

EXOTICS

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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:
 - Hidden Valleys
 - Unparticles
 - Dark Matter production through higher dimension operators
 - Black Holes

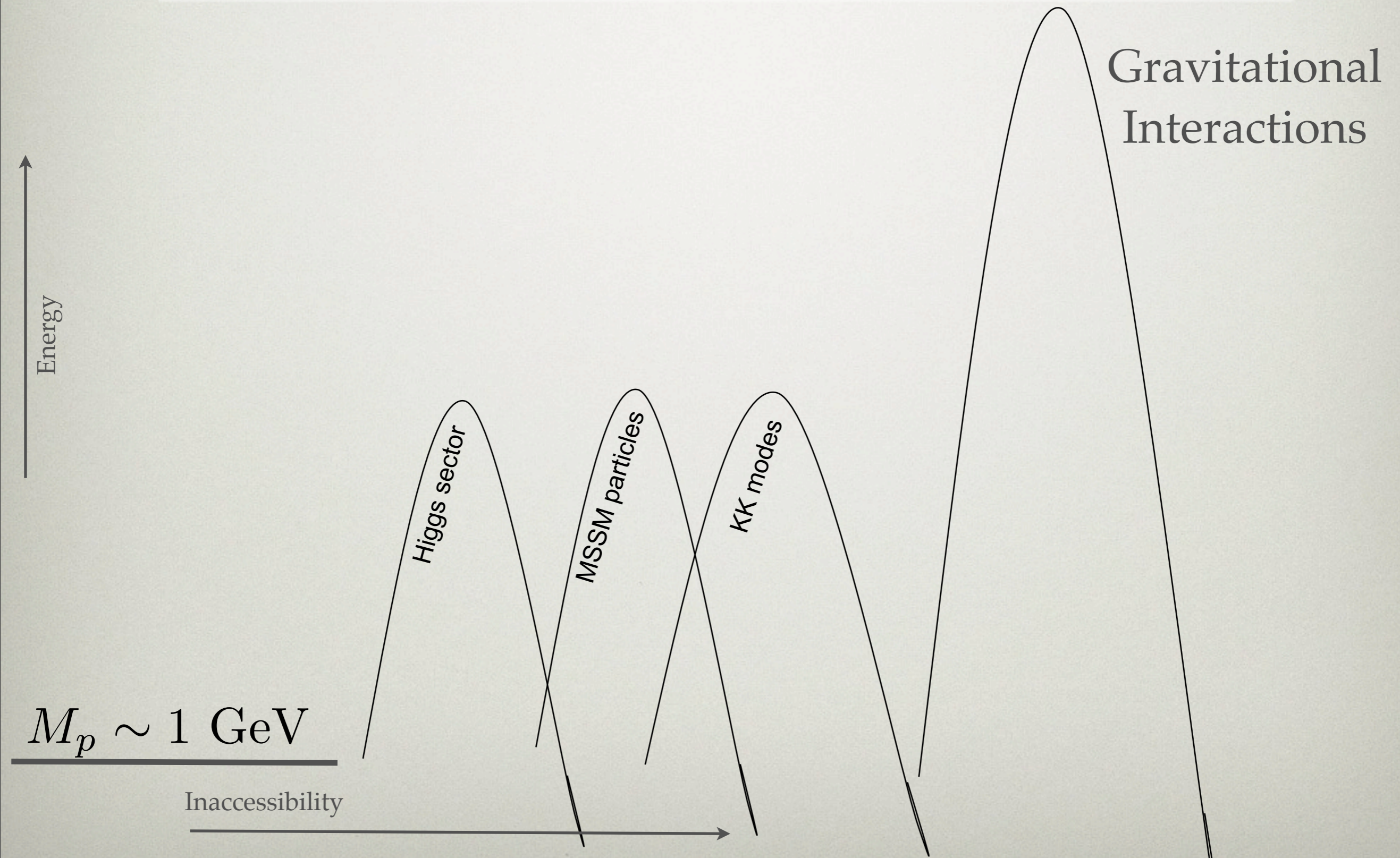
EXOTICS AS LOW SCALE EXTENSIONS OF EW

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

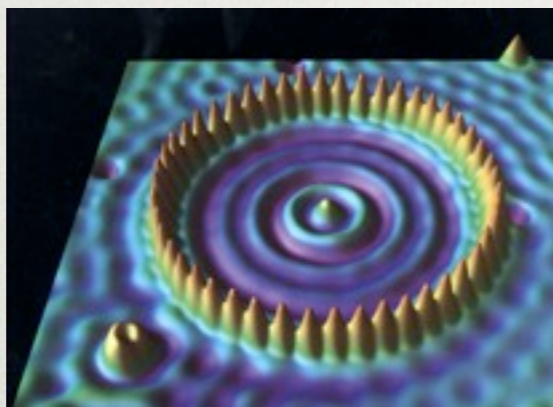
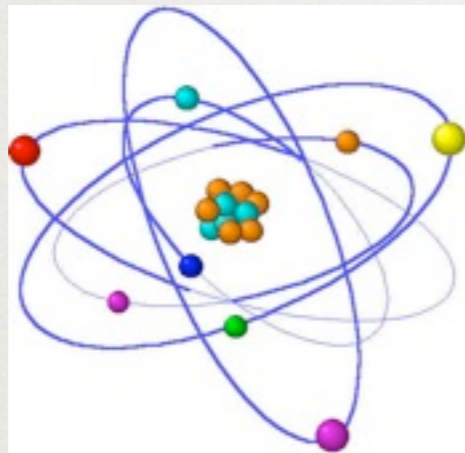
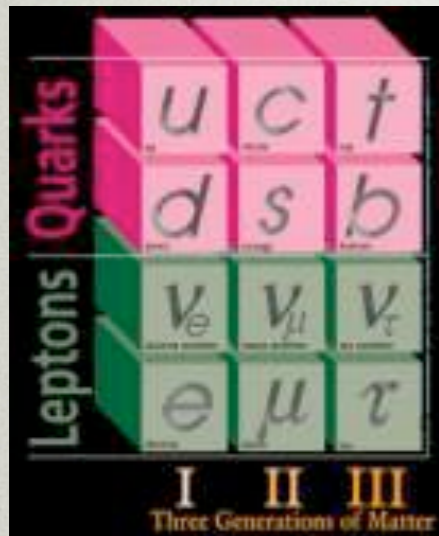
