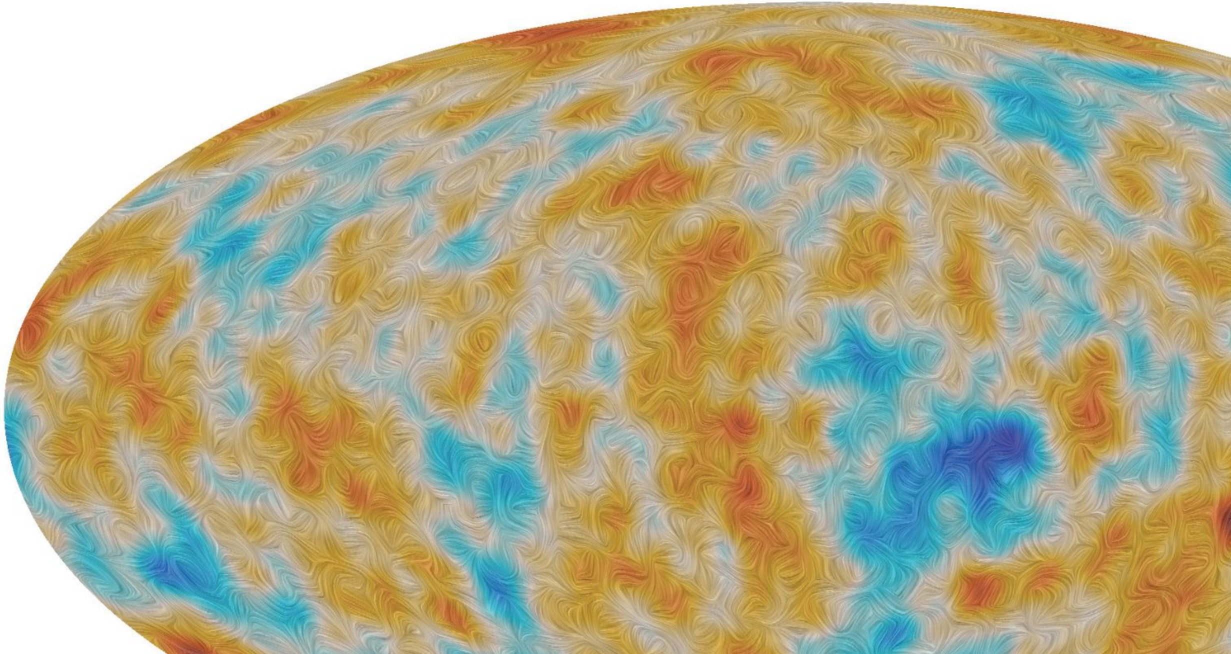
Simons Observatory : status on the deployment and analysis of Small Aperture Telescopes

Adrien La Posta

Oxford University

adrien.laposta@physics.ox.ac.uk

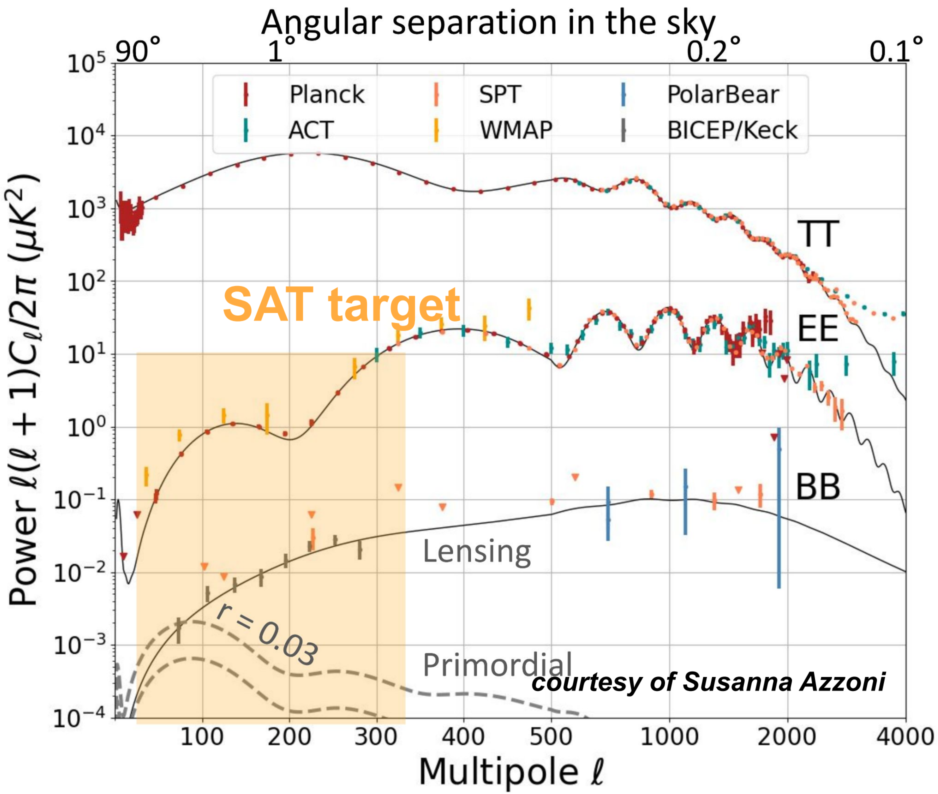
on behalf of the Simons Observatory collaboration



Meeting CMB-France #6

2024 December 19th

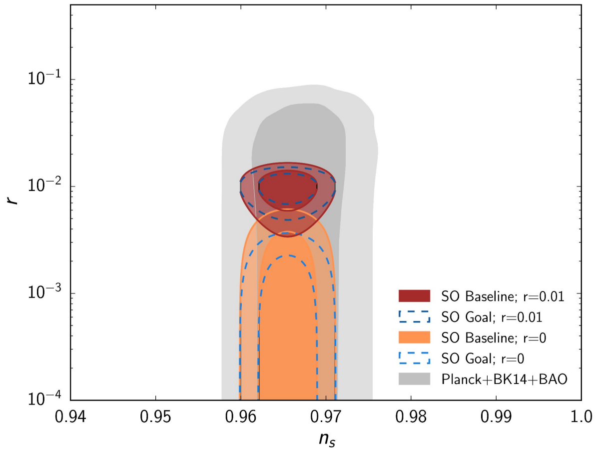
Measuring large-scale polarization



SAT target:
B-modes polarization from tensor perturbations on **degree scale**

Current constraint: r<0.032 (95%)
(Planck PR4 +BICEP/Keck)
Tristram et al., Phys. Rev. D 105, 083524

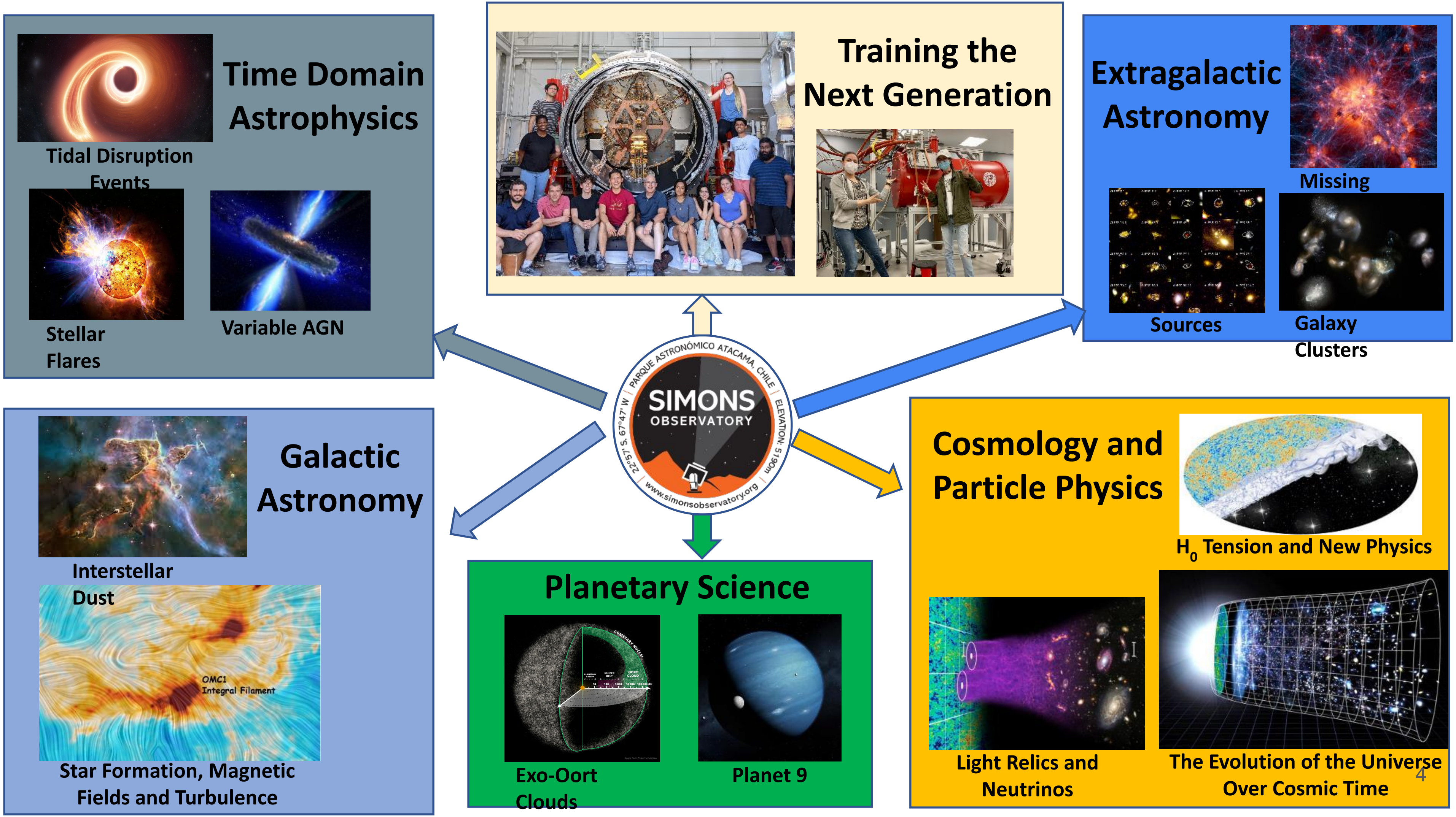
Expected sensitivity for SO : σ(r)~0.002-0.003
(3SATs)



