Hunting the Dark Higgs

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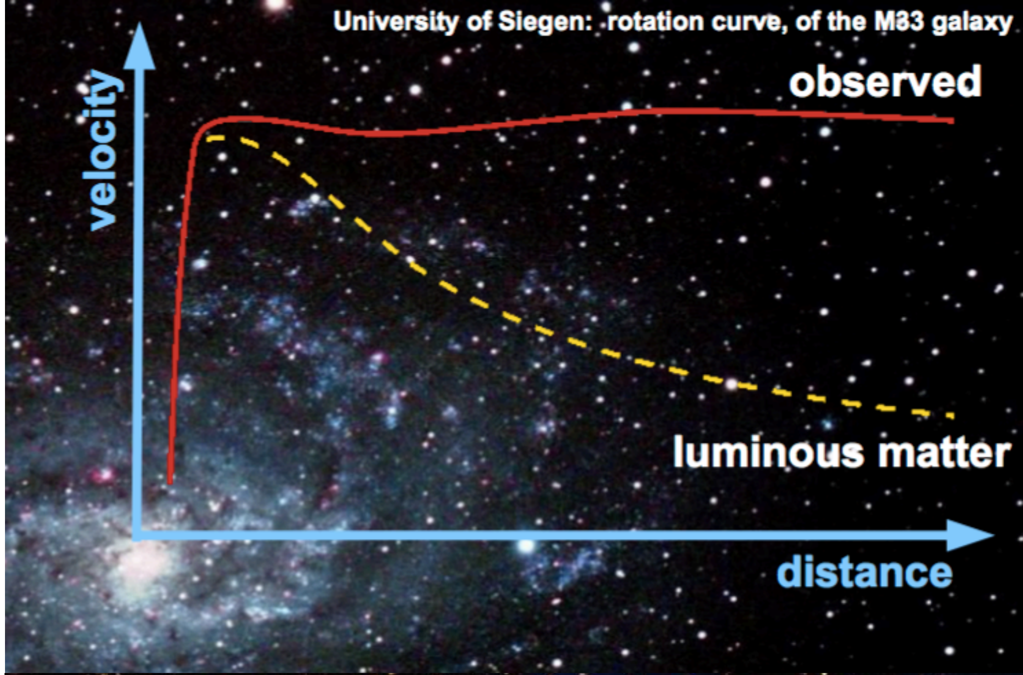
DESY

