Candidate Event Formation and Readout Dead Time Accounting in MINERvA

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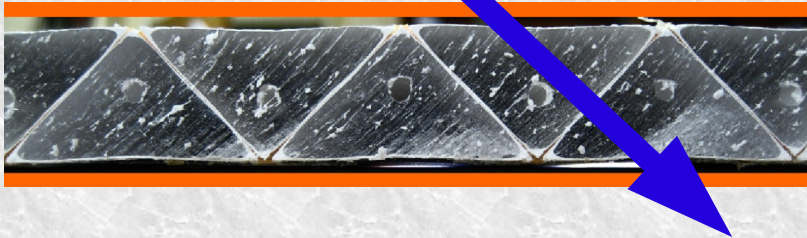
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Outline

- Introduction.

- Candidate Event Formation.

- Readout Dead Times.
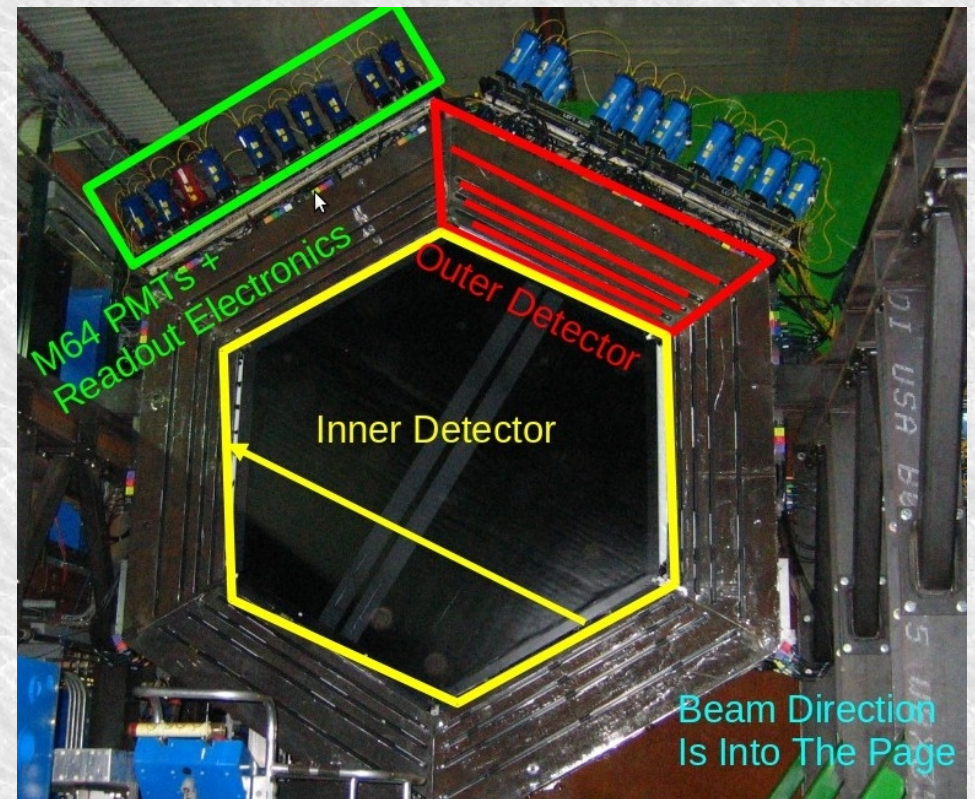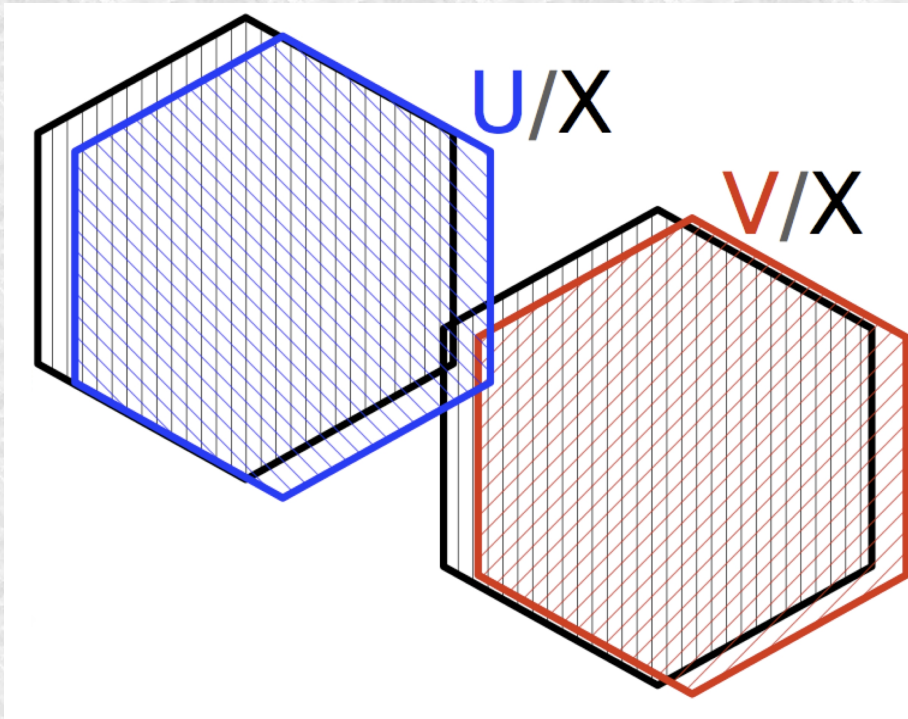
- Conclusions.

Introduction

particle

> The deposited energy in every scintillator strip is read by an electronic channel.

> MINERvA has ~32k readout channels in total.

> Every plane is composed of 127 scintillator strips in 3 orientations: X, U(-60^0) and V(60^0).

U/X

V/X

M64 PMTS + Readout Electronics

Outer Detector

Inner Detector

Beam Direction Is Into The Page

Candidate Event Formation

- MINERvA receives a neutrino beam spill of ~10 µs long every 2.2 s.

- Hits are bunched into event candidates, a.k.a. "**Time Slices**".

- A time slice is a collection of hits occurring in the same time window.

- Time slices are typically ~100 ns wide.