SO science goals and forecasts, JCAP 1902 (2019) 056

>375 researchers from over
15 countries & 60 institutions

SO 2024
Chicago F2F


Time Domain Astrophysics
Tidal Disruption Events
Stellar Flares
Variable AGN
Training the Next Generation
Extragalactic Astronomy
Missing
Sources
Galaxy Clusters
PARQUE ASTRONÓMICO ATACAMA, CHILE
SIMONS OBSERVATORY
ELEVATION: 5190m
22°57' S, 67°47' W
www.simonsobservatory.org
Galactic Astronomy
Interstellar Dust
OMC1
Integral Filament
Star Formation, Magnetic Fields and Turbulence
Planetary Science
Exo-Oort Clouds
Planet 9
Cosmology and Particle Physics
H0 Tension and New Physics
Light Relics and Neutrinos
The Evolution of the Universe Over Cosmic Time

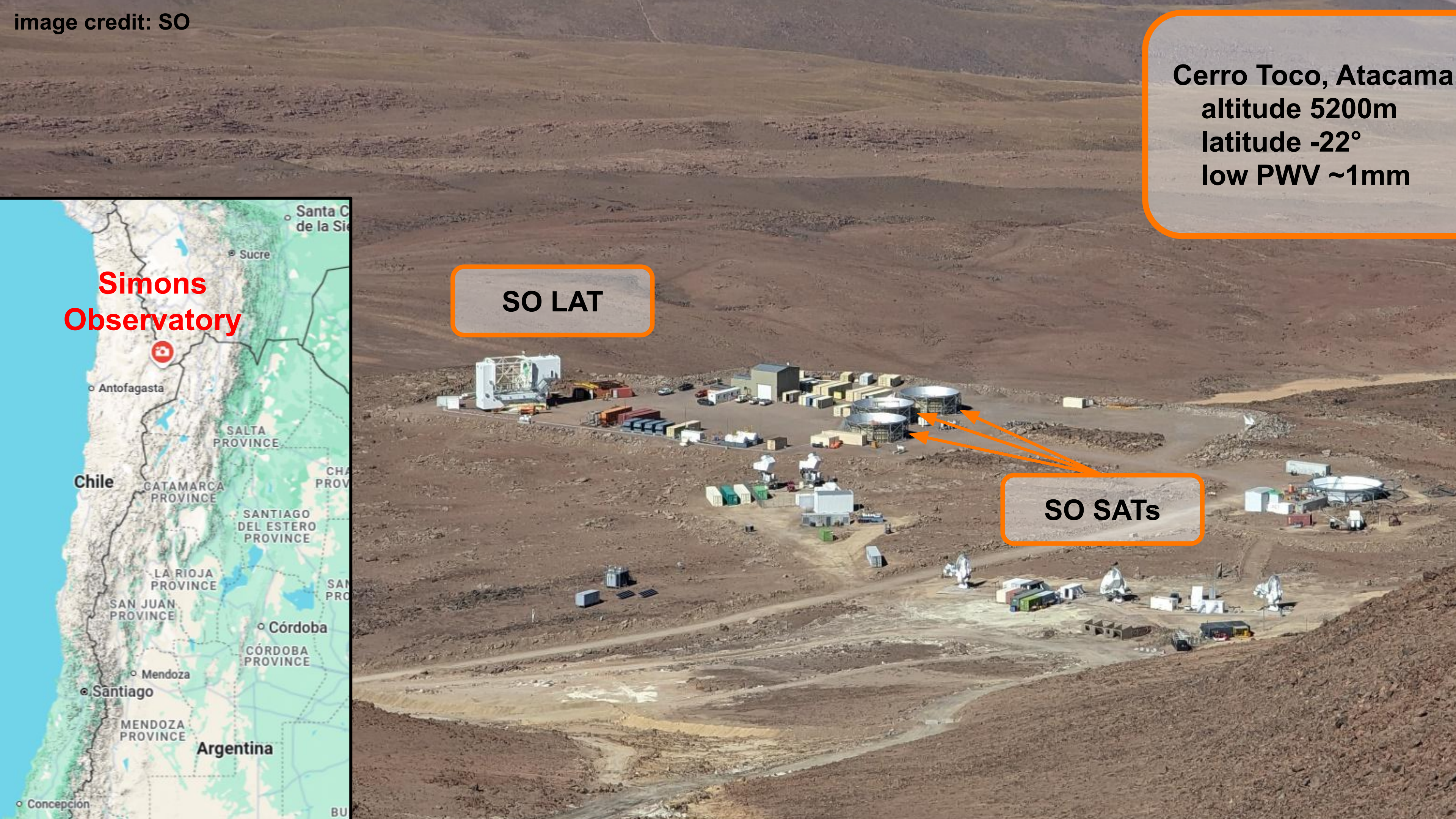


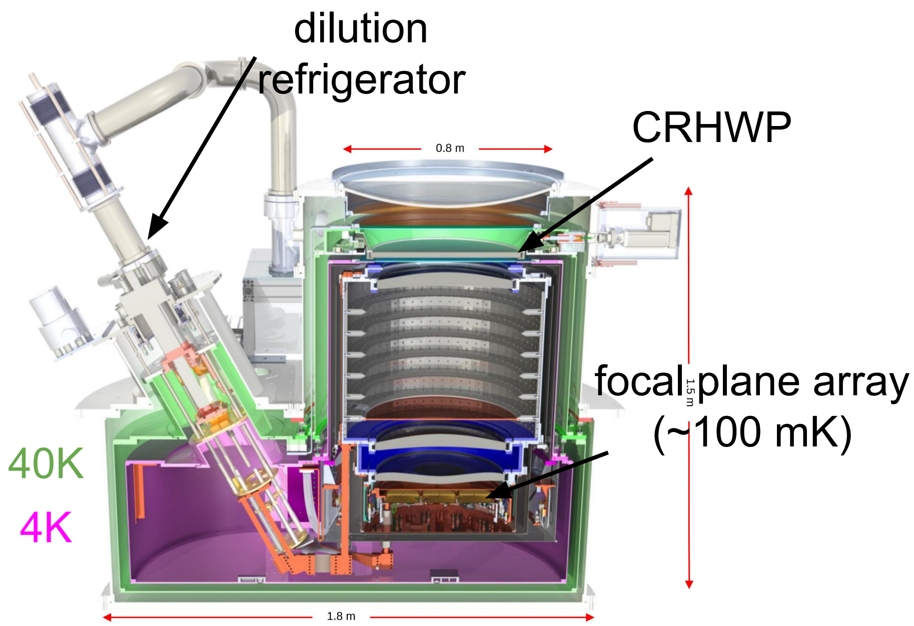
image credit: SO
Cerro Toco, Atacama
altitude 5200m
latitude -22°
low PWV ~1mm
SO LAT
SO SATs
Simons
Observatory
Sucre
Antofagasta
SALTA
PROVINCE
Chile
CATAMARCA
PROVINCE
SANTIAGO
DEL ESTERO
PROVINCE
LA RIOJA
PROVINCE
SAN JUAN
PROVINCE
Córdoba
CÓRDOBA
PROVINCE
Mendoza
Santiago
MENDOZA
PROVINCE
Argentina
Concepción

SAT instrument & survey

credit: Nicholas Galitzki

SAT instrument & survey

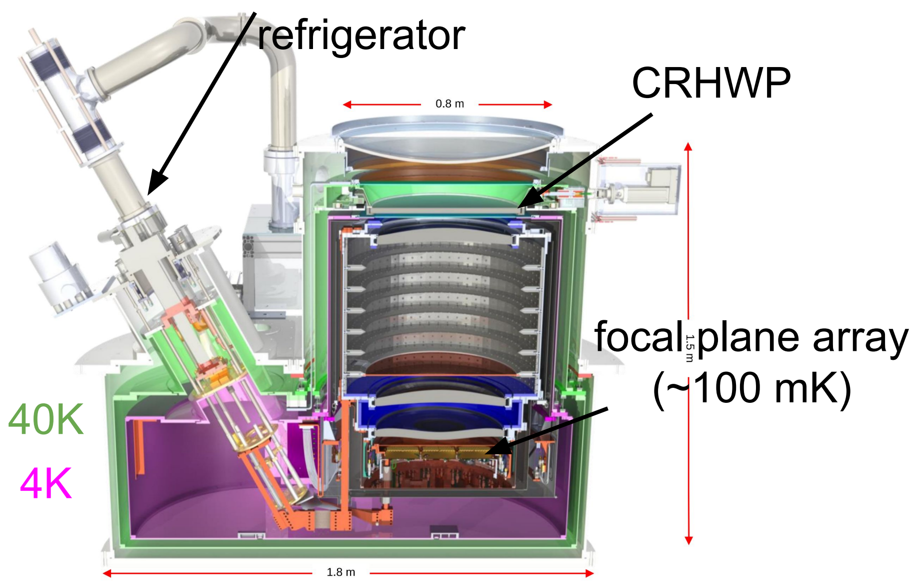
Galitzki et al., Design, integration, and testing of the small aperture telescopes



