Planck

Report on the status of the mission

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Outline

- CMB
- The Planck satellite
- Data processing center
- Expectations from Planck
- Planck data

CMB

CMB anisotropies

$T(n), Q(n), U(n), V(n)$

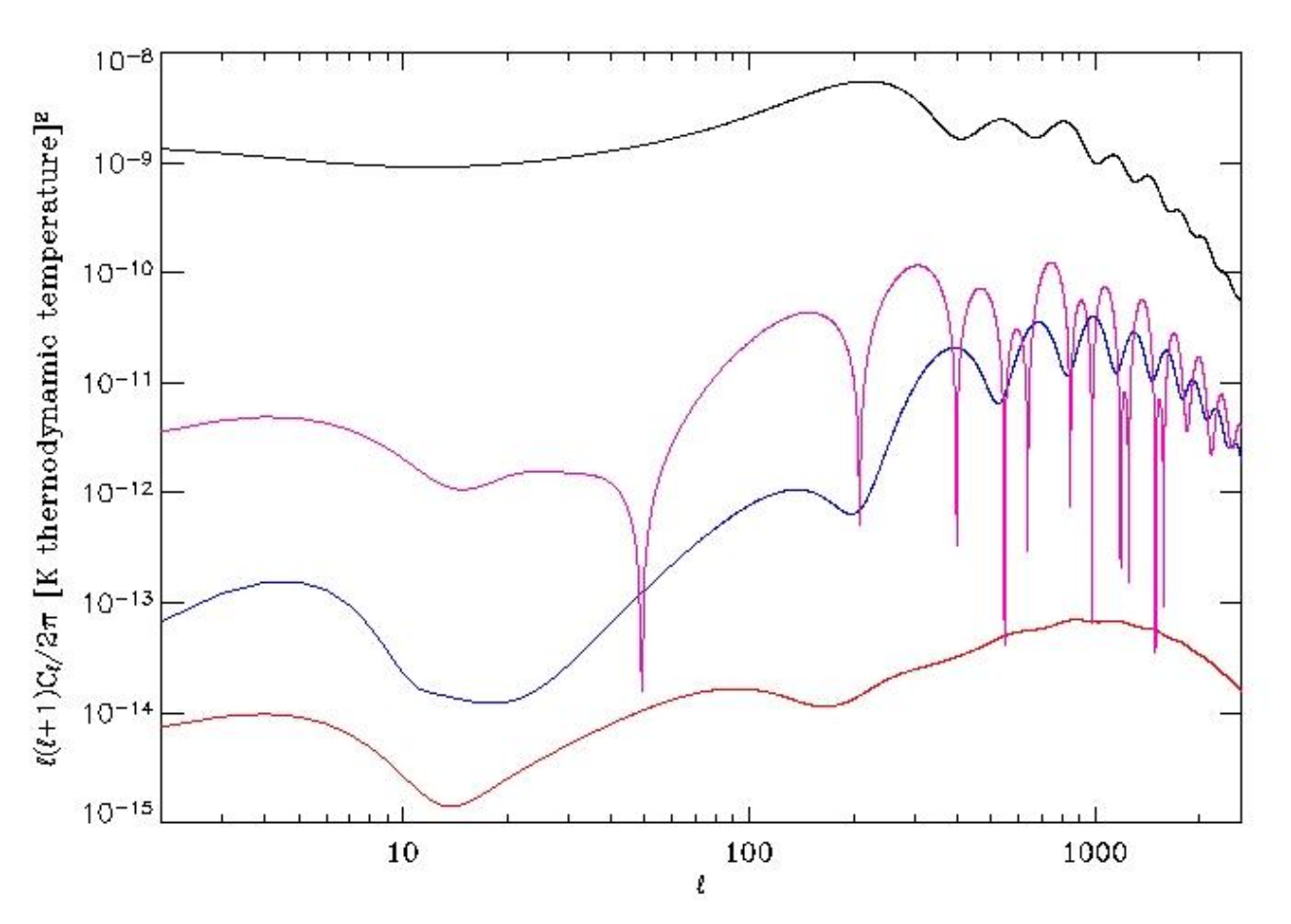
spherical harmonics

$a^{T}_{lm}, a^{E}_{lm}, a^{B}_{lm}$

information compression

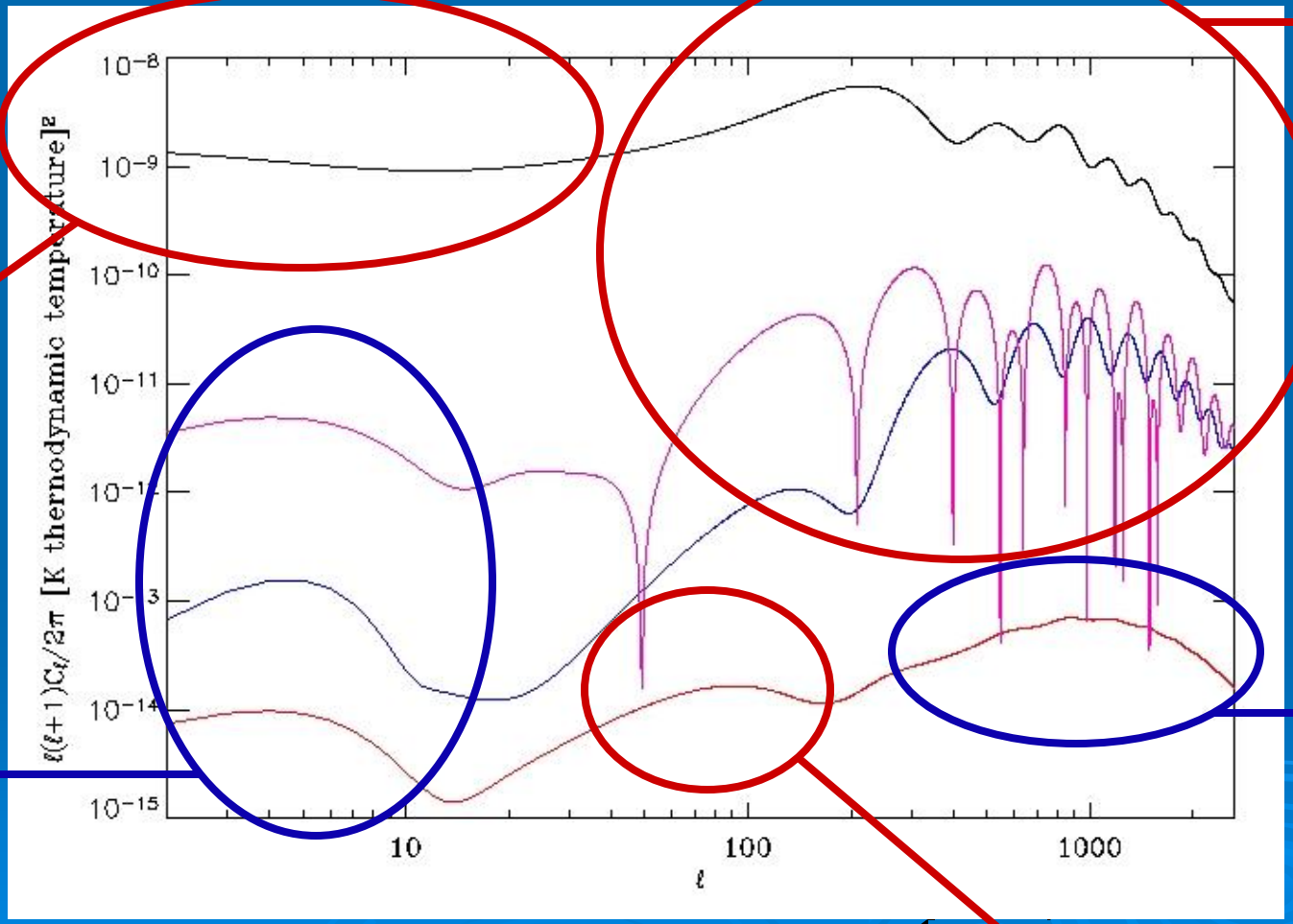
$C_l = \Sigma_m (a_{lm}^{T,E,B})(a_{lm}^{T,E,B})^*/2(l+1)$

