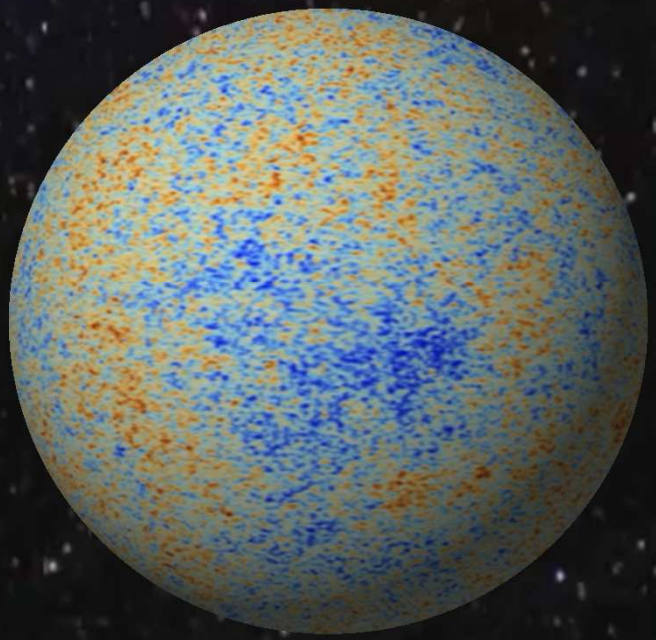
Università di Pavia – 23 Giugno 2016

Missione Planck

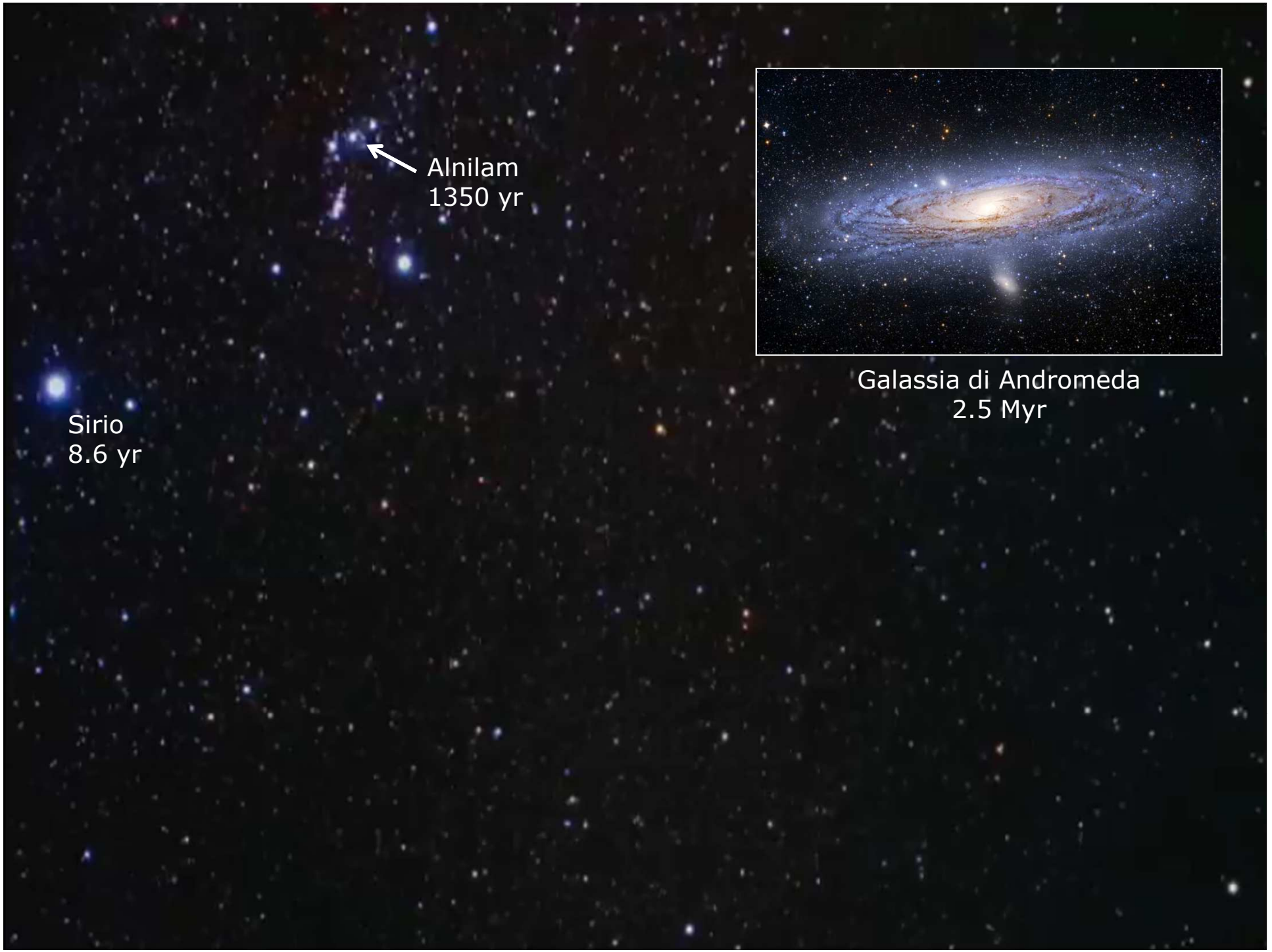
La prima luce dell'universo



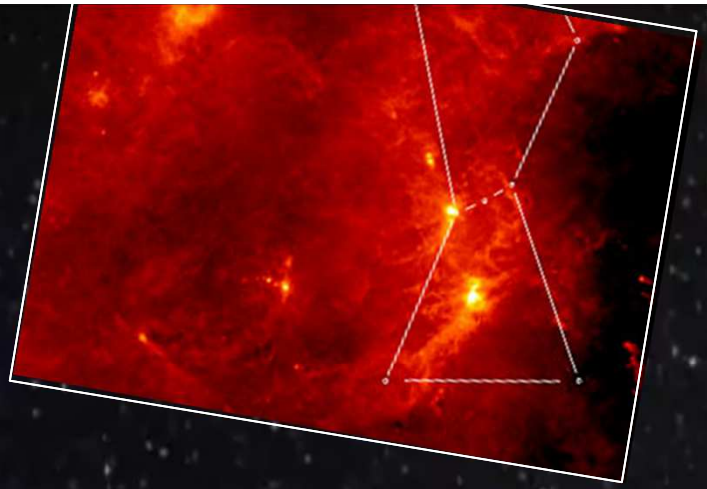
Marco Bersanelli

Università di Milano

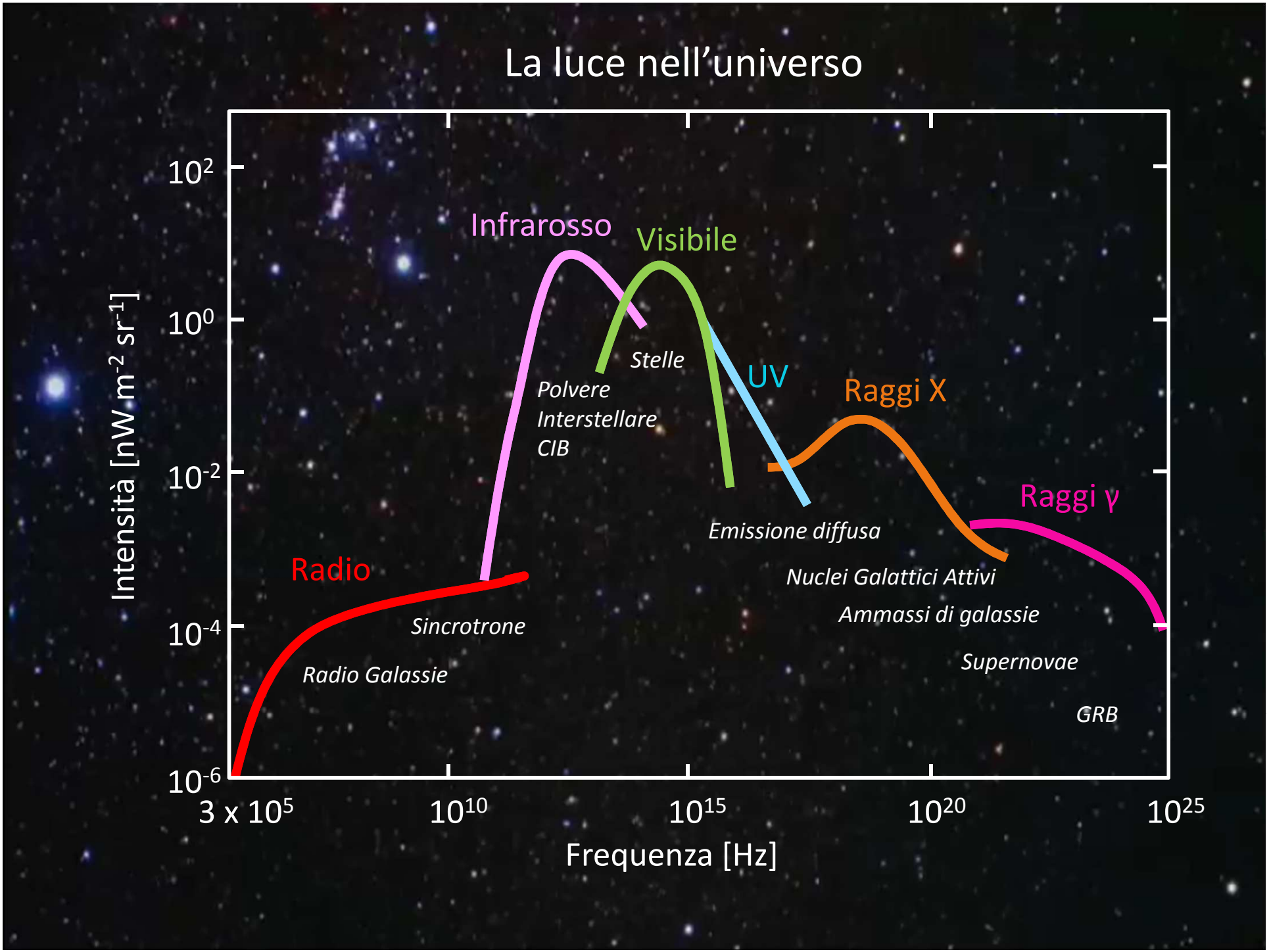
Planck LFI Instrument Scientist & Deputy PI

