Organizing and Implementing Efficient Geometry Strategies for Geant4

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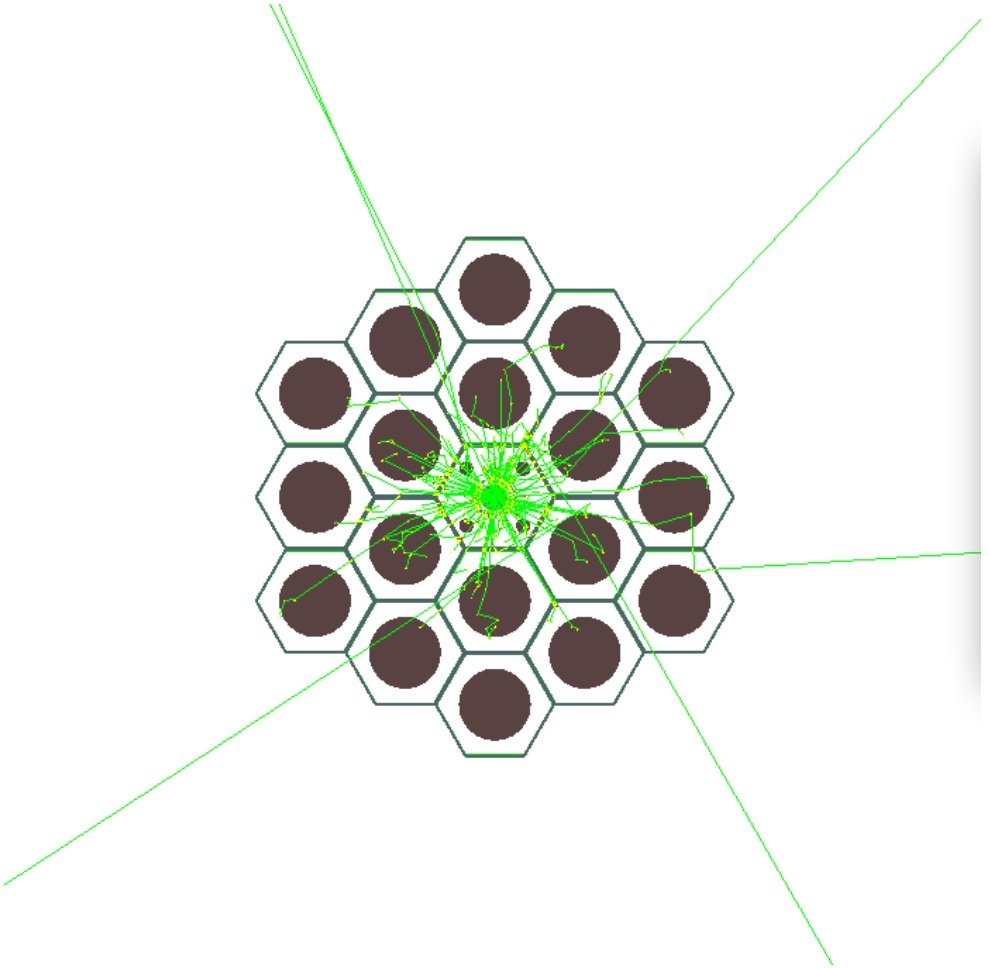
Overview

- MTAS (Modular Total Absorption Spectrometer)
  - Simplified Single Module for Speed Testing
- Scintillation Lattice and LENS (Low Energy Neutrino Spectrometer)
  - Binary Tree Organization
- Conclusion

MTAS

Currently under construction at ORNL

19 - 21"x 6.92"x 8" NaI(Tl) (53.34cm x 17.6cm x 20.32cm)
Central module has a 2.5" hole drilled through

