Timing of HF PMT Events

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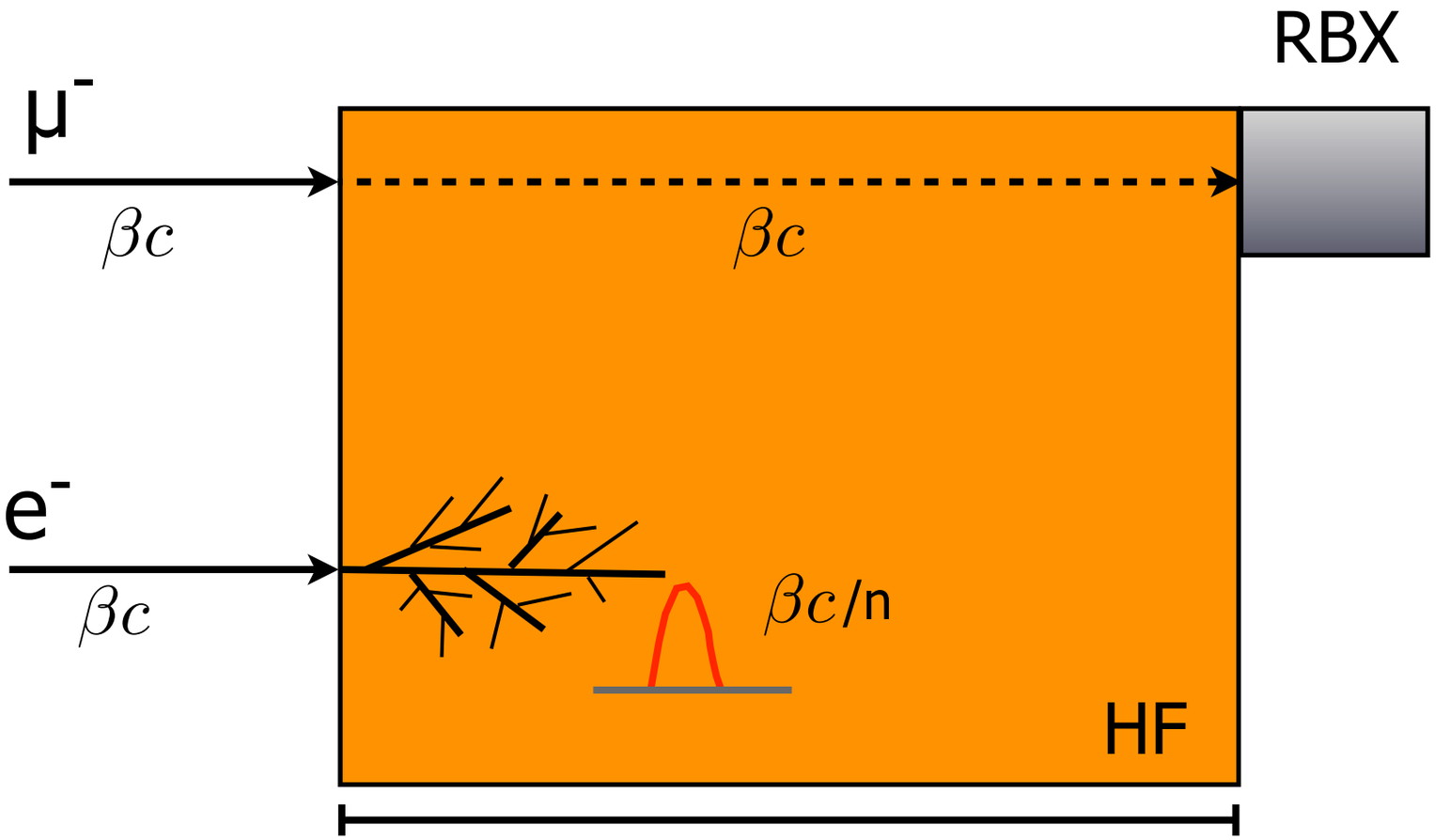
Introduction

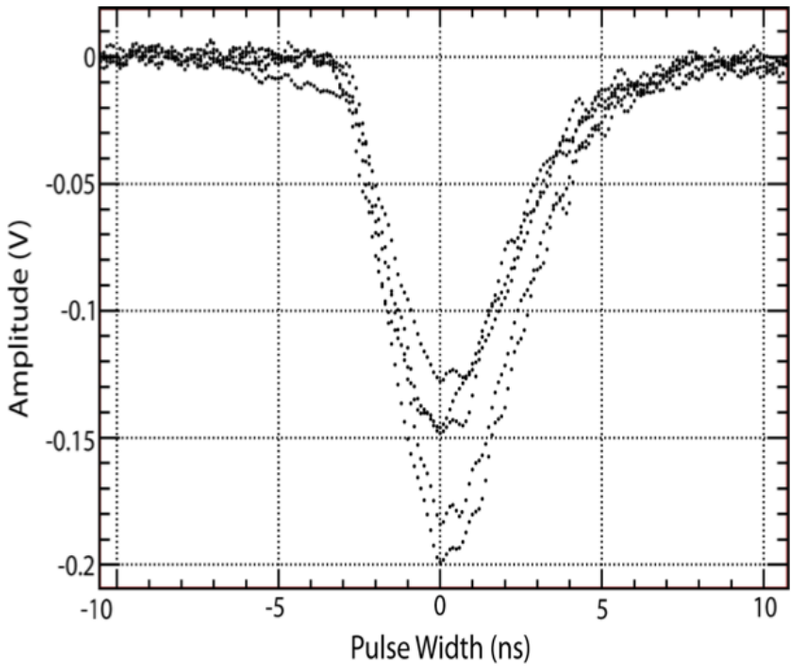


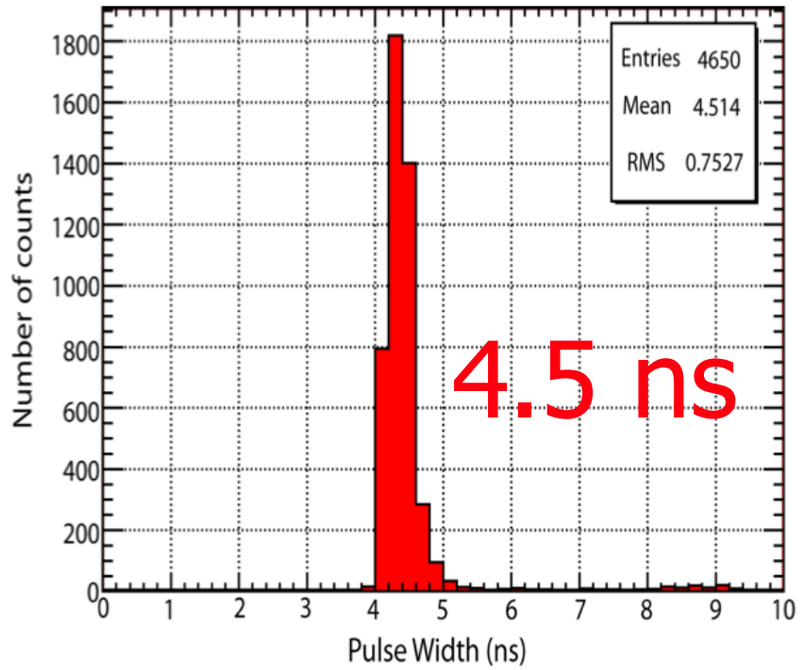
Because of the speed differences of the signal and punch through particle, ~5 ns early arrival time is expected for PMT events. We can observe it from 2004 test beam data. The characteristic of PMT event signal shape can help us to tag these events.

