



Light Relics Update

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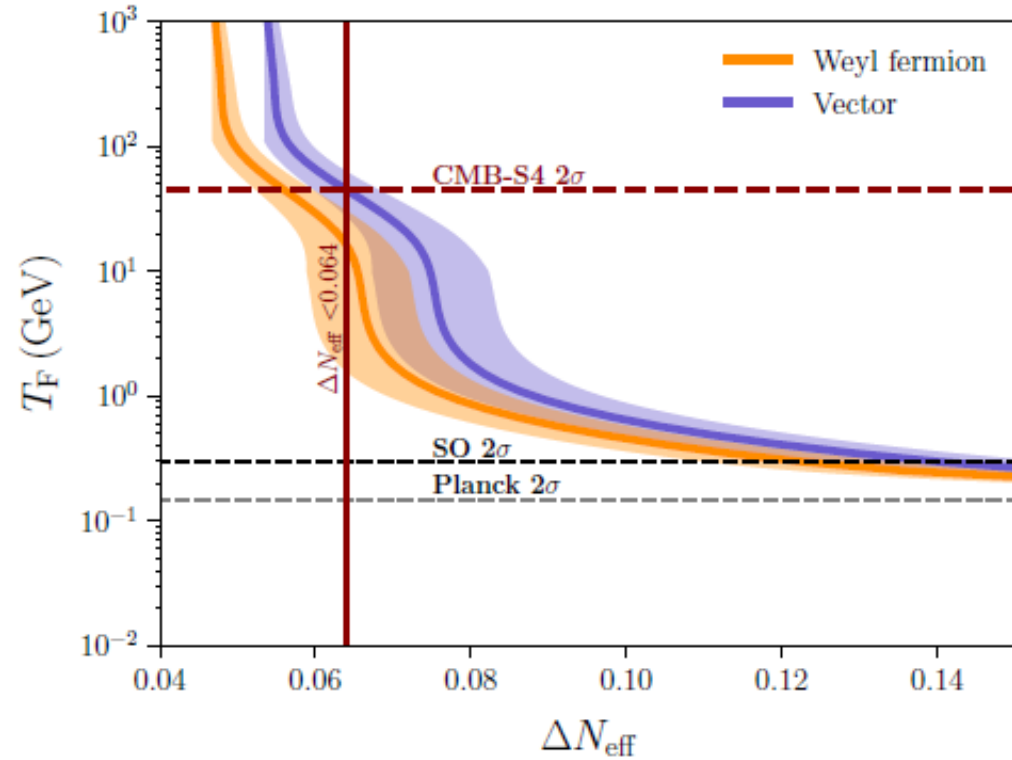
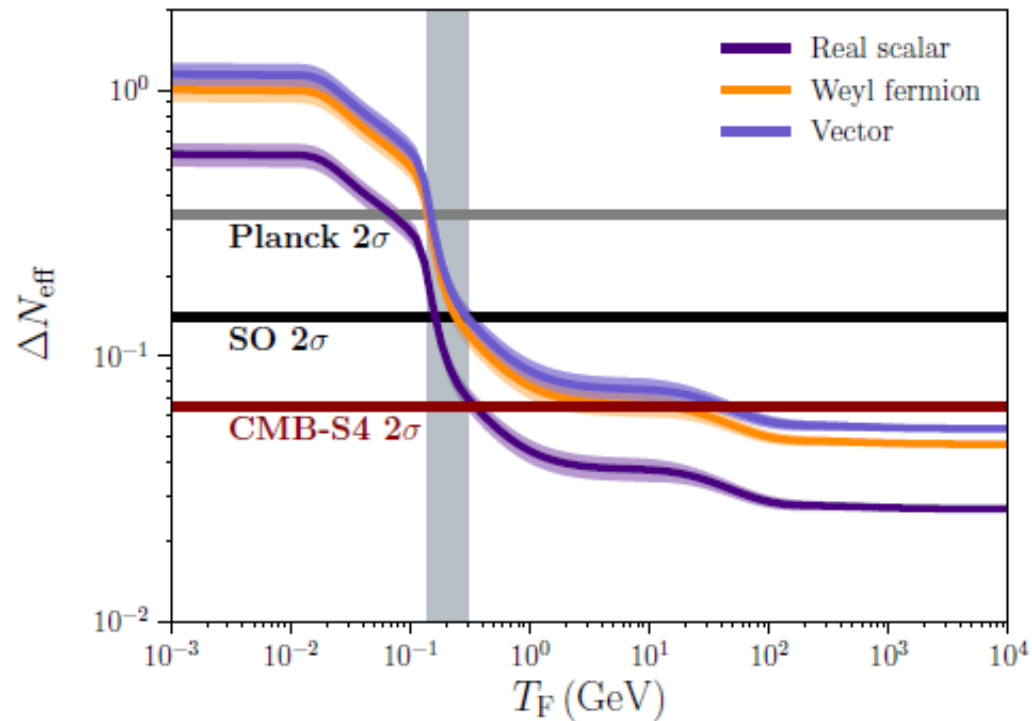
On behalf of the Light Relics Working Group

