Computing Performance Results and Issues: CMS

S. Banerjee (Wisconsin-Madison), N. Forzano (CERN), V. Innocente (CERN),
V. Ivantchenko (CERN/Princeton), N. Krammer (HEPHY), S. Muzaffar (CERN), D. Piparo (CERN)
On behalf of the CMS Collaboration

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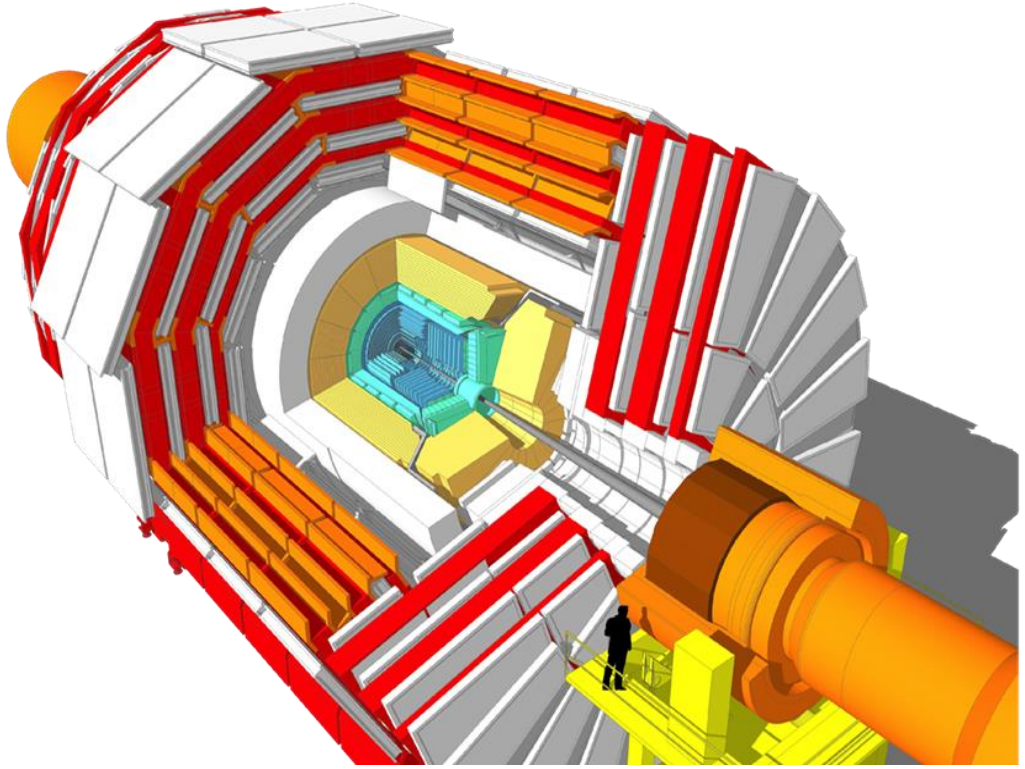
Outline

- CMS full simulation (FullSim)
- Updates for start of Run3
- CPU/memory monitoring
- Further improvements for Run3 FullSim
- Problems with Phase2 simulation

- Due to limited time for this talk, fast simulation for CMS will not be discussed. Fast simulation is used in some significant part of analyses of the CMS experiment data.

CMS FullSim

- FullSim of the CMS experiment include following stages
  - Monte Carlo generation of pp or ion-ion collision (GEN)
  - Geant4 particle transport and simulation of hits (SIM)
  - Digitisation and overlay of the pile-up (DIGI)
  - The most time-consuming part is GEN-SIM
    - Separate runs in production
  - References:
    - *D.J. Lange et al., J. Phys.: Conf. Ser. 608, 012056 (2015)*
    - *M. Hildreth et al., J. Phys.: Conf. Ser. 664, 072022 (2015)*
- For Run-2 SIM production it was used
  - MT mode from 2017
  - Geant4 10.4p03 + VecGeom since 2018 (legacy MC production)
  - The configuration of physics includes
    - FTFP_BERT_EMM Physics List
    - Russian roulette method
    - HF (forward hadronic calorimeter) shower library
  - References:
    - *M. Hildreth et al., J. Phys.: Conf. Series 898, 042040 (2017)*
    - *V. Ivanchenko and S. Banerjee, EPJ Web of Conf. 214, 02012 (2019)*



