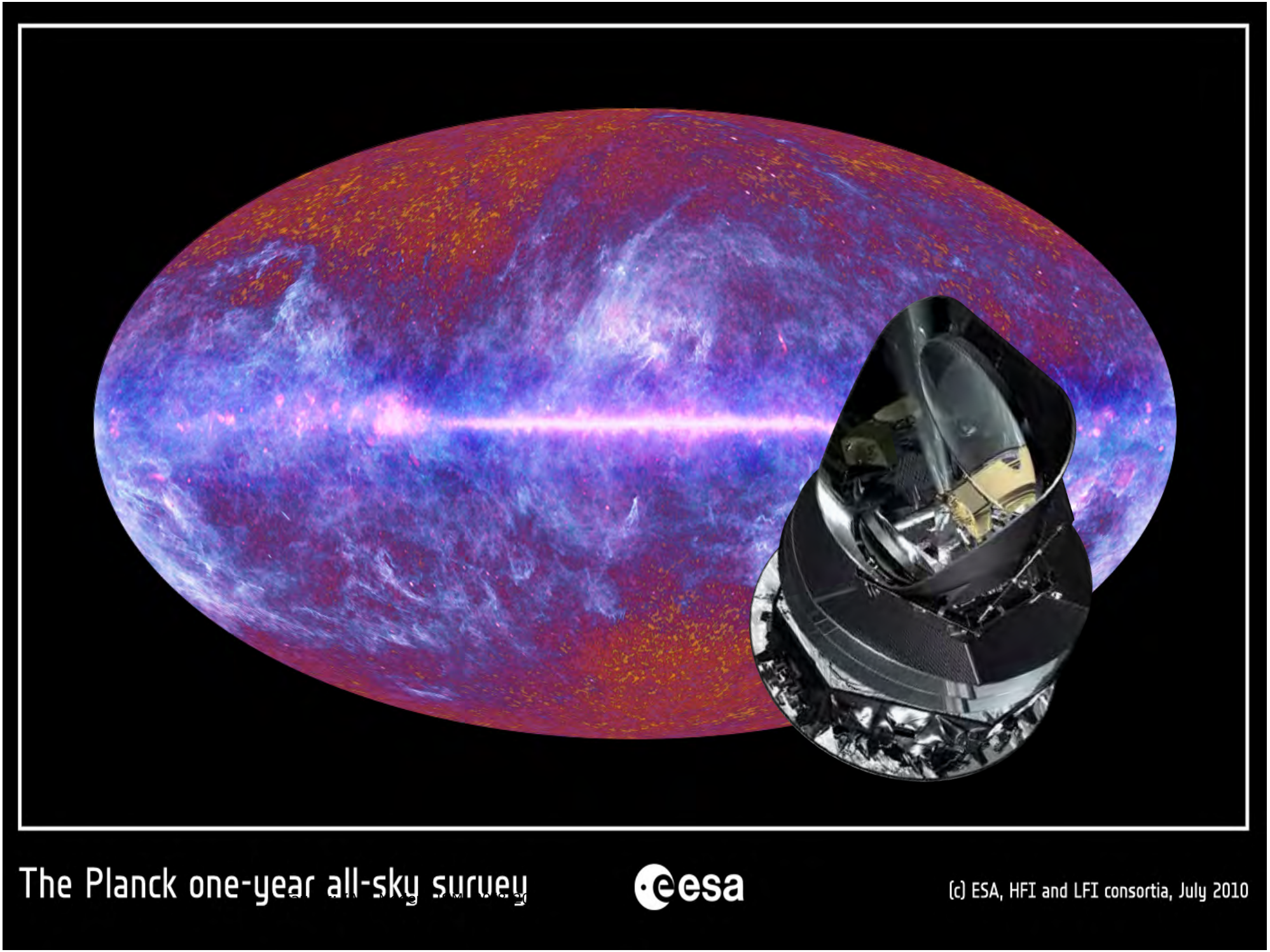
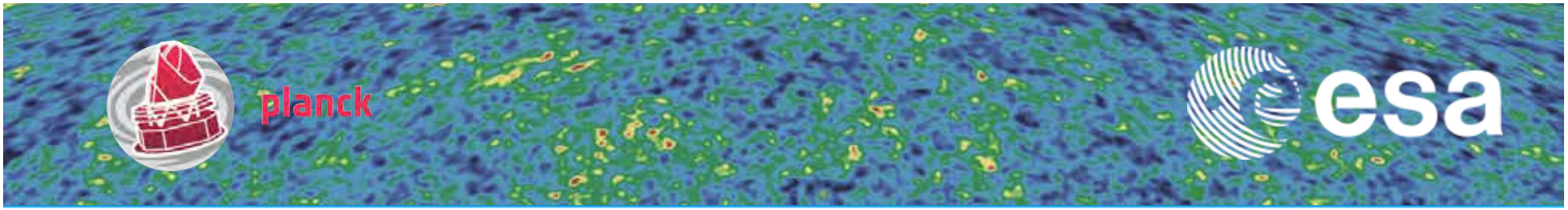

The Planck one-year all-sky survey
esa
(c) ESA, HFI and LFI consortia, July 2010



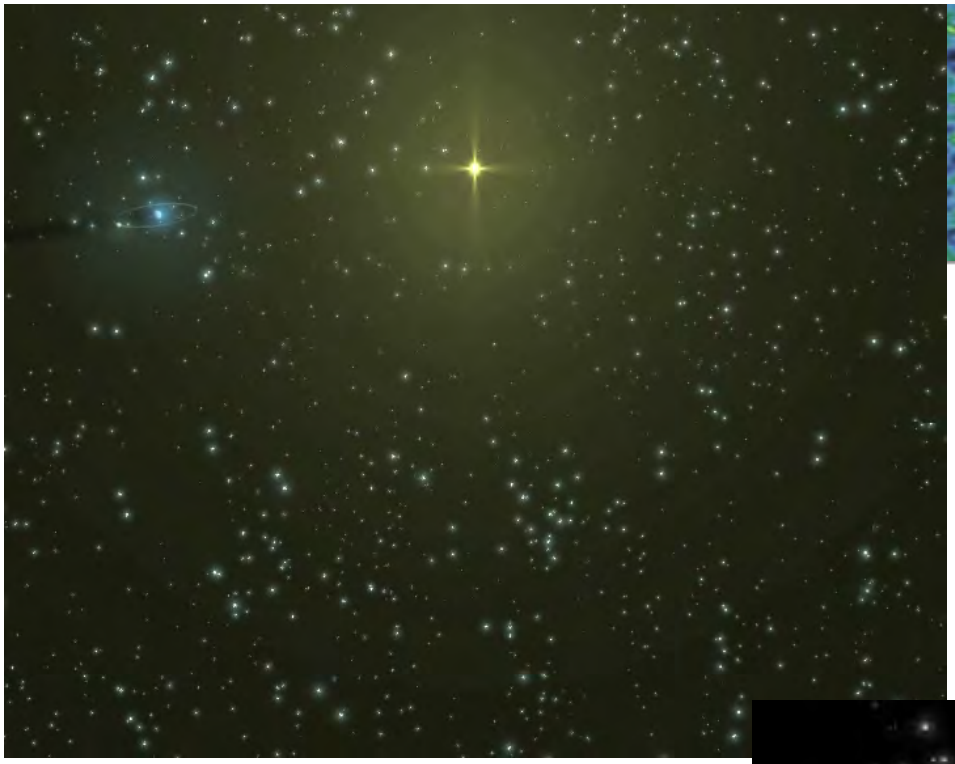
Planck's view of the ISM

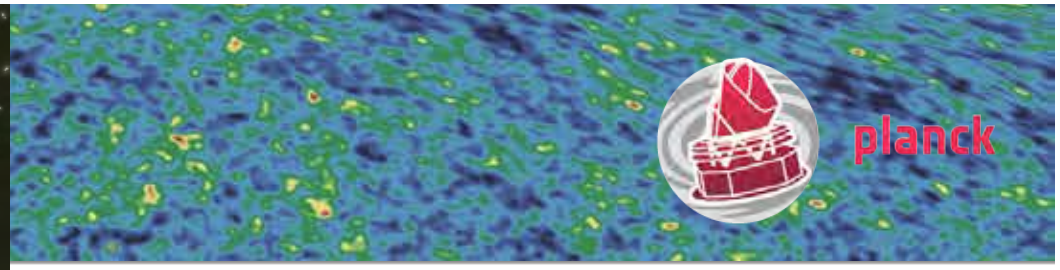
J. Tauber
Planck Project Scientist, ESA
on behalf of the Planck Collaboration

Info and publications at:
http://www.rssd.esa.int/Planck

The European mission to map the Cosmic Microwave Background

To image the temperature and polarisation anisotropies of the Cosmic Microwave Background (CMB), over the whole sky, with an uncertainty on the temperature limited by "natural causes" (foreground fluctuations, cosmic variance) rather than intrinsic or systematic detector noises, and an angular resolution ~5 arcminutes.



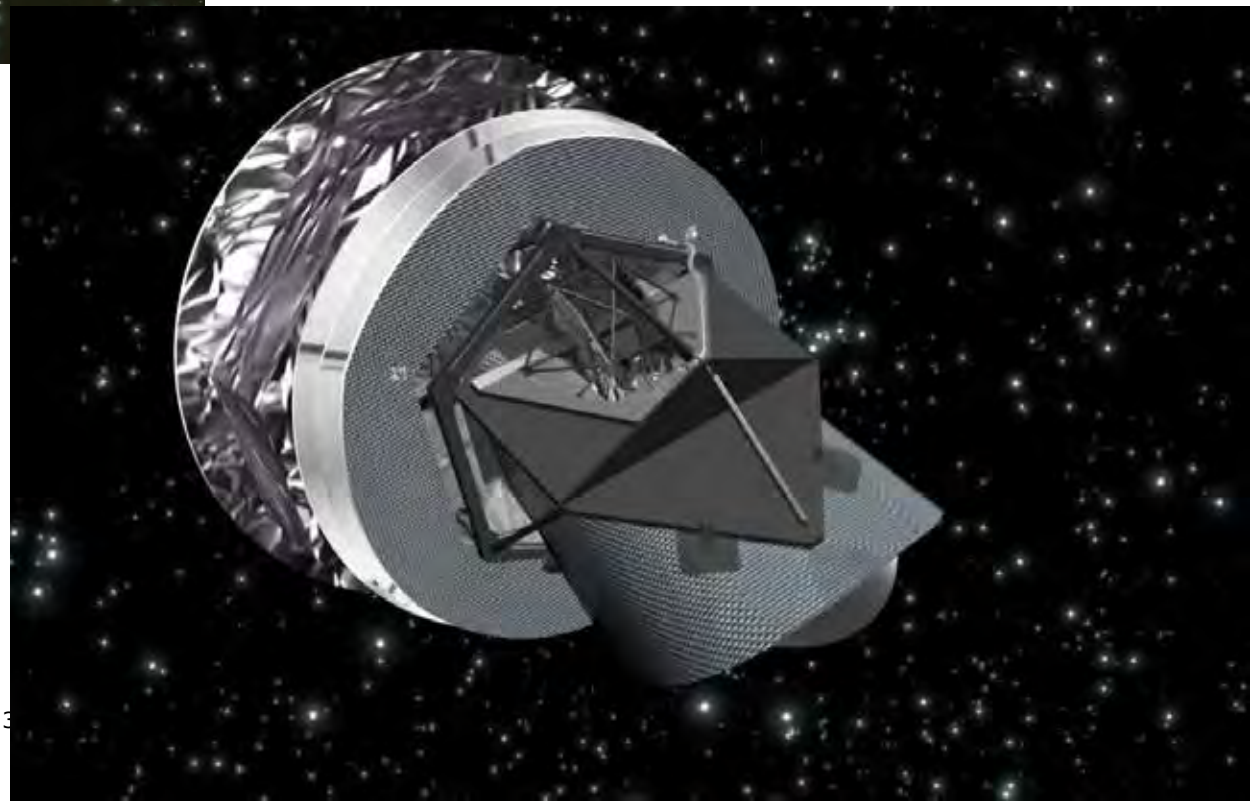


Launch = 14 May 2009

Nominal mission
= 15 months
= 2 full sky surveys
HAS BEEN COMPLETED in NOV 2010 !

Extended cryogenic mission
= 15 + 12 months
= ~5 full sky surveys
HAS BEEN COMPLETED IN JAN 2012 !

First LFI-only Extension:
> Dec 2012



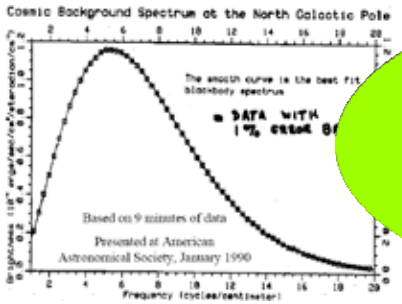
esa

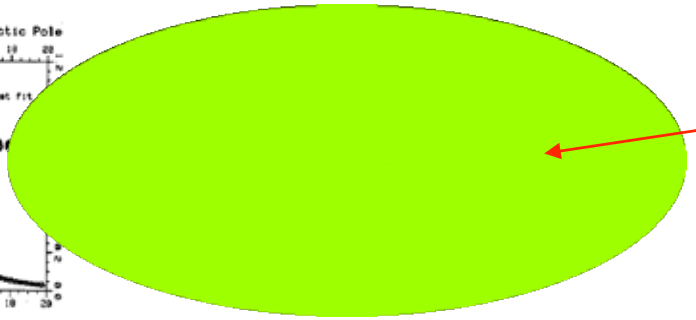
Today

The Cosmic Microwave Background is generated here

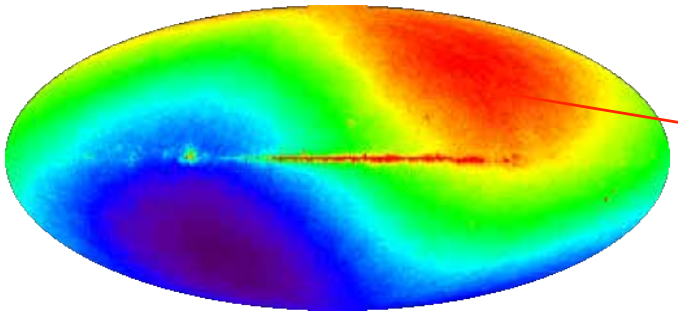
Inflation

The sky as seen by a CMB experiment, e.g. Planck

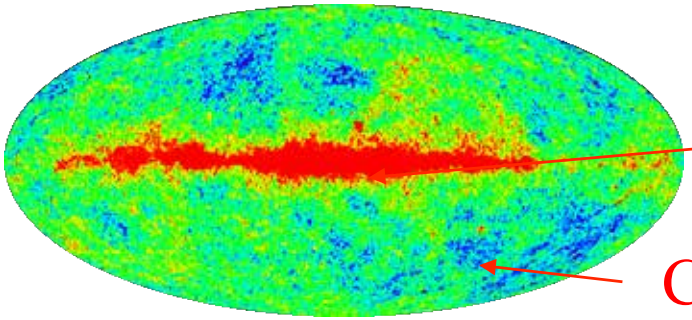




CMB, T ~ 2.7 K

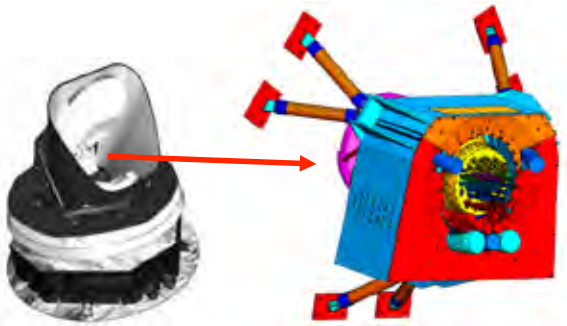


Dipole, ΔT ~3 mK

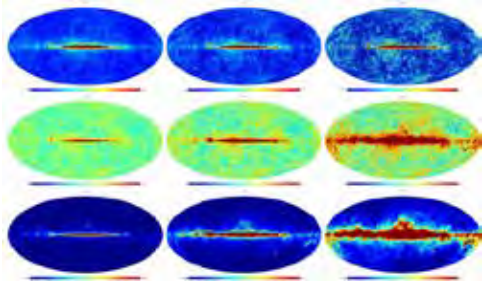


Milky Way, ΔT ~1 mK

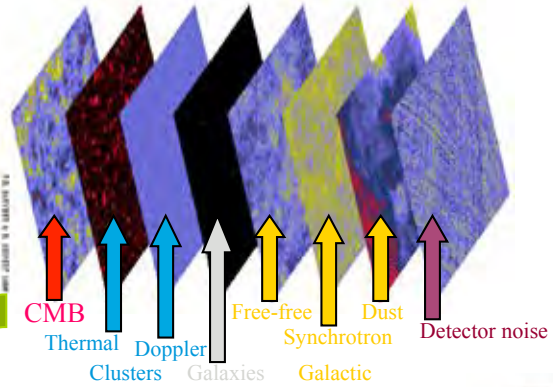
CMB anisotropies, ΔT ~50 μK



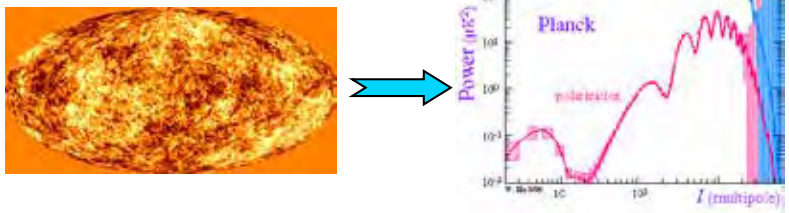
Acquiring and processing
time-ordered information



