

ND Software

Quick Status Update
BSM Group Meeting
December 15, 2020



Andy Mastbaum
Rutgers University
mastbaum@physics.rutgers.edu

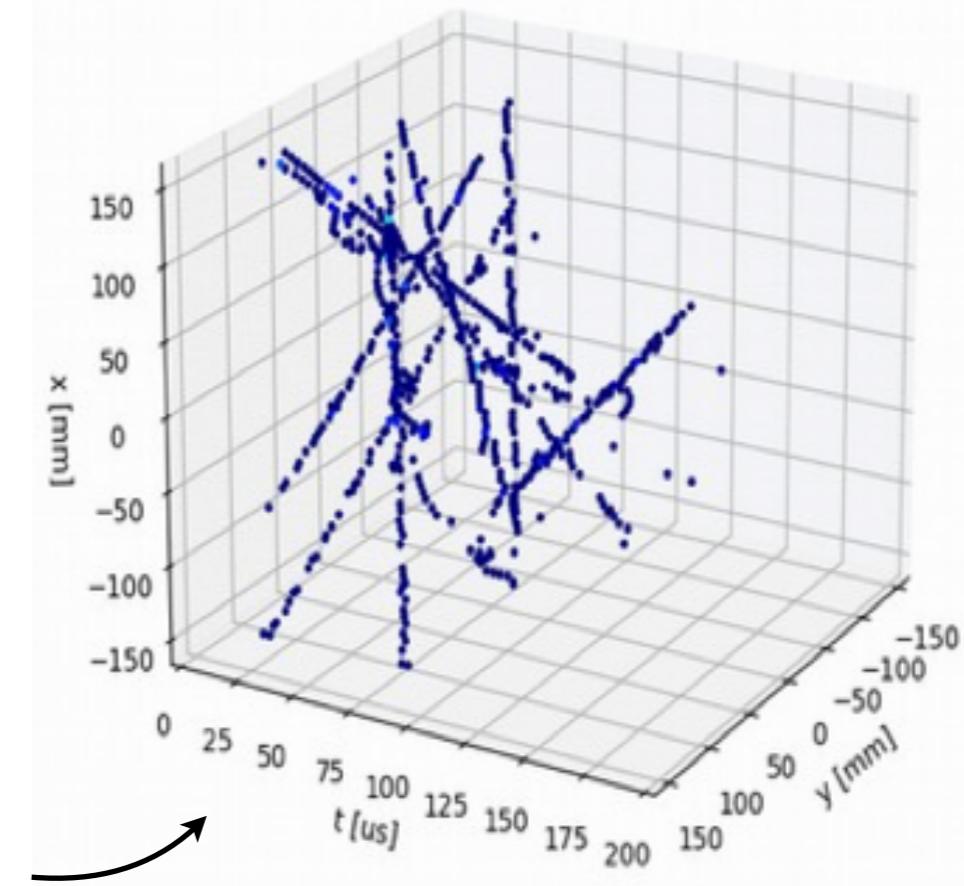
Overview

Software Integration

- Discussing spring production schedule & samples
- ND data model document in circulation

