Planck

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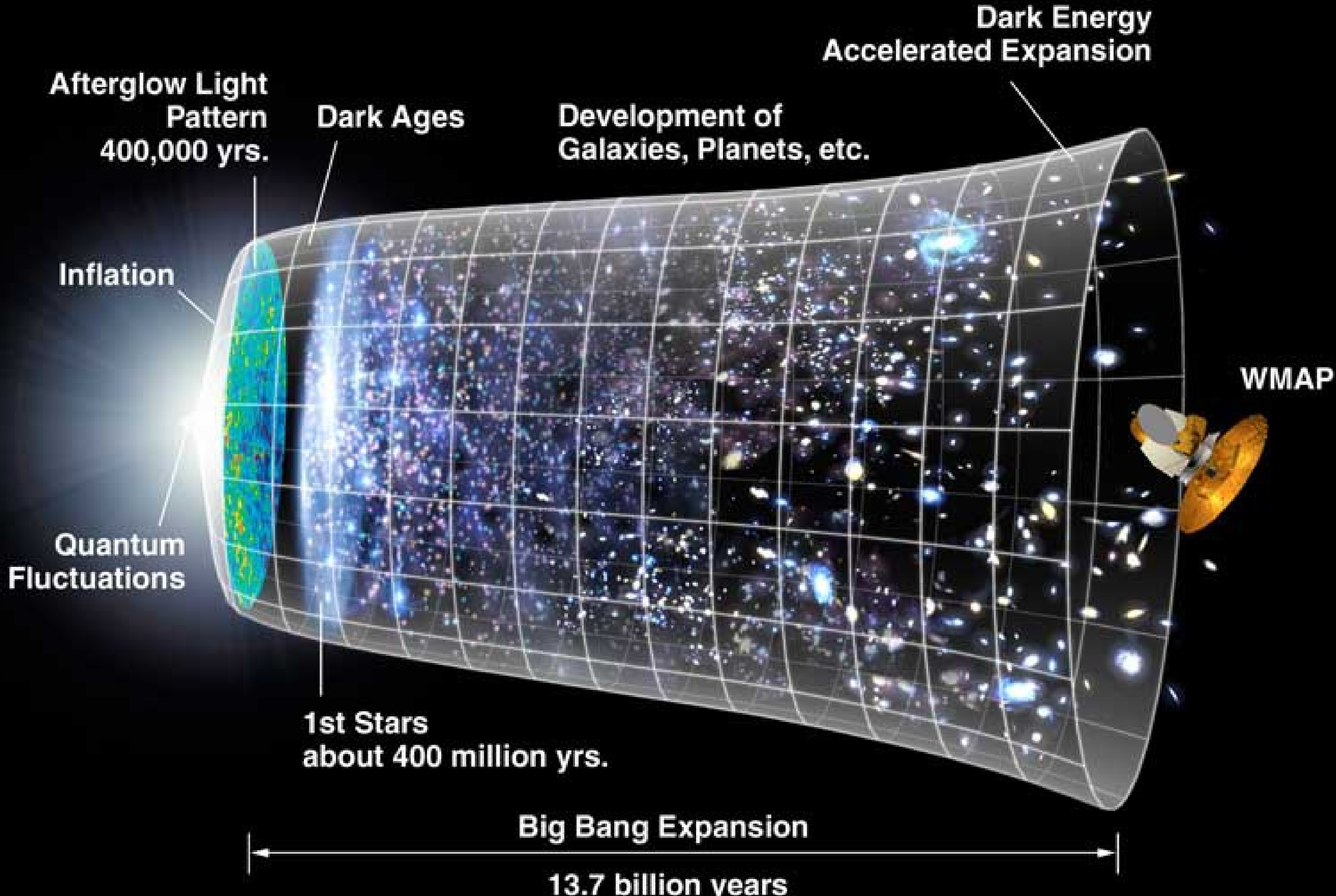
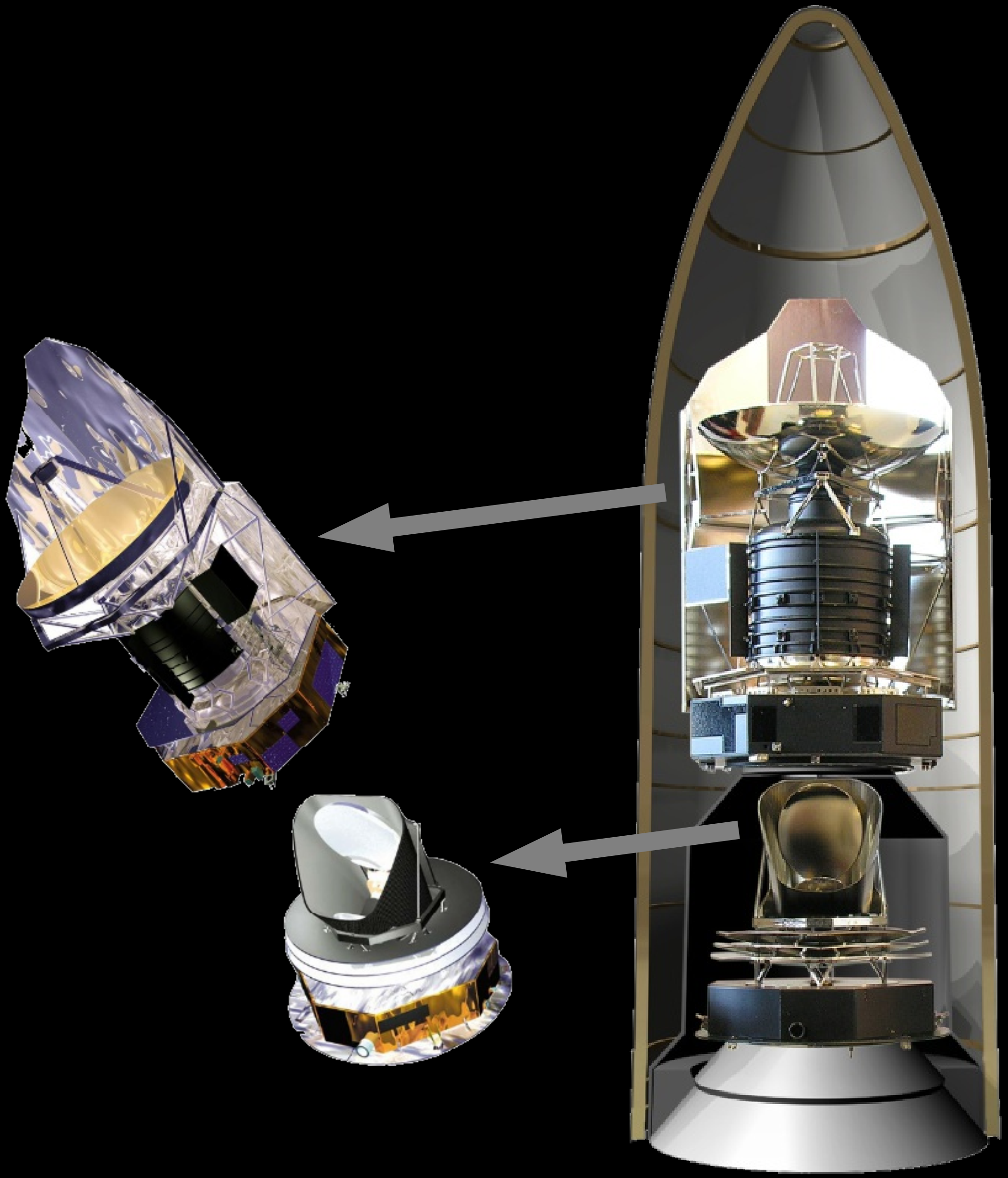
- Planck Basics
- Planck Early and Intermediate Results
- Planck Cosmology Predictions
- Planck Timeline

A Brief History of the Cosmos

The CMB was emitted when the Universe was about $3 \cdot 10^{-5}$ of its current age.



Launch

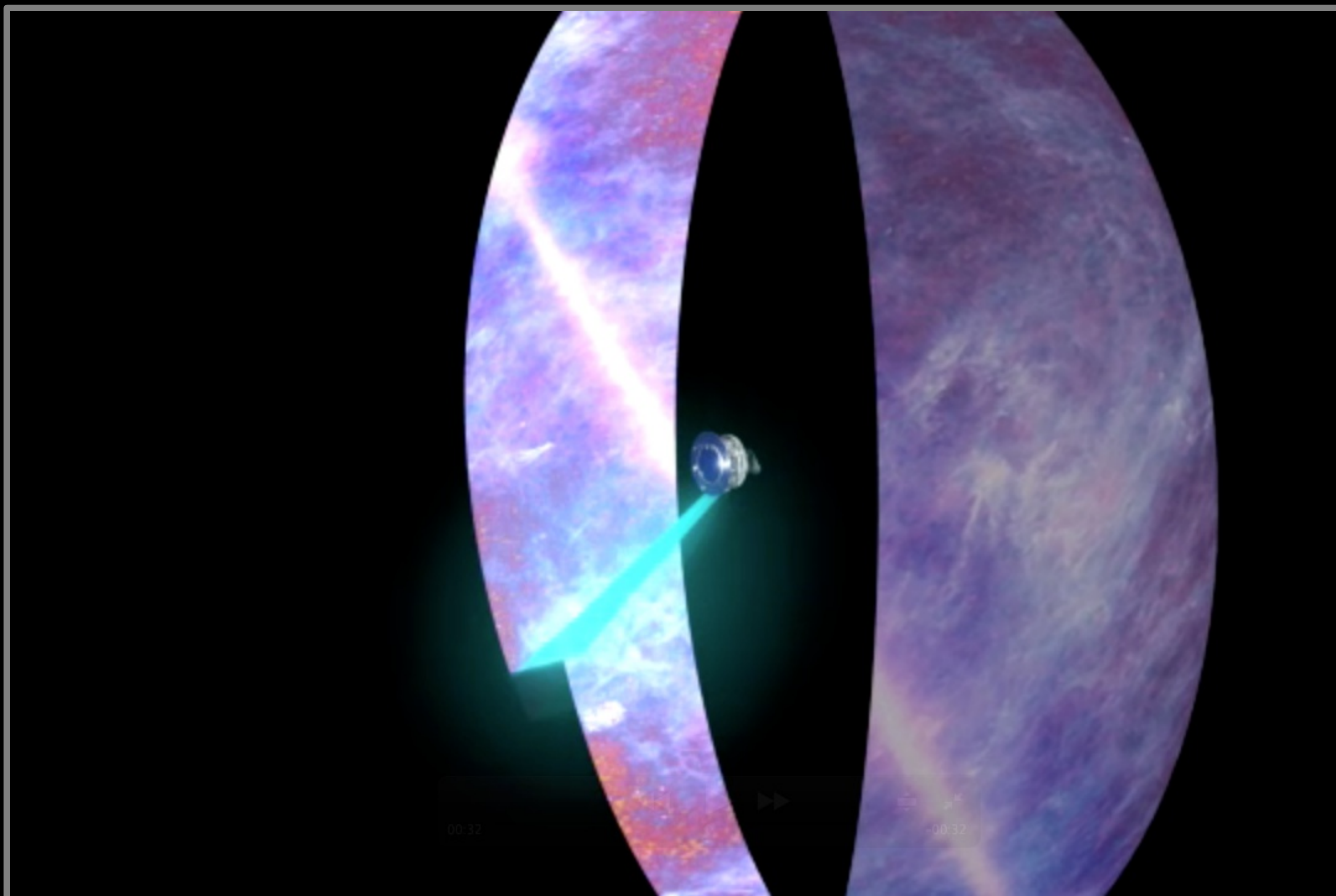


- Launch was May 1, 2009, from Guiana Space Center, Kourou, French Guiana
- Ariane 5 Launch Vehicle
- With Herschel (which is also at the Sun-Earth L-2 point)

Planck's Orbit around L2

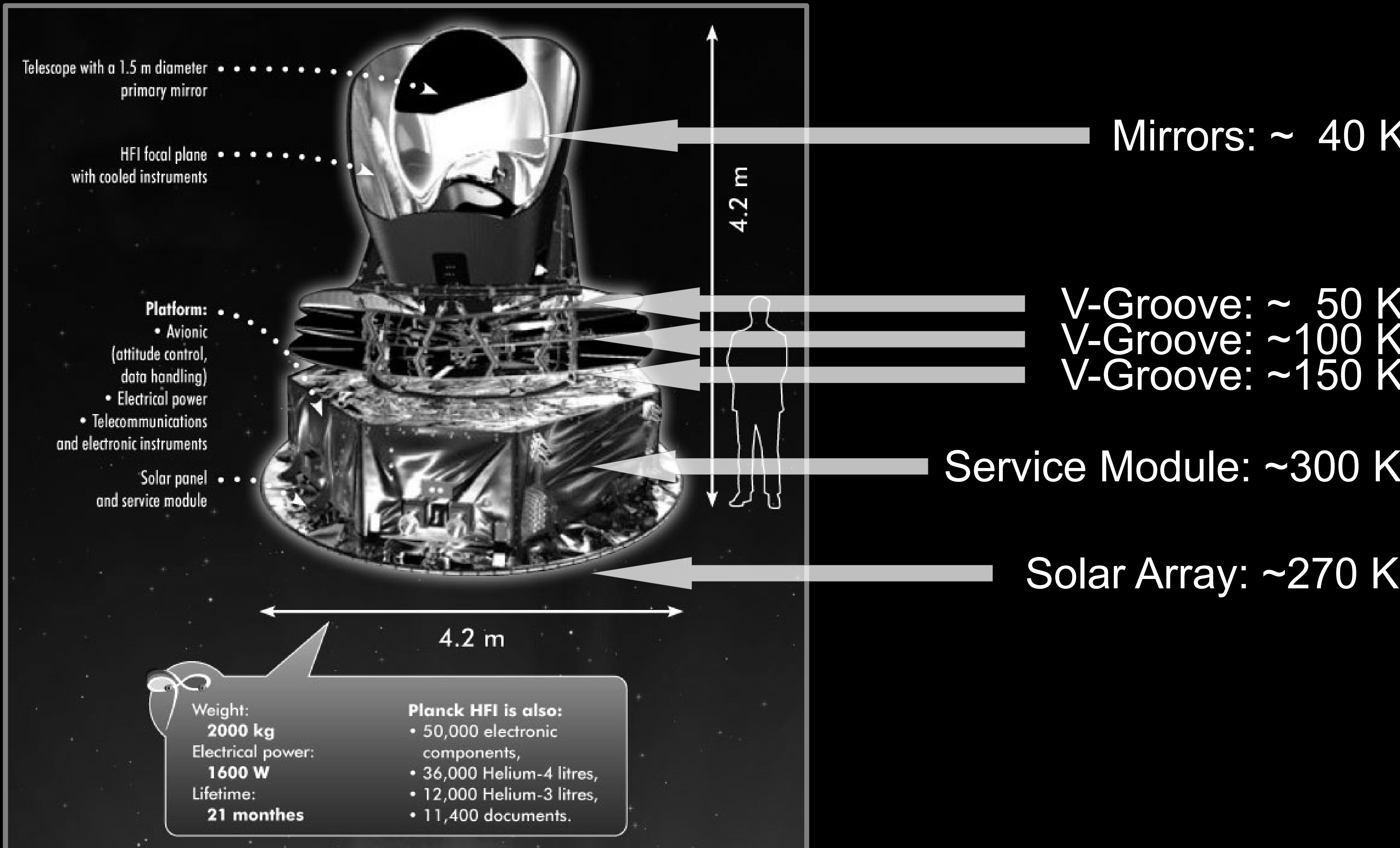
Planck orbits around the second Sun-Earth Lagrange point, approximately 1.5 million km further from the Sun than the Earth

