R&D on WRM application for DUNE

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Technological proposal the WRM:

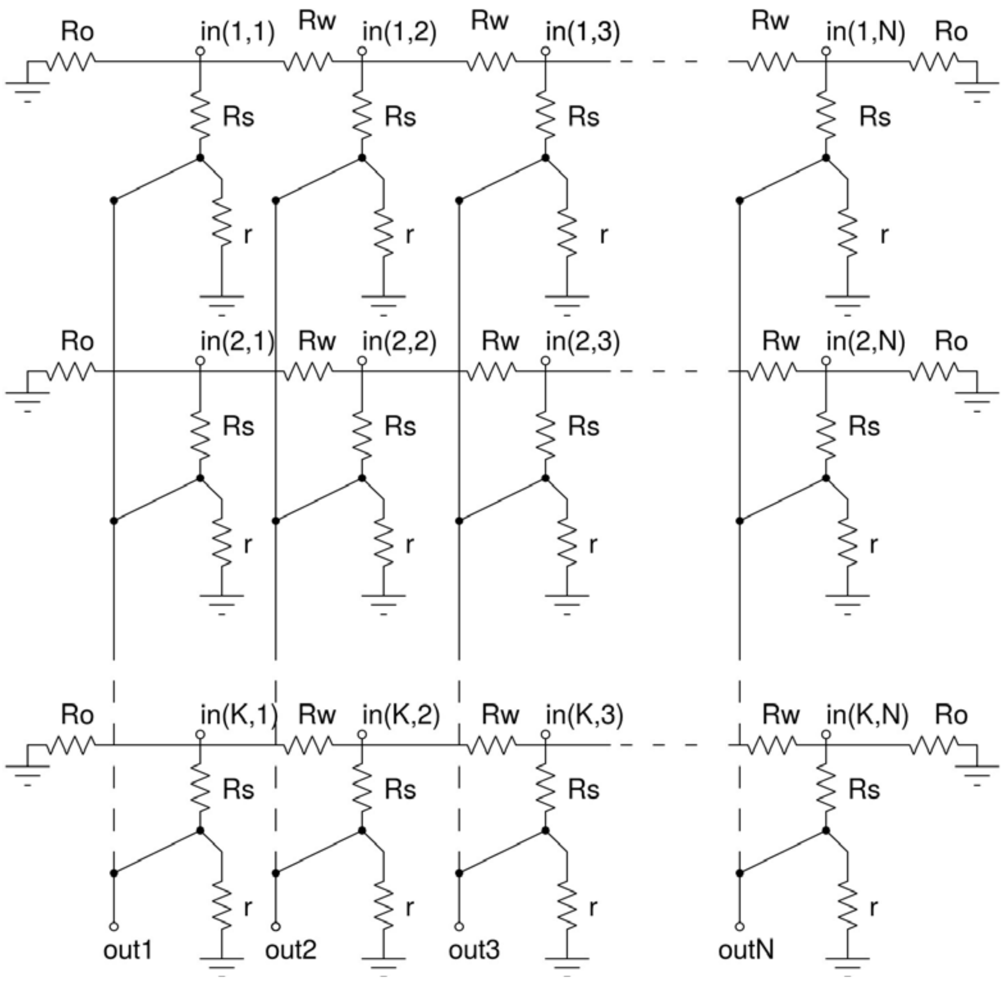
- Low power consumption hardware
- High throughput processing
- Online data reduction

In this report will be presented:

- An algorithm for pedestal subtraction
- Software approximation of the WRM working principle and ROI extraction based on it
- Comparison between ROI from WRM approximation and offline reconstruction ROI (from LArSoft reconstructed data)
- Software performance estimation in order to prove WRM principle

The WRM in brief

- The WRM (Weighting Resistive Matrix) is a data analysis method based on analog computing techniques
- The core processing is based on resistive networks, thus uses the energy of the input signal to carry out the computing
- The principle works using charge diffusion as a weight function on the input data, while the likelihood distribution is obtained by summing up along one direction



The WRM in brief

- Depending on its design and implementation, the WRM technique can be applied to different use cases (i.e. edge detector, vertex detector, track reconstruction, hit finding,…)
- We base on software simulation of the algorithms running on proto-DUNE data for validation purpose

The WRM implementation for DUNE

- We intend to exploit the WRM technology to enhance the local signal significance by exploiting its space-time correlation with respect to the noise
- The original WRM design must be adapted to the DUNE data case:
  - Come already diffused on the time coordinate, with a typical shape due to the detector physics
  - We are interested at the smallest signals (a few wires) where the linear correlation are not yet meaningful
  - the signal is unipolar on the collection and bipolar on the induction planes, is biased by an offset

What we would like to show with software:

- The application of the WRM-like algorithm for both collection and induction planes (this last yet to be optimized).
- Prove that WRM-like algorithm can reduce transmitted data (ROI) without information loss.
- Compare transmitted data (ROI) from WRM-like algorithm with offline reconstruction ROI

Technical proposal:

- Apply the WRM as online ROI detector
- Locate the WRM hardware between FELIX and hit finding system

Pedestal subtraction Algorithm:

- for each wire where n is n-th time tick:

1. diff(n) = ADC(n+1)−ADC(n) (raw derivative)
2. diff(n)+diff(n+1)

We use this algorithm because:

