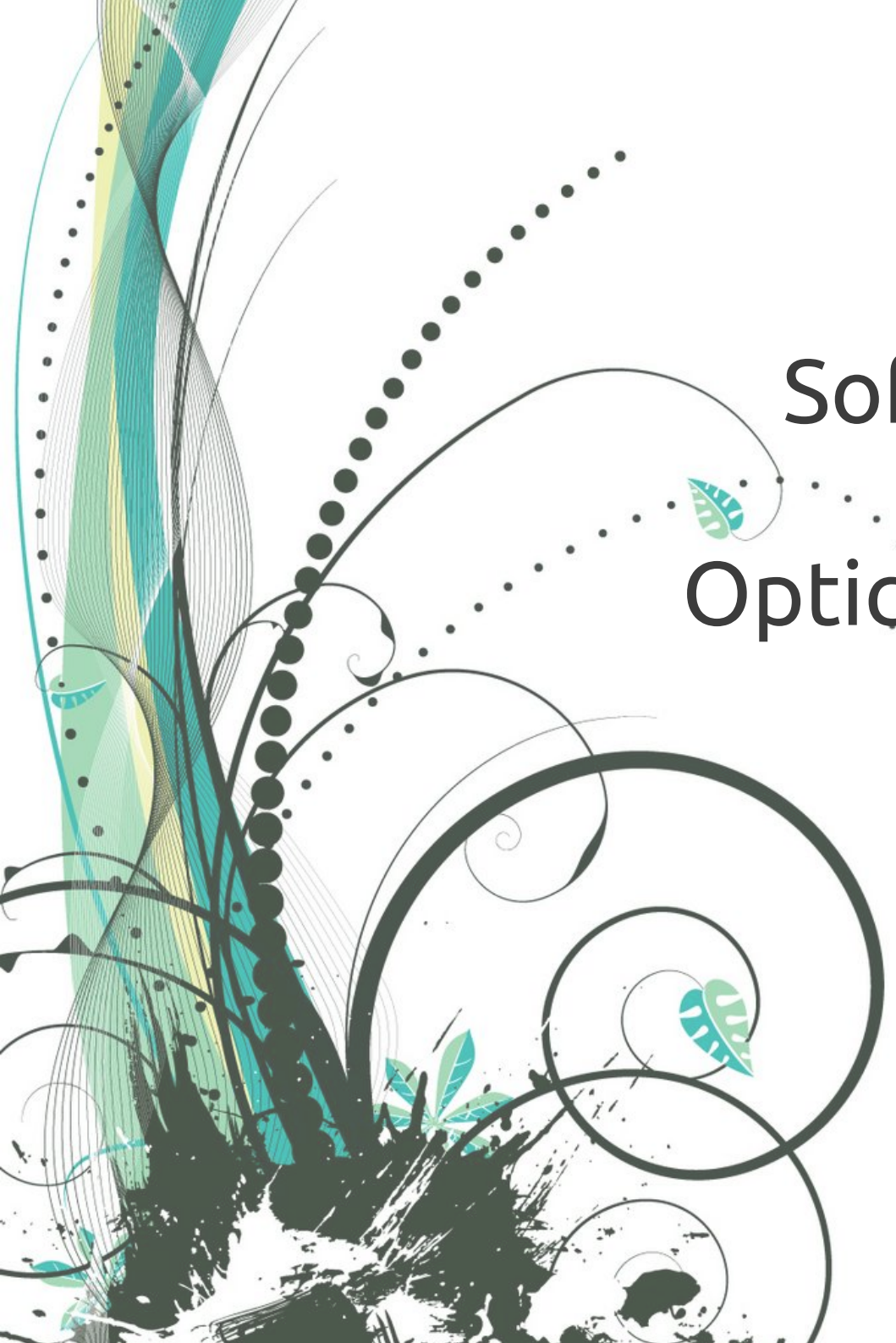
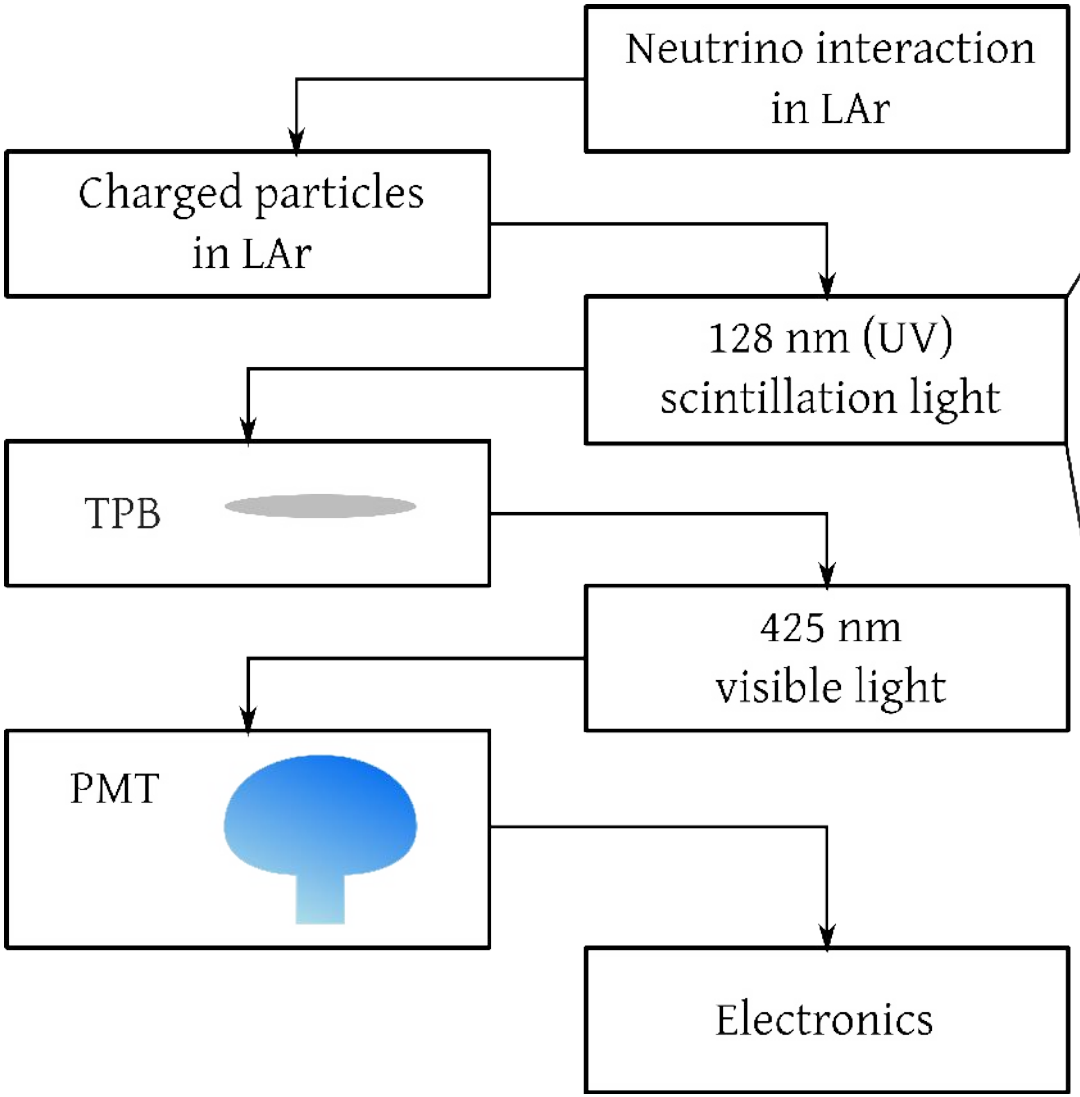


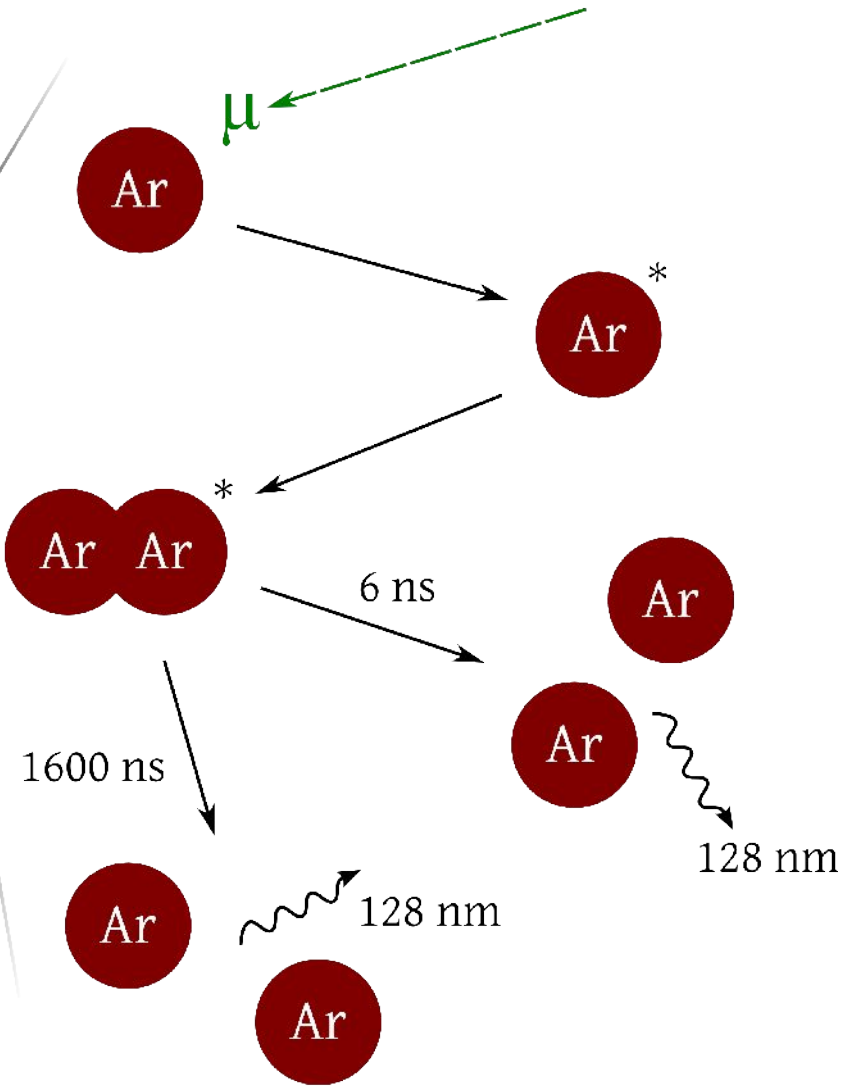
Hardware testing and Software development for the MicroBooNE Optical Detection System