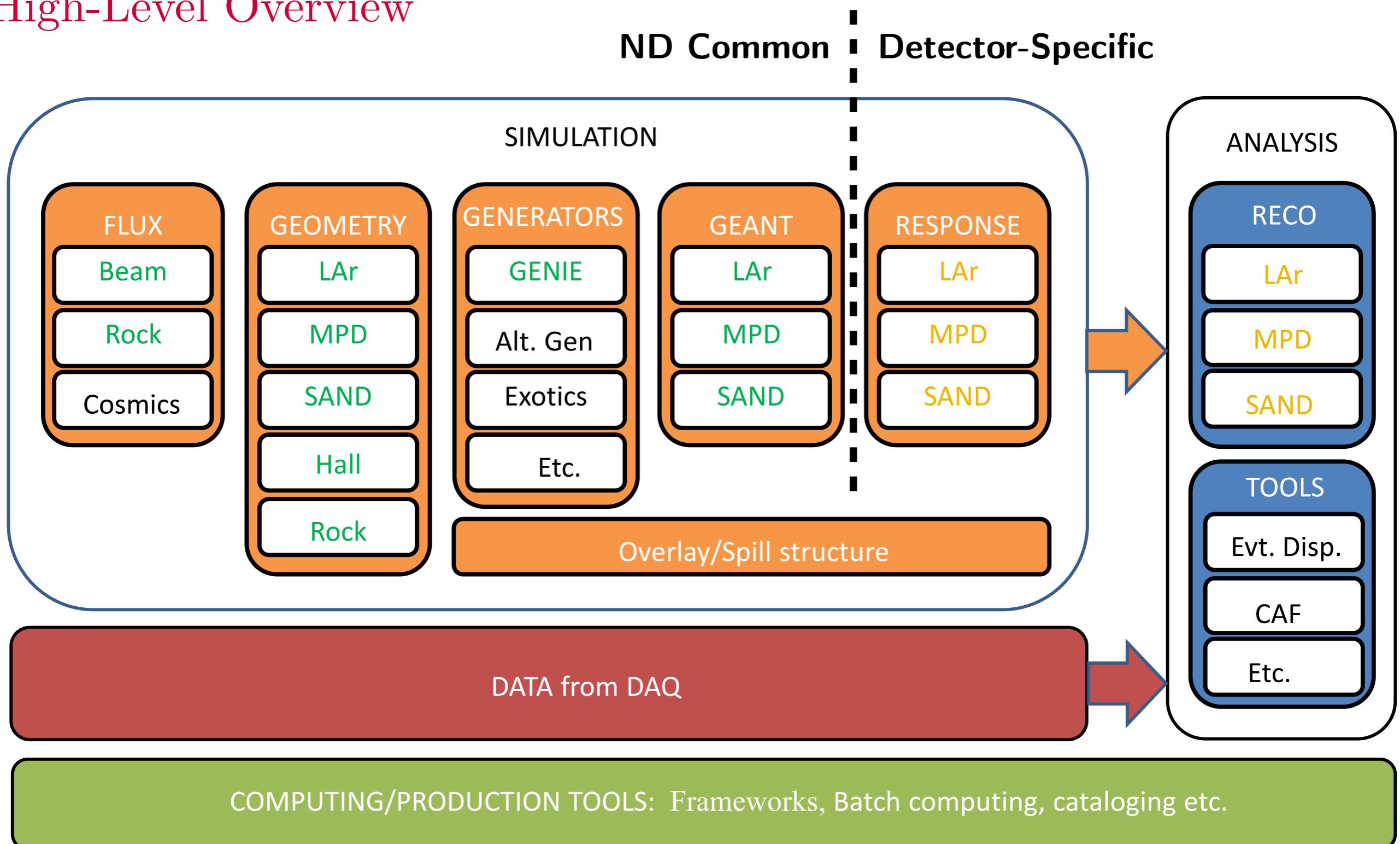
Detectors

- ND-LAr
 - Recent push to analyze detector prototype data
 - Refining charge & digitization simulation
 - Deep Learning-based reconstruction of edep-sim events
- ND-GAr
 - Mature simulation & analysis framework in GArSoft (LArSoft-like)
 - ParamSim parametric reconstruction and full reco paths
 - ND-GAr Lite: ND-GAr magnet + MINERvA-like scintillator tracker inside
- "Day One" Temporary Muon Spectrometer
 - Magnetized range stack with MINOS-like scintillator strips + SiPMs
 - Range-based momentum and sign ID, parametric with tracking underway



Software Integration

High-Level Overview



First draft of TDR datasets

- **Individual volumes (all mutually exclusive)** (2M events each mode?)
 - LAr active
 - ArgonCube excluding LAr active
 - HPgTPC active
 - MPD excluding HPgTPC active
 - 3DST
 - SAND excluding 3DST
 - Near upstream rock
 - Far rock
- **Useful combinations**
 - Everything
 - LAr active + ArgonCube + rock
 - LAr active + ArgonCube + near rock +MPD w/HPgTPC
 - This list should be extended as needed if there are specific combinations that are of general use. Otherwise overlay can be run at the analysis level.

Software Integration

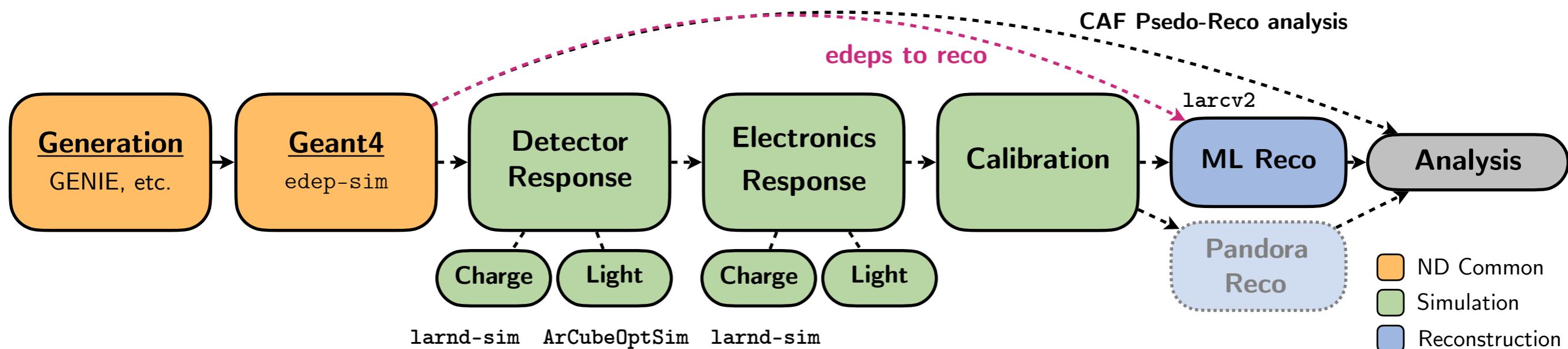
Data Model

- **Goal:** Define a robust data model for ND simulation & analysis
 - Ensure consistency/compatibility for ND SW development
 - Ensure consistency/compatibility with FD where possible
 - Support joint analyses, e.g. LAr + GAr matching, ND + FD
- **"Data products"** (in LArSoft terms) and "external" data (databases)
- **Initial draft** built from input from ND-LAr, ND-GAr, SAND, TMS
- **View link:** <https://www.overleaf.com/read/ypvkqbfmpmtx>
- **Feedback:** mastbaum@physics.rutgers.edu, mathew.Muether@wichita.edu

