TRIUMF Experiment 614

GEANT Event Processing Times

By: Dan Rankin
Supervisor: D. Gill

April 20, 2000

Abstract

In order to perform a Monte Carlo simulation of the experiment, it would be desirable to know the most effective way of running the simulation code. In order to characterize E614 GEANT and determine the most efficient way to run a full simulation, this study was undertaken to determine the effects of different event types and mechanism uses. It has been found that the greatest amount of processing time has been added by the production of Delta Rays. The use of a muon with spin adds approximately 20% to the processing time needed. The maximum time per event that was found in this study was 0.1024 seconds per event. Using a bounded volume decreased processing times by about 20%

INTRODUCTION

The purpose of this study was to examine the effects of the different physics mechanisms on the processing times of E614 GEANT V1.2. These tests were performed on the shared linux box LIN01. As this is a shared processor, there may be variations in the processing times recorded. As well, these number were generated with only 10,000 events, so there could be statistical variations between individual numbers. However, this study does give a good idea of the relative differences between the different types of events and different physics mechanisms.

For this study, four different types of events were produced. The four event types were: mu^+ (spin), mu^+ (no spin), mu^+ (spin)-> e^+, and e^+ only. Along with the four event types there were also different physics mechanisms to be examined. These physics flags were: annihilation, bremsstrahlung, delta ray production, muon nuclear interactions, and direct e^+/e^- pair production. As well as measuring the time per event, the fraction of events that produced each physics mechanism was recorded.

Two different boundary conditions were used, which we will call bounded and unbounded. In the unbounded case, the event was terminated when the particle in question left the entire experiment volume. This experiment volume is rather large, including beam pipe, the yoke, and other elements. In an effort to reduce the processing times needed, we used the bounded run. In this case, any particle exiting the detector through the G10 housing or the helium buffers terminates the event. In this manner we hoped to achieve shorter tracks and smaller processing times.

Unbounded Results

The recorded processing times per event are shown in Table 1. Shown in the run type column are the different types of physics flags that were used [1]. For each type of mechanism shown, there are at least two values for the corresponding flag. A value of one allows the mechanism with the generation of secondaries, while a value of two allows the mechanism without the generation of secondaries. The exception to this is the delta ray (DRAY) flag, which has three values. This is needed because the DRAY flag only works if the LOSS flag is set to one. In the control, the LOSS flag is set to two, so in fact the DRAY=0 case is the control for the delta ray production section.

Run Type	Mu+ (spin) only	Mu+ (no spin) only	Mu+ (spin) -> e+	e+ only
Control	0.0485	0.0402	0.0879	0.0449
Annihilation				
ANNI = 1	N/A	N/A	0.0918	0.0448
ANNI = 2	N/A	N/A	0.0923	0.0443
Bremsstrahlung				
BREM = 1	0.0490	0.0405	0.0925	0.0464
BREM = 2	0.0487	0.0405	0.0934	0.0461
Delta Ray production*				
DRAY = 0	0.0473	0.0390	0.0907	0.0447
DRAY = 1	0.0474	0.0392	0.1096	0.0644
DRAY = 2	0.0476	0.0394	0.0907	0.0447
Mu Nuclear Interactions				
MUNU = 1	0.0492	0.0407	0.0821	N/A
MUNU = 2	0.0480	0.0398	0.0887	N/A
Direct e+/e- pair production				
PAIR = 1	0.0490	0.0401	0.0881	0.0406
PAIR = 2	0.0490	0.0407	0.0880	0.0412
All Flags				
Value = 1	0.0480	0.0399	0.1024	0.0547
Value = 2	0.0482	0.0396	0.0869	0.0410

Table 1 – GEANT processing times (unbounded run)

From the results listed in Table 1, it seems that the longest event times are for the mu^+ (spin)-> e^+ run type. Also, it seems that the addition of spin to a mu event increases the processing time by 15-20%. It looks as though the mechanism that adds the most time to the processing is that of delta rays, at least for events involving positrons. In fact, there was little variation in processing time with muon only events when we changed the mechanisms. This will be explained when we look at the mechanism numbers in Table 3.

Table 2 shows the same information as in Table 1, except this time for bounded runs. The processing times for the muon only runs remain essentially unchanged, but there are significant reductions in the amount of processing time needed for the runs involving positrons. When all of the mechanism flags are set to 1, the time required for a mu^+ (spin)-> e^+ run is reduced by ~20% when the bounded run is used instead of the unbounded run. Bremsstrahlung had a noticable effect on the processing times in the unbounded runs, yet had no significant effect on the bounded runs.

