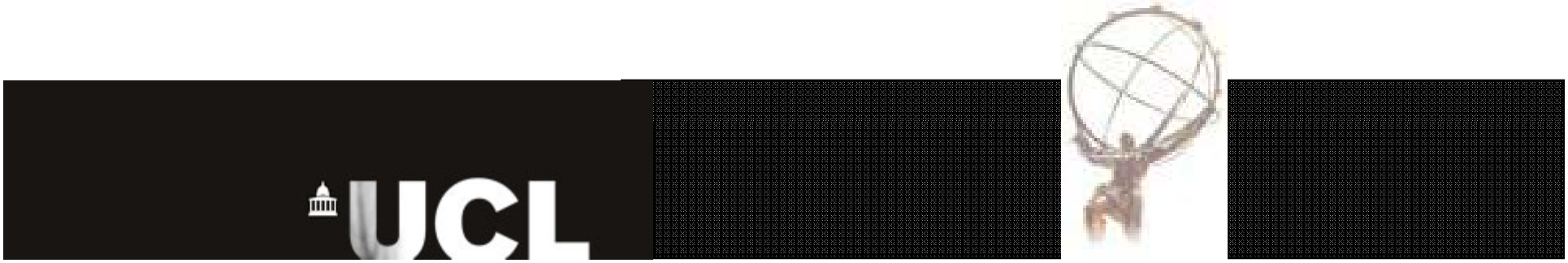


Fast Simulation in Atlas

Simon J.H. Dean

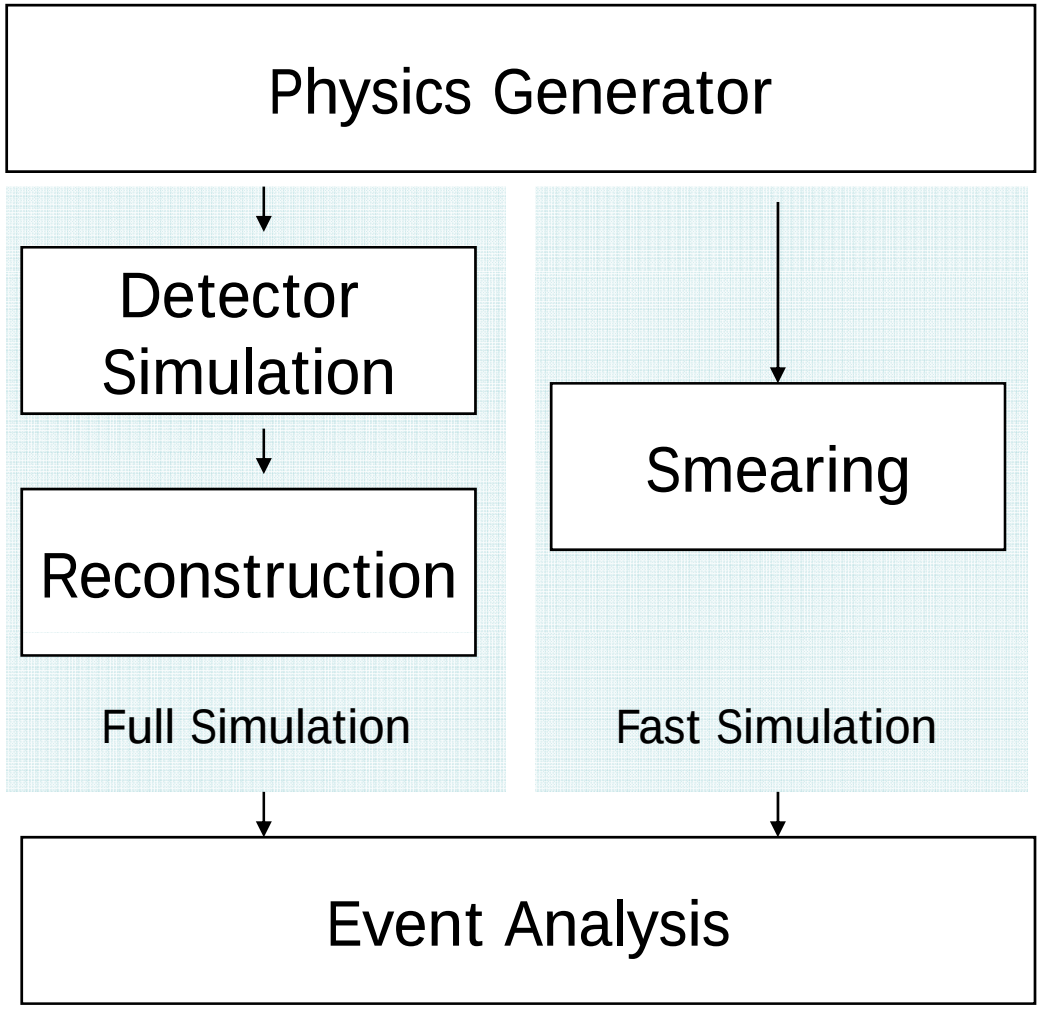
27/09/2007

Questions to be answered

- What is Atlfast?
- How does it perform?
- How to run Atlfast?
- How does it work?
- What are current areas of development?

What is Atlfast?

- ATLas FAST simulation
- Will talk mainly about the existing Atlfast in 12.0.X and 13.0.X ("Atlfast Phase 1")
- Replaces full chain



How does it perform?

- Full simulation + reconstruction currently takes ~$\frac{1}{2}$ hr per event (anecdotal)
- Atlfast test jobs in 12.0.3

Sample	$Z \rightarrow ee$ (10k, Pythia)	$ttH(H \rightarrow bb)$ (10k, Pythia)
Atlfast execute per event	8.15 ms	21.8 ms
Pythia execute per event	12.6 ms	200 ms
Total (includes initialisation)	307 s	2376 s

- 10^4-10^5 x faster than full chain

How does it perform?

- 30 fb^{-1} data low luminosity contains ~900k ttjj events
  - Background to ttH(H$\rightarrow$bb) analysis
- $\frac{1}{2}$ hr per event $\Rightarrow$ 51 CPU years
- 0.24 s per event $\Rightarrow$ 2.5 CPU days

How to run Atlfast?

