

Interactions between the CSM and ISM and their Effects on Dust Grains



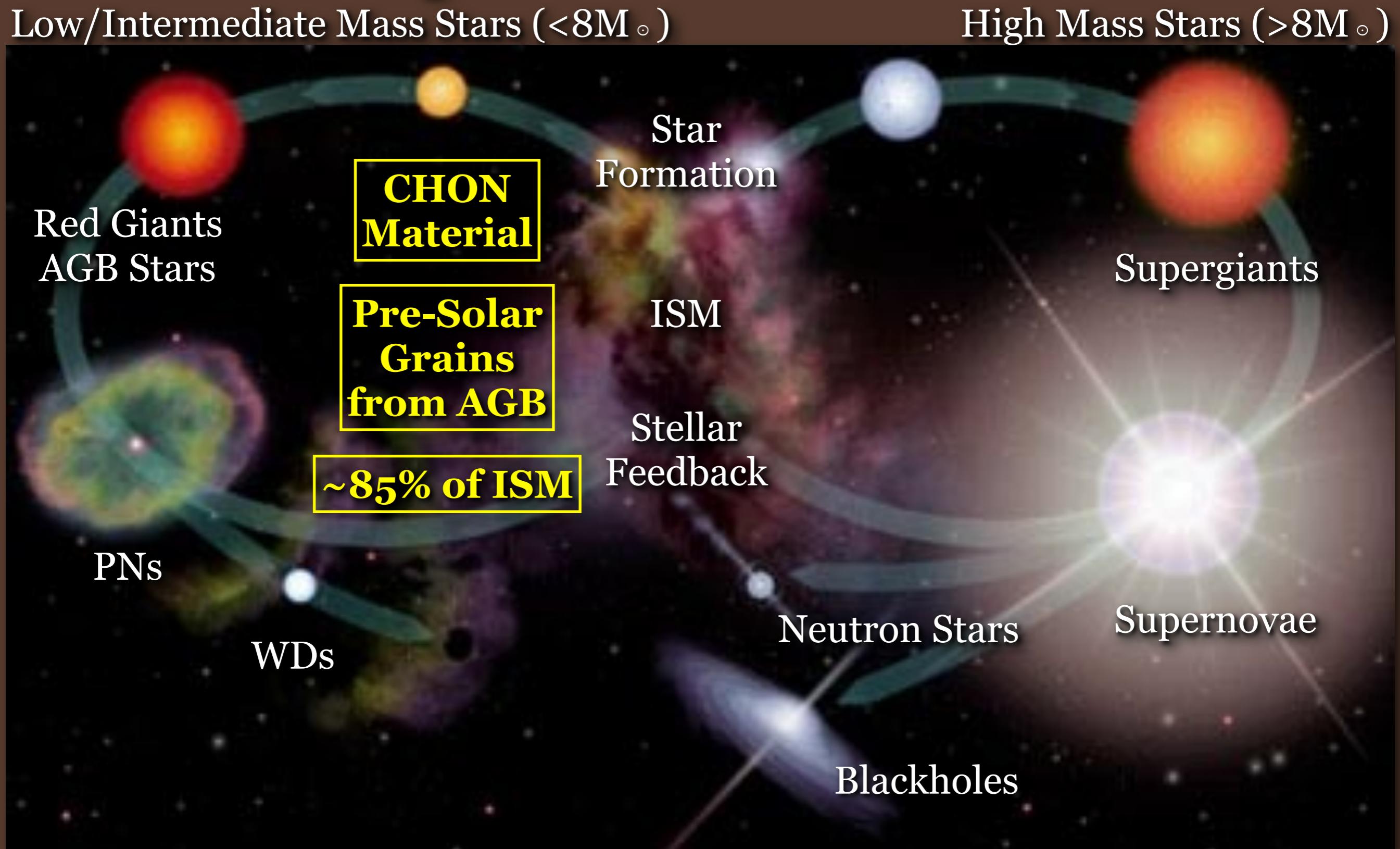
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University of Denver
Colorado, USA

第29回 Grain Formation Workshop/平成23年度銀河のダスト研究会
神戸大学惑星科学研究中心

November 11, 2011

Cycle of Matter



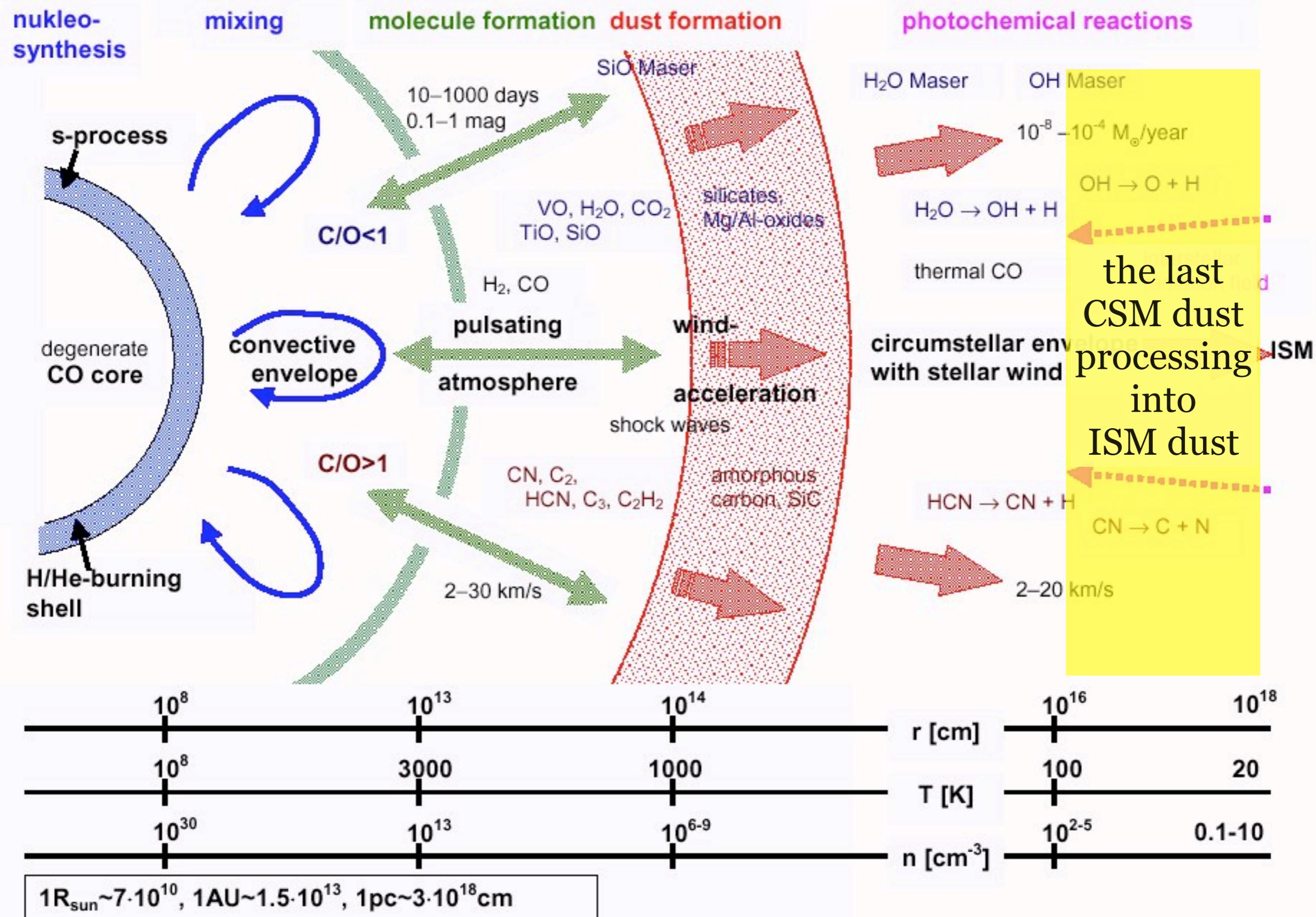
Dust Grains

Are CSM dust grains and ISM dust grains the same?

Not necessarily
(e.g. Jones et al. 2001)

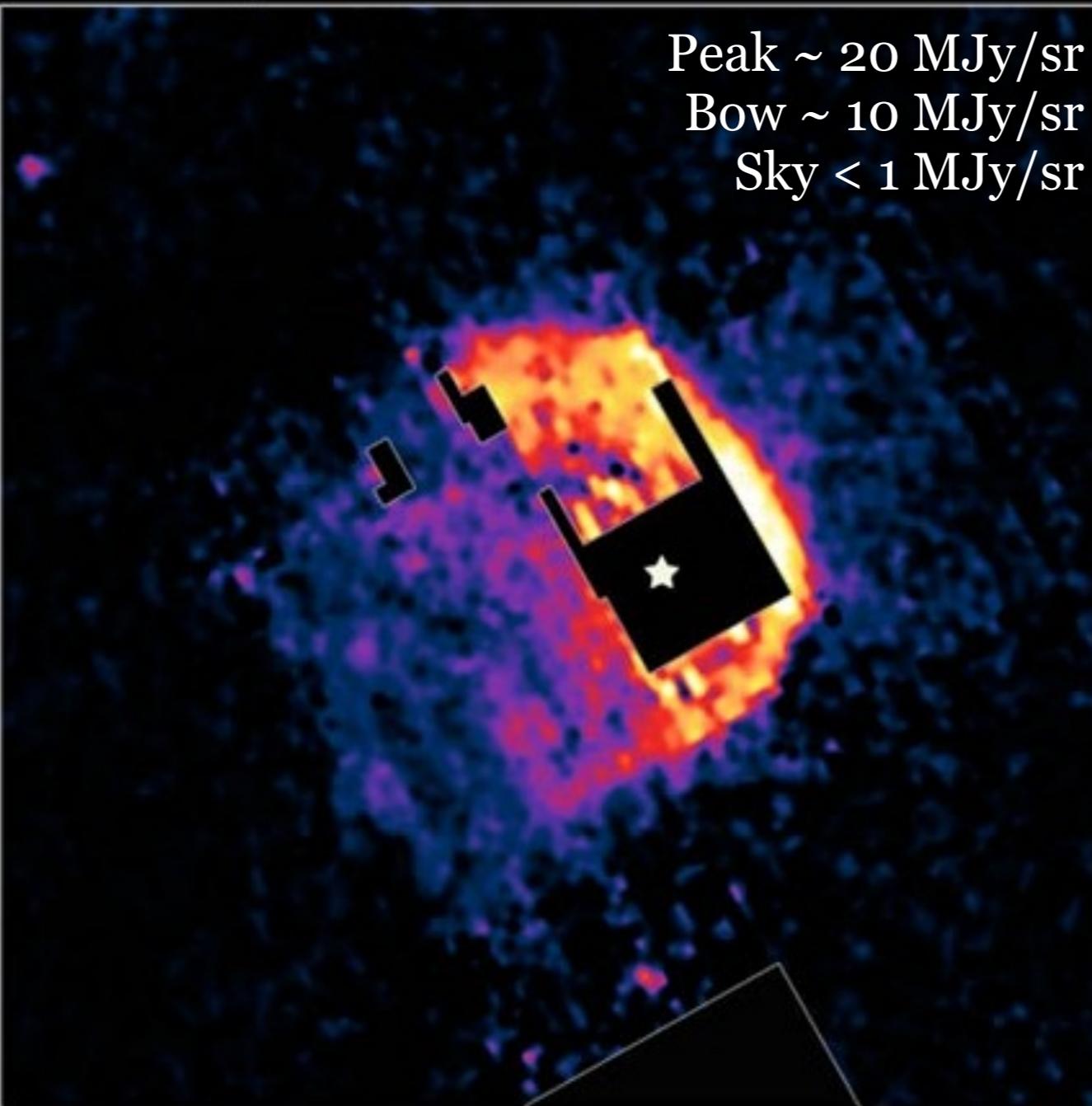
What happens to CSM dust before becoming ISM dust?

