Emerging jet probes of exotic Higgs decays

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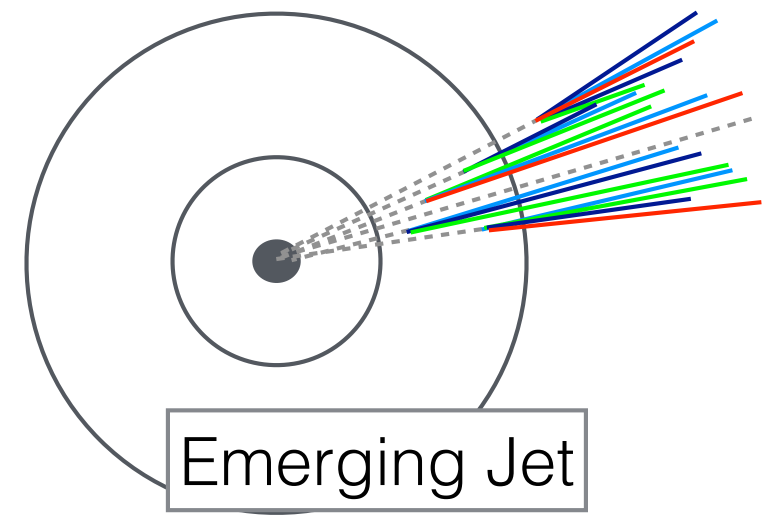
Emerging Jets

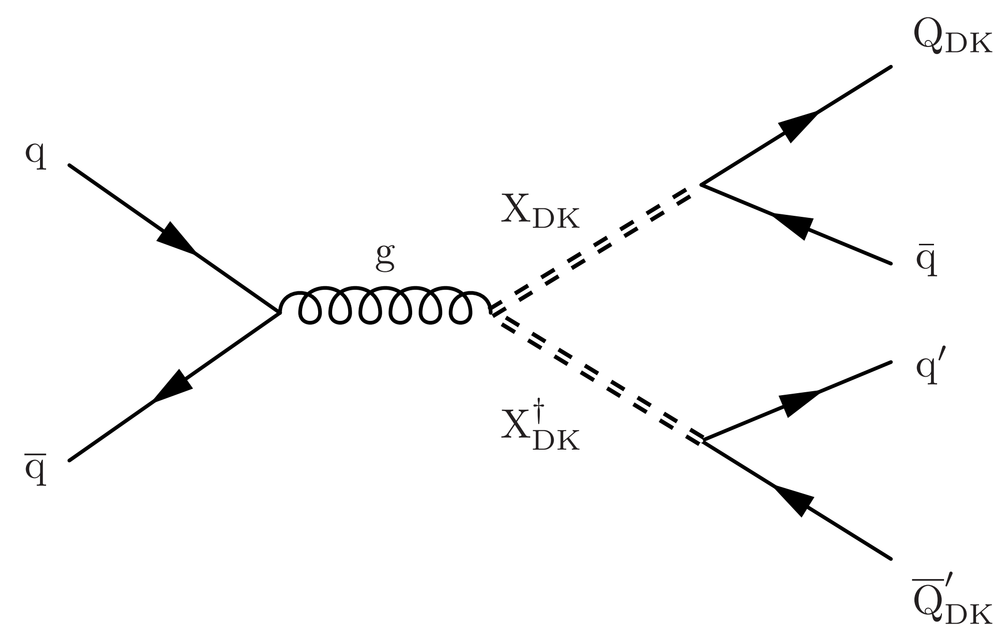
Schwaller et al., 1502.05409

- Dark showers arise from a new confining dark sector.
  - (Dark) jets containing dark states that may be stable or decay within DS or back to SM with a wide range of lifetimes.
- If all dark mesons decay into SM with finite lifetimes (0.001-1m)
  - high multiplicity of displaced vertices (DVs) within a jet. → Emerging Jet



Benchmark model (searched by CMS)

- Pair production of heavy bifundamental scalars X_d
- $m_{q_d} = \Lambda_d = 2m_{\pi_d} = 1/2m_{\rho_d}$
- Dark pions decay into SM with finite lifetime
- Free parameters: m_{X_D}, m_{π_D} , $c\tau_{\pi_D}$



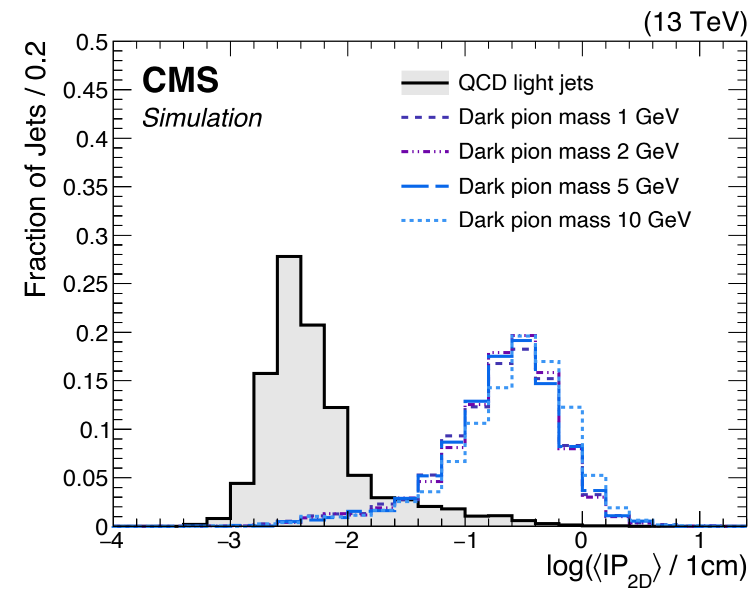
See talks of P. Schwaller and J. Pearkes!!!

