



Geant4 CPU and Memory Profiling and Benchmarking Status Report

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Geant4 Computing Performance Task (G4CPT)

- Purpose
 - Monitor Geant4 CPU & memory through the development cycle
 - Identify issues (if any)
 - Identify opportunities for code improvement
 - Provide feedback to the working group leaders
 - Close all open issues before the next release
- Ongoing activities
 - Regular profiling/benchmarking of Geant4 development and public release, and specific development tags as necessary
 - Addition of the new profiling applications as needed (if possible)
 - Maintenance and evolution of the profiling infrastructure in response to changing computing environment

G4CPT Resources at FNAL

- FY2019 members and contributions
 - J. Yarba, S. Y. Jun, K. Genser, D. Elvira, P. Canal
- FNAL Wilson cluster: <https://wilsonweb.fnal.gov/cpucluster.shtml>

Test Type(s)	Nodes	Cores	Node Hours	Core Hours
Sequential (amd32_g4perf)	21	32	~144	~4600
Sequential (intel12)	25	12	~50	~600
Multi-threaded (amd32)	2	up to 32	~14	~150
Multi-threaded (intel12)	2	up to 12	~10	~50
Memory (tevnfsg4)	1	1	~12	~12
Total				~5412

- Central web server: <https://g4cpt.fnal.gov>

G4CPT Tools and Software

- gcc 7.1.0
- IgProf 5.9.12
- Open | SpeedShop 2.3
- MemoryService module – monitors vsize, rss event-by-event
- Shell scripts
 - Build Geant4 libraries and applications
 - Preparation of the environment
 - Job submission and production workflow control
 - Analysis workflow control
- R applications for analysis
- Root scripts for composing summary

Profiling and Benchmarking through 10.5.rXX Cycle

2) Profiling Results

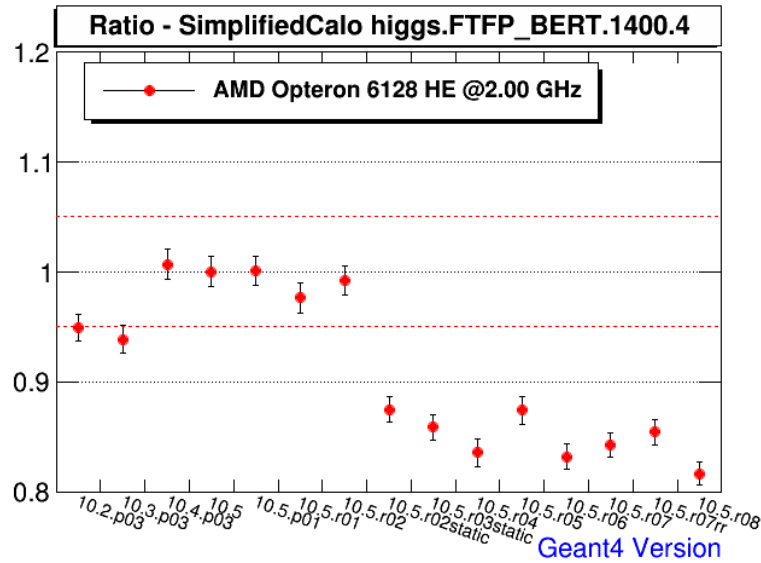
Profiled on [the Wilson CPU cluster](#) using AMD 6128HE Opteron 2GHz
 (green: gcc 7.1.0 -O3), (pink: gcc 6.3.0 -O2), (yellow: gcc 4.9.2 -O2)