Planck's Scanning Strategy

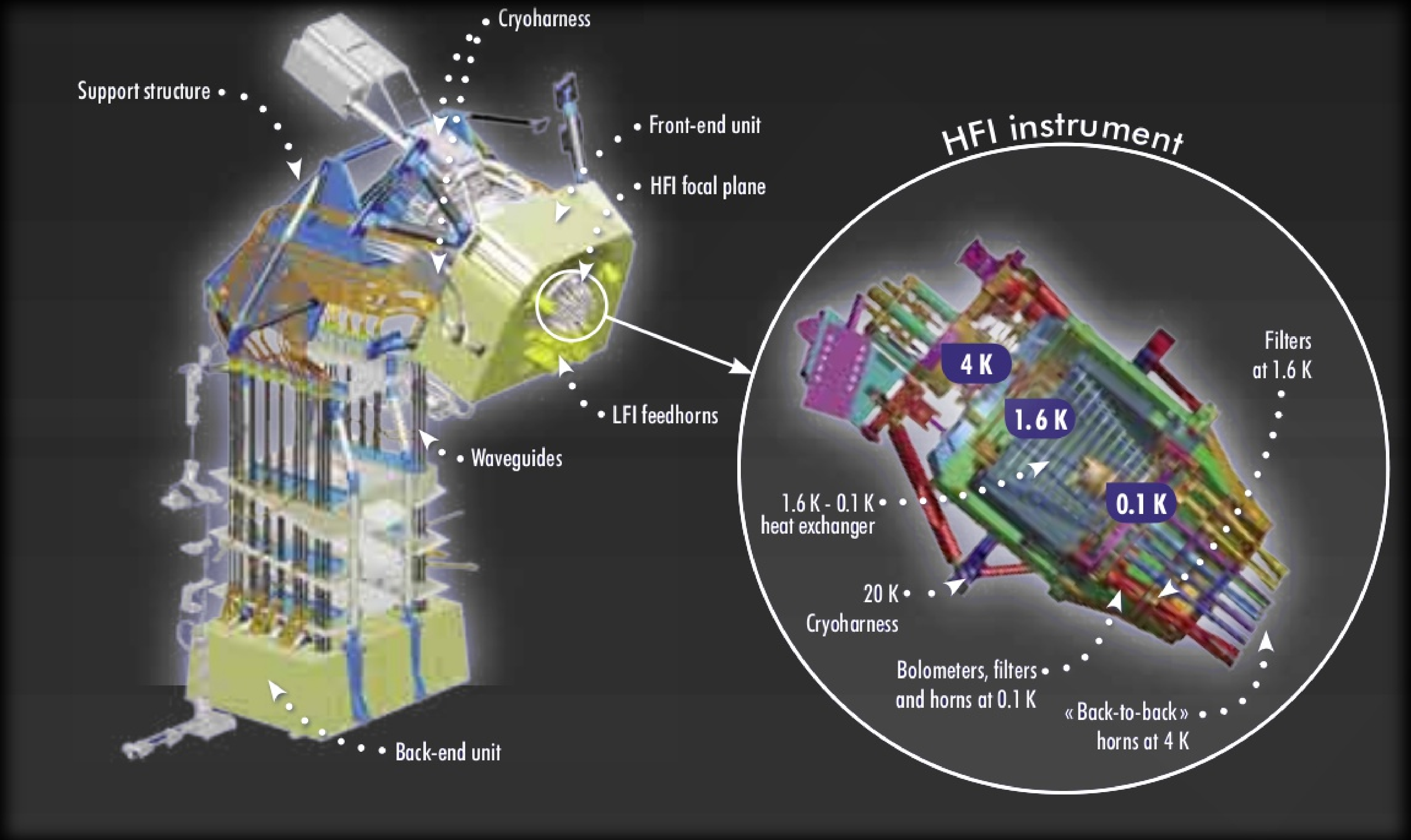


Planck scans the sky in (almost) great circles in a plane defined by the Sun-Earth axis. The full sky is (almost) covered each six months.

Exterior Temperatures

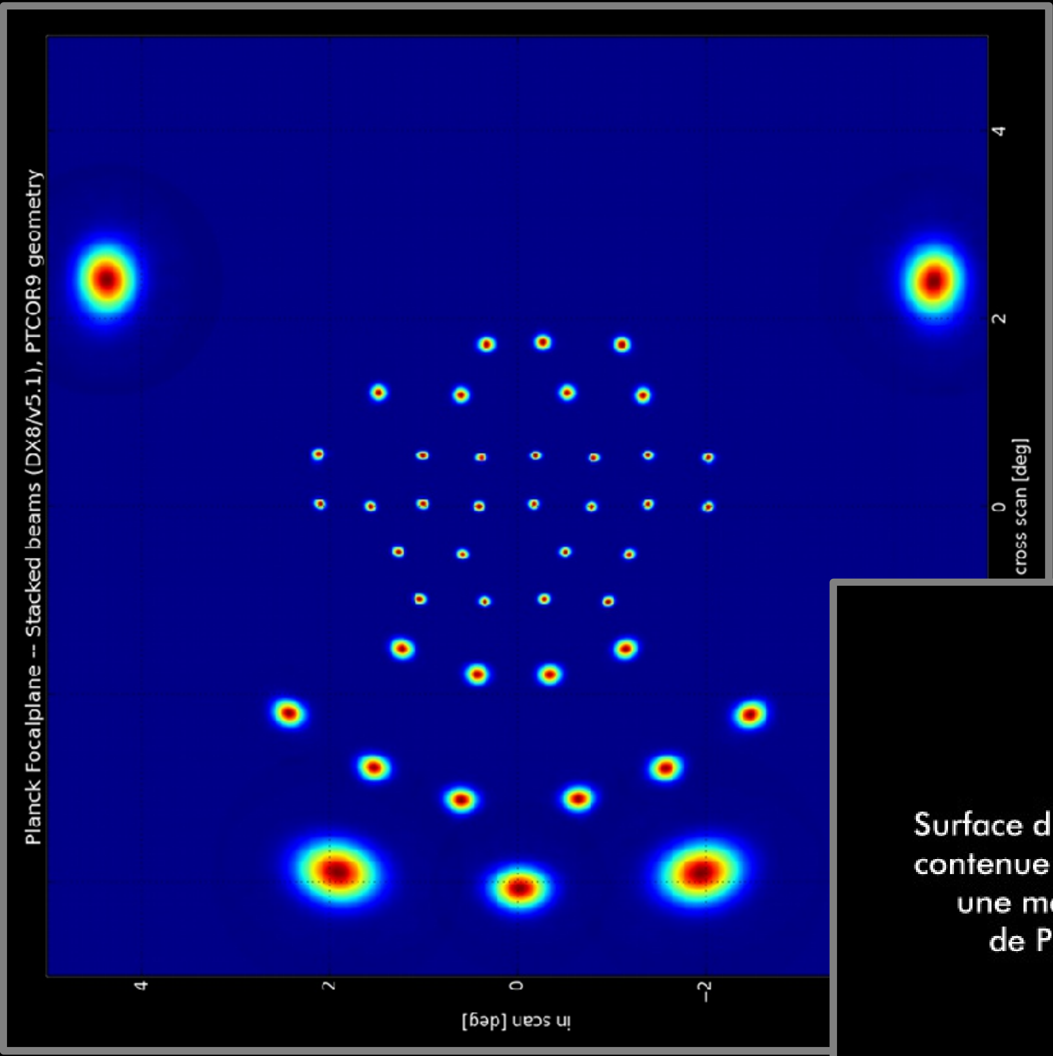


Planck Has Two Instruments

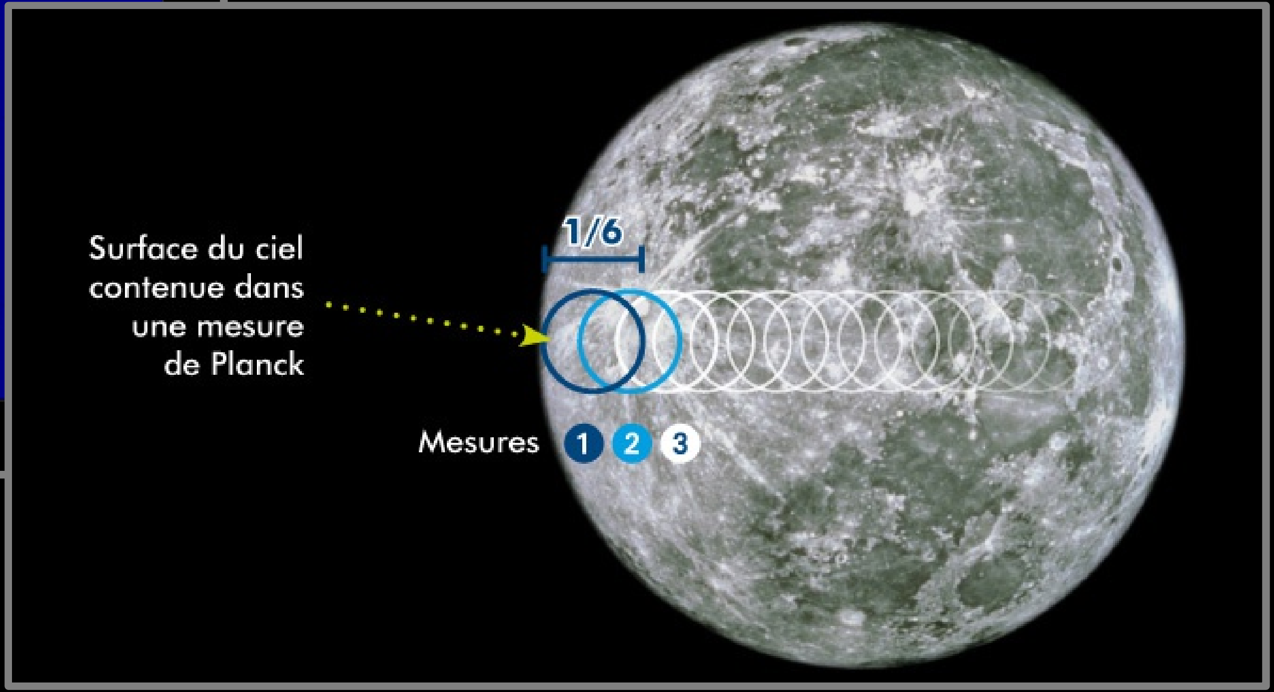


I will discuss mostly HFI. While the HFI was operating, the HFI detectors were the coldest things in space. The HFI took data until early 2012. LFI continues to take data, and will continue at least until the end of 2012, and perhaps to August, 2013.