42cm aperture
35° FOV

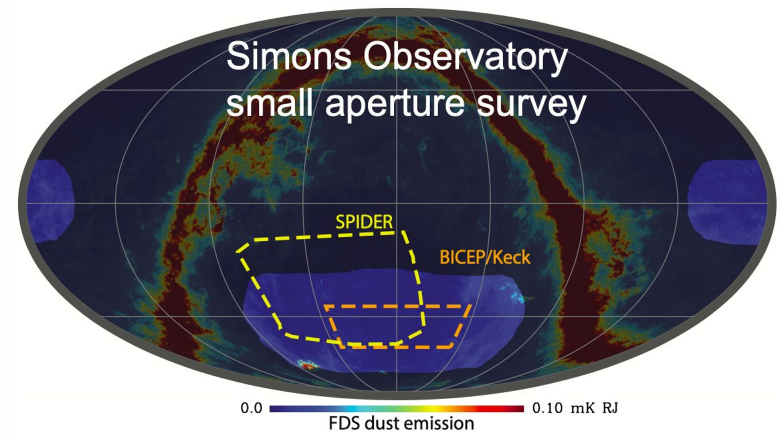
SAT instrument & survey

Galitzki et al., Design, integration, and testing of the small aperture telescopes
Ade et al., SO science goals and forecasts



42cm aperture
35° FOV
MF noise (93/145) ~ 2muK-arcmin
Sky coverage f_{sky}~10%

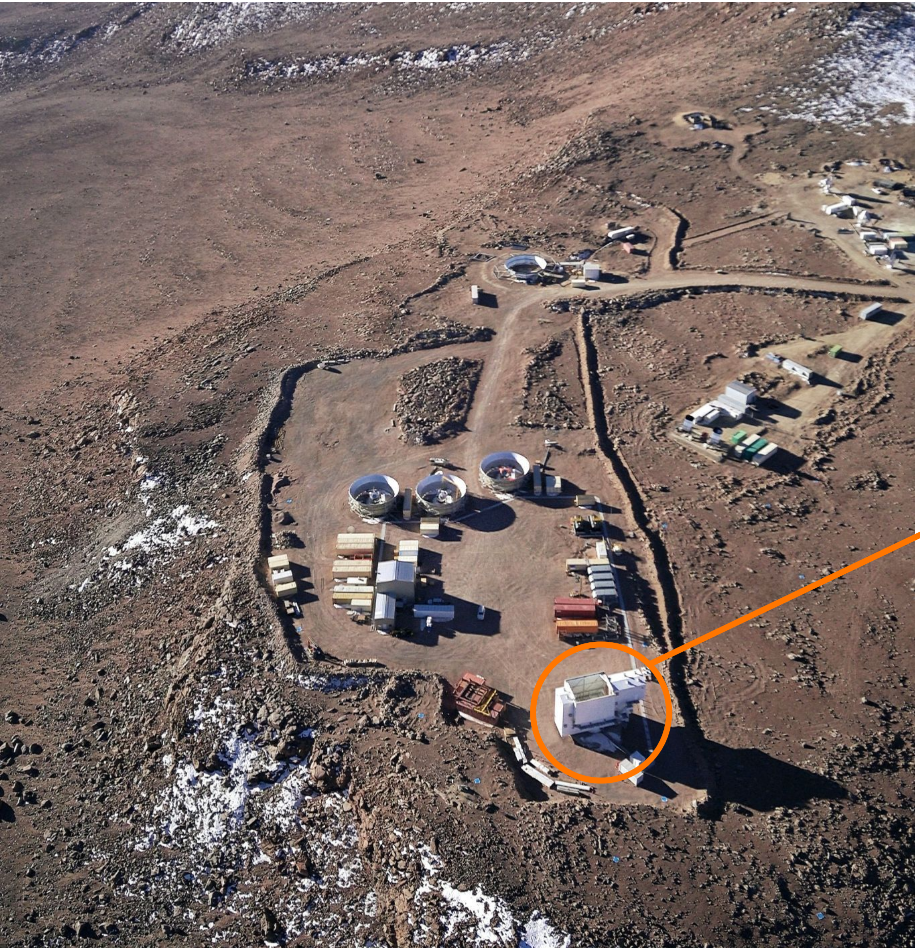
Frequency coverage:
2 MF SAT + 1UHF SAT (~30.000 detectors)
+2MF (UK) + 1LF (JP) (~60.000 detectors)



	SATs ($f_{\rm sky} = 0.1$)		
Freq. [GHz]	FWHM (′)	Noise (baseline) [μK-arcmin]	Noise (goal) [μK-arcmin]
27	91	35	25
39	63	21	17
93	30	2.6	1.9
145	17	3.3	2.1
225	11	6.3	4.2
280	9	16	10

Deployment status

image credit: SO drone flight 2024

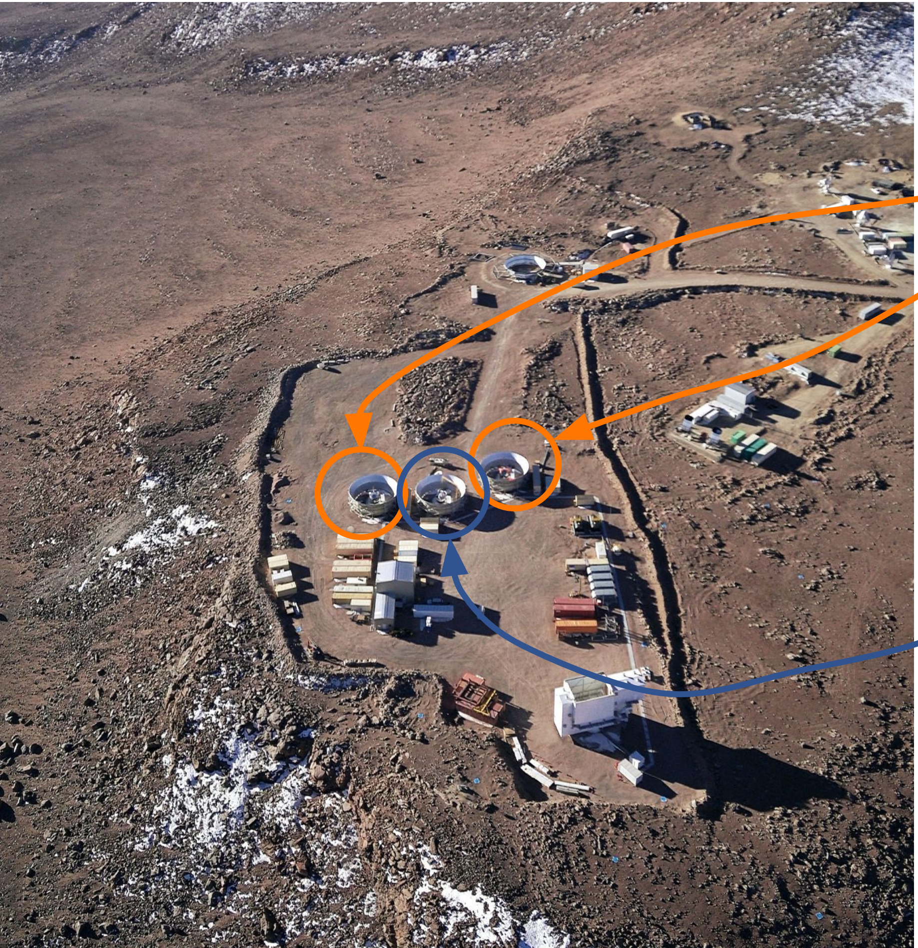


LAT mirrors are on their way !
(expected on site early January)

credit: Mark Devlin

Deployment status

image credit: SO drone flight 2024



SAT MF1 first light **Oct. 2023**
SAT MF2 first light **Dec. 2023**

under commissioning

SAT UHF mounted on platform
first light planned for **Feb. 2024**

First SO:UK platform on site !

image credit: SO

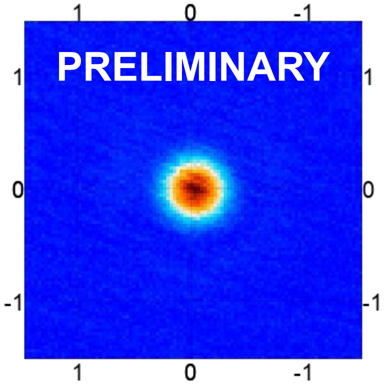
First observations of Jupiter/Moon

Day-Weiss et al. [to come soon]