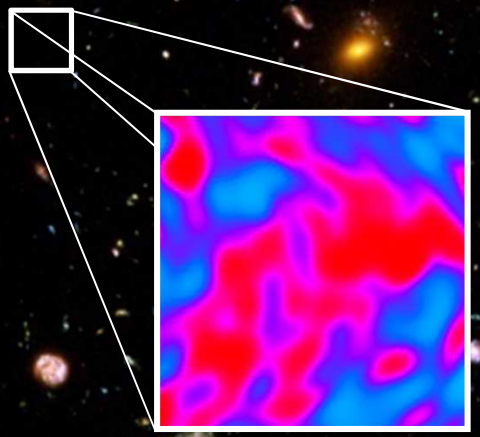

Alnilam
1350 yr
Sirio
8.6 yr
Galassia di Andromeda
2.5 Myr


Visibile

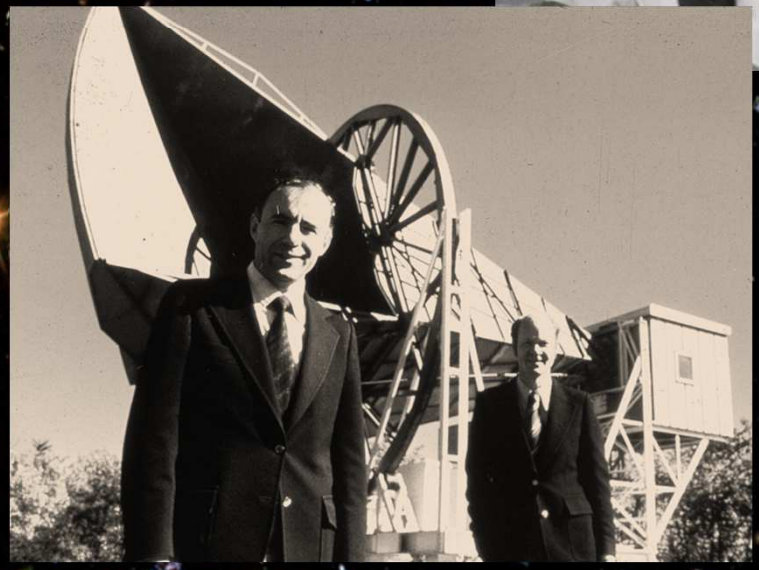


Infrarosso

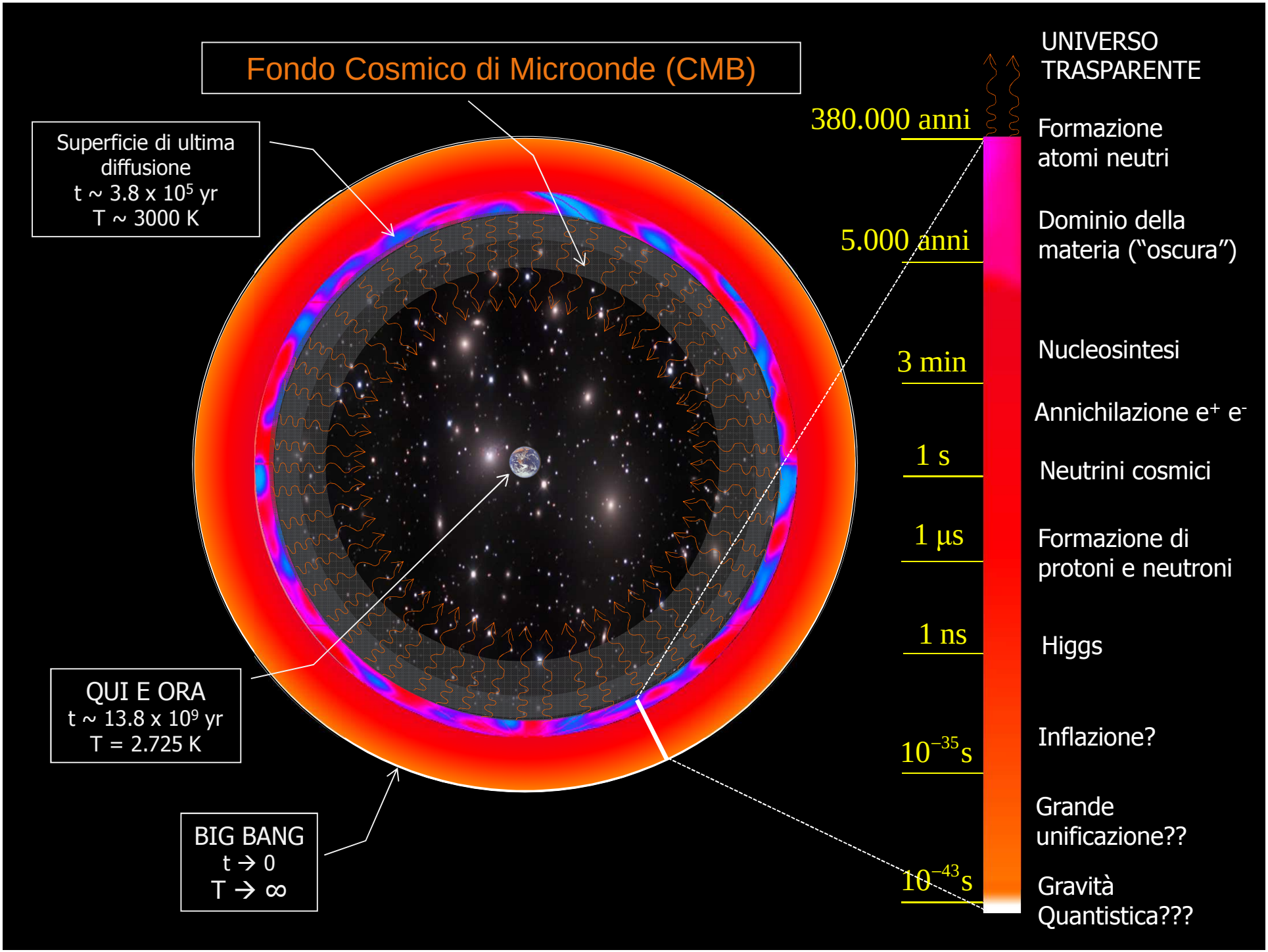

La luce nell'universo
Intensità [nW m-2 sr-1]
10^2
10^0
10^-2
10^-4
10^-6
Infrarosso
Visibile
UV
Raggi X
Raggi γ
Radio
Stelle
Polvere Interstellare CIB
Emissione diffusa
Nuclei Galattici Attivi
Ammassi di galassie
Supernovae
GRB
Sincrotrone
Radio Galassie
3 x 10^5
10^10
10^15
10^20
10^25
Frequenza [Hz]

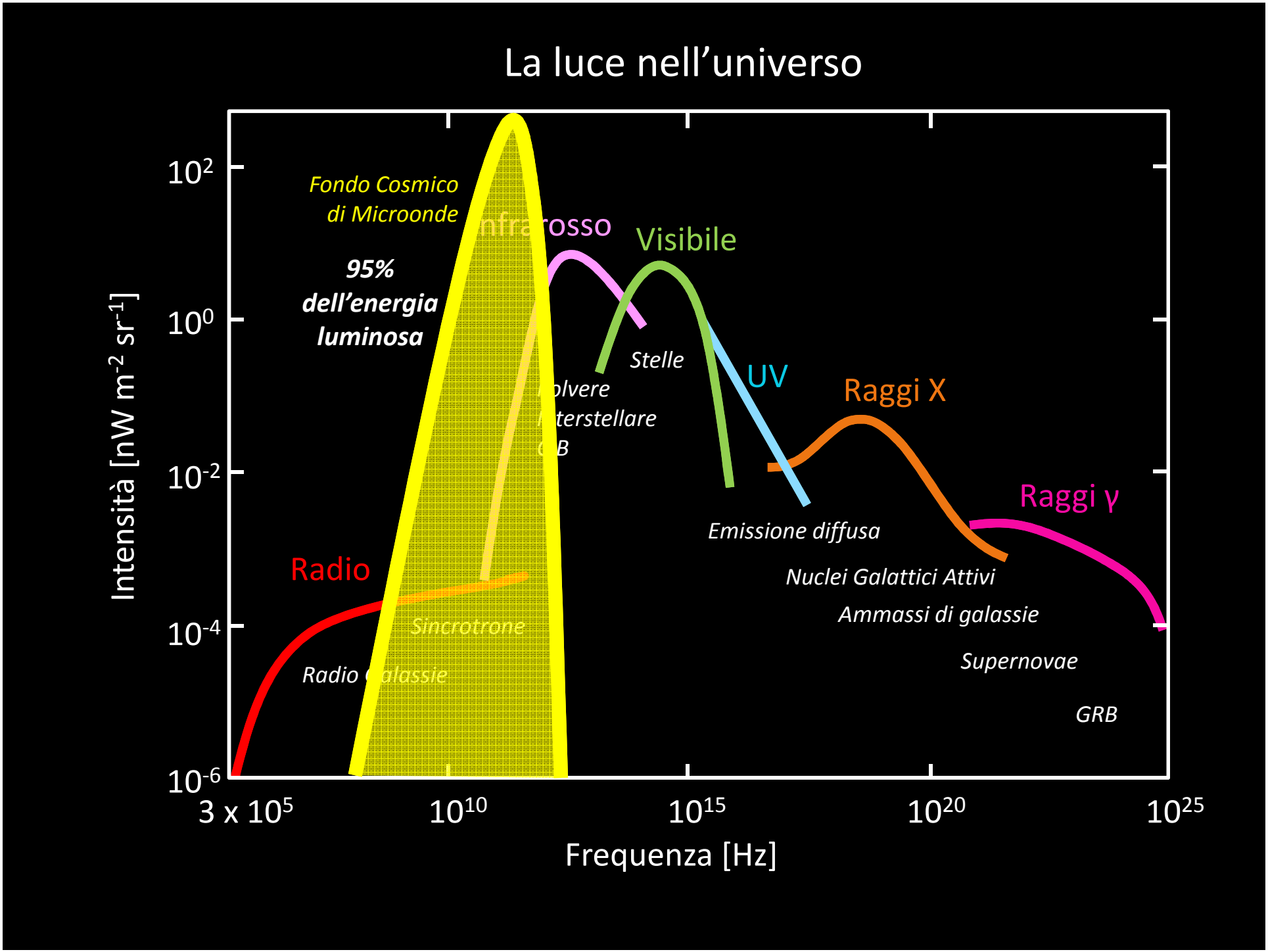


Георгий
Антонович
Гамов
(Predizione: 1948)



