Protostar Surve
(HOPS)

A multi-observatory s
of Spitzer identifi
Protostars in the O
Molecular cloud

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Osorio (Instituto de Astrofisica de Andalucia), Klaus Pontoppidan (Caltech),
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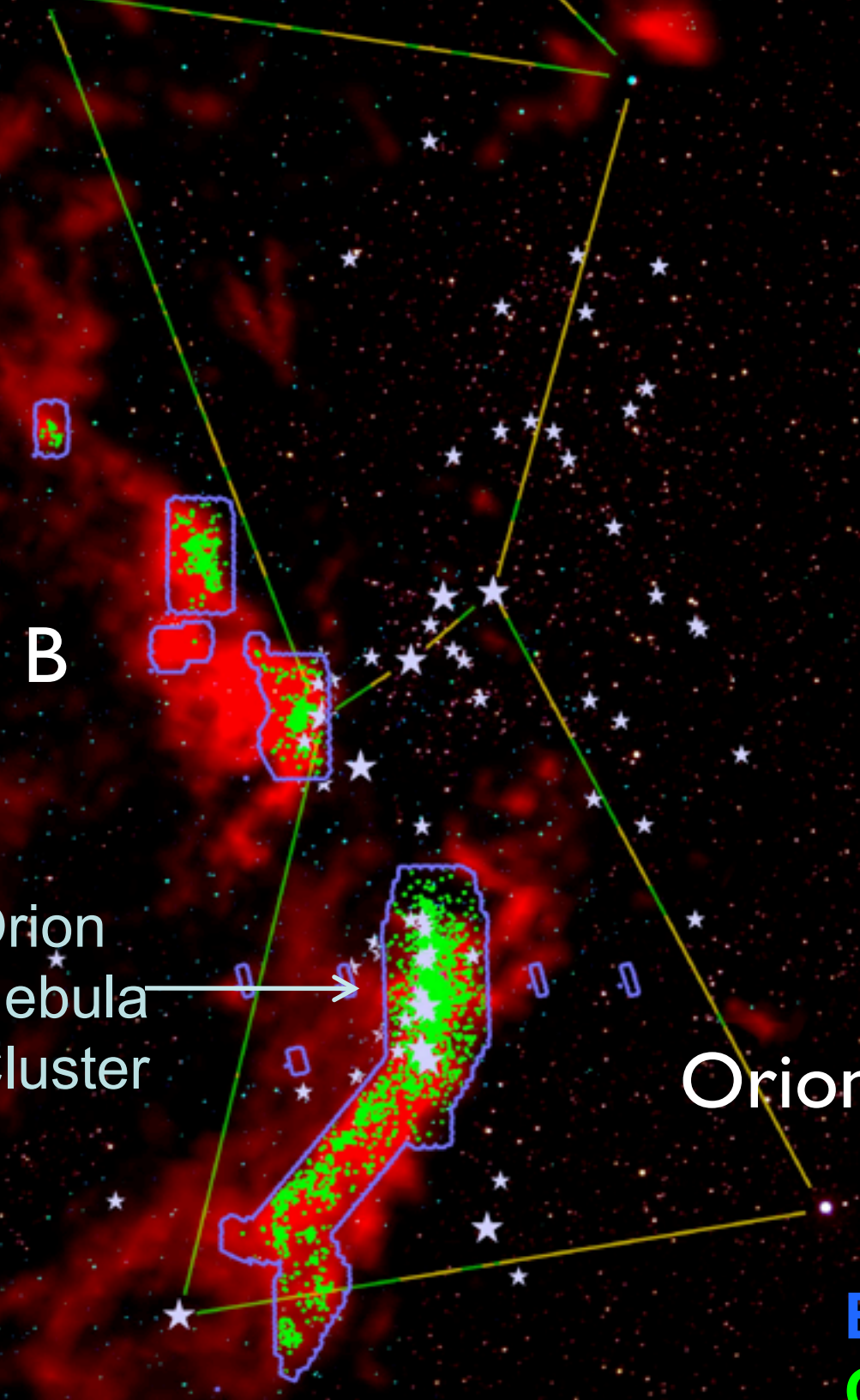
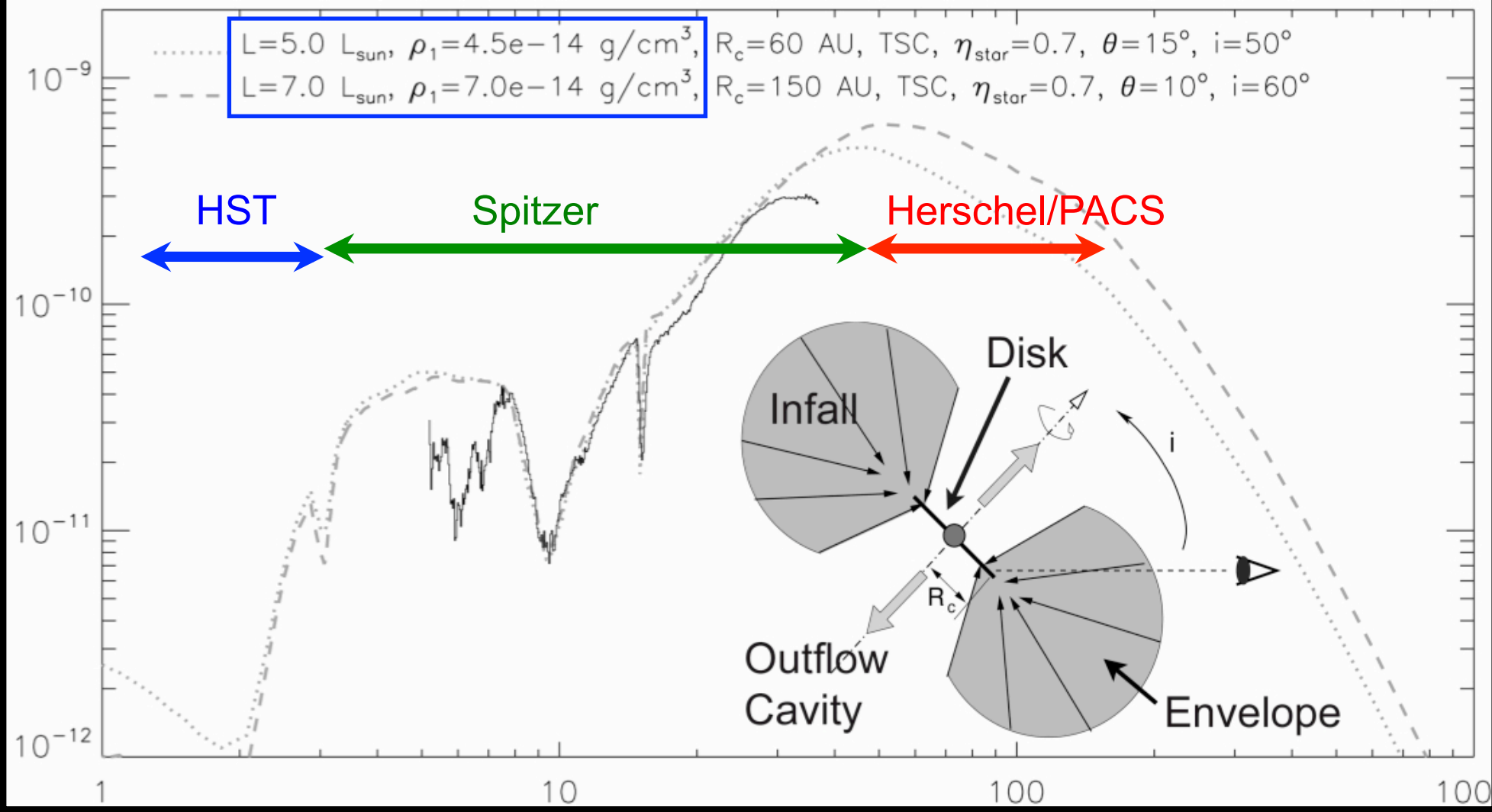


finding machine" in O

- ✓ Over 400 protostar candidat
- ✓ Spanning a large luminosity
- ✓ In a variety of evolutionary s
- ✓ And in a wide variety of environments

