Investigating Cross-Talk Between MicroBooNE Photomultiplier Tubes (PMT) and Wire Planes

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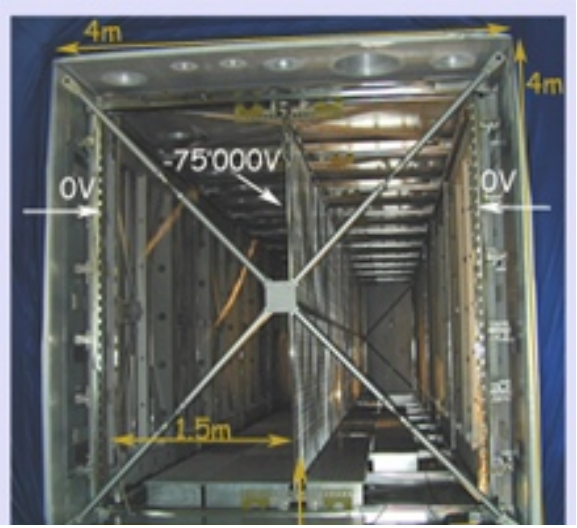
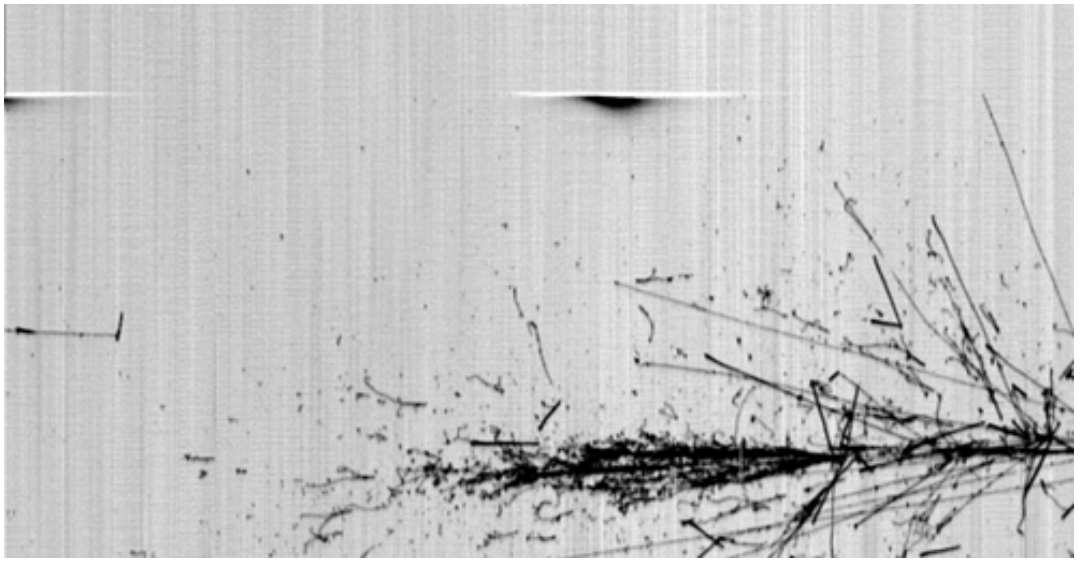
Outline

- Cross-talk seen by other experiments
- Our setup
- Cross-talk observed
- Shielding

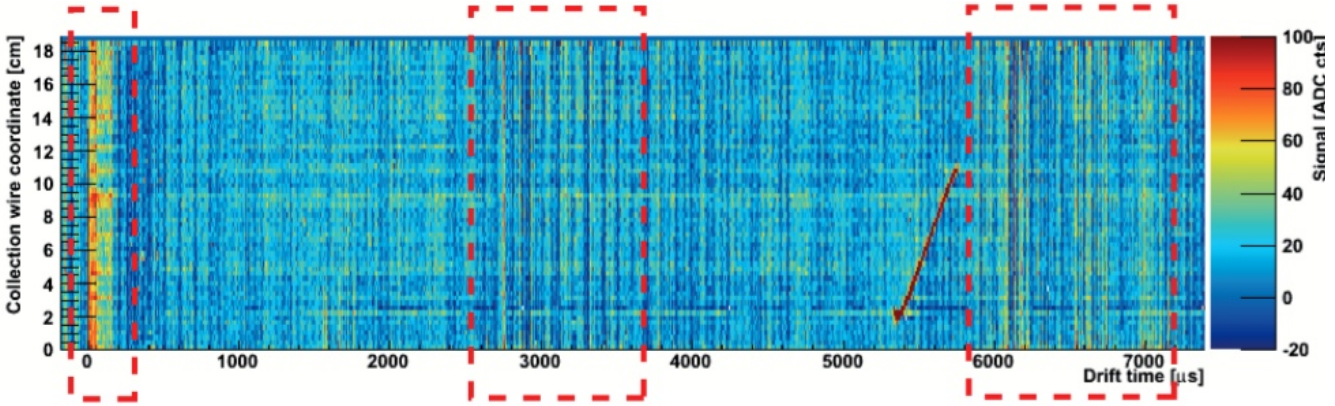
Cross-Talk Seen by ICARUS





- Signal seen on wire-plane near PMTs
- Seen on collection plane, but not induction planes
- Negative PMTs 5mm from wire plane

