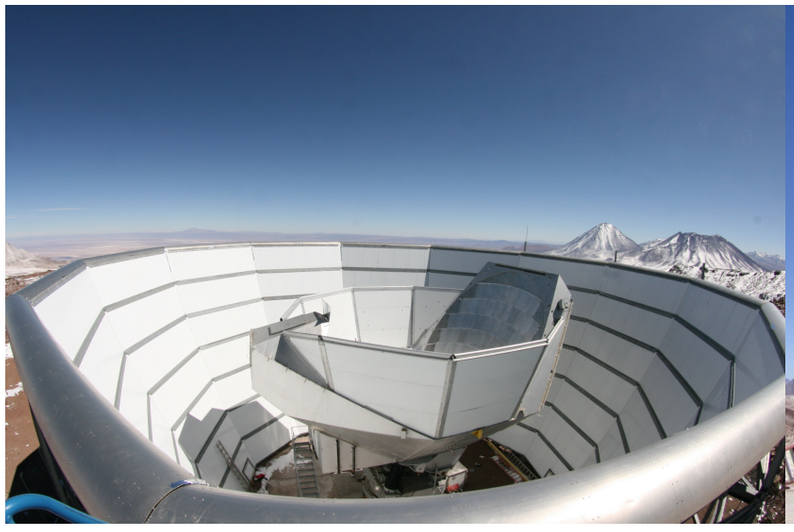
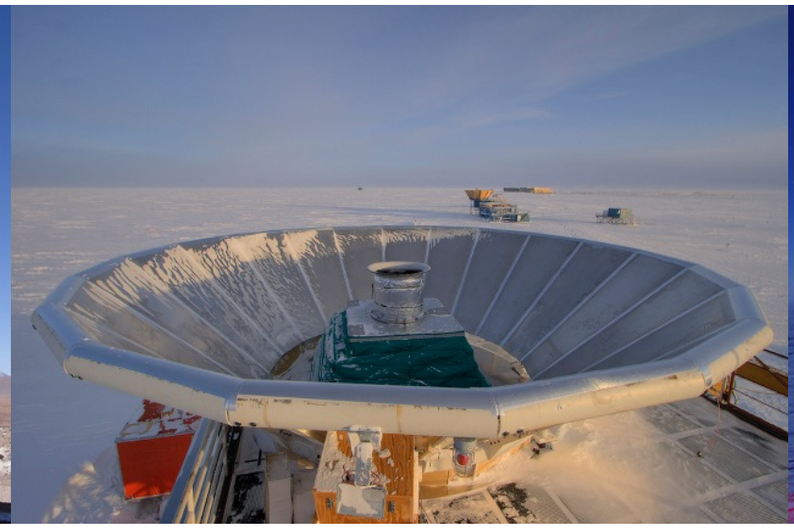
CMB Stage-4

The next generation of ground based CMB experiments



ACTPol

Polarbear



BICEP2

SPTpol

UNIVERSITÉ PARIS SUD

Thibaut Louis

LABORATOIRE DE L'ACCÉLÉRATEUR LINÉAIRE

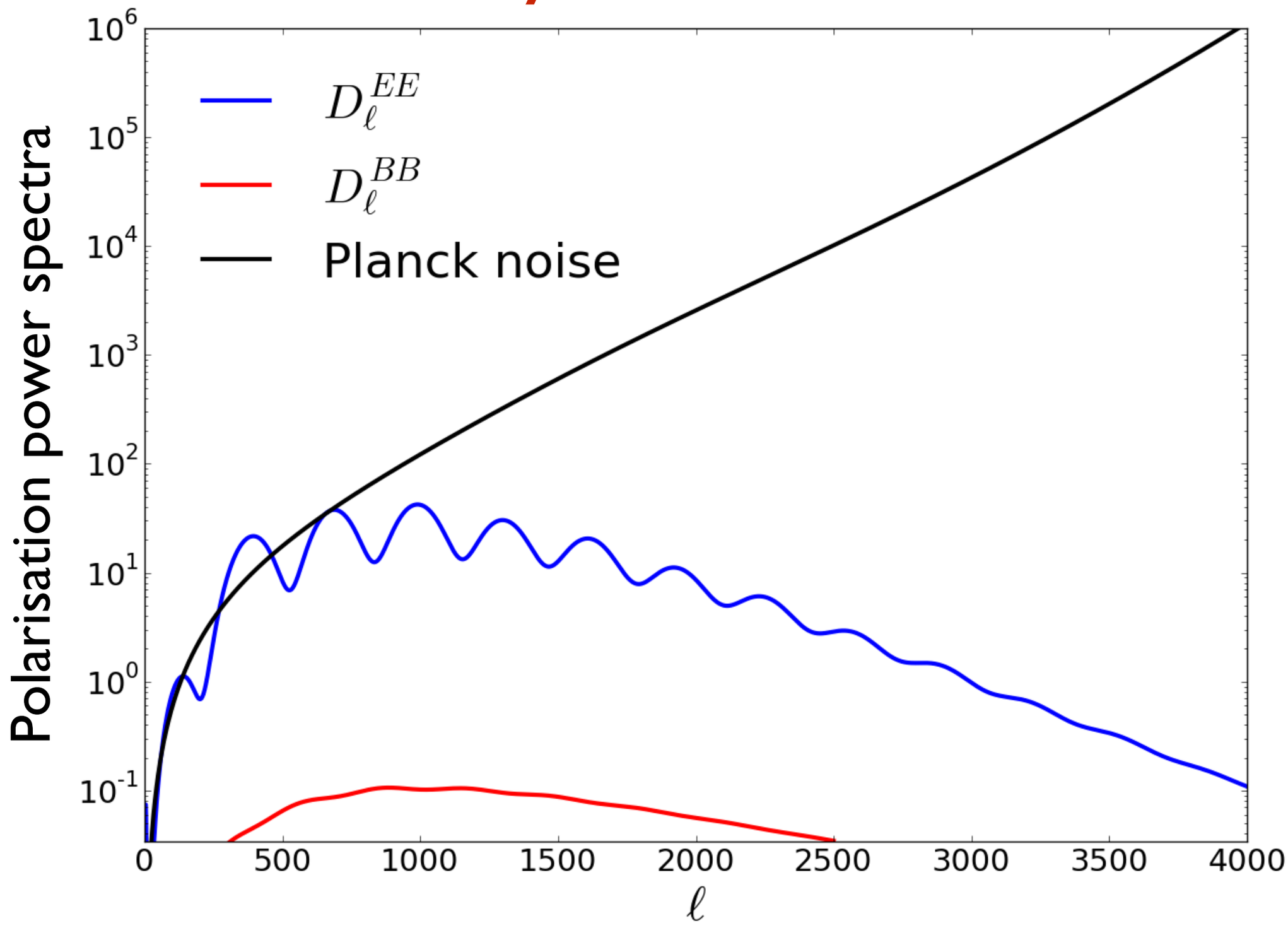
Planck has mapped most of the information in the CMB temperature anisotropies on large and intermediate angular scales

Planck has mapped most of the information in the CMB temperature anisotropies on large and intermediate angular scales

But: most of the information in CMB Polarisation is still yet to be measured

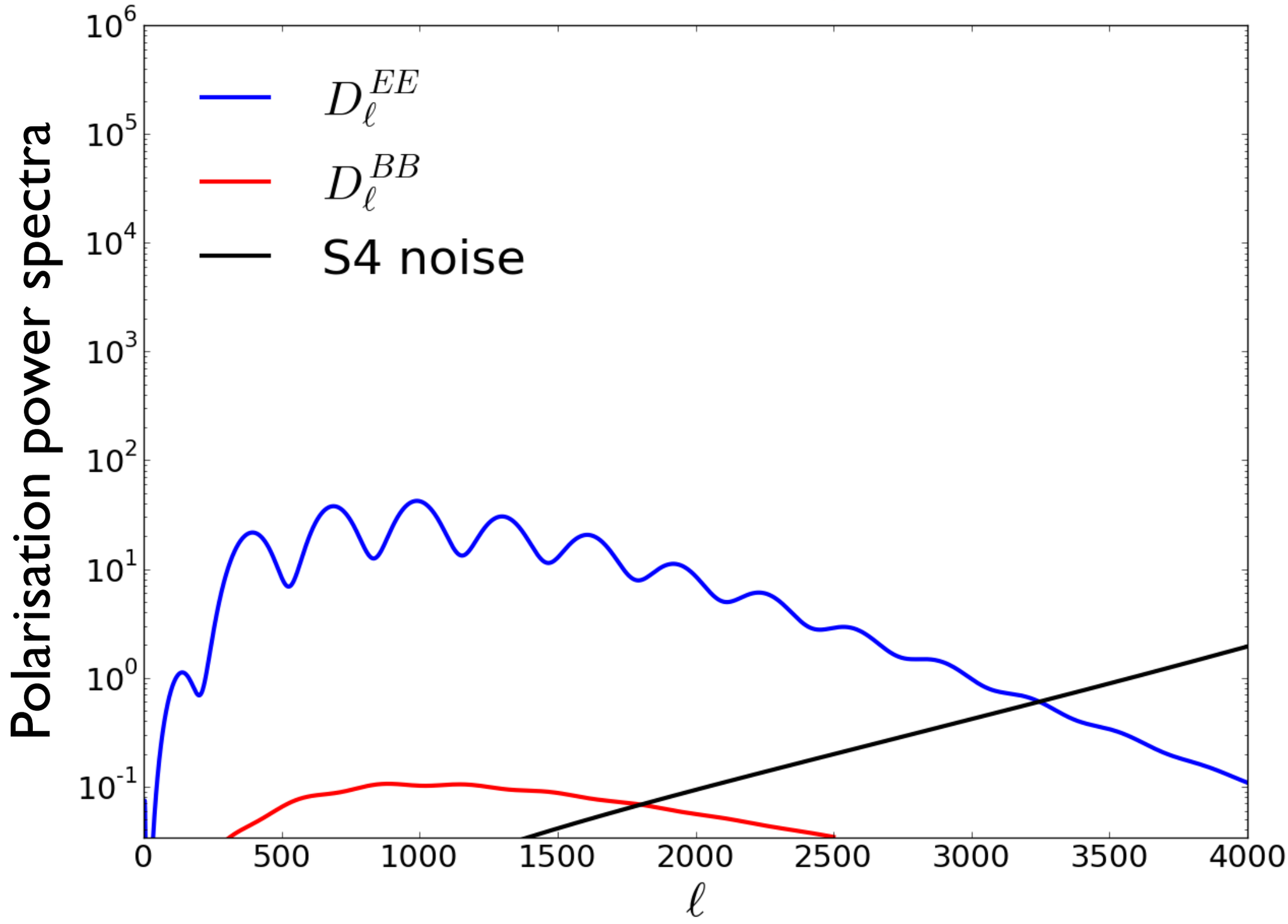
Planck has mapped most of the information in the CMB temperature anisotropies on large and intermediate angular scales