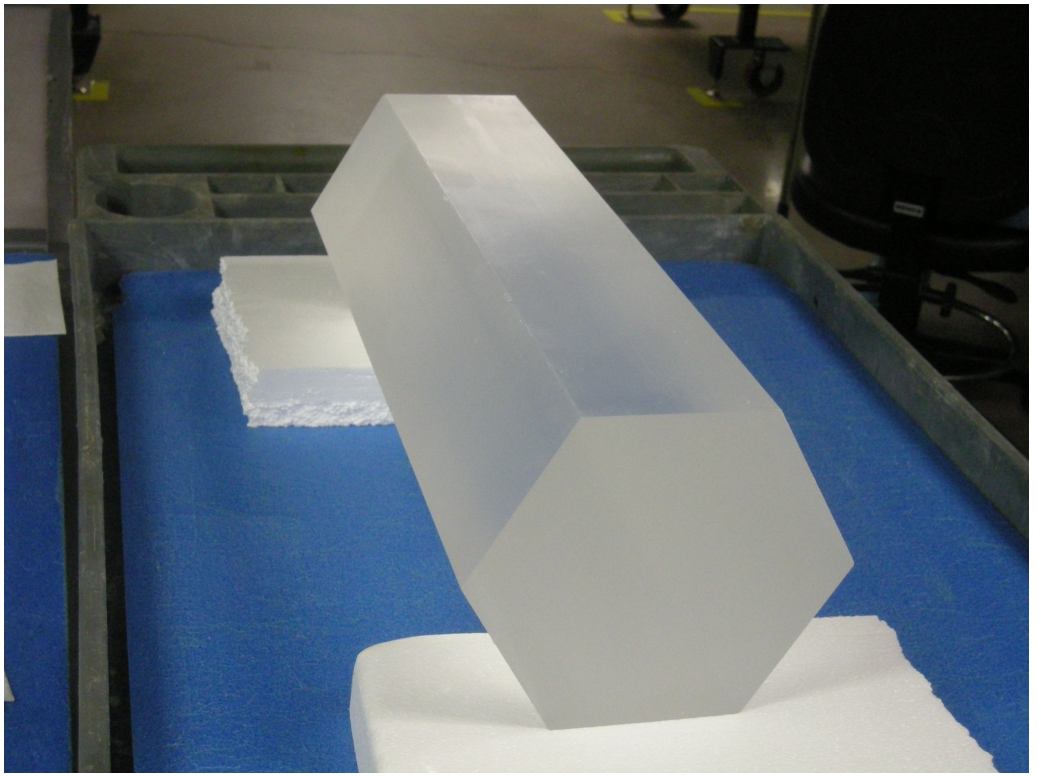


MTAS Individual Module

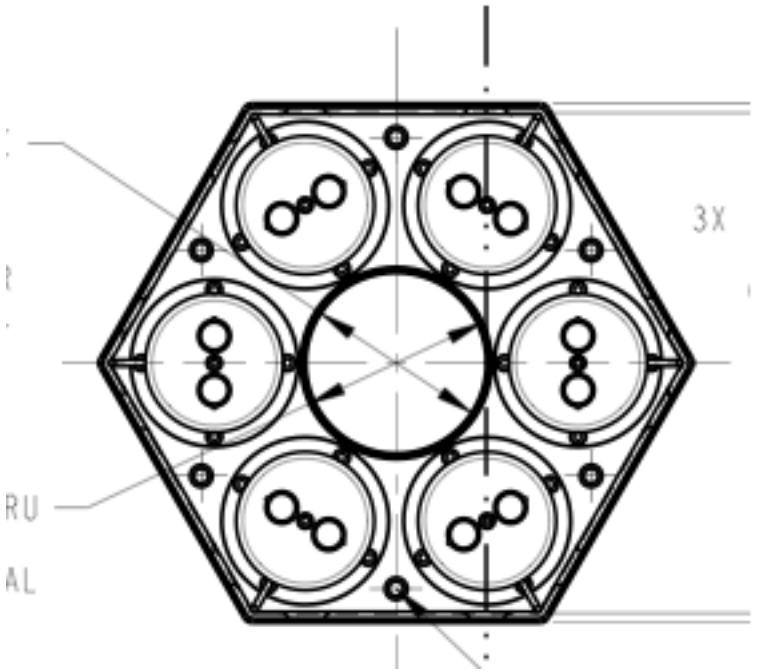
Currently under construction at ORNL

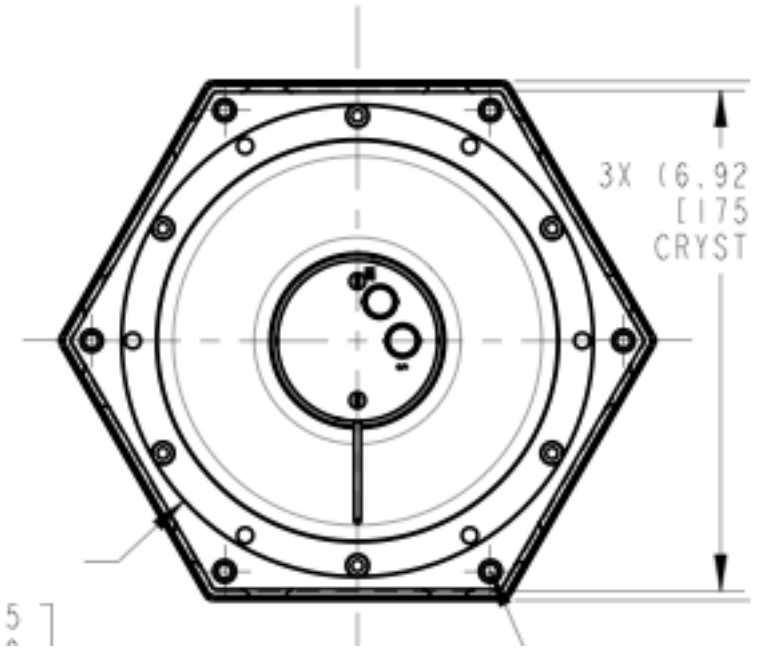
2-5" PMT on each bar
12-1.5" PMT for central holed bar

Housing consists of 4 layers:
~1.0mm Carbon FIber
~.03mm Stainless Steel
~1.5mm Silicon Putty
~0.5mm Low Density Teflon Tape