CMB-S4 Collaboration Meeting

Fermilab

March 13, 2019

Overview and Target

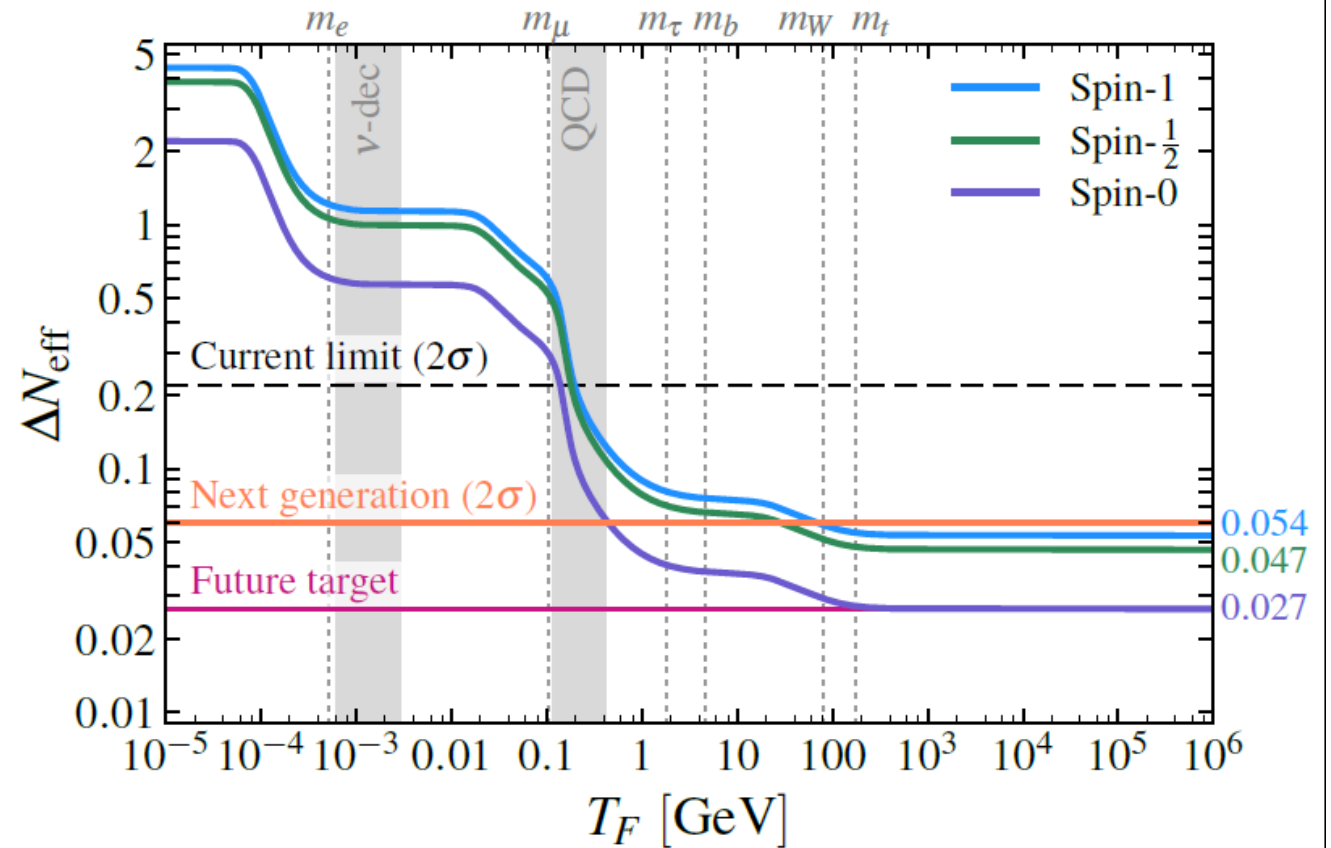
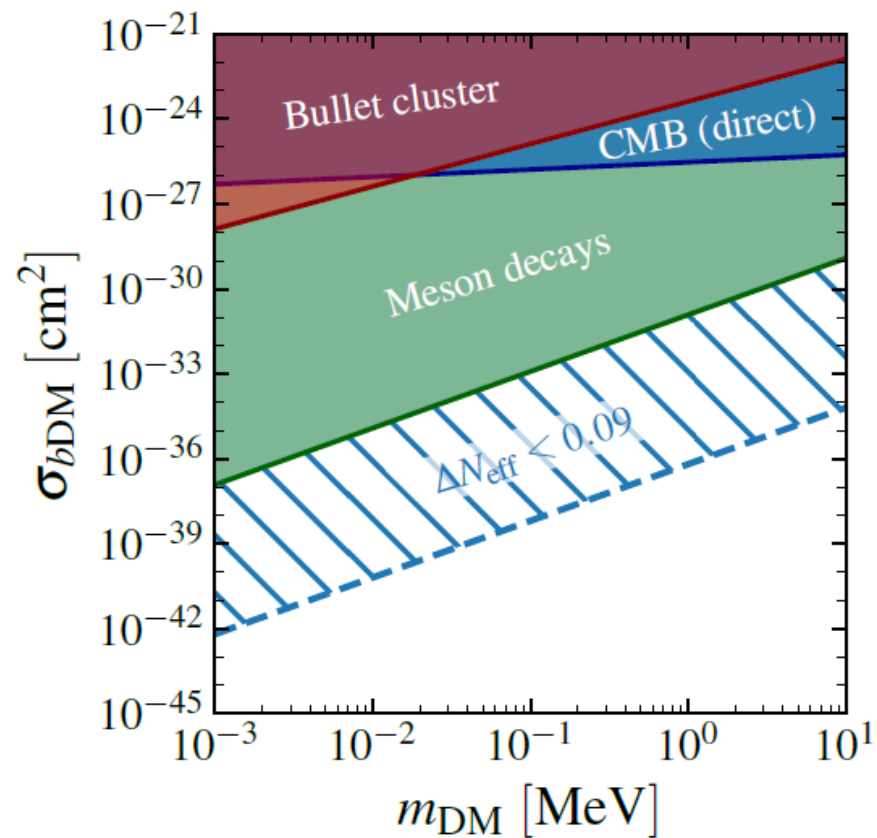


