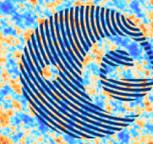
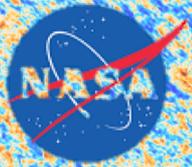




planck



esa



# Introduction to CMB sessions at COSPAR

**Graça Rocha**

**Jet Propulsion Laboratory/California  
Institute of technology**

***on behalf of the Planck Collaboration***

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Government sponsorship acknowledged.

Graça Rocha, COSPAR 2018, July 2018



# WELCOME!

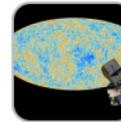


COSMOLOGY

## 2018 Gruber Cosmology Prize

Detailed information on the 2018 Gruber Cosmology Prize is forthcoming

"The Planck project has made definitive measurements of the properties of our expanding universe. This stunning achievement was the result of a large group effort, and we are pleased to recognize both the Planck team as a whole and its principal science team leaders." Says Robert Kennicutt, University of Arizona, Chair of the Selection Advisory Board to the Prize



Planck Team



Nazzareno Mandolesi



Jean-Loup Puget

Planck team receives Gruber Cosmology prize for Precise Measure of the Universe's Contents and Contours.

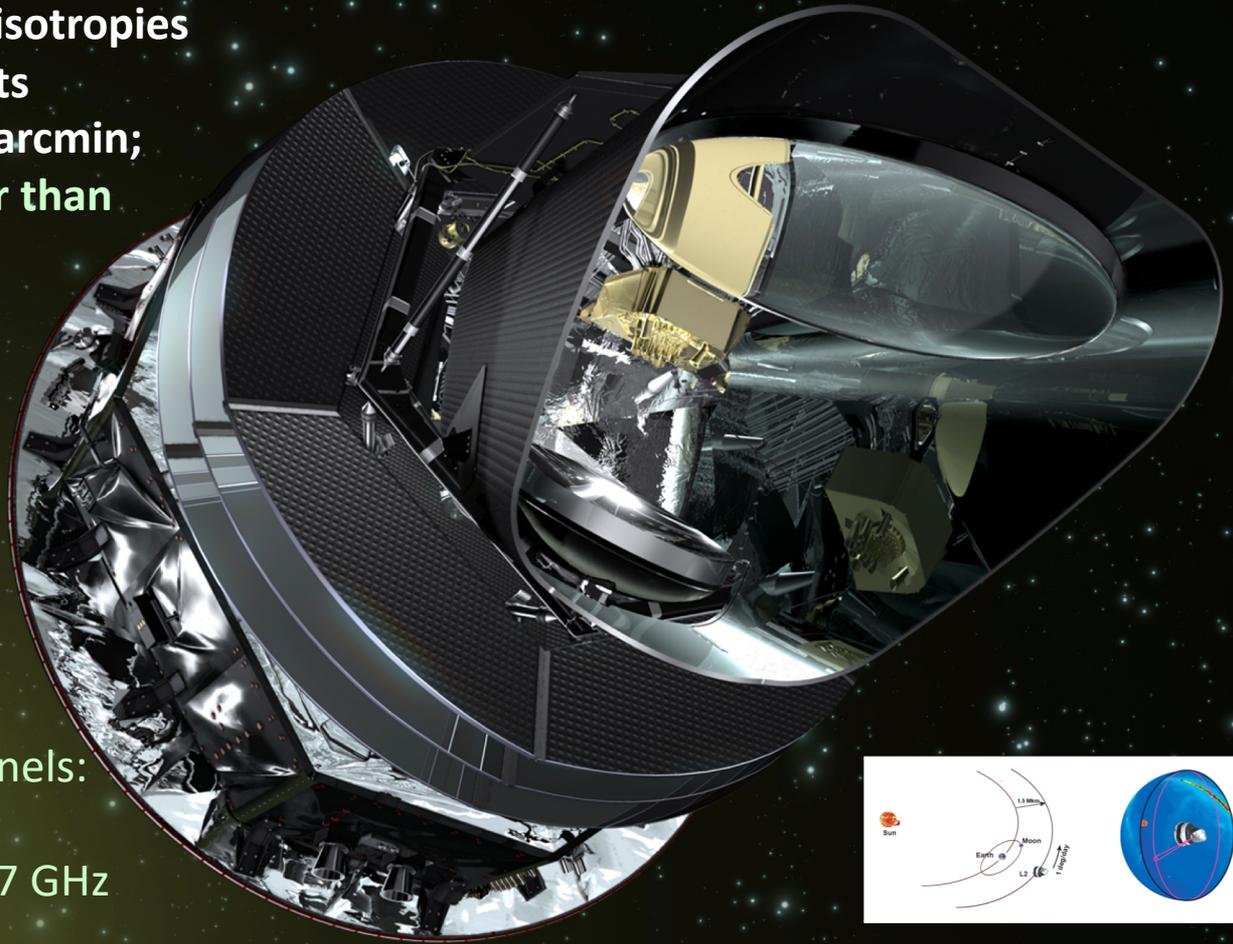


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✧ **Primary scientific goal:**  
To measure the temperature anisotropies of the CMB to fundamental limits down to angular resolution of 5arcmin; also measure polarization better than ever before

- ✧ Fly at Sun-Earth L2 point
- ✧ Use 4-stage cooling system
- ✧ Carry two instruments:
  - Low Frequency Instrument (LFI), 20-K cryogenic amplifiers
  - High Frequency Instrument (HFI), 0.1-K bolometers
- ✧ Observe at 9 frequency channels:
  - LFI - 30, 44, 70 GHz, and
  - HFI - 100, 143, 217, 353, 545, 857 GHzto deal with foregrounds



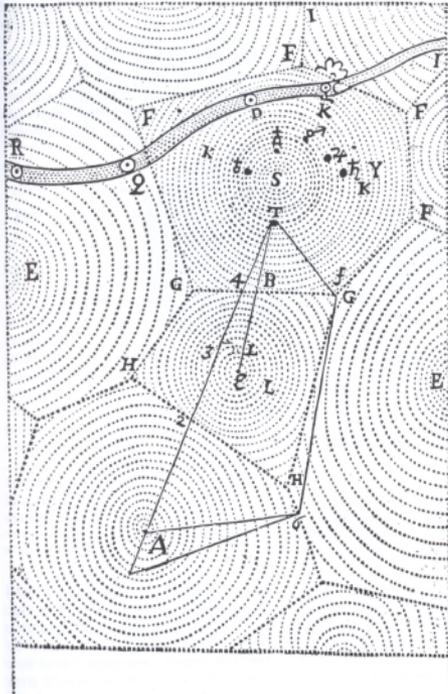
## Planck is the 3rd Generation Space CMB Mission

- Formally: “ESA mission with significant participation of NASA”
- Translation: thermal design, sorption coolers, all bolometers, delivery of ERCSC, supercomputing support, expertise and participation in data analysis, and science