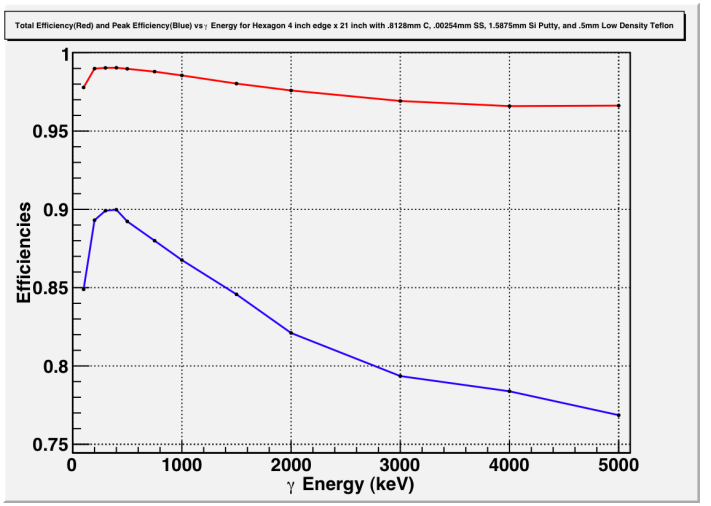
MTAS Module End Views



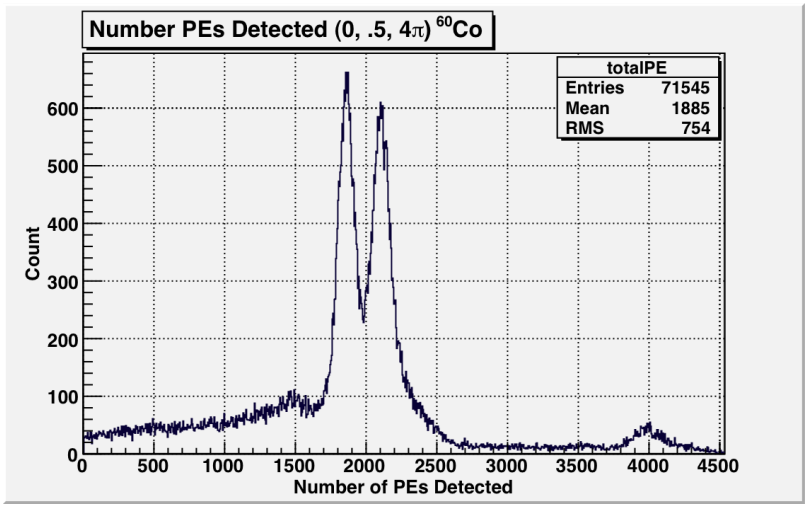


MTAS Calculations

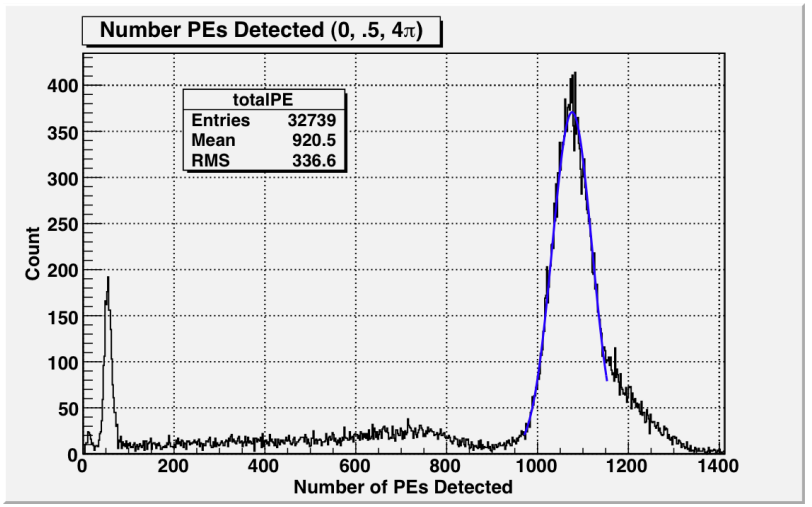
Total energy deposited by gammas
Energy deposited per cell
Number of cells hit
Light output for various sources
Light output vs energy deposited per cell
Light output versus approximate position
Time of arrival for optical photons
Relative light observed in each PMT
Similar neutrons and electrons calculations in order to distinguish from gamma signal



