Scalar/Pseudoscalar Mediators

- Simple extension of the Standard Model
  - Accommodates scalar or fermionic dark matter. Model files implemented with fermions as of now.

$$\mathcal{L}_{\text{fermion},\phi} = \mathcal{L}_{\text{SM}} + i\bar{\chi}\partial\!\!\!/\chi + m_\chi\bar{\chi}\chi + |\partial_\mu\phi|^2 + \frac{1}{2}m_\phi^2\phi^2$$
$$+g_\chi\phi\bar{\chi}\chi + \frac{\phi}{\sqrt{2}}\sum_i \left(g_u y_i^u \bar{u}_i u_i + g_d y_i^d \bar{d}_i d_i + g_\ell y_i^\ell \bar{\ell}_i \ell_i\right)$$
$$\mathcal{L}_{\text{fermion},a} = \mathcal{L}_{\text{SM}} + i\bar{\chi}\partial\!\!\!/\chi + m_\chi\bar{\chi}\chi + |\partial_\mu a|^2 + \frac{1}{2}m_a^2 a^2$$
$$+ig_\chi a\bar{\chi}\gamma^5\chi + \frac{ia}{\sqrt{2}}\sum_i \left(g_u y_i^u \bar{u}_i\gamma^5 u_i + g_d y_i^d \bar{d}_i\gamma^5 d_i + g_\ell y_i^\ell \gamma^5\bar{\ell}_i \ell_i\right)$$

- MFV assumption leads us to expect couplings $\propto$ SM fermion mass
  - Motivates searches in heavy flavor (top, bottom, tau) channels. Looking for deviations or non-universality of g_u, g_d, g_ℓ important

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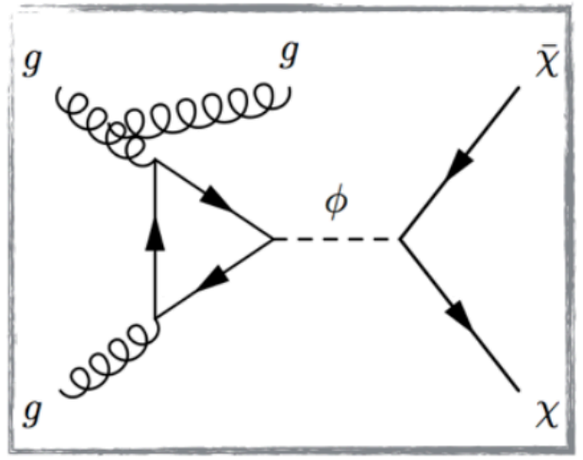
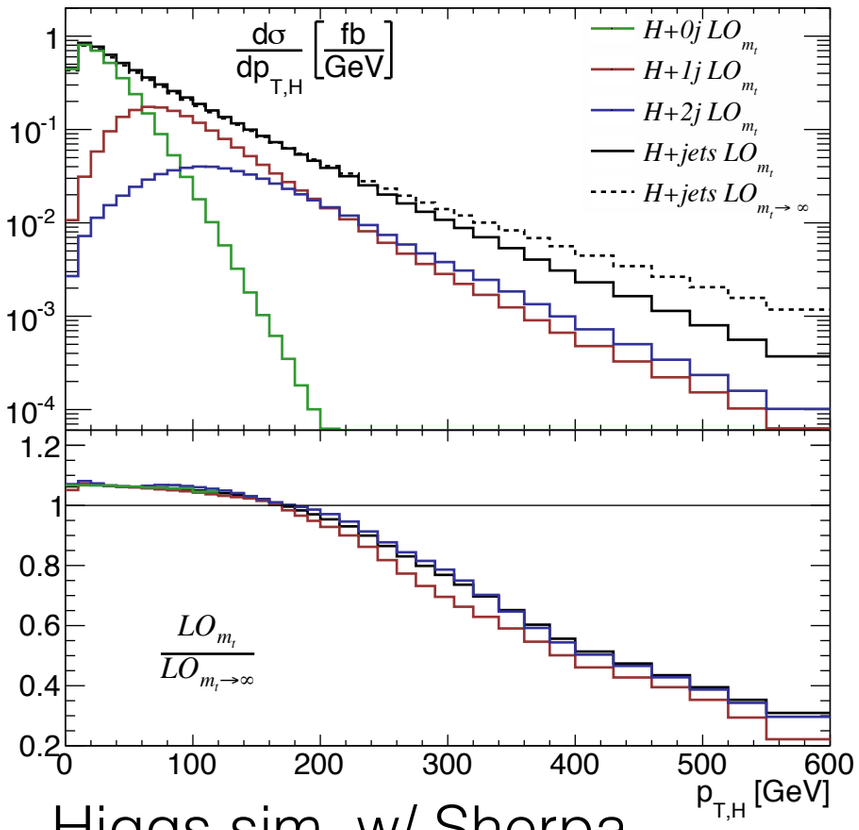


- Loop induced couplings to gluons (analogy with Higgs)
- Loop can be computed analytically for *on-shell* external gluons with momentum transfer small compared to m_t
- Not the case at LHC for reasonable MET cuts in monojets.
  - Need to either reweight MadGraph events
  - or use MCFM, Sherpa, *etc.*
  - Effect suppresses high-$p_T / \not{E}_T$ tails
  - Use available MG models with care
  - Can safely use MadGraph for

$$t\bar{t} + \phi, b\bar{b} + \phi$$

  - Working to get Sherpa implementation for experimental collaborations.



Higgs sim. w/ Sherpa

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Scalar/Pseudoscalar Mediators

- Even with universal couplings, multidimensional parameter space:

$$m_\chi, m_{\phi/a}, g_\chi, g_v \equiv g_u = g_d = g_\ell$$

- Cannot define an "effective coupling" $g^2_{\rm eff} = g_\chi g_v$ without specifying width of mediator separately.
  - Could treat width as additional free parameter.
  - For reasonable range of parameters, on-shell mediators have cross sections into specific channel scaling as branching ratios $\propto \Gamma^{-1}$
- Need to make a choice, just be consistent.
  - Propose: set $g_v = g_\chi$, calculate width of mediator in minimal model (no additional decay channels available), set limits on coupling as a function of $m_\chi,\ m_{\phi/a}$
  - Will make certain mediator final states appear to be "best" search targets. Keep in mind model-dependent assumptions when interpreting results.

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