Cross-Talk Seen by Bern Argontube



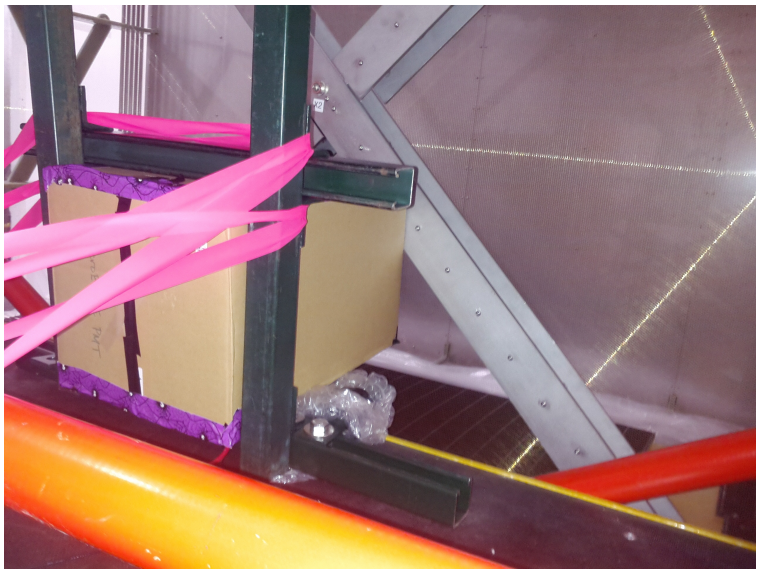
- Also seen by Argontube test group at Bern
- Single wire plane

Hypotheses

- RF Pulse
  - Electrons moving inside PMT send RF signal
  - But would expect to see on induction and collection planes in ICARUS
  - Would fall as 1/r^2
- Capacitive Effect
  - Would fall as 1/r

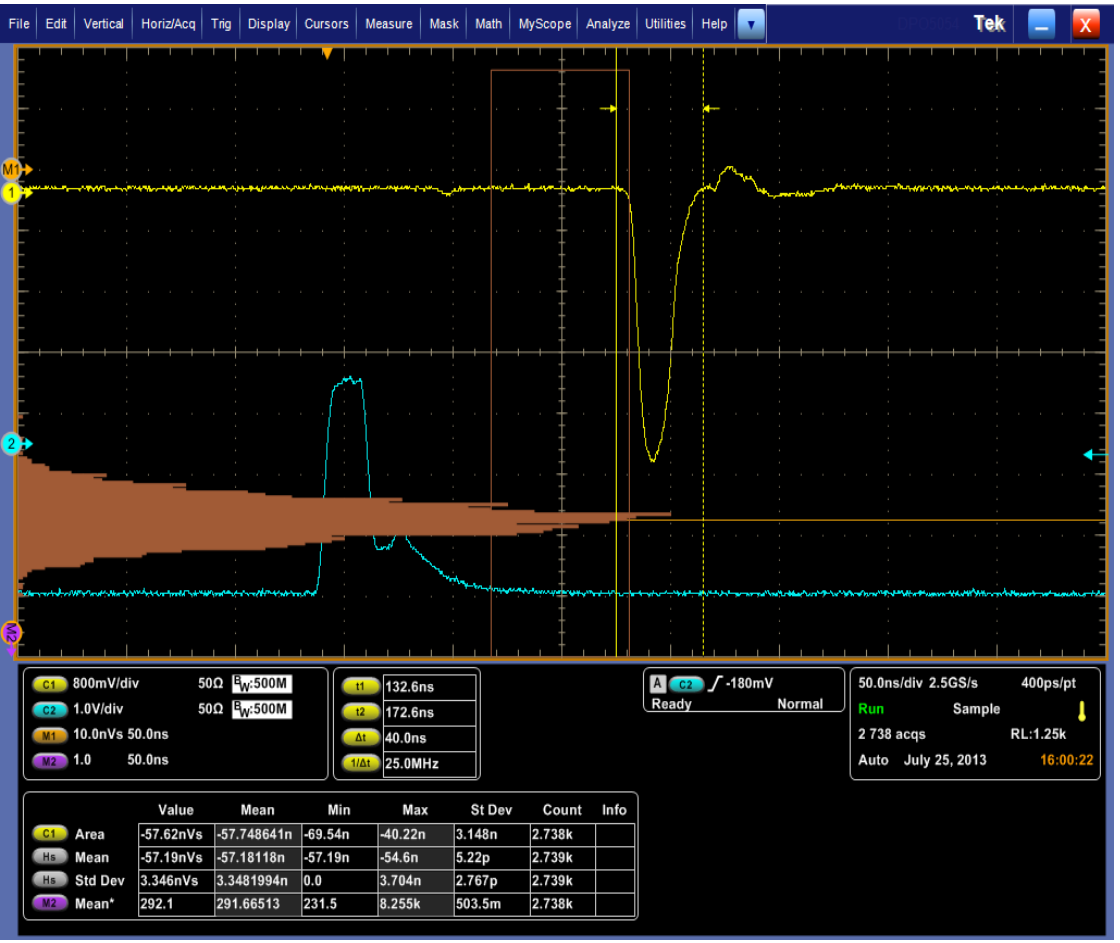
Set-Up

- MicroBooNE PMT inside darkbox held by unistrut frame
  - Optical fiber attached to LED pulser feeds into darkbox
  - LED pulser triggered by MRT
- Read out wire signal around trigger from MRT
- Systematic errors from background noise, #PEs,



Set-Up

Set-up: Examining PMT pulse



Pulse Area Histogram

$\mu = N_{pe} \times \text{gain} \times \text{electron charge} \times 50\ \Omega$

$\sigma = \text{sqrt}(N_{pe}) \times \text{gain} \times \text{electron charge} \times 50\ \Omega$

