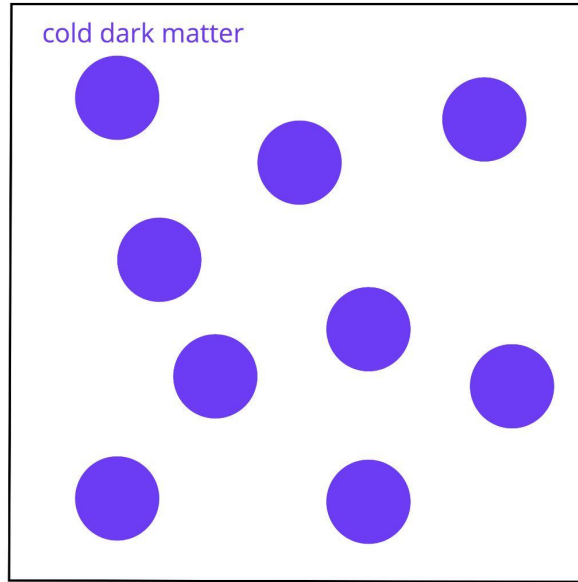


Atomic Dark Matter and Concordance of Cosmological Probes

Fei Ge (UC Davis)

With Francis-Yan Cyr-Racine, Ellie Hughes, Lloyd Knox and Srinivasan Raghunathan
(Hughes et al. in preparation)

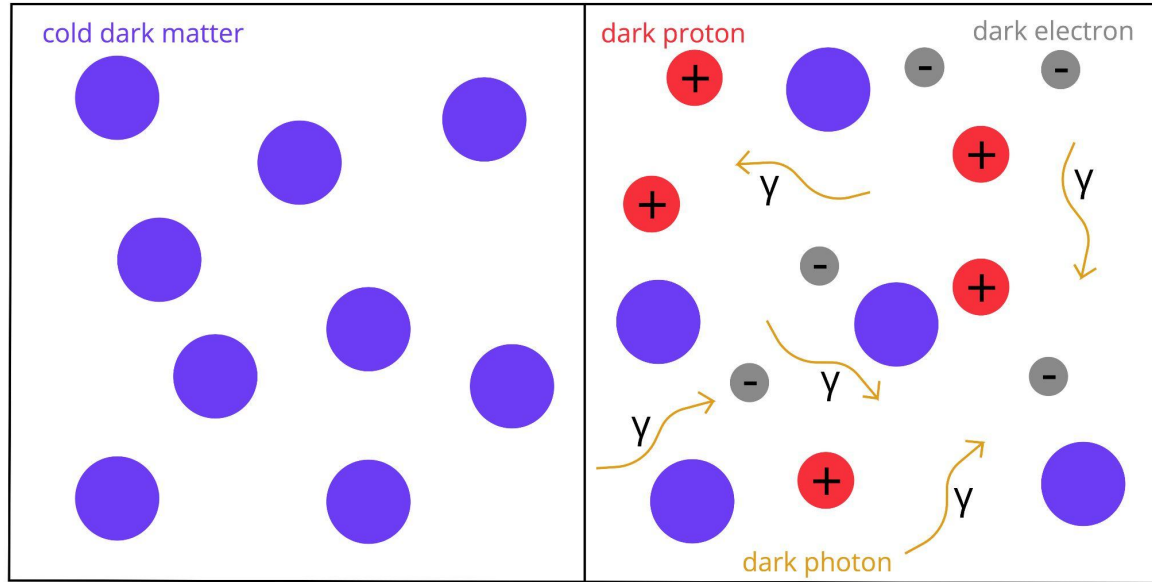
What is Atomic Dark Matter (ADM)?



Cold dark matter (Λ CDM model)

(Credit: Ellie Hughes)

What is Atomic Dark Matter (ADM)?

