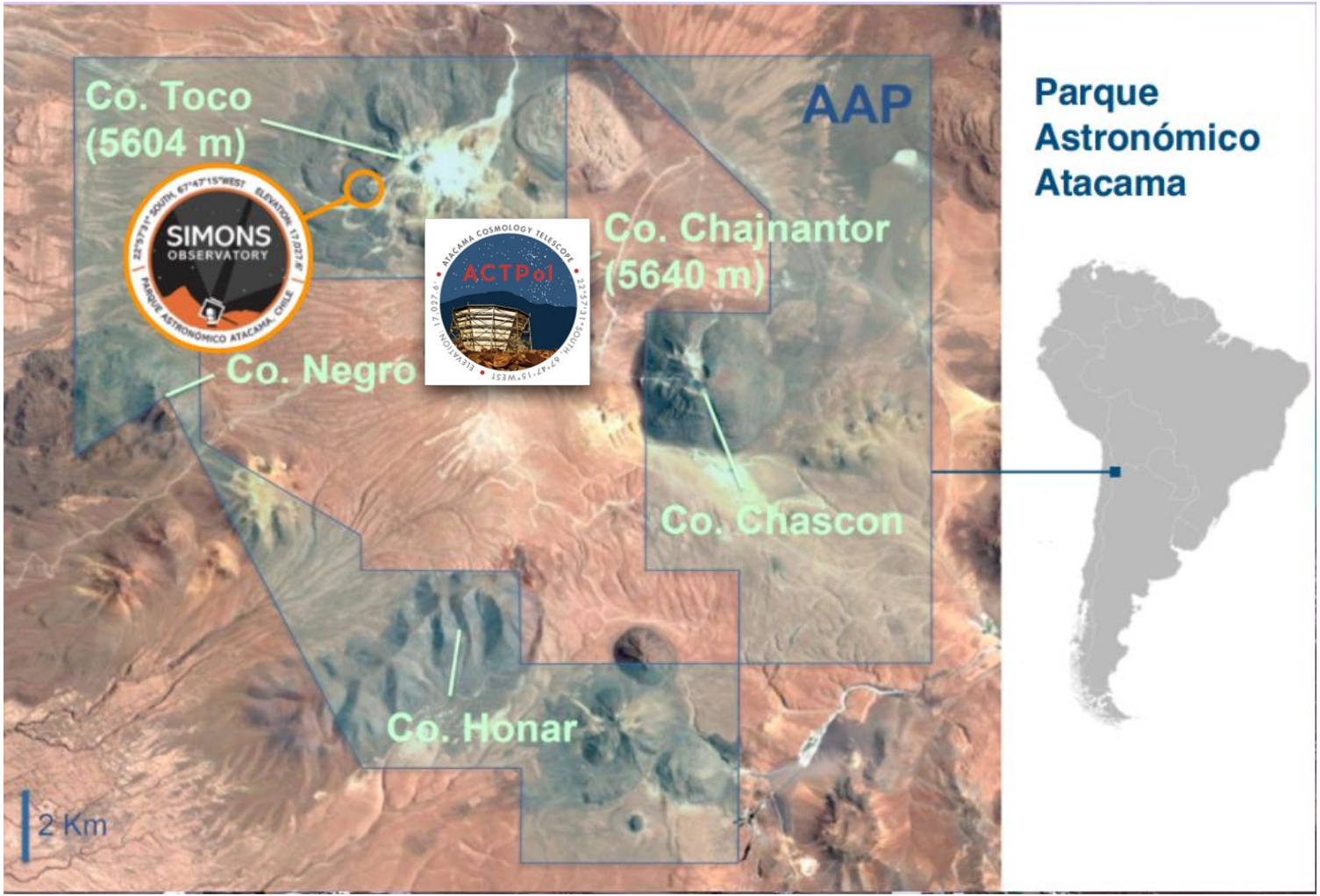
Other missions and synergy: Simons Observatory

Long history of CMB science from the Atacama

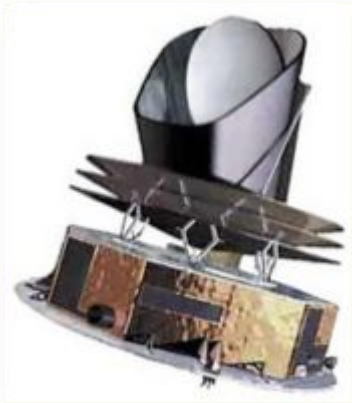
NSF-funded Atacama Cosmology Telescope (PI Staggs) has been running since 2008, now in middle of 2016-21 wide-field survey.

In 2016 Simons Observatory was formed through funding from Simons Foundation, Heising-Simons Foundation and institutional support. Combined POLARBEAR/Simons Array collaboration and Atacama Cosmology Telescope collaboration, and has additional members including former Planck members.

