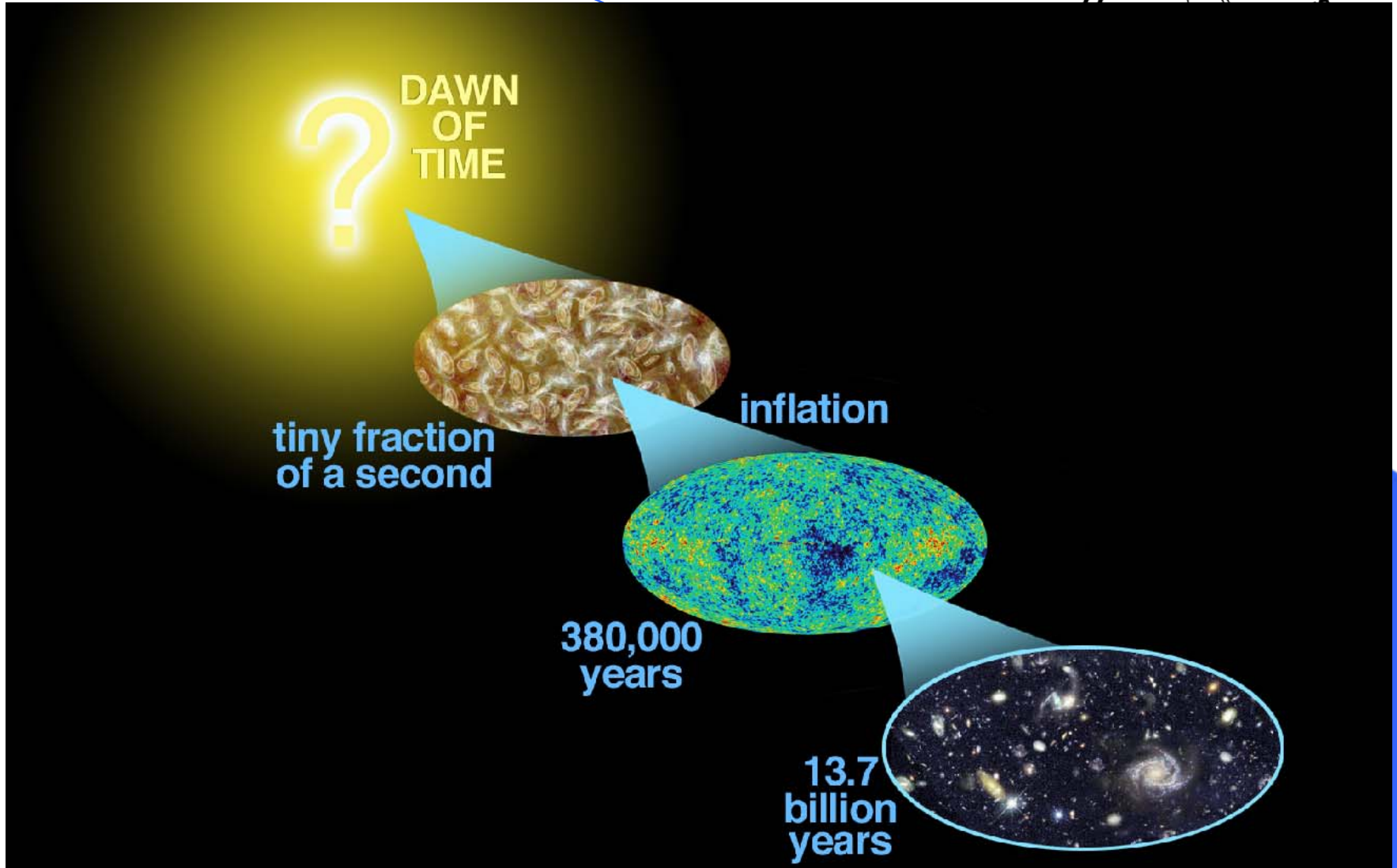


# PLANCK Reflector Programme



**Penzias and Wilson Nobel Price in Physics 1978**

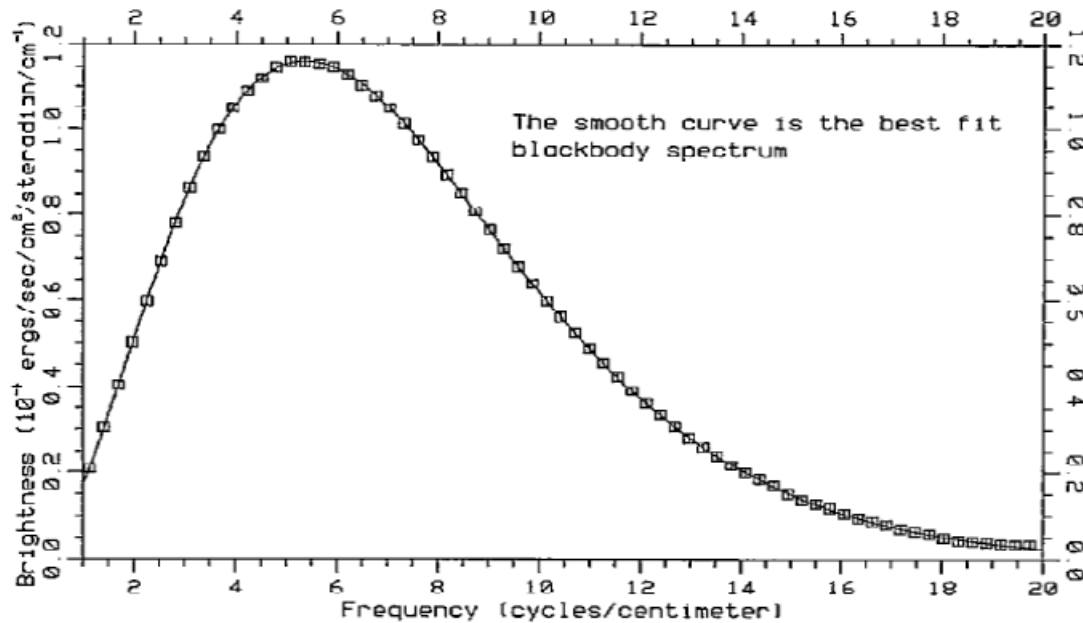
# PLANCK Reflector Programme



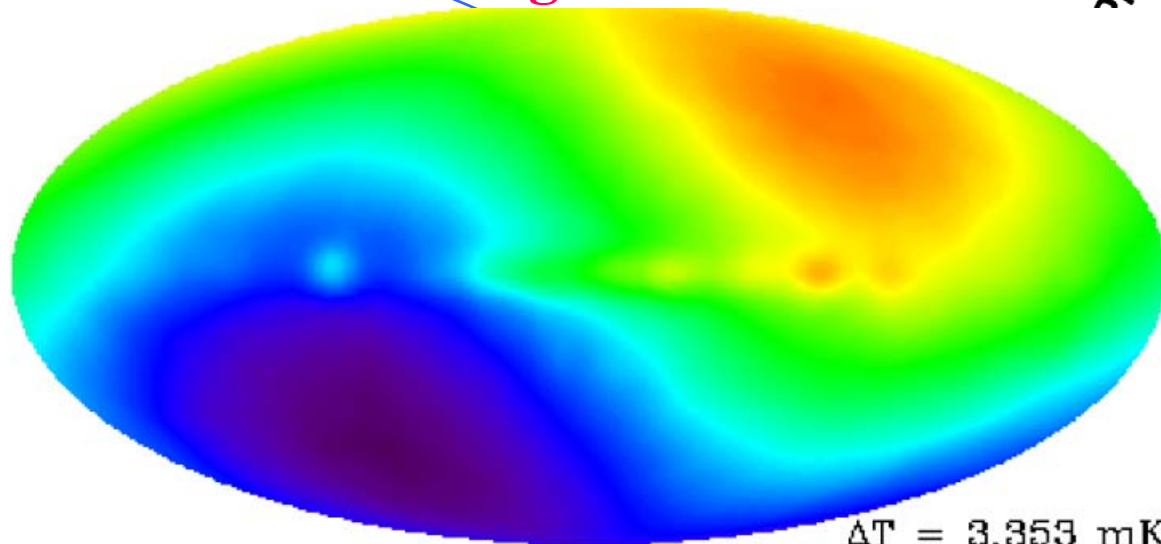
# PLANCK Reflector Programme



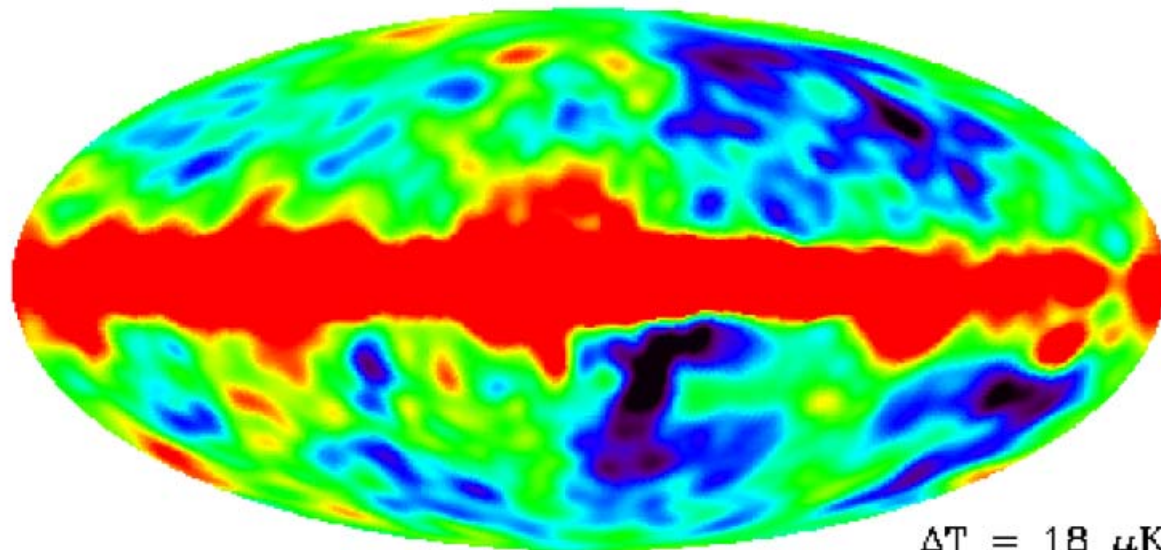
Figure 7 shows the deviations from a blackbody spectrum with a temperature of  $2.726 \pm 0.010$  K published 1994 (Mather et al. 1994). After careful studies of errors caused by the FIRAS calibrator (figure 4), the CMB temperature was finally given as  $2.725 \pm 0.002$  K (Mather et al. 1999) with deviations from a blackbody spectrum less than 1 part in  $10^5$ .



# PLANCK Reflector Programme



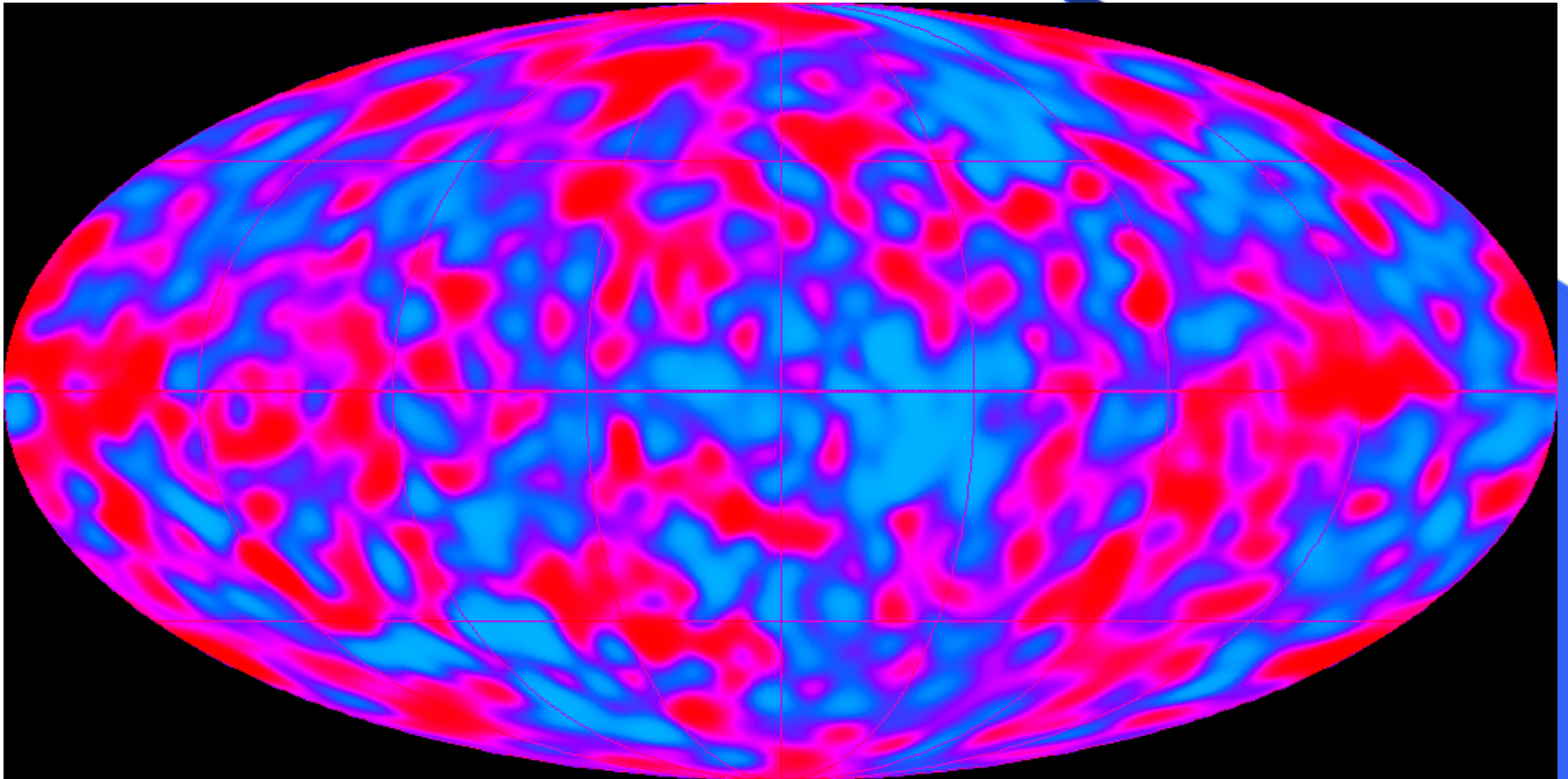
$\Delta T = 3.353 \text{ mK}$



$\Delta T = 18 \text{ } \mu\text{K}$

Planck Reflectors  
↓  
JK-PLANCK

# PLANCK Reflector Programme



# PLANCK Reflector Programme



The Nobel Prize in Physics 2006

"for their discovery of the blackbody form and anisotropy of the cosmic microwave background radiation"



