Title: Status of tau ID and reconstruction in ATLAS

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Abstract: TBA

Current state of τs in ATLAS

Saminder Dhaliwal

University of Toronto

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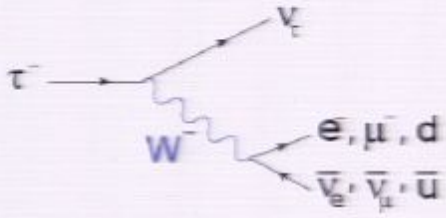
utline

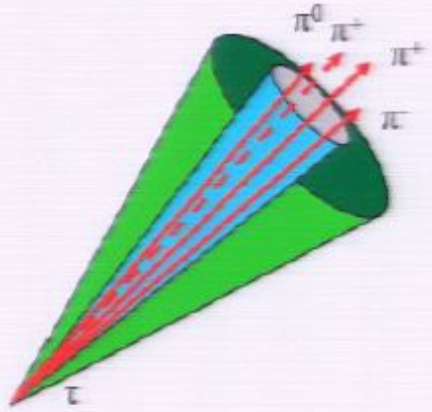
1. τ reconstruction and identification
   - Reconstruction algorithms: two possible seeds
   - Variables that go into identification methods
2. Observation of $Z \to \tau\tau$
   - Object selection
   - Event Selection
   - Background estimation

roperties of τs (in ATLAS)

- Heaviest lepton (mass of 1.78 GeV)
  - Only lepton that can decay both hadronically (65%) and leptonically (35%)
  - Of hadronic decays 77% have one final charged pion, 23% have three final charged pions



- Appear in final states of Higgs decay, supersymmetric processes and standard model processes



- Challenge in identifying hadronically decaying τ leptons is to distunguish them from hadronic jets, which are produced in processes with very large cross-sections
  - τ decay tends to be well collimated and the invariant mass of the visible decay products is usually smaller than those of jets
- τ lepton proper decay length is 87μm
  - Decay vertices can be resolved in the silicon tracker from the primary interaction vertex

reconstruction

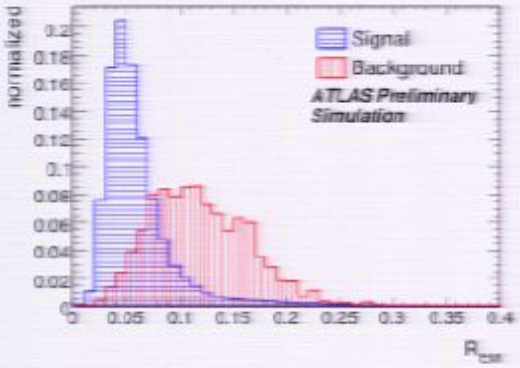
- Reconstruction is seeded by either a track or a calorimeter cluster
- Track seeded τ candidates
  - Track with $p_T > 6$ GeV
  - Must pass quality criteria on number of associated hits in the silicon tracker
  - Restrictions on impact parameter with respect to the interaction vertex
- Calorimeter seeded τ candidates
  - Seeded from AntiKT jets
  - cone radius of seed is $\Delta R \leq \sqrt{(\Delta\eta)^2 + (\Delta\phi)^2}$
- Those τs with a seed jet and matched seed track within $\Delta R = 0.2$ are considered to have two valid seeds
- In generated $Z \to \tau\tau$ samples 70% of τs have 2 valid seeds, 25% are calorimeter seeded and 5% have only a track seed
  - Considering only generated τs with $E_T^{vis} > 10$ GeV and $|\eta| < 2.5$

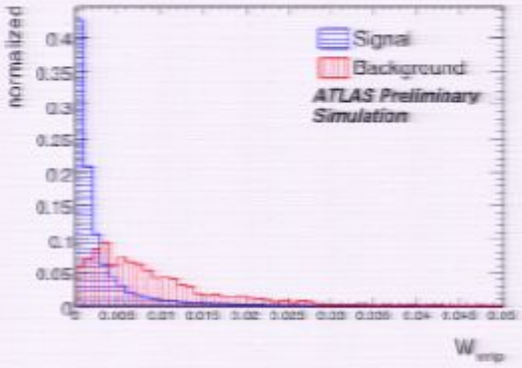
identification...

