spin-0 and spin-1 mediators with POWHEG (+ ideas for phenomenology)

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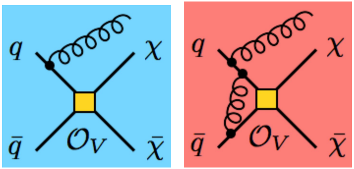
*in collaboration with Haisch,Kahlhoefer [1310.4491], Haisch,Hibbs [1311.7131] + ongoing work

mono-jet searches

- so far focused on phenomenology of "s-channel" signatures
- have studied QCD corrections to mono-jet processes, with V, A, S, P mediators, both in the EFT approach and using simplified models.
  Example:



$$\mathcal{L}_V = g_\chi^V \, (\bar{\chi}\gamma_\mu\chi) \, V^\mu + g_q^V \sum_q (\bar{q}\gamma_\mu q) \, V^\mu$$

$$\mathcal{O}_V = \frac{1}{\Lambda^2} \, (\bar{q}\gamma_\mu q) \, (\bar{\chi}\gamma^\mu\chi)$$

- have developed a public code that allows to perform full simulation. All has been included in the `POWHEG BOX` framework:

  `http://powhegbox.mib.infn.it/`

mono-jets with POWHEG

- `POWHEG` is a NLO+PS approach: it means that
  - total mono-jet x-section is NLO accurate, 1st jet spectrum @ NLO, 2nd jet @ LO (full ME), from the 3rd one onwards the parton shower takes over
  - this is better than matching 1 and 2-jet event samples generated with `Madgraph` using CKKW/MLM. Moreover, you don't have to deal with changing merging scale, etc...
  - code is very easy to run (~ as `Madgraph`):

    input-card → run → event file (`.lhe`) → shower/analysis
  - if improvements are needed in the IO interface for the studies to be performed in the near future, I'll make an effort to include them
- interactions available (short-cut notation: both EFT and explicit mediator)

$$\mathcal{O}_V = \frac{1}{\Lambda^2}\left(\bar{q}\gamma_\mu q\right)\left(\bar{\chi}\gamma^\mu\chi\right) \quad , \quad \mathcal{O}_A = \frac{1}{\Lambda^2}\left(\bar{q}\gamma_\mu\gamma_5 q\right)\left(\bar{\chi}\gamma^\mu\gamma_5\chi\right)$$

$$\mathcal{O}_S = \frac{m_q}{\Lambda^3}\left(\bar{q}q\right)\left(\bar{\chi}\chi\right) \quad , \quad \mathcal{O}_P = \frac{m_q}{\Lambda^3}\left(\bar{q}\gamma_5 q\right)\left(\bar{\chi}\gamma_5\chi\right)$$

$$\mathcal{O}_G = \frac{\alpha_s}{\Lambda^3} G^a_{\mu\nu}G^{a,\mu\nu}\left(\bar{\chi}\chi\right)$$

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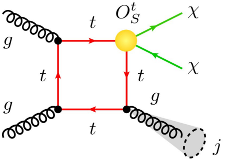
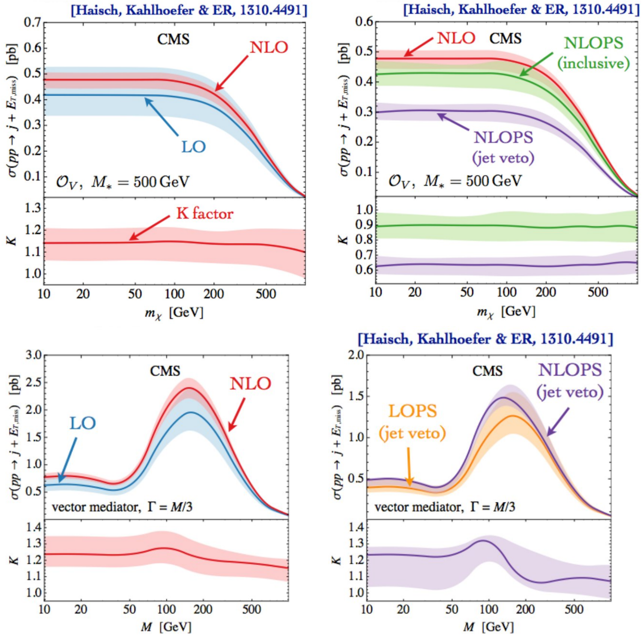
- public soon:

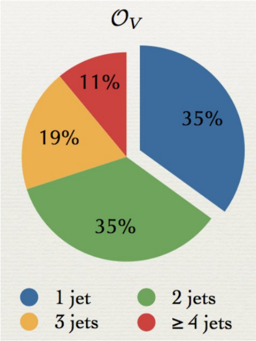


[and also $\mathcal{O}_{\tilde{G}} = \frac{\alpha_s}{\Lambda^3}\tilde{G}^a_{\mu\nu} G^{a,\mu\nu}(\bar{\chi}\gamma_5\chi)$]

some results



- important observations:
  - after cuts, a lot of events are 2-jet like
  - jet veto on 3rd jet cuts away a lot of x-section