- Instructions on web
  - www.hep.ucl.ac.uk/atlas/atlfast (static UCL page)
  - AtlfastDocumentation (Atlas TWiki portal)
- Easiest way is to
  - Set up a release directory
  - Set up run time environment (athena)
  - 'get_files XXXXtoAtlfasttoYYYY.py'
    - XXXX is Pythia or POOL
    - YYYY is CBNT, AOD and in r12 AAN
  - Configure script
  - 'athena XXXXtoAtlfasttoYYYY.py'

How to run Atlfast?

- cd Thessaloniki
- source setup.sh -tag=12.0.6
- export CMTPATH=/home/sdean/kits/12.0.6/AtlasProduction/12.0.6
- source /home/sdean/kits/12.0.6/AtlasProduction/12.0.6/AtlasProductionRunTime/cmt/setup.sh
- export CMTPATH="$TestArea:$CMTPATH"

Could go in setup script

- cd $TestArea
- mkdir run
- cd run
- get_files PythiatoAtlfasttoAOD.py
- emacs PythiatoAtlfasttoAOD.py & (to explain jobOptions)
- get_files DC3.005340.ttH_poslepnu_jj_bb.py (replace include in PythiatoAtlfasttoAOD.py)
- athena PythiatoAtlfasttoAOD.py

How does it work?

- Sequence of Algorithms
  - Defined in Atlfast_AlgSequence_(No)FastShower.py (r12) or Atlfast(No)FastShowerGetter.py (r13)
  - Each Algorithm configured in Atlfast_ConfigAlgs_(No)FastShower.py
- Run after generator (or reading in generator events from POOL file)

Generators Interface

- Accessed via HepMC
  - General output format for all generators
  - GenEvent, GenParticle, GenVertex
- Run over truth particle collections with Atlfast-based selectors
  - Predicate classes to accept/reject particle
  - "IsFinalState", "IsCharged", etc...

Atlfast Algorithms in r12

As in Atlfast_AlgSequence_NoFastShower.py

GlobalEventDataMaker

CellMaker
ClusterMaker
} Calorimetry

ElectronMaker
PhotonMaker
MuonMaker
} Create some basic physics objects

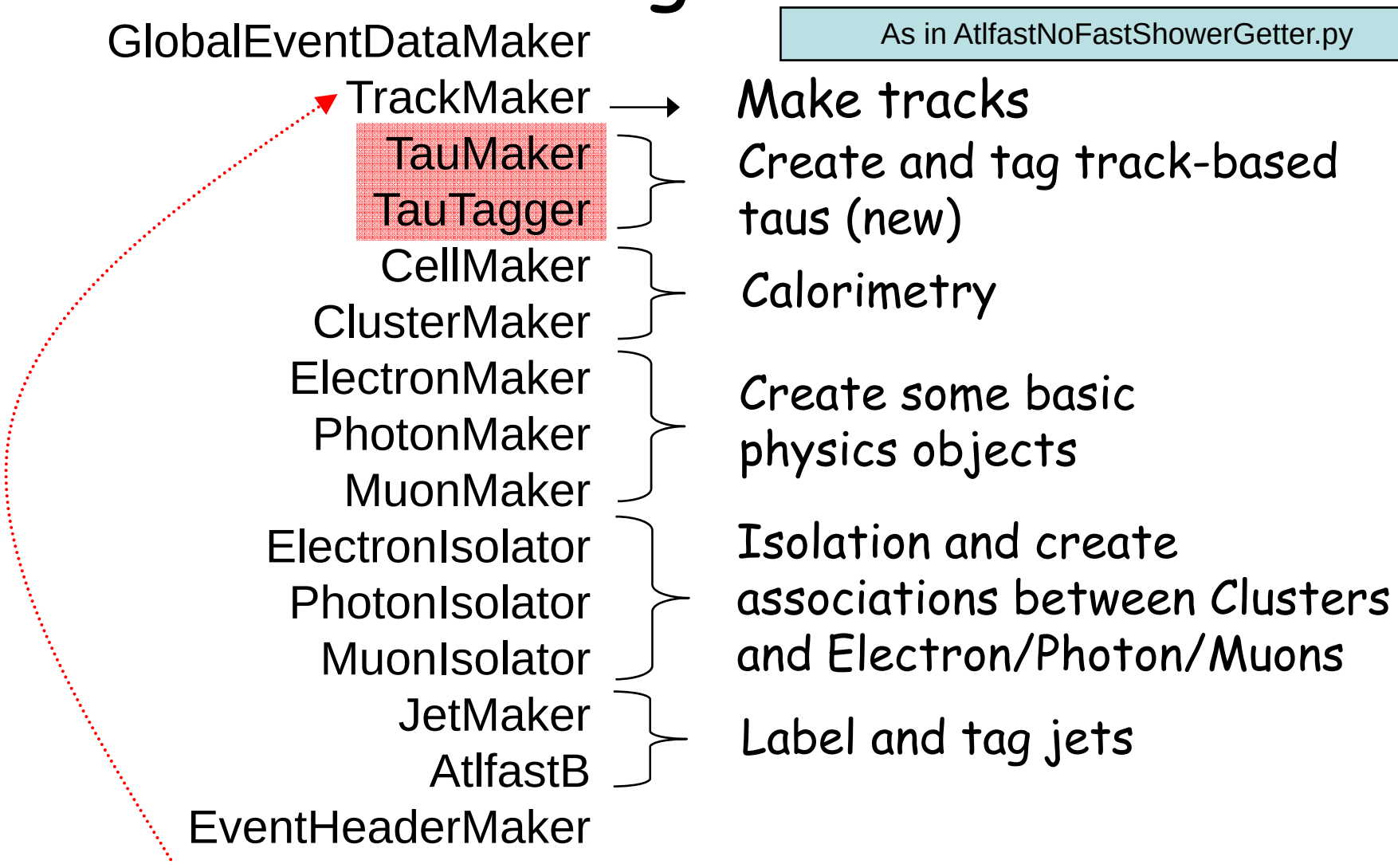
ElectronIsolator
PhotonIsolator
MuonIsolator
} Isolation and create associations between Clusters and Electron/Photon/Muons