The Planck Focal Plane

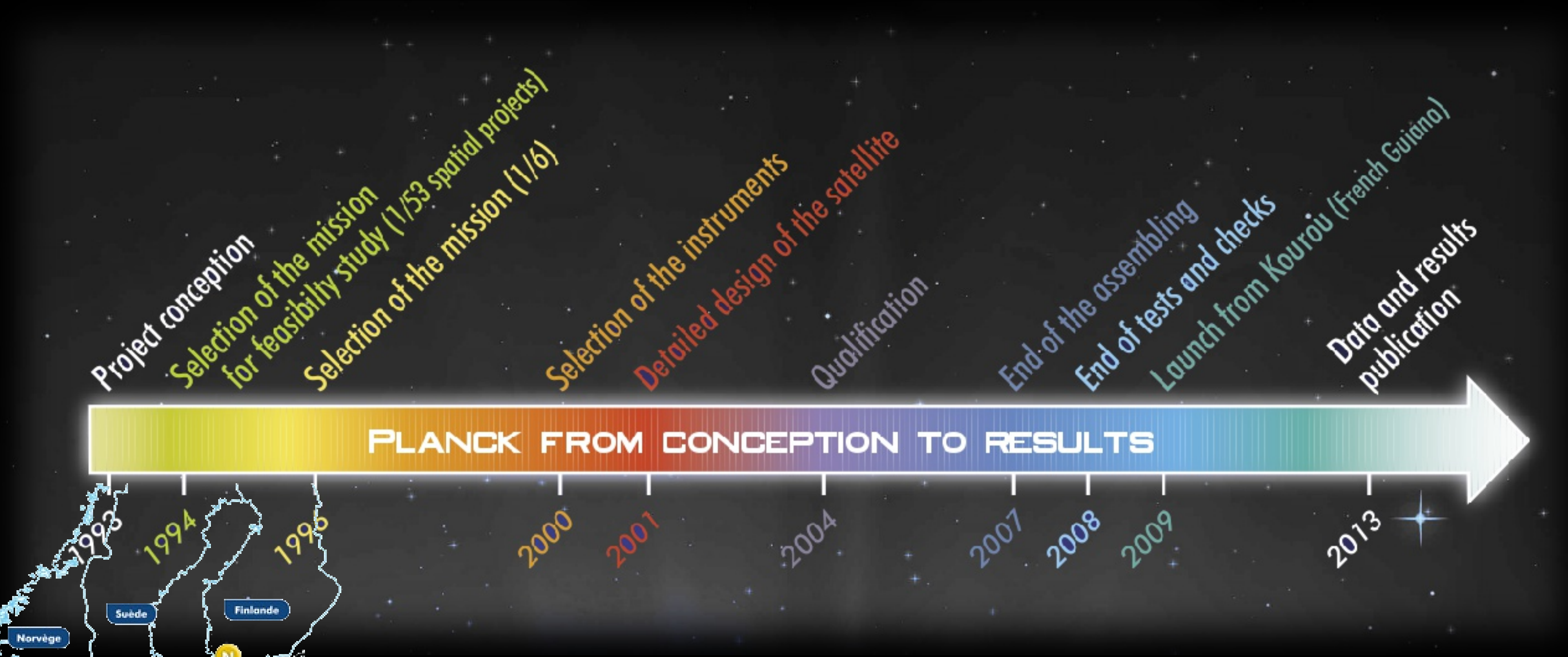


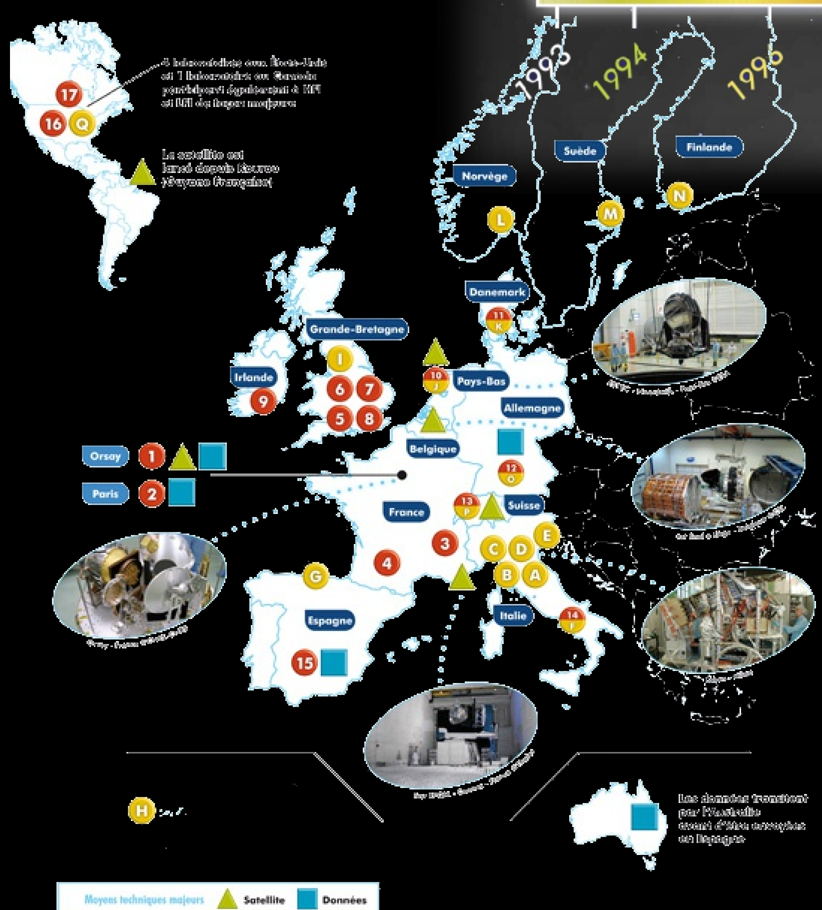
Planck has an ~1.5 m primary. Its angular resolution goes from about that of WMAP to about 5 arcminutes at 217 GHz and higher frequencies.



R. Keskitalo

Planck/HFI Timeline

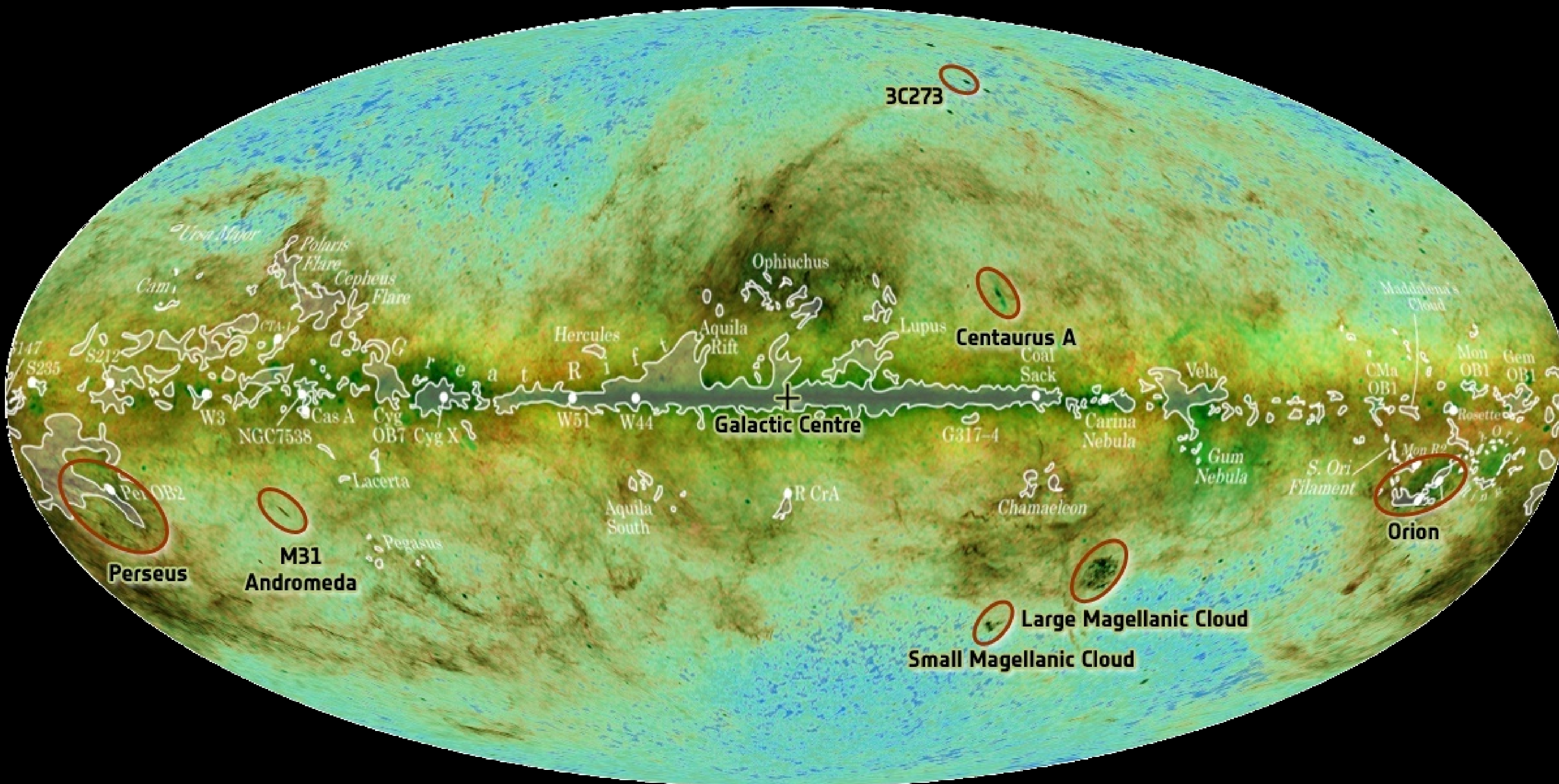




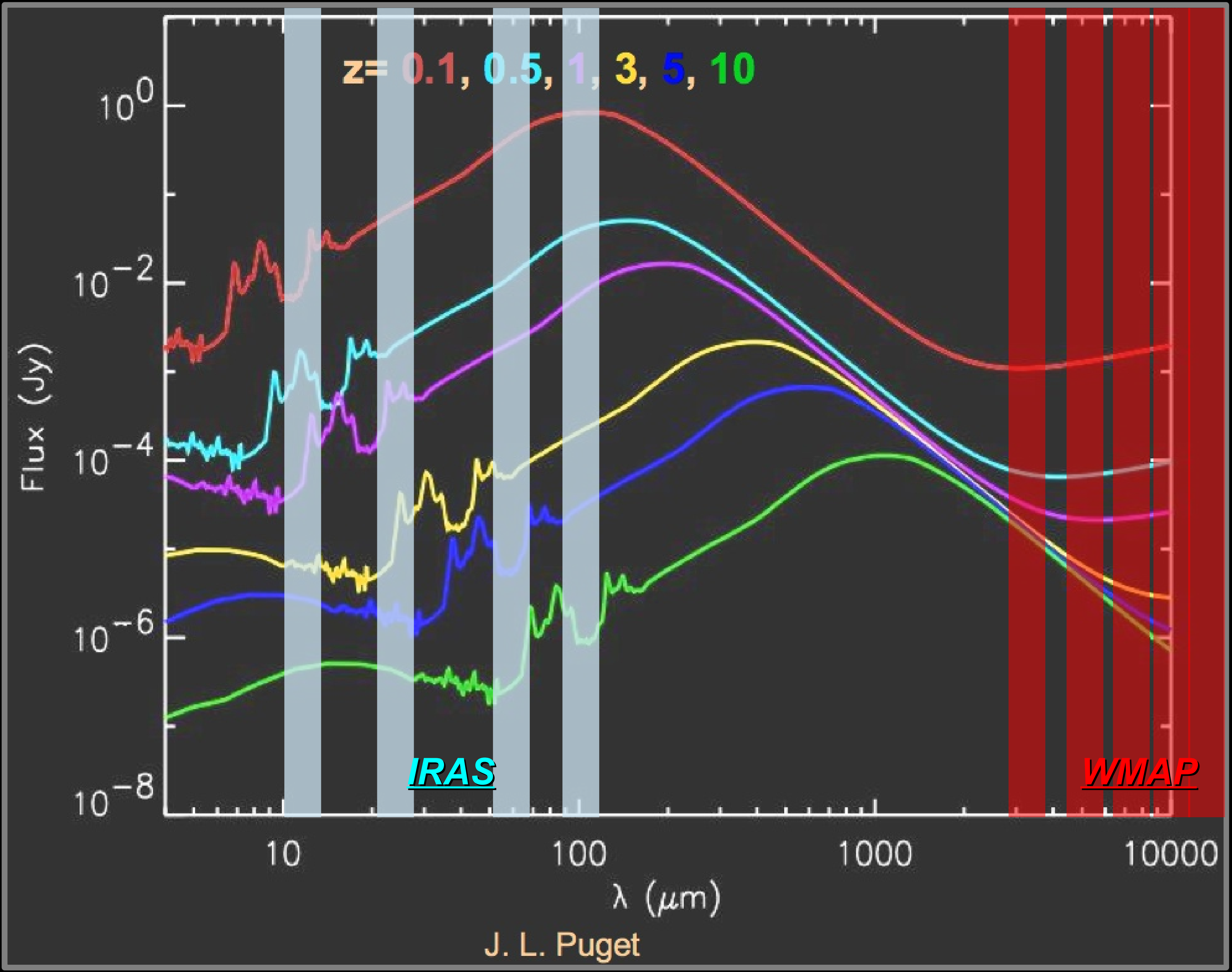
The HFI builds on the experience of a number of sub-orbital experiments, notably Archeops and BOOMERANG,

It represents over 20 years of work and cost roughly one euro per European.

