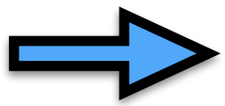
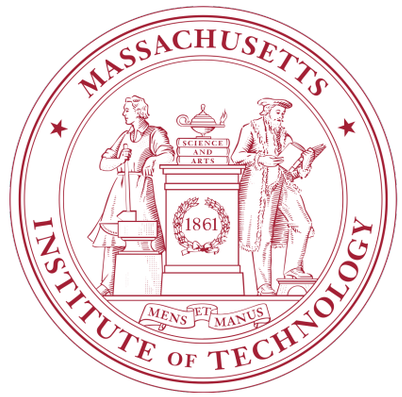
Testing Dark Matter with Galaxy Surveys

Mikhail (Misha) Ivanov
IAS —> MIT

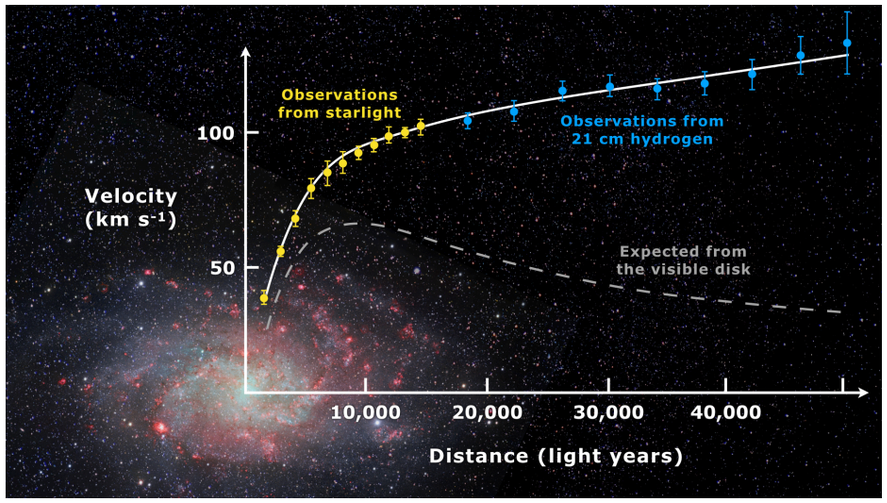




NHFP symposium, 18 Sep 2023

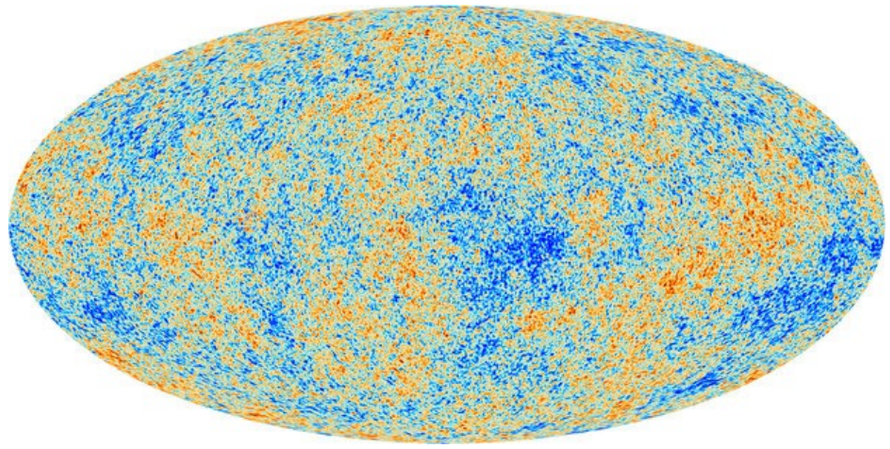
Thank you!