Run Type	Mu+ (spin) only	Mu+ (no spin) only	Mu+ (spin) -> e+	e+ only
Control	0.0489	0.0411	0.0746	0.0270
Annihilation				
ANNI = 1	N/A	N/A	0.0761	0.0269
ANNI = 2	N/A	N/A	0.0748	0.0271
Bremsstrahlung				
BREM = 1	0.0487	0.0405	0.0745	0.0267
BREM = 2	0.0489	0.0405	0.0748	0.0271
Delta Ray production*				
DRAY = 0	0.0481	0.0397	0.0735	0.0269
DRAY = 1	0.0478	0.0399	0.0794	0.0341
DRAY = 2	0.0476	0.0396	0.0750	0.0271
Mu Nuclear Interactions				
MUNU = 1	0.0492	0.0408	0.0745	N/A
MUNU = 2	0.0485	0.0404	0.0746	N/A
Direct e+/e- pair production				
PAIR = 1	0.0487	0.0405	0.0745	0.0268
PAIR = 2	0.0487	0.0406	0.0742	0.0266
All Flags				
Value = 1	0.0489	0.0402	0.0814	0.0337
Value = 2	0.0484	0.0399	0.0741	0.0409

Table 2 – GEANT processing times (bounded run)

It is important to note that the time per event for all flags seems not to be equivalent to the cumulative effects of individual flags, especially for the unbounded runs. A good example of this is a comparison between the unbounded DRAY=1 for mu^+ (spin)-> e^+ with the unbounded all flags =1. The DRAY =1 time is 0.1096, while the all flags =1 time is 0.1024. The same seems to be true for the bounded case, although the difference is more subtle. Again, there may be problems with the use of the LIN01 shared processor, but the difference seems to be quite large in this case.

Mechanism Frequency

As a key part in the understanding of this study, we wanted to see how often these physics mechanisms occurred. Table 3 shows the percentages for the unbounded case, while Table 4 represents the bounded condition.

	Mu+ (spin) only	Mu+ (no spin) only	Mu+ (spin) -> e+	e+ only
Annihilation				
ANNI = 1	N/A	N/A	10.32%	9.74%
ANNI = 2	N/A	N/A	10.29%	10.31%
Bremsstrahlung				
BREM = 1	0.00%	0.00%	67.60%	68.17%
BREM = 2	0.00%	0.00%	69.30%	67.76%
Delta Ray production*				
DRAY = 0	0.00%	0.00%	0.00%	0.00%
DRAY = 1	0.00%	0.00%	62.44%	65.44%
DRAY = 2	0.00%	0.00%	60.22%	61.80%
Mu Nuclear Interactions				
MUNU = 1	0.00%	0.00%	0.00%	N/A
MUNU = 2	0.00%	0.00%	0.00%	N/A
Direct e+/e- pair production				
PAIR = 1	0.00%	0.00%	0.00%	0.00%
PAIR = 2	0.00%	0.00%	0.00%	0.00%

Table 3 – GEANT mechanism frequency (unbounded run)

Table 3 shows that the events that are muons only do not experience any[1] effects from the physics mechanisms that are turned on. This accounts for the lack of variation in the processing times that is seen for the muon only events in tables 1 and 2.

[1] It is not possible with only 10,000 event runs to rule out the possibility that a given mechanism occurs. However, if that mechanism does occur it will do so at a very low rate, not appreciably affecting the processing time of GEANT.

	Mu+ (spin) only	Mu+ (no spin) only	Mu+ (spin) -> e+	e+ only
Annihilation				
ANNI = 1	N/A	N/A	0.74%	0.33%
ANNI = 2	N/A	N/A	0.70%	0.32%
Bremsstrahlung				
BREM = 1	0.00%	0.00%	8.39%	6.66%
BREM = 2	0.00%	0.00%	9.06%	7.07%
Delta Ray production*				
DRAY = 0	0.00%	0.00%	0.00%	0.00%
DRAY = 1	0.00%	0.00%	9.30%	8.25%
DRAY = 2	0.00%	0.00%	10.24%	8.04%
Mu Nuclear Interactions				
MUNU = 1	0.00%	0.00%	0.00%	N/A
MUNU = 2	0.00%	0.00%	0.00%	N/A
Direct e+/e- pair production				
PAIR = 1	0.00%	0.00%	0.00%	0.00%
PAIR = 2	0.00%	0.00%	0.00%	0.00%

Table 4 – GEANT mechanism frequency (bounded run)

The main result of comparing tables 3 and 4 is that Table 4 shows a large reduction in the rates of the various mechanisms when compared to Table 3. The size of this reduction is about one order of magnitude. This means that the vast majority of these mechanisms are occurring outside of the detector body, presumably in the yoke, beam pipes, and other dense structures.

CONCLUSIONS

With the information gathered in this study, it seems that a bounded environment would be the most efficient way in which to run a simulation of the experiment. With the use of a bounded run, there is a savings of ~20% in processing time over using an unbounded setup. Also, using a bounded run with all applicable physics mechanisms on seems to take less time than a similar unbounded run with no physics mechanisms on (besides multiple scattering and energy loss). The muon experience no (or very little) effects from the physics mechanisms, while the positrons experience the effects mainly outside of the body of the detector. Delta ray production and bremsstrahlung seems to be the most prevalent physics process experienced by the positrons.

In the future, it may be worthwhile to explore the effects of the TDC digitization, as the digitization would surely be incorporated into any large scale simulation. As well, it may be valuable to examine the effects of using a dedicated processor, to determine the viability and time savings of using one for a large scale simulation.

References

1. Brun R., Bruyant F., Maire M., McPherson A.C., Zanarini P. GEANT 3 Reference Manual, pp.BASE 30-7, BASE 40-2.