Schematic view of an AGB star

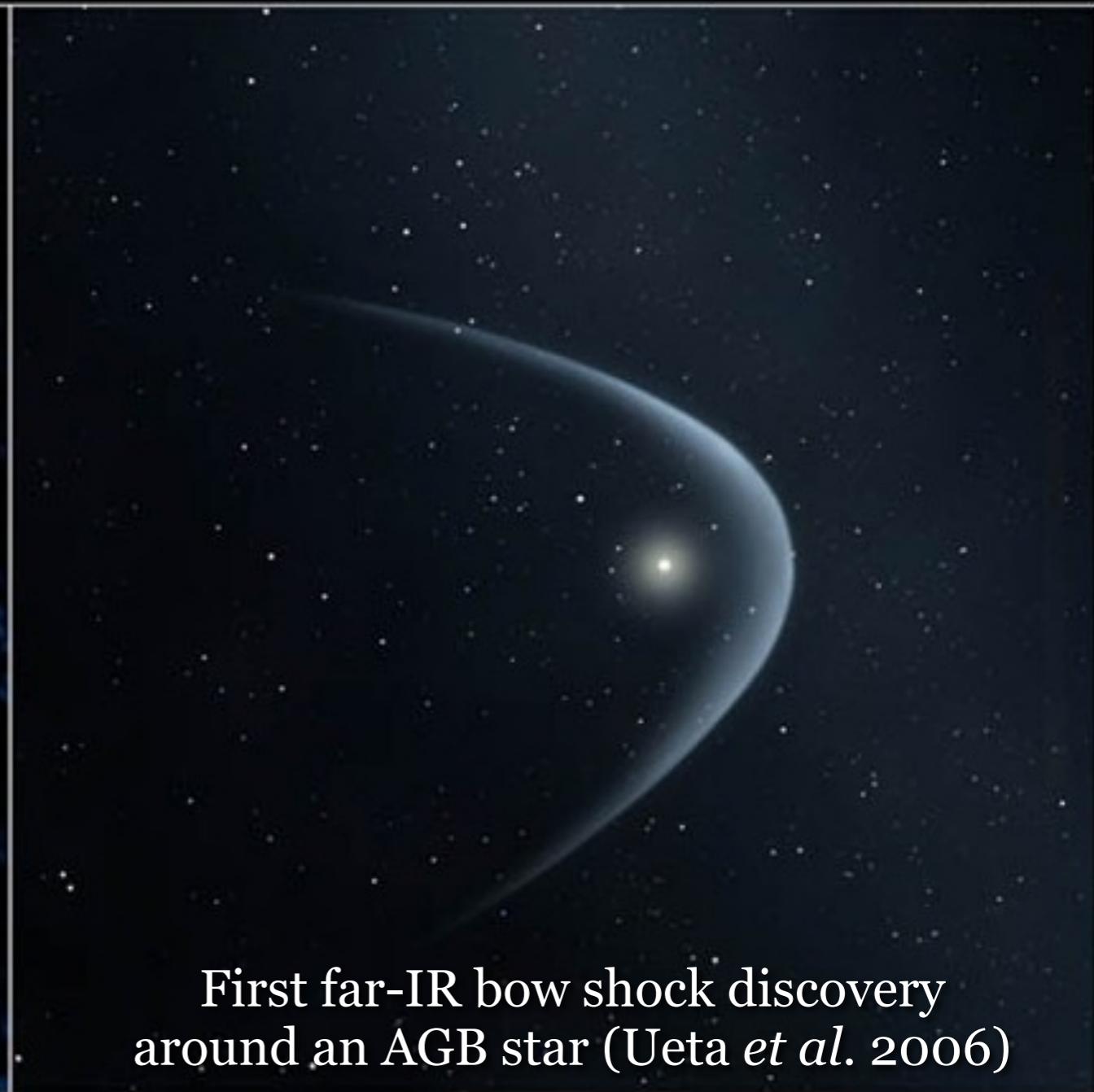


R Hydrae - AGB Bow Shock

Infrared Image



Artist's Concept



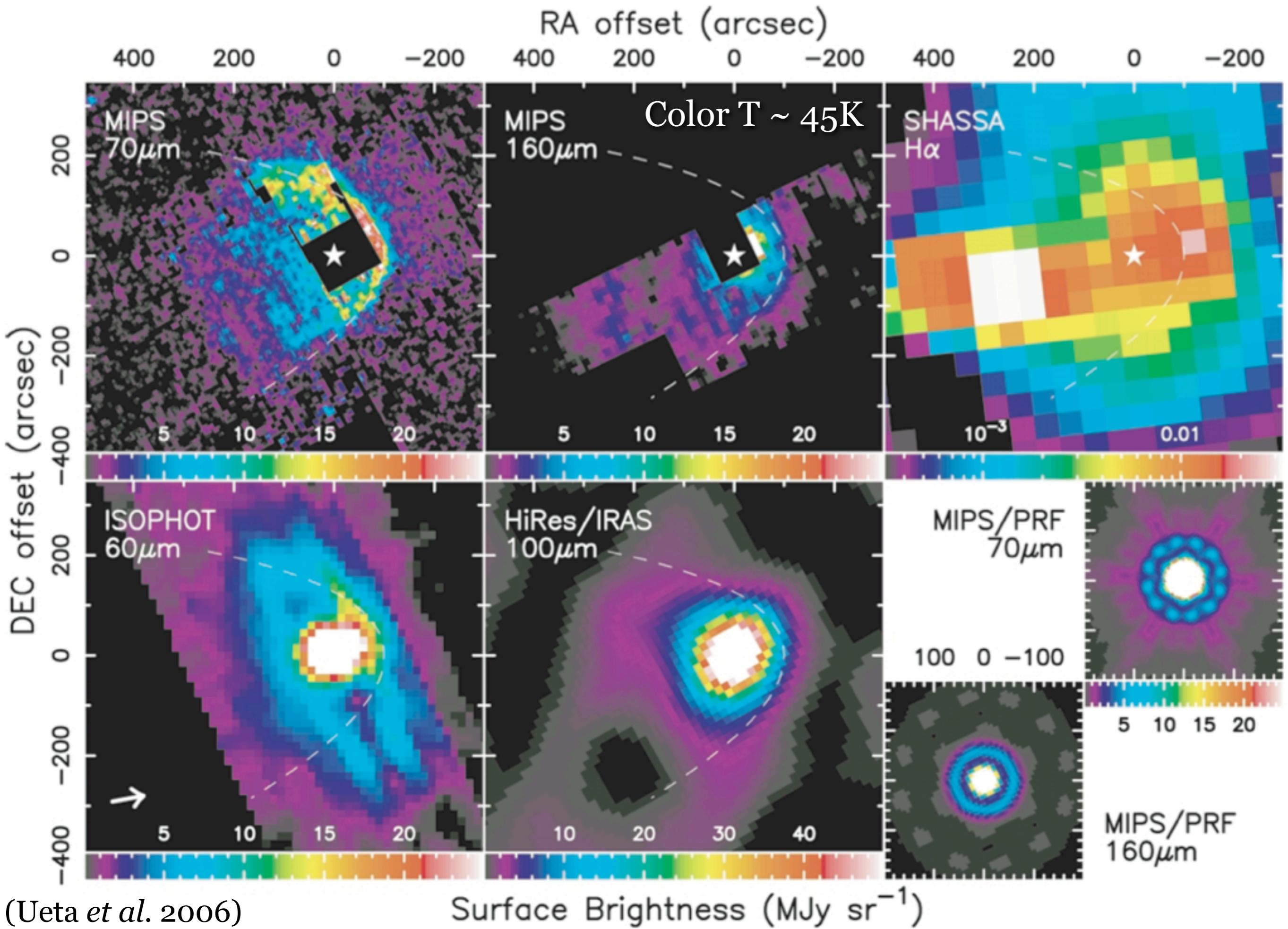
NASA/JPL-Caltech / T. Pyle (SSC)

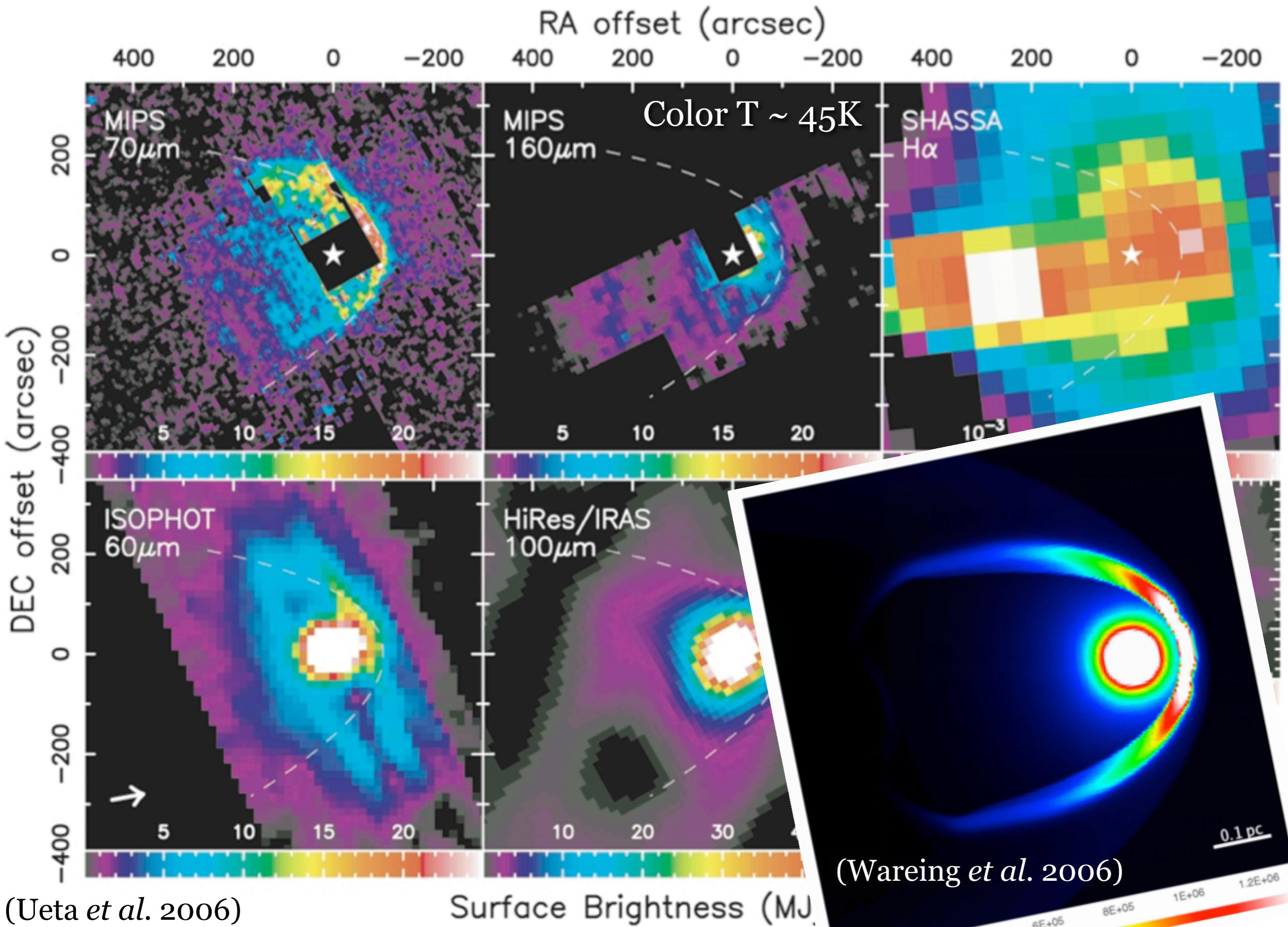
“Bow Shock” Around Star R Hydrae

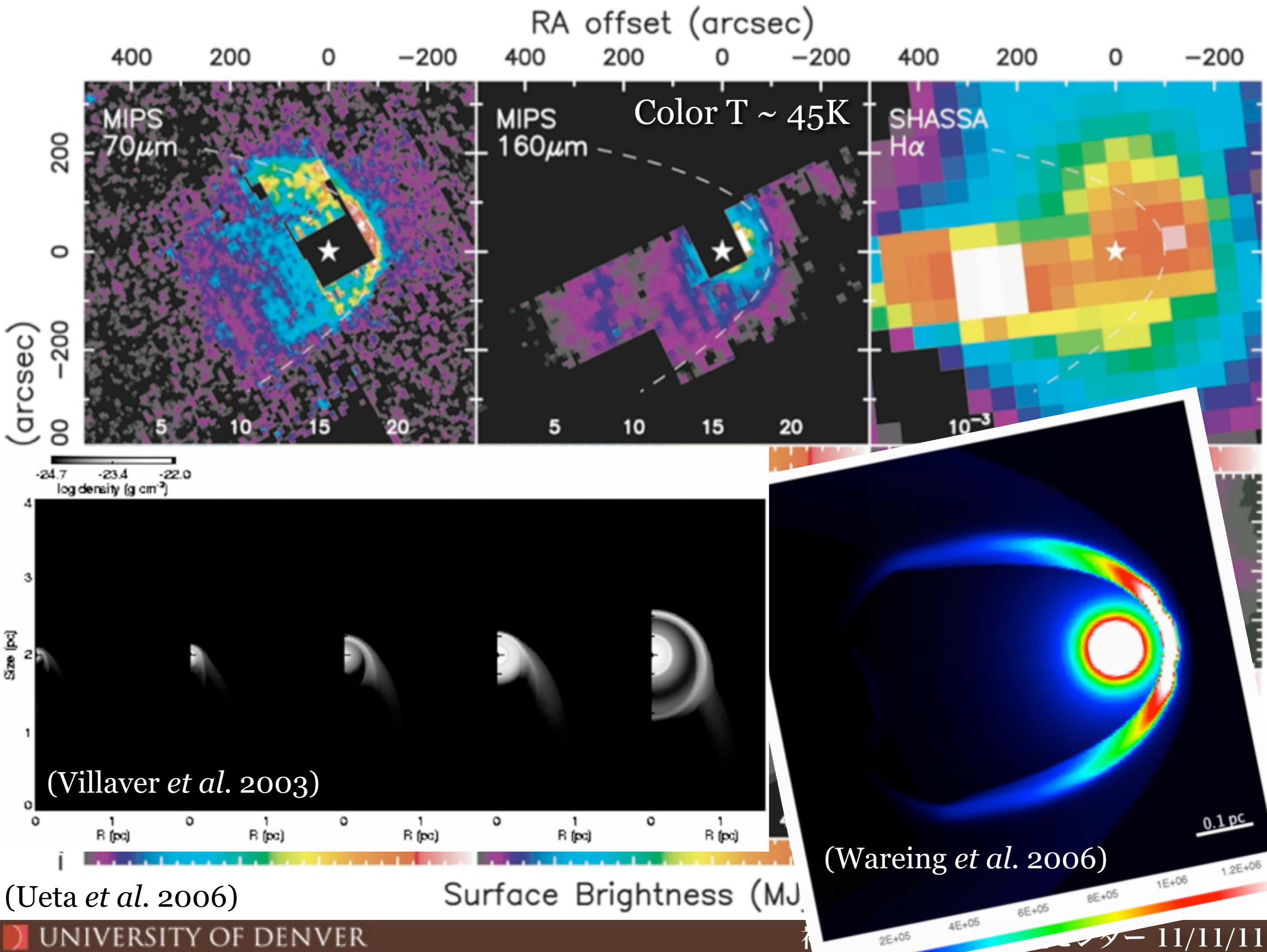
NASA / JPL-Caltech / T. Ueta (University of Denver)

