Tau Leptons at HERA

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We review recent analyses at HERA dealing with a tau lepton in the final state of ep-collisions. At the ZEUS experiment, a search for events containing isolated tau leptons and missing transverse momentum in addition to that due to the tau decay was performed. The analysis, based on isolated tracks from hadronic tau decays and the exploitation of the internal jet structure, yields 3 tau candidates where $0.40^{+0.12}_{-0.13}$ are expected from the Standard Model. With the H1 detector, the production of high-P_T isolated tau leptons was studied using typical one-prong hadronic tau decays as identification. In addition, an analysis of tau lepton pairs in elastic photon-photon collisions was performed. Furthermore, a search for doubly charged Higgs bosons includes also like-sign tau lepton pairs in the final state. Finally, the tau lepton was studied by both experiments in searches for new physics as a decay product of a resonantly produced leptoquark violating the conservation of lepton flavor.

1. Introduction

According to the Standard Model, the tau lepton can only be rarely observed in the final state of ep-collions at HERA. Nevertheless, various theoretical extensions of the Standard Model predict significant rates for final states with a tau lepton. This gives motivation for recent searches with the experiments H1 and ZEUS to include tau channels. In this note we review these analyses with a focus on their particular tau channel.

2. The HERA Collider and the experiments H1 and ZEUS

The Hadron-Electron Ring Accelerator (HERA), located at the DESY research site in Hamburg, Germany, is a unique storage ring of its kind, where electrons[2] and protons are accelerated and stored at an energy of $27.6\,\mathrm{GeV}$ and $920\,\mathrm{GeV}$ respectively. At two interaction points, the experiments H1 and ZEUS detect the ep-collisions at a rate of $10.5\,\mathrm{MHz}$ and a center of mass energy of $\sqrt{s} = 320\,\mathrm{GeV}$. A detailed description of the H1 and ZEUS detectors can be found in [1,2].

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[2]HERA can run with either an electron or positron beam

3. Recent analyses with tau leptons

3.1. Isolated tau leptons and missing P_T

The H1 and ZEUS collaborations have both previously reported the observation of events with isolated high energy electrons and muons in events with significant missing transverse momentum, P_T^{miss}, [3–6]. The dominant Standard Model (SM) contribution to this topology is the production of real $W^{\pm}$ bosons with subsequent leptonic decay. Such events can also be a signature of new phenomena beyond the Standard Model, for example the production of single top quarks via Flavor Changing Neutral Currents (FCNC) [7,8]. Production of stop quarks in R-parity violating (R_p) SUSY models [9] with subsequent two-body decay (e.g. $\tilde{\tau} \to \tau b$) or R_p-conserving three-body decay modes ($\tilde{\tau} \to \tau\tilde{\nu}_\tau b, \tilde{\tau}\nu_\tau b$) are also potential sources.

3.1.1. ZEUS

Using an integrated luminosity of 130 pb^{-1}, the search for tau leptons is concentrated on hadronic tau decays. The narrow, "pencil-like" shape and the low charged-particle multiplicity of the tau jets were used to distinguish them from quark- and gluon-induced jets.

The internal jet structure is generally well described by the Monte Carlo (MC) simulations [10]. Here, it was characterised by six observables, i.e. the first and second moments of both the longitudinal and radial extensions, the number of subjets and the invariant mass of the jets. The inclusive CC DIS data sample is well described by the MC CC events and the difference in the shapes between tau jets and quark- or gluon-induced jets is evident in all six variables.

To seperate the signal from the background, the six jet-shape variables were combined in a discriminant, $\mathcal{D}$, with

$$\mathcal{D} = \frac{\rho_{sig}(\vec{x})}{\rho_{sig}(\vec{x}) + \rho_{bg}(\vec{x})},$$

where $\rho_{sig}(\vec{x})$ and $\rho_{bg}(\vec{x})$ are the density functions in the six-dimensional jet-shape space of the signal and the background events, respectively. The resulting distribution of $\mathcal{D}$ in Figure 1 shows a clear seperation of the signal dominant at large discriminant values ($\mathcal{D} \to 1$). The observed distribution dominant at low discriminant values ($\mathcal{D} \to 0$) is well reproduced by the CC DIS simulation.

