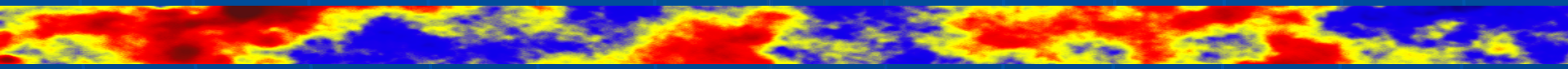
The Planck mission and early results



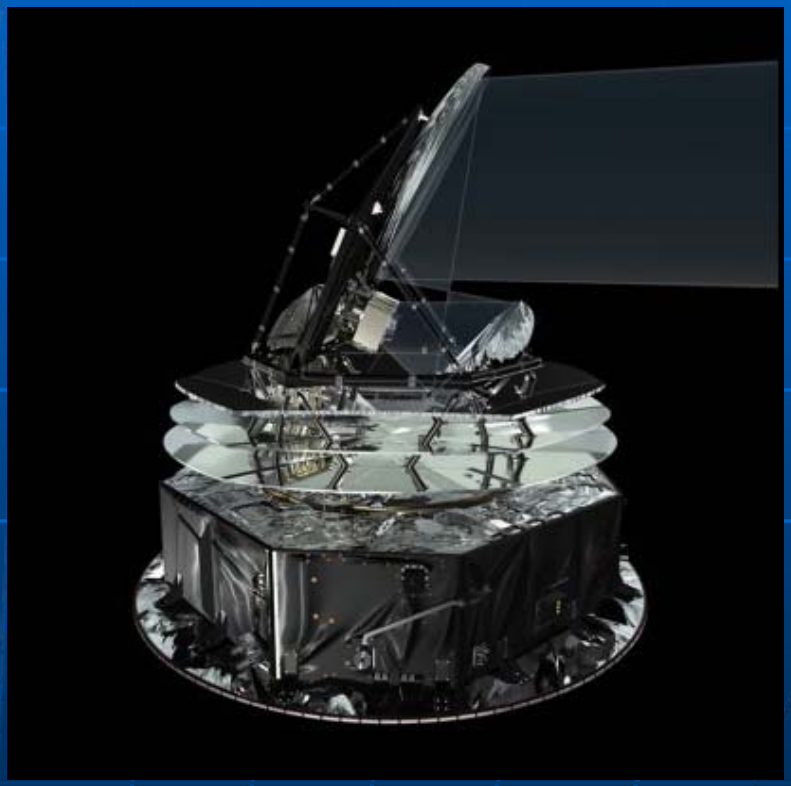
Anne Lähteenmäki
Aalto University
Metsähovi Radio Observatory

Planck satellite

- Measures the cosmic microwave background (CMB) temperature anisotropies + all foreground sources
- Two instruments (9 freq):
  - Low Frequency Instrument

    LFI (30 – 77 GHz)
  - High Frequency Instrument

    HFI (100 – 857 GHz)



Planck science in Finland

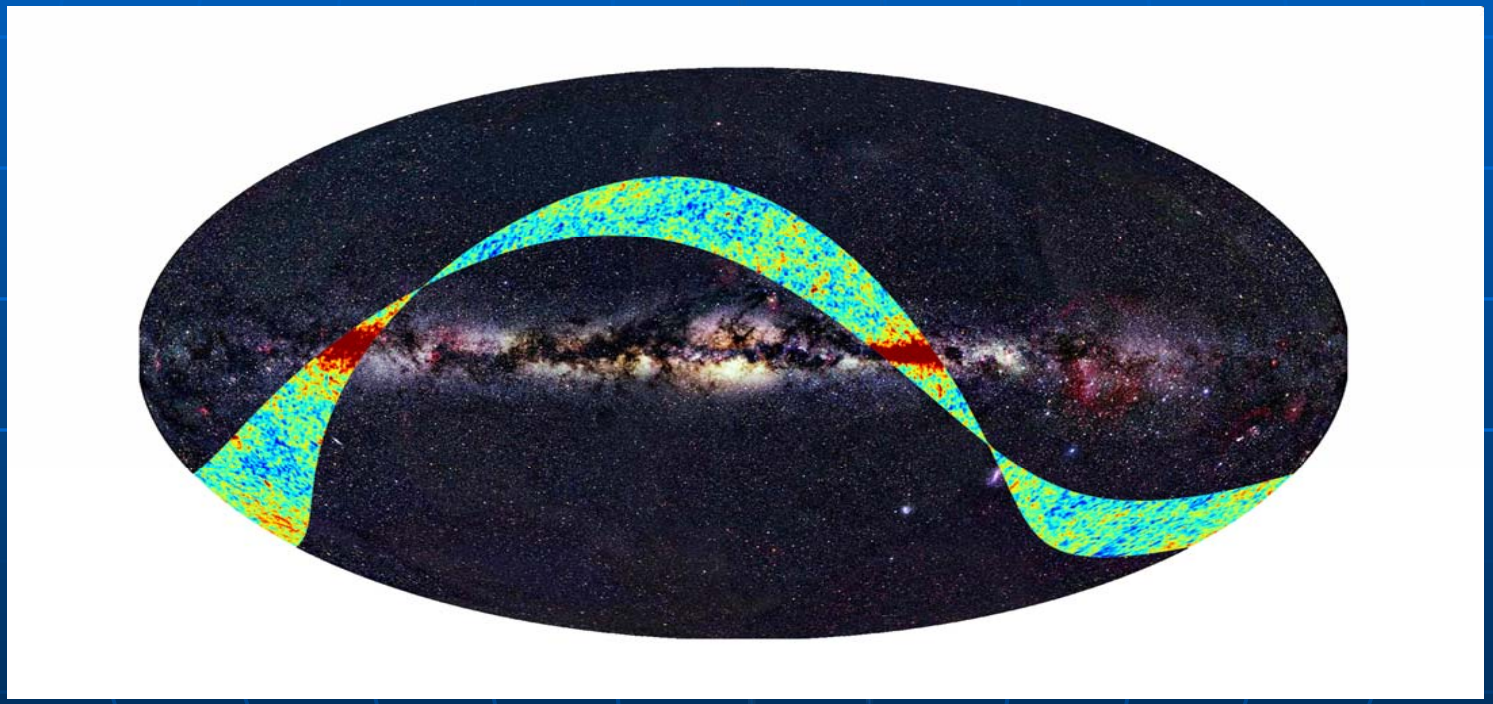
- Dept. of Physics, Univ. of Helsinki
  - Cosmology
  - Local interstellar matter; cold cores of molecular clouds; nearby molecular clouds; star formation; structure of the Galaxy
- Metsähovi Radio Observatory & Tuorla Observatory
  - Quasars, BL Lac and GPS sources; statistics of radio sources; galaxy clusters, Sunyaev-Zel'dovich effect

Planck schedule

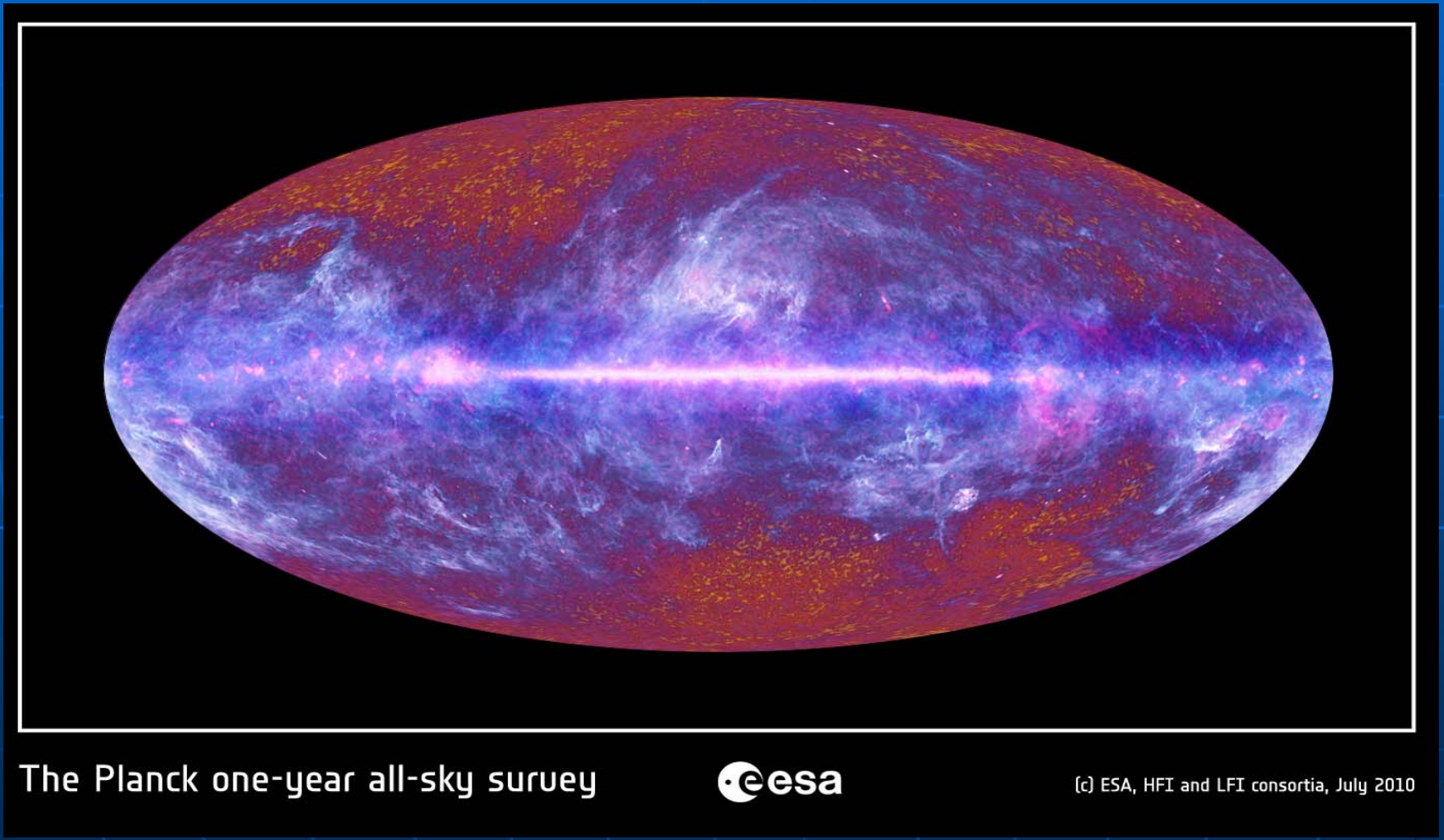
- Launch 14.5.2009
- 5 full-sky surveys
  - HFI ran out of coolant in Jan 2012, LFI continues
- Early Release Compact Source Catalog (ERCSC) in January 2011 together with a set of Planck early papers
  - all-sky catalogue of compact and point sources extracted from Planck's data
- Intermediate & cosmology papers early 2013, for the first 15 months (or so) of data
- Full data set released in 2014

