Extended dust emission around nearby Asymptotic Giant Branch stars

Thavisha Dharmawardena (ASIAA), Ciska Kemper (ASIAA)
Sundar Srinivasan(ASIAA), Peter Scicluna(ASIAA),
Alfonso Trejo-Cruz(ASIAA), Jan Wouterloot(EAO),
Albert Zijlstra(University of Manchester), Jan Cami(UWO)

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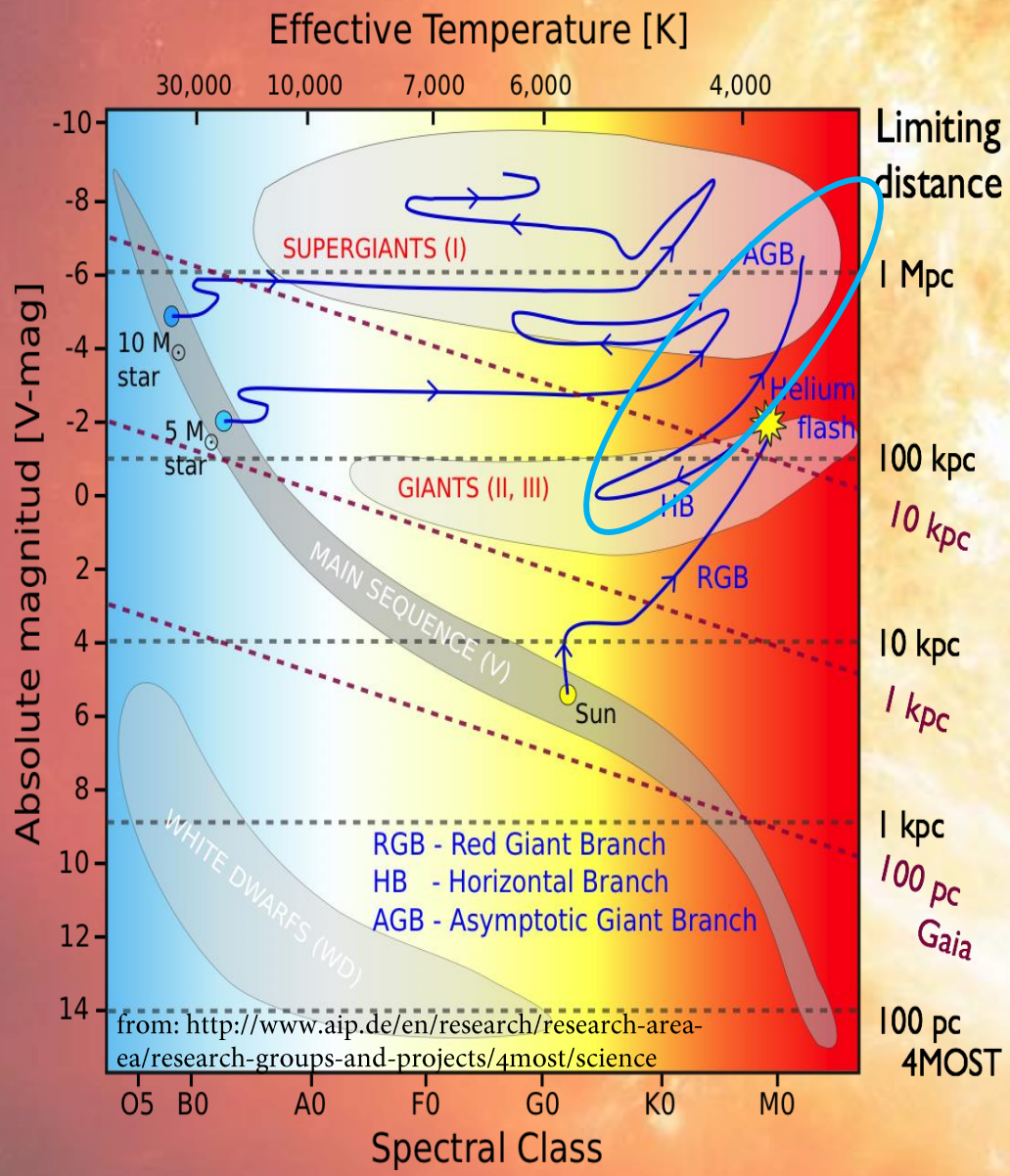
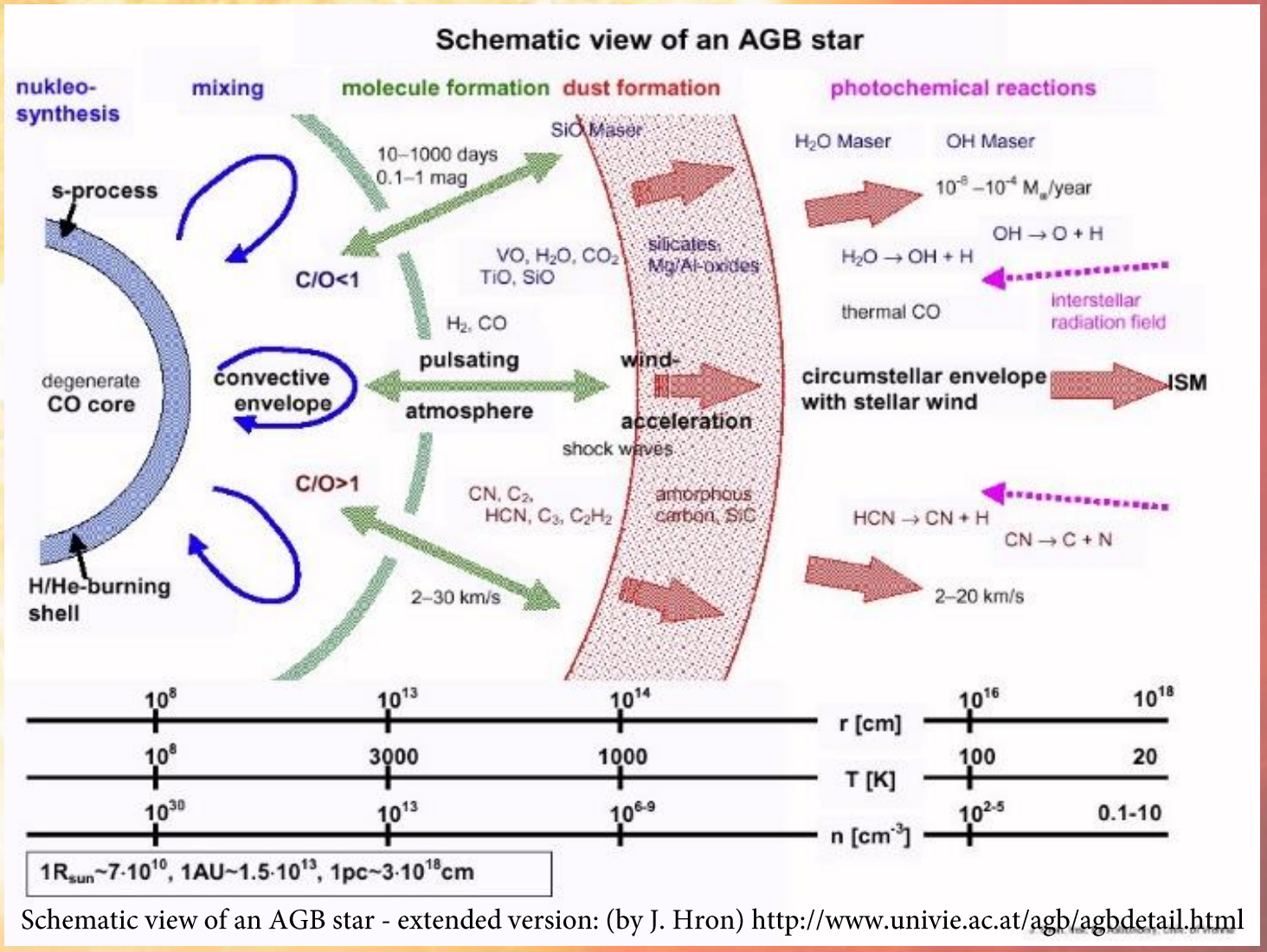
Asymptotic Giant Branch (AGB) Stars

