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# Lepton Jets

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Boost 2011

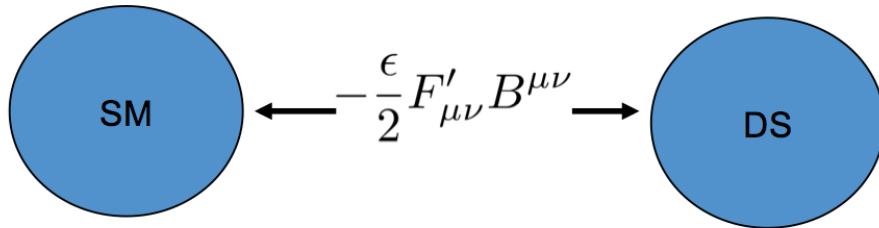
Princeton University

# Dark/Hidden Sectors

This phenomenon is very general. It occurs when we consider new light states coupled to the Standard Model,

## Marginal Operators

(Motivated by recent astrophysical anomalies – Arkani-Hamed and Weiner)



$$\mathcal{L}_{\text{SM}} = \dots$$

<http://pdg.lbl.gov>

$$\mathcal{L}_{\text{DS}} \supset i\bar{\chi}\gamma^\mu D_\mu\chi + M\bar{\chi}\chi$$

$$-\frac{1}{4}F'_{\mu\nu}F'^{\mu\nu} + \frac{1}{2}m^2 A'_\mu A'^\mu$$

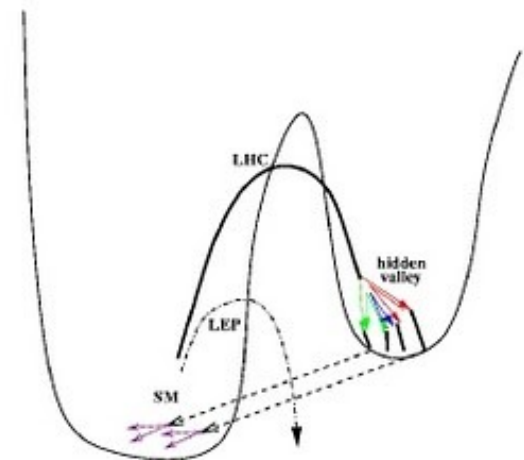
$$M \sim \text{TeV}$$

$$m \sim \text{GeV}$$

$$+|D_\mu h_i|^2 - V(h_i)$$

## Non-renormalizable Operators

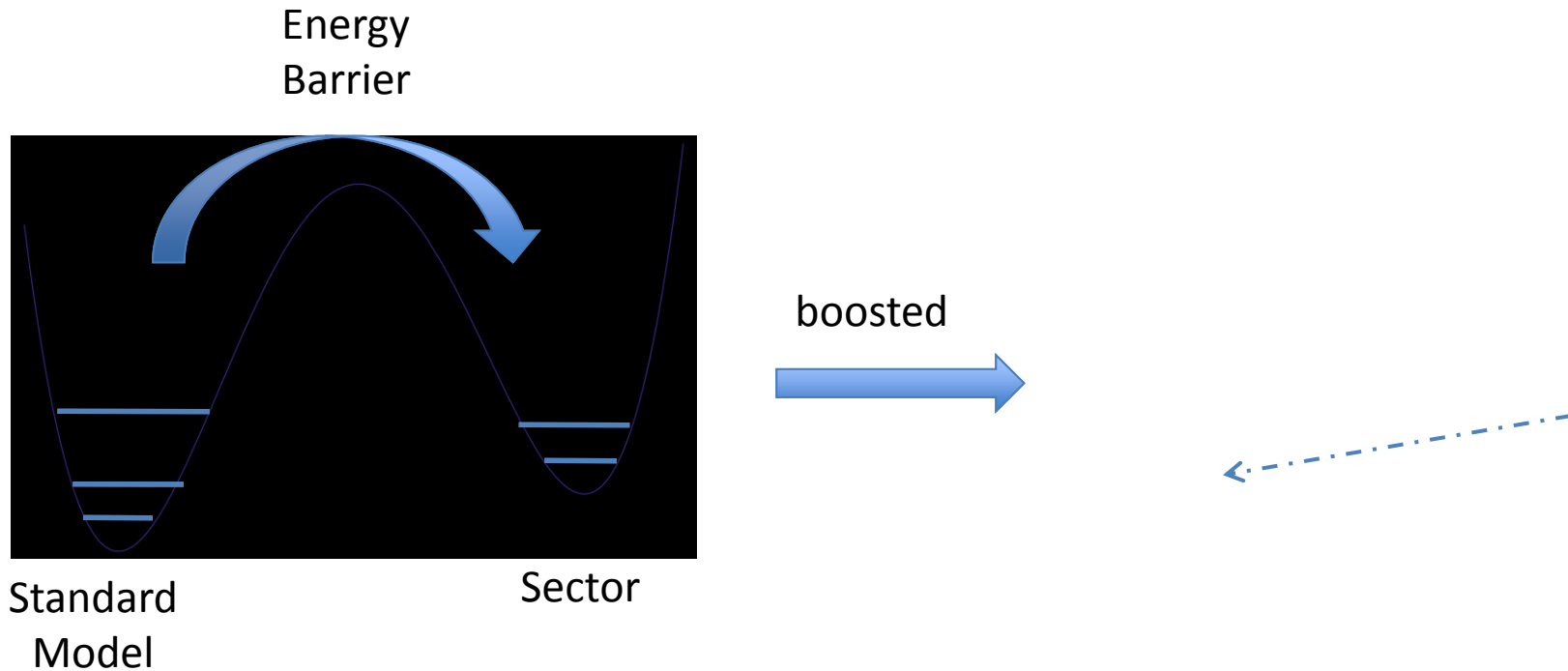
Hidden Valleys, Strassler and Zurek,  
hep-ph/0604261



