Fast MC simulation for top studies

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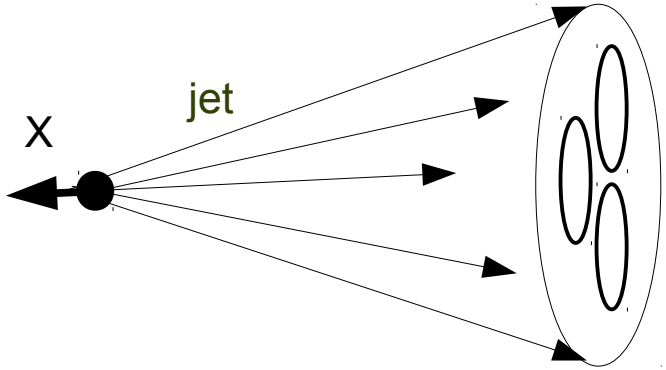
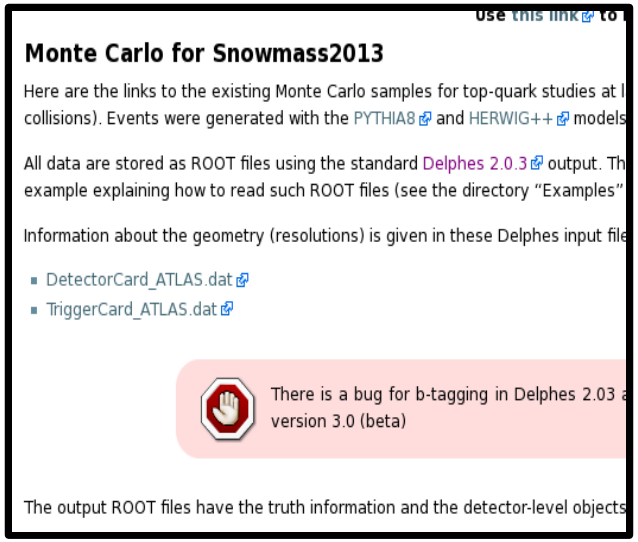
Introduction

- **~ 3 months ago we have started a new project called "Inclusive boosted top studies" using a fast MC simulation (Delphes) for LO+PS models + appox.NNLO (pp collisions with 14 TeV)**
  - **http://arxiv.org/abs/1301.5810**



- **MC samples are rather general and can be of interest for many doing top or QCD studies**
- **I'll try to summarize:**
  - MC types/ settings
  - What detector geometries were used?
  - How to download these samples?
  - How to analyse these sample?
  - Why do we need all of this?

See the wiki:



https://atlaswww.hep.anl.gov/asc/wikidoc/doku.php?id=snowmass2013:montecarlo

PYTHIA8 (v170) for high-pT inclusive jets (pp, 14 TeV)

- PYTHIA8 default tuning. No top quarks. No pile-up
  - gg-> gg, gg->qqbar, qg-> qg, W/Z+jets, gamma+jet, gamma+gamma
  - High-pT sample (good for pT(jet)>700-800 GeV):
    - PhaseSpace:mHatMin = 650 GeV
    - PhaseSpace:pTHatMin = **650 GeV**
- No any filtering at the truth level. Only the ME phase-space cuts
- 1.6M events, ~ 9.6 fb-1

Processed with Delphes 2.03 using the ATLAS geometry (S-term resolution ~10% for EM, 52% for HCAL). See:

- http://atlaswww.hep.anl.gov/asc/snowmass2013/info/DetectorCard_ATLAS.dat

- *Note:*
  - different compared to the "140" pile up events card from Tom LeCompte:
  - http://www.snowmass2013.org/tiki-index.php?page=Energy_Frontier_FastSimulation
  - Main difference: energy resolution for EM is larger (constant and the S term)
  - B-tagging has different pT dependents (constant term)
  - Hadronic calorimeter resolution does not change
  - see the discussion later

HERWIG++ 2.6.2 for inclusive jets (pp, 14 TeV)

- HERWIG++ defaults. No top quarks. No pile-up

  - set /Herwig/Cuts/JetKtCut:MinKT **650.0*GeV**
  - ## This should be <= 2 * JetKtCut:MinKT unless you *want* a mhat cut. Default is 20 GeV.
  - set /Herwig/Cuts/QCDCuts:MHatMin 1200.0*GeV
  - # Colour reconnection settings
  - set /Herwig/Hadronization/ColourReconnector:**ColourReconnection Yes**
  - set /Herwig/Hadronization/ColourReconnector:ReconnectionProbability 0.6165547
  - # Colour Disrupt settings
  - set /Herwig/Partons/RemnantDecayer:colourDisrupt 0.3493643
  - # inverse hadron radius
  - set /Herwig/UnderlyingEvent/MPIHandler:InvRadius 0.81

