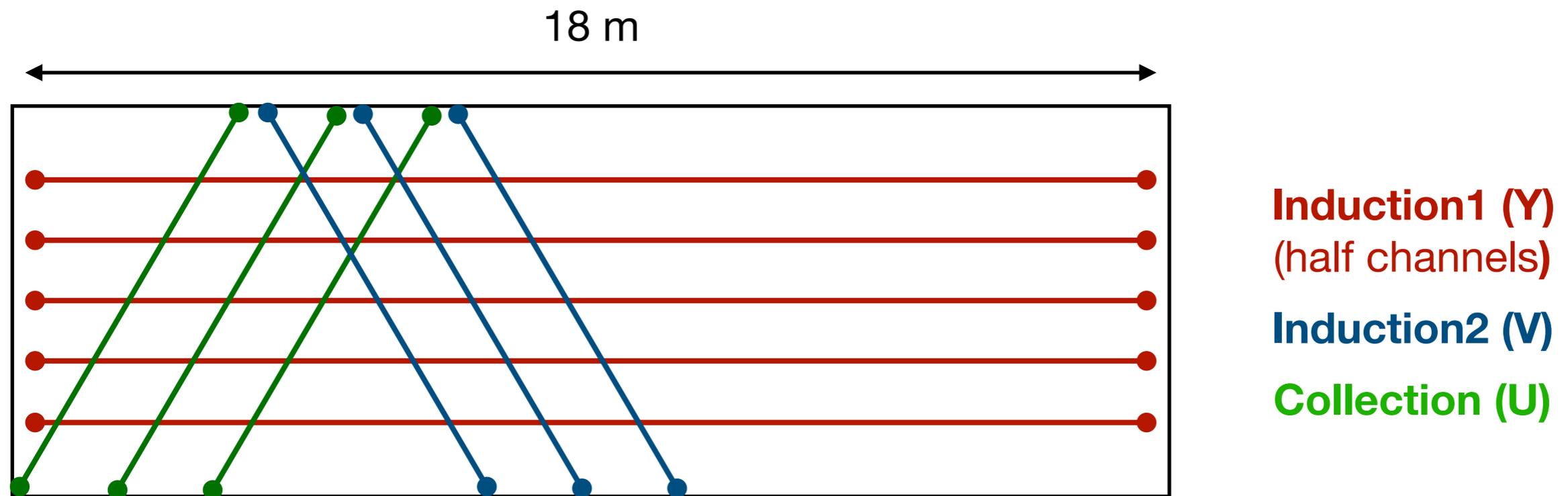


Status of ICARUS sim/reco and discussion for Wirecell integration

Andrea Scarpelli,
Wenqiang Gu

Geometry

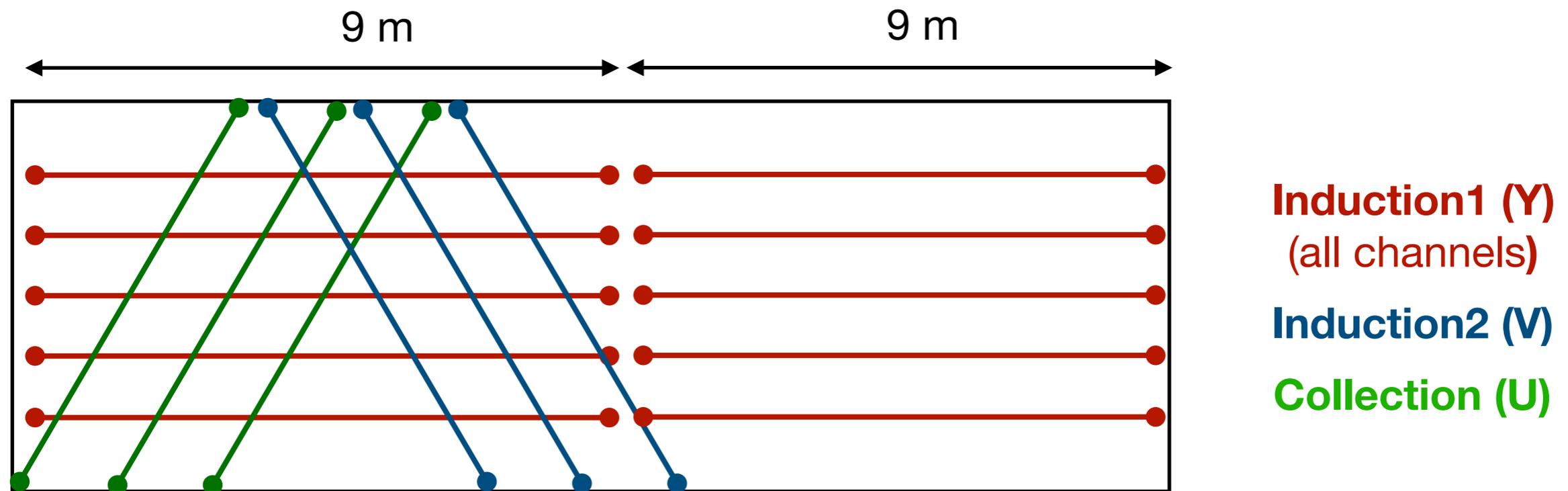
- ▶ All information in a useful fcl: https://cdcv.s.fnl.gov/redmine/projects/icaruscode/repository/revisions/master/entry/icaruscode/Geometry/geometry_icarus.fcl
- ▶ “Single wire” geometry is currently the standard, but approximation of real icarus geometry



- ▶ Latest status as Nov. collaboration meeting: <https://indico.fnl.gov/event/21469/session/1/contribution/10/material/slides/0.pdf>

Geometry

- ▶ All information in a useful fcl: https://cdcvs.fnal.gov/redmine/projects/icaruscode/repository/revisions/master/entry/icaruscode/Geometry/geometry_icarus.fcl
- ▶ *Realistic, “split wire” geometry*: there is a gdml implementing it, not made yet official



- ▶ Latest status as Nov. collaboration meeting: <https://indico.fnal.gov/event/21469/session/1/contribution/10/material/slides/0.pdf>

Field and FE electronics

- ▶ **Simulated using Garfield. 1D “fixed angle” simulation.**
 - ▶ **Configuration:** https://cdcvs.fnal.gov/redmine/projects/icaruscode/repository/revisions/master/entry/icaruscode/Utilities/signalservices_icarus.fcl