Dark Matter



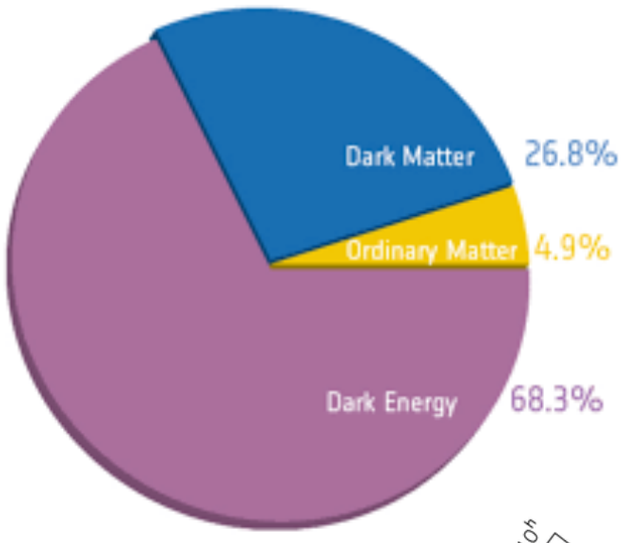
© Wikipedia

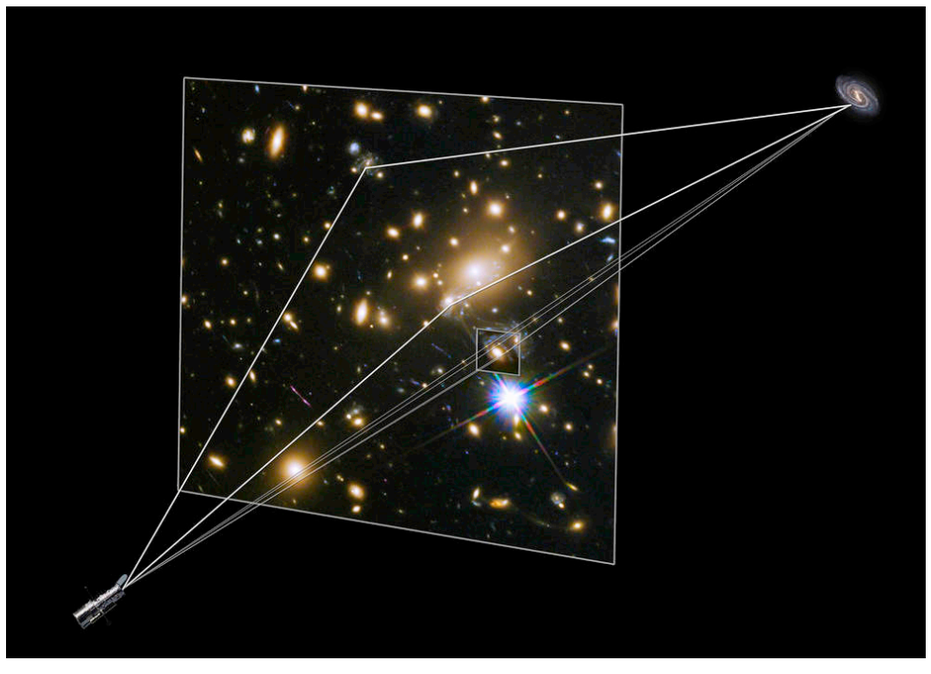
Rotation curves



Planck'18

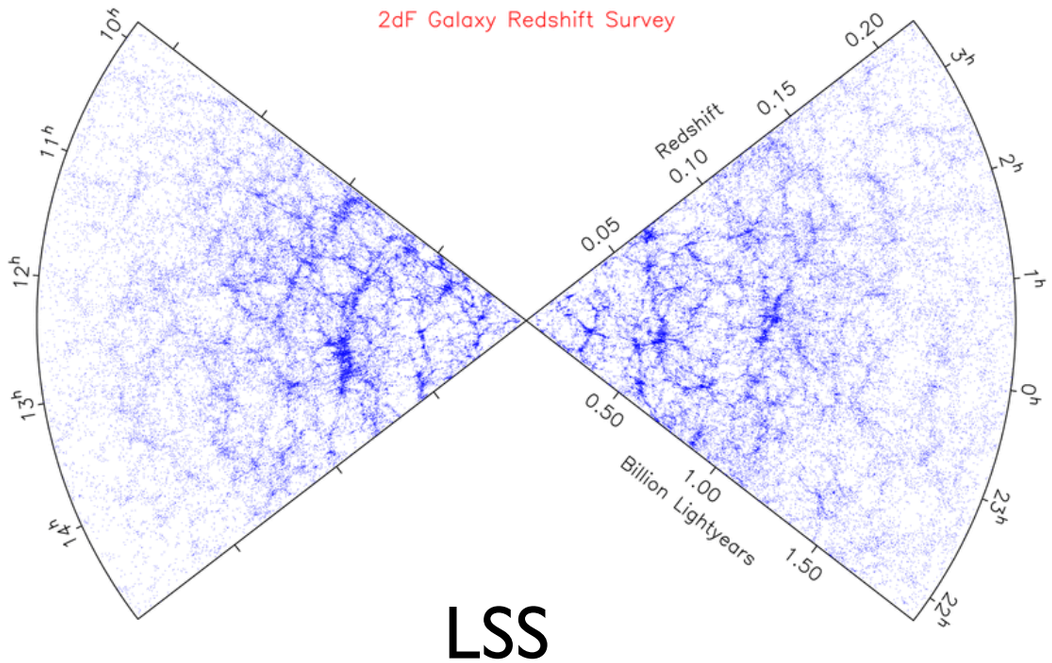
CMB





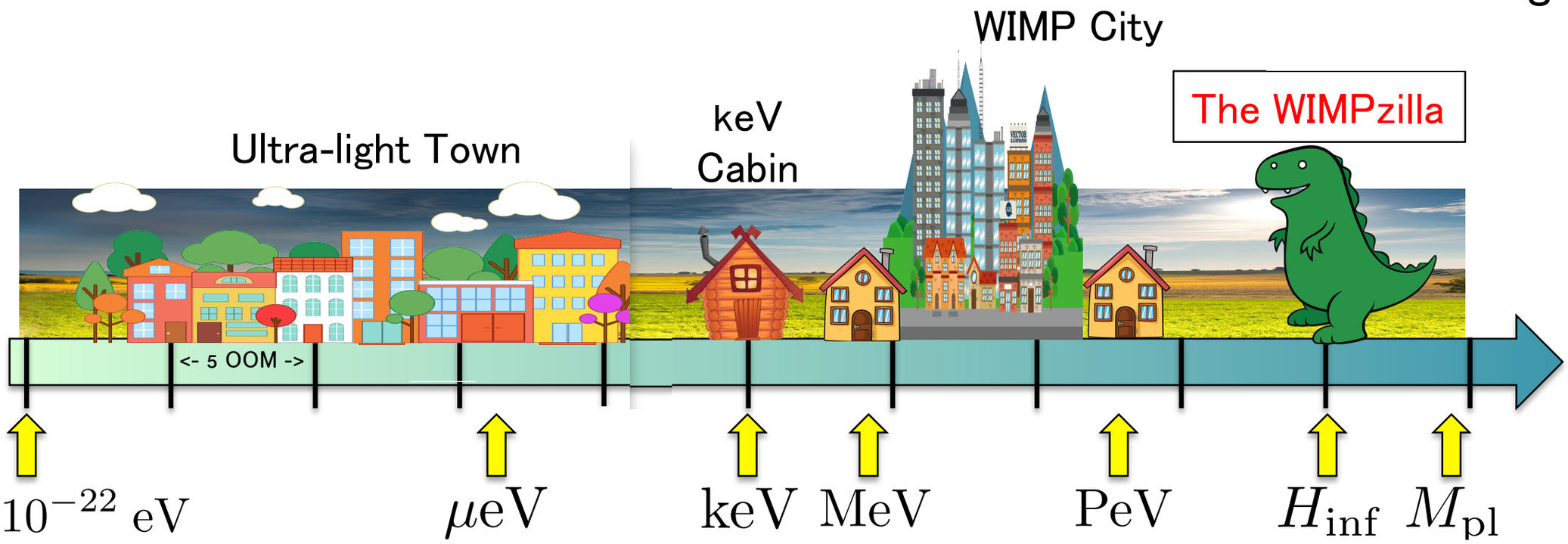
Lensing

© NASA+ESA



LSS

Dark Matter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WIMP City