Fraction of Peak and Total Energy Deposited in MTAS

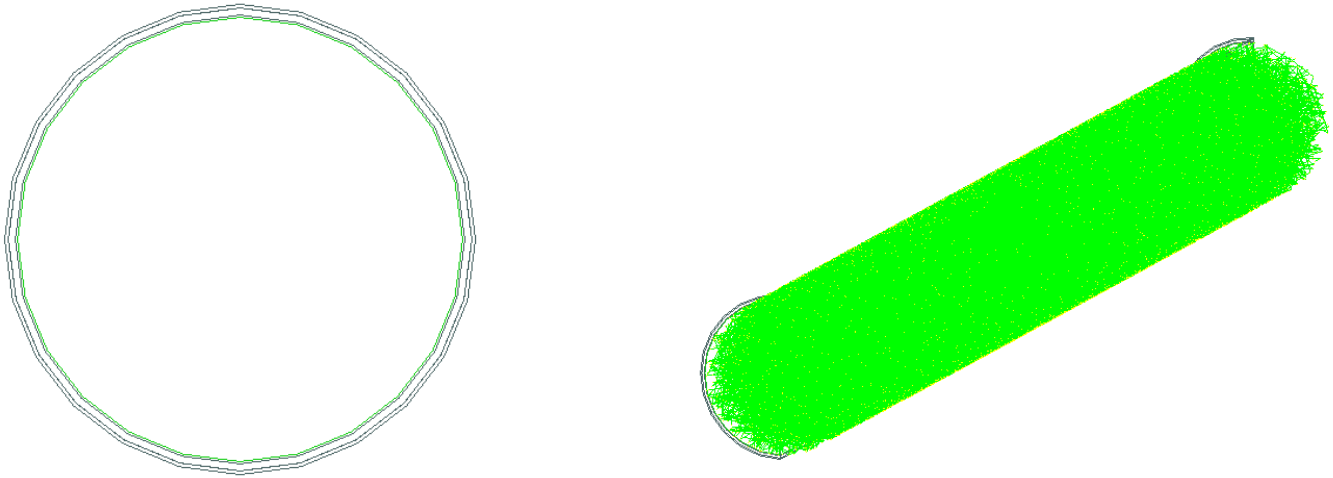


Number PE Detected for ^{60}Co Near Single MTAS Module



Number PE Detected for ^{137}Cs Near Single MTAS Module

Single Cylinder Speed Tests



500 keV electrons launched from center of cylinder

All in one mother volume placed outside to inside
Outside layers are G4Tubes with nonzero inner radii

10,000 events: ~350min

All in one mother volume placed inside to outside
Outside layers are G4Tubes with nonzero inner radii

10,000 events: ~342min

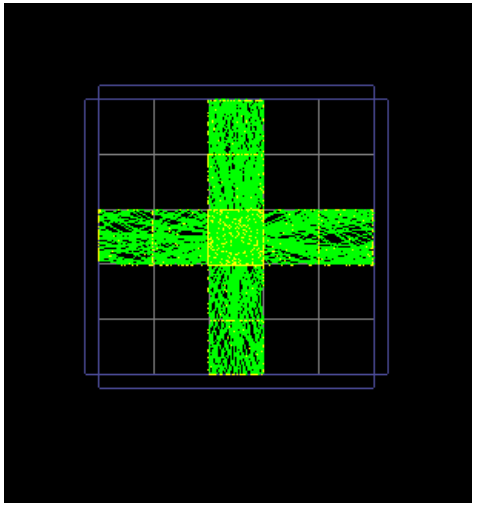
Hierarchical placement, each placed inside the next up volume
All layers are G4Tubes with zero inner radii

