Model-independent searches for new physics in multi-body invariant masses

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1. Introduction

Model-independent searches for physics beyond the Standard Model (BSM) typically focus on invariant masses of two objects (jets, leptons or photons). In this study we will explore opportunities for similar model-agnostic searches but using multi-body invariant masses. In particular, we will discuss physics processes when two-body invariant masses, that have been extensively explored at collider experiments, cannot provide reliable signatures for experimental observations of new heavy particles. Such cases have not been fully explored at the LHC with the same precision as that used for searches in two-body decays using background-smoothing techniques.

Model-independent searches for deviations in invariant masses of jets, leptons or photons usually require a background hypothesis representing our best expectation from the Standard Model. Such a background can be obtained using Monte Carlo simulations or "control regions", i.e. regions of actual data with similar kinematic features as for the signal regions, but without BSM contributions. An alternative approach for background hypothesis is to perform a fit of the entire mass spectra with some analytic function or using numeric smoothing techniques. When a background hypothesis is established, searches for BSM physics are performed by studying possible deviations above the established background. Previous searches for heavy resonances in dijet mass distributions using the techniques described above have recently been performed by ATLAS [1, 2, 3] and CMS [4, 5, 6].

In this contribution we will investigate cases for searches when direct observations of BSM signals in two-body decays (i.e. dijets, di-leptons or di-photons) are difficult due to their wide width, and the standard approach of observation of narrow "bumps" over a smooth background is not reliable. A typical requirement for the width (Γ) and the mass (m) of a heavy particle leading to signals in invariant masses that can be observed without relying on Monte Carlo predictions for background shape is $\Gamma/m < 0.15$, where Γ is the partial width and m is the mass of a resonance. We will discuss a possible class of unexplored BSM signatures that cannot be found using the popular

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experimental methods based on two-body invariant masses due to significant widths of exotic states produced in such processes. Such signatures can often be attributed to di-boson production (for a recent review see [7]), after assuming certain particle masses and widths. We will discuss several observables that should help make observations of such BSM events using model-independent techniques.

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