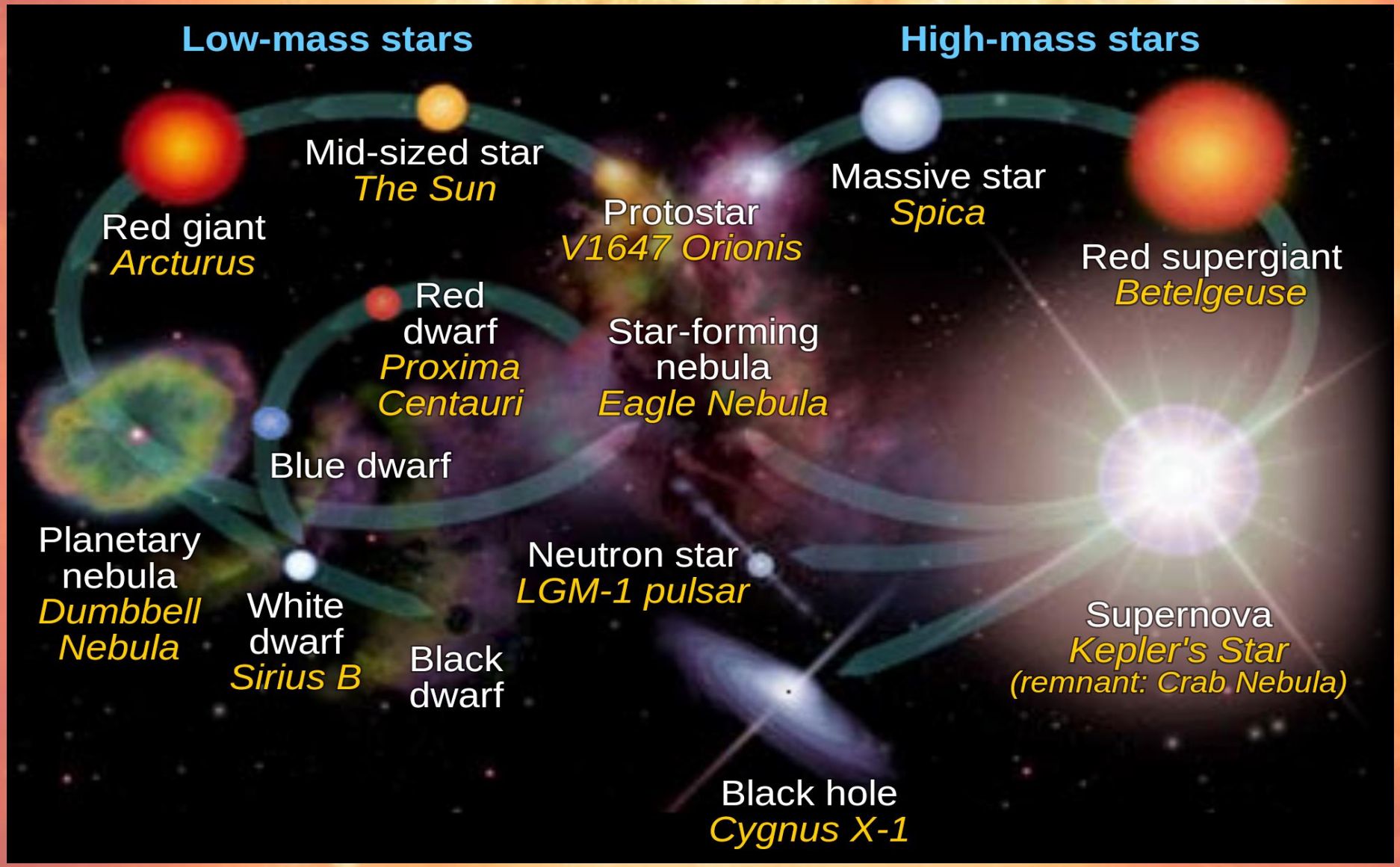


from: http://www.aip.de/en/research/research-area-ea/research-groups-and-projects/4most/science



Schematic view of an AGB star - extended version: (by J. Hron) http://www.univie.ac.at/agb/agbdetail.html

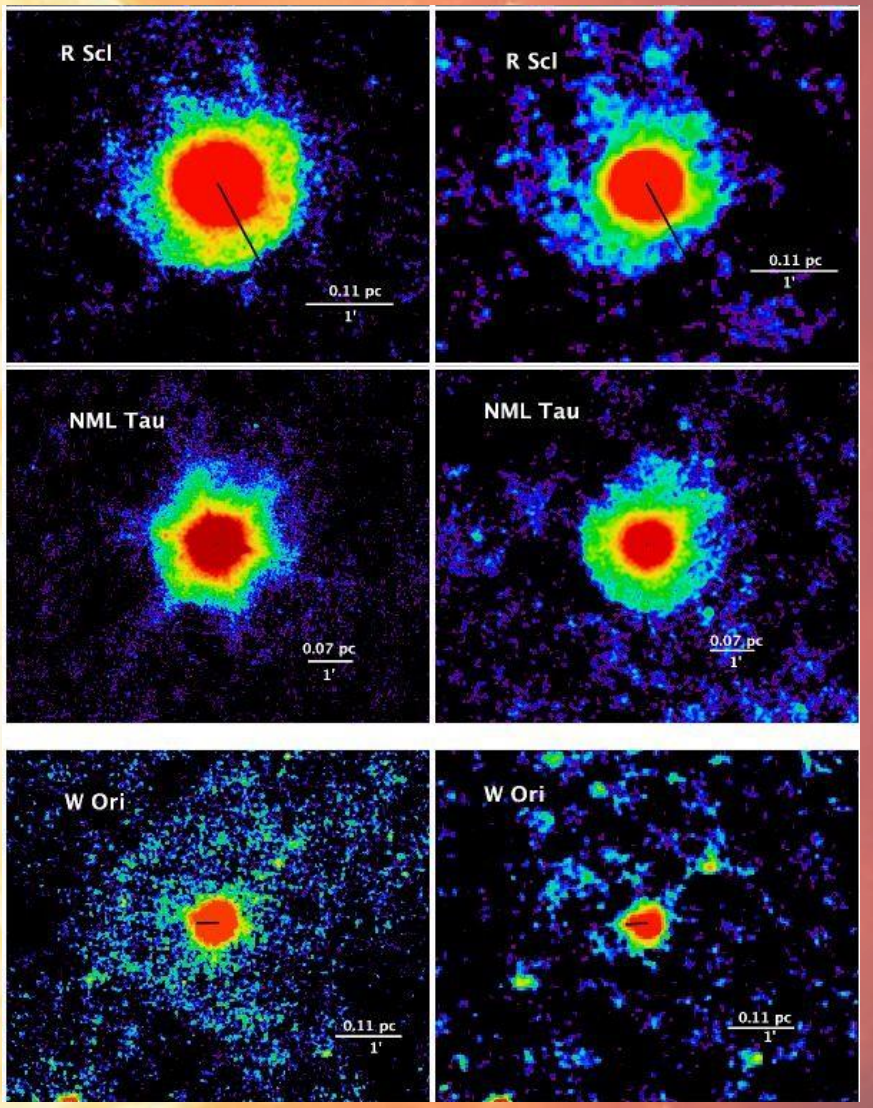
What makes AGB stars and their winds important to Galaxies?



http://imagine.gsfc.nasa.gov/teachers/lessons/xray_spectra/images/life_cycles.jpg by NASA's Goddard Space Flight Center.

Long overdue need for a study of nearby AGB stars

- The Herschel Mass-loss of Evolved StarS (MESS) survey - extended emission of nearby AGB stars - radii ~1´-2´ at 70 μm and 160 μm (Cox et al., 2012) using PACS.
- Most sub-mm observations of AGB stars - limited to central position pointings - lack spatial information.
- JCMT can overcome this - low resolution large scale maps.
- SCUBA2: Study thermal dust component of the stellar winds.
  850 μm beam size – 13″
  450 μm beam size – 7.9″
- Combined with PACS maps - derive dust mass loss histories.



Herchel MESS observations. Left: PACS 70 μm, Right: PACS 160 μm (right). Cox et al., 2012.