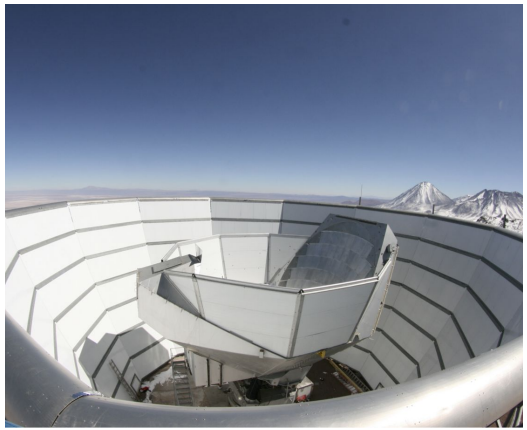

Co. Toco
(5604 m)
AAP
SIMONS
OBSERVATORY
ACTPol
Co. Chajnantor
(5640 m)
Co. Negro
Co. Chascon
Co. Honar
2 Km
Parque
Astronómico
Atacama

*SO will also have three Small Aperture Telescopes for gravitational-wave search

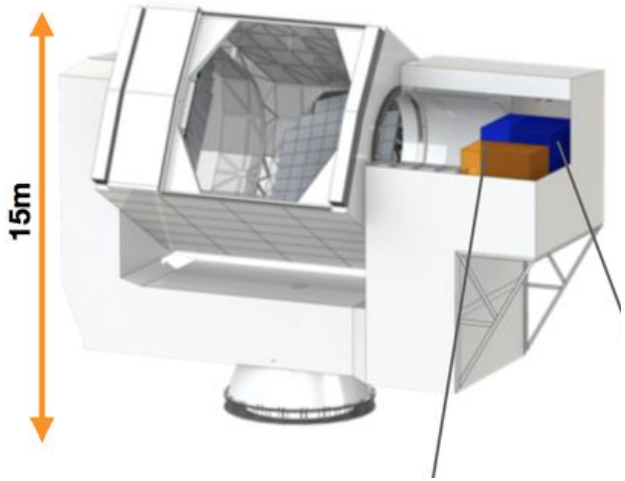
Planck → ACT → SO Large Aperture Telescope



Final release 2018
fsky=100% (70% science)
5-10’ resolution



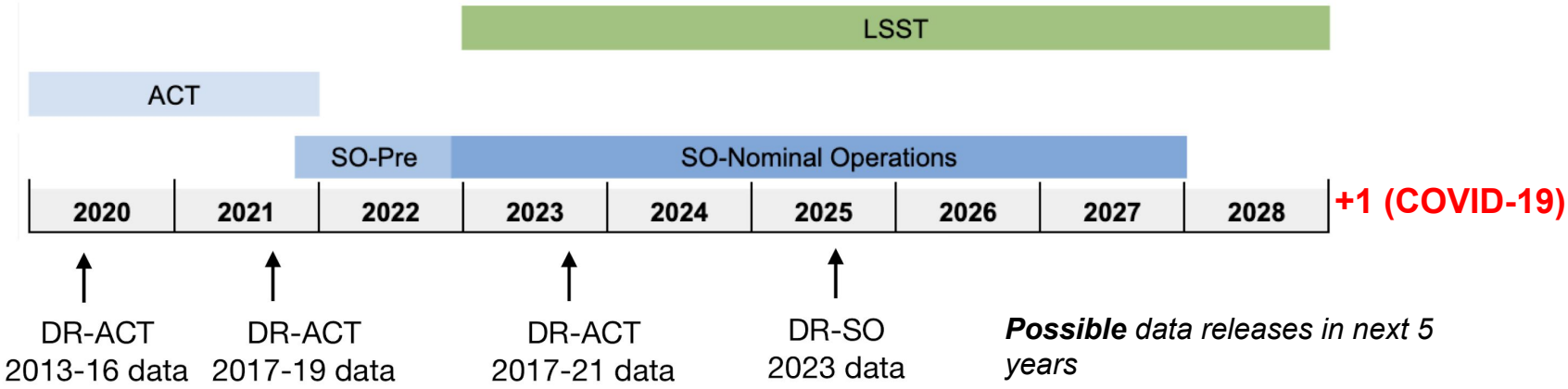
Observations 2016-21
fsky=40%
Noise 3 times < Planck
1’ resolution



Observations 2022-28
fsky =40%
Noise 3 times < ACT
1’ resolution
[S4 would come next incl 3 LATs]