Normal and PMT Event Signal Shapes

Scope data from ’09 test beam.

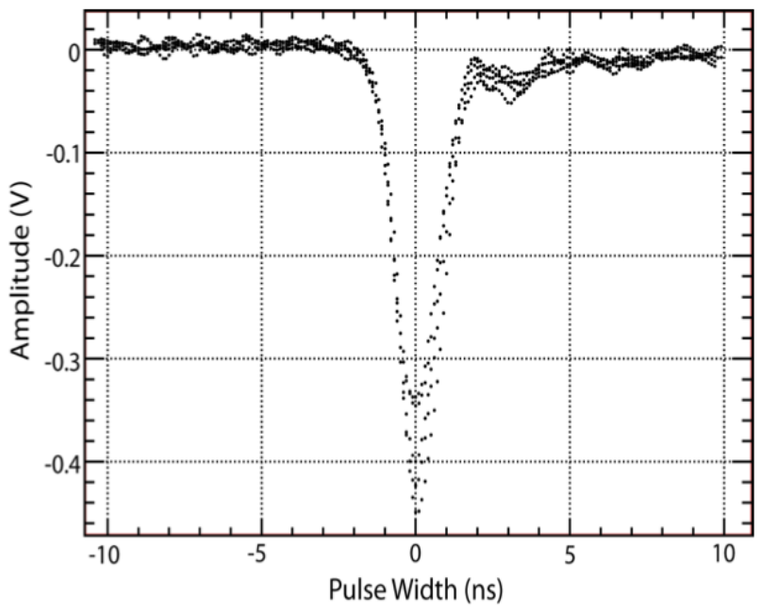
Normal Events

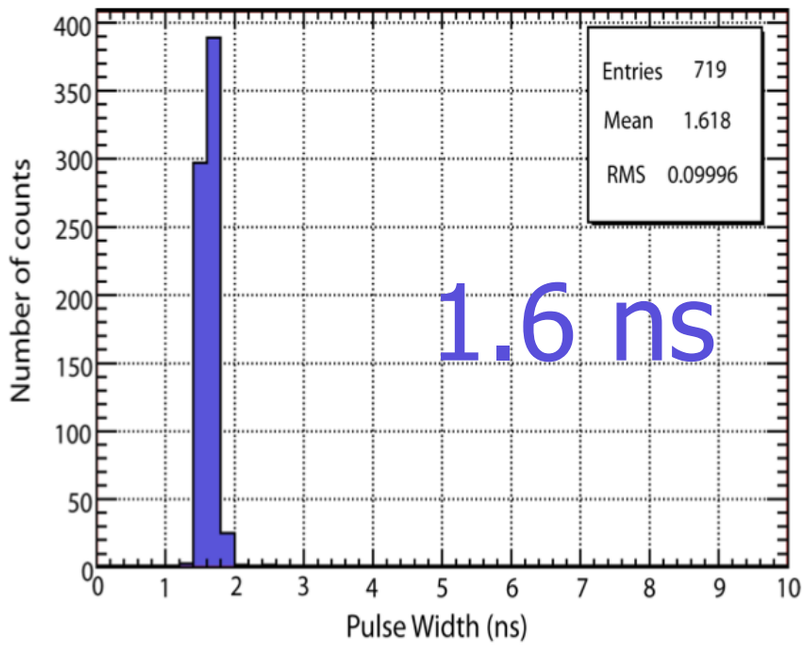




Cosmic muon data from Iowa HEP Lab.

