ND Software Integration Update

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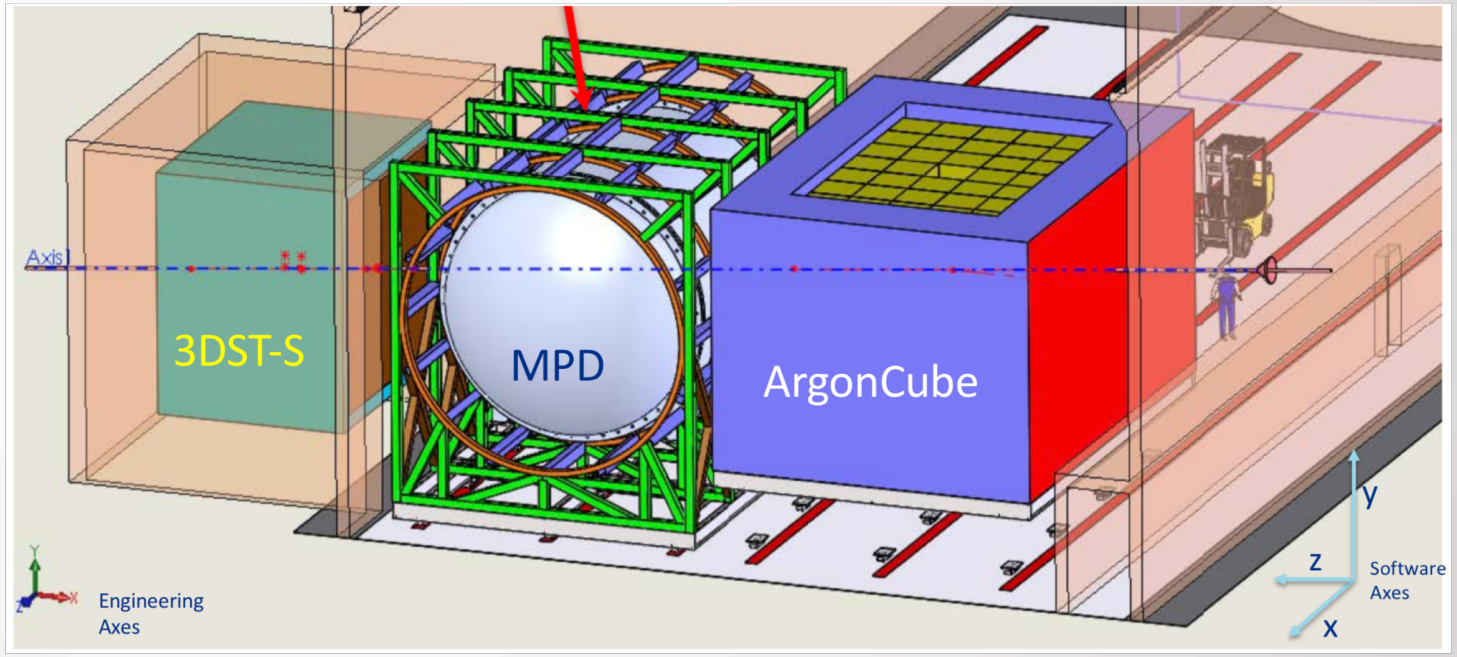
ND Workshop Summary

- We held a workshop on ND SW integration on July 24th
  - https://indico.fnal.gov/event/21249/other-view?view=standard
- The goal was to bring ND detector system groups and DUNE physics groups to build a plan to get us to a full ND simulation and software suite.