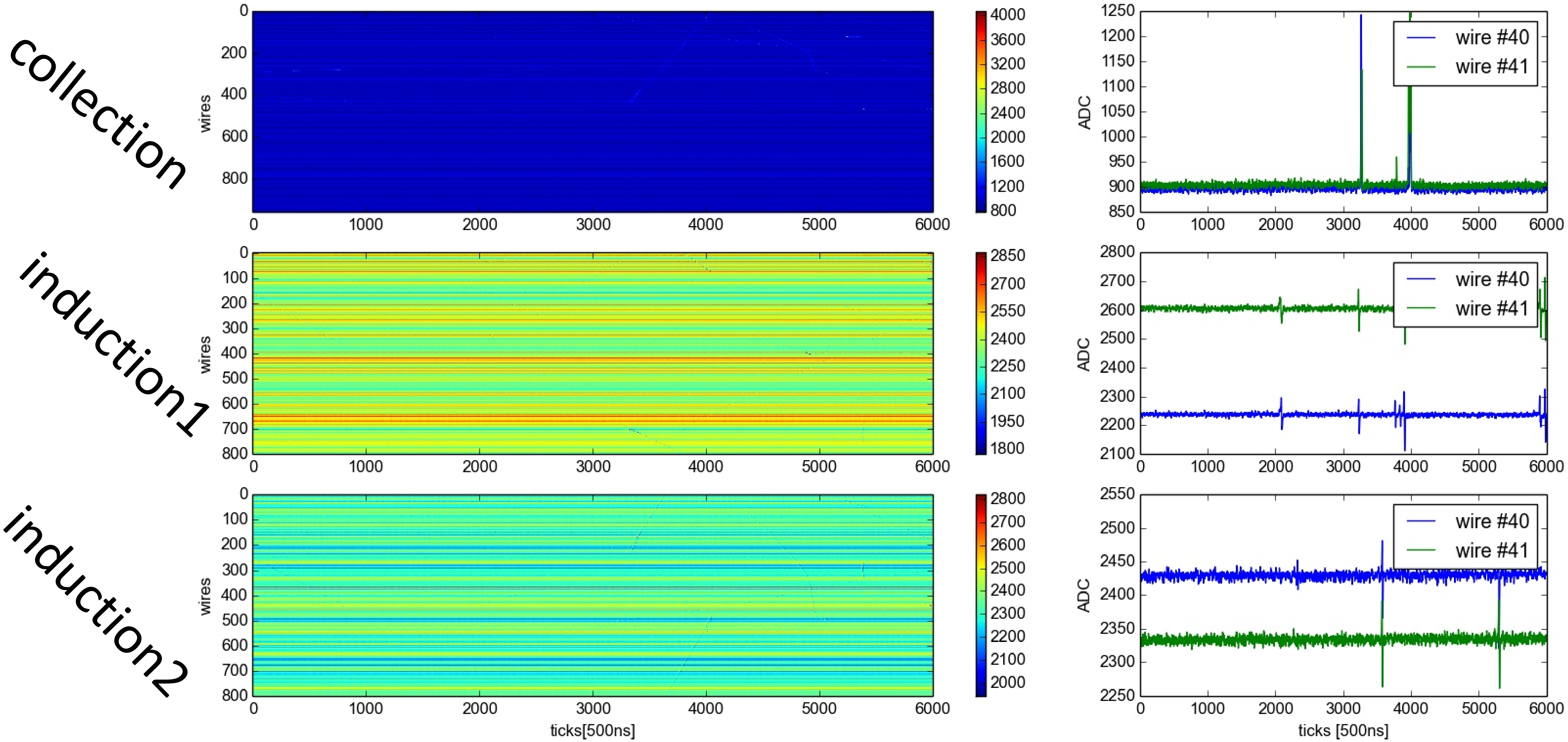
- is simple to implement in hardware, introduce only latency in an online system
- Works in both collection and induction views

We will apply our WRM-like algorithm after pedestal subtraction and also on the intermediate step of it (1. raw derivative step).

Thus, is possible to investigate the output of the same algorithm for both collection and inductions planes.

Raw Data from Event 5177 APA5

Sample of two waveforms



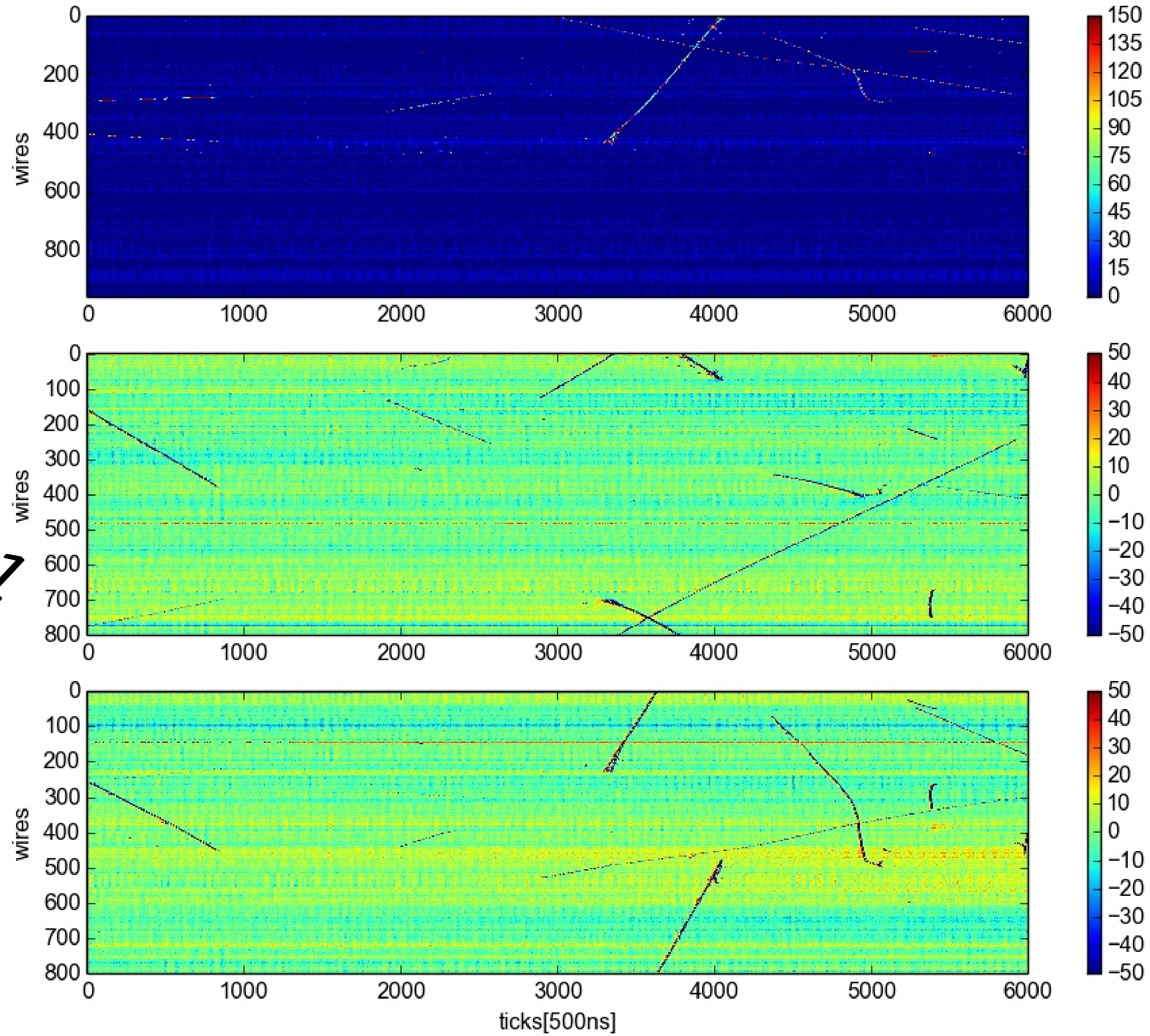
Pedestal subtracted Data Event 5177 APA5

