

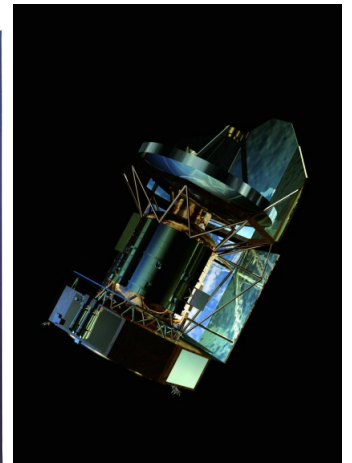
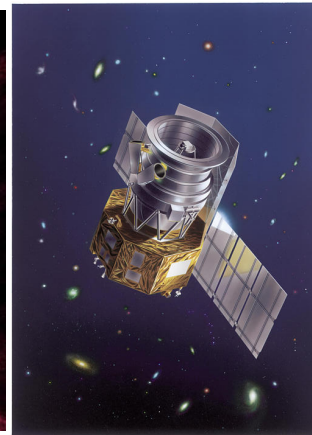
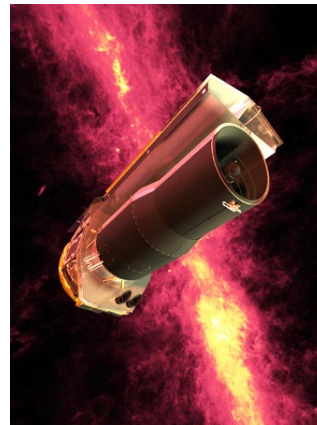
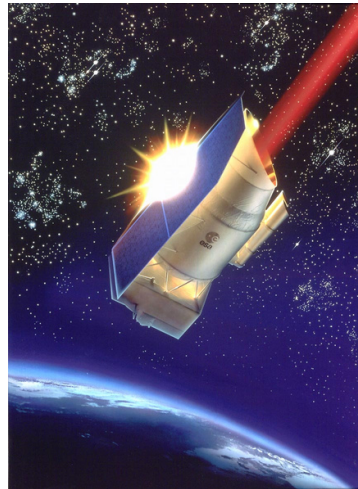
ISOPHOT Data in the Line of Observations with Far-Infrared Space Observatories from IRAS to Herschel

Ulrich Klaas

ISOPHOT Data Centre @ Max-Planck-Institut für Astronomie, Heidelberg

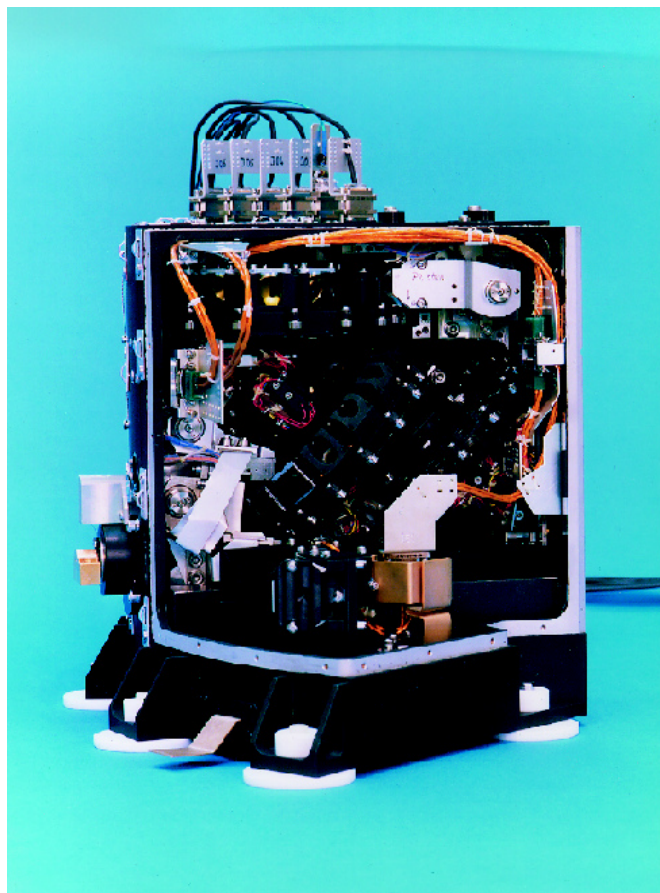
Colloquium on Infrared Space Missions in the Far-Infrared and
their Legacy to the Virtual Observatory

20 Years of Infrared Astronomy at Konkoly Observatory
Budapest, 11 May 2006



mission	IRAS	COBE	ISO	Spitzer	Akari	Herschel
instrument	camera	DIRBE	ISOPHOT	MIPS	FIS	PACS
launch	1983	1989	1995	2003	2006	2008
lifetime [y] (cryogenic)	0.75	0.85	2.4	2.5-5	1.5	3.5
telescope [m]	0.6	≈ 0.2	0.6	0.85	0.69	3.5
cooling	cryogenic	cryogenic	cryogenic	cryogenic	cryogenic	passive
type	all-sky survey additional pointings	all-sky survey	observatory serendipity survey	observatory	all-sky survey additional pointings	observatory
FIR # bands [μm]	3 25–100	5 25–240	12 25–200	3 24–160 SED mode	5 18–160	3 70–170
FWHM PSF (@100 μm) [“]	34	—	34	24	30	6
FIR (20 μm) arrays (70 μm) (160 μm)	— — —	— — —	 3\times3 2\times2	128\times128 32\times32 2\times20	256\times256 20\times3 15\times3	— 64\times32 32\times16
pixel sizes [“]	45–180 (in-scan)	2760	43.5 / 89.4	2.6 / 9.8 / 16	2.5 / 27 / 44	3.2 / 6.4