Christie Chiu

August 3, 2012

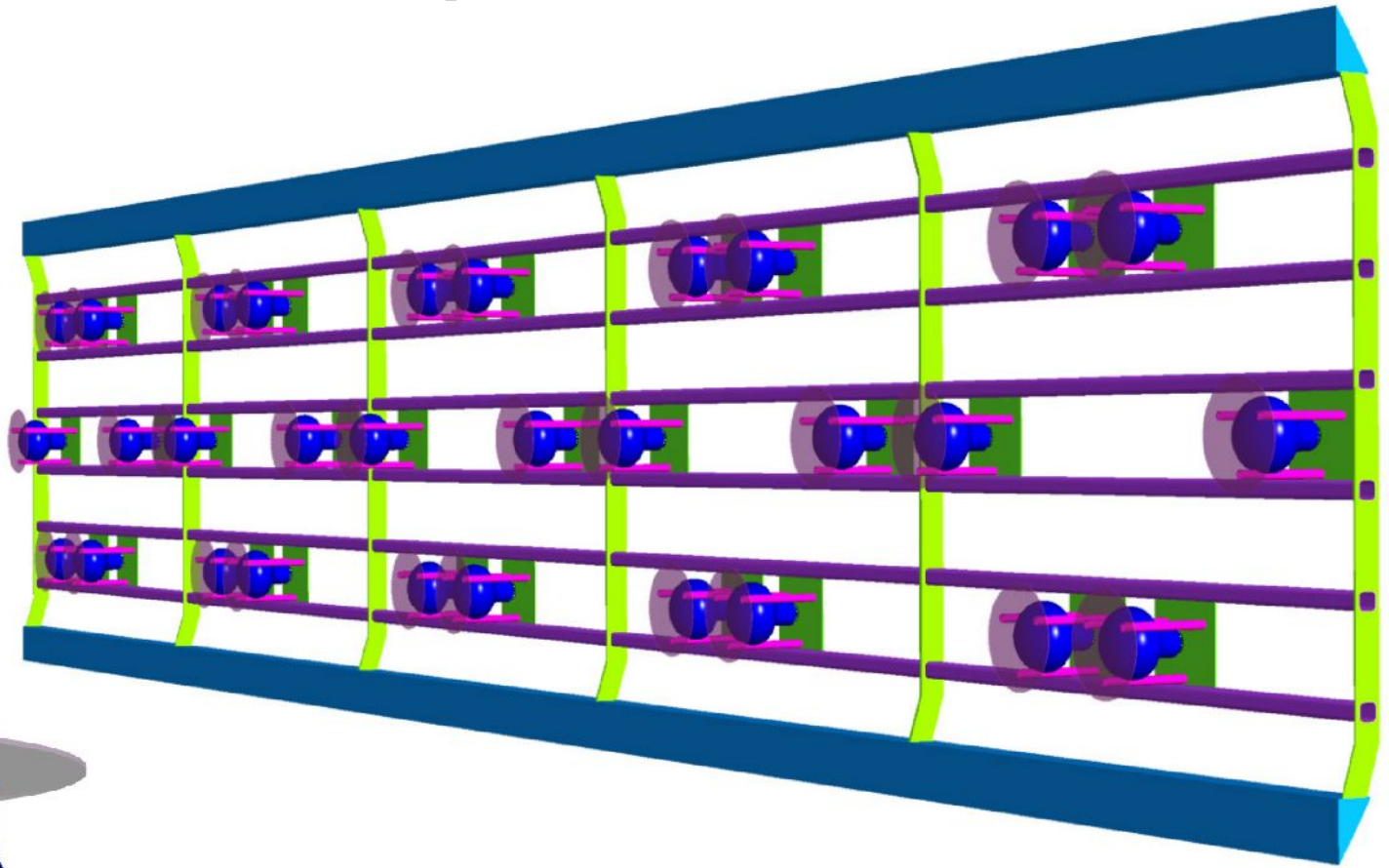
MicroBooNE Optical Detection

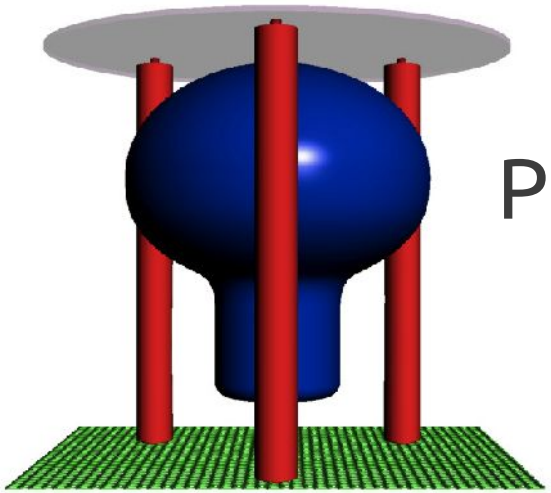




MicroBooNE Optical Detection

30 PMTs



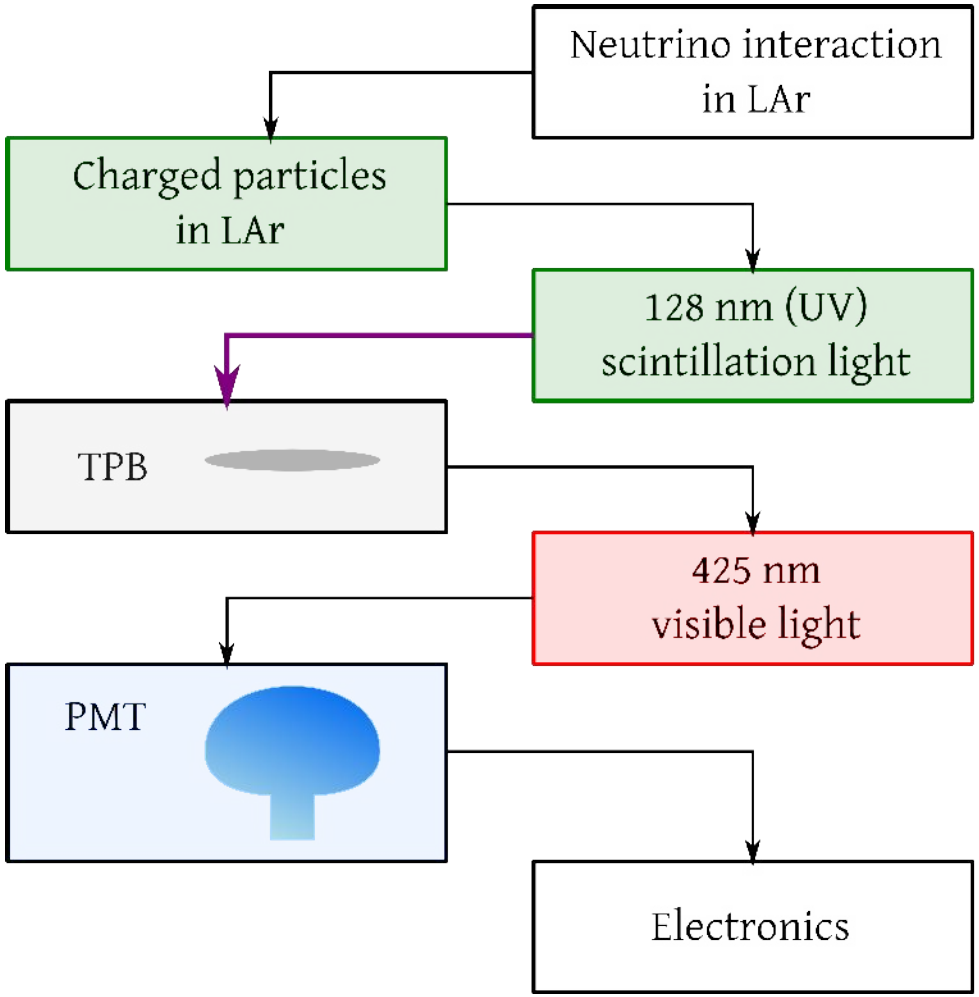


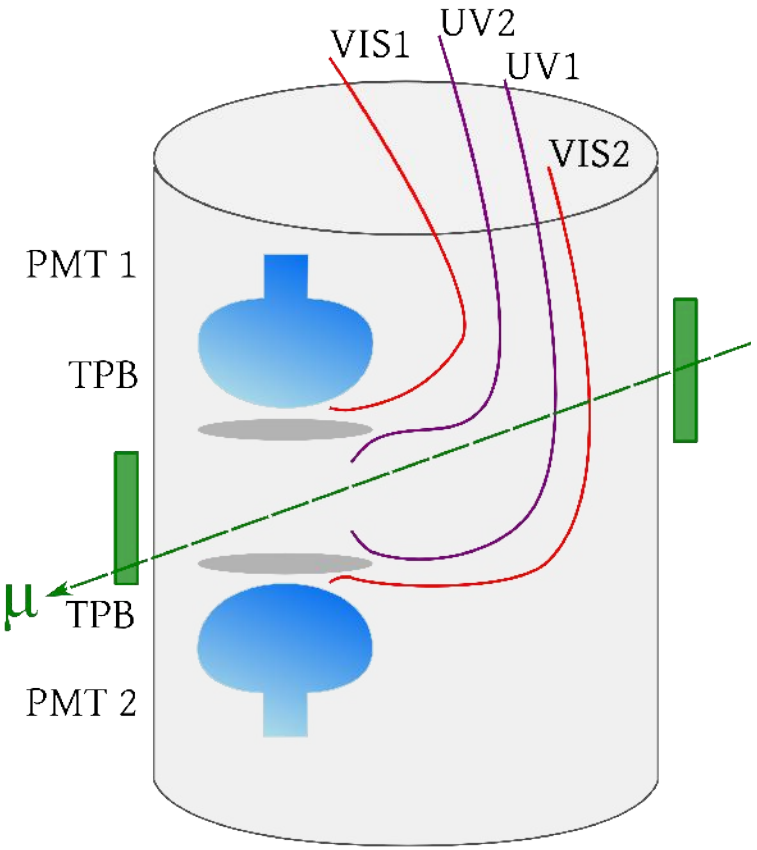
PMT module

Images courtesy of Tess Smidt

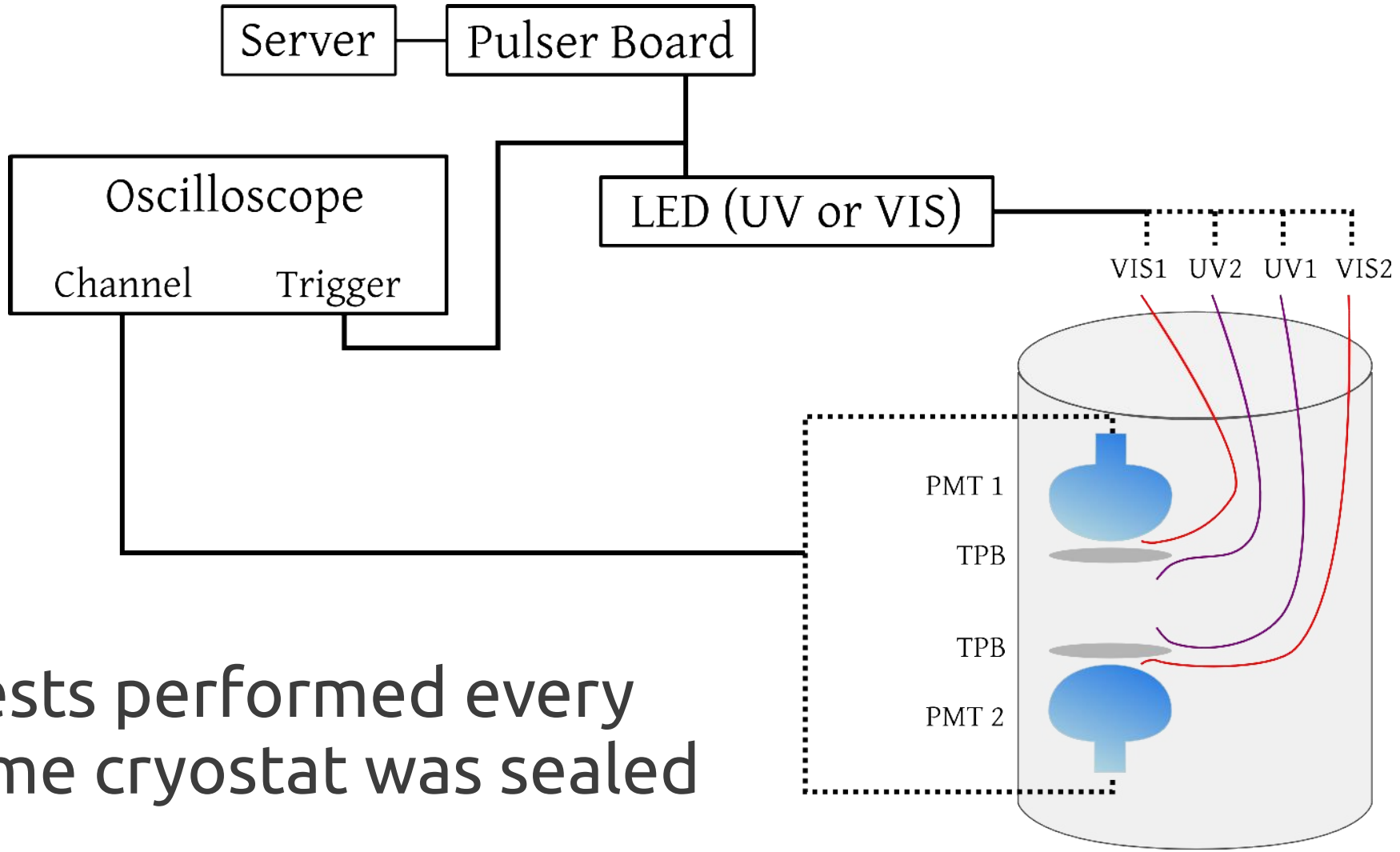
MicroBooNE Vertical Slice Test

Meet Bo


Neutrino interaction in LAr
Charged particles in LAr
128 nm (UV) scintillation light
TPB
425 nm visible light
PMT
Electronics