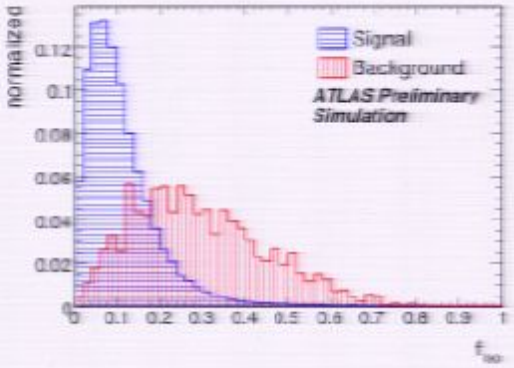
Primarily concerned with seperating hadroncially decaying τ leptons from QCD jets

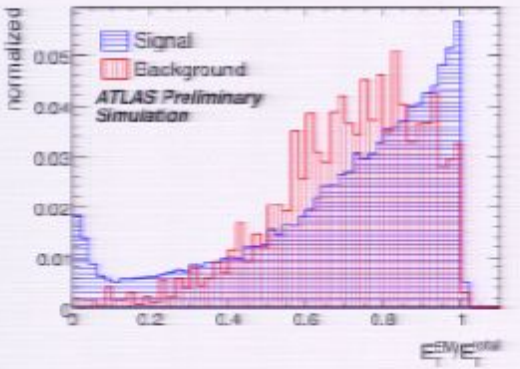
- R_{EM} (Electromagnetic radius)
  - $\frac{E_{T,i}^{EM}\sqrt{(\eta_i^{EM}-\eta_{caloseed})^2+(\phi_i^{EM}-\phi_{caloseed})^2}}{E_{T,i}^{EM}}$
  - Sum over all cells within EM calorimeter (all but last layer)
- W_{Strip} (Transverse energy width in η strip layer)
  - $\sqrt{\frac{E_{T,i}^{strip}(\eta)i-\eta_{caloseed})^2}{E_{T,i}^{strip}}}$
  - Sum over all strip cells
- f_{iso} (Isolation in calorimeter)
  - $\frac{E_{T,i}^{EM}}{E_{T,j}^{EM}}$
  - i runs for cells in $0.1 < \Delta R < 0.2$
  - j runs for cells in $\Delta R < 0.4$
- Ratio of EM energy and total energy
- E_T over p_T of leading track

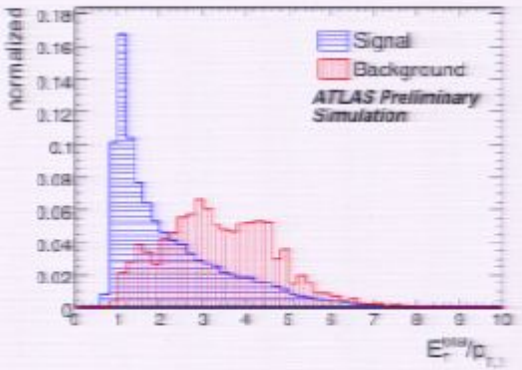
τ identification











bservation of $Z \to \tau\tau$: Data and Event Selection

- Use GRL (good runs list) from WZ observation group combined with GRL from Tau Combined performance group
  - Only include run information from stable beams with all subdetectors reporting no problems
- Events must pass either EF_e15_medium or EF_mu10 (we tag events using the electron/muon decay of a τ)

Electron Selection

- $p_T > 15$ GeV
- $|\eta| < 2.47$ (exclude $|\eta|$ between 1.37 and 1.52
- Exclude bad OTX
- Apply robust tight electron selection
- Isolation: p_TCone40$/p_T < 0.06$

Muon Selection

- $p_T > 15$ GeV
- $|\eta| < 2.4$
- $N_{pixhits} \geq 1$ and $N_{SCThits} \geq 1$
- Must be combined muon (track from ID meets muon spectrometer)
- Isolation: p_TCone40$/p_T < 0.06$