The final cut on the discriminant of $\mathcal{D} > 0.95$ leaves 3 tau candidate events where $0.40^{+0.12}_{-0.13}$ are expected from the Standard Model. Figure 2 shows the distribution of the discriminant before the final cut and the p_T^{had}-distribution after $\mathcal{D} > 0.95$ is applied. In particular the two events with highest p_T^{had} could serve as candidates for FCNC with single top production. Figure 3 illustrates one of these events.

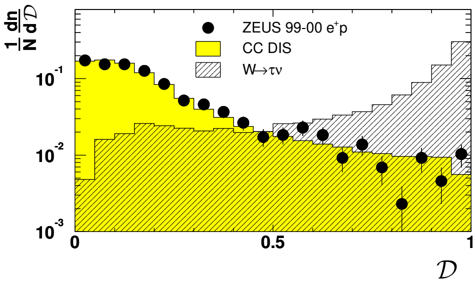

Figure 1. Distribution of the tau discriminant, $\mathcal{D}$, for inclusive CC DIS data events (dots) from e^+p-data taken in the years 1999-2000 only, a simulation of CC DIS events (shaded) and the simulation of the direct W-production signal, $W \to \tau\nu$, with subsequent hadronic tau decay (hatched).

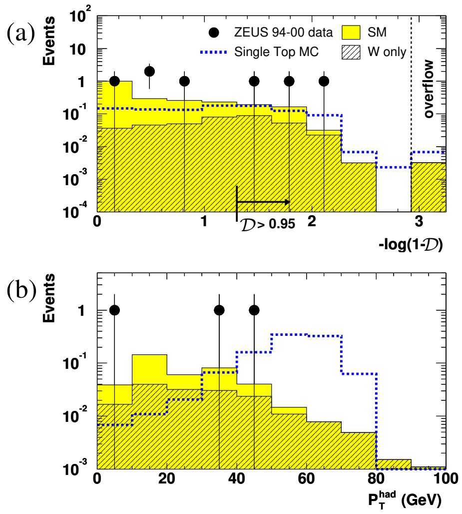

Figure 2. Distribution of (a) the tau discriminant, $-\log(1-\mathcal{D})$, before the cut on $\mathcal{D} > 0.95$ and (b) the hadronic transverse momentum, p_T^{had}, after applying the cut $\mathcal{D} > 0.95$. The dashed line represents the normalised distribution of the single-top MC, including all decay channels of the W boson.

3.1.2. H1

The H1 collaboration presents a search for events with tau leptons using the H1 detector with the data collected between 1996 and 2000, corresponding to an integrated luminosity of 108 pb^{-1}. The hadronic decays of tau leptons are searched for in events with significant missing transverse momentum. 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 is required.

The identification of events with missing transverse momentum is based on the following observables that quantify the momentum imbalance in the event:

- P_T^{miss}, the net transverse momentum.
- P_T^{calo}, the net transverse momentum measured from all energy deposits recorded in the calorimeters only.
- $E - P_z = \sum_i E_i(1 - \cos\theta_i)$, where E_i and θ_i denote the energy and polar angle

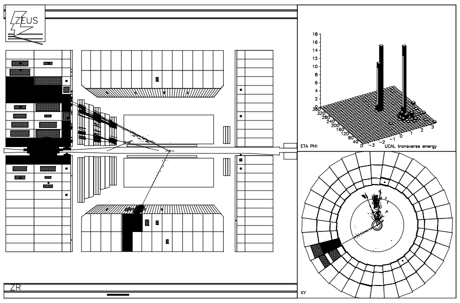

Figure 3. A tau-candidate event with $p_T^{had} = 38\,\mathrm{GeV}$ and $p_T^{\tau-\mathrm{jet}} = 41\,\mathrm{GeV}$ in the ZEUS detector.

of each particle in the event detected in the main detector. For an event where only momentum in the proton direction is undetected, $E - P_z = 2E_e = 55\,\mathrm{GeV}$ ($E_e = 27.5\,\mathrm{GeV}$ is the electron beam energy). This quantity gives a measure of the longitudinal momentum balance.

The hadronic final state (HFS) is measured by combining calorimeter energy deposits with low momentum tracks. Identified isolated electrons or muons are excluded from the hadronic final state. The calibration of the hadronic energy scale is made by comparing the transverse momentum of the precisely measured scattered electron to that of the HFS in a large NC event sample. Particles from the reconstructed HFS are combined into jets using an inclusive k_T algorithm [11] with a minimum P_T of 4 GeV.