PMT Events



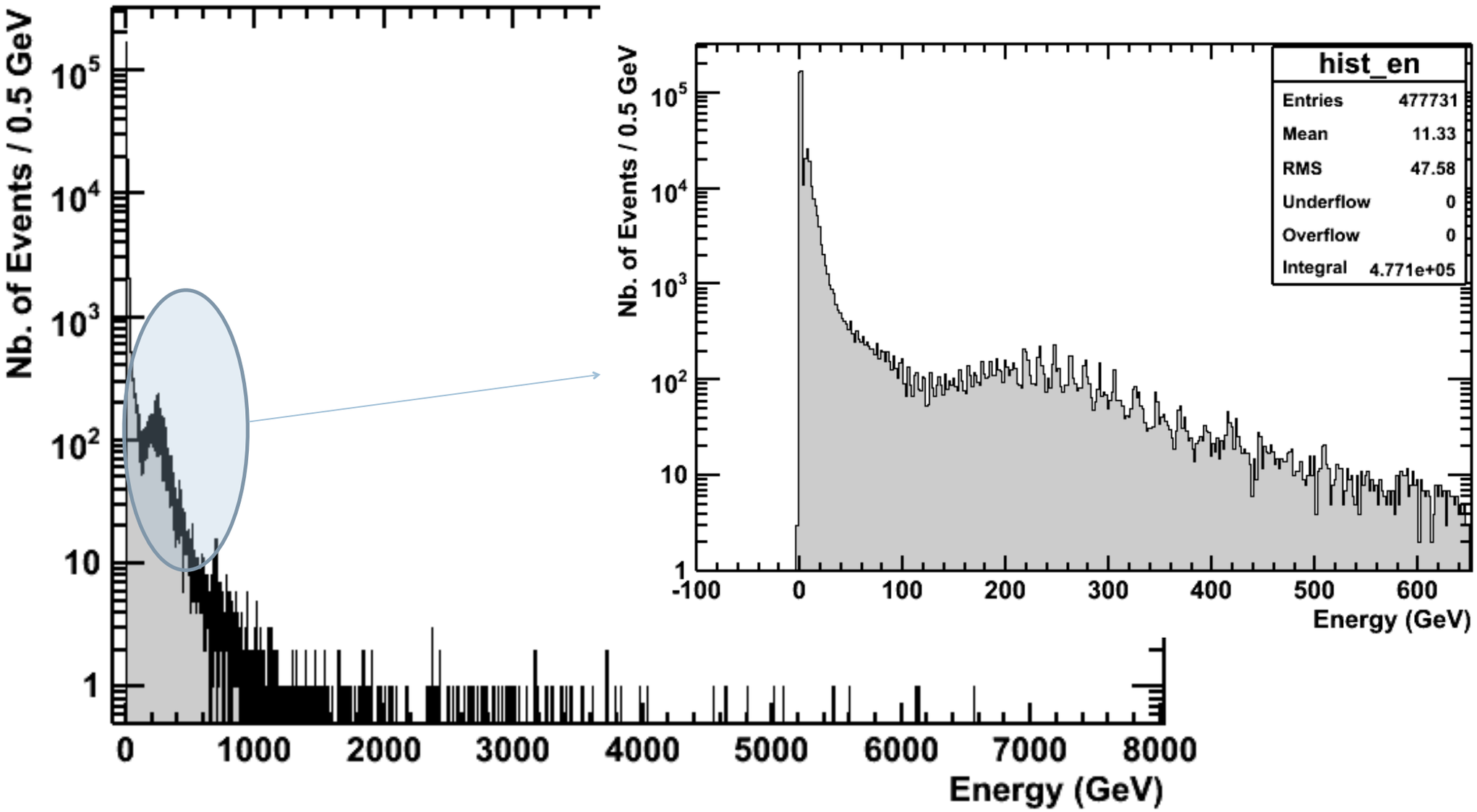


PMT : Symmetric and narrow pulse shape.

Normal : Asymmetric and wide pulse shape with sharp fall time.

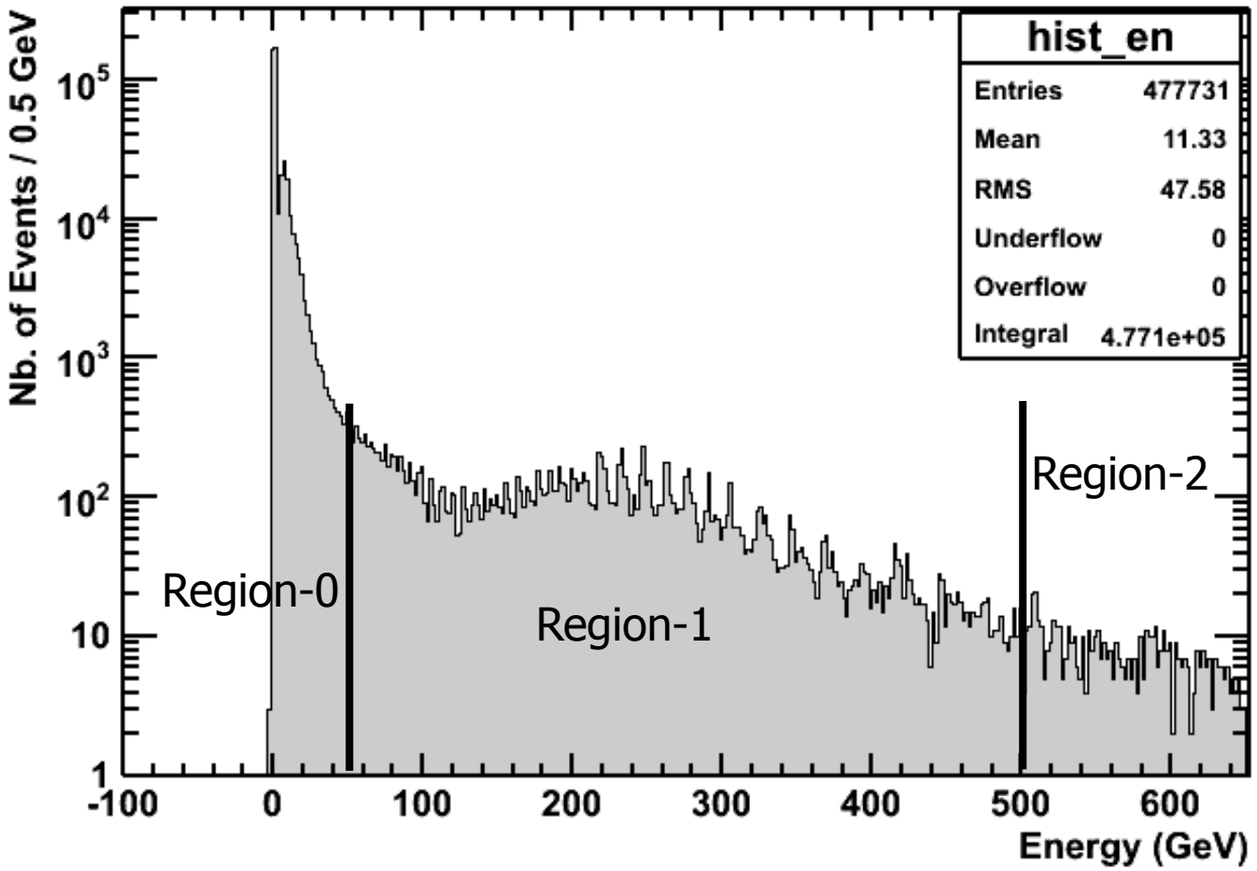
Muon Energy Spectrum

150 GeV Muon @ Tower 14 E Long Calibration with 100 GeV e-



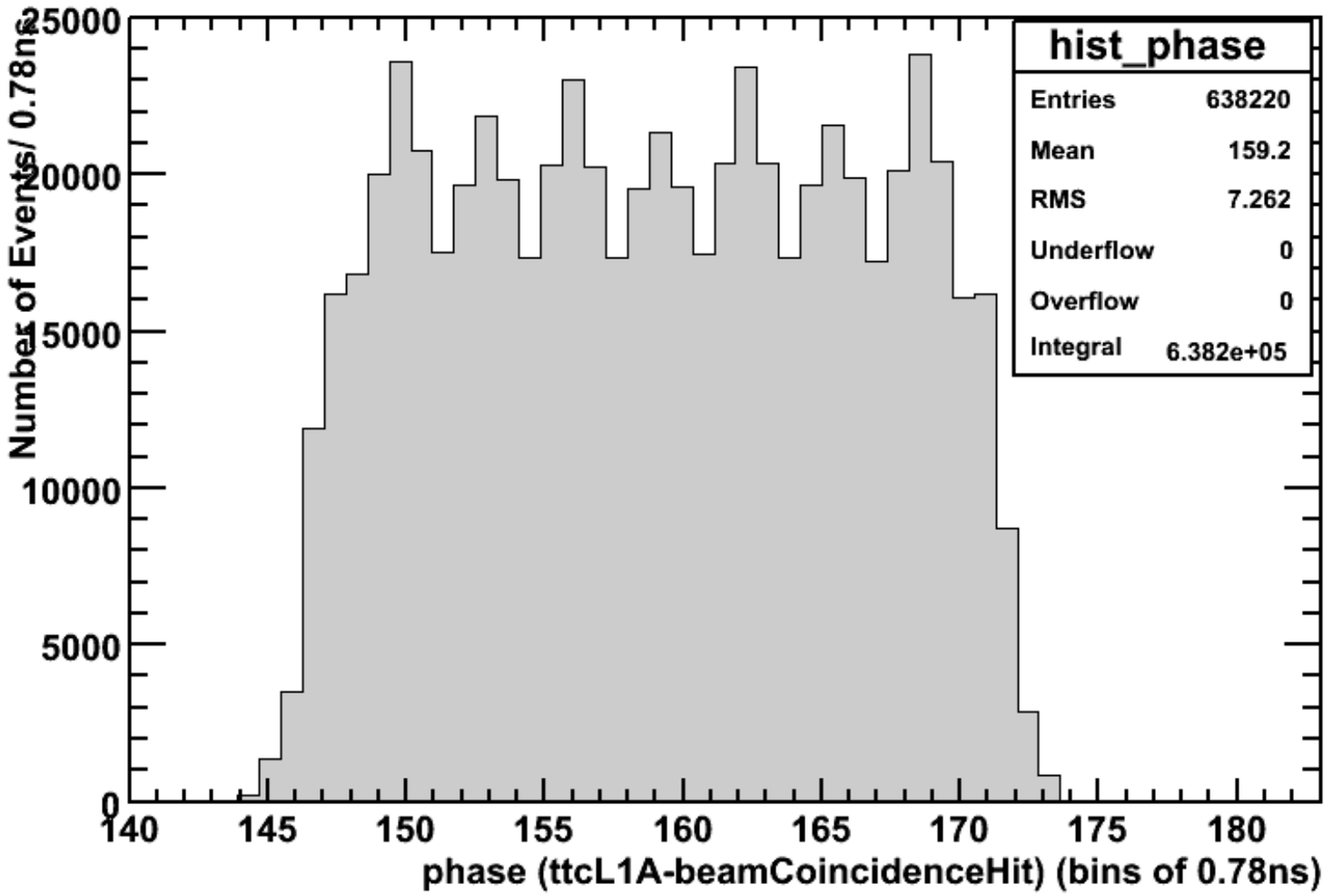
Categorize Muon Events with 'Energy Deposition'