 - ▶ **Parameters:** (not sure) should be standard icarus parameters. Response models are here: /cvmfs/icarus.opensciencegrid.org/products/icarus/icarus_data/v08_15_01/icarus_data/Responses/
- ▶ **New FE electronics described in paper: JINST 13 P12007(2018)**
 - ▶ **Standard integration in detsim using a tool:** https://cdcvs.fnal.gov/redmine/projects/icaruscode/repository/revisions/master/entry/icaruscode/Utilities/tools/ElectronicsResponseBesselApprox_tool.cc

Noise simulation

- ▶ **Noise simulation exists in LArSoft based on the noise from ICARUS@LGNS and 50L@CERN:**
 - ▶ Uncorrelated smooth component
 - ▶ Correlated peaks within same boards (32 channels) << slow
 - ▶ Noise models are here [/cvmfs/icarus.opensciencegrid.org/products/icarus/icarus_data/v08_15_01/icarus_data/Responses/](https://cvmfs/icecube.opensciencegrid.org/products/icarus/icarus_data/v08_15_01/icarus_data/Responses/)
- ▶ **From recent measurements on the T600 @FNAL**
 - ▶ Root file example (from Filippo Varanini) [/pnfs/icecube.opensciencegrid.org/users/varanini/ew05decoded.root](https://pnfs/icecube.opensciencegrid.org/users/varanini/ew05decoded.root)
 - ▶ Full access to data and elogs requires online privileges, which I'm requesting
 - ▶ Developers use this noise added on simulated particle guns to improve filters

