Tau leptons in ATLAS

reconstruction, identification & physics

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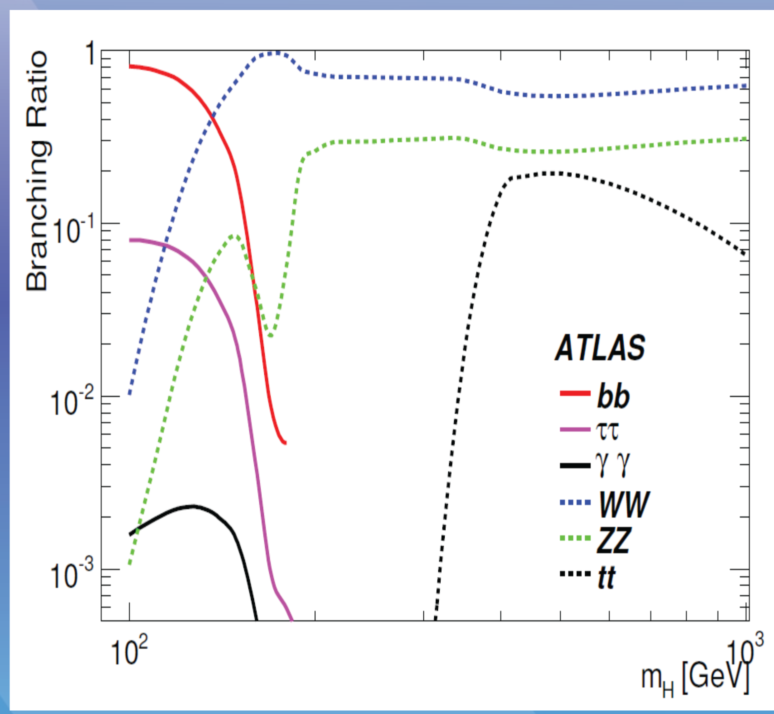
Motivation

why bother about taus at a QCD machine ?

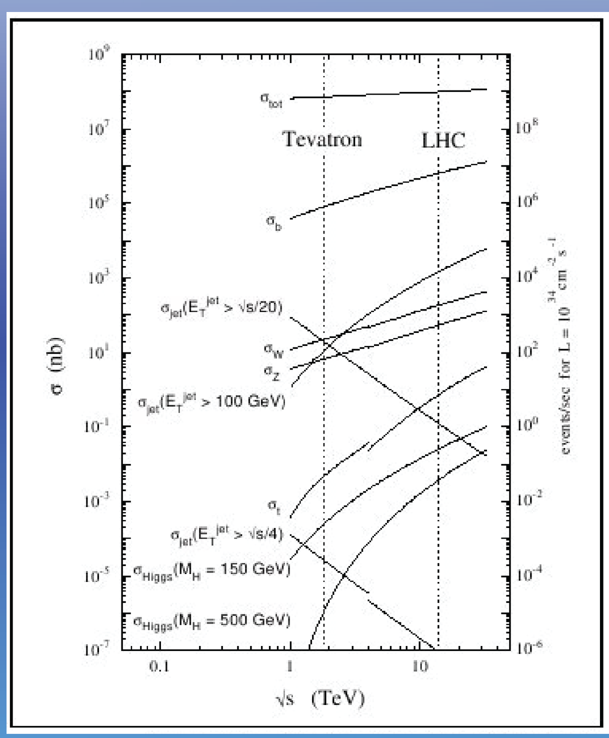
Tau leptons play essential role in many measurements planned at the LHC:

- important for **Standard Model** measurements (significant branching fraction of W/Z bosons)
- excellent probe for **SM Higgs** boson at low mass
- could be an important channel for **MSSM** Higgs and **SUSY** particles



The challenge

no risk - no fun



In ATLAS (14 TeV):

$\sigma(W \rightarrow \tau\nu) = 1.74 \times 10^4$ pb

σ(QCD jets) = 1.82×10^{10}pb

S:B = 10^{-6}

Need an efficient way to discriminate between signal and background.

S:B is 10x worse than at Tevatron.