Target selection for JCMT – SCUBA2 observations

- Observed in MESS survey
- Relatively nearby sources (within 500 pc)
- Spatially resolved - study dust mass loss and circumstellar envelope structure
- Strong CO lines

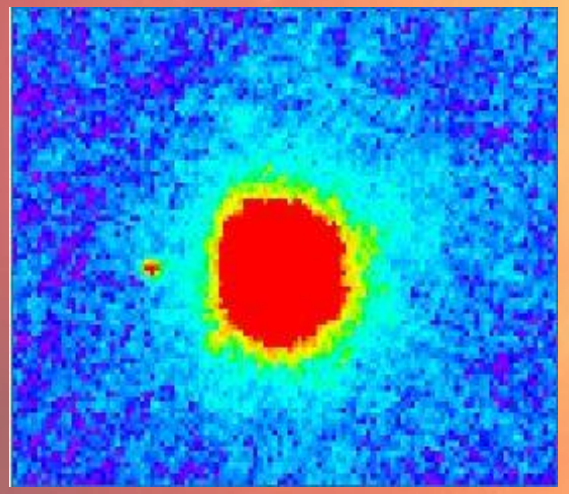
15 sources

- C – rich: 4
- O – rich: 9
- S-type: 1 (W Aql)
- RSG: 1 (NML Cyg)

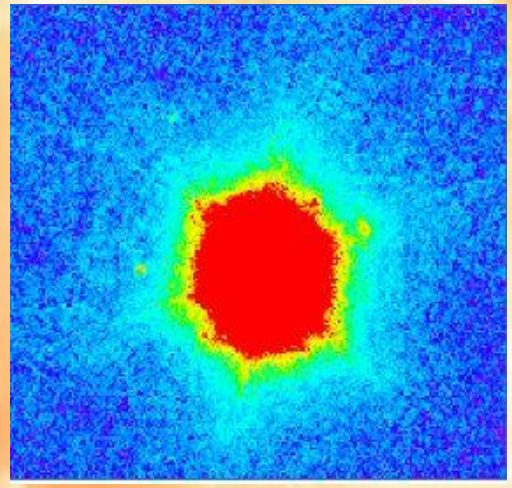
Thermal dust mass loss rates

- MESS survey maps using PACS at 70 μm and 160 μm.
- SCUBA2 thermal dust emission maps at 450 μm and 850 μm.

CIT 6



PACS 70μm
(1pix = 1.6 arcsec)



PACS 160μm
(1pix = 3.2 arcsec)

Thermal dust mass loss

- MESS survey maps using PACS at 70 μm and 160 μm.
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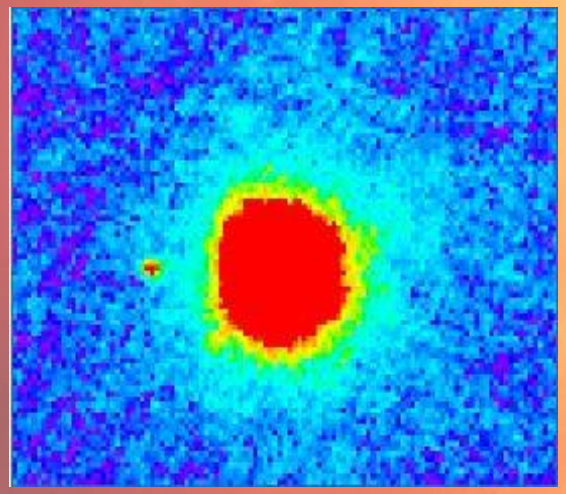
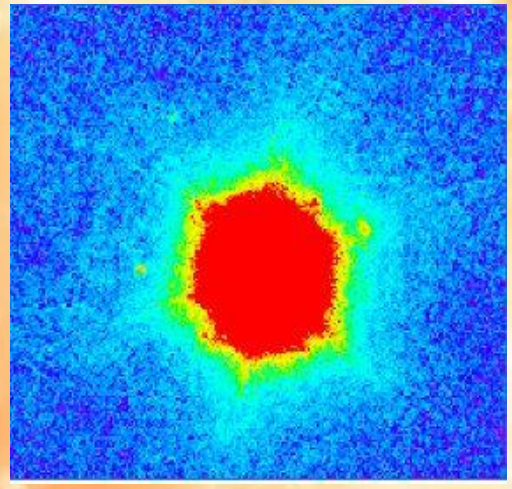
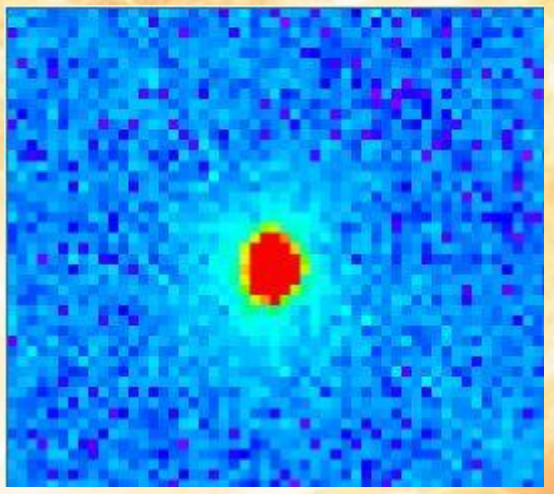
CIT 6



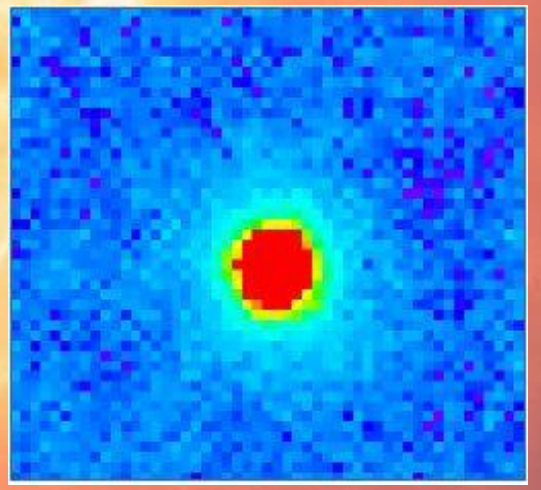
PACS 70μm
(1pix = 1.6 arcsec)



PACS 160μm
(1pix = 3.2 arcsec)