CMB angular power spectrum



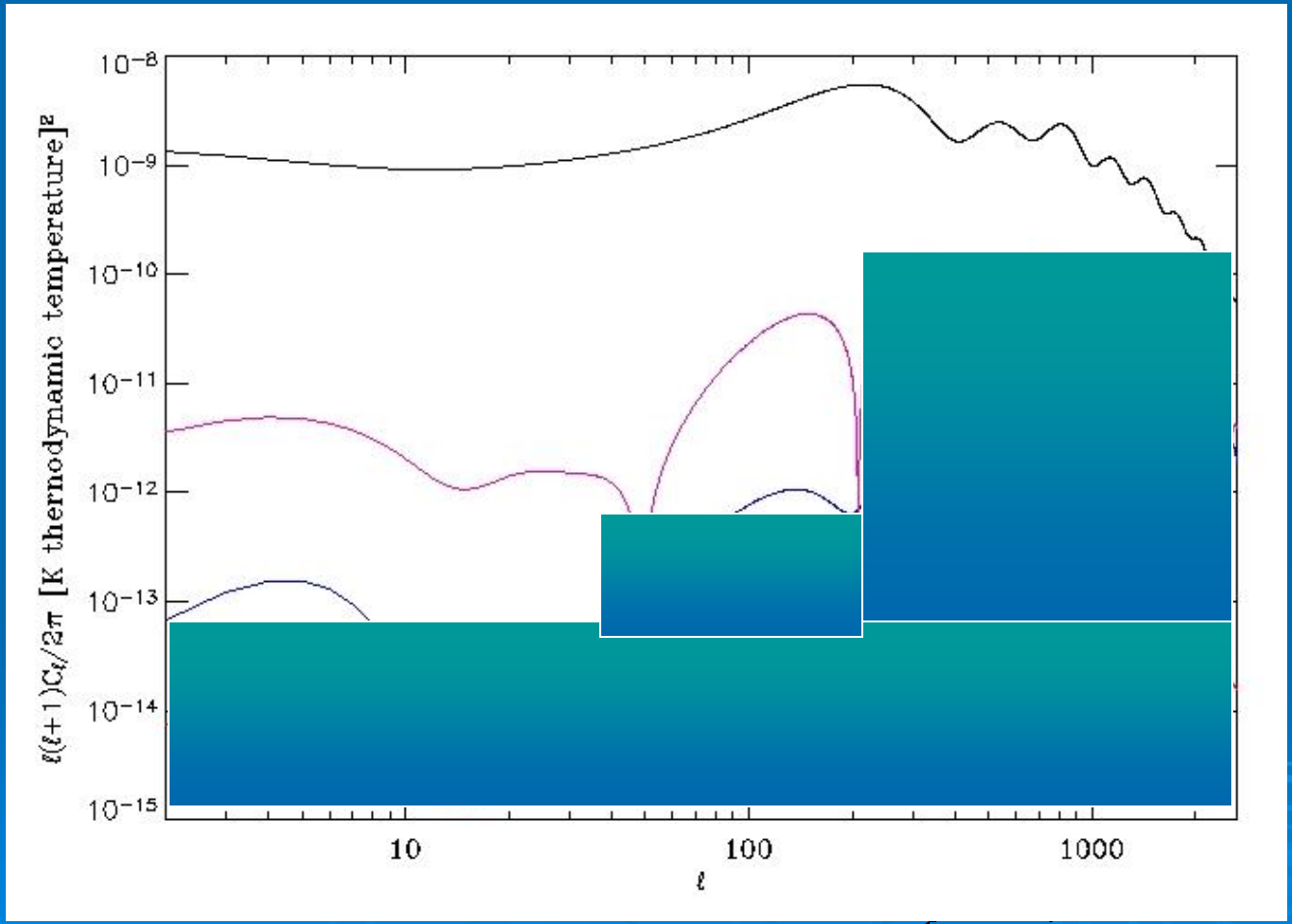
Angle ≈ 200/ℓ degrees

CMB angular power spectrum



Angle ≈ 200/ℓ degrees

Measured CMB anisotropies



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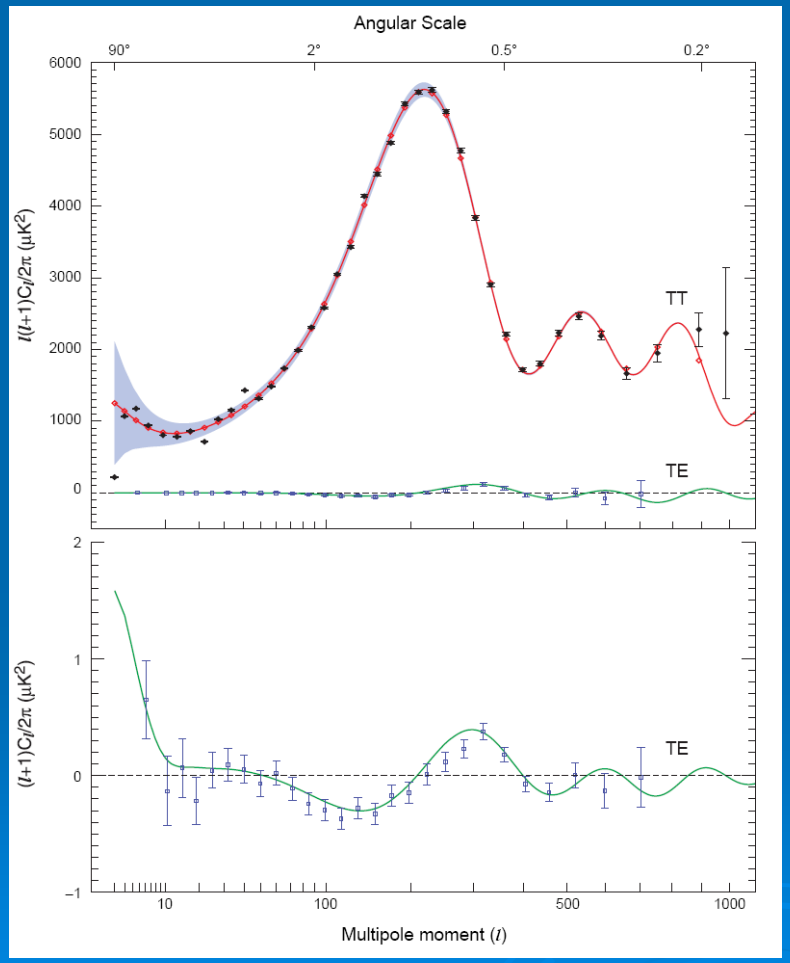
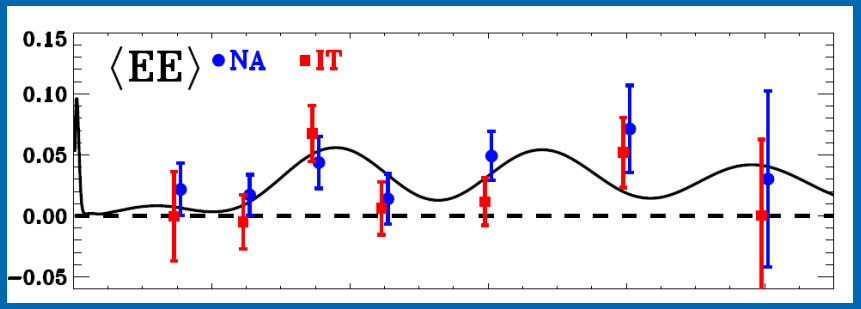
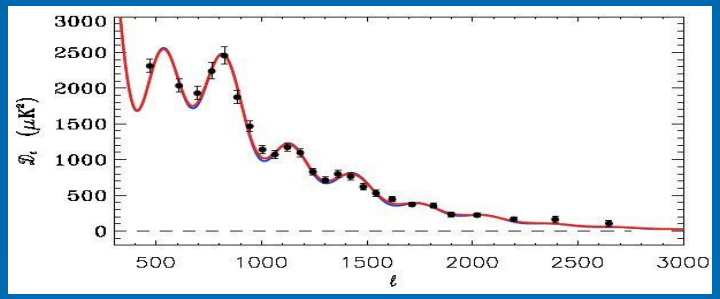
CMB angular power spectrum



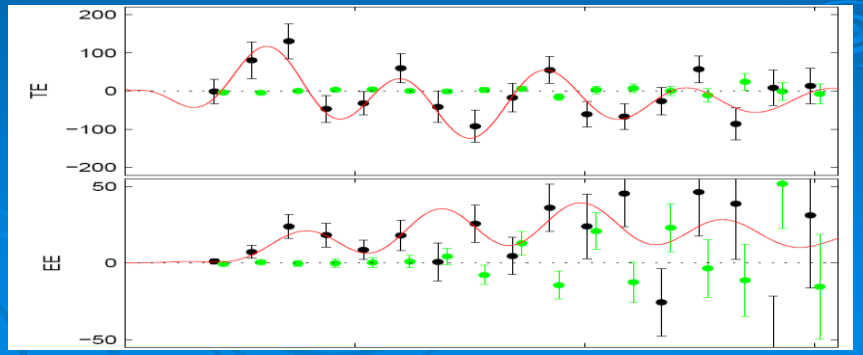
WMAP



boomerang

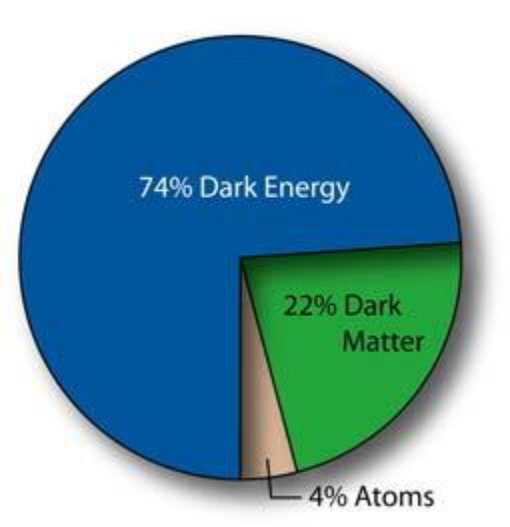


acbar



quad

Cosmological concordance model



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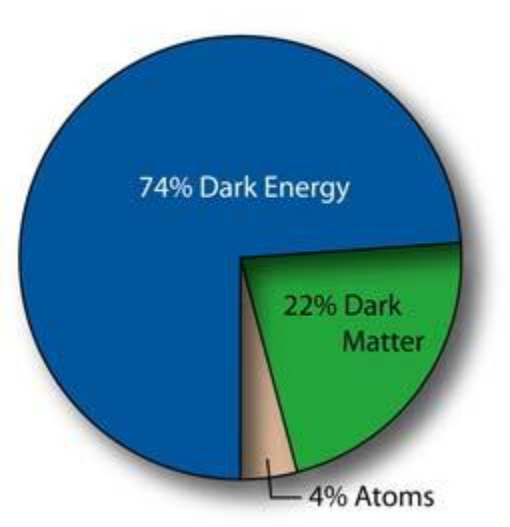

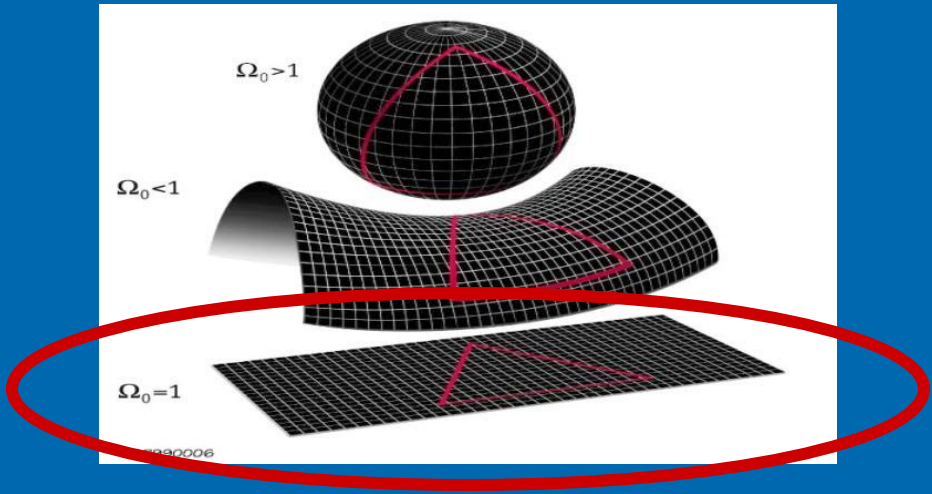

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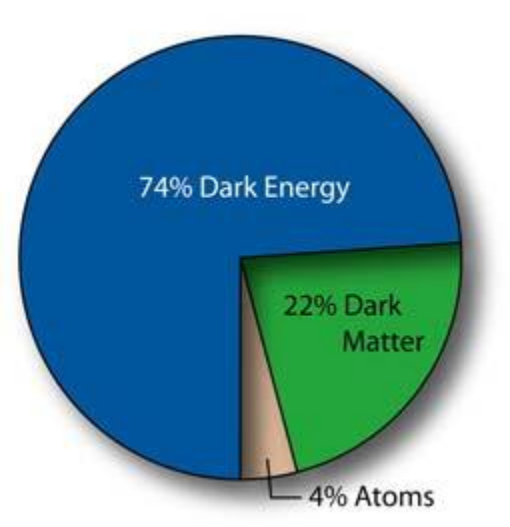
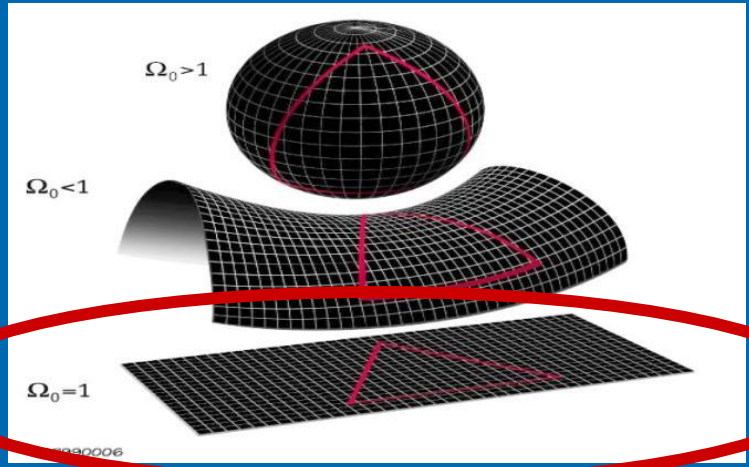


