Giant planet airglow induced by dark matter annihilation

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Outline

Dark matter accumulation

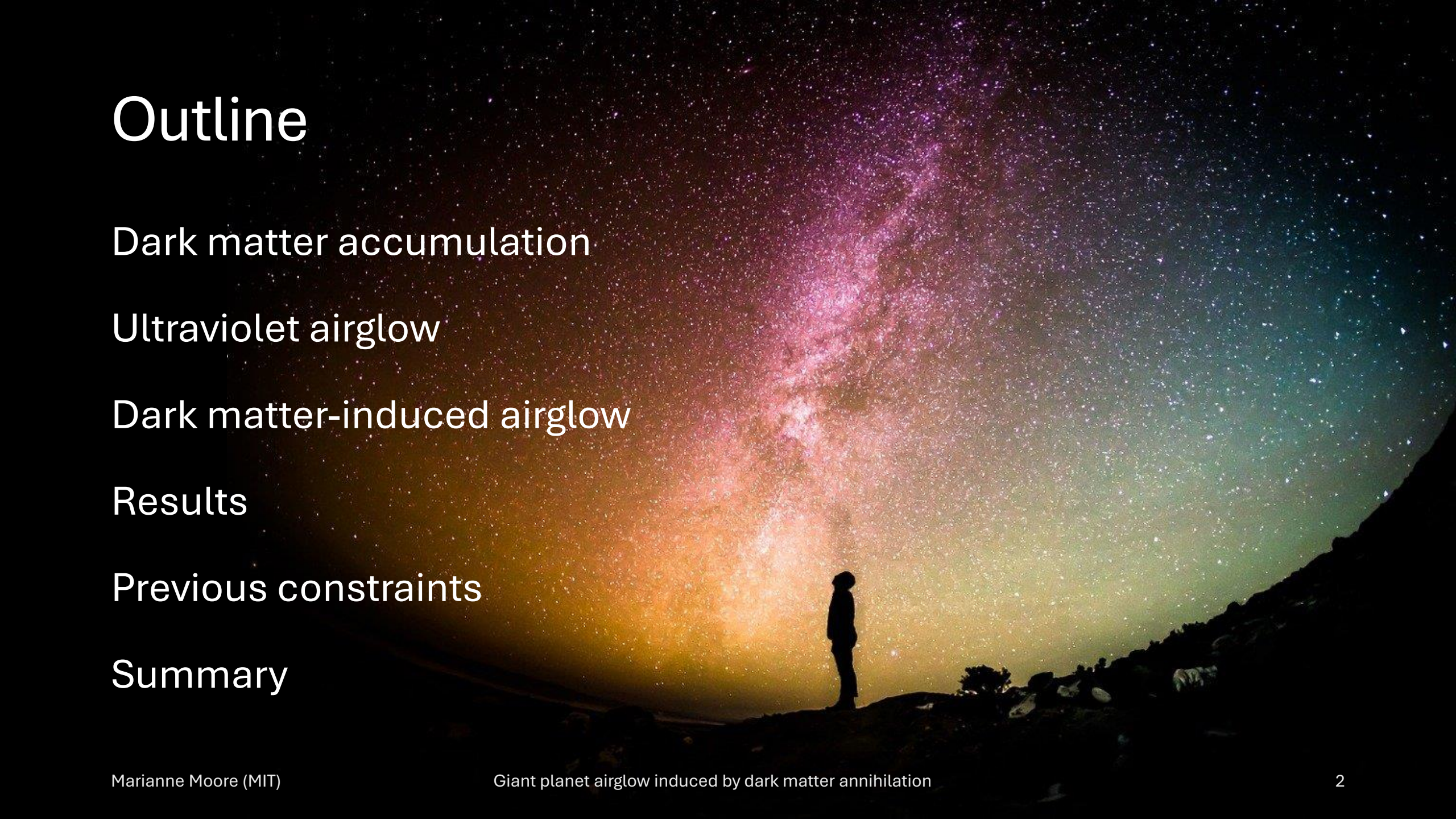
Ultraviolet airglow

Dark matter-induced airglow

Results

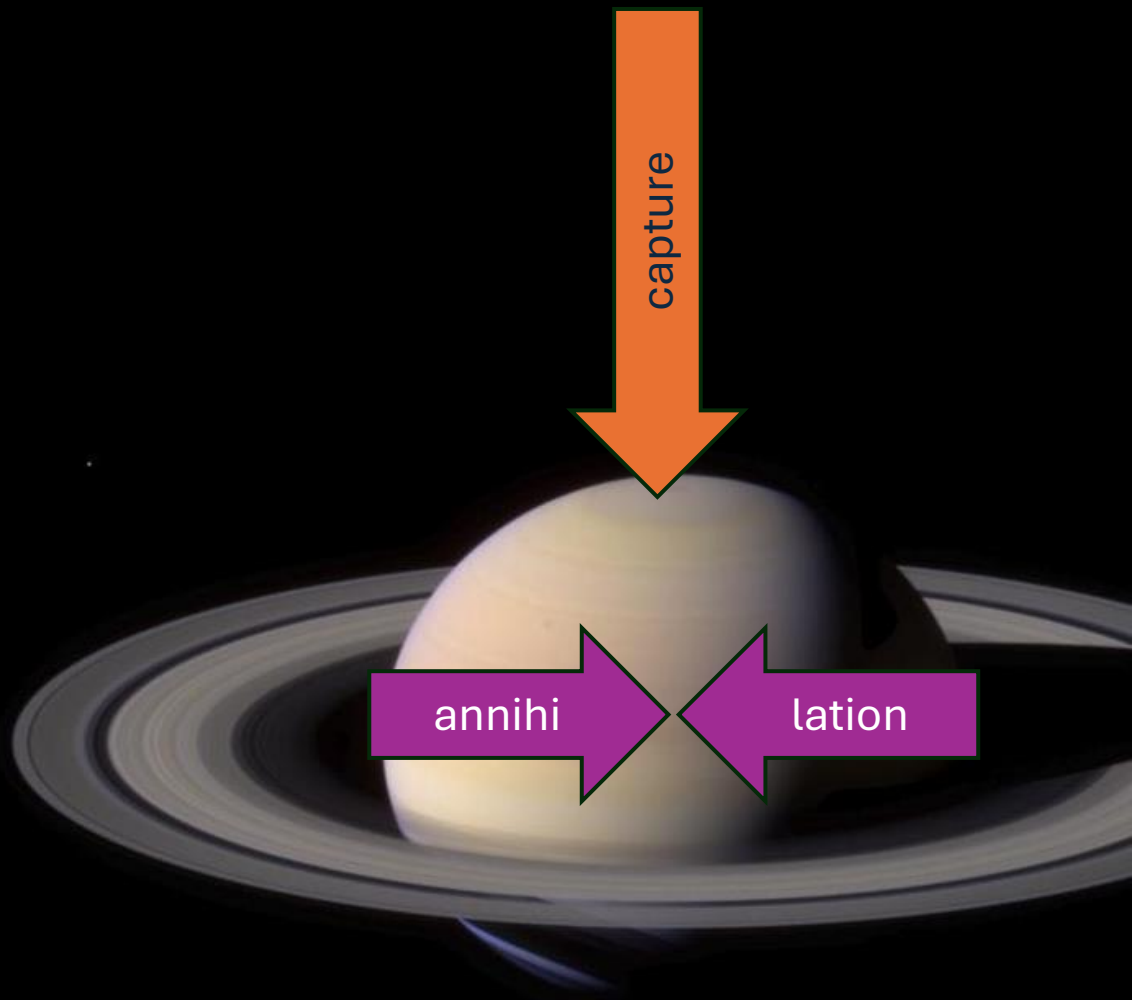
Previous constraints

Summary



Dark matter accumulation in planets

$$\frac{\mathrm{d}N_\chi}{\mathrm{d}t} = \Gamma_{\mathrm{capture}} - N_\chi^2 \Gamma_{\mathrm{annihilation}}$$



