Signal shape analysis on coldbox CRP1

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Motivations

- A more complete study than what I had done in https://indico.fnal.gov/event/55195/

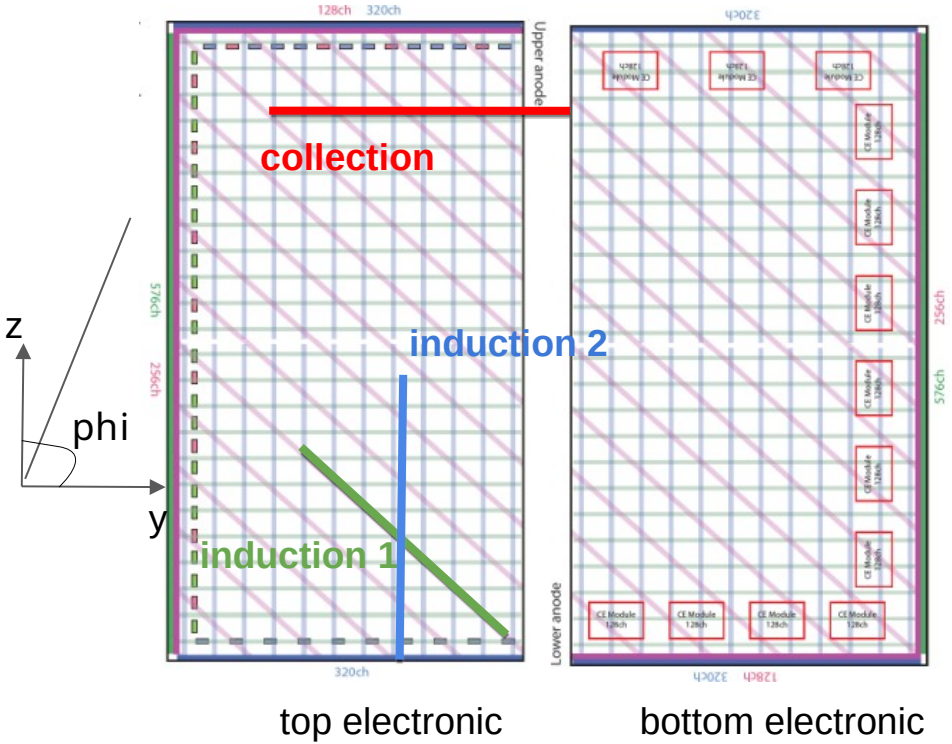
- Now using the new LArSoft module I wrote SigShapeAna : https://indico.fnal.gov/event/55837/

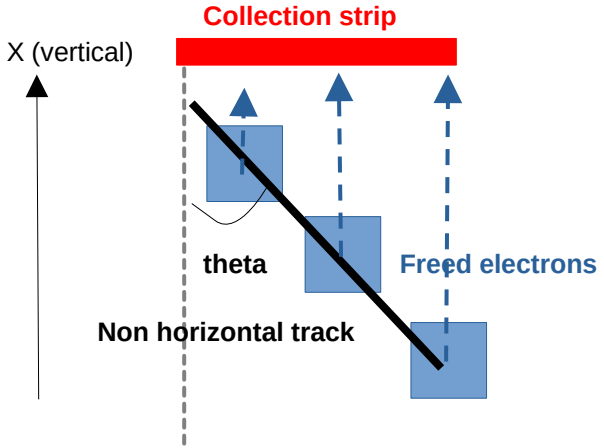
- First motivated by a work started by J. Pinchault at Grenoble (at the simulation level), and will to have a sim/data comparison.
  Typically simulations done by J. Pinchault and others simulate the signal formation at the single electron level : need for special care in data selection for comparison.

- Previous work presented by S. Martynenko, see https://indico.fnal.gov/event/55118/
  Also L. Zambelli, see https://indico.fnal.gov/event/55118/ + T. Houdy
  https://indico.fnal.gov/event/55837/

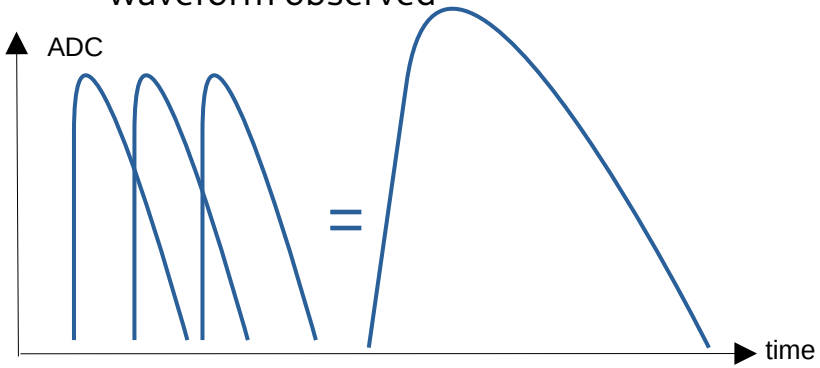
Framework (I)

- Require theta > 60° : non-horizontal track
- Best is phi ~ ±90° for collection
- Best is phi ~ 0° or 180° for induction 2
- Best is phi ~ 45° or -135° for induction 1