Values of Interest

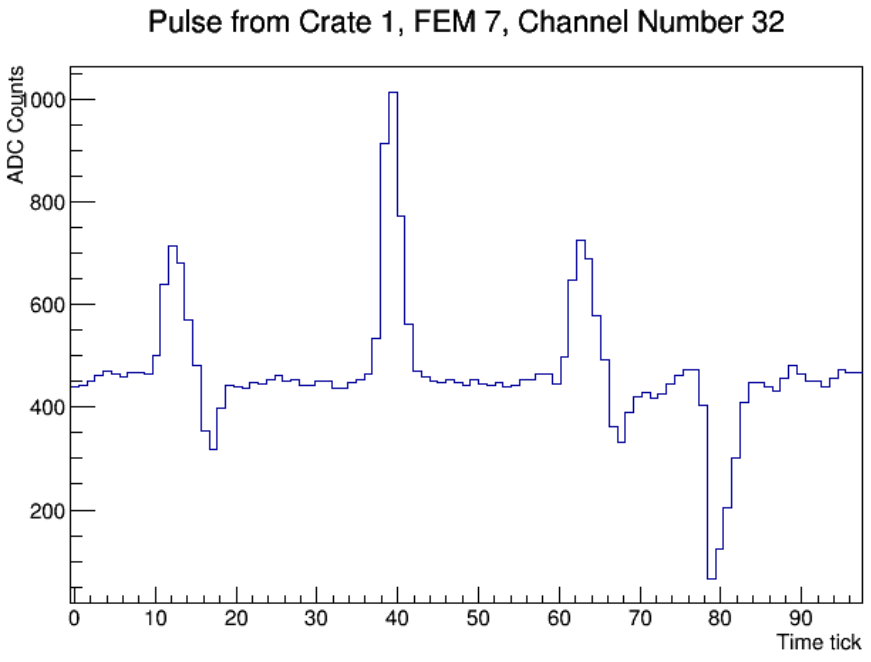
$N_{pe} = (\mu/\sigma)^2$

Gain = $\sigma^2/\mu * 1/(\text{electron charge} * 50\ \Omega)$

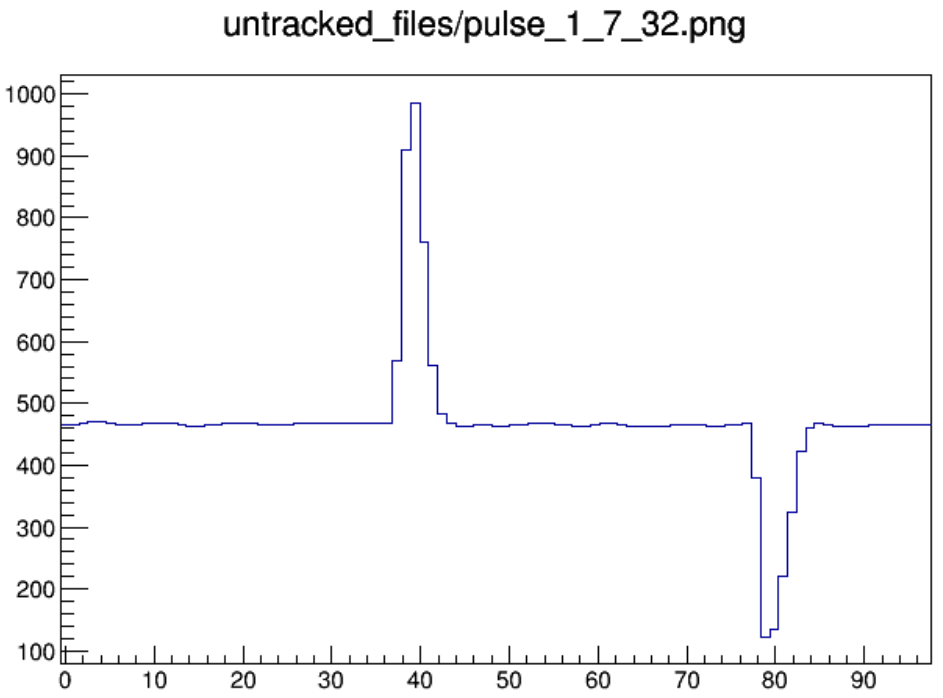
- Can adjust DC offset of LED pulser trigger to vary number of photoelectrons
- Area of PMT pulse corresponds to current at anode

