



# Fast Simulations' Status

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5 March 2008  
SLAC Atlas Forum



# Overview

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- Introduction (Full Simulation)
- Fast G4 Simulation
- ATLFAST-II
  - FATRAS
  - Fast Calo Sim
  - AOD to AOD corrections
- Validation and Development Plans

Many extra resources in the backup slides!!!



# Full Simulation

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- Fully Geant4-based Simulation is slow
  - New processors are ~3 kSI2K -> sim time is 5-20 min / event
  - Complex geometry (EM calorimeters especially!)
  - Detailed physics description (e.g. for hadronic calibration)
- We just changed hadronic physics description and multiple scattering in G4!!

	Sample	Time [kSI2K Seconds]
Full sim time per event	J2 (dijet)	2098
	H(130) to 4l	2153
Athena release 13.2.0	Min Bias	845
	SU3 SUSY	3588
With QGSP_BERT (new!)	Z to MuMu	1679
	Z to ee	1960
	Z to TauTau	1897



# The New Physics List

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- Lots of good news
  - Describes calorimeter test beam quite well
  - Showers are long enough and wide enough
  - Expected to allow *a priori* calibration to ~5% (?)
- Lots of bad news
  - CPU time increases by 2.5x, output files are 1.75x bigger
    - That CPU time isn't for nothing!
  - Jet punch through gets worse
  - Neutrons are a bigger problem
    - These might be cut out...
- The full simulation must (will) be further optimized...



# Fast G4 Simulation

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- Use pre-simulated low energy EM showers in the calorimetry (all EM calos and forward hadronic calo)
  - Max energy  $\sim 1$  GeV  $\leftrightarrow$  200 MB extra memory for libraries
  - Creeping up to 1 GB of memory
  - Very few high energy particles enter the calos
  - Even hadronic shower simulation is mostly spent on EM physics in EM calorimeters
- *Uses the default digitization and reconstruction*
  - Can produce byte-stream (FDR?)
  - Can be used for minbias & pileup (with data too)
  - Can be used for trigger studies



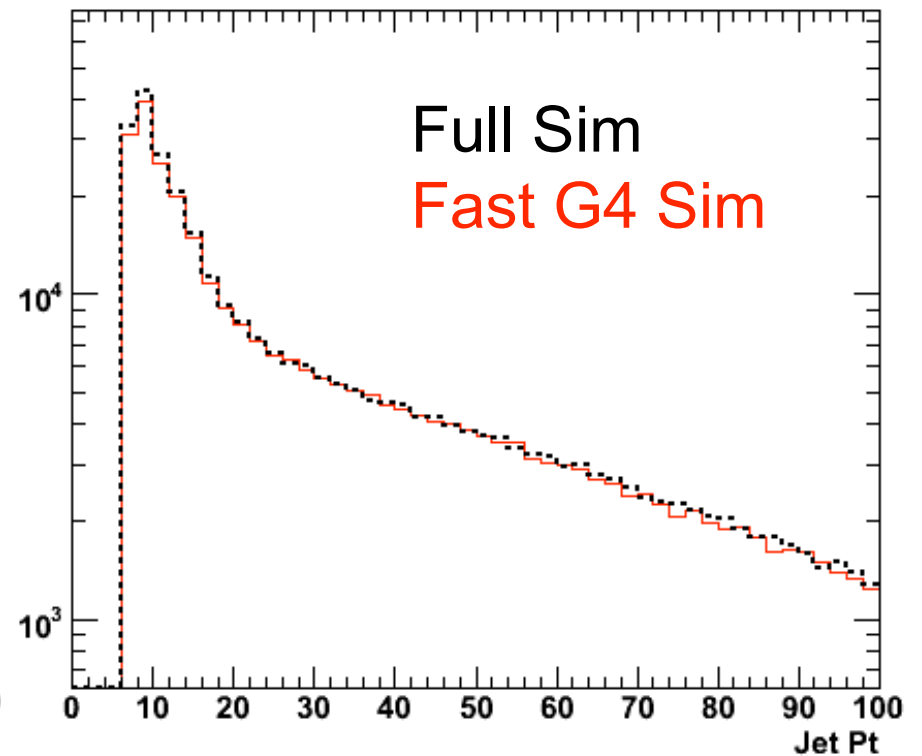
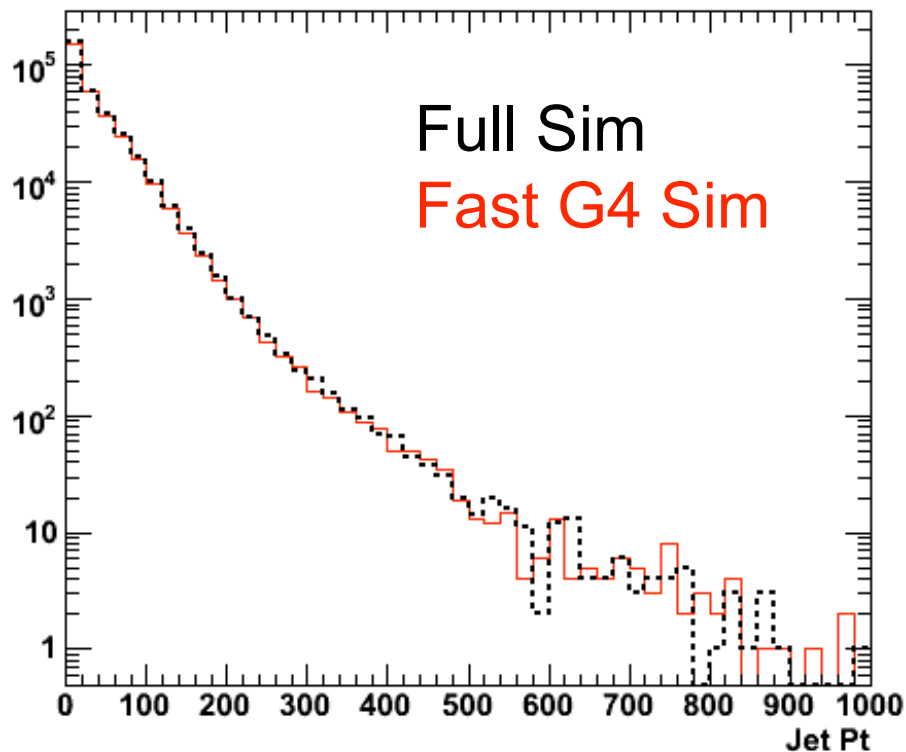
# Fast G4 Simulation Time

- Saves a factor of 2-3 in physics events
  - FCAL frozen showers give R14 improvement
- 1/2 of event is now other detector elements
  - No single item stands out any more
  - Fast G4 sim time scales with full G4 sim time (!)

		Improvement Factor (Full Sim / Fast Sim)	
	Sample	Release 13.0.30	Expected 14.0.0
Timing done in 13.2.0 (Out of the box for full sim)	J2 (dijet)	2.10	2.24
	H130->ZZ->4	2.29	2.32
	Min Bias	1.85	2.01
	SU3 SUSY	2.37	2.44
	Z to MuMu	1.91	2.17
	Z to ee	2.54	2.77
	Z to TauTau	2.00	2.29

# Fast G4 Simulation

Fast G4 simulation and full simulation  
Jet pT spectra (in GeV) in release 13.0.30.3 ttbar events

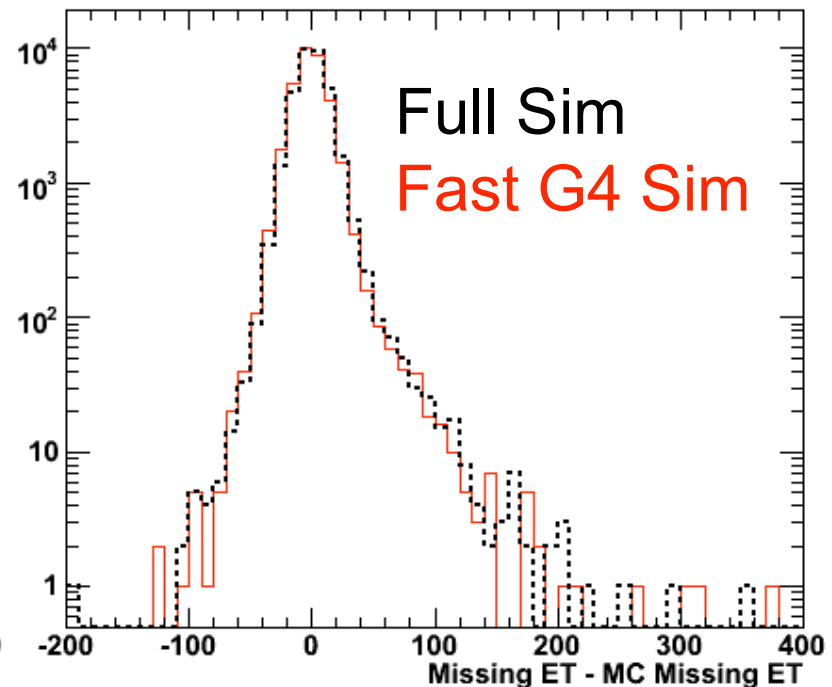
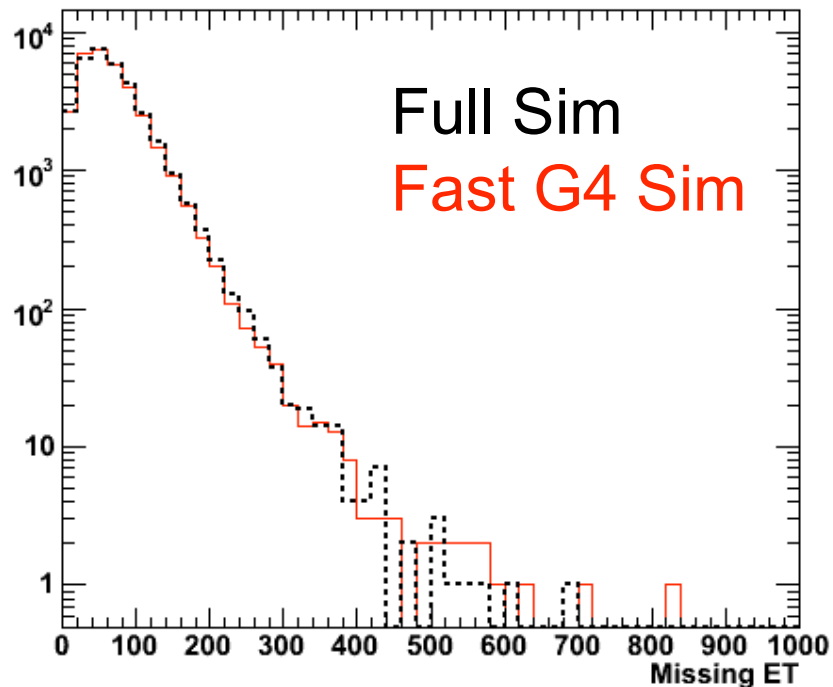