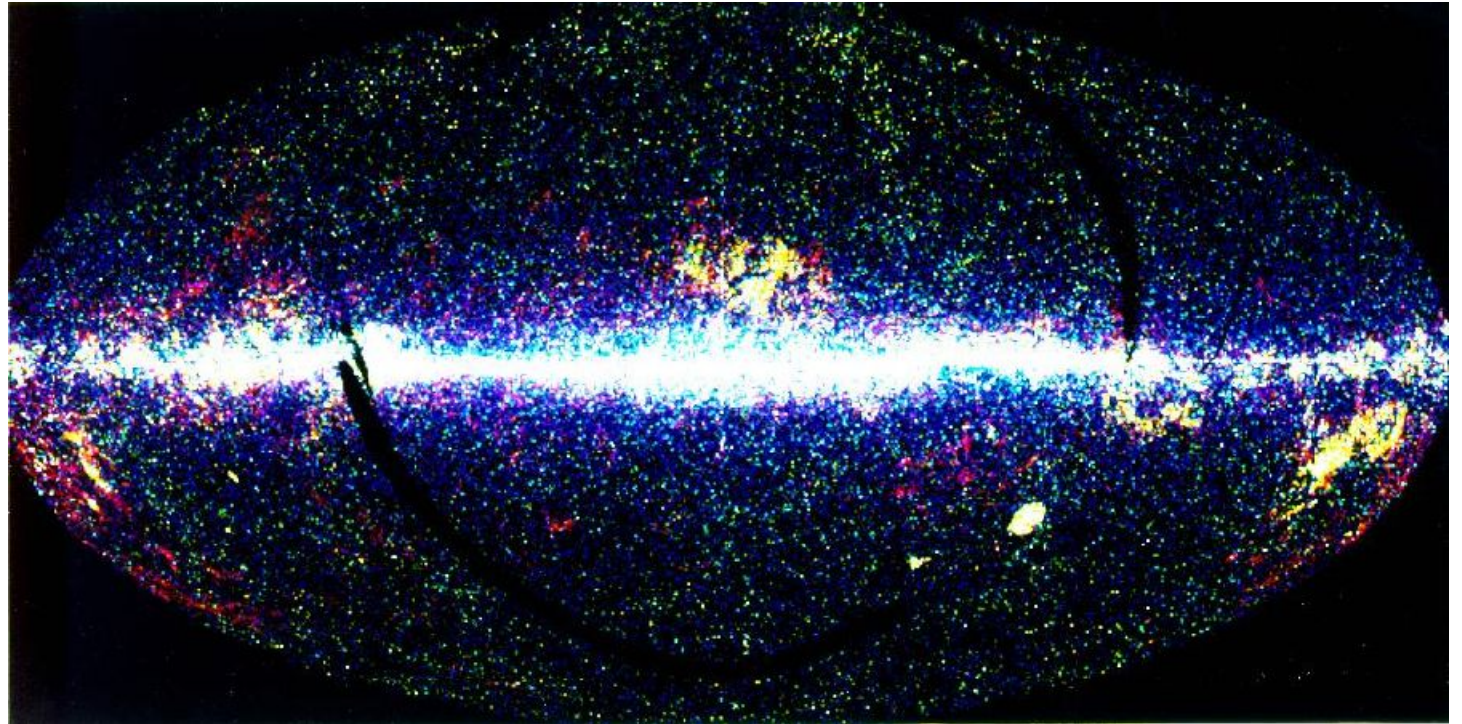
ISOPHOT: Instrument Characteristics



3 subinstruments

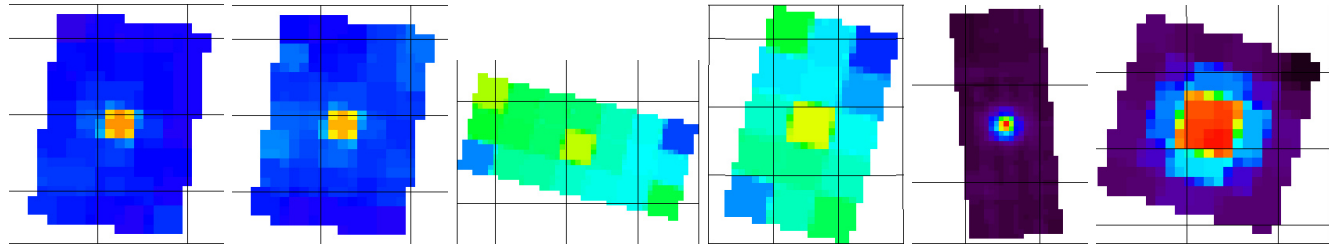
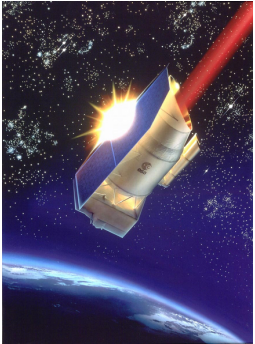
- ISOPHOT-P:
multi-filter & multi-aperture photometer
14 filters: $3.3\ \mu\text{m} - 100\ \mu\text{m}$
11 circular apertures: $5'' - 180''$
- ISOPHOT-C:
multi-filter array cameras
11 filters: $60\ \mu\text{m} - 200\ \mu\text{m}$
pixel sizes: $44''$ & $89''$ ($> \text{FWHM}(\lambda_c)$)
- ISOPHOT-S:
low resolution 2 channel spectrometer
 $2.5\ \mu\text{m} - 12\ \mu\text{m}$, $R = 90$
- Polarimetric capabilities in combination with ISOPHOT-P & ISOPHOT-C detectors

IRAS: All-Sky Survey @ 12, 25, 60, and 100 μm



- 350 000 point sources
- reference FIR source catalog
- sensitivity limit:
0.1 Jy (12, 25 μm) ... \approx 1 Jy (100 μm , cirrus confusion)
- photometry for sources up to several 10 000 Jy

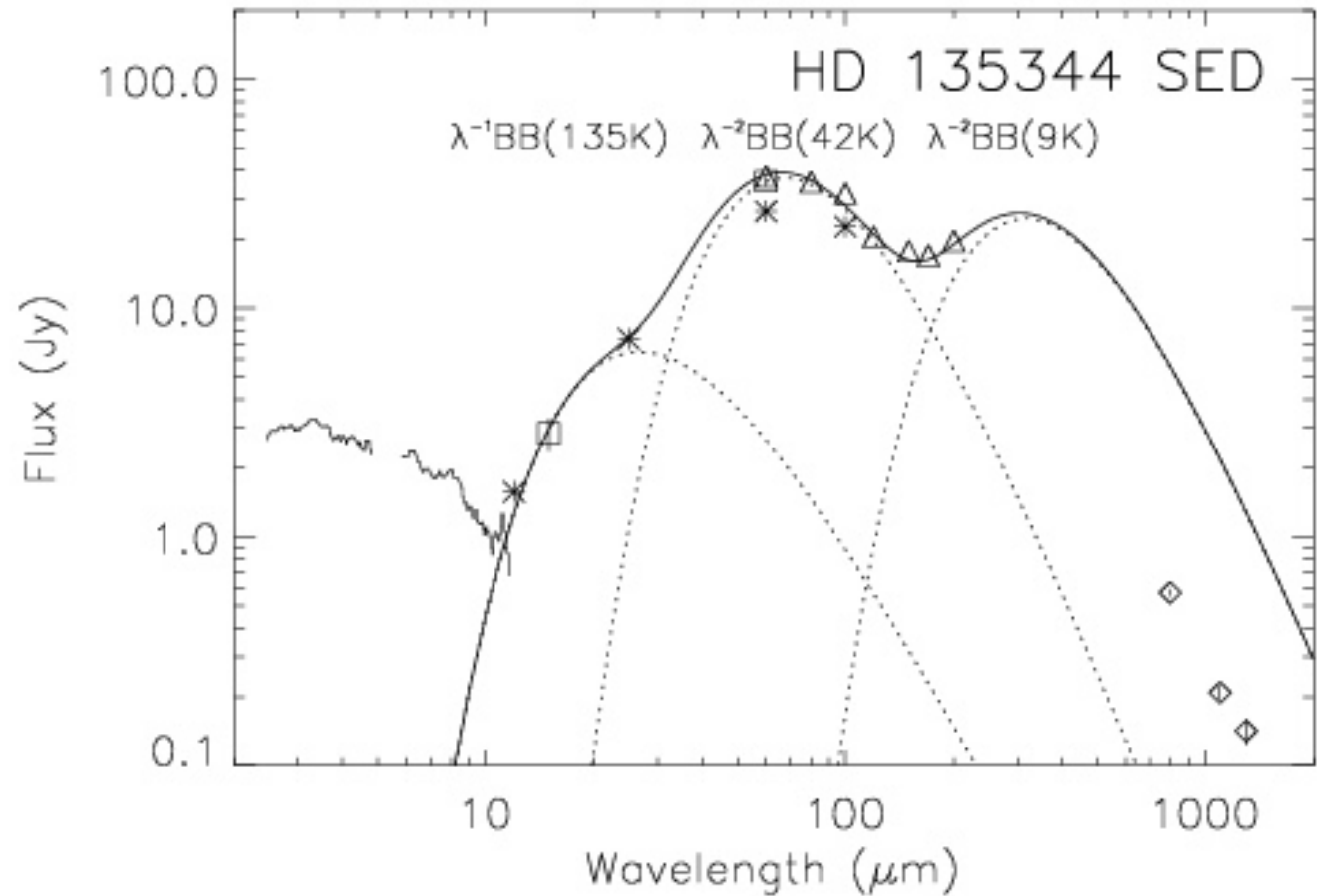
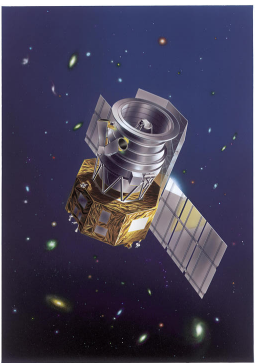
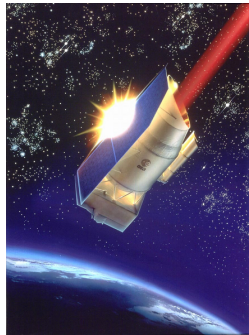
Photometric Catalogs from FIR ISOPHOT Mini-Maps



- Accurate FIR photometry with low cirrus confusion level.
- Flux range from 100 (200) mJy up to several hundred Jy.
- Variability studies w.r.t. IRAS and Akari photometry (1983 / 1997 / 2007).

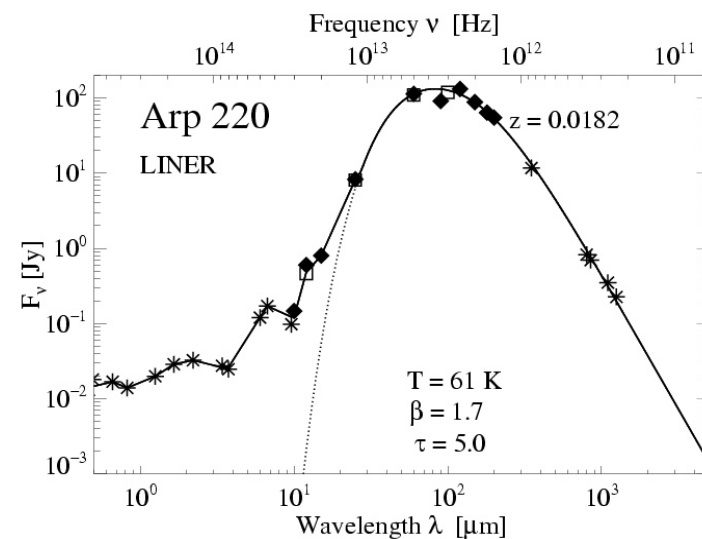
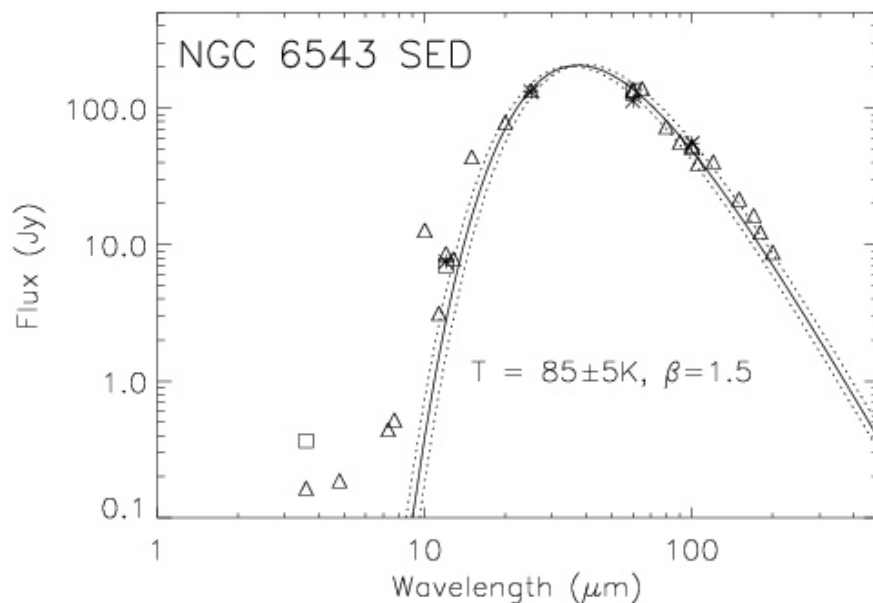
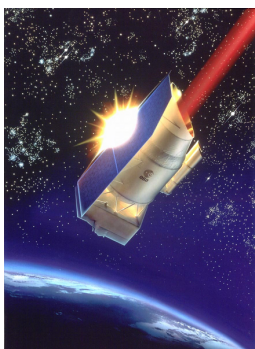
[illegible]

