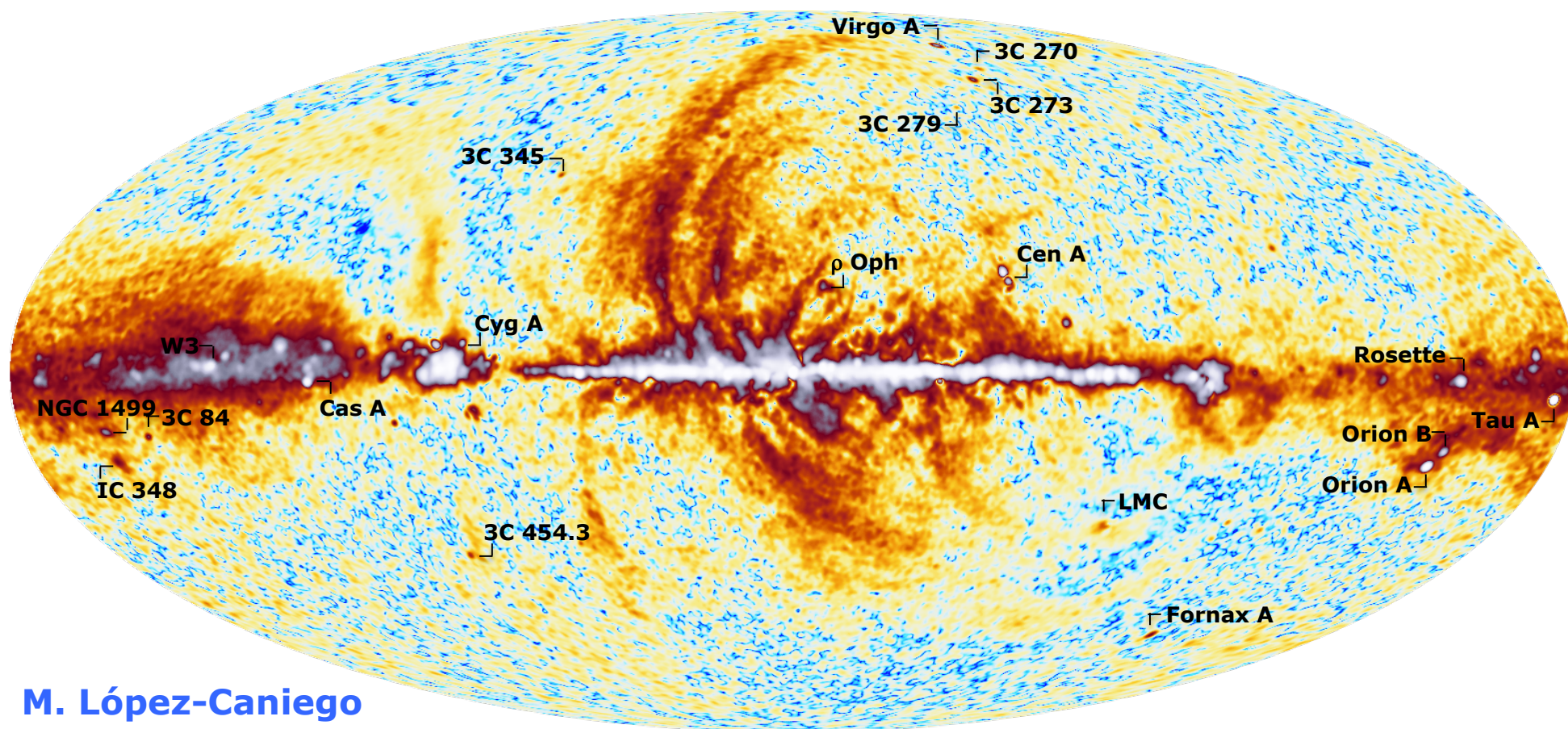




The *Planck* Compact Source Catalogues: Present and Future



M. López-Caniego

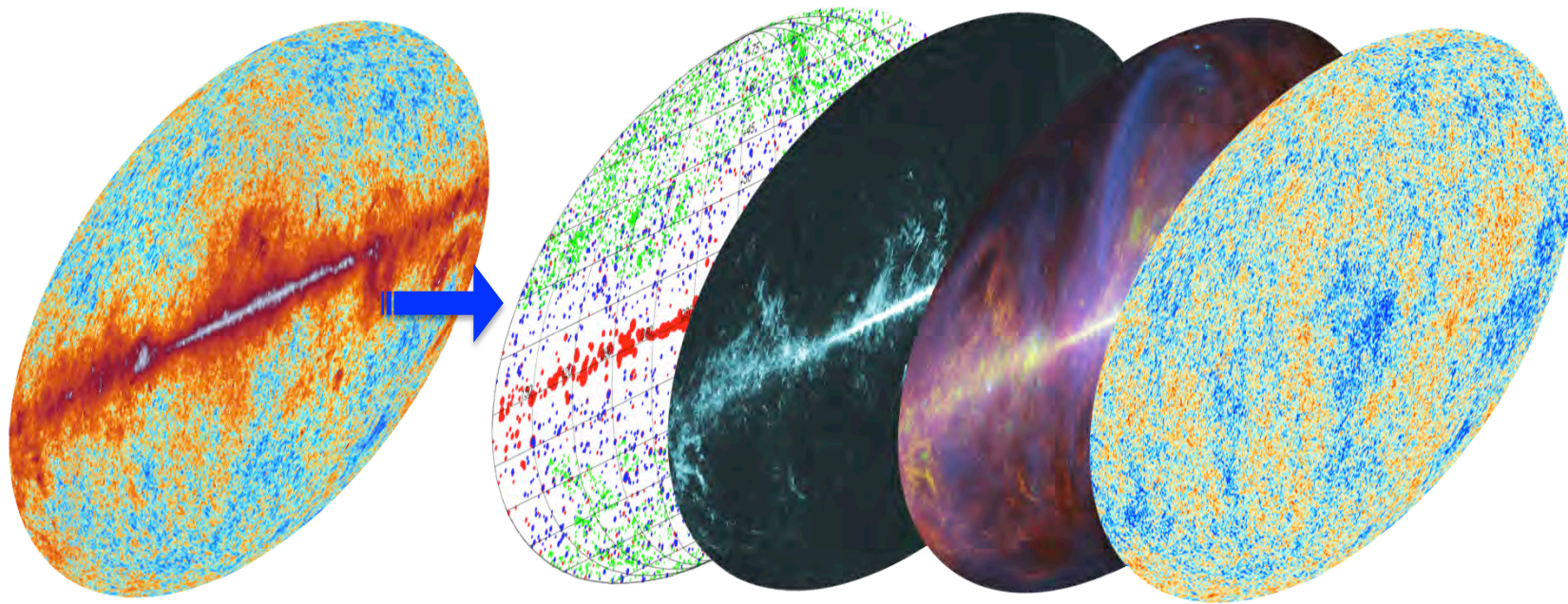
ESA/ESAC

on behalf of the Planck Collaboration

The *Planck* Compact Source Catalogues: Present



- The *Planck* satellite has observed the sky between 30-857 GHz (1cm-350 μm).

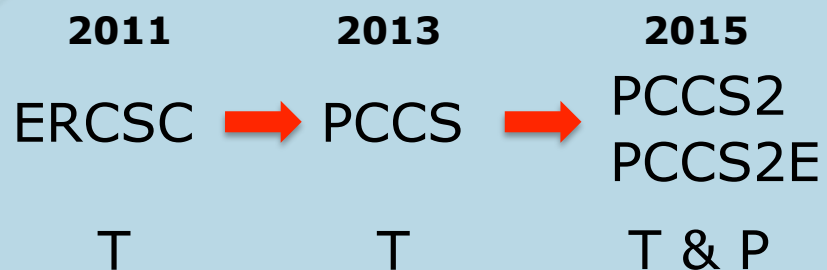


- There have been three releases of compact source catalogues between 2011 and 2015

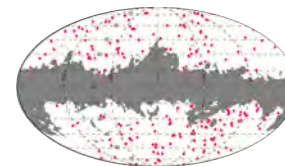
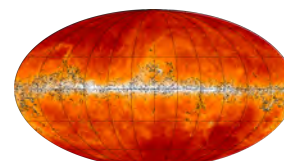
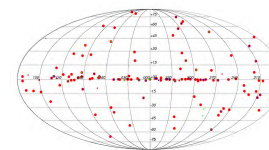
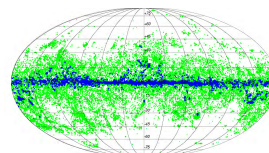
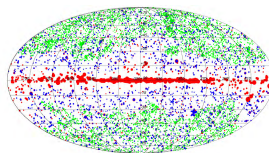
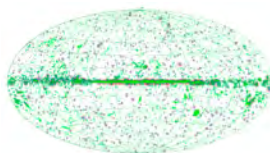
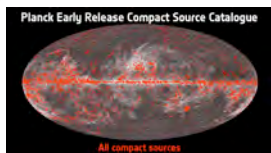
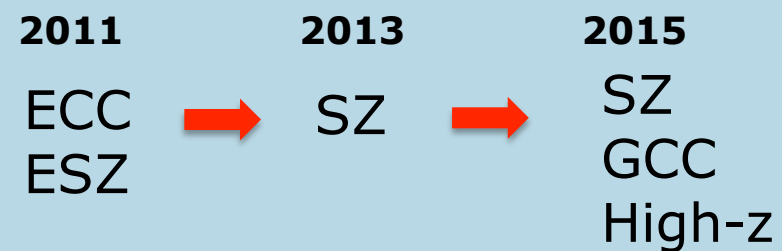
The *Planck* Compact Source Catalogues: Present



Single Frequency Catalogues



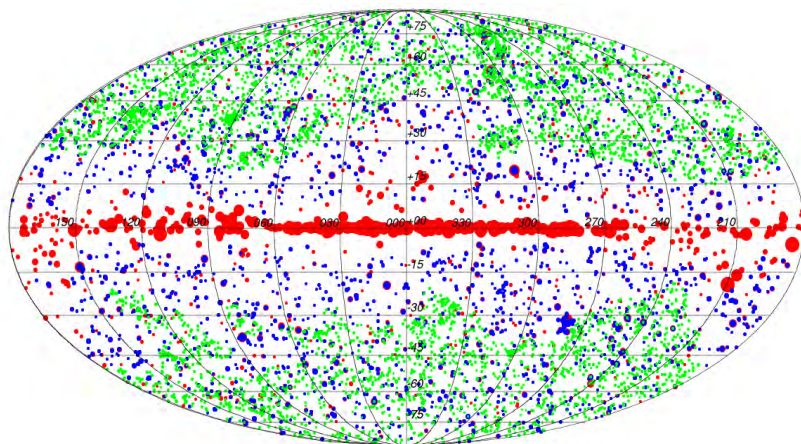
Other Planck Catalogues



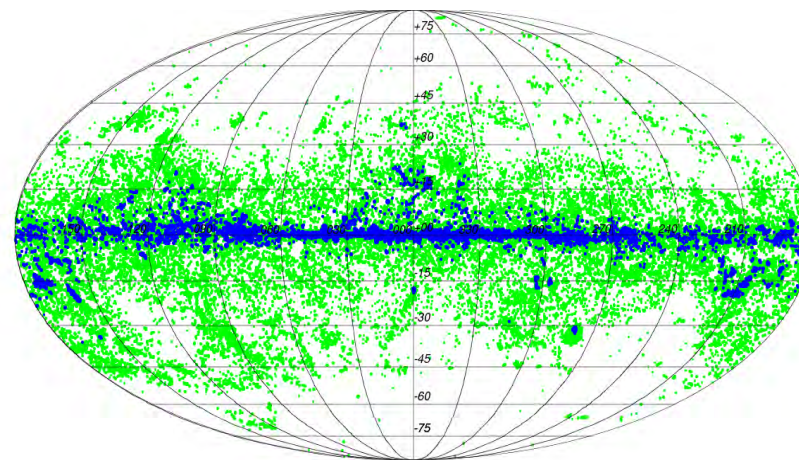
The *Planck* Compact Source Catalogues: Present



