

Tau Trigger Performance

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ATLAS UK Physics Meeting
Thursday 10th January 2008



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Aims

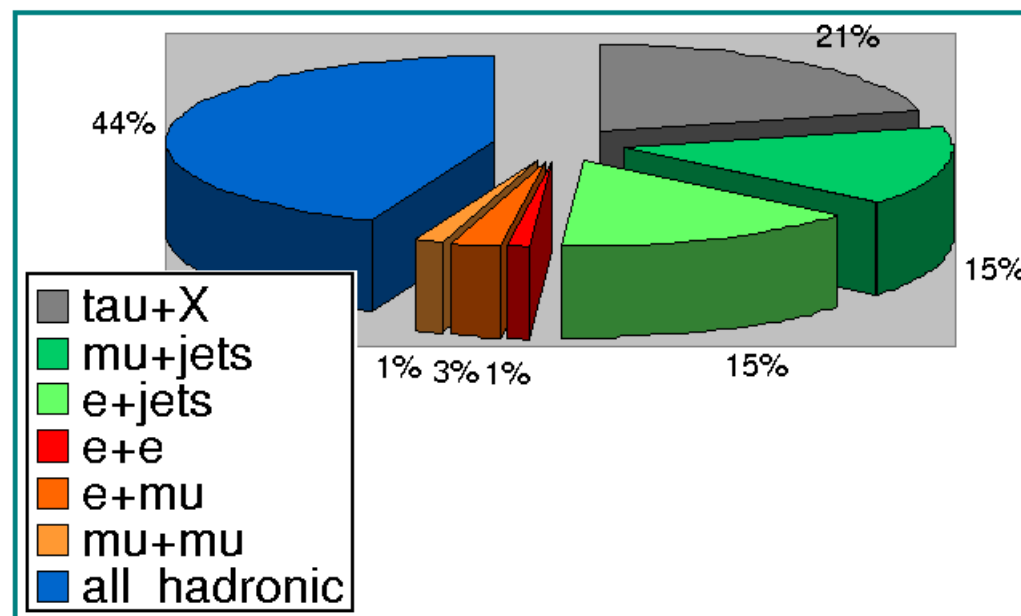
- To study the ATLAS level 1 tau trigger performance for different processes, isolation cuts and over a range of visible tau pt.
- $Z \rightarrow \tau\tau$ events provide a clean source of taus for easy triggering. Ttbar events test the trigger in a more complicated environment but one which will be normal at the LHC.
- $Z \rightarrow \tau\tau$ and ttbar events are of interest because ultimately they can both be used to examine the tau trigger performance in real data.

Datasets

- 005200 series (Semileptonic and dileptonic ttbar with taus).
- 005188 series ($Z \rightarrow \tau\tau$).
- 006536 series ($A \rightarrow \tau\tau$) – Not discussed here.

Motivations

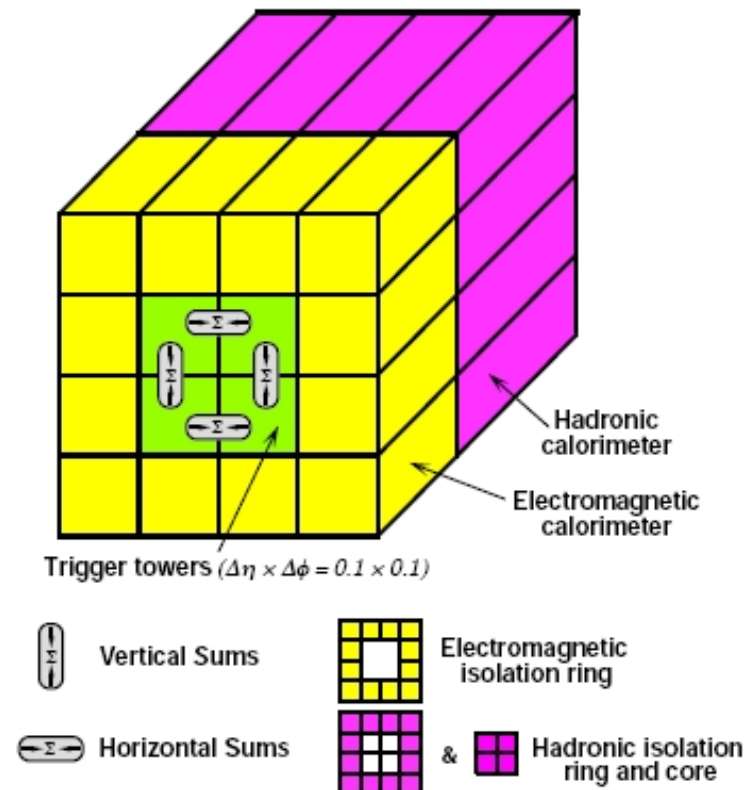
- Make better use of the available $t\bar{t}$ events:
 - Many $t\bar{t}$ studies use the semileptonic channel but usually only considering the electron or muon cases. These together have a combined branching ratio of 30%.
 - 21% of $t\bar{t}$ events contain one or more decays to taus. By making use of $t\bar{t}$ events containing a single tau lepton the size of the useful semileptonic dataset may be extended.



- Tau final states are predicted for a number of as yet unseen (or predicted) processes:
 - Standard model Higgs boson ($t\bar{t}h \rightarrow t\bar{t}\tau\tau$).
 - MSSM Higgs bosons ($H/A \rightarrow \tau\tau$).
 - Alternative SUSY processes etc.

ATLAS Level 1 Calorimeter Trigger

- Uses reduced granularity information from the calorimeters
- Looks for high pt electrons and photons, jets and taus decaying into hadrons, and large missing and total Et (transverse energy)
- Separate trigger towers exist for the EM and Hadronic calorimeters
- Towers are grouped into EM and Hd clusters, cores and isolation rings
- For electron, photon and tau triggers, isolation can be applied to reduce the jet background