Set-Up: Looking at Wires

- Put test pulses on wires
  - Trigger comes in at count 33



Single Event

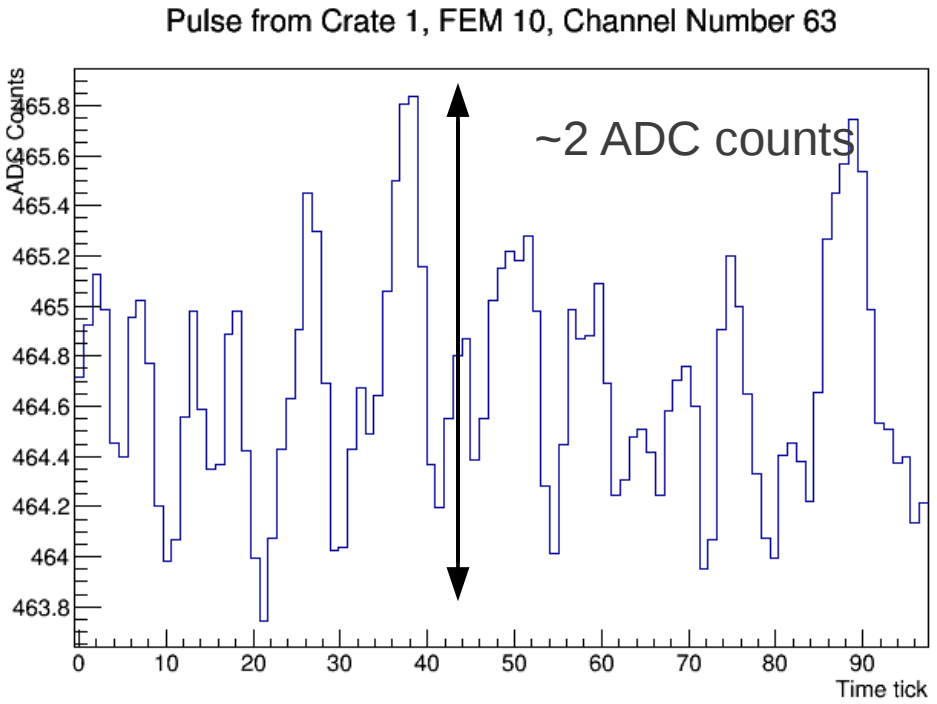


Averaged over 10k events

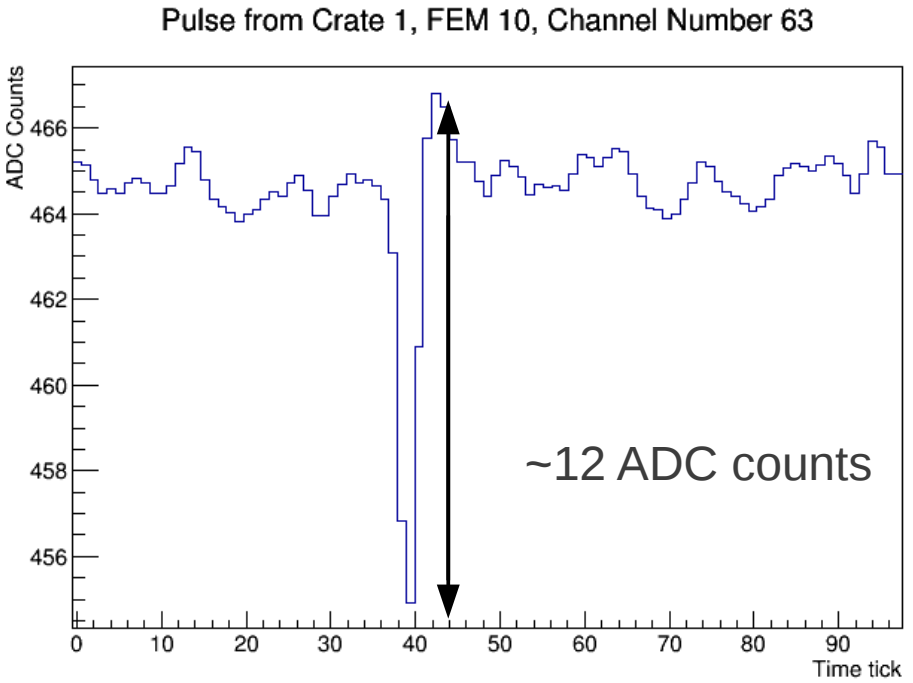
Cross-Talk Signal Observed

- Wire signal on y plane in front of PMT, averaged over 10k events
- PMT bulb 5” away, similar to µB PMT distance, considering dielectric of LAr (1.6) vs air, mu-metal off
- Ran at 1.4 kV, ~400 pe (high end of what we expect to see when running)
- For reference: expect MIP signal to be ~30 ADC counts
- Note differenced in y scale between the two plots

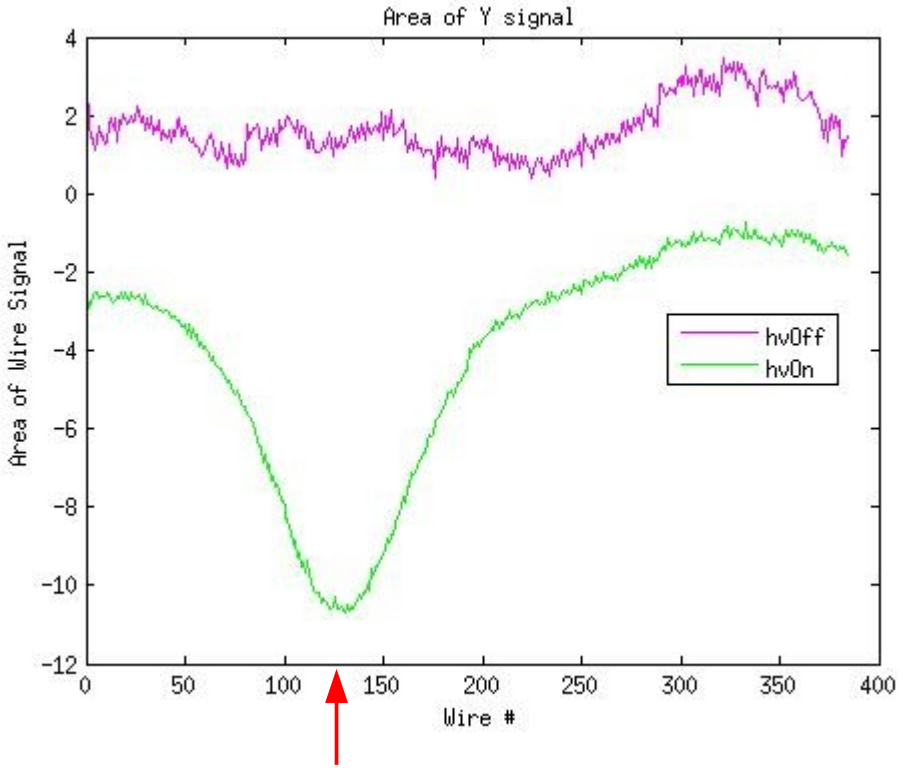
No Pulse from LED (PMT on)