Tau Selection

- $p_T > 10$ GeV
- $|\eta| < 2.5$
- Exclude bad OTX
- Apply tight selection criteria
- Elec and Muon veto

Event Selection

- Dilepton veto
- $|\tau_{charge}| = 1$, NTracks $= 1$ or 3
- Opposite sign τ and lepton
- M_T(lep, MET) < 50 GeV
- $\sum cos(\Delta\phi)$ >-0.15
- 35 GeV $< M_{vis}$ ¡ 75 GeV

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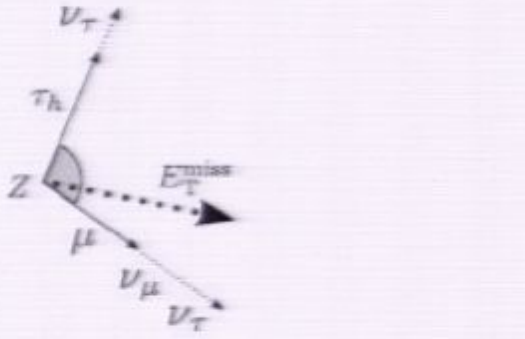
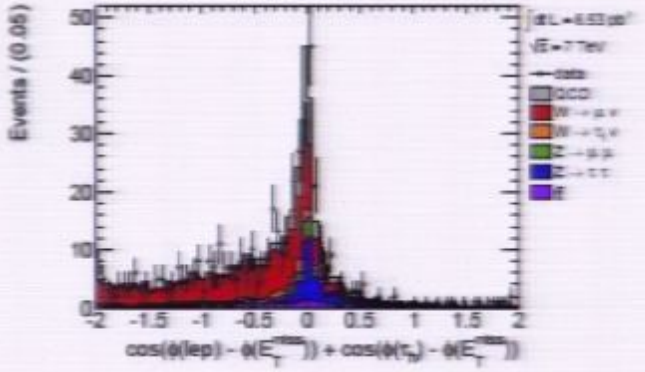
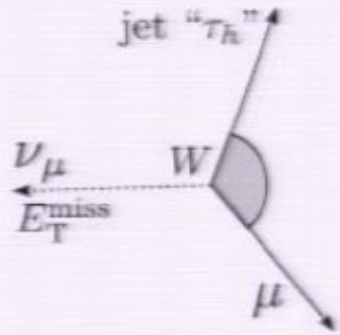
Observation of $Z \to \tau\tau$: W suppression

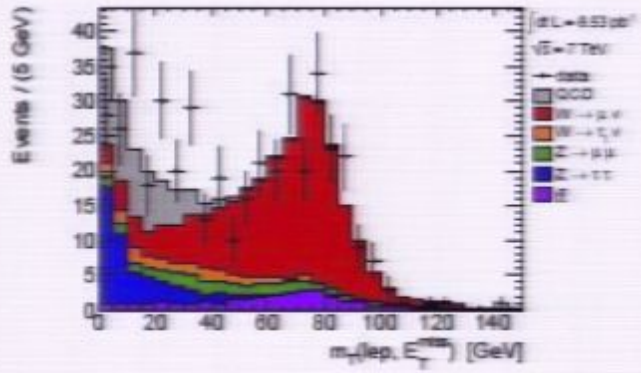
$$M_T = \sqrt{2E_T^{lep} E_T^{Miss}(1 - cos\Delta\phi(lep, E_T^{Miss}))}$$





$$\sum \cos\Delta\phi < -0.15$$





$$m_T < 50 \text{ GeV}$$

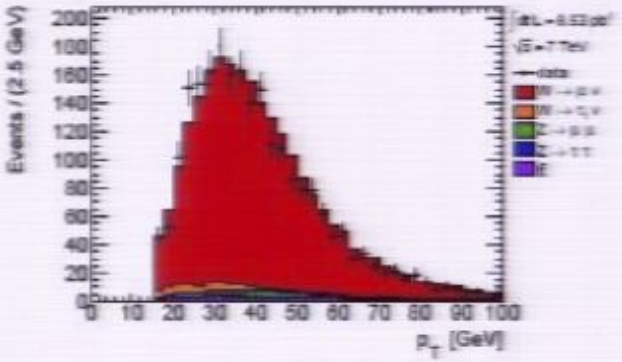
Observation of $Z \to \tau\tau$: Background Estimations (1st step: W Normalization)

