Discussions on Experimental Needs

Brookhaven National Laboratory

U.S. DEPARTMENT OF ENERGY

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MicroBooNE

- Sharing algorithms for other experiments
  - porting from wire-cell-prototype to wire-cell-toolkit
- Sharing knowledge and expertise to other experiments
  - happening now
  - see SBND and ProtoDUNE talks
- Benefit from new developments in other experiments
- Improvement on clustering/pattern recognition for single photon or e+e- pair searches in the context of exotic physics models
- Open-minded to use other reconstruction tools or in synergy with other reconstruction paradigms
  - exchange ideas and knowledge of the detector gained in the development of reconstruction tools --> well defined problem domain and do better
  - e.g. DL-assisted neutrino vertexing; RNN energy estimator; DNN ROI …

A question on DNN ROI

- DNN ROI shows better performance than traditional ROI (e.g. prolonged tracks).
- PyTorch-based implementation with multi-plane ROI matching concept. Currently implemented in WCT as as a better-performance alternative when compared to traditional ROI (traditional ROI is the current approach in SBND production workflow):
- Uses MP2/MP3/decon loose LF filter images in **time vs wire** bins as input for training and evaluation (HDF5 data format for internal WCT data handling)
- DNN ROI is a competitive approach w.r.t. traditional ROI. Is there an automated workflow w.r.t. training/validation?
- Is it possible to have a hybrid CPU/GPU usage on grid clusters? (depending on computing resources)

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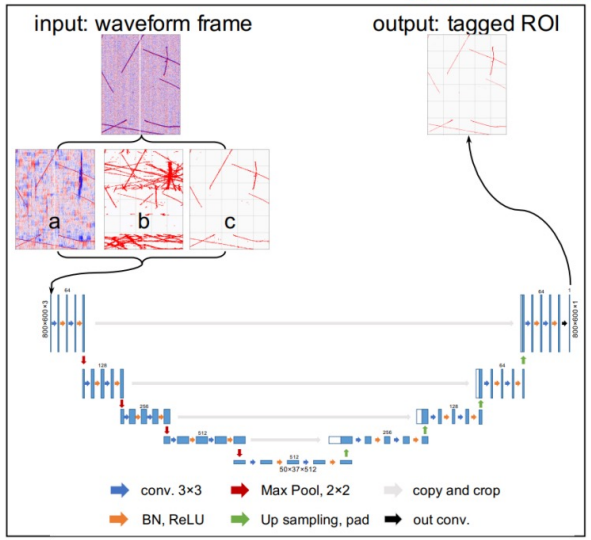

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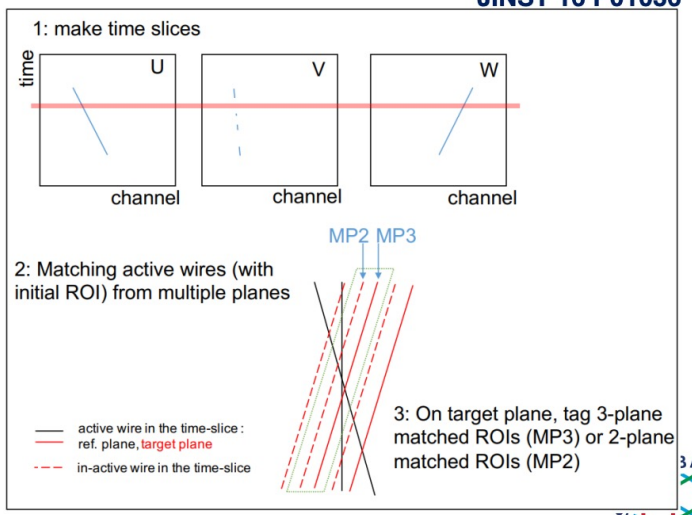


WireCell versus calibration database

- Current electronics response function has many parameters, which are currently hard-coded. Those parameters will be stored in SBND database. We expect noise filtering to need to store some info as well;

