CBI GALACTIC PLANE SCANS AT 31 GHZ

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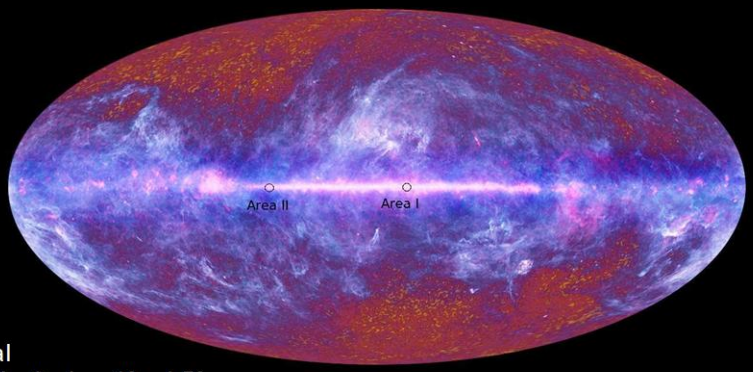
Why do that ?

- Better understanding
  - Accurate removal
  - Improve our understanding in galactic and extra galactic physics
- Foregrounds
  - Unresolved point sources
  - Sunyaev-Zeldovich (SZ) effect
  - Diffuse emission
    - Free-Free emission
    - Synchrotron emission
    - Thermal dust emission
      - Anomalous microwave emission (AME)

Observed Regions



- Areal
  - Latitude : -1° – 4.5°
  - Longitude: 349° – 353°
  - Period of Observations: 09/2007-10/2007
- AreaII
  - Latitude -3.3° – 1.5°
  - Longitude:47 °– 51°
  - Period of Observations: 02/2008-04/2008

http://www.bis.gov.uk/ukspaceagency

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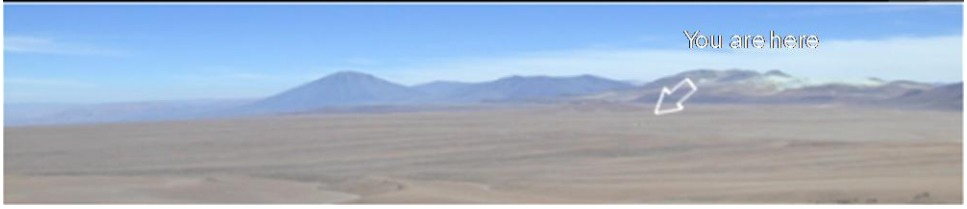
Cosmic Background Imager

- Interferometer
- Could measure total power and polarization
- Located in the Chilean Andes
- Placed on a rotating platform
- Built in Software packages (Tim Pearson)



Cosmic Background Imager

	CBI 1	CBI 2
Years of operation	1999-2006	2006-2008
Observing frequency (GHz)	26-36	
No of channels	10	
No of antennas	13	
No of baselines	78	
Antenna size (m)	0.9	1.4
Primary beam FWHM (arcmin)	45	28.2

Data analysis – Issues with Observations

www.astro.caltech.edu

- Unmounted receivers
- Unstable temperature
- Spurious signal
- Ground Contamination
- Large phase offsets
- Atmospheric contamination and Bad weather
- Observations happening during the day
- Calibration problems