➔ Follow up with *Herschel*

Blue lines: Spitzer Survey
Green dots: Spitzer YSOS



udy a large sample of protostars in a single cloud with
mbined Herschel, Spitzer, Hubble and ground-based dat

his data we can:

Determine fundamental properties of the protostars through modeling of the

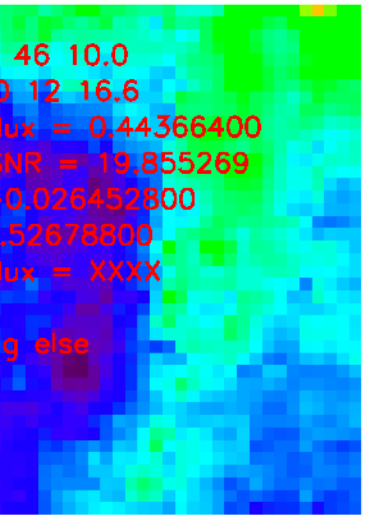
de by Side Comparison:

	Orion	**NGC 281**
Distance (pc)	470	2810
5.5 arc-sec equals	2586 AU	15455 AU
Number of Protostars	400+	?
Number of PBRs	A few dozen?	? (likely not detected)
Formation mechanism	Trigger + Spontaneous	Trigger
Distribution of stars	Clumped and distributed	Clumped
Types of protostars	Low and Highmass	Mostly high mass?

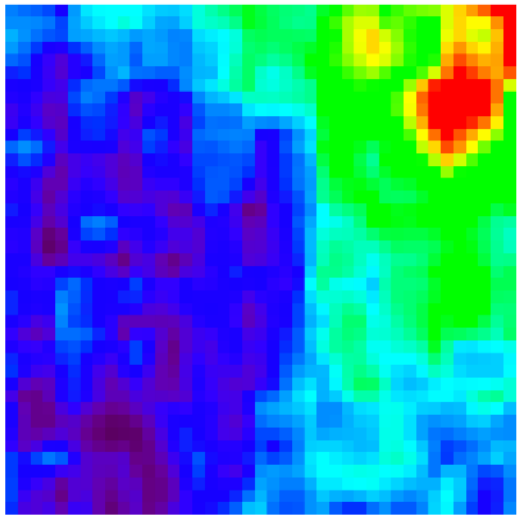
Expected Surprises

itzer at 24 microns

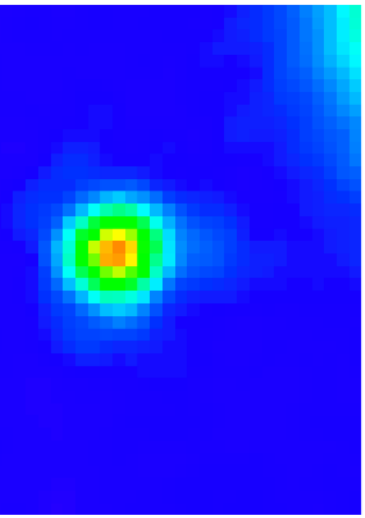
no detection at 24 μm but bright at 70 μm