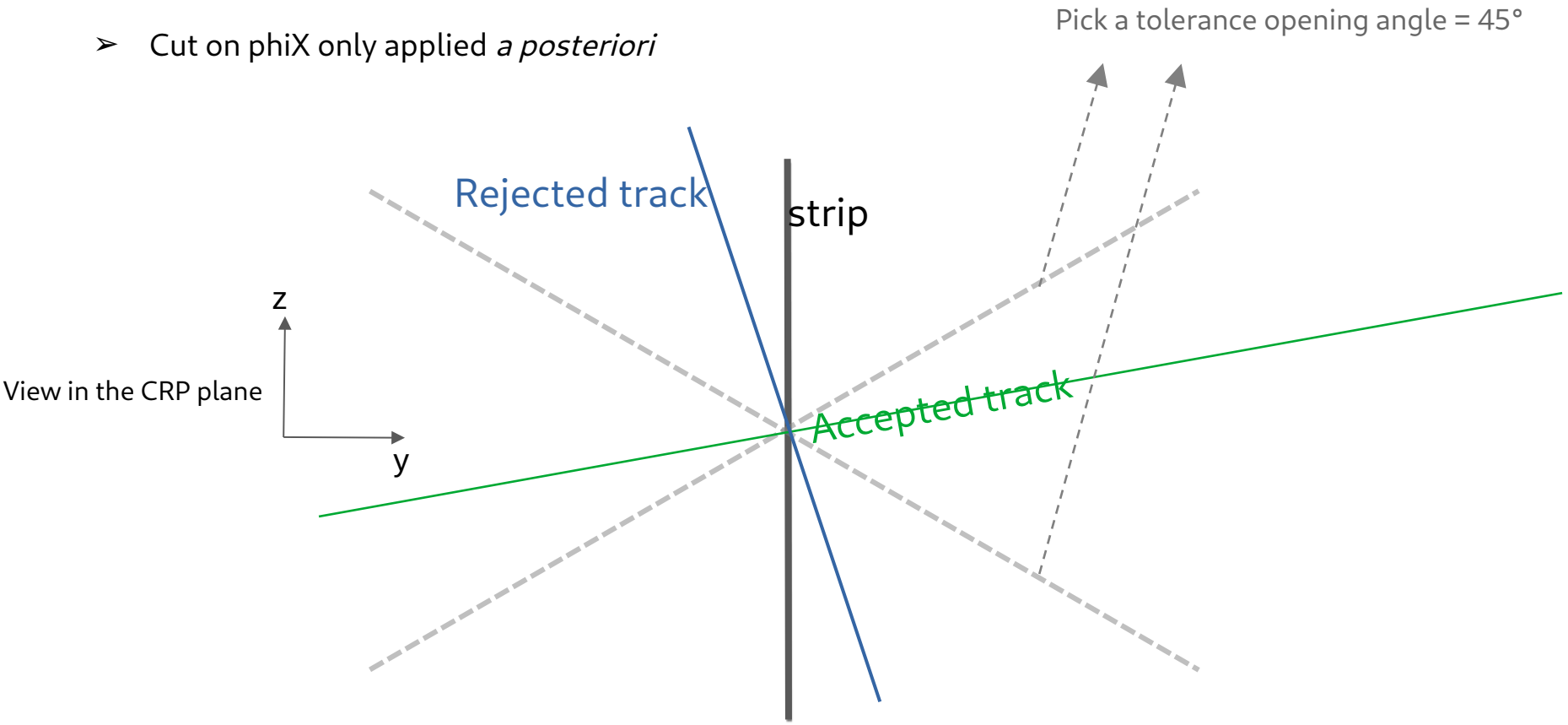


- Electrons time arrival to collection strip differ too much : “large” waveform observed



Framework (II)

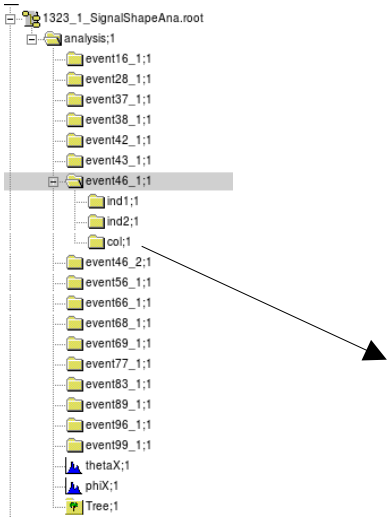
- Cut on thetaX is always applied : thetaX > 60°
- Cut on phiX only applied *a posteriori*