# Fast G4 Simulation

**Fast G4 simulation** and full simulation

Missing  $E_T$  distributions in release 13.0.30.3 ttbar events

Scale shift (1-2%) has been fixed for release 14







# ATLFAST-II

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- Big difference since ATLFAST-I: ATLFAST-II runs the standard reconstruction tools
  - Starts part way through the chain - no RDO
  - No way to overlay data right now, but can stack simulated events
- Calorimetry is simulated with Fast Calo Sim
- Inner Detector simulation is done with Geant4
  - For b-tagging studies, might always use full sim ID
  - Plan to integrate FATRAS (Fast Tracking) soon
- Muon results are simulated with ATLFAST-I
  - By 15.x will use FATRAS (prototype in 14.0.X)
- Warning: take care with MET (does not include  $\mu$ 's)

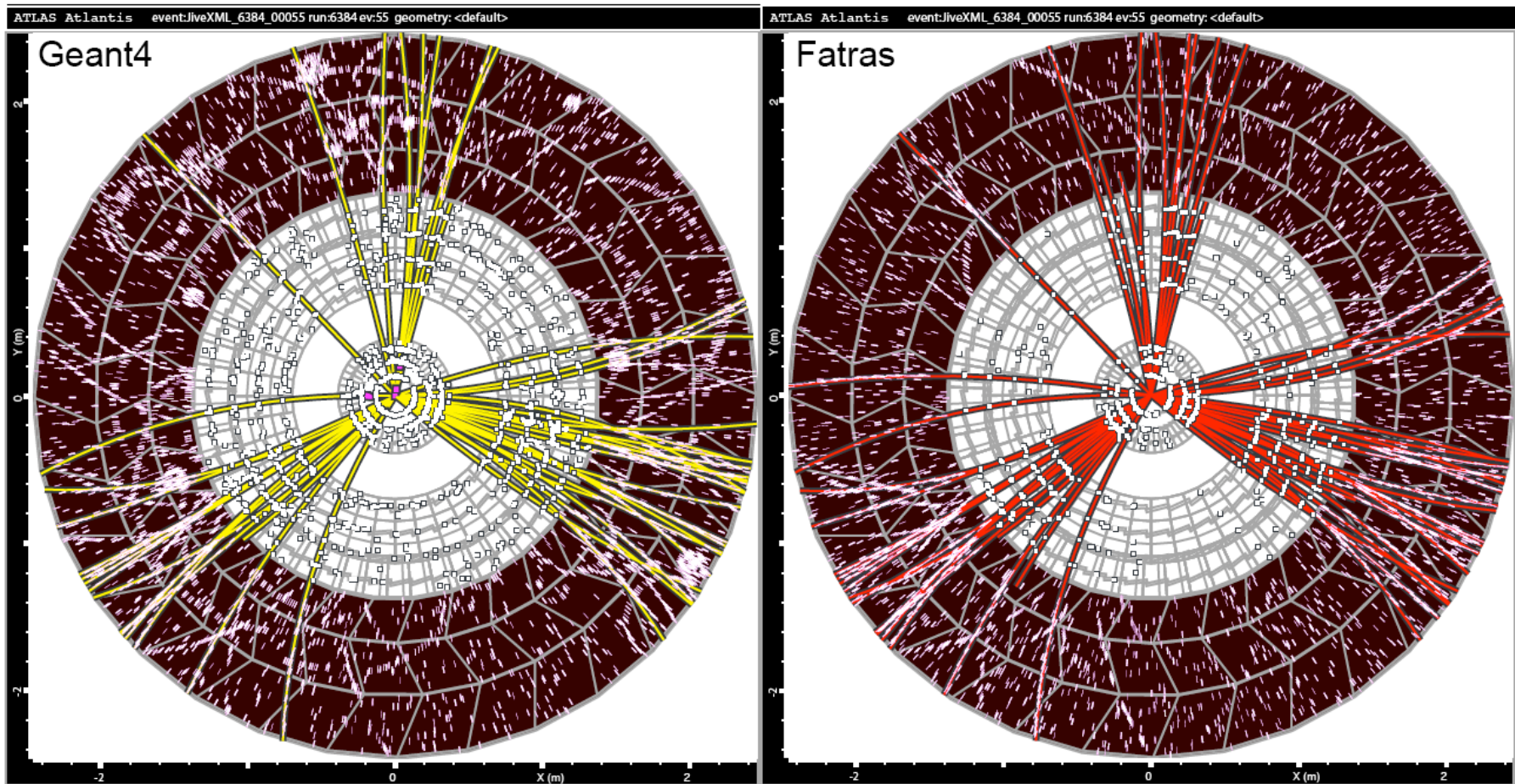


# FATRAS

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- Track simulation using reconstruction geometry (layers) instead of simulation geometry (volumes)
- Propagates particles with:
  - Multiple scattering (parameterization), ionization and radiation (incl. brem), photon conversions, hadronic decays (from G4), nuclear interactions with material
- Uses the Atlas standard track reconstruction
  - Noise included, but not tuned in detail yet