$$\tilde{\chi}_0 \rightarrow \gamma \tilde{G} \quad \tau \sim \frac{M_{\text{Pl}}^2}{M_{\text{weak}}^3} \sim 10^5 \text{ s} - 10^8 \text{ s}$$

- Exotics occur anytime there is a very weakly coupled light state in addition to the usual weak scale physics

HUNT FOR ELECTROWEAK PHYSICS



EXOTICS PRODUCTION



Energy

$$M_p \sim 1 \text{ GeV}$$

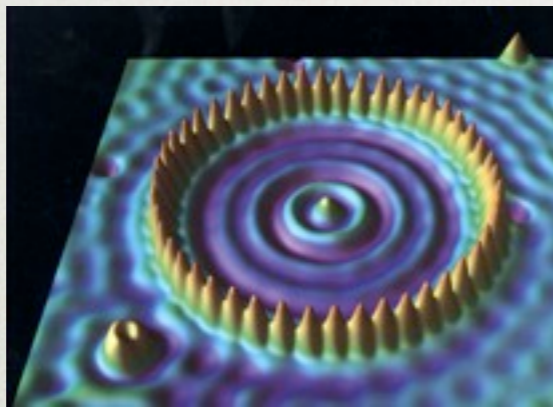
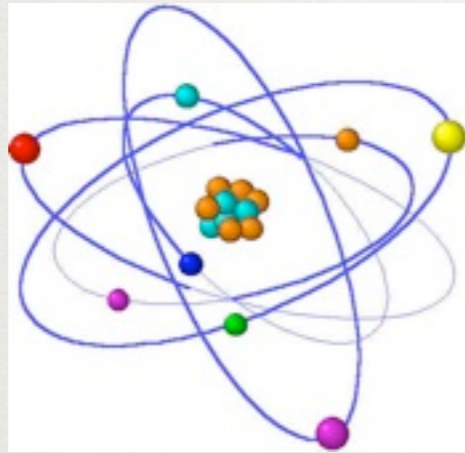
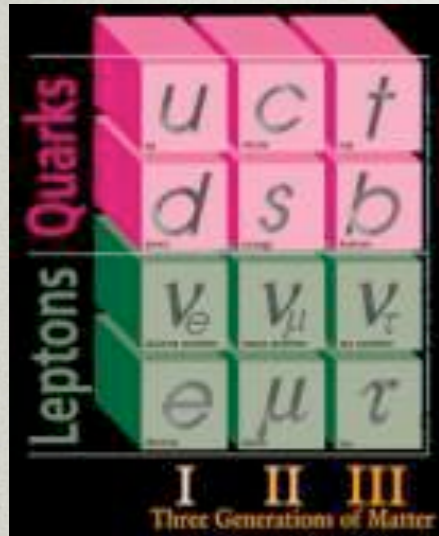
Standard Model