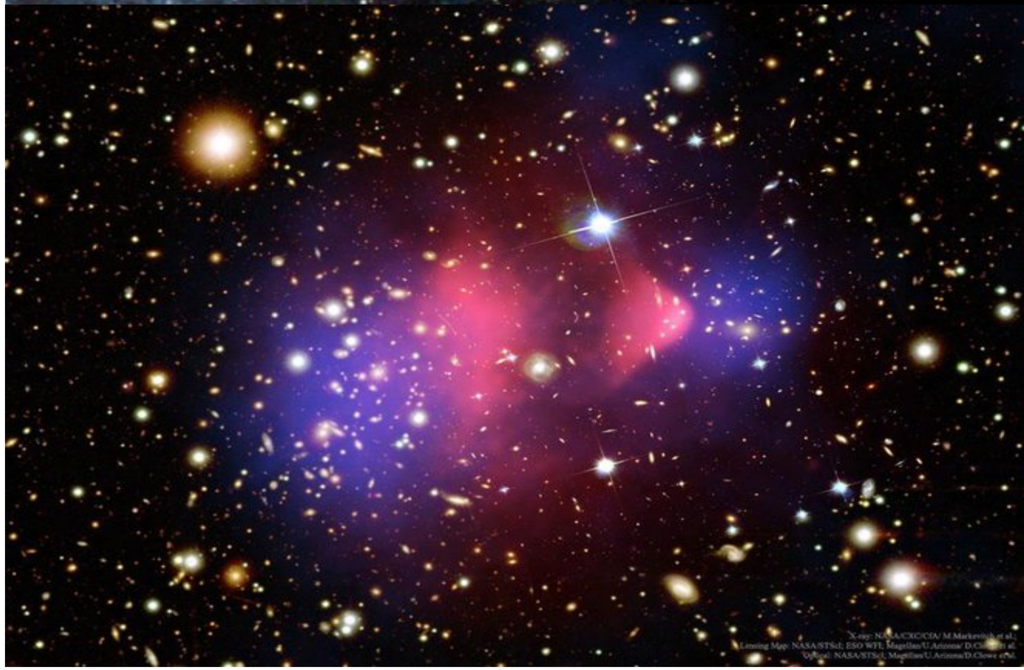
CMS
Compact Muon Solenoid

Contents

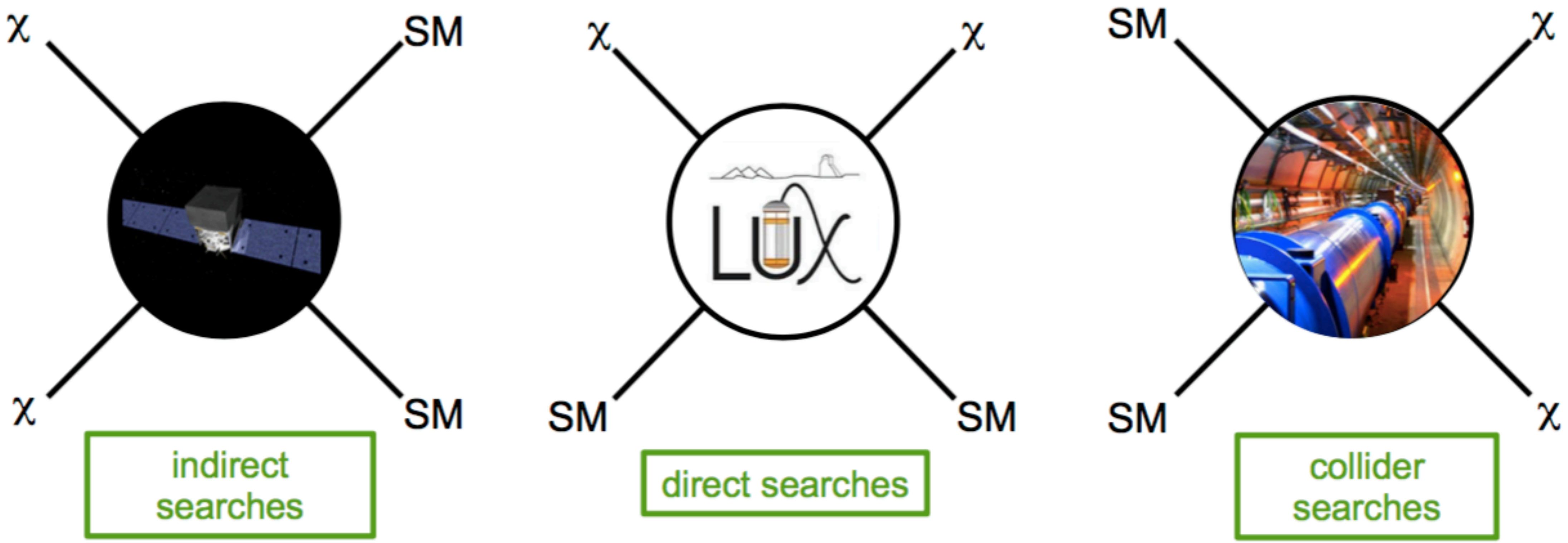
Dark Matter

- A popular assumption for Dark Matter is to regard them as WIMPs, weekly interacting massive particles

