A model independent probe for elusive dark sectors at future experiments

Work in progress

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inVisibles
neutrinos, dark matter & dark energy physics

SCUOLA NORMALE SUPERIORE

2 June '21

Artwork by Sandbox Studio, Chicago with Ana Kova

Dark Sector — Portal — **Standard Model**

$$\mathcal{L}_{\text{portal}} = \mathcal{O}_{DS}\mathcal{O}_{SM}$$

Dark sector Singlet operator

SM Singlet operator

- Contains dark matter
- Neutral under Standard Model : DARK

$\text{Dim}[O_{SM}\ O_{DS}] > 4$

Irrelevant Portals

ELUSIVE Dark Sector

Contino, Max, Mishra 2012.08537

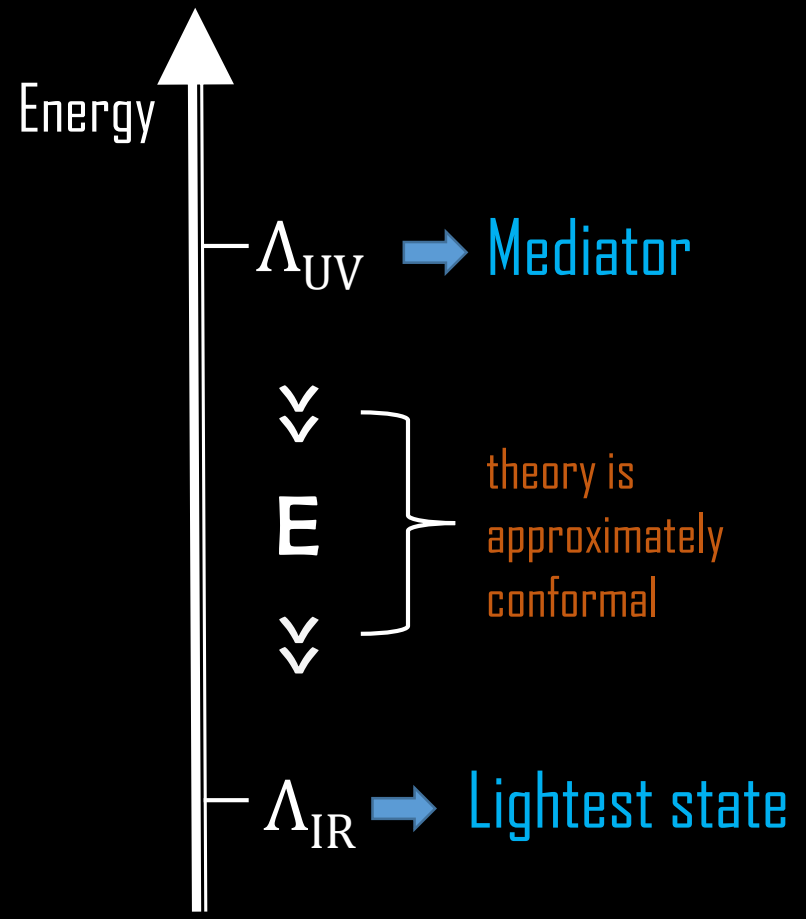
Can we be model independent?

Conformal Dynamics: let's us calculate rates and cross sections in a model independent way

Contino, Max, Mishra 2012.08537

Minimal Assumptions :

- ✓2 energy scales
- ✓Large hierarchy
- ✓Theory conformal



Can we be model independent?

$\Lambda_{IR} \ll \sqrt{s} \ll \Lambda_{UV}$

Consider contributions from conformal regime for DS production cross section

Optical Theorem

$$\sum_n \int d\,\Phi_{DS} |\langle 0 | O_{DS} | n \rangle|^2 = 2\ Im\,[i \langle 0 | T\{O_{DS} O_{DS}\} | 0 \rangle]$$