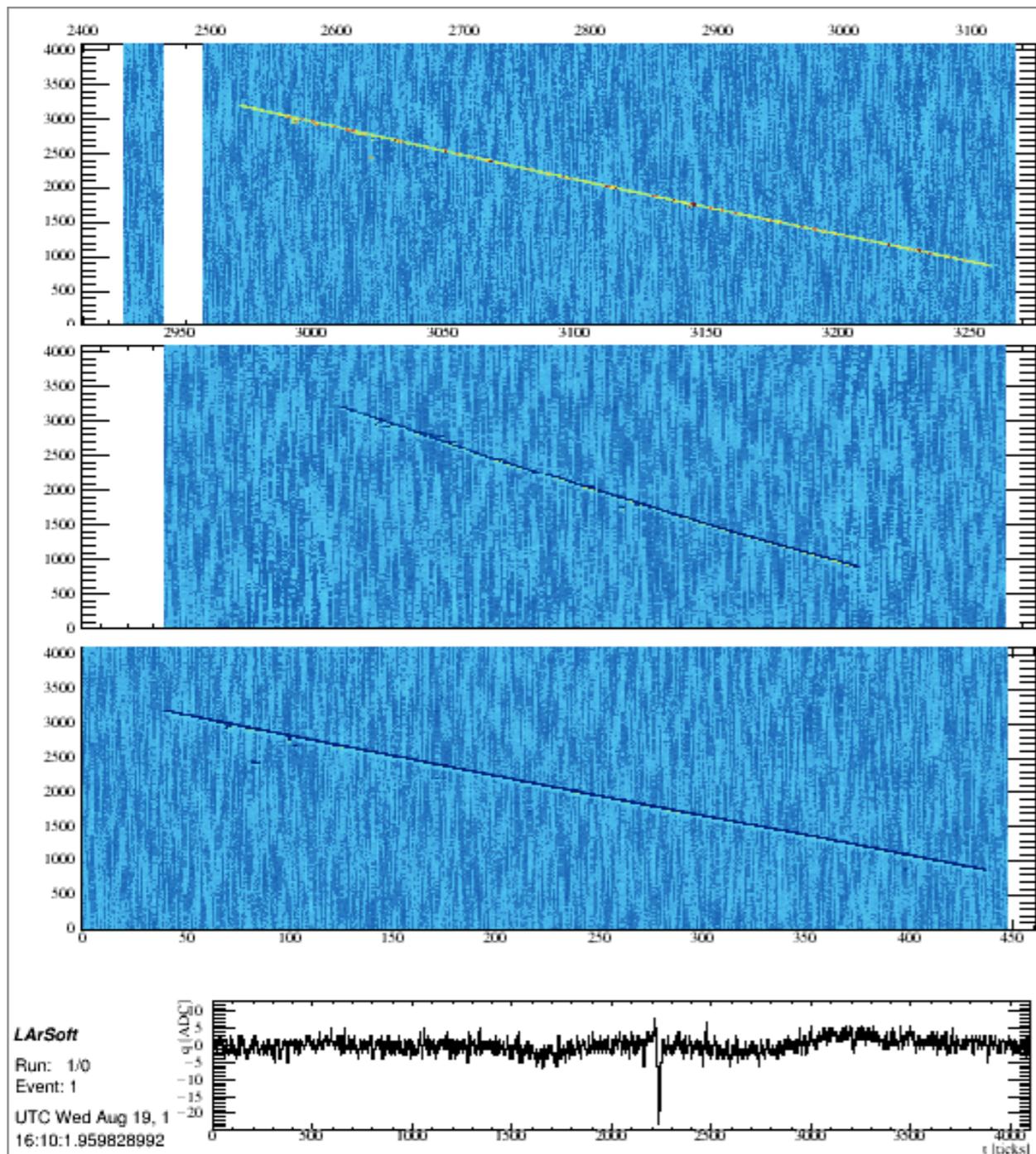
Signal processing

▶ Current chain in LArSoft

- ▶ Noise filtering: high frequency filter+coherent noise filter. Produce a rawDigit data product and relevant ROI
- ▶ 1D Convolution: produce recob::Wire object
- ▶ Gauss hit finder
- ▶ Raw hit funder (don't know much about it, it is the legacy ICARUS@LNGS hit finder)
- ▶ **Presented at the past collaboration meeting as sufficient to handle the first commissioning data** (<https://indico.fnal.gov/event/21469/contribution/6/material/slides/0.pdf>)
- ▶ MCC samples are being produced with this configuration

A test of the reco chain...