DUNE ND Data Model	
Data Model Committee	
DUNE ND Software Integration Group	
September 23, 2020	
Contents	
1 Overview	2
2 Metadata	2
2.1 Data Cataloging	3
3 External Data	3
3.1 Beam	3
3.2 Detector Hall	3
3.3 Detector and DAQ Status	4
3.4 Detector Status	4
3.5 Slow Monitoring	4
3.6 Hardware Database	4
3.7 Offline Data	5
3.8 Run Metadata	5
4 Raw Data	5
4.1 ND-LAr	5
4.1.1 LArPix Charge Readout	5
4.1.2 Light Readout	6
4.2 ND-TMS	7
4.3 ND-GAr	7
4.4 SAND	8
4.4.1 General description of SAND subdetectors	8
4.4.2 ECAL data	8
4.4.3 STT data	9
4.4.4 3DST data	9
5 Simulation	11
5.1 Conventions	11
5.2 Detector Coordinates	11
5.3 Generators	11
5.3.1 SAND Generators	12
5.4 Tracking	12
5.5 Signal Propagation	13
5.5.1 SAND Signal propagation	13
5.6 Electronics Response	14
6 Calibration	15
6.1 SAND Calibration	15

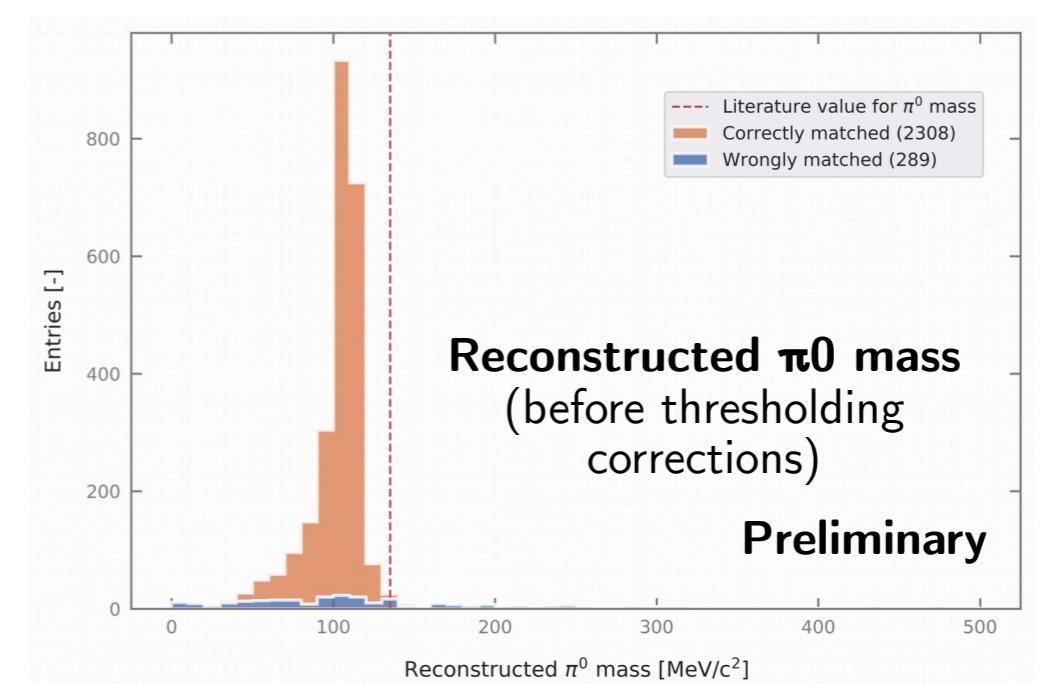
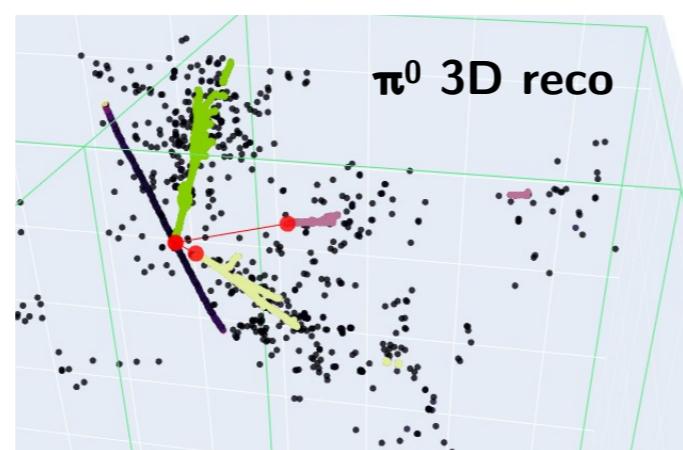
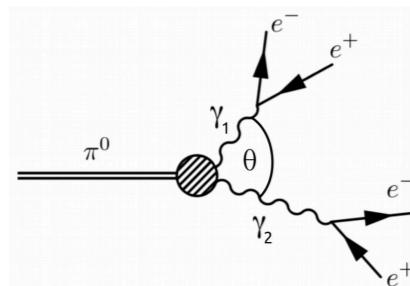
ND-LAr Analysis