DS phase space

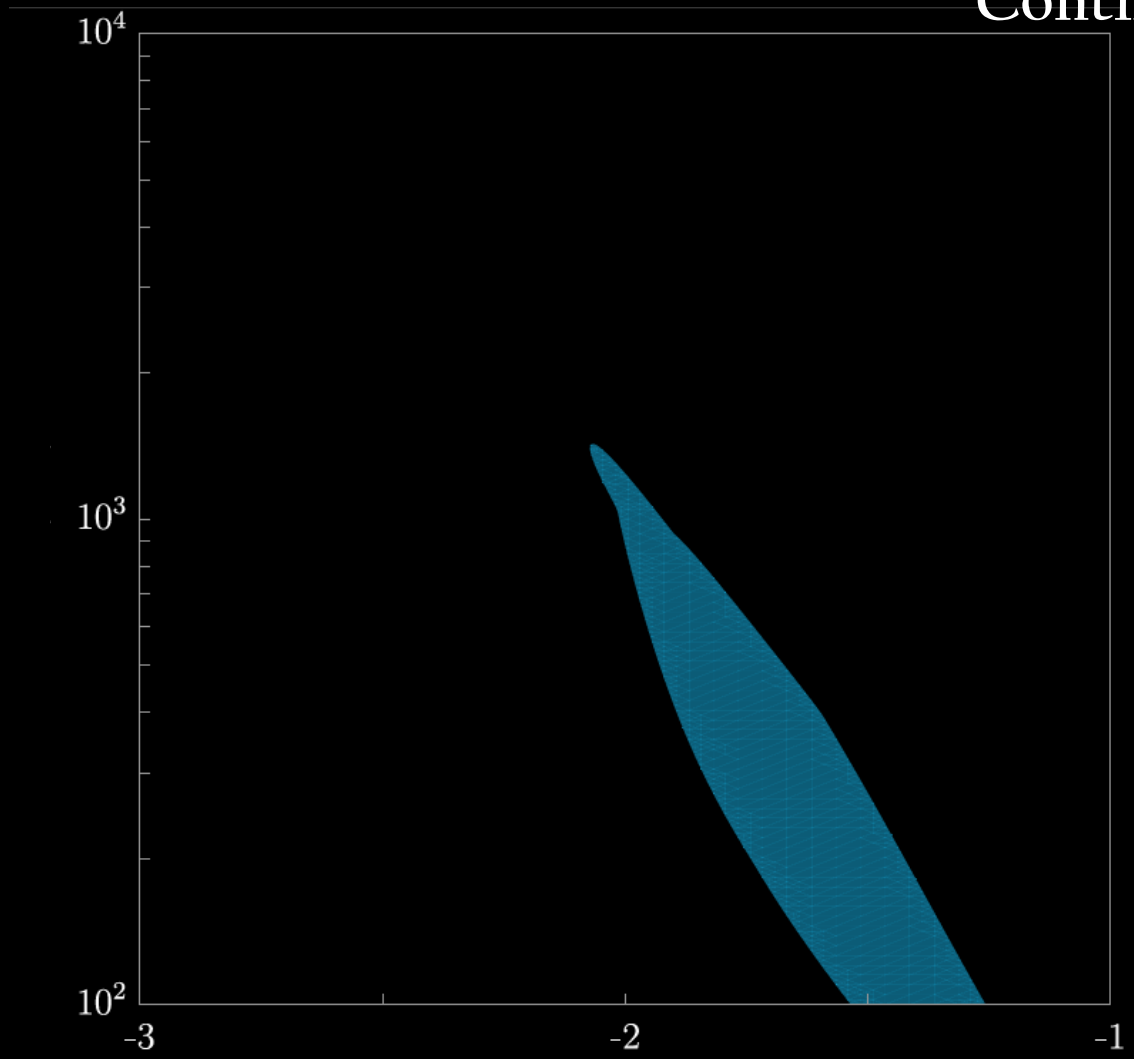
DS operator interpolating DS state $|n\rangle$ from vacuum

From conformal invariance

Approximate inclusive DS production cross section in a model independent way when well above threshold!

Do current searches probe them?