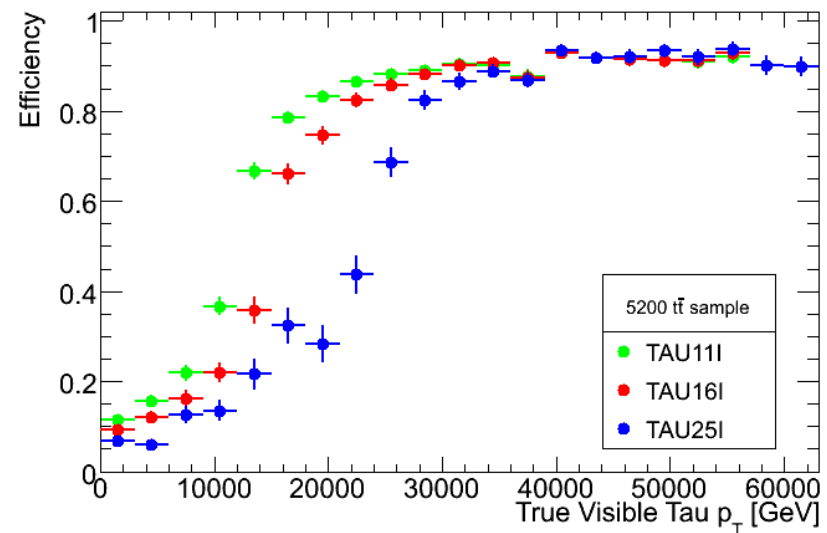
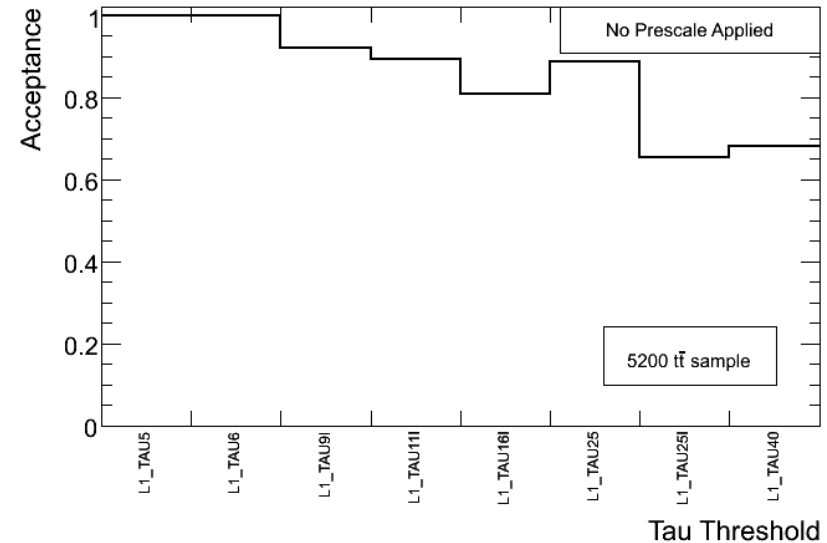


L1 Calo 'Regions of Interest' (RoI)

- If a tau/hadron object passes the conditions specified by the trigger algorithms, then an RoI (Region of Interest) is produced and sent to the level 2 trigger for all events selected by level 1.
- RoI contain information on position (in terms of η and Φ) and trigger thresholds passed.
- The level 2 trigger can use full event data and detector precision/granularity to analyse the event further for the level 2 decision.

Early tau trigger menu

- ATLAS early trigger menu proposed for 10^{31} luminosity contains a tau trigger.
- Eight LVL1 tau trigger thresholds are:
 - L1_TAU5
 - L1_TAU6
 - L1_TAU9I
 - L1_TAU11I
 - L1_TAU16I
 - L1_TAU25
 - L1_TAU25I
 - L1_TAU40
- Isolation condition used is $EM_{\text{isol}} \leq 6.0$ GeV. No H_d Isol cut is used.



Studying the Tau Trigger

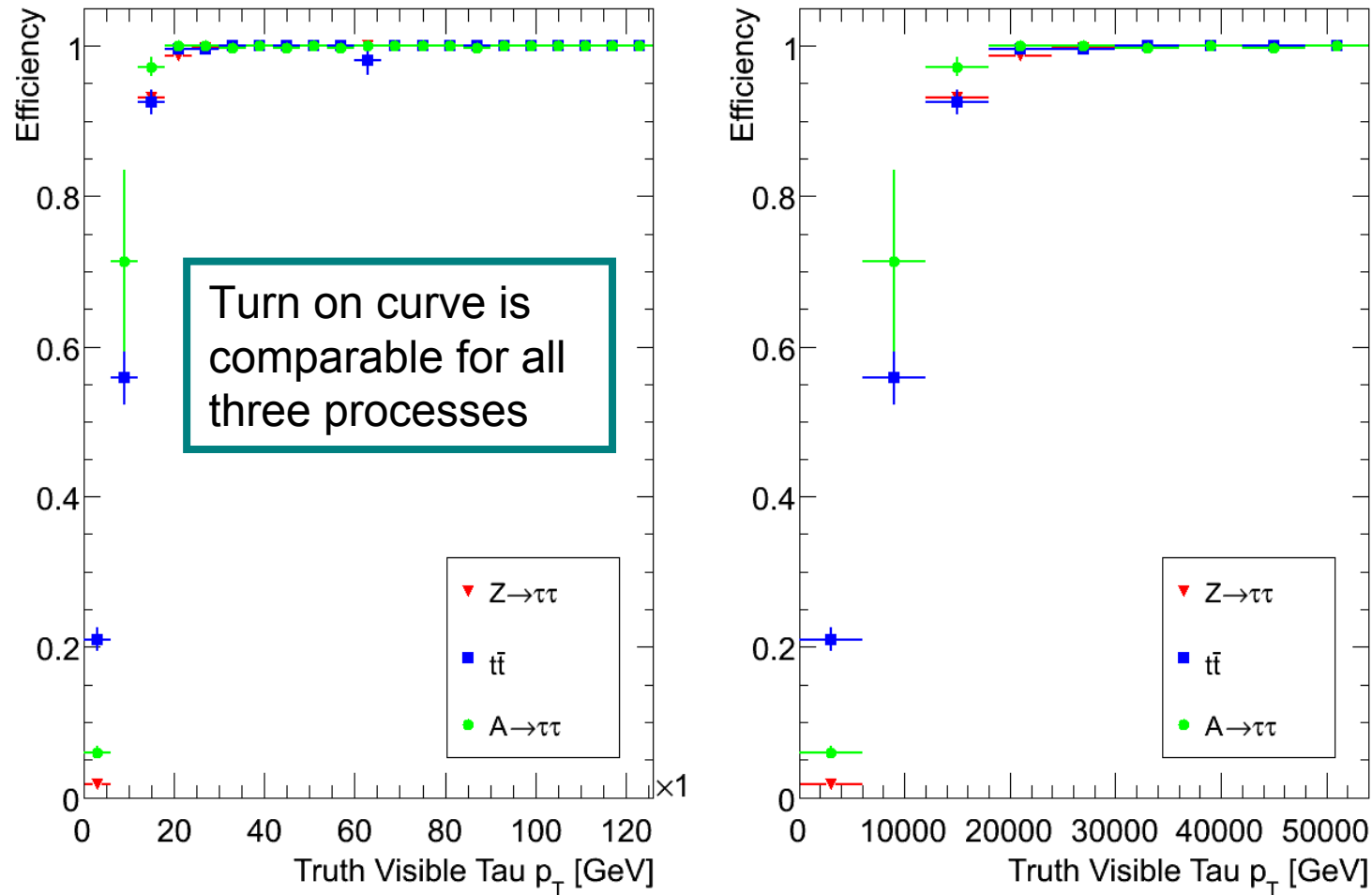
- Compare Monte Carlo truth or reconstructed particles to the Rol information.
- Calculate ΔR (Separation length) between each tau (or antitau) and each EMTau Rol:

$$\Delta R = \sqrt{(\Delta \eta^2 + \Delta \phi^2)}$$

- Assign the best matched Rol to each tau in each event as being the one that produced the smallest value of ΔR .
- Plot trigger efficiency as a function of the visible pt of the tau.
 - Tau Cluster threshold set to 20GeV (fixed).
 - Use EM isolation cuts of 4, 5, 6, 7 and 8 GeV.
 - Use Hd isolation cuts of 2, 3, 4, 5 and 6 GeV.
- Define the trigger condition (success) as being the presence of a tau spatially matched to an EMTau Rol, 'matched' being the possession of a ΔR value < 0.3 .
- Tau's only included within the real calorimeter coverage, i.e. $|\eta| < 2.5$.