CBI main contributions to science

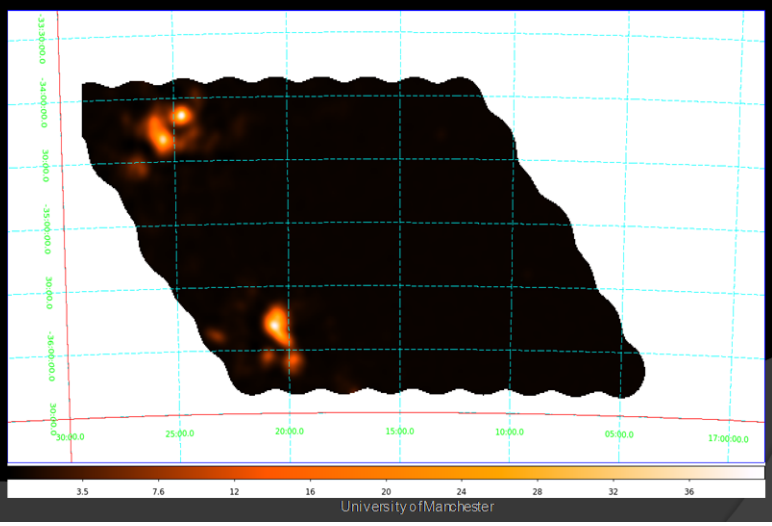
- Among the first to detect the E-mode CMB polarization (Readhead et al. 2004)
- Detected a damping tail and a subsequent excess in the high-latitude CMB anisotropies (Pearson et al. 2003; Mason et al. 2003)
- Observed and imaged a wide range of stellar objects and areas like molecular clouds, SNRs and HII regions

Data analysis

- Data reduction
- Ground subtraction
- Cleaning and creation of maps
- Optical comparison with ancillary data
- Deconvolution of ancillary data
- Creation of simulated maps
- Photometric methods
  - Gaussian fitting
  - Aperture photometry

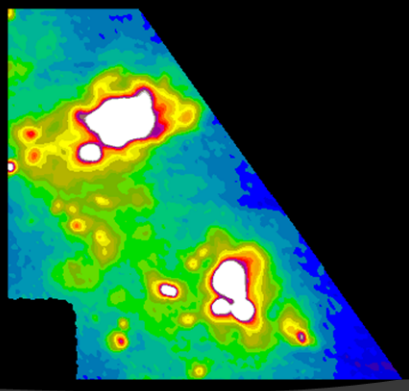
Results and comparison

- Area_I



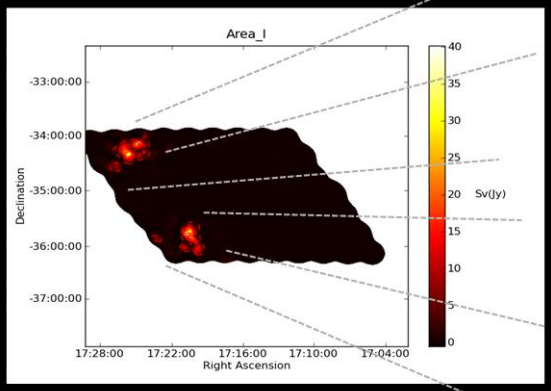
Results and comparison

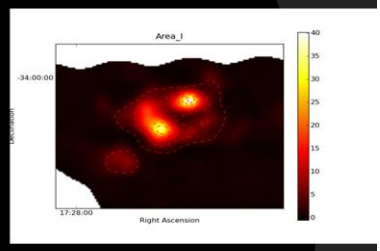
- Area_I
- Ancillary data from Parkes 64 m 6 cm

