LBL/ND Software

DUNE-ND-GGD & EDEP-SIM

Clark McGrew
Chang Kee Jung, Jose Palomino,
Brett Viren, Guang Yang
Stony Brook Univ. & BNL

- What these tools are for
- Simulation of Detector Geometry and Energy Deposition
  - DUNE-ND-GGD (https://github.com/gyang9/dunendggd.git)
  - EDEP-SIM (https://github.com/ClarkMcGrew/edep-sim.git)
- Next steps (design studies we anticipate)

Motivation

- Agreeing on a baseline in the next couple months will require tools to rapidly evaluate proposals
- Some things we are trying to achieve
  - Ability to try out ideas with little overhead
    - Easy installation/Easy start-up
    - Flexible (easy) geometry definition
    - Fast simulation that naturally transitions to a full simulation.
  - Scalable design
    - Start simple, but have all of the machinery needed for a detailed simulation
  - Designed (and "simple") to add a detailed response/electronics simulation
    - Based around the successful detector/response simulation used in T2K
    - Any "fast-sim" output is upgradeable to a full simulation.
- Our solutions
  - DUNE-ND-GGD: A library of tools to quickly build detector geometries
  - EDEP-SIM: An experiment independent tool to simulate energy deposition
  - Not included: A response simulation
    - Already have Scintillator, Gas TPC and LAr TPC (with wires) in hand, but this is more experiment independent.

DUNE-ND-GGD

- Python scripts and configuration files to define a detector geometry
  - This leverages GeGeDe tool produced by Brett Viren (BNL)
    - Pure python so very portable (https://github.com/brettviren/gegede.git)
    - Output to GDML that's compatible with both GEANT4 and ROOT
- Define geometries to evaluate the feasibilities of a wide range of possible detector configurations
- Flexibly and quickly define geometry configurations
  - Define different Detector configurations
  - Detectors are constructed from predefined Sub-Detectors
  - Sub-Detectors are constructed from a library of predefined Components
- All aspects of a particular detector configuration are controlled INI files provided on command line
  - Example:

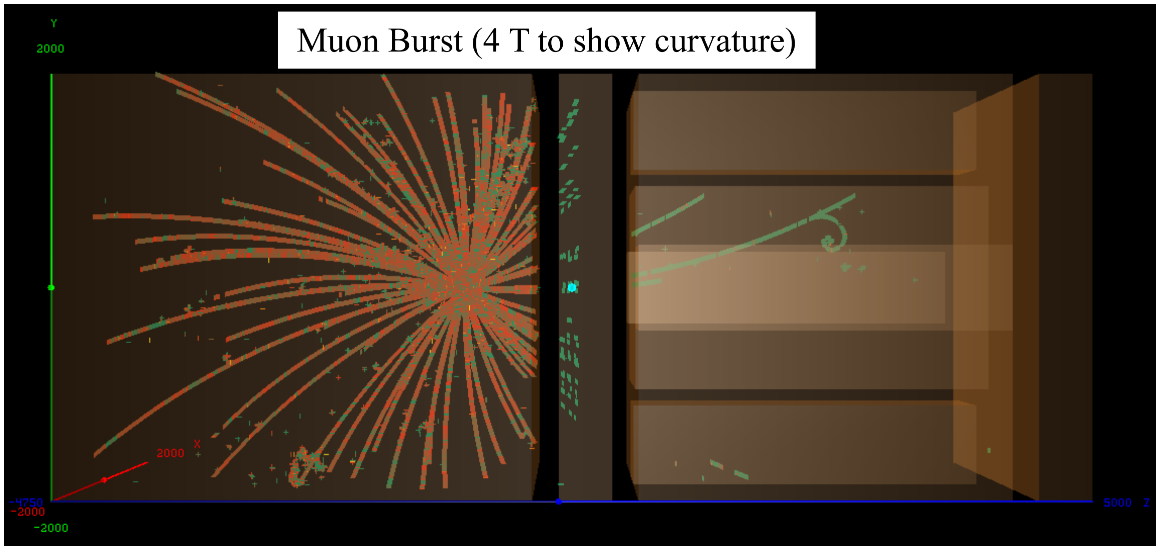
    gegede-cli LArTPC.cfg Magnet.cfg Enclosure.cfg World.cfg -w World
- Rapidly building a library of detector components and sub-detectors
  - Components: LAr TPC, Straw-Tube Planes, Gas TPC, Scintillator, RPC, &c
  - Sub-Detectors: LArTPC, Straw-Tube FGT, Oil Based Active Target, &c
  - Plenty of opportunity to define new geometry components