keV
Cabin
Ultra-light Town
The WIMPzilla
<- 5 OOM ->
10^{-22} eV
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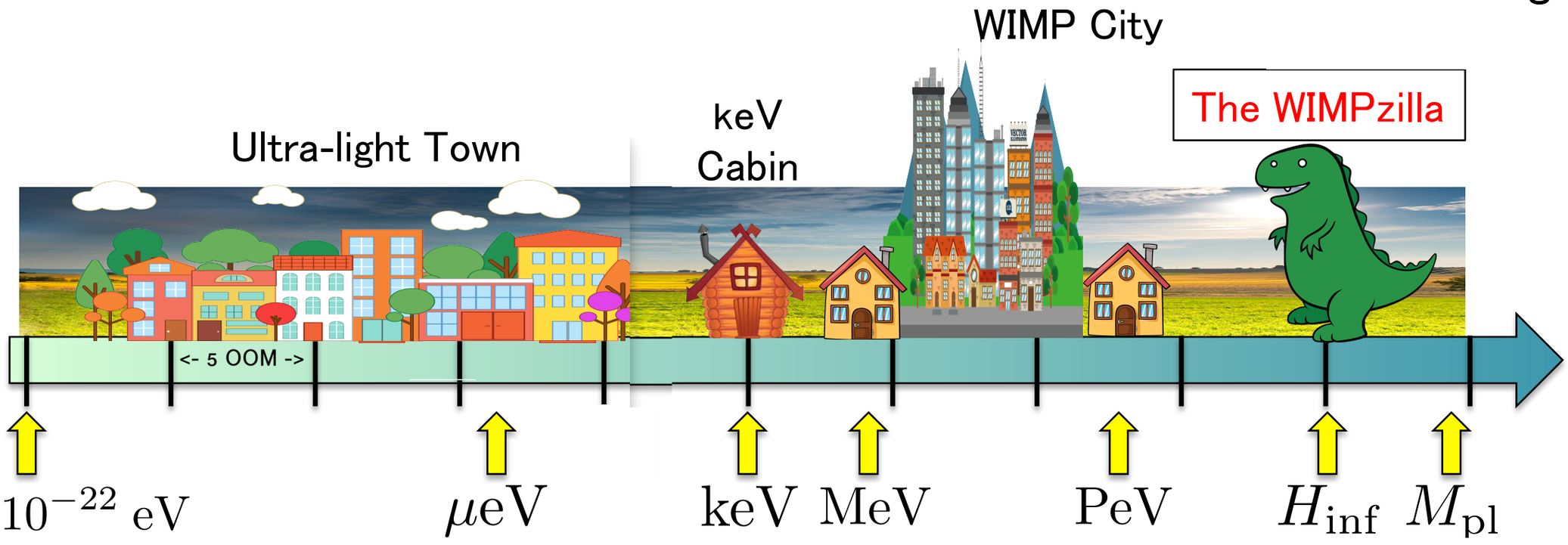
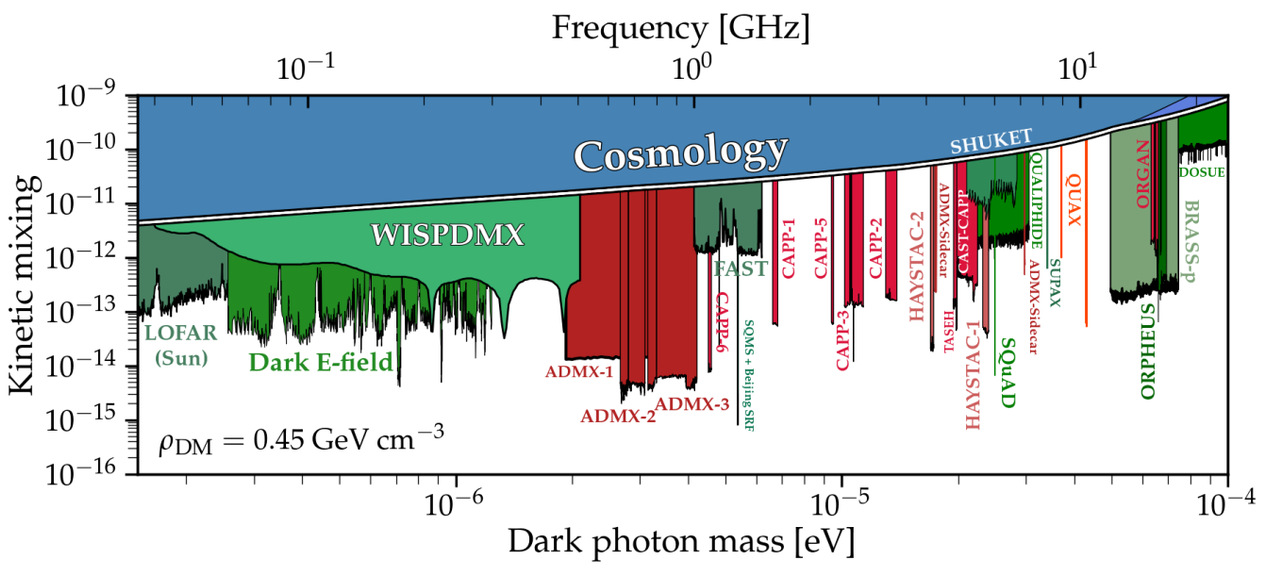
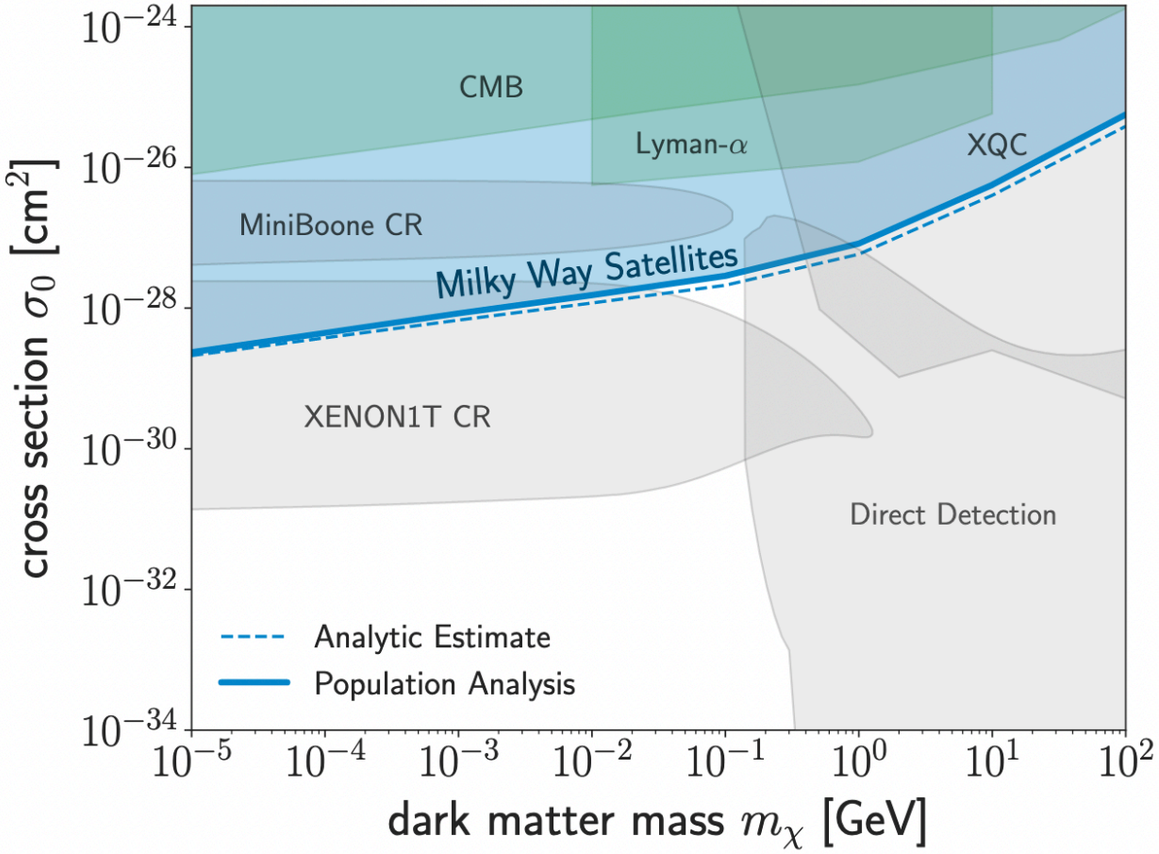
MeV
PeV
$H_{\rm inf}$
$M_{\rm pl}$