Planck First Light Survey

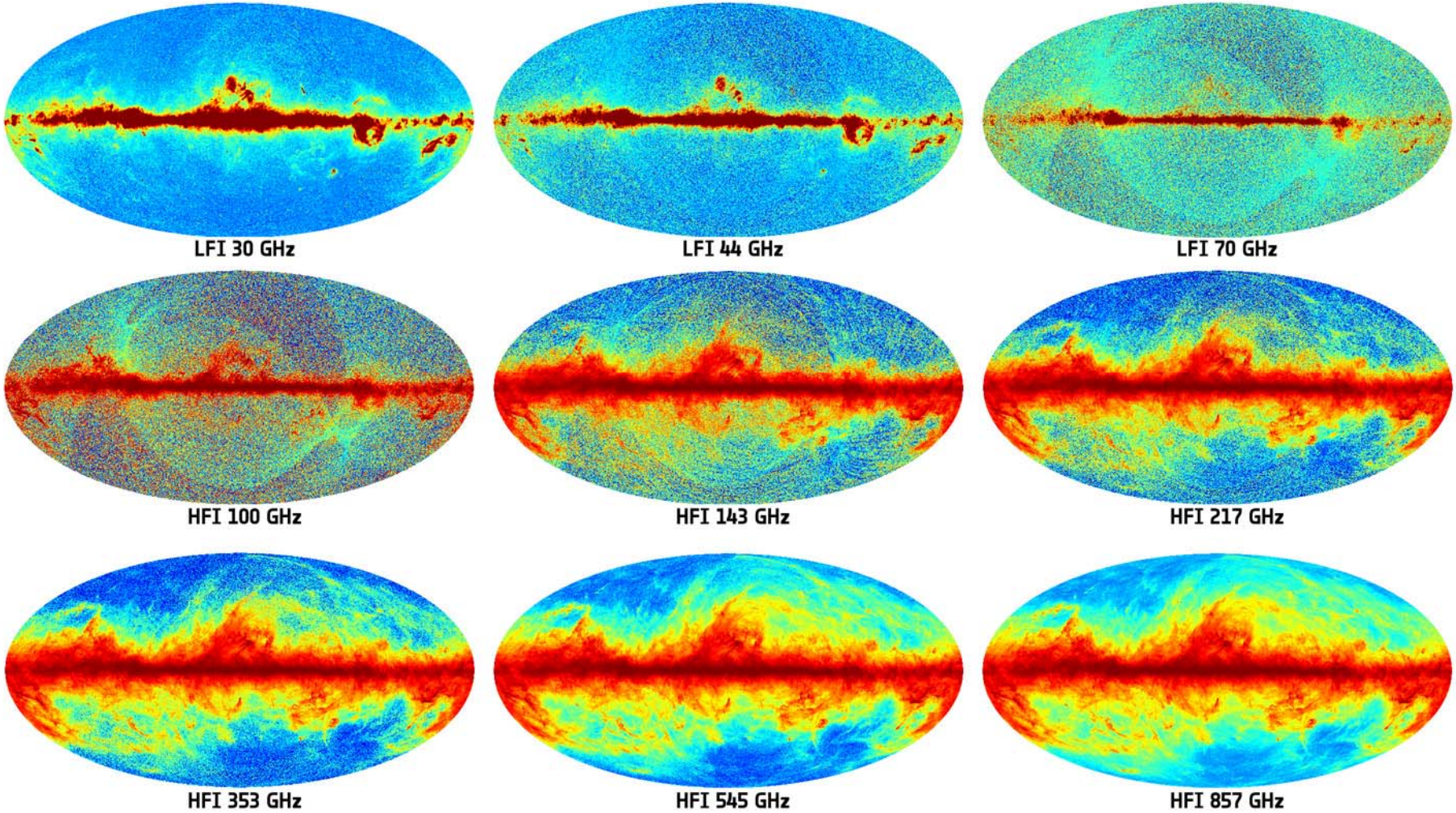
- The first two weeks



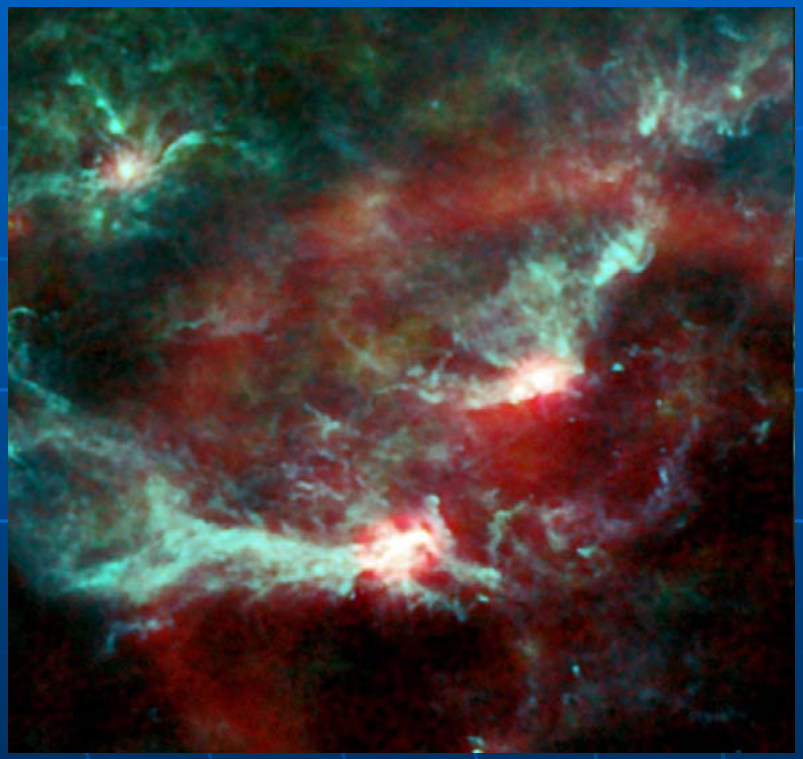
First all-sky image



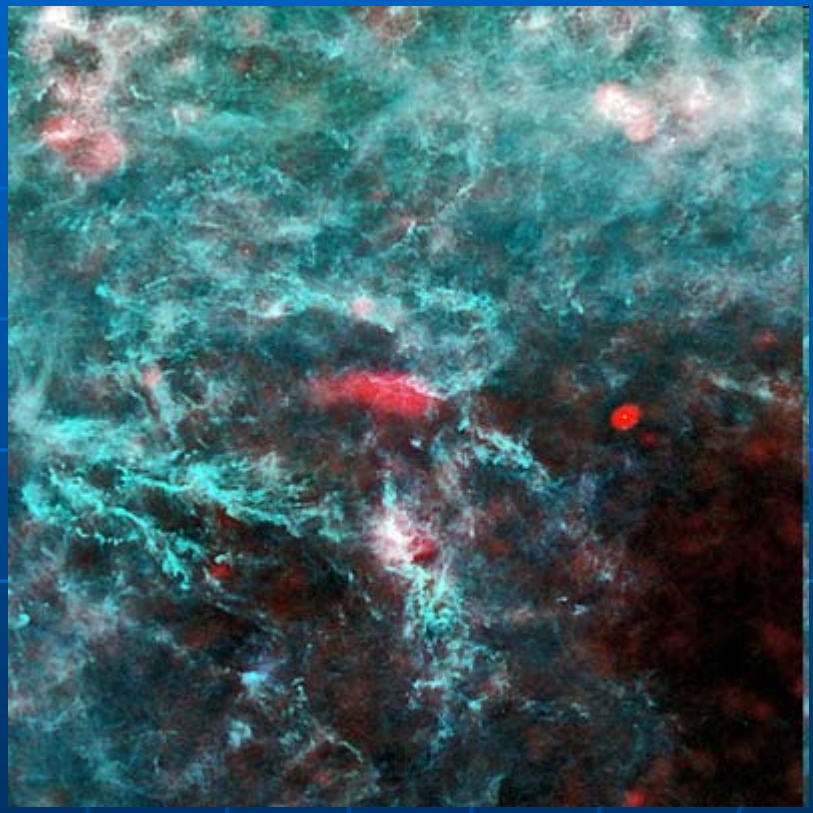
Planck all-sky foreground maps



Star formation



