Identification of τ lepton and Central PreShower detector

Romain Madar
CEA Saclay

DØ France

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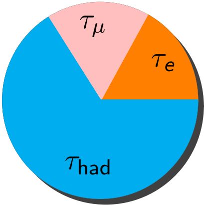
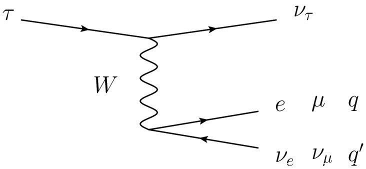
Overview

The τ lepton

Physical properties : $m_\tau = 1.78$ GeV, $c\tau_{\text{life}} = 87\ \mu$m





Reconstruction and τ type for hadronic decay :

- type 1
- type 2
- type 3

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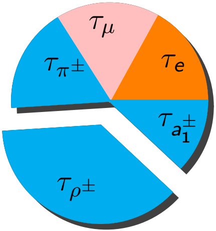
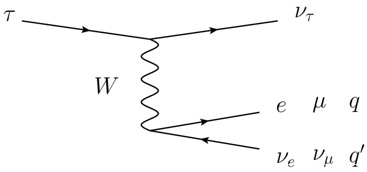
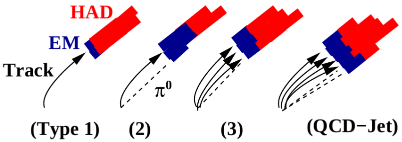




Reconstruction and τ type for hadronic decay :

- type 1 $\equiv$ had cluster, exactly 1 track ($\pi^\pm$-like)
- type 2 $\equiv$ had cluster, exactly 1 track, at least 1 EM cluster ($\rho^\pm$-like)
- type 3 $\equiv$ had cluster, at least 2 tracks ($a_1^\pm$-like)

Current τ ID



Jets could have the same experimental manifestations as hadronic τ.

$\sim$ 12 discriminant variables allow to identify τ

- track isolation variables,
- calo isolation variables,
- shape shower variables.

All theses variables are combined in a Neural Network.

Could we find new discriminant variable to improve τ ID ?

Physical motivations

Physical idea : hadronic decay of τ type 2 has specific resonance which could be exploited : $\tau^{\pm} \to \rho^{\pm}\nu \to \pi^{\pm}\pi^{0}\nu \to \pi^{\pm}\gamma\gamma\nu$.

Problem : the granularity of calorimeter doesn't allow us to separate objects of the final state.

Possible solution : Use the central preshower (CPS) to try to mesure discriminant variables such as :

- $\theta_{\gamma-\gamma}$,
- $\theta_{\pi^0-\pi^{\pm}}$ and $m_{\rho^{\pm}}$ ($\Longleftrightarrow$ separate the $\pi^{\pm}$ and the π^{0}).

Considering $m_{\phi} \approx 200$ GeV (concerning $\phi \to \tau^{-}\tau^{+}$), some order of magnitude show[1] that $\theta_{\gamma-\gamma}$ is not accessible contrary to $\theta_{\pi^0-\pi^{\pm}}$ (and so $m_{\rho^{\pm}}$) :

Let's consider the CPS information (π^{0}) and the track ($\pi^{\pm}$).

[1] see my τID talk of 01/21/09

Description of detector

The Central PreShower (CPS) is located right before the calorimeter and made of 3 layers of scintillating strips (2560/layer). It's radius is 73 cm from the beam. This detector works in central region : $-1.31 < \eta_d < 1.31$ *(DØnote 5673)*

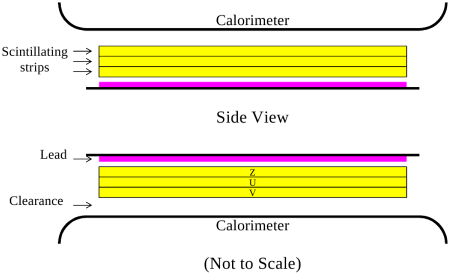


Fig.: Profile view of CPS.

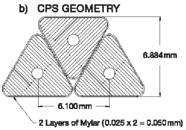


Fig.: View of a piece of layer (3 strips).