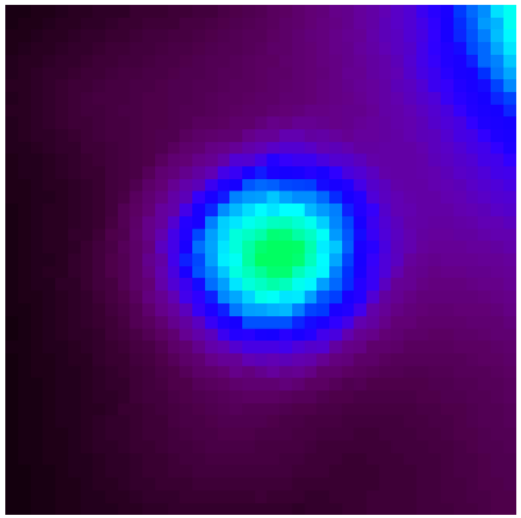
8 μm



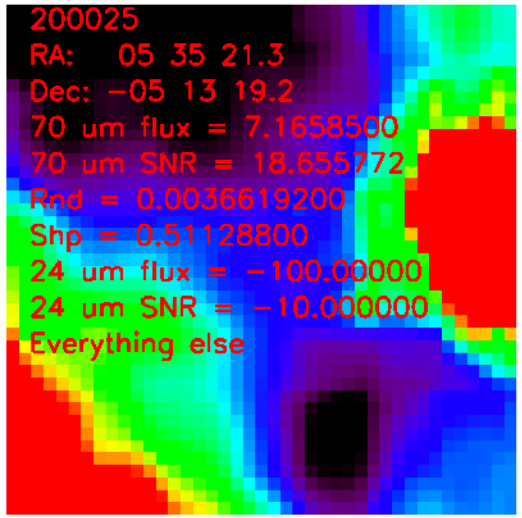
24 μm



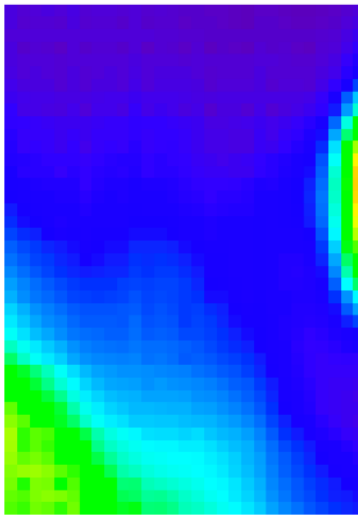
70 μm



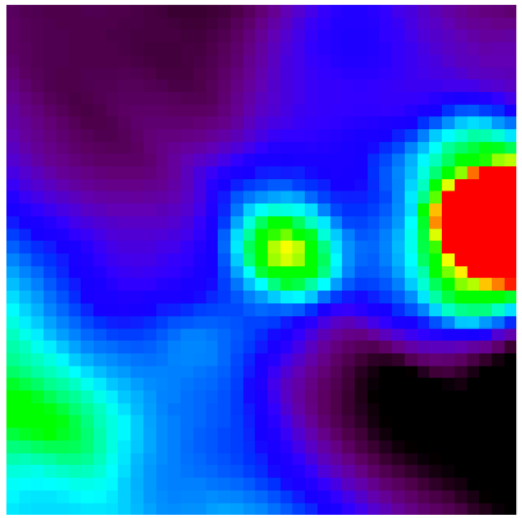
160 μm



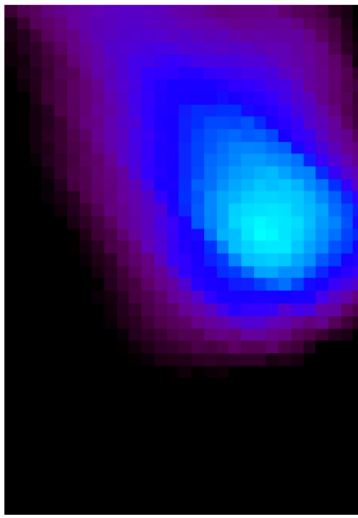
8 μm



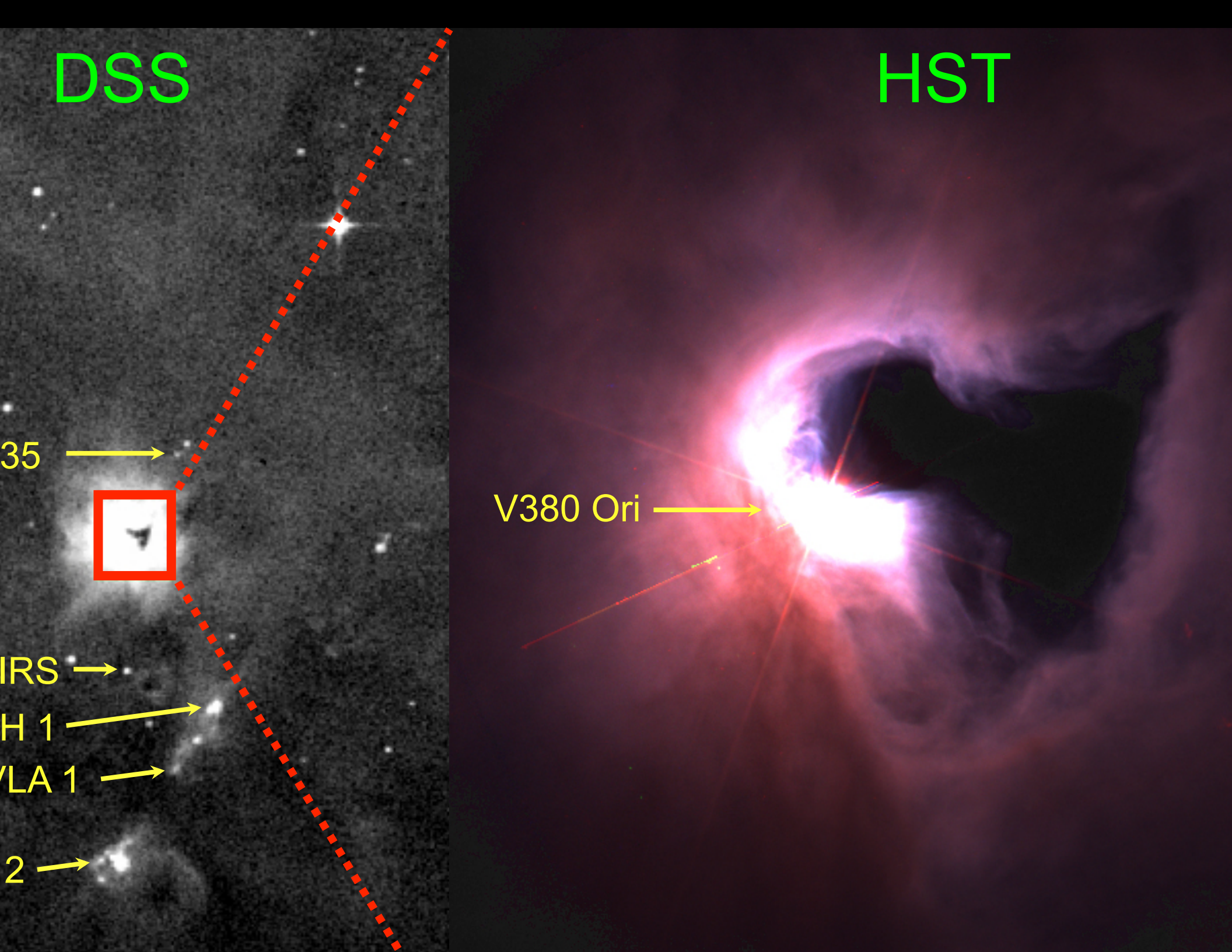
24 μm