CMS search for EJs

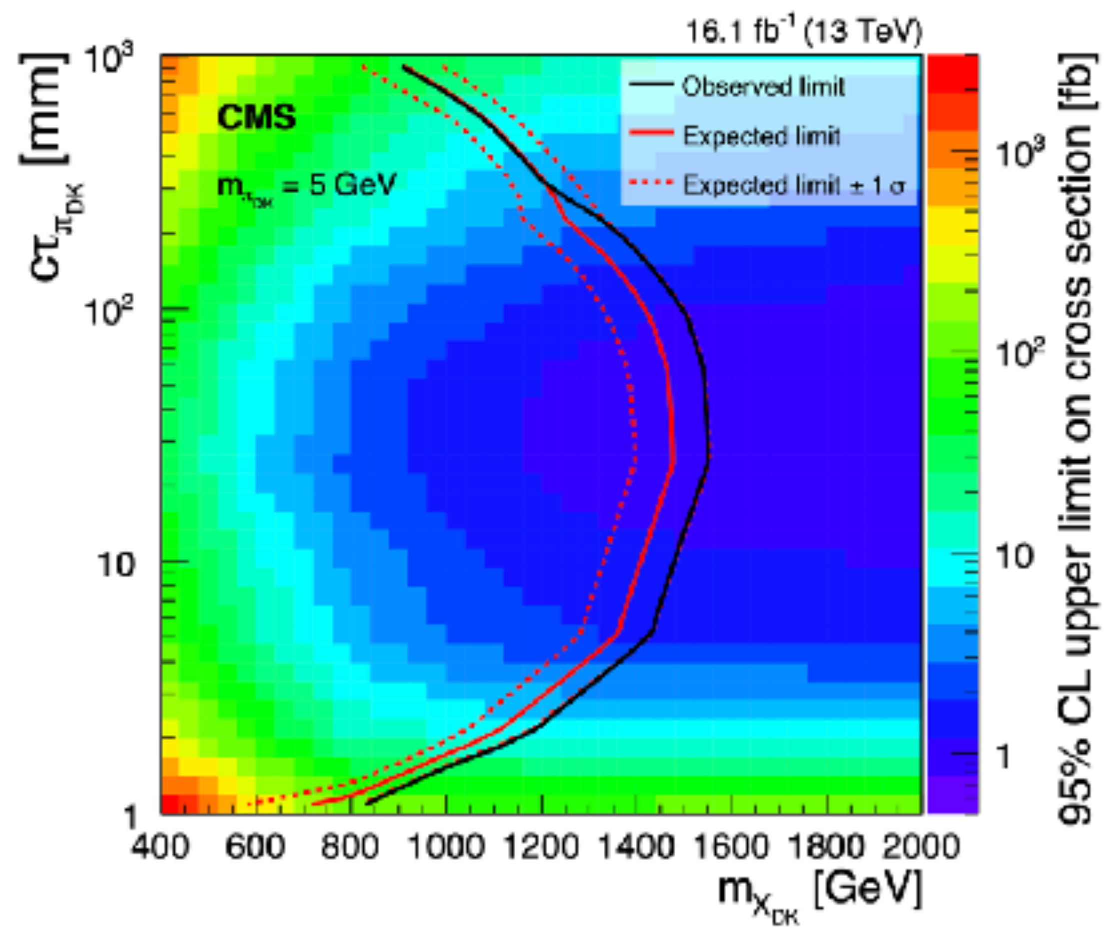
CMS Collaboration, 1810.10069

- Emerging Jet tagging variables:
  - $\langle IP_{2D} \rangle$: Median transverse impact parameter of associated tracks
  - α_{3D}: jet pT fraction associated to prompt tracks

  (there are 6 groups of criteria for EJ-tagging)
- Event selections
  - Four jets with (at least two are EJs or one EJ+large $\not{E}_T$)
  - Trigger on scalar p_T sum of jets $H_T > 900\text{GeV}$ and on p_T of each jet.