# FATRAS in Release 13

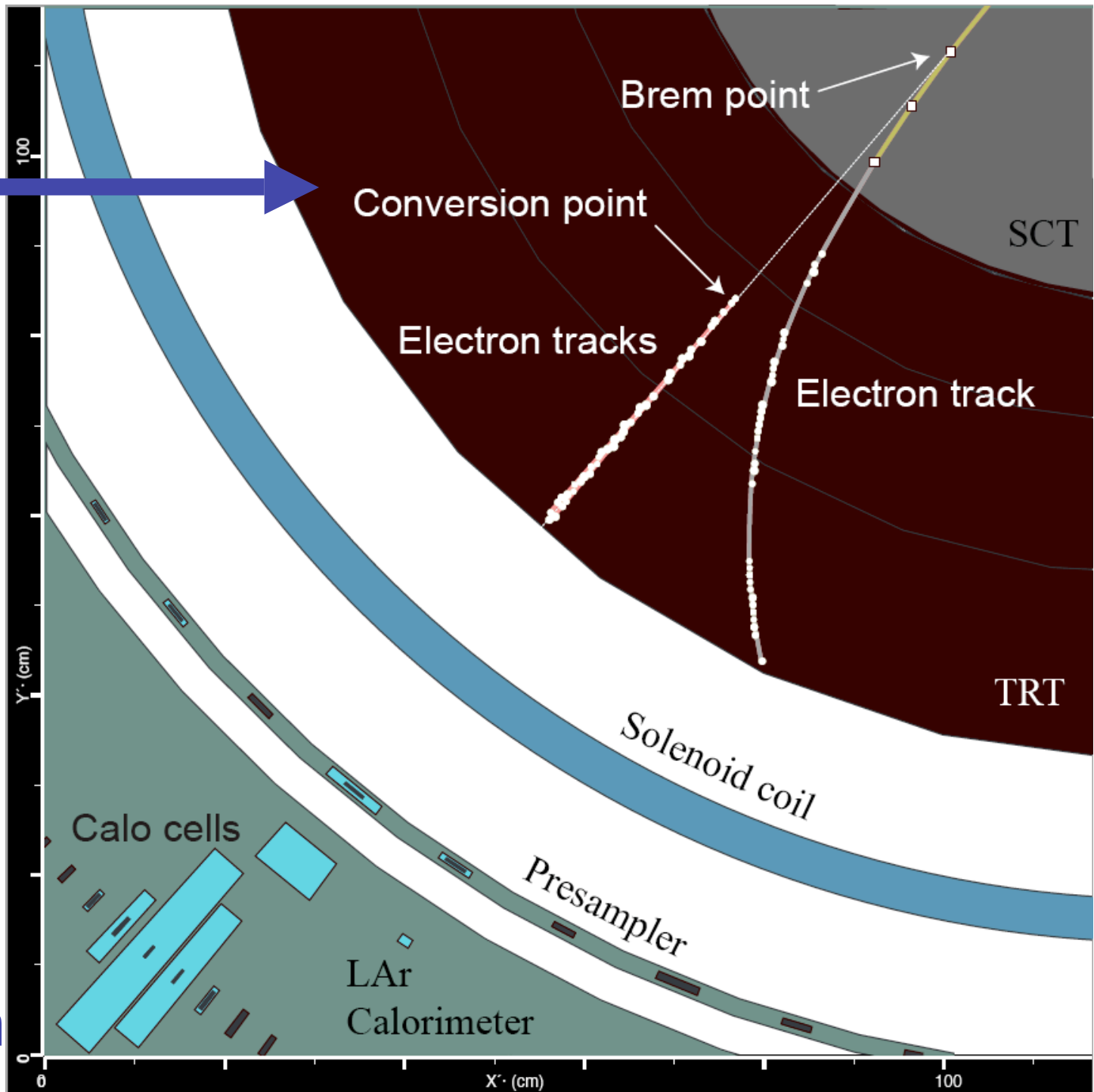


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**FATRAS**



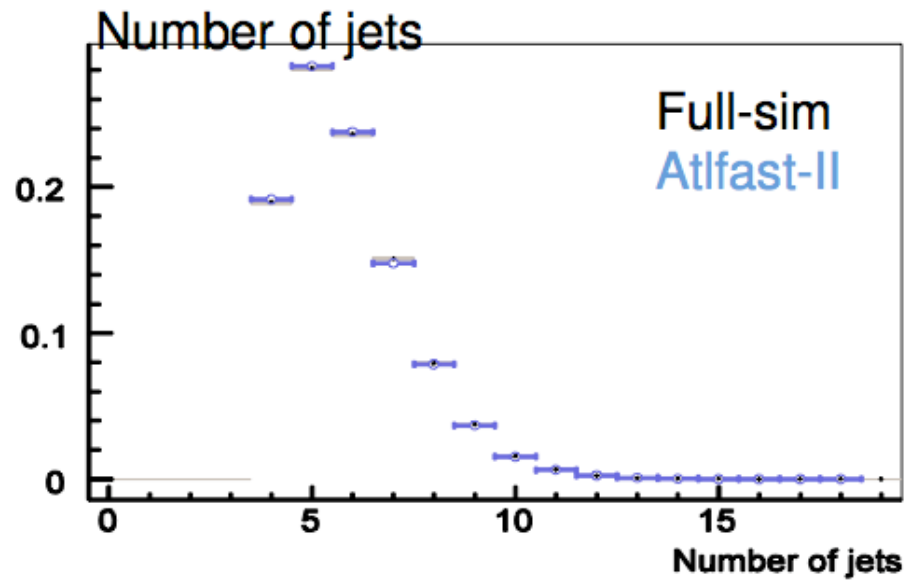
**Fast Calo  
Simulation**



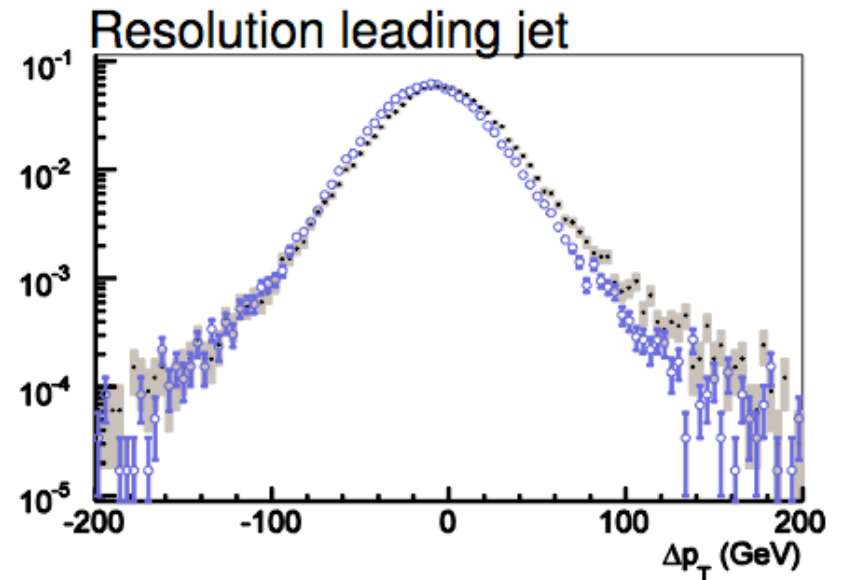
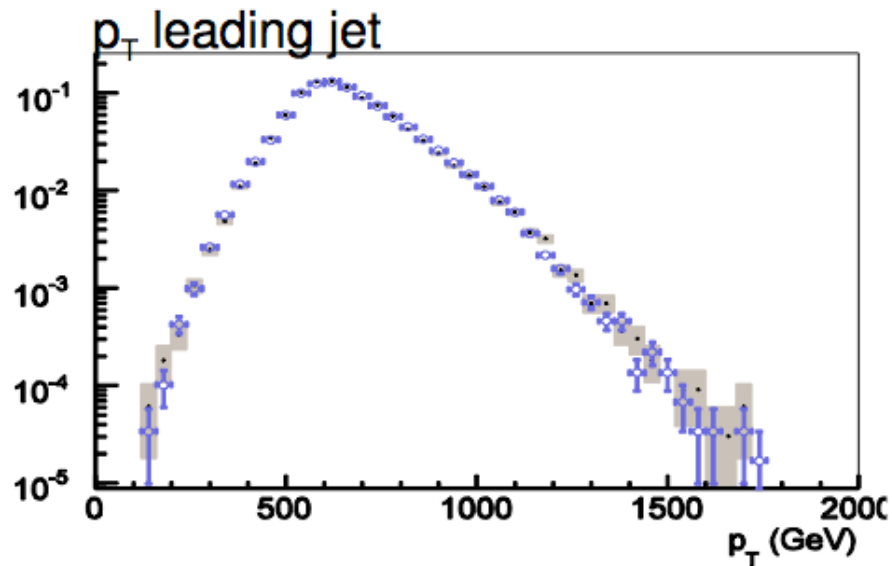
# Fast Calo Simulation

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- Parameterization of showers based on R10 Athena
  - Corrected to release 13.0.30 with AOD-to-AOD corrections
  - New corrections for QGSP\_BERT (will redo param. in R14)
- Single particle parameterizations
  - Photons for EM showers,  $\pi^{+/-}$  for hadronic showers
  - Resolution and response are parameterized (incl. correlations) - *readout cells* are populated with energy
- Electronic noise is added
- Runs standard Atlas calorimeter reconstruction
  - Ends with the **same** reconstructed objects!



Cone4TowerJets, J6  
4jets requirement  
( $p_{T,1st} > 100 \text{ GeV}/c$  &&  $p_{T,4th} > 50 \text{ GeV}/c$ )

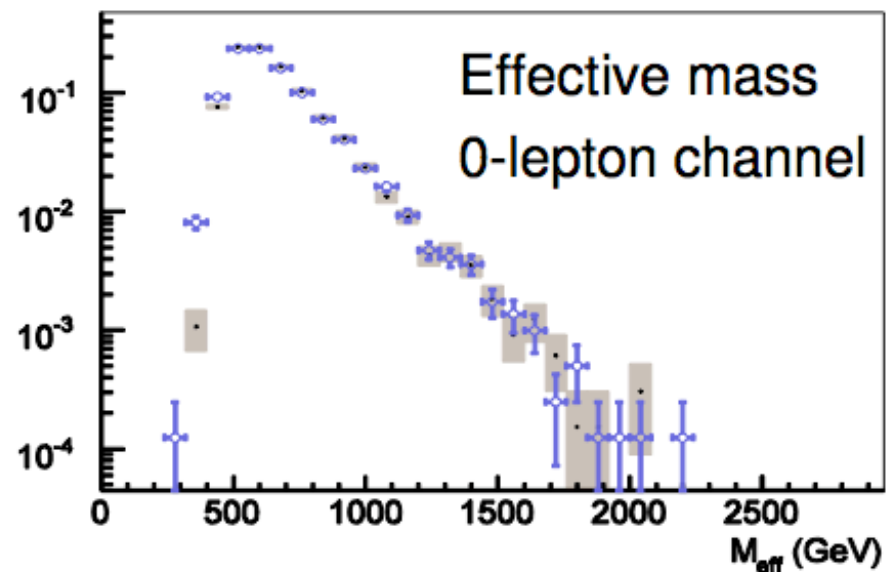
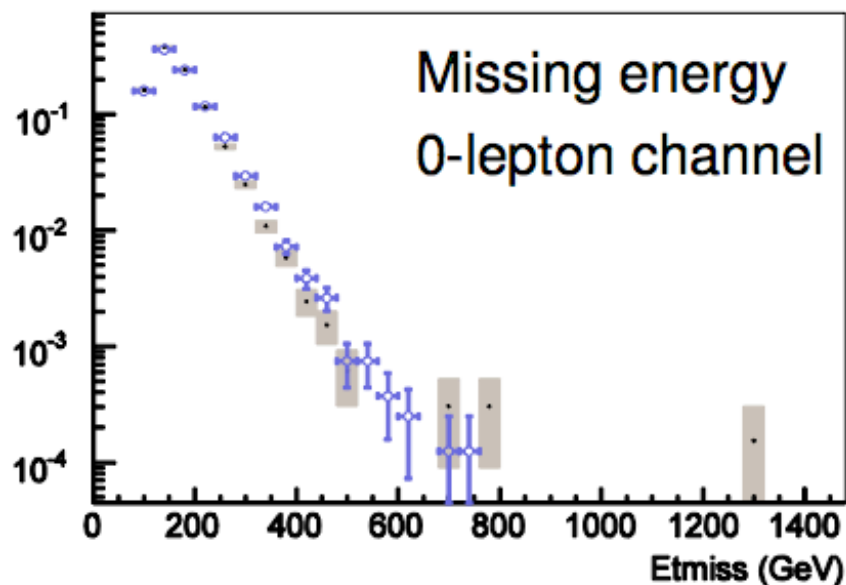


