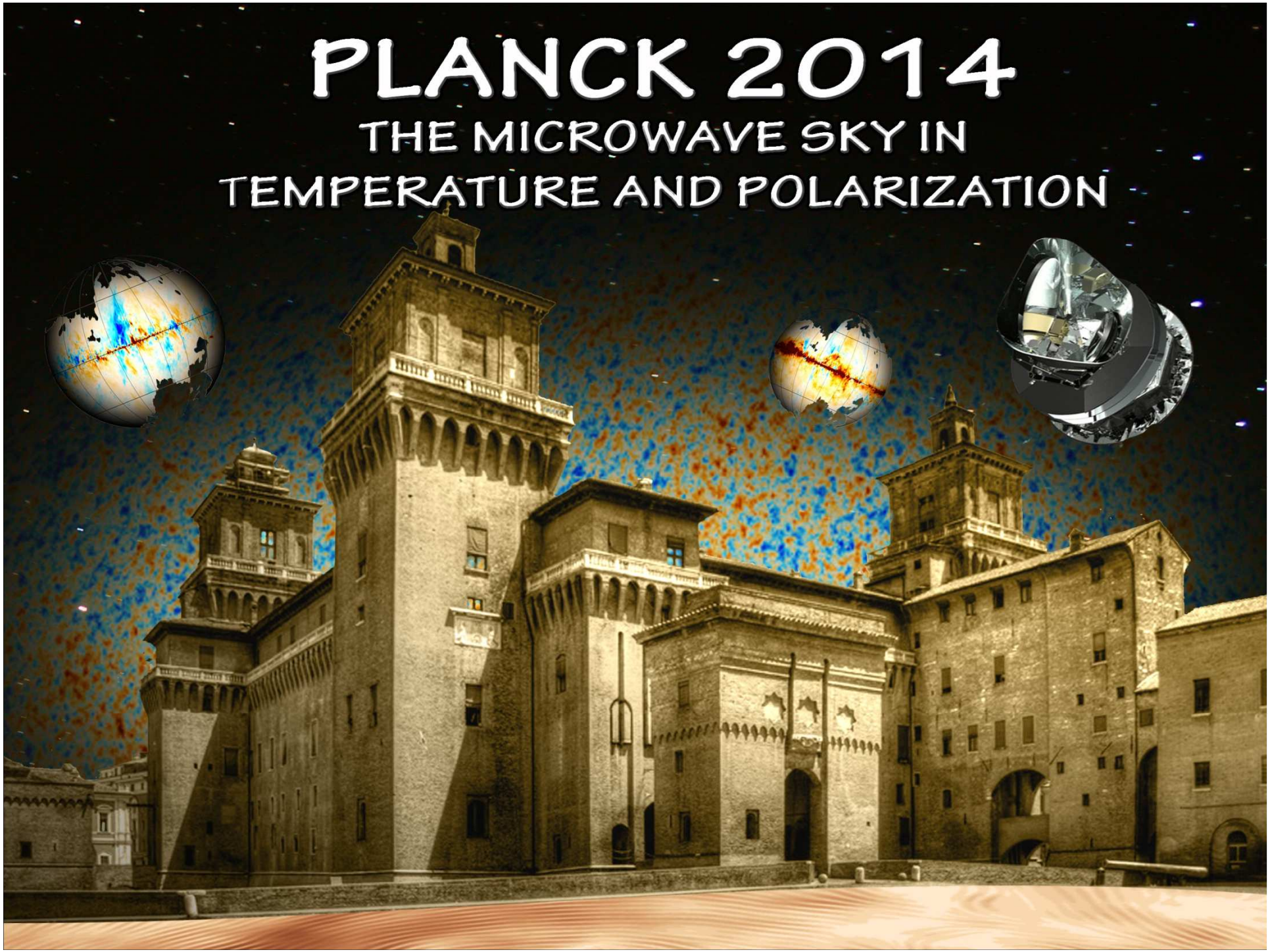
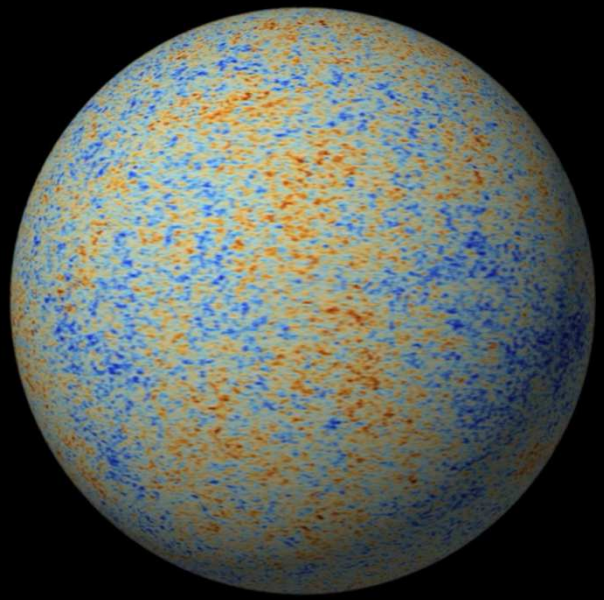
PLANCK 2014

THE MICROWAVE SKY IN TEMPERATURE AND POLARIZATION



Planck 2014 – The Microwave Sky in Temperature and Polarisation
Ferrara, 1–5 December 2014

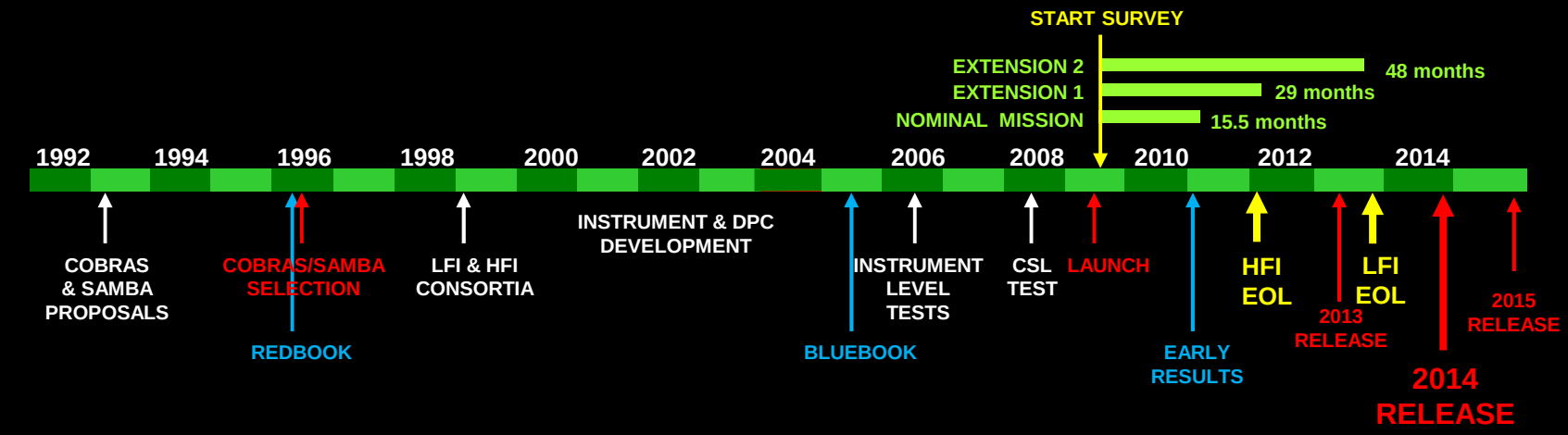
The Planck mission



Marco Bersanelli
Dipartimento di Fisica, Università degli Studi di Milano
Planck-LFI Deputy PI and Instrument Scientist