Lower cuts are too tight, later ones are more suitable for use

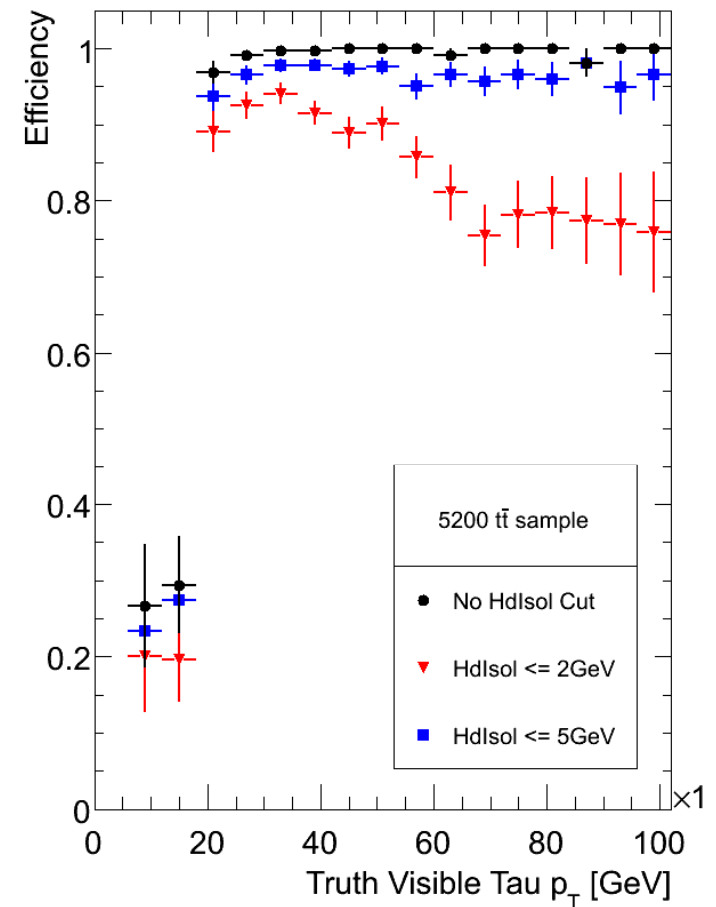
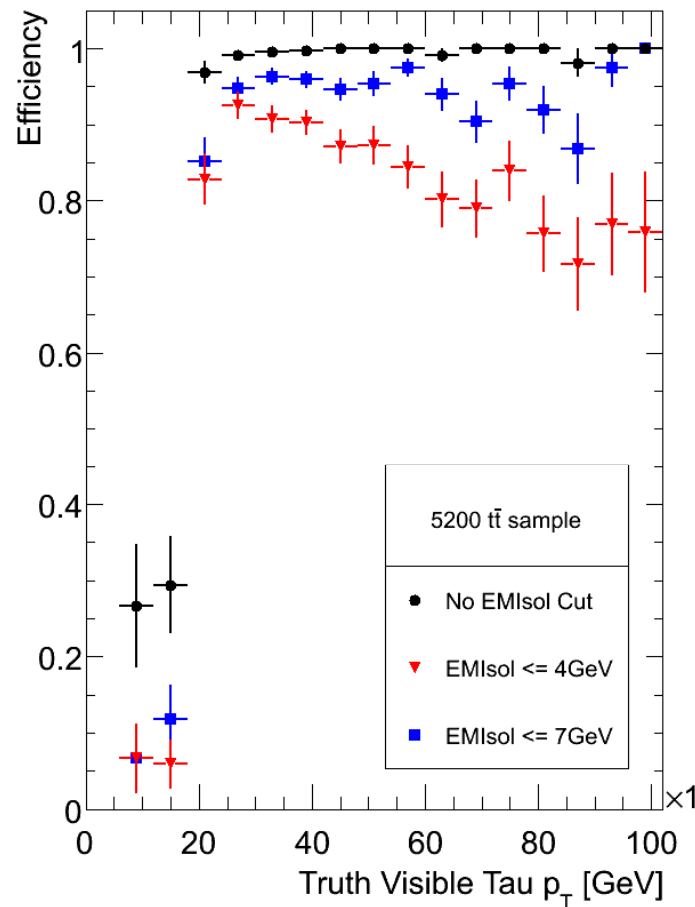
Efficiency without isolation applied

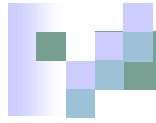


(All tau's used in the $t\bar{t}$ sample, whether originating from W 's or B 's).

Effect of isolation on efficiency

- Isolation causes efficiency to fall off as p_T increases (visible for tight cuts). As tau p_T increases, so the level of leakage which occurs into the isolation rings around the RoI clusters increases and so more events are likely to fail the isolation condition.
- 4GeV EM and 2GeV Hd cuts cause a dramatic efficiency fall off above 30GeV.
- 7GeV EM and 5GeV Hd cuts have little effect on the efficiency up to approximately 80GeV.

