Observation of $W \to \tau\nu_\tau$ at CMS

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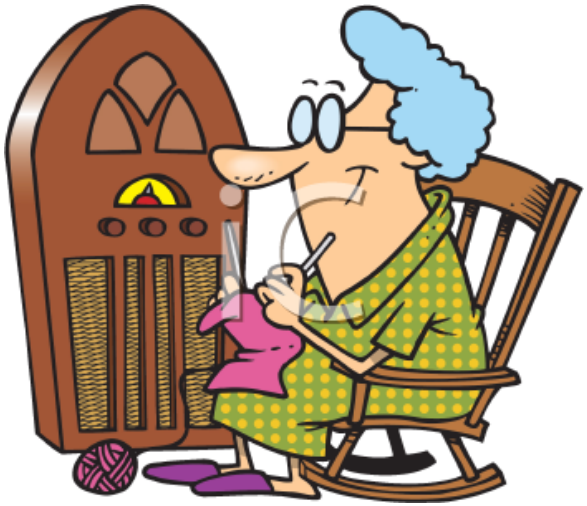
Moriond Conference 2011



A famous sentence says:

- "If You Can't Explain It To Your Grandmother....."
  - "... then you haven't understood it."

I would rather say:

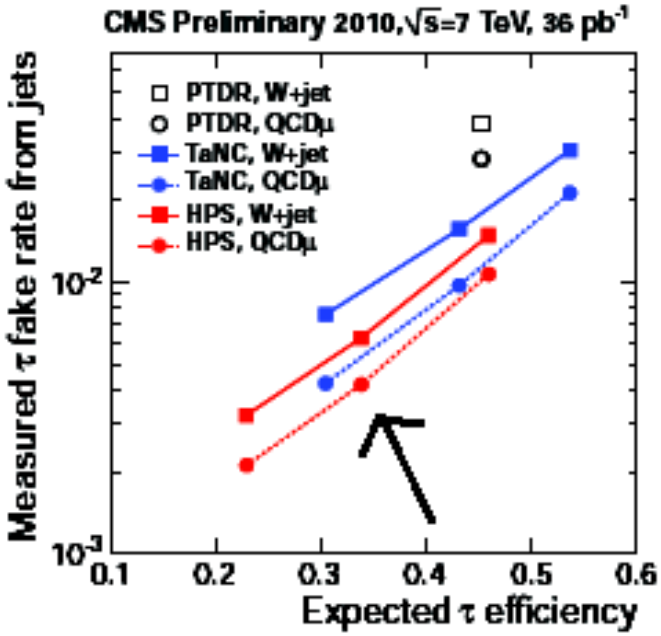
- "If You Can't Explain It in 5 minutes....."
  - "... then you haven't understood it."

Introduction

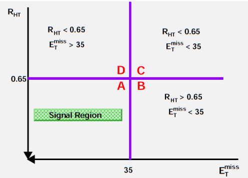
- Tau leptons are an important probe for new physics
- The largest sources of tau leptons at the LHC comes from $Z \to \tau\tau$ and $W \to \tau\nu_\tau$ production
- $W \to \tau\nu_\tau$ production has a cross section which is an order of magnitude larger than $Z \to \tau\tau$ but requires a good understanding of the reconstruction of hadronic taus and missing transverse energy (E_T^{miss})
- $W \to \tau\nu_\tau$ is the main background for charged Higgs boson searches in the τ_{had} final state
- $W \to \tau\nu_\tau$ production has been studied with 18 pb^{-1} of pp data at 7 TeV with the CMS detector

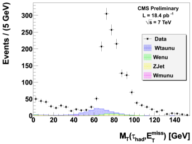
Events Selection (A needle in a hayStack!)