The MINERvA   event display for a spill (~35e12 POT/spill) looks like:
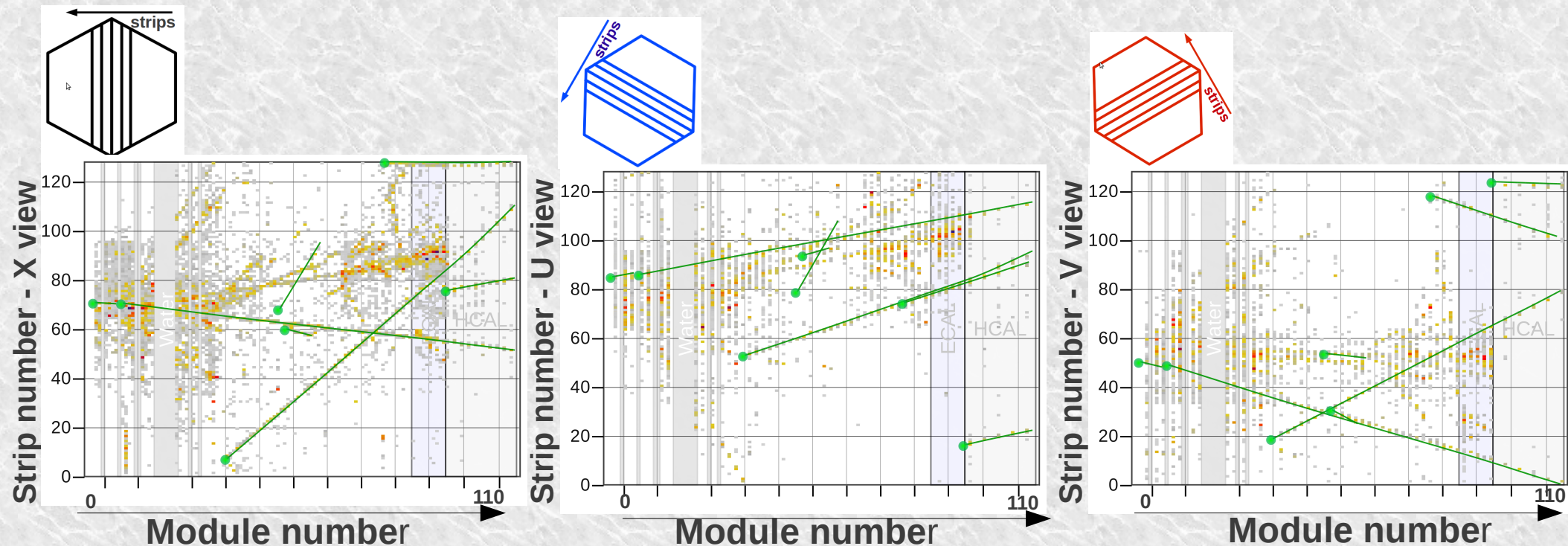
Time Slicing strategy

Method:

- Make a sweep over all hit times to looking for a minimum number of photo-electrons (PE) in a set time window.

- Start a slice when minimum PE (10 PE's) is found in sweeping window.

- Stop a slice when minimum PE is no longer found in sweeping window.

- For every scan point, we use a forward window (50 ns) to find the final point of the slice.
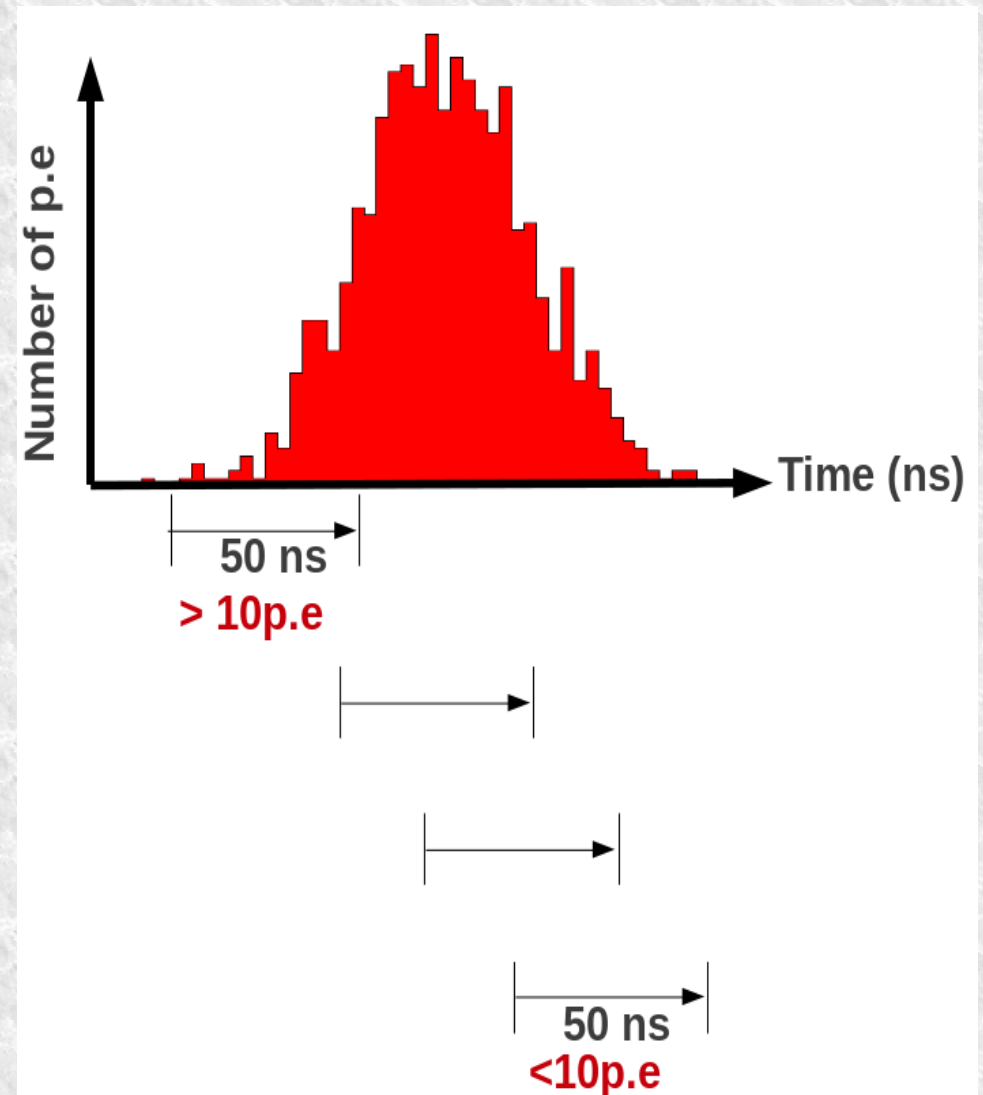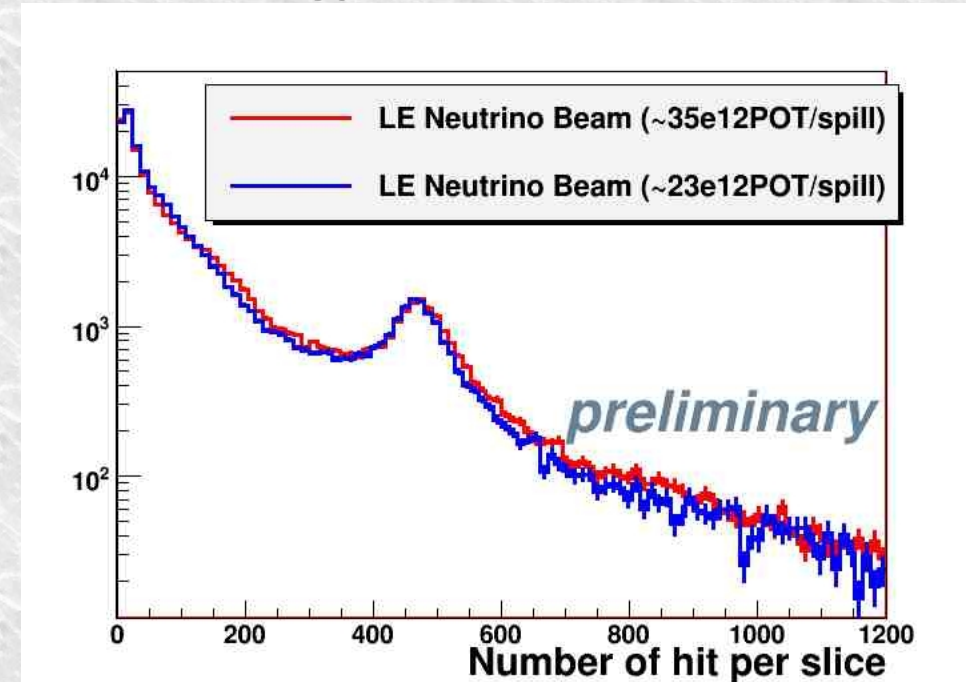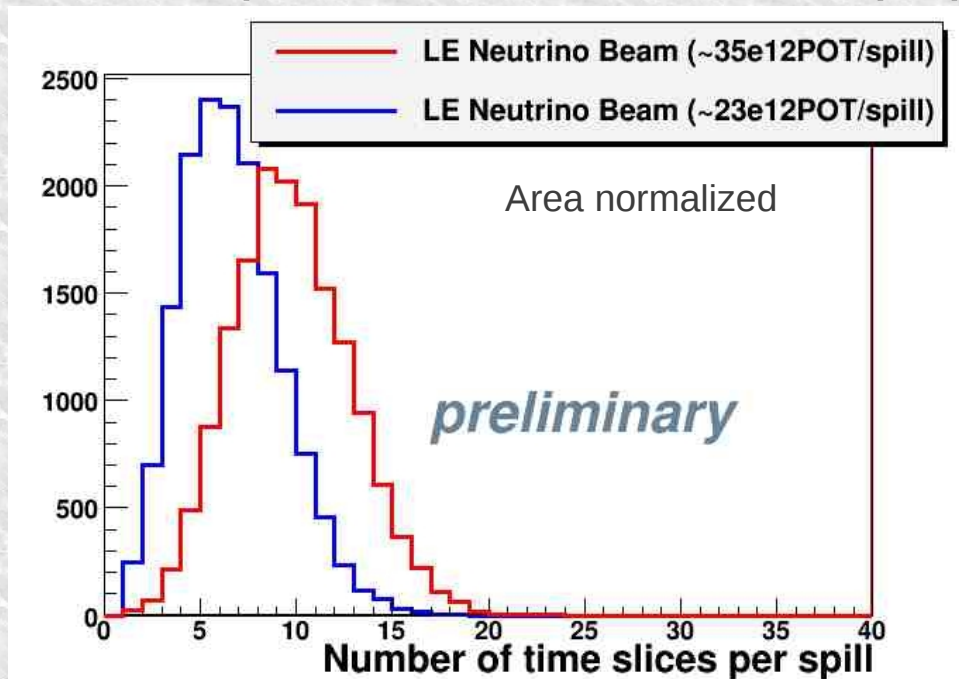
Time Slicing example