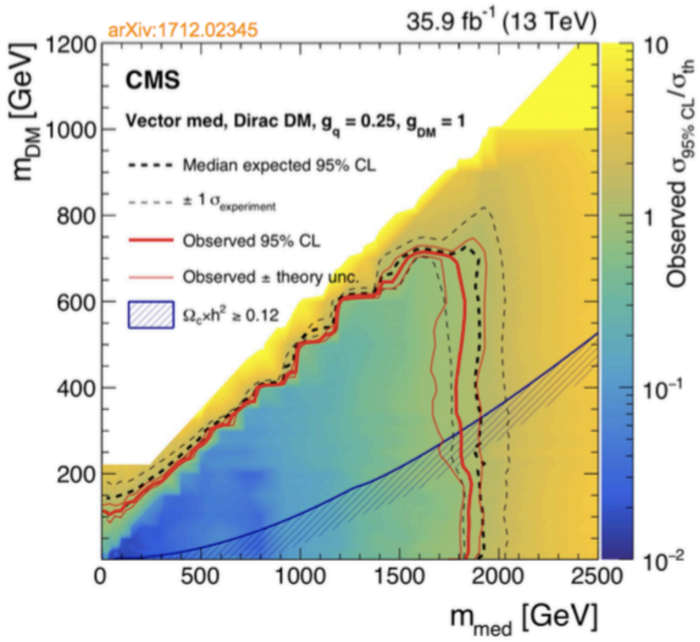


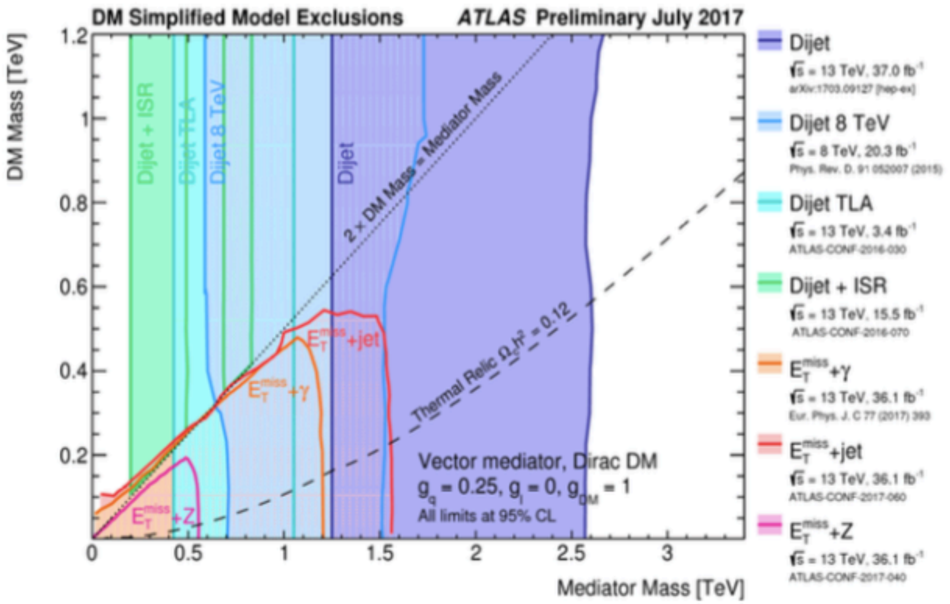


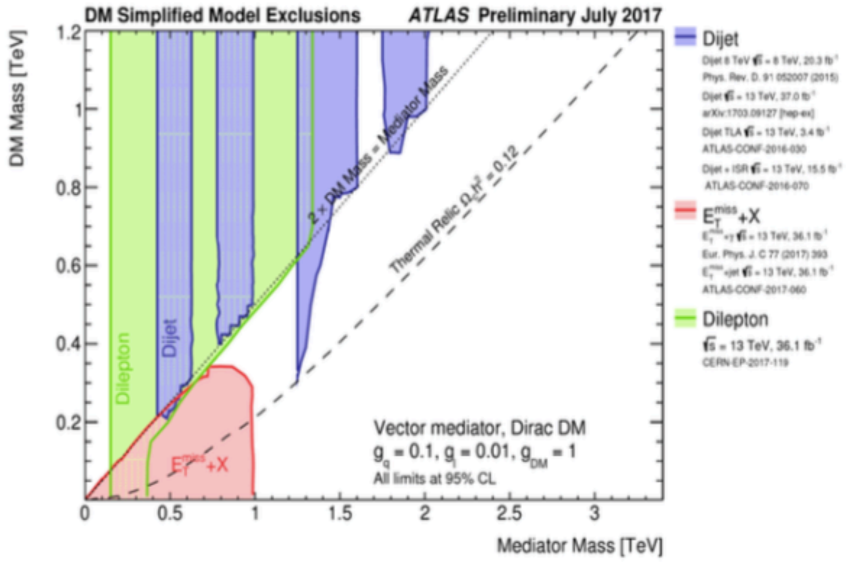
Dark Matter Search Strategies



Limitations of Simple Dark Matter Models





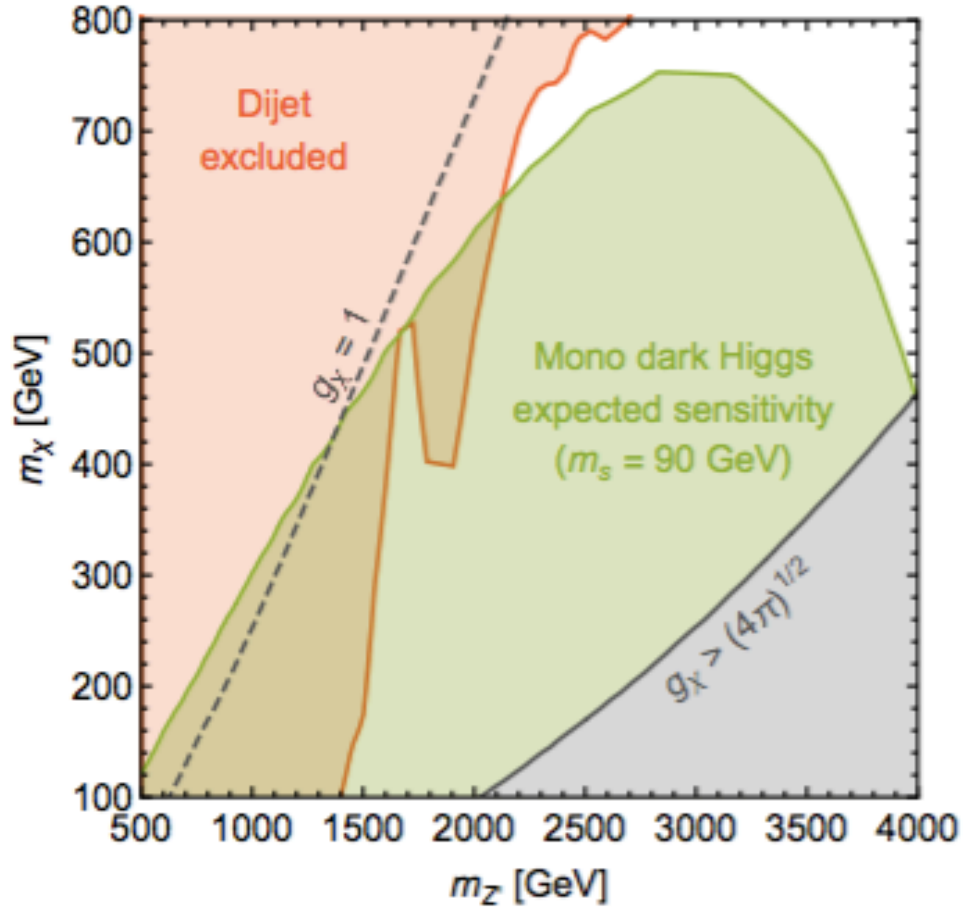


Advantage of the Dark Higgs Model

Adding a Dark Higgs which is lighter than Dark Matter enables an annihilation process for Dark Matter that relaxes the constraints for reaching the observed Dark Matter relic abundance

$$\chi\chi \rightarrow ss$$

$$s \rightarrow \mathrm{SM}$$



Dark Higgs Model

