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## GeantV Performance

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- ▶ Features about the FullCMS script
    - 1000 events
    - 10-GeV electrons per event
    - threads: 1
    - 10 tries per combination
    - Each plot uses the average of the combinations
    - configuration
      - + 0: scalar mode
      - + 1: vector mode
      - + 2: basketization enabled w/ scalar dispatch
- scalar/vector config: Fi\_Pj\_Gk\_Mn
- + F=magField
  - + P=(EM)physics
  - + G=geometry
  - + M=msc

This section has some performance results with different combinations using the single track flag=1, with the version of GeantV pre-beta-4

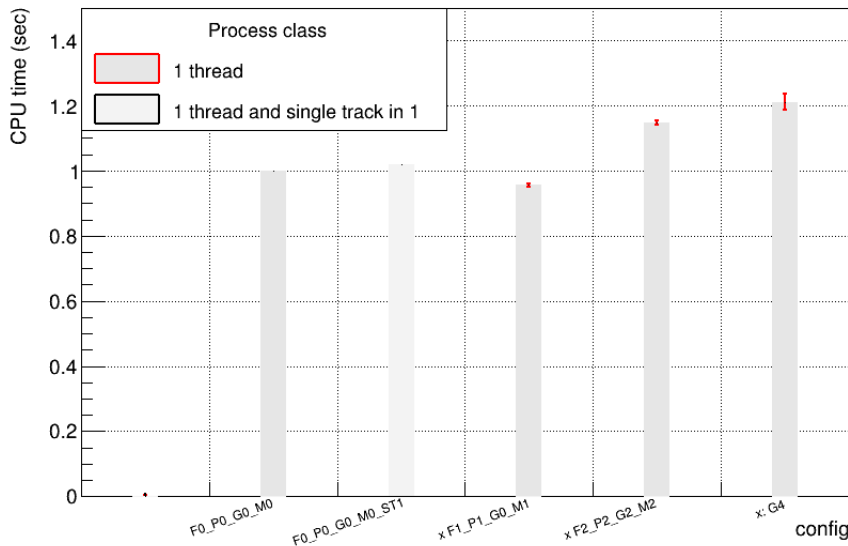
- ▶ `geantv(commit 0abf49ec2ca8cc433)`
- ▶ `geant4 10.04` version
- ▶ The latest `VecGeom` with `-DUSE_CACHED_TRANSFORMATIONS=ON`

## ► Software and microprocessor

- Ubuntu 16.04
- gcc 5.4.0
- veccore 0.5.2
- Vc 1.3.3
- Intel® Core™ i7-4790HQ CPU @ 2.50GHz × 8
- Instruction Set Extensions: AVX2
- SmartCache 8MB
- Level 1 cache size 4 × 32 KB 8-way set associative instruction caches
- Level 1 cache size 4 × 32 KB 8-way set associative data caches
- Level 2 cache size 4 × 256 KB 8-way set associative caches
- Level 3 cache size 8 MB 16-way set associative shared cache
- RAM Memory 32GB