Status form the ND Detectors - LAr

Software Overview

(last talk link)

Simulation

- Event generator, particle tracking, detector response … each piece developed separately
- Eco system
  - Now/Past: custom-made LAr simulation software developed @ LBNL team used
  - Plan: use LArSoft

Reconstruction

- Particle clustering + ID, neutrino vertex finding, neutrino event clustering
  - Machine learning based approach, development lead by SLAC
  - Eco system: custom software (can be in LArSoft)

Simulation Software Status

(last talk link)

… progress has been slow …

Simulation

1. Not yet: pixel geometry debugging still on-going
   - **Goal**: run largeant for wire & pixel geometry
2. Not yet: how-to prepared, will ask Patrick @ Bern
   - **Goal**: photon library within TPC active volume
3. Not yet: 1st ver. response made by Dan @ MSU
   - **Goal**: run drift simulation for wire & pixel geometry
4. Not yet: 1st ver. being finalized by Dan @ LBNL
   - **Goal**: run the whole readout chain for pixel (no wire)

Presented @ last ND workshop

Status form the ND Detectors - MPD

MPD: Reconstruction: GArSoft

Implemented

- Event Generation
- Detector Geometry
- Particle Interactions & Energy Deposits
- Drift and Diffusion
- Digitization
- Hit finding and clustering
- Pattern recognition
- Track fitting
- ECAL Digitization
- ECAL Reconstruction
- Ionization-Based Particle ID
  - Initial version exists – needs work

To do (to some degree optimization)

- TPC Field Response and Electronics Response
- Optimize pattern recognition in difficult cases
- Optimize track fit
- Very short tracks in crowded environments will require innovative algorithms
  - Deep learning methods being studied now
- Vertexing
  - Preliminary vertex-finding algorithm written and tested
- ECAL
  - Cluster-Track matching
  - Full energy reconstruction (only visible energy for now)
  - …..

Slide from Alan Bross

Software: To do list.

Open-ended list

- ECAL specific
  - More realistic electronic response
  - Improvement of clustering and possible Pandora integration
  - SSA to be finalised
  - Association TPC tracks to ECAL clusters
  - Implement particle identification / π^0 reconstruction / neutron reconstruction techniques
  - Full energy reconstruction (only visible energy so far)
- General
  - Full event reconstruction
- **Ideas and help are welcomed!**

Slide from Eldwan Brianne, TPC Mini-Workshop, 12 July 2019
https://indico.cern.ch/event/827540/

Status form the ND Detectors - 3DST

Stony Brook University

Flow

- Geometry
  - independent
- Neutrino flux generation
  - independent
- Neutrino interaction generation
  - consistent with LBL
- Energy deposition of final state particles
  - consistent with LBL
- Reconstruction
  - independent
- Analysis
- - independent