The tau candidate forms a narrow hadronic jet associated to one isolated charged track measured in the inner tracker. The present analysis restricts the search for hadronic tau decays to the "one-prong" decays, which make up about 50% of all tau decays. The size of the hadronic jet is estimated using the jet radius R_{jet}, defined as the energy weighted average distance in the $\eta - \phi$ plane between the jet axis and the hadrons making up the jet:

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

where the sum runs over all hadrons that belong to the candidate hadronic jet. The isolation of the tau candidate is measured by the distance in $\eta - \phi$ plane to the closest hadronic jet (D_{jet}) or to the closest track (D_{track}). The remaining hadronic system after excluding the tau jet candidate, is denoted by X hereafter.

The selection of events with isolated tau candidates and missing transverse momentum is perfomed in three steps. At first, the data is preselected with a minimum calorimetric tranverse momentum, P_T^{calo}, of $12\,\mathrm{GeV}$ and a longitudinal imbalance $E - P_z < 45\,\mathrm{GeV}$. At least one jet with $P_T > 7\,\mathrm{GeV}$ and a topological acoplanarity are further preselection criteria. Then, the candidate tau jet is required to have a $P_T > 7\,\mathrm{GeV}$ and to be in the polar angle range $20^\circ < \theta < 120^\circ$. The jet is required to contain only one charged track and to be isolated from other jets or charged tracks: $D_{jet} > 1$ and $D_{track} > 1$. Finally, narrow pencil-like jets are selected by the requirement $R_{jet} < 0.12$. The acoplanarity $\Delta\phi(jet, X)$ between the tau candidate momentum and the momentum of the remaining measured particles in the event must be below 170°. In order to further supress the mainly low P_T background, further cuts $P_T^{calo} > 20$ GeV and $P_{track} > 5$ GeV are applied.

After the final selection, five events are observed in the data sample compared to a SM expectation of 5.8 ± 1.4. The data 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. Table 1 summarizes the results of the search in comparison with the ZEUS experiment and previous searches for isolated electrons and muons.

This preliminary analysis completes the picture of the searches for events with isolated leptons and missing transverse momentum at HERA. The status after HERA I data taking is summarised in Table 1. While H1 reports events with electrons and muons in the high P_T^X region in excess of the SM prediction, ZEUS observes good agreement with the SM. In turn, ZEUS observes two tau events at large P_T^X for 0.20 ± 0.05 expected. The new H1 preliminary search for $\tau + P_T^{\mathrm{miss}}$ events reveals no candidate at large P_T^X. In the tau channel, the H1 analysis has a W detection efficiency which is roughly two times that of the ZEUS analysis in the high-P_T^X region. The background suppression of the ZEUS analysis is roughly two times stronger than that of the H1 analysis in the same region.

Table 1
Summary of the results of searches for events with isolated leptons, missing transverse momentum and large P_T^X at HERA.

1994-2000 $e^{\pm}p$		Electron obs./exp. ($W^{\pm}$ contrib.)	Muon obs./exp. ($W^{\pm}$ contrib.)	Tau (H1:108 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%)
	$P_T^X > 25$GeV	5 / 1.76±0.30 (82%)	6 / 1.68±0.30 (88%)	0 / 0.53±0.10 (49%)
	$P_T^X > 40$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%)
	$P_T^X > 25$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%)
	$P_T^X > 40$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%)

3.2. Tau pairs at H1

As a supplementary investigation of the ability of the H1 detector to detect tau leptons, a preliminary search for elastic tau–pair production in ep collisions is performed. Events with semi-leptonic tau decays are selected by requiring one identified electron or muon and one hadronic tau candidate (1-prong or 3-prong) with $P_T > 2$ GeV. The hadronic tau signature is verified by a neural network algorithm, based mainly on the hadronic cluster shape and trained differently for one- or three-prong candidates. In order to select elastic events, events with additional energy deposits or tracks that cannot be interpreted as being due to the scattered electron are rejected.

With this selection, 15 events are observed with opposite charges of the two tau leptons, compatible with an expectation of 17.6 ± 3.9 events, dominated by the tau–pair process. A selected data event is presented in Figure 4. In the event sample with like-sign charges, dominated by NC background, 1 event is observed for an expectation of 1.9 ± 1.2.

