

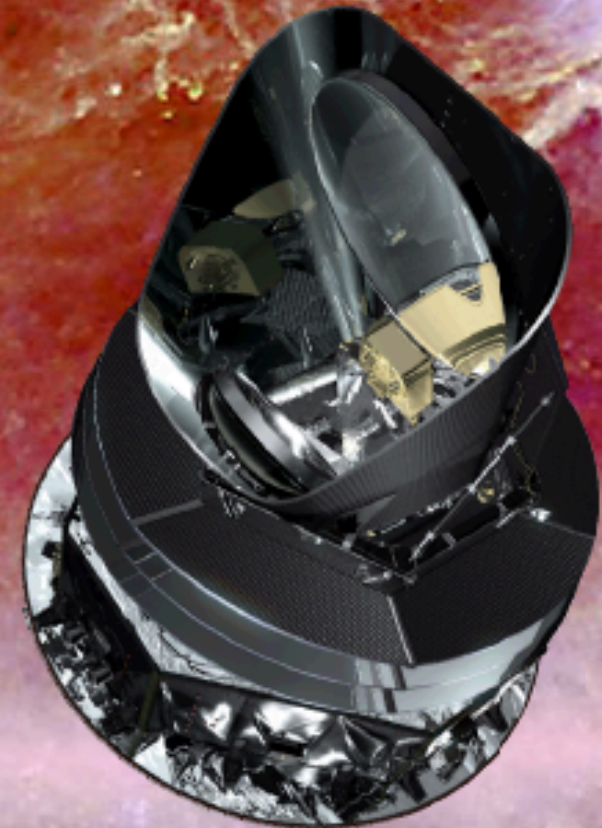
Astrophysical foregrounds from the Planck mission: lessons for the ALMA era

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On behalf of the *Planck* Collaboration

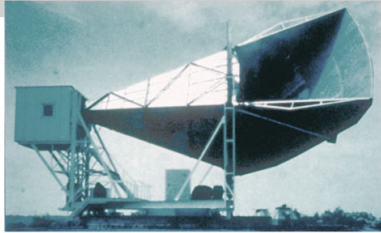
**Secondo Workshop
sull'Astronomia millimetrica e submillimetrica
in Italia**

Bologna, 2-3 Aprile 2012

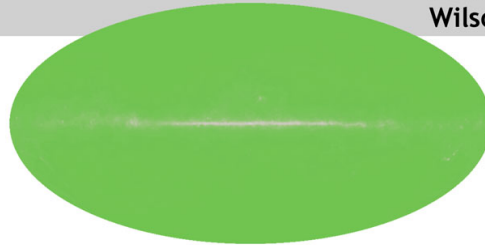


CMB space missions Overview

1965



Penzias and Wilson



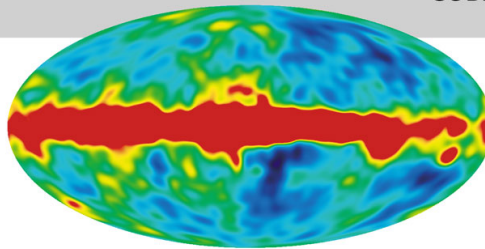
The oldest light or the first light of the Universe

Discovered the remnant afterglow from the **Big Bang**.
→ **2.7 K**

1992

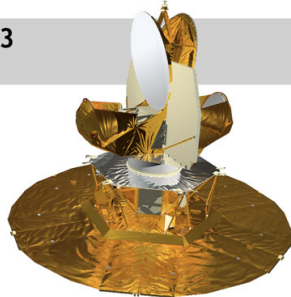


COBE

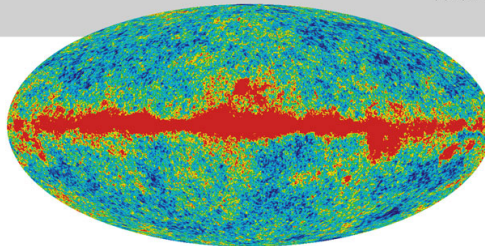


Blackbody radiation,
Discovered the patterns (**anisotropy**) in the afterglow.
→ **angular scale ~ 7°** at a level $\Delta T/T$ of 10^{-5}

2003

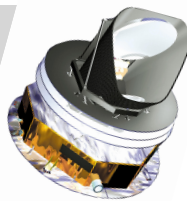


WMAP

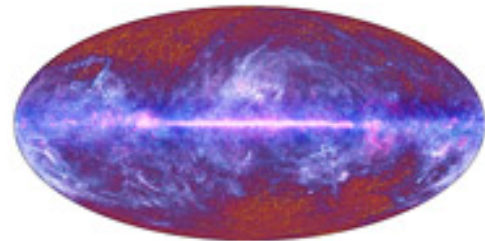


(Wilkinson Microwave Anisotropy Probe):
→ **angular scale ~ 15'**

2009



Planck



→ **angular scale ~ 5'**,
 $\Delta T/T \sim 2 \times 10^{-6}$, 30~867 Hz

COBE - 1989

4-years data



Why Planck?

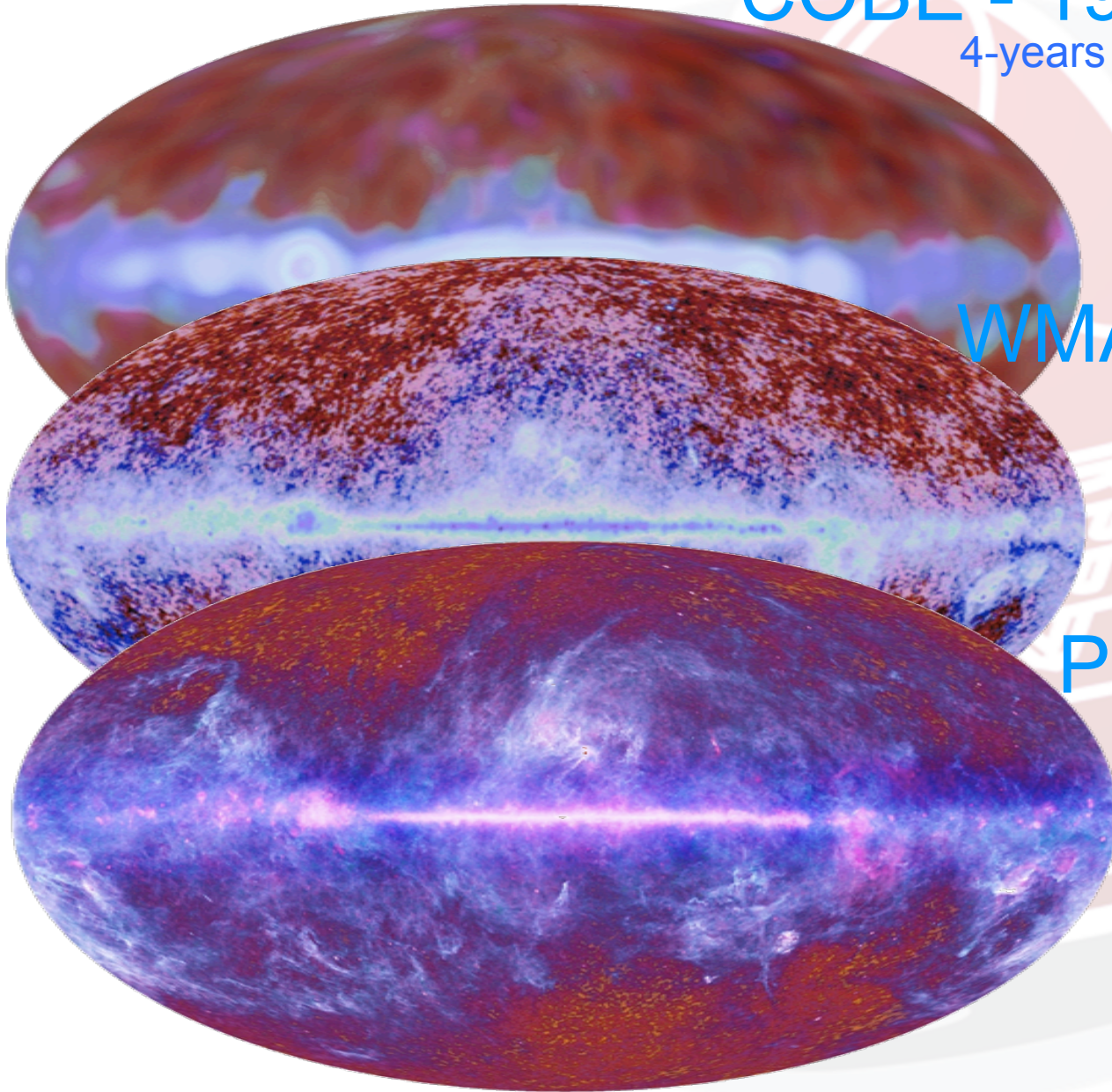
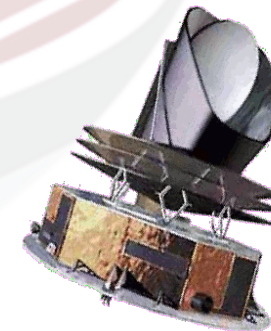
WMAP - 2001

7-years data



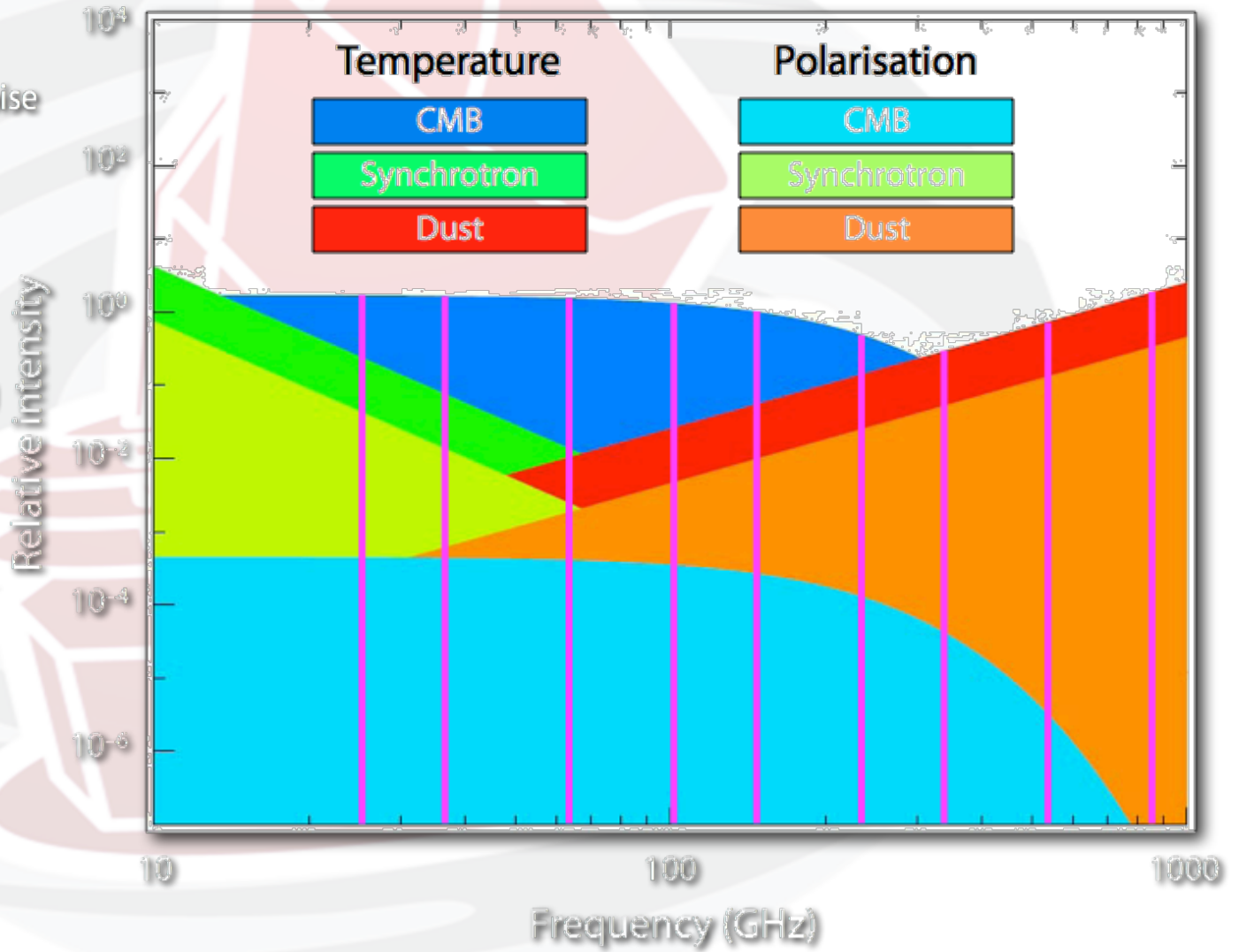
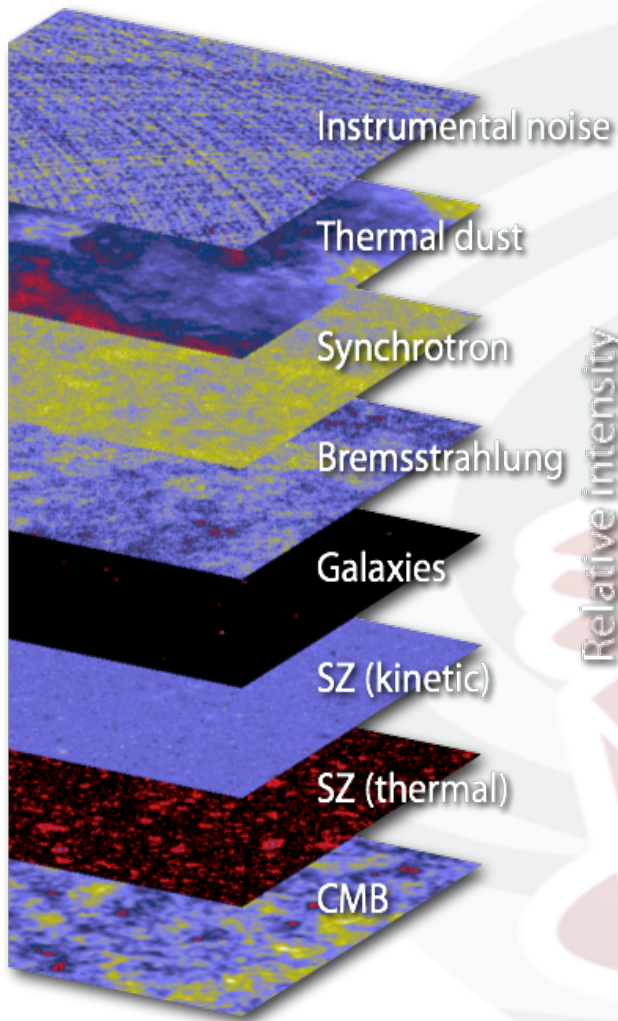
PLANCK - 2009

6-months data



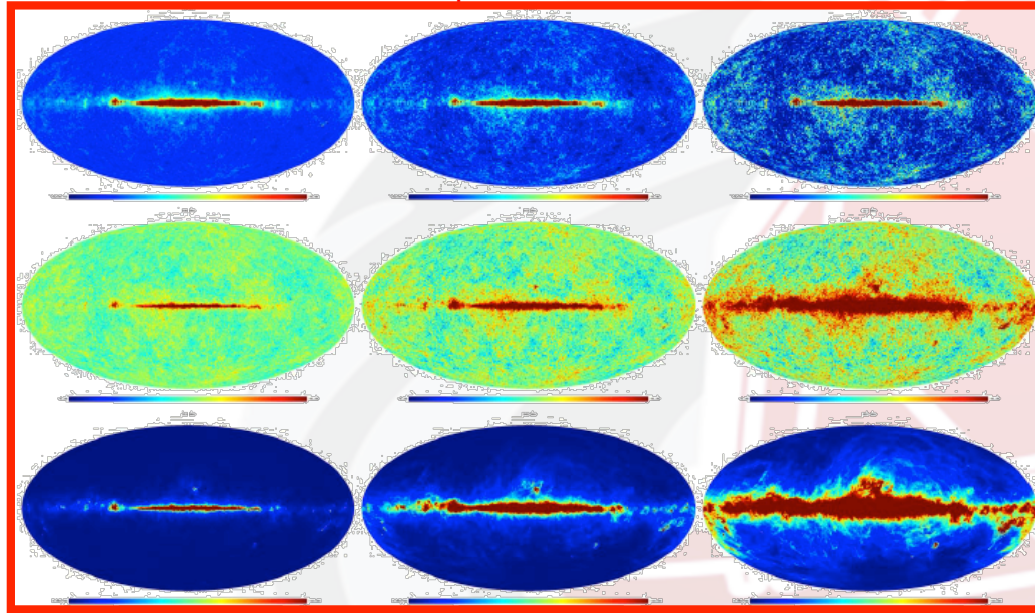
C. Burigana, Bologna, 2-3/4/2012



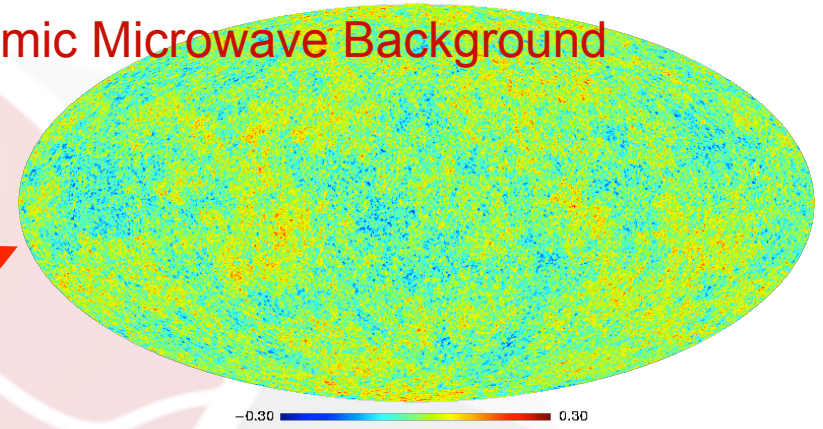


Expected results from simulations

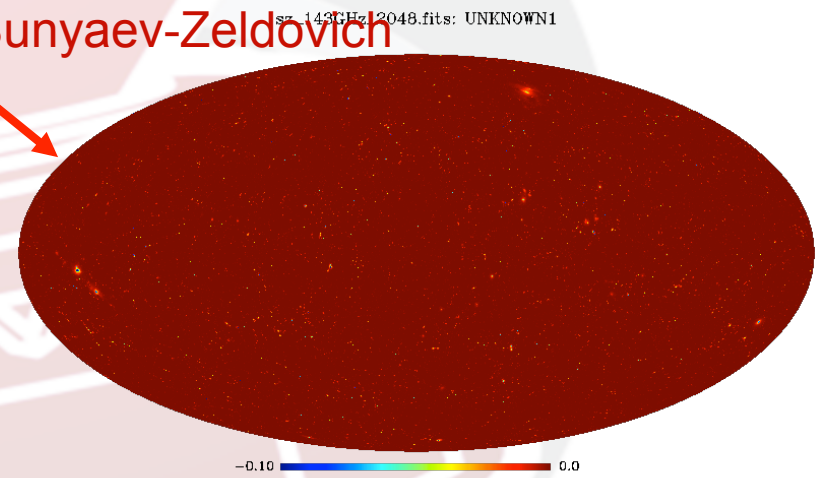
30, 44, 70, 100, 143, 217, 353, 545, 857 GHz – I, Q, U at all channels
Except 545 & 857 GHz



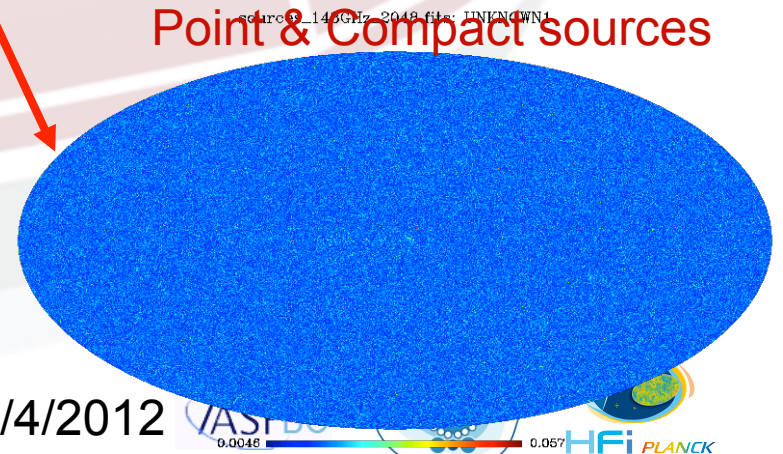
Cosmic Microwave Background



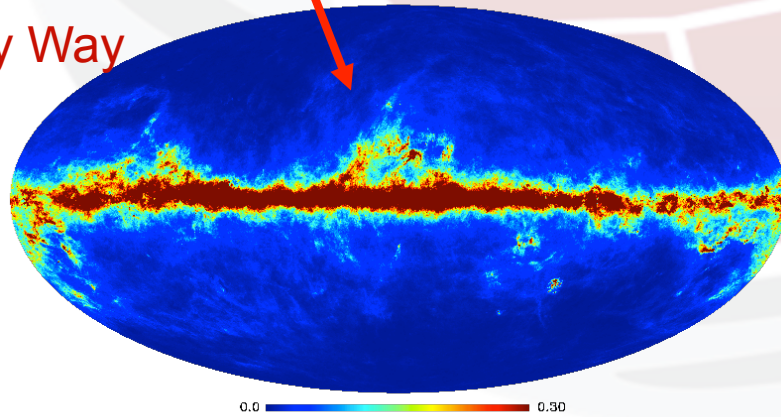
Sunyaev-Zeldovich



Point & Compact sources



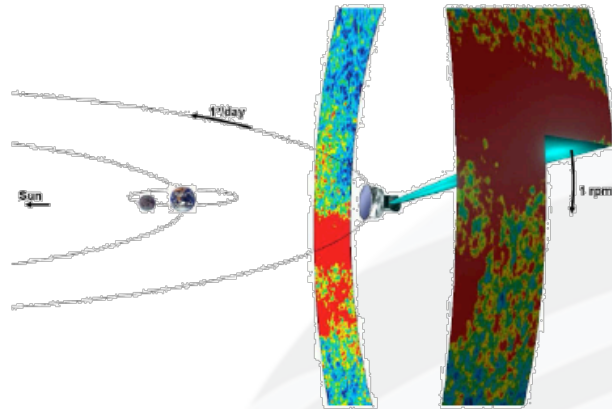
The Milky Way



Current Status

- @ 3 April 2012: 1154 days of operation since launch
- Satellite and instruments worked/working nominally and continuously since start of sky surveys (mid August 2009)
- Sky coverage is 100%
 - **All the sky has been surveyed for about 29.5 months, i.e. about five times with both instruments HFI + LFI, until the end of the cold phase (14 January 2012)**
 - **A further 12 months extension (up to the end of 2012 – beginning of 2013) has been approved (and indeed on-going) with LFI only**
 - **On 30 January 2012, Planck-LFI has started its sixth all-sky survey**

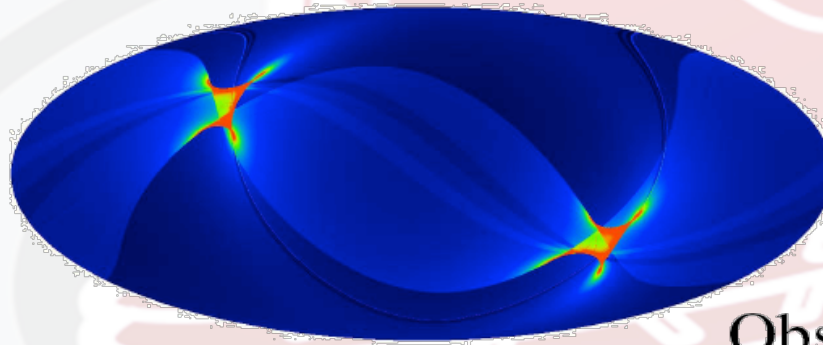




Planck is a survey mission

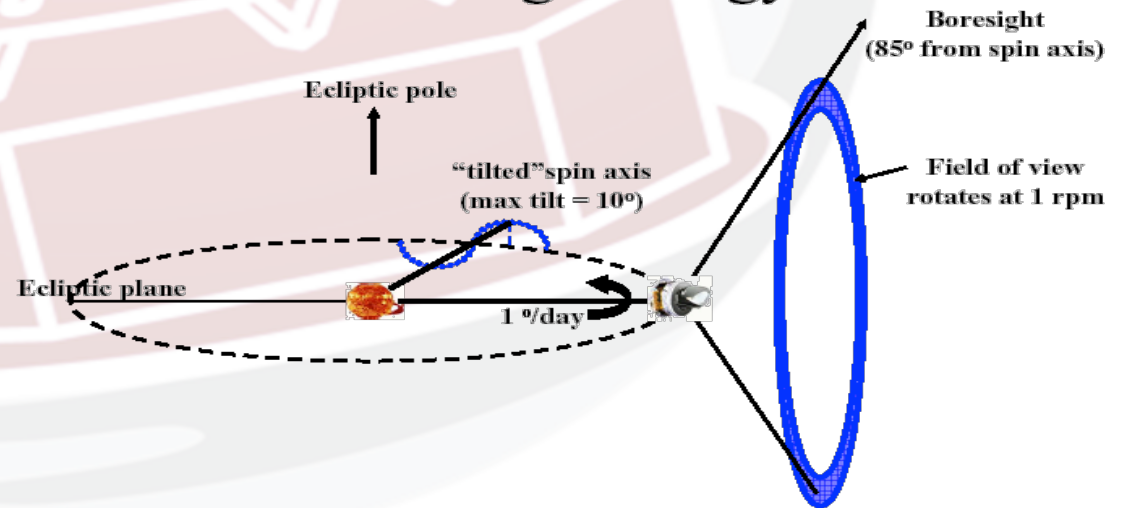
Planck Scanning Strategy

About 6 months are needed to cover ~95% of the sky.