JetMaker
AtlfastB
} Label and tag jets

EventHeaderMaker

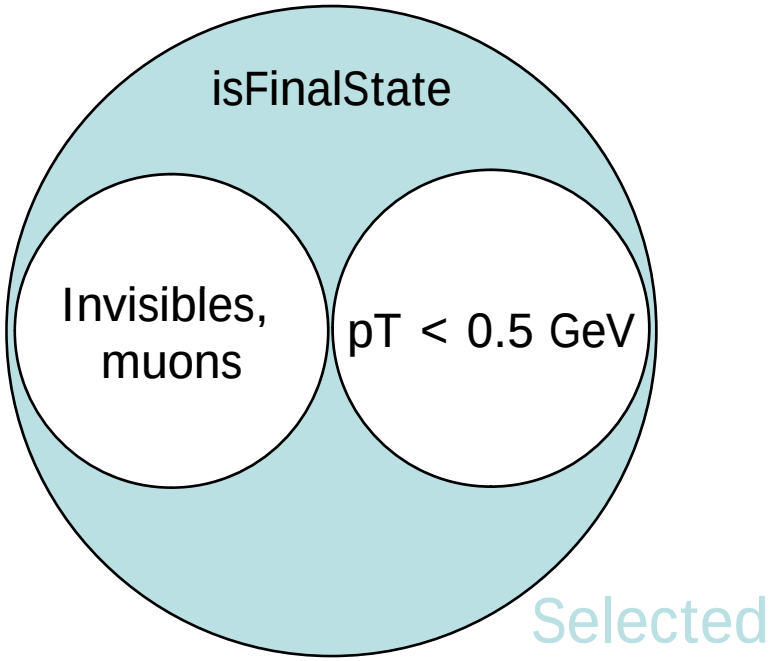
TrackMaker → After everything, make tracks

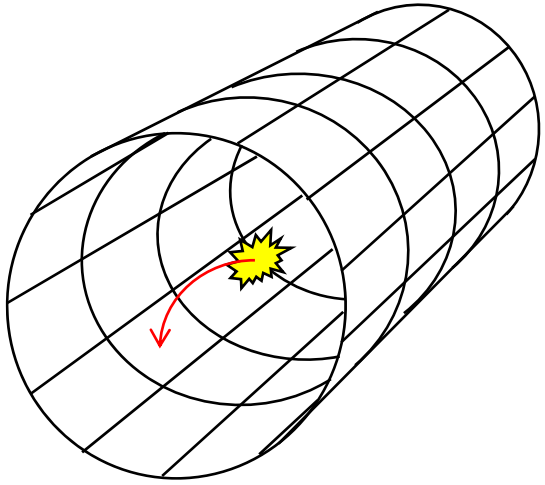
Atlfast Algorithms in r13



CellMaker

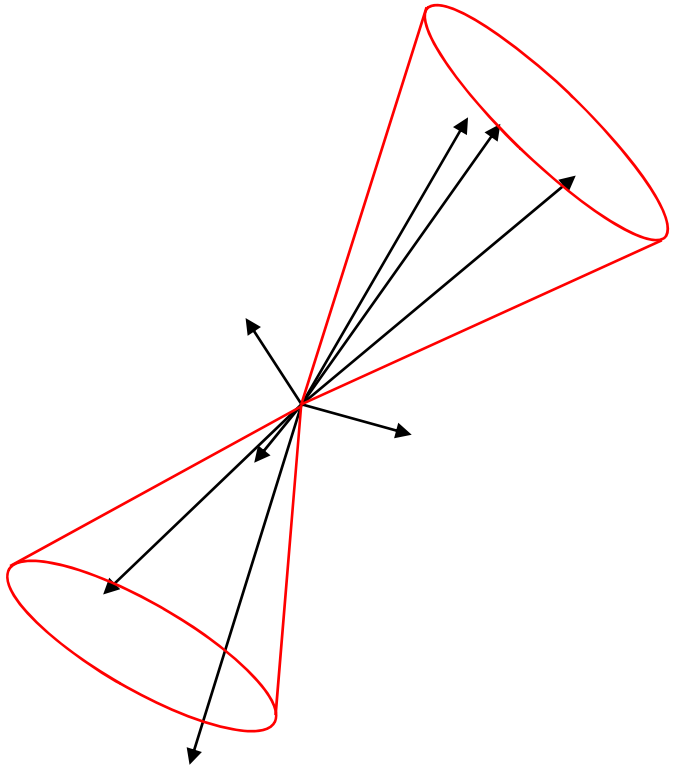
- Begins by selecting particles that will deposit in the calorimeter
- Transports them to the calorimeter face (simple 2T field approx.)
- Deposits true particle energies in 0.1x0.1 cells ($\eta x \varphi$ space) in range $|\eta|<5$





ClusterMaker

- Runs clustering routines on Cells (also possible for Tracks)
  - "Cone": Atlfast dedicated routine!
  - "Kt": interfaces KtEvent routine used also in full reco
  - "Shared": shares Cell energies between Clusters
- Keeps Clusters with ET > 5 GeV



FastShower

- Used from CellMaker to give more accurate calorimeter description
- Two compartments (EM, hadronic) considered
- Particle energies spread into neighbouring cells (shower shape)
- Not used by default
  - Run with "FastShower" scripts instead of "NoFastShower"
- Precursor to FastCaloSim ("Atlfast Phase 2")

Electrons, Muons, Photons

- ReconstructedParticles made with DefaultReconstructedParticleMaker
  - Configured with PDGID of specific particle
    - ParticleType = 11,13,22 for e,γ,μ respectively
  - Particle 4-vector smeared according to specific resolution function + random number generator

eg... electrons

$$\frac{\sigma}{E} = \frac{12\%}{\sqrt{E}} \oplus 0.7\% \oplus \frac{0.245}{E_T} \quad \text{for} \quad |\eta| \leq 1.4$$