But: most of the information in CMB Polarisation is still yet to be measured

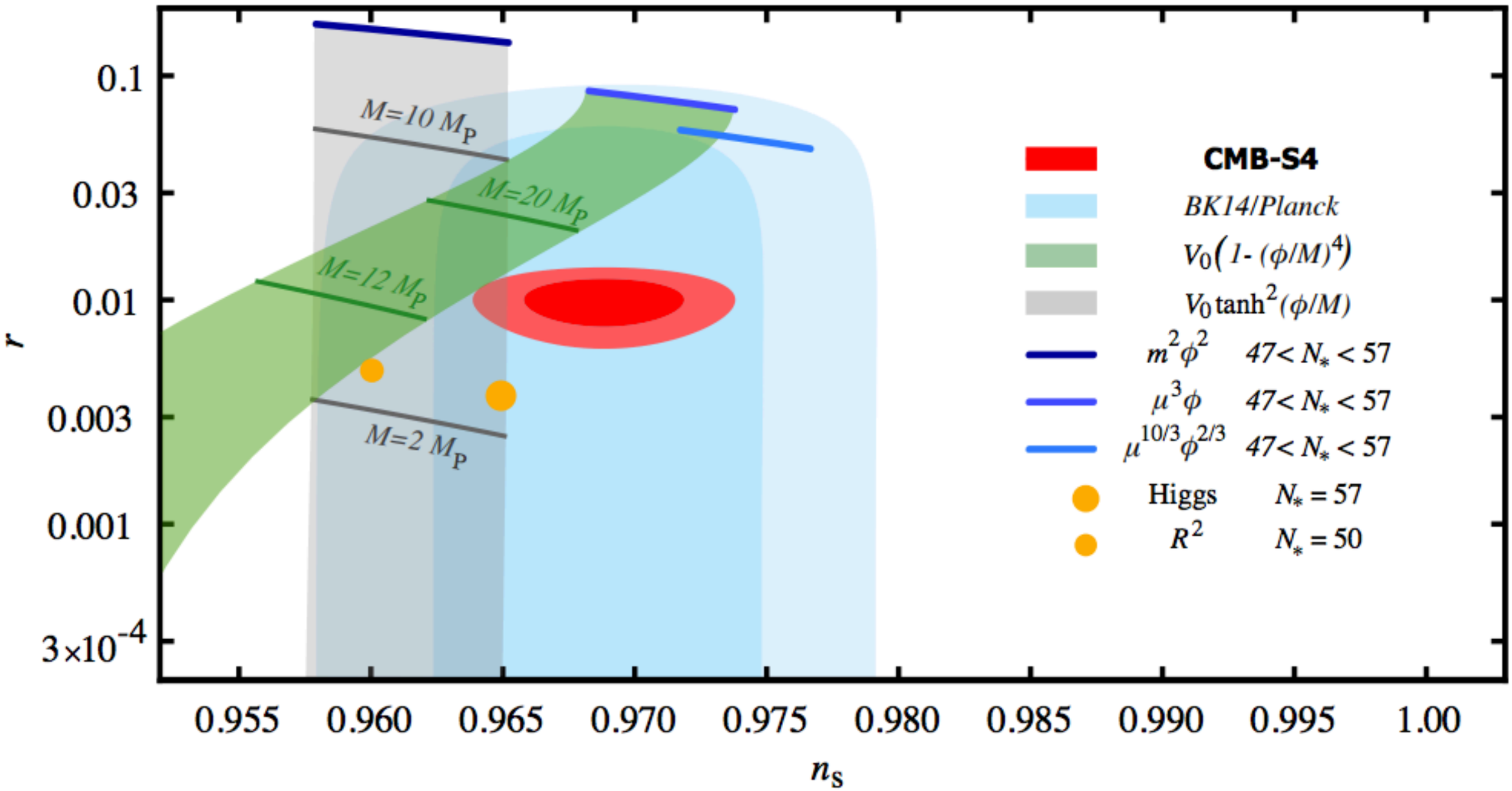


Planck has mapped most of the information in the CMB temperature anisotropies on large and intermediate angular scales

CMB S4 claim to be able to improve this by orders of magnitude !