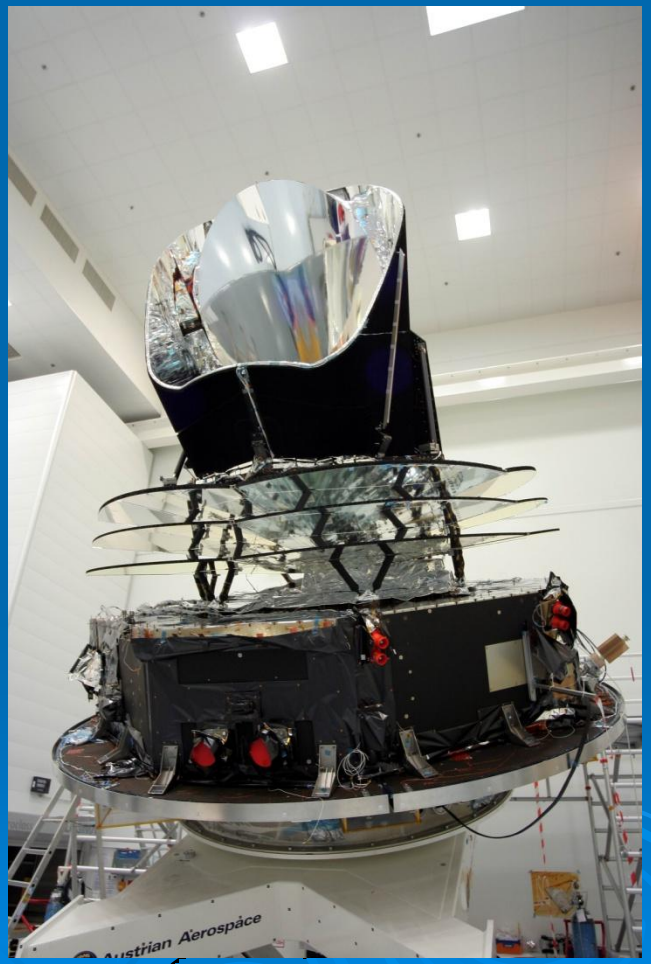


The Planck satellite

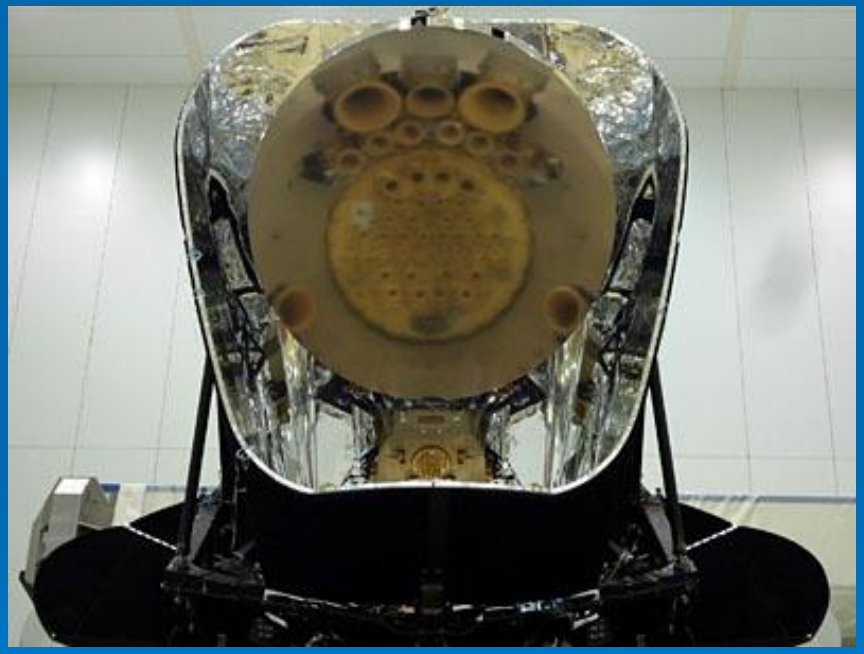
Source: Planck scientific program bluebook, available at www.rssd.esa.int/Planck

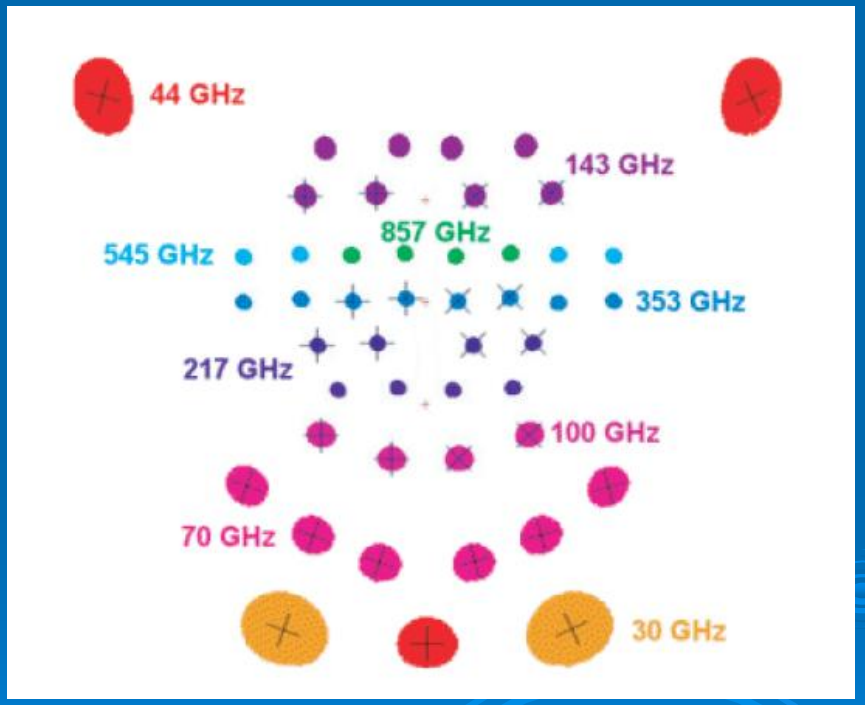
Planck

- Hardware: ~600 ME, third generation CMB probe, ESA medium size mission, NASA (JPL, Pasadena) contribution on cooling systems
- Low Frequency Instrument (LFI, Nazareno Mandolesi PI, instrument design and construction supervised by Marco Bersanelli) based on radiometer technology operating at three frequency channels, 30, 44, 70 GHz
- High Frequency Instrument (HFI, Jean-Loup Puget PI) based on bolometer technology, operating at 100, 143, 217, 353, 545 GHz
- About 16 years (1993-2009) of design and construction



The Planck focal plane



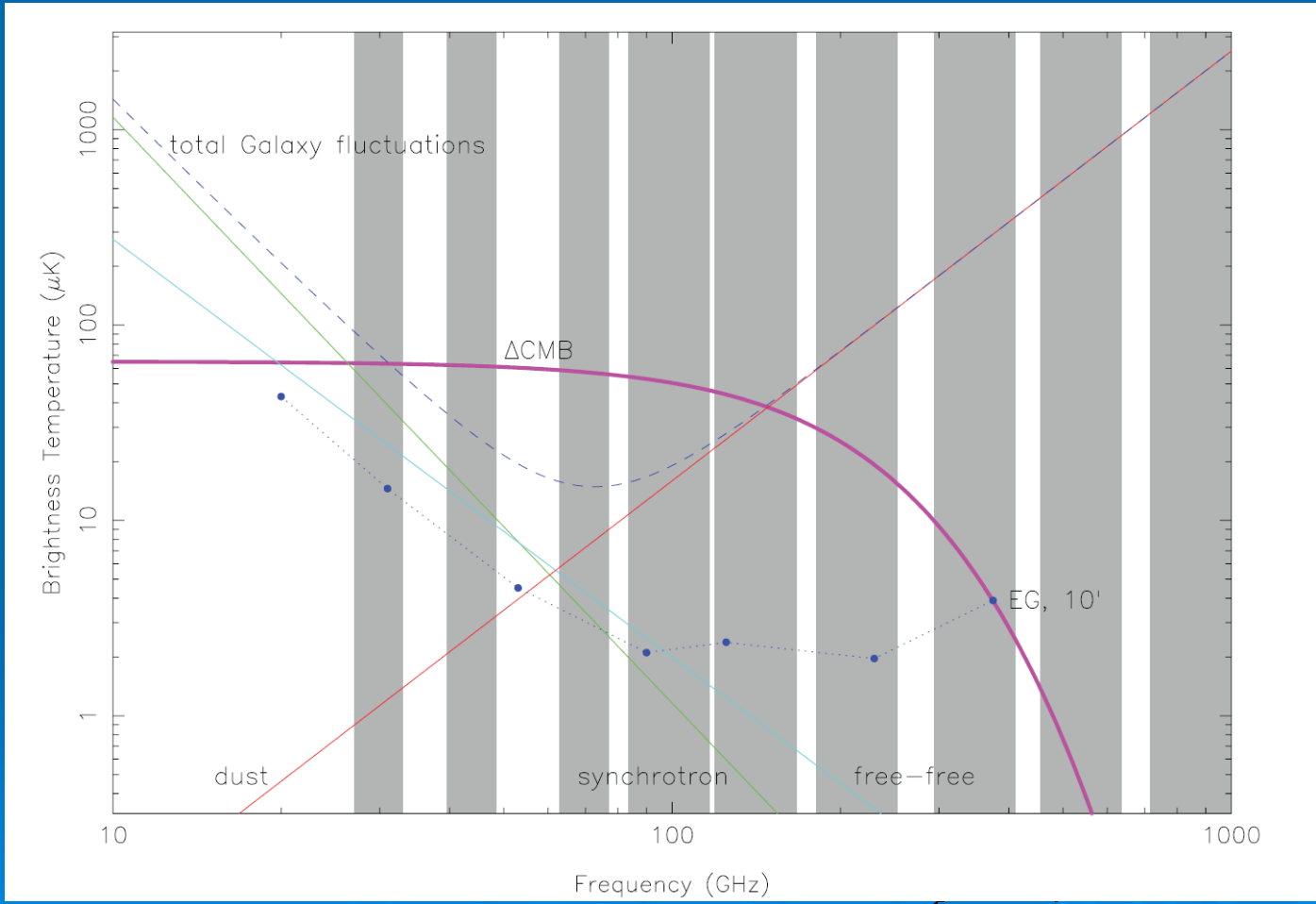


Planck detectors

Instrument Characteristic	Center Frequency [GHz]		
	30	44	70
InP HEMT Detector technology	MIC		MMIC
Detector temperature	20 K		
Cooling system	H_2 Sorption Cooler		
Number of feeds	2	3	6
Angular resolution [arcminutes FWHM]	33	24	14
Effective bandwidth [GHz]	6	8.8	14
Sensitivity [mK $Hz^{-1/2}$]	0.17	0.20	0.27
System temperature [K]	7.5	12	21.5
Noise per 30′ reference pixel [μK]	6	6	6
$\Delta T/T$ Intensity [b] [10^{-6} μK/K]	2.0	2.7	4.7
($\Delta T/T$) Polarisation (Q and U) [b] [μK/K]	2.8	3.9	6.7
Maximum systematic error per pixel [μK]	< 3	< 3	< 3