Physics with taus

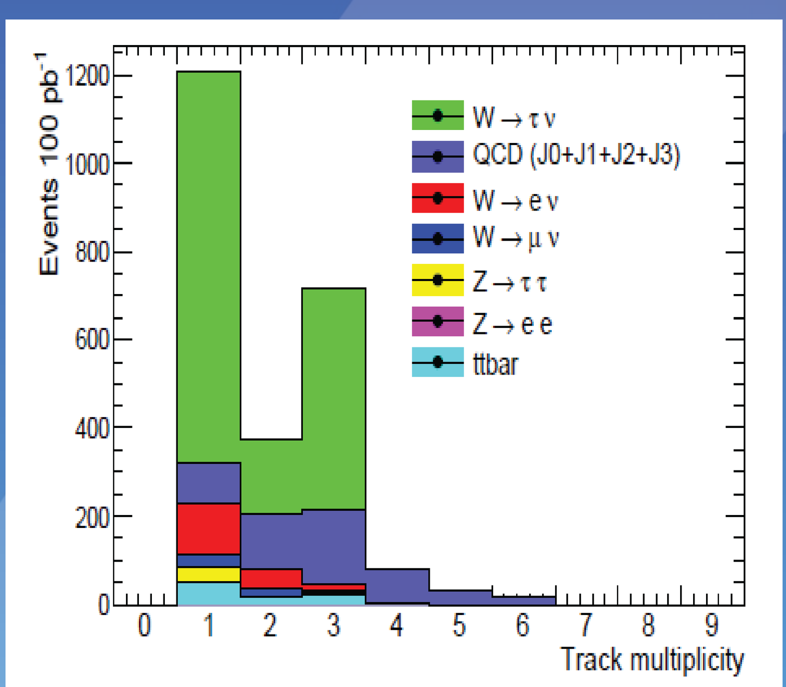
real business starts here

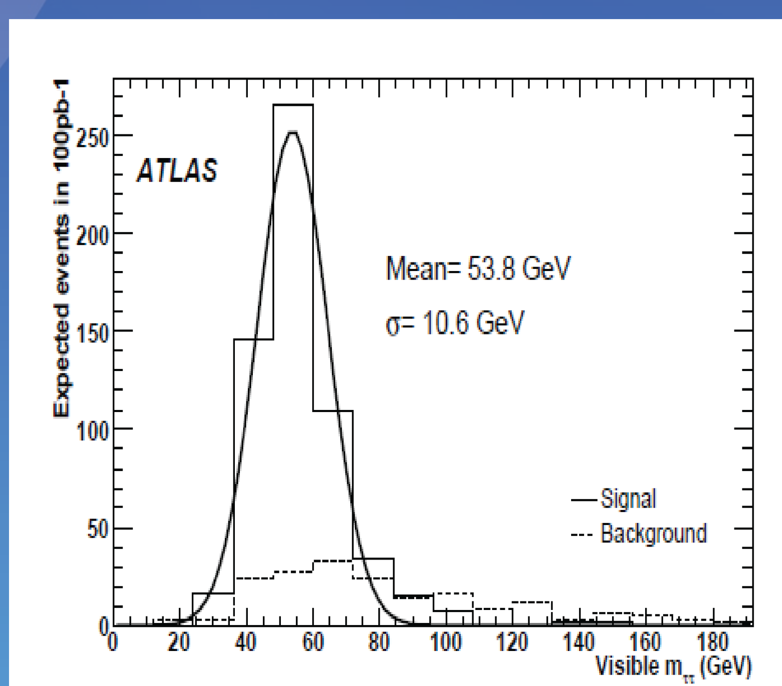
$W \rightarrow \tau\nu$

This process will be the most abundant source of taus in early ATLAS data. The signal will be extracted requiring events with exactly one identified tau with transverse momentum of 20 - 60 GeV. In addition a transverse missing energy is required to exceed at least 50 GeV. Observation of tau track multiplicity spectrum will be crucial for signal extraction. Events with electrons and muons must be vetoed due to high contribution to single-track tau candidates.

$Z \rightarrow \tau\tau$

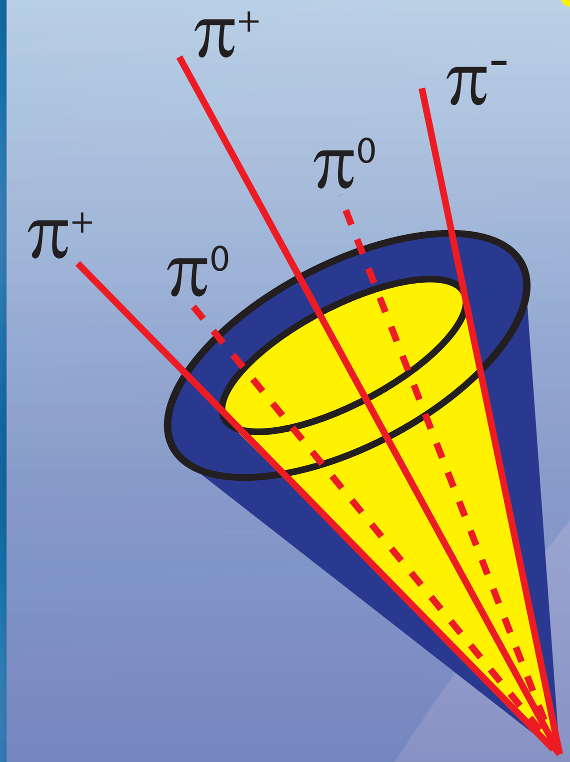
However the Z production cross-section is 10x lower than W, but this process will have a more robust prospects for analysis. In the first step it requires an isolated lepton (coming from the decay of one tau in the pair). Then a transverse missing energy threshold is set to 20 GeV and no b-jet can be present. Finally, a hadronic tau decay with transverse momentum above 15 GeV is required.