- QCD is not expected to be well modelled in MC
- Use data driven methods to estimate QCD
- Currently using two complemntary methods
- Both approaches use 4 regions and EWK contributions are corrected for in each region
- Use W rich control region to normalize to data to correct for over estimation of tau fake rate in MC
- Use MC predictions for Z and top backgrounds

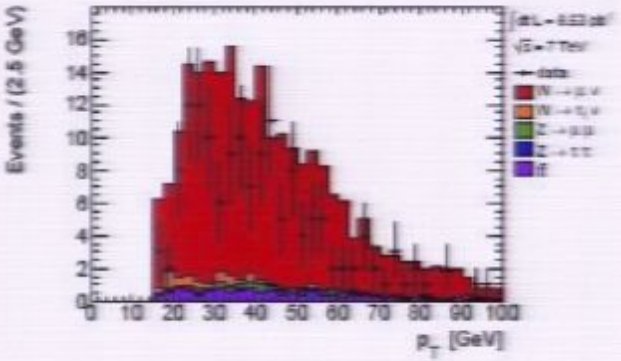
W Normalization

- Use a W control region with inverted W suppression cuts: $M_T > 50$ GeV and $\sum cos\Delta\phi < -0.15$
- Compare data and MC. Agrees well before tauID, after TauID we get a normalization factor K_W. This is used to correct W MC predictions in QCD estimation ($K_W = 0.6$)

Before tau ID



After tau ID



Observation of $Z \to \tau\tau$: Background Estimations

Tau ID/Isolation

	Low Isolation	High Isolation
Tight Tau	A	B
Loose Tau (upto dilepton veto)	C	D

$N_A = N_B * R_{QCD}$
$R_{QCD} = \frac{N_C}{N_D}$
Assume R_{QCD} is independent of Tau ID

OS SS/Isolation

	Low Isolation	High Isolation
OS	A	B
SS	C	D

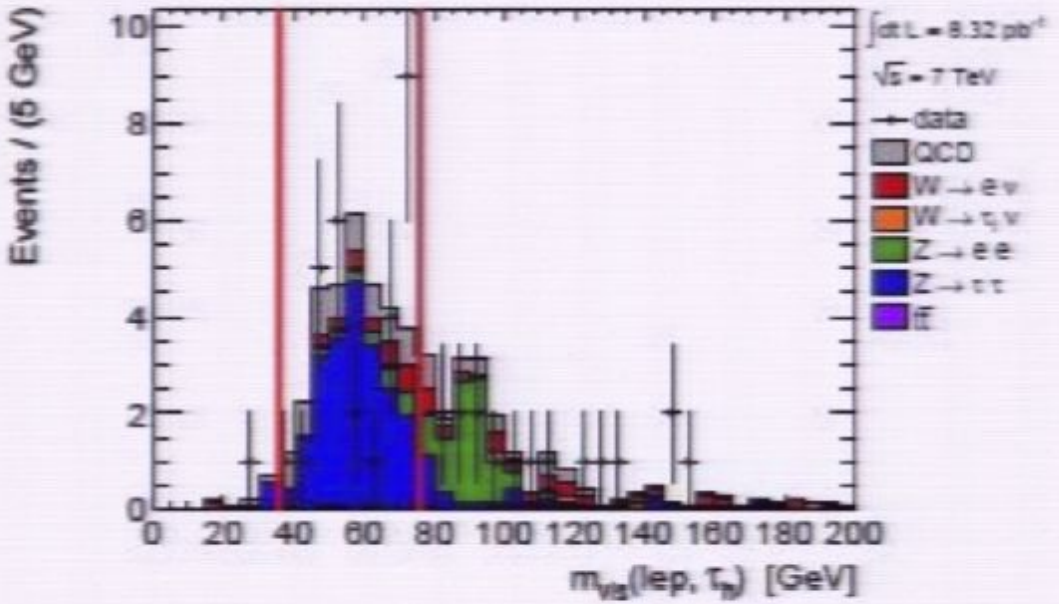
$N_A = N_C * R_{OS/SS}$
$R_{OS/SS} = \frac{N_B}{N_D}$
Assume $R_{OS/SS}$ is independent of isolation