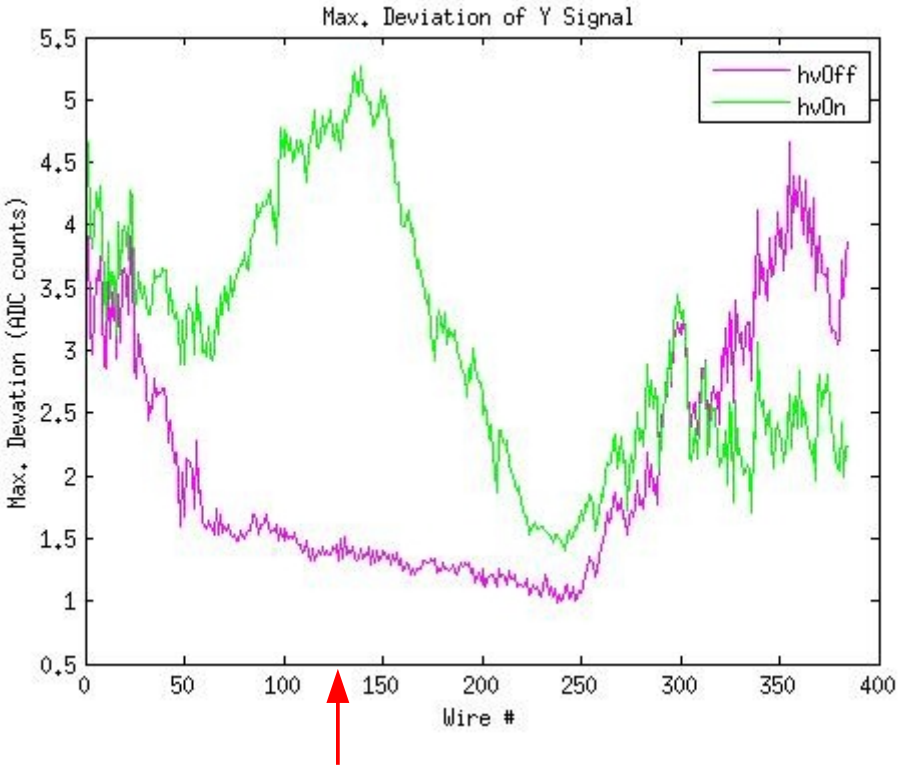


With LED pulse



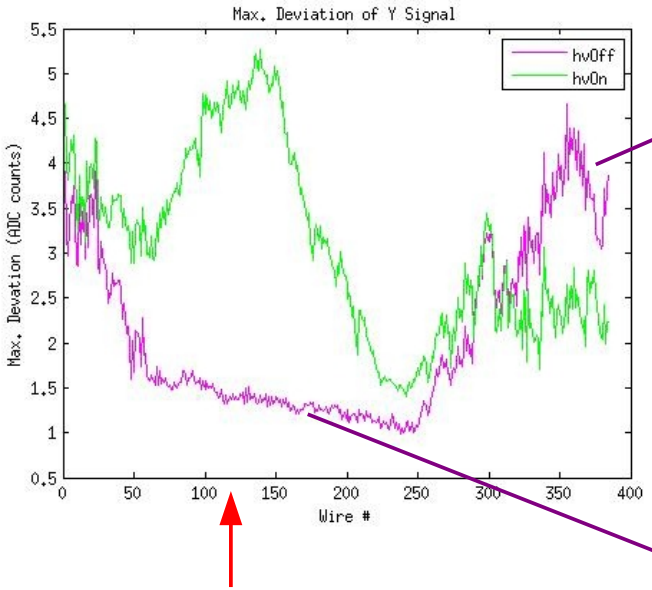
Spacial Distribution of Cross-talk



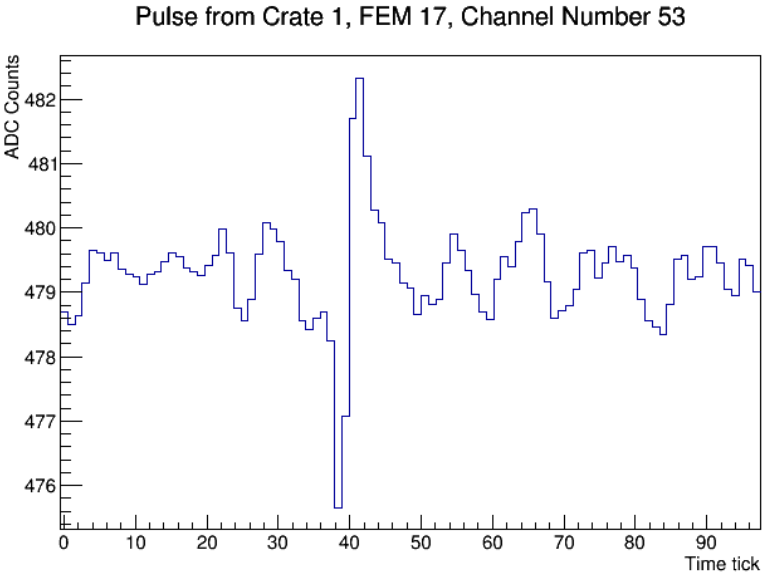


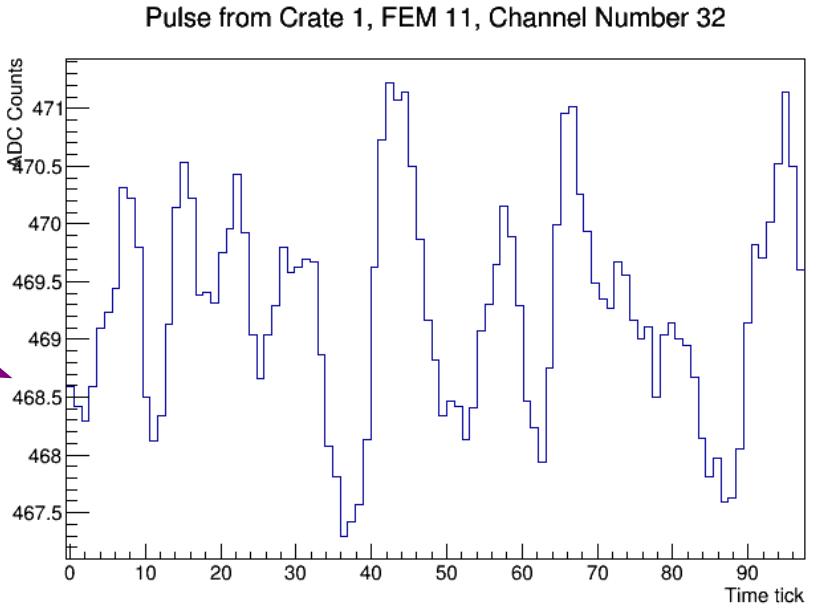
- HV 1.4kV, PMT 5” from wires, ~120 pe, mu metal shield on
- Mu-metal on
- Area: sum of wire signal at time counts 38, 39, 40 (around peak of pulse)