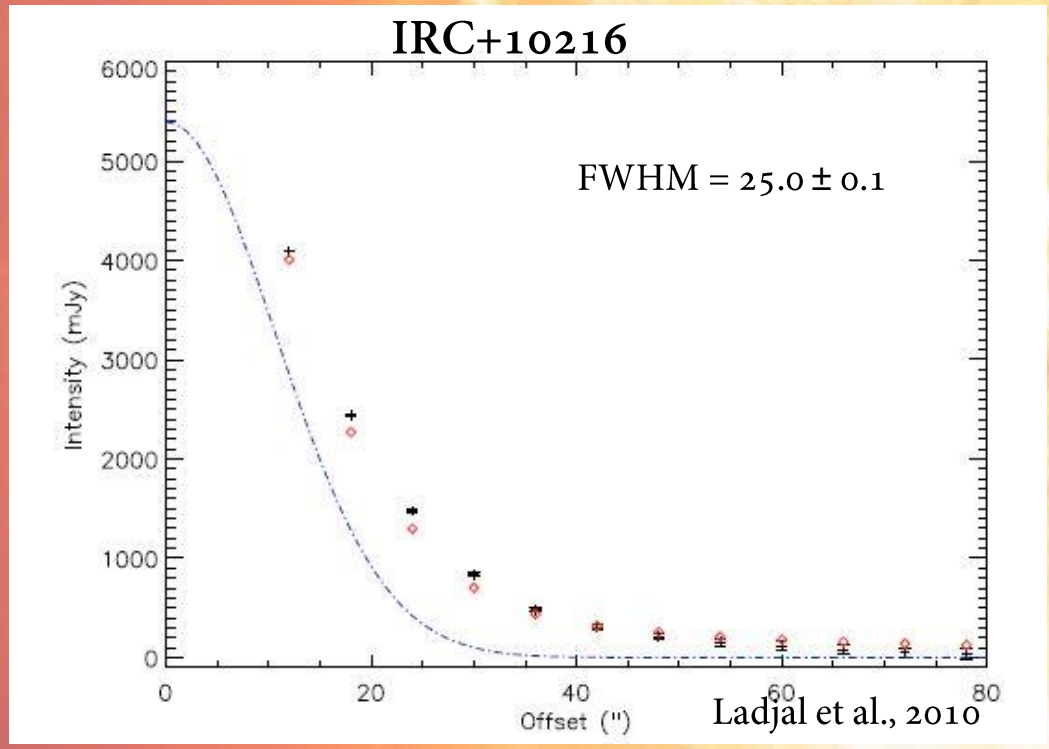


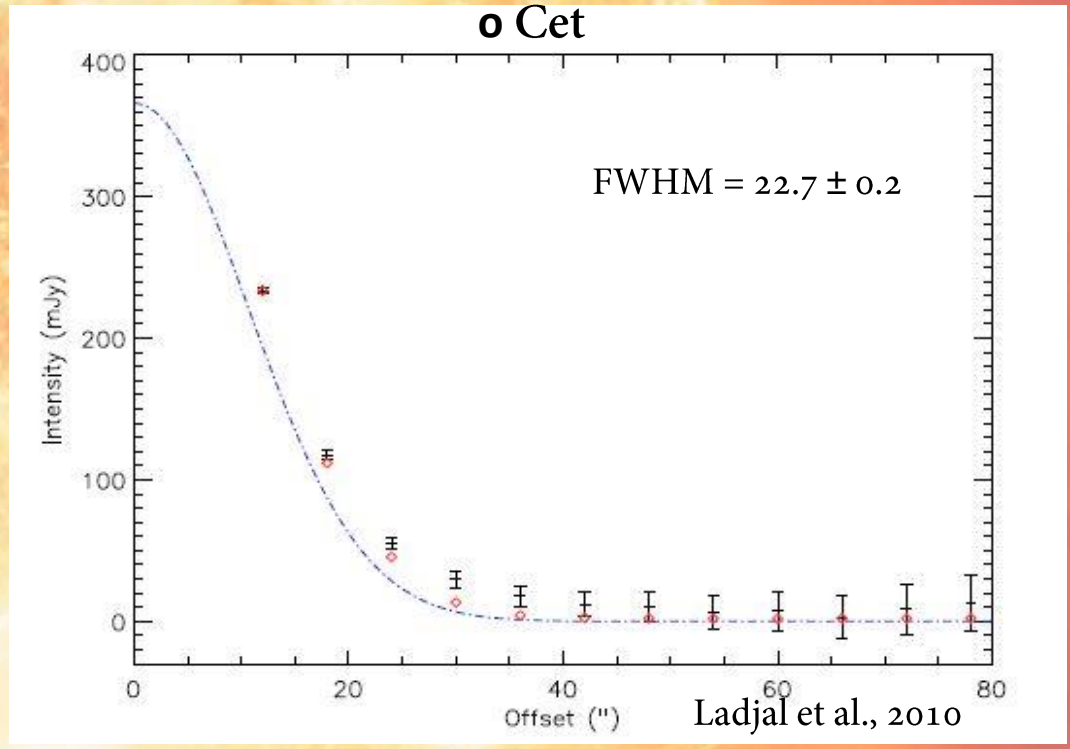
SCUBA2 450 μm
(1pix = 2 arcsec)



SCUBA2 850 μm
(1pix = 4 arcsec)

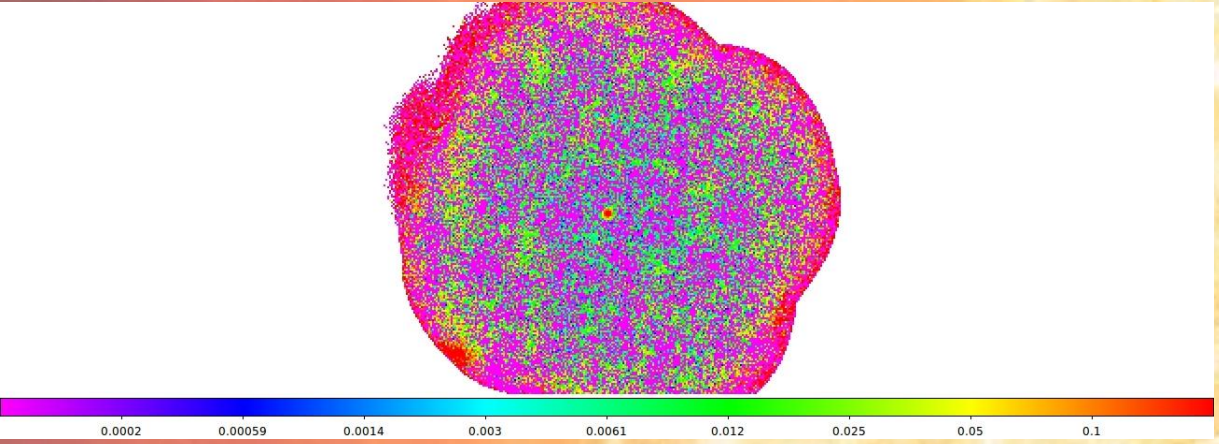
- APEX - LABOCA observations at 870 μm of several southern AGB stars showed extended emissions up to FWHM of ~20″-25″ (Ladjal et al., 2010).
- Similar wavelengths to SCUBA2 – good comparison.



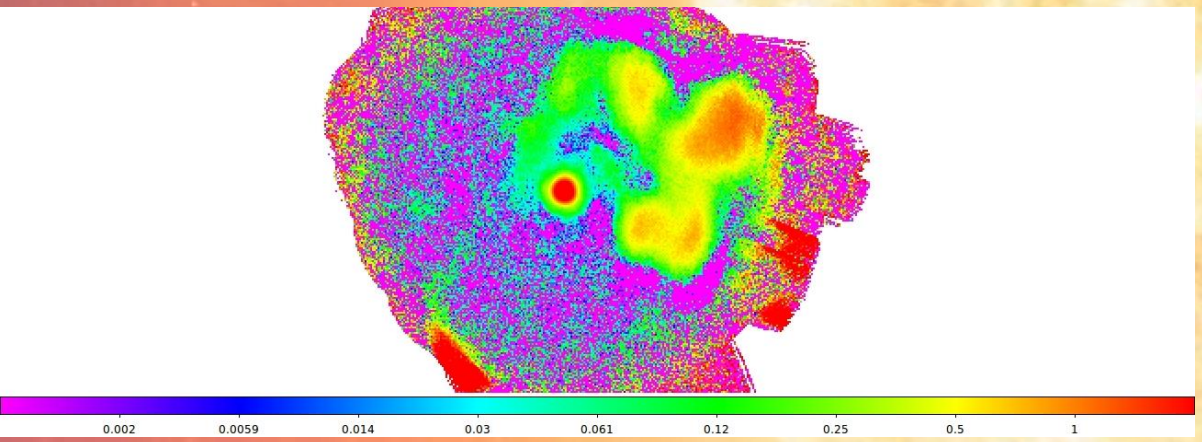


- Look deeper into the SCUBA2 observations.
- Generate radial profiles of surface brightness vs. radius at each wavelength for the SCUBA2 and PACS observations.

