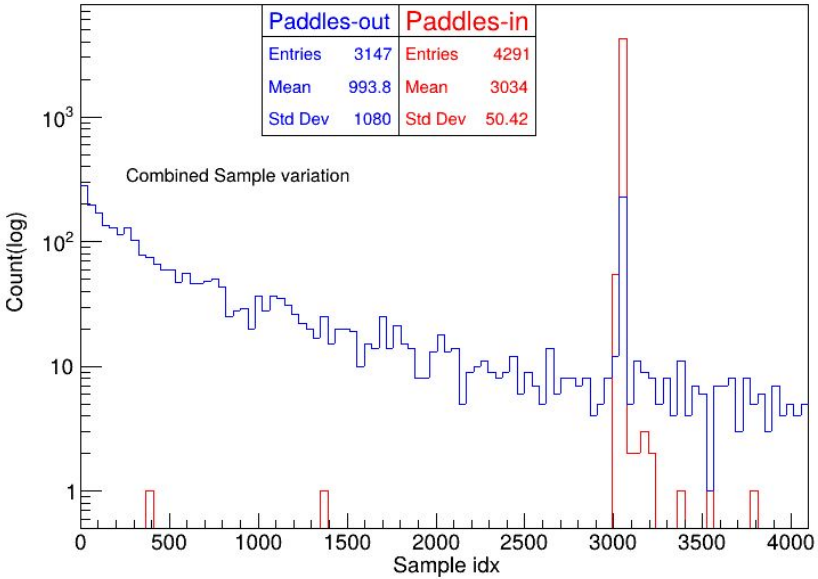


Mean height ~13 PE

Min height ~5 PE

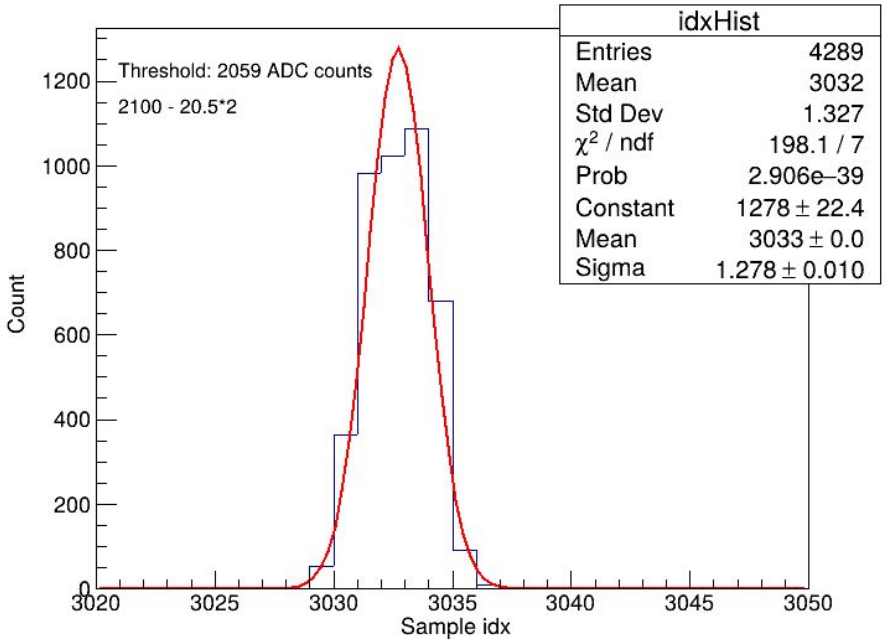
2 PE Threshold Applied

Sample index of the ADC min



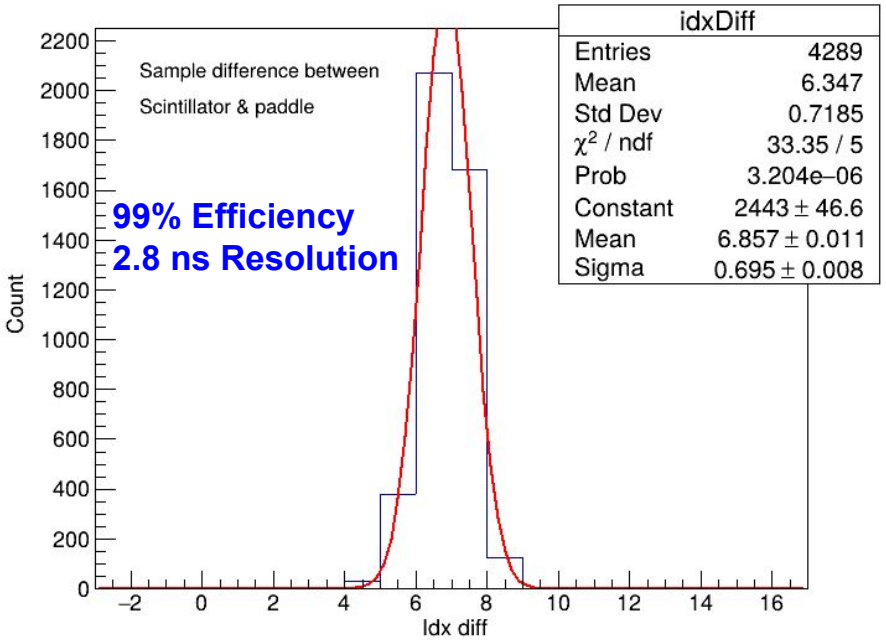
Hit Time of 2 PE below pedestal: Scint vs paddle-scinti

