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Semi-visible jets & the mystery of its' substructure

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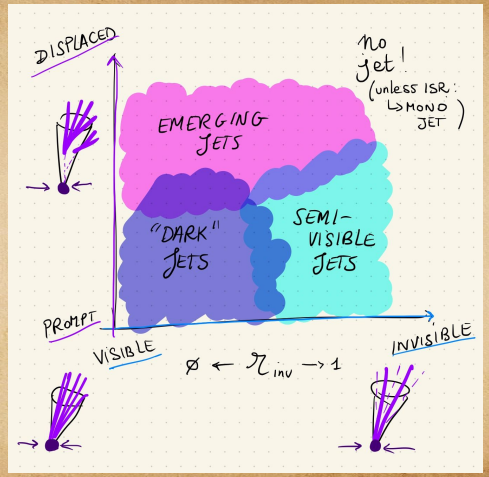
Introduction

We have not found any signs of new physics ... yet!

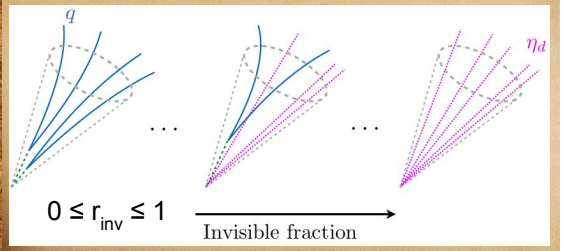
Looking at unusual topologies and hidden corners of the phase space

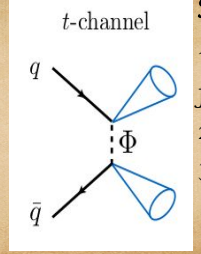
- signature based searches, using benchmark models.

Dark hadrons decaying in a QCD-like fashion, partially back to visible sector (semi-visible jets)



Based on: Tim Cohen et al [arXiv: 1707.05326]





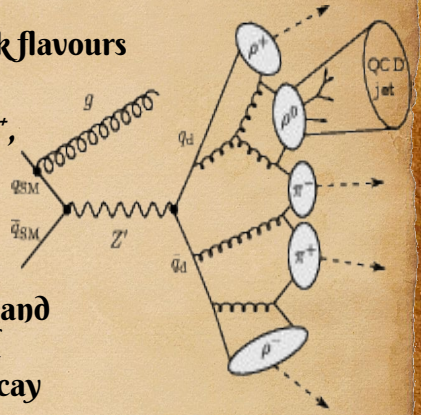
Model Parameters:

1. $\mathcal{M}_\Phi$ = mass of Scalar bi - fundamental (mediator)
2. $\mathcal{M}_D$ = mass of dark hadrons
3. r_{inv} = $\frac{\text{no. of stable dark hadrons}}{\text{no. of hadrons}}$

Hidden Valley: Semi-visible jets (SVJ) idea

Two different dark quark flavours

Combine to form π^+, π^-, π^0, and ρ^+, ρ^-, ρ^0



Only ρ^0 is unstable and (promptly) decays to SM quarks: more likely to decay to b pairs due to need for a mass insertion, to make the angular momentum conservation work out

Other mesons are (collider-)stable → invisible

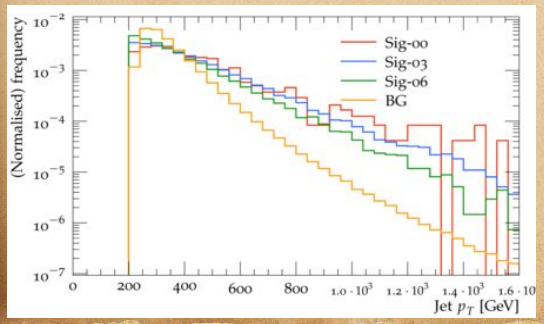
Showering mostly using Pythia Hidden Valley module: at best a guesstimate!

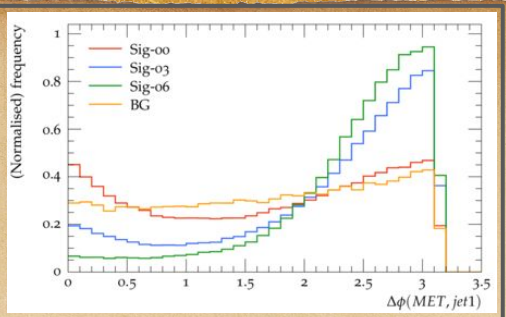
Jet substructure study

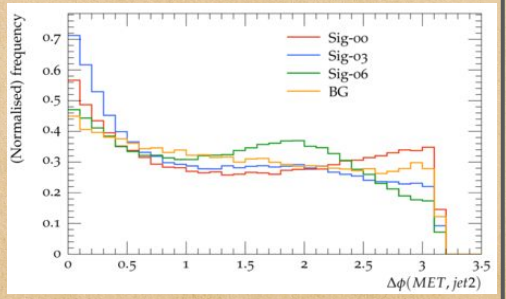
Comparing jet substructure (JSS) variables to see if SVJ substructure is different from light quark/gluon jets (BG).

