

Some thoughts on event generators in NuSTEC

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- new GENIE group structure
- GENIE-NuSTEC
- GENIE-NEUT-NuWro
- global tunes
- discussion encouraged at any time

Larger picture

- ▶ You are having successful school/workshop, sorry I can't be there.
- ▶ More and more attention to the need for more neutrino cross section/theory work.
- ▶ Room for both GENIE and NuSTEC working together. Problem is big enough for both groups to make important contributions.
- ▶ GENIE collaborators are part of NuSTEC.
- ▶ GENIE wants NuSTEC collaborators to work with us.
- ▶ LBNE needs better models and better organization.

GENIE group structure

- ▶ Until a year ago, small group (Costas Andreopoulos, Hugh Gallagher, SD+students/theorists/collaborators)
- ▶ Adopted by all recent experiments, but physics models don't follow theoretical understanding well enough
- ▶ With LBNE planning, goals get higher – better physics, validation, systematic error analysis
 - ▶ Significant discussion at Snowmass summer, 2013
 - ▶ Better software infrastructure, **more professional**
- ▶ Need more organization, look more like GEANT
 - ▶ Well-established working groups with core young people
 - ▶ Significant manpower at FNAL
 - ▶ Solid governmental support in US, Europe (proposals submitted)

Fermilab commitment

- ▶ Work toward hiring theorists in theory division
- ▶ Start hiring/reallocating people in Scientific Computing
 - ▶ Gabe Perdue (staff scientist) + 3 others
 - ▶ Tomasz Golan – postdoc from Wroclaw
- ▶ Validation major focus, provide tools for comparison
- ▶ Forum for experimenters (tests, tools, collaboration)
- ▶ Sponsor workshops
 - ▶ GENIE developer's Workshop - Mar, 2014
 - ▶ ~14 students/postdocs from US, Europe worked on model development with GENIE core developers
 - ▶ NusTEC school for neutrino interactions – Oct, 2014

GENIE organization

- ▶ **By-laws** nearly complete
 - ▶ Spokesperson – CA
 - ▶ **Executive Board** – CA, SD, HG, GP
 - ▶ **Working groups** – physics and technical
 - ▶ Nuclear structure – SD (nuclear models, QE, FSI, medium effects)
 - ▶ Primary processes – HG (pion, kaon prod ; DIS ; hadronization)
 - ▶ Systematics/Global Tuning – CA (default tune with error envelopes)
 - ▶ Technical coordination – CA, GP, RH (systematics, reweighting, validation, releases)
- ▶ All new code contributions must come through work grps
 - ▶ Work with us to develop models that fit, run fast enough
- ▶ More definite **release schedule** (2/year) with more definite (announced) model plans

Next releases

- ▶ 2.8.4 is production version today
 - ▶ Fix known bugs in 2.8.0 (coherent, FSI...)
 - ▶ Start to introduce broader validation procedures
- ▶ 2.9 in fall, spring 2014 (model introductions)
 - ▶ Include new packages that are complete and fully tested as alternate models
 - ▶ Updated Berger-Seghal coh/ Δ , kaon prod, SF, Valencia QE...
 - ▶ Code reviews underway on Mondays
- ▶ 2.10.0 in summer, 2015 (New default model)
 - ▶ Make new *default model with error bands*
 - ▶ Spectral function, Valencia QE+MEC model
 - ▶ Improved FSI
 - ▶ Others to be determined

EXAMPLE: 'Quasielastic' interaction

- ▶ Very basic to many expts, lots of theoretical work
- ▶ Includes nuclear model with correlations, 1 and 2 nucleon excitations. [Nuclear Structure working group].
- ▶ Code in latest release has relativistic Fermi Gas (RFG) nuclear model, impulse approximation, toy MEC as extra
 - ▶ Simple, applicable to all nuclei (except $A < 6$?)
 - ▶ Default model doesn't match eA or νA data (~20-30% issues)
- ▶ Goal for 2.9 (fall-spring, 2015)
 - ▶ Spectral function (Benhar, Effective)
 - ▶ Nieves QE model with RPA, Local FG (Pitt undergrad)
 - ▶ Valencia MEC model copied from T2K (Schwehr (CSU) + friends)

GENIE organization

- ▶ Use MCnet (European MC organization) guidelines
 - ▶ Integrity of code, ethics of credit for work
 - ▶ Private code versions should be called 'private GENIE version' or 'GENIE+xx'. They cannot be released privately if GENIE.
 - ▶ To be in GENIE release, must document changes, pass review
- ▶ Model tuning
 - ▶ Regular validation runs against world's data with numbers
 - ▶ Planning underway for a global tune next year (hA, eA, vA)
- ▶ Funding
 - ▶ Presently through individuals with growing help from organizations (PITTPAC, FNAL, UK,...)
 - ▶ Need **ongoing support** for dedicated postdocs/grad students, workshops/travel.

Some thoughts on the generators

(apologies for errors in info, judgment)

▶ NEUT

- ▶ Good - Excellent job for T2K through NIWG, systematic evaluation against MiniBooNE data, very good use of collaborators
- ▶ Room for improvement – tied to T2K, how do we use their work?

▶ NuWro

- ▶ Good – close attention to theory, great advice to expts
- ▶ Room for improvement – code linkage to expt (e.g. releases)

▶ GENIE

- ▶ Good – excellent code for expts, excellent organization in development, good ties to theory/FNAL.
- ▶ Room for improvement – ties to theory and expt should be improved, need more dedicated workers

▶ Unexpected surprise – we are all training young people

Relationship to NuSTec

- ▶ GENIE Goals (by-laws)
 - ▶ Provide free code to community that simulates neutrino-nucleus
 - ▶ Include best models consistent with core ideals (previous)
 - ▶ Show validation plots/statistics against wide range of data
 - ▶ Provide default tune and systematic errors on basic quantities
- ▶ NuSTec Goals (Jorge Morfin talk at NUINT14)
 - ▶ Don't need or want specific generator orientation
 - ▶ Sponsor schools for young people
 - ▶ Coordinate experimenter-theorist studies to find best models
 - ▶ Combine results to make global fits to advise the field
- ▶ Each wants to make theory compatible with event generators, do global fits to inform the community. Big job, ample room for each. Work it out.

Global tunes

- ▶ Even the name scares me, big job
 - ▶ Nuclear model, vector response, FSI from hA, eA.
 - ▶ Rapidly growing body of neutrino data
 - ▶ Large variety of models to consider
- ▶ GENIE has huge database, validation programs, Costas' experience with VALOR (T2K).
- ▶ We will produce **default model with estimated errors**.
 - ▶ Need help from NuSTEC and/or new funding to get it right
 - ▶ This can be start of NuSTEC global tuning exercises
- ▶ Comparisons with other models can be done inside GENIE or separately...
- ▶ But, it seems Monte Carlo code is best vehicle.

More thoughts

- ▶ Not a single fit, use graduated approach
 1. Electron scattering
 2. Hadron scattering, esp. electromagnetic production
 3. ~MiniBooNE energy neutrino scattering
 4. ~MINERvA energy neutrino scattering
 5. Loop back many times
- ▶ T2K did steps 2 & 3 with knowledge of 1
 - ▶ Required many person-months of effort
 - ▶ We can learn from this work
- ▶ GENIE hasn't done a global tune in many years
 - ▶ Last time used only neutrino data before MiniBooNE with implicit knowledge of 1 & 2.
 - ▶ Goal is to be set up to do all 5 steps.