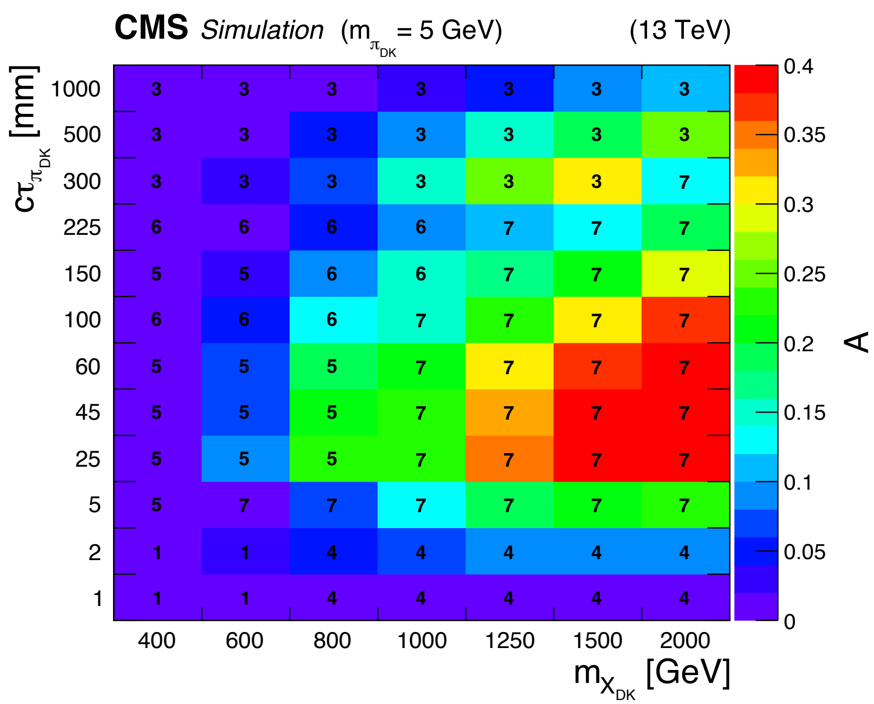


- 7 sets of selection requirements are defined, optimised for different configurations (the one with the highest expected sensitivity)



No significant excess observed above SM prediction

Validation (I)



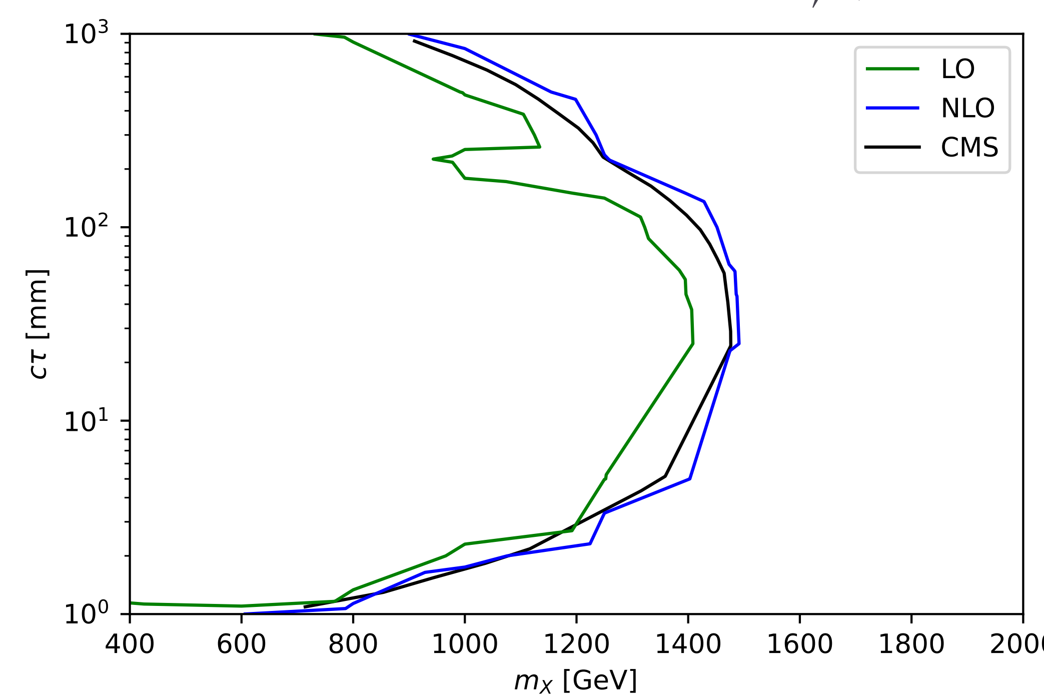
CMS Collaboration, 1810.10069

Set number	Expected	Observed	Signal
1	168 ± 15 ± 5	131	36.7 ± 4.0
2	31.8 ± 5.0 ± 1.4	47	(14.6 ± 2.6)× 10^2
3	19.4 ± 7.0 ± 5.5	20	15.6 ± 1.6
4	22.5 ± 2.5 ± 1.5	16	15.1 ± 2.0
5	13.9 ± 1.9 ± 0.6	14	35.3 ± 4.0
6	9.4 ± 2.0 ± 0.3	11	20.7 ± 2.5
7	4.40 ± 0.84 ± 0.28	2	5.61 ± 0.64

- Number for signal events for set i:
  $n_S^i = \sigma_{(pp \to XX)} \times BR(X \to qQ_D) \times \mathcal{A}_i \times L$

  With $\mathcal{A}_i$ the signal acceptance, a function of m_X, m_{π_d}, $c\tau_{\pi_d}$.

