Photon Detector Reconstruction Efficiency Study

Gleb Sinev
DUNE 35t/FD Sim, Reco, and Analysis
June 24, 2015
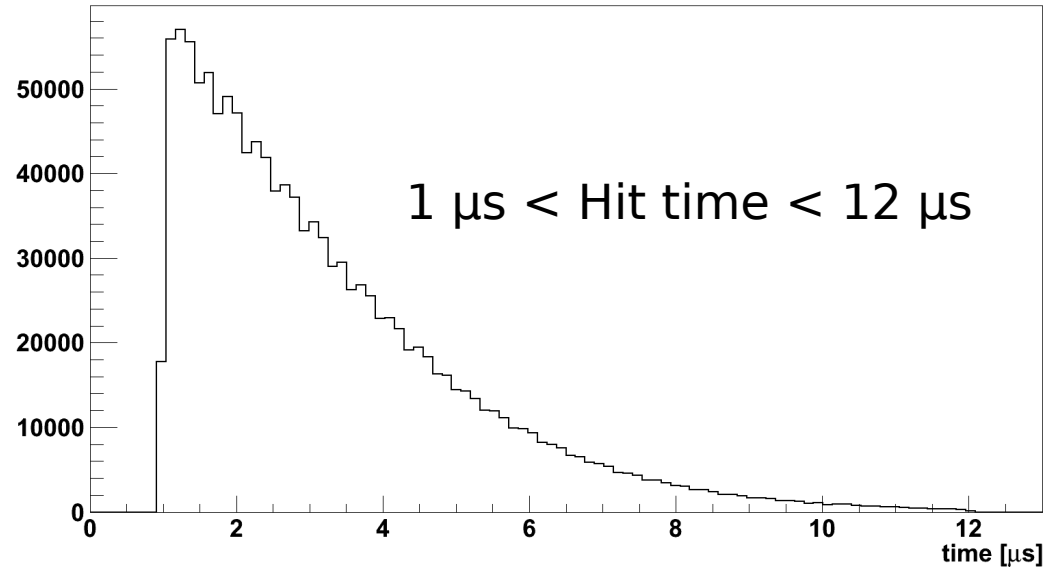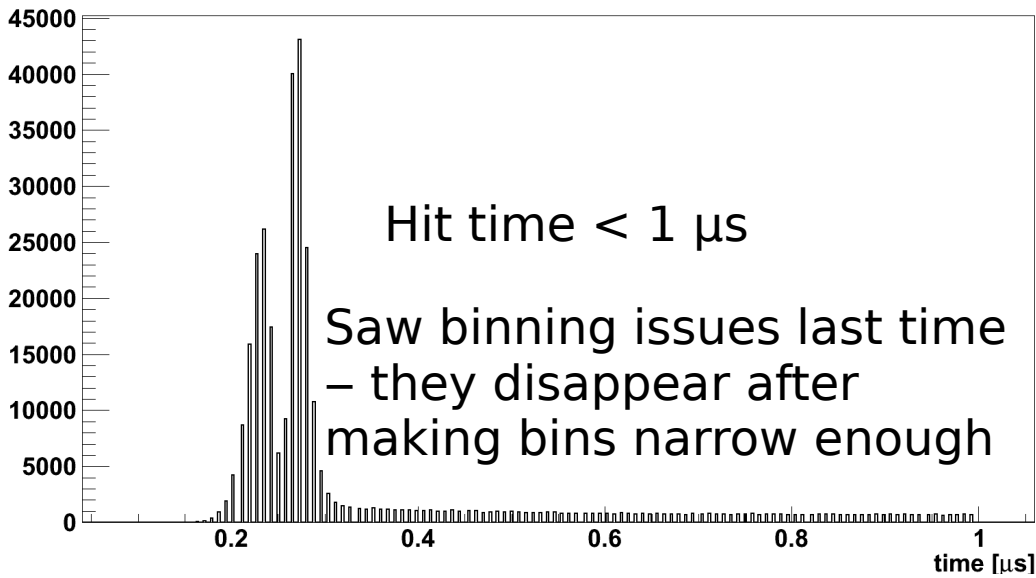
PD efficiency study