Dark Matter





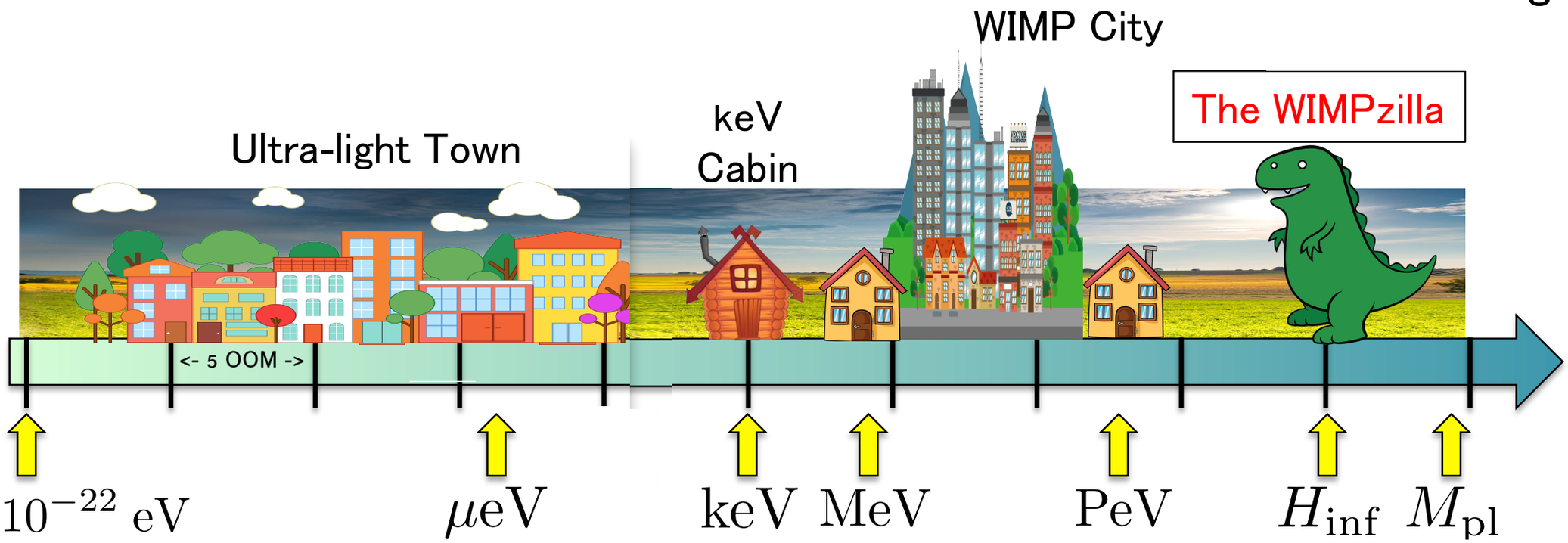


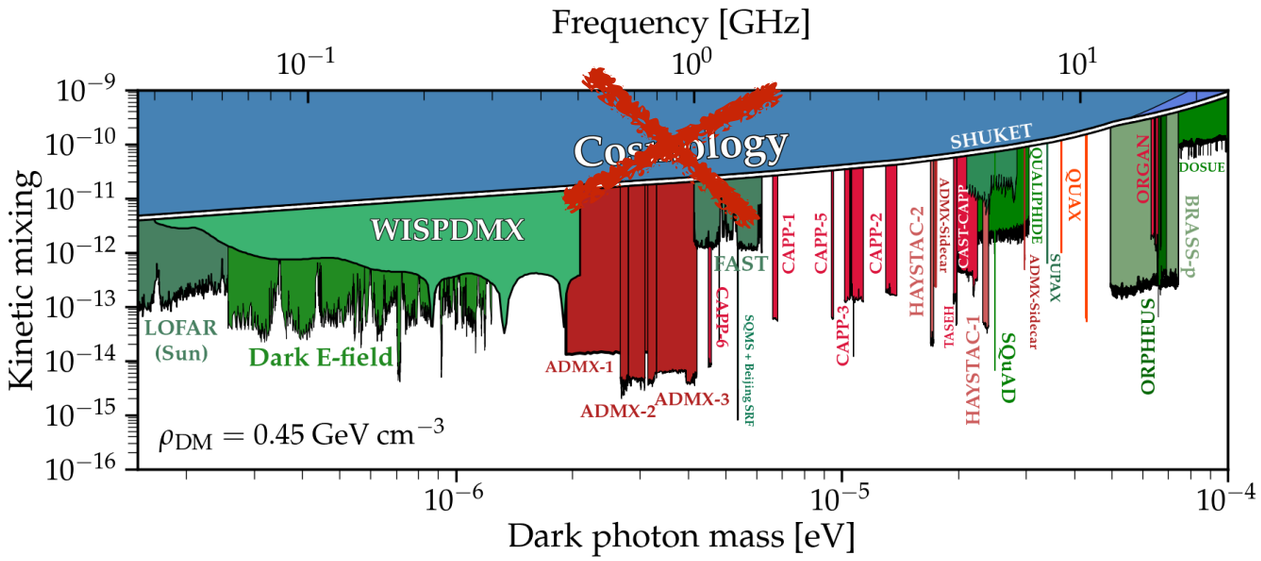
https://cajohare.github.io/AxionLimits/

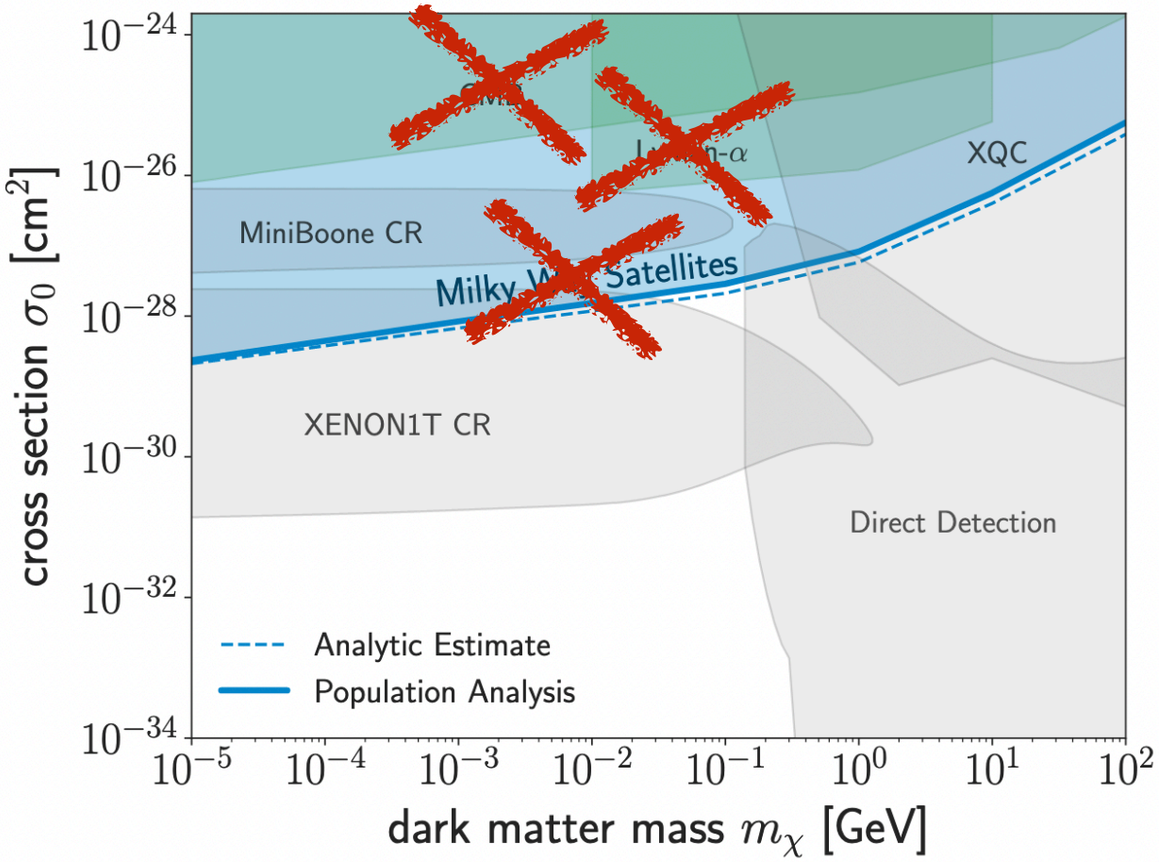
Nadler ++ (2020)

What if there are many DMs ?

