Leptonic WIMP Coannihilation and the Current Dark Matter Search Strategy

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Dark Matter models with $t$-channel mediators @ LHC (LHC DM WG public meeting)

26 Apr 2019

Based on 1806.07896 (JHEP) MJB & Andrea Thamm
• Leptonic (leptophilic) $t$-channel models
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Model parameters

$m_\chi, m_\phi, y_\chi, (\Gamma_\phi)$
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Proton collider signature
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![Diagram of leptonic $t$-channel models]

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Two (SF) OS leptons + MET
• Simplified Model - New Fields & Lagrangian
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$$\mathcal{L} \supset y_\chi \phi_i \overline{\chi} \ell_R + h.c.$$
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A simplified model version of Bino DM with everything except the sleptons decoupled
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$\chi \bar{\chi} \to \ell^- \ell^+$ and $\phi \bar{\phi} \to \ell^- \ell^+$ are much slower than $\chi \ell^+ \to \phi \ell^+$

as long as $m_{\phi} - m_{\chi} \lesssim T$, or $\frac{m_{\phi} - m_{\chi}}{m_{\chi}} \equiv \Delta \lesssim 3\%$
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Coannihilation can **decrease** the effective freeze-out cross-section
Relic Surface

Yukawa coupling which yields observed relic abundance
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![Graphs showing relic surface for Majorana and Dirac particles.]

- Majorana $\chi$, $n = 1$
- Dirac $\chi$, $n = 1$
• Relic Surface

Yukawa coupling which yields observed relic abundance

Although the collider process will not depend on this coupling, direct and indirect detection will
• Proton collider signature and cross-section
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**Backgrounds and cuts**

We do a theorists analysis (Madgraph, Pythia, Delphes)

Main backgrounds are di-boson

Background cross-sections in fb are

| Channel                                    | $\mu^+\mu^-\nu_{\text{all}}\nu_{\text{all}}$ | $\mu^+\mu^-l_{\text{all}}\nu$ |
|--------------------------------------------|---------------------------------------------|--------------------------------|
| Energy [TeV]                               | 27                                          | 27                            |
| No Cuts                                    | 2100                                        | 560                           |
| $p_T^{\mu_1(\mu_2)} > 35(20)$ GeV & Lepton veto | 1100                                        | 120                           |
| Jet veto                                   | 690                                         | 45                            |
| $m_{\mu\mu} > 20$ GeV & $|m_{\mu\mu} - m_Z| > 10$ GeV | 470                                         | 6.6                           |
| $m_{T2} > 200$ GeV                         | 0.26                                        | 0.022                         |


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\[ \mathcal{L}_{27 \text{ TeV}} = 15 \text{ ab}^{-1} \]

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This simple analysis does not probe small $\Delta$ since leptons are soft
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Results for the electron case very similar
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Thank you!
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Ask me more in the coffee break!