Do they behave more multi-pronged as opposed to mostly single prong?

Comparison done in p_T bins as there is no resonance.







Subleading jets tend to align more with MET, which makes it harder to study

Variables considered for the study

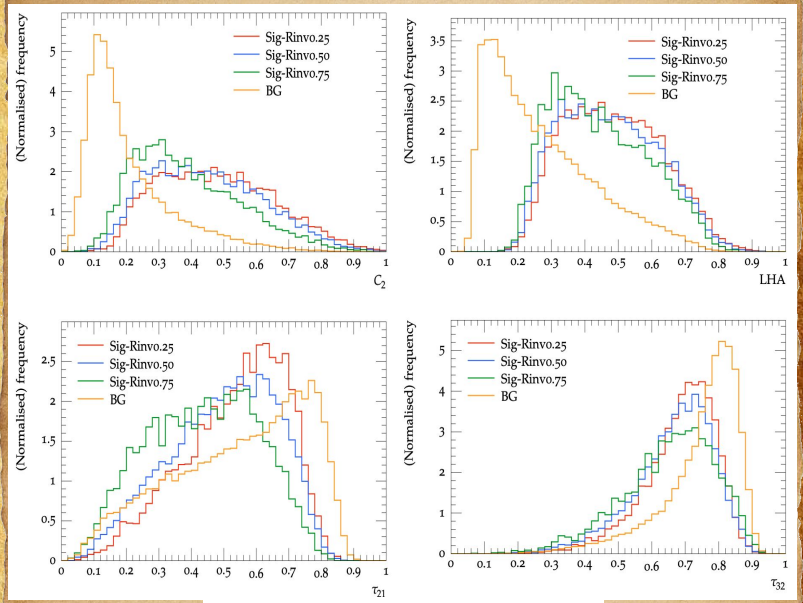
Energy correlation double ratios, C2: Higher value has more subjets

2/3-Subjettiness, τ_{21}/τ_{32} : Lower values indicate more 2/3 subjet like behaviour

Les Houches Angularity: higher value means hard radiations are more separated

Effects responsible for specific jet substructure of semi-visible jets

Signals generated at different r_{inv} fractions and multijet BG considered



BG, signal rinv 25, 50, 75

For finite r_{inv} values, subtle substructure difference observed for different r_{inv} values, when only the visible hadrons are clustered in jets.

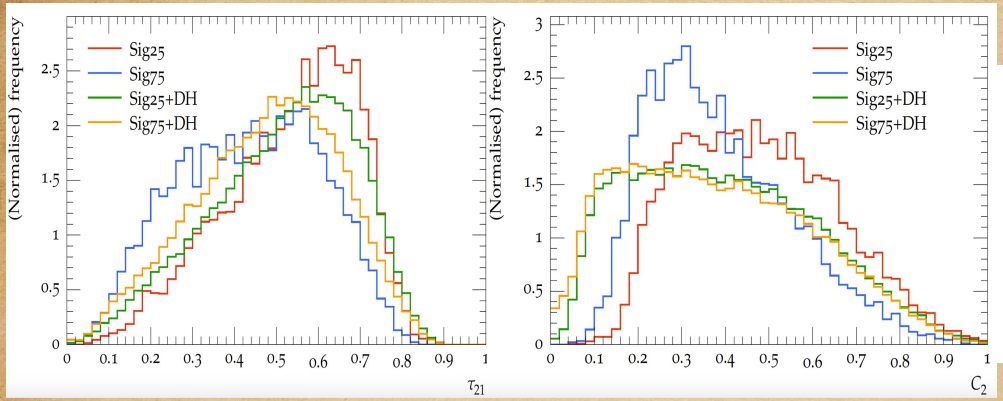
HOGWARTS

DECODING THE DARK ARTS

Is the dark sector responsible for the different jet substructure of SVJ?

Cluster final dark hadrons into jets

- expect this difference to go away, since the different amount of missing hadrons in each case presumably is responsible for the difference.



Only visible: r_{inv} 0.25, 0.75

Visible+dark hadrons: r_{inv} 0.25, 0.75

Conclusions:

- The substructure becomes less two-pronged with visible and dark hadrons in them, and the absence of the dark hadrons create the two-pronged structure -> The substructure is created by the interspersing of visible hadrons with dark hadrons.
- Specific hidden valley parameter configurations can reduce the dark shower model dependent features of the signal jets.

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Exploring jet substructure in semi-visible jets

Deepak Kar, Sukanya Sinha

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However... there's always something else lurking behind the shadows...

Only one dark shower module so far, need more for estimating theory/model uncertainties ---> Exploring potential Herwig dark shower module

Possibility of other JSS observables that distinguish SVJ from q/g jets better?
---> Maybe along the lines of Energy flow Polynomials... [based on arXiv:1712.07124]