- Tools available for G4-level, psuedo-reco-level, or reco-based analysis
- "Analysis-driven development" helps!



Neutral Pions in ArgonCube (R. Berner)

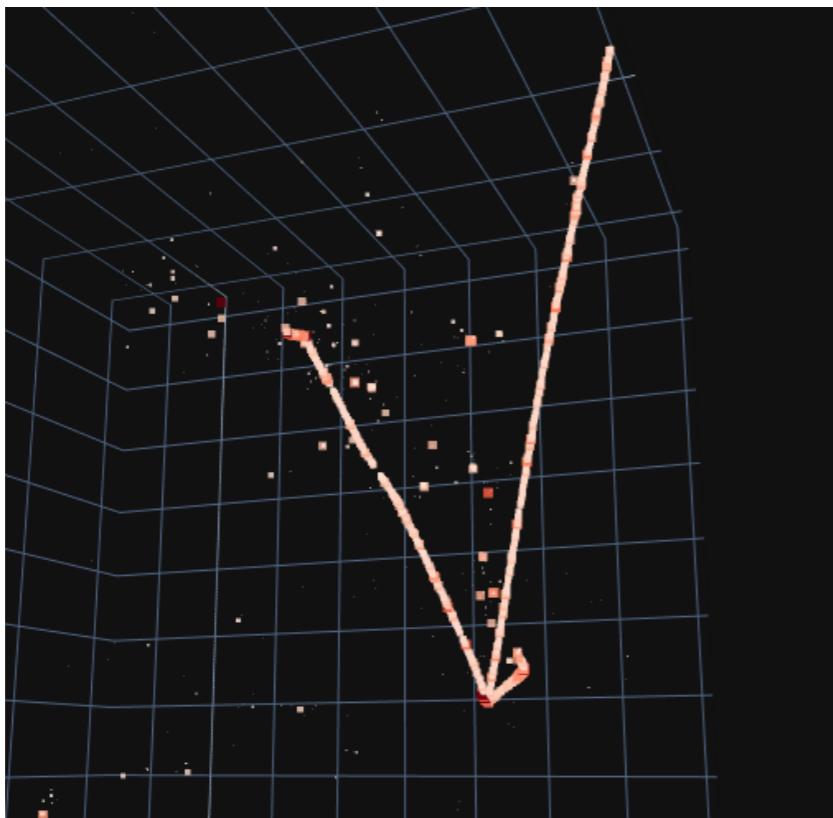
- $\pi^0 \rightarrow \gamma\gamma$ standard candle for EM energy calibration
- Built on **Machine Learning** reconstruction [SLAC]



