Tau Trigger at the ATLAS Experiment

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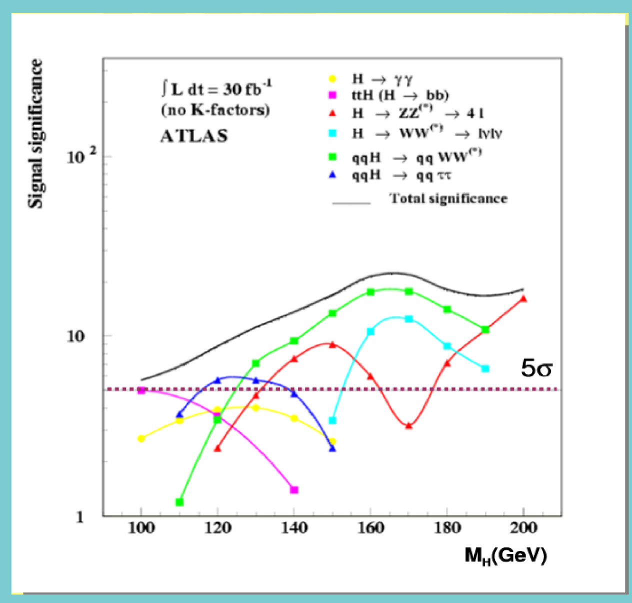
The tau trigger is designed to select hadronically decaying taus efficiently while keeping the QCD background rate under control at the same time. This challenging task is motivated by the possibility to improve the prospects of new physics discoveries at higher energy scales, as accessible by the LHC. In many searches at higher luminosities for new physics, among them the search for a SM Higgs and for signatures of various SUSY models, the signal significance can be increased substantially with the help of tau decay channels.

The ATLAS collaboration has developed tools to identify taus at the trigger level that use the advanced tracking and calorimetry capabilities of the ATLAS detector. This poster summarizes the motivation, implementation and expected performance as well as the future prospects of the ATLAS Tau Trigger.

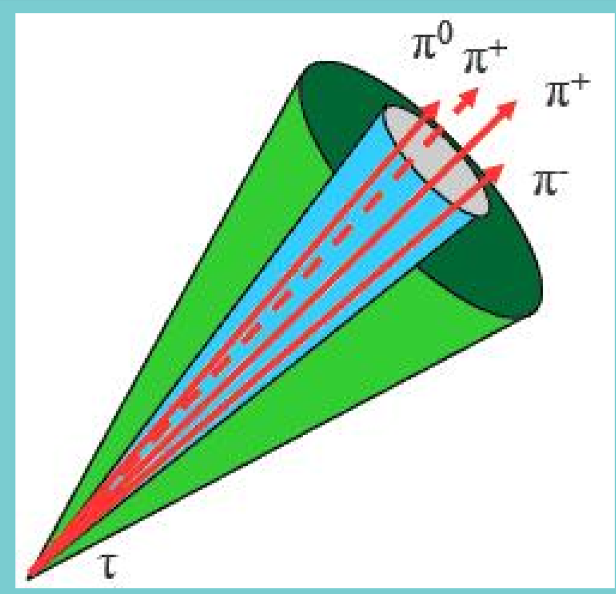
Motivation

Triggering at hadronically decaying taus will substantially increase the significance of new physics searches.
SM Higgs boson discovery potential is shown on the right. For a Higgs mass between 115 and 125 GeV, the significance is highest for the tau decay channel.



Tau Properties

The hadronic decays of taus mainly consist of one or three charged pions with a neutrino and possibly neutral pions. This leads to the following characteristics: low track multiplicity, isolation, and narrowness.
The plots shows a typical tau decay to three charged pions and a neutral pion.



The Atlas trigger is designed as a 3-level system:

LHC bunch crossing rate: 40 MHZ

Latency 2.5 µs

Level 1: Hardware, identifies geometrical "Regions of Interest"(RoI) for higher level systems

L1 output rate: 75 kHz

L2 latency: O(40 ms)

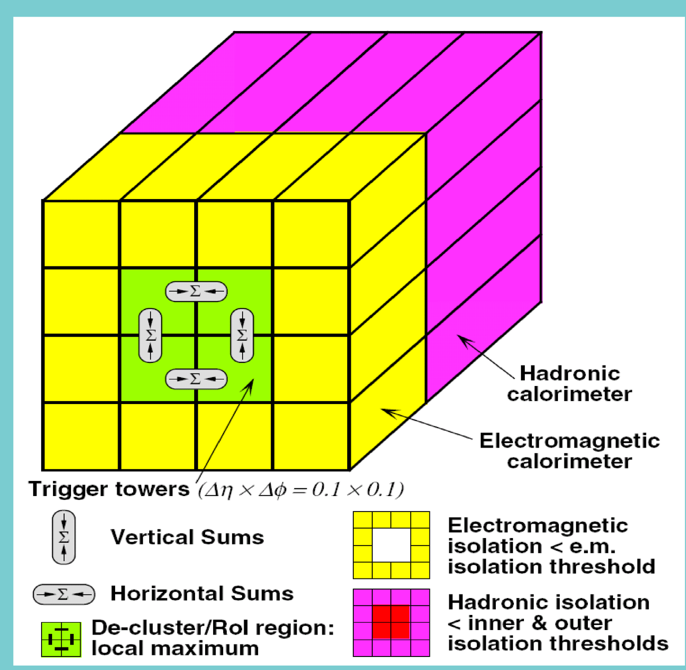
Level2: analyzes data inside the RoI indicated by L1 using the full granularity of the detector, with use of regional detector readout, without noise suppression