- New U(1)’ gauge group with three new particles
  - A vector boson, *Z’*
  - A fermionic Dark Matter particle, χ
  - A scalar boson, *s* (the Dark Higgs)
- The masses of *Z’* and χ and the existence of the Dark Higgs are a result of spontaneous symmetry breaking of the new U(1)’ symmetry group

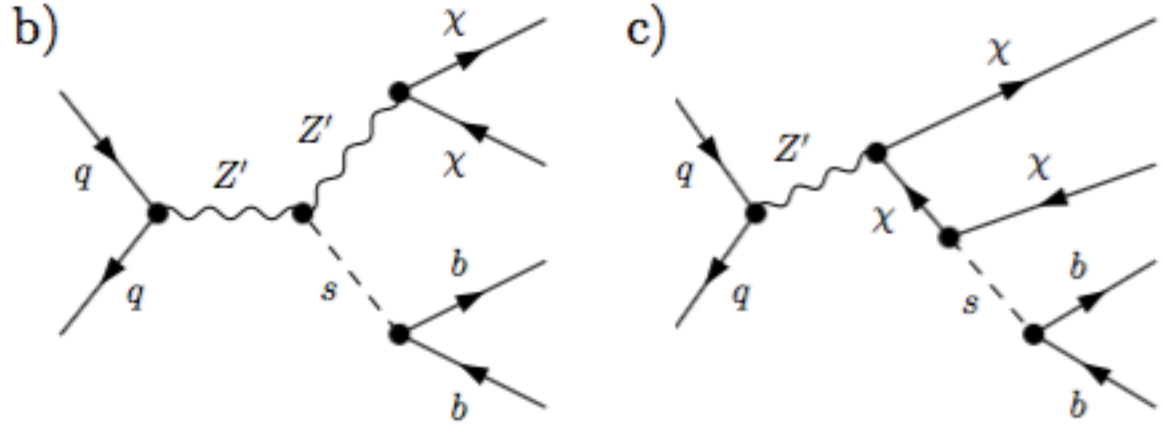
$$\mathcal{L}_\chi = -\frac{1}{2} g_\chi Z'^\mu \bar{\chi}\gamma^5\gamma_\mu\chi - g_\chi \frac{m_\chi}{m_{Z'}} s\bar{\chi}\chi + 2\, g_\chi\, Z'^\mu Z'_\mu \left(g_\chi\, s^2 + m_{Z'} s\right)$$