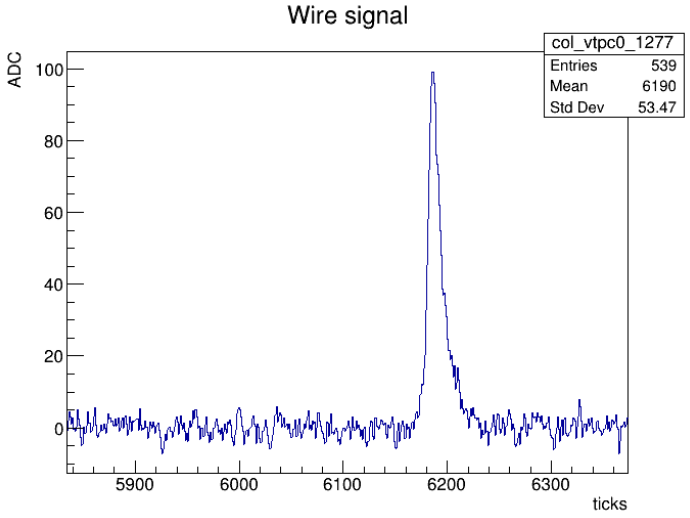
SigShapeAna module

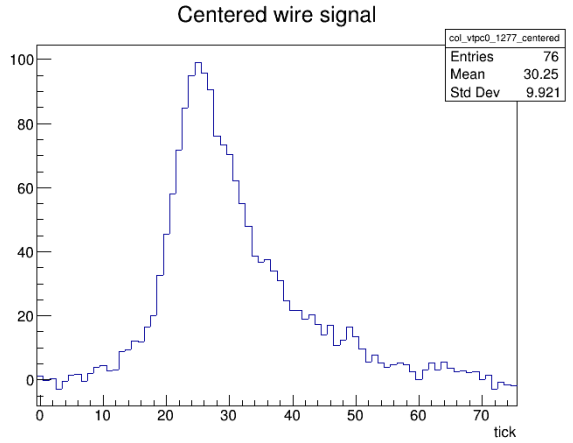
https://indico.fnal.gov/event/55837/

- Retrieves the recob::Wire (mostly I want to work with raw digits for which the coherent noise was removed, but waveforms not filtered).
- Stores the waveforms of all wires associated to the track at play in a root file SignalShapeAna.root.
- Waveforms are coherently added and aligned based on the max of the signal (collection & induction)



Keep track of theta and phi angles for "non-noise tracks" (I.e length great enough)



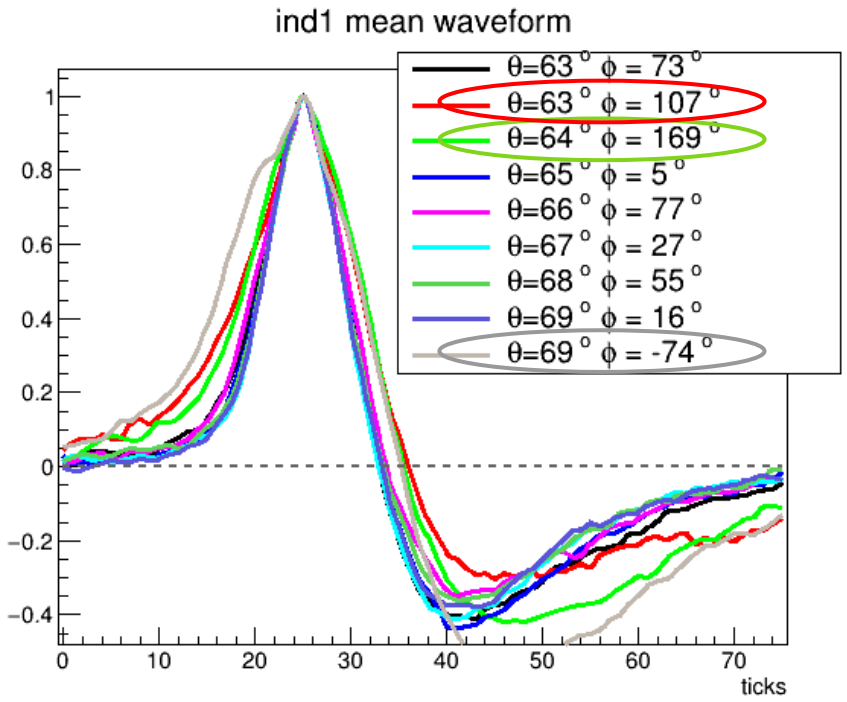


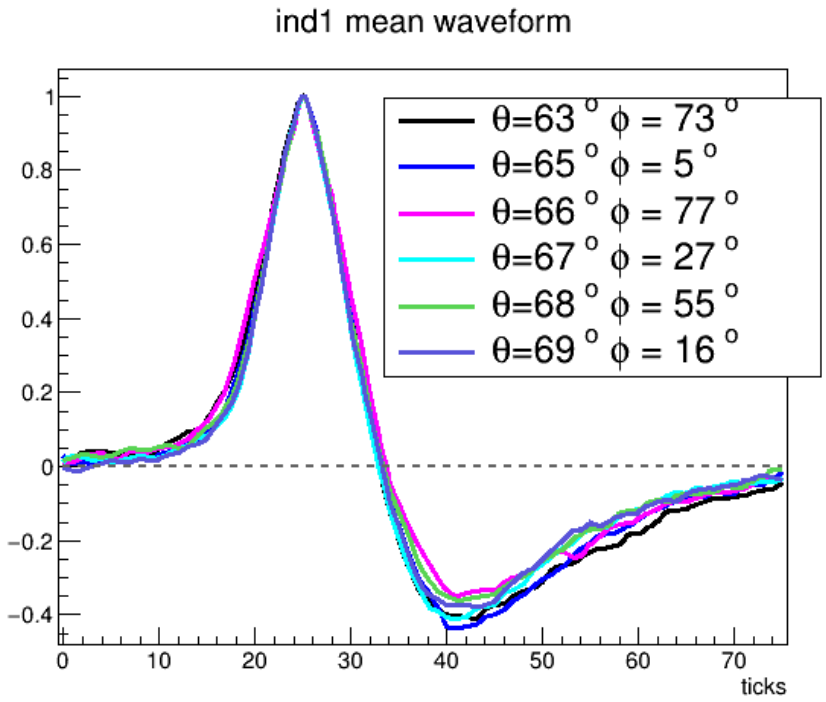
- Also store the 'centered' waveform (use max value for col/ind signal) with a fix tick window.