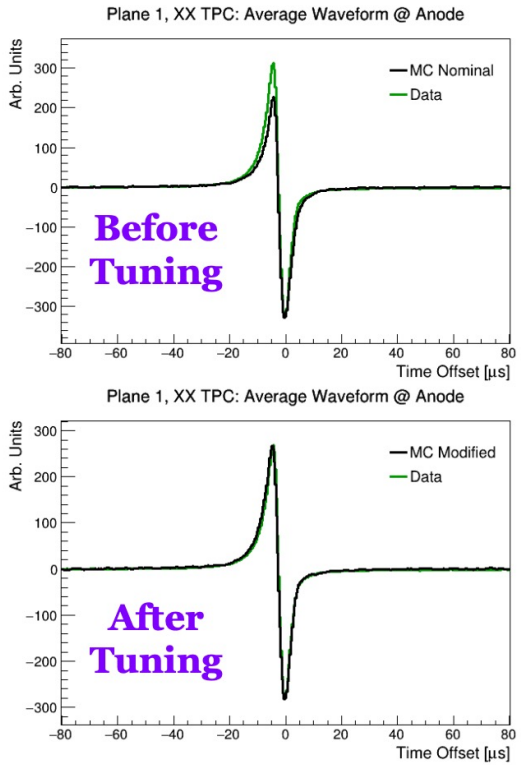
- Is it possibleto have WireCell communicating with the SBND calibration database (accessible via **ssh –K sbnd@sbnd-gateway01.fnal.gov**)? WireCell stores some data as a “jsonnet-based” internal database (e.g. chndb.jsonnet).

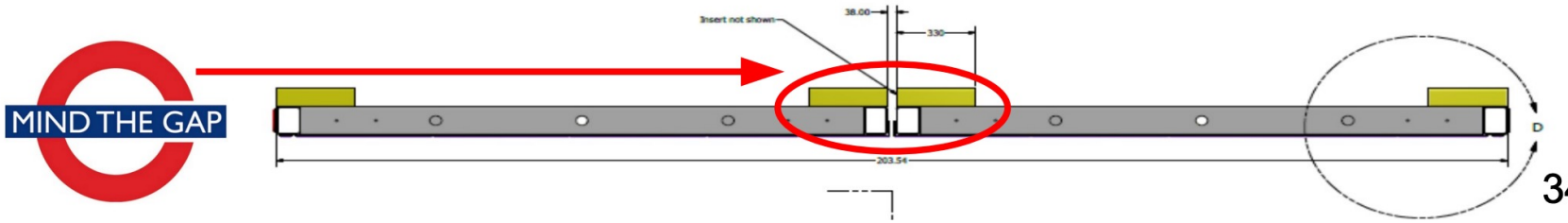
WireCell usage and areas for improvement

- The following is a list of ideas/needs of improved usage of WireCell tools in SBN. Apologies if any of them sounds trivial to experts!
  - Improved WireCell 2D ROI finding for warm electronics detector?
    - interesting discussions yesterday, the perspective of using AI/ML for ROI finding is attractive
  - Jsonnet configuration import&replacement for detector variations?
    - may be a limitation of the fhicl-Jsonnet interplay?
  - Input/ideas for detector systematics?
    - non-reweightable, huge production efforts
  - Optimization of WireCell modules?
    - Turning on multi-threading and other speedups?
    - Further reduce memory footprint?
      - Are already limited by I/O reads/writes? 2D deconvolution memory usage was already reduced by ~2x. thanks to Haiwang and the WireCell team for the prompt help!

Field Response @ SBND

- SBND still in early commissioning days, but hopefully no transparency issues to deal with like ICARUS (fingers crossed!)
- SBND does have a **gap between the APAs** requiring special consideration
  - Induction wires only in gap, so response more like collection plane
  - Can still use same approach as for ICARUS transparency issues for modeling different field response in SBND MC simulation





Discussion and Final Thoughts

- Wire-Cell TPC signal simulation and signal processing in significant use at both SBND and ICARUS
  - Already heard a lot about SBND effort from Lynn and Ewerton
  - ICARUS not using "nominal" Wire-Cell ROI-finding – is it possible to get this to work, or should we pursue different ideas like ML?
  - Wire-Cell 3D imaging not currently being explored at ICARUS (to my knowledge at least) – will this effort receive attention? Is it compatible with lower S/N of ICARUS?
- Detector calibrations being explored w/ ICARUS data helpful for improving modeling of TPC field response, including use in Wire-Cell TPC deconvolution
- Ongoing effort to model TPC signal shape/magnitude effects due to ICARUS transparency issues within Wire-Cell simulation
  - Can Wire-Cell simulation also be made to accommodate spatial variations in electron lifetime (observed at e.g. ProtoDUNE-SP)?