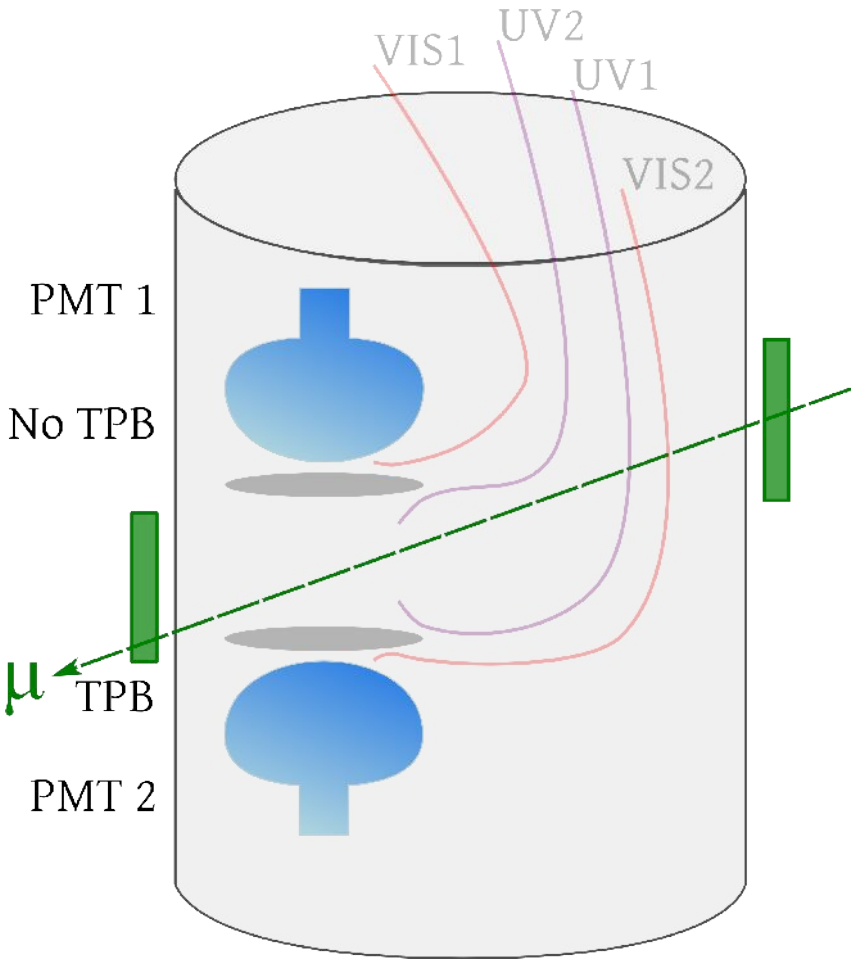

VIS1
UV2
UV1
VIS2
PMT 1
TPB
μ
TPB
PMT 2

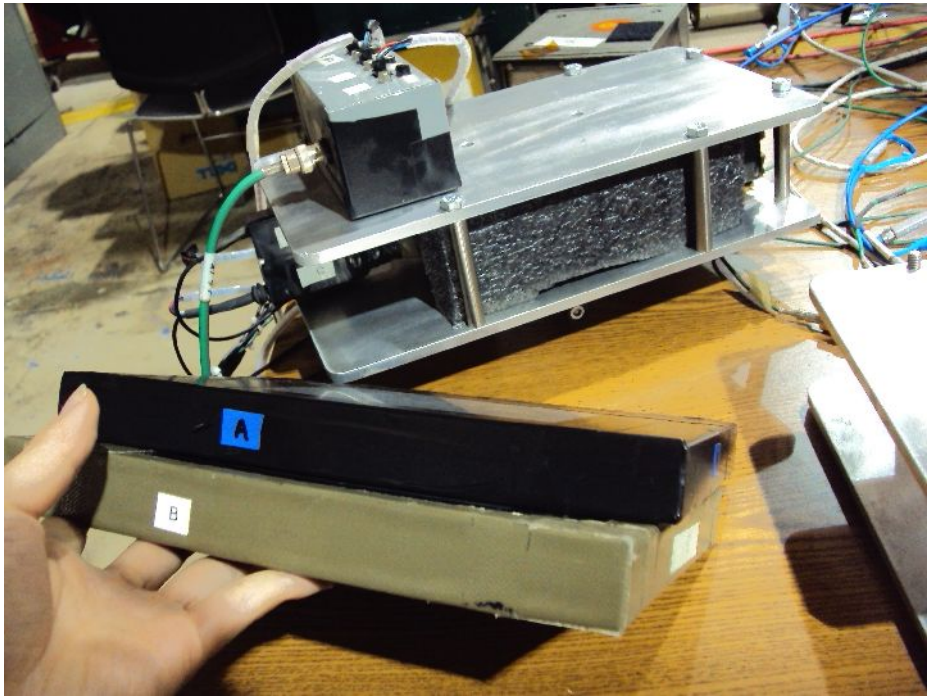
LED visibility tests



Tests performed every time cryostat was sealed

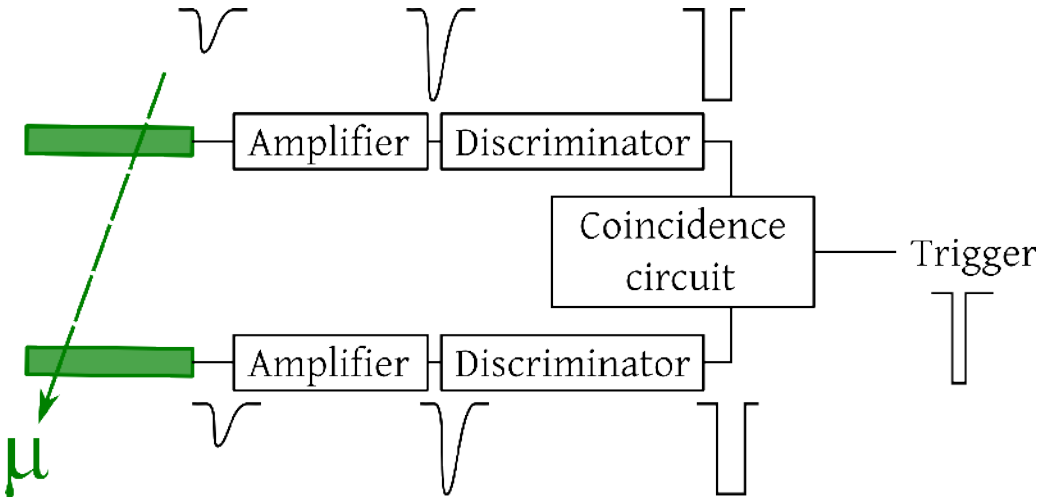
Cosmic ray trigger installation

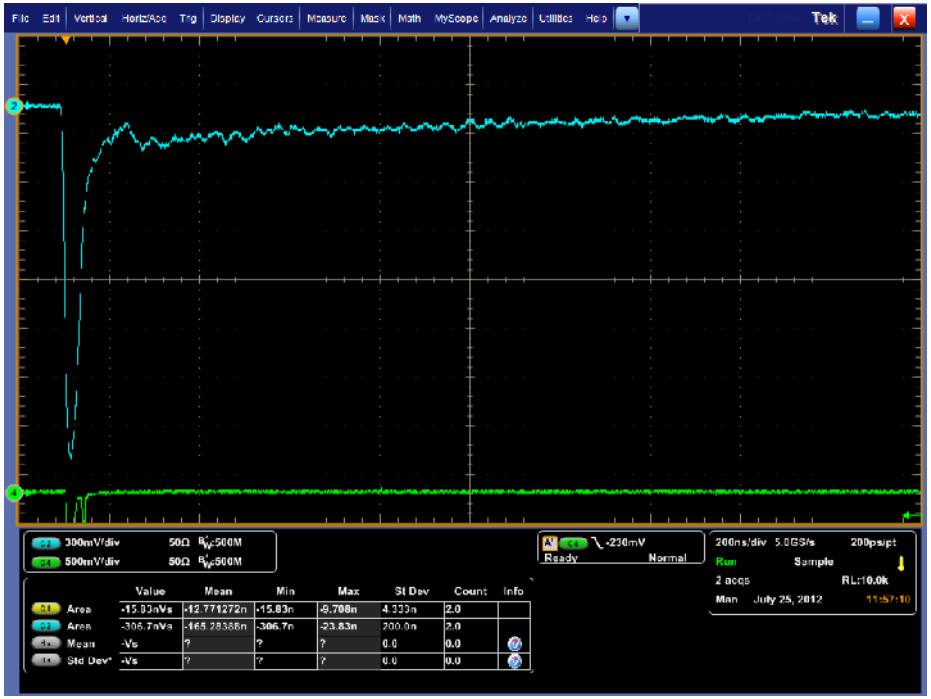




Paddle sizes: 6”x 8”, 4”x 6”

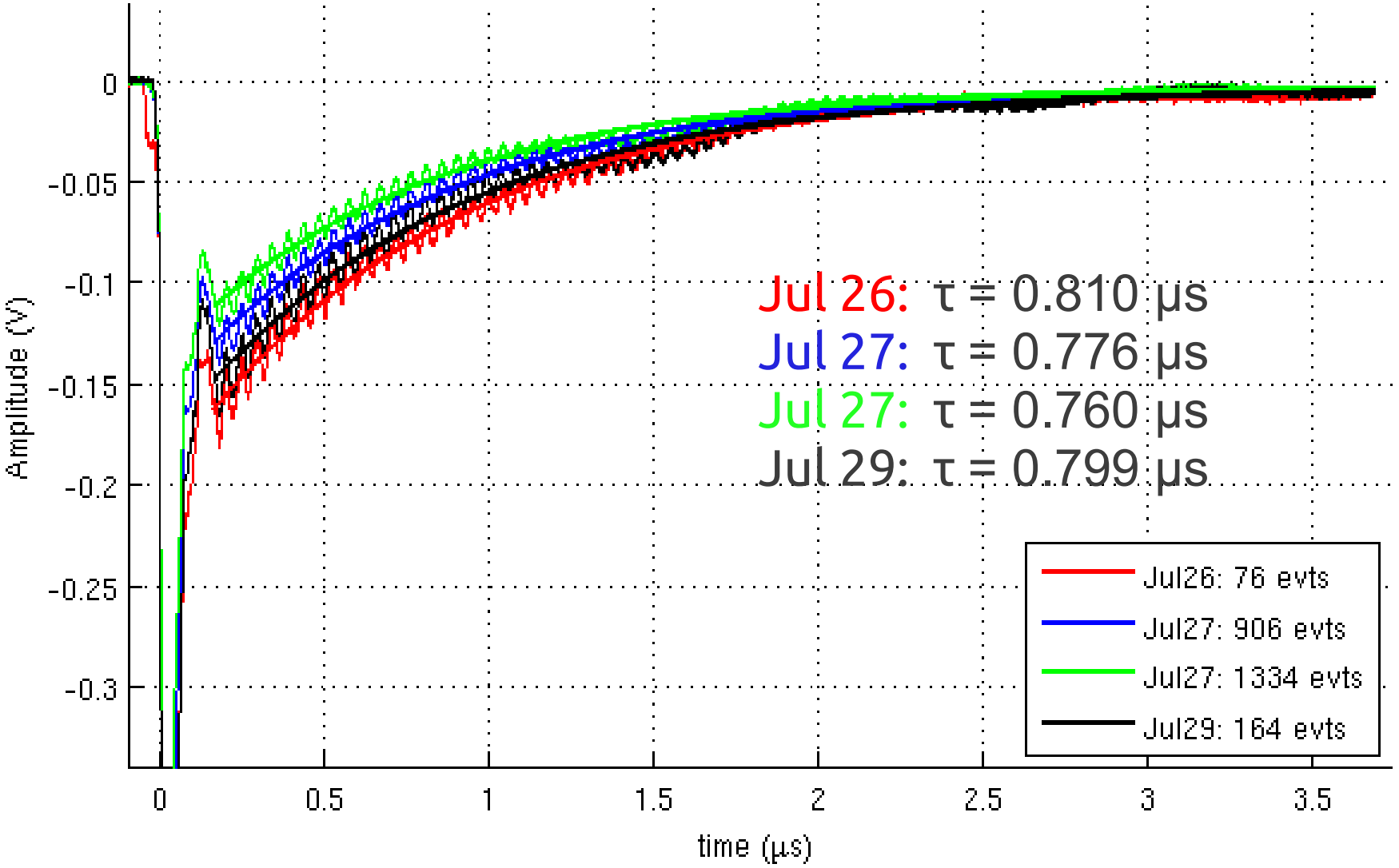
Cosmic ray trigger installation





Rate: 1 pulse every 3 minutes

Measuring late light



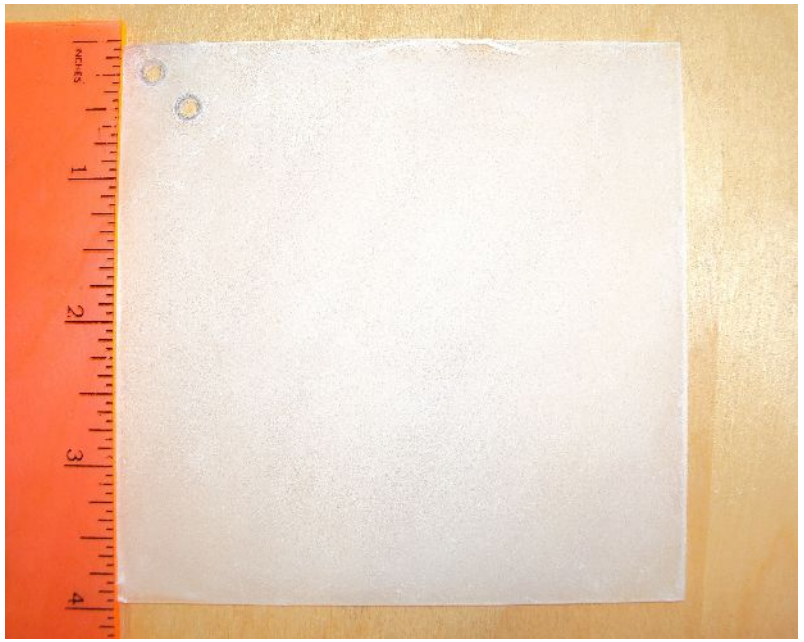
Further studies

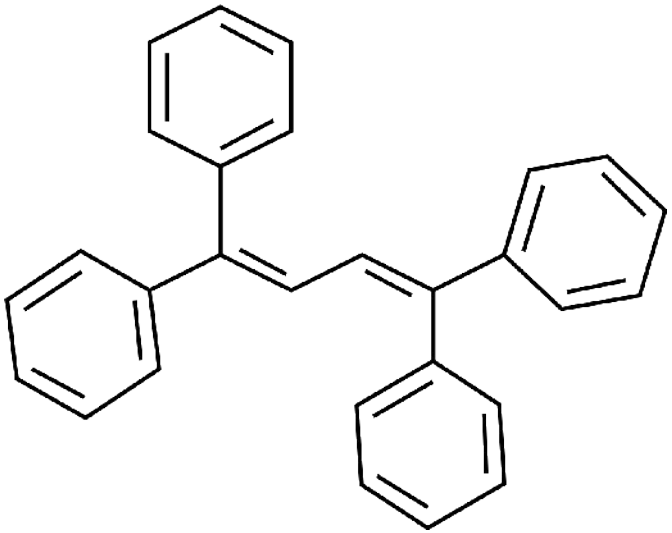
- Reduce noise in PMT signal
- Track purity of LAr through late light measurements
- Measure ratio of prompt light to late light
- Monitor light with N_2 impurity level

TPB Degradation Study

What is TPB?

