ProtoDUNE-DP light data integration in LArSoft

J. Soto

DRA meering

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GOBIERNO DE ESPAÑA
MINISTERIO DE CIENCIA E INNOVACIÓN
Ciemat
Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas
DUNE

Content

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- Importing light data into LArSoft.
- Pending things.
- Bonus: Status of the light simulation in LArSoft.

Where the light data is?

- Light data is in eos:

  /eos/experiment/neutplatform/protodune/rawdata/np02/PMT/ROOT/

- (New) Structured in subfolders:
  - 000 for runs from 0 to 999.
  - 001 for runs from 1000 to 1999, and so on.
- Every run has a certain number of subruns (depending of the length of the run and the data rate):

```
[np02lro@lxplus778 ROOT]$ ls /eos/experiment/neutplatform/protodune/rawdata/np02/PMT/ROOT/001/*1005_*
/eos/experiment/neutplatform/protodune/rawdata/np02/PMT/ROOT/001/output_001005_0000.root
/eos/experiment/neutplatform/protodune/rawdata/np02/PMT/ROOT/001/output_001005_0001.root
/eos/experiment/neutplatform/protodune/rawdata/np02/PMT/ROOT/001/output_001005_0002.root
/eos/experiment/neutplatform/protodune/rawdata/np02/PMT/ROOT/001/output_001005_0003.root
/eos/experiment/neutplatform/protodune/rawdata/np02/PMT/ROOT/001/output_001005_0004.root
/eos/experiment/neutplatform/protodune/rawdata/np02/PMT/ROOT/001/output_001005_0005.root
/eos/experiment/neutplatform/protodune/rawdata/np02/PMT/ROOT/001/output_001005_0006.root
/eos/experiment/neutplatform/protodune/rawdata/np02/PMT/ROOT/001/output_001005_0007.root
/eos/experiment/neutplatform/protodune/rawdata/np02/PMT/ROOT/001/output_001005_0008.root
/eos/experiment/neutplatform/protodune/rawdata/np02/PMT/ROOT/001/output_001005_0009.root
```

run sub run

- Simple root files. Data structured has been already explained by Clara, and there is a link in the twiki:

  https://twiki.cern.ch/twiki/pub/CENF/DUNEProtDPOps/ProtoDUNE_LightData_191119.pdf

- Many analysis already started:

  https://indico.fnal.gov/event/20144/session/7/contribution/83/material/slides/0.pdf

Importing light data into LArSoft

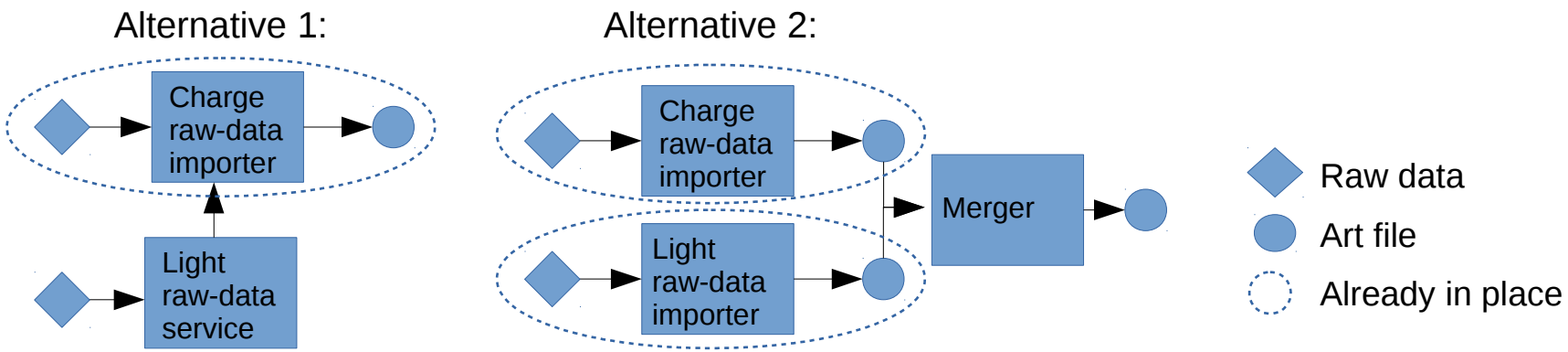
- There is a module available in a feature branch to import the light data into LArSoft format (not yet in the general repository): **feature/jsoto_PDDP_PMTRawDataImporter**
- In this branch, the module lives in **dunetpc/dune/Protodune/dualphase/RawDecoding**
- How to run it?
  - Install LarSoft (version v08_38_01 -qe17:prof).
  - Download dunetpc (**mrb g dunetpc**), and move into the branch (**git checkout feature/jsoto_PDDP_PMTRawDataImporter)**
  - Compile and go to srcs/dunetpc/dune/Protodune/dualphase/RawDecoding
  - Run: **lar -c pddp_pmtdaq_converter.fcl output_001663_0000.root**
  - It creates the art file: **output_001663_0000_pddprawdata.root**
- Output file contains the following art objects (standard objects, same as Single Phase):
  - Raw::OpDetWaveforms: The raw waveforms for all channels.
  - Raw::RDStatus: An object that store information about the data integrity.
  - Raw::RDTimeStamps: The White Rabbit timestamps.