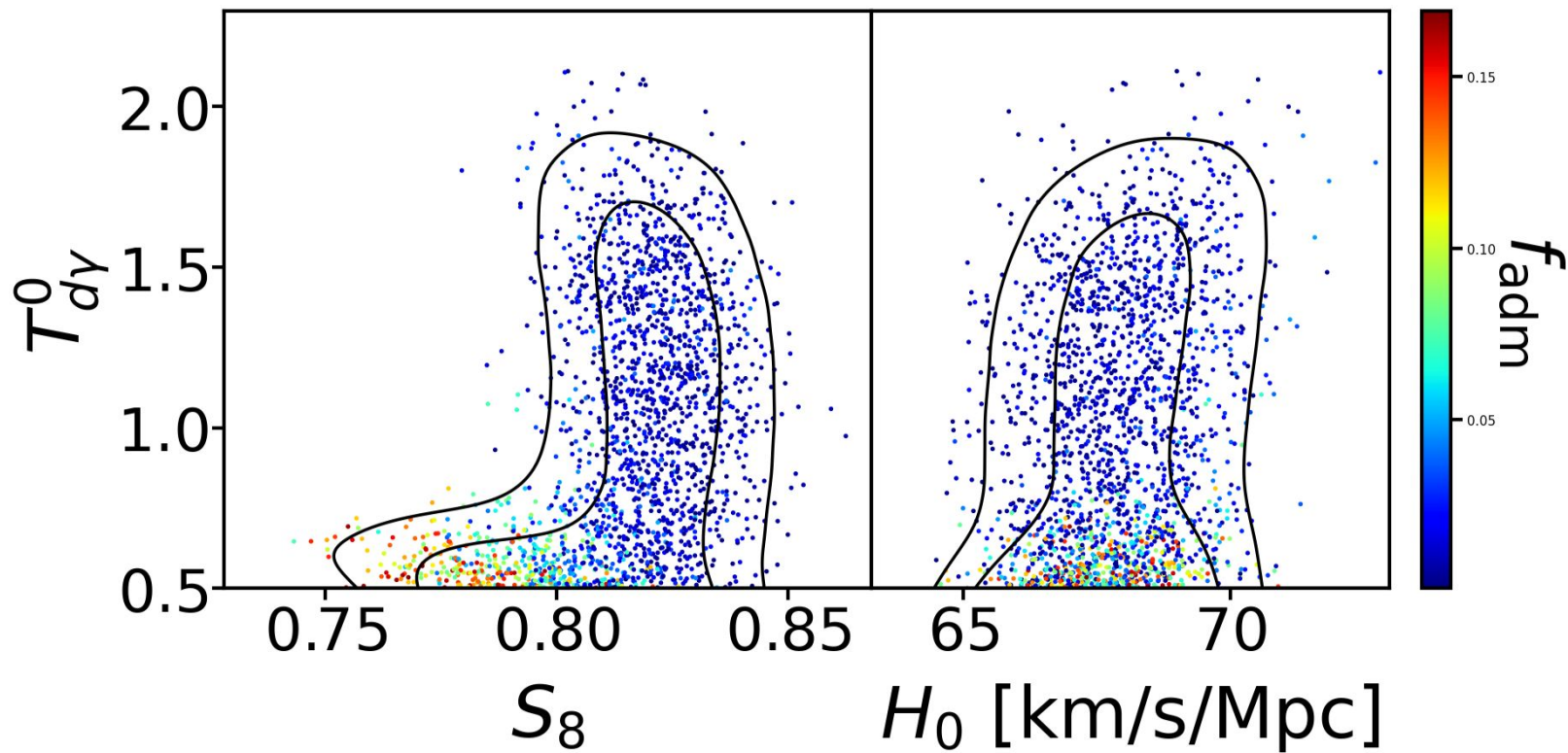


Cold dark matter (Λ CDM model)

Cold dark matter and
atomic dark matter
before dark recombination

(Credit: Ellie Hughes)

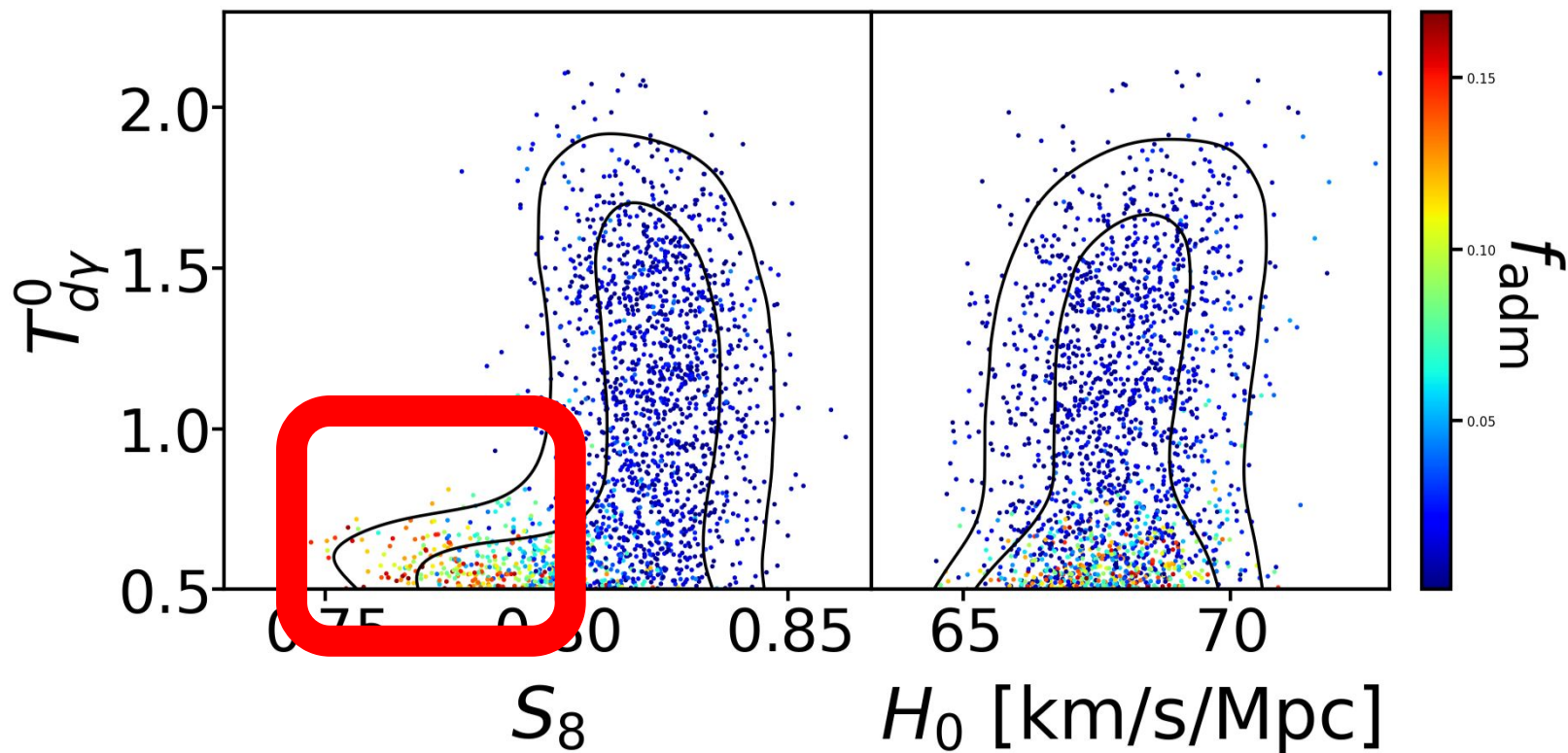
Parameter Constraints



$\{6 \Lambda\text{CDM param.}, N_\nu, f_{adm}, B_d/T_{d\gamma}^0, T_{d\gamma}^0\}$