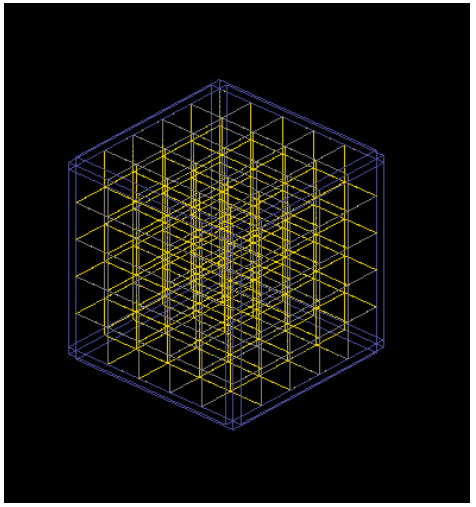
10,000 events: ~330min

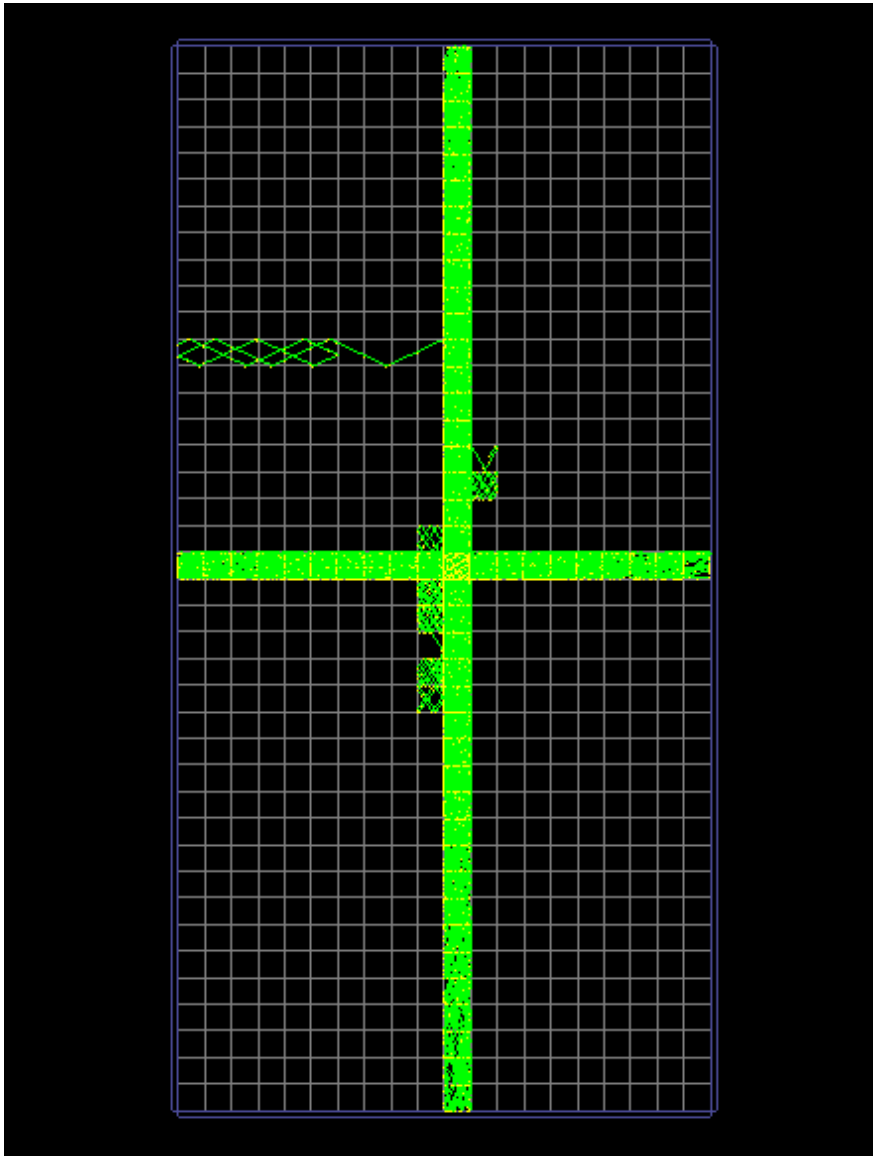
A Few MTAS Calculation Details

- MacBook 2.4 GHz Intel Core 2 Duo
- Geant4 version 4.9.2 patch 1
- All recording turned off
- Optical Photons(OP) most common particle by far
- OP only live and travel in one logical volume
- Rough surfaces for OP reflection
- For simulations with particles that are evenly spread over various logical volumes, volumes can be placed based on volume size