Spitzer Space Telescope • MIPS

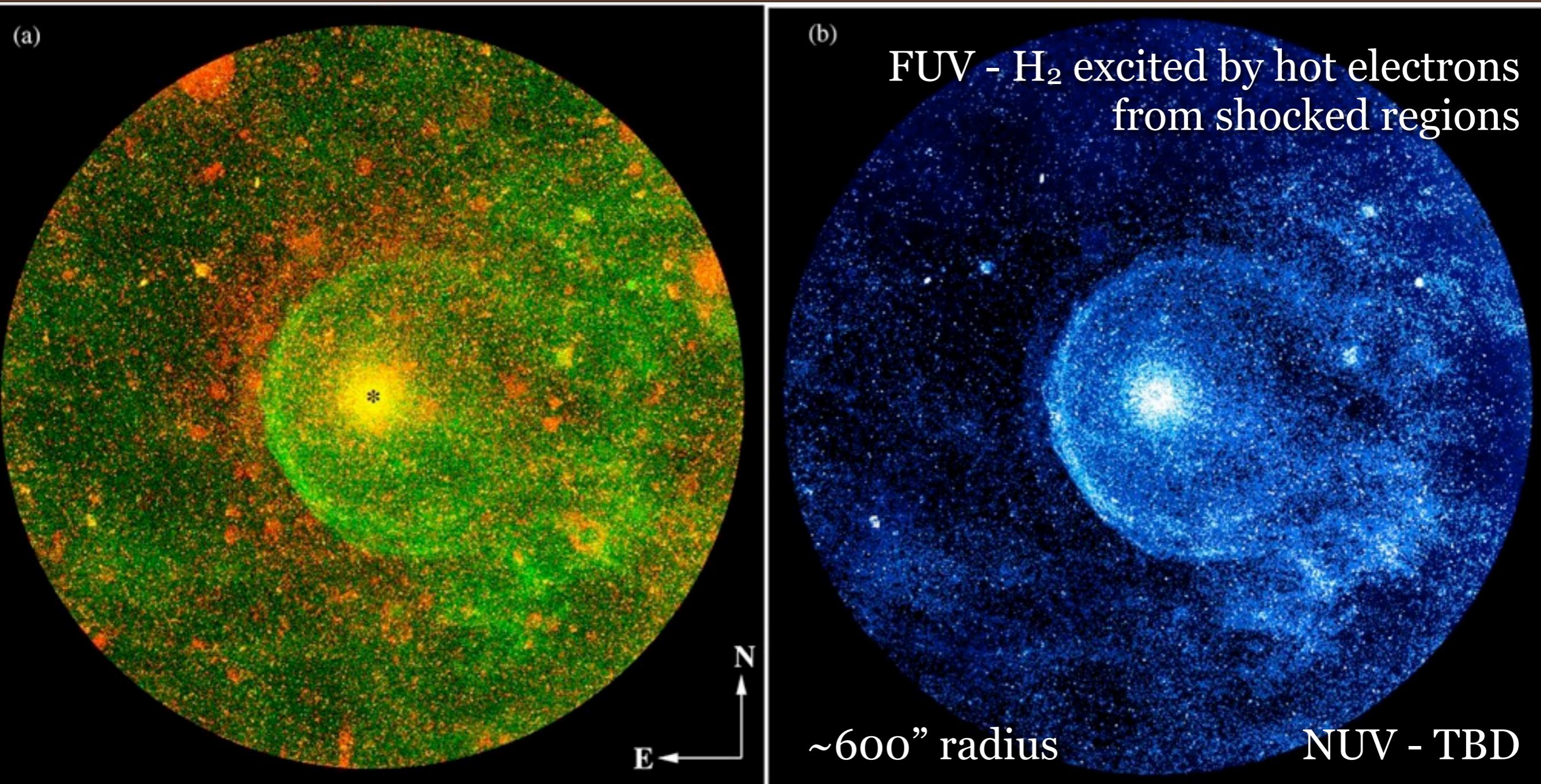
sig06-029







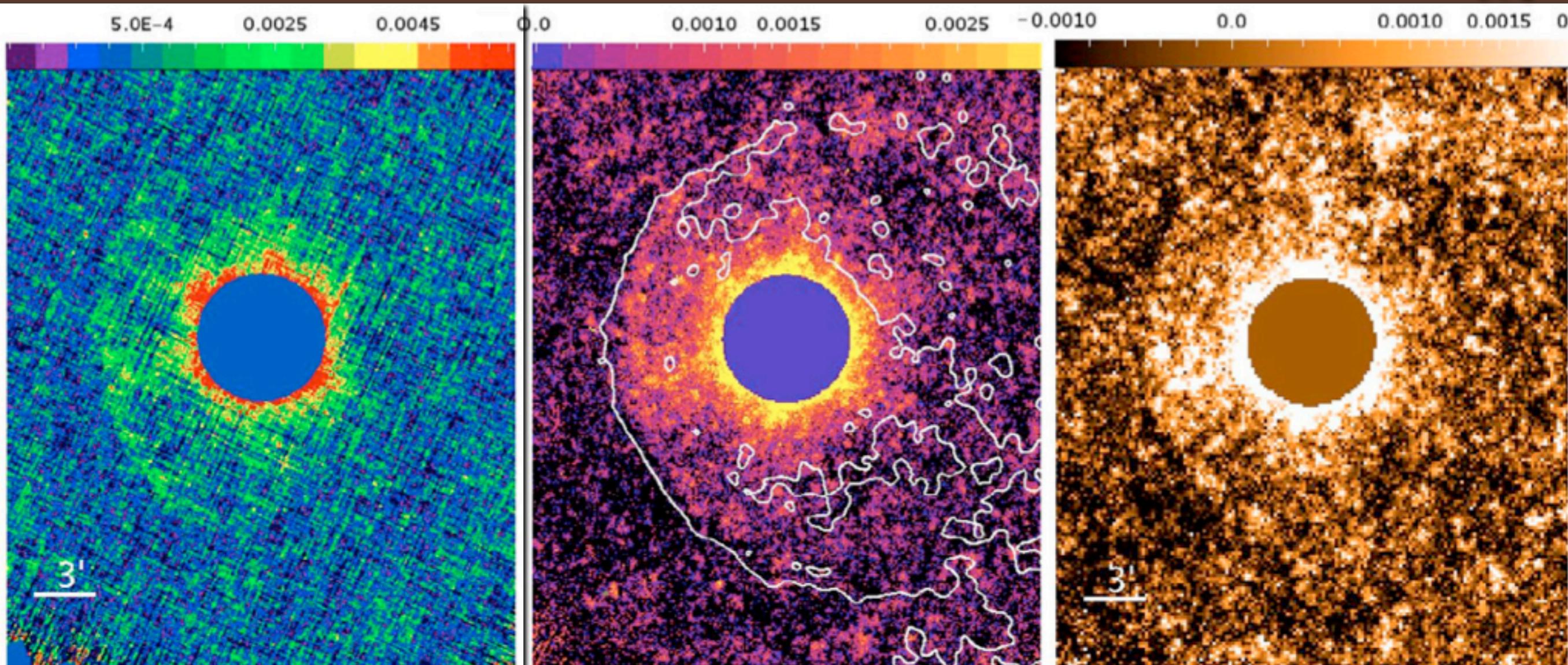
CW Leo - GALEX & Herschel



(Sahai & Chronopoulos 2010)

CW Leo - GALEX & Herschel

Jy/pix



160 μ m

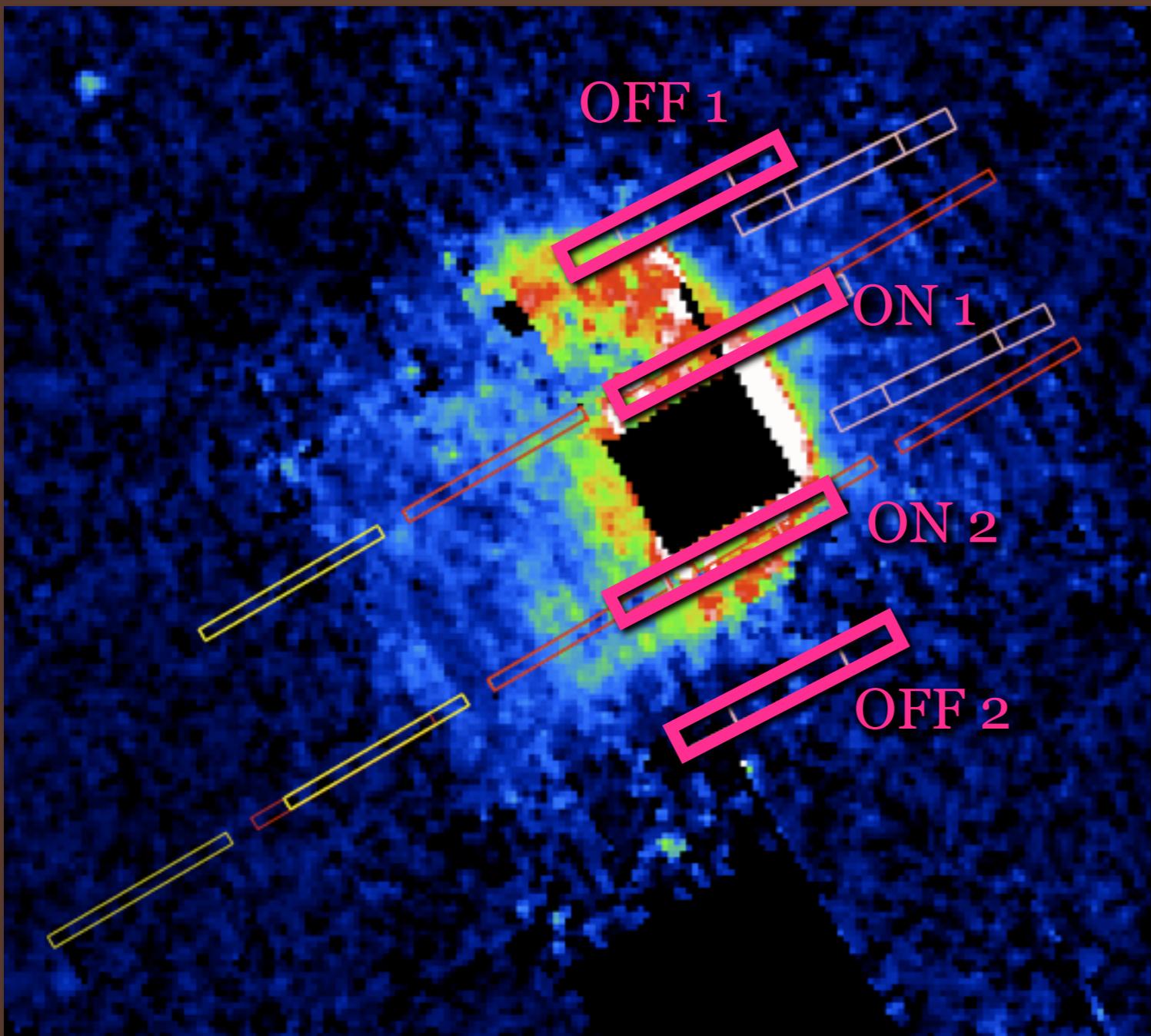
Color T ~ 25K

250 μ m
+
GALEX FUV
(contour)

350 μ m

Ladjal *et al.* (2010)

Why bright at Far-IR?

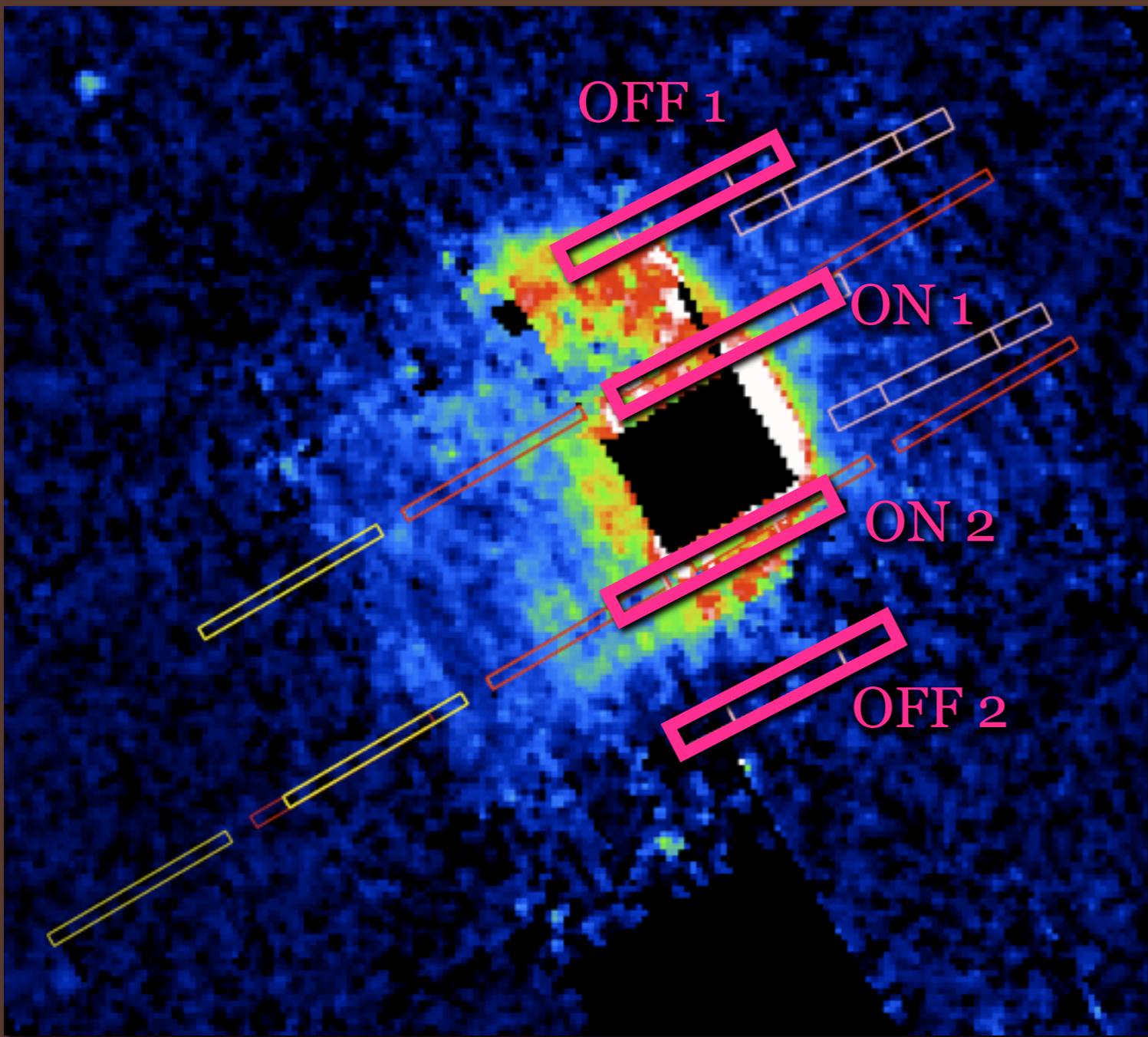


Spitzer follow-up

To obtain shock diagnostics

- IRS Long-Low
(14 - 38 μ m, 7 pointings, red & yellow)
- MIPS SED Mode
(52 - 97 μ m, 3 pointings, pink)

Why bright at Far-IR?



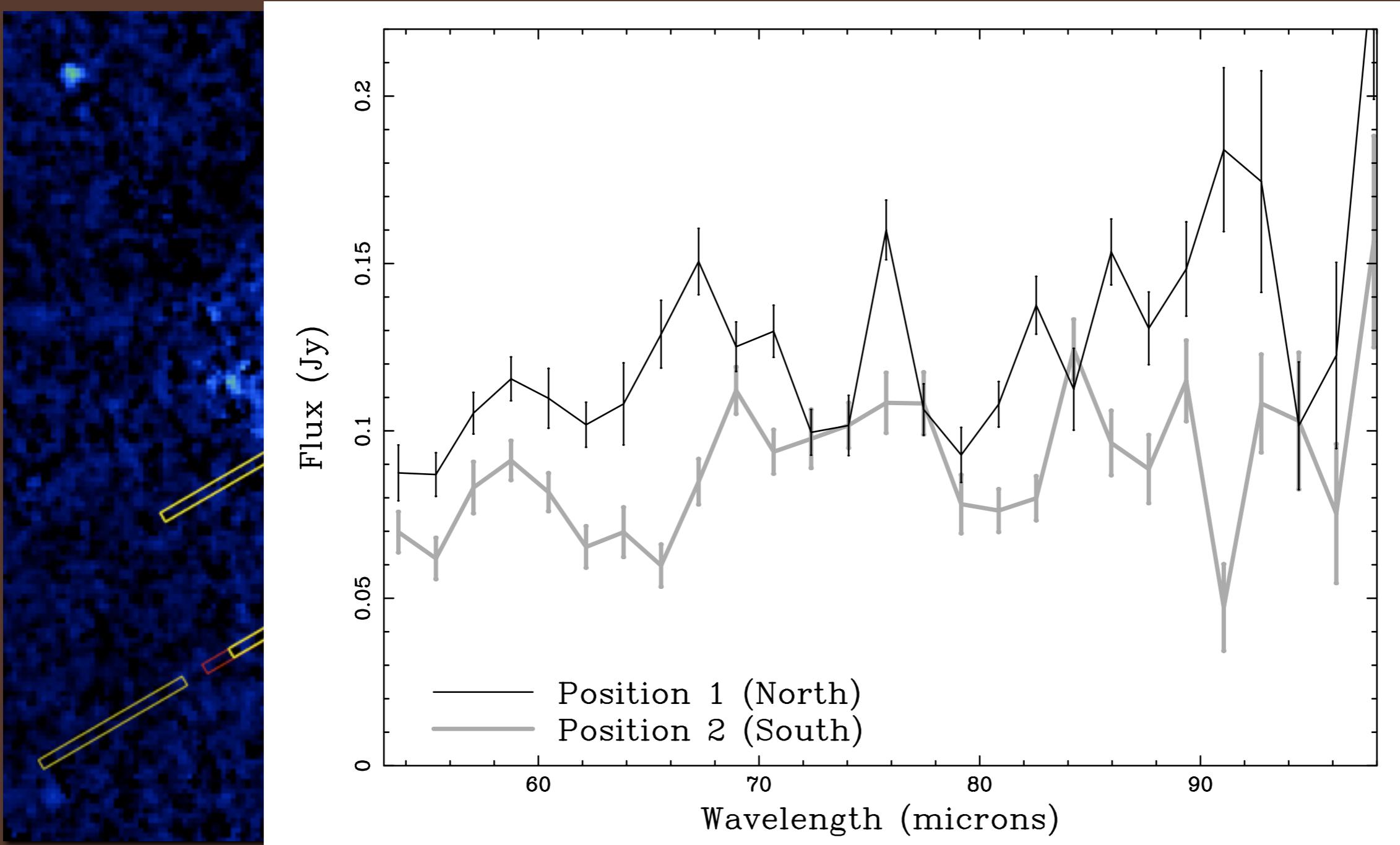
Not detected by IRS.