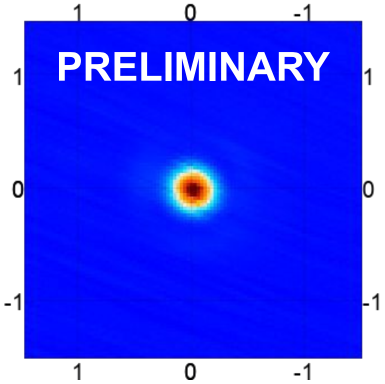
data

Beam measurements from Jupiter observations

90 GHz



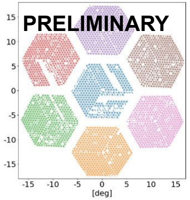
150 GHz



data

Pointing model from Jupiter/Moon observations

90 GHz



150 GHz

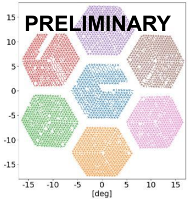


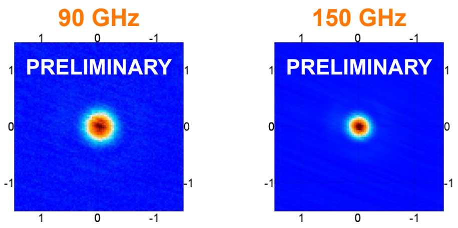
image credit: SO

First observations of Jupiter/Moon

Day-Weiss et al. [to come soon]

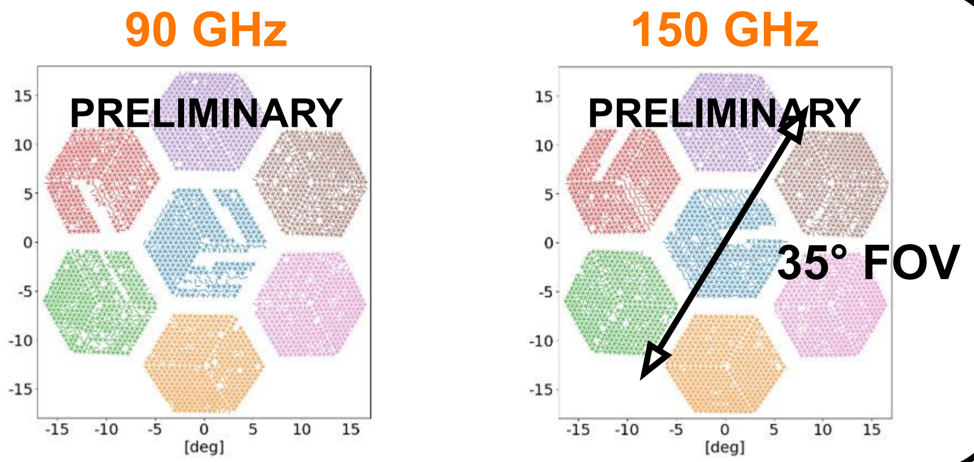
data

Beam measurements from Jupiter observations



data

Pointing model from Jupiter/Moon observations



Mitigation of atmospheric noise

Yamada et al. [Rev. Sci. Instrum. 95, 024504 (2024)]

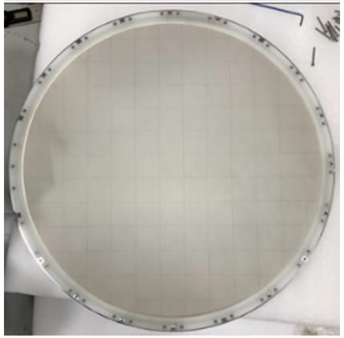
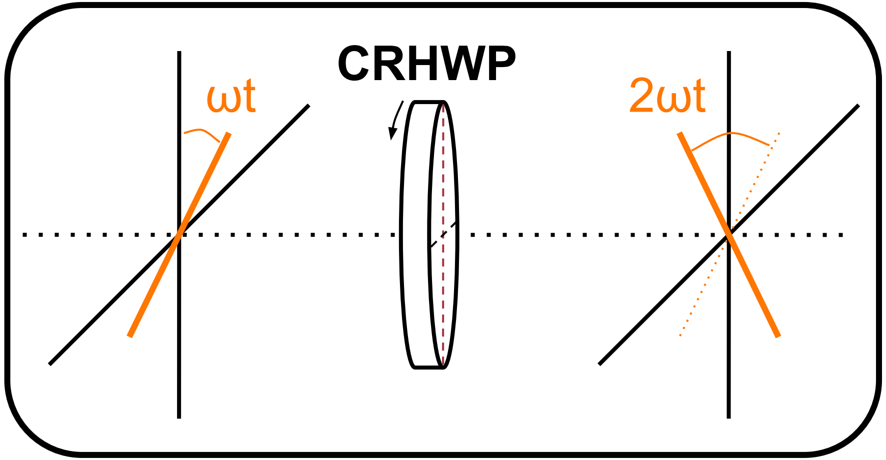
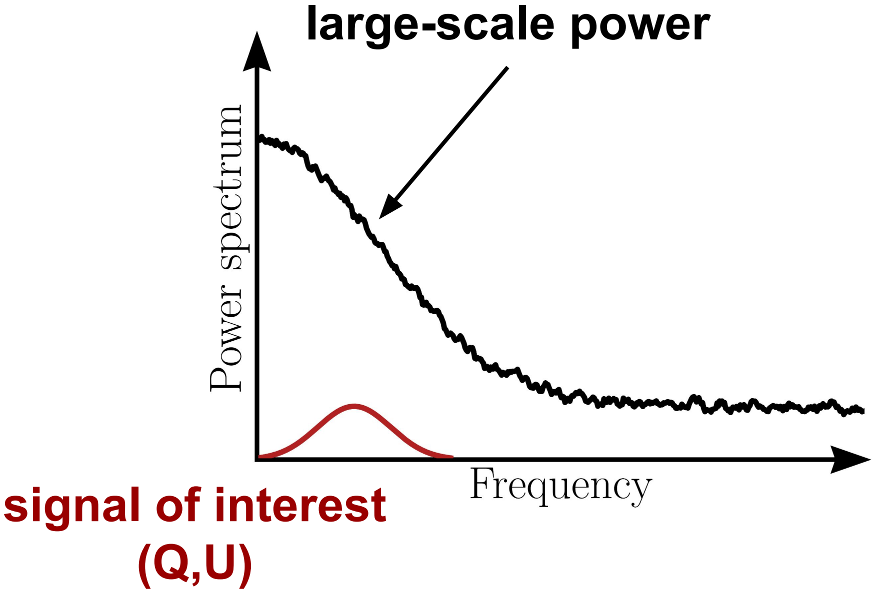


image credit: SO

$$d_{\mathrm{mod}}(t) = I(t) + \epsilon\left[Q(t) + iU(t)\right]e^{-i4\omega_{\mathrm{HWP}}t}$$





Mitigation of atmospheric noise

Yamada et al. [Rev. Sci. Instrum. 95, 024504 (2024)]

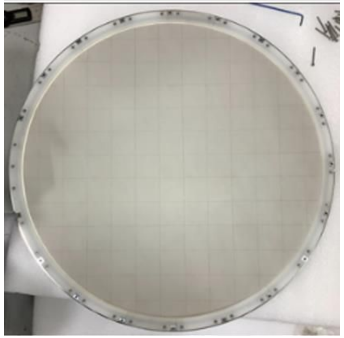
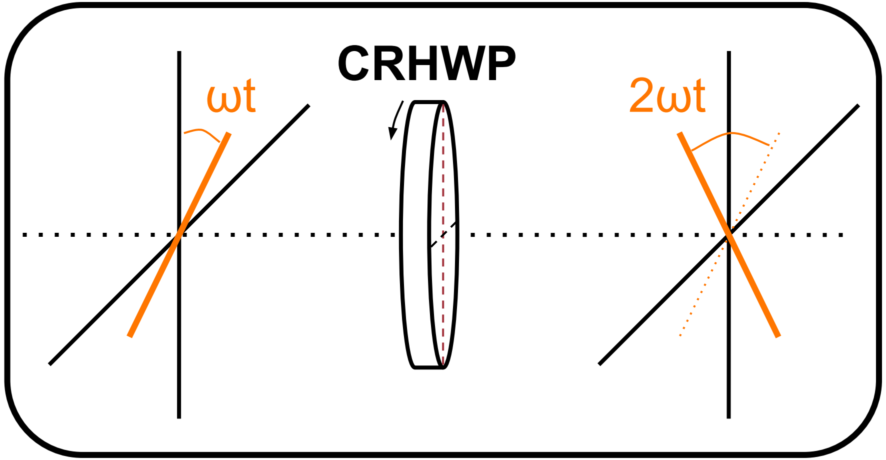
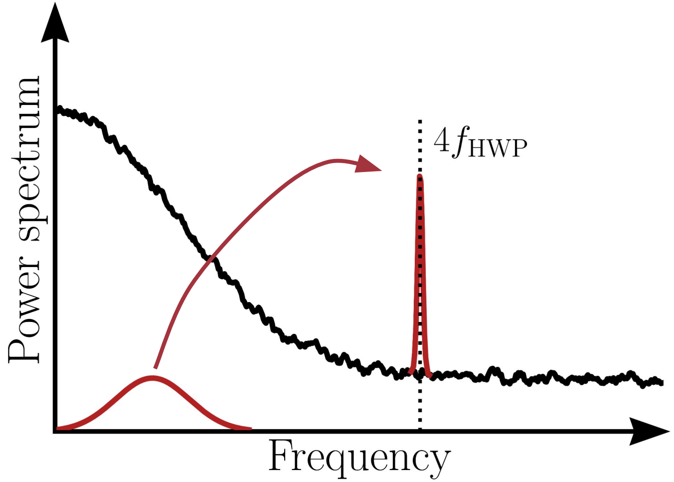


image credit: SO

$$d_{\mathrm{mod}}(t) = I(t) + \epsilon\left[Q(t) + iU(t)\right]e^{-i4\omega_{\mathrm{HWP}}t}$$





modulated above large-scale noise

Mitigation of atmospheric noise

Yamada et al. [Rev. Sci. Instrum. 95, 024504 (2024)]