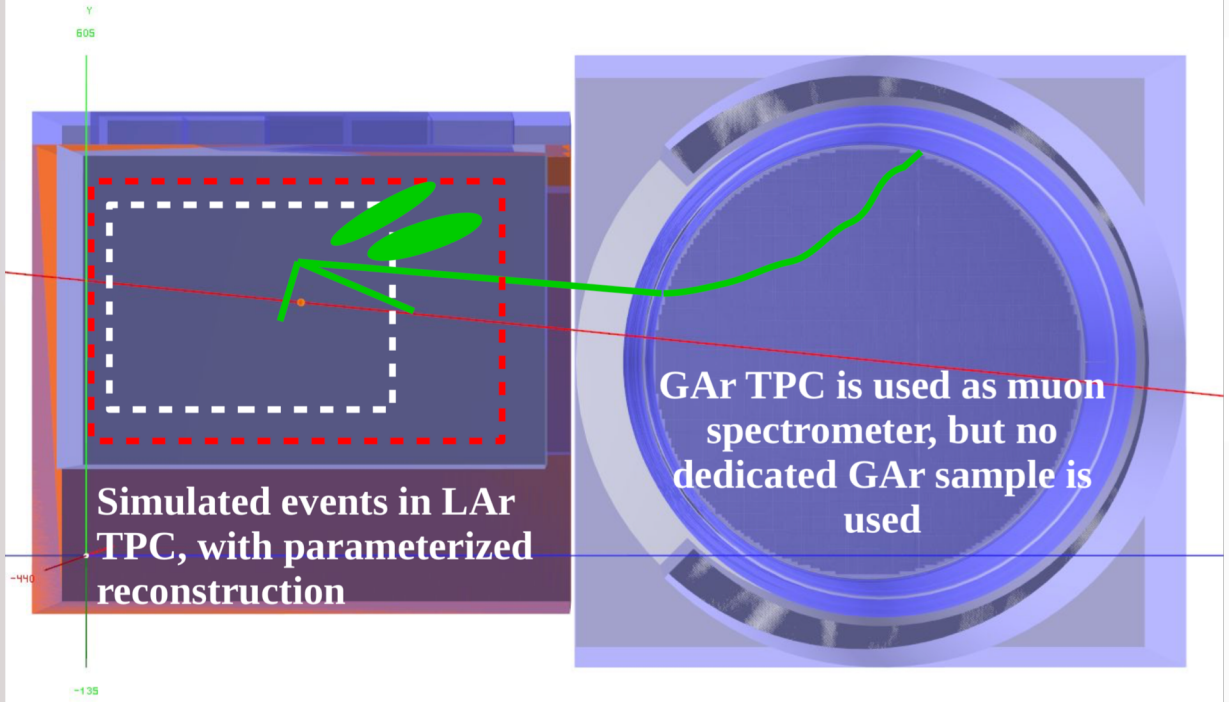
Stony Brook University

Comments

- It would be good that we have a unified geometry → we need a little more time to figure out how 3DST looks like.
- For most flux files, we can use the same as other detectors, but we may need some dedicated beam condition variations.
- Would be good to have a unified GENIE and edep-sim generation.
- It would be difficult to merge our electronics simulation, reconstruction and analysis with other systems.
  - in a special scenario, for example, 3DST as a tracker for LAr at early stage, we could consider to merge the event tree that after electronics sim. And reconstruction also.