- **2015 PCCS2/PCCS2E:** The PCCS2 has changed its structure based on our ability to validate it.
 - 3 lists of sources 30-70 GHz & 12 lists of sources 100-857 GHz, 45.000 sources

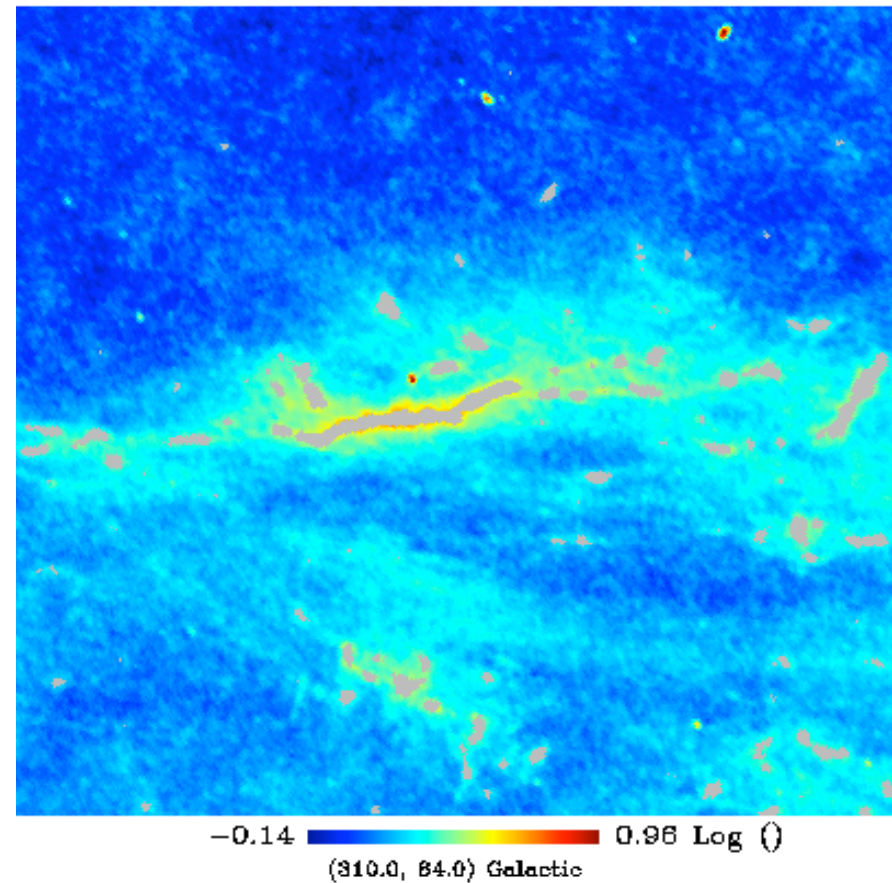
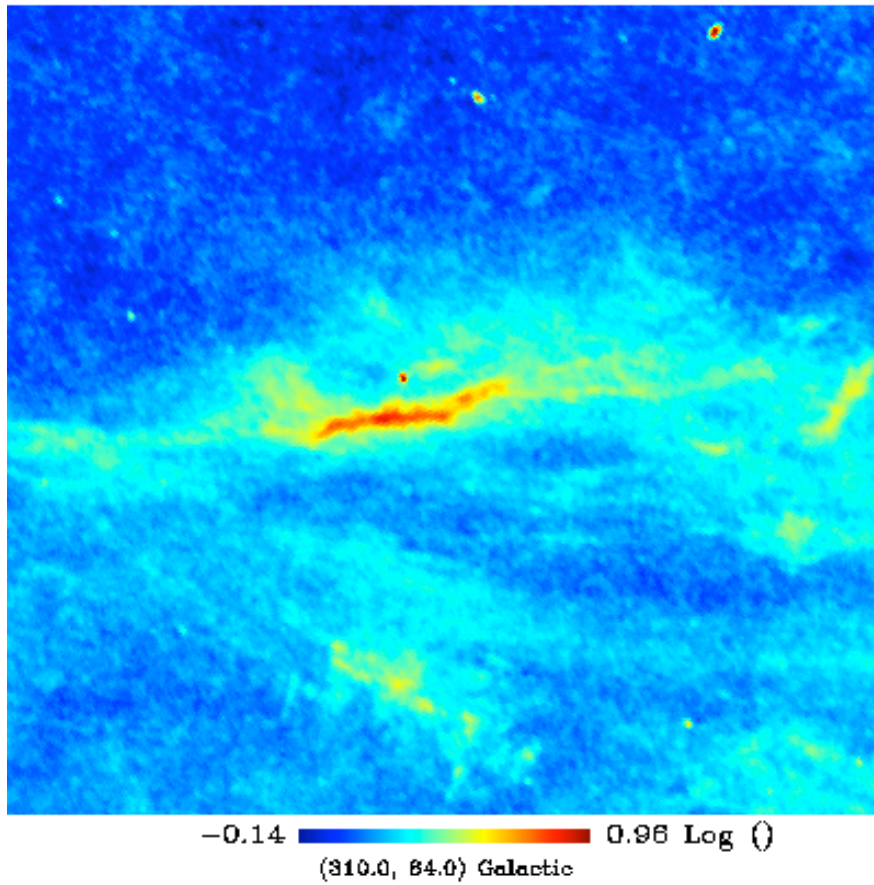


PCCS2 T 30, 143 857 GHz



PCCS2E T 143 & 857 GHz

The *Planck* Compact Source Catalogues: Present

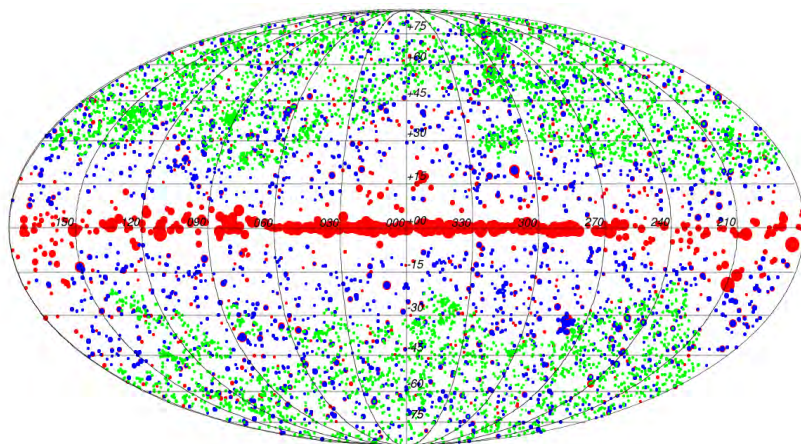


Example of the Galactic filamentary cirrus in the higher frequency Planck channels

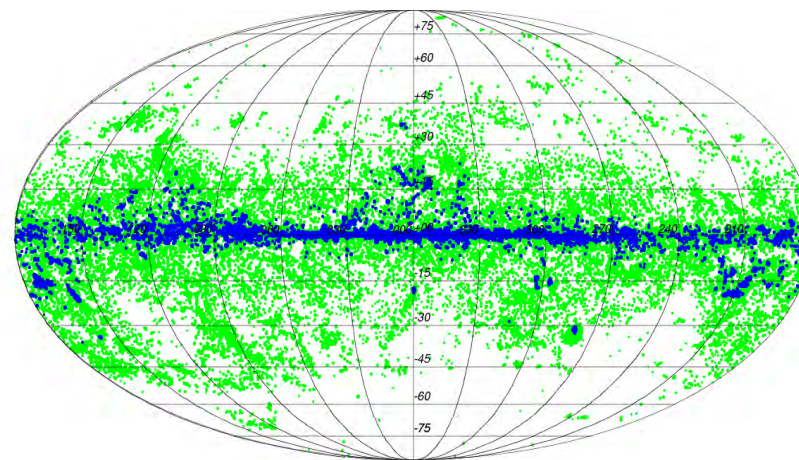
The *Planck* Compact Source Catalogues: Present



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PCCS2 T 30, 143 857 GHz

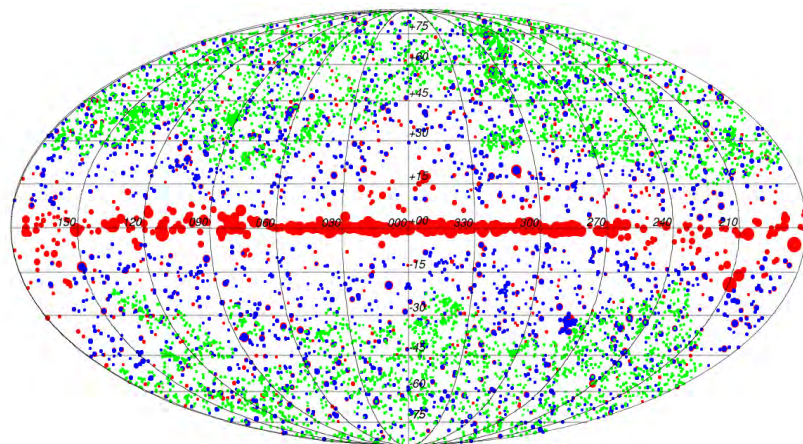


PCCS2E T 143 & 857 GHz

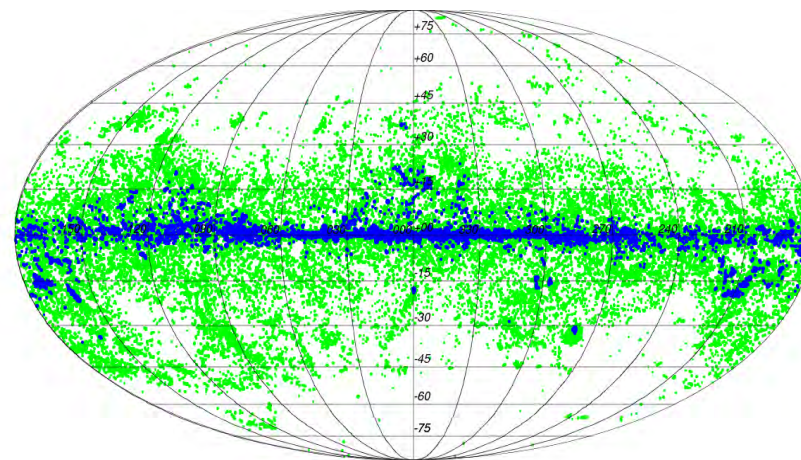
The *Planck* Compact Source Catalogues: Present



- **2015 PCCS2/PCCS2E:** The PCCS2 has changed its structure based on our ability to validate it.
 - 3 lists of sources 30-70 GHz & 12 lists of sources 100-857 GHz, 45.000 sources

