# Exotics

## Kathryn Zurek

# What Belongs to Exotics?

- Searches often focused only on weak scale phenomena, solutions to hierarchy problem

- New heavy quarks, new heavy vectors, superpartners

- Exotics are not these things, though in many cases they are limits of these theories

# Exotics

- Examples of exotics:
  - Often contain displaced vertices & high multiplicity events
  - Hidden Valleys
  - Unparticles
  - Dark Matter production through higher dimension operators
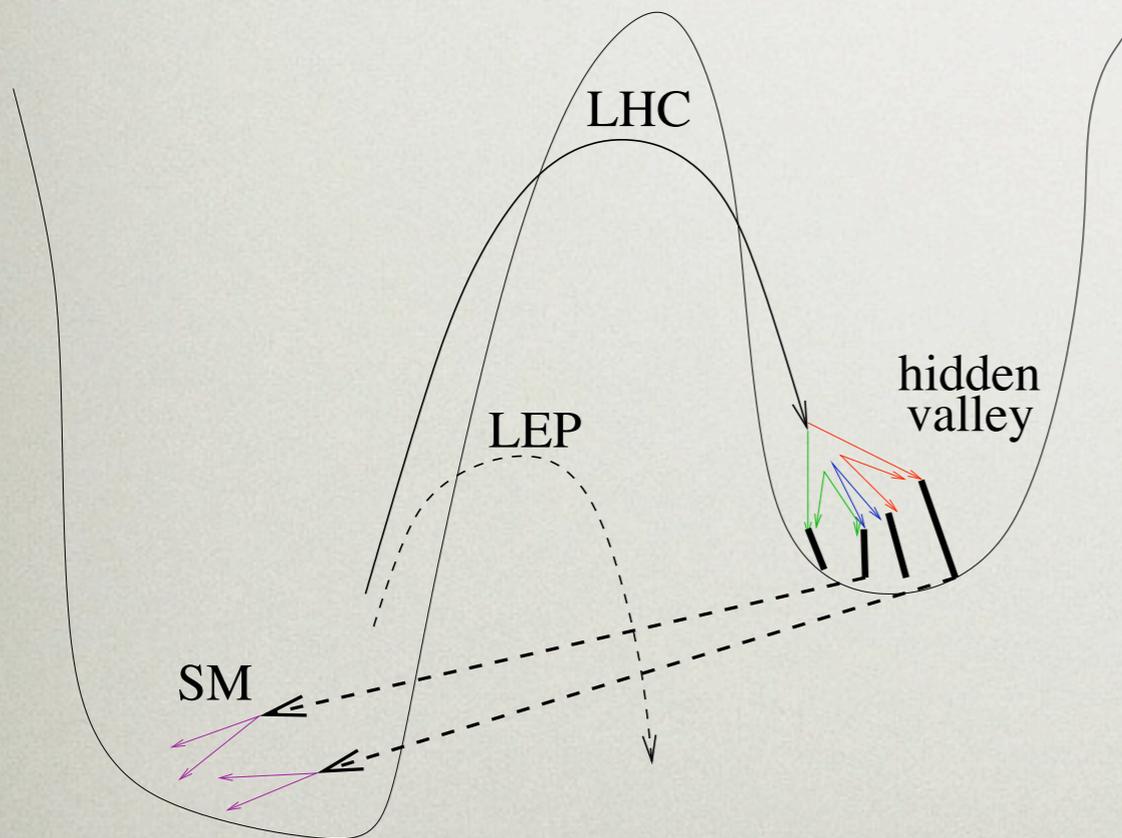  - Black Holes

# Exotics as Low Scale Extensions of EW

- e.g. gauge mediation

- Naturally obtain macroscopic or mesoscopic displaced vertices, e.g.