Photo: NASA

**John C. Mather**

🏆 1/2 of the prize

USA

NASA Goddard Space  
Flight Center  
Greenbelt, MD, USA

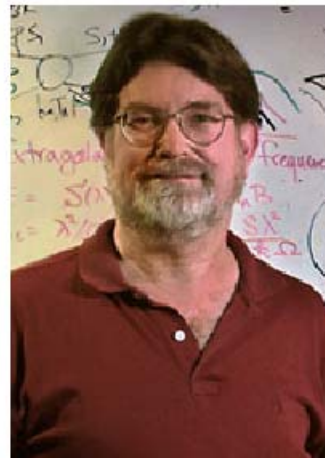


Photo: R. Kaltschmidt/LBNL

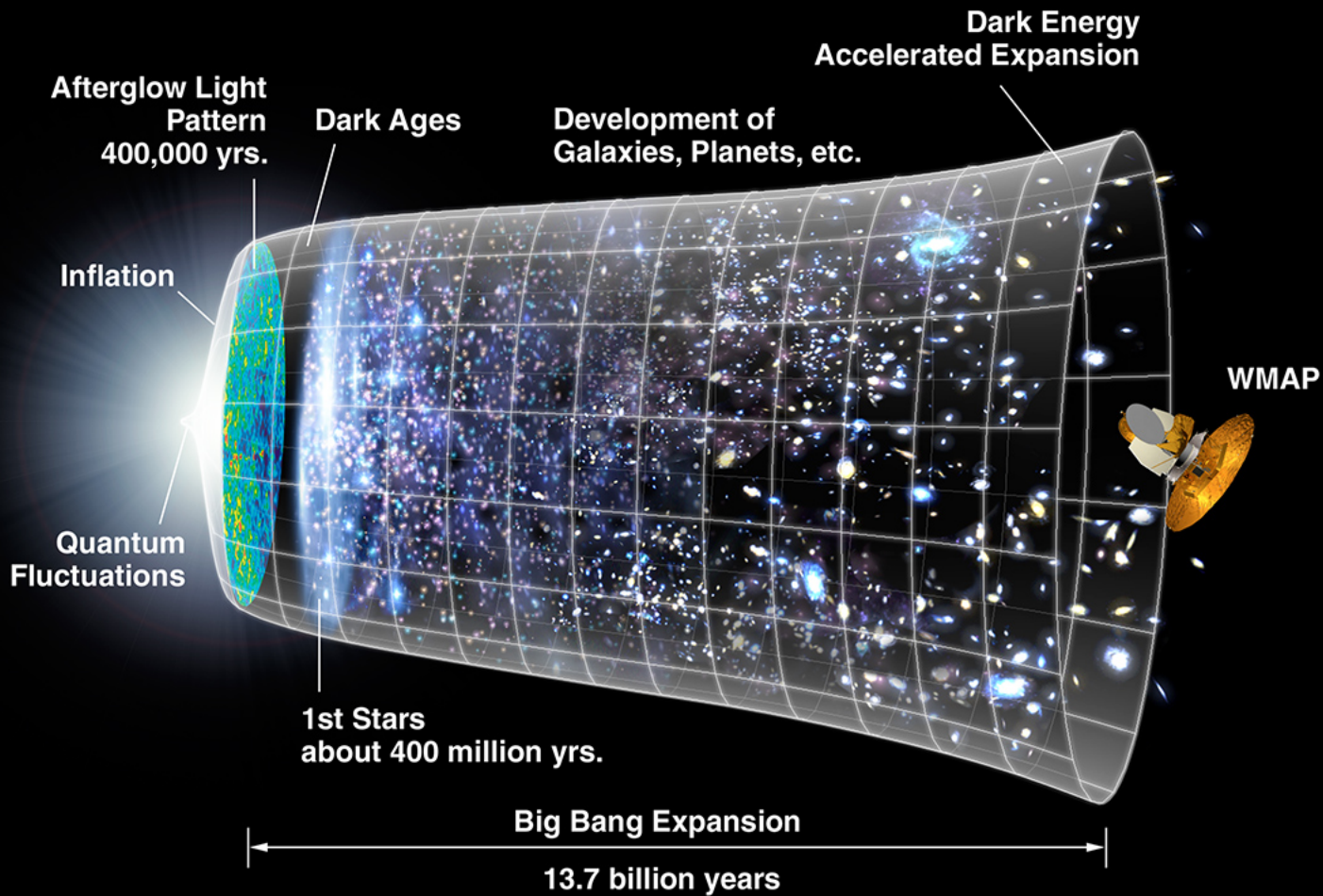
**George F. Smoot**

🏆 1/2 of the prize

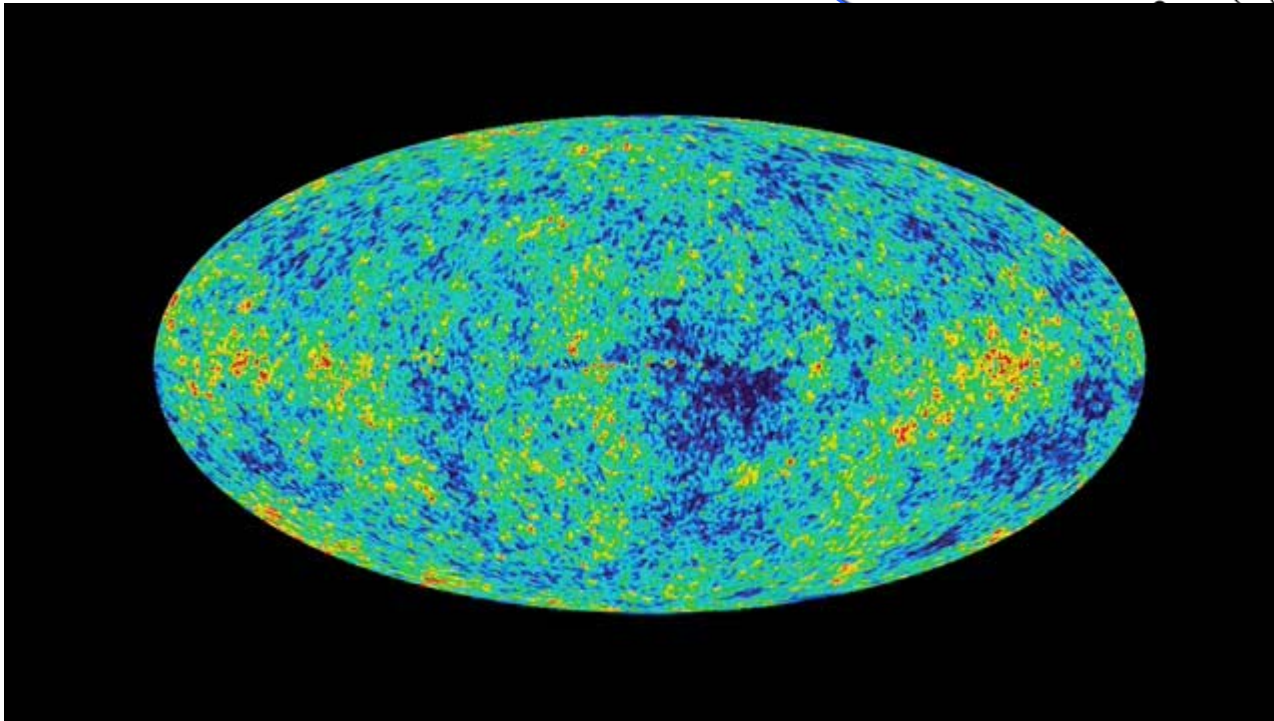
USA

University of California  
Berkeley, CA, USA





# PLANCK Reflector Programme



**A trip from Big Bang to present day Universe**



# PLANCK Reflector Programme



**DTU Space: PI status in the Planck mission ->  
assuring Danish scientists direct access to  
the Planck database**

**Support from SNF and ESA – Følgeforskning**

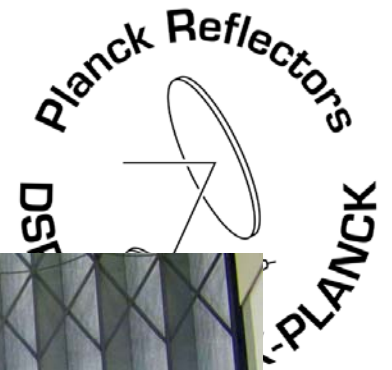
**Planck was launched May 14 2009**

**July 5. 2009 in orbit around L2**

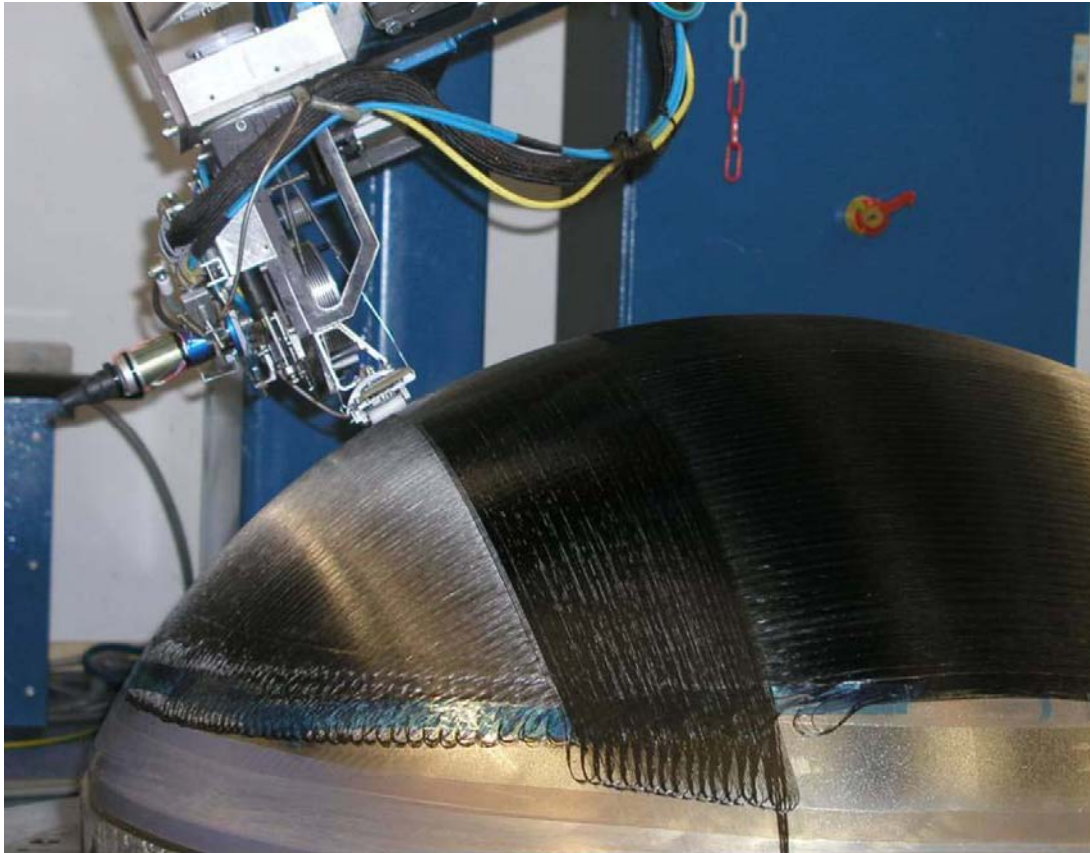
**July 5 – August 13 CPV**

**August 13 – 27 First Light Survey**

# PLANCK Reflector Programme



# True angle lay up af Sekundær spejlets skin



**Numerisk styret  
vikle maskine.**

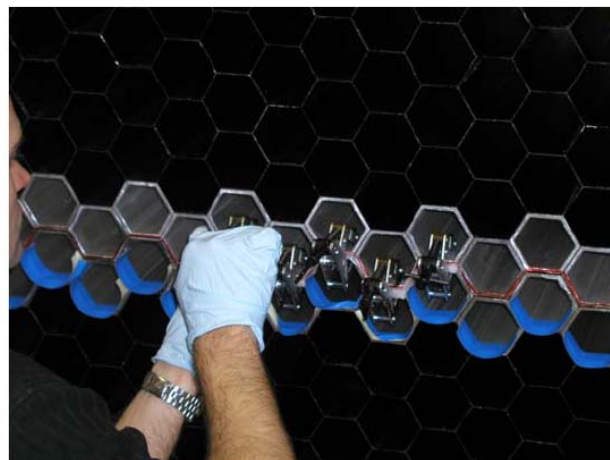
**Samme vinkel  
mellem  
fiberlagerne.**

**Ens temperatur  
udvidelse.**

# Fremstilling af skin til spejlene



# Fremstilling af Honeycomp



**Temperatur  
udvidelse  
tilpasset Skin.**

**2 halvdele.**

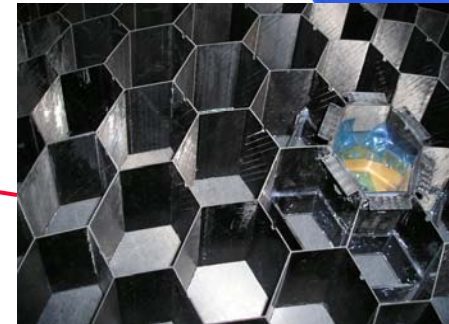
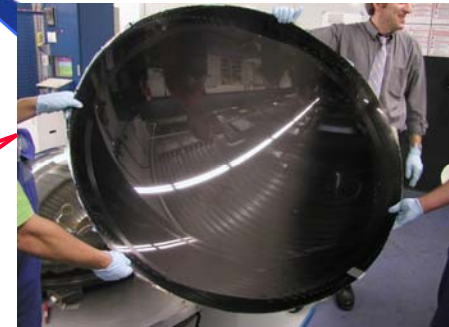
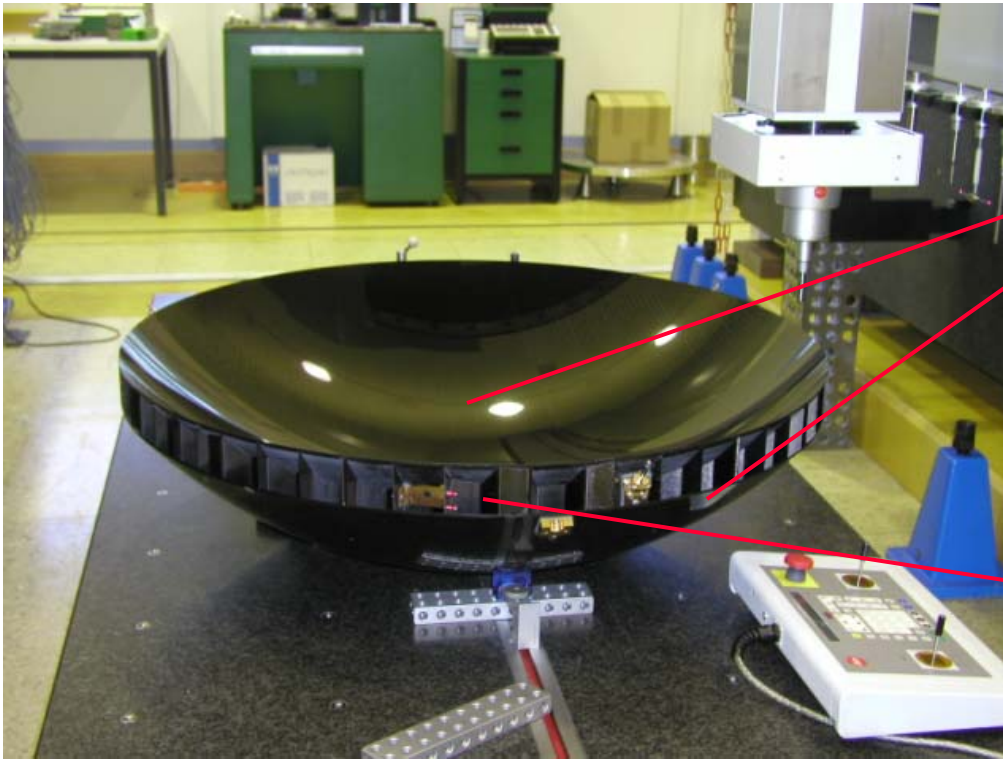
**Bearbejdes til  
formen af skin**

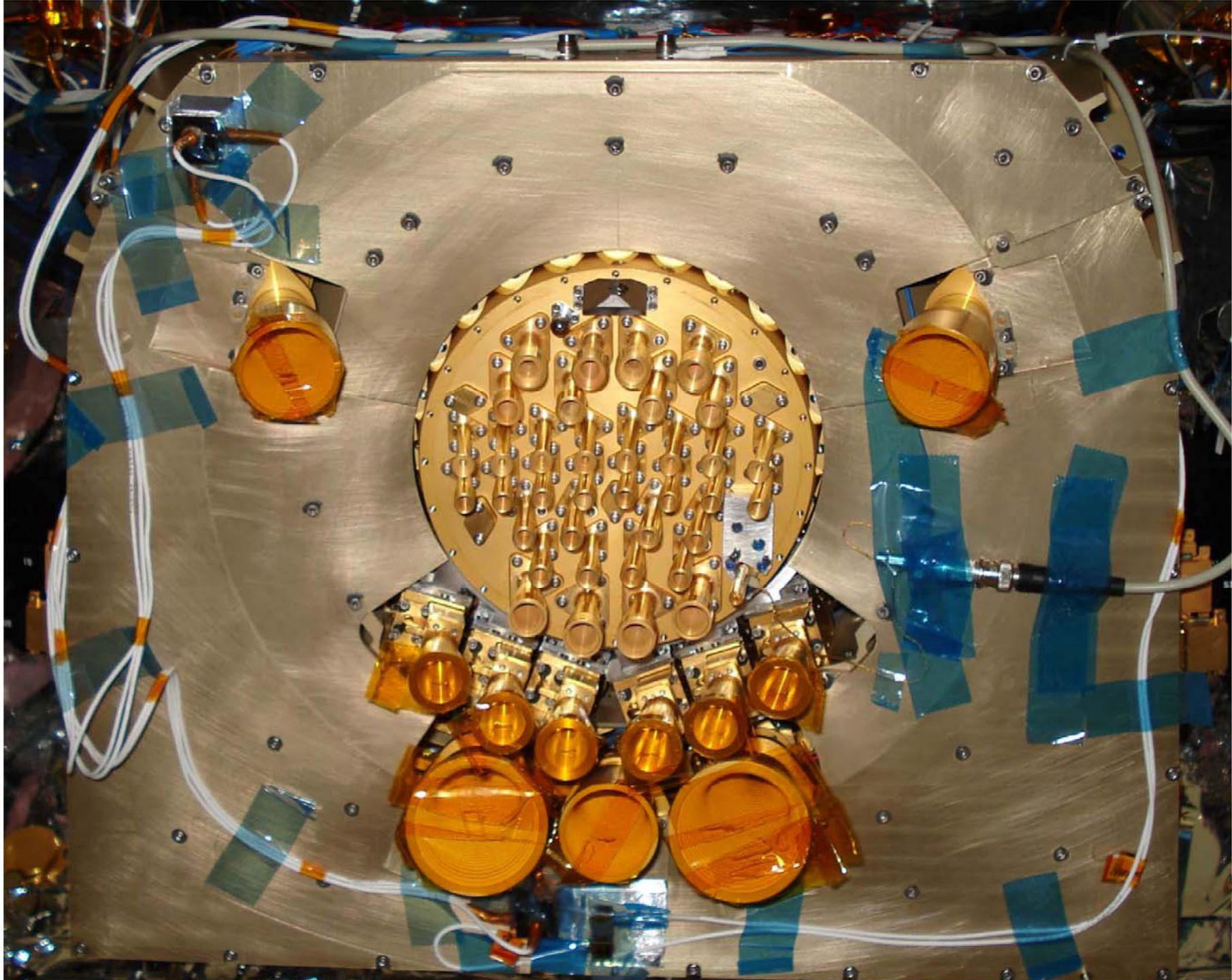
# Limning af skin til Honeycomp



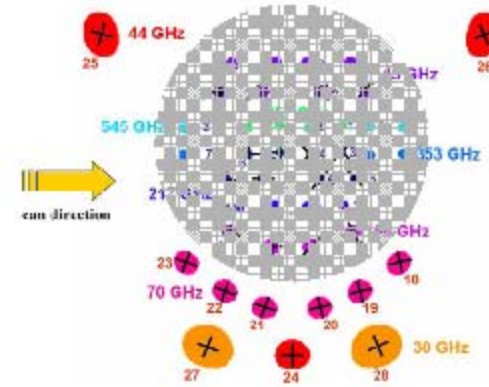
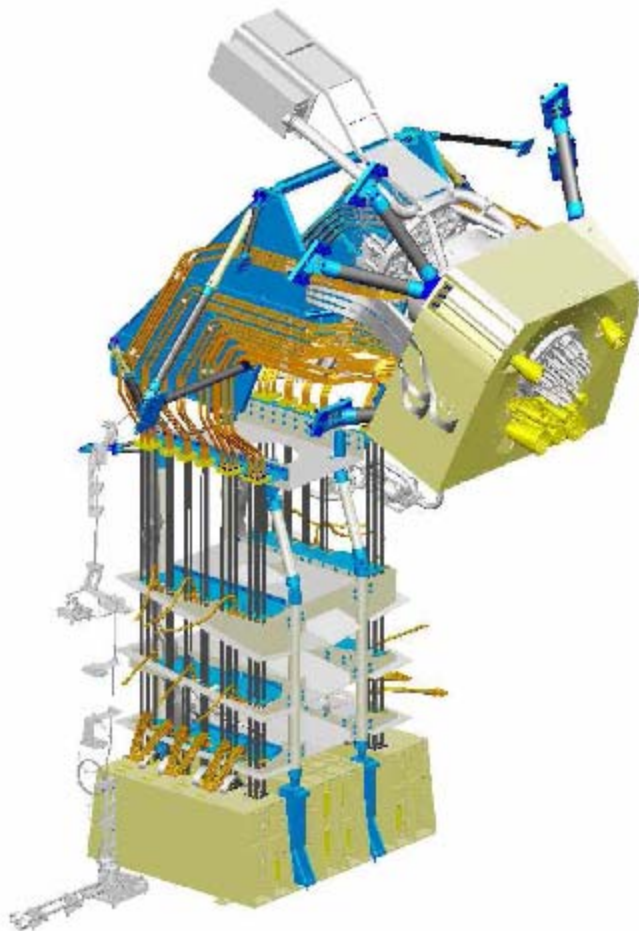
**Volumenet af limen er kritisk og skal være så lille som muligt.**

# Letvægtsdesign af spejlene



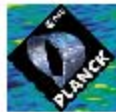






## LFI: Low Frequency Instrument

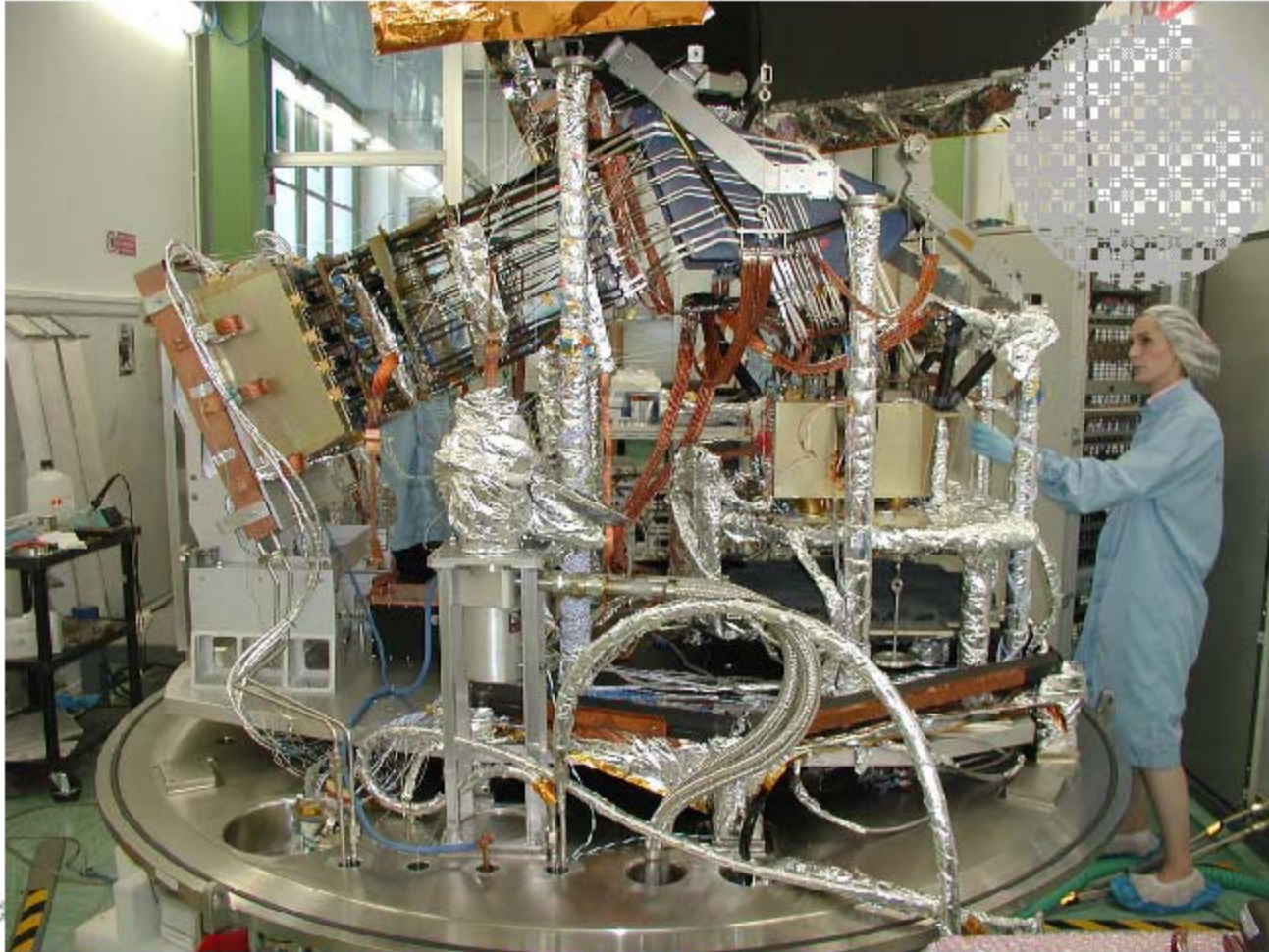
- 22 pseudo-correlation radiometers, based on HEMT LNAs operated at 20 K
- 3 bands, 30 – 70 GHz, linearly polarised