After this, we can separate different interactions.
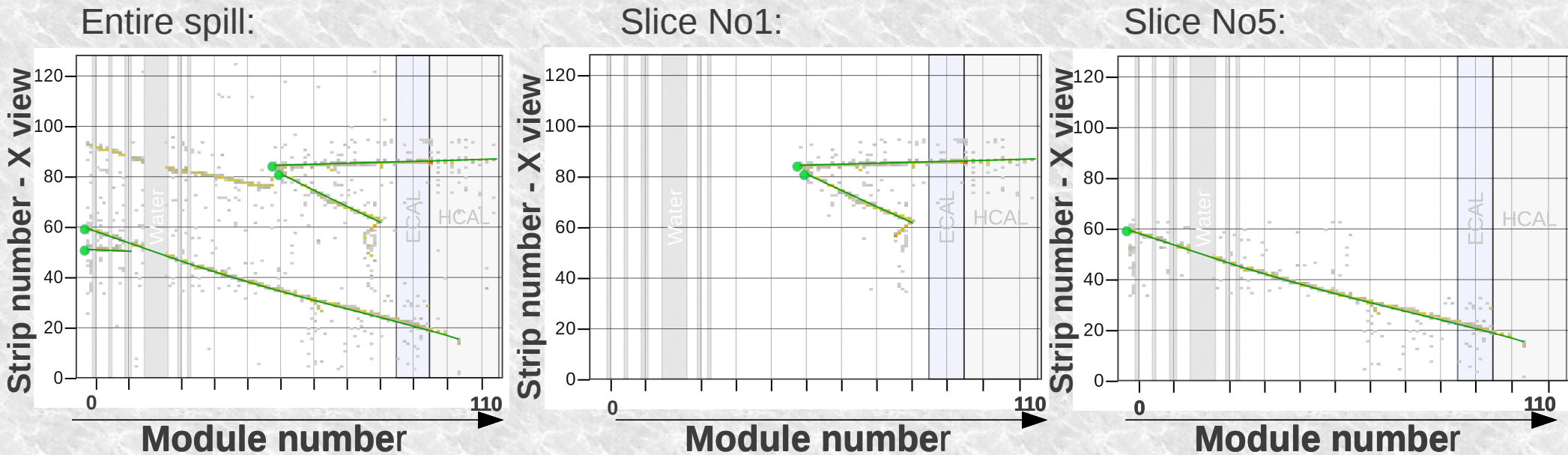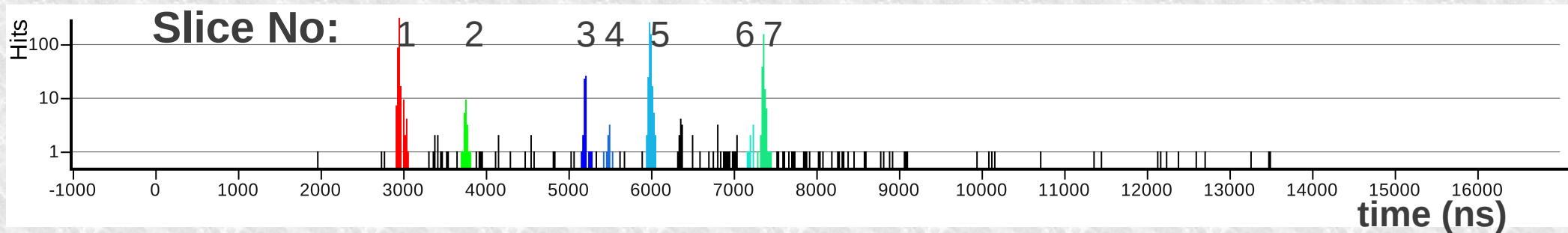
Time Slicing plots

- We show the number of time slices per spill and the number of hits per slice for MINERvA data for two different intensities (~35e12 POT/spill and ~23e12 POT/spill) for Low Energy NuMI beam.