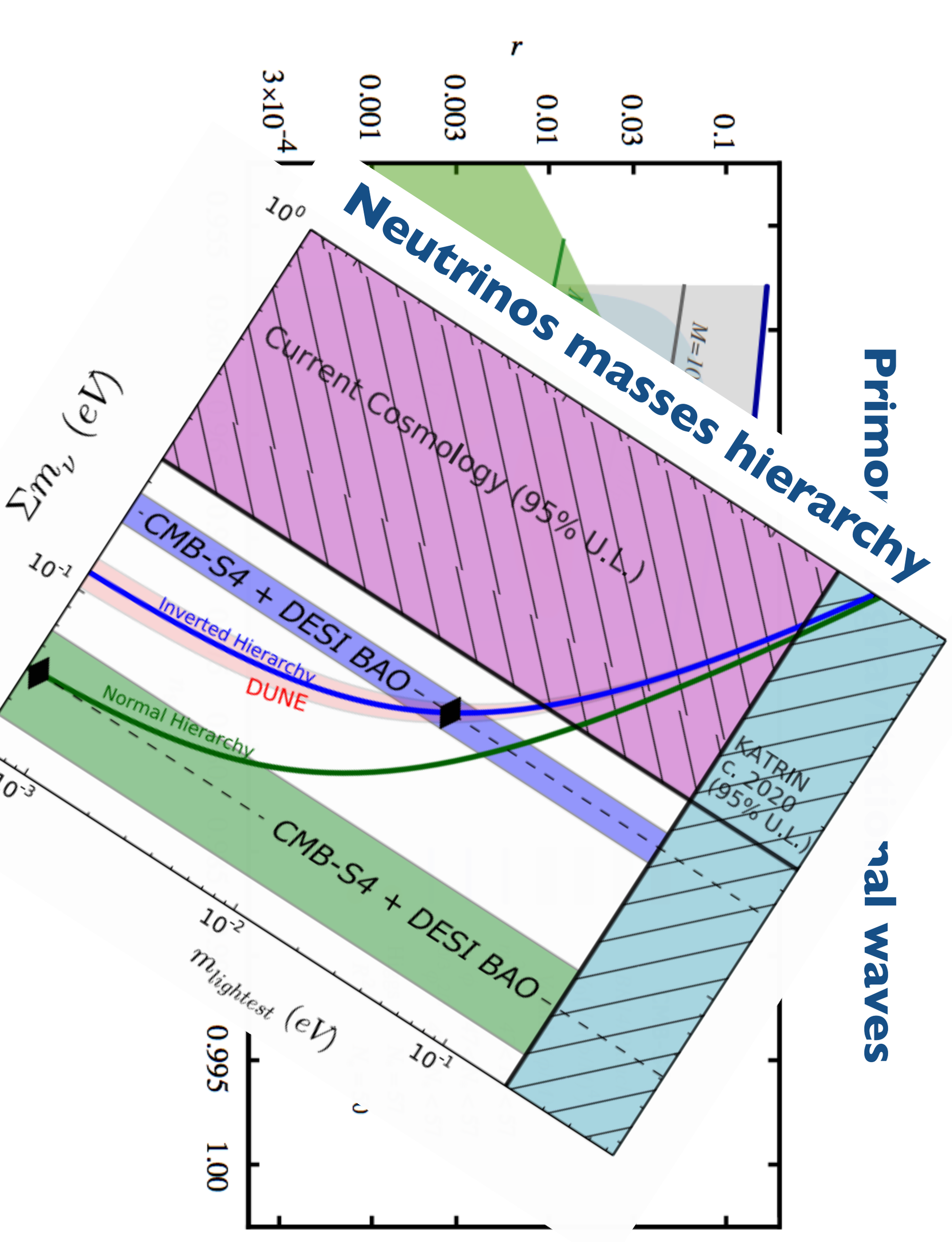


Primordial gravitational waves

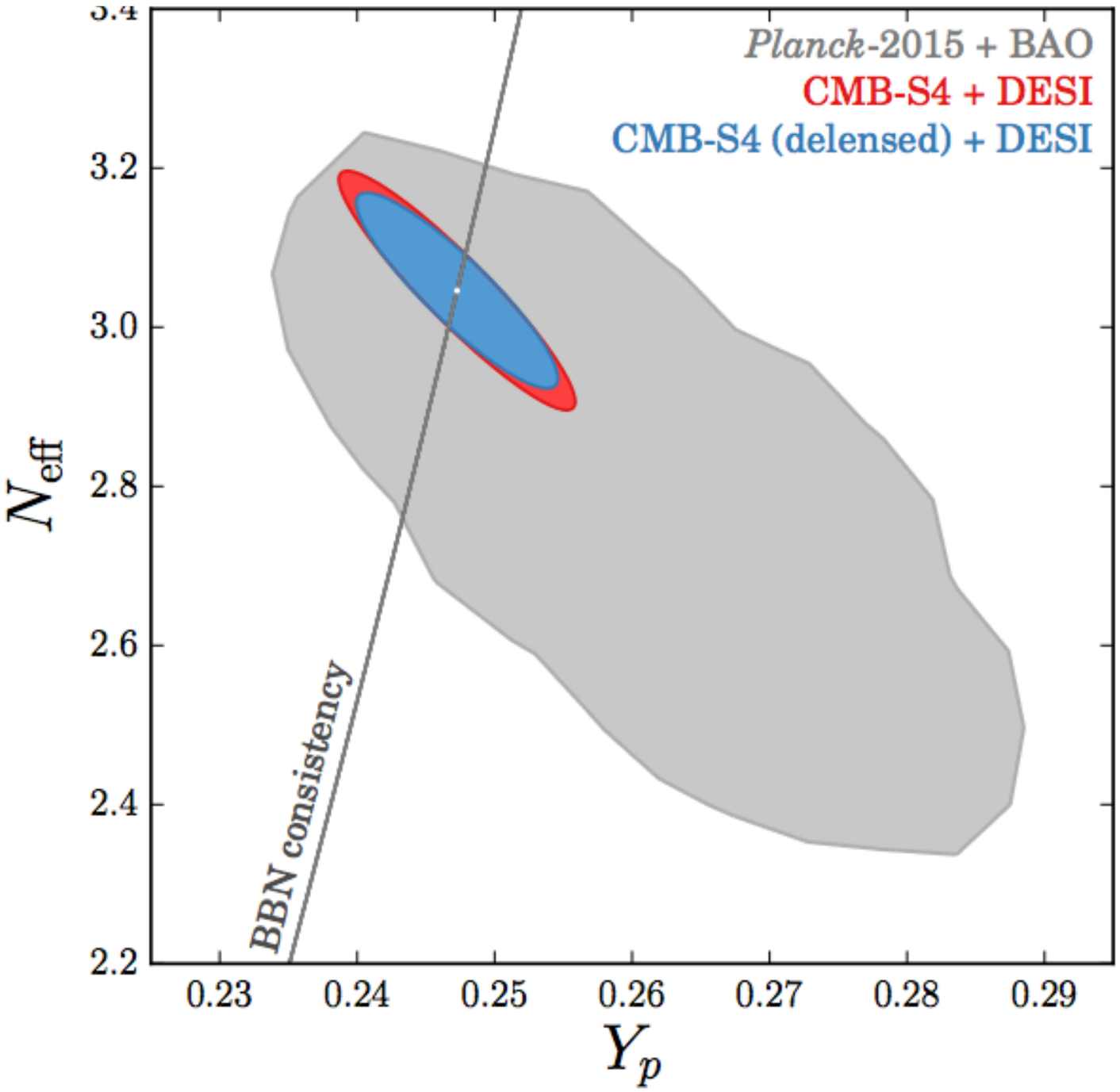


Neutrinos masses hierarchy

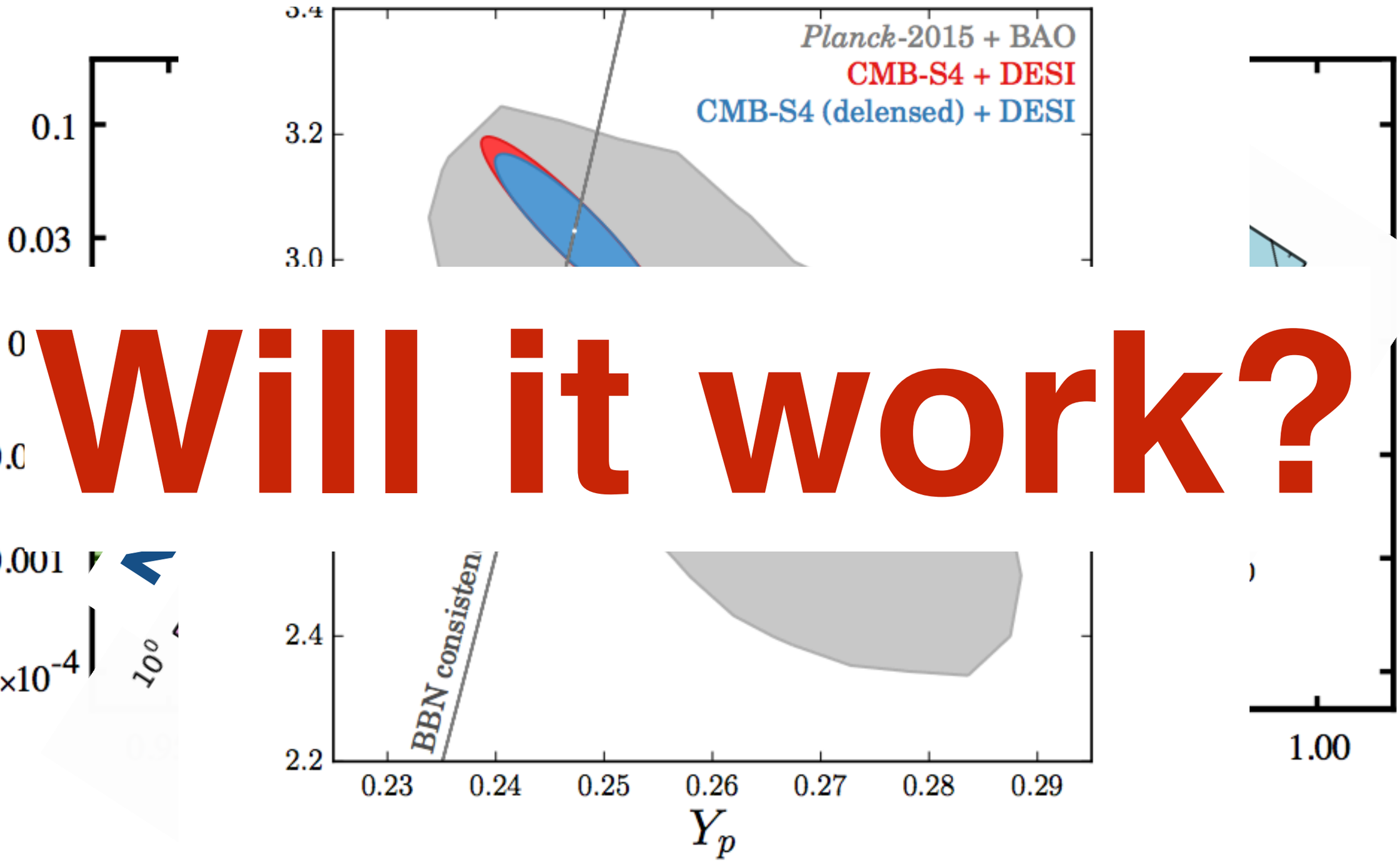
Primordial waves



Beyond SM of particles physics



Beyond SM of particles physics



Will it work?

Source of the claim

	Planck	CMB S4
Number of detectors	~70	few 100 000
Number of telescopes	1	few tens
Mirror size	1.5 m	from 50 cm to 6m

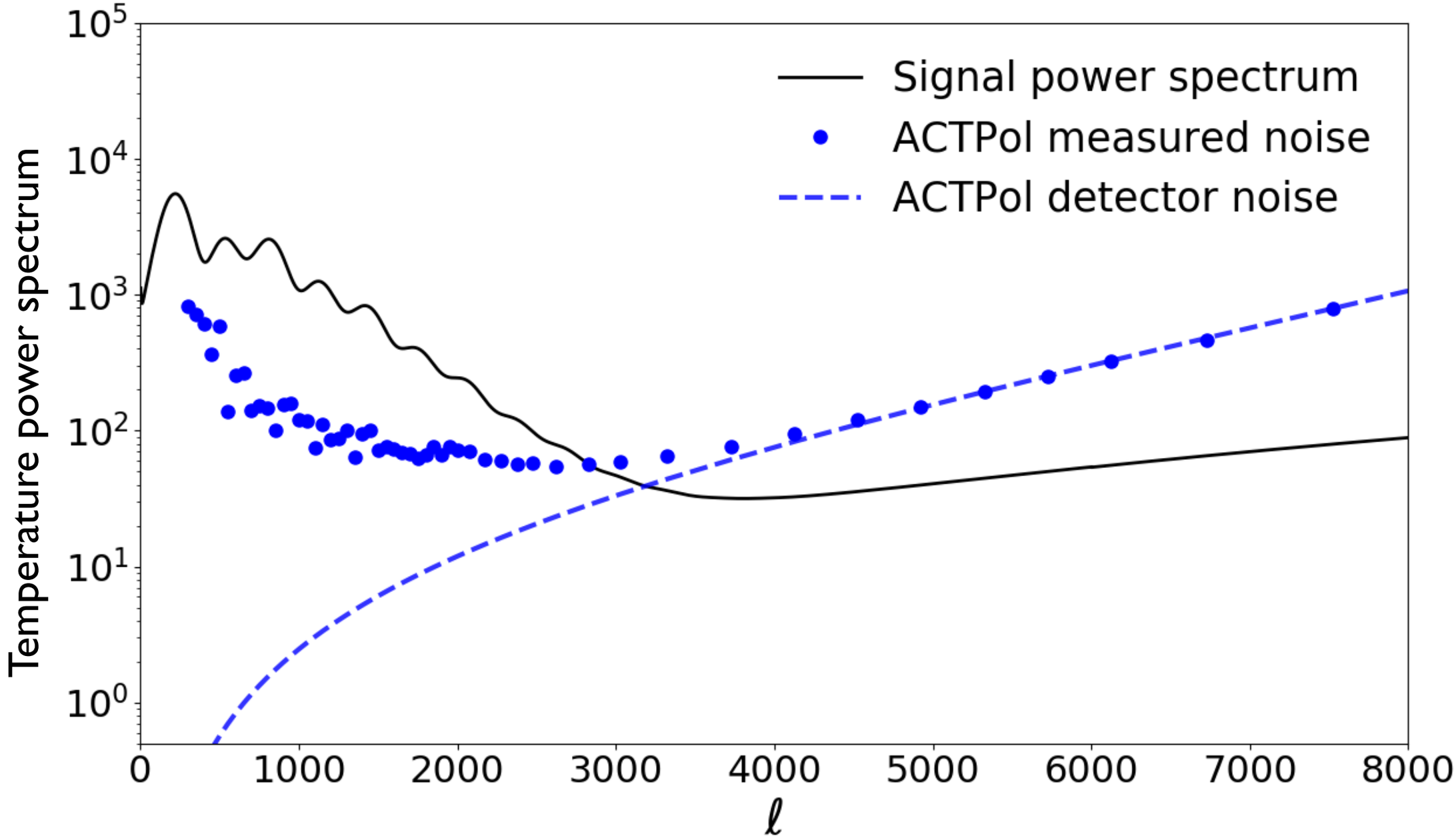
Important on-going effort to consolidate these numbers