- Used both DUNE 35t and DUNE FD 4APA (reference and alternative PD designs) geometries to estimate PD reconstruction efficiency
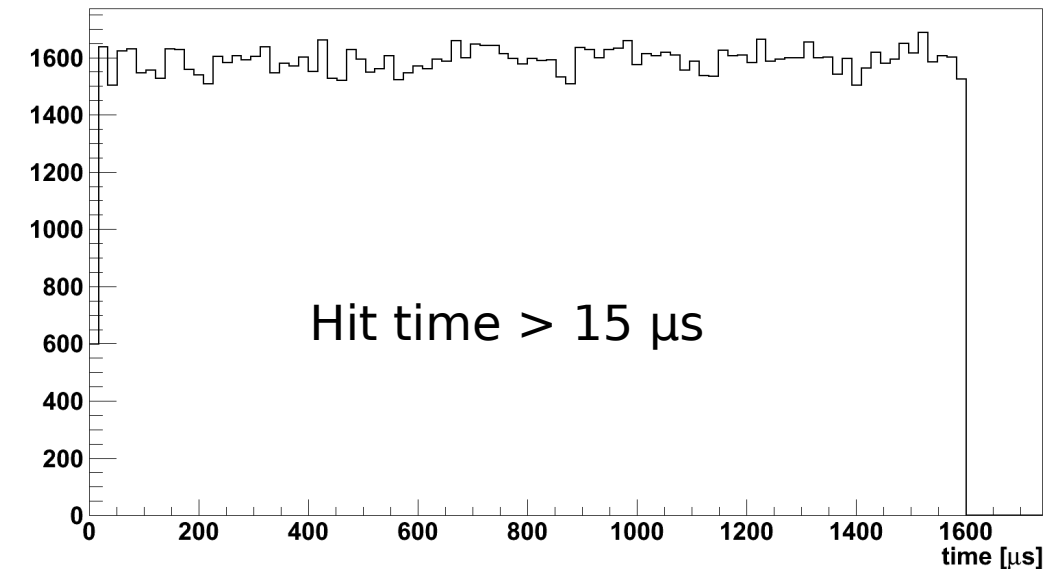
Simulation

- ~100 000 events per geometry/PD design
- Single electrons
- Energy: 0.005, 0.010, 0.200, 0.500 GeV
- X0: 0 to 220/350 cm in 10 cm steps
- Isotropic direction
- Y0 and Z0 are randomly generated in YZ plane
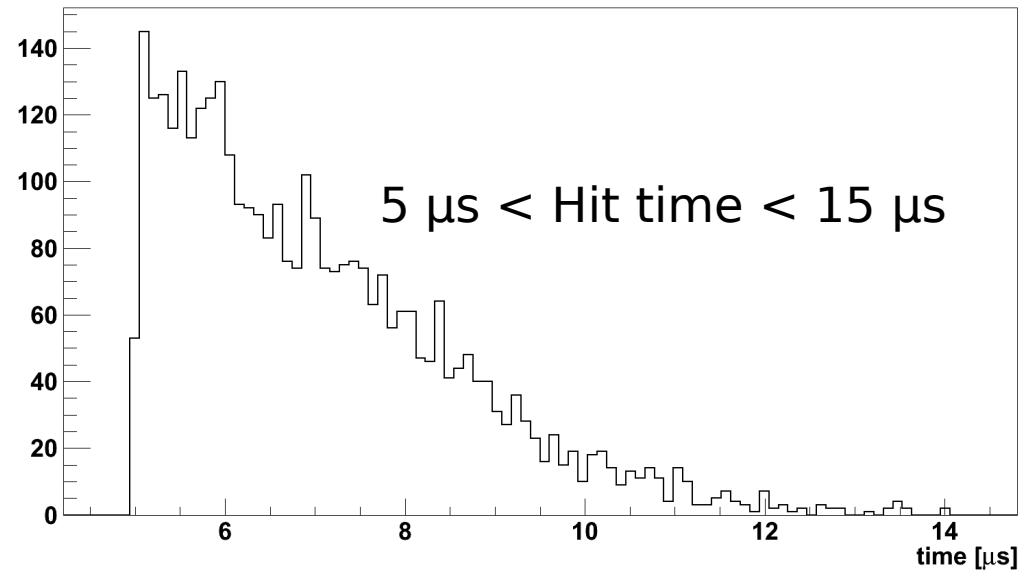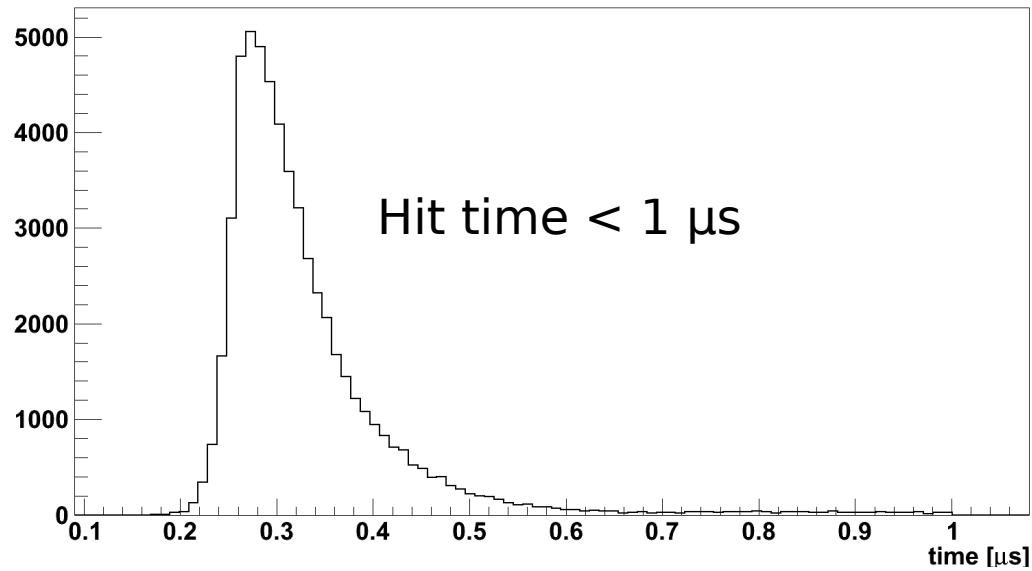
OpHit time distribution