Observing strategy

During LFI only phase Scanning strategy combines standard mode with deep annuli on calibration sources to improve the quality of calibration and systematic effect control



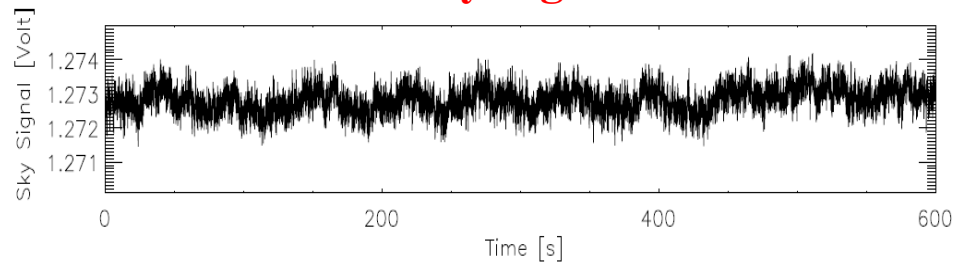
C. Burigana, Bologna, 2-3/4/2012



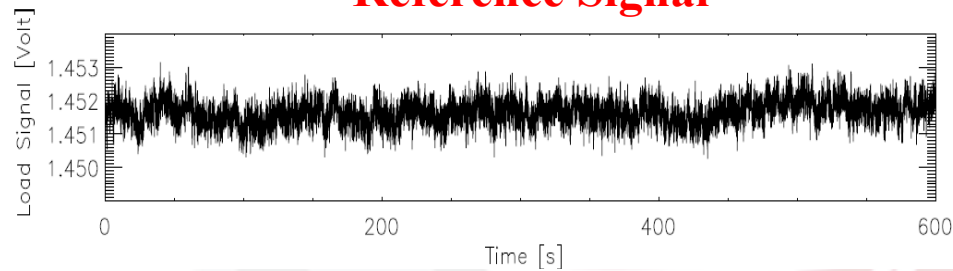
Planck-LFI: rough data

10min of flight data – 1/44 LFI detectors

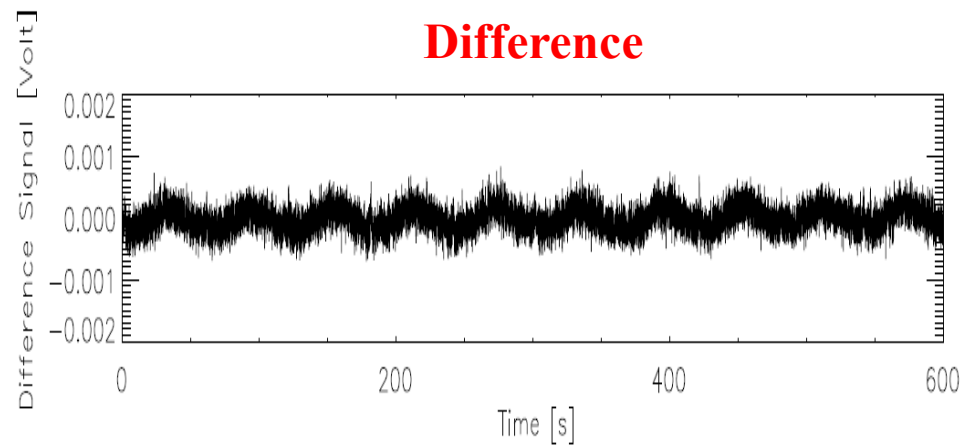
Sky Signal



Reference Signal

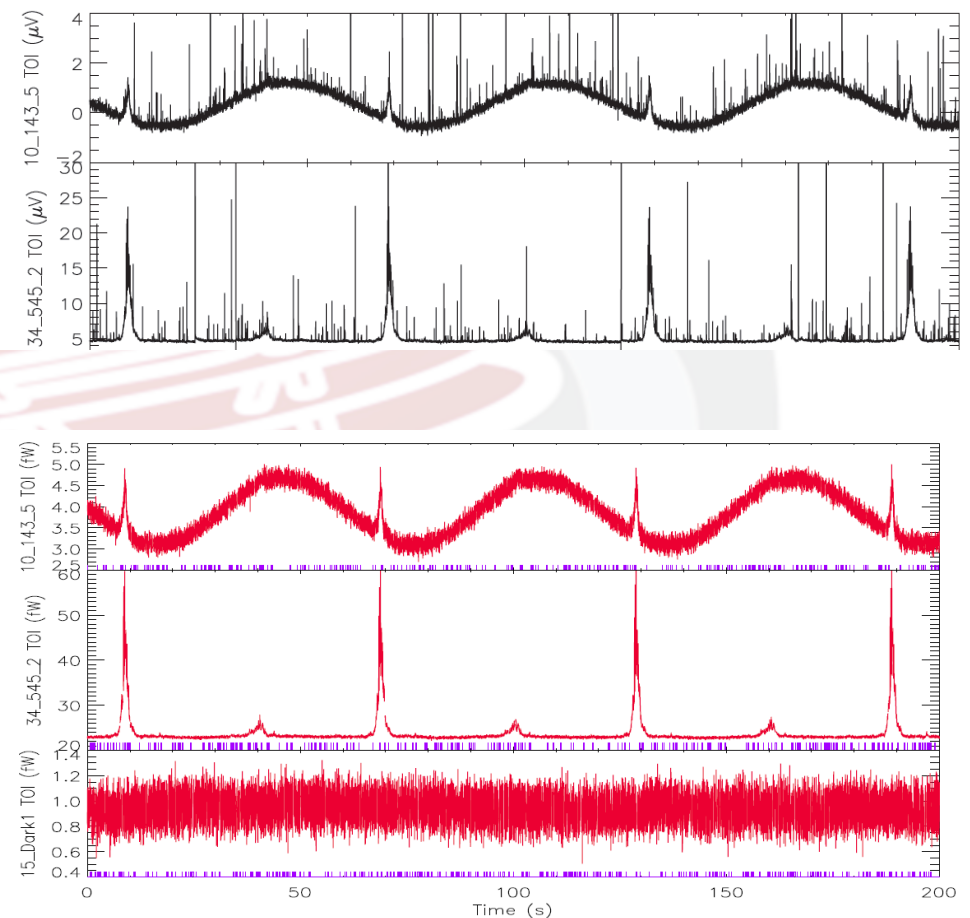


Difference



Planck-HFI: rough data

3min of flight data – 1/54 HFI detectors

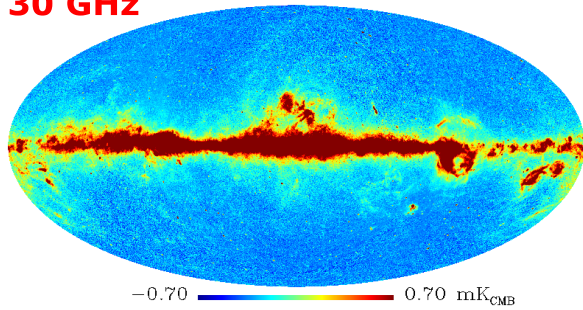


From simulations to reality!

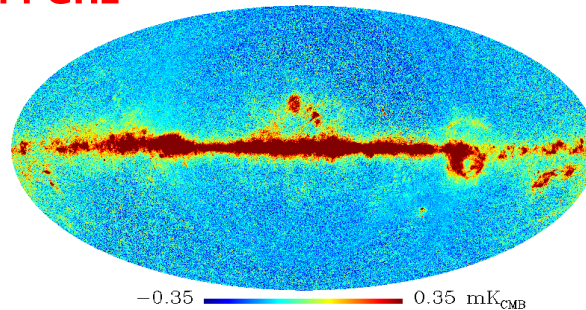
The Planck view of the sky after almost one year of operations (CMB removed)



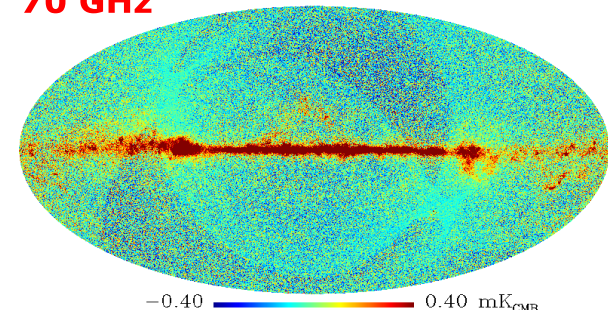
30 GHz



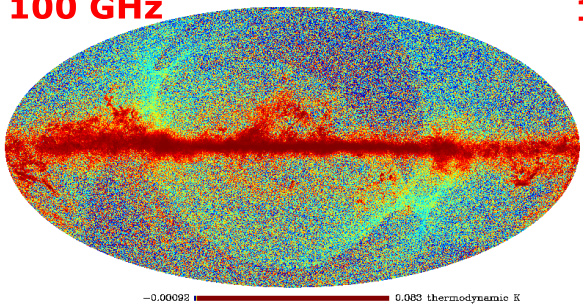
44 GHz



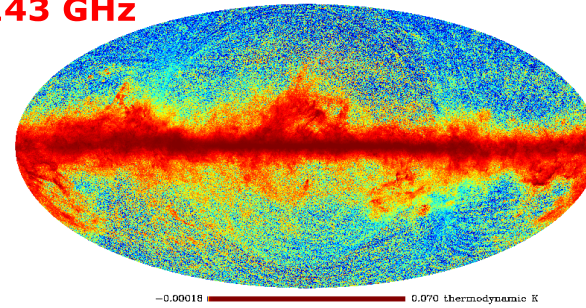
70 GHz



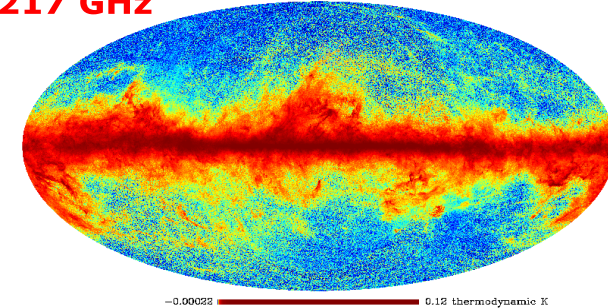
100 GHz



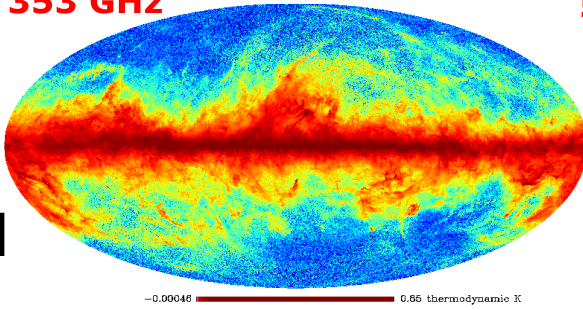
143 GHz



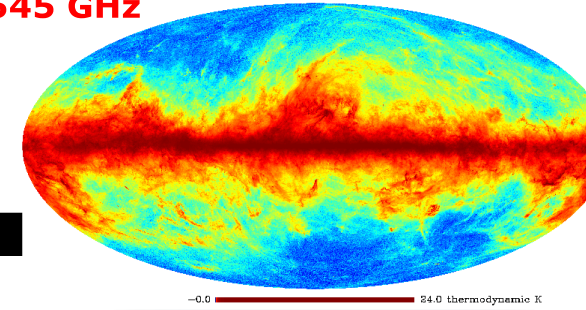
217 GHz



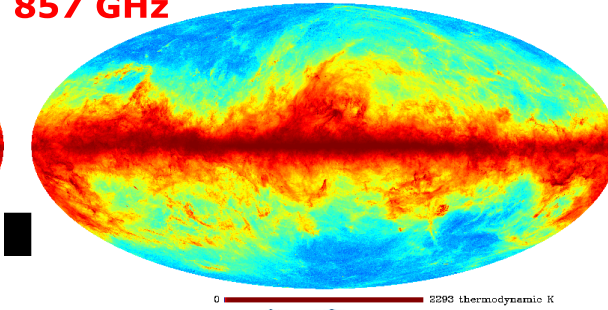
353 GHz



545 GHz



857 GHz



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ERCSC papers, A&A 536

- **Planck Early Results: The Early Release Compact Source Catalogue 1101.2041**
- **The Explanatory Supplement to the Planck Early Release Compact Source Catalogue, Planck Collaboration 2011 ESA, available @ Planck esa web site <http://www.rssd.esa.int/Planck>**
- ❖ **Revised ERCSC: On 31 Jan 2012, ESA and the Planck Collaboration have released a revised version of the ERCSC**
- ❖ **In this new version, some quantities have been updated although there is no change in the number of sources and their flux compared to the previous version of the catalogue**
- ❖ **Explanatory Supplement - Version: 6 February 2012**
- ❖ **The Early Release Compact Source Catalogue v1.3 can be accessed by the world-wide community from**
- ❖ **Planck Legacy Archive**

http://www.sciops.esa.int/index.php?project=planck&page=Planck_Legacy_Archive



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- The catalogue is based on the entire sky once and 60% of the sky a second time
- A Monte-Carlo algorithm based on the injection and extraction of artificial sources into the Planck maps was implemented to select reliable sources among all extracted candidates such that the cumulative reliability of the catalogue is $\geq 90\%$.
- As a result of the Monte-Carlo assessment of the reliability of sources from different techniques, the PowellSnakes source extraction technique was used at the 5 frequencies between 30 and 143 GHz while the SExtractor technique was used between 217 and 857 GHz.
- The 10 sigma photometric flux density limit of the catalogue at $|b| > 30$ deg is 0.49, 1.0, 0.67, 0.5, 0.33, 0.28, 0.25, 0.47 and 0.82 Jy at each of the nine frequencies between 30 and 857 GHz. Sources which are up to a factor of 2 fainter than this limit, and which are present in "clean" regions of the Galaxy where the sky background due to emission from the interstellar medium is low, are included in the ERCSC if they meet the high reliability criterion
- The Planck ERCSC provides a robust list of stars with dust shells, stellar cores, radio galaxies, blazars, infrared luminous galaxies, Galactic interstellar medium features, 915 cold molecular cloud core candidates, 189 SZ cluster candidates as well as unclassified sources from the first high sensitivity radio/submillimetre observations of the entire sky.



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The Planck ERCSC in brief

Notes. ^(a) The precise beam values are presented in Planck Collaboration (2011e) and Planck Collaboration (2011f). This table shows the values which were adopted for the ERCSC. ^(b) Flux density of the median $>10\sigma$ source at $|b| > 30^\circ$ in the ERCSC where σ is the photometric uncertainty of the source. ^(c) Flux density of the faintest $>10\sigma$ source at $|b| > 30^\circ$ in the ERCSC. ^(d) Faintest source at $|b| > 30^\circ$ in the ERCSC.

Freq [GHz]	30	44	70	100	143	217	353	545	857
$\lambda(\mu\text{m})$	10000	6818	4286	3000	2098	1382	850	550	350
Sky Coverage (%)	99.96	99.98	99.99	99.97	99.82	99.88	99.88	99.80	99.79
Beam FWHM ($'$) ^a	32.65	27.00	13.01	9.94	7.04	4.66	4.41	4.47	4.23
# of Sources	705	452	599	1381	1764	5470	6984	7223	8988
# of $ b > 30^\circ$ Sources	307	143	157	332	420	691	1123	2535	4513
$10\sigma^b$ (mJy)	1173	2286	2250	1061	750	807	1613	2074	2961
$10\sigma^c$ (mJy)	487	1023	673	500	328	280	249	471	813
Flux Density Limit ^d (mJy)	480	585	481	344	206	183	198	381	655

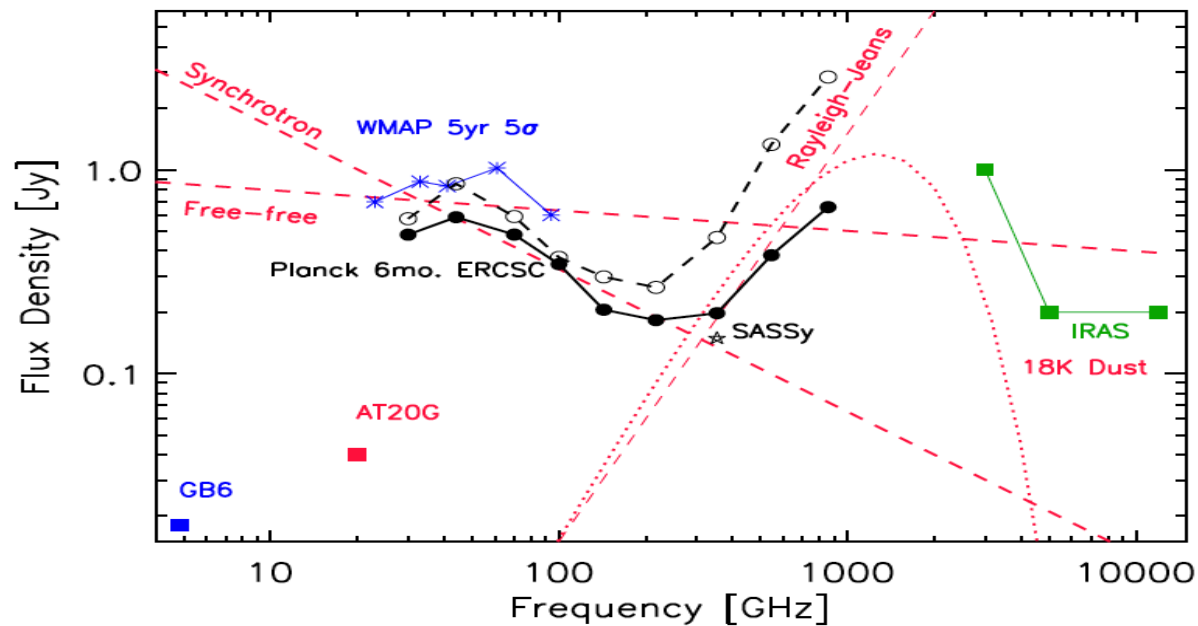


Table 2. ERCSC Catalogue Columns

Column Name	Description
Identification	
NAME	Source name
FLUX	Flux density (mJy)
FLUX_ERR	Flux density error (mJy)
CMBSUBTRACT	Flag indicating detection of source in CMB subtracted maps
EXTENDED	Flag indicating that source is extended
DATESOBS	UTC dates at which this source was observed
NUMOBS	Number of days this source observed
CIRRUS	Cirrus flag based on 857 GHz source counts
Source Position	
GLON	Galactic longitude (deg) based on extraction algorithm
GLAT	Galactic latitude (deg) based on extraction algorithm
POS_ERR	Standard deviation of positional offsets for sources with this SNR (arcminute)
RA	Right Ascension (J2000) in degrees transformed from (GLON, GLAT)
DEC	Declination (J2000) in degrees transformed from (GLON, GLAT)
Effective beam	
BEAM_FWHMAJ	Elliptical Gaussian beam FWHM along major axis (arcmin)
BEAM_FWHMMIN	Elliptical Gaussian beam FWHM along minor axis (arcmin)
BEAM.THETA	Orientation of Elliptical Gaussian major axis (measured East of Galactic North)
Morphology	
ELONGATION	Ratio of major to minor axis lengths
Source Extraction Results	
FLUXDET	Flux density of source as determined by detection method (mJy)
FLUXDET_ERR	Uncertainty (1 sigma) of FLUXDET (mJy)
MX1	First moment in X (arcmin)
MY1	First moment in Y (arcmin)
MX2	Second moment in X (arcmin ²)
MY2	Second moment in Y (arcmin ²)
MXY	Cross moment in X and Y (arcmin ²)
PSFFLUX	Flux density of source as determined from PSF fitting (mJy)
PSFFLUX_ERR	Uncertainty (1 sigma) of PSFFLUX (mJy)
GAUFLUX	Flux density of source as determined from 2-D Gaussian fitting (mJy)
GAUFLUX_ERR	Uncertainty (1 sigma) of GAUFLUX (mJy)
GAU_FWHMAJ	Gaussian fit FWHM along major axis (arcmin)
GAU_FWHMMIN	Gaussian fit FWHM along minor axis (arcmin)
GAU.THETA	Orientation of Gaussian fit major axis
Quality Assurance	
RELIABILITY	Fraction of MC sources that are matched and have photometric errors < 30%
RELIABILITY_ERR	Uncertainty (1 sigma) in reliability based on Poisson statistics
MCQA_FLUX_ERR	Standard deviation of photometric error for sources with this SNR
MCQA_FLUX_BIAS	Median photometric error for sources with this SNR
BACKGROUND_RMS	Background point source RMS obtained from threshold maps (mJy)
Bandfilling (857 GHz catalog only)	
BANDFILL217	217 GHz Aperture Photometry Flux Density at 857 GHz Source Position (mJy)
BANDFILL217_ERR	Uncertainty in BANDFILL217
BANDFILL353	353 GHz Aperture Photometry Flux Density at 857 GHz Source Position (mJy)
BANDFILL353_ERR	Uncertainty in BANDFILL353
BANDFILL545	545 GHz Aperture Photometry Flux Density at 857 GHz Source Position (mJy)
BANDFILL545_ERR	Uncertainty in BANDFILL545

ERCSC_f030.fits
 ERCSC_f044.fits
 ERCSC_f070.fits
 ERCSC_f100.fits
 ERCSC_f143.fits
 ERCSC_f217.fits
 ERCSC_f353.fits
 ERCSC_f545.fits
 ERCSC_f857.fits

ESZ.fits
 ECC.fits

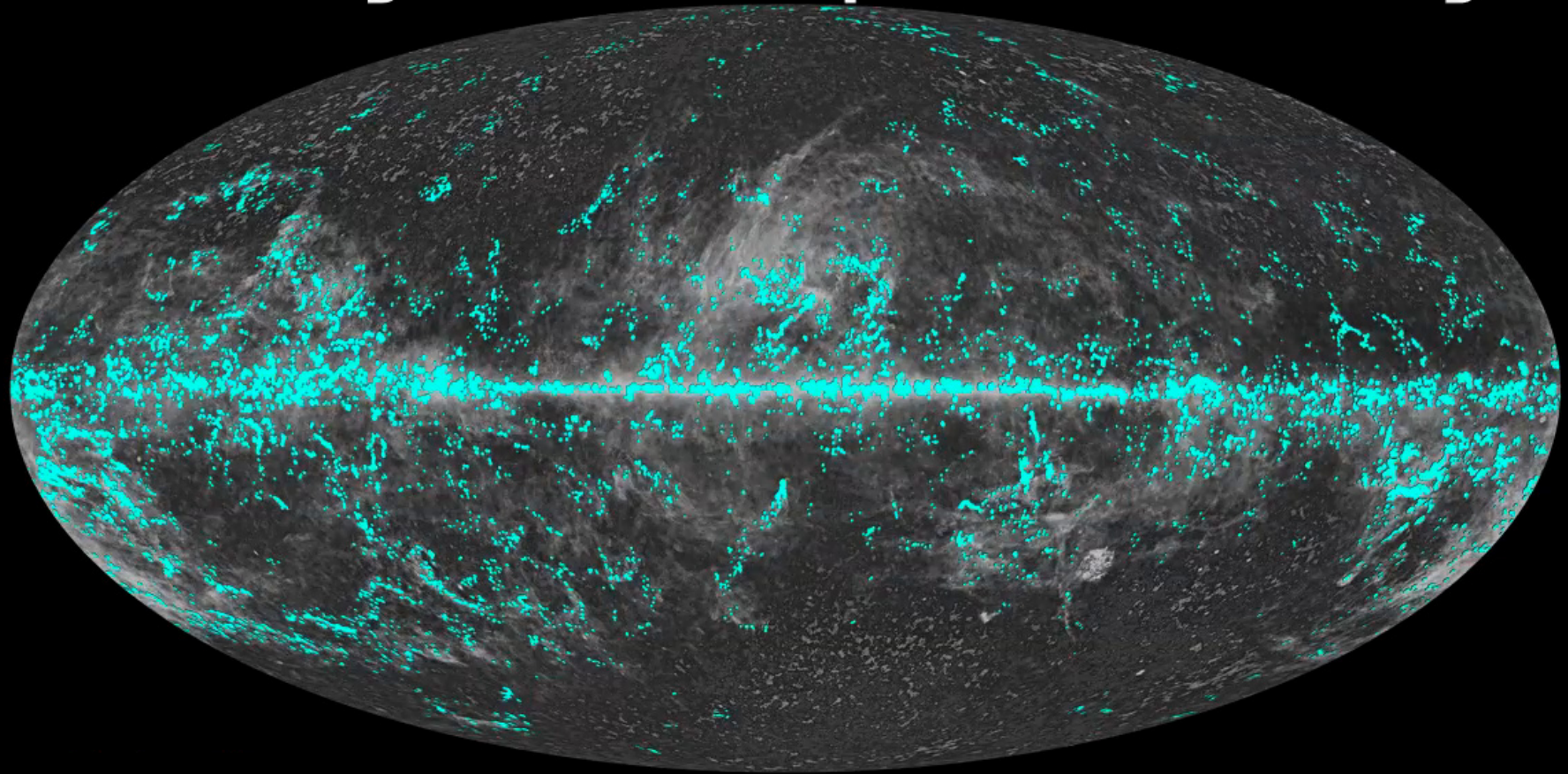
Table 6. ESZ Catalogue Columns

Keyword	Type
INDEX	Index of clusters i.e., 1, 2, 3...
NAME	<i>Planck</i> name of cluster candidate
GLON	Galactic Longitude from <i>Planck</i> (deg)
GLAT	Galactic Latitude from <i>Planck</i> (deg)
RA	Right Ascension (deg) from <i>Planck</i> (J2000)
DEC	Declination (deg) from <i>Planck</i> (J2000)
SNR	Signal-to-noise ratio returned by the matched multi-filter (MMF3)
ID	External identifier of cluster e.g., Coma, Abell etc.
REDSHIFT	Redshift of cluster from the MCXC X-ray cluster compilation (Piffaretti et al. 2010) unless stated otherwise in the notes
GLON_X	Galactic Longitude of the associated X-ray cluster (deg)
GLAT_X	Galactic Latitude of the associated X-ray cluster (deg)
RA_X	Right Ascension (deg) of the associated X-ray cluster (J2000)
DEC_X	Declination (deg) of the associated X-ray cluster (J2000)
THETA_X	Angular size (arcmin) at 5R500 from X-ray data.
Y_P SX	Integrated Compton-Y (arcmin ²) at X-ray position and within 5R500 (THETA_X)
Y_P SX_ERR	Uncertainty in Y_P SX
THETA	Estimated angular size (arcmin) from matched multi-filter (MMF3)
THETA_ERR	Uncertainty in THETA
Y	Integrated Compton-Y (arcmin ²) at <i>Planck</i> position and within THETA from matched multi-filter (MMF3)
Y_ERR	Uncertainty in Y

Table 7. ECC Catalogue Columns

Keyword	Type
NAME	Source name
SNR	Signal to Noise ratio of detection
GLON	Galactic longitude (deg) based on bandmerge algorithm
GLAT	Galactic latitude (deg) based on bandmerge algorithm
RA	Right Ascension in degrees (J2000)
DEC	Declination in degrees (J2000)
APFLUX353	Aperture flux density at 353 GHz (mJy)
APFLUX545	Aperture flux density at 545 GHz (mJy)
APFLUX857	Aperture flux density at 857 GHz (mJy)
APFLUX3000	Aperture flux density at 3000 GHz (mJy)
APFLUX353_ERR	Uncertainty (1 sigma) in APFLUX353
APFLUX545_ERR	Uncertainty (1 sigma) in APFLUX545
APFLUX857_ERR	Uncertainty (1 sigma) in APFLUX857
APFLUX3000_ERR	Uncertainty (1 sigma) in APFLUX3000
TEMPERATURE	Temperature from greybody fit (K)
BETA	Emissivity index from greybody fit
S857	Flux density at 857 GHz from greybody fit (mJy)
TEMPERATURE_ERR	Uncertainty (1 sigma) in TEMPERATURE (K)
BETA_ERR	Uncertainty (1 sigma) in BETA
S857_ERR	Uncertainty (1 sigma) in S857
BESTNORM	Summed squared residuals for best fit (mJy ²)
TEMPERATURE-CORE	Core Temperature from greybody fit to cold residual emission (K)
BETA_CORE	Emissivity index from greybody fit to cold residual emission
MAJ_AXIS_FWHM_CORE	Ellipse major axis of cold residual emission (arcmin)
MIN_AXIS_FWHM_CORE	Ellipse minor axis of cold residual emission (arcmin)
TEMPERATURE_CORE_ERR	Uncertainty (1 sigma) TEMPERATURE_CORE (K)
BETA_CORE_ERR	Uncertainty (1 sigma) BETA_CORE
MAJ_AXIS_FWHM_CORE_ERR	Uncertainty (1 sigma) MAJ_AXIS_FWHM_CORE
MIN_AXIS_FWHM_CORE_ERR	Uncertainty (1 sigma) MIN_AXIS_FWHM_CORE