Contino, Max, Mishra 2012.08537



Λ_{UV} (GeV)

$\text{Log}_{10}\ (\Lambda_{IR} / \Lambda_{UV})$

2 DV ATLAS Searches

Production Portal $\mathcal{O}_{\mathcal{D}S} H^\dagger H$

Decay of LDSP: $\mathcal{O}_{\mathcal{D}S} H^\dagger H$

*ATLAS search for Displaced Vertex PRD (2019)(2020)

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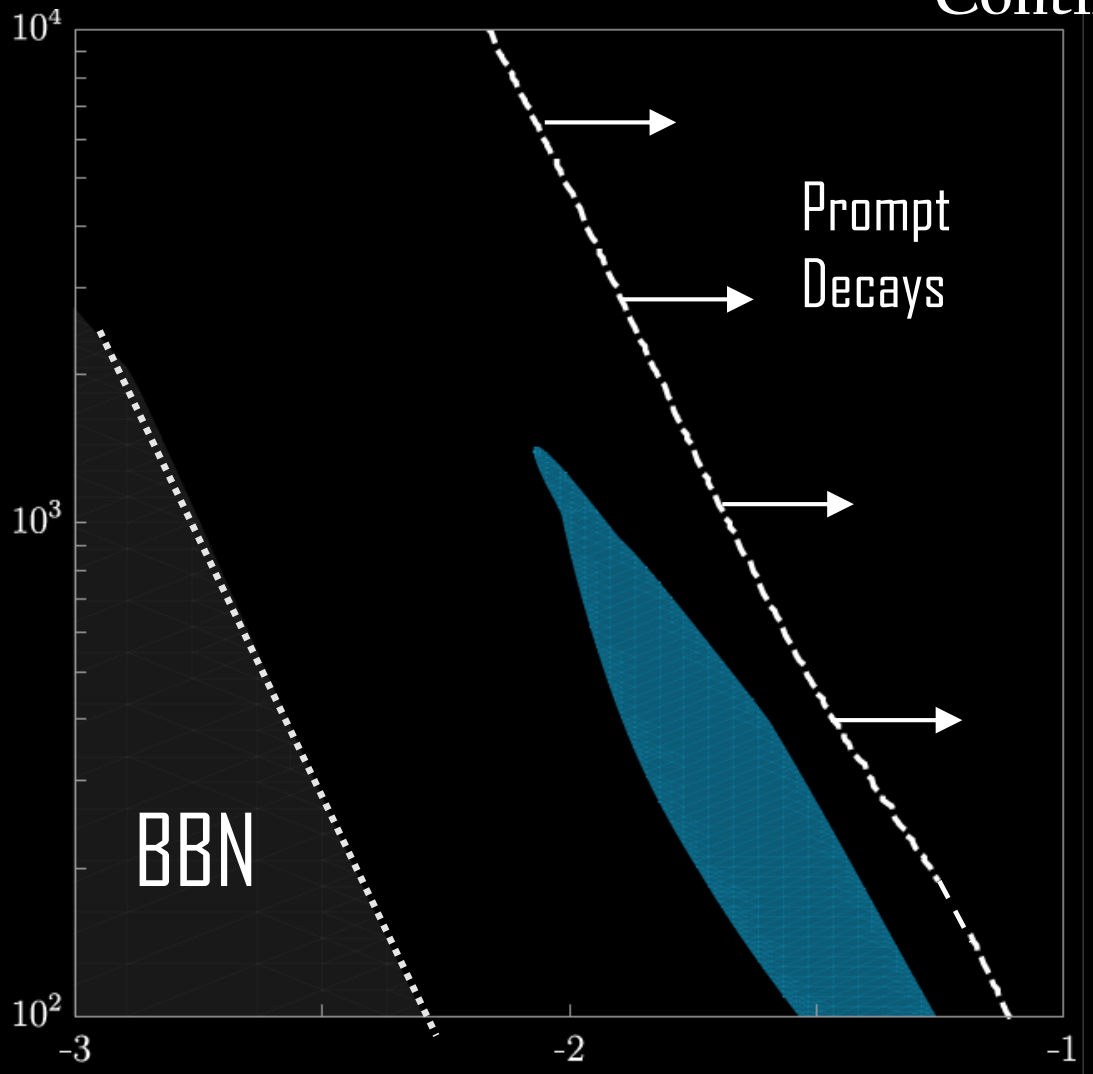