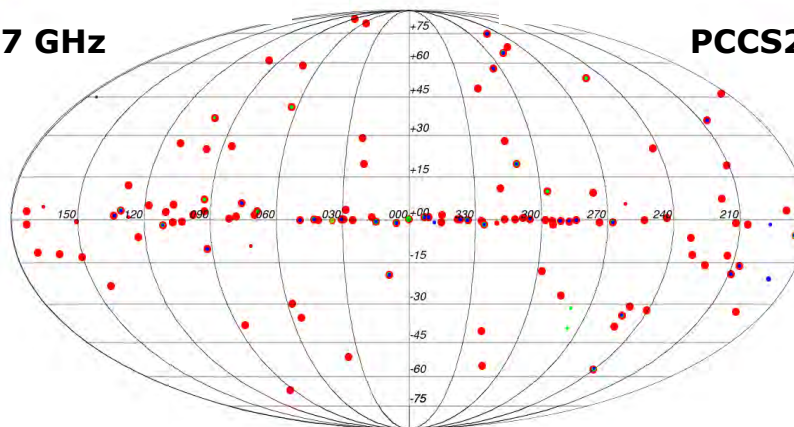


PCCS2 T 30, 143 857 GHz



PCCS2E T 143 & 857 GHz

Polarization

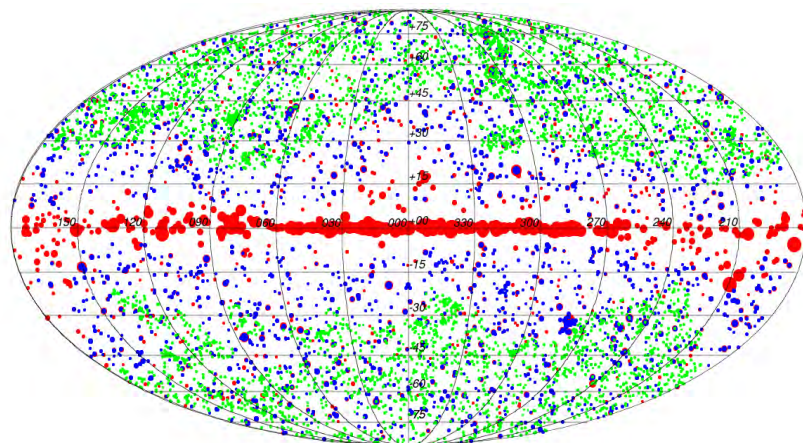


PCCS2 POL 30, 44 70 GHz

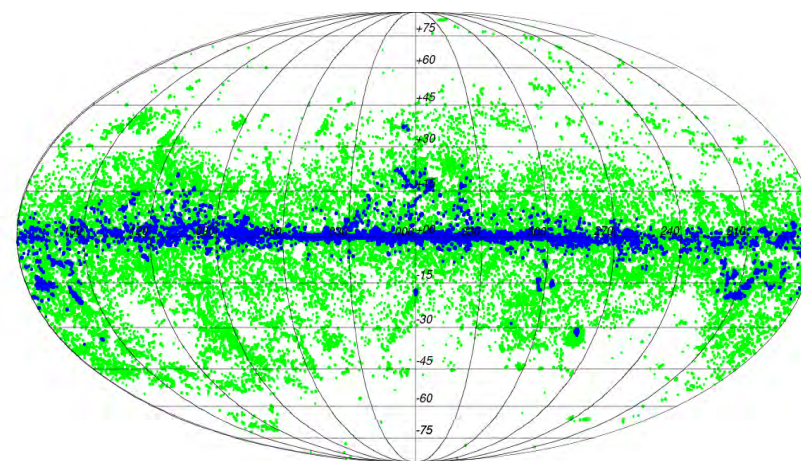
The *Planck* Compact Source Catalogues: Present



- **2015 PCCS2/PCCS2E:** The PCCS2 has changed its structure based on our ability to validate it.
 - 3 lists of sources 30-70 GHz & 12 lists of sources 100-857 GHz, 45.000 sources



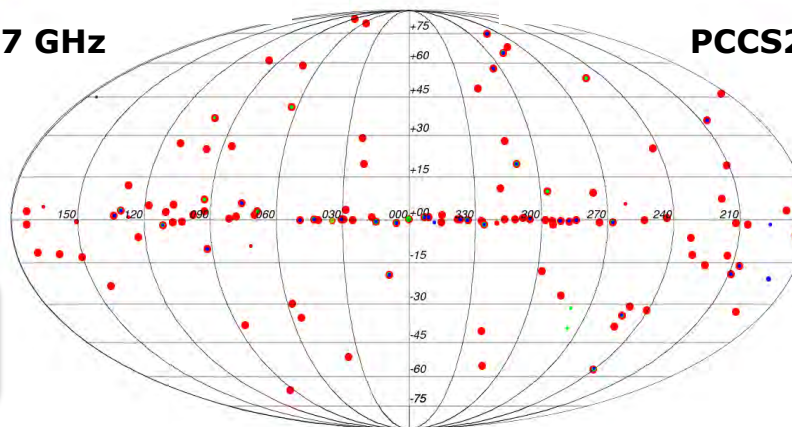
PCCS2 T 30, 143 857 GHz



PCCS2E T 143 & 857 GHz

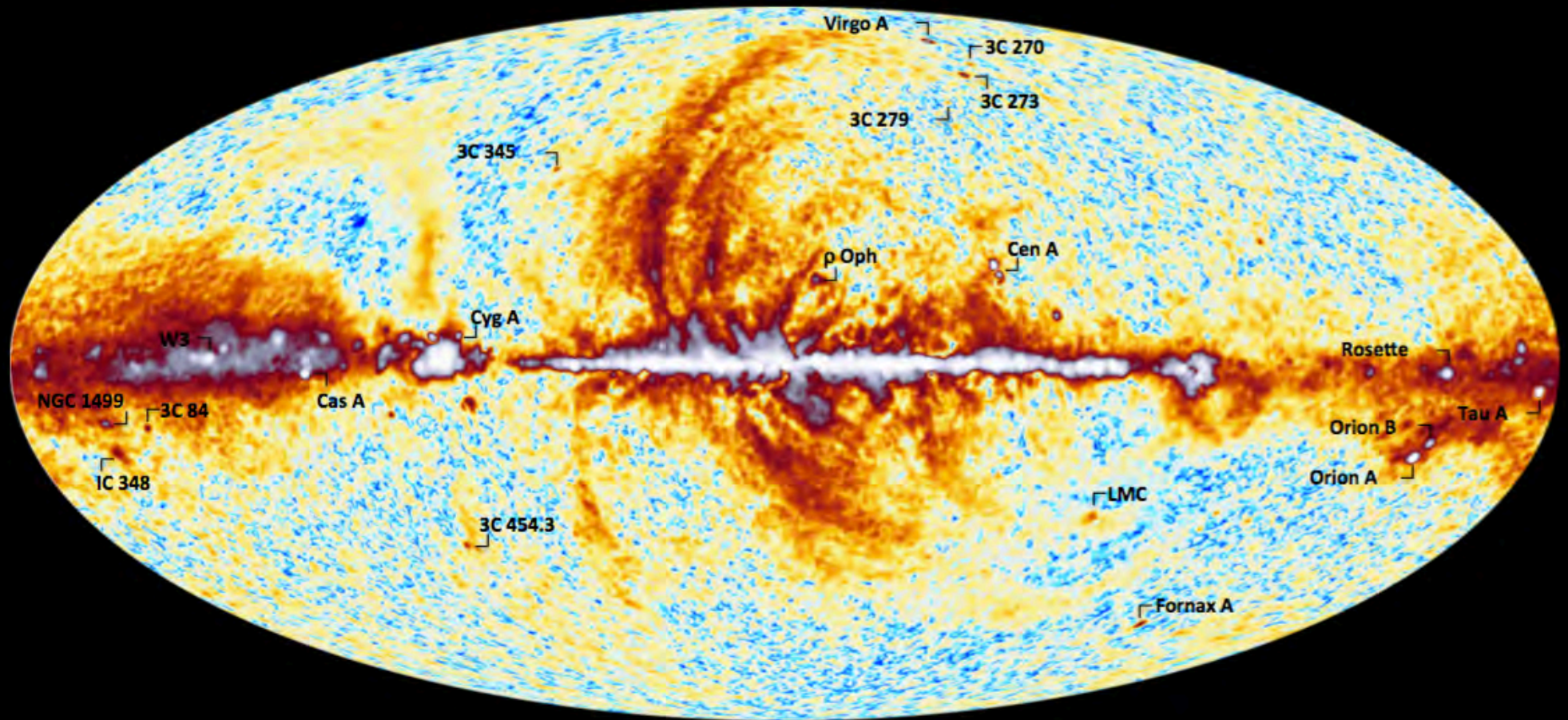
Polarization

**Read cautionary
notes in the paper**

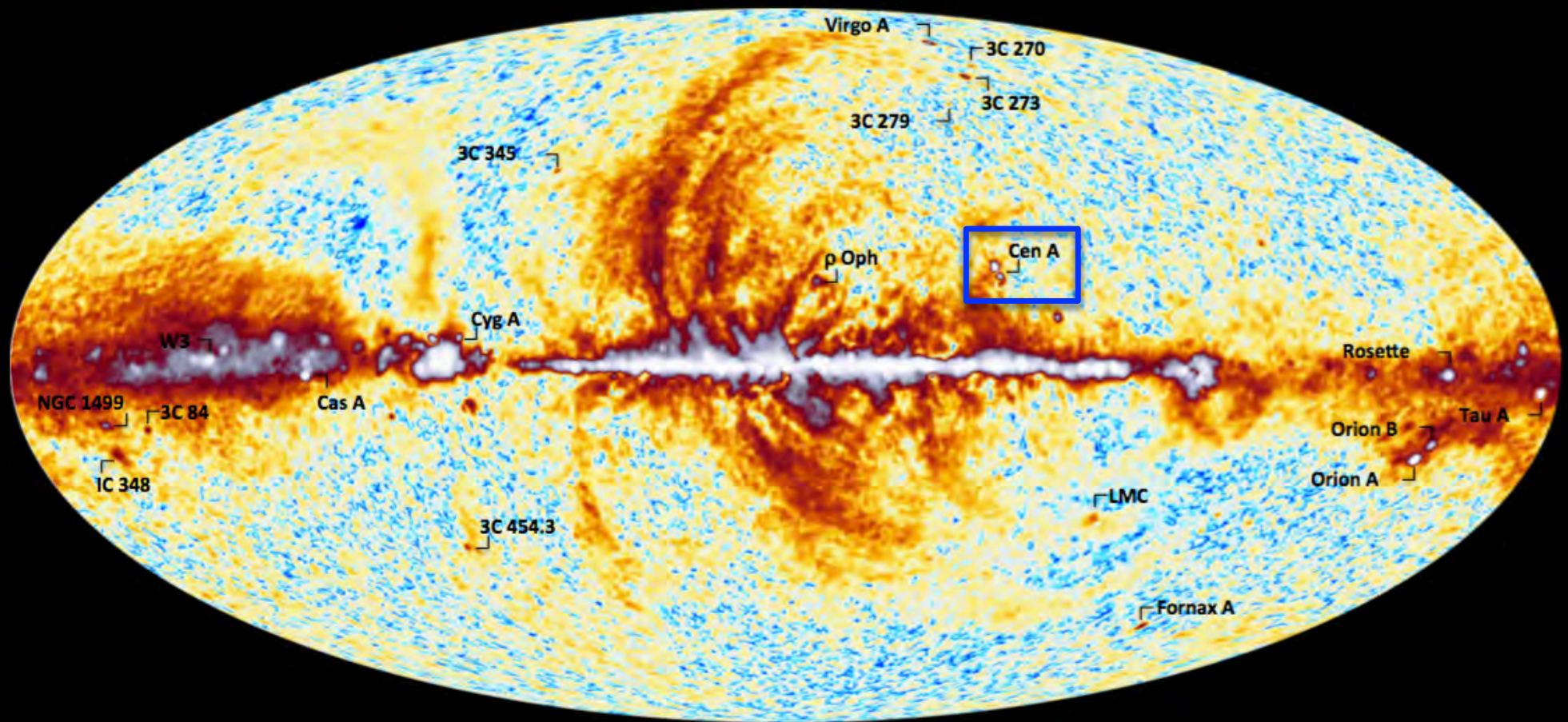


PCCS2 POL 30, 44 70 GHz

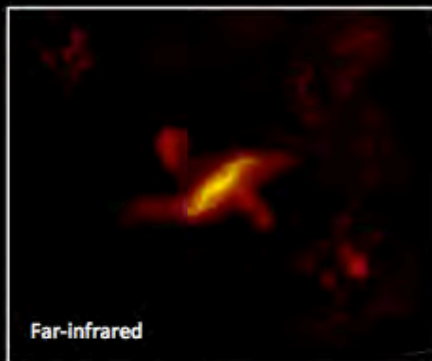
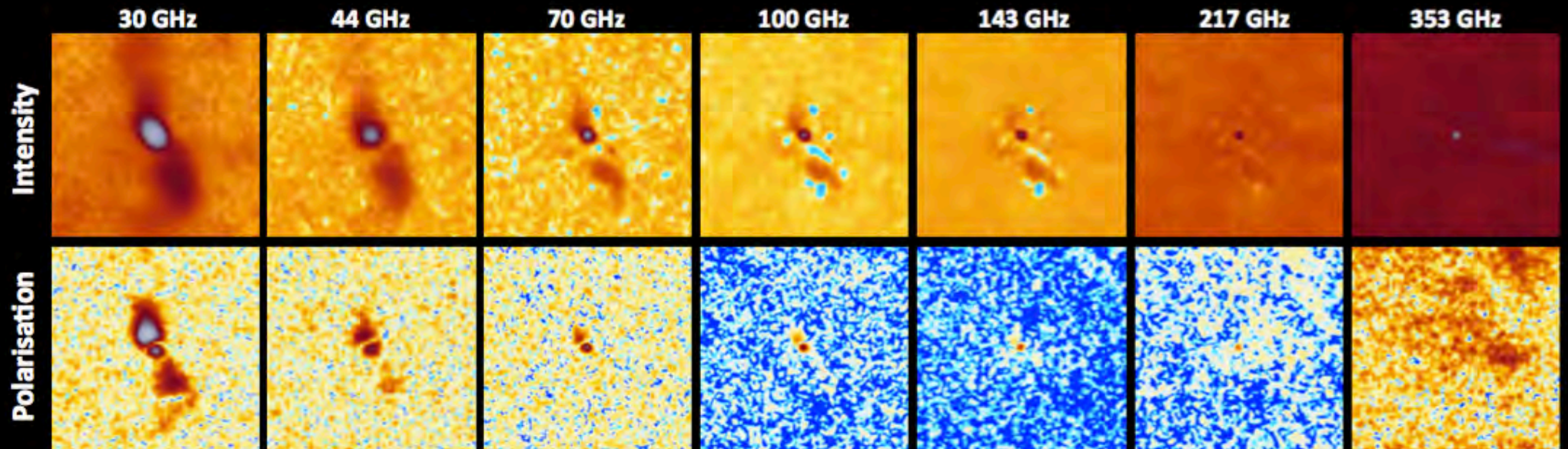
The Planck 30 GHz Sky in Polarization