Scintillator hit time



CAEN V1720 12 bit samples 4 ns times.
x-axis in 4 ns unit samples

Paddle and Scintillator hit time difference

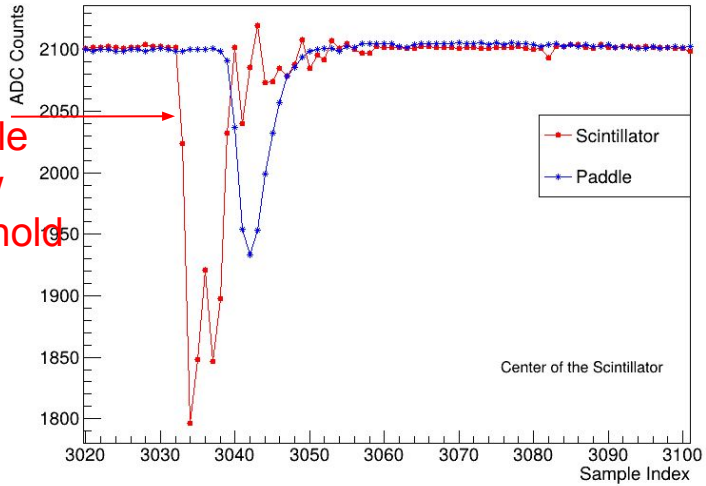


x-axis in Δt of paddle and scint hit time difference

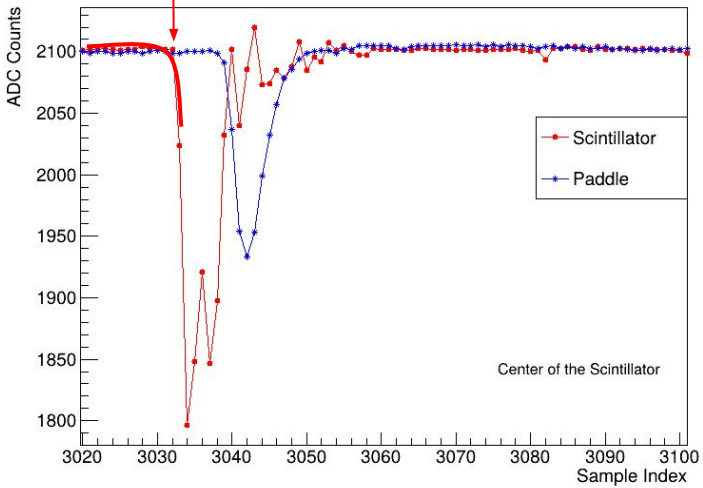
Current Issue

- **With Cosmics we get about 2.8 ns timing resolution at 99% efficiency with a simple algorithm to find first sample below threshold**
- A fitting algorithm suitable for hardware implementation will improve the timing
- Scintillation light from 8 fibers picks up a detailed structure of initial interaction and internally reflected light

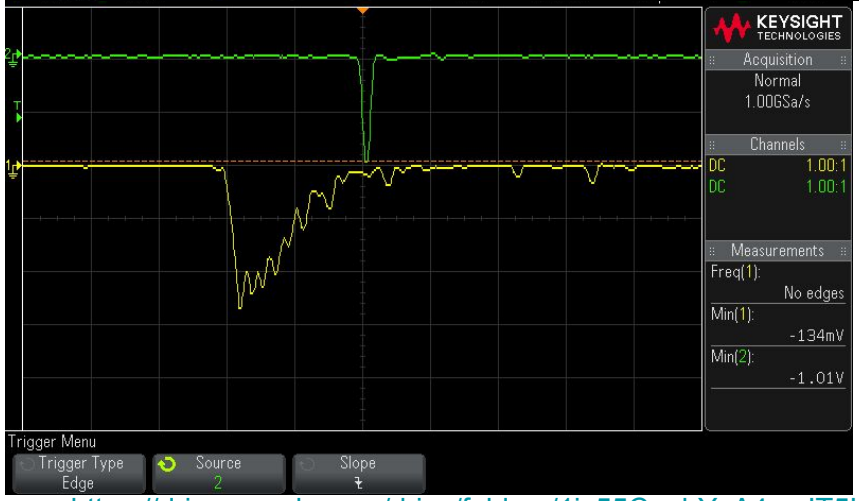
first sample below threshold



fitting algorithm



Scope Traces of Cosmic Hits



https://drive.google.com/drive/folders/1jv55CpgbYcA4oaJT5UJ1r8QliLw_trpd?usp=sharing

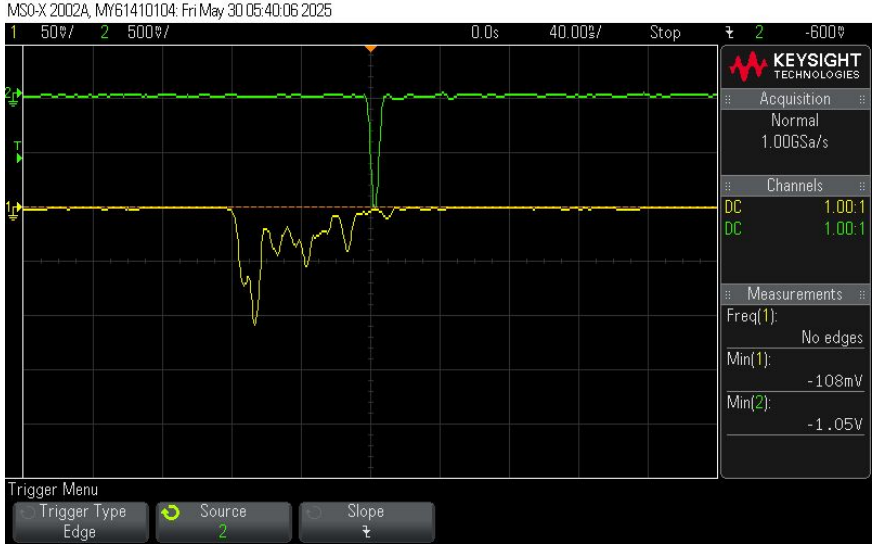
MSO-X 2002A, MY61410104: Fri May 30 05:43:12 2025

