

# Ubiquitous Corotation of Dark Matter Halos

## and Implications for Direct Detection

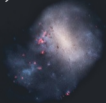
*PHENO26, May 11, 2026*

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Princeton University

with C. Blanco, M. Lisanti

arXiv:2607±1



## What is dark matter?

- In the early Universe, matter was too hot to clump up
- Need *something* non-interacting to form the seeds of structure
- Galaxies in the present day live inside one of these dark matter clumps

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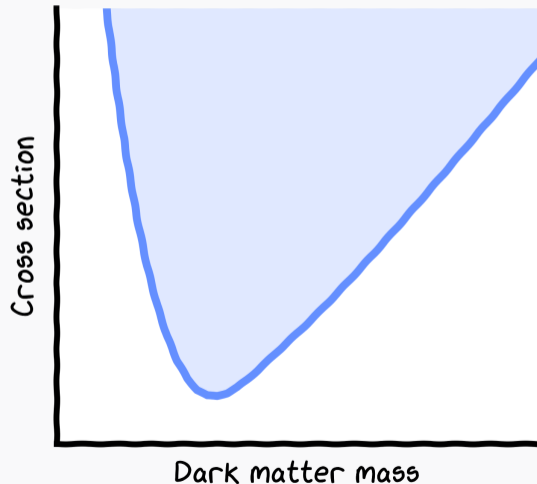
Since the Milky Way is also in one of these “halos,”  
**can we say anything about the dark matter around us?**

## Dark matter detection (specifically WIMP–nucleon)

- Scattering rate is essentially

$$\Gamma = \sigma n v \quad (\text{interaction prob.} \times \text{flux})$$

- Only notice a scattering happens if the nucleus recoils strongly enough

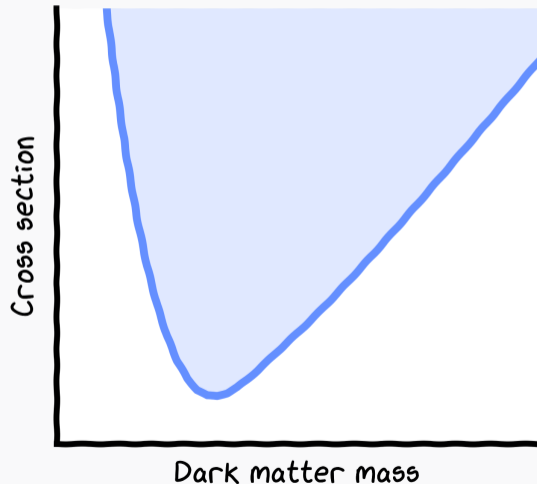


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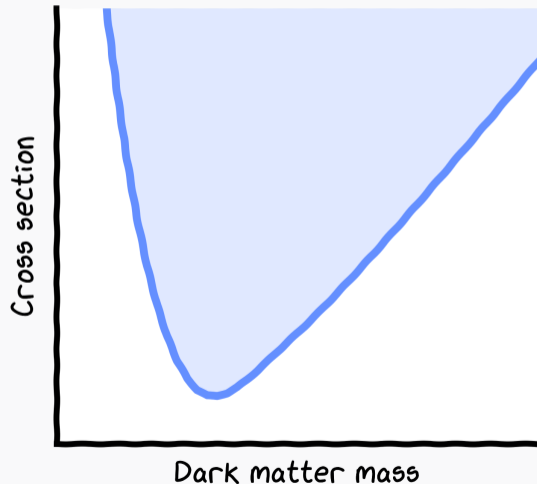