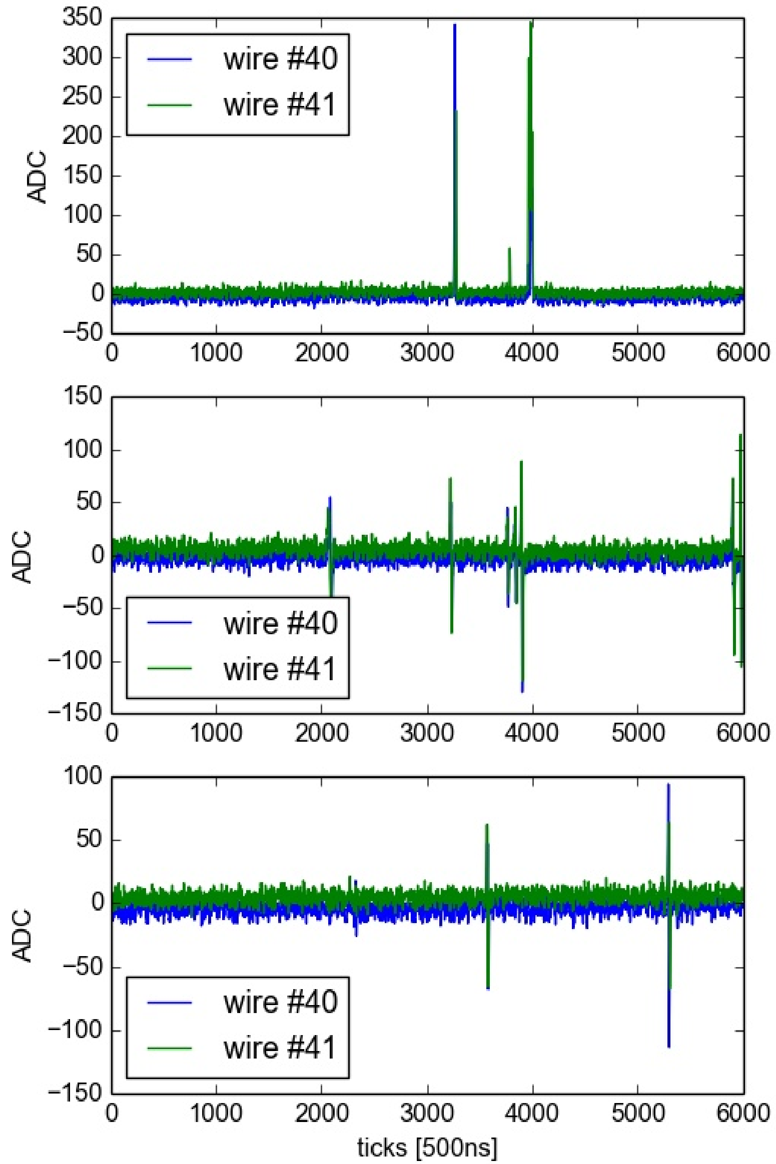
Sample of two waveforms

collection

induction1

induction2





Our Ground-truth :ROI from offline reconstruction

From recob::Wire Library, Signal() accessor has been extracted:

- if Signal() == 0

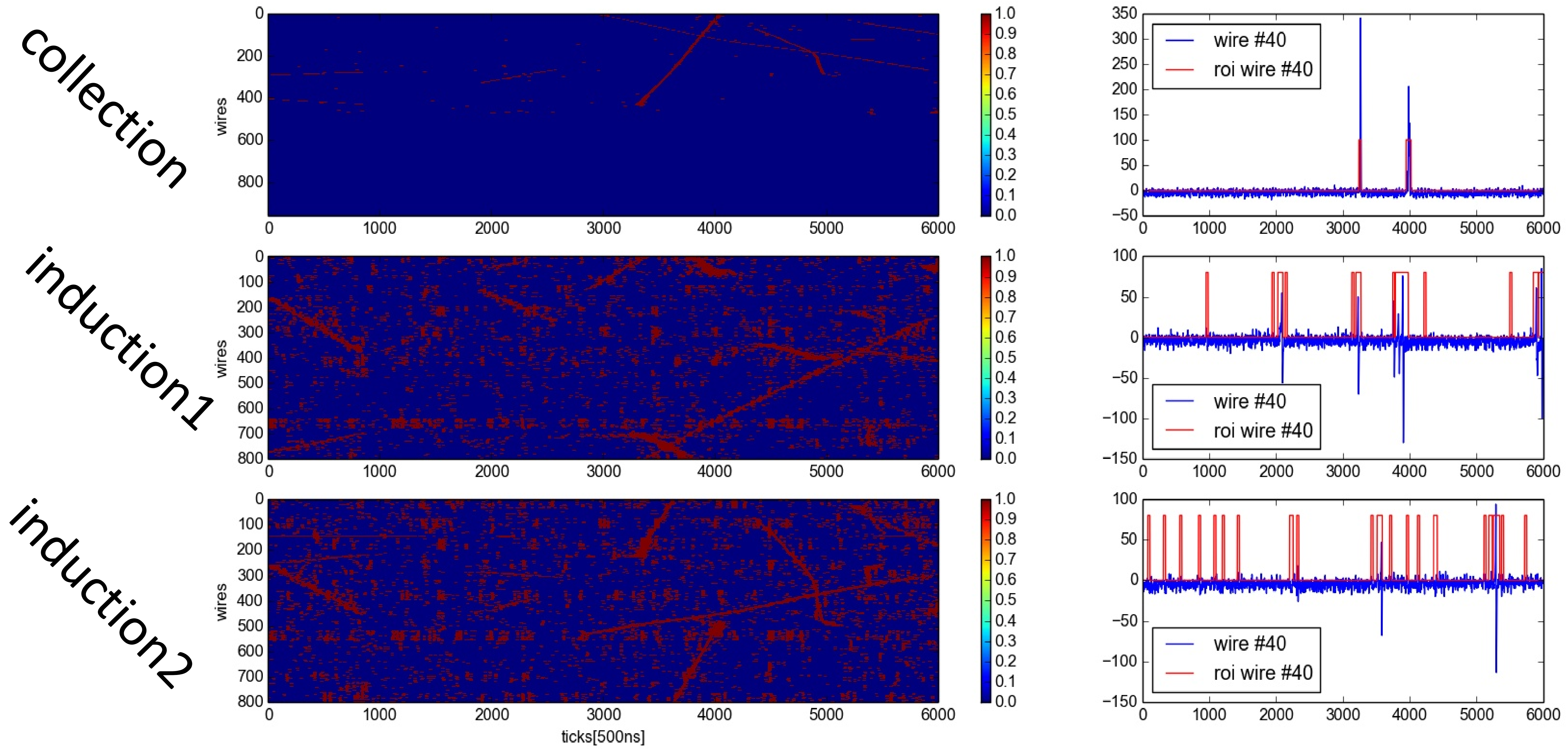
..... save tick,channel,0

else

..... save tick,channel,1

From now on we refered to ROI from offline reconstruction with recob::Wire

recob::Wire VS pedestal subtracted data



About recob::Wire vs pedestal subtracted data

- Matching between data and offline ROI!
- On induction plane recob::Wire as no enough selectivity then:

1. Recob::Wire could not be the right variable as ground-truth for induction planes
2. Is important (and convenient) research on a common strategy for both collection and induction planes with same performance and efficiency

WRM-like algorithm: description and performance

For both collection and induction planes

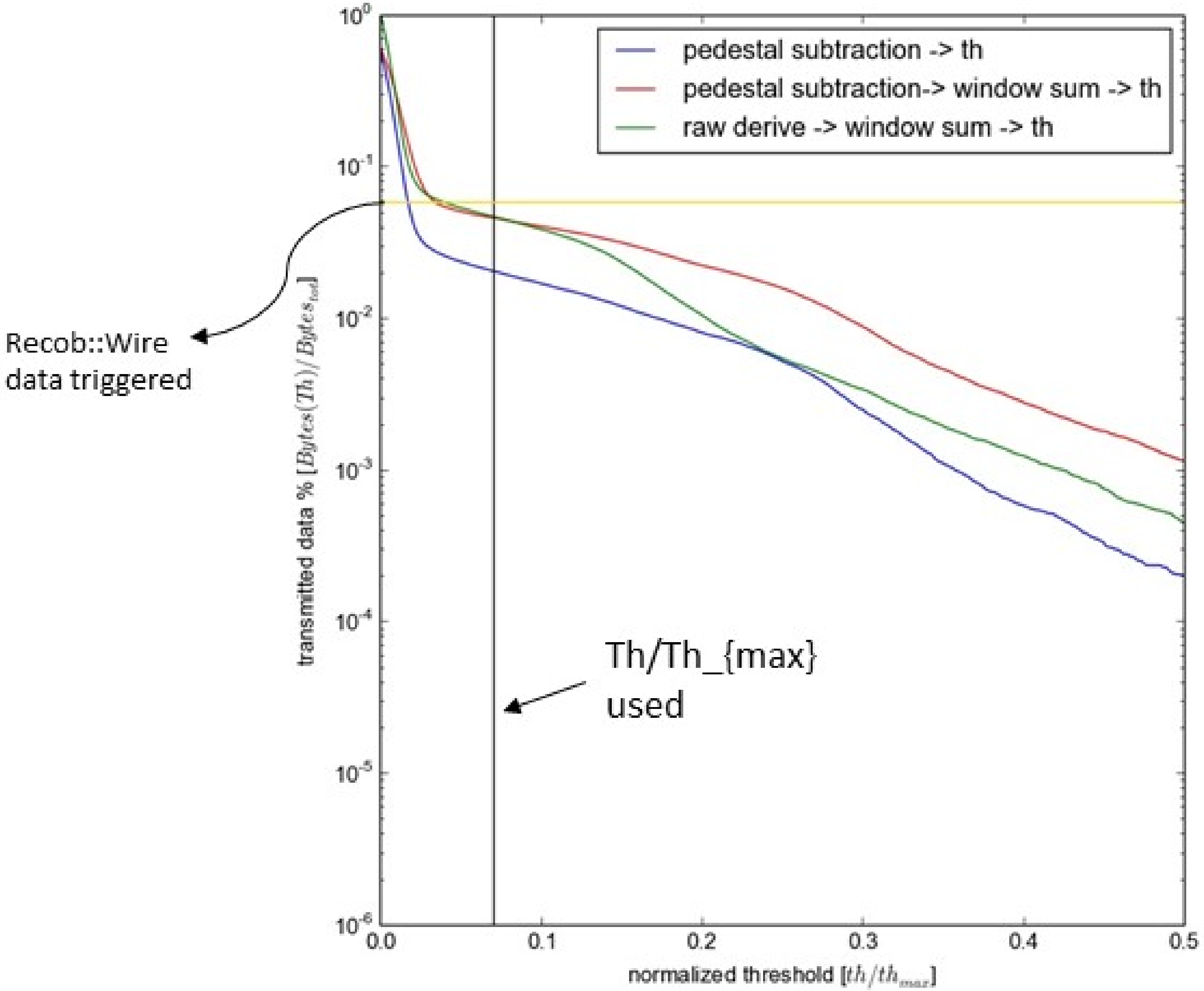
- We are going to compare the amount of transferred data in function of the threshold for:

1. Simple threshold on pedestal subtracted data
2. Threshold on the output of a window sum (WRM-like algorithm) applied on the pedestal subtracted data
3. Threshold on the output of a window sum applied on diff(n)=ADC(n+1)-ADC(n) (raw derivative preprocessing)

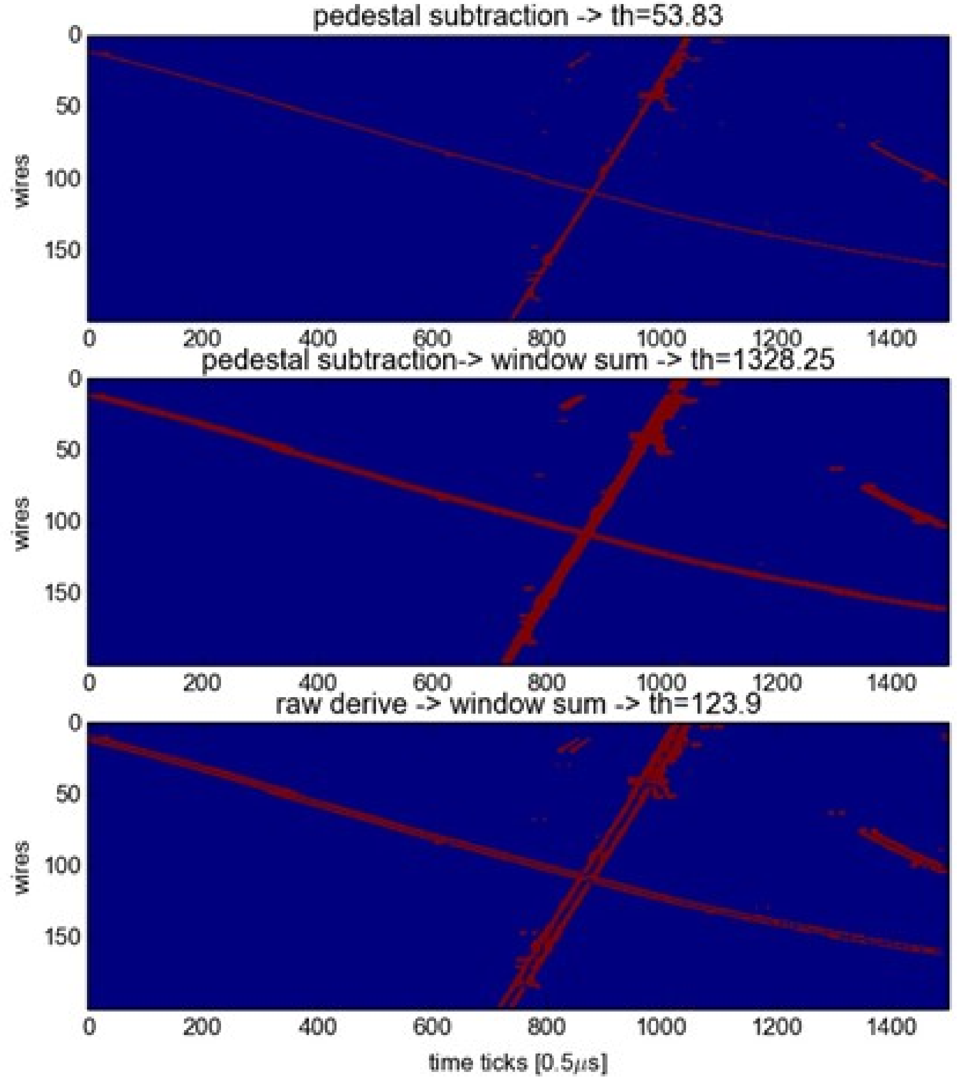
In order to compare the algorithms, thresholds are normalized by the maximum output value of each algorithm (i.e. for 1. th_max = max ADC)