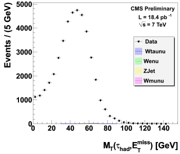
- tau-E_T^{miss} cross-trigger
- tau $p_T >$ 30 GeV, $|\eta| < 2.3$ and leading track $p_T >$ 15 GeV
- Identified and Isolated tau (HPS algorithm [backup])
- Rejecting muons or electrons fake taus
- Rejecting those events with good electron and muons
- $E_T^{miss} >$ 35 GeV
- $R_{HT} = \frac{tau\, p_T}{\sum jet\, p_T} > 0.65$

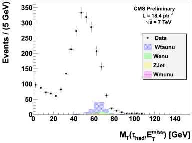


Amount of QCD from data (ABCD Method)









QCD is the main background

After applying all cuts except E_T^{miss} and R_{HT}, divide their phase space to 4 regions.If:

- In Region B,C and D, QCD dominates in data (left bottom)
- Low correlation between E_T^{miss} and R_{HT} (in backup)

Number of QCD is A = B*D/C

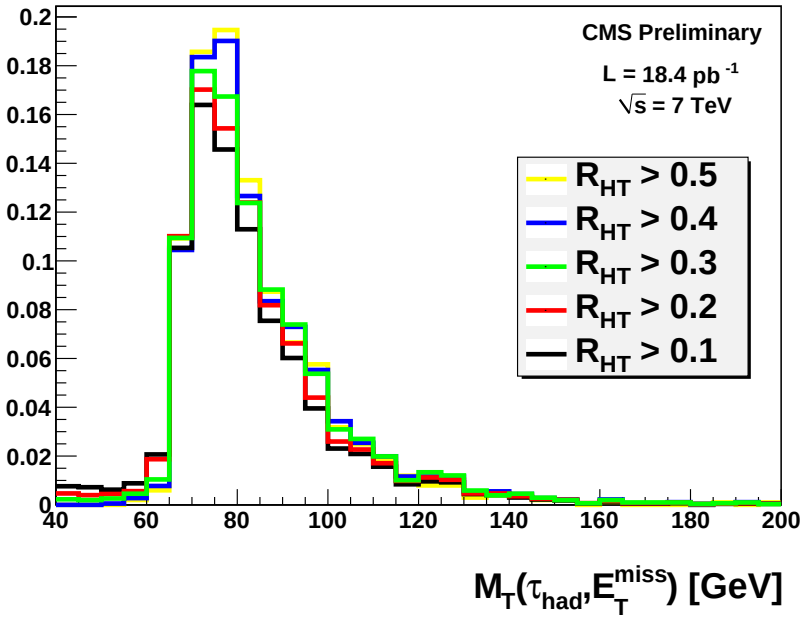
At the end:

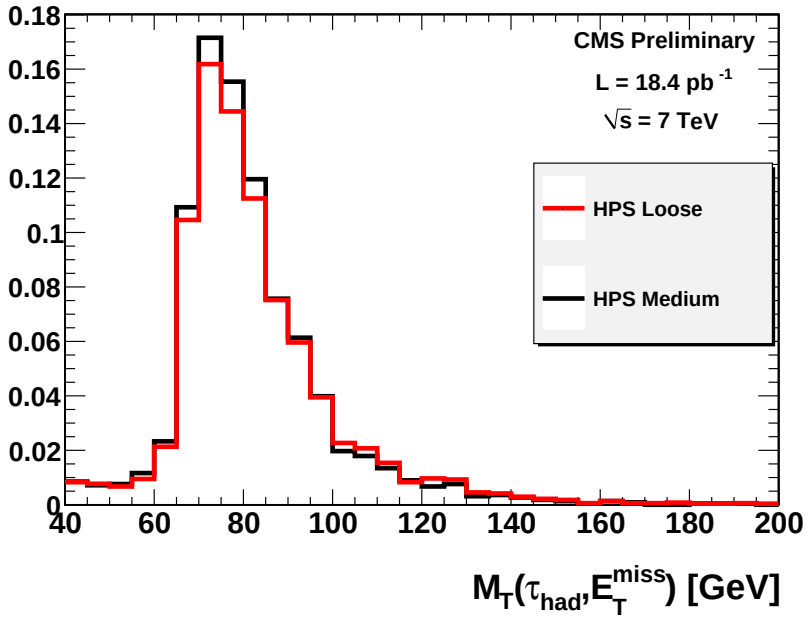
- Number of signal events : 174 ± 3
- Number of electroweak BG : 46 ± 2
- Number of QCD events : 109 ± 6
- Number of selected events in data: 372

Errors are statistical only, we have not yet assessed systematic uncertainties.