# Fast Calo Simulation

Shimpei Yamamoto

## Full Geant 4 Simulation vs Fast Calo Sim

Missing transverse energy and  $M_{\text{eff}}$  in a release 13 ttbar sample

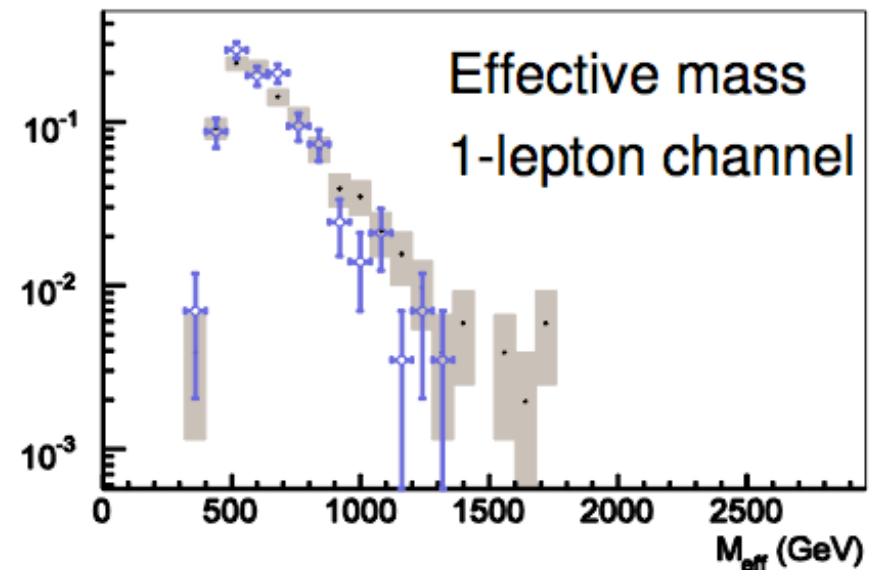
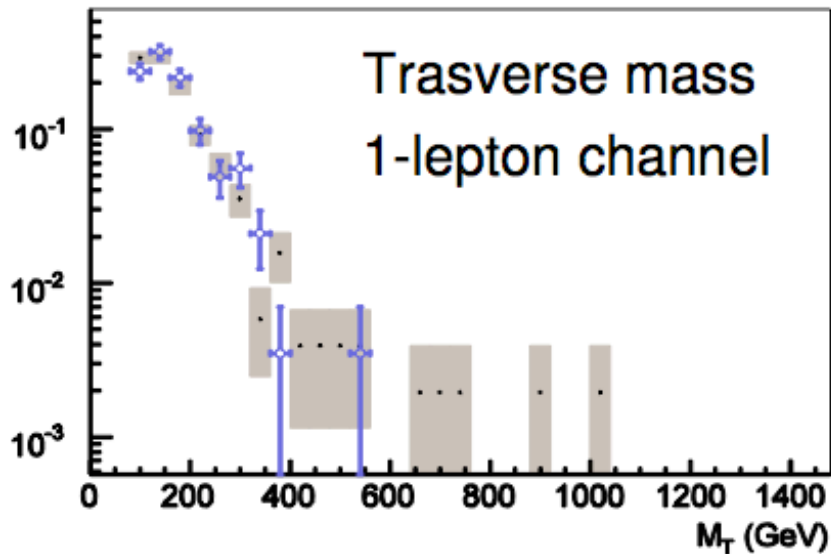


# Fast Calo Simulation

Shimpei Yamamoto

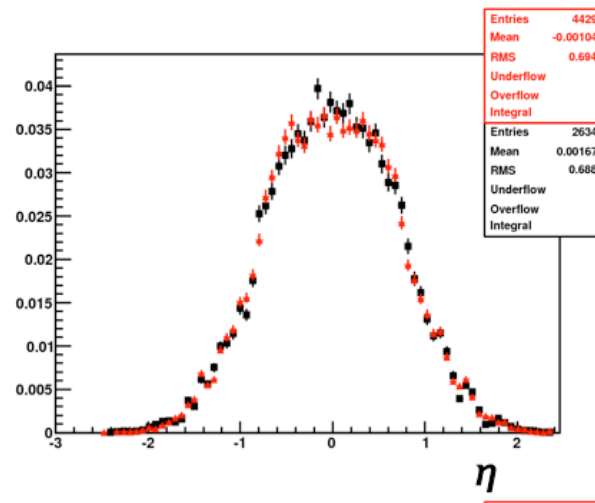
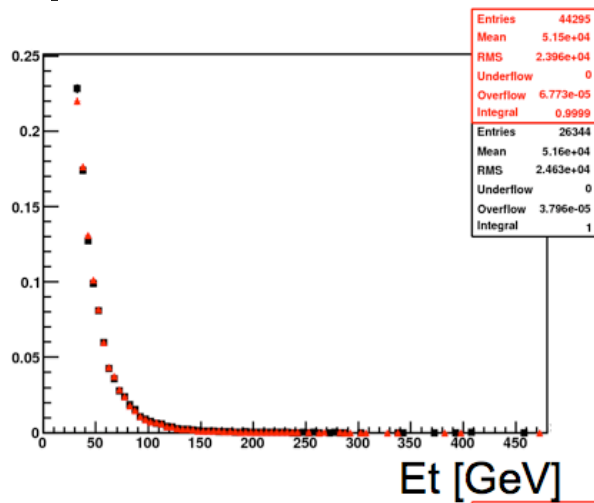
## Full Geant 4 Simulation vs Fast Calo Sim

Missing transverse energy and  $M_{\text{eff}}$  in a release 13 ttbar sample



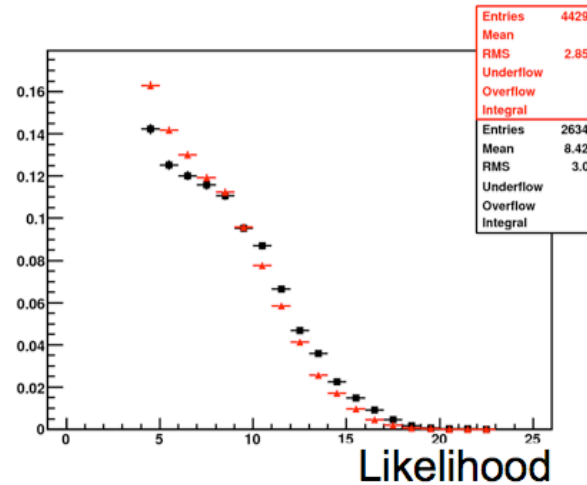
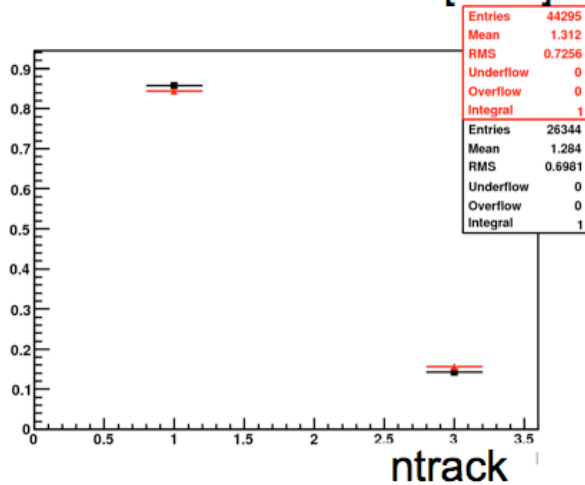


# Tau Candidates



Full sim vs  
**ATLFAST-II**

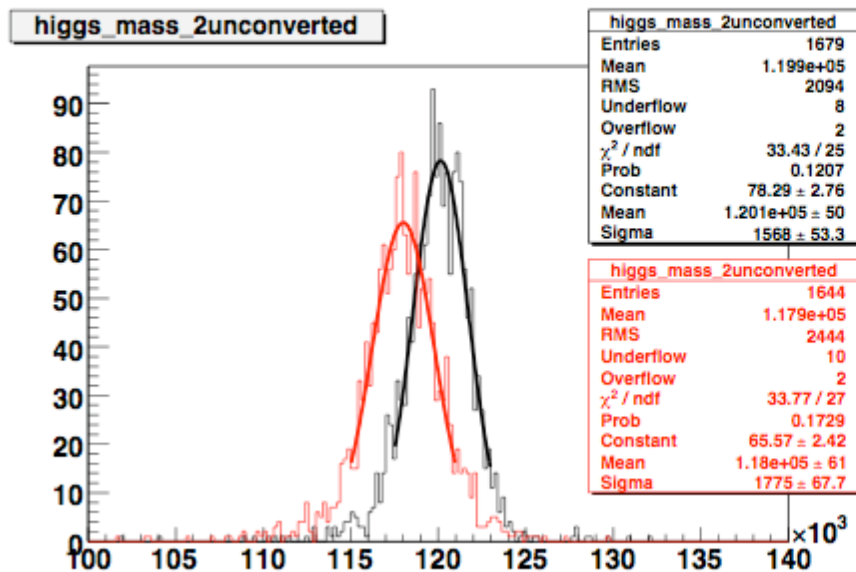
Taus in a  
ttbar sample



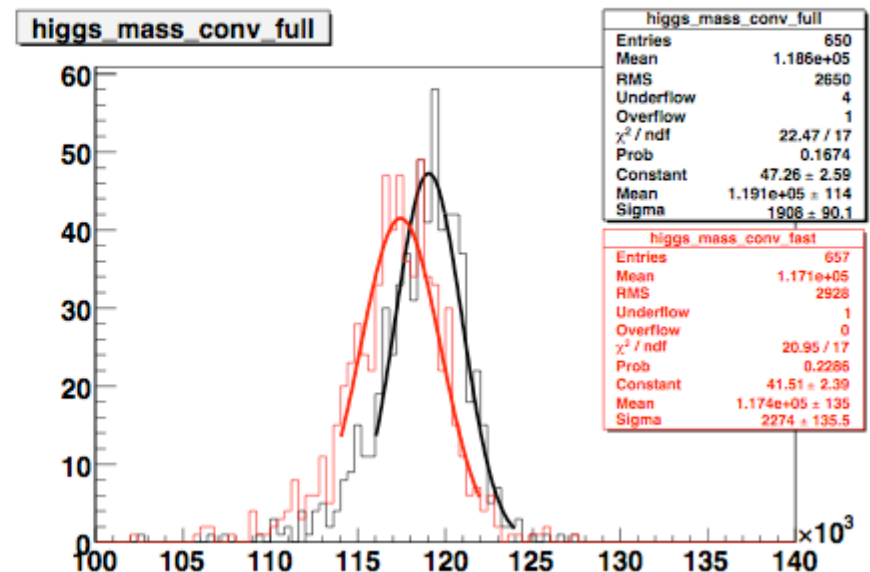
After cuts, 2-3x  
more taus in  
ATLFAST-II!