On behalf of the Planck Collaboration

The Planck Collaboration



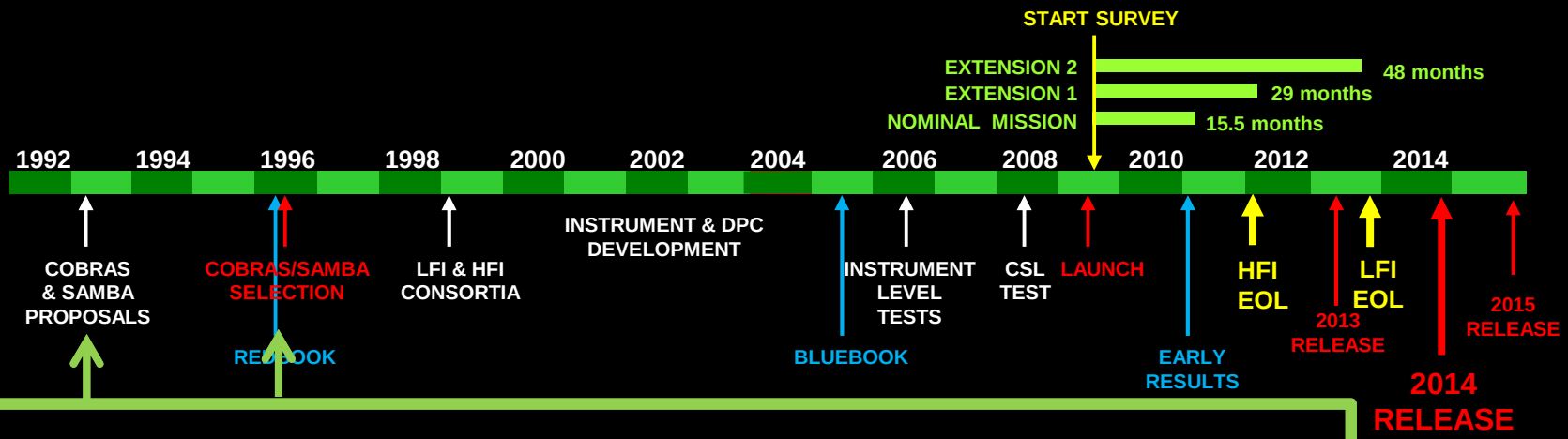
esa

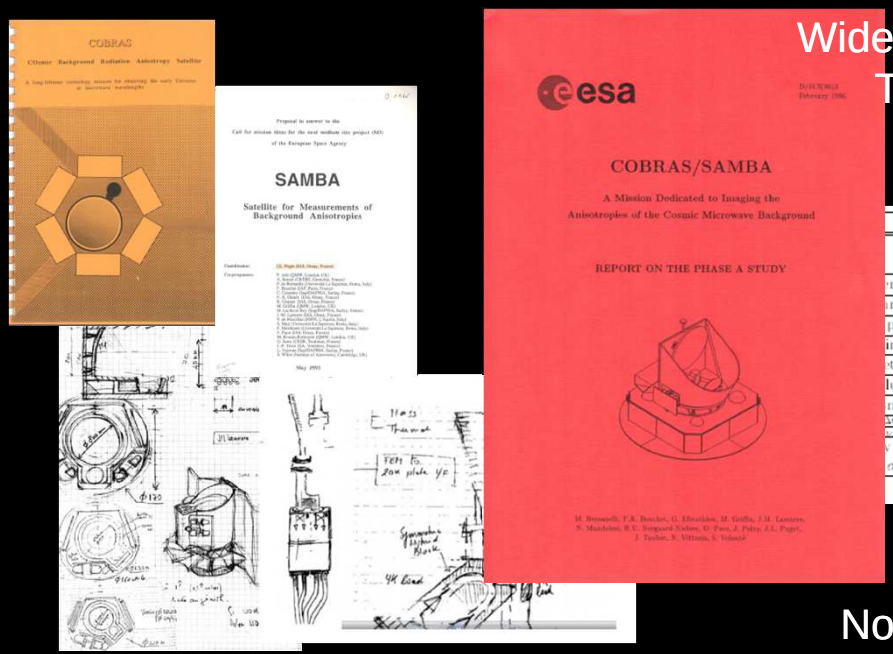
planck

PLANCK LFI

HFI PLANCK
a look back to the birth of Universe

Early times





Wide spectral range (30-850 GHz)
Two different technologies
Control of systematics

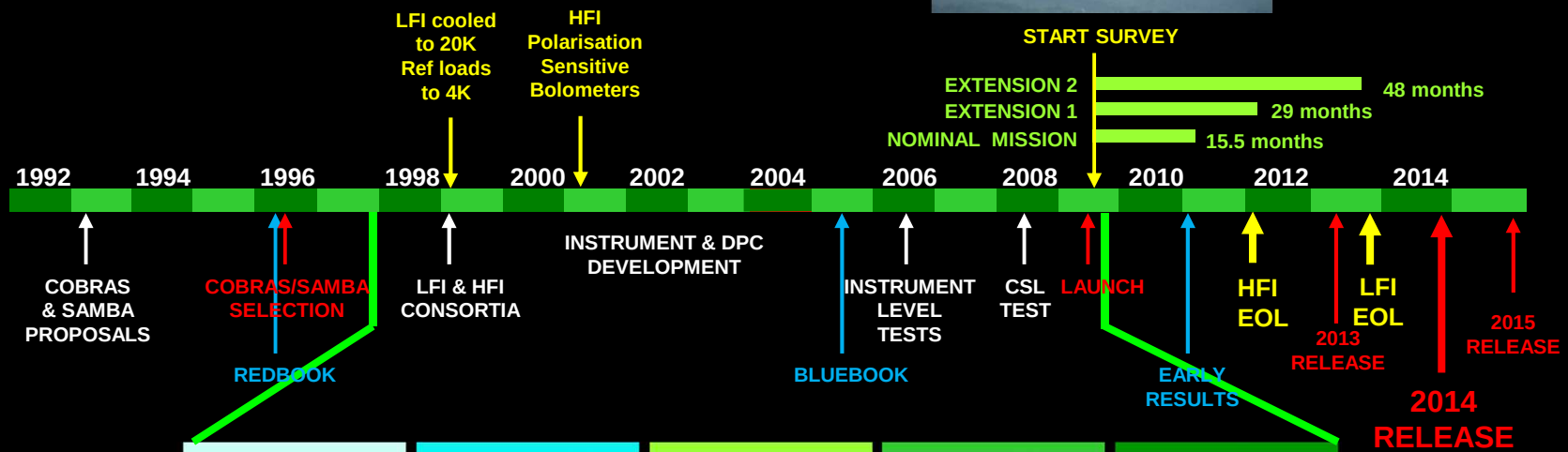
PAYLOAD									
	1.5 m Diam. Gregorian; shared focal plane; system emissivity 1% Viewing direction offset 70° from spin axis.								
ency (GHz)	31.5	53	90	125	143	217	353	545	857
nology	HEMT radio receiver arrays				Bolometer arrays				
perature	~100 K				0.1-0.15 K				
irements	Passive				Cryocooler + Dilution system				
tectors	4	14	26	12	8	12	12	12	12
lution (arcmin)	30	18	12	12	10.3	7.1	4.4	4.4	4.4
mission	1	1	1	1	0.3	0.3	0.3	0.3	0.3
)	0.15	0.15	0.15	0.15	0.37	0.37	0.37	0.37	0.37
per res. element σ, 10^{-6} units)	7.8	7.5	14.4	35.4	1.2	2.0	12.1	76.6	4166

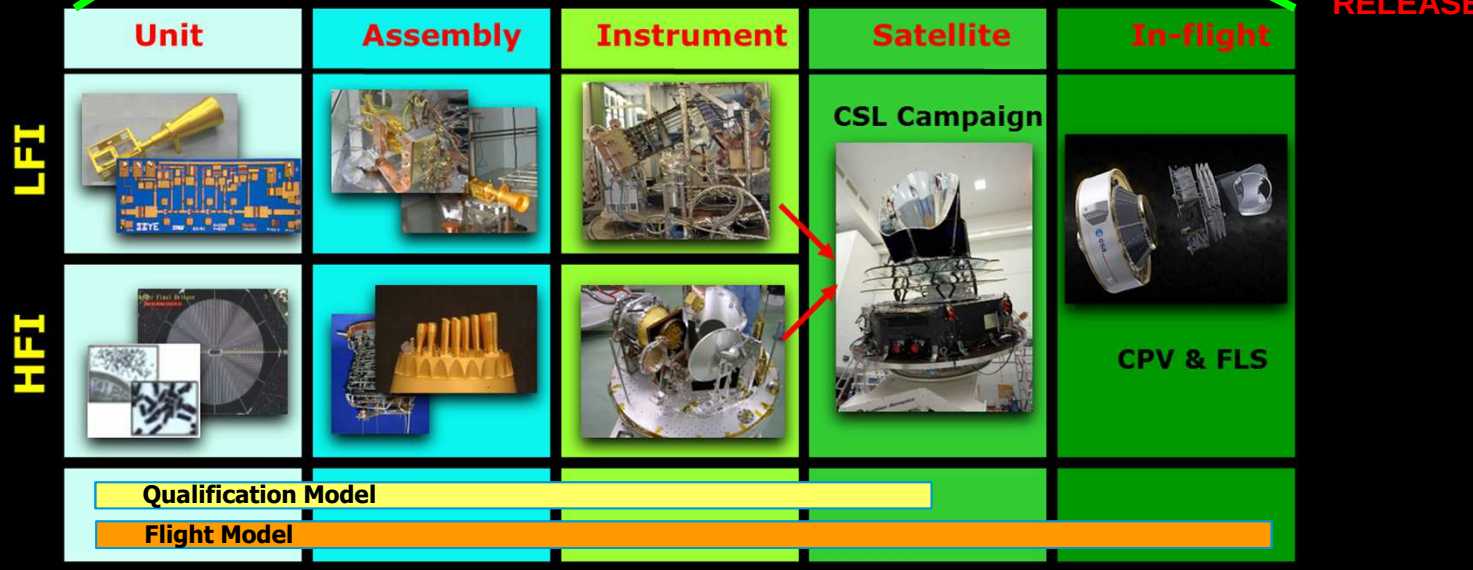
$dT/T \sim 2 \times 10^{-6}$ $\theta \sim 15'$

No requirements on polarisation

Instrument & DPC development
Ground & in-flight calibration

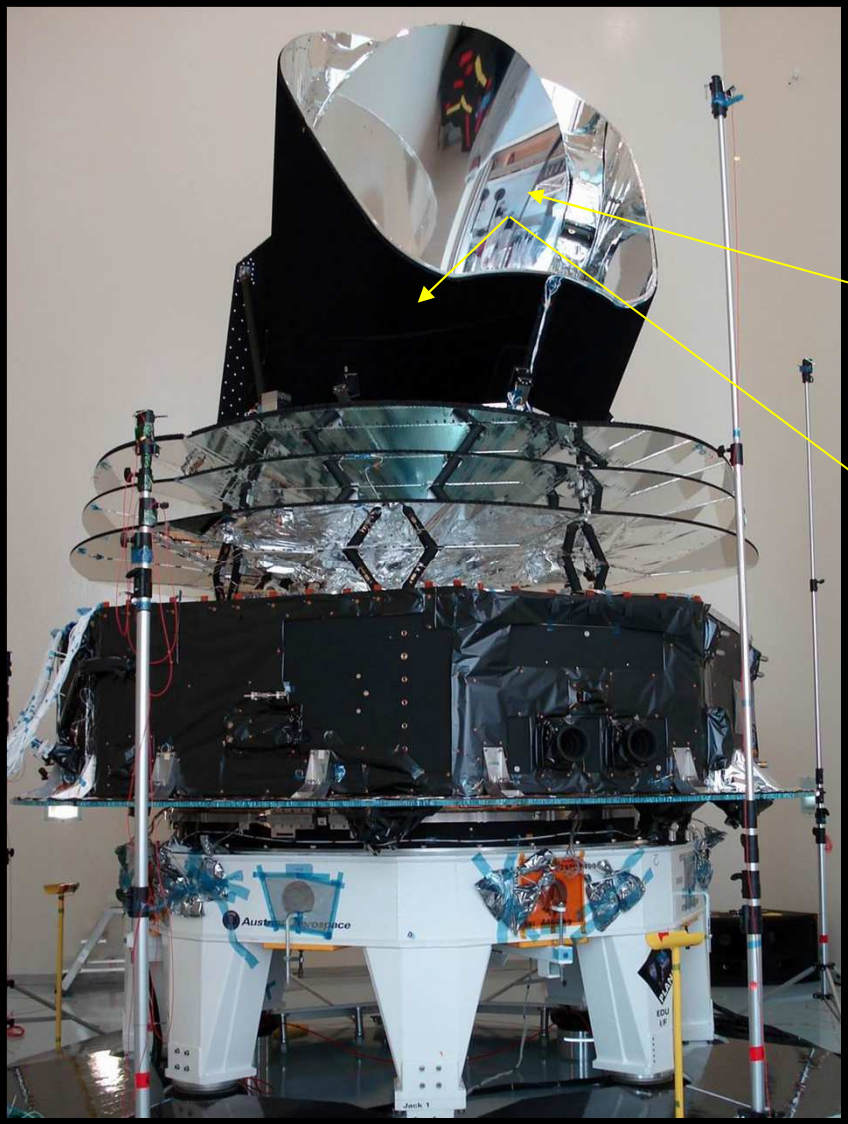
Kourou, French Guyana,
14 May 2009, h 10:12