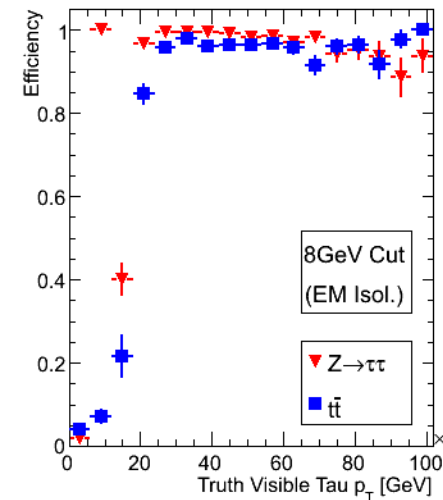
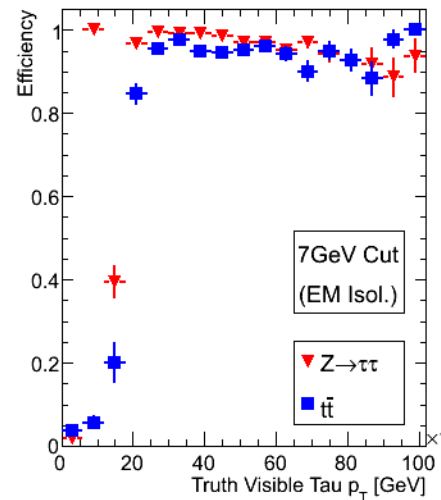
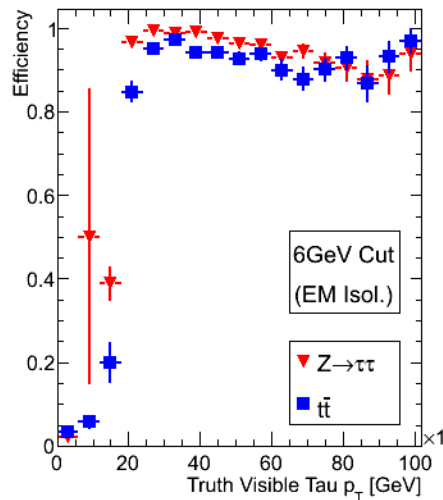
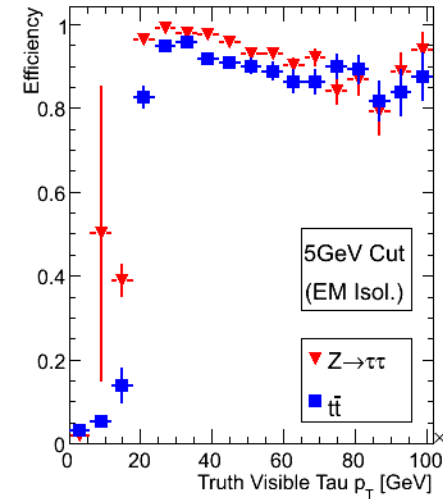
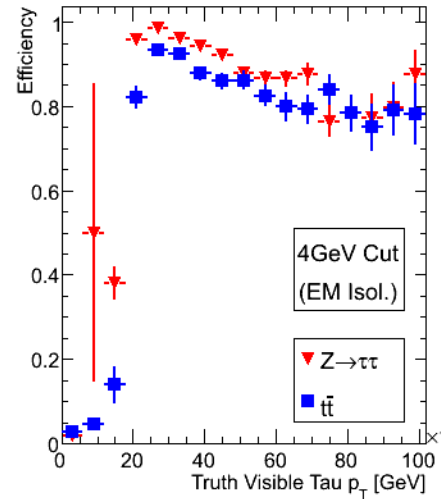
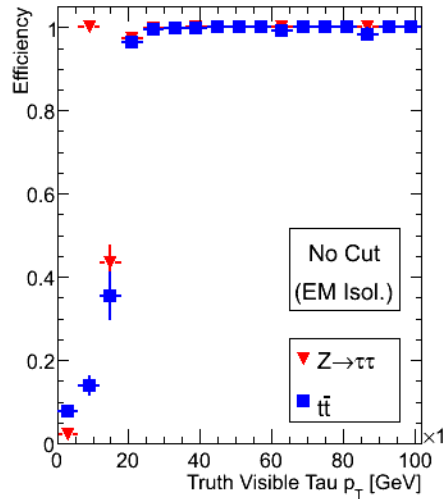




Comparing the effect of isolation in $t\bar{t}$ and $Z \rightarrow \tau\tau$ events

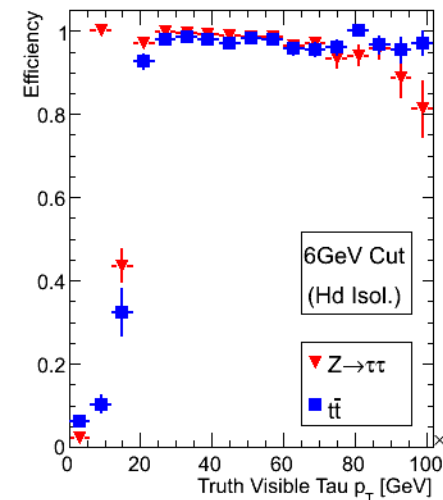
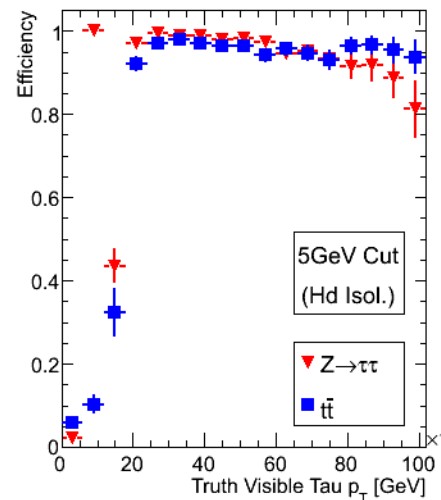
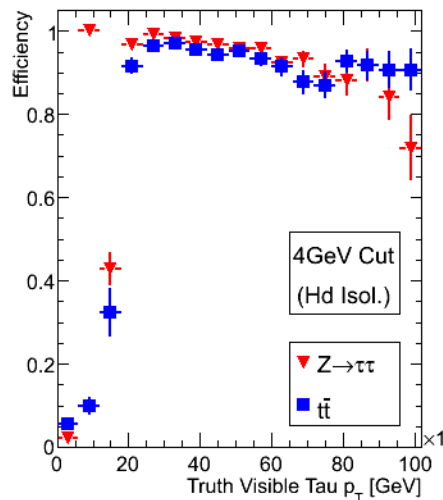
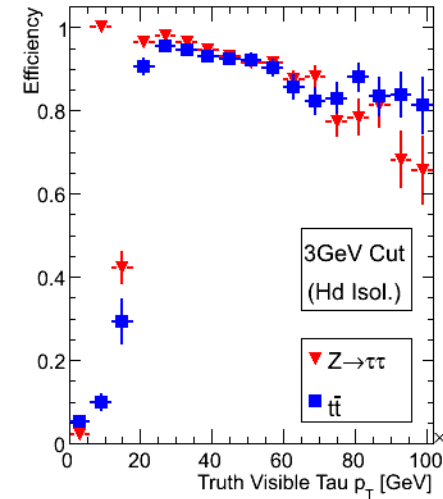
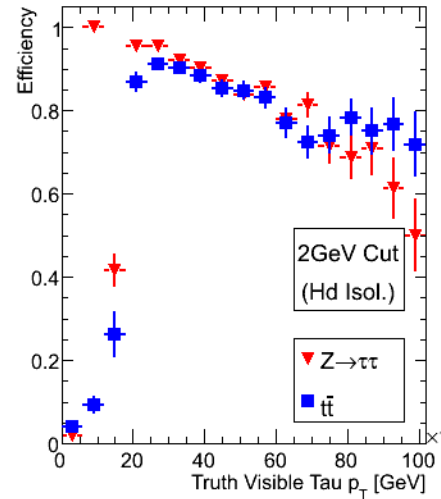
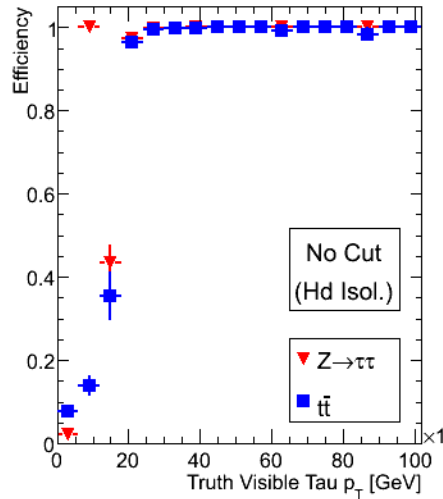
Cut by cut comparison (EM Isol)