Spitzer follow-up

To obtain shock diagnostics

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($14 - 38\mu\text{m}$, 7 pointings, red & yellow)
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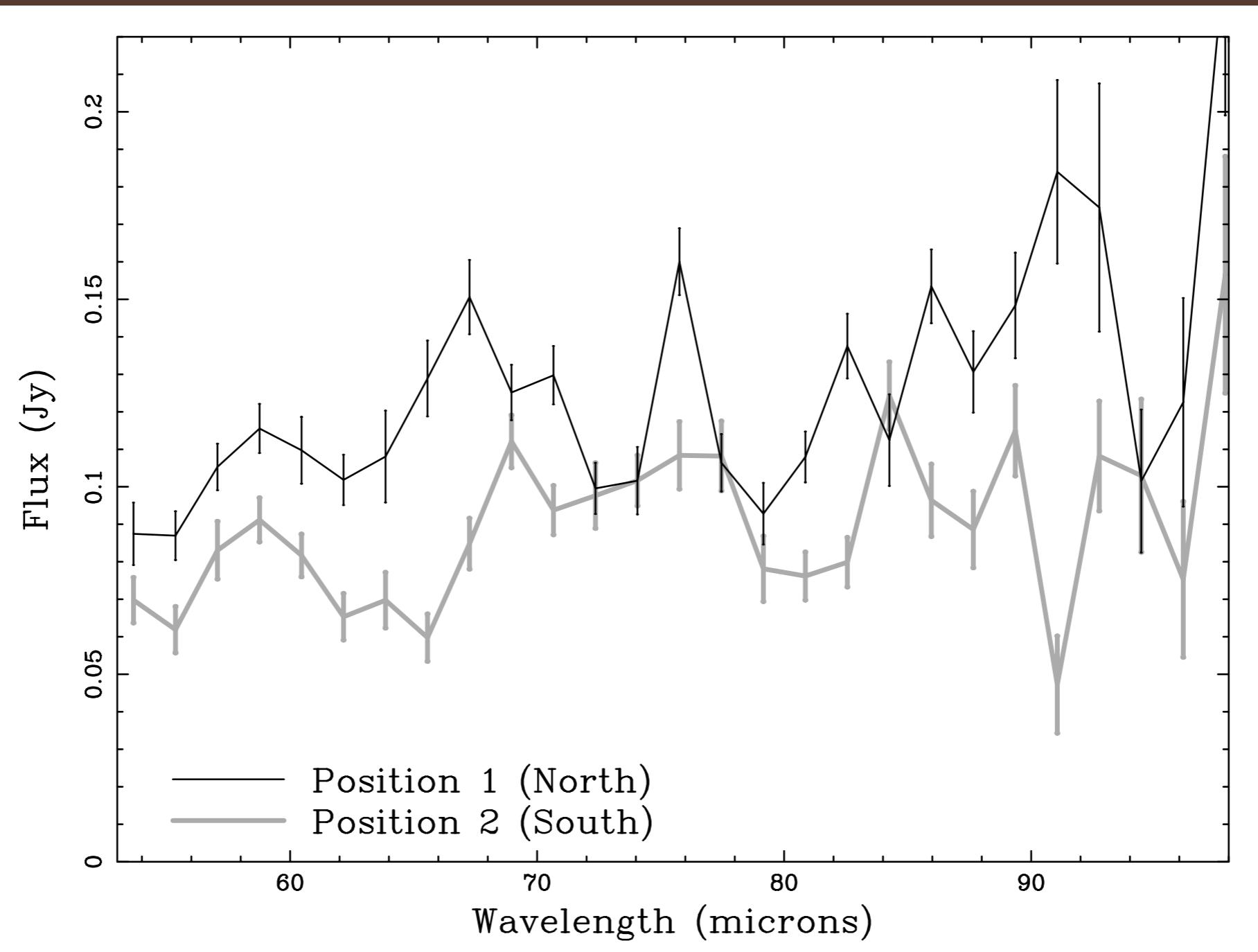
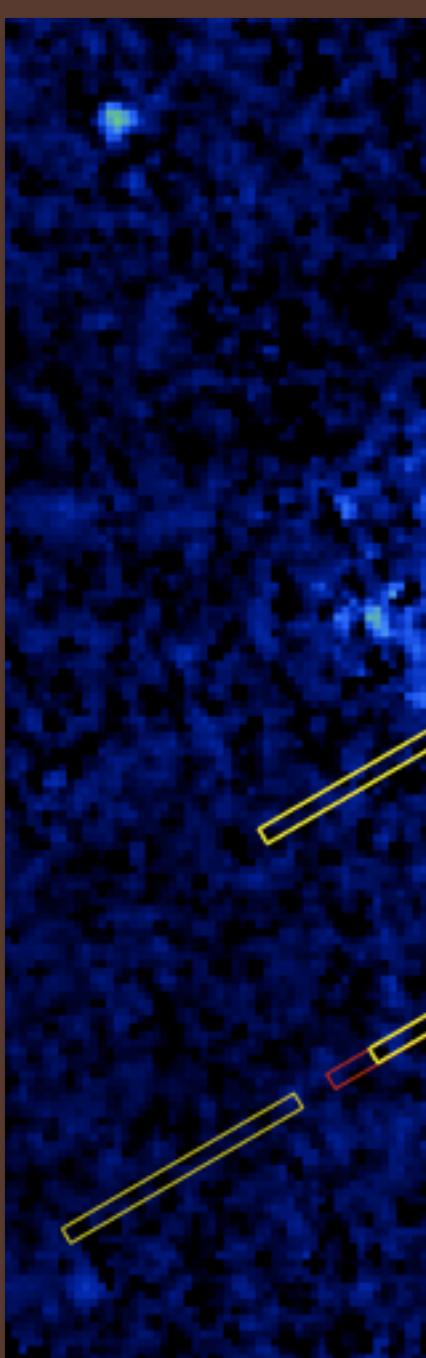
Why bright at Far-IR?



p
tis
red & yellow)
pink)

Not detected by IRS.

Why bright at Far-IR?

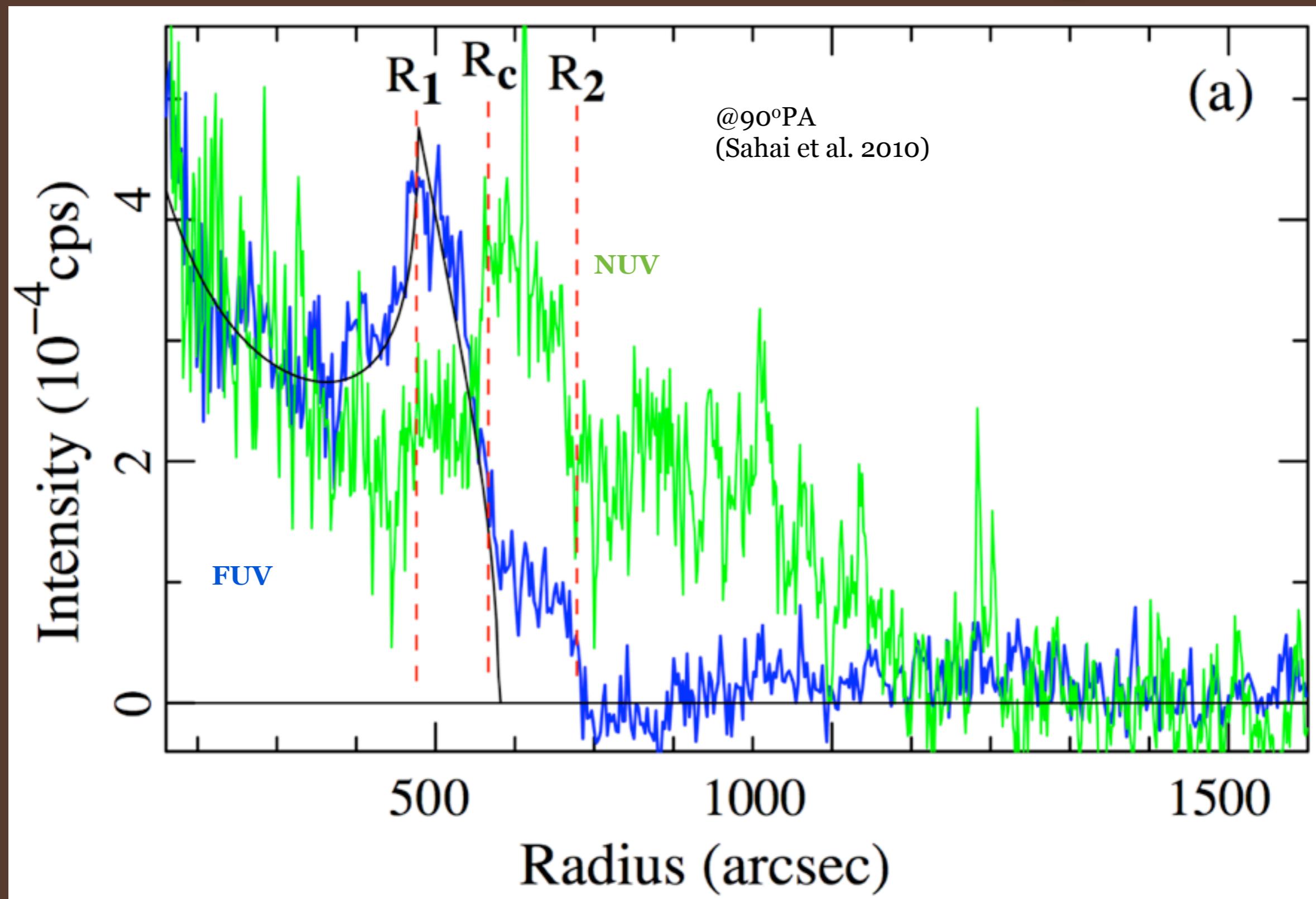


politics
red & yellow)
pink)

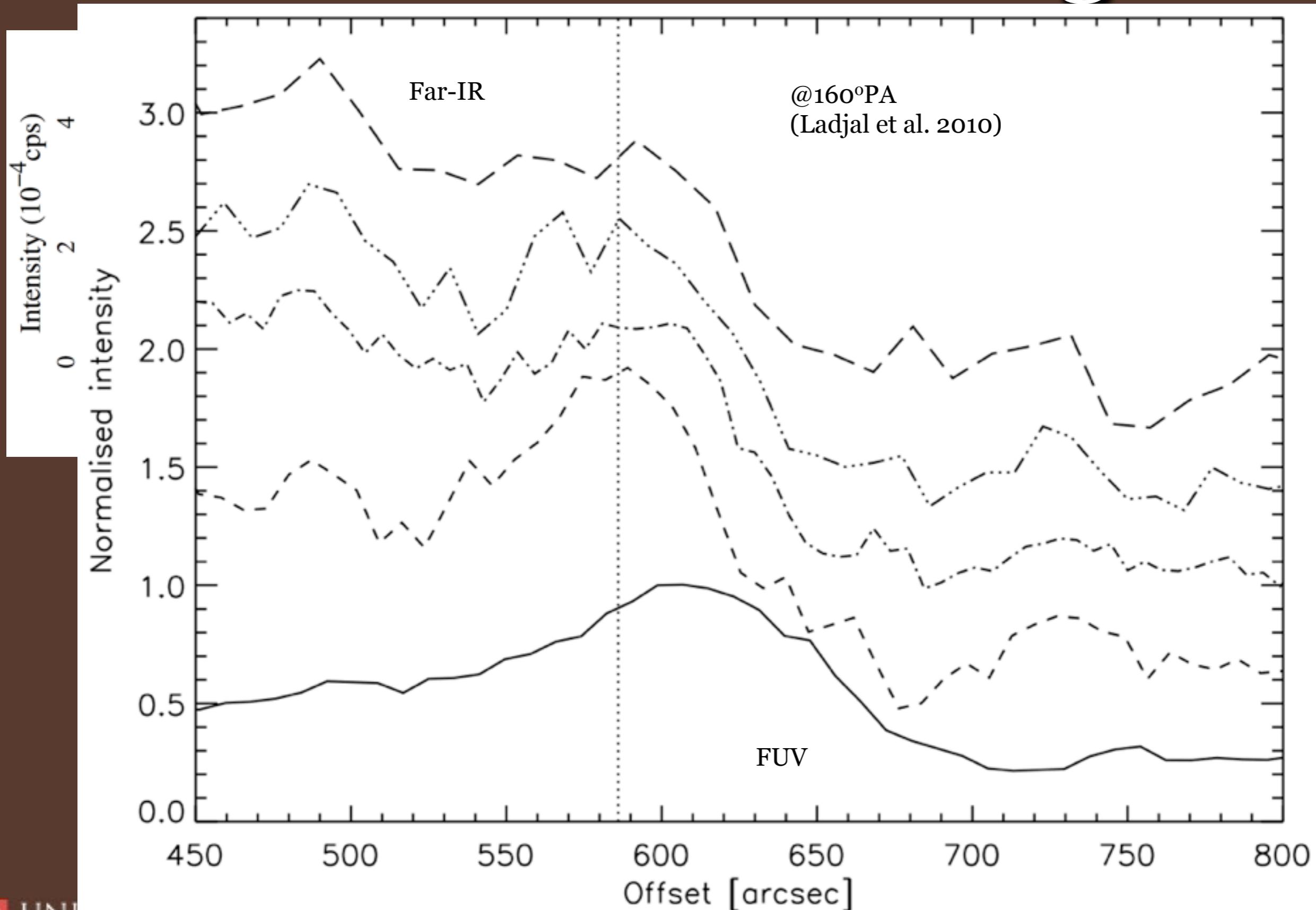
Not detected by IRS.