$$\tilde{\chi}_0 \rightarrow \gamma \tilde{G} \qquad \tau \sim \frac{M_{\text{Pl}}^2}{M_{\text{weak}}^3} \sim 10^5 \text{ s} - 10^8 \text{ s}$$
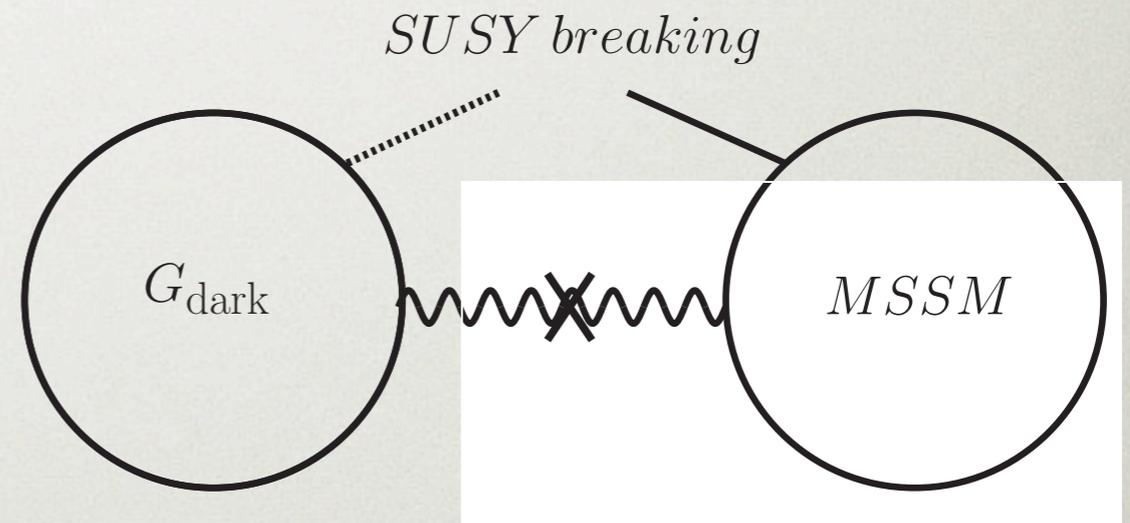
- Exotics occur anytime there is a very weakly coupled light state in addition to the usual weak scale physics

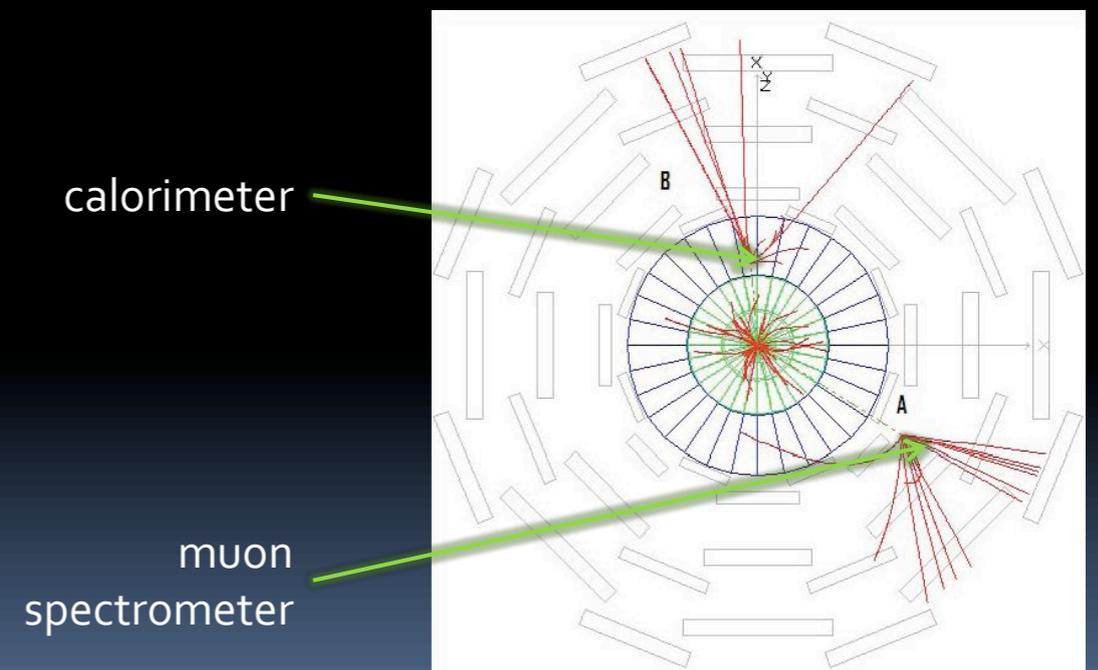- Probe different types of hidden sector physics