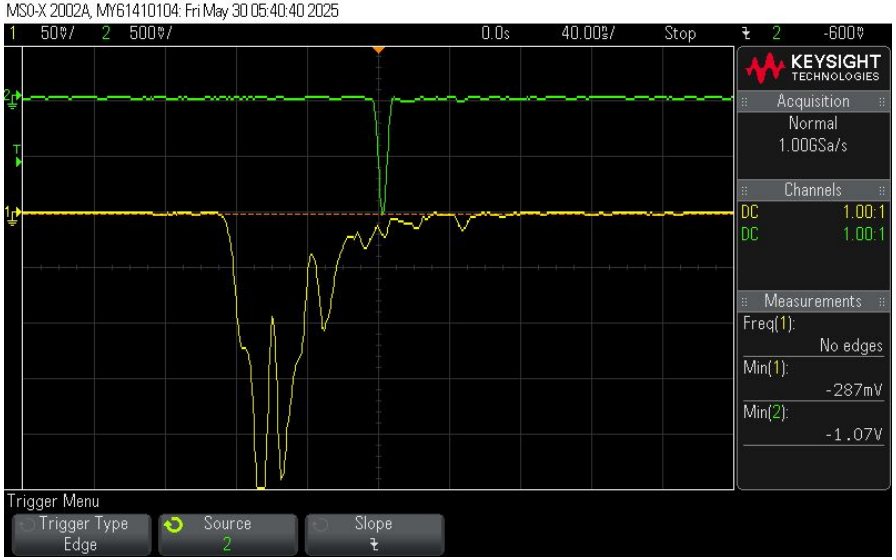
MSO-X 2002A, MY61410104: Fri May 30 05:40:17 2025

MSO-X 2002A, MY61410104: Fri May 30 05:41:13 2025

r8QliL

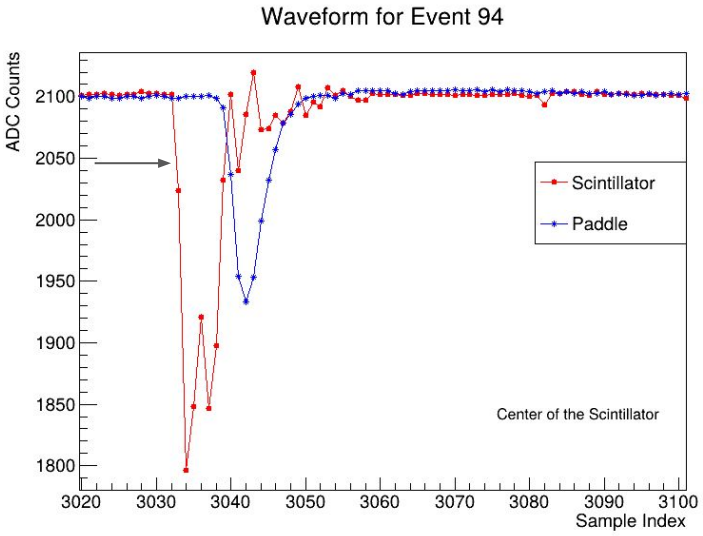
MSO-X 2002A, MY61410104: Fri May 30 05:42:46 2025

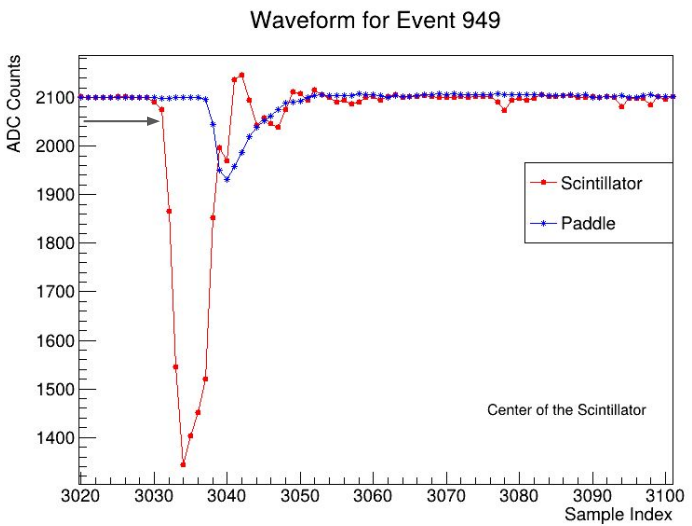


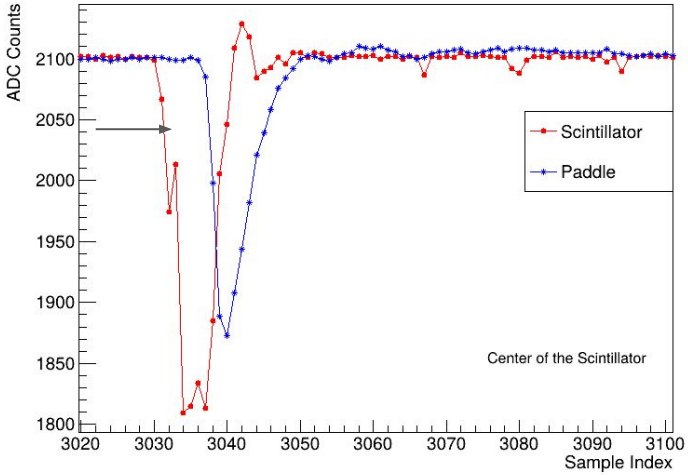


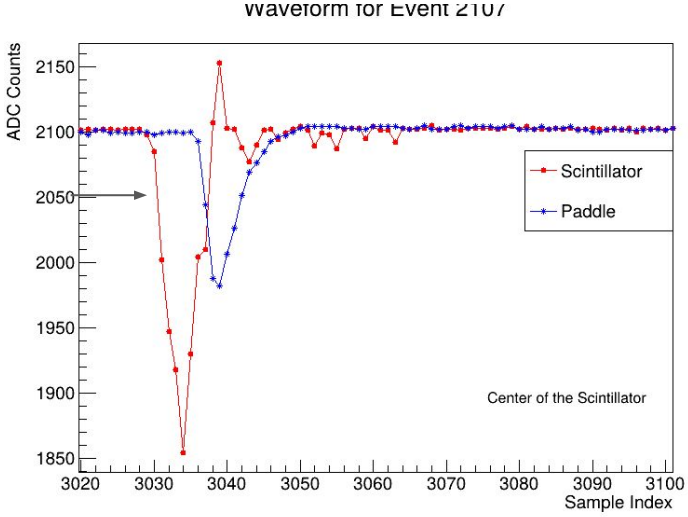
https://drive.google.com/drive/folders/1jv55CpgbYcA4oaJT5UJ1r8QliLw_trpd?usp=sharing