Planck Early Release Compact Source Catalogue



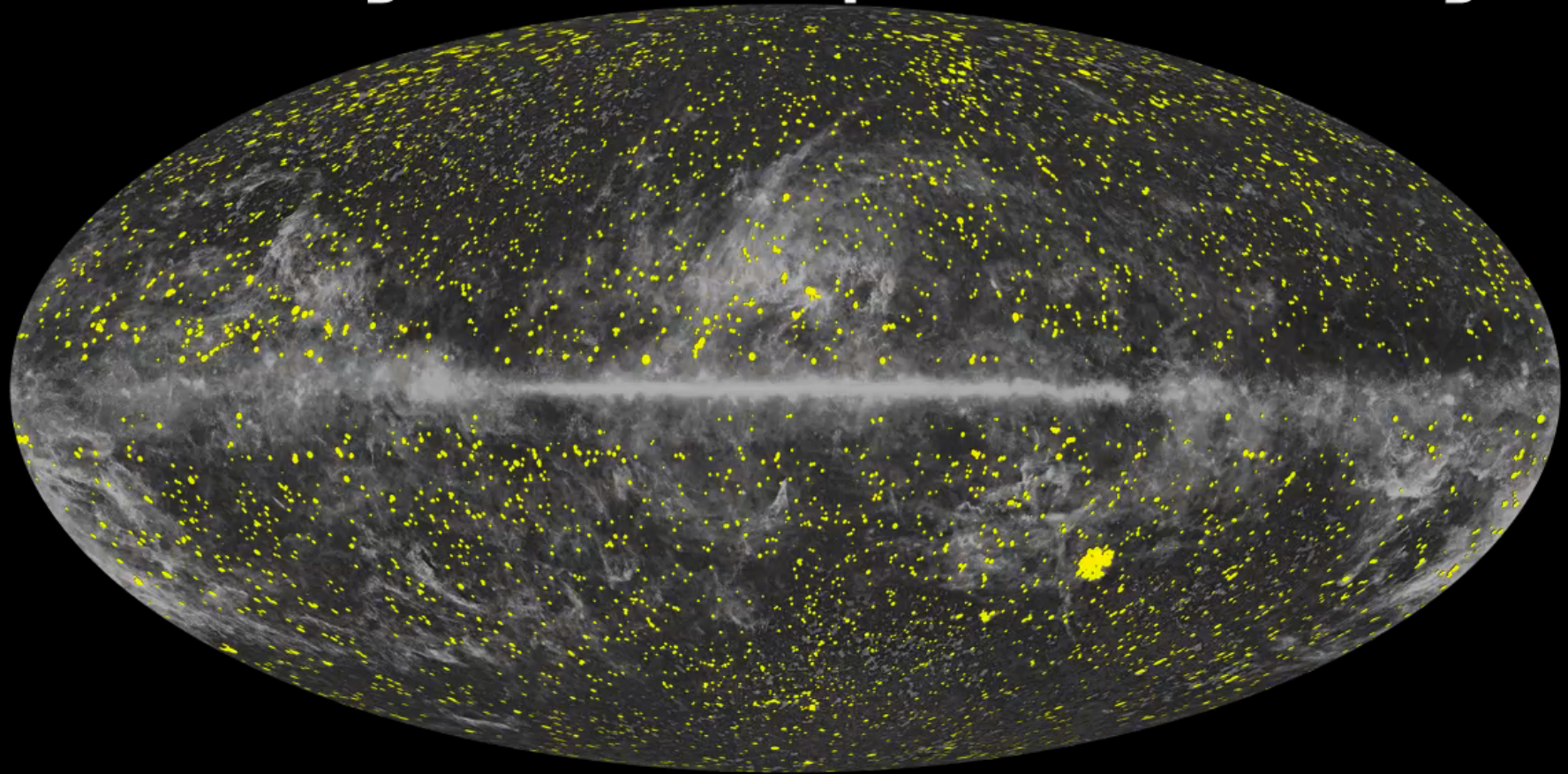
Galactic sources



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Planck Early Release Compact Source Catalogue



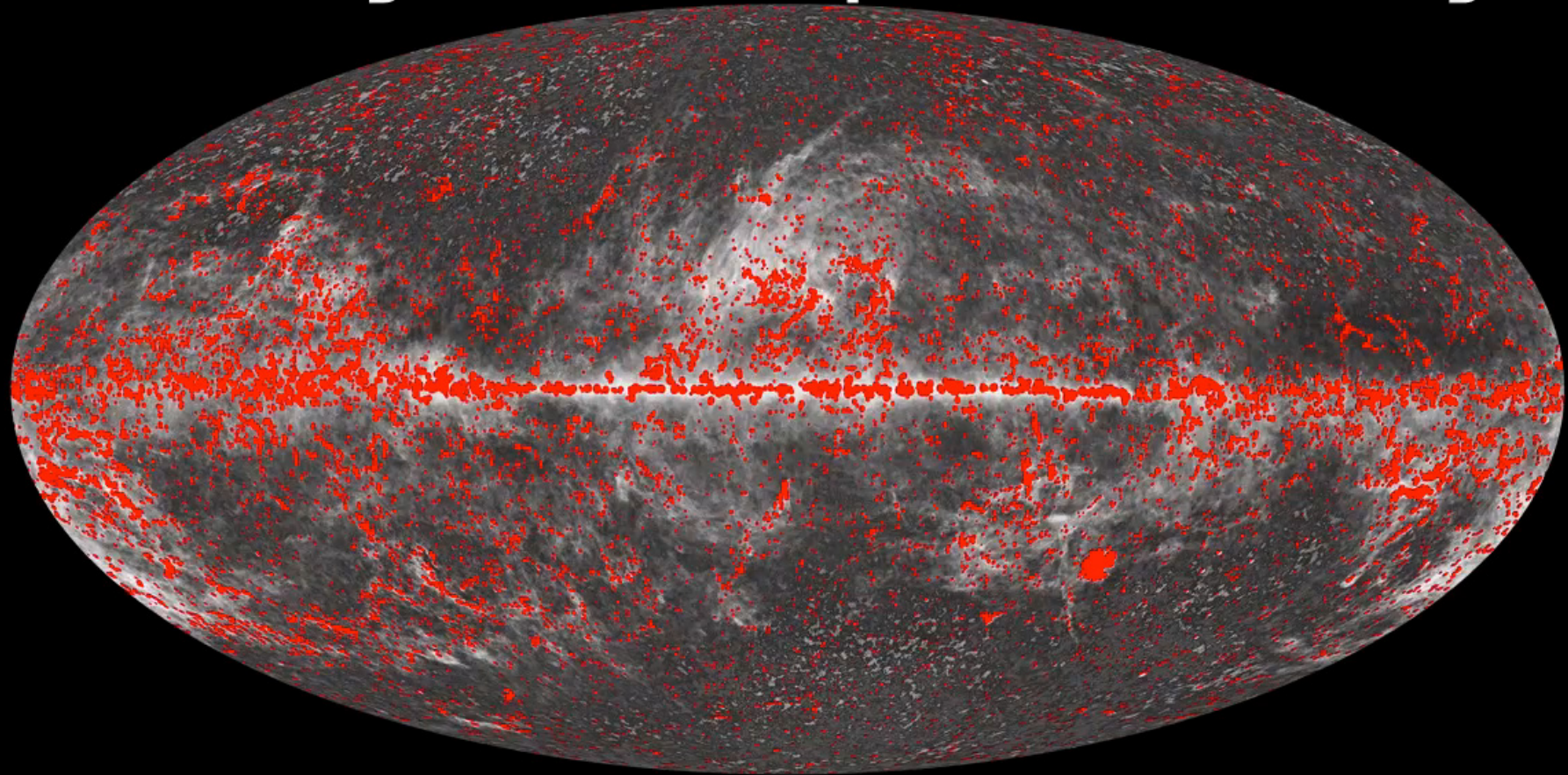
Extragalactic sources



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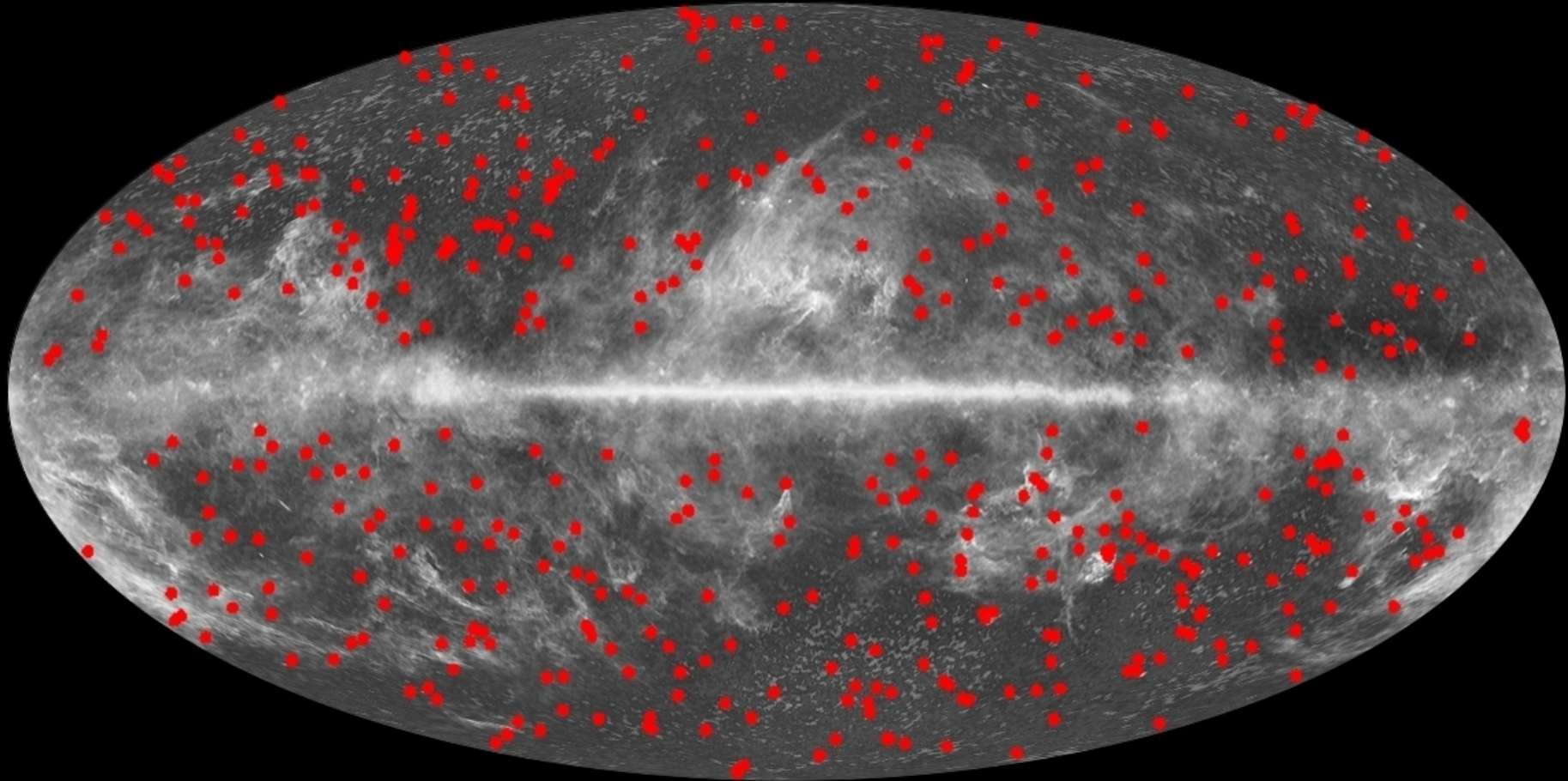


Planck Early Release Compact Source Catalogue



All compact sources

WMAP 7Year Point Source Catalogue



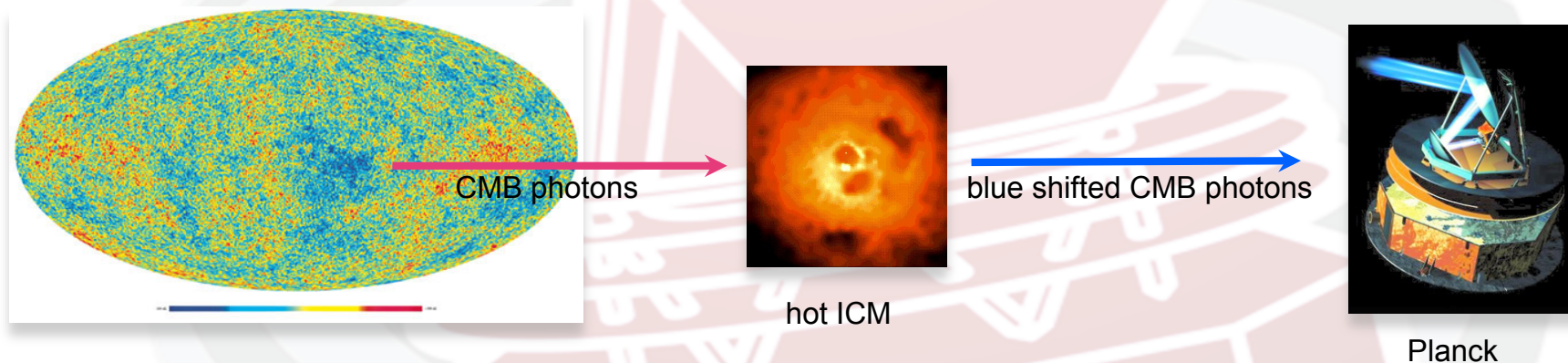
Overlapped to the Planck one-year all-sky map

WG5 Clusters papers, A&A 536

- Planck early results: Statistical analysis of Sunyaev-Zeldovich scaling relations for X-ray galaxy clusters 1101.2043
- Planck early results: Cluster Sunyaev-Zeldovich optical scaling relations 1101.2027
- Planck Early Results: Calibration of the local galaxy cluster Sunyaev-Zeldovich scaling relations 1101.2026
- Planck early results: XMM-Newton follow-up for validation of Planck cluster candidates 1101.2025
- Planck Early Results: The all-sky early Sunyaev-Zeldovich cluster sample 1101.2024
- Planck Early Results XXVI: Detection with Planck and confirmation by XMM-Newton of PLCK G266.6–27.3, an exceptionally X-ray luminous and massive galaxy cluster at $z \sim 1$ 1106.1376

Sunyaev-Zeldovich effect: basics

It is a secondary anisotropy predicted in 1972 due to inverse Compton Scattering between CMB photons (~ 0.3 meV) and free electrons (\sim few KeV) of the hot Intra-Cluster Medium. **CMB photons acquire energy!**



- Thermal SZ : CMB photons are scattered by random motion of thermal electrons
- Kinetic SZ : CMB photons are scattered by bulk motion of electrons

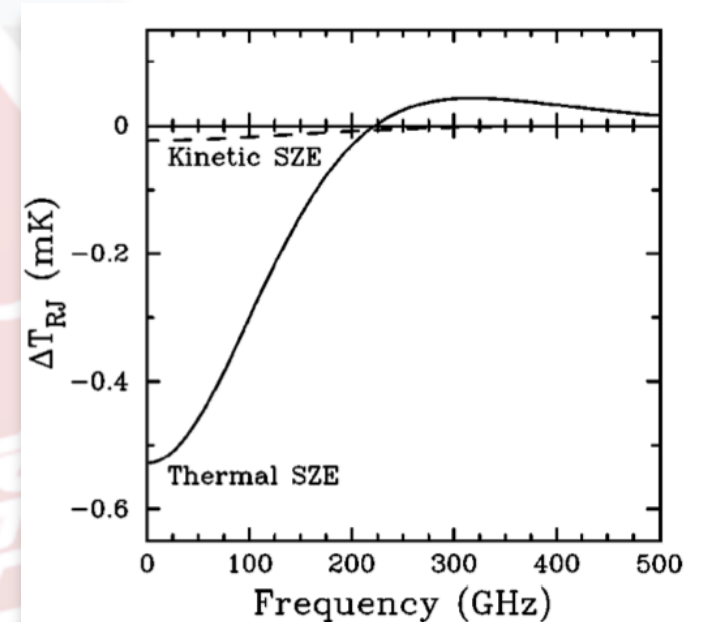
Sunyaev-Zeldovich effect: properties

$$\frac{\Delta T_{SZ}}{T_{CMB}} = f(x) y$$

$$y = \int_{los} n_e \sigma_T \frac{kT_e}{m_e c^2} dl \quad \text{y-Compton parameter}$$

$f(x)$ provides the frequency dependence $x = \frac{h\nu}{kT_{CMB}}$

$$Y = \int_{cluster} y d\Omega \quad Y D_A^2 = \frac{\sigma_T}{m_e c^2} \int P dV$$

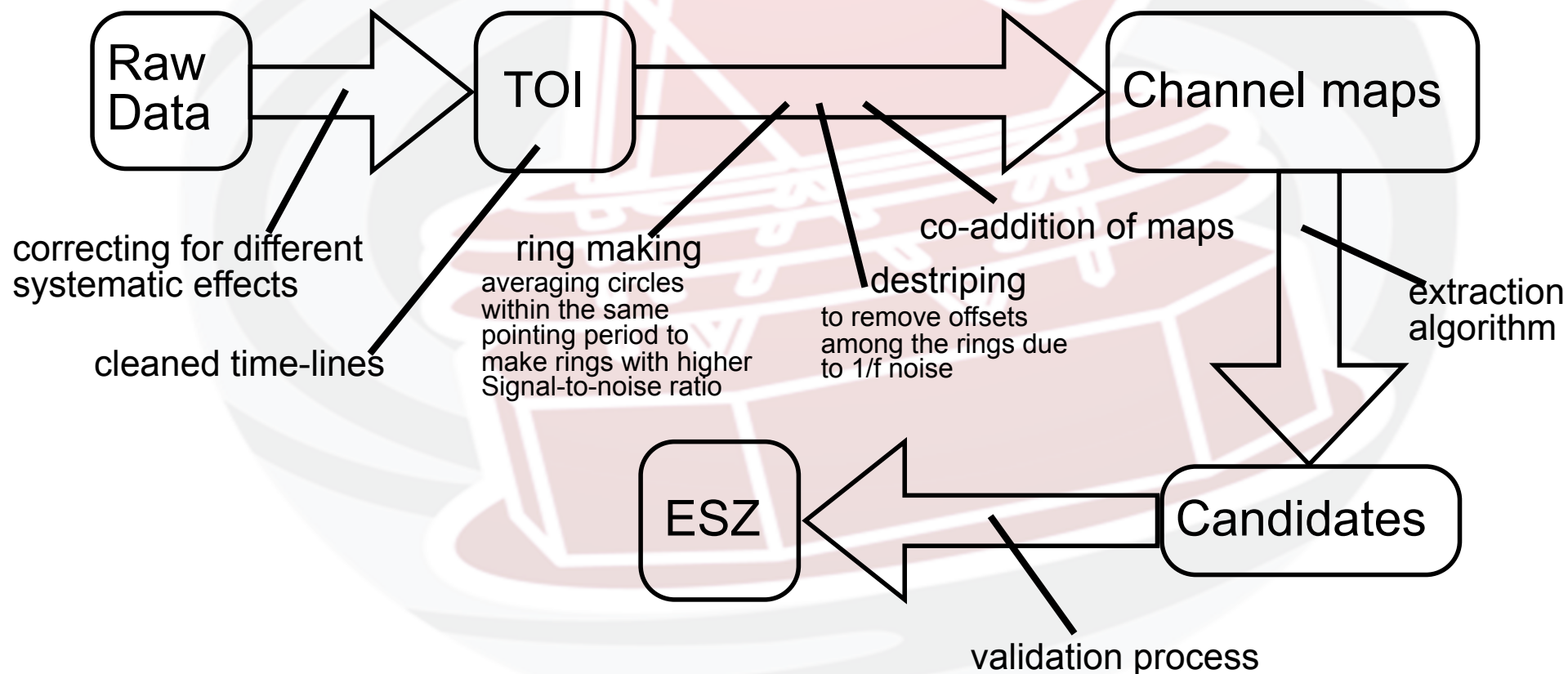


Carlstrom, Holder and Reese 2002

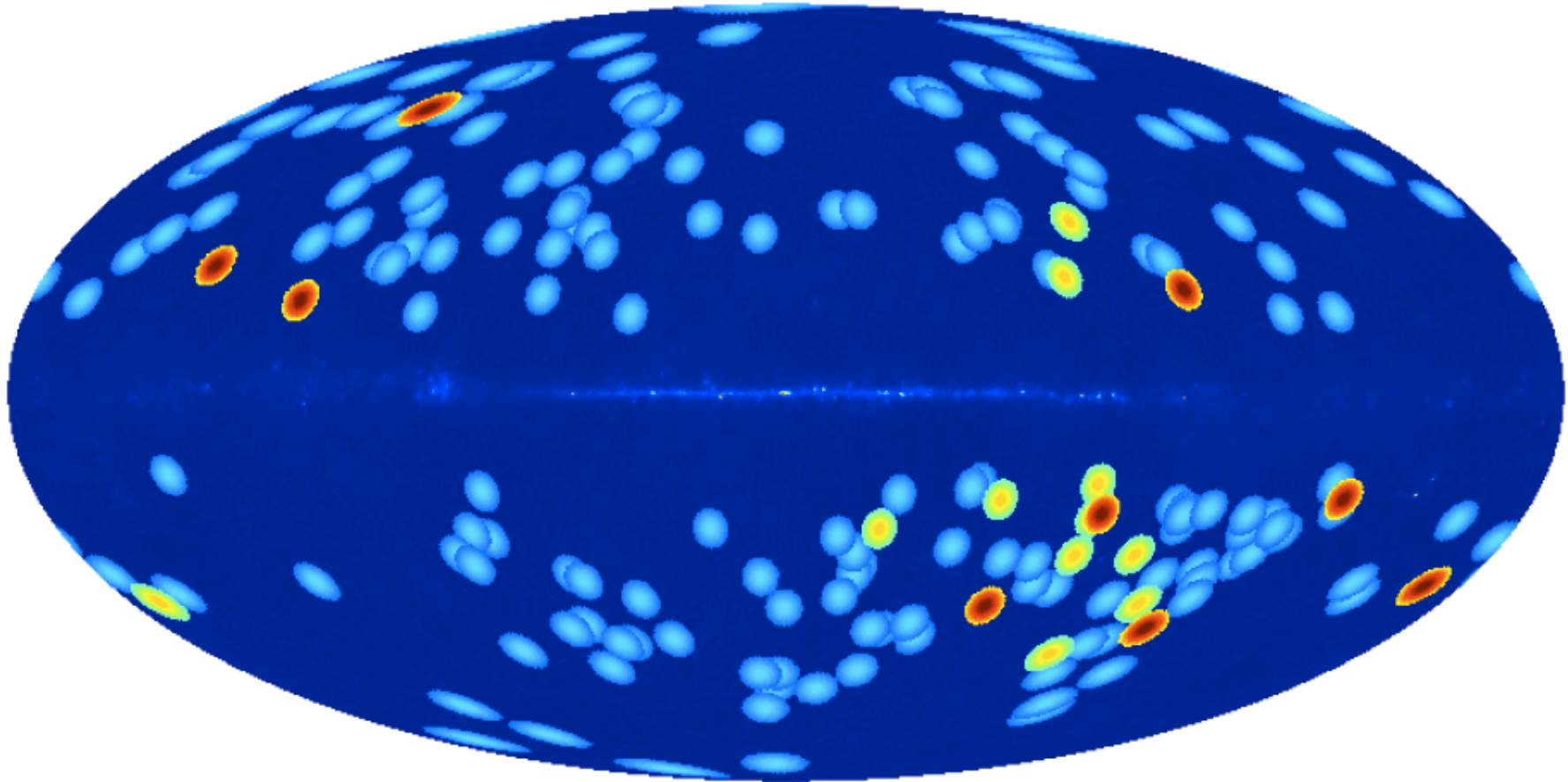
- SZ effect does not depend on z ;
- y -Compton gives the amplitude of the effect (~ 1 mK)
- SZ vanishes for ~ 217 GHz (signature of the effect; one of the Planck channels is centered @ 217 GHz specifically to identify the zero transition of TSZ);
- Y is the integrated Compton that is proportional to the temperature-weighted mass of the cluster divided by the angular diameter distance D_A which is the only term depending on z (weakly). This is an useful relation for extracting cosmological information (that are in D_A) when combined with other observations (X-ray typically).

The Early SZ (ESZ) cluster sample from Planck

ESZ is made of 189 SZ clusters or candidates detected over the whole sky during the first ten months of CMB temperature observation.



ESZ candidates



189 clusters detected (ESZ sample)

169 are known

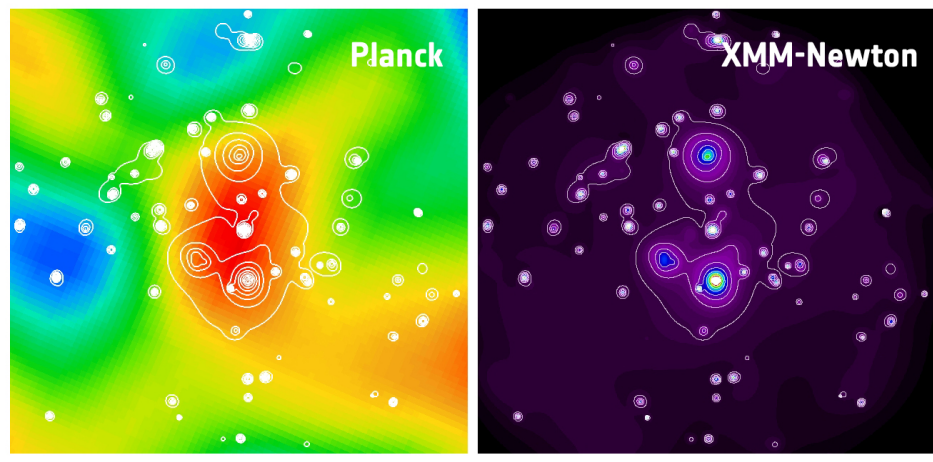
20 are new Planck clusters

12 have been confirmed (11 by XMM and 1 by AMI)

8 are candidate new clusters

The Early SZ (ESZ) cluster sample from Planck

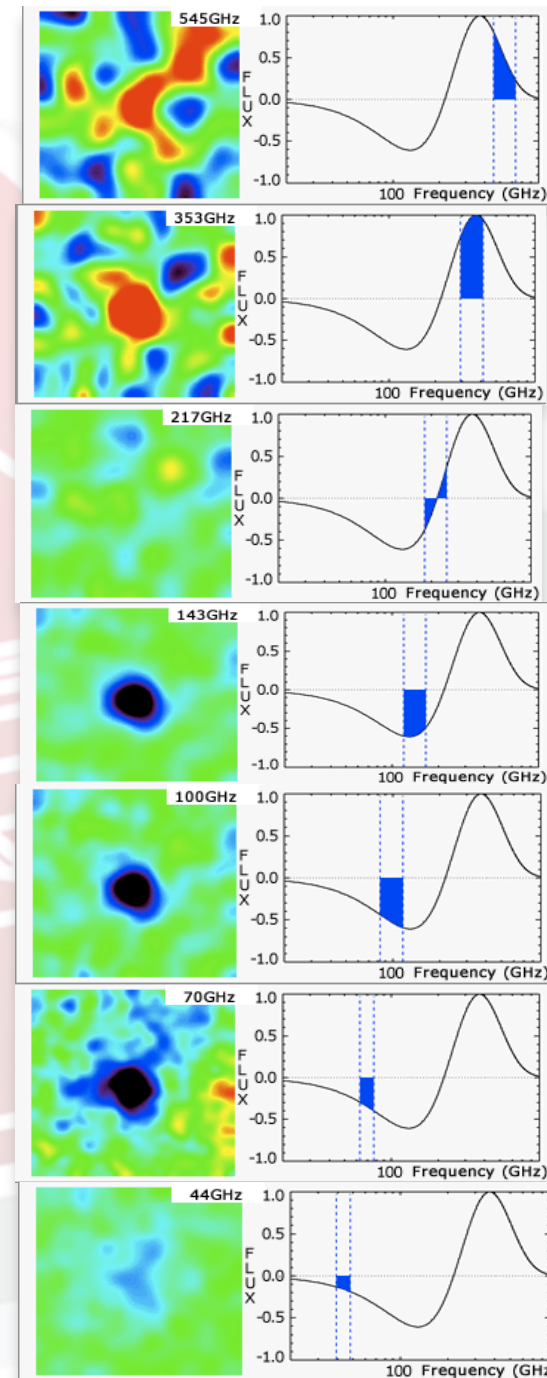
Abell 2319



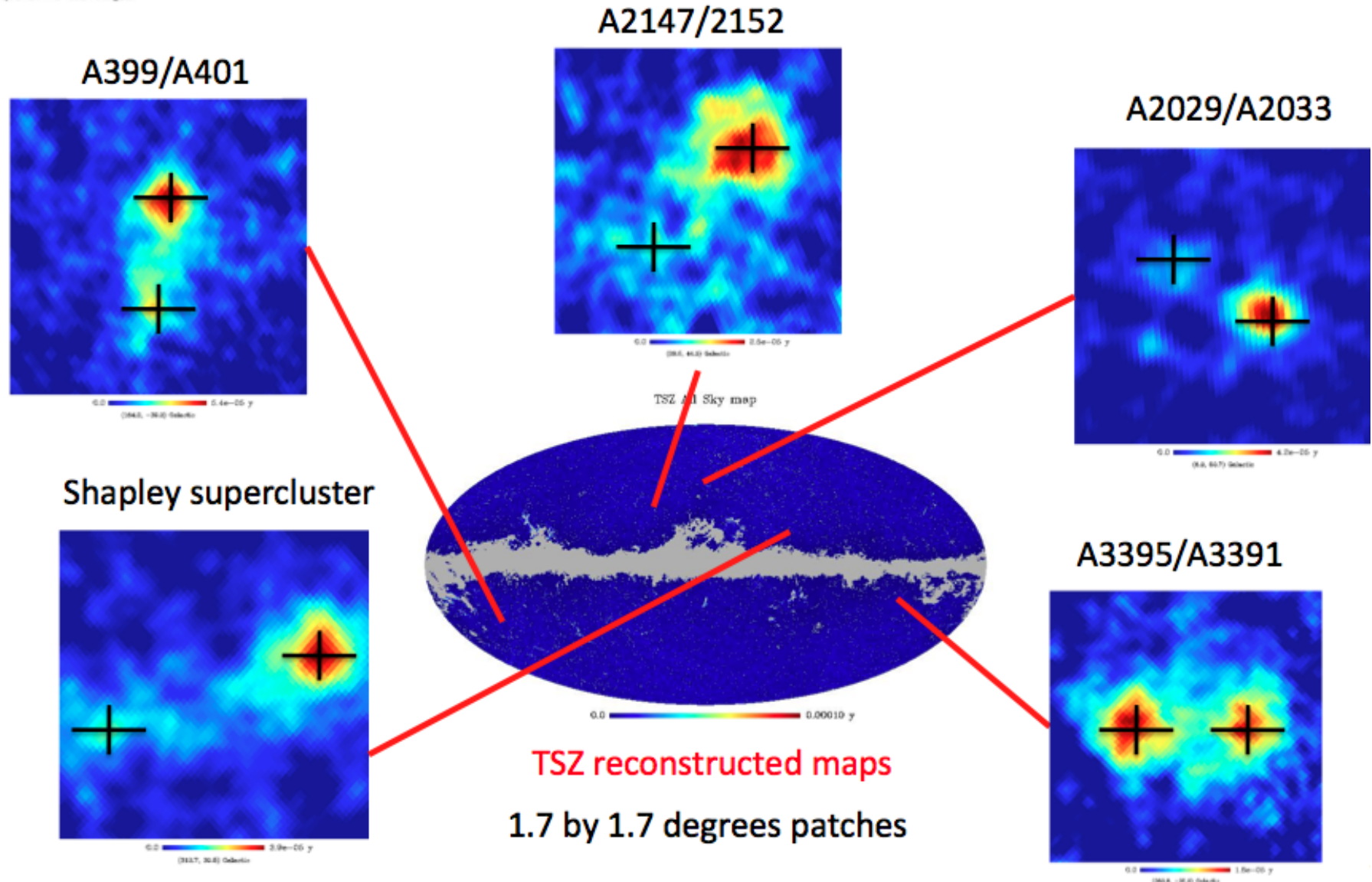
newly discovered supercluster, PLCK G214.6+37, Planck (left) and XMM-Newton (right panel)

At the end of the mission it will be delivered the Planck SZ cluster catalogue containing many hundreds of clusters at $z \sim 1$.