- Achieve $\sigma(N_{\text{eff}}) = 0.06$ at 2σ to improve reach for new light species
- Sensitivity driven by wide survey of T and E on small angular scales

Recommendations from DSR Review

- “More context and the physical meaning of the quantitative constraints that S4 will get are needed”
- Make plot putting light relics constraints in context with dark matter constraints, i.e. a “Dark Physics” plot
- “Where possible, highlight constraints on dark matter candidates”

Light Relics Science White Paper (1903.04763)



- Highlights improved reach in T_F and how it translates to model constraints
- Provides specific example of constraints on dark matter model

Dark Physics Plot

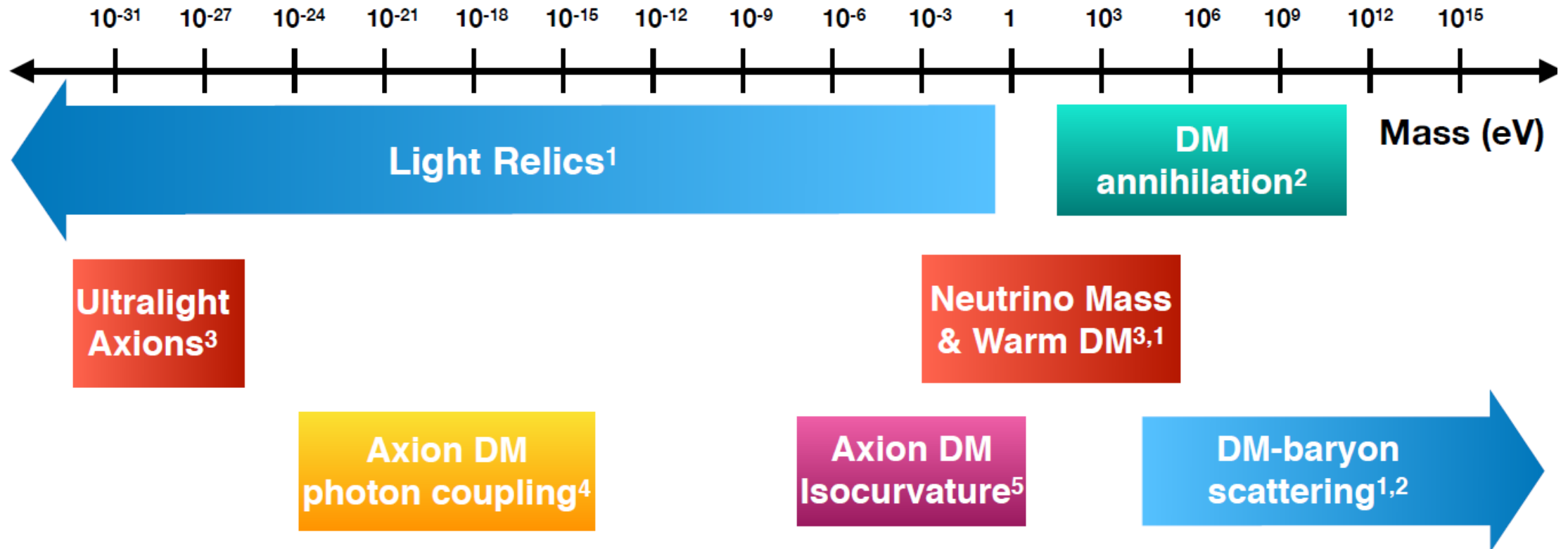
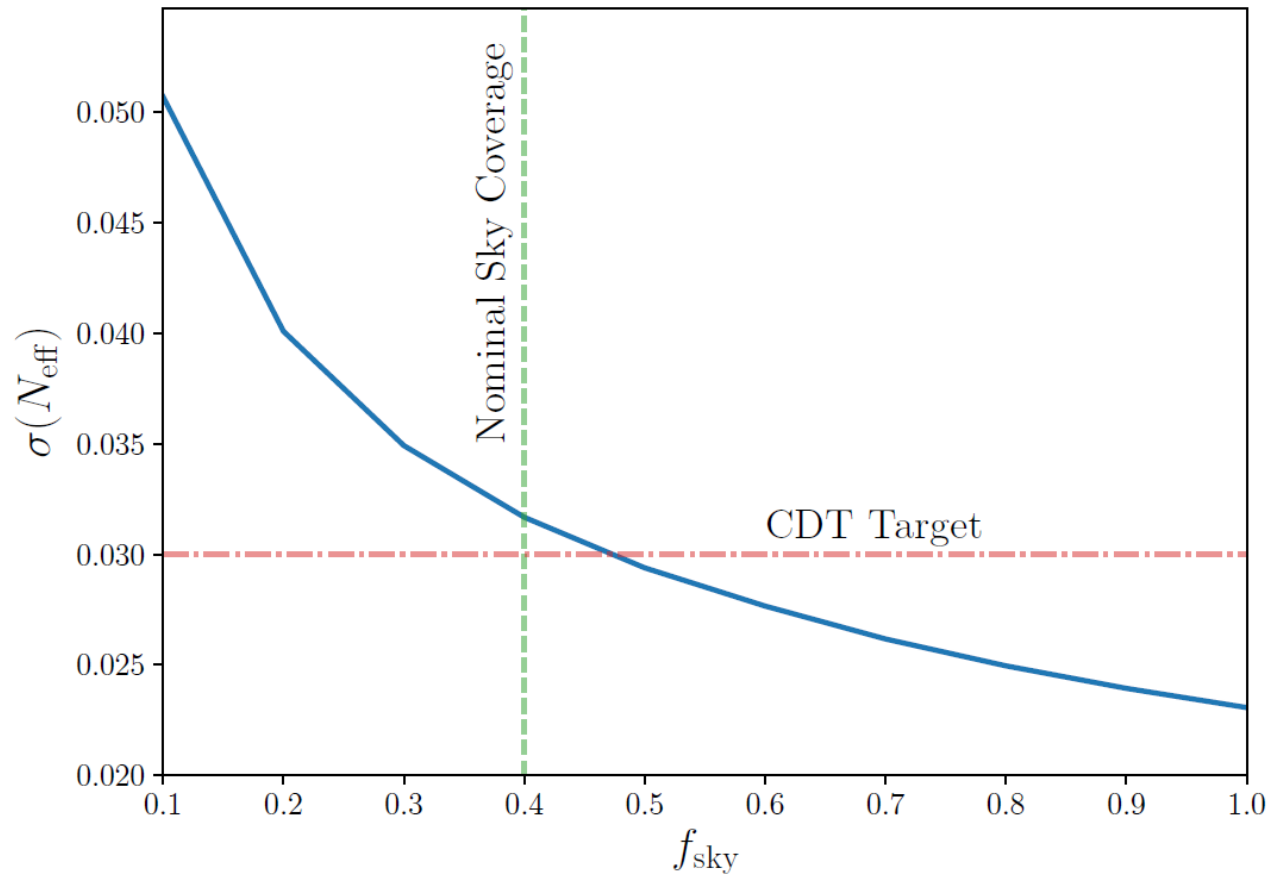