Hit time < 1 μs

Saw binning issues last time – they disappear after making bins narrow enough

1 μs < Hit time < 12 μs

Late light

Hit time > 15 μs

Dark noise

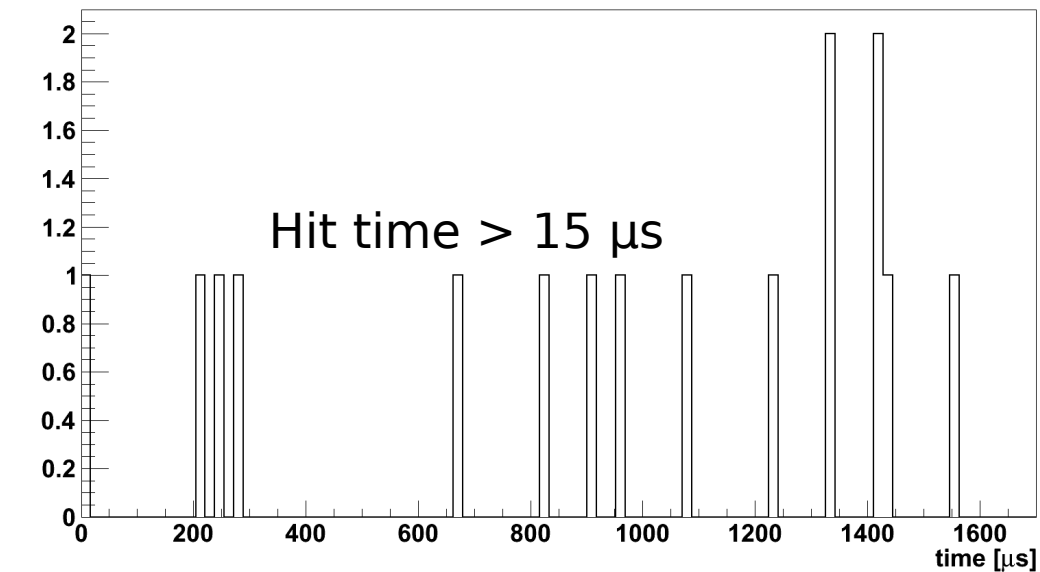# Flash time distribution

Hit time < 1 µs

5 µs < Hit time < 15 µs
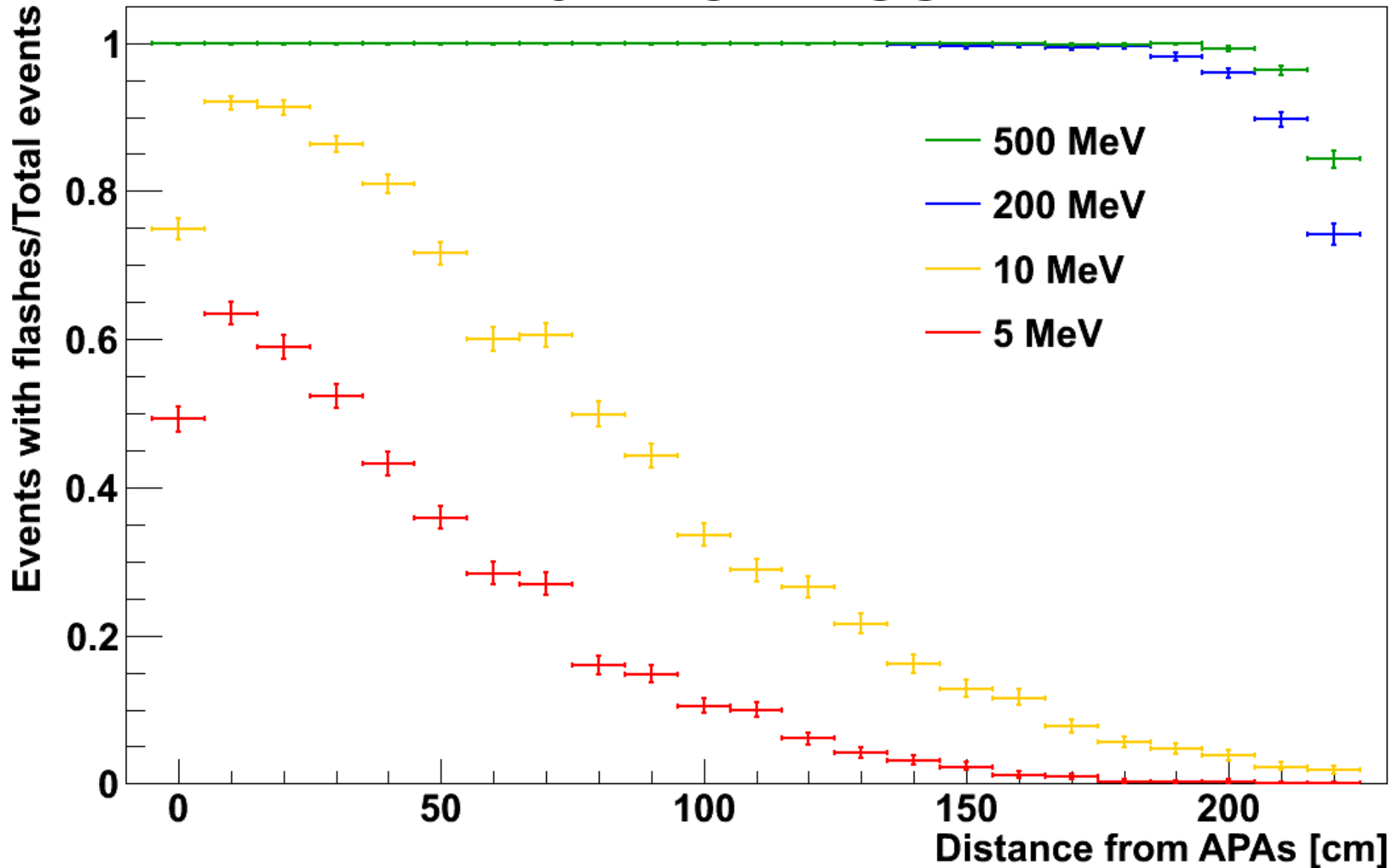
Late light

Hit time > 15 µs

Dark noise

Study

5

Quick summary of PD reconstruction

- Get waveforms from optical channels (simulation or data)

