Simulation of the DAMPE detector

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DAMPE Offline Software

The DAMPE offline software is the platform for data production including simulation, calibration, reconstruction and analysis, based on a light-weight, flexible, functional and efficient framework [1], as is shown in Fig1. This framework is widely exercised and applied for the cooperation in DAMPE collaboration.

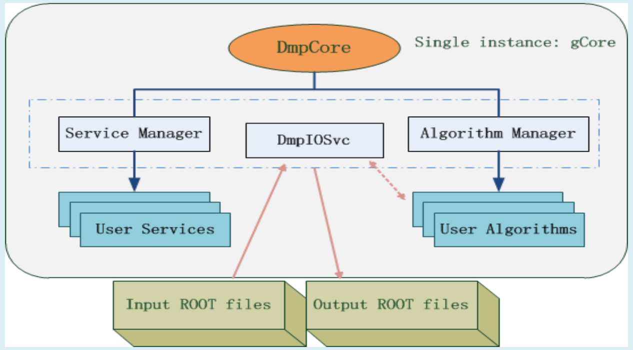

Figure 1: Core of DAMPE framework [1]

Computing Farms

Site	Computing Resource
Purple Mountain Observatory	2000 CPUs/day
Sunway Taihu Light	4000 CPUs/day
Beijing Super Cloud Computing Center	Flexible, ~10000 CPUs/day
CNAF Tier 1	300 CPUs/day
Bari Tier 3	700 CPUs/day
University of Geneva	170 CPUs/day
Swiss National Supercomputing Centre	Flexible

Summary: 7170 CPUs/day and more flexibility

Detector Simulation

The DAMPE simulation tool employs two types of widely used software, GEANT4[2] and FLUKA [3], which implement various physics lists to simulate the interactions of particles in the detector. The CRMC [4] is linked to GEANT4 via GEANT4-CRMC interface [5] for the simulation up to PeV of hadronic processes. The geometric model is shown in Fig 2.

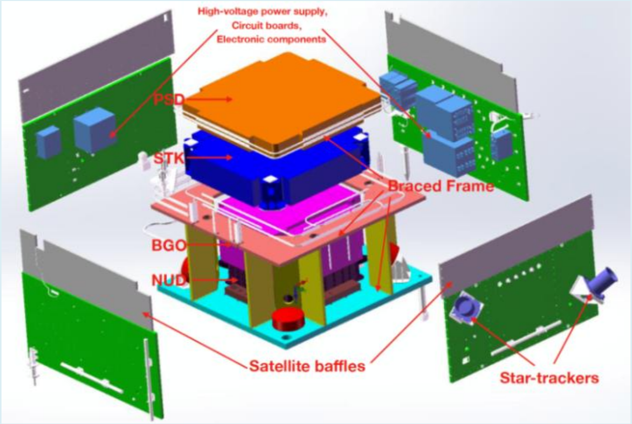

Figure 2: The visualization of the geometry of the DAMPE detector for MC simulation, including the payload and the entire satellite platform [6].

Physics modes for simulation:

- GEANT4
  - **QGSP_FTFP_BERT**: officially recommended
  - **FTFP_BERT**: hadronic model up to 100 TeV
  - **FTFP_BERT_HP**: High Precision neutron modes
  - **EPOS_LHC**: hadronic model up to 1 PeV, GEANT4-CRMC interface
- FLUKA
  - **PEANUT**: default configuration
  - **RQMD**: hadronic model above 0.125 GeV
  - **DPMJET-III**: hadronic model up to 1 PeV

MC Data Comparison

An important reason why we spend so much doing so many different simulations is to determine the largest systemic uncertainties in cosmic ray nuclei energy spectrum measurements from the hadronic interaction models, such as Fig3, the systematic uncertainty for proton spectrum [6].

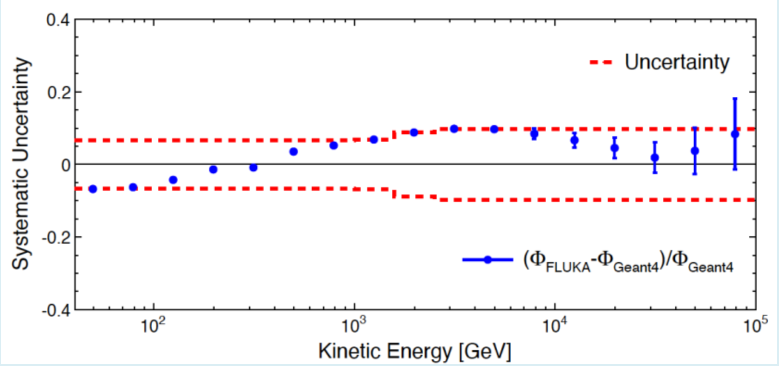

Figure 3: Energy dependence of the proton flux difference between GEANT4 and FLUKA [6] The blue points show the difference of measured proton spectrum assuming FLUKA simulation with respect to the spectrum based on GEANT4 simulation. The dashed lines correspond to the associated systematic uncertainty claimed in Ref. [7].

References:

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[5] A. Tykhonov et al., PoS(ICRC2019) (2019), vol. 358, p. 143.
[6] W. Jiang et al., Chin. Phys. Lett., 37, 119601 (2020)
[7] Q. An et al. (DAMPE), Science Advances, 5, eaax3793 (2019)