© A. Long @LWD





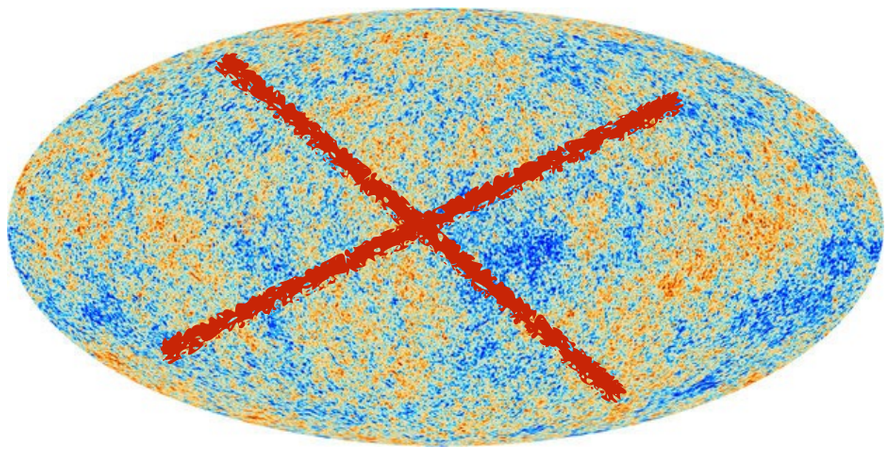


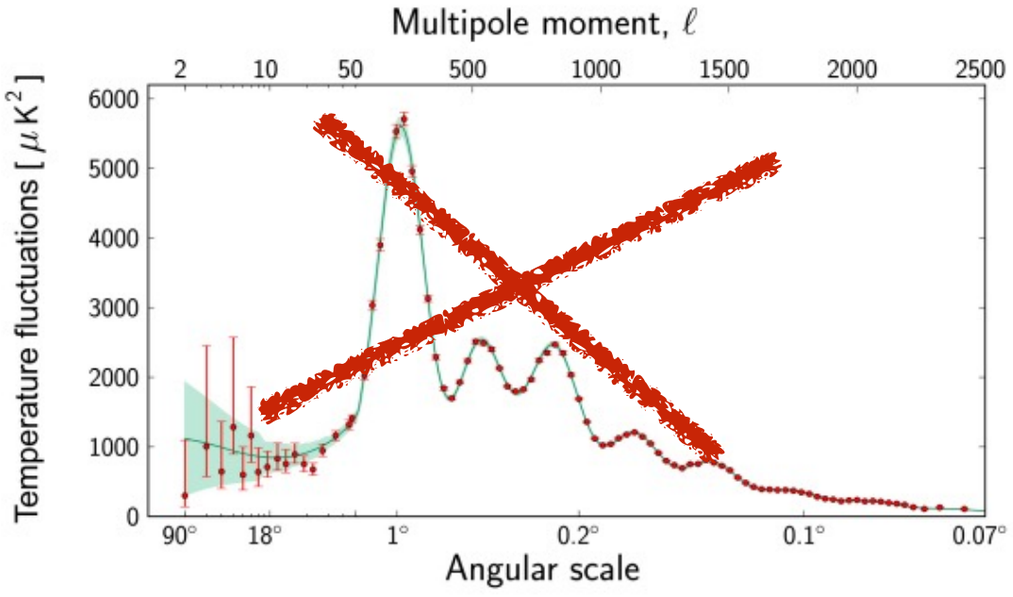
https://cajohare.github.io/AxionLimits/

Nadler ++ (2020)

Why did we loose the sensitivity ?

- Hard to sample parameter space with simulations
- CMB isn't very sensitive to DM fluctuations

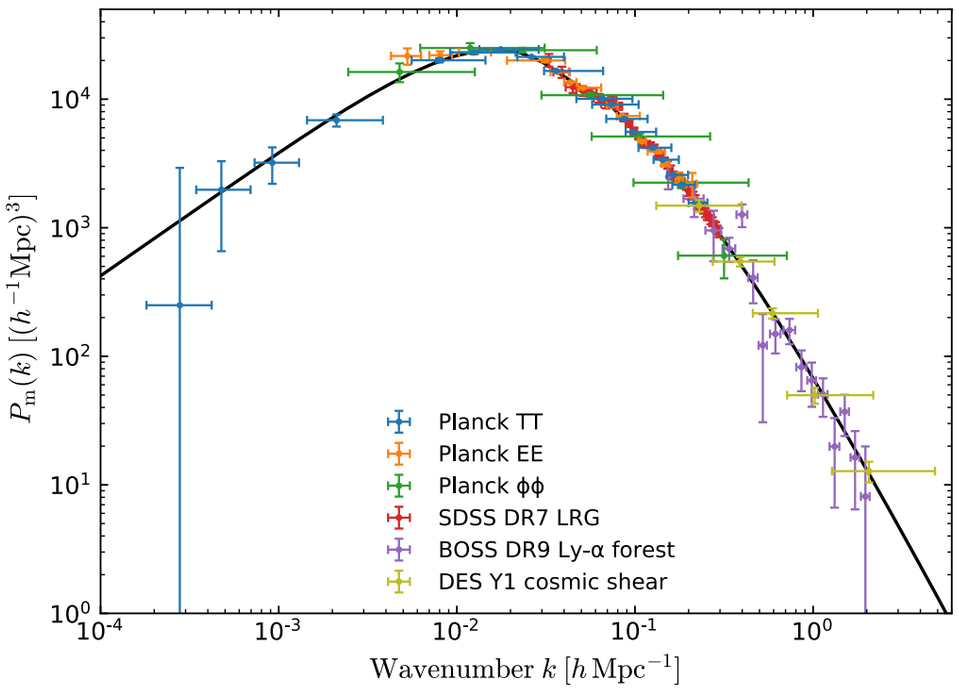


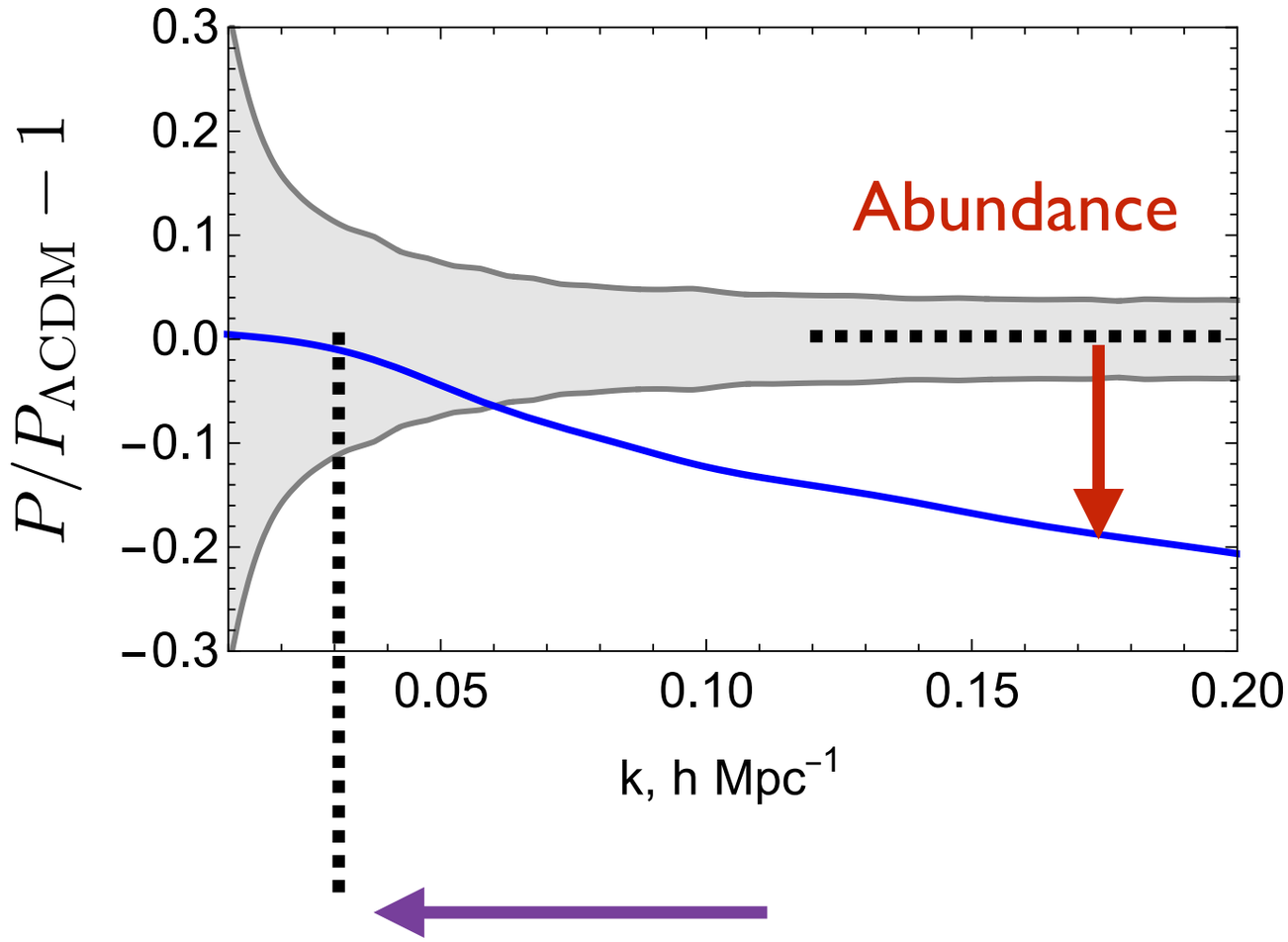


Weinberg DM decoupling theorem

We can do better with Galaxies!