(Also see [Bansal et al](#))

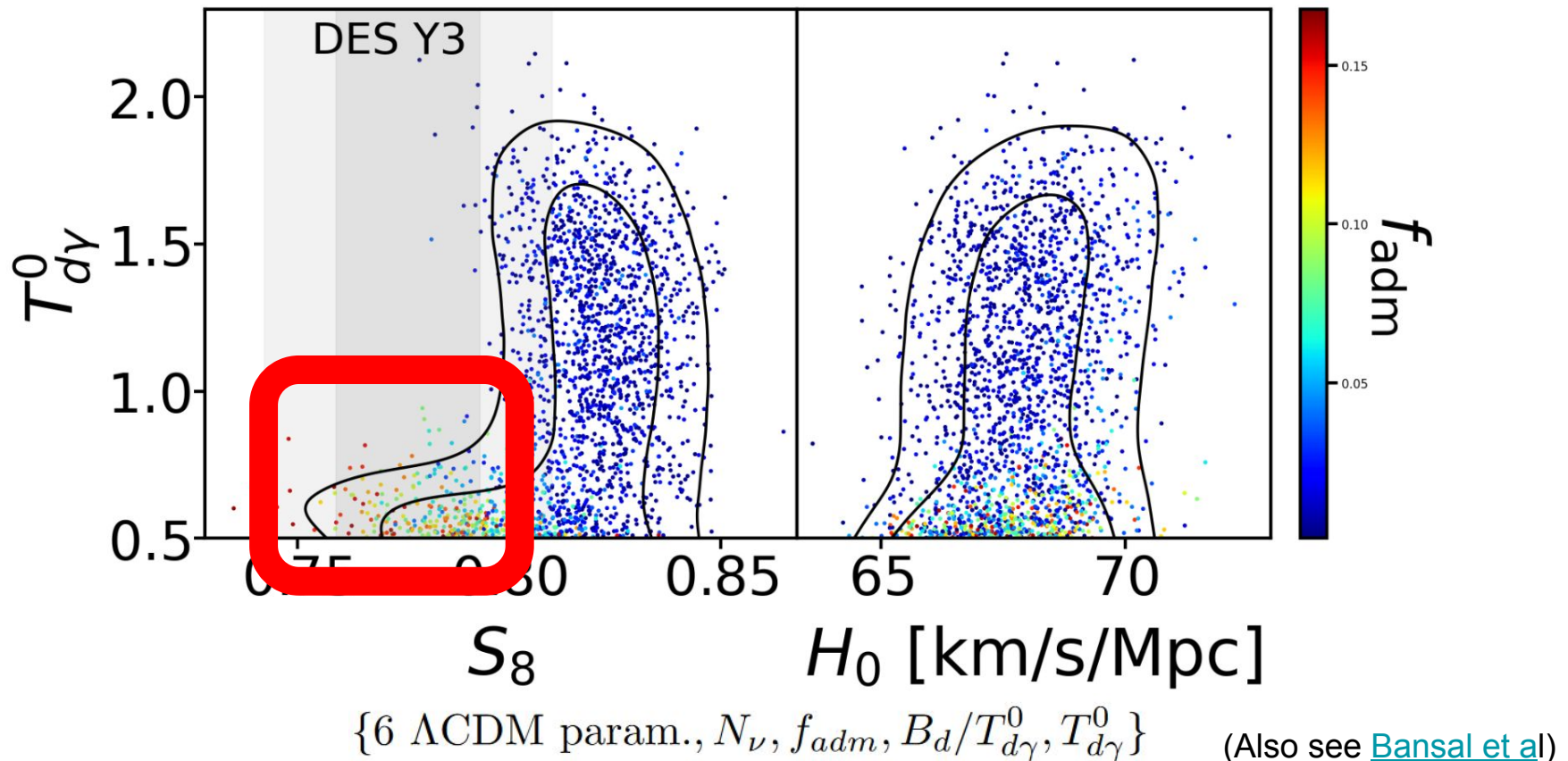
Parameter Constraints



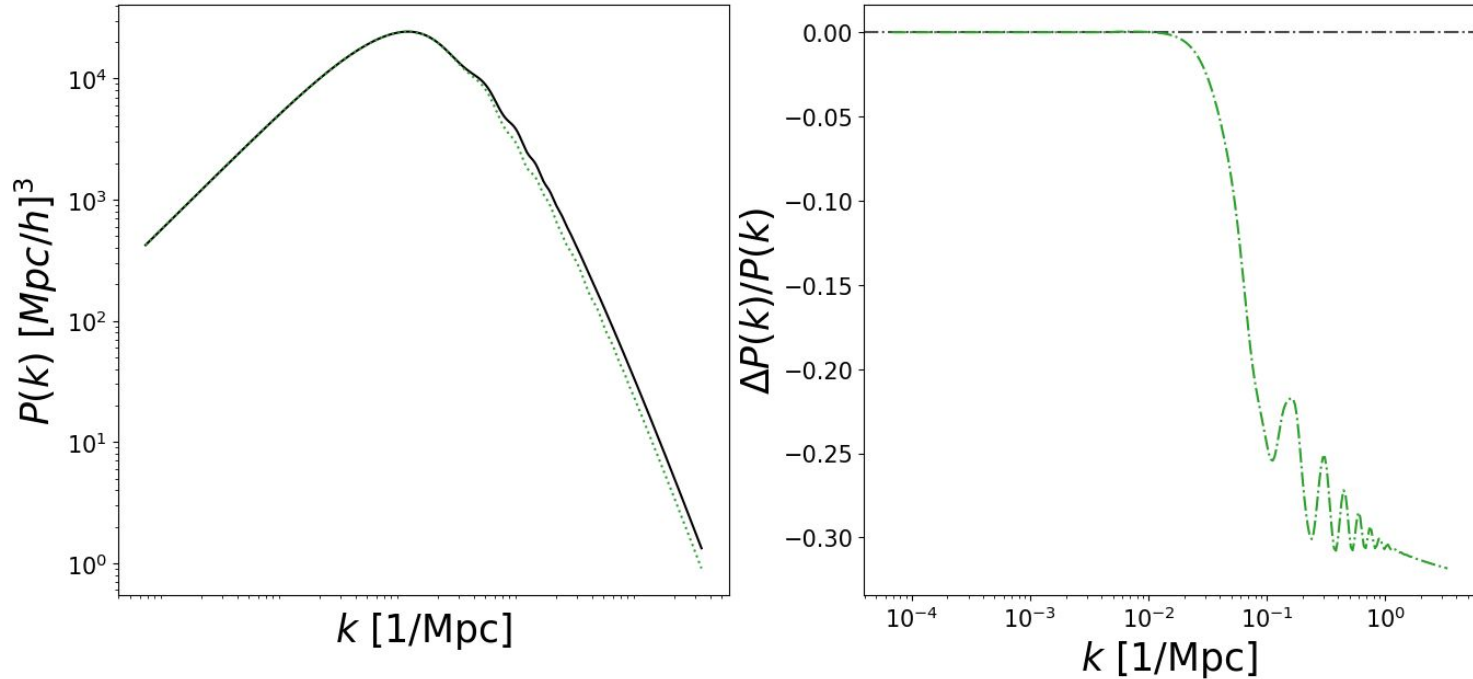
{6 Λ CDM param., N_ν , f_{adm} , $B_d/T_{d\gamma}^0$, $T_{d\gamma}^0$ }

(Also see [Bansal et al](#))