Top drift electronics - Induction 1

Run 1323 Subrun 1

- Mean waveform dispersion limited when selecting only tracks with phi ~ 45° or -135°. ThetaX and PhiX have limited influence



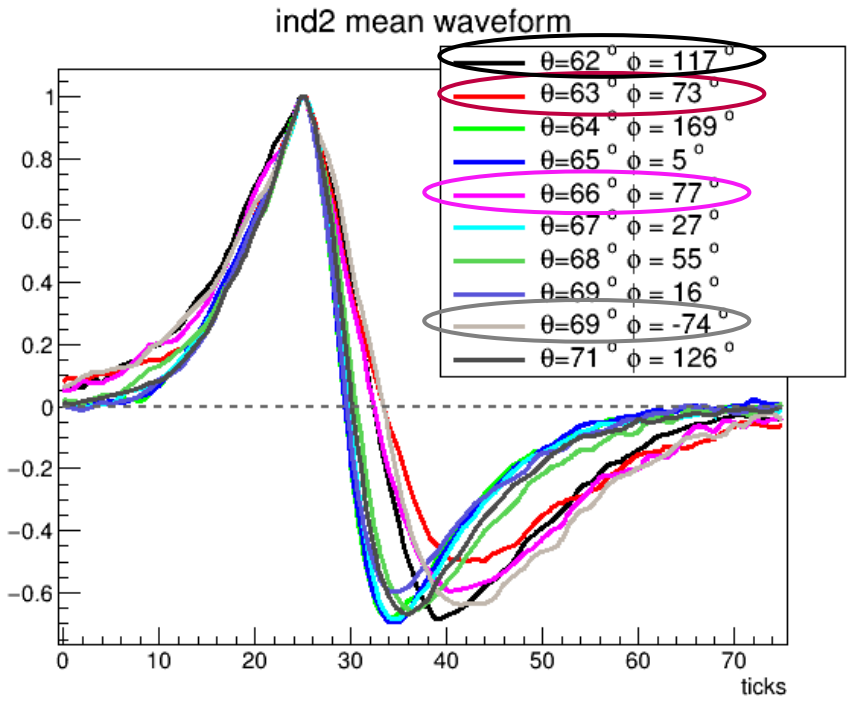


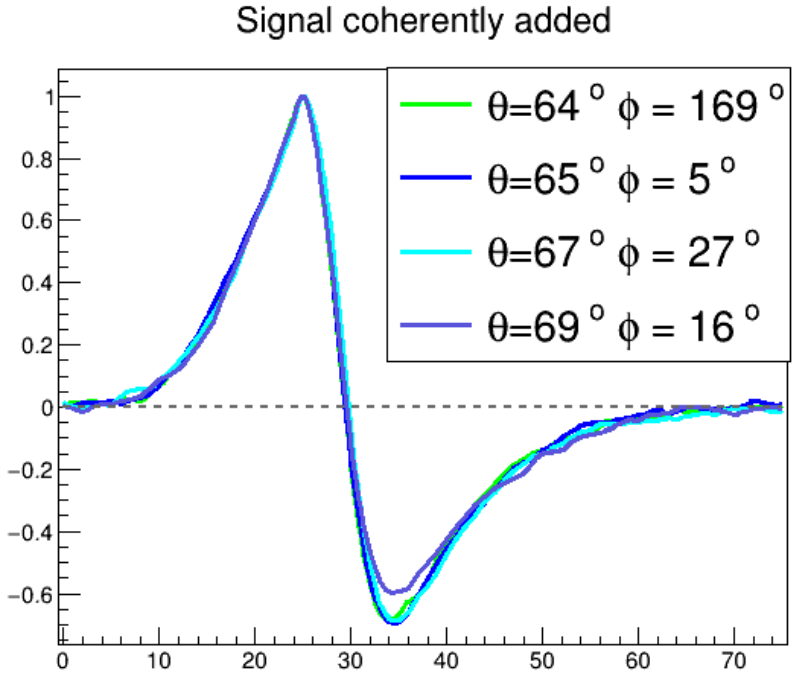
Wider waveforms are circled, correspond to values of phi closest to -45° or 135° (i.e parallel to ind2 wires).

Top drift electronics - Induction 2

Run 1323 Subrun 1

- Mean waveform dispersion limited when selecting only tracks with phi ~ 0° or 180°