ND-LAr Analysis

edep-sim to ML Reco Progress

Gallery



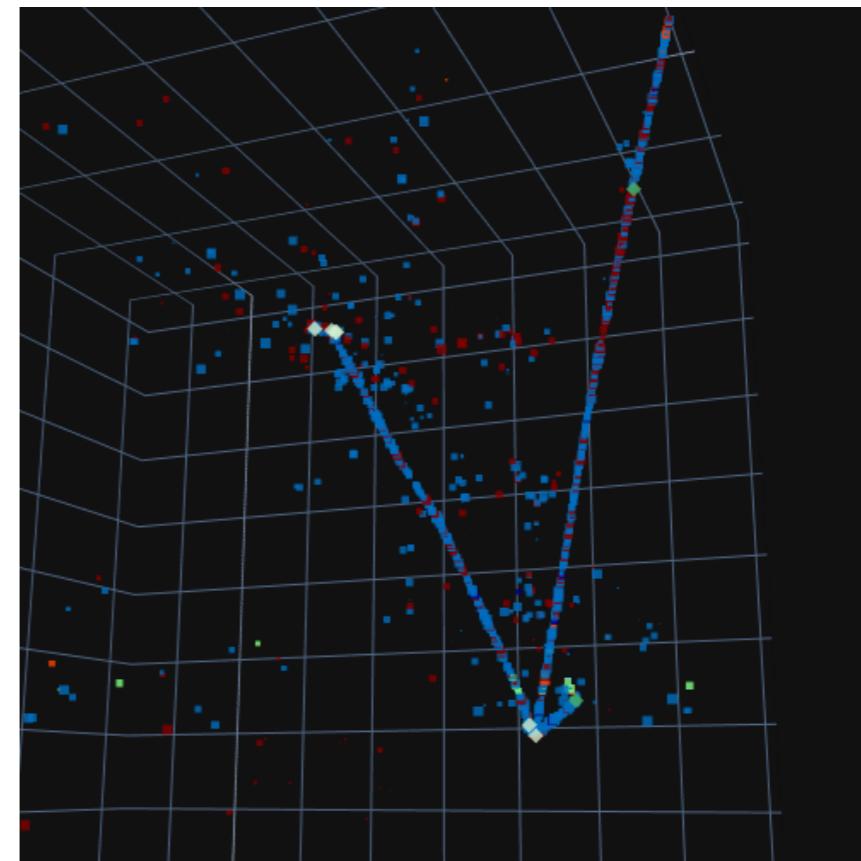
Energy deposits

Voxel
classification
(cubes)

track
shower
delta ray
Michel electron
“low energy scatter”

POI
classification
(diamonds)

track
shower
delta ray



Predictions

Features to note:

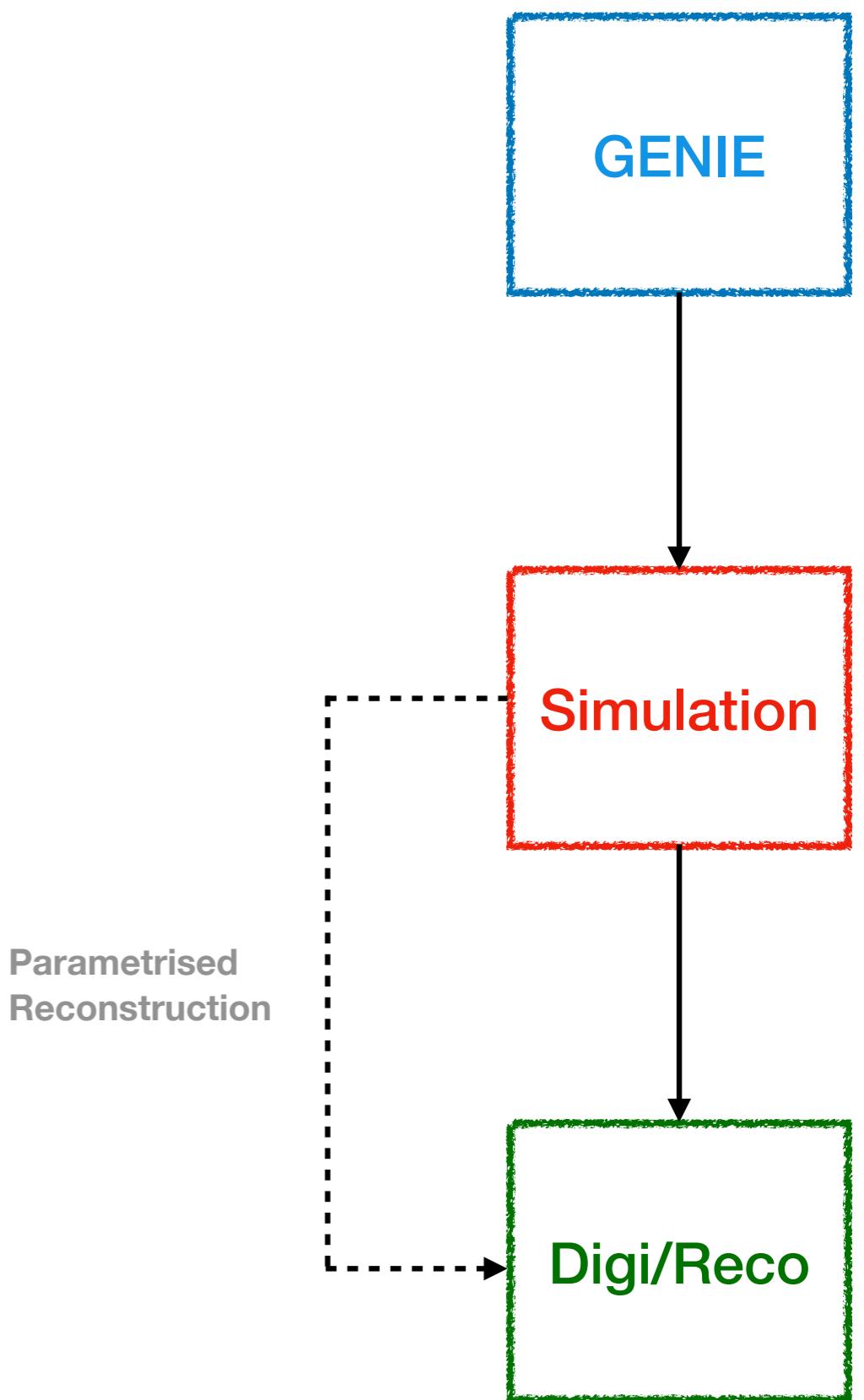
- Correctly identified Michel electron hits (green at end of lower right track)
- No POI at end of longest track

