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EVENTS WITH τ LEPTONS AT HERA

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A study of the production of τ leptons in ep-collisions with the H1 detector at HERA is presented. The τ identification algorithm is based on the search for isolated charged tracks associated to narrow hadronic deposits detected in the calorimeters. This signature corresponds to the one-prong hadronic τ decay. Using this identification procedure, a search for events with high-P_T isolated τ leptons and missing transverse momentum is performed using a data sample corresponding to an integrated luminosity of 108 pb^{-1} collected with the H1 detector at HERA in the period 1996-2000. This search complements the observation of isolated electrons and muons in events with missing transverse momentum. A preliminary search for events with τ lepton pairs produced in elastic photon-photon collisions is also presented.

1 Introduction

The HERA collaborations H1 and ZEUS have previously reported the observation of events with isolated high energy electrons and muons in events with significant missing transverse momentum (P_T^{miss}) [1,2,3,4] . The dominant Standard Model (SM) contribution to this topology is the production of a real W boson with its subsequent leptonic decay. Such events can also be a signature of new phenomena beyond the Standard Model, for instance the production of single *top* quarks via flavour changing neutral currents (FCNC) [5]. This talk presents the first H1 search for events containing isolated high energy τ leptons associated with large P_T^{miss}. A similar search has been performed by ZEUS [6].

2 Search for Events with Missing Transverse Momentum and Isolated τ leptons

This search aims to complement the previous observation of events with electrons or muons and significant P_T^{miss}. Due to the difficult *tau* lepton identification, more powerful background supression was required with respect to the e and μ channels. This analysis was performed using a data sample corresponding to an integrated luminosity of 108 pb^{-1} collected with the H1 detector at HERA in the period 1996-2000.

The candidate events are selected if there is significant calorimetric transverse momentum $P_T^{calo} > 12$ GeV and a longitudinal momentum imbalance $E - P_z <$ 45 GeV ($E - P_z$ is the sum over all measured particles and is expected to be 55 GeV for fully measured events). In addition, at least one jet with $P_T > 7$ GeV is required and a set of topological filters are applied in order to reject non ep events due to cosmic or halo muons. After these cuts, 4142 events are selected in the HERA-I dataset and these are shown to be in good agreement with the prediction from the SM.

In the remaining data sample, events containing τ candidates are selected. The τ candidate selection is based on the typical signature of the hadronic one-prong τ decay: one charged track associated to a narrow ("pencil-like") hadronic deposit in the calorimeter. The τ lepton candidates are selected from the reconstructed hadronic jets. The candidate hadronic jet is required to have a $P_T > 7$ GeV and to be in the polar angle range $20° < \theta < 120°$. The jet is required to contain only one charged track and to be isolated from other jets, electrons and muons.

To discriminate between τ leptons and the QCD jets, a jet radius R_{jet} is calculated using the calorimetric deposits E_i associated to the jet:

$$R_{jet} = \frac{1}{E_{jet}} \sum_i E_i \sqrt{\Delta\phi(jet,i)^2 + \Delta\eta(jet,i)^2}$$

Narrow jets are selected by the requirement $R_{jet} < 0.12$.

The acoplanarity between the τ candidate momentum and the momentum of the remaining measured particles in the event is required to be above $10°$ in the azimuthal plane. In order to further supress the background, mainly present at low P_T, further cuts $P_T^{calo} > 20$ GeV and $P_{track} > 5$ GeV were applied.

The P_T^X spectrum after these cuts is shown in Fig. 1. Table 1 summarizes the results of the search. 5 events were observed for 5.8 ± 1.3 expected from the SM. All of these events are in the very low P_T^X region. In the region at large hadronic momentum $P_T^X > 25$ GeV no events are observed.

H1 Preliminary

H1 Data 96-00 108 pb^{-1}	Data	All SM Processes	SM W	Single top Efficiency * BR
Full Sample	5	5.81 ± 1.36	0.87 ± 0.15	0.52 %
$P_T^X > 25$ GeV	0	0.53 ± 0.10	0.26 ± 0.05	0.49 %
$P_T^X > 40$ GeV	0	0.22 ± 0.05	0.12 ± 0.03	0.42 %

Table 1. Observed and predicted number of events in the 1996-2000 dataset after the final selection. The last column quotes the expected efficiency for an anomalous single top production Monte Carlo, used as a template process with high-P_T isolated τ-leptons in the final state.

3 Observation of τ Pairs produced in elastic $\gamma\gamma$ collisions

To check the possibility of τ identification with the H1 detector, the analysis of τ lepton pairs produced in the elastic $\gamma\gamma$-collisions has been performed.