PLANCK

Looking back to the dawn of time



Planck Telescope
1.5x1.9m off-axis
Gregorian
T = 50 K

LFI Radiometers
30-70 GHz, T = 20 K

HFI Bolometers
100-857 GHz, T = 0.1 K

agenzia spaziale italiana

CENTRE NATIONAL D'ÉTUDES SPATIALES

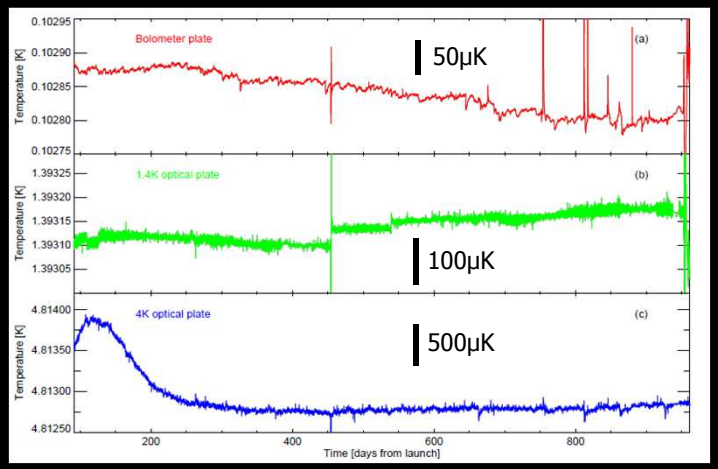
In-flight cryo-chain performance & mission lifetime

Thermal stability

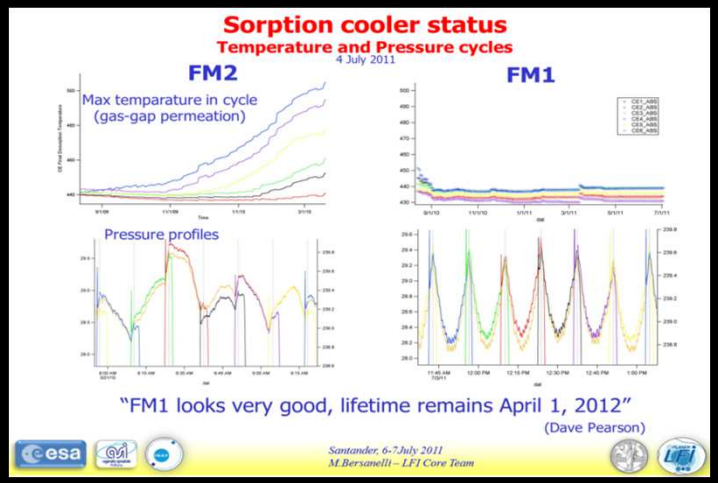
0.1K

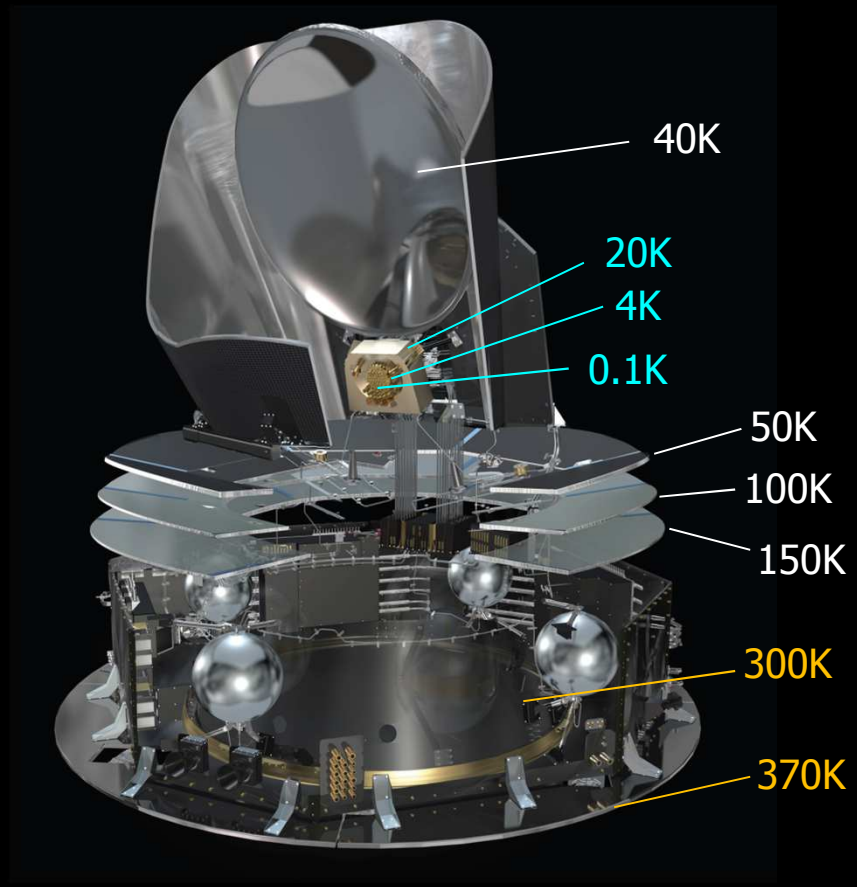
1.4K

4K



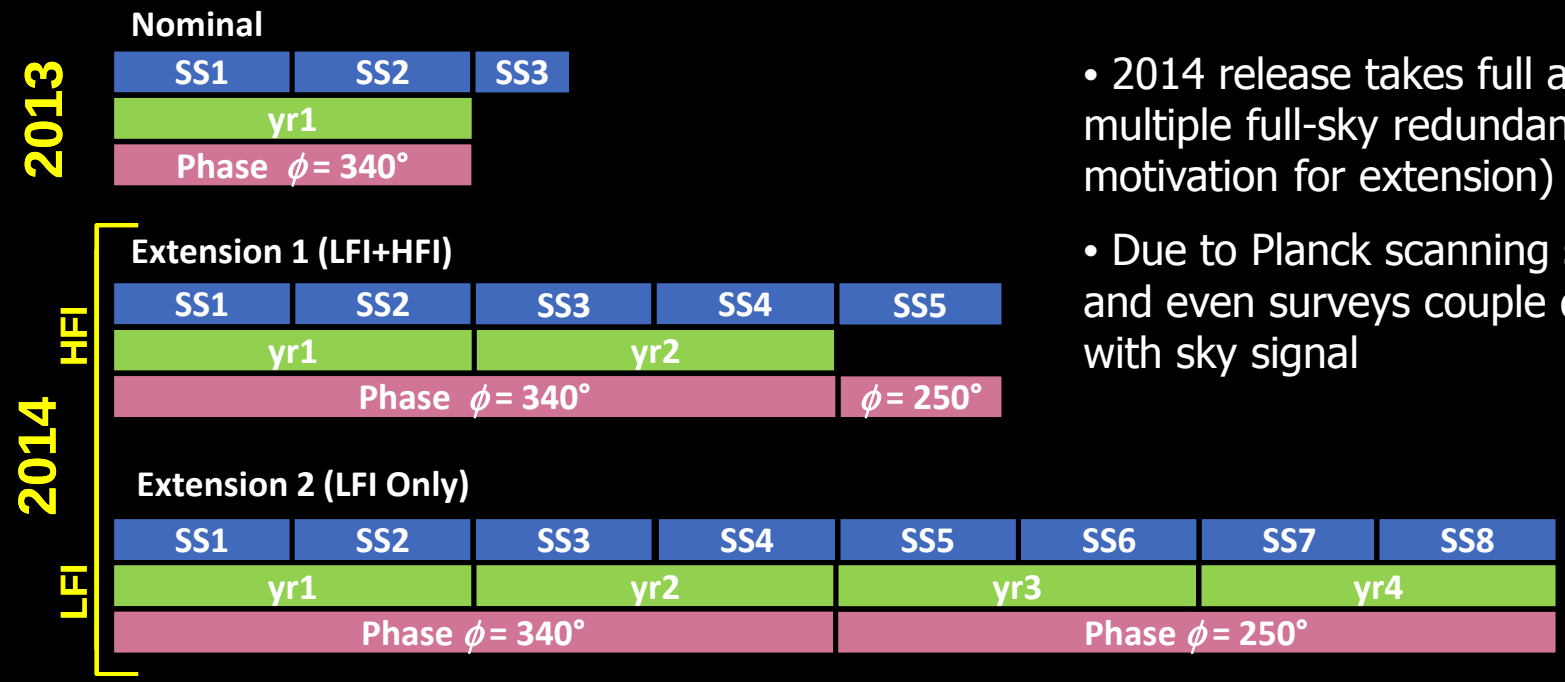
20K





Excellent Planck cryo-chain performance
more-than-doubled mission lifetime

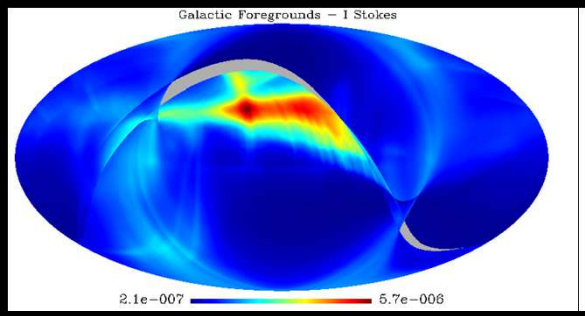
2014 release: Planck full mission



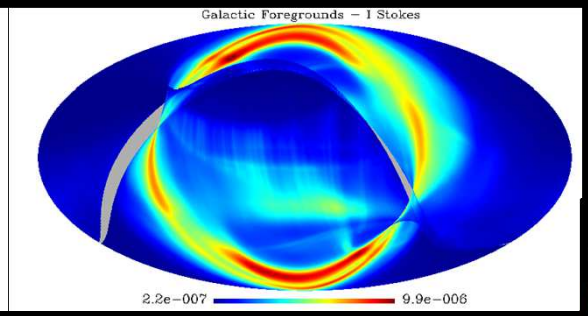
- 2014 release takes full advantage of multiple full-sky redundancies (main motivation for extension)
- Due to Planck scanning strategy, odd and even surveys couple differently with sky signal