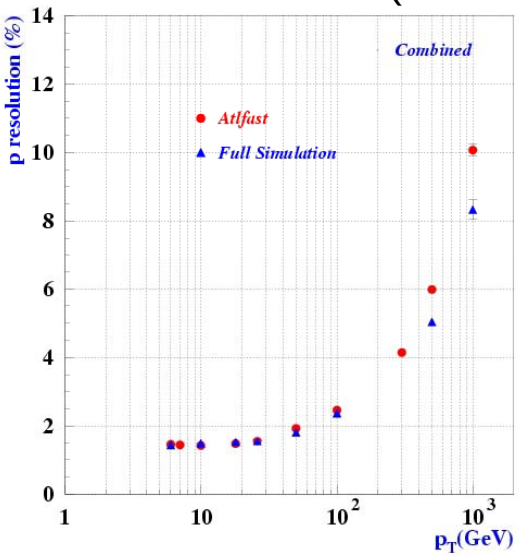
$$\frac{\sigma}{E} = \frac{12\%}{\sqrt{E}} \oplus 0.7\% \oplus \frac{0.306 \cdot (2.4 - |\eta|) + 0.228}{E} \quad \text{for} \quad 1.4 < |\eta| < 2.5$$

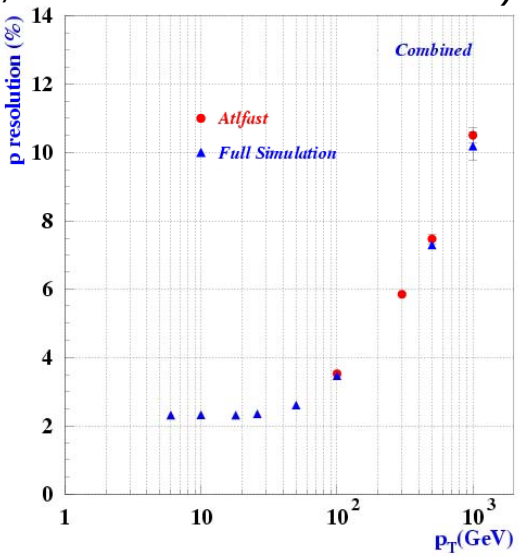
  - p_T and η cuts for MC and smeared particle

Lepton Performance

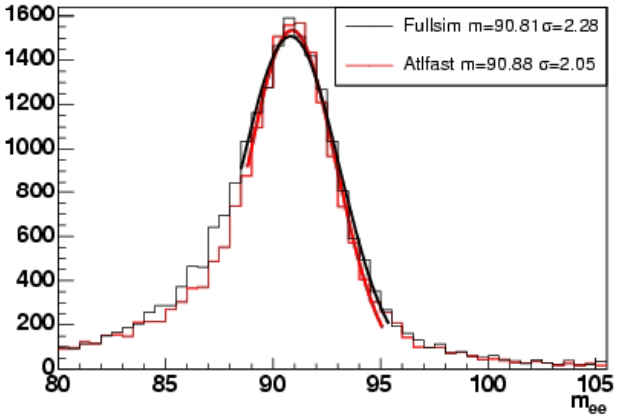
- Improved muon resolutions in 12.0.6 (Samira)
- Electrons were sufficient

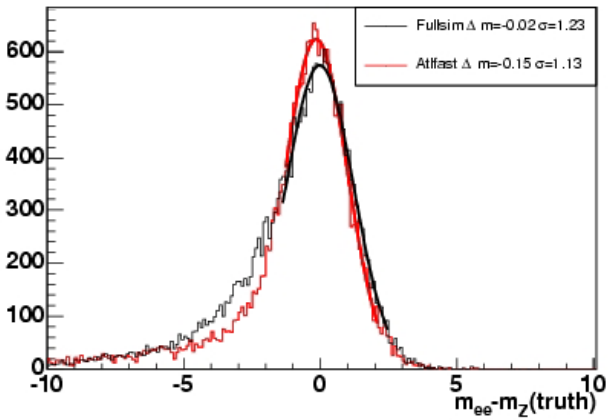
Muons (S. Hassani, ATL-PHYS-INT-2007-005)

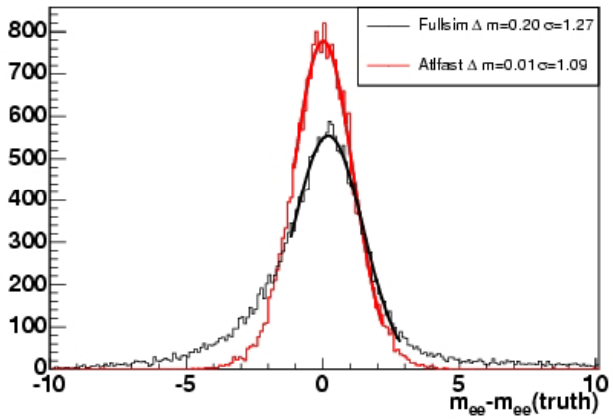




Electrons (M. Duehrssen, ATL-PHYS-INT-2007-005)







Isolators

- Run for e,γ,μ
- Check to see if within dR < 0.15 of a Cluster
- If so, isolated particle must have
  - No other Clusters within dR < 0.4
  - Sum of all unclustered cell ETs within dR < 0.2 less than 10 GeV
- Electron-Cluster and Photon-Cluster associations made too

JetMaker

- Examines Clusters which have not been associated with ReconstructedParticle
- Smears 4-vector with resolution function

$$\frac{\sigma}{E} = \frac{50\%}{\sqrt{E}} \oplus 3\% \qquad \text{for } |\eta| \leq 3.2 \text{ and}$$

$$\frac{\sigma}{E} = \frac{100\%}{\sqrt{E}} \oplus 7\% \qquad \text{for } 3.2 < |\eta| < 4.9$$

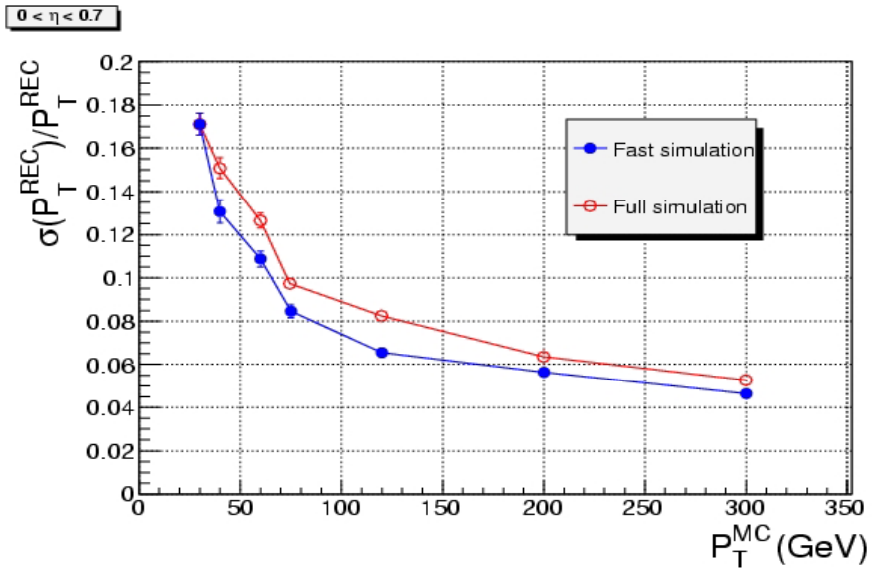
Adds 4-vector of any non-isolated muons within dR < 0.4

