



Using TurboSim for Fast Detector Simulation

A. P. Singh⁽¹⁾, S. B. Beri⁽¹⁾, L. K. Saini⁽¹⁾, H. B. Prosper⁽²⁾



⁽¹⁾Panjab University, Chandigarh, IN.

⁽²⁾Florida State University, U.S.

Abstract: The new physics searches like SUSY in the CMS detector at the LHC will require a very fine scanning of the parameter space over a large number of the points. Accordingly we need to address the problem of developing a very fast setup to generate and simulate large MC samples. We have explored the use of TurboSim as a fast and the standalone setup for generating such samples. TurboSim does not intend to replace full simulation rather it uses the full simulation to create a lookup table for mapping the generator level particles into the particle level objects. Here we present the details of validation exercise performed by comparing TurboSimulated events with the full detector simulation using (Z->ee) candle analysis. TurboSim was trained using the datasets created with the full detector simulation, then it was used to simulate the detector response for a parton level Z->ee sample. Currently, we show some preliminary comparisons between the kinematic distributions obtained from complete simulation and TurboSim.

CMS SIMULATION

FULL SIMULATION

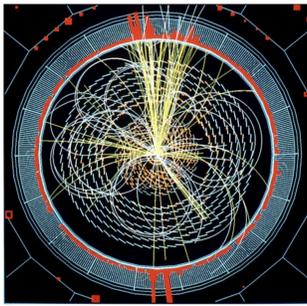
CMS uses Geant4 [1] toolkit to simulate the detector response (FullSim). Huge efforts are required for tuning such a framework. Also the CPU time to simulate a single event can be very large.

FAST SIM

The FastSim (FAMOS) [2] uses "Gflash" for parameterized simulation of showers.

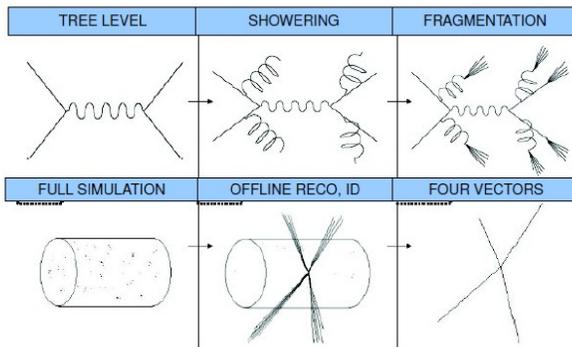
TURBOSIM (??)

Uses the lookup tables (LUT) [3] instead of actual parametrized functions. The LUTs are created using FullSim samples.

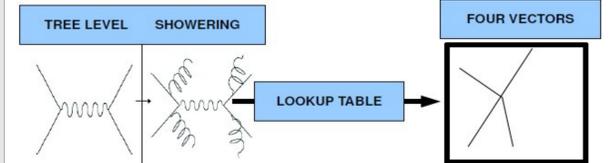


- Quaero@CDF [4]
- Unexplored at CMS !!!
- We present a very simple study to check the performance and fidelity with TurboSim

FULL SIMULATION CHAIN



TURBOSIM STRATEGY



- Replace "fragmentation", "full simulation" and "offline reconstruction" with "lookup tables".
- Tables are created using "parton" and "reconstruction" level samples from FullSim.
- Tables can then act like "parametrized functions" used by "FAMOS".....only this is much faster !!!

TURBOSIM:INPUT/OUTPUT

- "partonEvent_train.txt": The gen level input file (both for training and simulation).

Sig 0 1 pp 10000 xxx zvtx part pt eta phi jet mass pt eta phi.;

Sig 0 1 pp 10000 143.652 0 tau+ 95.925 3.939 -75.52 j 0 38.54 4.252 96.56;

Sig 1 1 pp 10000 241.04 0 tau- 38.47 2.92 153.27 j 0 182.218 3.78 -36.1 ;

- "recoEvent_train.txt": The reco level input/output file (Note the events without any reconstructed particle).

Sig 33 1 pp 10000 0 -0.00229183 ;

Sig 34 1 pp 10000 108.37 -0.002 j 8.55 49.10 1.30 -162.93 e- 20.19 1.257 -167.61 ;

Sig 35 1 pp 10000 218.17 -0.002 j 6.35 72.17 1.25 3.80 j 4.26 67.07 0.056 179.51 e+ 40.81 0.07 -178.79 e- 38.11 1.25 1.19 ;

- Create the Morphism Tables: The morphism tables are created with following command,

turboSim -create turbosimMorphisms.txt partonEvent_train.txt recoEvent_train.txt

MORPHISM TABLES

SEPARATE FILE FOR EACH END STATE

turboSimMorphisms.txt_e+j.txt turboSimMorphisms.txt_mu+tau+.txt

turboSimMorphisms.txt_e+mu+.txt turboSimMorphisms.txt_mu+tau-.txt

turboSimMorphisms.txt_e+mu-.txt turboSimMorphisms.txt_pairingFraction_.txt

A PEEP INTO MORPHISM TABLES:

PARTON LEVEL

10 sig 9 0 mu+ 15.874 -1.07 160.55 ; -> ;

12 sig 11 0 mu+ 27.926 1.036 -140.09 ; -> ;

22 sig 21 0 mu+ 64.204 -1.065 -59.11 ; -> ;

23 sig 22 0 mu+ 60.457 0.279 7.67 ; -> ;

29 sig 28 0 mu+ 56.197 -1.532 22.49 ; -> ;

38 sig 37 0 mu+ 27.433 -3.276 174.9 ; -> ;

40 sig 39 0 mu+ 34.059 -0.783 -126.09 ; -> ;

RECO LEVEL

mu+ 27.948 1.036 -140.16 ;

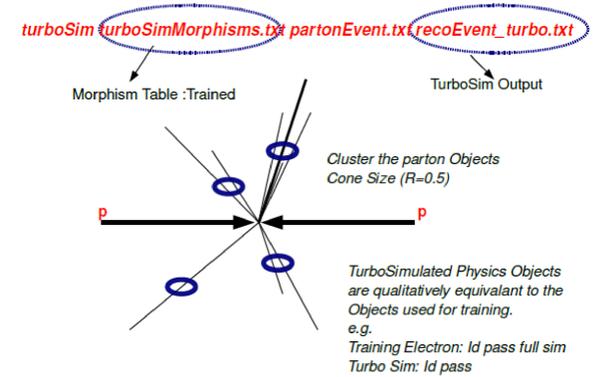
mu+ 62.89 -1.06 -59.14 j 12.07 49.69 -1.50 -42.0;

mu+ 61.002 0.279 7.68 ;

mu+ 57.437 -1.533 22.48 ;

mu+ 33.929 -0.783 -126.16 ;

TURBO SIMULATE !!!



VALIDATION EFFORT

- Training Sample:

We need to train the TurboSim using a sample containing most of the possible endstates at the CMS. Current study uses the SUSY LM0 samples, since they contain events with multiple leptons, jets, taus and large missing Et. We expect slight bias in morphism tables toward high pT regions due to topology of the LM0 events. Another motivation for working with these samples is that SUSY searches can provide an important application scenario where TurboSim may be used to simulate events over a large number of points in the SUSY parameter space.

- Testing Sample:

The trained TurboSim framework (morphism tables) were used to simulate the the Z+Jet samples generated using MadGraph. The current study compares the kinematic distributions of electrons and muons in samples simulated with FullSim and TurboSim frameworks. The invariant mass and kinematic distributions for dielectrons and dimuons are also compared. Another study is underway for comparing the yields, and distributions in each bin of jet multiplicity. The angular correlations between the jet-jet, jet-lepton and lepton-lepton pairs are being looked into.

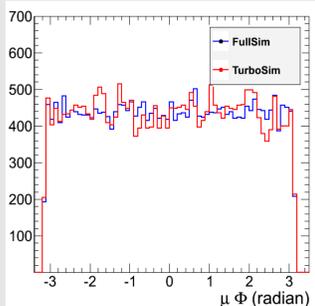
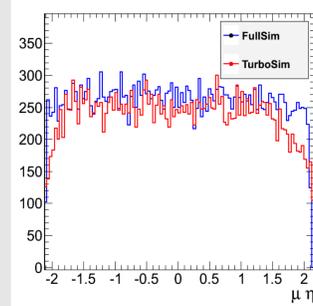
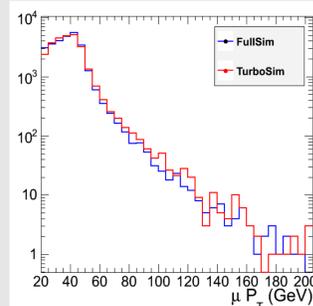
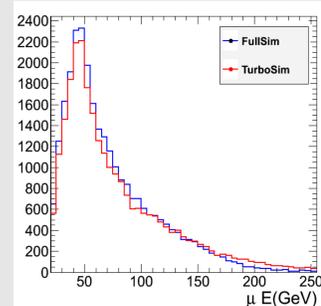
Energy