The previous all-sky catalogue is RASS (Rosat All Sky Survey) but at much lower depth (i.e. $z \sim 0.1$)



PLANCK DATA : target selection



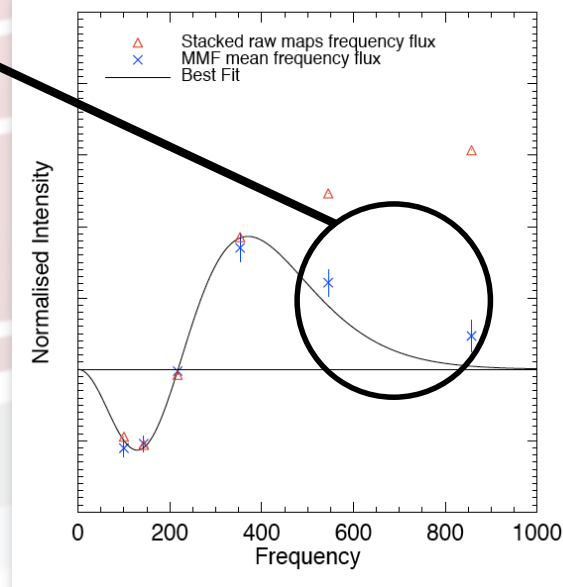
The Early SZ (ESZ) cluster sample from Planck

•Error budget on the cluster parameters

1. Position cluster reconstruction: average error ~ 2 arcmin (based on sims)
2. Cluster size-flux degeneracy depends on signal-to-noise ratio. This is important for Planck since the vast majority of Planck detections are close to the lower threshold. This effect doubles the error bars for Y . This problem has been addressed re-estimating Y for all the ESZ candidates considering prior information on the size of the cluster derived from X-ray observations
3. Systematic effect (uncertainties on the recovered beams is $\sim 1-7\%$: this implies a 10% error on Y ; uncertainties on calibration impacts Y at $\sim 2\%$ level; bandpass errors affects Y less than 3%; astrophysical contaminations $\sim 3\%$)

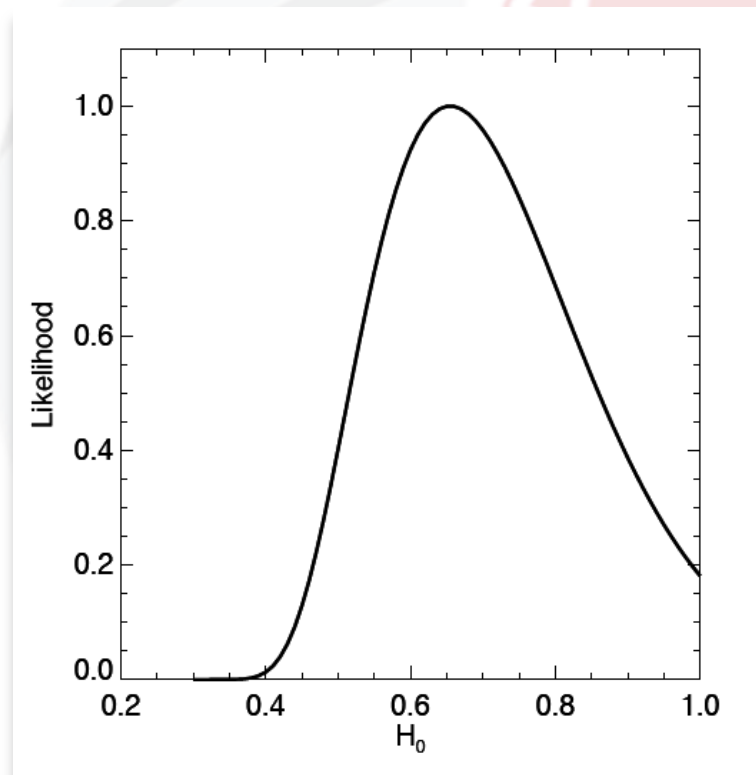
•Purity and completeness

1. A significant fraction of the clusters and candidate clusters of ESZ lies near the selection cut. This implies problems of selection bias (the properties of the catalogued clusters are not representative of the true underlying cluster population). A careful analysis shows that Y is upward biased (on average) for M smaller than $4 \times 10^{14} M_{\odot}$.



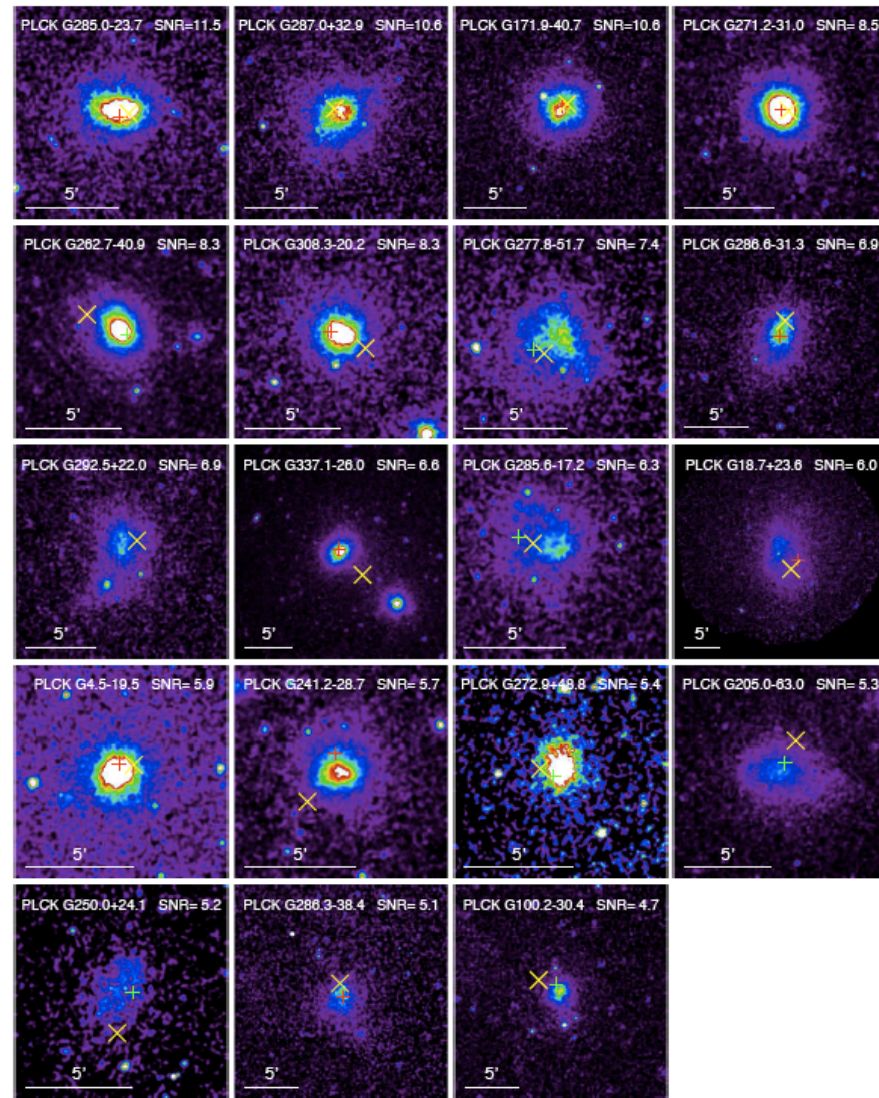
The Early SZ (ESZ) cluster sample from Planck

- Validation consistency check: Integrated Compton parameters of ESZ are used to extract the Hubble parameter



- reference used $h = 0.7$
- recovered parameter $h = 0.71$

XMM-Newton follow-up for validation of Planck discovered clusters



- 25 Planck candidates analyzed
- 21 are confirmed
- 17 are single clusters
- 4 are double or triple systems

XMM-Newton images (0.3-2 KeV) of the confirmed cluster candidates, except for two triple systems

WG6 Extragalactic sources & Far-IR background papers, A&A 536

- Planck Early Results: Spectral energy distributions and radio continuum spectra of northern extragalactic radio sources 1101.2047
- Planck Early Results: Origin of the submm excess dust emission in the Magellanic Clouds 1101.2046
- Planck Early Results: The Planck View of Nearby Galaxies 1101.2045
- Planck Early Results: Statistical properties of extragalactic radio sources in the Planck Early Release Compact Source Catalogue 1101.2044
- Planck Early Results: The Power Spectrum Of Cosmic Infrared Background Anisotropies 1101.2028
- Planck Early Results: ERCSC Validation and Extreme RadioSources 1101.1721

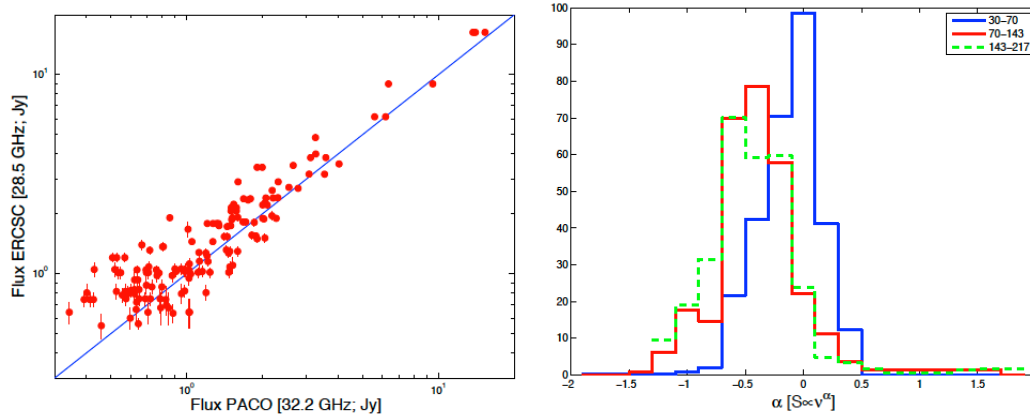


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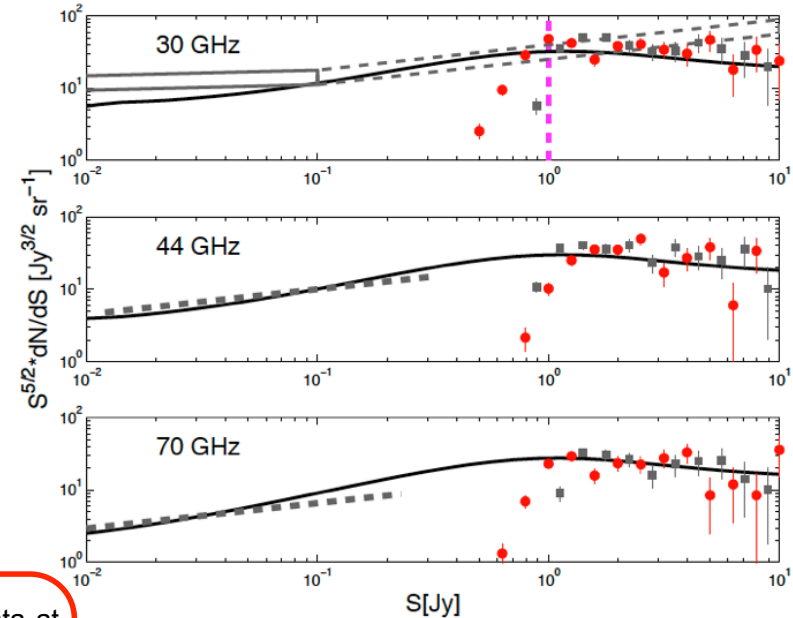
Planck Early Results: Statistical properties of extragalactic radio sources in the Planck Early Release Compact Source Catalogue

First estimate of the Early Release Compact Source Catalogue at 100, 143, and 217 GHz counts of extragalactic radio sources at bright flux density levels.



Comparison between the ERCSC flux densities at 30 GHz and at 44 GHz with the almost simultaneous ATCA measurements (PACO project) at 32.2 and 39.7 GHz, respectively. No correction for the slightly different frequencies has been applied.

Spectral index distributions for different frequency interval calculated by taking into account all sources selected at 30 GHz with $S_v > 1$ Jy. There is clear evidence for a steepening above 70 GHz.

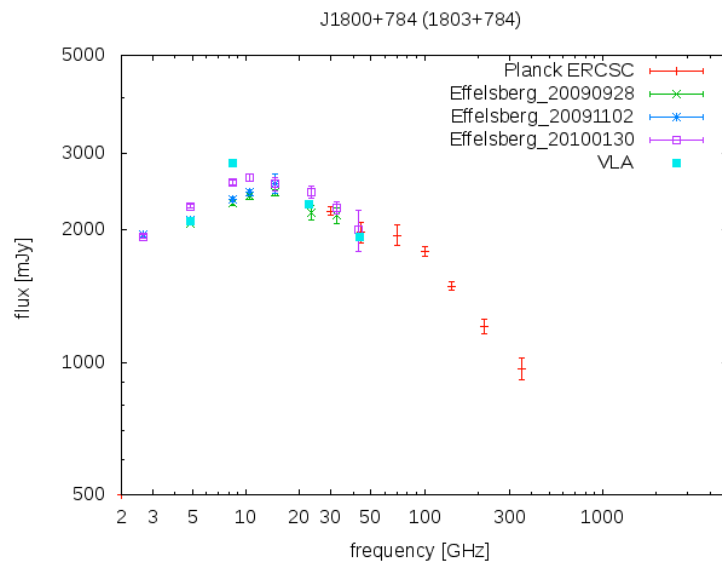


Euclidean normalized differential number counts at the LFI frequencies: red circles show the counts of sources with counterparts in our reference 30 GHz sample; solid curves show the total number counts of extragalactic radio sources predicted by the de Zotti et al. (2005) model. Also shown are: the counts at 31 GHz from DASI (grey dashed box); at 33 GHz from the VSA (grey box); counts from WMAP 5-yr survey (grey squares); counts estimated by Waldram et al. (2007) (grey dashed line); dashed magenta line in the upper panel indicates the flux completeness limit, 1.0 Jy.

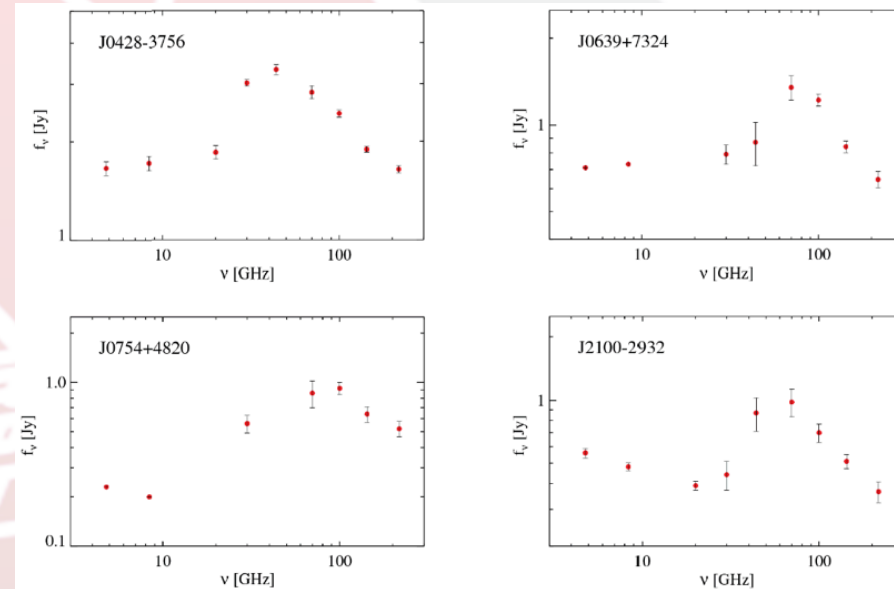
- Counts at 30, 44, and 70 GHz in good agreement with those derived from WMAP data at nearby frequencies;
- The completeness limit of the ERCSC is somewhat deeper than that of WMAP at 30 and 70 GHz and somewhat shallower at 44 GHz;
- At higher frequencies the ERCSC has allowed us to obtain the first estimate of the differential number counts at bright flux density levels.
- At 30, 143 and 217 GHz, the present counts join smoothly to those from deeper surveys over small fractions of the sky.
- An analysis of source spectra finds clear evidence of a steepening of the mean spectral index above ≈ 70 GHz: the contamination of the CMB power spectrum by radio sources below the detection limit is significantly lower than previously estimated.

Planck Early Results: Validation and Extreme Radio Sources in the ERCSC

The ERCSC contains hundreds of extragalactic radio sources, many with SEDs extending to frequencies 143 GHz or higher. The Planck observations are complemented by approximately simultaneous ground-based observations at frequencies below and overlapping Planck frequency bands. The flux density scales of the ground-based and Planck observations are found to be consistent.



Effelsberg, VLA and Planck measurements of a true GPS quasar: J1800+784 flaring during the Planck observations

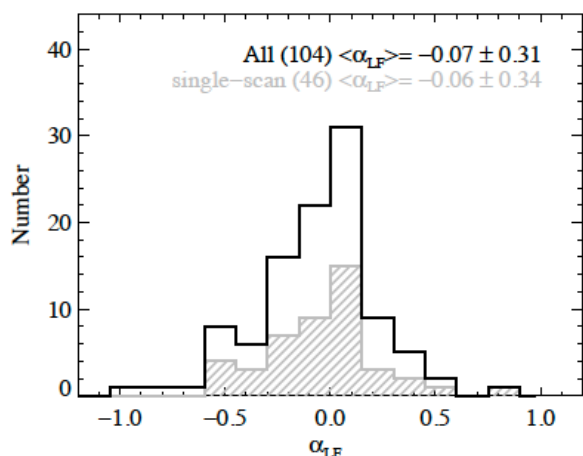


SEDs of possible new GPS candidates emerged when combining the Planck data with the low frequency archival data.

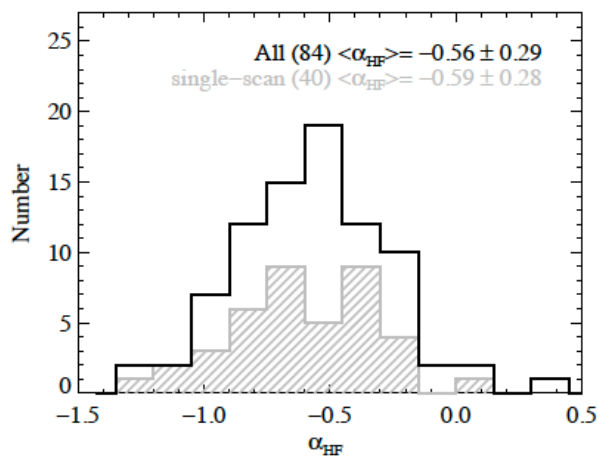
- Planck has demonstrated that the high frequency counts (at least for frequencies ≤ 143 GHz) of bright extragalactic sources are dominated at the bright end by synchrotron emitters, not dusty galaxies;
- In many cases, the spectra can reasonably be fit with a single power law, as expected for one component synchrotron emission. In some cases, such as J1800+784, the quality of the data permits us to clearly see the expected spectra break of ~ -0.5 expected from the aging of the synchrotron-producing electrons;
- In the case of some of the apparently flat spectrum sources, we find clear evidence that the nominally flat spectrum is made up of two or more peaked components.

Planck Early Results: Spectral energy distributions and radio continuum spectra of Northern extragalactic radio sources

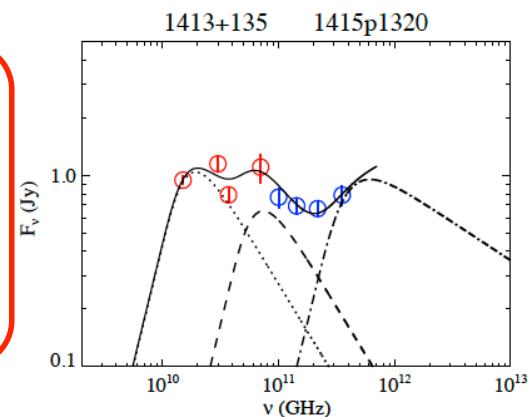
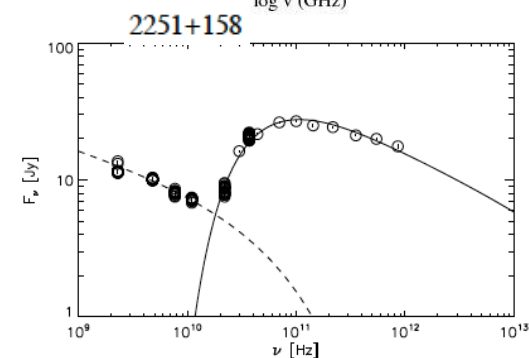
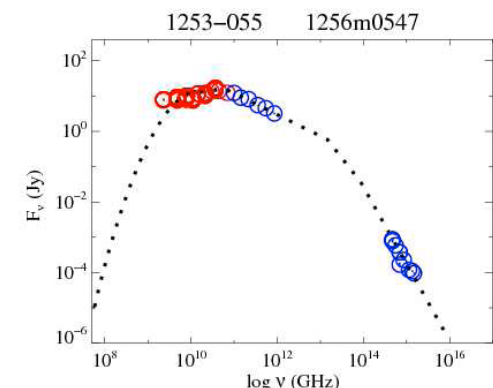
The nine Planck frequencies, from 30 to 857 GHz, are complemented by a set of simultaneous observations ranging from radio to gamma-rays.



Distribution of LF spectral indices for the whole sample (104 sources).



Distribution of HF spectral indices for the 84 sources that had three or more data points. The sources that have only been scanned once by Planck are shown hatched (40 sources).

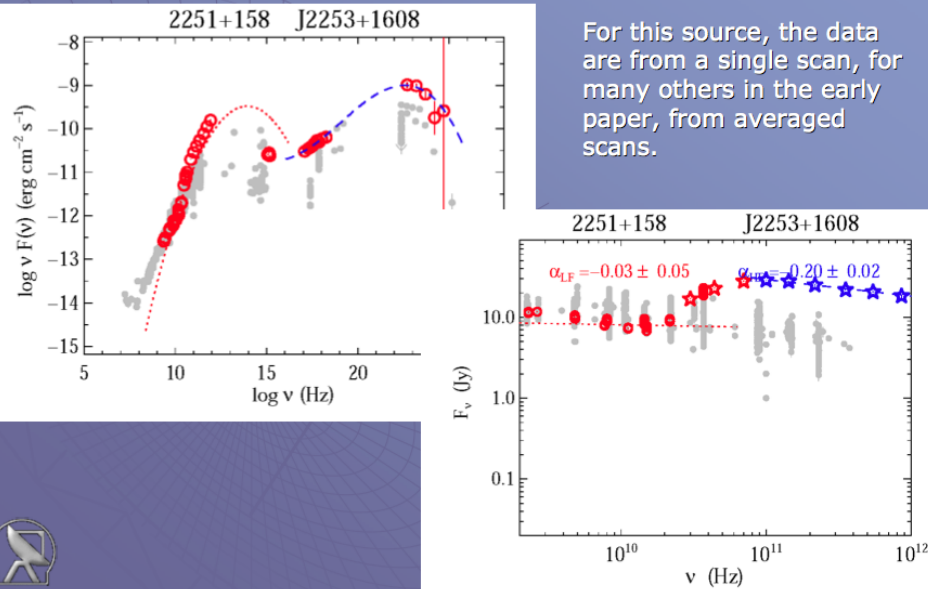


- The 104 SEDs, supplemented with archival data, demonstrate the usefulness of *Planck* data in determining the SED peak frequencies and fluxes and in modelling the spectral energy distributions in greater detail.

- The data demonstrate that the synchrotron spectrum contains contributions from several physically distinct AGN components;

- We have presented some examples of total flux density monitoring to demonstrate in how different activity stages sources have been observed during Planck scans.