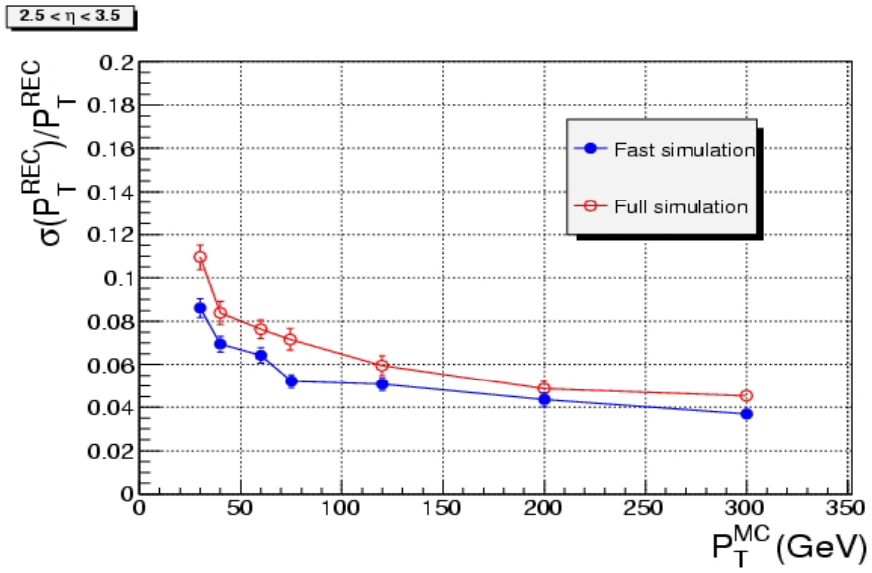
- Creates Jet if
  - p_T > 10 GeV
  - $|\eta|$ < 5
- Assigns labels if close to b-quark, c-quark or tau hadrons (dR < 0.3)

Jet Performance

- Noticeable differences between full and fast sim looking at default cone jets

I. Vivarelli, ATL-PHYS-INT-2007-005





- Underlying jet finder is fundamentally different

AtlfastB

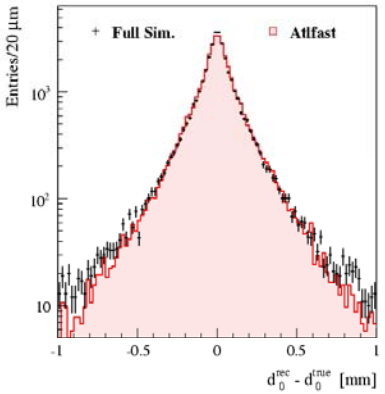
- Reads in Jet collection from JetMaker
- Applies measured efficiencies and rejections to Jet labels to produce tags
- B-tagging
- Tau-tagging
- Jet energy correction
  - Light or b-jet correction
  - Light jet correction for hadronic taus

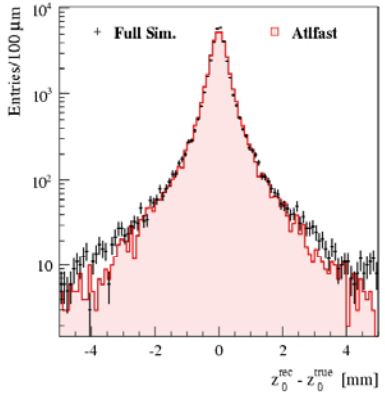
TrackMaker

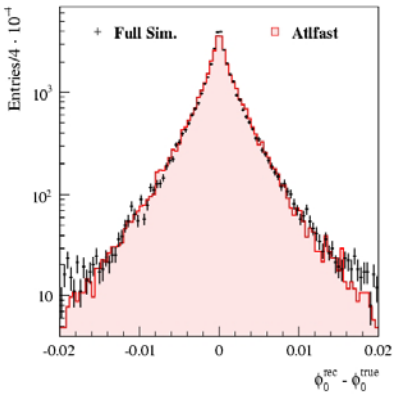
- Selector used to get charged final-state particles from MC event with
  - $p_T > 0.5$ GeV
  - $|\eta| < 2.5$
- Track parameters ($d_0, z_0, \varphi_0, \cot\theta, q/p_T$) made and smeared
  - Correlated smearing, complicated
  - Produces covariance matrix

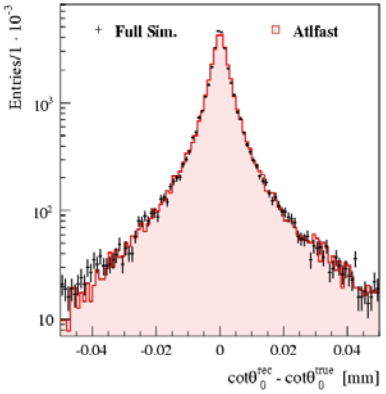
Tracking Performance

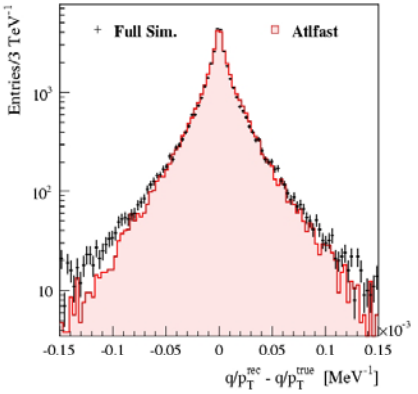
- Residuals show impressive agreement
- Even better in r13
  - improved correlations
  - improved electron tracks (conversions)