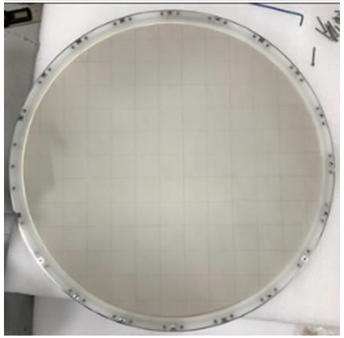
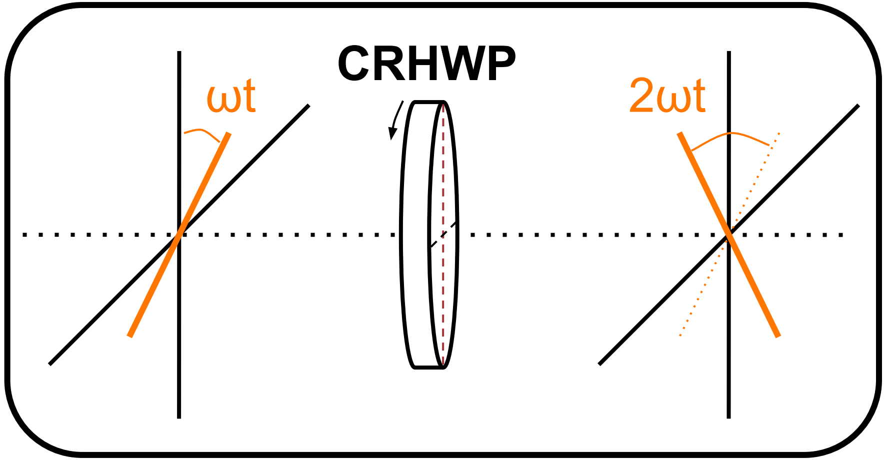


image credit: SO

$$d_{\mathrm{mod}}(t) = I(t) + \epsilon\left[Q(t) + iU(t)\right]e^{-i4\omega_{\mathrm{HWP}}t}$$



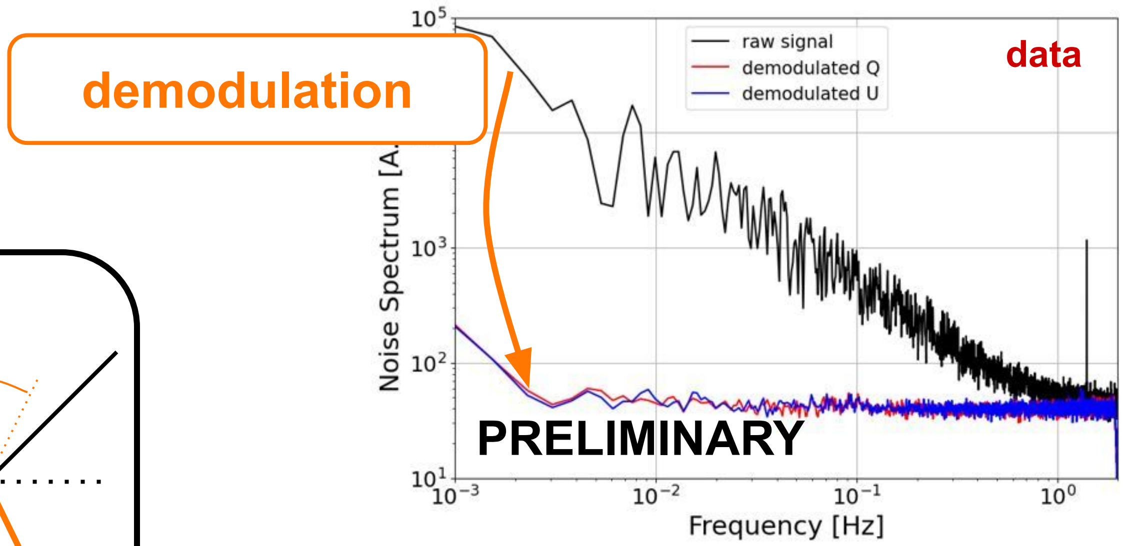
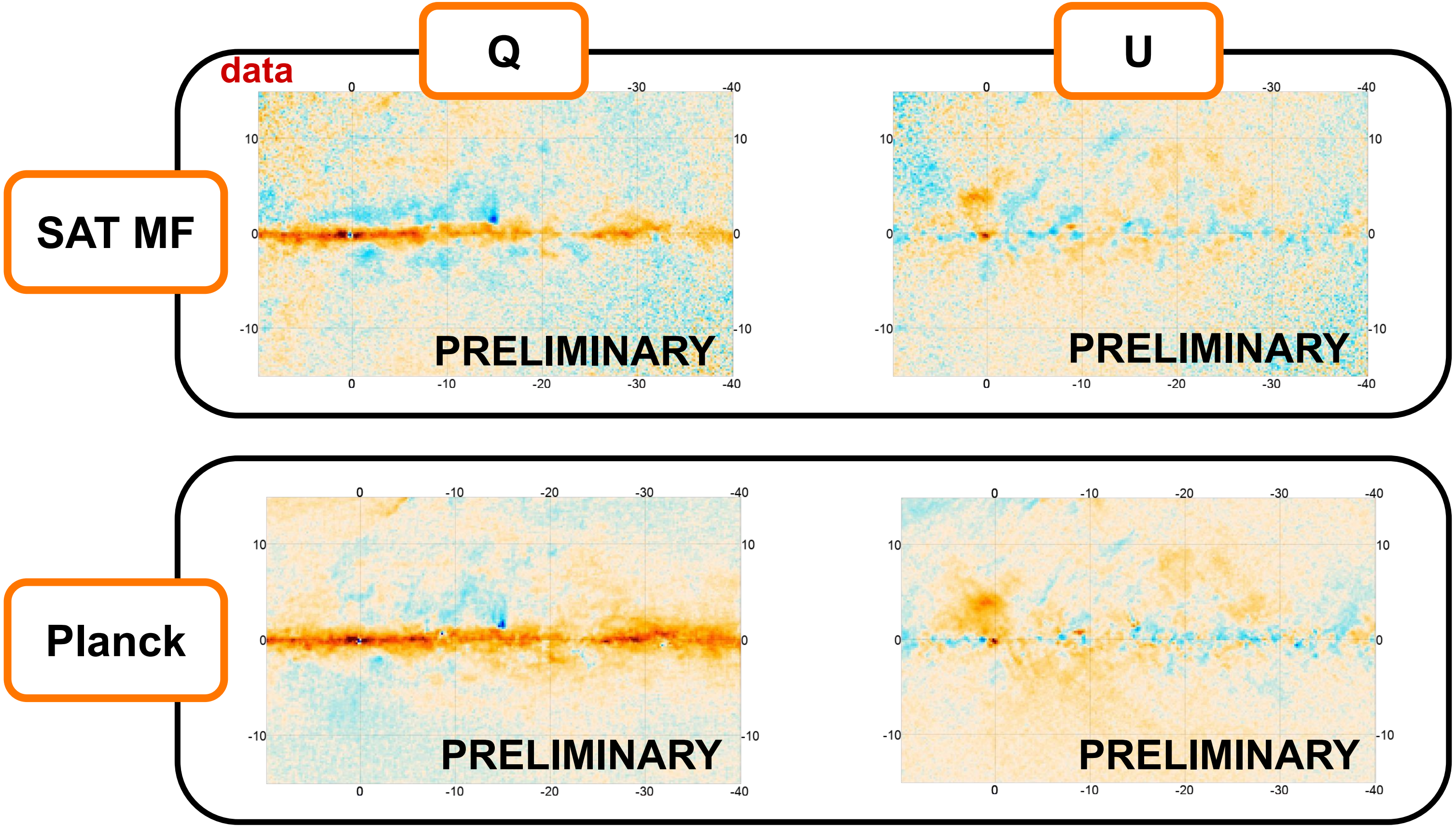