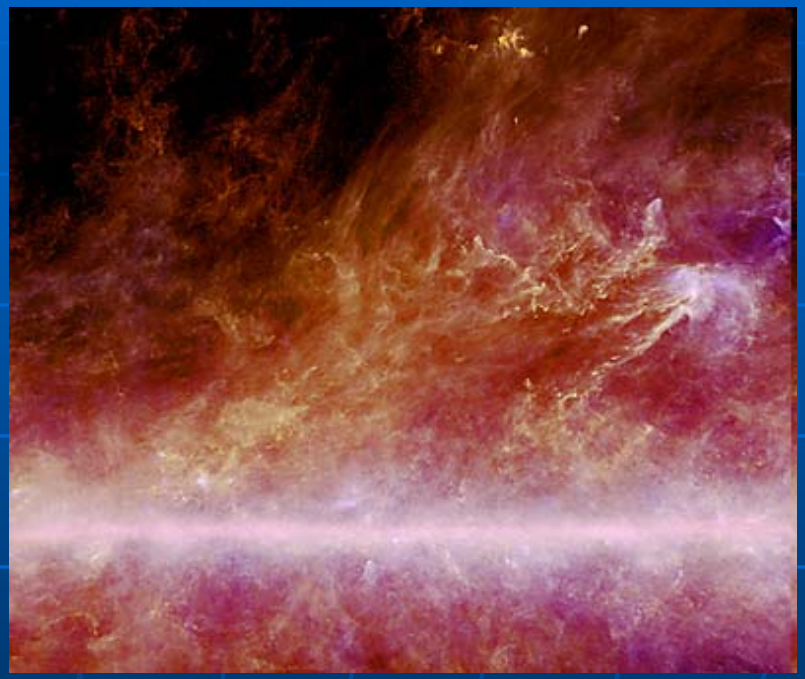
Orion



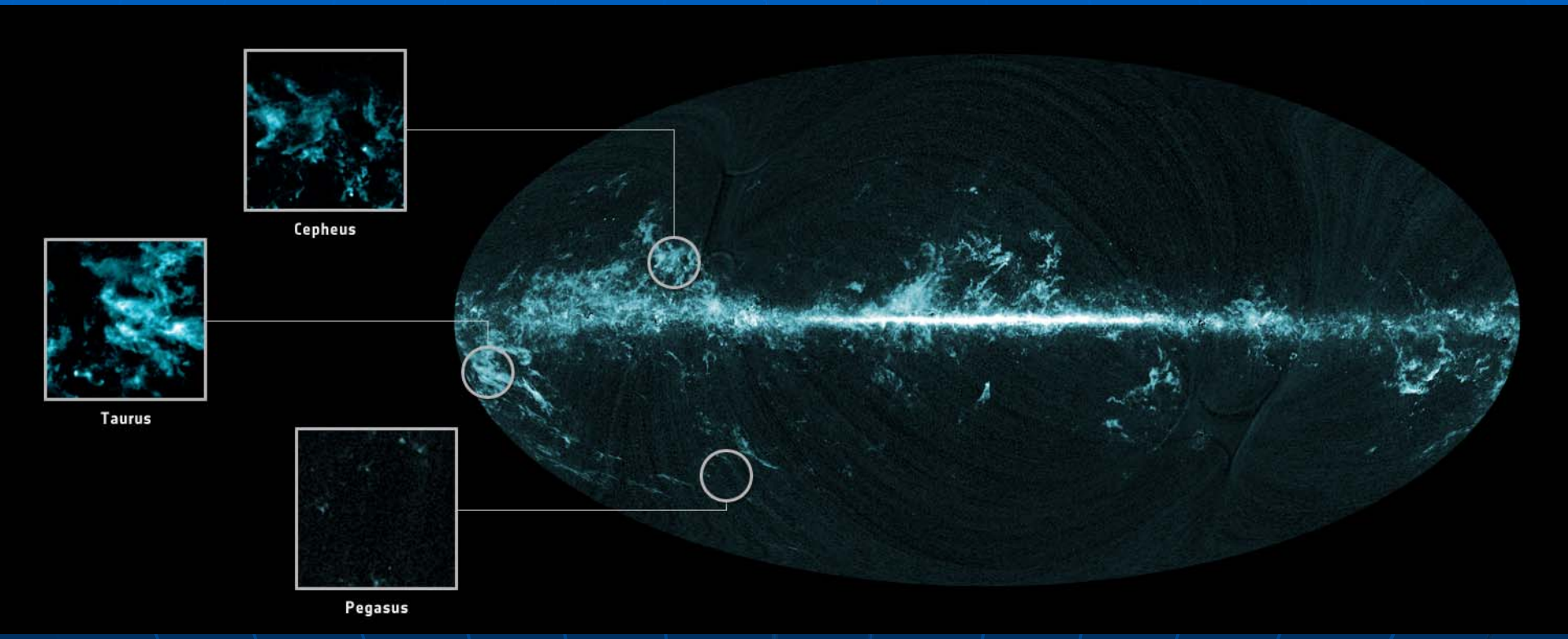
Perseus

Cold dust in the Galaxy

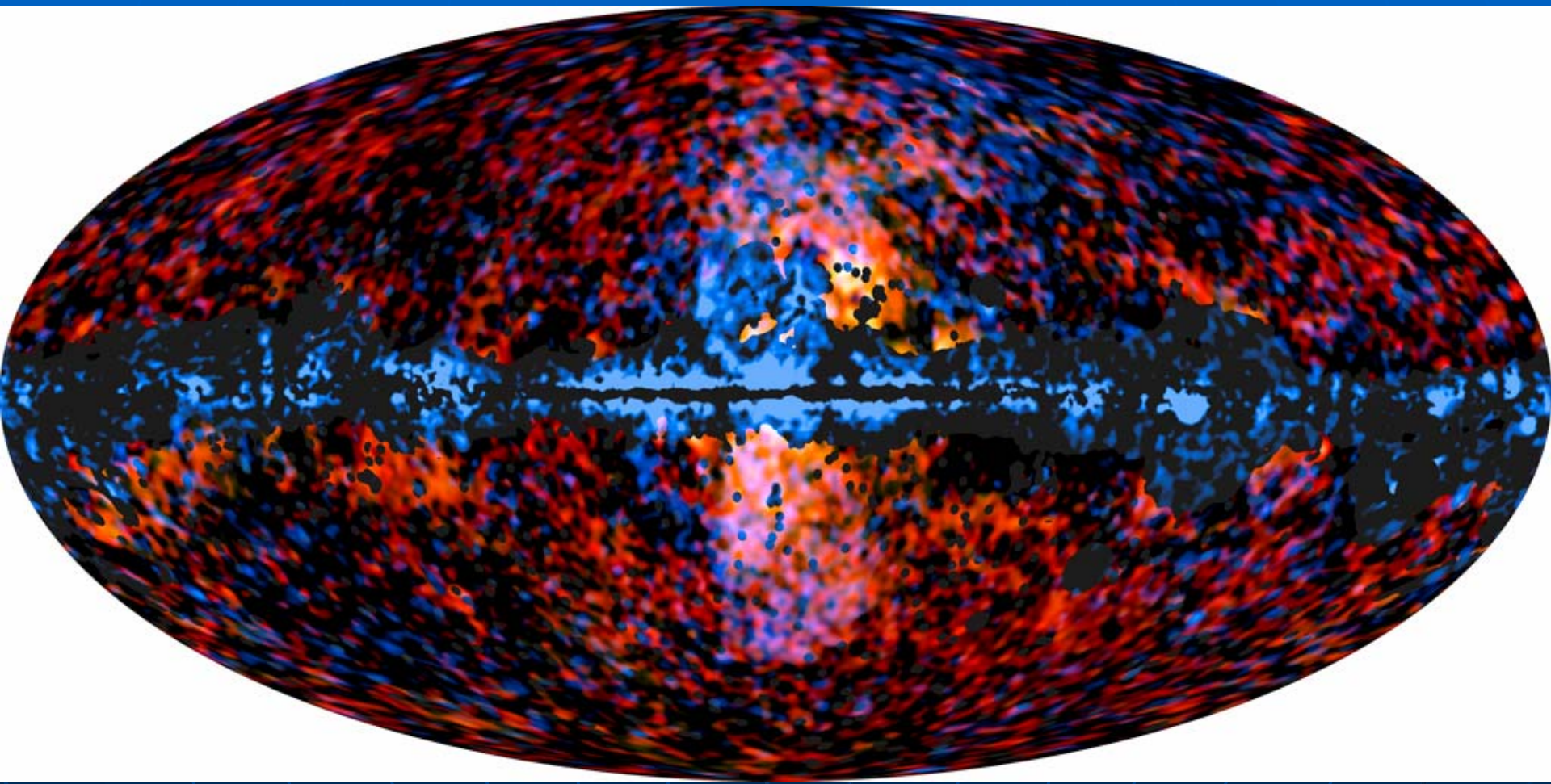
- Filamentary structure of dust in the solar neighbourhood, within about 500 light-years of the Sun.



