Coordinate Detector Commissioning:
Study of Crosstalk

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How do we perform commissioning?

- Half module setup, 196 channels, 196 optical fibers, in 14 groups of stacked scintillating bars, 14 PMTs
  - Channels are oriented so that thin side of paddles face upwards
  - Allows for vertical tracks of cosmic rays to occur in individual channels without interacting with other channels
- How do we collect data?
  - Use coincidence setup with two trigger scintillating paddles above and below detector
  - Triggers act as a gate in which ADC data is recorded to increase counting rate
- How do we observe crosstalk?
  - Use multichannel oscilloscope connected to signal output for ADC and TDC
  - We can count events to verify analysis by using rough approximation of crosstalk percentages

What is crosstalk?

- Crosstalk is undesirable artificial correlation between signals in different channels of the detector. This parasitic correlation is caused by undesirable affects which lead to problems in the data.

What is the concern?

- We want to know which are the real signals and which are not and in which channel a real signal actually occurs.

Causes of Crosstalk

1. Displacement of fibers in relation to PMT, leads to optical leak of photons into incorrect pixels
    - Can be corrected by precision alignment which can be done since optical fiber is 2 mm and pixel area is 4x4 mm
2. Close proximity of fibers to each other, leads to leaking of photons between fibers
    - Can be corrected by improving system to include sleeves between fibers to avoid contact
3. Electrical crosstalk, caused by capacitive coupling in PMT between individual channels

Study of Probability of Crosstalk

- Utilize ADC data to define unambiguously good event
  - Good event – high ADC signal in main channel, high TDC signal in main channel, low ADC signal in adjacent channels
  - Crosstalk event – high ADC signal in main channel, high TDC signal in main channel, low ADC signal in adjacent channels, high TDC signal in any other channel
- Used number of crosstalk events over total events to get crosstalk percentages between channels

Results of Study on Probability of Crosstalk

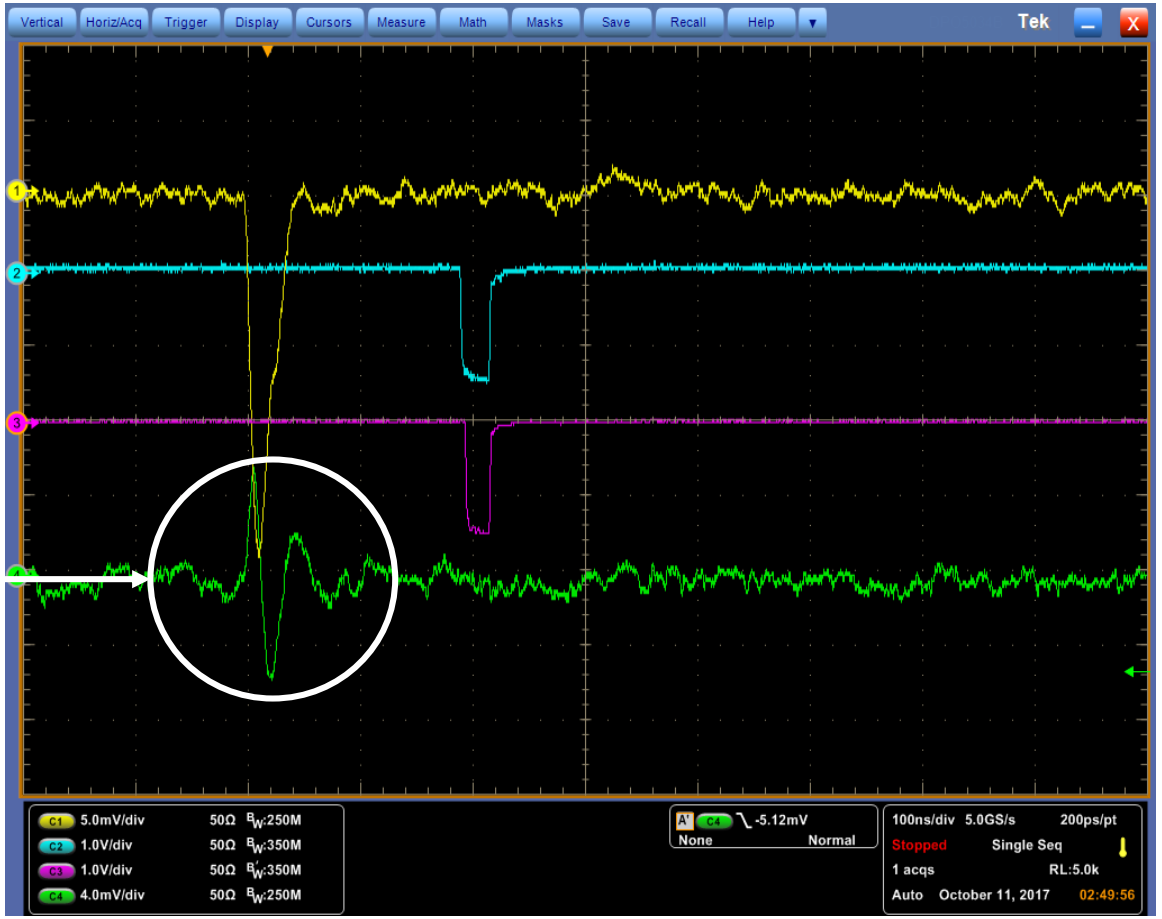
1. Probability increases with HV and varies between PMTs and channels