Combined First Survey Map

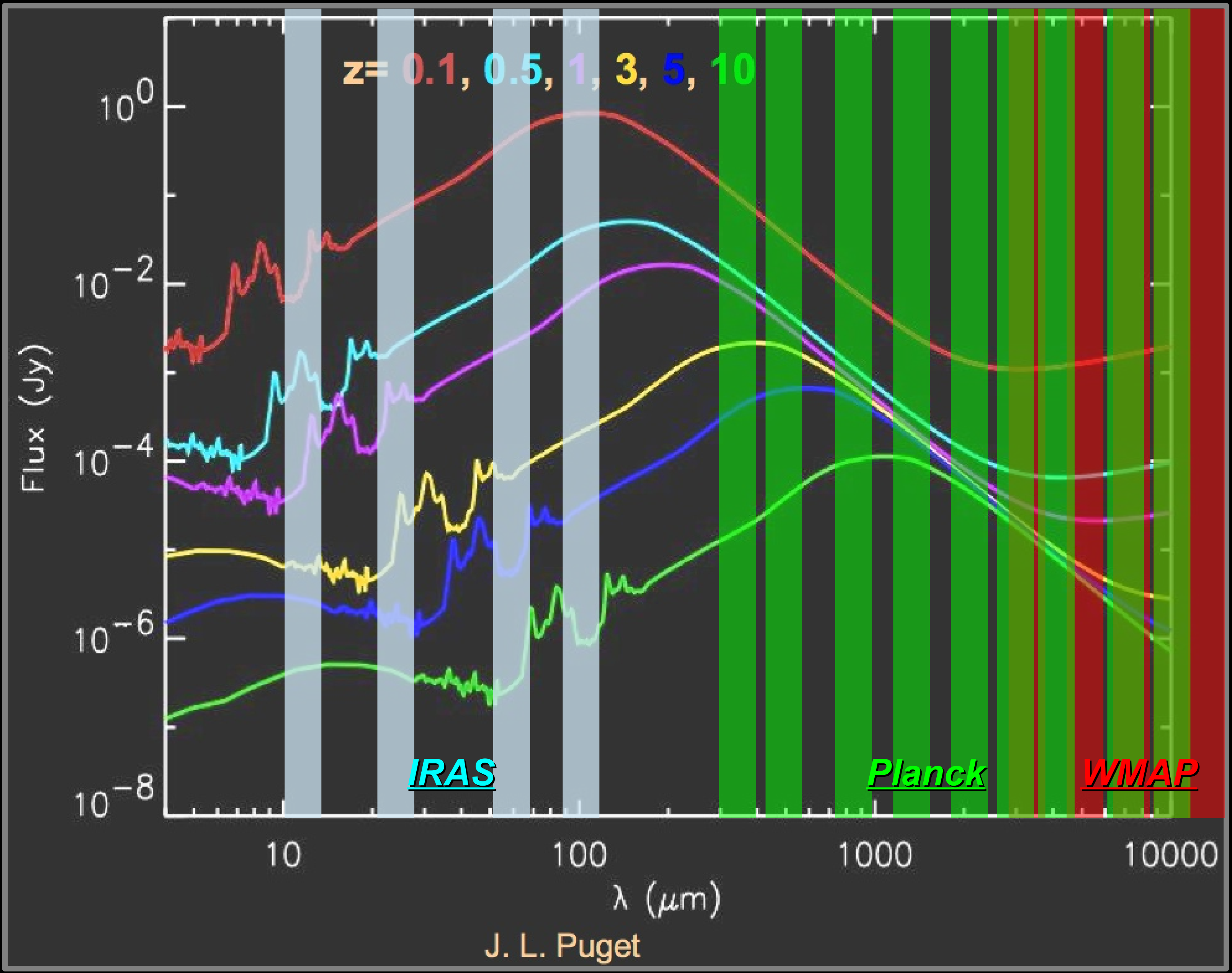


Frequency Coverage



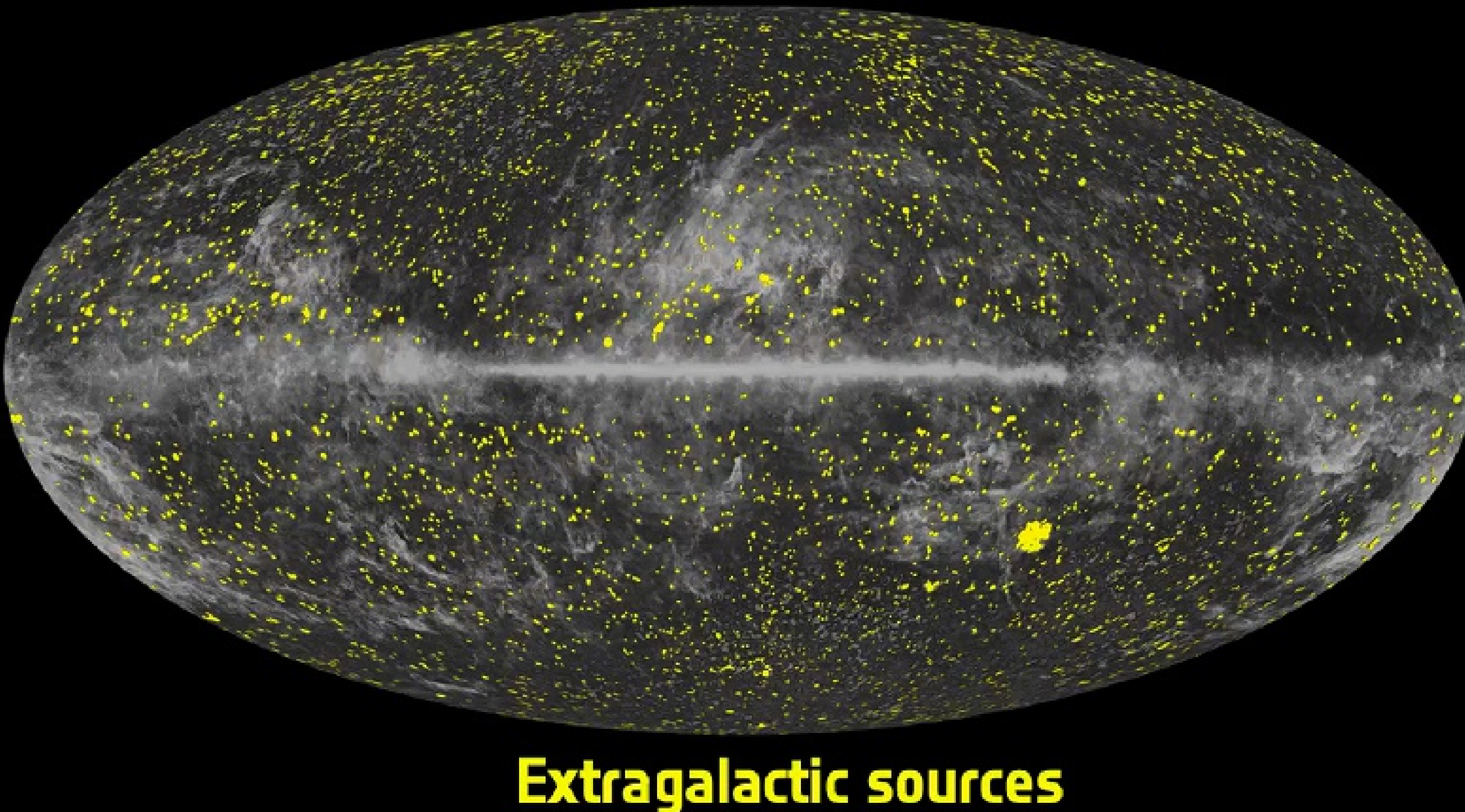
Planck fills the SubMM range, so in addition to CMB science, Planck will be able to say a lot about dust emission in our Galaxy and in others.

Frequency Coverage



Planck fills the SubMM range, so in addition to CMB science, Planck will be able to say a lot about dust emission in our Galaxy and in others.

The ERCSC*



* The Early Release Compact Source Catalog

A Full-Sky SZ Cluster Catalog

A&A 536, A8 (2011)

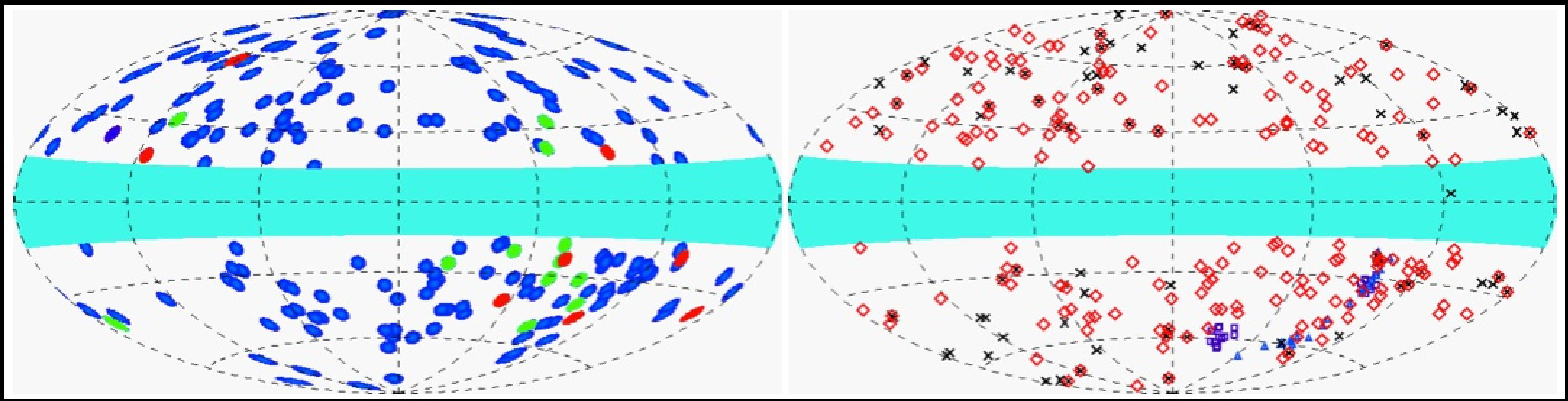


Fig. 3. Distribution of ESZ clusters and candidate clusters on the sky (Galactic Aitoff projection). *Left panel*: in blue are ESZ clusters identified with known clusters, in green the ESZ confirmed candidates, and in red the ESZ candidate new clusters yet to be confirmed. *Right panel*: in red diamonds the ESZ sample, in black crosses the compilation of SZ observations prior to 2010, in dark blue triangles ACT clusters from Menanteau et al. (2010), and in purple squares SPT clusters from Vanderlinde et al. (2010). The blue area represents the masked area of $|b| < 14$ deg.

189 SZ Detections were released as part of the "Early Results". More will follow in the 2013 release.

The Coma Cluster

A study of the Coma cluster has allowed Planck to:

Study the SZ further from the center of a cluster than ever done before

Detect the presence of shock waves

Note differences between the actual and simulated pressure profiles

Compare the 'y' and radio signals

arxiv/1208.3611

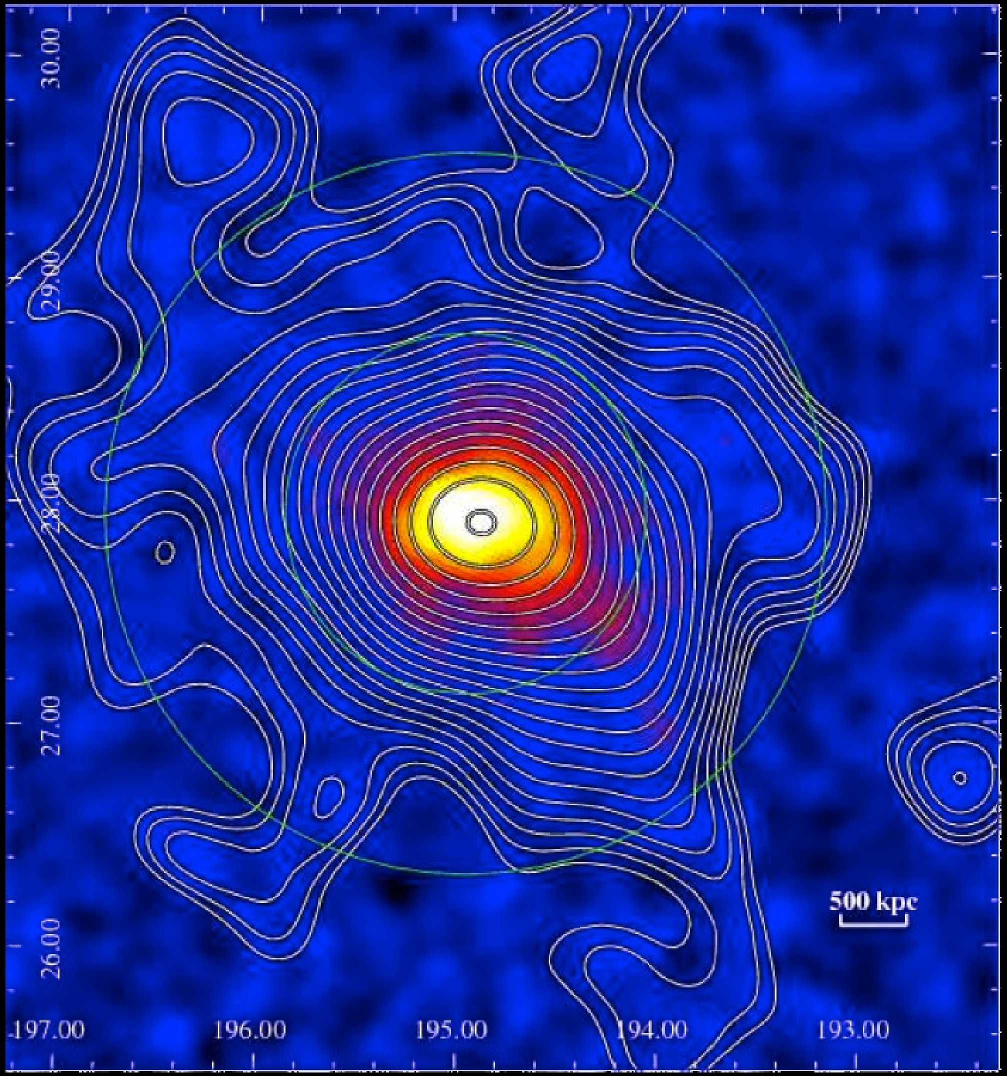
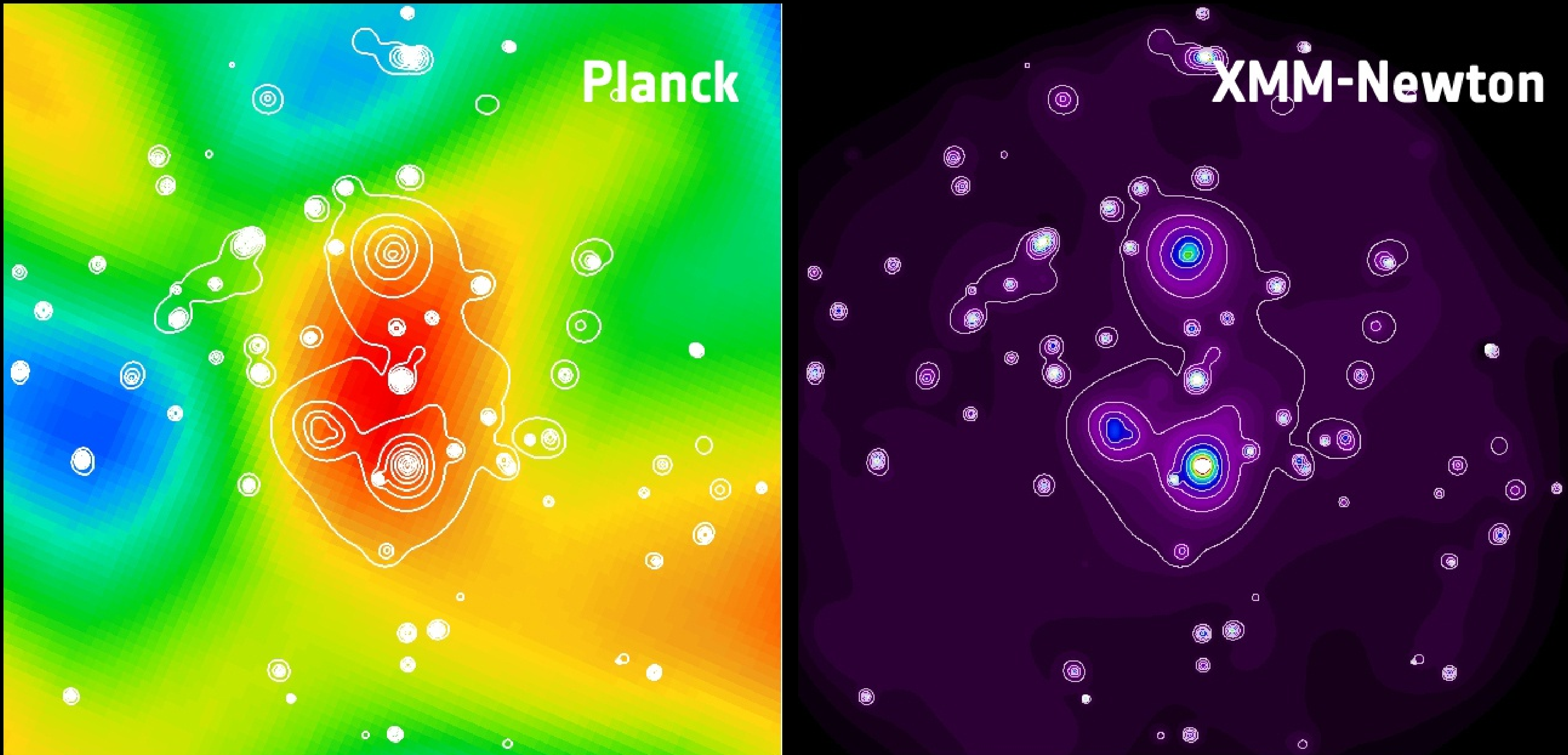