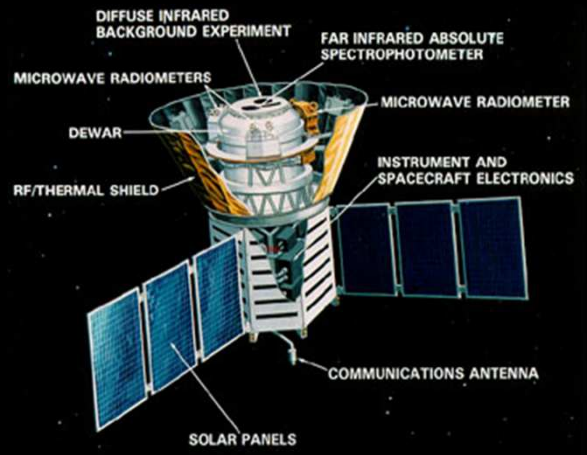
A.Penzias & R.Wilson +
(Scoperta: 1965)

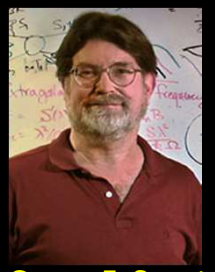

Fondo Cosmico di Microonde (CMB)
Superficie di ultima diffusione
t ~ 3.8 x 10^5 yr
T ~ 3000 K
QUI E ORA
t ~ 13.8 x 10^9 yr
T = 2.725 K
BIG BANG
t → 0
T → ∞
UNIVERSO TRASPARENTE
380.000 anni
Formazione atomi neutri
5.000 anni
Dominio della materia ("oscura")
3 min
Nucleosintesi
Annichilazione e+ e-
1 s
Neutrini cosmici
1 μs
Formazione di protoni e neutroni
1 ns
Higgs
10^-35 s
Inflazione?
Grande unificazione??
10^-43 s
Gravità Quantistica???


La luce nell'universo
Intensità [nW m-2 sr-1]
10^2
10^0
10^-2
10^-4
10^-6
3 x 10^5
10^10
10^15
10^20
10^25
Frequenza [Hz]
Fondo Cosmico di Microonde
95% dell'energia luminosa
Infrarosso
Visibile
UV
Raggi X
Raggi γ
Stelle
Polvere interstellare
CIB
Radio
Sincrotrone
Radio Galassie
Emissione diffusa
Nuclei Galattici Attivi
Ammassi di galassie
Supernovae
GRB