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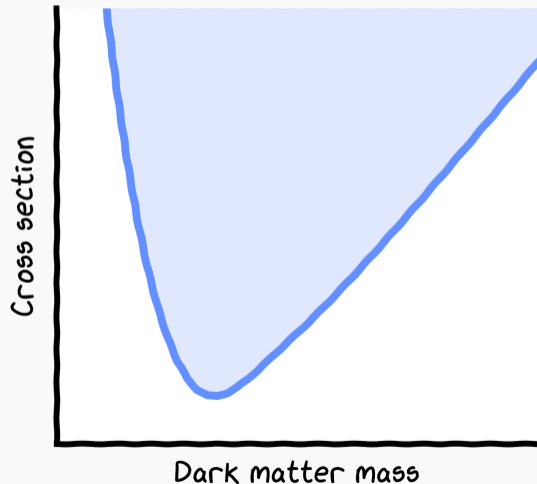
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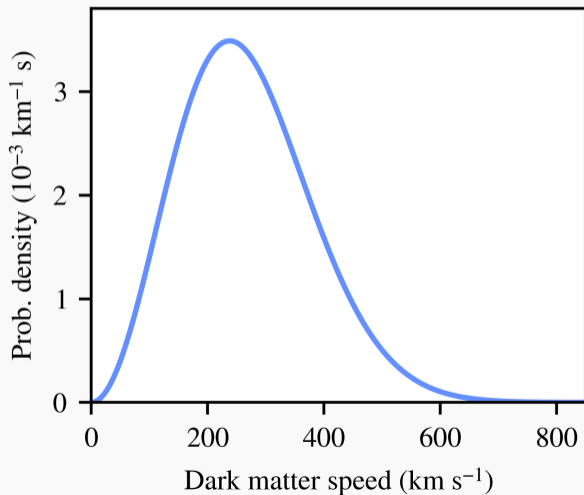
To constrain  $\sigma$ , **need** to know DM speed



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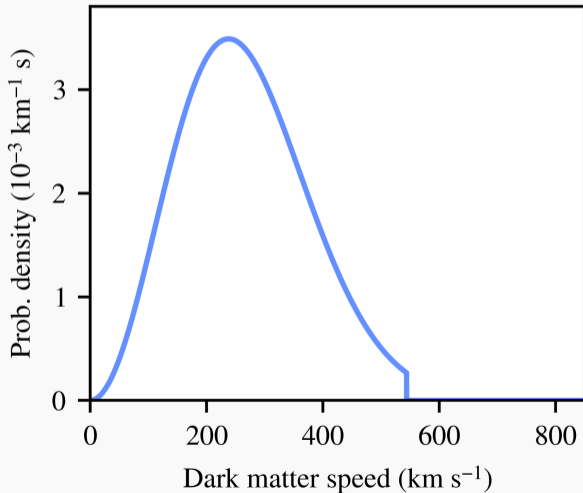
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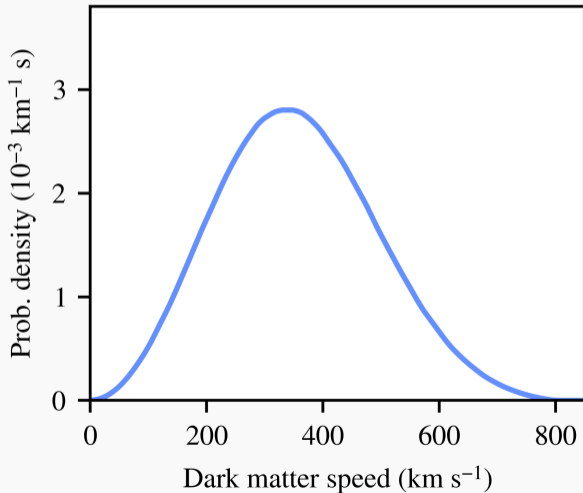
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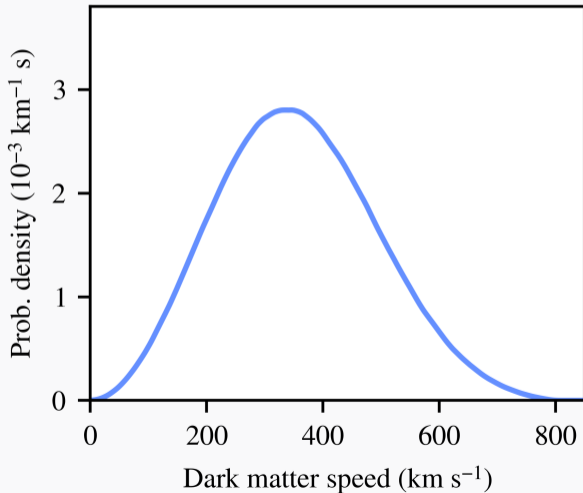


