Searches in CMS for New Physics in Final States with Tau Leptons

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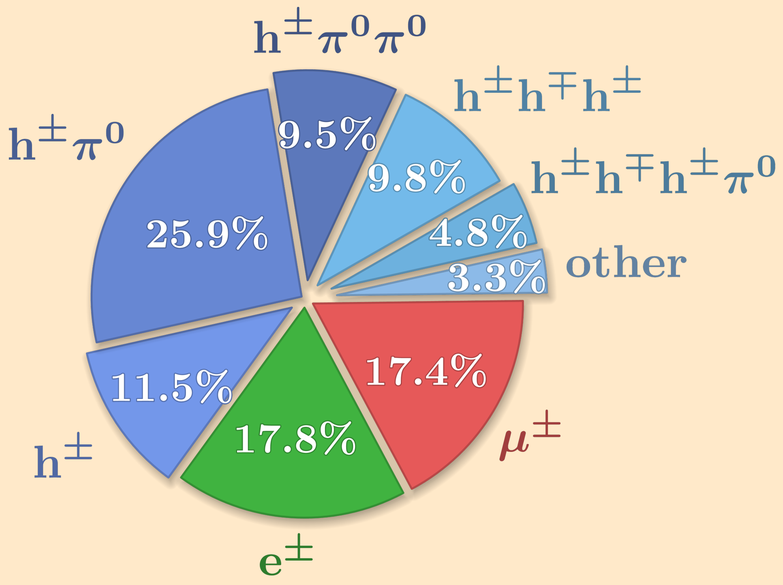
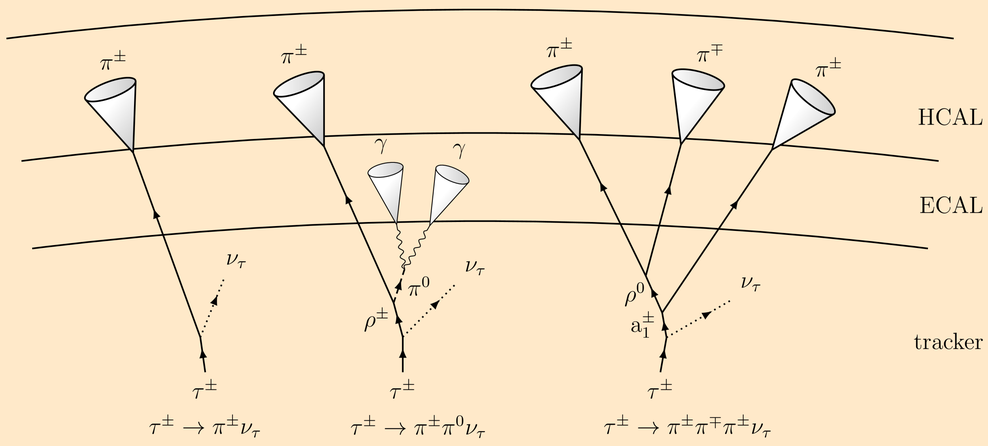
THE TAU LEPTON

Third generation lepton
- charge: +/-1
- mass: 1776.86 ± 0.12 MeV
- mean lifetime: 2.9×10^{-13} s

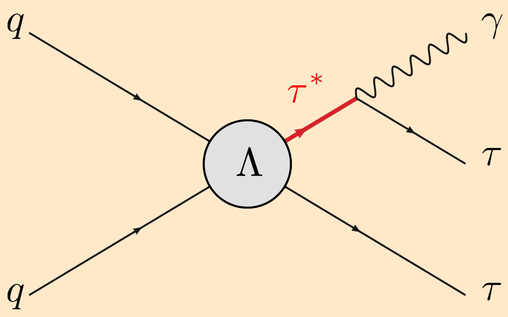
Taus decay weakly
- leptonic $e/\mu + 2\nu$
- hadronic $+ \nu$

At CMS taus are never fully reconstructed due to the presence of neutrinos

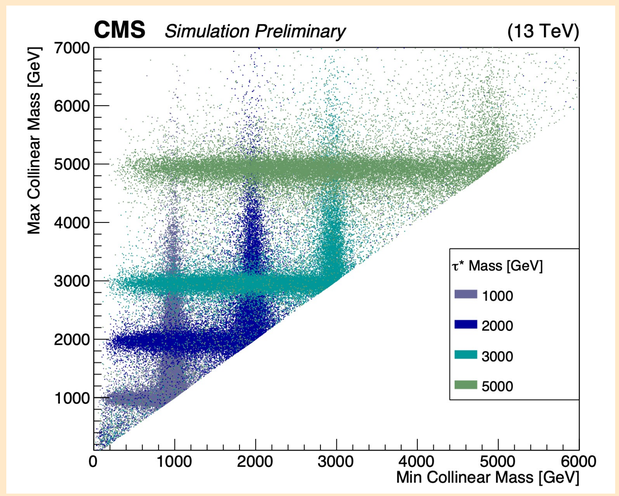




SEARCH FOR AN EXCITED TAU LEPTON



- **First $\tau\tau\gamma$ search since LEP** ($m_{\tau^*} > 102.8$ GeV @95%CL)
- Excited state would give evidence of compositeness (scale Λ)