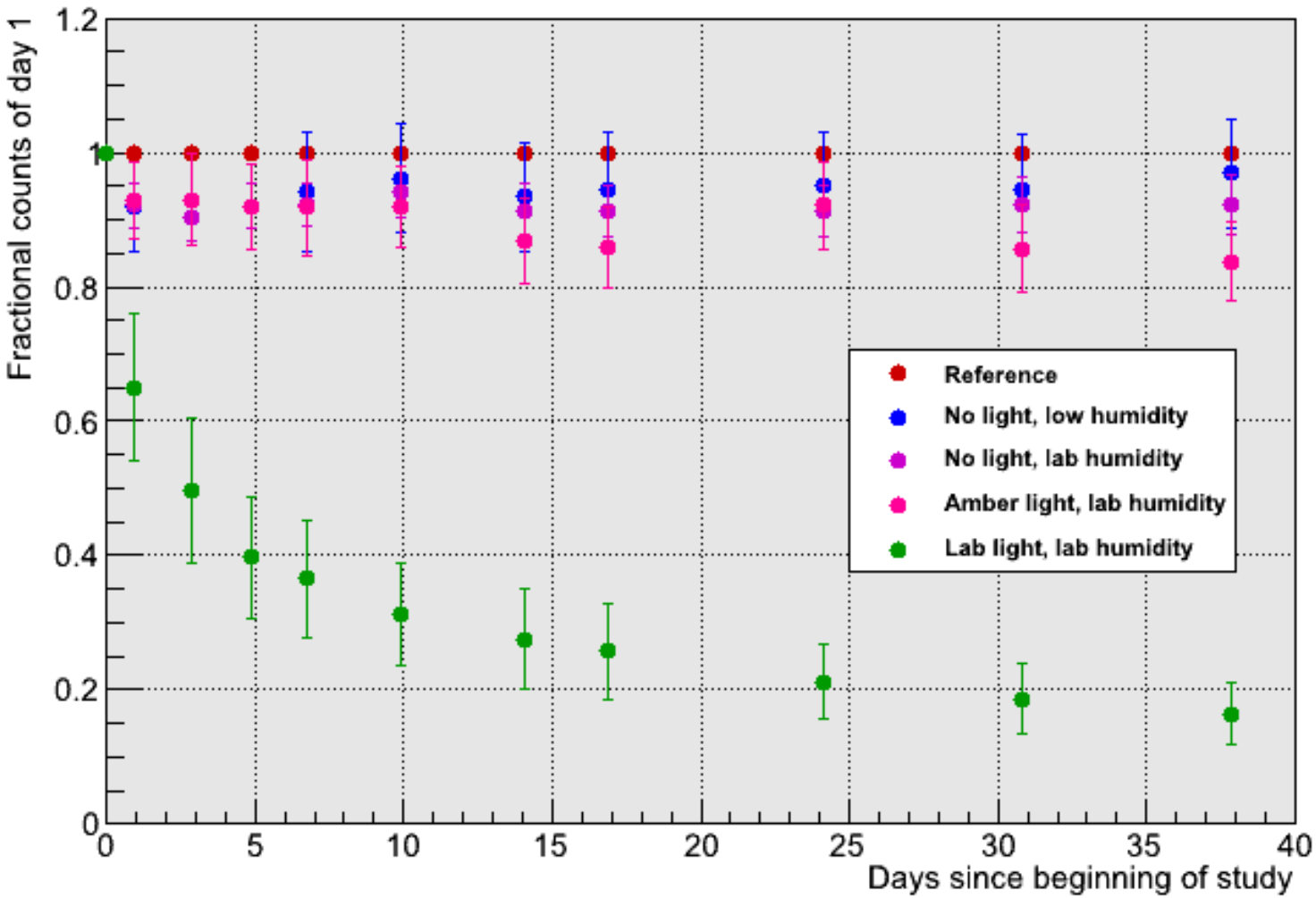
- Tetraphenyl Butadiene
- Shifts UV light to visible
- Standard grade (99%) or scintillation grade (>99%)





- Dissolve TPB and polystyrene in toluene
- Paint onto acrylic plates

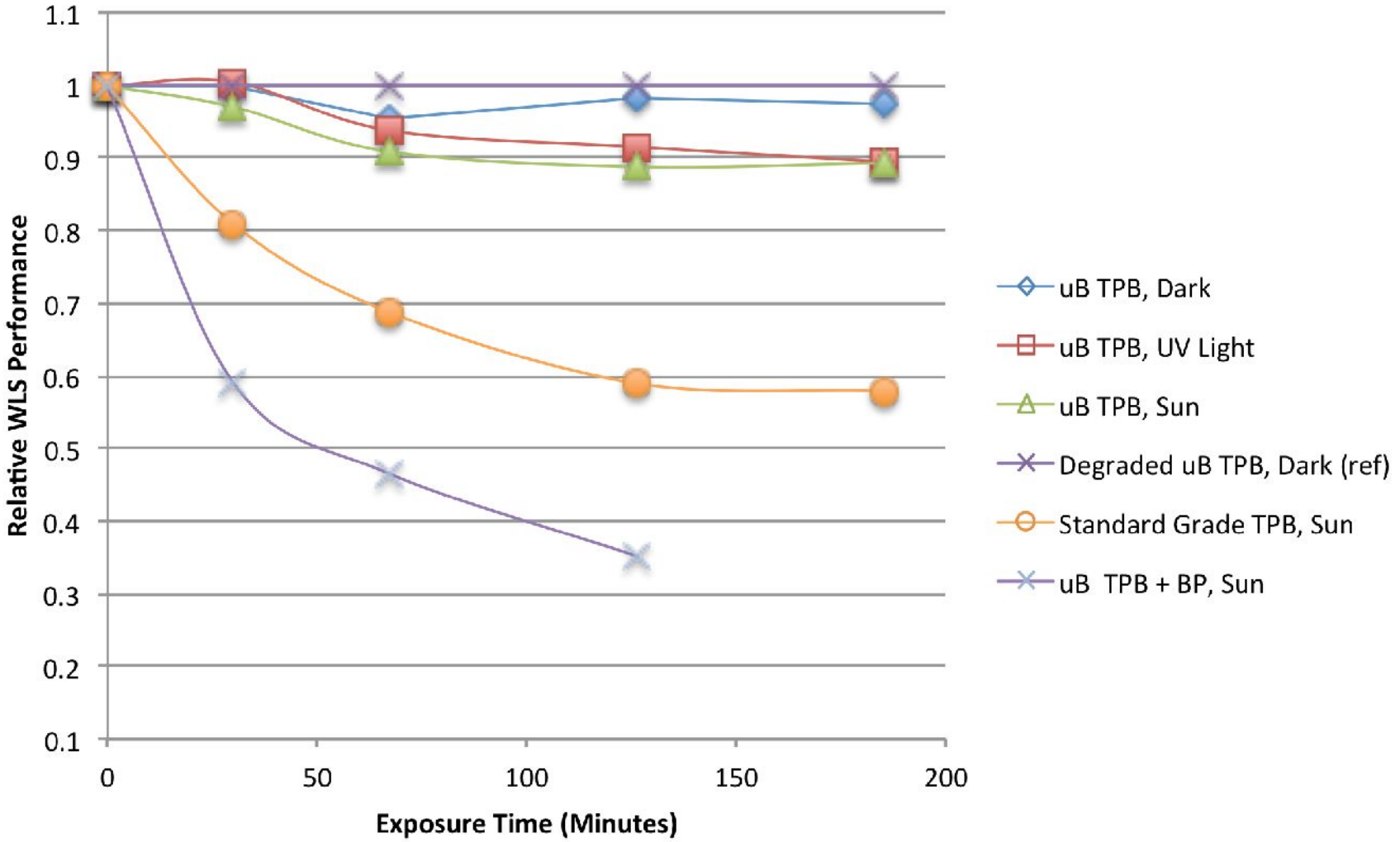
Recent Results



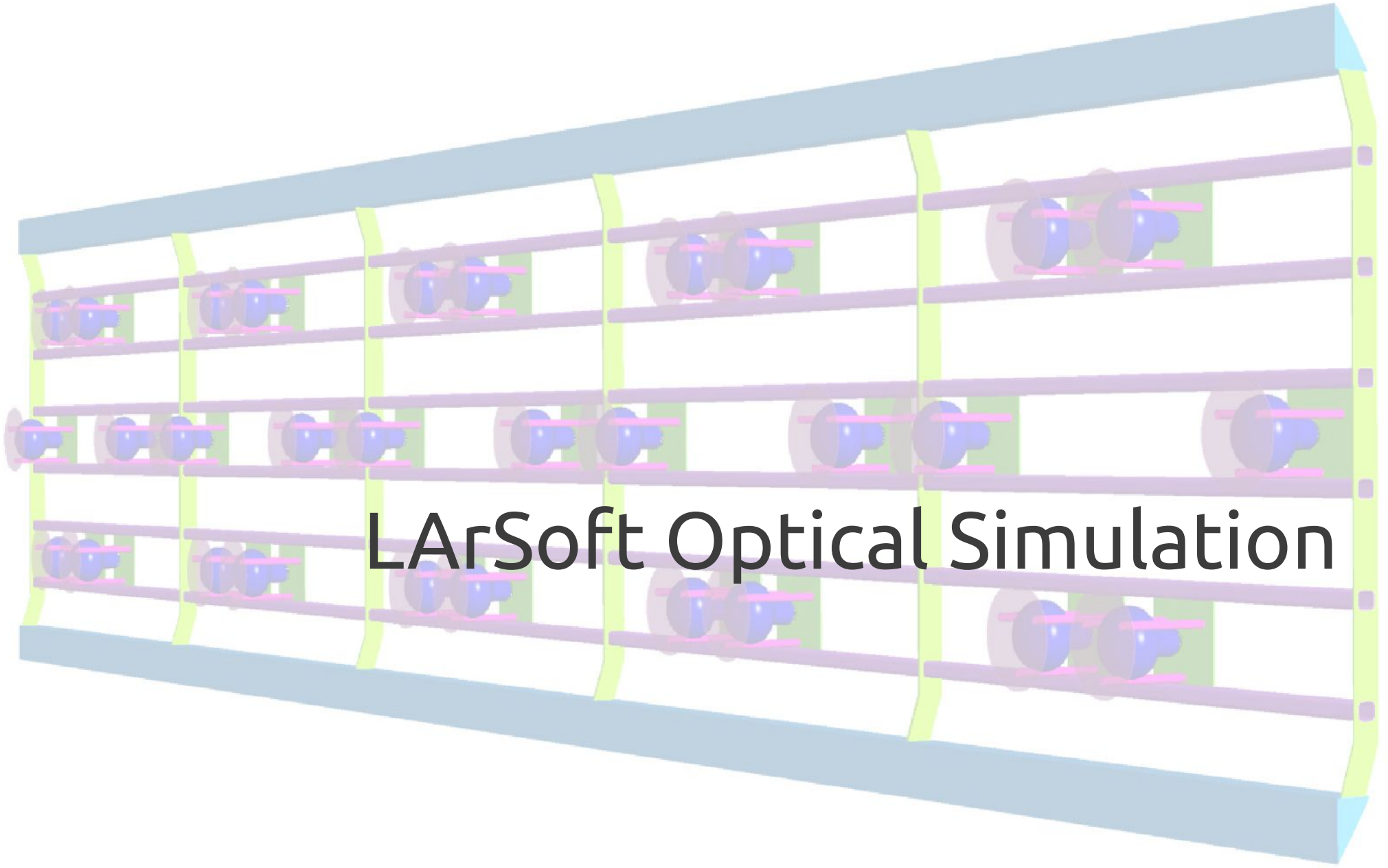
Degradation and TPB purity

- Plate coatings:
  - Scintillation grade TPB
  - Standard grade TPB
  - Scintillation grade TPB + Benzophenone
- Lighting conditions:
  - Dark
  - UV lamp (weak)
  - Sunlight (strong)
- Excitation at 250 nm
- Measured peak emission (at 425 nm)