Collection Plane event 5177

transmitted data vs normalized threshold

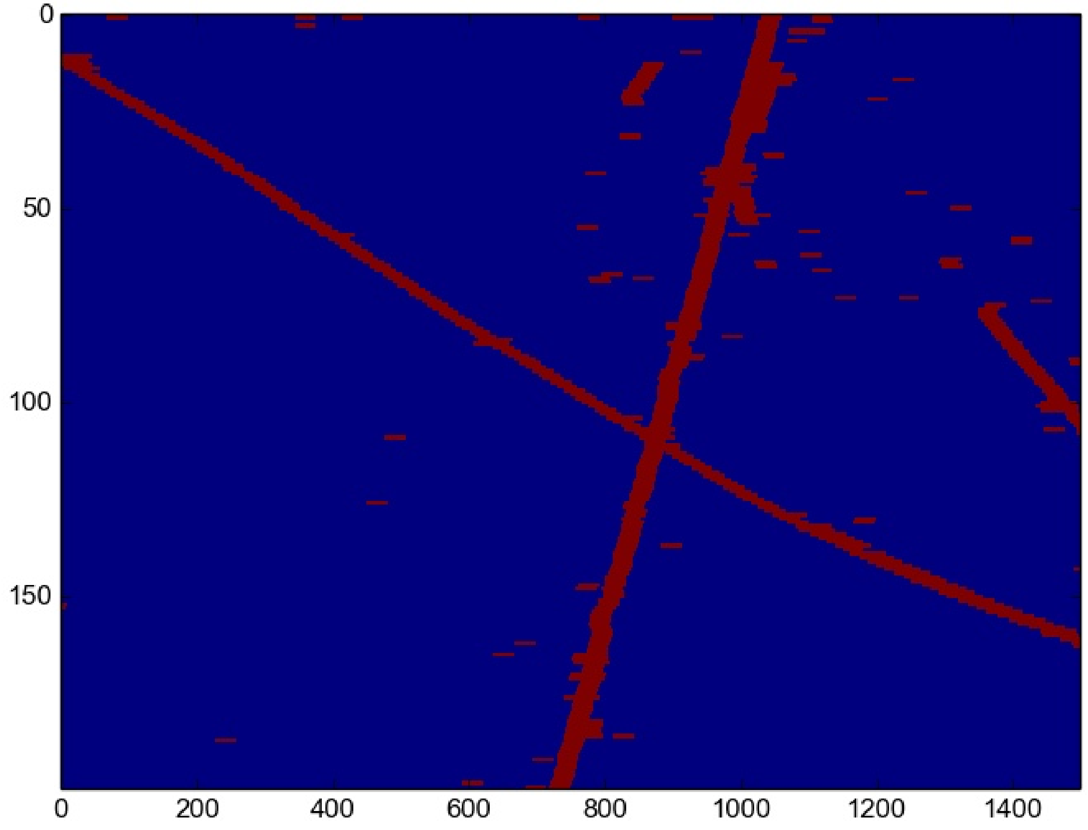


ROI for fixed th

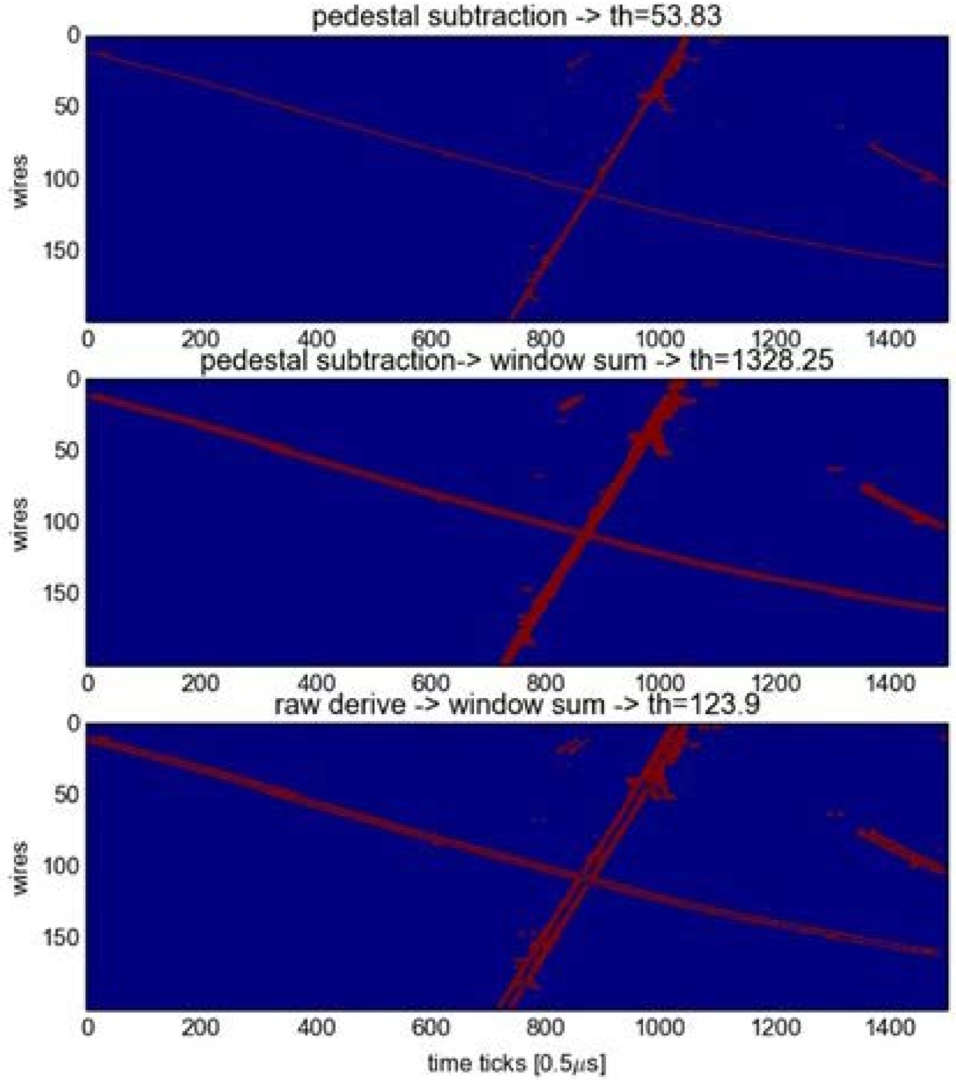


Visual comparison between offline ROI and WRM-like ROI

ROI recob::wire

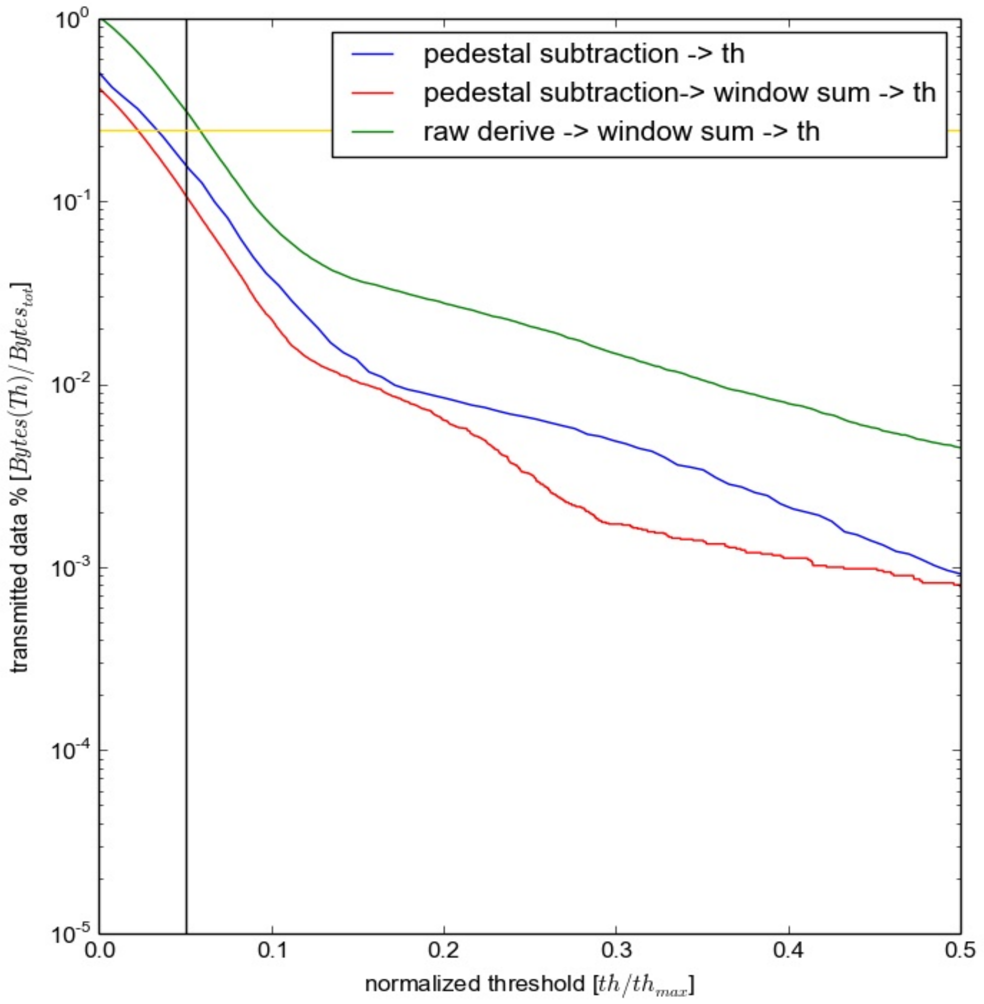


ROI for fixed th