The Planck 30 GHz Sky in Polarization



Planck's view of Centaurus A



Far-infrared

ESA/Herschel/SPIRE/PACS



Visible

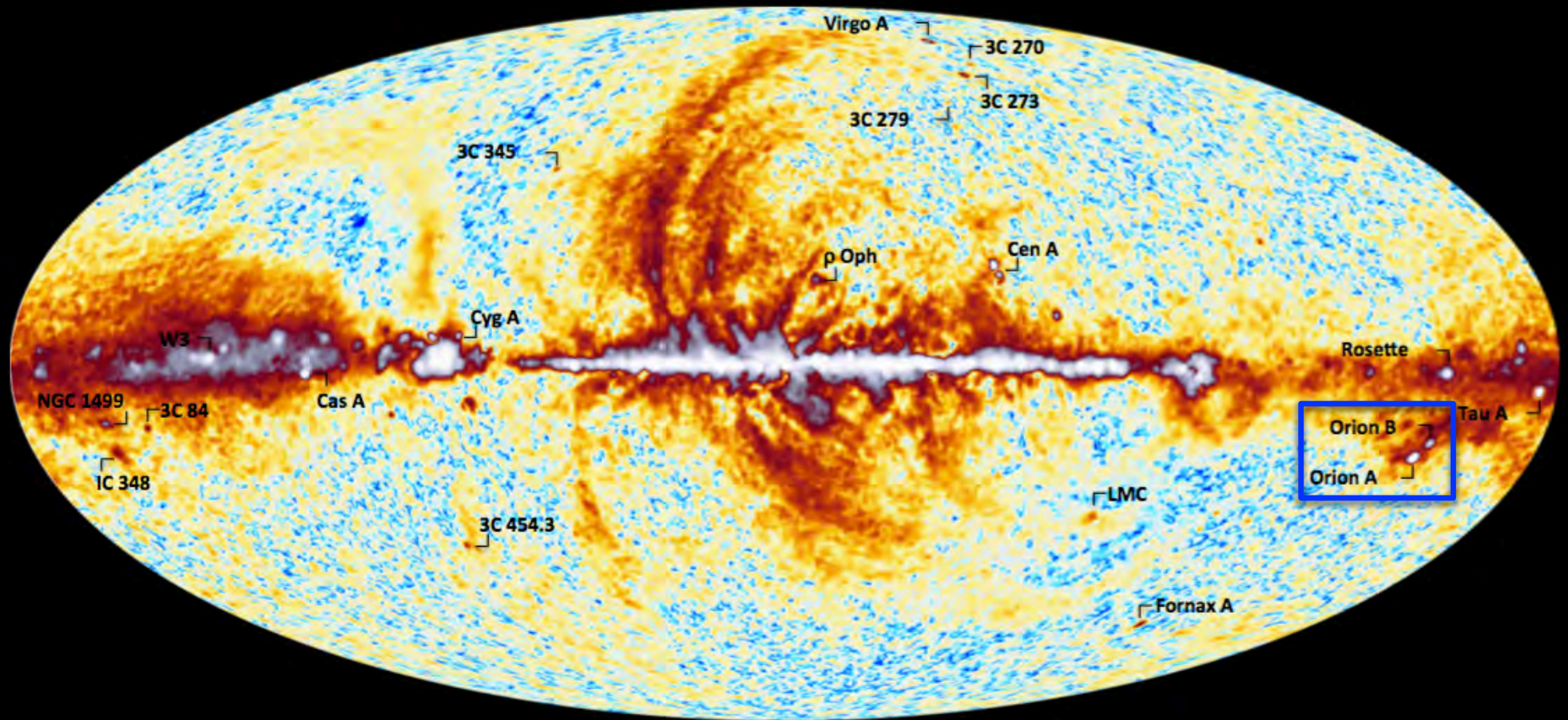
ESO



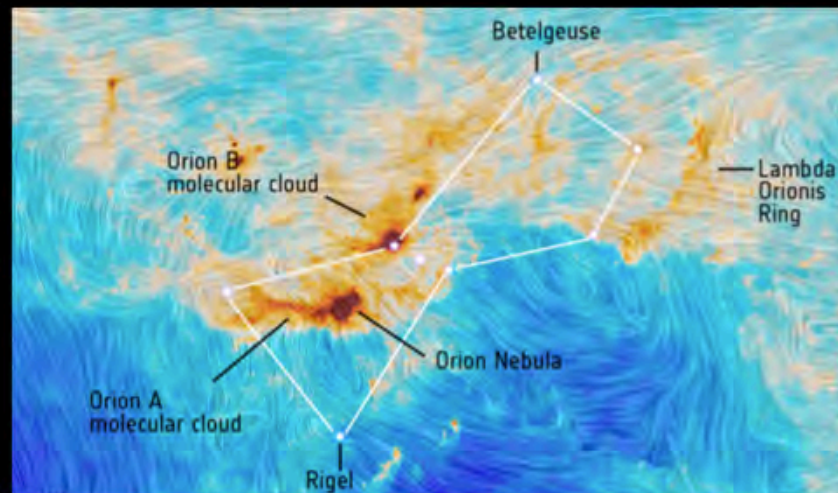
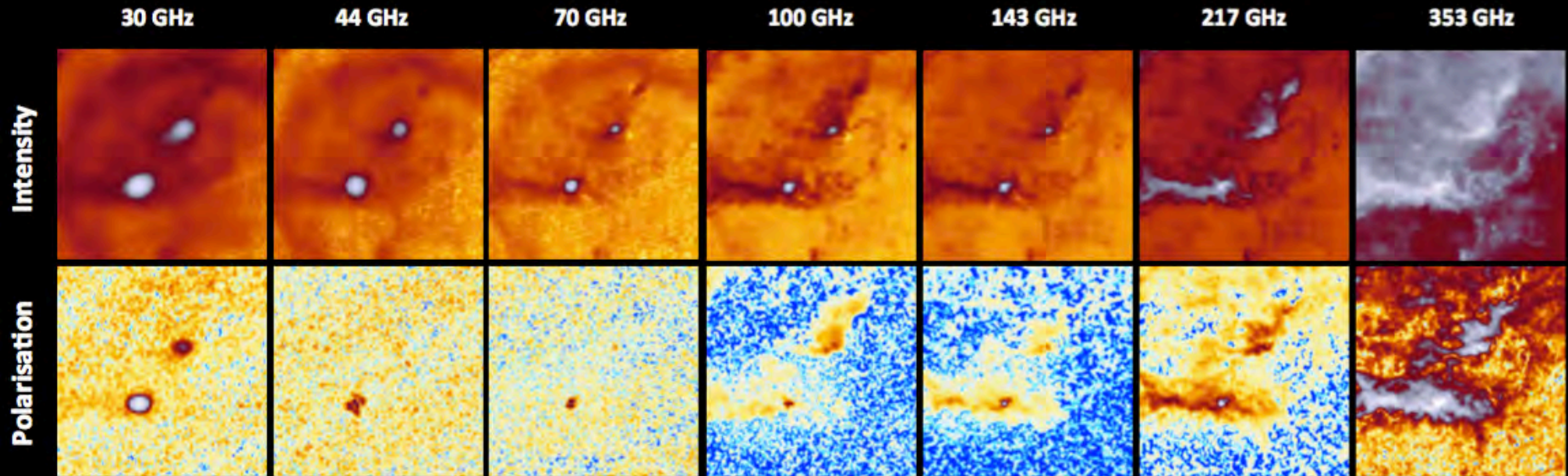
X-rays

ESA/XMM-Newton/EPIC

The Planck 30 GHz Sky in Polarization



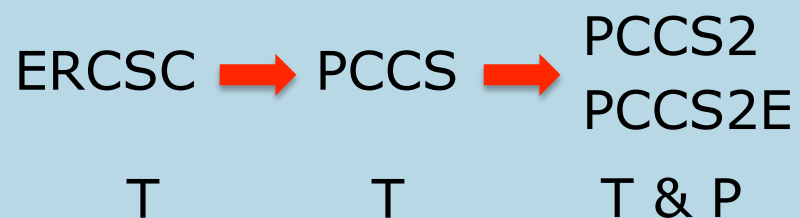
Planck's view of the Orion Molecular Complex



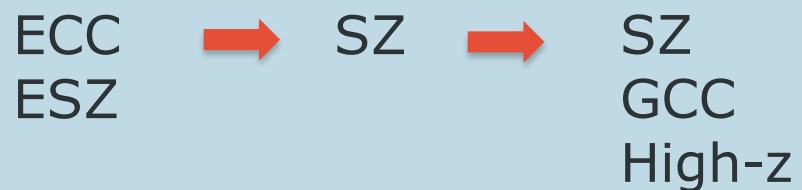
The *Planck* Compact Source Catalogues: Future



