Simulation Strategy

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Braidwood Collaboration Meeting
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Overall Strategy

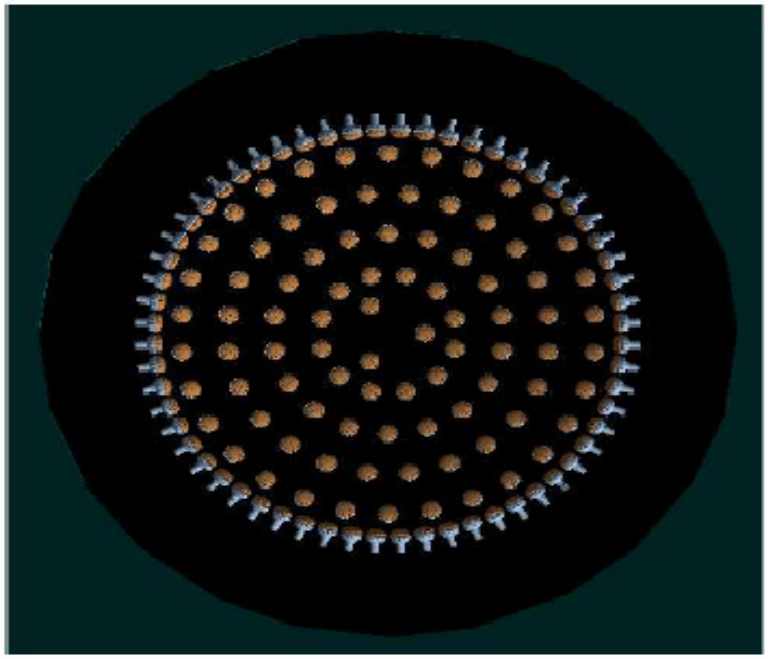
- Maintain two detector simulations
  - full Geant4 detector simulation:
    - all that physics not in a fast simulation
    - easy to do complicated geometry
    - new tools, event display
    - merge with existing veto simulation code
  - ReactorFsim “fast” simulation:
    - only physics is what we put in it
    - large-statistics detector studies

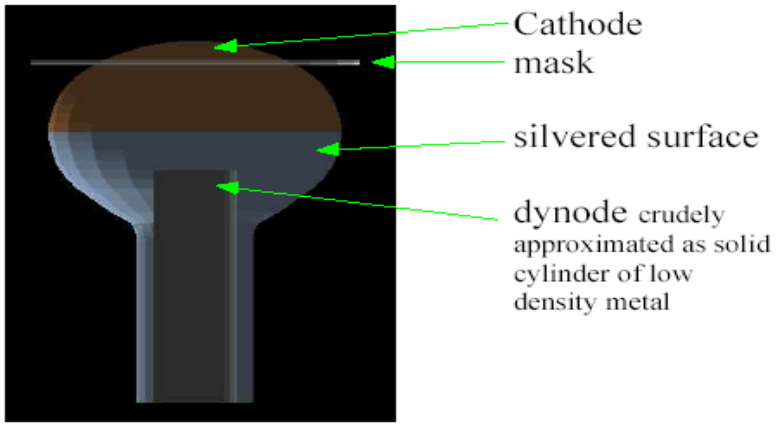
What I Did for My Summer Vacation

- Simulation group goal:
  - Have a full Geant4 detector simulation able to reproduce ReactorFsim results by the end of the summer:
    - IBD event kinematics
    - positron energy response
    - two vs. three zone design
    - calibration studies
  - Did we make it?
    - no…

Starting Point

- Glenn Horton-Smith's GenericLAND Geant4 simulation (GLG4sim):
  - based on G4 simulation of KamLAND
  - vertex, position generator for primary particles
  - event mixing, separation can be done at event generator
  - detailed scintillation processes
  - detailed PMT model →
- Use as library in Braidwood simulation:
  - implement own detector design, optical model