- Imagine two DM components, one is not exactly cold
- ~ there's a Jeans scale beyond which it won't cluster!



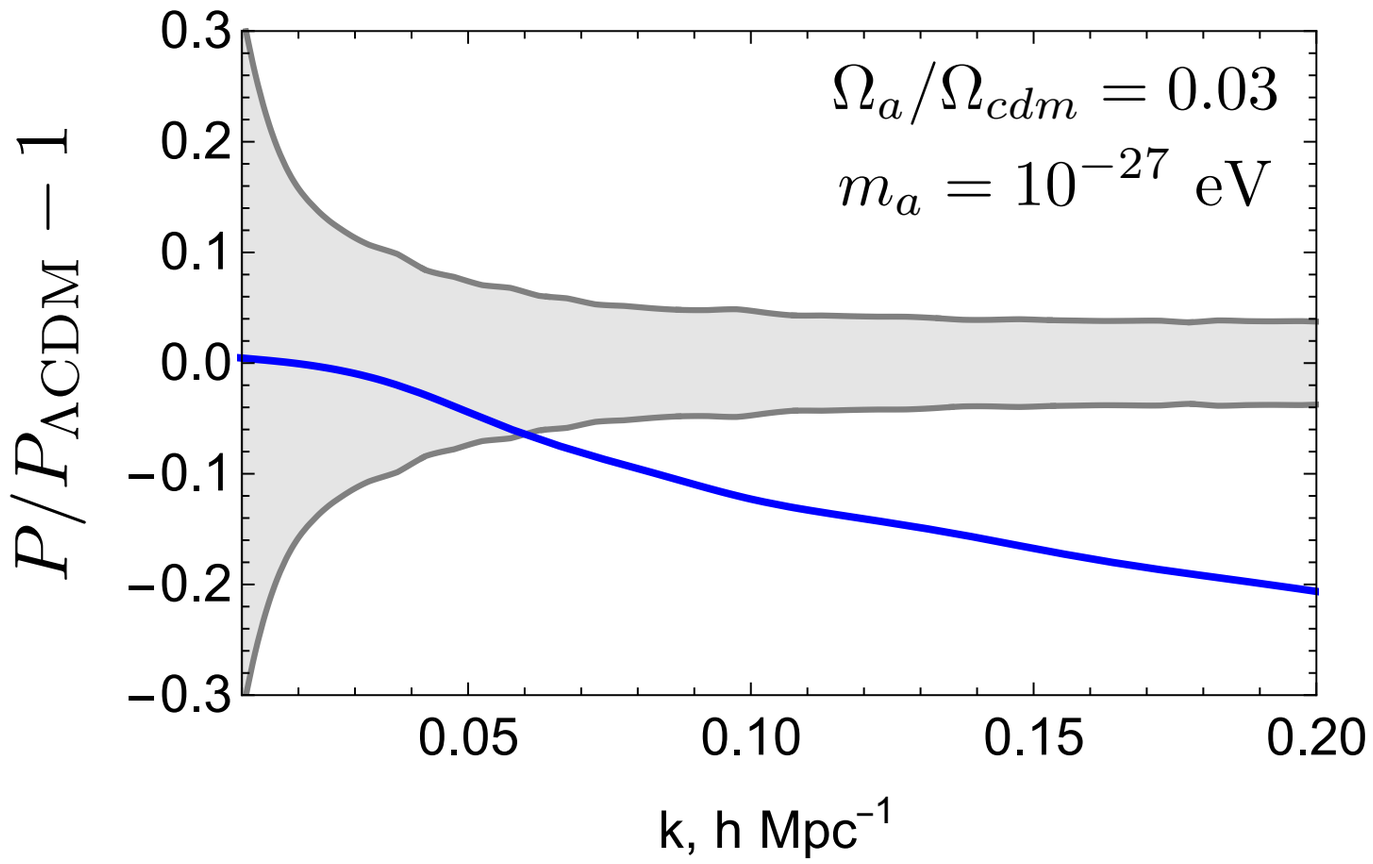


Application to axions

$$\dot{\boldsymbol{v}} + H\boldsymbol{v} + \frac{1}{a}(\boldsymbol{v}\cdot\nabla)\boldsymbol{v} = -\frac{1}{a}\nabla\Phi - \frac{\hbar^2}{2m^2a^3}\nabla p$$

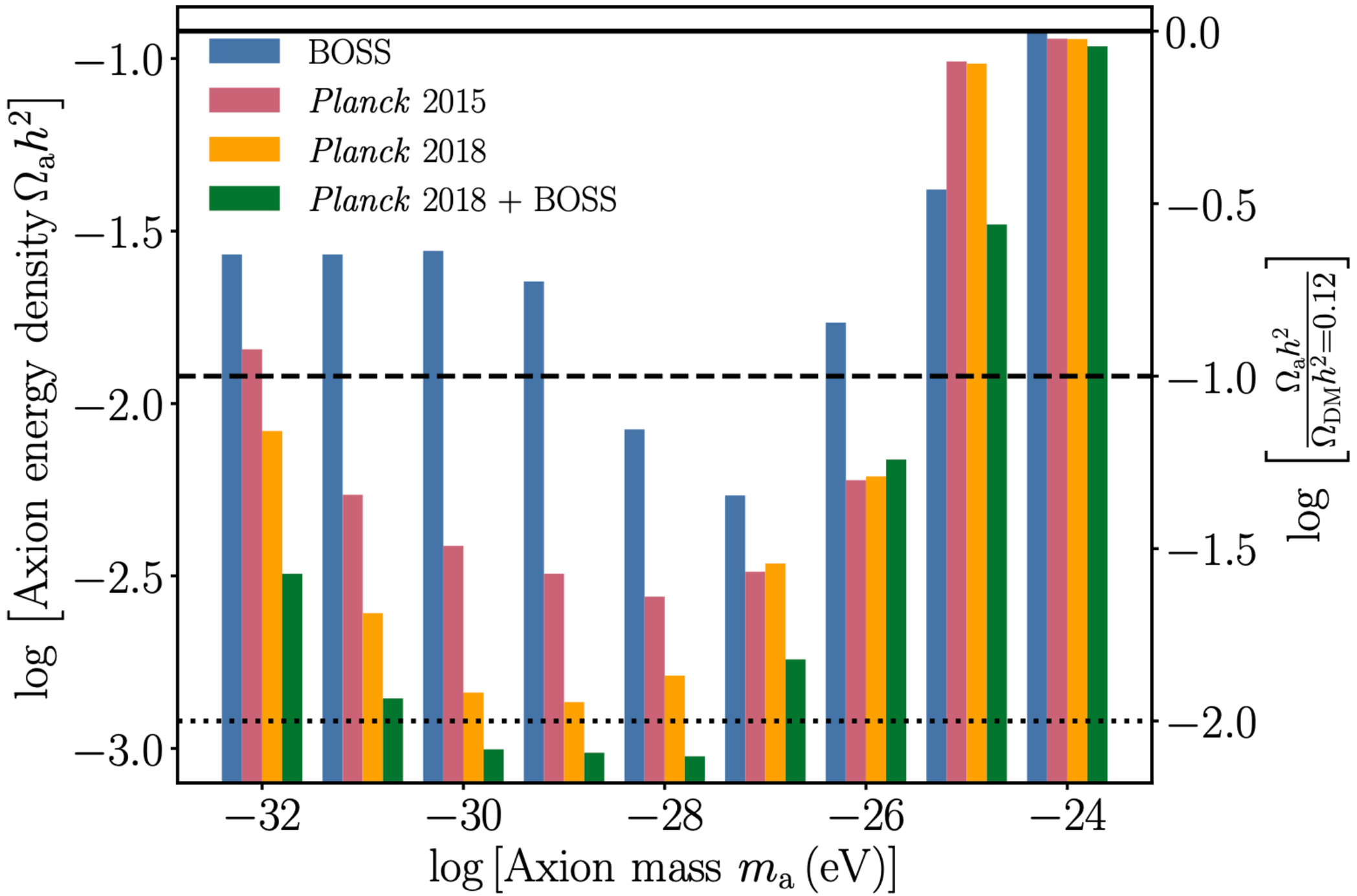
Hu, Barkana, Gruzinov (2000)