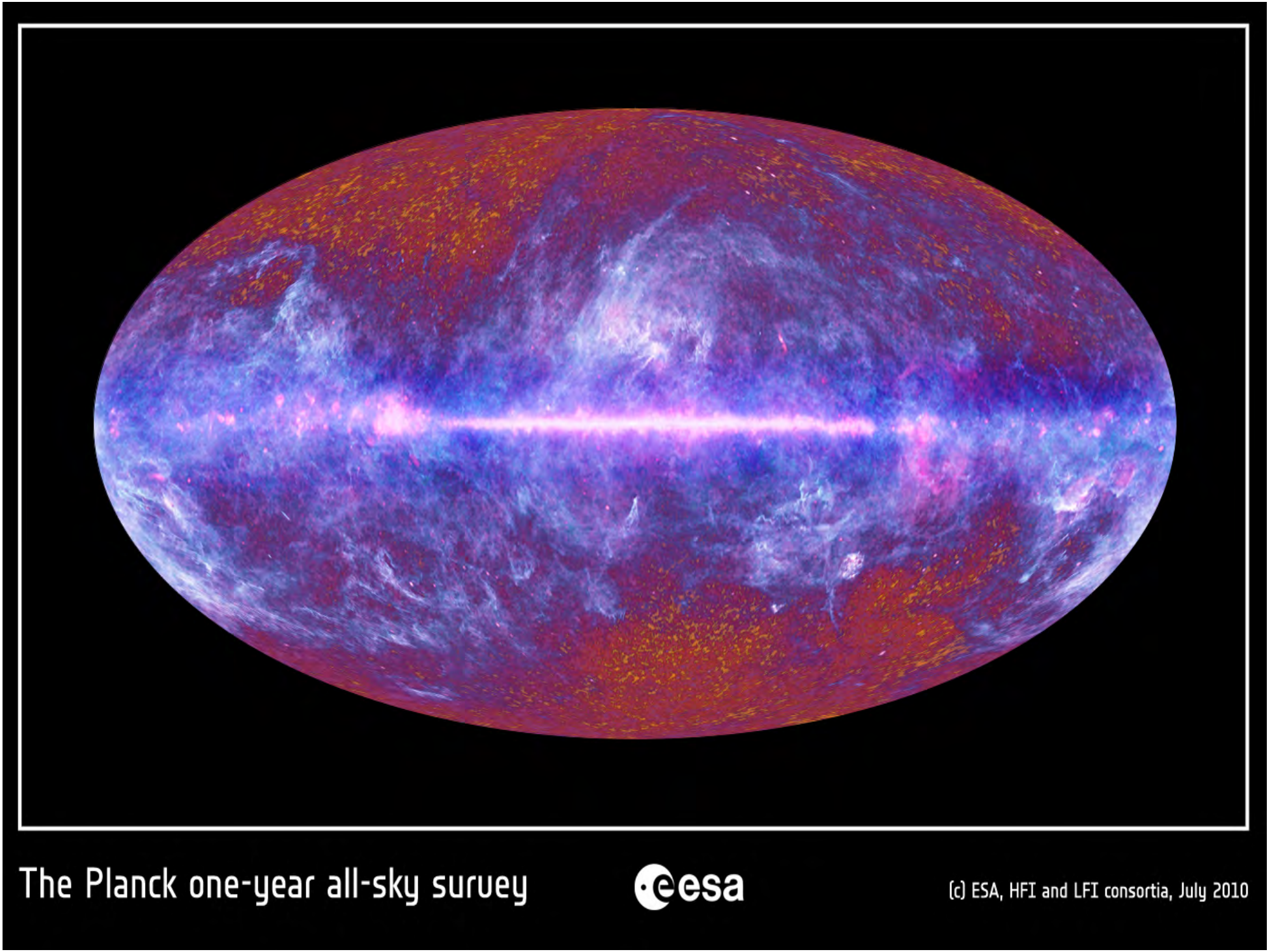
Converting time-ordered data
to maps of the sky emission
at many frequencies



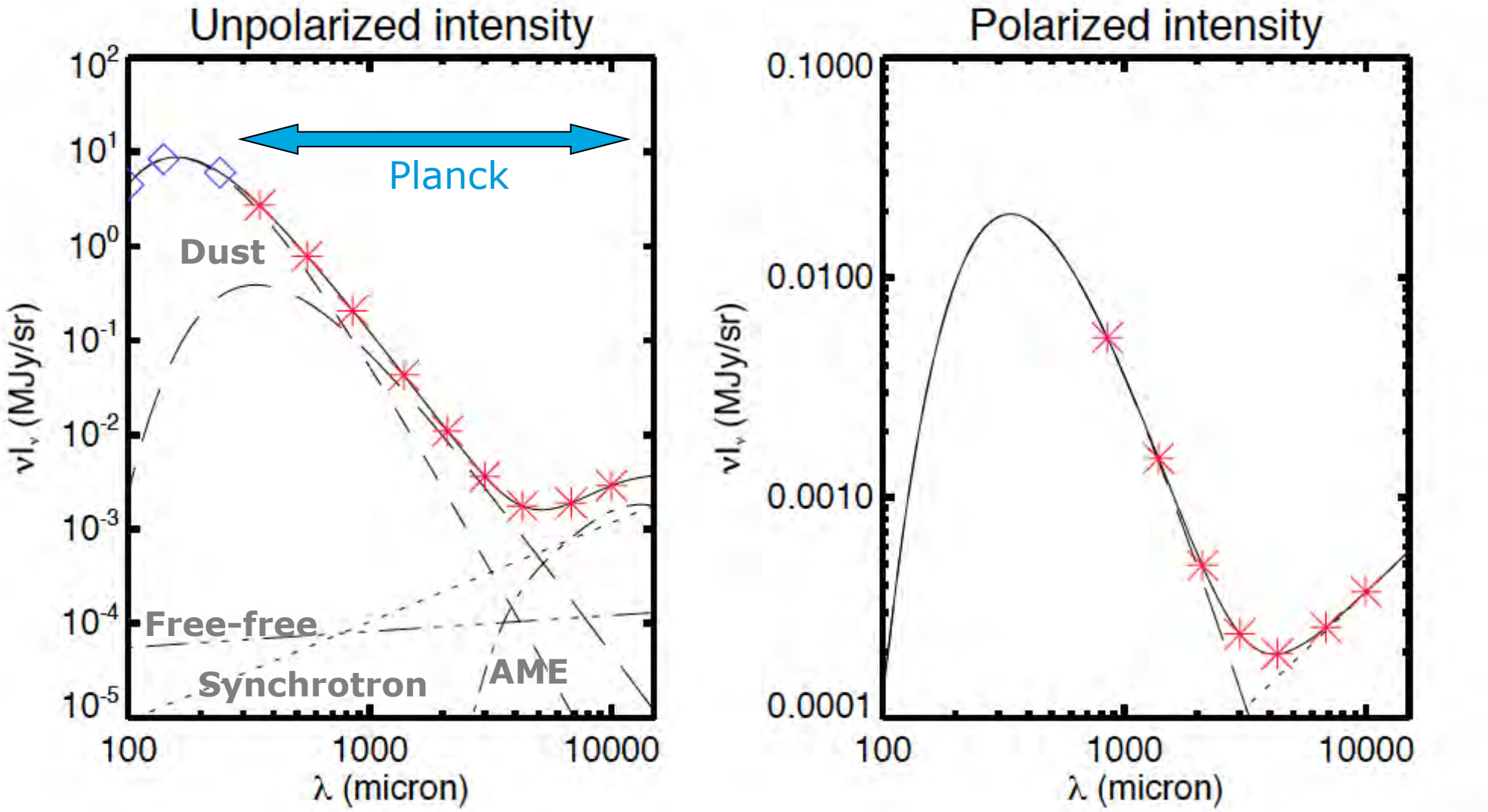
Converting frequency
maps to component maps,
e.g. the Cosmic Microwave Background



Estimating the CMB
angular power spectrum
and cosmological parameters

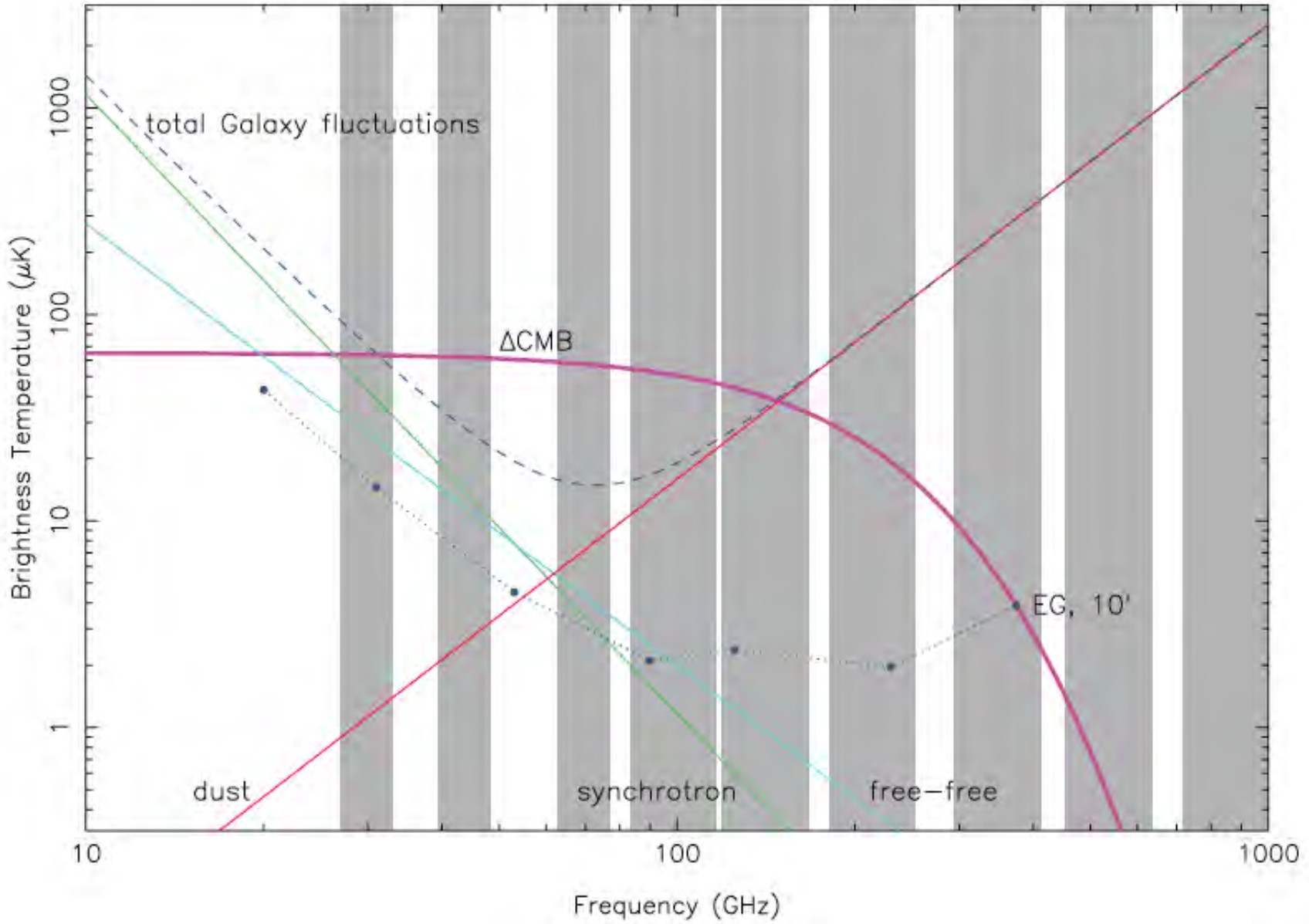

The Planck one-year all-sky survey
esa
(c) ESA, HFI and LFI consortia, July 2010

Spectra of diffuse ISM

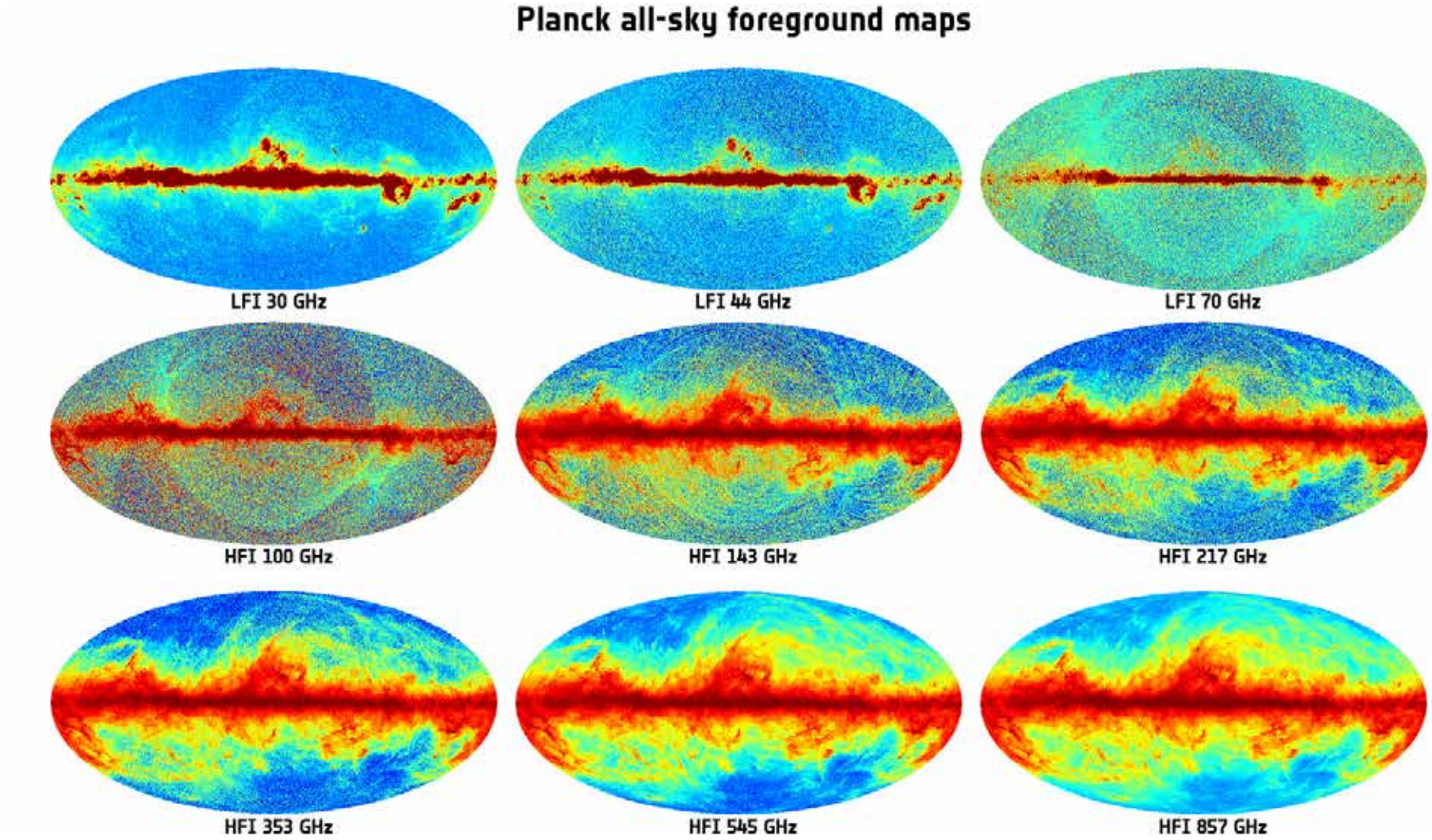


Planck Sky Model: Miville-Deschenes et al 2009

Fluctuation levels

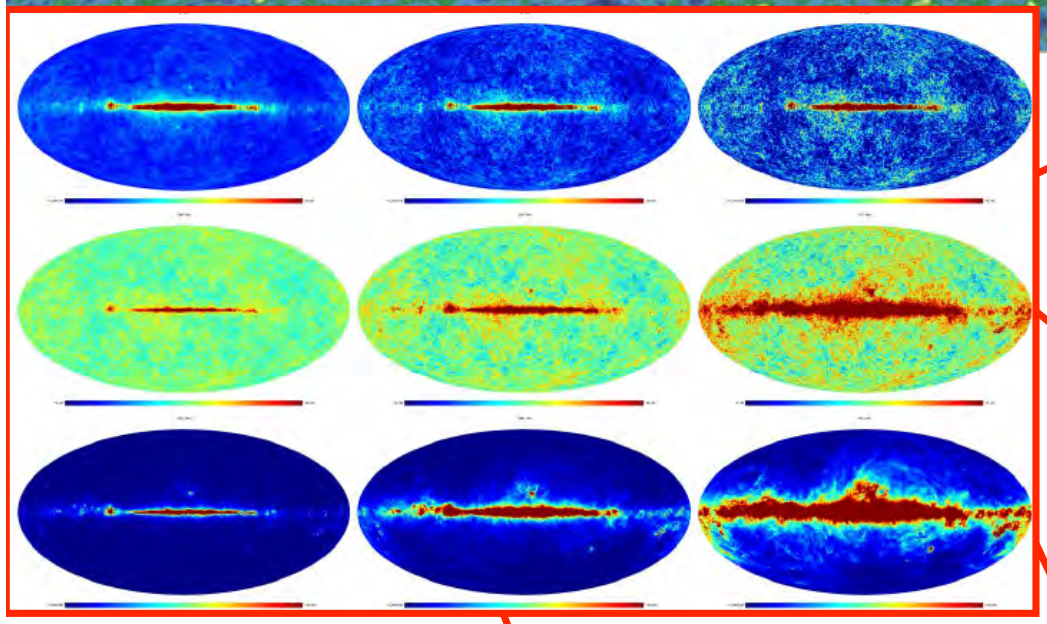


Planck foregrounds (CMB subtracted)