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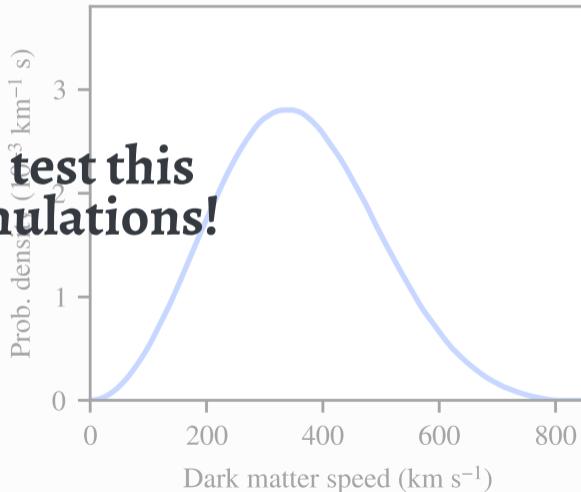
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**We can test this  
with simulations!**



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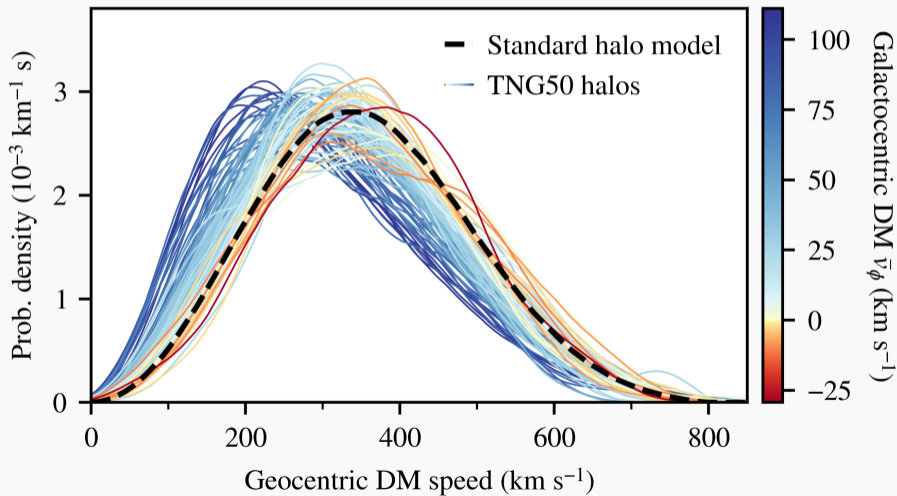
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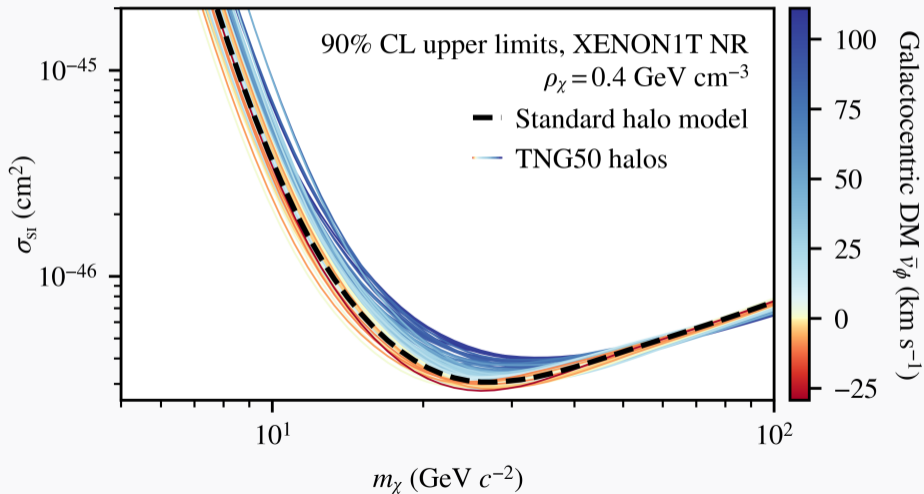
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  - Modifies the lab-frame speeds: **the geocentric boost isn't as strong**