$$p \equiv -\frac{\nabla^2\sqrt{\rho}}{\sqrt{\rho}}$$



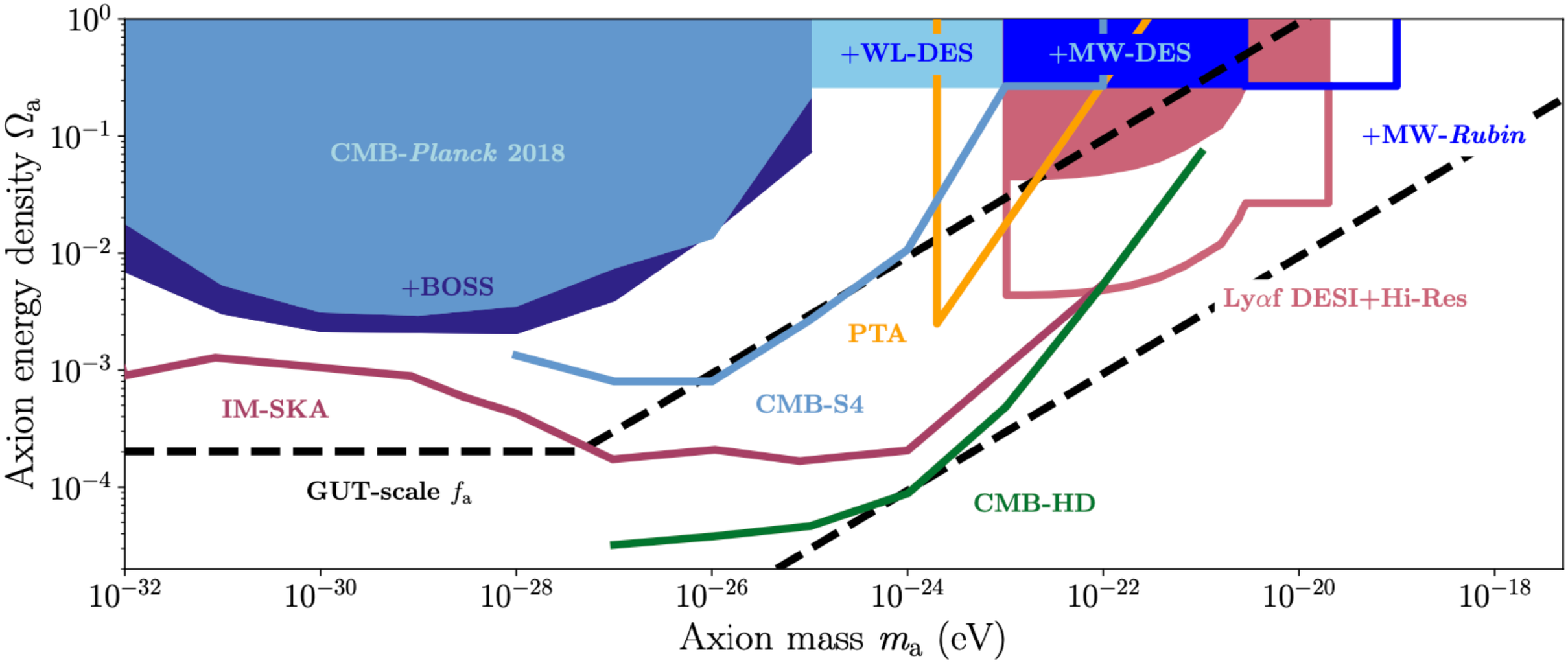
Lague, Rogers, ++(2021) ++ MI (2023)

Axion Dark Matter constraints



Rogers, … MI … (2023)