Higher Energy

More Luminosity

# Higher Energy Or Higher Luminosity

- Higher luminosity implies more squeezing on triggers for exotic events

**recent analyses**

| | |
|---|---|
| Hidden Valley | Jets appearing late |
| Charged, Massive Particles | $dE/dx$ |
| Anomaly-Mediated SUSY Breaking | Truncated Tracks |

calorimeter

muon spectrometer

bunch spacing, protons in bunch, beam tunes and focus → your favorite trigger squeezed here ← rate limit driven by $$ disk, cpu, etc.
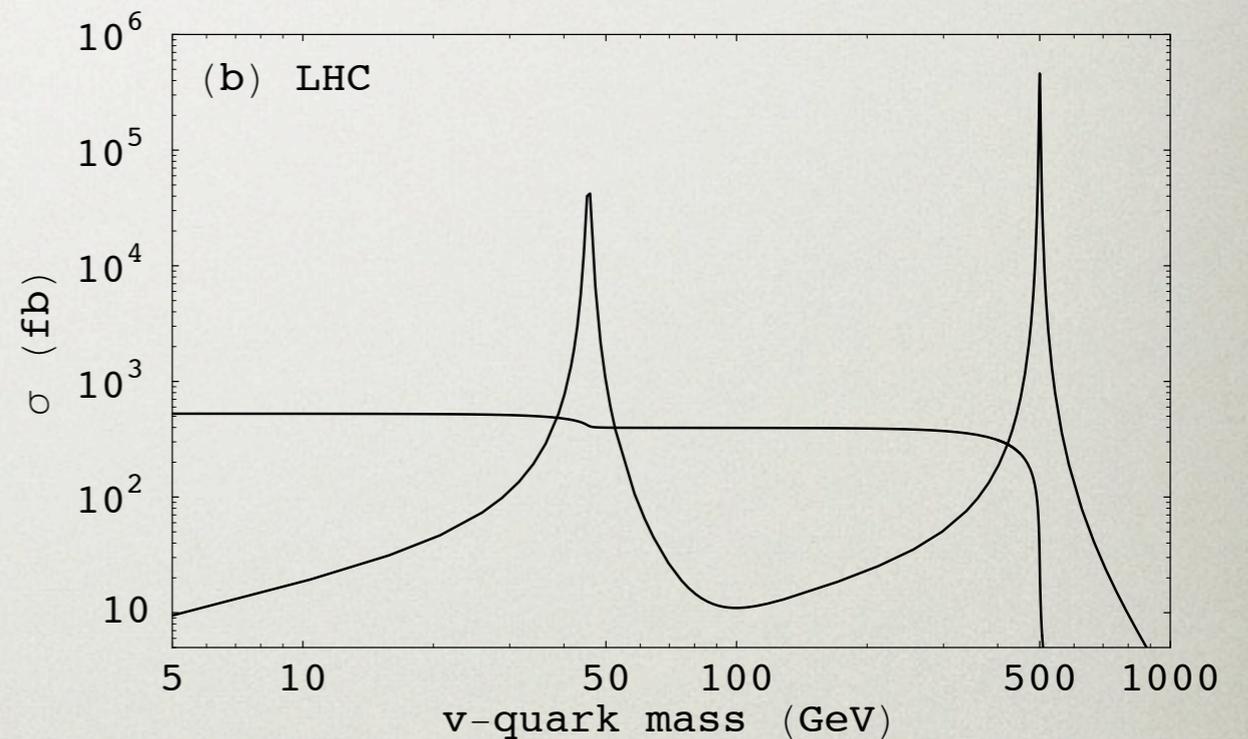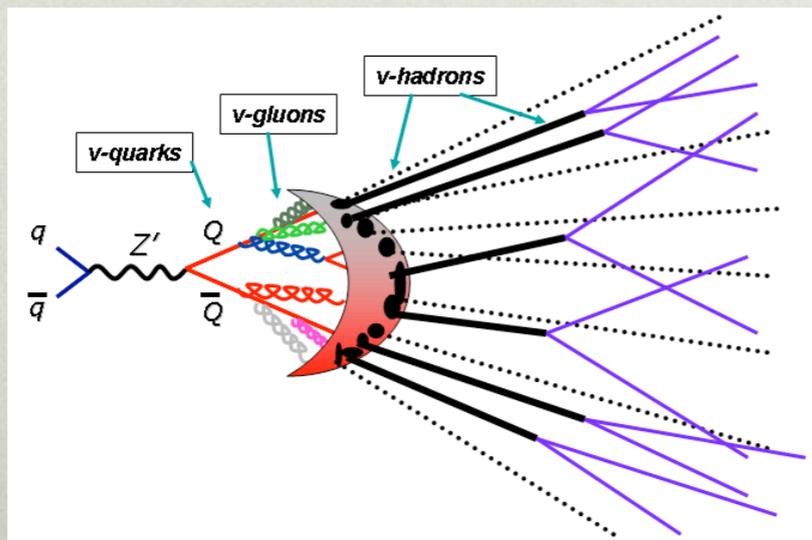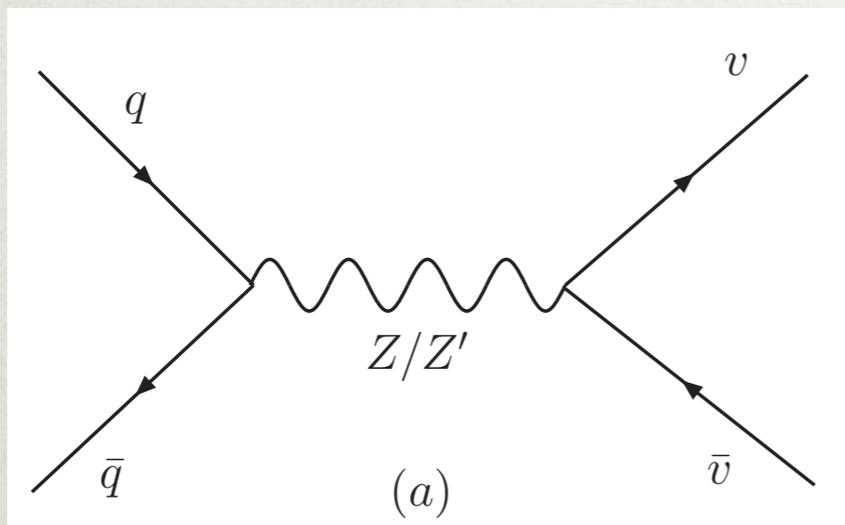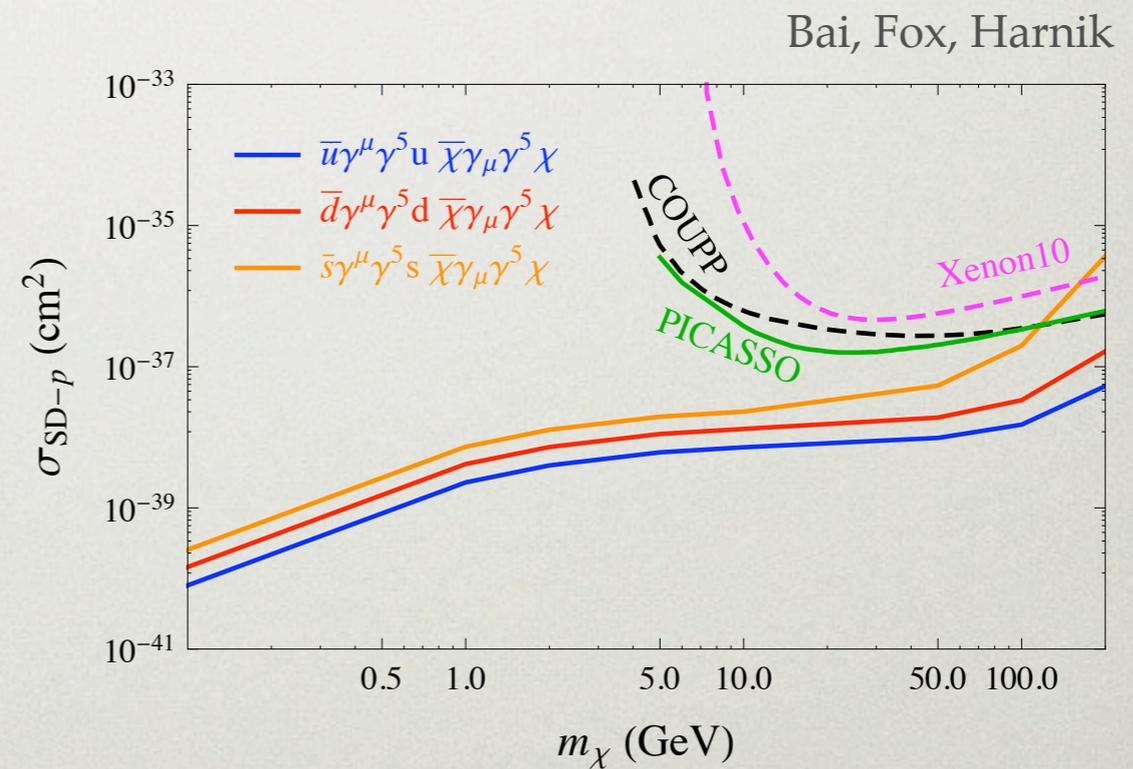
G. Watts, Search 2012