SEDs and radio spectra using Planck ERCSC data

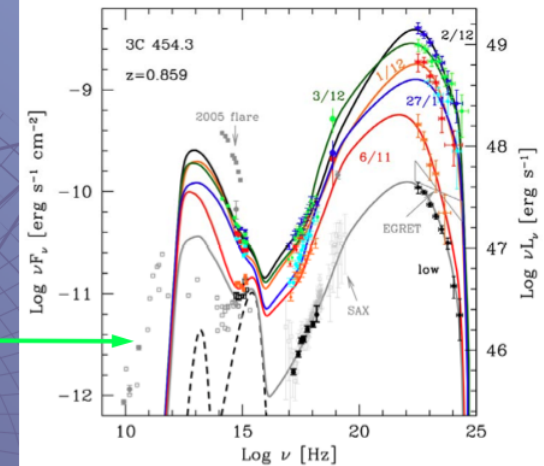


Modelling and understanding the synchrotron spectra of blazars

The physics determining SED shapes in blazars

Spectral energy distributions, SEDs

- Contemporary models fit the high-energy inverse Compton (IC) part rather nicely, but (still) almost completely ignore the synchrotron (=radio) part which most likely is the source for the high-energy emission

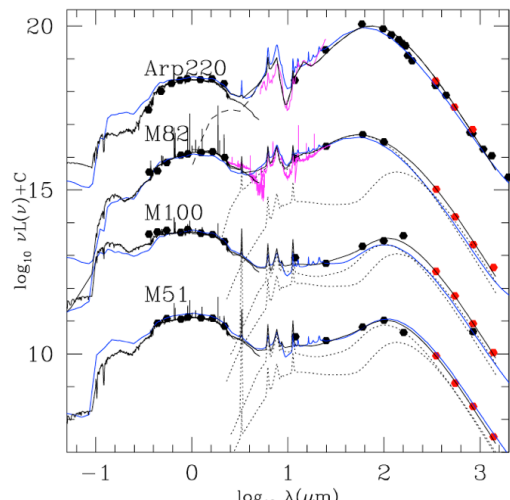


Bonnoli et al. 2010

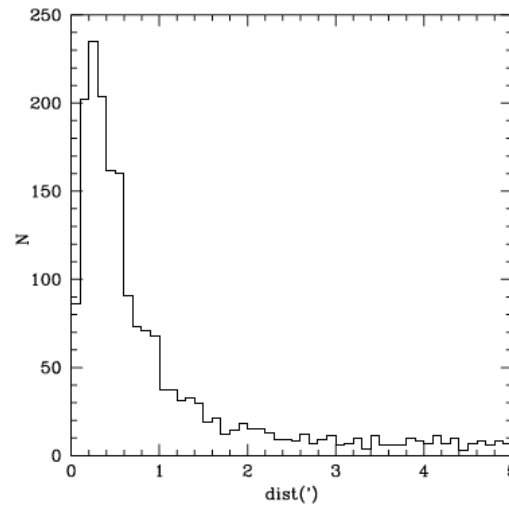
Planck Early Results: The Planck View of Nearby Galaxies

ERCSC provides an unsurpassed survey of galaxies at sub-millimeter wavelengths, representing a major improvement in the numbers of galaxies detected, as well as the range of far-IR/submm wavelengths over which they have been observed.

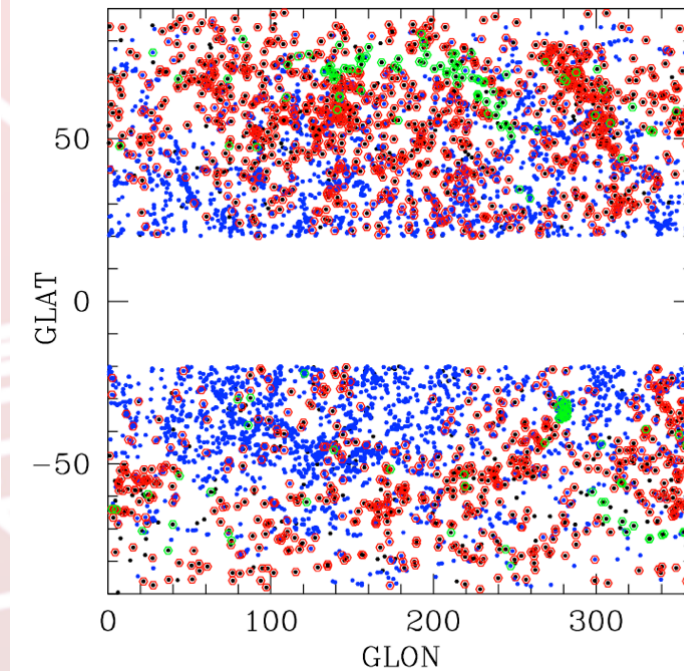
ERCSC catalogue has been matched to *IRAS*-detected galaxies in the Imperial *IRAS* Faint Source Redshift Catalogue (IIFSCz)



Template fits for the four archetypal nearby galaxies, M51, M100, M82 and Arp 220. Black curves: fits with Efstathiou and Rowan-Robinson templates (black dotted lines), blue curves: Silva et al. (1998) models. *Planck* ERCSC data shown as red filled hexagrams. *ISO-SWS* mid-infrared spectroscopy data are shown in magenta.



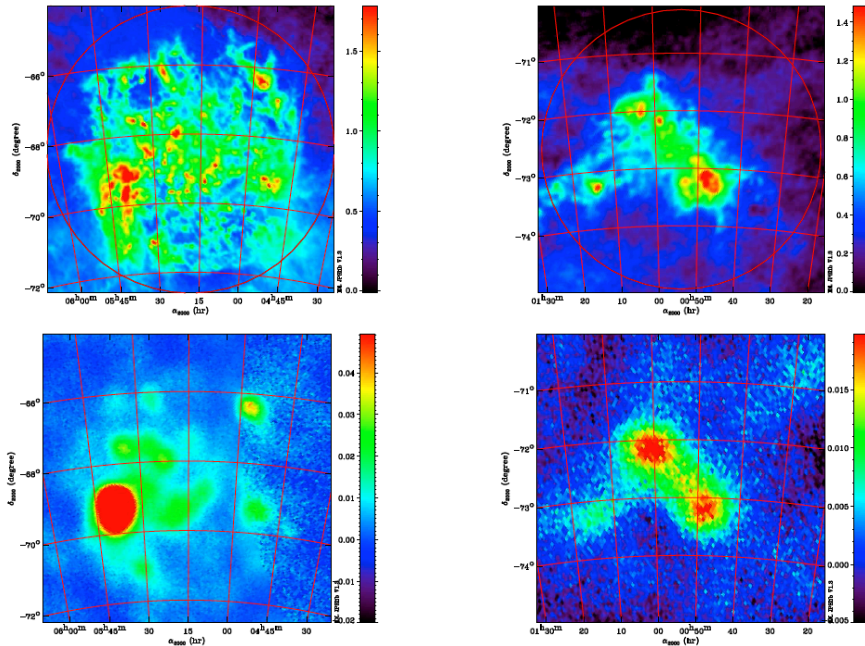
Histogram of offsets between ERCSC and IIFSCz positions.



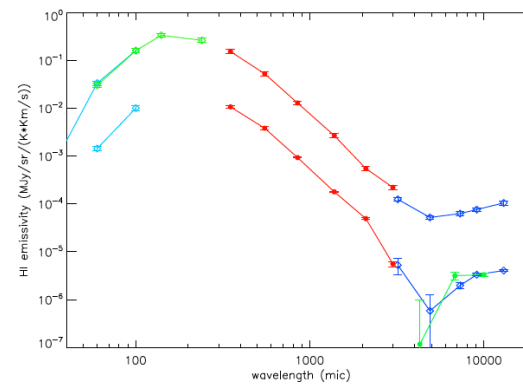
Sky plot of ERCSC sources in galactic coordinates. Black filled hexagons are ERCSC point-sources and blue filled hexagons are ERCSC sources flagged as extended. Red hexagons are sources associated with IIFSCz *IRAS* FSC galaxies, after scrutinising suspect categories with NED (and excluding some, as described in the text). Green hexagons are ERCSC sources not associated with IIFSCz, but associated with bright galaxies in NED (only for $|b| > 60^\circ$ for extended sources).

- Our studies of nearby galaxies detected by Planck have shown evidence for colder dust than has previously been found in local galaxies. This suggests that previous studies of dust in local galaxies have been biased away from such luminous cool objects;
- We also find that the dust SEDs in most galaxies are better described by parametric models containing two dust components, one warm and one cold, with the cold component reaching temperatures as low as 10K.

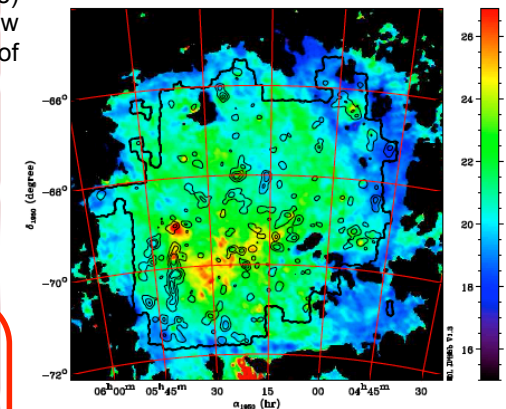
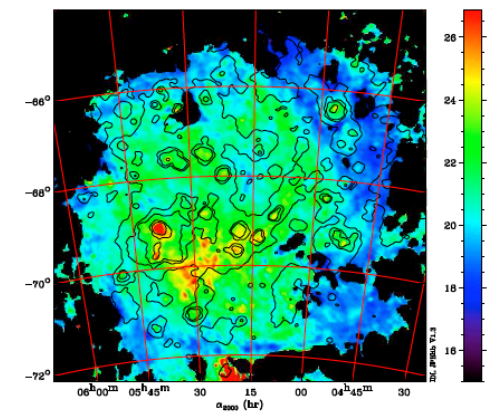
Planck Early Results: Origin of the submm excess dust emission in the Magellanic Clouds



Planck Data for the LMC (Left) and SMC (right) at 857 (top) and 28.5 GHz (bottom) at full resolution. The upper panels are shown in log scale. The circle shows the region used to extract average SEDs.



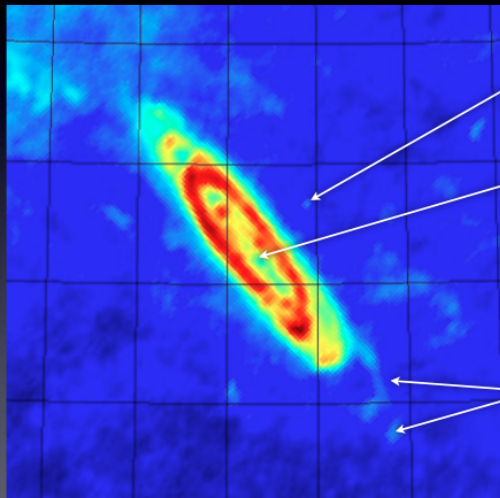
Average foreground SED toward the LMC and SMC including DIRBE , IRAS-IRIS , Planck-HFI , Planck-LFI and WMAP (lower curve) compared to the SED of the high latitude low column-density SED, scaled up by a factor of 10 for clarity (upper curve).



Comparison between the dust temperature map of the LMC with H_{alpha} (Top) and CO emission (Bottom). The CO contours are at 0.5, 2, 4 and 10 Kkm/s. H_{alpha} contours are at 1, 10, 50, 100, 500 and 1000 Rayleigh. The thick line shows the edge of the available CO surveys.

- We assessed the existence and investigated origin of millimeter excess emission in the LMC and the SMC using the Planck data.
- The LMC temperature map shows the presence of a warm inner arm already found with the Spitzer data, but also shows the existence of a previously unidentified cold outer arm.
- We show that the excess previously reported in the LMC can be fully explained by CMB fluctuations.
- Possible interpretation of the SMC excess employs the Two-Level-System (TLS) model developed by Meny et al. (2007) combined with spinning dust.

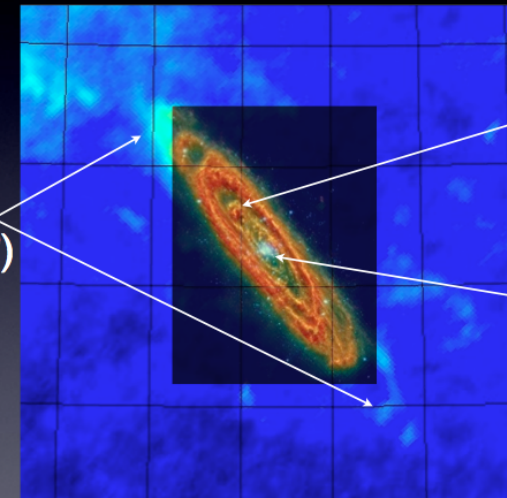
Morphology



NGC 205
No central
bulge
New arm?

Planck 857GHz (log), DX5

Herschel (HELGA)



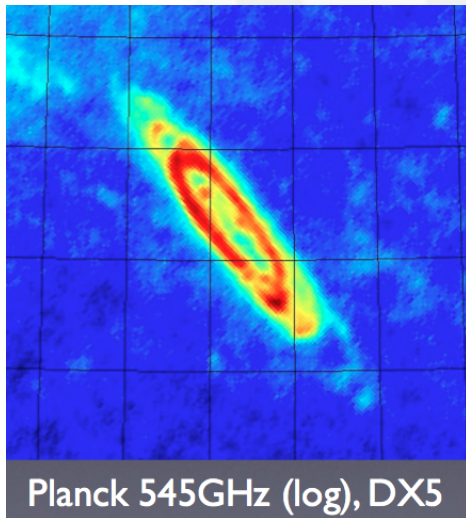
Misses
outskirts(?)

NB: using press
release image
Includes XMM

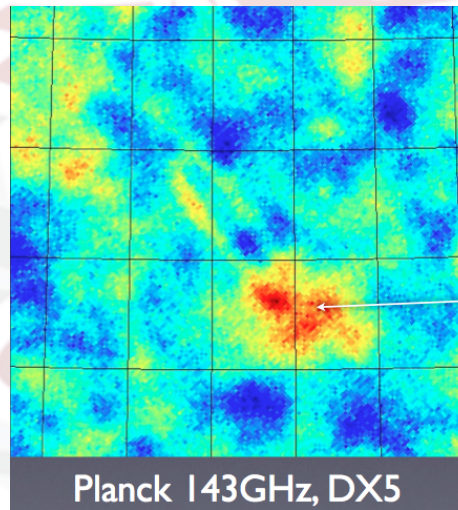
Cold dust
spot
No sign of
central
emission

Data will become
public later this year

Planck 857GHz (log), DX5

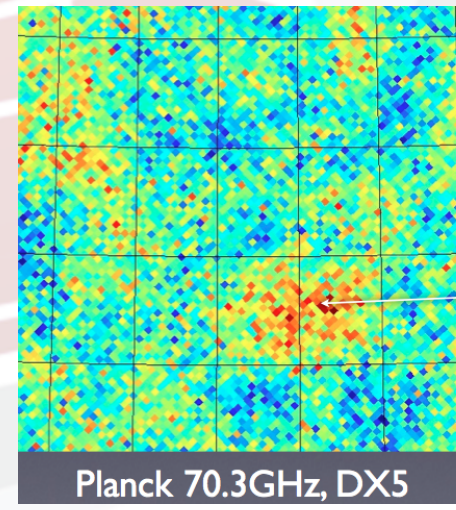


Planck 545GHz (log), DX5



Large CMB
anisotropy

Planck 143GHz, DX5



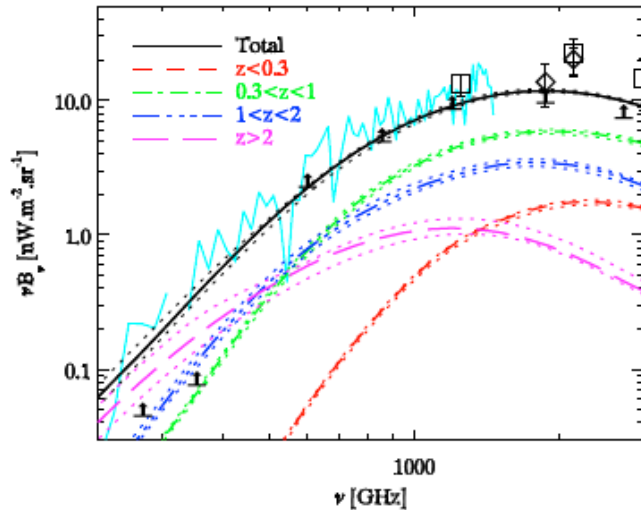
'Just' CMB?

Planck 70.3GHz, DX5

The case of NGC 205

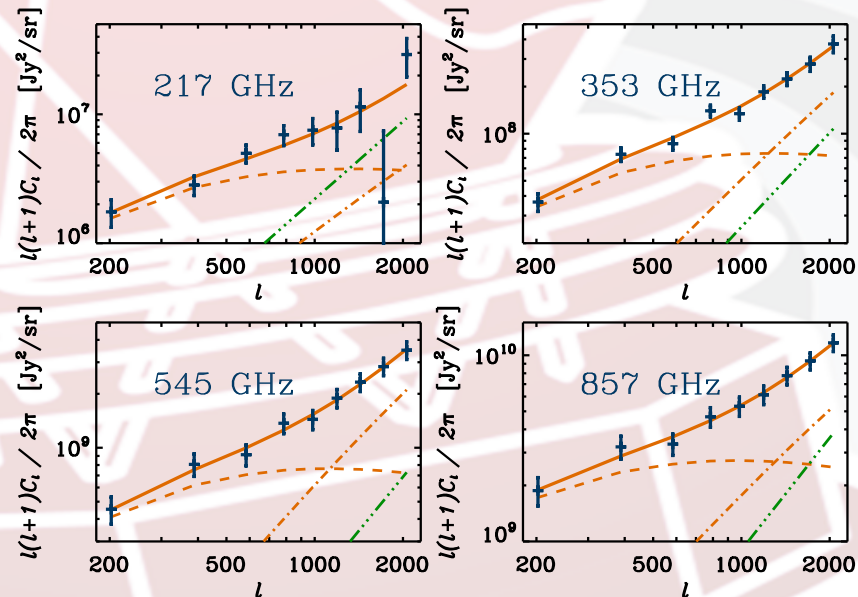
Planck Early Results: Power spectrum of CIB anisotropies with Planck/HFI

Cosmic Infrared Background records much of the radiant energy released by processes of structure formation that have occurred since the decoupling of matter and radiation following the Big Bang.



Contribution to the CIB per redshift slice, extracted from Bethermin et al. (2010b). Black solid line: CIB spectrum predicted by the model.

Due to its frequency coverage from 100 to 857 GHz, the HFI instrument onboard Planck is sensitive to the complete history of star-formation and is thus ideally suited to probe the dark matter/star-formation connection.



Power spectra are measured independently for the 6 fields and are then combined.

- First measurements at those wavelengths and spatial scales;
- We measure strong frequency-correlated structures consistent with the expected CIB signal. The correlation decreases with increasing frequency;
- No significant difference between the frequency spectrum of the CIB anisotropies and the CIB mean is observed;

WG7 Galactic science

papers, A&A 536

- Planck Early Results: Dust in the diffuse interstellar medium and the Galactic halo 1101.2036
- Planck Early Results: The Galactic Cold Core Population revealed by the first all-sky survey 1101.2035
- Planck Early Results: The submillimetre properties of a sample of Galactic cold clumps 1101.2034
- Planck Early Results: Properties of the interstellar medium in the Galactic plane 1101.2032
- Planck Early Results: New Light on Anomalous Microwave Emission from Spinning Dust Grains 1101.2031
- Planck Early Results: All sky temperature and dust optical depth from Planck and IRAS: Constraints on the “dark gas” in our Galaxy 1101.2029
- Planck Early Results: Thermal dust in Nearby Molecular Clouds 1101.2037



C. Burigana, Bologna, 2-3/4/2012



Galactic studies with Planck

- The Planck multifrequency view of our Galaxy allowed for the first time a detailed investigation of many interesting topics
- Early studies/papers achieved crucial results on the following aspects:
 - Dark gas in the Galaxy
 - Microwave anomalous emission
 - Interstellar medium
 - Cold cores
 - Thermal dust on nearby molecular clouds

All sky temperature and dust optical depth from Planck and IRAS: Constraints on the "dark gas" in our galaxy

The temperature map trace the spatial variations of radiation field intensity associated to star formation in the Galaxy

Correlations between the dust optical depth and gas column density as derived from HI and CO observations

The optical depth in the intermediate column density range shows

→ an excess in all photometric channels considered in this study

We interpret the excess as dust emission associated to Dark-Gas, most likely in the molecular phase where H₂ survives photodissociation, while the CO molecule does not

The derived mass of the dark molecular gas, assuming the same dust emissivity

as in the HI phase is found to correspond to

≈ 28% of the atomic mass and ≈ 115% of the molecular gas mass



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All-sky maps of thermal dust temperature

optical depth
column density

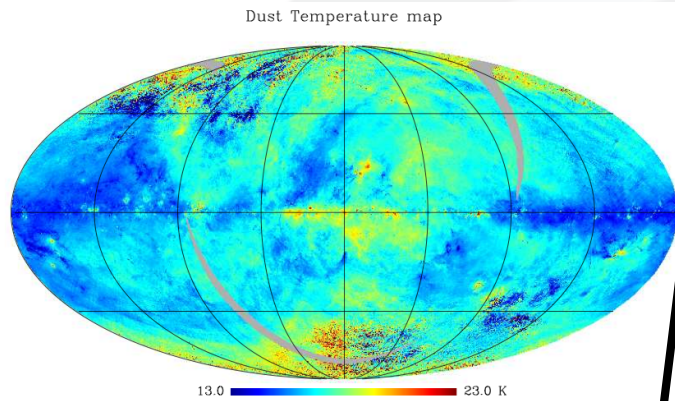


Fig. 3. All-sky map of the dust temperature in K. The temperature is derived from modeling the IRIS 100 μ m and the Planck-HFI emission at 857 and 550. The map is shown in galactic coordinates with the galactic center at the center of the image.

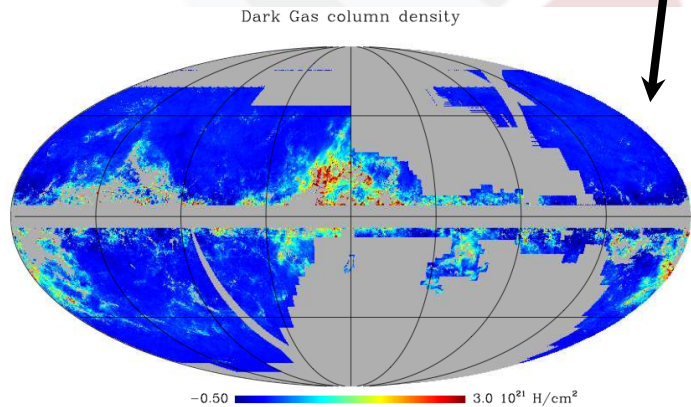


Fig. 8. Map of the excess column density derived from the 857 GHz Data. The maps is shown in galactic coordinates with the galactic center at the center of the image. The grey regions corresponds to those removed in the calculation of the dark-gas mass fraction ($W_{CO} > 1 \text{ K km/s}$ or $|b| < 5^\circ$.)

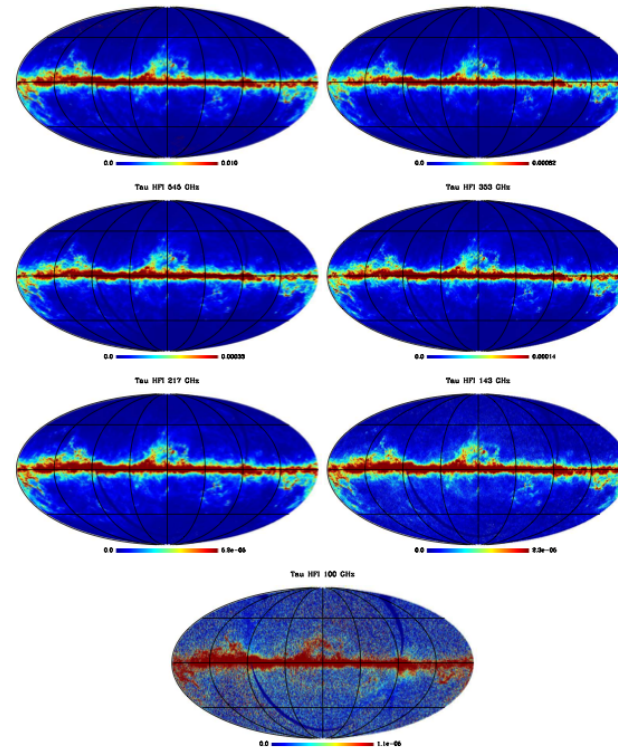


Fig. 5. Maps of the dust optical depths in the IRAS 100 μ m and Planck-HFI bands. All maps are shown in galactic coordinates with the galactic center at the center of the image. The upper bound of the color scale is set as $\tau_{max} = 0.01 \cdot (\lambda/100\mu\text{m})^{-2}$.

The comparison of this value with the recent calculations for molecular clouds more massive than the ones present in the solar neighborhood indicates a **dark gas fraction about 3 times larger in the solar neighborhood.**

The threshold for the onset of the Dark-Gas transition is found to be $\approx 0.37\text{mag}$ and appears compatible to, although slightly larger than the ones predicted by this model

New Light on Anomalous Microwave Emission from Spinning Dust Grains

Planck, combined with ancillary radio and FIR data, has provided a unique opportunity to establish a comprehensive spectrum of AME: **present observations strongly favour the spinning dust (electro-dipole radiation) mechanism** which provides a good fit to the microwave (10 – 100 GHz) part of their spectra which peaks at ≈ 30 GHz

The two best-studied AME sources that have extensive ancillary data are in

Perseus and ρ Ophiuchus molecular clouds

Using parameters constrained at smaller angular scales, the 20 – 40 GHz AME peak in Perseus is well explained with spinning dust emission arising from dense, molecular gas ($n_{\text{H}} > 200 \text{ cm}^{-3}$) subjected to a few times the interstellar radiation field. The contribution from low density gas appear to only play a minor role

In the case of ρ Ophiuchus, irradiated, high density molecular gas from the PDR appears to contribute in the range 50 – 100 GHz. The picture seems to be that smaller PAHs are found in PDRs ($G_0 > 100$) as suggested by recent Spitzer observations

- Determination of the PAH size degenerate with that of n_{H} and G_0 and quantitative conclusions will be obtained from consistent modeling of the gas state, radiative transfer and spinning dust
- At this level of modelling it is not possible to constrain the electric dipole moment of PAHs
- Planck data provide a rich source of observations that can be used as a basis for developing a realistic understanding of the AME mechanism in a range of Galactic environments



C. Burigana, Bologna, 2-3/4/2012



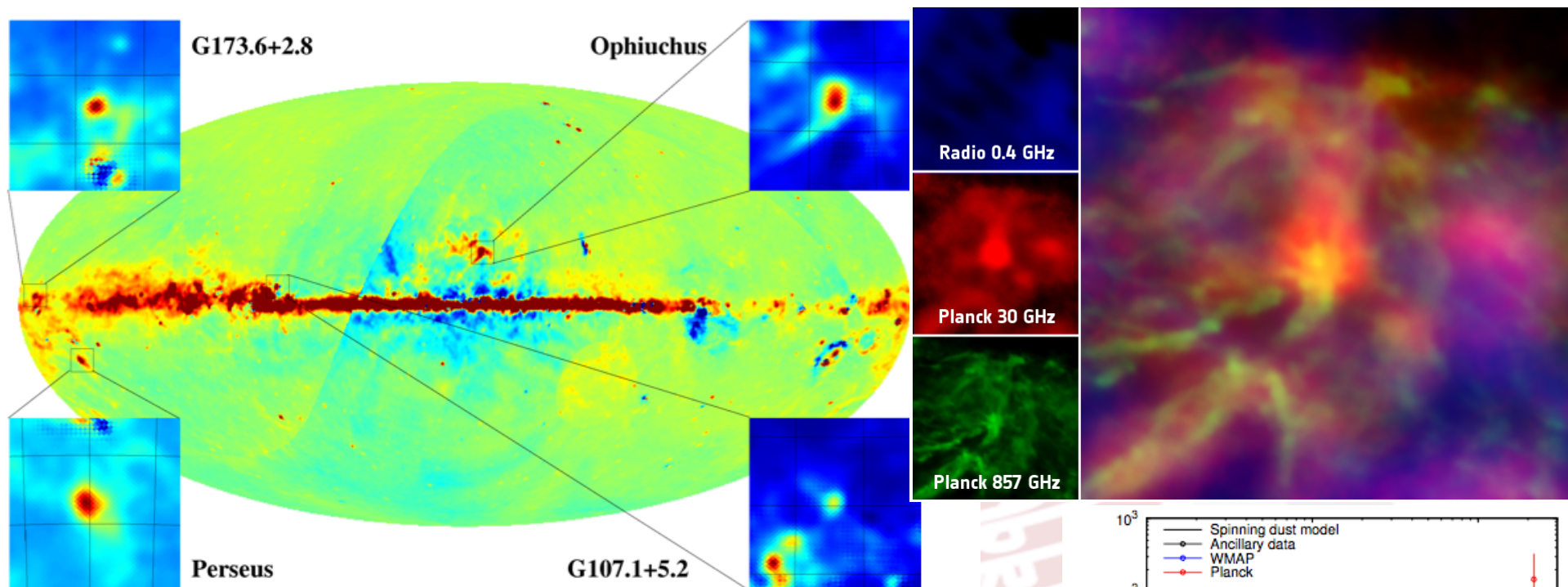


Fig. 10. Residuals in the full sky *Planck* LFI 28.5 GHz 1° smoothed map after subtraction of synchrotron, free-free and thermal dust emission (see text). $12.5^\circ \times 12.5^\circ$ cut out maps are shown for the Perseus and ρ Ophiuchus molecular clouds, and the two new regions of AME, G107.1+5.2 and G173.6+2.8.