CO in the Galaxy



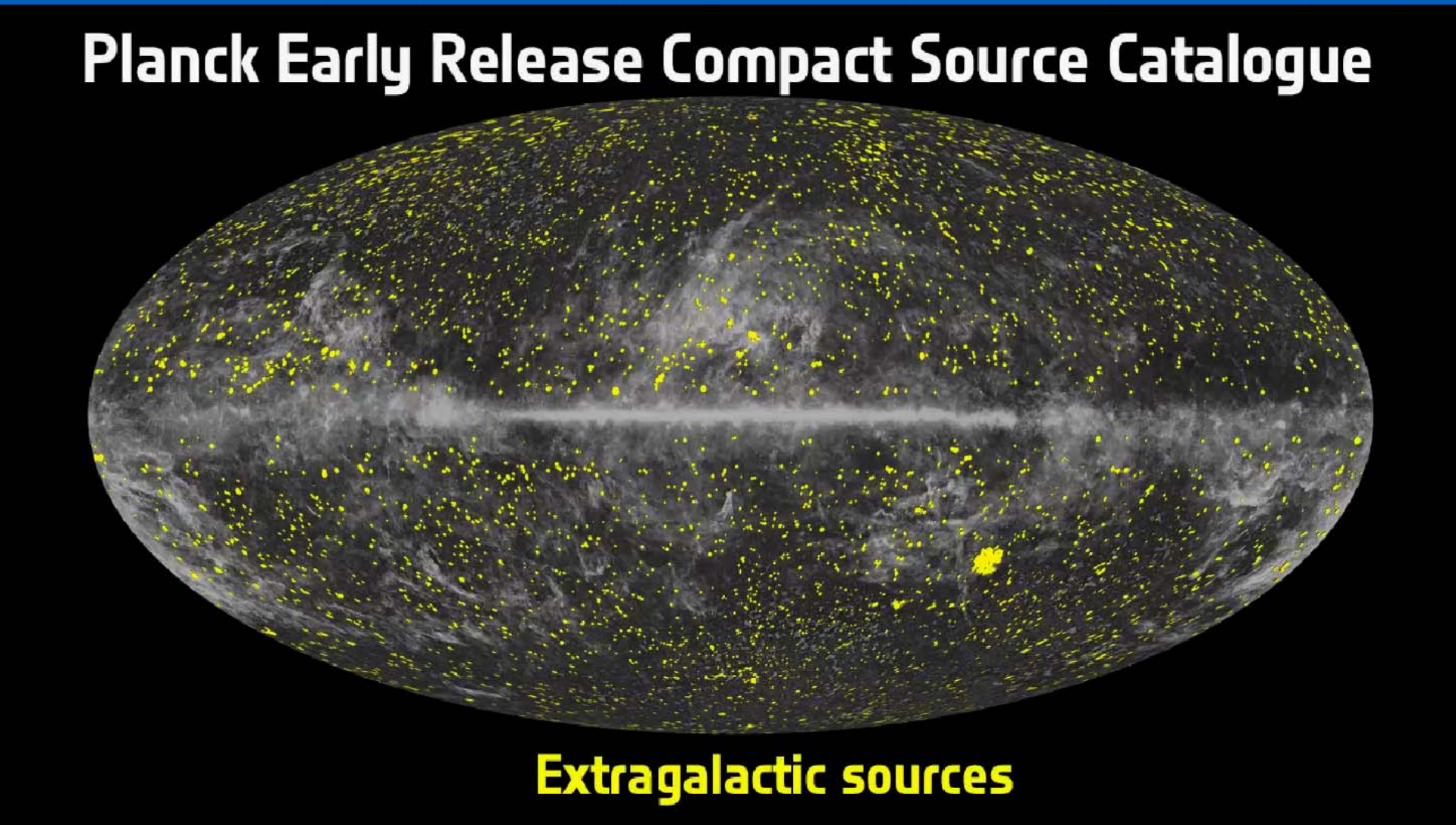
Galactic haze



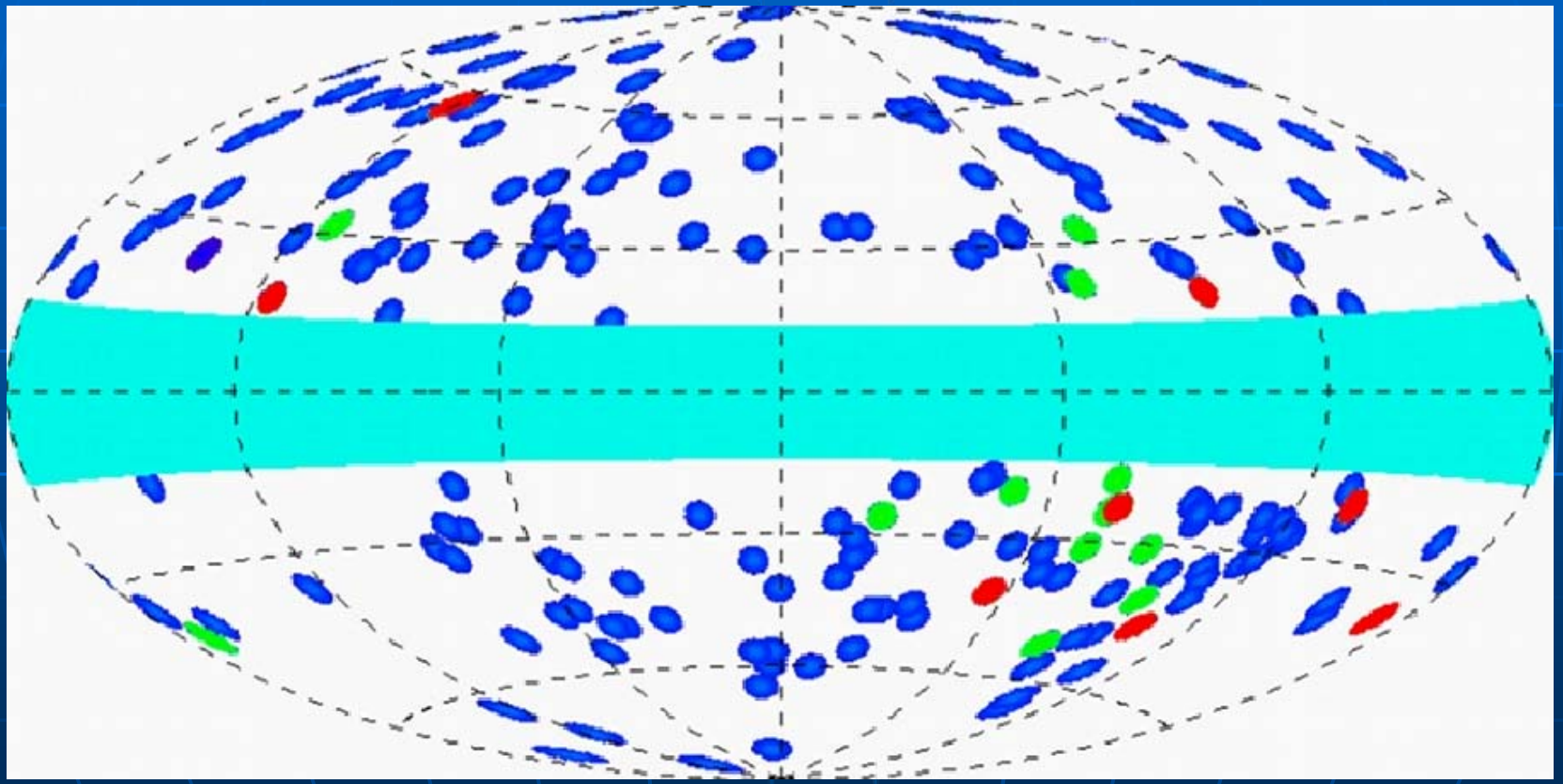
Planck 30 & 44 GHz

Fermi 10-100 GeV

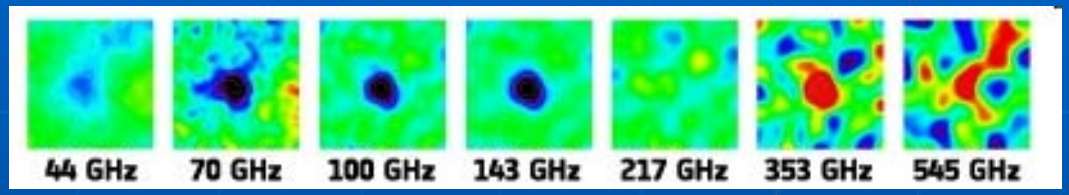
Extragalactic sources in ERCSC



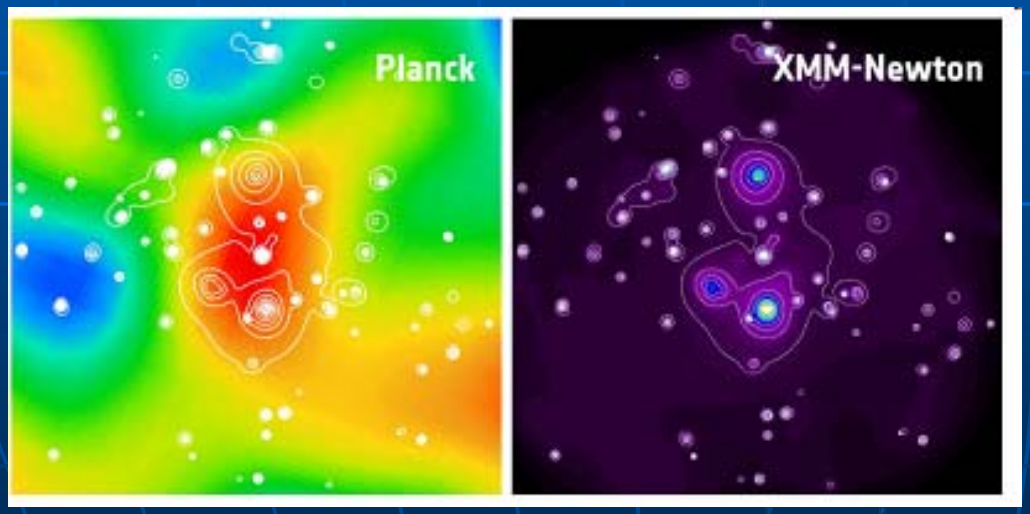
Early Sunyaev-Zel'dovich (ESZ) sample (part of ERCSC)



Galaxy clusters and superclusters

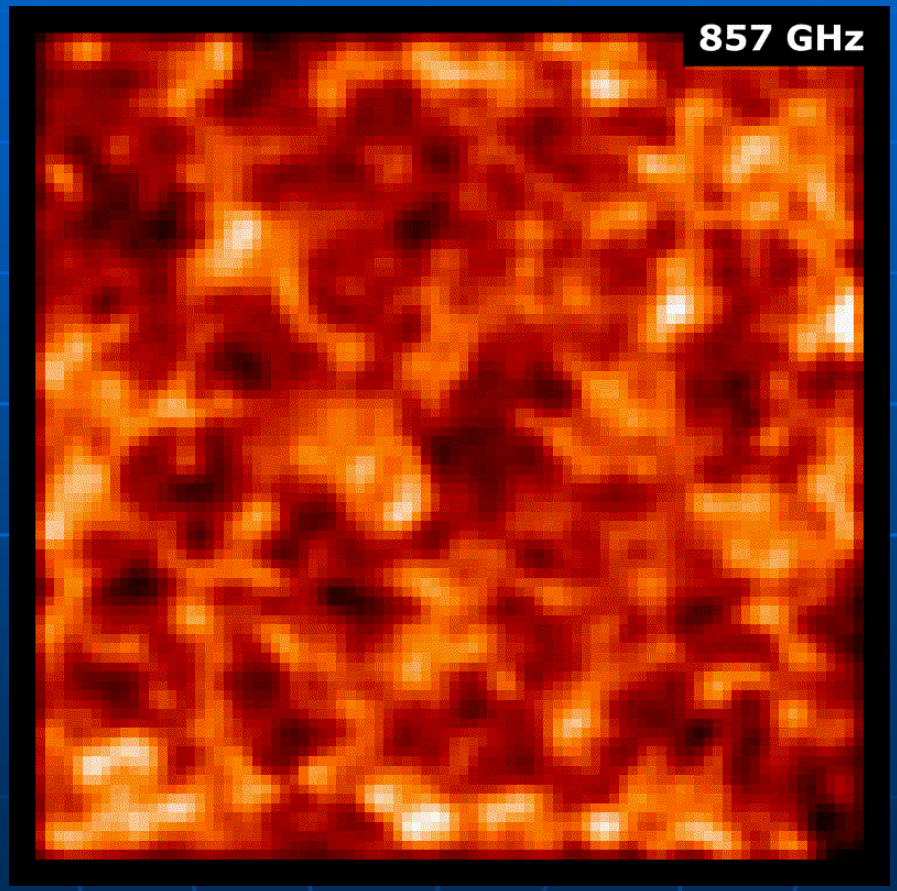


Abell 2319



A newly discovered supercluster

Cosmic Infrared Background (CIB)