Area normalized

preliminary

preliminary

As we expect, the fraction of intensities (~ 23/35 = 0.657) and the fraction of the mean of time slices per spill (6.14/9.24 = 0.665) are in good agreement.

As we expect, these plots are almost the same, showing the robustness of time slice method.

Readout dead times

A few words about MINERvA timing:
- For readout purposes, 32 channels form a group.
- When a charge is over a threshold due to a hit, the readout system opens a window of ~150 ns to read all hits in its channel group with a granularity of 2.5 ns.
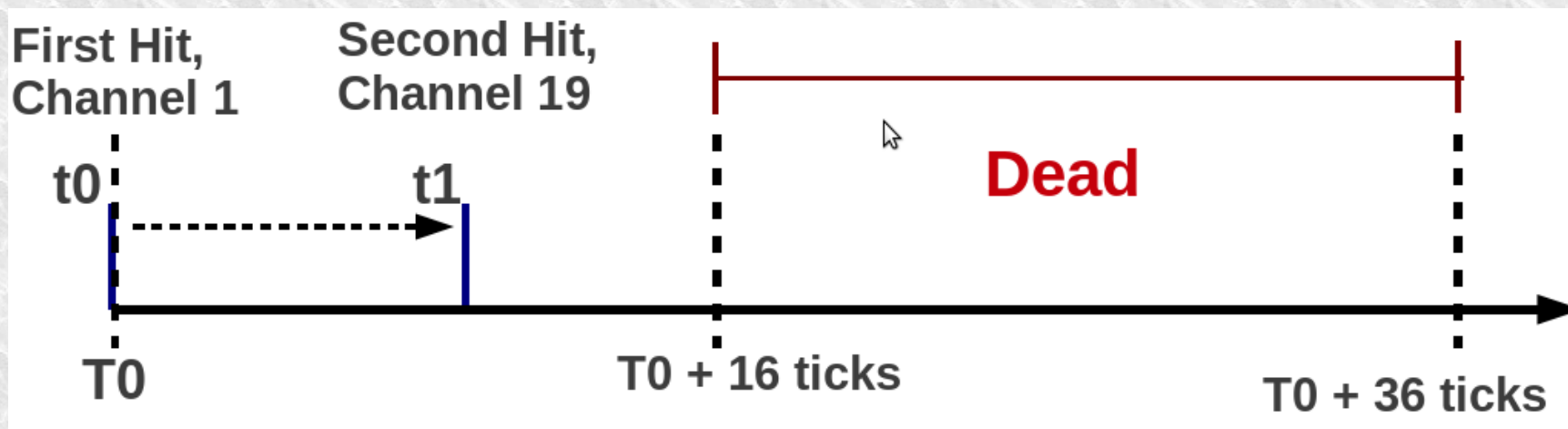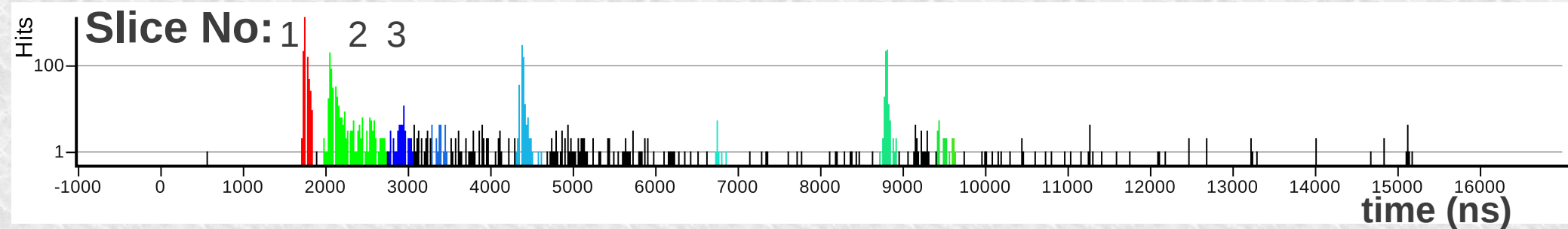

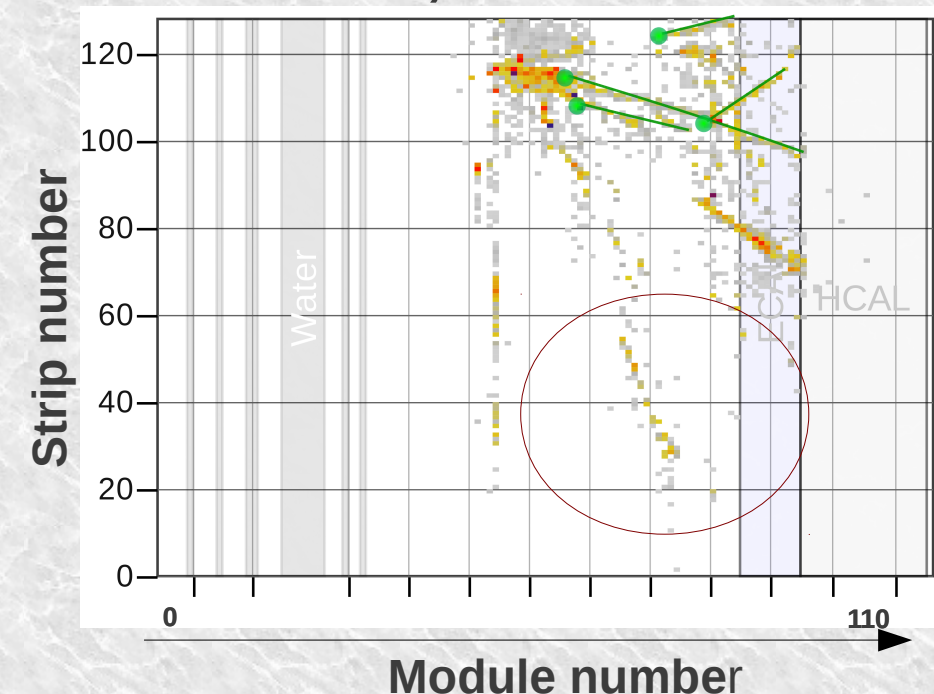After this time window, it is effectively dead to new signal for ~188 ns.