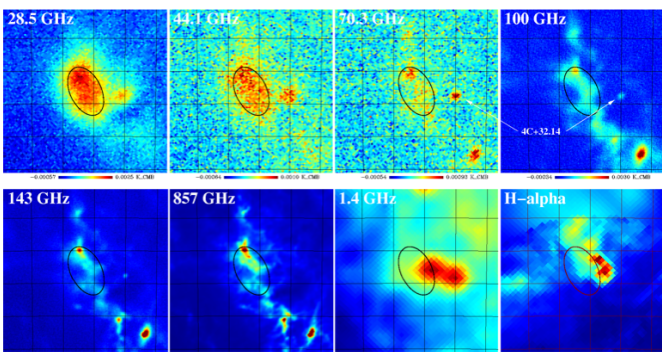


Fig. 1. Maps of the Perseus molecular cloud region at their original angular resolution. From left to right, top row: *Planck* 28.5, 44.1, 70.3 and 100 GHz, bottom row: *Planck* 143 and 857 GHz, 1.4 GHz and H α . The maps cover $5^\circ \times 5^\circ$ centred on $(l, b) = (162.26, -18.62)$ and have linear colour scales. The graticule has $1'$ spacing. The FWHM of the elliptical Gaussian model used to fit the flux density in the filtered maps (see text) is shown. The strong AME is evident at 30 – 70 GHz.

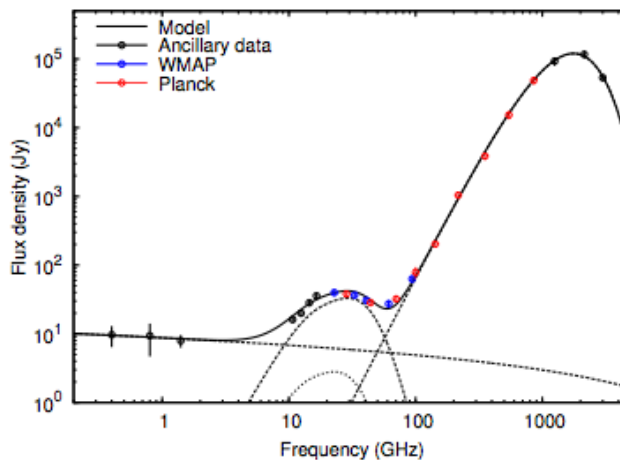


Fig. 4. Spectrum of G160.26-18.62 in the Perseus molecular cloud. The best-fitting model consisting of free-free, spinning dust (2 components), and thermal dust is shown.

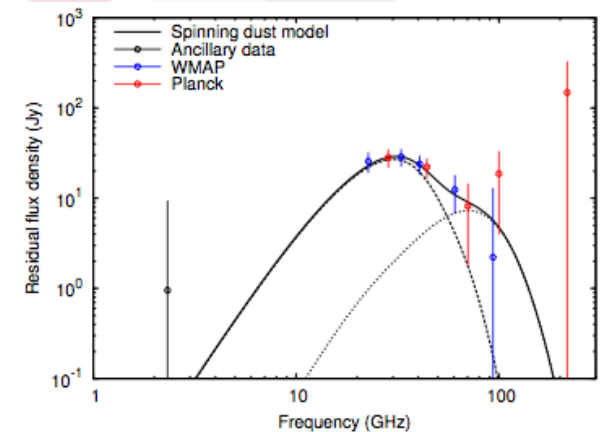


Fig. 9. Spectrum of G353.05+16.90 in the ρ Ophiuchus molecular cloud after subtracting the best fit free-free, CMB and thermal dust components. A theoretical spinning dust model consisting of two components (dark cloud and PDR; see text), is shown.

The Galactic Cold Core Population revealed by the first all-sky survey - I

- Statistical properties of the first version of the **Cold Core Catalogue of Planck Objects (C3PO)**, in terms of their **spatial distribution, temperature, distance, mass, and morphology**
- Statistics of the Early Cold Core Catalog (ECC): it is a subset of the complete catalogue that contains only the most reliable detections
- ECC is delivered as a part of the ERCSC
- CoCoCoDeT algorithm to extract **about 10 thousands cold sources**
- The method uses the **IRAS 100 μ m data as a warm template** that is extrapolated to the Planck bands and subtracted from the signal, leading to a detection of the cold residual emission
- **Cross-correlation with ancillary data** to increase the reliability of our sample, and to derive other key properties like distance and mass
- **Temperature and spectral index values** derived using the fluxes in the **IRAS 100 μ m band** and the **three highest frequency Planck bands**



C. Burigana, Bologna, 2-3/4/2012



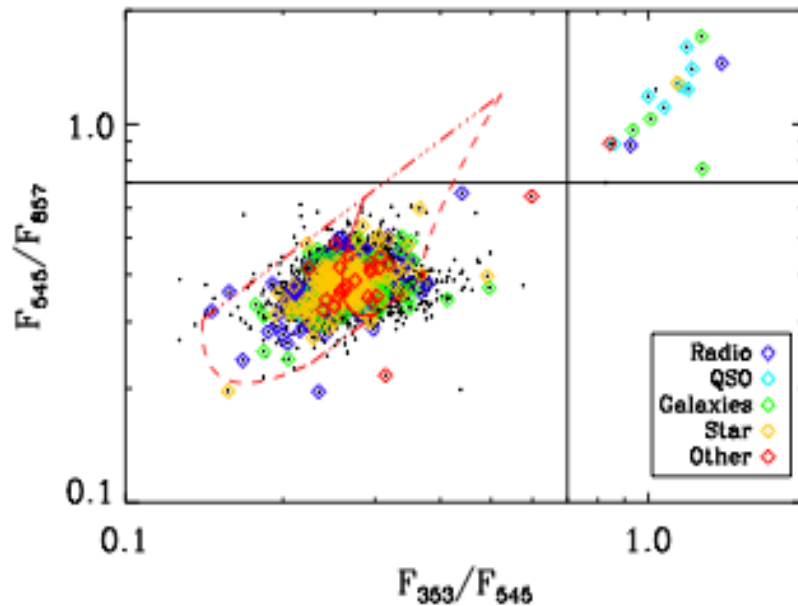


Fig. 1. Color-Color diagram of the catalogue. The over-plotted symbols stand for the positive cross-matches with non ISM objects. The red contours give the domain of the diagram filled by Archeops cold cores assumed to follow a grey-body law, with a temperature ranging from $6\text{ K} < T < 25\text{ K}$, and a spectral index β given by Désert et al. (2008).

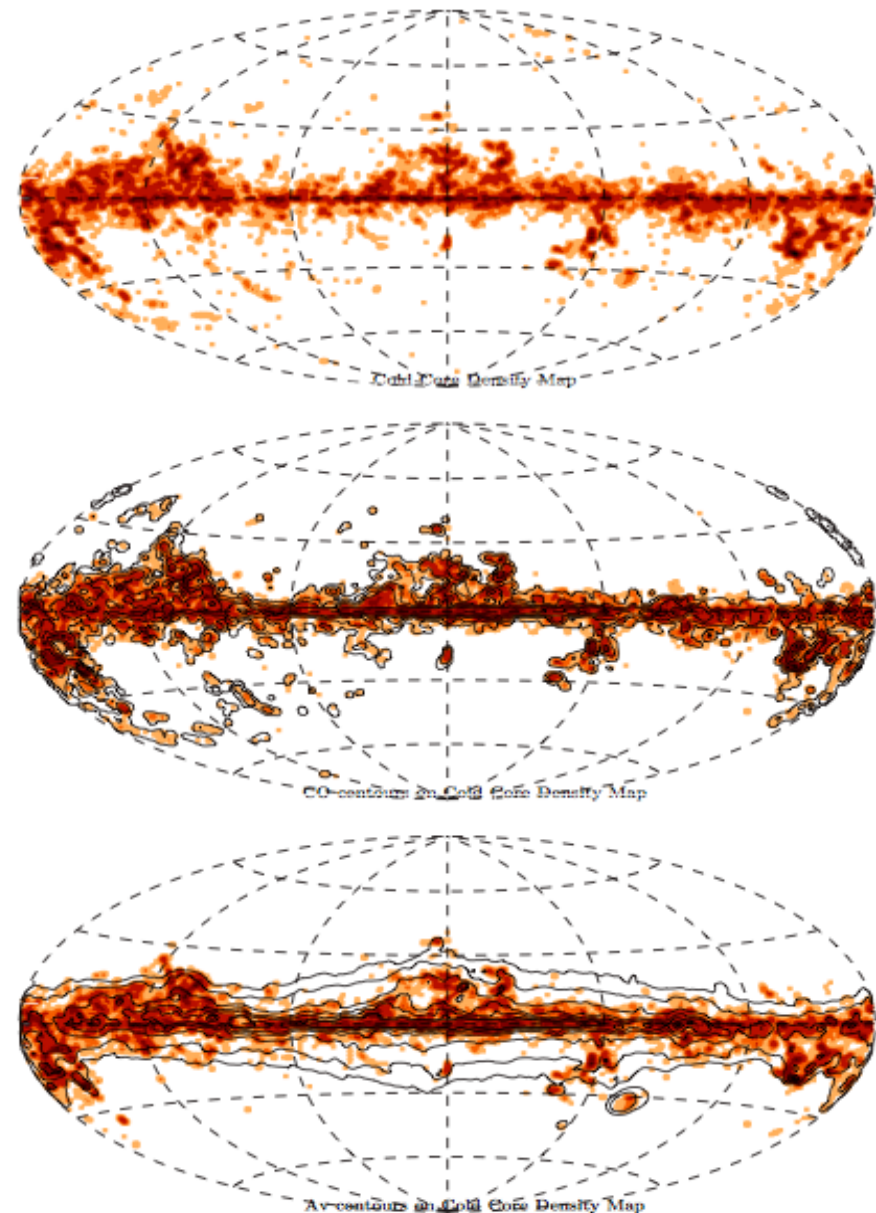
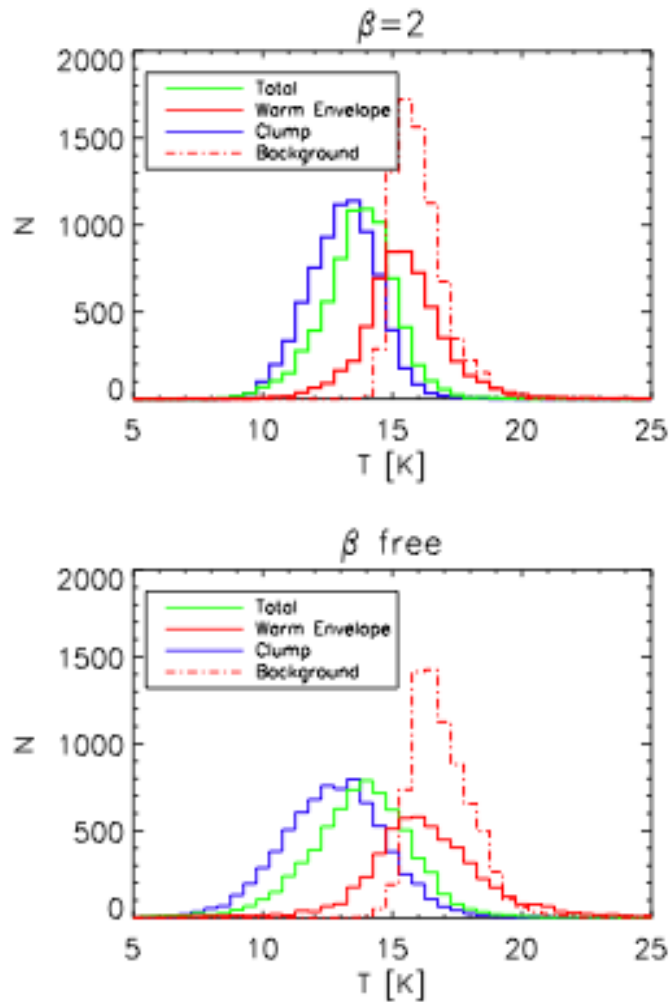


Fig. 3. Upper panel: All-sky density map of the C3PO Planck Cold Clumps, smoothed at $3'$. Middle panel: CO contours are over-plotted on the C3PO density map which is set to 0 where CO map is not defined. Lower panel: A_V contours are over-plotted on the C3PO density map which is set to 0 where A_V map is lower than $0.1 A_V$.



v1.0

Fig. 6. Distribution of the temperature of the cold clumps (blue), of the warm envelope (red) and of the total (green) estimated inside the elliptical gaussian of the clump itself. The averaged temperature of the local background is plotted in red dot-dash line.

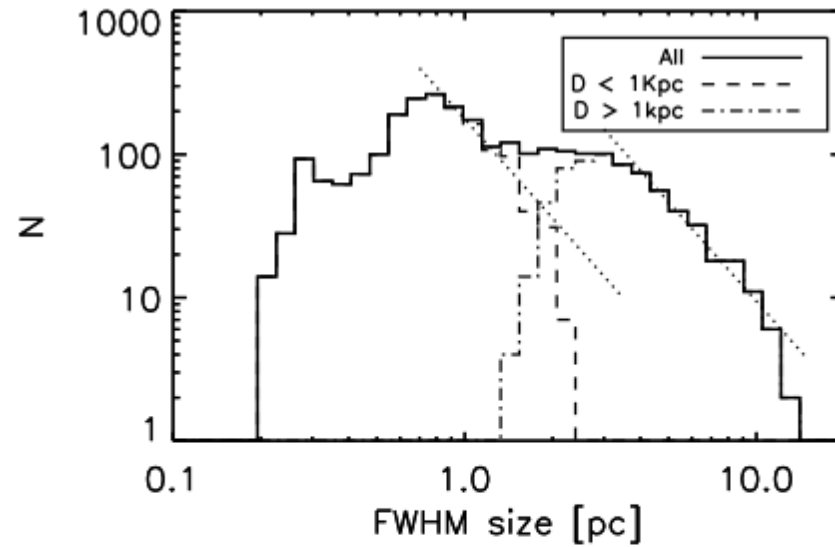


Fig. 9. Distribution of the physical size of the cold clumps in pc. The distinction is done between the local sample ($D < 1\text{kpc}$, dashed line) and the distant sample ($D > 1\text{kpc}$, dot-dash line). A power law with $\alpha = -2.3$ is overlaid in dotted line over the 2 subsets.

Current/Next steps

- Intermediate papers will appear almost continuously during 2011, with a “first presentation” already done at February 2012 in occasion of the *Planck 2012 Conference in Bologna CNR Area "Astrophysics from radio to sub-millimeter wavelengths: the Planck view and other experiments"* (Feb 13-17) and then again continuously during 2012 and later.
- ❖ P. Giommi et al., Simultaneous Planck, Swift, and Fermi observations of X-ray and gamma-ray selected blazars 2011arXiv1108.1114G
- ❖ Planck Intermediate Results. I. Further validation of new Planck clusters with XMM-Newton 2011arXiv1112.5595P
- **2013 – delivery of Planck products & release of cosmological papers based on the first 15 months of data.**
- Astrophysical papers will be roughly divided into two wide categories: those mainly based only total intensity data and those requiring well established polarization data; this (but not only of course!) will reflect into readiness/ submission period.



C. Burigana, Bologna, 2-3/4/2012



Current Galactic *Planck* Intermediate Papers

- Anomalous microwave emission in Galactic HII regions and Galactic clouds
- Component separation in the Gould Belt System
- **A map of CO extracted from *Planck***
- **The Galactic Haze as seen by *Planck***
- Galactic PNe with *Planck*
- Herschel observations of selected *Planck* cold clumps

Current Extragalactic *Planck* Intermediate Papers

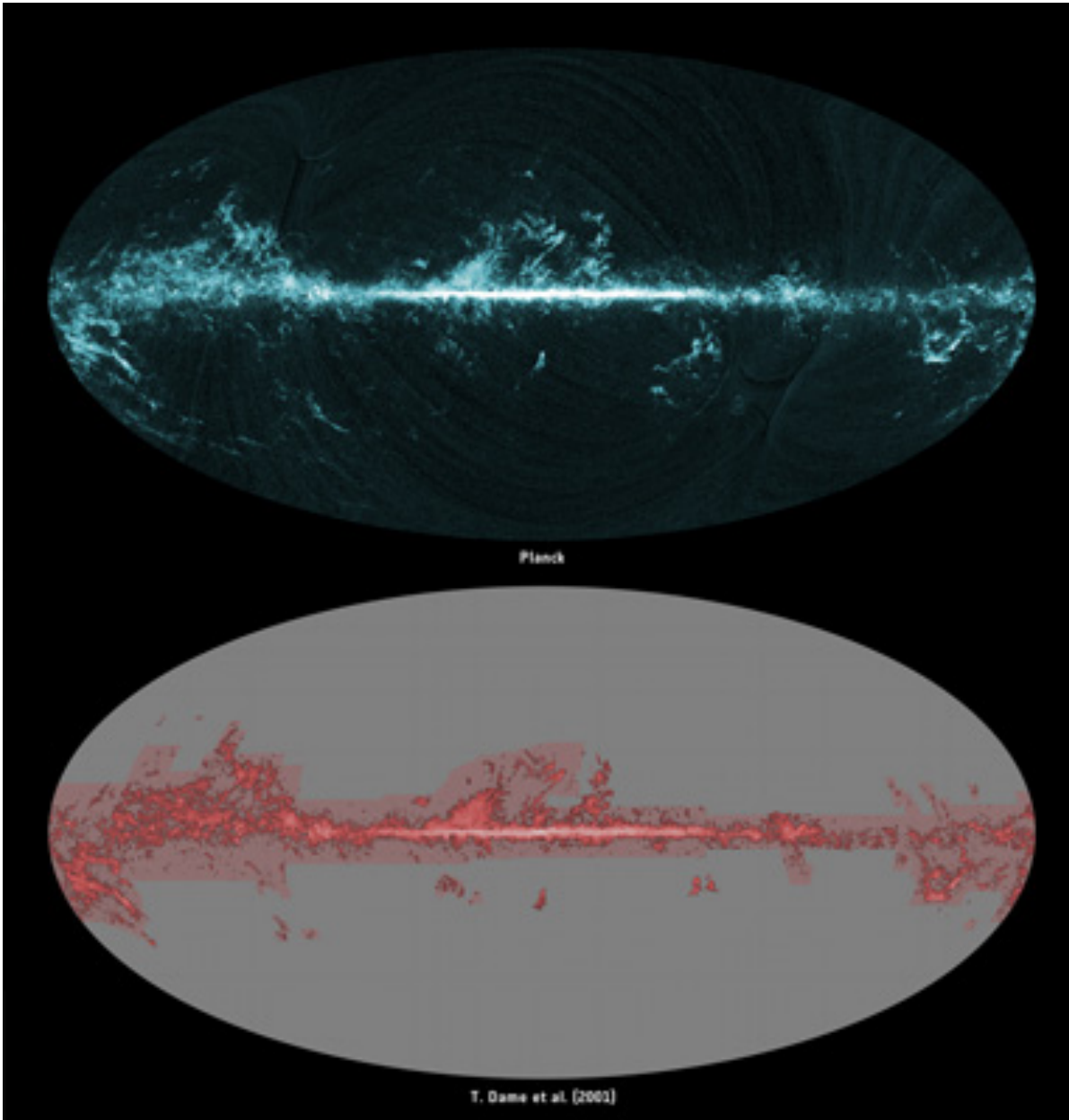
- Comparison of VLA/ERCSC fluxes
- Characterization of the first *Planck* high-z candidates
- Statistical Properties of Infrared and Radio Sources from the *Planck ERCS Catalog*
- Confirmation and first scientific characterization of new *Planck* clusters from *XMM* validation follow-up
- The gas content of dark matter halos: the Sunyaev-Zel'dovich stellar mass relation for central galaxies
- Physics of the hot gas in the Coma cluster
- Comparison of Sunyaev-Zel'dovich measurements from *Planck* and from the Arcminute Microkelvin Imager for 11 galaxy clusters
- The relation between galaxy cluster mass and Sunyaev-Zel'dovich effect

CO map

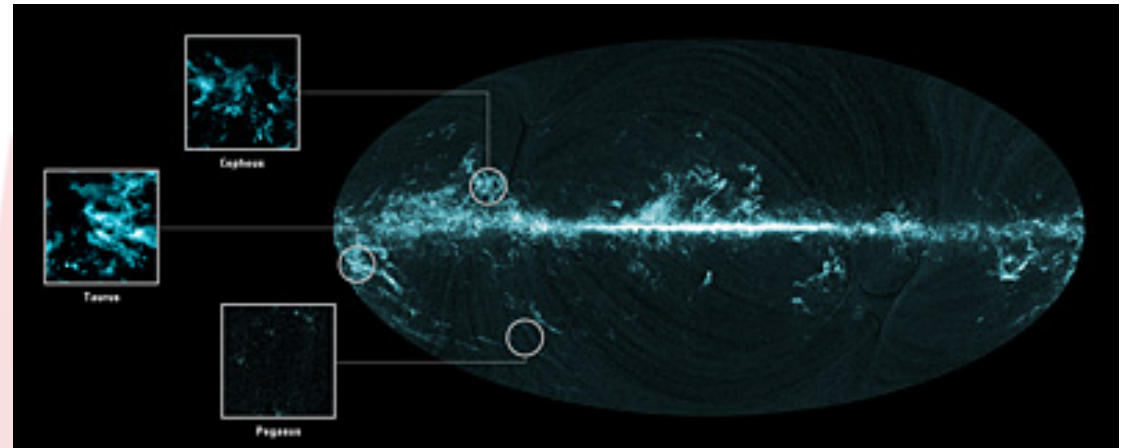
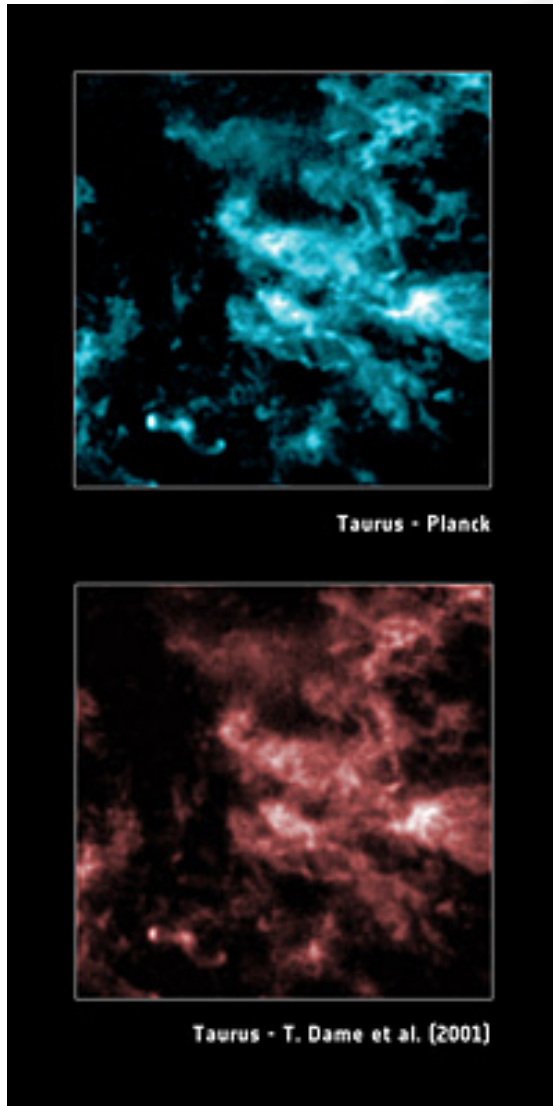
This all-sky image shows the distribution of carbon monoxide (CO), a molecule used by astronomers to trace molecular clouds across the sky, as seen by Planck (blue).

Carbon monoxide (CO) emits a number of rotational emission lines in the frequency range probed by Planck's High Frequency Instrument (HFI).

A compilation of previous surveys (Dame et al. (2001)), which left large areas of the sky unobserved, is shown for comparison (red).

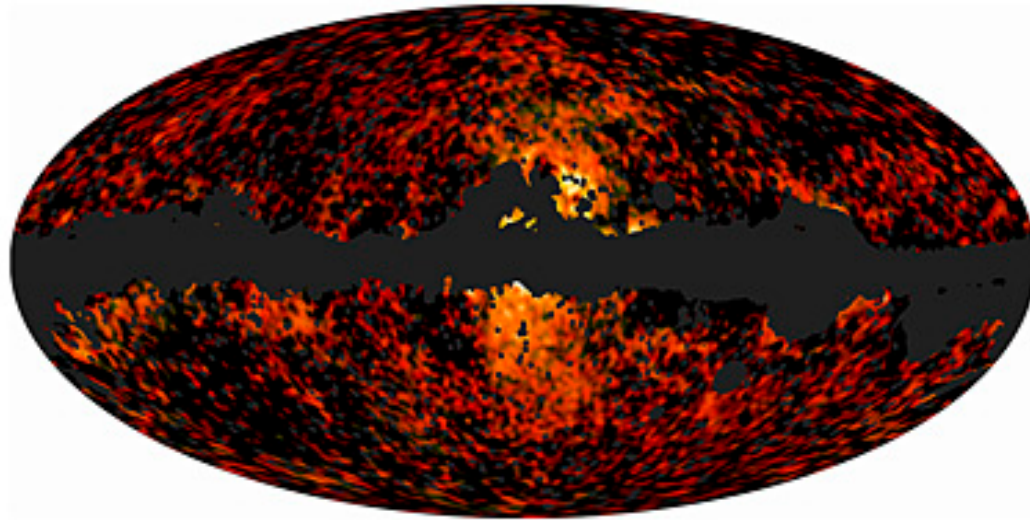


CO map & specific sky areas



The inserts provide a zoomed-in view onto three individual regions on the sky where Planck has detected concentrations of CO: Cepheus, Taurus and Pegasus, respectively.

Taurus molecular cloud complex as seen through the glow of carbon monoxide (CO) with Planck (blue). The same region is shown as imaged by previous CO surveys (Dame et al., 2001) for comparison (red).

