TAU PRODUCTION AT HERA

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The production of tau leptons in *ep* collisions is investigated using data recorded by the H1 detector at HERA in the period 1994-2005. The cross section for the production of tau lepton pairs is measured for the first time at HERA. Furthermore, a search for events with an energetic isolated tau lepton and with large missing transverse momentum is performed. The results are found to be in agreement with the Standard Model predictions.

1. Introduction

In the Standard Model (SM), in *ep* collisions tau leptons are produced either in pairs in photon-photon collisions, or in association with a tau anti–neutrino from the decay of singly produced W bosons, as expected from lepton flavour conservation.

The H1 experiment has performed an analysis [1] of production of tau lepton pairs ($\tau^+\tau^-$) and a search for events with an isolated tau lepton accompanied by large missing transverse momentum due to an undetected neutrino ($\tau + P_T^{\rm miss}$). The analysis is based on data from electron or positron–proton collisions at a centre–of–mass energy of 301 or 319 GeV, recorded by the H1 experiment at HERA in the period 1994–2000. The total integrated luminosity amounts to 106 pb^{-1} for the measurement of $\tau^+\tau^-$ production and 115 pb^{-1} for the search for $\tau + P_T^{\rm miss}$ events. A preliminary result for the $\tau + P_T^{\rm miss}$ search, for the period 1994–2005 corresponding to a total luminosity of 278 pb^{-1} (153 pb^{-1} e^+p, 125 pb^{-1} e^-p) , is also presented.

2. Measurement of tau pair production

Tau pairs produced in elastic *ep* collisions are identified using final states containing both hadronic and leptonic tau decays. The signature of a tau

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decay is either an electron (e), a muon (μ), or a narrow hadronic jet with one or three tracks (τ–jet). Candidate events must contain one of the following combinations: $e\mu$, $e(\mu)\tau$–jet or τ–jet τ–jet. Final states with two leptons of same flavour ee or $\mu\mu$ are not used in the analysis since the background from lepton pair production is large. The tau candidates are required to have P_T >5 (e) or 2 (μ, τ–jet) GeV and θ between 20-140°(e,μ) or 20-120° (τ–jet). In $\tau^+\tau^-$ production, taus generally have low P_T, and populate therefore a region where the background from the jet production is very large. In order to select hadronic tau decays, a Neural Network (NN) algorithm is used in order to perform an efficient background rejection. NN's are trained to reject one– or three–prong background jets as well as misidentified electrons or muons.

The algorithm selects about 50% of tau decays, while accepting 0.5%-4% of quark/gluon initiated jets. In order to further reject Neutral Current events, $E-P_z$, the longitudinal momentum balance, is required to be below 50 GeV. The event selection has a total efficiency of 1.2% on elastic tau pair events where both tau have P_T >2 GeV and θ between 20-140°.

The results are shown in Table 1 and figure 1.

Table 1. Number of selected events and SM prediction for the $\tau^+\tau^-$ analysis. The expected relative contribution of the $\tau^+\tau^-$ process to the SM prediction is also shown.

DecayChannel	*Leptonic*	*SemiLeptonic*		*Hadronic*	*Total*
	$e\ \mu$	$e\ \tau-jet$	$\mu\ \tau-jet$	$\tau-jet\ \tau-jet$	
H1Data	7	2	10	11	30
SM	2.9 ± 0.4	6.3 ± 0.9	7.0 ± 1.3	11.0 ± 2.0	27.1 ± 4.1
$\tau^+\tau^-$	56%	47%	85%	50%	59%

A measurement of the cross section for tau pair production is performed in the kinematic region defined by 20< θ_τ <140° and P_T^τ >2 GeV. The measured cross section for elastic tau pair production is 13.6 ± 4.4(stat) ± 3.7(sys) pb, in agreement with the expectation of 11.2 ± 0.3 pb.

3. Search for events with an isolated tau lepton and large P_T^{miss}

In this analysis tau decays are searched in the hadronic channel, since the events containing leptonic tau decays cannot be distinguished from events with electrons and muons and $P_T^{\rm miss}$, discussed elsewhere [2]. Since the background is less severe, hadronic tau decays are identified as one–

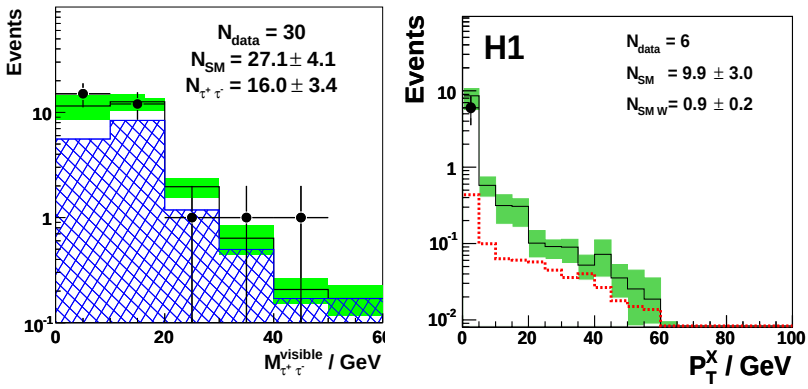

Figure 1. Left: Visible reconstructed mass for tau pairs selected at the final level. Dots are H1 data, full histogram with error band for total SM prediction, hatched histogram for the contribution from tau pair production. Right: Reconstructed transverse momentum of the hadronic final state excluding tau decay products at the final level of the $\tau + P_T^{\rm miss}$ selection. Dashed histogram is SM W signal. Data collected in 1994–2000

