Jefferson Lab

Simulation of the CLAS12 Forward Electromagnetic Calorimeter
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Motivation:

The primary mission of Jefferson Lab (JLab) is to reveal the quark and gluon structure of nucleons and nuclei and to deepen our understanding of confinement. At JLab there is a need for high-performance computing for data analysis and simulations. The precision of many future experiments will be limited by systematic uncertainties and not statistical ones; making accurate simulations vital. A physics-based simulation of a new detector (CLAS12) is currently being developed called gemc. This new program uses the package Geant4 to calculate the interactions of particles with matter in the components of CLAS12. We have developed a mathematical model of the Electromagnetic Calorimeter (EC) geometry and added a simulation of the calorimeter to gemc.

JLab, CEBAF

Jefferson Lab (JLab) is located in Newport News Virginia (see figure below) The central scientific instrument is the Continuous Electron Beam Accelerating Facility (CEBAF), a super-conducting , racetrack accelerator about a mile long. with three unique detectors in Halls A,B and C. CEBAF runs at energies up to 6 GeV now and is being upgraded to 12 Gev.

CLAS 12 Upgrade

JLab is being upgraded to twice its current operating energy, and will have a new detector in Hall B based on the current detector (CLAS6) called CLAS12. We are focused on the CLAS12 forward detector. It is composed of many alternating layers such as drift chambers, Cerenkov counters, time of flight Scintillators (TOF), and electromagnetic calorimeters (EC). These components each contribute to the identification and measurement of a particles 4-momenta. **Right:** Exploded view of one sector of the Hall B CLAS12 detector illustrating the High Threshold Cherenkov Counter, Drift Chambers, Time of Flight Detectors, and the EC.
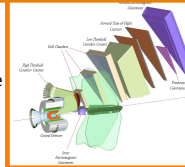
The Hall B Electromagnetic Calorimeter

The EC is an electromagnetic sampling calorimeter that will cover the forward region (5° < θ <45°) of the HallB CLAS12 detector. It is constructed from 39 trapezoidal alternating layers of plastic scintillator strips and lead sheets. The scintillator layers are made up of 37 strips each and have three orientations (views) that are labeled u,v,w (see EC figure)
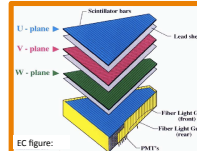
Adding the EC to gemc.

The CLAS6 EC geometry is describes in Ref 1. The description in Ref 1 relies on a large set of equations and parameters and we have streamlined that model to make it more robust and easier to maintain. The description uses eleven parameters. The EC geometry is generated in gemc using parameters from a MySQL database. Perl scripts are used to put the geometry parameters into the detector.

ec_build.pl:

Contents- ec.build is a Perl script that creates input values for geant4. We used Geant4 to construct a volume in gemc called the G4Trap. The EC is made up of 77 G4traps. The figure below shows the coordinates used to define this generalized trapezoid.

geant4 volume named G4trap
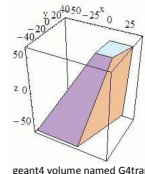
Inputs-We used values from our EC mathematical model.
Output- Input values for geant4 .

go_table

CONTENTS - go_table is a shell script that reads the output from ec.build, and writes it into a MySQL geometry database at JLab. When gemc is given the option, it uses values from the geometry database to create volumes.
INPUT-input values for geant
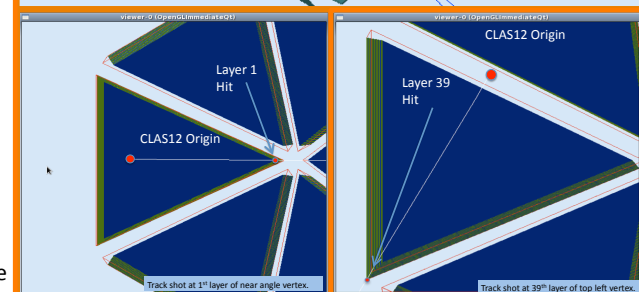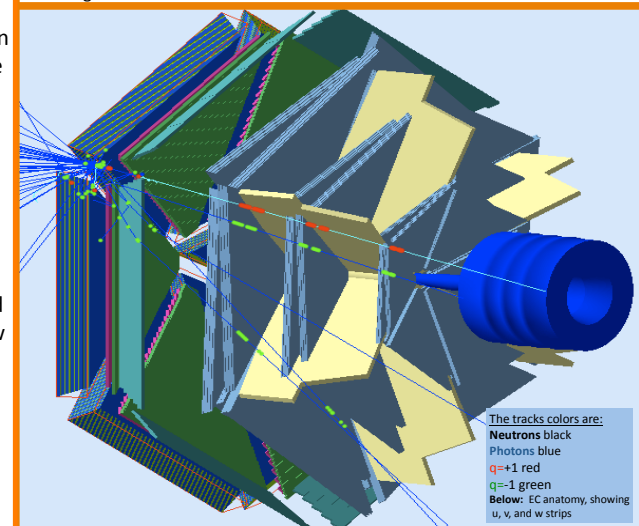OUTPUT- MySQL geometry database

Results from the model:

Below are screenshots of CLAS12 in the gemc GUI. The green line in the top panel represents a scattered electron and the red dots are hits in CLAS12 from this track. The blue lines are neutrons; their hits are green.

To test our geometry, we fired tracks from the target to the boundaries of the EC. See the bottom panel which shows examples of layer 1 and layer 39 hits. The electron track is in white. Calculating values that would place a particle on a boundary would check that our geometry is correct . To be as precise as possible, we turned off the magnetic field of the torus magnet so that tracks would be straight and used a geantino. The geantino is a special simulated particle that doesn't interact with the matter it passes through.

We checked the accuracy of our geometry with 36 test tracks. We sent a track through the 1st and last layer of the EC for each of the three vertexes. We tested all six regions.

The tracks colors are:
Neutrons black
Photons blue
q=+1 red
q=−1 green
Below: EC anatomy, showing u, v, and w strips

CLAS12 Origin
Layer 1 Hit
CLAS12 Origin

Track shot at 1st layer of near angle vertex.

CLAS12 Origin
Layer 39 Hit

Track shot at 39th layer of top left vertex.

References:
R. Minehart, 'EC Geometry', EC Geometry, http://www.jlab.org/~gilfoyle/CLAS12software/CLAS6ECGeometry.pdf, UVA
G.P. Gilfoyle . M. Ungaro. J Carbonneau. C Musalo. M. Moog – Simulation of the Electromagnetic Calorimeter in CLAS 12 (In Preparation)
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