

Recent Mono-Higgs Studies at CERN and LHC DM WG Recommendations

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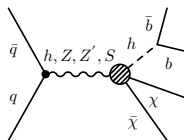


Mono-Higgs Event Selection

- 1 Resolved Analysis: $150 \text{ GeV} < E_T^{\text{miss}} < 500 \text{ GeV}$
- 2 Merged Analysis: $E_T^{\text{miss}} > 500 \text{ GeV}$

Resolved analysis

- ▶ xe70 HLT trigger
 - ▶ lepton veto
 - ▶ Missing transverse momentum (ID):
MPT > 30 GeV
 - ▶ Missing transverse energy (Calo): 150 GeV < MET < 500 GeV
 - ▶ $\min\Delta\Phi(\text{MET}, \text{jet}) > 20^\circ$
 - ▶ $\Delta\Phi(\text{MET}, \text{MPT}) < 90^\circ$
 - ▶ at least two jets, jet1 or jet2 > 45 GeV
 - ▶ $\Delta\Phi(\text{jet1}, \text{jet2}) < 140^\circ$
 - ▶ $\sum_1^{2(3)} p_{T,i}^{\text{jet}} > 120 (150) \text{ GeV}$
 - ▶ $\Delta\Phi(\text{MET}, \text{jet1jet2}) < 140^\circ$
 - ▶ b-tag requirement on calo jets
- ⇒ 0/1/2 b-tag region

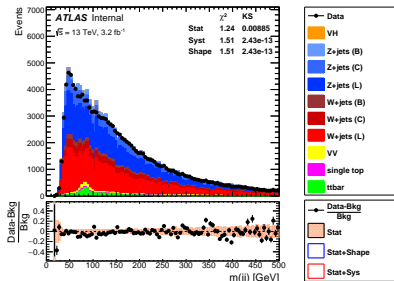


Merged analysis

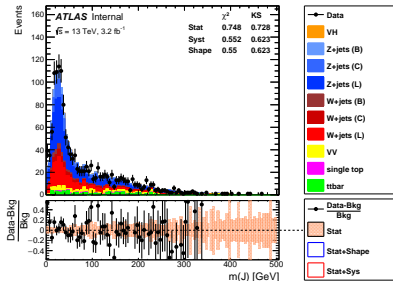
- ▶ xe70 HLT trigger
 - ▶ lepton veto
 - ▶ MPT > 30 GeV
 - ▶ MET > 500 GeV
 - ▶ at least one fatjet (= large-R jet)
 - ▶ b-tag requirement on ghost associated track jets
- ⇒ 0/1/2 b-tag region

These cuts were defined/decided during last week, especially for the merged analysis!
Resolved selections more explicitly defined [here](#) see the $VH \rightarrow \nu\nu bb$ analysis.

Analysis is blinded, due to this just 0 btag region today... but with highest statistics :-)



mass of the two leading jets
 $150 \text{ GeV} < \text{MET} < 200 \text{ GeV}$



mass of the leading fatjet

- 1 selection of 1 lepton control region is defined
 - ▶ designed to have pure W +jets ($W \rightarrow \nu\mu$) events
 - ▶ one muon
 - ▶ MET \rightarrow MET + muon
- 2 selection of 2 lepton control region is defined **not valid anymore!!!**
[2016/01/27]
 - ▶ designed to have pure Z +jets ($Z \rightarrow \ell\ell$) events
 - ▶ single lepton trigger instead of MET trigger
 - ▶ 2 leptons
 - ▶ additional dilepton mass cut
 - ▶ MET \rightarrow MET + lepton +lepton **not valid anymore!!!**
- 3 muon-in-jet correction has been implemented, in order to correct for the muon energy ($b \rightarrow c\mu\nu$), will improve the resolution of $m(jj)$ and $m(J)$
- 4 systematics from CP groups are available as well as MC generator variations

Dark Matter Forum

- ▶ In the past: [ATLAS–CMS Dark Matter Forum](#)
 - ▶ Now: [LHC Dark Matter Working Group](#)
- ⇒ presentation of the DM WG report in the Jet-Dark-Matter (=JDM) meeting last friday

- ▶ platform for experimentalists from ATLAS and CMS and for theoretician
- ▶ goal: harmonization of the strategy by the ATLAS and CMS experiment for the search for Dark Matter
- ▶ define proper channels to look for Dark Matter and prospects on their sensitivity
- ▶ define signal models: effective field theories (EFT) (mediator mass, couplings) and simplified models (2HDM, Z' , S)
- ▶ answer questions like the validity of EFT models for large \sqrt{s}
- ▶ provide mass points for the Monte Carlo generation of signal samples

- brings together theorists and experimentalists to define guidelines and recommendations for the benchmark models, interpretation, and characterisation necessary for broad and systematic searches for dark matter at the LHC.
- develops and promotes well-defined signal models, specifying the assumptions behind them and describing the conditions under which they should be used.
- works to improve the set of tools available to the experiments, such as higher- precision calculations of the backgrounds.
- assists theorists with understanding and making use of LHC results.
- develops and maintains close connections with theorists and other experimental particle DM searches (e.g. Direct and Indirect Detection experiments) in order to help verify and constrain particle physics models of astrophysical excesses, to understand how collider searches and non-collider experiments complement one another, and to help build a comprehensive understanding of viable dark matter models.