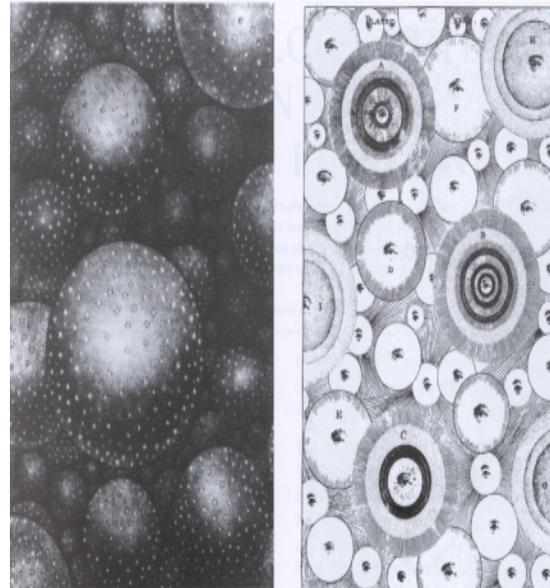
# Cosmology: the Journey



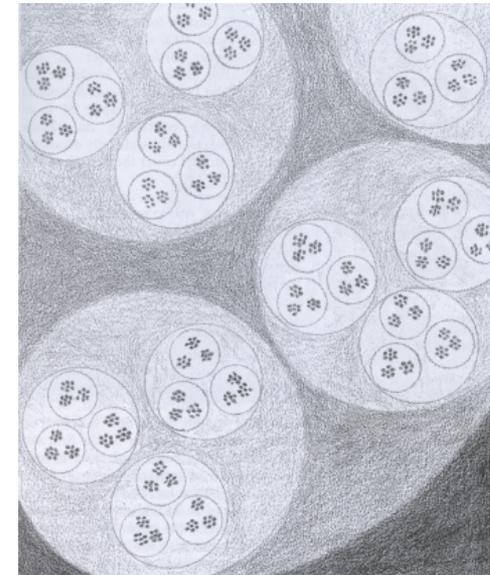
From early speculations without quantitative observational support



Descartes *The World*  
1636



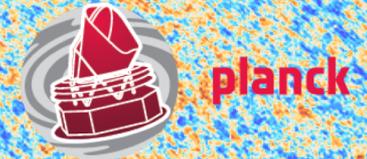
Wright *An Original  
Theory of the  
Universe*  
1750



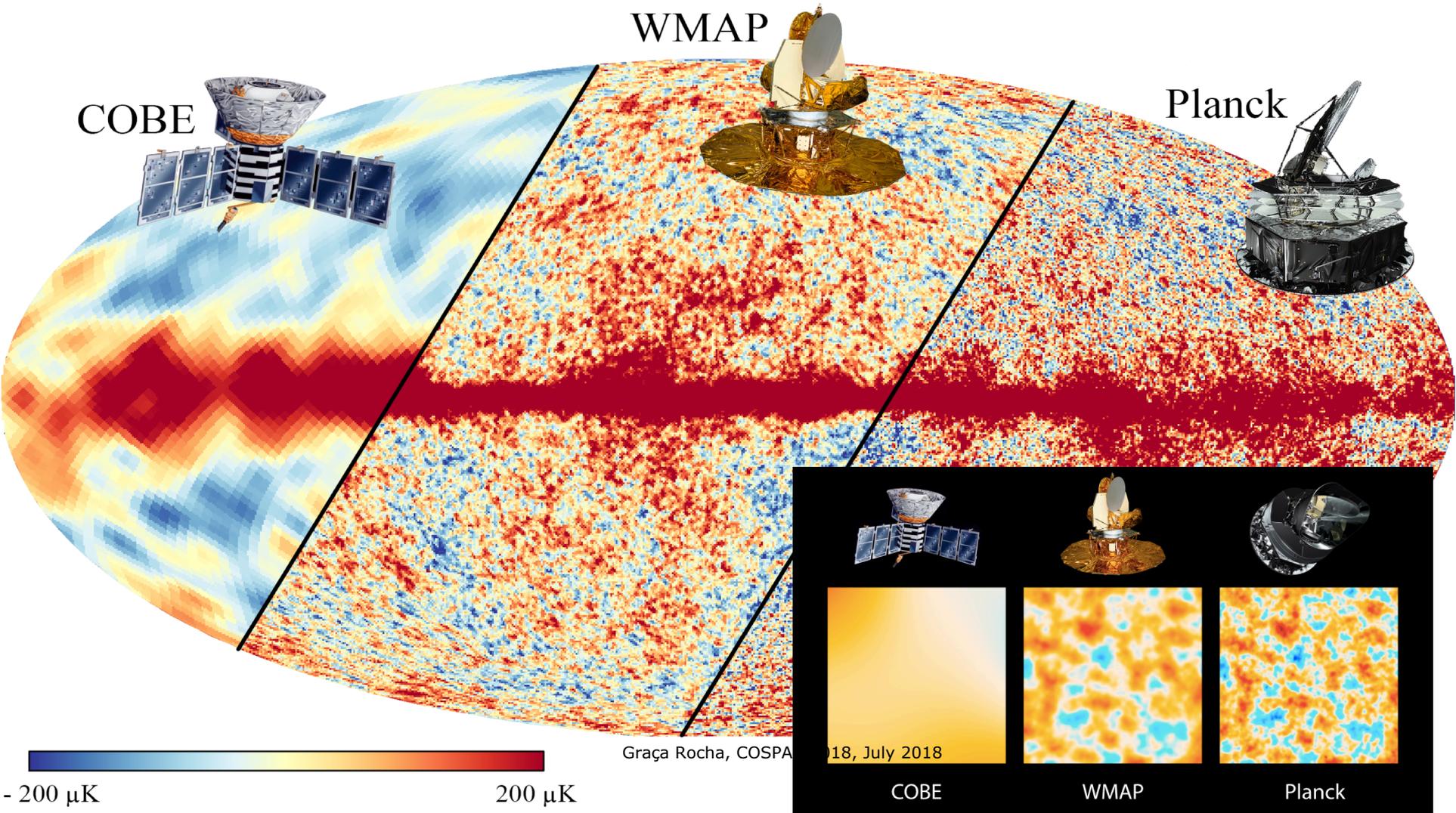
The hierarchical (fractal)  
Universe of Kant (1755) and  
Lambert  
1761