LFI PI: N. Mandolesi, IASF Bologna



ck Refle

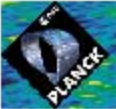


3 GHz

GHz

y

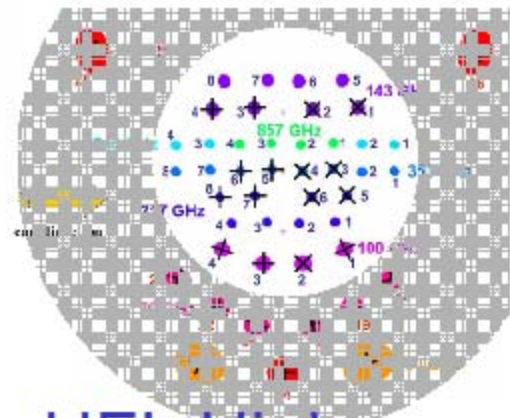
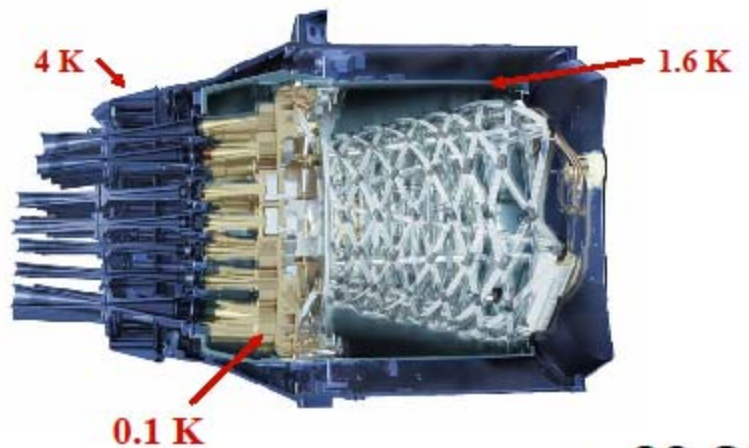
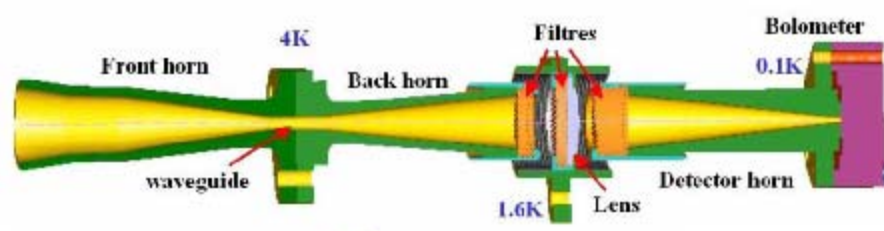
PLANCK



LFI PI: N. Mandolesi, IASF Bologna

J. Tauber: LAU GA 2009, 14 Aug 2009





# HFI: High Frequency Instrument

- 20 Spider-web bolometers, and 16 pairs of Polarisation-sensitive bolometers, cooled to 0.1 K
- 6 bands, 100 – 857 GHz

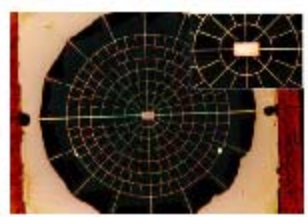
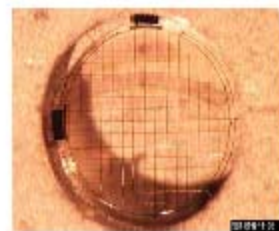


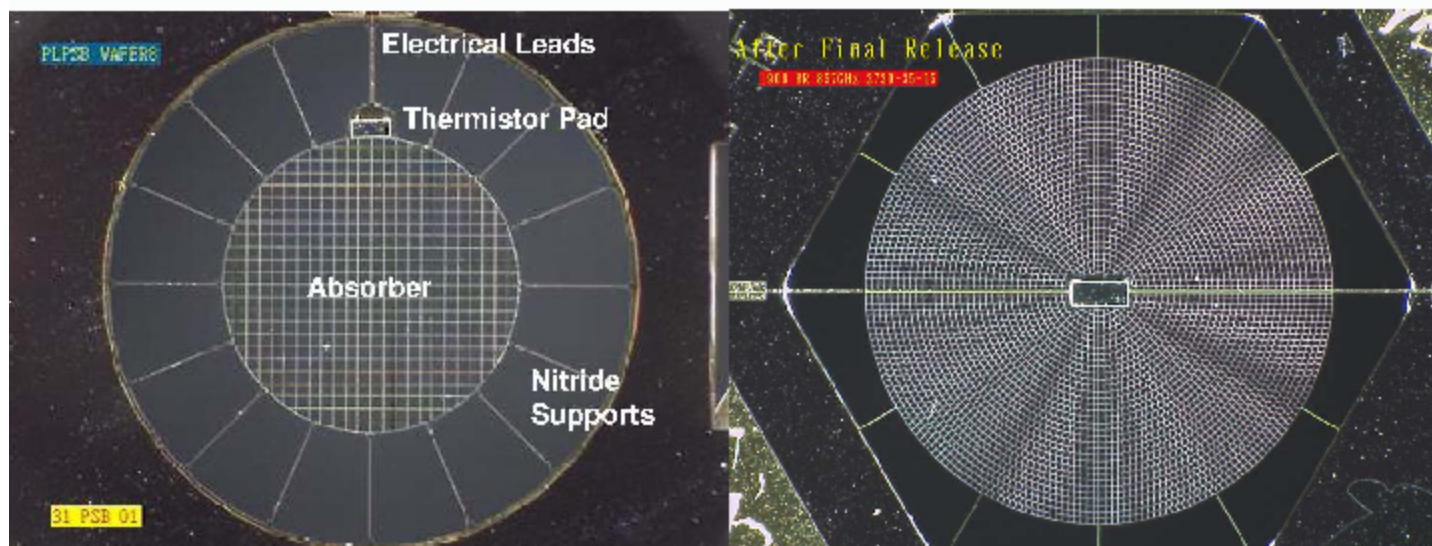
Figure 3.1.1 Prototype spider-bolometer (SFB). Active element diameter: outer spider webs, to 1.475 mm. Inset shows SFB in use in the center with the two 10-ohm current carrying and thermal conductance coated thin wiring, one horizontally to electrical contact and the other radially.

WCK

# PLANCK Reflector Programme



## Spider Web Bolometers & PSBs



145 GHz Polar Sensitive Bolometers

857 GHz SpiderWeb Bolometer

All HFI flight bolometers have been built by Caltech/JPL, integrated into pixels and tested in Cardiff, integrated into HFI – notably. JFET (Rome) + REU (CESR) and then tested at instrument level @ IAS, Orsay.  
**NB: Flight Model includes 4 PSB pairs @ 100 GHz**  
(following the descoping of the 100 GHz receivers from the LFI)

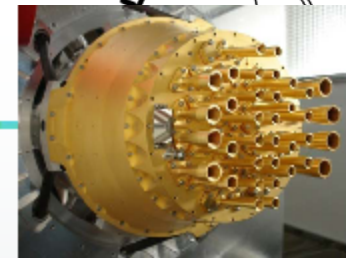


# PLANCK Reflector Programme

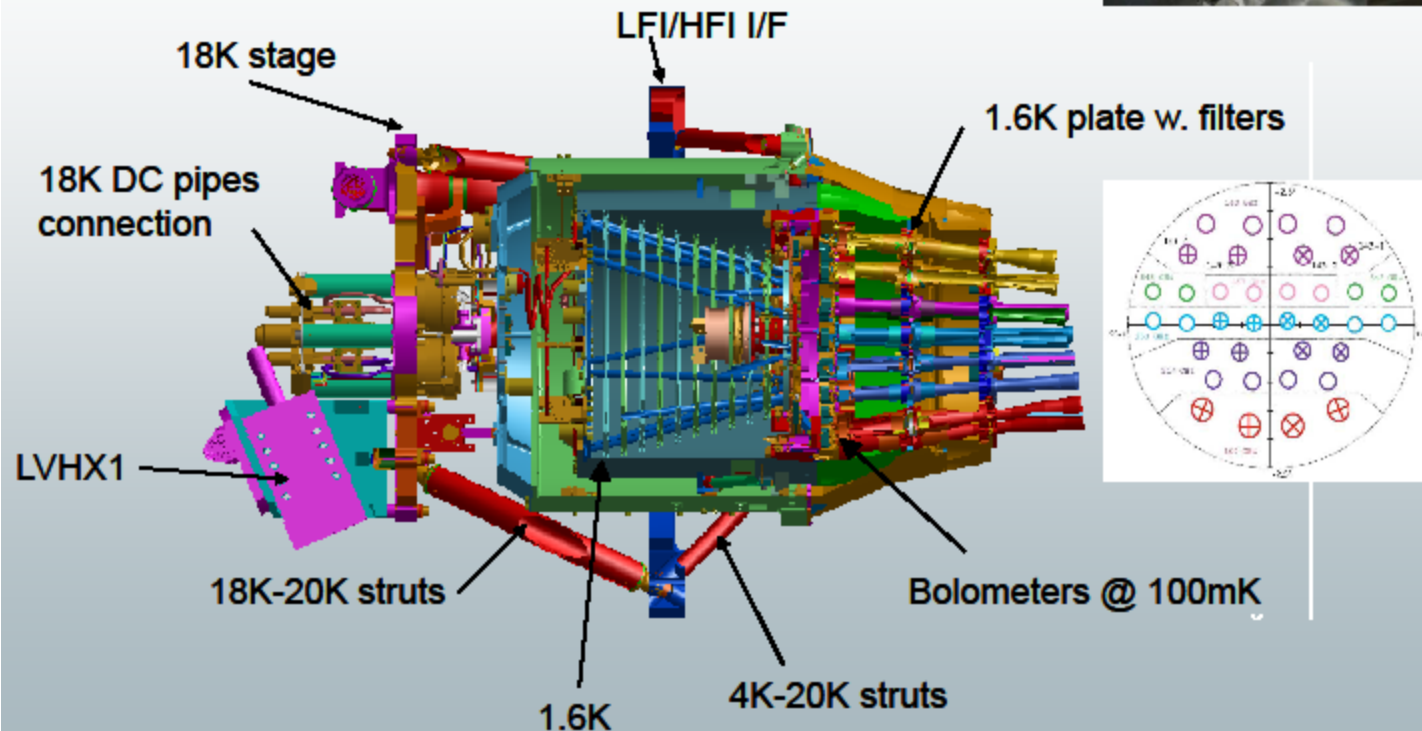


HFI (Russian-doll) cut-away

## THERMAL STABILITY ?

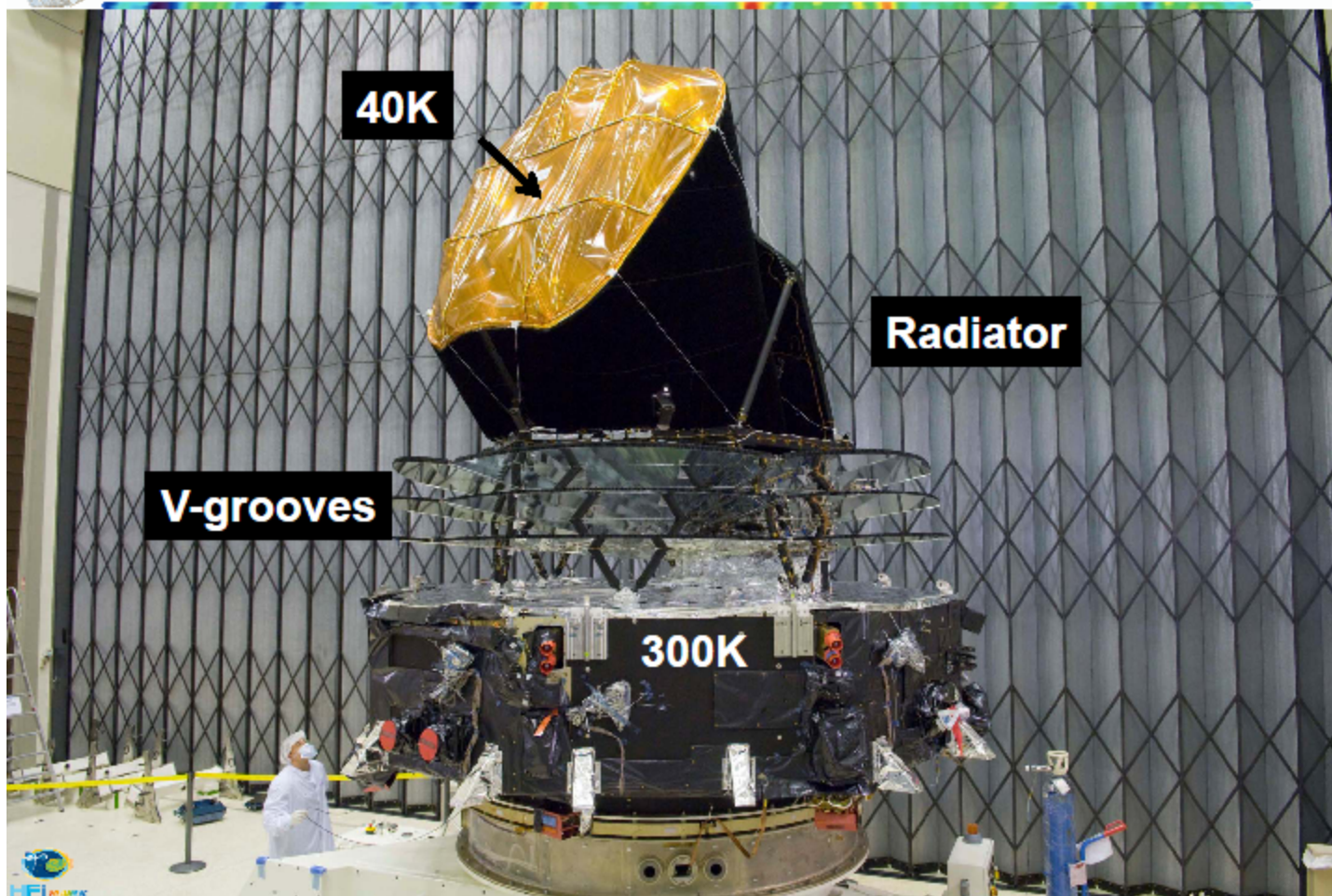


Planck Reflectors  
PLANCK





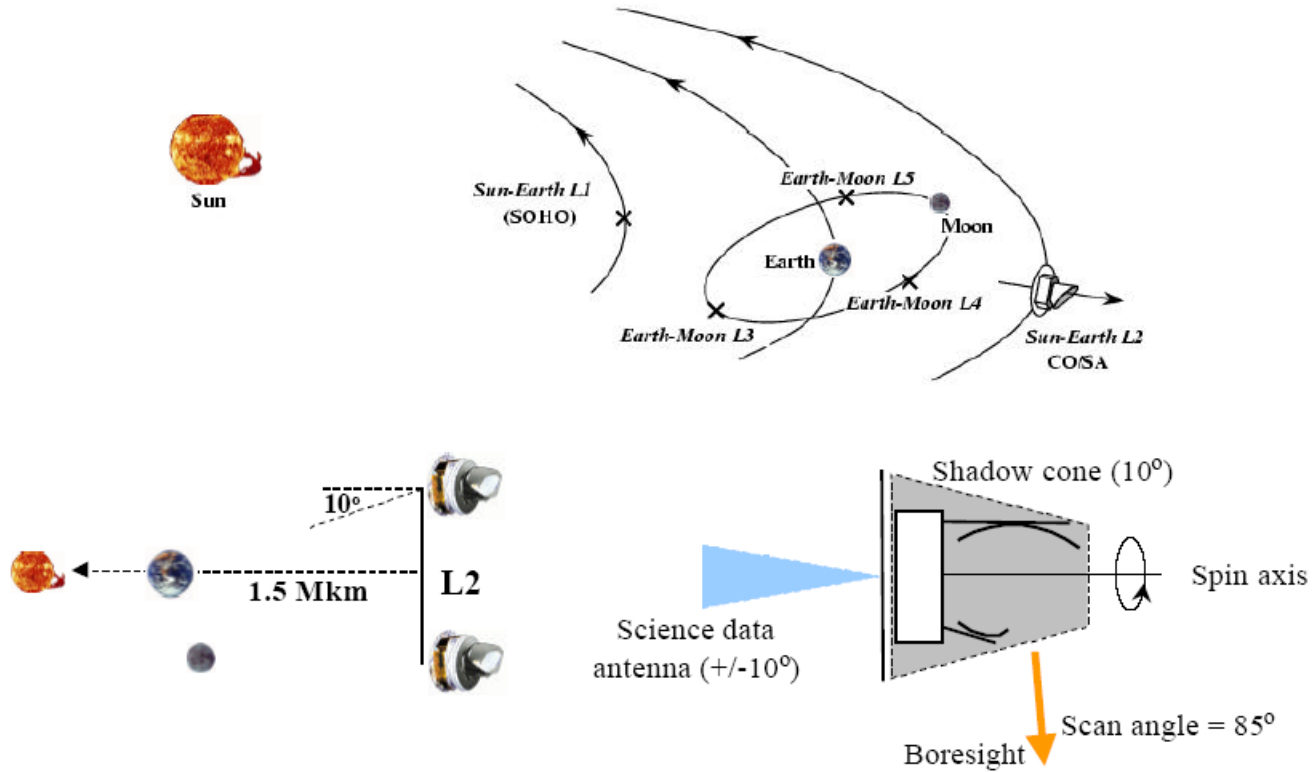
# Cooling chain (1/4)



# PLANCK Reflector Programme

Planck Reflectors  
-PLANCK

## Choice of orbit



PLANCK

esa  
ASTROPHYSICS

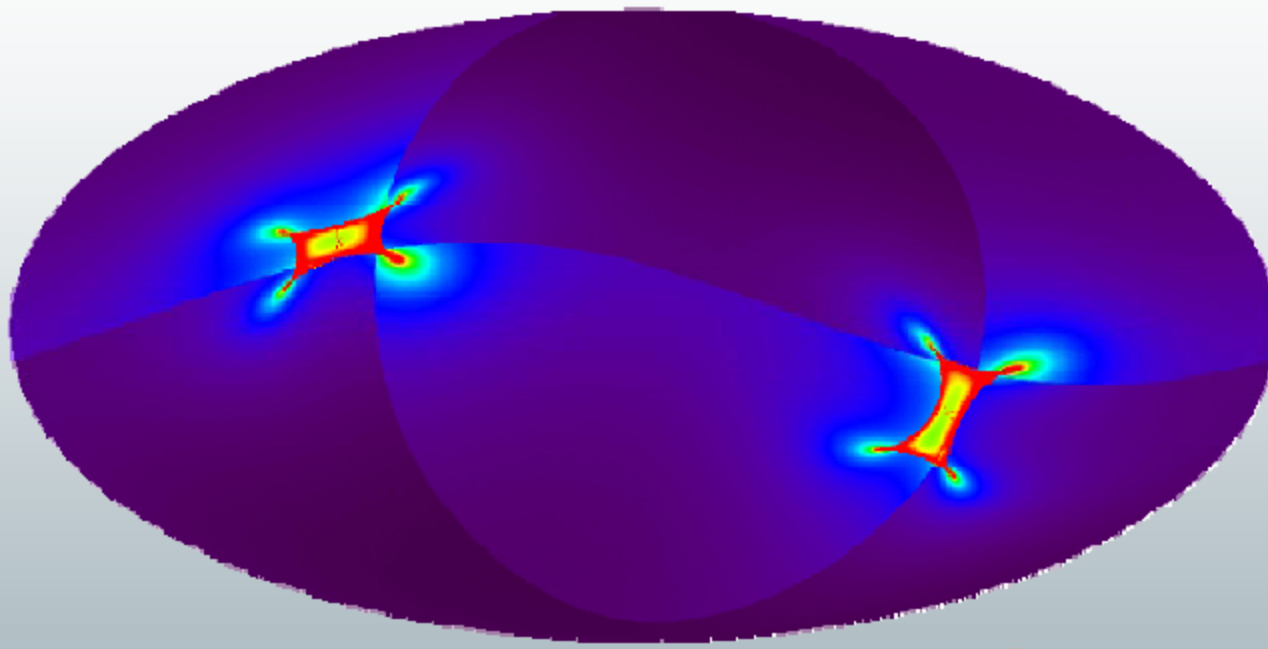
# PLANCK Reflector Programme



1 detector coverage after 15 months



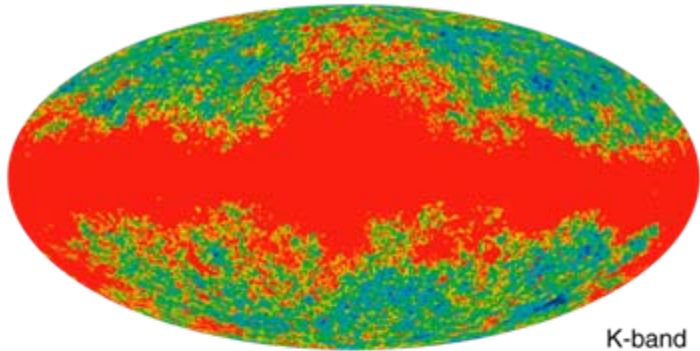
100 GHz



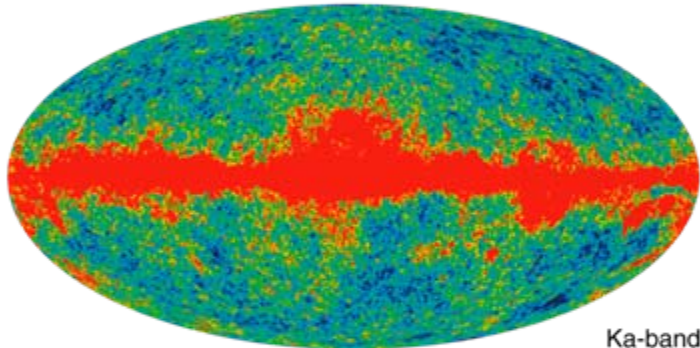
0 7000 sec / sq. deg.