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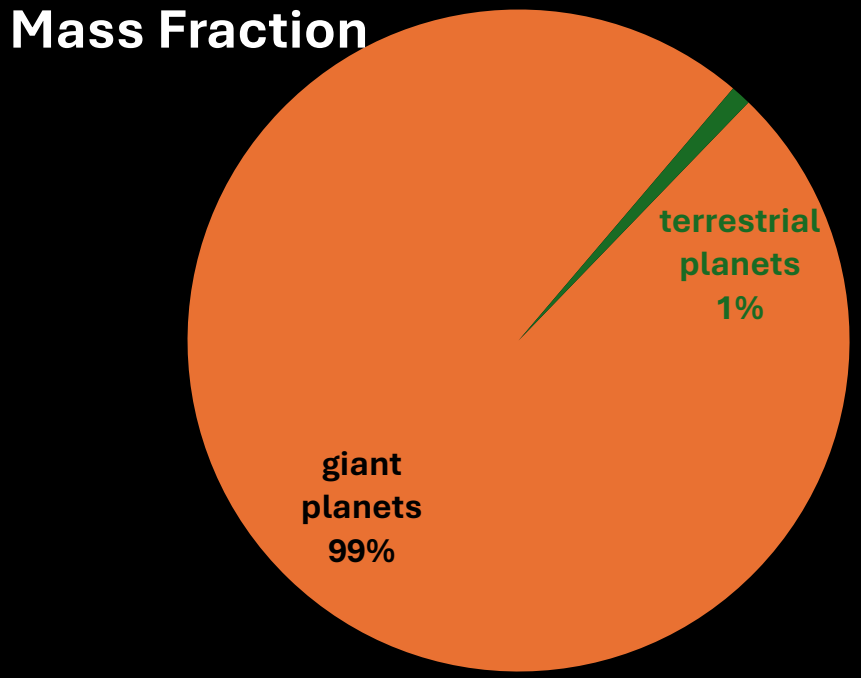
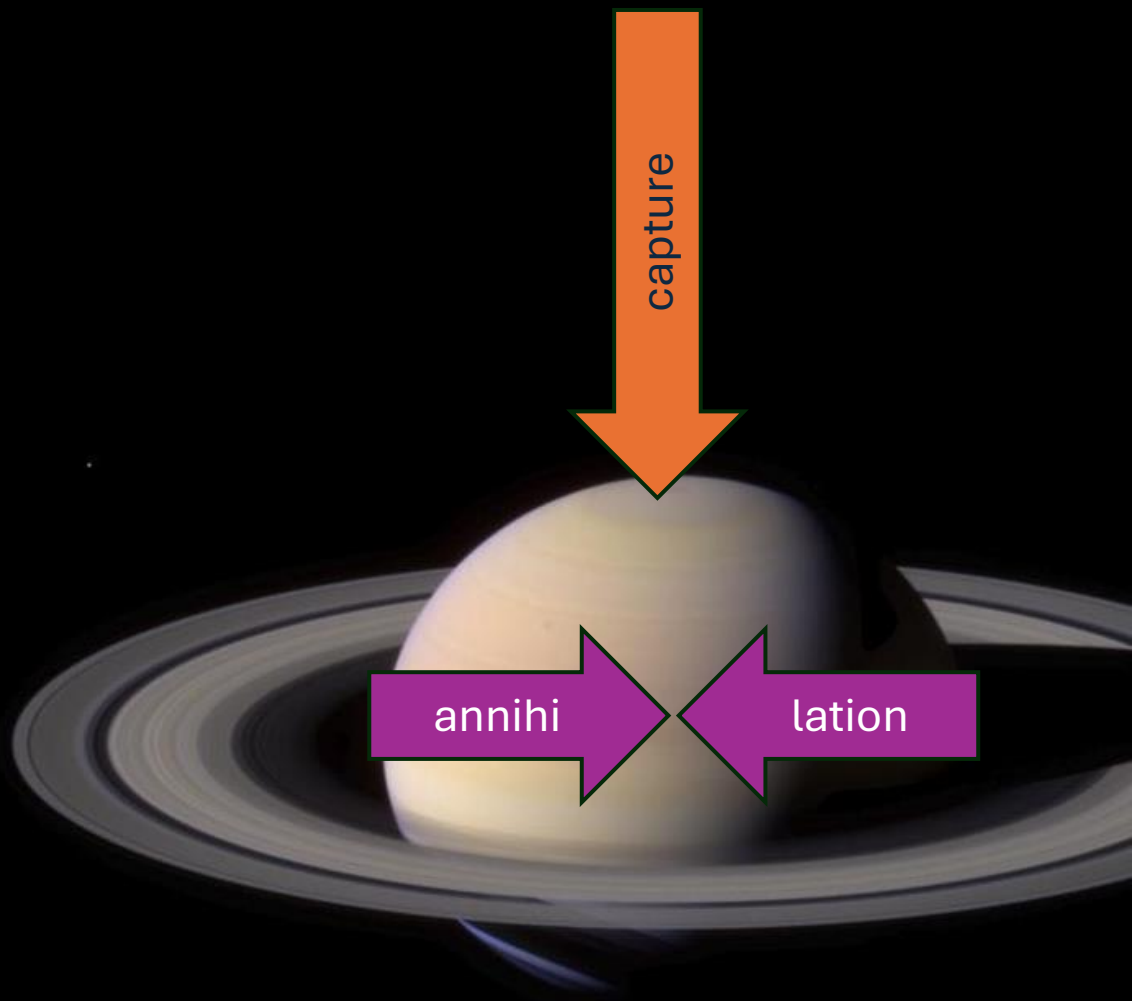
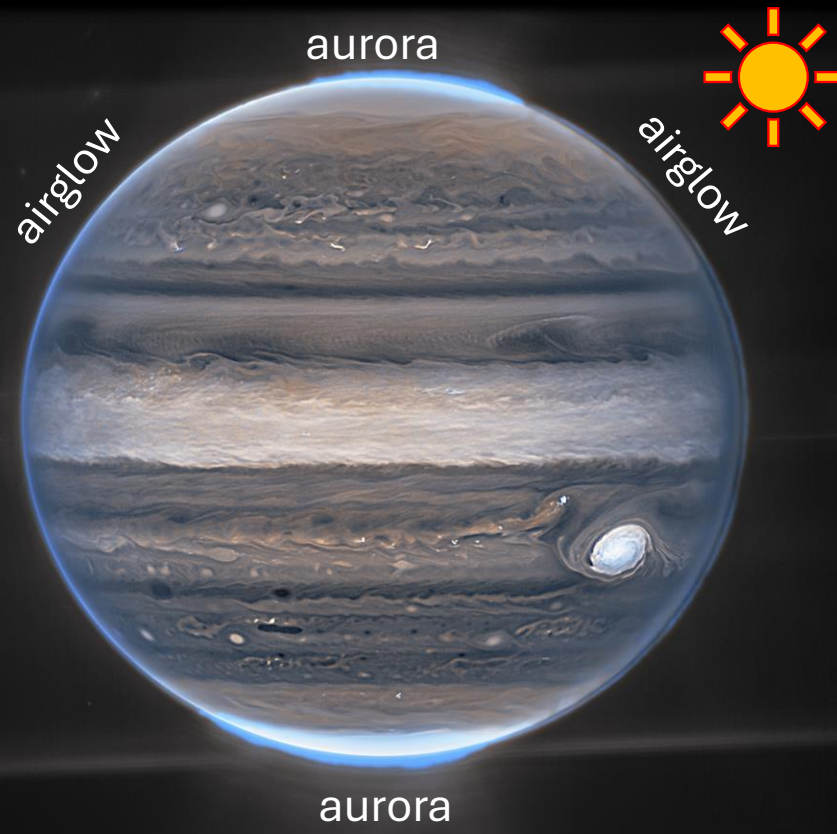




Ultraviolet airglow

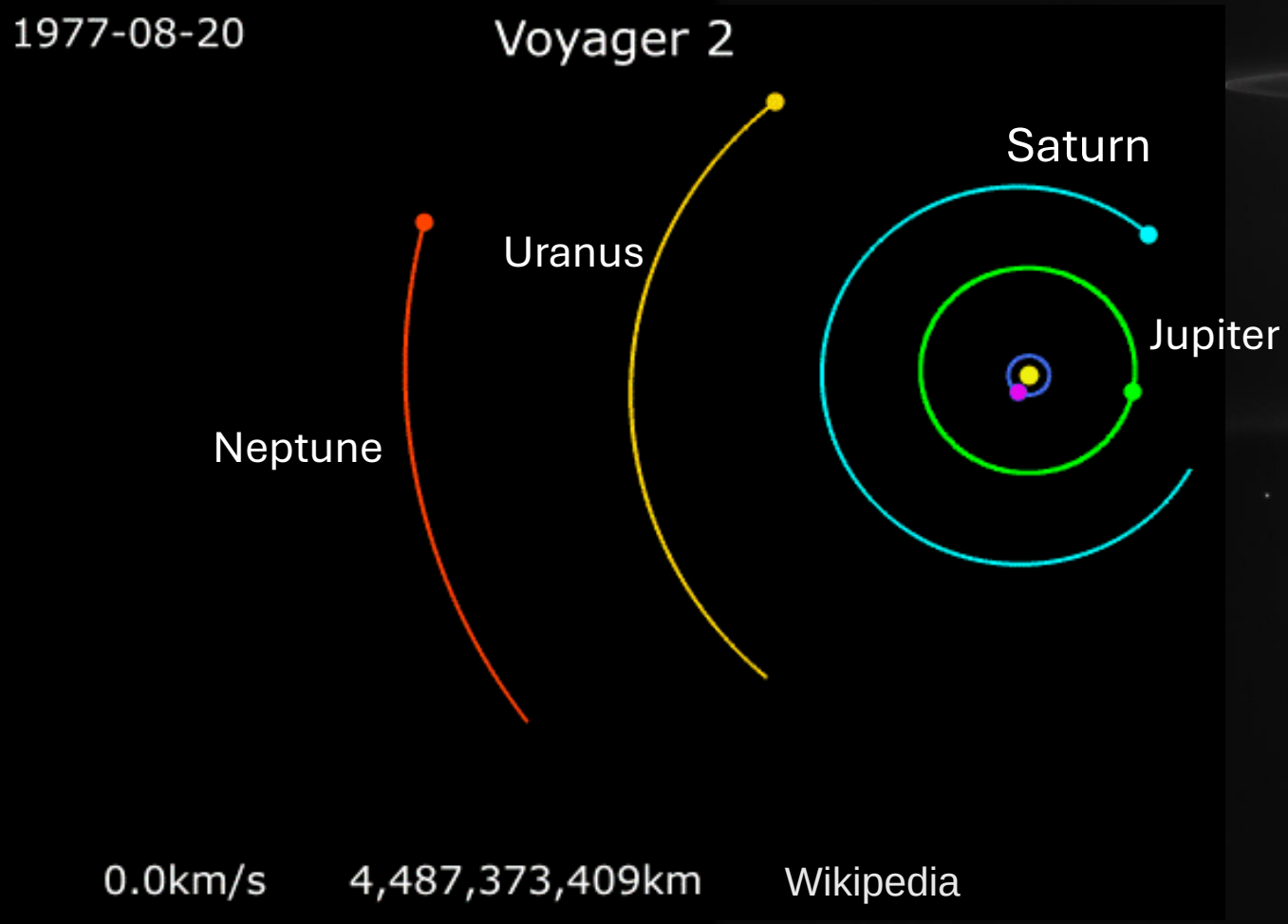
- The giant planets emit an isotropic airglow and auroras
- Mostly produced by electron precipitation
  - With contamination by solar radiation on dayside
- Focus on molecular hydrogen lines
  - Clear relationship observed flux ⇔ input electron power