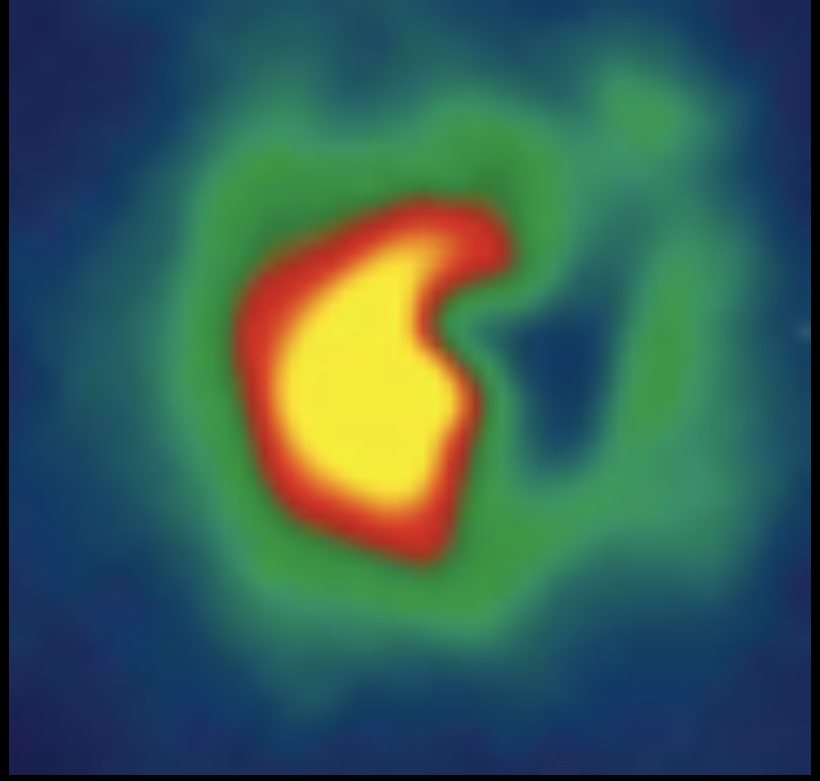


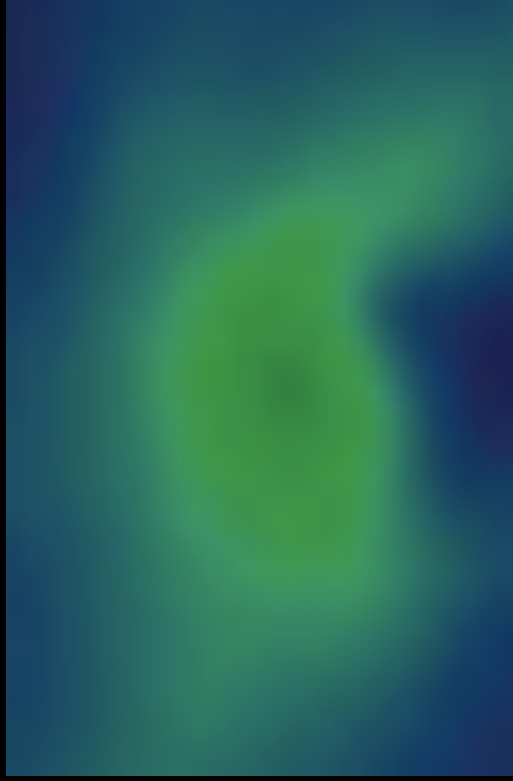
70 μm



160 μm


DSS
HST
35
IRS
H 1
LA 1
2
V380 Ori





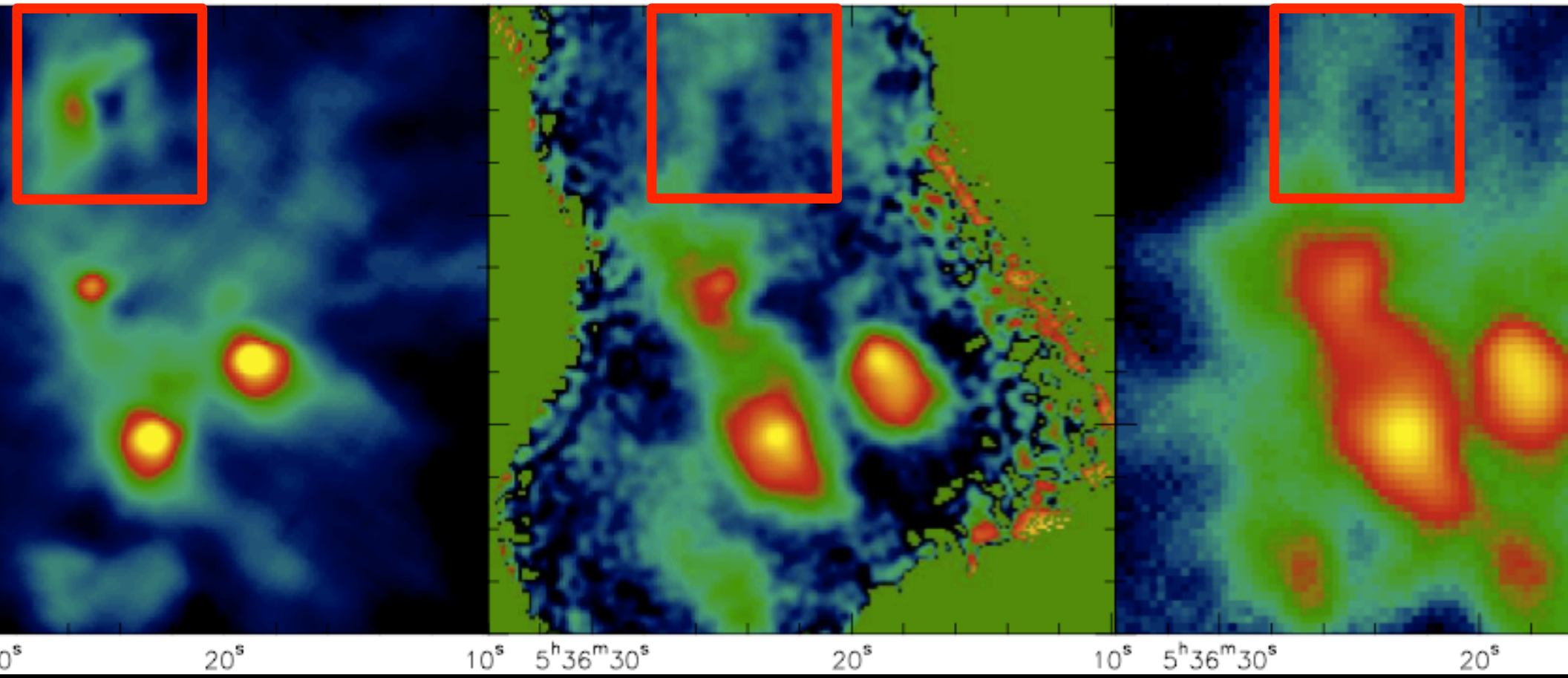
region remains dark at 70 and 160 μm: a far-IR dark clo

ss responsible for the flux decrement is wavelength-endent!? (A. Stutz)