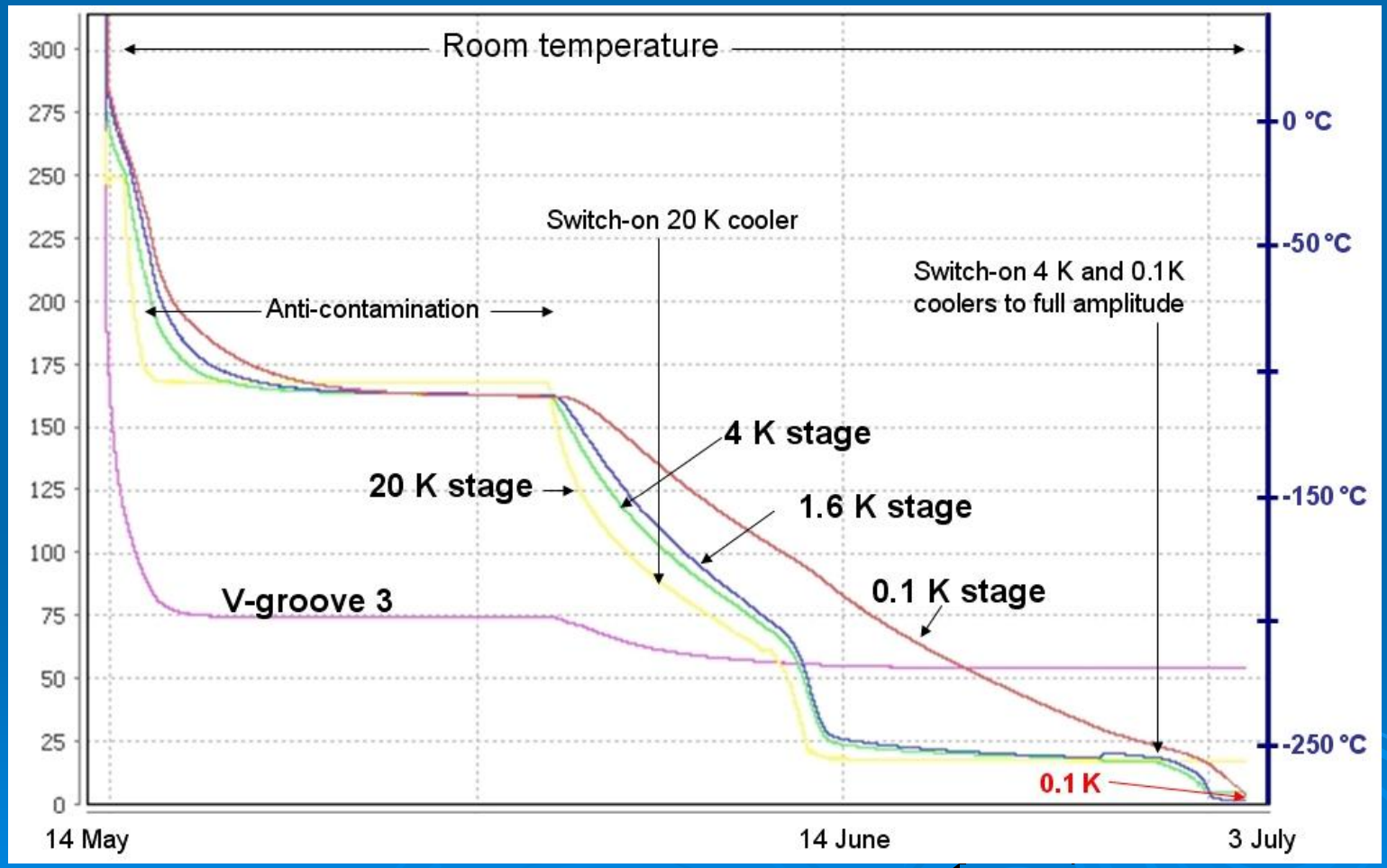
Instrument Characteristic	Center Frequency [GHz]					
	100	143	217	353	545	857
Spectral resolution $\nu/\Delta\nu$	3	3	3	3	3	3
Detector technology	Spider-web and polarisation-sensitive bolometers					
Detector temperature	0.1 K					
Cooling system	20 K Sorption Cooler + 4 K J-T + 0.1 K Dilution					
Number of spider-web bolometers	0	4	4	4	4	4
Number of polarisation-sensitive bolometers	8	8	8	8	0	0
Angular resolution [FWHM arcminutes]	9.5	7.1	5.0	5.0	5.0	5.0
Detector Noise-Equivalent Temperature [$\mu K s^{0.5}$]	50	62	91	277	1998	91000
$\Delta T/T$ Intensity [b] [$10^{-6}\mu$K/K]	2.5	2.2	4.8	14.7	147	6700
$\Delta T/T$ Polarisation (U and Q)[b] [$10^{-6}\mu$K/K]	4.0	4.2	9.8	29.8	...	...
Sensitivity to unresolved sources [mJy]	12.0	10.2	14.3	27	43	49
ySZ per FOV [10^{-6}]	1.6	2.1	615	6.5	26	605

Planck frequency coverage



The Planck launch, May 14th, 2009

Planck cooling



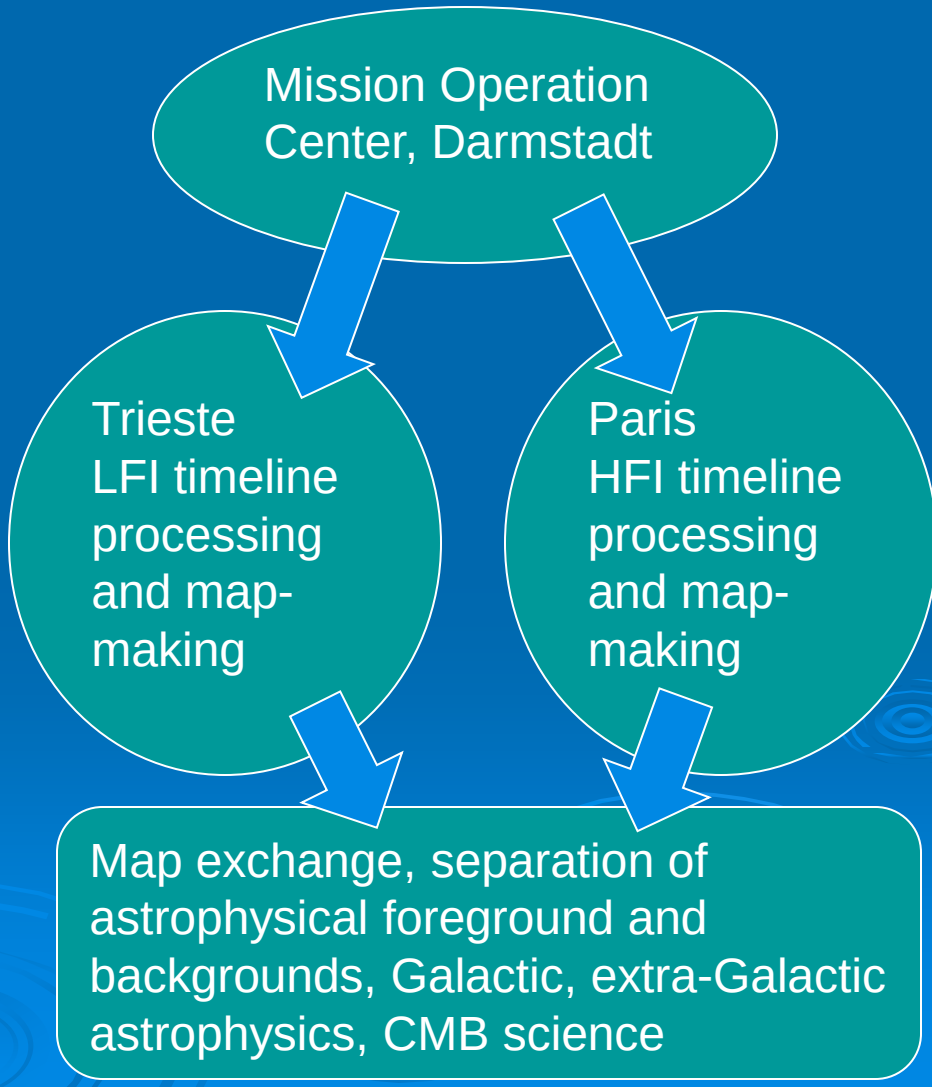
Data processing center

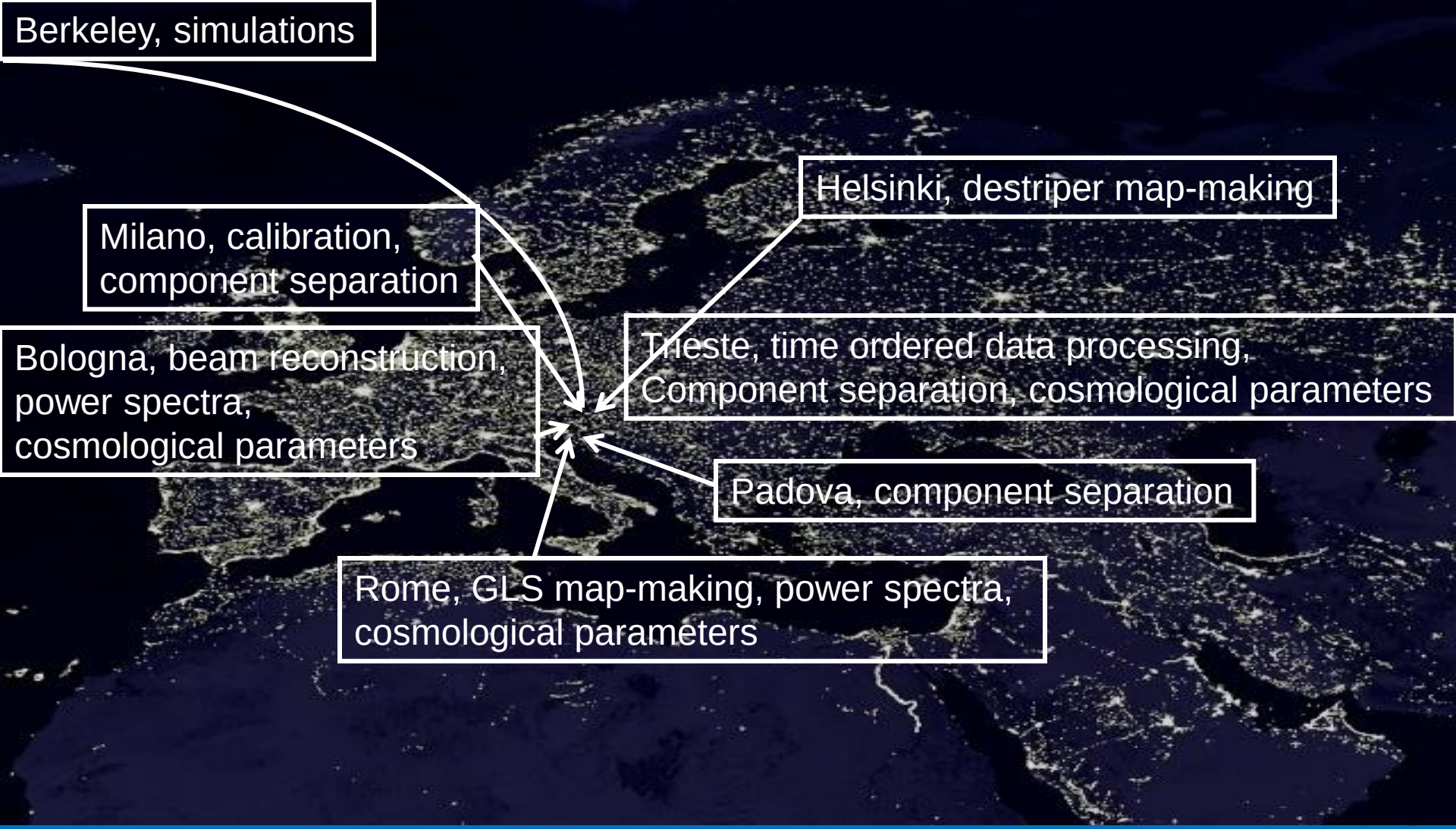
Planck contributors

Planck data processing centers

Data flow and analysis levels

- Level 1, telemetry, timeline processing, calibration
- Level 2, map-making
- Level 3, multi-frequency analysis, production of Galactic, extra-Galactic and CMB science products




