Physics with taus at CMS

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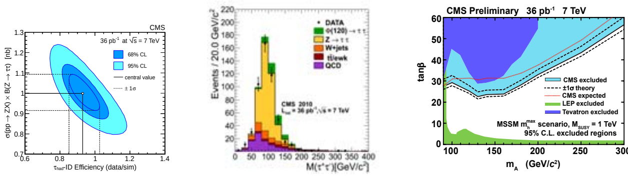
1 Introduction

The importance of decays of new particles to taus led to the development of innovative tau reconstruction algorithms by the CMS collaboration. The performance of tau reconstruction algorithms, their validation and searches for new physics processes are presented by using 36 pb^{-1} of data collected by CMS[1] during 2010.

2 Tau identification and physics results

In two-thirds of the cases τ leptons decay hadronically (τ_{had}), typically into either one or three charged mesons in the presence of up to two neutral pions and a ν_τ, and in the other cases leptonically ($\tau_{e,\mu}$). The $Z/\phi \to \tau\tau$ final states are: $\tau_\mu\tau_{had}$, $\tau_e\tau_{had}$, $\tau_e\tau_\mu$, $\tau_\mu\tau_\mu$. Two different algorithms, based on Particle Flow (PF) algorithm, have been developed to reconstruct and identify hadronic tau decays. PF is able to use the informations coming from all the subdetectors to indentify and reconstruct all the particles in the event[2]. In HPS (Hadron Plus Strip) algorithm neutral pions are reconstructed by organizing PF electromagnetic objects in "strips" to take into account photon conversion effects. Charged hadrons and strips are combined to reconstruct one-prong and three-prong taus. In TaNC (Tau Neural Classifier) algorithm neutral pions are reconstructed starting from PF photons. Five different decay modes are considered and five neural networks decide the decay mode of the reconstructed tau [3]. The expected tau identification (τ_{had} − ID) efficiency , fake-rate from jets (by means of samples containing at least one jet) and electrons (by means of a $Z \to ee$ sample) have been estimated through a "tag & probe" technique [4]. Fake-rate from jets is at a level of ~ 1 %[3]. For the $Z \to \tau\tau$ cross-section measurement muons and electrons are reconstructed and identified by quality criteria while hadronic taus are identified using the HPS algorithm. A global fit of the four channels (Figure 1.a) provided an estimation of the $Z \to \tau\tau$ cross-section ($\sigma(pp \to ZX) \times \mathcal{BR}(Z \to \tau^+\tau^-) = 1.00 \pm 0.05(\text{stat.}) \pm 0.08(\text{syst.}) \pm 0.04(\text{lumi.})$ nb) and of the $\tau_{had}-$ID correction factor (0.93 ± 0.09). A more precise estimation of the $\tau_{had}-$ID efficiency has been obtained by performing a fit of the $\tau_\mu\tau_{had}$ and $\tau_e\tau_{had}$ final states, where the cross section is fixed to the value measured by CMS in the electron and muon decay channels [4]. The extracted value of the $\tau_{had} -$ ID correction factor is 0.96 ± 0.07, which corresponds to a $\tau_{had} -$ ID efficiency of $(47.4 \pm 3.3)\%$ in data [5]. For the search of neutral Minimal Supersymmetric Standard Model Higgs bosons only $\tau_\mu \tau_{had}$, $\tau_e \tau_{had}$, $\tau_e \tau_\mu$ final states have been considered. The observed tau-pair mass spectrum reveals no evidence for neutral Higgs boson production (Figure 1.b). An upper bound on the product of the Higgs boson cross section and tau-pair branching fraction as a function of m_A has been established. The upper bound on $\sigma \times BR$, in the m_h^{max} scenario, excludes a region reaching as low as $\tan\beta = 23$ at $m_A = 130$ GeV/c^2 in the $\tan\beta$ vs m_A parameter space (Figure 1.c)[6].



(a) (b) (c)

Figure 1: Likelihood contours for the joint parameter estimation of the cross section and the $\tau_{had} -$ ID [5] (a). Visible mass of the $\tau_\mu \tau_{had}$ final state after all selections [6] (b). Region in the parameter space of $\tan\beta$ vs m_A excluded at 95% CL [6] (c).

References

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[3] CMS Collaboration, “Tau identification in CMS”, CMS-PAS-TAU-11-001.

[4] CMS Collaboration, “Measurements of Inclusive W and Z Cross Sections in pp Collisions at $\sqrt{s}$ =7 TeV”, J. High Energy Phys. 01 (2011) 080.

[5] CMS Collaboration, “Measurement of the Inclusive Z Cross Section via Decays to Tau Pairs in pp Collisions at $\sqrt{s}$ = 7 TeV”, arXiv:1104.1617; CERN-PH-EP-2011-035.

[6] CMS Collaboration, “Search for Neutral MSSM Higgs Bosons Decaying to Tau Pairs in pp Collisions at $\sqrt{s}$ = 7 TeV”, arXiv:1104.1619; CMS-HIG-10-002; CERN-PH-EP-2011-027 (2011).