Single Frequency Catalogues



Other Planck Catalogues



The *Planck* Compact Source Catalogues: Future



Single Frequency Catalogues

ERCSC → PCCS → PCCS2
T T T & P



Multi-Frequency Catalogues

Radio-selected MF catalogue

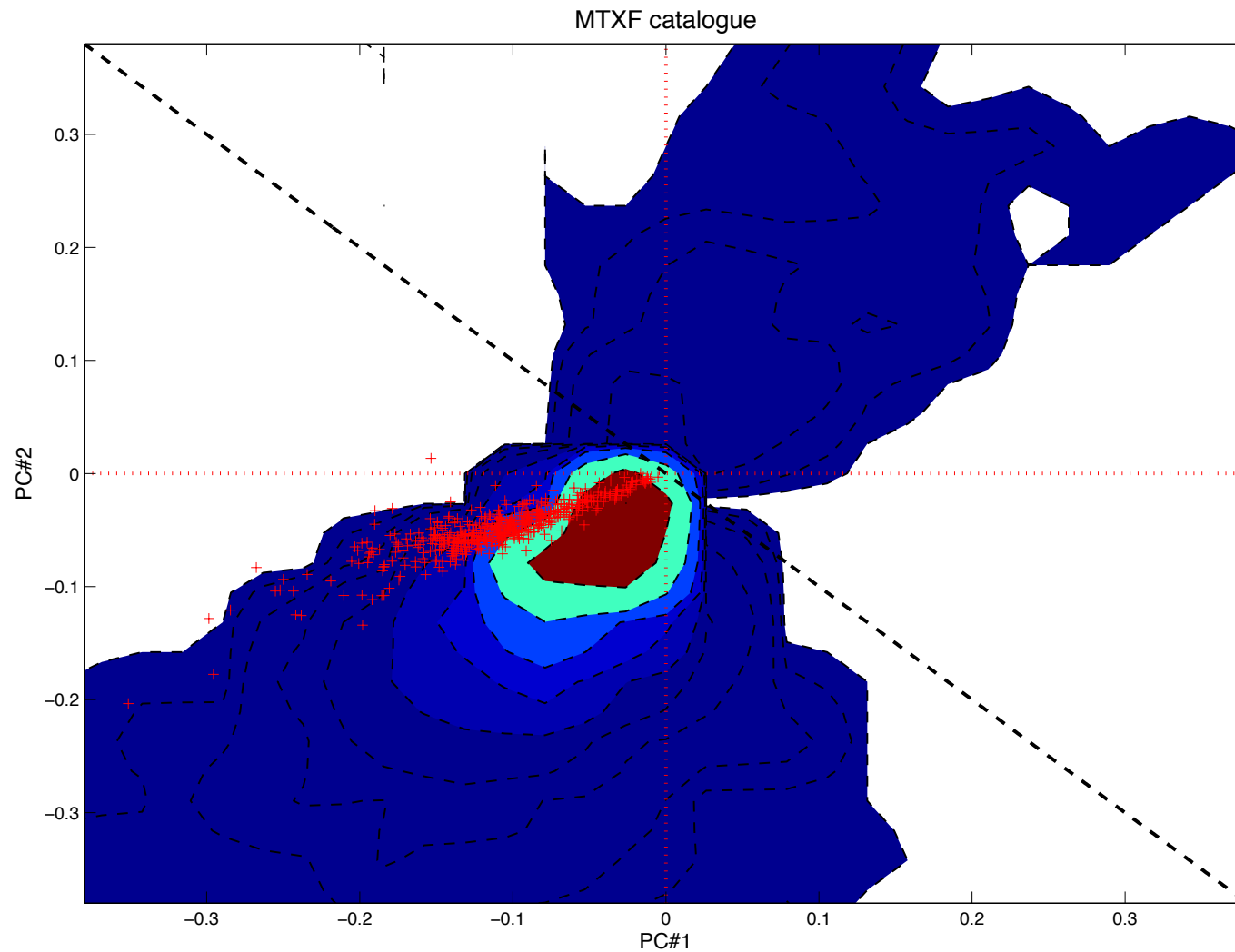
Other Planck Catalogues

ECC → SZ → SZ
ESZ GCC
High-z

Radio-selected multi-frequency catalogue

- One catalogue and one entry per source across all Planck bands, very useful for SED analysis.
- Different beam sizes makes the association process very challenging.
- Sample of sources detected at 30 and 143 GHz with $\text{SNR} > 3\sigma$
- Non-blind multi-frequency analysis at the position of these sources
- Optimal combination of maps to improve the SNR of the candidates keeping objects with $\text{SNR} > 4\sigma$ in at least one of the channels.
- Some degree of contamination from thermal sources is expected
- Principal component analysis to separate the two main populations from radio and infrared galaxies. Use blazar catalogues to test this PCA.

The *Planck* Compact Source Catalogues: Future



The *Planck* Compact Source Catalogues: Future



Single Frequency Catalogues

ERCSC → PCCS → PCCS2
T T T & P



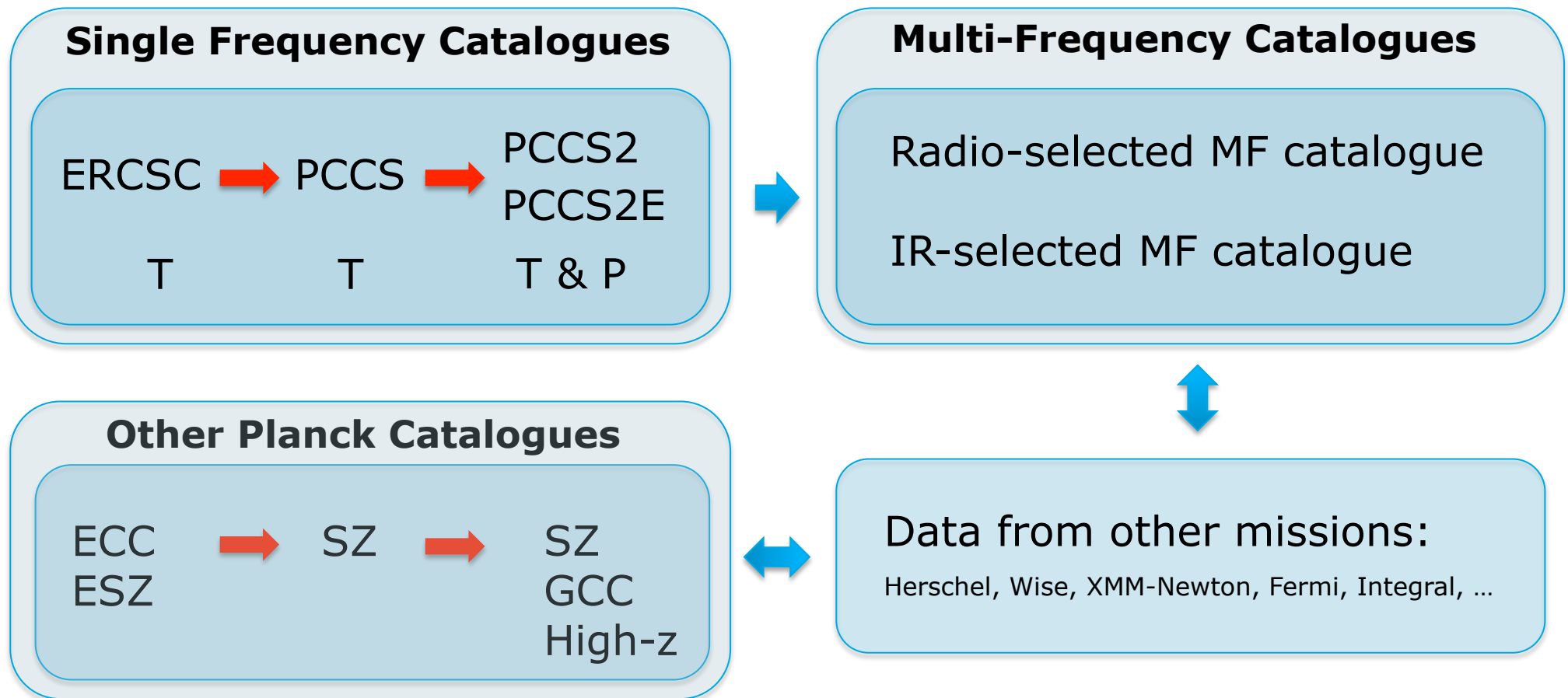
Multi-Frequency Catalogues

Radio-selected MF catalogue
IR-selected MF catalogue

Other Planck Catalogues

ECC → SZ → SZ
ESZ GCC
High-z

The *Planck* Compact Source Catalogues: Future



Variability of compact sources across the Planck Mission

- There are several Planck papers on variability of compact sources, but there is a lot of science to be done.
- We provide single survey maps (6 month period)
- In addition, hours and days variability analysis could be done using the crossing of the compact sources across the focal plane.
- In the PLA one can download the timelines, searching in time and location, at all frequencies and detectors...

The *Planck* Compact Source Catalogues: Future



Timelines type

- ☒ Science data
- ☒ Pointing
- ☐ TAI
- ☐ Baseline
- ☐ House keeping
- ☐ Any

Instrument ☐ Both ☐ HFI ☒ LFI

Frequency

TIME FILTERS

Date selection

- ☒ Survey
- ☐ Operational day
- ☐ Calendar

First Survey

Last Survey

Start time

End time

SELECT SKY REGION

Name or position ☒ Name ☐ Equatorial ☐ Galactic ☐ Ecliptic

Name for

Radius

cen a resolved by Simbad. [GLon: 309.52d - GLat: 19.42d]

Variability of compact sources across the Planck Mission

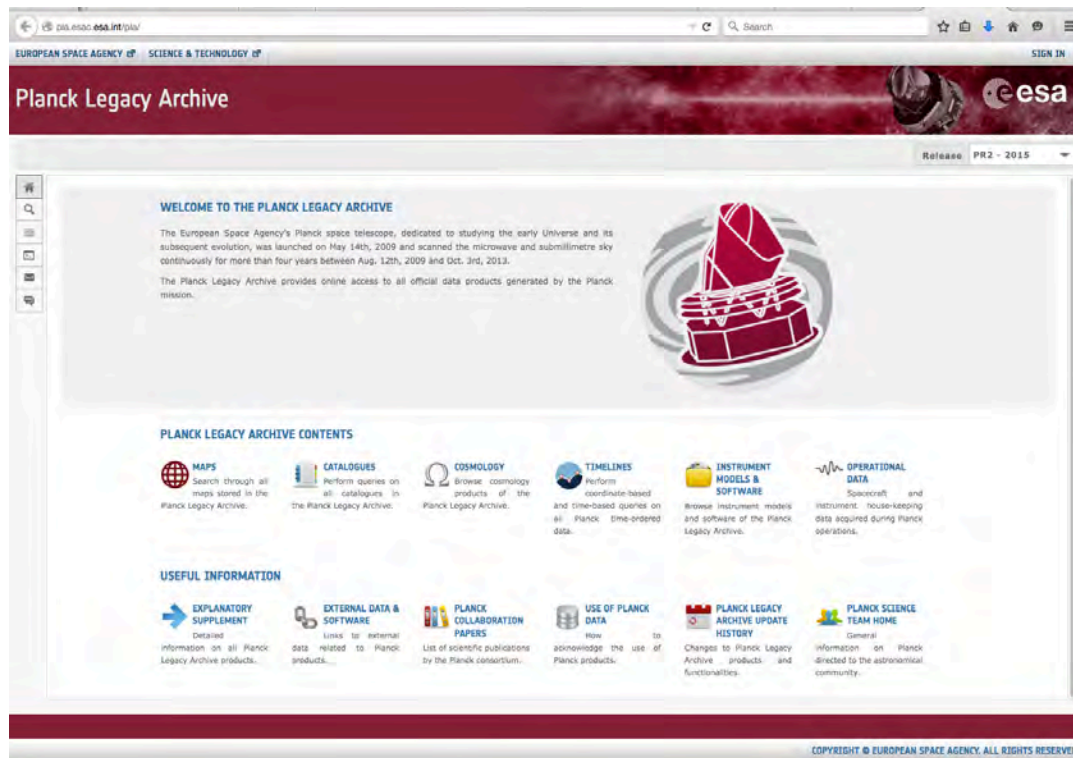
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- In addition, hours and days variability analysis could be done using the crossing of the compact sources across the focal plane.
- In the PLA one can download the timelines, searching in time and location, at all frequencies and detectors...
- Additional tools will be available in the PLA in the future, like tools to generate maps of specific periods of time.