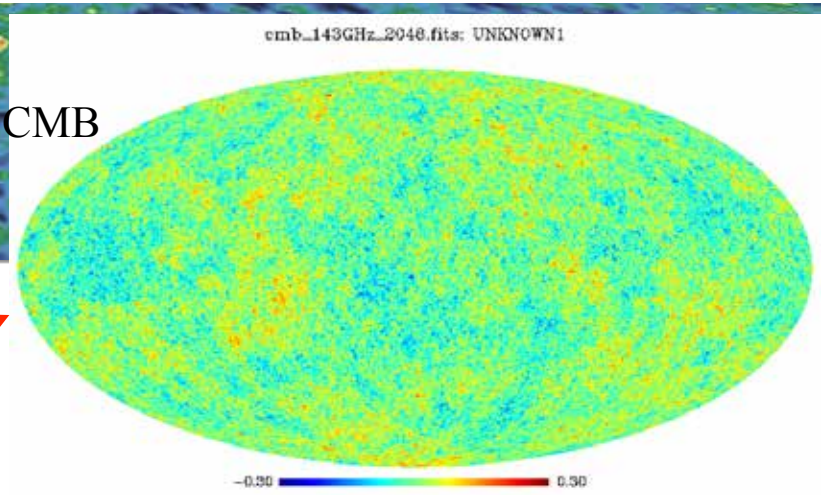


PlanckColl 5, 6

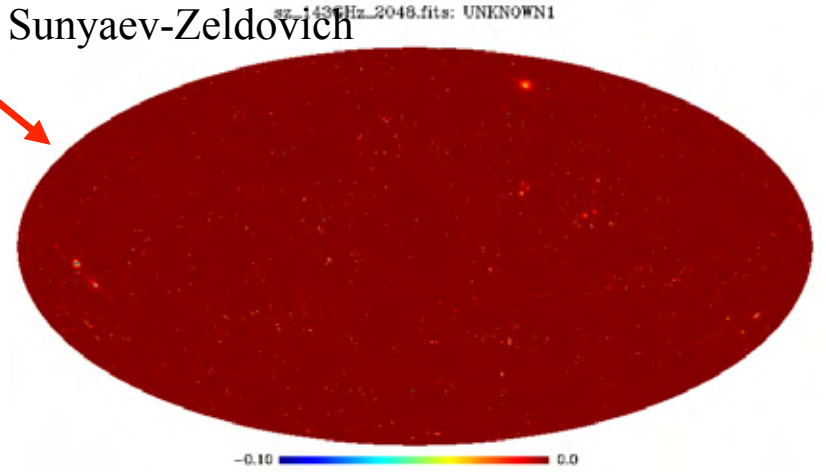
Foregrounds



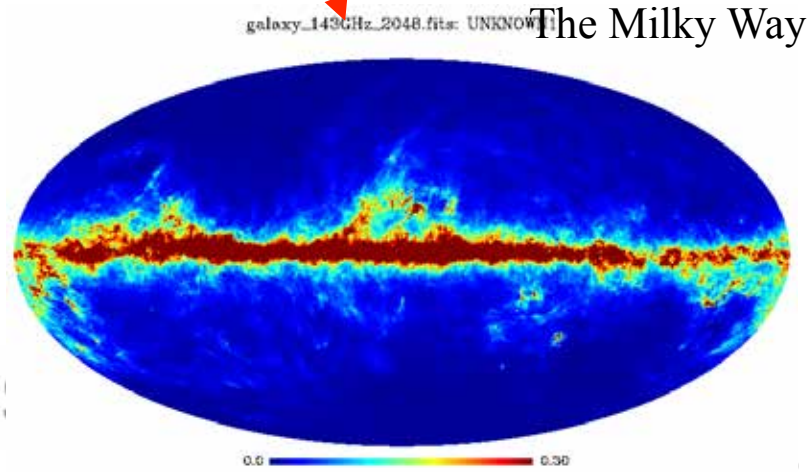
CMB



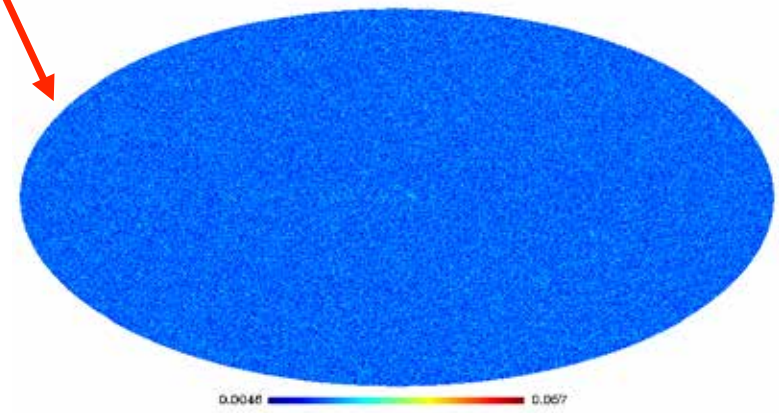
Sunyaev-Zeldovich



The Milky Way



Point & Compact sources



Key non-CMB science with Planck

planck

Sunyaev-Zeldovich-selected sources

- Measurement of y in ~ 10^3 galaxy clusters
- Cosmological evolution of clusters to z ~ 1
- Gas properties (w/ X-ray, IR measurements)
- Bulk velocities on scales > 300 Mpc

Extragalactic sources and backgrounds

- SEDs of IR and radio galaxies
- SEDs of AGN's, QSO's, blazars
- Evolution of galaxy counts to z > 1
- Far-IR background fluctuations

Maps of Milky Way at frequencies 30-1000 GHz

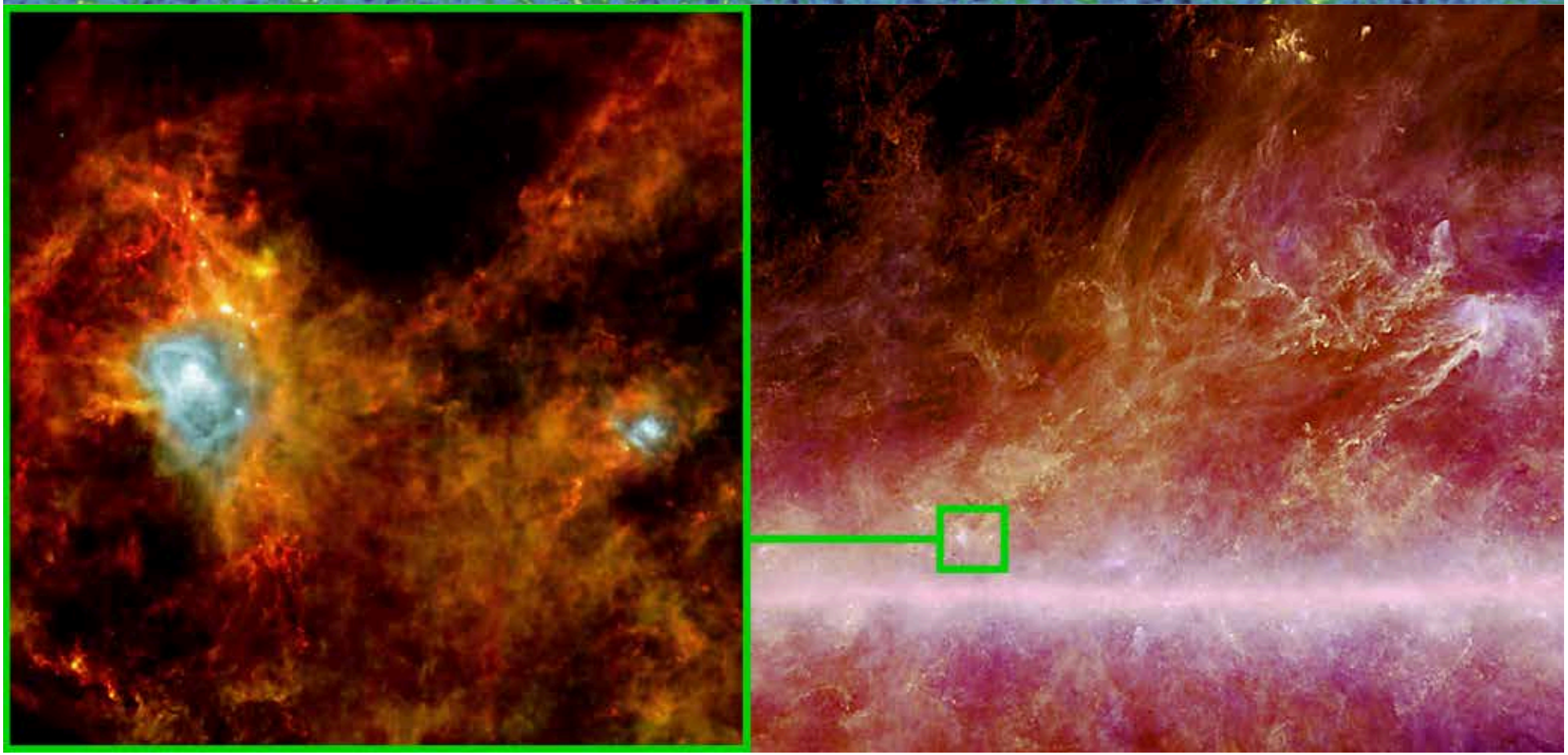
- Dust properties, Cloud and cirrus morphology
- Star forming regions, Cold molecular clouds
- Galaxy-scale distribution of gas and dust
- Polarisation-based science, e.g. Galactic magnetic field

Unique capabilities for the ISM

1. Wide frequency range (radio to submm):
    a. characterise the coldest dust components
    b. characterise components with uncommon spectra e.g. spinning dust, galactic haze
2. All-sky coverage:
    a. global studies of the Milky Way
    b. complete samples of selected objects
    c. statistical studies of the ISM in external galaxies
3. Measure polarisation
    a. Dust properties
    b. Magnetic field properties
4. Accurate calibration

Illustrative examples follow…

Complementarity with Herschel

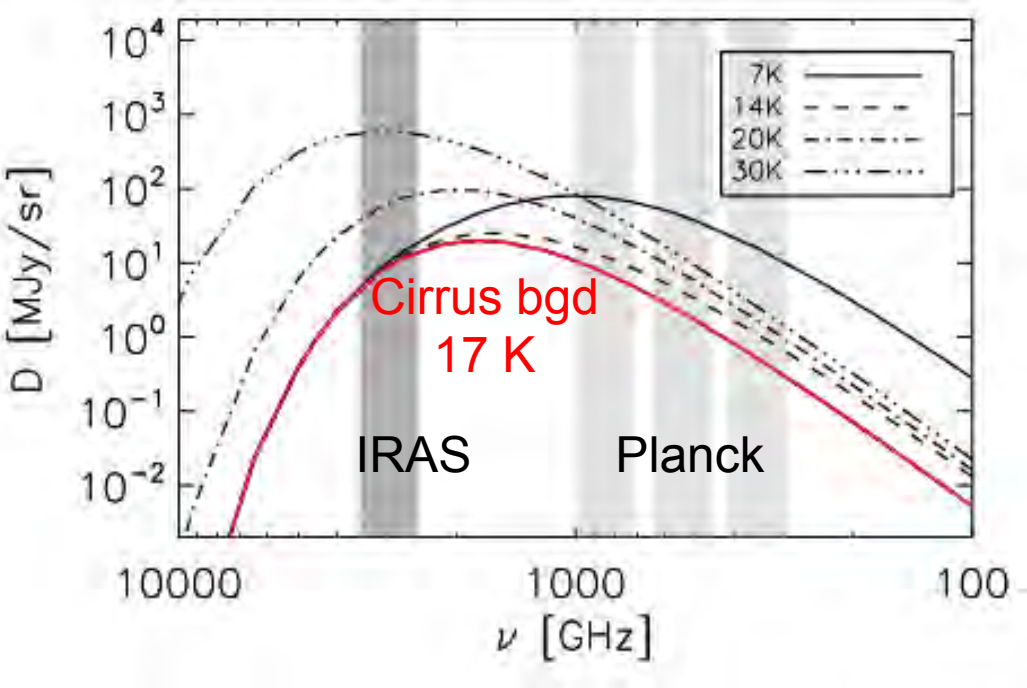


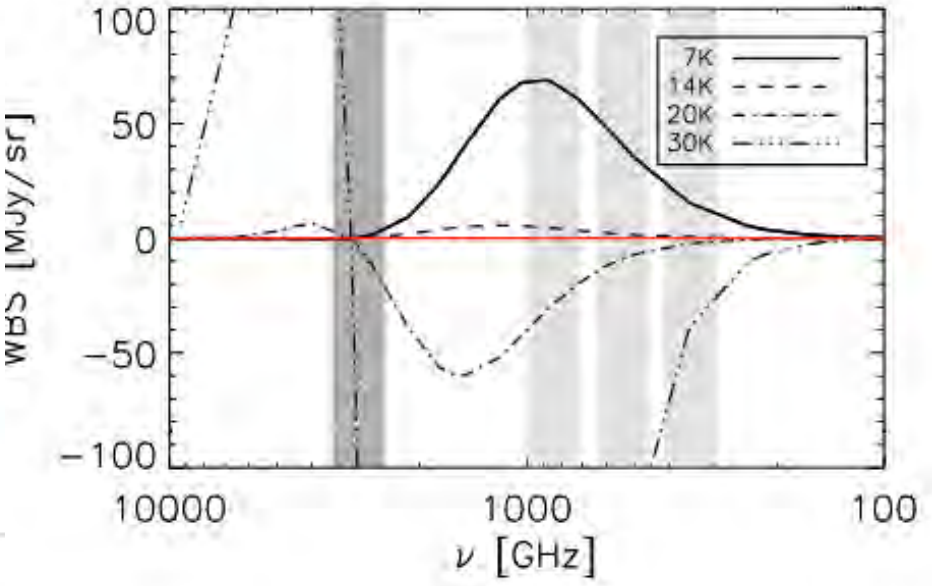
Herschel

Planck and IRAS

Measuring dust temperature

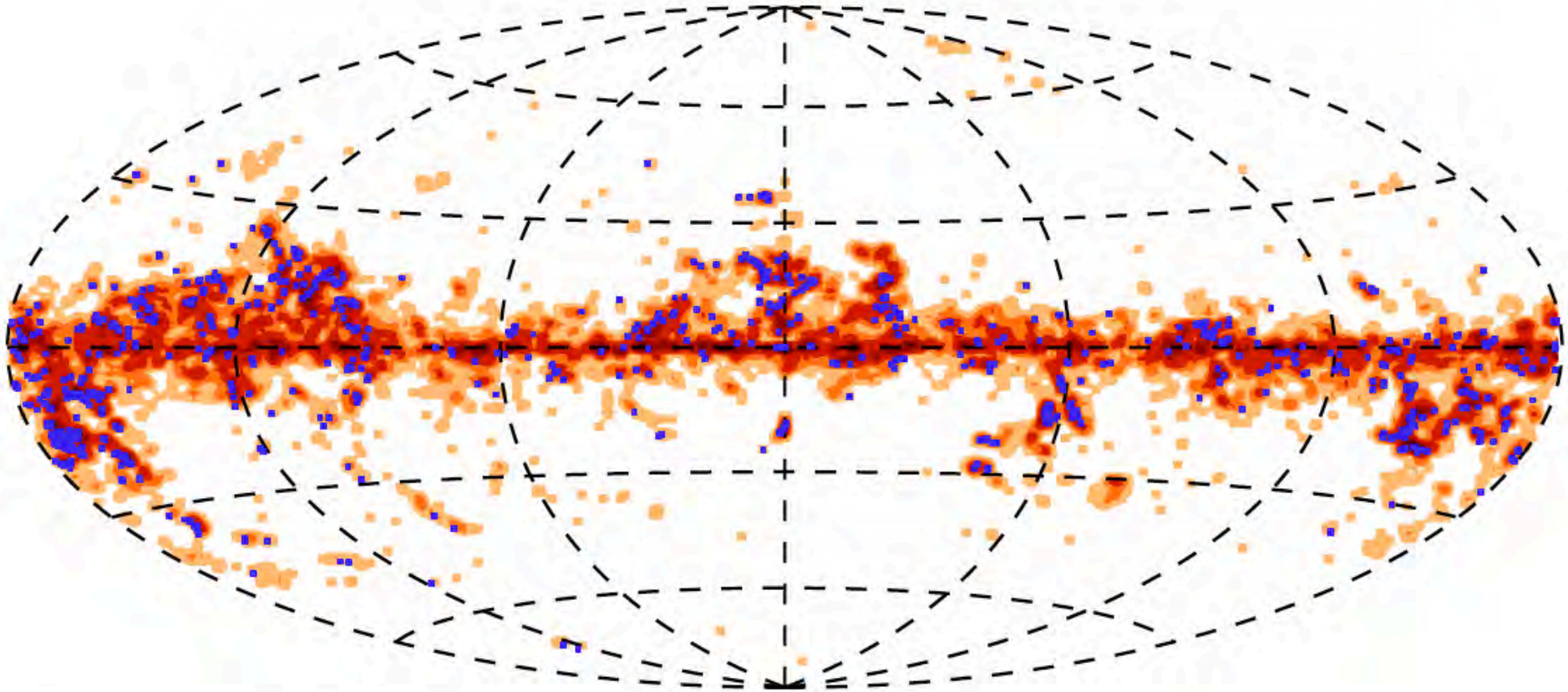
Residual after subtraction
of a warm component based
on 100 μm and 857 GHz





- The combination of IRAS and Planck allows to measure accurately the temperature of the coldest dust (if we know the dust physical properties)

