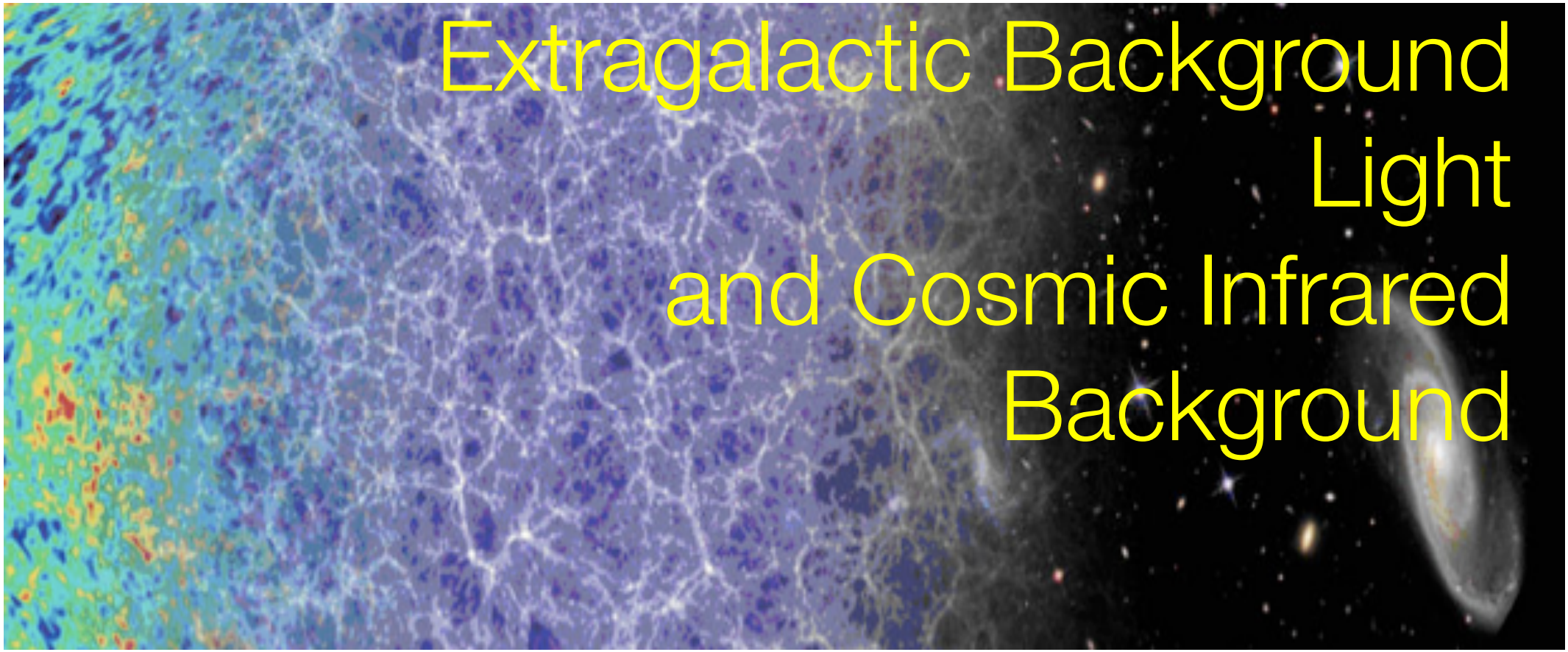


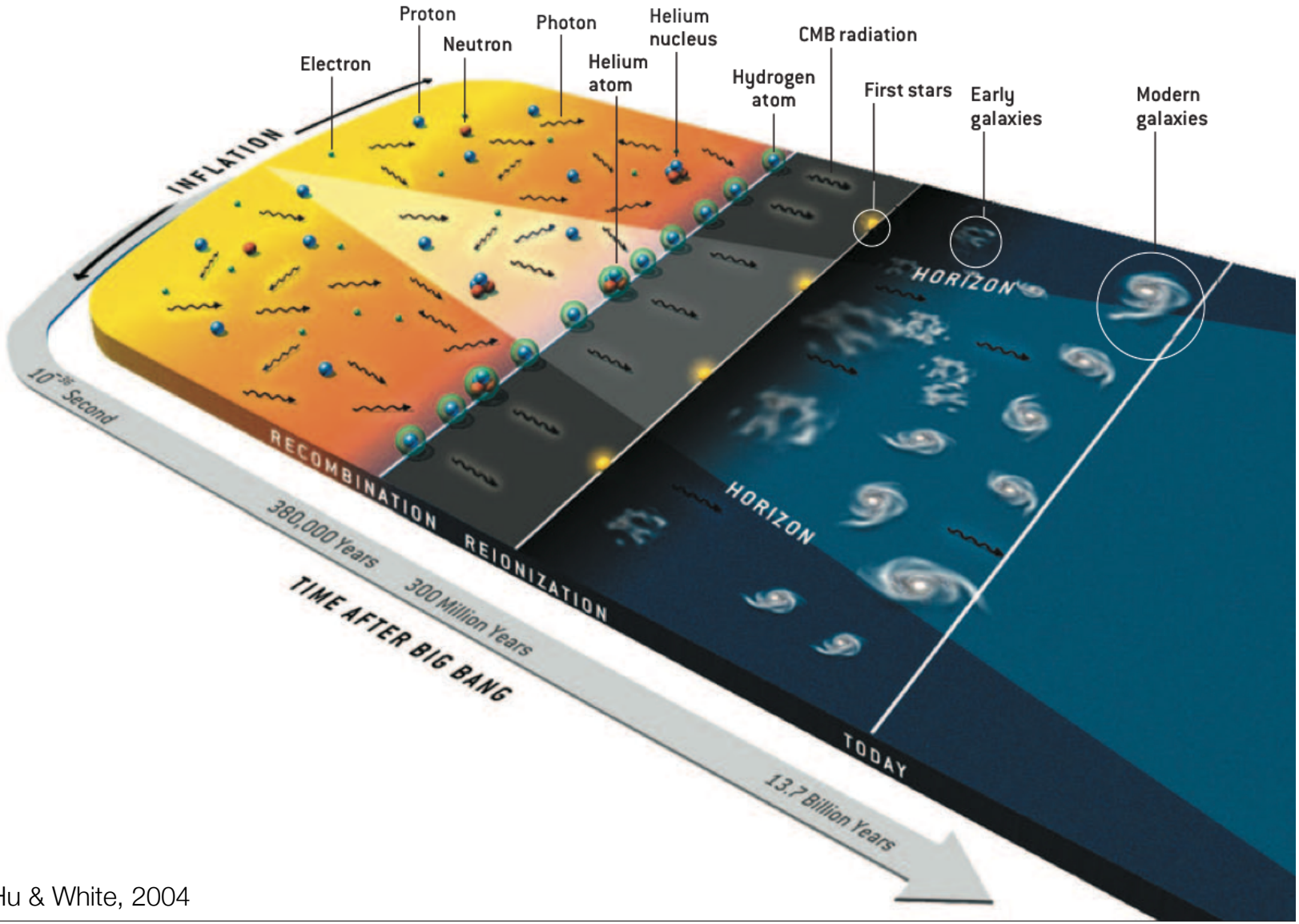
# Extragalactic Background Light and Cosmic Infrared Background


Hervé Dole

Institut d'Astrophysique Spatiale
Université Paris Sud 11 & CNRS, Orsay
http://www.ias.u-psud.fr/irgalaxies