Parameter Constraints



Effects of ADM

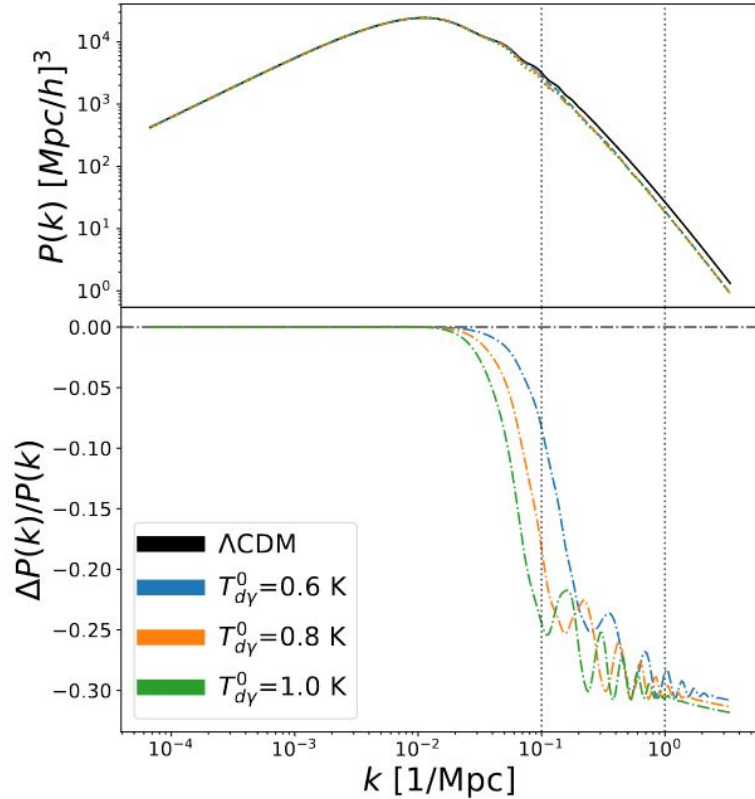


$$f_{adm} = 0.1, B_d = 10 \text{ eV}, T_{d\gamma}^0 = 1.0 \text{ K}, \alpha_d = 0.007299, m_{H,d} = 938 \text{ MeV}$$

(Also see [Cry-Racine et al](#))