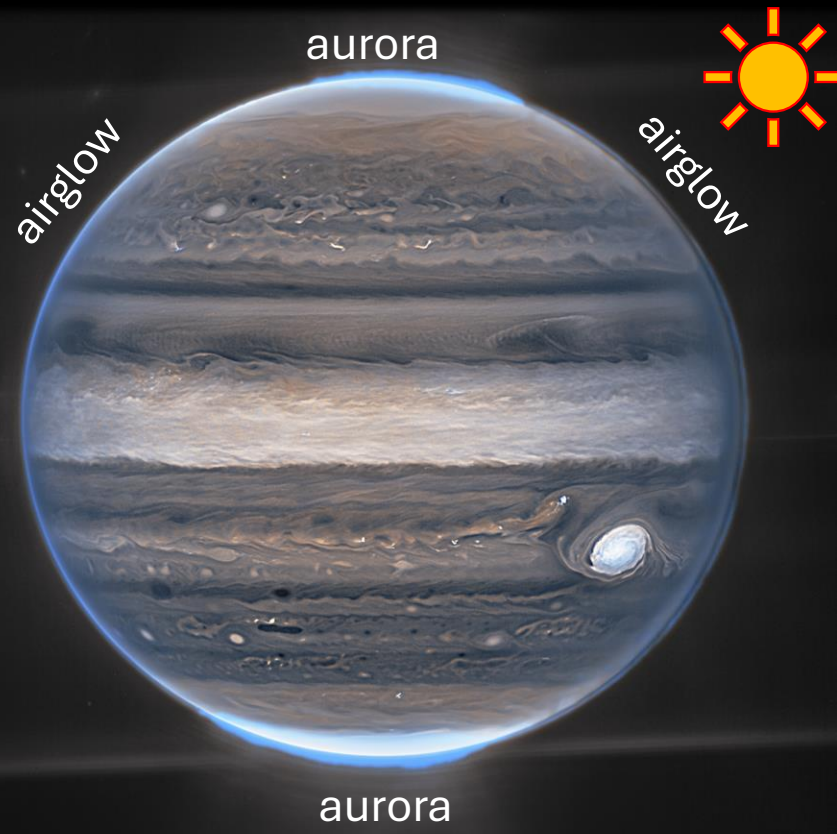


$$H_2^* \rightarrow H_2 + h\nu$$

Ultraviolet airglow

Ultraviolet airglow





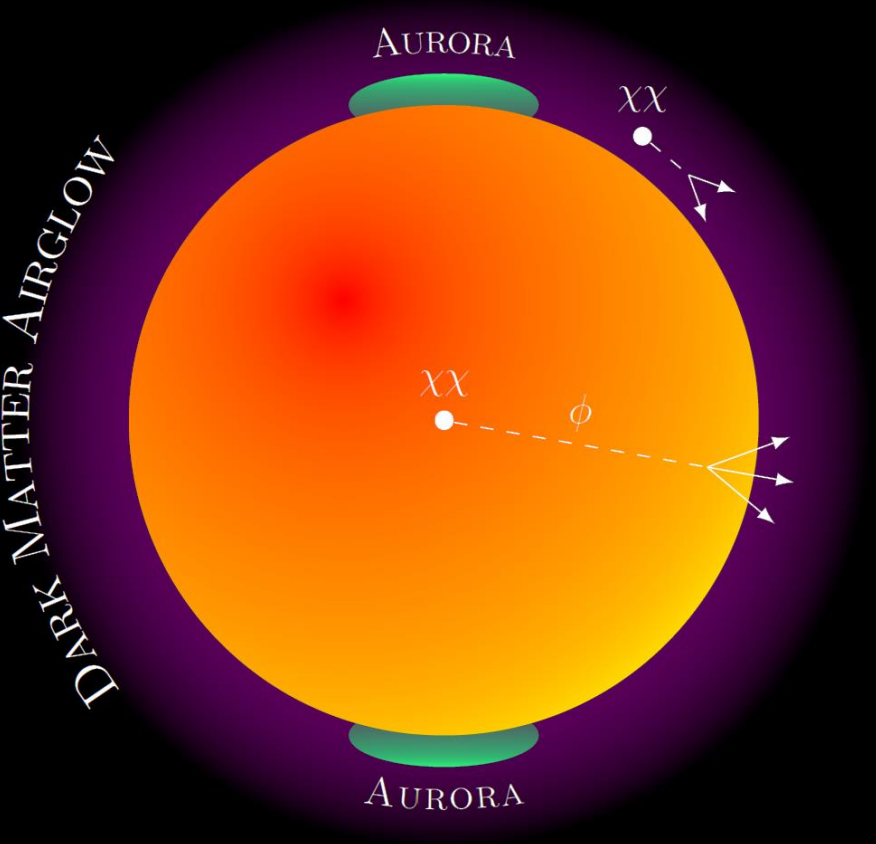
Dark matter-induced airglow

If

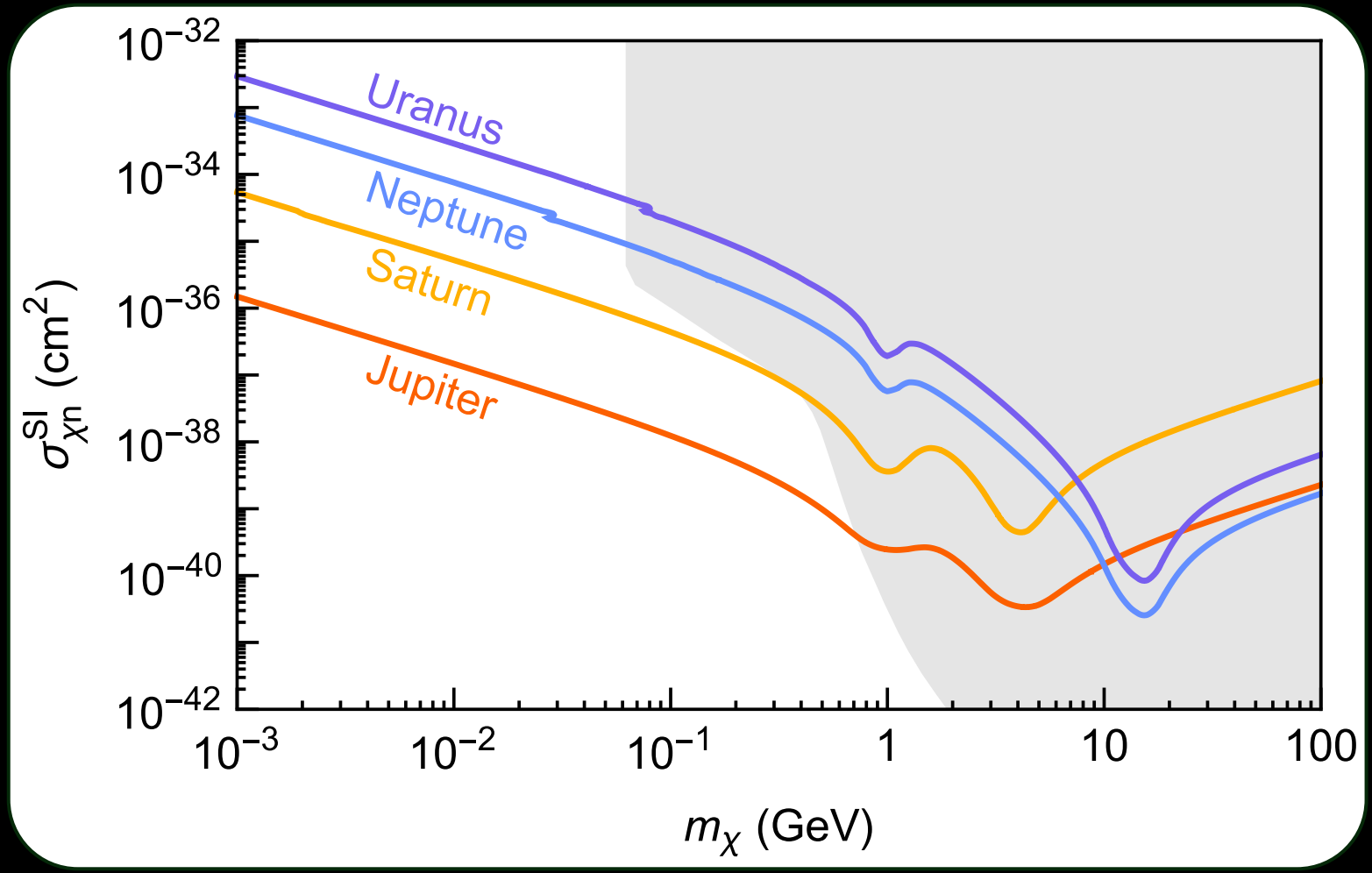
- dark matter annihilates to electrons

$$P_{\mathrm{DM}}^{\mathrm{airglow}} \leq P_{\mathrm{observed}}^{\mathrm{airglow}}$$