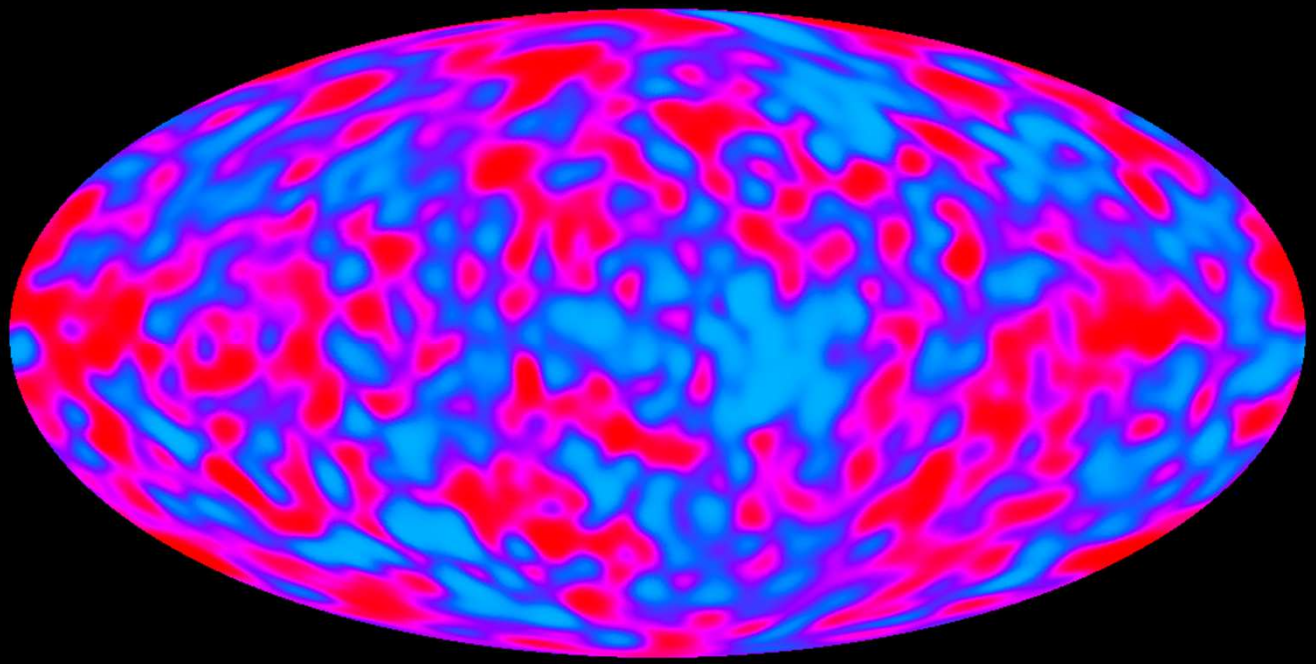
Cosmic Background Explorer, 1992

John C. Mather

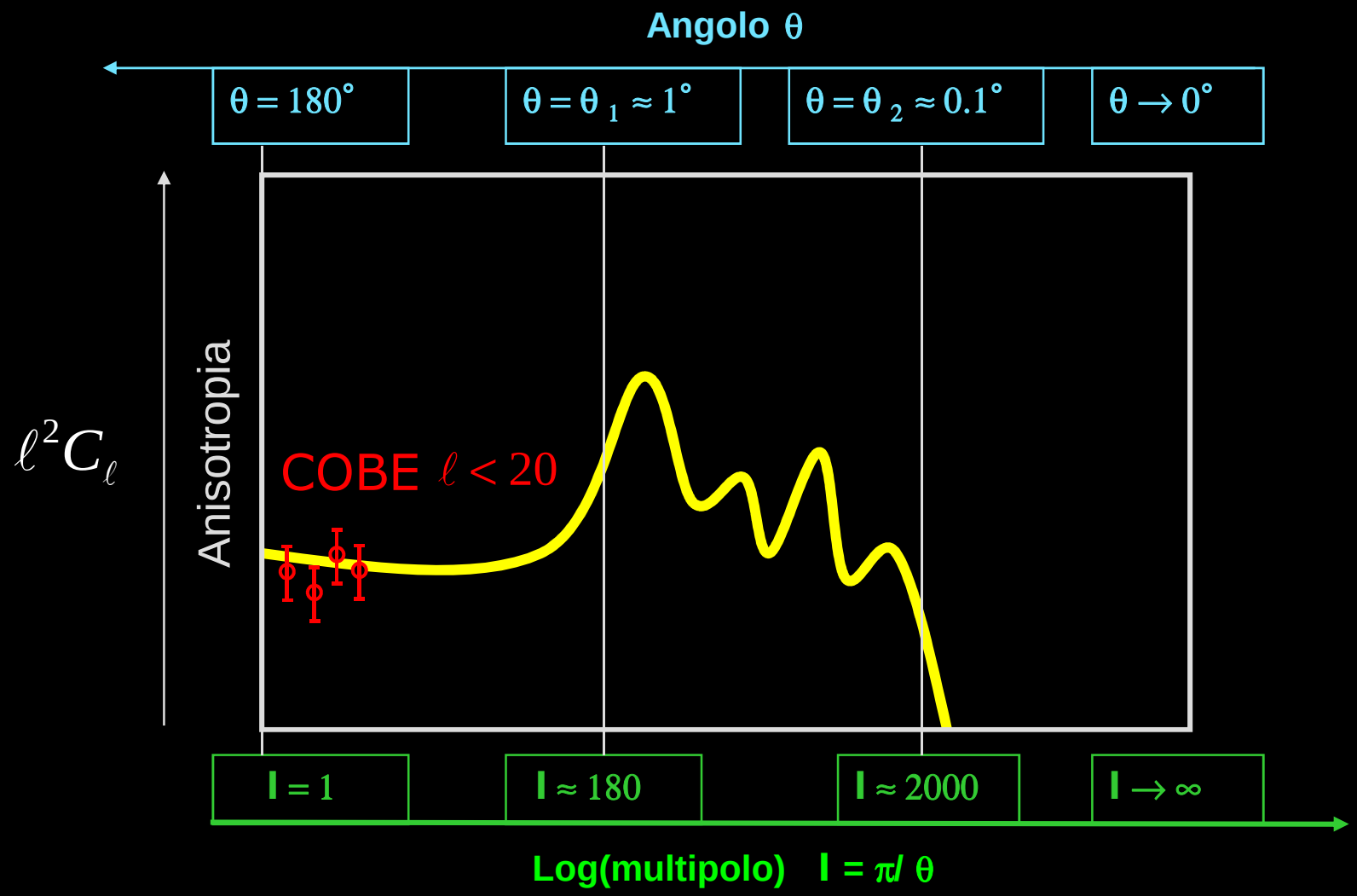




George F. Smoot

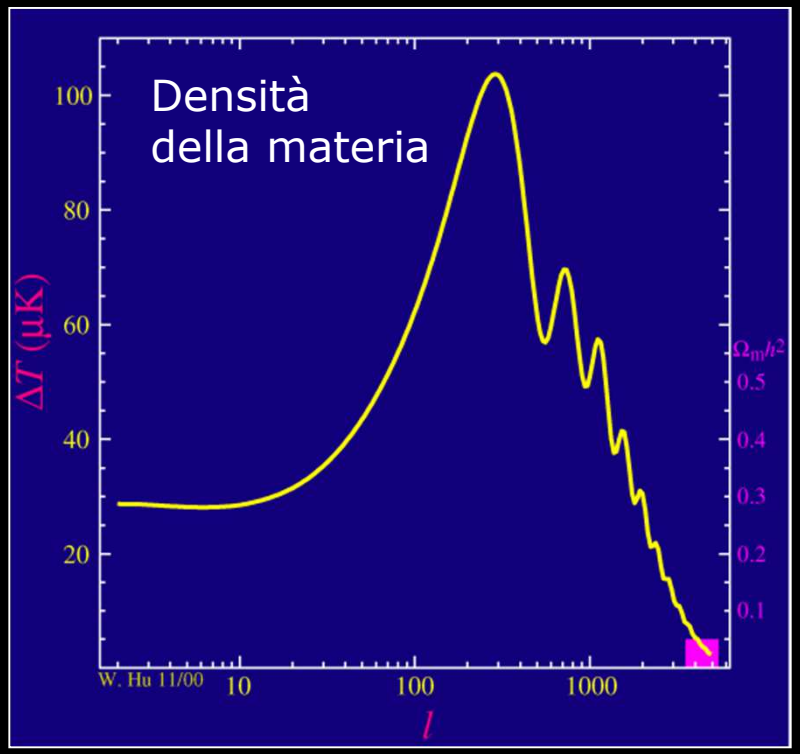


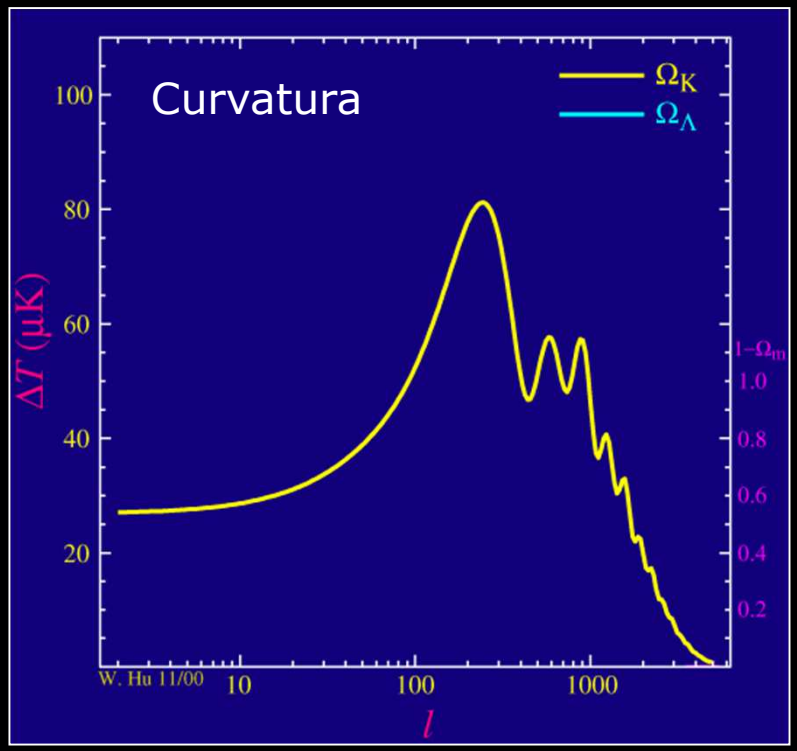
CMB: Spettro di potenza



$\rightarrow A_S,\ n_S,\ \Omega_b h^2,\ \Omega_c h^2,\ \theta_{MC},\ \tau,\ [...]$

I dettagli dello spettro di potenza dipendono dal valore del parametri cosmologici





by Wayne Hu

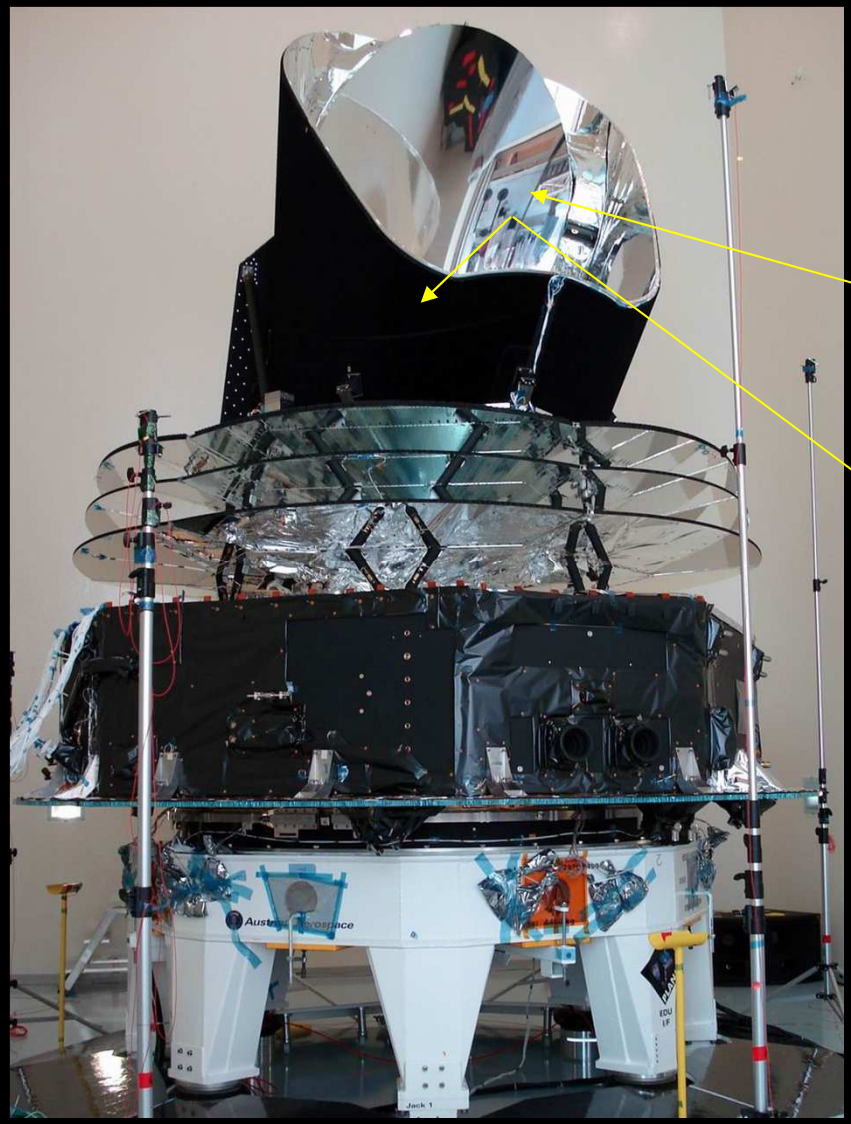
Misure accurate e ad alta risoluzione della CMB