Fig. 3: The *Planck* y map of the Coma cluster obtained by combining the 70 GHz channel of LFI and the HFI channels from 100 GHz to 857 GHz. The map has been smoothed to have a PSF with FWHM = 30′. The image is about 266x266 arcmin^2. The outermost contour corresponds to $y = 2\times\sigma_{\rm noise30} = 6.7\times10^{-7}$. The green circles indicate R_{500} and $2\times R_{500} \approx R_{200}$.

An Interesting System



Planck and XMM have been used to investigate the dynamics of what appears to be a system of *three* clusters of galaxies. The analysis suggests that the system is in an early phase of Interaction, and Planck was not able to detect “inter-cluster” material.

arxiv/1207.4009

Intra-Cluster Filaments

Planck Collaboration: P. A. R. Ade et al.: SZ in merging clusters

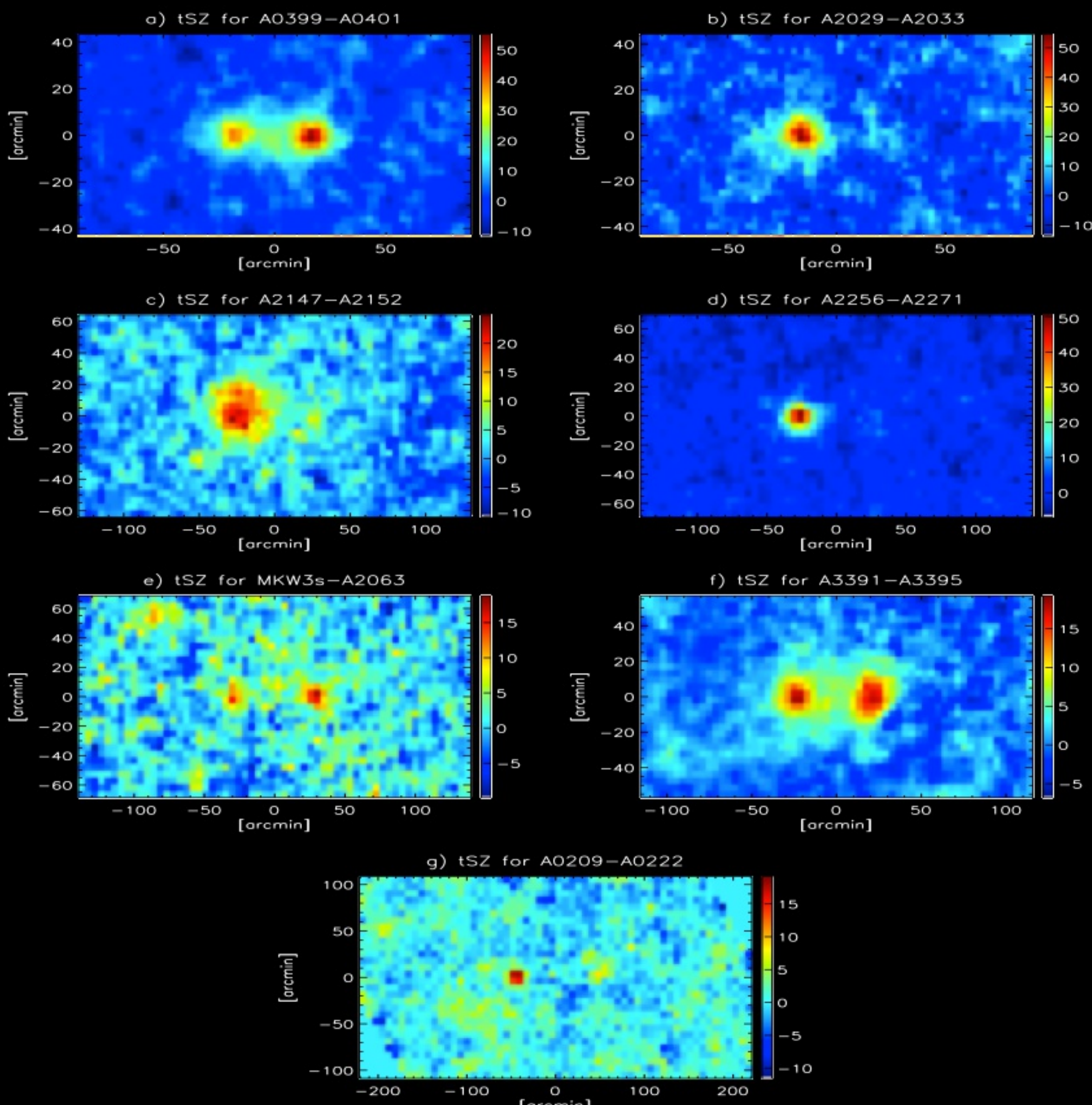


Fig. 1. MILCA maps of the Compton parameter $y \times 10^6$ for the selected pairs of clusters. From left to right and from top to bottom we show the pairs of clusters a) A0399-A0401, b) A2029-A2033, c) A2147-A2152, d) A2256-A2271, e) MKW 3s-A2063, f) A3391-A3395 and g) A0209-A0222.

Planck has been used to try to detect the hot, diffuse intercluster gas between pairs of clusters using the thermal Sunyaev-Zeldovich effect.

arxiv/1208.5911

Millimeter Excess in the SMC

Planck collaboration: Origin of the millimetre excess in the LMC and SMC

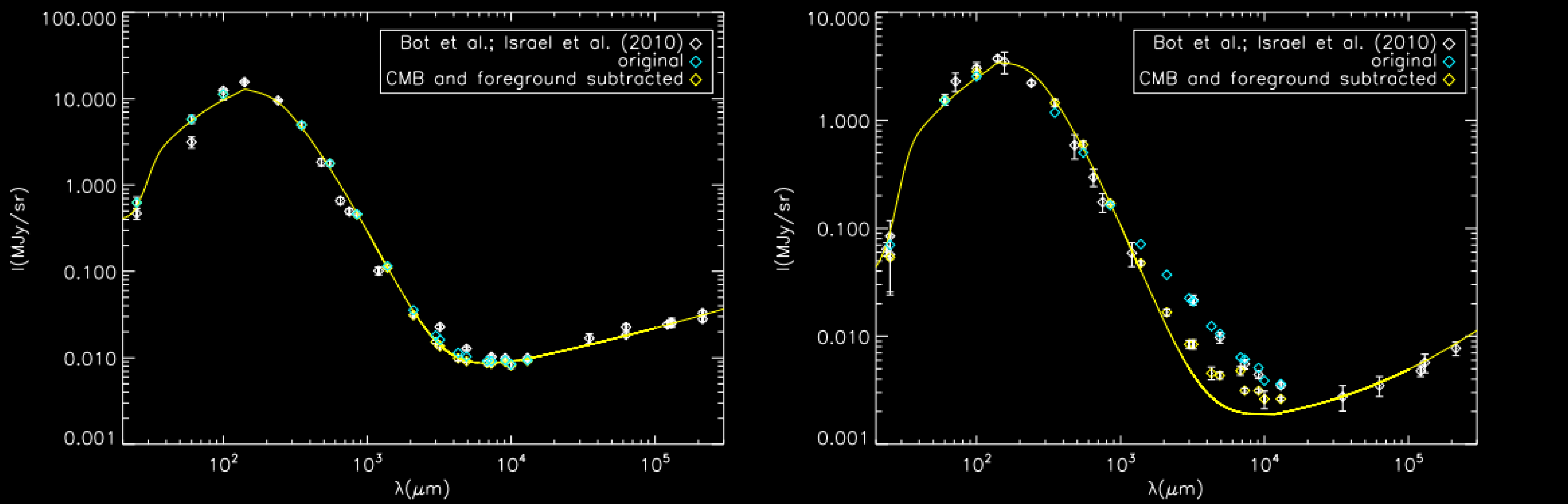


Fig. 5. Integrated SEDs of the LMC (left) and SMC (right) before and after CMB subtraction. The black points and model are taken from Bot et al. (2010b). The red symbols show the SEDs derived from the *DIRBE*, *IRAS*, and *WMAP* data before CMB subtraction. The blue symbols show the same after CMB subtraction.

A millimeter excess is seen in the Small Magellanic Cloud, and is possibly attributed to a combination of a two-level system and spinning dust.

Arxiv/1101.2046

Dark Gas in the Galaxy

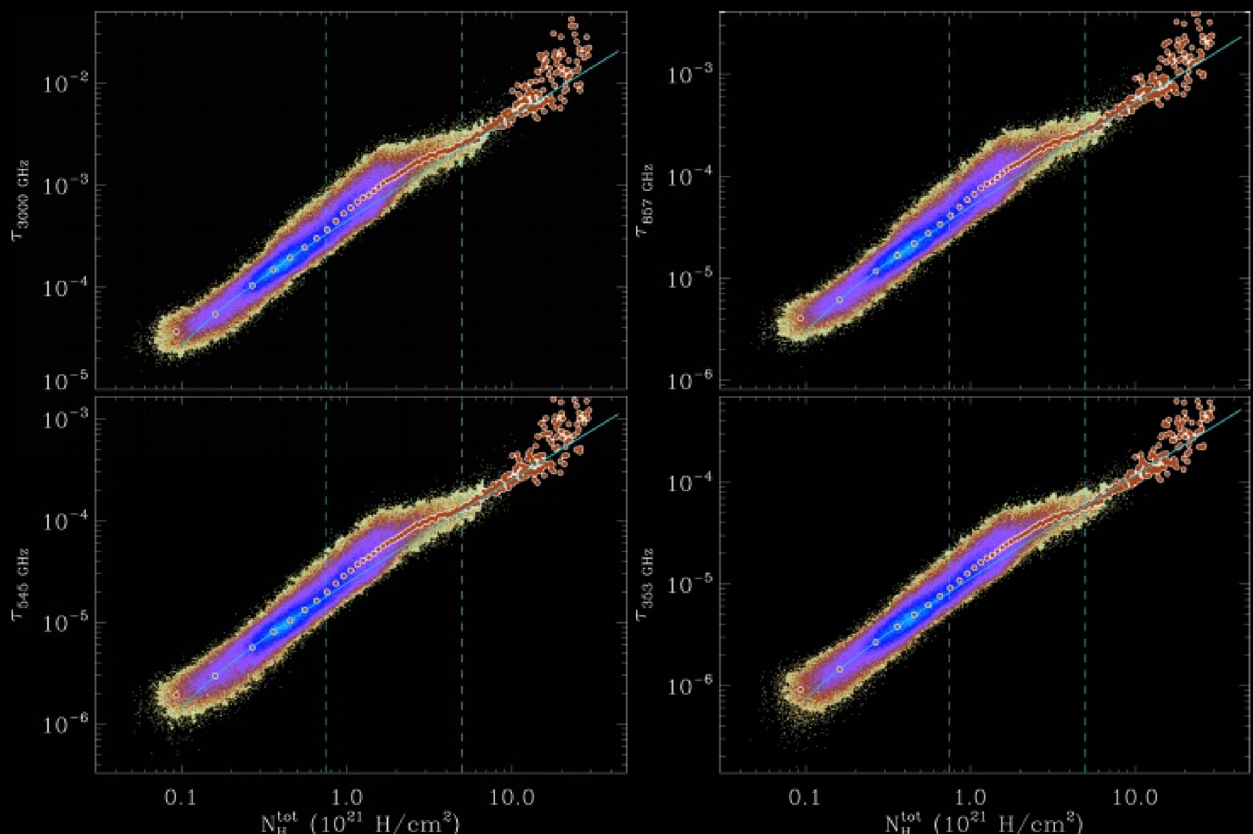


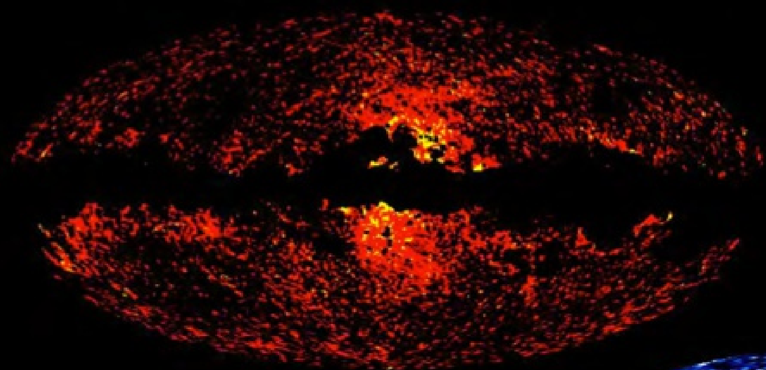
Fig. 6. Correlation plots between the dust optical depth at *IRAS* 100 μm (upper left), *HFI* 857 GHz (upper right), 545 GHz (lower left) and 353 GHz (lower right) and the total gas column density N_H^{obs} in the solar neighbourhood ($|b_{II}| > 10°$). The color scale represents the density of sky pixels on a log scale. The blue dots show a N_H^{obs}-binned average representation of the correlation. The red line shows the best linear correlation derived at low N_H^{obs} values ($\tau = \left(\frac{\tau_D}{N_H}\right)^{ref} * N_H^{obs} + cste$). The vertical lines show the positions corresponding to $A_V = 0.37$ mag and $A_V = 2.5$ mag. These figures are shown for a single $X_{CO} = 2.3 \times 10^{20}\ H_2 cm^{-2}/(K\ km\ s^{-1})$.

