



EventWeight interface to GENIE v3

Steven Gardiner

LArSoft Coordination Meeting

23 February 2021

GENIE Reweighting Overview

- GENIE is the primary event generator for simulating neutrino interactions in LArSoft
 - Used by all Fermilab neutrino experiments, including non-LAr ones like NOvA
- Assessment of systematic uncertainties related to neutrino interaction modeling is a critical task
 - Needed for oscillation measurements as well as extraction of neutrino cross sections
- Direct re-simulation of events is computationally expensive
 - Many variations of GENIE model needed, all of which must be run through a full detector simulation
- Standard solution: event reweighting
 - Weight by likelihood ratio
 - Experiments must consider “non-reweightable” systematics carefully



GENIE v2 → v3

- Significant upgrades to GENIE in late 2018 led to major version 3
 - LArSoft develop now uses genie v3_00_06k
- Various model & framework improvements
- New “comprehensive model configurations” (CMCs or “tunes”)
 - v2: GENIE provides a single blessed default model. Alternatives require user edits to configuration XMLs
 - **v3**: Multiple official model sets co-exist, and a tune specifier given at runtime is used to choose between them
- In LArSoft, the active v3 tune is managed by the genie_xsec ups product:
 - `setup genie_xsec v3_00_04a -q G1810a0211a:e1000:k250`
- Accessible via the \$GENIE_XSEC_TUNE environment variables

GENIE reweighting in LArSoft

- Managed by the larsim EventWeight module
 - Allows configuration of multiple weight calculators in the same job
 - Treatment is very general. μ BooNE uses this package for reweighting the flux and Geant4 models in addition to GENIE.
- Interface to GENIE lives in larsim/EventWeight/Calculators/GenieWeightCalc.cxx
 - Current version provides a wrapper to the `rwgt::NuReweight` class from nugen
 - I believe the nugen code is common to LArSoft and NOvASoft
- ArgoNeuT recently reported problems in running EventWeight after upgrading to GENIE v3
- MicroBooNE experienced similar issues in the past
 - Solution: refactor the GenieWeightCalc class
 - MicroBooNE runs patch releases of larsoft v08_05_00 in production
- Proposal to merge refactored GenieWeightCalc into LArSoft develop branch

Issues addressed by the refactored code (1)

- Old EventWeight module was not “multi-tune aware”
 - Unless reweighting is run in the same job as event generation, GENIE will not be initialized with the correct tune specifier
 - Potential for various problems, e.g., incorrect weights
- Remedied by adding a call to `evgb::SetEventGeneratorListAndTune` in `larsim/EventWeight/App/EventWeight_module.cc`
 - Utility function defined in `nugen/EventGeneratorBase/GENIE/GENIE2ART.h`
- All weights were previously calculated with respect to the nominal GENIE model
 - Problematic for experiments that adopt an adjusted GENIE model as their central value
- New code from MicroBooNE allows fcl configuration of a new CV for an arbitrary number of GENIE parameters
 - Automatically propagated to all weight calculators which handle systematic variations from the CV

Issues addressed by the refactored code (2)

- No configuration checking for “incompatible GENIE knobs”
 - Some GENIE variations cannot be handled simultaneously
 - **Example:** knobs that vary a single parameter versus those that split its impact into normalization + shape-only variations (M_A for CCQE interactions)
 - Weight calculator mode must be set to choose between the available options
- New code in the `GenieWeightCalc` class throws an exception if incompatible knobs are requested
- Solution is a bit hacky at present (hard-coded `std::map`)
 - Ideal alternative would be configuration checking in the GENIE classes themselves

Issues addressed by the refactored code (3)

- Three separate enums are used to label GENIE knobs in the current system
 - Native GENIE: GSyst_t (RwFramework/GSyst.h)
 - nugen: ReweightLabel_t (nugen/NuReweight/ReweightLabels.h)
 - Direct aliases for GSyst_t
 - GenieWeightCalc::EReweight (larsim/EventWeight/Calculators/GenieWeightCalc.cxx)
 - Private to GenieWeightCalc class
 - Distinct from GSyst_t, may represent combinations of knobs. Used to interpret fcl.
- These “dueling enums” require regular maintenance and can be confusing
 - GENIE/nugen/LArSoft use different names for the same parameters!
- New code interfaces with GENIE directly
 - GSyst_t values used consistently, including string equivalents for fcl configuration
 - Able to handle new GENIE knobs automatically (interpretation delegated to GENIE)

Summary of proposed changes

- Add configuration of active GENIE tune to the EventWeight module
- Near-total rewrite of GenieWeightCalc class
 - No longer dependent on NuReweight from nugen
 - Direct use of GENIE knob names: all fcls based on old version will break
- Toy fcl for testing: `genie_reweight_generic.fcl`
 - Uses a bare-bones set of services to be experiment-agnostic
 - Runs LArSoft GENIE reweighting on an artroot file from any experiment
 - Required data products: `simb::MCTruth` and `simb::GTruth` objects from the event generation stage
- Trivial configuration in `genie_eventweight.fcl`
 - Used to configure weight calculators
 - Now varies just the CCQE axial mass in two systematic variation universes
- Feature branch for review: **`feature/gardiner-refactor-genie-rwght`**
 - See [GitHub pull request #64](#)

Next steps

- I'd like feedback on the plan and testing from experiments interested in this code
- Unclear to me whether the full-fledged fcl configurations should live in larsim or be added only for individual experiments
 - Each collaboration's standard recipe for GENIE systematics will likely be somewhat different
 - Variations to include, unisim versus multisim strategy, use of a tuned CV, etc.
- We have working examples in MicroBooNE. I will be happy to help other experiments in getting their fcl configuration up and running
- I believe NOvA is also running GENIE v3 reweighting using a different strategy, but I am unfamiliar with the technical details
 - If the changes described here sound too drastic, we can ask them for more information