A Study of Track-based Taus in Atlfast 1.

University of Glasgow | Experimental Particle Physics

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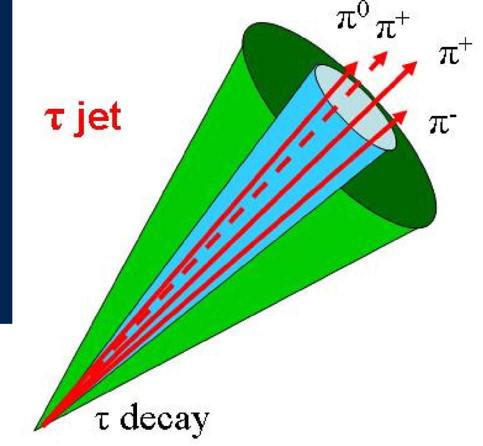

Introduction.

Although ATLAS is by design a multi-purpose detector one of the chief aims is the discovery of the Higgs boson. Fits of the theory to existing electroweak precision data suggest a relatively low mass standard model Higgs [1]. Incorporating the lower exclusion limit from LEP results [2], in the remaining low mass range, decays to taus and photons are the most promising for discovery [3].

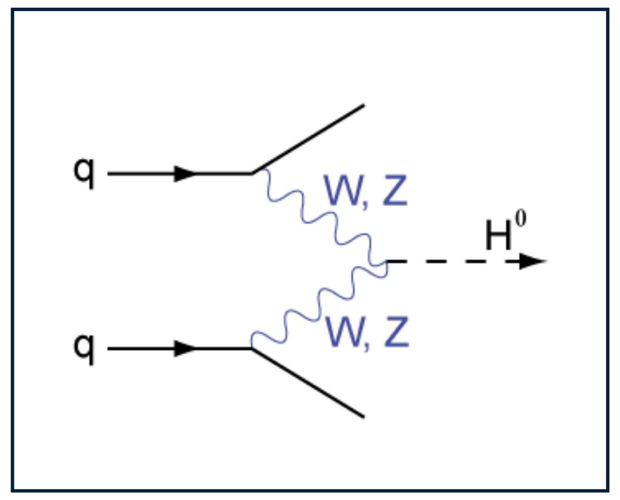

Figure 1: Vector Boson Fusion.

Vector boson fusion (see fig 1.) is predicted to be the second largest Higgs production process at the LHC. VBF Higgs decaying to two taus produces a very distinctive signature enabling good signal extraction.

Taus decay hadronically 64.8% of the time else decaying to an electron (17.8%) or a muon (17.4%). The hadronic decays are characterised as being either one prong (one charged pion – 77% of all hadronic decays) or three prong. A tiny amount (0.1%) of hadronic decays have five charged pions in their final state although these are too difficult to reconstruct in a jet heavy environment.

Three final states for $H\rightarrow\tau\tau$ are considered. A fully leptonic final state (e, μ), a semi-leptonic final state with one leptonically decaying tau and one hadronically decaying tau and finally the fully hadronic channel.

Hadronic taus are reconstructed using one of (or a combination of) two algorithms; one track-based and one calorimeter deposit based. This study focuses on taus reconstructed using the track-based algorithm, comparing those from Atlfast 1 simulation and those from full simulation.

Atlfast 1 replaces the full simulation chain by smearing Monte Carlo generated events according to resolutions calculated from full simulations (see fig 2). It is in general 4 or 5 orders of magnitude faster than full simulation making it a useful tool for quick analysis with large statistics.

Analysis presented in this poster is performed on a $Z\rightarrow\tau\tau$ dataset generated using Pythia. $Z\rightarrow\tau\tau$ is important to Higgs analysis for this channel, as an irreducible background and also as a good way of checking the reconstruction algorithms.

