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# Searches for a scalar resonance with Di-photon in association with leptons in the range 130 −200 GeV in the ATLAS detector at the LHC

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Searches for di-photon resonances at the ATLAS experiment have primarily focused on the mass range of 200–3000 GeV. However, phenomenological studies based on Run 1 data have reported excesses-commonly referred to as multi-lepton anomalies-suggesting the possible existence of a scalar resonance with a mass of $150 \pm 5\,\mathrm{GeV}$. Further investigations of $\gamma\gamma$ and $Z\gamma$ sidebands, using ATLAS and CMS data, have further motivated the presence of a narrow resonance in this region, with a reported local significance of $5.4\sigma$. The analysis aims to highlight this gap by proposing further investigation into this phase space, which is deliberately chosen to avoid overlap with the Standard Model (SM) Higgs boson. Two theoretical models are explored: the Two-Higgs-Doublet Model with an additional singlet (2HDM+S), and the Triplet Model ($\Delta$SM) with hypercharge $Y = 0$. Both frameworks predict rich di-photon phenomenology in association with final states containing tau jets ($\tau$), leptons ($\ell = e/\mu$), b-jets, jets, and missing transverse energy (MET). Significant progress has been made within the 2HDM+S framework, particularly in key channels such as $gg \to H(250\,\mathrm{GeV}) \to S(\gamma\gamma)\, S'(\tau\tau/b\bar{b}/\ell + b/\ell\ell)$. Future work will extend the analysis to the $\Delta$SM model to fully explore this promising region of parameter space.

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