Skepticism 1: How to deal with atmosphere?

Largest foreground emission in temperature in the mm bands
Non stationary
Dominant source of noise in large and intermediate angular scales

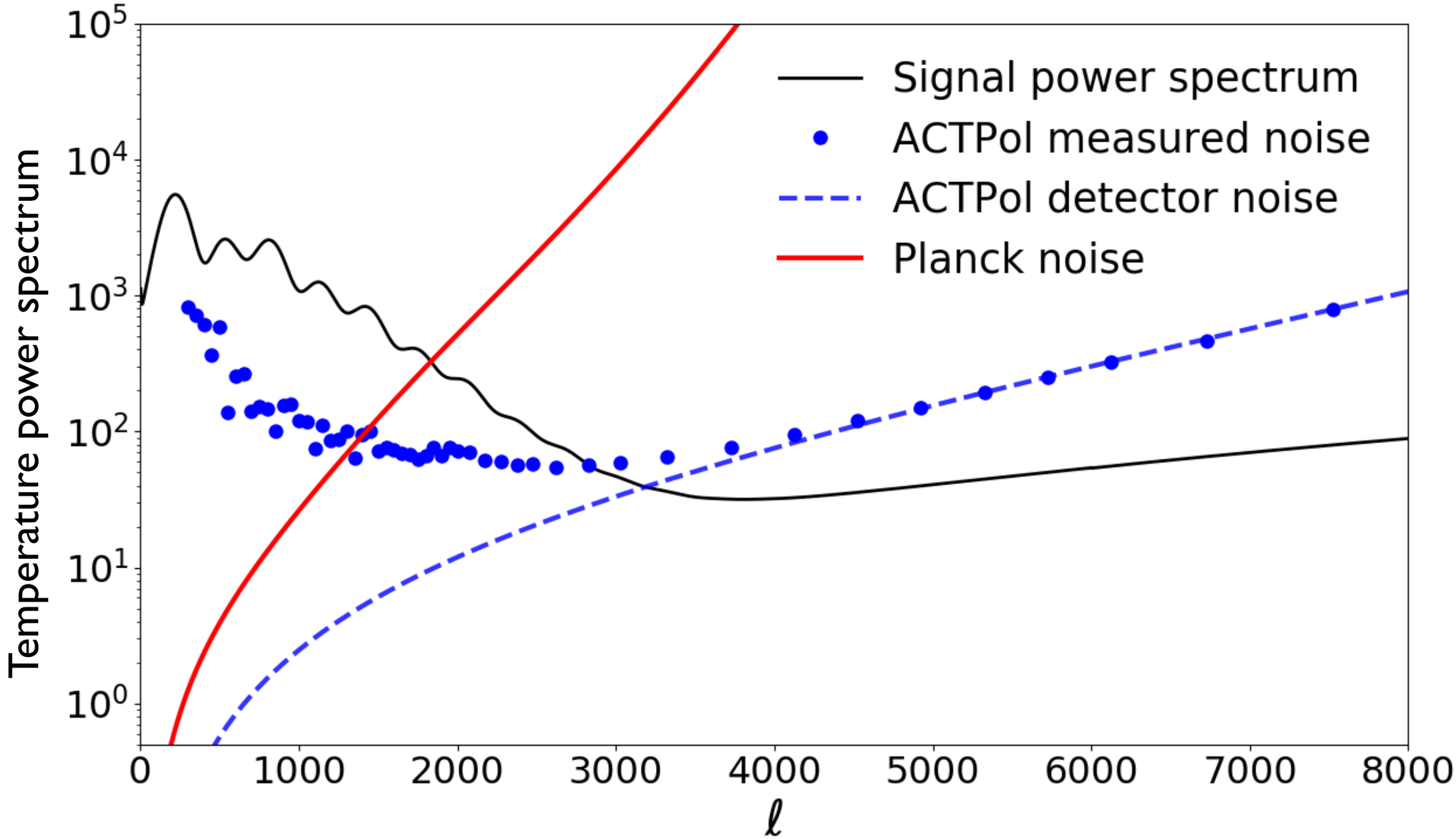
Skepticism 1: How to deal with atmosphere?

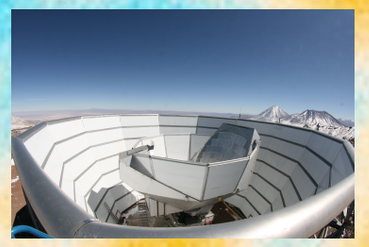
Largest foreground emission in temperature in the mm bands
Non stationary
Dominant source of noise in large and intermediate angular scales



Skepticism 1: How to deal with atmosphere?

Largest foreground emission in temperature in the mm bands
Non stationary
Dominant source of noise in large and intermediate angular scales





How does the atmosphere look in Polarisation?

The atmosphere is very poorly polarized

How does the atmosphere look in Polarisation?

The atmosphere is very poorly polarized

But: instrumental systematic can lead to leakage of temperature atmospheric noise into PoI.

How big is this effect ?

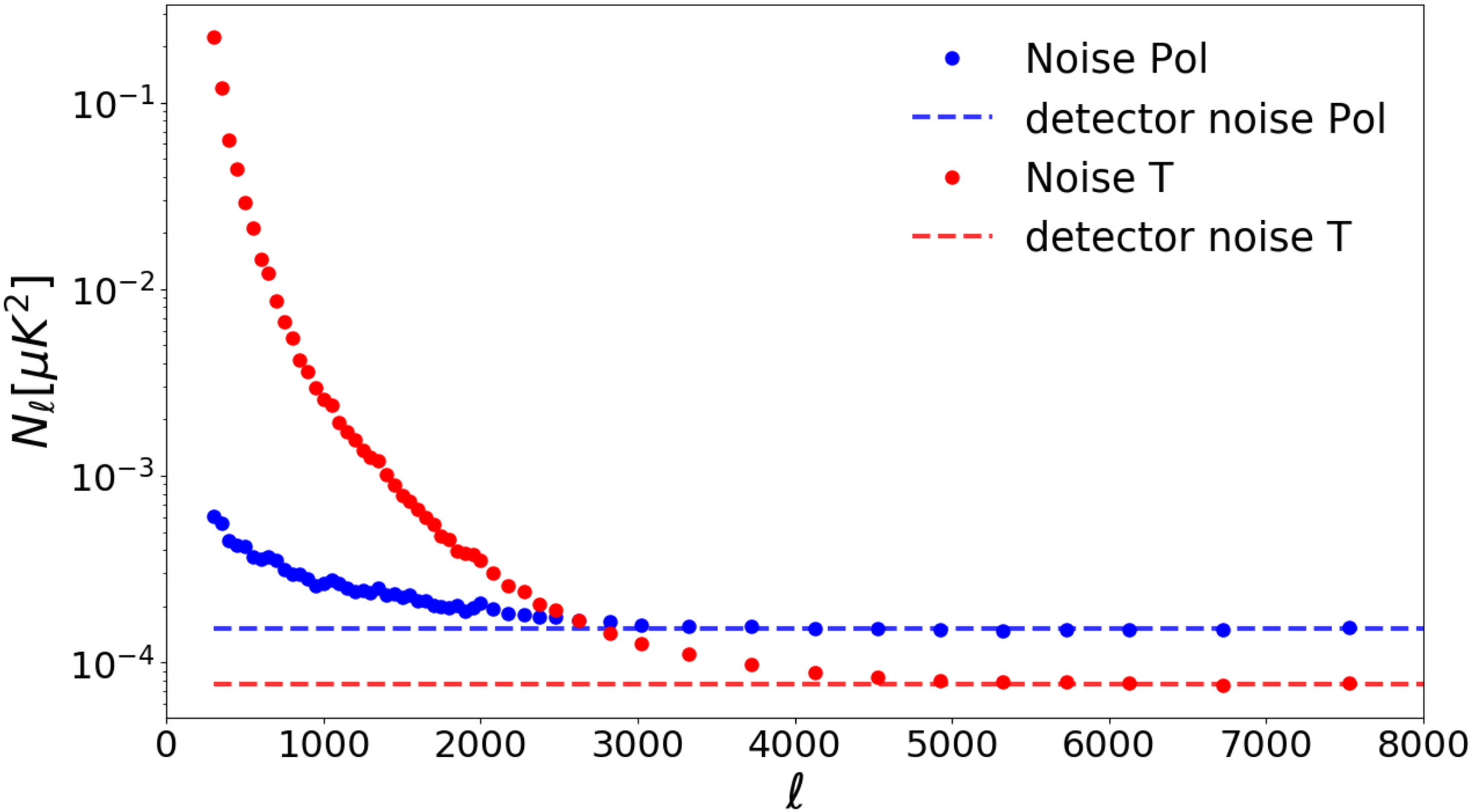
How does the atmosphere look in Polarisation?