Spacial Distribution of Cross-Talk



Location of PMT





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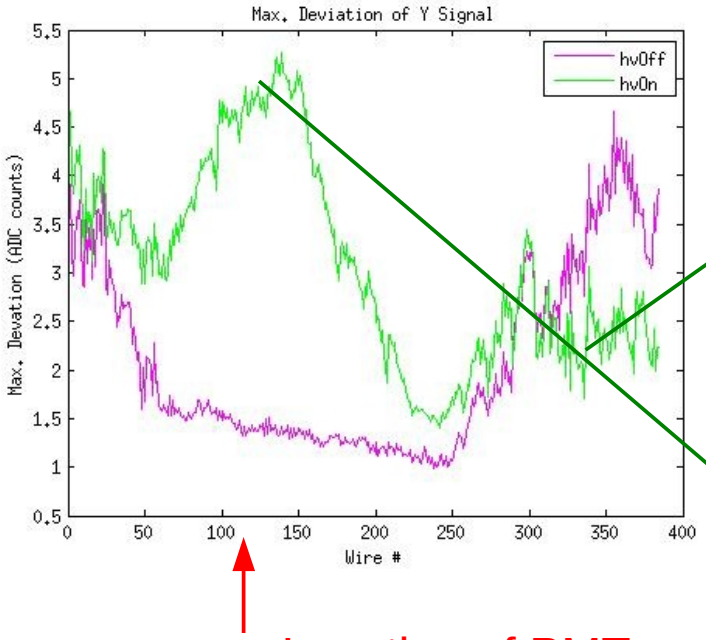
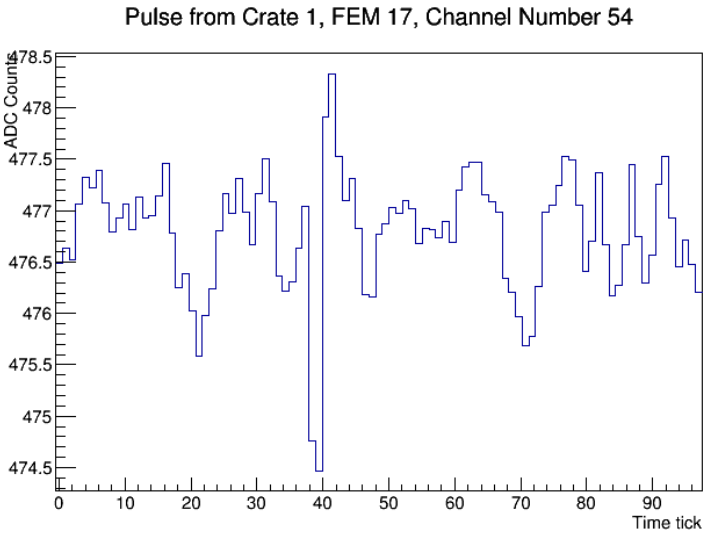
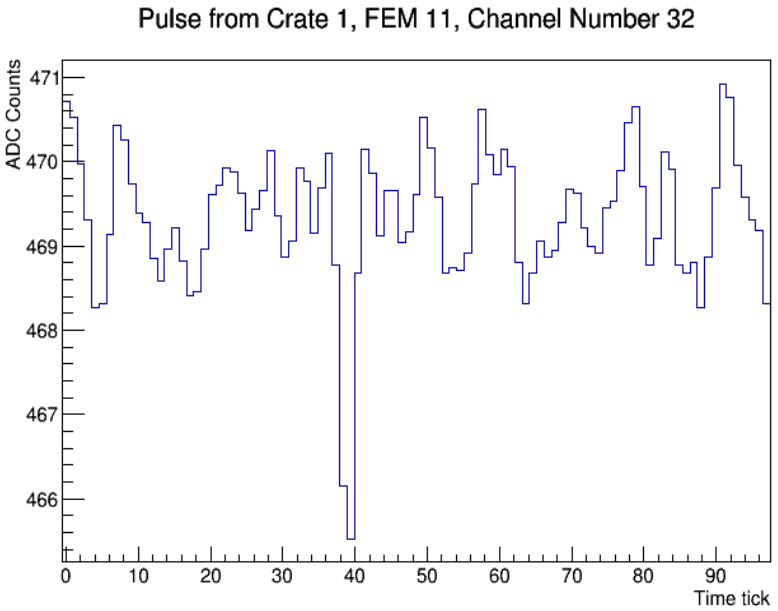
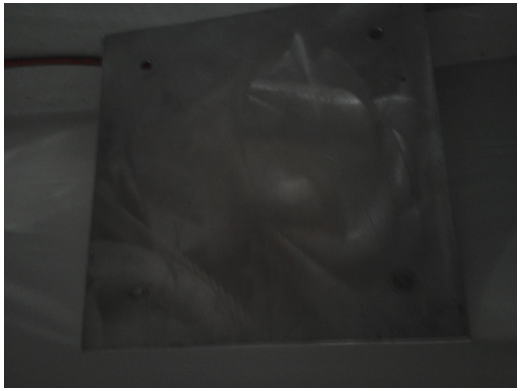