- ▶ Just the results of a quick test using some standard cfg files



- ▶ Seems fine up to Detsim stage
- ▶ Couldn't make reco work! Data products are all empty. I must ask what has been used for production (or revise step by step with more attention)
- ▶ MultiTPC approach: filter rawDigits between Cryo and TPC and use different configuration for each.

Current efforts and plans

- ▶ **OVERVIEW (from last Friday meeting):** concerns about noise, tape space, and speed of the noise filtering and 1D deconvolution. A chain already exists, but not sure of its scalability. Better and faster tools are being studied
 - ▶ Currently usual LArSoft data products will be used. Compression on rawDigits products is studied and smart ways to save only relevant part of the event on disk following the type of trigger
 - ▶ Some code for C++ and python developers is available for testing outside the bulky LArSoft framework (i think it is here: <https://github.com/SFBayLaser/icarus-sigproc-tools>)
- ▶ Multithreaded noise filtering and convolution: not a clear update of the status was given
- ▶ Noise filtering on recent test data: new coherent noise filtering is being improved on the noise data. Seems improving the signal protection of isocotronus tracks. It is (I understand) not yet in LArSoft
- ▶ ML for signal identification: The model is an auto-encoder with 1D convolutional filters able to isolate the signal from the noise. Still work in progress, but seems quite promising, and fast

WireCell integration with ICARUS

- Status of WireCell team analysis
 - MicroBooNE
 - ProtoDUNE-SP
- Status of the WireCell development
 - ML SP

- Wires
- Field response
- Noise model
- Sample nticks, trigger window
 - 500V/cm -> 1.6mm/us
- CE response
- Noise filter from uB?