Publications

- Technical papers in 2009: J. Inst. 4
- Pre-launch papers in 2010: Astronomy & Astrophysics 520
- **Early papers in 2011**: A&A 536, special issue
- Intermediate papers in 2012 & 2013
- ”Final” and cosmology papers in 2013 ->

- http://www.rssd.esa.int/planck/

Planck Early Results

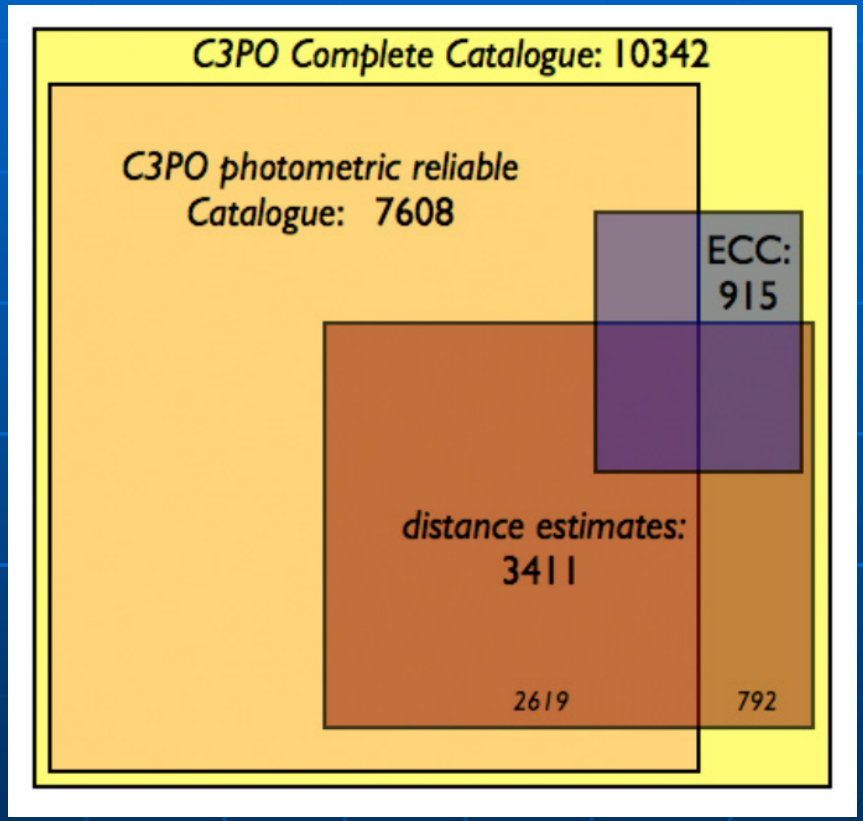
- 27 scientific papers published in Astronomy & Astrophysics (http://www.rssd.esa.int/planck/)
  - Galactic
  - Extragalactic
  - Galaxy clusters
- Many based on the Early Release Compact Source Catalog

”Planck Early Results. XXIII. The Galactic cold core population revealed by the first all-sky survey”

- Looking for cold and compact interstellar clouds that are potentially sites of future star formation

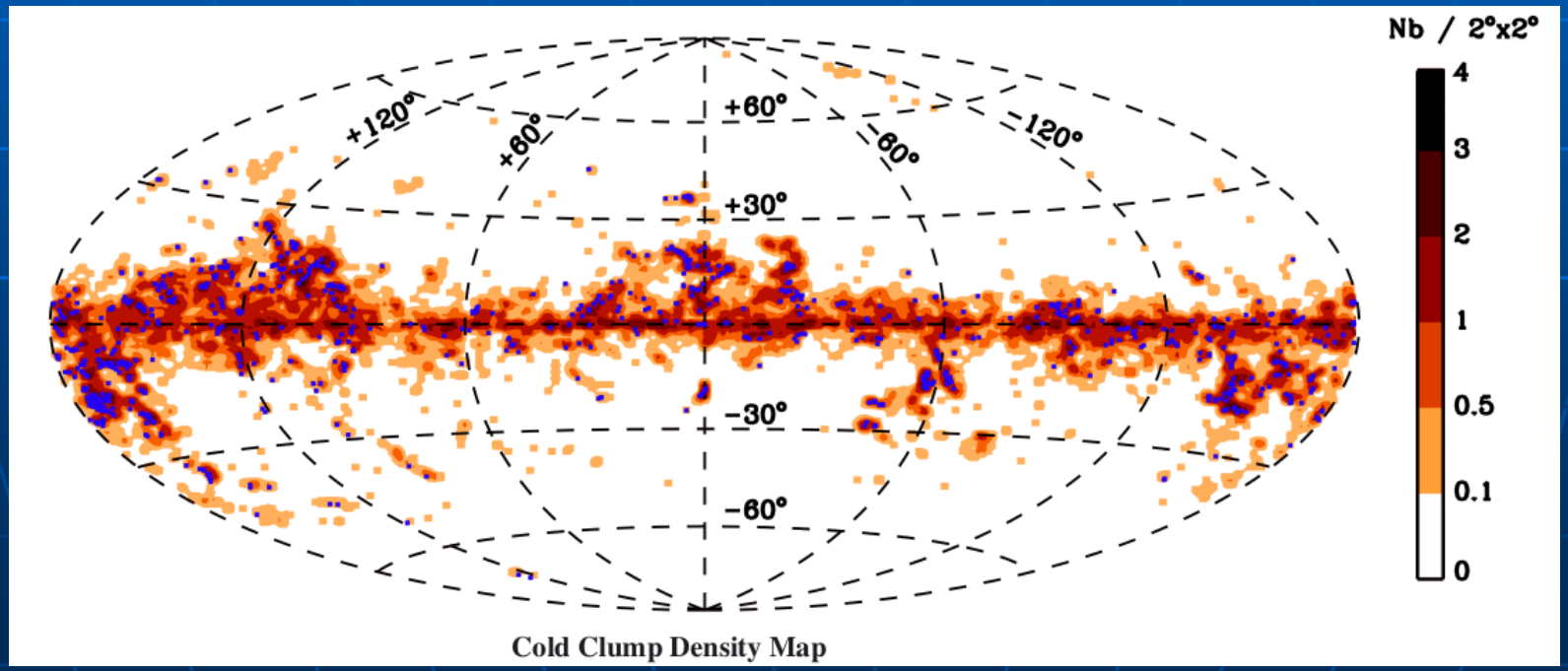
Cold Cores

- Final source catalogue will be published in 2013, the Early Cold Clumps catalogue (ECC) was made public with the ERCSC; ECC contained only the most reliable sources



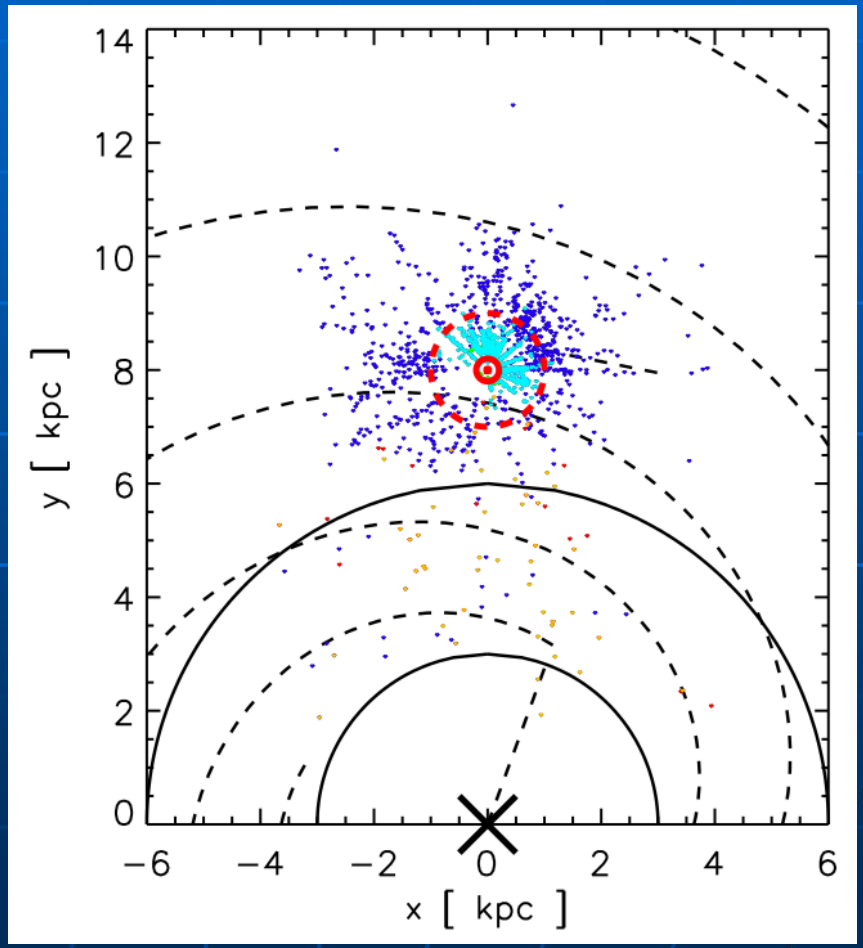
Cold Cores

- The detected sources cover all directions on the sky, most sources still being found near the Galactic plane



Cold Cores

- The distances have been derived with various methods, some sources are at kiloparsec distances but most are in the nearby molecular clouds

