Search for a light CP-odd Higgs boson decaying into a pair of τ-leptons in pp collisions at 13 TeV with the ATLAS detector

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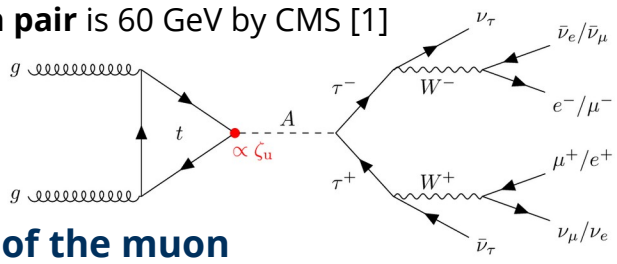
Motivation

Exploring uncovered low-mass range

☆ Lowest mass probed for a **gluon–gluon fusion** produced CP-odd Higgs boson decaying into a **τ-lepton pair** is 60 GeV by CMS [1] (90 GeV by ATLAS [2])

☆ Now probing mass range **m_A = 20 – 90 GeV**



Explaining g-2 discrepancy of the muon

☆ Deviation of up to 5σ between experiment and theory [3]

☆ Could be explained by a loop contribution involving a **light CP-odd Higgs** boson within the **flavor-aligned 2HDM** [3]

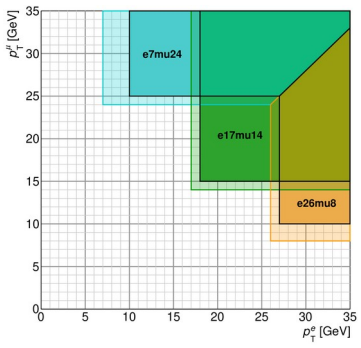
Strategy and selection

Strategy

☆ **Leptonic decay channels** to exploit low lepton p_T trigger thresholds

☆ Exactly **one electron** and **one muon** to reduce background from Z boson decays

☆ Estimate invariant mass of $\tau^+\tau^-$ system with likelihood-based **Missing Mass Calculator** algorithm



Selection

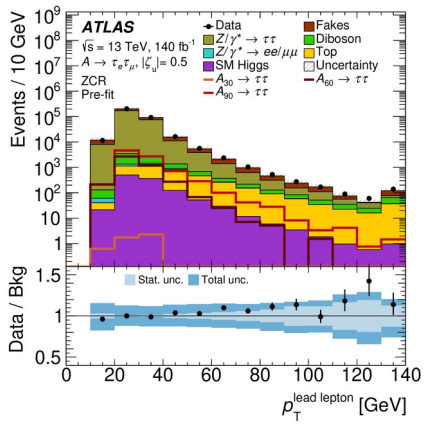
	SR		ZCR	TCR	FVR
	Low-mass	High-mass			
E_T^{miss}	> 50 GeV	> 30 GeV	–	> 30 GeV	–
m_T^{tot}	< 45 GeV	< 65 GeV	< 65 GeV	< 65 GeV	< 65 GeV
$\Delta R_{\ell\ell}$	< 0.7	< 1.0	> 1.4	< 1.0	> 1.4
$q_e \times q_\mu$	−1	−1	−1	−1	1
$n_{b\text{-jets}}$	0	0	0	≥ 2	0

Background modeling

$Z \to \tau\tau$ control region

☆ Validate **most important background** of the analysis: $Z \to \tau\tau$

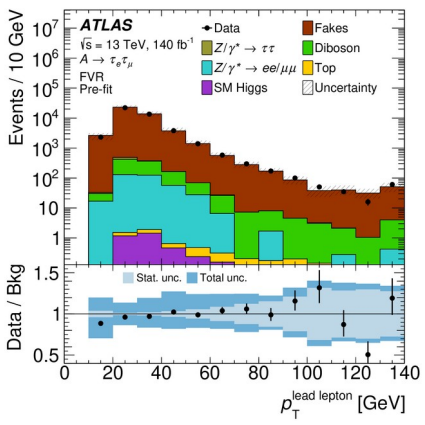
☆ Extract weights to **reweight $Z \to \tau\tau$ MC** background to data