- Normal Muon Events E < 50 GeV
  - Region-0: 1.0 GeV <E < 50 GeV
- High Energy (PMT) Events E > 50 GeV
  - Region-1: 50 GeV < E < 500 GeV
  - Region-2: E > 500 GeV



Phase of the Beam

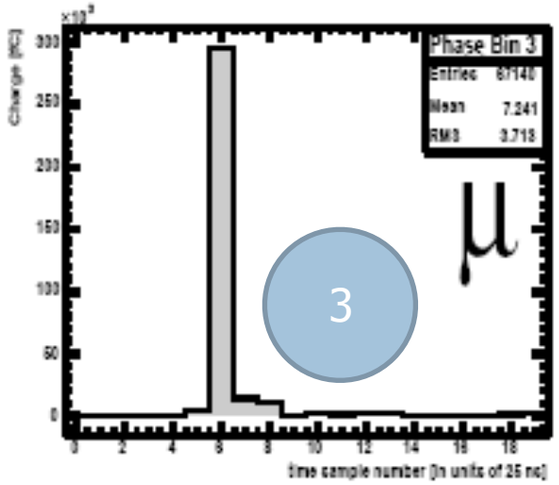
32 clock bins are divided such that it gives 25 ns buckets (0.78125 ns/bin)

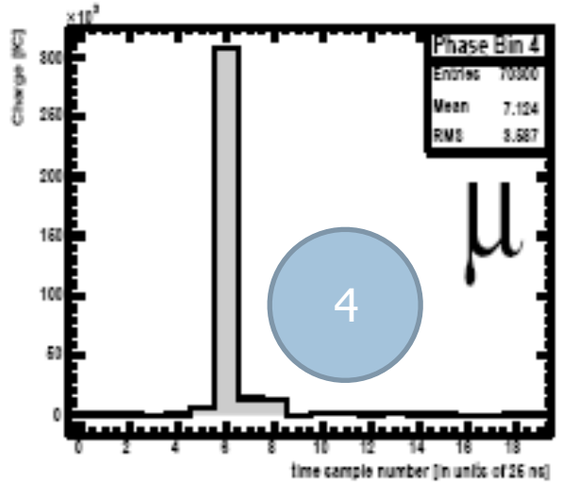


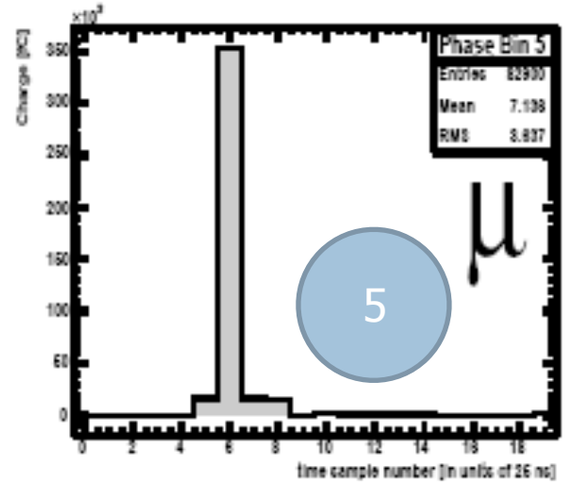
Beam was not structured. Exact beam timing is unknown. Find the phase bin where signal is shared between two time slices and then use it as reference.

