H1prelim-04-061

Search for events with τ leptons in ep collisions at HERA

H1 Collaboration

Abstract

The production of τ-leptons in ep collisions is studied with the H1 detector at HERA by using an identification algorithm based on the search for isolated charged tracks associated to narrow hadronic jets detected in the calorimeters, a typical signature of 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. In addition, a preliminary search for events with τ-lepton pairs produced in elastic photon-photon collisions is performed.

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1 Search for events with isolated high-P_T τ-leptons and missing transverse momentum.

1.1 Search for events with τ leptons and missing transverse momentum

P_T^{miss} **Preselection**	
Data Quality (HV,triggers,vertex, timing)	
P_T^{calo}	> 12 GeV
P_T^{miss}	> 12 GeV
$\Delta\phi\,(Calo, \text{PLUG})$	$< 150^\circ + 30^\circ \cdot \left(\frac{P_T^{calo}-12}{13}\right)$
$\Sigma(E - P_z)$	< 45 GeV
N_{jets}	≥ 0
P_T^{jet}	> 7 GeV

Table 1: The preselection of events with missing transverse momentum: P_T^{calo} is the total calorimetric transverse momentum, P_T^{miss} is the total transverse momentum of all reconstructed particles, $\Delta\phi\,(Calo, \text{PLUG})$ is the acoplanarity between the momentum measured in the main calorimeter and the momentum measured in the forward PLUG calorimeter, $\Sigma(E - P_z)$ sums the $E - P_z$ contributions of all measured particles and is 55.2GeV for events with fully measurable final state. At least one jet is required with a transverse momentum above 7 GeV.

$\tau + P_T^{miss}$ **Preselection**	
P_T^{miss} Preselection	(see table 1)
P_T^{jet}	> 7 GeV
θ^{jet}	from 20° to 120°
N_{tracks}	$= 1$
P_T^{track}	> 2 GeV
$R_{e,\mu,jets}^{\eta\varphi}$	> 1.0

Table 2: The preselection of events with significant missing transverse momentum and a single track jet, corresponding to a τ candidate. The jet polar angle θ^{jet} is required to be in the central region and to contain exactly one charged track $N_{tracks} = 1$ with a transverse momentum above 2 GeV. The jet is required to be isolated by asking the minimum distance in the $\eta - \varphi$ plane $R^{\eta\varphi}$ of electrons, muons or other jets in the event to be above 1.

$\tau + P_T^{miss}$ **Final Selection**	
P_T^{miss} Preselection	(see table 1)
P_T^{calo}	$>$ 20 GeV
P_T^{jet}	$>$ 7 GeV
θ^{jet}	from 20° to 120°
N_{tracks}	$= 1$
P_T^{track}	$>$ 5 GeV
$R^{\eta\varphi}_{e,\mu,jets}$	$>$ 1.0
$\Delta\phi(jet, X)$	$<$ 170°
R^{jet}	$<$ 0.12 GeV

Table 3: Final selection of events with isolated τ candidates and missing transverse momentum. Narrow calorimetric deposits are identified using the variable R^{jet} (jet size), defined by $R_{jet} = \sum_i \frac{E_i \Delta^i(\varphi,\eta)}{E^{jet}}$ (i runs over all particles in the jet, E_i is the particle energy and $\Delta^i(\varphi, \eta)$ the distance in $\eta - \varphi$ plane to the jet axis). The hadronic final state excluding the τ candidate jet is denoted by X. A significant acoplanarity requirement $\Delta\phi(jet, X) < 170°$ ensures further background rejection.

H1 Preliminary

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

Table 4: 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.