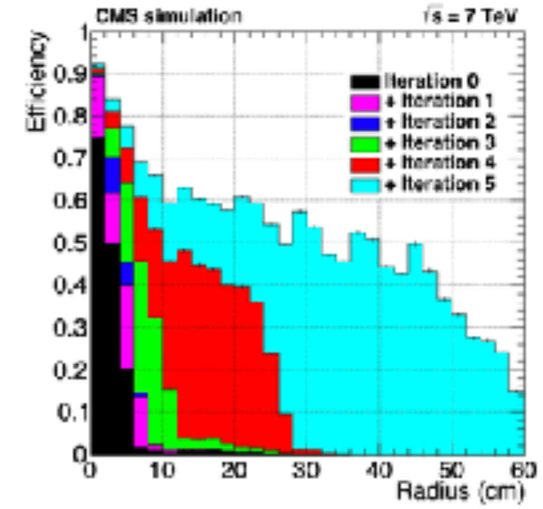
For L =16.1 fb^{-1}, $\sqrt{s}$ =13TeV



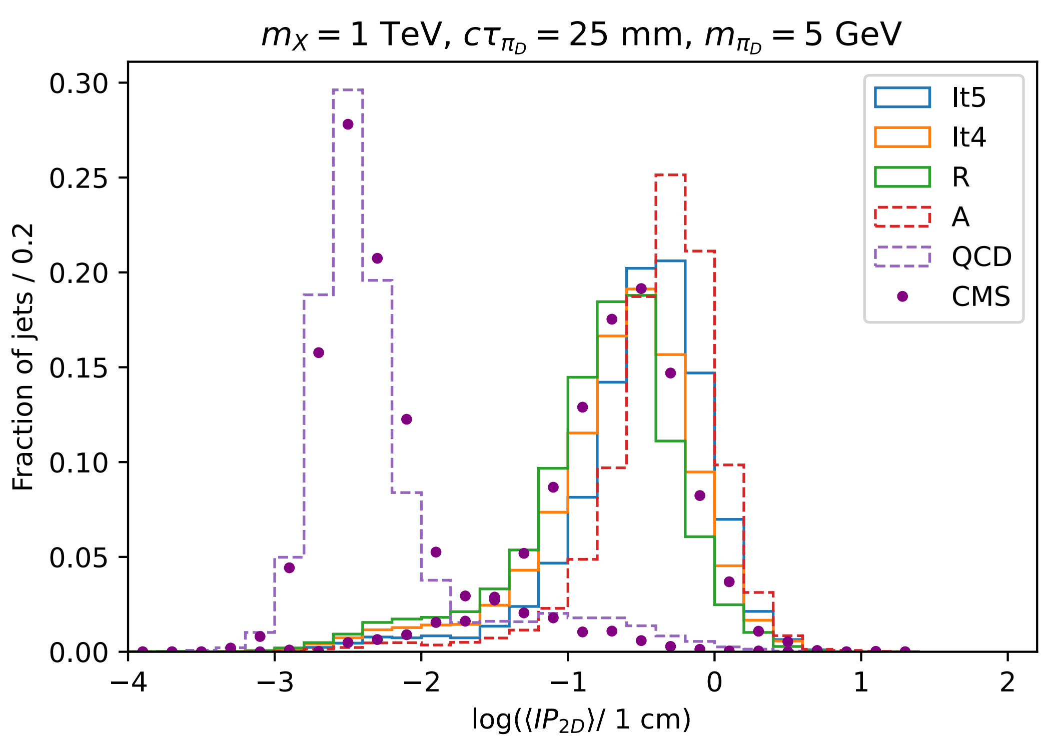
Also see: Mies, et al, 2011.13990

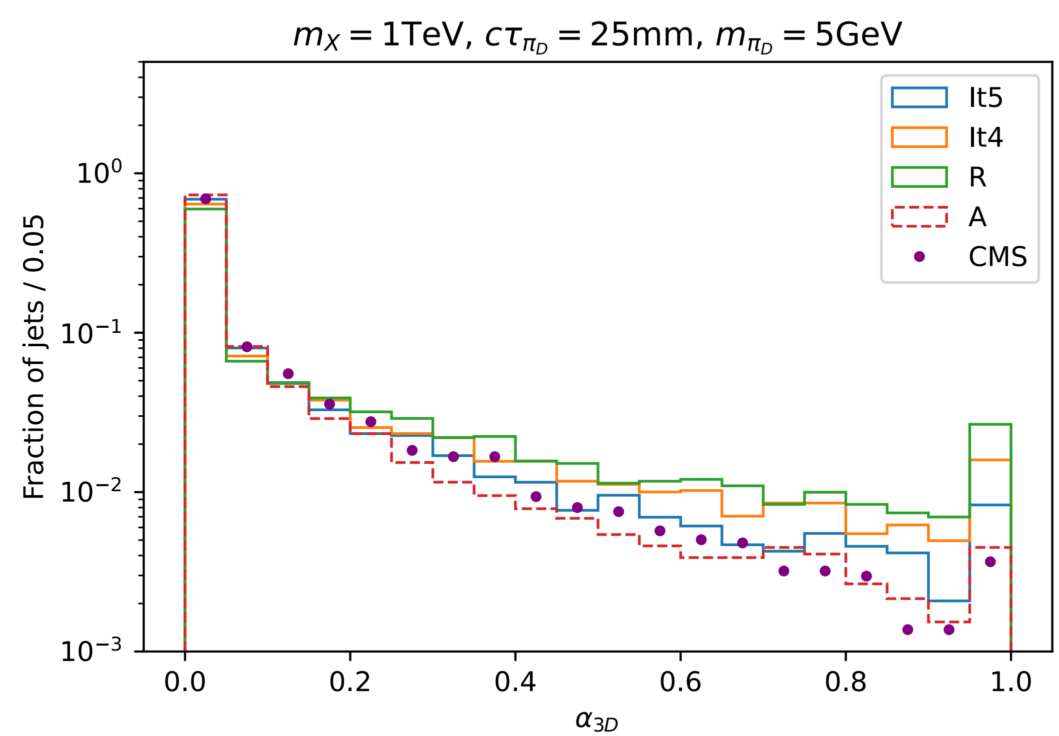
Validation (II)