Epoch of the ISO mission important for FIR variability studies

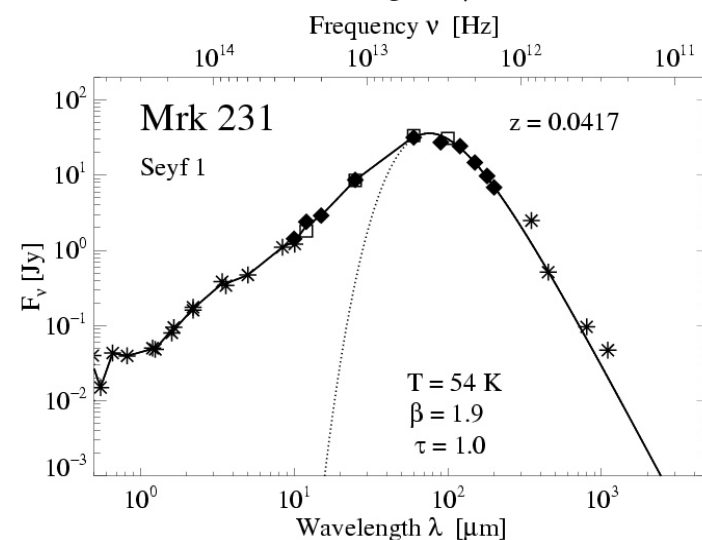


SED of young stellar object indicates variation in FIR dust emission from 1983 to 1997.

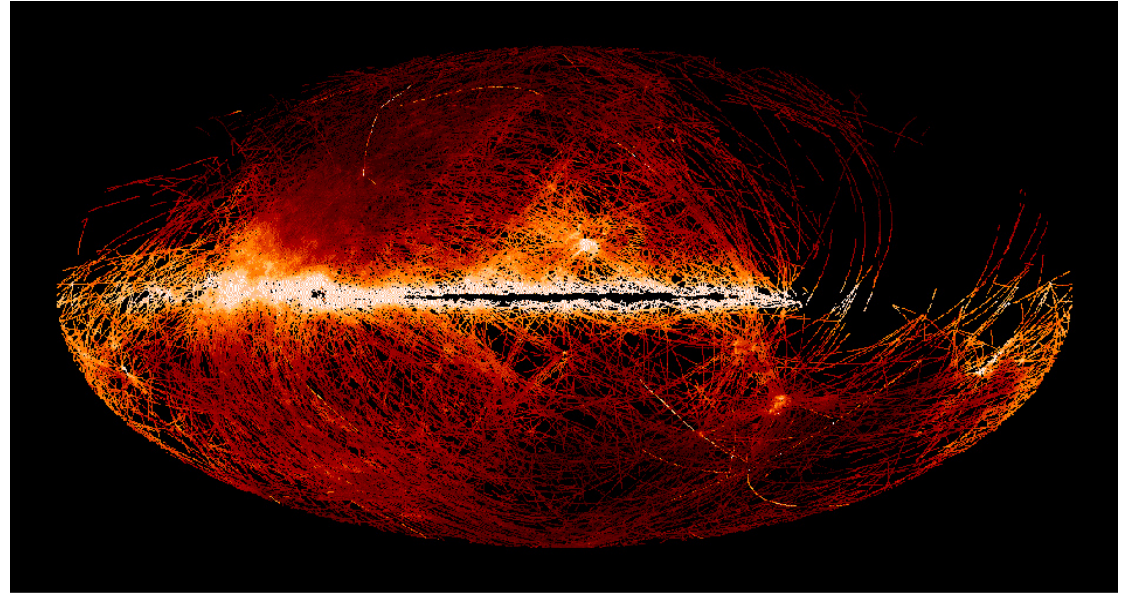
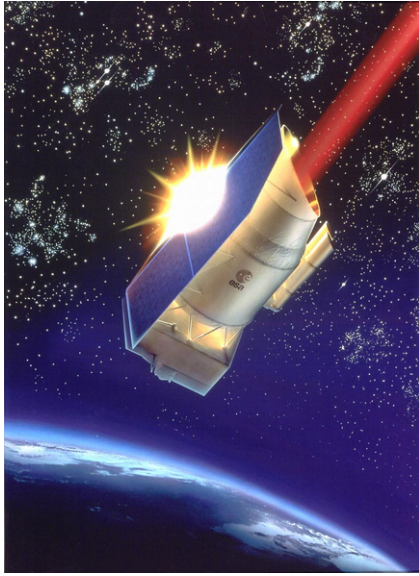
ISOPHOT multi-filter capabilities: establishment of FIR templates



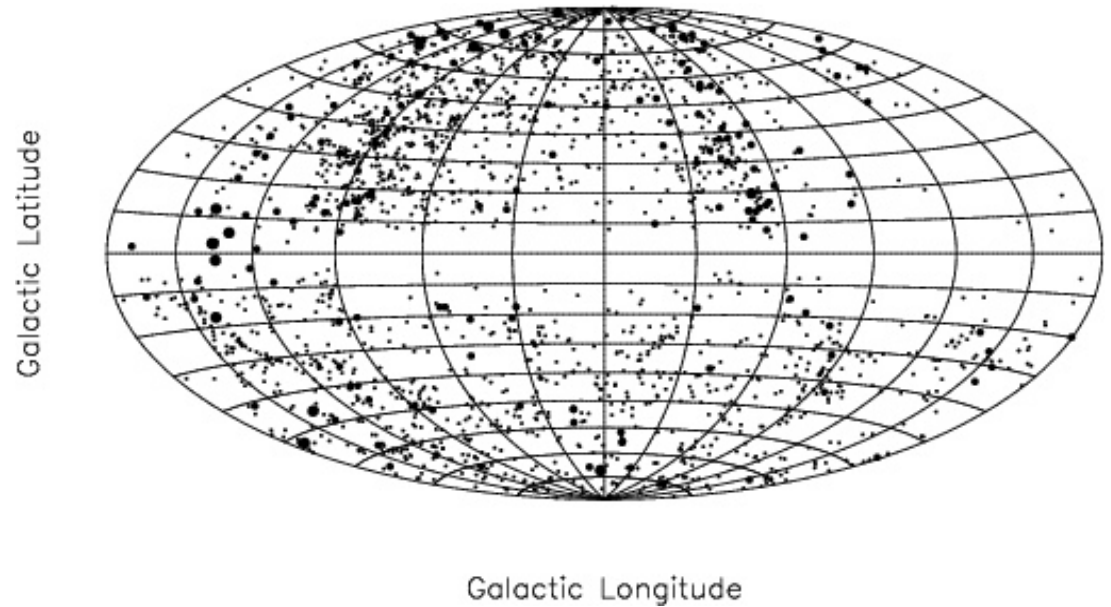
- Maximum of 25 filters:
12 from 3.3 to 25 μm ;
13 from 60 to 100 μm .
- Good coverage of FIR emission peaks.
- Photometric redshift determination of high- z submm sources.