The atmosphere is very poorly polarized

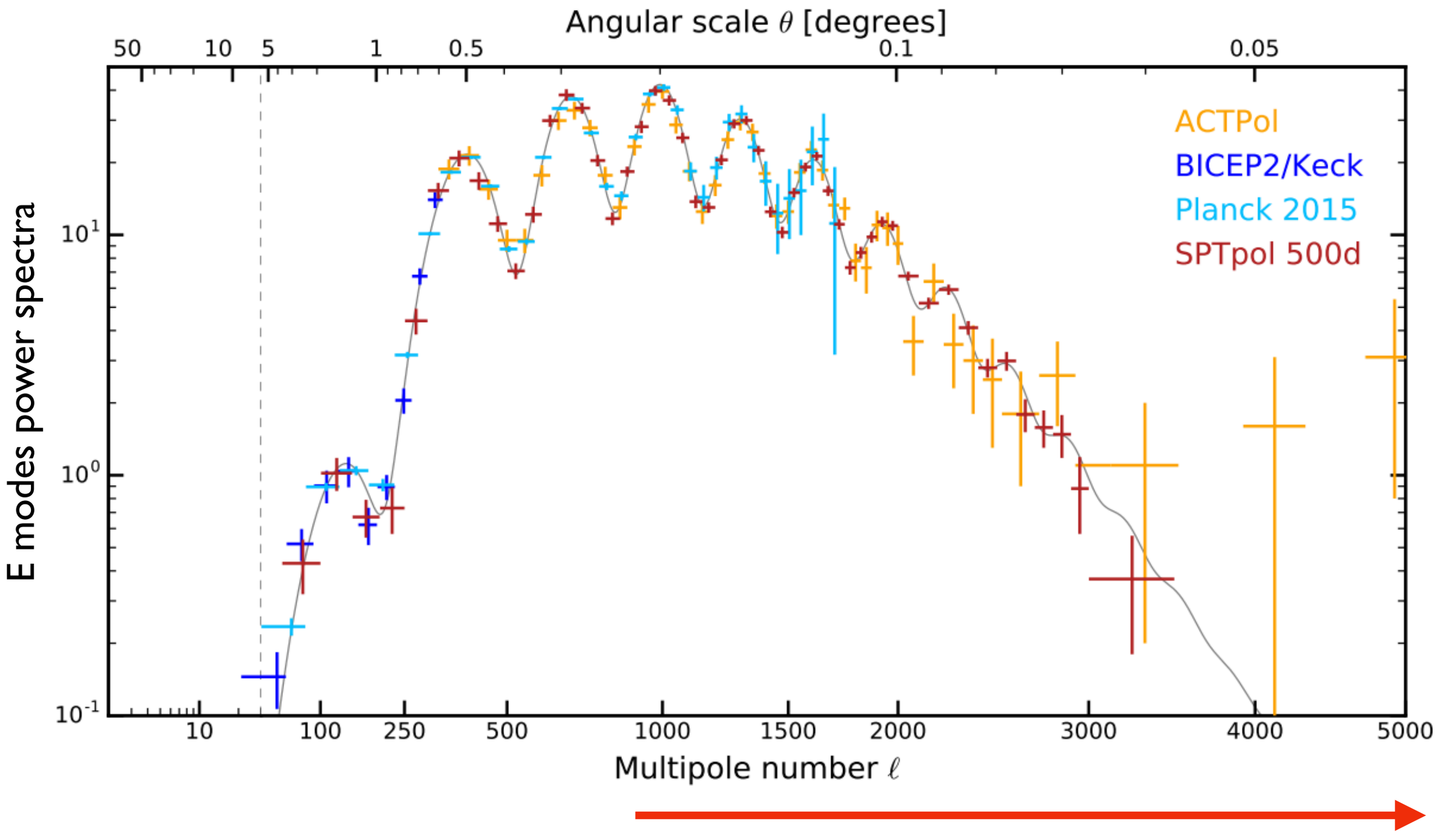
But: instrumental systematic can lead to leakage of temperature atmospheric noise into Pol.

How big is this effect ?

ACTPol



Implication I

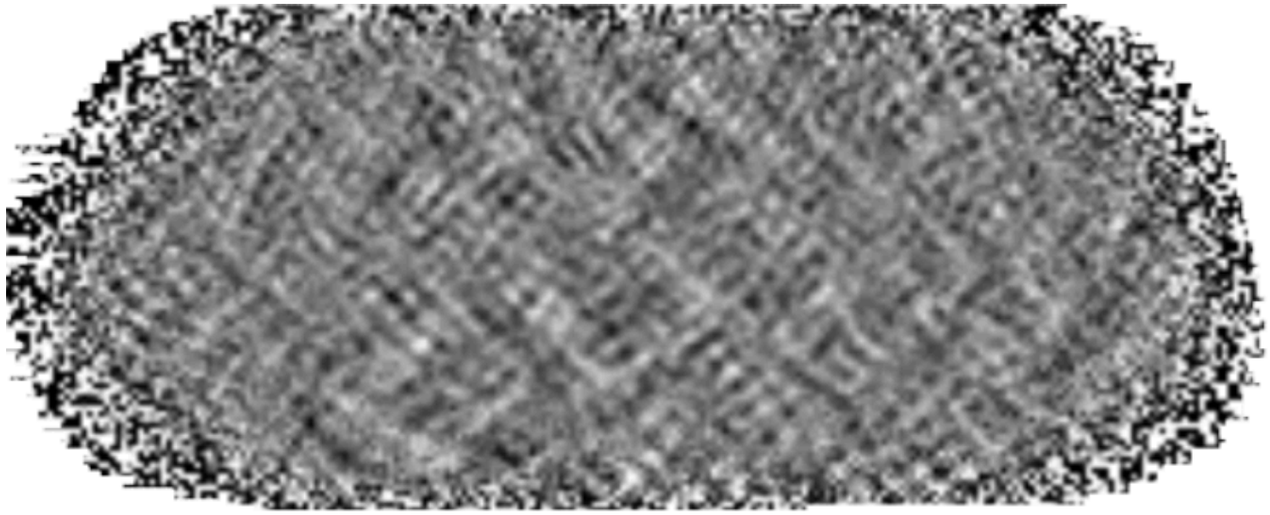


For l>1000 (angular scales <0.3 degrees), best measurement of EE power spectrum comes from ground based experiments

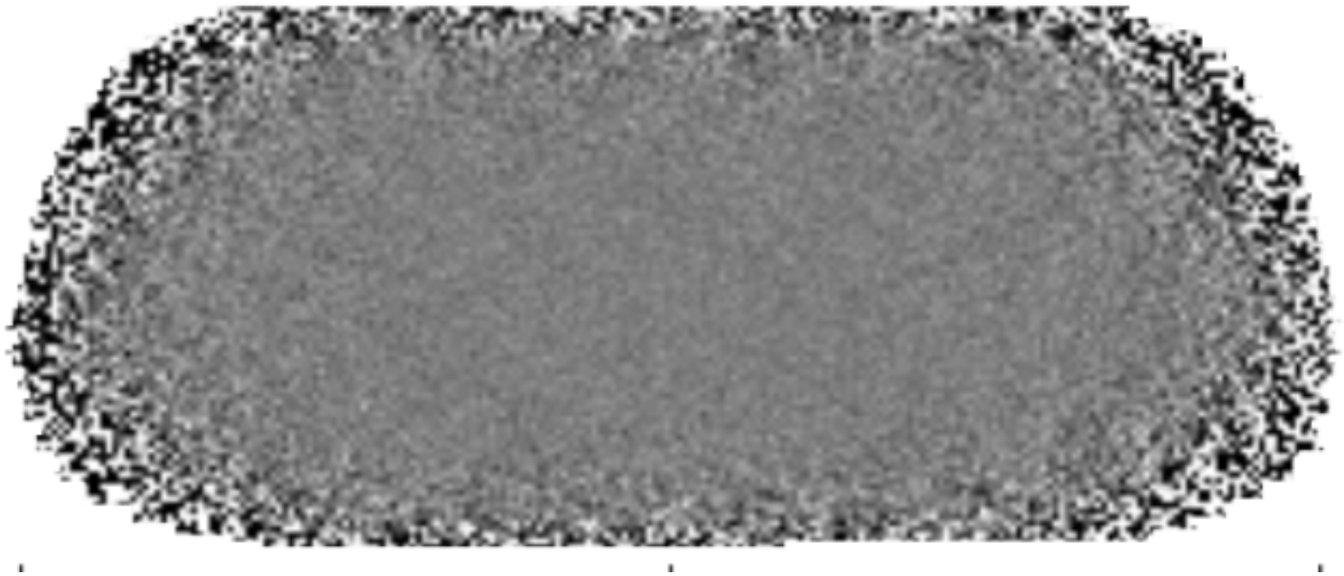
Implication 11

The deepest polarisation map to date are obtained by BICEP2

BICEP2 signal in polarisation



BICEP2 noise in polarisation



Best constrain on primordial GW

r< 0.07 (95% confidence)