Galactic straylight (simulation)

Odd survey

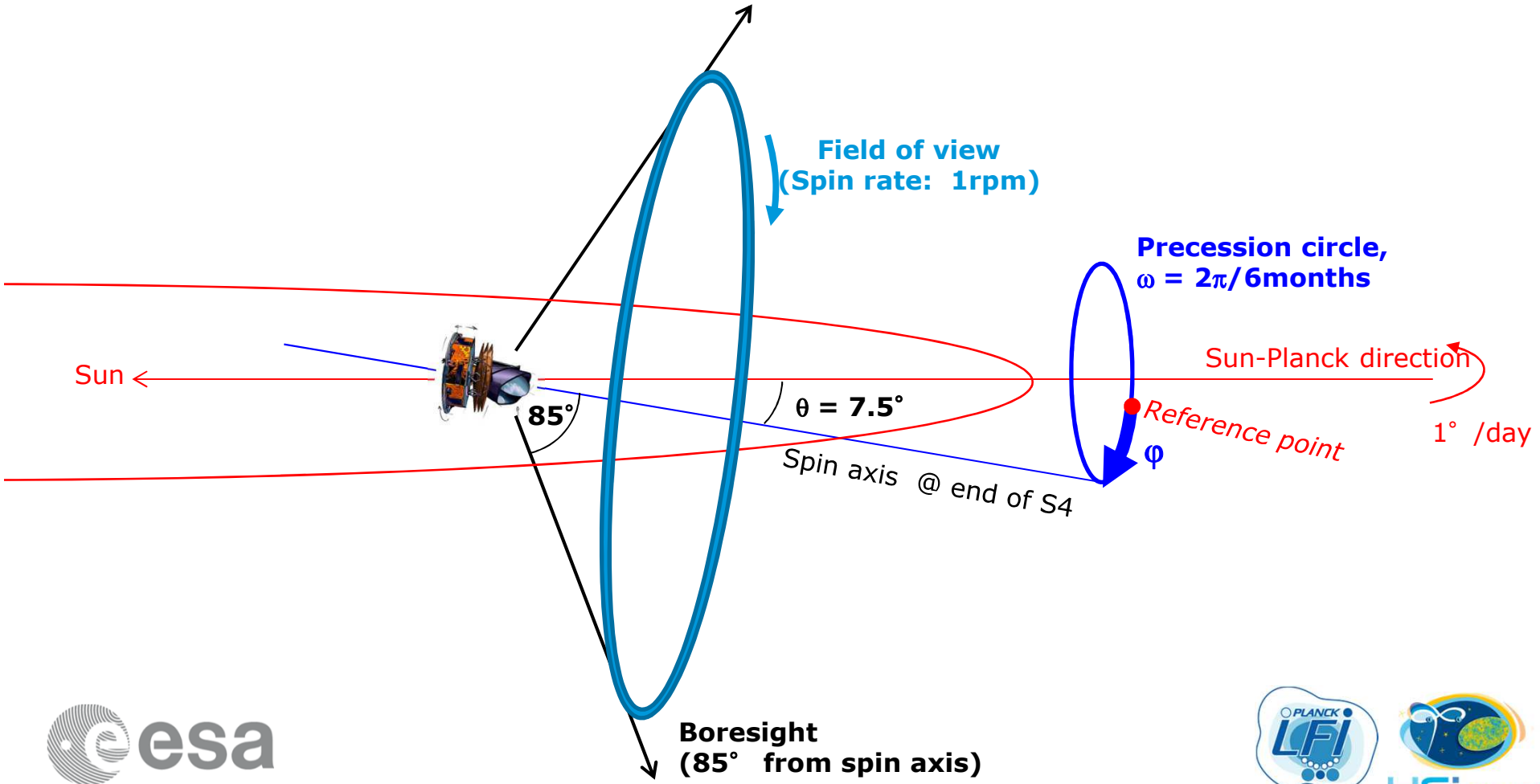


Even survey



Planck scanning strategy
Phase shift between S4 and S5

At beginning of Survey 5 the precession phase φ was shifted by Δφ = 90 degrees with a dedicated maneuvre



Planck scanning strategy
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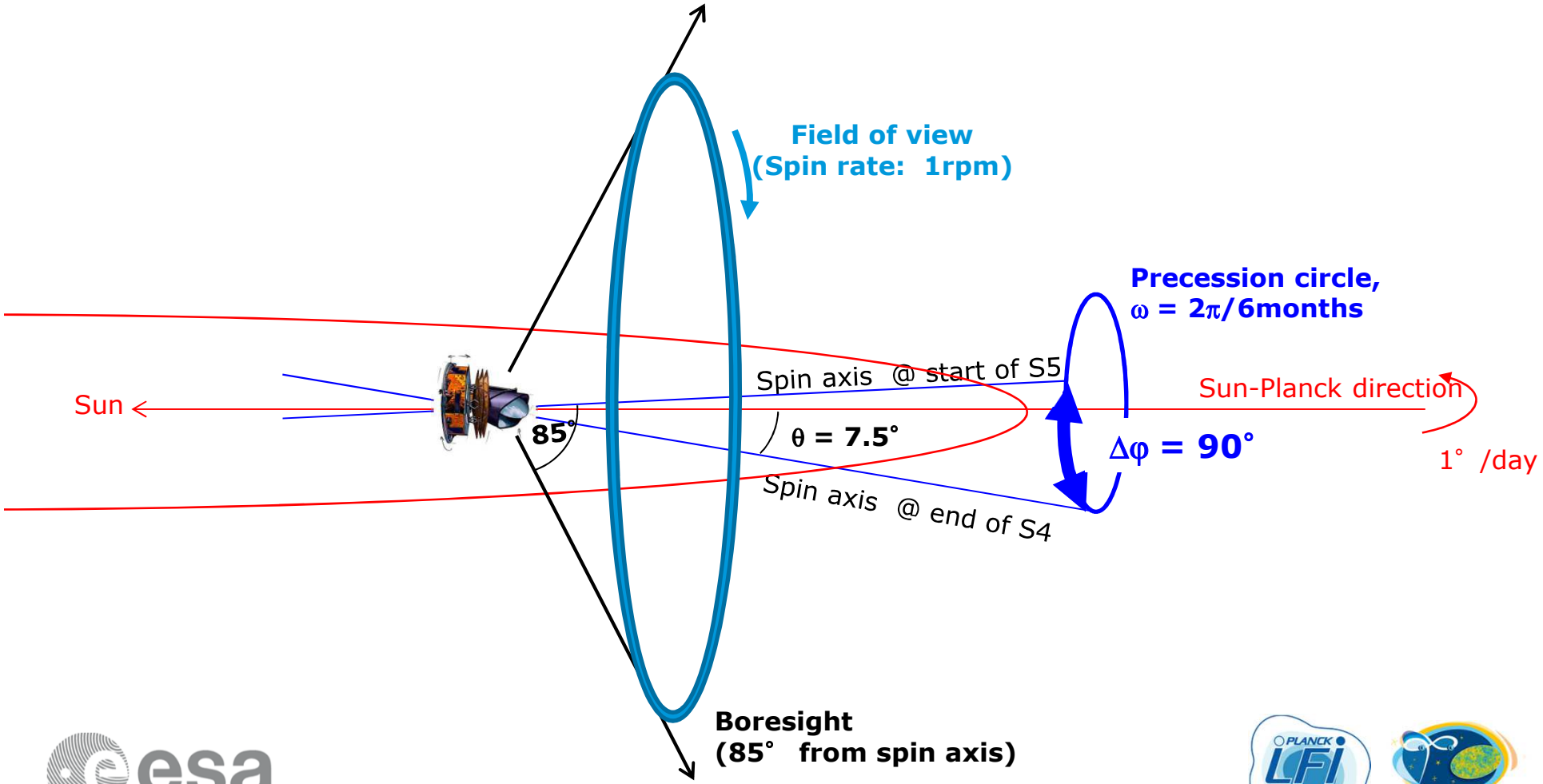
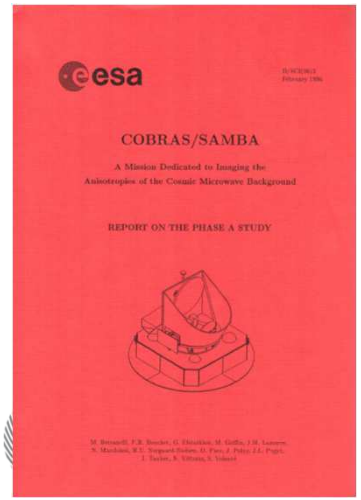
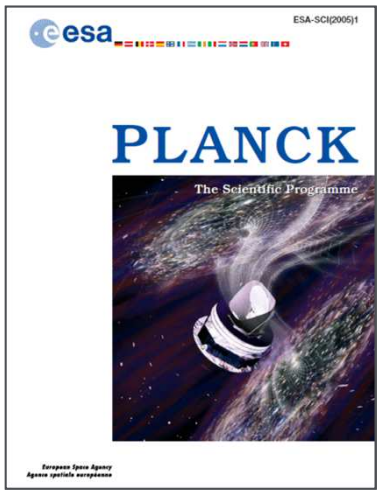


Planck sensitivity

Noise **measured in-flight**, full mission (CMB channels)

	30GHz	44GHz	70GHz	100GHz	143GHz	217GHz	353GHz
Angular resolution [arcmin]	33.2	28.1	13.1	9.7	7.3	5.0	4.9
Noise sensitivity [$\mu K_{CMB}\ s^{1/2}$]	148.5	173.2	151.9	41.3	17.4	23.8	78.8
NOISE/PIXEL							
From detector sensitivity [μK_{CMB}]	9.2	12.7	23.9	9.6	5.4	10.7	36.5
Measured from maps [μK_{CMB}]	9.2	12.5	23.2	11.2	6.6	12.0	43.2
Extended mission [months]	*48*	*48*	*48*	*29*	*29*	*29*	*29*
End-of-missioni [μK_{CMB}]	5.2	7.1	13.2	8.2	4.8	8.8	31.6
Measured End-of-Mission [$\Delta T/T$, $\mu K/K$]	**1.9**	**2.6**	**4.8**	**3.0**	**1.8**	**3.2**	**11.6**
2005: Blue book GOAL [$\Delta T/T$, $\mu K/K$]	**2.0**	**2.7**	**4.7**	**2.5**	**2.2**	**4.8**	**14.7**
1996: Red book GOAL [$\Delta T/T$, $\mu K/K$]				**~ 2**			