Berkeley, simulations
Helsinki, destriper map-making
Milano, calibration, component separation
Trieste, time ordered data processing, Component separation, cosmological parameters
Bologna, beam reconstruction, power spectra, cosmological parameters
Padova, component separation
Rome, GLS map-making, power spectra, cosmological parameters

The LFI DPC

Planck DPC facilities

- DPC people physically in Trieste are about 20 at OATs and SISSA
- The data are hosted on two computers, ENT (OATs, front-end database and computing resource, 256 CPUs, hundreds of GB RAM, tens of TB disk space), HG1 (SISSA, computing resources, 160 CPUs, hundreds of GB RAM, tens of TB disk space)

Planck milestones

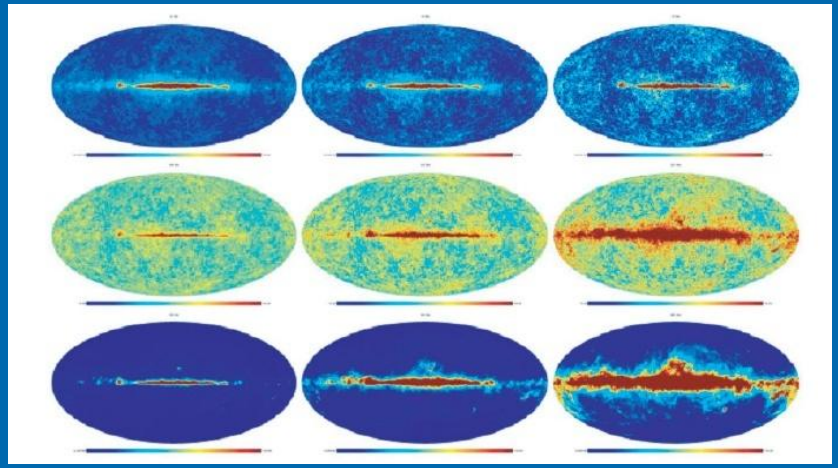
- May 14th, 2009, launch, the High Frequency Instrument (HFI, bolometers) is on
- June 1st, 2009, active cryogenic systems are turned on
- June 8th, 2009, the Low Frequency Instrument (LFI, radiometers), is turned on
- Summer 2009, Planck gets to L2, survey begins, 14 months
- 2 years of proprietary period and data analysis
- Early papers on extra-Galactic astrophysics, early 2011
- Complete results including cosmology, end of 2012
- Mission extended! Survey doubled, beginning October 2010, ending end of 2011

Expectations from Planck

Source: Planck scientific program bluebook, available at www.rssd.esa.int/Planck

Planck deliverables

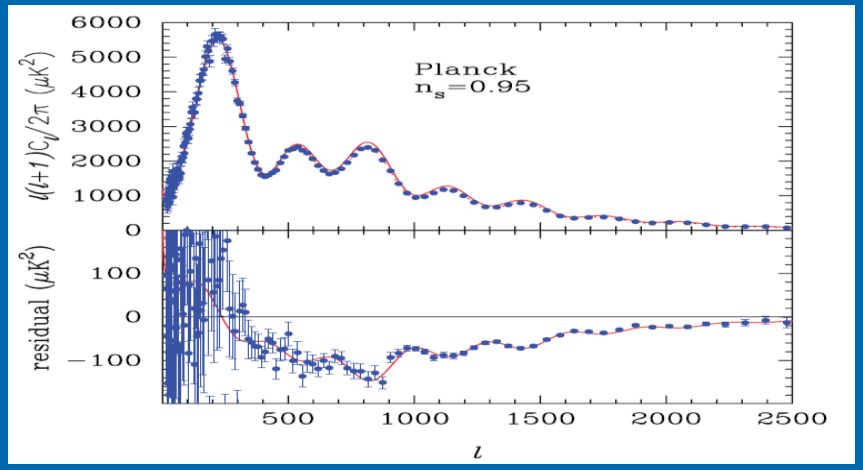
- All sky maps in total intensity and polarization, at 9 frequencies between 30 and 857 GHz
- Angular resolution from 33’ to 7’ between 30 and 143 GHz, 5’ at higher frequencies
- S/N ≈ 10 for CMB in total intensity, per resolution element
- Catalogues with tens of thousands of extra-Galactic sources

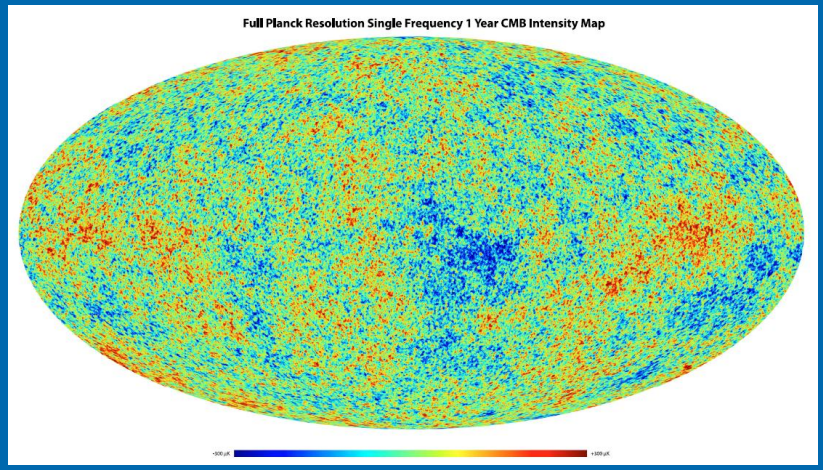


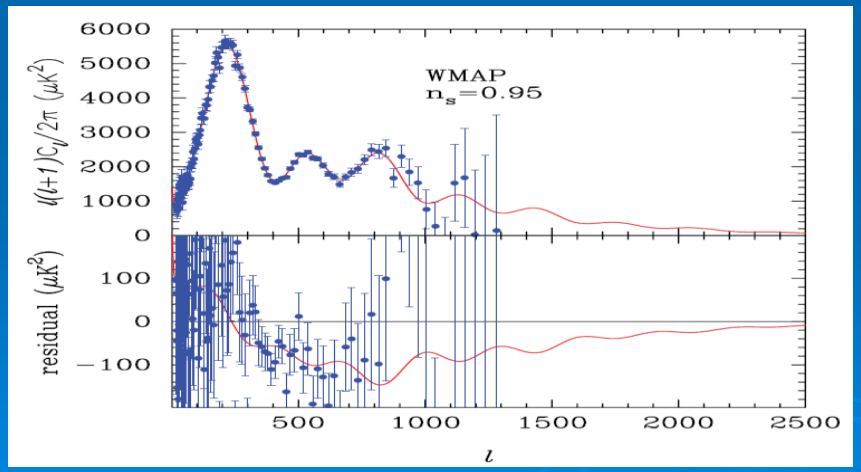
PLANCK GALAXY SURVEYS

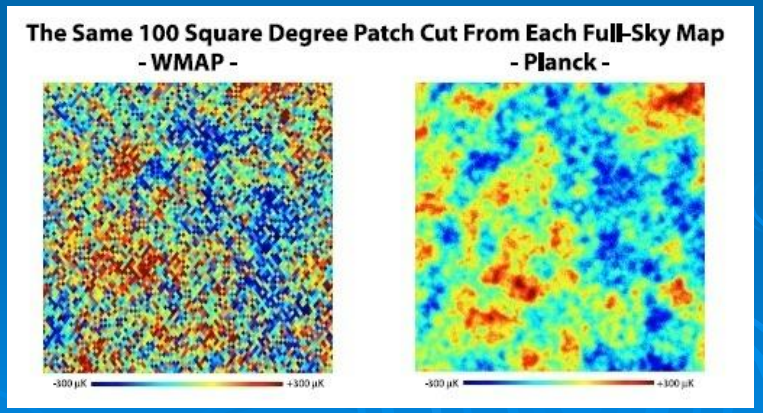
	FREQUENCY [GHz]				
	143	217	353	550	850
Confusion limit [mJy, 3σ]	6.3	14.1	44.7	112	251
Planck All Sky Survey sensitivity [mJy, 3σ]	26	37	75	180	300
Planck Deep Survey sensitivity [mJy, 3σ]	10	18.4	49	170	280
Number of galaxies [all sky]	570	860	1700	4400	35000

CMB imaging

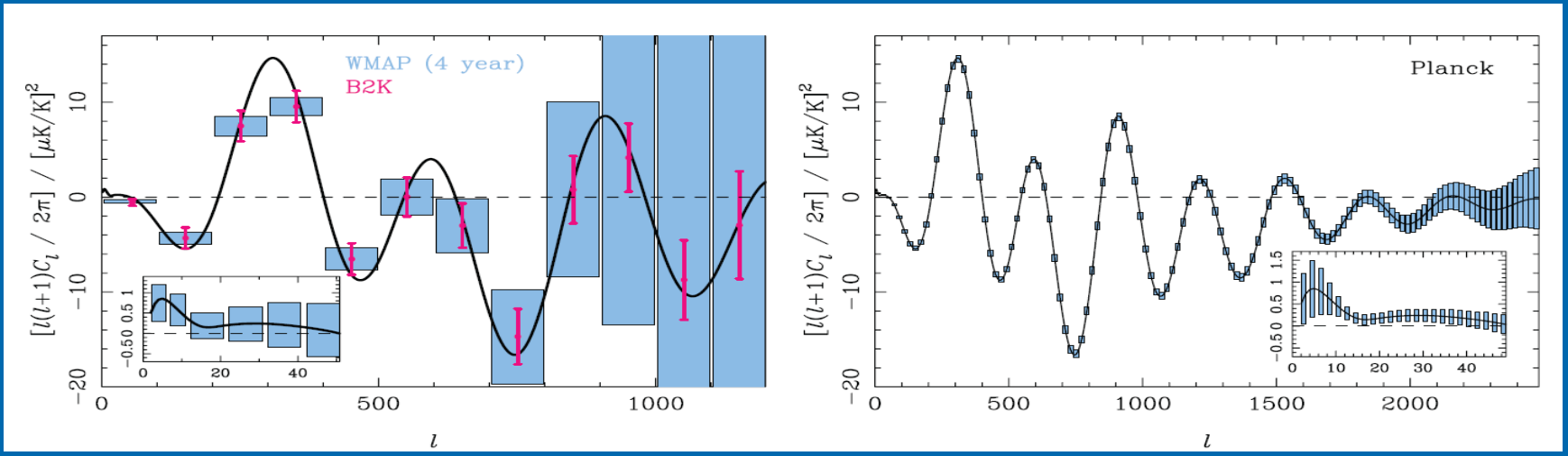

Planck
n_s=0.95
$l(l+1)C_l/2\pi$ (μK^2)
residual (μK^2)
6000
5000
4000
3000
2000
1000
0
100
0
−100
500
1000
1500
2000
2500
l