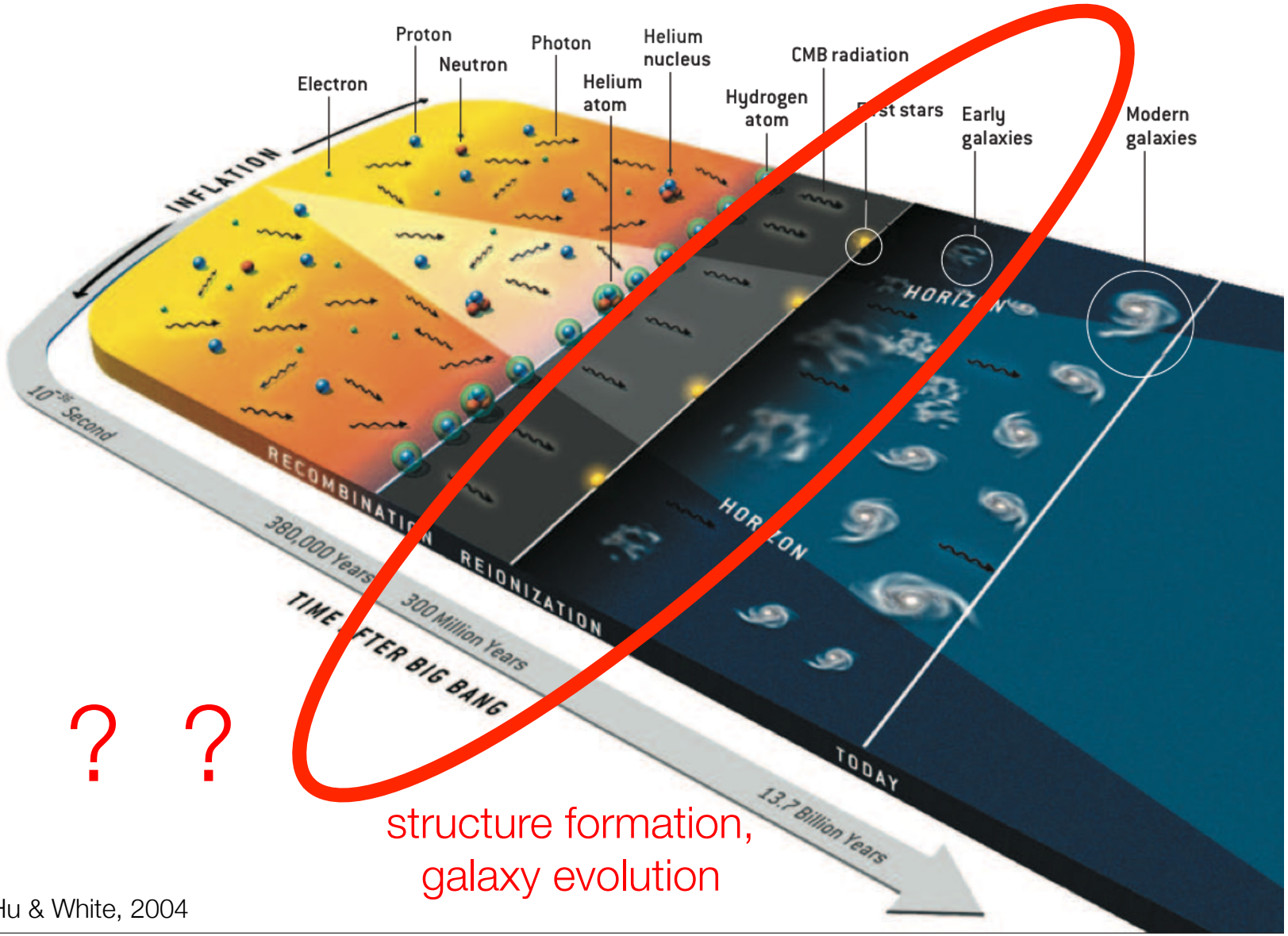

Montage: CMB, LSS, galaxies: SPACE

# history of the universe




Hu & White, 2004

# history of the universe



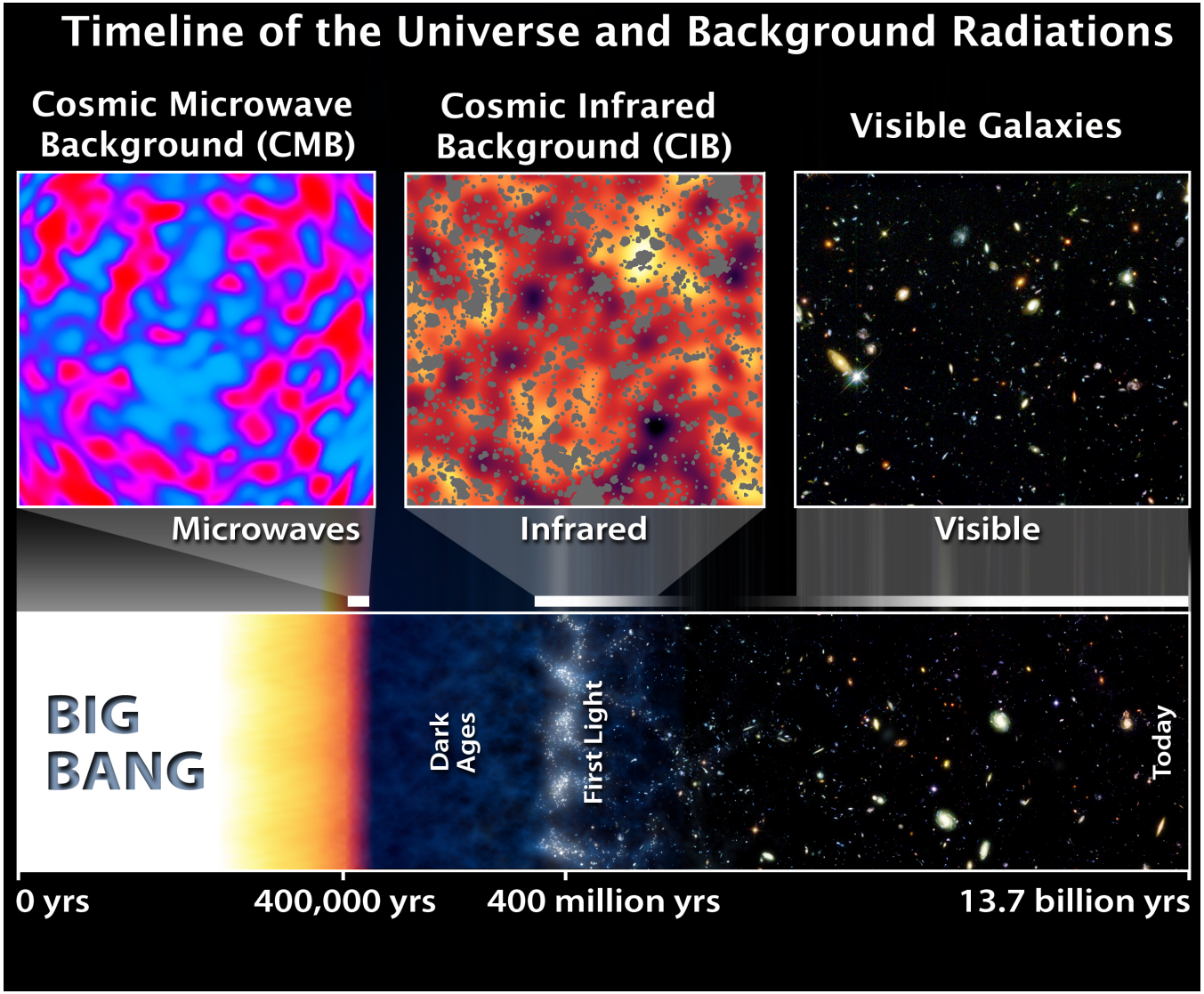

Hu & White, 2004

# extragalactic background light

EBL (Extragalactic Background Light) tells us about the processes involved in galaxy formation & evolution (budget for radiation emission by nucleosynthesis & gravitation, presence of dust, …)

*CIB (Cosmic Infrared Background) level and structure depend on history of energy production in the post-recombination Universe* [Kashlinsky, 2005]

# naive view of cosmic backgrounds




Kashlinsky et al. 2006, very controversial Press Release

# from EBL to galaxy populations

- galaxies
  - physical processes driving the evolution?
  - gravitation: black hole and AGN
  - strong, weak, electromagnetic: nucleosynthesis: star formation
  - relative importance ? redshift evolution ?

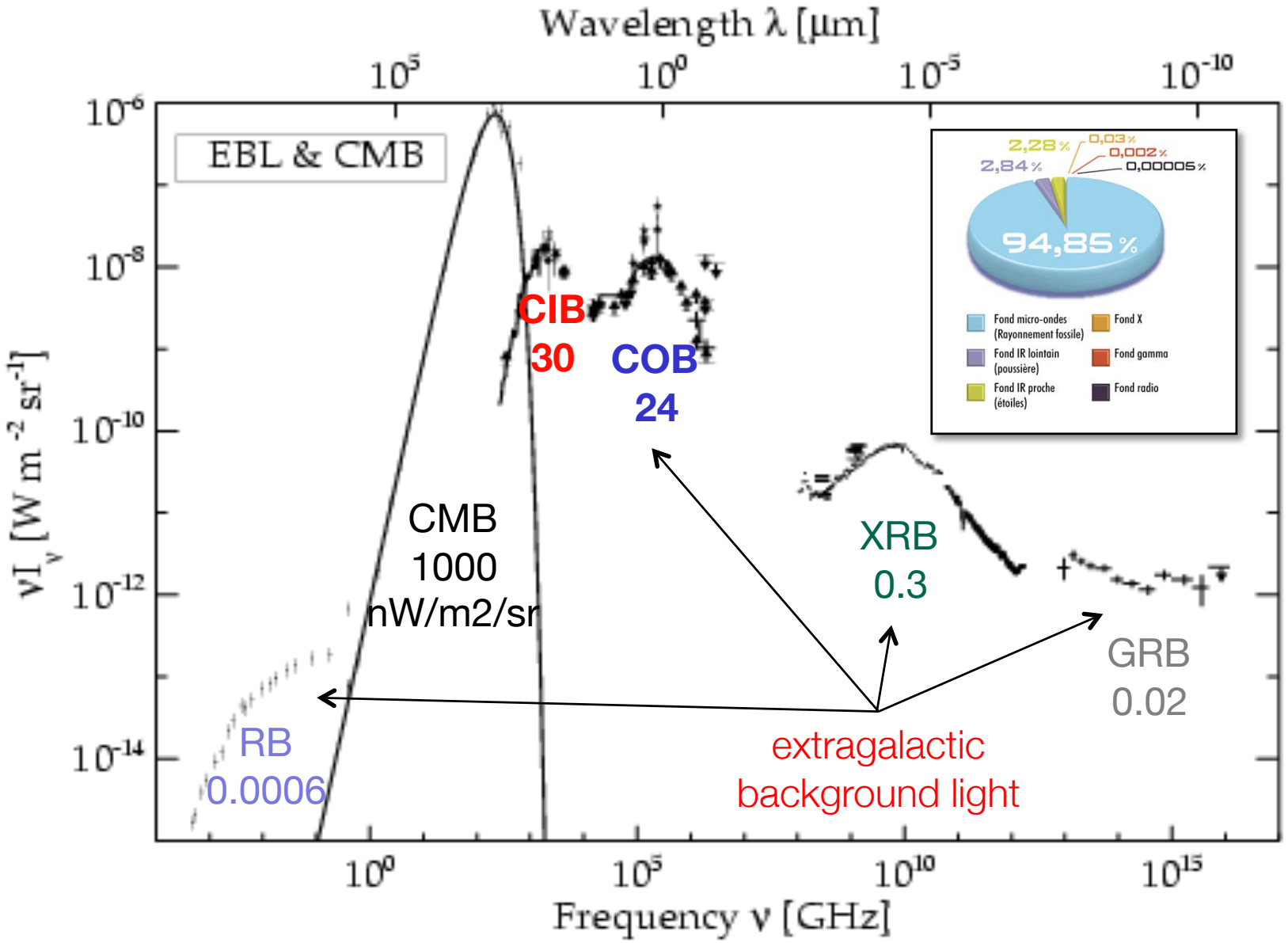
- TeV gamma emission of AGN
  - peak of photon-photon interaction
    - $\lambda$IR($\mu$m) ~ E$\gamma$(TeV)
  - constraints on the intrinsinc spectrum of blazars ?

# outline

- the extragalactic background light
  - summary of measurements
- encoded informations in the extragalactic background
  - the role of galaxies
  - what tells us the extragalactic background
- the contribution of Planck & Herschel

