Delphes 3 Experiences (& ATLAS Smearing)

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ATLAS EXPERIMENT
http://atlas.ch

Outline

- Intro to Delphes 3 (as a user)
- Modifying Delphes
- ATLAS Smearing in Delphes

You're strongly urged to check out Sergei Chekanov's page at Argonne: https://atlaswww.hep.anl.gov/asc/wikidoc/doku.php?id=snowmass2013:montecarlo

Introduction – Delphes

- Delphes is a C++ framework for fast detector simulation
  - Muons, electrons, taus, jets, b-tagging, lepton isolation, …
- Delphes 3 is a modular system
  - algorithms configured, scheduled via .tcl file
  - modules communicate entirely through data objects: TObjArrays of *Candidate* four-vector objects
  - extremely easy to add modules, change data flow, alter output information
- Delphes can read Les Houches format, STDHEP, HepMC, …
- Outputs ROOT TTree

Download/Build Delphes

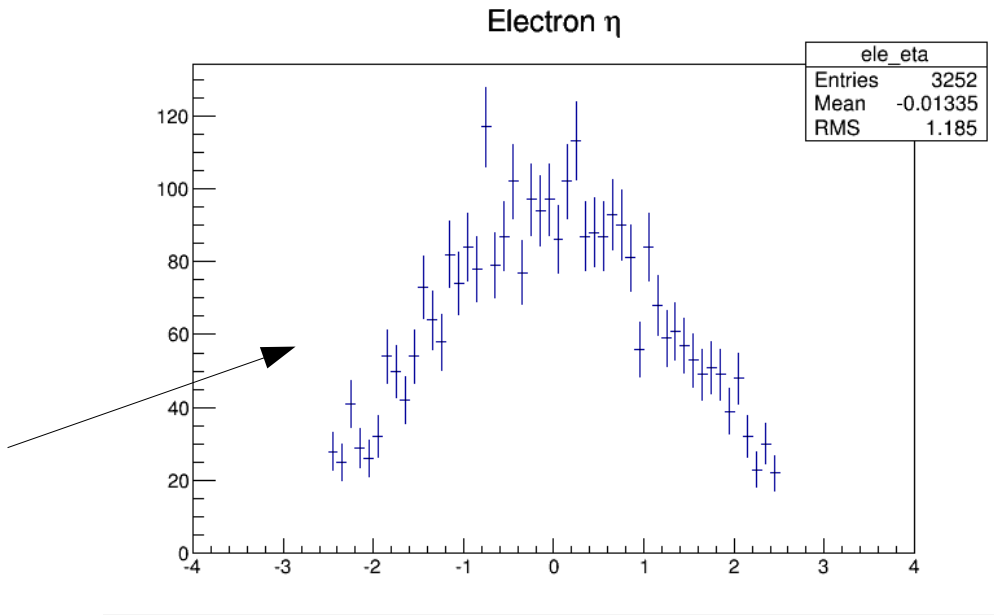
- Follow instructions here: https://atlaswww.hep.anl.gov/asc/wikidoc/doku.php?id=snowmass2013:howto_d3
- (If you're using ATLAS-Delphes [later], follow instructions in linked README)
- Requires ROOT to build

Using Delphes

- Once checked out and downloaded, Delphes is simple to run:
  `./DelphesSTDHEP delphes_card_ATLAS.tcl output.root pythia.hep`
- The output TTree can be read with or without loading the Delphes library (it's nicer if you load it)

```
import ROOT
from ROOT import TH1F, TH2F, TProfile, TEfficiency
ROOT.TH1.SetDefaultSumw2()

ROOT.gSystem.Load('libDelphes.so')

import sys
f = ROOT.TFile.Open(sys.argv[1])

t = f.Delphes

h = ROOT.TH1F('ele_eta', 'Electron #eta', 80, -4, 4)

c1 = ROOT.TCanvas()

for e in t:
    for electron in e.Electron:
        h.Fill(electron.Eta)

h.Draw()
c1.Print('ele_eta.png')
```

PyROOT script



Delphes with Pileup

- Delphes mixes random min bias events into detector response modeling
  - "realistically" models extra jets
- Requires MC file of min bias events
- Can be downloaded from Argonne
- Follow instructions at https://atlaswww.hep.anl.gov/asc/wikidoc/doku.php?id=snowmass2013:howto_d3
- Warning: *much* slower than no-pileup Delphes

Modifying Delphes

- It is *incredibly* easy to modify Delphes
  - write "modules" that transform input 4-vector-like objects into output ones, then specify those inputs/outputs with .tcl card file

```
void ATLASMuonMomentumSmearing::Process()
{
  Candidate *candidate, *mother;
  Double_t pt, eta;

  fItInputArray->Reset();
  while((candidate = static_cast<Candidate*>(fItInputArray->Next())))
  {
    const TLorentzVector &candidatePosition = candidate->Position;
    const TLorentzVector &candidateMomentum = candidate->Momentum;
    eta = candidatePosition.Eta();
    pt = candidateMomentum.Pt();

    // resolution; 2 = GeV
    Double_t sigma = MCP_resol(pt, eta, 2);
    pt = gRandom->Gaus(pt, sigma);

    if(pt <= 0.0) continue;

    mother = candidate;
    candidate = static_cast<Candidate*>(candidate->Clone());
    eta = candidateMomentum.Eta();
    Double_t phi = candidateMomentum.Phi();
    candidate->Momentum.SetPtEtaPhiE(pt, eta, phi, pt*TMath::CosH(eta));
    candidate->AddCandidate(mother);


    fOutputArray->Add(candidate);
  }
}
```

Example new module implementing ATLAS muon resolutions

I was writing working Delphes modules within 2h of starting to look at code!

Modifying Delphes (2)

- Technical aside: the hardest part when modifying Delphes is you have to alter several files to ensure you compile and link the code
  - edit modules/ModulesLinkDef.h to include your new module class
  - run "tclsh doc/genMakefile.tcl > Makefile" to pick up new C++ files

ATLAS-Delphes

WARNING! This only applies to "official" ATLAS studies!

- ATLAS has an internal set of efficiency & resolution parametrizations that should be applied to truth for official ATLAS results
- These can be applied by Delphes
  - Delphes here just acts as a data flow and bookkeeping engine
  - output is in Delphes ROOT format
- Code is in ATLAS SVN

https://svnweb.cern.ch/trac/atlasgroups/browser/PhysicsAnalysis/EuropeanStrategy/SnowmassDelphesImplementation/trunk/README-ATLAS