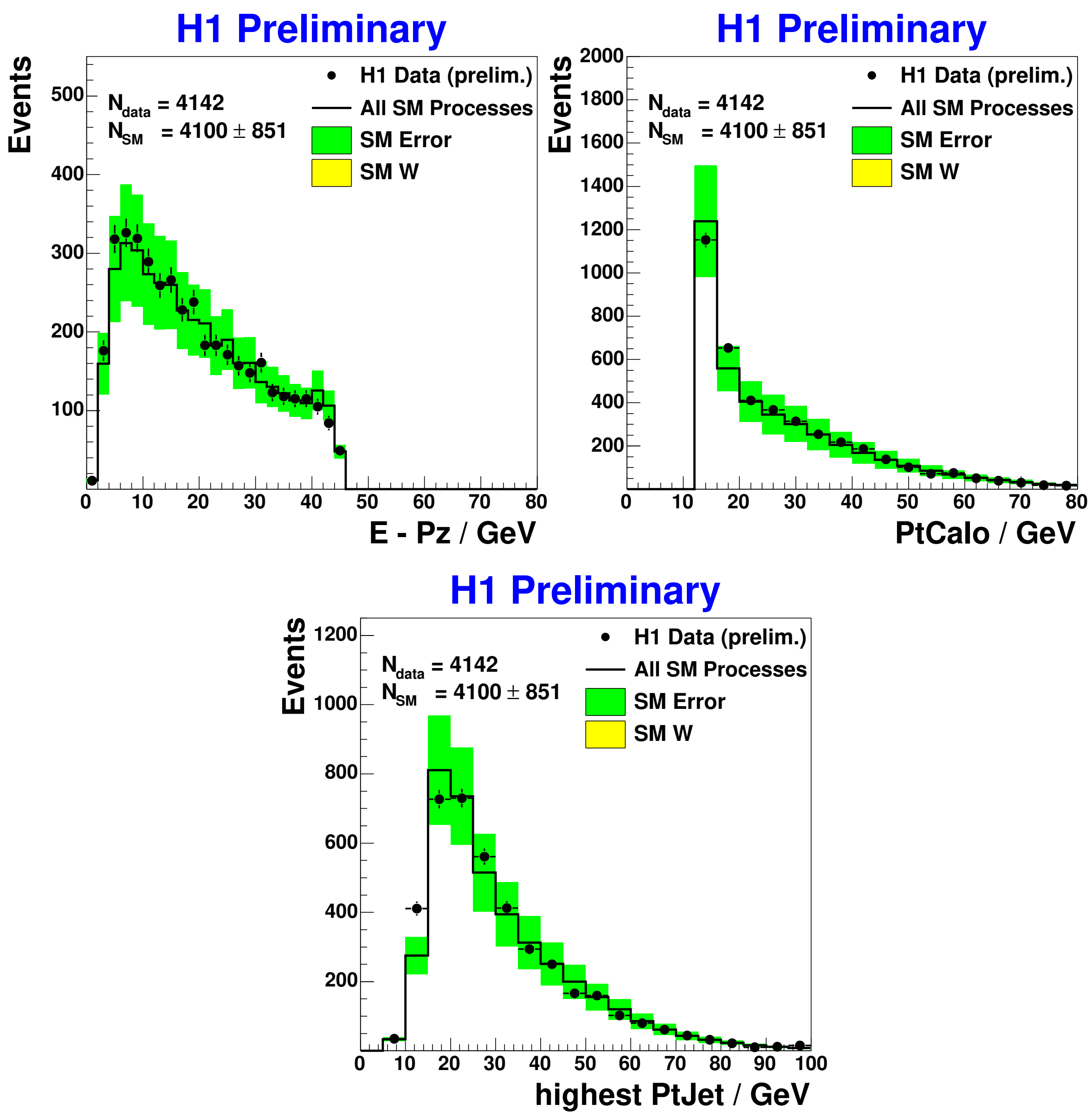

Figure 1: The distributions of $\Sigma(E - P_z)$, P_T^{calo} and the highest P_T^{jet} in the data compared to the Monte Carlo simulation for the P_T^{miss} event preselection described in table 1.