↓

Composizione, dinamica, geometria dell'Universo

PLANCK

Verso l'alba del tempo



Telescopio
1.5x1.9m off-axis
Gregorian
T = 50 K

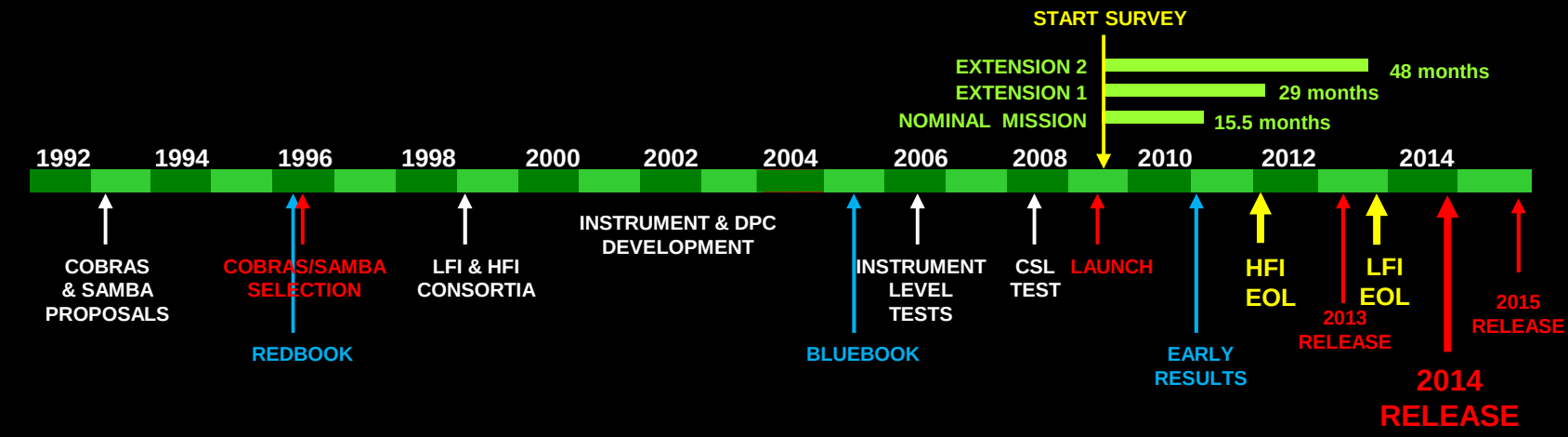
LFI Radiometri
30-70 GHz, T = 20 K

HFI Bolometri
100-857 GHz, T = 0.1 K

agenzia spaziale italiana

CENTRE NATIONAL D'ÉTUDES SPATIALES

La Collaborazione Planck



esa

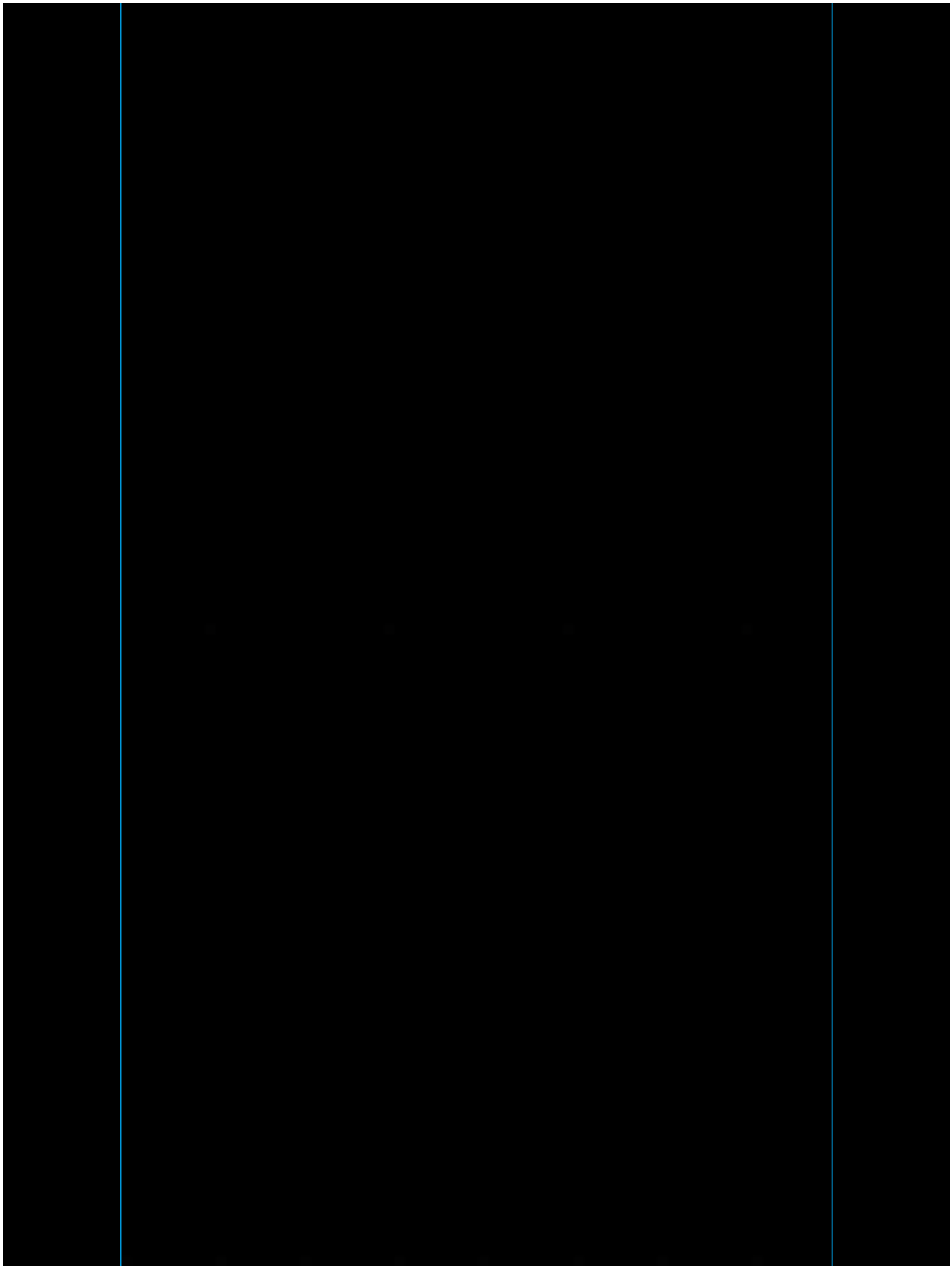
planck

PLANCK LFI

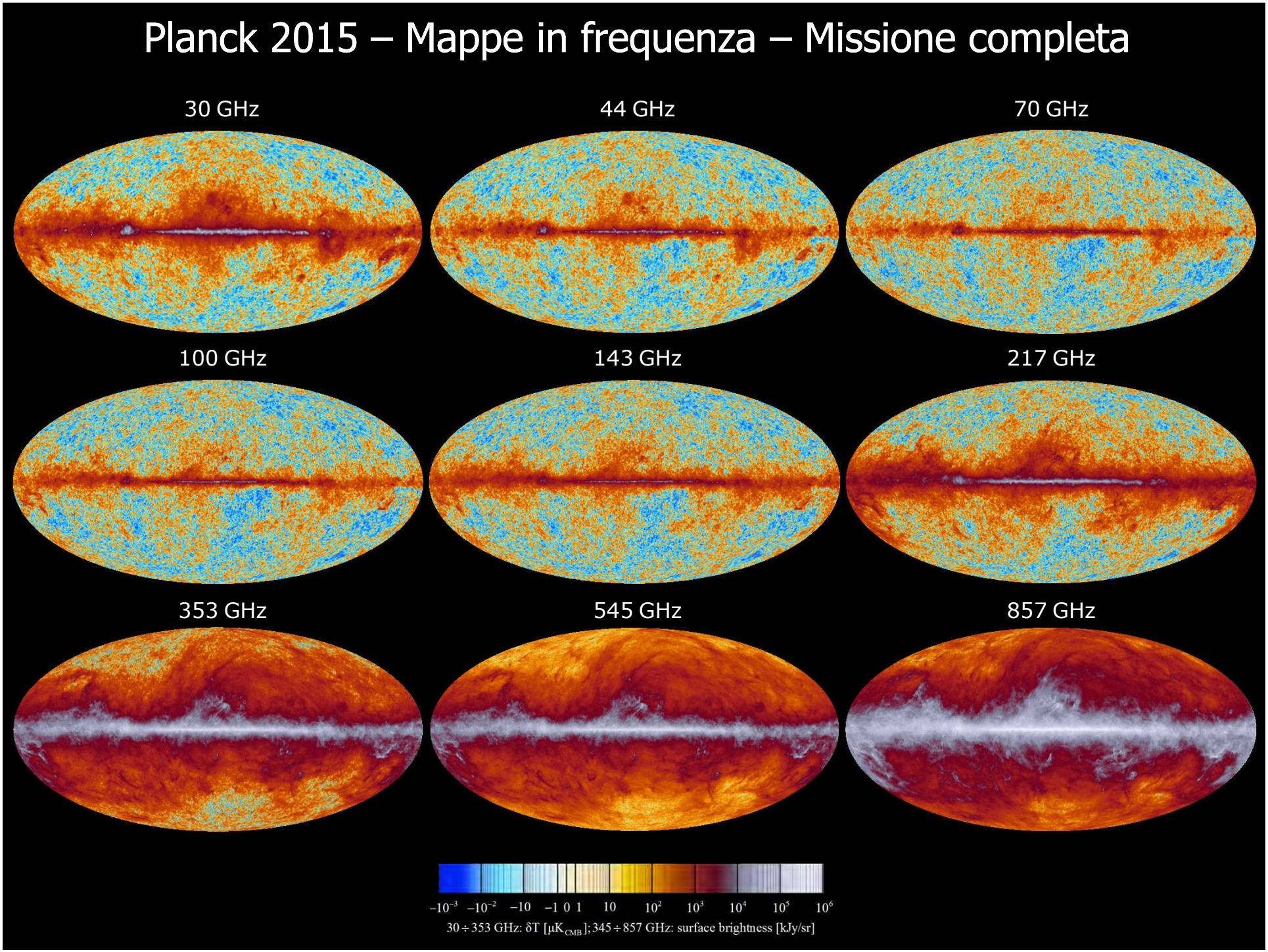
HFI PLANCK
a look back to the birth of Universe