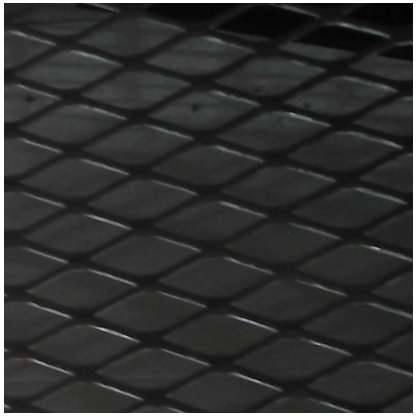


- HV 1.4kV, PMT 5” from wires, ~120 pe, mu metal shield on

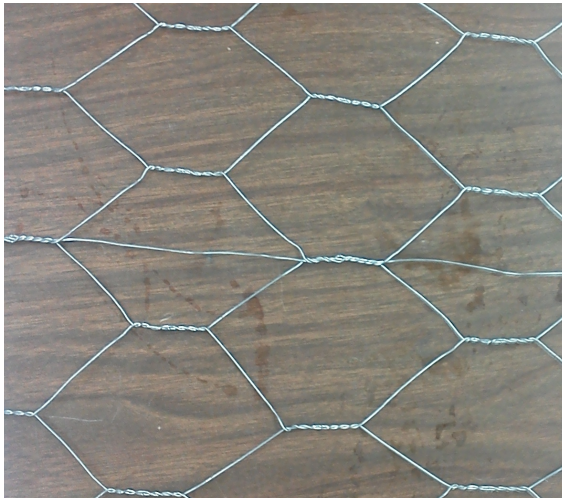
Shielding Types



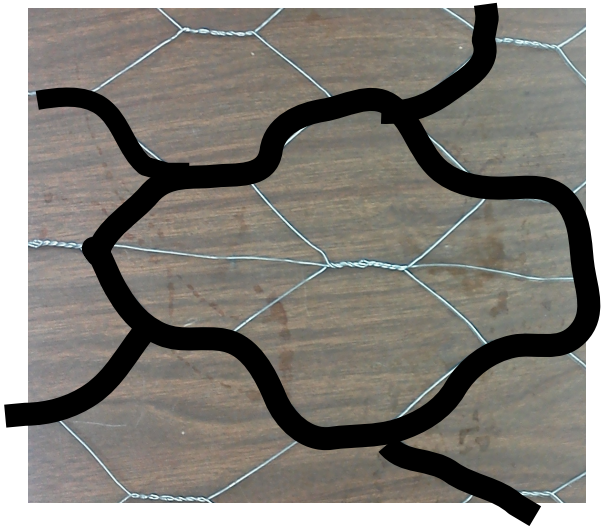
Solid Plate



Heavy Mesh

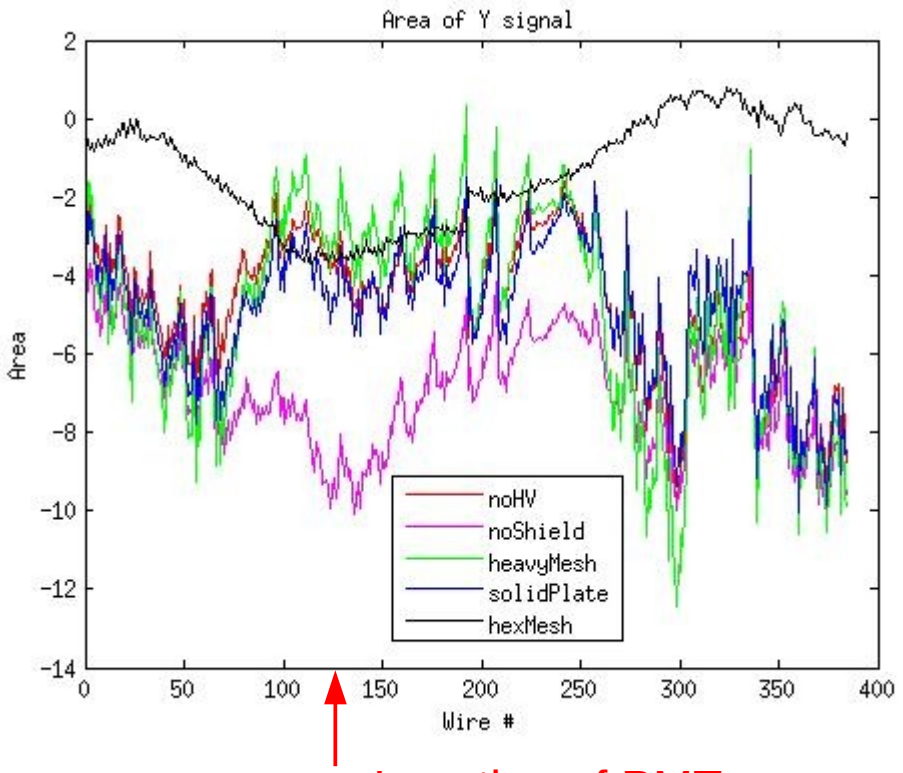


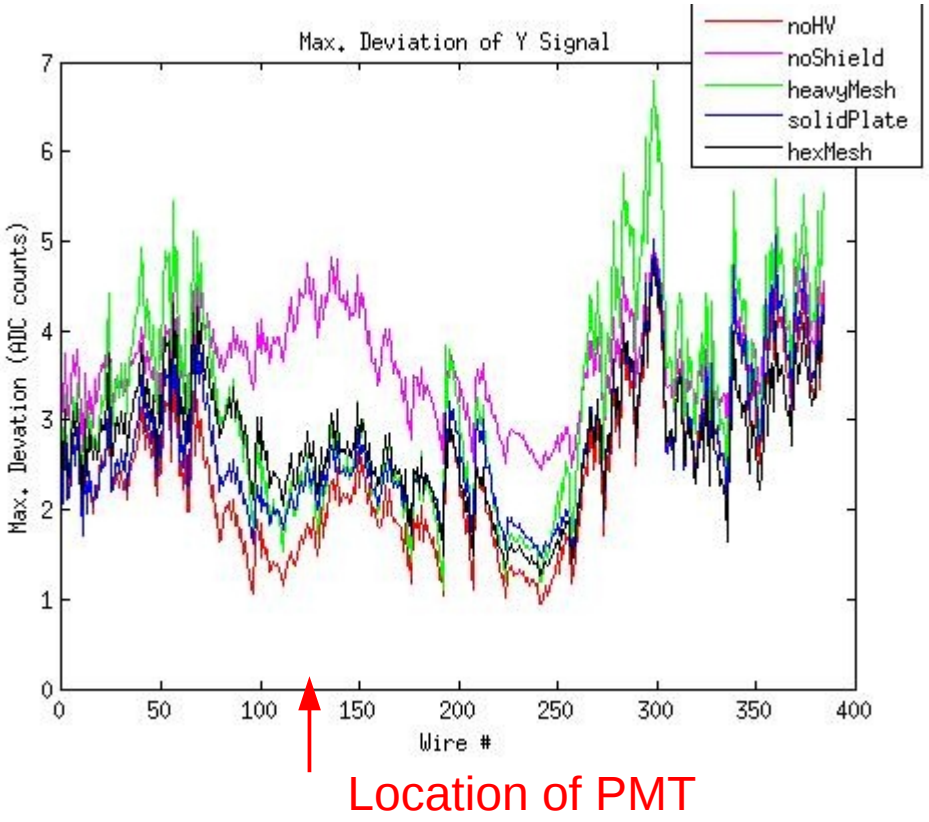
Hex Mesh (2” x 3” holes)