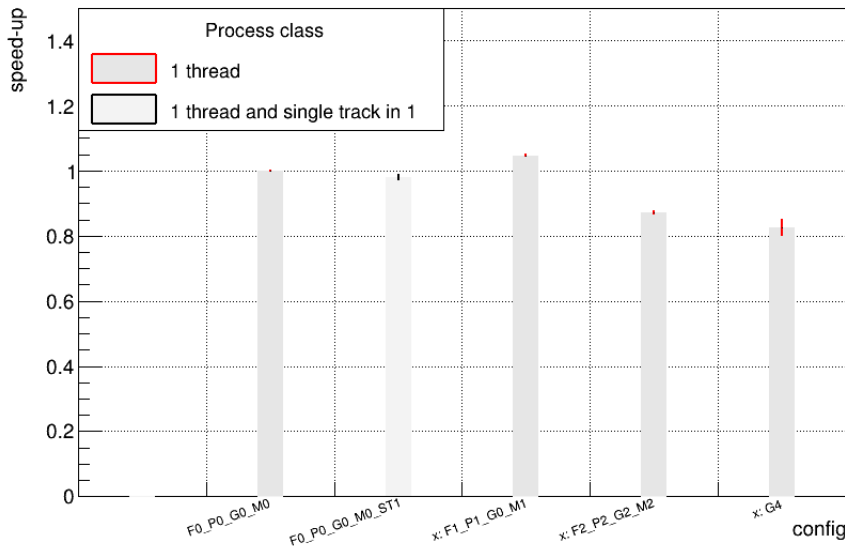
# FullCMS Results - Ubuntu 16.04

## CPU time per event (1000 events)



# FullCMS Results - Ubuntu 16.04

## CPU Speedup (1000 events)

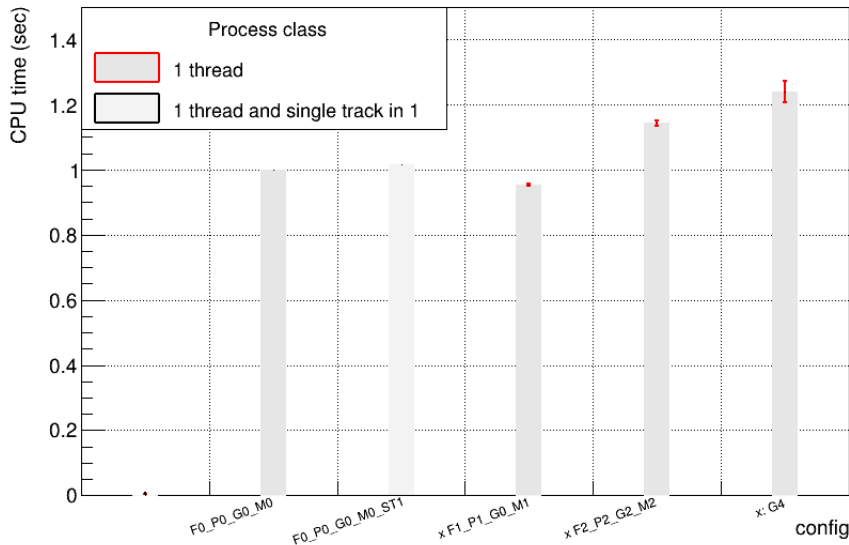


## ► Software and microprocessor

- Ubuntu 18.04
- gcc 7.3.0
- veccore 0.5.2
- Vc 1.3.3
- Intel R Core TM i7-4710HQ CPU @ 2.50GHz × 8
- Instruction Set Extensions: AVX
- SmartCache 6MB
- Level 1 cache size 44 × 32 KB 8-way set associative instruction caches
- Level 1 cache size 4 × 32 KB 8-way set associative data caches
- Level 2 cache size 4 × 256 KB 8-way set associative caches
- Level 3 cache size 6 MB 12-way set associative shared cache
- RAM Memory 8GB

# FullCMS Results - Ubuntu 18.04

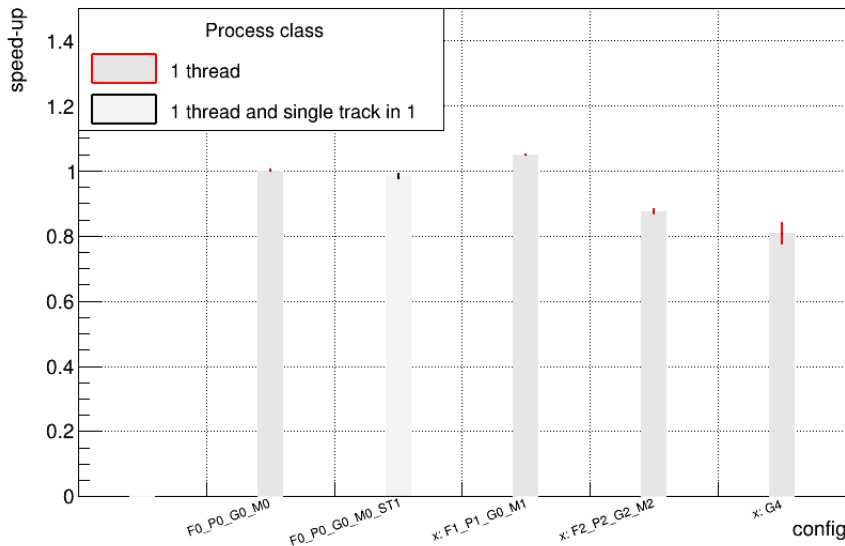
## CPU time per event (1000 events)