Degradation and TPB purity



Plot courtesy of Ben Jones



LArSoft Optical Simulation

LArSoft

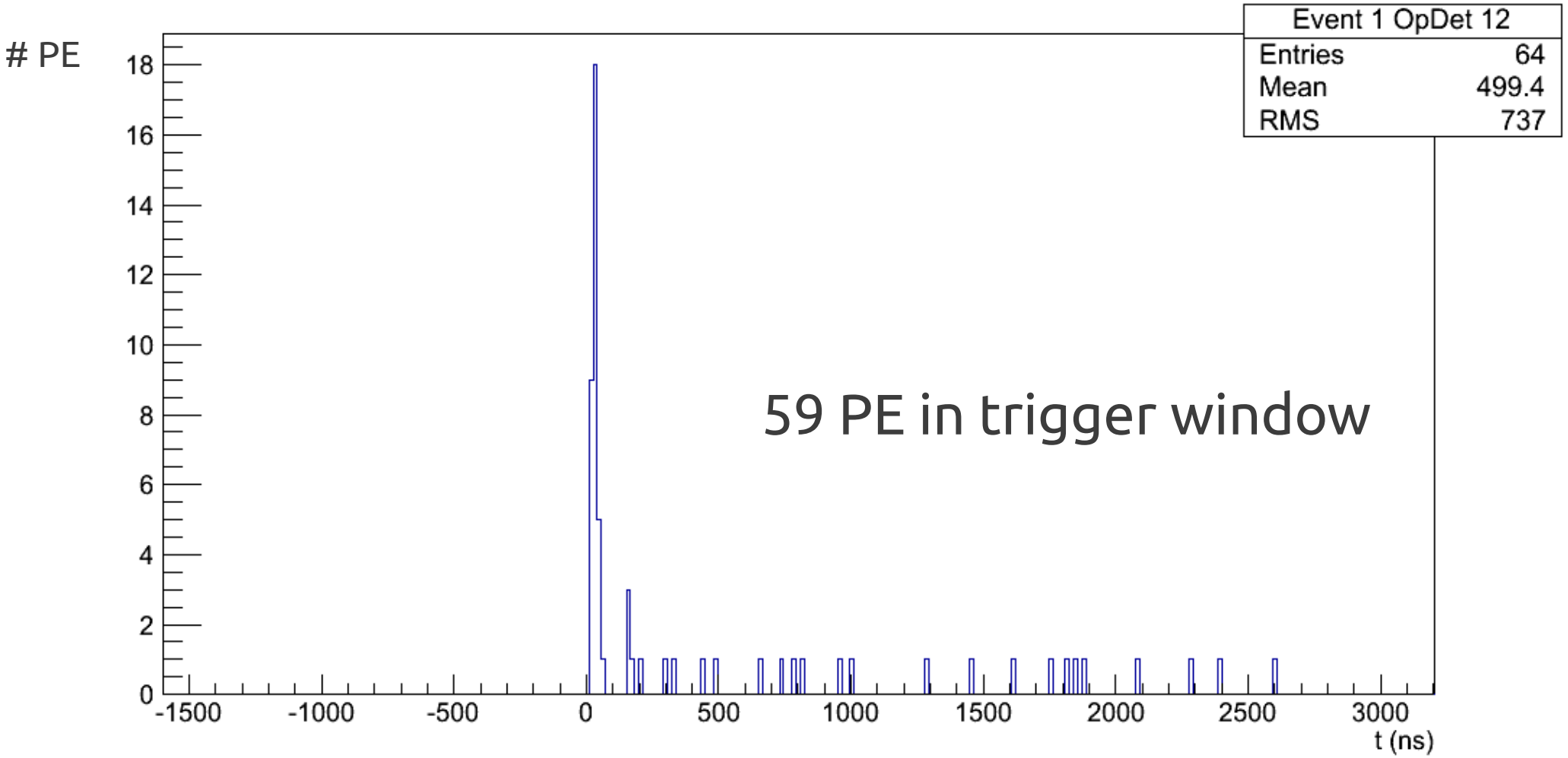
- Liquid Argon Software project
- For LAr TPC detectors
- Simulation
- Reconstruction

Optical Detectors in LArSoft

- **Simulation:**
  - PMT locations in MicroBooNE
  - Simulate events and track photons to PMTs
  - Record arrival times of photons to each PMT
  - Simulate electronics data from arrival time
- **Reconstruction**
  - Given electronics data, find photon arrival times
  - Match photons to particle tracks