Very powerful tools for compact source analyses in T and P

Accessing the PCCS Catalogues in the PLA



The ERCSC, PCCS & PCCS2 can be downloaded from the **Planck Legacy Archive**:



Planck Legacy Archive

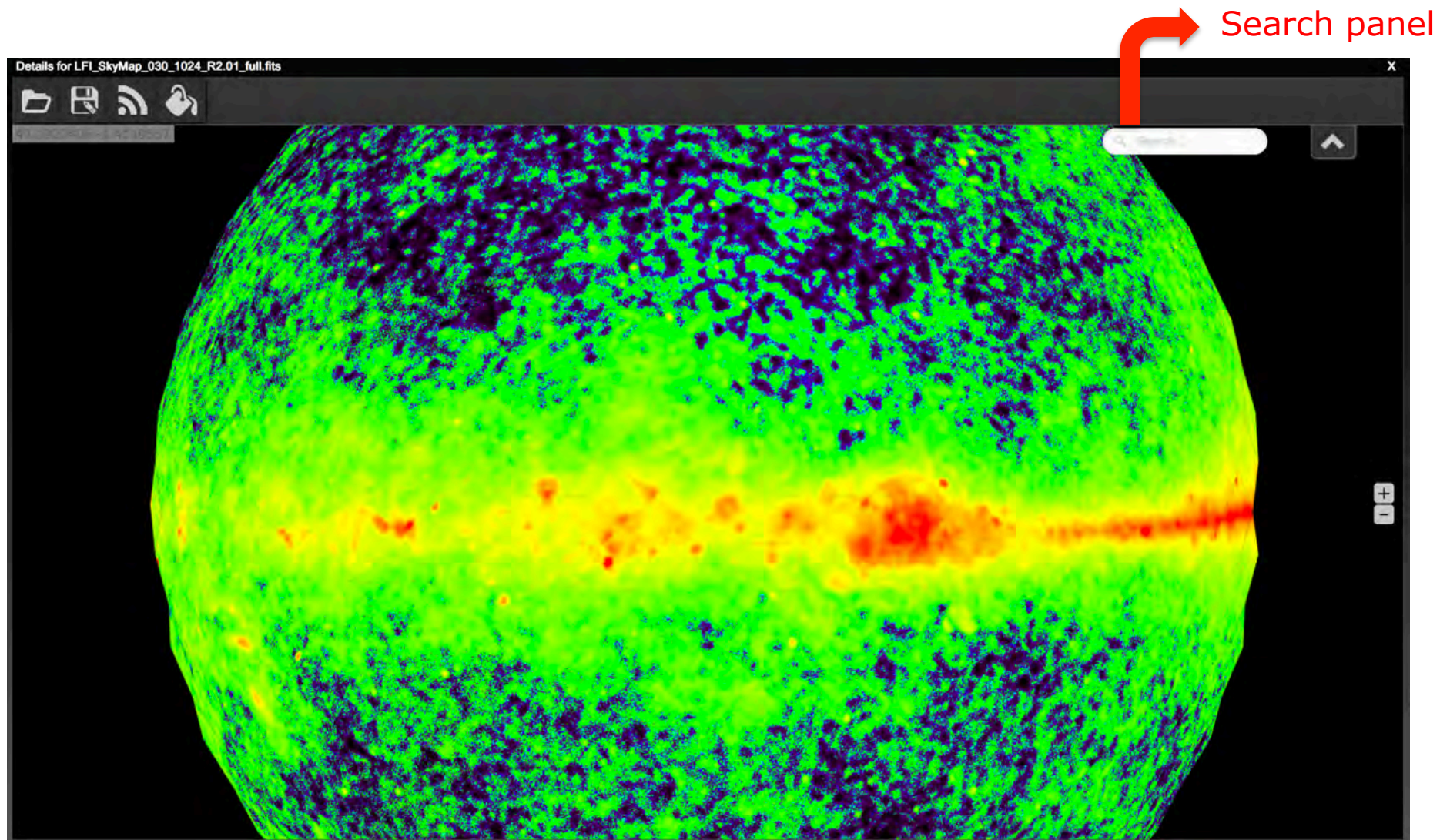
<http://archives.esac.esa.int/pla/>

**ESA booth
(#328 in the Exhibition Hall)**

The PCCS2 has been released and is described in the Planck Collaboration XXVI (2015) paper

Additional information: **Planck Explanatory Supplement** <http://wiki.cosmos.esa.int/planckpla2015/>

Accessing the PCCS Catalogues in the PLA



Accessing the PCCS Catalogues in the PLA



PR2 - 2015 CATALOGUES

→ ES

Catalogues

PCCS_2.0	>	✓ COM_PCCS_030_R2.04.fits
PCCS_GCC_2.0	<	✓ COM_PCCS_044_R2.04.fits
PCCS_SZ_2.0	<	✓ COM_PCCS_070_R2.04.fits
All catalogues	<	<input type="checkbox"/> COM_PCCS_100_R2.01.fits

[Advanced search panel] ☐ Group results by source list

Download fits

Linked items

Send to

SELECT SKY REGION

Target in

☒ Circle ☐ Box

Name or position ☒ Name ☐ Equatorial ☐ Galactic ☐ Ecliptic

Name for Radius arcminutes

Cen A resolved by Simbad. [GLon: 309.52d - GLat: 19.42d]































Submit Clear

Accessing the PCCS Catalogues in the PLA



RESULTS Close All << < PR2 Catalogues #1 > >>

PCCS2 30GHz sources (1560) X

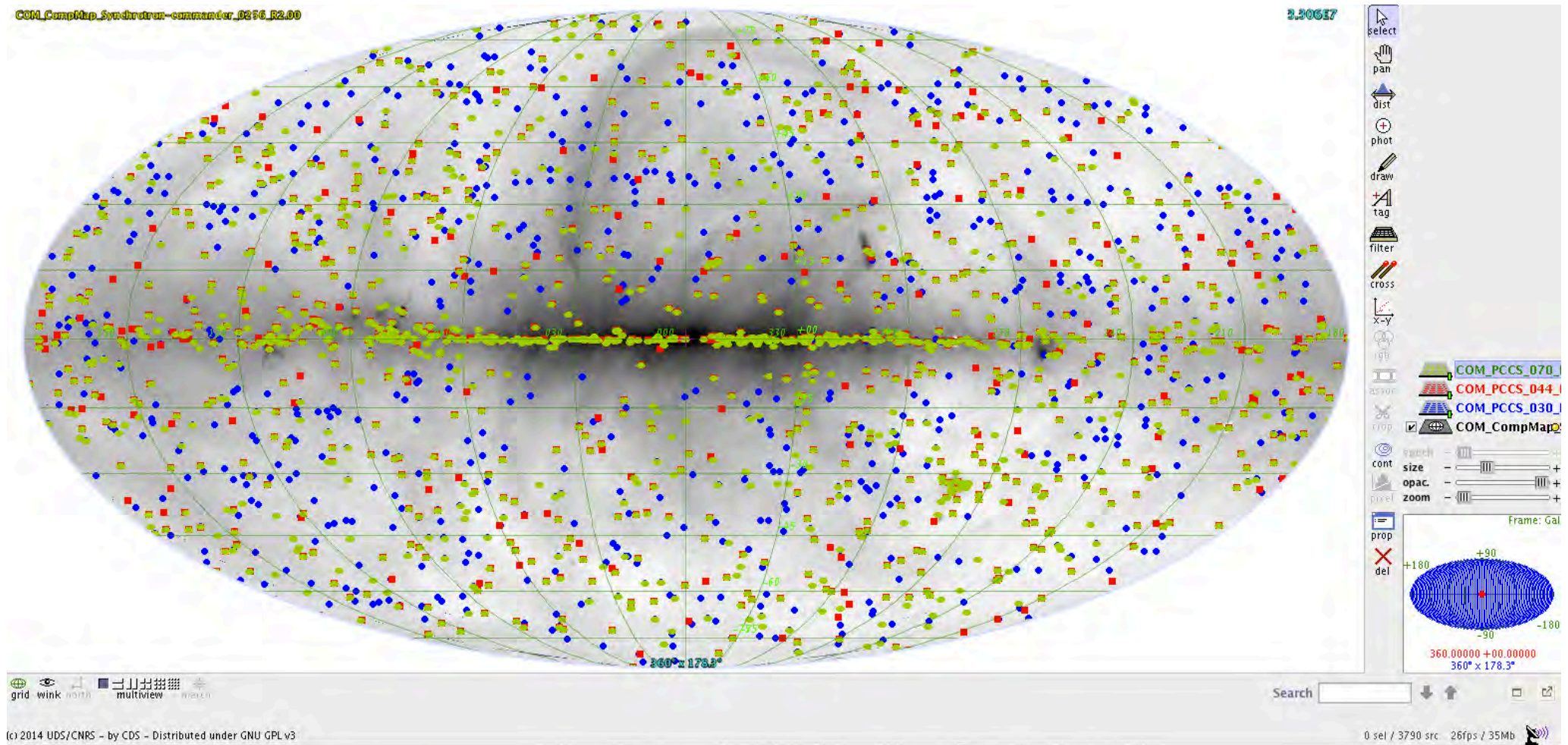
	SOURCE NAME	GLON [degrees]	GLAT [degrees]	RA [degrees]	DEC [degrees]	APERFLUX [mJy]	APERFLUX_ERR [mJy]
  	PCCS2 030 G000.07-00.06	.067	-.059	266.5024	-28.9097	478023.16	41337.125
  	PCCS2 030 G000.07+81.65	.068	81.651	200.4398	22.3973	234.7045	293.7857
  	PCCS2 030 G000.16-12.70	.163	-12.701	279.7133	-34.7624	196.1117	261.1733
  	PCCS2 030 G000.52-58.35	.518	-58.345	337.7135	-39.6806	781.7406	233.3367
  	PCCS2 030 G000.67-42.84	.674	-42.842	317.3952	-41.1745	697.3953	273.8648
  	PCCS2 030 G001.40+45.99	1.4	45.986	229.1761	.2593	1871.8344	234.1458
  	PCCS2 030 G001.58-28.96	1.576	-28.963	299.5045	-38.7553	1949.06	227.305
  	PCCS2 030 G002.28+65.92	2.277	65.92	214.0066	13.3652	694.7573	355.4213
  	PCCS2 030 G002.38+05.86	2.382	5.856	262.2972	-23.7963	2341.0562	487.4417
  	PCCS2 030 G002.46+61.45	2.464	61.454	217.6375	10.6555	838.3499	273.2589

1 of 16 Page size: 100

Displaying 1-100 of 1560

**Tables can be sent Aladin & Topcat
Or downloaded as fits, csv or html**

Accessing the PCCS Catalogues in the PLA



Accessing the PCCS Catalogues in the PLA

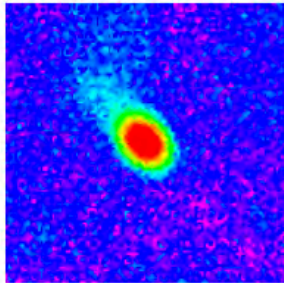



<< ✂ **PREVIEW IMAGE OF GNOMONIC MAP CUTOUT OF LFI_SKYMAP_070_2048_R2.01_FULL.FITS** x


MAP CUTOUT SETTINGS


Extension/column	FREQ-MAP/I_Stokes
ROI center name	cen a
ROI center (degrees)	Lon: 309.52; Lat: 19.42
ROI width (degrees)	2
Pixel size (arcminutes)	1
Drizzling algorithm	no
Rotation (degrees)	0.0


MAP CUTOUT



 **Download cut map**

 **View image**

 **Send cut map**



Conclusions



- The Planck satellite has **simultaneously** observed at nine frequencies 30-857 GHz the diffuse and compact emission from our Galaxy and from distant galaxies for the duration of the mission
- One of the products from the mission is the **Second Compact Source Catalogue**.
- This is the first Planck catalogue that provides simultaneous T and P information.
- In the PLA catalogues can be downloaded, searched or sent to Aladin/Topcat.
- Very interesting science is already coming out using the ERCSC/PCCS/PCCS2: variability and flares, blazar, high-z source candidates, polarization, source contamination for other studies, etc.
- **Future plans:**
 - Multi-frequency catalogues of radio and IR selected samples.
 - Single survey maps open to the community for variability analyses.
 - **PLA Map cutting** and **Timeline cutting** tools also available.
 - PLA added value tools to simulate the sky, extract maps of specific periods of time, etc.

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



Planck is a project of the European Space Agency, with instruments provided by two scientific Consortia funded by ESA member states (in particular the lead countries: France and Italy) with contributions from NASA (USA), and telescope reflectors provided in a collaboration between ESA and a scientific Consortium led and funded by Denmark.



Thank you

PCCS2: Detection pipeline



Selection criteria

There was a demand to include information in the PCCS to allow the users to extract subsets of sources with their desired level of reliability: a new **High Reliability Flag** has been added.

The reliability of every source in the catalogue could not be assessed and we splitted the PCCS:

- **PCCS2**: sources that have been validated and with an estimation of their reliability.
- **PCCS2E**: the remaining sources.