Modified Hex Mesh (4” x 6” holes)

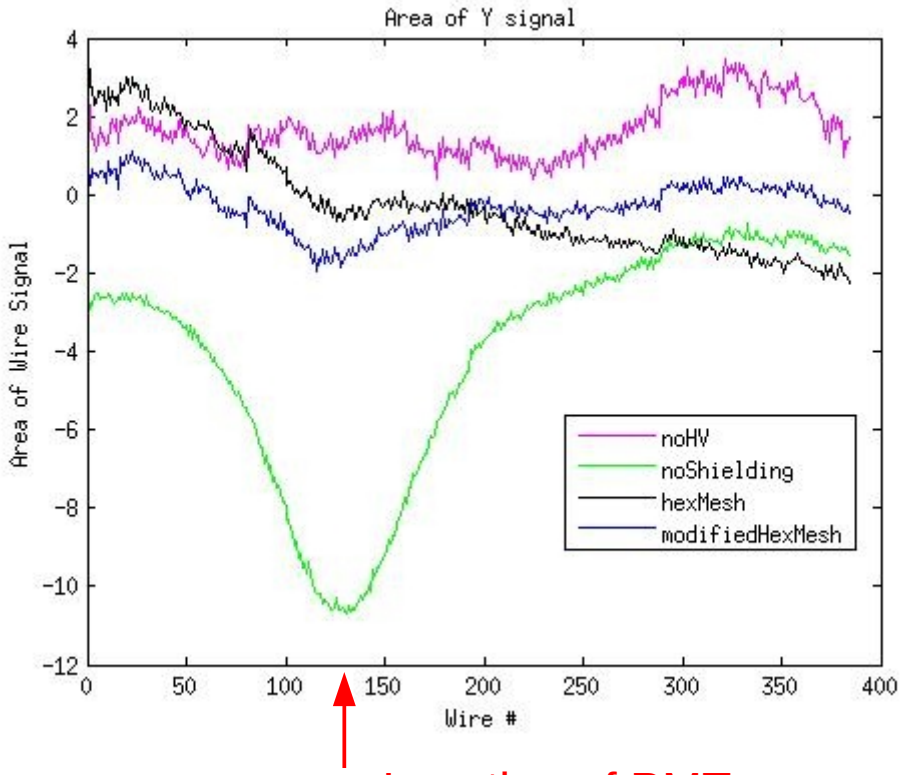
Shielding

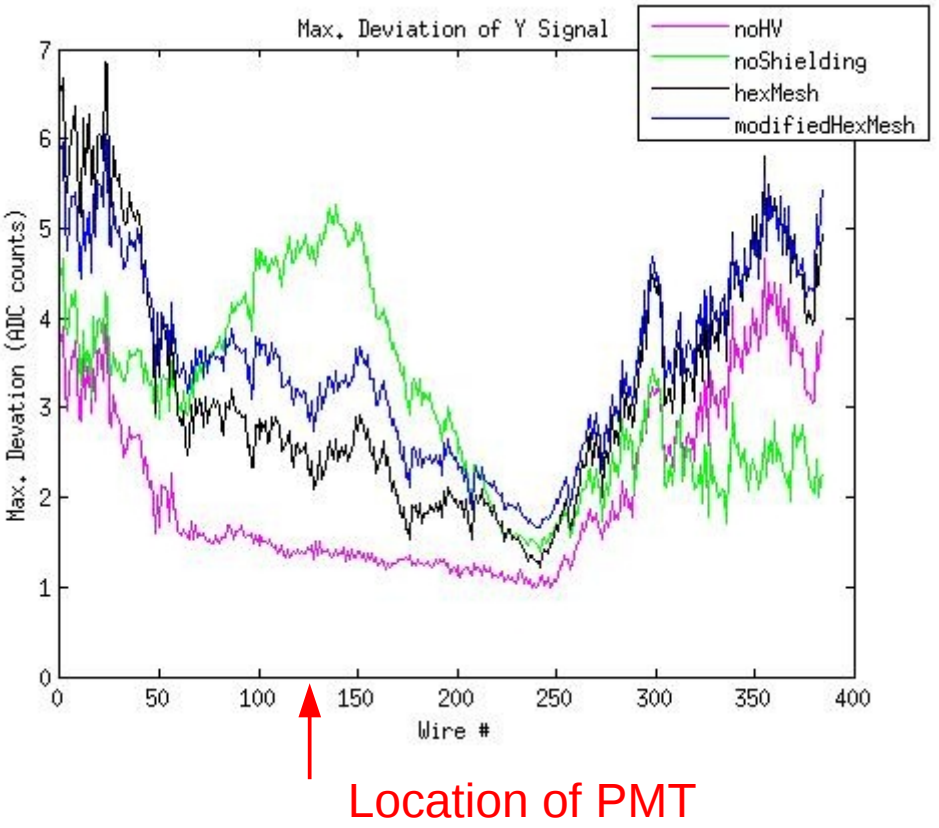




- Lighter hex mesh blocks signal as well as solid plate

More Shielding





- Modified hex mesh with bigger holes performs slightly worse than hex mesh
- Calculate that hex mesh will reduce PMT light by ~3%

Conclusions

- There is a cross-talk signal between MicroBoone PMTs and TPC wires
- In warm air, without bias voltage on wires, the size of this cross-talk is ~5 ADC with mu-metal shield
- Can use hex mesh to virtually eliminate cross-talk, in case size increases in LAr