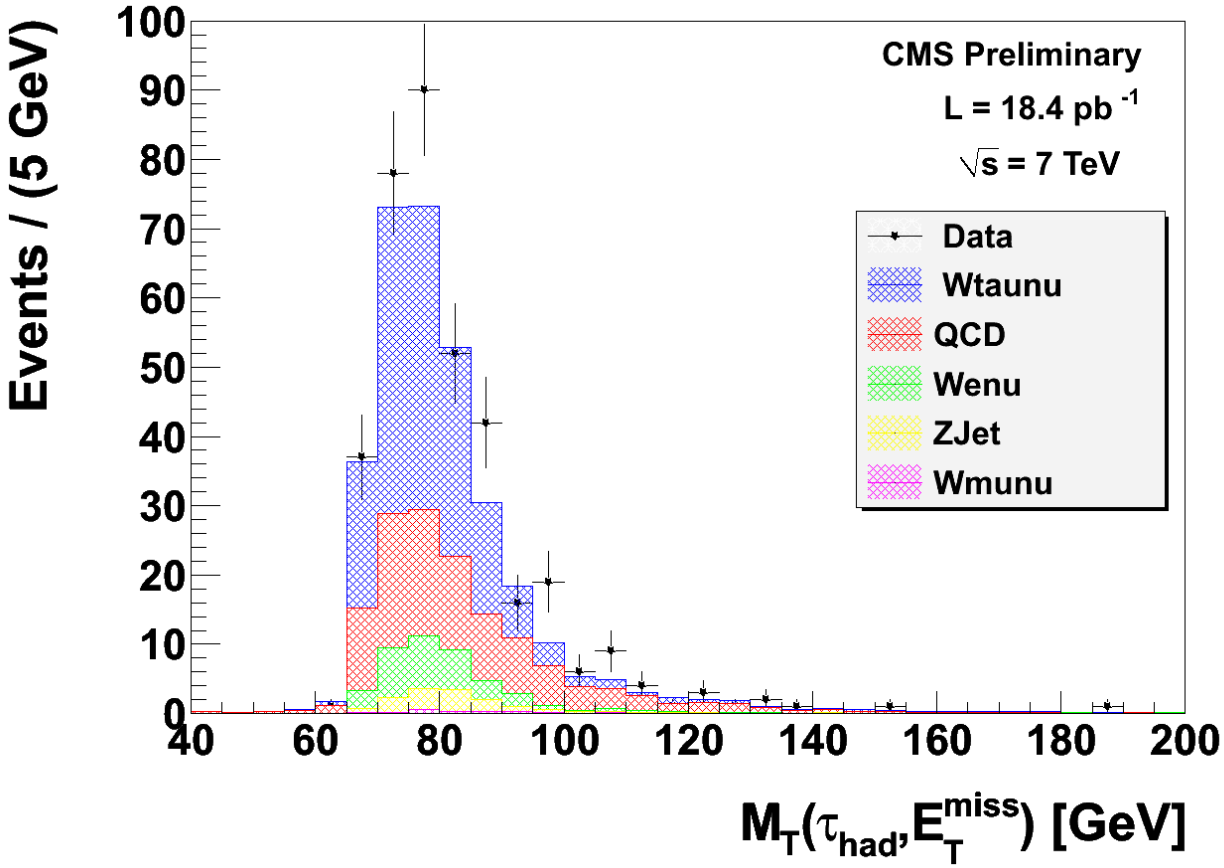
Shape of QCD from data

- To get $M_T(\tau, E_T^{miss})$ shape of QCD, loosen cuts on R_{HT} and isolation in data.
- The shape does not change alot with different selection criteria.
- we use $R_{HT} > 0.3$ and looser isolation. (at this point, QCD is still dominant.)