Planck has made maps of the temperature and emissivity of the entire sky, and comparing with H2 and CO data, infers the existence of dark gas, largely associated with Galactic clouds.

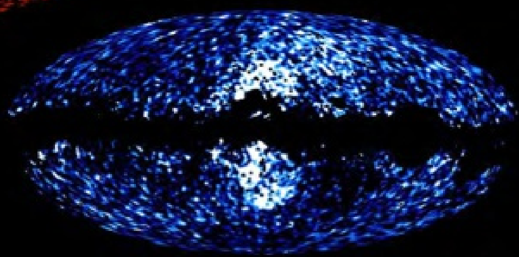
Arxiv/1101.2029

The Haze

PLANCK images a giant eruption from the heart of the Milky Way

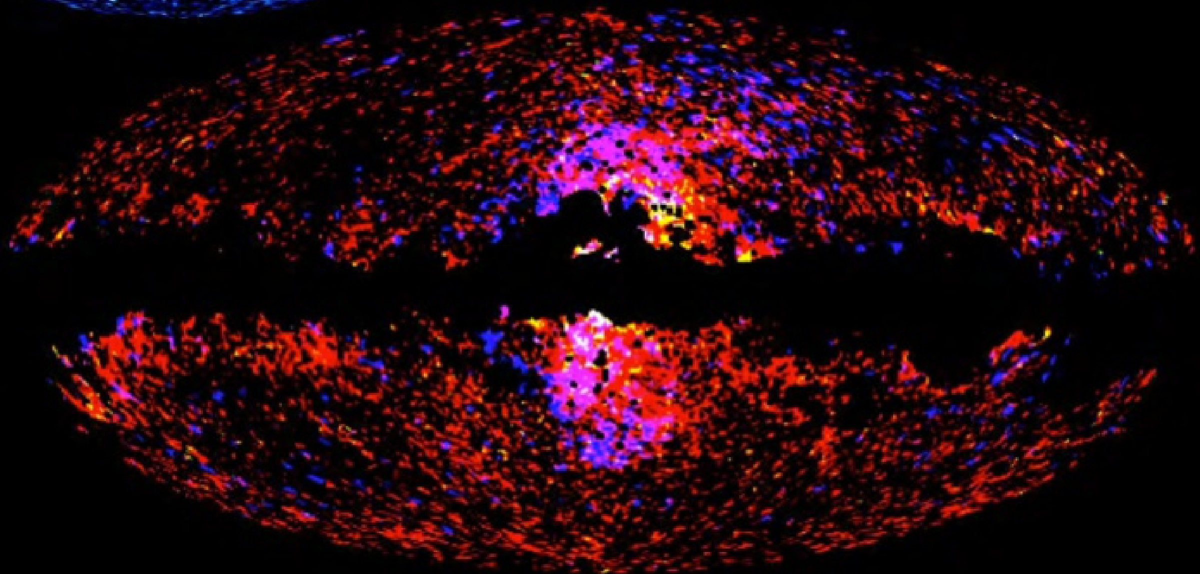


The Galactic haze/bubbles is shown here in *PLANCK* data from *30-44* GHz



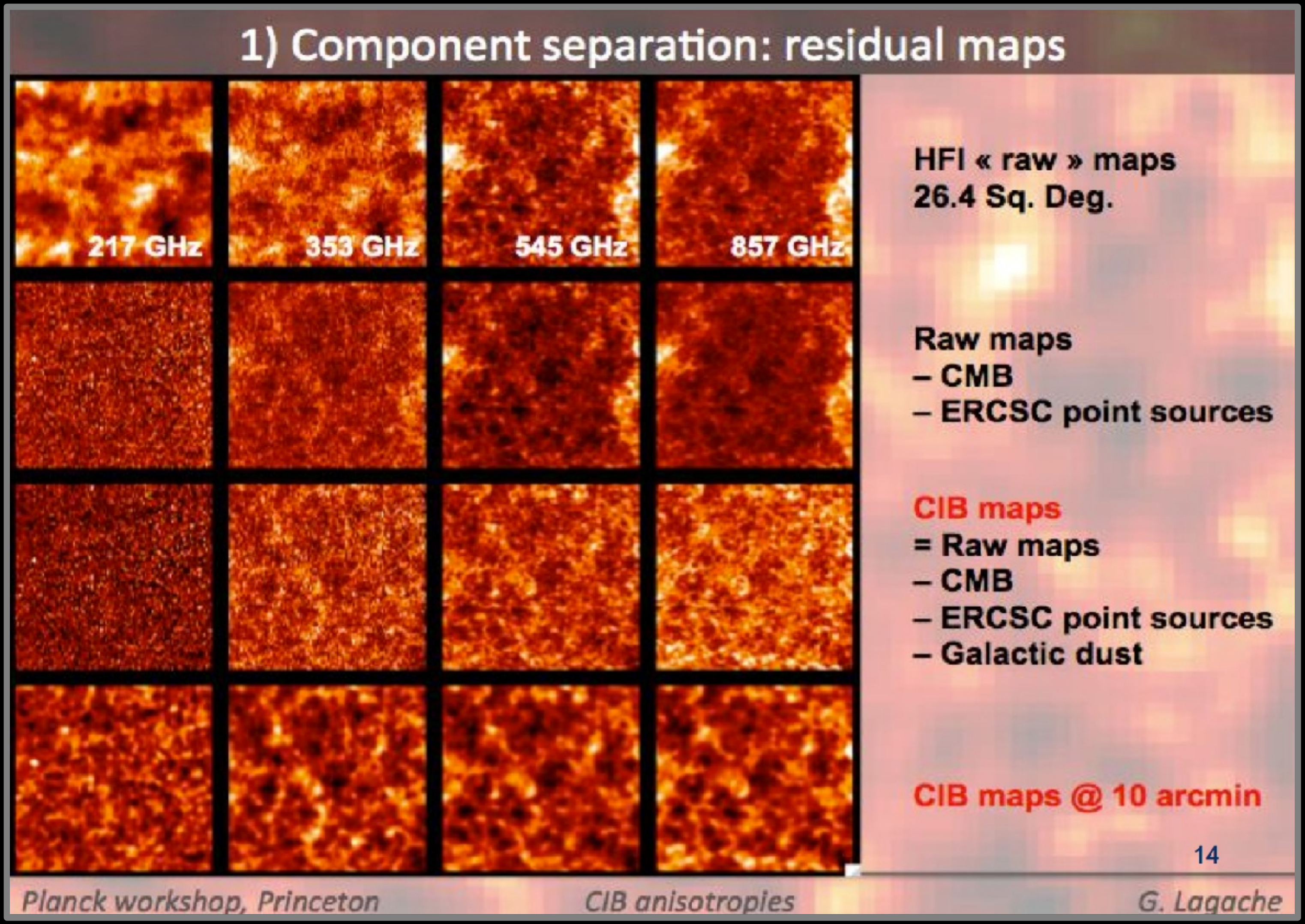
The same structure at 2-5 GeV as seen by the *Fermi Gamma-Ray Space Telescope*

A multi-wavelength composite image showing both microwaves and gamma-rays: *PLANCK 30* GHz (red), *44* GHz (green), and *Fermi* 2-5 GeV (blue).



arxiv/1208.5483

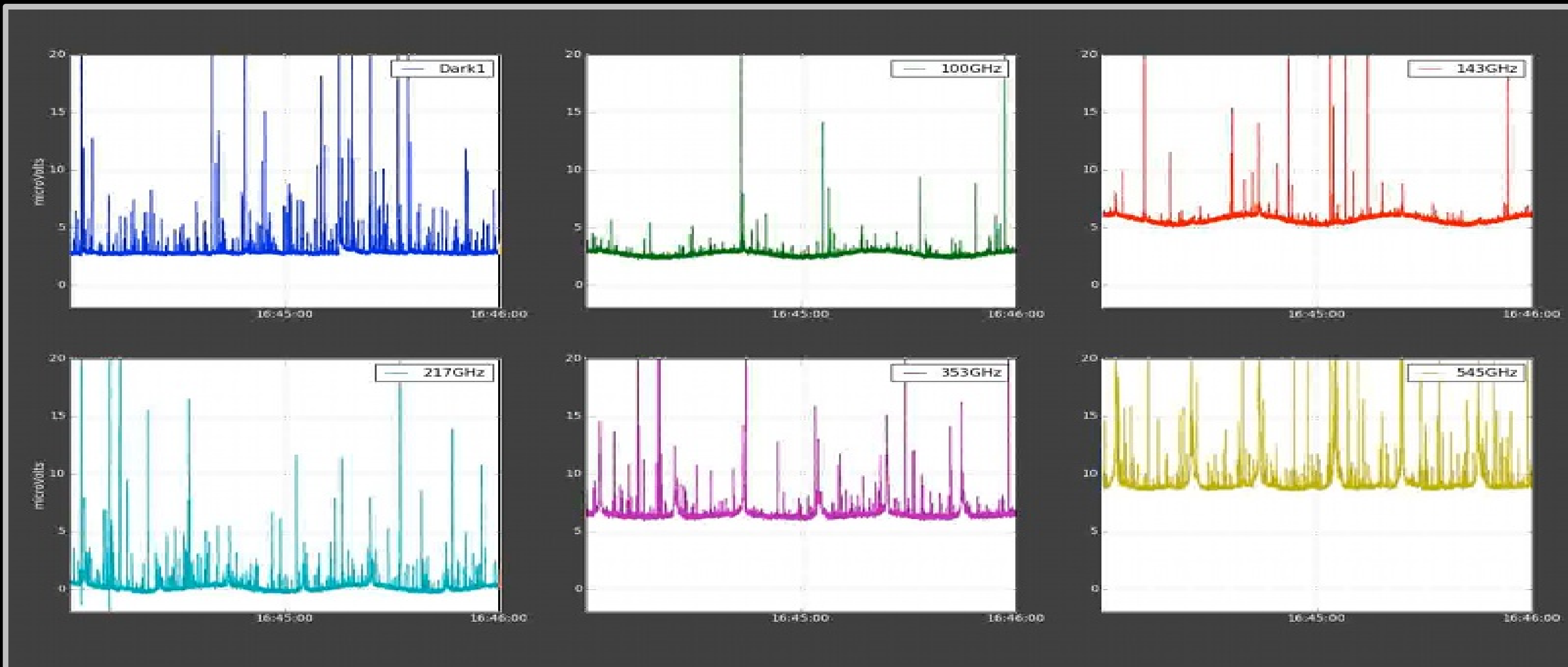
Cosmic Infrared Background



Far Infrared Background anisotropies from 10' to 2º measured at 217, 353, 545 and 857 GHz over 140 deg.² of the sky. This will be improved with more sky, and compared with with results from CMB analyses.

A&A 536, A18 (2011)

More Cosmic Rays than Expected



HFI saw many more cosmic ray hits than was expected, due to a combination of surface areas sensitive to cosmic rays but not to light, to much more sensitivity per detector than any previous experiment, and to a period of exceptionally low Solar activity. The worst part of each hit is masked, and any “tails” are modeled and removed, so we are not limited by this.