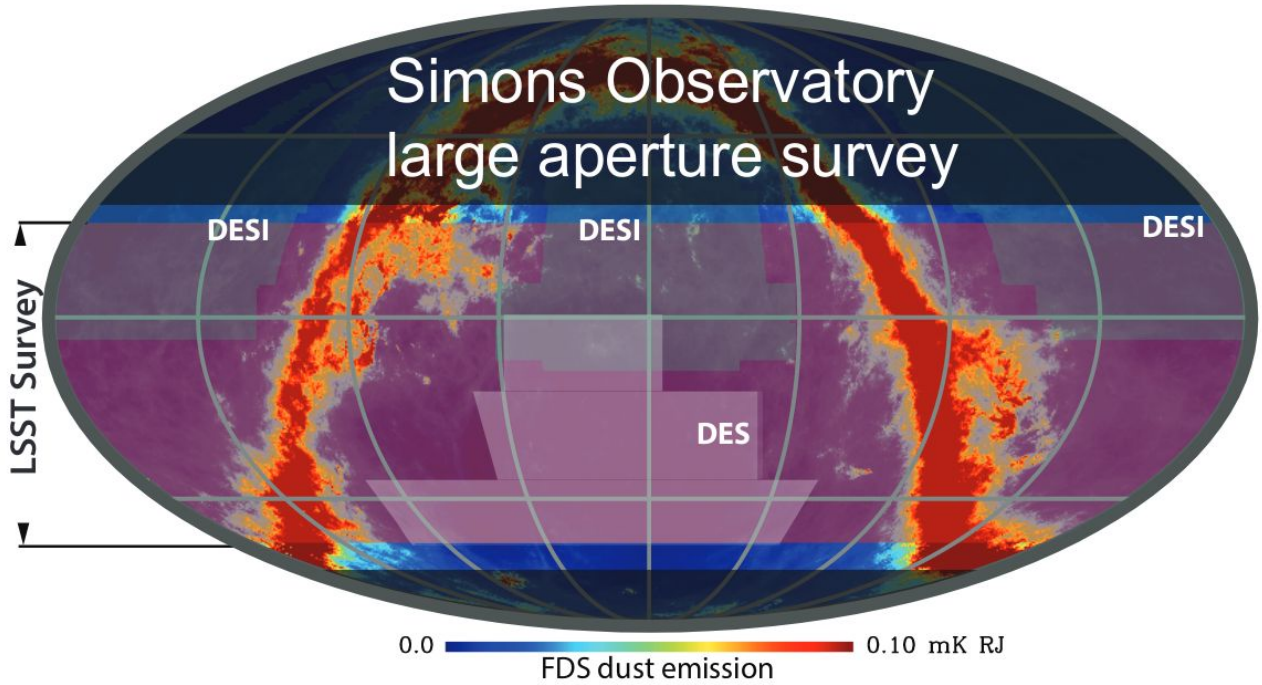
*SO/ACT can’t measure largest scales in temperature (atmosphere), so combine with Planck

Timeline



Plan to deliver ACT+Planck, then SO+Planck products (maps and likelihoods) in common framework
More regular/extensive data delivery depending on our analysis support (NSF proposal for data release support + ongoing European support)
Much of our core science comes from correlations → we want to work with DESC! (and Euclid, DESI++)

Then: SO-Large Aperture Telescope 2022-28



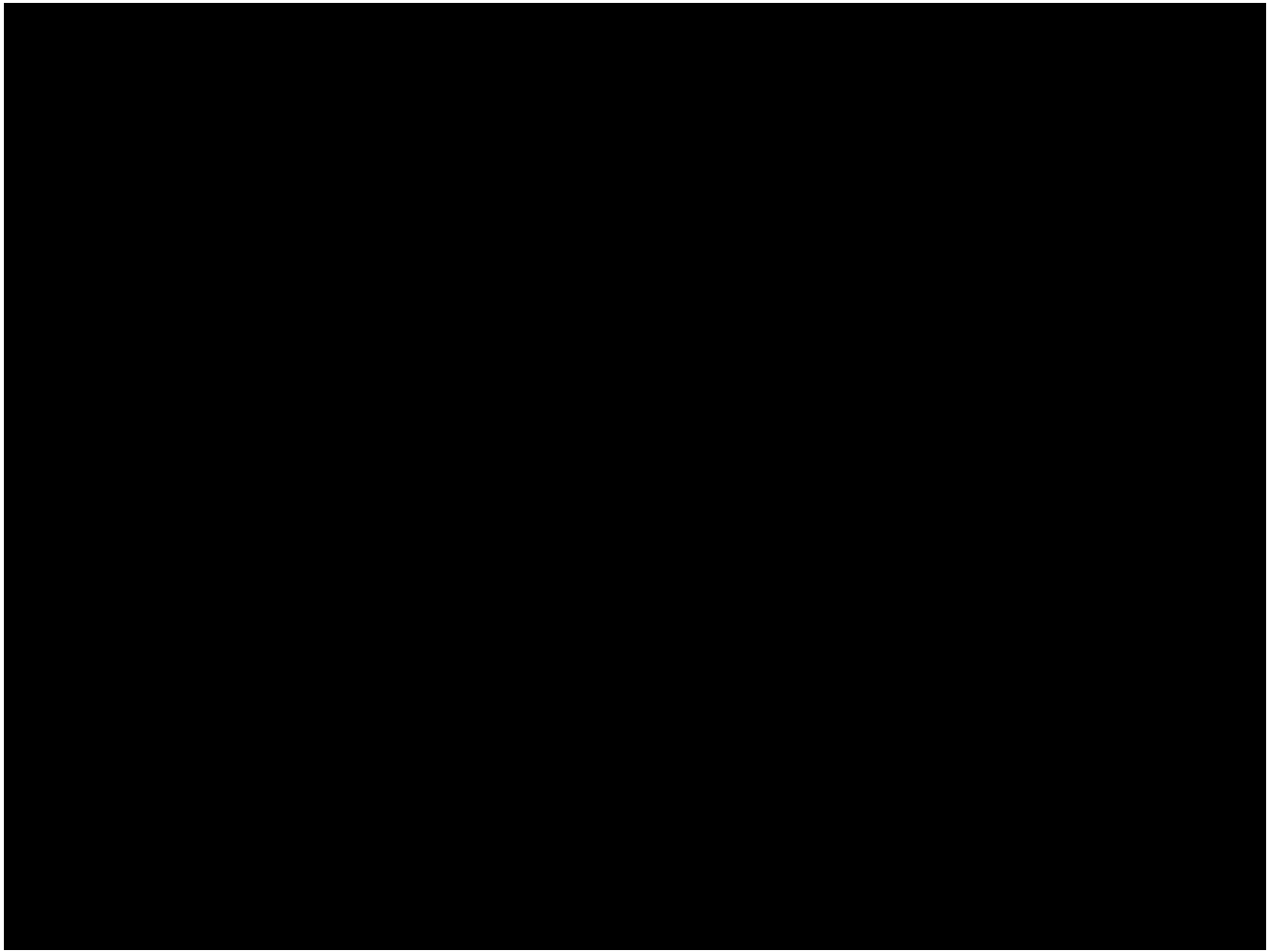
Combined white noise level: 4-6 μK*arcmin