image credit: SO

image credit: SO

SAT-MF Galactic maps

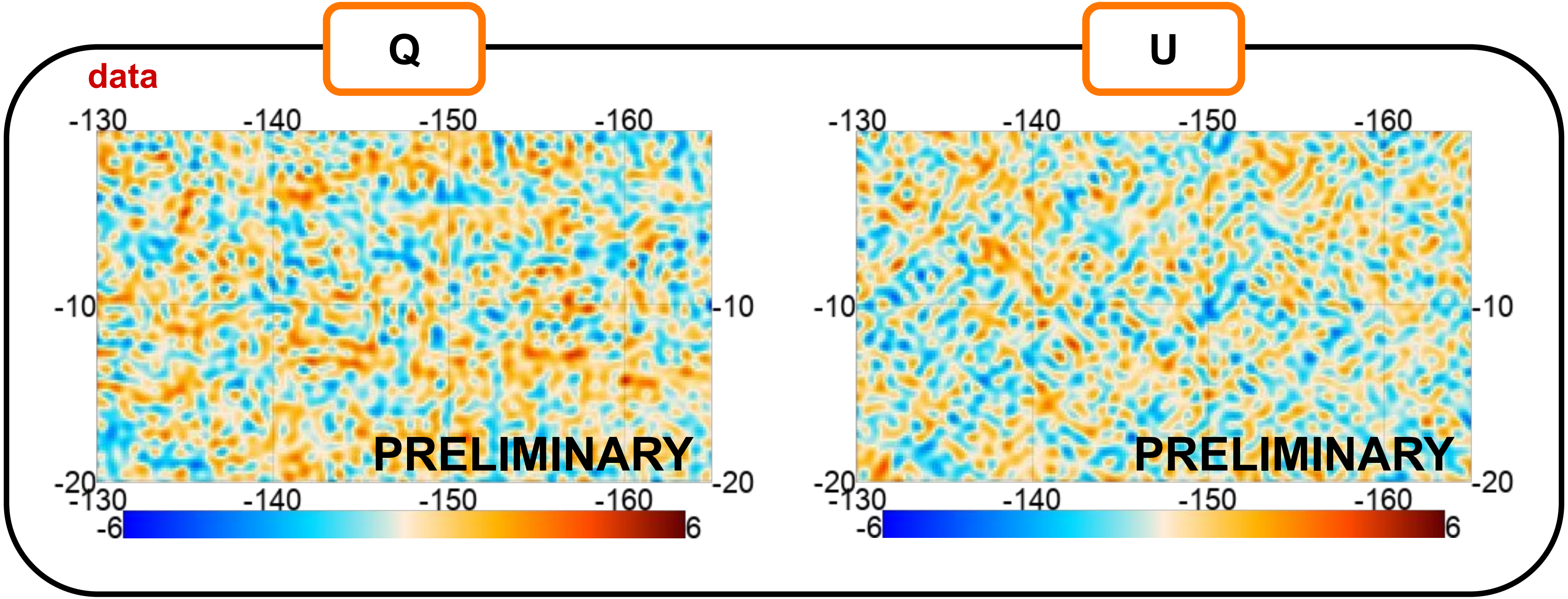
Azzoni et al. (soon)



QU CMB polarization maps

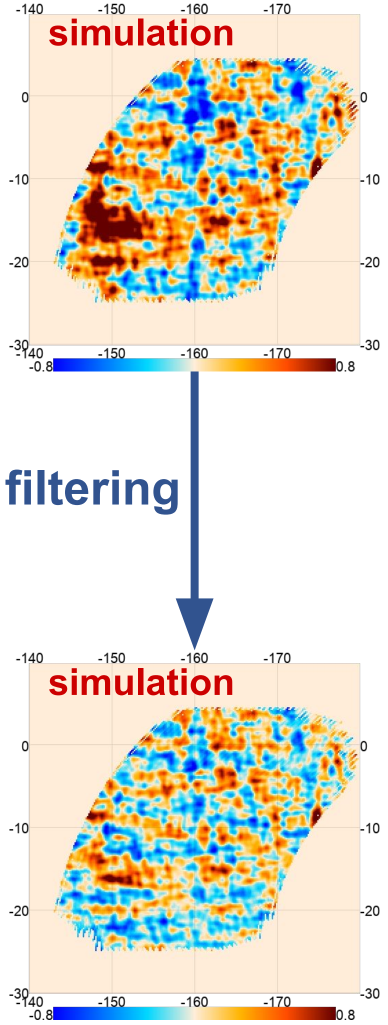
image credit: SO

Azzoni et al. (soon)



Quantifying the effect of filters

Hervias et al. [to come soon]

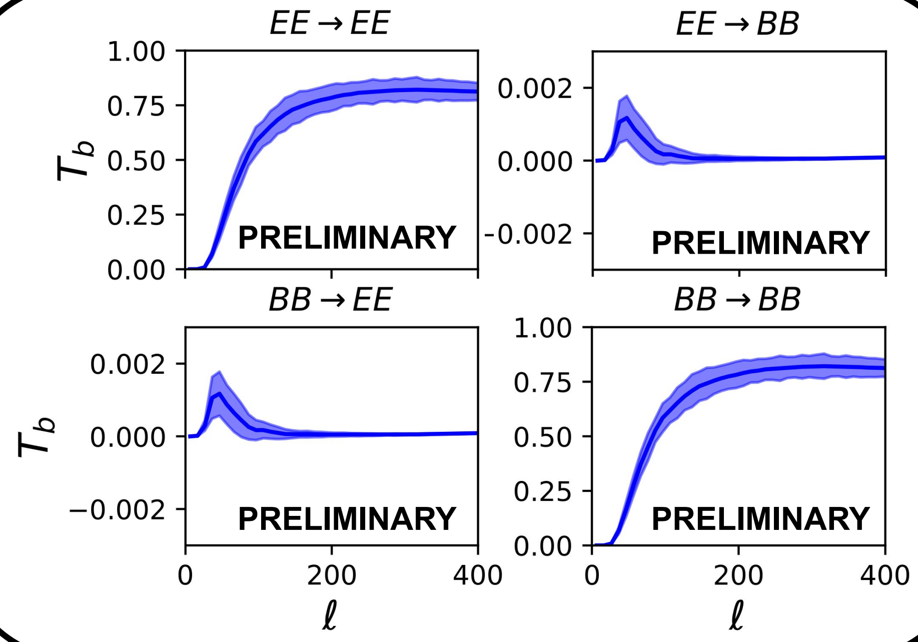


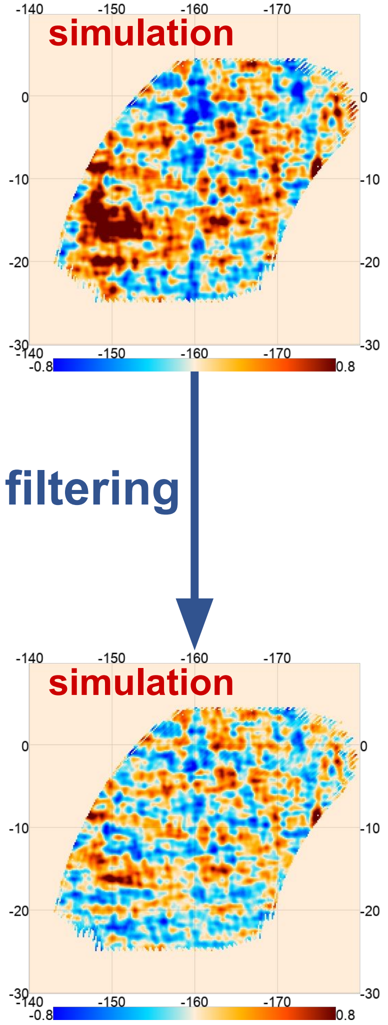
Quantifying the effect of filters

Hervias et al. [to come soon]

simulations with aggressive filtering

$$\tilde{C}_b^{\alpha\beta} = \sum_{\alpha'\beta'} T_b^{\alpha'\beta'\to\alpha\beta} C_b^{\alpha'\beta'}$$