- Run hit finder on each waveform -> produce optical hits

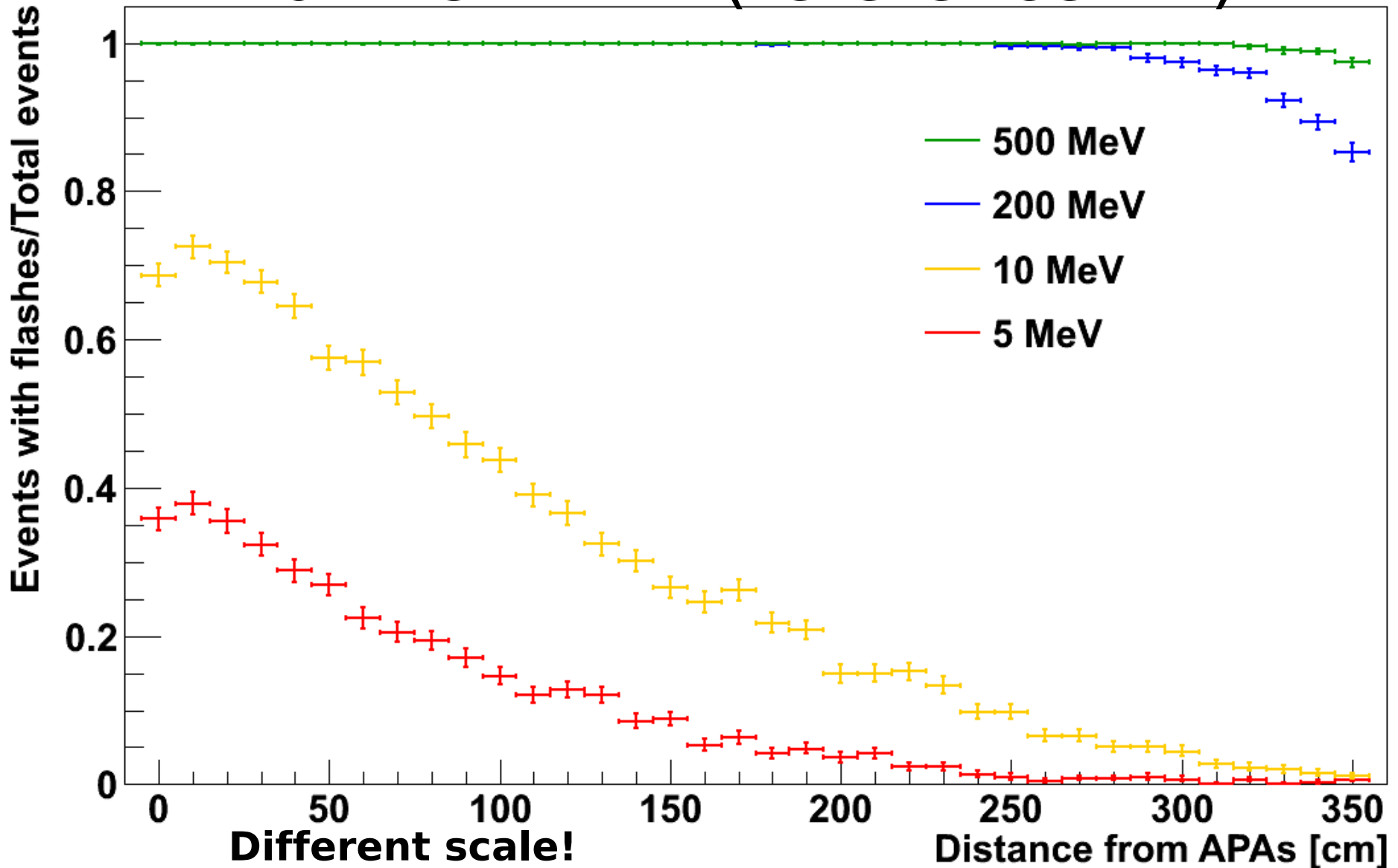- Run flash finder on all optical hits in event -> produce flashes