16

ND-GAr

Reminders (9/2020)

- The ND-GAr software is quite **mature** now
 - Full digitisation and reconstruction
 - Trying to keep it flexible for ND-GAr optimisation and ND integrat
- A lot of **improvements** made in the last months:
 - Improved tracking performance
 - Improved vertex resolution
 - Custom B-field maps
 - ECAL improvements
 - Pandora Integration
- Main software chains:
 - *Fully integrated* from generation (GENIE v3) to reconstruction
➡ **GArSoft**
 - Integration *within the ND Software framework*
 - **Generation** standalone ➡ GENIE v2
 - **Simulation** standalone ➡ G4 wrapper edep-sim
 - **Conversion, digitisation and reconstruction** ➡ GArSoft
 - “Fast Simulation”
 - Parametrised reconstruction from MCTruth ➡ **ParamSim**



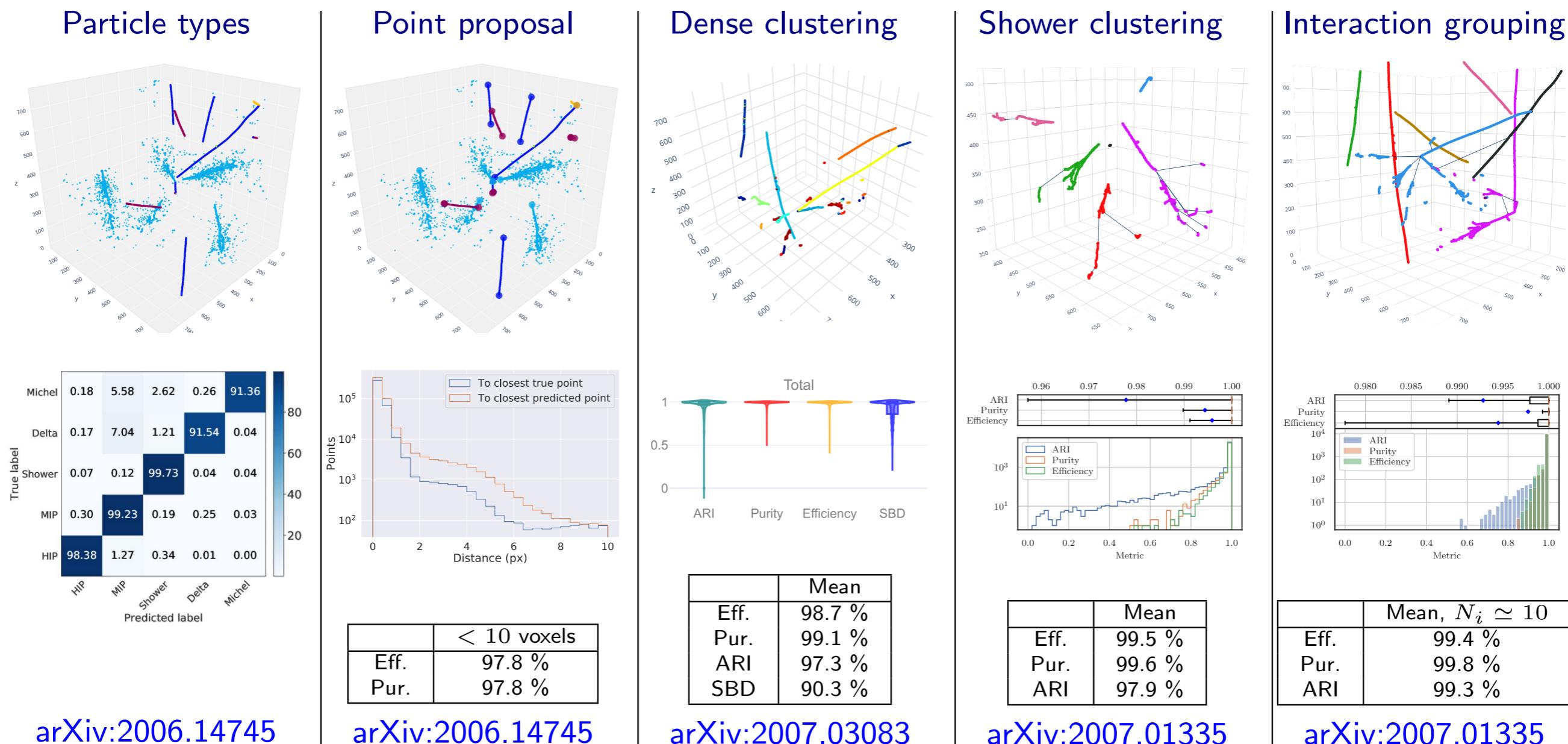
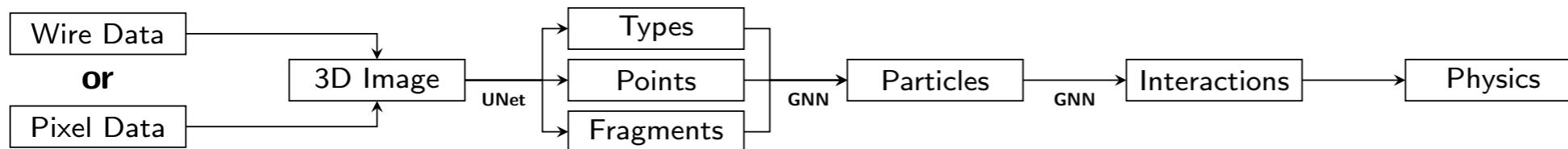
Organization