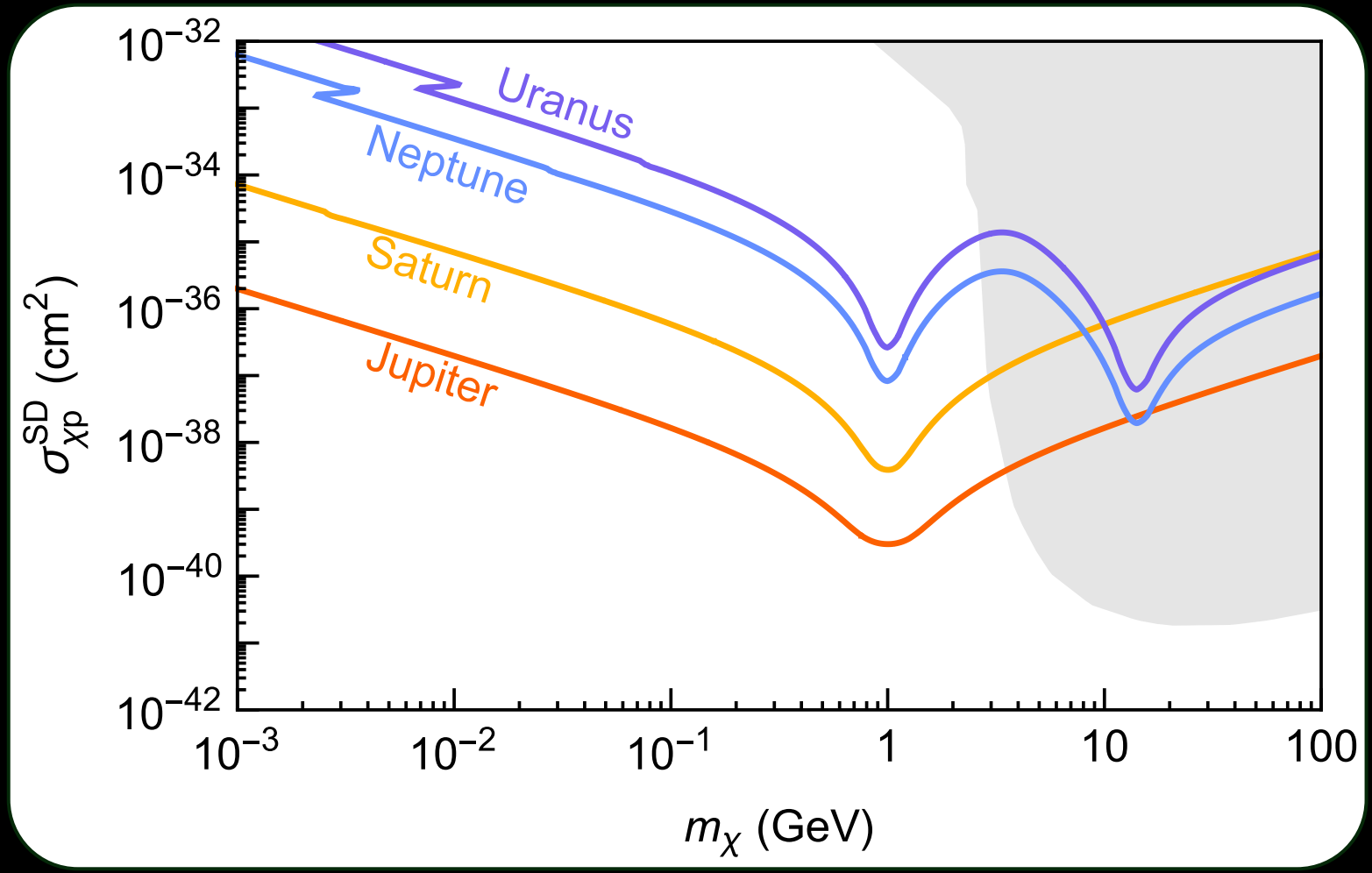
- dark matter annihilates to other final states
  - The limit is reduced by a factor of a few