Inaccessibility



Dark Matter?

EXOTICS PRODUCTION



Energy

$$M_p \sim 1 \text{ GeV}$$

Standard Model

Inaccessibility

Multiple resonances

Hidden Valley
Could be complex!

Dark forces and dark
Higgs mechanism

STRONG DYNAMICS IN THE HIDDEN SECTOR?

Strassler, KZ

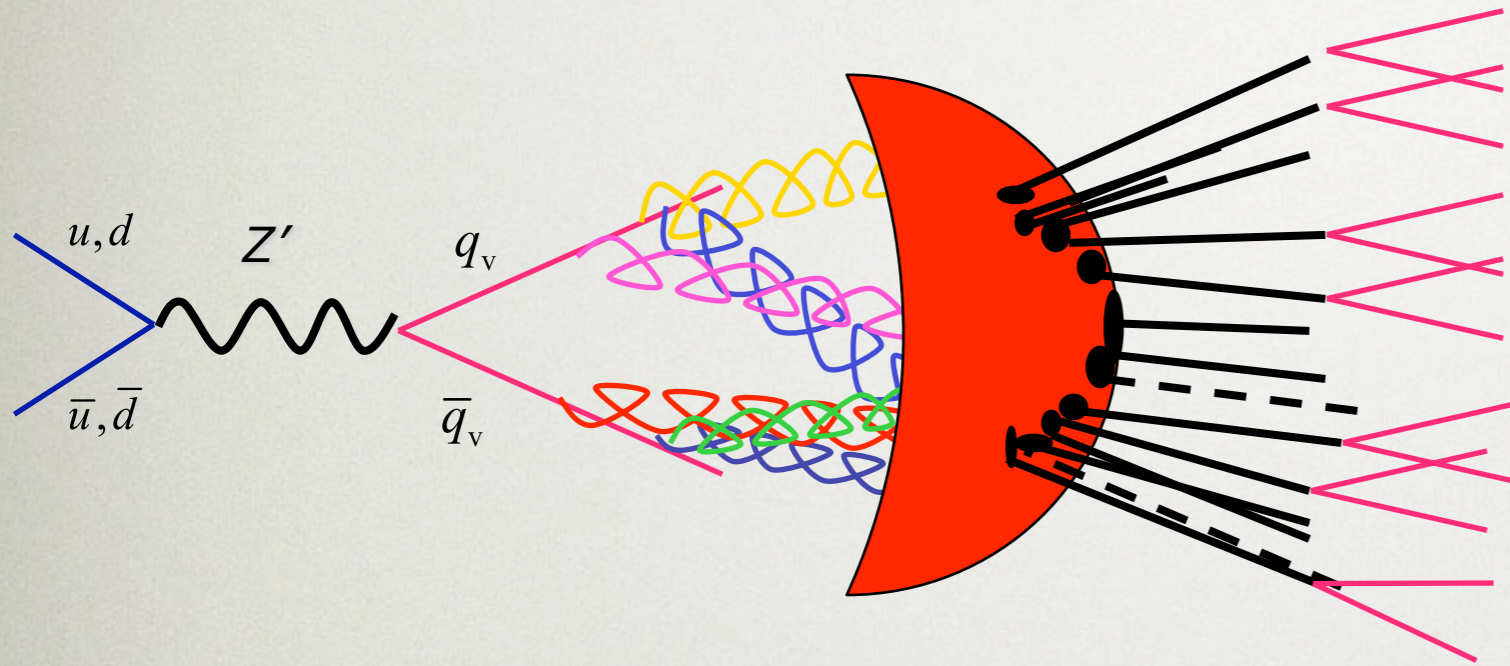
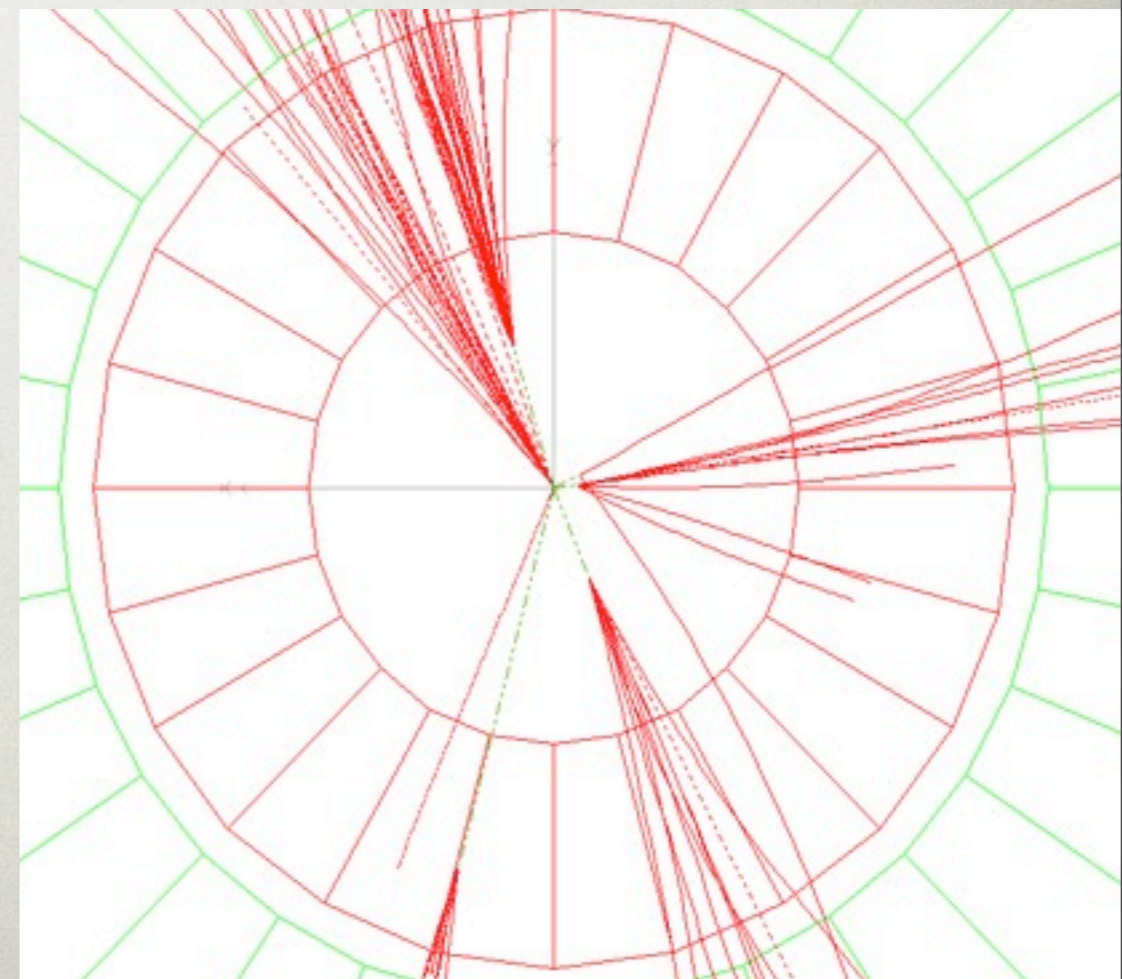