Fake validation region

☆ Using **data-driven matrix method** to estimate background from **non-prompt leptons** & validate it

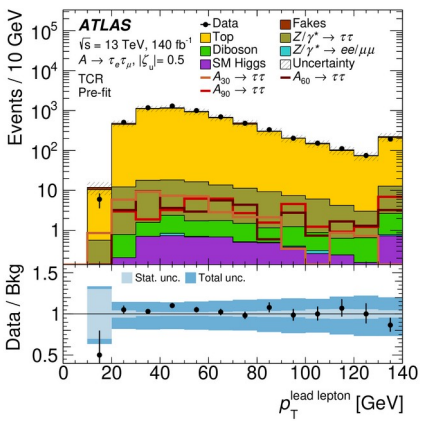
☆ Parametrize lepton efficiencies in tightness of accompanying lepton



Top control region

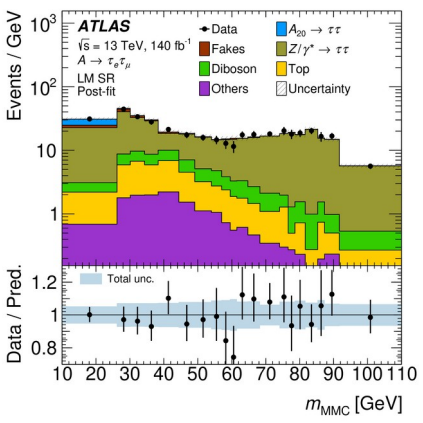
☆ Validate background from **top-quark processes**

☆ Reweighting $p_T^{\text{lead lepton}}$ of $t\bar{t}$ process to apply NNLO QCD and NLO EW corrections

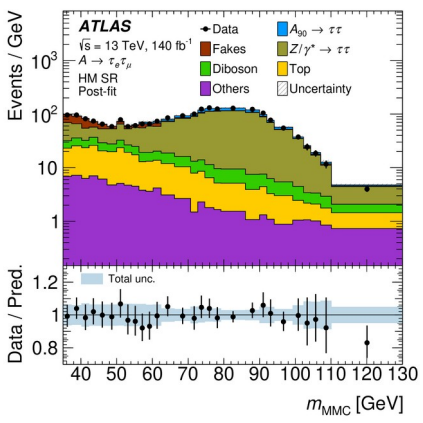


Results

Fit results in the signal regions



☆ m_A = 20 GeV in the **low-mass** signal region

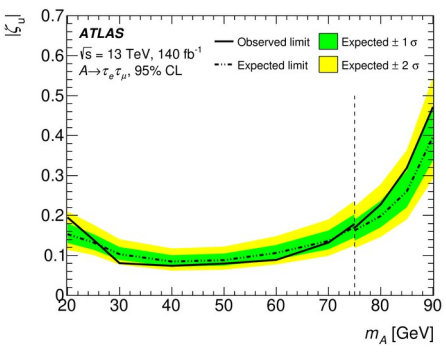


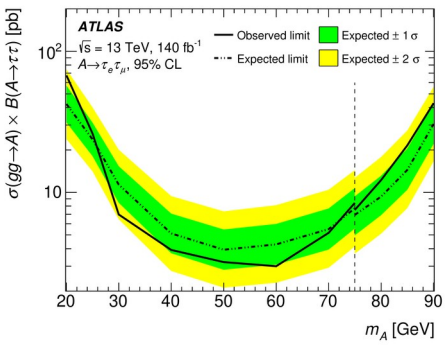
☆ m_A = 90 GeV in the **high-mass** signal region

☆ **No significant excess** above SM prediction observed

☆ **Exclusion limits set** on the cross-section times branching ratio

☆ **First time** exploring the mass range **20–60 GeV**





☆ **Exclusion limits set** on the absolute value of the up-type quark coupling parameter $|\zeta_u|$ within the flavor-aligned 2HDM [3]

☆ **Improving on previous limits** $|\zeta_u| < 0.5$ [3] over the full mass range

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References
[1] JHEP **07** (2023) 073
[2] JHEP **11** (2014) 056
[3] JHEP **09** (2021) 080

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