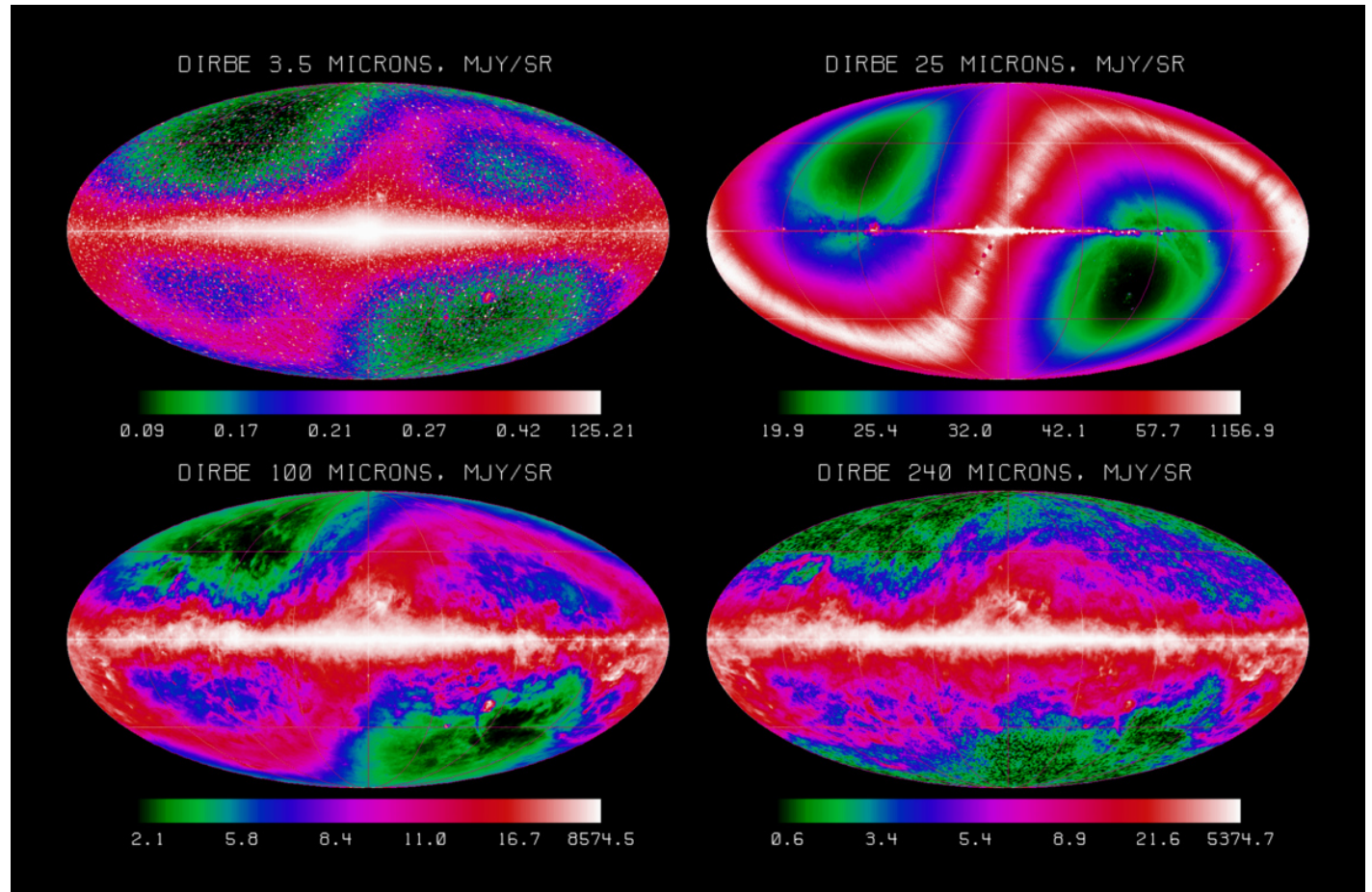
ISOPHOT Serendipity Survey @170 μm



- Complementary to IRAS sky survey.
- 15% sky coverage.
- Catalog of 2000 galaxies.
- Akari all sky survey @140 μm (FIS WIDE-L) and @160 μm (FIS N160).

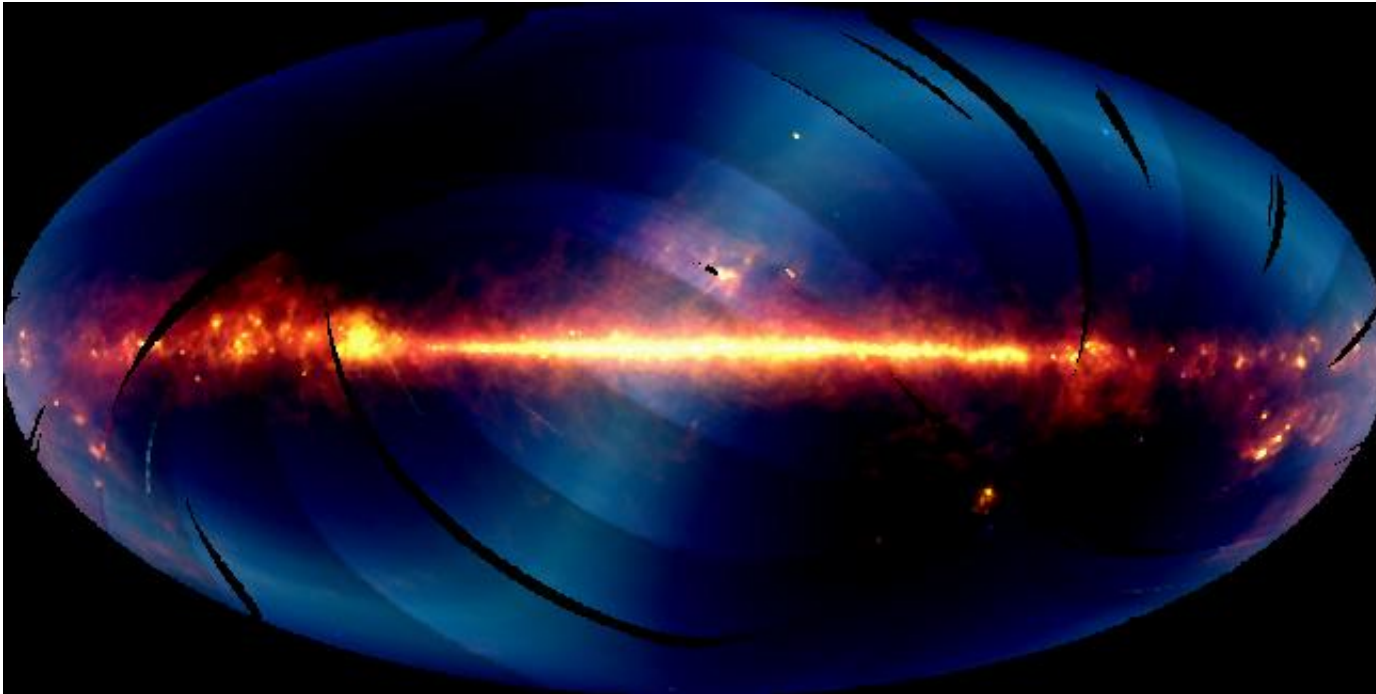


COBE-DIRBE: Absolute Sky Surface Brightness $1.25\ \mu\text{m} - 240\ \mu\text{m}$

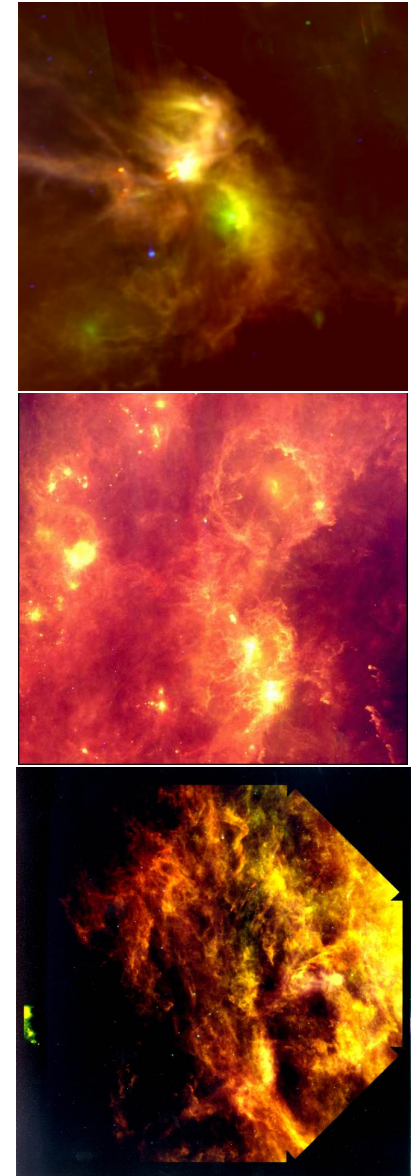


- FIR filters: 25, 60, 100, 140, 240 μm (in total 10 bands)
- Zodiacal Light model
- spatial resolution: $\approx 0.7^\circ/\text{pixel}$

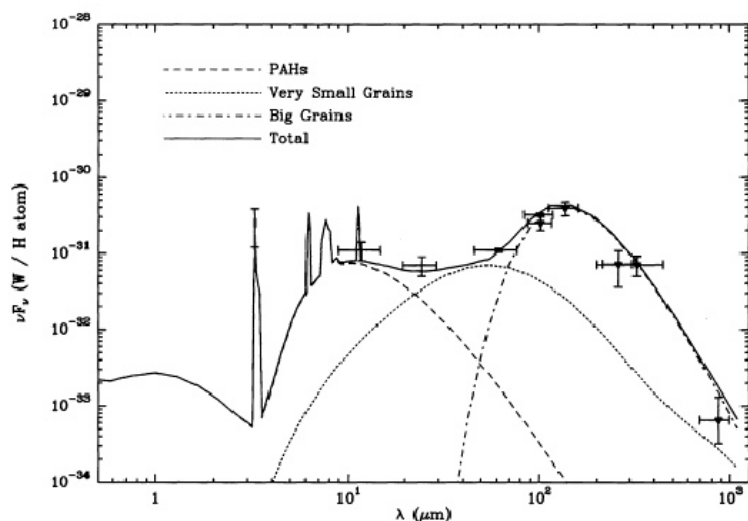
IRAS: Sky Survey Atlas Maps @ 12, 25, 60, and 100 μm