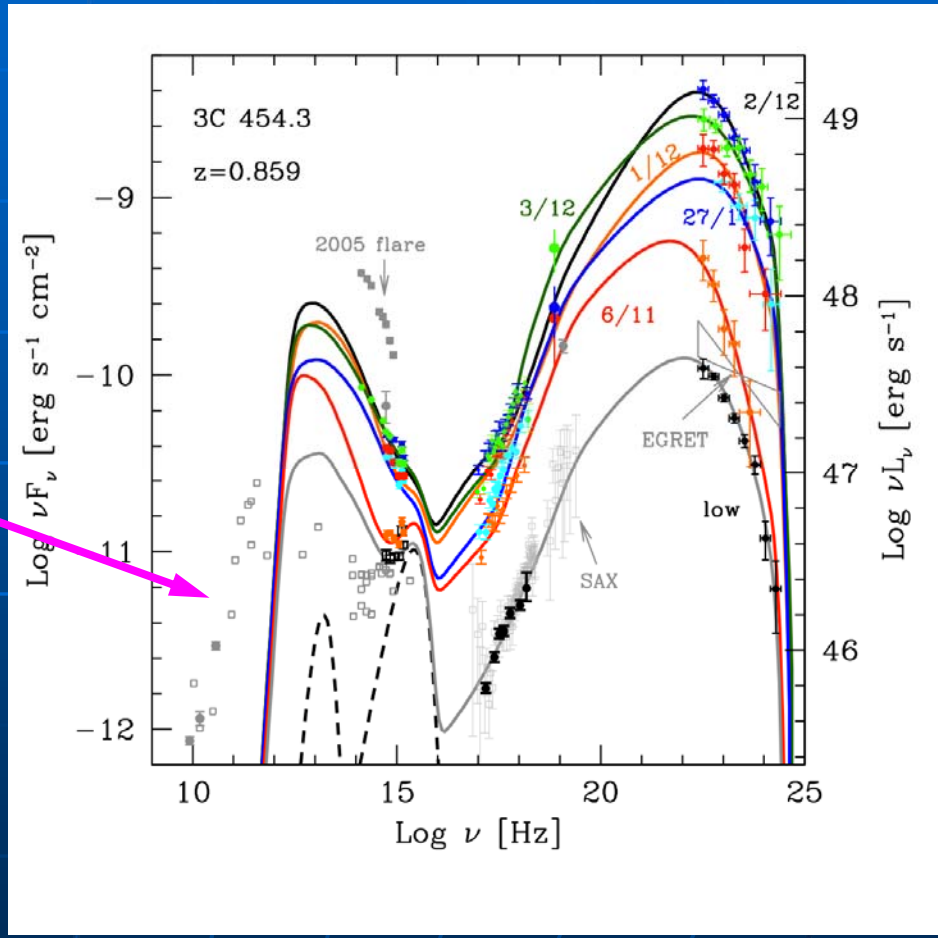


”Planck Early Results. XV. Spectral energy distributions and radio continuum spectra of northern extragalactic radio sources”

- Building Spectral Energy Distributions (SEDs) for a complete northern 1 Jy sample of 104 extragalactic radio sources (AGN) using simultaneous Planck, Fermi, and other multifrequency data

Spectral energy distributions, SEDs

- Contemporary models fit the high-energy inverse Compton part rather nicely, but (still) almost completely ignore the synchrotron (=radio) part which most likely is the source for the high-energy emission
- Extended SEDs from Planck
- Multicomponent (jet + shocks)

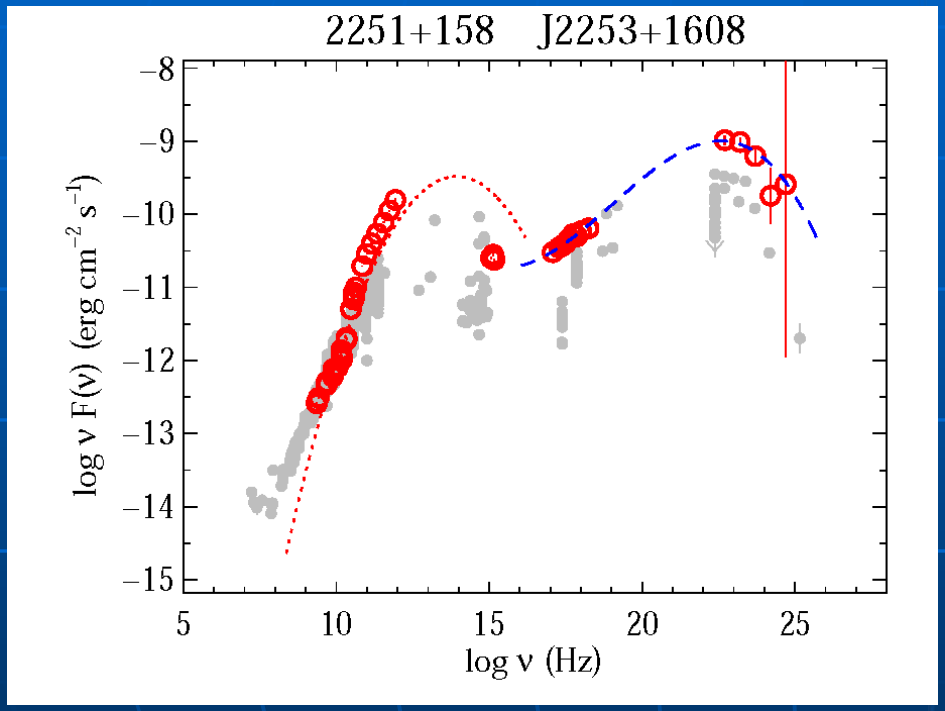


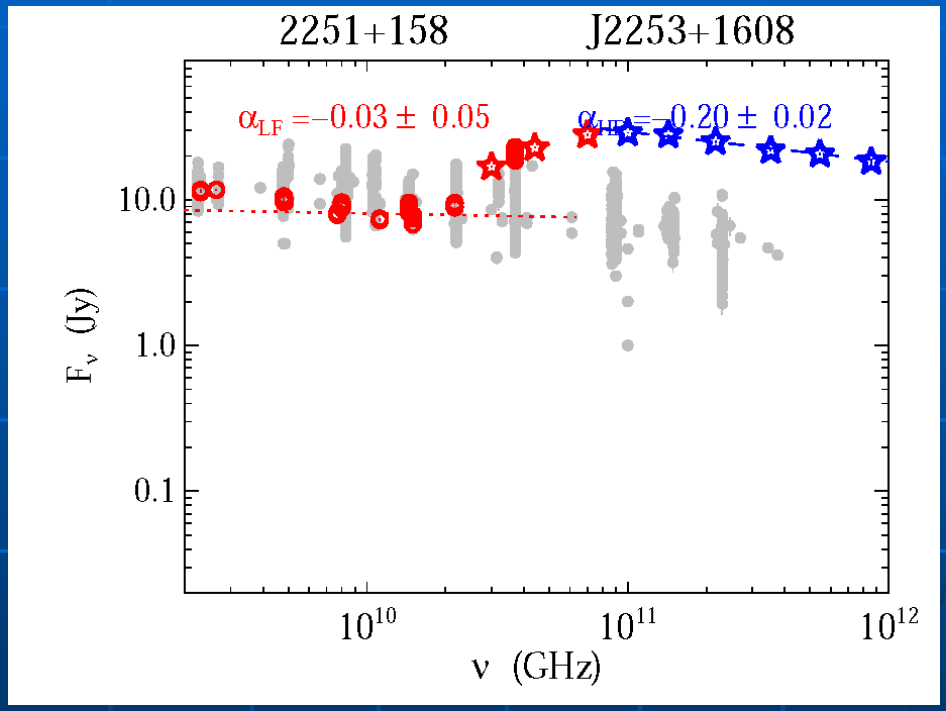
Bonnoli et al. 2010

The (simultaneous) data

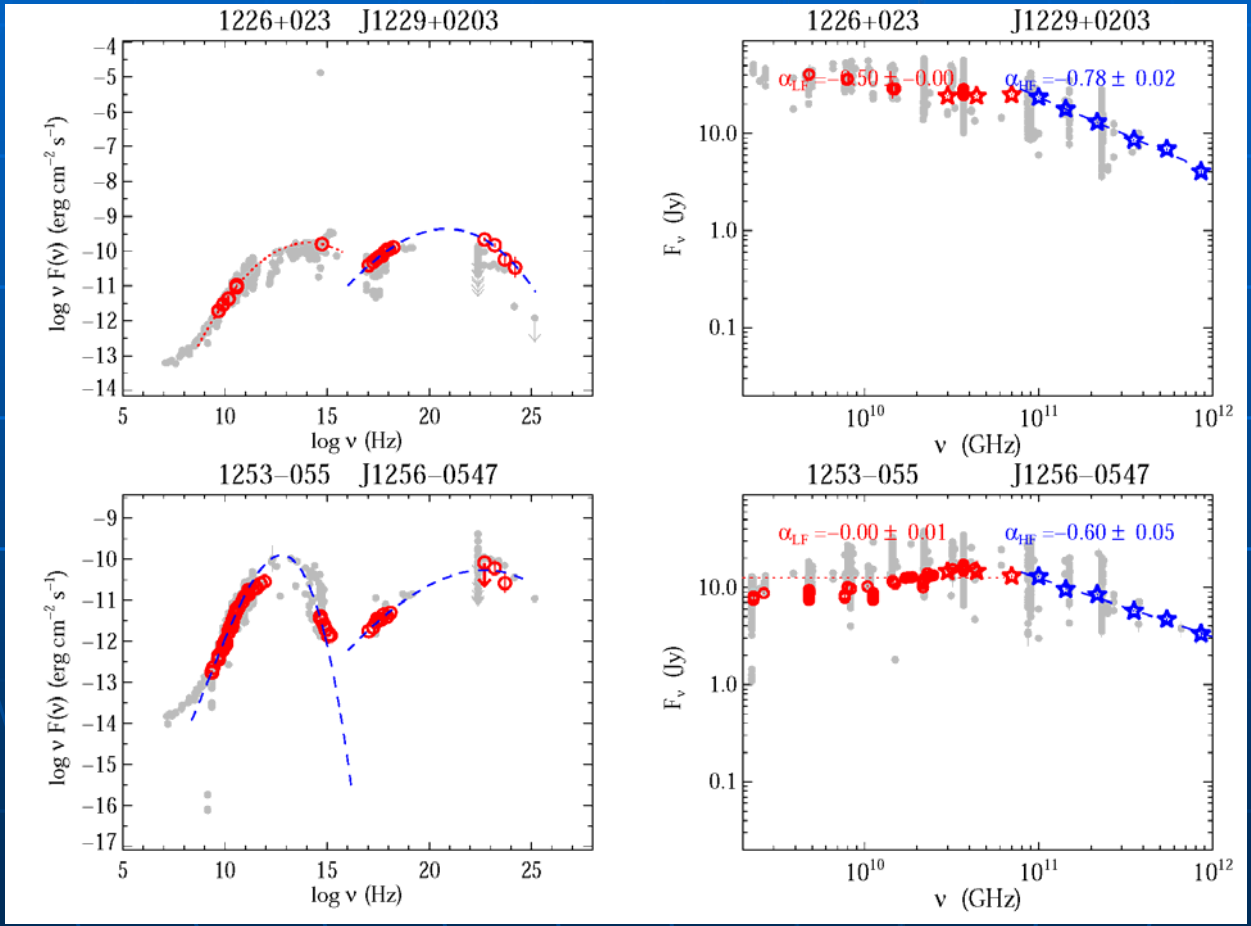
- Planck, 9 frequencies
- Radio
  - Metsähovi, RATAN-600, UMRAO, VLA, IRAM, Effelsberg, ATCA & APEX (southern sources), OVRO, Medicina
- Optical
  - Tuorla + KVA (La Palma), Xinglong, Liverpool 2m
- X-rays (+optical+UV)
  - Swift
- Gamma-rays
  - Fermi
- Target-of-Opportunity TeV
  - MAGIC, VERITAS