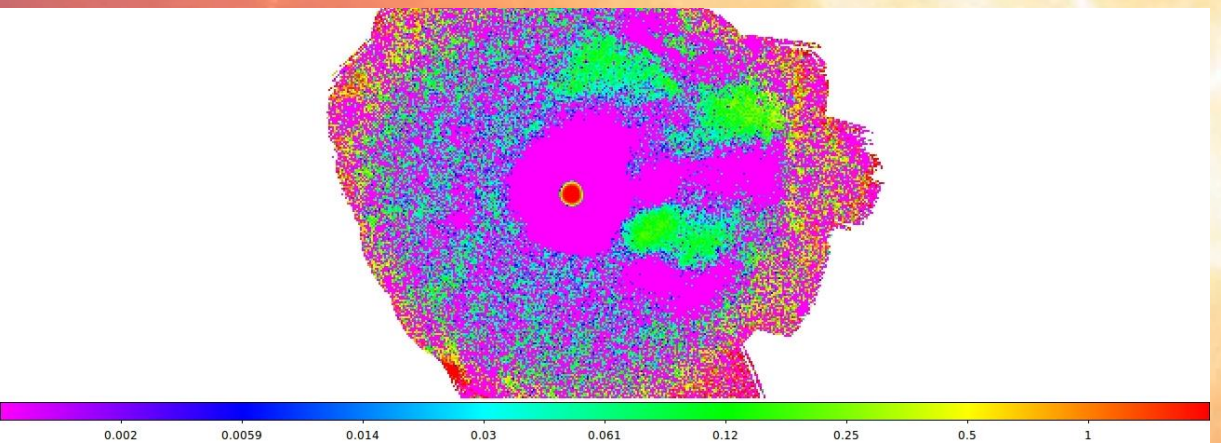
SCUBA-2 Data Reduction



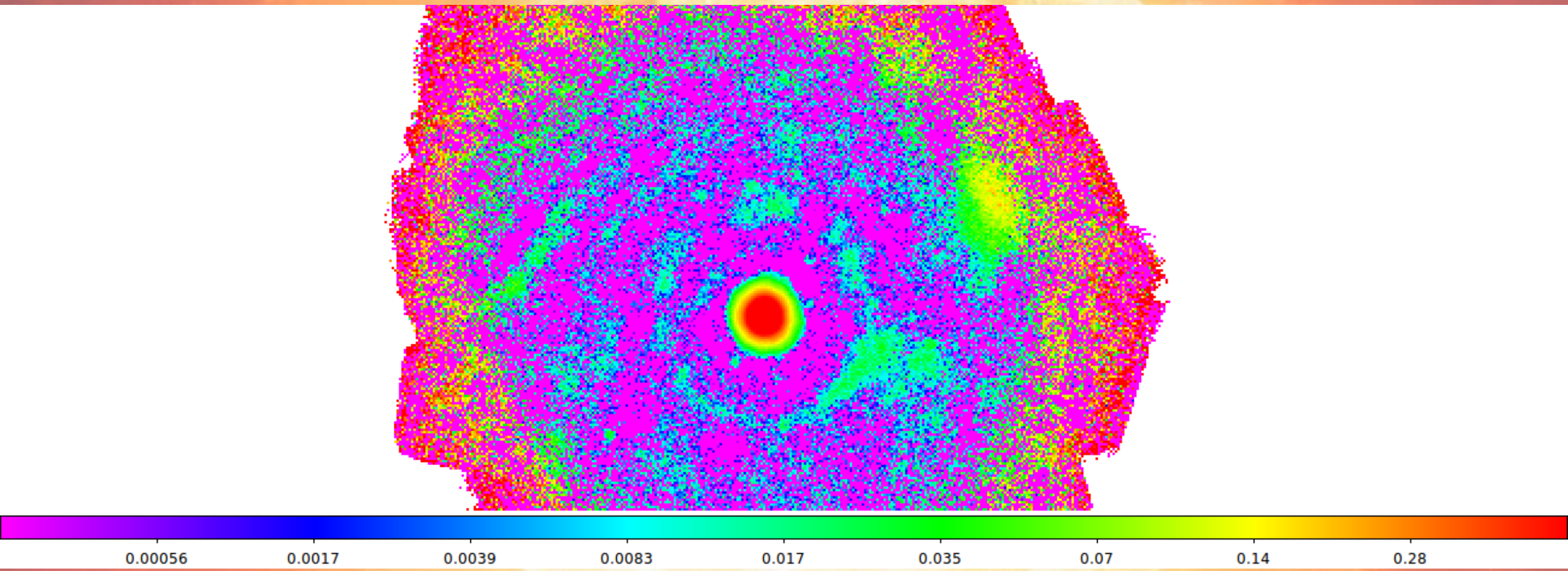
U Hya
SCUBA-2 850
(1pix = 4”)
Extended Source pipeline - dimmconfig_bright_extended



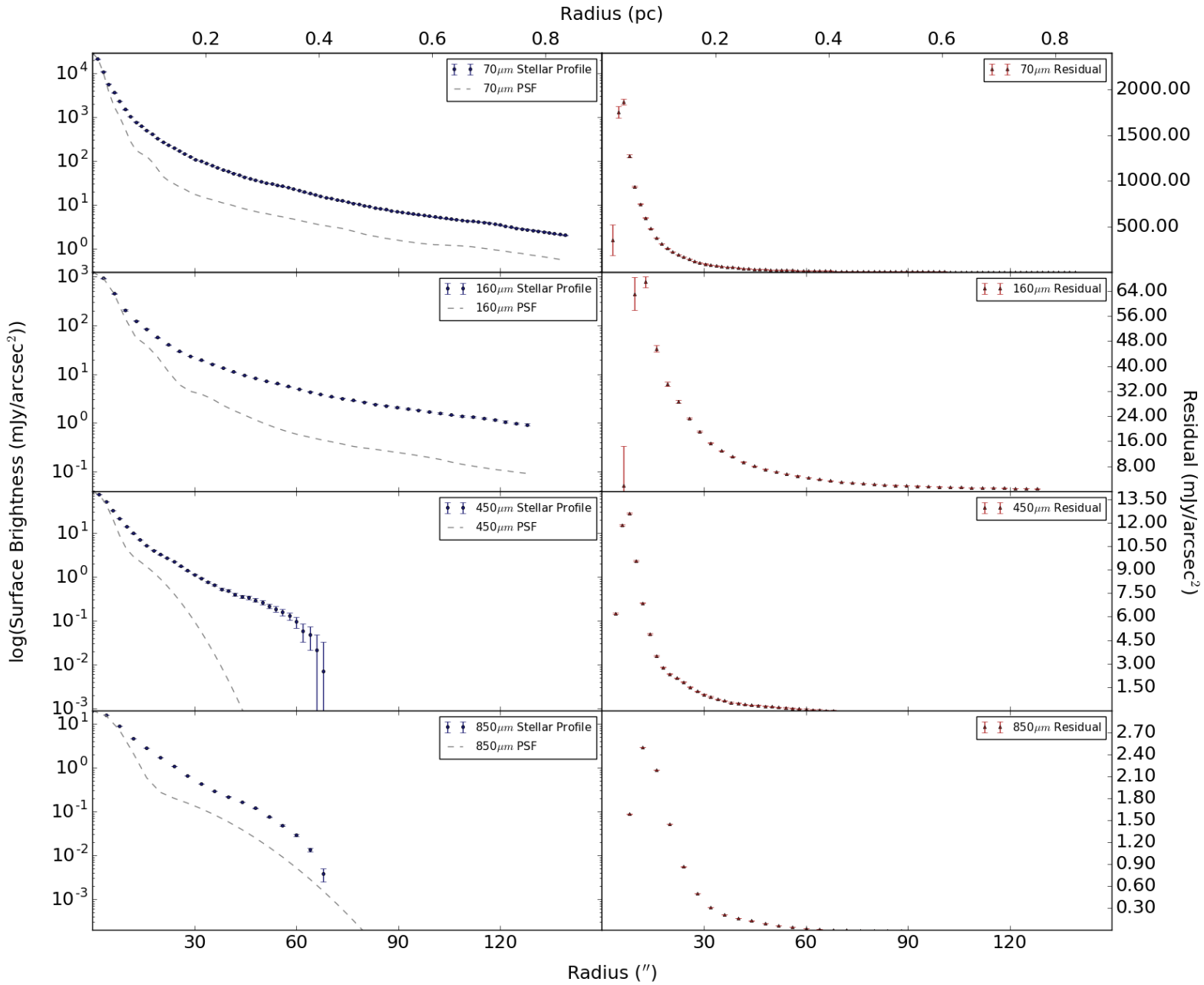
IRC+10216
SCUBA-2 850 Scan Maps
(1pix = 4”)
Extended Source pipeline - dimmconfig_bright_extended



IRC+10216
SCUBA-2 850 Scan Maps
(1pix = 4”)
Isolated Source pipeline - dimmconfig_bright_compact - ast.zero_circle = 2’



IRC+10216
SCUBA-2 850 Scan Maps
(1pix = 4”)
Isolated Source pipeline -
dimmconfig_bright_compact
- ast.zero_circle = 1.5’



IRC+10216

PACS 70

Extension at 3σ detection – 284.8″
Total Flux – (3482.2 ± 2.7) Jy
Extended Region Flux – (1990 ± 21.7) Jy
(~57% of the Total Flux)