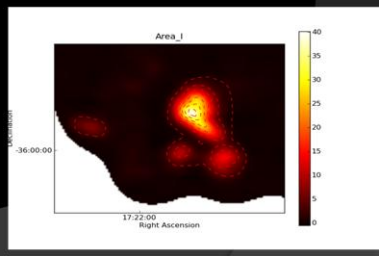


Results and comparison

- Area_I

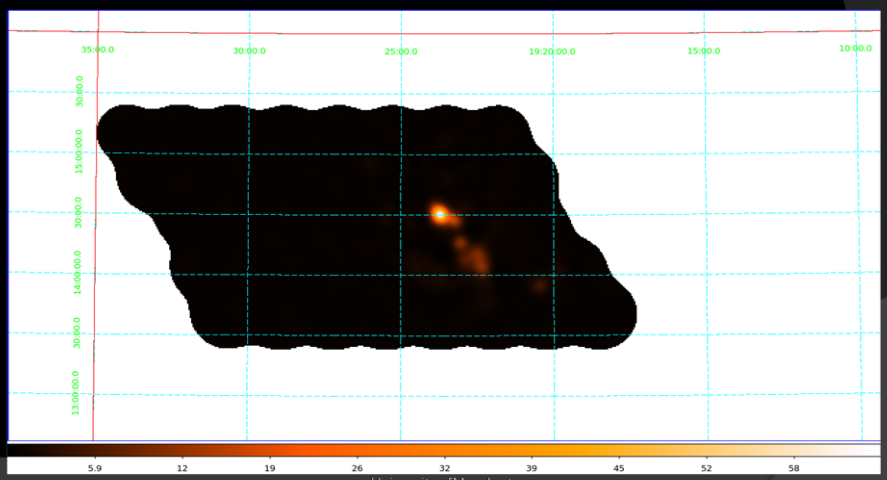






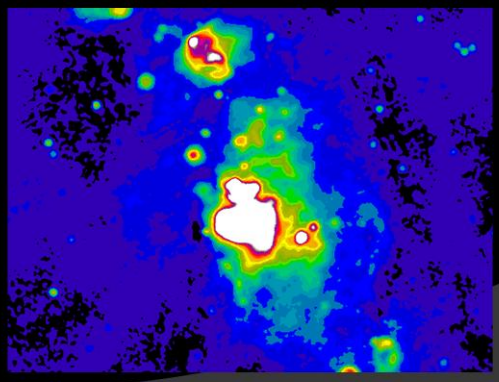
Results and comparison

- Area_II



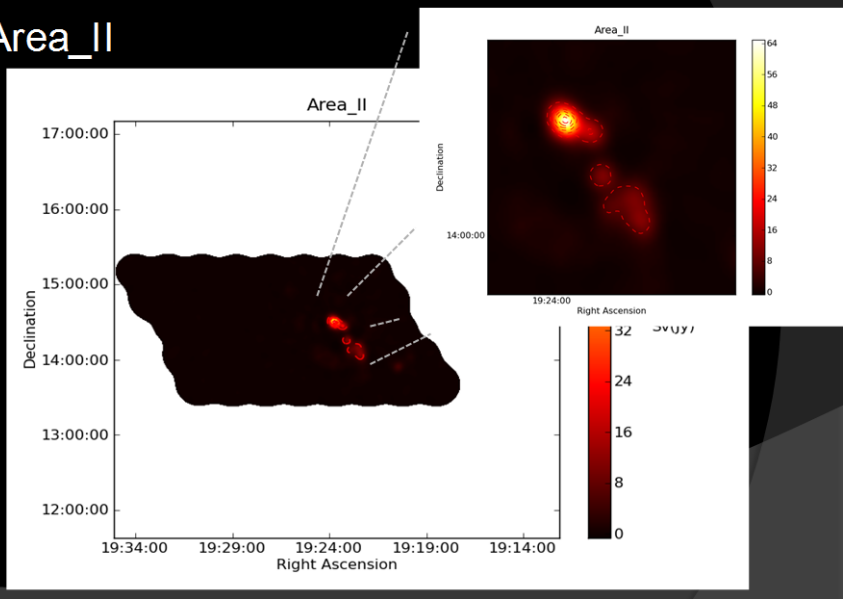
Results and comparison

- Area_II
- Ancillary data from Effelsberg 100 m 11cm



Results and comparison

- Area_II



Information about observed sources

- NGC 6357
  - Also called the war and peace nebula
  - lies about 1.75 Kpc away toward the constellation of the Scorpios.(Russeil et al 2012).
  - Spans about 400 parsecs
  - Forming some of the most massive stars ever discovered

http://www.ipac.caltech.edu/

Information about observed sources

http://www.ipac.caltech.edu/

- NGC 6334
  - Also called Cat's Paw Nebula and Bear Claw nebula
  - Among the largest (>0.5 °) star forming regions (Mcbreat et al 1979)
  - Located near the heart of the Milky Way
  - Lies about 1.75 kpc from Earth in the constellation of Scorpius (Russeil et al 2012)

