NuWro in LArSoft

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Introduction

- Currently, most experiments/analyses using LArSoft rely on a single event generator, GENIE.
- Trying to encourage the use of NuWro as an alternative event generator.
- I have been using NuWro almost exclusively for my own thesis research on MicroBooNE.

Motivations

- Adoption of models across different MC generators is quite varied - what if your model isn't available in GENIE?
- A couple of examples: The Martini model of MEC, final state interactions for Λ/Σ baryons.

- Can be subtle/significant differences in how "real" physics is interpreted in MC codes.
- For example, the RES $\longleftrightarrow$ DIS transition occurs at lower hadronic invariant mass in NuWro.

Current Implementation

- NuWro comes with its own flux/geometry drivers, originally designed for the T2K near detector (ND280).
- Previously the POT counting and flux/geometry had assumptions about units and neutrinos/POT hard coded in.
- I've removed these and added extra parameters, letting the user choose.

Geometry

- NuWro requires the geometry to be provided as a root file with TGeo* objects.
- This can be generated from gdml. Modify this to add/remove volumes depending on simulation needs.

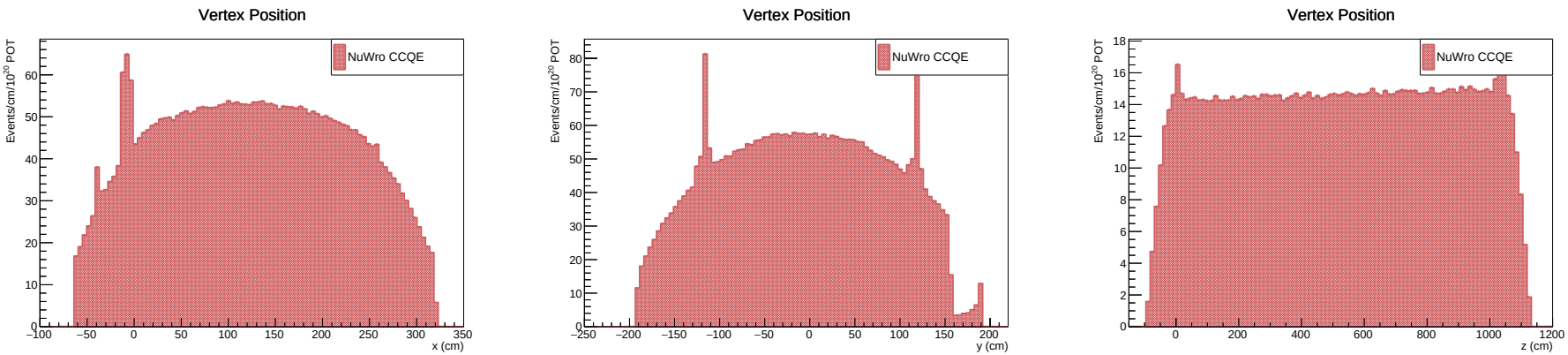

Figure: Vertex distributions of simulated neutrino interactions in the MicroBooNE cryostat using NuWro (NuMI FHC flux).

Flux

- Read neutrino information from a TTree. Requires flavour, kinematics and start position.
- Produce this using a root macro that reads GSimple files.
- Specify POT per flux file in configuration.

Interfacing With LArSoft

- Generate events in standalone NuWro, convert them to *.hepmc* and then to LArSoft with a modified TextFileGen module[2].
- I wrote a script to choose and copy these *.hepmc* files onto grid nodes so we can produce large samples.
- Cumbersome, would be nice if we could “cut out the middle man” - call NuWro from inside LArSoft.