Sensitivity to Galactic CO

Planck HFI Core Team: Planck early results. VI. HFI data processing: AA 536, A6 (2011)

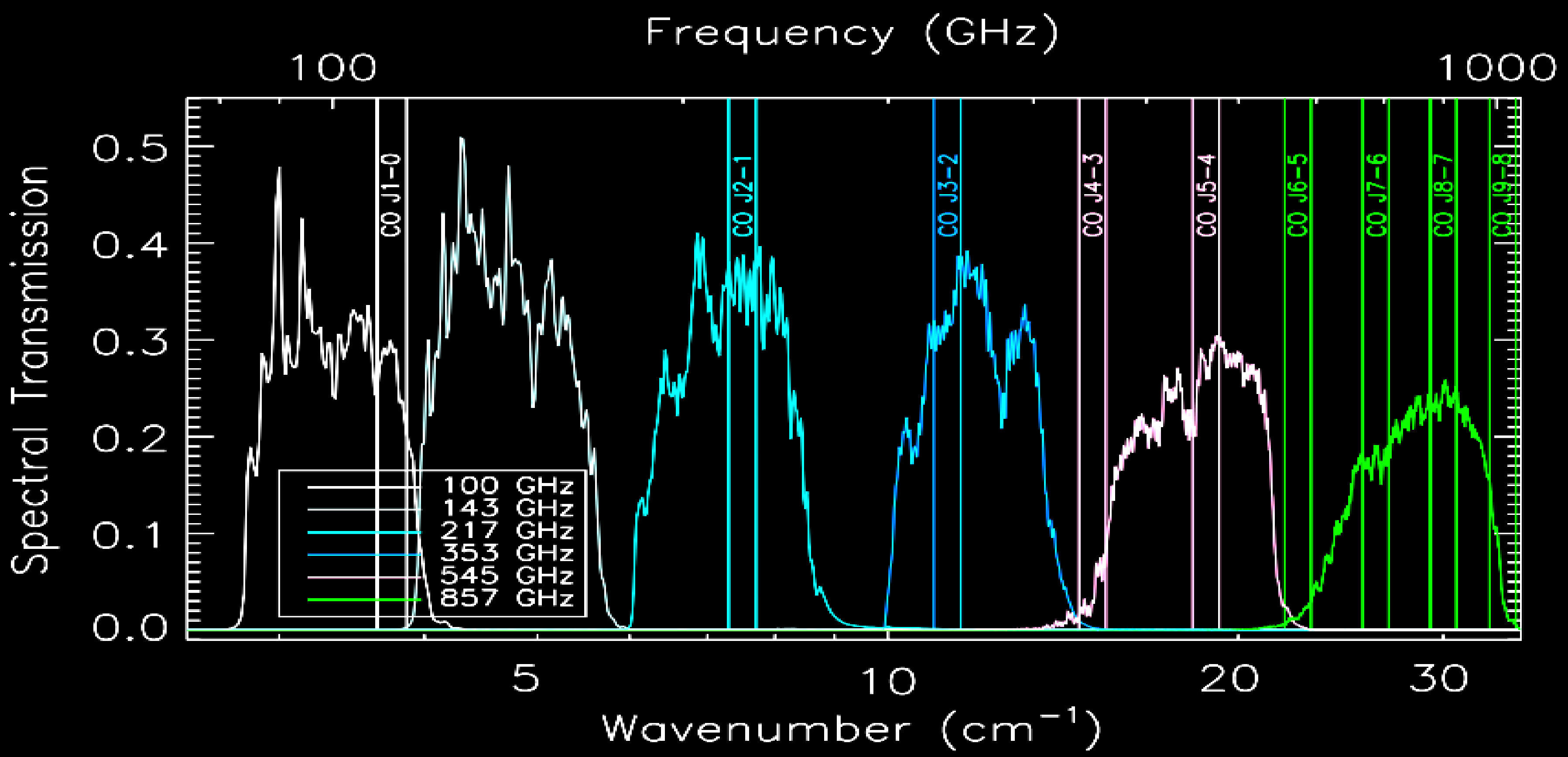
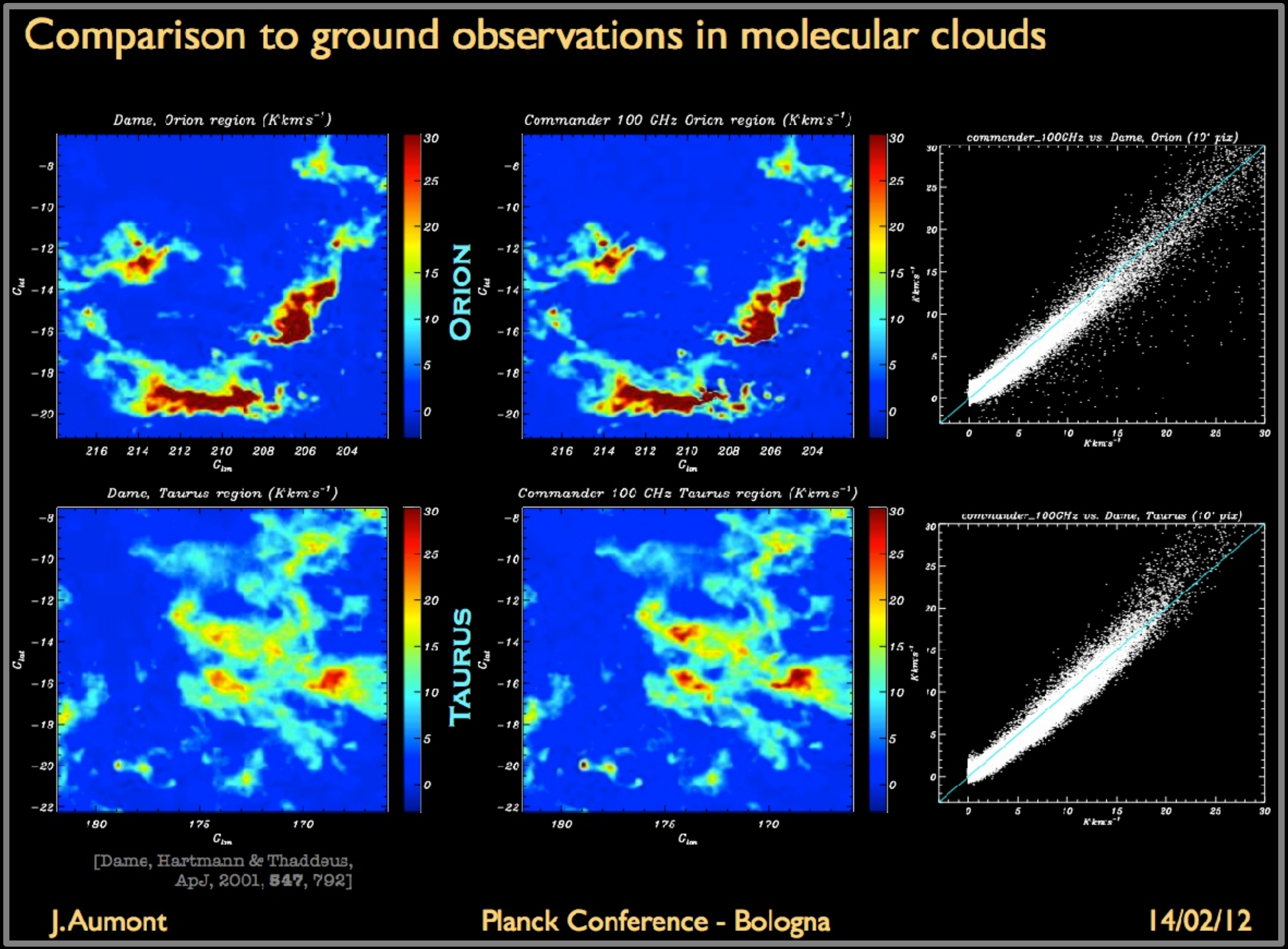


Figure 44. The average spectral response for each of the HFI frequency bands. The vertical bars represent the spectral regions of CO transitions and are interpolated by a factor of ~ 10.

A "broader than usual" 100 GHz filter means that Planck has more foregrounds in this channel than expected. Planck is also sensitive to higher CO transitions.

Full-Sky Maps of CO



Planck is working on full-sky J1-0, J2-1 and J3-2 maps of Galactic CO, which does not exit at the moment.

(OLD) CMB Spectra Predictions

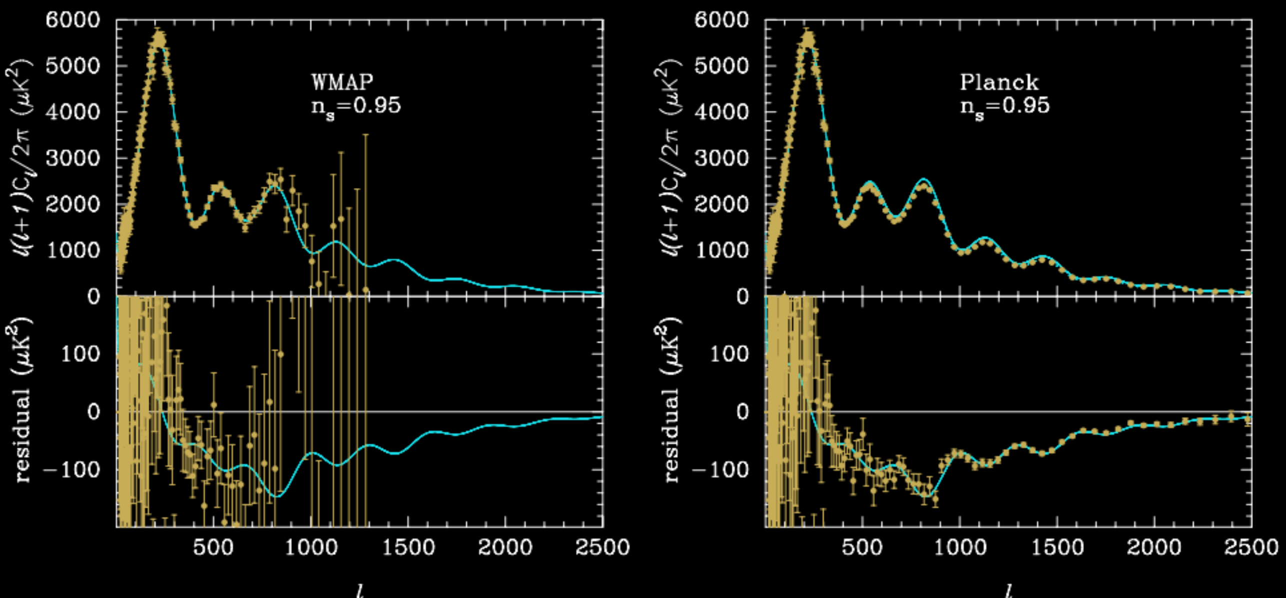


FIG 2.11.—The solid lines in the upper panels of these figures show the power spectrum of the concordance ΛCDM model with an exactly scale invariant power spectrum, $n_S = 1$. The points, on the other hand, have been generated from a model with $n_S = 0.95$ but otherwise identical parameters. The lower panels show the residuals between the points and the $n_S = 1$ model, and the solid lines show the theoretical expectation for these residuals. The left and right plots show simulations for *WMAP* and *Planck*, respectively.

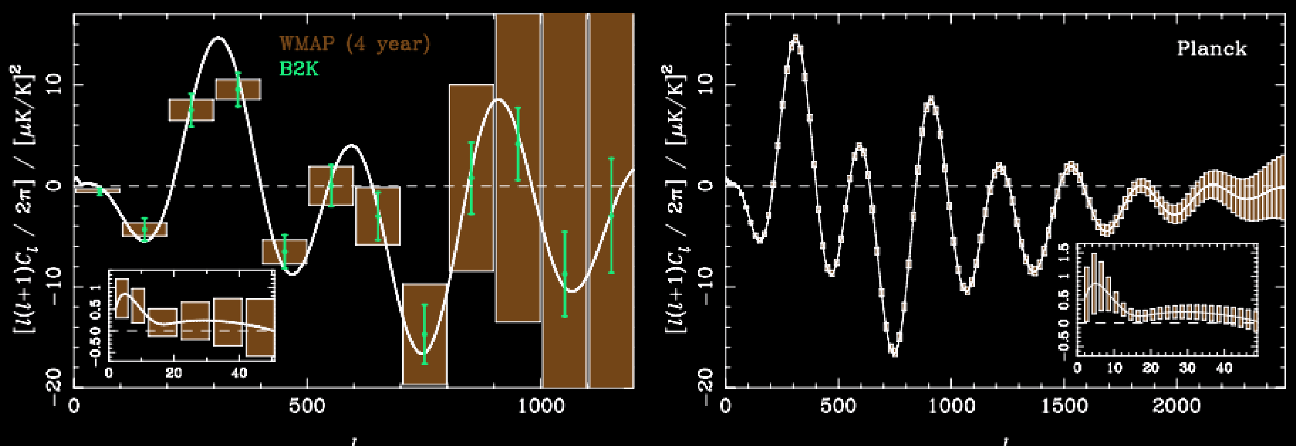


FIG 2.13.—Forecasts for the $\pm1\sigma$ errors on the temperature-polarization cross-correlation power spectrum C_ℓ^{TE} in a ΛCDM model (with $r = 0.1$ and $\tau = 0.17$) from *WMAP* (4 years of observation) and BOOMERanG2K (left) and *Planck* (right). In the left-hand plot, flat band powers are estimated with $\Delta\ell = 100$ for both experiments for ease of comparison. The inset shows the *WMAP* forecasts on large angular scales with a finer $\Delta\ell$ resolution. For *Planck*, flat band powers are estimated with $\Delta\ell = 20$ in the main plot, but with $\Delta\ell = 2$ in the inset on large scales.

Top: Temperature
Bottom: T-E Spectra

Left: WMAP 4-Year*
Right: Planck 1-Year Prediction*

WMAP will ultimately have 9 years, and HFI will have at least 2.

These plots are outdated and should be used only for *rough comparison only.*

(OLD) Predicted Polarization Spectra

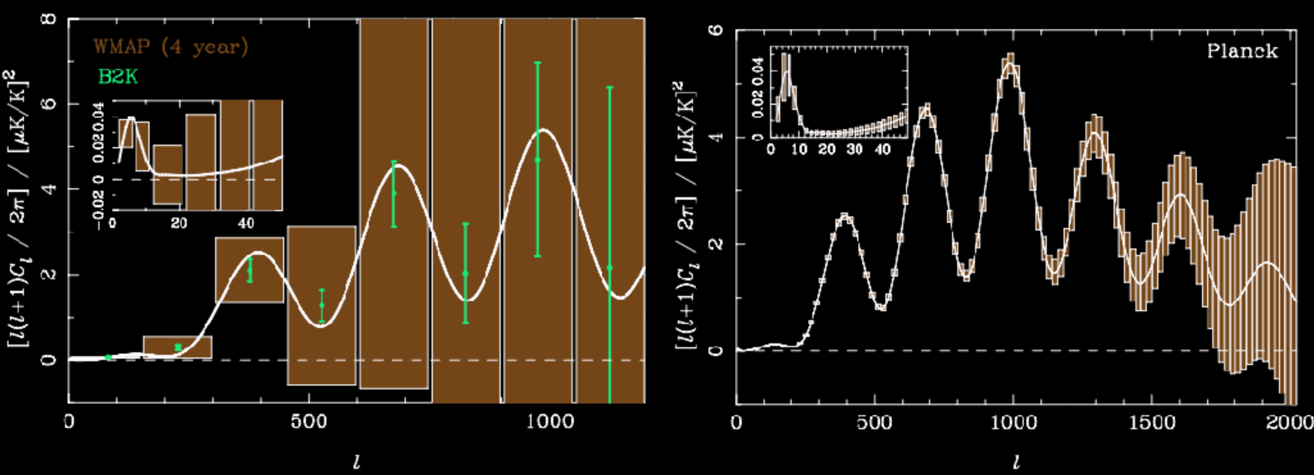


FIG 2.14.—Forecasts for the $\pm1\sigma$ errors on the E-mode polarization power spectrum C_ℓ^E from *WMAP* and B2K (left) and *Planck* (right). The cosmological model, and the assumptions about instrument characteristics, are the same as in Figure 2.13. For *WMAP* and B2K, flat band powers are estimated with $\Delta\ell = 150$ (with finer resolution on large scales for *WMAP* in the inset). For *Planck* we have used the same ℓ-resolution as in Figure 2.13.