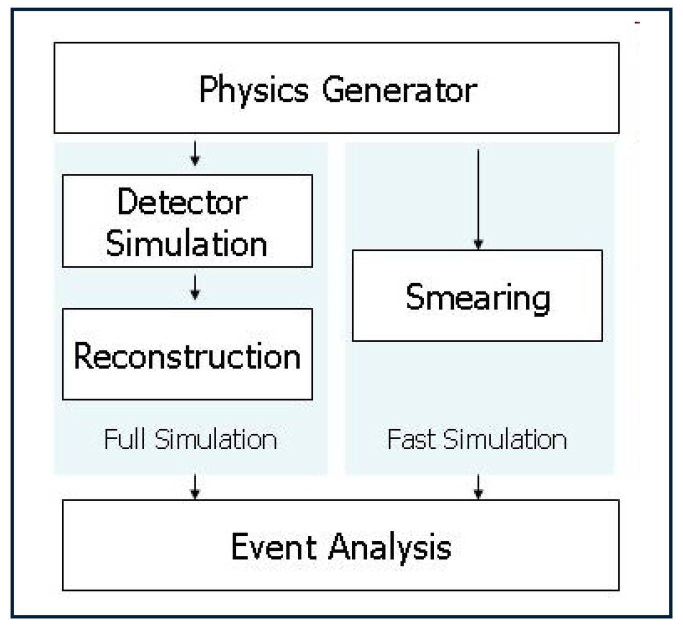

Figure 2: Flow chart representing fast and full simulations.

Results.

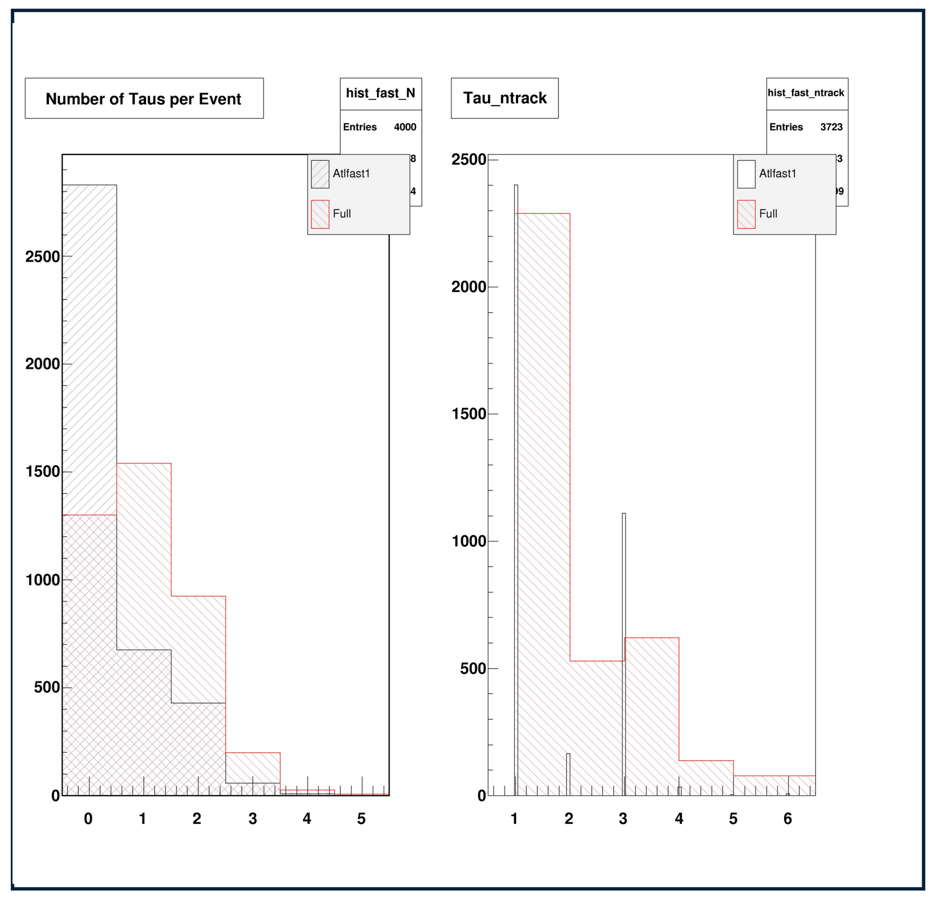

Figure 3: Comparison between fast and full simulations. Left hand plot shows number of taus per event, right hand plot shows (normalised to same number of taus) tracks per tau.

Figure 3 shows a comparison of the reconstruction of taus in full simulation and Atlfast simulation. The plot on the left is a comparison of the number of taus per event, normalised to the same number of events. Full simulation reconstructs more taus than Atlfast. Atlfast output shown here has already been identified, one step of which is matching to Monte Carlo Truth information, meaning there are no fakes. Another explanation could be that the efficiencies applied to the Atlfast simulation (based on parameters obtained from full simulation) are too low.