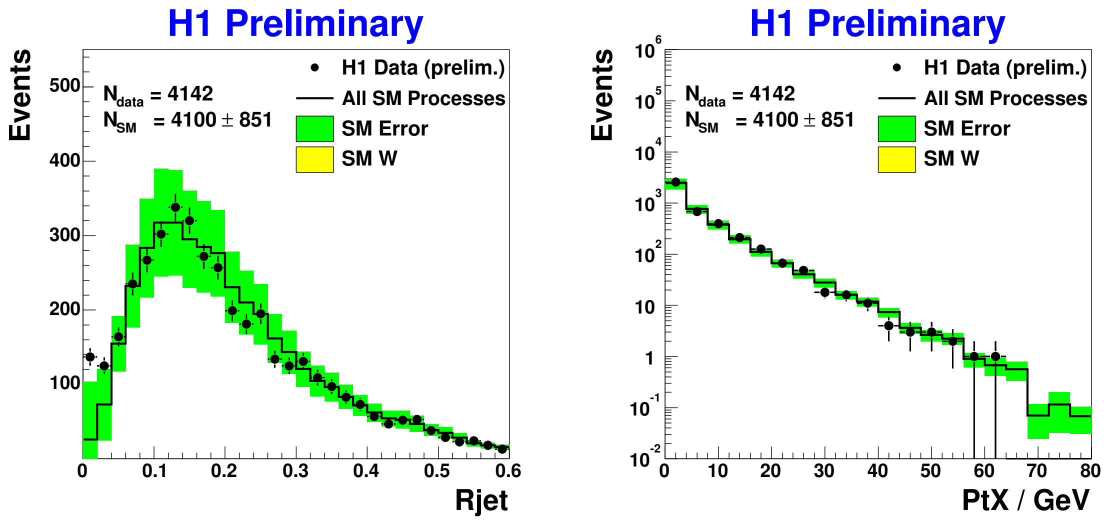

Figure 2: The distributions of R^{jet} and P_T^X in the data compared with the Monte Carlo simulation for the P_T^{miss} event preselection described in table 1. The SM W contribution is still negligible at this level.

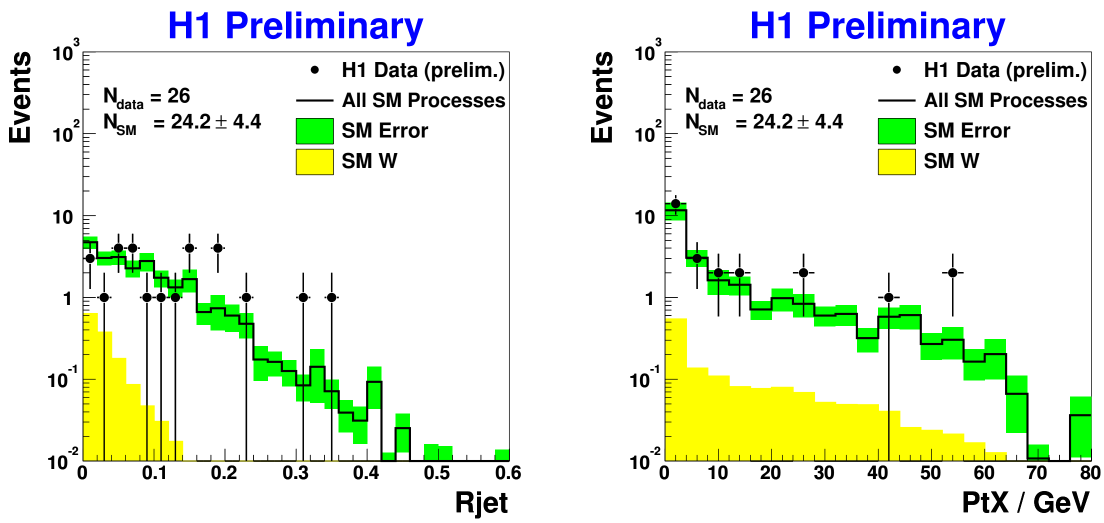

Figure 3: The distributions of R^{jet} and P_T^X in the data compared with the Monte Carlo simulation for the $\tau + P_T^{miss}$ event preselection described in table 2. Note that the jet radius R^{jet} of jets selected in the Standard Model W Monte Carlo are narrow, as expected from τ-jets. A cut $R^{jet} < 0.12$ will be applied in the final selection.