However…

The atmosphere becomes a very serious problem at high frequency even for polarisation data

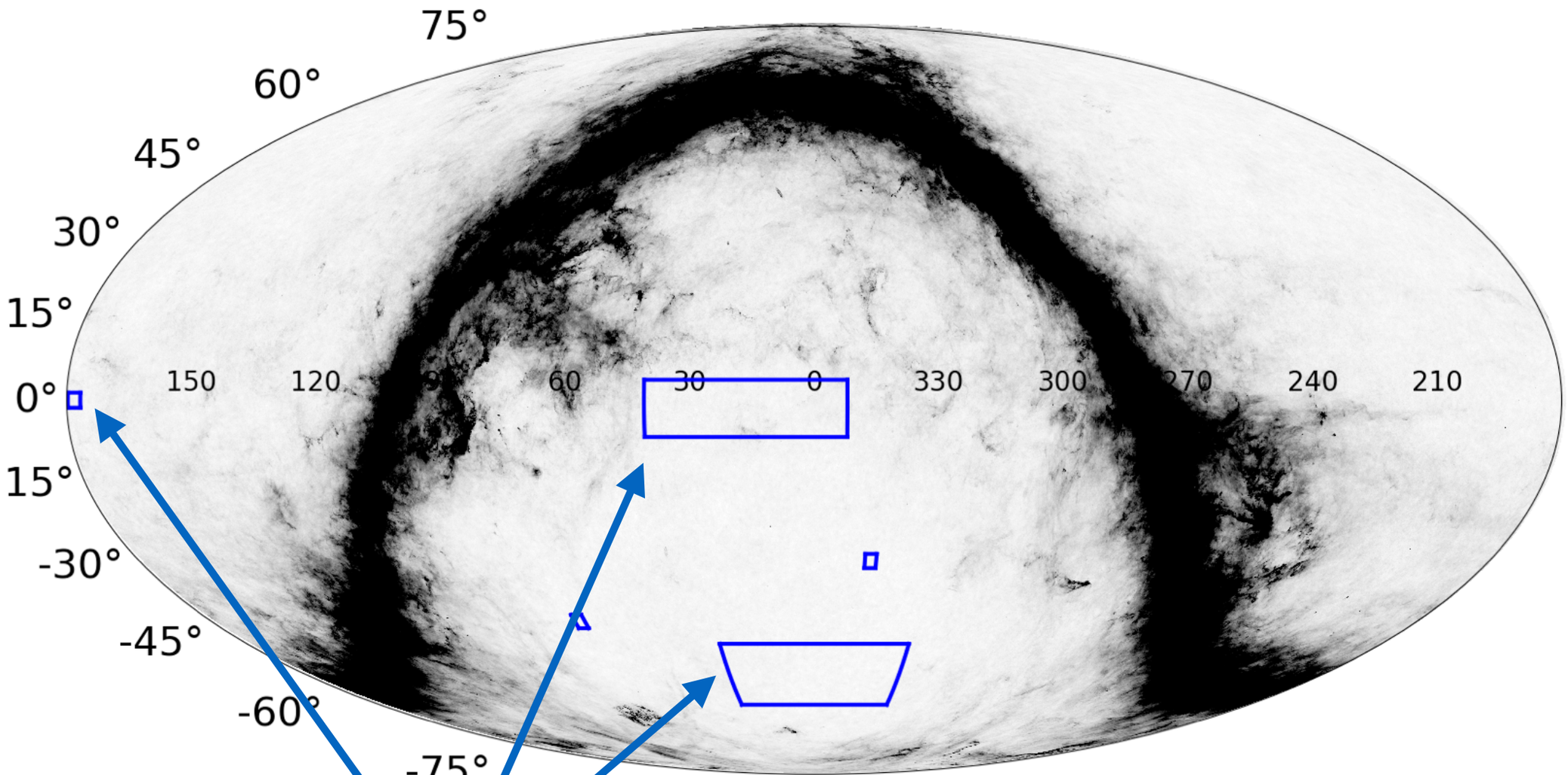
We need to complement ground based observations with high frequency channels coming from balloon or satellite

French/European proposal
for high frequency
telescope on the Litebird satellite

Skepticism 11: Sky coverage and scan strategy

Until now, polarisation from the ground only cover few % of the sky

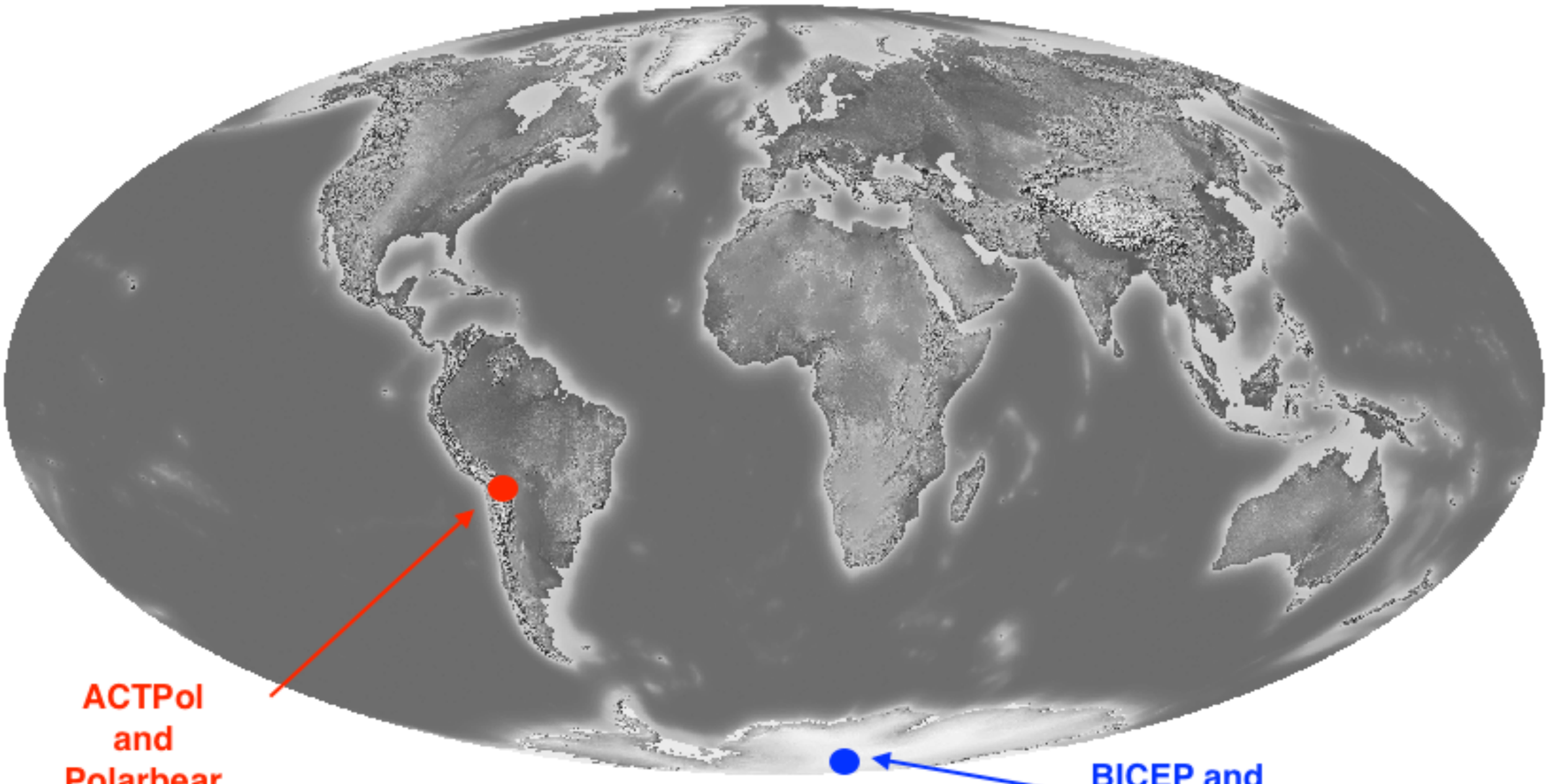
Map of the sky in equatorial coordinates