EDEP-SIM

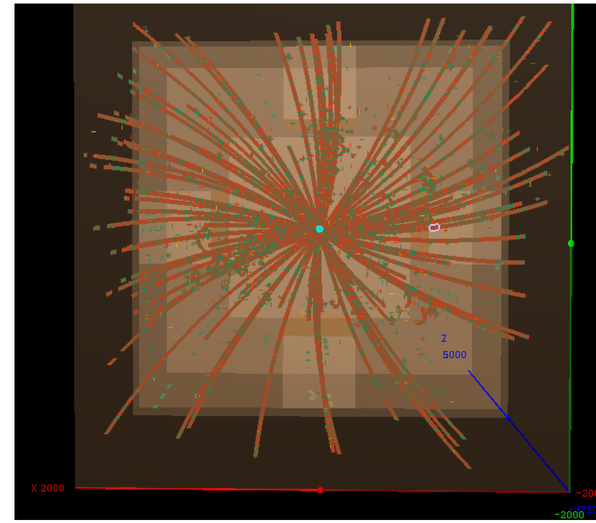
- Experiment independent Energy DEPosition SIMulation
  - Derived from the T2K near detector simulation
  - Provides the bookkeeping and infrastructure needed to track truth information and energy deposition.
    - In T2K, the output then drives a response/digitization simulation.
  - Can be called as a library, or to used to directly write a ROOT tree
  - Being used to simulate/debug the DUNE-ND-GGD geometries
- Detailed simulation
  - Electric and magnetic fields (from GDML)
  - Can simulate full beam structure, upstream and magnet interactions.
  - Detailed model for LAr recombination using NEST†
    - Handles both ionization and optical photon production
    - Validated by CAPTAIN collaboration against published ICARUS ionization measurements
- Major Features
  - Minimal dependencies (only ROOT and GEANT4 via cmake)
  - ROOT tree format designed to make analysis easy (more in some other meeting).
  - Provides a simple ROOT (Eve) based event display
  - Fast (can simulate 10's of GeV per second)
  - Reads interactions from GENIE, NEUT, NUANCE (easily expanded)
  - Scalable: Users can start with simple geometry, but edep-sim already handles the complexity needed for a running experiment.
  - Mature code. Except for cosmetic changes, it's been in used for a long time and has been thoroughly exercised.
  - Produces geometry that's ready for GENIE

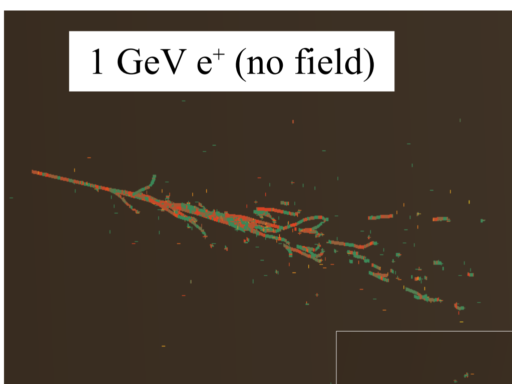
†Enhancement of NEST capabilities for simulating low-energy recoils in liquid xenon, M Szydagis, A Fyhrie, D Thorngren and M Tripathi, Journal of Instrumentation, Volume 8, (2013)