Figure credit: Dan Green

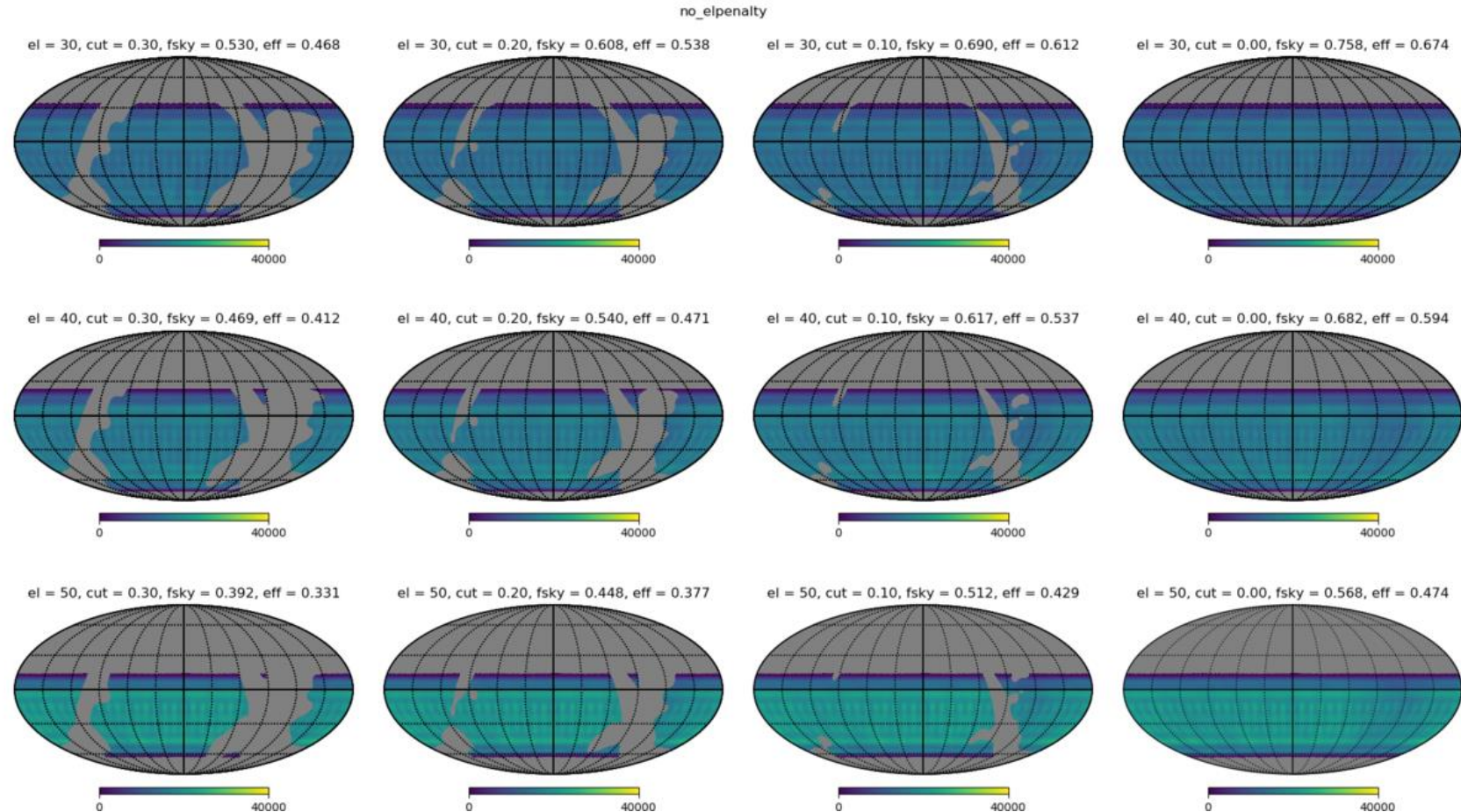
Forecasting – Sky Coverage



- Nominal CDT design does not achieve light relics target of $\sigma(N_{\text{eff}}) = 0.03$
- Steep drop of power in damping tail implies wider sky coverage at fixed effort can achieve better constraints
- Motivates more detailed study of sky coverage