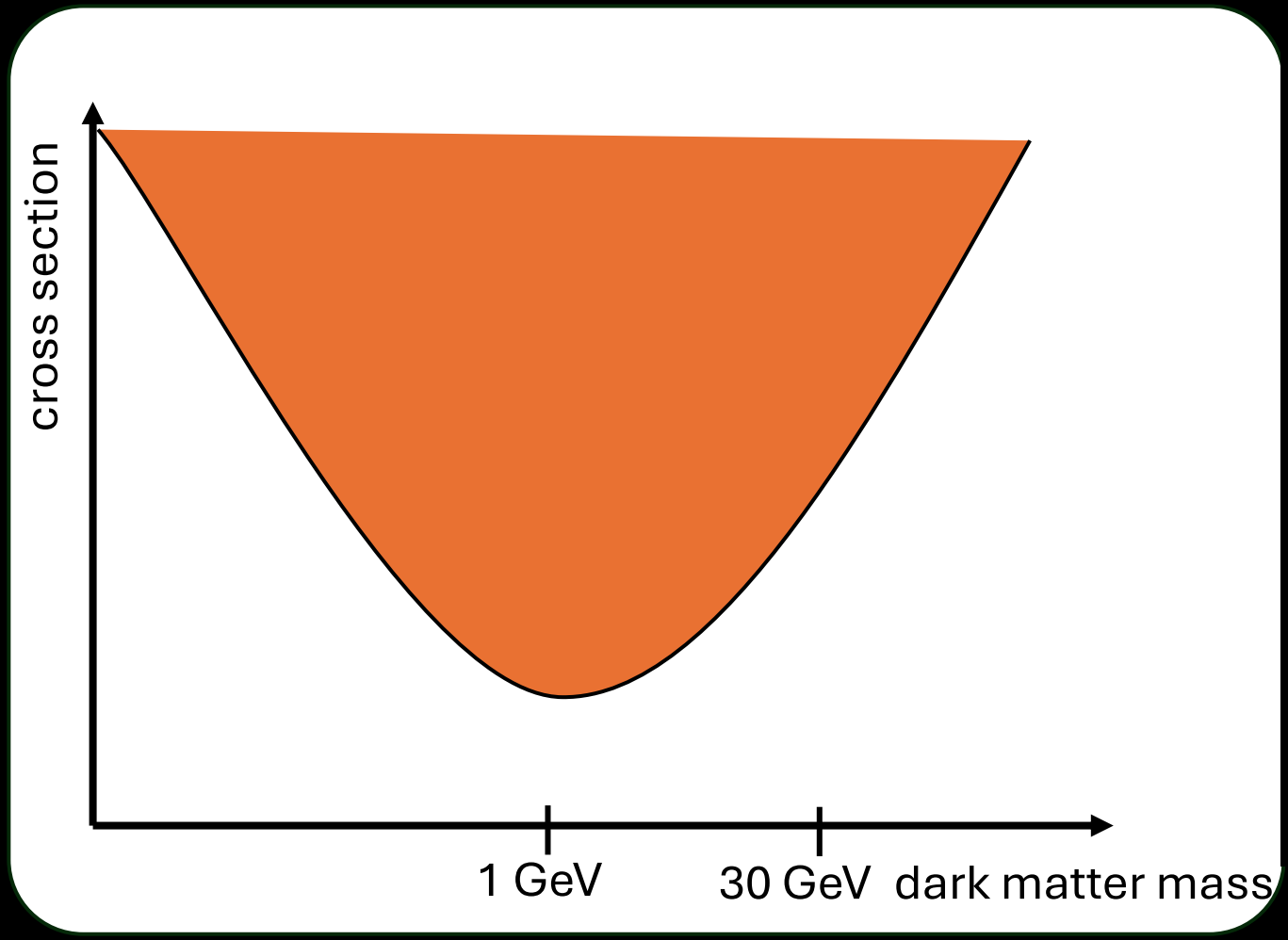
Results: spin-independent



Results: spin-dependent proton

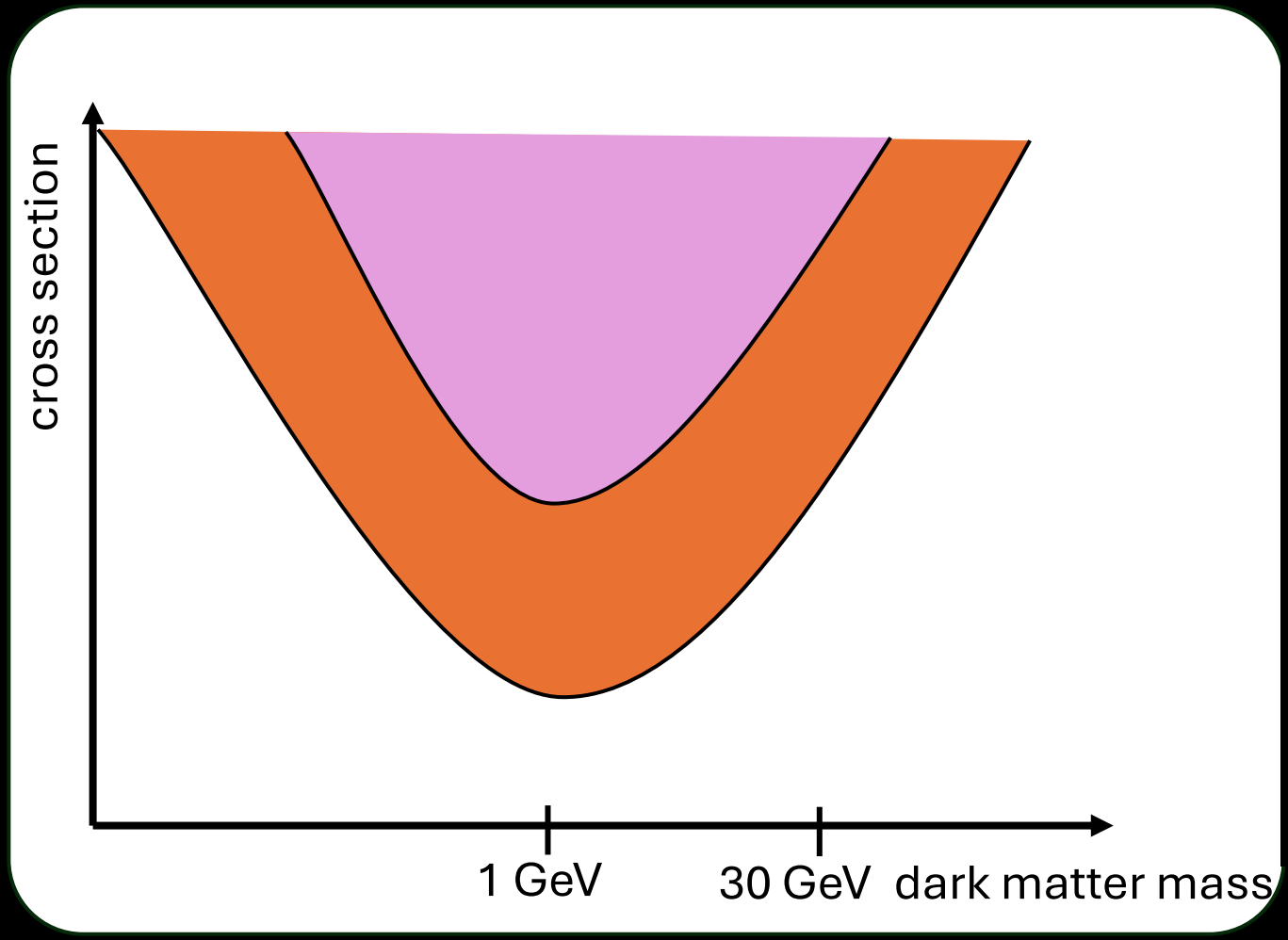


Our results vs previous constraints



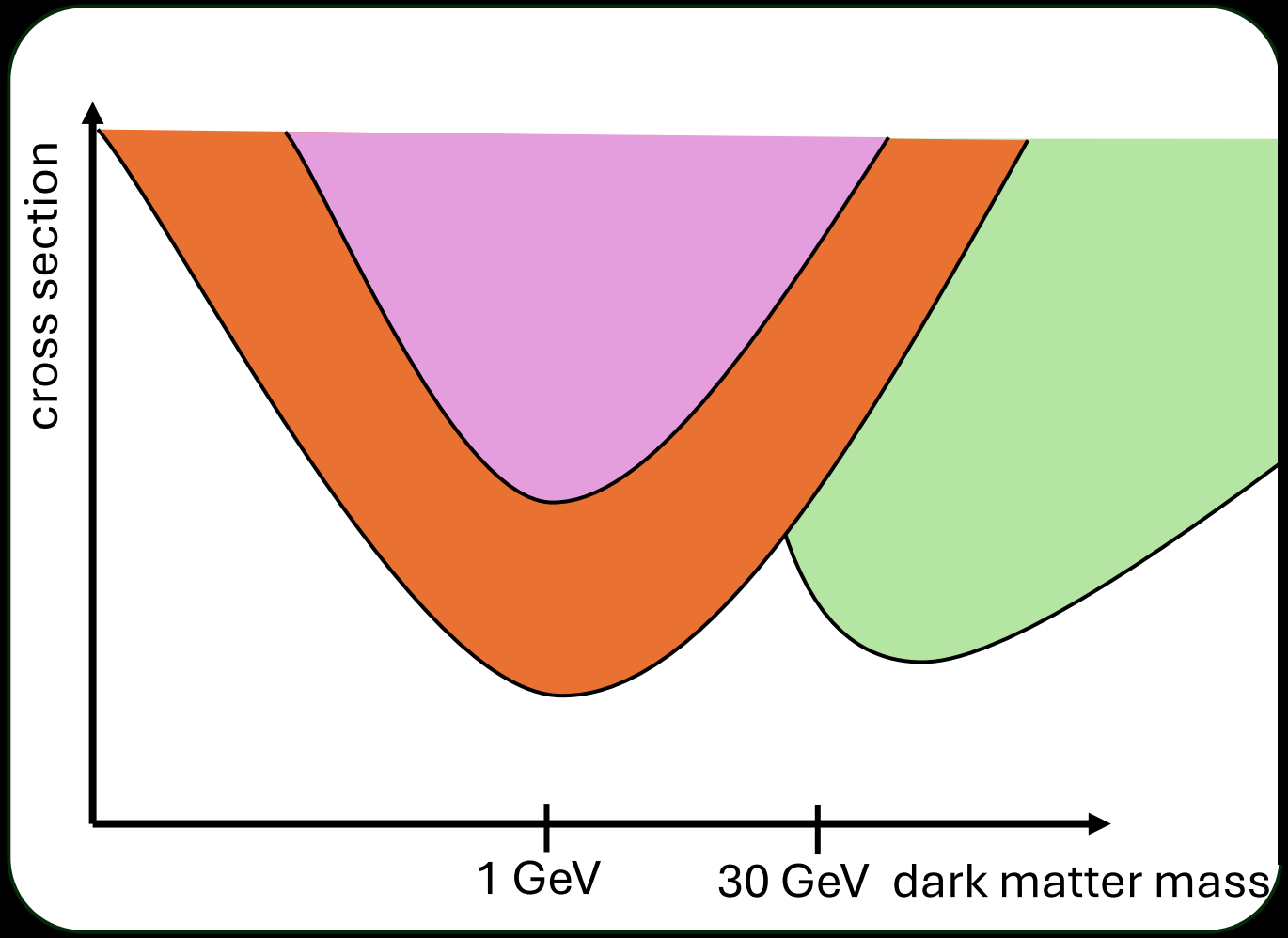
Our results vs previous constraints

- Atmospheric cooling by H_3^+ (2312.06758)



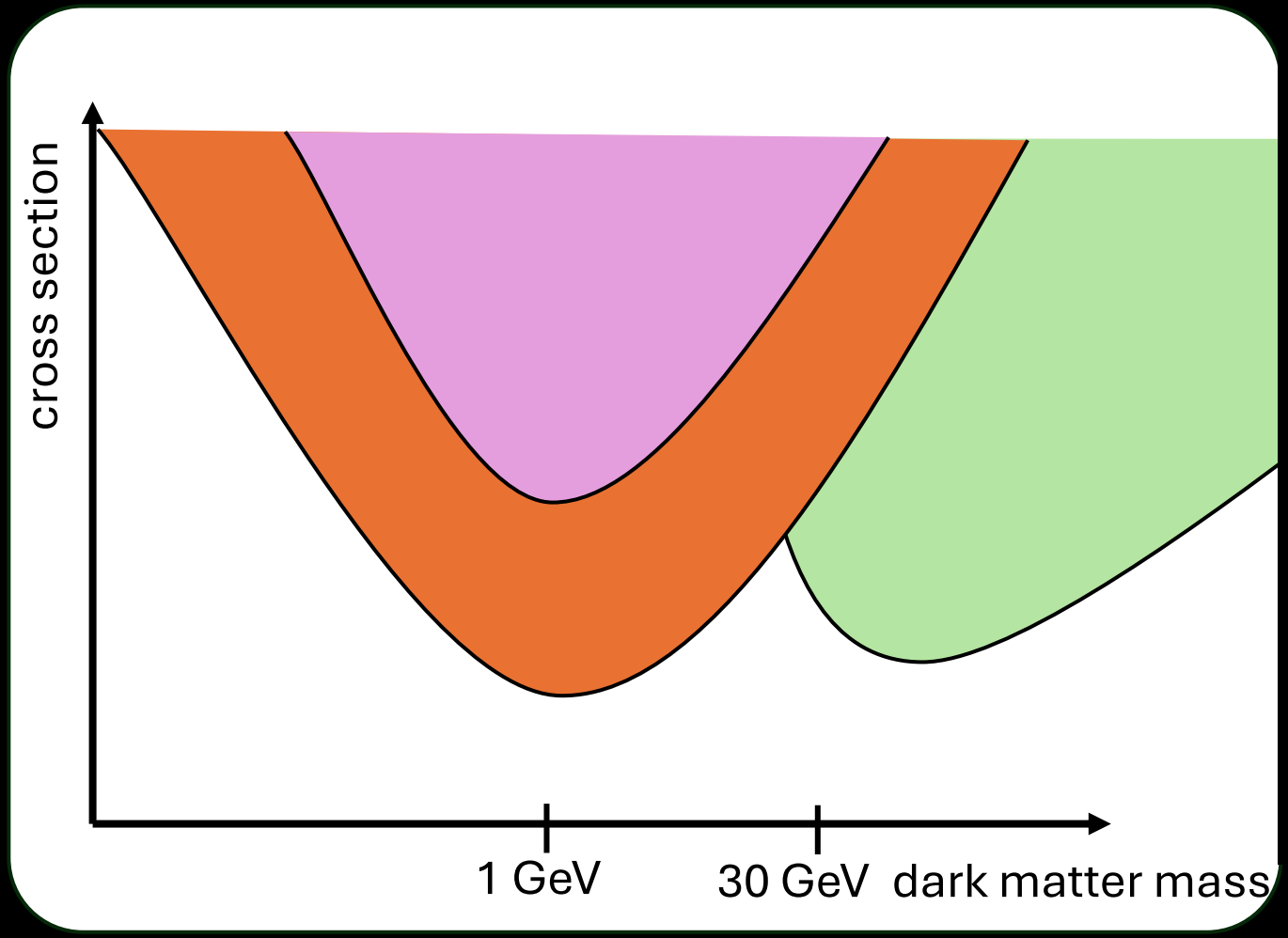
Our results vs previous constraints

- Atmospheric cooling by H_3^+ (2312.06758)
- Anomalous heating of the planetary interior (e.g. 0705.4298, 0808.2823, 1909.11683, 2210.01812)