prong hadronic isolated jets (P_T >7 GeV, 20< θ_τ <120°) using a simplified algorithm. The jet radius, defined as the energy weighted average $\eta - \phi$ distance of the particles contained in the jet to the jet axis, is required to be below 0.12. Using this identification, an efficiency of 80% on one–prong tau decays is achieved with a corresponding efficiency on quark/gluon initiated jets of less than 1% A total missing momentum above 12 GeV (indication of the presence of neutrinos) is required. To reject the NC and photoproduction backgrounds, cuts are applied on the azimuthal imbalance of the tau with respect to the rest of the hadronic system ($\mathbf{X}$), on $E - P_z$, and on the ratio of transverse energy antiparallel over parallel respect to the total $p_T^{\rm miss}$ direction.

In the final selection of $\tau + P_T^{\rm miss}$ events, 6 events are observed, for $9.9^{+2.5}_{-3.6}$ observed, out of which $0.89^{+0.15}_{-0.26}$ are expected from SM W production. The distribution of P_T^X is shown in figure 1. In the region $P_T^X > 25$ GeV, where an excess of events containing isolated electrons or muons is observed [3,4,5], no event is found for $0.39^{+0.09}_{-0.11}$ expected from the SM. An upper limit at 95% confidence level is obtained for the production cross section of $\tau + P_T^{\rm miss}$ events, $\sigma(P_T^X > 25\ {\rm GeV}) < 0.31$ pb. The present measurement is compatible with the previous measurement of events with an electron or muon and $P_T^{\rm miss}$, as expected if lepton universality is assumed.

A preliminary result for the luminosity period 1994–2005 (278 pb^{-1})

is also obtained, with 25 events observed for a total SM expectation of 24.2 ± 5.0 (stat. and syst. error added). Distributions of P_T^X are shown in figure 2. In the region $P_T^X > 25$ GeV, 3 events are observed, for a SM expectation of 0.74 ± 0.18. More specifically, at high P_T^X, for e^+p collisions 0 events are observed for a SM expectation of 0.40 ± 0.10, and for e^-p collisions 3 events are observed for a SM expectation of 0.35 ± 0.09.

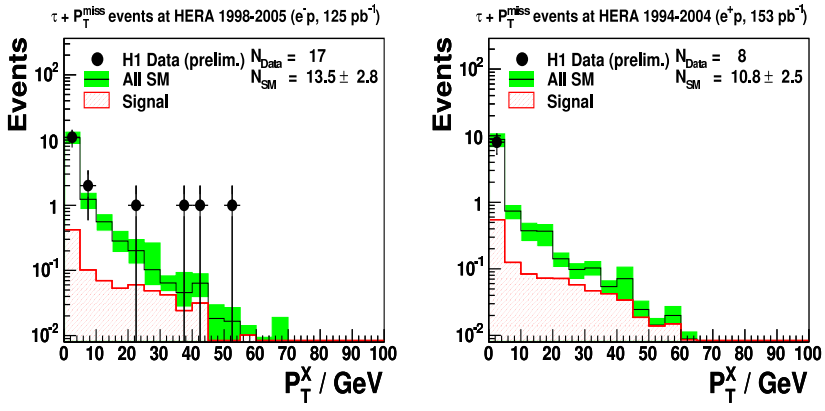

Figure 2. Preliminary result for $\tau + P_T^{\rm miss}$ analysis on the reconstructed transverse momentum of the hadronic final state excluding tau decay products at the final level, for luminosiy period 1994–2005. Left: e^-p collisions. Right: e^+p collisions. Dots are H1 data, full histogram with error band for total SM prediction, shaded histogram for the contribution from SM W production.

4. Conclusion

H1 collaboration measured for the first time the tau pair production in $e^\pm p$ collisions. The search for $\tau + P_T^{\rm miss}$ has been extended to the data sample collected at HERAII. In both cases, good agreement with the SM prediction is observed.

References

1. A. Aktas *et al.* [H1 Collaboration], Subm. to *Eur. Phys. J. C* [hep-ex/0604022].
2. David South, these proceedings
3. T. Ahmed *et al.* [H1 Collaboration], DESY 94-248 (1994).
4. C. Adloff *et al.* [H1 Collaboration], *Eur. Phys. J. C* **5**, 575 (1998)
5. V. Andreev *et al.* [H1 Collaboration], *Phys. Lett. B* **561**, 241 (2003)