# FullCMS Results - Ubuntu 18.04

## CPU Speedup (1000 events)

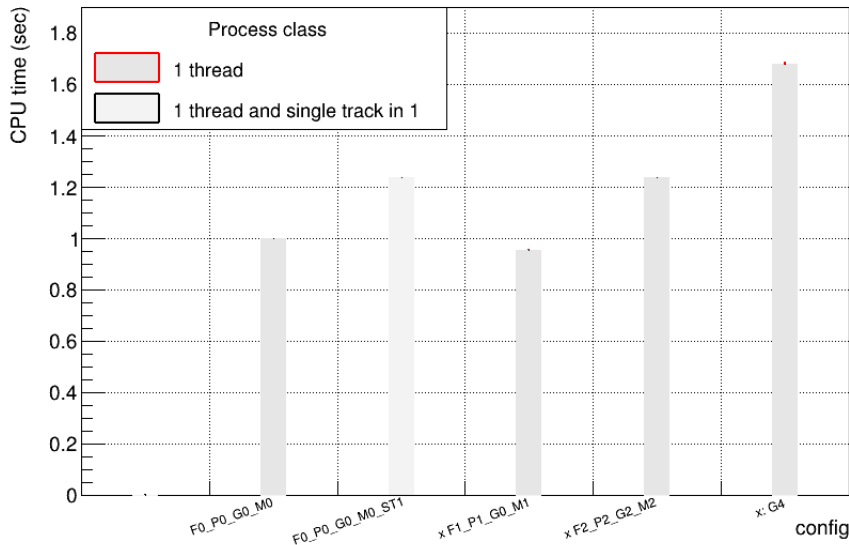


## ► Software and microprocessor

- Fedora Workstation 29
- gcc 8.2.1
- veccore 0.5.2
- Vc 1.3.3
- AMD® A10-7700k radeon r7, 10 compute cores 4c+6g × 4
- Instruction Set Extensions: AVX
- Cache memory 4MB
- Level 1 cache size 2 × 96 KB 3-way set associative shared instruction caches  
Level 1 cache size 4 × 16 KB 4-way set associative data caches
- Level 2 cache size 2 × 2 MB 16-way set associative shared caches
- RAM Memory 16GB

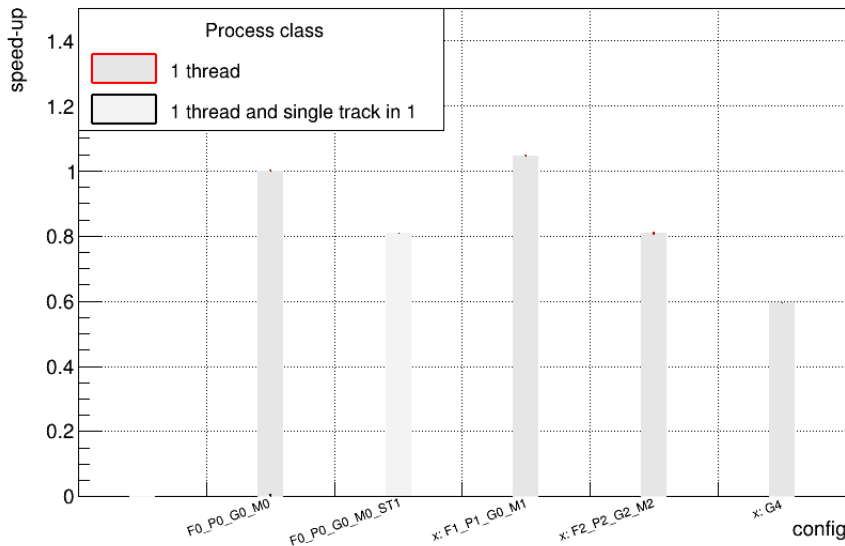
# FullCMS Results - Fedora Workstation 29

