Search for a low-mass ditau resonance with the CMS detector using 2016 data

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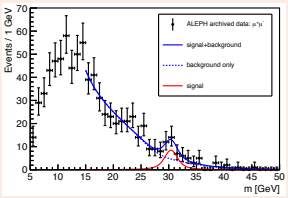
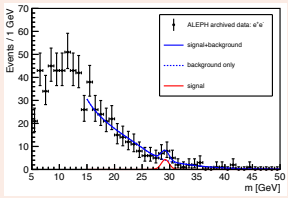
Abstract A search for a 30 GeV particle which decays into two leptons and is produced in association with a b quark and a light quark, using proton-proton collision data at 13 TeV that was collected by the CMS detector. This is a phase space that has not yet been probed by other analyses. A signal model based on a vector-like quark model with one 28 GeV particle decaying into two tau leptons is considered.

Motivation: 30 GeV bump ?

An excess was found in electron-positron collision data at ALEPH.

- 30 GeV in the invariant mass distribution of a muon pair
- in association with jets originating from bottom quarks
- no significant excess was found for events with a pair of electrons.



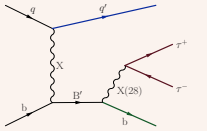


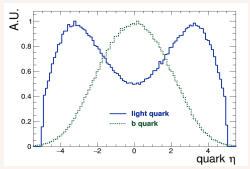
arXiv:1610.06536

Signal: VLQ

The ALEPH excess might point to a new particle that can be observed at the LHC.

- we consider **vector-like quark (VLQ) model**
  $qb \to q'B'$ where $B' \to bX \to b\tau\tau$
- VLQs can solve theoretical problems such as the hierarchy problem
- our signal process will have one b quark and one forward-scattered light quark



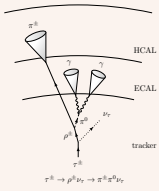


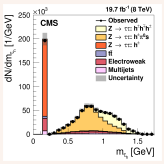
Tau reconstruction

arXiv:1510.07488
arXiv:1109.6034.

Tau lepton decay before they can be measured.

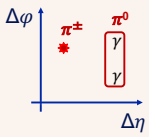
Decay mode	Meson resonance	$\mathcal{B}$ [%]
$\tau^- \to e^- \bar{\nu}_e \nu_\tau$		17.8
$\tau^- \to \mu^- \bar{\nu}_\mu \nu_\tau$		17.4
$\tau^- \to h^- \nu_\tau$		11.5
$\tau^- \to h^- \pi^0 \nu_\tau$	$\rho(770)$	26.0
$\tau^- \to h^- \pi^0 \pi^0 \nu_\tau$	$a_1(1260)$	9.5
$\tau^- \to h^- h^+ h^- \nu_\tau$	$a_1(1260)$	9.8
$\tau^- \to h^- h^+ h^- \pi^0 \nu_\tau$		4.8
Other modes with hadrons		3.2
All modes containing hadrons		64.8





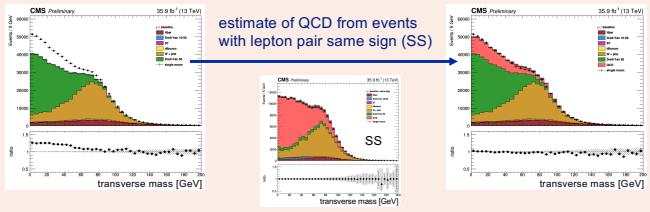
CMS uses the **Hadron Plus Strip** (HPS) algorithm for hadronically-decayed taus.

- charged hadrons like $\pi^\pm$ are identified by their track
- $\pi^0 \to \gamma\gamma$ is are identified as a "strip": energy clusters in the ECAL of some maximum $\Delta\varphi$, $\Delta\eta$ size



Background estimation

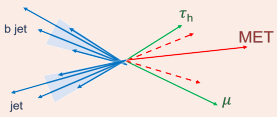
Processes like top quark pair production, Drell Yan ($Z/\gamma^* \to \tau\tau$) and QCD can be reconstructed as having a tau pair. Most samples can be reliably estimated with Monte Carlo (MC) simulation, however, QCD is estimated using data-driven control regions

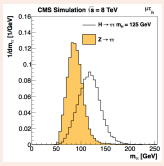


Tau pair mass

This analysis selects tau pairs that decay to $\mu\tau_h$ or $e\tau_h$ **pairs.**

- missing information due to neutrinos
  ⇒ find most likely $m_{\tau\tau}$ using all the tau decay candidates and missing energy information



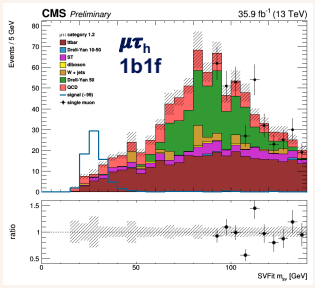


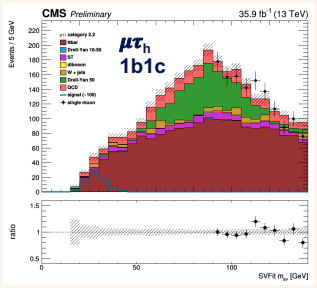
arXi:1401.5041

Selections: two jet categories

The signal process has a $\tau\tau$bj signature, where one jet is typically forward. Therefore, we divide up our final jet selections to increase sensitivity:

1. one **central b jet** ($|\eta|$<2.4) plus at least one **forward jet** ($|\eta|$>2.4)
2. one **central b jet** ($|\eta|$<2.4) plus only one other **central jet** ($|\eta|$<2.4)





Results & Conclusions

Expected upper limits on the cross section times branching ratio σ*BR(X $\to \tau\tau$) have been derived.

- $\mu\tau_h$ channel is more senstitive than the $e\tau_h$, due to more efficient and precise reconstruction of the muon
- the jet selections with a forward jet (1b1f) have better upper limits that those with only central ones (1b1c), as the 1b1f selections are more signal-like

We are looking forward to unblind our results soon.