Forecasting – Wide Area f_{sky} Tiger Team

- Hit maps using opportunistic scheduler for various minimum elevations and galactic cuts (due to Reijo Keskitalo)
- Penalty for low elevation observations is also possible



Forecasting – Wide Area f_{sky} Tiger Team

Noise characteristics for minimum elevation of 40 degrees

Galactic cut (in %)	0	10	20	30
Sky fraction (in %)	68	63	55	48
Effective sky fraction for noise (in %)	63	58	51	44
Effective sky fraction for signal (in %)	59	54	47	41

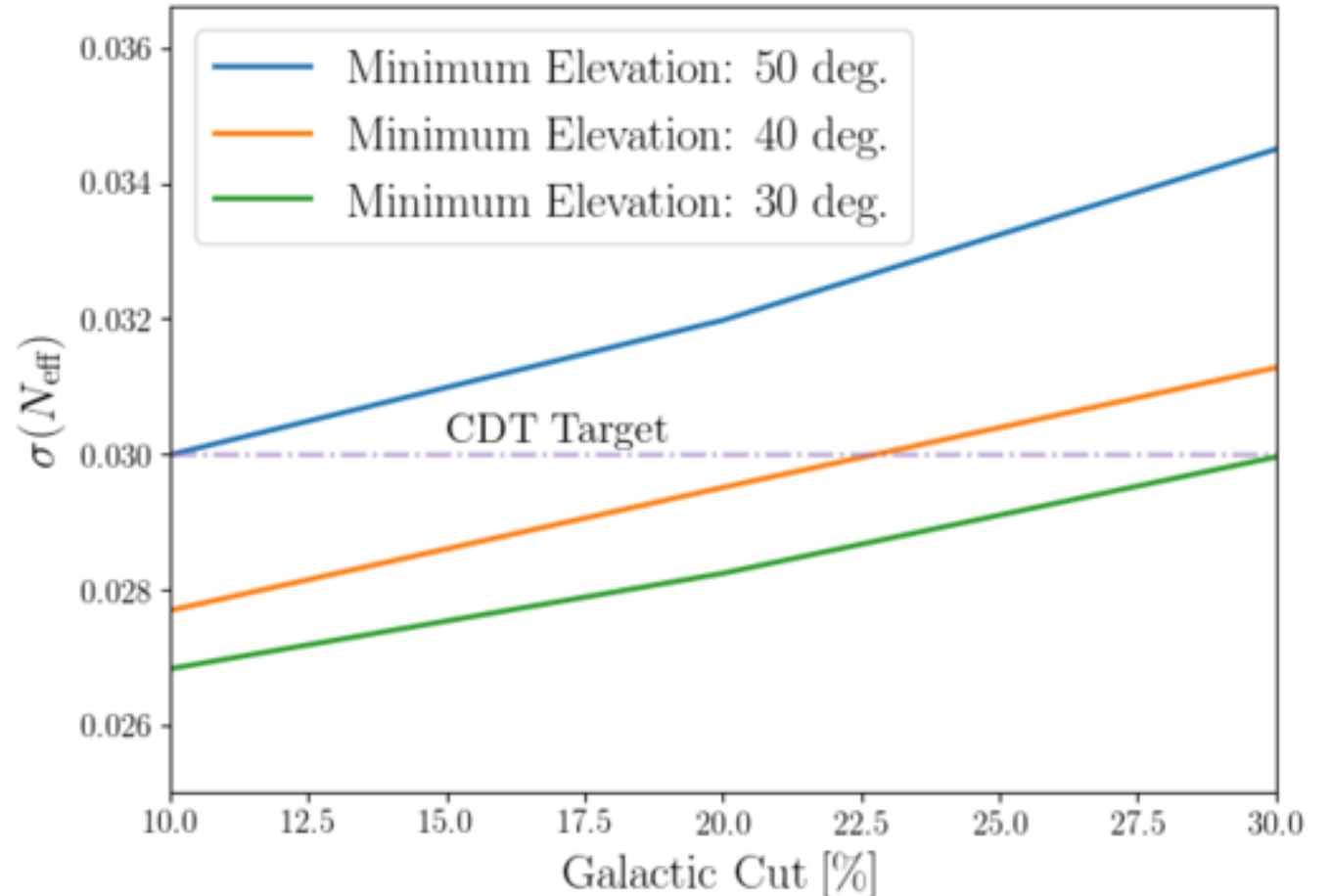
Frequency (GHz)	20	27	39	93	145	225	280
white noise level TT (uK-arcmin)	58.0	19.6	10.9	1.8	1.9	6.1	14.6
ell knee TT	480	435	401	1327	4666	4519	4531
1/f exponent TT (uK-arcmin)	-3.5	-3.5	-3.4	-3.1	-2.3	-3.4	-3.4
white noise level E/B (uK-arcmin)	82.0	27.7	15.5	2.6	2.7	8.6	20.6
ell knee E/B	700	467	467	467	467	467	467
1/f exponent E/B (uK-arcmin)	-1.4	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1
Penalty (relative to f_{sky} scaling)	0.99	1.00	0.99	1.00	1.00	1.02	1.03