Information about observed sources

http://www.ifa.hawaii.edu/

- W51
  - Extended (1°) radio source
  - Located at the tangential point of the Sagittarius arm, 5.5kpc from the sun (sato et al.2010)
  - It is composed of
    - Two complex H II regions, W51A and W51B
    - The supernova remnant (SNR) W51C

Error Consideration

Area-I		
Uncertainties due	Gaussian fitting	Aperture photometry
Calibration error	~ 4%	~4%
Simulation errors	>2%	>2%
Aperture size	~1%	~3%
Cmb contribution	Negligible	Negligible
Deconvolution	2-4%	2-4%
Ancillary data(Parkes 5 GHz)	10%	10%

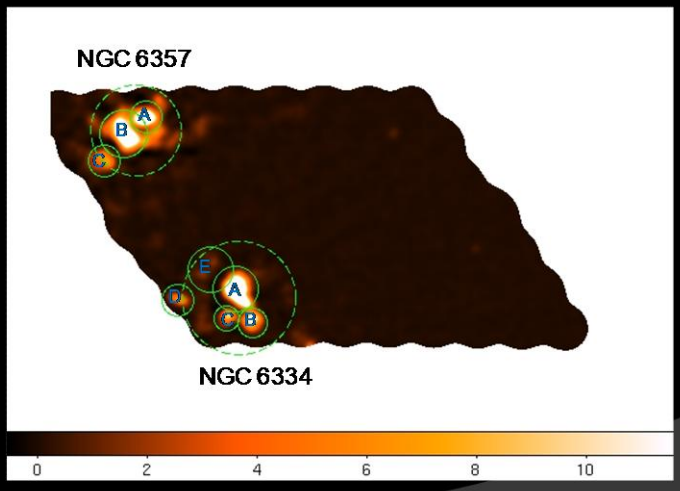
Area-I overall error		
	Gaussian	Aperture
CBI data	4.5%	5%
Ancillary data	11%	11.5%

Error Consideration

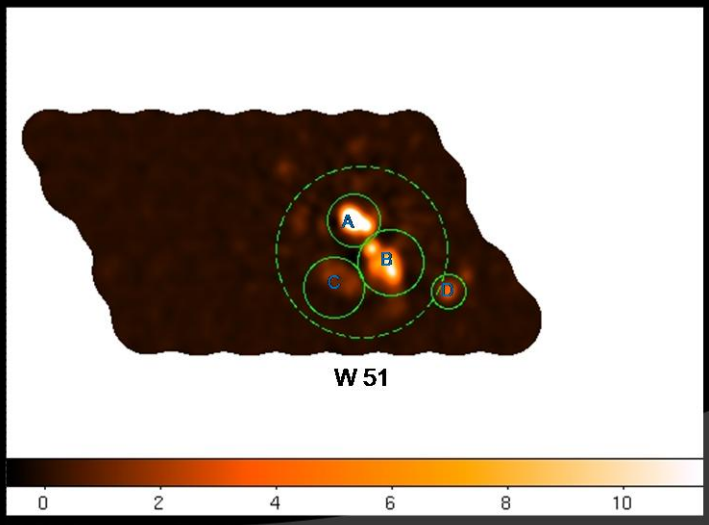
Area-II		
Uncertainties due	Gaussian fitting	Aperture photometry
Calibration error	--	--
Simulation errors	>2%	>2%
Aperture size	~1%	~3%
Cmb contribution	Negligible	Negligible
Deconvolution	2-4%	2-4%
Ancillary data(Effeslberg 11cm)	10%	10%

Area-II overall error		
	Gaussian	Aperture
CBI data	10%	10%
Ancillary data	11%	11.5%