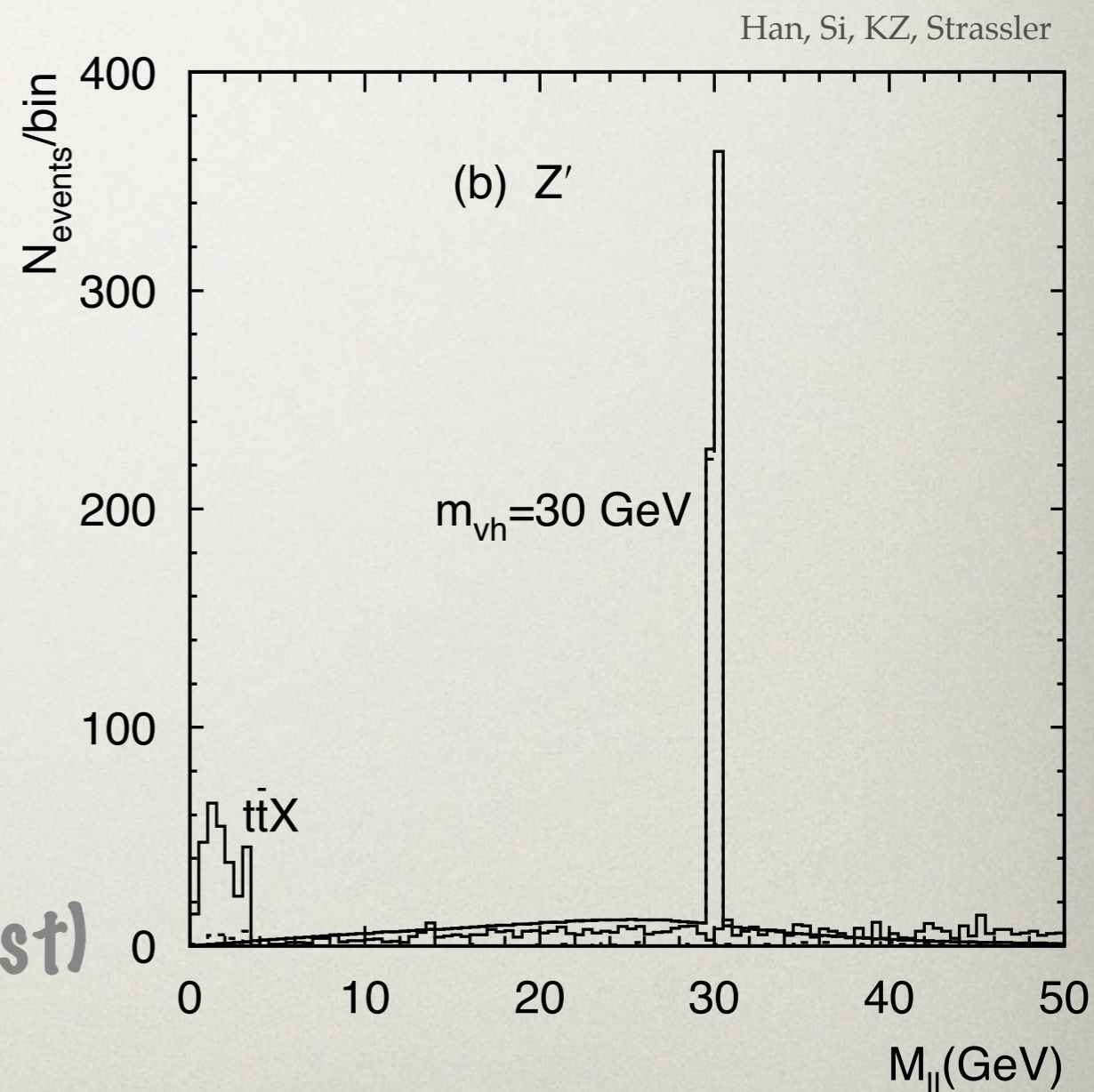
Image courtesy of Rome/Seattle ATLAS working group on displaced decays



Features:
High multiplicities?
Long Lifetimes?
Hadronically busy events?
Low mass resonances?