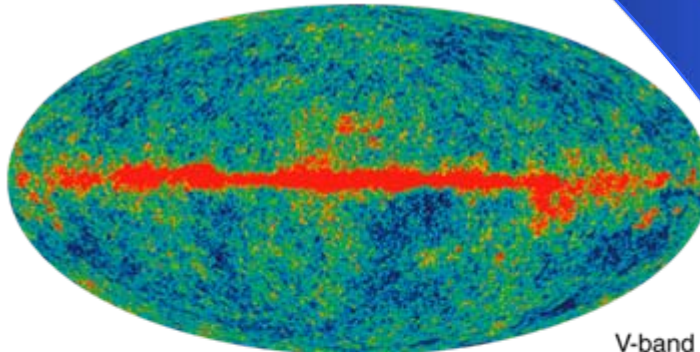
# PLANCK Reflector Programme



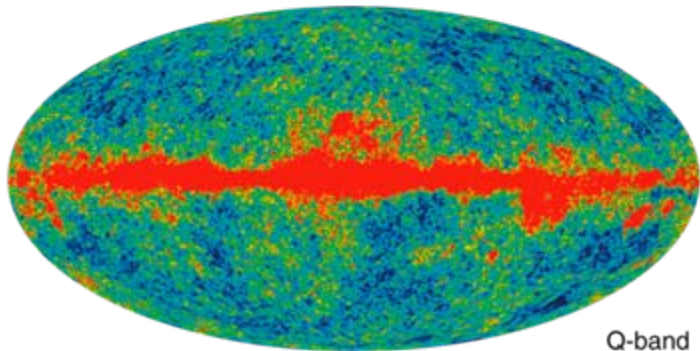
K-band



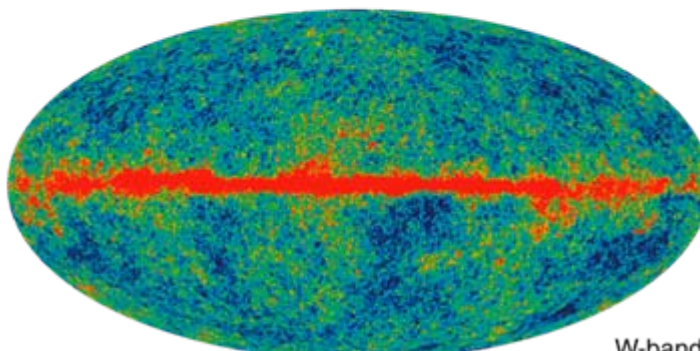
Ka-band



V-band



Q-band

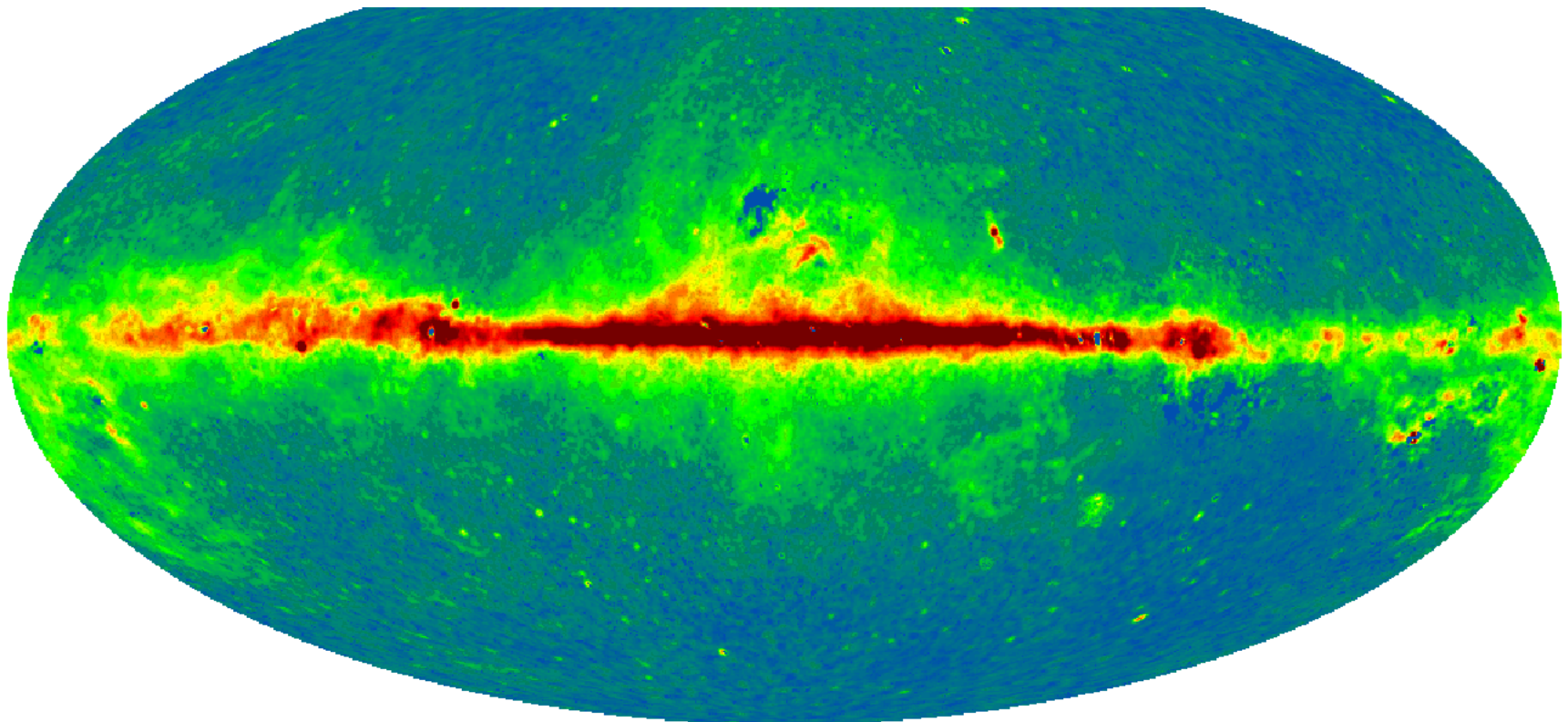


W-band



the interstellar medium). The synchrotron emission is

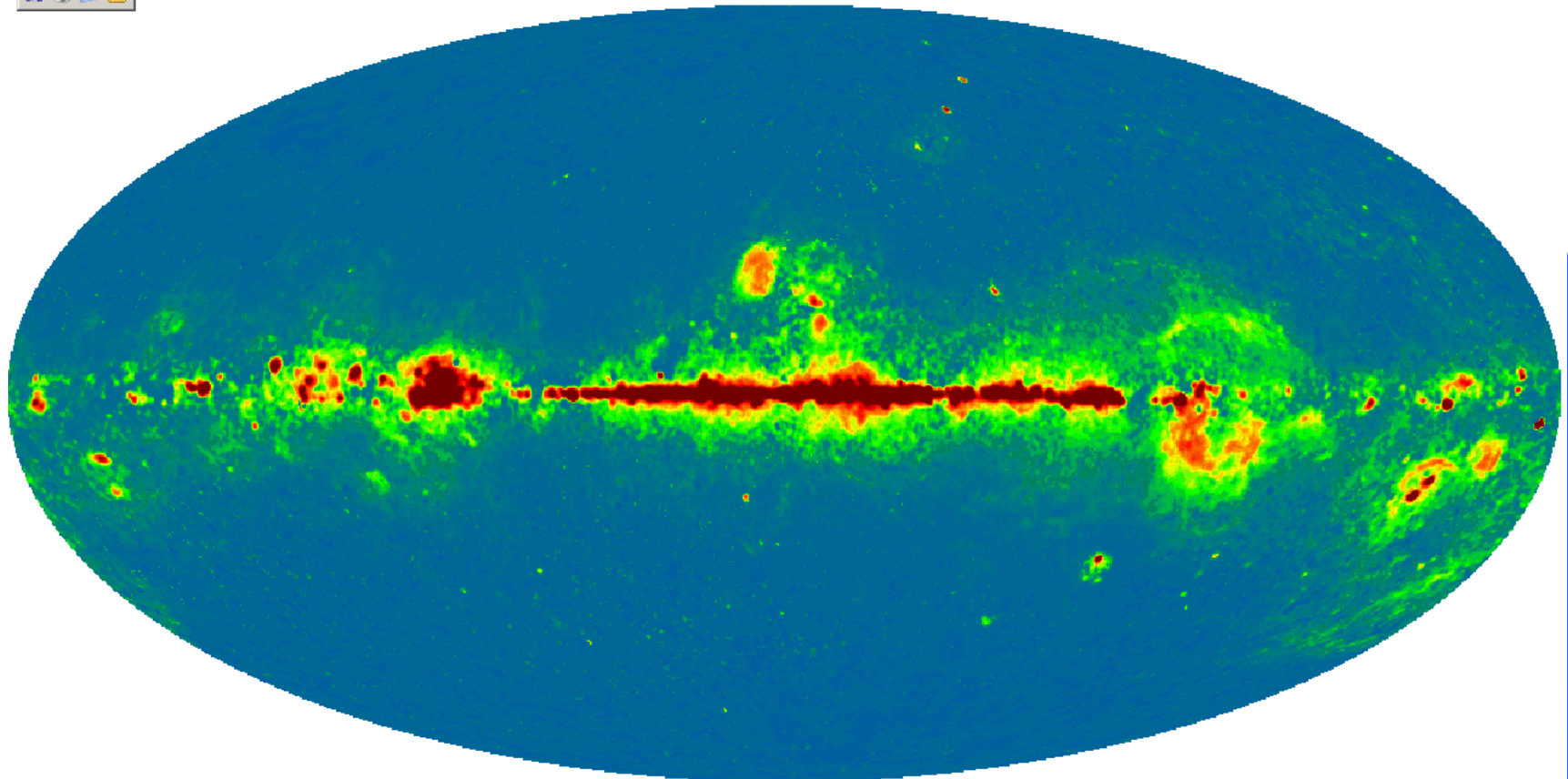
$$S_s(\nu) = A_s \left( \frac{\nu}{\nu_0} \right)^{\alpha_s}$$



Free - free emission

WMAP Free - Free Map K band (23 GHz)

$$S_{ff}(\nu) = A_{ff} \left( \frac{\nu}{\nu_0} \right)^{\alpha_{ff}}$$

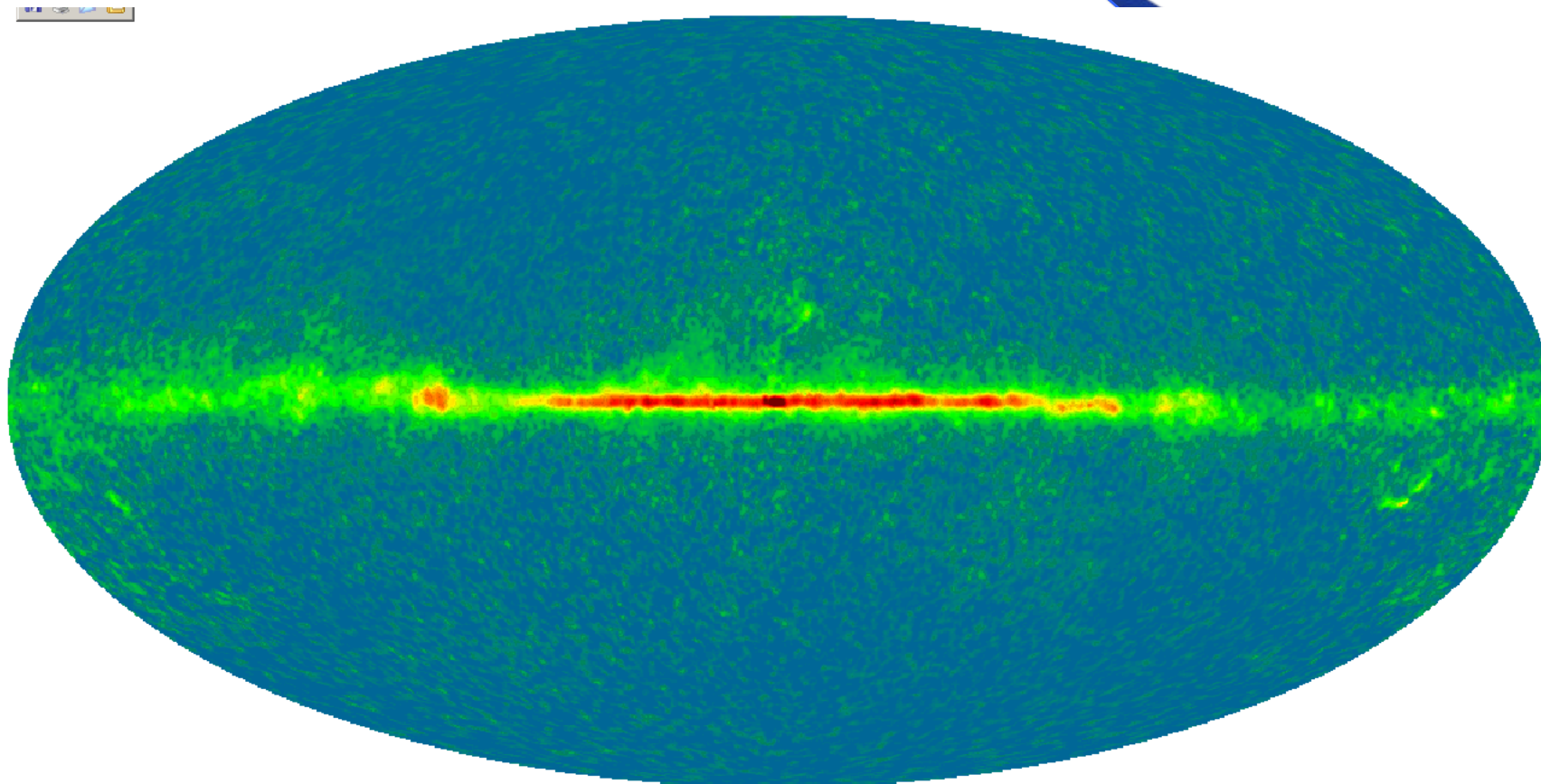


used a single component FDS model 3, with a temperature  $T_1 = 18.1$  K.

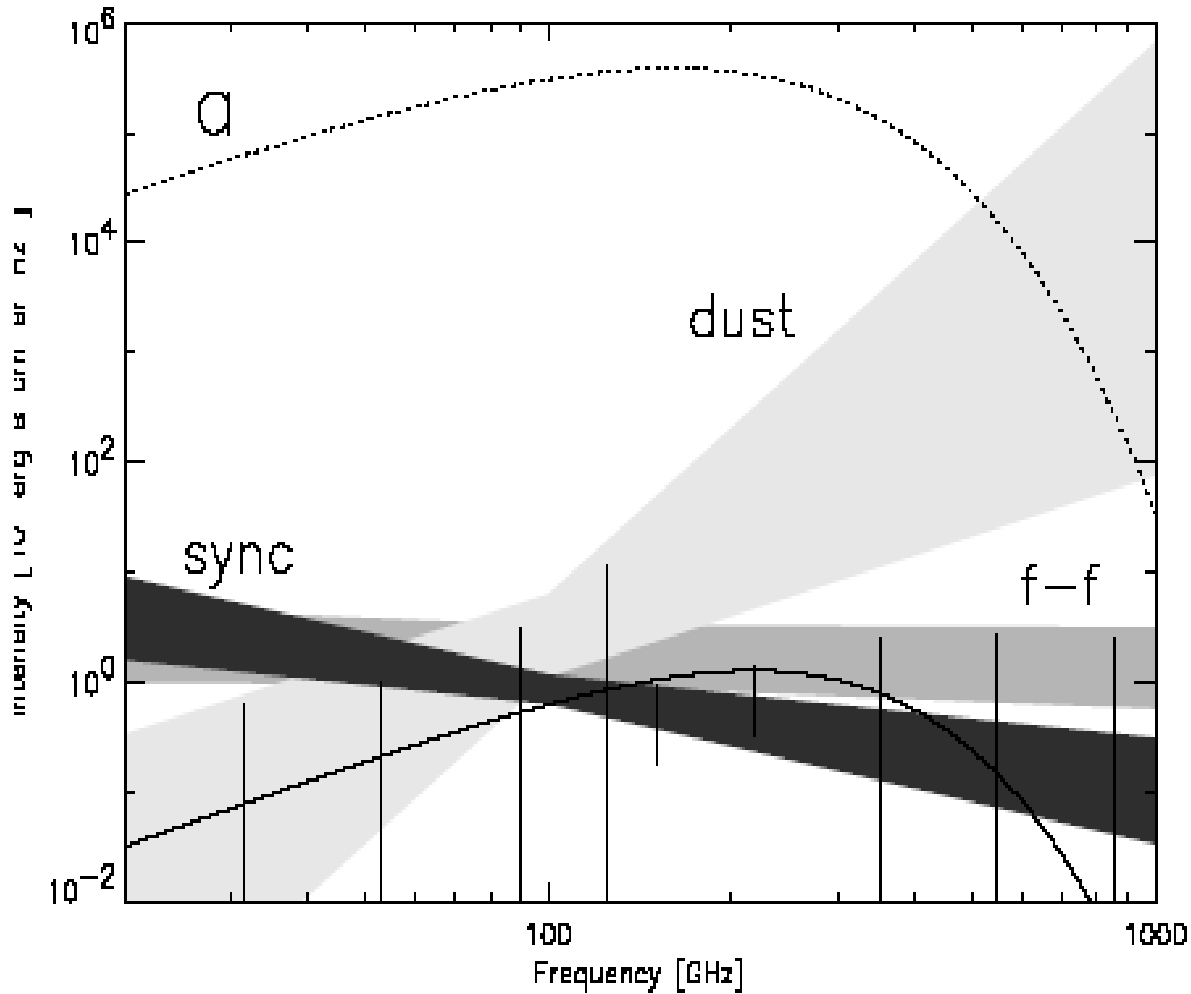
$$s_d(\nu) \sim \left( \frac{e^{\frac{h\nu_{0,d}}{kT_1}} - 1}{e^{\frac{h\nu}{kT_1}} - 1} \right) \left( \frac{\nu}{\nu_{0,d}} \right)^{\alpha_d + 1}$$