PACS 160

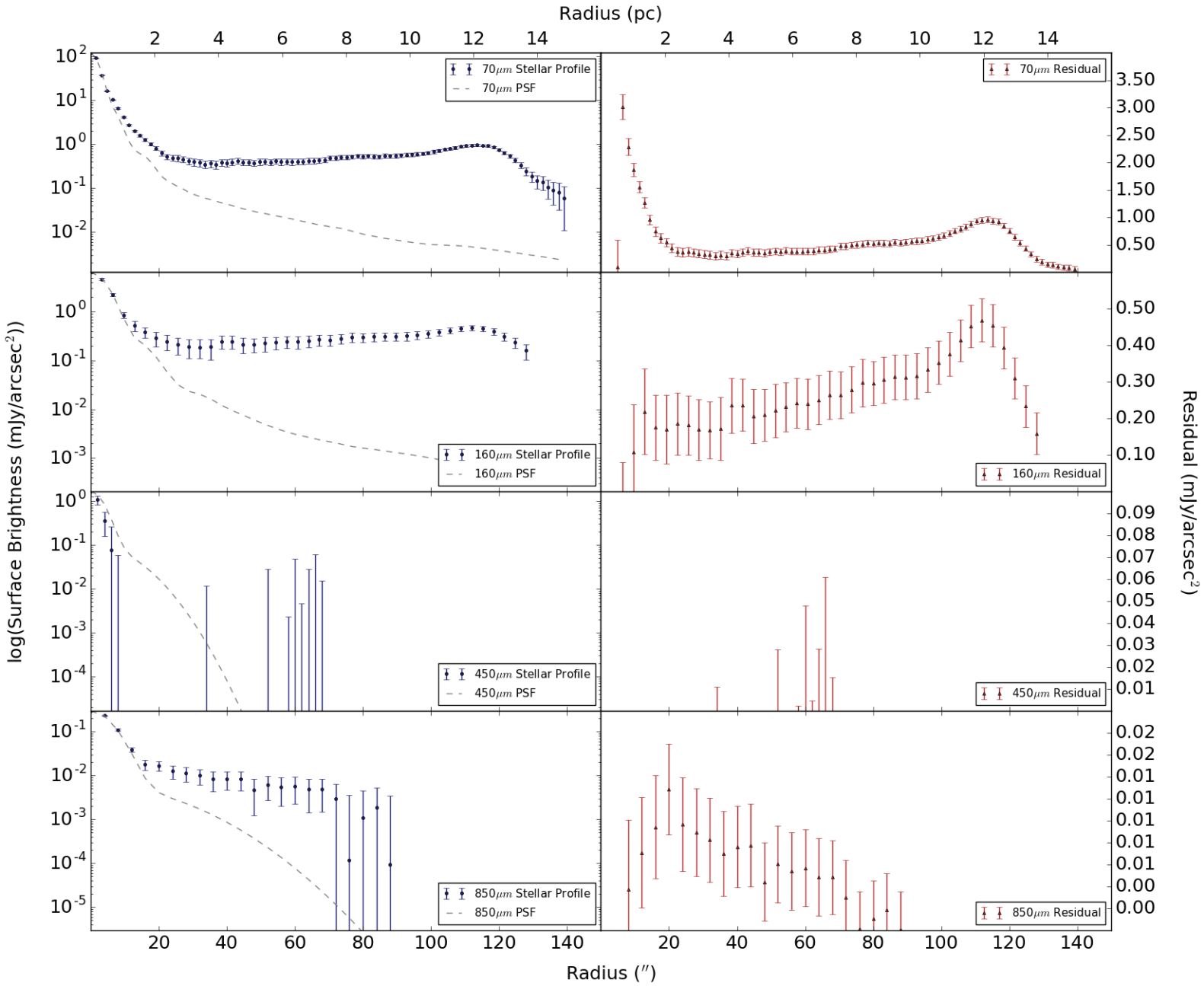
Extension at 3σ detection – 265.6″
Total Flux – (555.6 ± 0.45) Jy
Extended Region Flux – (329.1 ± 8.3) Jy
(~59% of the Total Flux)

SCUBA-2 450

-Scan + Pointing (~ 50 hrs)
Extension at 3σ detection – 60.0″
Total Flux – (25.2 ± 0.3) Jy
Extended Region Flux – (25.2 ± 0.03) Jy
(~64% of the Total Flux)

SCUBA-2 850

-Scan + Pointing (~ 50 hrs)
Extension at 3σ detection – 64.0″
Total Flux – (10.8 ± 0.003) Jy
Extended Region Flux –(6.06 ± 0.002) Jy
(~56% of the Total Flux)



U Hya

PACS 70
Extension at 3σ detection – 129.6″
Total Flux – (37.1 ± 0.1) Jy
Extended Region Flux – (30.0 ± 0.2) Jy
(83~% of the Total Flux)

PACS 160
Extension at 3σ detection – 124.8″
Total Flux – (15.2 ± 0.07) Jy
Extended Region Flux – (14.0 ± 0.2) Jy
(92~% of the Total Flux)

SCUBA-2 450
- Scan Maps ~ 2.5 hrs
Extension at 3σ detection –4.0″ (No ext)

SCUBA-2 850
- Scan Maps ~ 2.5 hrs
Extension at 3σ detection – 20″
Total Flux – (84.8 ± 2.2) Jy
Extended Region Flux – (23.6 ± 3.11) mJy
(30~% of the Total Flux)

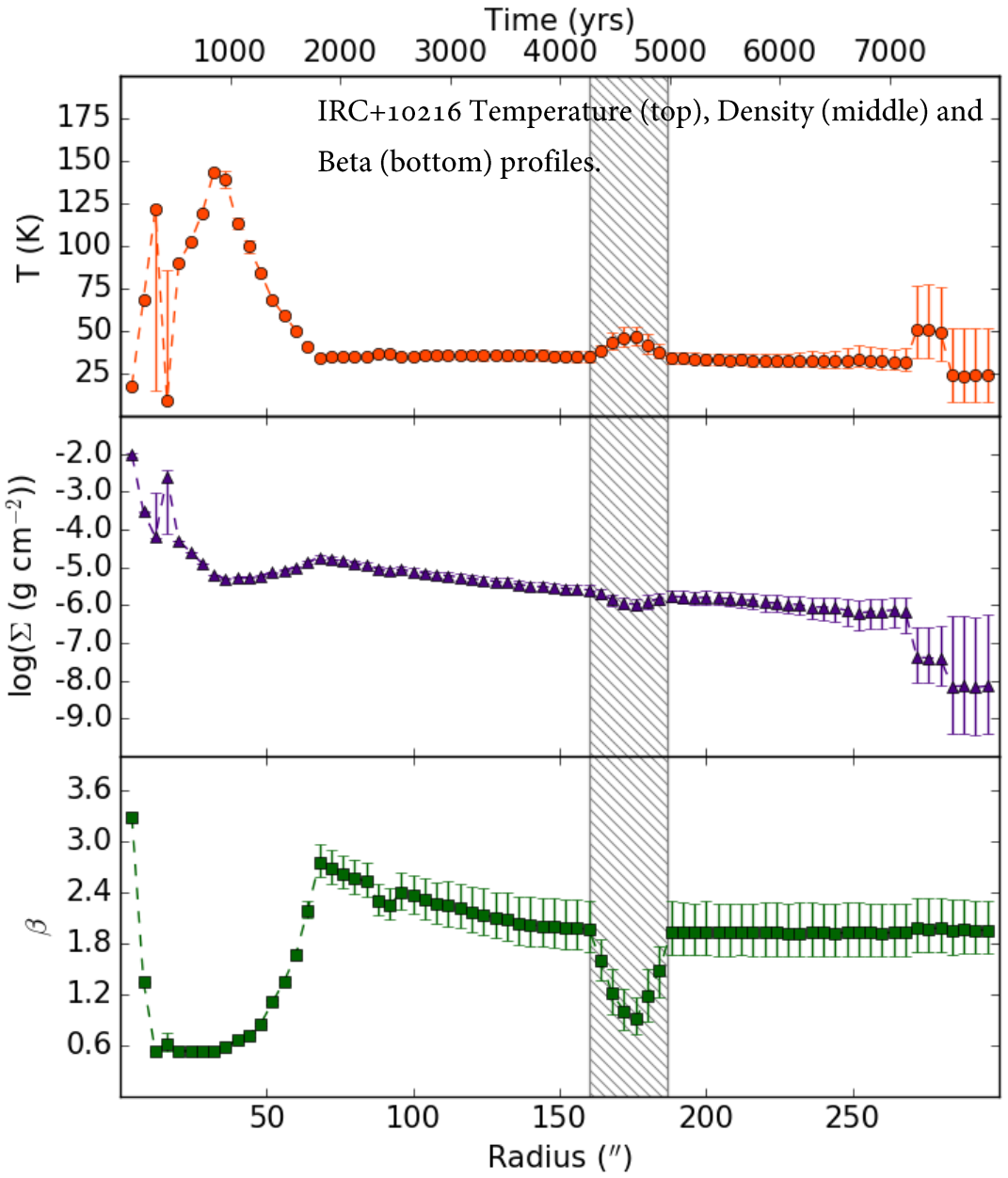
- Fit PACS/SCUBA2 data at each radial point with modified blackbody using *emcee* (Foreman-Mackey et al., 2012).
- Radially dependent Dust Temperature (T_{dust}), Spectral Index of the Dust Emissivity (β) and the Dust Column Densities (ρ_{dust}) profiles (Gordon et al., 2010 methods).
- Probe the dust mass-loss history, and detect any changes in physical properties of dust as a function radius (hence time).