HANDLES ON NON-ABELIAN HIDDEN VALLEY

- Use occasional decays of resonances to leptons
- * High invariant mass
- * Multiplicity
- * Hard muons (two, $p_T > 10$ GeV)
- * Event shape (sphericity and thrust)



TOOLS AVAILABLE FOR SIMULATION

Carloni, Sjostrand

- Adaptable MC program available in
PYTHIA 8

name	partner	code	name	partner	code
D_v	d	4900001	E_v	e	4900011
U_v	u	4900002	ν_{Ev}	ν_e	4900012
S_v	s	4900003	MU_v	μ	4900013
C_v	c	4900004	ν_{MUv}	ν_μ	4900014
B_v	b	4900005	TAU_v	τ	4900015
T_v	t	4900006	ν_{TAUv}	ν_τ	4900016
g_v		4900021			
γ_v		4900022			
q_v		4900101			

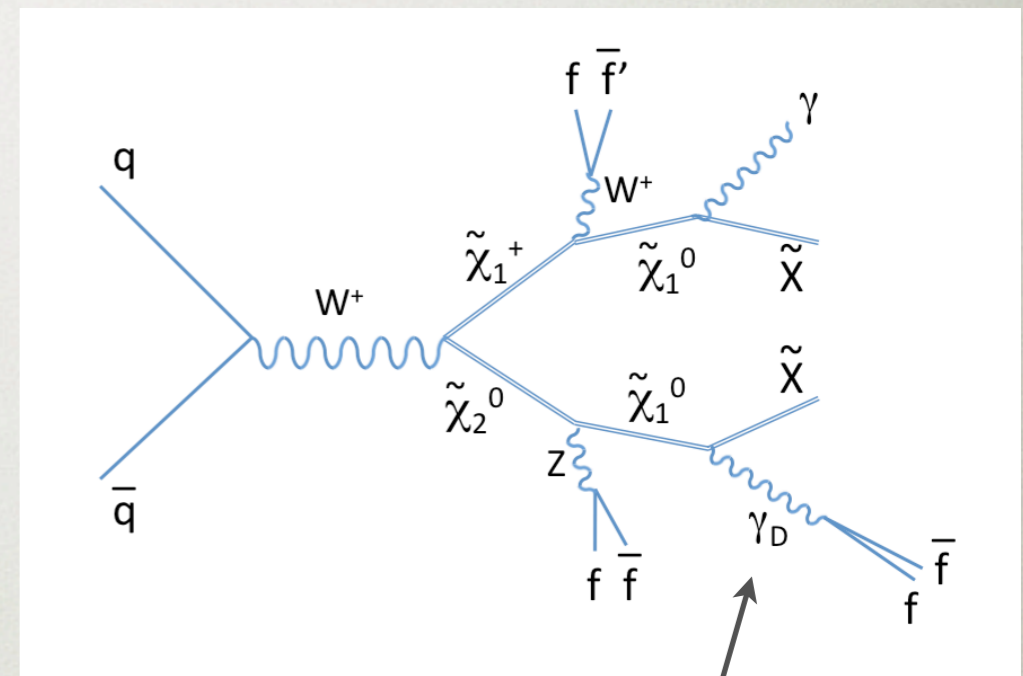
- Allows one to set the hidden coupling
and confinement

ABELIAN DYNAMICS IN THE HIDDEN VALLEY?

Strassler
Arkani-Hamed, Finkbeiner, Slatyer, Weiner

- Dark U(1)
- Make use of lepton jets
- Low mass resonances
- Sometimes displaced vertices