- 98% sky coverage
- surface brightness absolutely calibrated against COBE-DIRBE
- spatial resolution: 0.7' (12, 25 μm) ... 3' (100 μm)

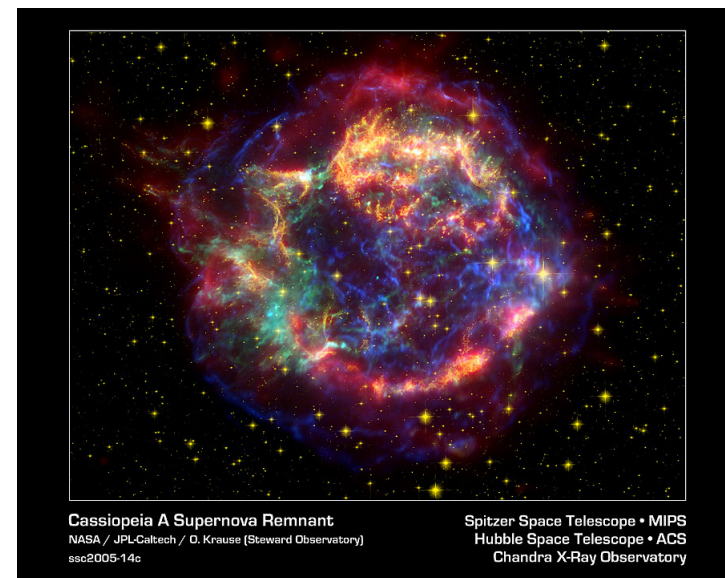
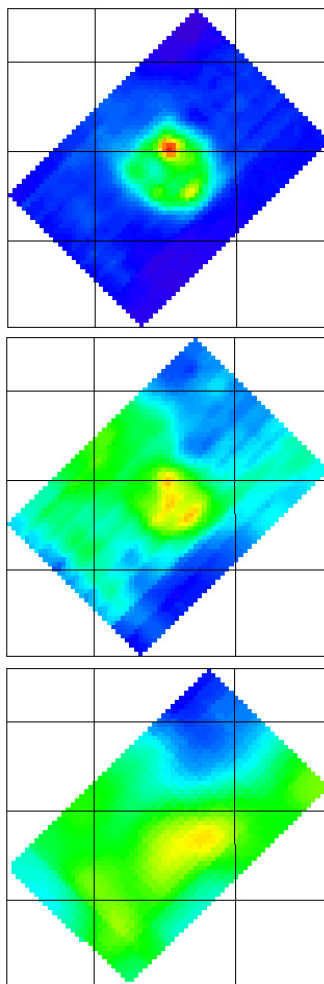


ISOPHOT surface brightness photometry: properties of dust clouds



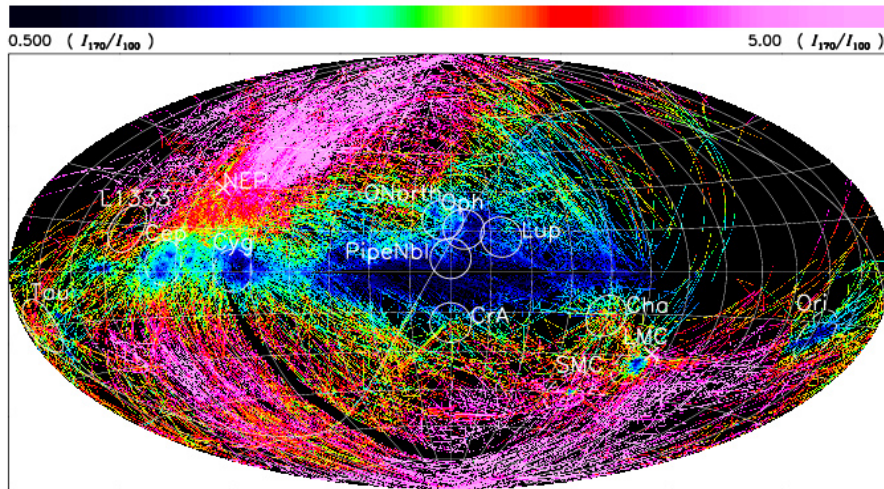
- Disentangling of mixed dust components.
- Multi-filter dust morphology for wide range of surface brightnesses.

Cas A @ 60, 100, 200 μm
(ISOPHOT)

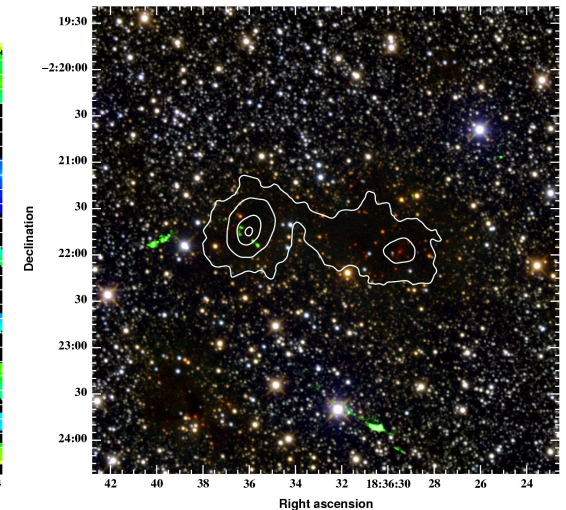
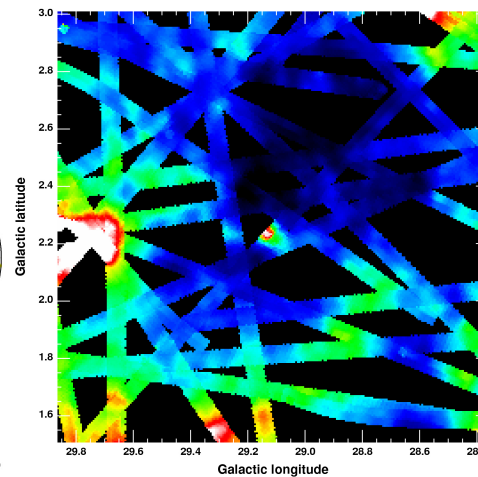
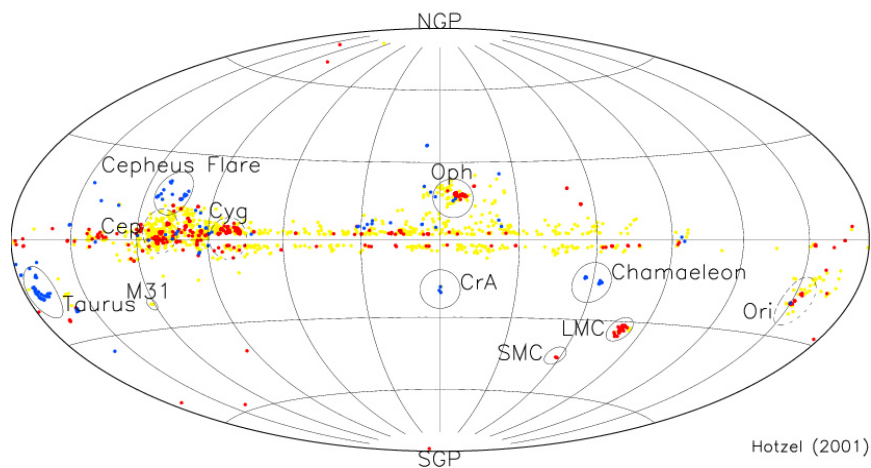
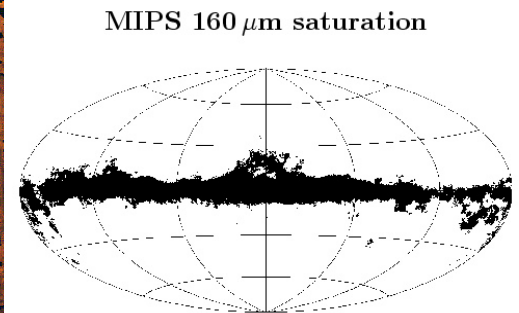
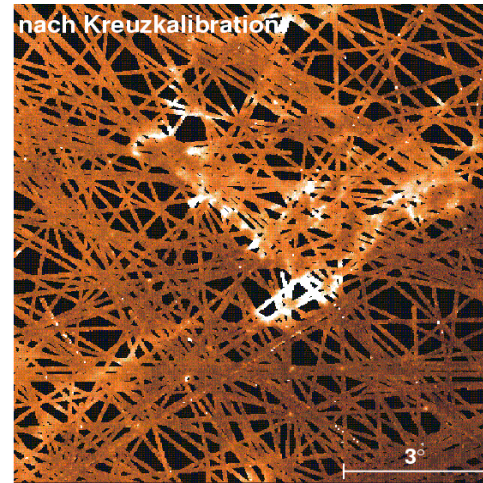


- Contamination of emission by foreground molecular cloud the SNR is embedded into.
- Production of huge amount of dust in SNR type II not confirmed.