2. Crosstalk for many channels are high (> 10%) so needed to investigate further on how to remove significant amounts of crosstalk

3. Next step involves utilizing TDC data to remove crosstalk events

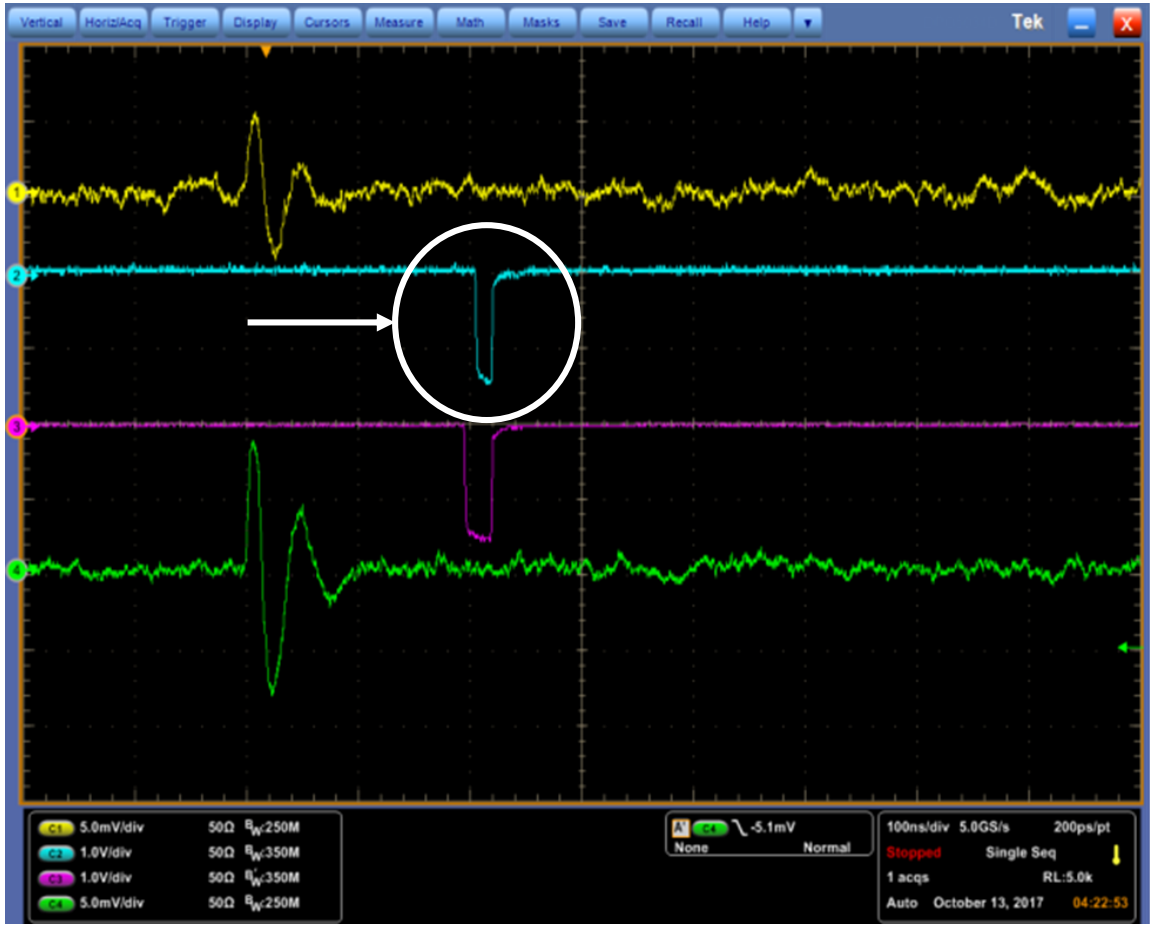
Oscilloscope Observations

- What does a normal event look like?
  - Uni-polar negative ADC signal with corresponding TDC
- What does a crosstalk event look like?
  - Bi-polar ADC signal with corresponding TDC
- Means we can distinguish crosstalk event by small ADC signal



Oscilloscope Observations

- We can also distinguish crosstalk event based on TDC signal width
- Observed many crosstalk events have shorter TDC signal widths