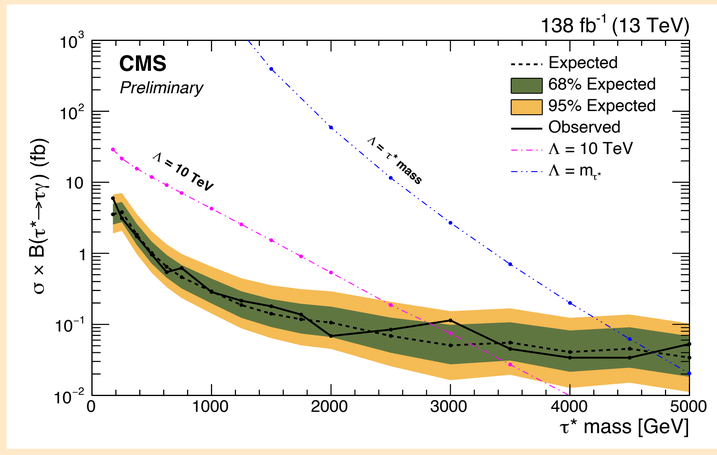


Reconstruct full τ decays using "collinear mass"

- Covers $m_{\tau^*} \in [175, 5000]$ GeV through $e\tau_h$, $\mu\tau_h$, $\tau_h\tau_h$ channels
- Fit performed for each mass hypothesis
- Backgrounds do not exhibit L-band shape and cluster at low masses

↑ Full Result↑

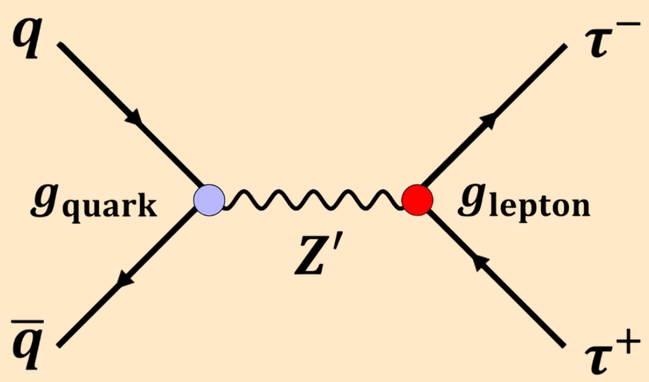
No evidence of τ^* is observed
- $m_{\tau^*} > 2800$ GeV for Λ = 10 TeV
- $m_{\tau^*} > 4700$ GeV for $\Lambda = m_{\tau^*}$ TeV



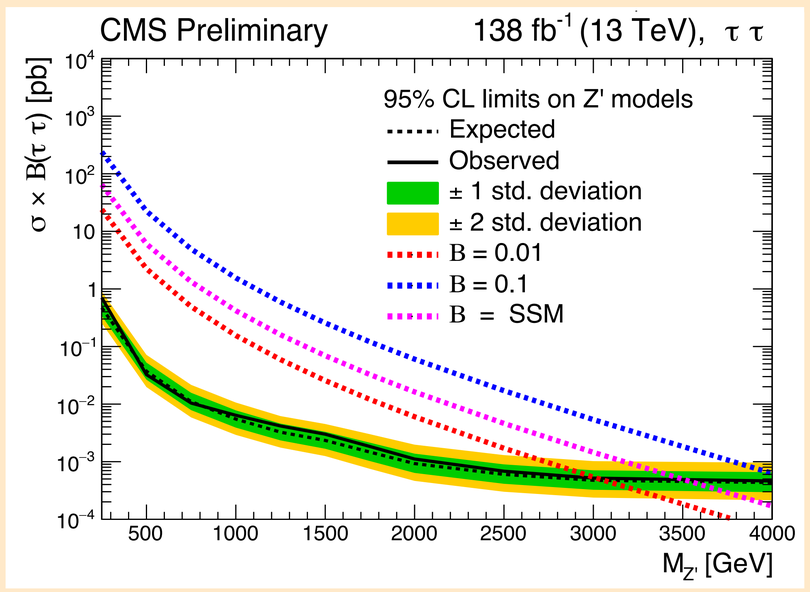
SEARCH FOR HEAVY NEUTRAL RESONANCES

- Search for Z' resonance from pp collisions via the Drell-Yan mechanism
- Explore models with non-universal couplings to fermions (NUFC) by probing $Z' \to \tau\tau$ decays
- Shape-based analysis using the $m_{rec}(Z')$ distribution as the fit discriminant
- These exclusion limits are the most stringent to date for a $Z' \to \tau^-\tau^+$