- Since track reconstruction efficiencies are hard to parametrise. We considered different criteria for the tracking efficiencies, including different iteration levels or requiring $r_{trk} < 102$mm.



CMS Collaboration, 1405.6569





Validation (III)

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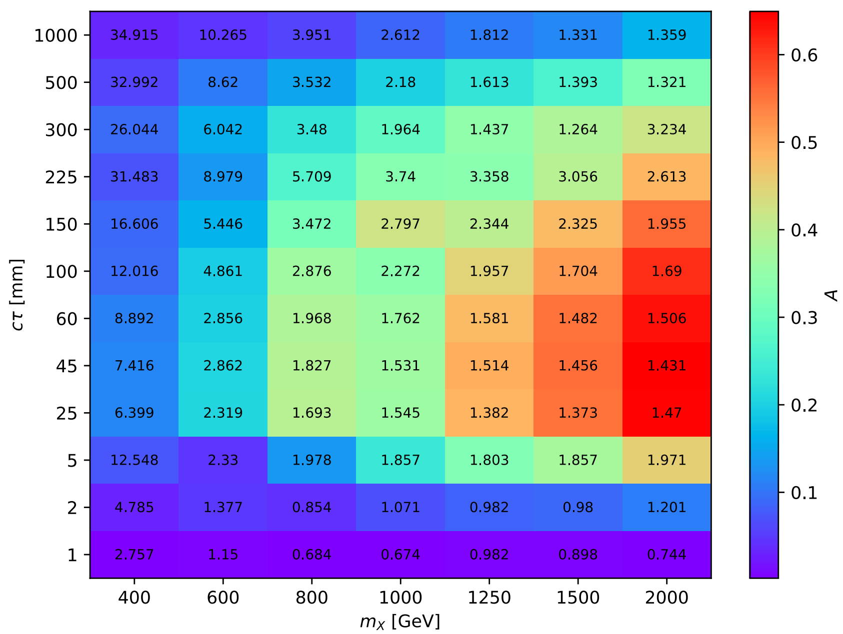