- The Z’ is also coupled to quarks, giving rise to the following term:

$$\mathcal{L}_\chi = -g_q Z'^\mu \bar{q}\gamma_\mu q$$

Expected Signal

- The Dark Higgs can decay to Standard Model particles via a small but non-zero mixing angle to the Standard Model Higgs
- We assume the following mass relations: $m_{Z'} > 2m_{\chi}$, $m_{\chi} > m_s$

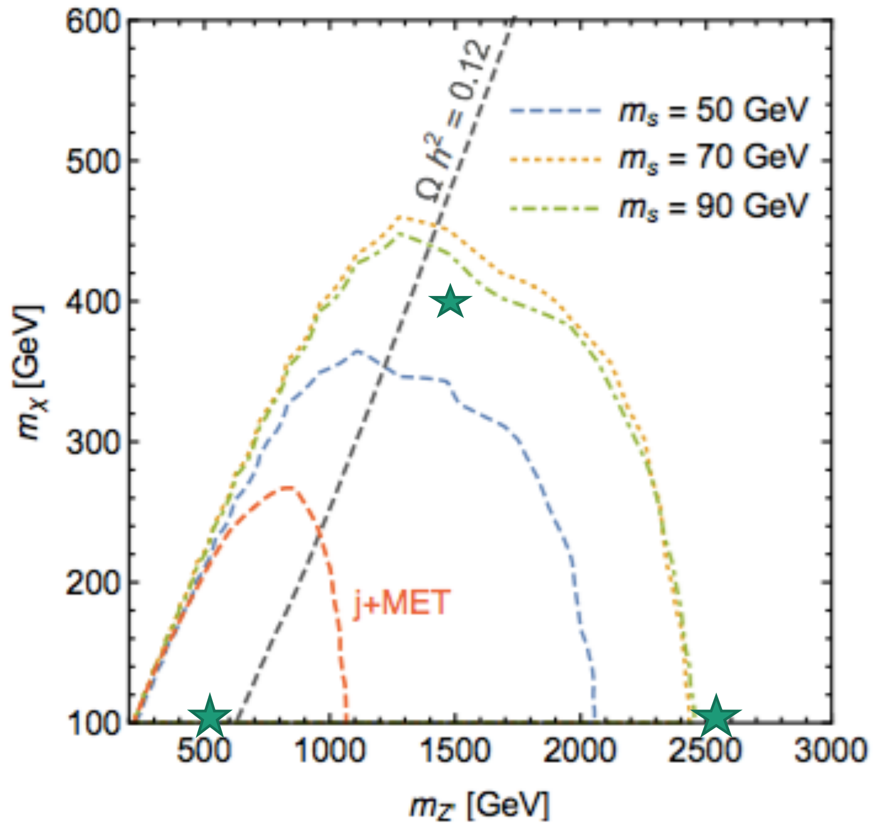


M. Duerr et al., *"Hunting the dark Higgs"*
arXiv:1701.08780v1 [hep-ph] 30 Jan 2017

With 10 GeV < m_s < 160 GeV, we have the dominant decay:
$s \rightarrow b + \bar{b}$