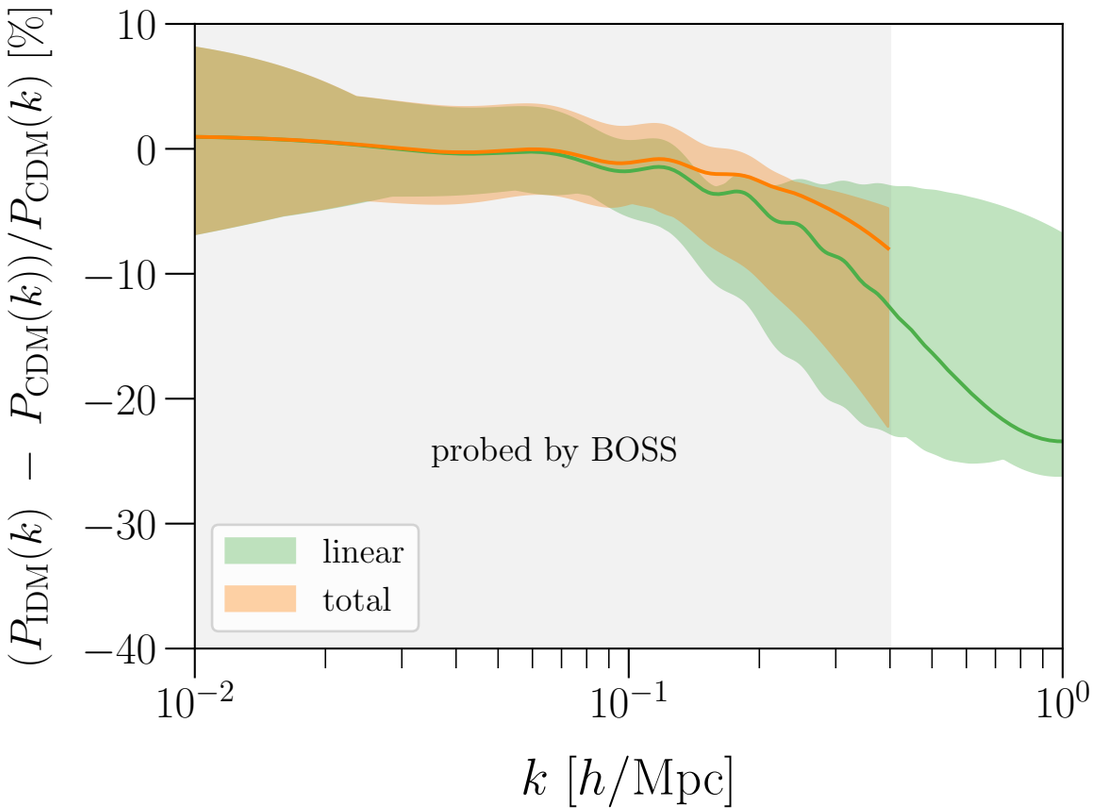
Axion Dark Matter constraints

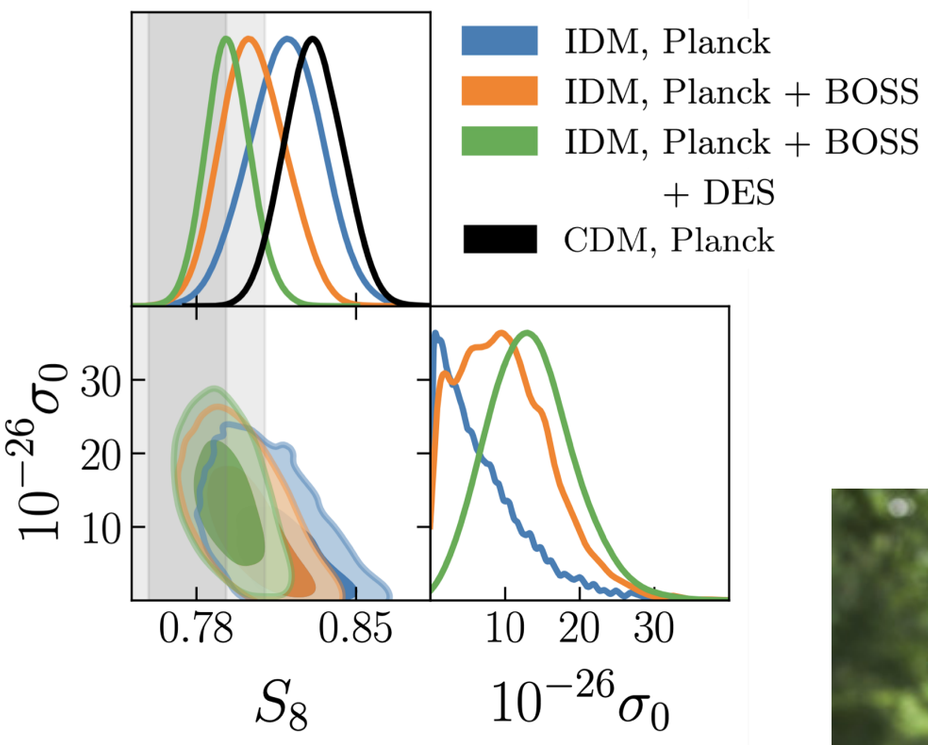


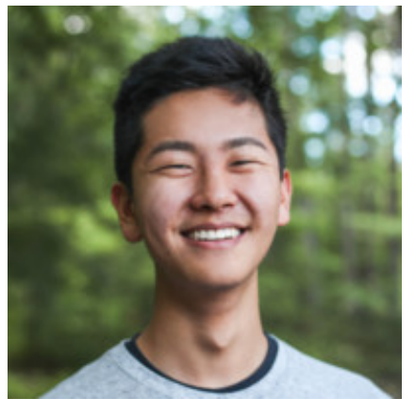
Rogers, Lague, MI ++ (2023)

DM - baryon interactions: apparent evidence ?

- motivated by direct detections







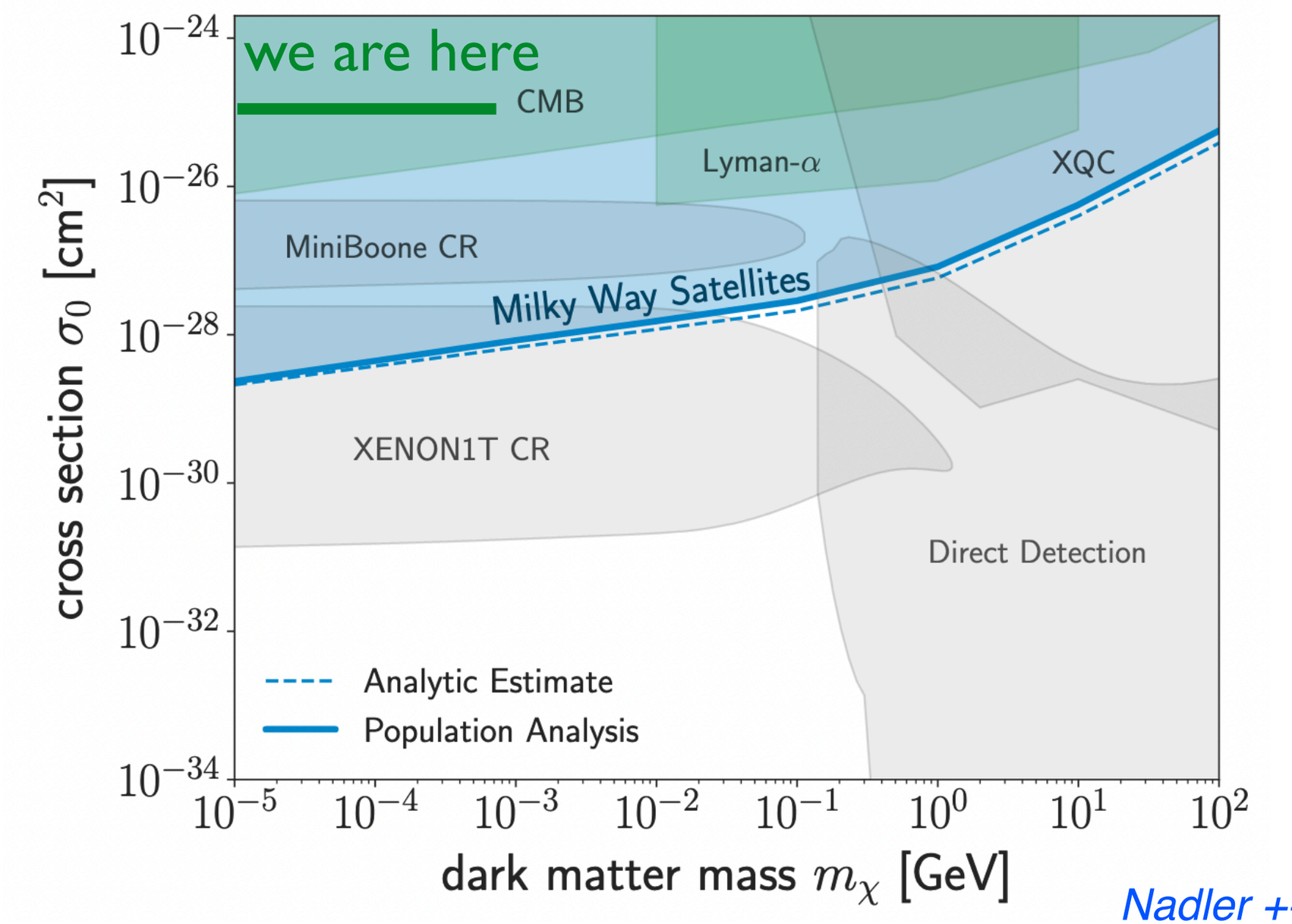
Adam He, MI, Rui, Gluscevic (2023)

$\sim 10\%$ **of DM ~** $m_\chi \sim 1$ MeV **interacts w/ baryons**

$$\sigma_0 = 1.34^{+0.51}_{-0.67} \times 10^{-25}\ \mathrm{cm}^2$$

Dvorkin, Blum, Kamionkowski ++ (2014)
Gluscevic, Boddy (2018)
Slatyer, Wu (2018)

DM - baryon interactions



Nadler ++ (2020)

- Assumptions! e.g. 100% DM interacts w/ baryons

Summary

- Galaxy Power Spectrum - unique probe of DM
- Intriguing results with BOSS
- More DM science with future galaxy surveys

Thank you!