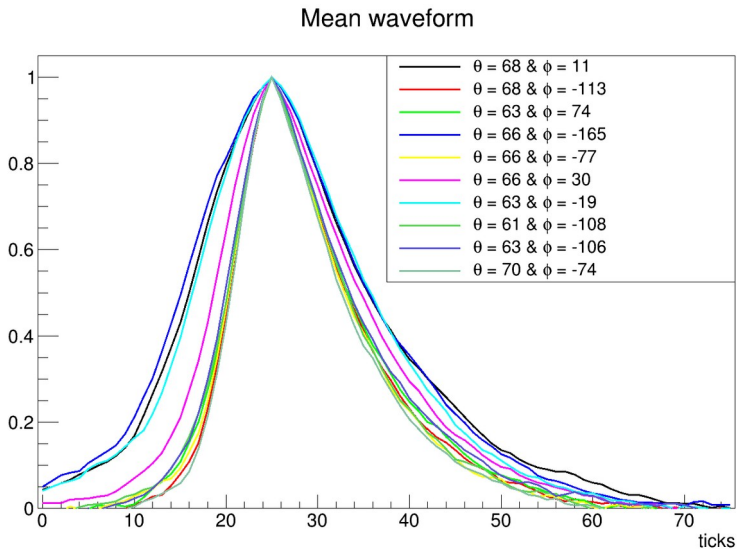


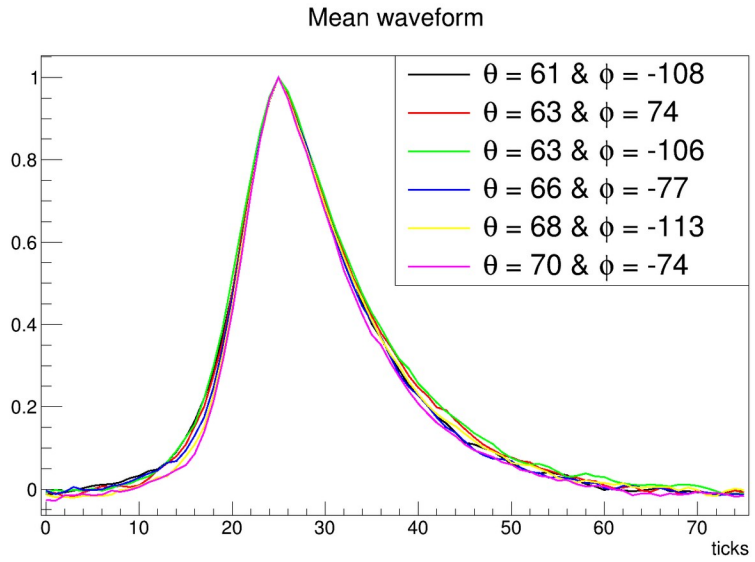
Wider waveforms are circled, correspond to values of phi closest to 90° or -90° (i.e parallel to ind2 wires).

Top drift electronics - Collection

Run 429 Subrun 1

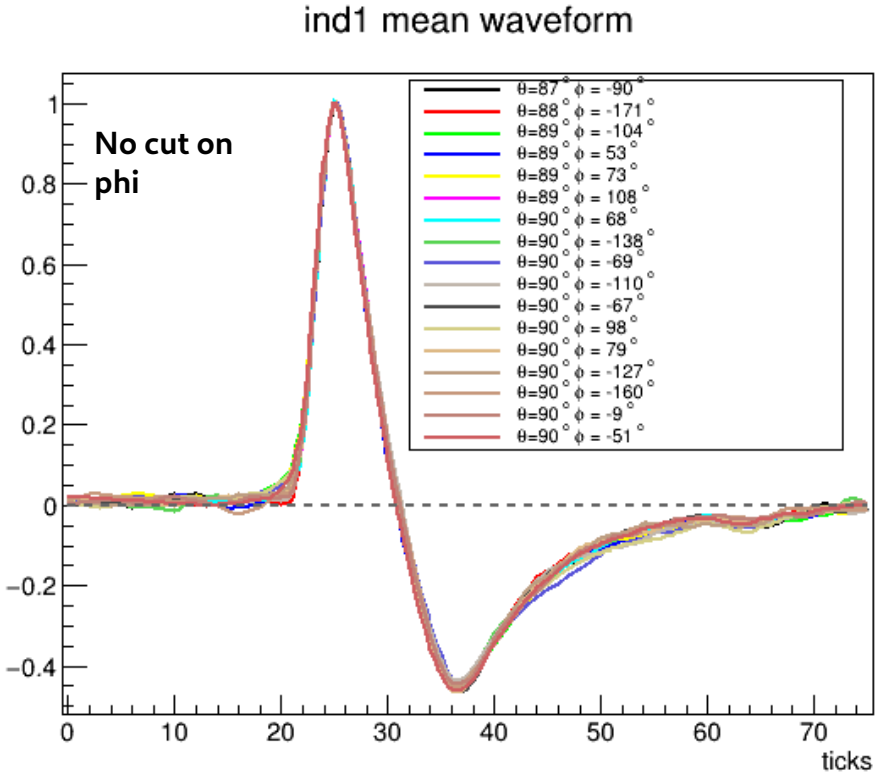
- Mean waveform dispersion limited when selecting only tracks with phi ~ ±90°