Flash

- A collection of hits

- Contains number of PEs, x, y, z, t

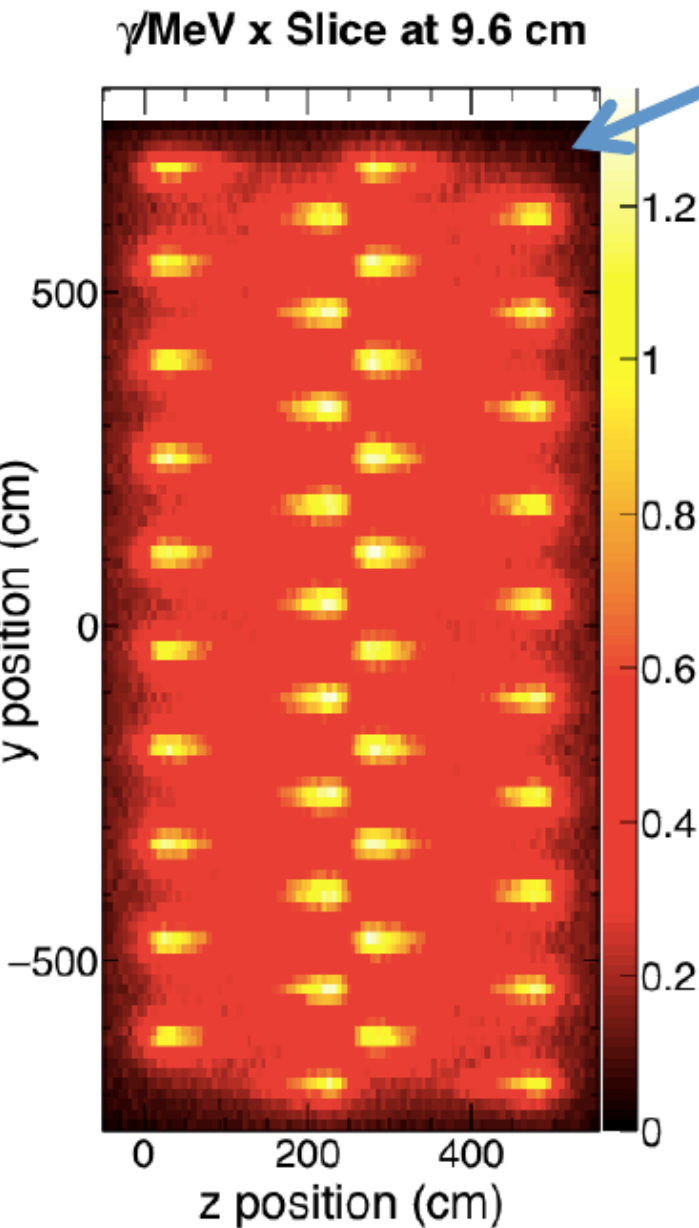- Equivalent of an event + vertex
  in a water Cherenkov detector

