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Statistical Search for High-Mass Dimuon Resonances using ATLAS Open Data

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Heavy neutral gauge bosons (Z') arise in well-motivated extensions of the Standard Model with additional $U(1)'$ symmetries and are important targets for direct searches at hadron colliders [1]. Motivated by the ATLAS high-mass dilepton resonance search [2], we develop an independent analysis of the process $pp \rightarrow Z' \rightarrow \mu^+\mu^-$ using ATLAS Run-2 Open Data.

The dimuon invariant mass is used as the main discriminating observable after selecting high-momentum muons. The steeply falling Standard Model background, dominated by Drell-Yan production, is modeled with alternative analytic parameterizations. Their robustness is evaluated through nested-model comparisons, spurious-signal studies, and signal-injection tests. Generic resonance hypotheses are then incorporated into a profile-likelihood framework, following standard LHC statistical methodology [3], to test the background-only hypothesis and estimate exclusion sensitivity.

This work provides a reproducible framework for high-mass resonance searches with public collider data and for model-independent tests of spin-1 physics beyond the Standard Model.

[1] P. Langacker, Rev. Mod. Phys. 81, 1199 (2009).

[2] ATLAS Collaboration, Phys. Lett. B 796, 68 (2019).

[3] G. Cowan et al., Eur. Phys. J. C 71, 1554 (2011).

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