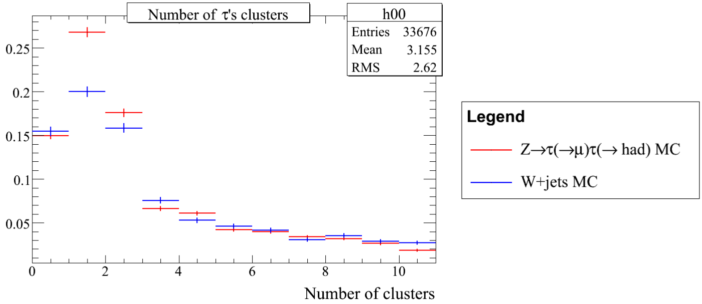
Samples used for this study :

- $Z \rightarrow \tau(\rightarrow \mu)\tau$ Monte Carlo (Alpgen) for signal,
- $W(\rightarrow \mu) +$ Jets Monte Carlo (Alpgen) for background.

Cuts applied :

- Exactly one μ :
  - loose and matched with central track ;
  - track must be tight : $n_{hit}^{SMT} > 0$, dca < 0.02, $\frac{\chi^2}{ndf} < 4$;
  - NP isolation criteria : trk Iso, Calo Iso < 2.5 GeV ;
  - $p_{\mu}^{T} > 12$ GeV.
- Exactly one τ type 2 candidate :
  - $E_{\tau} > 15$ GeV and $p_{track}^{T} > 5$ GeV ;
  - $\Delta R_{\mu-\tau} > 0.5$;
  - $n_{\tau CPSclusters} \geq 1$.

Reconstruction : when a EM particle goes trough CPS, several strips in each layer are hit. A clustering algorithm form clusters from strips (DØnote 4014).

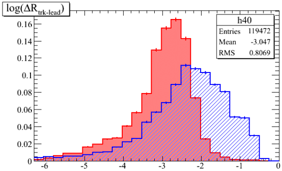


A lot of clusters are associated[2] with the τ :
we will consider the leading one.

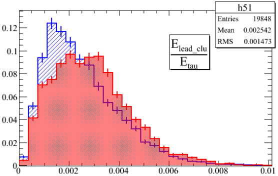
[2] $\Delta R_{\text{cluster}-\tau} < 0.3$

Discriminant variables from CPS clusters

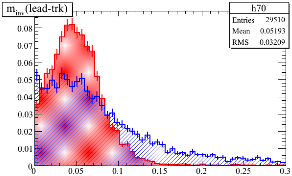
red = sig ($Z \to \tau_{\text{had}}\tau_\mu$ MC) blue = bkg ($W(\to \mu)$+jets MC)



$\log(\Delta R_{\text{trk-clu}})$



E_{clu}/E_τ

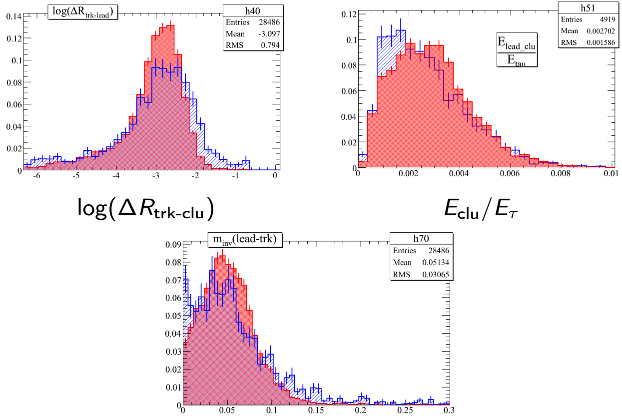


$m_{\text{inv}}(\text{trk,clu})$

red = sig ($Z \to \tau_{had}\tau_\mu$ MC) blue = bkg ($W(\to \mu)$+jets MC)

For the events with $NN_{out}(\tau) > 0.2$:

$(NN_{out}(\tau) = 1 \to$ true τ, $NN_{out}(\tau) = 0 \to$ fake $\tau)$



$\log(\Delta R_{\text{trk-clu}})$ E_{clu}/E_τ

$m_{\text{inv}}(\text{trk,clu})$

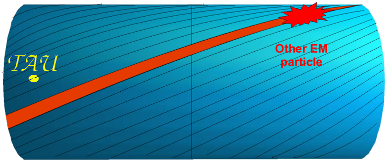
How to build one object from digits ?