70 μ m emission seems *dust continuum*.

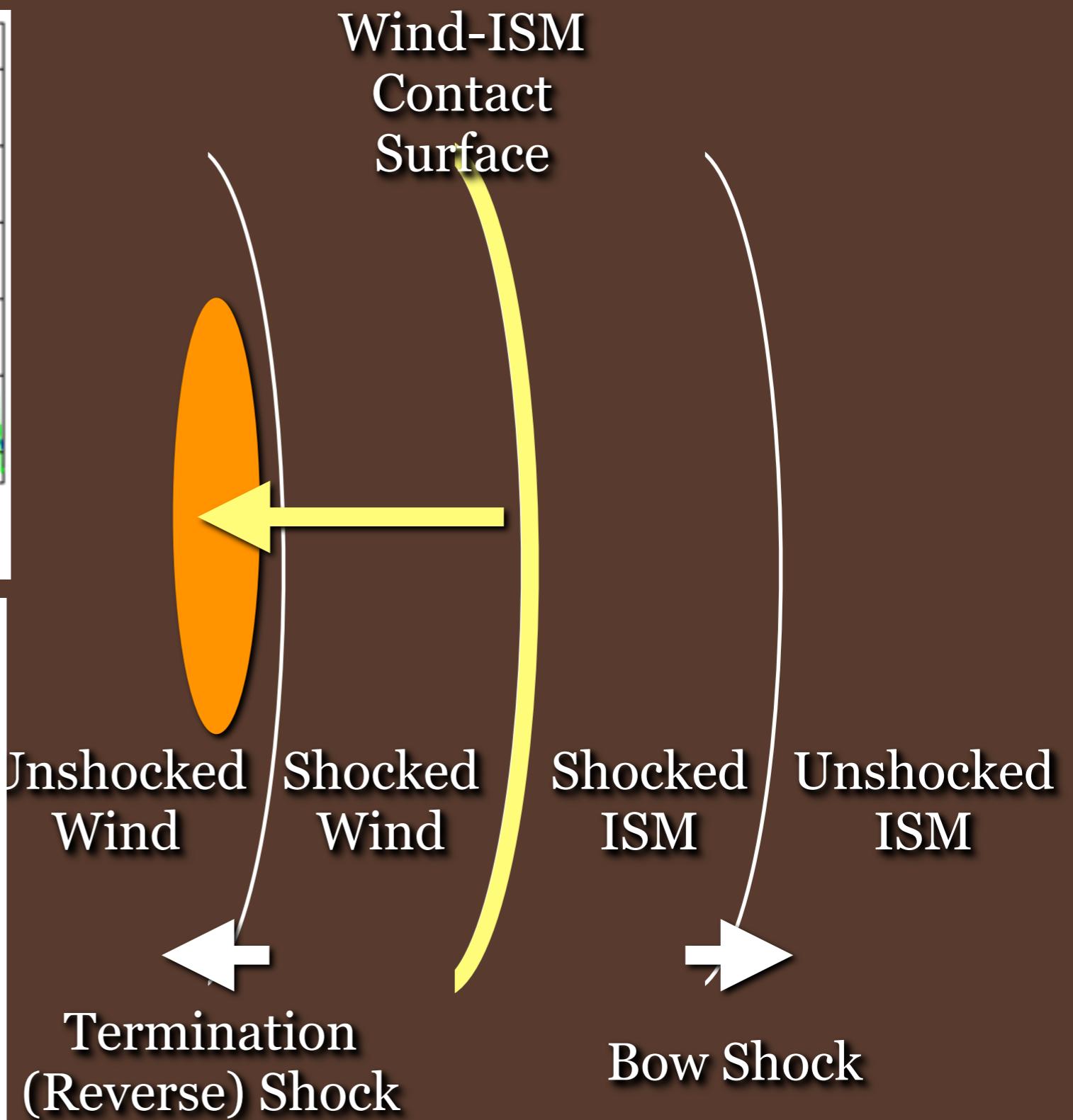
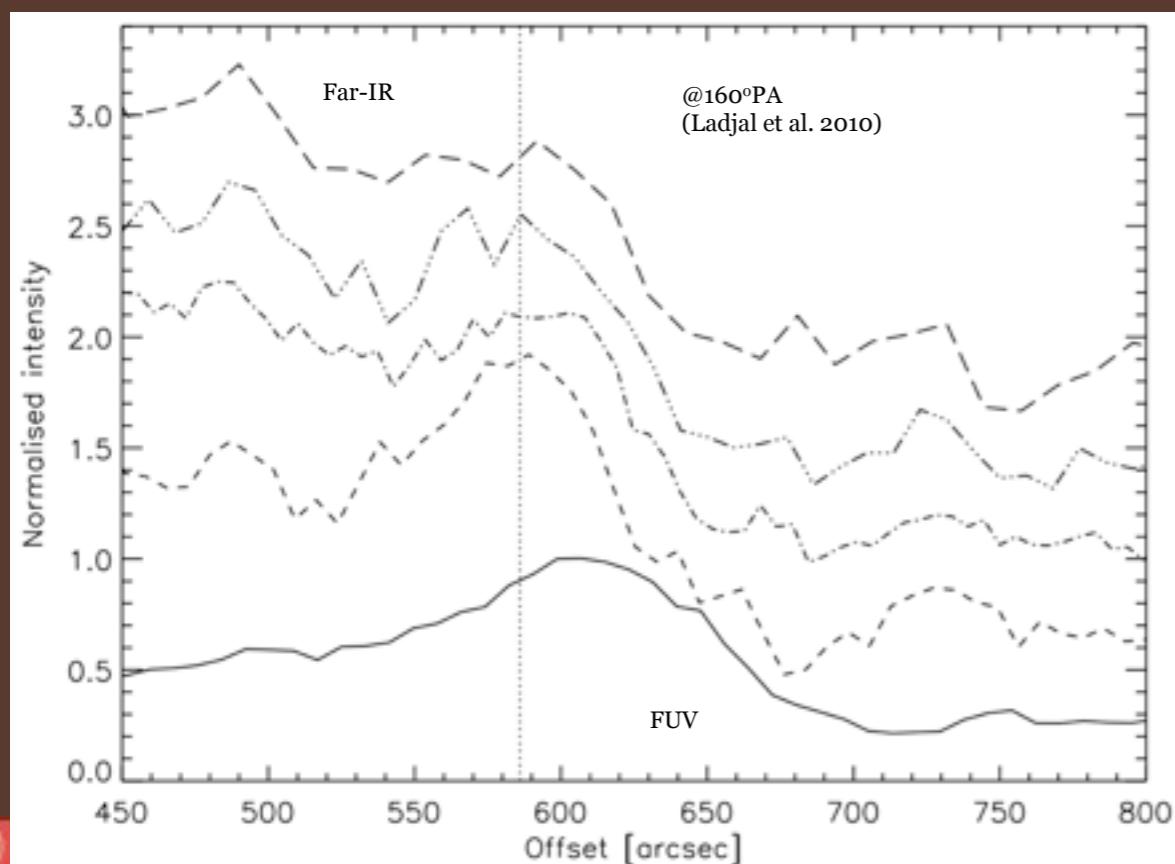
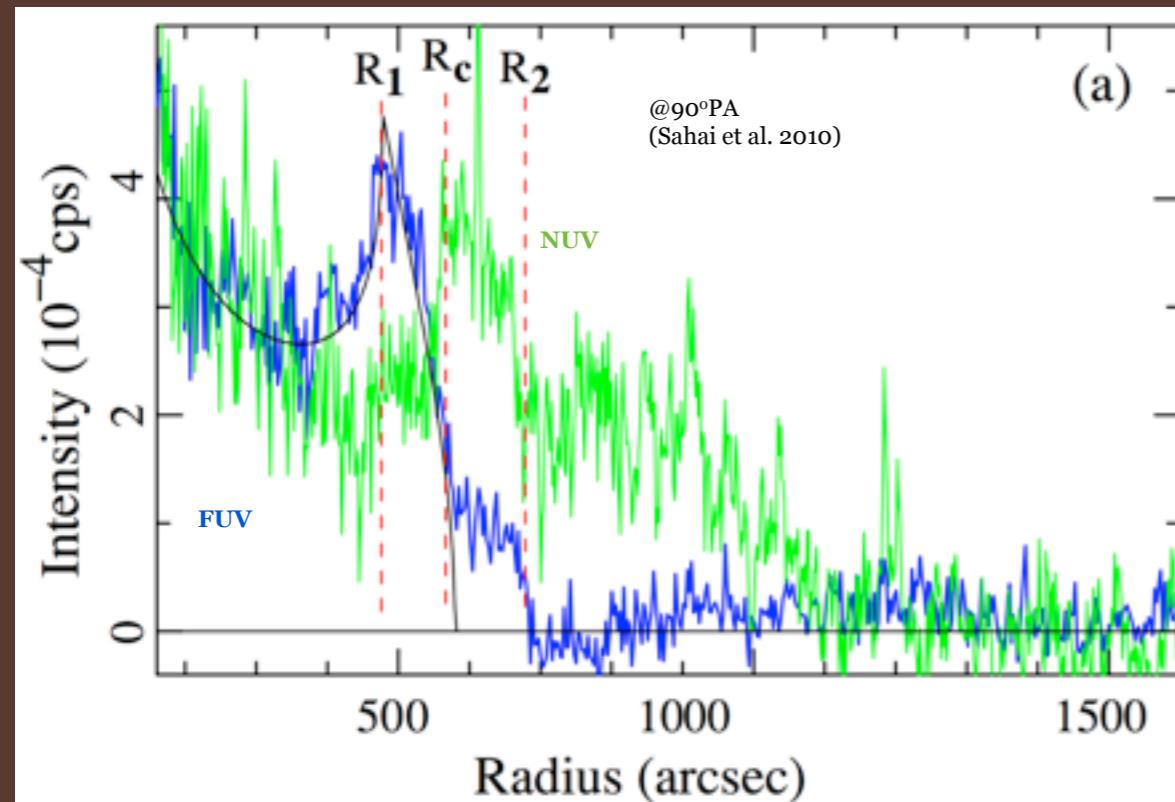
Far-IR Emission Region