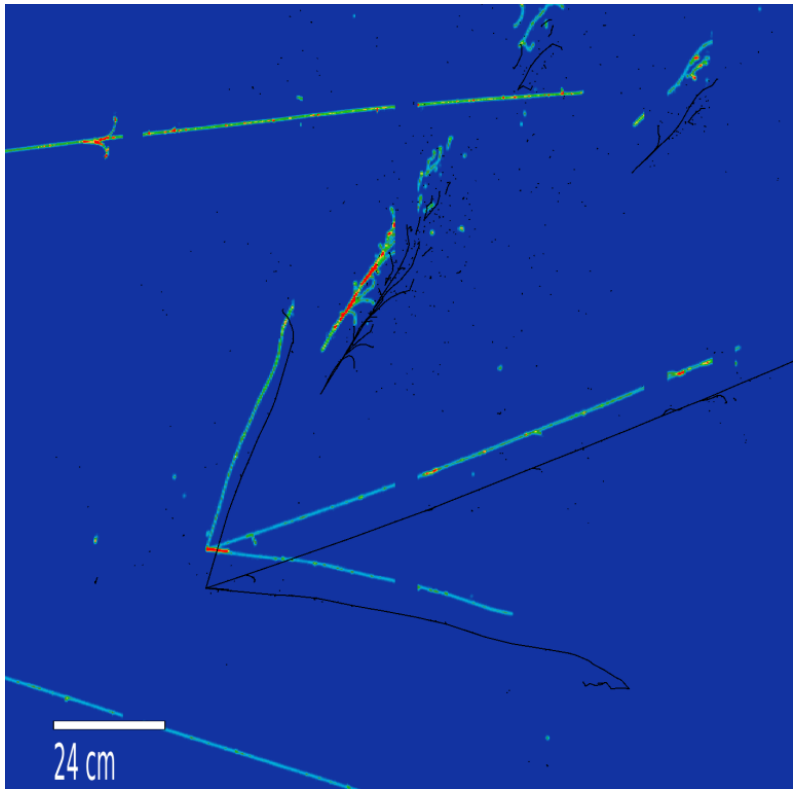

Figure: A DIS event from the NuMI flux simulated in MicroBooNE using NuWro, overlaid with cosmic data. Black lines are Geant4 particle trajectories.

[2]Originally created by Marco del Tutto.

Libraryization

- Recent work on NuWro by Eric Marzec (University of Pennsylvania) lets you compile the generator into a linkable library[3].
- I have been able to link this into a LArSoft module, eliminating the need to use *.hepmc* as a bridge.

```
#Libraries required by NuWro
$ENV{PYTHIA6_LIBRARY}/libPythia6.so
${ROOT_EGPYTHIA6}
${ROOT_EG}
${ROOT_GEOM}
gfortran
$ENV{NUWRO_LIB}/libnuwro.a
```

```
//-------------------------------------------------------------------------
void evgen::NuWroGen::produce(art::Event & e)
{

        //Create nuwro event object
        NUWRO::event my_event;

        //generate it
        if(nuwro_handle->simulate_event(&my_event)) {

                // Do stuff with the event
                for(int i=0;i<my_event.post.size();i++){

                        std::cout << "pdg=" << my_event.post.at(i).pdg << std::endl;

                }

        }
```

- However, this and the flux/geometry support live on separate branches of the repository. These need to be merged.

[3] https://github.com/marzece/nuwro/tree/libraryization.

Additional Features

- Given the flux and geometry files, we can start generating events.
- Many users will want more functionality, in ascending order or difficulty:
  - Flux simulation information - neutrino parent etc.
  - Flavour swapping of neutrinos.
  - Pileup.
  - Reweighting - a few reweightable variables in NuWro. No FSI reweighting at the moment.
  - *Insert your suggestions here*.
- We can work on adding these once the basic implementation is done, but will likely require help.

Summary

- Can make events with valid POT counting if flux and geometry are provided using standalone NuWro.
- Integrated NuWro on the way, largest remaining obstacle is merging the flux/geometry and library support into the same version.
- A number of features provided by GENIE are not part of NuWro at present. More people needed to develop the same tools for NuWro.