Lepton-jets are the hallmarks of an extra weakly coupled sector with a low scale.

# New Objects in Colliders

Independently of this or that anomaly, a Dark/Hidden/Secluded sector will lead to qualitatively new type of objects in colliders,

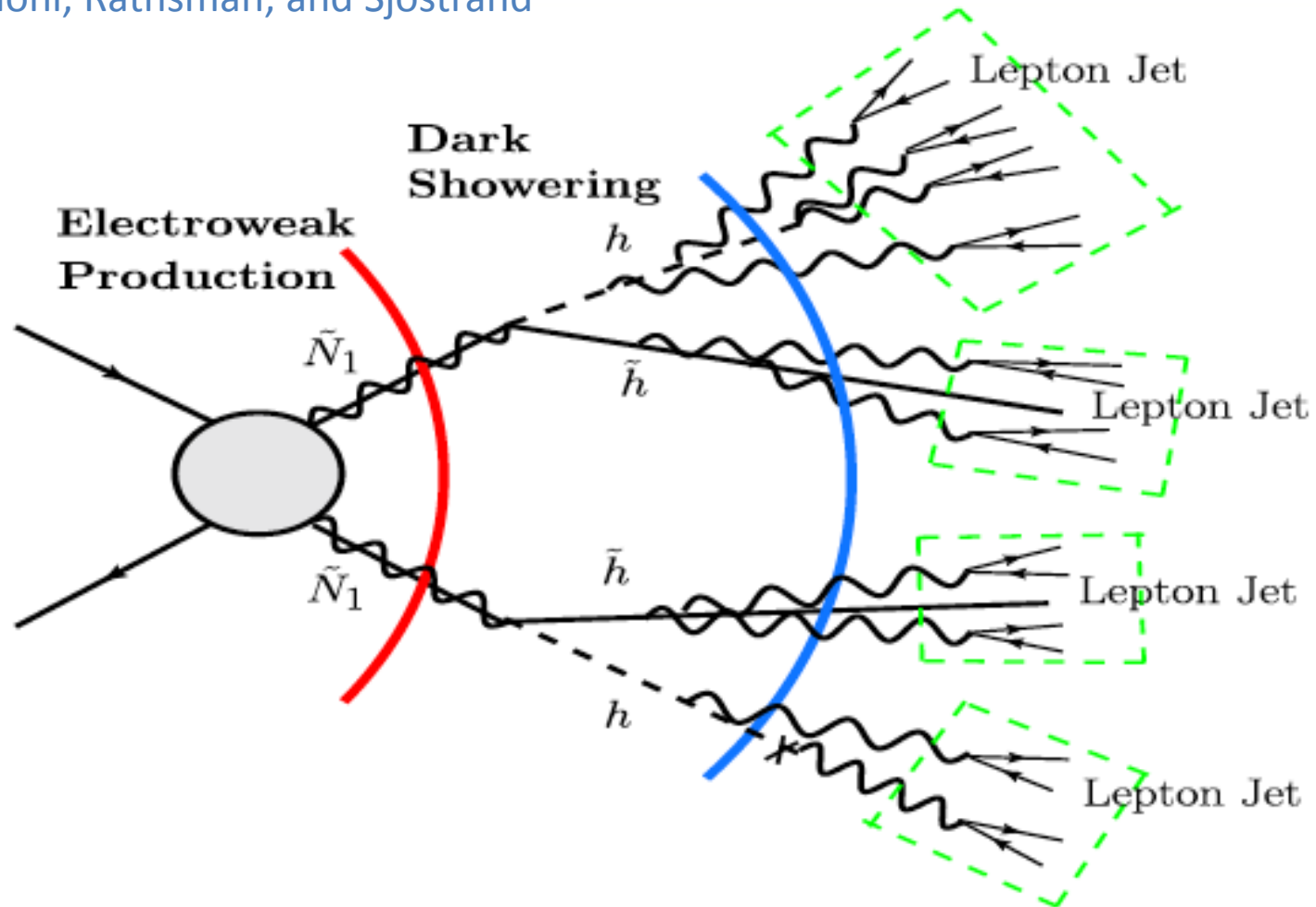