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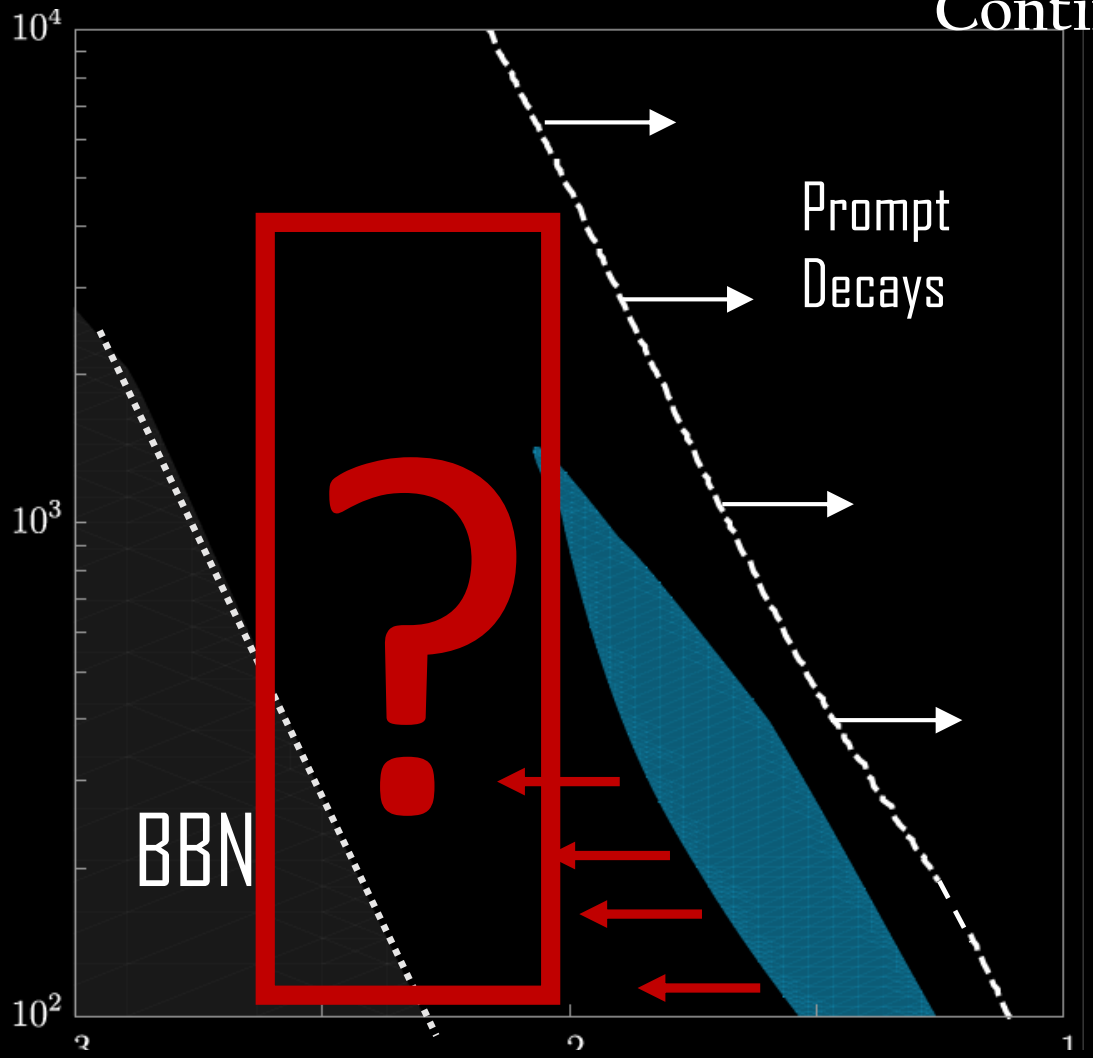

Λ_{UV} (GeV)