EF latency: O(4 s)

Event Filter: At the Event Filter(EF) level, events accepted by L2 are analyzed using algorithms based on the offline reconstruction. Data is accessed as necessary from the whole detector

HLT output rate: 200 Hz

Level 1 TAU Trigger:

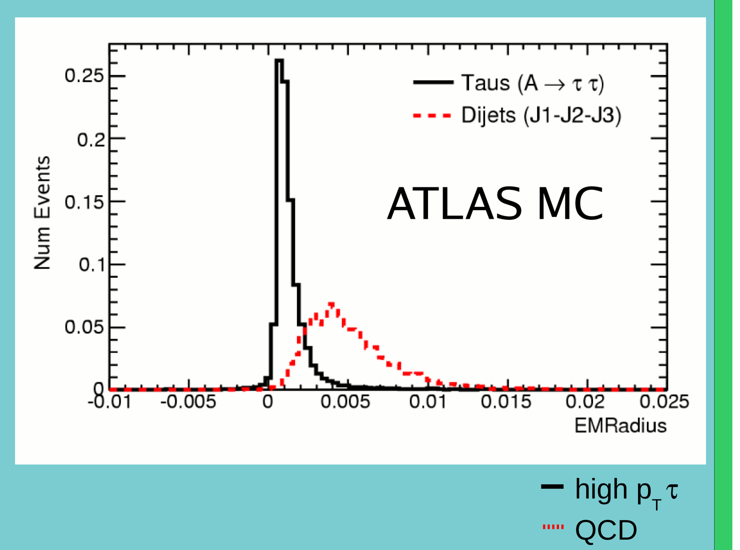


Hardware trigger using the electromagnetic and hadronic calorimetry trigger towers $\Delta\eta\times\Delta\phi=0.1\times0.1$
At L1, taus are identified based on following features:
- energy in 2×1 pairs of EM towers
- energy in 2×2 Hadronic towers behind EM clusters
- EM energy in isolation region

Current settings apply relatively low threshold at L1 and use the identification power and better energy determination at HLT.

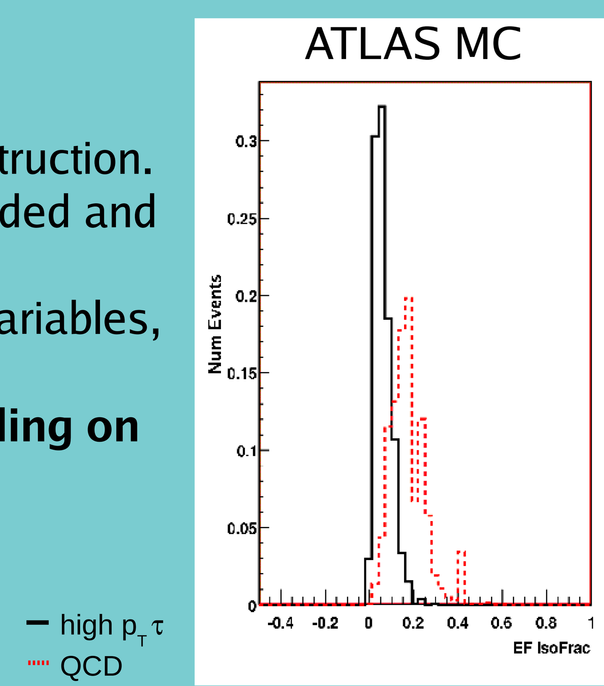
HLT Level 2:

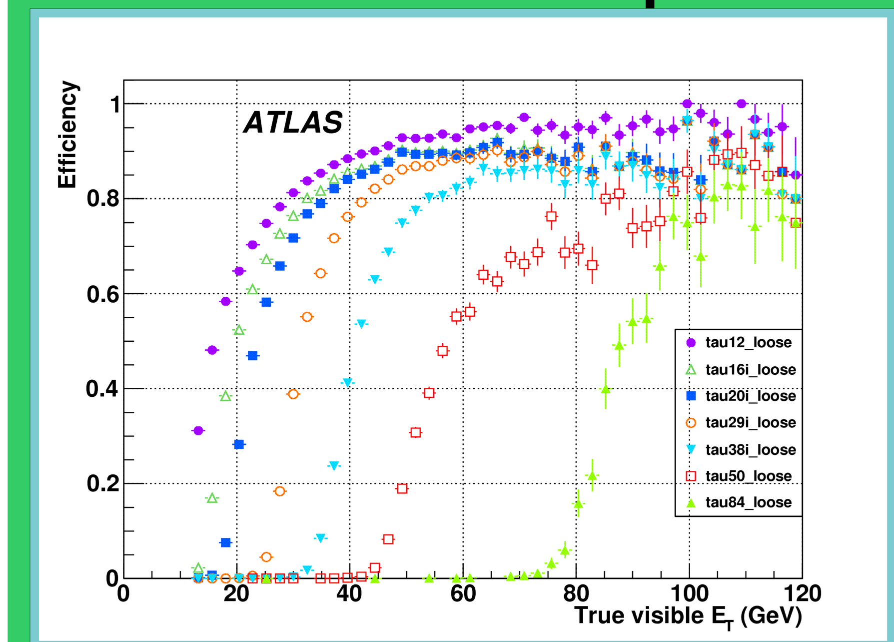
Tracks are reconstructed beginning at L2. The characteristic narrowness and low track multiplicity of the tau jet is used to discriminate against background. The plot shows the electromagnetic radius, which is the squared EM energy weighted cluster radius, for high pt signal (black) and background (red).



HLT EF:

Using the L2 tau objects as seeds, the EF tau candidates are reconstructed using algorithms derived from the offline reconstruction. Two reconstruction algorithms could be used: calorimeter seeded and track seeded.
The EF tau candidates provide a wide range of identification variables, refined with respect to L2.
Rejection of jets at HLT is of the order 10 or more , depending on the pT range and tightness of selection.





Turn on curves:

Trigger efficiency for tau which is also reconstructed offline for various trigger items (produced from Z->tautau Monte Carlo Simulation).

Menu Evolution:

Various tau trigger signatures are planned for early running and for higher luminosities. The pt threshold applied at EF is reflected in the signature name. Different efficiencies with respect to tau leptons identified offline (loose, medium and tight) are foreseen for every signature. Loose will be used for early running while medium and tight are planned for higher luminosities.

For 10^{31} cm^{-2} s^{-1}

Menu	Goal	Trigger	Rate [Hz]
Single tau	Searches at high Pt	tau50	1.5
tau+lepton	Z-> ττ	tau12+e10/tau16+mu10	1.8/0.5
tau+MET	W-> τυ, tt, Z-> ττ	tau16i+xe30	0.7
tau+(b)jets	tt	tau16i+3j23	0.2

For 10^{33} cm^{-2} s^{-1}

Menu	Goal	Trigger	Rate [Hz]
Single tau	Searches at high Pt	tau84	3.1
tau+lepton (+jets)	H-> τυ, H-> ττ, SUSY	tau16i+e15(i)/mu15(i)	3.2/2.9
tau+MET	SUSY, H-> τυ	tau38i+xe40	3.0
tau+tau	H-> ττ	2tau29i	5.3

Measurement of Tau Trigger efficiency:

In this section tau trigger efficiency is tau trigger efficiency with respect to offline tau reconstruction; this is the tau trigger efficiency that will be measured in early data.
Fakes: A estimate of tau trigger efficiency can be made by counting tau triggers on fake taus from QCD jets that pass offline reconstruction. The basic premise is that an object that resembled a tau sufficiently to pass the offline reconstruction algorithms should resemble a tau sufficiently to pass the hadronic tau trigger.
Tag-and-Probe: Z bosons can be used for tau trigger efficiency determination in the medium pT range (30 –60 GeV). Events are selected with single object electron or muon triggers (tag side). The tau trigger efficiency is then determined on the other side (probe side) for tau leptons reconstructed and identified offline. This selection method is expected to minimally bias the probability of a single particle tau trigger, once the overlap between offline electrons, muons, and taus has been removed. The statistics available for this measurement, after an offline selection is applied to increase the purity, is 500 events in $100 pb^{-1}$.
Top events are used to measure efficiency for tau + MET trigger. In semi-leptonically decaying ttbar events, triggered by a 4-jet trigger, the tau and neutrino(missing ET) can be used as probe for the trigger efficiency measurement (~ 300 events in $100 pb^{-1}$).
Bootstrap Method (QCD jets): Efficiency for trigger A can be measured using events triggered by a lower-pt threshold trigger B for which the efficiency is known. The efficiency of trigger A is $\epsilon_A = \epsilon_{A|B} * \epsilon_B$.

The plot on the right shows the efficiency of the Tau16i trigger wrt. offline reco Et for real taus with 3 charged tracks from Z->ττ decay(dot) and for fake taus from QCD jets (triangle).