- No any filtering at the truth level. Only ME phase-space cuts
- 1.6M events, ~ 9.6 fb-1

Exactly as PYTHIA8: Processed with Delphes 2.03 using the ATLAS geometry

PYTHIA8 (v170) for $t\bar{t}$ (pp, 14 TeV)

- PYTHIA8 default tuning. No pile-up
  - *Top:gg2ttbar = on*
  - *Top:qqbar2ttbar=on*
  - *PhaseSpace:mHatMin* = ***650 GeV***
  - *PhaseSpace:pTHatMin* = 650 GeV

- No filtering at the generator level
- Good for “boosted ” high-pT top studies
- 400k events, > 100 fb-1

Processed with Delphes 2.03 using the ATLAS geometry input
  - S-term resolution ~10% for EM, 52% for HCAL

HERWIG++ 2.6.2 for $t\bar{t}$ (pp, 14 TeV)

- HERWIG++ default tuning. $t\bar{t}$. No pile-up

  - set /Herwig/Cuts/JetKtCut:MinKT **650.0*GeV**
  - ## This should be <= 2 * JetKtCut:MinKT unless you *want* a mhat cut. Default is 20 GeV.
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  - # inverse hadron radius
  - set /Herwig/UnderlyingEvent/MPIHandler:InvRadius 0.81

- 400k events, > 100 fb-1

Exactly as PYTHIA8: Processed with Delphes 2.03 using the ATLAS geometry

PYTHIA8 (v170) for low-pT $t\bar{t}$ (pp, 14 TeV)

- PYTHIA8 default tuning. No pile-up
  - Top:gg2ttbar = on
  - Top:qqbar2ttbar=on
  - no ME cuts
- Good for “inclusive” top studies
- 400k events

Processed with the **Delphes 3.0**(b) fast simulation using the CMS geometry

- ATLAS geometry is not included in this release
- b-tagging is claimed to be fixed (did not check yet)
- Delphes 3(b) has cleaner C++ code & simpler examples.

How to get the ROOT files

First, get the ROOT files from the ANL server (~10 Gb/s)

https://atlaswww.hep.anl.gov/asc/wikidoc/doku.php?id=snowmass2013:montecarlo

Use the "download.py" script to copy any number of ROOT files.
Each file has 5,000 generated events
Example: download 5 files with PYTHIA $t\bar{t}$ (pT>650 GeV):

```
python download.py 5 pythia8/ttbar650pt pythia8_ttbar_pt650
```

Nr of files to download

Directory

Generic name

(can stop it as [Ctrl]-[C] and restart it an any time)

Do not try to download all files (~80). Try first a few files

For ATLAS folks, I can try to register these samples on the ATLAS VO grid.

