

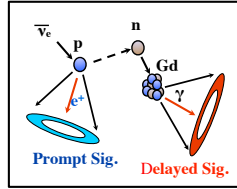


Study of Geant4 based Simulation for Super-Kamiokande Experiment

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Introduction & Purpose

- The Super-Kamiokande-Gadolinium (SK-Gd) project is an upgrade of the Super-Kamiokande (SK) detector.
- The SK is simulated in Geant3 (SKDetSim), which is written by FORTRAN and is never updated any more.
- In order to use the latest physics model, Geant4-based simulation (SKG4) is the best solution.

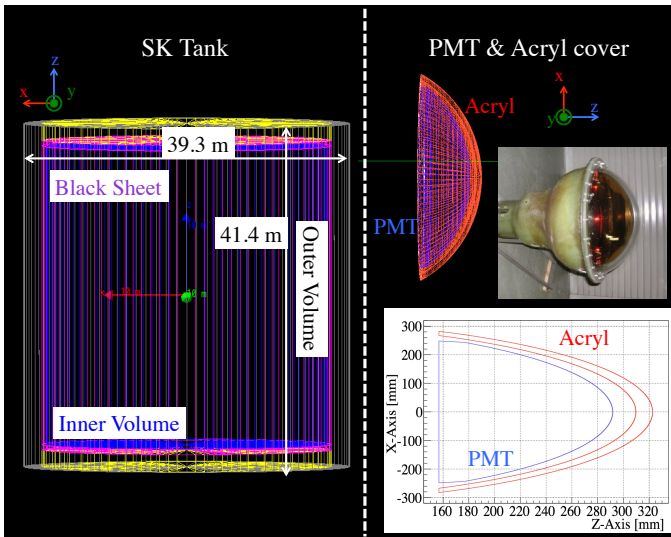


Purpose

- To calculate the physics process using latest models. In Geant4, all physics process have been upgraded from Geant3. We must use latest physics model and compare with experimental data.

Geometry of SK

Geometry of SK has already been completed which used Geant4.10.03 version. It was based on the SK-IV version of SKDetSim. These structures were compared with SKDetSim and it was confirmed that there was no problem.



Electromagnetic Physic Process

Geant4 has many Electromagnetic (EM) physics lists. Focus on electron in lists are shown below. "local" is example code (developed for underground physics). Geant4 low energy group suggests "option4", "Penelope", and "Livermore" lists.

Process	EM standard	option1	option2	option3	option4
Multiple Scattering					
Ionisation					
Bremsstrahlung					
Coulomb Scattering					
Pair Production					

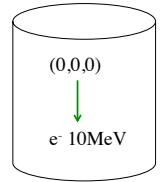
Process	Penelope	Livermore	local
Multiple Scattering			
Ionization			
Bremsstrahlung			
Coulomb Scattering			
Pair Production			

■ : Default Model
■ : Default Model+option
■ : Penelope Model
■ : Livermore Model

Status

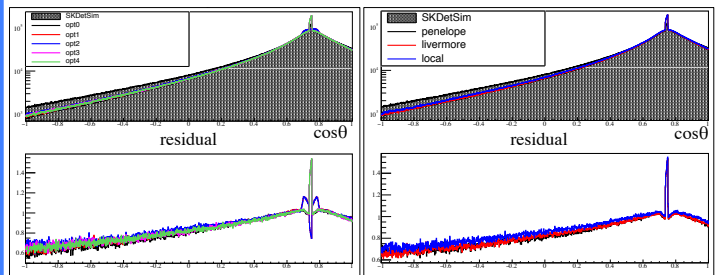
An electron (10 MeV) is generated downward (0,0,-1) from center of tank (0,0,0).
Comparison between SKG4 and SKDetSim in all physics lists.

1. Cerenkov angle
2. Total generated photons per event
3. Number of photons that hit PMT



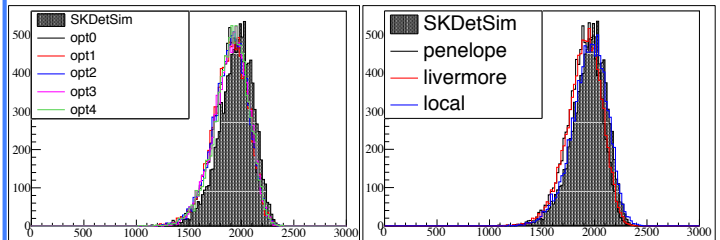
1. Cerenkov Angle

Calculation was done by the inner product of the direction of electron (0,0,-1) and the direction of Cerenkov light. A large difference is seen around $\cos\theta=0.74$ ($\approx 42^\circ$). Option 2 doesn't have a peak around 42° , other models are almost same structure.



2. Total Generated Photons per Event

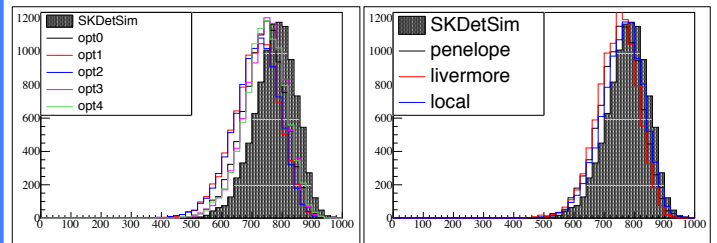
Number of generated photons from an electron (10 MeV). All physics lists are about 2% different from SKDetSim.



	DetSim	Opt0	Opt1	Opt2	Opt3	Opt4	Penelope	Livermore	local
Mean	1948	1891	1888	1893	1899	1900	1922	1899	1951
Sigma	162	167.2	167.2	168.9	166.3	165.1	168.8	166.6	170.2

3. Number of Photons that hit PMT

Following figure is histogram of number of photons hit PMT per event. SKDetSim is grater than SKG4 about 4%.



	DetSim	Opt0	Opt1	Opt2	Opt3	Opt4	Penelope	Livermore	local
Mean	775	743.1	740.4	741.8	744.2	754.3	743.0	745.2	762.9
Sigma	68.9	69.57	69.81	69.50	68.20	68.39	68.22	68.55	70.42

Summary & Next Step

- Geant4 based simulation project called SKG4 was started.
- Geometry of SK tank and PMT were reproduced in Geant4.
- Comparison between SKG4 and SKDetSim was done using various physics lists, and we found several difference about 2-4%.
- Livermore physics list was chosen as default EM physics list in SKG4.
- Other comparison will be done.
- Transportation of photon process will be constructed.