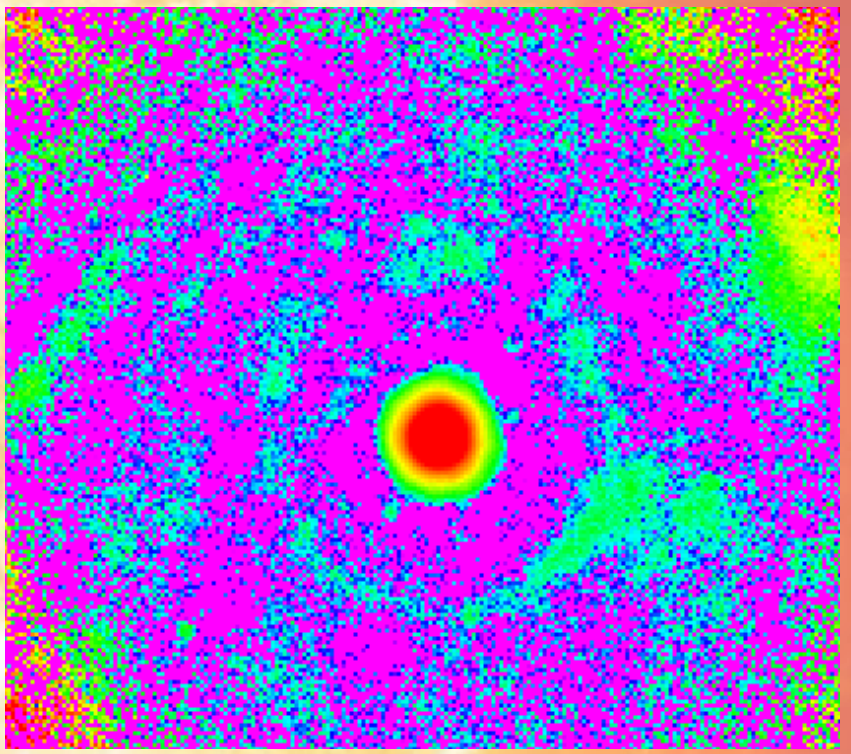
$$F_\nu \propto \lambda^{-\beta} B_\nu(T_{\rm dust}).$$

Modified black body. (Gordon et al., 2010)

$$M_{\rm dust} = \frac{4}{3} \frac{a\rho d^2}{Q_{\rm em}(160)} \frac{F_{160}}{B_\nu(T_{\rm dust})}$$

Dust Mass (a – grain radius). (Gordon et al., 2010)

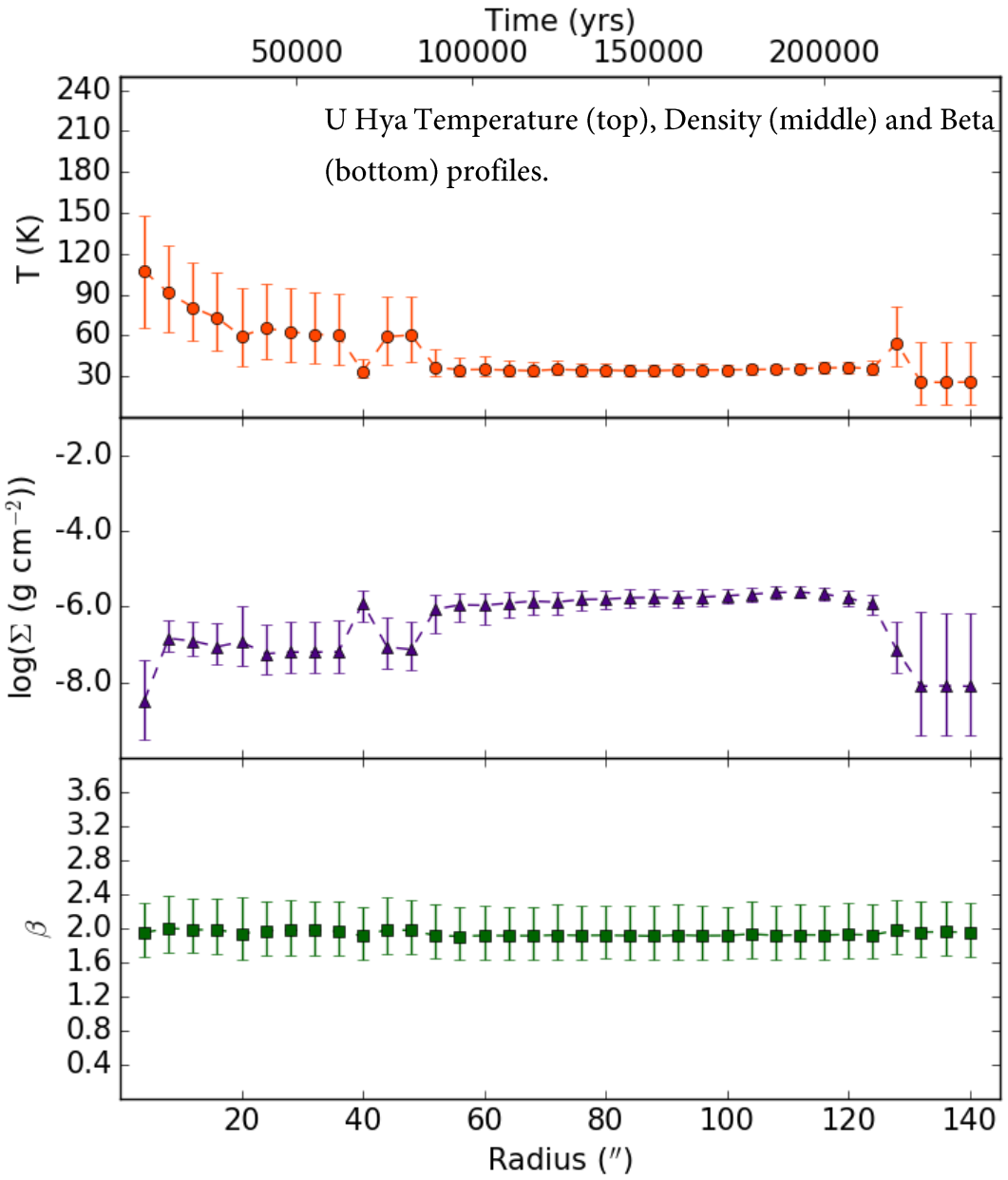




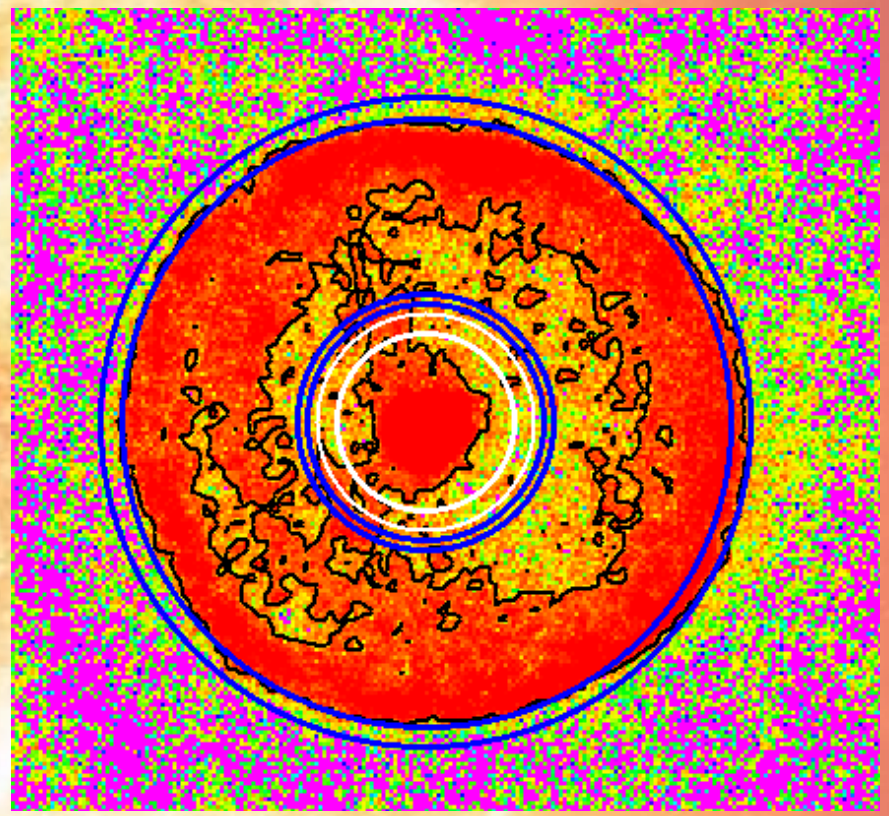
IRC+10216 Beam
SCUBA-2 850 Scan Maps
(1pix = 4”)