Importing light data into LArSoft

- Comments and warnings for analyzers:
  - The module takes care of the different ADC channel-PMT mapping for every run.
  - LArSoft channel numbering depends on the geometry (drift in Y or drift in X). Only drift in Y geometry is supported.
  - We haven't processed all the files for now: If the analyzer wants to have a look, he has to convert the file itself as explained in the previous slide.
- About the light data reconstruction:
  - Dedicated Dual-Phase reconstruction modules were developed for the TDR studies, and they work, creating the standard light reco objects (OpHits and OpFlashes, same as Single-Phase).
  - However a dedicated fcl file needs to be created and validated (the ones available now are for the Far Detector).
  - Also new software will be needed. For example to take care of the different gains per pmt/run (now it assumes a fixed gain, given by a fcl parameter, and it is unpractical when processing several runs).

Pending...

- The importer module is light stand-alone, it does not consider CRT or TPC charge information.
- In the future we want to have all charge, light and CRT data in the same files:
  - Alternative 1: Modify the light raw data importer module to be a service that provides the light information per event when decoding the charge data given its time stamp.
  - Alternative 2: Once light and charge has been imported separately, merge them event by event in a separate step (maybe easier to implement, but slower).



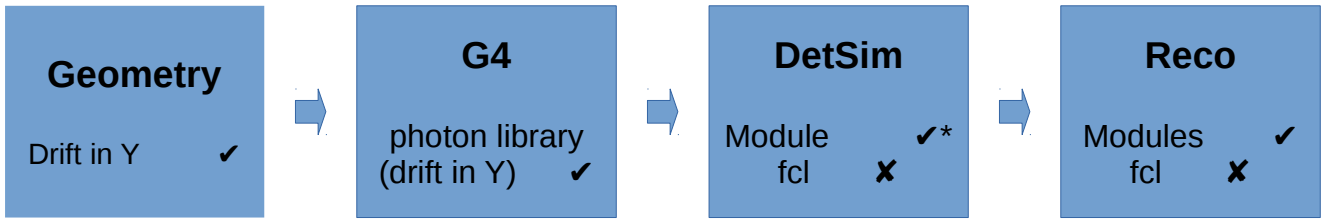
→ To do this, **we will need to be using the same geometry in both, charge and light** (I expect the charge will move towards the drift in Y geometry soon).

- This will allow to do t0 reconstruction studies easily, and charge-light combined analysis.

Status of light simulation in protoDUNE-DP

- DONE:
  - ProtoDUNE-DP geometry is fully simulated with the drift in Y. Cathode, ground grid, field cage are included and PMT positions are up-to-date (including PEN/TPB differences).
  - One light map has been generated with this new geometry, and will be available soon in the general repository (some crosschecks ongoing).
- TO BE DONE:
  - DetSim step:
    - To check and validate the fcl parameters (sampling, dynamic range…)
    - To improve the PMT response simulation, as the PMT characterization studies advance.
  - Reco: Same as for raw data: Create and validate a fcl file.

* For newcomers: https://cdcvs.fnal.gov/redmine/projects/dunetpc/wiki/Photon_Simulation_Tutorial



Summary

- Light data can be already analyzed using LArSoft.
- Importing and reconstruction works, but the reco fcl parameters needs to be validated.
- The system is still not robust for batch processing and some new software will be needed.
- Merging charge and light data in the same art files is pending, and hopefully will be done once the charge moves to the drift-in-Y geometry.
- The light simulation framework is almost ready, we only need to adapt the fcl parameters to the protoDUNE-DP photon detection system characteristics in the detector simulation step.

Thank you