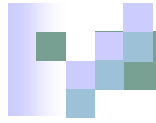
Using tau's from W boson decays only in ttbar events



Cut by cut comparison (Hd Isol)

Using tau's from W boson decays only in ttbar events





Observations

- Effect of EM isolation is slightly larger for $t\bar{t}$ events than for $Z \rightarrow \tau\tau$ events for isolation cuts up to 8GeV.
- For hadronic isolation there is little to distinguish between the $t\bar{t}$ and $Z \rightarrow \tau\tau$ samples (when only taking taus from W bosons into account in $t\bar{t}$ events).
- Note that in the $t\bar{t}$ sample ~82% of taus well matched to an EMTauRoI originate from a W. Plotting the efficiency for ALL taus in the $t\bar{t}$ sample produces a larger discrepancy between the samples for EM isolation and a discrepancy is also visible for hadronic isolation (due to the non - isolated nature of taus from B mesons).



Work with reconstruction

- For real data the trigger performance must be studied with respect to reconstructed objects.
- Two types of ATLAS reconstructed taus currently exist:
 - TauRec
 - Tau1p3p
- Equivalent matching analysis is currently being carried out for both tau types to allow comparisons to be made.

Reconstruction plot (Example)

- Plots have been produced both with and without the recommended cuts:

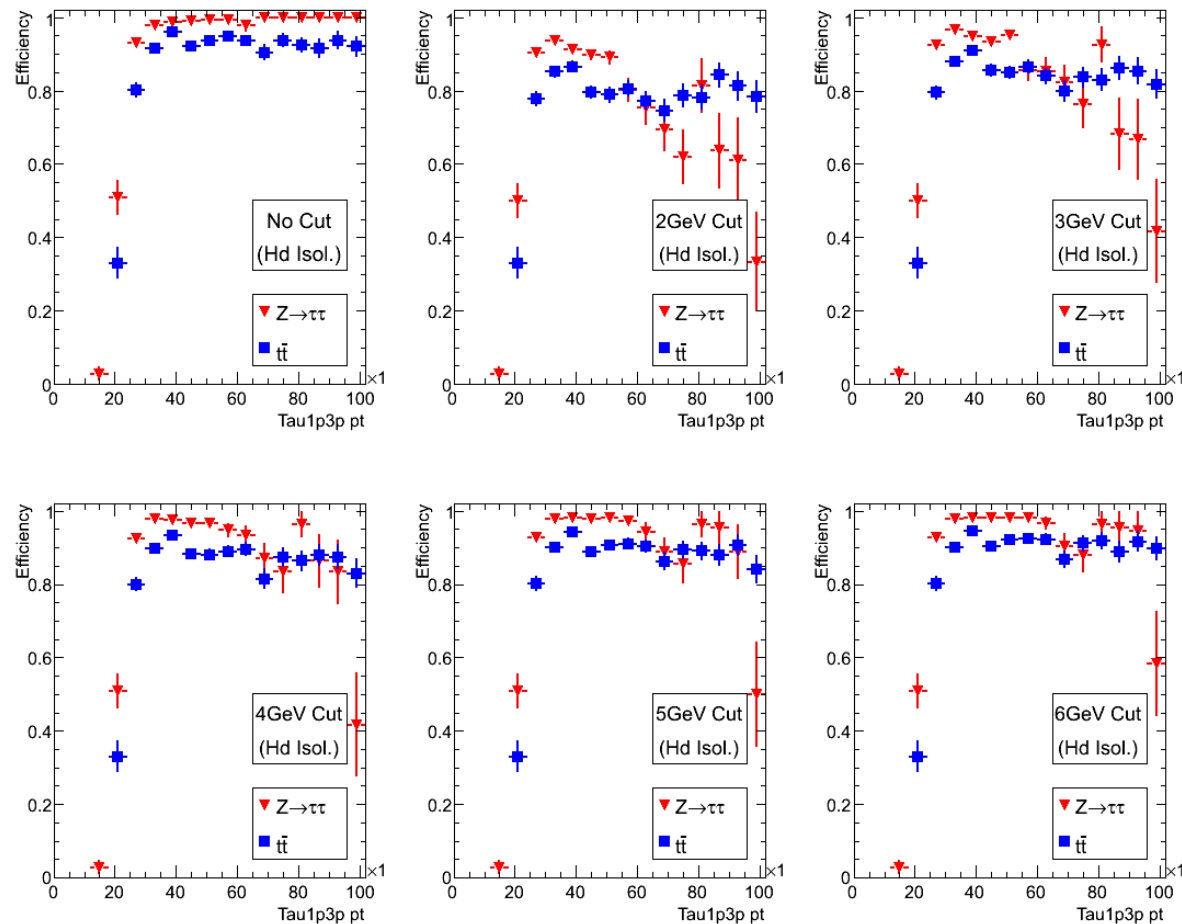
- TauRec:

- Likelihood > 4
 - nTrack ≤ 3

- Tau1p3p:

- Discriminant = 1
 - nTrack ≤ 3

- Plot shown is for Tau1p3p with the cuts on.
- Behaviour is seen to be broadly similar to that in the truth case.



Tau1p3p cut-by-cut (Hd Isol)



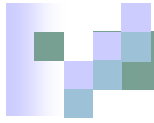
Summary

- Threshold acceptances shown for proposed 10^{31} trigger menu, together with turn on curves for three menu thresholds.
- Have shown efficiency turn on to be equivalent for $t\bar{t}$, $Z \rightarrow \tau\tau$ and $A \rightarrow \tau\tau$ samples when no isolation is applied.
- For a fixed cluster threshold and isolation cut efficiency can be seen to continue to fall off as the event p_T continues to increase.
- A degree of process dependence exists for the tau trigger efficiency, visible with respect to EM isolation. Different turn on curve shapes have been observed for $t\bar{t}$ and $Z \rightarrow \tau\tau$ samples.
- A start has been made on work with reconstructed taus, for both TauRec and Tau1p3p.