Kourou, French Guyana, 14 May 2009, h 10:12

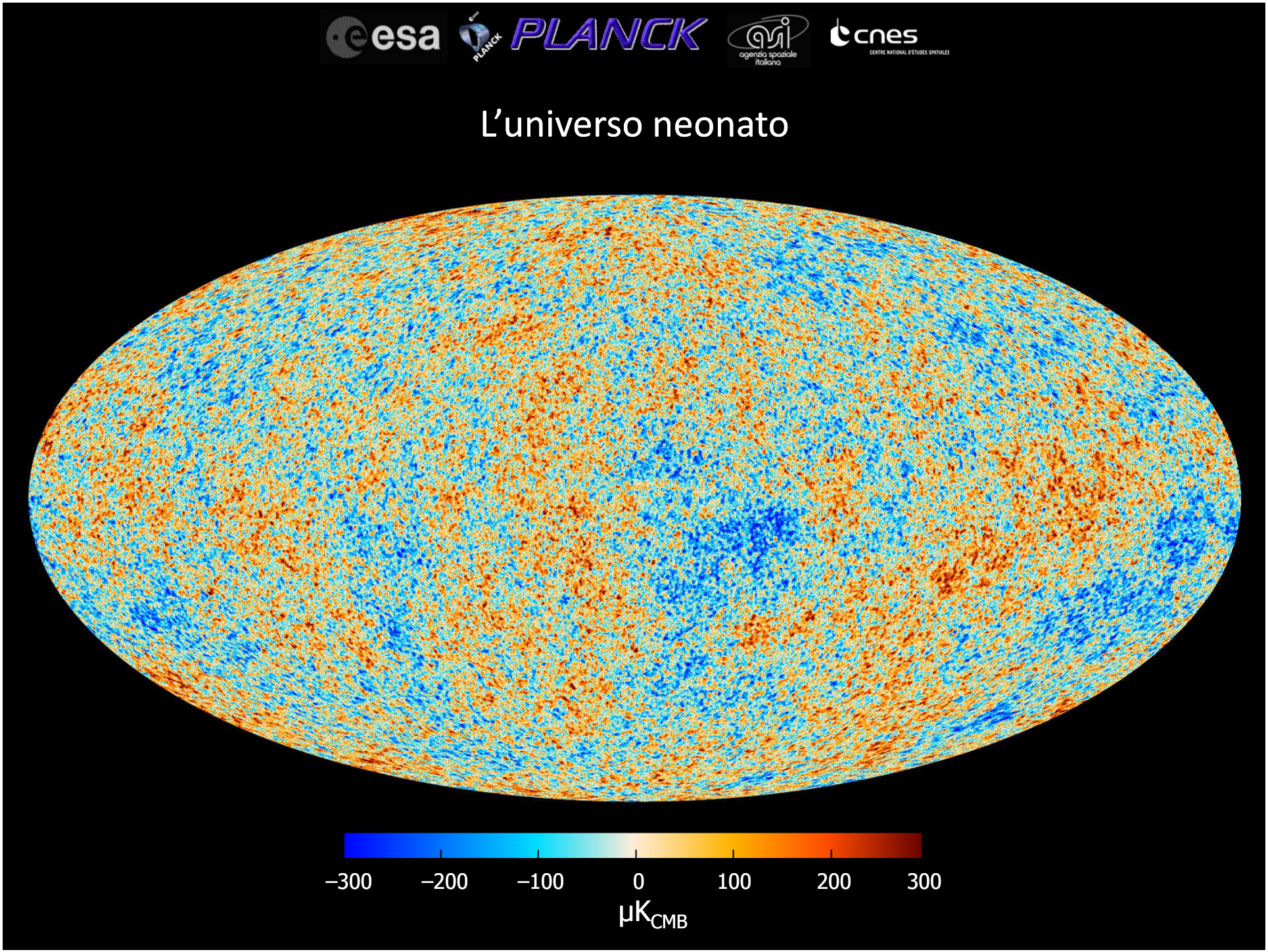

esa



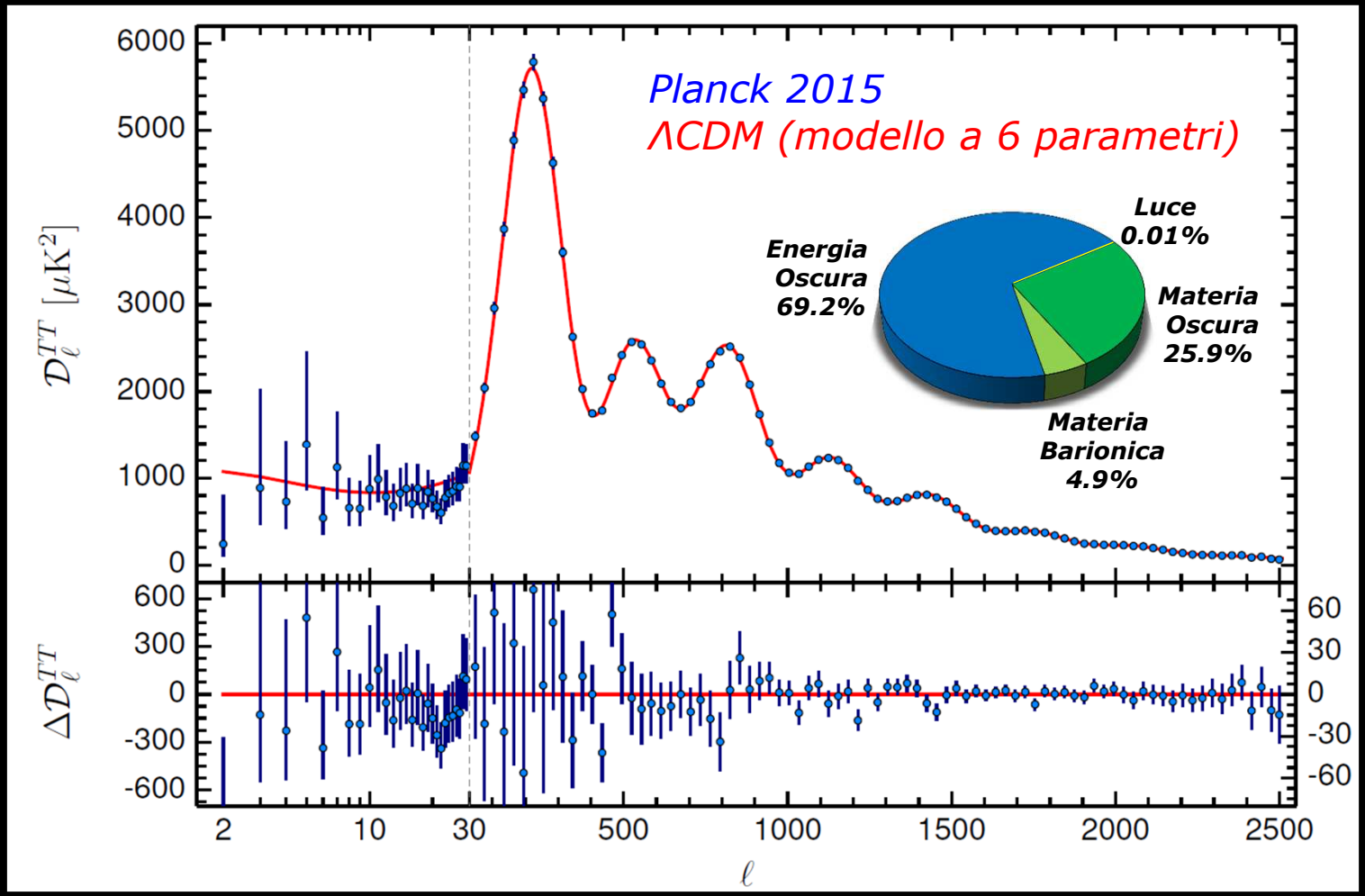
Planck 2015 – Mappe in frequenza – Missione completa



L’universo neonato

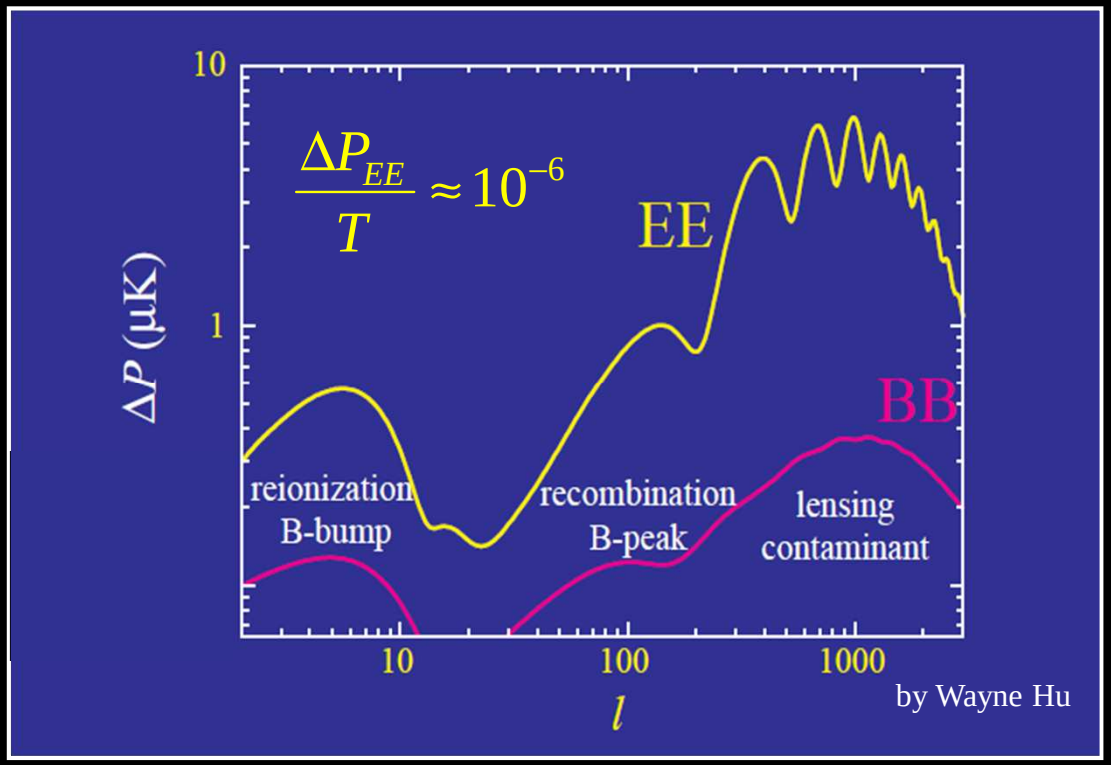


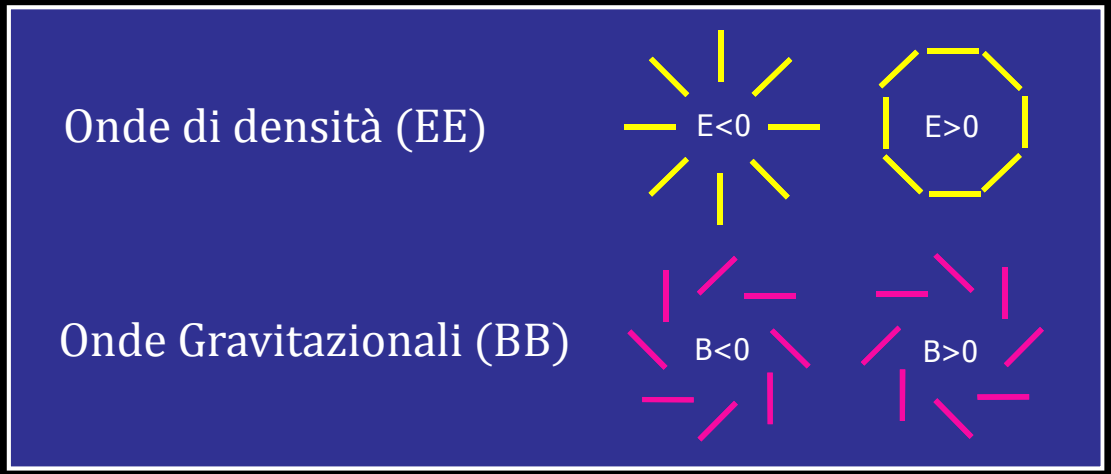
Planck 2015: Spettro di potenza



$\rightarrow A_S,\ n_S,\ \Omega_b h^2,\ \Omega_c h^2,\ \theta_{MC},\ \tau,$ [...]

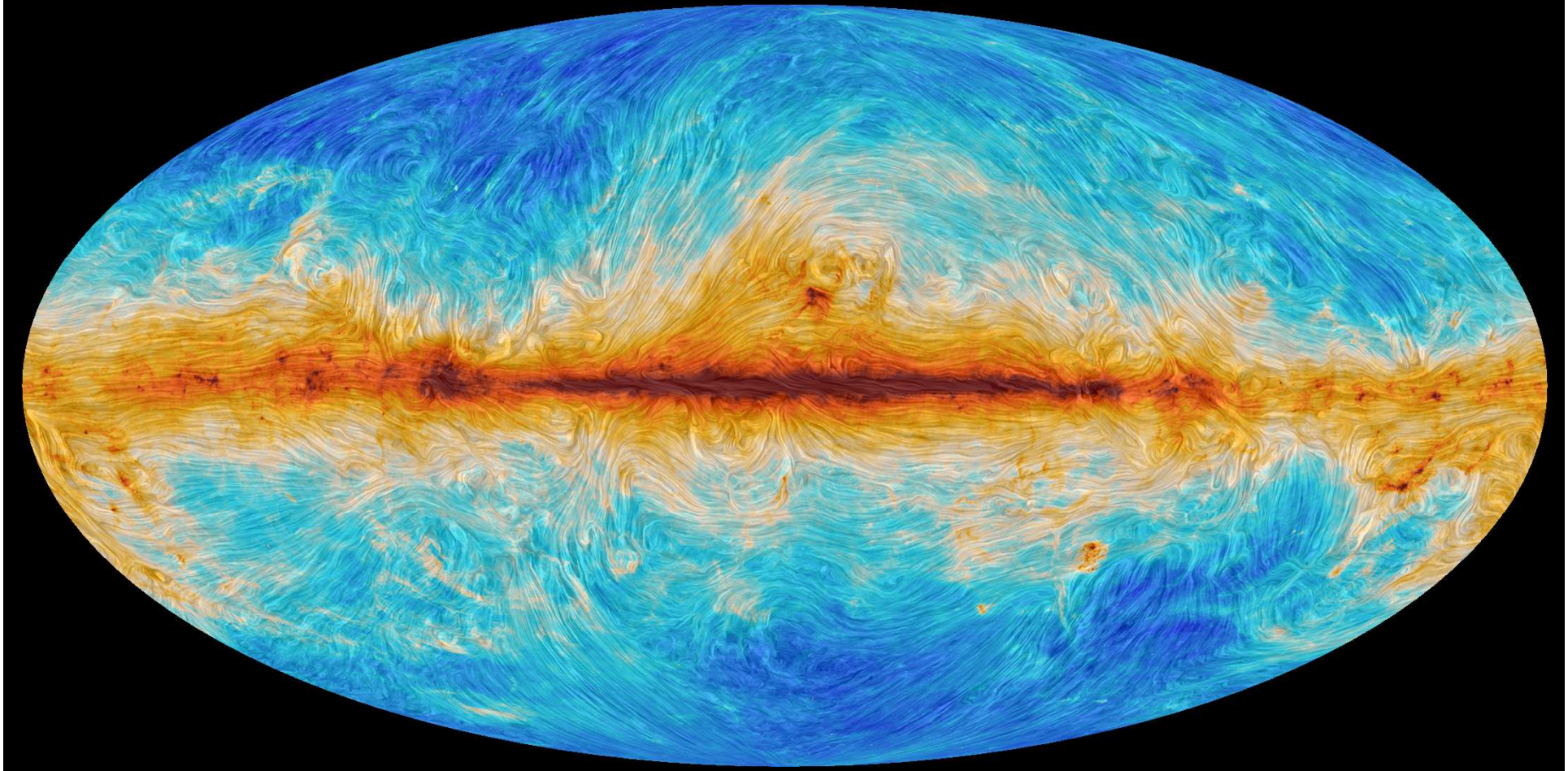
CMB: Spettro di potenza in polarizzazione