Average Timing for Region-0

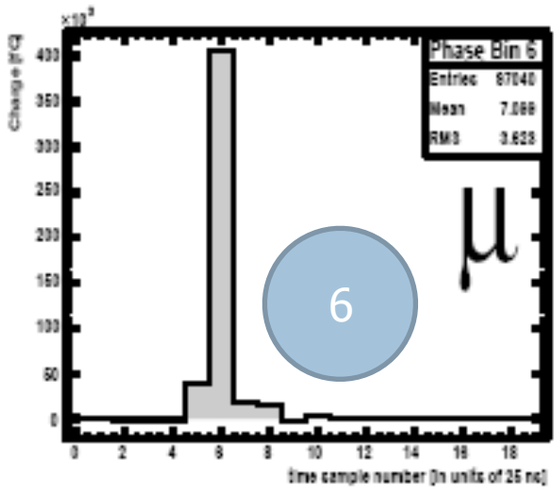
Phase Bins

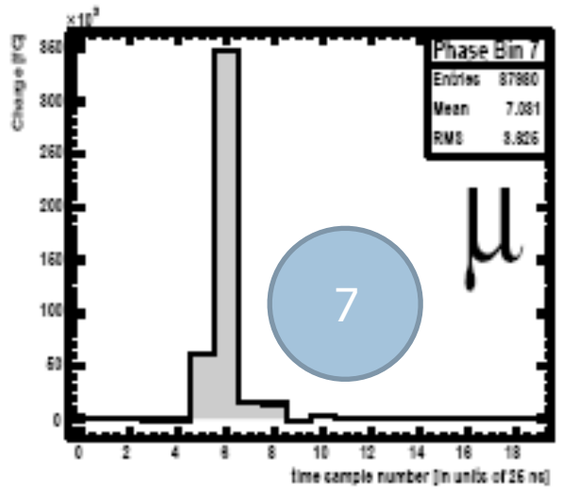


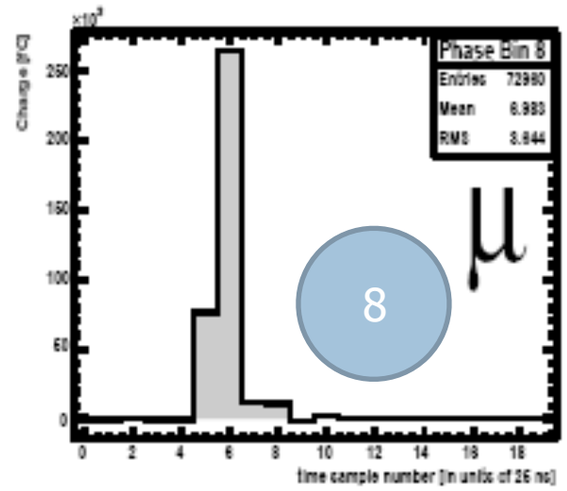




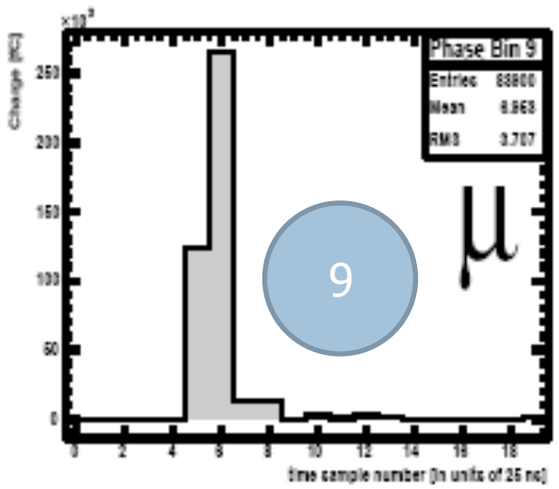
Phase Bins

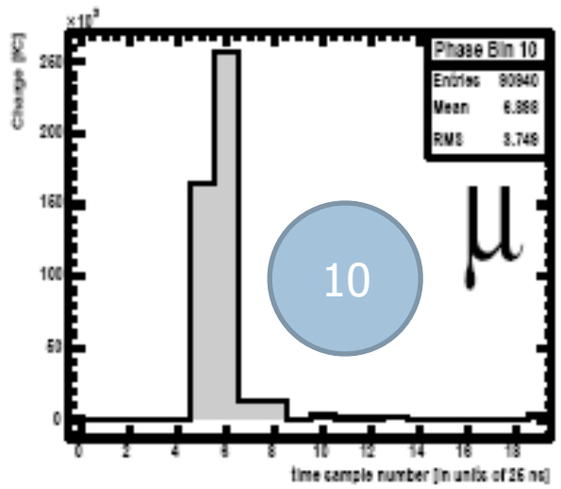


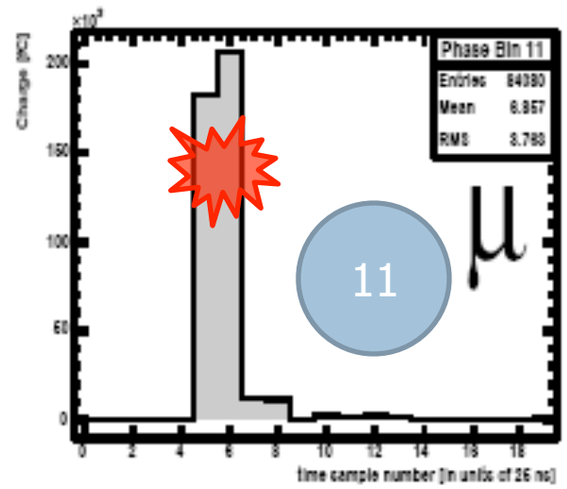




Phase Bins

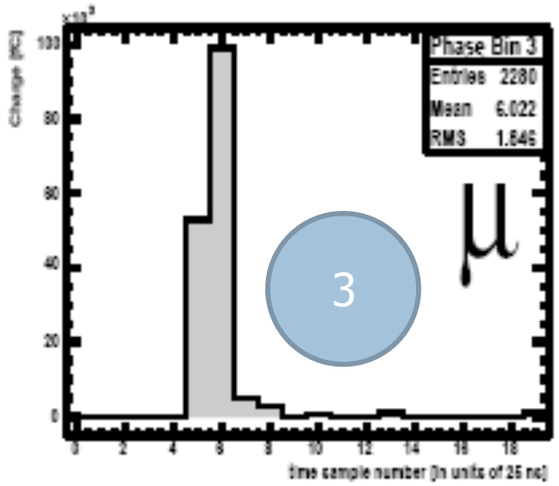