Relativity tells us that the decay products of the dark state are going to be extremely collimated!

# Full Evolution

To simulate all the physics involved it has to be implemented into some Monte-Carlo based simulation:

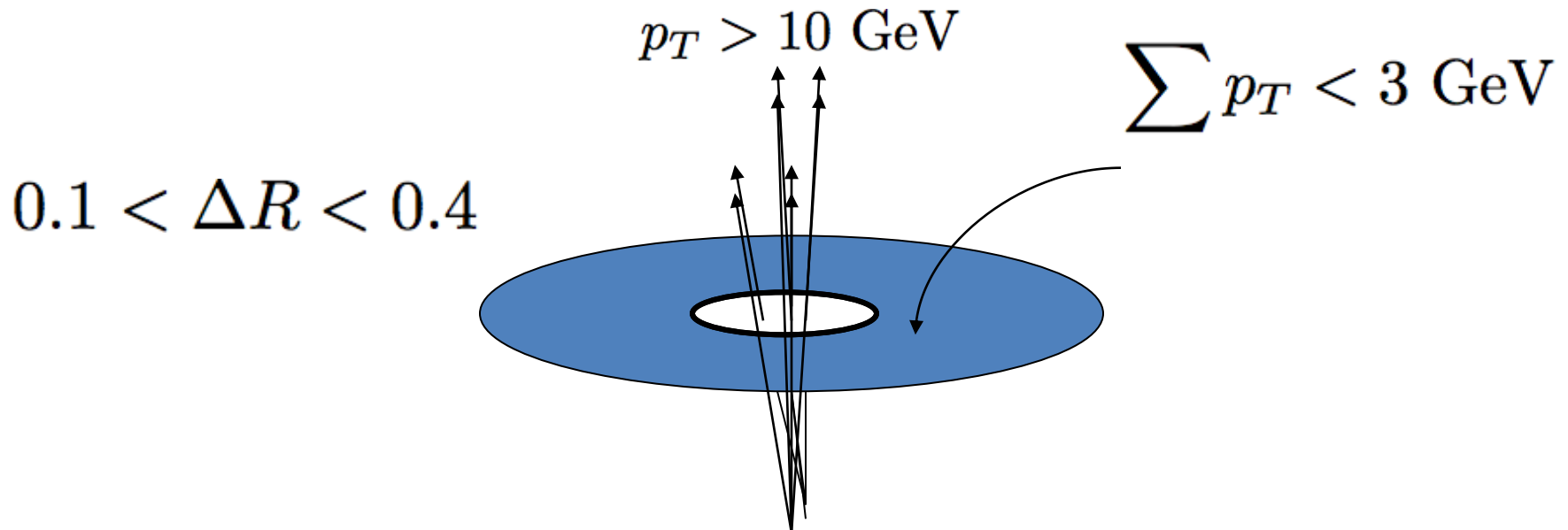
Ruderman and IV,  
Carloni, Rathsman, and Sjostrand



