Minutes for Maryland Simulation Workshop
Friday May 5, 2006

Attendance: Andrew Smith, Vlasios Vasileiou, Buckley Hopper, Jodran Goodman, Bob Ellsworth, Brenda Dingus, Chaun Chen, Jim Linnemann, Aous Abdo

Simulation Components – Status

Air shower simulations – CORSIKA

Uses NeXus for high energy air showers and FLUKA for low energies. Nexus is a combined effort of the authors of QGSJET and VENUS. In newest version of the simulation, a curved atmosphere is simulated. Mostly effects showers with zenith angles larger than 50 deg. Protons and Helium are simulated from 30GeV to 100 TeV on a -2.75 spectrum. Gamma-rays are simulated from 30 GeV to 100 TeV with a -2.40 spectrum. The CORSIKA library contains ~500M, 250M and 315M showers from the three populations (p, He, g).

Action Items:
1) Generate high energy hadron and gamma-ray showers from 100 TeV to 500 TeV. Check if the HE showers are important.
2) Make a plot of eff area vs energy. Confirm low energy limit.

Simulation software – GEANT4

Milagro implementation called g4sim. Many improvements compared to GEANT3. It is maintained, and in C++, but most important the low energy electromagnetic interaction model is greatly improved. G3 has not intrinsic Cherenkov photon interaction models (no scattering or absorption. Properties of surfaces (eg refractive index) are also not available in G3.

Geometry of the pond from diagrams obtained from Peter N. Numbers nearly identical to the numbers in G3.

Currently not simulating with air under the cover. miniHAWC is simulated with air over the cover. G3 has no cover in the simulation. G4 simulates a cover that allows for for reflectivity. Reflectivity of cover/liner materials is modeled with Fresnel's eqn. with refractive index of 1.49 (polypropylene). The material does not transport photons. The cover and liner are modeled as “diffuse” reflectors. The surface is modeled as “micro facets”, which means that the normal to the surface is modeled as random. D. Smith memo indicates that the refractive index may change abruptly below 400nm (~ factor of 3 lower).

Baffles are simulated with a material called “liner” which is a white material with a cut off near 400nm, not as good as Tyvek for low wave lengths.

Outrigger geometry from T. Shoup diagrams. Depths of OR's are not 91cm as designed. Scott measured the depths in the range 76 +/-10 cm. GEANT randomly selects OR depths within the measured range.

G3 simulated using 18m absorption length and no scattering. G4 has both Mie and Rayleigh scattering. Two configurations are used based on information from Don Coyne. 18m total extinction length is modeled as a combination of 27m absorption and 54m Mie scattering length. Mei scattering is modeled with the Henyey-Greenstein function which
has a single parameter $g$, the “asymmetry factor” which is equal to the mean scattering angle. Functional form used by deep ocean neutrino experiments. $g=0.99$ was used. Back scattering has not been measured for Milagro water. There is still much uncertainty in the properties of the Milagro water.

Use detailed PMT geometry geometry used by other experiments. Detailed PMT includes glass and internal components (mirrors, dynode, etc). Three elements used in PMT efficiency measurement.

- Absorption probability for photo cathode. (AP)
- Probability of electron liberation into the vacuum. (LP)
- Collection efficiency for electron (CE)

Hamamatsu's quantum efficiency (QE) is defined as the product of AP and LP for photons with normal incidence. The photo cathode materials are used simulated as an absorber with uniform wave length. The wavelength dependent part of is added to LP so that $QE(\lambda) = LP(\lambda) \times AP$.

In the lab, 3 PMTs were measured to have a sharp drop in collection efficiency at angles larger than $\sim 60$ deg. Efficiency at the edge is $\sim 30\%-40\%$ compared to the top.

Noise is simulated using low energy showers 5GeV – 100 TeV thrown uniformly over +/- 5km. Showers with at least one pond hit somewhere and no more than 10 AS layer hits were to a file that is randomly sampled to produce noise events.

**Action Items:**
1) Generate a sample of G4 with air under the cover.
2) Add a method for increasing reflectivity of the bottom surface to investigate contribution of PVC, Al oxide etc.
3) Curtains for GEANT4.

**Comparison of Data and Simulation:**

There is a difference in the muon peak between the 600 series calibration compared to the 500 series calibrations, $\sim 125$ PE’s vs $110$ PE’s. In the G3 MC, a muon make $\sim 230$ PE’s. In the G4 MC (raw hits) we observe $\sim 180$ PE’s. After adding the laboratory measured collection efficiencies for the PMT’s, the muon peak drops to $\sim 110$ PE’s which is consistent with what is measured. X2 has excellent agreement with data.

A background data sample was created combining He (35%) and P (65%) with corrected spectra. There is in general good agreement, but the MC sees in general slightly too few hits in the muon layer. There is also a general deficit of hits at the highest multiplicity. We speculate that this could be due to the 100 TeV high energy cut for the MC, or some cross talk effects that are not simulated. Outriggers have poorer agreement than the pond. A problem was encountered with pond hits with amplitudes higher than 700 PE’s.

There seems to be a deficit of late light in the Tchi distributions. This could indicate a problem with the late light due to reflections off the bottom of the pond. Another indication
that the bottom is not

Action Items:
  1) Investigate the 700PE cut off in the pond MC data, and fix it.
  2) Are we consistent with HEGRA flux with the new MC?
  3) Change new data and meaning of PE's in MC to agree with old PE levels.
  4) Change the MC to rescale PE's to account for old calibration error.
  5) Readdress risetime trigger simulation.
  6) Fix time jitter for outriggers.
  7) Do one PE tubes contribute to angle fits?

Open Questions:
  1) Why is the predicted trigger rate low?