# summary of EBL measurements

# universe's spectral energy distribution

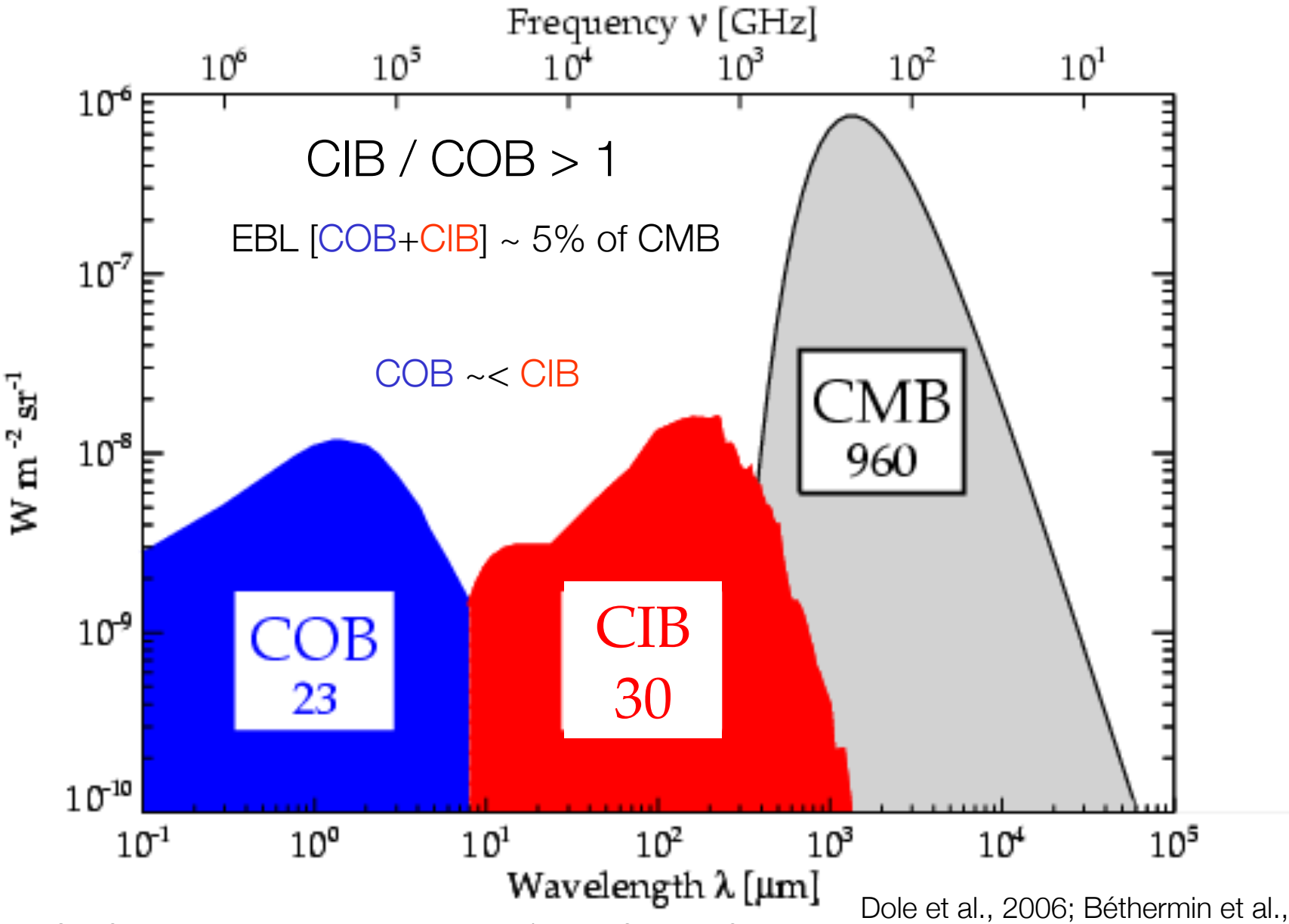



Dole et al., 2006 ; Béthermin et al., 2010; Dole et al., in prep

# extragalactic background light

- Gamma-rays
- X-rays
- UV
- optical
- infrared – submillimeter
- radio

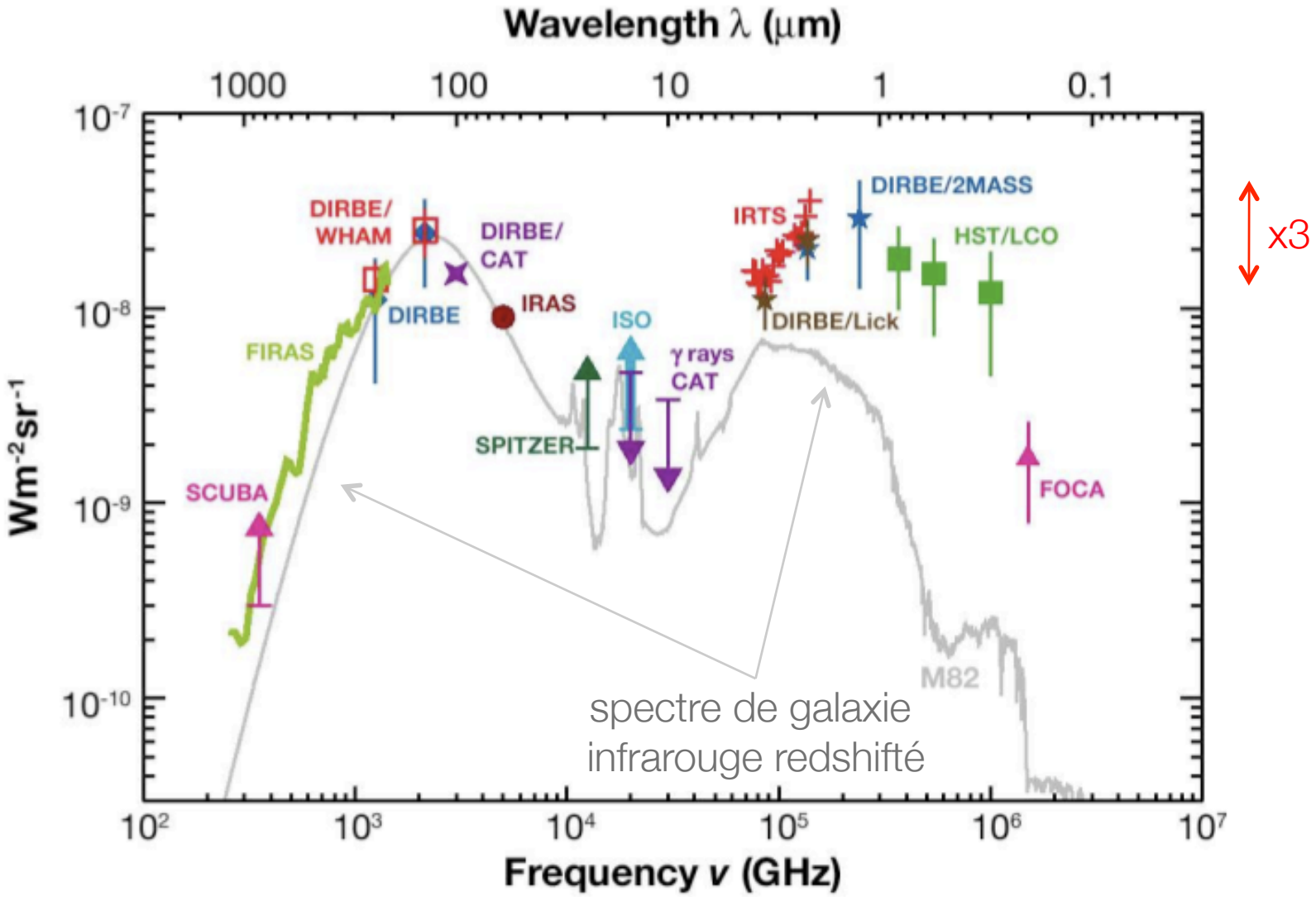
# summary of CIB measurements




Dole et al., 2006; Béthermin et al., 2010

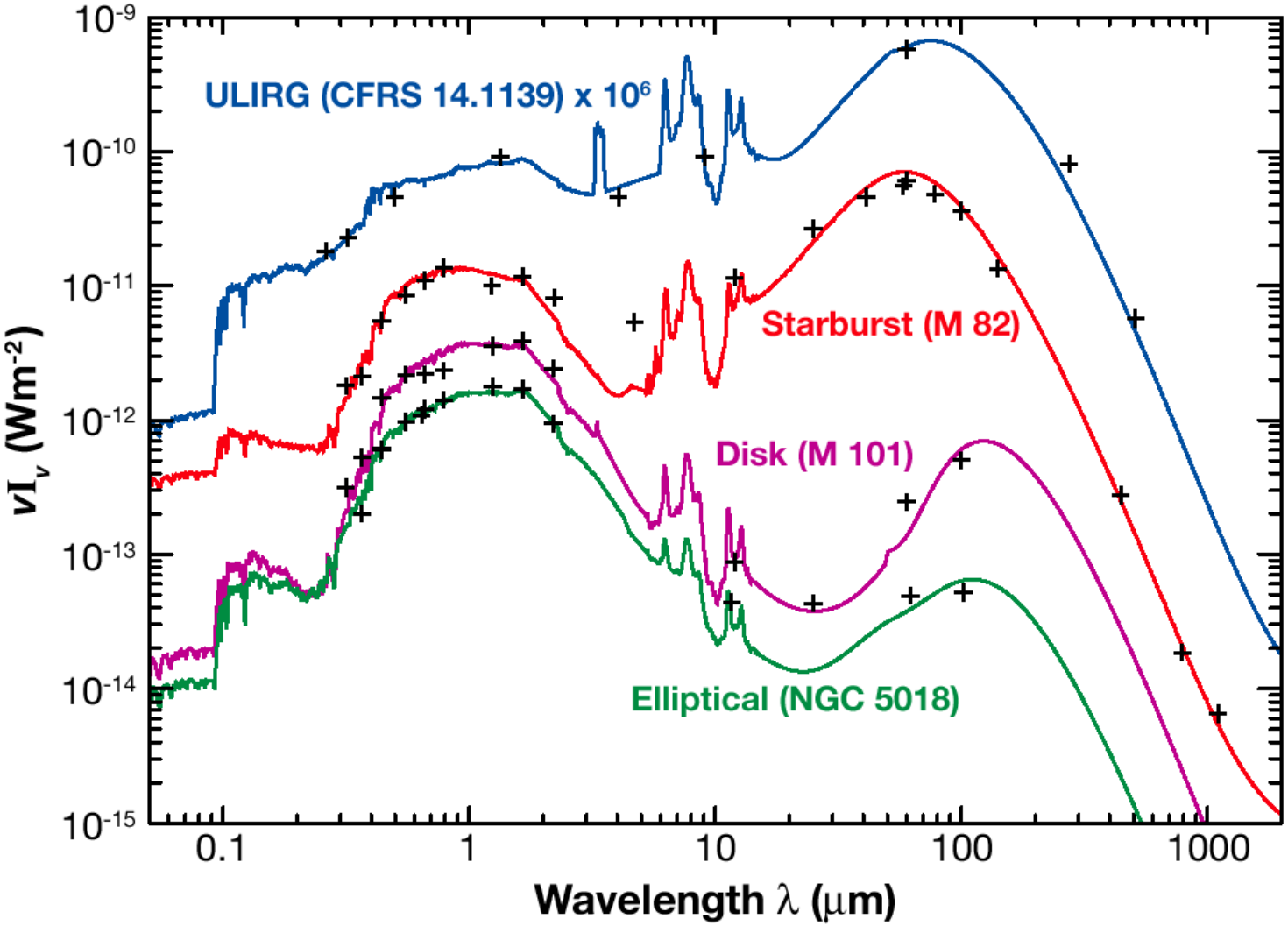
# encoded information in the EBL

# galaxies contributing to the EBL ?




Lagache, Puget, Dole, 2005, ARAA

# many types of galaxies




the ratio:

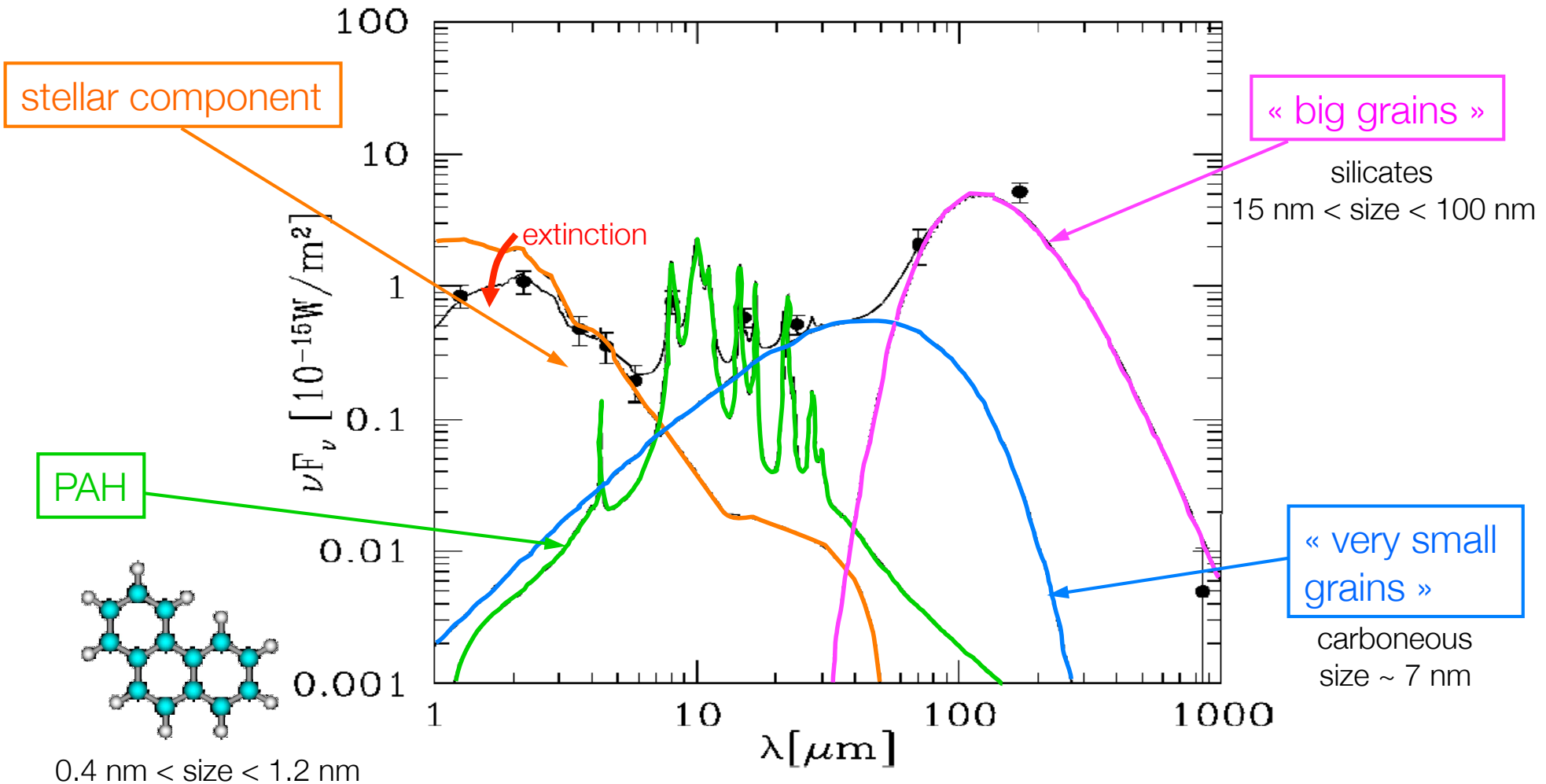
[UV+visible] / infrarouge

varies with the galaxy type

why such differences ?

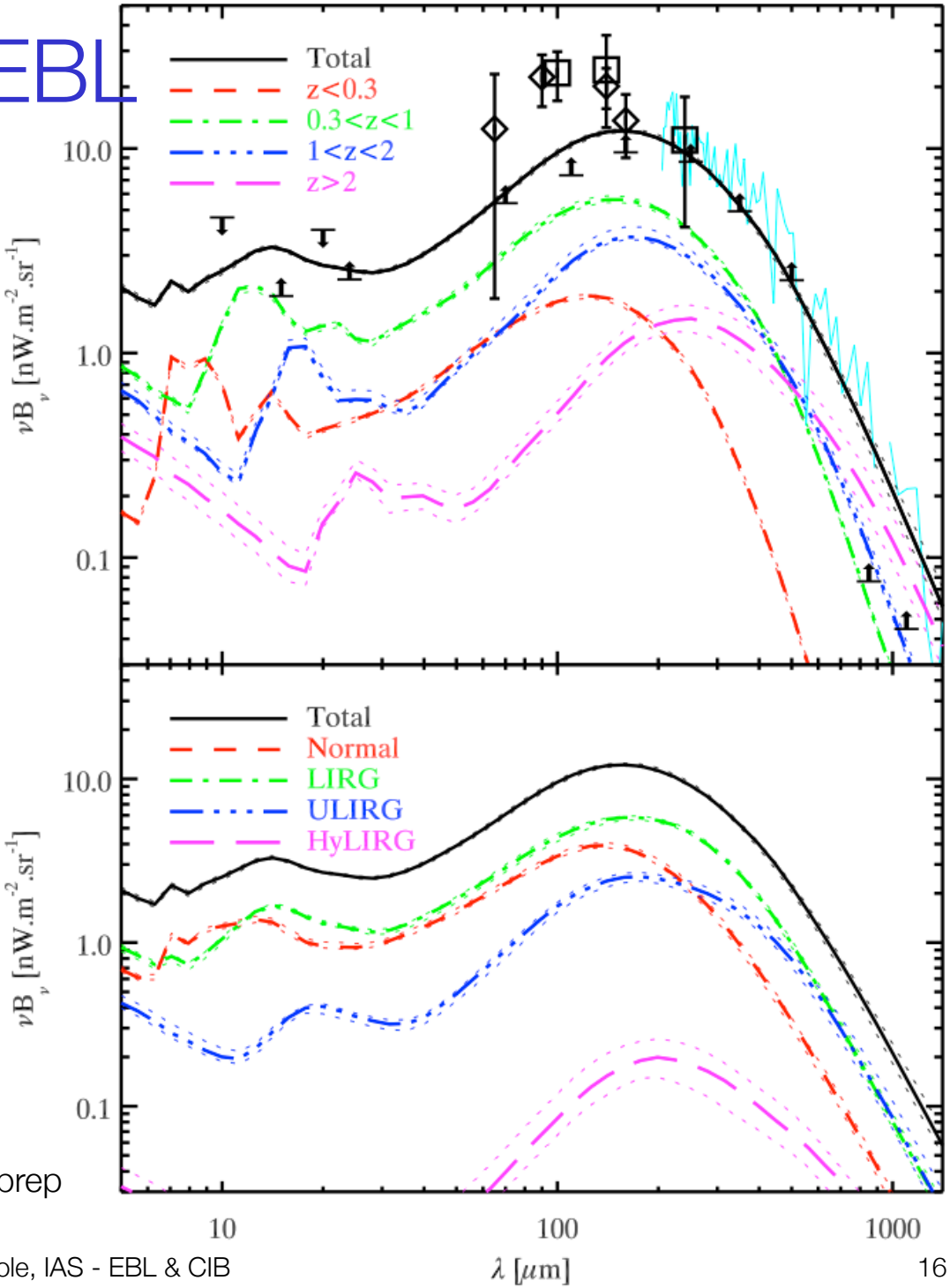
Galliano, dans Lagache, Puget, Dole, 2005, ARAA

# galaxies: stars and dust



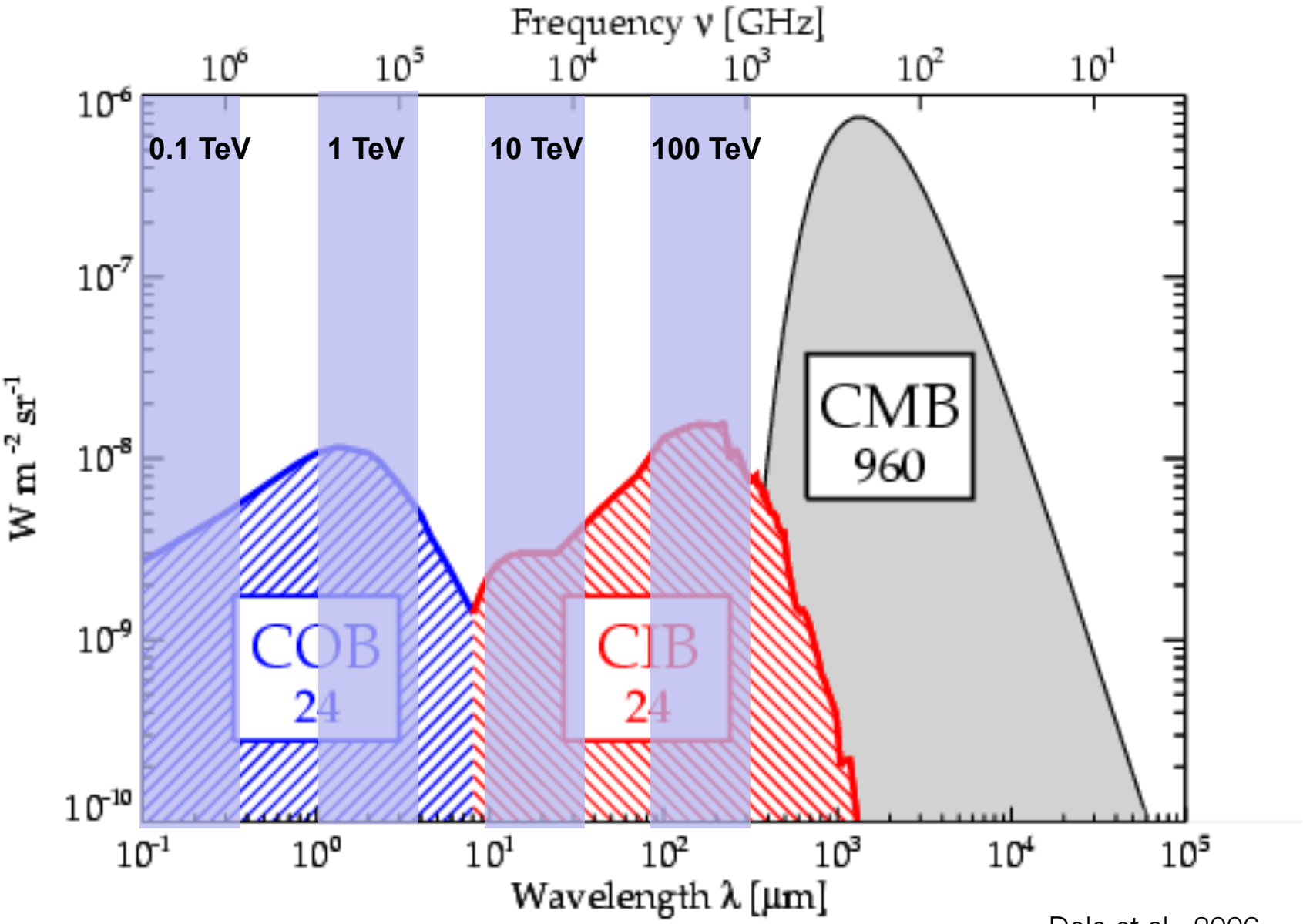

Sajina et al., 2006
Courtesy of N. Bavouzet

# contributions to the EBL




Bethermin et al., in prep

# implications for TeV opacity




Dole et al., 2006

# implications for TeV opacity

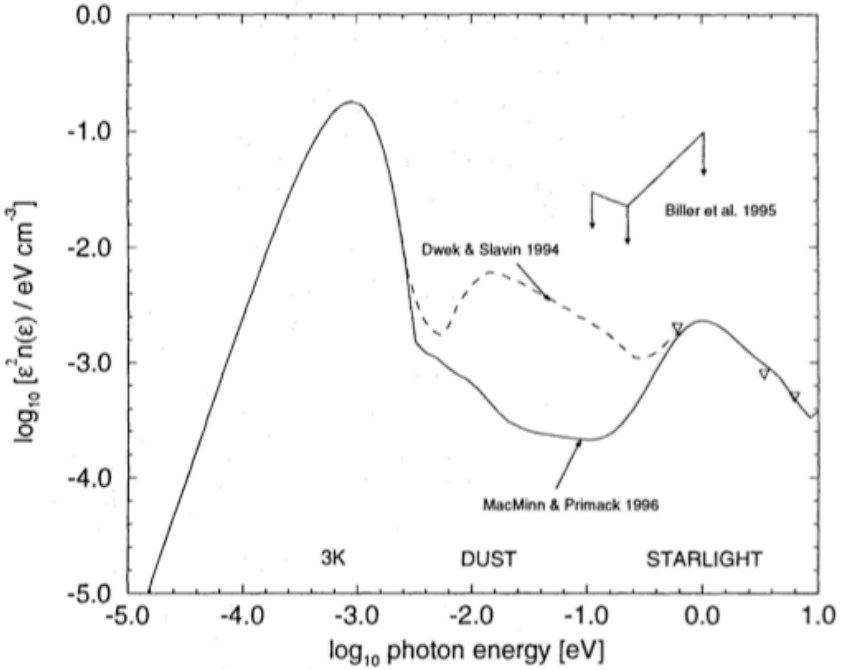



**Fig. 2.** Solid line: the infrared-to-ultraviolet diffuse background radiation field adopted in the present work. Dashed line: a diffuse background assuming that the $\gamma$-ray spectrum of Mrk421 cuts off at TeV due to cosmic absorption. Triangles denote estimates by Madau & Phinney (1996) of the optial-to-ultraviolet diffuse background based on deep galaxy surveys