Recent published data in polarisation

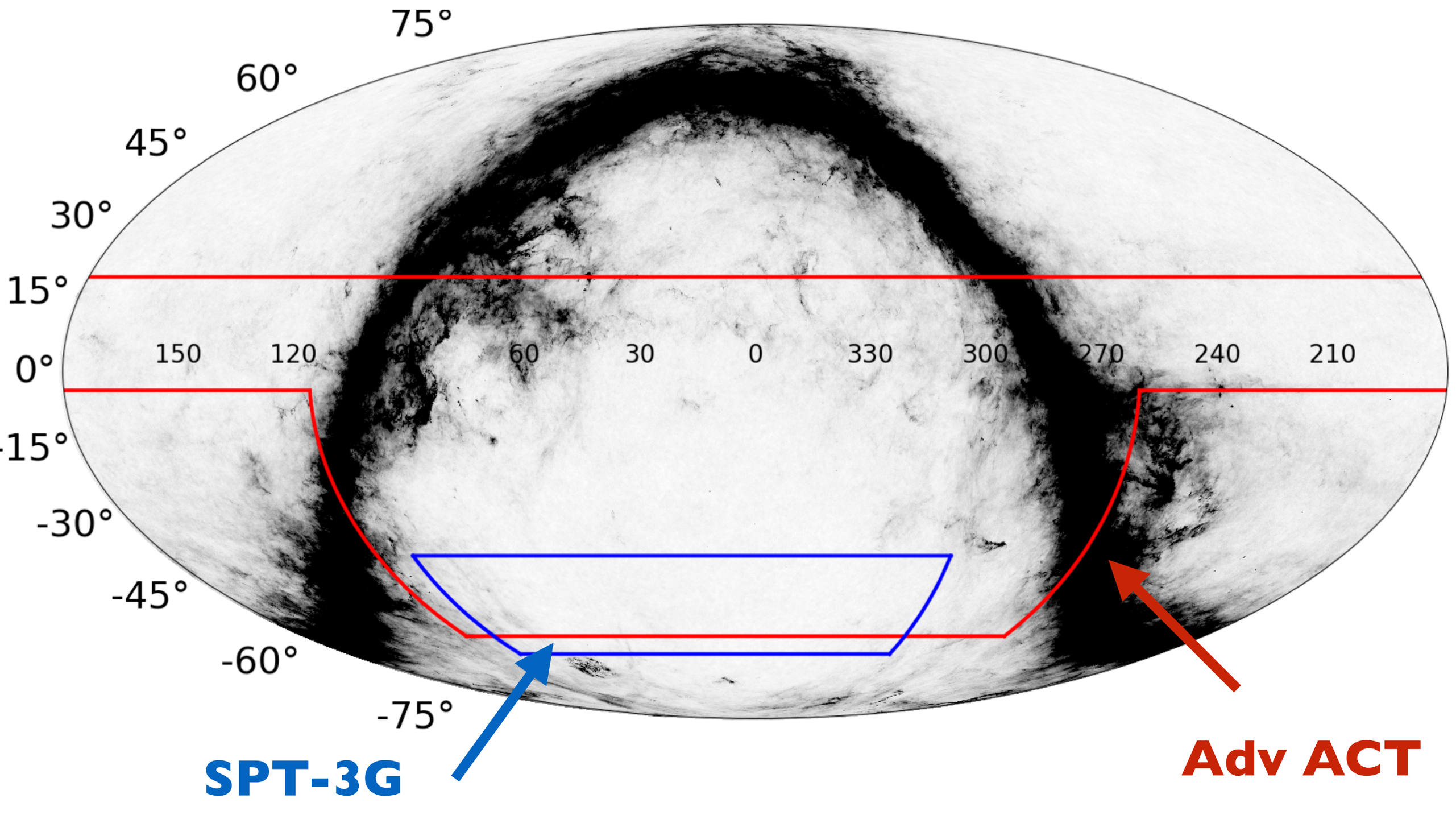
Skepticism 11: Sky coverage and scan strategy

Given the telescope locations we can cover much more



Skepticism 11: Sky coverage and scan strategy

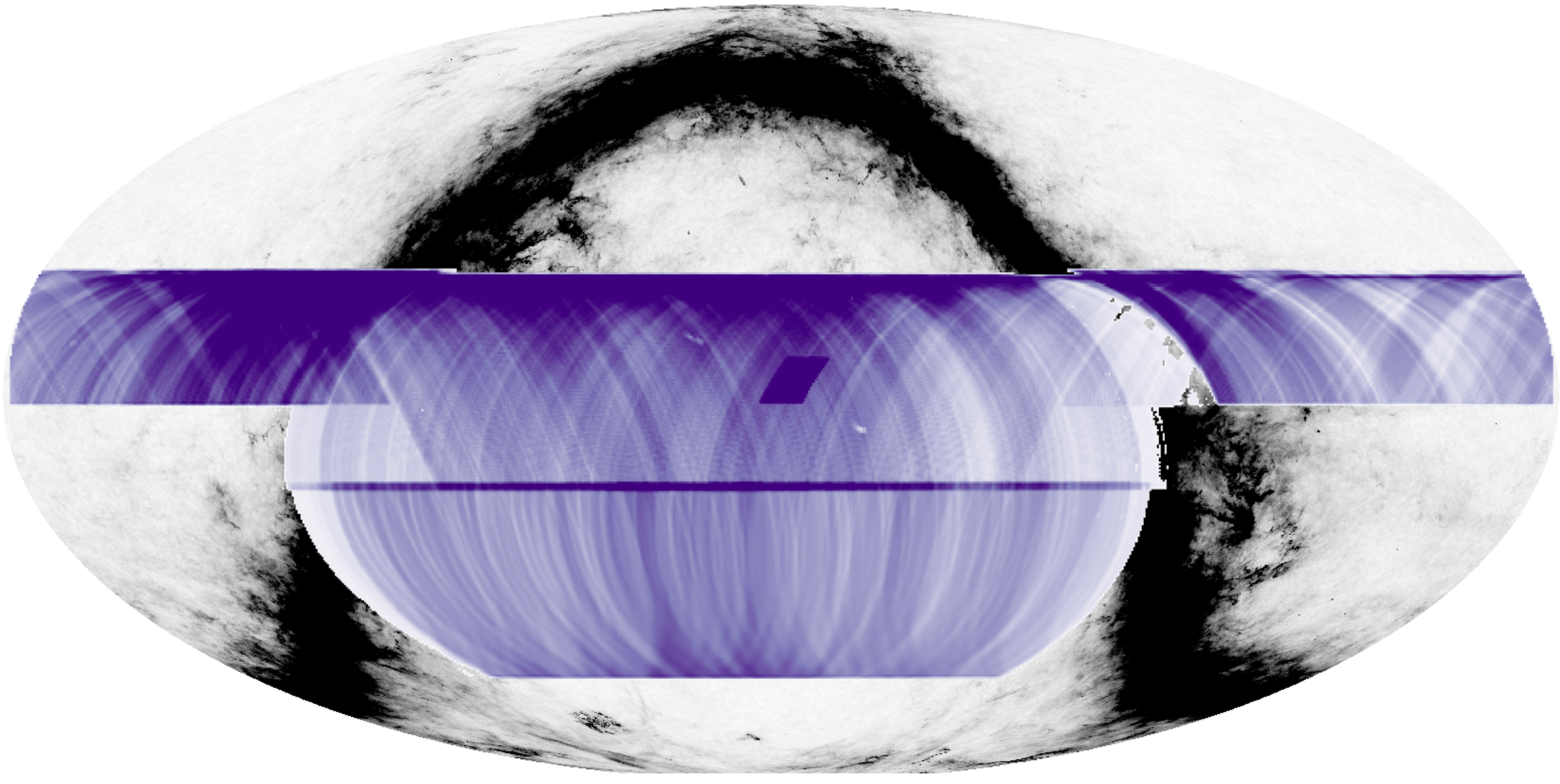
Map of the sky in equatorial coordinates



Scan strategy

However, due to the limited scan strategy of ground based experiments it is hard to get an even coverage of the sky

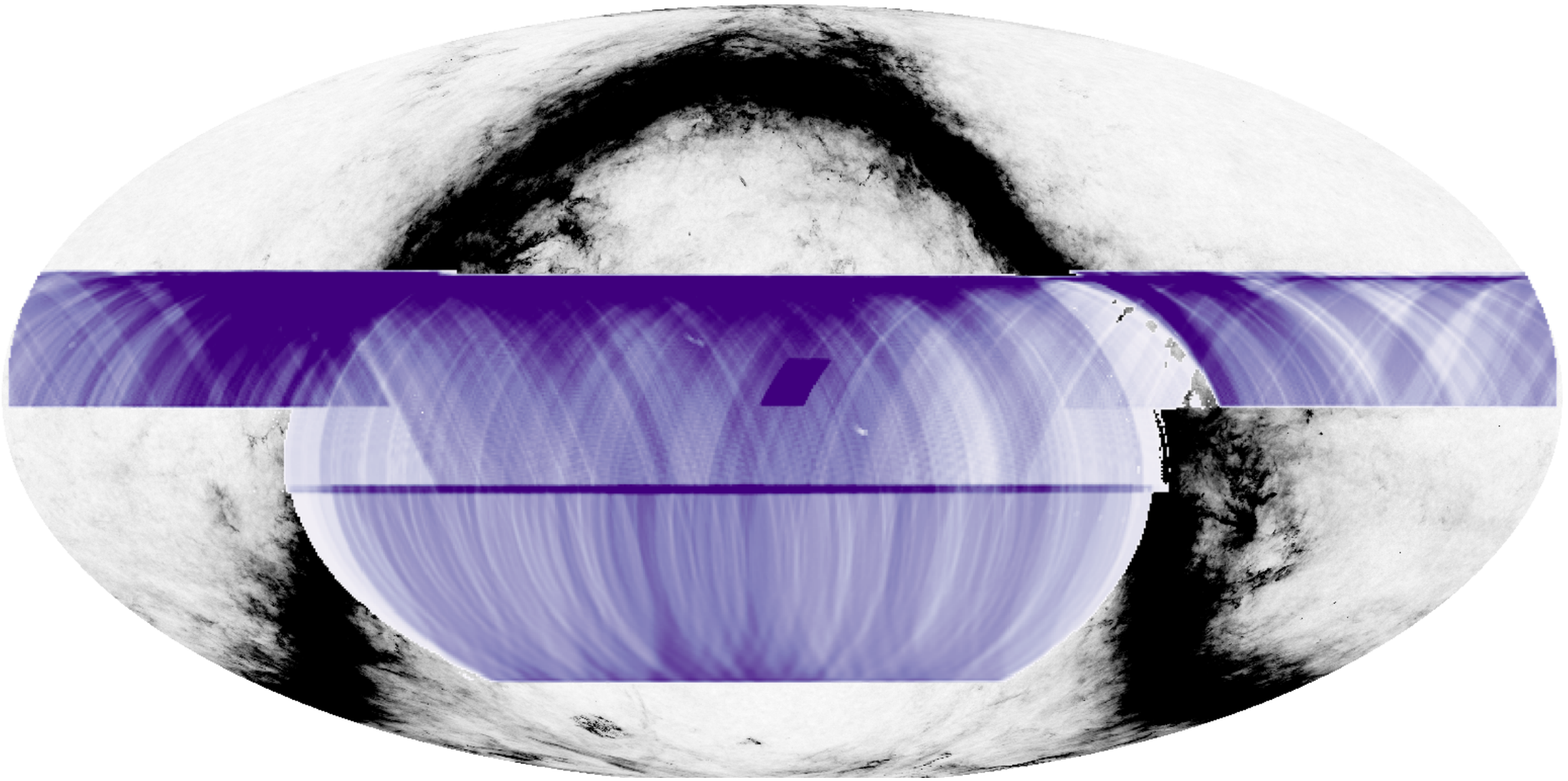
AdvACT hit counts



Scan strategy

However, due to the limited scan strategy of ground based experiments it is hard to get an even coverage of the sky

AdvACT hit counts



SHOW STOPPER? **No !**

but we will need to develop smarter statistical estimators to deal with noise inhomogeneities

Take away

-The atmosphere makes CMB from the ground hard in temperature but ground measurements can complement Planck data on small scales

-CMB polarisation from the ground has been demonstrated to be much simpler and could improve even further with improved technology.