Our results vs previous constraints

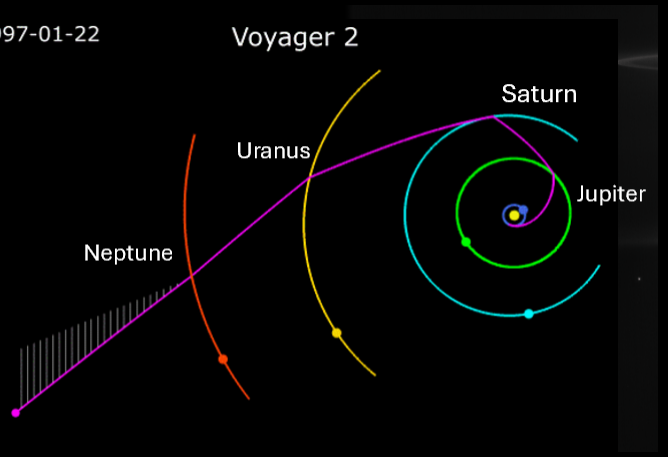
- Atmospheric cooling by H_3^+ (2312.06758)
- Anomalous heating of the planetary interior (e.g. 0705.4298, 0808.2823, 1909.11683, 2210.01812)
- Limits from the Galactic center



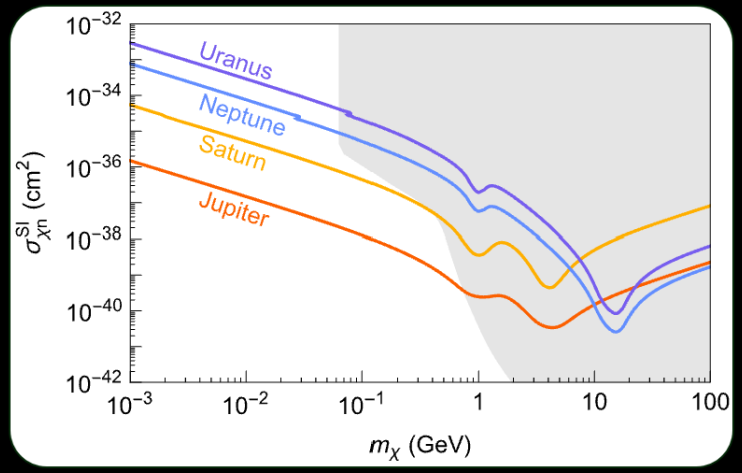
Summary

Signal

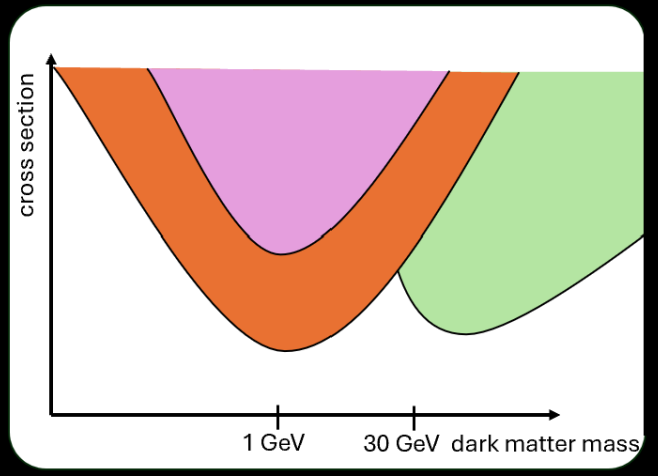
Data



Our constraints



Competing constraints



Summary

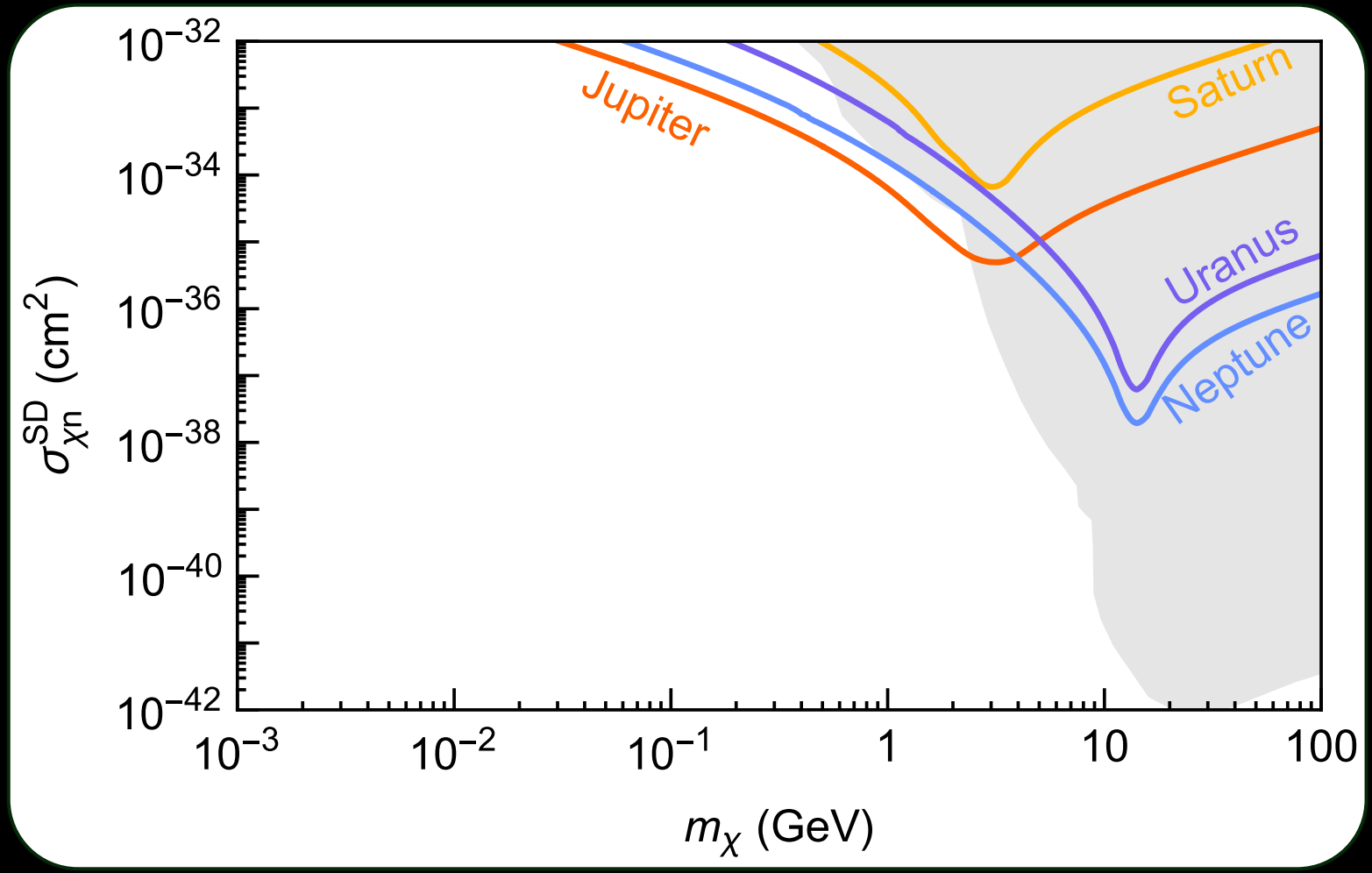
UV airglow is a promising avenue to search for dark matter