The plot on the right of figure 3 shows the number of tracks per tau, normalised to have the same number of taus per simulation. Atlfast is a much simpler simulation and closer to the truth information reflected by the reduced number of taus mis-identified as having 2 prongs.

[1] D Rainwater *et al.*, Phys. Rev. D 59, 014037 (1999).
[2] ALEPH,DELPHI,L3 and OPAL Collaborations, Physics Letters B, Volume 565 (2003).
[3] The ATLAS Collaboration, Detector and physics performance technical design report (Volume 2), CERN-LHCC/99-15 (1999).

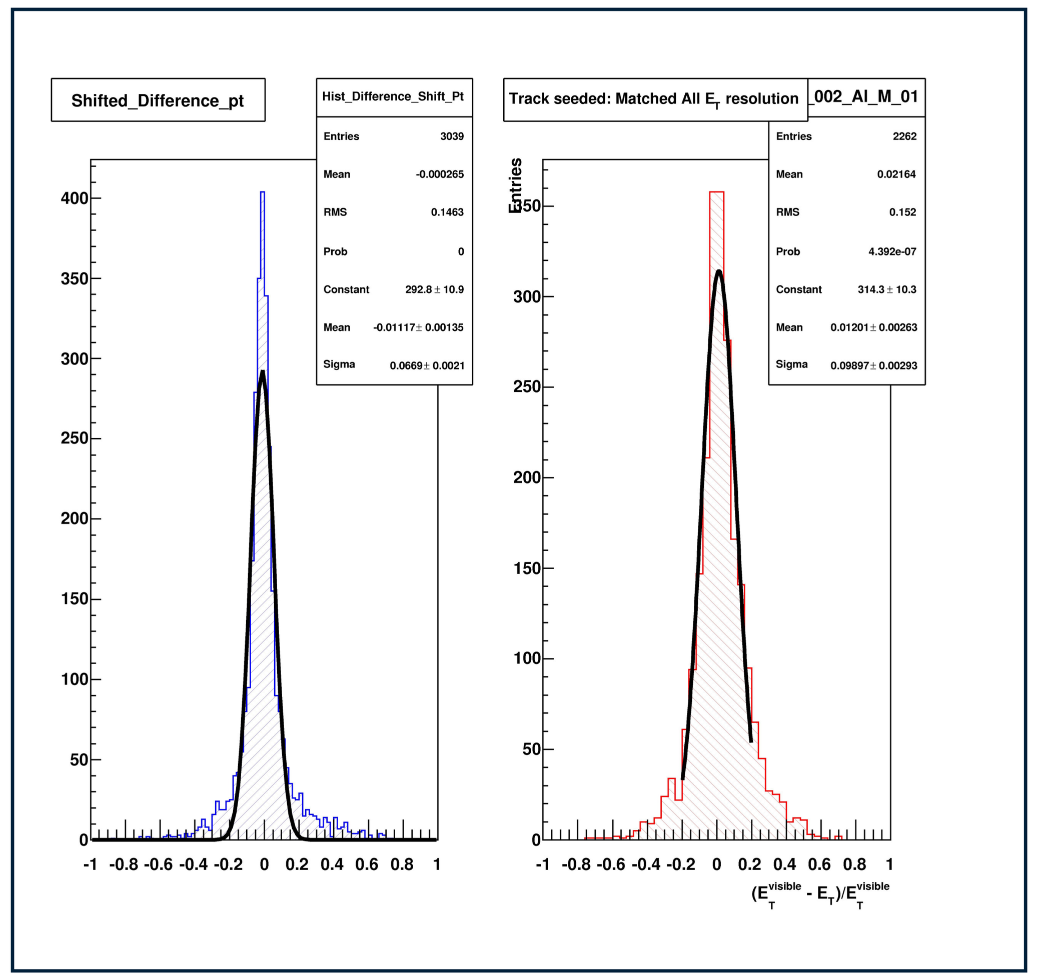

Figure 4: Transverse momentum resolution. Fast on the left in BLUE and full on the right in RED. Resolution is calculated by subtracting the p_T of a reconstructed tau that is matched to a truth tau from the p_T of the truth tau, all divided by the truth transverse momentum. Black line on both plots is a Gaussian fit, parameters of which are shown in the key.