## CPU time per event (1000 events)



# FullCMS Results - Fedora Workstation 29

## CPU Speedup (1000 events)

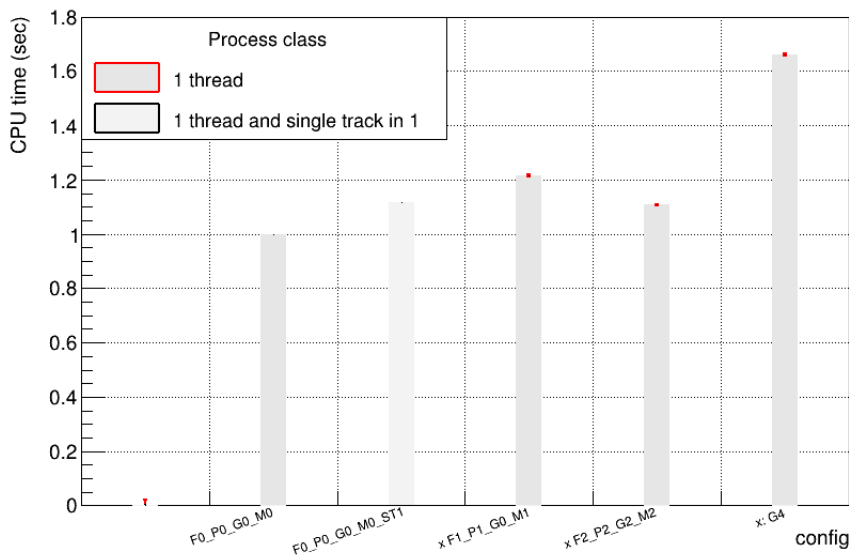


## ► Software and microprocessor

- Fedora Workstation 29
- gcc 8.3.1
- veccore 0.5.2
- Vc 1.3.3
- Intel Celeron(r) CPU 1000M @ 1.80GHzx2
- Instruction Set Extensions: SSE4
- 2 MB SmartCache
- Level 1 cache size 2 x 32 KB 8-way set associative instruction caches
- Level 1 cache size 2 x 32 KB 8-way set associative data caches
- Level 2 cache size 2 x 256 KB 8-way set associative caches
- Level 3 cache size shared 2 MB 8-way set associative cache
- RAM Memory 4GB

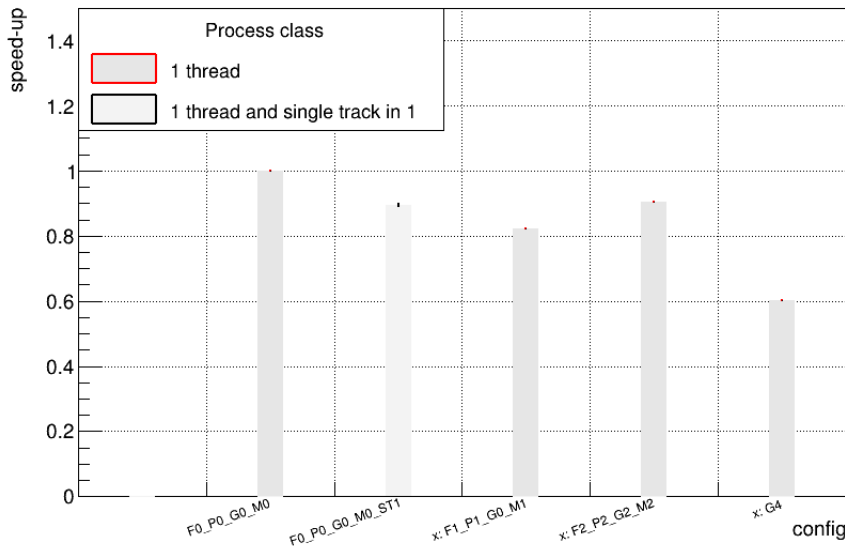
# FullCMS Results - Fedora Workstation 29

