

Physics with Tau Leptons at CMS

International Workshop on e^+e^- collisions from Phi to Psi

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Compact Muon Solenoid at the Large Hadron Collider



2

Berge

CERN

7 km



Tau decays overview



What CMS can do:

Standard e/µ reconstruction for leptonic decays









- Reconstruct physics objects combining sub-detectors information
- Reconstruct and identify 5 classes of particles:
- Electrons
 - Muons

- Photons
- Charged/Neutral hadrons



Hadron Plus Strips Algorithm (HPS)



Seeds from particle-flow jet constituents (previous slide)

 e^{\pm} , h^{\pm} , γ , h^0 , μ

- Good charged hadron: $p_T > 1.5 \text{ GeV}$
- Compatibility of tracks with the nearest primary vertex

Neutral pions promptly decay to $\gamma\gamma$

- Reconstruction from conversions, bremsstrahlung
- e^{\pm} , γ with $p_T > 1$ GeV clustered into **calorimeter strips** with a dynamic size depending on p_T of the strip and e^{\pm} , γ

au_h Candidate Requirements

- Tracks and strips are within dynamic size Signal Cone
- Charge of the candidate ± 1
- Mass of τ_h candidate consistent with intermediate resonance: ρ , a_1

In case of more than one candidate within a jet the one with highest p_T is given a preference

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CMS TAU-16/003





Hadron Plus Strips





Reconstructed τ_h candidates with defined decay mode



Discrimination against Jets





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0.5

 $\Box \tau_{h}$

Jets

Identification Performance in MC





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- Tau energy scale \longrightarrow correction factor to τ_h four-momentum
- Measure correction to MC by fitting mass templates to data



- Visible $\mu \tau_h$ for τ_h decays separately
- τ_h mass for $h^{\pm}\pi^0 v$ and $h^{\pm}h^{\mp}h^{\pm}v$ categories

Total correction at 1% level



Tau Identification Performance



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Tag&Probe to measure the identification efficiency in data

- Using Drell-Yan process $Z/\gamma \rightarrow \tau\tau \rightarrow \mu\tau_h$ + neutrinos
- Tag event with a good muon

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• Probe au_h candidate to PASS and FAIL the identification



Simultaneous fit of signal + background to data in both categories

Similar measurement in $t\bar{t}~$ and off-shell $W\to\tau\nu~$ tau sources to cover large range of p_T

Data/MC scale factor uncertaintiy ranges between $\approx 1-7~\%$

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Application in Physics Analysis



Observation of SM Higgs decay to τ pair





Analysis of 2016 data at 13 TeV

- > Best fit of the signal strength (combined categories): $1.09^{+0.27}_{-0.26}$
- > Data in agreement with 125 GeV Higgs signal



Searches for Heavy Bosons (W'/Z') UF













Conclusions

FLORIDA

- **Robust Hadron Plus** Strips algorithm for τ identification
- **Excellent description** of the detector
- Successfully exploited in numerous physics analyses