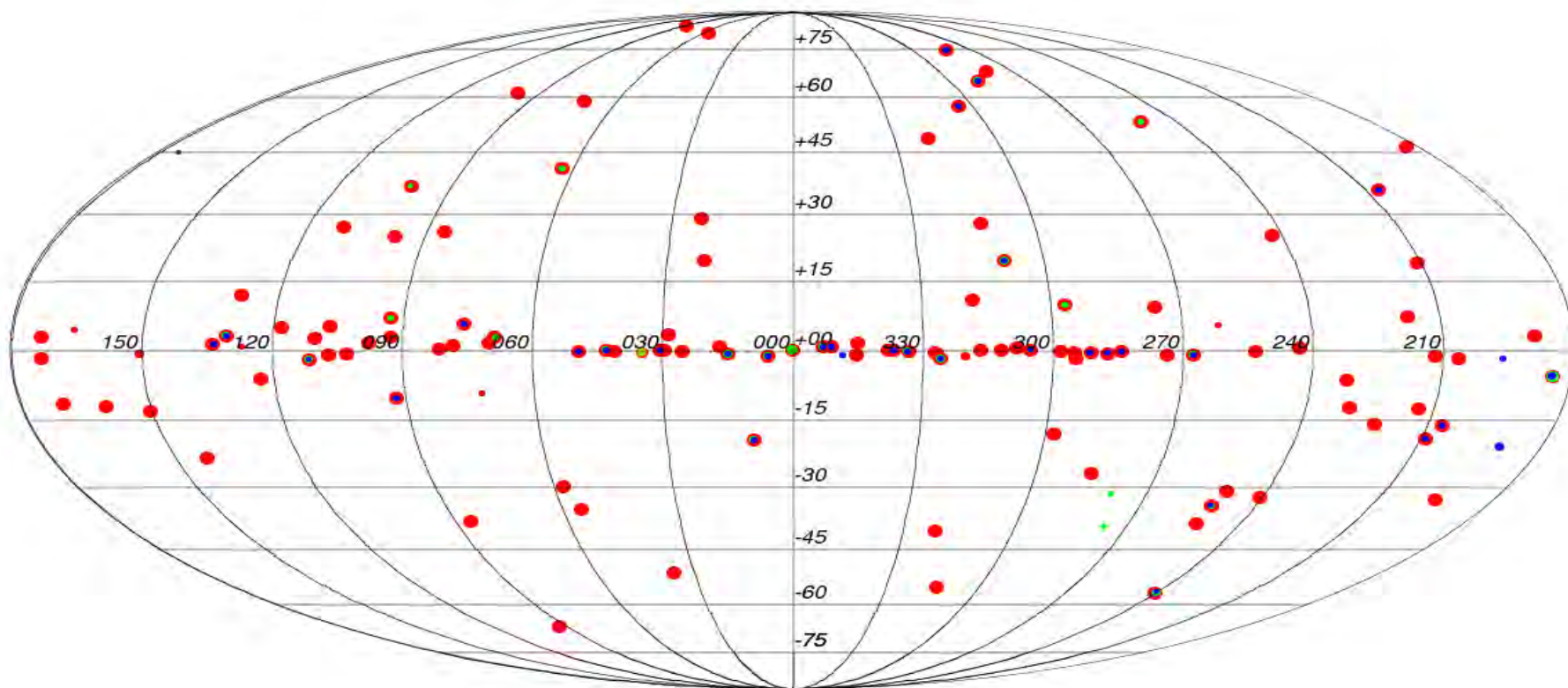
Lower frequencies 30 - 70 GHz: The reliability has been assessed cross-matching with external catalogues of radio sources. Sources detected in more than one Planck band with a multi-frequency analysis or validated assessing the counterparts found in NED at their position are also in the catalogue. A few tens of dubious sources worth studying.

Higher frequencies 100 – 857 GHz: at these frequencies there is little information that can be used to perform an all-sky validation of the catalogues. In order to assess the reliability of the sources, we followed an approach based on statistical analysis and a combination of **galactic masks**, to exclude galactic objects difficult to validate, and when needed, **a filament mask**, to exclude objects that lie along dusty filaments.

PCCS2: Detection pipeline



Distribution of the 30, 44 and 70 GHz sources



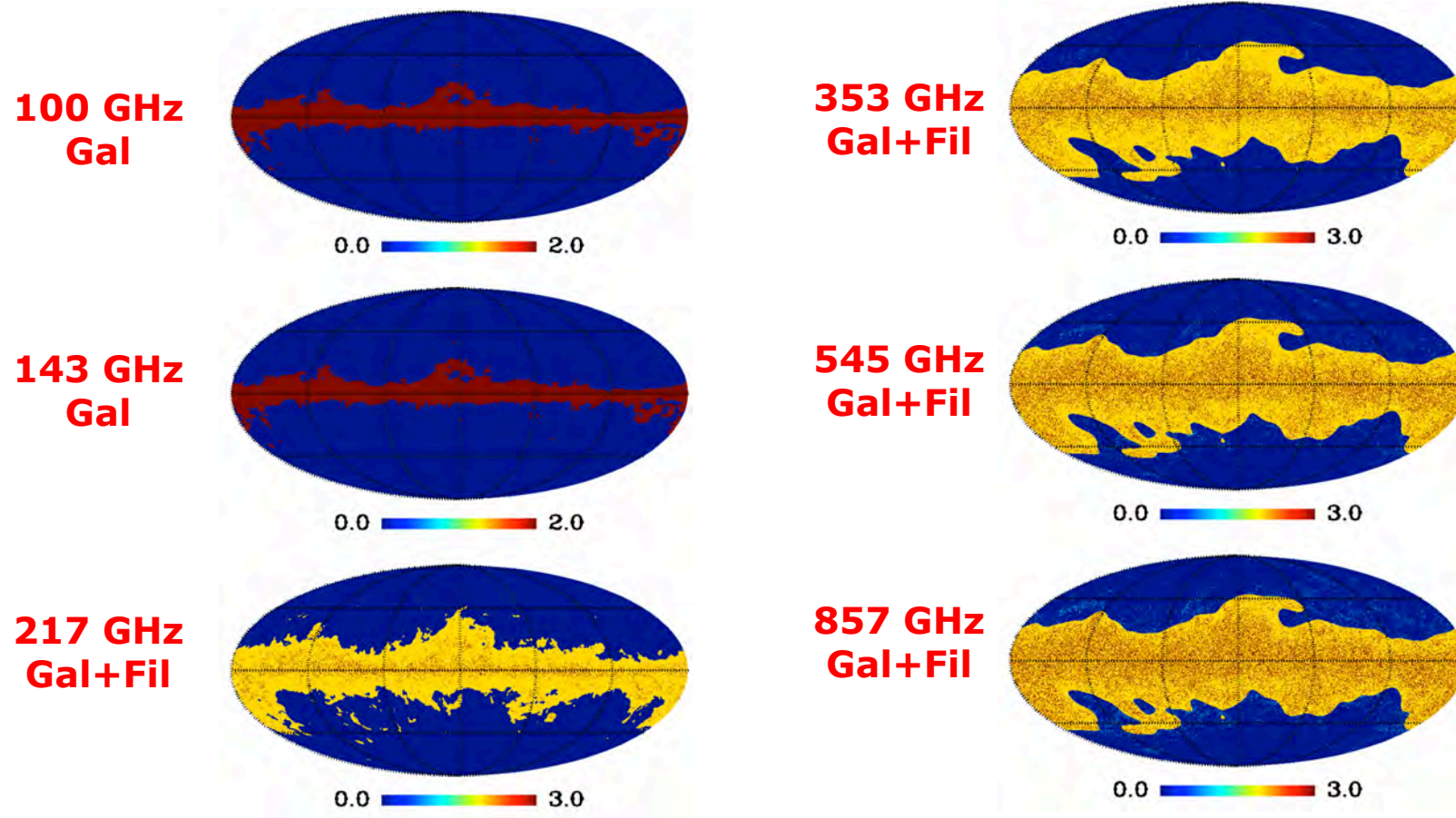
Galactic coordinates
Mollweide projection

PCCS2 in Polarization

PCCS2: Detection pipeline



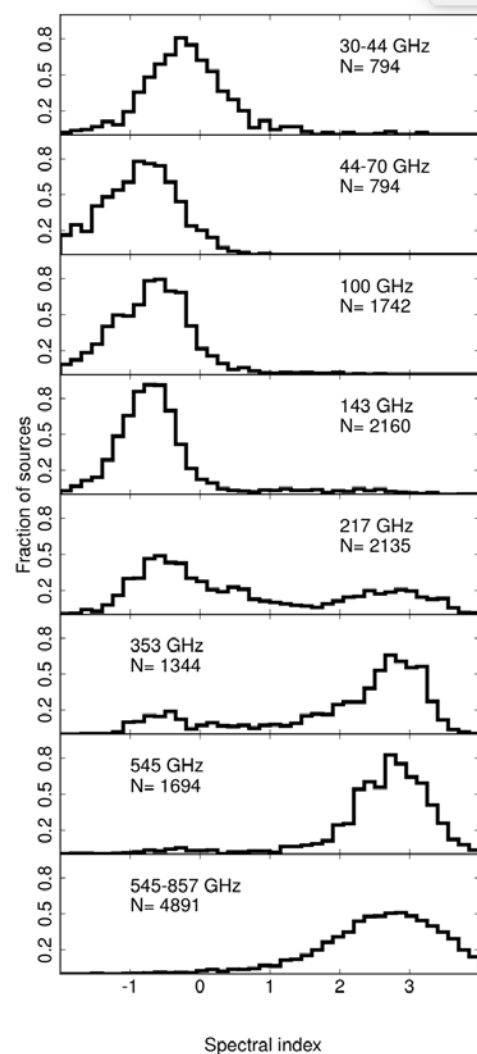
Galactic and Filament masks used to separate PCCS2 and PCCS2E