Trans. Momentum

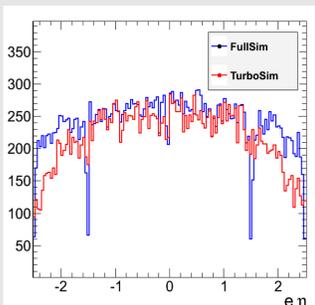
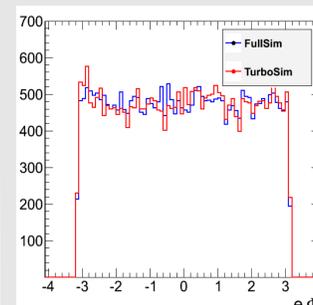
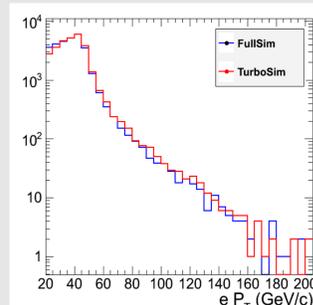
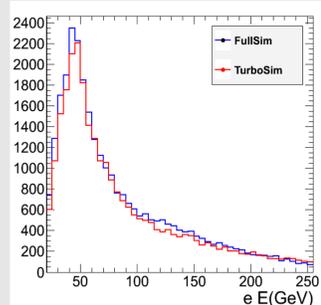
Pseudo-Rapidity

Azimuthal-Angle

Muons



Electrons



OBSERVATIONS

- Events used for training are independent of those used for test, yet the distributions from TurboSim and FullSim are well correlated.
- Individual events classified into a particular state by TurboSim are n't necessarily classified into same state by FullSim. Still TurboSim does good job reproducing the various distributions.
- The topology of the events used for training may introduce bias in the morphism tables, for example our study shows clear biasing toward higher side of lepton pT. This may also cause suppression of possible new signals which might be absent in training sample.

SUMMARY

TurboSim is a self tuning detector simulation framework which uses the knowledge of full simulations. Earlier successes for TurboSim were the commissionsng at ALEPH [5] and CDF [6].

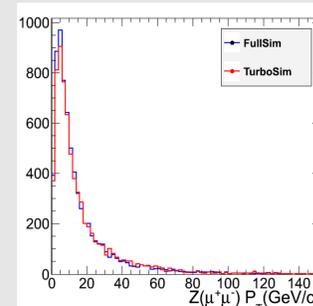
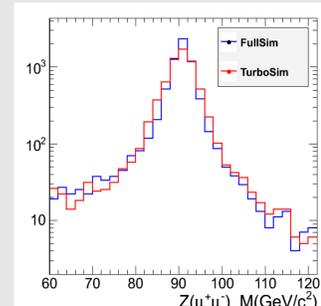
We presented the preliminary results for a simple validation exercise for TurboSim at CMS detector. These initial results are encouraging since we obtained a reasonable agreement between kinematic distributions in FullSim and TurboSim samples.

More involved studies looking into the various final states, correlations between the observables and CPU requirements are underway. The final aim of this validation exercise is to check the usability of "TurboSim" for quick generation of large MC samples.

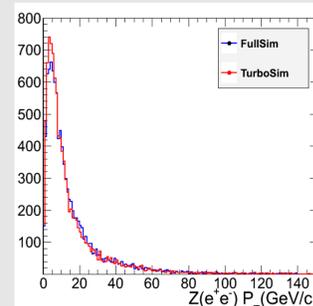
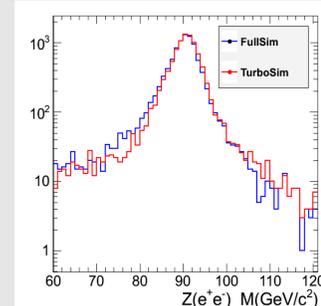
Invariant Mass

Trans. Momentum

Di-Muons



Di-Electrons



OUTLOOK

As a post validation scenario we intend to use the TurboSim for generating large MonteCarlo samples at various points in SUSY parameter space. Such searches at the moment use the CMSSW MC productions at certain low mass (LM) points. Samples generated at additional points using TurboSim can be used as complementary to FullSim samples thereby allowing finer scanning.

REFERENCES

- [1]. The CMS Offline Workbook. <https://twiki.cern.ch/twiki/bin/view/CMS/WorkBook>
- [2]. Dongwook Jang 2009. CMS-CR-2009/343
- [3]. B. Knuteson 2004. TURBOSIM A self Tuning Fast Detector Simulation; <http://mit.fnal.gov/knuteson/papers/turboSim.ps>
- [4]. B. Knuteson 2003. The QUAERO Algorithm; <http://mit.fnal.gov/knuteson/Quaero/quaero/doc/algorithm/algorithm.ps>
- [5]. Kyle S. Cranmer 2005, Searching For New Physics: Contribution to LEP and the LHC; PhD Dissertation submitted to "University of Wisconsin-Madison".
- [6]. B. Knuteson, D. Friend, K. Makhoul 2005, presentation titled: TurboSim: A fast, self tuning detector simulation.