Backup slides

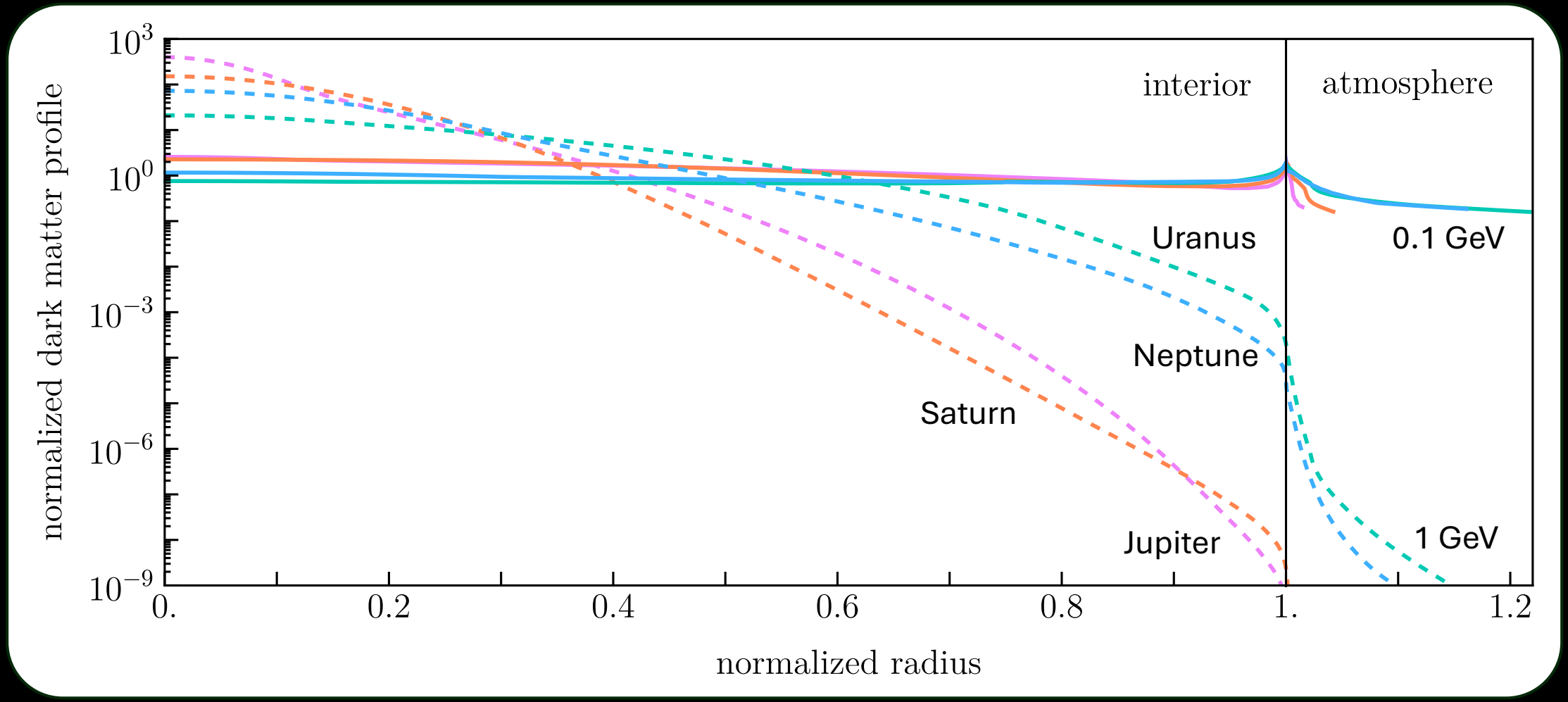
UV airglow values

Planet	$P_{observed}^{airglow}$ (μW/m²)	Space probe
Jupiter	$0.31^{+0.19}_{-0.15}$	New Horizons
Saturn	<1	Voyager 1
Uranus	4.6	Voyager 2
Neptune	1.9 ± 0.3	Voyager 2

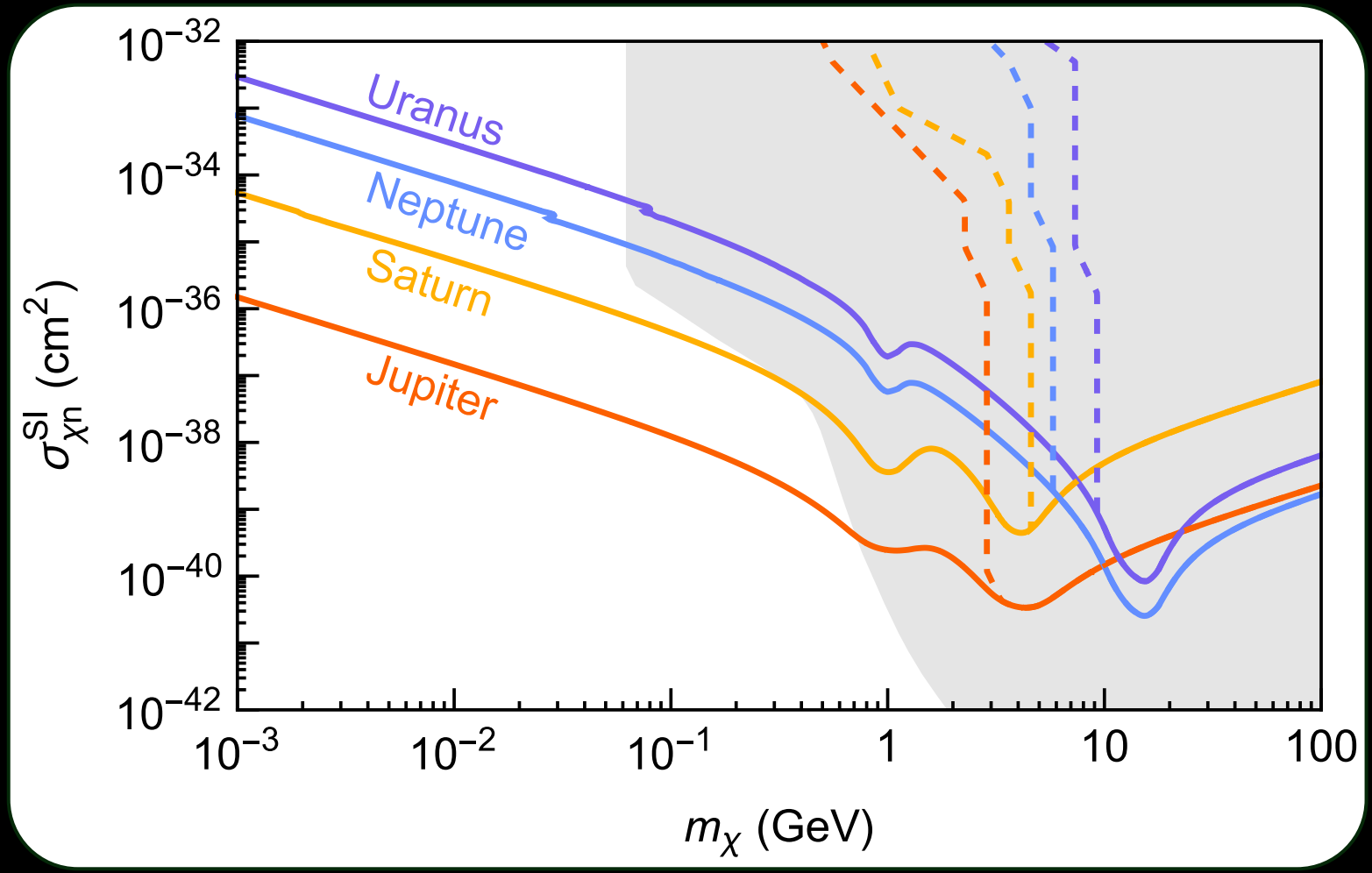
Results: spin-dependent neutron



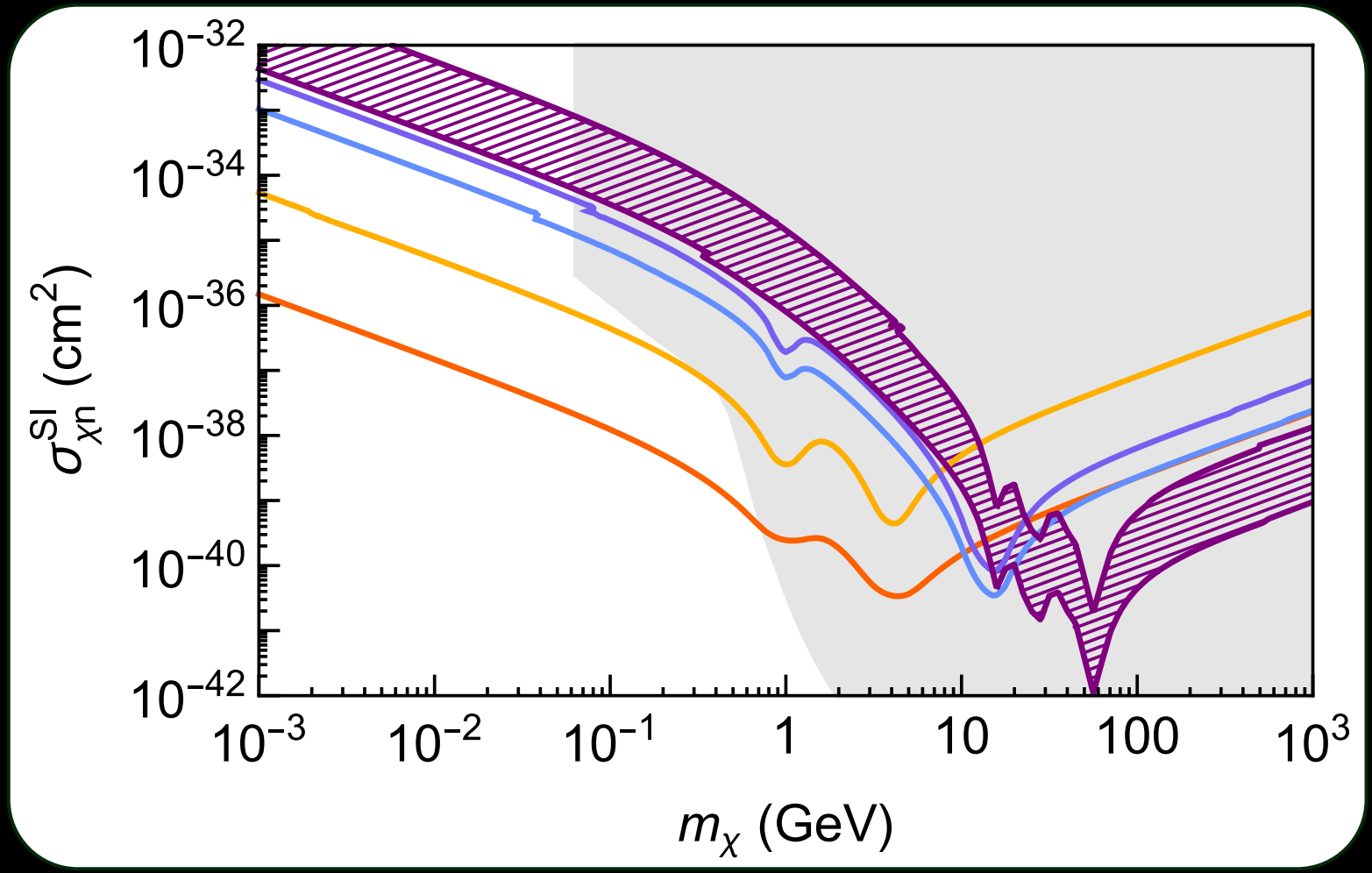
Preliminary results: dark matter radial profile