At end of mission Planck fulfills completely the very ambitious sensitivity goals proposed in the design phase several years ago

Dipole calibration: Planck vs WMAP

- 2014: Orbital dipole calibration for both LFI and HFI

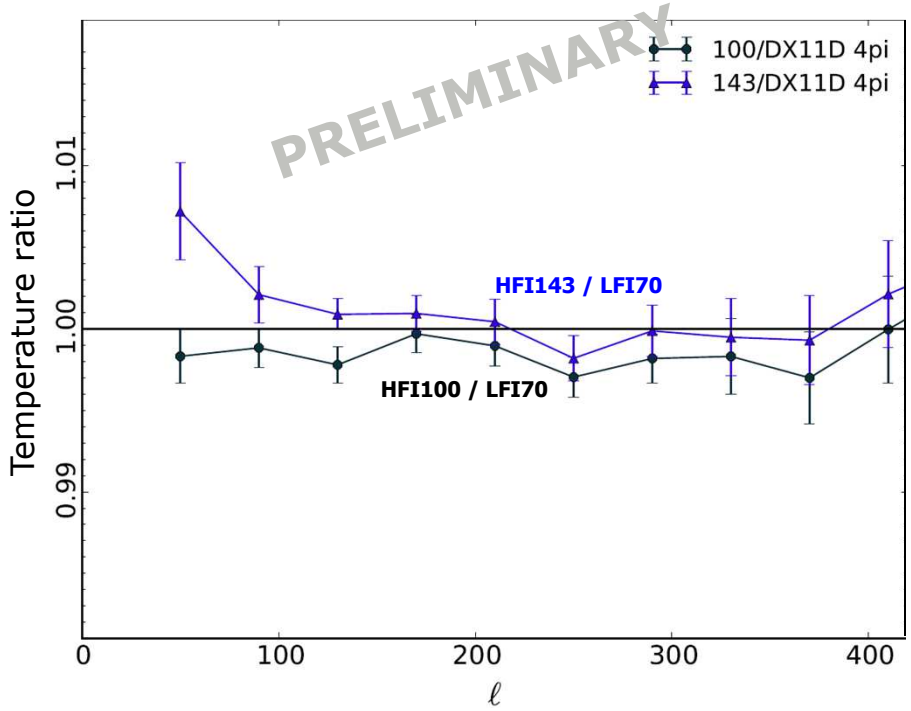
	Amplitude (μK)	**Latitude** (deg)	**Longitude** (deg)
LFI	3365.5±2	48.26	264.01
HFI	3364.1±2	48.23±0.1	263.96±0.03
Planck (LFI+HFI)	3364.5±2	48.24±0.1	264.00±0.03
WMAP	3355±8	48.26±0.03	263.99±0.14

PRELIMINARY

- Accuracy ~0.05%, limited by foregrounds
- Residual dipoles from component separation: ~1μK
- Very good agreement with WMAP
  (1σ, 0.3% amplitude, 3’ direction)

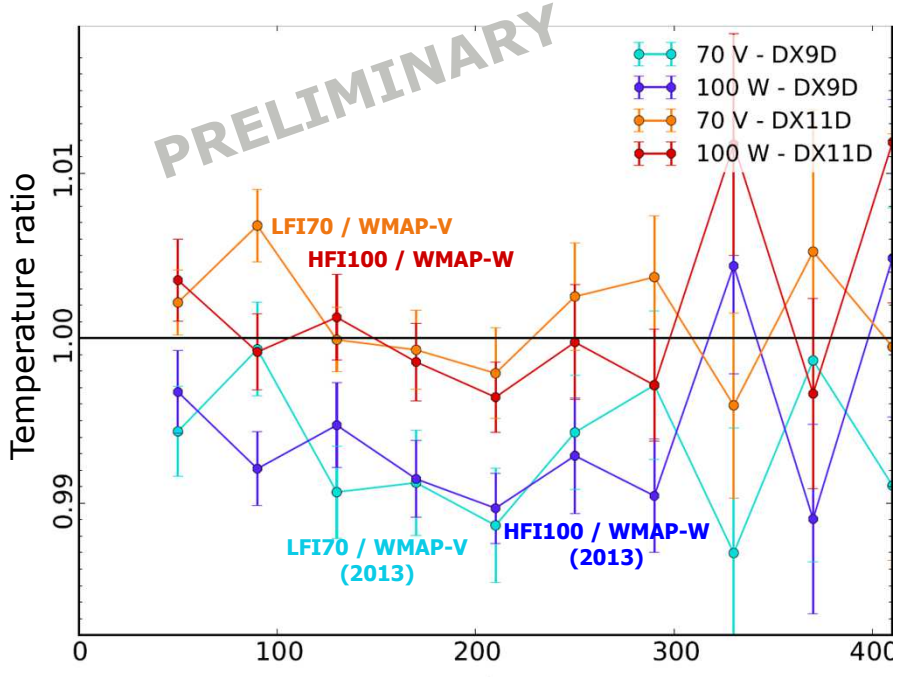
Calibration consistency
LFI vs HFI, Planck vs WMAP