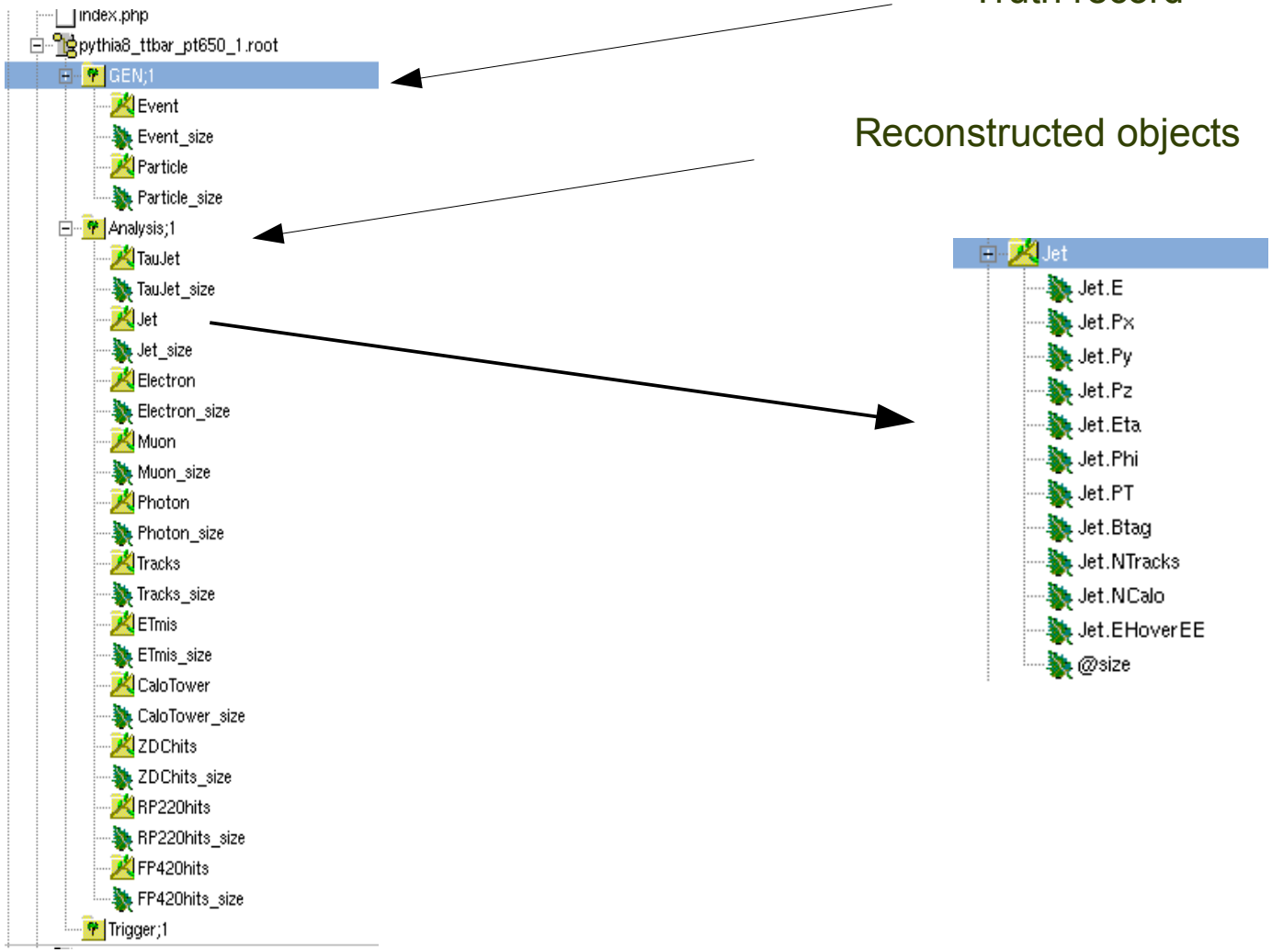
How to analyze

Get a few files and open them in TBrowser to see what is inside

>> root
>> TBrowser a

- A more complicated C++ program which reads all ROOT files from a given directory is posted on the web
- Note:
  - The program tightly integrated with the Delphes libraries
  - You should still install Delphes
  - Also Delphes 2.03 and 3.0(b) are quite different and need to be compiled separately

Look at the structure:



How to generate Delphes samples (i.e. what I do).

- Install PYTHIA8, Herwig++-2.6.1 and ThePEG-1.8.1 ,
- Install HepMC library to convert original event record to *.hepmc (can be large!)
- Install Dephes (many useful libraries, like “FastJet” etc. are included)
- Generate HepMC record (5000 events) and process with Delphes
- This is all done automatically using ANL Tier3
  - Condor+Arcond front-end & 160 processing cores

- I can develop a step-by step installation instruction & prepare installation package if needed
  - needs some time to design it
- To generate ~tens of thousands events is realistic on a single desktop
  - much less realistic to have realistic statistics for inclusive QCD backgrounds

What next ?

- Pile up simulation?
- Generate samples using “140” pile up events card from Tom?
- Working on merging truth event record (HepMC) from signal & MB events using 7-TeV MB extrapolation parameters
- Then events will be processed with Delphes as before
  - will be ready in several weeks

Back to physics

- All MC's were generated for rather specific analyses (boosted top), but can also be used in many studies

- Questions:
  - are these MCs realistic to describe hadronic final states in terms of jet resolution etc.?
  - are they realistic to describe the known top-quark spectra?
    - Note: ALPGEN and MC@NLO are more popular (but do not expect much change for "boosted" jet properties given by PS)
  - should the simulation be done for lower CM energies (7 or 8 TeV)
  - Pile-up treatment? try overlay 140 soft events to see the pile-up effect?
  - The trigger is probably not realistic & requires some thinking