We need to know the effects of the dead time in the reconstruction
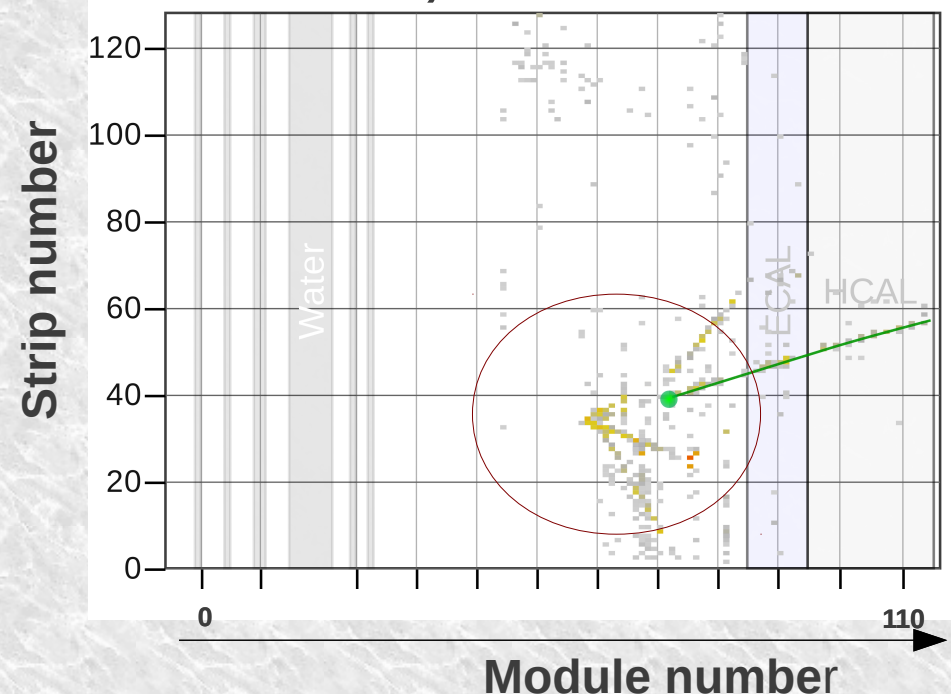
Motivation 1

The readout of the information in one time slice could affect the reconstruction of the event in the next time slice.
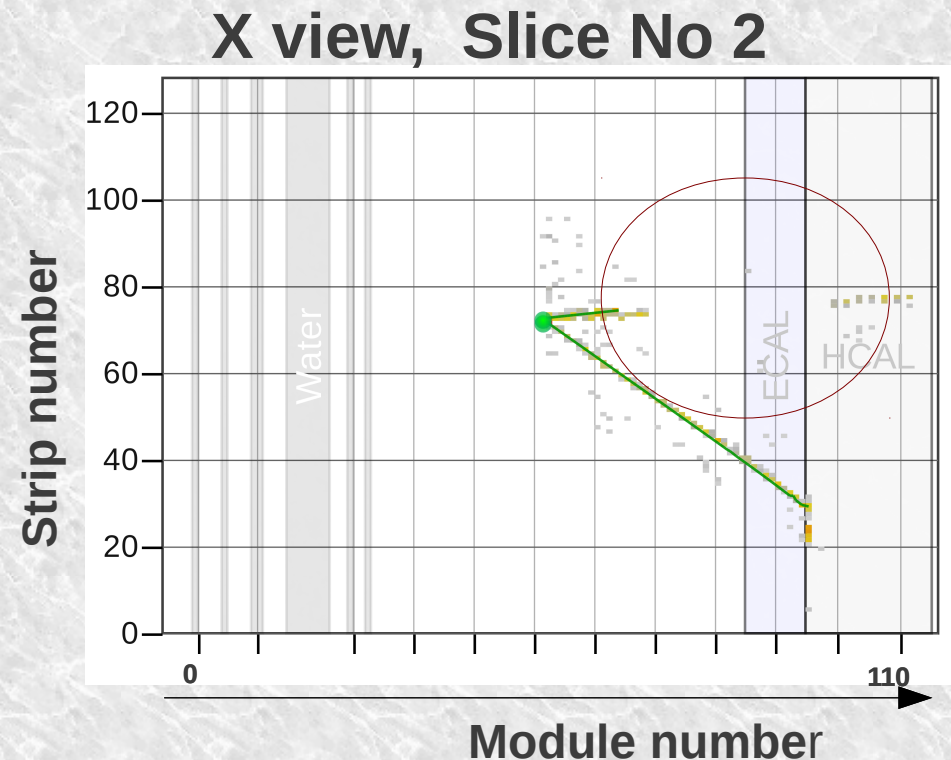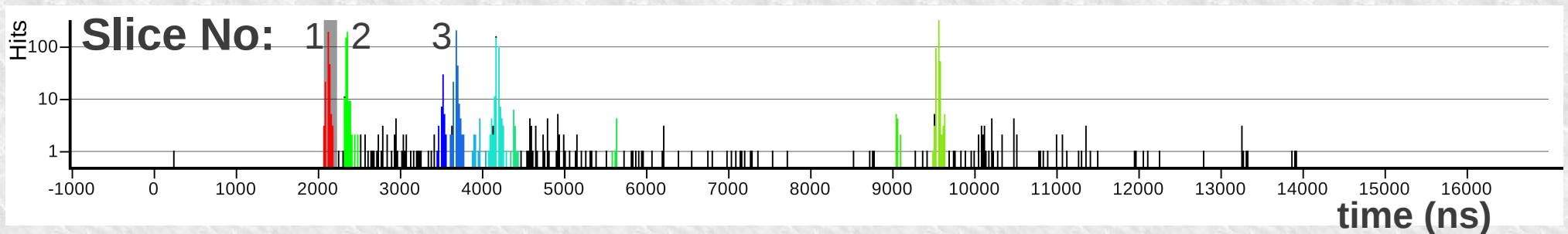
Motivation 2

The readout in one time slice could affect the MINOS and MINERvA match for muons. For slice No2 there is a muon track in MINOS.

Dead times strategy

- During the MINERvA data processing, we store the times that open the readout window for every channel group.

- The key idea is to set a 2- dimensional lookup table with two indices: one for time and other for channel group of dead time flags (bits).

- This allows to us to have:

> a complete map of the readout live and dead times of the detector per every spill at the beginning of our reconstruction or analysis just using
> (1K channel groups) x (1601 bits) ~ 0.2MB

Time (ticks)	0	1	2	3	4	…	N	…	1600
Channel group 1	0	0	1	1	1		0		0
Channel group 2	0	0	0	0	0		1		0
…									
Channel group N	0	0	0	1	1		0		1

Dead time accounting example

For instance, if we want to check the quality of the vertex reconstruction we can count the number of dead channel groups around the upstream projection of the track for the vertex time.