Efficiency vs distance from APAs for DUNE 35t

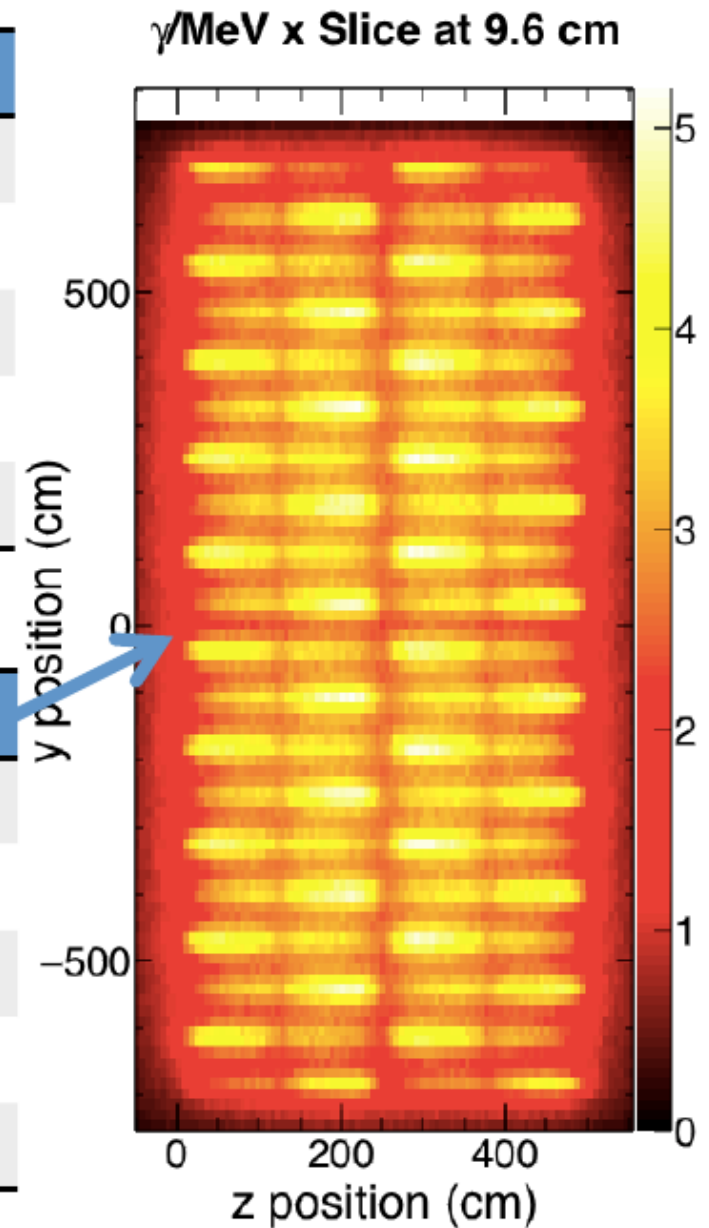