We therefore search a signal with two b-tagged jets and large E_T^{miss}

Selected Mass Points



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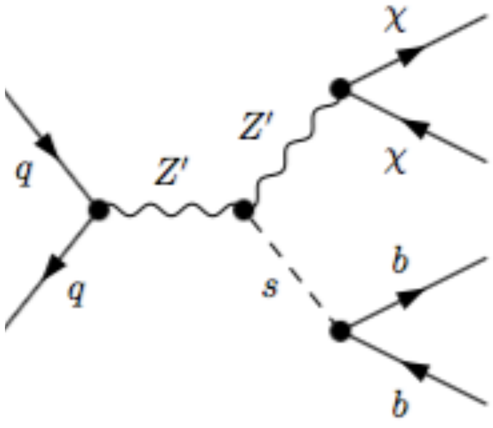
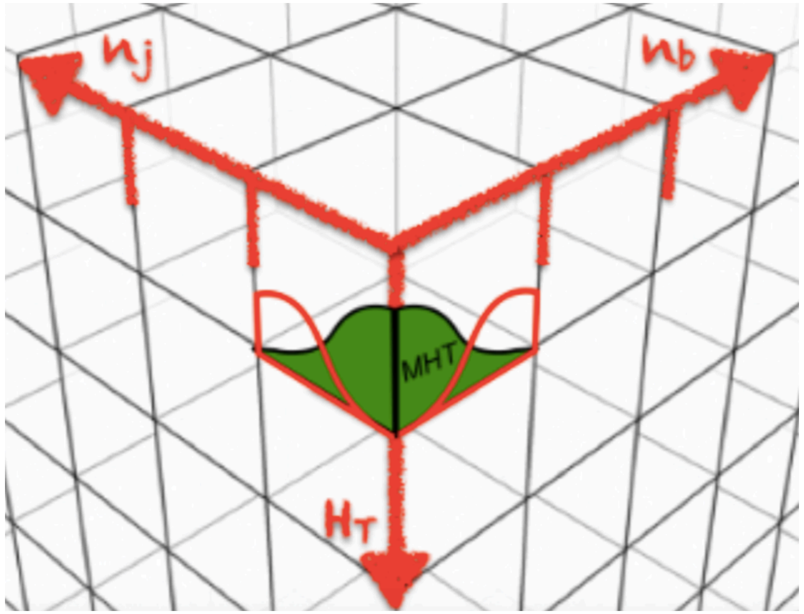
- 3 mass points selected with the following assumptions:
  - Dark Higgs mass: 70 GeV
  - Integrated luminosity: 35.9 fb^{-1}
  - Assuming g_q=0.25 and g_χ=1

Applied Analysis

- Inclusive search for SUSY/Dark Matter
  - Low thresholds on H_T (200 GeV) and H_T^{miss} (120 GeV)
  - Starts from n_{jet}=1 and n_b=0
  - Veto on leptons and photons
- Background control
  - QCD suppression with tight cuts on α_T, $\Delta\phi^*$ and H_T^{miss}/E_T^{miss}
  - Data driven estimation of remaining backgrounds (W, Z and ttbar)
- Sensitivity
  - Splits data into bins of H_T ,H_T^{miss}, n_{jet} and n_b