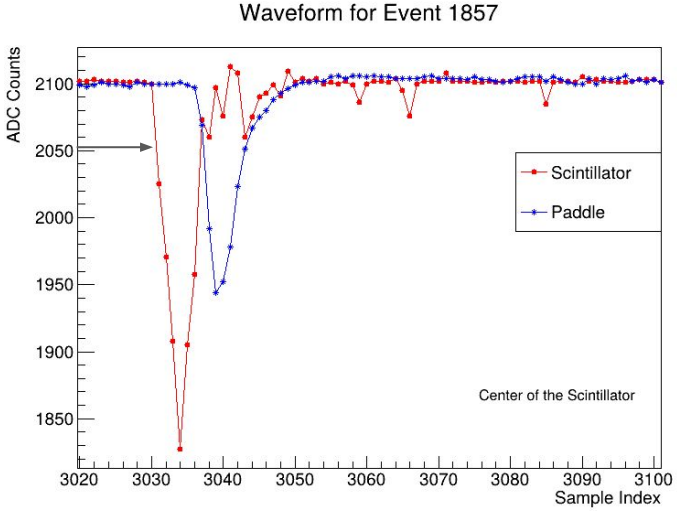
Waveforms of Cosmic Hits Sampled (4ns) by CAEN ADC

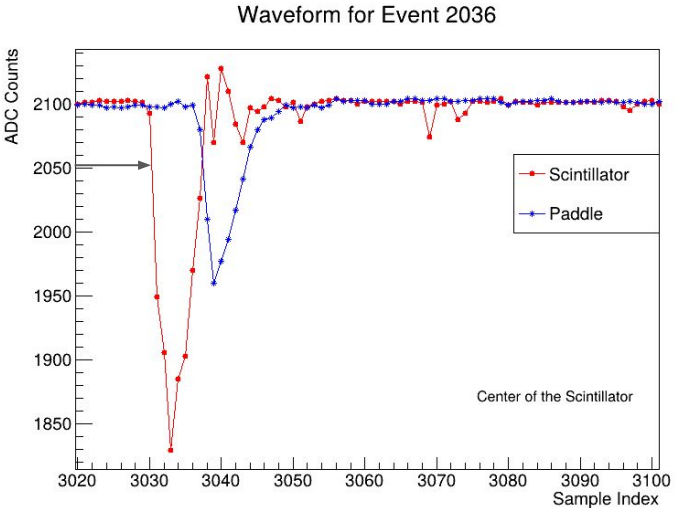

Waveform for Event 94
ADC Counts
Sample Index
Scintillator
Paddle
Center of the Scintillator

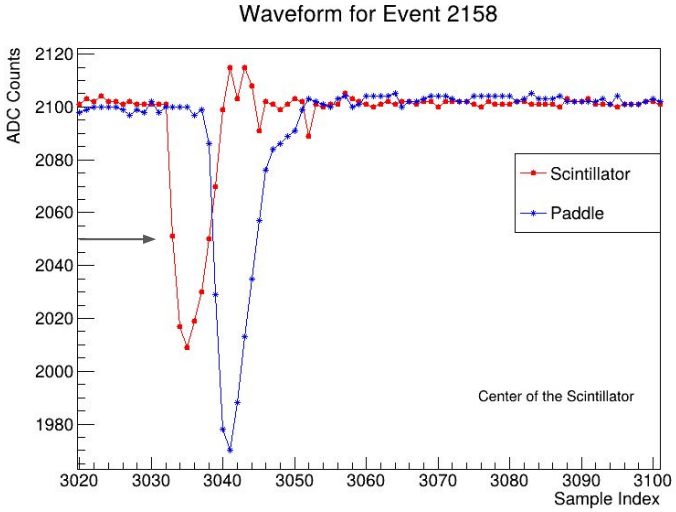

Waveform for Event 949
ADC Counts
Sample Index
Scintillator
Paddle
Center of the Scintillator

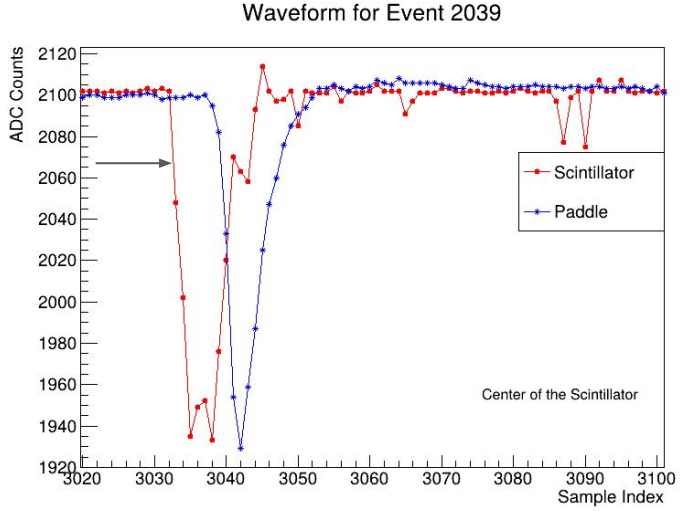

ADC Counts
Sample Index
Scintillator
Paddle
Center of the Scintillator

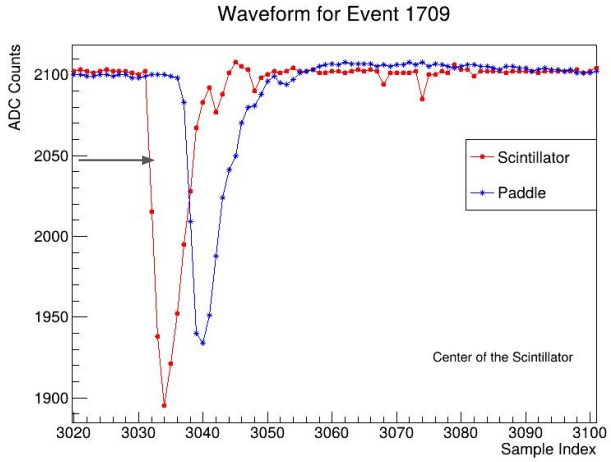

Waveform for Event 2107
ADC Counts
Sample Index
Scintillator
Paddle
Center of the Scintillator