# Reconstructed Higgs- $\rightarrow\gamma\gamma$

Unconverted photons



All converted photons



Scale shift (fixed in 13.0.40.3); some differences in cut variables but not apparently enough to affect ID.  
 Pretty good for a 2+ year old tuning!!



# ATLFAST-II Timing

- Simulation times with release 13.0.40.1
  - No change in 14.x expected
- Without FATRAS, ID sim is >90% of the time
- With FATRAS, reco step is slowest

Sample	Time kSi2k Sec	Ratio Full / Fast Sim	Time w/FATRAS (Estimated)	Ratio w/FATRAS (Estimated)
J2 (dijet)	135	6.0	10	80
H(130) to 4l	123	7.2	10	90
Min Bias	75	4.6	6	60
SU3 SUSY	169	8.5	14	100
Z to MuMu	125	5.5	9	80
Z to ee	120	7.8	9	100
Z to TauTau	125	5.9	9	80

# AOD to AOD Corrections

- Package for corrections called MonteCarloReact
  - Reads metadata from the AOD to select corrections to apply
  - Shifts results based on its stored data files
- First use-case was ATLFAST-II efficiency corrections
  - Loose, medium, & tight electrons are corrected
  - Efficiency correction for taus
- Just the beginning for these corrections
  - Scale and resolution corrections (prototype for electrons)
  - Fake rates (requires MC Truth matching)
  - Correct other objects
  - Version containers (add containers instead of changing obj)



# Validation

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- All of these are validated in a computing sense
  - Very rare ( $\ll 1\%$ ) crashes, no build problems
- Fast G4 Sim and ATLFAST-II w/o FATRAS are on roughly the same schedule
  - Both have been examined by physics validation group
  - Both are in need of larger scale tests ( $10^{-6}$  effects?)
  - Both are being examined by physics groups now
- ATLFAST-II w/ FATRAS is behind by roughly one major release
- Full Simulation changed physics lists
  - Fast G4: will generate new libraries for 14.0.1 or 14.1.0
  - ATLFAST-II: AOD-to-AOD corrections in  $\sim 1$  minor release (14.1.0?)
  - ATLFAST-II: *Retuning* will be redone with release 14 (6 months?)



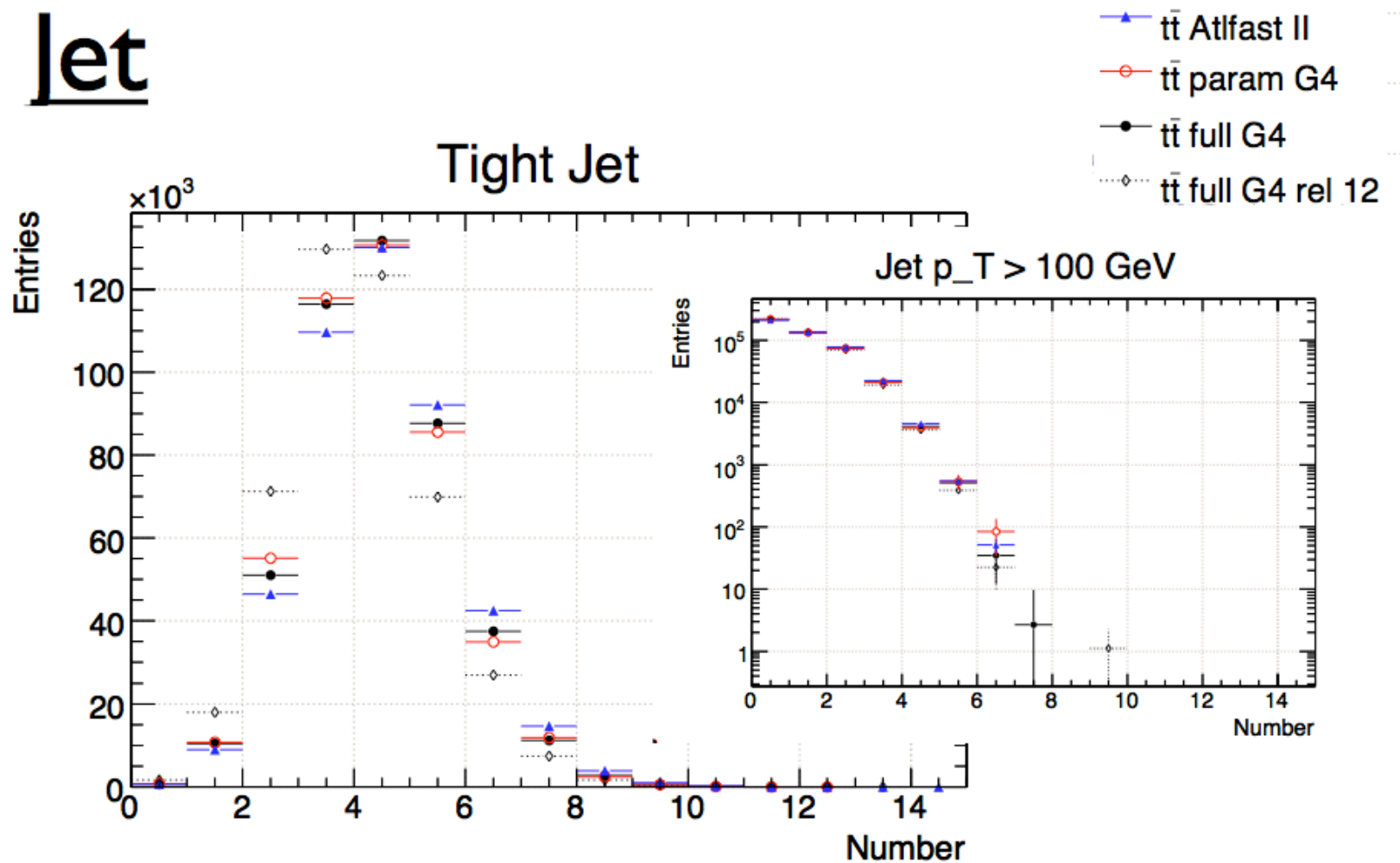
# Development

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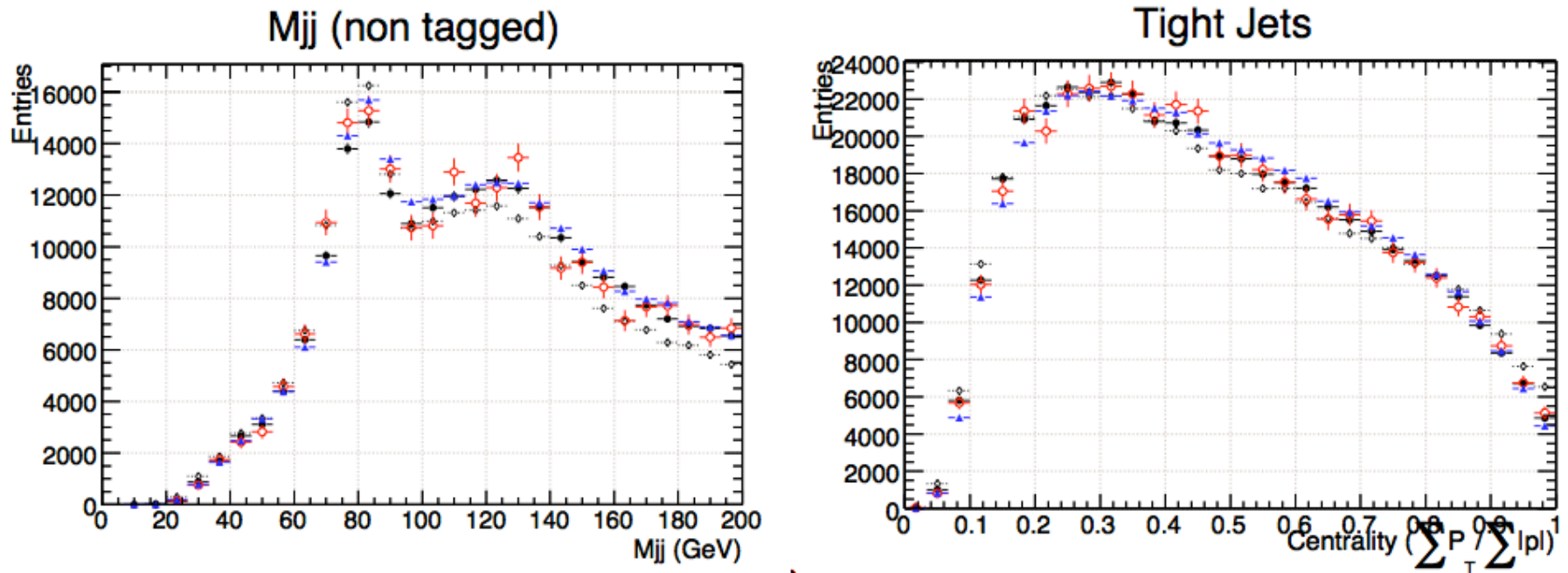
- Full G4 Simulation
  - Neutrino killing is now *on* in 14.0.0
  - Neutron killing limit is 10 us! Cut by an order of magnitude?
  - We could change G4 stepper
- Fast G4 Sim
  - Adding more higher order (1% level) effects in 14
  - Possible extension of showers to other calorimeters
- Fast Calo Sim
  - L1 Trigger for 14.0.X, L2 Trigger possible (but no developers)
- FATRAS
  - New nuclear interactions in 14.0.0
  - Combination with Fast Calo Sim ready for 14.0.0 or 14.0.1
  - Muon model for 15.x