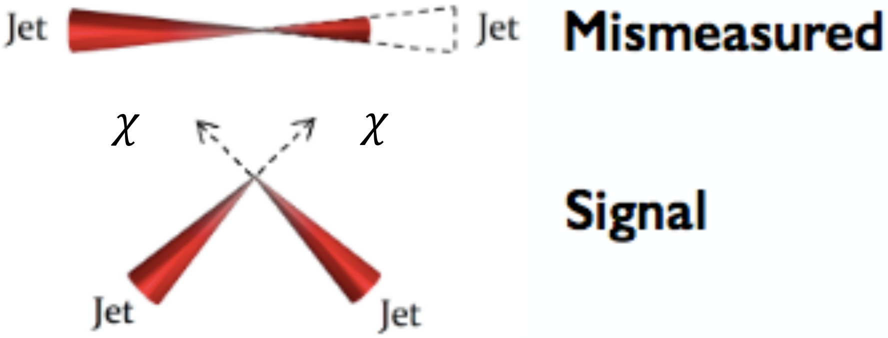




The α_T variable

α_T<0.5

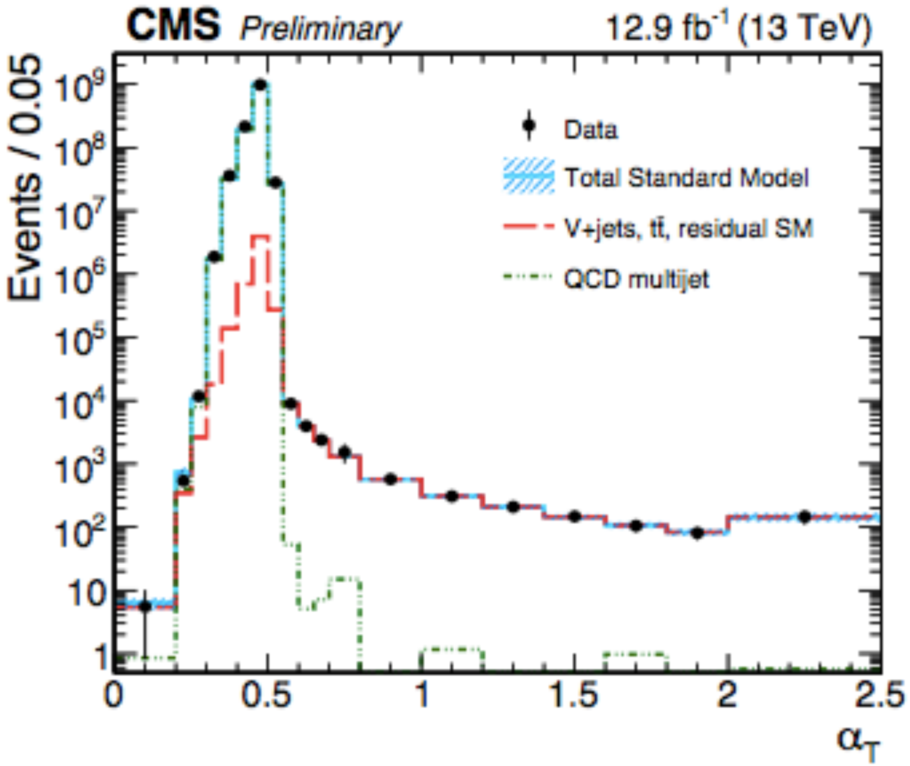
α_T>0.5



$$\alpha_T = \frac{1}{2} \times \frac{H_T - \Delta H_T}{\sqrt{H_T^2 - (H_T^{miss})^2}}$$

For a pseudo di-jet system with pseudo jet p_T difference: ΔH_T

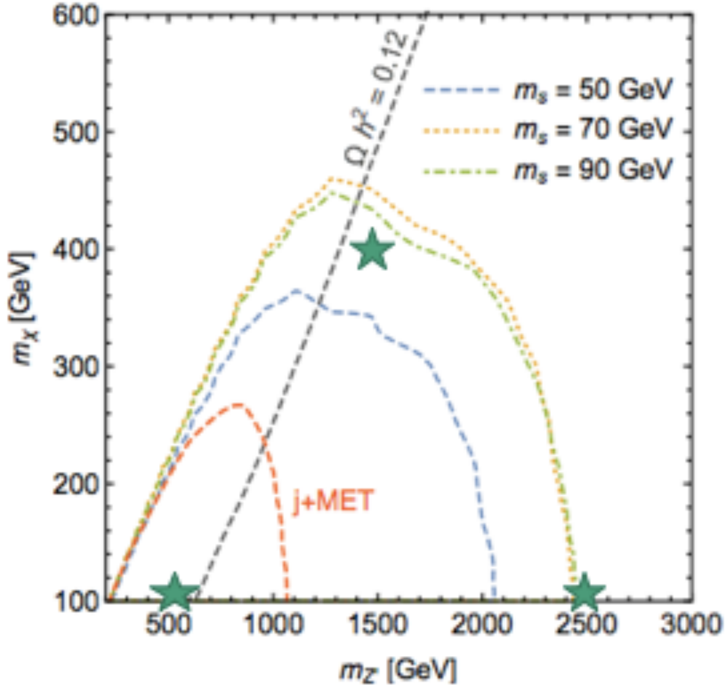
The pseudo jets are constructed from a sum of all jets in the system so as to minimise ΔH_T