Area-I observed regions



Area-II observed regions



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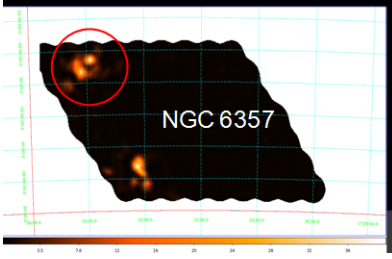
Area-I

Gaussian fitting

	Fitted S^{31}(Jy)	Predicted S^{31}(Jy)	(Decon.pro) S^{31}(Jy)	(Rich-lucy alg) S^{31}(Jy)	Excess 100-μm emissivity [μK(MJy sr^{-1})$^{-1}$]
NGC 6357	270 ± 12.2	247.1 ± 27.2	281.1 ± 30.9	268.1 ± 29.5	<10.5
NGC 6357-A	76 ± 3.5	74.6 ± 8.2	84.3 ± 9.3	76.5 ± 8.4	<9.9
NGC 6357-B	135.9 ± 6.1	129.1 ± 14.2	146.9 ± 16.2	142.6 ± 15.7	<6.3
NGC 6357-C	22.8 ± 1.0	19.5 ± 2.2	22.4 ± 2.5	21.7 ± 2.4	<14.3
NGC 6357 Res	18.7 ± 0.9	14.9 ± 1.6	16.9 ± 1.9	16.4 ± 1.8	3.1 ± 2.7 (1.1 σ)
NGC 6357 Res (shield)	11.6 ± 0.5	8.5 ± 0.9	10.5 ± 1.2	9.9 ± 1.1	3.5 ± 2.5 (1.4 σ)



Free-free accounts for all emission
Excess emission
Less emission than expected

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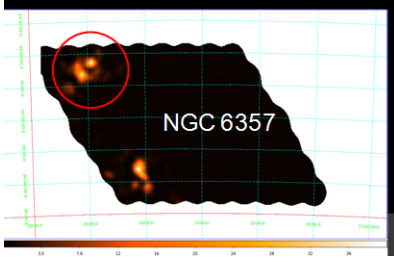
Area-I

Aperture photometry

	Fitted S^{31}(Jy)	Predicted S^{31}(Jy)	(Decon.pro) S^{31}(Jy)	(Rich-lucy alg) S^{31}(Jy)	Excess 100-μm emissivity [μK(MJy sr^{-1})$^{-1}$]
NGC 6357	281 ± 14.1	255 ± 28.1	270 ± 29.7	259 ± 28.5	<12.9
NGC 6357-A	76 ± 3.8	74.6 ± 8.2	82.4 ± 9.1	77.2 ± 8.5	<9.7
NGC 6357-B	140.5 ± 7.0	126.7 ± 13.9	145 ± 16.0	141.3 ± 15.5	<7.9
NGC 6357-C	22.3 ± 1.1	18.1 ± 1.9	20.7 ± 2.3	20.2 ± 2.2	<17.5
NGC 6357 Res	33.7 ± 1.7	29.3 ± 3.2	33.4 ± 3.7	31.7 ± 3.5	<9.7
NGC 6357 Res (shield)	16.1 ± 0.8	14.8 ± 1.6	17.4 ± 1.9	17.3 ± 1.9	<6.4



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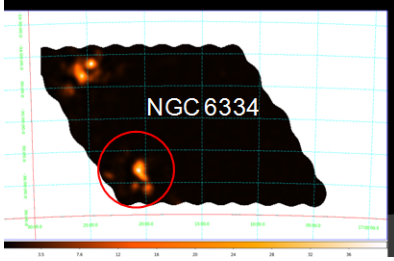
Area-I