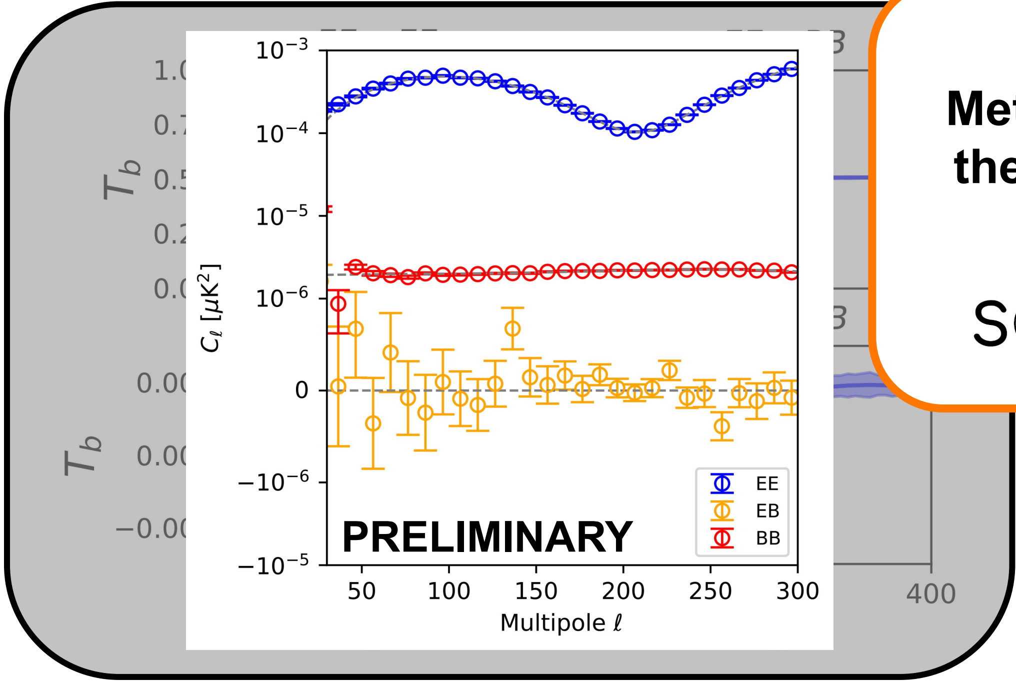




Quantifying the effect of filters

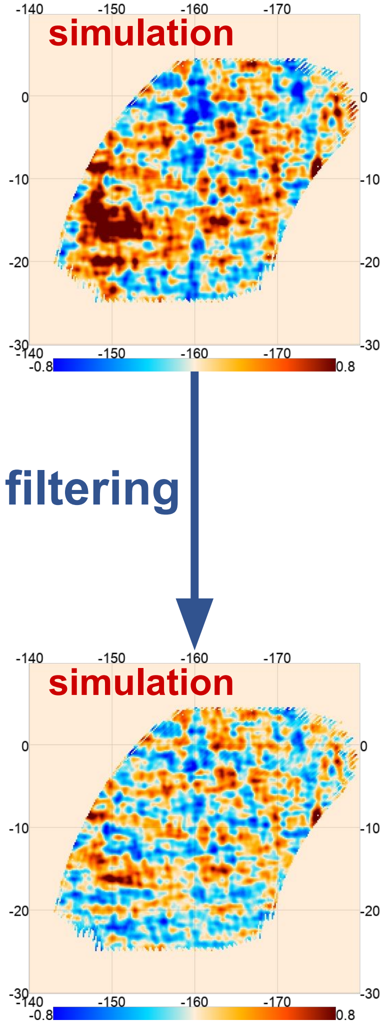
Hervias et al. [to come soon]

Recovering unbiased power spectra



Method integrated in the power spectrum pipeline

SOOPERCOOL

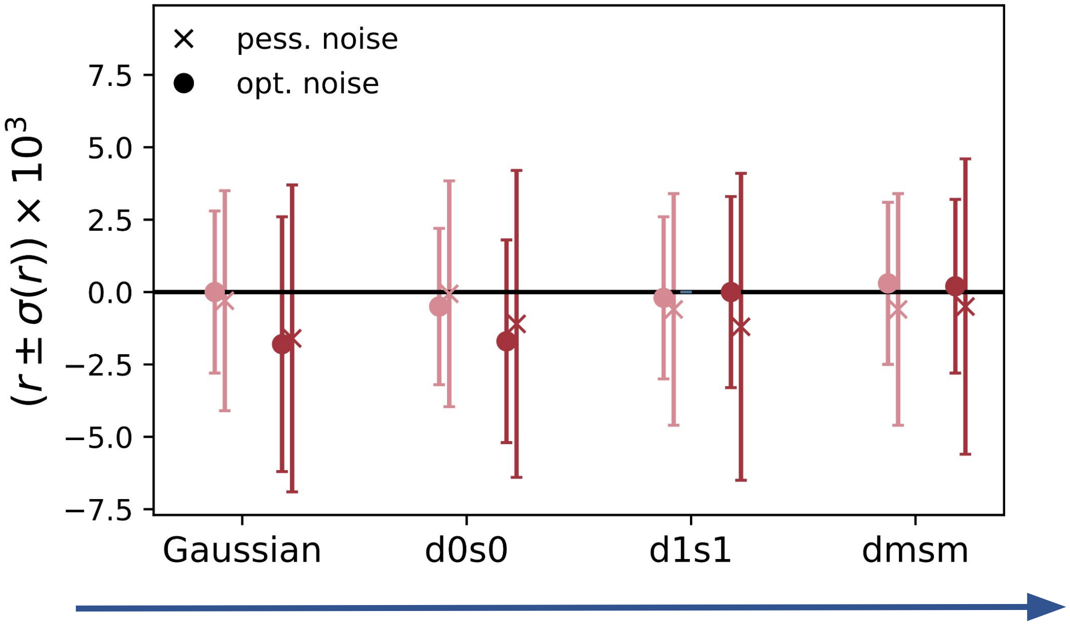


Component separation

Wolz et al. [A&A 686 A16 (2024)]

cross-C_l cleaning (+moments)

parametric map-based (+dust marg.)



increasing foreground complexity

Recover unbiased constraints on tensor-to-scalar ratio

See @Baptiste Jost talk for details about parametric map-based component separation

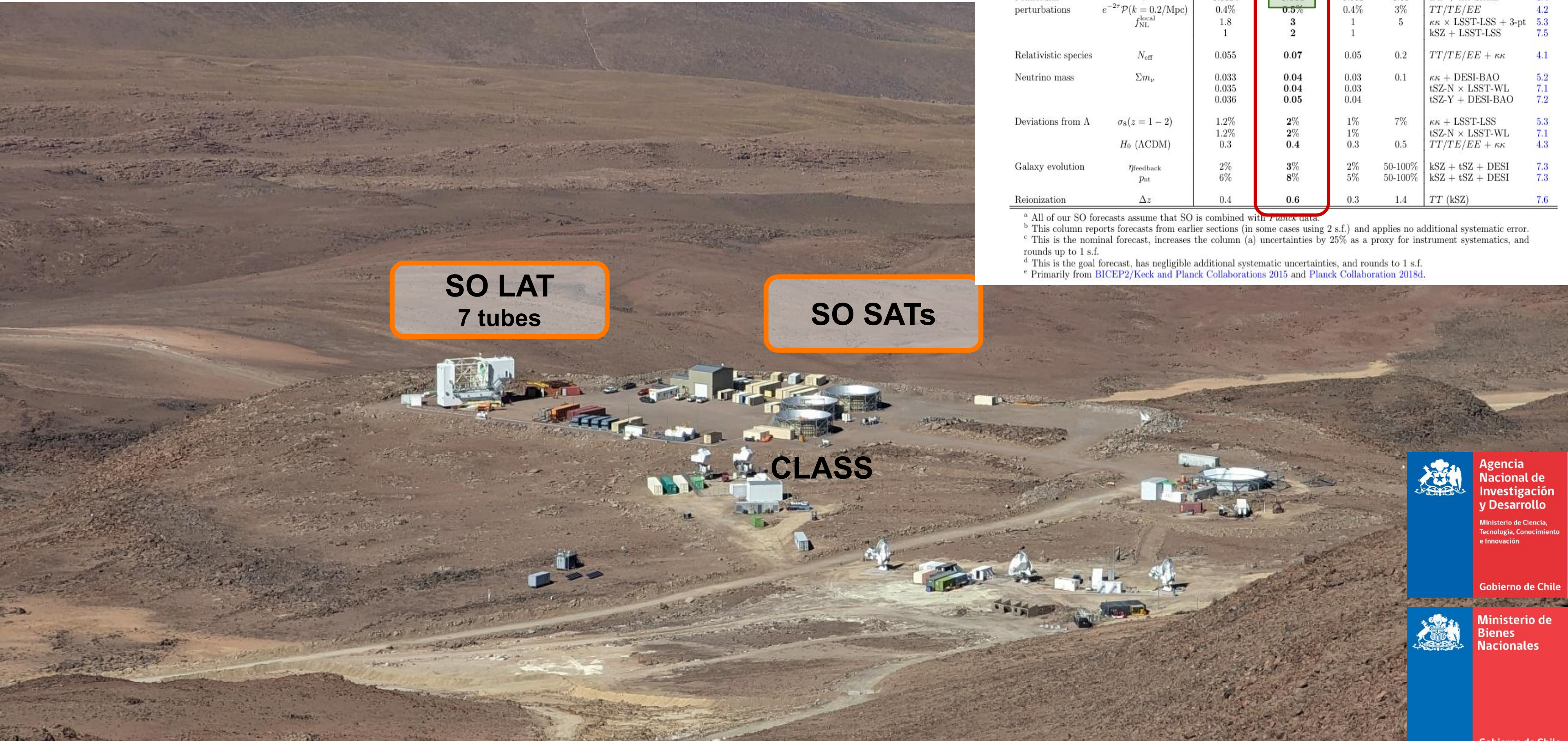
The future of Simons Observatory

SO Science Goals 47

Table 9
Summary of SO key science goals[a]

	Parameter	SO-Baseline[b] (no syst)	**SO-Baseline**[c]	SO-Goal[d]	Current[e]	Method	Sec.
Primordial perturbations	r	0.0024	**0.003**	0.002	0.03	BB + ext delens	3.4
	$e^{-2\tau}\mathcal{P}(k=0.2/\mathrm{Mpc})$	0.4%	**0.5%**	0.4%	3%	$TT/TE/EE$	4.2
	$f_{\mathrm{NL}}^{\mathrm{local}}$	1.8	**3**	1	5	$\kappa\kappa$ × LSST-LSS + 3-pt	5.3
		1	**2**	1		kSZ + LSST-LSS	7.5
Relativistic species	N_{eff}	0.055	**0.07**	0.05	0.2	$TT/TE/EE + \kappa\kappa$	4.1
Neutrino mass	Σm_ν	0.033	**0.04**	0.03	0.1	$\kappa\kappa$ + DESI-BAO	5.2
		0.035	**0.04**	0.03		tSZ-N × LSST-WL	7.1
		0.036	**0.05**	0.04		tSZ-Y + DESI-BAO	7.2
Deviations from Λ	$\sigma_8(z=1-2)$	1.2%	**2%**	1%	7%	$\kappa\kappa$ + LSST-LSS	5.3
		1.2%	**2%**	1%		tSZ-N × LSST-WL	7.1
	H_0 (ΛCDM)	0.3	**0.4**	0.3	0.5	$TT/TE/EE + \kappa\kappa$	4.3
Galaxy evolution	η_{feedback}	2%	**3%**	2%	50-100%	kSZ + tSZ + DESI	7.3
	p_{nt}	6%	**8%**	5%	50-100%	kSZ + tSZ + DESI	7.3
Reionization	Δz	0.4	**0.6**	0.3	1.4	TT (kSZ)	7.6