The results of the preliminary search for elastic tau–pair production are in agreement with the expectation and demonstrate the ability of the H1 detector to detect tau leptons.

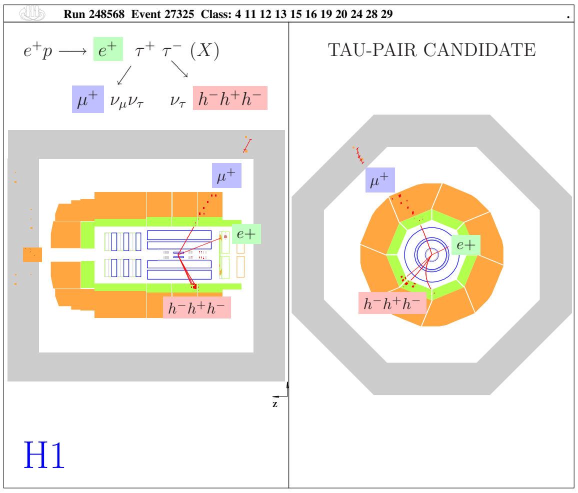

Figure 4. Tau–pair candidate event with one tau lepton decaying leptonically to a muon, and the other tau lepton decaying to three charged hadrons (3-prong topology). The scattered positron is also detected in the backward calorimeter.

3.3. Search for $H^{++} \to \tau^+\tau^+$ at H1

Doubly charged Higgs bosons ($H^{\mp\mp}$) appear in several extensions to the Standard Model and can in principle be light enough to be detectable at HERA. Examples are provided by some Left-Right Symmetry (LRS) models [12–14], where the extended symmetry $SU(2)_L \times SU(2)_R \times U(1)_{B-L}$ is spontaneously broken to the SM symmetry $SU(2)_L \times U(1)_Y$ by a $SU(2)_R$ triplet of scalar fields, whose neutral component acquires a non-vanishing vacuum expectation value (vev).

At the tree level, doubly charged Higgs bosons couple to charged leptons and to other Higgs and gauge bosons. Couplings to quarks are not allowed by charge conservation. Their coupling to charged leptons can be generally described by the Lagrangian

$$\mathcal{L} = h_{ij}^{L,R} H^{--} \bar{l}_i^c P_{L,R} l_j \;\; + \;\; h.c. \, ,$$

where $i, j = e, \mu, \tau$ are lepton generation indices, $P_{L,R} = (1 \mp \gamma^5)/2$, l are the charged lepton fields and the superscript c denotes the charge conjugate spinors. The Yukawa couplings $h_{ij}^{L,R}$ are free parameters of the model.

Since the production processes at HERA I[3] are insensitive to the chirality of the lepton fields, the generic case of an either right-handed or left-handed coupling, h_{ij}, is considered here.

The tau channel contribution for the Higgs decay in this analysis is restricted to the diagonal coupling $h_{\tau\tau}$ in the Lagrangian. The analysed e^+p H1 data set of the period 1999-2000 corresponds to an integrated luminosity of $64.5\,\mathrm{pb}^{-1}$. Therefore, the production process $e^+p \to e^- H^{++} X$ followed by a decay $H^{++} \to \tau^+\tau^+$ is searched for.

The selection of $\tau\tau$ final states requires two high-P_T tau candidates in the central detector region. The tau identification is based on charged tracks measured in the central drift chamber with transverse momenta of $P_T^{\tau 1} > 10\,\mathrm{GeV}$ and $P_T^{\tau 2} > 5\,\mathrm{GeV}$. The leptonic tau decays $\tau \to e\bar{\nu}_e\nu_\tau$ and $\tau \to \mu\bar{\nu}_\mu\nu_\tau$ are reconstructed by identifying the electron in the LAr calorimeter or the muon in the central muon detector, respectively. Remaining tau candidates are reconstructed as hadronic tau decay, if at least 40% of the charged track momentum is reconstructed in the hadronic calorimeter. Further track isolation criteria and different additional phase space cuts for each decay mode are applied to reduce mainly photoproduction and NC DIS background. Finally, the Higgs mass is reconstructed via the invariant mass of the tau-tau system, $M_{\tau\tau}$, by imposing $\sum_i E^i - P_z^i = 2E_e$ and assuming the missing neutrinos to be boosted into the direction of the tau tracks with minimal missing transverse momentum in the event.