Different EBL (level and history)
create different gamma-ray horizon

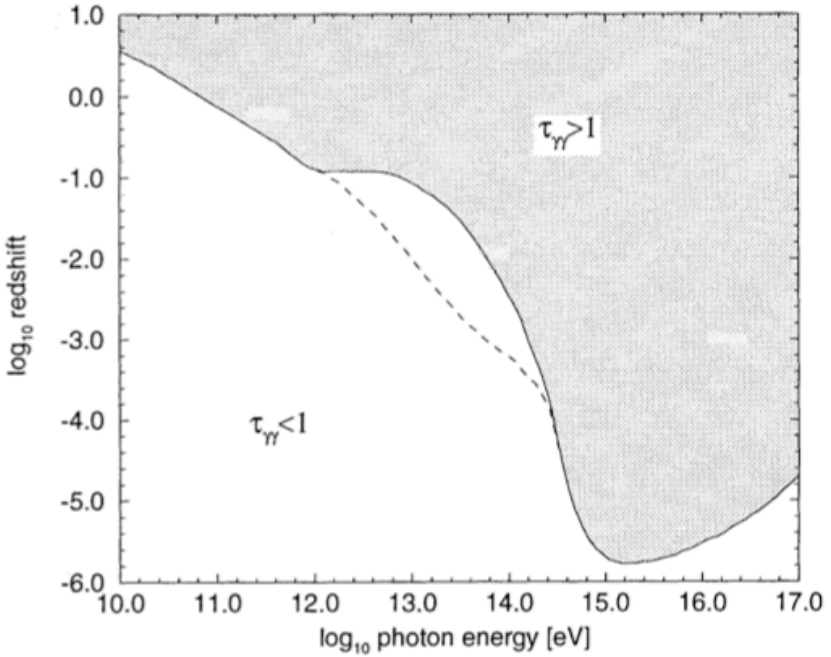



**Fig. 1.** The $\gamma$-ray horizons $\tau_{\gamma\gamma}(E, z) = 1$ corresponding to the two different diffuse background models shown in Fig. 2. The horizons were calculated assuming $\Omega = 1$, $q_\circ = 0.5$, $H_\circ = 75$ km s$^{-1}$ Mpc$^{-1}$ and a photon number density evolving with redshift as $n'd\epsilon' = (1+z)^3 nd\epsilon$ (conserved number of photons)

Mannheim et al., 1996

# what tells us the EBL [1]

- gives the energy budget (photons) for galaxy formation and evolution; useful to:
  - constrain the models
  - quantify the relative contributions of nucleosynthesis vs accretion
- need for more output energy in the infrared at higher z
  - testimony of the central role of LIRG (Luminous IR galaxies)
    - what are those LIRG ? why ?
- gives a degenerate information
- tells us about the opacity to TeV photons

# what tells us the EBL [2]

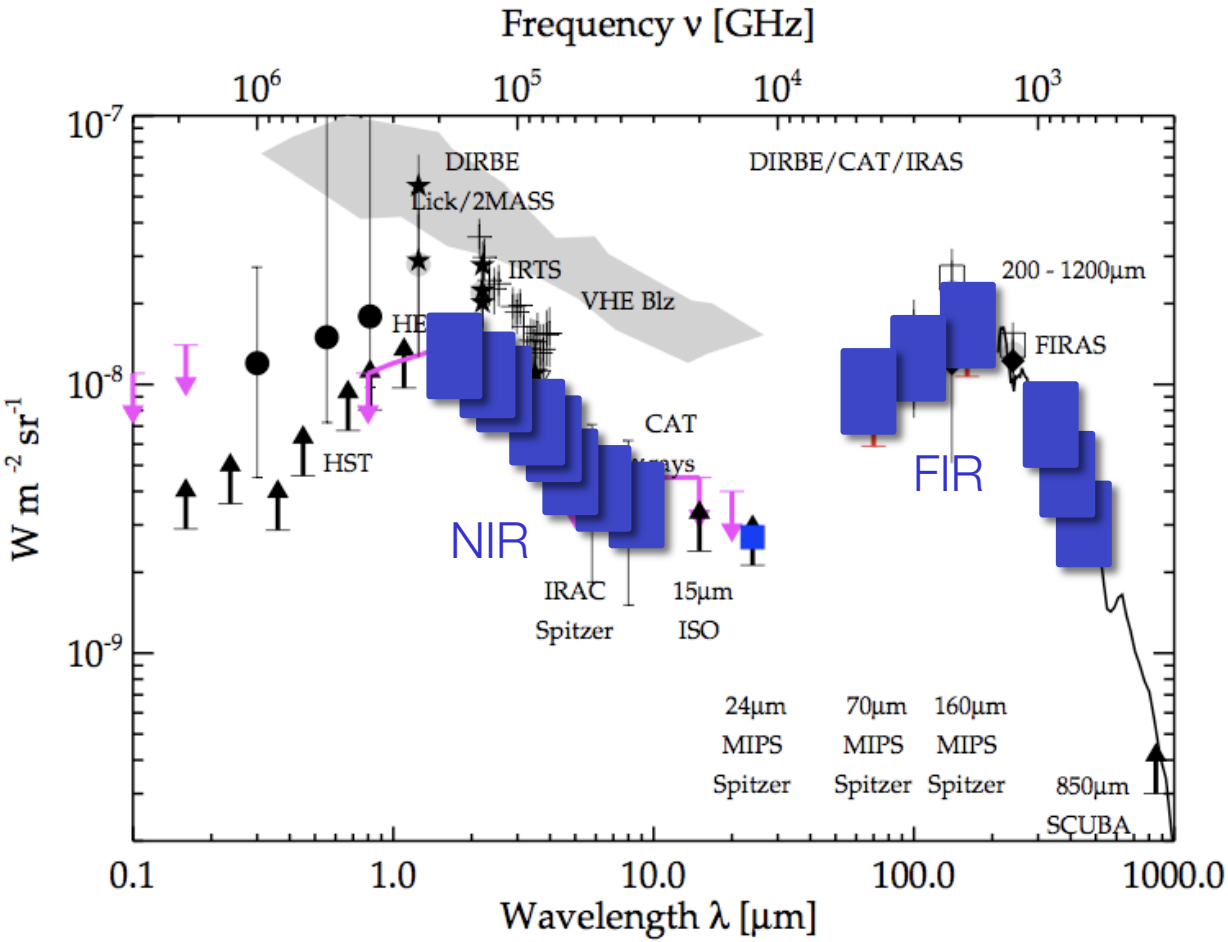
- beyond the EBL intensity: its angular structure: extragalactic background fluctuations
  - tell us about the emitting sources

- in the far-infrared (> 70um)
  - CIB not completely resolved in galaxies
  - fluctuations probe the galaxies populations making-up the bulk of the background

- in the near- and mid-infrared (<30um)
  - CIB almost resolved into galaxies
  - fluctuations probe the faintest populations:
    - popIII ? zodi ou cirrus ? very high-z galaxies ? faint galaxies ?

# infrared background fluctuations

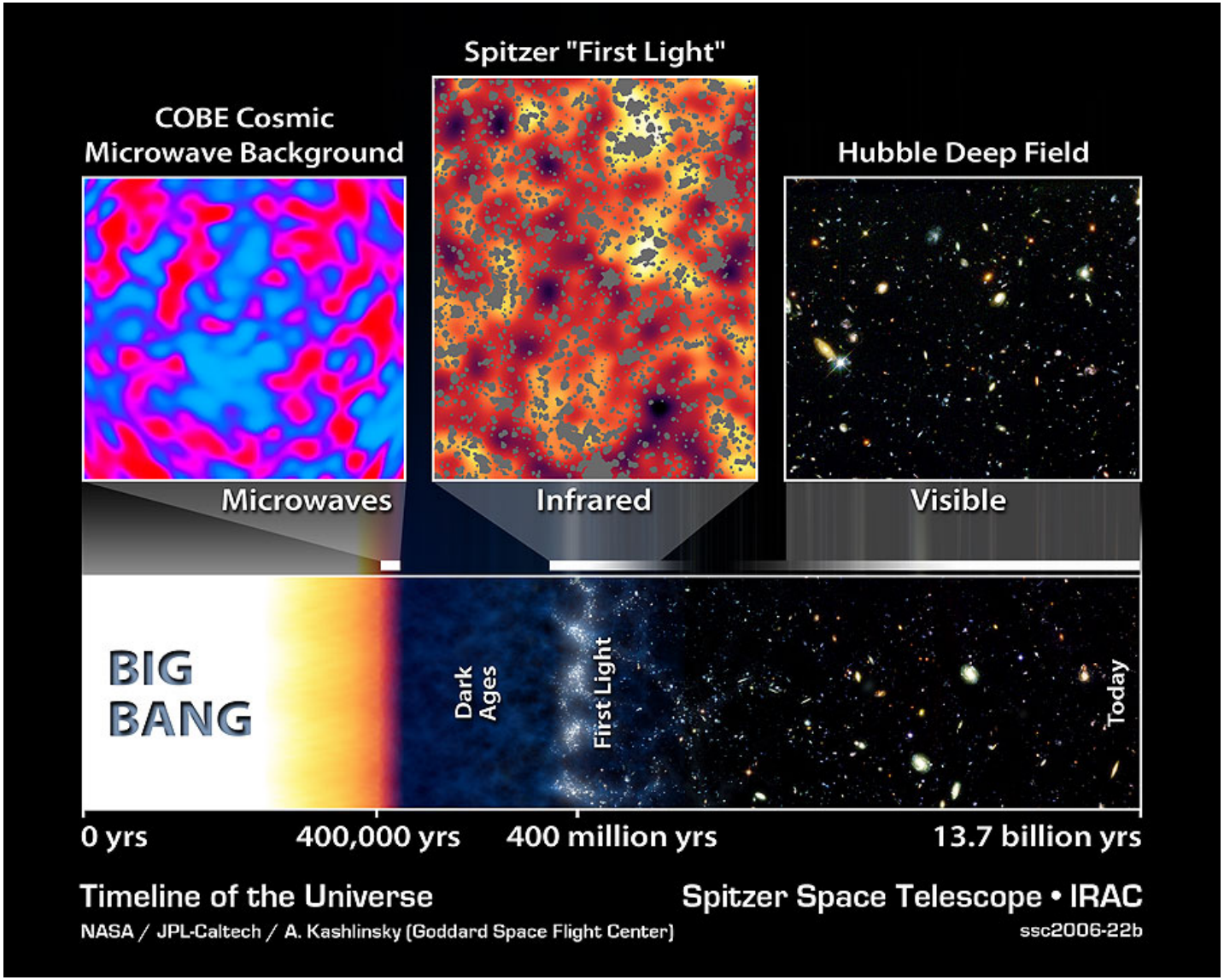
Detections:
- 250, 350, 500um: Marsden et al., 2009, BLAST
-170um: Lagache & Puget, 2000, ISOPHOT
- 160um: Lagache et al., 2007, Spitzer
-100um & 60um: Miville-Deschênes, Lagache, Puget, 2002, IRAS
-3.6, 4.5, 5.8, 8.0um: IRAC Kashlinsky et al
-1.25, 2.2, 3.5, 5um: Kashlinsky & Odenwald, 2000, DIRBE
-1.6um: Thompson et al. 2007, NICMOS
-1.4-2.4um: Matsumoto et al., 2004, IRTS
-J, H, K (1.25, 1.65, 2.17um): Kashlinsky et al. 2002 & Odenwald et al., 2003, 2MASS




