PROCEEDINGS OF SCIENCE

Evidence for $Z \to \tau^+\tau^-$ production in 7 TeV proton-proton collisions at CMS

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The reconstruction of tau leptons in a hadronic environment can be challenging, yet it is important for many searches for new particles as well as studies of Standard Model processes. The production of Z bosons decaying into tau pairs serves as a "standard candle" for the commissioning of the tau reconstruction as well as test bench for analogous $H \to \tau^+\tau^-$ decays. Proton-proton collision events collected with the CMS experiment at the LHC corresponding to an integrated luminosity of 70 nb^{-1} are used to compare the performances of the Hadron plus Strip tau identification algorithm in data events and MC simulations considering the $Z \to \tau^+\tau^-$ process. The efficiency of the τ identification algorithm fully satisfies the CMS requirements as demonstrated by the successful identification of the first $Z \to \tau^+\tau^- \to \mu + \tau_{had}$ candidate event, which is also presented here.

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1. Introduction

Tau leptons are expected to play a significant role in discovering new physics phenomena at LHC. Many physics analyses are expected to benefit from an efficient reconstruction of tau leptons which should be complemented by a good performance in rejecting possible background contaminations. In about two thirds of cases tau leptons decay hadronically, typically into either one or three charged mesons (predominantly π^+, π^-) in presence of up to two neutral pions, decaying via $\pi^0 \to \gamma\gamma$. Similar signature is expected for generic, quark and gluon, QCD jets production. Since the cross-section of jet production exceeds the cross-section of tau lepton production by several orders of magnitude, the experimental challenge in reconstructing and identifying hadronic tau decays is to discriminate efficiently between genuine tau lepton hadronic decays (tau jets) and quark/gluon jets misreconstructed as tau candidates.

2. Control analysis and first candidate

The pp collision data collected with the CMS experiment [1] at a center-of-mass energy of $\sqrt{s}$ = 7 TeV in 2010 corresponding to an integrated luminosity of 70 nb^{-1} are expected to contain very few tau leptons but, nevertheless, they can be used to test the level of agreement between data and Monte Carlo (MC) simulation for events containing tau jet candidates.

In particular, $Z \to \tau^+\tau^- \to \mu + \tau_{had}$ candidates are selected by requiring the presence of opposite-charged, not-overlapping global muon [2] and a τ_{had} reconstructed by means of the Hadron Plus Strips (HPS) algorithm [3]. The HPS algorithm employs cuts on the multiplicity and invariant mass of charged hadrons and neutral pions reconstructed in a narrow cone of size $\Delta R = 2.8/p_T$, together with the requirement that there be no other particles of p_T above a certain threshold within the jet. The neutral pions are reconstructed using topological criteria which account for photons conversion effects. No lepton isolation is applied in order to enhance the contributions of QCD multi-jet and $W^{\pm} \to \mu^{\pm}\nu$ backgrounds. Distributions of the transverse mass $M_T(\mu, \text{MET})$ and of the $\mu + \tau_{had}$ visible mass $M_{vis}(\mu, \tau_{had})$ for data events selected with this control cuts are compared to MC predictions in Figure 1. Their agreement is good. The visible mass distributions for events containing leptons of like-sign (LS) and opposite-sign (OS) charges are also reported in Figure 1. The LS and OS distributions match within statistical uncertainties, in agreement with the expectation for a background dominated event sample. When isolation cuts are applied (selection purity of 75%), a single event is selected in data. Figure 2 shows the corresponding event display.

3. Conclusions

The performances of the tau identification algorithm fully satisfy the requirements of CMS analyses of processes which include tau lepton hadronic decays in the final state as demonstrated by the successful identification of the first $Z \to \tau\,\tau \to \mu + \tau_{had}$ candidate event in CMS.

References

[1] The CMS Collaboration, *"The CMS experiment at the CERN LHC"*, JINST **3**:S08004 (2008).

[2] The CMS Collaboration, *"Performance of muon identification in pp collisions at $\sqrt{s}$ = 7 TeV"*, CMS PAS **MUO-10-002** (2010).

[3] The CMS Collaboration, *"Study of Tau reconstruction algorithms using pp collisions data collected at $\sqrt{s}$ = 7 TeV"*, CMS PAS **PFT-10-004** (2010).

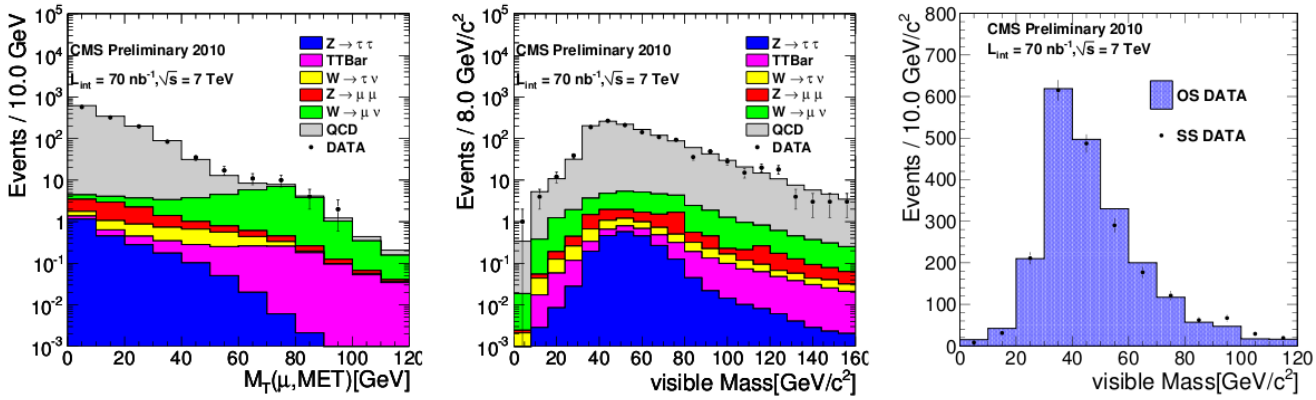

Figure 1: Distributions of $M_T(\mu, \text{MET})$ (left), $M_{vis}(\mu,\tau_{had})$ (middle) and comparison of $\mu+\tau_{had}$ mass distributions for data events containing a pair of OS versus LS charge leptons (right) after the control selection.

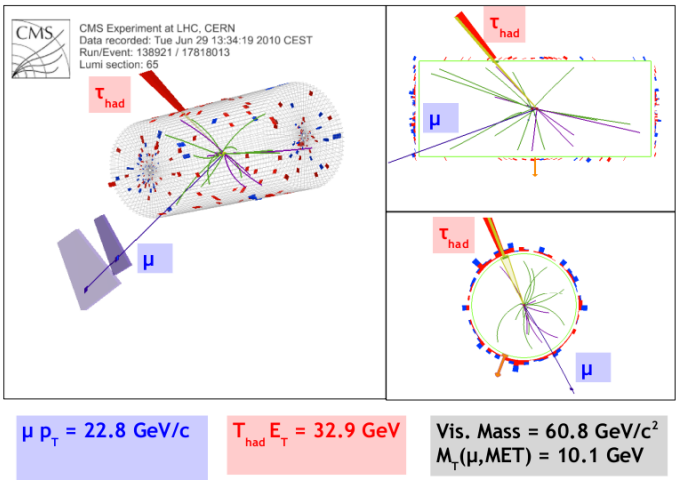

Figure 2: Display of the $Z \to \tau^+\tau^- \to \mu+\tau_{had}$ candidate event passing all selection criteria observed in a dataset of pp collisions at $\sqrt{s}$ = 7 TeV (total integrated luminosity of 70 nb^{-1}).