D0



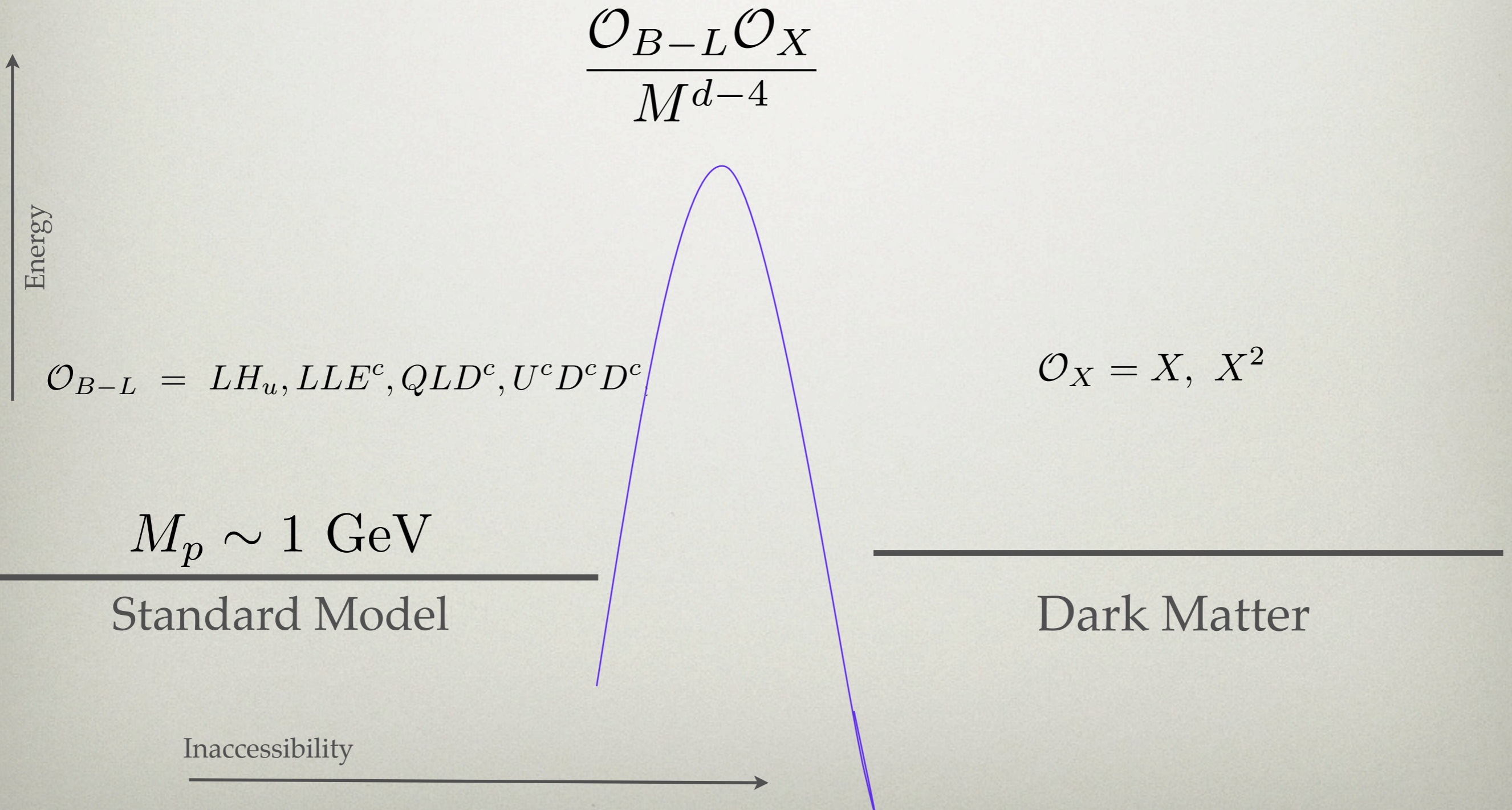
Small couplings via small
kinetic mixing parameter

DARK MATTER MODELS

- Dark Matter may also reside in a Hidden Valley
- MSSM LSP unstable to decay into DM sector
- NEW supersymmetry signatures

ASYMMETRIC DM

Luty, Kaplan, KZ



“OTHER” EXOTICS

Meade, Randall

- Black Holes
 - Very high multiplicity thermal distributions
 - Standard Compositeness tests can be used, looking for leptonic and hadronic resonances in the final state

“GENERIC” SEARCHES

“Simplified Models”
document

- di-photon resonance plus anything in high HT event
- di-lepton resonance plus anything in a high HT event
- high HT with reduced missing energy in extended SUSY decays
- multi-lepton, multi-jet high HT events, where weak p_T cuts on the jets, photons are traded for high multiplicities of objects

SUMMARY

- Simple extensions of weak scale models give rise to “exotic” Hidden Valley like signatures in broad class of models
- This can affect supersymmetry and dark matter searches
- LHC experiments have broad reach capabilities with the right types of search techniques