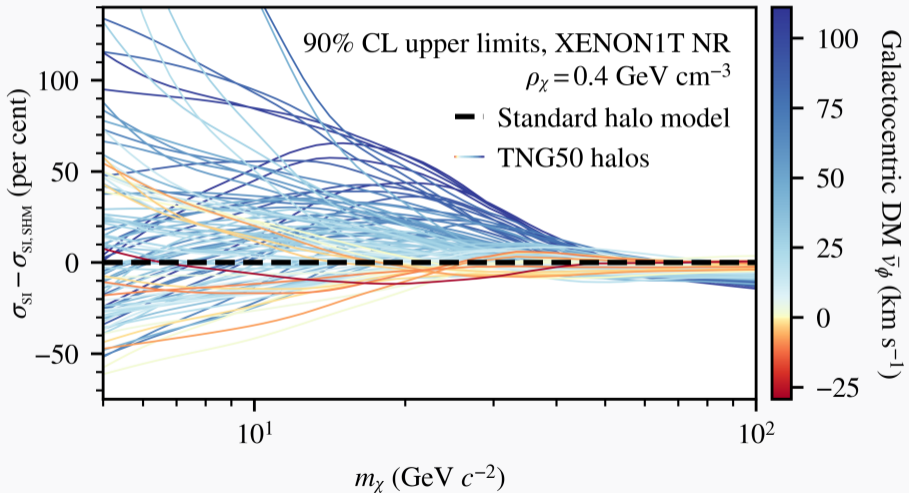
## TNG50 speed distributions



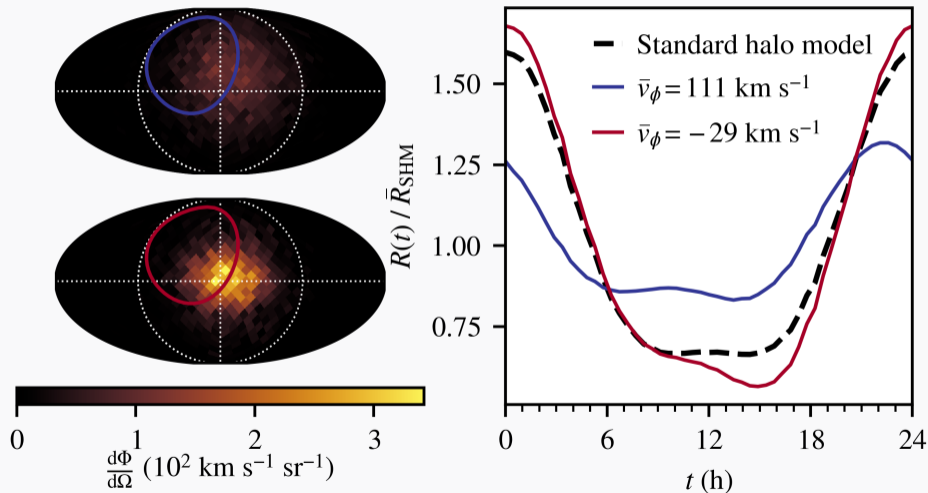
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## Implications: flux and daily modulation



The blue halo has sensitivity 50% that of the SHM, the red halo 115%

# Takeaways

- Simulated halos **generically co-rotate** with their baryons!
  - Typical rotation speeds are  $\bar{v}_\phi = 12\text{--}39$  km/s, smaller than  $v_\oplus$  but still nontrivial
- Isotropic scattering limits can be  $\sim 40\%$  weaker than SHM prediction
- Directional detectors suffer, too: flux is weak & spread out on the sky

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Both of these effects are **strongly correlated** with corotation;  
if we **measure**  $\bar{v}_\phi$ , the uncertainty shrinks **a lot!**

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# Thank you!

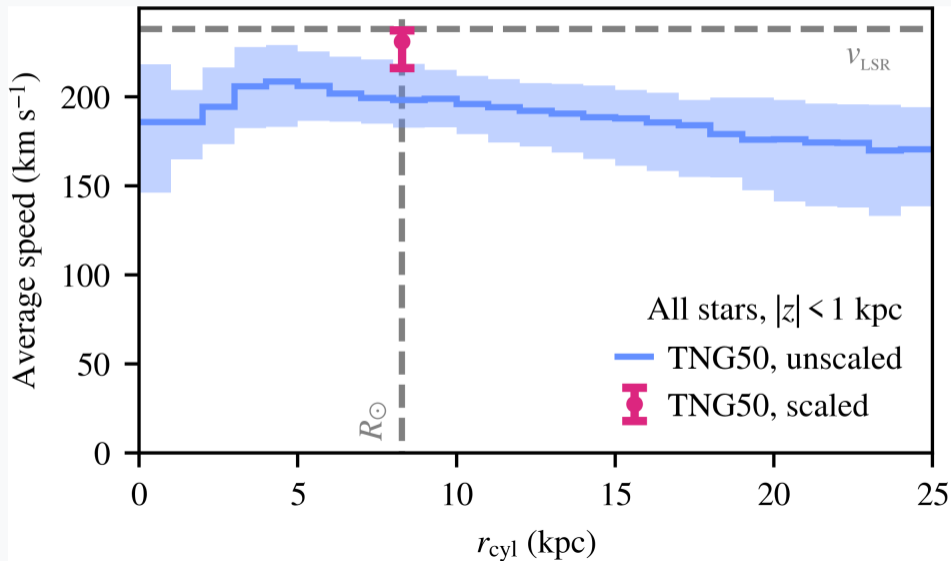
[dfolsom.com/research](http://dfolsom.com/research)