Using a MINERvA tool, we found 11 dead channel groups for two modules upstream of the projection of the track.
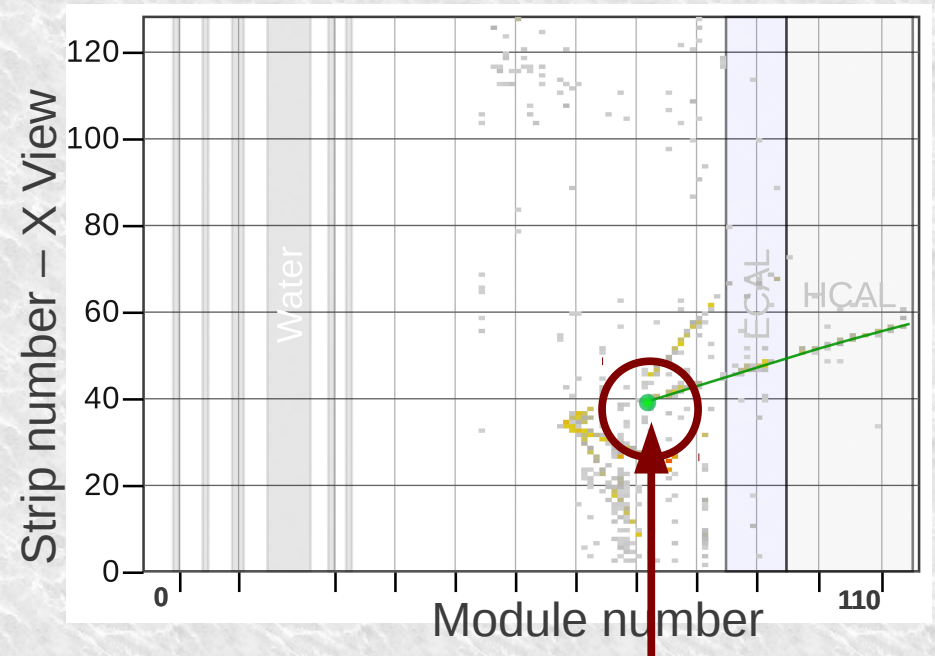
2000 ns / 9,4 ns/tick ~ 213 tick

Time (ticks)	0	1	…	212	213	214	…	1600
Channel group 1	0	0		0	1	1		0
…								
Channel group 506	0	0		1	1	1		0
Channel group 507	0	0		0	1	1		0
Channel group 508	0	0		1	1	1		0
…								
Channel group N	0	0		0	0	0		0

Impact of the readout dead times

- We show the fraction of the tracks that have dead channel groups for charged current events.

- In the upper plot, as we expect, this fraction is reduced when we have less neutrino beam intensity.