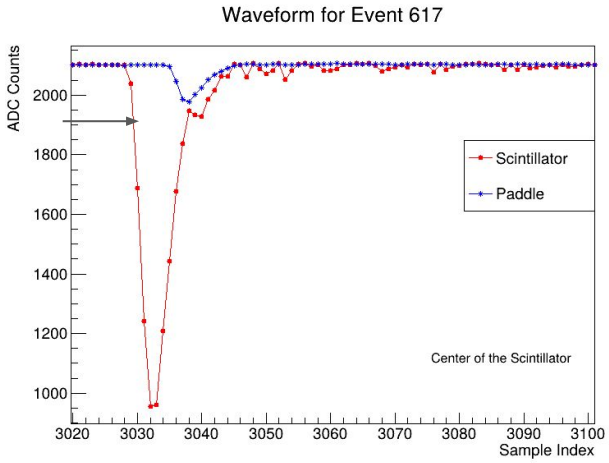

Waveform for Event 1857
ADC Counts
Sample Index
Scintillator
Paddle
Center of the Scintillator

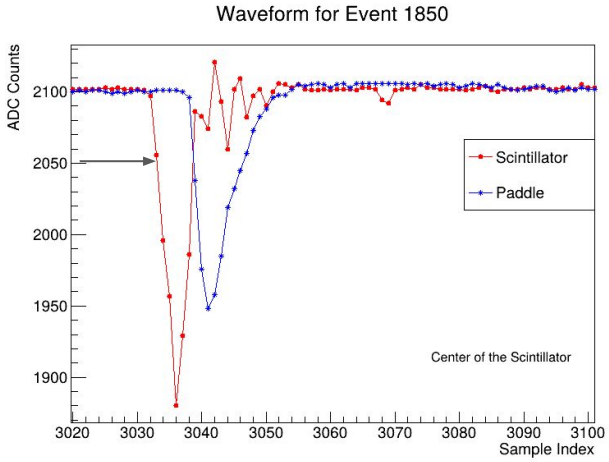

Waveform for Event 2036
ADC Counts
Sample Index
Scintillator
Paddle
Center of the Scintillator

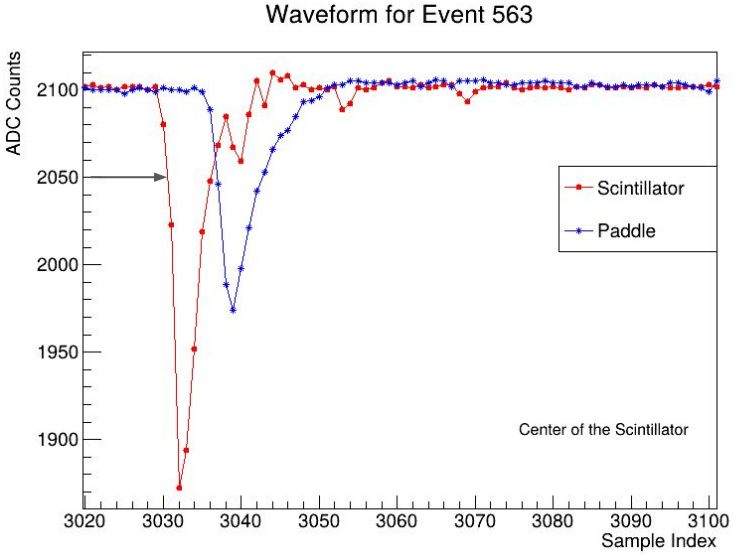

Waveform for Event 2158
ADC Counts
Sample Index
Scintillator
Paddle
Center of the Scintillator

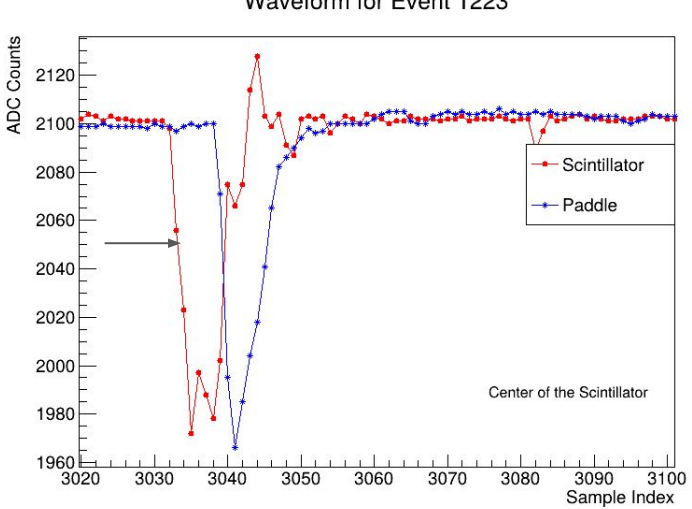

Waveform for Event 2039
ADC Counts
Sample Index
Scintillator
Paddle
Center of the Scintillator