ISOPHOT Serendipity Survey: The coldest spots in the Milky Way

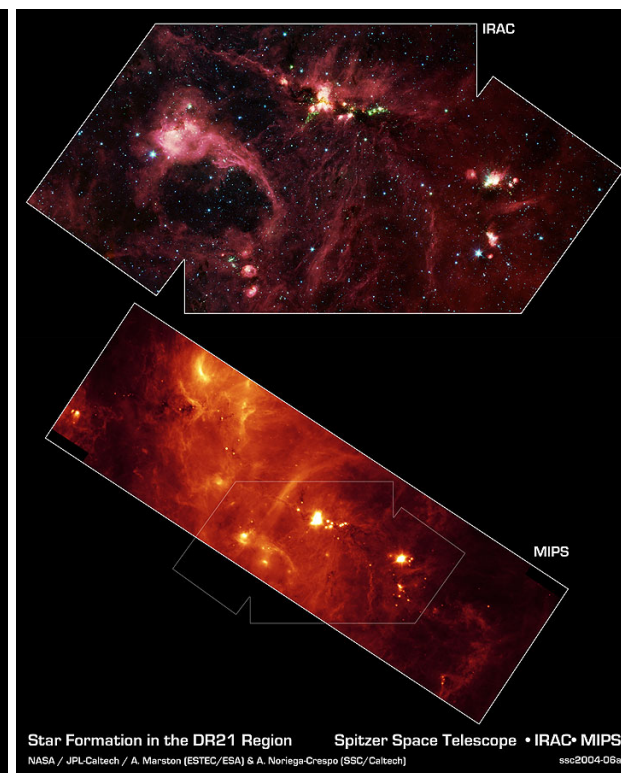
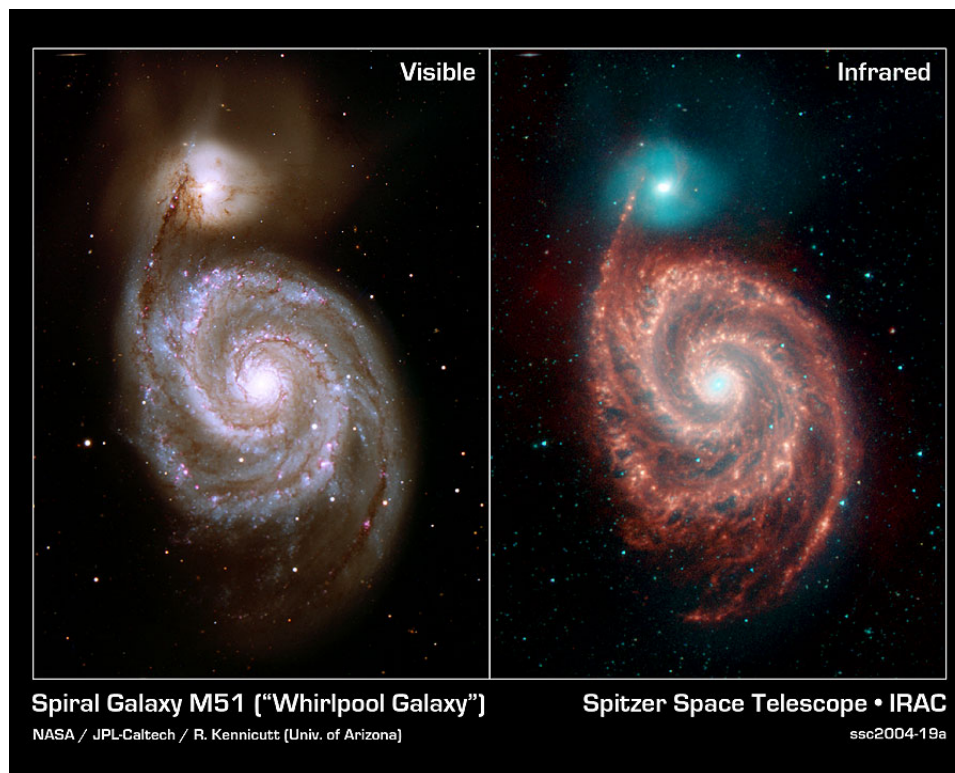
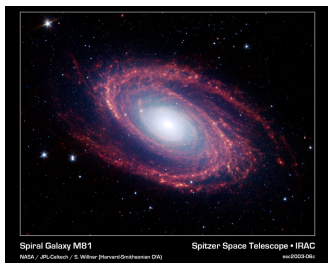
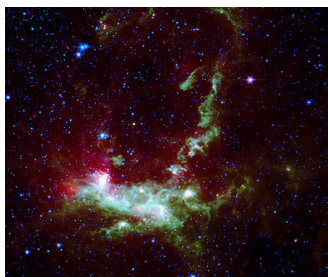


Dusty clouds in the Serendipity Survey



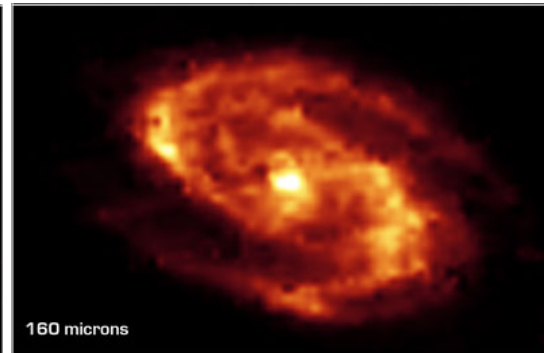
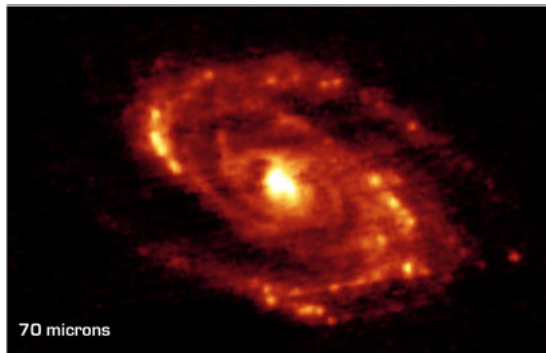
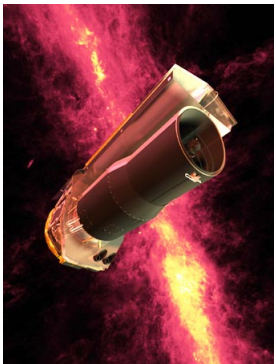
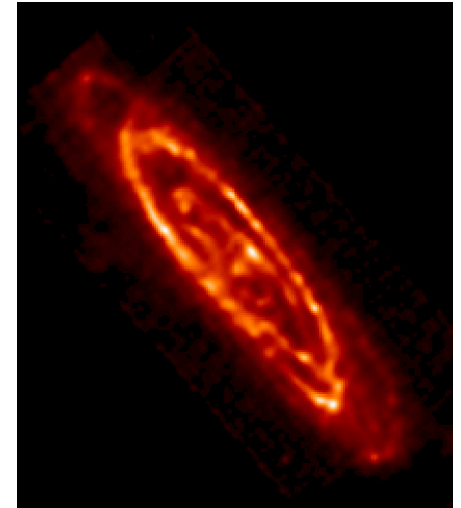
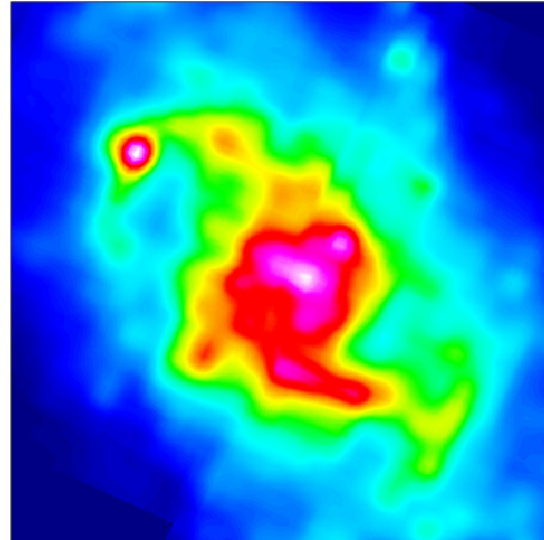
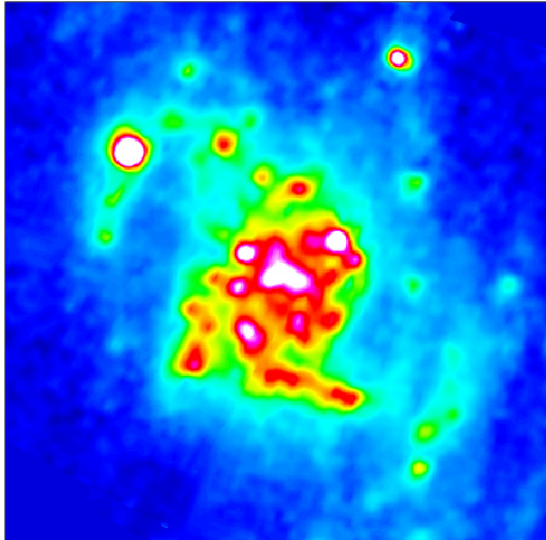
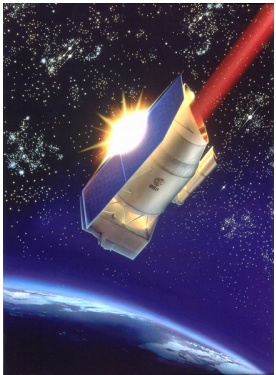
- Color temperature ISOPHOT Serendipity Survey Sky Atlas 170 μm / IRAS 100 μm
- Very early phases of massive star formation

