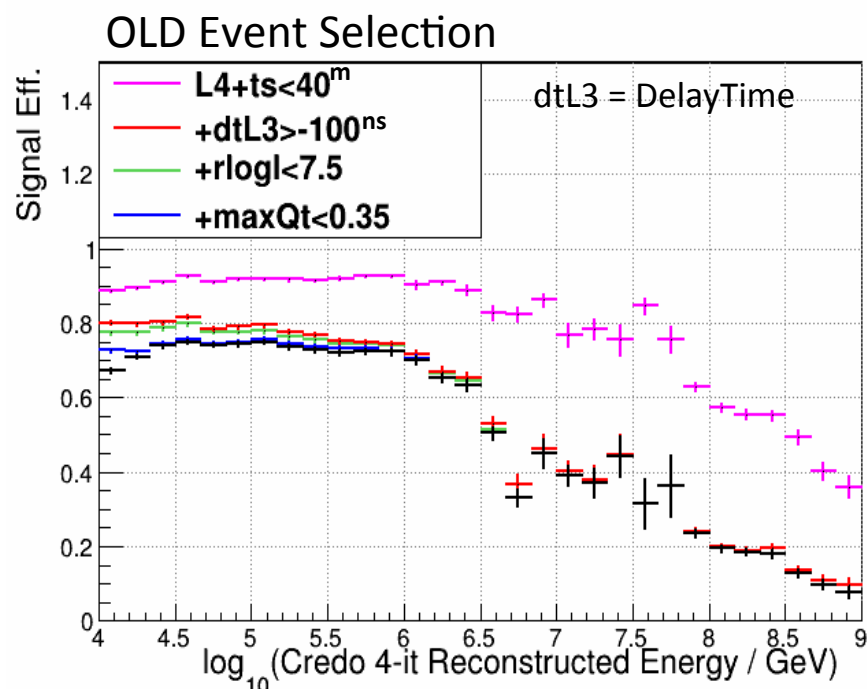# Rationale for Noise Cleaning of Input Pulses for DelayTime Variable

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DelayTime Cut Variable

- Before (E^{-2}): DelayTime > -100 ns cut (energy independent)
- After plotting signal efficiency using E^{-1} files (same cut values as for E^{-2}), the sudden drop in efficiency at higher energies is clearly visible and it comes from DelayTime cut


The drop of signal efficiency comes from DelayTime cut

Then, I looked at the signal events removed with DelayTime cut (DelayTime<-100 ns) and found they looked GOOD – no obvious reason why they have so large negative DelayTime value

Problem with DelayTime Cut Variable

- Example of NuE MC event that survives all the cuts but fails DelayTime>-100 ns (my cut value optimized with E^{-2})
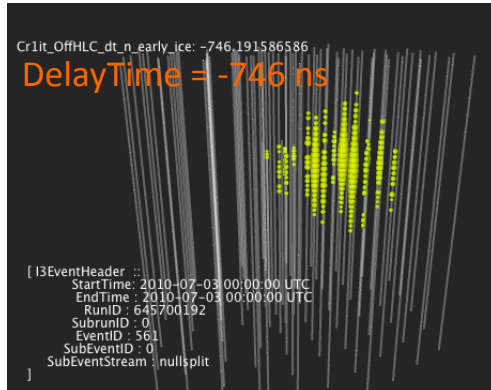
TimeDiff = time of the first hit - vertex time
DelayTime = min(TimeDiff)

PulseMap = OfflinePulsesHLC (w/o saturated DOMs)
Vertex = Credo 1-it

Then, I looked a time difference between all DOMs and vertex time to identify DOMs that give large negative values of DelayTime

Looked at the TimeDiff values for each DOM and time of the first hit t(start) on each DOM

OM(45,13) t(start) = 11387 ns TimeDiff = 663 ns
OM(45,15) t(start) = **9884** ns   TimeDiff = -746 ns
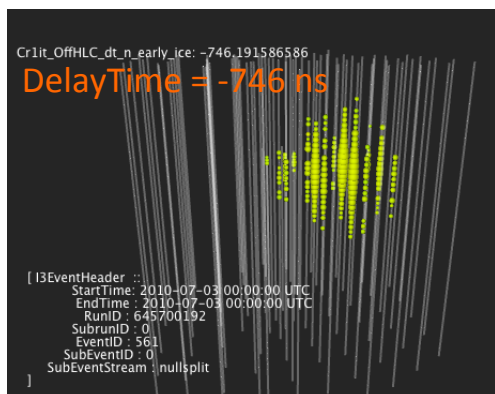OM(45,15) t(start) = 11929 ns TimeDiff = 1338 ns

DelayTime = -746 ns because of the early hit on OM(45,15)

→**Look at waveforms on the same string**

Problem with DelayTime Cut Variable

- Example of NuE MC event that survives all the cuts but fails DelayTime>-100 ns (my cut value optimized with E^{-2})