Geant4 Version	Application	Performance		Summary	
10.5.r08	SimplifiedCalo	OpenSpeedshop	lgProf(Memory)	CPU	MEM
10.5.r07rr	SimplifiedCalo	OpenSpeedshop	lgProf(Memory)	CPU	MEM
10.5.r07	SimplifiedCalo	OpenSpeedshop	lgProf(Memory)	CPU	MEM
10.5.master.july.09.19	SimplifiedCalo	OpenSpeedshop	lgProf(Memory)	CPU	MEM
10.5.r06	SimplifiedCalo	OpenSpeedshop	lgProf(Memory)	CPU	MEM
10.5.r04rrr	SimplifiedCalo	OpenSpeedshop	lgProf(Memory)	CPU	MEM
10.6.b01	SimplifiedCalo	OpenSpeedshop	lgProf(Memory)	CPU	MEM
10.6.b00	SimplifiedCalo	OpenSpeedshop	lgProf(Memory)	CPU	MEM
10.5.r05+f1e50db	SimplifiedCalo	OpenSpeedshop	lgProf(Memory)	CPU	MEM
10.5.r05noverb	SimplifiedCalo	OpenSpeedshop	lgProf(Memory)	CPU	MEM
10.5.r05	SimplifiedCalo	OpenSpeedshop	lgProf(Memory)	CPU	MEM
10.5.r04rr	SimplifiedCalo	OpenSpeedshop	lgProf(Memory)	CPU	MEM
10.5.r04	SimplifiedCalo	OpenSpeedshop	lgProf(Memory)	CPU	MEM
10.5.r03rr(static)	SimplifiedCalo	OpenSpeedshop	lgProf(Memory)	CPU	MEM
10.5.r02static	SimplifiedCalo	OpenSpeedshop	lgProf(Memory)	CPU	MEM
10.5.r03	SimplifiedCalo	OpenSpeedshop	lgProf(Memory)	CPU	MEM
10.5.r02rerun	SimplifiedCalo	OpenSpeedshop	lgProf(Memory)	CPU	MEM
10.5.r02	SimplifiedCalo	OpenSpeedshop	lgProf(Memory)	CPU	MEM
10.5.r01rr	SimplifiedCalo	OpenSpeedshop	lgProf(Memory)	CPU	MEM
10.5.r01	SimplifiedCalo	OpenSpeedshop	lgProf(Memory)	CPU	MEM
10.5.p01	SimplifiedCalo	OpenSpeedshop	lgProf(Memory)	CPU	MEM
10.5	SimplifiedCalo	OpenSpeedshop	lgProf(Memory)	CPU	MEM
10.4.p03	SimplifiedCalo	OpenSpeedshop	lgProf(Memory)	CPU	MEM
10.3.p03	SimplifiedCalo	OpenSpeedshop	lgProf(Memory)	CPU	MEM
10.2.p03	SimplifiedCalo	OpenSpeedshop	lgProf(Memory)	CPU	MEM
10.4	cmsExp-2018	OpenSpeedshop	lgProf(Memory)	CPU	MEM
10.3.p03	cmsExp-2018	OpenSpeedshop	lgProf(Memory)	CPU	MEM
10.2.p03	cmsExp-2018	OpenSpeedshop	lgProf(Memory)	CPU	MEM

Geant4 Version	Application	Performance		Summary	
10.4	LARTest	OpenSpeedshop	lgProf(Memory)	CPU	MEM