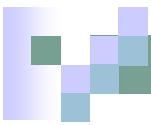


Details of the csc notes

- Work covered has been documented within two ATLAS CSC notes:
 - T5 Top Trigger (D Berge)
 - L1Calo Performance (A Watson, F Ledroit)
- Details of the T5 note can be found at:
<https://twiki.cern.ch/twiki/bin/view/Atlas/TopGroupNoteT5Trigger>



Backup Slides

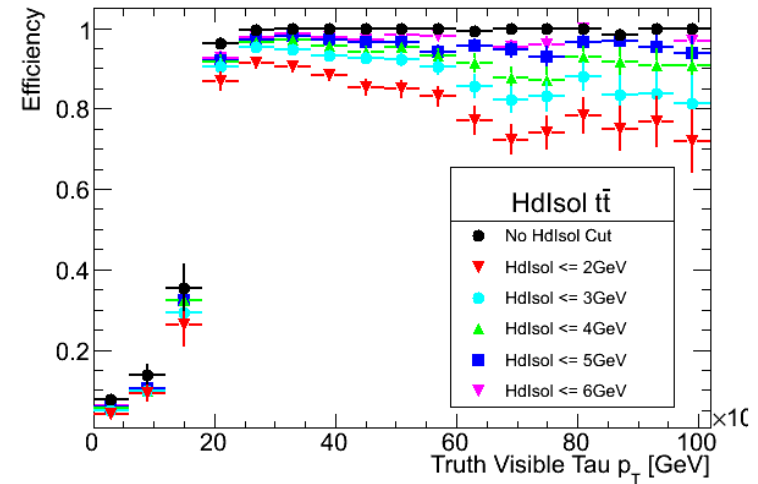
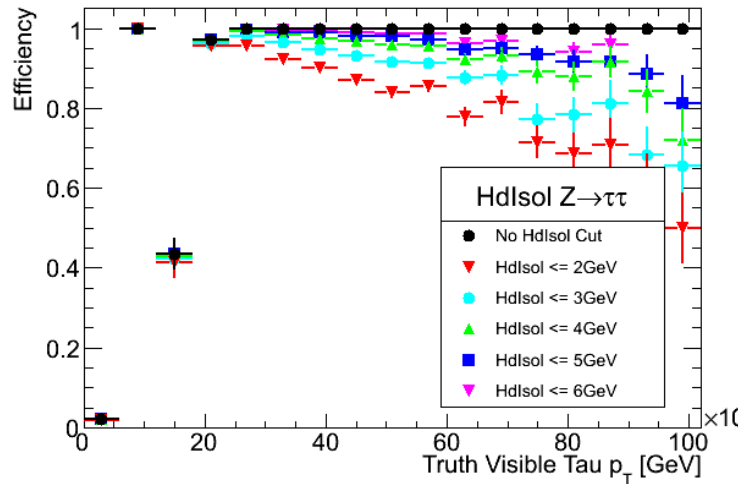
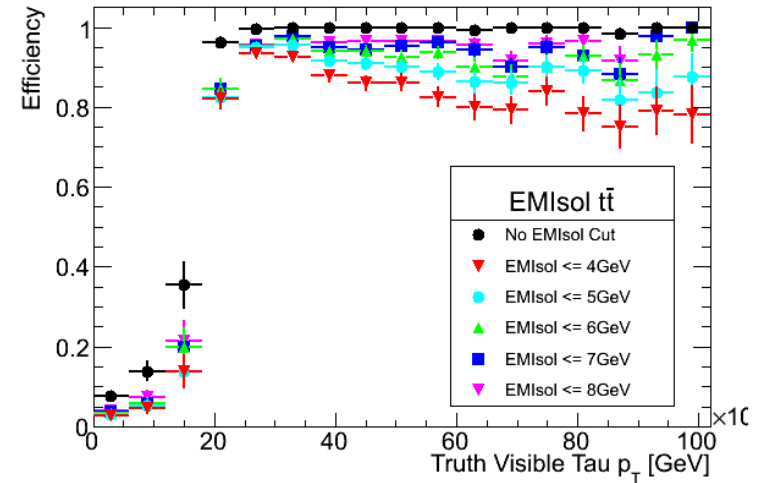
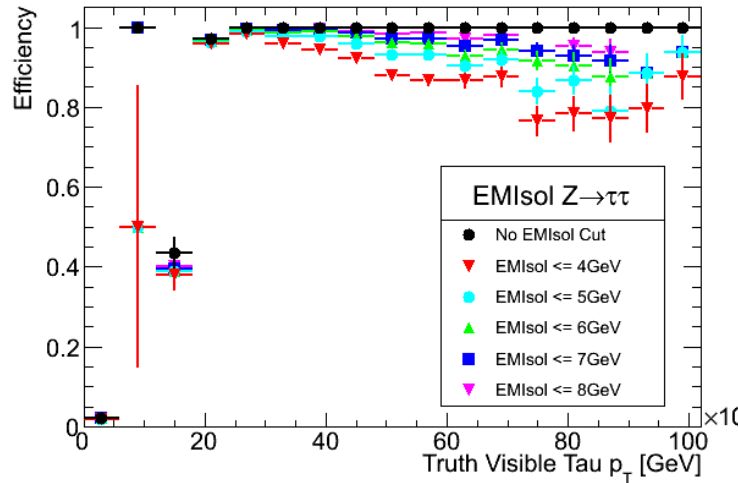


Analysis Tools for Trigger Studies

- Used Athena 12.0.6 (Analysis Examples package).
- ‘DoROIMatch’ algorithm performs the trigger studies on the AOD directly.
- Looking at three main data sets:
 - 005200 series (Semileptonic and dileptonic ttbar with taus).
 - 005188 series ($Z \rightarrow \tau\tau$).
 - 006536 series ($A \rightarrow \tau\tau$).
- Trigger information is available in two separate places:
 - Inside the LVL1_ROI object.
 - As a series of trigger object containers (Used L1EMTauObject).
- L1EMTauObject contains values for η , Φ , EmCore, HdCore, EmClus, TauClus, EmIsol and HdIsol.
- MC Truth information contained within the TruthParticleContainer (Including values for η , Φ and pt).