- 0.1 M_{sun} at 70 μm
- 2.5 M_{sun} at 160 μm

$$\tau = - \ln [(f + f_{BG}) / (f_0 + f_{BG})]$$

PACS 160 μm SABOCA 350 μm LABOCA 870

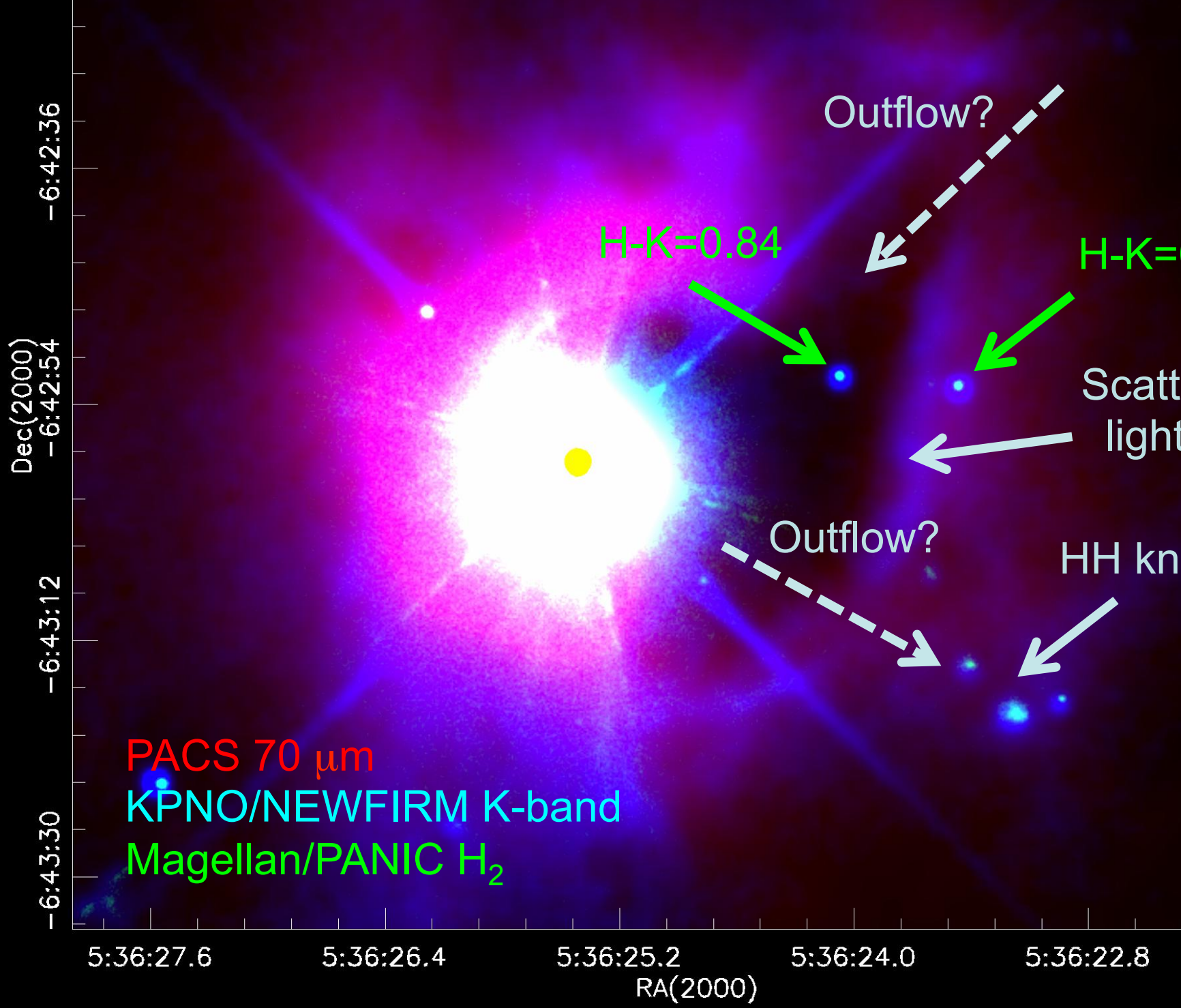


R dark cloud should be bright in sub-mm

Not detected

SABOCA (350 μm) upper mass limit: 2.4 x 10^{-2} M_{sun}

Tobin,
Allen,
ryukova)