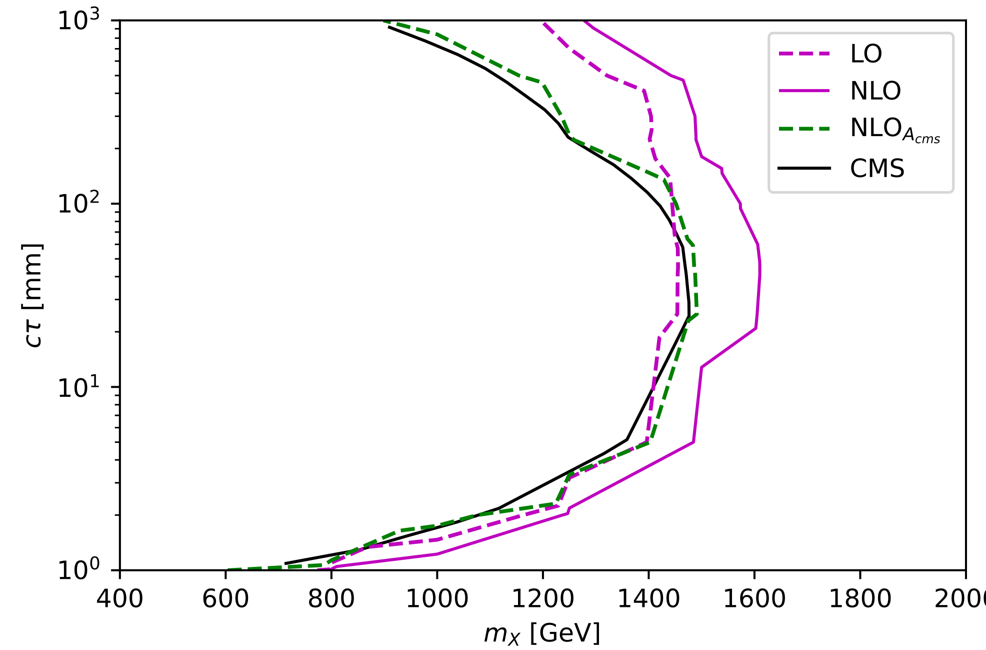

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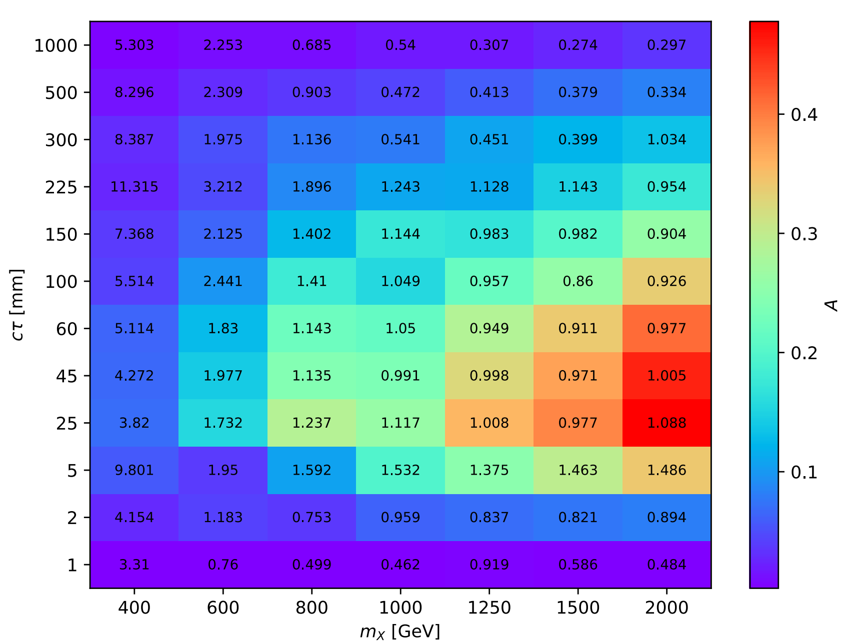
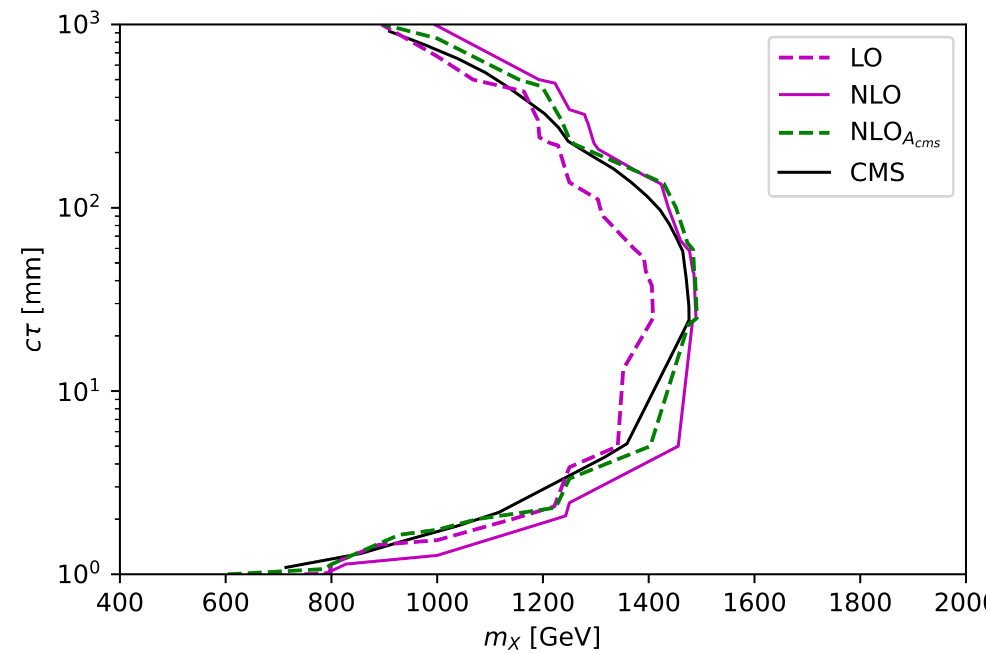
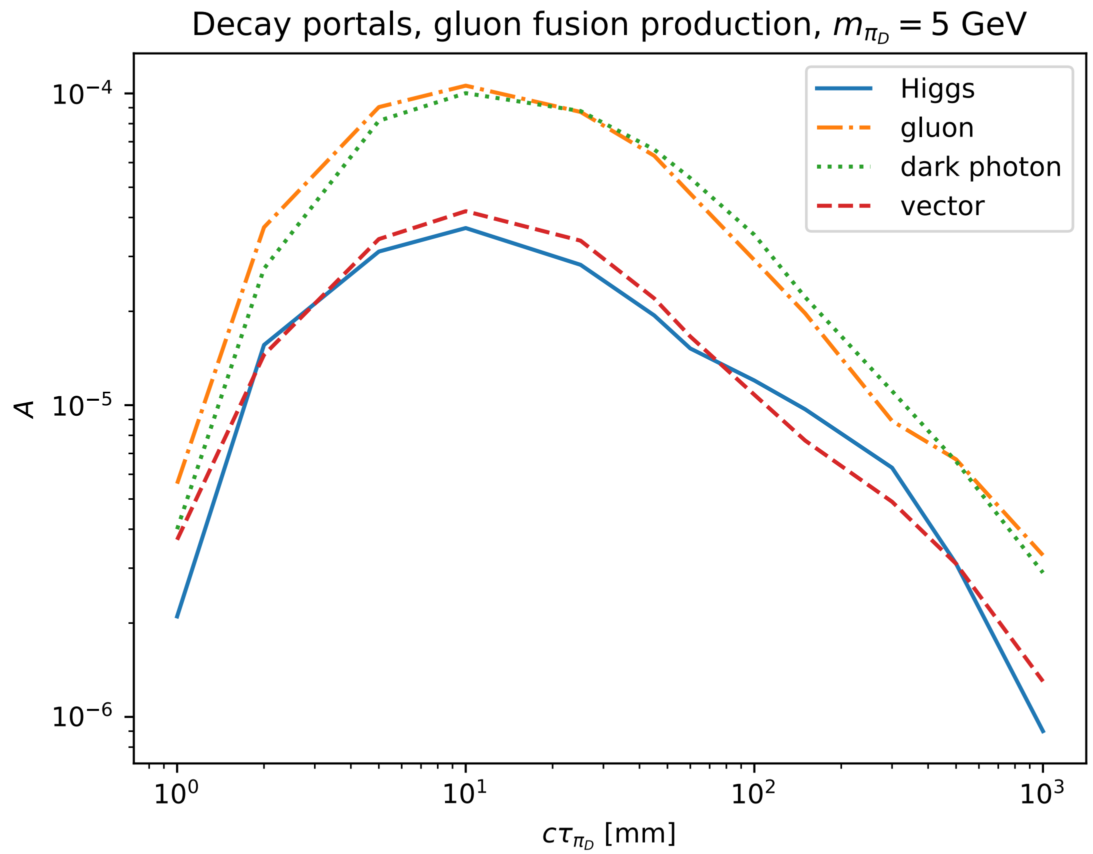