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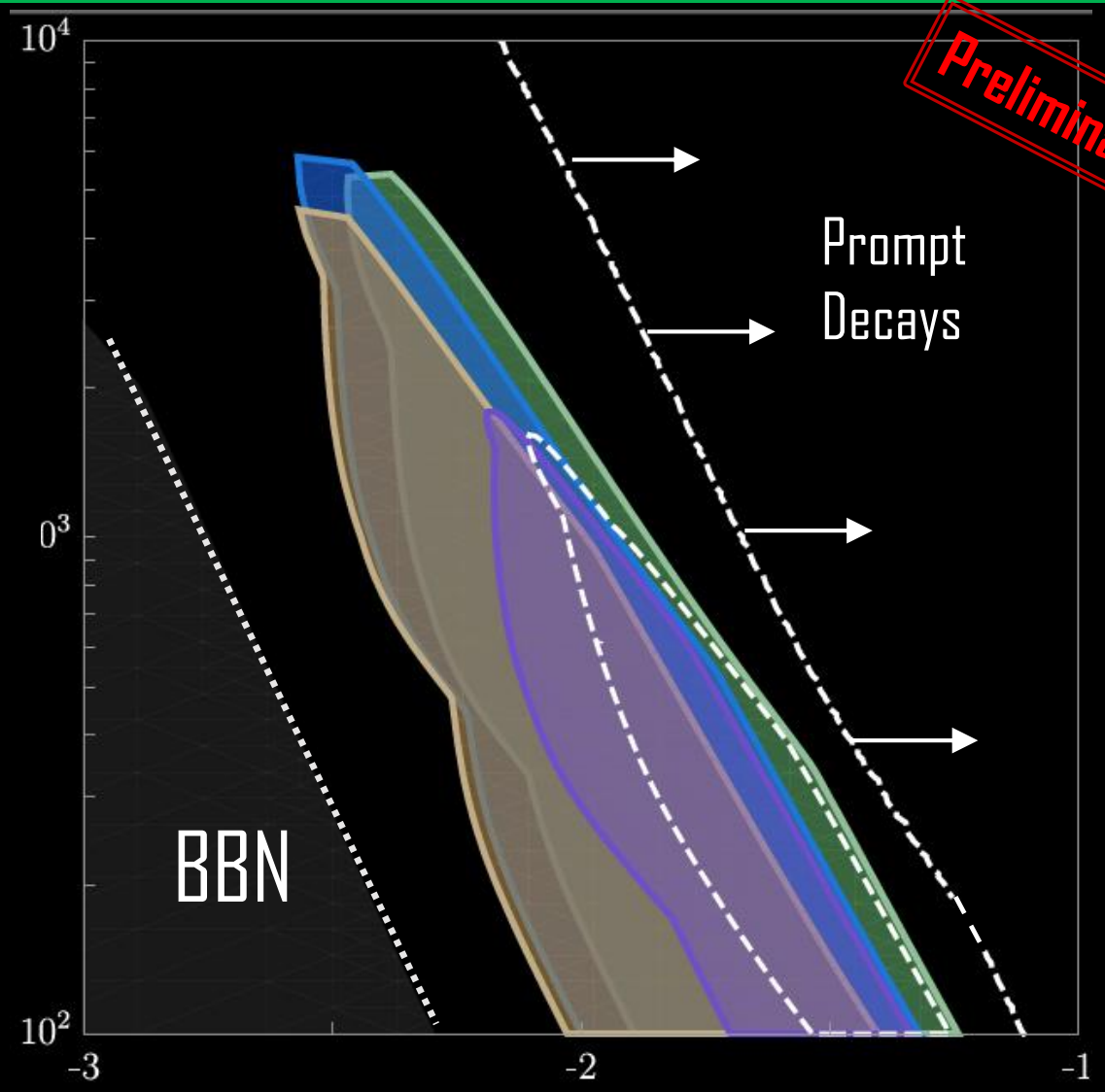
Can we improve reach on lower Λ_{IR} ?

What about future probes?



2 DV ATLAS Search

1 DV ANUBIS

1 DV MATHUSLA

1 DV AL3X

1 DV CODEX-b

Production Portal $\mathcal{O}_{DS}H^\dagger H$

Decay of LDSP: $\mathcal{O}_{DS}H^\dagger H$

Conclusions

- Dark Sectors interacting with SM via irrelevant portals are very elusive.
- Current searches leave the parameter space rather untouched.
- Future experiments dedicated for long lived particle searches will be important probes for elusive dark sectors.

Outlook

- Model independent bounds v/s a particular model?
- Fixed dump experiments/neutrino experiments?
- You have a model in mind and you want to see how our bounds do for you?
- You have a future experiment for detecting Long Lived Particles up your sleeve and want us to include that?

CONTACT US!
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