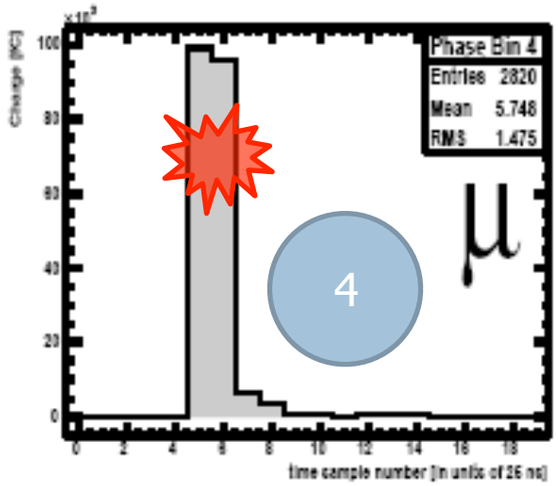


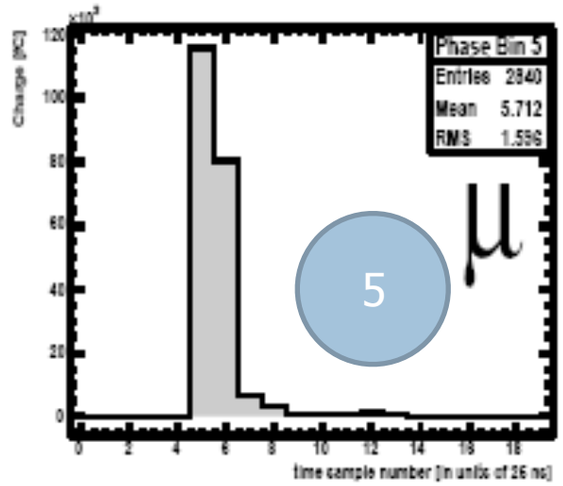


Average Timing for 100 GeV < E < 200 GeV

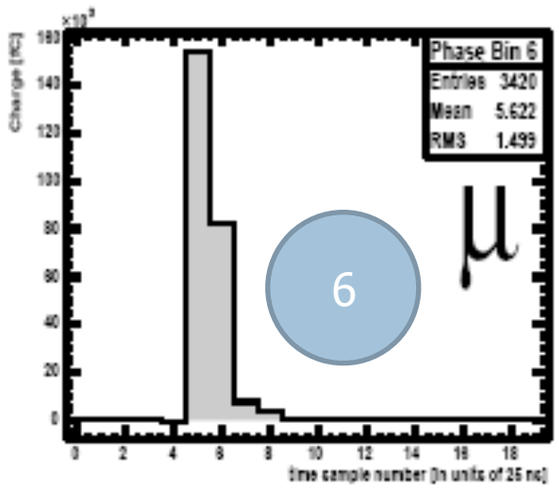
Phase Bins

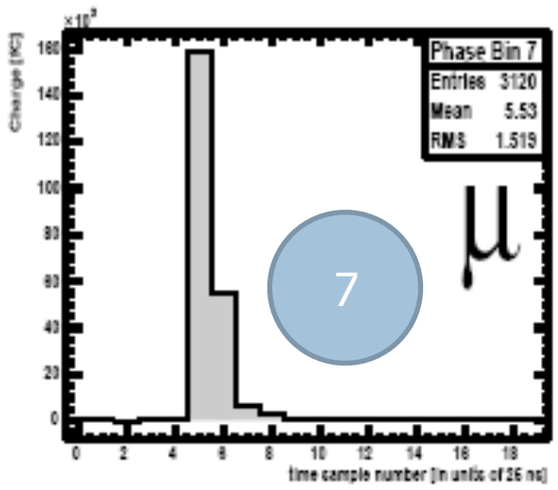


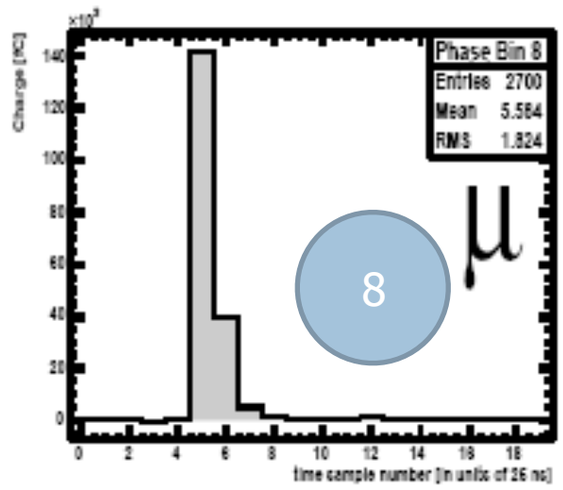




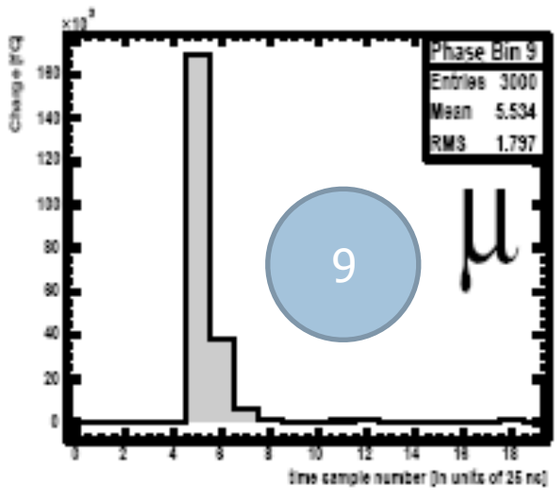
Phase Bins

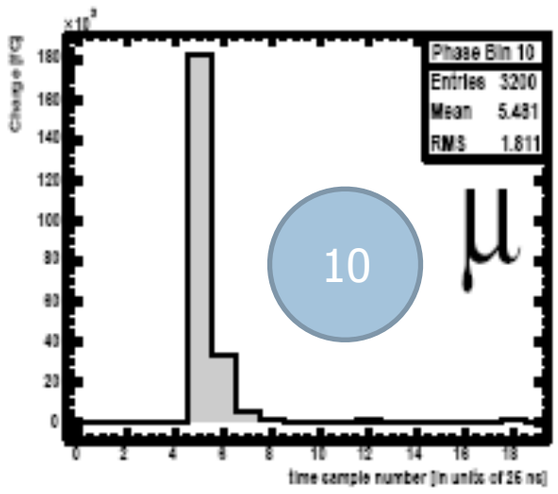