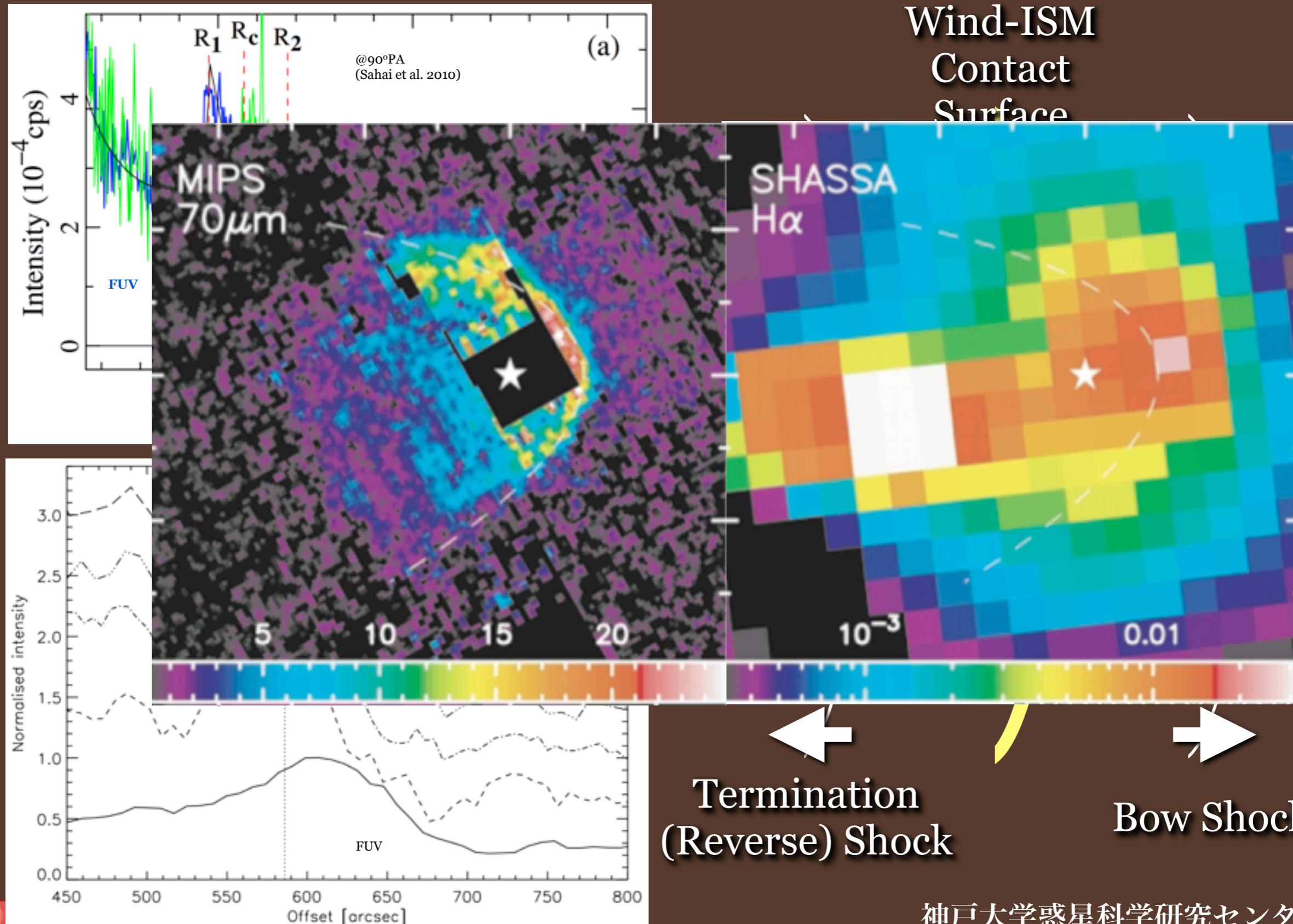
Far-IR Emission Region



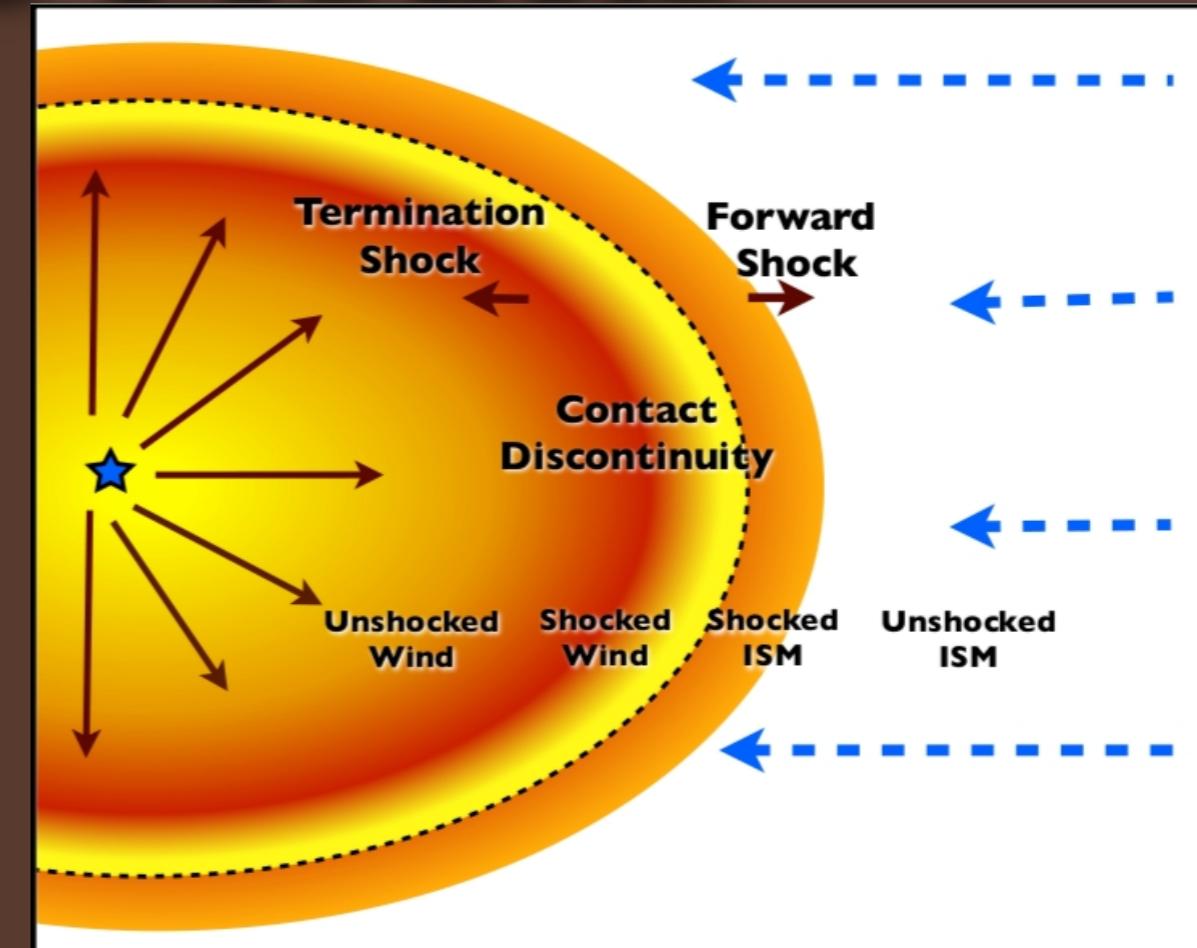
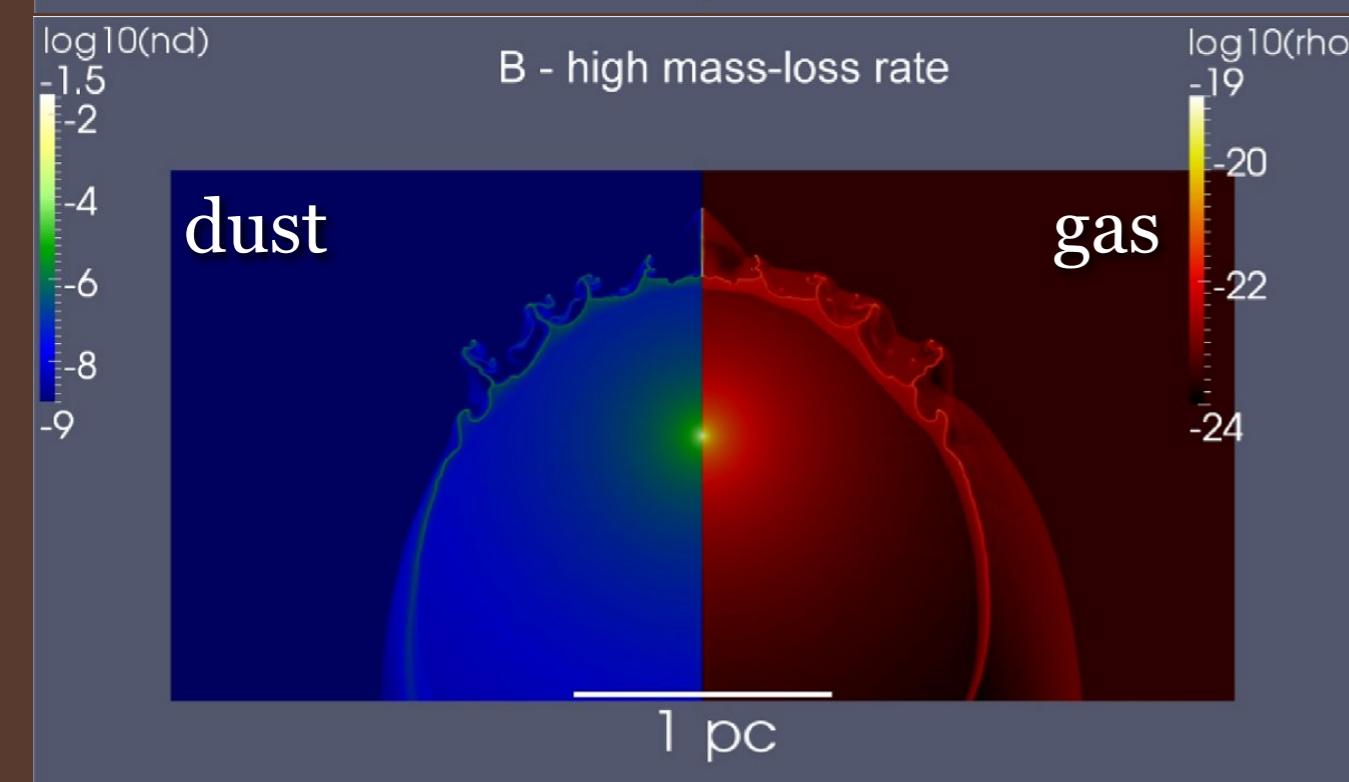
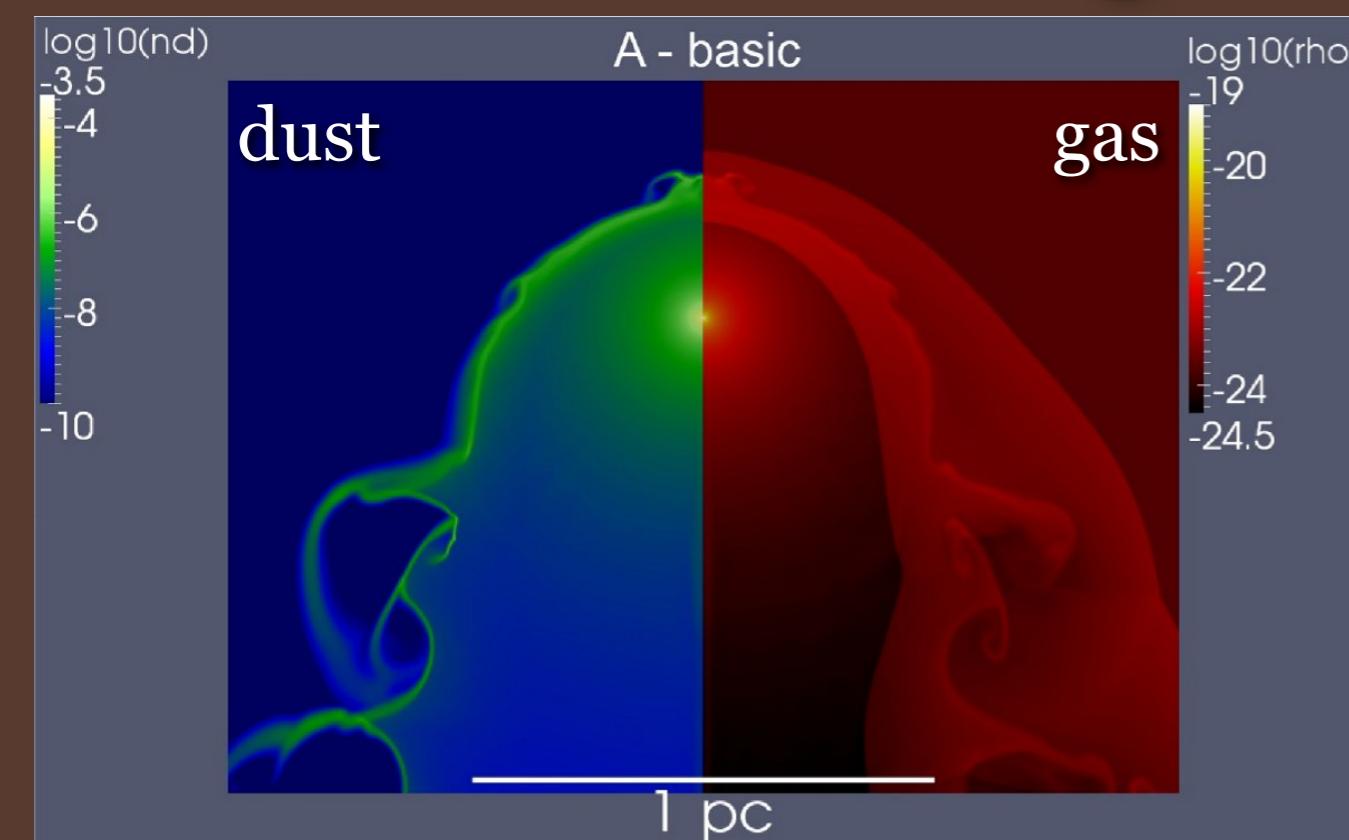
Far-IR Emission Region



Far-IR Emission Region



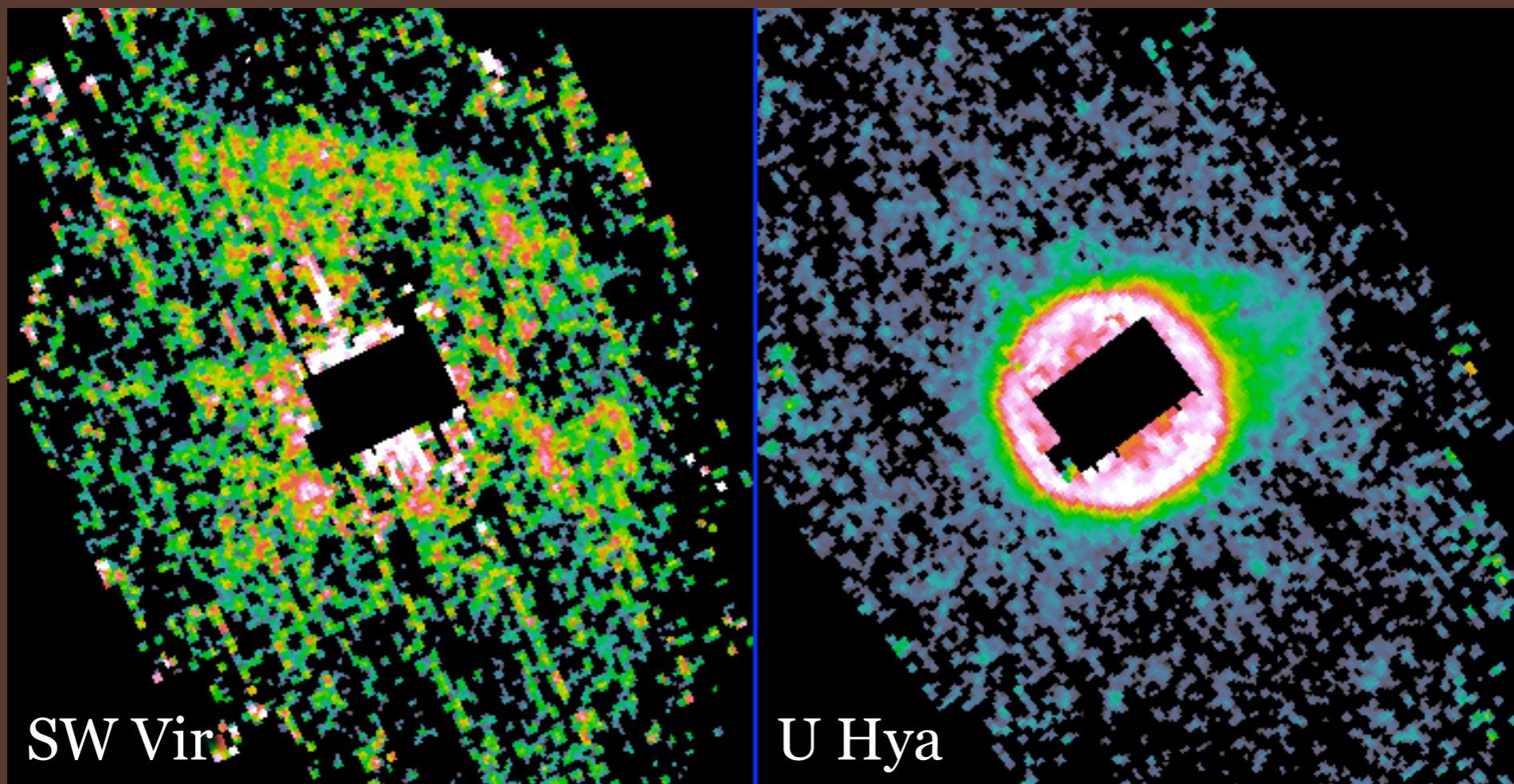
Gas Hydro Models



CSM dust passes the termination shock into the shocked wind region and piles up at the CSM-ISM boundary

van Marle et al. (2011)
Cox et al. (in press)

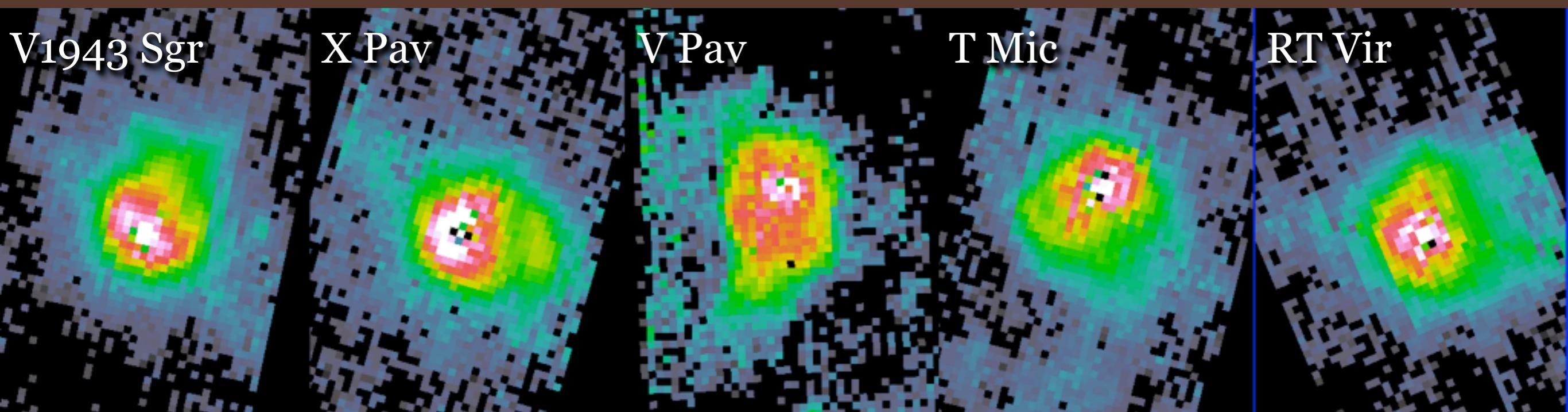
Other AGB Wind-ISM Interaction Cases



Sky Noise < 1 MJy/sr

Spitzer - MLHES
(Ueta *et al. in prep*)