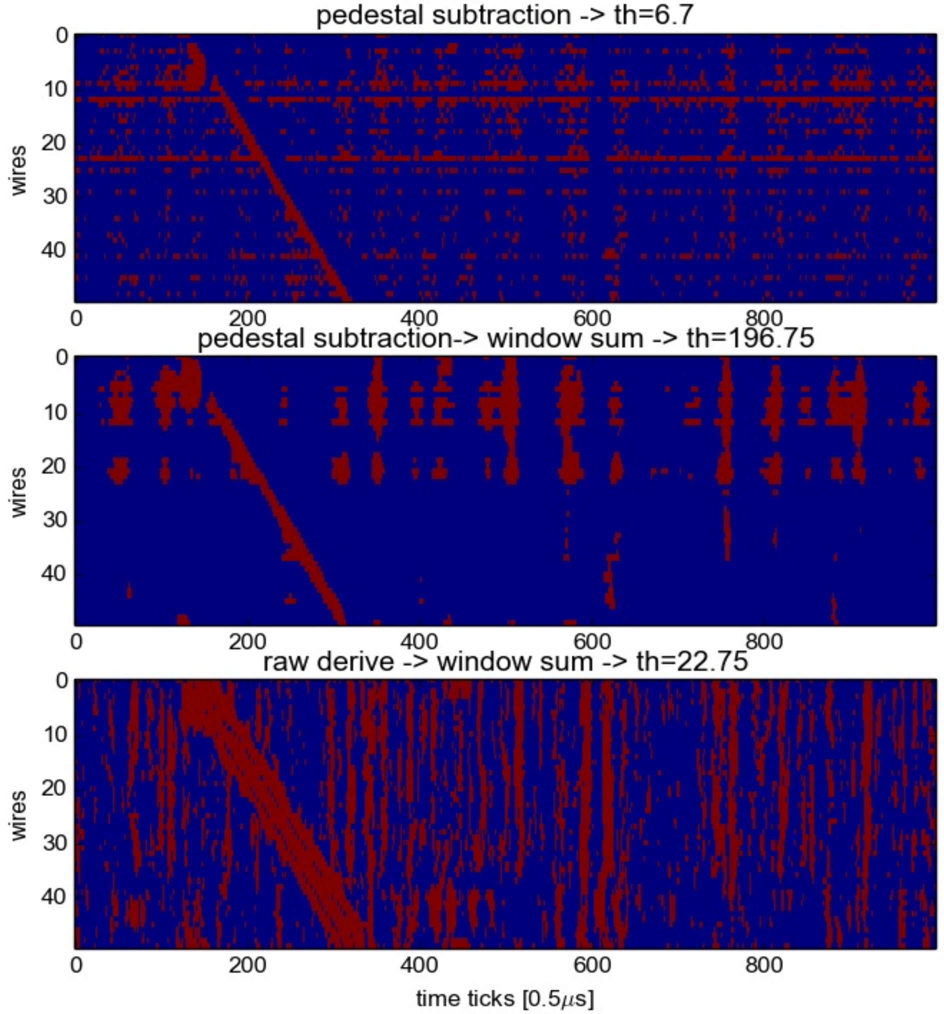


Induction Plane event 5177

transmitted data vs normalized threshold

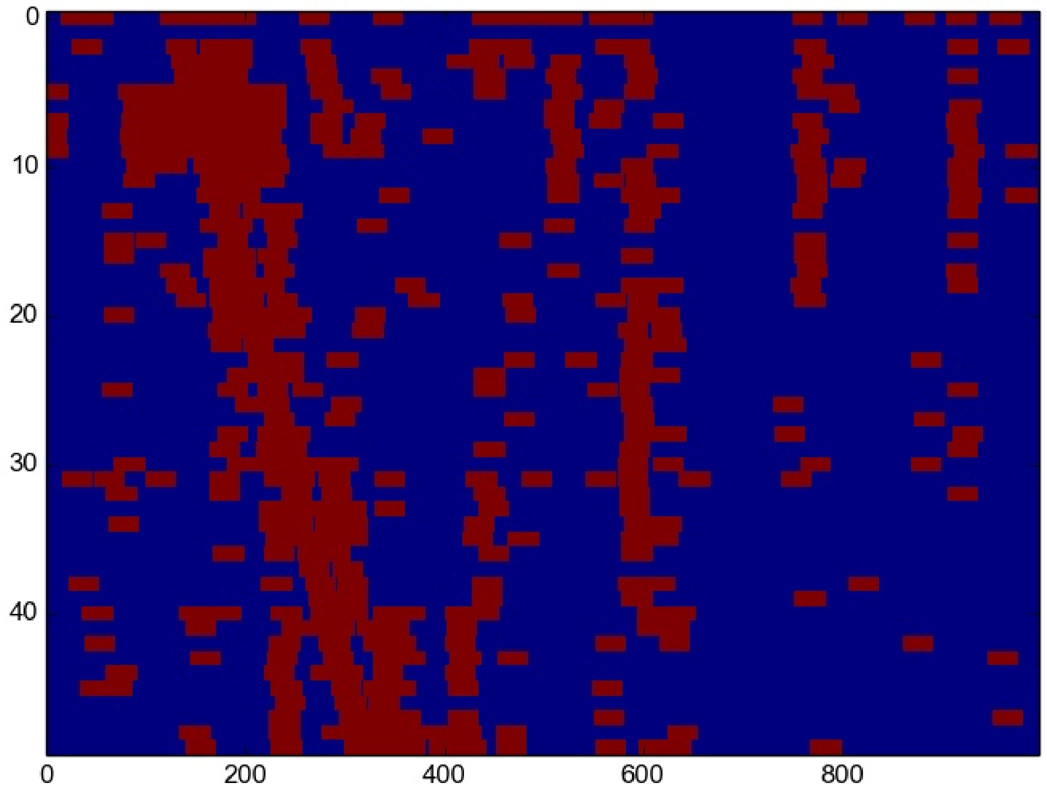


ROI for th used

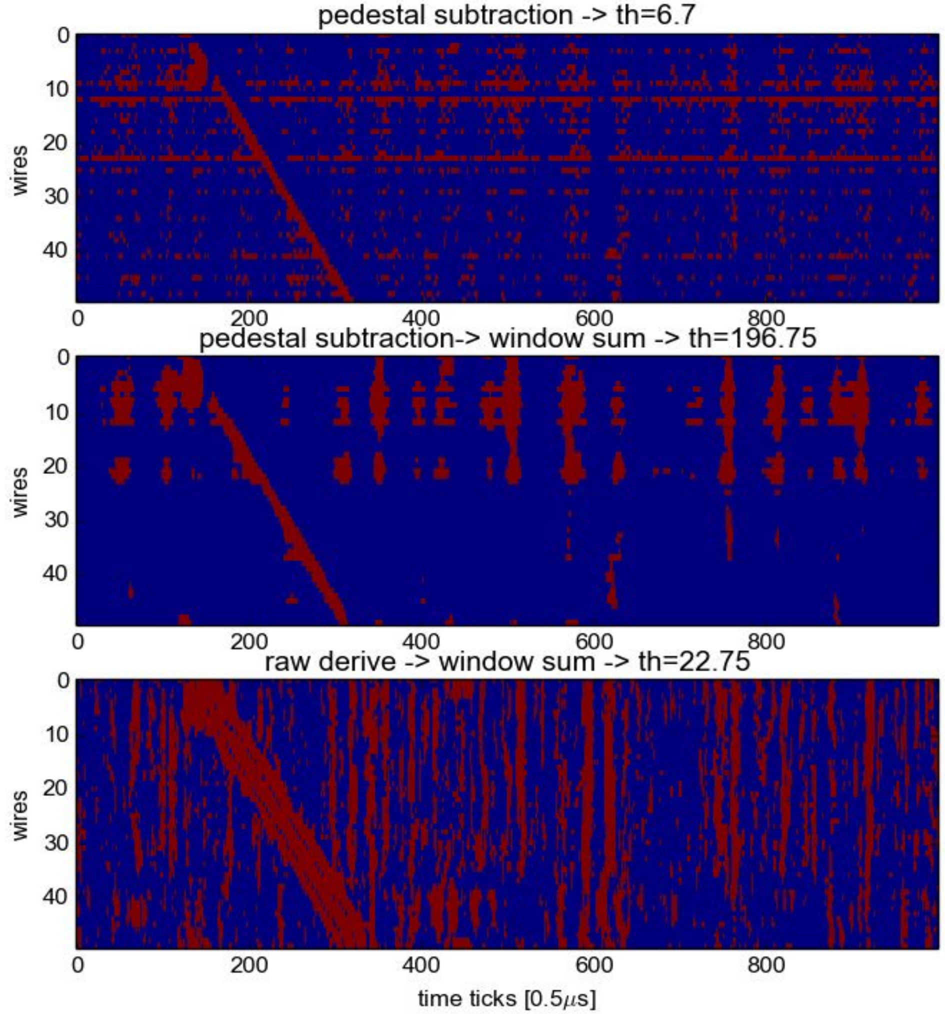


Visual comparison between offline ROI and WRM-like ROI

ROI recob::Wire



ROI for th used



To do:

- A quantitative estimation of efficiency is under development.
- Tune WRM-like algorithm in induction planes in order to increase selectivity.
- Find a valid ground-truth for induction planes.

Next steps are:

- Design and development of WRM hardware based on software results