For each layer i :

- loop over strips j closed by the τ ($\Delta R < 0.3$) and save (η_j, ϕ_j, E_j) ;
- compute $(\langle\eta\rangle_i, \langle\phi\rangle_i, E_i^{tot})$ and RMS$_i$ of deposited energy ;

Combine 3 layers :

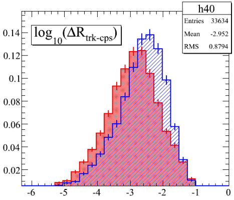
- take into account a particle far away from τ which can light on a strip closed by τ ;
- Use correlations between the 3 layers ;



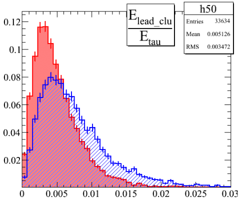
Result : **One cluster with** $(\eta, \phi, E^{tot}, \text{RMS})$.

Discriminant variables

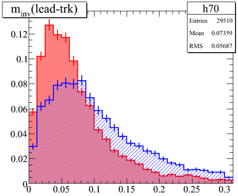
red = sig ($Z \to \tau_{\text{had}}\tau_\mu$ MC) blue = bkg ($W(\to \mu)$+jets MC)



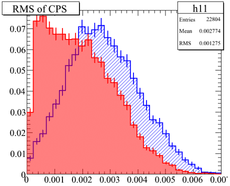
$\log(\Delta R_{\text{trk-lead}})$.



$E_{\text{lead-clu}}/E_\tau$.



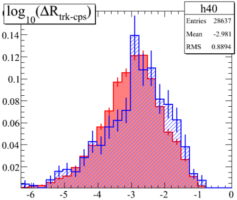
$m_{\text{inv}}(\text{trk-lead})$.



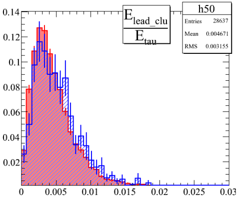
RMS of deposited energy.

red = sig ($Z \to \tau_{had}\tau_\mu$ MC) blue = bkg ($W(\to \mu)$+jets MC)

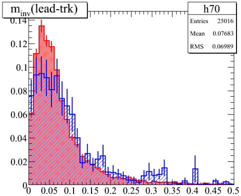
For the events with $NN_{out}(\tau) > 0.8$:



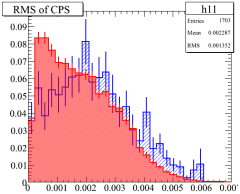
$\log(\Delta R_{\text{trk-lead}})$.



$E_{\text{lead-clu}}/E_\tau$.



$m_{\text{inv}}(\text{trk-lead})$.



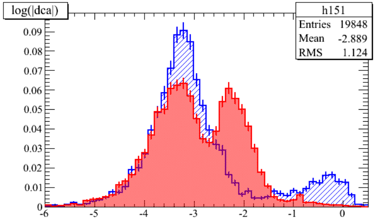
RMS of deposited energy.

One more variable (not from CPS)

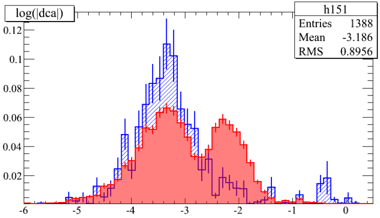
red = sig ($Z \to \tau_{had}\tau_\mu$ MC) blue = bkg ($W(\to \mu)$+jets MC)

One more discriminant variable : $\log(|dca|)$ (where dca is the τ distance of closest approach).

(for the τ lepton : $c\tau_{life} = 87\mu m$)



$\log(|dca|)$



$\log(|dca|)$, $NN_{out}(\tau) > 0.8$

Concerning the last results :

- The CPS seems to be useful for τ identification if we consider the RMS of deposited energy (which is stable with Neural Net cut),
- $\log(|\mathrm{dca}|)$ seems to be a discriminant variable (which is stable with Neural Net cut).

Outlook :

- Train the neural net with theses new variables
- Exploit the dca variable for τ type 3 (should be efficient : more than one track),
- Try the official training with a QCD sample instead of a $W +$ jet MC sample.