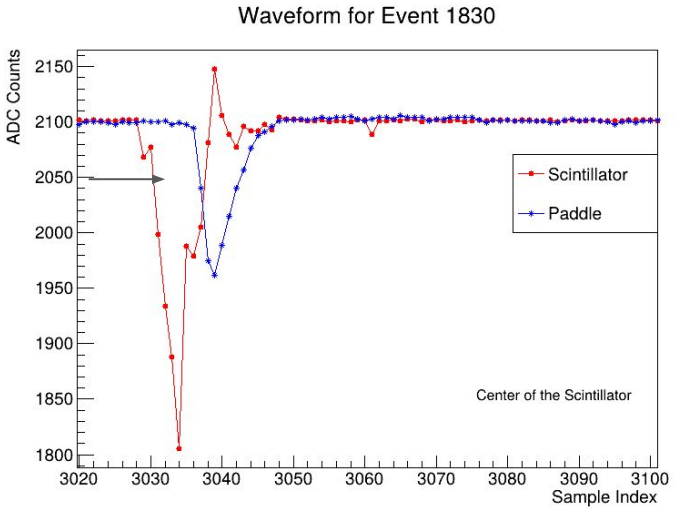

Waveform for Event 1709
ADC Counts
Sample Index
Scintillator
Paddle
Center of the Scintillator

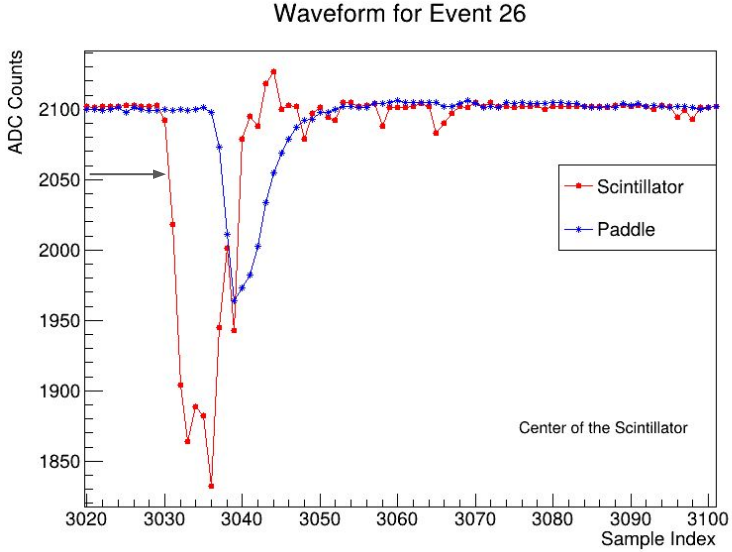

Waveform for Event 617
ADC Counts
Sample Index
Scintillator
Paddle
Center of the Scintillator

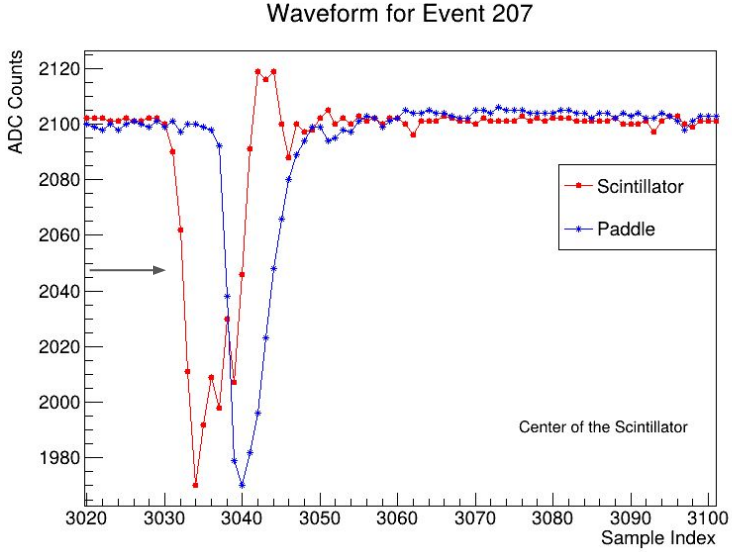

Waveform for Event 1850
ADC Counts
Sample Index
Scintillator
Paddle
Center of the Scintillator

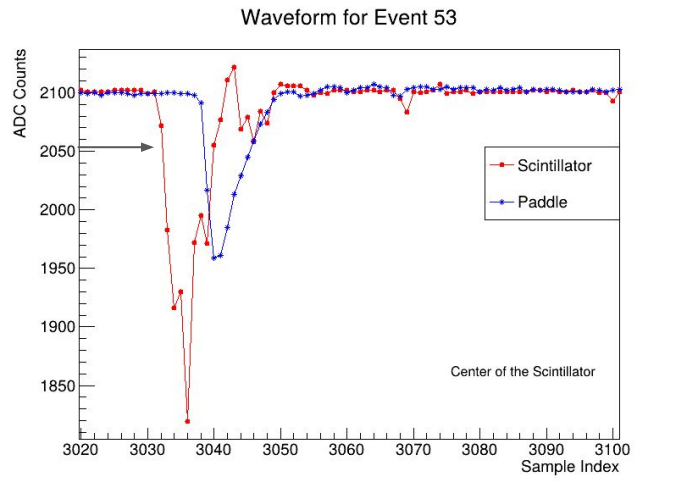

Waveform for Event 563
ADC Counts
Sample Index
Scintillator
Paddle
Center of the Scintillator

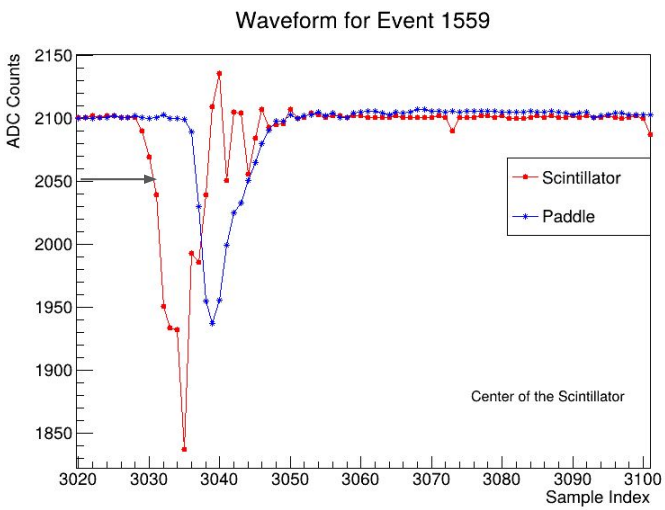

Waveform for Event 1223
ADC Counts
Sample Index
Scintillator
Paddle
Center of the Scintillator