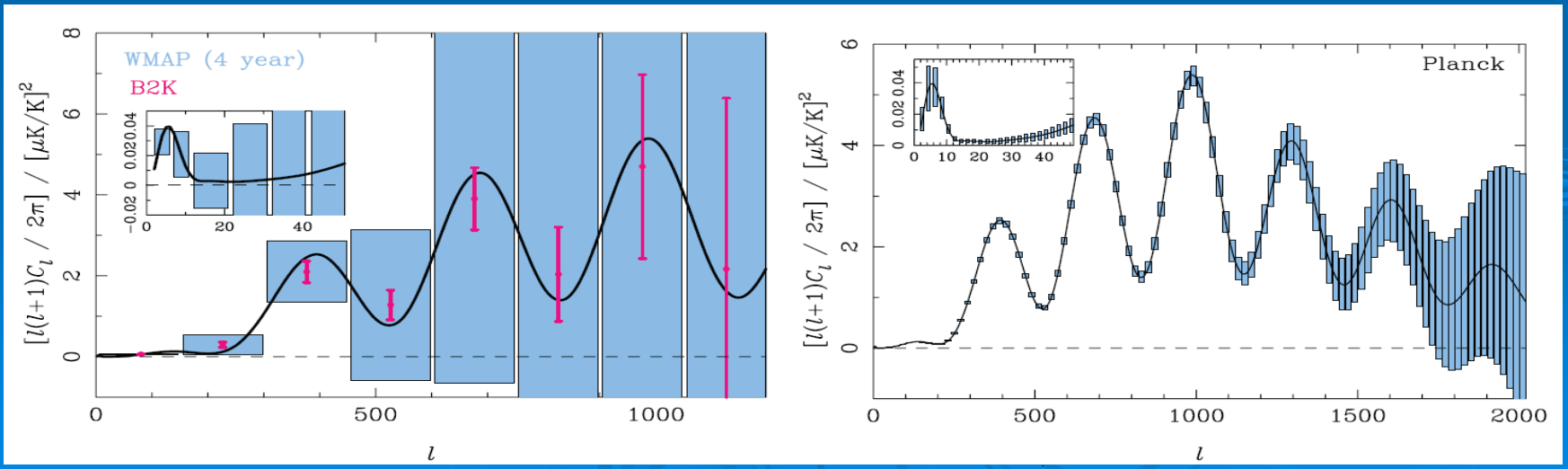

Full Planck Resolution Single Frequency 1 Year CMB Intensity Map


WMAP
n_s=0.95
$l(l+1)C_l/2\pi$ (μK^2)
residual (μK^2)
6000
5000
4000
3000
2000
1000
0
100
0
−100
500
1000
1500
2000
2500
l

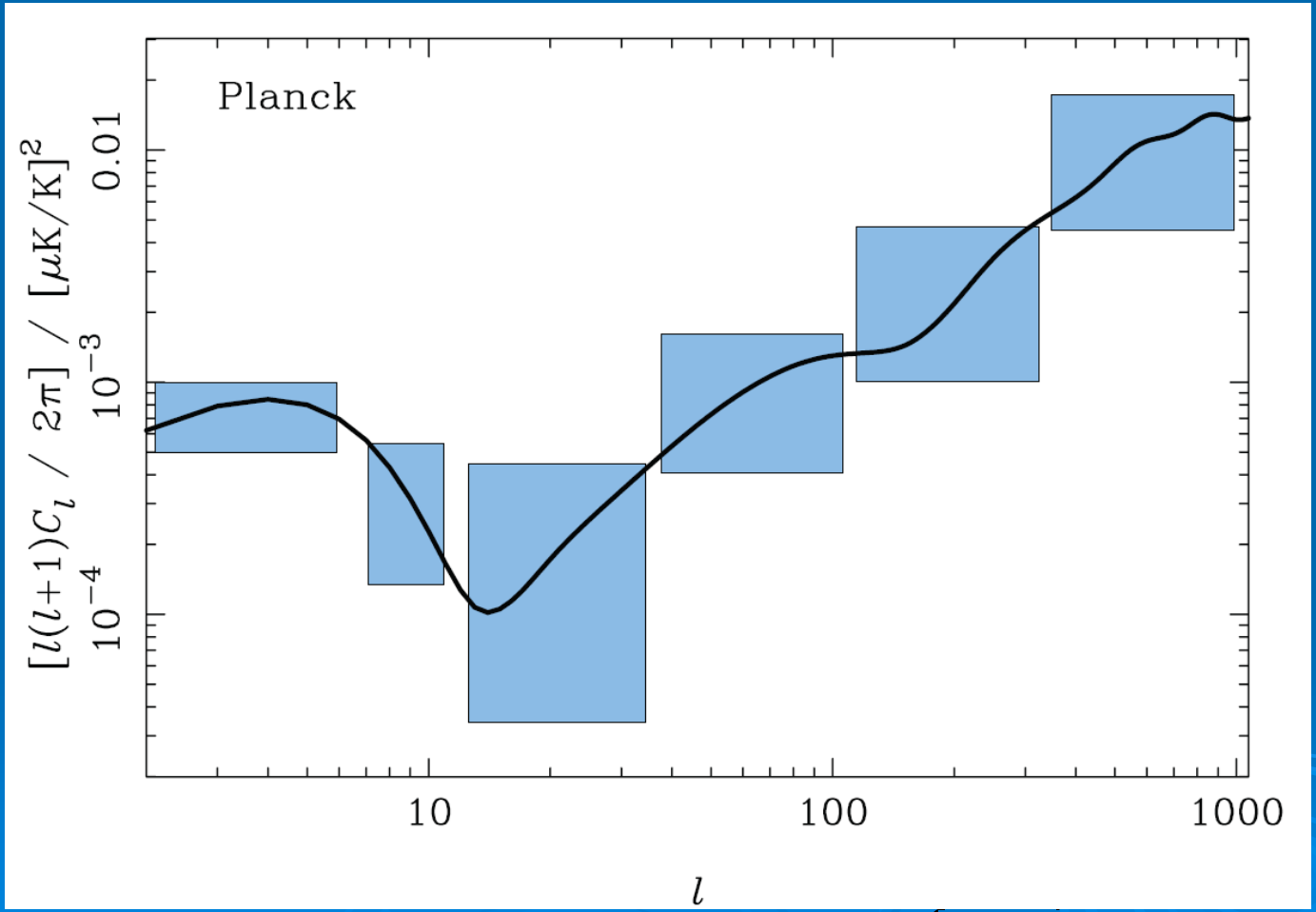

The Same 100 Square Degree Patch Cut From Each Full-Sky Map
- WMAP -
- Planck -
-300 μK
+300 μK
-300 μK
+300 μK