# More comparisons ( $t\bar{t}$ ): ATLFAST-II, Fast G4, and Full Sim

## Jet



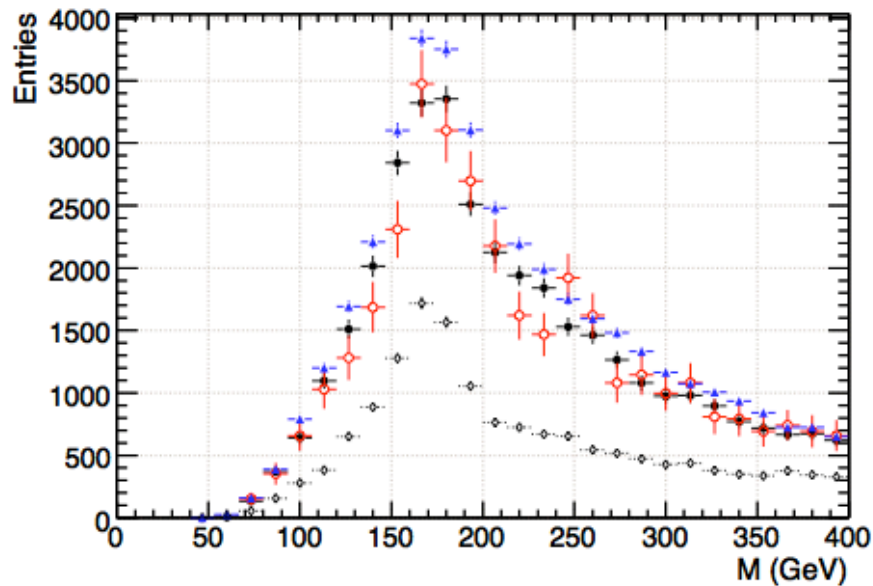
# More comparisons (ttbar): ATLFAST-II, Fast G4, and Full Sim



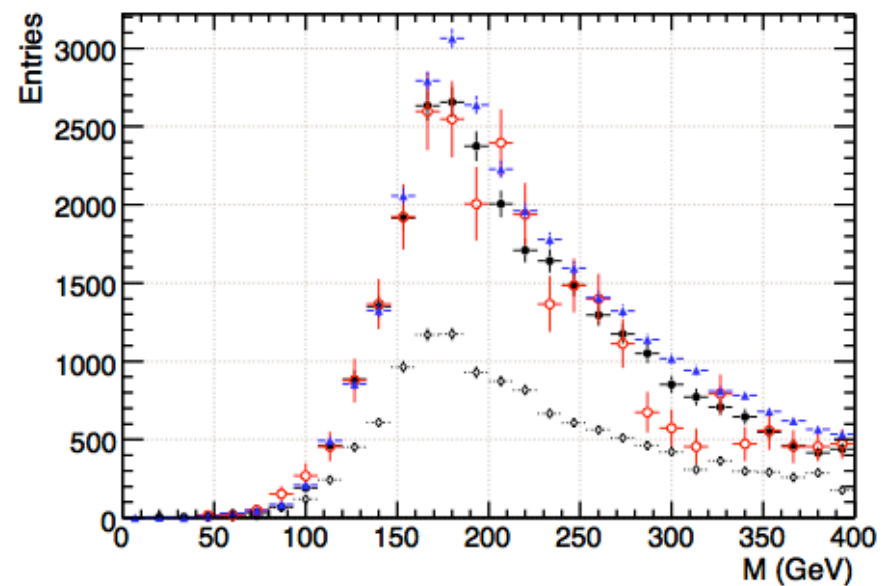


# More comparisons (ttbar): ATLFAST-II, Fast G4, and Full Sim

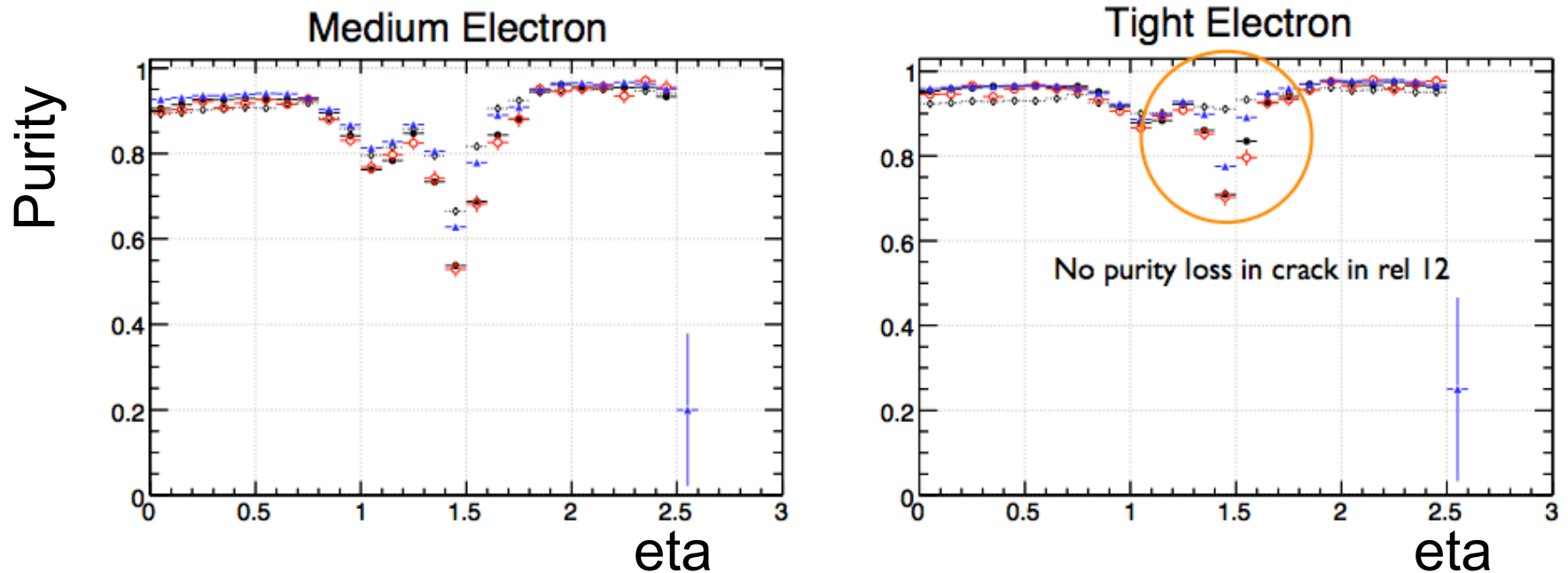
Hadronic Top (pass selection)



Leptonic Top (pass selection)



# More comparisons (ttbar): ATLFAST-II, Fast G4, and Full Sim





# Summary

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- Full simulation is too slow to complete all the necessary simulation - even if the physics description is perfect, we need other options available
- Several flavors of faster simulation exist
  - Fast G4 Sim (shower libraries)
  - ATLFAST-II (w/ and w/o FATRAS)
- Users are needed for validation
  - Need to establish physics performance in several channels for each simulation flavor
  - Only once that has been done can we provide better guidance (possible errors, biases) to physics groups
- Samples for ATLFAST-II going back in with 13.0.40.3 right now! (fixed scale shift, done soon!)



