Validation of the MadAnalysis 5 implementation of the multijet + missing energy analysis of ATLAS (ATLAS-CONF-2016-086)

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In this note, we describe the validation of the implementation in the MadAnalysis5 framework [1] of the ATLAS's multijet + MET analysis [2]. For this purpose, we have used the MA5 1.6 version jointly with the Delphes3 program [3], used for the simulation of the detector's response. The validation has been achieved on the basis of one benchmark provide by ATLAS, for which we have generated hard scattering events with the MadGraph5_aMC@NLO program [4]. The parton showering and the hadronisation have then been handled by PYTHIA 6. The necessary configuration files, UFO model and customized detector card can be found on the public analysis database webpage of MadAnalysis, `http://madanalysis.irmp.ucl.ac.be/wiki/PublicAnalysisDatabase`.

The ATLAS multijet search relies on an integrated luminosity of 13.3 fb^{-1} of proton-proton collision at a center-of-mass energy of $\sqrt{s} = 13$ TeV. The analysis contains one signal region involving a large amount of missing transverse energy, larger than 150 GeV, and two jets identified as containing B-hadrons (b-jets) of high transverse momentum p_T. This signal region is also characterized by the absence of lepton in the final state and a large angular separation between jets.

This analysis is interpreted into the context of simplified dark matter models, in which the standard model is extended by two additional fields; a Dirac field χ, corresponding to the dark matter particle, and a scalar (Φ) or a pseudoscalar (a) field, mediating the interaction between the standard model sector and the dark sector. This scenario involves the introduction of four parameters: the mass of the mediator m_Φ or m_a, the mass of the dark matter particle m_χ, the DM-mediator coupling g_χ and the flavour-universal SM-mediator coupling g_v. Therefore, the studied process is $pp \to \chi\bar{\chi}b\bar{b}$. The simulation is done at leading order. The ATLAS benchmark used for this analysis is the following:

$$\mathrm{g}_\chi = \mathrm{g}_v = 1,\ \mathrm{m}_{\Phi/a} = 20 \text{ GeV and } \mathrm{m}_\chi = 1 \text{ GeV}.$$

In order to validate the implementation of the analysis, we reproduce the official plots provided by ATLAS. In figure 1, we present the transverse momentum imbalance Imb(b1, b2) distribution with all selection cuts except the Imb(b1, b2) requirement. This quantity is defined as followed :

$$Imb(b1, b2) = \frac{p_T(b1) - p_T(b2)}{p_T(b1) + p_T(b2)},$$

where $p_T(b1)$ is the transverse momentum of the leading b-jet and $p_T(b2)$, the transverse momentum of the second b-jet. We found our results to be in good agreement with the ATLAS numbers, at the level of 89% of agreement.

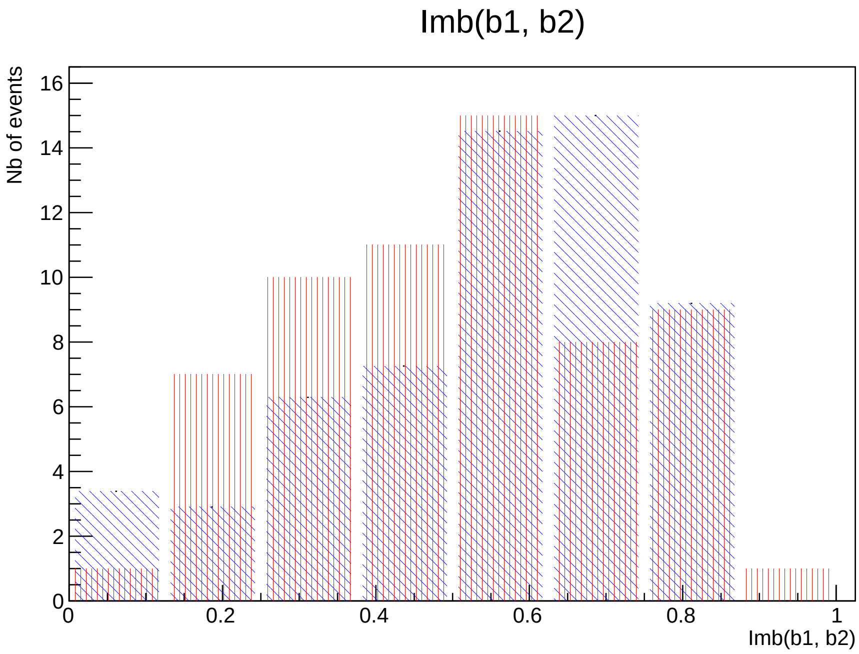

Figure 1: Transverse momentum imbalance in the signal region with all selection criteria applied except the one on the Imb. The red part is the official plot and the blue part is our own reimplementation.

We are also providing the exclusion plot that this reimplemented analysis allowed us to generate (Figure 2), which is in good agreement with what was expected according to [5].

Due to the lack of information provided by the ATLAS collaboration, this validation note is very brief. Nevertheless, we have been able to validate our reimplementation of this multijet analysis in the MadAnalysis 5 framework by making use of MadGraph and Pythia in order to simulate events that can be compared to the results provided. These results are found to be in a good agreement with the ones given by ATLAS.

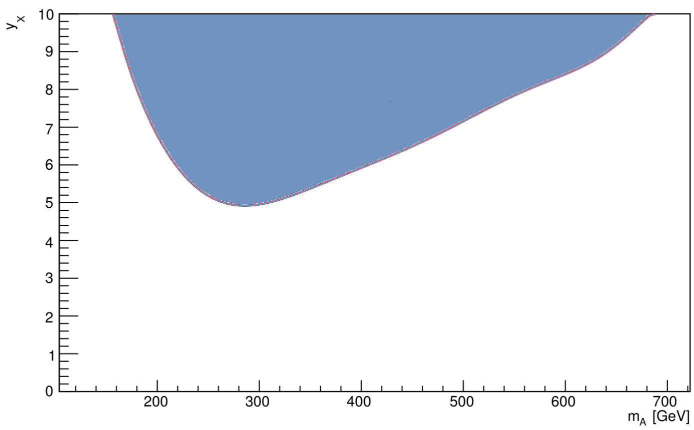

Figure 2: Exclusion plot at 95% CL in the plan (m_A, y_χ) for m_χ = 100 GeV.

References

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