Abstract
We have simulated the high energy neutron flux from the Spallation Neutron Source (SNS) in a C4 detector located in the basement of the facility. The neutron background is due to the interactions of 1 GeV protons with mercury. We used Geant4, an Object Oriented Monte Carlo simulation toolkit in C++, on the midway computer cluster at the University of Chicago. Importance sampling was used to bias the neutrons to track them through large volumes of shielding. A computation time of 185K cpu hours was used to optimize and run the simulations.

Neutrino-Nucleus interactions
Coherent neutral-current (NC) neutrino-nucleus scattering was first predicted theoretically in 1974 but has never been observed experimentally. The neutrino-nuclear interactions are important to understand nuclear structure related to weak interaction, the mechanism by which core collapse supernovae explode, the resulting nucleosynthesis, and the results of neutrino astronomy.

The Spallation Neutron Source facility at Oak Ridge National Laboratory provides a unique opportunity to study the neutrino scattering. The neutrinos are produced via spallation neutron decay.

Coherent Neutrino Scattering Detector
C4, Coherent Neutrino Scattering with Cesium Iodide, is an experiment that has been built at K2K (UChicago-Juan Collar’s Group) to detect the coherent interactions of neutrinos with nuclei. C4 is being installed at the Spallation Neutron Source (SNS) facility at Oak Ridge National Lab.

Backgrounds for Coherent Neutrino Scattering
For the upcoming neutrino measurements, understanding and reducing backgrounds is of vital importance. A beam-related background for this neutrino measurement is the flux of high-energy neutrons that can generate significant amounts of shielding and which can, occasionally, mimic a neutrino interaction in the detector.

To estimate neutron fluxes at the neutrino detector location, the method of Monte Carlo simulation was used.

Simulation of Neutron Flux by Monte Carlo Method
Geant4 (http://geant4.org) is an Object Oriented C++ toolkit for the simulation of the passage of particles through matter. It was used to develop an application to simulate the neutron flux due to the proton beam entering through the proton shield and hitting the target inside the monolith. The geometry, created using OpenGML visualization, is shown here as full view, wire frame, and cut view. 1 GeV protons are shot into the mercury target and the resulting neutrons produced in all the stages are tracked down to the detector in the basement (red strip). The basement and shielding, having about 25 meters in radius, attenuate the neutrons.

Importance Sampling (event biasing)
An Importance value is set in each volume. The particles in relevant volumes are multiplied (up to 10^6 by the importance value (weight factor)). Most (almost) volumes are not affected by the biasing volumes set in parallel geometry. A fraction of the particles crossing to less important regions are killed based on the importance value in the cell. This is called Russian Roulette. Track weight is its inverse. This weight is used to multiply by the detection so as to compensate for the splitting effect.

Geometry with Sampling Volumes

Result
High energy neutron flux and the resulting energy deposition were obtained as shown in the plots. The flux is \( 1 \times 10^{13} \) J/cm^2/s/MeV in the forward direction of the proton beam and \( 1 \times 10^{16} \) J/cm^2/s/MeV at the location where the detector is being installed. A proton rate of \( 6.56 \times 10^{55} \) J/cm^2/s/MeV was used in the simulation. More runs are being done to increase the statistics of the neutrons that seed the cascades.

Computation Time
Due to the large volume of shielding and basement, the number of sampling cells needed is high. But a very high number can result in never-ending runs due to large number of particles created in the important volumes. Considerable time had to be spent in optimizing this number. We have used 86 cells of parallel volumes, total computation time used for optimizing and running the simulations : 180,000 CPU hours.

Summary
We have done Monte Carlo simulation using Geant4 to simulate the high energy neutron flux and the resulting energy in detector. Particle biasing (Importance sampling) was used to sample them in important regions in order to compensate for the attenuation between the neutron production volume and the detector. The result is useful to analyze the data from the detector which is being installed at Oak Ridge National Laboratory. The midway cluster is used for running the simulations. Efforts are on to improve the efficiency of the simulation by using parallel processing.

Acknowledgements:
* The University of Chicago Research Computing Center for support of this work.
* Douglass H. Rho, RCC for help on computation.
* Coherent Collaboration.