Spitzer MIR mapping capabilities

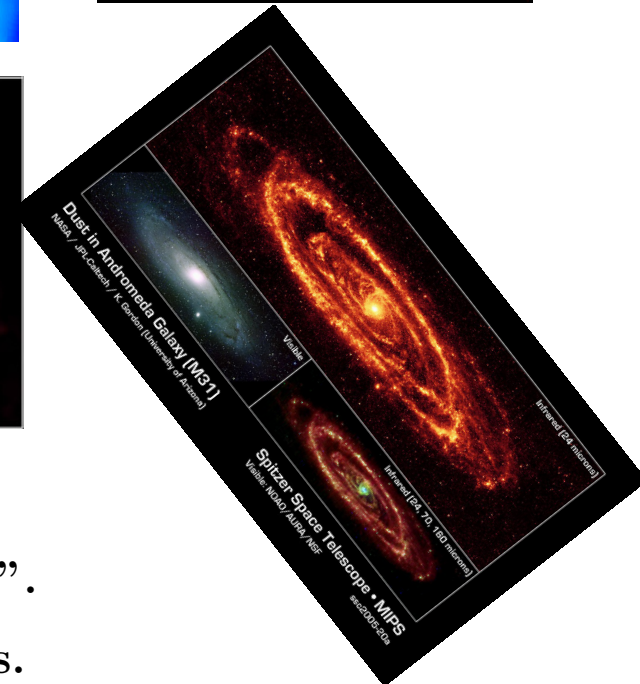


- Superior image quality (resolution, sensitivity) than ISO by IRAC @ 3.6, 4.5, 5.8 and 8 μm ; by MIPS @ 24 μm .

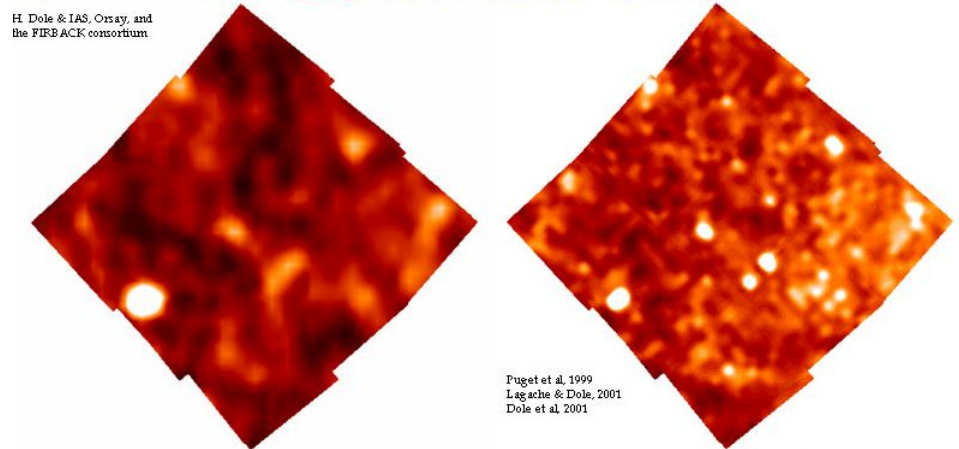
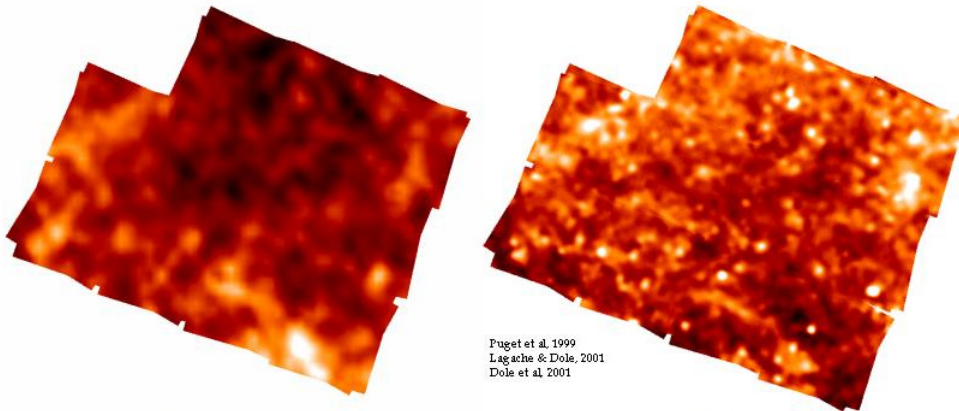
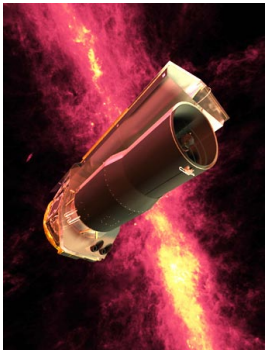
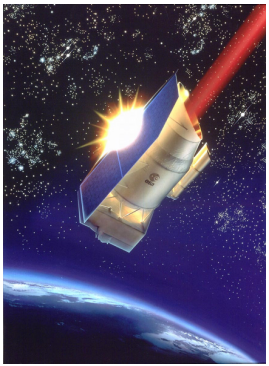
ISOPHOT and Spitzer FIR mapping capabilities (extended sources)



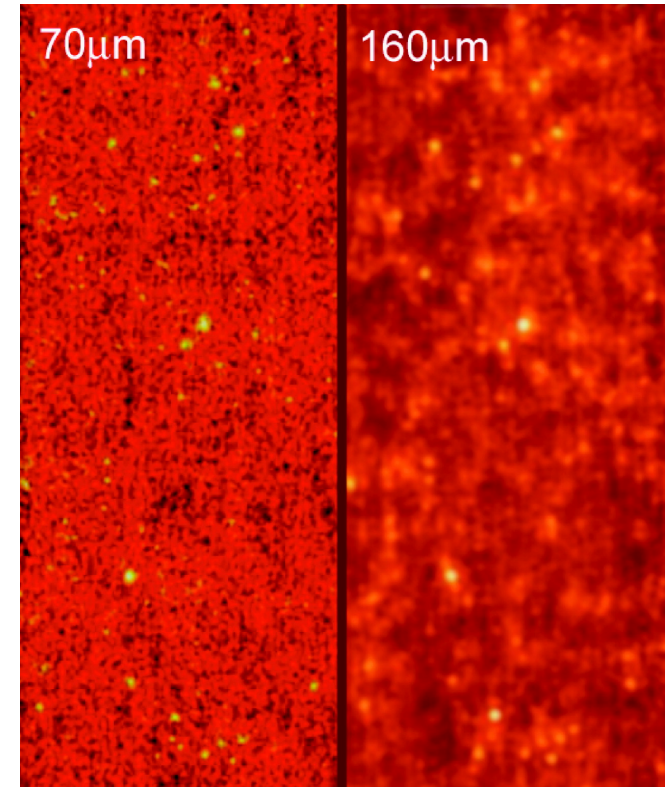
- ISO $D_{\text{tel}} = 0.6 \text{ m}$ – Spitzer $D_{\text{tel}} = 0.85 \text{ m}$.
- PHT pix = $43.5''/89.4''$ – MIPS pix = $9.8''/16''$.
- PHT maps unsaturated for rel. bright regions.



ISOPHOT and Spitzer FIR mapping capabilities (faint sources)