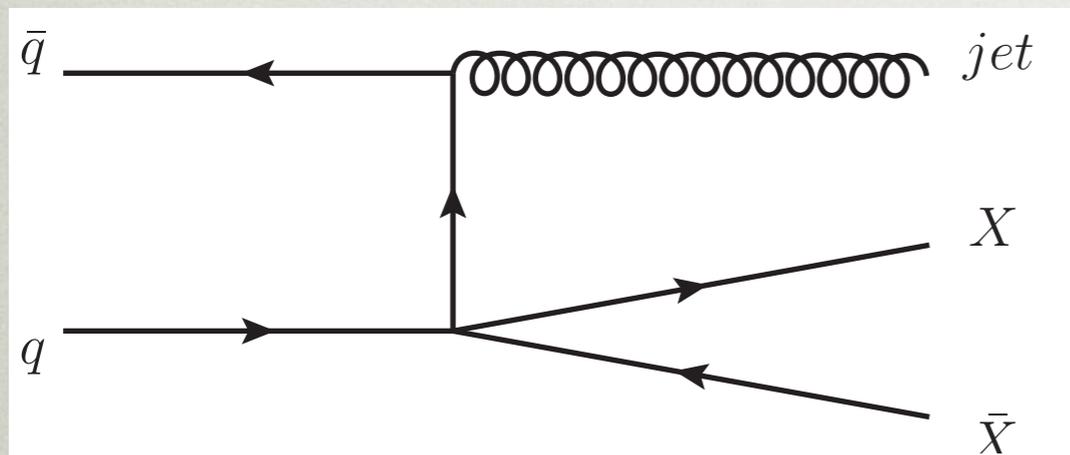# HIGHER ENERGY AND HIGHER LUMINOSITY



(c) Tevatron

- Complex topologies from complex events; small cross-sections to boot



(a)