Work in progress

σ/σ_{theory} for exclusion at 95 % confidence

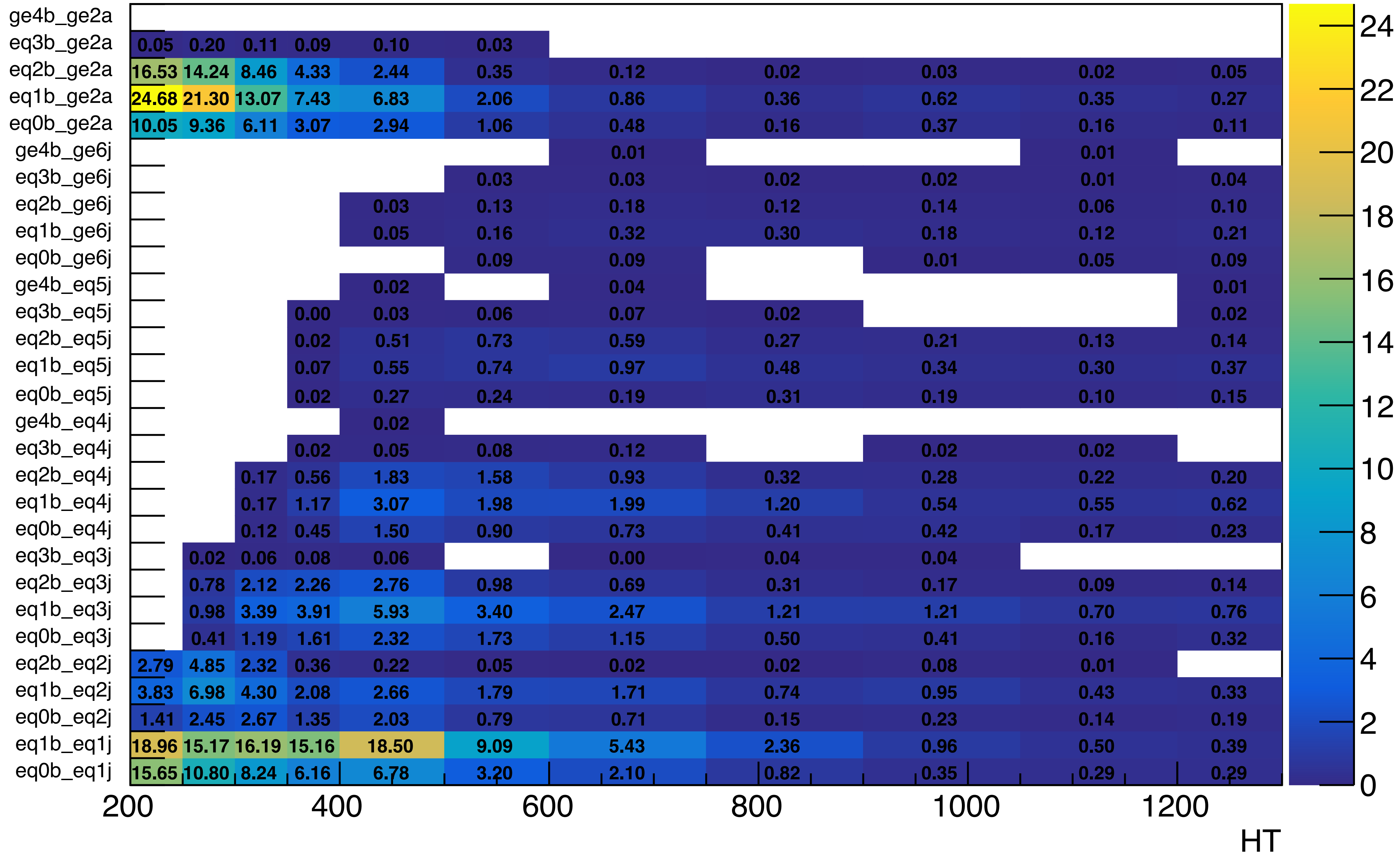
$m_{Z'}$	m_{DM}	Expected limit median(σ/σ_{theory})		Signal events at 35.9 fb^{-1}	Signal events passing cuts
500	100	0.113	+0.045	122,024	6043
			-0.032		
1500	400	1.051	+0.428	2,314	440
			-0.292		
2500	100	1.348	+0.564	478	153
			-0.386		



Conclusion and Outlook

- Searching for a Dark Higgs allows us to probe regions of parameter space not covered by searches based on simpler Dark Matter models
- The applied analysis is sensitive to the Dark Higgs model, but still lacks behind in sensitivity compared to a dedicated search
- The plan ahead is to make a dedicated analysis for a long lived version of the Dark Higgs model

Backup



$M_{Z'}=1500$
$M_{DM}=400$