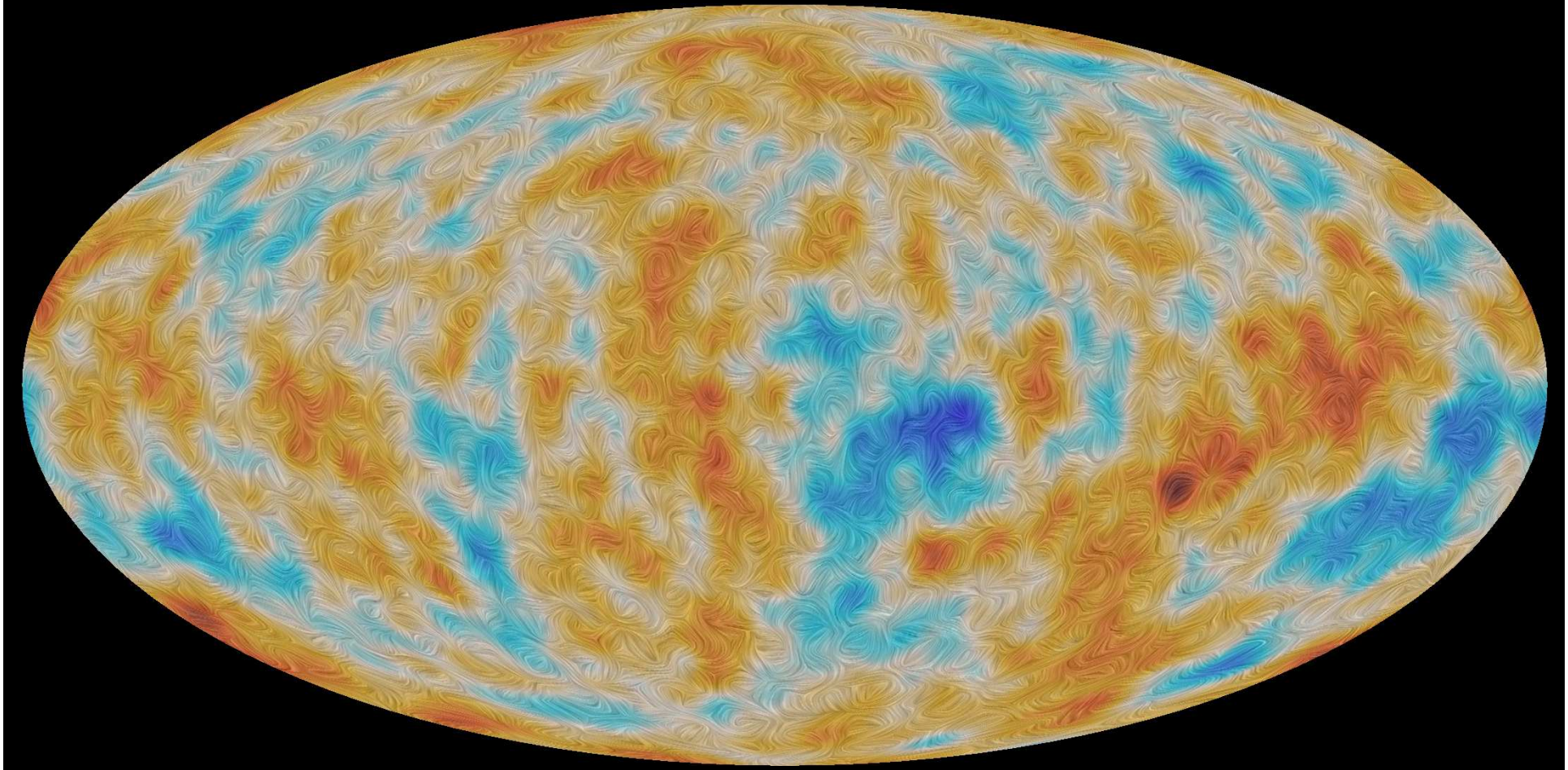
L'indizio decisivo dell'inflazione

L’uinverso in luce polarizzata



Planck 2015

L’uinverso in luce polarizzata



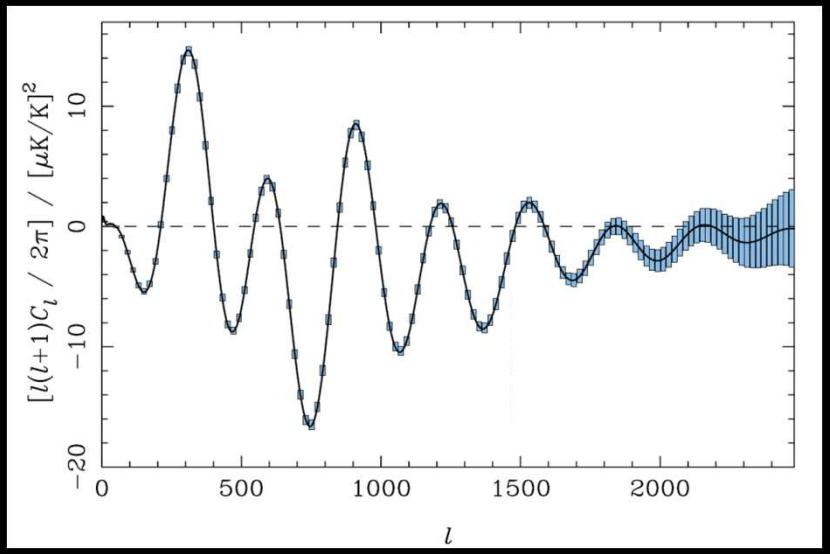
Planck 2015

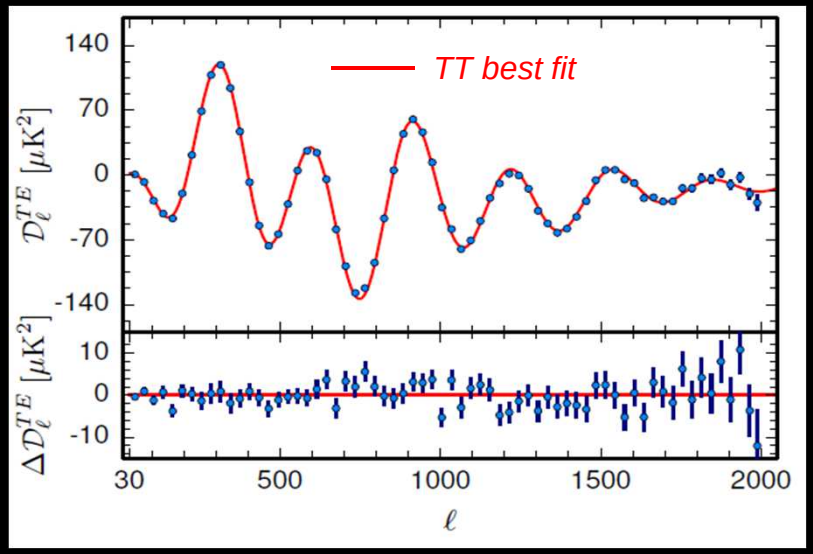
Planck 2015: spettri di polarizzazione

Simulazioni (2005)

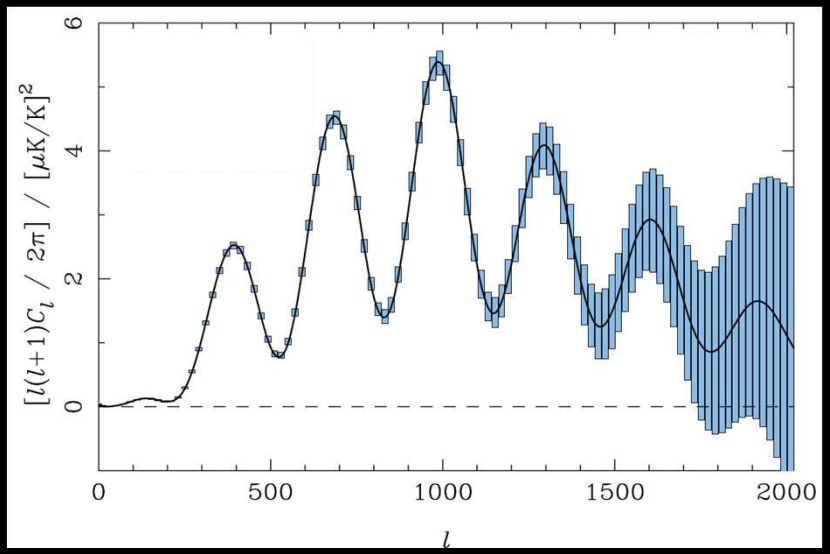
TE

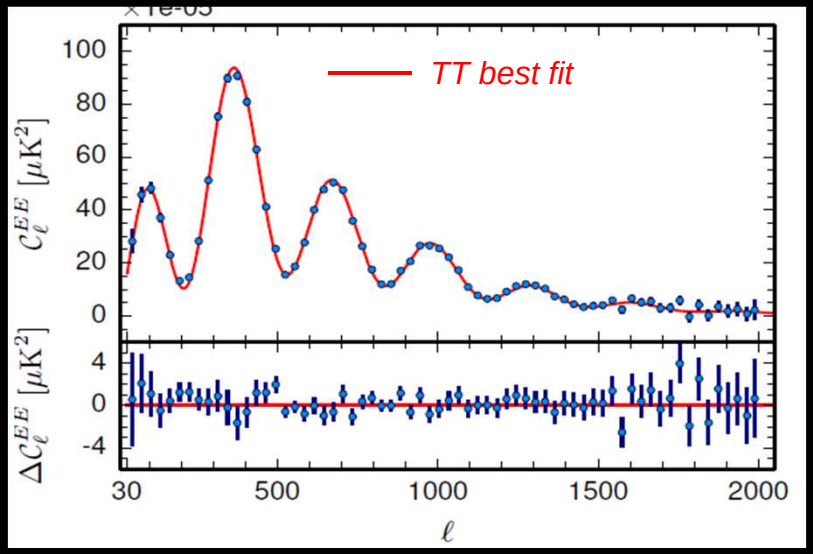
Planck 2015





EE





ΛCDM modello cosmologico standard (6 parametri)