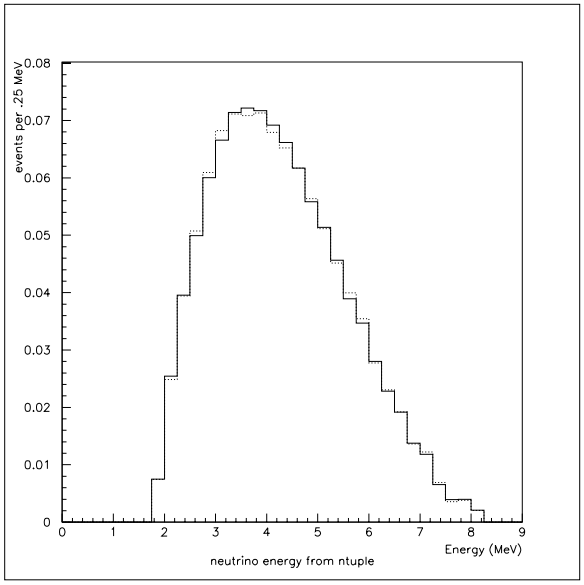
Braidwood Software

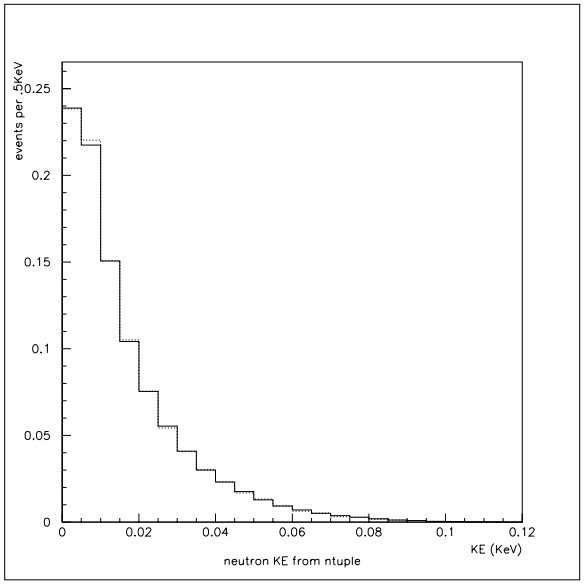
- Reactor Analysis Tools (RAT)
  - adapted from SNO software “processor” design:
    - series of processors to handle events
    - data or MC events handled by same software
    - DAQ, reconstruction, ROOT output separate processors
  - runs GLG4sim as a MC processor
    - could also run ReactorFsim, others
  - also contains the code to overload GLG4sim functions:
    - detector and veto system design, materials
    - ROOT tree output

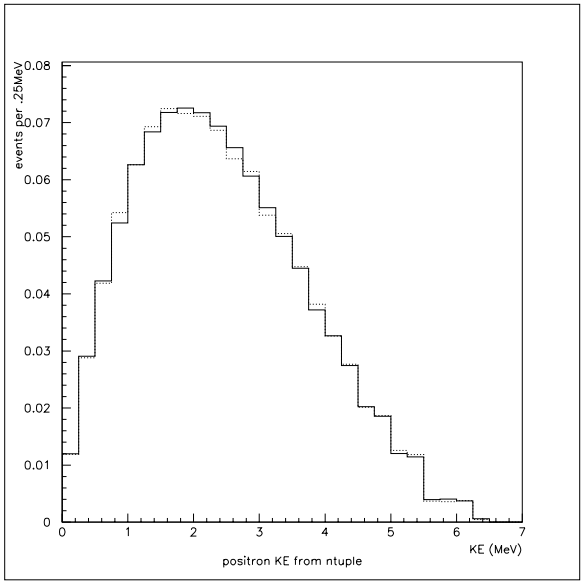
Pieces of the MC Puzzle

- Huge initial effort by Texas:
  - entire RAT framework, documentation
  - BW detector-specific code
  - RAT database, logging, signal handling, etc…
- Veto simulation code added by MIT:
  - can be implemented by switch
- IBD event generator added by Chicago
- Reconstruction code starting from work done by KSU for ReactorFsim
- Gadolinium added recently:
  - n+Gd cross-sections needed in G4NDL
  - radiative model of n+Gd capture gammas