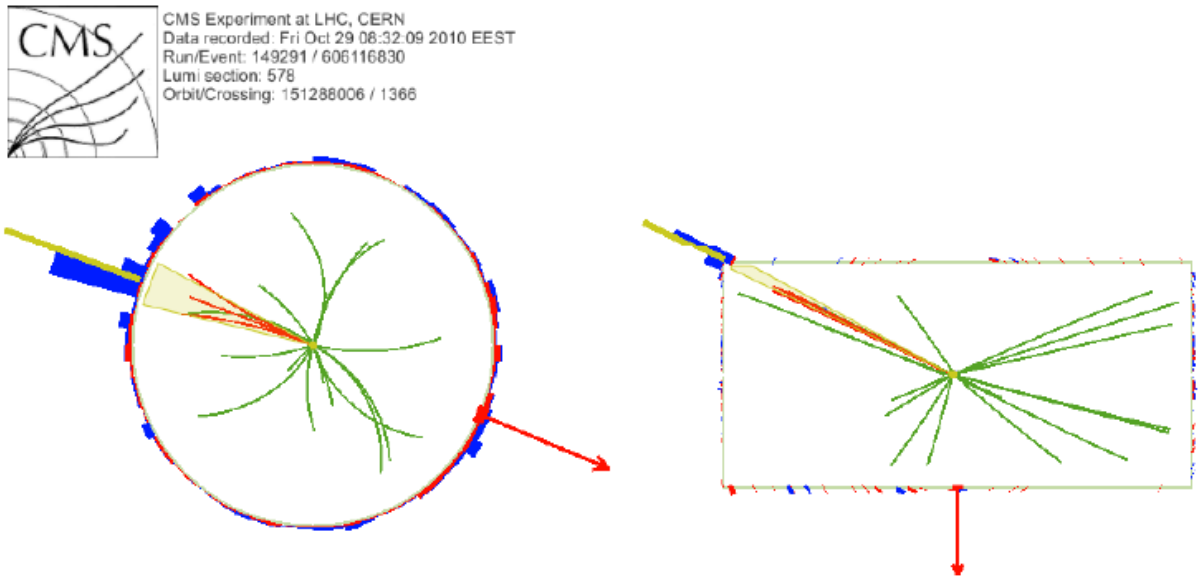


Transverse Mass



- QCD is the main background and its shape is obtained from data and normalized to the yield from ABCD method.
- EWK backgrounds are from simulation.
- Very clean signal obtained on top of the QCD and EWK backgrounds.