Finkbeiner, Davis and Schlegel et al. (1999):  
Model 3

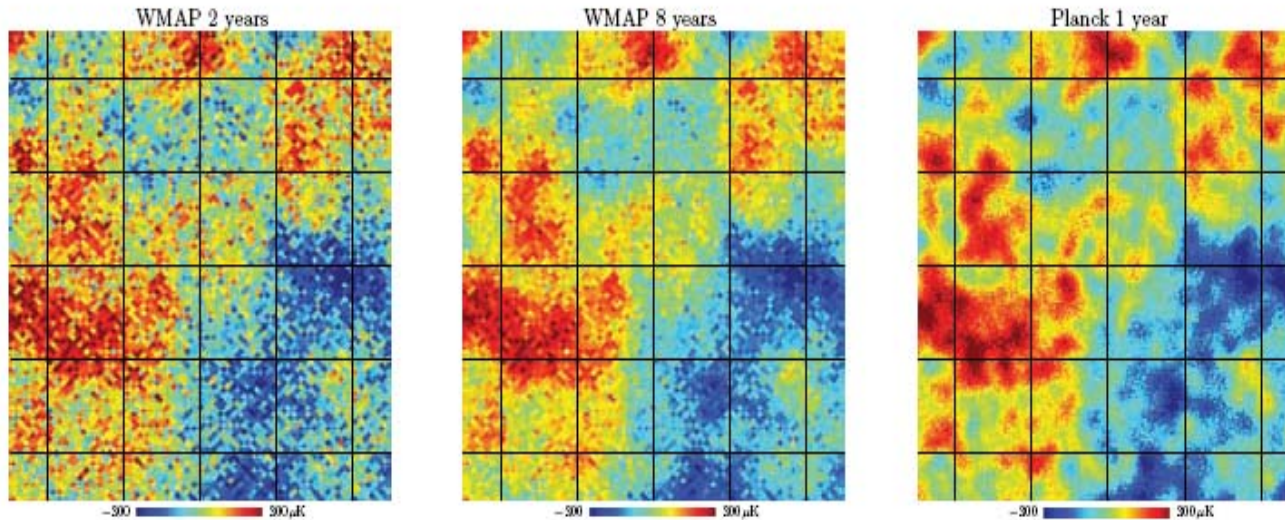
WMAP Dust Map W band (94 GHz)



# PLANCK Reflector Programme



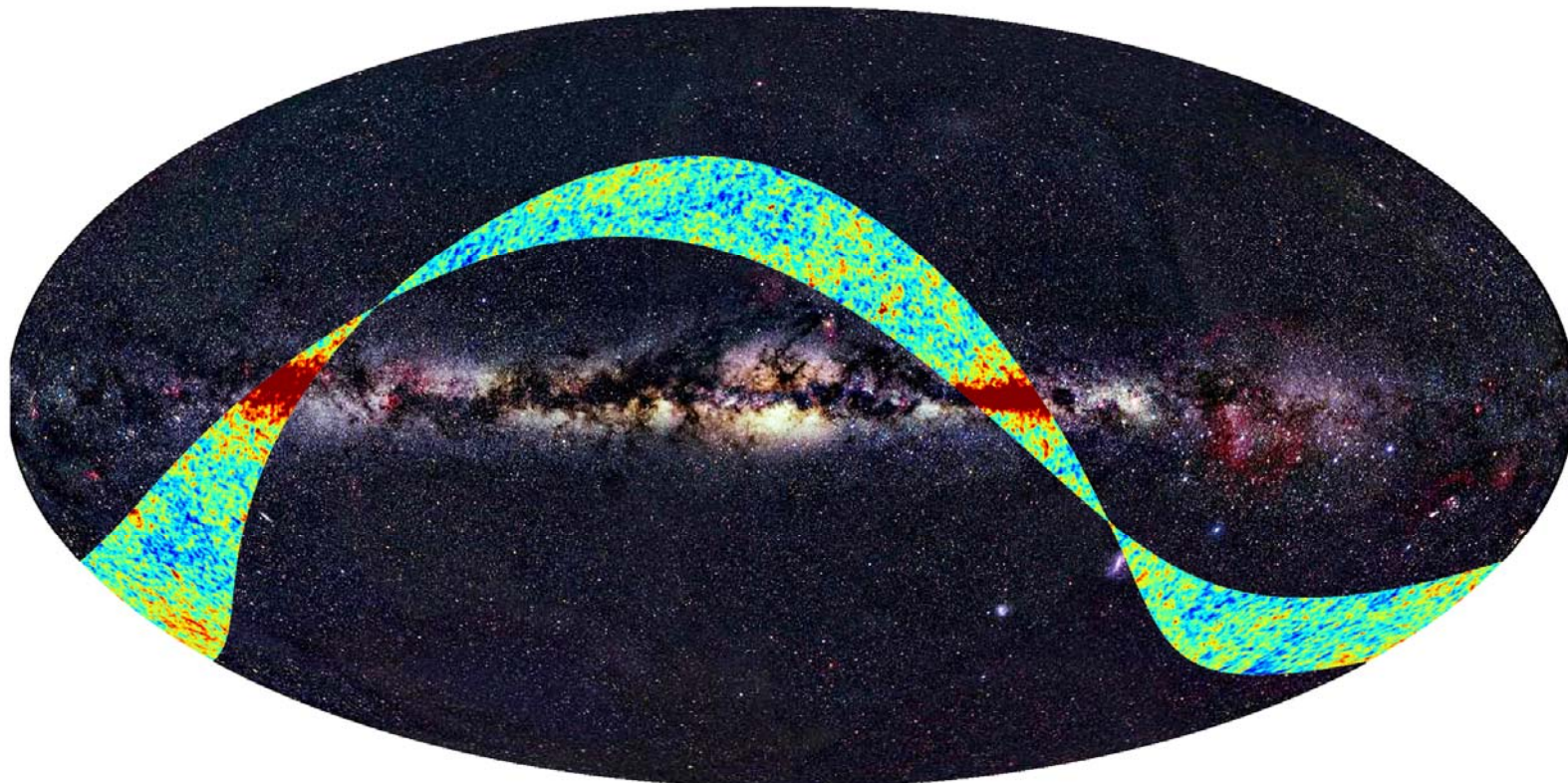
# PLANCK Reflector Programme



**Significant improvement already obtained in the FLS**

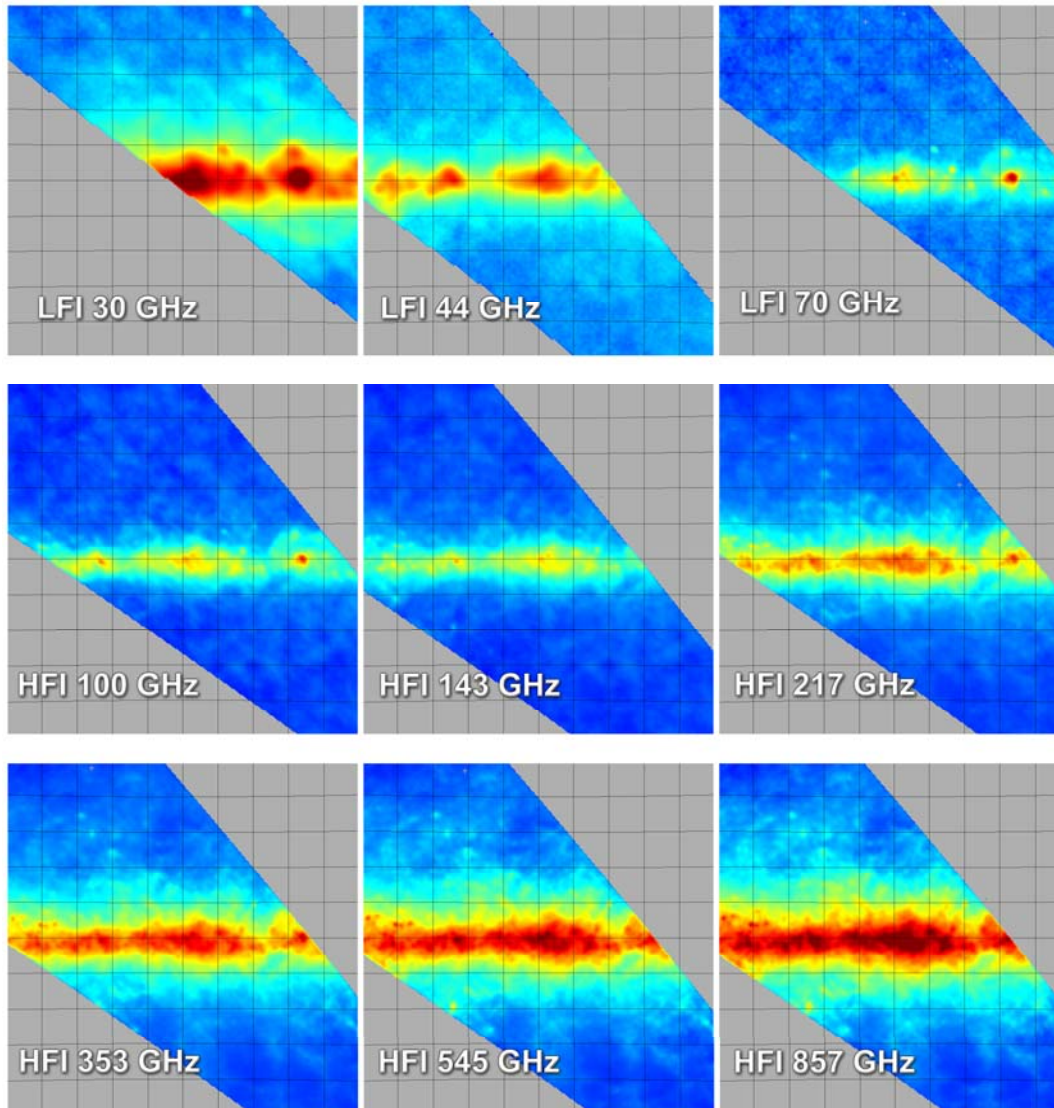
# PLANCK Reflector Programme

## Planck First Light Survey



# PLANCK Reflector Programme

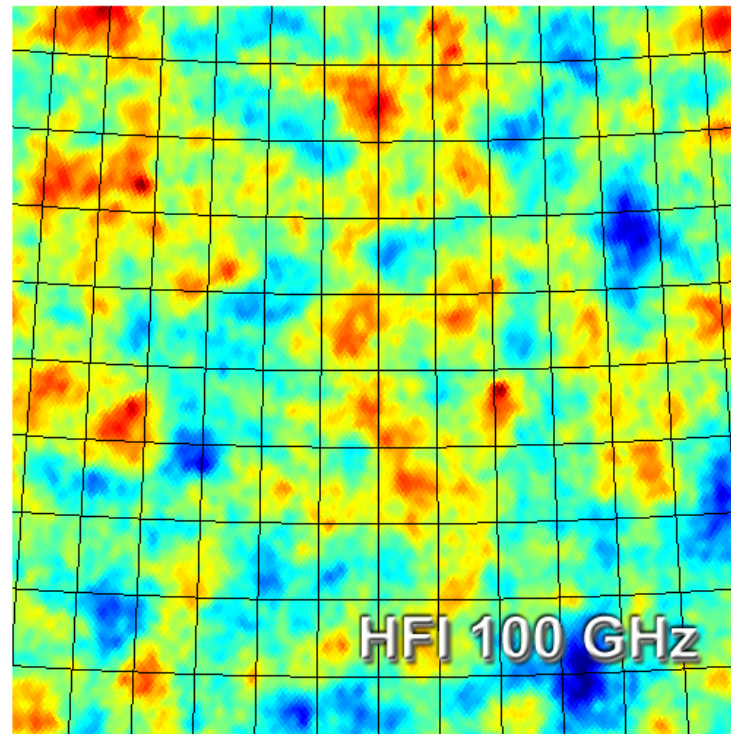
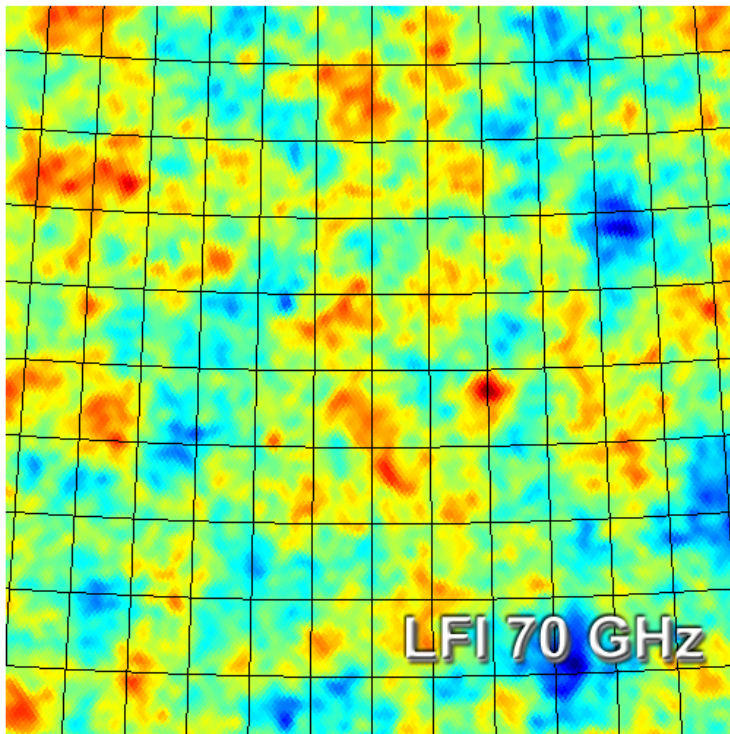
## Planck First Light Survey