LFI vs HFI



Internal consistency confirmed by tests from component separation analysis

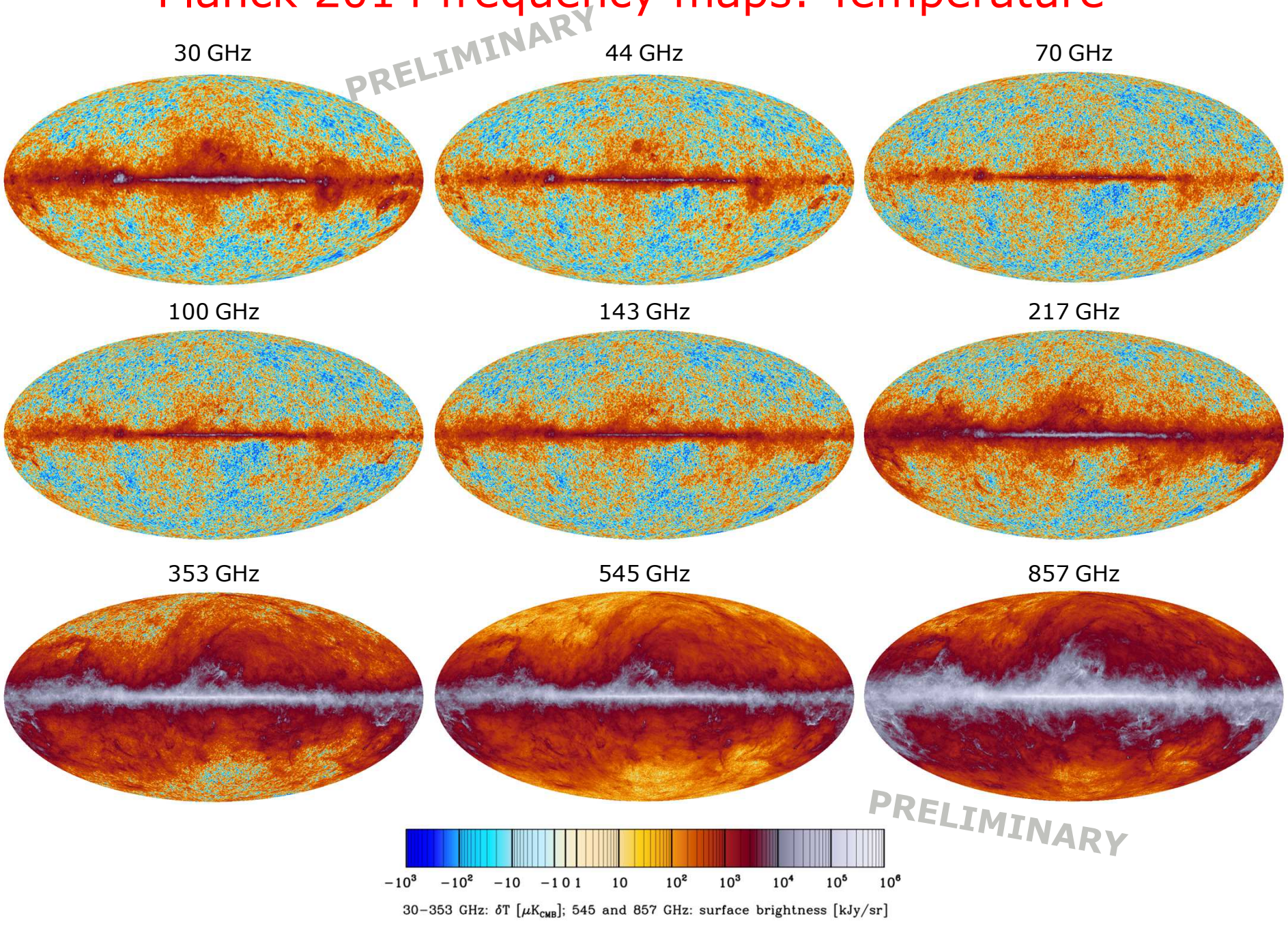
Planck vs WMAP



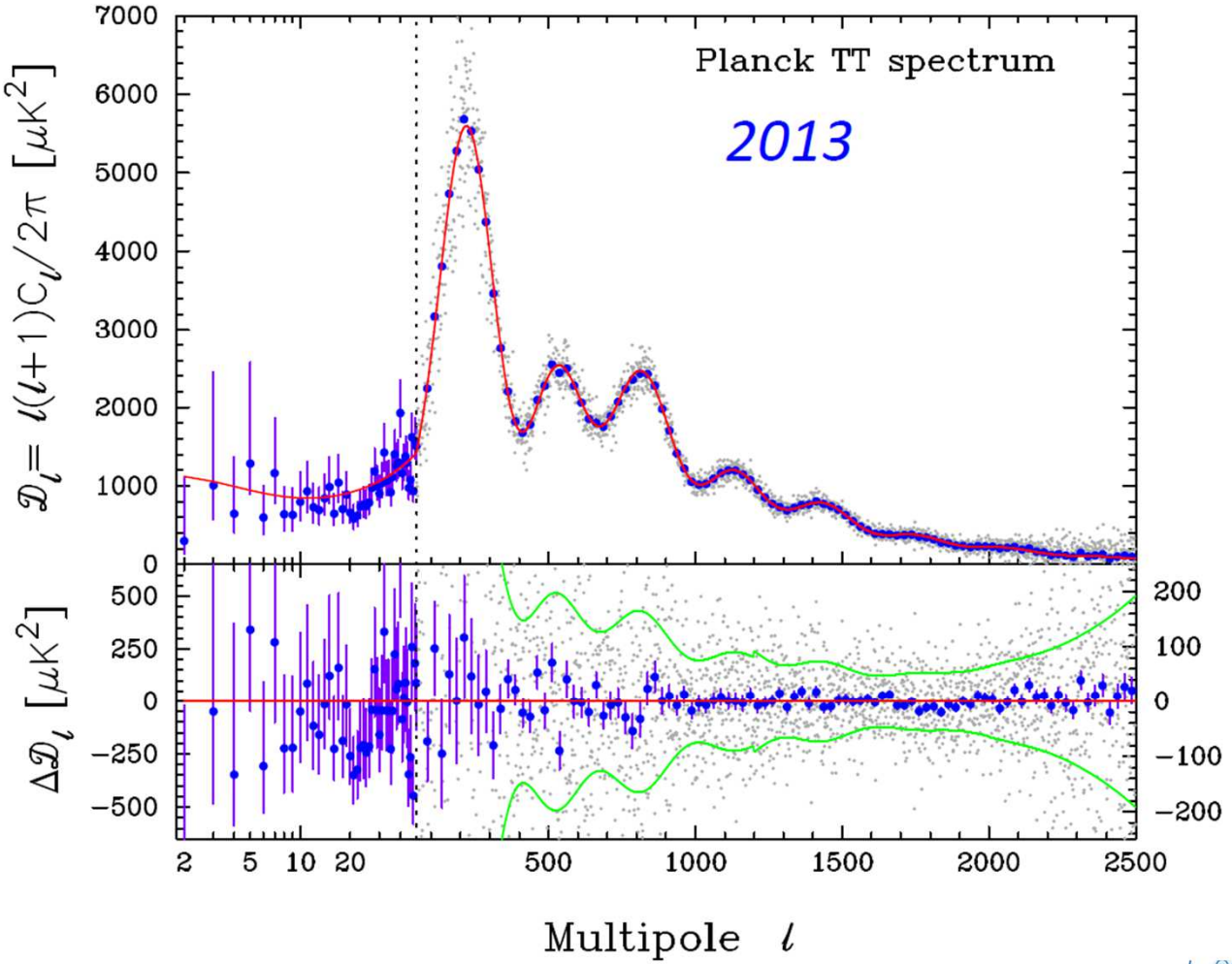
Changes in LFI and HFI since 2013 from better control of (independent) systematics and beams

Excellent consistency between independent experiments

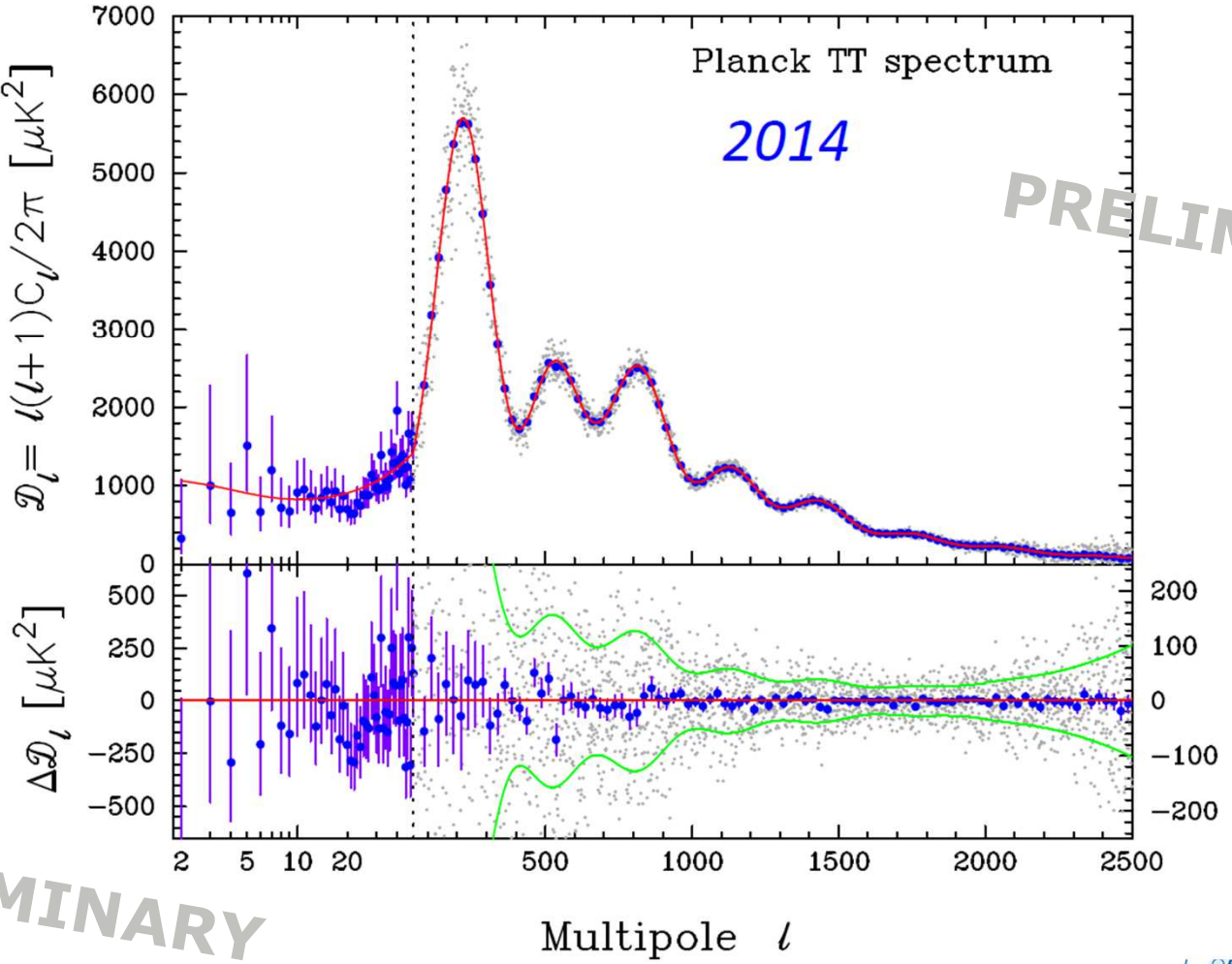
Planck 2014 frequency maps: Temperature



Planck Temperature power spectrum



Planck Temperature power spectrum



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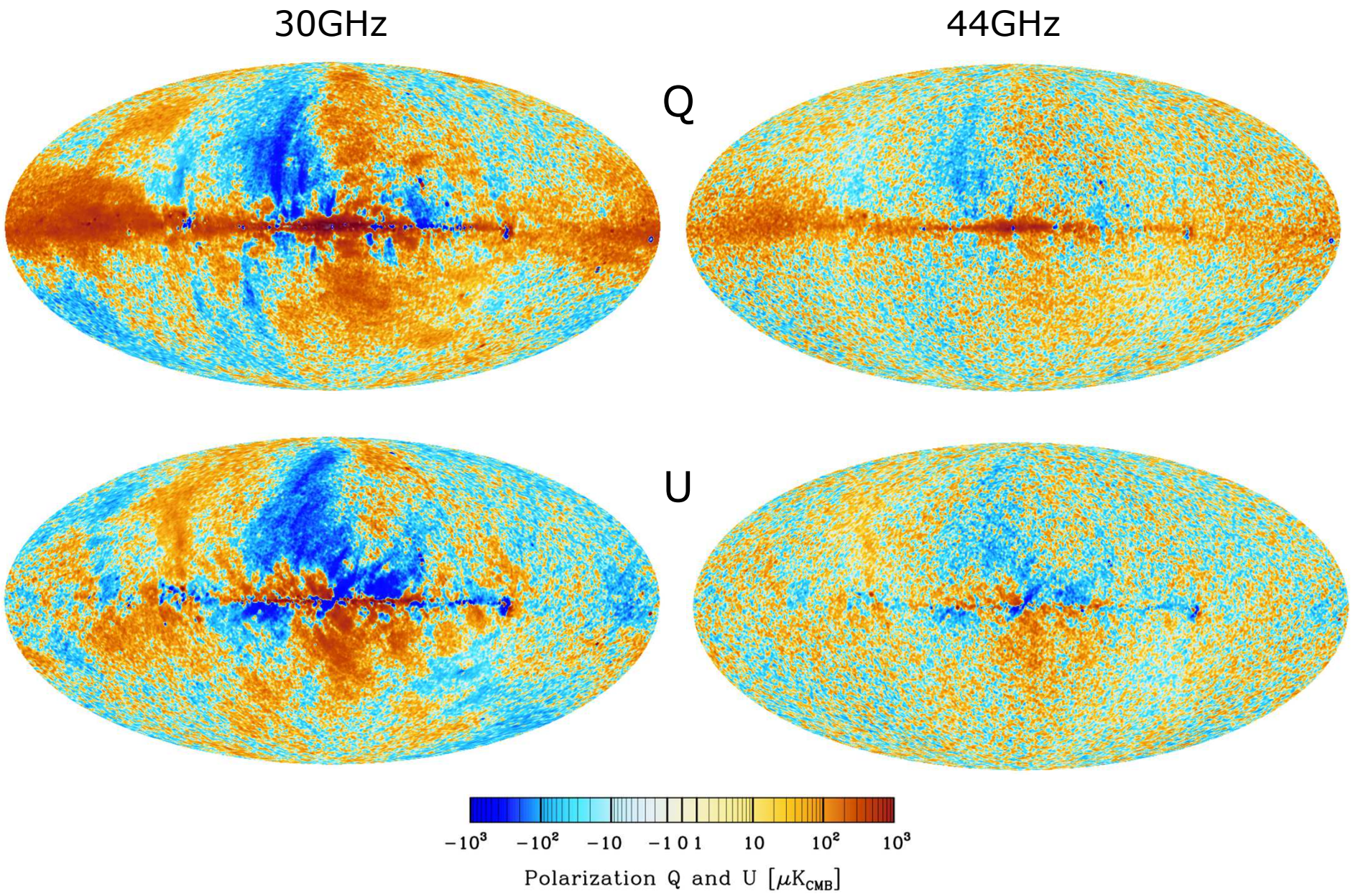
planck