6 frequencies: 30-270 GHz

Coverage being finalized; aim for maximum LSST/DESI overlap

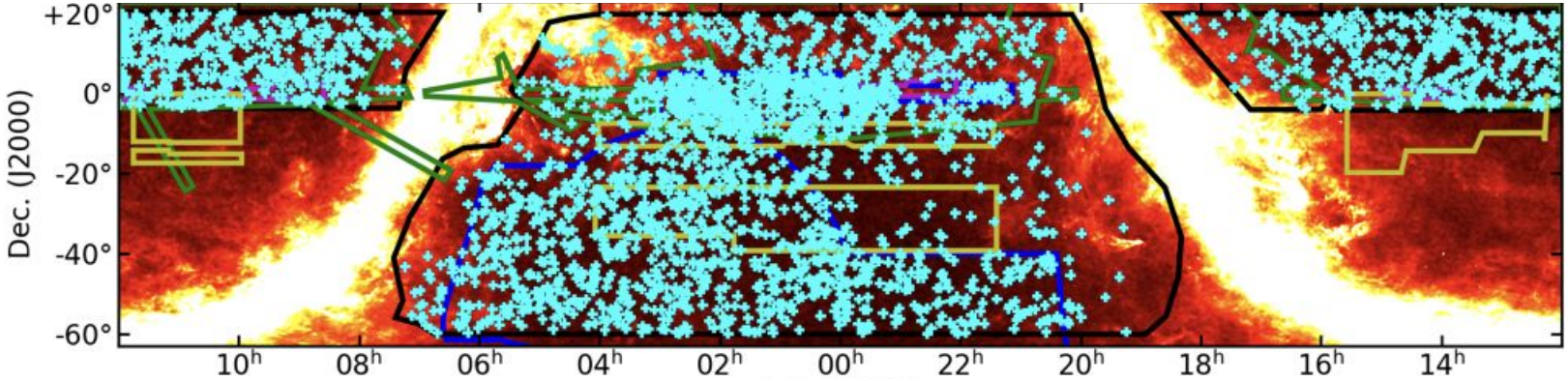
Zoom in on a small patch, comparison with Planck

Map, power spectra, cosmology papers:
Aiola et al. 2020
Naess et al. in prep
Choi et al. in prep