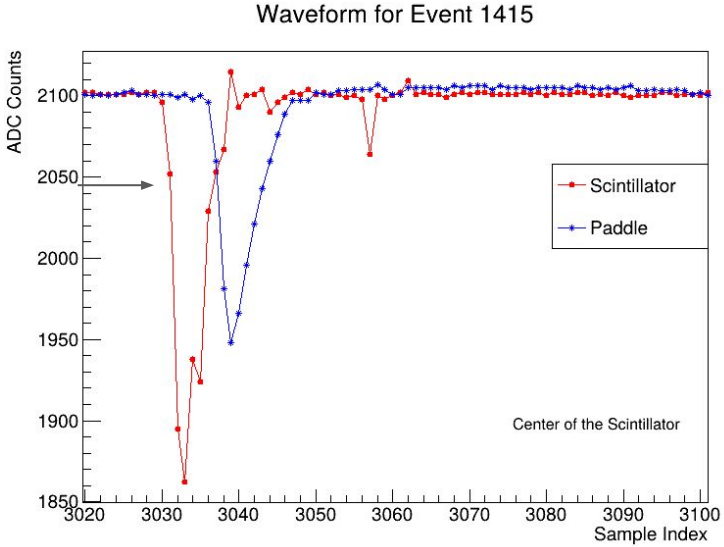

Waveform for Event 1830
ADC Counts
Sample Index
Scintillator
Paddle
Center of the Scintillator

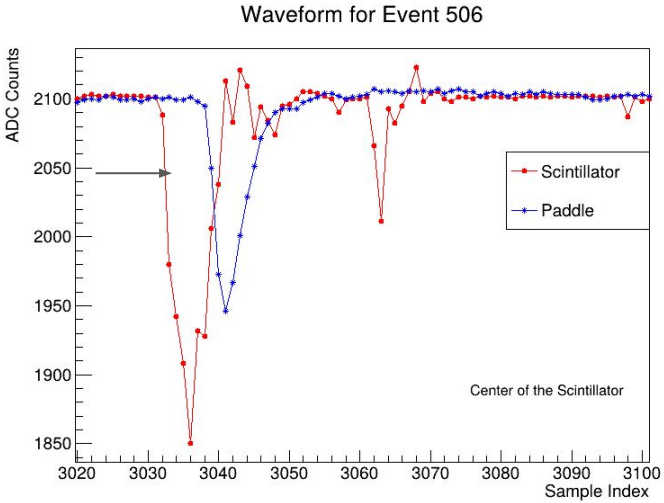

Waveform for Event 26
ADC Counts
Sample Index
Scintillator
Paddle
Center of the Scintillator


Waveform for Event 207
ADC Counts
Sample Index
Scintillator
Paddle
Center of the Scintillator


Waveform for Event 53
ADC Counts
Sample Index
Scintillator
Paddle
Center of the Scintillator


Waveform for Event 1559
ADC Counts
Sample Index
Scintillator
Paddle
Center of the Scintillator


Waveform for Event 1415
ADC Counts
Sample Index
Scintillator
Paddle
Center of the Scintillator


Waveform for Event 506
ADC Counts
Sample Index
Scintillator
Paddle
Center of the Scintillator

Current Issue

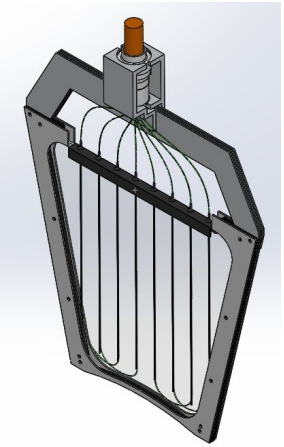
- Scintillation light from 8 fibers picks up a detailed structure of initial interaction and internally reflected light
- This effect adds uncertainty to timing resolution
- Major concern is at high noise experimental conditions, current timing resolution could further degrade due to how light is picked up by fiber set.
    - **Not sure how much more PEs we need to overcome this effect?**

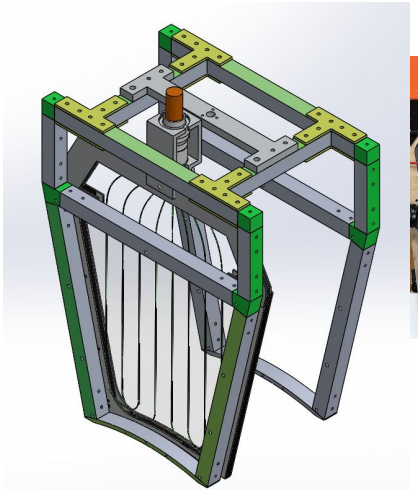
How to Proceed

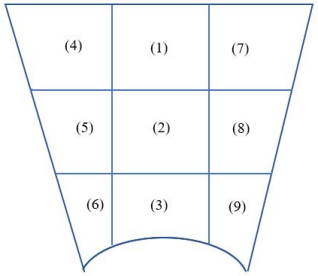
- **With Cosmics we get about 2.8 ns timing resolution (CAEN V1720 sample size is 4 ns) at 99% efficiency**
  - **No pulse amplification**
  - **This is with PMT at -900 V can we can up to -1100 V**
- What is acceptable for the experiment?
- Can a trigger algorithm like fitting algorithm improve to the timing?
- As a contingency we are going to have a Light guide design ready?
  - Due to space constraints, we may need dual light guides on the top of the scintillator with two PMT
  - In communication with Eljen to get parts for lighguide based prototype
- Explore adding more fibers to smooth out the pulse structure and increase light yield
- Currently we use Kuraray Y-11 1.3 mm fibers,
  - Go to 2 mm fibers to increase yield
  - Try different fiber vendor that minimizes the effects we see from Y-11
- Any suggestions?