Effects on matter clustering

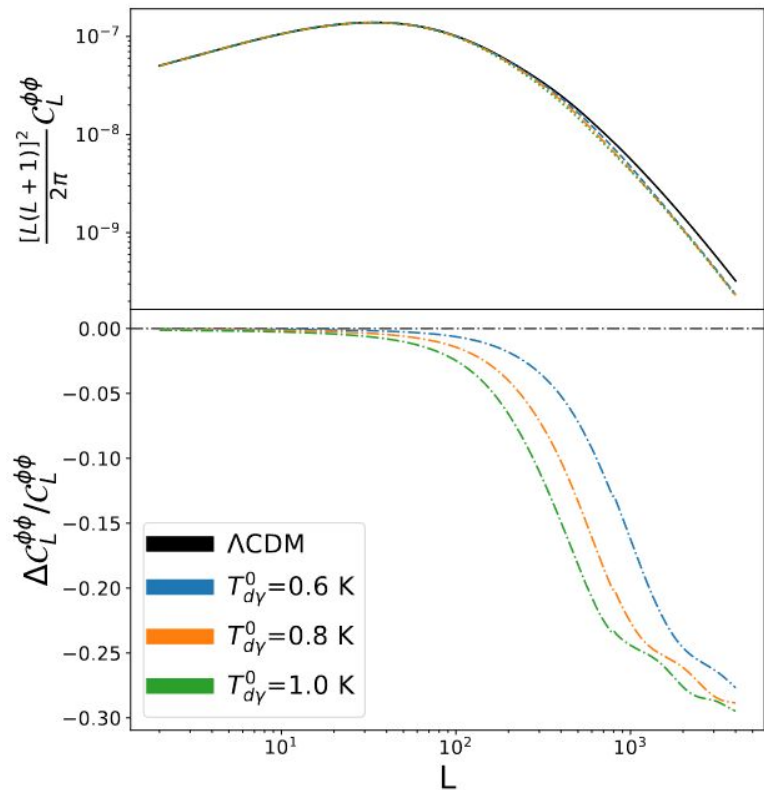
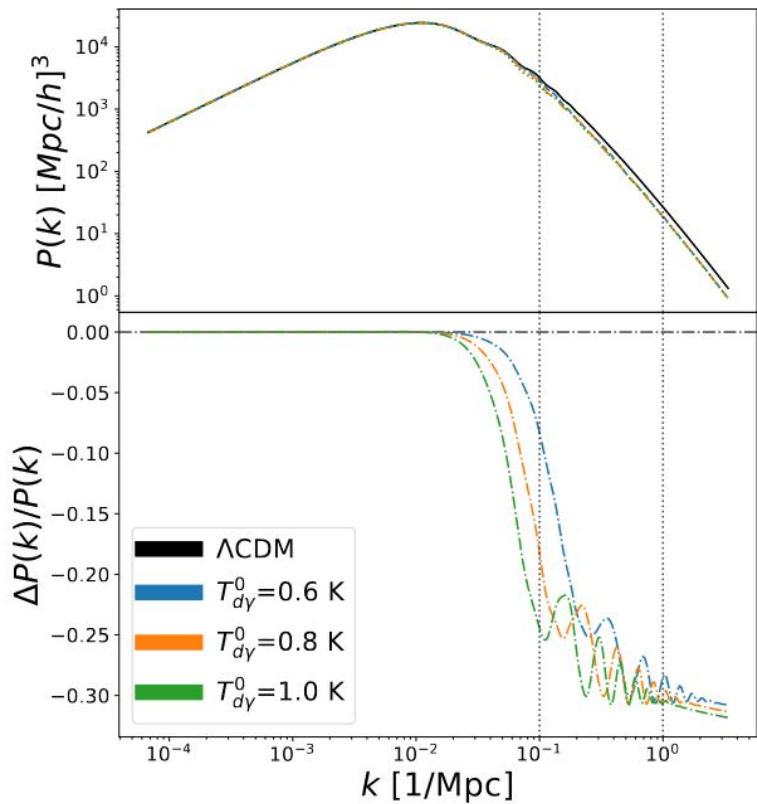
$$f_{adm} = 0.1, B_d/T_{d\gamma}^0 = 10 \text{ eV/K}$$



(linear theory)

Effects on matter clustering

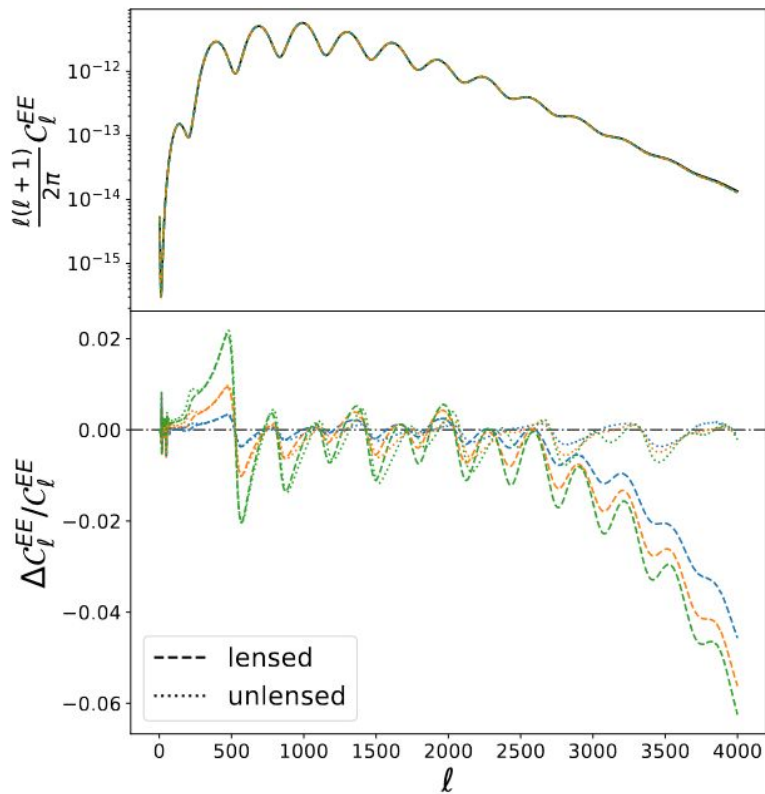
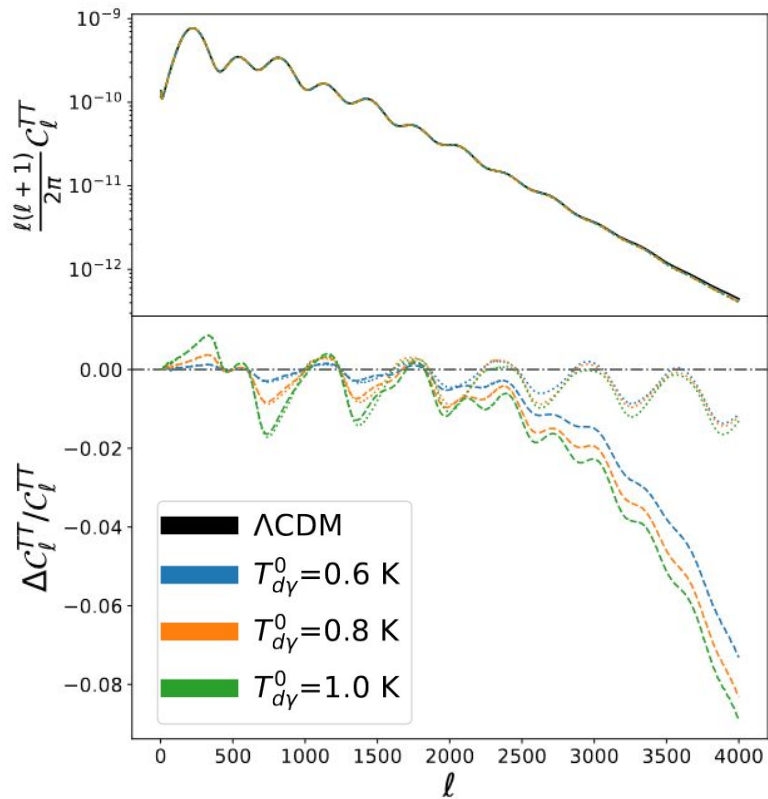
$$f_{adm} = 0.1, B_d/T_{d\gamma}^0 = 10 \text{ eV/K}$$