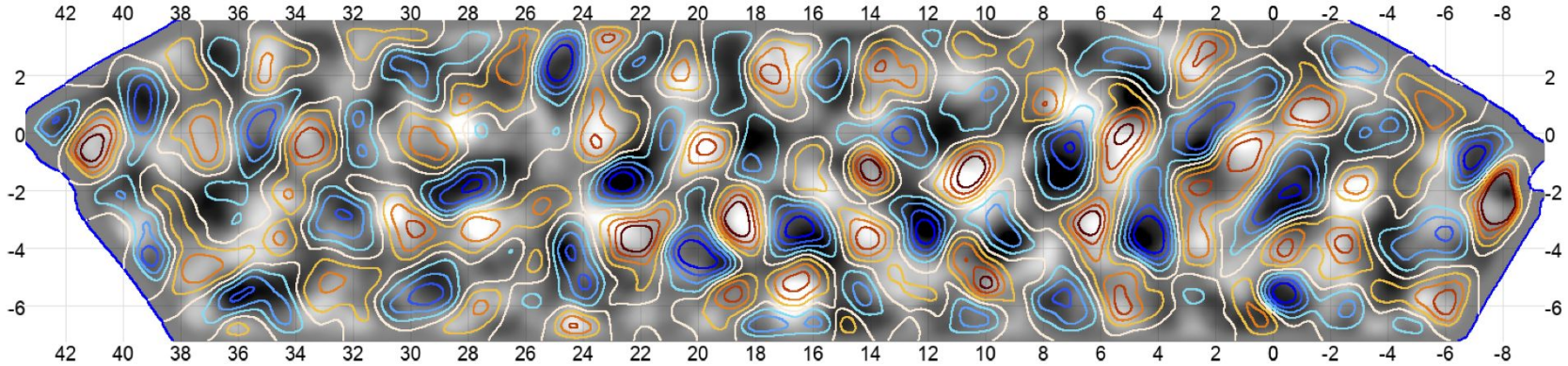


Movie from Sigurd Naess

ACT: progress towards large-field clusters/lensing/Compton-Y

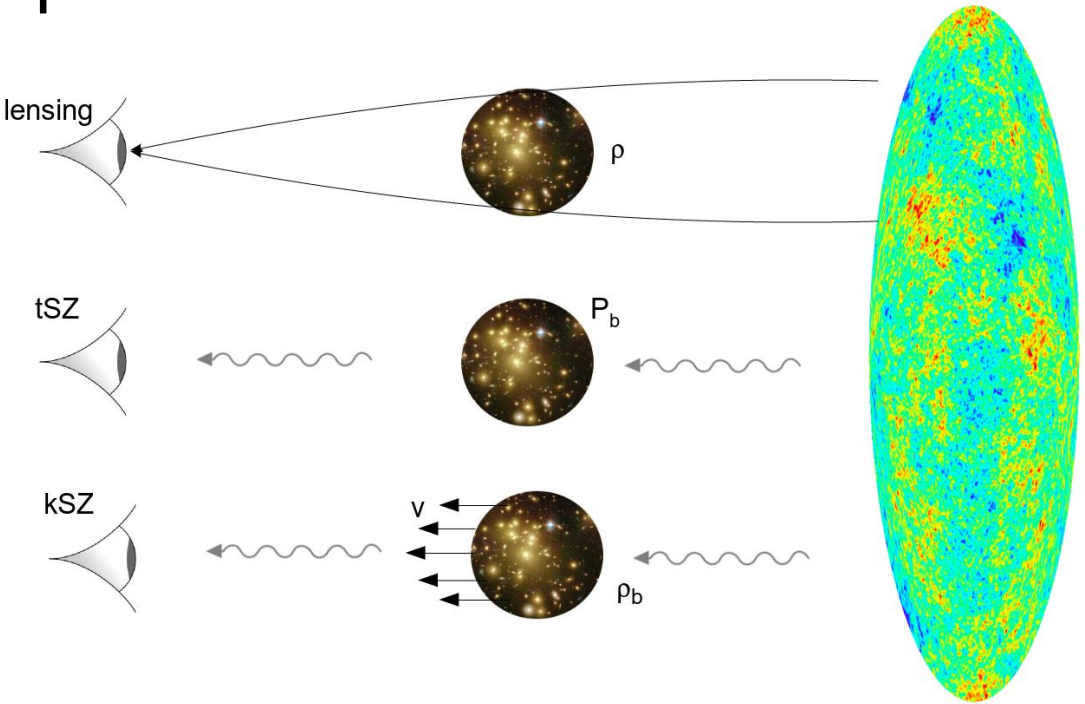


>2500 confirmed SZ clusters over 16000 deg2 with redshifts to date - sample due for release 2020 (Hilton et al. 2020)



ACT lensing map (Darwish et al. 2020) over 2000 deg2 → extending to 16,000 deg2 in next 1-2 years (data in hand)

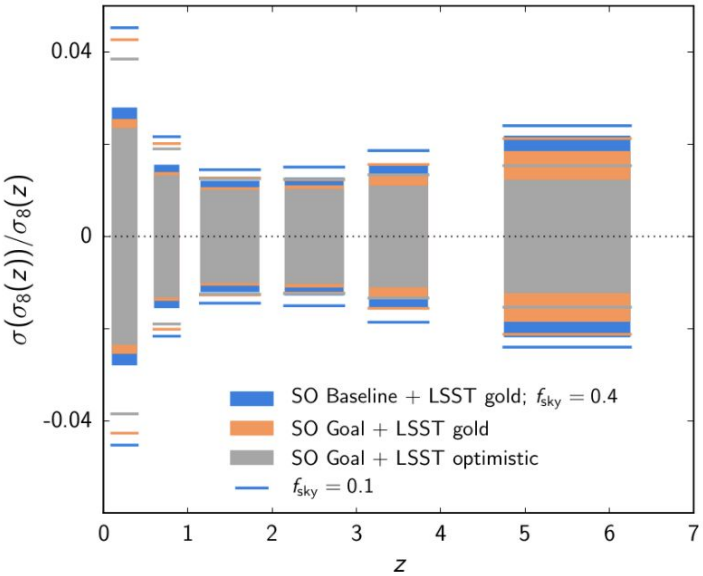
SO-LSST science: Primary & secondary CMB anisotropies