- Hit maps were converted to map depths, accounting for additional atmosphere at lower elevation (by Matthew Hasselfield)
- Atmosphere primarily affects large scales and wider sky coverage nearly achieves naïve scaling with f_{sky}

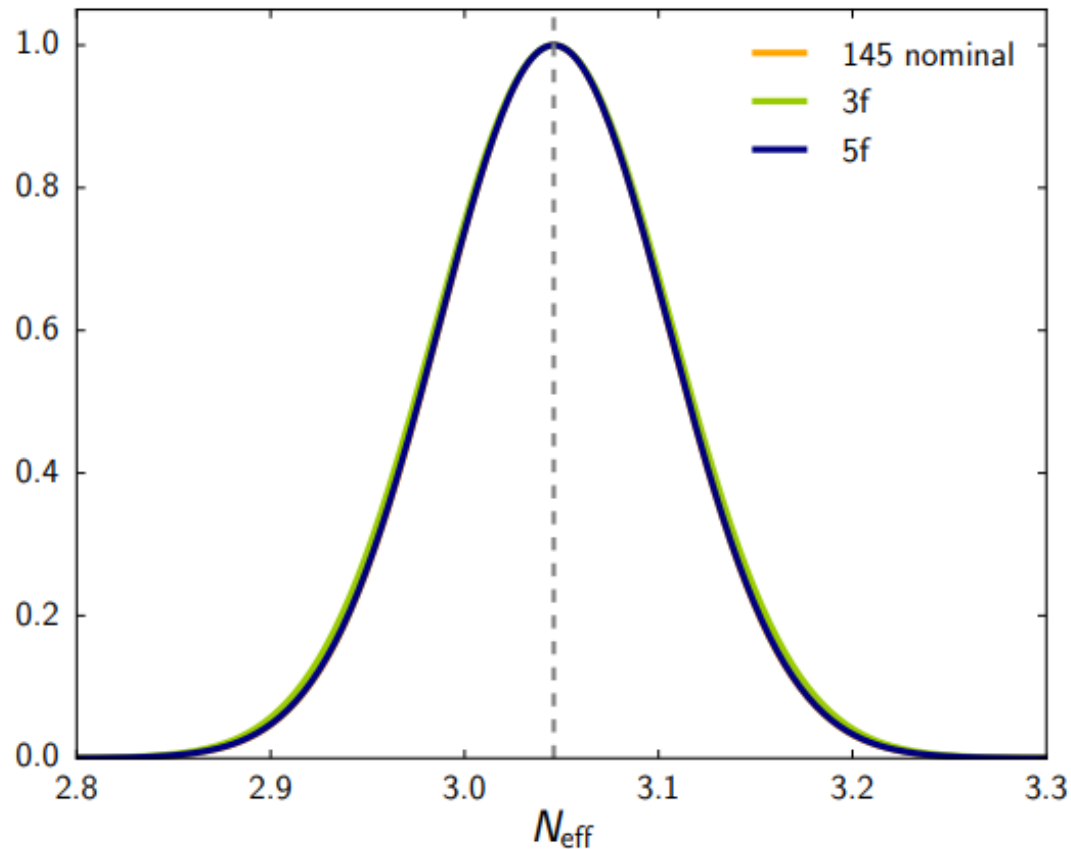
https://cmb-s4.org/wiki/index.php/Noise_models_and_sky_fractions_for_WAFTT

Forecasting – Wide Area f_{sky} Tiger Team

- Galactic foregrounds were removed by ILC (due to Raphael Flauger) and resulting noise curves were used to forecast constraints
- Results show that using lower sky coverage and/or more aggressive galactic cut can achieve target



Flowdown – Frequency Coverage



- LAT frequency coverage needs to be justified by science case
- Experience from Simons Observatory study shows that light relics are unlikely to motivate detectors outside of CMB bands

Figure from Simons Observatory Forecast paper (1808.07445)

Flowdown – Frequency Coverage

- Residual point sources may have some impact on light relic constraints
- Study is underway to assess impact and optimize frequency coverage including extragalactic point sources (Kevin H., Raphael F., Daniel G., Joel M.)