$q$, $\bar{q}$, $Z/Z'$, $v$, $\bar{v}$



v-hadrons, v-gluons, v-quarks, $q$, $\bar{q}$, $Z'$, $Q$, $\bar{Q}$
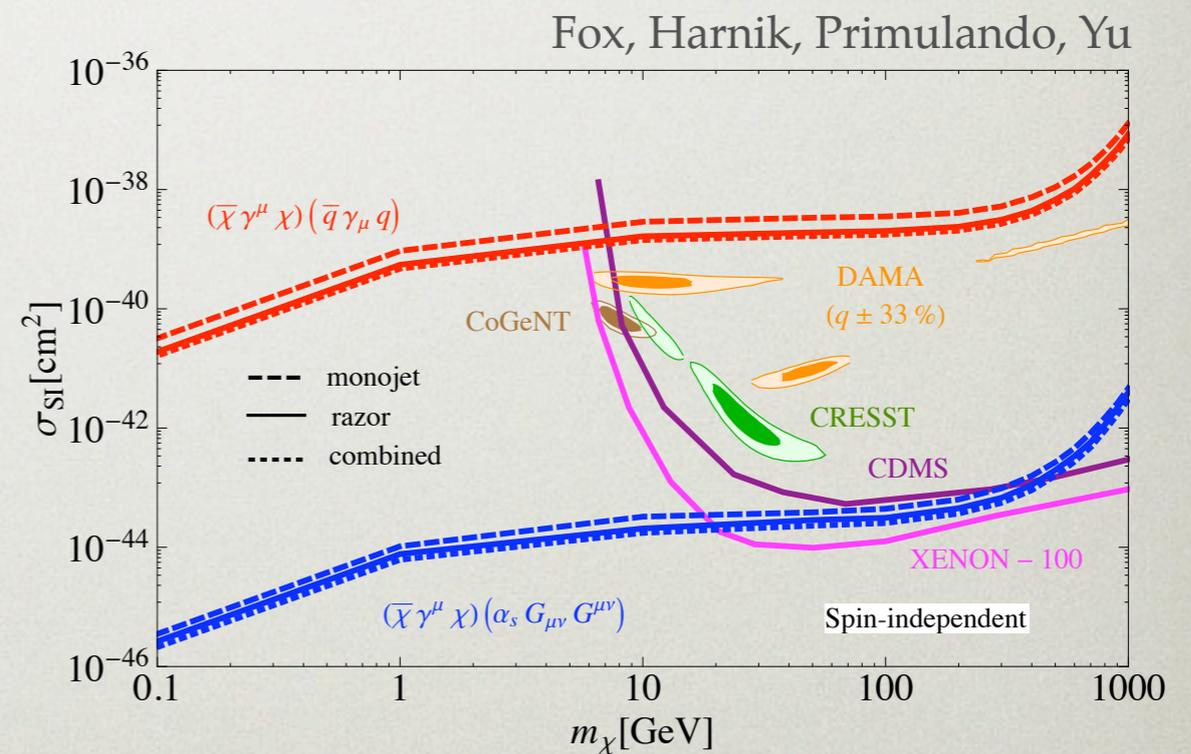


(b) LHC

$\sigma$ (fb)

v-quark mass (GeV)

# DM and Higher Dimension Operators

- Already reaching the limit of where higher dimension operator is reasonable approximation