secondary anisotropies
correlated to low redshift probes

primary anisotropies
early Universe physics

Fundamental science: Dark Energy and primordial NG



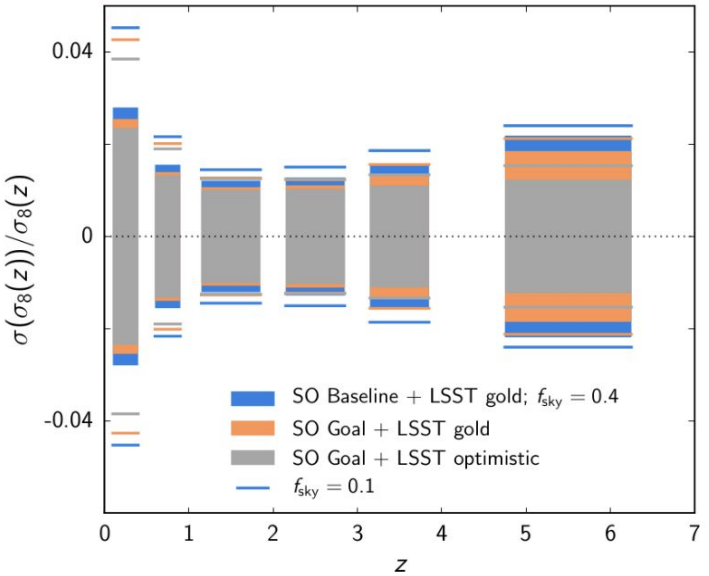
Combination of $C_\ell^{\kappa\kappa}, C_\ell^{g\kappa}, C_\ell^{gg}$

Sample variance cancelation

Break parameter degeneracies.

SO Collab., 2019. Münchmeyer et al., 2019.

Fundamental science: Dark Energy and primordial NG



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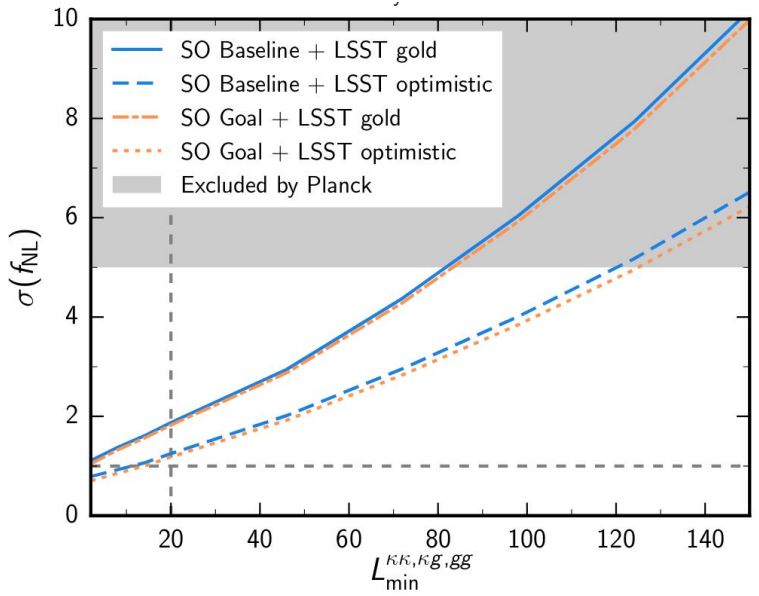
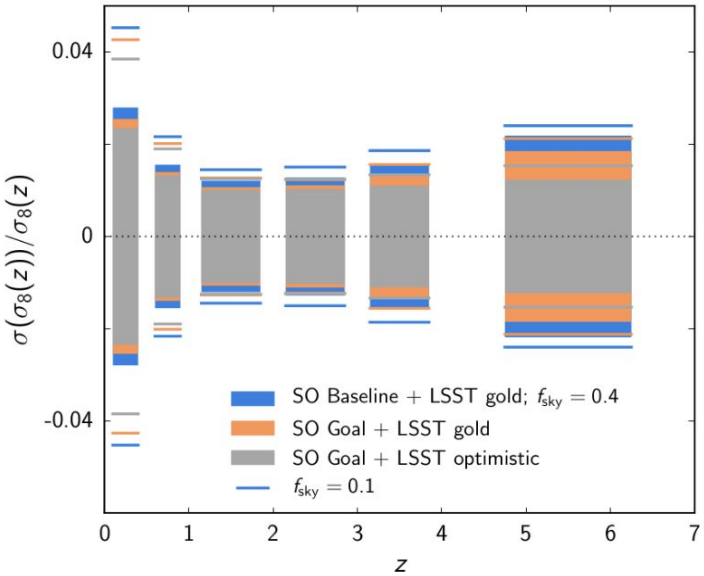


Same principle for f_{NL}
kSZ cross-correlation particularly powerful (1/k weighting)

SO Collab., 2019. Münchmeyer et al., 2019.