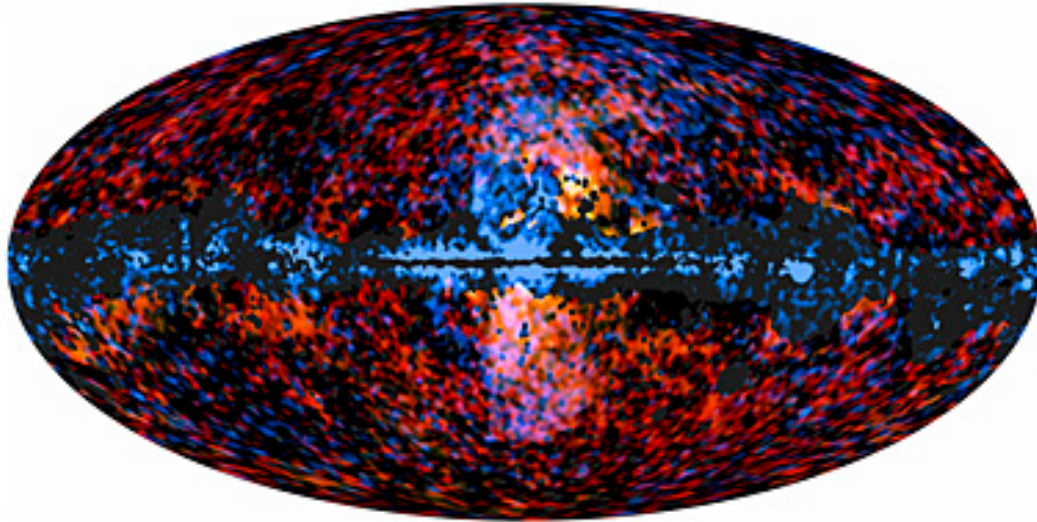


Haze with *Planck*

❖ Galactic Haze at 30 and 44 GHz, extracted from the Planck observations. In addition to this component, other foreground components such as synchrotron and free-free radiation, thermal dust, spinning dust, and extragalactic point sources contribute to the total emission detected by Planck at these frequencies. The prominent empty band across the plane of the Galaxy corresponds to the mask that has been used in the analysis of the data to exclude regions with strong foreground contamination due to the Galaxy's diffuse emission. The mask also includes strong point-like sources located over the whole sky.

❖ The Galactic Haze is seen to be distributed around the Galactic Centre and its spectrum is similar to that of synchrotron emission. However, compared to the synchrotron emission seen elsewhere in the Milky Way, the Galactic Haze has a 'harder' spectrum, meaning that its emission does not decline as rapidly with increasing frequency. Diffuse synchrotron emission in the Galaxy is interpreted as radiation from highly energetic electrons that have been accelerated in shocks created by supernova explosions.

Haze with *Planck & Fermi*



- ❖ The Fermi data (shown here in blue) correspond to observations performed at energies between 10 and 100 GeV and reveal two bubble-shaped, gamma-ray emitting structures extending from the Galactic Centre.
- ❖ The two emission regions seen by Planck and Fermi at two opposite ends of the electromagnetic spectrum correlate spatially quite well and might indeed be a manifestation of the same population of electrons via different radiation processes.

- ❖ Distribution of the Galactic Haze seen by ESA's Planck (shown here in red and yellow at LFI frequencies of 30 and 44 GHz) mission at microwave frequencies superimposed over the high-energy sky as seen by NASA's Fermi Gamma-ray Space Telescope.
- ❖ Several explanations have been proposed for this unusual behaviour, including enhanced supernova rates, galactic winds and even annihilation of dark-matter particles. Thus far, none of them have been confirmed and the issue remains open.

Next steps

- All papers will be reviewed by the (*Planck* Internal) Editorial Board & the *Planck* Science Team.
- Astrophysical projects are carried out by dedicated project teams in the context of *Planck* Working Groups (5 – clusters & secondary anisotropies – 6 – extragalactic sources – 7 – Galactic & solar system science).
- Each project team will prepare one or (typically) more papers.
- We expect several tens of papers in next year.

Topics: extragalactic sources

- (a) Analysis of the statistical properties and evolution of radio and sub-mm sources, and their classification into dominant populations.
- (b) Survey of extreme radio sources, i.e. those with unusual, sharply peaked, or inverted spectra.
- (c) Construction and analysis of a catalogue of quasars and BL Lac objects, combining Planck data with data from a wide variety of other wavelengths. Specific effort is being made to detect flaring sources and follow them up quickly with ground facilities.
- (d) Construction and analysis of a catalogue of nearby galaxies, and the detailed study of a small number of resolved galaxies (LMC, SMC, M 31, M 33).
- (e) All-sky survey and analysis of bright high-redshift dusty galaxies, and possibly proto-clusters.
- (f) Extraction of the cosmic far-infrared background believed to consist of unresolved galaxies, and analysis of the angular power spectra of this component.

Topics: Galactic science

- (a) Construction of a model of the large scale ordered magnetic field in the Galaxy, based on the polarised Planck maps.
- (b) Study of the diffuse warm ionized gas in the Galaxy, based on the Planck map of free-free emission.
- (c) Reconstruction of the Galacto-centric distribution of emission of the different phases of the interstellar medium in the Galaxy (H_2 , HI, H), by correlation of the Planck maps to tracers of each phase.
- (d) Study of the diffuse synchrotron emission from the Galaxy, in particular its spectrum and its spatial structure.
- (e) Study of the physical characteristics of the circumstellar environment of various types of stellar objects in the final phases of their evolution.
- (f) Construction and analysis of a catalogue of compact and ultra-compact HII regions and massive young stellar objects.
- (g) Construction and analysis of a catalogue of cold pre-stellar cores in the Galaxy.

Topics: Galactic science

- (h) Study of the spectral energy distributions of Supernova Remnants across the Planck bands.
- (i) Study of the spatial and spectral distribution of thermal dust polarisation to elucidate the nature of dust in the various phases of the interstellar medium.
- (j) Establishment of the spatial and spectral properties of the anomalous emission so far attributed to spinning dust particles.
- (k) Combination of Planck maps with lower frequency large-scale ground based surveys to study the relationships between the various phases of the Galactic interstellar medium (atomic, molecular, ionized, relativistic, magnetic, etc.).
- (l) Study of the properties of dust in regions at high Galactic latitudes and in intermediate and high velocity clouds, using the Planck data in combination with other tracers such as HI, IRAS/IRIS etc.
- (m) Study of the Planck maps to determine the structure and distribution of mass in molecular clouds.
- (n) Study of the structure and intensity of the magnetic fields (ordered and tangled components) within nearby inter-stellar clouds, in relation with their density and velocity structure.

Detailed characterization of Galactic diffuse components

- 1. Synchrotron: pattern, spectral behaviour
- 2. Free-free: its relevance in particular close to the Galactic plane
- 3. Thermal dust: cold, warm components
- 4. Anomalous emission (spinning dust?)
- 5. Haze (astrophysics vs DM annihilation ?)
- → Galactic magnetic fields
(ordered vs turbulent components)

see interesting recent papers
by Fauvet et al. 2011, 2012

- Dust grain properties
- ISM history

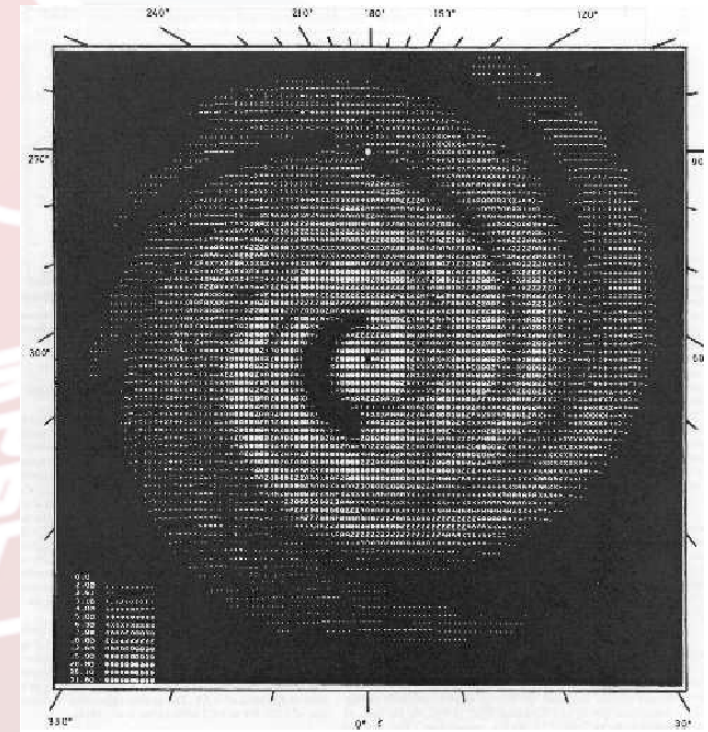
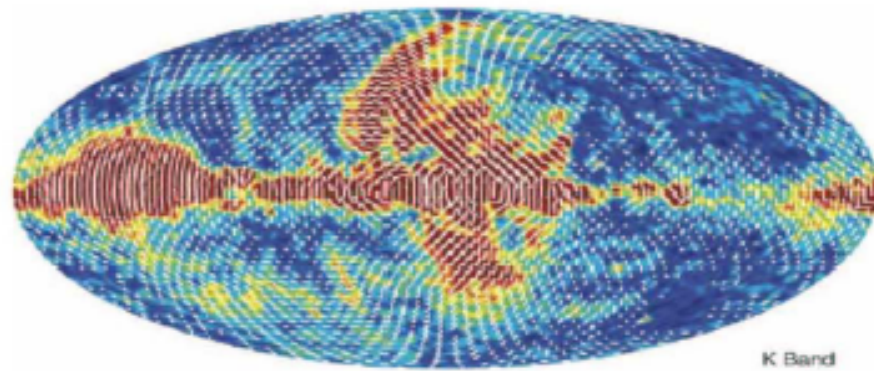


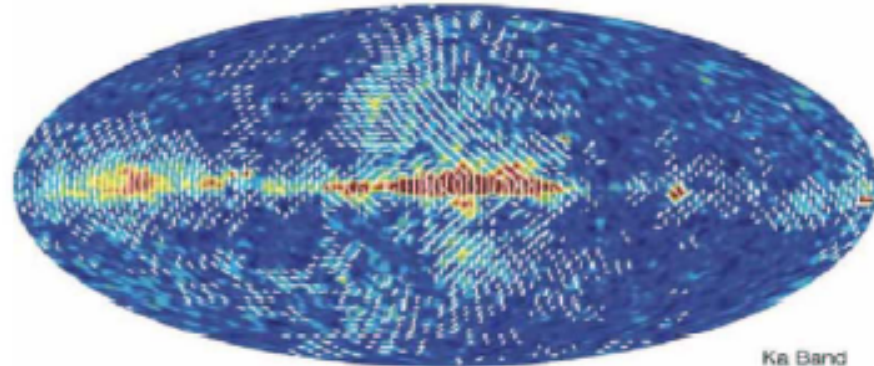
FIG 5.7.— Top view of the 3-D model of synchrotron emissivity derived from the Haslam map by Beuermann et al. (1985). The model contains assumptions on the Galactic magnetic field orientation and degree of alignment along the spiral arm, and therefore can be used to synthesize a map of synchrotron polarisation around the Sun (filled circle).

• Synchrotron Polarization

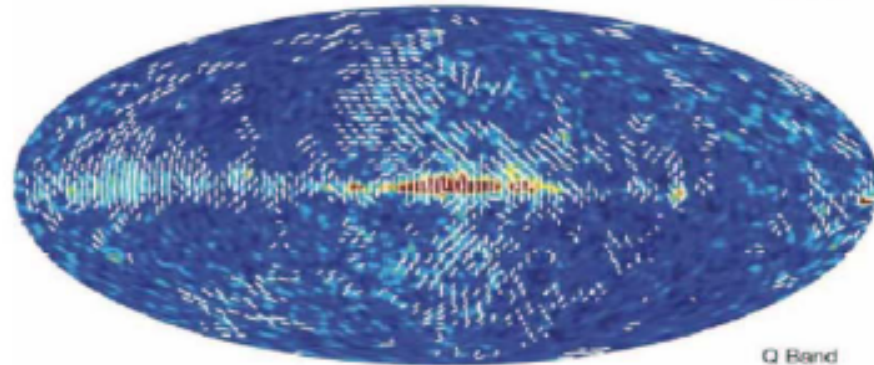
- Info from WMAP
- Info from radio surveys
- Relevance of Planck



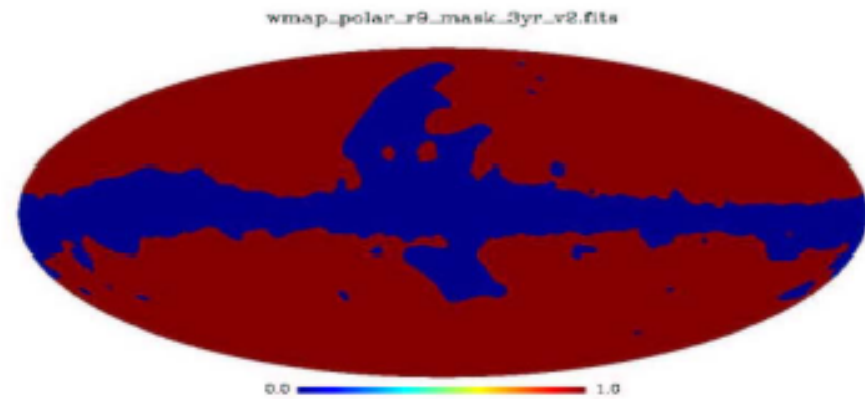
K Band



Ka Band



Q Band



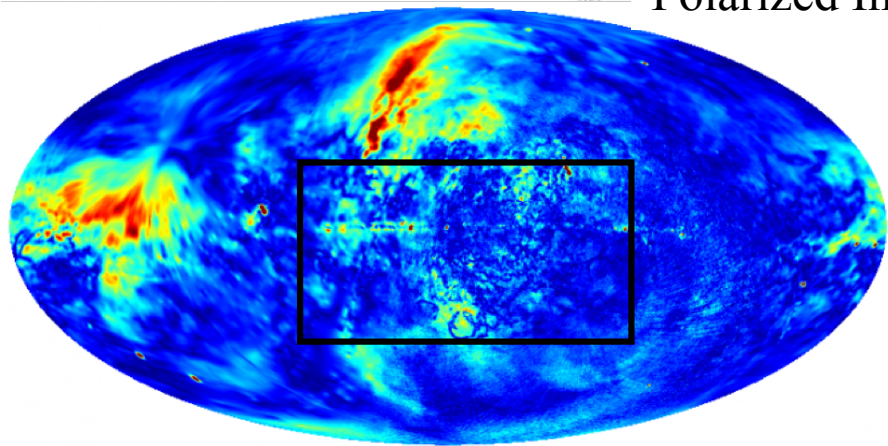
WMAP 3 yr Pol. maps and mask.

Polarization: Comparison of radio 1.4 GHz surveys with WMAP

PI @ 1420 MHz ($n_{\text{side}}=512$)

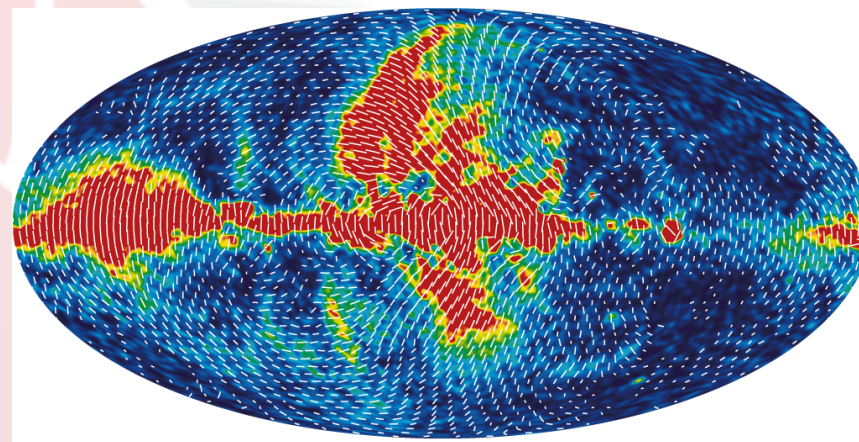
PI @ 1420 MHz ($n_{\text{side}}=6$)

Polarized Intensity



0 500 (mK)

Polarized Intensity

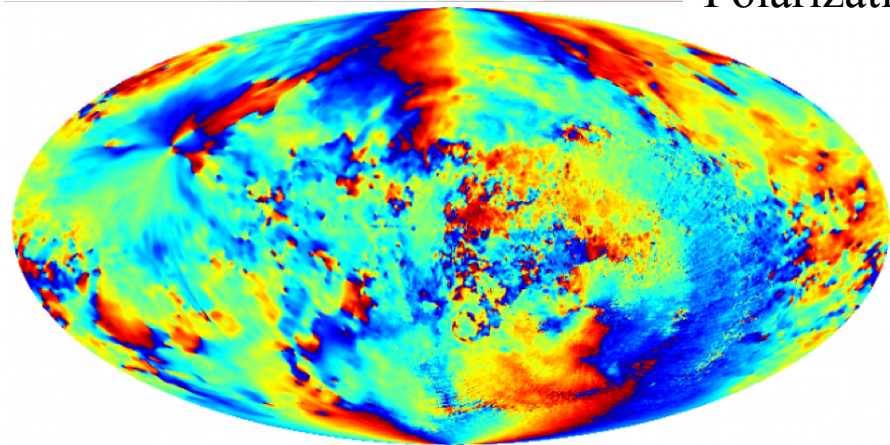


0 T(μ K) 50

Polarization Angle @ 1.4 GHz

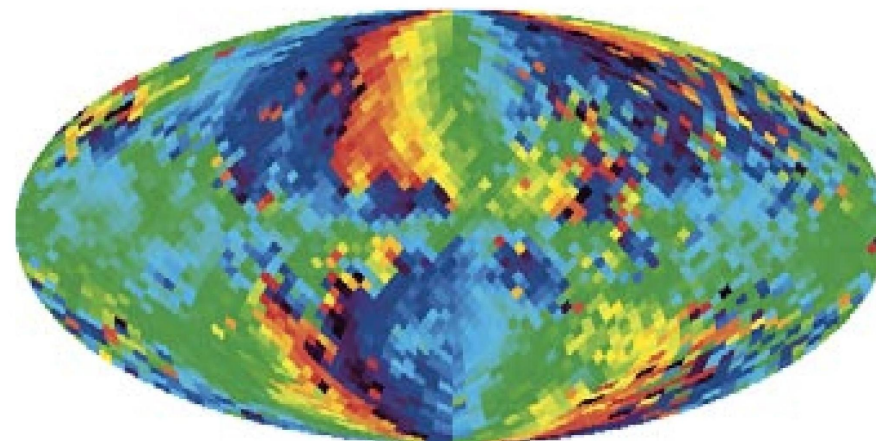
Polarization Angle @ 1.4 GHz

Polarization Angle



-90.0 90.0

Polarization Angle + 90°



0° 180°

1.4 GHz [Reich et al., in preparation]

WMAP 23 GHz

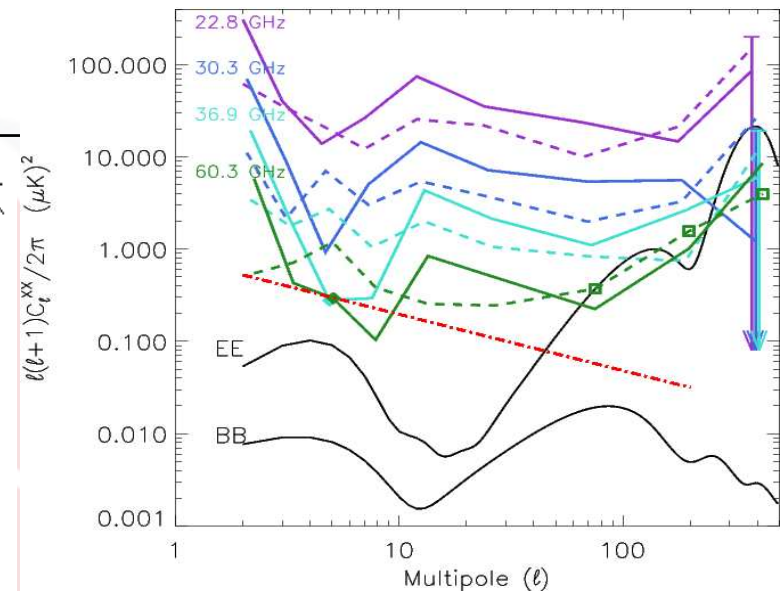
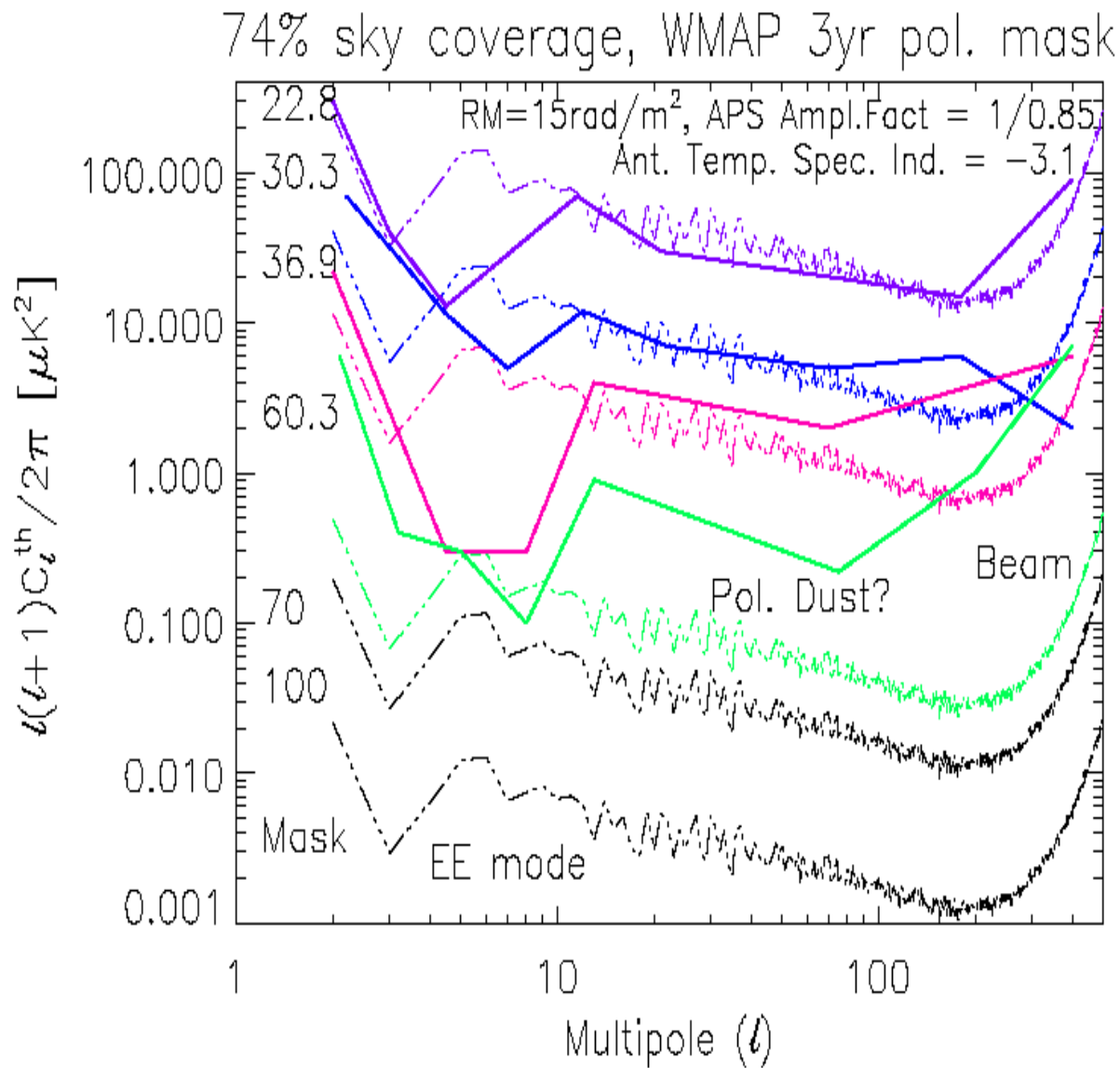
PLANCK 2006



C. Burigana, Bologna, 2-3/4/2012 [Page et al. 2006]



Polarization: radio vs WMAP



In agreement with WMAP results at intermediate ℓ ($\sim 10-100$) within a factor ~ 2 or better, @ $\nu \leq$ of about 40 GHz. Dust important @ higher ν

1.4 GHz new polarization maps good template of the large scale synchrotron emission

Burigana et al. 2006, PoS(CMB2006)016

Solar System Science

Detection and analysis of the emission from several classes of objects, such as main belt asteroids, planets, and comets.

NUMBER OF DETECTABLE MAIN BELT ASTEROIDS^a

R/d	Differential Number	Cumulative Number ^b
$1-2 \times 10^{-7}$	299	397
$2-3 \times 10^{-7}$	76	98
$3-4 \times 10^{-7}$	15	22
$4-5 \times 10^{-7}$	4	7
$R/d > 5 \times 10^{-7}$	0	3

^a The lower threshold considered here for asteroid detection is set to a radius to distance ratio $R/d \sim 10^{-7}$, derived by assuming a typical asteroid temperature of ~ 150 K and by taking into account the *Planck* sensitivity at different channels (see Cremonese et al. 2003 for details).

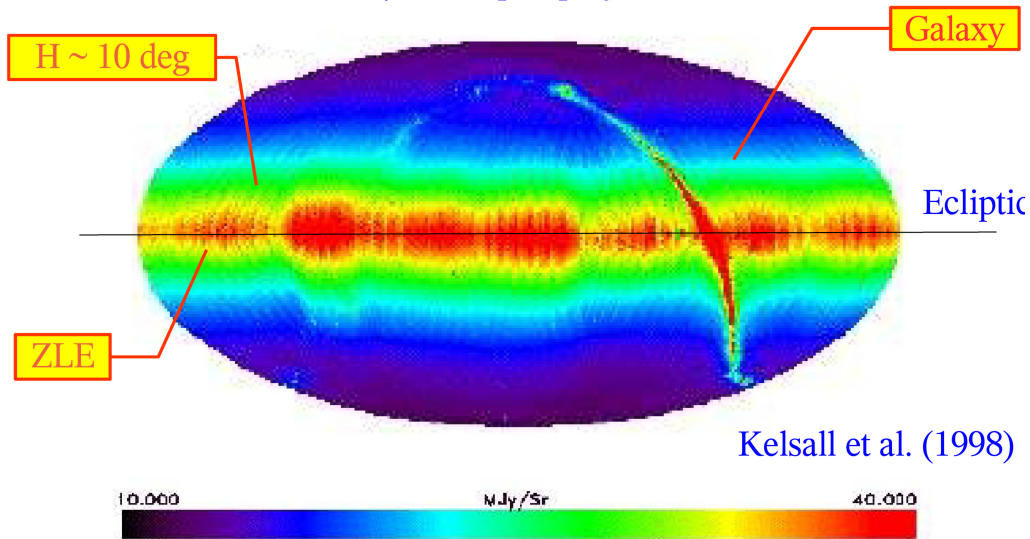
^b The cumulative number is computed at the lower limit of the range listed for the differential number.

