IMPLEMENTATION AND PERFORMANCE OF THE TAU TRIGGER IN THE ATLAS EXPERIMENT

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This note presents the ATLAS trigger for taus, which is a challenging task in the LHC environment with its hard limitations on event processing time and rate of the output events which can be recorded.

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1. Introduction

Possibility of identifying and triggering taus will be very important in many searches for new physics at the LHC, like the SM and beyond SM Higgs, and in a significant part of the SUSY parameter space. Some examples are VBF $H \rightarrow \tau\tau$ that plays an important role in the discovery of the SM Higgs, Charged Higgs for which the $H^\pm \rightarrow \tau\nu$ is the dominant channel at high tan$\beta$, or SUSY decay chain with a large component of taus in the final decay products. The possibility of triggering on hadronic decays of taus will improve the acceptance and the discovery potential.

The ATLAS detector \cite{ref1}, within the Large Hadron Collider experiment is expected to start data taking in 2008 at CERN (European Organization for Nuclear Research). LHC will provide proton–proton collisions with a bunch...
crossing rate of 40 MHz, at a center of mass energy of 14 TeV and design luminosity of $10^{34} \text{cm}^{-2}\text{s}^{-1}$. The affordable output trigger rate for ATLAS is around 200 Hz, meaning an overall trigger rejection of $2 \times 10^5$ is needed.

Tau trigger is one of the several components of the ATLAS trigger system used standalone to collect high $p_T$ taus as well as in combination with other signatures like $e$, $\mu$, jet or missing $E_T$.

2. The ATLAS tau trigger

The ATLAS trigger system is organized in three levels. The first level [2] has the task to reduce collision rate of 40 MHz to 75 kHz and has to take a decision in 2.5 $\mu$s. It is hardware, calorimeter based system with granularity of 0.1 $\times$ 0.1 in $\eta/\phi$. For each cluster of energy deposition in the calorimeter it defines a “Region of Interest” (RoI) around it which will be passed to the next trigger level.

The second and third trigger levels [3] (Level2 and Event Filter, respectively) are software based, and analyze calorimeter and tracking data only within the RoI provided by the Level1 in order to speed up the decision. They are able to perform a more refine event reconstruction and reduce the rate to less than 200 Hz. The decision average time must be of 2 ms for Level2 and 0.2 s for Event Filter.

An example of the rejection power of the HLT variables is shown in Fig. 1.

![Fig. 1. Left: number of tracks found within the RoI, for taus (blue) and jets (red). Right: Width of calorimeter cluster in eta, for taus (blue) and jets (red).](image)

Various candidate tau trigger menus items are under study. Proposed menus with the physics goals for different luminosities and expected number of events of reference samples are shown in Table I.
Several tau menus in combination with electron, muon, jets, $b$-jet and missing $E_T$ signatures.

<table>
<thead>
<tr>
<th>Signature</th>
<th>Physics goal at $10^{31}$</th>
<th>Physics goal at $10^{33}$</th>
<th>$# \text{ev}(100\text{pb}^{-1})$ for $W \rightarrow \tau \nu$</th>
<th>$# \text{ev}(100\text{pb}^{-1})$ for $Z \rightarrow \tau \tau$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tau55i</td>
<td>$W \rightarrow \tau \nu$</td>
<td>High pt physics</td>
<td>$32 \times 10^3$</td>
<td>$4.6 \times 10^3$</td>
</tr>
<tr>
<td>Tau10i+El10i</td>
<td>$Z \rightarrow \tau \tau, \text{SUSY}$</td>
<td>$H \rightarrow \tau \tau, Z \rightarrow \tau \tau, \text{SUSY}$</td>
<td>100</td>
<td>$1.5 \times 10^3$</td>
</tr>
<tr>
<td>Tau15i+MET30</td>
<td>$W \rightarrow \tau \nu, t \bar{t}$</td>
<td>$W \rightarrow \tau \nu, t \bar{t}, \text{SUSY}$</td>
<td>$50 \times 10^3$</td>
<td>$3 \times 10^3$</td>
</tr>
<tr>
<td>Tau+Jets</td>
<td>SUSY, $t \bar{t}$</td>
<td>VBF Higgs, SUSY, $t \bar{t}$</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Tau15i+b18</td>
<td>$t \bar{t}$</td>
<td>$t \bar{t}$</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Tau10i+tau15i</td>
<td>$Z \rightarrow \tau \tau, \text{SUSY}$</td>
<td>$H \rightarrow \tau \tau, Z \rightarrow \tau \tau, \text{SUSY}$</td>
<td>$4 \times 10^3$</td>
<td>$4 \times 10^3$</td>
</tr>
</tbody>
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REFERENCES