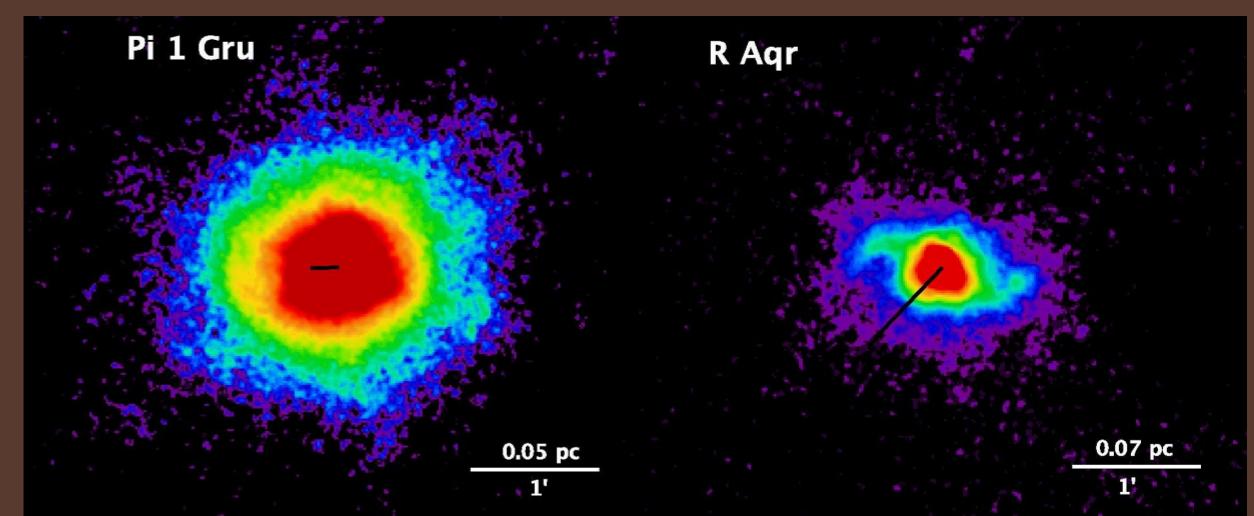
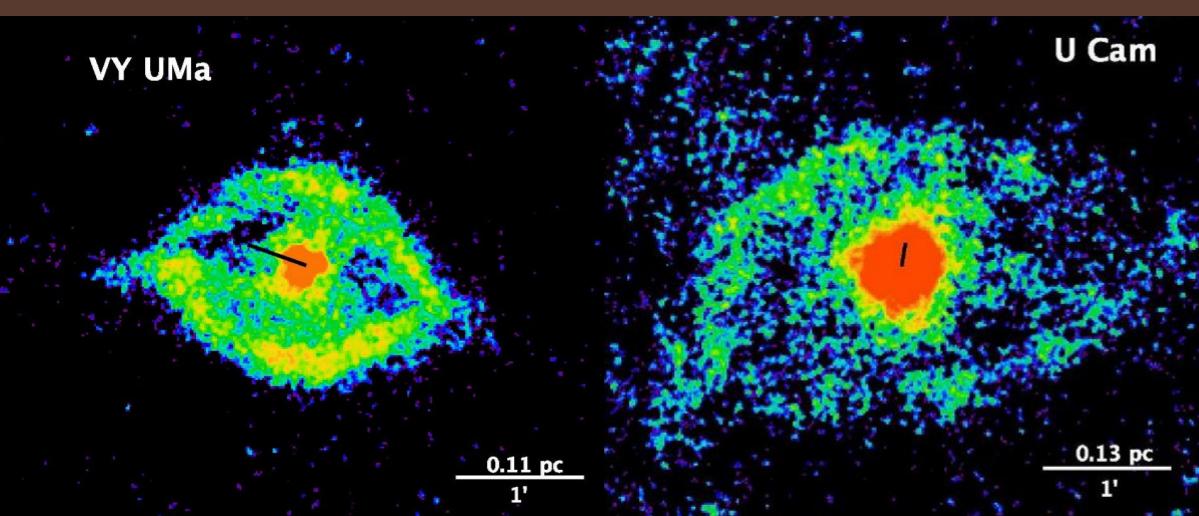
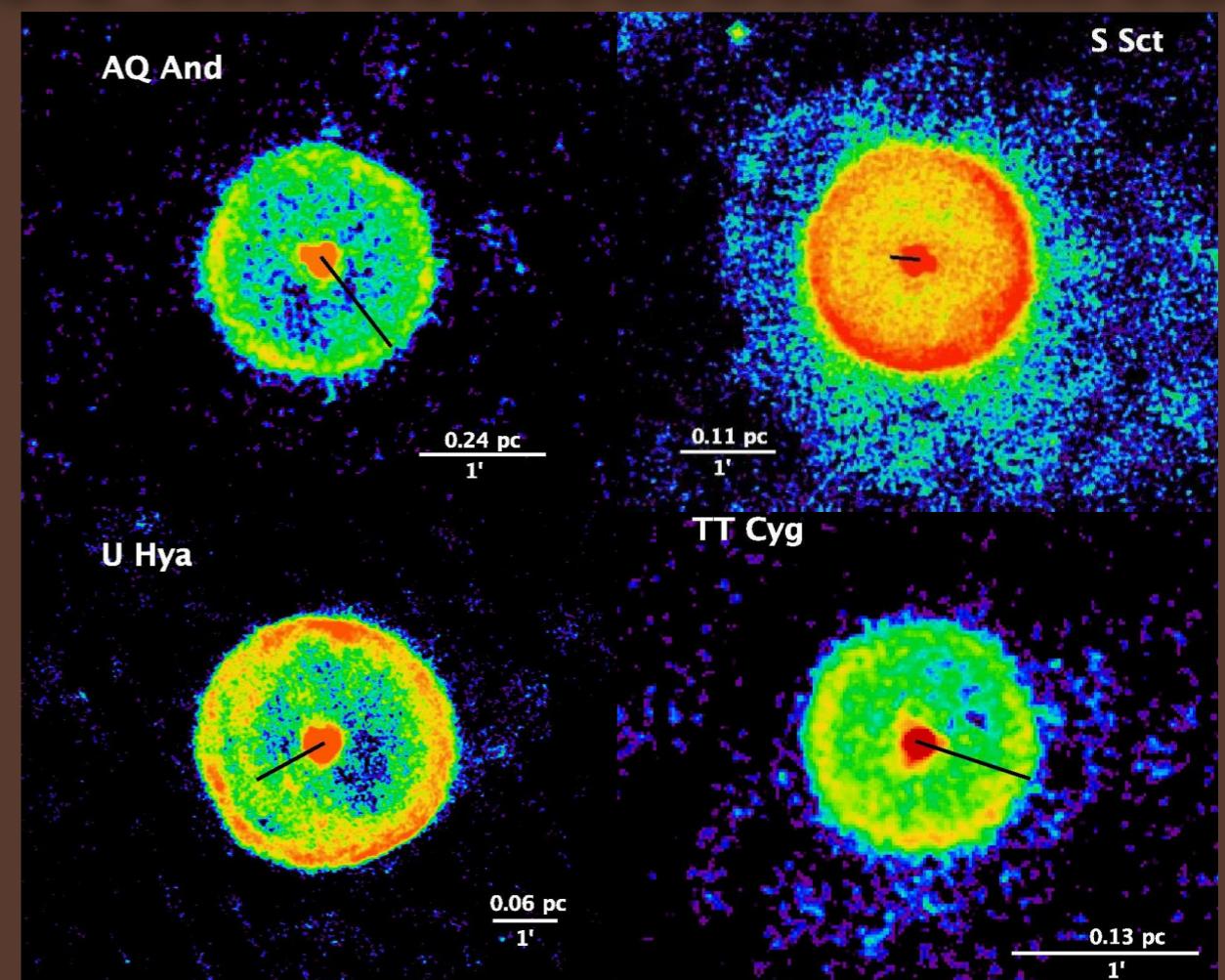
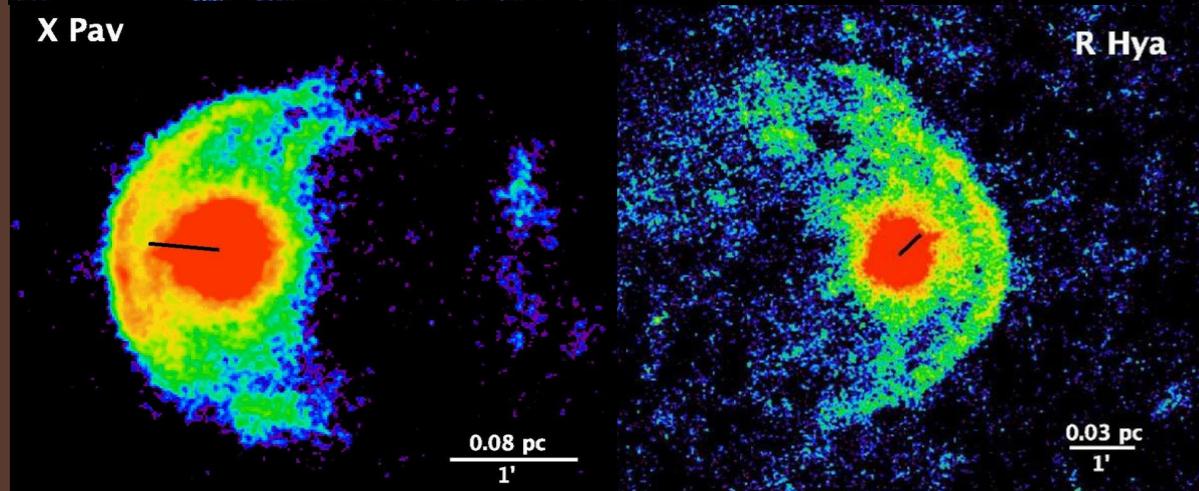
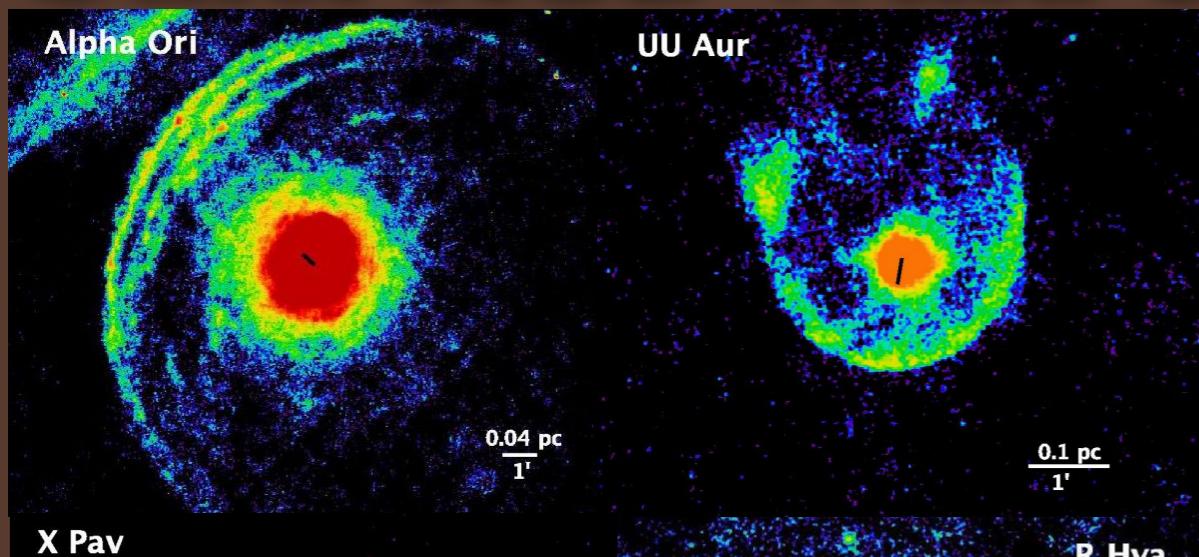
Other AGB Wind-ISM Interaction Cases



Sky Noise $< 1 \text{ MJy/sr}$

AKARI - MLHES
(Izumiura *et al.* 2011)