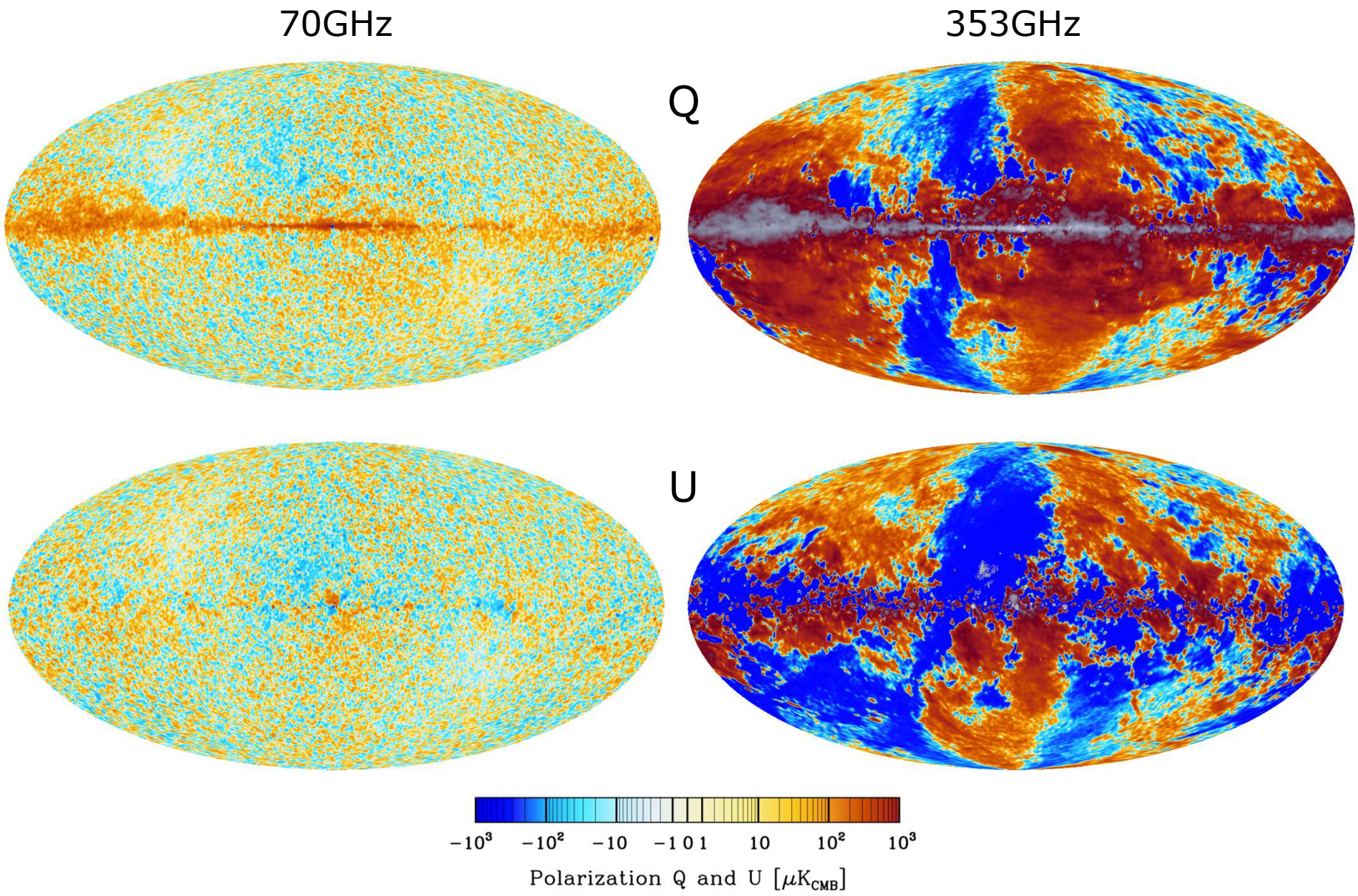
PLANCK LFI

HFI PLANCK

Planck 2014 frequency maps: Polarisation

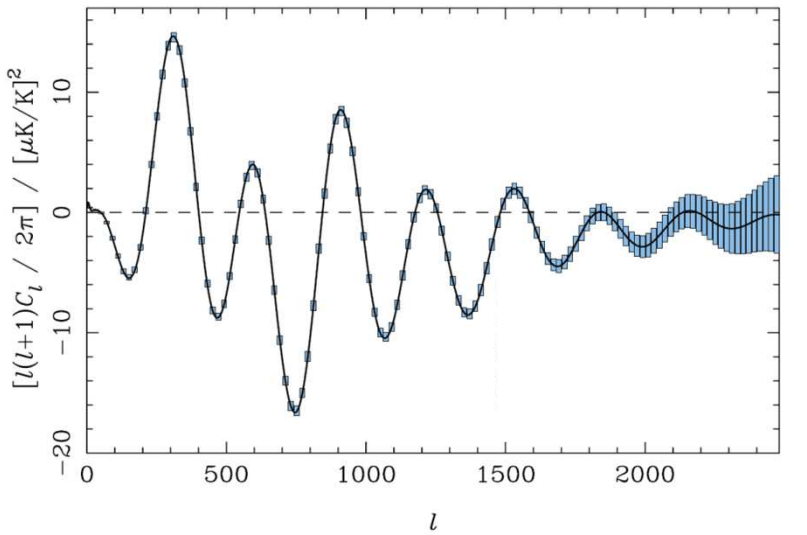


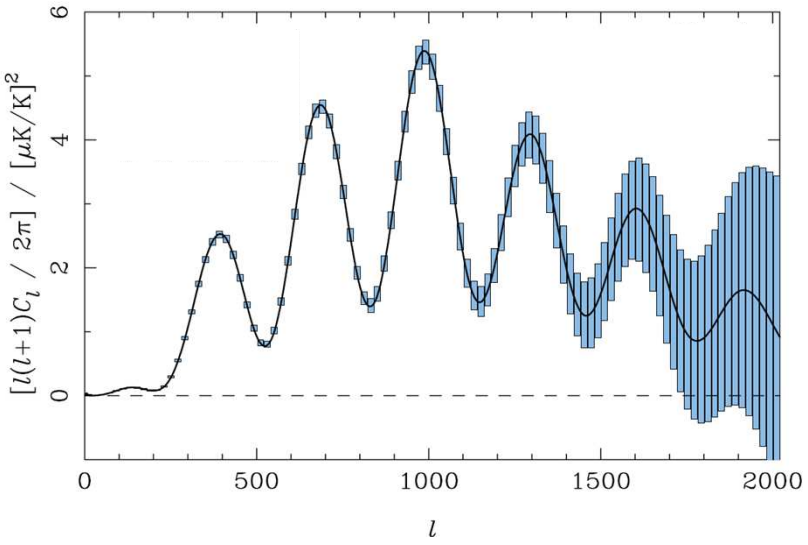
Planck 2014 frequency maps: Polarisation



Planck polarisation power spectra

BlueBook predictions





Planck 2014

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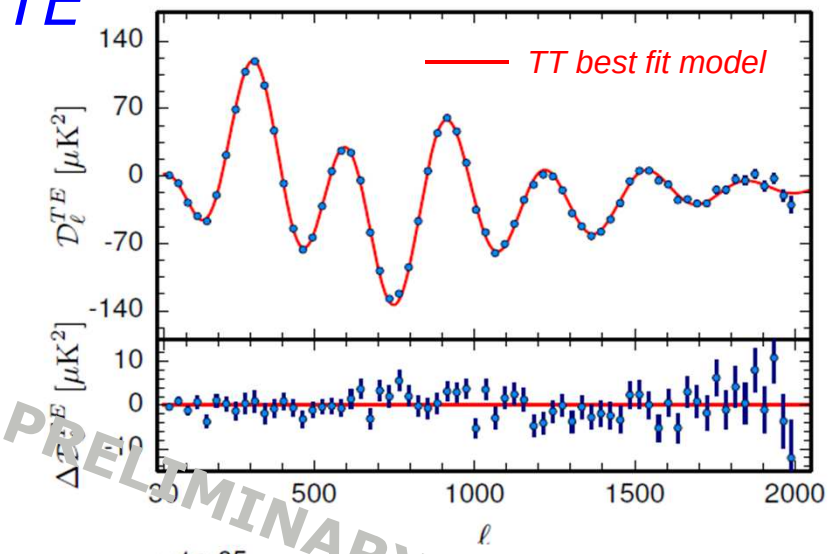
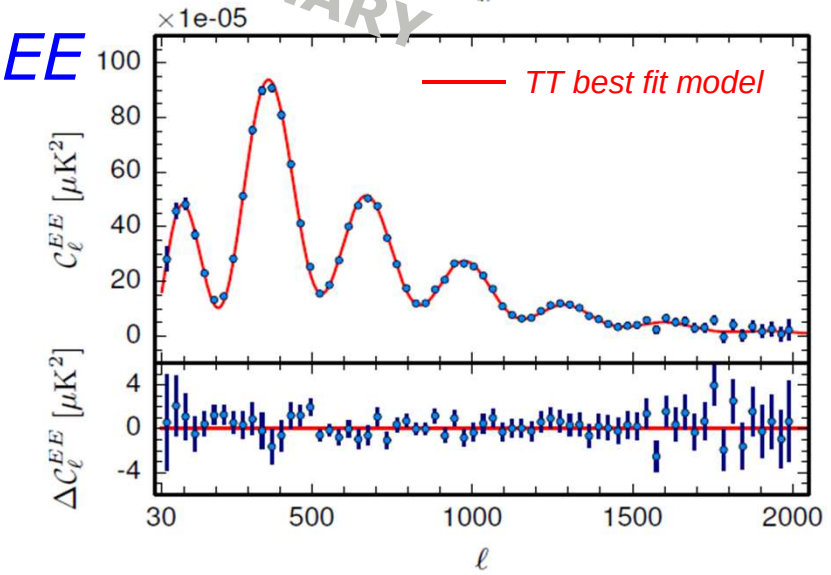