Bai, Fox, Harnik
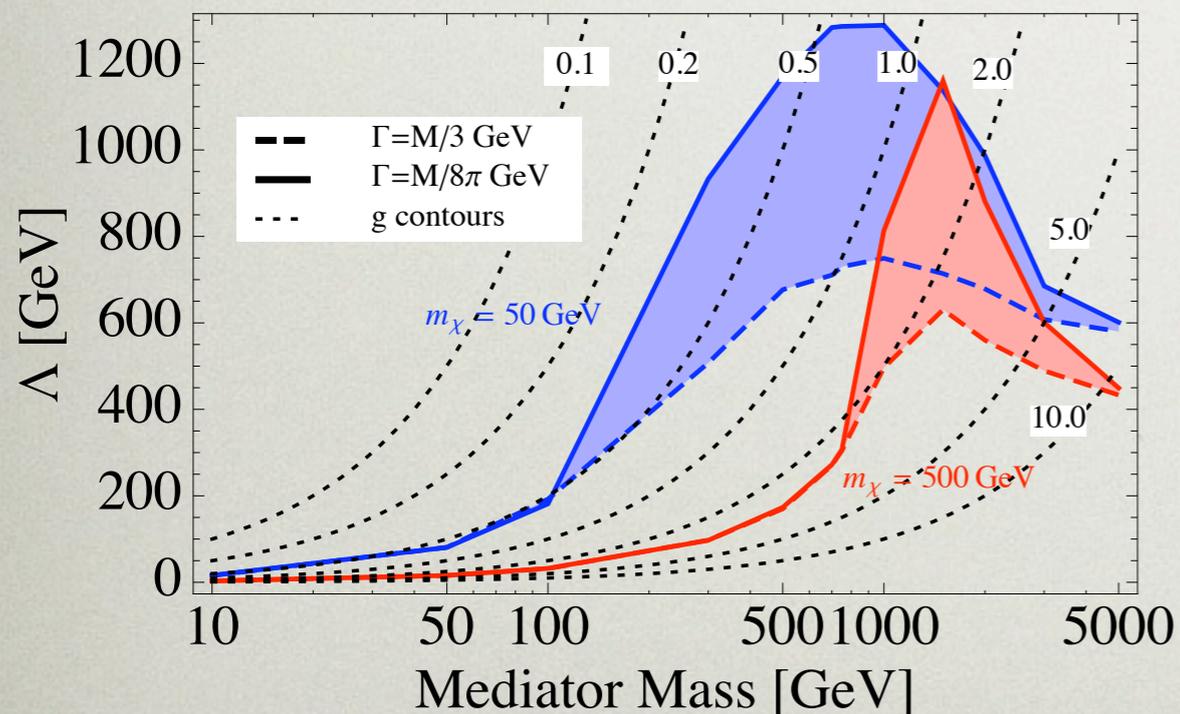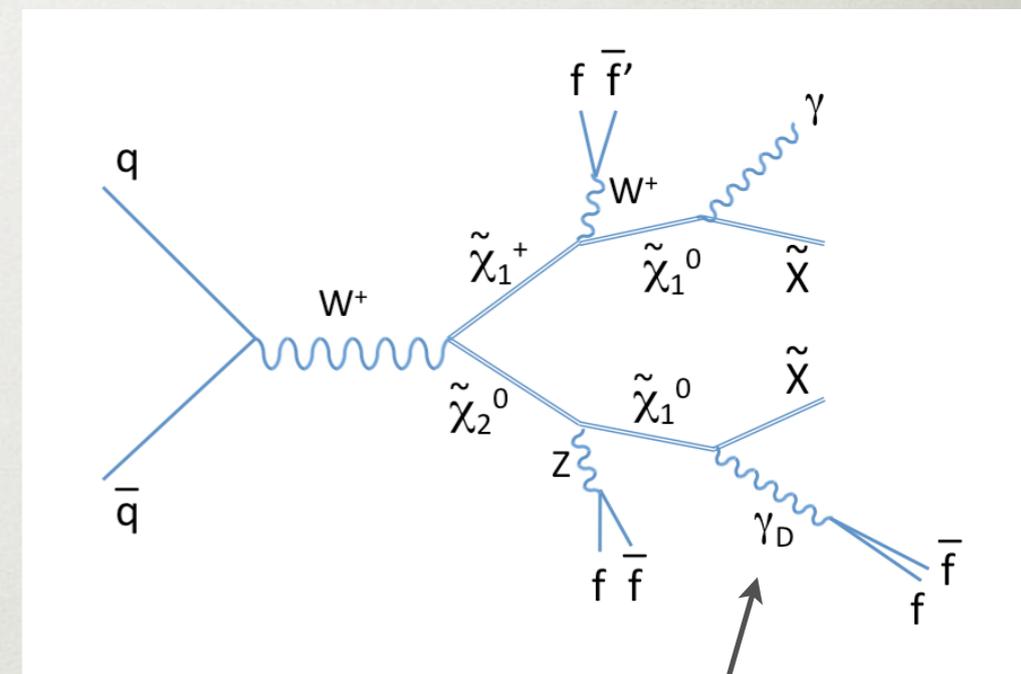
# DM and Higher Dimension Operators

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Fox, Harnik, Primulando, Yu

# SUSY and Exotics

- More sensitivity to EW SUSY usually implies more sensitivity to exotics with displaced vertices



Small couplings via small kinetic mixing parameter

# Discussion

- How can we maximize the luminosity / energy interplay for exotics with exotic topologies?

- Are there additional handles that can be utilized for topologies with displaced vertices when the displaced vertex handles are reduced?

- Topologies with high multiplicities, often with a lot of soft activity?