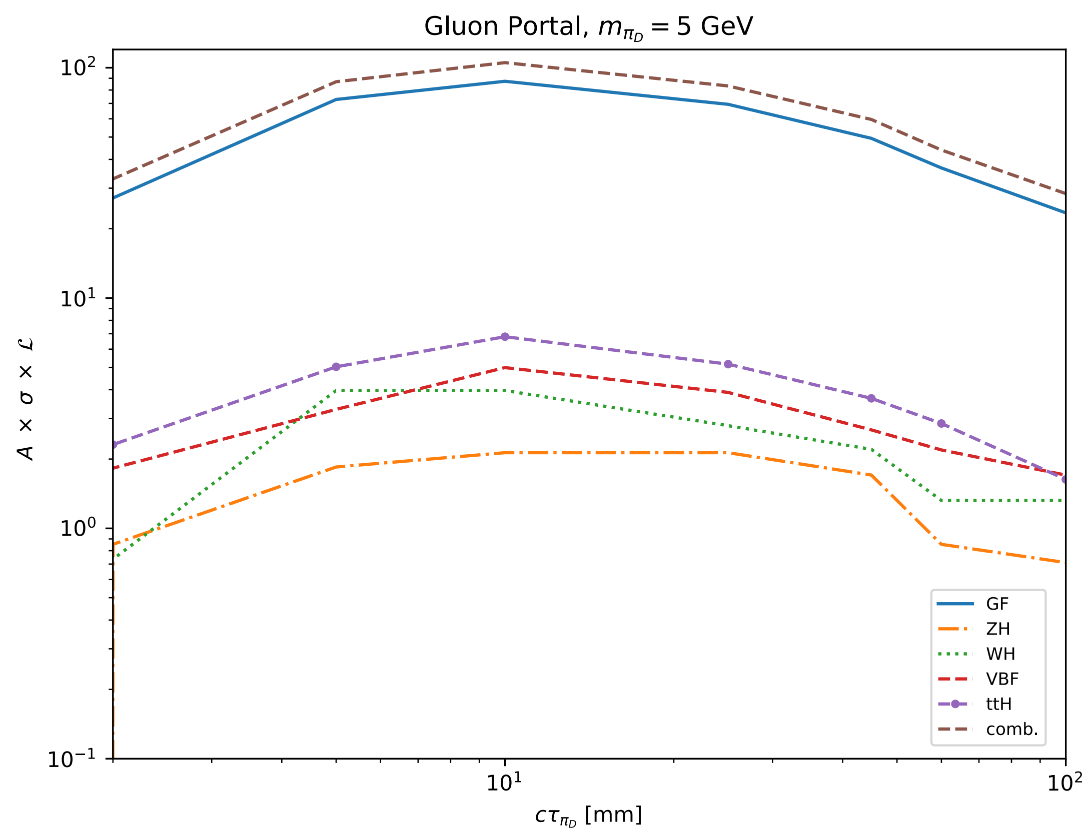


Reinterpretation for Higgs mediated dark showers

- Consider production through the SM Higgs boson, through different mechanisms.
- Furthermore, use different decay portals for the dark pion decays into SM: *gluon, higgs, darkphoton and vector-portal* (defined by Knapen et al. 2103.01238).