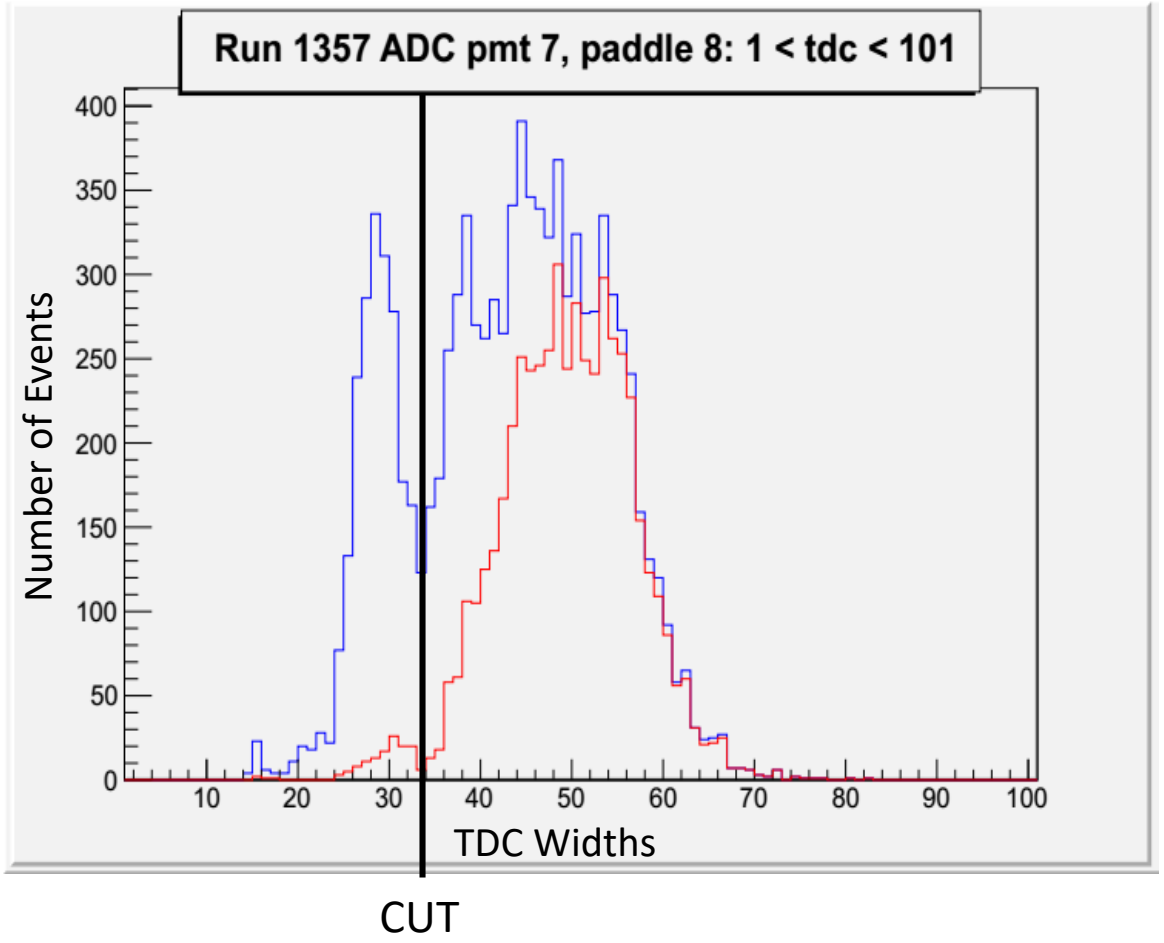


Study of Crosstalk Reduction

- Utilize TDC data to define unambiguously good event
  - Good event – high TDC signal in main channel, high ADC signal in main channel
  - Crosstalk event – high TDC signal in main channel, low ADC signal in main channel
- Used number of crosstalk events over total events to get crosstalk percentage for main channel

How do we determine TDC width cut?

- Plot difference between TDC leading edge and TDC trailing edge
  - Blue – All TDC widths
  - Red – TDC widths w/ high ADC Signals (“good events”)
- Found large spike at lower TDC widths representing a large portion of crosstalk events



Example of Percent Crosstalk Reduction

- PMT 1, HV = 725V
- Results show large reduction of crosstalk across all channels
- This is not a physical solution, only an analytical solution

Channel #	Before TDC Width Cut	After TDC Width cut
0	6.24%	1.66%
1	6.81%	1.87%
2	6.32%	1.70%
3	-	
4	-	
5	2.97%	0.43%
6	7.22%	1.86%
7	10.50%	2.63%
8	9.38%	2.03%
9	3.80%	0.70%
10	3.64%	0.39%
11	8.67%	2.15%
12	14.74%	4.61%
13	3.18%	0.68%
14	6.78%	1.45%
15	10.01%	2.78%

What are we currently doing?

- Continuing with study on every channel in half module setup
- Writing up documentation which summarizes the study
- Plan on final completion of study in January 2018, ready for presentation of results at Winter Collaboration Meeting in February

What experience was gained?

- Further understanding of crosstalk, its negative affect on data, how to identify crosstalk in data, and how to reduce crosstalk