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# Measurement of tau identification efficiency at CMS

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We report the measurement of the hadronic tau identification efficiency using a tag and probe method. The technique exploits $Z \rightarrow \tau\tau$ decays using as tag a tau decaying into a muon. This result was obtained using an integrated luminosity of 1.2 fb$^{-1}$ collected with the CMS detector in the first part of 2011.

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## 1. $\tau$ identification at CMS

The $\tau$ lepton is the heaviest known lepton with a mass of 1.78 GeV. It decays weakly with $c\tau = 87$ $\mu$m. The branching ratio into lighter leptons ($\tau_\mu$,$\tau_e$) is about 17% each while the remaining fraction of the decays is into hadrons ($\tau_{had}$), mainly pions. Hadronic tau decays are usually classified from the number of charged particles involved (one or three-prong decays). Due to the low number of decay products and the large $\tau$ boost at LHC, tau jets can be identified from the low detector activity around the jet constituents (*isolation*). The $\tau$ lepton can be a powerful discovery tool for SUSY-related searches [1, 2], or an important cross-check channel for SM Higgs boson.

The CMS detector is described elsewhere [3]. Tau identification at CMS (TauID) exploits the Particle Flow (PF) reconstruction [4], which gives a complete description of the event linking physics objects reconstructed in different sub-detectors. The output is a collection of different candidate types (electrons, muons, charged and neutral hadrons, jets). Tau candidates are built from PF jets.

Hadron Plus Strip (HPS) [5] is the tau identification algorithm in CMS. The algorithm initially builds photon candidates from ECAL clusters in a 0.20 rad $\times 0.05$ strip in the $(\phi,\eta)$ plane centered in the cluster position. All the other clusters within the strip boundaries are merged together to form a photon candidate, thus recovering a possible undetected photon conversion inside the inner detector. Photon candidates are then used to build $\pi^0$ candidates, which, together with the hadrons, concur to build the tau candidate. Initially, all the possible combinations fulfilling an existing tau decay kinematics are built, but only the most isolated one is taken into account after this step.

Isolation is computed from all the candidates inside the PF jet not forming the tau candidate. There are several ways to compute it: counting the number of candidates above a defined $p_T$ threshold or summing up the their $p_T$ (with or without threshold). Summing the $p_T$ with very loose threshold is the most performing way and therefore is adopted in this paper. The output of this calculation is used as figure of merit to decide whether to reject the tau candidate or not. Different isolation requirements corresponding to a fake rate of about 1%, 0.5%, 0.1% are used to set loose, medium and tight working points, respectively. Cross cleaning steps against muons and electrons are also included.

## 2. Measuring the algorithm efficiency

There are three possible methods to measure the $\tau_{had}$ identification efficiency: from the ratio of $Z \to \tau\tau$ over $Z \to \mu\mu$ yields, measuring $Z \to \tau_{\mu(e)}\tau_{had}$ and $Z \to \tau_{\mu(e)}\tau_\mu$ yields, and the “tag and probe” method. Amongst the various methods, tag and probe is the most unbiased and suitable also for analyses searching for di-tau resonances in the mass region of the Z resonance [1]. Tag and probe method exploits the decay channel $Z \to \tau_\mu \tau_{had}$, using the muon to tag the event, then looking at the jets passing and failing the tau identification.

All the events are required to have a jet with $p_T > 20$ GeV, $|\eta| < 2.3$ and with a leading track with $p_T > 5$ GeV. The tagging muon is required to have $p_T > 20$ GeV and $|\eta| < 2.1$. The events are required to have only one reconstructed muon. Both the muon and the jet are required to pass loose isolation requirements. The events are further selected requiring a tightly isolated muon, a jet with opposite sign with respect to the muon and the transverse mass of the muon plus missing transverse

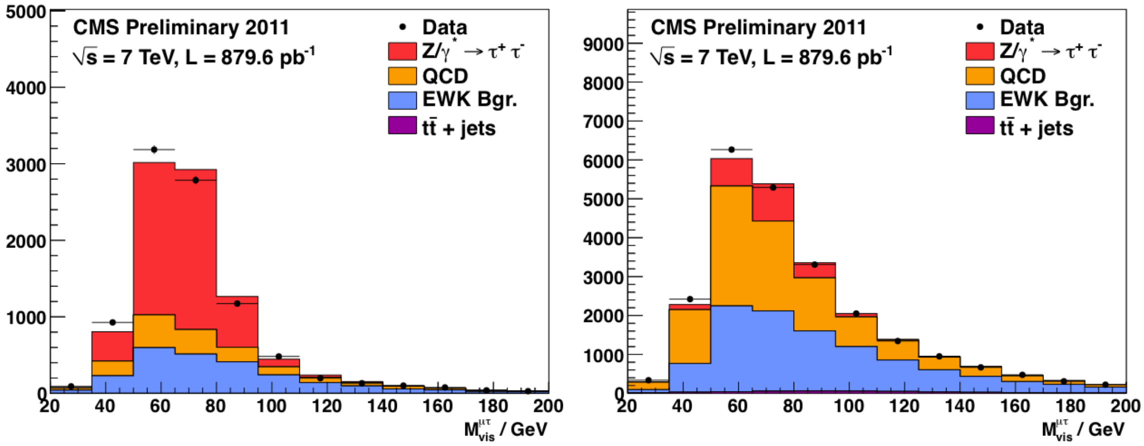

**Figure 1:** Distribution of $M_{vis}^{\mu\tau}$ with different signal and background processes from the fit in signal region for passing the identification (left) and failing the identification (right)

energy, $M_T$, below 40 GeV. Events not passing this tighter selection are classified in four sidebands: (A) muon with loose isolation and jet with opposite charge; (B) muon with loose isolation and jet of same charge; (C) muon with tight isolation and jet of opposite charge, not passing the $M_T$ cut; (D) muon with tight isolation and same charge jet.

The events in the signal region where divided according to the output of the identification algorithm. For the signal region the visible invariant mass of the muon and jet, $M_{vis}^{\mu\tau}$, was used as observable, while for the others $M_T$ was used. In order to better constrain the fit, the shapes of the different backgrounds where taken from Monte Carlo simulation except the QCD background in the signal region, which was taken from data (see Figure 1). The fit was performed leaving the following parameters floating for each process: the overall normalization, the probability to pass the opposite charge requirement, the probability to pass the tight isolation requirement, the probability to pass the $M_T$ cut and the probability to pass the tau identification.

## 2.1 Results

The measured algorithm efficiency was found to be in agreement with the Monte Carlo expectations: 59.7%, 47.1% and 43.7% for loose, medium and tight working points, respectively. Including statistic and systematics uncertainties the overall precision of the measurement is 6%. Main systematic uncertainties are the hadron track reconstruction efficiency (3.9%), the correction factor for jets faking taus in the $Z \rightarrow \tau\tau$ template (1.2%), the preselection cut efficiencies (1.6% for leading track, 2.1-1.5% for loose isolation of the jet). This measurement was used in the search for a neutral Higgs boson into tau pairs, presented at this conference [6].

## References

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