Gaussian fitting

	Fitted S^{31}(Jy)	Predicted S^{31}(Jy)	(Decon.pro) S^{31}(Jy)	(Rich-lucy alg) S^{31}(Jy)	Excess 100-μm emissivity [μK(MJy sr^{-1})$^{-1}$]
NGC 6334	153.6 ± 9.4	144.6 ± 15.2	160.0 ± 16.8	155.2 ± 16.3	<5.5
NGC 6334-A	150.1 ± 9.2	134.9 ± 14.2	148.9 ± 15.6	144.6 ± 15.2	<6.1
NGC 6334-B	34 ± 2.1	35.3 ± 3.7	41.6 ± 4.3	40.5 ± 4.3	<3.7
NGC 6334-C	15.2 ± 0.9	13.2 ± 1.4	17.4 ± 1.8	16.8 ± 1.8	<5.3
NGC 6334-D	11.1 ± 0.7	16.5 ± 1.7	17.8 ± 1.9	16.4 ± 1.7	—
NGC 6334-E	6 ± 0.4	1.5 ± 0.2	2.1 ± 0.2	1.7 ± 0.2	15.4 ± 1.6 (9.5σ)
NGC 6334-Res	5.7 ± 0.4	2.9 ± 0.3	3.3 ± 0.3	3.8 ± 0.4	17.3 ± 5.1 (3.4σ)



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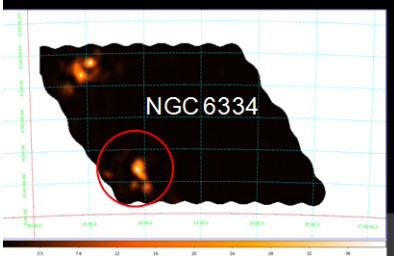
Less emission than expected

Area-I

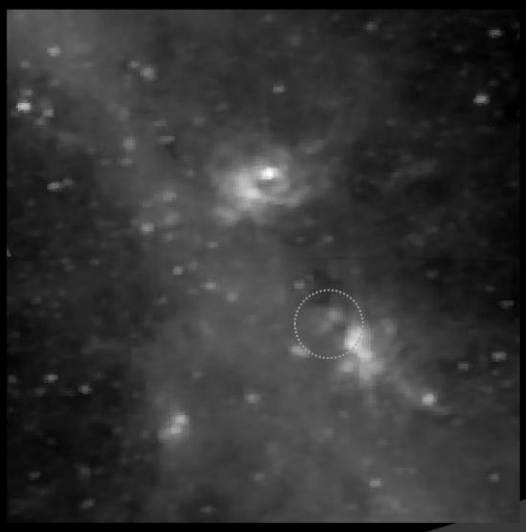
Aperture Photometry

	Fitted S^{31}(Jy)	Predicted S^{31}(Jy)	(Decon.pro) S^{31}(Jy)	(Rich-lucy alg) S^{31}(Jy)	Excess 100-μm emissivity [μK(MJy sr^{-1})$^{-1}$]
NGC 6334	215 ± 14.4	191.5 ± 21.0	216 ± 23.9	212.1 ± 23.3	<7.2
NGC 6334-A	149.5 ± 10.0	131.7 ± 14.5	146.4 ± 16.1	142.2 ± 15.6	<6.8
NGC 6334-B	32.5 ± 2,2	33.5 ± 3.7	39.2 ± 4.3	38.6 ± 4.2	<3.5
NGC 6334-C	15.0 ± 1.0	12.5 ± 1.4	16.5 ± 1.8	16.3 ± 1.8	<6.4
NGC 6334-D	11 ± 0.7	14.8 ± 1.6	15.8 ± 1.7	15.9 ± 1.7	—
NGC 6334-E	6.0 ± 0.4	1.4 ± 0.2	1.8 ± 0.2	1.8 ± 0.2	15.5 ± 1.6 (9.5σ)
NGC 6334-Res	9.7 ± 0.7	9.6 ± 1.1	9.4 ± 1.0	10.9 ± 1.2	<12.1