SED and radio spectrum of 2251+158 (3C 454.3)

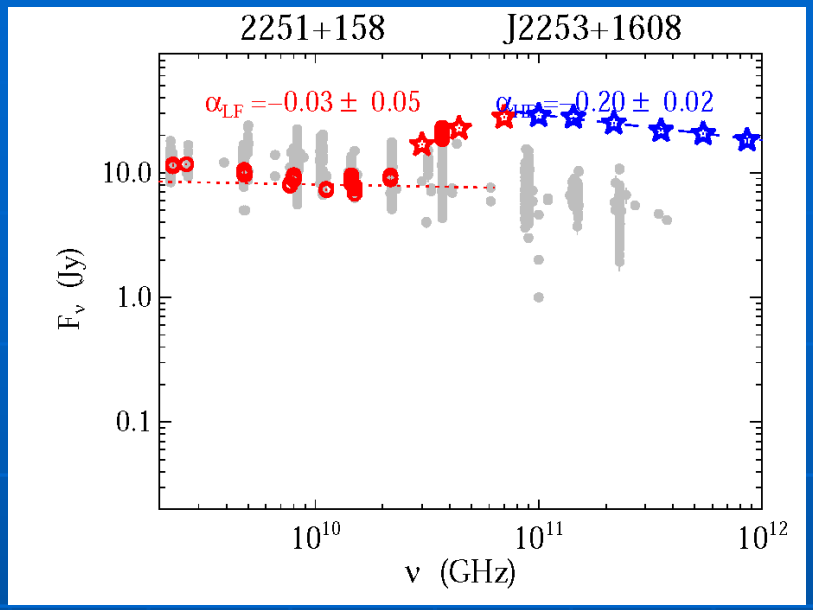


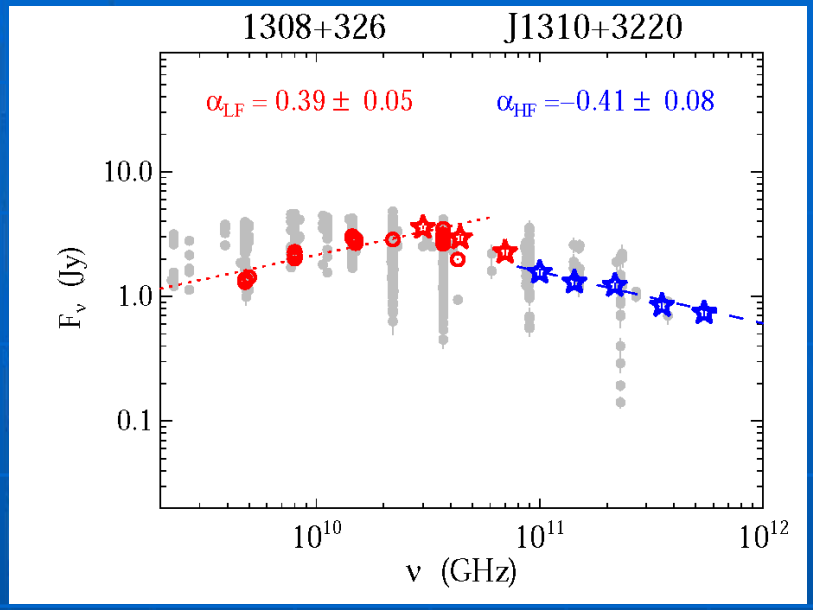


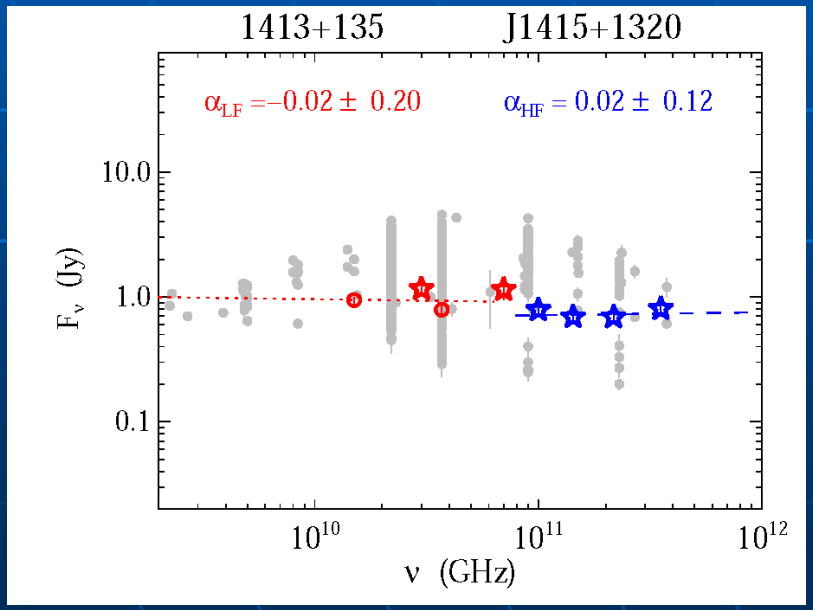
Examples of SEDs and radio spectra: 3C 273 and 3C 279

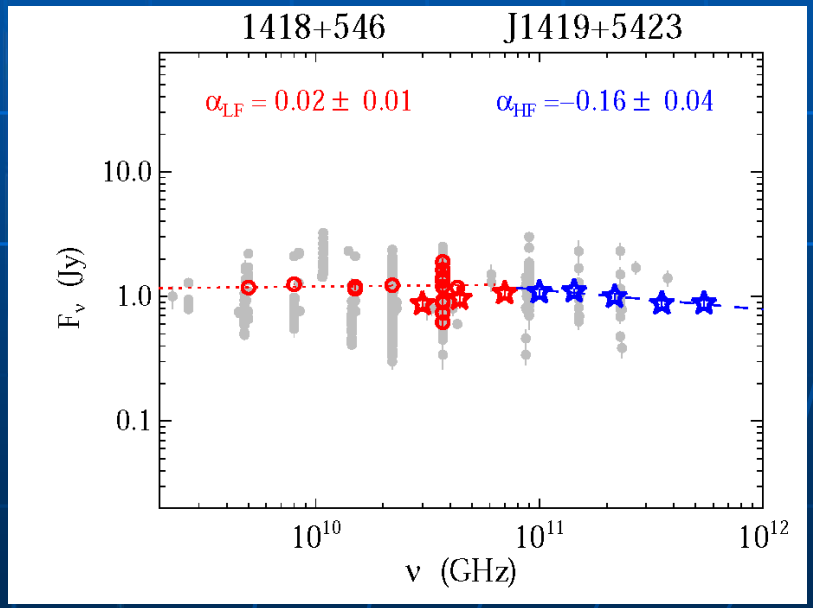


No room for mid-IR component, indicating that the IC emission also comes from the synchrotron component.

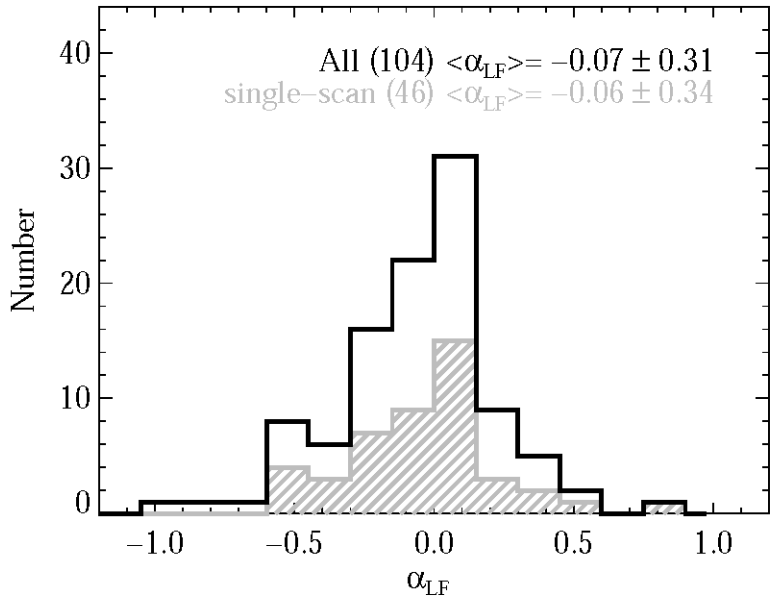

2251+158
J2253+1608
α_{LF} =–0.03 ± 0.05
α_{HF} =–0.20 ± 0.02
10.0
1.0
0.1
F_ν (Jy)
10^{10}
10^{11}
10^{12}
ν (GHz)