Backups

Prototype production model







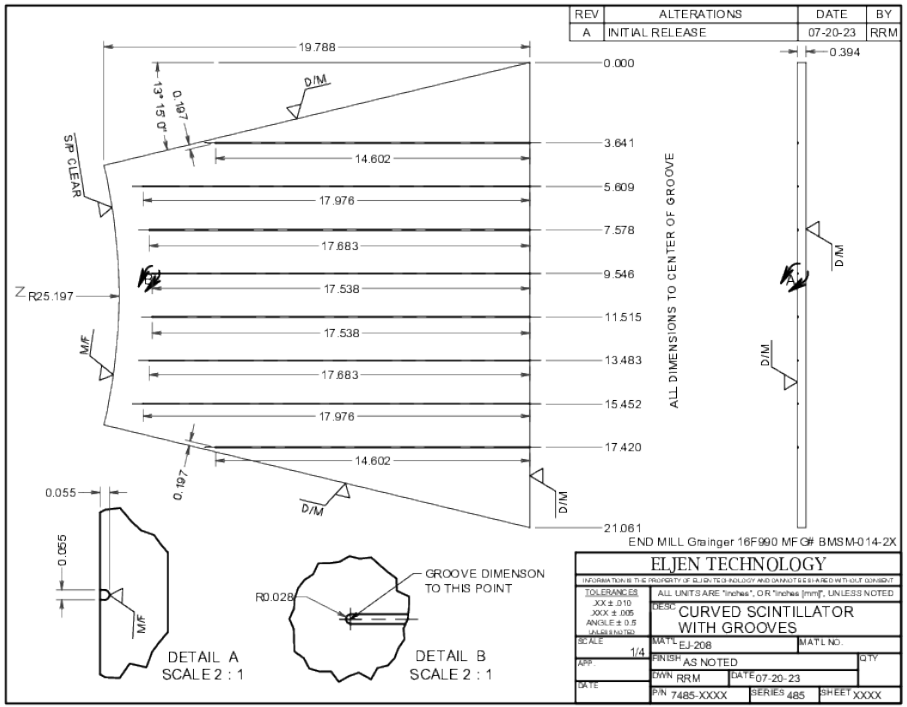
Different testing positions

Efficiency and timing resolution results

Position	Efficiency for > SPE (%)
1	100.00
2	99.87
3	99.80
4	99.02
5	99.83
6	99.96
7	99.83
8	99.43
9	98.03
Average	99.58

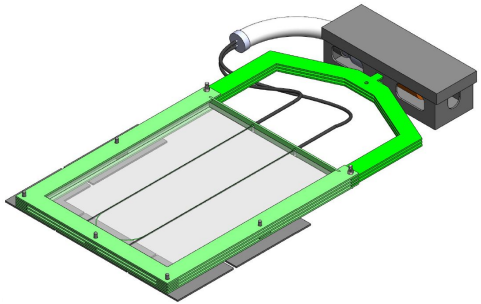
Final Design

- Curved scintillator model to fit in the tracking rotator
- 8 WLS fibers
- Surface is diamond milled
- The grooves are circular and machine finished
- The bottom is sanded and polished
- Fibers will be glued to the scintillator grooves using optical glue EJ500
- Scintillator to be wrapped in 3M DF2000MA (over 99% reflective wrap for wavelengths relevant)

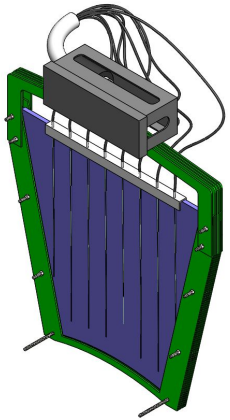


Scintillator design and progress

- 4 parts in the design
  - Scintillator
    - EJ-208
  - Mounting frames
    - G10 high pressure fiber glass
  - Wavelength shifting (WLS) fibers
    - Kurary Y-11
  - Photo-Multiplier Tube (PMT)
    - Et-enterprises 9181SB
- Optical cement to hold WLS fibers in the scintillator
  - EJ-500
- We developed and tested two prototypes



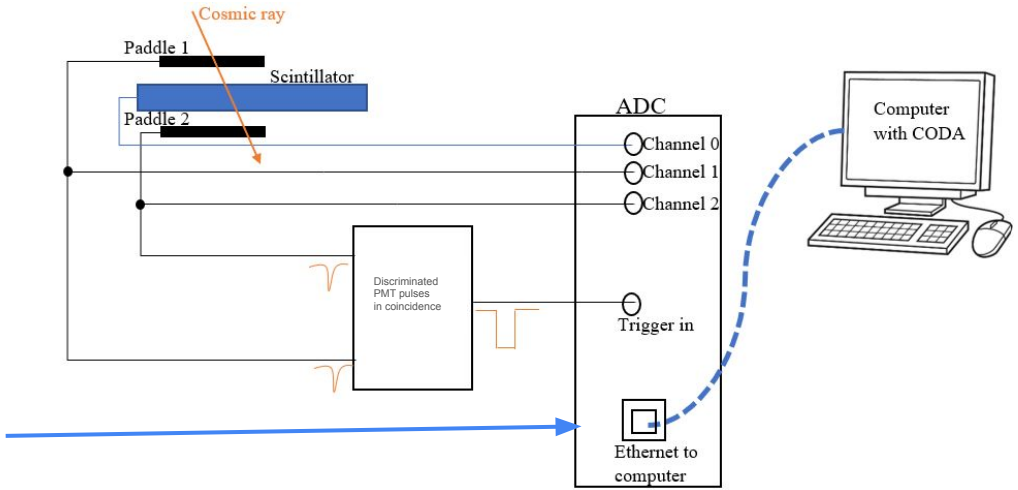
Initial prototype *SolidWorks* model and constructed model



Final prototype *SolidWorks* model and constructed model

Trigger Setup

CAEN, Module V1720,
8 channel 12 bit - 250 MS/s



Schematic of the cosmic ray testing setup