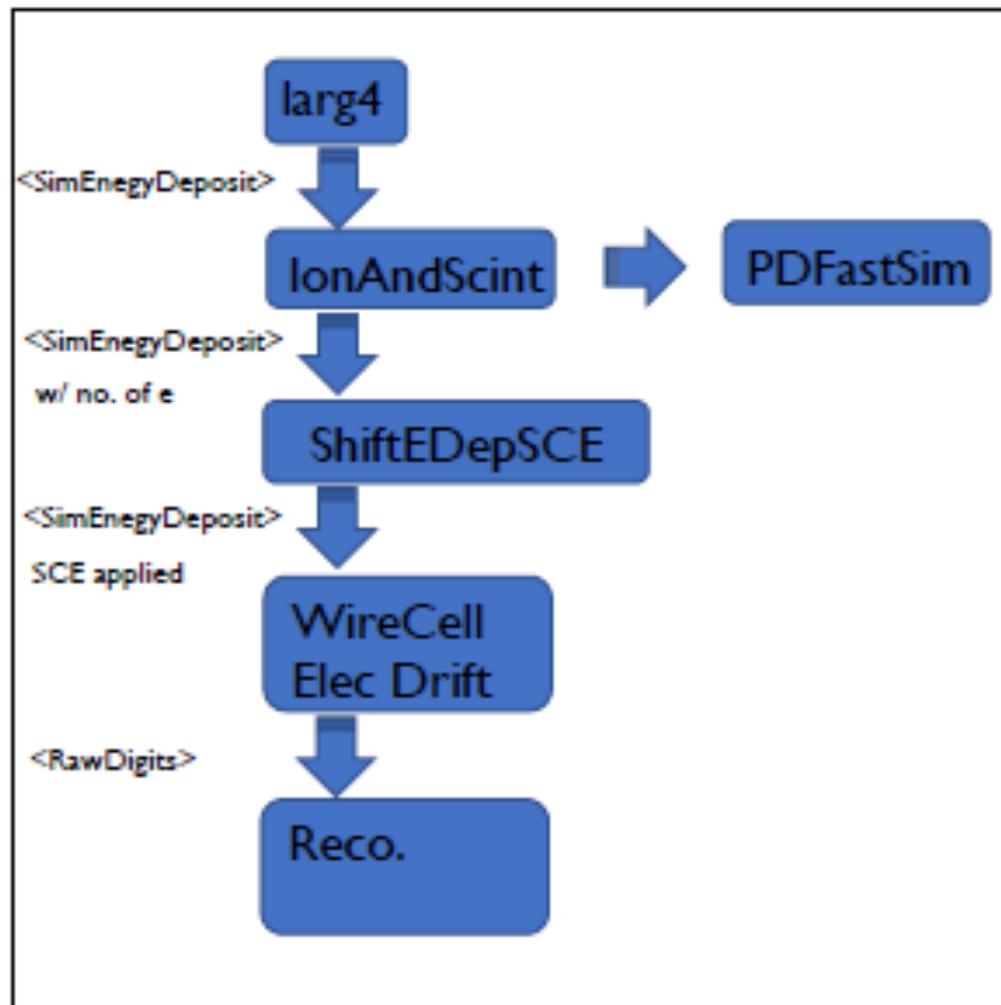
ICARUS questions

- ADC dynamic range: 0 ~ 1.4?
- Baseline for each wire plane?
- Coordinate system? Xyz origin?

- 2 cryostats -> tpc 0,1,2,3

- What's the plan towards the Jan 16 meeting?

Simulation and reconstruction chain



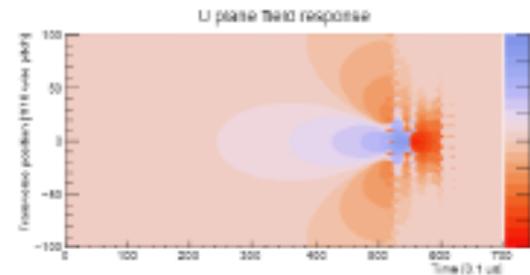
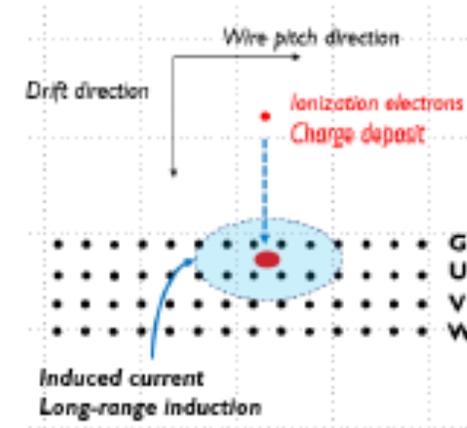
- Two major contributions of WireCell team in MicroBooNE/protoDUNE-SP
 - WireCell TPC simulation (electron drift)
 - TPC signal processing
- Good start for commissioning

WireCell Electron Drift Simulation



<SimEnergyDeposit>
* x, y, z, t, # of e

- Ionized electron absorption (lifetime in LAr)
- Gaussian random diffusion (longitudinal/transverse) $\sigma^2 = 2Dt$
- Fluctuation in electron absorption