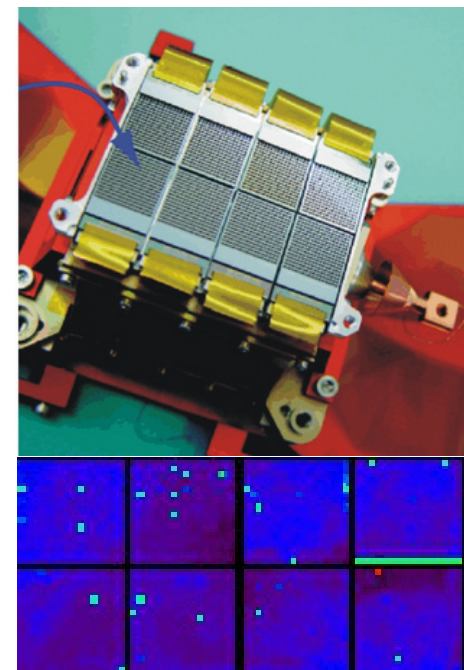
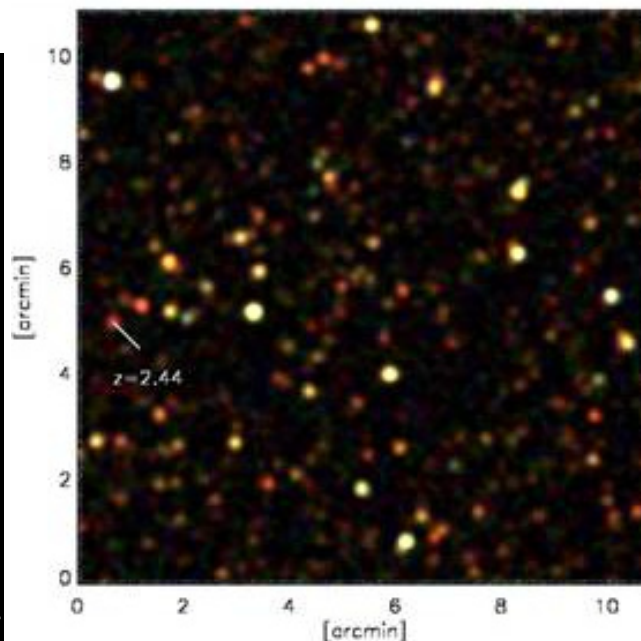
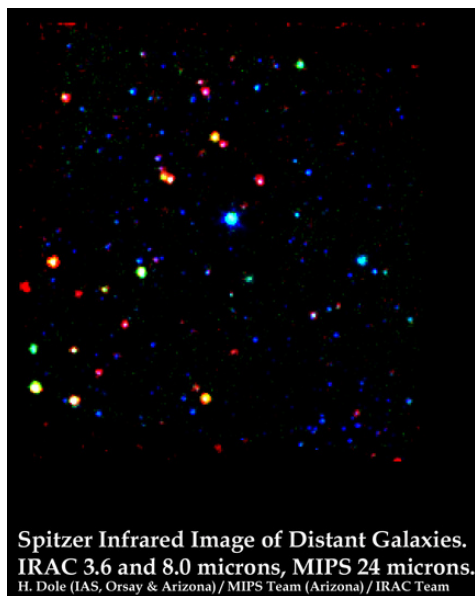
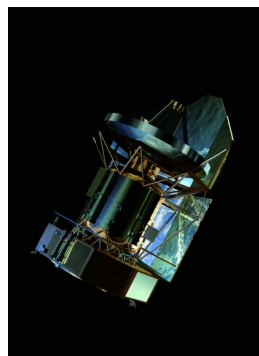


- ISOPHOT sensitivities
(5σ in ≈ 500 s, mini-map raster mode)
90 μm : 70–90 mJy 170 μm : 100–150 mJy



- MIPS sensitivities
(5σ in 500 s)
70 μm default: 7.2 mJy
160 μm : 29 mJy
 40 mJy w/conf

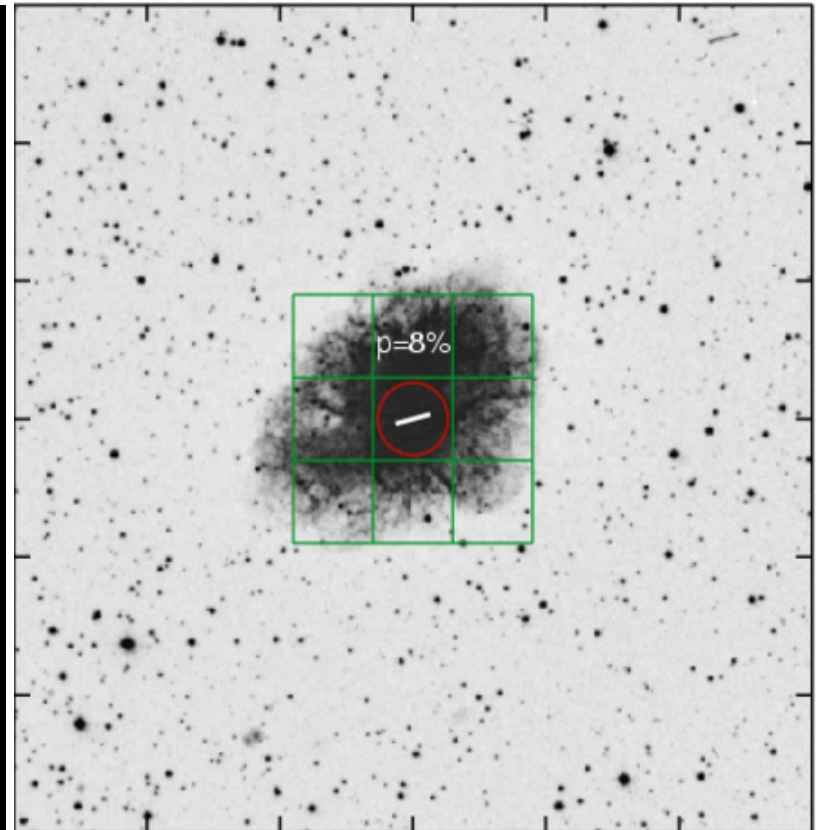
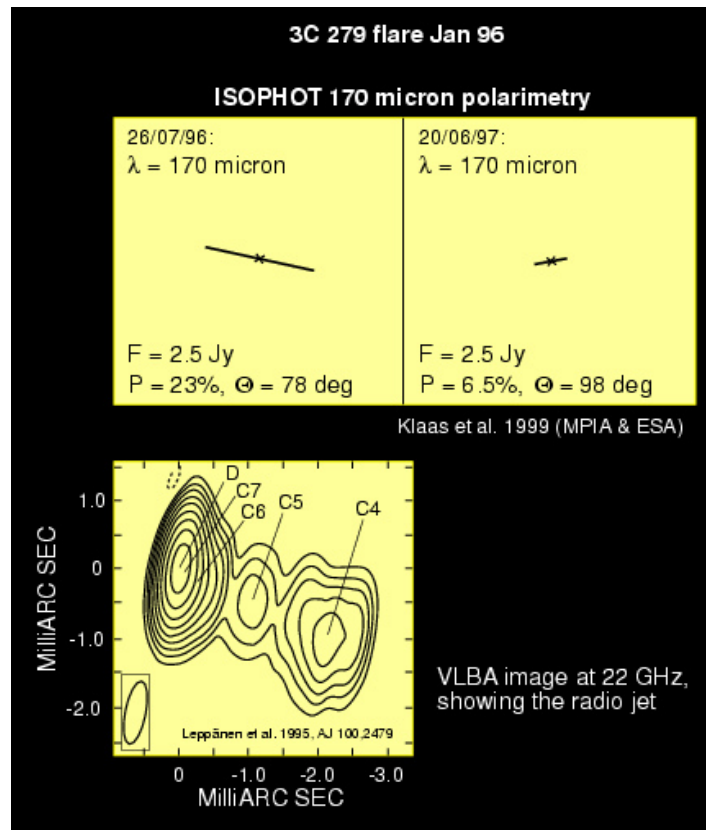
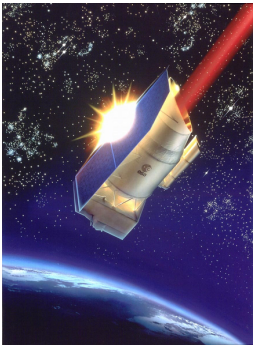
Herschel-PACS: unprecedented spatial resolution & sensitivity @ long λ



- Spatial resolution of Herschel-PACS @100 μm comparable to Spitzer-MIPS resolution @24 μm .
- Passively cooled telescope: not sensitive to faint extended emission due to differential measurement mode.

- Considerably lower confusion noise due to cirrus & high source density.
- Sensitivity limits (5σ in 1 h): 2–3 mJy

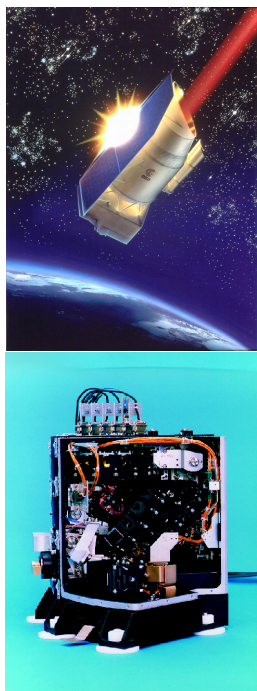
ISOPHOT unique data sets: FIR polarimetry



- High and variable polarisation of quasar after flare.
- Polarimetry of Crab Nebula (and its pulsar?).
- Polarimetry of star formation clouds – the role of magnetic fields.

Conclusions: The Role of ISOPHOT Data

- Valuable ISOPHOT FIR data products
 - Multi-filter photometry/maps:
accurate dust property characterisation & establishment of templates.
 - Catalogs with accurate photometry:
celestial standards & variability assessment.
 - Absolute surface brightness maps (extended emission)
down to a resolution (FWHM) of $40''$ ($60\ \mu\text{m}$) – $80''$ ($200\ \mu\text{m}$)
from faint emission ($10\ \text{MJy sr}^{-1}$, EBL)
to brightest star formation regions ($>1000\ \text{MJy sr}^{-1}$, Orion).
 - ISOPHOT Serendipity Survey ($170\ \mu\text{m}$).
 - Unique data sets like ISOPHOT FIR polarimetry.
 - Spectroscopy of dust features ($R = 90$)
 $2.5\ \mu\text{m} - 4.8\ \mu\text{m}$ and $5.8\ \mu\text{m} - 11.6\ \mu\text{m}$.



⇒ many ISOPHOT data have their value in the line of
FIR space observatory data products “from yesterday to tomorrow”,
also thanks to excellent contributions by the Konkoly/KISAG group.