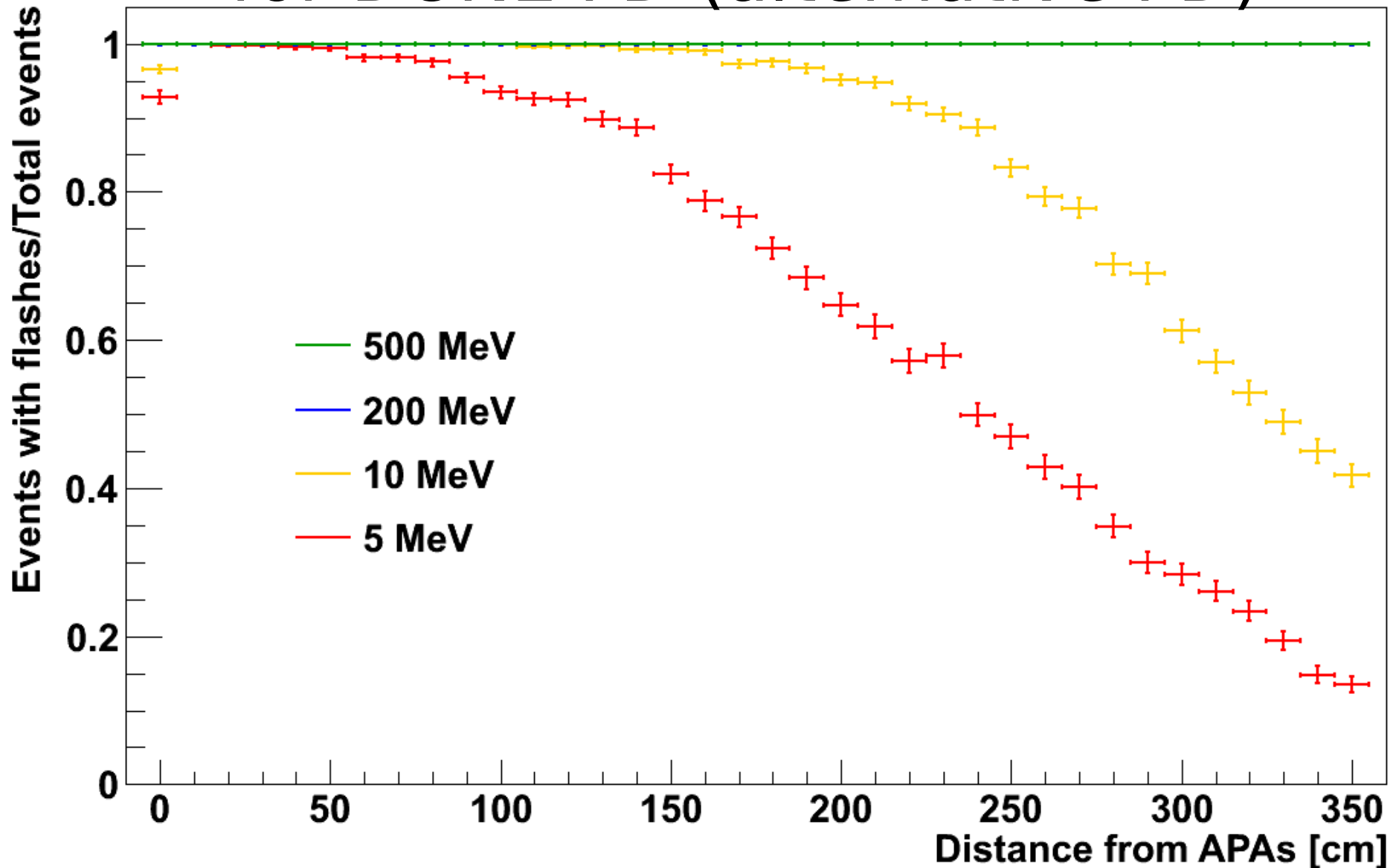# Efficiency vs distance from APAs for DUNE FD (reference PD)