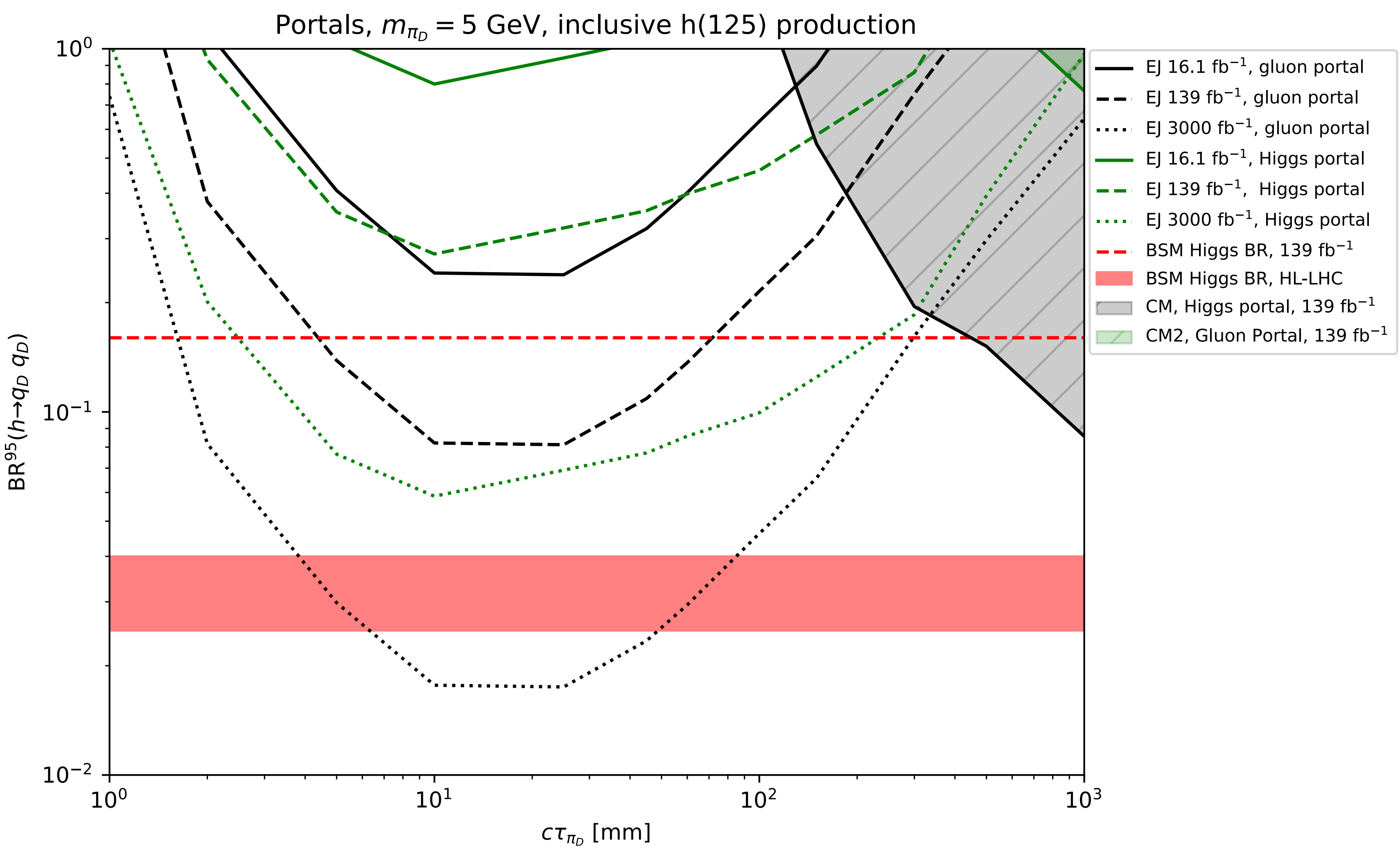
  e. g : $\pi_D G^{\mu\nu}\tilde{G}_{\mu\nu}$ or $\pi_D H^\dagger H$
- Expected number of signal events: $n_S^i = \sigma_{(pp\to h)} \times BR(h \to Q_D Q_D) \times \mathscr{A}_i \times L$





Bounds on exotic higgs decays

- Current indirect bounds on branching ratio for exotic higgs decays: *BR(h→ QdQd)<0.21* at 95%CL with 80fb^{-1} at $\sqrt{s}$ =13TeV (ATLAS, 1909.02845)



Summary

- Strongly interacting dark sector are well motivated scenarios, theoretically and experimentally.
- At colliders, these give rise to exotic and unexplored signatures, such as Emerging Jets.
- We reproduced with reasonable agreement the published limits of the CMS emerging jets search.
- We performed the reinterpretation of the CMS emerging jet search for exotic decays of the SM Higgs boson. Our limits are competitive with those obtained from the model-independent searches of the non-standard SM Higgs boson decays (BSM higgs branching fraction) from ATLAS, for certain lifetime ranges.

Thank you!