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CMS Simulation Software

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The CMS simulation, based on the Geant4 toolkit, has been operational within the new CMS software framework for more than four years. The description of the detector including the forward regions has been completed and detailed investigation of detector positioning and material budget has been carried out using collision data. Detailed modelling of detector noise has been performed and validated with the collision data. In view of the high luminosity runs of the Large
Hadron Collider, simulation of pile-up events has become a key issue. Challenges have raised from the point of view of providing a realistic luminosity profile and modelling of out-of-time pileup events, as well as computing issues regarding memory footprint and IO access. These will be especially severe in the simulation of collision events for the LHC upgrades; a new pileup simulation architecture has been introduced
to cope with these issues.

The CMS detector has observed anomalous energy deposit in the calorimeters and there has been a substantial effort to understand these anomalous signal events present in the collision data. Emphasis has also been given to validation of the simulation code including the physics of the underlying models of Geant4. Test beam as well as collision data are used for this purpose. Measurements of mean response, resolution, energy sharing between the electromagnetic and hadron calorimeters, shower shapes for single hadrons are directly compared with predictions from Monte Carlo. A suite of performance analysis tools has been put in place and has been used to drive several optimizations to allow the code to fit the constraints posed by the CMS computing model.

Student? Enter 'yes'. See http://goo.gl/MVv53

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Summary

CMS has been validating the physics models inside Geant4 using its test beam as well as collision data. Several physics lists inside the most
recent version of Geant4 provide good agreement of the energy response, resolution of $\pi^{\pm}$ and protons. More work is needed to improve
the physics for charged kaons,anti-protons and hyperons.

Electromagnetic physics in Geant4 gives a good description of shower shapes for electron and photon candidates in the collision data. Isolated charged particles are used to measure calorimeter response of hadrons as a function of particle energy. These are used to compare data with Monte
Carlo predictions. There is an impressive agreement between Geant4 predictions and data in the barrel region. The agreement worsens in the endcap region. This is currently under investigation.

Rare anomalous hits in the calorimeter can be explained using the present transport codes in Geant4. Thus bulk as well as rare events can
be handled by the physics models within Geant4.

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