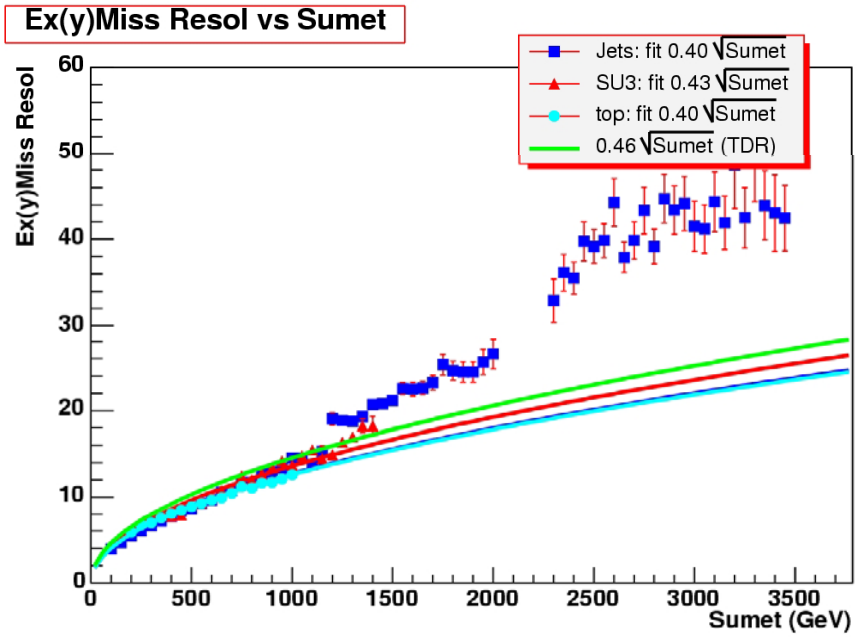


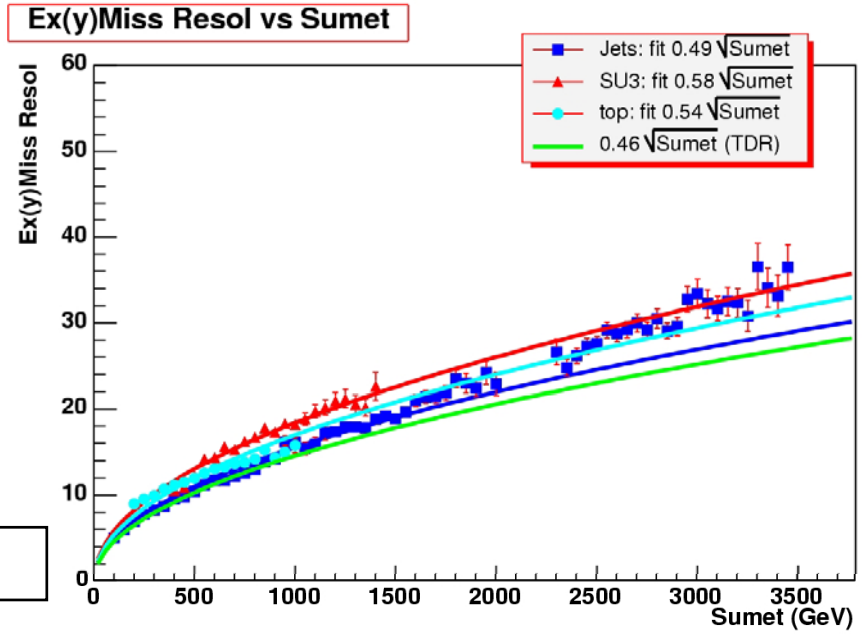




Missing ET

- Evaluated in EventHeaderMaker
- Add 4-vectors of
  - Isolated electrons
  - Isolated photons
  - All muons
  - Jets
- Subtract muons in jets
- Smear unclustered cells and add these in too
- Missing ET = ($-p_x$, $-p_y$, $-p_z$, 14TeV-E)