(linear theory)

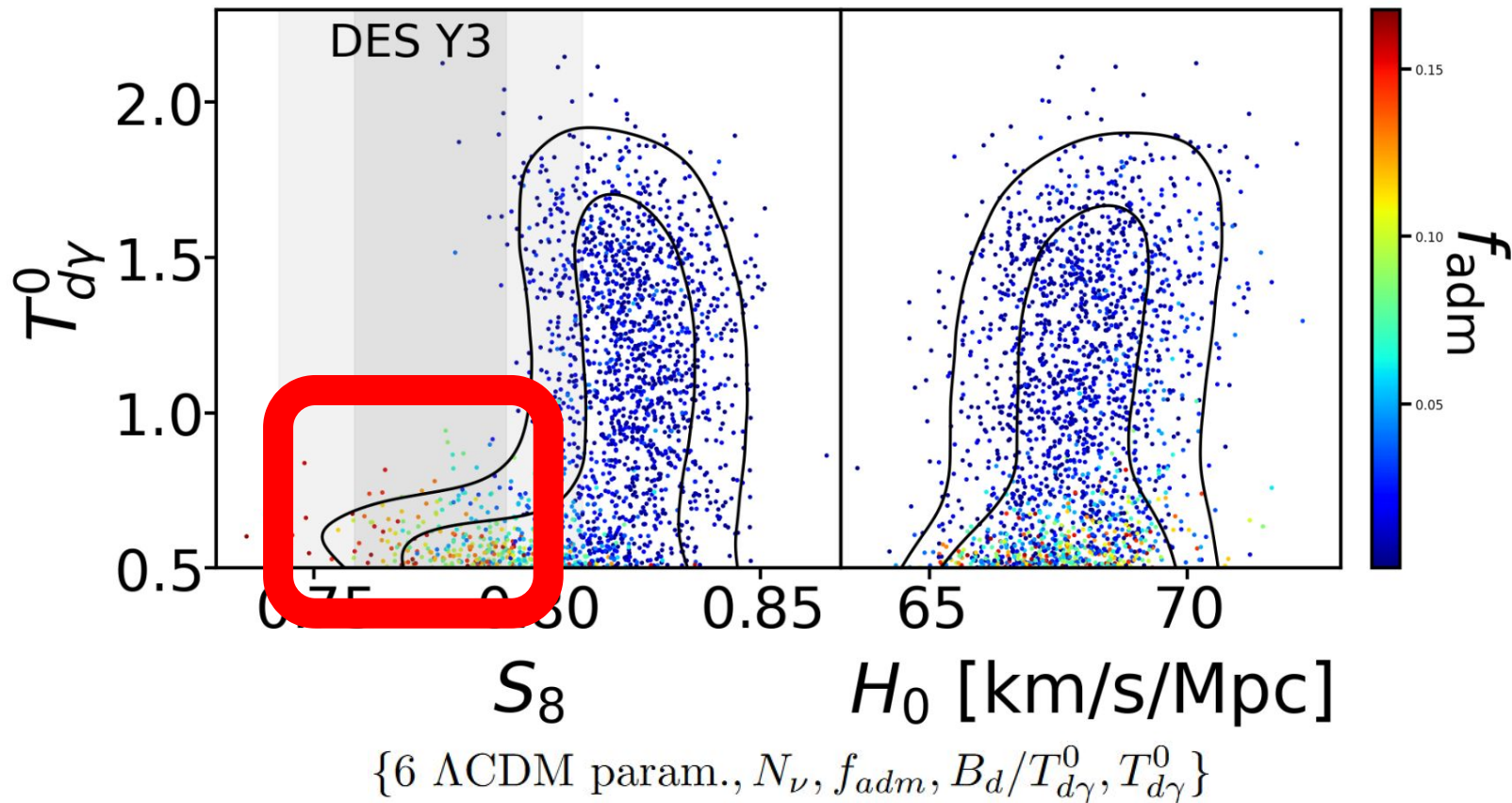
Effects on CMB

$$f_{adm} = 0.1, B_d/T_{d\gamma}^0 = 10 \text{ eV/K}$$



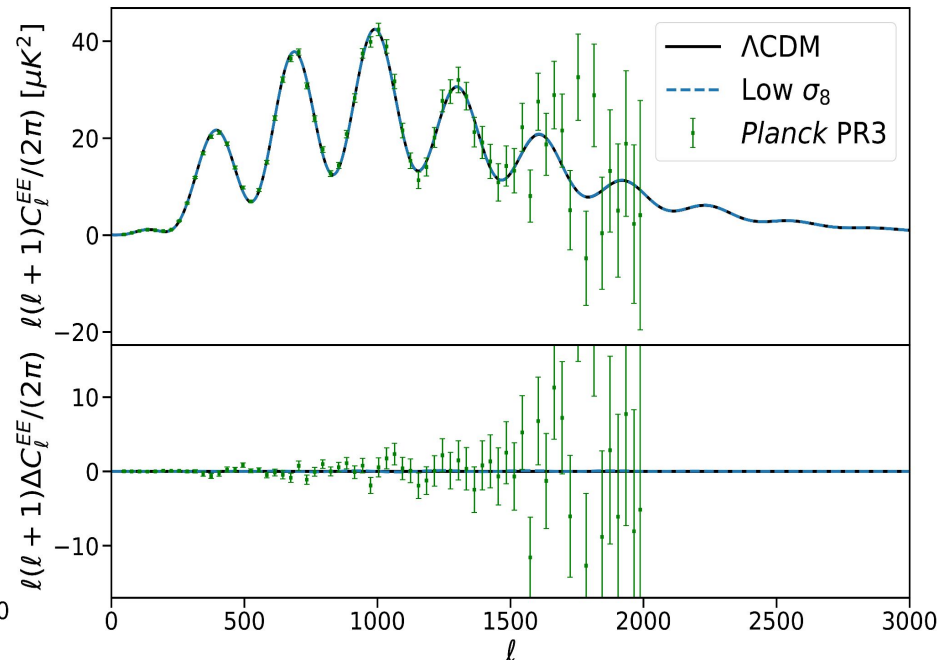