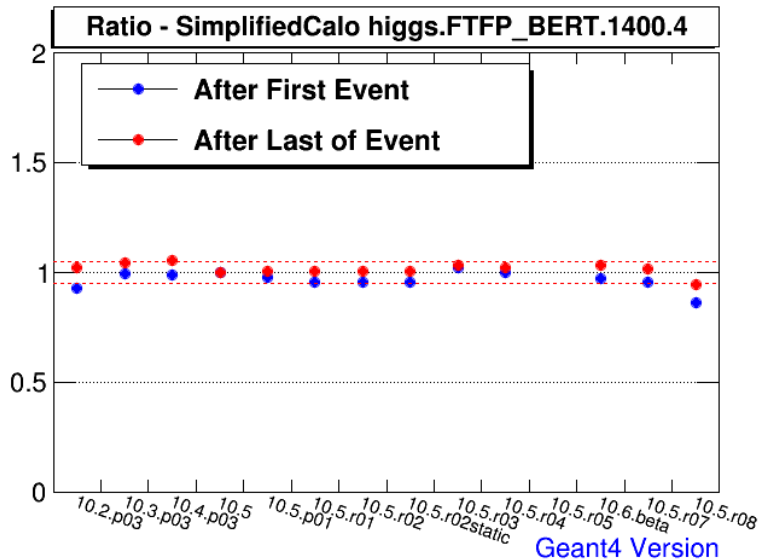
Example Trend in Geant4 CPU and Memory

CPU Time Ratio <10.X.X/10.5>



The sharp deep in CPU at the beginning of 10.5 development cycle is because we have switched to using Geant4 static libraries instead of shared ones. We have opted to use static libraries because this approach yields more stable results that are less sensitive to fluctuations in the computing environment. If we scale results (dynamic vs static libraries, based on 10.5.r02) we can estimate CPU improvement of ~5-6% for Higgs sample through this development cycle.

Total Memory Ratio <10.X.X/10.5>



Memory usage has been mainly stable through the development cycle (except in one release where the issues was promptly corrected). Memory usage has improved by ~7% for e.g. Higgs sample towards the end of this development cycle

Collection of Profiling Applications: 52 study cases

OpenSpeedShop

Geant4.10.5.r07 SimplifiedCalo

Sample	Physics List	B-Field	Energy
Higgs->ZZ	FTFP_BERT	ON (4.0T)	14 TeV PYTHIA
100 MeV e- (5K e-/event)	FTFP_BERT	ON (4.0T)	100 MeV
	Shielding	ON (4.0T)	100 MeV
	Shielding_EMZ	ON (4.0T)	100 MeV
Electrons	FTFP_BERT	ON (4.0T)	1 GeV 5 GeV 10 GeV 50 GeV
		OFF (0 T)	1 GeV 5 GeV 10 GeV 50 GeV
Pions-	FTFP_BERT	ON (4.0T)	1 GeV 5 GeV 10 GeV 50 GeV
		OFF (0 T)	1 GeV 5 GeV 10 GeV 50 GeV
	QGSP_BERT	ON (4.0T)	1 GeV 5 GeV 10 GeV 50 GeV
	QGSP_BIC	ON (4.0T)	1 GeV 5 GeV 10 GeV 50 GeV
Protons	FTFP_BERT	ON (4.0T)	1 GeV 5 GeV 10 GeV 50 GeV
		ON (4.0T)	1 GeV 5 GeV 10 GeV 15 GeV
	FTFP_BERT_HP	ON (4.0T)	1 GeV 5 GeV
	Shielding	ON (4.0T)	1 GeV 5 GeV
Anti-Protons	FTFP_BERT	ON (4.0T)	1 GeV 5 GeV 10 GeV 50 GeV
Gamma	FTFP_BERT_EMZ_AugerOff	OFF (0 T)	250 MeV 1 GeV
Gamma	FTFP_BERT_EMZ_AugerOn	OFF (0 T)	250 MeV 1 GeV

We believe that, in general, we reasonably cover all aspects that can be critical for the Geant4 development.

However, since representatives of various experiments and projects are presenting their vision, we would like to use the opportunity and to inquire if we miss something important.