-Only few percent of the sky have been observed in polarisation from the ground, but current telescope look at much bigger sky fraction.

-There is no reason to believe that CMB-S4 will fail, although the exact numbers in the proposal are probably not extremely solid.

-The US is on the way of mapping all the CMB sky in the south hemisphere.

Take away

-The atmosphere makes CMB from the
temperature but ground measureme
data on small scales

-CMB polarisation from th
simpler and could impr

-Only few perce
from the gr

-There
th
not

-The US

Europe

What about

?

k

uch

plate.

sation

igger sky fraction.

ail, although

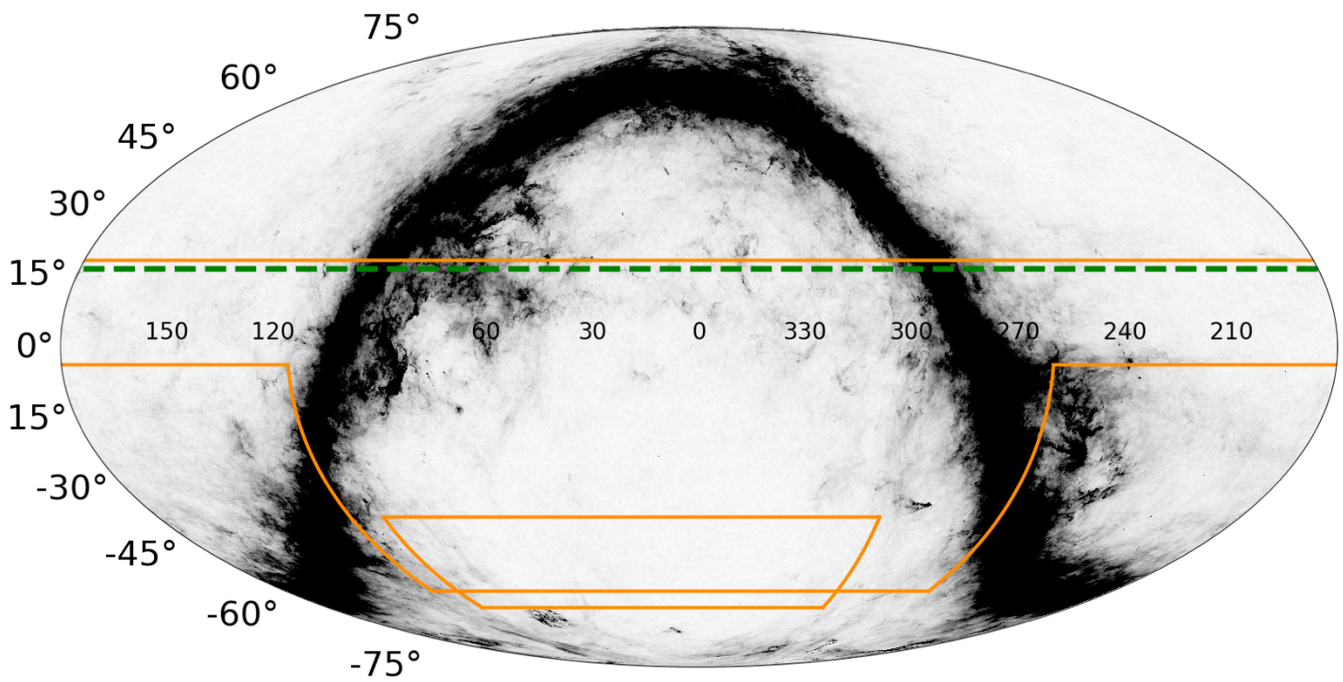
ly

l the CMB sky in the south hemisphere.

GREENLAND:

Greenland

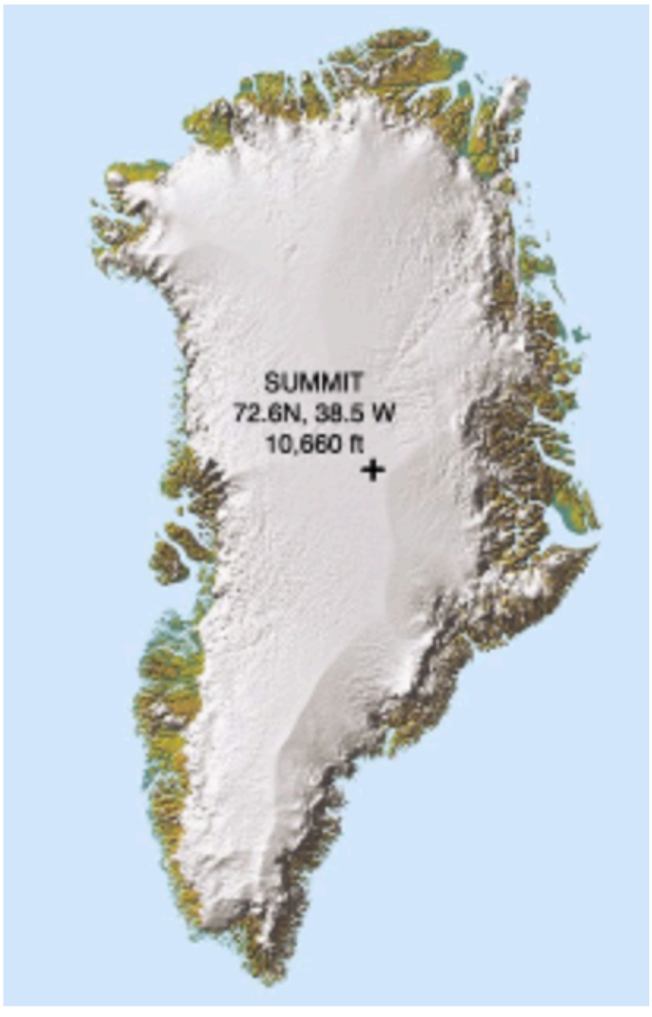
Chile
+
south pole



-Put a telescope in the north
-Greenland has comparable atmospheric properties with Chile
-Already existing project/infrastructure (VLBI)

	elev. (m)	*PWV* (mm)			d*PWV* (mm)		
		25%	**50%**	75%	25%	**50%**	75%
Dome A	4,093	0.105	**0.141**	0.191	3.65E-03	**6.56E-03**	1.21E-02
South Pole	2,835	0.231	**0.321**	0.448	1.04E-02	**1.77E-02**	3.17E-02
Chajnantor (SO)	5,190	0.618	**0.993**	1.871	1.07E-01	**2.20E-01**	4.32E-01
Cerro Chajnantor	5,612	0.48	**0.746**	1.439	8.28E-02	**1.71E-01**	3.47E-01
Ali1	5,250	0.871	**1.343**	2.125	1.59E-01	**2.66E-01**	4.45E-01
Ali2	6,100	0.459	**0.759**	1.207	1.01E-01	**1.81E-01**	3.21E-01
Greenland	3,216	0.509	**0.817**	1.436	4.14E-02	**7.89E-02**	1.56E-01

The Greenland Telescope will be deployed at Apex Station, a new NSF operated Arctic research station to be constructed 5 miles north of the existing Summit Station at 72° 35′N 38° 25′W and 3,210 m (10,530 ft) above mean sea level. The site is near the peak of the Greenland ice sheet, near the center of Greenland.



The NSF has operated Summit Station for the past 15 years, and weather data exist for almost all of this period. From 2010, twice daily radiosonde observations have been carried out alongside radiometer observations at 22, 60, 90 and 150 GHz as part of the ICECAPS program, while ASIAA has operated a 225 GHz radiometer from August 2011. The site is extremely dry during the Oct-May observing season, with a median PWV column of 0.75 mm and PWV below 0.25mm for approximately 10% of this time. Calculated atmospheric transmission is shown in Figure . The site is extremely flat and wind speeds are generally low. Winter temperatures reach -65C during the coldest and clearest conditions.

The site is manned all year round – currently there are 5 winter-over staff at Summit, working 10 week shifts, with 1 week overlap at each end. With the move to Apex Station, and deployment of the GLT, this will increase to 12 winter-over staff, including 5 dedicated to the GLT. Summer staffing levels are significantly higher with maintenance and traverse crew, and summer campaign science operations. Access to the site is via ski-equipped Air National Guard C130-LC and charter Twin Otter aircraft from Kangerlussuaq and Thule, and by an annual overland sled traverse from Thule. Twin Otter aircraft can reach site year round, but avoid the 2 month period of total darkness in Dec/Jan.