- In the lower plot, this fraction is increased when we have more neutrino beam energy.
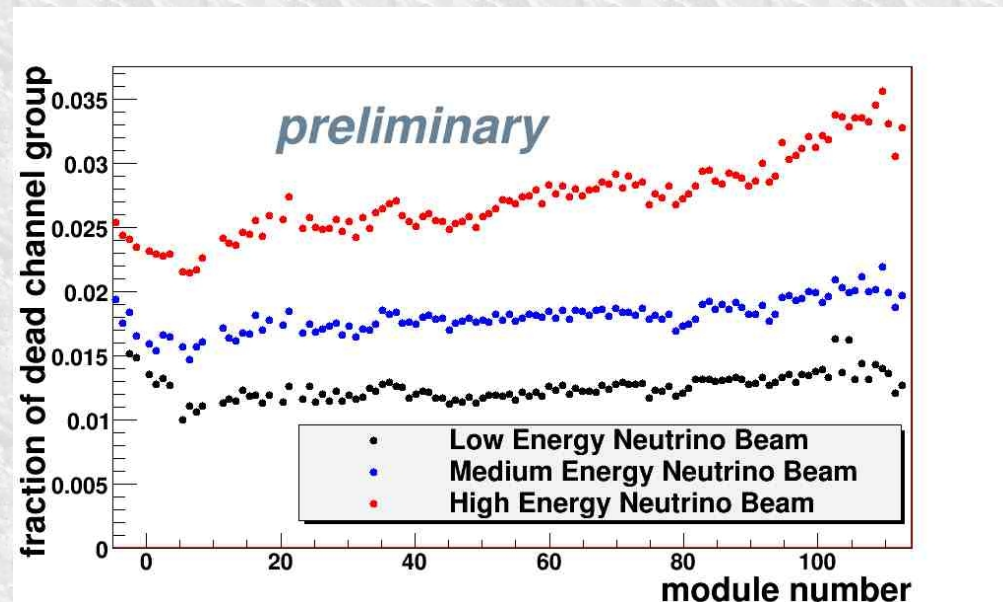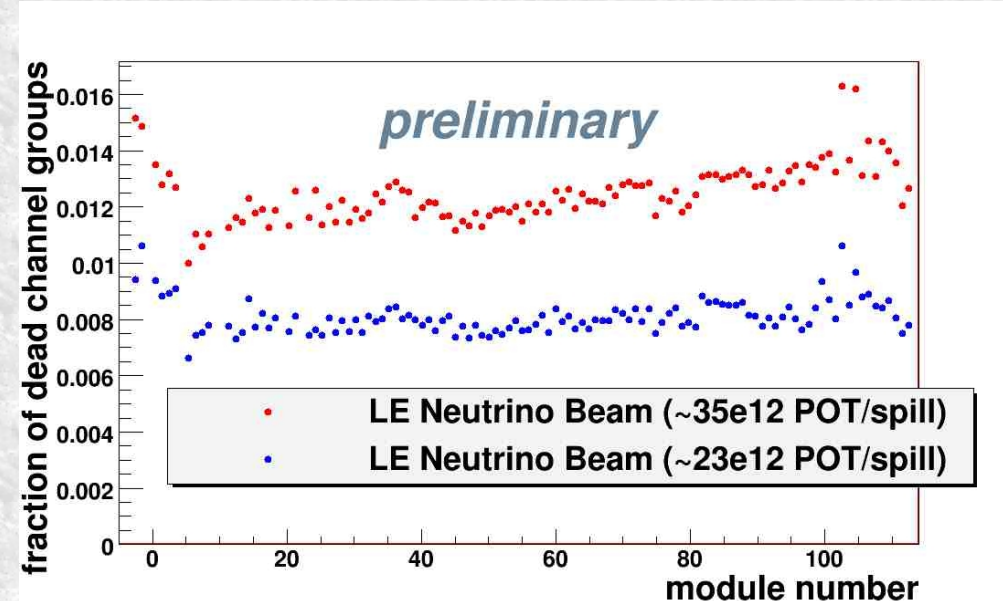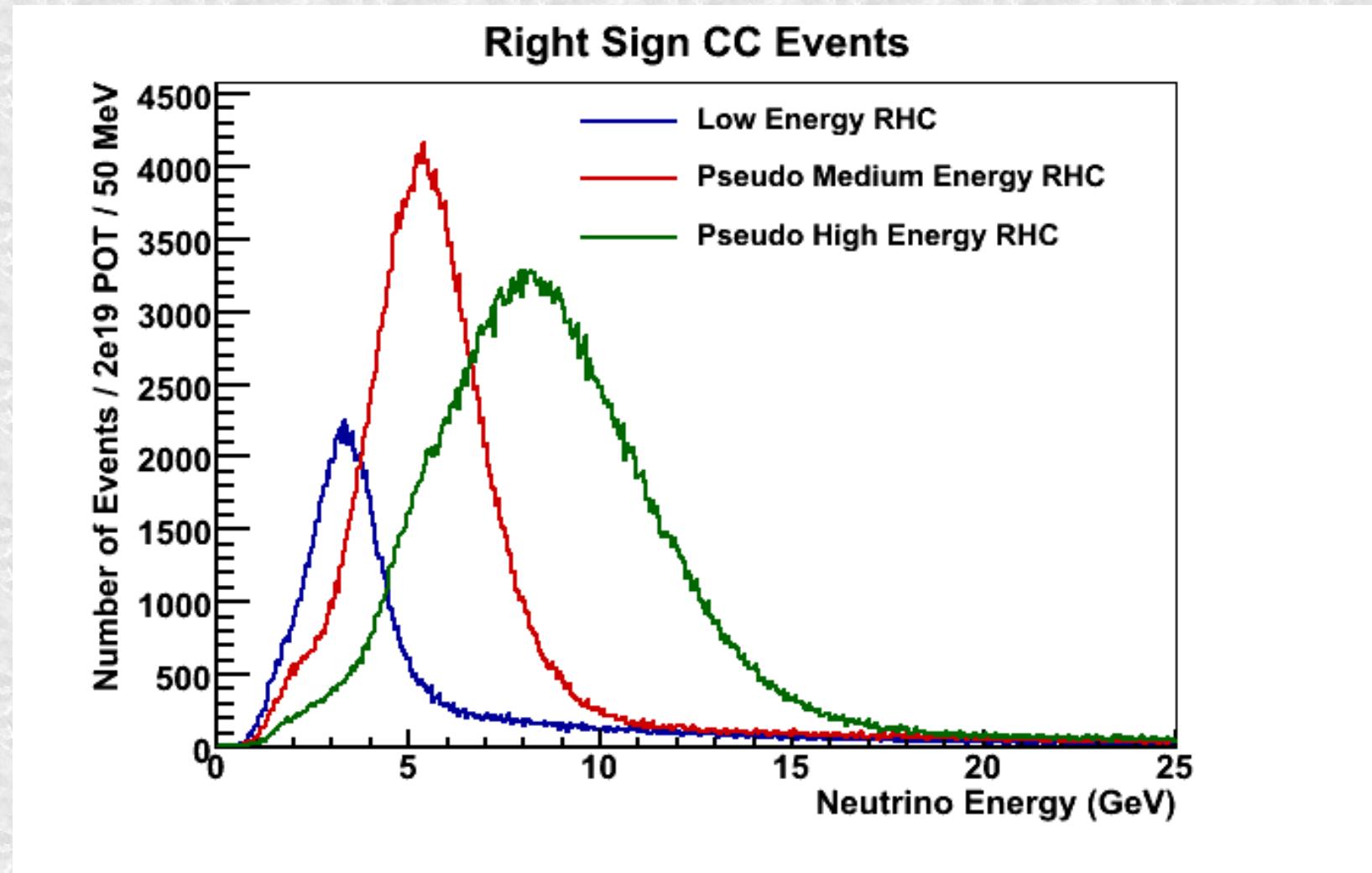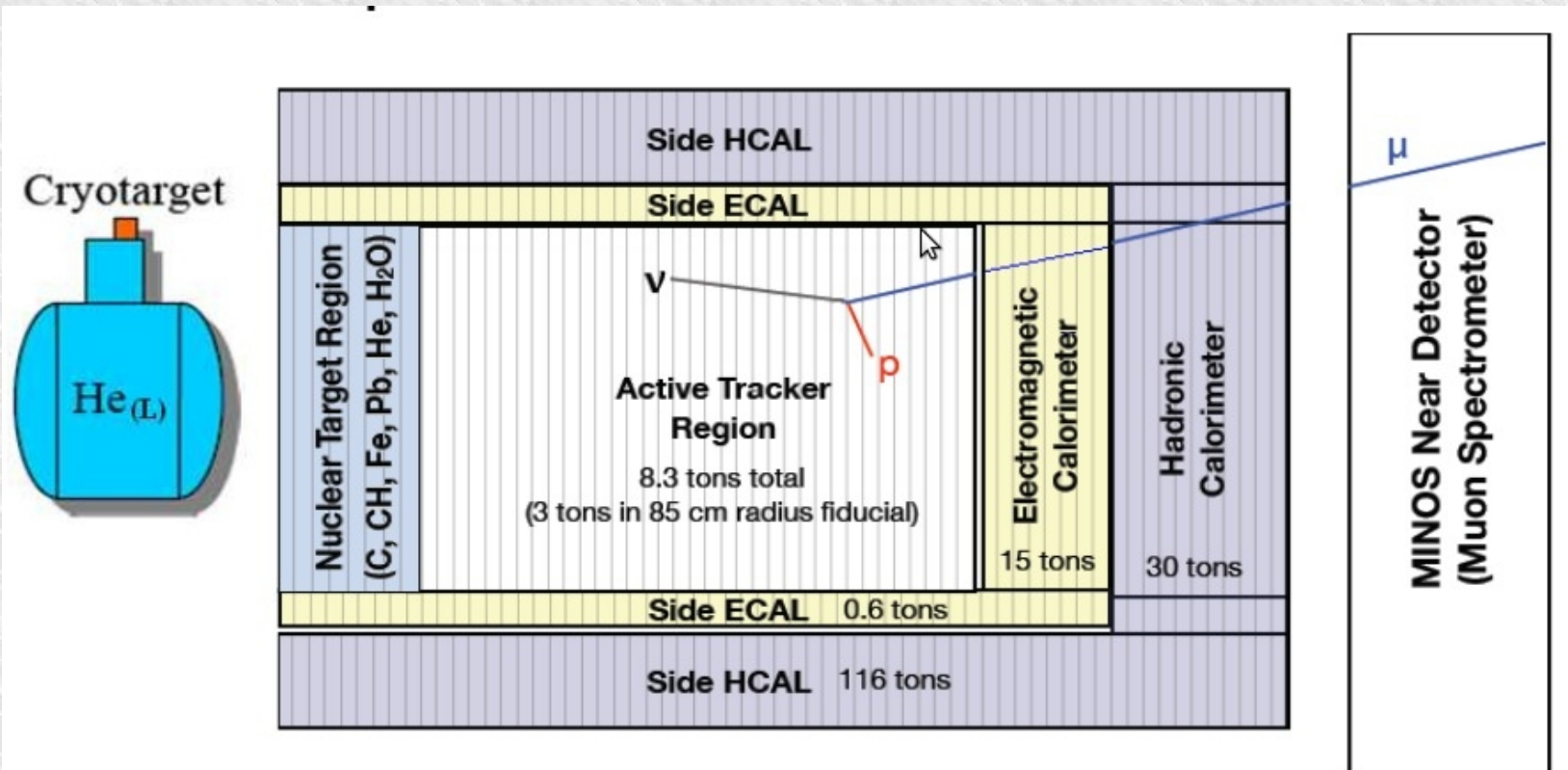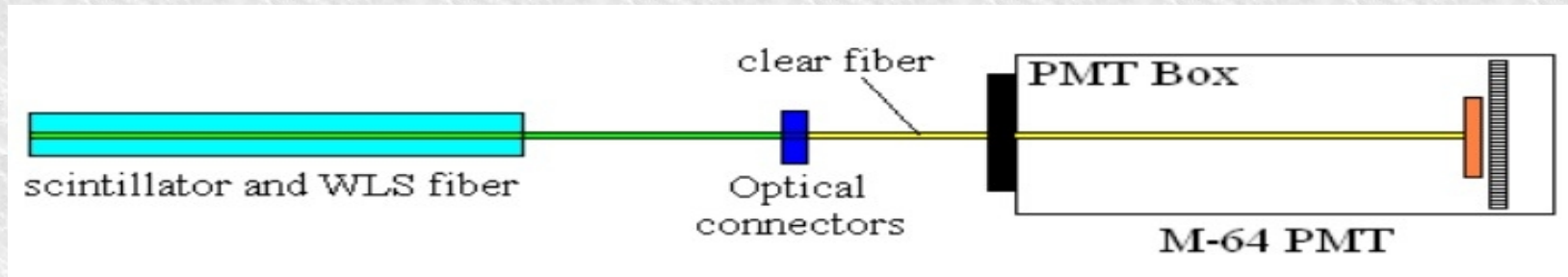
Conclusions

