SEARCH FOR HIGH-MASS RESONANCES DECYING TO $\tau\nu$ IN $pp$ COLLISIONS AT 13 TeV WITH THE ATLAS DETECTOR

Motivation

- New heavy gauge bosons ($W'$) predicted by physics beyond the Standard Model (SM).
- $W'$ with enhanced couplings to $3^{rd}$ generation fermions is motivated by the high mass of the top quark and the indications of lepton flavor universality violations in $B$-meson decays.
- LHC collisions allow the production and direct detection of such bosons.

Signal Processes

Sequential Standard Model:
Benchmark model - $W'$ and SM $W$ bosons have same couplings.

Non-Universal model:
Enhanced couplings to $3^{rd}$ generation fermions are motivated by the high mass of the top quark and the indications of lepton flavor universality violations in $B$-meson decays.

Tau Leptons

This search looks for final states where the $\tau$-leptons decay into hadrons ($\tau_{\text{had}}$). The branching fraction is $\sim65\%$.

Use of the transverse mass:
- Due to neutrinos in the final state, full reconstruction of the invariant mass of the $W'$ is not possible.

Analysis Strategy

Event Topology:
The highest-$m_T$ $W'$-boson like event observed in data from 2016.

Selecting Events with:
- High missing transverse momentum, $E_T^{\text{miss}}$ (Trigger).
- High-$p_T$ tau.
- $E_T^{\text{miss}}$ and tau $p_T$ balanced and back-to-back.
- Large transverse mass:
  $$m_T = \sqrt{2 p_T \cdot E_T^{\text{miss}} (1 - \cos \Delta \phi (p_T, E_T^{\text{miss}}))}$$
  (m$_T$ thresholds optimized for each signal mass hypothesis)

Cut & Count method:
- Count expected, observed events above $m_T$-thresholds.
- Use results into a fit to obtain 95% CL upper limits on the signal strength parameter.

Systematic Uncertainties

- High-mass $W'$ and $W$ backgrounds with real leptons estimated from simulation.
- Backgrounds with jet $\rightarrow$ $\tau$ had misidentification estimated from data (“fake-factor” method). Mainly $Z(\rightarrow \nu\nu)+$jet or $W(\rightarrow l\nu)+$jet

Results

Sequential Standard Model:
$W'$ masses below 3.7 TeV (expected 3.8 TeV) excluded at 95% CL.

Non-Universal model:
$W'$ masses below 2.3–3.8 TeV excluded at 95% CL (depending on mixing angle $\Phi$).

Model independent upper limits on the visible cross section as a function of the transverse mass threshold are provided for re-interpretations. Instructions: https://www.hepdata.net/record/80812

Conclusions

- First search of $W'$ in this decay channel performed by ATLAS.
- Highest mass exclusions in this channel up to date.
- Large exclusion of Non-Universal Model parameter space
- Provide upper limits on $\tau\nu$ visible production cross section for re-interpretation.

References

[1] A search for high-mass resonances decaying to $\tau\nu$ in $pp$ collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector – the ATLAS Collaboration – arXiv 1801.06992 (Subm. PRL)

This poster is based on the analysis presented in [1]