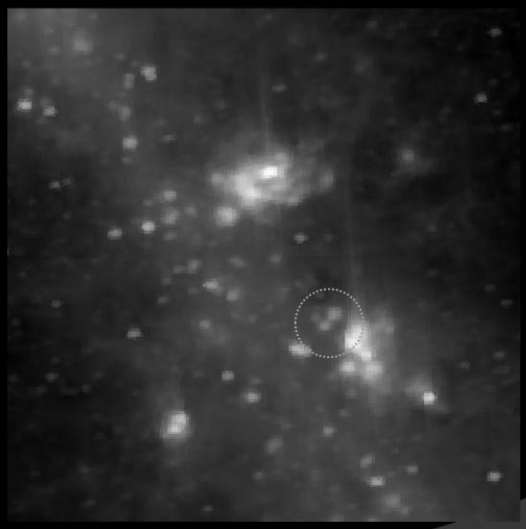
Free-free accounts for all emission
Excess emission
Less emission than expected

Sky view - IRAS Maps



IRIS 12

Sky view - IRAS Maps



IRIS 25

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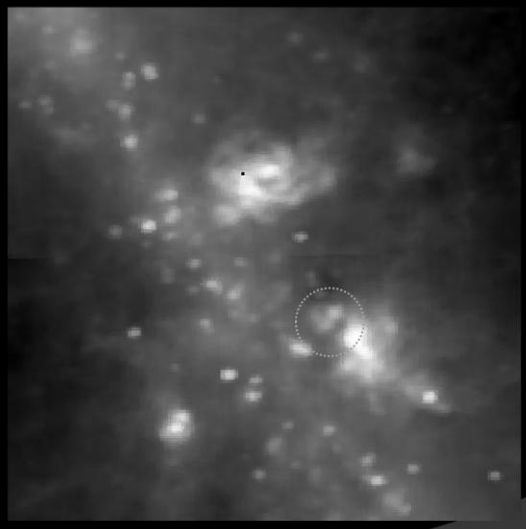
Sky view - IRAS Maps



IRIS 60

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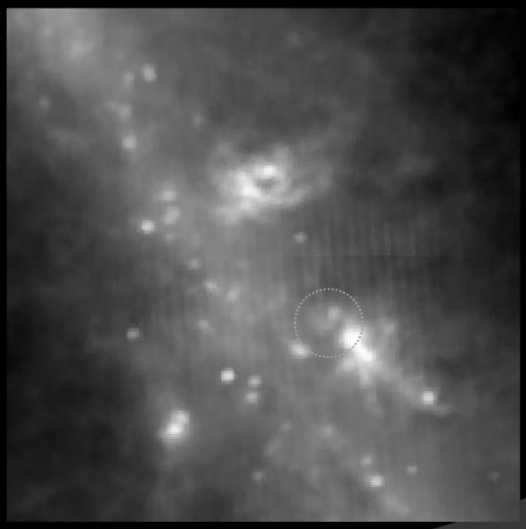
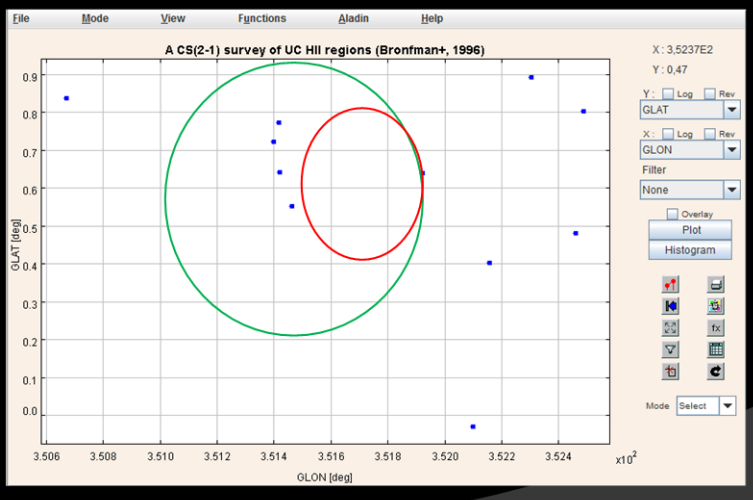
Sky view - IRAS Maps