Cr1it_OffHLC_dt_n_early_ice: -746.191586586

DelayTime = -746 ns

[I3EventHeader ::
StartTime: 2010-07-03 00:00:00 UTC
EndTime : 2010-07-03 00:00:00 UTC
RunID : 645700192
SubrunID : 0
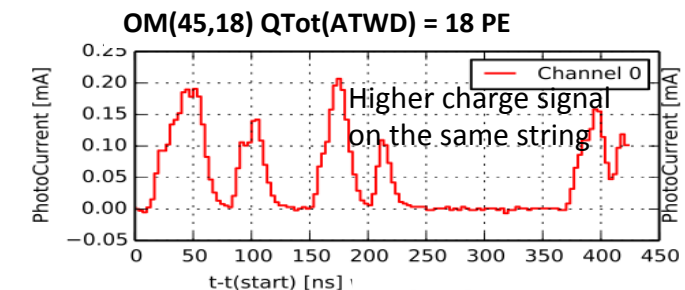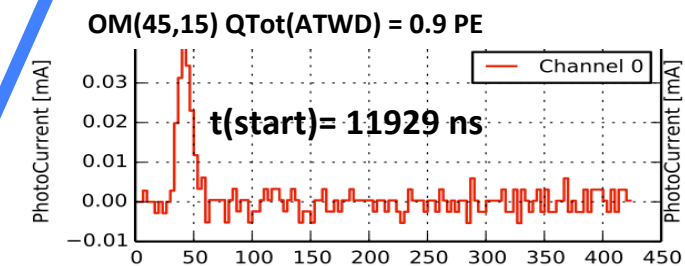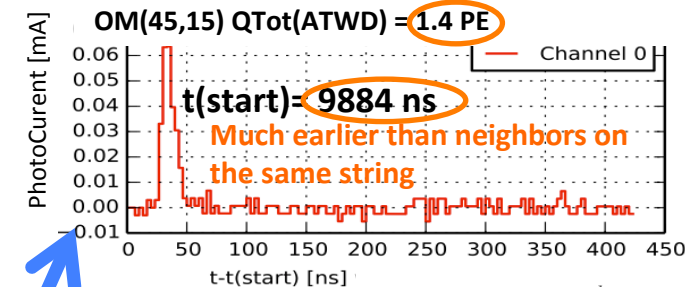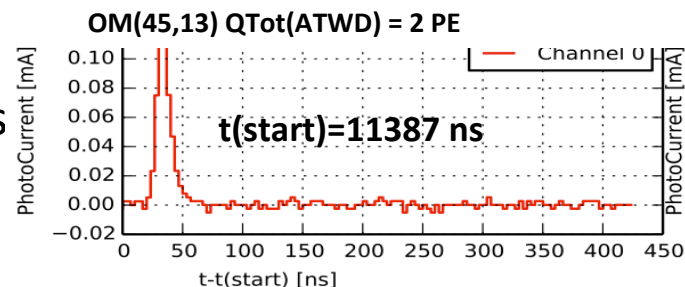EventID : 561
SubEventID : 0
SubEventStream : nullsplit
]

TimeDiff = time of the first hit - vertex time
DelayTime = min(TimeDiff)

PulseMap = OfflinePulsesHLC (w/o saturated DOMs)
Vertex = Credo 1-it

Looked at the TimeDiff values for each DOM and time of the first hit t(start) on each DOM
OM(45,13) t(start) = 11387 ns TimeDiff = 663 ns
OM(45,15) t(start) = **9884** ns   TimeDiff = -746 ns
OM(45,15) t(start) = 11929 ns TimeDiff = 1338 ns

→ OM(45,15) has an early hit with small charge (<2PE) - needs to be removed from pulse map

OM(45,13) QTot(ATWD) = 2 PE

t(start)=11387 ns

OM(45,15) QTot(ATWD) = 1.4 PE

t(start)= 9884 ns
Much earlier than neighbors on the same string

OM(45,15) QTot(ATWD) = 0.9 PE

t(start)= 11929 ns

OM(45,18) QTot(ATWD) = 18 PE

Higher charge signal on the same string

DelayTime Variable Solution

Old and new (recalculated) value of DelayTime

- I found the following problem:
  - On a string there is an early (much earlier than the neighbors) hit with small charge (of ~few PE) that causes DelayTime to get large negative values (< -100 ns) thus rejects those events

- My solution:
  - clean input pulse series used in DelayTime calculation: for each string remove DOMs with early hits* and re-calculate DelayTime

New DelayTime

Cr1it_OffHLC_Delay_ice: 3.6606737842

Cr1it_OffHLC_dt_n_early_ice: -746.191586586

Old DelayTime

[I3EventHeader ::
        StartTime: 2010-07-03 00:00:00 UTC
        EndTime : 2010-07-03 00:00:00 UTC
        RunID : 645700192
        SubrunID : 0
        EventID : 561
        SubEventID : 0
    SubEventStream : nullsplit
]

* Early hit = time difference of the first hit between a given DOM and a neighboring DOM is bigger than 1000 ns and charge is smaller than 2 PE