Cold Clumps in the ERCSC



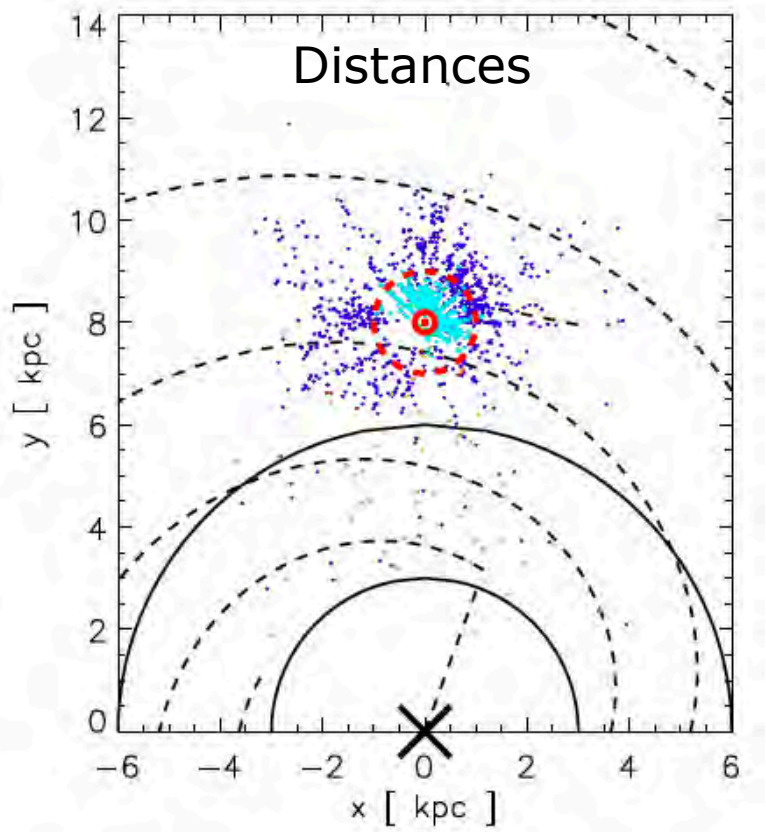
All-sky map of the number of C3PO objects per square degree

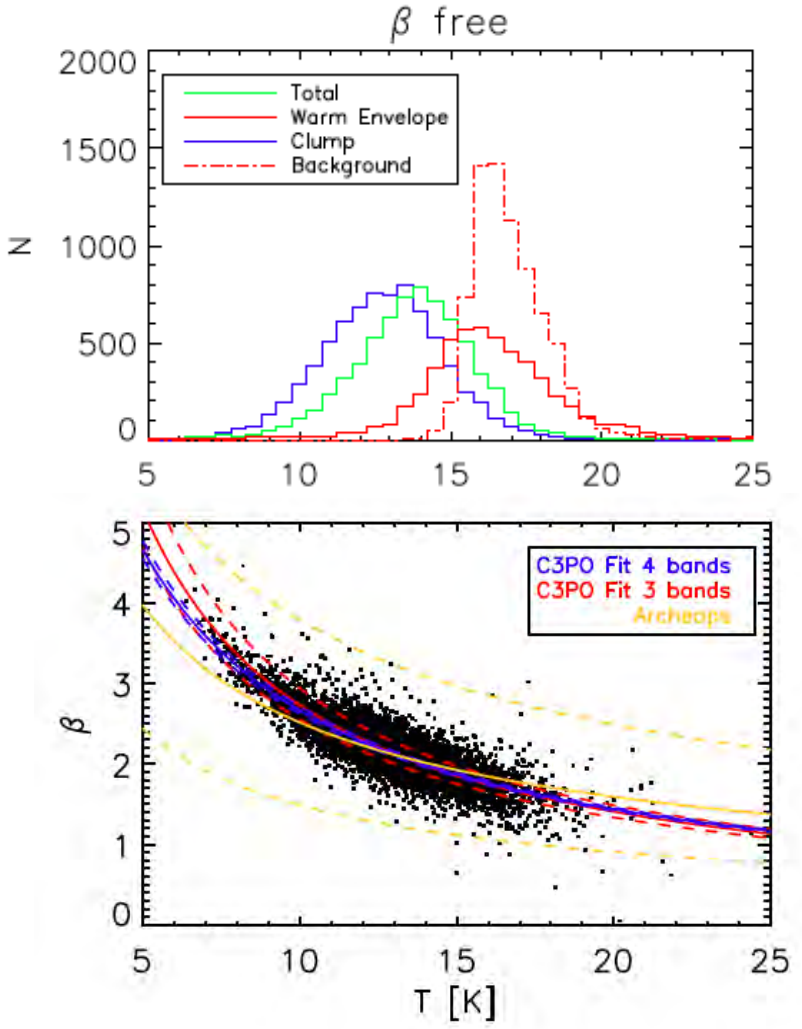
(10783)

■ ECC Selection

(915)

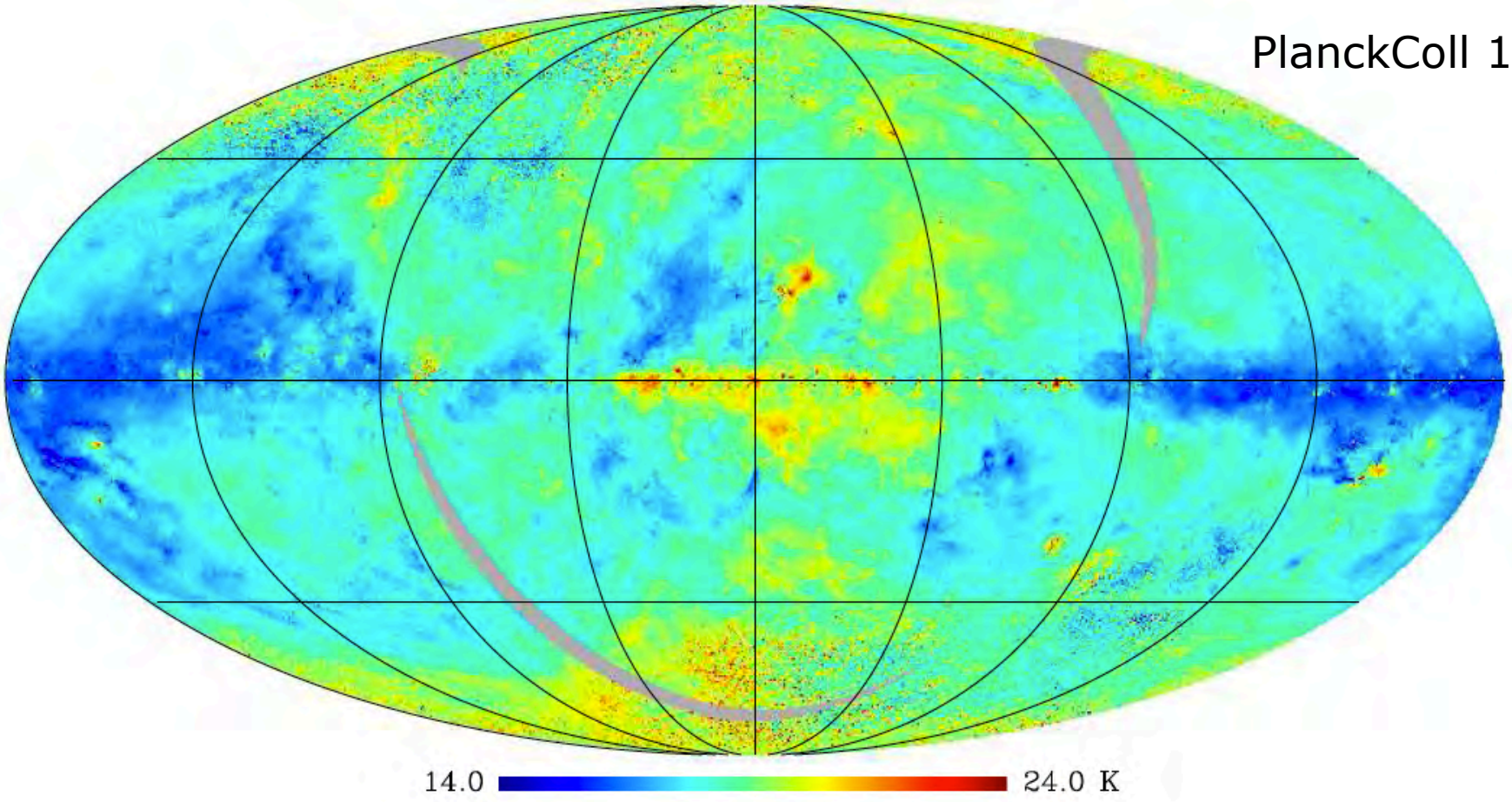
Cold clump properties





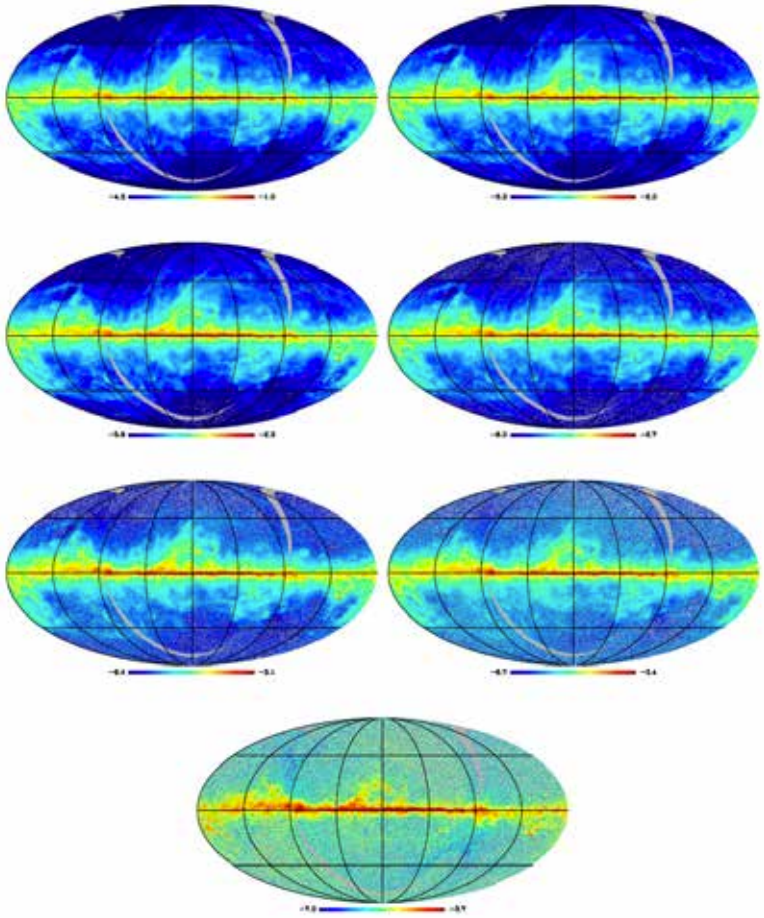
- Distances can be obtained from extinction or association
- Many of the clumps approach the lower temperature limits for the ISM !

The temperature of dust

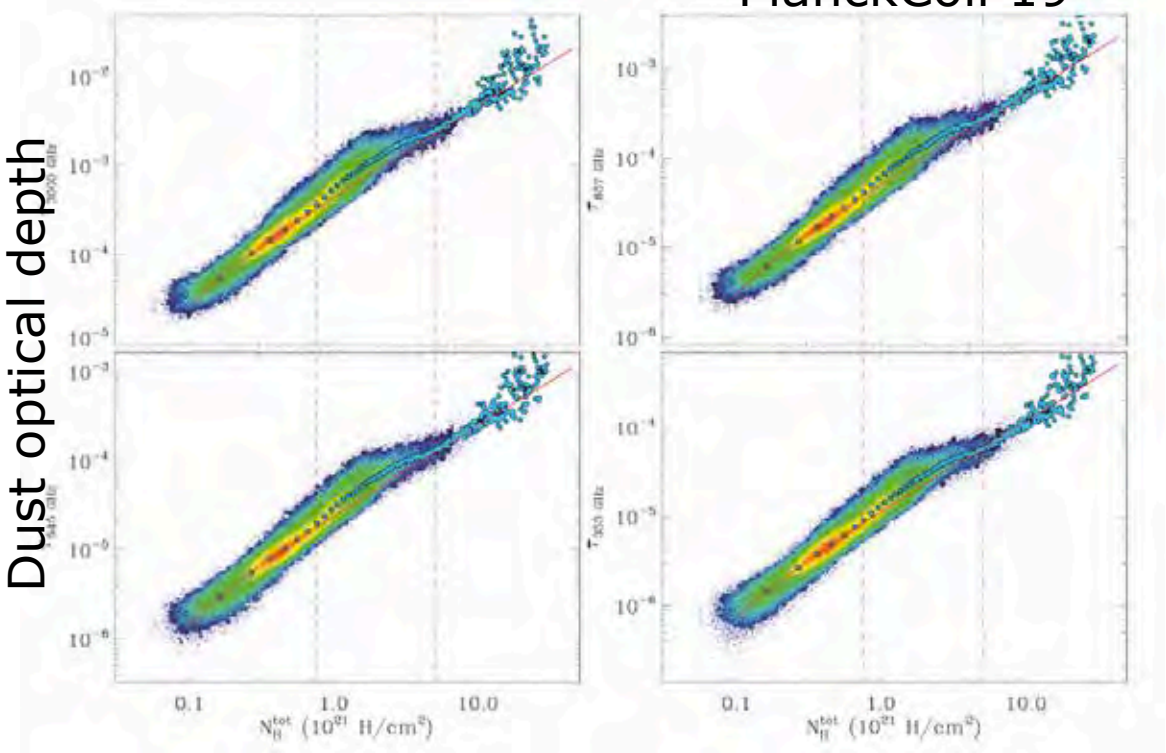


- As expected, there is a temperature gradient in the galactic plane

Dust optical depth



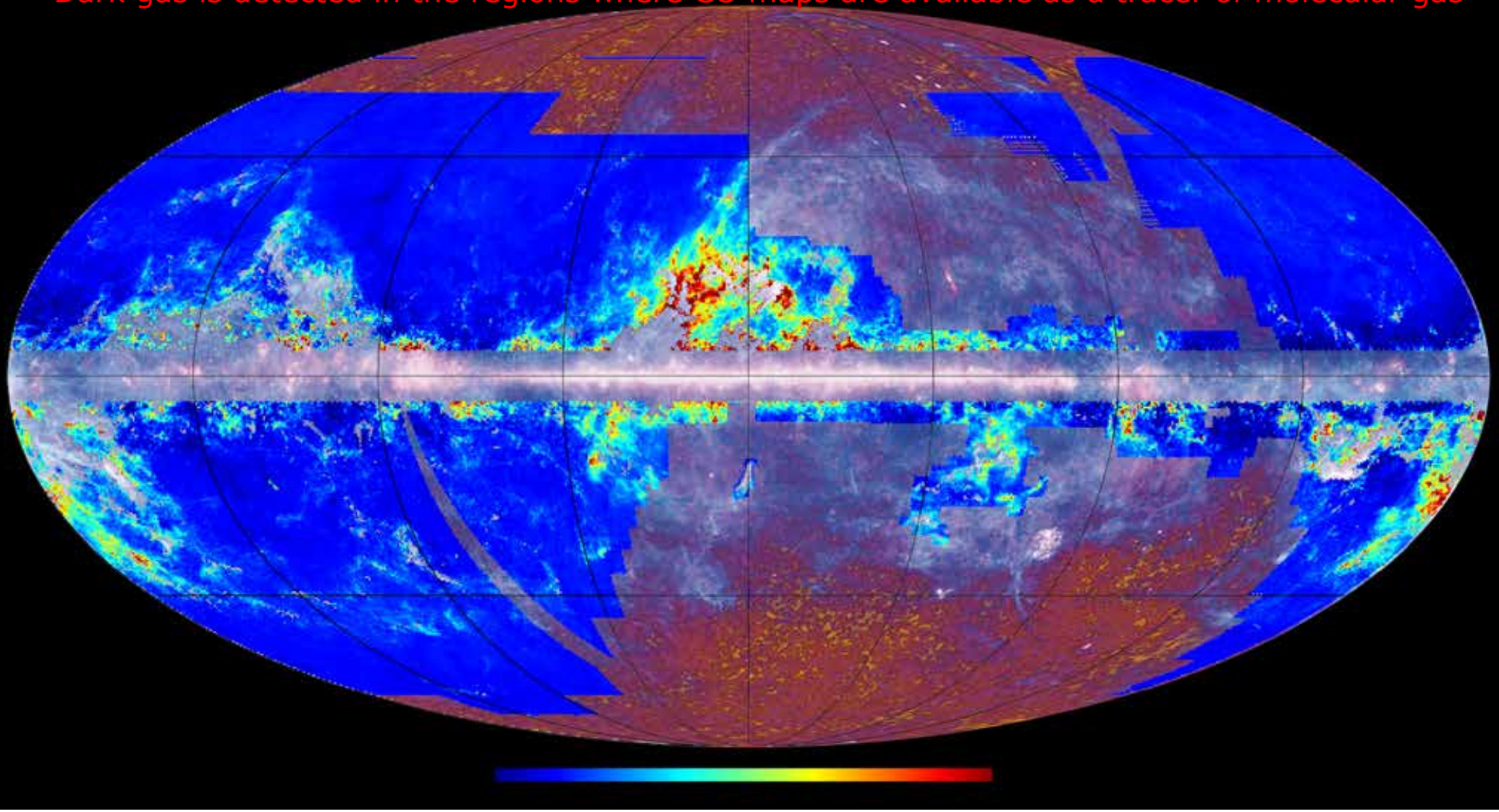
PlanckColl 19



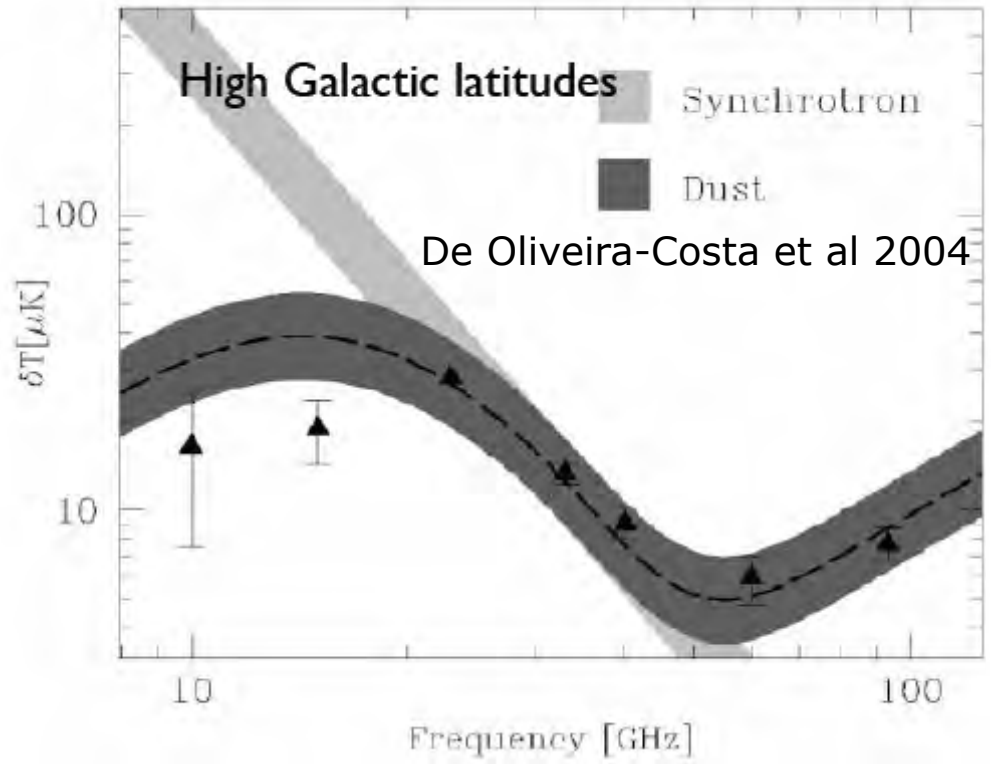
Correlation of dust optical depth to the total gas column density (HI+H2) shows the presence of a molecular gas component which does not contain CO: "dark gas"