- DUNE ND SW Integration group
 - Meetings: Mondays, 8:00 AM CT
 - dune-nd-sw-integration@fnal.gov
 - `#nd_software_integrate`
- Contacts
 - Integration (`#nd_software_integrate`)
 - Mathew Muether, mathew.Muether@wichita.edu
 - ND-LAr (`#lar_nd_analysis`)
 - Andy Mastbaum, mastbaum@physics.rutgers.edu
 - ND-GAr (-lite) (`#hpgtpc`)
 - Tom Junk (trj@fnal.gov), Eldwan Brianne (eldwan.brianne@desy.de)
 - TMS (`#nd_muon_spectrometer`)
 - Chris Marshall (chris.marshall@rochester.edu)
 - SAND: L. Dinoto (lea.dinoto@ge.infn.it), G. Yang, et al.

ND-LAr Reco

Machine Learning Reco

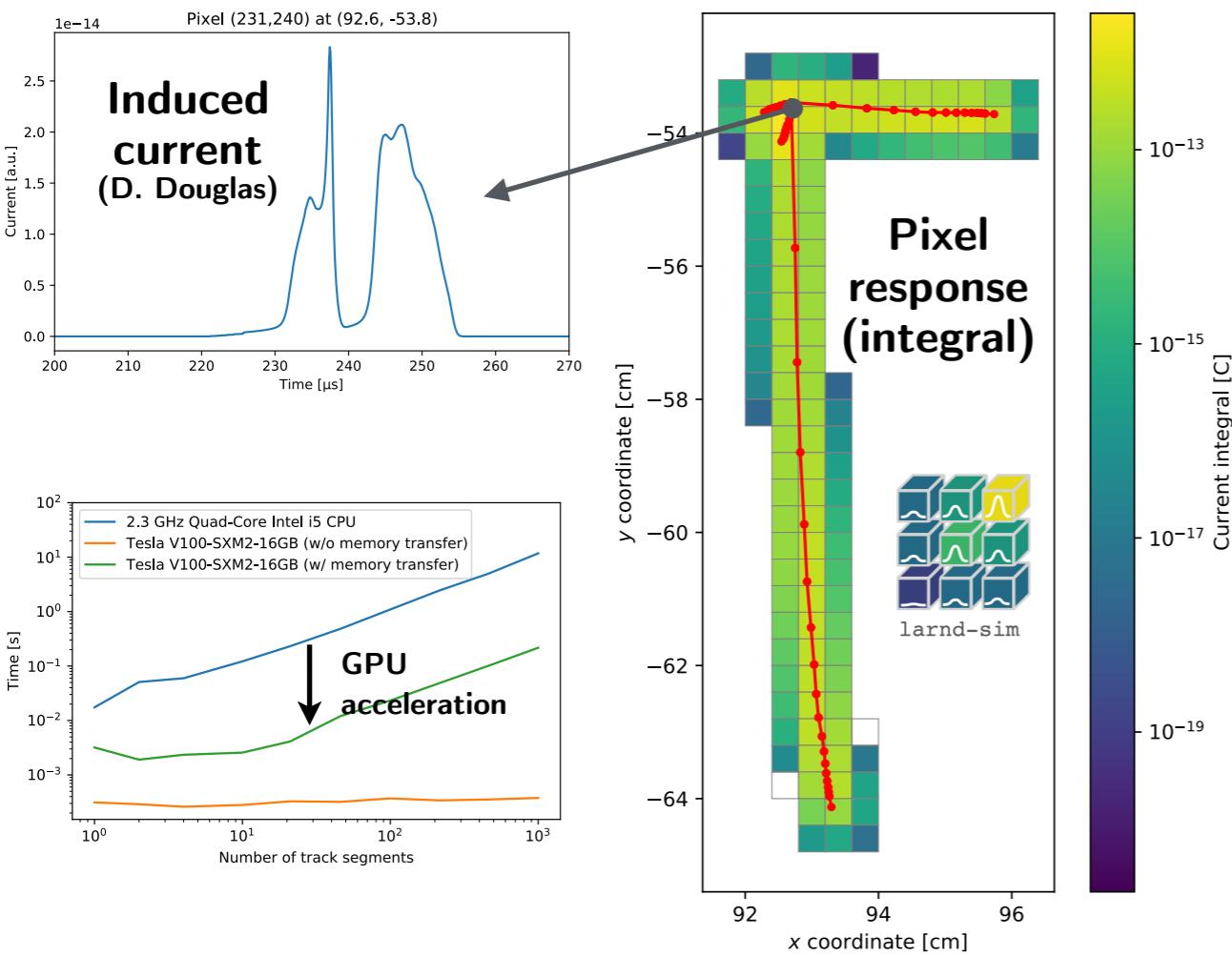
- Machine Learning-assisted pixel readout
- LArTPC reco
- Clustering, **particle ID**, **particle flow**