PRELIMINARY

EE



2014 Low-ell polarisation: based on 70GHz, cleaned with 30GHz and 353GHz

Component separation

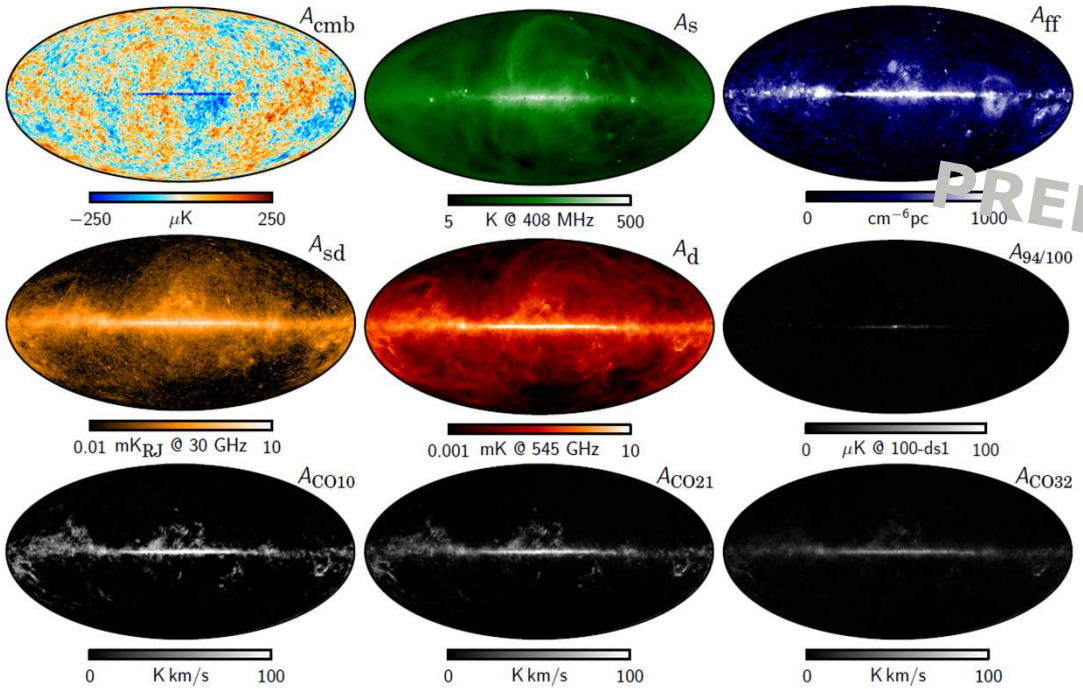
Temperature

CMB maps: 4 versions coming from different methods

SMICA, SEVEM, COMMANDER, NILC

→ Excellent agreement

Foregrounds: dust, synchrotron, free-free, spinning dust, diffuse SZ, CO

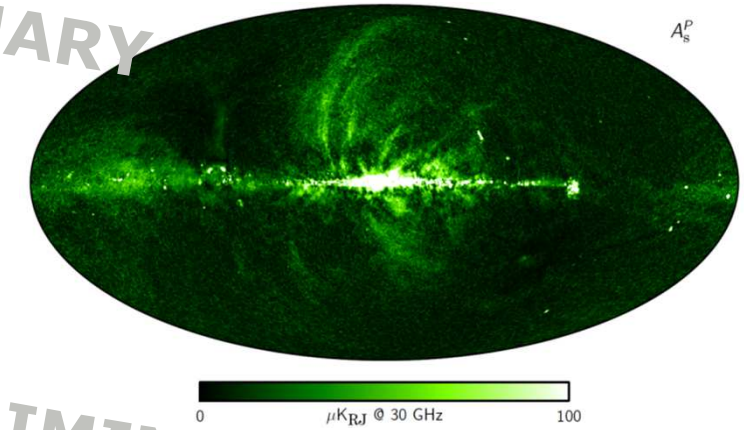


Polarisation

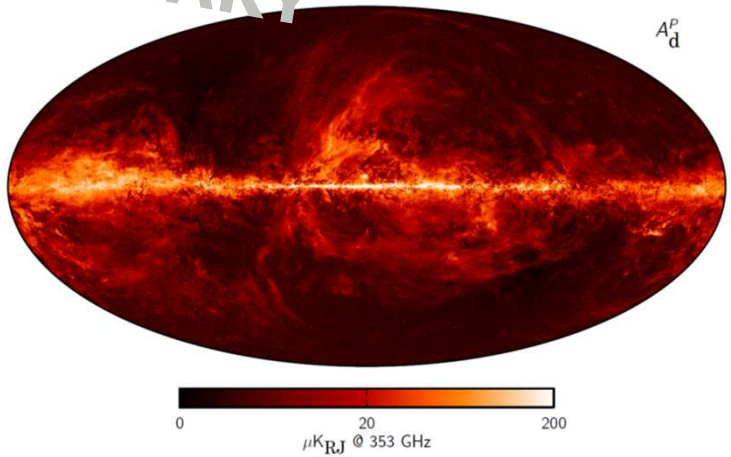
CMB map (ell>30)

Foregrounds: dust, synchrotron

Synchrotron @ 30GHz



Dust @ 353GHz



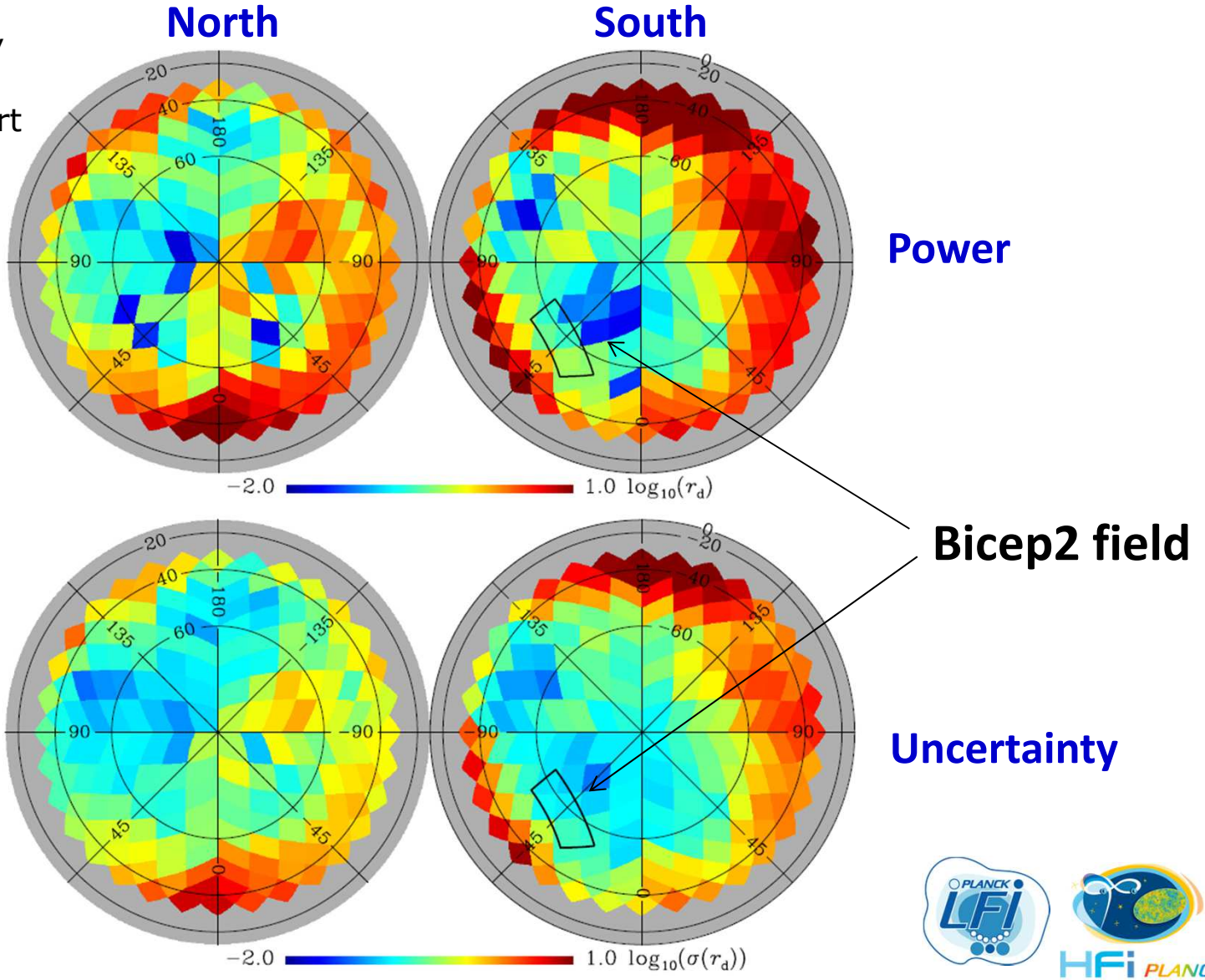
PRELIMINARY

PRELIMINARY

Estimating B-contamination from foregrounds

Planck multifrequency polarisation maps provide unique support to new generation of ground-based experiments seeking to measure B-modes

Collaborative effort is on-going between Bicep2/Keck/Planck teams



Planck Collaboration, 2014
A&A Submitted
arXiv:1409.5738

Summary of main products of 2014 Planck release

- Frequency maps: intensity and polarization: 30,44,70,353 GHz; intensity only: 100-217 GHz and 545-857 GHz;
- CMB map: intensity and polarization (ell> 30), four versions from comp separation methods;
- Likelihood: CMB+lensing Temp+Pol;
- Low-ell likelihood based on LFI 70 GHz (replaces WMAP);
- Foregrounds: dust (temp and pol), synchrotron (temp and pol), free-free, spinning dust, diffuse SZ emission (temp), CO emission;
- Map of integrated lensing potential;
- New catalogue of compact sources;
- New catalogue of SZ sources (from 1227 to 1653 sources; cosmological sample more than doubled)
- *And more…*

Aim at delivering data & papers before end of 2014

The scientific results that we present today are a product of the Planck Collaboration, which includes individuals from more than 100 scientific institutes in Europe, the USA and Canada

Planck is a project of the European Space Agency, with instruments provided by two scientific Consortia funded by ESA member states (in particular the lead countries: France and Italy) with contributions from NASA (USA), and telescope reflectors provided in a collaboration between ESA and a scientific Consortium led and funded by Denmark.