At this stage, one event with $M_{\tau\tau} = 85\,\mathrm{GeV}$ and two hadronic one-prong tau decays is selected, where a total SM background of 2.12 ± 0.32 is expected. However, the two tracks are found to have different signs of charge. Imposing a like-sign tau pair as a final cut removes this event and also remaining background from $\gamma \to \tau^+\tau^-$ processes.

Therefore, no candidate event for a doubly charged Higgs is found in the tau channel, where 1.03 ± 0.19 are expected from SM. Together with the other decay channels of the doubly charged Higgs boson, Figure 5 shows the resulting upper limits at 95% confidence level on the product of the $H^{\mp\mp}$ production cross-section and the decay branching ratio as a function of the doubly charged Higgs mass.

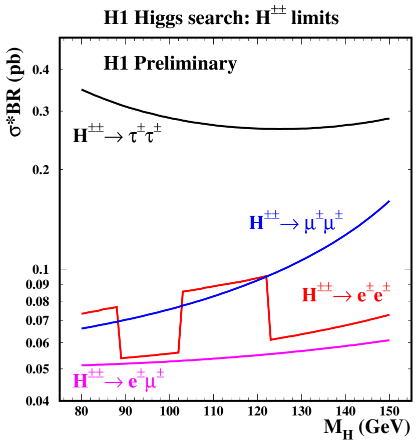

Figure 5. Upper limits at 95% confidence level on $\sigma(e^\mp p \to e^\pm H^{\mp\mp} X) \times BR(H^{\mp\mp} \to l^{\mp\mp})$ as a function of the doubly charged Higgs mass.

3.4. Search for lepton flavor violation via leptoquarks decaying to a tau lepton and a quark

In the SM, all known interactions involving leptons conserve the lepton flavors individually. However, from a theoretical point of view, there is no underlying gauge symmetry supporting this experimental observation. In fact, experimental evidence for lepton flavor violation (LFV) in atmospheric neutrino oscillations has already been reported in 1998 [15].

In e^+p collisions at HERA, a LFV process can induce the appearence of a muon or tau instead of the positron in the final state. A convenient concept to explain such exotic signatures is the exchange of a *leptoquark* (LQ). Leptoquarks couple to both quarks and leptons and can therefore be resonantly produced in ep-collisions at HERA. Here, we focus on the searches for LFV processes, where the exchange of a leptoquark leads to a tau in the final state.

[3] data taking period 1994-2000 with longitudinally unpolarised beams

Leptoquarks are color triplet scalar or vector bosons, carrying both lepton (L) and baryon (B) number. The fermion number $F = L + 3\,B$ is conserved and takes values of $F = 2$ for $e^- q$ and $F = 0$ for $e^+ q$ states. A detailed overview of the Buchmüller-Rückl-Wyler (BRW) effective model using the Aachen notation for the leptoquark coupling to u and d quarks can be found elsewhere [16,17,21].

These processes can also be mediated by squarks in R_p-violating SUSY models. Further details on these models and on the cross-section calculation can be found in [18]. Although there are strong constraints from low energy experiments [19] on some of the LFV processes, HERA has a unique discovery potential for some cases where high generations of quarks are involved.

3.4.1. ZEUS

This analysis supplements previous searches for LFV by the ZEUS collaboration [20]. The search is performed using data of $e^- p$- and $e^+ p$-collisions collected in the years 1994 to 2000 at a centre-of-mass energy, $\sqrt{s}$, of 300 GeV and 318 GeV corresponding to an integrated luminosity of altogether $130\,\mathrm{pb}^{-1}$.

A preselection for events with the reaction $e^\pm p \to \tau^\pm X$ is mainly based on a CC DIS trigger and a requirement of $P_T^{\mathrm{miss}} > 12\,\mathrm{GeV}$. The analysis covers hadronic and leptonic decays of the tau lepton and imposes individual cuts for these channels. In the hadronic selection electrons with $E^e > 10\,\mathrm{GeV}$ are vetoed, $E_T > 50\,\mathrm{GeV}$ and $15 < E - P_z < 60\,\mathrm{GeV}$ is applied. At least one tau jet candidate which fulfills $P_T^\tau > 15\,\mathrm{GeV}$, $15^\circ < \theta^\tau < 164^\circ$, $f_{em}^{\tau-\mathrm{jet}} < 0.95$, $f_{em}^{\tau-\mathrm{jet}} + \mathrm{ltf}^{\tau-\mathrm{jet}} < 1.6$, $\mathcal{D} > 0.9$ and $|\Delta\phi| < 20^\circ$ is required[4].