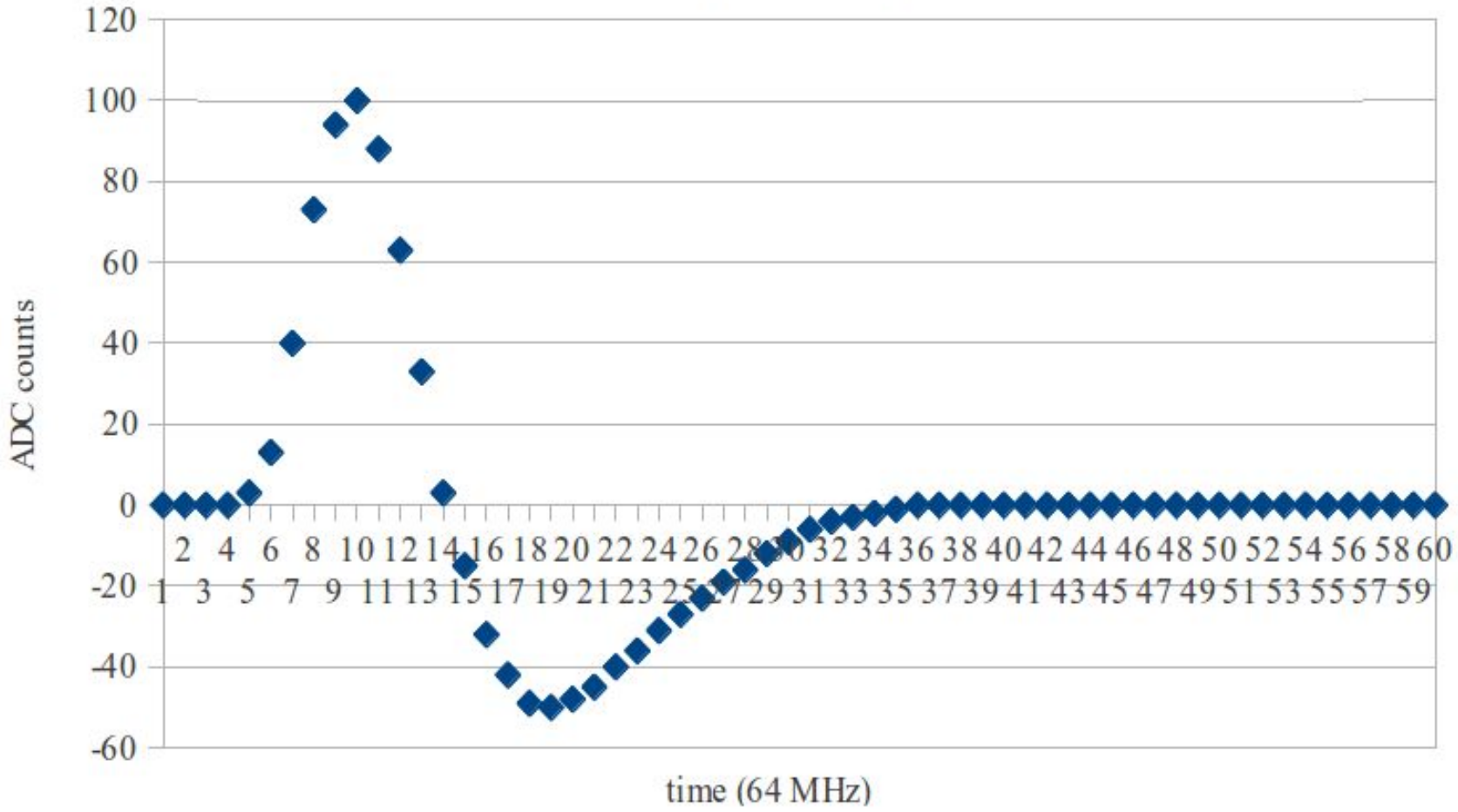
OpDet digitized signal simulation

Photon arrival times



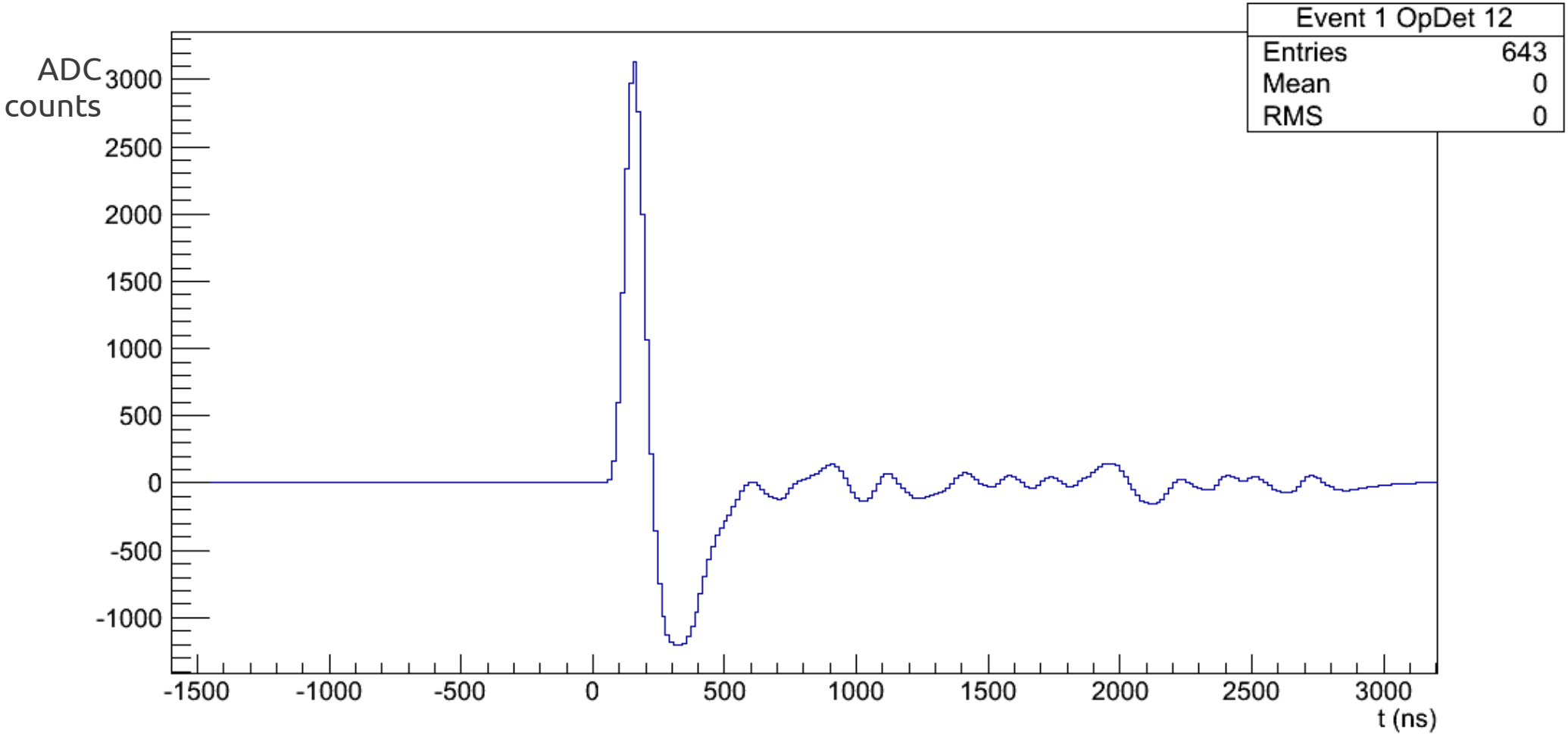
OpDet digitized signal simulation

Bare 1 PE signal (input parameter)