CMB polarization

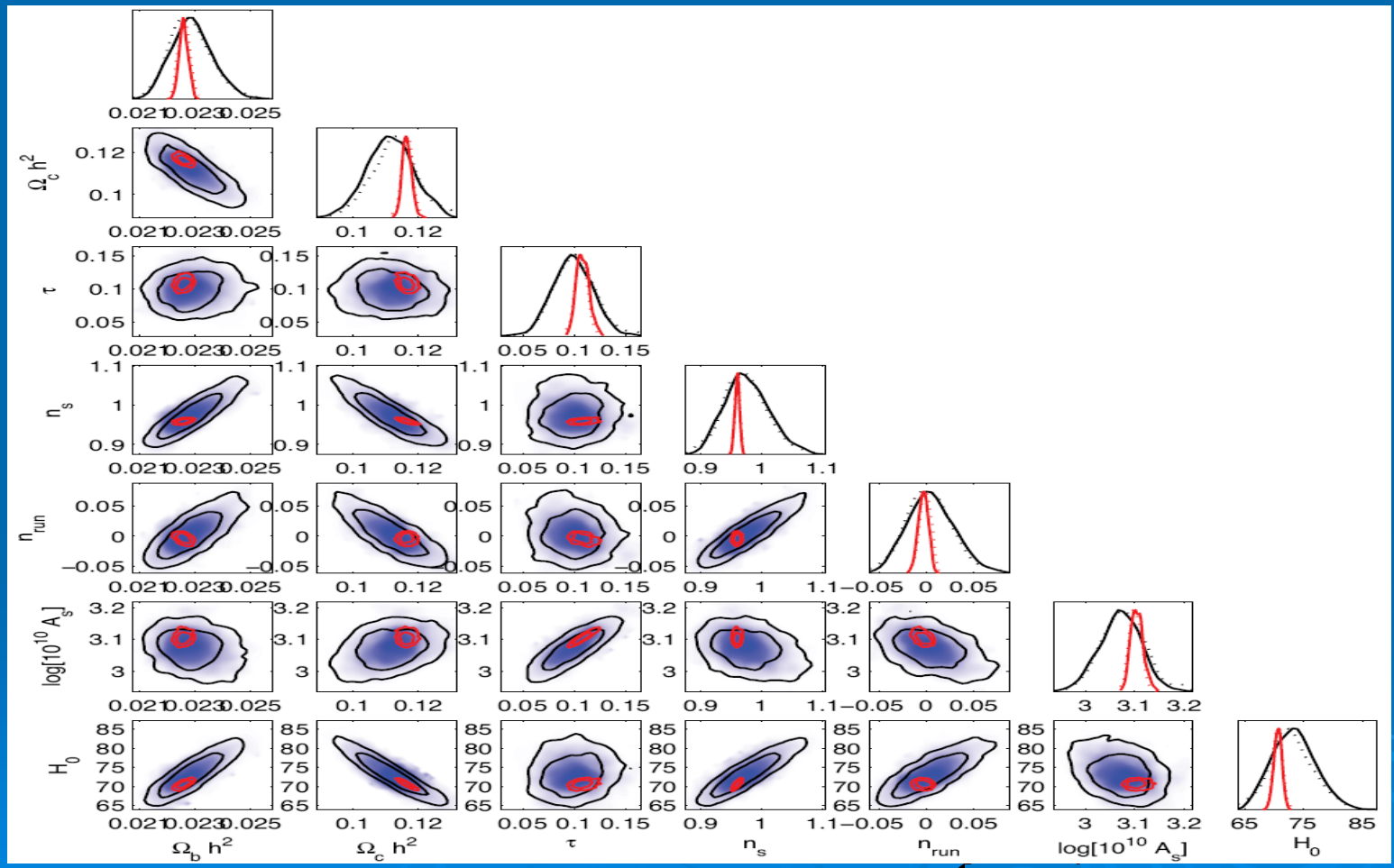




Probing next generation CMB goals



Cosmological parameters

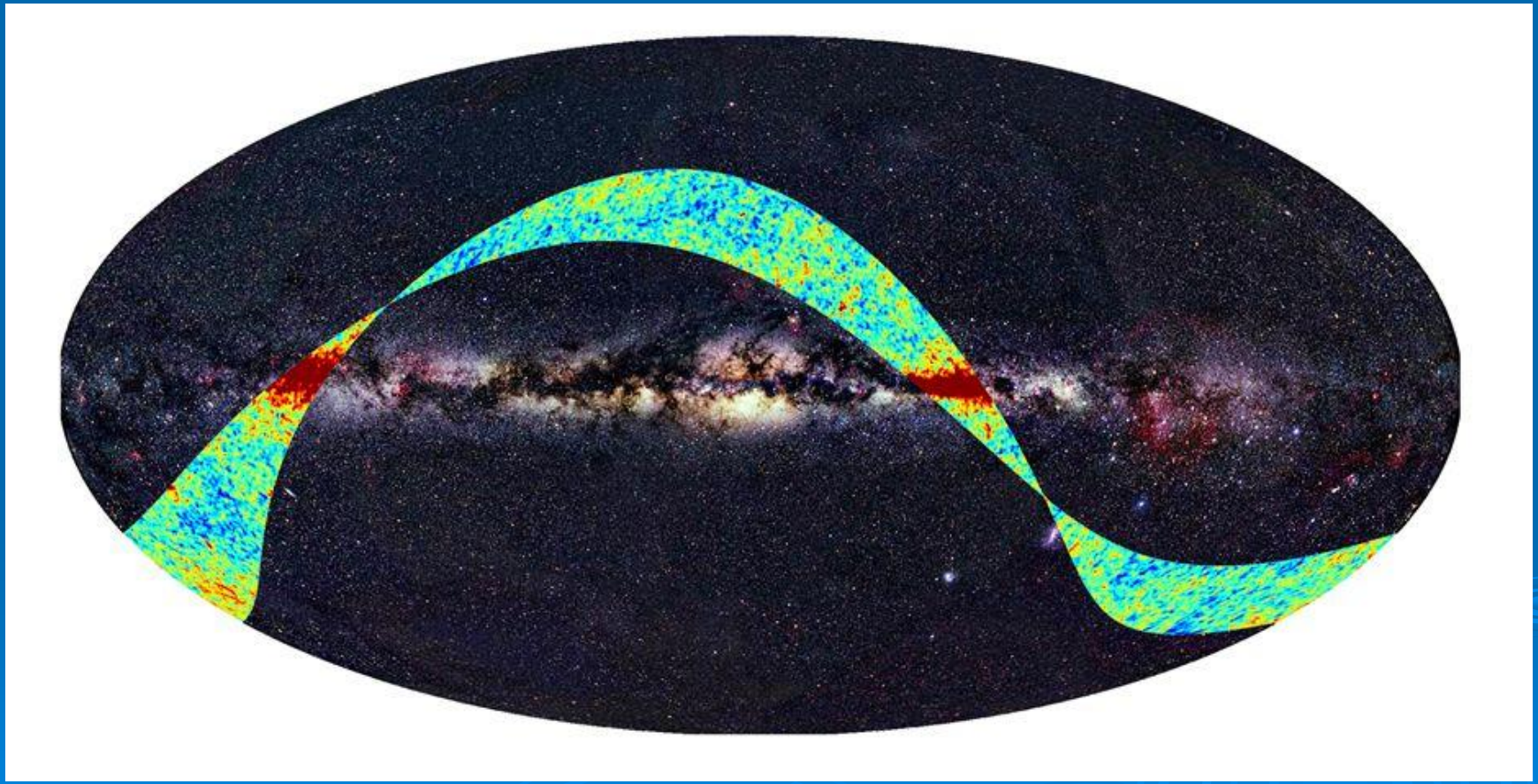


Non-CMB Planck scientific deliverables

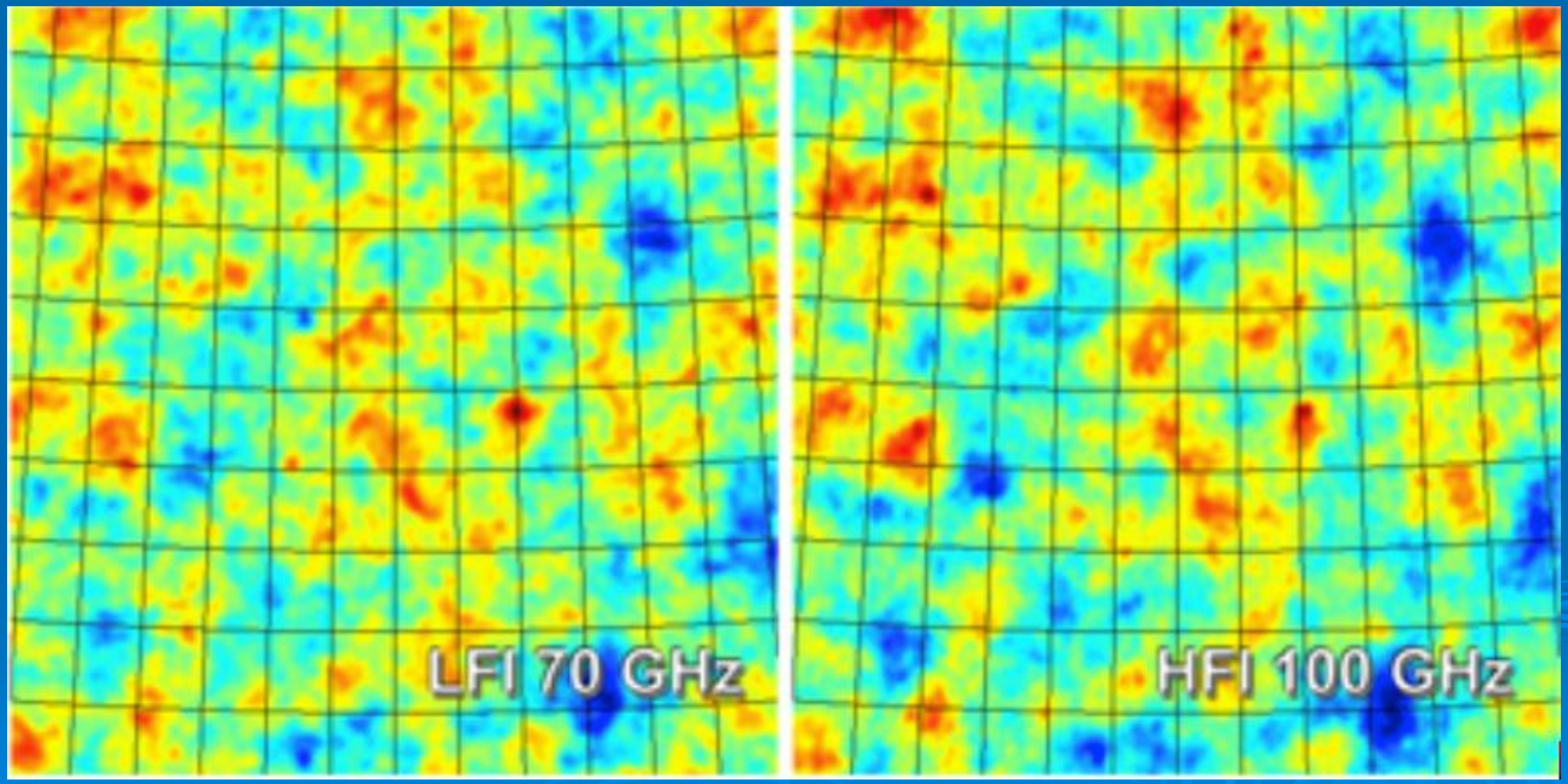
- ~10^3 galaxy clusters
- ~10^4 radio and infrared extra-Galactic sources
- Unprecedented insight into the physics of diffuse gas in the Galaxy, Galactic magnetic field, …
- …