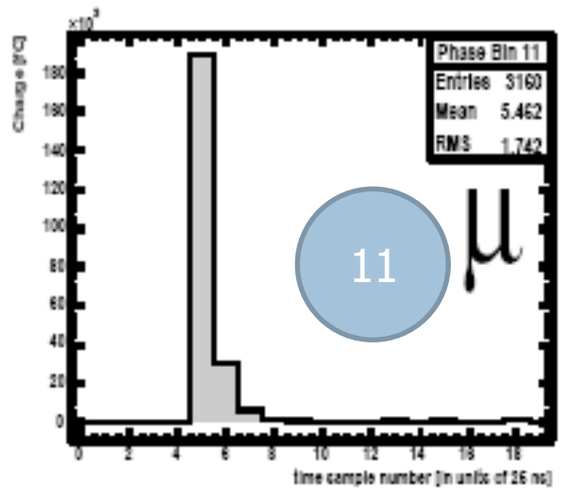




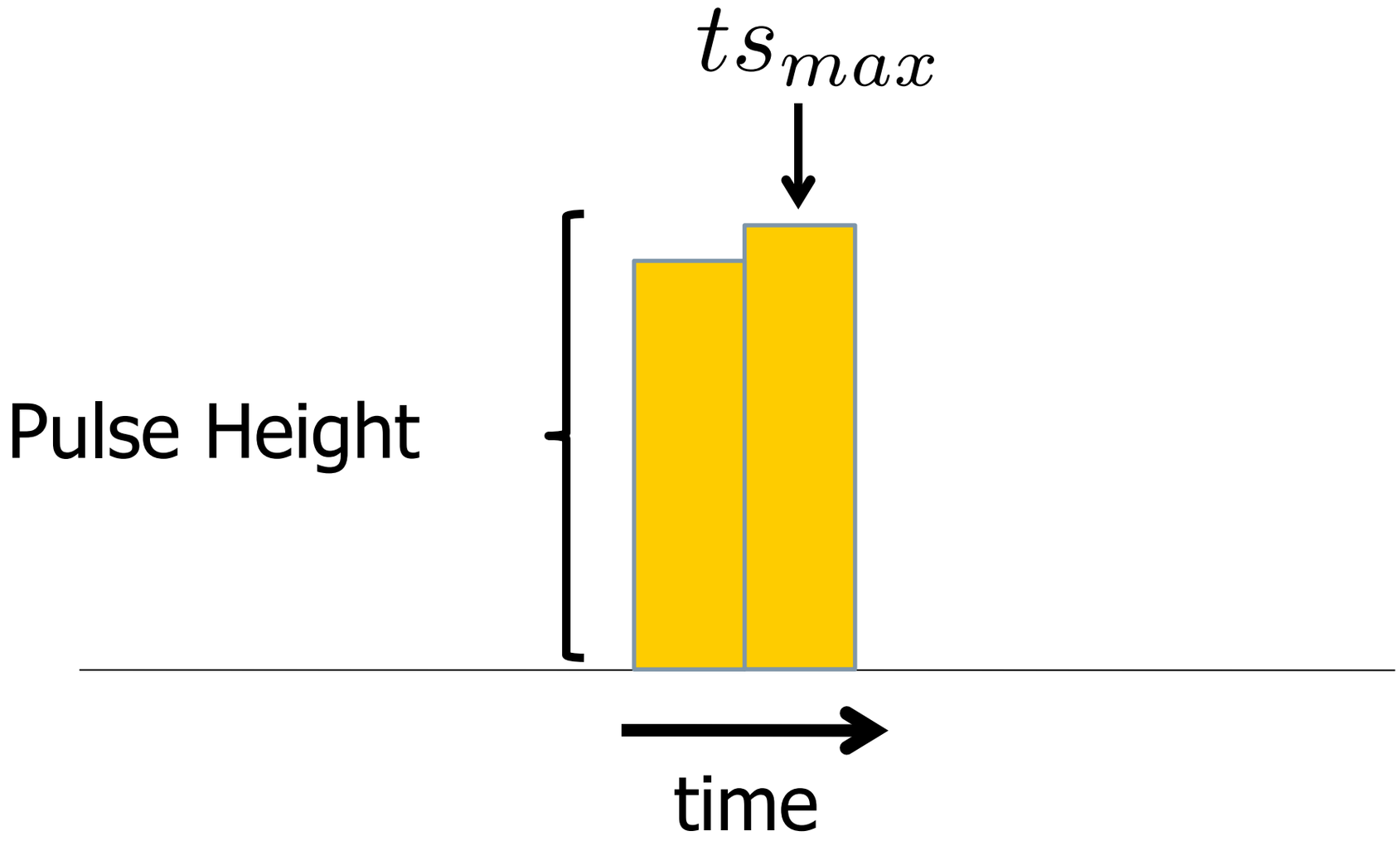
Phase Bins







Choosing A Reference Phase Bin for Signal Arrival



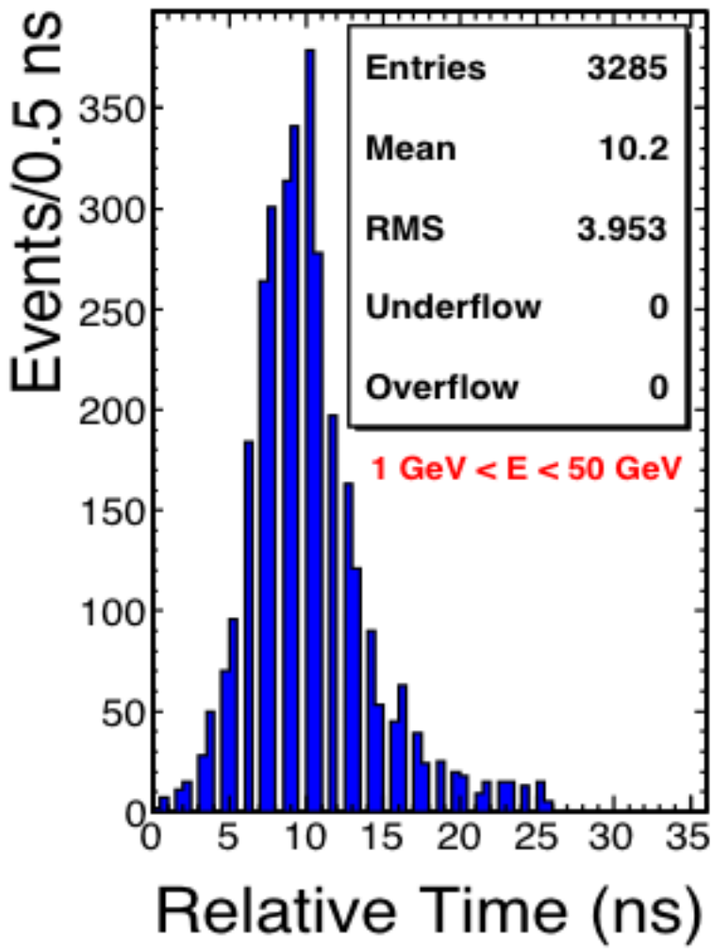
Require that $Q_{(ts_{max}-1)} + Q_{(ts_{max}+1)} > 0.25 \times Q_{ts_{max}}$

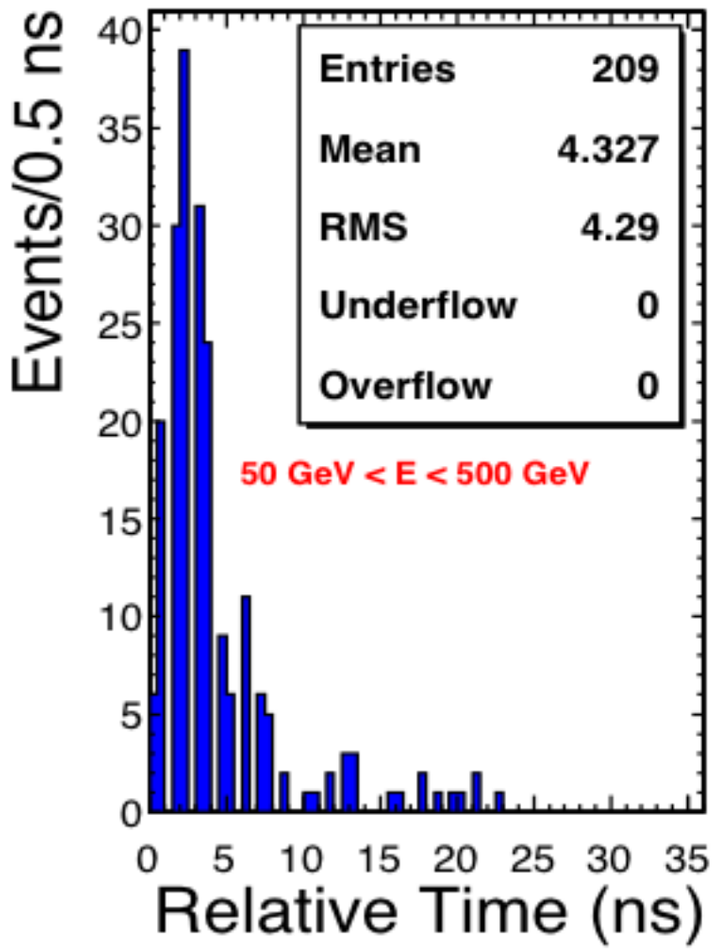
Find the phase bin where energy sharing occurs with