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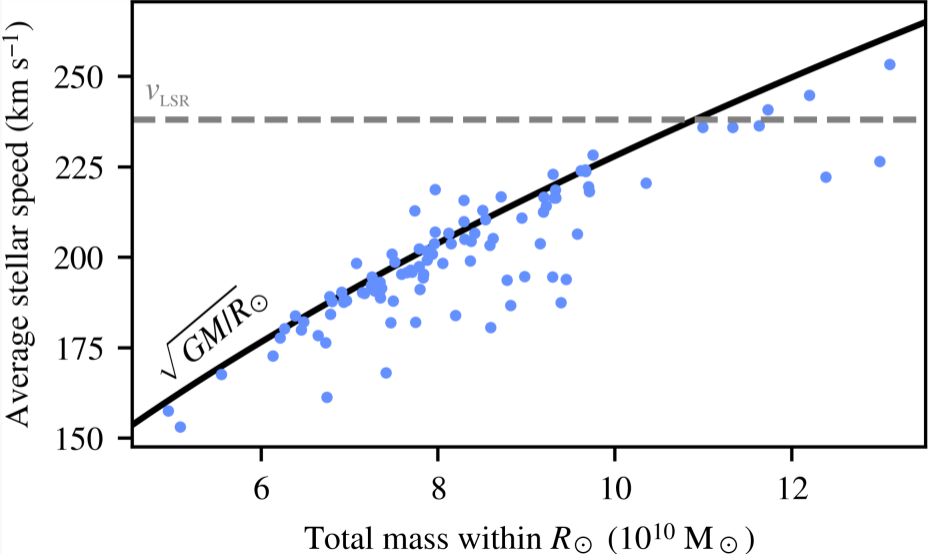
# Backup: MW compactness

[2505.07924]



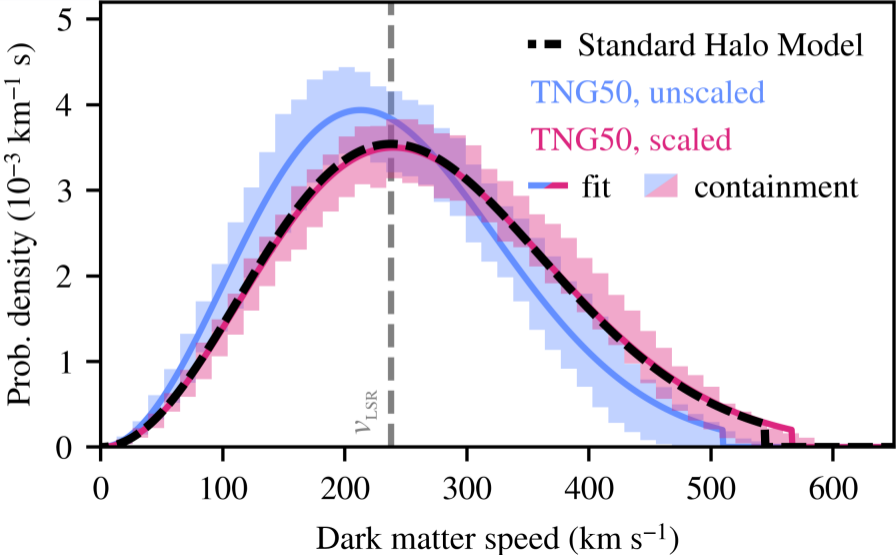
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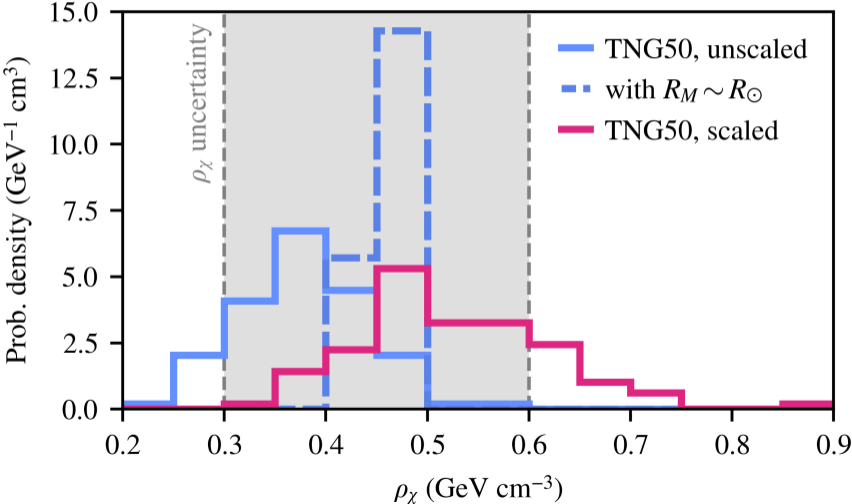
[2505.07924]