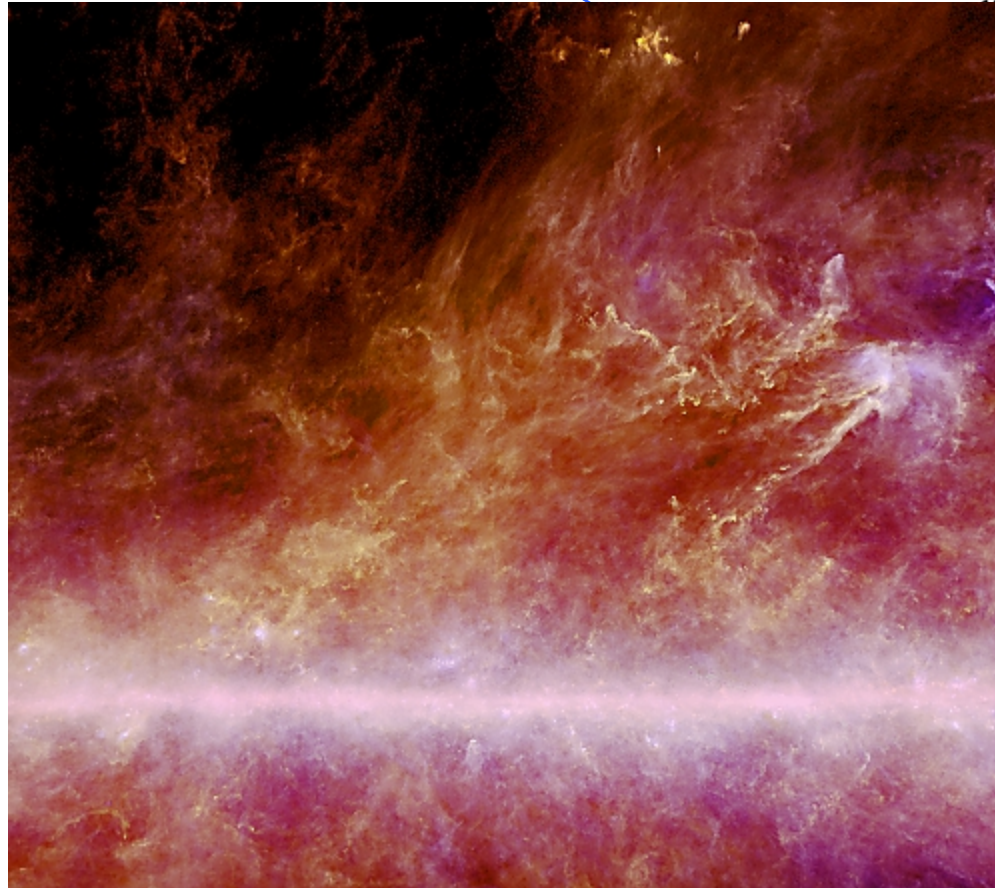


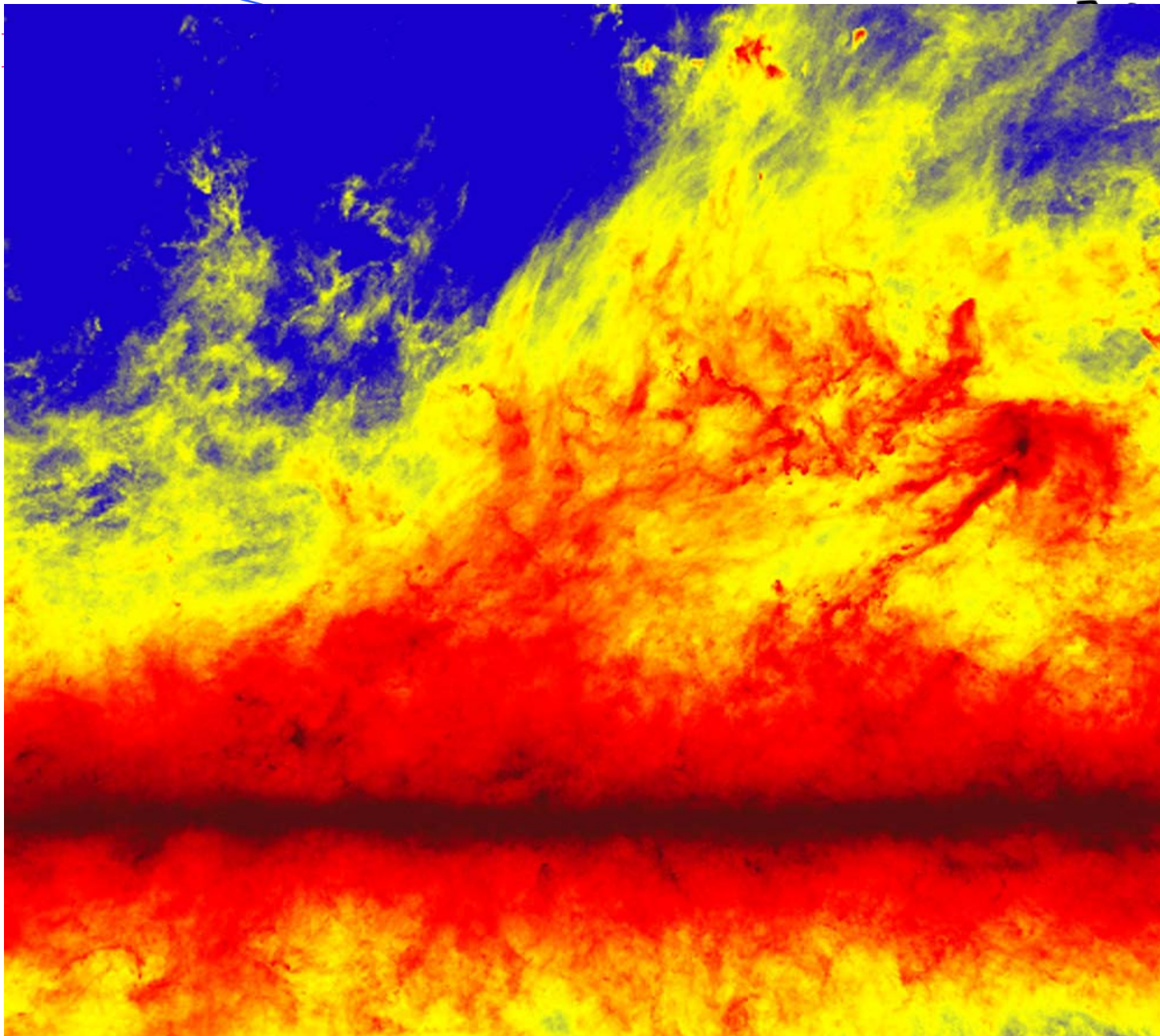
# PLANCK Reflector Programme

## Planck First Light Survey



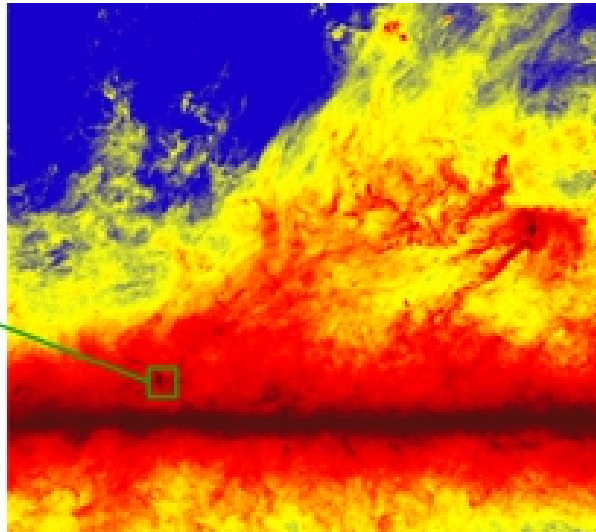
# PLANCK Reflector Programme



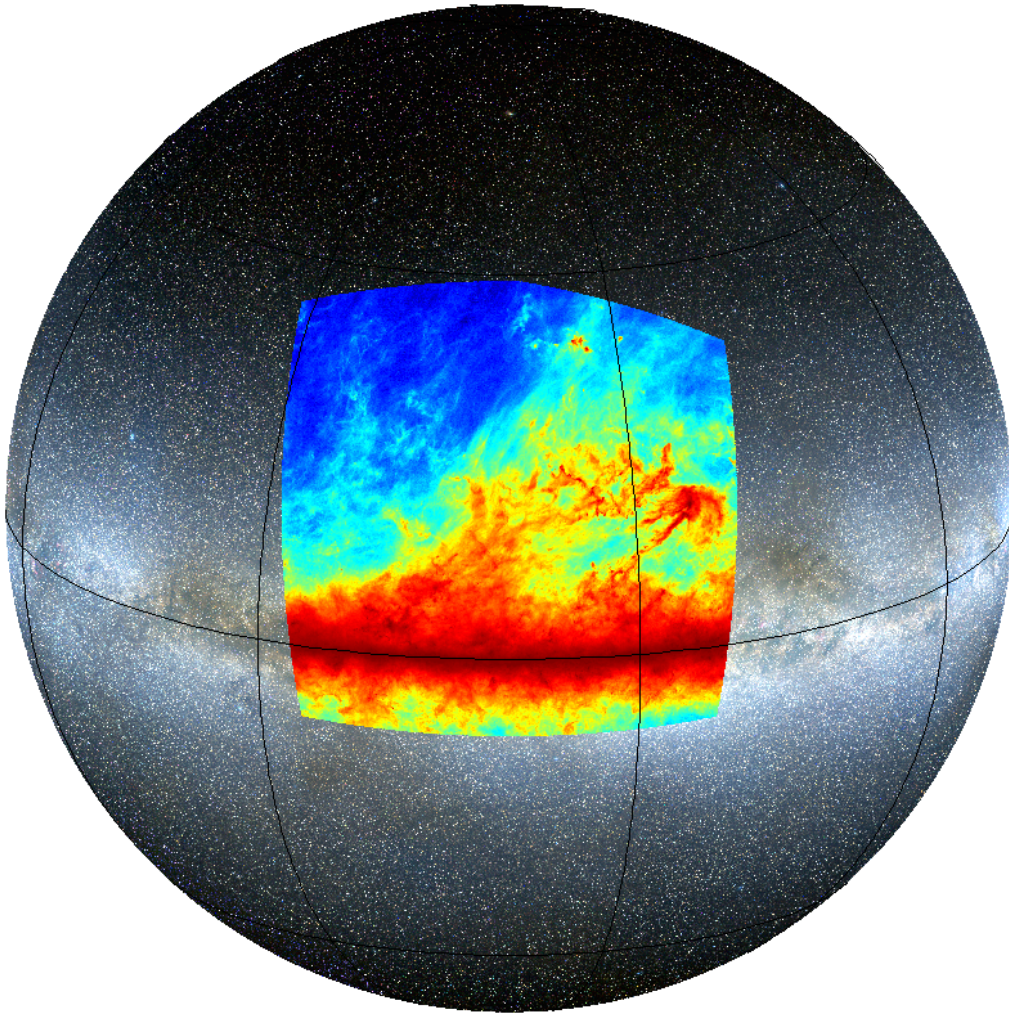


ectors  
PLANCK

# PLANCK Reflector Programme



# PLANCK Reflector Programme





14 May 2009

J. Tauber: LAU GA 2009, 14 Aug 2009





**HERSCHEL** SPACE OBSERVATORY

**PLANCK**

**PLANCK**

*J. Tauber: LAU GA 2009, 14 Aug 2009*

# PLANCK Reflector Programme

Planck Reflectors  
PLANCK



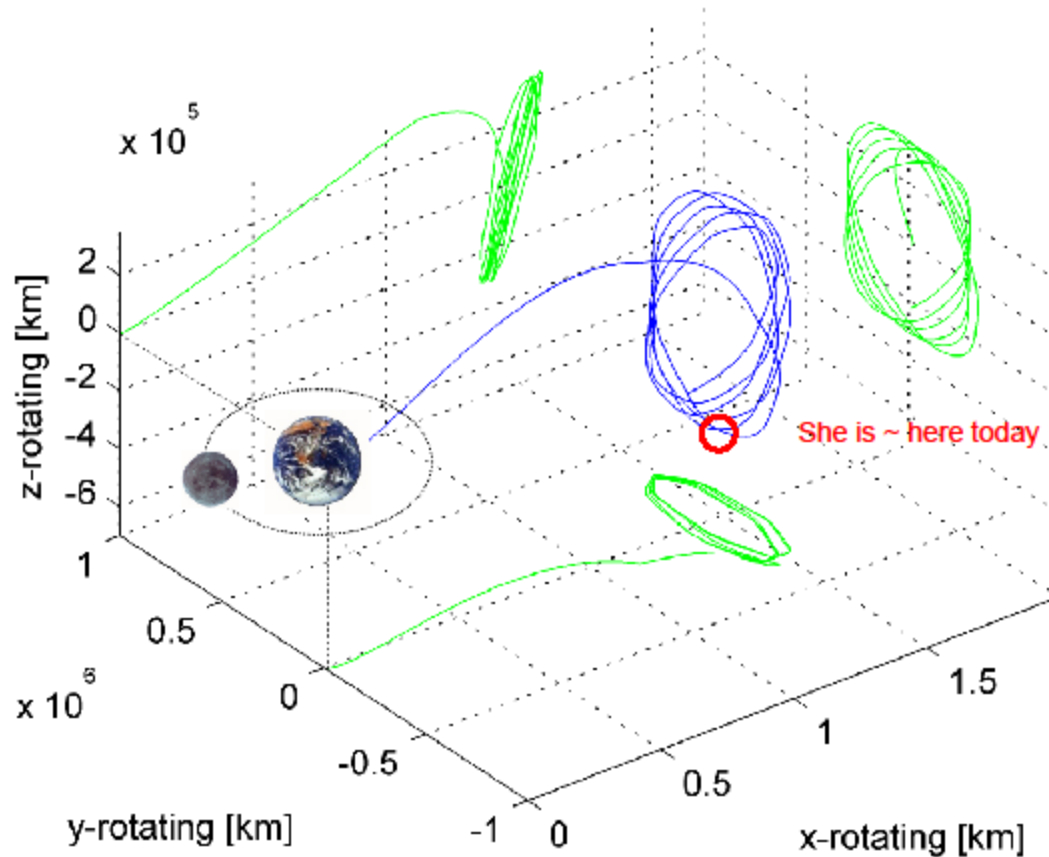
**Ariane 5 ECA Launch • HERSHEL - PLANCK** - May 14, 2009



# PLANCK Reflector Programme



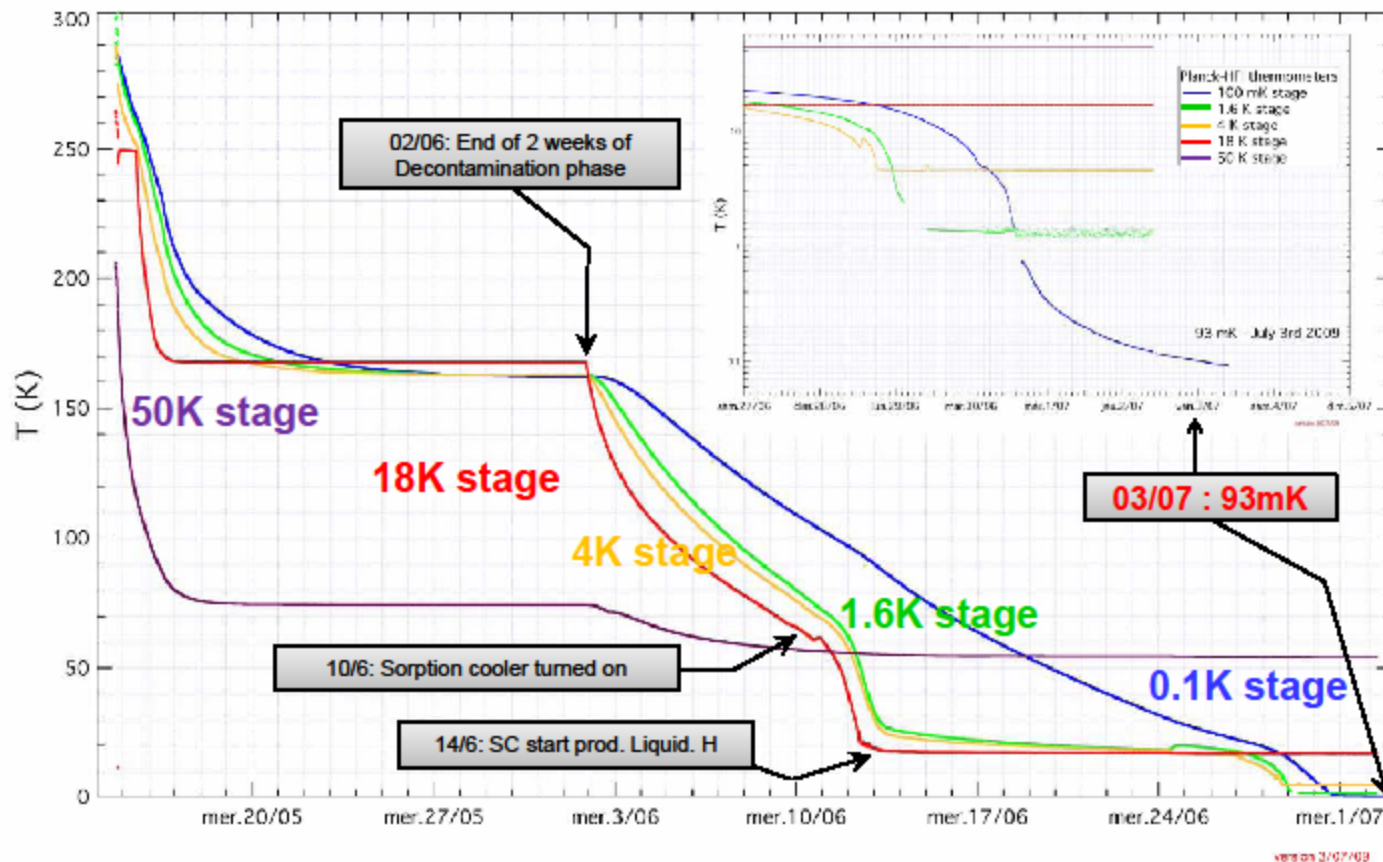
Planck is in L2 orbit since July



# PLANCK Reflector Programme



Planck is cool...



# PLANCK Reflector Programme



## The Launch of Herschel/Planck

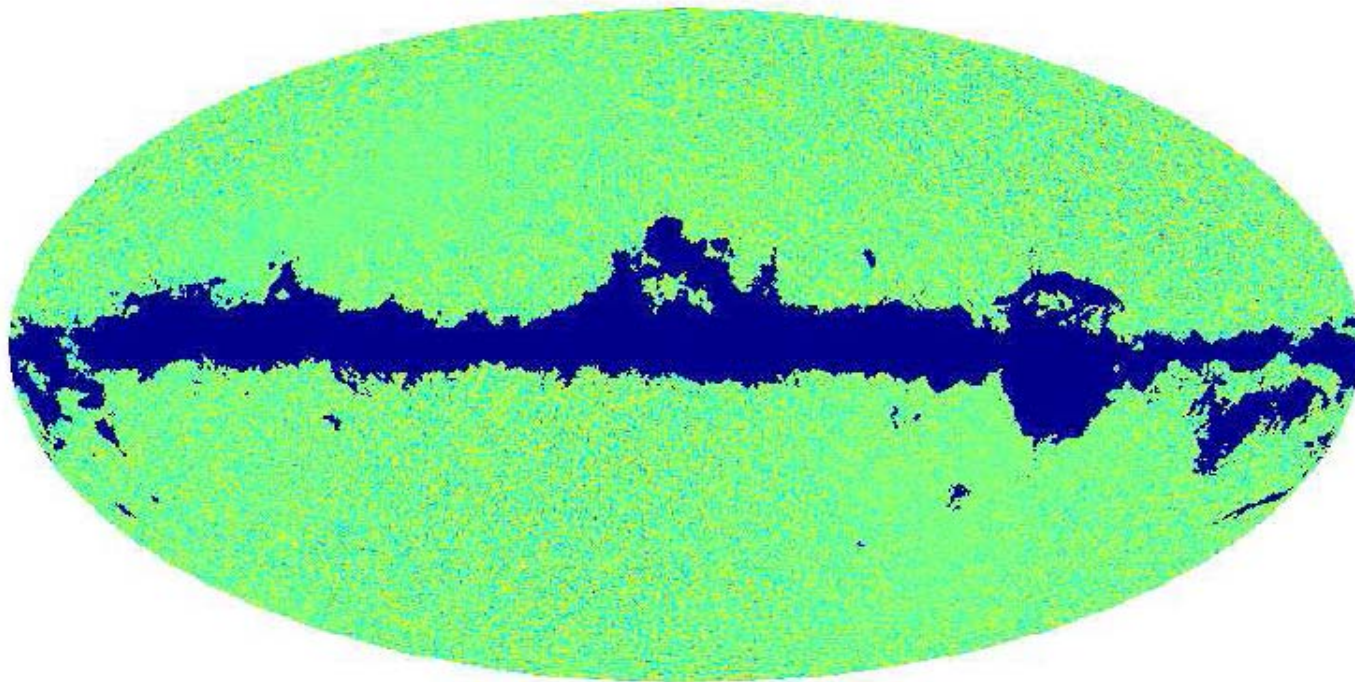
# PLANCK Reflector Programme



# PLANCK Reflector Programme

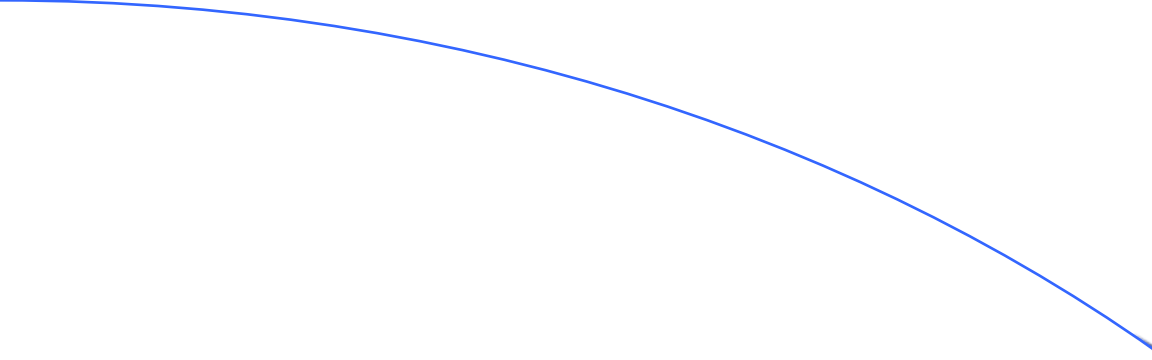
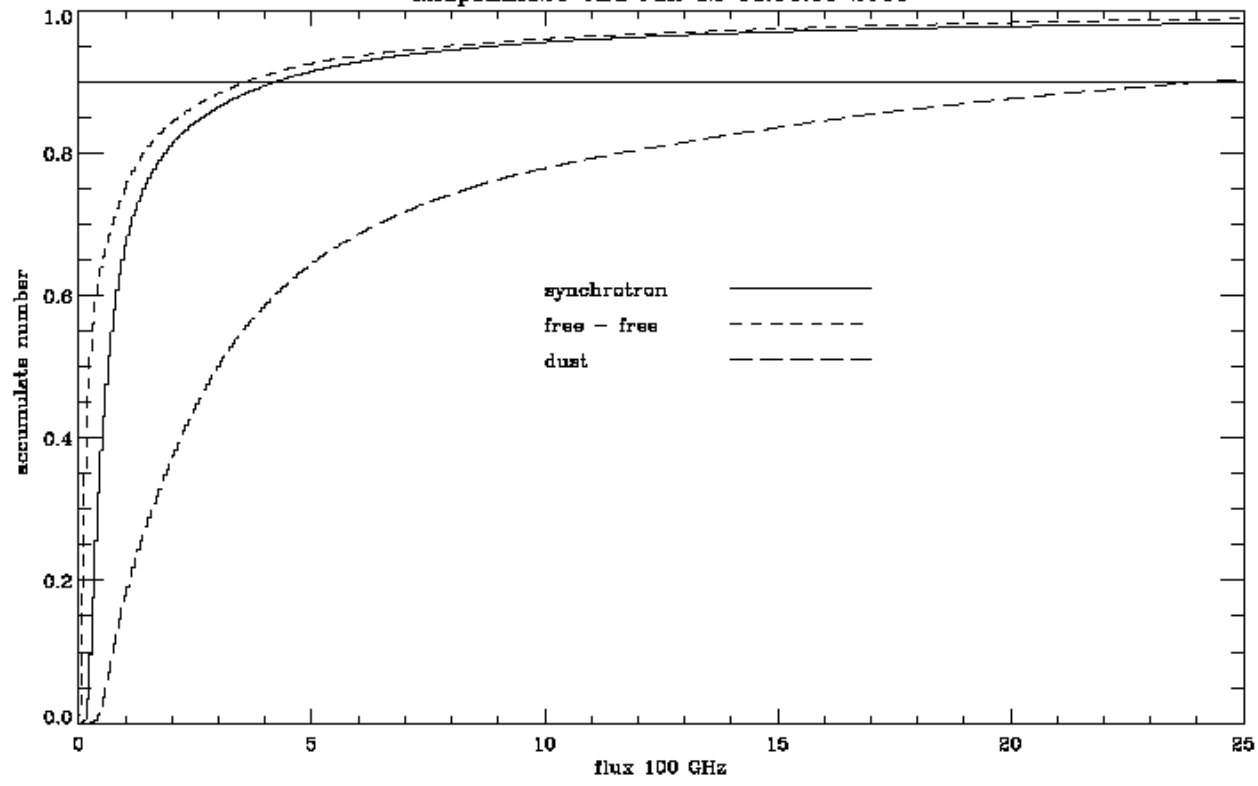