Observation of $Z \to \tau\tau$: Electron channel results

- EF_e15_medium (8.32 pb^{-}1)
- $N_{Data} = 29$
- $N_{EWK} = 4.4 \pm 0.8$ (stat)

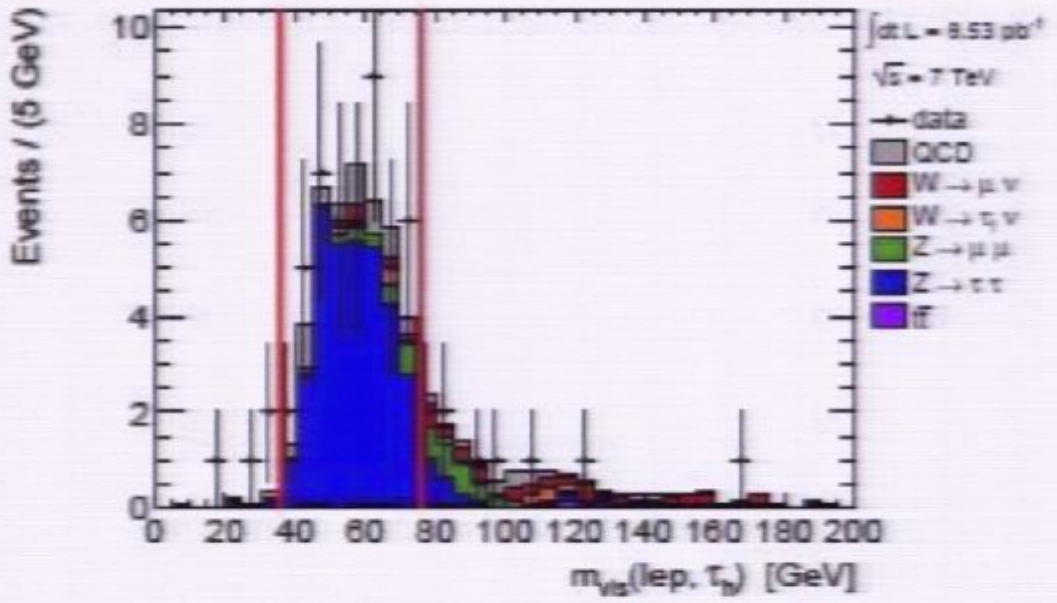
- OS/SS Method
- $N_{QCD} = 1.8 \pm 2.0$ (stat)
- $N_{Z\to\tau\tau} = 22.8 \pm 2.2$ (stat)

- TauID Method
- $N_{QCD} = 6.1 \pm 0.7$ (stat)
- $N_{Z\to\tau\tau} = 20.9 \pm 1.3$ (stat)



Observation of $Z \to \tau\tau$: Muon channel results

- EF_mu10 (8.53 pb^{-}1)
- $N_{Data} = 46$
- $N_{EWK} = 3.5 \pm 0.4$ (stat)
- OS/SS Method
- $N_{QCD} = 2.2 \pm 2.3$ (stat)
- $N_{Z \to \tau\tau} = 40.3 \pm 2.3$ (stat)
- TauID Method
- $N_{QCD} = 4.4 \pm 0.6$ (stat)
- $N_{Z \to \tau\tau} = 33 \pm 1.7$ (stat)



ummary and Conclusions

- 'Advanced' τ analysis at the LHC (from start of running)
- Observation of $W \to \tau\nu$ has been observed at ATLAS
- Publication of $Z \to \tau\tau$ in ATLAS is in progress
- Will soon start using multivariate techniques for τ identification
- Standard model cross section measurements to come soon...