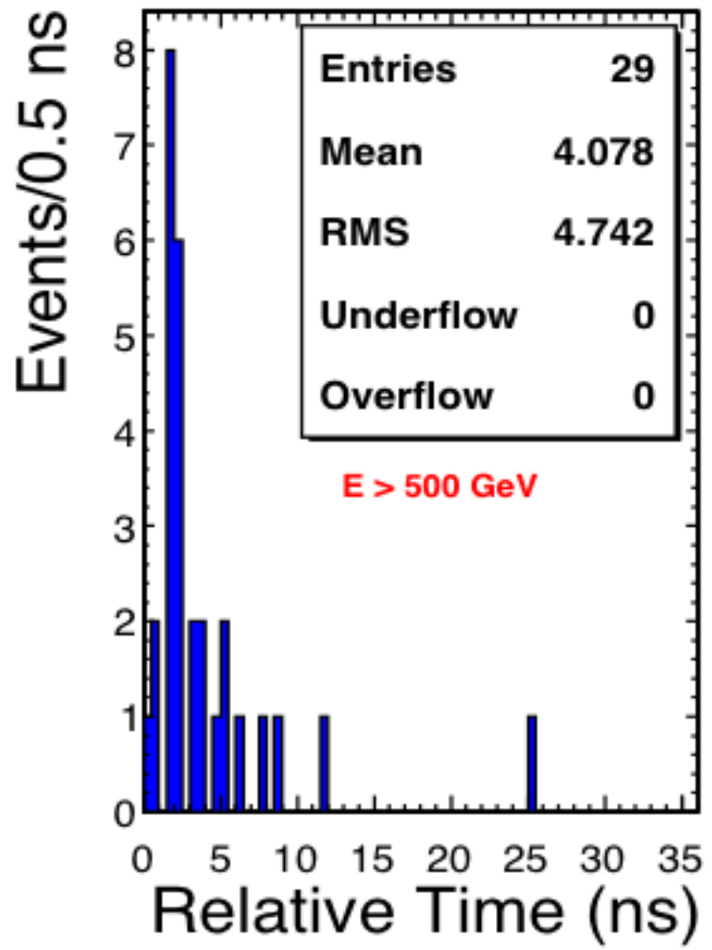
$$Q_{ts} > 0.85 \times Q_{ts_{max}}$$

where ts = ts+1 or ts-1.

Event by Event Timing





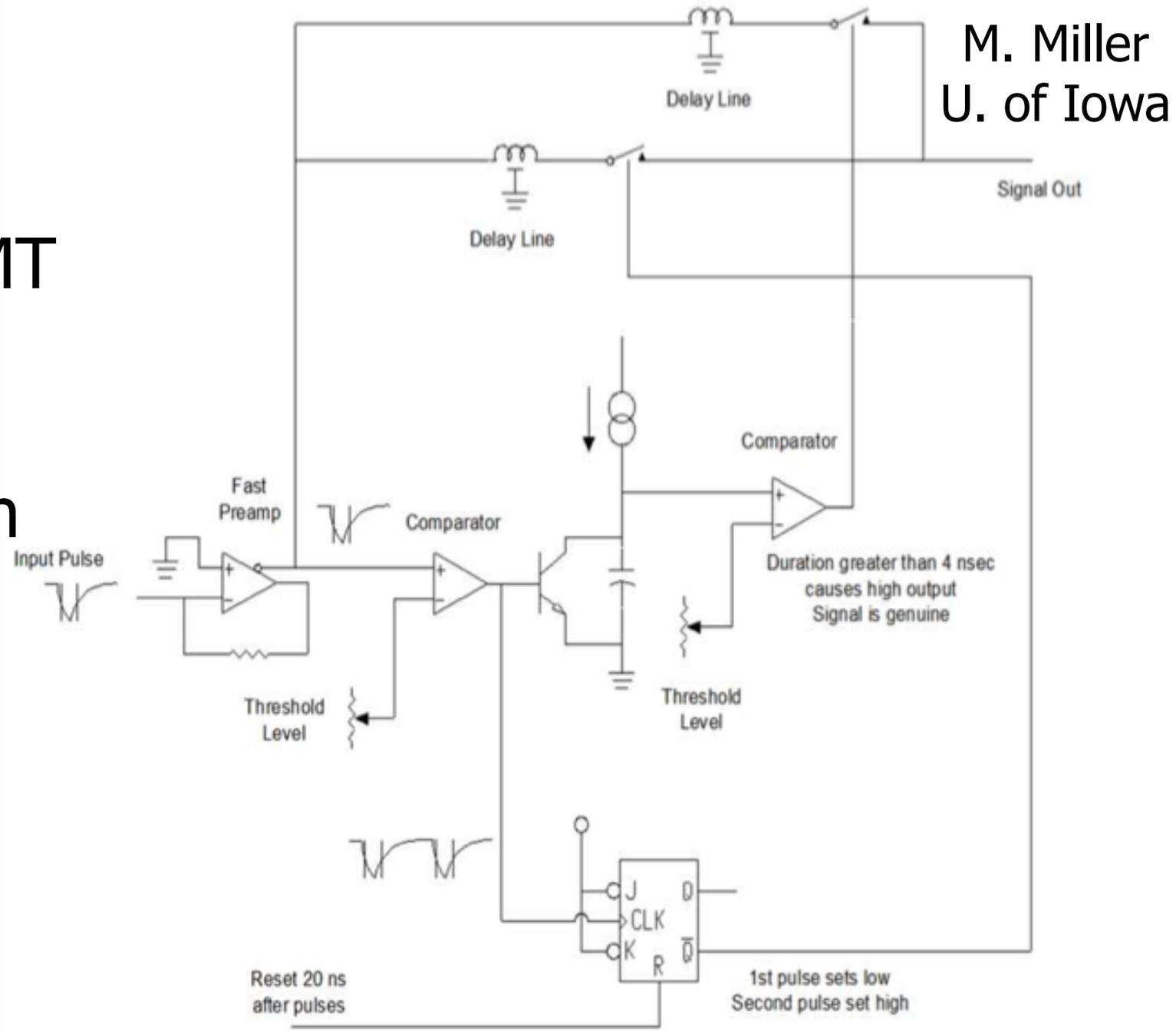


- Signal arrival time for normal events is ~10 ns (in agreement with HF specs).
- Signal from PMT events arrive ~5 ns earlier compared to normal events.

An Electronics Unit to Tag PMT Events

M. Miller
U. of Iowa

Given the pulse shape characteristics of the PMT events and their arrival time, an electronics circuit (< $100/unit) can be build and put in HF PMT base board.



Summary and Conclusions

- PMT events generate signal before the events which generate in HF.
- Timing information can be used (if signal timing is precise, i.e., not wide RMS) to discriminate "PMT events".
- An algorithm sensitive to 1 ns differences or an electronics devices sensitive to pulse shape can help to eliminate PMT events.
- More information can be found in CMS DN-2009/014