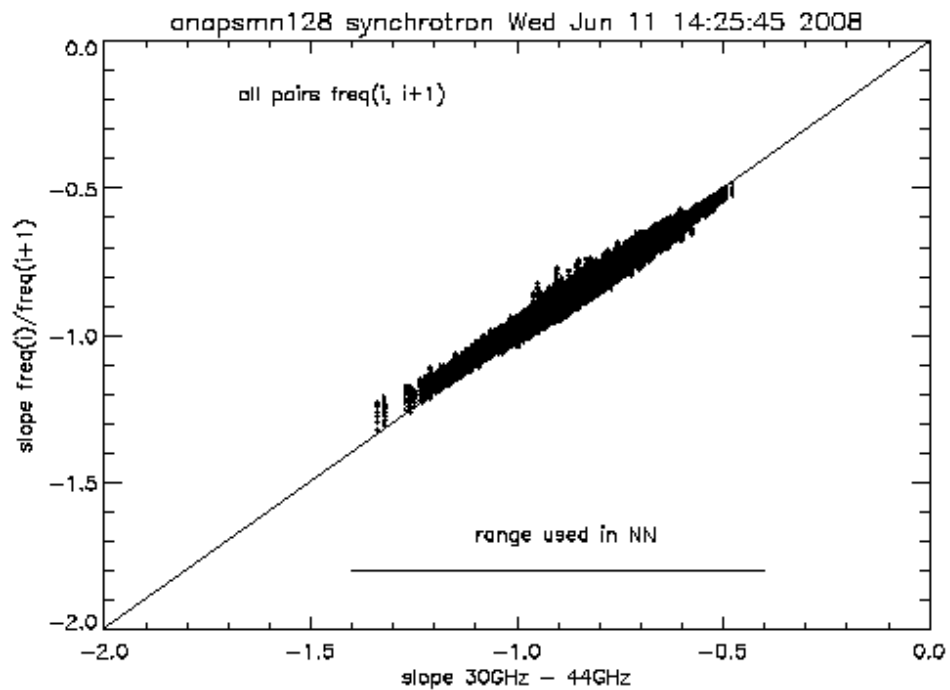
cmbres: X0



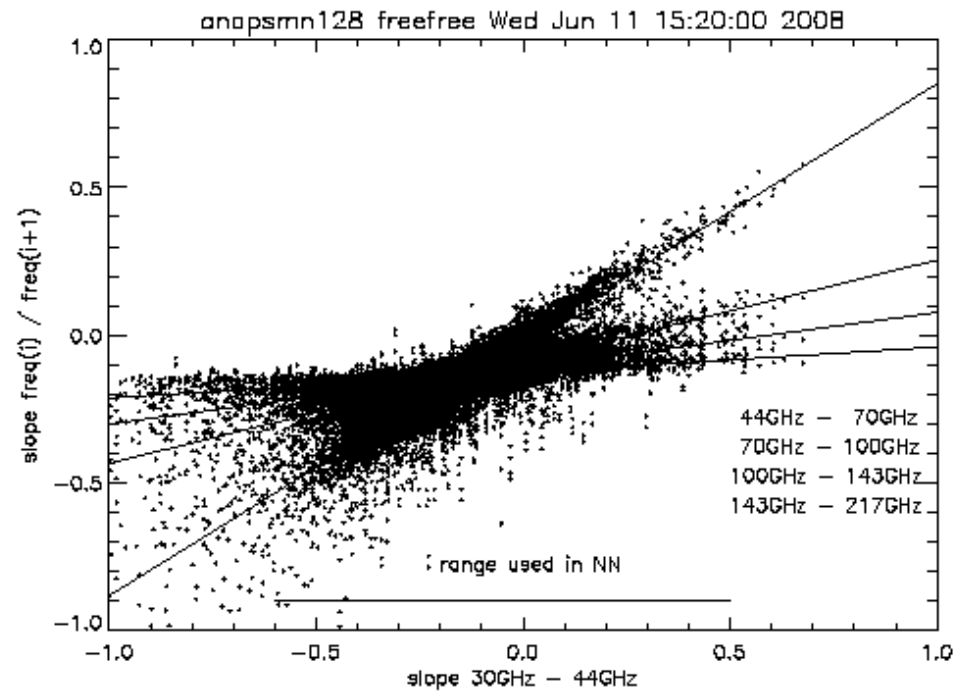
-30.0 30.0

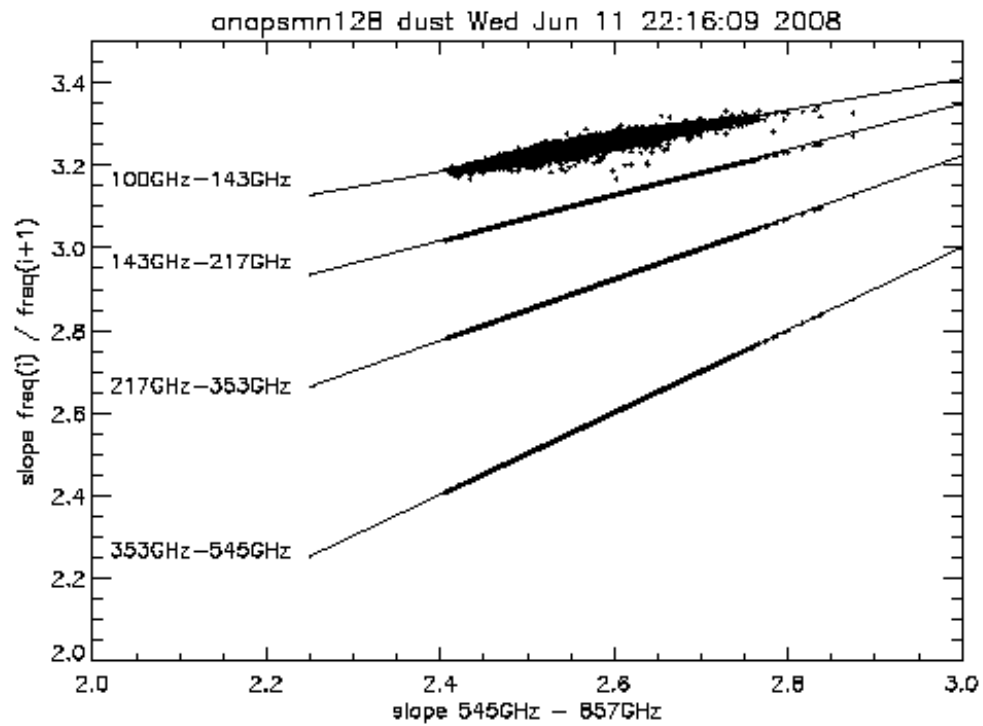
anapsmn128 Thu Jun 12 11:51:05 2008



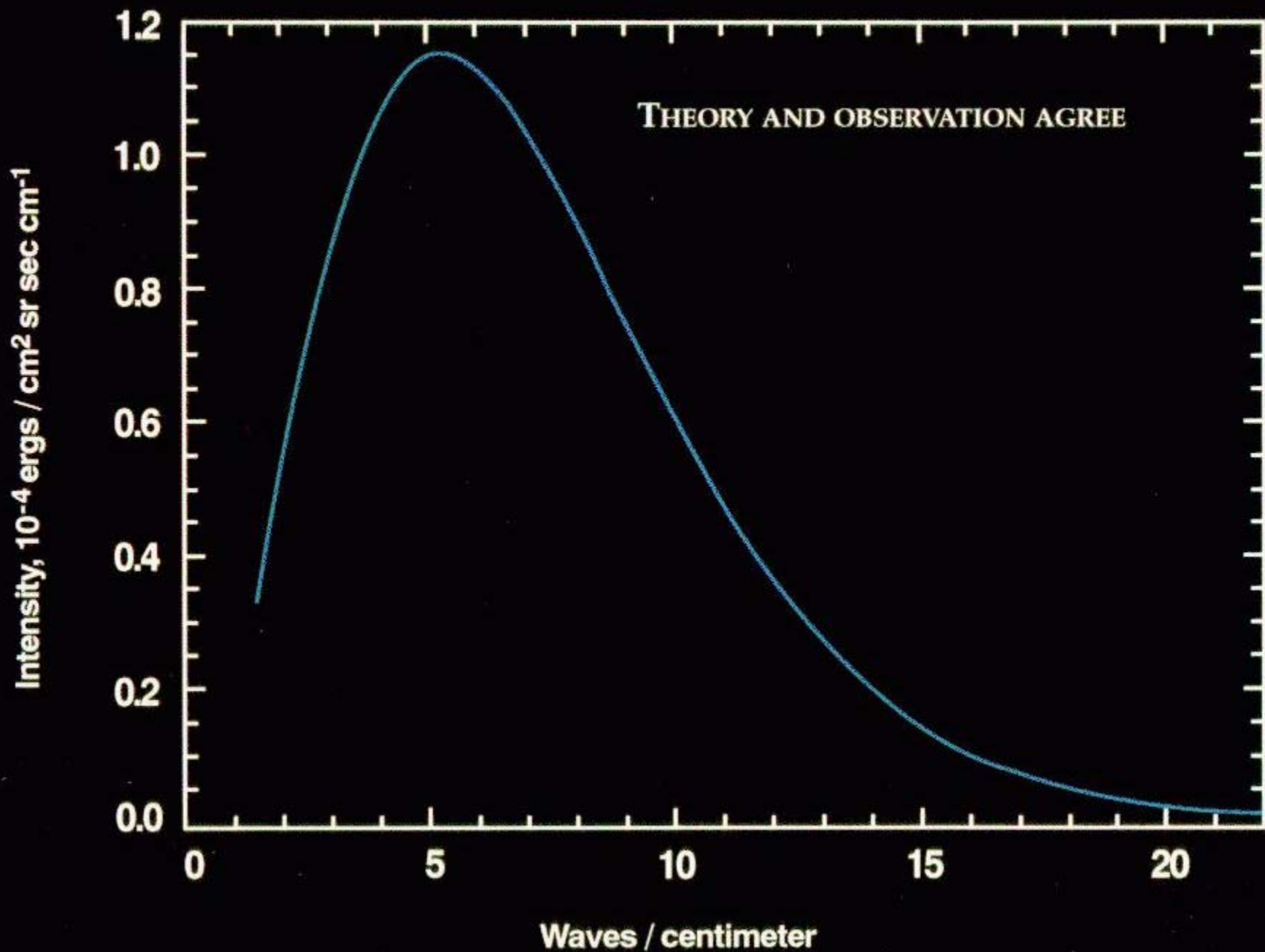


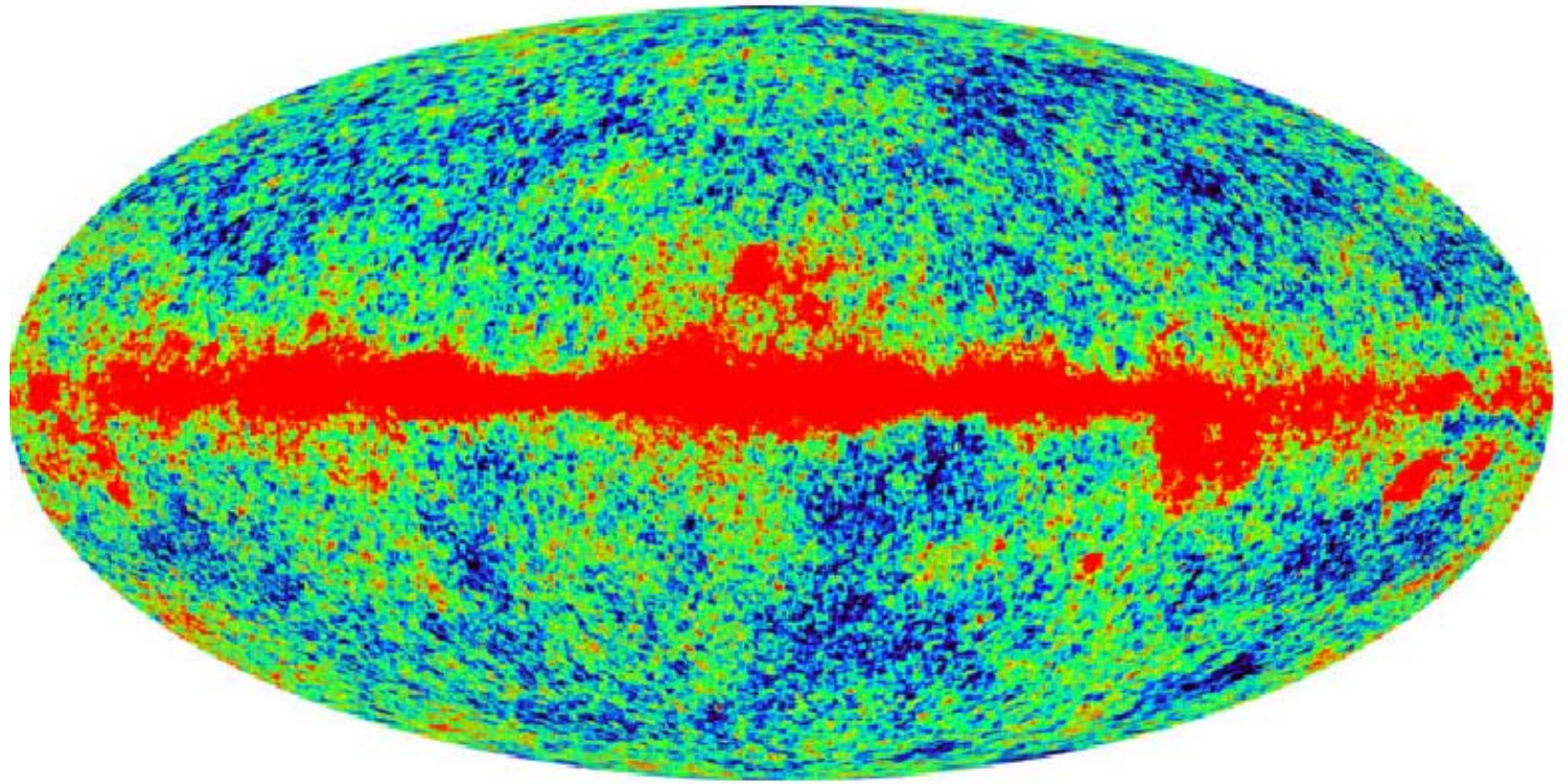






# COSMIC MICROWAVE BACKGROUND SPECTRUM FROM COBE

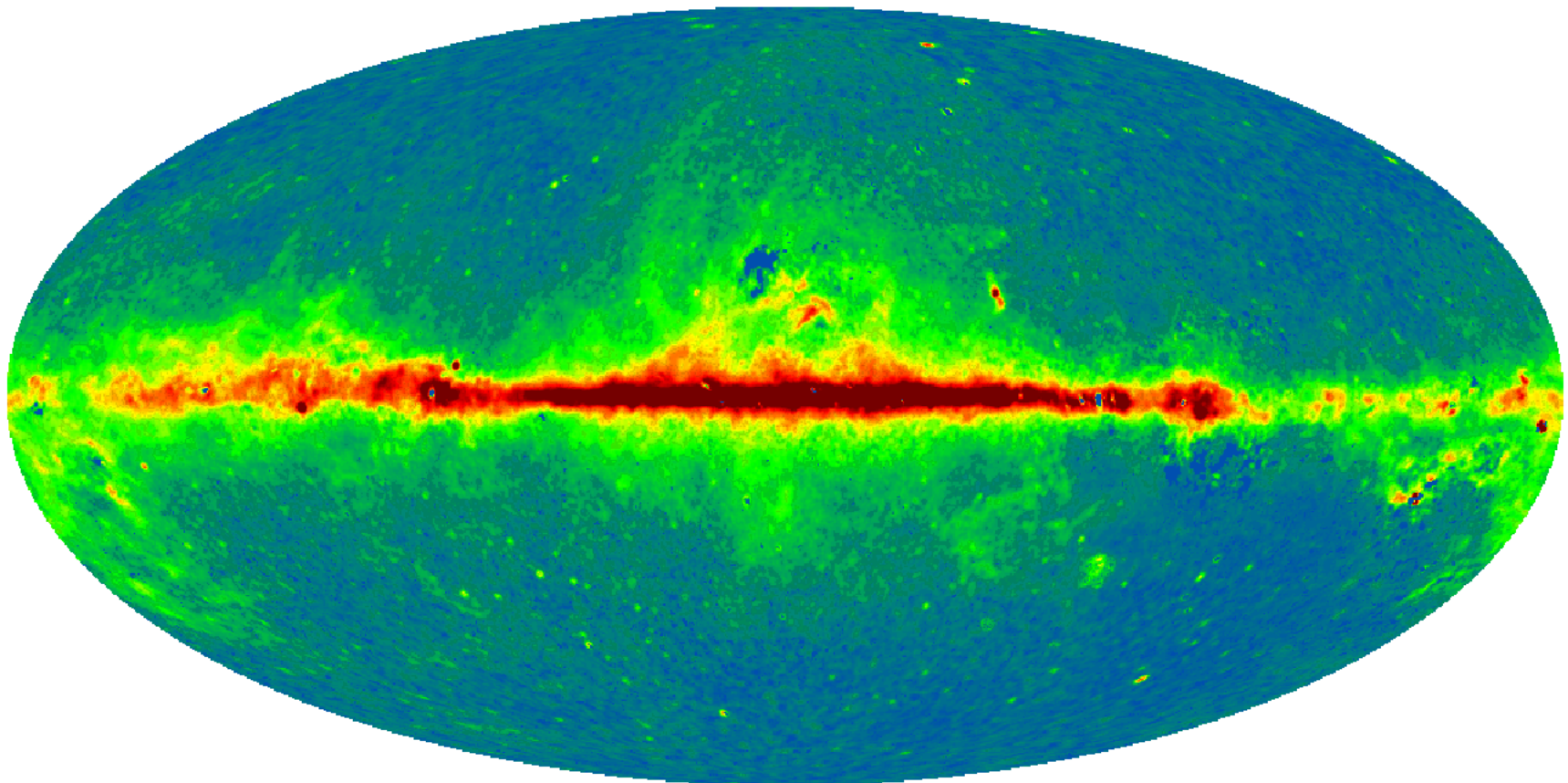




# PLANCK Reflector Programme



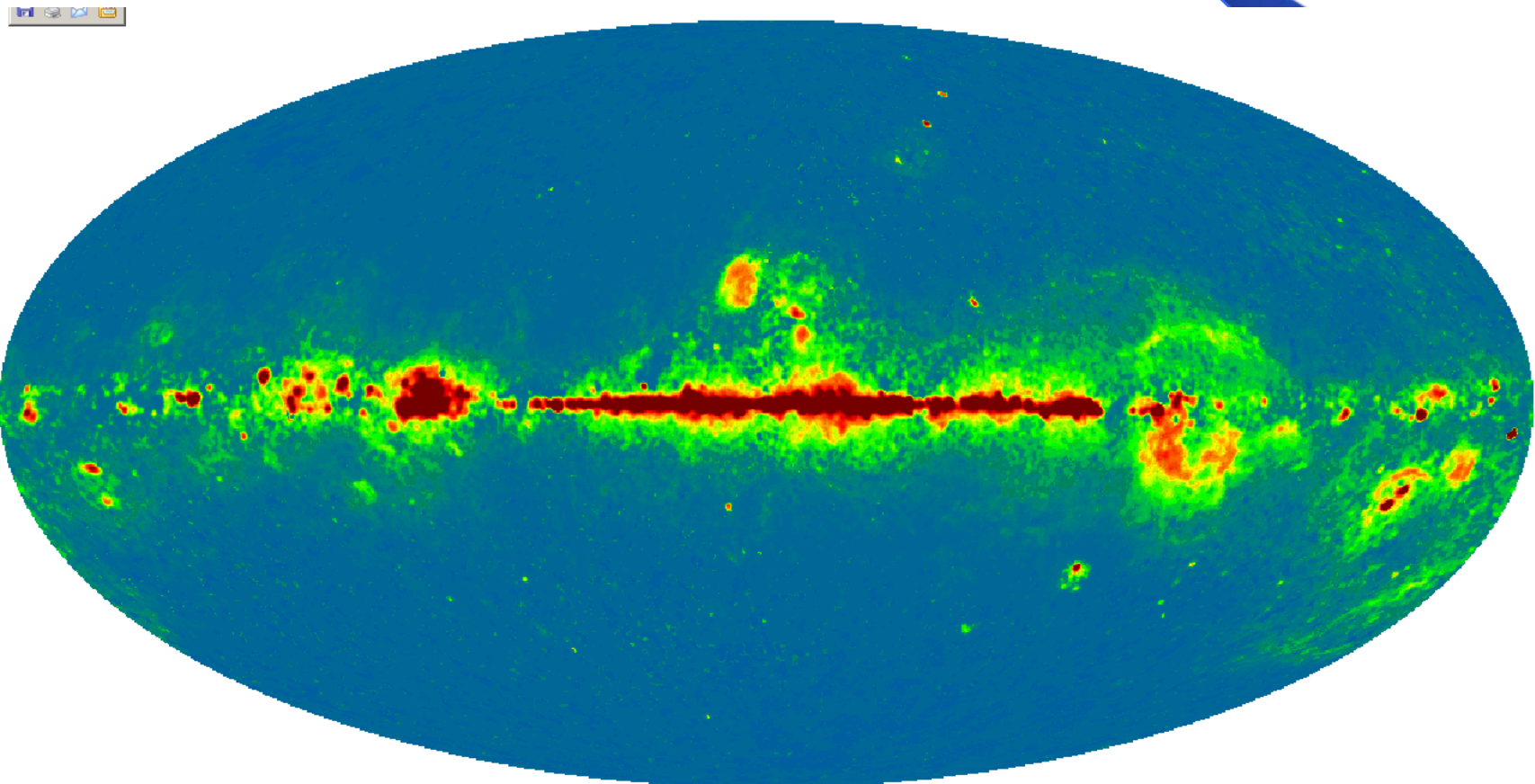
WMAP Synchrotron Map K band (23 GHz)



