Fermilab

Evaluating the use of Geant4 through LArSoft in the LArIAT simulation

Hans Wenzel

LArSoft Coordination Meeting

October 6th 2015

Charge

Begin a two week (FTE effort not real time) project evaluating the use of Geant4 through LArSoft in the LArIAT simulation. The scope includes everything from reading in the stdhep particle list/or single particle gun through digitization (Wire Sim.)

https://cdcvs.fnal.gov/redmine/projects/larsoft/documents

Fermilab

Goals

A primary goal of this project is to improve LArSoft. Also, all of the code and procedures that are in the scope of this project are in common with other LAr experiments. Any suggested improvements will benefit users of LArSoft. Another major goal is to fit this project to the effort available. Recommendations that point out problematic areas that need further study are highly appropriate.

Effort: The best candidates for this work are Hans (primary), Soon (secondary), and Krzysztof (secondary).
This project should be limited to two people working for one week (two weeks total effort).
This includes evaluation and production of the major findings. The final report can be modeled after the previous MicroBooNE profiling report.

Fermilab

To be evaluated:

This evaluation includes:

- <u>physics lists</u> - provide recommendations for improving the low-energy physics lists that are currently in use. (currently: QGSP_BERT, what about BIC, INCLXX for hadronic or precise em Option? → what are the figure of merits?)

- <u>geometry use and energy deposition</u> - examine voxelization and parallel geometry that is currently used for the LAr TPC. (is it too fine?)

- <u>stepping and other Geant parameters</u> - provide recommendations for improvement to Geant4 configuration.

- <u>code speed</u> - use profiling to locate slow sections of code and identify high-level causes if possible. (see microboone report)

- <u>upstream detector integration</u> - if there is time, provide guidance for integrating upstream auxiliary detectors into the simulation.

🔷 **Fermilab**

Prerequisites

There are several questions that need to be answered and preliminary work that needs to be completed before this project can start.

- Geant4 version - LArSoft appears to still be using 4.9.6.p04. How important is it to move to 4.10.p02 to make necessary or useful improvements? There are known bug fixes affecting the physics LArIAT is interested in → recommend updating.
- Running LArIAT simulation - The team needs to be able to run the LArIAT simulation, and have the necessary profiling tools installed and useable on an appropriate test platform. → Johnny provided me with instructions was able to run it.
- Input particle list - what set of particles will be used to drive this evaluation? (single $K^{+/-}$, p, $\pi^{+/-}$, $e^{+/-}$, $\mu^{+/-}$)
- Contacts - who are the primary experiment contacts that will answer questions about the simulation? (Brian and Jason)

Fermilab

Test Setup

- lariatsoft v01_07_00
- geant v4_9_6_p04b.
- The fcl file was provided to us by Johnny Ho from LArIAT
- We use a particle generator (particle gun) to produce single charged pions with a few hundred MeV of kinetic energy.
- These are then processed through geant 4 and the wire simulation.
- We used the lariatgpvm03 interactive machine to run our tests.

🔷 **Fermilab**

Results:

Followed Johnny's instructions 100 single $\pi^{+/-}$ events took about 90 seconds (lariatgpvm03) and produced 56Mb output file.

Module	Percentage
Geant 4	18%
Wire Simulation	38%
RootIO	44%

Without wiresim:

Module	Time/evt	Percentage
Geant 4	0.135 sec/evt	86%
RootIO	0.022 sec/evt	14%

Fermilab

Compression factors of output files produced

Module	Compression Factor	Max Compression
Geant 4 + wiresim	7.59	> 80
Just Geant 4	1.53	

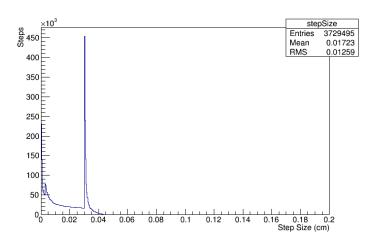High cost CPU/Memory: compressing and uncompressing the data.
→ Investigate software should create compressed data in the first place, consider data compression at daq/hardware stage.

Fermilab

Effect of Voxel size:

Note no estimate of the effects on the physics performance!

Voxel size [μm]	Total CPU time [sec]	Memory reported by ps [MB]	Average G4step size [μm]
300	164	165	172
600	126	159	290
1300	104	142	473
2000	90	131	

- The current implementation is quite expensive it creates many copies of small geant 4 volumes (Voxel cubes) and forces the geant 4 stepping to adjust to the voxel size (see table above) instead of letting geant4 calculate the best stepping size in liquid Argon.
- It also makes geant 4 visualization nearly impossible (too many volumes).
- We recommend that alternative and optimized methods for realizing the Readout geometry are evaluated:

 e.g. ILC experiments used lcdd (slic) to realize readout segmentation. Also Geant 4 provides the *G4VReadoutGeometry mechanism to create* a readout geometry which is a virtual, parallel geometry for obtaining the channel number. Or custom solution.

🜂 Fermilab

Comments regarding Geometry

- Visualization is an important tool to debug the detector geometry but we were not able to enable geant 4 visualization in larsoft.
- Running the geant 4 overlap checker (after loading the gdml file into the CaTS framework) on the lariat.gdml file revealed several overlaps.
- The lariat.gdml file actually doesn't provide a complete description of the geometry (Voxels are added in a later step).
- The wire geometry is very regular, so why not use loops (which are supported in gdml) in the gdml file, which would make it more human readable.
- Use of magic words to make a volume a sensitive detector. Why not use special xml tag (a la artg4tk)? gdml is designed as an extendable language.

🔷 Fermilab

Comments regarding Geometry (continued)

- Not many types of sensitive detectors are available which makes it difficult to describe anything besides liquid Argon TPC. (E.g. for lariat: the beam is characterized by wire chambers, muon paddles, and TOF flight systems.)

Hans Wenzel, LArSoft Coordination meeting

Fermilab

To do (WORKING ON IT)

- find module to check that physics performance is affected by voxel size and to check if there are gains moving to high precision em physics list (dE/dx of muons in the TPC?)
- Identify physics processes to be able to make physics list recommendations (dE/dx for em, nuclear reaction for hadronic)
- check how easy it is in larsoft to access geant 4 user actions (stepping, stacking, tracking etc.) as in artg4tk.

Fermilab