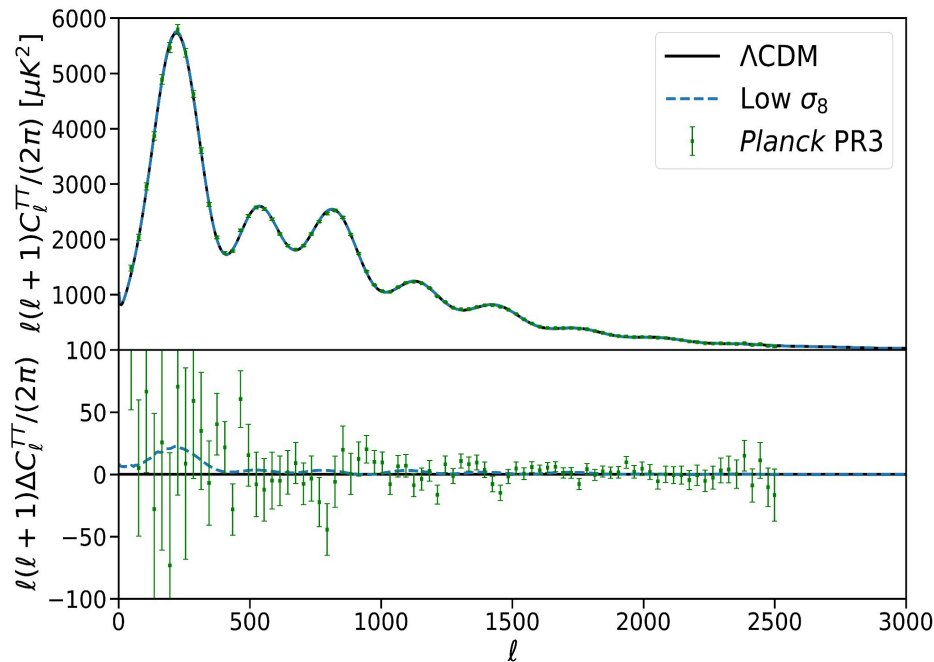
(linear theory)

Parameter Constraints



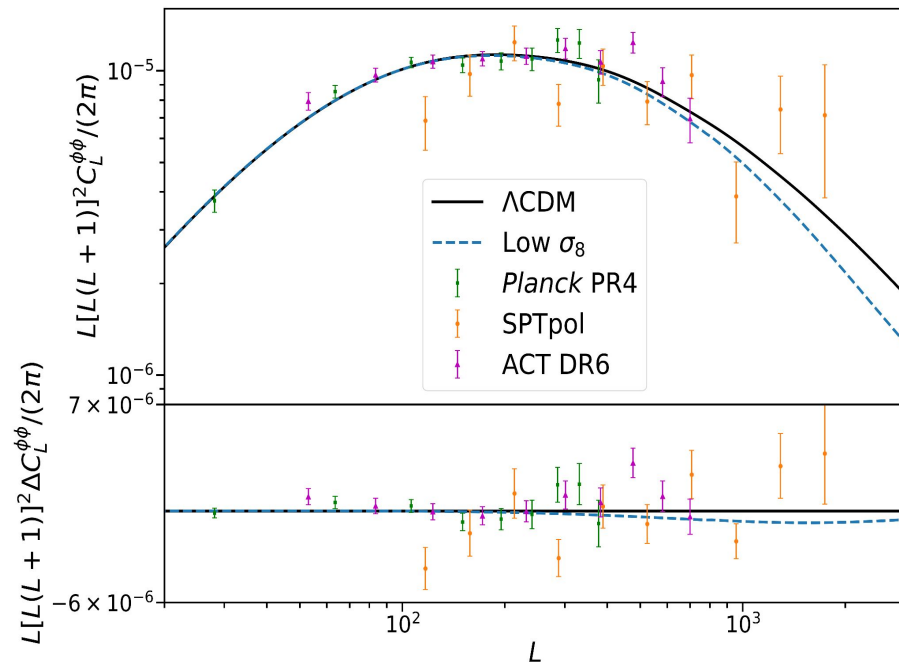
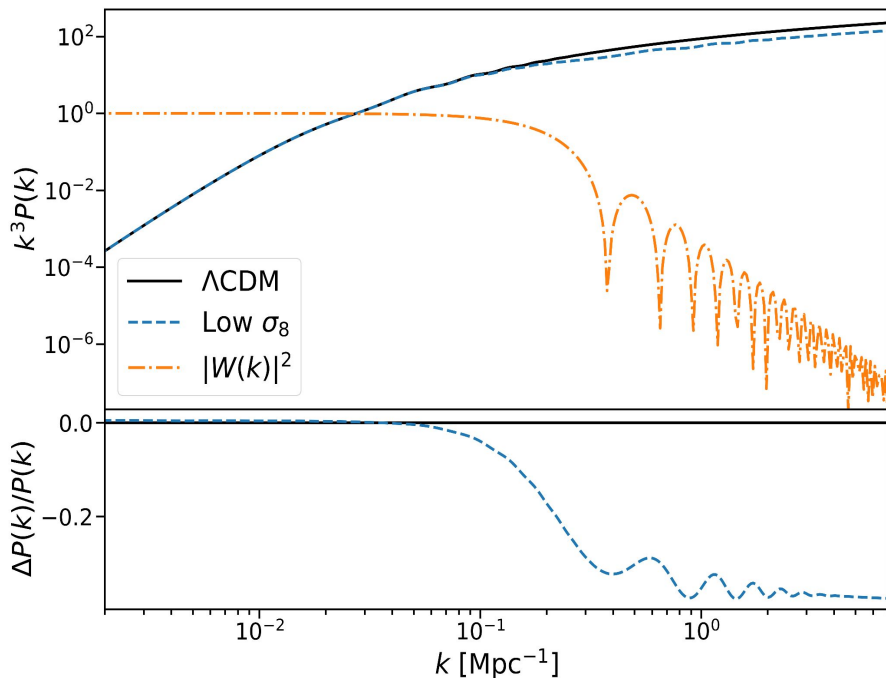
Low S8 direction