## CPU time per event (1000 events)



# FullCMS Results - Fedora Workstation 29

## CPU Speedup (1000 events)

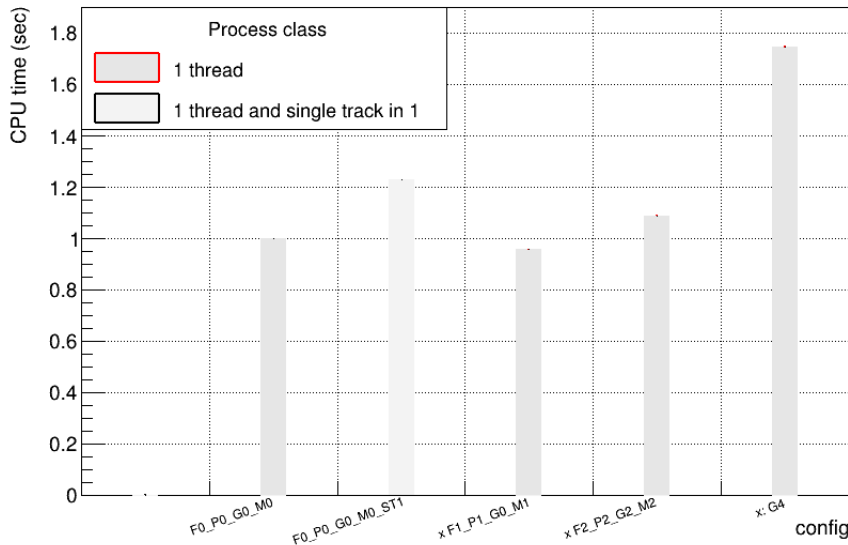


- ▶ Software and microprocessor
  - Fedora Workstation 29
  - gcc 8.2.1
  - veccore 0.5.2
  - Vc 1.3.3
  - IntelCentrino 2
  - Instruction Set Extensions: AVX
  - Cache Memory 4 MB L2
  - Level 2 cache size 6
  - RAM Memory 4GB



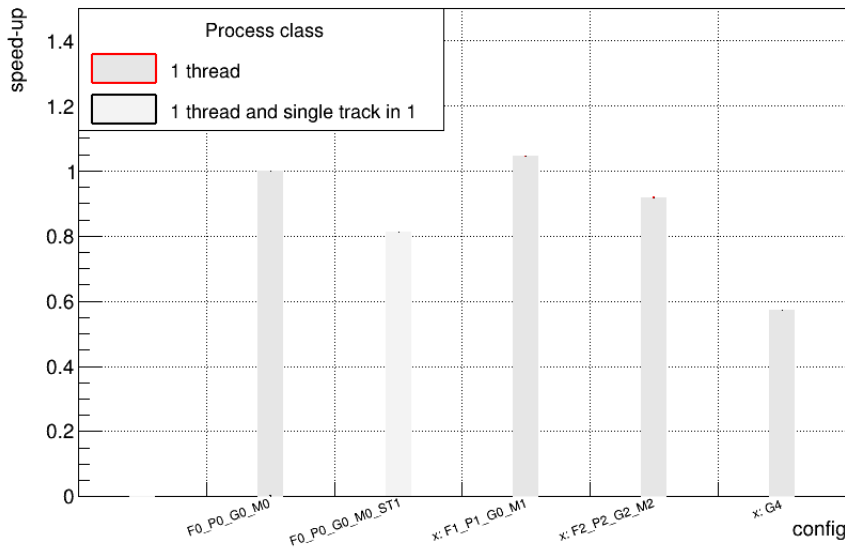
# FullCMS Results - Fedora Workstation 29

## CPU time per event (1000 events)



# FullCMS Results - Fedora Workstation 29

## CPU Speedup (1000 events)



## ► Software and microprocessor

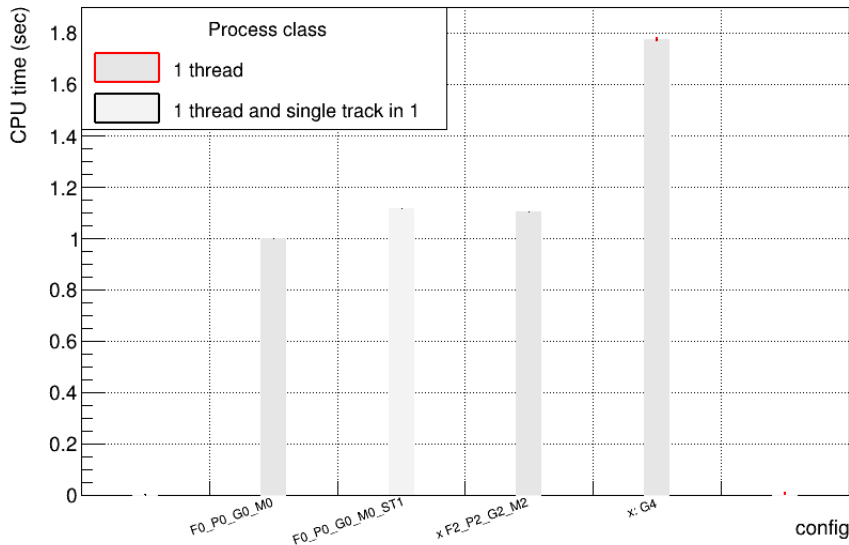
- Ubuntu 18.10
- gcc 8.2.0
- veccore 0.5.2
- Vc 1.3.3
- amd e-300 apu with radeon(tm) hd graphics
- Instruction Set Extensions: SSE2
- Cache Memory 1 MB L2
- Level 1 cache size 2 x 32 KB 2-way set associative instruction caches
- 2 x 32 KB 8-way set associative data caches
- Level 2 cache size 2 x 512 KB 16-way set associative caches
- RAM Memory 4GB