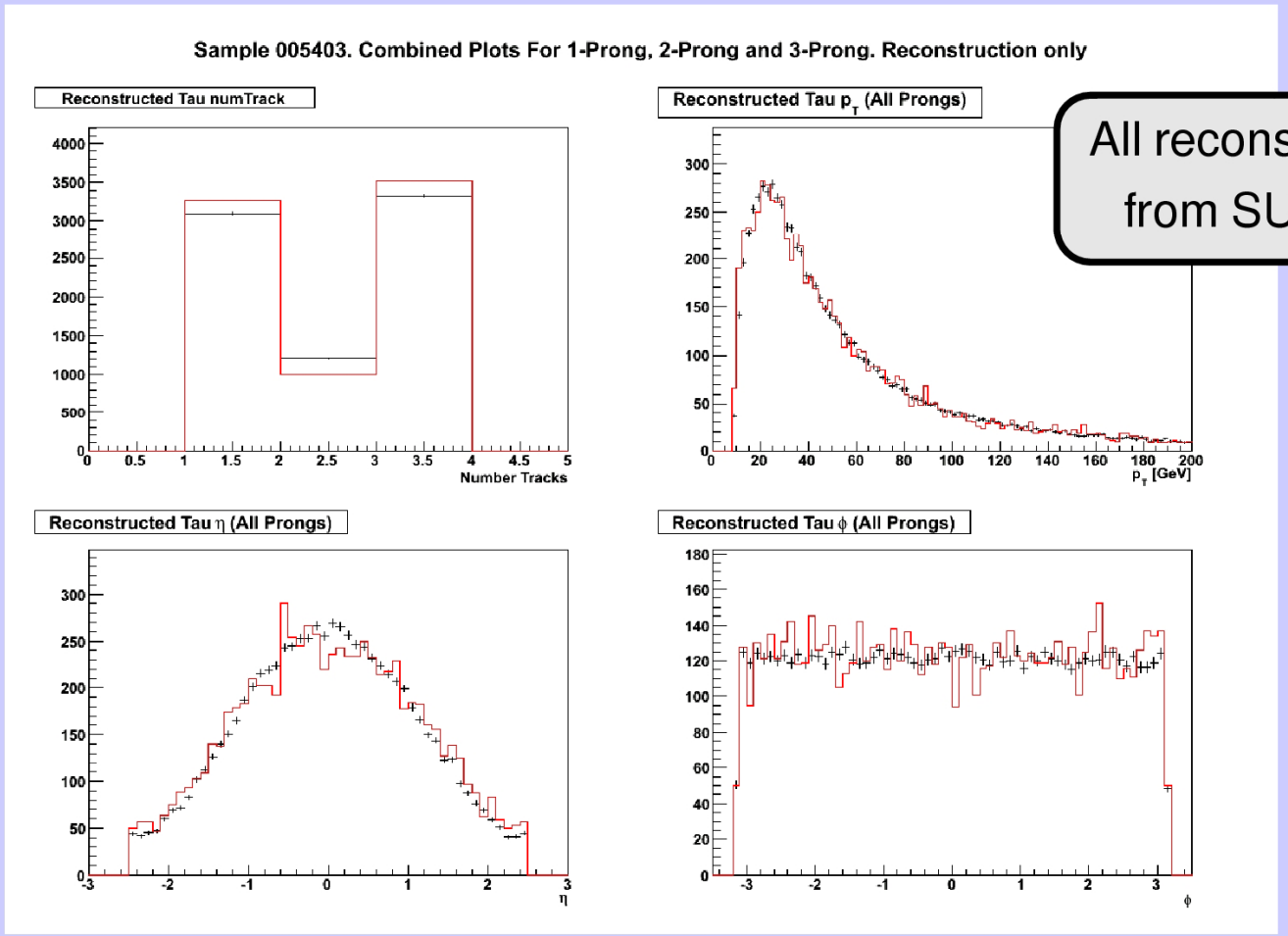


D. Cavalli, ATL-PHYS-INT-2007-005

Track-based tau1p3p

- New in r13!
- Work done by TauID group (primarily Alan Phillips)
- TauMaker constructs Tau objects from tracks
- TauTagger applies a correction to simulate tagging results

Track-based tau1p3p



All reconstructed taus from SUSY events

A. Phillips

AtlfastC

- In development by Glasgow group
- Addresses two big gaps in Atlfast-1:
  - ID efficiencies
  - Modelling of fakes
- Need to measure well and apply elements from matrix ε

C. Collins-Tooth, S. Allwood, S. Ferrag, C. Wright

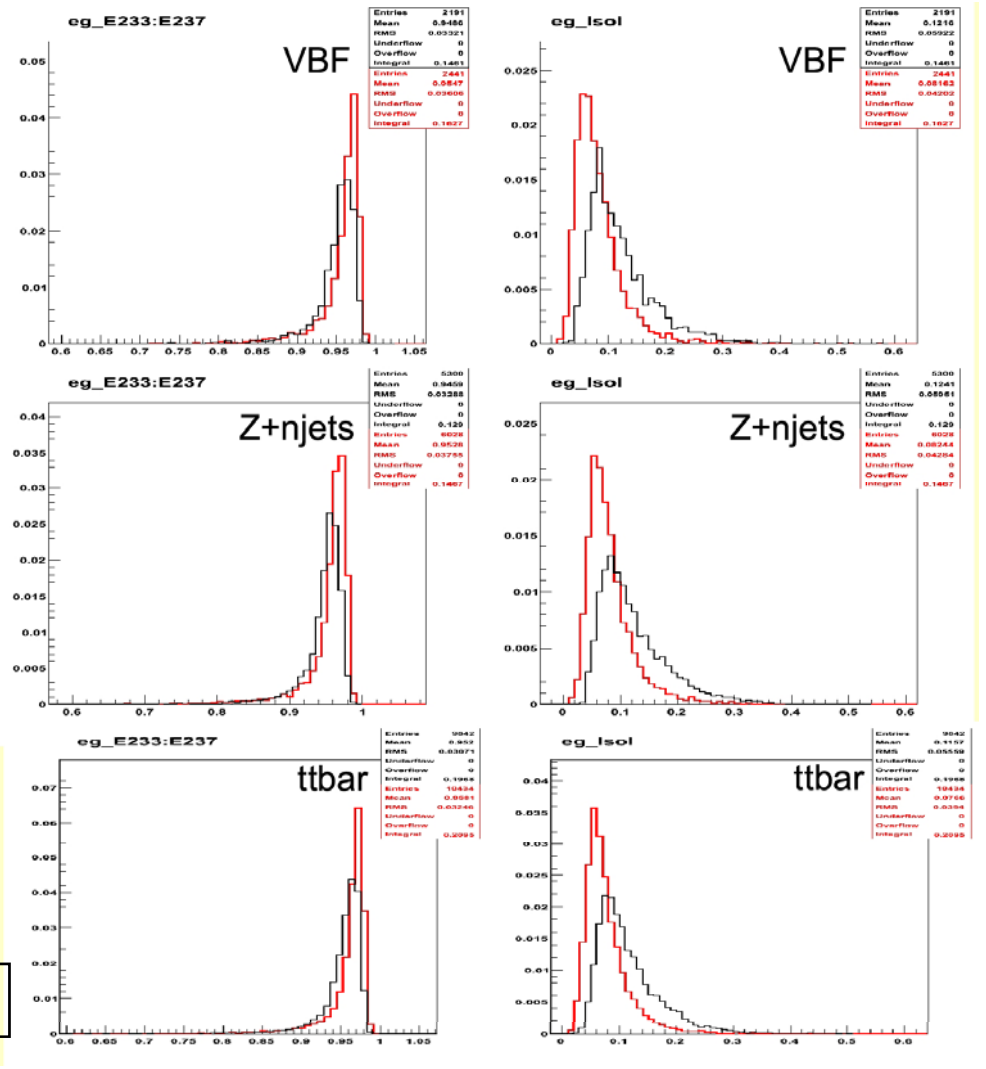
$$\epsilon = \begin{pmatrix} \epsilon_{ee} & \epsilon_{e\gamma} & \epsilon_{e\mu} & \epsilon_{ejet} & \epsilon_{e\pi} \\ \epsilon_{\gamma e} & \epsilon_{\gamma\gamma} & \epsilon_{\gamma\mu} & \epsilon_{\gamma jet} & \epsilon_{\gamma\pi} \\ \epsilon_{\mu e} & \epsilon_{\mu\gamma} & \epsilon_{\mu\mu} & \epsilon_{\mu jet} & \epsilon_{\mu\pi} \\ \epsilon_{jete} & \epsilon_{jet\gamma} & \epsilon_{jet\mu} & \epsilon_{jetjet} & \epsilon_{jet\pi} \\ \epsilon_{\pi e} & \epsilon_{\pi\gamma} & \epsilon_{\pi\mu} & \epsilon_{\pi jet} & \epsilon_{\pi\pi} \end{pmatrix}$$

Towards "Atlfast Phase 2"

- More "Atlas", less "Fast"
- Necessary due to complexity of full simulation routines and demand for high stats samples
- FastCaloSim
  - Parameterised showers in a full calorimeter
- Fatras
  - Fast tracking via hit simulation

Towards "Atlfast Phase 2"

- Single electrons
  - ET > 25 GeV
  - Truth-matched
  - IsEM = 0
- Fine calorimeter quantities measurable.



