Getting ready for LHC run 2: hunting dark matter at colliders

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Outline

1.) Introduction to Notre Dame High-Energy Physics

2.) Hunting for (supersymmetric) dark matter at colliders

University of Notre Dame



University of Notre Dame











Particle Physics at Notre Dame

theory





Particle Physics at Notre Dame

students





Capdevilla, Rodolfo

postdocs



Joe Bramante

Alvarado, Carlos



Elahi, Fatemeh

Α



Lehman, Landon





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In addition to the topic I'll talk about there are several other ideas we're interested in



that I'd be happy to discuss

Part II:

Hunting Dark Matter at the LHC

specifically = superpartners of Higgs electroweakinos boson, W, Z, X

Motivation







Probe *up to* the quoted mass limit

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in ascending order Jar I asequidase in the limit $m_{\tilde{Q}}$, $m_{\tilde{L}} \gg m_{\chi}$: phenomenology set by 4 parameters: $M_1, M_2, \mu, \tan\beta$ (Sp) SW In K $\dot{c}_{\beta} \dot{s}_{W} m_{Z}$ ggs scalai e mixing matrix for the positively charged left handed fermions y charged left-handed fermions? They are chosen so that $-\mu$ $-s_{\beta}c_W \tilde{m}_Z$ $S_{\beta} S_W m_Z$ v charge we have

Naturalness: Higgsino mass is related to the Z mass

$$\frac{1}{2}M_Z^2 = -m_{H_u}^2 - |\mu|^2$$
weak scale
to avoid big cancellations,
both of these should be weak
scale (~100 GeV) too!

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Dark Matter: lightest superparticle is stable, can be DM

right amount of DM achieved from admixtures of electroweakinos, mass ~ 100 GeV - TeV

"Well-tempered electroweakino" scenario

[Arkani-Hamed, Delgado, Giudice '06]

Current electroweakino searches



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Current electroweakino searches



struggle when the states are nearly degenerate ($m_{\chi 2} \sim m_{\chi \pm} \sim m_{\chi 1}$)

leptons become inefficient to trigger upon (25 GeV for single lepton trigger, 17 GeV/8 GeV for 2-lepton)... Doesn't improve at 14 TeV

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Monojet searches



[Han, Kribs, AM, Menon 1401.1235]

projected to 14 TeV, high L, limits still feeble

LHC limits are weakest when states are nearly degenerate

but approximately-degenerate spectra are exactly what is required for well-tempered scenarios to fit DM abundance



improved searches needed

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[Han, Kribs, AM, Menon 1401.1235]

basic cuts: jet $p_T > 100$ GeV, $|\eta_j| < 2.5$, MET > 100 GeV for triggering

then require 2 leptons, $p_T > 7 \text{ GeV}, |\eta_\ell| < 2.5$

there are SM backgrounds (WW+j, $t\bar{t}, \tau^+\tau^-+j$), but they can be controlled with cuts















Improving mono-jet searches: jet + {+{++ MET

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• signal is large MET + **soft** leptons (low m_l)

Improving mono-jet searches: jet + l+l-+ MET

why are these working?

- signal is large MET + **soft** leptons (low m_l)
- in background (di-boson), MET and lepton come from the same particle (W)



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in fact, most current, viable models of EW DM with have a set of states with similar mass



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co-annihilation fixes the tension, but co-annihiliating states must be nearly same mass as DM

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Summarizing

If supersymmetry is the (or part of) the theory beyond the Standard Model, expect the electroweakinos to be light, fairly degenerate

.. this is exactly where they're hard to find

new idea to access these compressed spectra

- use initial radiation to trigger, look for accompanying softer objects (l⁺l⁻,etc.) offline
- should work for non-SUSY setups too!

look good at simulation level, work better for smaller splittings

THANK YOU!

have a great Masterclass, and hope to see you again soon!