$$m_{rec}(Z') = \sqrt{\left(E_1^{\tau\,vis} + E_2^{\tau\,vis} + \left|\boldsymbol{p}^{Z'miss}\right|\right)^2 - \left(\boldsymbol{p}_1^{\tau\,vis} + \boldsymbol{p}_2^{\tau\,vis} + \boldsymbol{p}^{Z'miss}\right)^2}$$

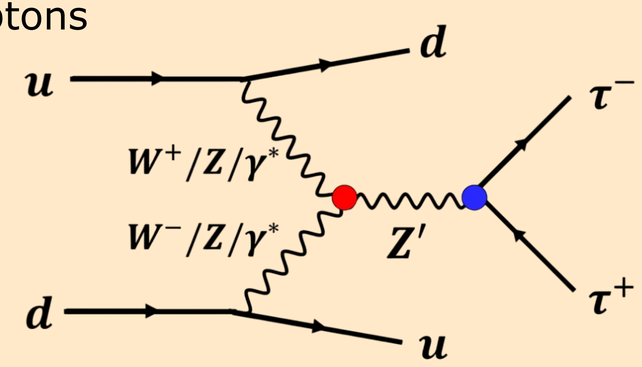


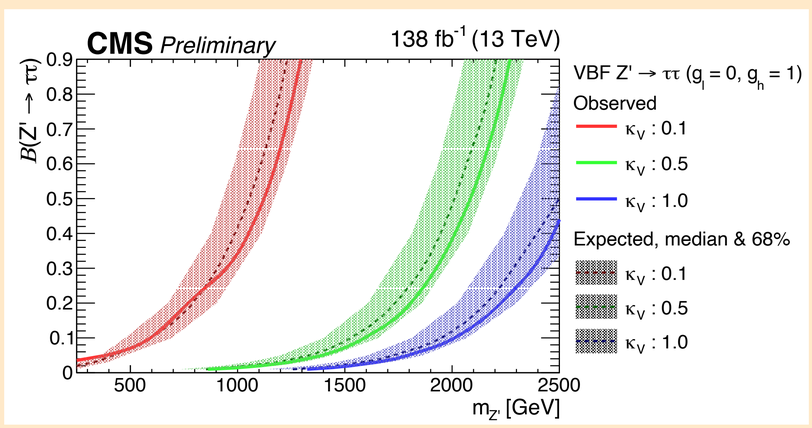
↑ Full Result↑

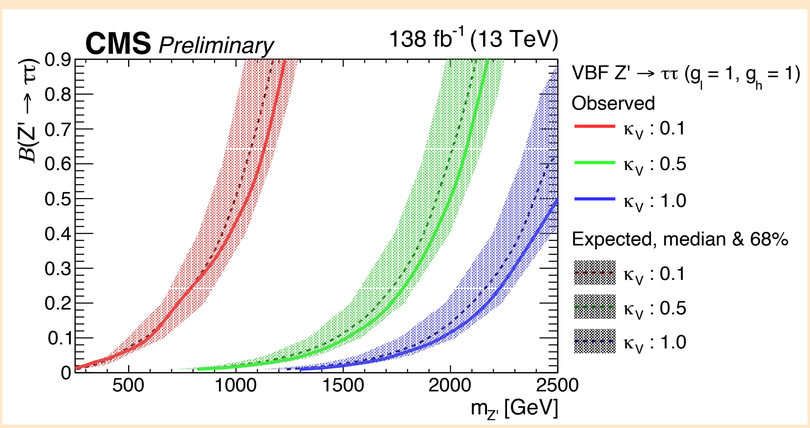


SEARCH FOR A NEUTRAL GAUGE BOSON WITH NON-UNIVERSAL FERMION COUPLINGS IN VBF

- **First Vector Boson Fusion (VBF) Z' search at the LHC**
- Sequential SM + coupling to vector bosons (κ_V ; $g_{Z'VV} = \kappa_V g_{Z'VV}^{max}$) and non-universal coupling to quarks and leptons







- Considered Z' with suppressed (g_l = 0) and allowed (g_l = 1) coupling to light fermions
- κ_V ranges from 0.1 to 1 to probe weak to strong coupling scenarios

↑ Full Result↑

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Analyses (in order from top to bottom):
CMS PAS EXO-22-007
CMS PAS EXO-21-016
CMS PAS EXO-21-015
Tau decay diagrams by Izaak Neutelings