Extraction and analysis of the zodiacal light emission, and constraints on dust properties and content within the solar system

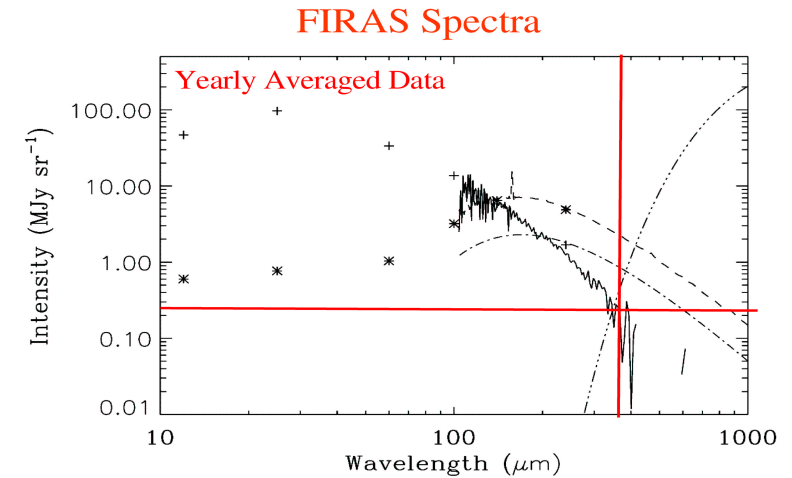
ZLE with *Planck*

ZLE COBE/DIRBE MAP

12 μm , ecliptic projection



Kelsall et al. (1998)



Fixsen, Dwek, 2002 ApJ, 578, 1009

WG7 Meeting - 16 Jan 2007 - Catania - Italy - EU

Maris, Burigana. - ZLE and Planck

7

Two Components Signal $F_f(P)$

f = Frequency (857 GHz, 550 GHz, ...)

$$F_f(P, R_p) = E_f \underbrace{Z_f(P, R_p)}_{\text{Spatial Pattern}} + \underbrace{G_f(P)}_{\text{Galaxy}} + n$$

Pointing (to Z_f) Planck Position (to Z_f)

Emissivity Correction (to E_f) Function of size distribution and grains properties (to Z_f)

Black Body emission averaged for grains spatial density (to G_f)

$$E_f(\text{Smooth}) \sim 0.5$$

$$E_f(\text{Secondary}) \sim 1 \pm 0.2$$

WG7 Meeting - 16 Jan 2007 - Catania - Italy - EU

Maris, Burigana. - ZLE and Planck 4

WG7 Meeting - 16 Jan 2007 - Catania - Italy - EU

Maris, Burigana. - ZLE and Planck 8

KBOE - Large Scale Traces of Solar System Cold Dust on CMB Anisotropies

M. Maris, C. Burigana, A. Gruppuso, F. Finelli, J.M. Diego - MNRAS 2011, 415, 2546

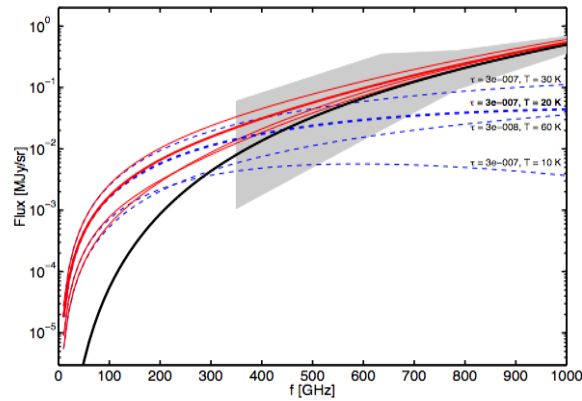


Figure 1. Comparison of ZLE fluxes compatible with COBE/FIRAS data (Fixsen & Dwek 2002) and a set of possible models of KBOE (Stern 1996). The black solid line shows the ZLE derived from the best fit model to COBE/FIRAS data and extrapolated to lower frequencies. The gray band represents a sketch of the allowed region obtained from the error bars in Fixsen & Dwek (2002). The blue dashed lines display four different models of KBOE corresponding to different values of τ and T . The resulting fluxes, sum of KBOE and ZLE, are represented by the red solid lines. Note that the classical ZLE (estimated on the basis of COBE data) is negligible in practice at WMAP frequencies, whereas KBOE might not be ignored.

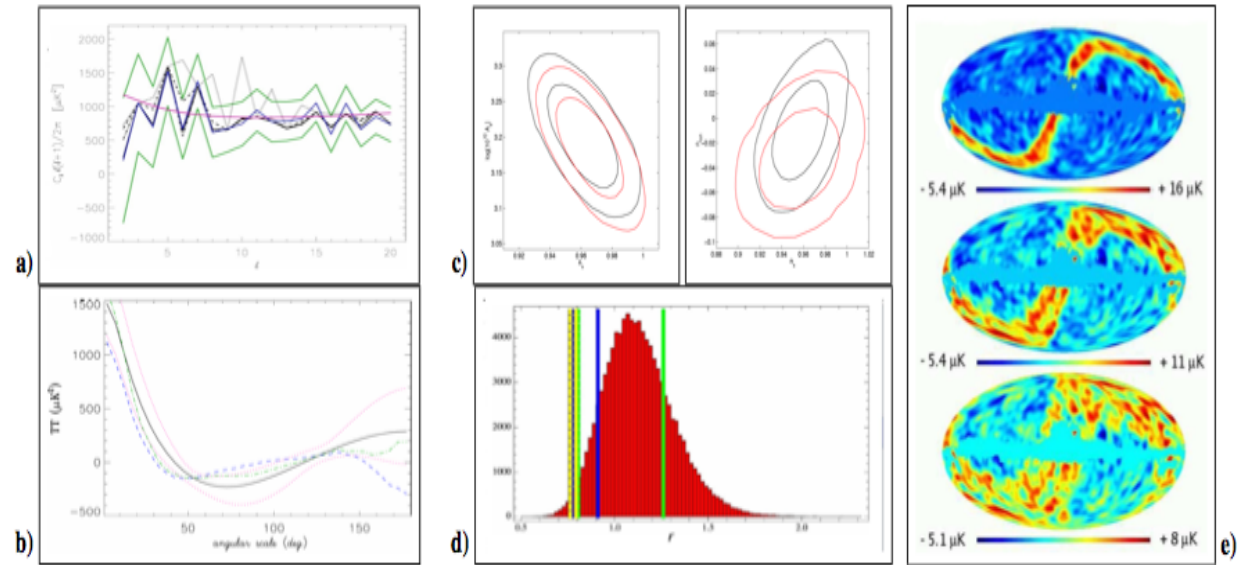
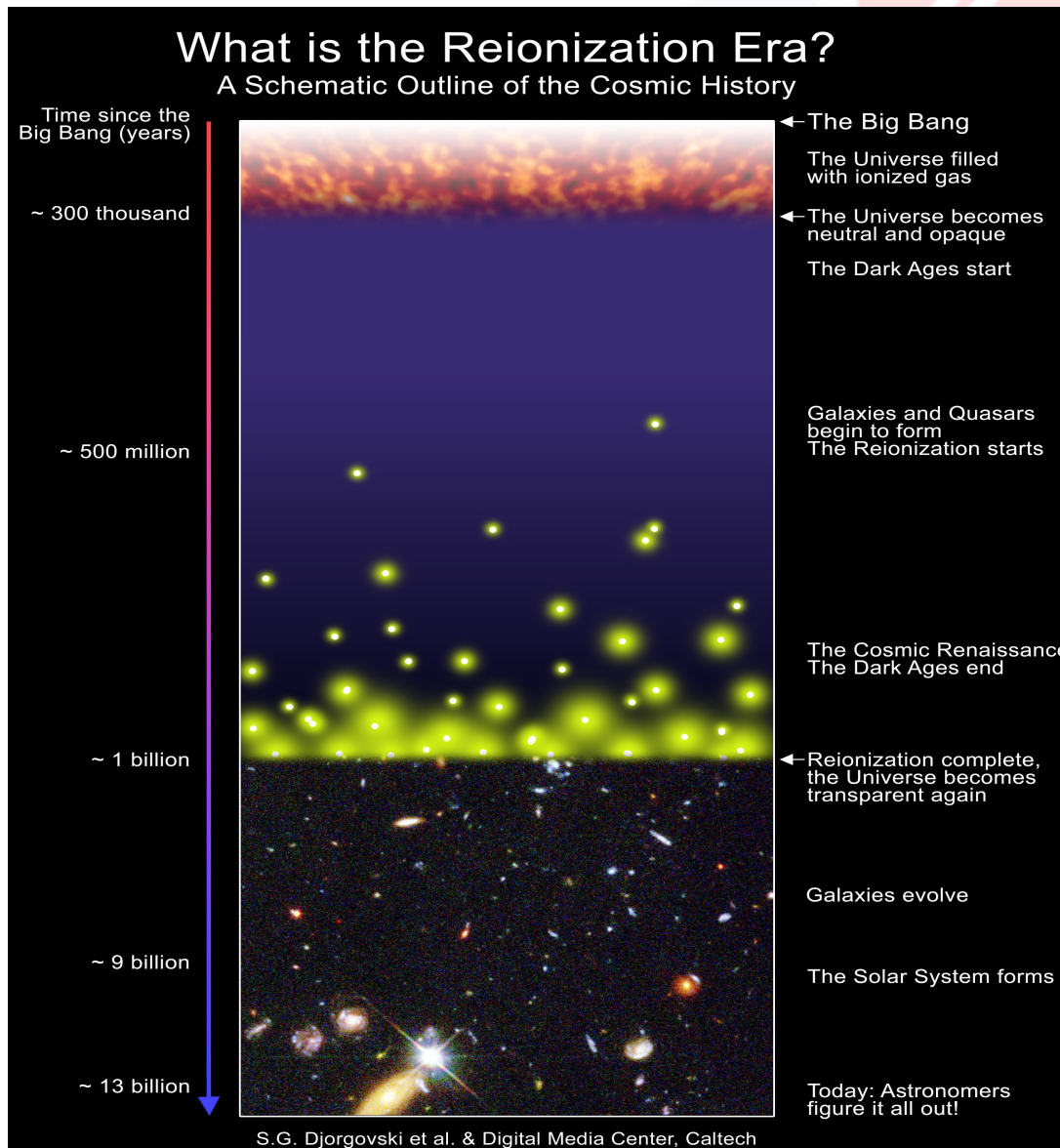


Figure 2. Panel a): APS at low multipoles as derived by the WMAP team analyzing the ILC 7 yr map (blue solid line) with its 1σ errors (green solid lines); APS of the ILC 7 yr map derived using AnaFast (black solid line); APS of the ILC 7 yr map after the subtraction of our KBOE template with $H_{KBOE} = 70^\circ$, 35° and 17.5° (black dotted-dashed line, dashed line, and dotted line, respectively). The dust model with $\tau = 3 \times 10^{-7}$ and $T = 30$ K (CM) and the V band is here considered. The red solid line shows APS of the best fit Λ CDM model for the WMAP 7 yr map. Panel b): two-points correlation function computed for maps at HEALPix resolution $N_{\text{side}} = 16$. The solid line displays the average of 10^5 MC realizations of CMB anisotropy maps extracted from the WMAP 7 yr best fit Λ CDM model APS shown in panel a). The red dotted lines show the corresponding 1σ level fluctuations of the MC simulation. The blue dashed line refers to the ILC 7 yr map. The green dotted-dashed line refers to the map derived subtracting from the ILC 7 yr map one of our KBOE model, namely that obtained for the CM with $H_{KBOE} = 17.5^\circ$. Panel c): Two dimensional marginalised probability distributions for cosmological parameters by removing (black lines) or not removing (red lines) the KBOE template for the CM with $H_{KBOE} = 35^\circ$ (curves are the 68% and 95% confidence level). To the left (right) the plot for $A_s(n_{\text{run}})$ vs n_s for a standard Λ CDM model (including running of the scalar spectral index). Panel d): parity anomaly of the estimator $r = P_+/P_-$ as defined in the text with $\ell_{\text{max}} = 22$. The histogram (in red) displays the distribution of r obtained from 10^5 MC realizations. Vertical lines correspond to the maps considered in this work: the black solid line (on the left) refers to the ILC 7 yr map; colored solid lines refer to the CM; colored dashed lines refer to the WM. Green, blue, and yellow lines are for $H_{KBOE} = 17.5^\circ$, 35° , and 70° , respectively. Panel e): predicted signal in the combination $V + W - 2Q$ from the CM with $H_{KBOE} = 70^\circ$ (bottom), $H_{KBOE} = 35^\circ$ (middle), and $H_{KBOE} = 17^\circ$ (top). The map units are μK and it has been smoothed with a 7° Gaussian. Compare this plot with Fig. 1 of Diego et al. (2010) based on WMAP data: the model with $H_{KBOE} = 70^\circ$ seems to agree better with the observations.

Topics: clusters & secondary anisotropies

- (a) Production and analysis of a catalogue of Sunyaev-Zeldovich (SZ) sources detected by Planck.
- (b) Analysis of the combination of Planck SZ-selected galaxy clusters with a wide range of other observations (X-ray, optical, near-IR, sub-mm), either from existing surveys or by dedicated follow-up, to study their physics and evolution.
- (c) Reconstruction of the ionisation history of the Universe.
- (d) Estimation of the Integrated Sachs-Wolfe effect and its constraints on cosmological parameters e.g. the dark energy equation of state.
- (e) Extraction and analysis of diffuse and kinetic Sunyaev-Zeldovich components.

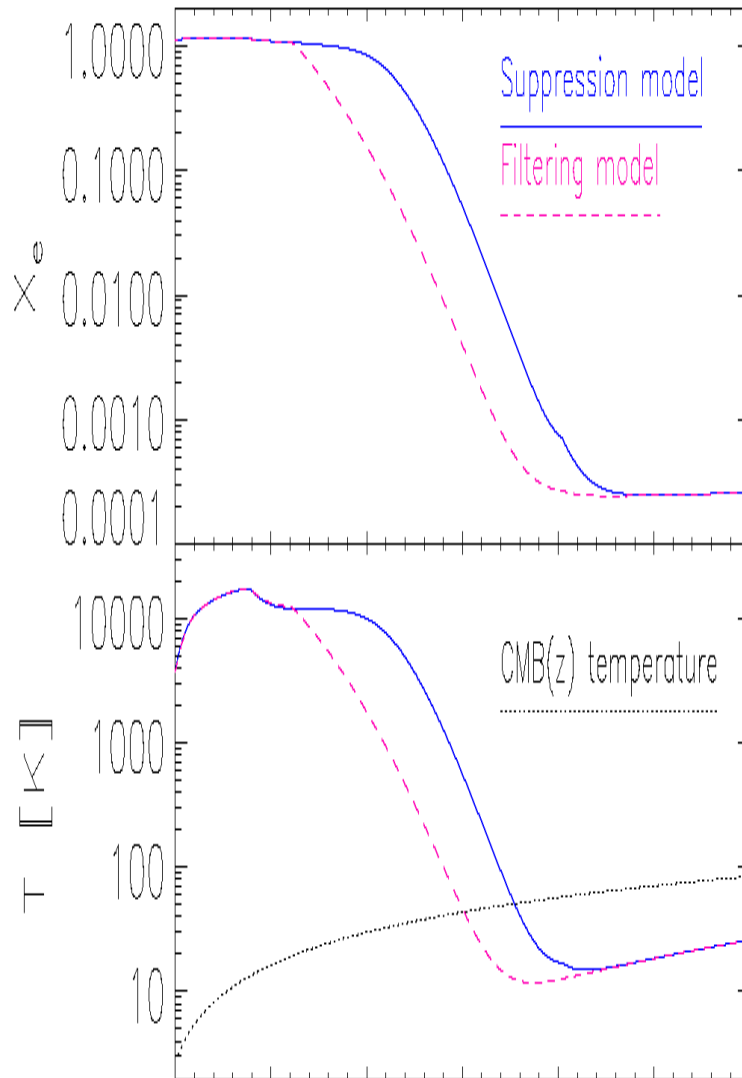
Reionization



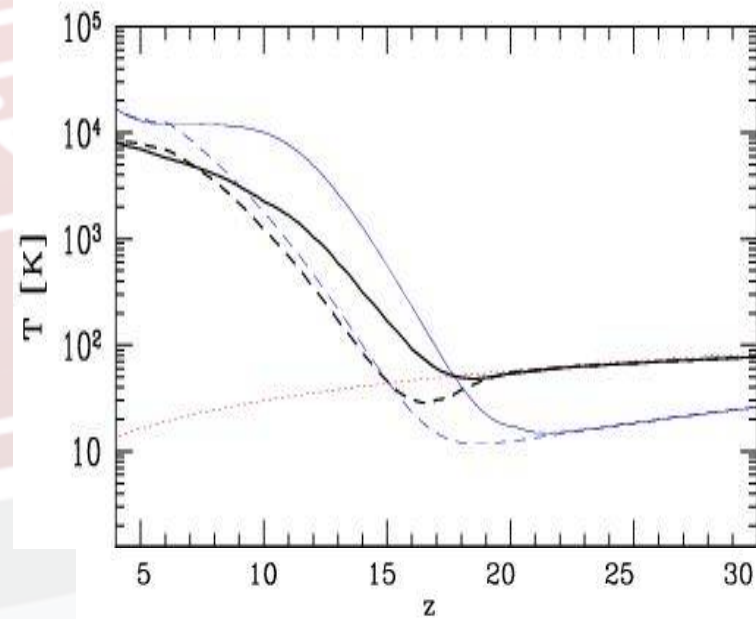
According to the seven-year WMAP analysis, the **current 68% uncertainty on τ is $\approx \pm 0.015$** , almost independently on the specific model considered. **Under various hypotheses** (simple Λ CDM model with six parameters, inclusion of curvature and dark energy, of different kinds of isocurvature modes, of neutrino properties, of primordial helium mass fraction, or of a reionization width) the best fit of τ lies in the range **0.086–0.089**. On the other hand, allowing for the **presence of primordial tensor perturbations or (and) of a running** in the power spectrum of primordial perturbations the best fit of τ goes to **0.091–0.092 (0.096)**.

Reionization history and temperatures [kinetic (CMB) & spin (21 cm)]

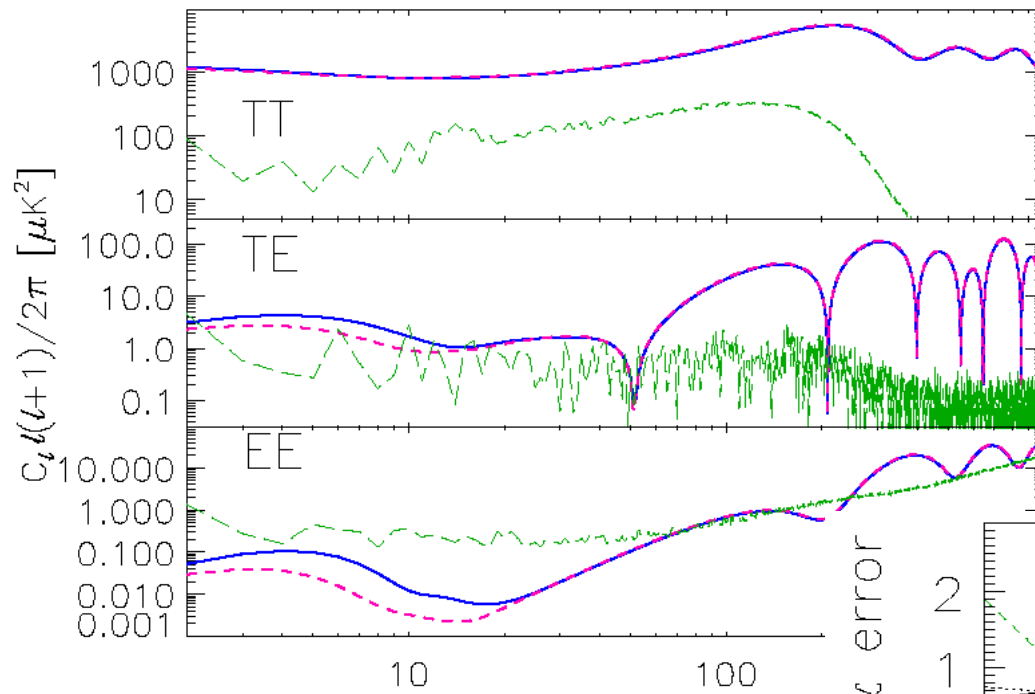
Reionization history



Gas temperature



CMB anisotropy signal / EE detectability



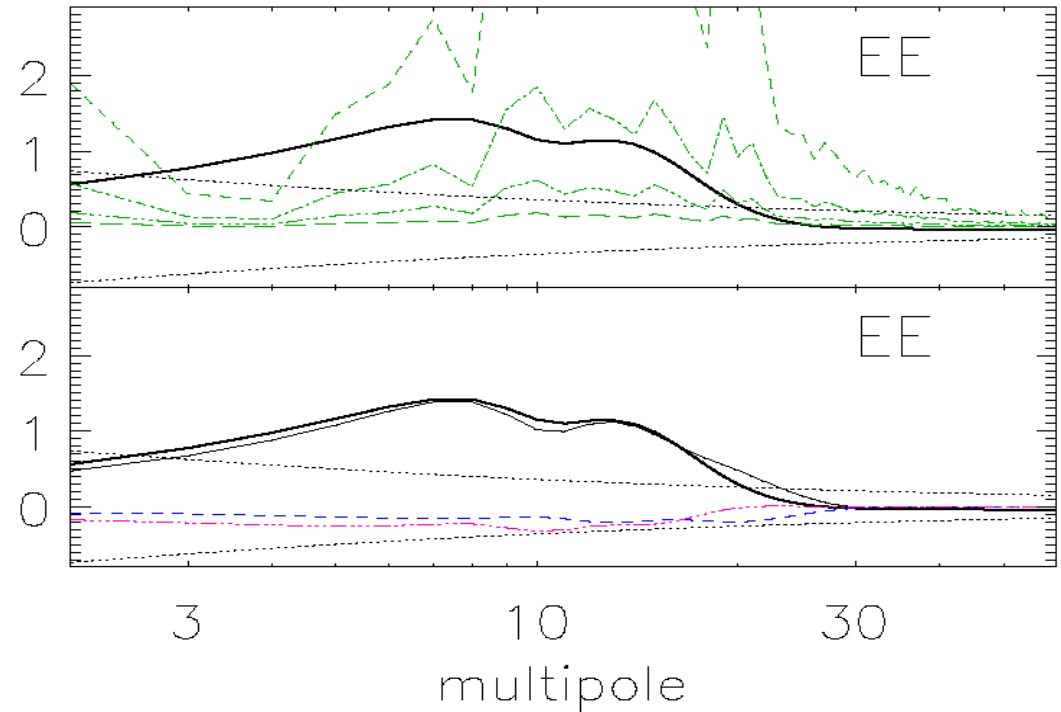
Planck: multipole

integrated information

**Next facilities:
direct view of
reionization**

astrophysical sources

rel. difference & error



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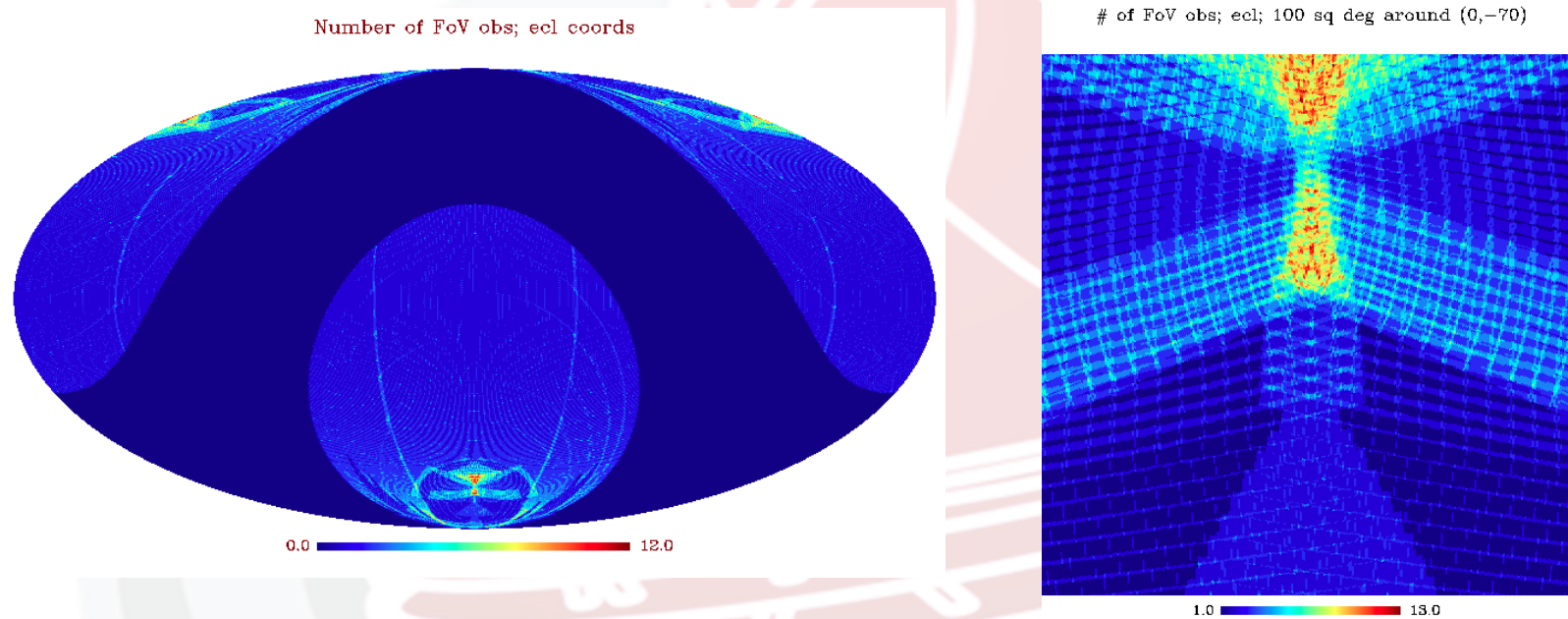
Extragalactic (radio)sources

Ancillary data / Almost coeval data / Synergy with different observatories

Acquisition & analysis of ancillary data in many frequency bands
(Tool by Massardi & Burigana 2010, POFF) Some examples:

- Coeval observations of blazar with Planck, Swift & Fermi
- New survey at high frequency of northern sky (K-band Northern Wide-area Survey – KNOWS, PI: E. Carretti)
- Observations with the Medicina radiotelescope coeval with Planck of samples of radiosources (SiMPIE - PI: M. Massardi)
- Data analysis of AT20G survey (Australian Telescope 20 GHz, PI: R.D.Ekers):
- ATCA observations, many of them coeval with Planck, of samples of radiosources (project PACO)
- Identification of sub-mm sources detected by Planck in the survey Herschel-ATLAS
- Selection of sub-mm sources with strong gravitational amplification of fluxes

❖ Tools elaborated in the *Planck* context: heritage for *Euclid* – A work example



Simulation work of wide survey for Euclid: from tabulation of pointings into all-sky maps in HEALPix (Gorski et al. 2005) of # of FoV & Observation Time in ecliptic (& galactic) coordinates, for each desired interval of time (example, different years). Visualization of overlapping of FoV, Zoom of dedicated sky areas. Thanks to: E. Maiorano, F. Cacciatore, R. Scaramella, L. Valenziano, of Euclid Consortium & Deimos)

❖ Maps from *Planck*:

- improvements of priority maps for *Euclid*:
Galactic dust extinction – Zodiacal Light modelling

Conclusions

- ***Planck*** is working as expected
- DPCs, instruments, CTs, WGs are working well & intensively to produce accurate TOD, frequency maps, component maps, source catalogs & to scientifically analyze data
- ***Planck*** is probed to be a powerful “astrophysical surveyor” & we are working to deliver products & scientific results (2012-2013-2014 and ... in following years)
- ***Planck*** is providing & will provide targets of astrophysical sources & regions for mm dedicated observations
- From large to small & to very small angular scales ... !!!
- Roles of coeval multifrequency observations!!!
- Astrophysical lessons & tools (!!!) useful for scientific community



C. Burigana, Bologna, 2-3/4/2012



Thanks for your attention!

Acknowledgements

- I warmly acknowledge the *Planck* Collaboration
- *Planck* is an ESA project with instruments funded by ESA member states (in particular the PI countries: France and Italy), and with special contributions from Denmark and NASA (USA)



C. Burigana, Bologna, 2-3/4/2012