In order to reduce the enormous background from multi-jet photoproduction, one τ lepton is required to decay leptonically and is identified as an isolated e or μ. The second τ lepton is required to decay hadronically. It's typical signature was detected using a neural network based discriminant. Input to the neural network

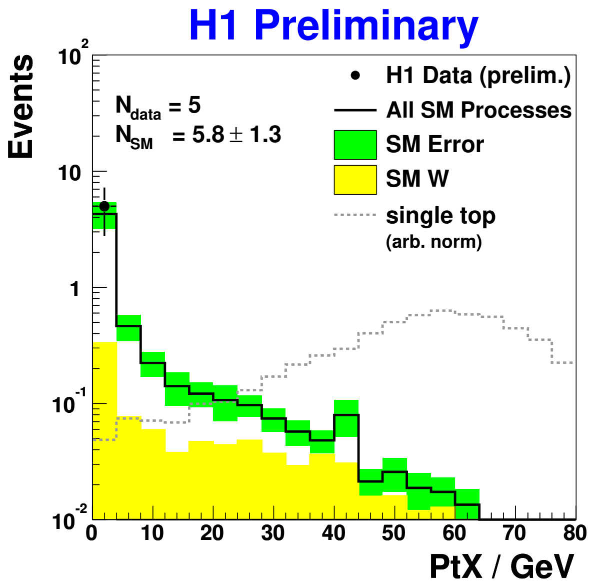

Figure 1. Transverse Momentum of the Remaining Hadronic System P_T^X in the Final Sample. No events are observed in the interesting region of $P_T^X > 25$ GeV

were 10 observables discriminating τ jets from QCD jets. The two τ candidates were required to have opposite charge, as expected in lepton pairproduction. Except for the τ candidates, the detector was required to be empty, thus ensuring elastic production and significantly reducing SM background.

After this selection, 15 τ pairs have been observed, for 16.3 ± 3.7 expected from the SM, dominated by the signal from the τ pairproduction. In a second ("wrong charge") sample, where the two τ candidates were required to have the same charge, 1 event was observed with 1.9 ± 1.2 expected.

4 Summary and Outlook

The search for isolated τ leptons presented here completes the analyses of isolated leptons and missing P_T performed by the H1 and ZEUS experiments using the data collected during the HERA-I running period. Table 2 summarizes these results. While H1 reports events with electrons and muons in the high-P_T^{had} region in excess to the SM prediction, ZEUS observes good agreement with the Standard Model. The ZEUS collaboration observes in turn two atypical τ events at large P_T^{had}. The new H1 preliminary search for $\tau + P_T^{miss}$ events presented here reveals no candidate at large P_T^{had}. Comparing the τ analyses directly, H1 has a W detection efficiency which is roughly two times that of ZEUS in the high-P_T^{had} region. On the other hand, the background suppression of ZEUS is roughly two times as powerful as that of H1 in the corresponding region. The new data taking period HERA-II with an aspired collected luminosity of $700pb^{-1}$ will hopefully solve the puzzle of the isolated leptons at HERA.

1994-2000 $e^{\pm}p$		Electron obs./exp. ($W^{\pm}$ contrib.)	Muon obs./exp. ($W^{\pm}$ contrib.)	Tau (108 pb^{-1}) obs./exp. ($W^{\pm}$ contrib.)
H1 118.4 pb^{-1}	Full Sample	11 / 11.54±1.50 (71%)	8 / 2.94±0.50 (86%)	5 / 5.81±1.36 (15%)
	$p_T^{\text{had}} > 25$ GeV	5 / 1.76±0.30 (82%)	6 / 1.68±0.30 (88%)	0 / 0.53±0.10 (49%)
	$p_T^{\text{had}} > 40$ GeV	3 / 0.66±0.13 (80%)	3 / 0.64±0.14 (92%)	0 / 0.22±0.05 (54%)
ZEUS 130.2 pb^{-1}	Full Sample	24 / 20.6 $^{+1.7}_{-4.6}$ (17%)	12 / 11.9$^{+0.6}_{-0.7}$ (16%)	3 / 0.40$^{+0.12}_{-0.13}$ (49%)
	$p_T^{\text{had}} > 25$ GeV	2 / 2.90$^{+0.59}_{-0.32}$ (45%)	5 / 2.75$^{+0.21}_{-0.21}$ (50%)	2 / 0.20$^{+0.05}_{-0.05}$ (49%)
	$p_T^{\text{had}} > 40$ GeV	0 / 0.94$^{+0.11}_{-0.10}$ (61%)	0 / 0.95$^{+0.14}_{-0.10}$ (61%)	1 / 0.07$^{+0.02}_{-0.02}$ (71%)

Table 2. Summary of the results of searches for events with isolated leptons, missing transverse momentum and large p_T^{had} at HERA. The number of observed events is compared to the SM prediction. The $W^{\pm}$ component is given in parentheses in percent. The statistical and systematic uncertainties added in quadrature are also indicated.

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