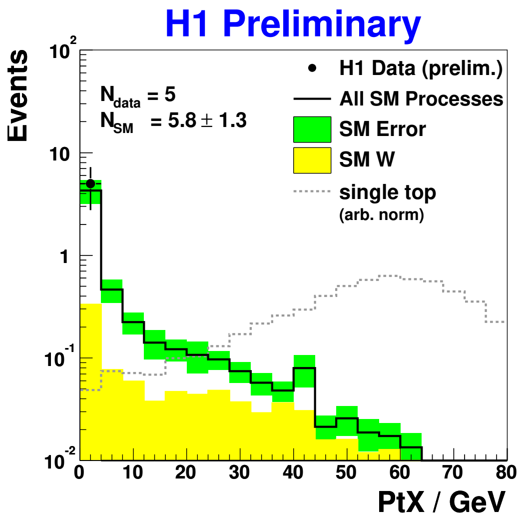

Figure 4: The distribution of the hadronic transverse momentum P_T^X in the data compared with the Monte Carlo simulation for the $\tau + P_T^{miss}$ final selection described in table 3. No events are observed in the high P_T^X region, where events for the template signal process single top production are expected.

2 Observation of τ-pairs in elastic $\gamma\gamma$-processes.

As a supplementary investigation of the H1 detector capabilities to detetect τ leptons, a preliminary search for τ-pair production in ep collision is performed in the channel where one τ decays leptonically and the other hadronically. Events are selected by requiring one identified electron or muon and one hadronic τ candidate (1-prong or 3-prong) with $P_T > 2$ GeV. The hadronic τ signature is performed by using a neural network algorithm based mainly on hadronic cluster shape and trained differently for one– or three-prong channels. In order to select elastic τ–pair production channel, events with other hadronic deposits besides the hadronic τ candidate are rejected.

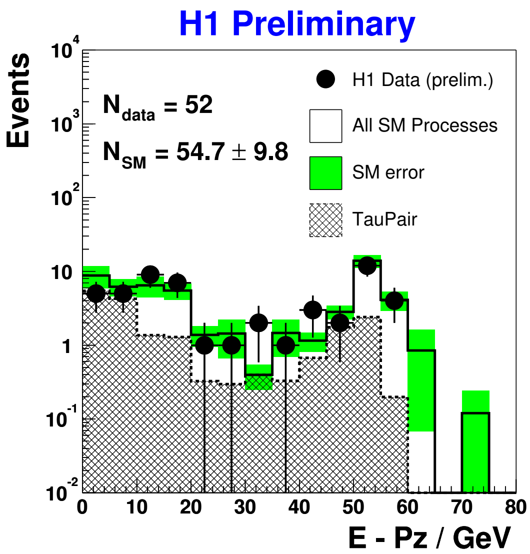

Figure 5: The $\Sigma(E - P_z)$ distribution of the pre-selected τ-pair candidate events in data compared with the Monte Carlo simulation.