DM + 2 jets (EFT)

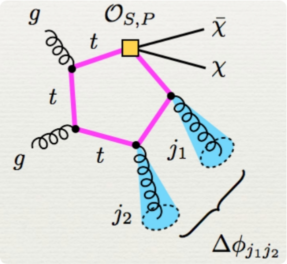
- we looked at the case where DM-SM interactions take place via

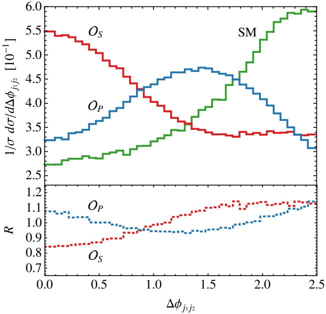
$$\mathcal{O}_S = \frac{m_t}{\Lambda^3}(\bar{t}t)(\bar{\chi}\chi) \quad \text{or} \quad \mathcal{O}_P = \frac{m_t}{\Lambda^3}(\bar{t}\gamma_5 t)(\bar{\chi}\gamma_5\chi)$$

- bounds from $j + E_{T,\mathrm{miss}}$ and $t\bar{t} + E_{T,\mathrm{miss}}$:
  $\Lambda \gtrsim 150 - 170$ GeV [$m_\chi = 50$ GeV]

- (normalized) azimuthal correlation $\Delta\Phi_{jj}$:
  - ☞ distinguish between background and signal hypothesis
  - ☞ distinguish between $\mathcal{O}_S$ and $\mathcal{O}_P$ (and $\mathcal{O}_{V/A}$)

- LHC 14 TeV w/ CMS cuts + $m_{jj} > 600$ GeV:
  $\sigma(E_{T,\mathrm{miss}} + jj) \simeq 0.3\sigma(E_{T,\mathrm{miss}} + j)$, $\sigma_S \simeq \sigma_B$





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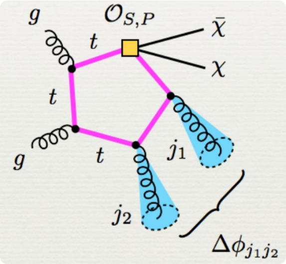

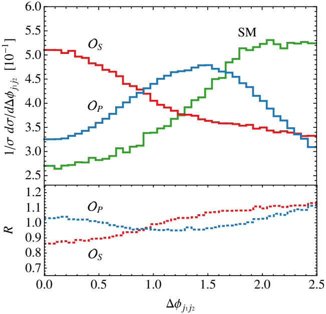

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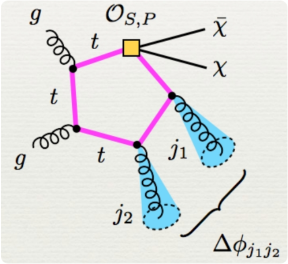
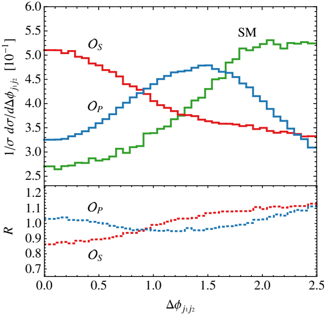
- pattern visible also in heavy-top limit [$G_{\mu\nu}G^{\mu\nu}\bar{\chi}\chi$]
  (although x-section overestimated (factor 10))





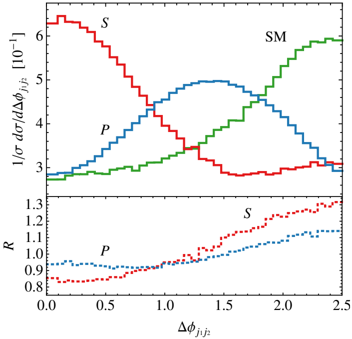
DM + 2 jets (full theory)

- with previous settings, EFT validity questionable
- studied specific case with simplified s-channel model:

$$\mathcal{L}_S = g_\chi^S\,(\bar{\chi}\chi)\,S + g_t^S\,\frac{m_t}{v}\,(\bar{t}t)\,S$$

  - (pseudo)-scalar mediator, $M_{P/S} = 500$ GeV, $m_\chi = 200$ GeV, $g = 1$
- all constraints from LHC and cosmology satisified
- width explicitly computed (here turns out $\Gamma/M \simeq 3 - 6\%$)

☞ modulation pattern survives



More comprehensive study is in progress...