Total Dust Mass: 7.06 x 10^{-4} solar masses

Dust:Gas ratio: 0.07 (accepted standard value = 0.01)



U Hya Temperature (top), Density (middle) and Beta (bottom) profiles.



U Hya Detached Shell
PACS 70
(1pix = 1.6”)

Total Dust Mass: 6.96 x 10^{-2} solar masses

Dust:Gas ratio: 6.94

Further Studies

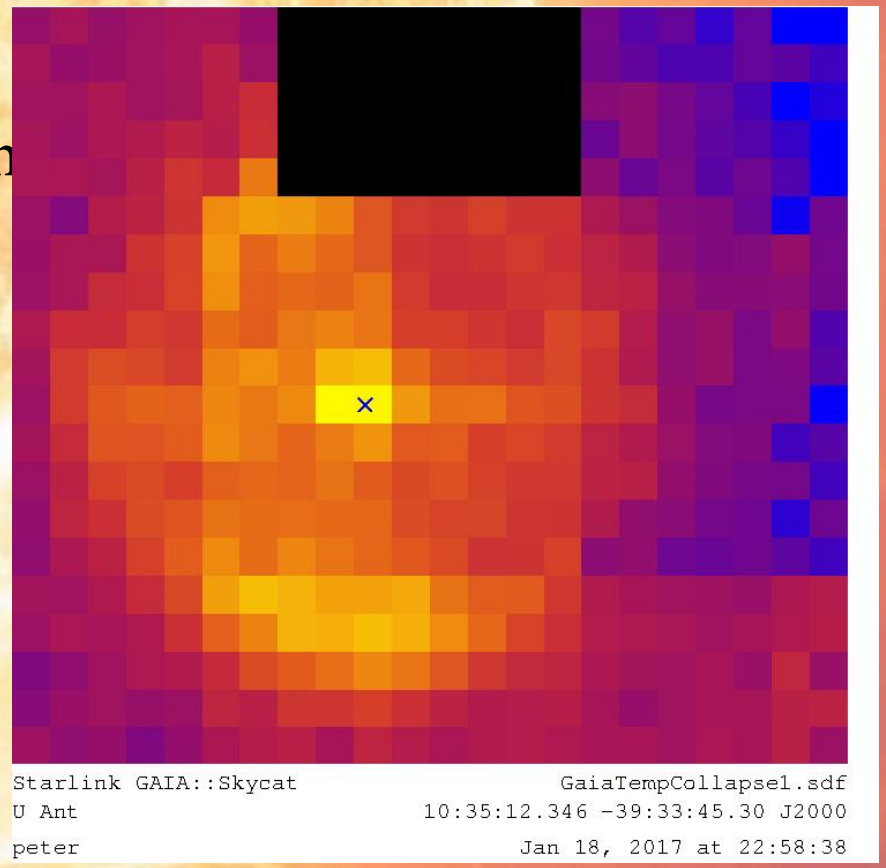
1) HARP CO 3-2 observations – Gas mass loss rates

2) The Nearby Evolved Star Survey – NESS

- Extend this study to a volume limited (300 pc) sam

- Multi telescope data

JCMT – SCUB2 and HARP - S17A + 17BL
APEX
SMA
ALMA

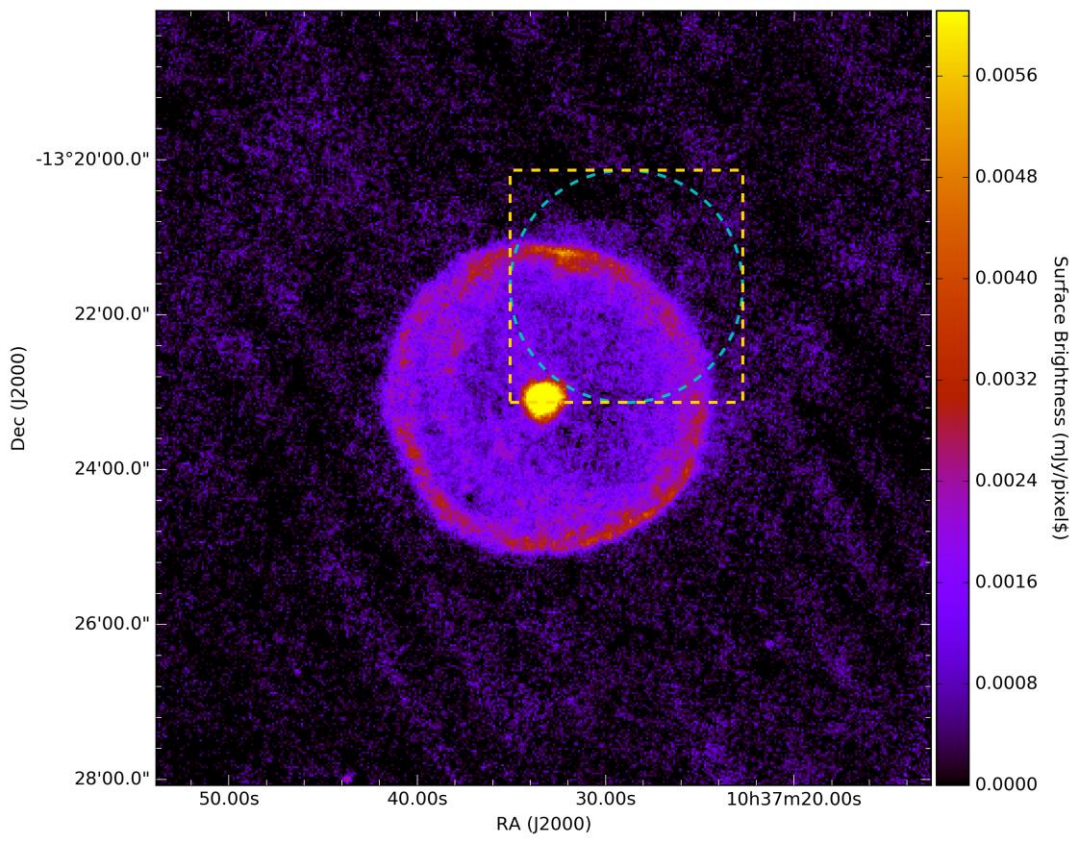


HARP observation of U Ant obtained in semester 17A as part of the NESS project

Further Studies

3) U Hya detached shell – proposal in prep for JCMT cycle 18A

- SCUBA2 - Dust properties: composition, grain cross section limits
- HARP CO 3-2 – Wind velocities (data cube and merged peak CO peak – slow winds)



U Hya Detached Shell - PACS 70
(1pix = 1.6")
Proposed observations
Blue circle – inner 3' radius of SCUBA-2 daisy map
Yellow square – 3' x 3' HARP raster map

Summary

- We observe extended emission in a sample of 15 AGB stars using JCMT - SCUBA2 (450 μm and 850 μm) and Herschel PACS (70 μm and 160 μm) observations.
- Extensions at 3σ detection for SCUBA2 850 μm observed upto ~80 ″.
- Flux within the extended region up to ~56% for SCUBA2 850 and ~60% for PACS.
- Fitting SEDs at each individual radial point and deriving radially dependent dust temperature, mass and beta profiles.
- Probe the dust mass-loss history, and detect any changes in physical properties of dust as a function radius.