- We have a robust procedure to get event candidates based on the hits distribution on time.

- The readout dead times have a low impact over the total number of events candidates.

- However, we need to handle the events with a big number of dead channel groups.
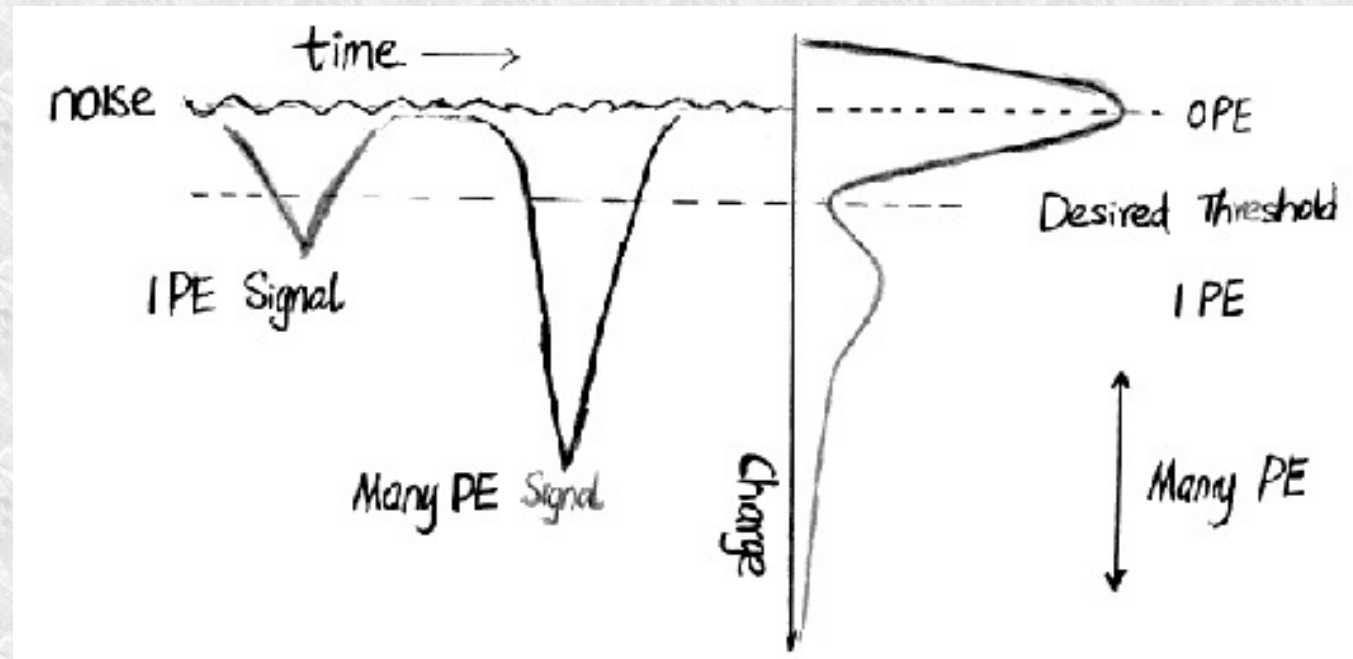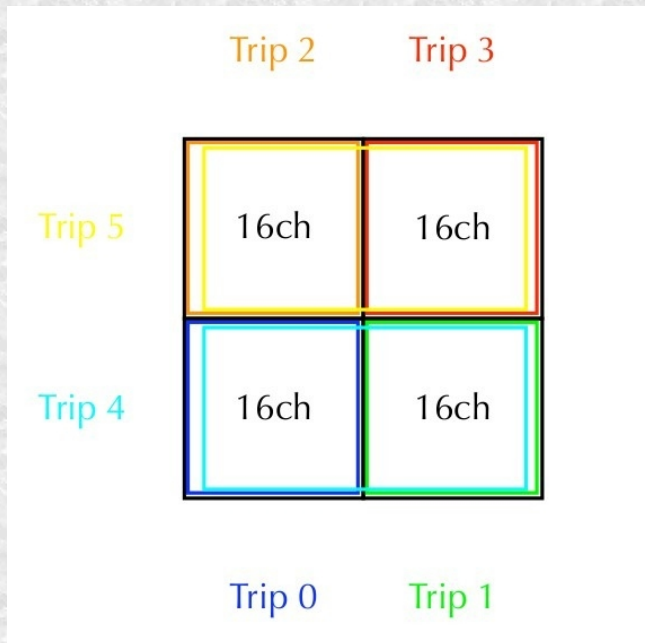
Backup slides

Neutrino Beam Energy Distribution for MINERvA

Right Sign CC Events

Detector layout

About discriminators

Variables in DeadTime Gaudi Tool