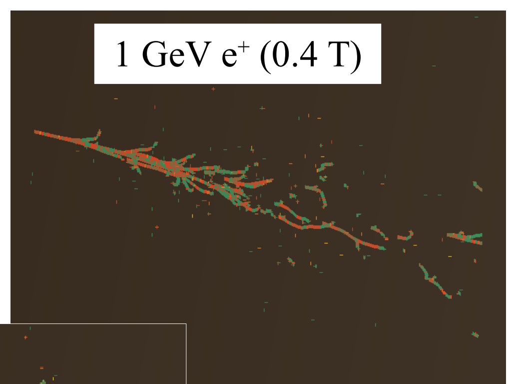
A Few Quick Examples

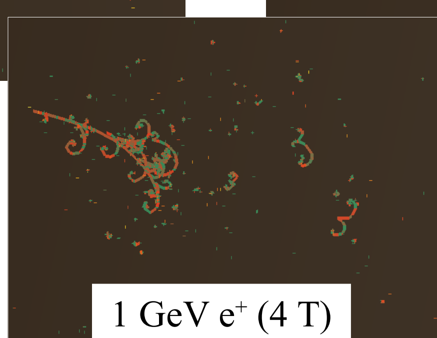


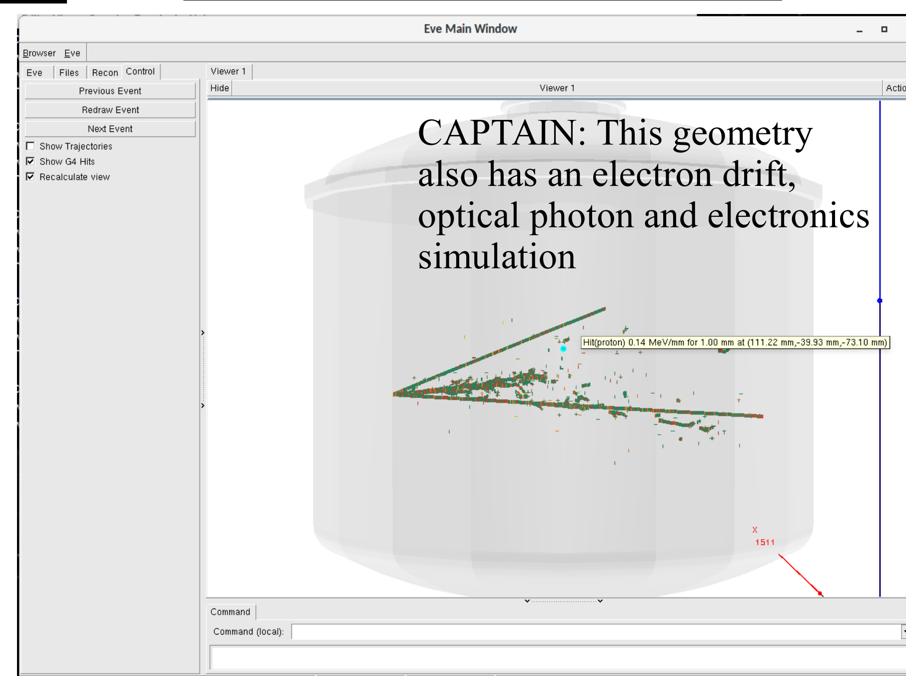
Muon Burst (4 T solenoid to show curvature)











Backup Slides

Next Steps

- We're just starting to apply these tools to design studies.
  - Concentrate on sorting through studies that don't require full reconstruction to help identify weaknesses in design proposals
  - There are more questions than we could possibly address at SBU!
- Acceptance Studies
  - LAr TPC in and out of the magnet → acceptance to measure momentum
  - Dead material → intrinsic momentum/energy resolution
  - Orientation of the magnetic field
    - Solenoid vs Dipole
- Full spill/cosmic simulation
  - Interaction overlap and occupancy
  - "Magnet" interactions
- Containment
  - Energy contained within the active region
    - Hadronic/EM/MIP
    - Energy Leakage
  - Hermeticity
  - Entering backgrounds
  - Magnetic Field → Electron energy resolution
  - Veto/Timing/Tracking surrounding the LArTPC?
- Secondary interaction physics (e.g. the effect of the hadronic interaction model)