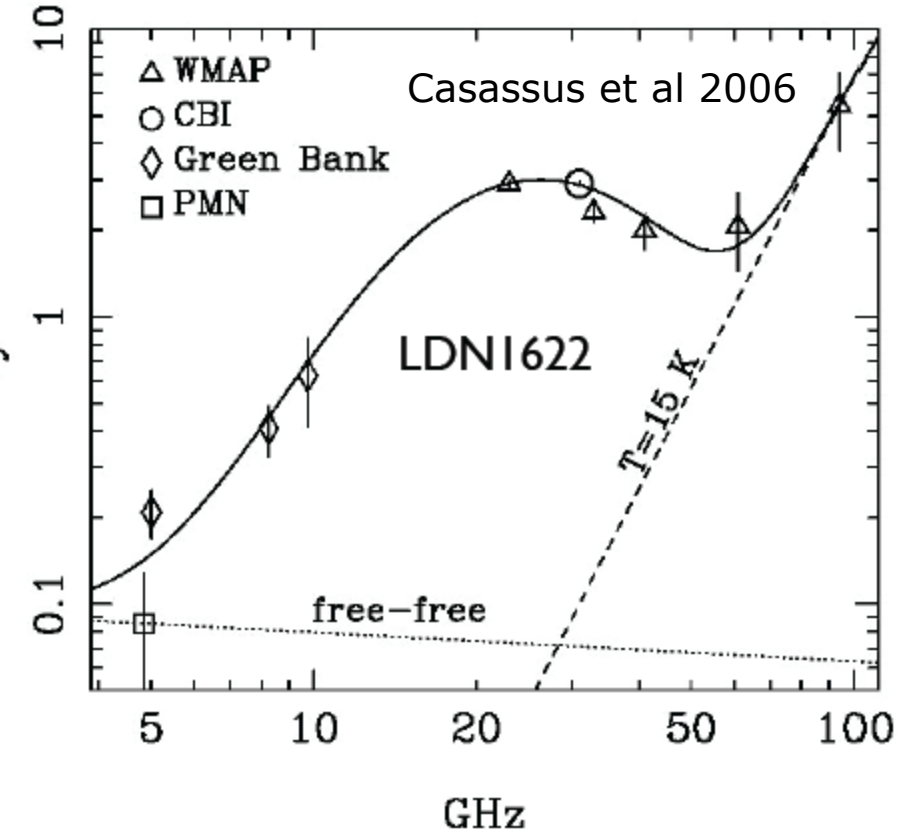
Dark gas

Dark gas is detected in the regions where CO maps are available as a tracer of molecular gas



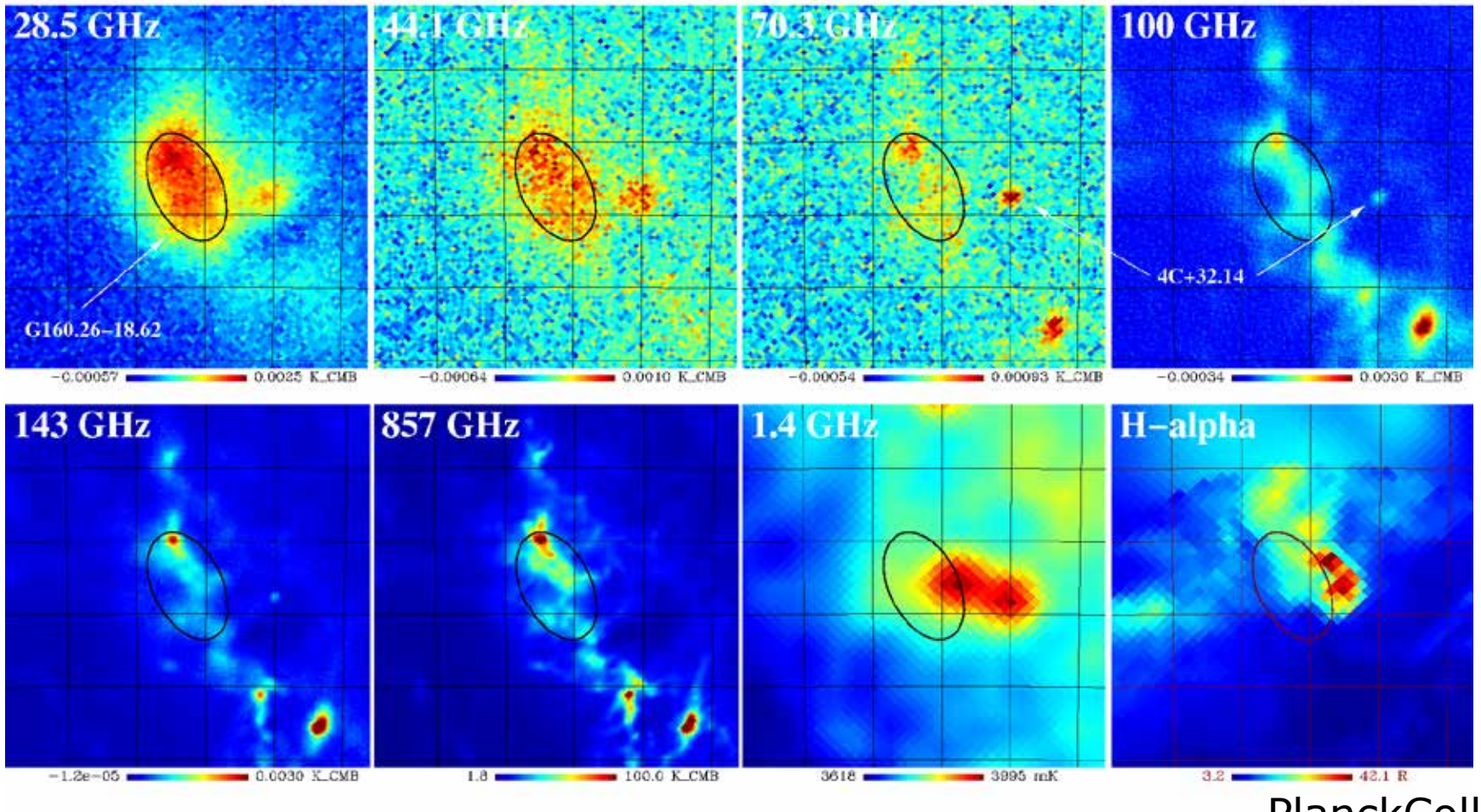
Anomalous emission





- Anomalous emission has been observed for about a decade
- The favoured explanation is emission due to small rapidly spinning dust grains

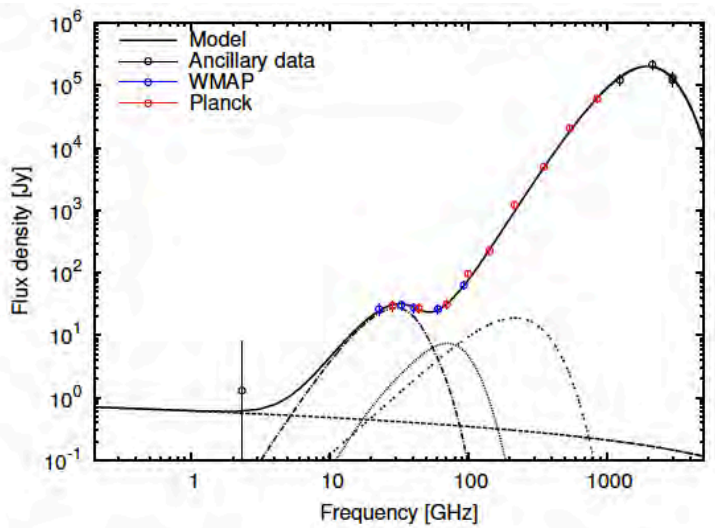
AME in Perseus

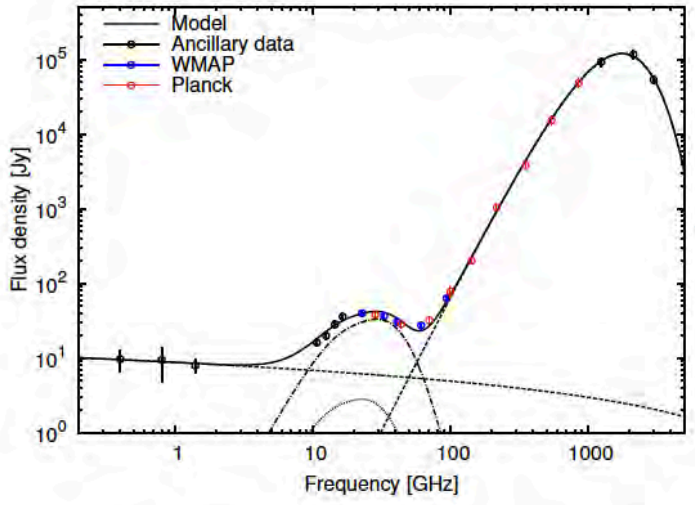


PlanckColl 20

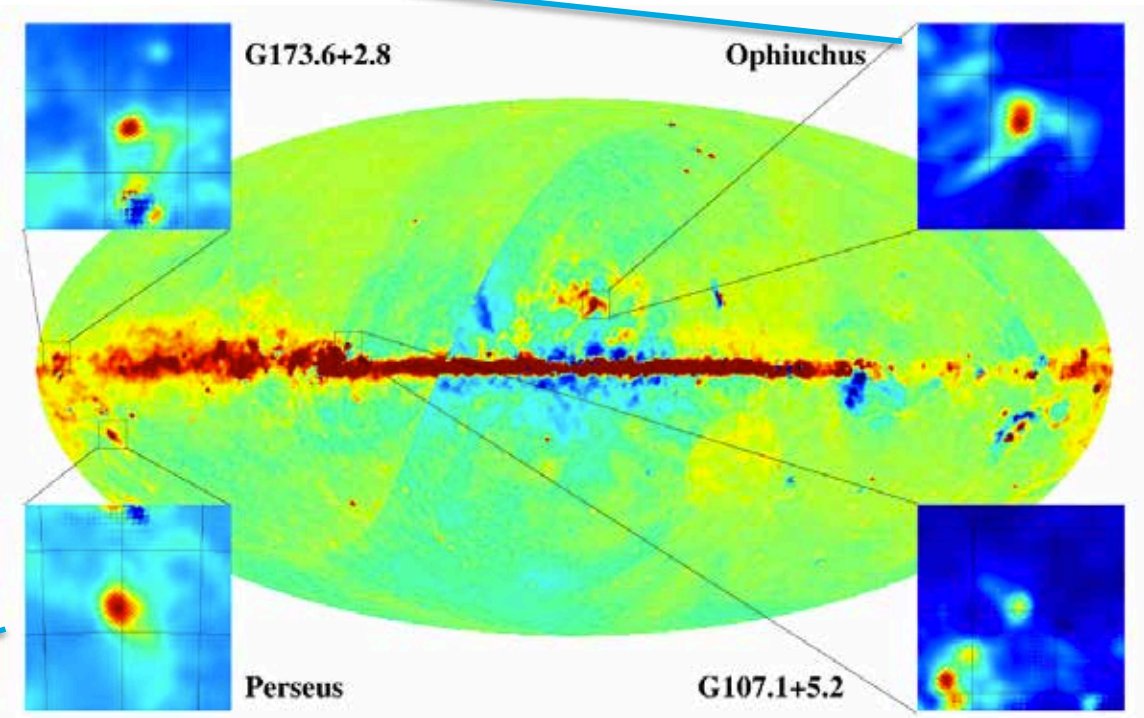
- Planck detections are very robust: in some regions, the AME can be isolated by eye !

Anomalous emission seen by Planck



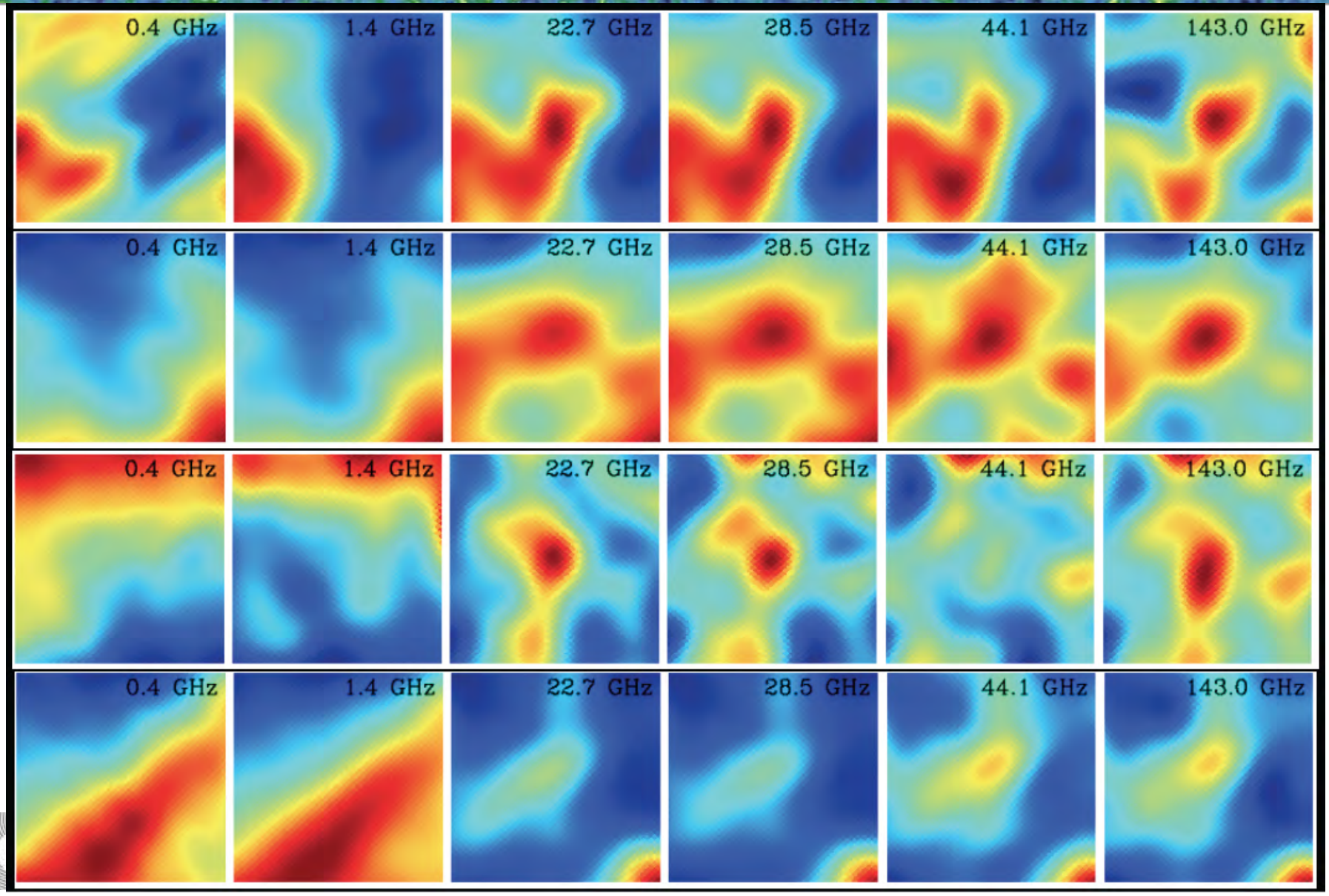


PlanckColl 20



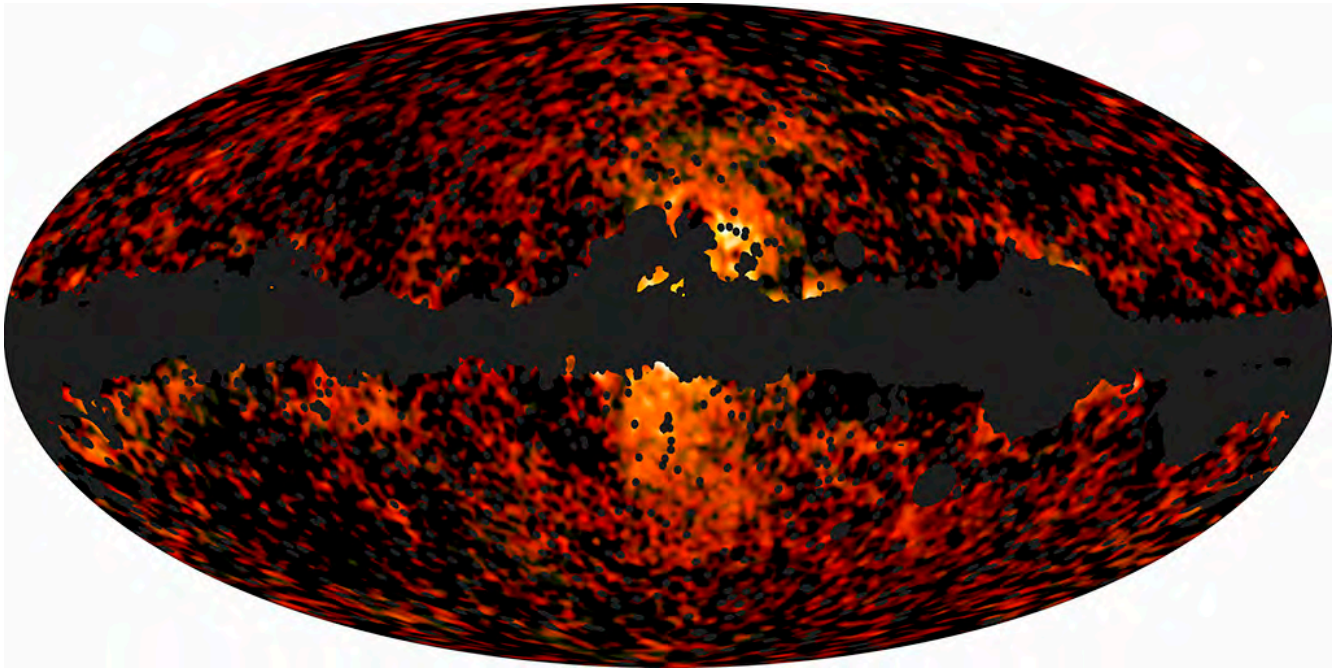
- Simple removal of synchrotron, free-free, and dust emission reveal anomalous mission permeating the galactic plane