## Error in the combination F1\_P1\_G0\_M1

```
19953 =====
19954 = GeantV run started with 1 propagator(s) using 1 worker threads each ====
19955 Runge-Kutta integration ON with epsilon= 0.0003
19956 =====
19957 Info in <RunSimulation>: Starting propagator 0x561f6483ee20 with 1 threads
19958 === Worker thread 0 created for propagator 0x561f6483ee20 ===
19959
19960 *** Break *** illegal instruction
19961 Generating stack trace...
19962 0x00007f06bb1ba8d5 in void Vc_1::Common::Trigonometric<Vc_1::ImplementationT<4u> >::sincos<Vc_1::Vec
Vc_1::VectorAbi::Sse> const&, Vc_1::Vector<double, Vc_1::VectorAbi::Sse>*, Vc_1::Vector<double, Vc_1:
libGeant_v.so
19963 0x00007f06bb5ac6cb in geantphysics::GSMSCModelSimplified::SampleMSCp2(std::vector<geant::cxx::Track*
0x5db from /opt/GeantV/geant/install/lib/libRealPhysics.so
19964 0x00007f06bb5b0460 in geantphysics::GSMSCModelSimplified::SampleMSC(std::vector<geant::cxx::Track*,
from /opt/GeantV/geant/install/lib/libRealPhysics.so
19965 0x00007f06bb5b0495 in geantphysics::GSMSCModelSimplified::SampleScattering(std::vector<geant::cxx::T
std::allocator<bool> >&, geant::cxx::TaskData*) + 0x1d from /opt/GeantV/geant/install/lib/libRealPhys
19966 0x00007f06bb5cd431 in geantphysics::MSCModel::AlongStepDoIt(std::vector<geant::cxx::Track*, std::al
opt/GeantV/geant/install/lib/libRealPhysics.so
19967 0x00007f06bb6547dd in geantphysics::PostPropagationVectorHandler::DoIt(geant::cxx::Basket&, geant::c
install/lib/libRealPhysics.so
19968 0x00007f06bb15b3db in geant::cxx::SimulationStage::Process(geant::cxx::TaskData*) + 0x18b from /opt/
19969 0x00007f06bb16818d in geant::cxx::WorkloadManager::SteppingLoop(geant::cxx::TaskData*, bool) + 0x1ad
19970 0x00007f06bb168d77 in geant::cxx::WorkloadManager::TransportTracksV3(geant::cxx::Propagator*) + 0x47
19971 0x00007f06bafca63f in <unknown> from /usr/lib/x86_64-linux-gnu/libstdc++.so.6
19972 0x00007f06bb6ce164 in <unknown> from /lib/x86_64-linux-gnu/libpthread.so.0
19973 0x00007f06bac96def in clone + 0x3f from /lib/x86_64-linux-gnu/libc.so.6
```