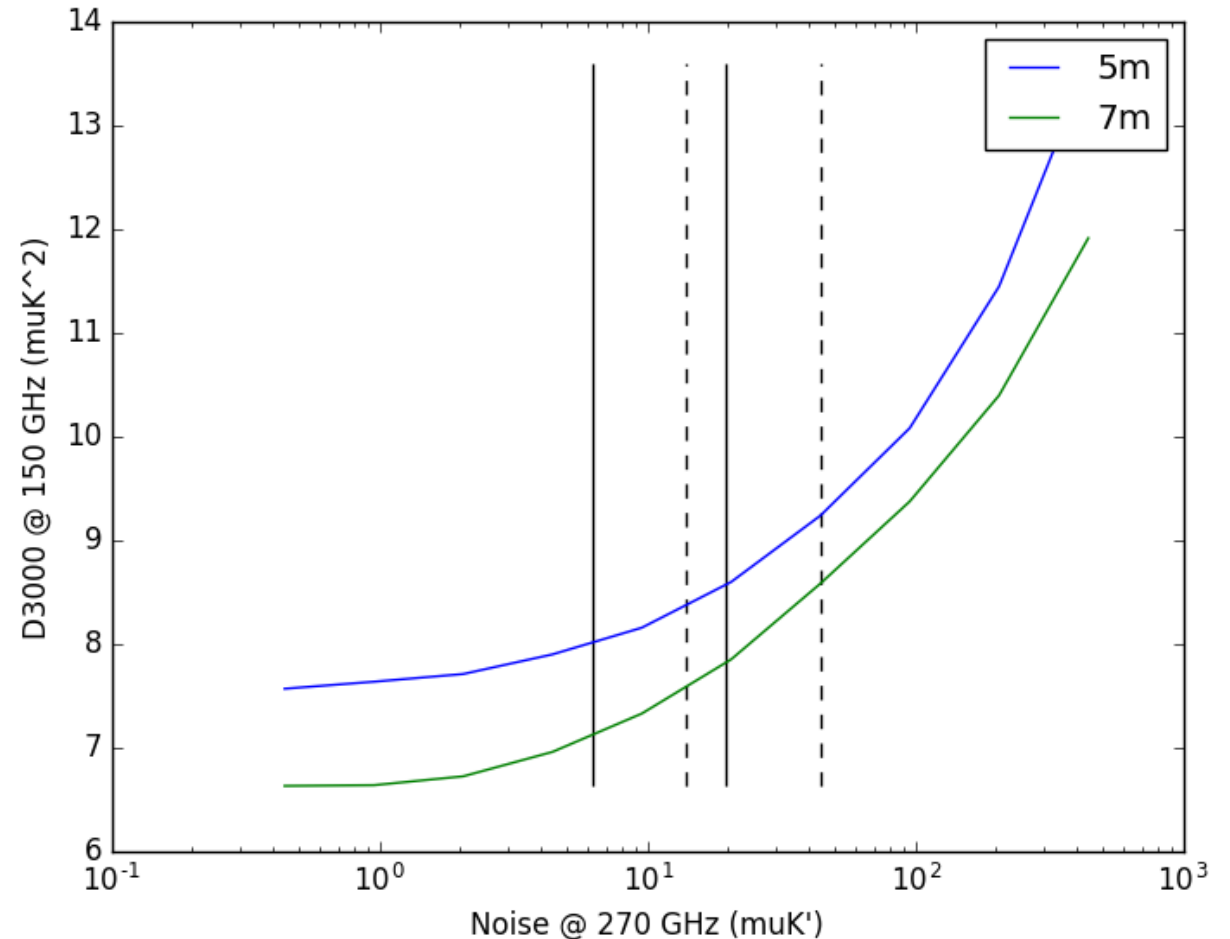


Figure credit: Kevin Huffenberger

Summary

- Improve messaging in response to DSR review
 - Connect to Dark Matter science cases where possible
- CDT target can be met with wider sky coverage
 - WAFTT studying realistic observing strategies to achieve larger f_{sky}
- Need to quantify impact of frequency coverage on light relics
 - Residual point source study is underway