Wavelengths at which EBL (CIB) fluctuations have been detected

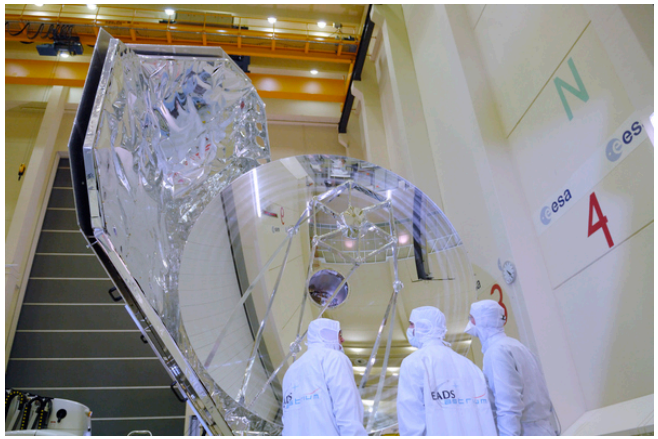
# fluctuations: z<2 or z>6 or popIII ?

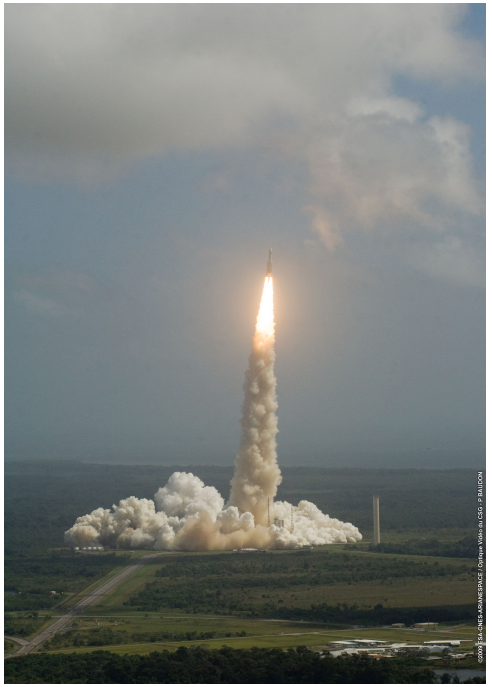
Kashlinsky et al., 2007, ApJ




controversy...