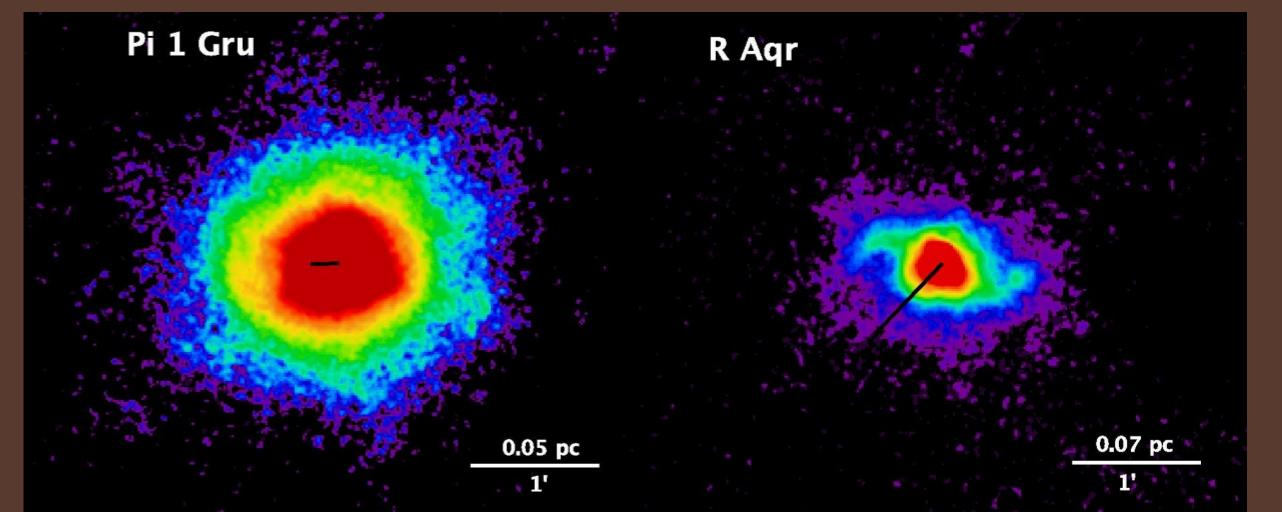
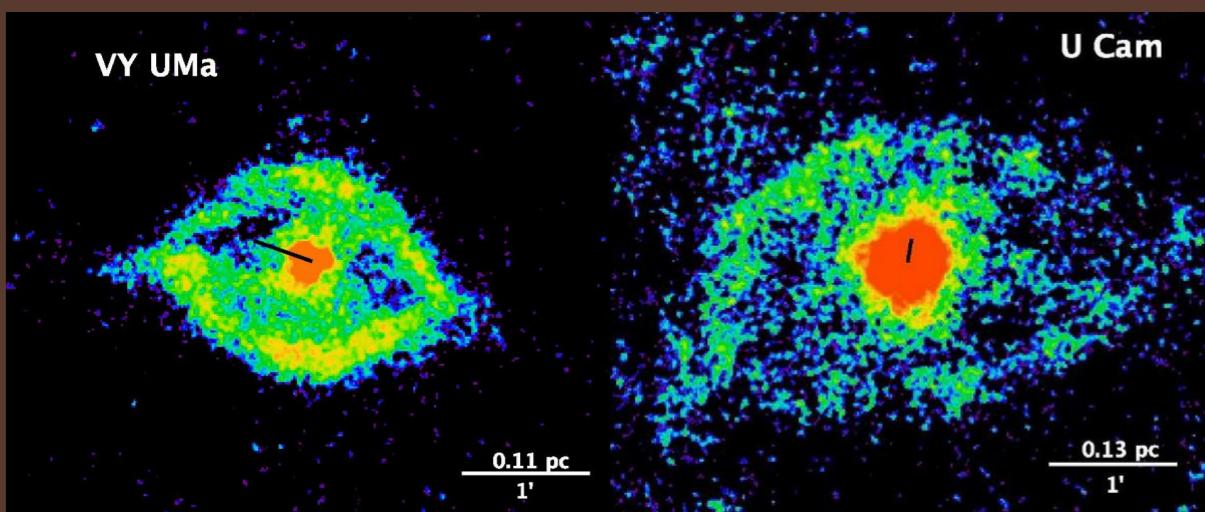
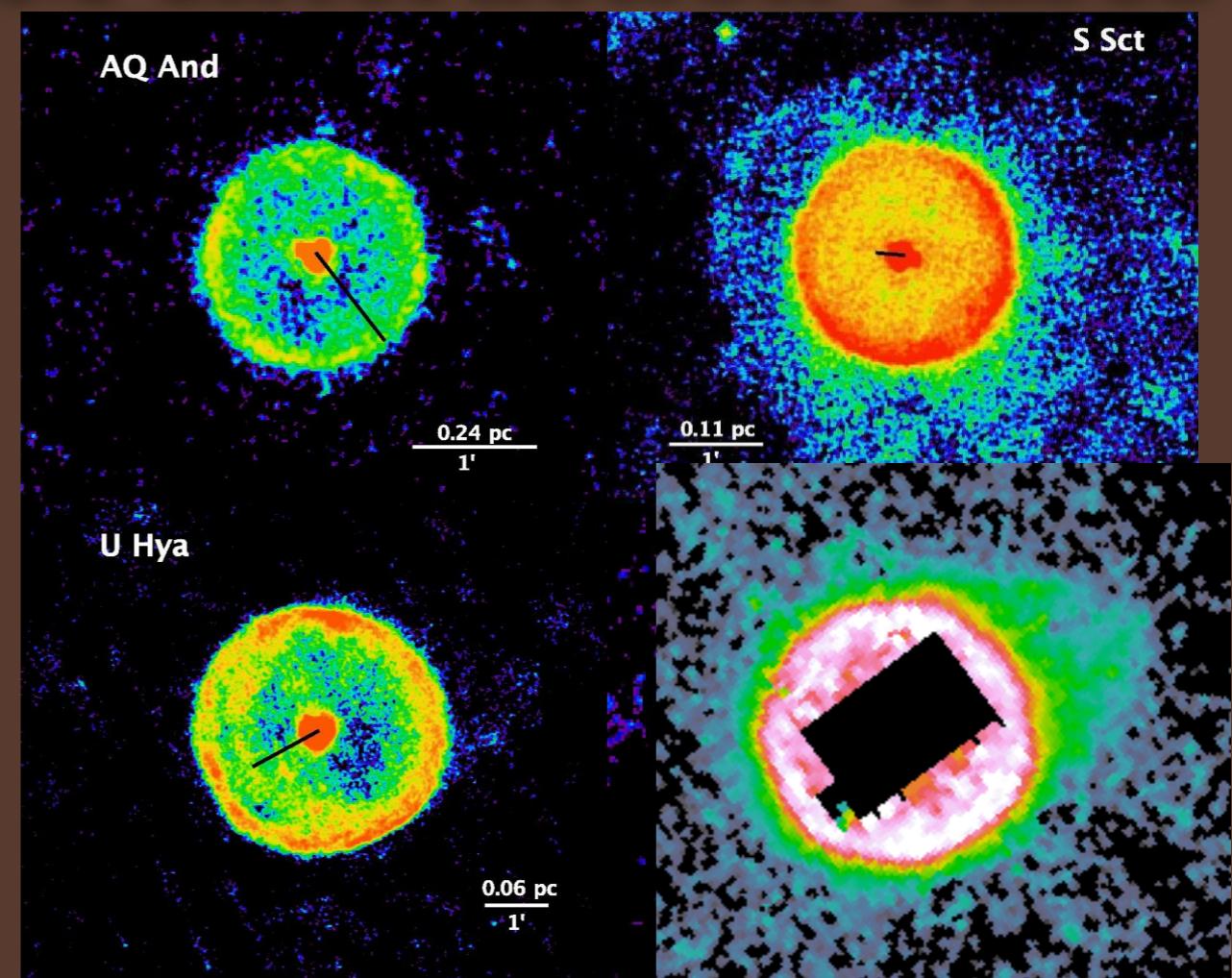
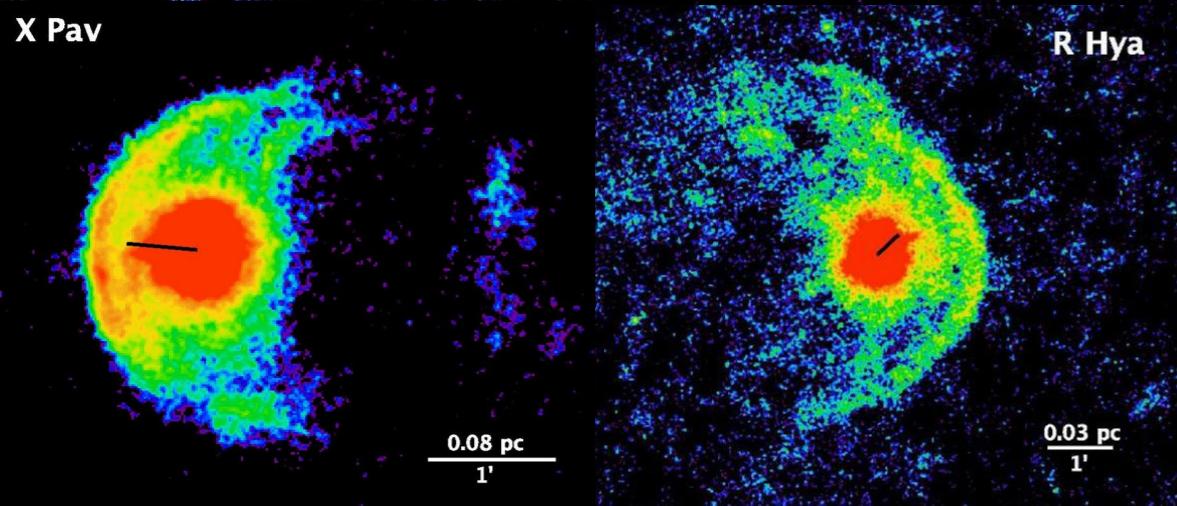
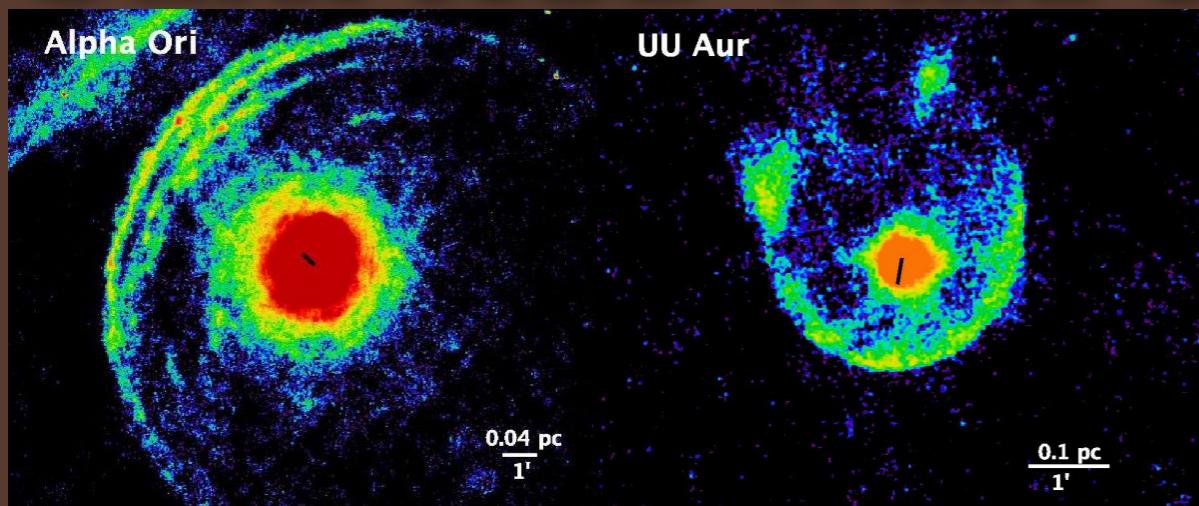
Other AGB Wind-ISM Interaction Cases



Herschel - MESS
(Cox *et al. in press*)

Sky Noise ~ 5 MJy/sr

Other AGB Wind-ISM Interaction Cases



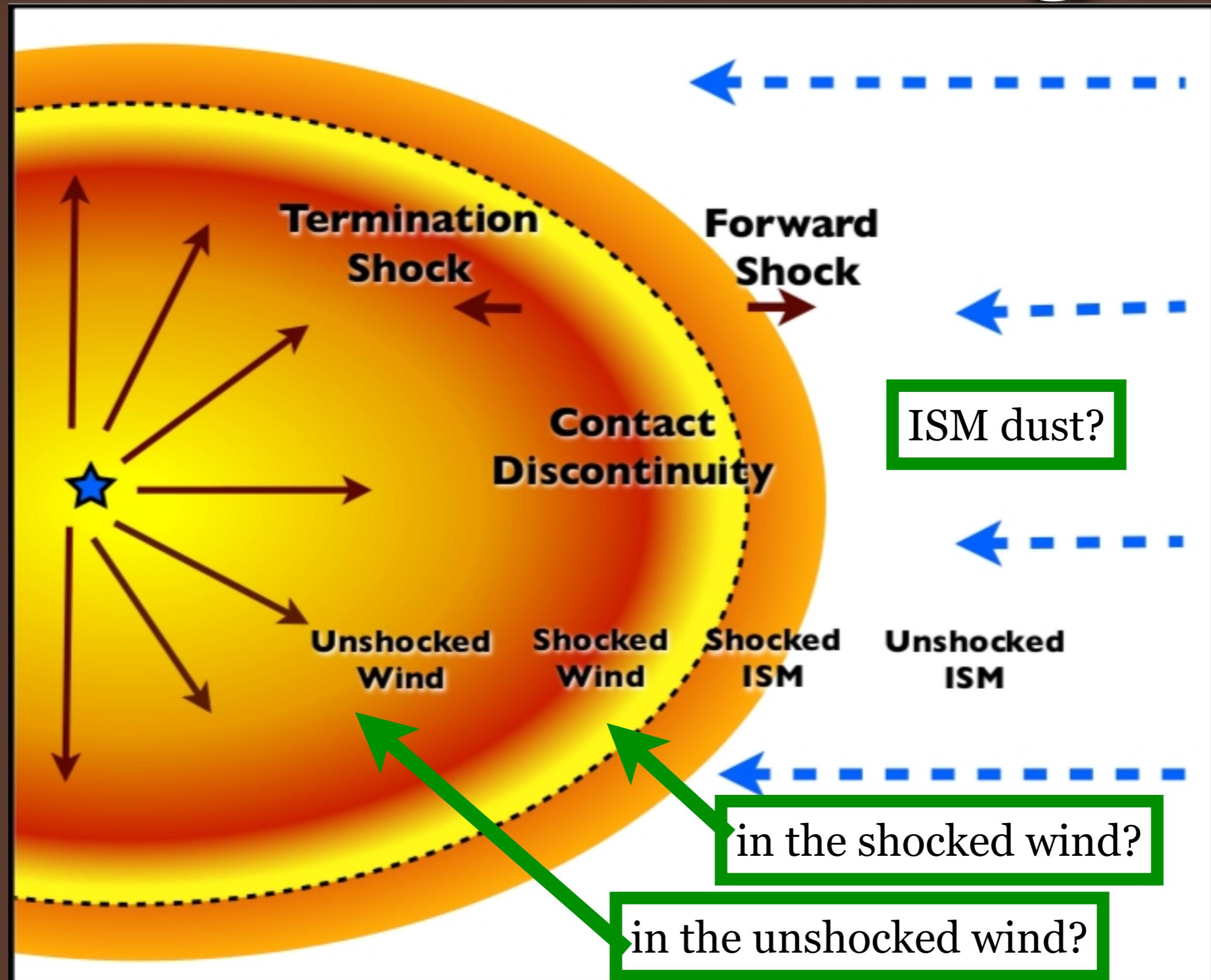
Herschel - MESS
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Sky Noise ~ 5 MJy/sr

AGB Wind-ISM Interaction Cases

- Observed ~60% (up to 80%) of the time
- Dust processing happening ~60% (up to 80%) of the time

Where is far-IR emitting dust?



Summary

- (1) CSM-ISM interacting regions provide THE LAST processing sites for CSM dust grains before becoming ISM dust grains
- (2) Far-IR emission of the CSM-ISM interaction regions appears in ~60% (up to 80%?) of the observed cases
 - a) in the reverse-shocked wind region, or
 - b) in the unshocked wind region illuminated by radiation from the shocked regions
 - c) what about ISM dust grains?
- (3) Spectroscopic shock diagnostics
 - a) Herschel sensitivity is not enough
 - b) IPHAS, WISE follow-up on the presence of shocks
 - c) ALMA, JWST, SPICA follow-up of shock diagnostics

Where? Mechanisms?