Wtanu candidate with a 3 prong hadronic tau

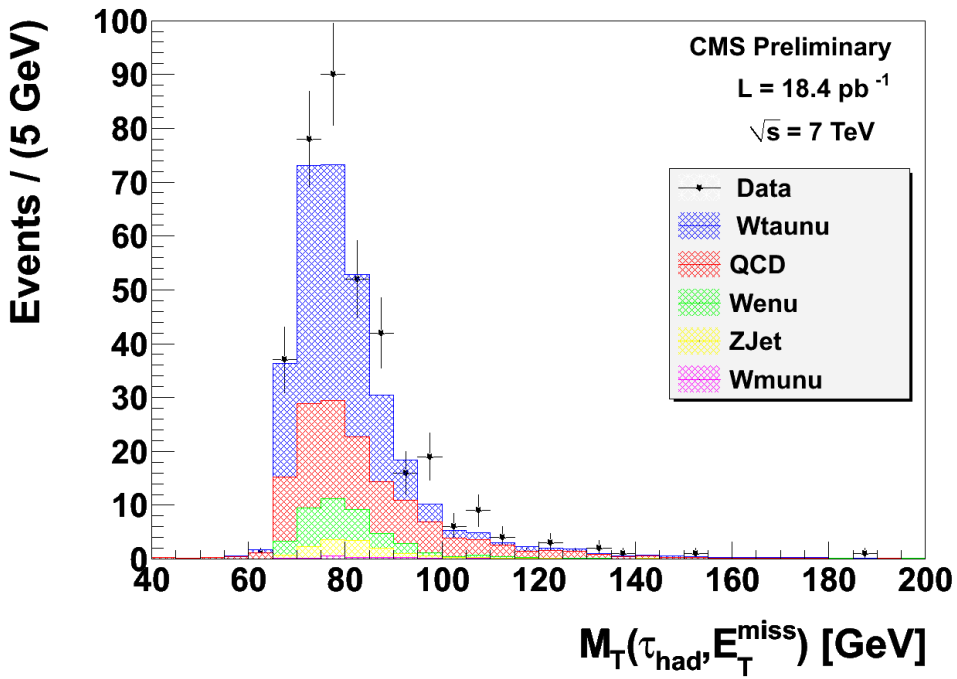


m_{vis} = 0.87 GeV

τ_{had} (3 prong):
p_T = 33 GeV
η = -1.45
p_T(lead. track)− 23 GeV
E_T miss= 43 GeV
$m_T(\tau,\upsilon)$ = 73 GeV

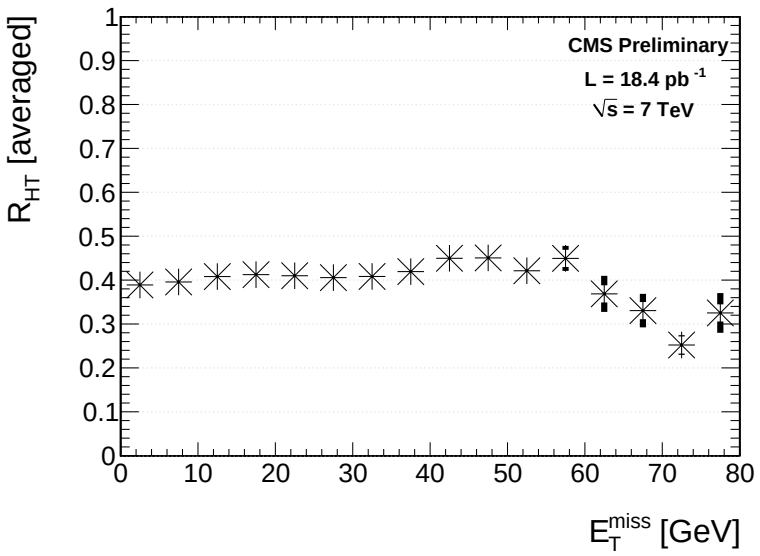
Summary

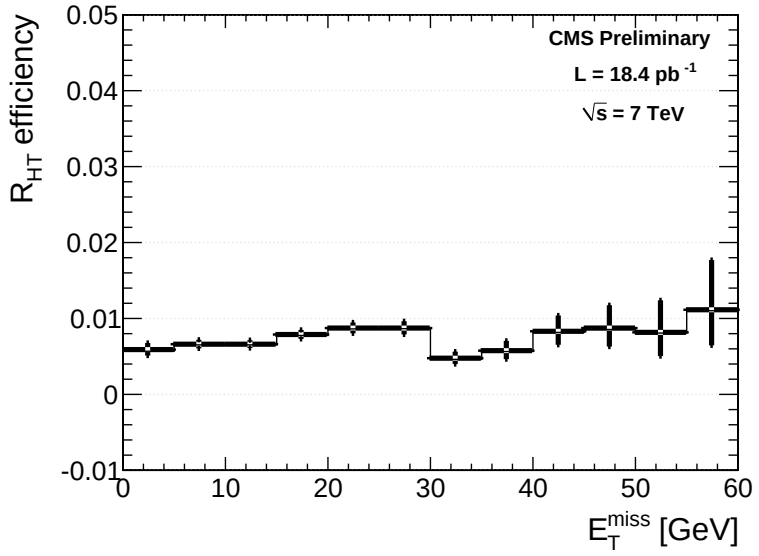
- We have observed a significant signal for $W \rightarrow \tau\nu_\tau$ in the final state with a hadronic tau and missing transverse energy using 18 pb^{-1} of CMS data.
- The main background comes from QCD multi jet production and the yield and shape have been estimated from data.