Request from the Physics Groups

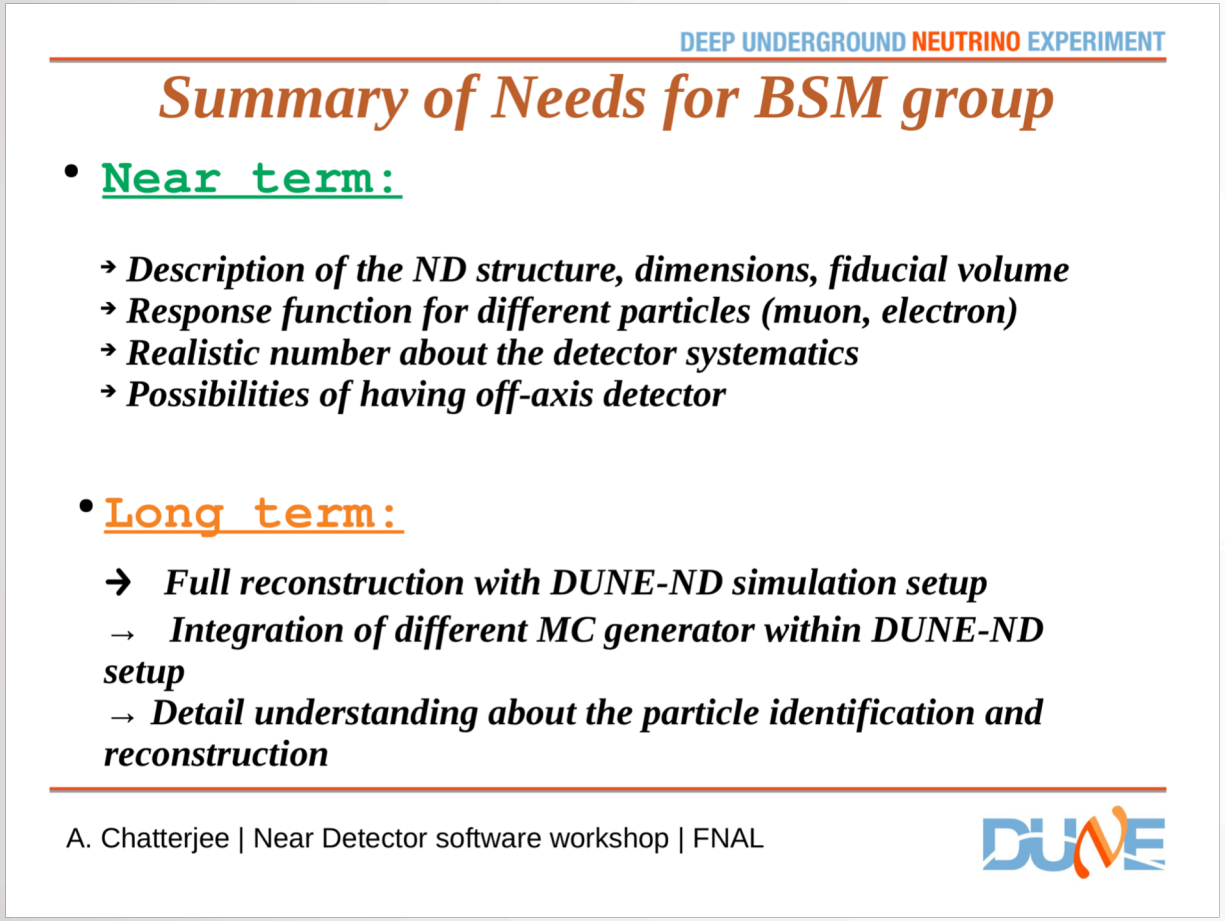
Current status of ND in LBL



Current status of ND in LBL

- For CDR, this level of study is sufficient
- Most urgent priority is building on existing work to demonstrate the physics case for each ND component, and demonstrate that ND as designed is sufficient for LBL measurements
- For TDR, we want to replace existing ND with full simulation + reconstruction

Request from the Physics Groups



- We also heard from Daniel Ruterbories about the Minerva/ MINOS experience and were urged to keep care early on to design an integrated solution.

Integration Action Items

- GEOMETRY
  - We need a GDML merger with Overlap checker
    - Each detector needs a well defined volume and global position to develop.
      - Solution should allow easy independent development of each component.
    - Coordinate system
      - This need to be well define and common across groups. (Watch for “magic” directions)
    - **Need a Hall geometry. (**Stony Brook Student, Perri Zilberman, will be working on this. Thanks!)
  - Need a module to allow Geant4 step sizes etc by volume.
    - Contact Hans Wenzel and Adam Lyon (g-2) for advice/recommendations.
  - Setup a Umbrella repository
    - Move to git to use tools for distributing large files?
  - Versioning
    - Distinct naming convention.
    - Geometry stored in Data File?

Integration Action Items

Other considerations for Unified Simulation/Framework

- Event display
- Framework comments
  - Should be robust, last into the 2020s
- Computing- What's are expected data volume:
  - **Need to report in August at computing workshop.**
- Generators
  - Genie
  - Other neutrino interaction generators (Neut, NuWro, etc)
    - **Extracting data to refill stripped GENIE event records is likely the path forward.**
  - Cosmics, Rock event
    - **Generate to detector boundaries and save in genie event record for overlays.**
- Reconstruction
  - **Make sure everyone is doing something compatible with ART.**
  - **Will need matching algorithms for full analysis.**

Continuing the effort

- All of the items above need effort so please contact me if your interested in helping.
- I have setup a doodle, https://doodle.com/poll/r8f29fefya7q5z49, to find a bi-weekly meeting time to discuss progress and effort.
- There is also now a mailing list for the this effort
  - DUNE-ND-SW-INTEGRATION@LISTSERV.FNAL.GOV.
- Also #nd_software_integrate on slack.