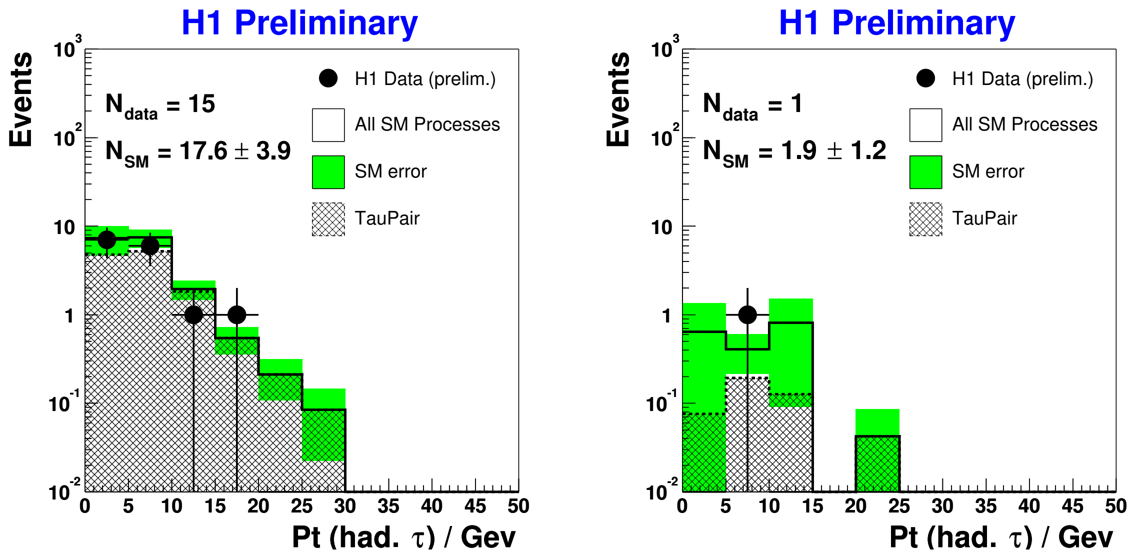

Figure 6: Control Plots of the visible transverse momentum distributions of the hadronically decaying τ-lepton; on the left for opposite charges of the two decaying τ-candidates, on the right for equally charged τ-candidates. In $\gamma\gamma \rightarrow \tau^+\tau^-$ processes only candidates of opposite charge are expected.

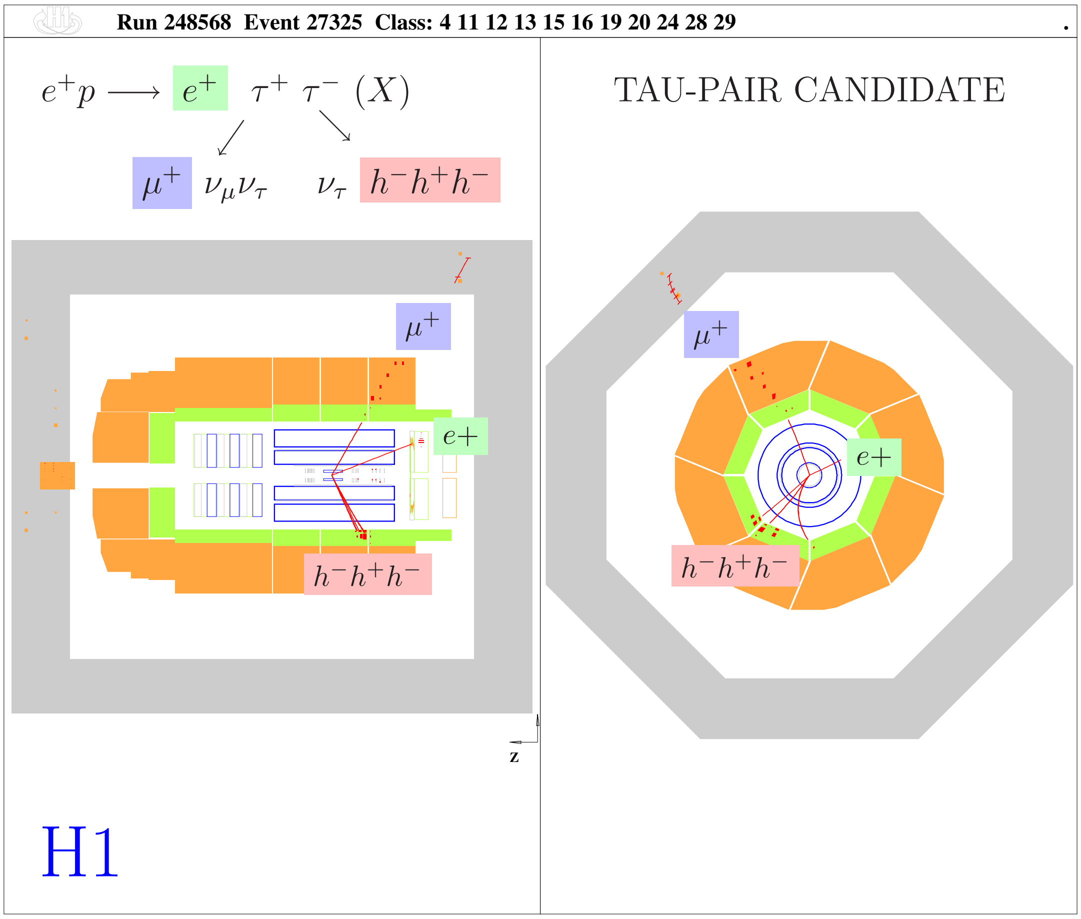

Figure 7: τ-pair candidate event with one τ-lepton decaying leptonically to a muon, and the other τ-lepton decaying to three charged hadrons (3-prong topology). The scattered positron is also detected in the backward calorimeter.