# Backup: MW compactness

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## Backup: scattering rate equations

[1603.03797]

The differential scattering rate is given by

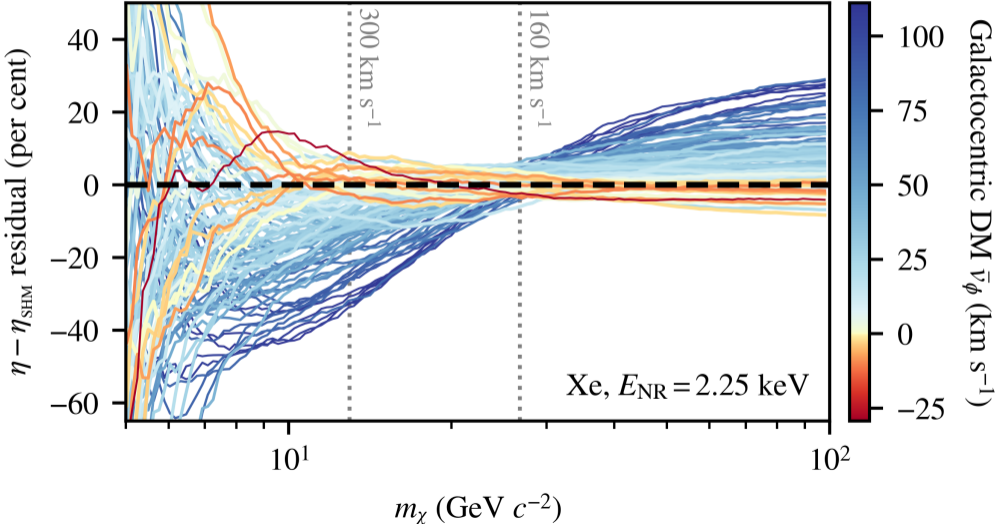
$$\begin{aligned}\frac{dR}{dE} &= \frac{n_\chi}{m_N} \left\langle v \frac{d\sigma}{dE} \right\rangle = \frac{\rho_\chi}{m_\chi m_N} \int_{v_{\min}}^{\infty} f(v_{\text{geo}}) v_{\text{geo}} \frac{d\sigma}{dE} d^3 v_{\text{geo}} \\ &= \frac{\rho_\chi}{m_\chi m_N} \int_{v_{\min}}^{\infty} \frac{f(v_{\text{geo}})}{v_{\text{geo}}} \frac{2m_N}{\pi} \langle |\mathcal{M}|^2 \rangle d^3 v_{\text{geo}}\end{aligned}$$

with DM–nucleus scattering amplitude  $\mathcal{M}$ . The lower limit of integration is set by the minimum speed  $v_{\min}(m_\chi)$  that can impart a given recoil energy  $E$ ,

$$v_{\min}(m_\chi) = \sqrt{\frac{E(m_N + m_\chi)}{2m_\chi}}, \quad \text{and} \quad \eta(v_{\min}) = \int_{v_{\min}}^{\infty} \frac{f(v_{\text{geo}})}{v_{\text{geo}}} d^3 v_{\text{geo}},$$