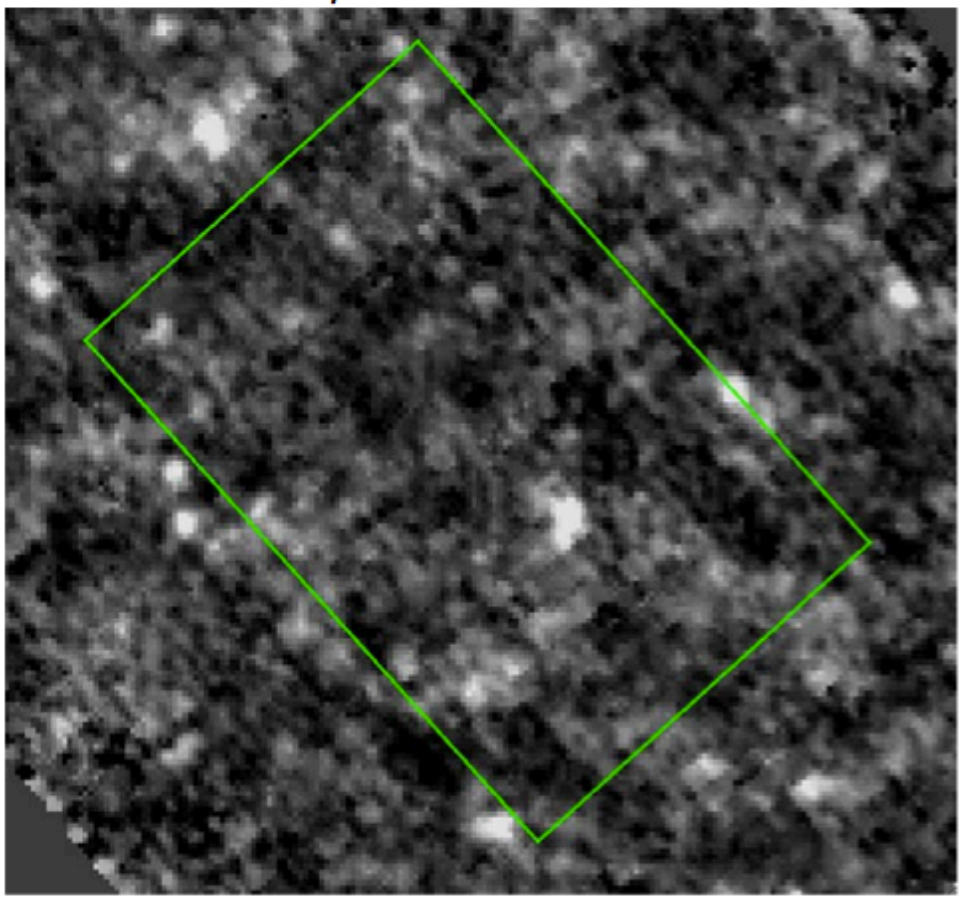
# the Planck et Herschel era



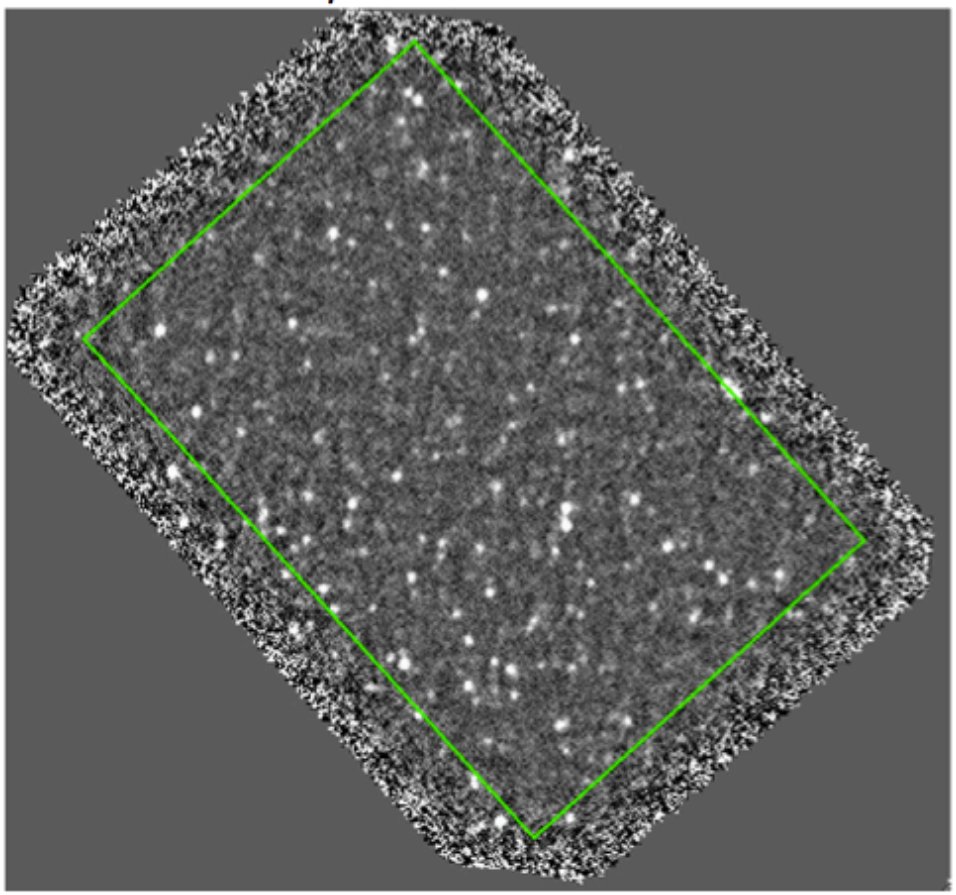
# CIB almost resolved in galaxies

GOODS-N 160$\mu$m



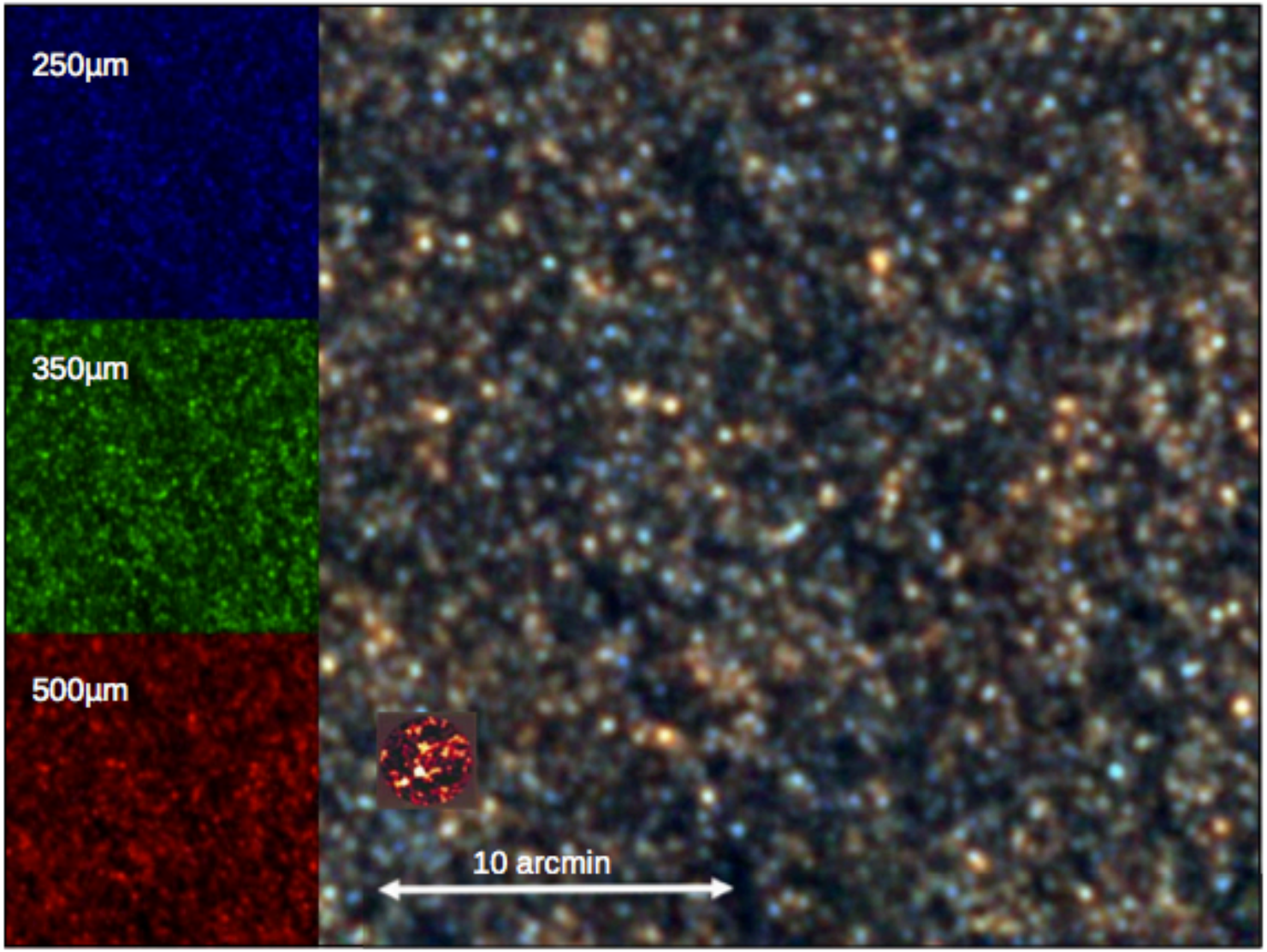
Spitzer MIPS 160um
FIDEL
2005

GOODS-N 160$\mu$m



Herschel PACS 160um
PEP
2010

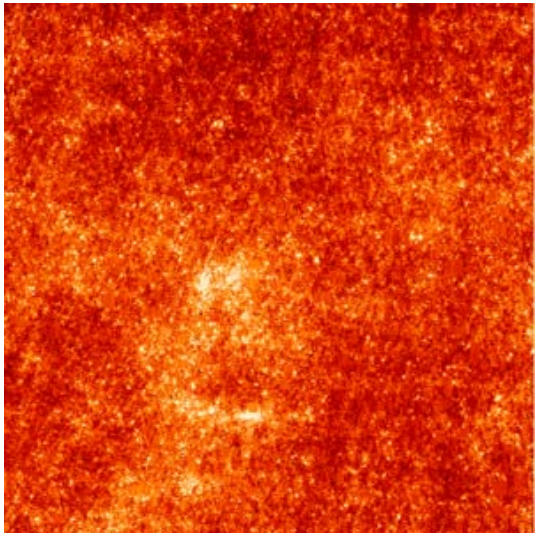
# CIB almost resolved in galaxies



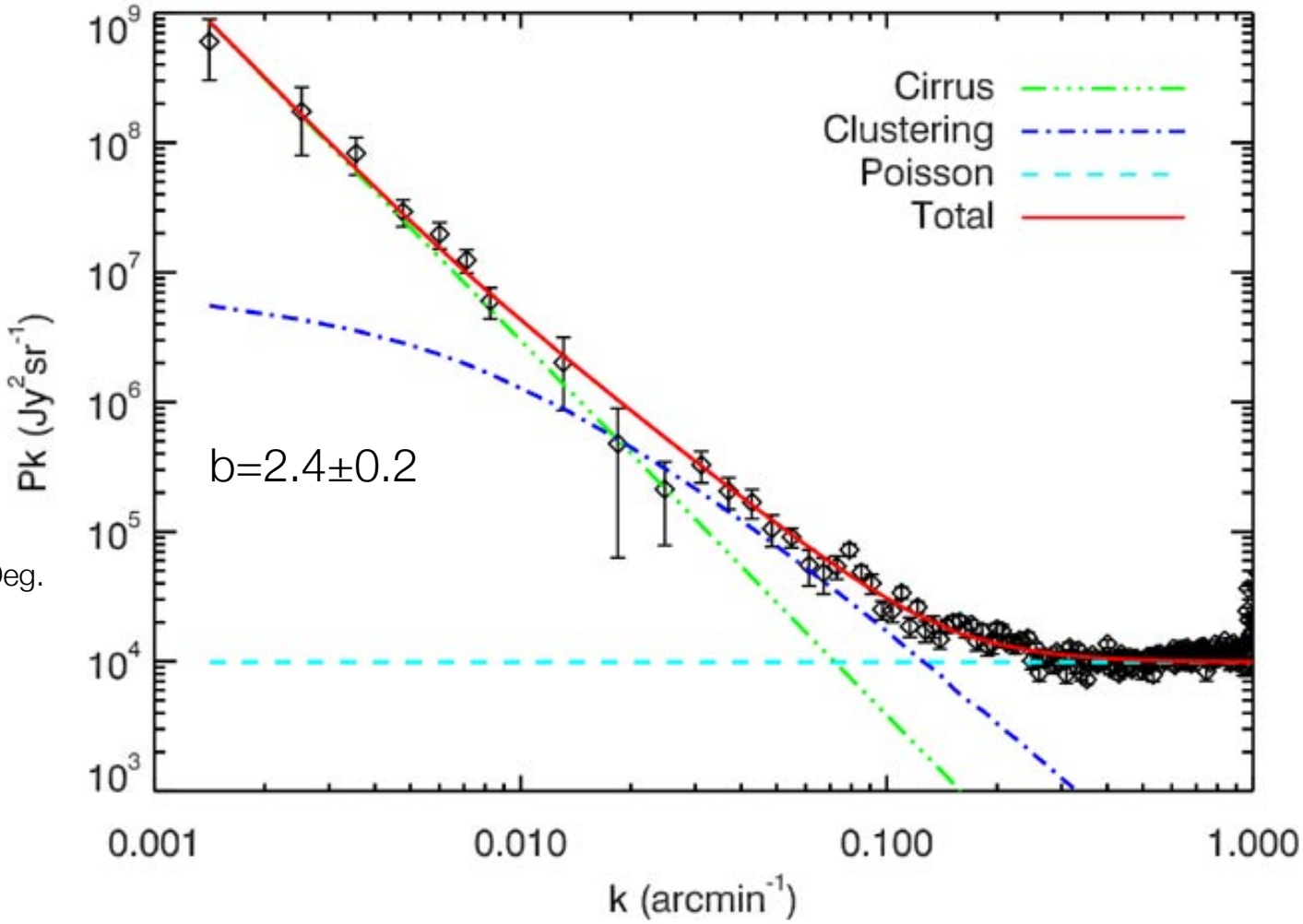

Herschel SPIRE 250, 350 & 500um – HERMES

# fluctuations of CIB

Power Spectrum of CIB fluctuations at 160um.
Fluctuations are dominated by z~1 sources



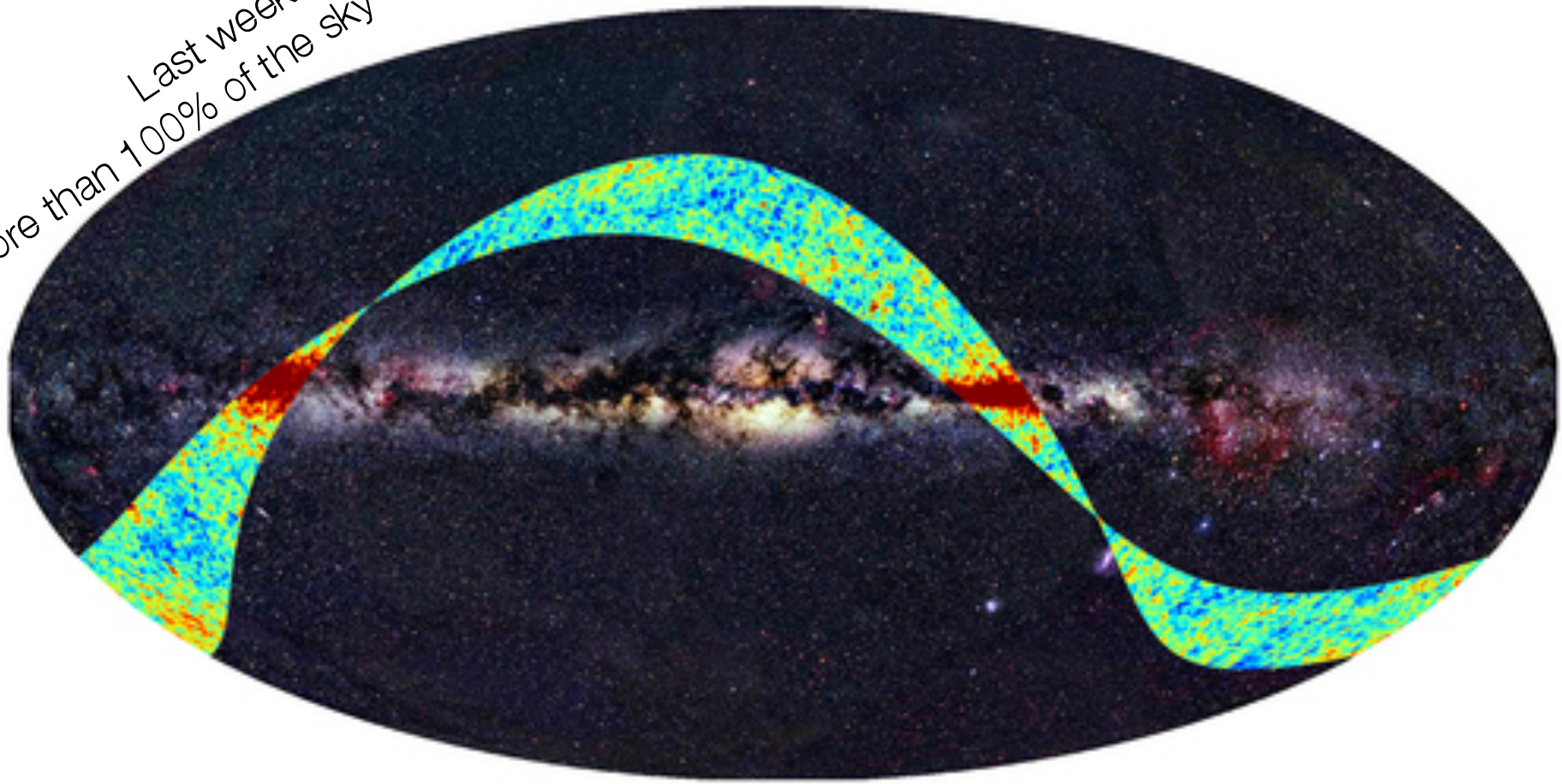
SWIRE 160um field of about 10 Sq. Deg.