The selection for tau leptons decaying to electrons (muons) involves $P_T^{\mathrm{miss}} > 15\,\mathrm{GeV}\,(20\,\mathrm{GeV})$, $15 < E - P_z < 60\,\mathrm{GeV}$, veto energy deposits in the rear calorimeter (RCAL) with $E > 7\,\mathrm{GeV}$, $P_T^{\mathrm{miss}}/\sqrt{E_T} > 2.5\,\sqrt{\mathrm{GeV}}\,(3\,\sqrt{\mathrm{GeV}})$ and $8^\circ < \theta^e < 125^\circ$ ($8^\circ < \theta^\mu < 164^\circ$). The discriminant variable for the selection of the hadronic tau decays is identical to the one previously discussed in Section 3.1.1 and well described by the simulation.

After the final cut on the acoplanarity, $|\Delta\phi| < 20^\circ$, no candidate event is found for any of the three channels, while 1.7 ± 0.4 are predicted by SM simulation (see Figure 6). Limits on $\lambda_{eq} = \lambda_{\tau q}$ and $\lambda_{eq} \times \sqrt{\beta_{\tau q}}$, i.e. the product of the coupling at resonant leptoquark production and the branching ratio for the decay process $LQ \rightarrow \tau q$, for all 14 kinds of leptoquarks in the BRW model are derived and shown for LQs with $F = 0$ in Figure 7.

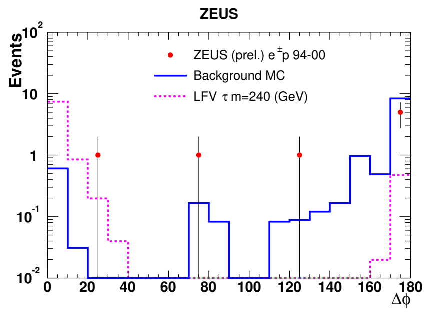

Figure 6. Distribution of the acoplanarity in azimuth between P_T^{miss} and τ-jet, $|\Delta\phi|$, after the cut on the discriminant, $\mathcal{D} > 0.9$.

3.4.2. H1

In this analysis, the search for leptoquarks is preformed in $e^+ p$ collisions only and therefore only leptoquarks with $F = 0$ are considered. For the determination of the signal detection efficiencies the LEGO [21] event generator is used and the complete H1 detector response is simulated. The contributions from several SM background processes which may mimic the signal through measurement fluctuations are evaluated in this analysis. These processes include NC DIS, lepton pair production, W-production, photoprodution and charged current deep-inelastic scattering (CC DIS) modelled by the generators described in [22–28].

The search for leptoquarks possessing couplings to a third generation lepton leading to $\tau + q$ final states is restricted to the hadronic decays of the tau. The hadronic decays of a high P_T tau lead to a typical signature of a high P_T "pencil-like" τ-jet. This τ-jet is characterised by a narrow shape in the calorimeter and low track multiplicity, i.e. one to three tracks in the identification cone of the jet. The neutrinos from the decay of the tau are boosted with the hadrons in the direction of the τ-jet. Therefore, the signal topology

[4] f_{em} = electromagnetic energy fraction, ltf = leading track fraction, $|\Delta\phi|$ = acoplanarity in azimuth between P_T^{miss} and τ-jet