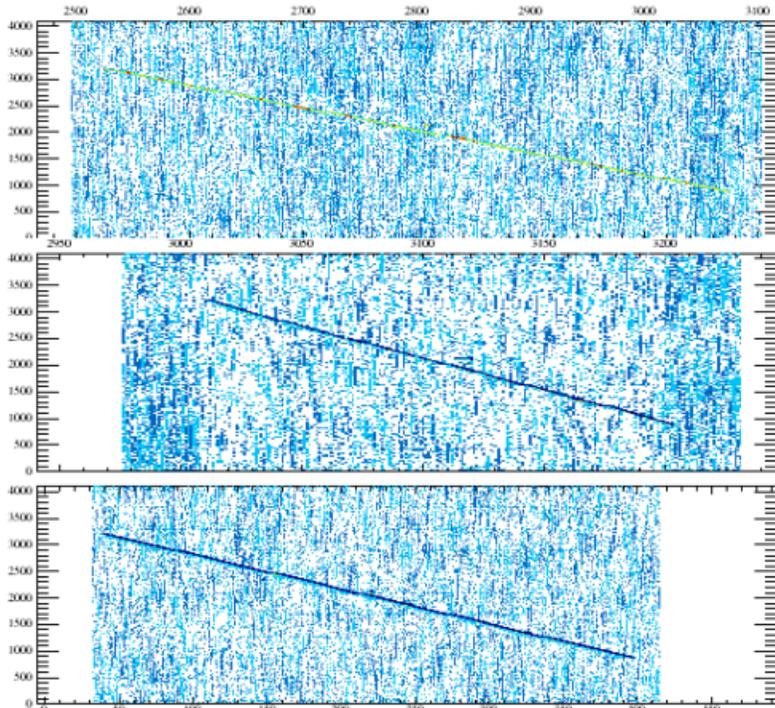


- Electronics response
- Preamp shaping
- AC coupling
- Noise
- Digitizer

- Wire geometry
- Field response

- Good approximation in noise simulation

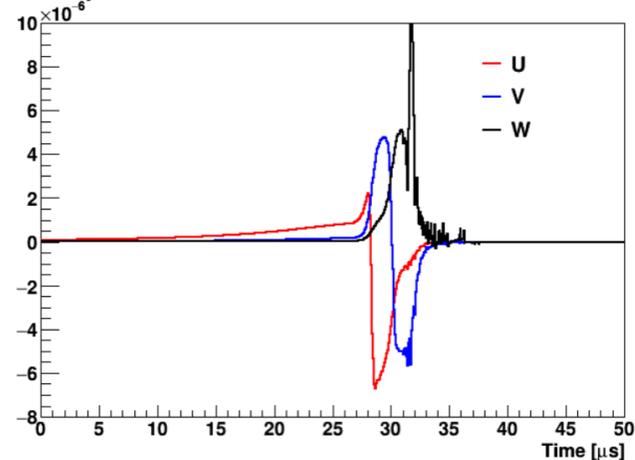
Current ICARUS simulation



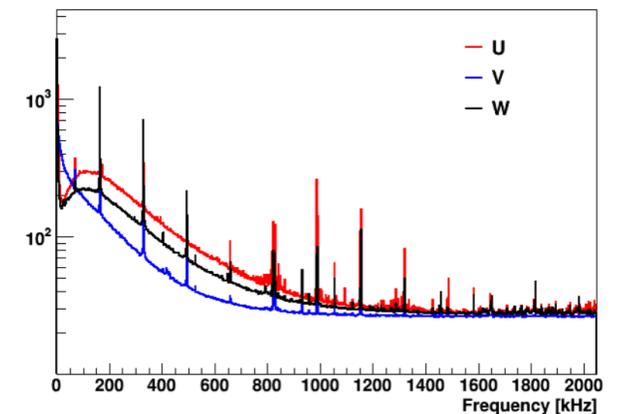
Event display of a 2GeV cosmic muon simulation

- Wire geometry is not correct
- TPC simulation
 - 1D field response cannot simulate long-range induction
- Measured noise model is implemented (better to check it)