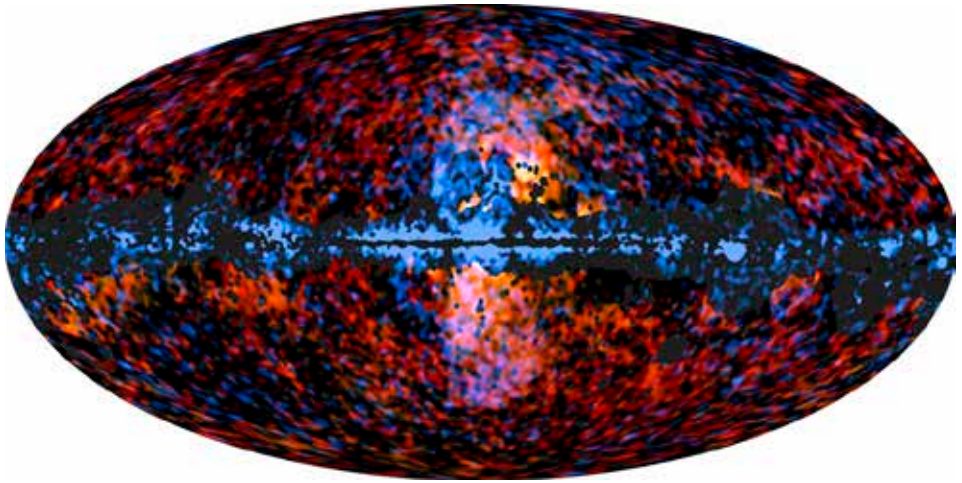
Many new AME regions are being identified



The Galactic Haze

- component separation reveals the presence of residuals which correspond to "non-standard" foregrounds.
- One of these is the "Galactic Haze", an emission concentrated near the GC, with a hard-synchrotron-like spectrum, whose origin is poorly understood



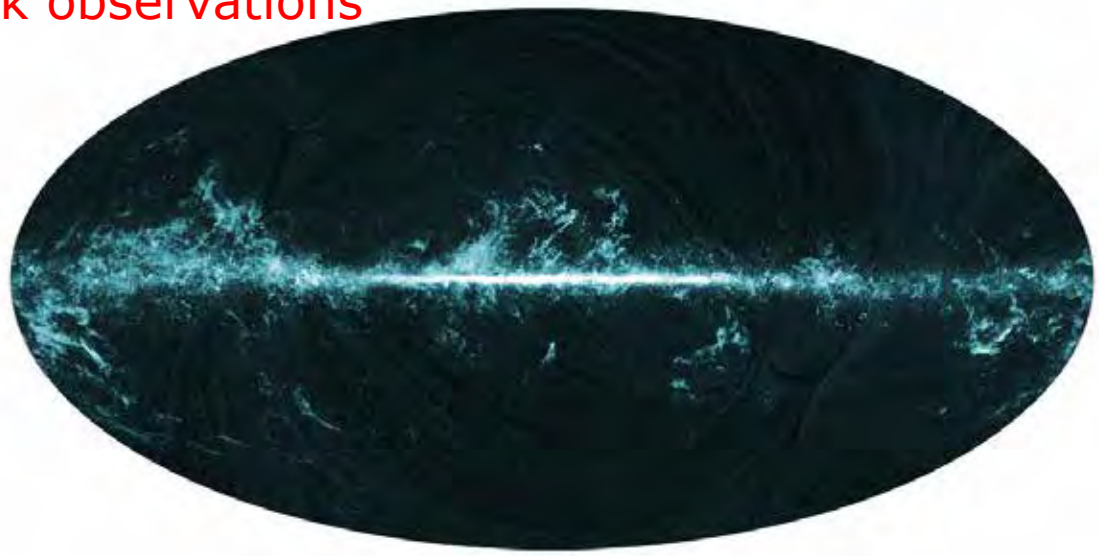


Paper about to be submitted

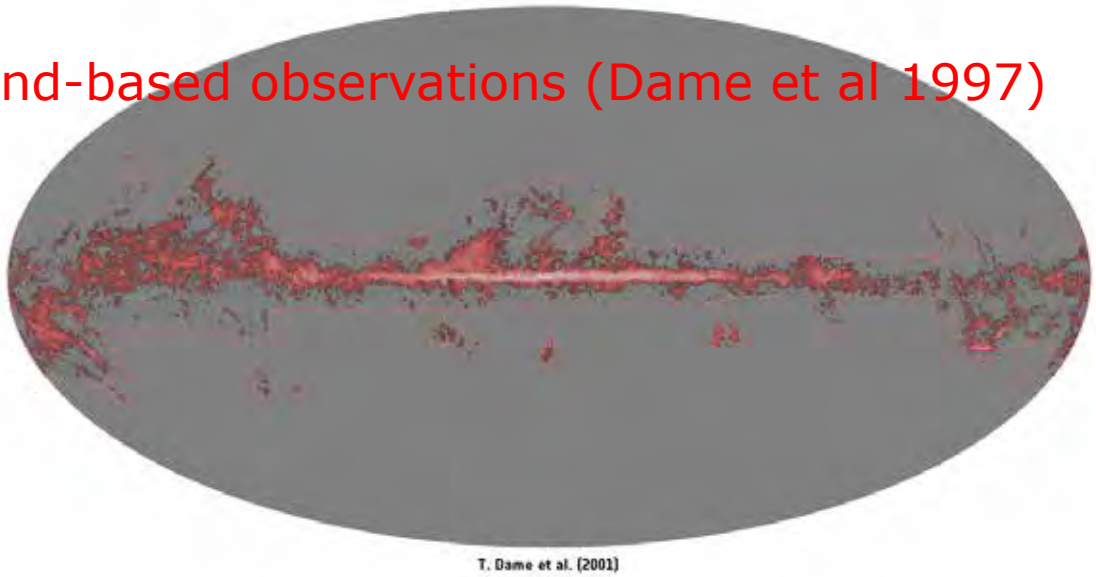
Planck maps molecular emission lines !

- CO emission dominates the total galactic flux in some of Planck's bands
- Maps can be derived of some strong lines over the whole sky

Planck observations



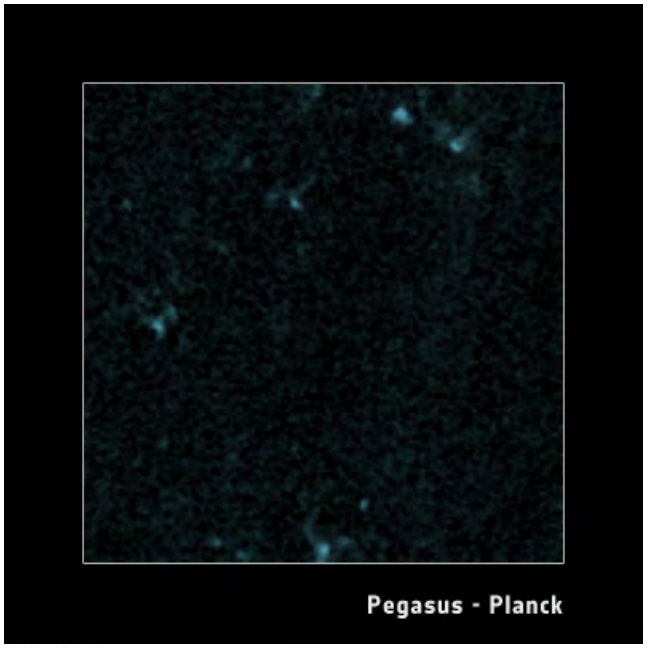
Ground-based observations (Dame et al 1997)

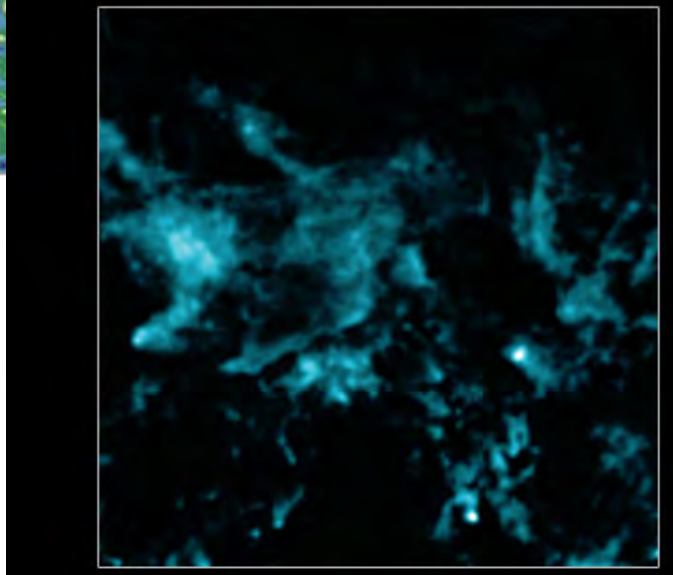


Planck-measured CO

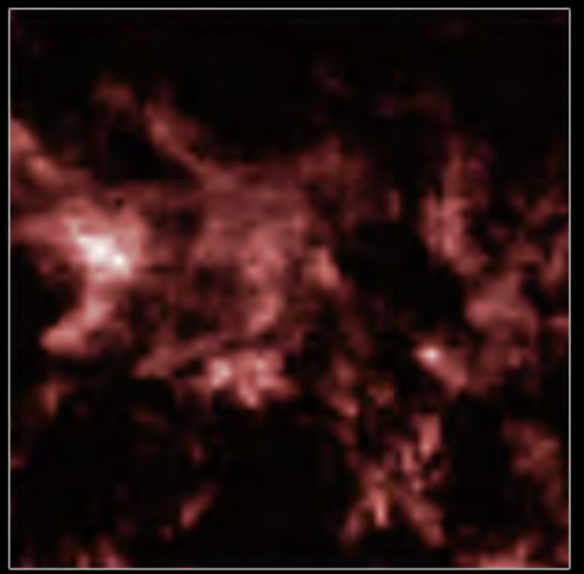
Detailed comparison of small regions reveals no significant bias

Planck's all-sky maps reveal faint CO in unexplored regions





Cepheus - Planck



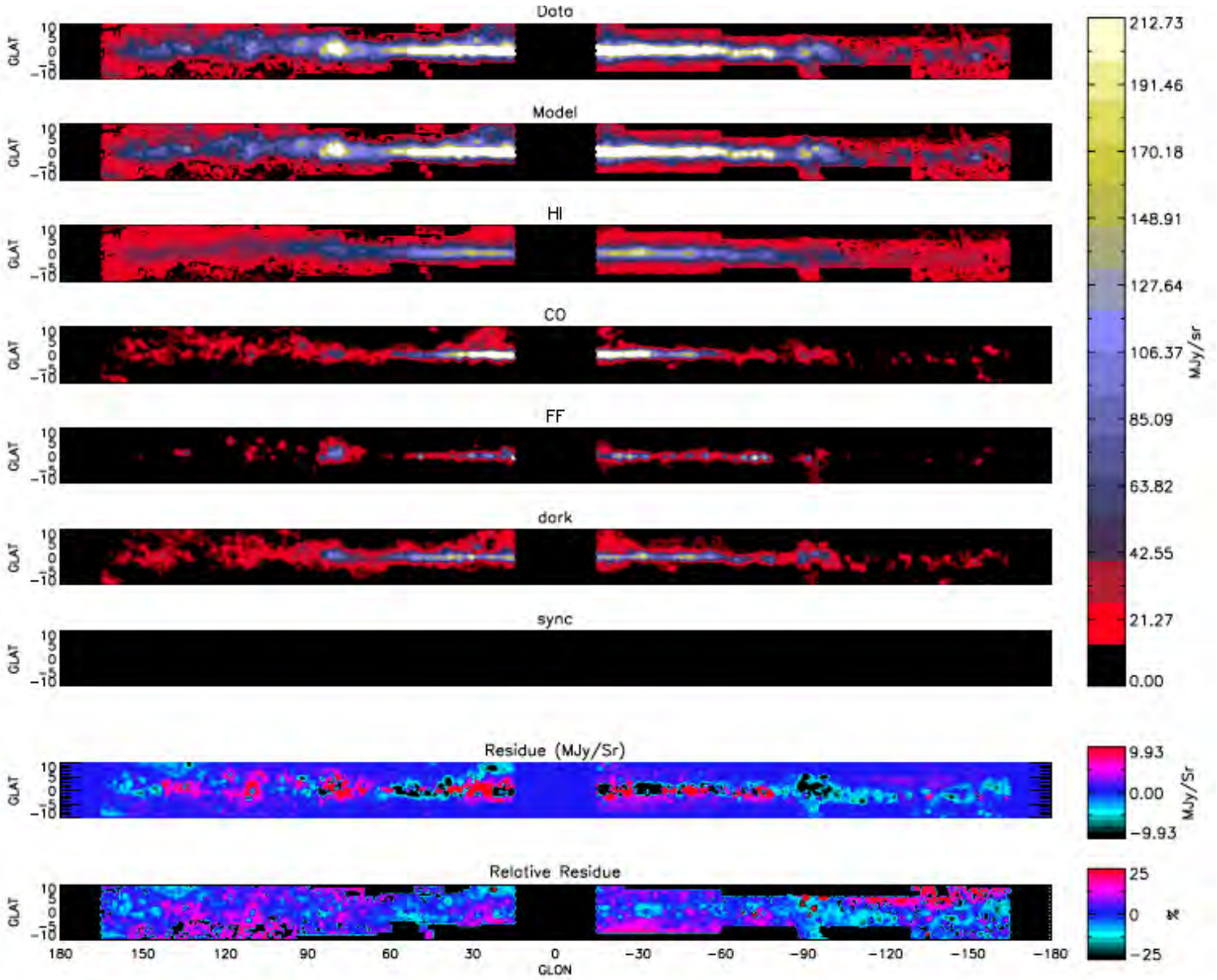
Cepheus - T. Dame et al. (2001)

Radial distribution of galactic ISM

857 GHz

Emission templates of ISM components, based on ancillary data are fitted to the Planck maps to recover the radial distribution of each.