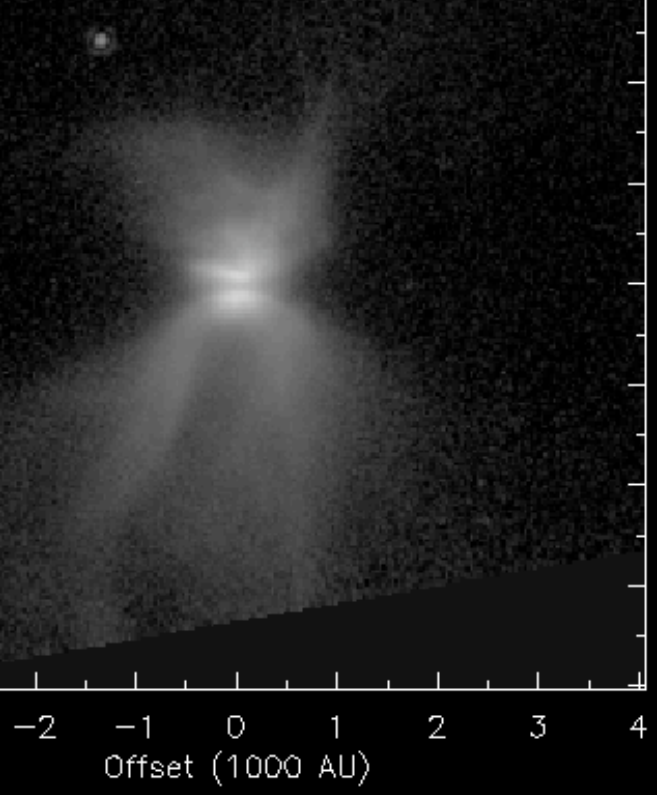


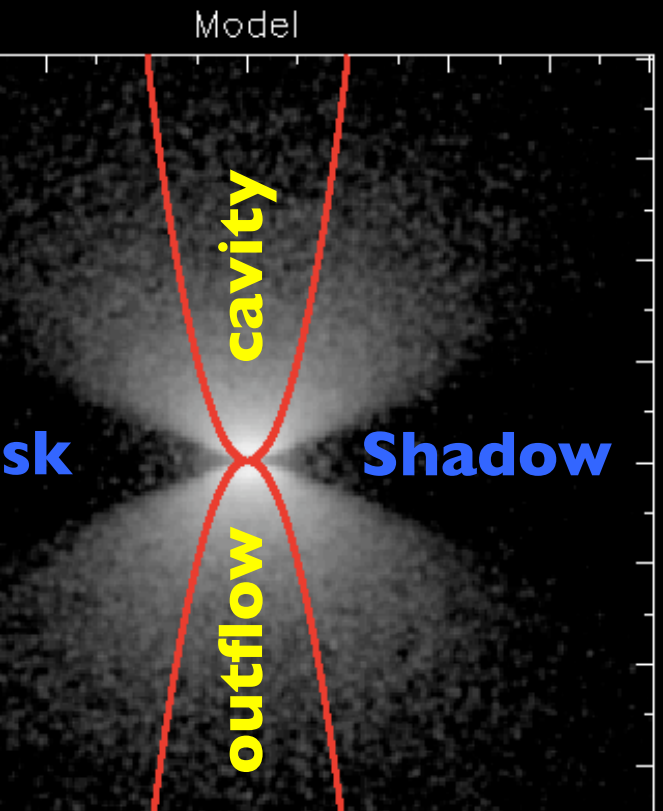
colors of stars imply A_V~10, not 100

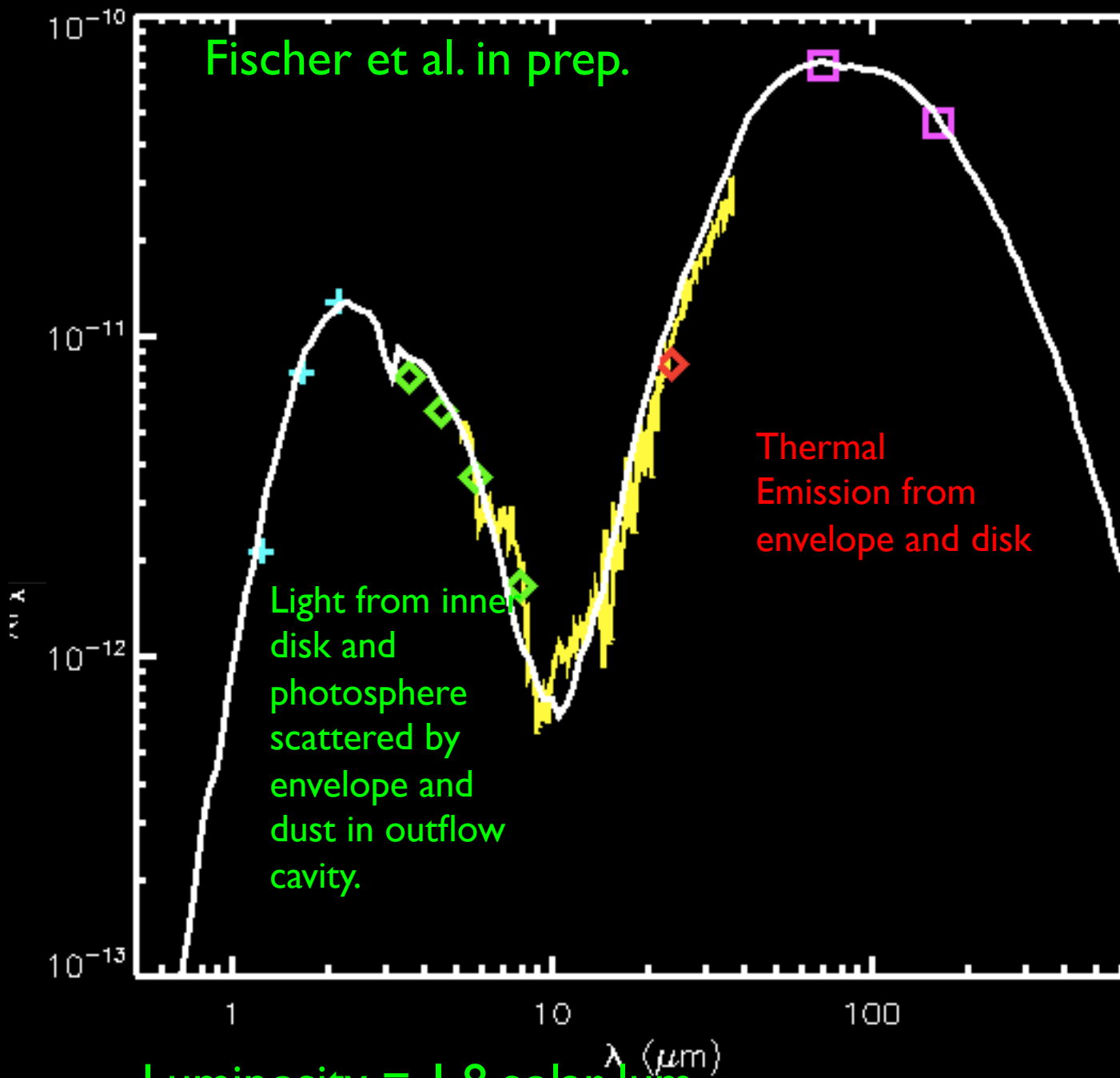
colors of stars inside the dark patch are bluer than those of stars outside the