ND-LAr Simulation

Charge Response Simulation

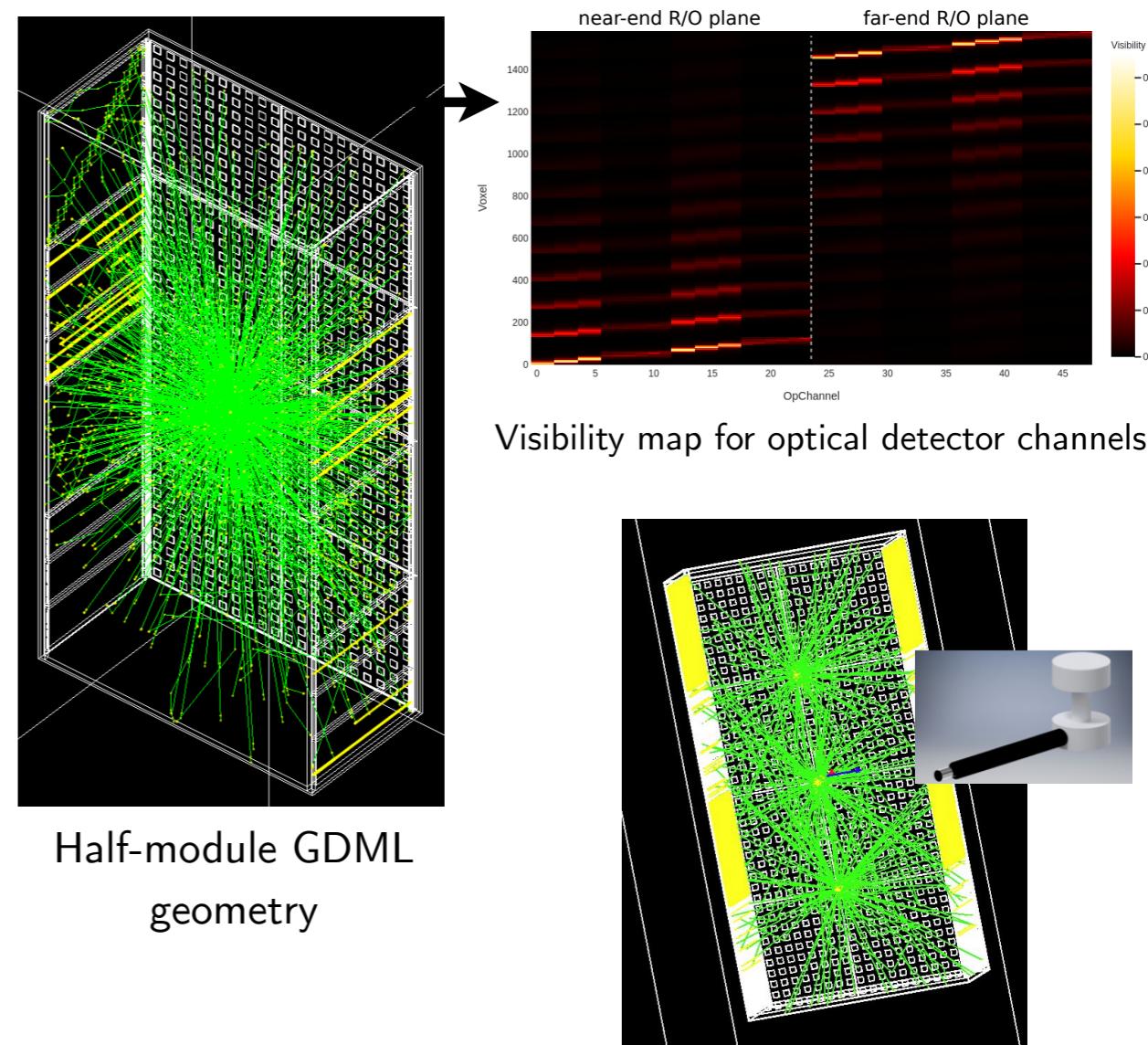
- Initial version of the charge simulation completed, run on edep-sim files
- Track segments → pixel induced current
- Self-trigger digitization also implemented



LBL (Roberto Soleti), Caltech (Zoya Vallari)

Optical Simulation

- Microphysical G4 simulation in an ArgonCube "unit cell" with ArCLight and LCM



Bern (Patrick Koller)