# Additional Resources

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- Full Sim:
  - Benchmarks: <http://atlas-computing.web.cern.ch/atlas-computing/packages/simulation/geant4/validation/Comparisons.html>
  - Sim Optimization: <https://twiki.cern.ch/twiki/bin/view/Atlas/SimulationOptimization>
  - Validation: <http://indico.cern.ch/categoryDisplay.py?categId=250>
    - Includes some Fast G4 Sim and ATLFAST-II validation in the last two months
- Fast G4 Sim:
  - Twiki: <https://twiki.cern.ch/twiki/bin/view/Atlas/AtlasShowerParam>
    - Has talks, papers, lists of samples
  - Meetings: <http://indico.cern.ch/categoryDisplay.py?categId=1175>
  - Phys Val: <http://indico.cern.ch/conferenceDisplay.py?confId=25227>
  - Phys Val: <http://indico.cern.ch/conferenceDisplay.py?confId=24674>



# Additional Resources

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- ATLFAST-II:
  - Twiki: <http://twiki.cern.ch/twiki/bin/view/Atlas/AtlfastII>
    - Includes links to components
  - Meetings: <http://indico.cern.ch/categoryDisplay.py?categId=879>
  - Phys Val: <http://indico.cern.ch/conferenceDisplay.py?confId=27303>
  - Fast Calo Sim Twiki: <http://twiki.cern.ch/twiki/bin/view/Atlas/FastCaloSim>
  - Notes forthcoming for both FATRAS and Fast Calo Sim / ATLFAST-II
  - FATRAS Twiki: <http://twiki.cern.ch/twiki/bin/view/Atlas/FatRas>
  - FATRAS Validation: <http://twiki.cern.ch/twiki/bin/view/Atlas/AtlfastII>
  - AOD-to-AOD Corrections:  
<http://twiki.cern.ch/twiki/bin/Atlas/MonteCarloReact>



## 13.0.40.1 Samples

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- Sample list compiled by Wouter Verkerke
- Newest fast simulation samples available with 13.0.40.1
- No need to dig through panda queries on your own!
- <https://twiki.cern.ch/twiki/bin/view/Atlas/SimulValidationSamplesR13>



# Fast G4 Sample Availability

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- Fast G4 Simulation is looking for users!
  - Validation is well underway
  - Agreement may be good enough for you already
  - Samples on the grid (Z- $\rightarrow$ ee, Z- $\rightarrow$  $\tau\tau$ , ttbar, JX)
  - [http://gridui02.usatlas.bnl.gov:25880/server/pandamon/query/?mode=taskquery&qDSInput=fast2&qTaskTRF=csc\\_reco\\_trf.py&qStatus=LiveTasks&qsubmit=QuerySubmit](http://gridui02.usatlas.bnl.gov:25880/server/pandamon/query/?mode=taskquery&qDSInput=fast2&qTaskTRF=csc_reco_trf.py&qStatus=LiveTasks&qsubmit=QuerySubmit)
  - [http://gridui02.usatlas.bnl.gov:25880/server/pandamon/query/?mode=taskquery&qDSInput=fast%25valid&qTaskTRF=csc\\_reco\\_trf.py&qStatus=LiveTasks&qsubmit=QuerySubmit](http://gridui02.usatlas.bnl.gov:25880/server/pandamon/query/?mode=taskquery&qDSInput=fast%25valid&qTaskTRF=csc_reco_trf.py&qStatus=LiveTasks&qsubmit=QuerySubmit)
  - More details from Ian Hinchliffe:  
<http://indico.cern.ch/getFile.py/access?contribId=9&resId=0&materialId=slides&confId=27621>
- For samples, contact Zach Marshall (zmarshall@caltech.edu)



# ATLFAST-II Sample Availability

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- Many samples on the grid
  - Large scale production:
    - [http://gridui02.usatlas.bnl.gov:25880/server/pandamon/query/?mode=taskquery&qTaskTRF=csc\\_recoFastCaloSim\\_IDonly\\_trf.py&qTaskTRFVersion=13.0.40.1&qStatus=LiveTasks&qsubmit=QuerySubmit](http://gridui02.usatlas.bnl.gov:25880/server/pandamon/query/?mode=taskquery&qTaskTRF=csc_recoFastCaloSim_IDonly_trf.py&qTaskTRFVersion=13.0.40.1&qStatus=LiveTasks&qsubmit=QuerySubmit)
    - [http://gridui02.usatlas.bnl.gov:25880/server/pandamon/query/?mode=taskquery&qTaskTRF=csc\\_simulID\\_recoFastCaloSim\\_trf.py&qStatus=LiveTasks&qsubmit=QuerySubmit](http://gridui02.usatlas.bnl.gov:25880/server/pandamon/query/?mode=taskquery&qTaskTRF=csc_simulID_recoFastCaloSim_trf.py&qStatus=LiveTasks&qsubmit=QuerySubmit)
    - Others available on their webpage:
      - [https://twiki.cern.ch/twiki/bin/view/Atlas/AtlfastII#Existing\\_samples](https://twiki.cern.ch/twiki/bin/view/Atlas/AtlfastII#Existing_samples)
  - For samples, contact Michael Duehrssen (Michael.Duehrssen@cern.ch)





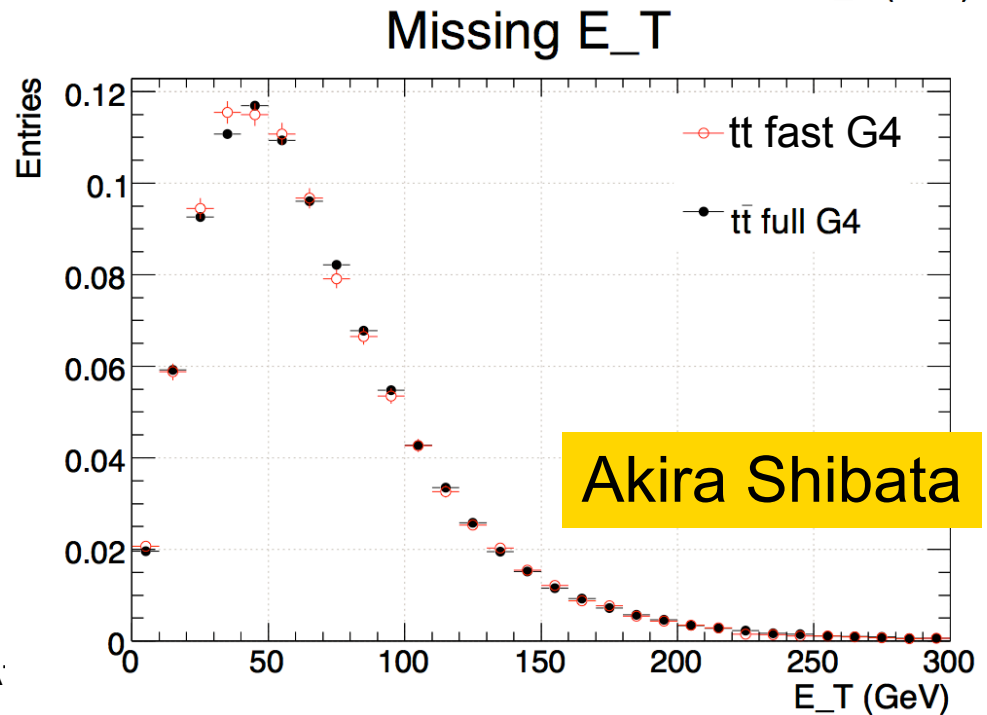
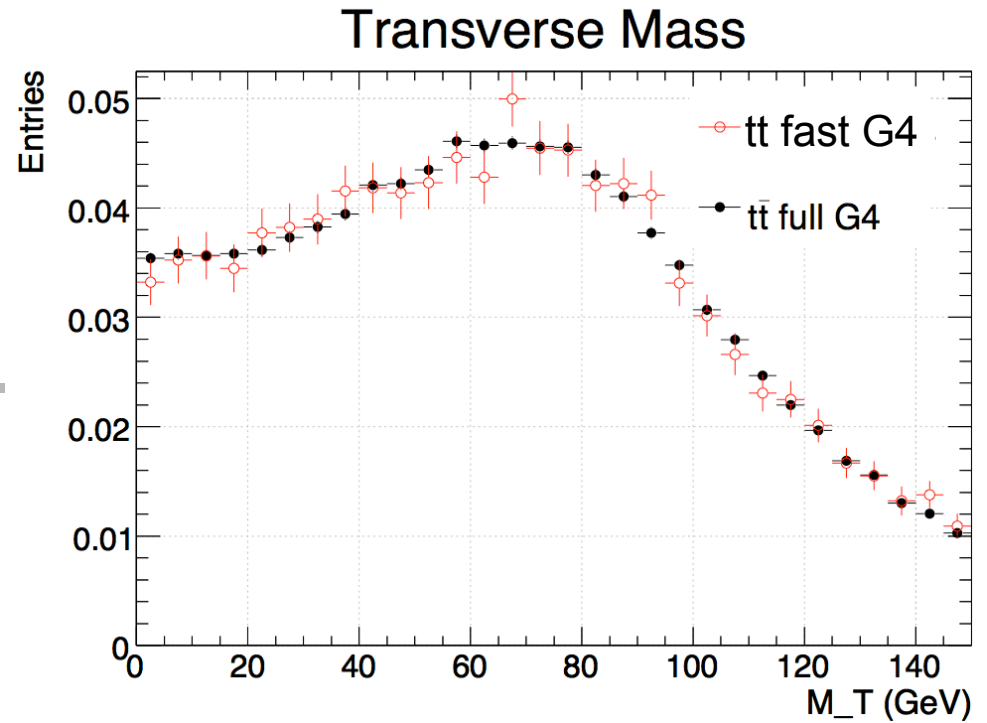
# Fast G4 Simulation

Fast G4 simulation and full simulation

Transverse mass and missing transverse energy in a  $t\bar{t}$  sample simulated with release 13

