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Selection of Tau Leptons with the CDF Run 2 Trigger System

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We have implemented triggers for hadronically decaying tau leptons within a framework of the CDF Run 2 trigger system. We describe the triggers, along with their physics motivations, and report on their initial performance.

1. Introduction

Run II of the Tevatron is expected to produce $p\bar{p}$ interactions with an instantaneous luminosity of about $10^{32} \text{ cm}^{-2}\text{s}^{-1}$. The CDF trigger system [1] is designed to decrease the resulting initial event rate of 1.7 MHz down to 70 Hz for data storage and offline analysis, with the goal of efficient extraction of interesting physics events. One important subset of these physics signatures, with τ leptons, covers various Standard Model (SM) processes such as $Z \rightarrow \tau\tau$, $t\bar{t}$ with $W \rightarrow \tau\nu_\tau$, and $H \rightarrow \tau\tau$. Taus could also extend the reach of searches for physics beyond the SM, including SUSY Higgs bosons. These physics goals drive us to look for τ -like objects at Level-3 (L3) of the three-level trigger system [1]. Our implementation selects events with two leptons in the final state: $e\tau_h$, $\mu\tau_h$, $\tau_h\tau_h$ and also $\tau_h\nu$, as well as ee , $e\mu$ and $\mu\mu$. With “ τ_h ” we indicate hadronically de-

caying τ 's, while the e or μ can be either produced directly or through a leptonic decay of the τ .

These tau triggers benefit from the upgraded CDF trigger system, in particular the new fast tracking processor (XFT) at Level-1 (L1) and the refined tracking information available at Level-2 (L2) [1,2].

2. Implementation of the Tau Triggers and First Results

Taus promptly decay in leptonic (35%) or hadronic (65%) modes with at least one ν in the final state. Hadronic τ decays have the distinct signature of a narrow isolated jet with low multiplicity (1 or 3 prongs) and low visible mass ($< M_\tau$). The basis for our triggers, therefore, is a τ -cone algorithm for the reconstruction of these decays. To build the τ -cone object, we start with a narrow calorimeter cluster, above a suitable E_T threshold, matched to a seed track with momen-

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tum above a P_T cut. The region within an angle Θ_{Sig} from the seed track direction is used to define a cone of tracks to be associated with the τ . The region between Θ_{Sig} and Θ_{Iso} defines the isolation annulus: we require that no tracks with P_T higher than a fixed low threshold be found in this region. At the L3 of the trigger, Θ_{Sig} and Θ_{Iso} have values of 10° , and 30° , respectively, and are determined in three dimensions.

Four different triggers were implemented in January 2002 and are collecting data stably. Below we describe their main features.

Electron plus track The selection for the e plus track trigger starts with L1 and L2 requirements of a single EM tower with $E_T > 8$ GeV with an associated XFT track with $P_T > 8$ GeV/ c and a second track with $P_T > 5$ GeV/ c . At L3, these conditions are refined and charged track isolation around the reconstructed (second) track is imposed. The current average cross-section for this L3 trigger is 29 nb.

Muon plus track For the μ plus track trigger we require a muon stub matched at L1 to an XFT track with $P_T > 4$ GeV/ c , with an increased threshold of 8 GeV/ c at L2. The “track” requirements are identical to those for the electron plus track trigger. The current average cross section for this trigger is 16 nb.

Di- τ At L1 the di- τ trigger requires two calorimeter towers with $E_T > 5$ GeV and two matching XFT tracks with $P_T > 6$ GeV/ c , separated by an angle of $\phi > 30^\circ$. L2 requires cluster $E_T > 10$ GeV and imposes track isolation. At L3, using the full reconstruction code, two τ candidates with seed track $P_T > 6$ GeV/ c , originating from the same vertex, are required. The L3 cross section for this trigger is 12 nb.

Tau plus missing transverse energy The τ plus missing transverse energy (E_T^{miss}) trigger requires $E_T^{miss} > 10$ GeV at L1. At L2 this is increased to $E_T^{miss} > 20$ GeV and a calorimeter cluster with an isolated track with $P_T > 10$ GeV/ c is required. This is followed by full event reconstruction at L3, requiring at least one τ candidate having seed track $P_T > 4.5$ GeV/ c . The present trigger cross section is 5 nb.

The first result on $W \rightarrow \tau\nu$ has been presented [3]. Here we show the study of $Z \rightarrow \tau\tau \rightarrow e\nu\nu + \tau_h$ using 72 pb^{-1} of data taken with the e plus track trigger [4]. The track multiplicity associated with the τ_h candidate found in events passing selection cuts is shown in Fig. 1. We observe a clear τ signal over background levels even before requiring an opposite sign charge for the electron and the τ_h . The mass distribution of the electron- τ_h - E_T^{miss} system in the data is also found to be consistent with the $Z \rightarrow \tau\tau$ hypothesis [4].

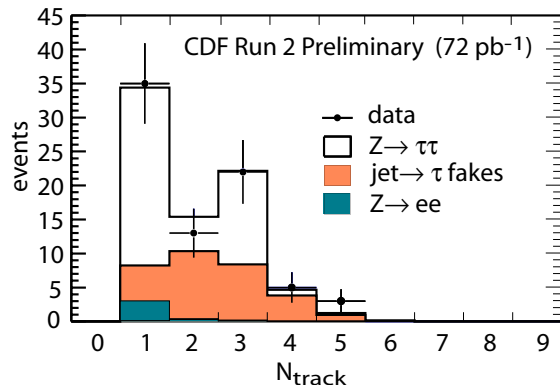


Figure 1. Track multiplicity for the τ candidate.

3. Summary

We have implemented four dedicated triggers for τ -like objects and reported the first associated physics results.

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