Updates for start of Run3

- Updates for start of FullSim production for Run3
  - Reference:
    - *V. Ivanchenko et al. EPJ Web Conf. 251 (2021) 03016 • Contribution to: vCHEP2021*
  - New software platform el8_amd64_gcc10
  - Geant4 10.7.2 + backport of few critical patches
  - DD4hep geometry description
  - Tuned FTFP_BERT_EMM physics configuration
    - Overlap energies between the Bertini Cascade and the FTFP string model for pions from 3 to 12 GeV
    - The Birks coefficient for the HCAL scintillator is increased by about 15%
  - Three sets of parameters for tracking in field
    - set 1 - for central detector region R < 8 m, |Z| < 11 m, and E > 200 MeV;
    - set 2 - for low-energy particles E < 15 MeV;
    - set 3 - for the rest.

Magnetic field parameters	Parameter set 1	Parameter set 2	Parameters set 3
DeltaIntersection (mm)	10^{-6}	0.01	10^{-4}
DeltaOneStep (mm)	10^{-4}	0.1	10^{-3}
DeltaChord (mm)	10^{-3}	0.1	$2 \cdot 10^{-3}$
MaxStep (cm)	150	150	50

Further improvements for Run3 FullSim

- Already adopted
  - Gamma general process
  - CMSTDormandPrince45 stepper
  - Tracking cut increased from 1 to 25 keV
  - Overall CPU effect ~5%
- Under preparation
  - New platform el8_amd64_gcc11
  - G4FLowE Gflash for e+- (*EPJ Web Conf. 251 (2021) 03016*)
  - Geant4 11.1
    - *Geant4 11.0.7 is integrated into CMSSW*
    - *CPU/memory effect is promising*
  - Neutron general process – to be confirmed
  - Transportation with MSC – to be confirmed
  - Advanced compiler options – next slide

Advanced compiler options (LTO/PGO)

- Full report will be at ACAT 2022
- LTO: runtime reduction for ttbar 3.2 %
- PGO: it was confirmed that optimisation for ttbar events work for other type of events
- LTO+PGO variant provides ~10% speedup

# of Events	For running →	150	384	384	384	150
To create profile ↓	Processes	TTBar	MinBias	Zmumu	Single e	Phase-2 TTBar
25	TTBar	10,7%	10,2%	10,4%	16,0%	9,2%
64	MinBias	8,9%	9,5%	10,8%	11,9%	9,0%
64	Zmumu	9,5%	11,0%	9,5%	12,0%	8,2%
64	Single e	6,8%	7,7%	6,9%	12,6%	6,6%
25	Phase-2 TTBar	7,6%	8,4%	7,0%	8,8%	12,1%

Problems with Phase2 simulation

- Phase-2 geometry includes a novel HGCal fine grain calorimeter
- For testing 2 workflows are used:
  - Run3 geometry (2021) and Phase2 geometry (2026D88)
  - each for 5 physics lists: FTFP_BERT, FTFP_BERT_EMM, FTFP_BERT_EMN, FTFP_BERT_EMY, and FTFP_BERT_EMZ
- Phase-2/Run-3 time per event is more than factor 2

		2021	Setup			2026D88	Setup	
	Min.	Bias	t-	tbar	Min.	Bias	t-	tbar
	CPU	RSS	CPU	RSS	CPU	RSS	CPU	RSS
EMM	1.000	0.75 GB	1.000	0.60 GB	1.981	0.73 GB	2.351	0.73 GB
EMN	1.078	0.75 GB	1.363	0.76 GB	3.829	1.19 GB	3.999	1.24 GB
EMY	1.585	0.76 GB	1.917	0.76 GB	3.320	0.93 GB	3.232	0.98 GB
EMZ	2.571	1.06 GB	3.558	1.06 GB	4.607	1.25 GB	5.959	1.34 GB
Standard	1.722	0.59 GB	1.505	0.60 GB	2.854	0.74 GB	2.570	0.78 GB

Summary

- CMS FullSim evolution during LS2:
  - Geant4 10.4.3 -> 10.7.2
  - Reduced CPU per event
  - Increased RSS memory
- In CMS short term plans for Run-3
  - Geant4 11.1
  - Faster FullSim without compromise of physics performance
- Phase-2 FullSim is a challenge
  - Factor 2-3 depending on event type and physics configuration