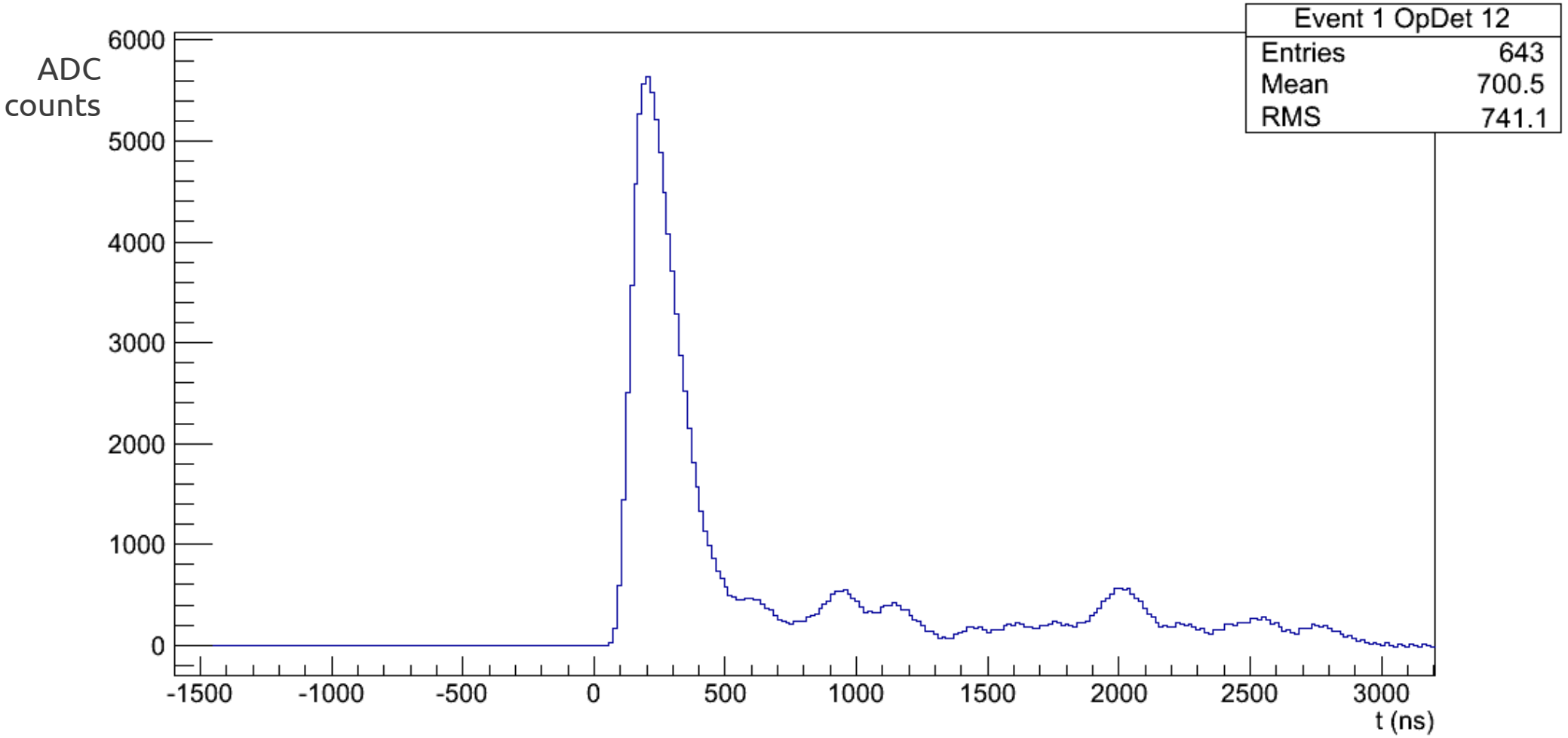
OpDet digitized signal simulation

Digitized PMT signal



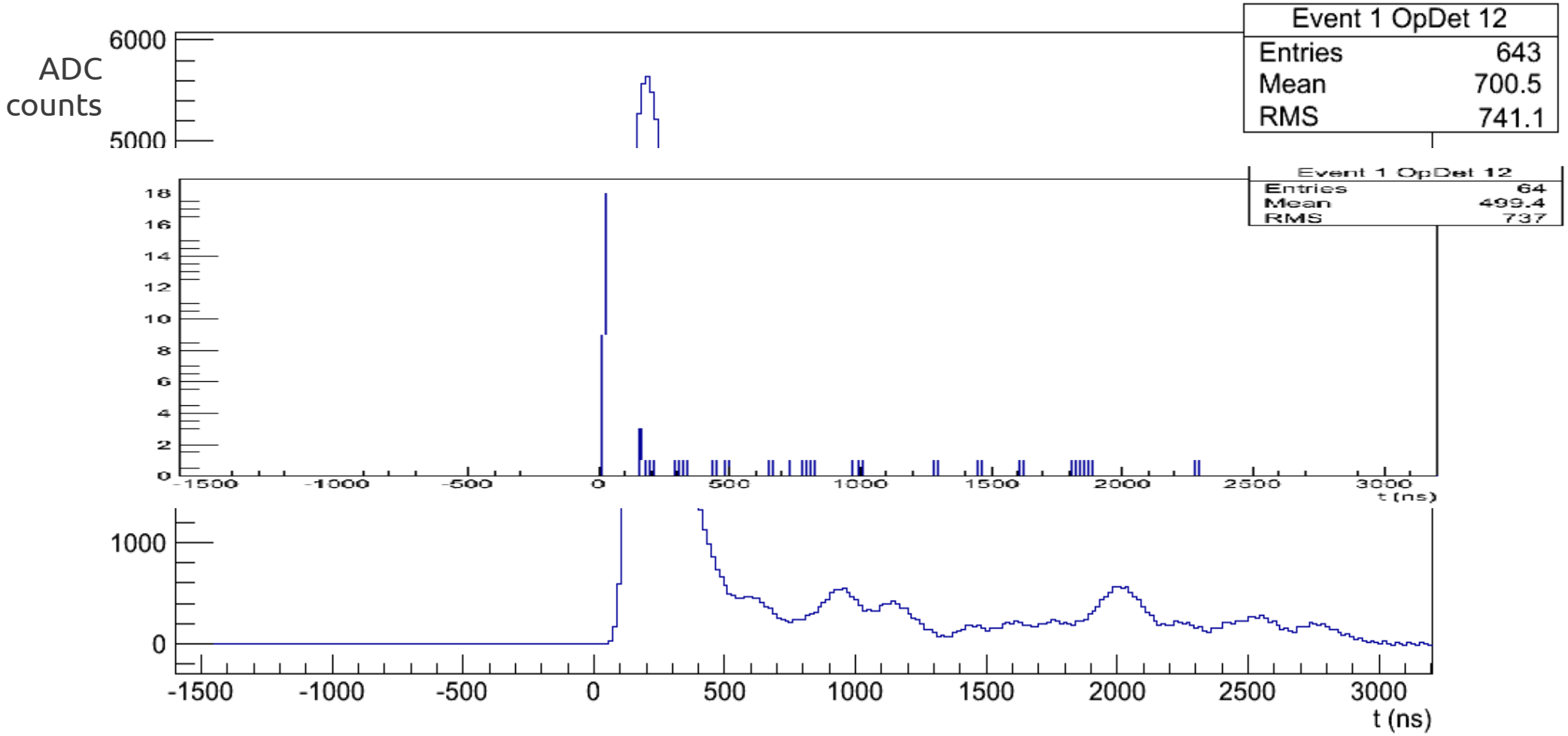
Signal deconvolution

$\tilde{a}_n = a_n - a_{n-3}$



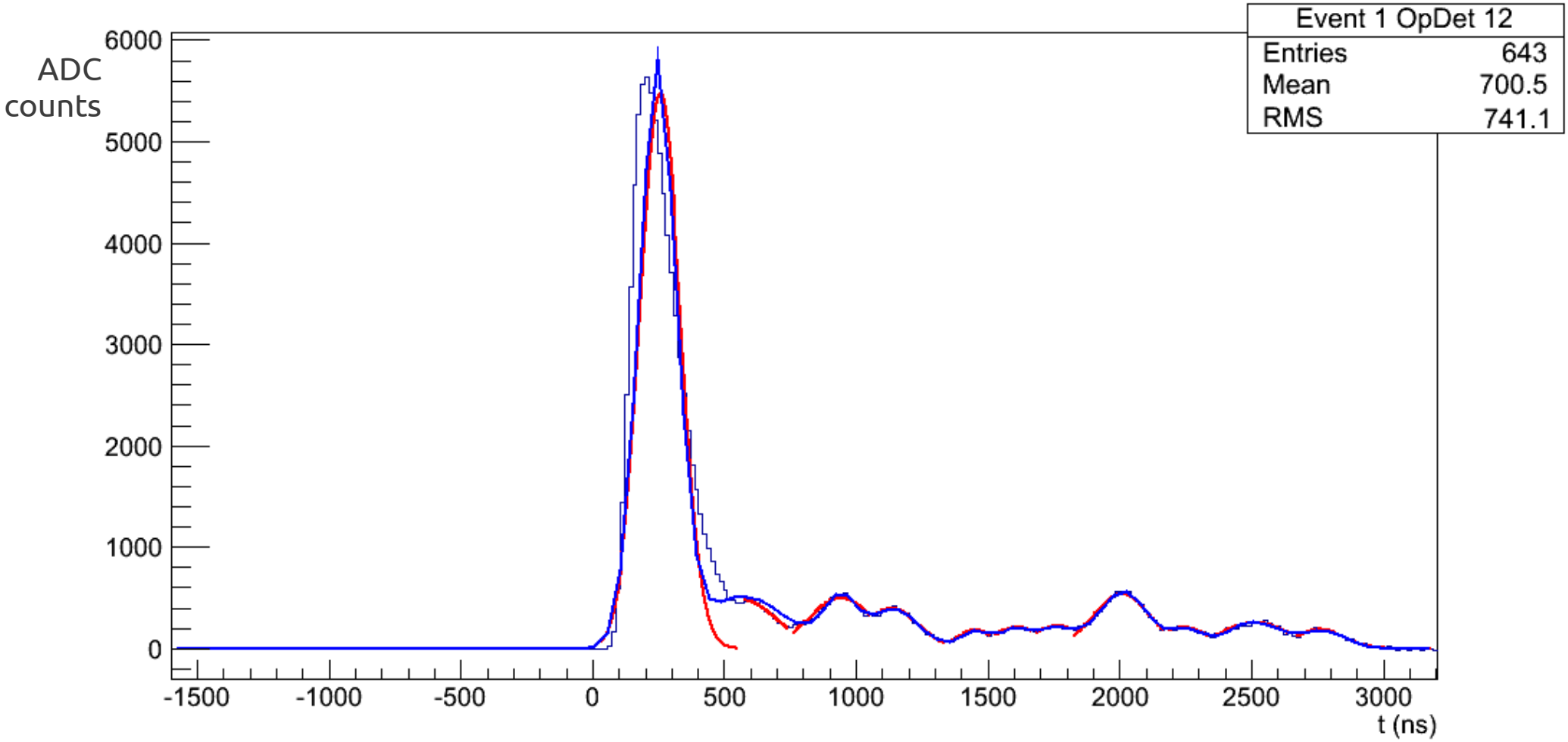
Signal deconvolution

Notice peaks line up with photon arrival times



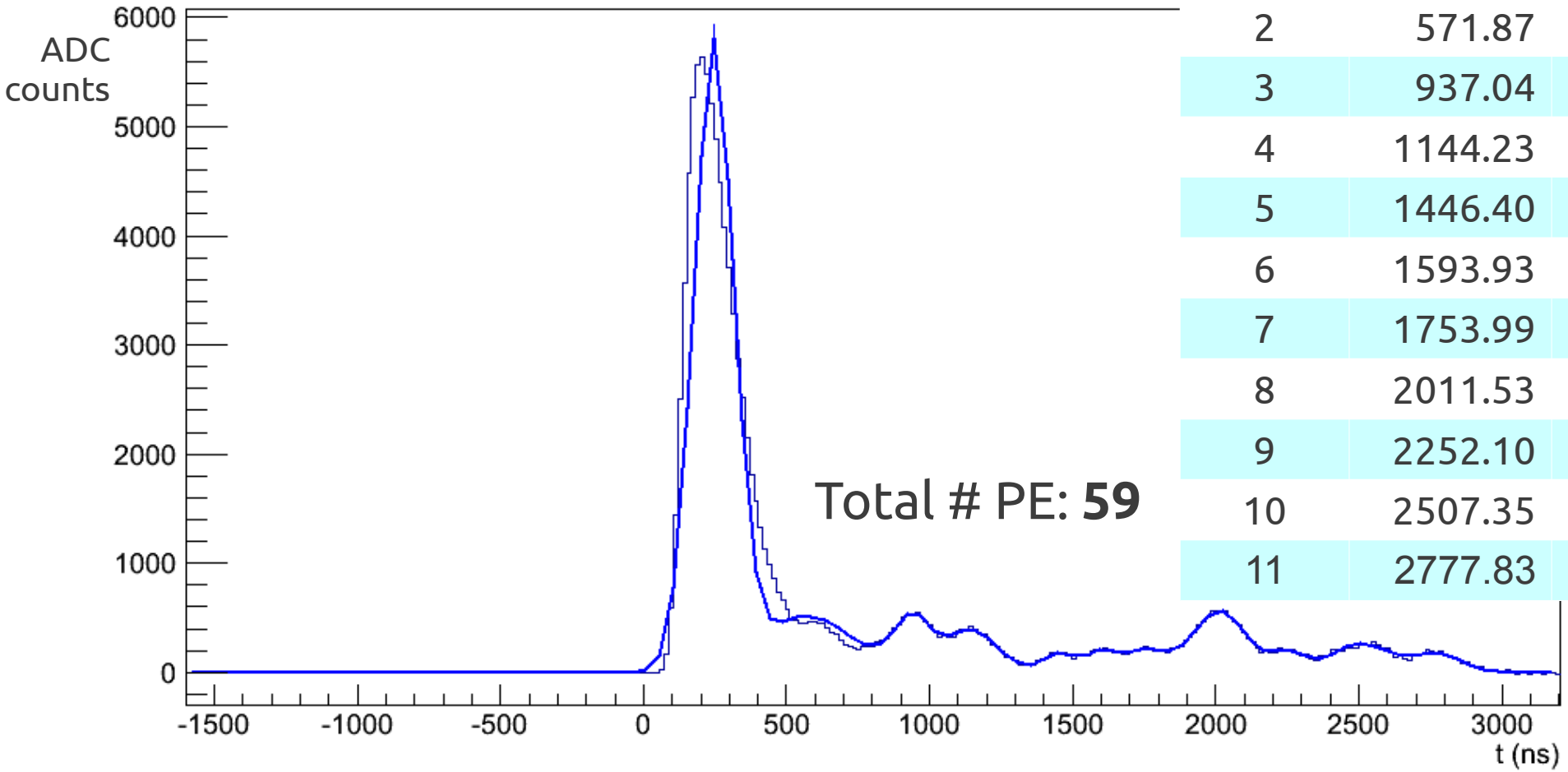
Gaussian fits

Preliminary 1-peak fits & Final *n*-peak fit



Data extraction

Use pulse area to find # of PE



Peak #	Time (ns)	# PE
1	244.57	35
2	571.87	7
3	937.04	3
4	1144.23	3
5	1446.40	1
6	1593.93	1
7	1753.99	1
8	2011.53	4
9	2252.10	1
10	2507.35	2
11	2777.83	1

Data extraction

Accuracy:

- PE counts are off by ±3 at most
- 2.6% error

Tested on 66 signals so far

Next steps

- Match up peaks from different PMTs which arise from the same particle
- Identify particle via track reconstruction
- Determine t_0 for particle tracks

Conclusion

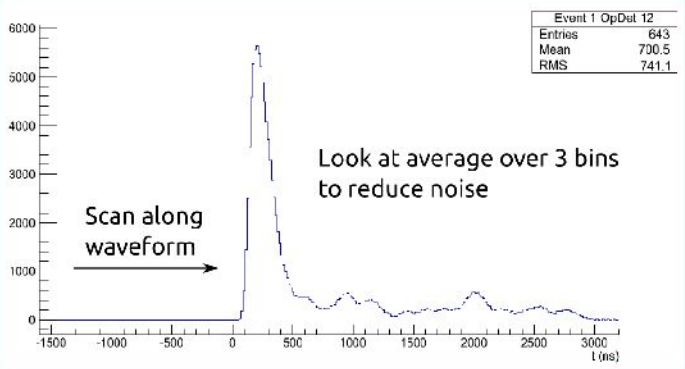
- **Hardware**
  - Vertical Slice Test
    - LED visibility tests
    - Cosmic ray muon measurements
  - TPB Degradation
- **Software**
  - LArSoft Optical Simulation
    - Simulate electronics data
    - Provide timing information for particle tracks

Thank you!

- Many thanks for a great summer!
  - Ben Jones
  - Teppei Katori
  - Janet Conrad
  - Stephen Pordes
  - William Miner
  - Anna Pla-Dalmau
  - Meryl and Stewart Robertson UROP Fund

Gaussian fits

Find fit regions for each peak



Increase in amplitude → Save end of fit range *i*, start of fit range *i+1*

looking for minimum
(end of fit range *i*,
beginning of fit range *i+1*)

Observed "shoulder"behavior:
extra inflection point

looking for maximum
(of fit range *i*)

Save end of fit range *i*,
start of fit range *i+1*

Decrease in amplitude
Maximum > 1 PE pulse height

Cleanup incomplete fit range at end of trigger window:
If we've seen a maximum, set last point as end of fit range
Otherwise, discard current fit range

Perform fits to each peak separately

Use fit parameters from above as seeds

Perform 1 fit to total waveform