Abstract

- Many proofs of the dark matter (DM) existence; its nature and interactions with Standard Model (SM) particles are still unknown
- At colliders, dark matter particles could be produced in pair and be probed through the production of an associated SM particle with high transverse momentum ($p_T$)
- Leading to different final states: photon / jet / $l^+l^-$ / $Z^0$ / Higgs / heavy flavour + missing transverse energy ($E_T^{miss}$)
- Complementary way to probe DM: compare with results from direct and indirect DM searches
- Various models: effective field theories (EFT), simplified model or complete theories e.g. supersymmetry (SUSY)

Three Analyses as Examples

**Mono-jet**
- Large $E_T^{miss}$ with one central high-$p_T$ jet, well separated from $E_T^{miss}$
- Lepton veto

**Mono-$\gamma$**
- Large $E_T^{miss}$ with one central high-$p_T$ photon, well separated from $E_T^{miss}$
- Lepton veto

**Mono-Z(II)**
- Large $E_T^{miss}$ with a well-identified Z(II), well separated from $E_T^{miss}$
- Jet veto

Free parameters:
- $M$ and $m_h$
- Electroweak coupling strengths $k_{1,2}$
- Heavy boson mass $m_H$
- Mediator type and its parameter: mass $M$ and $\Gamma$ (related to $g_2, g_3$)

Simplified Model

Explicit mediator: such as a Z'-like vector mediator

For a given effective operator

Hypothesis:
- $g_2 < M_{med} = M(g_2, g_3)^{1/2}$, where $g_2, g_3$ are coupling strengths

Remove problem of validity

- $m_H$ and $g_2, g_3$ need to be tuned

EFT validity truncation:
- Remove events not satisfying $Q_2 < M(g_2, g_3)^{1/2}$

Towards 13 TeV

- LHC started to run at 13 TeV in June
- Studies are ongoing:
  - Mono-$\gamma$: Trigger fully efficient in the SR
  - Mono-jet: Good data/MC agreement on $E_T^{miss}$ in CR

General EFT Model

- Define Signal enriched Region (SR)
- Define Control Regions (CR) with certain background processes enriched in order to normalize the MC expectation in the SR
- Validate the background estimation technique in a Validation Region (VR)

Un-blind data in SR to check if a significant excess is observed
- Good data/MC agreement on $E_T^{miss}$ in SR
- Validate the background estimation technique in a Validation Region (VR)

Lightest Neutralino in SUSY: Compelling Candidate to DM

- R-parity conserving simplified SUSY model, mass degenerate 1st and 2nd generation squarks $\tilde{q}$
- $\Delta M_{\chi_1^0} < 10$ GeV $\rightarrow X + E_T^{miss}$

An EFT Model Inspired by Fermi-LAT Spectrum

- A tentative DM signal at 130 GeV seen in 2012 Fermi-LAT public data
- ATLAS, the nature of this signal can be probed by:
  1. $\geq 200 \text{ GeV}$
  2. High Missing transverse energy
  3. Dominant lepton veto

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