Planck Coll XXI

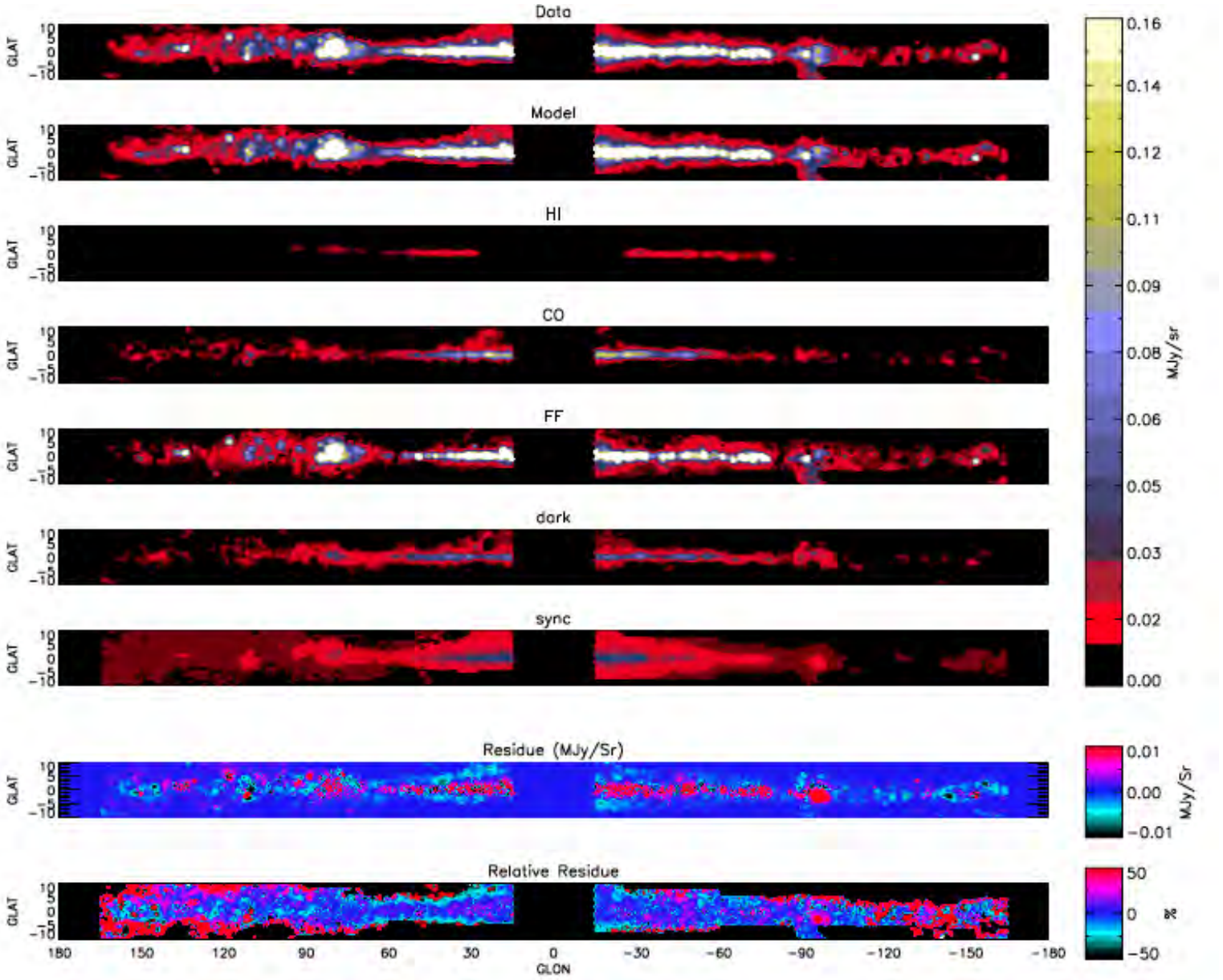


Radial distribution of galactic ISM

30 GHz

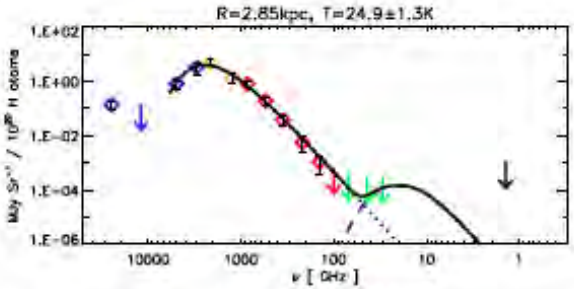
Emission templates of ISM components, based on ancillary data are fitted to the Planck maps to recover the radial distribution of each.

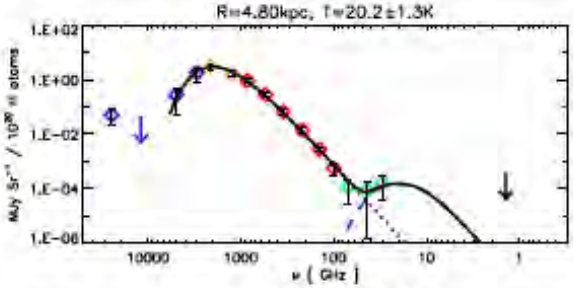
Planck Coll XXI

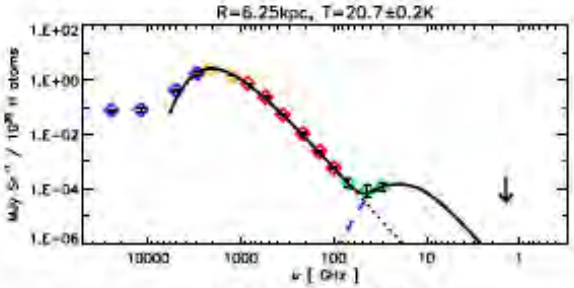


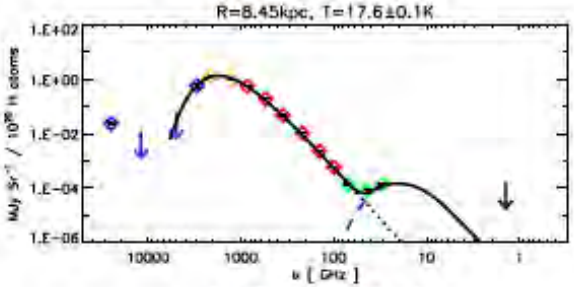
Components of the ISM

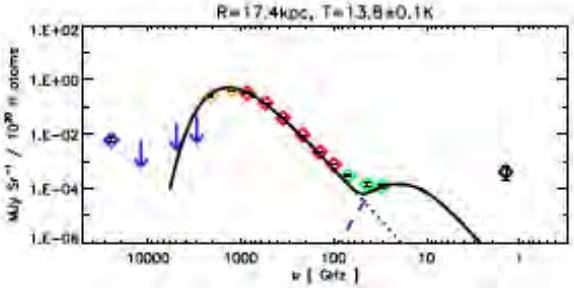
- SEDs by galactic radius

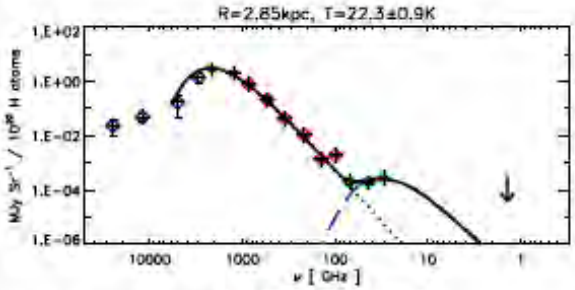


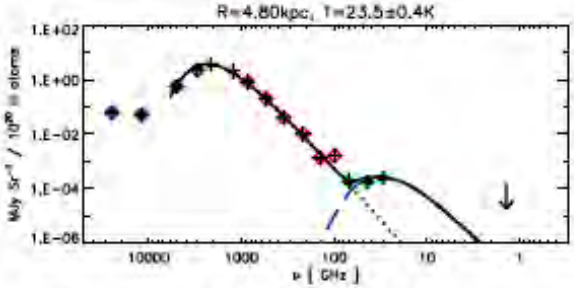


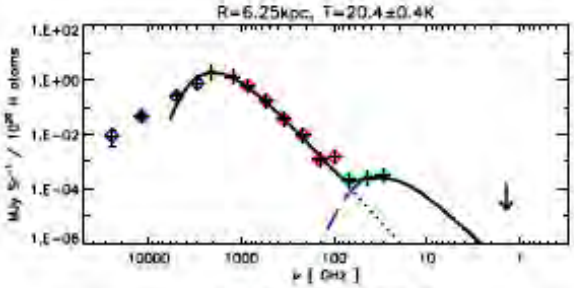


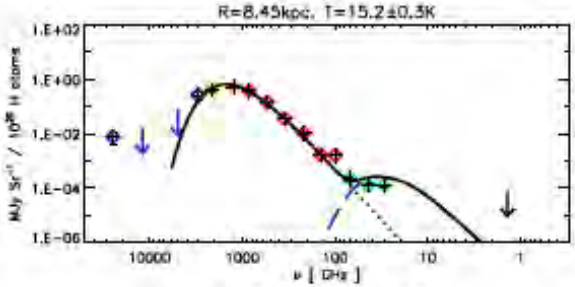


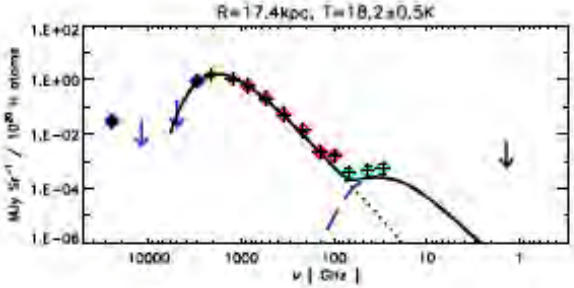






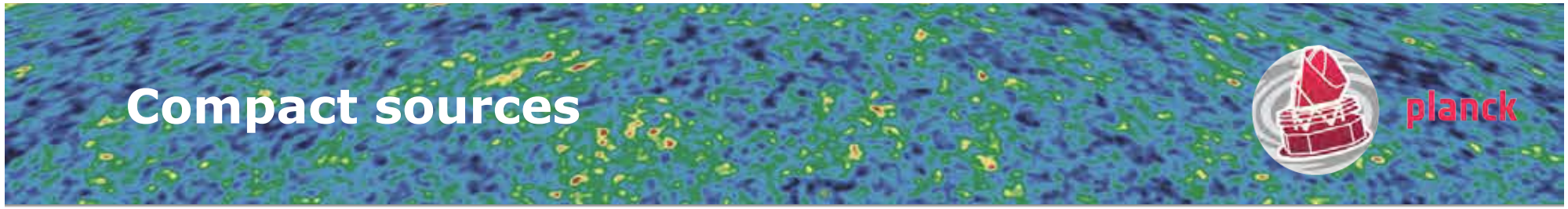






Planck Coll 21

Compact sources

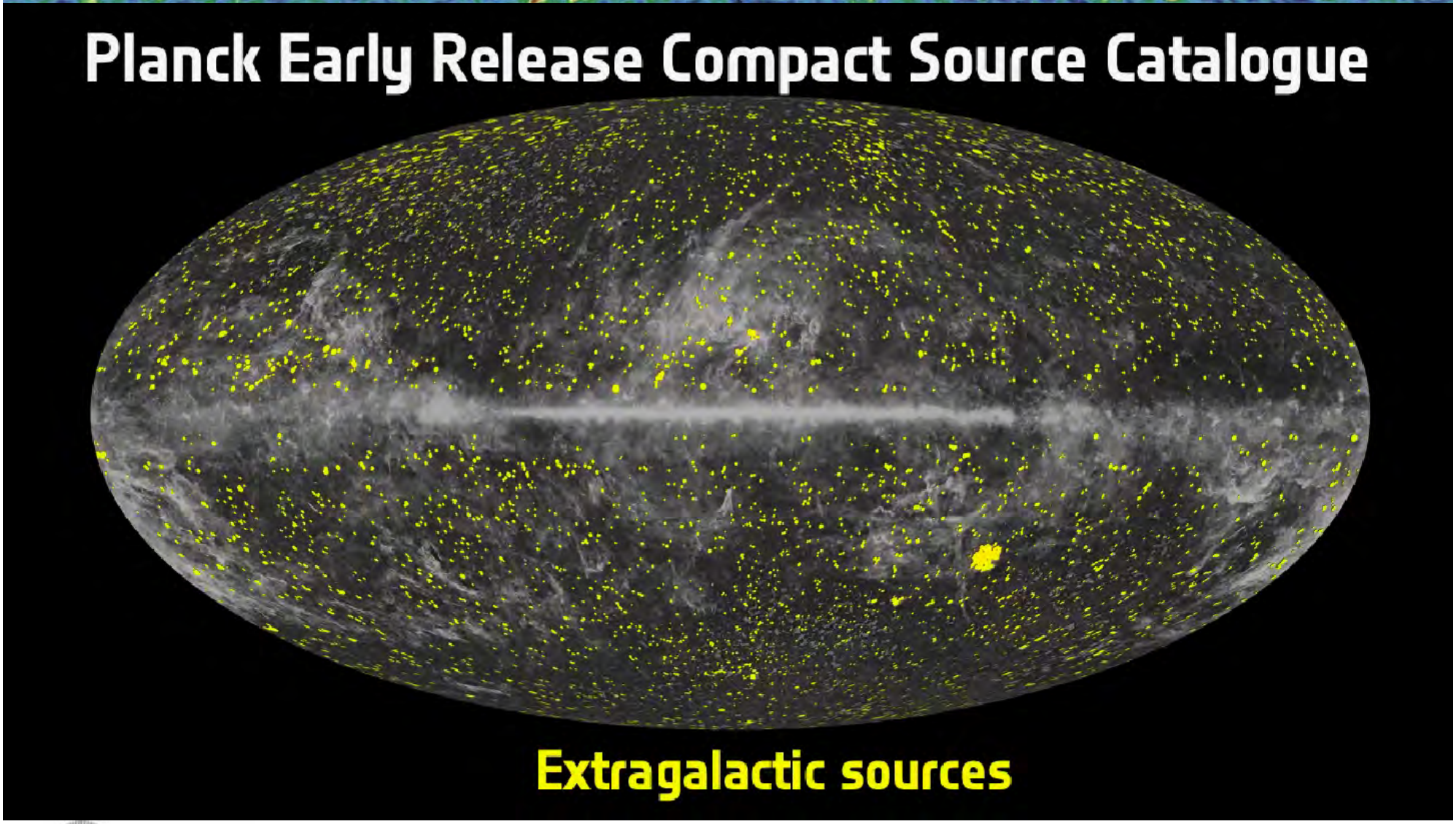


- The Early Release Compact Source Catalogue was released to the public in January 2011
- It is a catalogue of compact sources extracted from the first all-sky survey with high reliability (>90%) - designed for follow-up. Available through

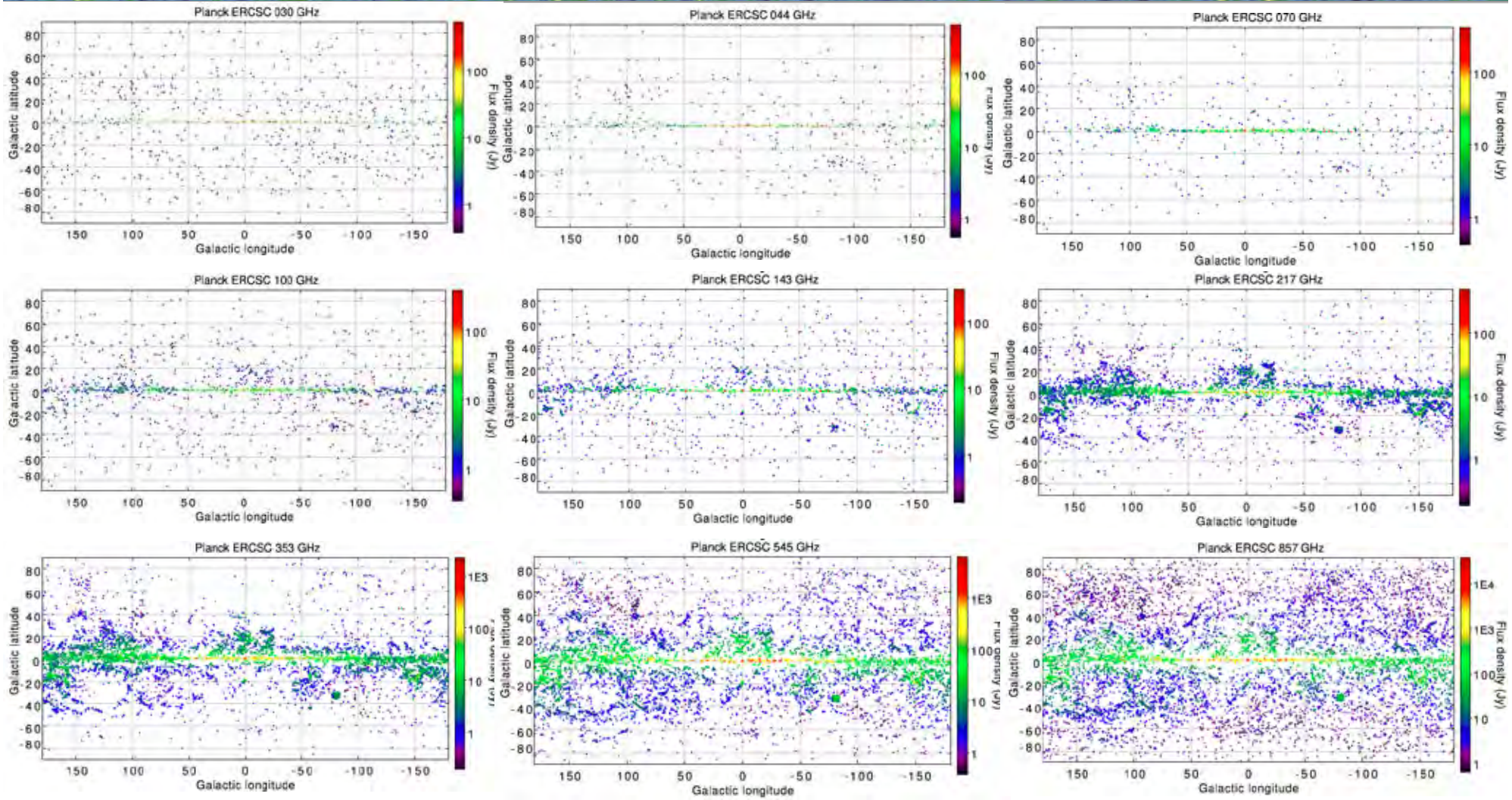
  http://www.rssd.esa.int/Planck

- It contains
  - ~15000 individual sources with detectable fluxes in individual Planck channels (range 30-857 GHz)
    - Sources in the Milky Way
    - Near and distant galaxies
  - A catalogue of cold cores, selected by their temperature
  - A catalogue of galaxy clusters selected via the Sunyaev-Zeldovich effect