Scintillation Lattice Concept – LENS and MiniLENS







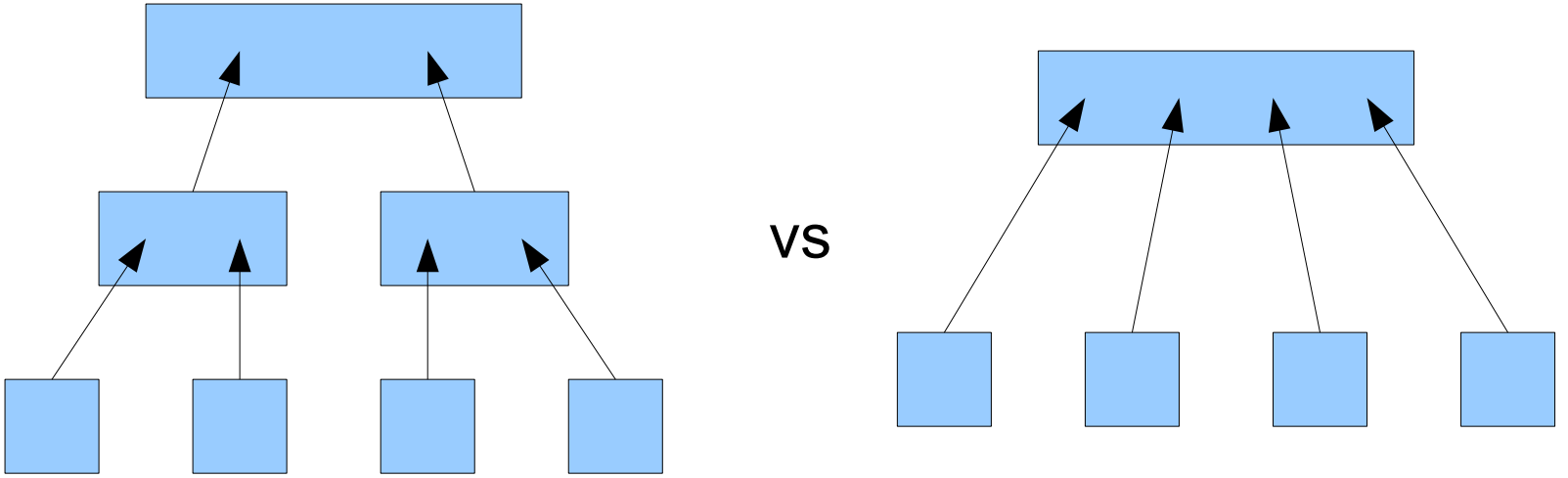
Large volume of liquid scintillator optically segmented by thin clear fluoropolymer film providing precise digital position information

Scintillated light gets channeled down lengths of teflon and acrylic in the scintillator due to index of refraction

Optical properties are crucial to performance

Being developed for LENS, a next generation detector for low energy neutrinos

Binary Trees in One Dimension



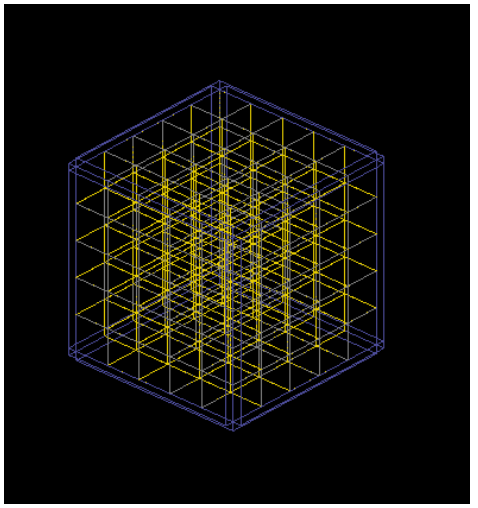
In binary tree it takes 1 or 2 checks at each level to see in which logical volume a particle is located

In example above it takes from 1-4 checks and if particles are evenly spread average is 2 ½ checks

Binary Tree Generating Code Outline

1) Choose number of cells wide, high, and deep
2) Code figures needed sizes of logical volumes required based on splitting parent volumes as close as possible into halves
3) Generate logical volumes and placements into binary tree

LENS Binary Tree Speed Tests



500 keV electron from center of detector

NxNxN - No Binary Tree – All Single Mother Volume – used to be really really really slow
NxNxN – Binary Tree – Used to be much faster

Now both are about equivalent in speed!
So nevermind.

Conclusion

Simple reordering of logical volume placements reduces geometry tracking time

Binary trees are fast but more programatically complex and new (GEANT4 9.1-ish) particle tracking is fast

Can extend binary trees to allow non-homogeneous cells