Photometry Results

Edge-on Protostar



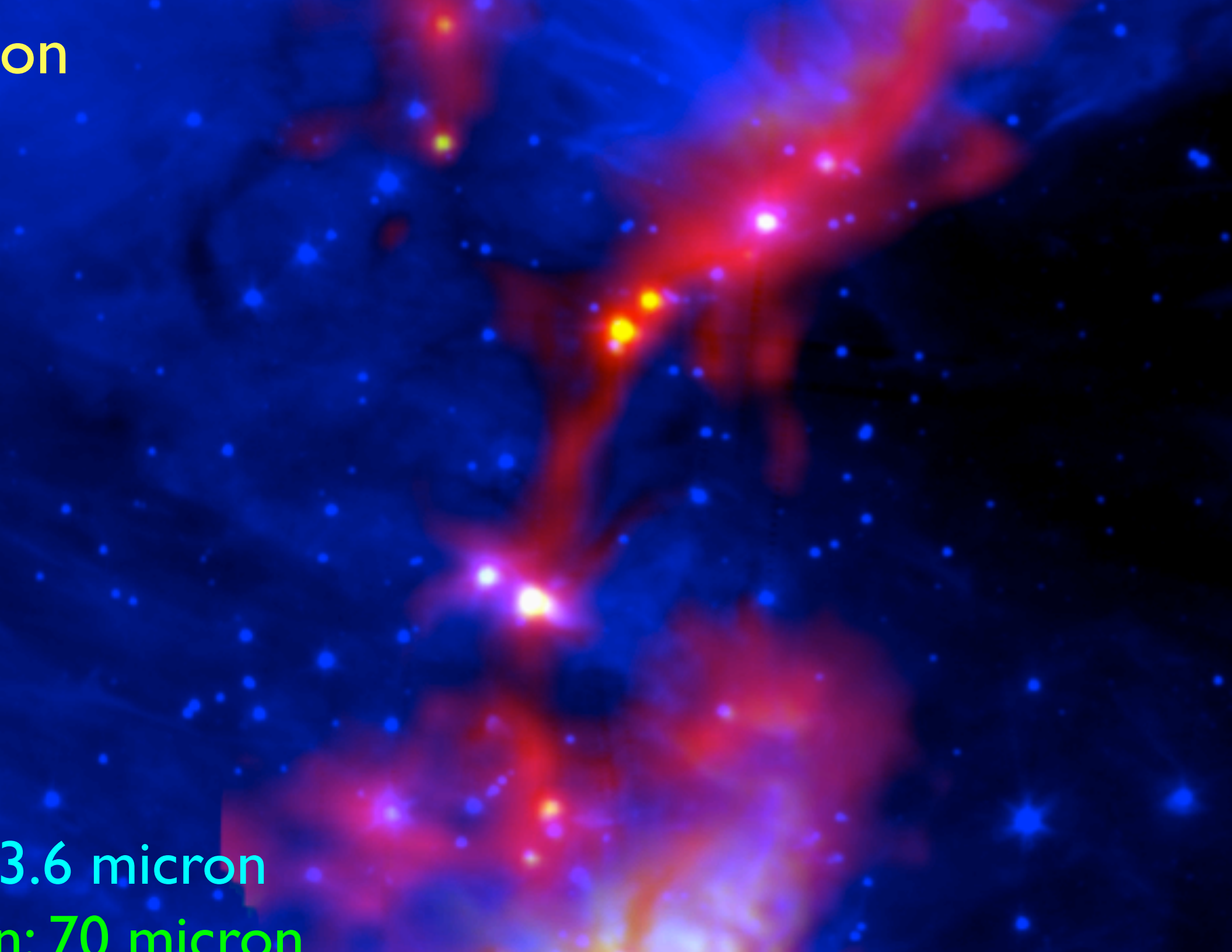


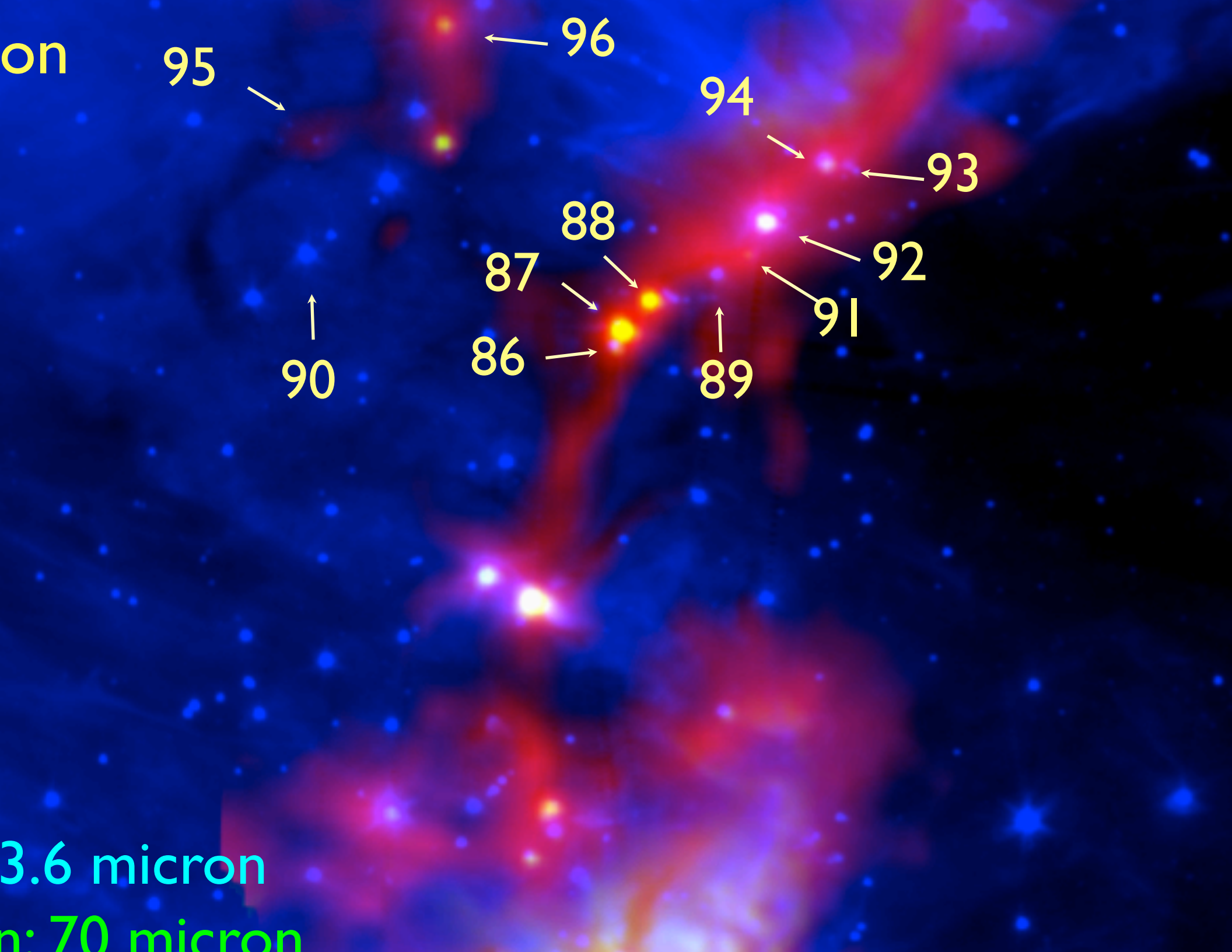


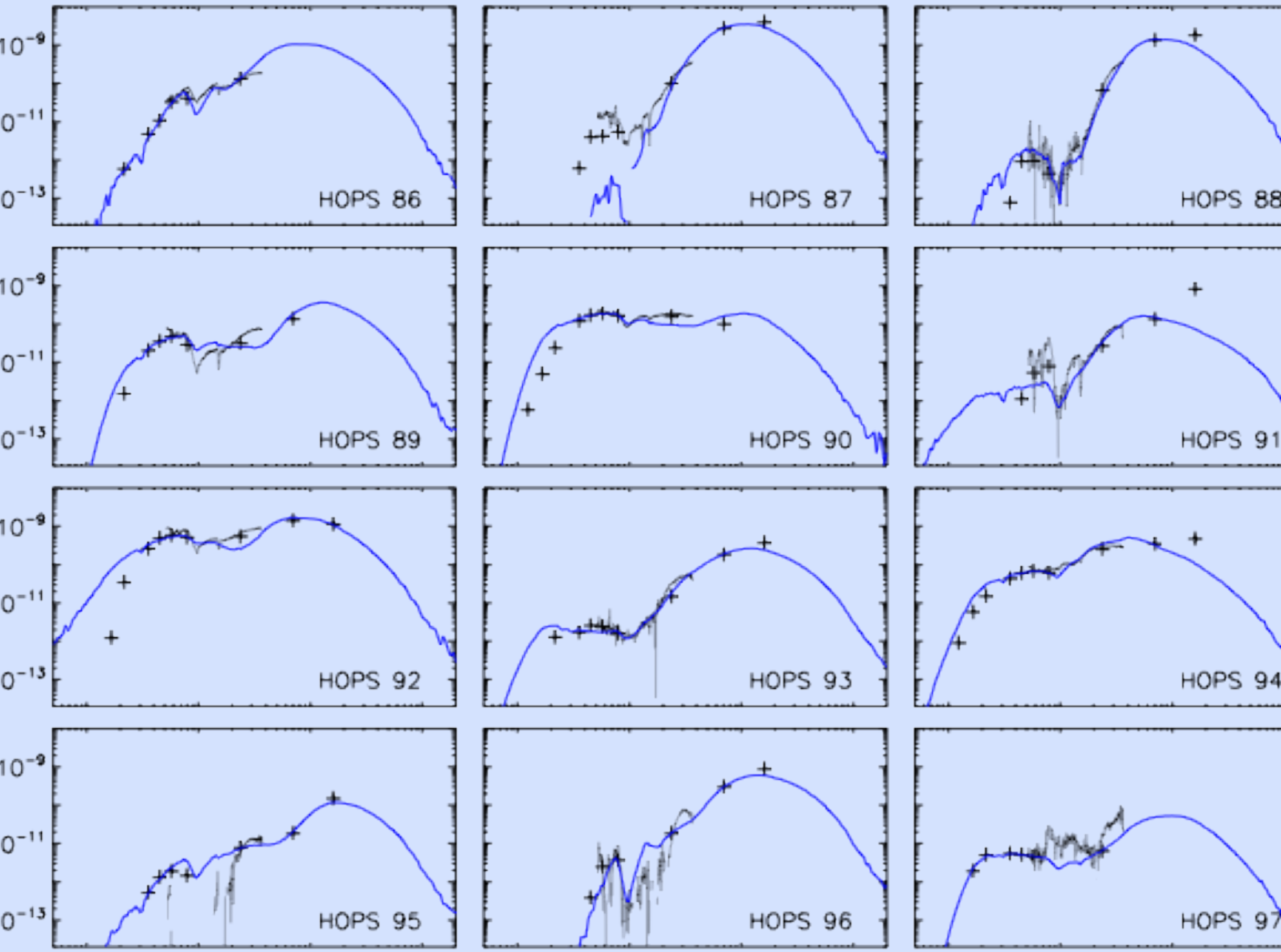
Luminosity = 1.8 solar lum.