# When are Lepton Jets useful?

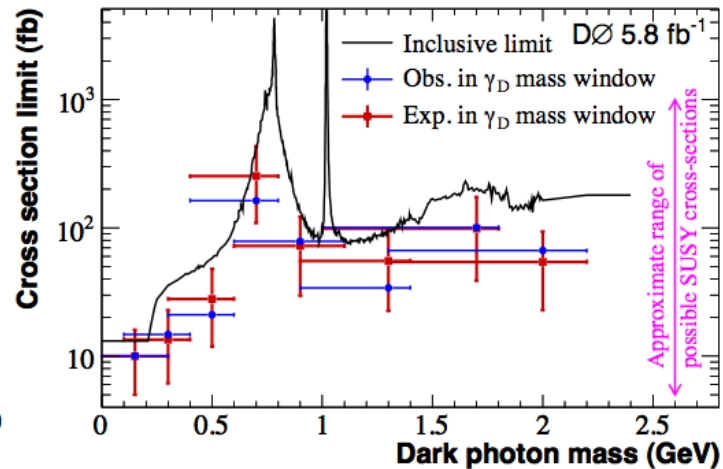
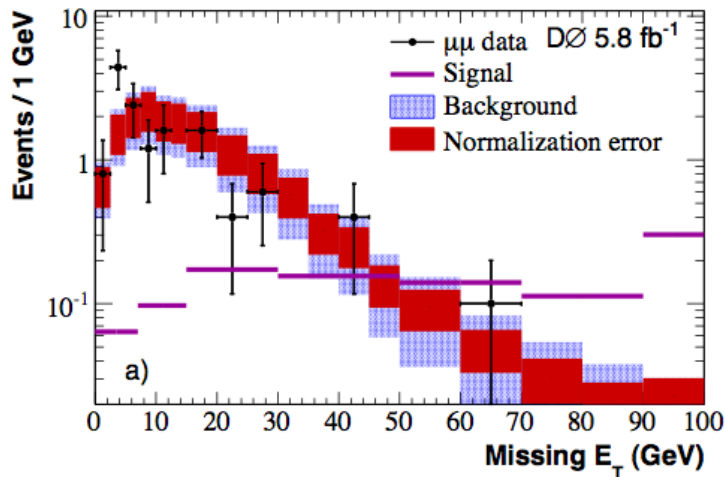
Why not just discuss individual leptons? When is the concept of Lepton Jets useful?

Lepton-Jets are useful when the collimation effect is so strong as to render the usual lepton isolation and reconstruction requirements harmful. There are so many other tracks and energy flow nearby that this object will likely fail the usual lepton searches.



# Experimental Search

Y. Gershtein and A. Haas have recently concluded the first search for these exotic objects at the Tevatron for D0 - Phys.Rev.Lett. 105 (2010)

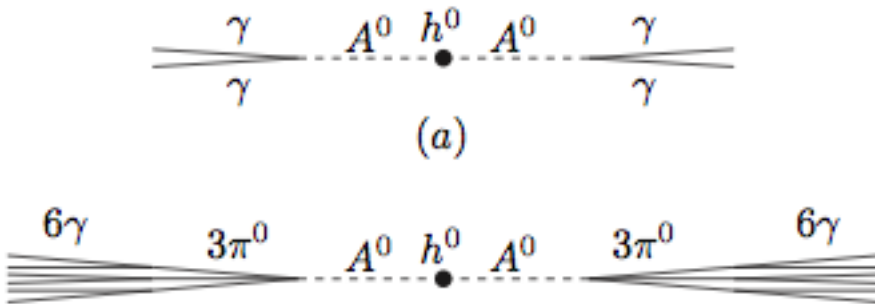


Other efforts under way:

- 1) CMS (see A. Safonov's talk)
- 2) CDF (see S. Wilbur's talk)
- 3) ATLAS (see E. Strauss' talk)
- 4) Long-lived lepton-jets (Ruderman, Volansky, Lubati. . .)
- 5) Lepton-jet efficiencies (Cranmer and van Huysduyenen for ATLAS)

# Photon Jets

Dobrescu, Landsberg, and Matchev, hep-ph/0005308 proposed Higgs to photons as an interesting signature. More generically light axion-like particle will yield many photons.



Taken from hep-ph/0005308

$$\frac{-\sqrt{2}}{16\pi\langle S \rangle} A^0 \epsilon^{\mu\nu\rho\sigma} (\alpha_s \mathbf{G}_{\mu\nu} \mathbf{G}_{\rho\sigma} + N_c e_\chi^2 \alpha F_{\mu\nu} F_{\rho\sigma})$$

Couples to gluons and photons.

Have to worry a little bit about the decay length . . .

$$L_A \approx 4 \text{ mm} \frac{M_h \langle S \rangle^2}{(100 \text{ GeV})^3} \left( \frac{1 \text{ GeV}}{M_A} \right)^4$$