Inverse Beta Decay Generator







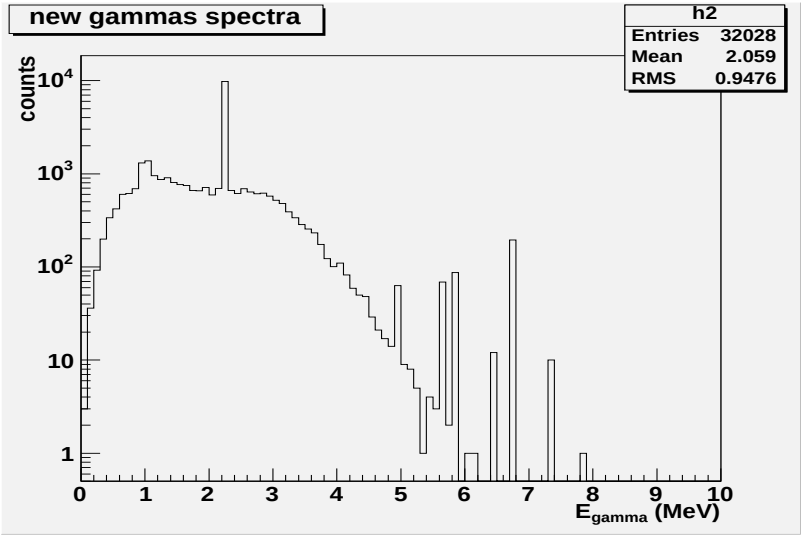
- No default IBD event generator in GLG4sim:
  - load IBD vertex e+ and n into GLG4sim via HEPEVT format interface
  - create standalone code to provide ascii file with e+ and n information (kept in gen directory of RAT)
  - copied from ReactorFsim IBD event generator

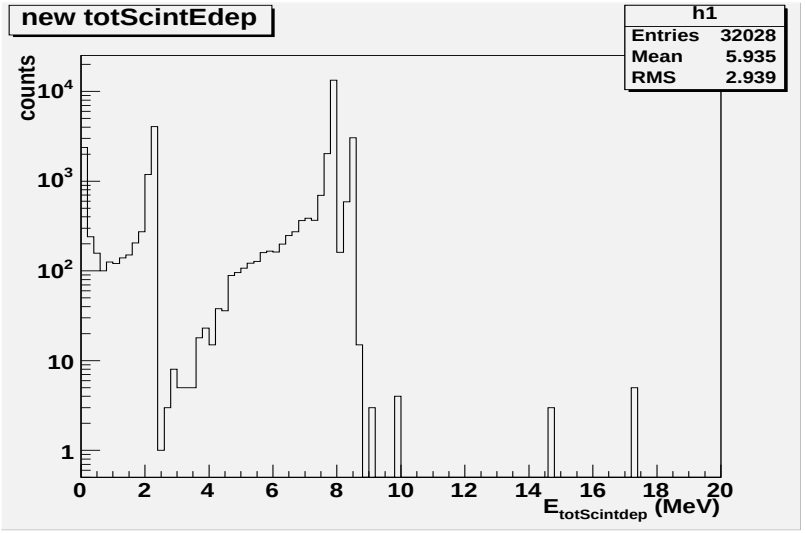
Detector and Secondaries

- BW detector two zone design defined in settings_spherical.dat:
  - GdLoadedScint < 2600mm
  - _acrylic < 2700mm
  - PMT radius = 3400mm
  - _mineralOil < 3500mm
  - StainlessSteel < 3600mm
- G4 tracked particles follow physics defined in GLG4PhysicsList.cc:
  - e+: multiple scattering, ionization, Bremsstrahlung and annihilation
  - n: elastic and inelastic scattering and radiative capture
  - gamma: conversion, Compton scattering, photoelectric effect