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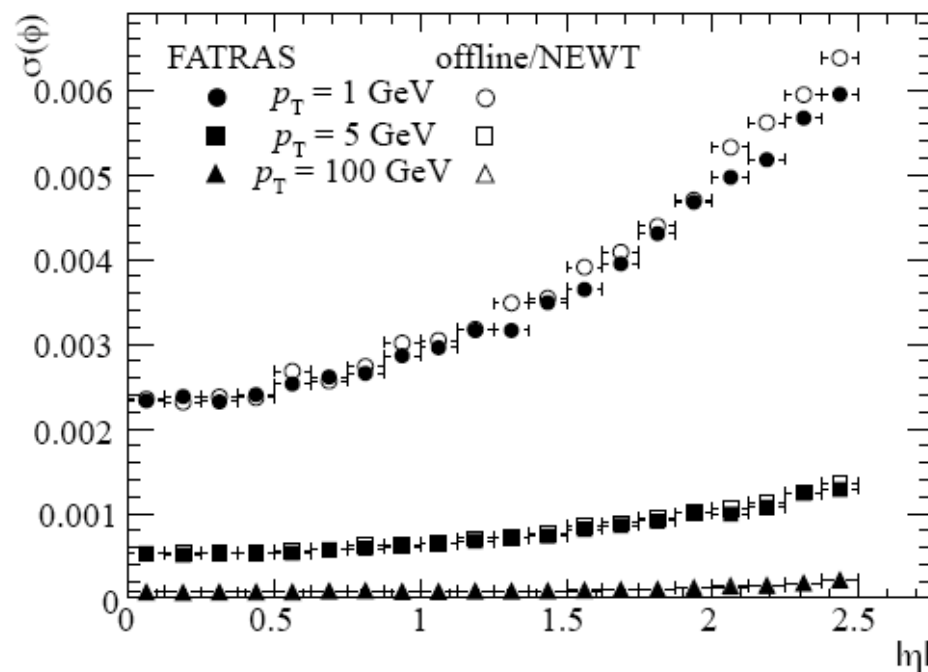
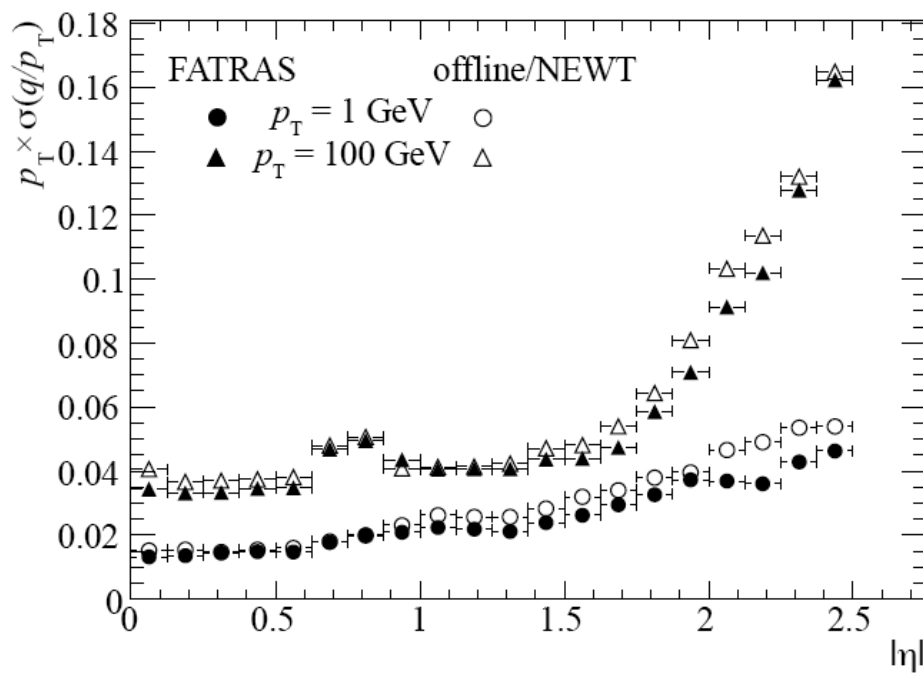
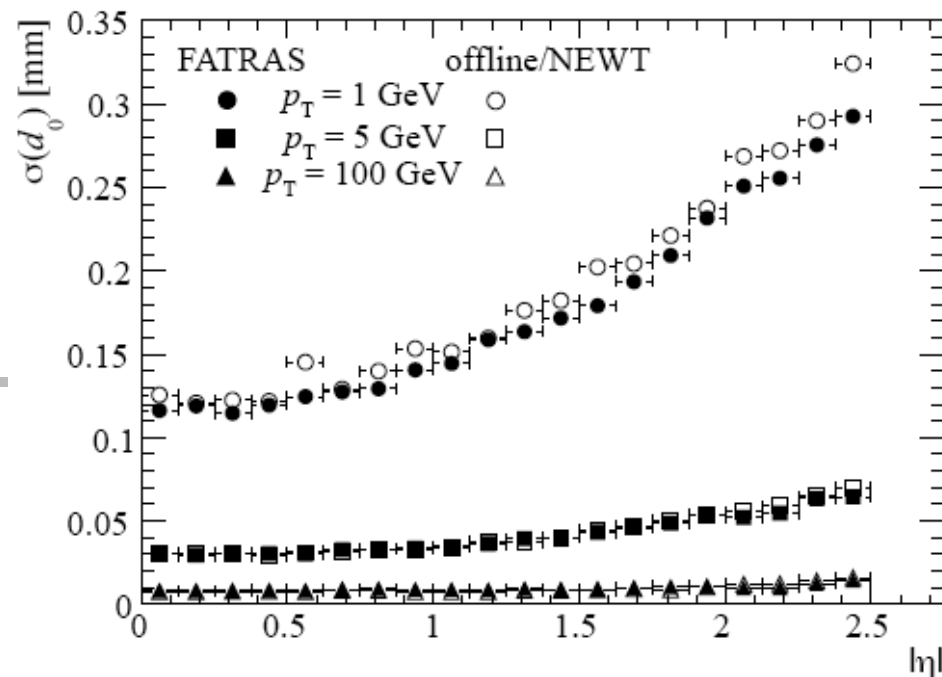


Akira Shibata

# FATRAS

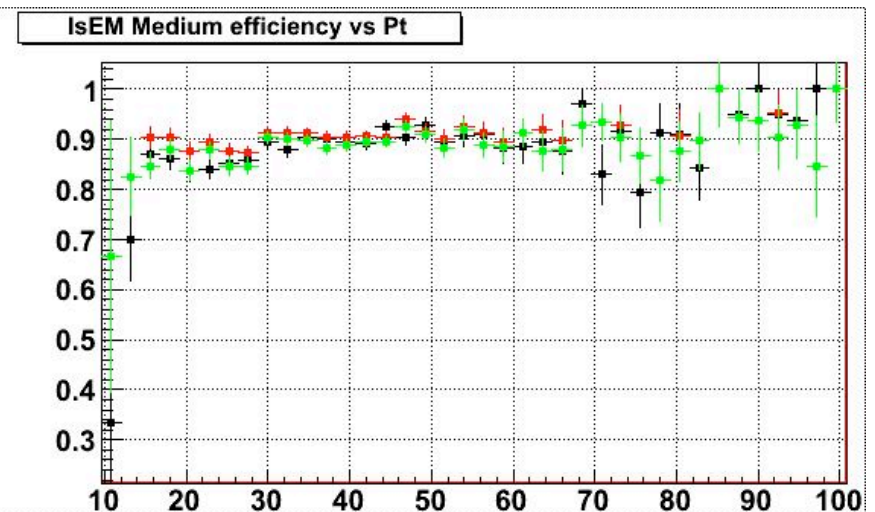
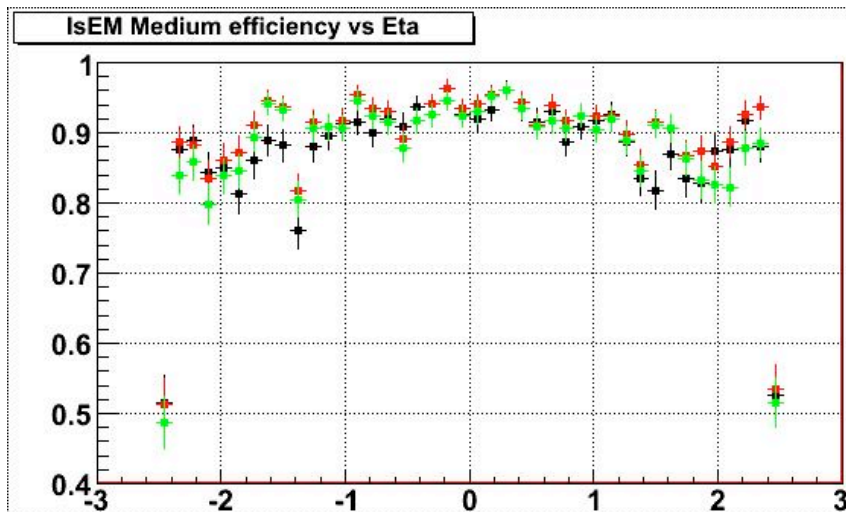
# Resolutions

NEWT = New Tracking



# AOD to AOD Corrections

- Electron identification efficiency in release 13 full simulation, **ATLFAST-II**, and **ATLFAST-II after AOD to AOD corrections** in a  $Z \rightarrow ee$  sample





# Simulation time by Subdet.

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<b>Subsystem</b>	<b>Full Sim</b>	<b>Fast G4 Sim</b>
Tracker	44	38
EM Barrel Calorimeter	91	23
EM Endcap Calorimeter	393	107
Forward Calorimeter	155	55
Hadronic Endcap Calorimeter	50	47
Hadronic Barrel Calorimeter	29	27
Muon System	21	21
Other Systems	124	89
<b>Event</b>	<b>907</b>	<b>406</b>

Fast sim: time  
spread amongst  
subdetectors

J5 dijet events in  
release 13.0.30

<b>Particle Type</b>	<b>Full Sim</b>	<b>Fast G4 Sim</b>
Electrons and Positrons	344	124
Photons	259	88
Other Particles	304	194
<b>Event</b>	<b>907</b>	<b>406</b>