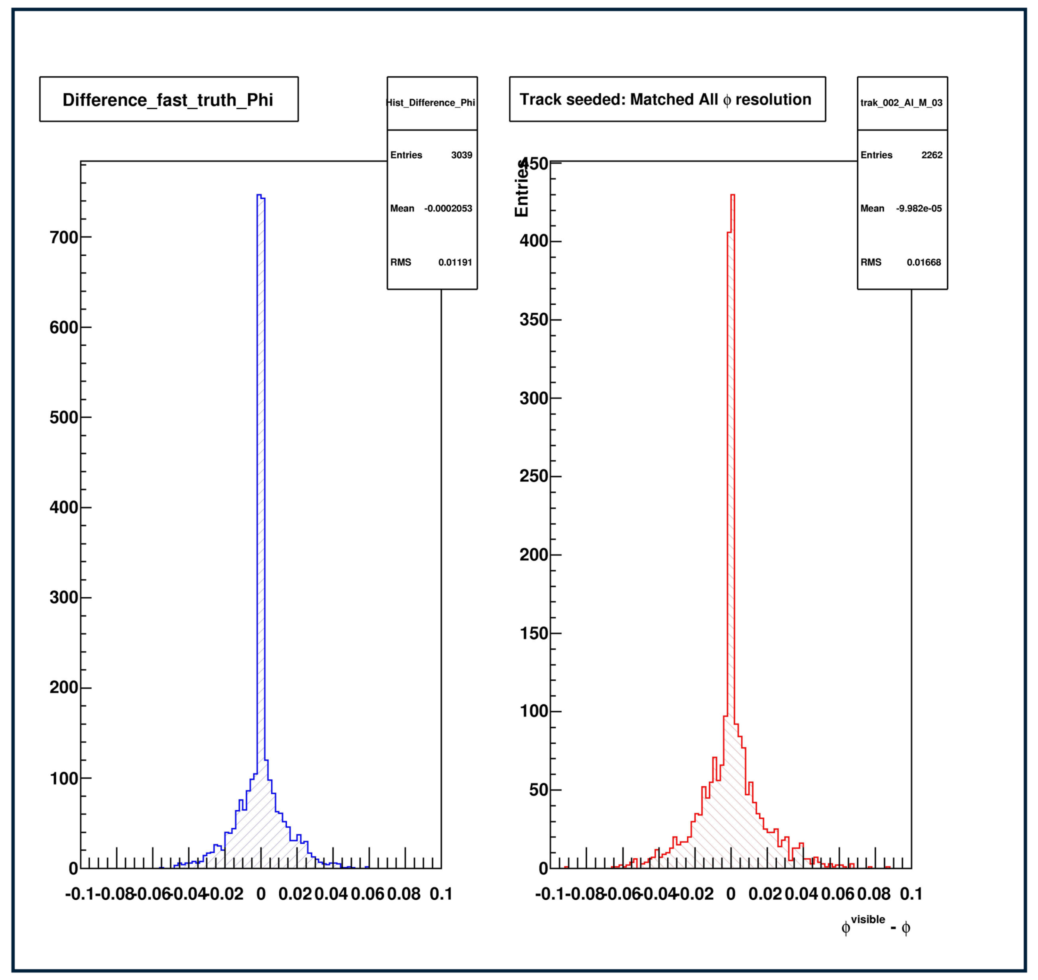

Figure 5: Phi Resolution, same colour scheme as figure 4. Resolution is here calculated by subtracting reconstructed and matched tau phi from truth tau phi.

Resolution of the physical properties of reconstructed tau candidates offers a view of the performance of the detector. Figures 4 and 5 show that the fast simulation is currently slightly over optimistic about the performance of the detector.