Lagache et al., 2007, ApJ

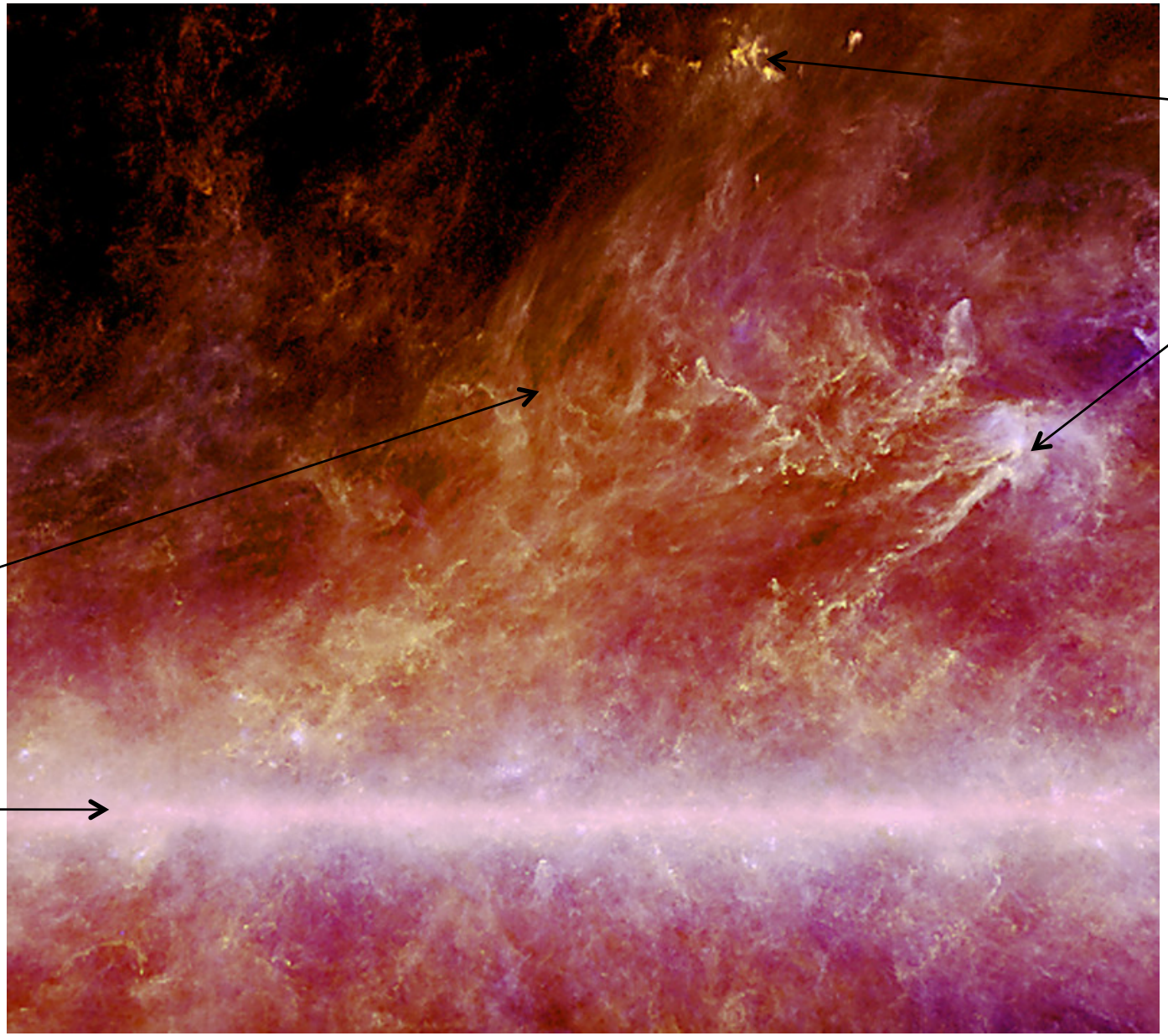
# first public images of Planck

Last week:
more than 100% of the sky covered !!



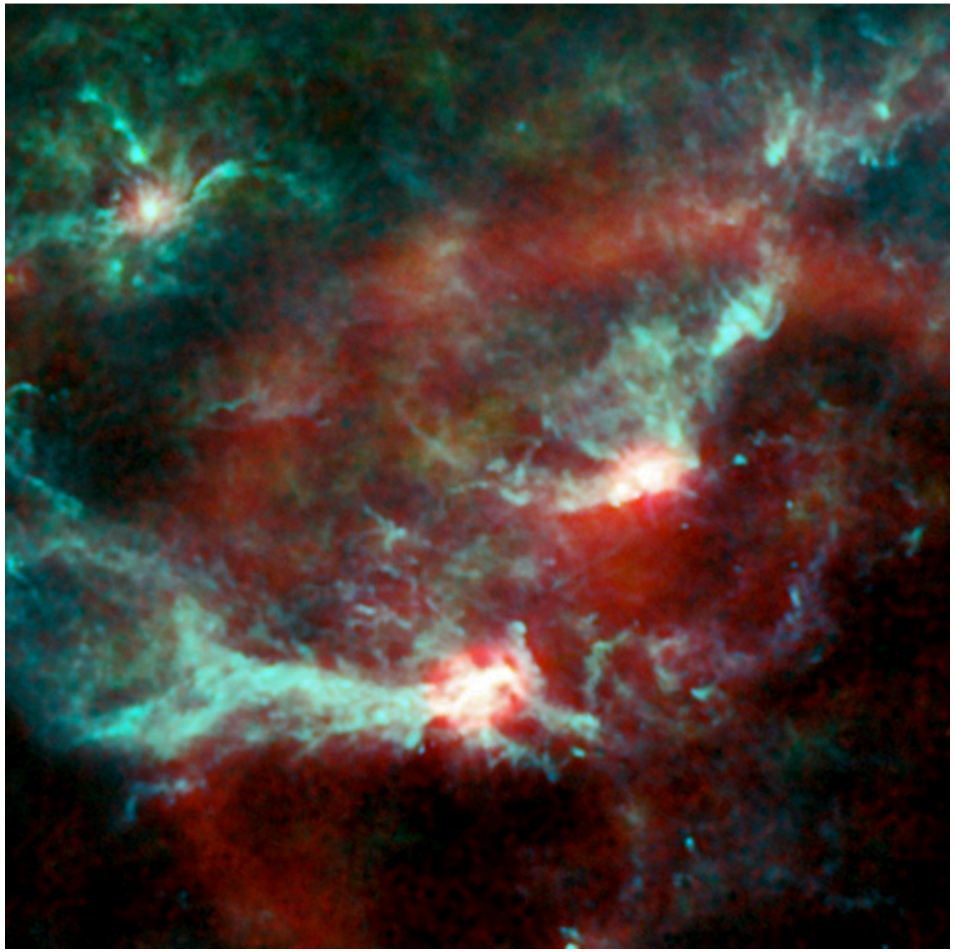
Planck First Light Survey – HFI – Septembre 2009

# first public images of Planck



# first public images of Planck

Planck HFI & LFI - Mars 2010 - Orion



# Planck daily operations at IAS, Orsay

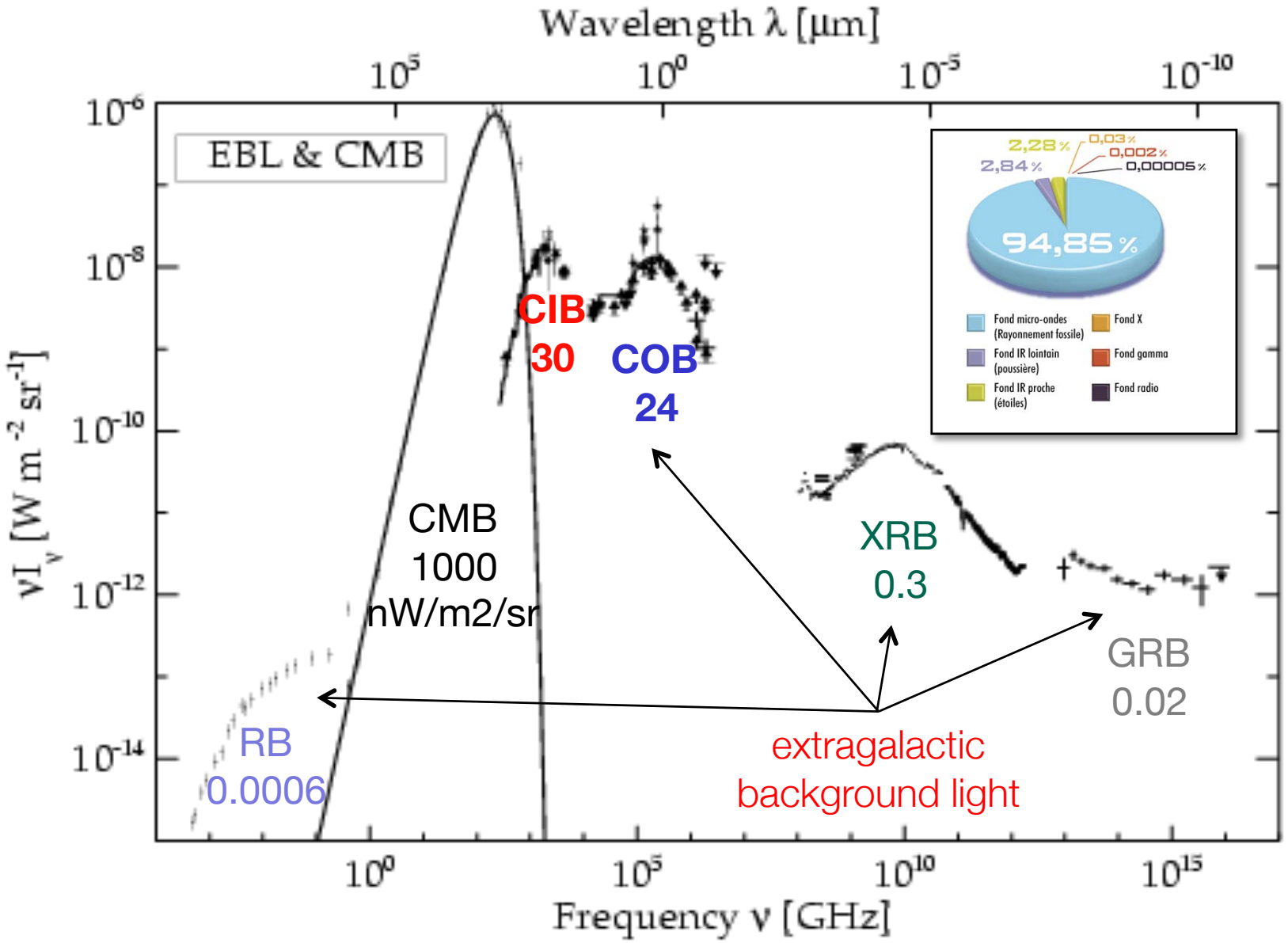

Planck HFI – Instrument Operation Room – Institut d'Astrophysique Spatiale

⇒ Visit is possible tomorrow at 1pm !
- calibration facility
- Planck HFI Operation Room

http://www.planck.fr

http://www.ias.u-psud.fr/irgalaxies/

# universe's spectral energy distribution




Dole et al., 2006 ; Béthermin et al., 2010; Dole et al., in prep