**Minutes of the meeting on Neutrino Experiments Simulation – 03/04/2013**

(also in <https://indico.fnal.gov/conferenceDisplay.py?confId=6496>)

The FNAL Detector Simulation – ADSS team and the FNAL neutrino community met to discuss a strategy to improve the accuracy of detector simulation tools for neutrino experiments.

People attending: Sam Zeller, Steve Brice, Craig Group, Laura Fields, Raphael Schroeter, Eric Church, Brian Rebel, Mike Kirby, Tom Junk, Mike Kordosky, Alex Sousa, David Schmitz, Nikolai Mokhov, Daniel Elvira, Robert Hatcher, Hans Wenzel, Krzysztof Genser, Julia Yarba

**Presentations**:

* D. Elvira - Introduction
* R.Hatcher - Simulation Tools in the Neutrino Experiments
* J.Yarba - Application of Geant4 Hadronic Physics Models in Simulation for Neutrino Experiments

**Round Table Discussion**:

1. **Beamline simulation and neutrino flux prediction**
* Neutrino flux prediction is sensitive to the quality of the G4 physics at both intermediate energy (Booster) or high energy (Main Injector). Modeling of the 1st interaction is of high importance.
* Most experiments use Geant4 as part of their beamline simulations.
* MINERvA uses Geant4 but applies corrections calculated with FLUKA since it gives more accurate physics than old incarnations of Geant4 (Mike Kordosky).
* NOvA traditionally employed FLUKA/flugg application, but also has newer Geant4 efforts.
* There is a strong suggestion that the investment should go to Geant4.
* Steve Brice suggested that Fermilab plays a principal role in developing a
Geant4 simulation tools for the three Fermilab neutrino beamlines.
* The current situation is that each experiment has developed its own version of the beamline simulation. Steve Brice shared documentation on the MiniBooNE’s beamline simulation (A.A. Aguilar-Arevalo et al., "The Neutrino Flux Prediction at MiniBooNE", Phys. Rev. D79, 072002, 2009).
* It is important that the future work is benchmarked vs existing MC results/tunes.
1. **Detector simulation after the first neutrino interaction**
* First interaction is modeled by GENIE (a separate important tool).
* For detector simulation after the 1st neutrino interaction most experiments use Geant4. We all agreed that effort should be invested to validate existing “physics lists” and eventually develop customized lists for the neutrino experiments.
* As a starting point, the DS-ADSS group agreed to the request (B. Rebel, S. Brice) to provide more detailed information on the physics lists (than offered by official Geant4 manual) and to link such information on the current physics lists to the local FNAL Geant4 web page.

* Modeling of hadronic showers following the first neutrino interaction is sensitive from the few-GeV intermediate energy range and down to several tens of MeV.

 T. Junk added another example relevant to background study: high energy

 cosmic rays gradually going down to a few MeV.

* Other important physics to model: muon polarization at the point of decay (S. Zeller), proton stopping and dEdx measurements in Liquid Argon (B. Rebel, E. Church), hadronic and intra-nuclear scattering at low energy (M. Kordosky), muon-nuclear interactions (E.Church) and possibility to add “custom” features or tuning.

**Straw-man plan**:

* The DS-ADSS team will create “physics lists” documentation and add it to the local Geant4 web page which will also be improved. This will include information on the model components, ranges of validity, and tips to make modifications.
* The DS-ADSS team will work with the neutrino community on the software infrastructure for validating Geant4 physics relevant to neutrino experiments at the model and physics list levels using thin/thick target, test beam, and experiment data. At a second stage, this software validation tools will be used to customize a family of physics lists designed for neutrino experiments.
* Example activities related to the items above: collect feedback and/or experimental data that can be used for G4 validation, with the help of

S. Zeller, B. Rebel, M. Kordosky. Introduce tests at the physics list level at the intermediate and high energy, for protons incident on a thin or thick targets (materials of interest are C, Be, and perhaps Ta), and compare with experiments such as HARP, NA61, NA49, MIPP. Test of physics lists will also aim to study overlap regions. Test physics lists at low energy for protons incident on a low-density target (for example, Liquid Argon) to study interplay of models/processes down to the KeV range.