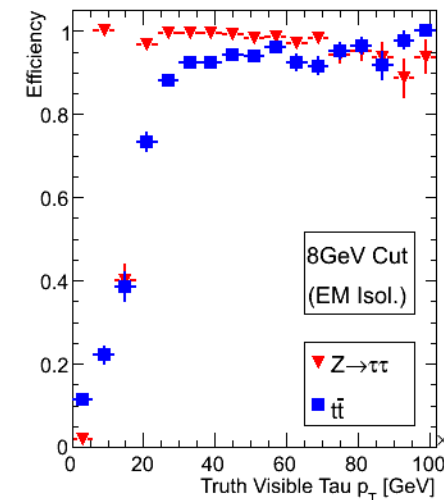
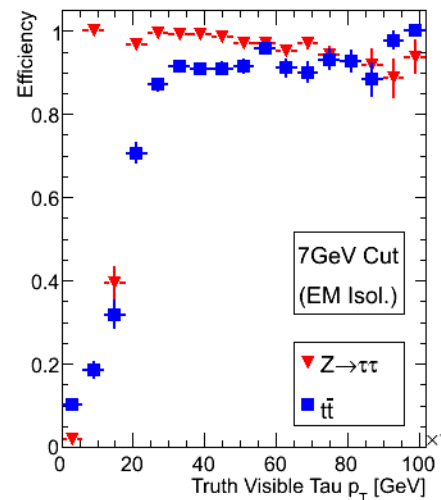
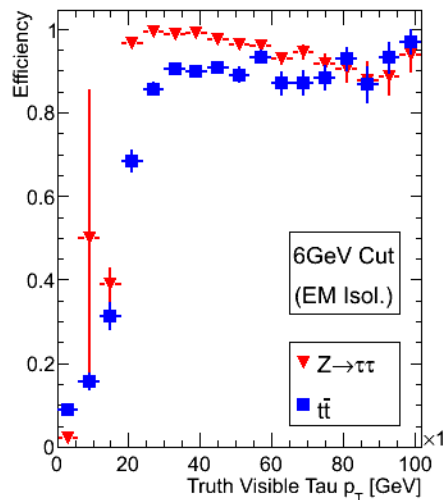
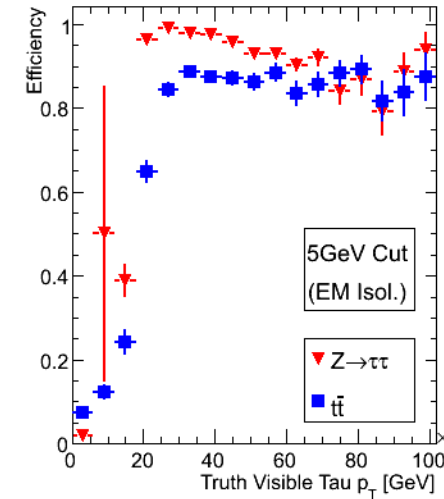
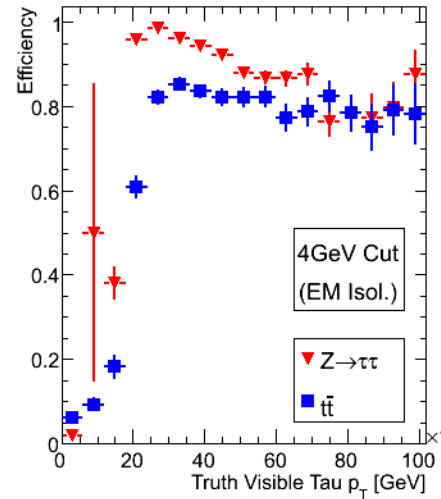
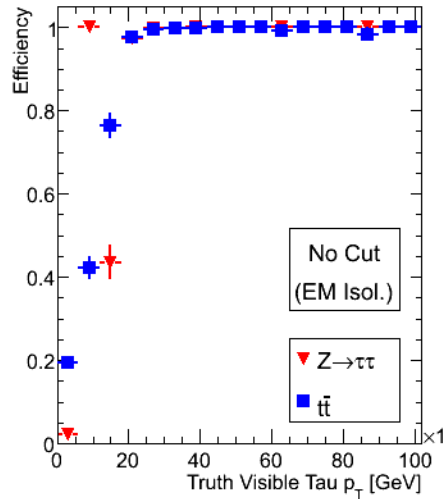
Efficiency versus visible pt (Isol)

Using tau's from W boson decays only in ttbar events



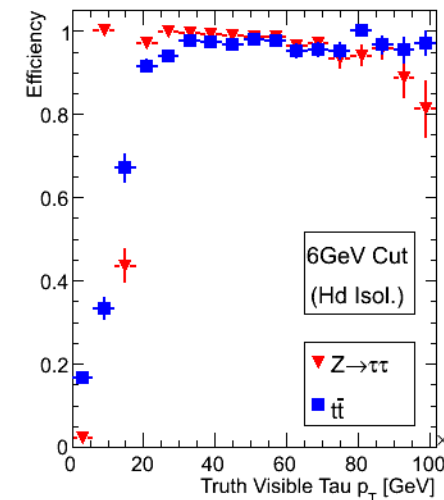
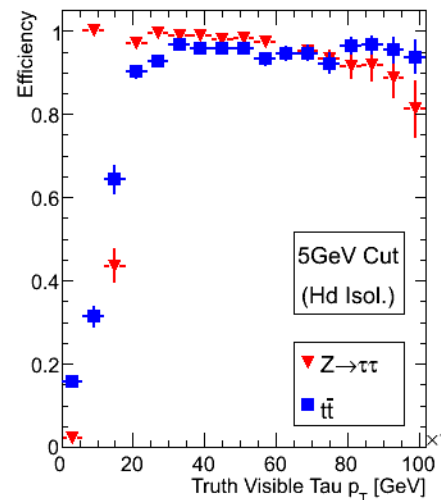
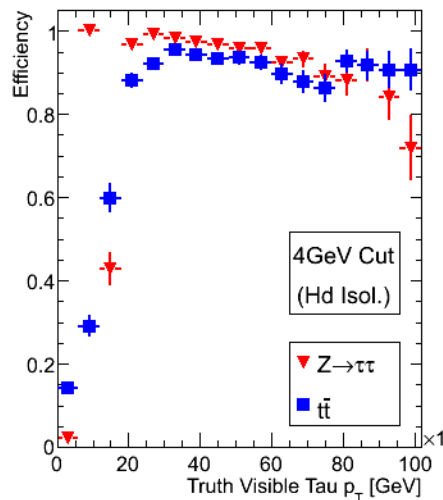
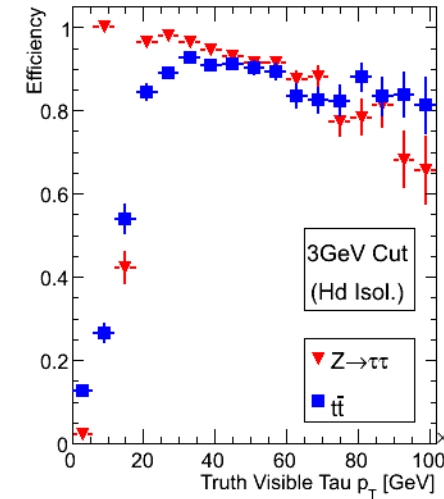
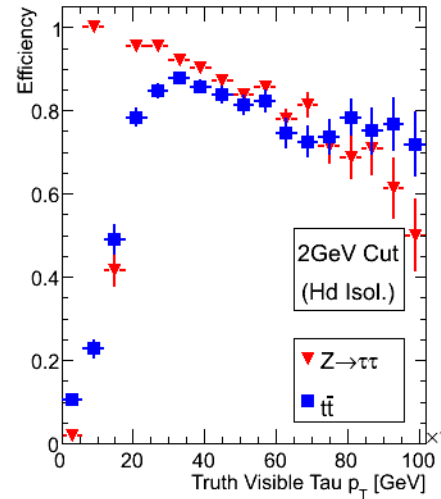
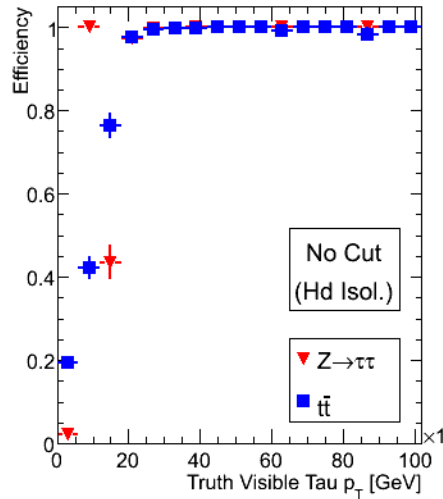
Cut by cut comparison (EM Isol)