# Cosmology: the Journey

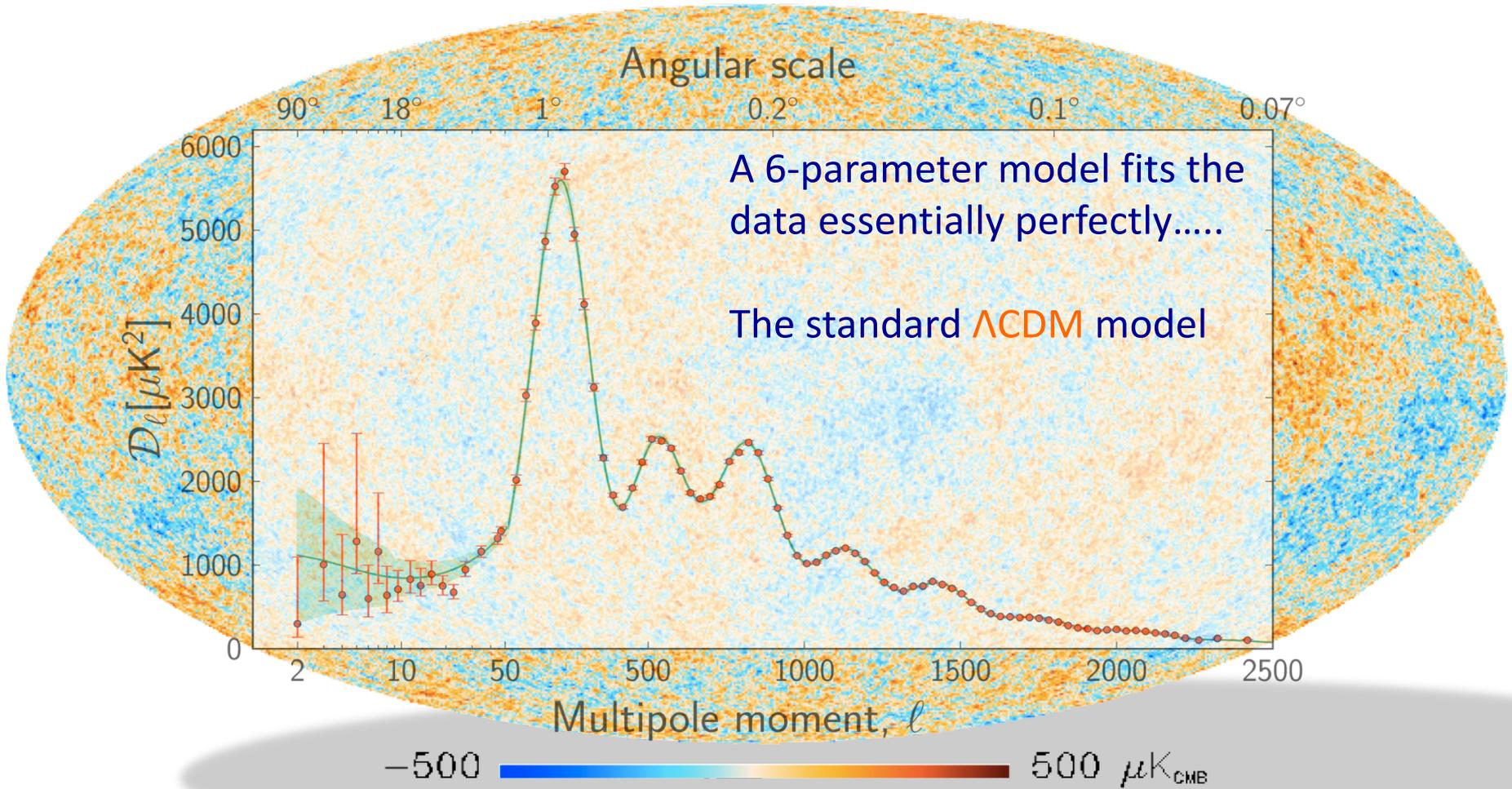
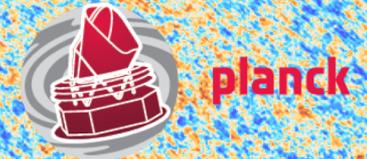