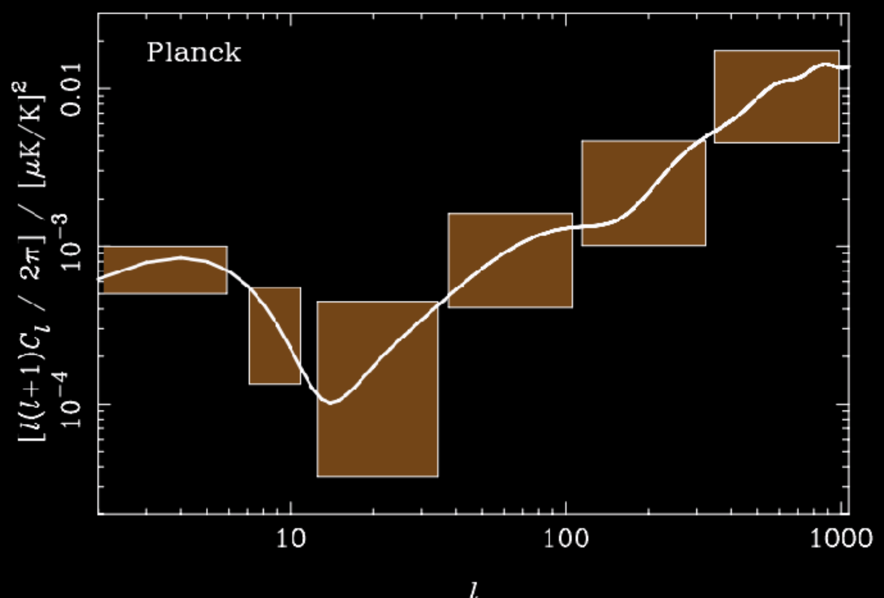


FIG 2.17.—Forecasts for the $\pm1\sigma$ errors on the B-mode polarization power spectrum C_ℓ^B from *Planck* (for $\tau = 0.1$ and $\tau = 0.17$). Above $\ell \sim 150$ the primary spectrum is swamped by weak gravitational lensing of the E-polarization produced by the dominant scalar perturbations. The cosmological model, and the assumptions about instrument characteristics, are the same as in Figure 2.13.

Top: E-E Spectra

Left: WMAP 4-Year*
Right: Planck 1-Year Prediction*
WMAP will ultimately have 9 years, and HFI will have at least 2.

This plots is outdated and should be used only for *rough comparison only.*

Bottom: B-B Spectra

(OLD) Predicted Comparison with WMAP

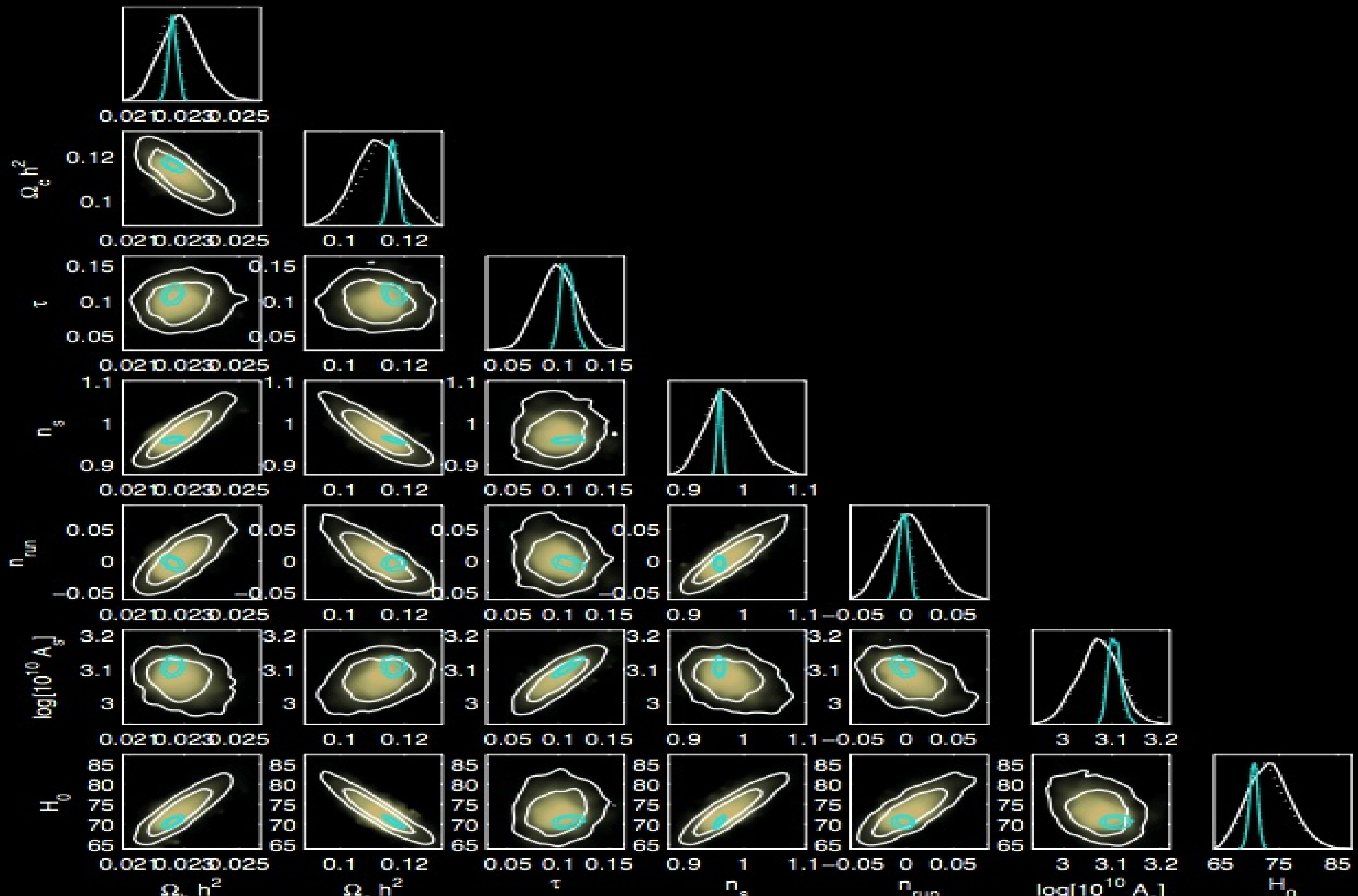


FIG 2.18.—Forecasts of 1 and 2σ contour regions for various cosmological parameters when the spectral index is allowed to run. Blue contours show forecasts for *WMAP* after 4 years of observation and red contours show results for *Planck* after 1 year of observations. The curves show marginalized posterior distributions for each parameter.

Expected Limits on r = T/S

B-mode Detection with an Extended Planck Mission

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Abstract. The *Planck* satellite has a nominal mission lifetime of 14 months allowing two complete surveys of the sky. Here we investigate the potential of an extended *Planck* mission of four sky surveys to constrain primordial B-mode anisotropies in the presence of dominant Galactic polarized foreground emission. An extended *Planck* mission is capable of powerful constraints on primordial B-modes at low multipoles, which cannot be probed by ground based or sub-orbital experiments. A tensor-scalar ratio of $r = 0.05$ can be detected at a high significance level by an extended *Planck* mission and it should be possible to set a 95% upper limit of $r \lesssim 0.03$ if the tensor-scalar ratio is vanishingly small. Furthermore, extending the *Planck* mission to four sky surveys offers better control of polarized Galactic dust emission, since the 217 GHz frequency band can be used as an effective dust template in addition to the 353 GHz channel.

Schedule

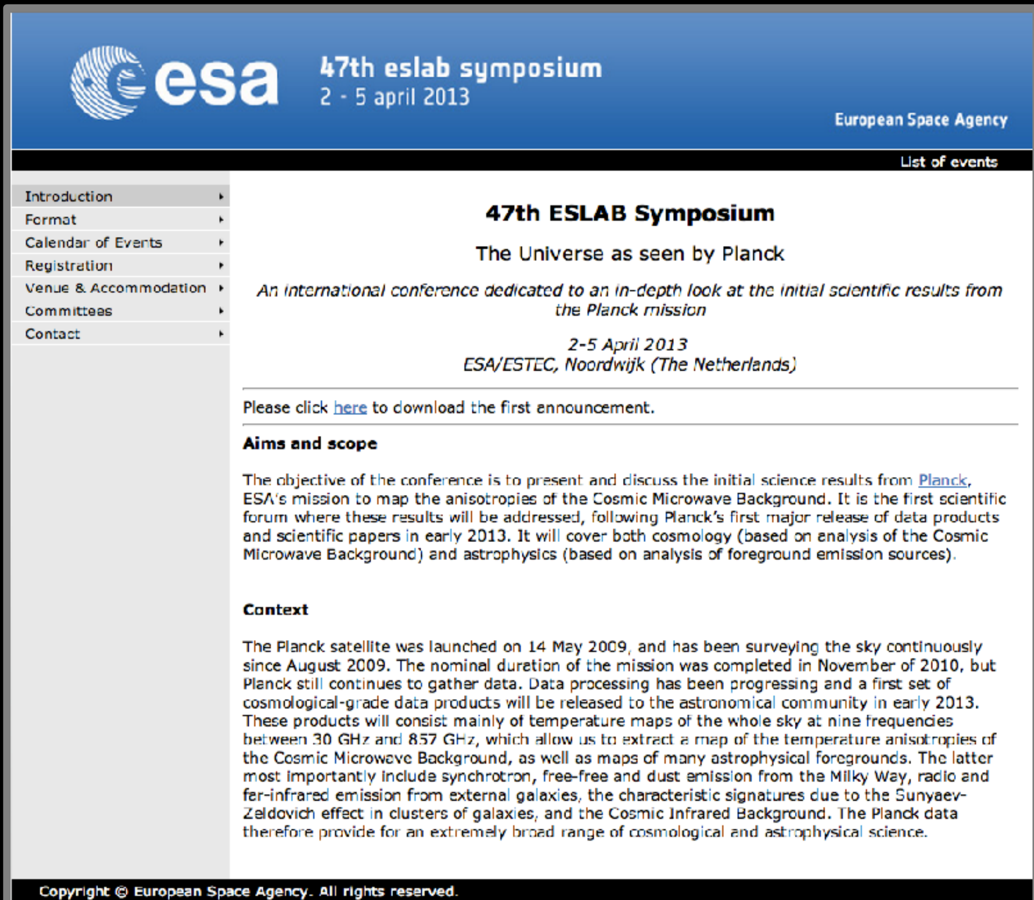
- 2011-01: Planck Early Papers
- 2012: Planck Intermediate Papers
- The products that will become public are being made NOW
- 2012-12: First delivery to ESA (15 months of data; no timelines; no polarization)
- 2013-03: Science papers; ESA Data release 1
- 2013-04: The Universe as Seen by Planck
  - 2013-07: Rencontres du Vietnam
- 2014-02: Second delivery to ESA
  (full mission, with timelines and polarization)
  Science papers; ESA full mission data release

What will be Released in 2013?

- Papers
  - LFI and HFI Instrument and Processing
  - Component Separation, Foreground Modeling and Compact Source Extraction
  - Power Spectra, Cosmological Parameters, Inflation, Lensing, Infrared Background
- Products
  - Frequency Maps
    - Individual Survey Maps
  - Component Maps
    - Including CO, Opacity
  - Source Catalogs
  - Power Spectra
  - Likelihood Code
  - Non-Gaussianity
  - Documentation

...and we're working hard to continue to release polarization, timelines and more...

The Universe as Seen by Planck


esa 47th eslab symposium
2 - 5 april 2013
European Space Agency
List of events

- Introduction
- Format
- Calendar of Events
- Registration
- Venue & Accommodation
- Committees
- Contact

47th ESLAB Symposium

The Universe as seen by Planck

An international conference dedicated to an in-depth look at the initial scientific results from the Planck mission

2-5 April 2013
ESA/ESTEC, Noordwijk (The Netherlands)

Please click here to download the first announcement.

Aims and scope

The objective of the conference is to present and discuss the initial science results from Planck, ESA's mission to map the anisotropies of the Cosmic Microwave Background. It is the first scientific forum where these results will be addressed, following Planck's first major release of data products and scientific papers in early 2013. It will cover both cosmology (based on analysis of the Cosmic Microwave Background) and astrophysics (based on analysis of foreground emission sources).

Context

The Planck satellite was launched on 14 May 2009, and has been surveying the sky continuously since August 2009. The nominal duration of the mission was completed in November of 2010, but Planck still continues to gather data. Data processing has been progressing and a first set of cosmological-grade data products will be released to the astronomical community in early 2013. These products will consist mainly of temperature maps of the whole sky at nine frequencies between 30 GHz and 857 GHz, which allow us to extract a map of the temperature anisotropies of the Cosmic Microwave Background, as well as maps of many astrophysical foregrounds. The latter most importantly include synchrotron, free-free and dust emission from the Milky Way, radio and far-infrared emission from external galaxies, the characteristic signatures due to the Sunyaev-Zeldovich effect in clusters of galaxies, and the Cosmic Infrared Background. The Planck data therefore provide for an extremely broad range of cosmological and astrophysical science.

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This will be the first Planck-sponsored forum after the initial release of Planck cosmological results.

This is the seventh "Rencontres du Vietnam", is organized by the same group who does the Moriond meeting, but will require less jet lag!