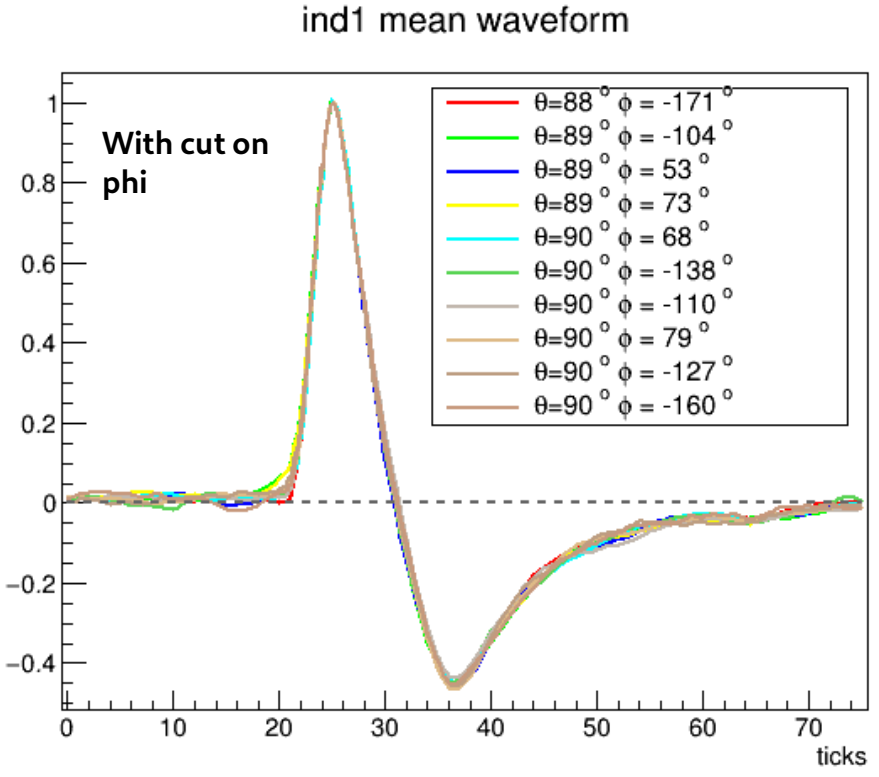




Simulations Top Drift Electronics – Induction 1

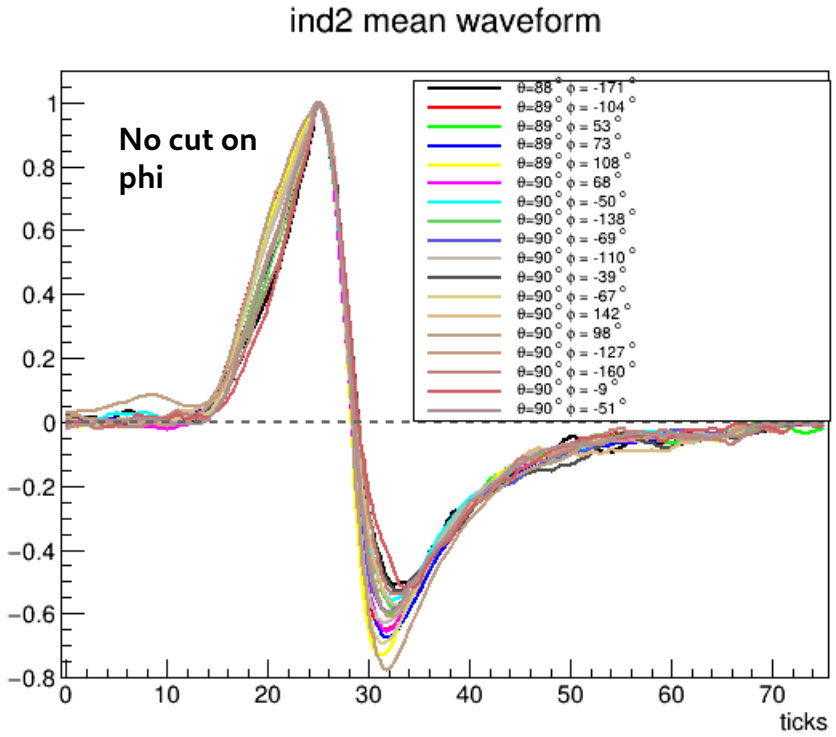
- Launched a bunch (= 20) of horizontal 2 GeV muons with isotropic random phi values. Simulations much less sensitive to phi than real data.