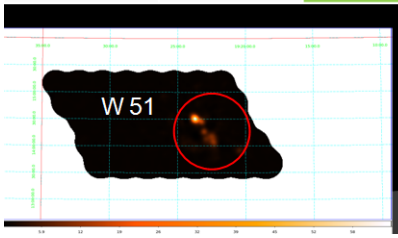
IRIS 100



Area-II

Gaussian fitting

	Fitted S^{31}(Jy)	Predicted S^{31}(Jy)	(Decon.pro) S^{31}(Jy)	(Rich-lucy alg) S^{31}(Jy)	Excess 100-μm emissivity [μK(MJy sr^{-1})$^{-1}$]
W 51	85.6 ± 8.6	87.6 ± 9.6	98.2 ± 10.9	83.5 ± 9.2	<4.6
W51-A	85.9 ± 8.6	87.8 ± 9.7	98 ± 10.8	83 ± 9.1	<4.8
W51-B	56.8 ± 5.7	58.2 ± 6.4	65.4 ± 7.2	64.7 ± 7.1	<0.3
W51-C	10.9 ± 1.1	27.6 ± 3.0	30.6 ± 3.4	31 ± 3.4	—
W51-D	7.3 ± 0.7	7.4 ± 0.8	8 ± 0.9	7.5 ± 0.8	<2.8
NGC 6357 Res	3.7 ± 0.4	0.9 ± 0.1	1.9 ± 0.2	4.6 ± 0.5	<12.7
NGC 6357 Res (shield)	2.6 ± 0.3	2.4 ± 0.3	1.5 ± 0.2	3.2 ± 0.4	<2.0

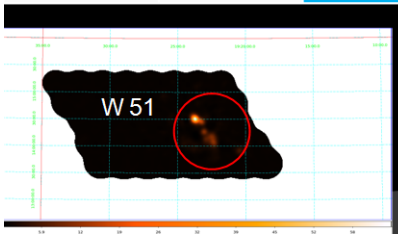


Free-free accounts for all emission
Excess emission
Less emission than expected

Area-II

Aperture photometry

	Fitted S^{31}(Jy)	Predicted S^{31}(Jy)	(Decon.pro) S^{31}(Jy)	(Rich-lucy alg) S^{31}(Jy)	Excess 100-μm emissivity [μK(MJy sr^{-1})$^{-1}$]
W 51	181.2 ± 18.1	183.1 ± 21.1	217.4 ± 25.0	198.0 ± 22.8	<4.2
W51-A	99.3 ± 10.0	91.4 ± 10.5	108 ± 12.4	92 ± 10.6	<6.3
W51-B	56.4 ± 5.6	55 ± 6.3	61.6 ± 7.1	61.0 ± 7.0	<4.4
W51-C	9.9 ± 1.0	25.2 ± 2.9	28 ± 3.2	28.4 ± 3.3	—
W51-D	7.6 ± 0.8	7.1 ± 0.8	7.8 ± 0.9	7.5 ± 0.9	<3.8
W51 Res	15.1 ± 1.5	11.1 ± 1.3	19.5 ± 2.2	15.5 ± 1.8	<5.2
W51 Res (shield)	11.5 ± 1.2	6.6 ± 0.8	10.9 ± 1.3	9.2 ± 1.1	4.0 ± 2.8 (1.4 σ)



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Excess emission
Less emission than expected

Conclusions

- Clear detection of excess emission in NGC 6334 E
- Possible excess emission in the diffuse part of NGC 6334 and W51
- Free-free emission is, clearly, not the dominant mechanism in W51 C.
- Possible mixture of free-free and synchrotron emission in NGC 6334 D
- More high resolution low frequency data (<30 GHz) are needed in both regions
- More accurate data are needed