Using all tau's in the ttbar events



Cut by cut comparison (HdIsol)

Using all tau's in the ttbar events



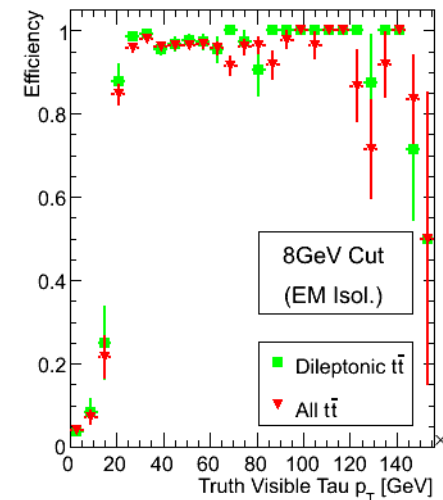
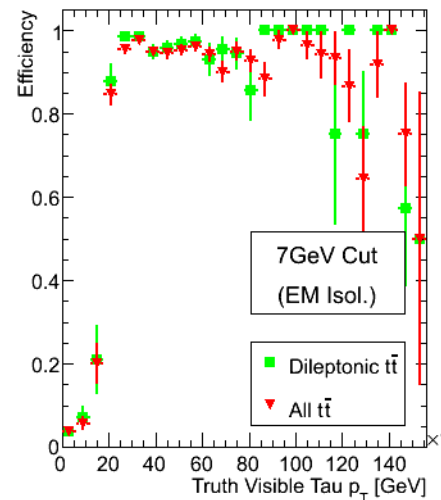
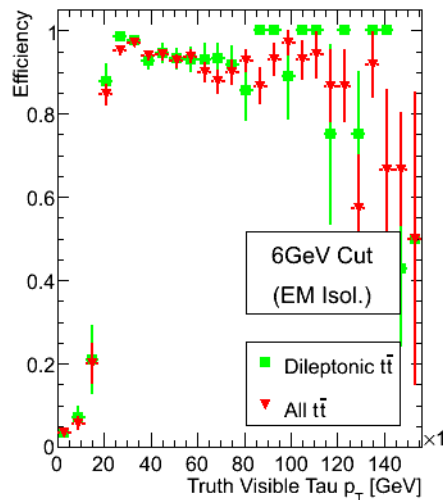
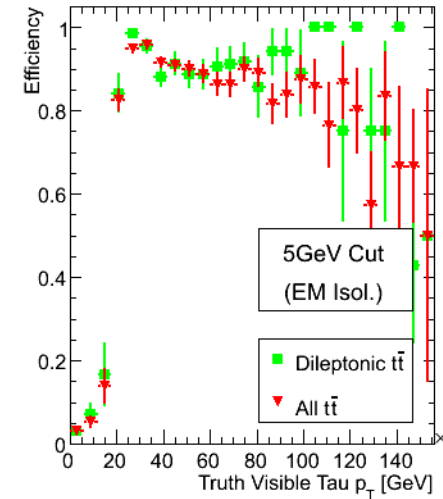
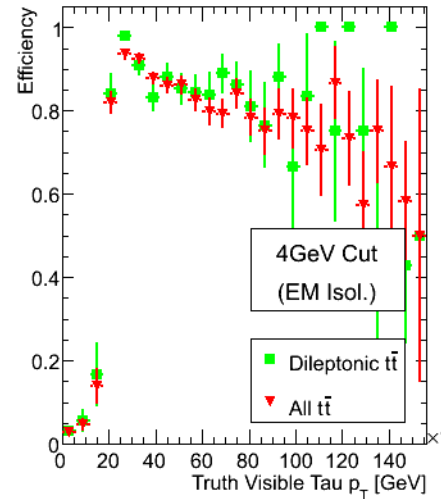
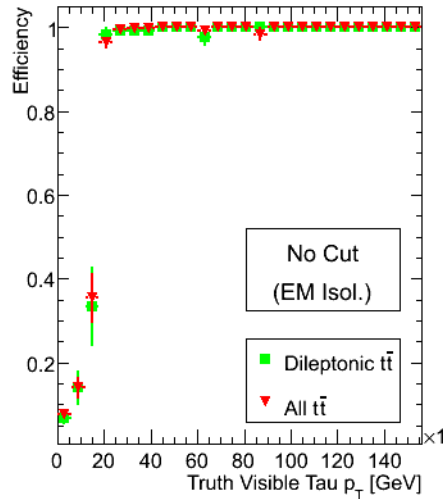


Examining the effect of jets

- Check to see if the effect of isolation is different in fully leptonic $t\bar{t}$ events compared to mixed semileptonic and dileptonic $t\bar{t}$ events.
- Produced equivalent efficiency plots for dileptonic $t\bar{t}$ events only, both for the case where all taus were used, and for the case where only taus from W 's were used.
- No difference was observed, within errors, between the efficiency produced using all the $t\bar{t}$ events, and that produced using only dileptonic $t\bar{t}$ events.

Cut by cut comparison (EM Isol)

Using tau's from W boson decays only



Cut by cut comparison (Hd Isol)

Using tau's from W boson decays only