To the era of **Precision Cosmology** with observations of the **CMB**



# Planck initial scientific results

## March 2013

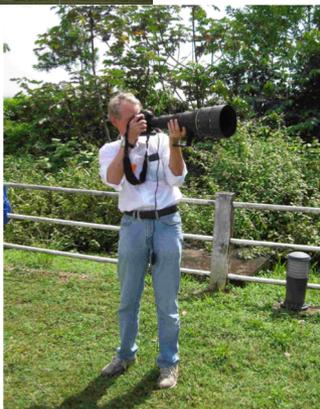
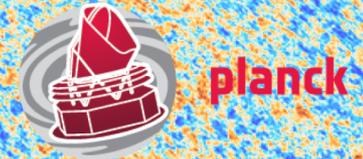


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# The launch 14<sup>th</sup> May 2009, 13:12:02 UT



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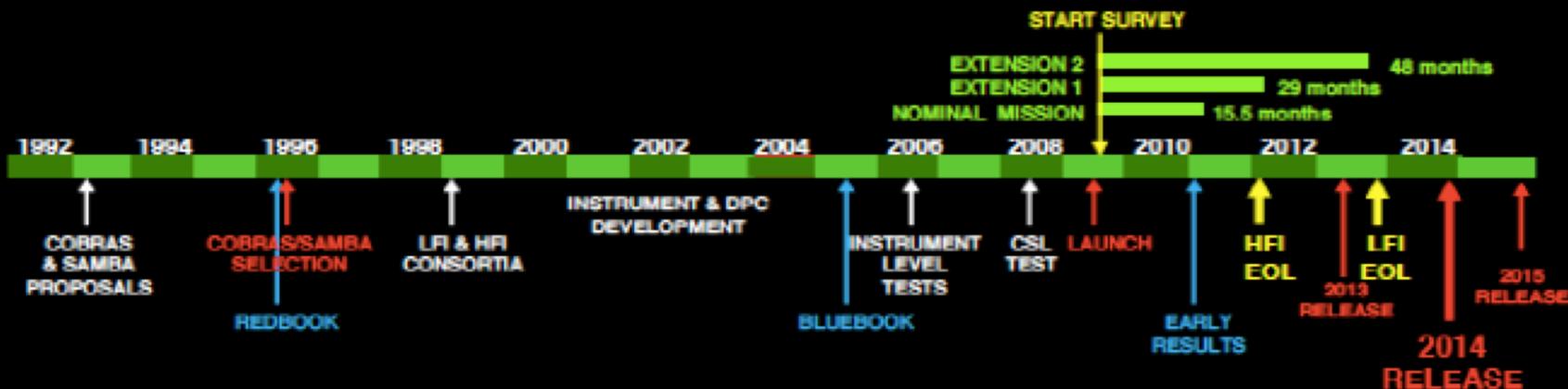
# Kourou, French Guyana, May 14, 09, 10.12am LAUNCH!