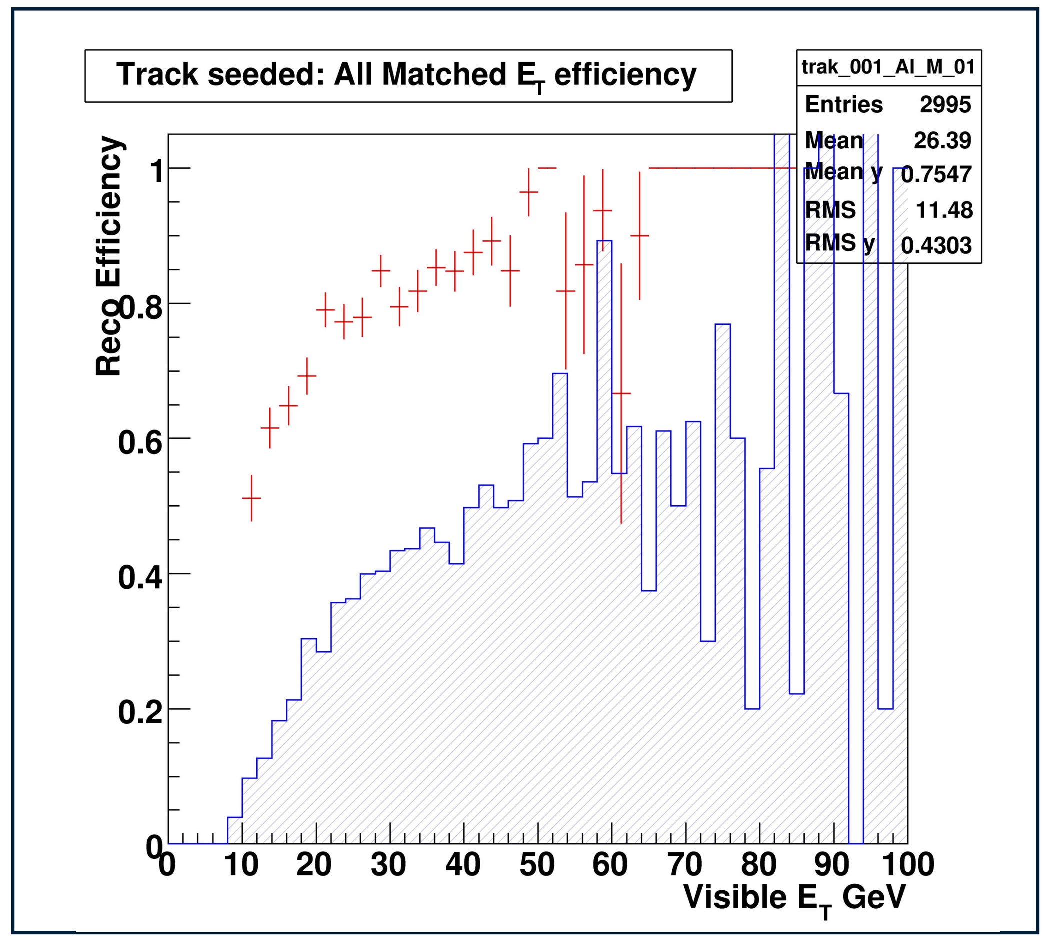

Figure 6: Comparison of efficiencies as a function of transverse momentum. Fast simulation is in blue and full in red.

Efficiencies represent the fraction of truth taus that are reconstructed. In red in figure 6 is the full simulation efficiencies as a function of transverse momentum. A histogram of the transverse momentum of truth taus that are matched to reconstructed taus is divided by a histogram the transverse momentum of all truth taus.

Due to an anomalous low match rate in fast event analysis, the fast efficiency shown uses reconstructed data as well, resulting in binning problems particularly for higher momenta.

The fast efficiency shown can be compared to the efficiencies which are entered into the Atlfast simulation. The outputted efficiency is lower than those entered, more so for lower momenta. There is clearly another effect which is masking the efficiency.

The full efficiency seems to be higher than those entered into Atlfast although more detailed studies sorting the taus by the number of prongs would be required to verify this.

Conclusions and Further Work.

Fast simulation currently reconstructs fewer tau candidates than full simulation. The resolutions are similar with Atlfast being slightly optimistic on the detector performance. Initial investigations would suggest that full simulation has a higher efficiency than Atlfast. If further investigations show this to be the case the efficiency parameters used by Atlfast can be altered. Therefore continuing work will be to;

- Investigate the low match efficiency in fast simulation event analysis.
- Ascertain what is suppressing the fast efficiency at low momenta – current work is looking towards electron/muon discrepancies.
- Sort taus by the number of prongs in their decays.
- Compare current fast efficiencies with the efficiencies inputted into Atlfast which are supposed to simulate them.
- Update Atlfast 1 efficiency parameters.