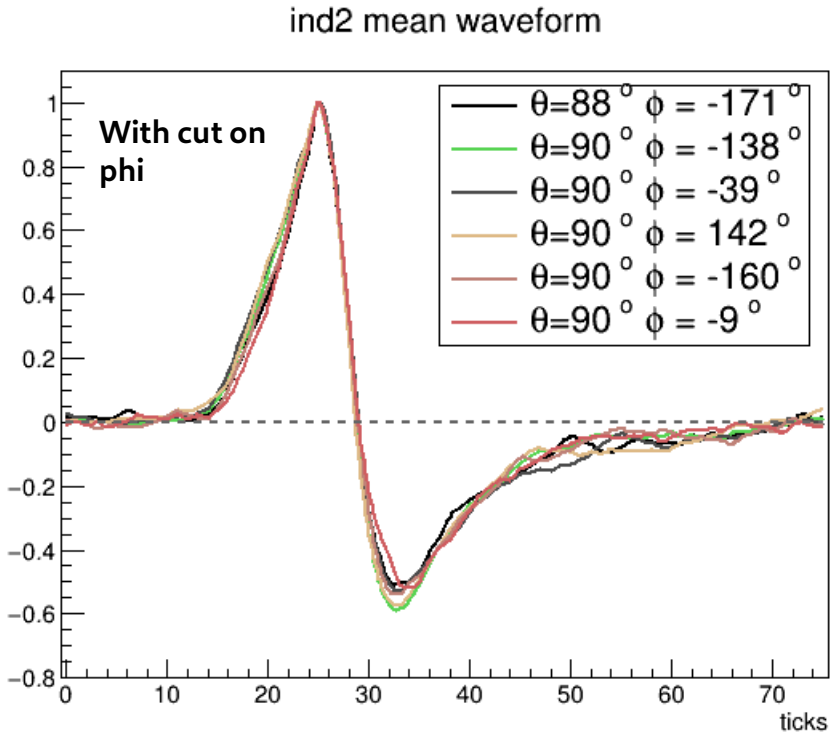




Simulations Top Drift Electronics – Induction 2

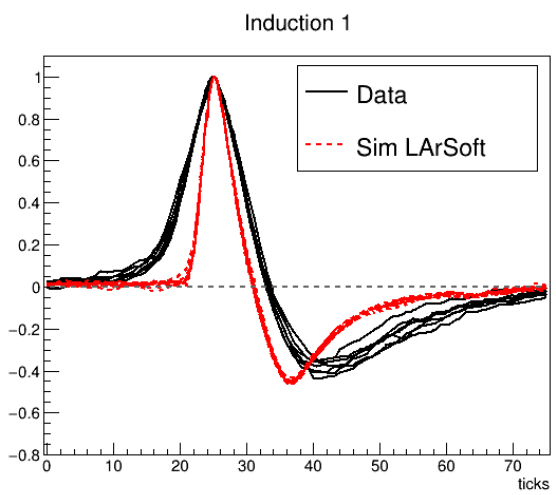
- Launched a bunch (=20) of horizontal 2 GeV muons with isotropic random phi values. Induction 2 plane barely sensitive to phi value.

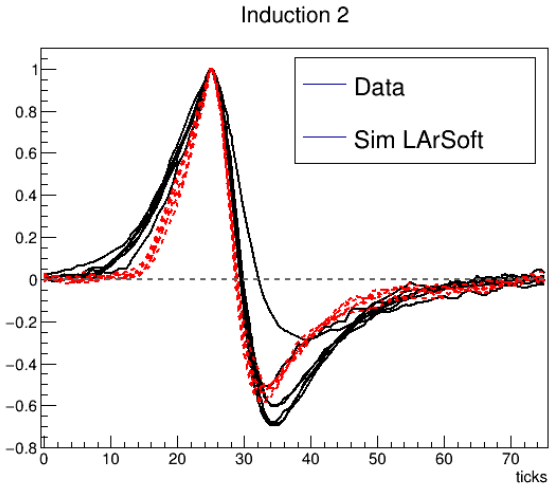


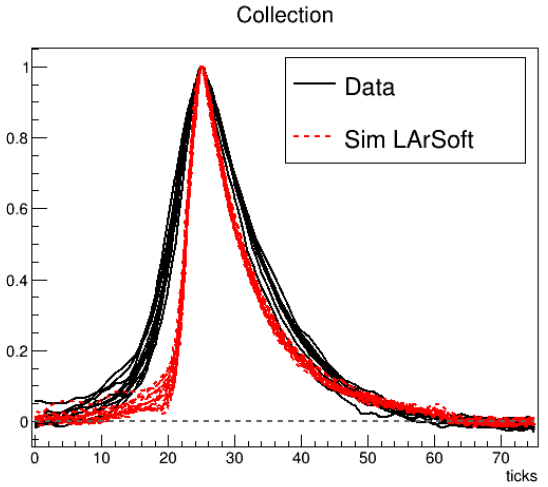


Run 1323 subrun 1

Sim/Data Comparisons top drift electronics





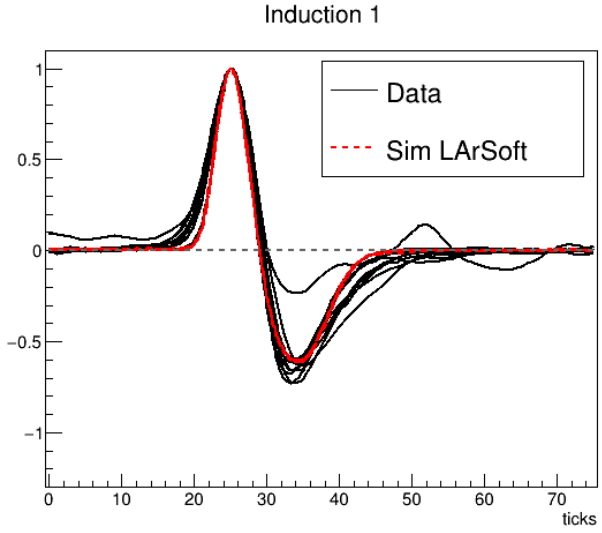


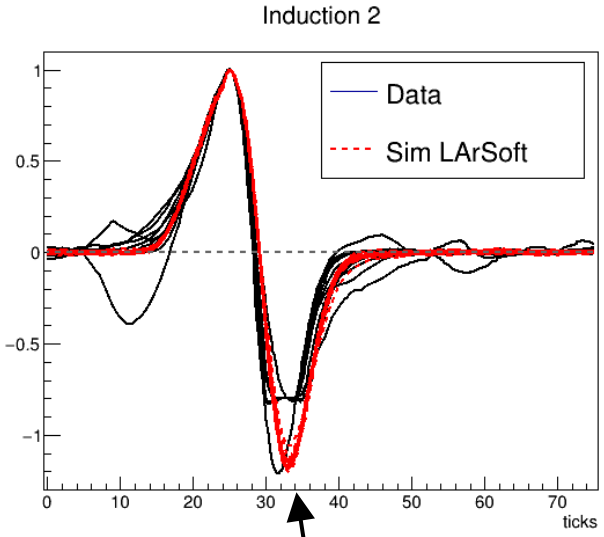
- Cuts on theta and phi included to work only with ~horizontal tracks (theta > 60°) and ~perpendicular (opening angle of 45°) to strips.