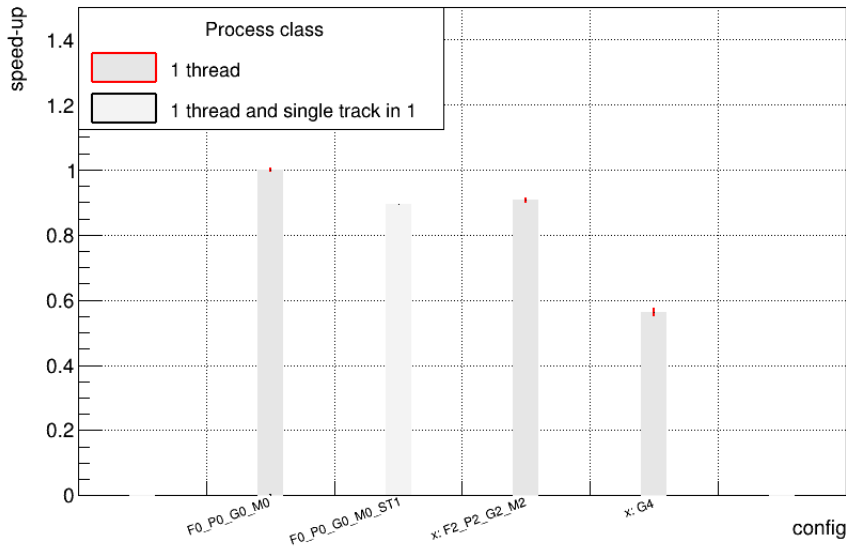
# FullCMS Results - Ubuntu 18.10

## CPU time per event (1000 events)



# FullCMS Results - Ubuntu 18.10

## CPU Speedup (1000 events)



# Summary

| Test | CPU                  | Instruction set | Time-F0-P0-G0-M0(GV0) | G4/GV0           | strk/GV0         | F1-P1-G0-M1/GV0    | F2-P2-G2-M2/GV0  |
|------|----------------------|-----------------|-----------------------|------------------|------------------|--------------------|------------------|
| 1    | Intel i7<br>2.5GHz   | AVX2            | 1,015.27s<br>± 0.4%   | 1.2102<br>± 2%   | 1.0206<br>± 1.1% | 0.9561<br>± 0.5%   | 1.1473<br>± 0.6% |
| 2    | Intel R<br>2.5GHz    | AVX             | 1,170.861s<br>± 0.5%  | 1.2382<br>± 2.6% | 1.0167<br>± 1.1% | 0.9526<br>± 0.4%   | 1.1430<br>± 0.8% |
| 3    | AMD A10-<br>7700k    | AVX             | 1,848.917s<br>± 0.7%  | 1.6797<br>± 3.4% | 1.2376<br>± 1.3% | 0.9555<br>± 0.4%   | 1.2373<br>± 0.8% |
| 4    | Intel R<br>1.8GHz    | SSE4            | 2,356.618s<br>± 0.2%  | 1.6614<br>± 0.2% | 1.1163<br>± 0.6% | 1.2164<br>± 0.3%   | 1.1069<br>± 0.2% |
| 5    | Intel Cen-<br>trino2 | AVX             | 2,767.556s<br>± 0.1%  | 1.7454<br>± 0.2% | 1.2290<br>± 0.3% | 0.9573<br>± 0.1%   | 1.0887<br>± 0.1% |
| 6    | AMD<br>e-300         | SSE2            | 10,011.05s<br>± 0.7%  | 1.7742<br>± 0.1% | 1.1168<br>± 0.4% | Error <sup>1</sup> | 1.1030<br>± 0.7% |

<sup>1</sup>The error is specified in slide 20

# Summary

Performance gain ( $\alpha$ ) with respect to Test 1 (Time0)

$$\alpha = \frac{\text{Time0} \times \text{CPU0}}{\text{Time} \times \text{CPU}} \quad (1)$$

| Test | CPU                    | Instruction set | Time GV0 | G4     | strk   | F1-P1-G0-M1 | F2-P2-G2-M2 |
|------|------------------------|-----------------|----------|--------|--------|-------------|-------------|
| 1    | Intel i7 2.5GHz        | AVX2            | 1        | 1      | 1      | 1           | 1           |
| 2    | Intel R 2.5GHz         | AVX             | 0.8671   | 0.9774 | 1.0038 | 1.0037      | 1.0038      |
| 3    | AMD A10-7700k          | AVX             | 0.5491   | 0.7205 | 0.8247 | 1.0006      | 0.9273      |
| 4    | Intel R 1.8GHz         | SSE4            | 0.43083  | 0.7284 | 0.9143 | 0.7860      | 1.0365      |
| 5    | Intel Centrino2        | AVX             | 0.3668   | 0.6934 | 0.8304 | 0.9987      | 1.0538      |
| 6    | AMD e-300 <sup>2</sup> | SSE2            | 0.1014   | 0.6821 | 0.9139 | Error       | 1.0402      |

<sup>2</sup>The compiled Vc library was not the default library, because it did not compile, I used another SSE2 configuration



## Results of GV0 of the Test 6

| Number of trie | Realtime (s) | CPUTime (s) |
|----------------|--------------|-------------|
| 1              | 10062.1      | 10016.4     |
| 2              | 10038.5      | 9996.3      |
| 3              | 10051.5      | 10008.9     |
| 4              | 10172.2      | 10127.9     |
| 5              | 10127.7      | 10086.5     |
| 6              | 9977.21      | 9934.95     |
| 7              | 10054.3      | 10009.5     |
| 8              | 9967.63      | 9924.54     |
| 9              | 10124.3      | 10081.3     |
| 10             | 9966.36      | 9924.21     |