Fundamental science: Dark Energy and primordial NG



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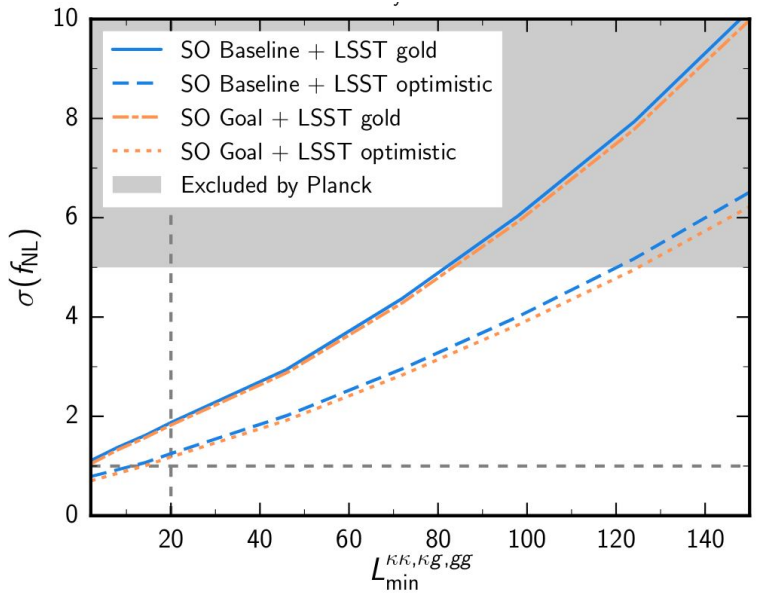

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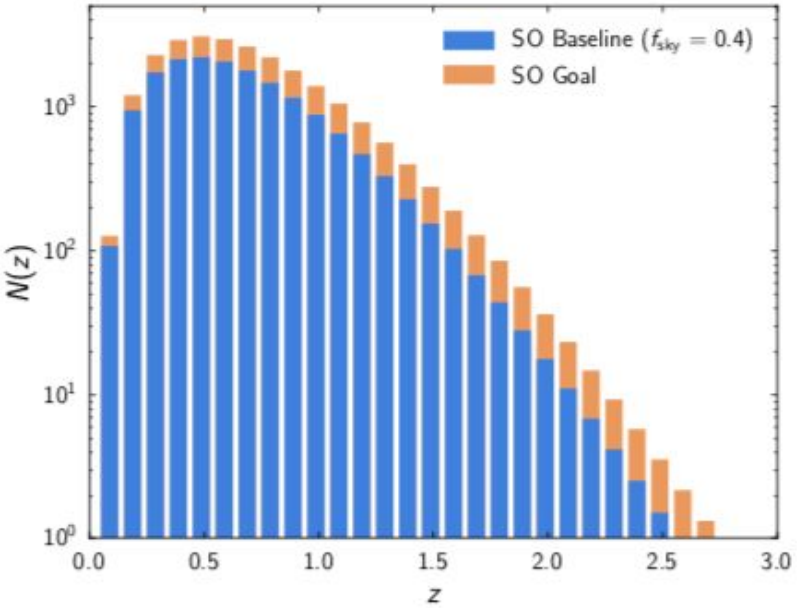
SO Collab., 2019. Münchmeyer et al., 2019.

+ neutrino mass, H_0!

Cluster science and systematics



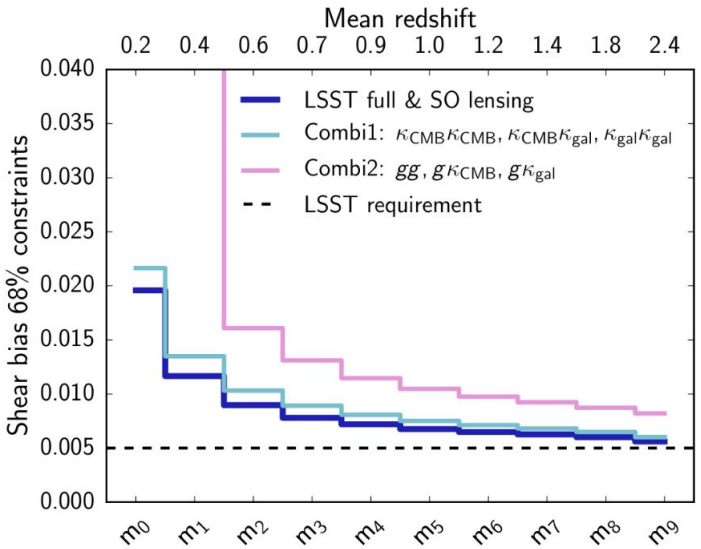
LSST WL mass-calibration for tSZ cluster analyses
CMB halo lensing allows for mass-calibration of high-z optical clusters (3% at z~1)