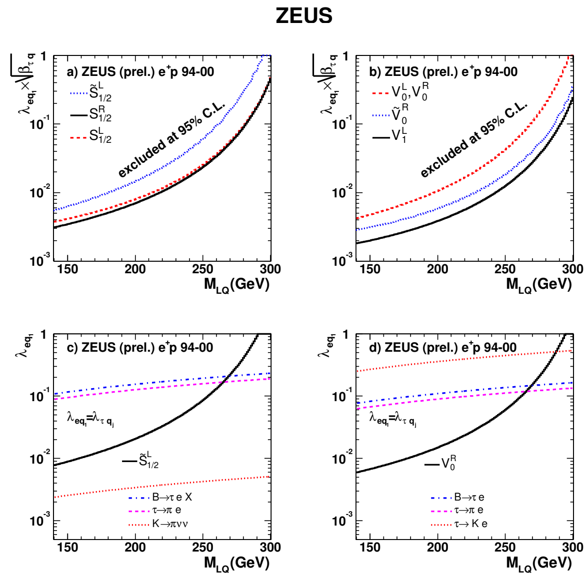

Figure 7. Top: Limits on $\lambda_{eq} \times \sqrt{\beta_{\tau q}}$, i.e. the product of the coupling at resonant leptoquark production and the branching ratio for the decay process $LQ \to \tau q$, at 95% C.L. as a function of LQ mass. Bottom: Limits on particular LQs with $\beta\tau q = 0.5$. Here, only the results for LQs with $F = 0$ from e^+p-data are shown.

is a dijet event with no leptons. The missing transverse momentum in the event carried by the neutrino is aligned with the second highest P_T jet (jet2), which has to fulfil the τ-jet criteria.

The following selection criteria are applied for high P_T dijet events with no lepton: No $e^{\pm}$ or $\mu^{\pm}$ found, at least 2 jets with $P_T^{\text{jet1}} > 25$ GeV, $P_T^{\text{jet2}} > 15$ GeV, $7^\circ < \theta^{\text{jet1,jet2}} < 145^\circ$ and $f_{em}^{\text{jet1,jet2}} < 0.95$. The subsequent selection of events with jet2 fulfilling τ-jet criteria involves $P_T^{\text{miss}} > 20$ GeV, $1 \leq N_{\text{tracks}}^{\text{jet2}} \leq 3$, no tracks in an outer cone in the $\eta\phi$-plane around jet2 with $0.12 < D_{\text{track}} < 1.0$, $M^{\text{jet2}} < 7$ GeV, $R^{\text{jet2}} < 0.12$ and $|\phi^{\text{jet2}} - \phi^{\text{miss}}| < 30^\circ$. One data event is found as a high P_T tau candidate from a LQ decay compared to a SM expectation of 0.56 ± 0.16. This SM background is dominated by NC DIS and photoproduction. The selection efficiency for the LFV signal of scalar LQs decaying to a $\tau + q$ final state varies between 12% at a LQ mass of 100 GeV and 24% at $200 - 250$ GeV. For vector LQs the efficiency rises up to 32% and falls steeply near the kinematic limit of $\sqrt{s} = 319\,\text{GeV}$ to become stable at 10% above the kinematic limit.

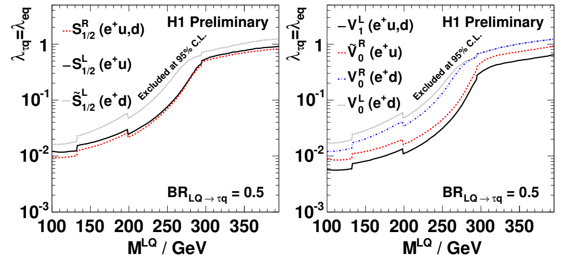

Figure 8. Limits on the coupling constant strength λ_{lq} at 95% C.L. as a function of LQ mass for scalar (left) and vector (right) LQs in the tau decay channels.

In order to set limits on the signal cross-section, the mass spectra are scanned for signals using a sliding mass window with optimised borders. Within this window the number of data events, background events and the selection efficiency are used to calculate an upper limit on the signal at a 95% confidence level (CL) [29]. These limits are converted into limits on the coupling $\lambda_{\tau q}$. The obtained limits are shown in Figure 8 for scalar and vector LQs with an assumed LFV branching ratio of $BR_{\text{LQ}\to\tau q} = 0.5$.

4. Summary

We reviewed the latest analyses at the HERA experiments H1 and ZEUS dealing with a tau lepton in the final state. The difficult identification of tau leptons in the final state of ep-collisions was successfully performed in all analyses.

The three tau candidate events with significant missing transverse momentum found with the ZEUS detector go along with the previously reported events with isolated high energy electrons and muons. The SM prediction of W-production can not be significantly ruled out. Furthermore, the H1 experiment observes no such tau candidate events with high P_T^{had}.

Limits on theories beyond the Standard Model could be set, extended or improved in searches for doubly charged Higgs bosons and lepton flavor violation by both experiments H1 and ZEUS.

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