SEARCH FOR HIGH-MASS DIMUON RESONANCES USING PROTON-PROTON COLLISIONS AT $\sqrt{s} = 13$ TEV WITH THE ATLAS DETECTOR

S. Rettie1,2, on behalf of the ATLAS Collaboration

1The University of British Columbia, TRIUMF

Motivation

**Z Prime ($Z'$)**
- Additional spin-1 neutral gauge boson
- Benchmark signal is Sequential Standard Model (SSM) $Z'$, additional heavy boson with same fermion couplings as SM $Z$.
- Predicted by GUT models based on the $E_6$ gauge group.
- Two additional $U(1)$ gauge fields $Z'(\phi) \rightarrow Z'(\phi_0) + Z(\phi_0) + 2\phi_0$.
- Observable as narrow resonances in dimuon invariant mass spectrum.

The ATLAS Detector

- **Muon Spectrometer (MS):**
  - Barrel region: $|\eta| < 1.1$.
  - Endcap region: $1.1 < |\eta| < 2.7$.
- Toroidal magnetic field allows for transverse momentum ($p_T$) measurements by measuring the curvature of the muon tracks.
- $p_T$ resolution up to 10% for muons with $p_T \sim 1$ TeV.
- Inner Detector (ID):
  - Contains in a 2T magnetic field.
  - Used for the tracking of charged particles.
- ID track combined with MS track to form "combined" muon.

Backgrounds

- **Drell-Yan Production**
  - Generator: Powheg Box
  - Shower: PyNLO 8.10B
  - PDF: CT10

- **Top Production**
  - Generator: Powheg Box
  - Shower: PyNLO 8.10B
  - PDF: CT10

- **Diboson Production**
  - Generator: Sherpa 2.1.1
  - Shower: Sherpa 2.1.1
  - PDF: CT10

- **Event Level Criteria**
  - Good Run List (GRL)
  - Single-muon trigger: 1 isolated $\mu$ with $p_T > 26$ GeV OR 1 $\mu$ with $p_T > 50$ GeV.
  - At least 2 combined muons.
  - Require Opposite Charge.
  - Select highest $p_T$ pair: $m_{\mu\mu} > 80$ GeV.

Event Selection

- **Muon Selection**
  - High-$p_T$ muon working point improves momentum resolution at high $p_T$.
- Require track origin to be consistent with primary vertex:
  - $d_0$ significance $< 3$.
  - $|z_0 \sin\theta| < 0.5$ mm.
  - Loose isolation on tracks.

- **Exclusion Limits**
  - No significant deviation from the Standard Model prediction was observed, so various theoretical models are constrained by setting limits on their parameters, e.g. the $Z'$ boson masses or the contact interaction binding energy scale $\Lambda$.

- **Highest $m_{\mu\mu}$ Event (1.99 TeV)**

Data/MC Comparisons

- **Leading $\mu$ ($p_T, \eta, \phi$):** (637 GeV, -0.43, -2.16)
- Subleading $\mu$ ($p_T, \eta, \phi$): (546 GeV, 1.81, 0.90)
- Missing $E_T$: 109 GeV

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