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$Z \to \tau\tau$ production at CMS

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Summary. — The first measurement of the $Z \to \tau\tau$ cross-section reconstructing hadronic and leptonic tau final states is presented. The data collected in 2010 with the CMS detector (CMS Collaboration, *JINST* **3** (2008) S08004) from p-p collisions at $\sqrt{s} = 7\,\text{TeV}$, corresponding to an integrated luminosity of about $36\,\text{pb}^{-1}$, are used. The cross section has been measured to be in good agreement with the next-to-next-to-leading order electroweak prediction. The production of Z bosons decaying into tau pairs serves as an important benchmark for tau reconstruction and constitutes a reference Standard Model process for searches at the LHC, like the Minimal Supersymmetric Standard Model $H \to \tau\tau$.

PACS 07.05.Hd – Data acquisition: hardware and software.
PACS 07.05.Kf – Data analysis: algorithms and implementation; data management.
PACS 07.05.Rm – Data presentation and visualization: algorithms and implementation.
PACS 29.85.fJ – Data analysis.

1. – Introduction

At LHC Z boson is produced mainly via $q\bar{q}$ scattering and it decays into a tau pair in 3.4% of the cases. In about 65% of cases, taus decay hadronically (τ_{had}) and in the other cases leptonically (τ_e, τ_μ). The $Z \to \tau\tau$ final states are: $\tau_\mu\tau_{had}$, $\tau_e\tau_{had}$, $\tau_e\tau_\mu$, $\tau_\mu\tau_\mu$.

2. – Event selection

Events are required to pass a single-muon or single-electron trigger selection (lepton + tau triggers in the last period of data taking). A well-defined primary vertex is required. At offline level other selections are applied on leptons: transverse momentum, pseudorapidity, identification and isolation [1]. The τ_{had} identification is performed using the Hadrons Plus Strips algorithm in which one or three charged hadrons are combined with photons to reconstruct τ decay modes individually [2]. A specific topological cut is applied to reject W+jets background. The reconstructed pairs are required to have a zero charge. Some specific selections are applied in the case of the $\tau_\mu\tau_\mu$ final state [3].

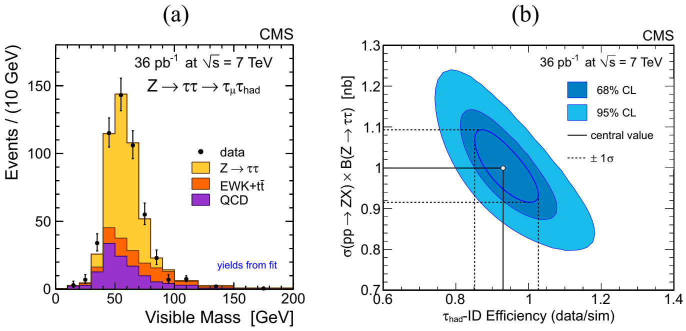

Fig. 1. – Visible mass distribution of the $\tau_\mu \tau_{had}$ final state (a). Likelihood contours for the joint parameter estimation of the cross section and the τ_{had} – ID (b).

3. – Background estimation, efficiencies and systematic uncertainties

All major backgrounds are measured in control regions where their contribution is enhanced and extrapolated to the signal region using selection efficiencies determined either from data or simulation. All the selection efficiencies are estimated from data with "tag & probe" techniques [1]. Correction factors for data/simulation differences are determined. The major source of uncertainty comes from the τ_{had} identification (23%).

4. – Cross sections and global fit

The cross sections for each final state are calculatated extracting the signal yield by means of a fit to the visible mass. Its shape is taken from data in the case of QCD and $Z \to ee$ contributions and from simulation in the case of other background sources. The background yields and signal shapes for the $\tau_\mu \tau_{had}$ final state are shown in fig. 1 (left).

A simultaneous fit to all four final states is performed to obtain the cross section and a correction factor for the τ_{had} – ID efficiency. The result of the global fit is shown in fig. 1 (right). The value of the cross section extracted from the fit is $\sigma(pp \to ZX) \times \mathcal{BR}(Z \to \tau^+\tau^-) = 1.00 \pm 0.05(\text{stat.}) \pm 0.08(\text{syst.}) \pm 0.04(\text{lumi.})$ nb. In the simultaneous fit, the τ_{had} – ID correction factor is measured to be 0.93 ± 0.09. A more precise value of the τ_{had} reconstruction efficiency can be 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 [1]. The extracted value of the τ_{had} – ID correction factor is 0.96 ± 0.07, which corresponds to a τ_{had} – ID efficiency of $(47.4 \pm 3.3)\%$ in data [3].

5. – Conclusions

The measured cross section is compatible both with theoretical expectations and previous $Z \to ee, \mu\mu$ values [1]. A global fit of the semi-leptonic channels incorporating previous measurements provides a 7% constraint on the efficiency for reconstructing τ_{had}.

REFERENCES

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