Good fit to CMB data. $f_{\text{adm}} = 0.1304, B_d = 6.947 \text{ eV}, T_{d\gamma}^0 = 0.5197 \text{ K}, \Delta\chi^2 = 8$



Low σ_8 direction

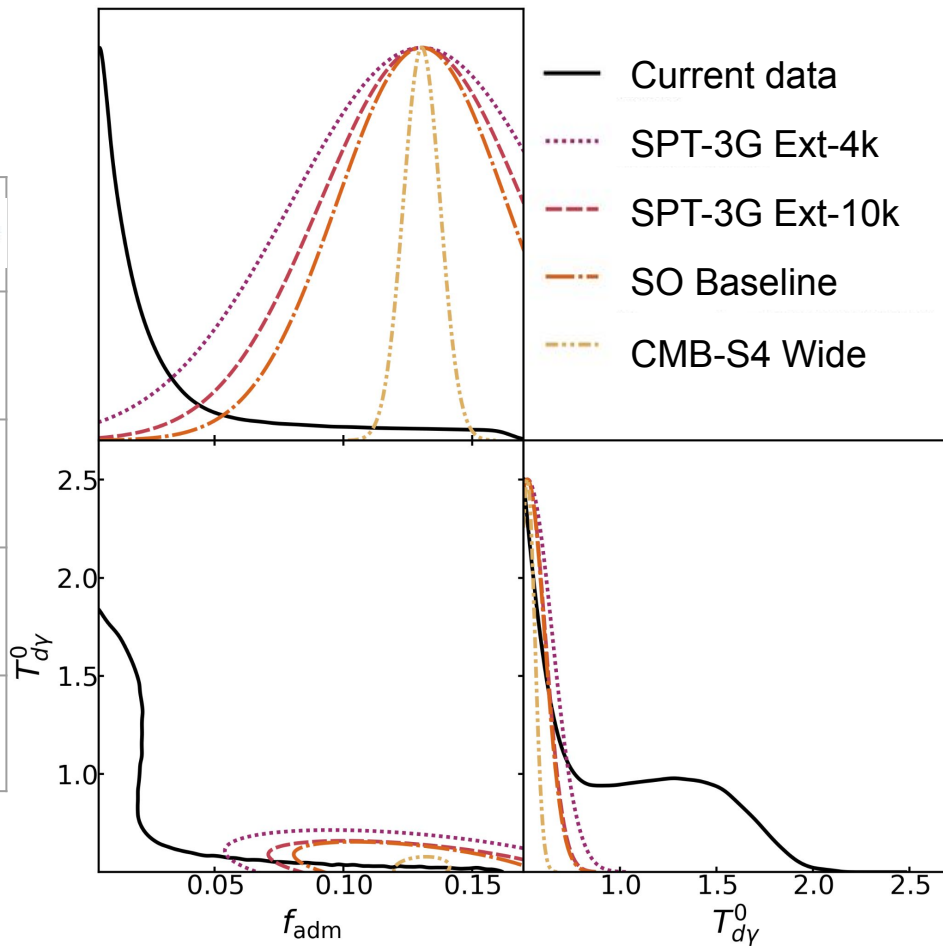
Deviates in $P(k)$ and Lensing potential spectra at small scales.



$$f_{\text{adm}} = 0.1304, B_d = 6.947 \text{ eV}, T_{d\gamma}^0 = 0.5197 \text{ K}, \Delta\chi^2 = 8$$

Forecasts

Surveys	σf_{adm}	$\sigma T_{d\gamma}^0$	σN_{eff}
SPT-3G Ext-4k (2023)	0.051	0.013 K	0.13
SPT-3G Ext-10k (2026)	0.039	0.009 K	0.10
SO Baseline (2029)	0.033	0.009 K	0.08
CMB-S4 (2035)	0.007	0.004 K	0.04



Conclusion

- Low-temperature ADM can possibly alleviate the S8 tension.
- This solution can be testable with CMB measurements in the near future.
- The main impact on CMB observables, in the low temperature region, is via CMB lensing effect.
- The signal arises in a regime where non-linear evolution is important. Our work is entirely with linear theory.
- Our work motivates working future work on the non-linear predictions of ADM model.