The first area of focus: how to present results on the DMF simplified models and compare fairly to non-collider searches.

Discusses issues to consider when conveying collider results on the parameters of the simplified models, and when comparing these results to relic density calculations, theory ‘constraints,’ dark-matter—nucleon scattering searches, and astroparticle searches.

Recommends how to produce limit plots, and when and where to compare with results beyond the LHC.

Provides formulae and results for making these comparisons.

Is not final!

Still asking for feedback you, and from theorists as well (but the main pieces shouldn’t change).

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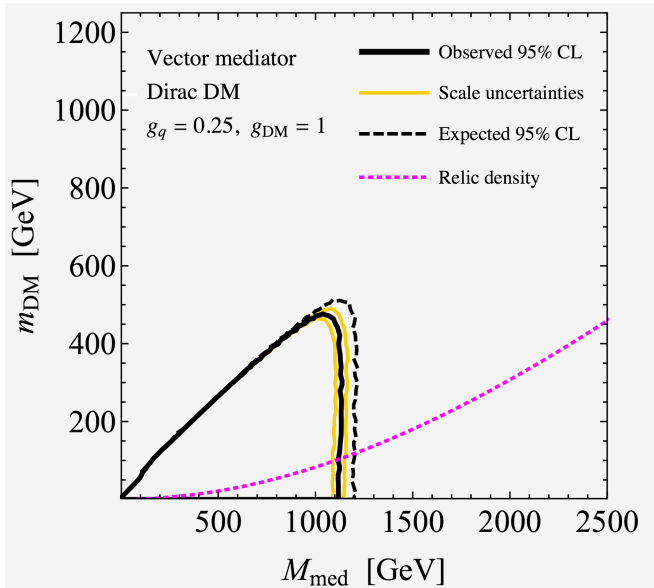
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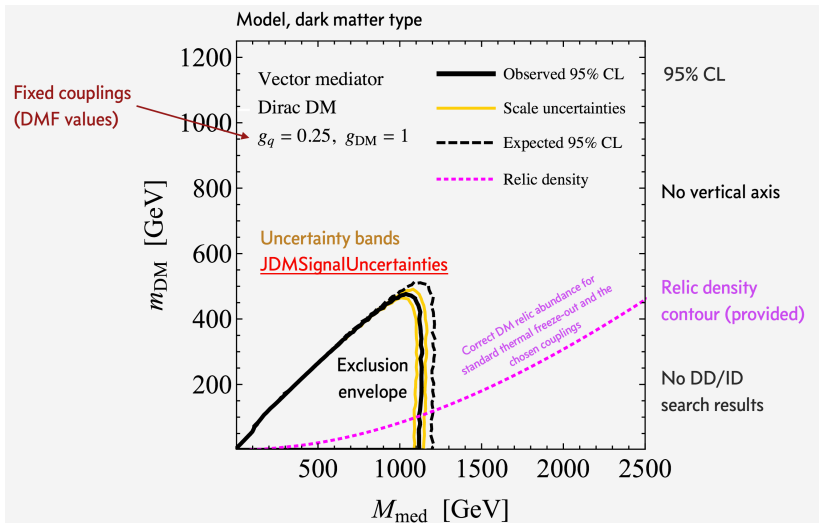
1 Introduction

The ATLAS/CMS Dark Matter (DM) Forum report [1] provides a first set of concrete simplified DM models used by the ATLAS and CMS to interpret their searches for missing transverse energy (MET) signatures. This document provides recommendations for how to present the LHC search results involving these models and how to compare these results to the results of direct (DD) and indirect detection (ID) experiments.

The relevant details of simplified DM models involving vector, axial-vector, scalar and pseudo-scalar s -channel mediators are first reviewed in Section 2. Section 3 presents a recommendation for the primary treatment of LHC DM bounds and introduces all of the basic assumptions entering the approach. Section 4 describes a well-defined translation procedure, including all relevant formulas and corresponding references, that allows for meaningful and fair comparisons with the limits obtained by DD and ID experiments.

The approach outlined here was discussed at the first LHC DM Working Group public meeting [2] and is based on work described recently in [3–9]. For earlier articles discussing aspects of simplified s -channel DM models, see also [10–16].





Direct detection comparison (DM-nucleon, DM-proton, $\langle \sigma \cdot v \rangle$)

- ▶ Translate observed and expected 90 or 95% exclusion bounds (follow DD/ID convention) for mediator with fixed couplings using C++ code provided by DM WG
- ▶ Overlay strongest results to date from DD/ID (references for ATLAS analysers provided by Astro Forum)
- ▶ specify:
 - ▶ Type of mediator
 - ▶ Type of DM (Dirac only)
 - ▶ Coupling values

- ▶ monoH analysis is aiming for Moriond
- ▶ if the time schedule is too tight: conversion for a later paper/conf note
- ▶ which would be fine, due to the lack of statistics
- ▶ in my opinion: more careful studies are needed, wait till $> 5 - 10/\text{fb}$ of recorded data and go for the summer/fall conferences