LSSTxSO tSZ clusters

$$\sigma(\Sigma m_\nu) = 27 \text{ meV} \quad \Lambda\text{CDM} + \Sigma m_\nu$$

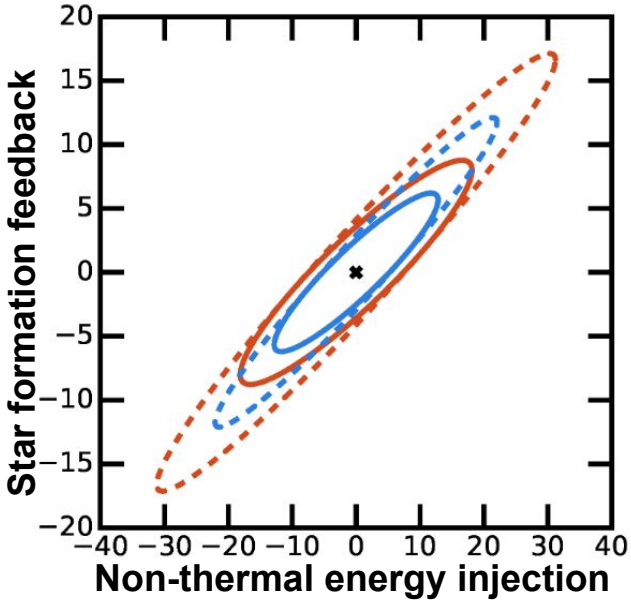
SO Collab., 2019

Shear systematics: shape measurement and baryons



Joint analyses of CMB lensing and shear constrain multiplicative bias to LSST requirements.

SO Collab., 2019
Schaan et al., 2017



High-res tSZ & kSZ constrain baryon distribution in ICM, IGM.
Constrain baryonic effects in WL.

SO Collab., 2019
Battaglia et al., 2017
Amodeo et al. 2021

Goals

	Parameter	SO-Baseline[b] (no syst)	**SO-Baseline**[c]	SO-Goal[d]	Current[e]
Primordial perturbations	r	0.0024	**0.003**	0.002	0.03
	$e^{-2\tau}\mathcal{P}(k = 0.2/\mathrm{Mpc})$	0.4%	**0.5%**	0.4%	3%
	$f_{\mathrm{NL}}^{\mathrm{local}}$	1.8	**3**	1	5
		1	**2**	1	
Relativistic species	N_{eff}	0.055	**0.07**	0.05	0.2
Neutrino mass	Σm_ν	0.033	**0.04**	0.03	0.1
		0.035	**0.04**	0.03	
		0.036	**0.05**	0.04	
Deviations from Λ	$\sigma_8(z = 1 - 2)$	1.2%	**2%**	1%	7%
		1.2%	**2%**	1%	
	H_0 (ΛCDM)	0.3	**0.4**	0.3	0.5
Galaxy evolution	η_{feedback}	2%	**3%**	2%	50-100%
	p_{nt}	6%	**8%**	5%	50-100%
Reionization	Δz	0.4	**0.6**	0.3	1.4

Goals

All these require combining LSST and SO!

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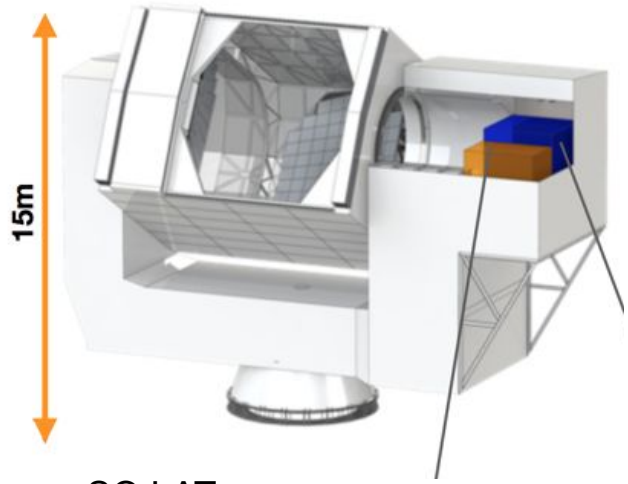
SO:UK

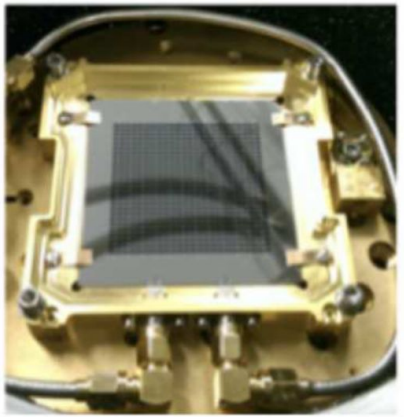
- Long track record of UK involvement in CMB experiments, both in instrumentation and analysis.
- Large number of UK-based active members of SO.
- SO:UK aims to be a consortium-level contribution to SO from the wider UK CMB community.

- **Three main components:**
  - UK Data Centre (deliver science-ready data for SO)
  - Pipeline algorithm development (e.g. map-making)
  - A single KIDs LAT optics tube at high-freq (demonstrate UK's expertise)
- Currently in STFC-funded Phase A study (tech demonstration and project planning).
- Will capitalize on existing analysis WG leadership role.
- Will position UK community optimally to do science with SO (and SO+LSST!).

SO:UK consortium: Manchester (Battye, **Brown**, Chluba, Piccirillo, Roddis), Cardiff (Ade, Calabrese, Doyle, Hargrave, Sudiwala, Tucker), Cambridge (Challinor, Ferguson, Shellard, Sherwin), Oxford (Alonso, Jones, Taylor), Imperial (Clements, Contaldi, Heavens, Jaffe), Sussex (Lewis).



SO LAT



KIDs array designed @ Cardiff