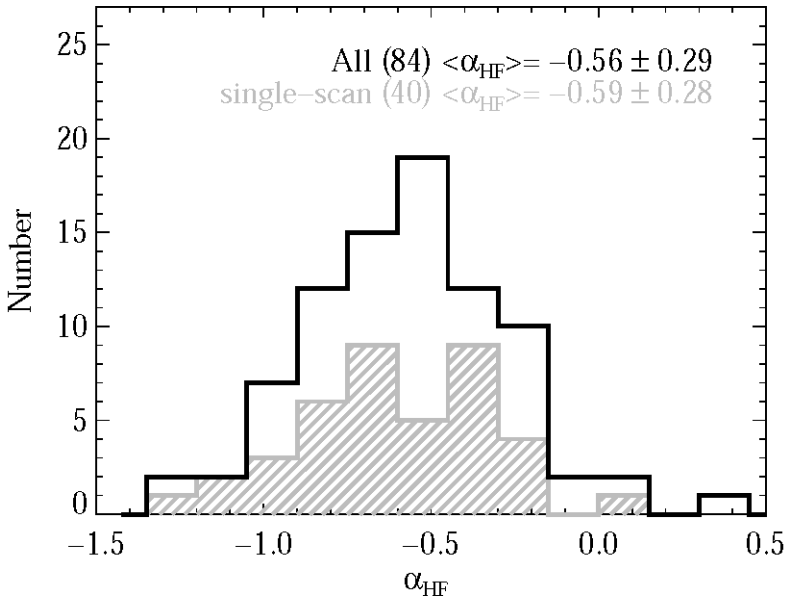

1308+326
J1310+3220
α_{LF} = 0.39 ± 0.05
α_{HF} =–0.41 ± 0.08
10.0
1.0
0.1
F_ν (Jy)
10^{10}
10^{11}
10^{12}
ν (GHz)


1413+135
J1415+1320
α_{LF} =–0.02 ± 0.20
α_{HF} = 0.02 ± 0.12
10.0
1.0
0.1
F_ν (Jy)
10^{10}
10^{11}
10^{12}
ν (GHz)


1418+546
J1419+5423
α_{LF} = 0.02 ± 0.01
α_{HF} =–0.16 ± 0.04
10.0
1.0
0.1
F_ν (Jy)
10^{10}
10^{11}
10^{12}
ν (GHz)

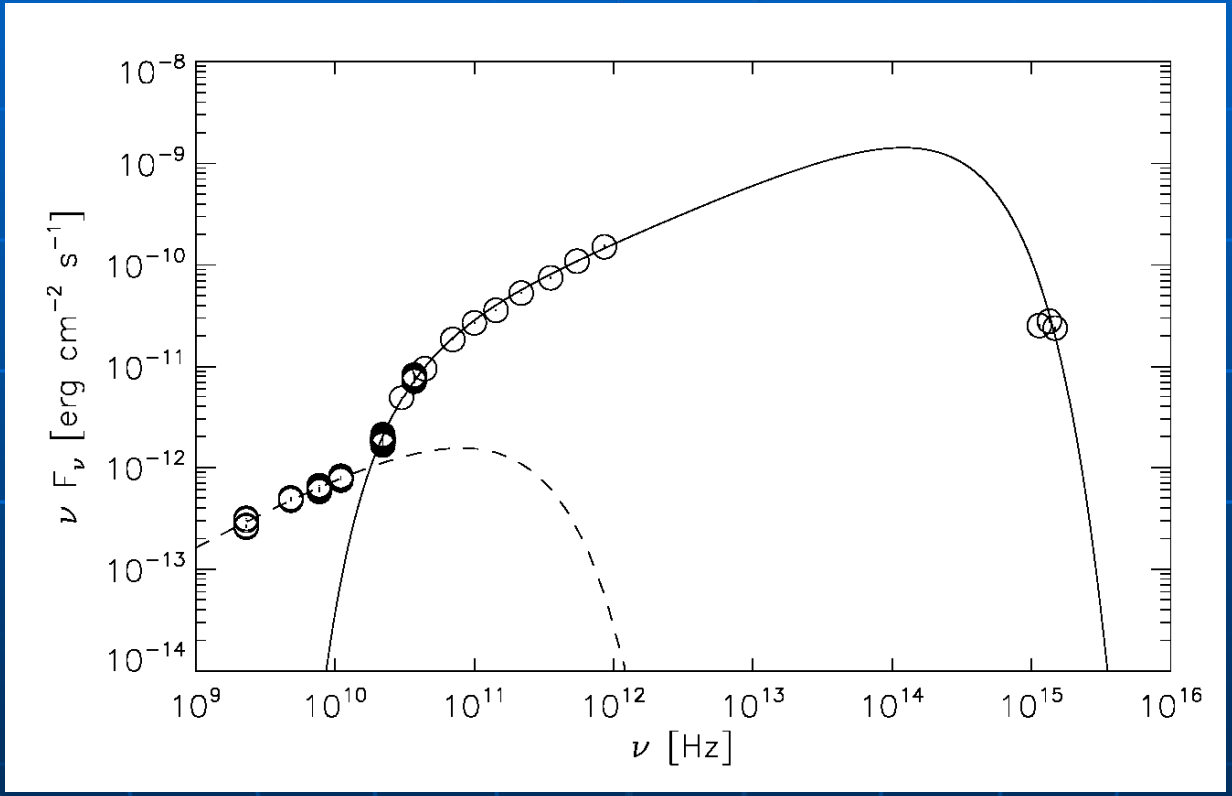
Flat high radio frequency spectra?

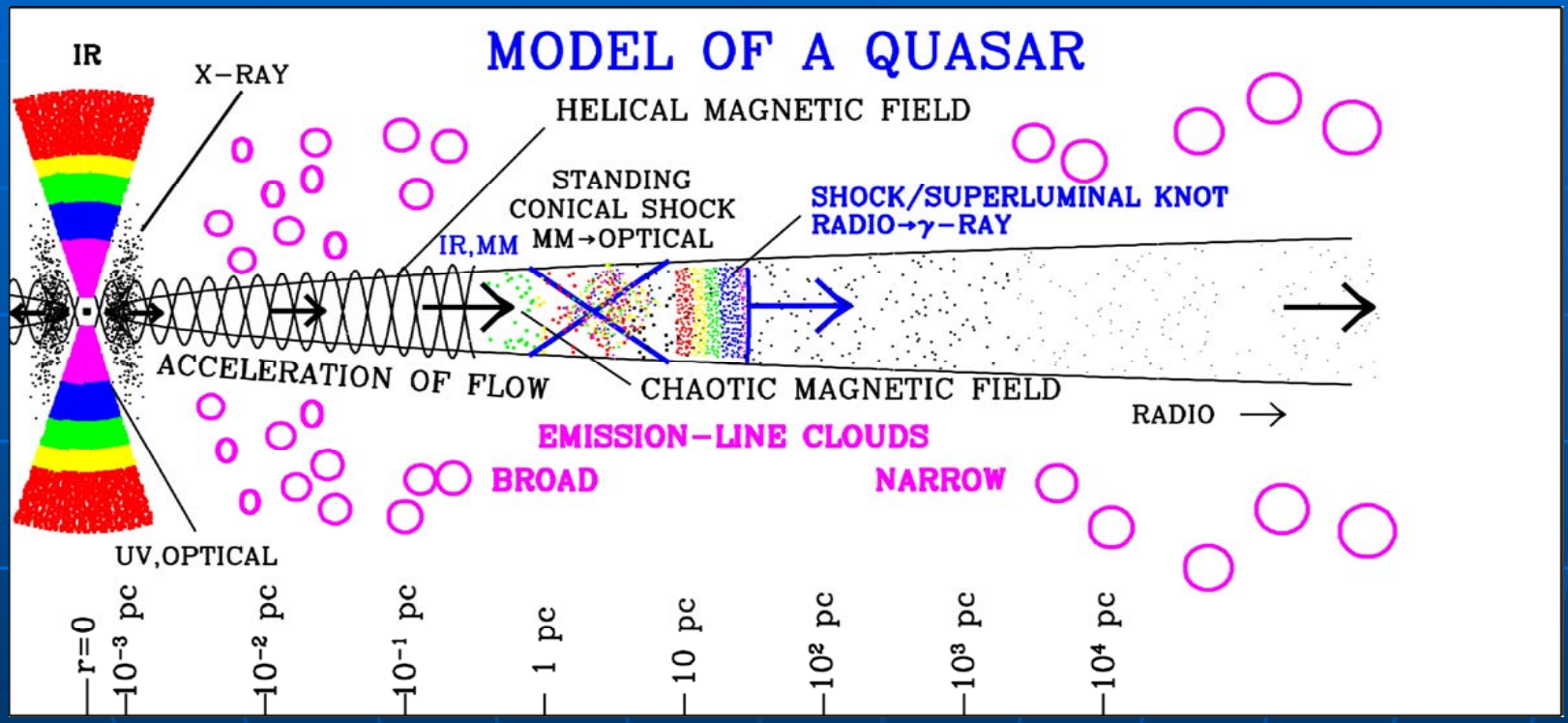




Smallest values of α_{thin} around -0.2 to -0.4 and a maximum around -0.7 indicate electron energy index s ≈ 1.5.

Example of multicomponent modelling: 3C 454.3




MODEL OF A QUASAR
IR
X−RAY
HELICAL MAGNETIC FIELD
STANDING
CONICAL SHOCK
MM→OPTICAL
IR,MM
SHOCK/SUPERLUMINAL KNOT
RADIO→γ−RAY
ACCELERATION OF FLOW
CHAOTIC MAGNETIC FIELD
RADIO
EMISSION−LINE CLOUDS
BROAD
NARROW
UV,OPTICAL
r=0
10⁻³ pc
10⁻² pc
10⁻¹ pc
1 pc
10 pc
10² pc
10³ pc
10⁴ pc

The scientific results that we present today 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.

To be continued...