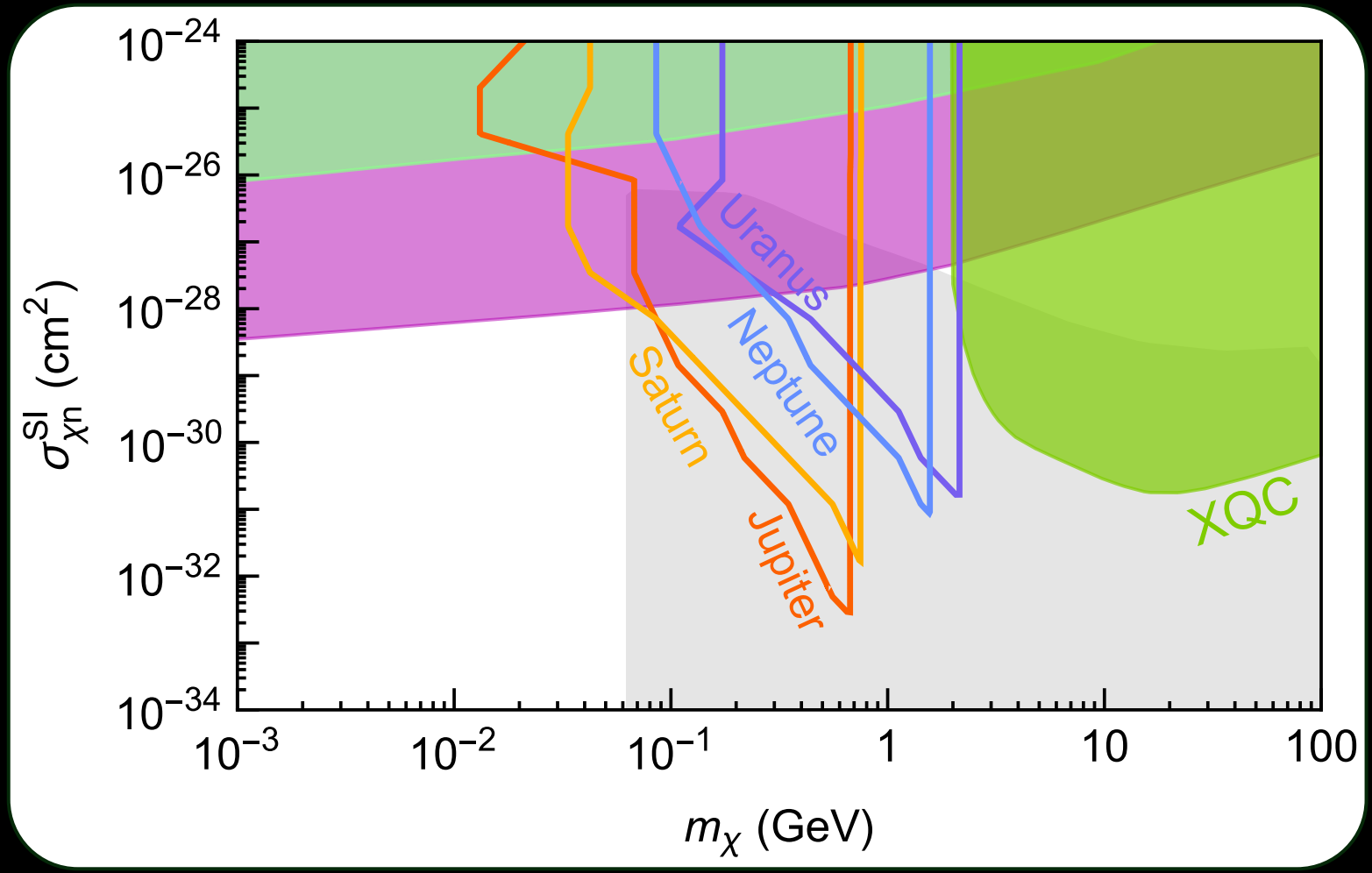
Preliminary results: evaporation



Preliminary results: what about Earth?

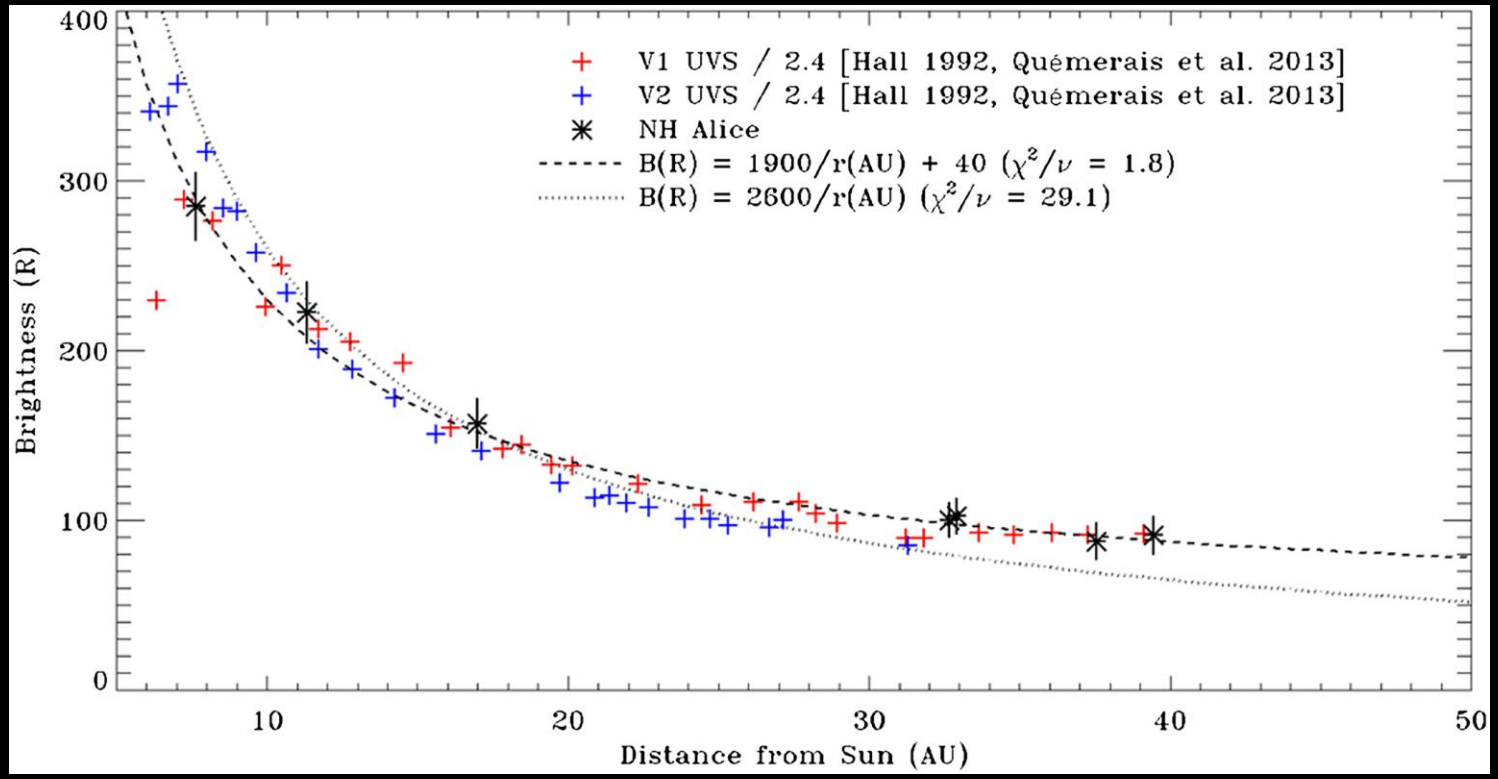


Preliminary results: heavy mediator annihilation



Why not Lyman-alpha?

Non-negligible background on the nightside due to the interplanetary medium



Gladstone *et al.*, GRL 2018