Specific Designs

γ/MeV x Slice at 9.6 cm (left plot, y position (cm) vs z position (cm))

γ/MeV x Slice at 9.6 cm (right plot, y position (cm) vs z position (cm))

Reference Design	
IU dip-coated acrylic bars	
Short attenuation	5.6 cm
Long attenuation	44.1 cm
Efficiency at SiPM	0.16%
Average efficiency	0.02%

Alternative Design	
IU WLS bars with radiators	
Short attenuation	66 cm
Long attenuation	350 cm
Efficiency at SiPM	0.57%
Average efficiency	0.32%

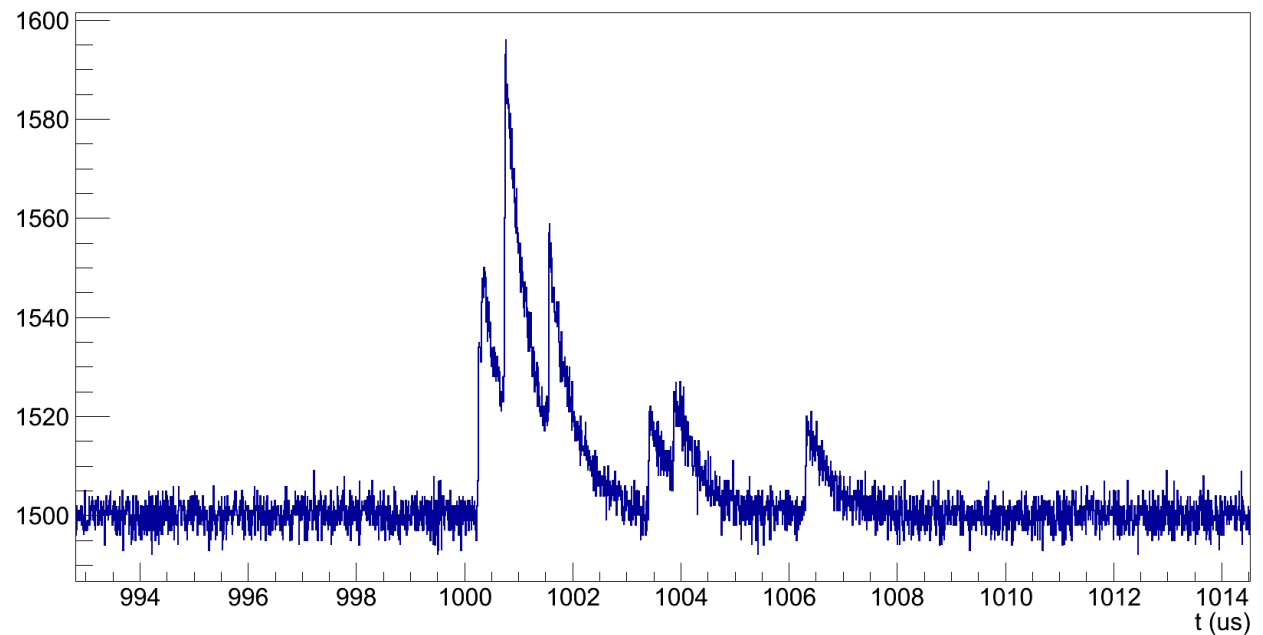Efficiency vs distance from APAs for DUNE FD (alternative PD)

Summary

- PD reconstruction efficiency for electrons >200 MeV is close to 1

- Alternative PD design dramatically improves efficiency for low energy events

Backup slides

PD Reco Efficiency Study

PD simulation

- Dark noise rate: 10 Hz

- Line noise RMS: 2.6 ADC counts

- Cross-talk: 16.5%

- Pedestal: 1500 ADC counts

This is how a waveform looks like (1 OpChannel, 1 event)

Optical hit

- Optical channel
- Peak time
- Width
- Area
- Peak height
- Number of PEs

Flash finder (approximate) algorithm

- Loop trough hits, assigning them to flashes (trying to relate as many as possible hits to one flash)

- Remove late light

- Check that $PE_{Flash} > PE_{Threshold}$

- Calculate flash parameters from hits assigned

Simulating Optical Transport

- Particularly important for simulating the 35ton prototype

- Multiple photon detector technologies with different attenuation behavior