Early Release Compact Source Catalogue



Early Release Compact Source Catalogue

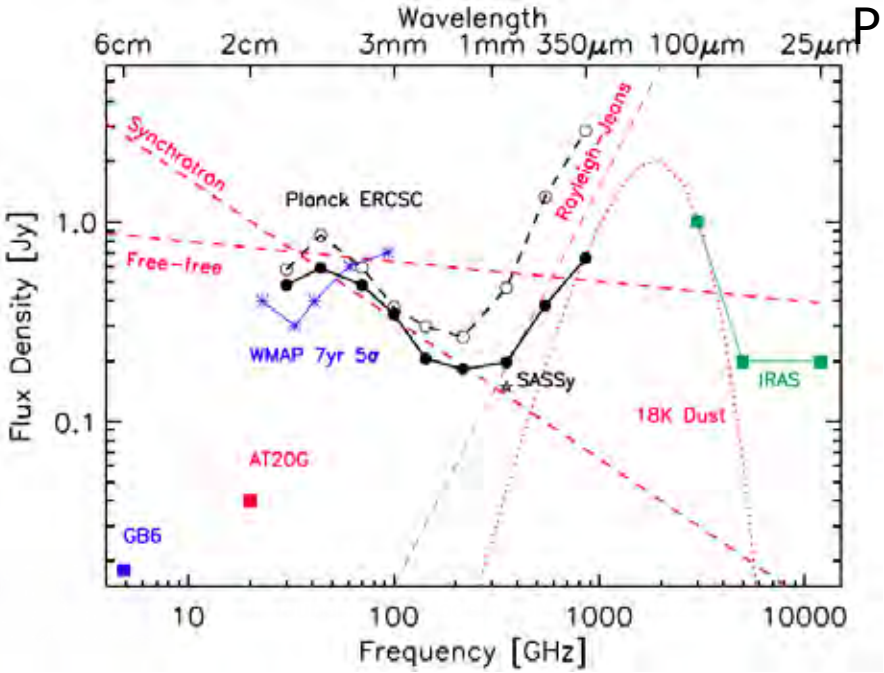


PlanckColl 7

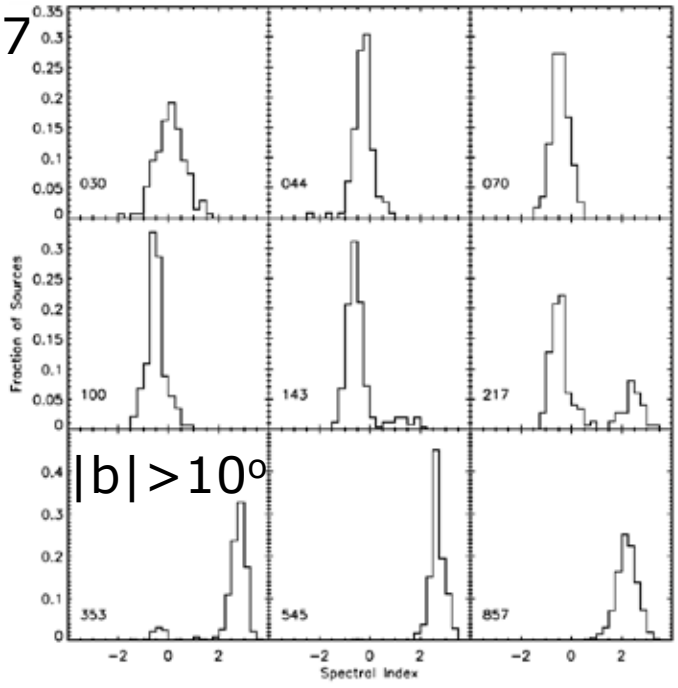
Early Release Compact Source Catalogue

planck

Freq [GHz]	30	44	70	100	143	217	353	545	857
λ [μm]	10000	6818	4286	3000	2098	1382	850	550	350
Sky Coverage in %	99.96	99.98	99.99	99.97	99.82	99.88	99.88	99.80	99.79
Beam FWHM [arcmin][a]	32.65	27.00	13.01	9.94	7.04	4.66	4.41	4.47	4.23
# of Sources	705	452	599	1381	1764	5470	6984	7223	8988
# of $\|b\| > 30°$ Sources	307	143	157	332	420	691	1123	2535	4513
10σ[b] [mJy]	1173	2286	2250	1061	750	807	1613	2074	2961
10σ[c] [mJy]	487	1023	673	500	328	280	249	471	813
Flux Density Limit[d] [mJy]	480	585	481	344	206	183	198	381	655

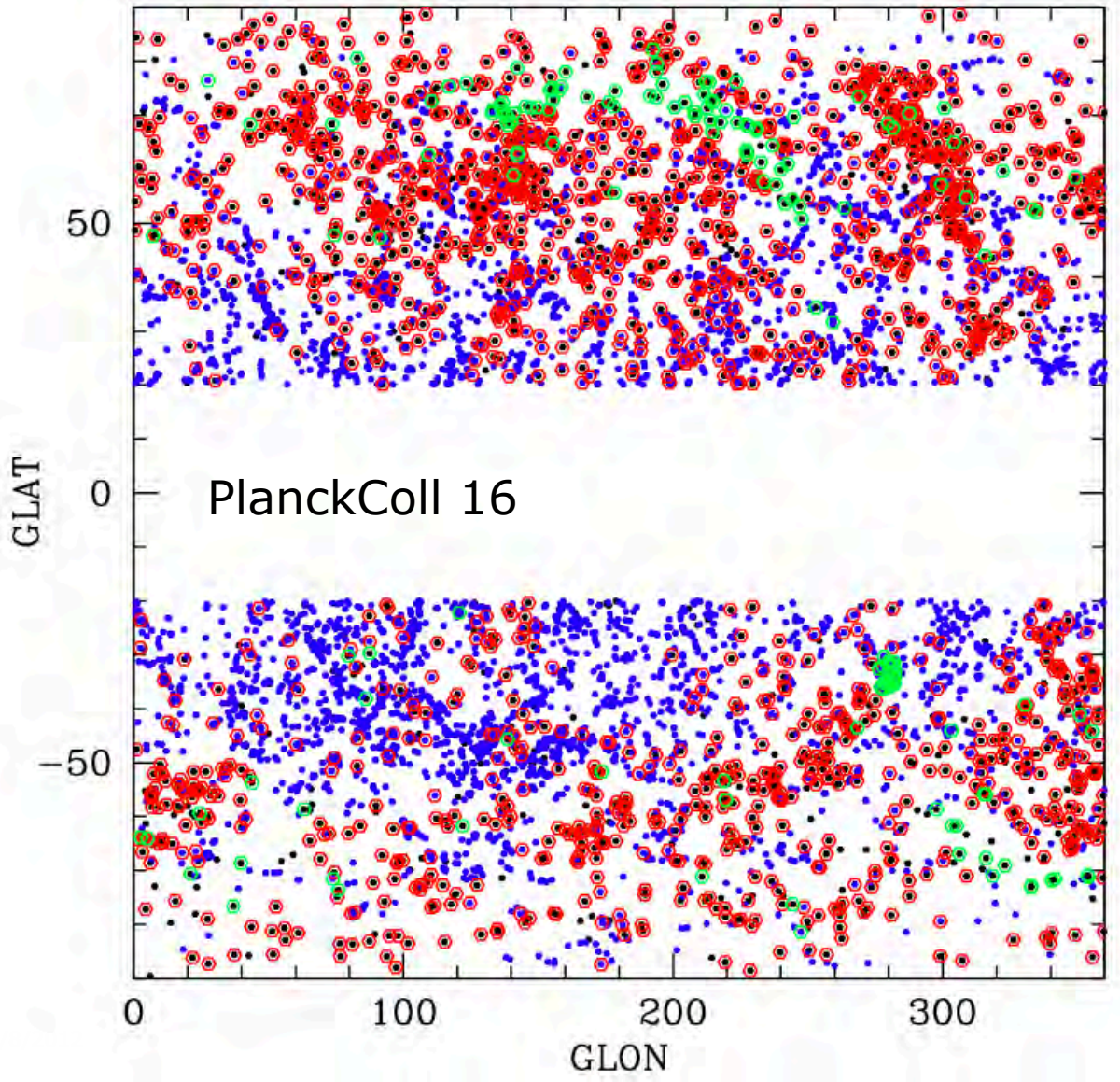


PlanckColl 7



Dusty galaxies in the ERCSC

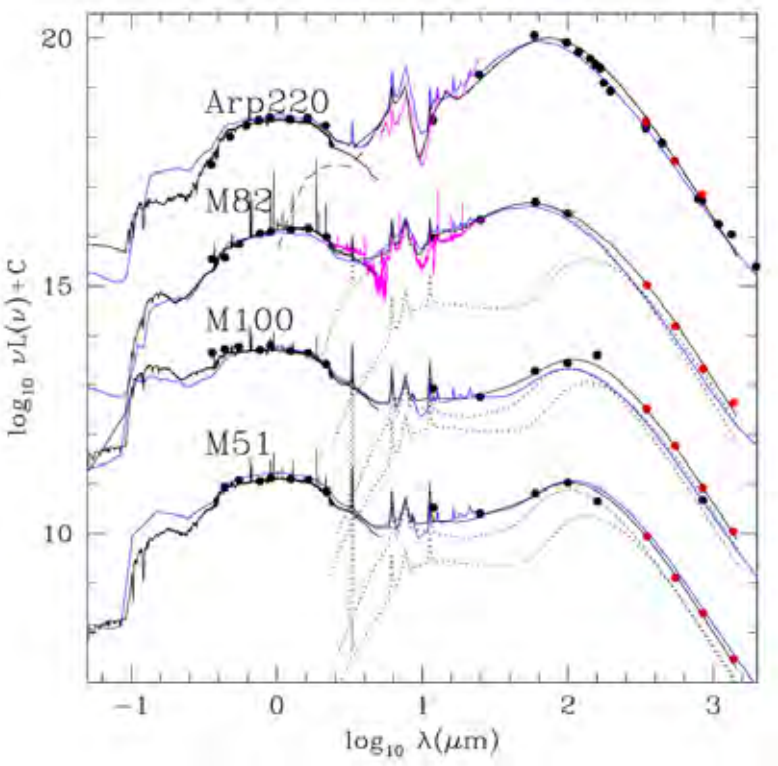
- The ERCSC contains thousands of dusty galaxies
- Confusion with cirrus complicates analysis



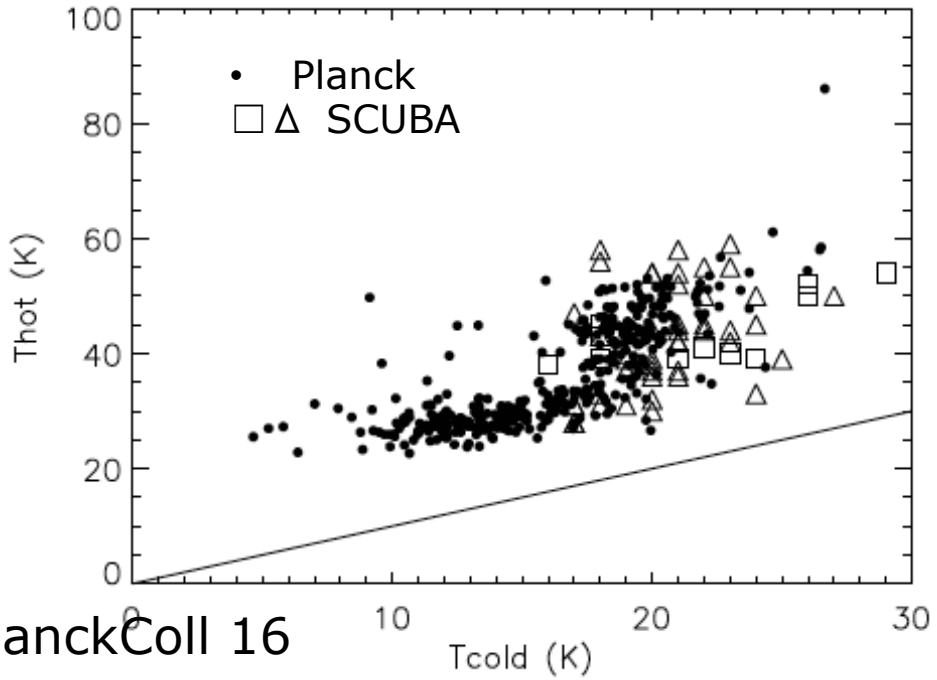
- objects matching IRAS/FSC
- extended objects
- NED objects

IR galaxies

- Planck



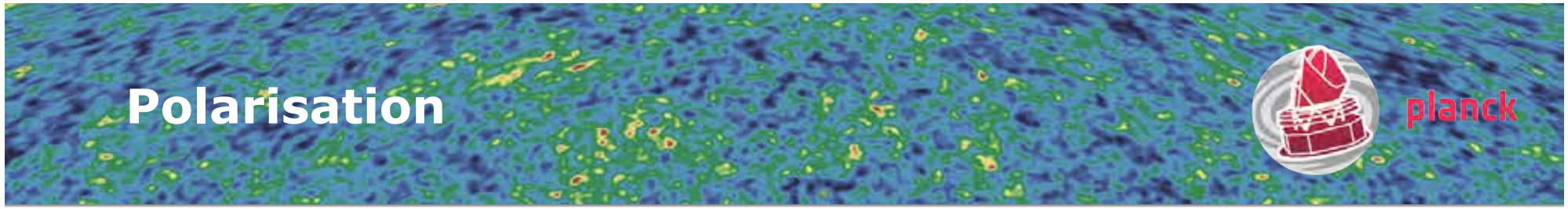
2-temperature fit



PlanckColl 16

- SED of archetypal galaxies fit well the Planck observations
- Nearby galaxies detected by Planck appear to have colder dust than previously found – hints for a new population

Polarisation

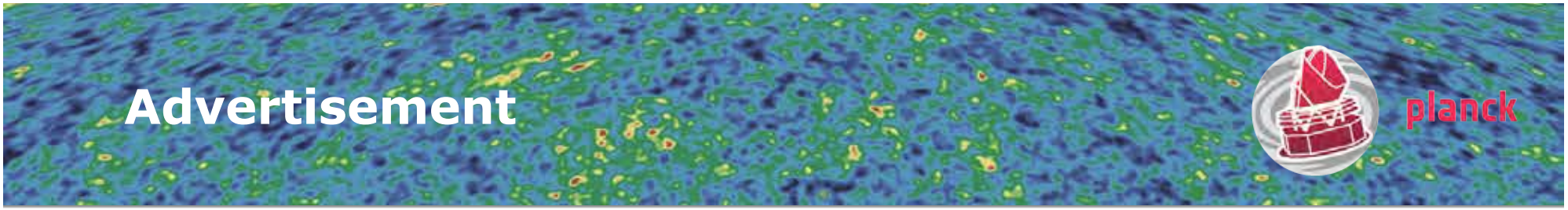


1. Measurement of polarisation presents very significant challenges in terms of calibration and systematics.
    a. We believe that for foreground studies these effects now start to be under control
2. all-sky maps of dust polarisation up to 353 GHz show high SNR even at high latitudes; they show large coherent regions of highly polarised emission
3. Maps of dust polarisation in individual clouds allows to deduce the large scale and small scale structure of the magnetic field
4. One of the strengths of Planck lies in its ability to infer magnetic field via more than one mechanism: synchrotron and dust polarisation

Summary & outlook

1. Planck has been working flawlessly and without interruption since it started surveying the sky in mid-August 2009
2. It has completed its cryogenic mission (5 surveys), and continues to acquire data with one instrument (LFI)
3. It will continue to operate until at least the end of this year, and possibly longer
4. Although designed for CMB cosmology, Planck also provides a wide range of astrophysics, in particular studies of the ISM in the Milky Way and in other galaxies
5. The data and early scientific results already released emphasize the high quality of the data that is being produced, and provide a foretaste of the far better results which are yet to come
6. In early 2013, Planck will release its first maps and the first cosmological results, as well as new astrophysical results

WATCH THIS SPACE !



ESLAB 2013: The Universe as seen by Planck

2-5 April 2013

ESA/ESTEC, Noordwijk, The Netherlands

http://congrexprojects.com/13a11

A conference dedicated to present and discuss the initial science results from Planck, ESA's mission to map the anisotropies of the Cosmic Microwave Background (http://www.esa.int/Planck). 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).

esa

The scientific results are a product of the Planck Collaboration, including individuals from more than 50 scientific institutes in Europe, the USA and Canada

Planck is a project of the European Space Agency -- ESA -- 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.

Planck Early Results (Jan 2011)

1. Planck early results 01: The Planck mission
2. Planck early results 02: The thermal performance of Planck
3. Planck early results 03: First assessment of the Low Frequency Instrument in-flight performance
4. Planck early results 04: First assessment of the High Frequency Instrument in-flight performance
5. Planck early results 05: The Low Frequency Instrument data processing
6. Planck early results 06: The High Frequency Instrument data processing
7. Planck early results 07: The Early Release Compact Source Catalogue
8. Planck early results 08: The all-sky early Sunyaev-Zeldovich cluster sample
9. Planck early results 09: XMM-Newton follow-up for validation of Planck cluster candidates
10. Planck early results 10: Statistical analysis of Sunyaev-Zeldovich scaling relations for X-ray galaxy clusters
11. Planck early results 11: Calibration of the local galaxy cluster Sunyaev-Zeldovich scaling relations
12. Planck early results 12: Cluster Sunyaev-Zeldovich optical scaling relations
13. Planck early results 13: Statistical properties of extragalactic radio sources in the Planck Early Release Compact Source Catalogue
14. Planck early results 14: Early Release Compact Source Catalogue validation and extreme radio sources
15. Planck early results 15: Spectral energy distributions and radio continuum spectra of northern extragalactic radio sources
16. Planck early results 16: The Planck view of nearby galaxies
17. Planck early results 17: Origin of the submillimetre excess dust emission in the Magellanic Clouds
18. Planck early results 18: The power spectrum of cosmic infrared background anisotropies
19. Planck early results 19: All-sky temperature and dust optical depth from Planck and IRAS – constraints on the "dark gas" in our Galaxy
20. Planck early results 20: New light on anomalous microwave emission from spinning dust grains
21. Planck early results 21: Properties of the interstellar medium in the Galactic plane
22. Planck early results 22: The submillimetre properties of a sample of Galactic cold clumps
23. Planck early results 23: The Galactic cold core population revealed by the first all-sky survey
24. Planck early results 24: Dust in the diffuse interstellar medium and the Galactic halo
25. Planck early results 25: Thermal dust in nearby molecular clouds

Planck Intermediate Results (>Jan 2011)

1. Planck intermediate results 01: Further validation of new Planck clusters with XMM-Newton
2. Planck intermediate results 02: Comparison of Sunyaev-Zeldovich measurement from Planck and from the Arcminute Microkelvin Imager for 11 galaxy clusters
3. Planck intermediate results 03: The relation between galaxy cluster mass and Sunyaev-Zeldovich signal
4. Planck intermediate results 04: The XMM-Newton validation programme for new Planck clusters

+ ~20 additional intermediate results papers expected to be submitted in the coming 6 months


Thank you !