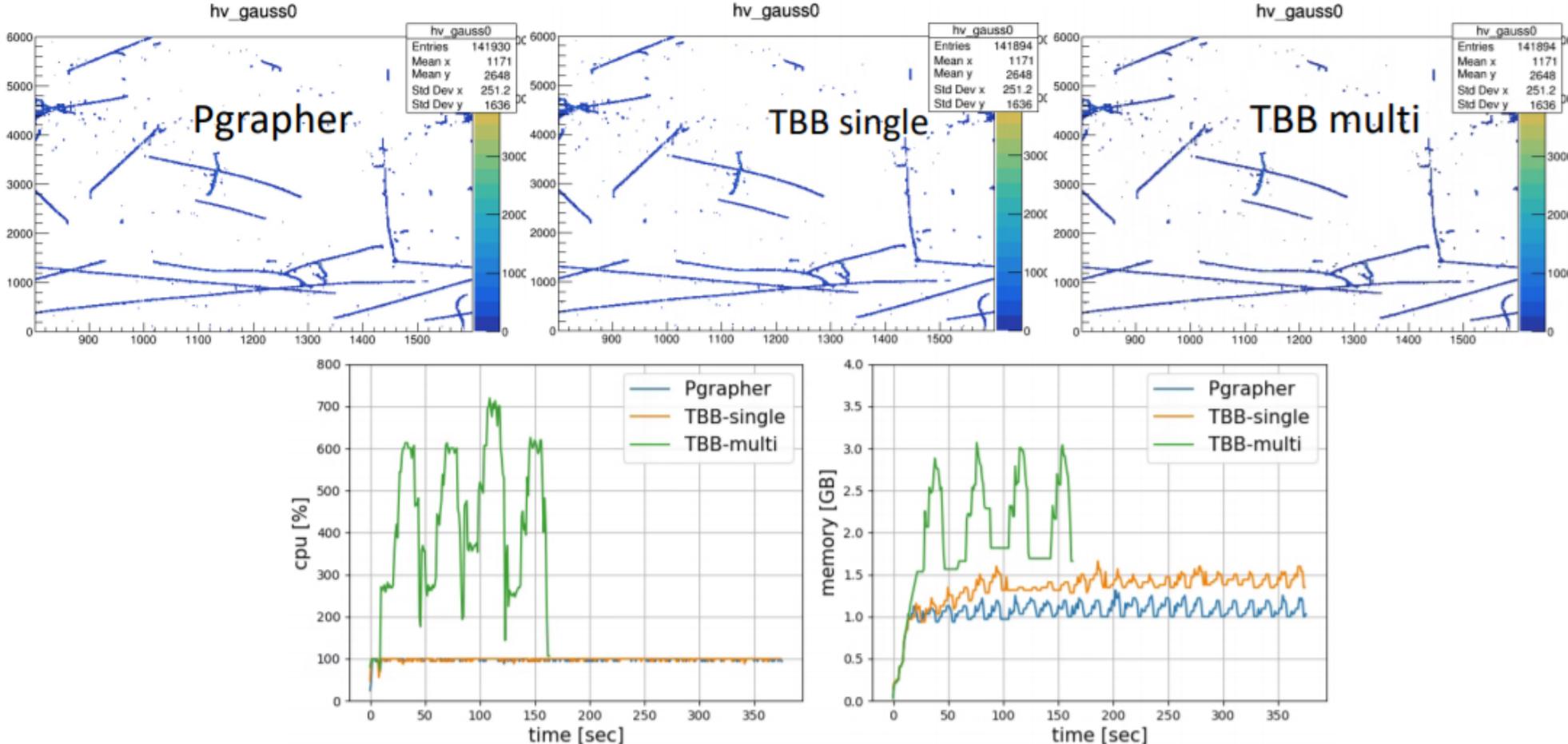
Field Responses Functions



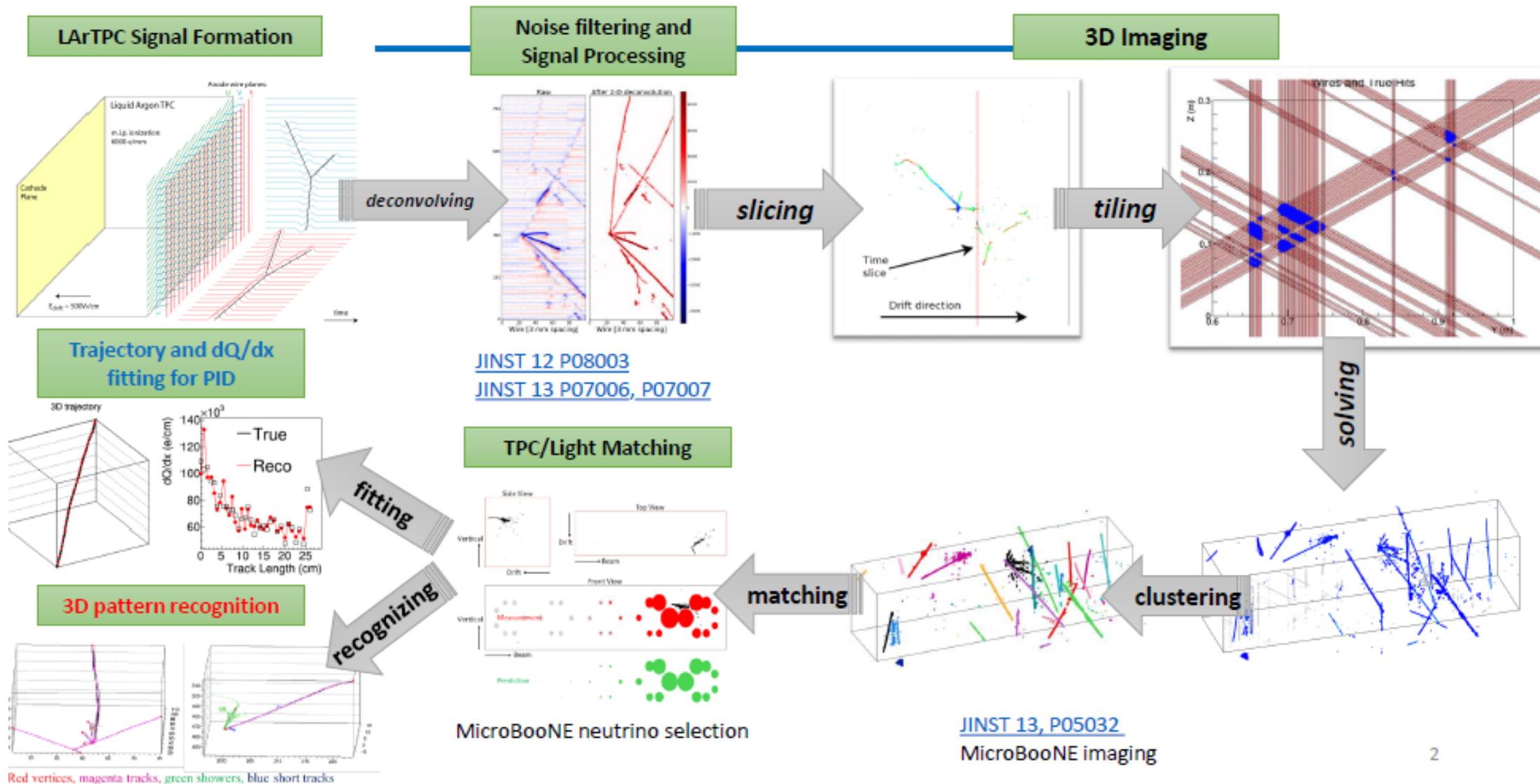
Noise Spectrum



Multithreading support in WireCell



Overview of Wire-Cell Reconstruction



Long term WC integration plan

Sim/reco wg will review the status of the algorithms before cooling down at the end of January.

Sim/reco wg expect us to perfect the algorithms over summer

- ▶ Step 1A - Geometry
- ▶ Step 1B - Make simulation with realistic noise
- ▶ Step 1C - Add realistic Coherent noise to WC **Cooling down (after January)**

- ▶ Step 2 - test existing WCT implementation, understand data scale, noise, and if new/better tools are necessary **Comissioning (April)**

- ▶ Step 3 - Be ready to use WC on commissioning data. Retune to accommodate experimental condition (bias voltages and noise).
- ▶ Step 4 - Performance evaluation, better LArSoft integration if necessary, higher level reconstruction

Discussion and short term plans

- ▶ Correct way to move forward with geometry integration
- ▶ Should we propose our own 2D filed simulation to the collaboration, how about the bias and voltage settings (?)
- ▶ Performances of the WCT to the larger scale of the detector, possible synergies with multithreading signal processing
- ▶ Calendar and deadlines? **What should be achieved in one month time?**

Thank you!