# Next: the hard work of data analysis... Core team meetings



## The Planck Collaboration



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# 47<sup>th</sup> ESLAB SYMPOSIUM

## The Universe as seen by Planck

2-5 April 2013



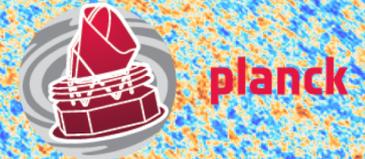
*The initial scientific results from the Planck mission*



Graça Rocha, COSPAR 2018, July 2018



**Today**



A new and improved version of the Planck data has been released  
on July 17, 2018

**The final official release from Planck**

New scientific results based on this data are described in a set of  
papers that will be presented here in the session:

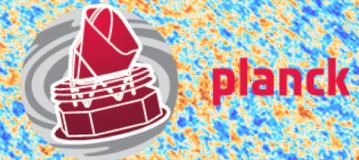
**The Legacy of Planck mission**



Graça Rocha, COSPAR 2018, July 2018



# CMB – what's next?



Our picture of the Cosmos is not complete yet.....

There are still puzzles to solve: anomalies at large angular scales, tensions on cosmological parameters, eg.  $H_0$ , .....

Inflation models predict a significant stochastic background of gravitational waves that should have left a faint polarized CMB signal

Currently joint analysis of Planck/BICEP/Keck only places limits on the amplitude of these signals

A detection of this gravity wave so-called B-mode signature would reveal fundamental physics at energy scales inaccessible to any terrestrial laboratory

Efforts are on their way!



Graça Rocha, COSPAR 2018, July 2018



# The future of CMB exploration



Second part of this CMB session will give us an overview of the status  
of

## The future of CMB exploration

Why the quest for B modes?

What are the main stumbling blocks? **Foregrounds, systematics,...**

CMB in the pursuit of the footprint of Inflation:

**LITEBIRD, PICO, PIXIE, BICEP, POLARBEAR, SPT, CMB-S4...**

Foregrounds:

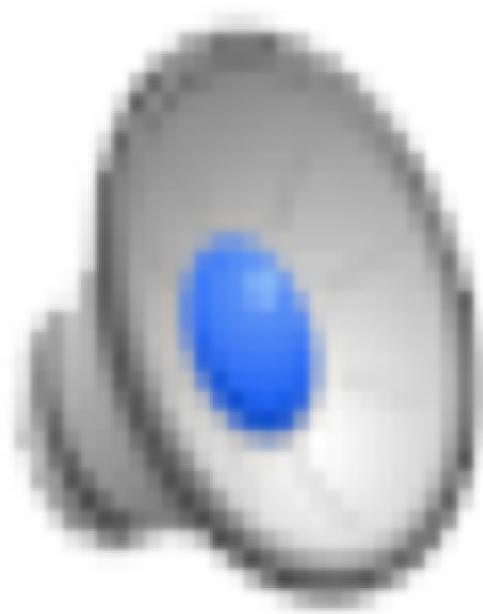
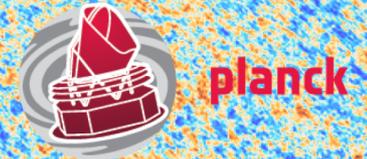
**PILOT, PASIPHAE..**



Graça Rocha, COSPAR 2018, July 2018



# The Legacy of Planck



Graça Rocha, COSPAR 2018, July 2018



HFI PLANCK

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



planck



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.



X, COSPAR 2018, July 2018