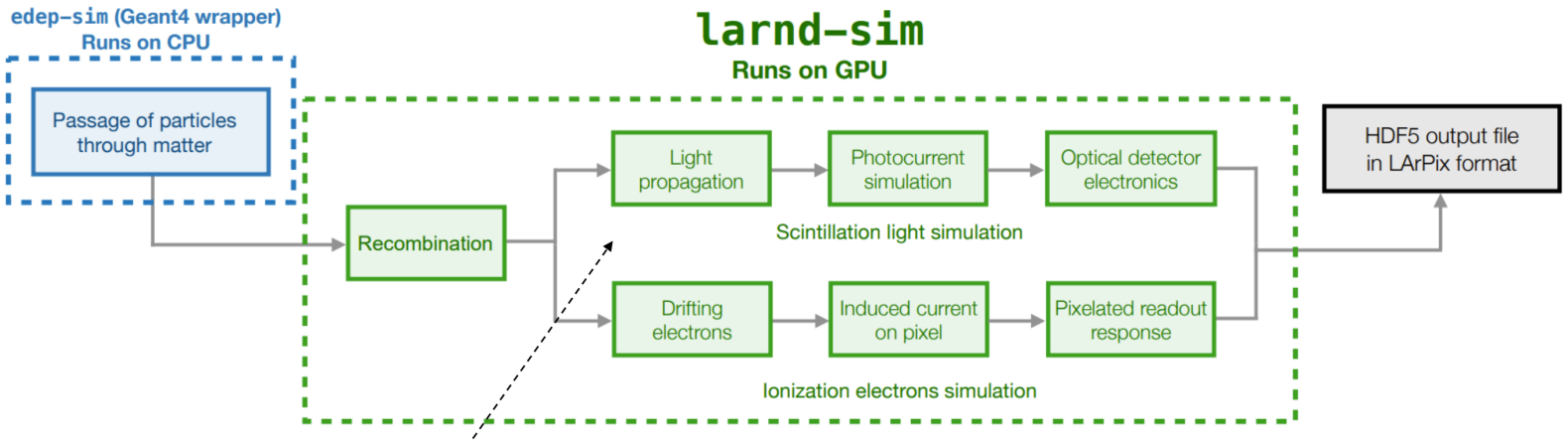
ProtoDUNEs

What have we learned?

- **many aspects of WCT implemented with PD-SP are solid & can be used as base frame for other generations of ProtoDUNEs**
- newly developed electronics per-channel calibration show good performance, should be used in future
- **noise filtering is generally good across, but need careful detector-specific checks**
  - all PDs show good noise filtering performance
  - PD-HD; some type of evaluation against DataPrep and CNR validation needed
  - coherent noise removal may need the most careful checks & optimization; channel grouping, signal protection, ,,,
- **DNN ROI is expected to boost signal processing performance**
  - development in near-final stage
  - once finished, validation across different PDs and electronics can be performed
- **for PD-VD, downstream WC is being ported, active efforts needed**

Simulation Chain: Detector Simulation

- Edep-sim provides the electrons and photons
  - larnd-sim (*JINST* **18** P04034) takes those inputs for the detector response.

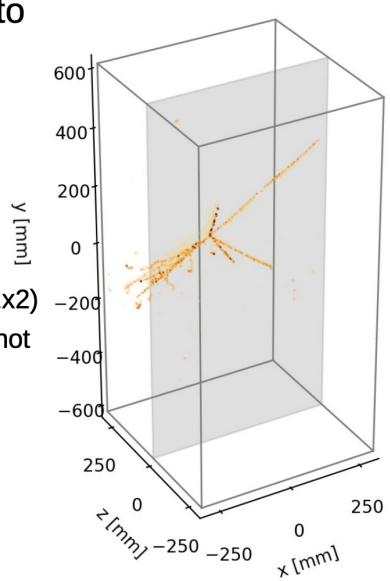


Currently uses lookup table.

Wire-Cell at ND-LAr

See R. Diurba's talk earlier today on ND-LAr/2x2 Software Interfaces

- Wire-Cell native 3D charge pattern recognition should be very natural to apply to ND-LAr pixel readout data
  - Existing software infrastructure is well equipped to study the nuanced differences between the native Wire-Cell tomographic imaging and true 3D charge data from LArPix
    - `larnd-sim` detector simulation is benchmarked against O(10 M) cosmic-ray events
  - LArPix effects likely to complicate Wire-Cell adaptation:
    - Single channel successive triggers - configurable electronics response (can modify at 2x2)
    - Far-field advanced hits and lobing effects - geometry-dependent hardware effects (cannot modify at 2x2 without detector extraction)
- Wire-Cell toolkit has demonstrated the capability to adapt scintillation light signal processing to aid charge reconstruction
  - Small modifications to existing Wire-Cell techniques have the potential to quickly make a significant impact on interaction-level charge-light signal association
    - Scintillation light waveform unfolding with compressed sensing
    - Many-to-many charge-light signal matching with fast external-tracker boundary conditions



Cosmic-ray raw data

DUNE-FD

Working on applying DNN-ROI for multiple experiments

- ref. Wenqiang, Avinay/Moon's talk

Skip processing for DUNE-FD almost ready for production tests

Better FR ready

Major discussion focus is the Wire-Cell->LArSoft IO

In addition, Wire-Cell has the potential to directly read in HDF5 DAQ files, but this may be discussed in the IO session. Ref. BV's talk