Reconstruction

a tau recipe for happiness



Track-based approach:

- Take 1 or 3 (up to 6) tracks of a good quality, within a $\Delta R<0.2$ cone around the leading one
- Add an isolation cone of $\Delta R<0.4$ - no tracks allowed in that region!
- Determine the energy using „energy - flow" approach (charged energy from calo is replaced by matching tracks momenta)

Calo-based approach:

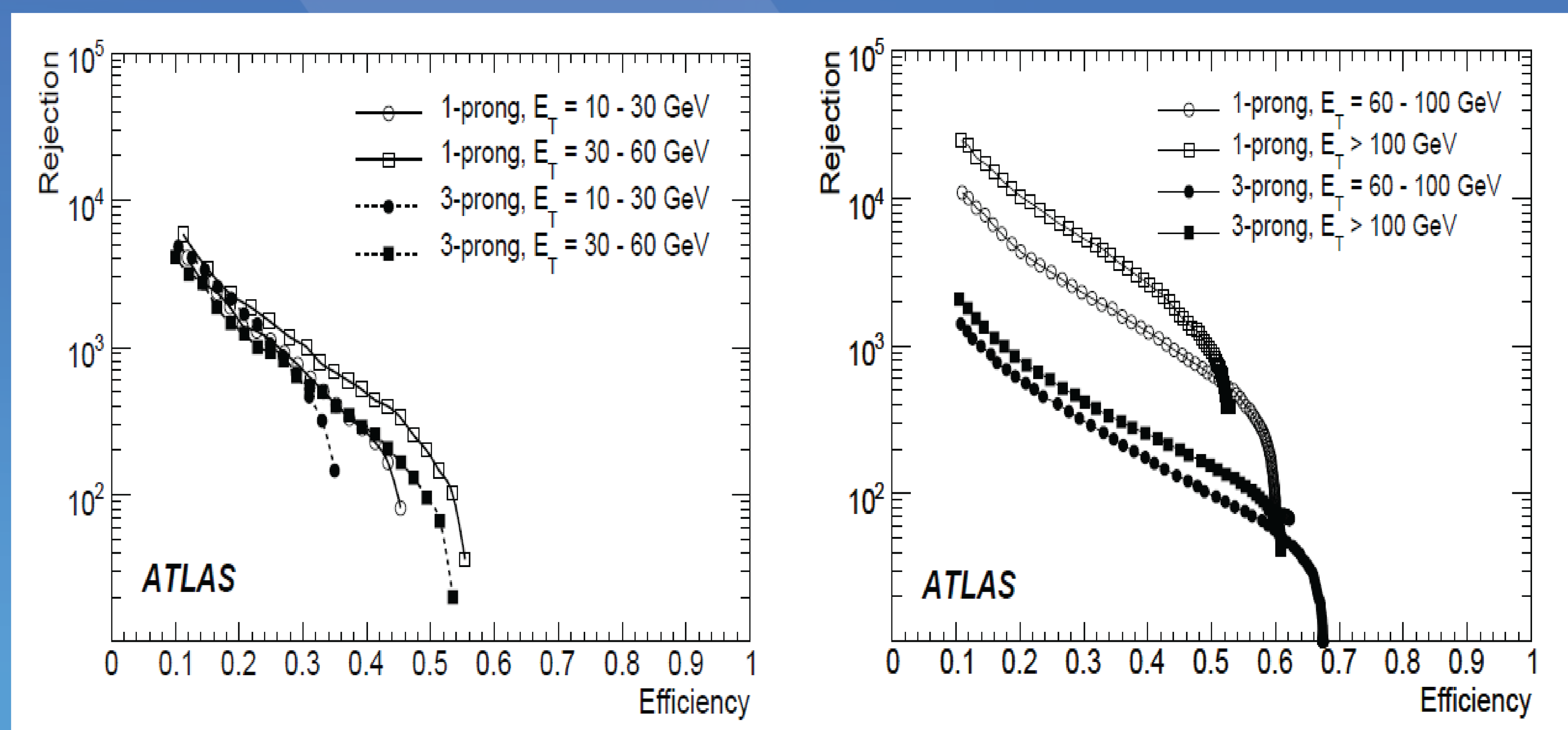
Take calorimeter clusters as seeds. They are obtained from a sliding window clustering algorithm applied to so called calorimeter towers which are formed from cells of all calorimeter layers on a grid of size $\Delta\eta \times \Delta\phi = 0.1 \times 2\pi/64$

Identification

to tau or not to tau - that is the question

The identification step is done by calculating discriminants using basic cut methods, cut methods optimized by the TMVA package, multi-variate analyses based on neural network technique, and from PDRS discrimination.

The rejection power expected from the identification step only is quite modest, given that a quite good rejection is already achieved in the reconstruction step. For an efficiency of about 30% with respect to all hadronic decays in the energy range 10–30 GeV, rejection rates of 200/360 for one-prong/three-prong hadronic τ decays can be achieved with the cut based selection and of 500/700 with multi-variate selection techniques.



Tau properties

in case you forgot

$m = 1.777$ GeV/c^2

$c\tau = 87.11$ μm

$\tau = 291 \times 10^{-15}$ s

Br($\tau \rightarrow$ leptons) = 35.2%

Br($\tau \rightarrow$ 1 ch.had.) = 49.5%

Br($\tau \rightarrow$ 3 ch.had.) = 14.6%