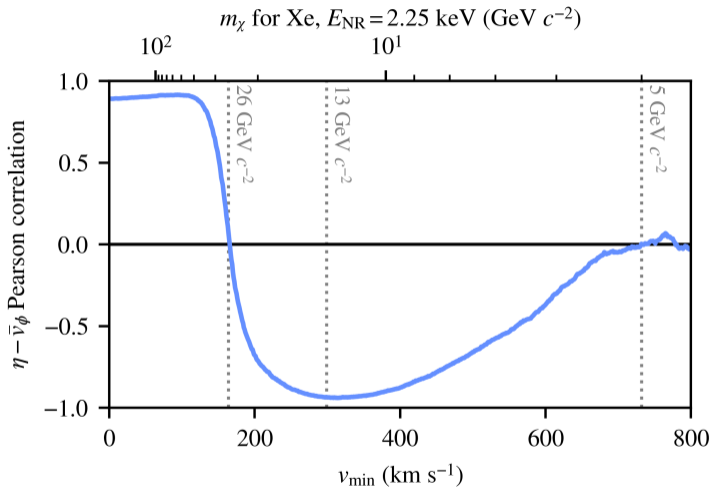
called the “halo integral,” parameterizes the astrophysics

# Backup: $\eta$ residual



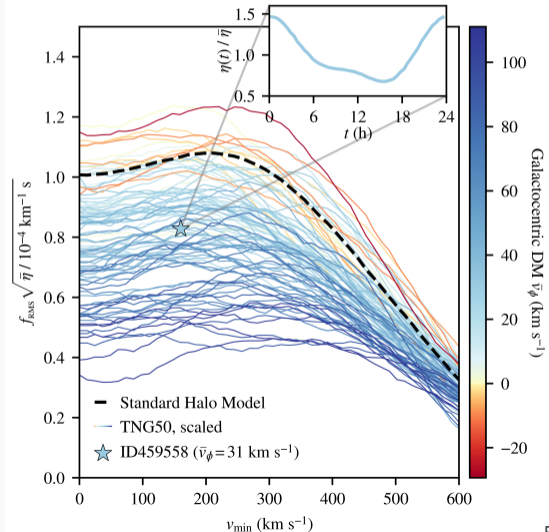
## Backup: $\eta - \bar{v}_\phi$ correlation

- Low mass: sensitive to high-speed tail, stochastic
- $\sim 13 \text{ GeV } c^{-2}$ : corotation effects maximized
- High mass: sensitive to  $\langle v^{-1} \rangle$

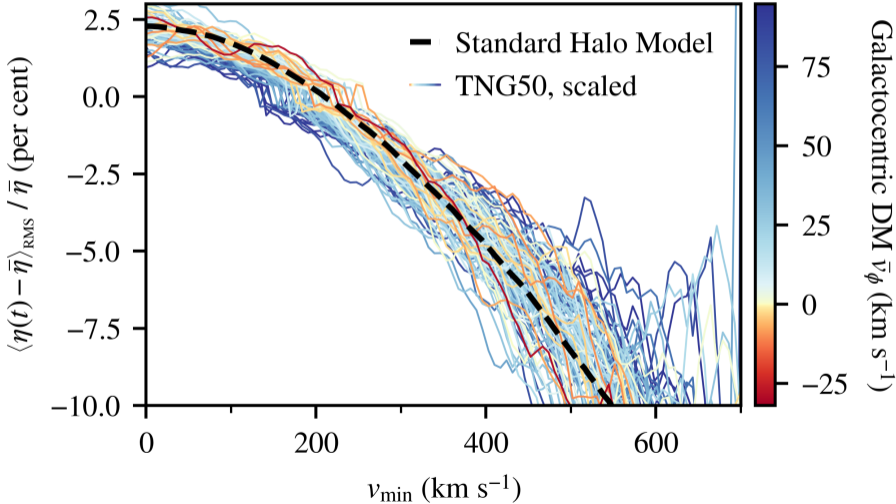


# Backup: daily modulation limit strength

- Sensitivity depends on:
  - Overall event rate – here,  $\eta(v_{\min})$
  - Root-mean-square amplitude of daily modulation
- Figure of merit:  $f_{\text{RMS}} \sqrt{\bar{\eta}}$
- Corotation suppresses  $\eta$  and  $f_{\text{RMS}}$
- Figure of merit depends strongly on  $\bar{v}_{\phi}$



# Backup: annual modulation



# Backup: corotation origins