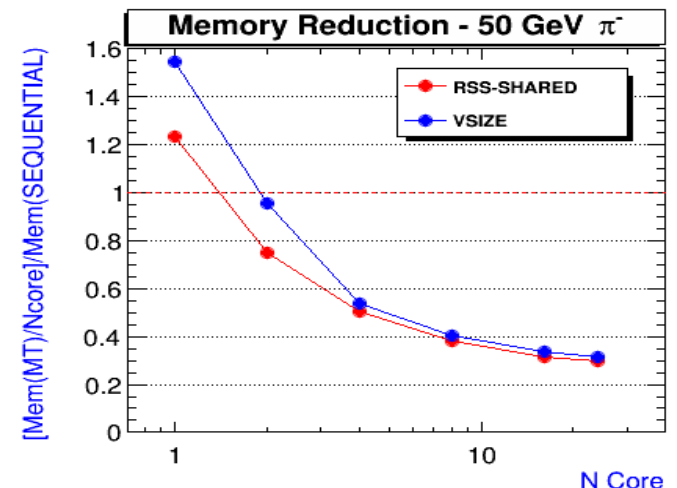
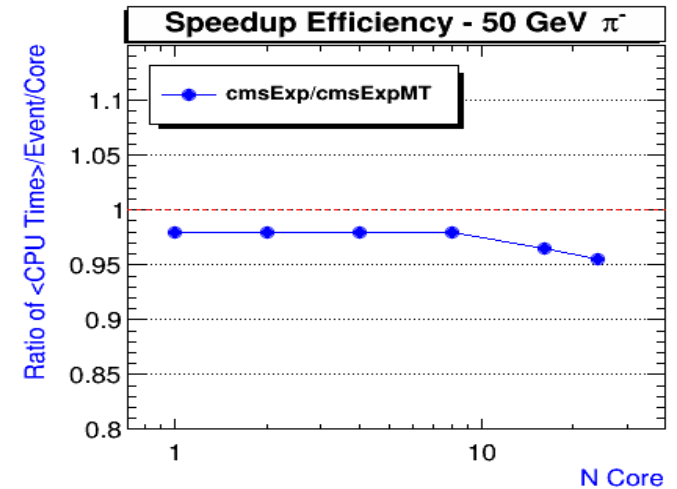
- Newly added applications: 250MeV or 1GeV gamma incident on sampling calorimeter, FTF_BERT_EMZ physics list with simulation of Auger e- ON/OFF

Profiling Multi-threaded Application

6) Geant4 MT Performance

Geant4 Version	Application	Performance	
10.5.r08	cmsExpMT	AMD Intel	OpenSpeedShop
10.5.r07	cmsExpMT	AMD Intel	OpenSpeedShop
10.5.r06	cmsExpMT	AMD Intel	OpenSpeedShop
10.5.r05+f1e50db	cmsExpMT	AMD Intel	OpenSpeedShop
10.5.r04	cmsExpMT	AMD Intel	OpenSpeedShop
10.5.r03	cmsExpMT	AMD Intel	OpenSpeedShop
10.5.r02	cmsExpMT	AMD Intel	OpenSpeedShop
10.5.r01	cmsExpMT	AMD Intel	OpenSpeedShop
10.5.p01	cmsExpMT	AMD Intel	OpenSpeedShop
10.5	cmsExpMT	AMD Intel	OpenSpeedShop
10.4.p03	cmsExpMT	AMD Intel	OpenSpeedShop
10.3.p03	cmsExpMT	AMD Intel	OpenSpeedShop
	ParFullCMS	XeonPhi	XeonPhi
10.2.p03	cmsExpMT	AMD Intel	OpenSpeedShop
	ParFullCMS	XeonPhi	XeonPhi

Geant4 Version	Application	Performance	
10.3.r06dev	IArTestMT	AMD Intel	OpenSpeedShop



Potential Updates (FY2020 or beyond)

- We have been using FNAL Wilson cluster resources that provide stable, well controlled test environment
- FNAL Wilson cluster needs to evolve
 - FNAL plans to upgrade its HPC cluster with modern hardware
- When newer resources eventually replace Wilson cluster, we will need to migrate and to adapt profiling infrastructure
- Various updates in the analysis scripts, as needed
- Periodically review profiling applications, remove obsolete tests (if any) and/or incorporate new tests (if possible)
- Suggestions are welcome !

Summary

- Performed CPU and memory profiling for development and public releases, and for specific candidates (dev. tags)
- Identified a number of “hot spots” through the release cycle
- Reported results to the working group leaders and, if needed, to developers
- Modified the profiling protocol to include newly added applications
- Regularly presented (S.Y. Jun) results and issues of computing performance at the Steering Board meetings