# PLANCK Reflector Programme



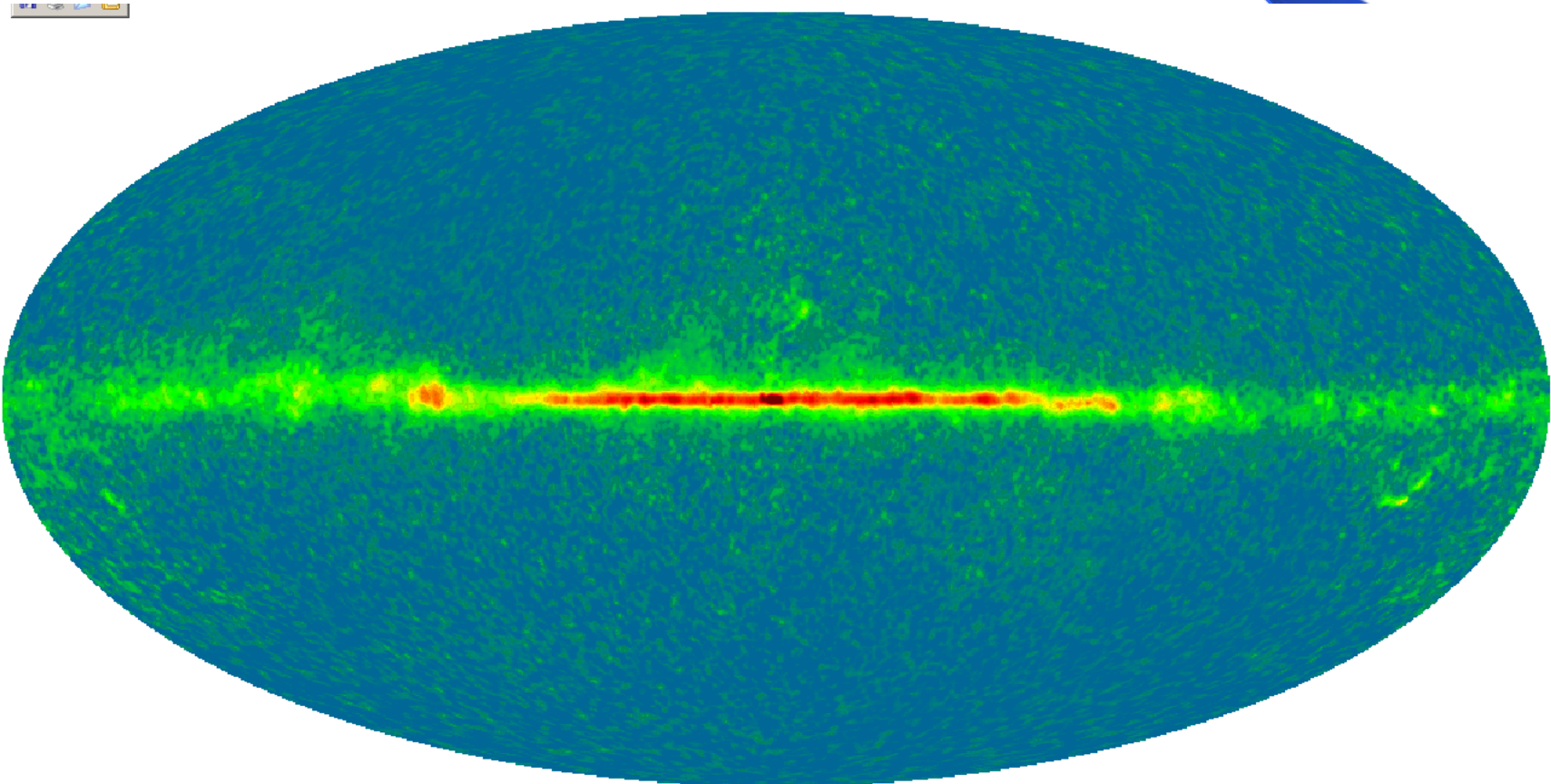
WMAP Free – Free Map K band (23 GHz)



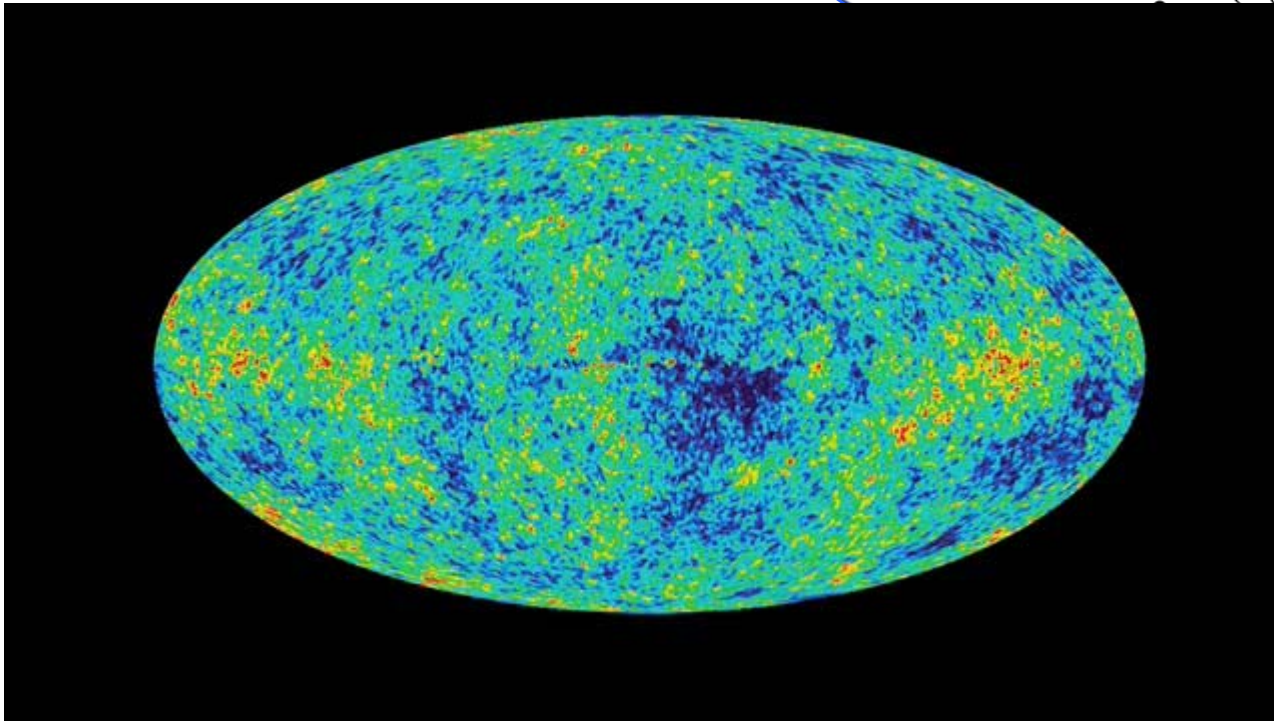
# PLANCK Reflector Programme



**WMAP Dust Map W band (94 GHz)**



# PLANCK Reflector Programme



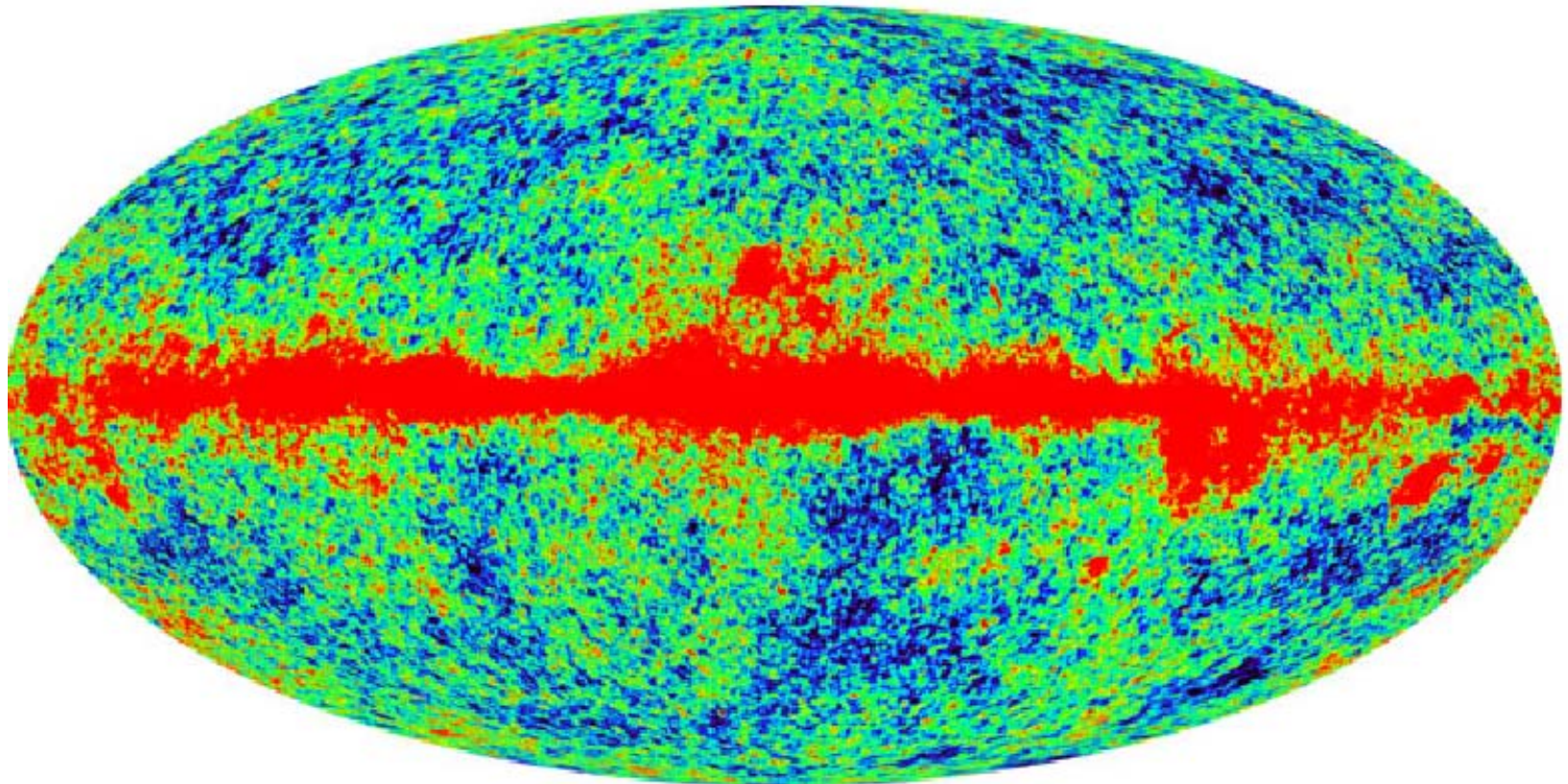
**A trip from Big Bang to present day Universe**



# PLANCK Reflector Programme



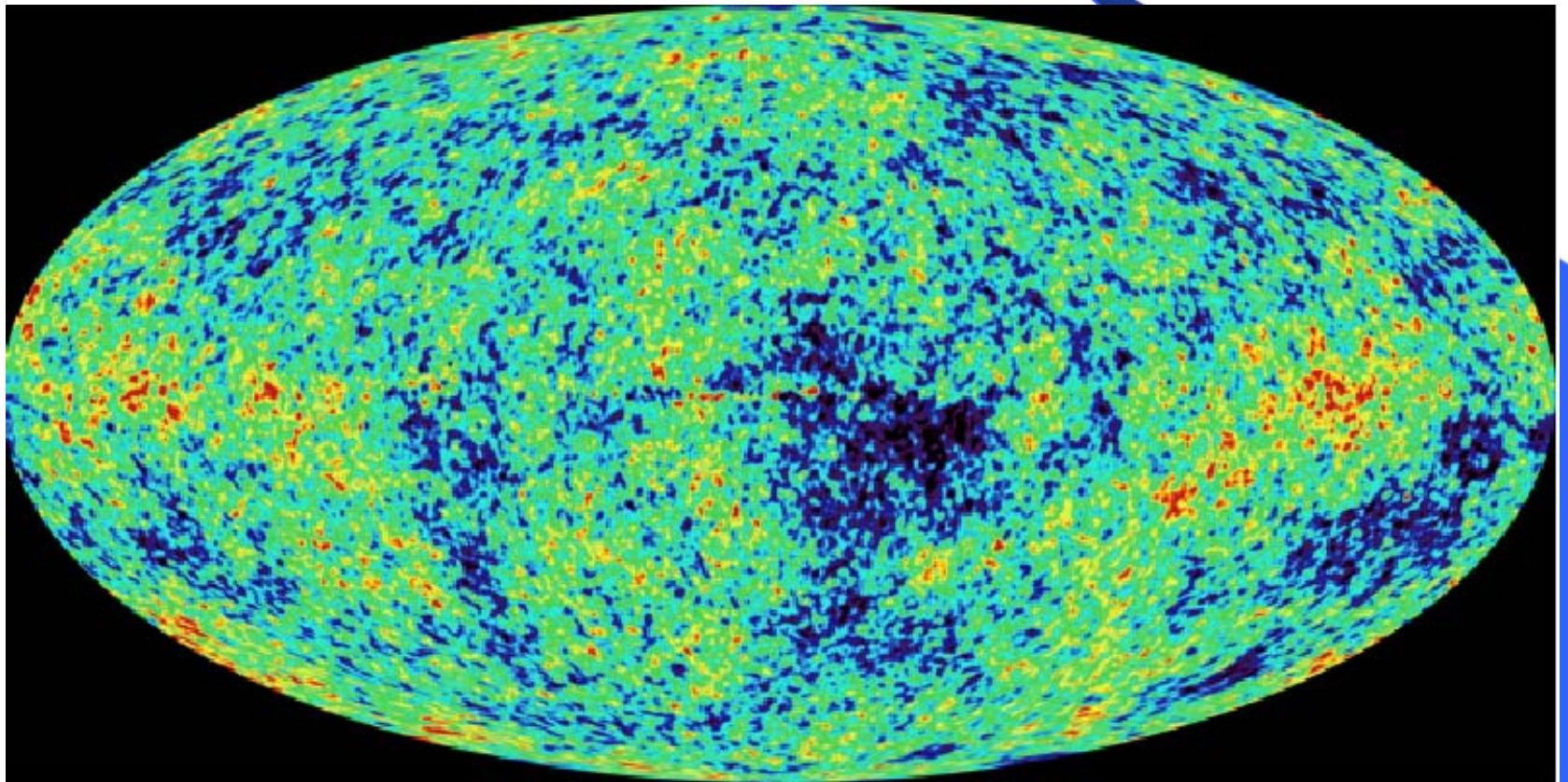
WMAP Q band (41 GHz)



# PLANCK Reflector Programme



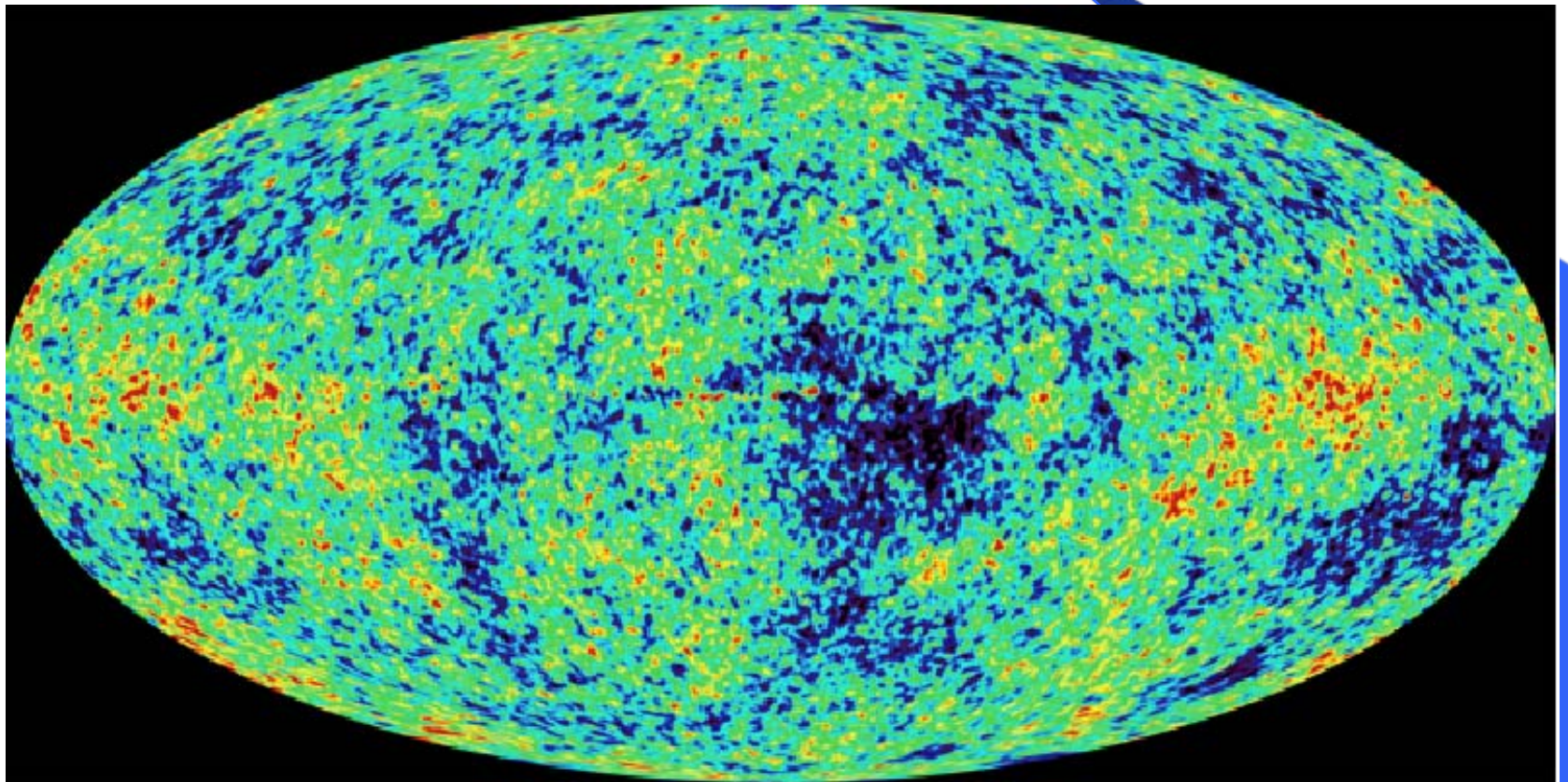
WMAP Internal Linear Combination Map ( $\pm 200 \mu\text{K}$ )



# PLANCK Reflector Programme



WMAP Internal Linear Combination Map ( $\pm 200 \mu\text{K}$ )



# PLANCK Reflector Programme



# PLANCK Reflector Programme



## The Launch of Herschel/Planck

# PLANCK Reflector Programme