TT+LowP+lensing

$\Omega_b h^2$ ..... 0.02226 ± 0.00023 ← Densità barionica, ±1%

$\Omega_c h^2$ ..... 0.1186 ± 0.0020 ← Detezione a 60σ di materia oscura a *z*=1100

$100\theta_{MC}$ ..... 1.04103 ± 0.00046 ← Altissima precisione, 0.05%

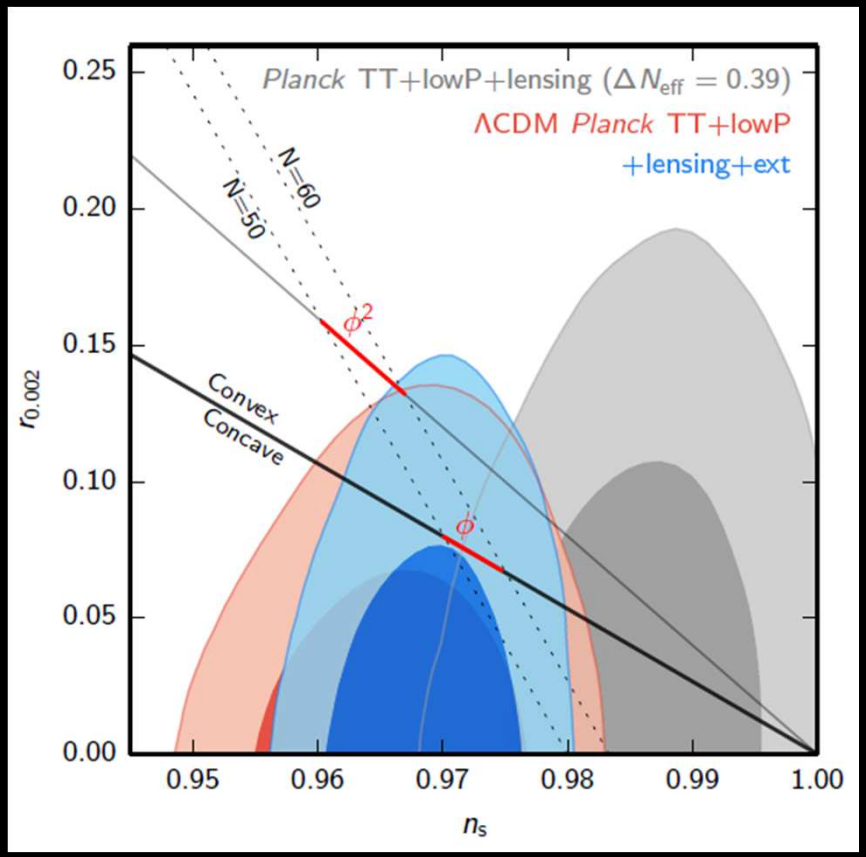
τ ..... 0.066 ± 0.016 ← Non c'è bisogno di "early reionization sources"?

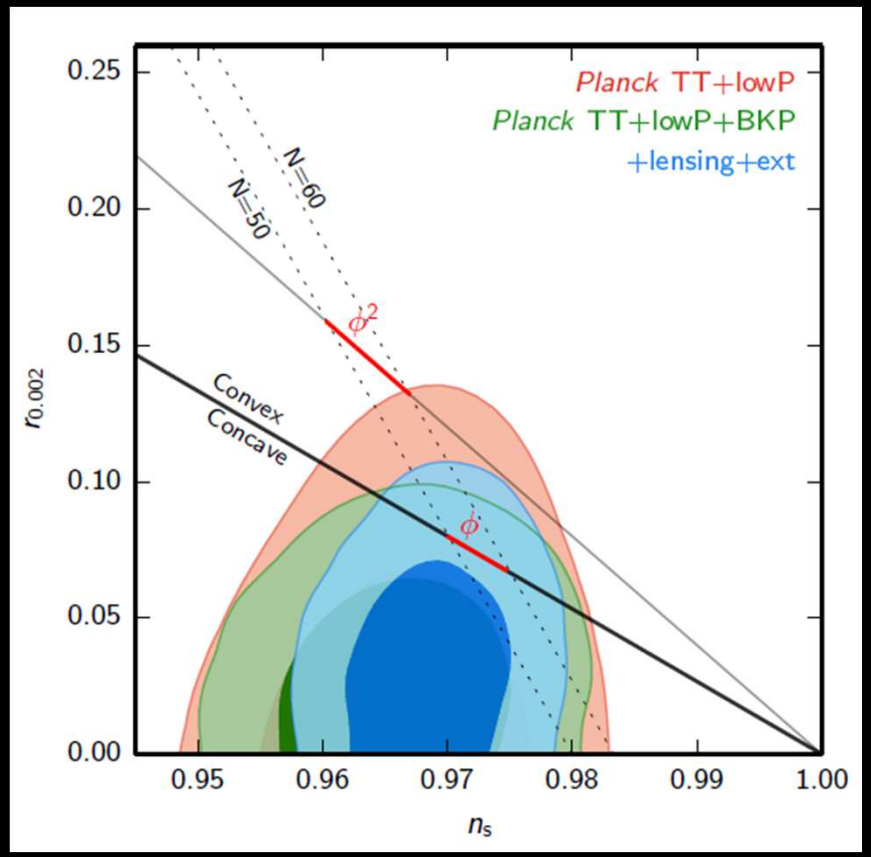
$\ln(10^{10} A_S)$ ..... 3.062 ± 0.029

n_S ..... 0.9677 ± 0.0060 ← Pendenza dello spettro primordiale (5σ, 0.6%)

Planck Collaboration, 2015
XIII. Cosmological parameters

Planck 2015: limiti sull'inflazione





Limiti sui modi tensoriali:

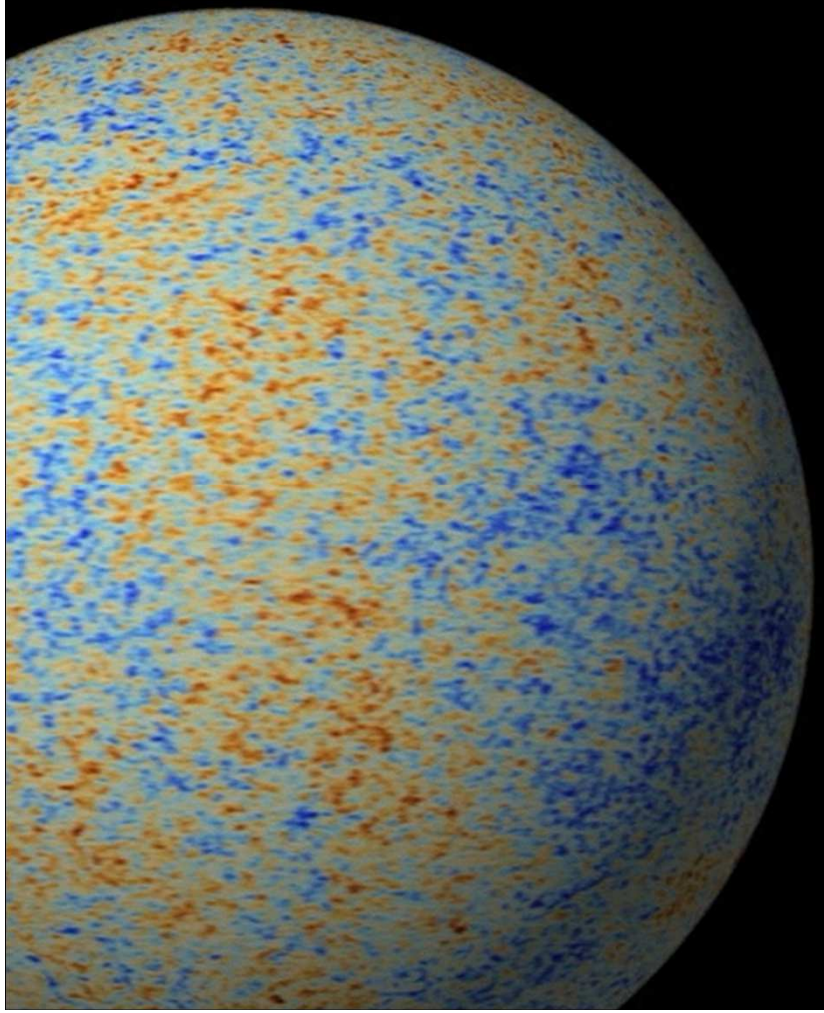
Planck: $r < 0.11$ (95%)

Planck+B2K: $r < 0.09$ (95%)

Modelli di inflazione con $V(\phi) \propto \phi^2$ sono fortemente sfavoriti

«Chi ha raggiunto lo stadio di non meravigliarsi più di nulla
dimostra semplicemente di aver perduto l'arte del ragionare
e del riflettere.»

Max Planck



«Non smetteremo di esplorare
E alla fine di tutto il nostro andare
Ritorneremo al punto di partenza
Per conoscerlo per la prima volta.»

Thomas Eliot