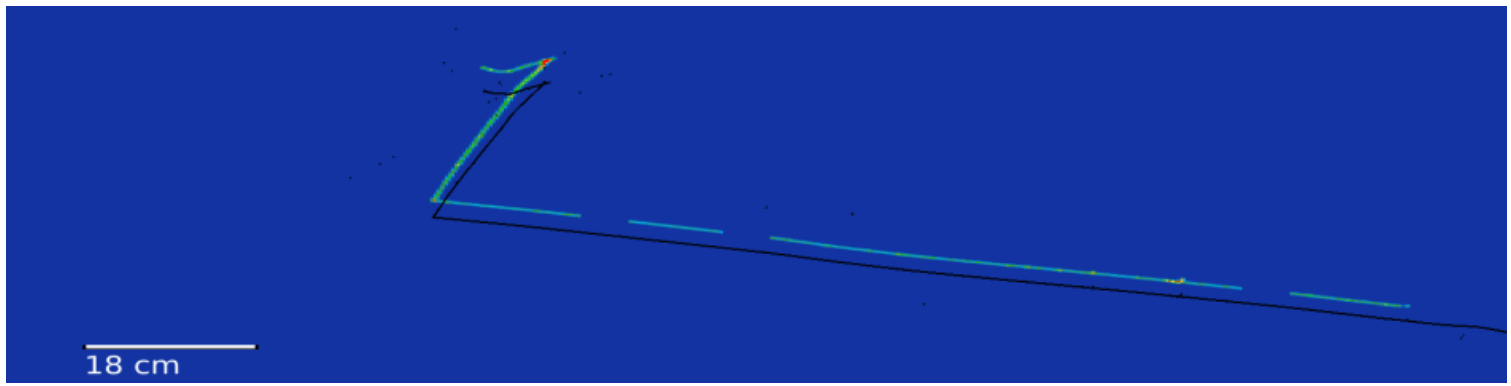

Figure: A NuWro CCQE event from the NuMI flux in MicroBooNE. Converted to LArSoft and run through the MicroBooNE Geant4/detector simulation/reconstruction chain.

Backup

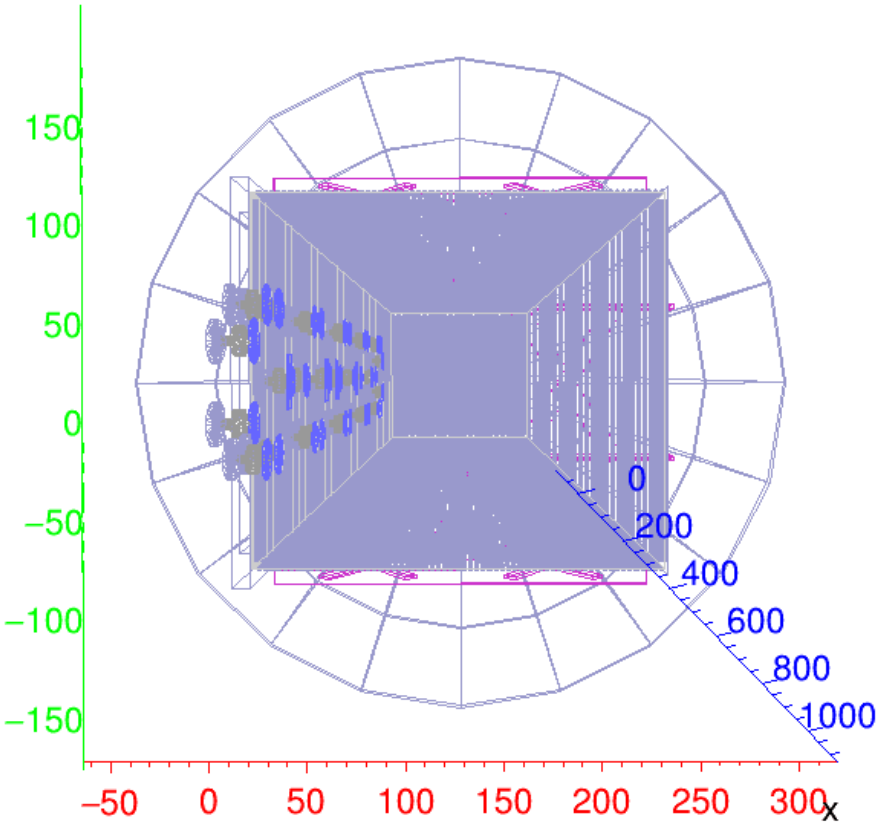

Figure: End on view of the geometry used on slide 5.