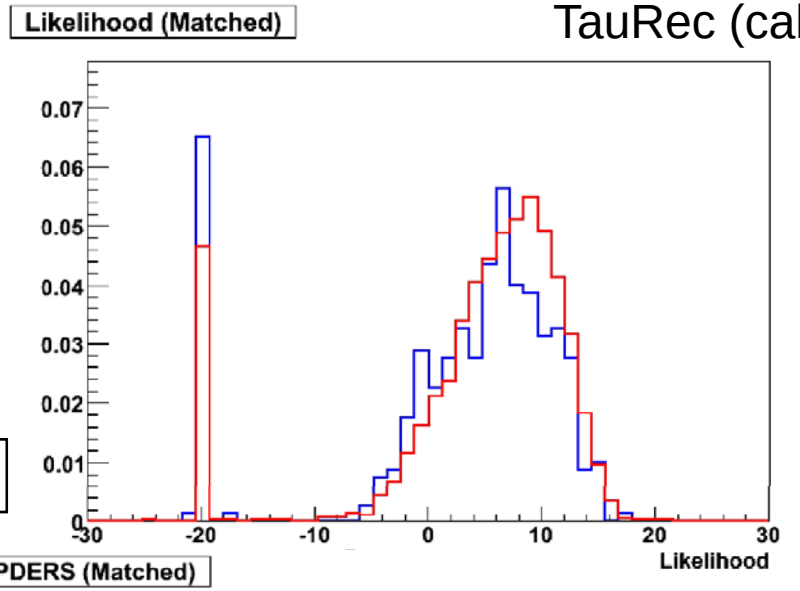
E. Schmidt, M. Duehrssen

Towards "Atlfast Phase 2"

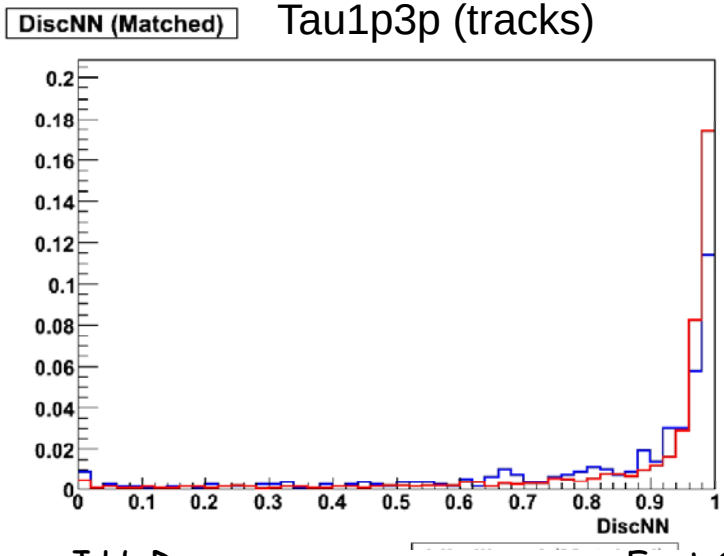
- Taus produced with FastCaloSim + Fatras
  - $Z \rightarrow \tau\tau$ events
- Tracks and calorimeter

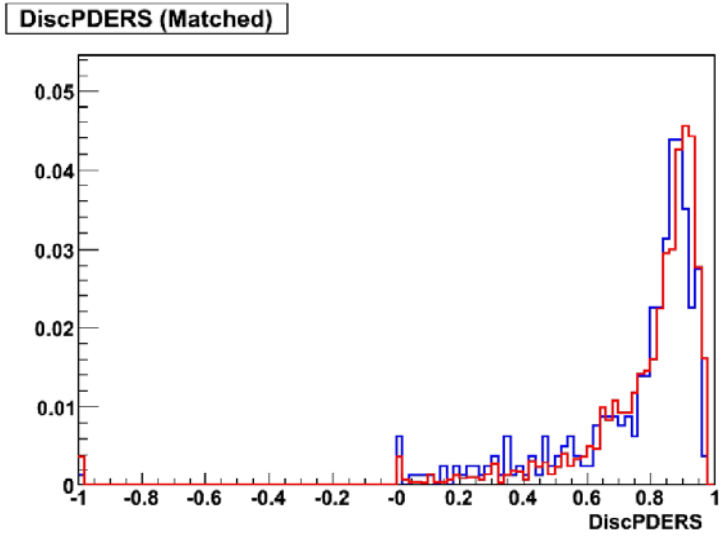
A. Phillips

TauRec (cal)



Tau1p3p (tracks)





Towards "Atlfast Phase 2"

- Timing still prohibitive but getting better.....
- Project is at validation stage

• Atlfast	20ms
• FATRAS	200ms
• FastCaloSim	1200ms
- EmptyCellBuilderTool	320ms (always the same...)
- FastShowerCellBuilderTool	690ms
- AddNoiseCellBuilderTool	120ms
- MisCalibTool	30ms
- CaloCellContainerFinalizerTool	50ms
• CaloClusterXXX	650ms (mainly topocluster)
• JetsXXX	2000ms (4 jet algs)
• MET	600ms
• other	200ms
• CBNT	150ms
All	5500ms

Could be avoided if calo is not deleted after every event

Depends on event activity, still room for optimization

M. Duehrssen

What is planned for the future?

- Understanding the value of hybrids
  - eg.. muons from Atlfast-1, clusters from FastCaloSim, full-sim/Fatras tracks.
- Further development on AtlfastC
  - May be required by Atlfast-2 in any case