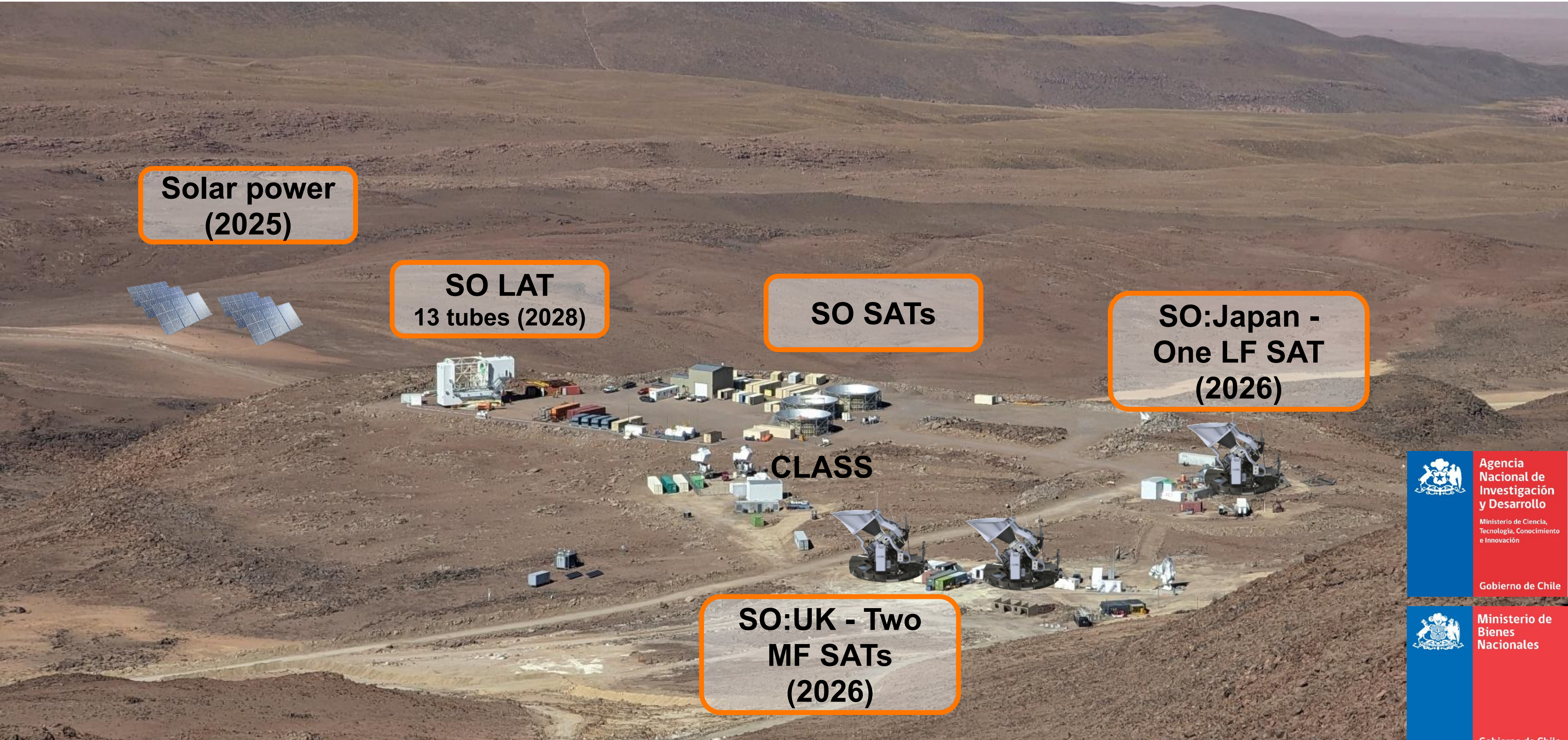
[a] All of our SO forecasts assume that SO is combined with *Planck* data.
[b] This column reports forecasts from earlier sections (in some cases using 2 s.f.) and applies no additional systematic error.
[c] This is the nominal forecast, increases the column (a) uncertainties by 25% as a proxy for instrument systematics, and rounds up to 1 s.f.
[d] This is the goal forecast, has negligible additional systematic uncertainties, and rounds to 1 s.f.
[e] Primarily from BICEP2/Keck and Planck Collaborations 2015 and Planck Collaboration 2018d.



Agencia Nacional de Investigación y Desarrollo
Ministerio de Ciencia, Tecnología, Conocimiento e Innovación
Gobierno de Chile

Ministerio de Bienes Nacionales

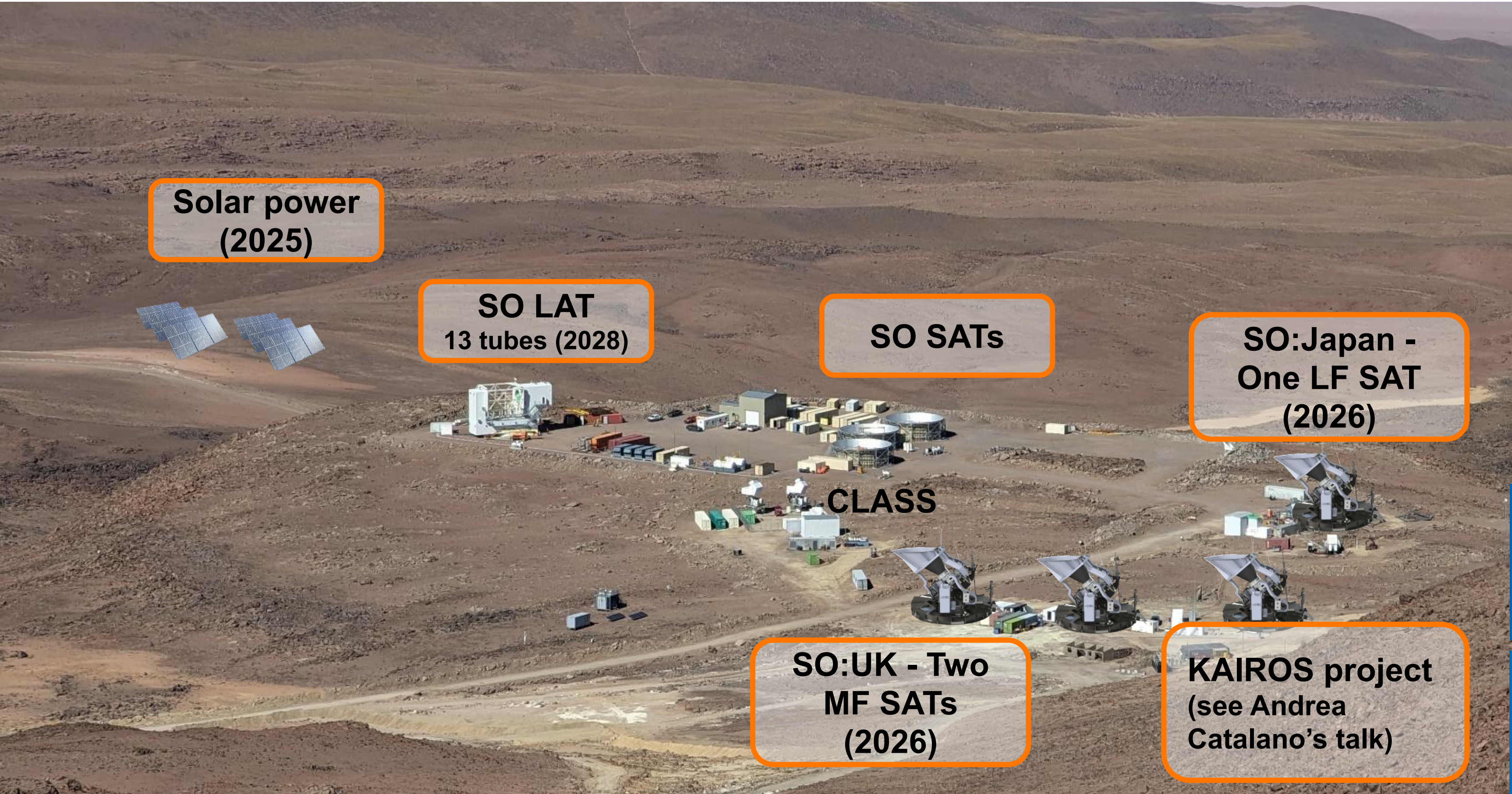
The future of Simons Observatory



Agencia Nacional de Investigación y Desarrollo
Ministerio de Ciencia, Tecnología, Conocimiento e Innovación
Gobierno de Chile

Ministerio de Bienes Nacionales

The future of Simons Observatory



Agencia Nacional de Investigación y Desarrollo
Ministerio de Ciencia, Tecnología, Conocimiento e Innovación
Gobierno de Chile

Ministerio de Bienes Nacionales