BackUp

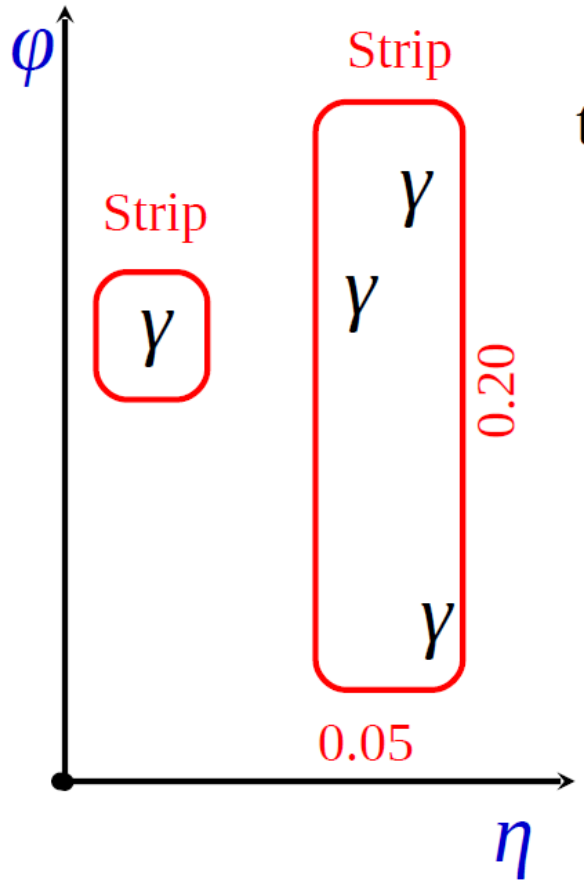
Correlation between R_{HT} and E_T^{miss}





- Each plot shows low correlation between R_{HT} and E_T^{miss}

Hadron Plus Strip Algorithm



Build all possible taus
that have a 'tau-like'multiplicity
from the seed jet

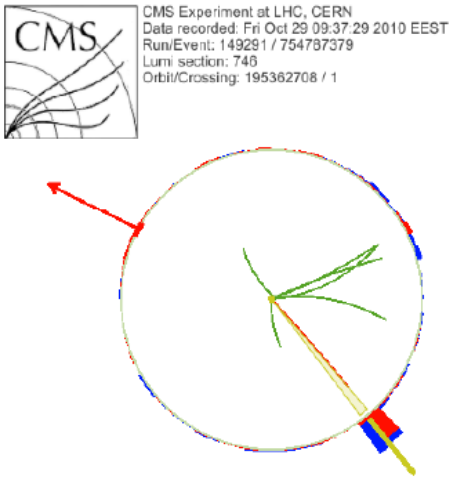
π^+

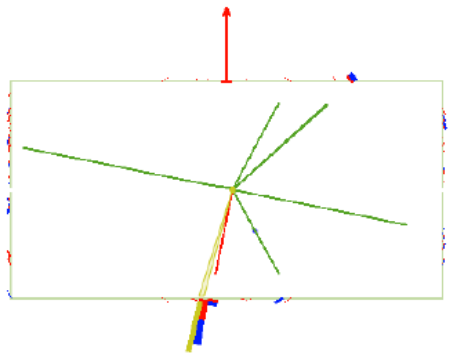
$\pi^+ \pi^0$

$\pi^+ \pi^+ \pi^-$

tau that is 'most isolated'
with compatible m_{vis}
is the final tau candidate
associated to the seed jet

Wtanu candidate with a 1 prong hadronic tau





m_{vis} = 0.87 GeV

τ_{had} (1 prong, 1 π^0):
p_T = 33 GeV
η = -0.25
p_T(lead. track)= 21 GeV
E_T miss= 57 GeV
EM-fraction = 0.38
$m_T(\tau,\upsilon)$ = 88 GeV