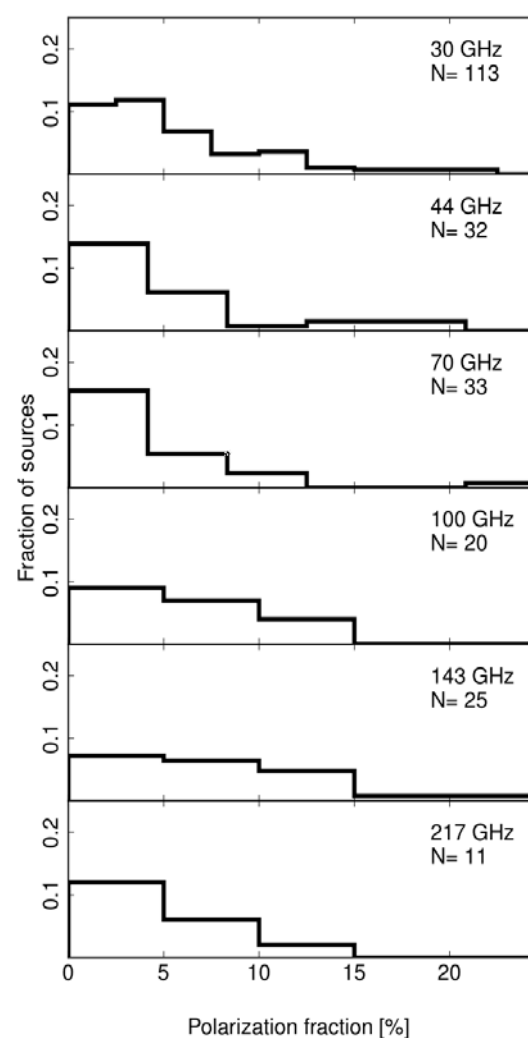
PCCS2: Statistical properties



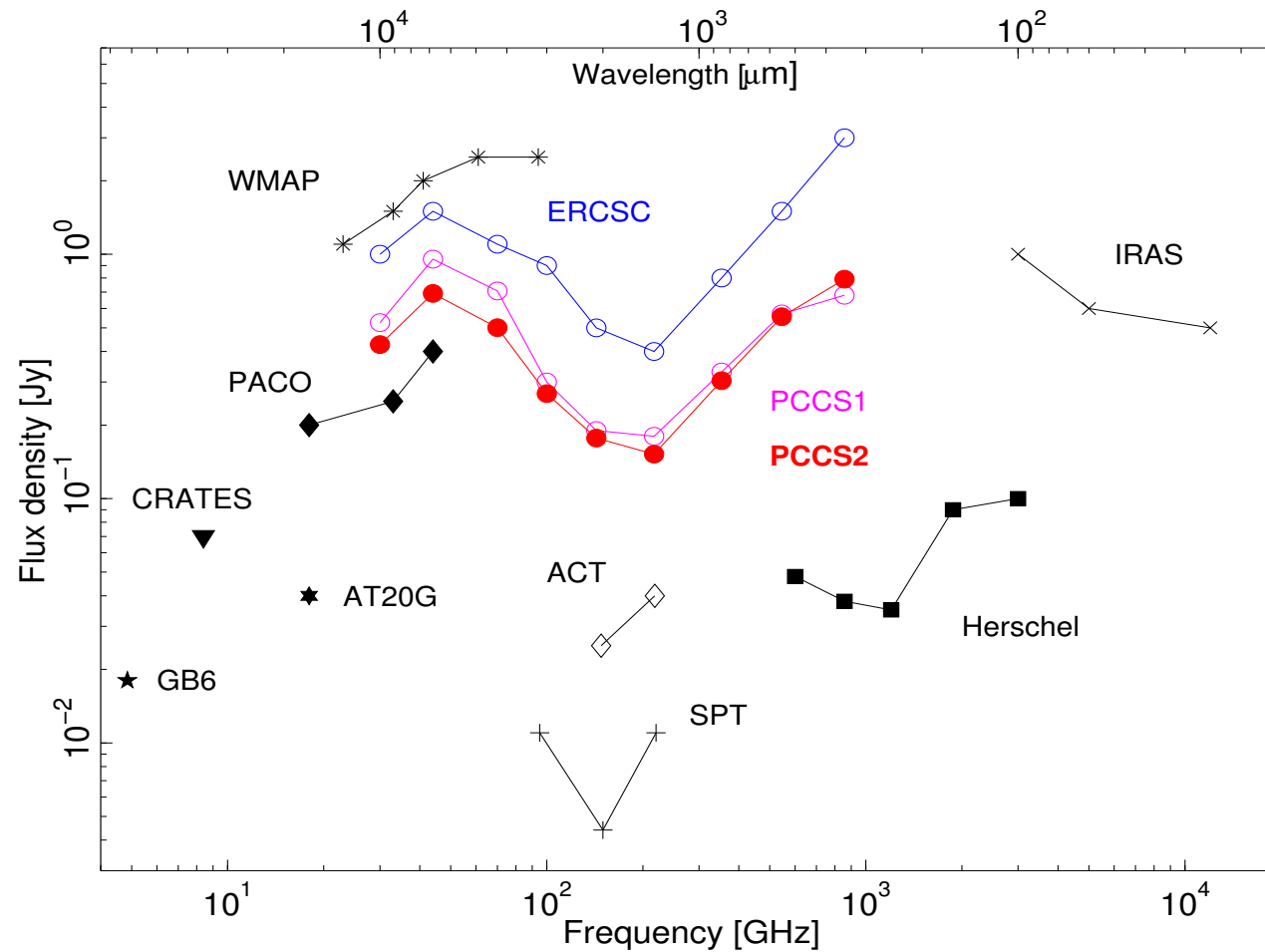
Spectral Index



Polarization Fraction



PCCS2: Sensitivity



PCCS2: Detection pipeline



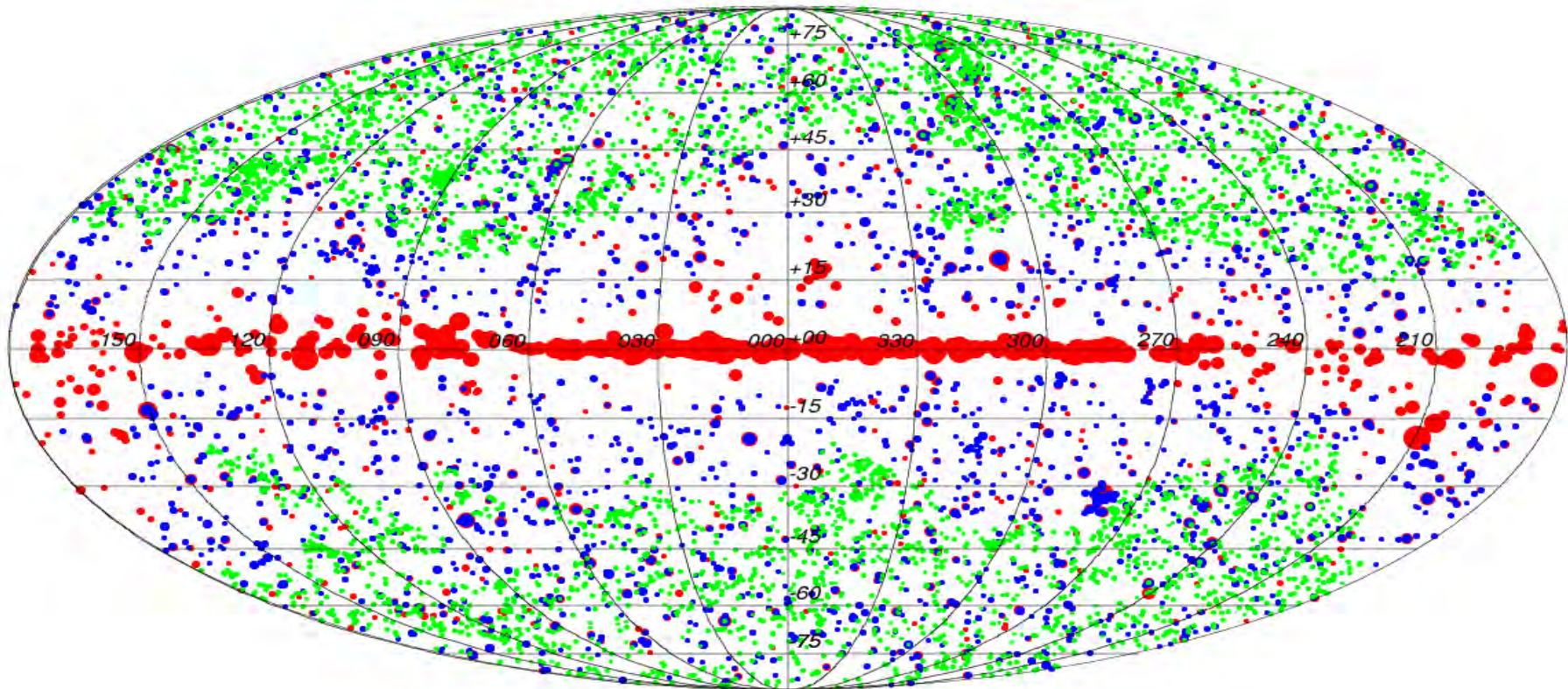
Summary Total Intensity

Channel	30	44	70	100	143	217	353	545	857
Freq [GHz]	28.4	44.1	70.4	100.0	143.0	217.0	353.0	545.0	857.0
λ [μm]	10561	6807	4260	3000	2098	1382	850	550	350
<i>Number of sources</i>									
PCCS2	1560	934	1296	1742	2160	2135	1344	1694	4891
PCCS2E . . . . .	...	...	...	2487	4139	16842	22665	31068	43290
Union PCCS2+PCCS2E . . . . .	...	...	...	4229	6299	18977	24009	32762	48181
PCCS ^a	1256	731	939	3850	5675	16070	13613	16933	24381

Summary Polarization

Channel	30	44	70	100	143	217	353
Number of significantly polarized sources in PCCS2	122	30	34	20	25	11	1
Minimum polarized flux density ^a [mJy]	117	181	284	138	148	166	453
Polarized flux density uncertainty [mJy]	46	88	91	30	26	30	81
Minimum polarized flux density completeness 90% [mJy]	199	412	397	135	100	136	347
Minimum polarized flux density completeness 95% [mJy]	251	468	454	160	111	153	399
Minimum polarized flux density completeness 100% [mJy] . . .	600	700	700	250	147	257	426
Number of significantly polarized sources in PCCS2E . . . . .	...	...	...	43	111	325	666
Minimum polarized flux density ^a [mJy] . . . . .	...	...	...	121	87	114	348
Polarized flux density uncertainty [mJy] . . . . .	...	...	...	52	44	55	178
Minimum polarized flux density completeness 90% [mJy] . . . .	...	...	...	410	613	270	567
Minimum polarized flux density completeness 95% [mJy] . . . .	...	...	...	599	893	464	590
Minimum polarized flux density completeness 100% [mJy] . . .	...	...	...	835	893	786	958

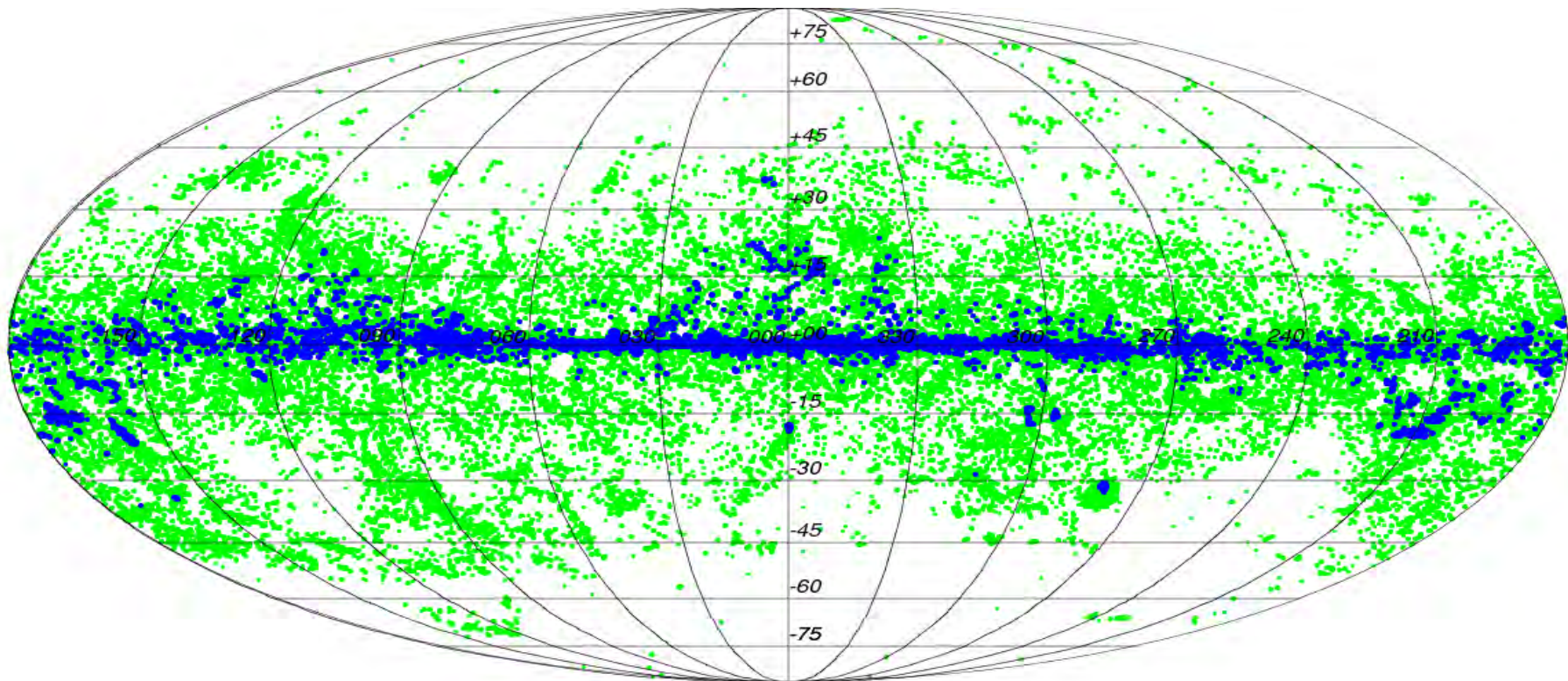
Distribution of the 30, 143 and 857 GHz sources



Galactic coordinates
Mollweide projection

PCCS2 in Intensity

Distribution of the 143 and 857 GHz sources



Galactic coordinates
Mollweide projection

PCCS2E in Intensity