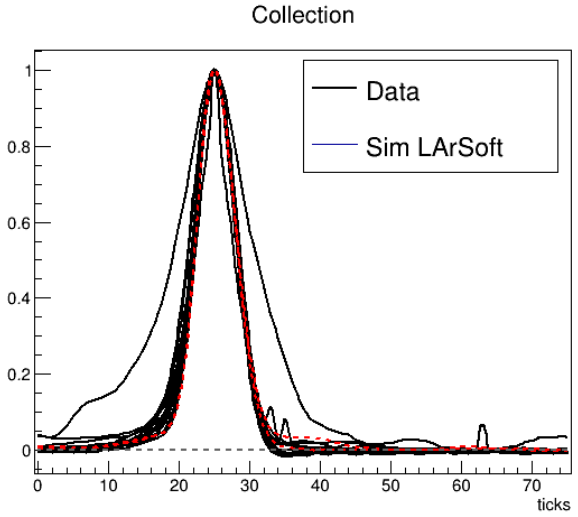
- Data waveforms are larger than simulated waveforms for top drift electronics data. Need to understand that.

Sim/Data Comparisons bottom drift electronics

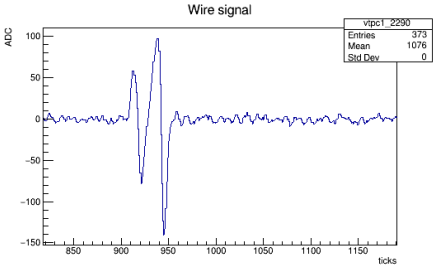
Run 013383_0008







- Much better agreement between data & simulation for bottom drift electronics signal shapes.
- Some distorted waveforms are due to non-rejection of obvious "not correct" waveforms : Need for a better data selection at the single waveform level.
- Not clear what's happening on minimal extremum for induction 2.



Discussion

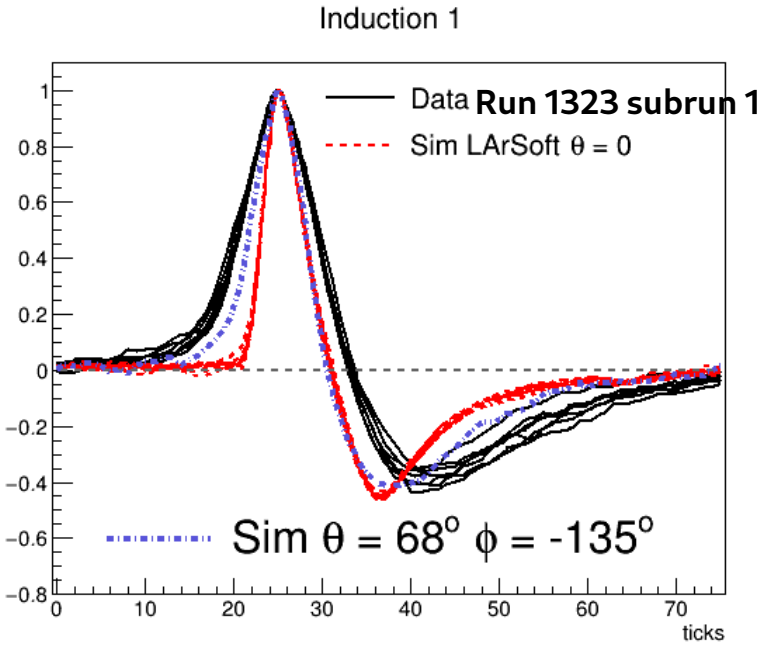
- Reproducibility of “mean” waveforms on three views along different tracks suggests robustness of the method. One current weak point is the lack of quality selection at the individual waveform level, which from time to time can affect significantly the resulting mean waveform (obtained by adding coherently all individual waveforms together).

- I have studied waveforms corresponding to tracks ‘not too vertical’ (i.e thetaX > 60°, 90° being horizontal tracks) and phi ranging in [-180° ; 180°].
  - Theta effect not studied here.
  - Phi effect is limited when one considers only tracks contained in opening angle ±45° with respect to strip normal direction.

- The simulation/data agreement looks good for bottom drift electronics but not for top drift electronics.
  - Theta effect ?
  - Incorrect simulation configuration ?
  - Incorrect electronic response model (but I infer this would have been seen already) ?

Some discussion and possible solutions for TDE data/sim discrepancy

- My gun muon simulations are composed of horizontal tracks (theta=90°) while data have theta < 90. So I generated a non-horizontal track as well (theta = 68°) : still a step away from a satisfying agreement.



- Drift field and other physical parameters related to data taking should affect both TDE and BDE, thus the issue is specific to TDE data taking.
- Have more data/sim comparison, especially on sim. side
- Have simulation comparisons between vdcoldbox and dune10kTon vertical drift