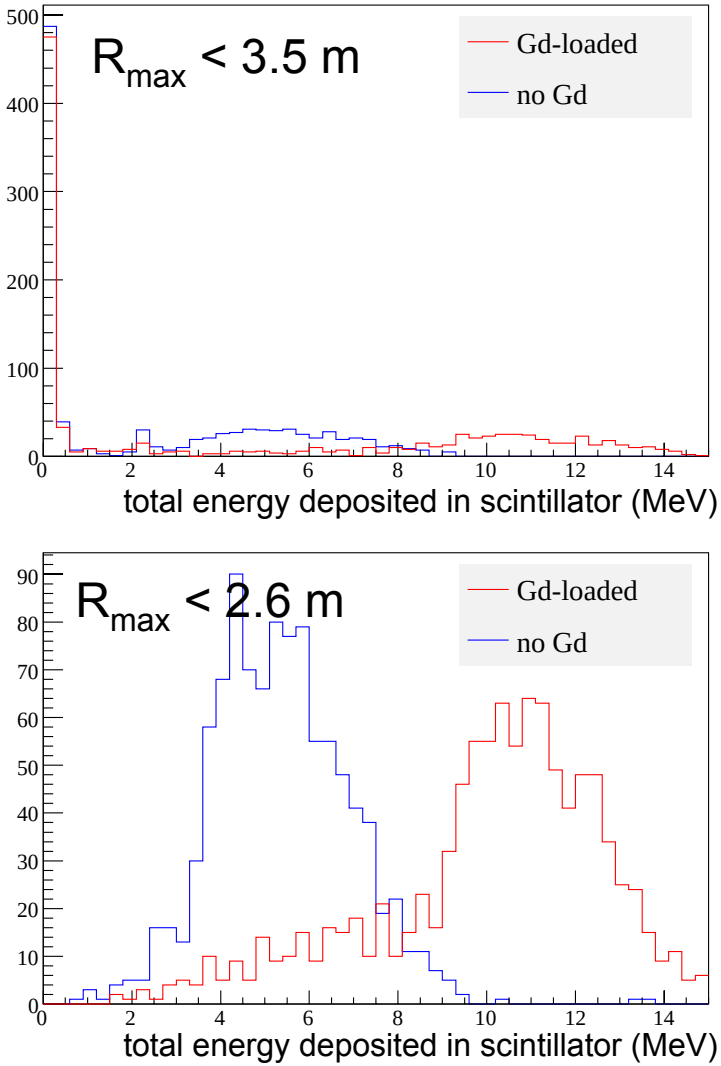
Radiative Neutron Capture on Gd

- n+Gd cross-section tables from ENDF/B-VI
  - final state information actually ^{49}In
  - kept in data/neutron
- radiative decay model received gratis from 2xCHOOZ:
  - top 2 ^{155}Gd cascades
  - top 3 ^{157}Gd cascades
  - otherwise continuum
  - kept in GdHPCapture





Current Status



- First IBD events generated with n capture on Gd:
  - no event mixing at generation
  - all energy (e+ and n) included for each event
- Positron energy response studies started
- 2 vs. 3 zone design studies:
  - needs work on the BW detector construction code
  - more information in tree
- Just starting to shake down a huge piece of software

Further G4 Work

- Calibration studies:
  - allow calibration constants in reconstruction to vary from those used in MC
  - started with attenuation in ReactorFsim
- Sources:
  - study detector response to ^{252}Cf and other gamma and correlated neutron sources
  - extensive source models in MCNP, ^{252}Cf in ReactorFsim
- Fast mode:
  - design a “fast” mode for RAT:
    - remove unnecessary physics processes in GLG4sim?
    - parameterize optical photon tracking in Geant4?
- More hands working on e+ and n energy response:
  - most groups just starting to learn
- …?

Fast Simulation

- ReactorFsim will be maintained as a fast detector simulation:
  - Geant4 is slow (~1 Hz on desktop)
  - primarily for large-statistic simple-event (IBD, fast neutron) studies
- Issues:
  - much physics added for NuSAG, may not be needed now
  - memory leaks and unnecessary time sinks can be removed
  - still a few “features” to be “improved”
- Good project for a small group