Planck data

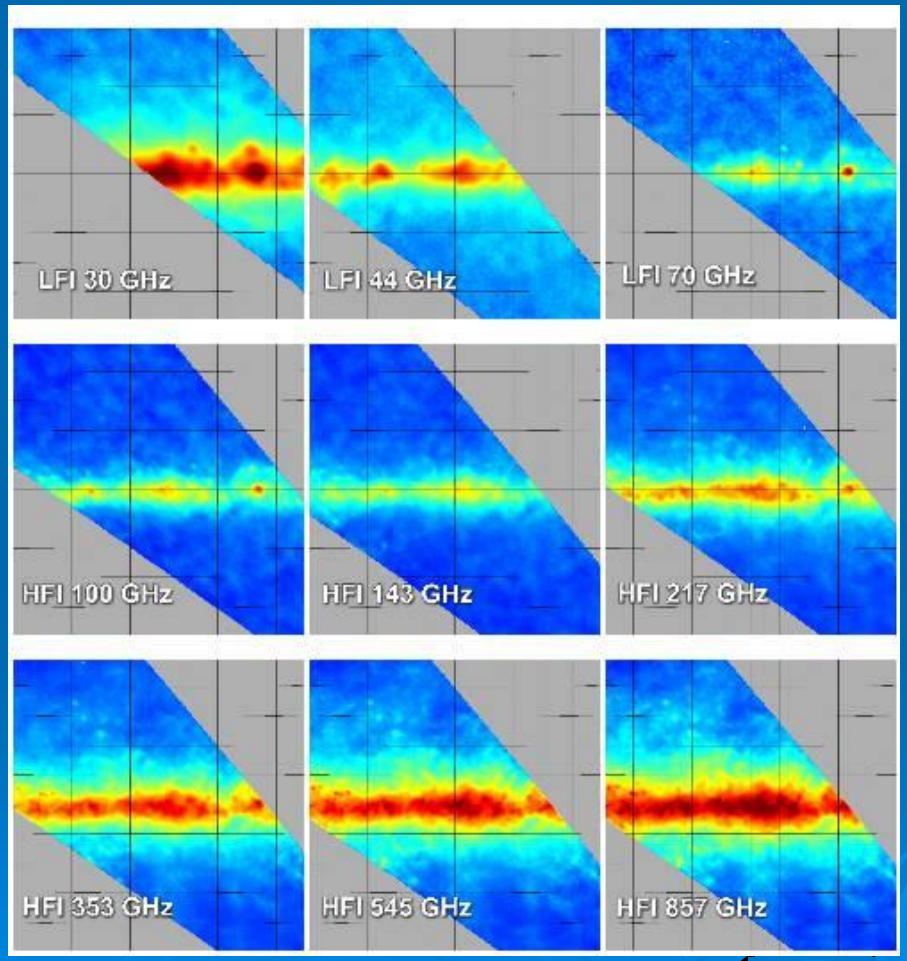
First light survey



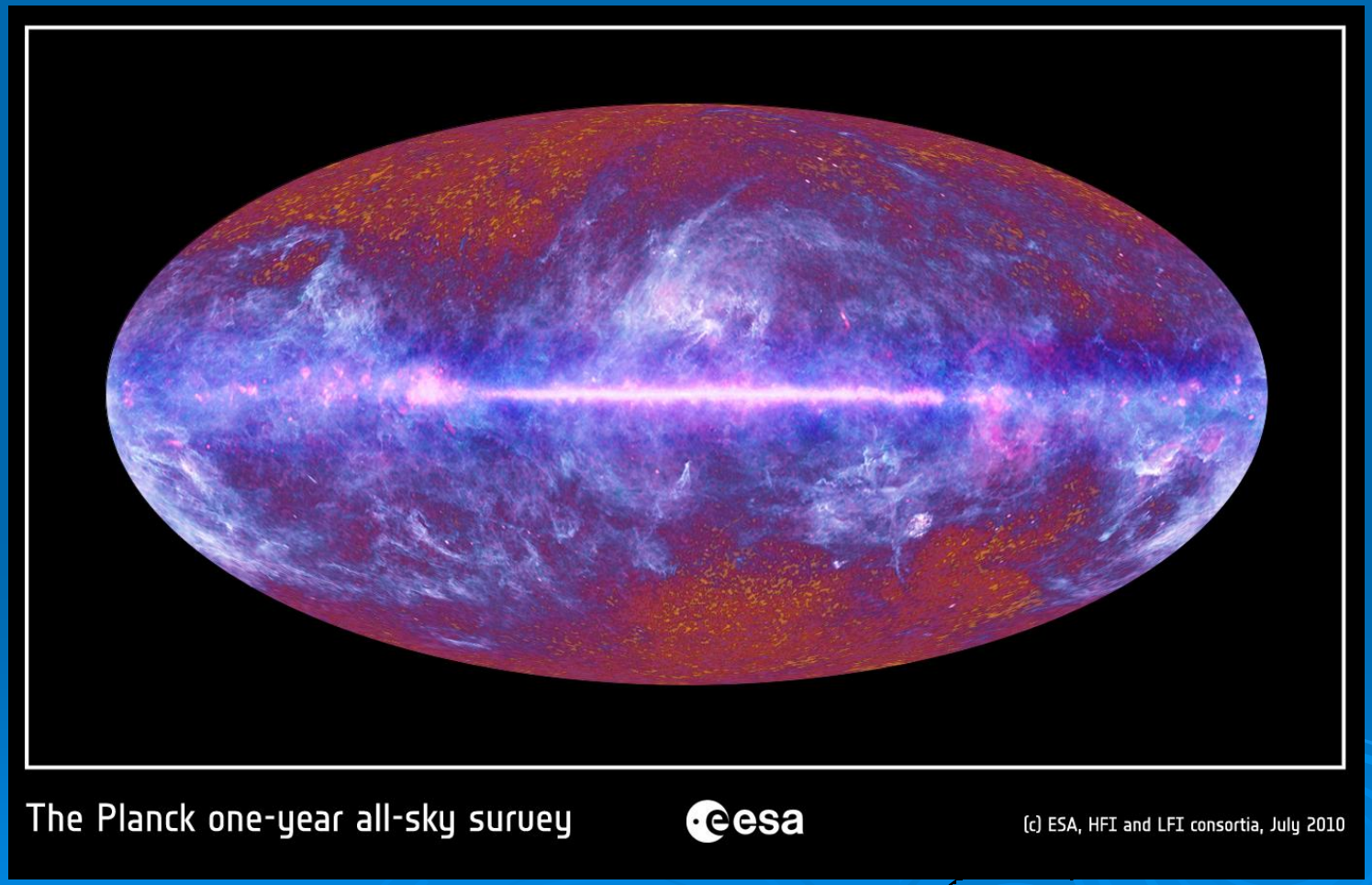
First light survey



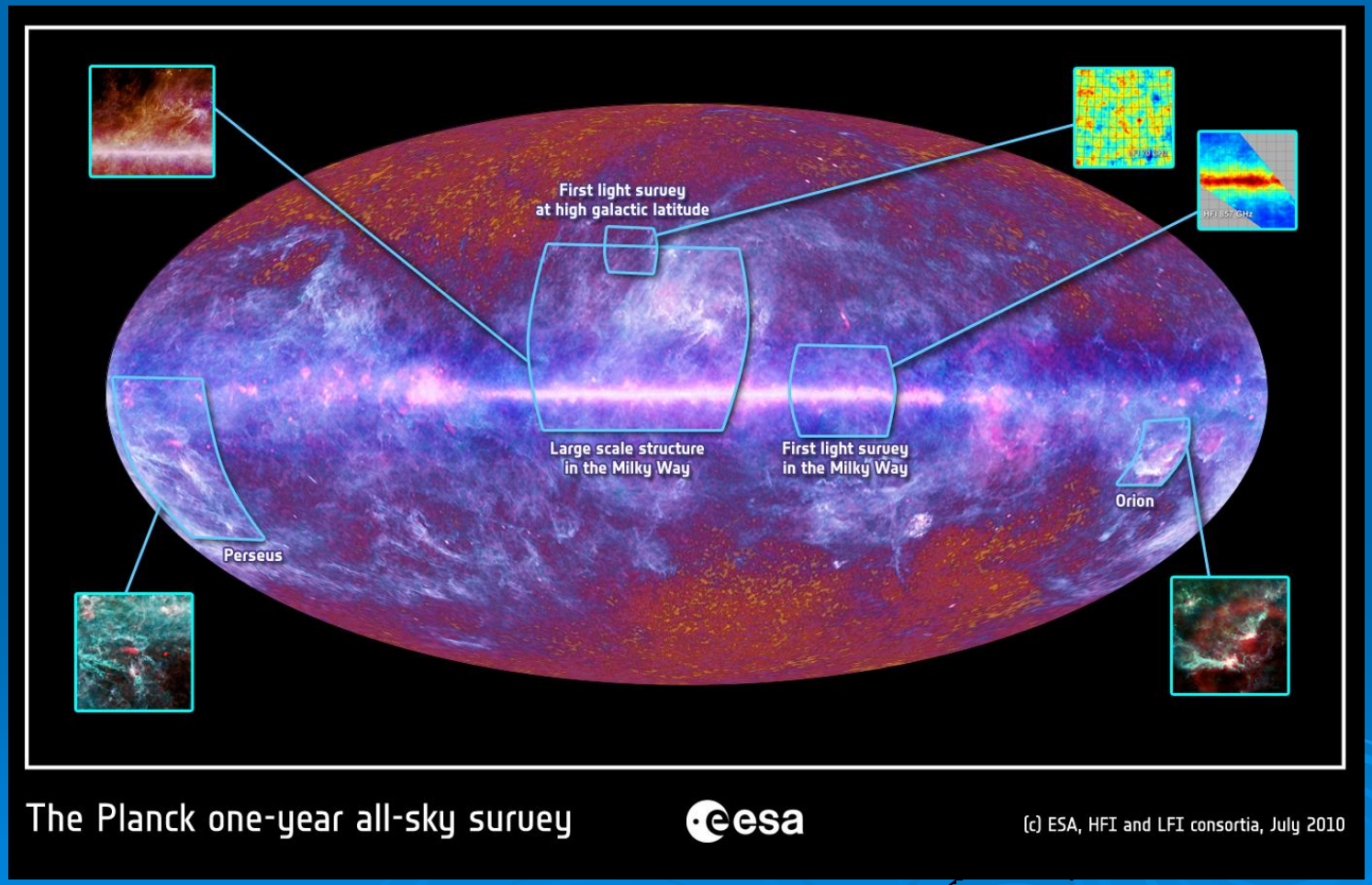
First light survey

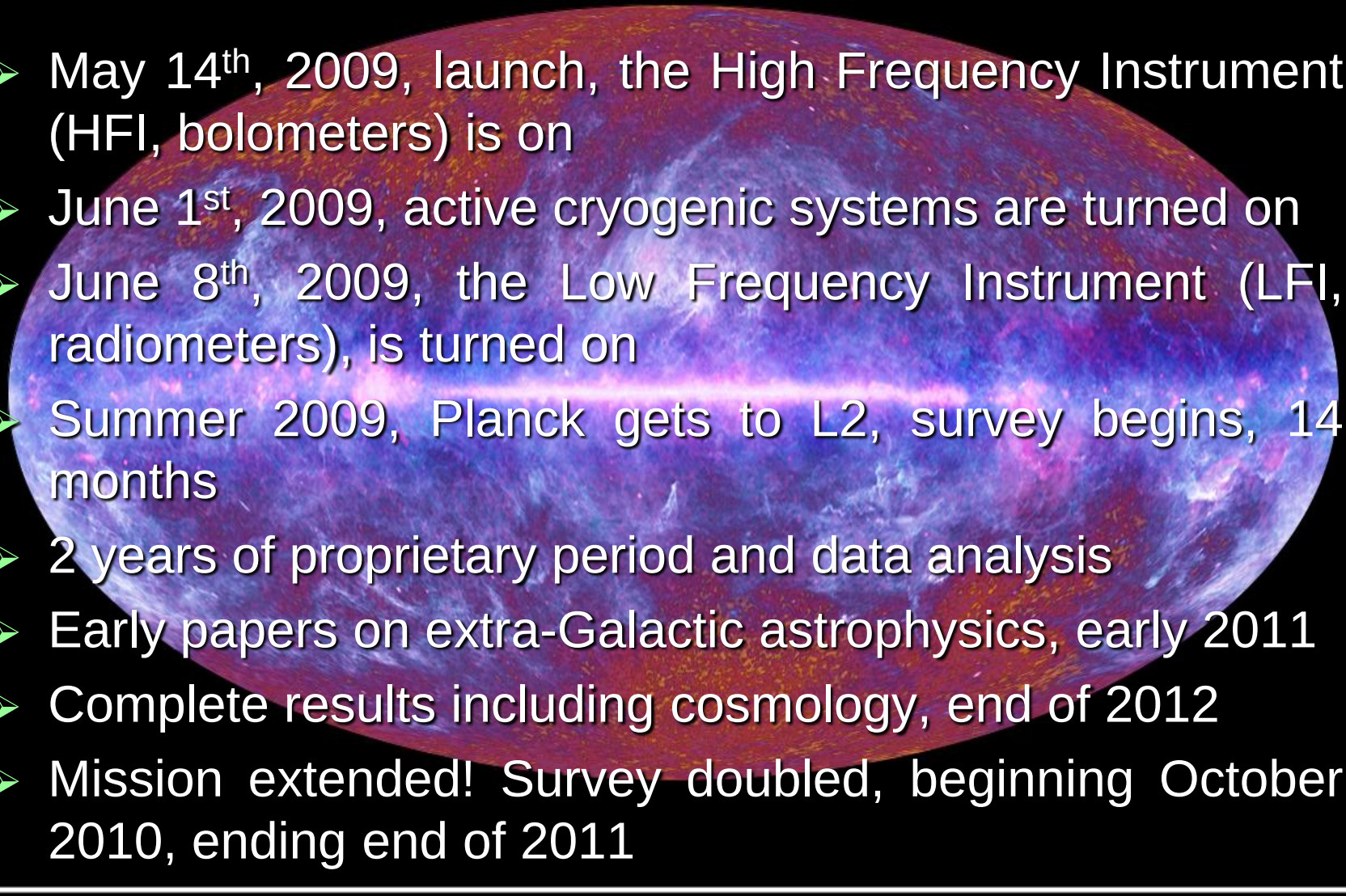


First year survey



First year survey





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