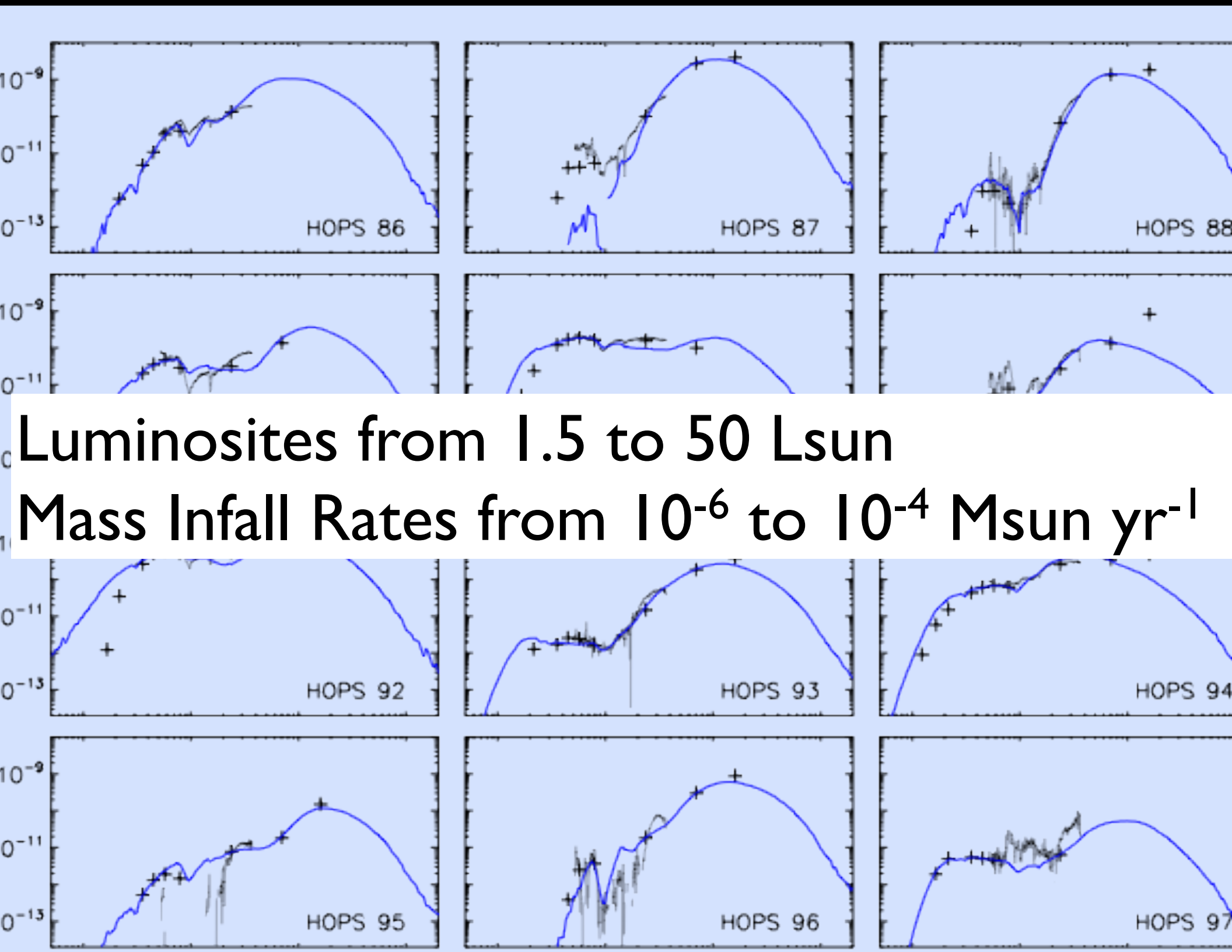
Mass infall = 3×10^{-6} solar masses per year

Rc = 500 AU


on
3.6 micron
n: 70 micron

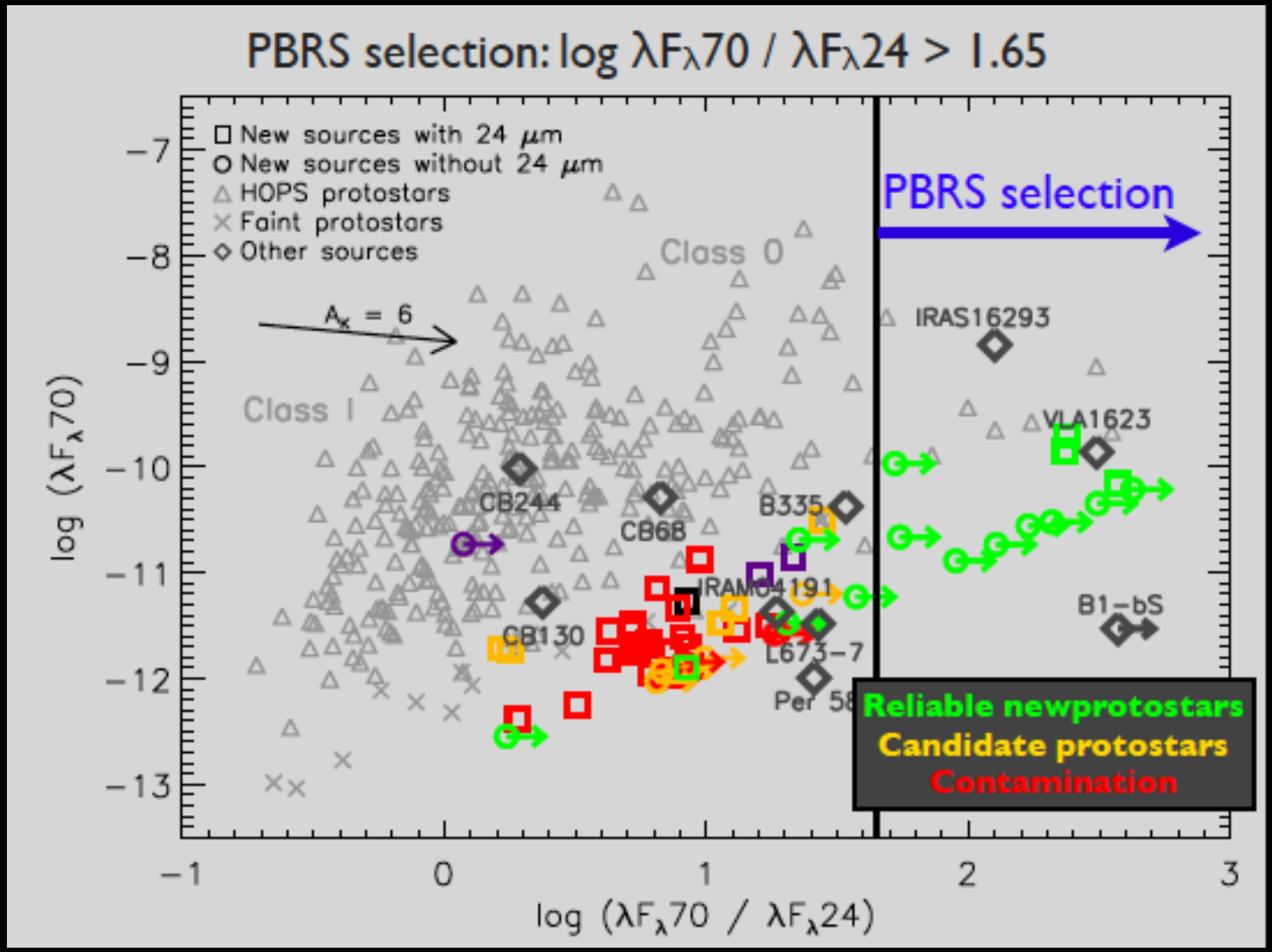

on
95
96
94
93
88
87
92
91
90
86
89
3.6 micron
n: 70 micron

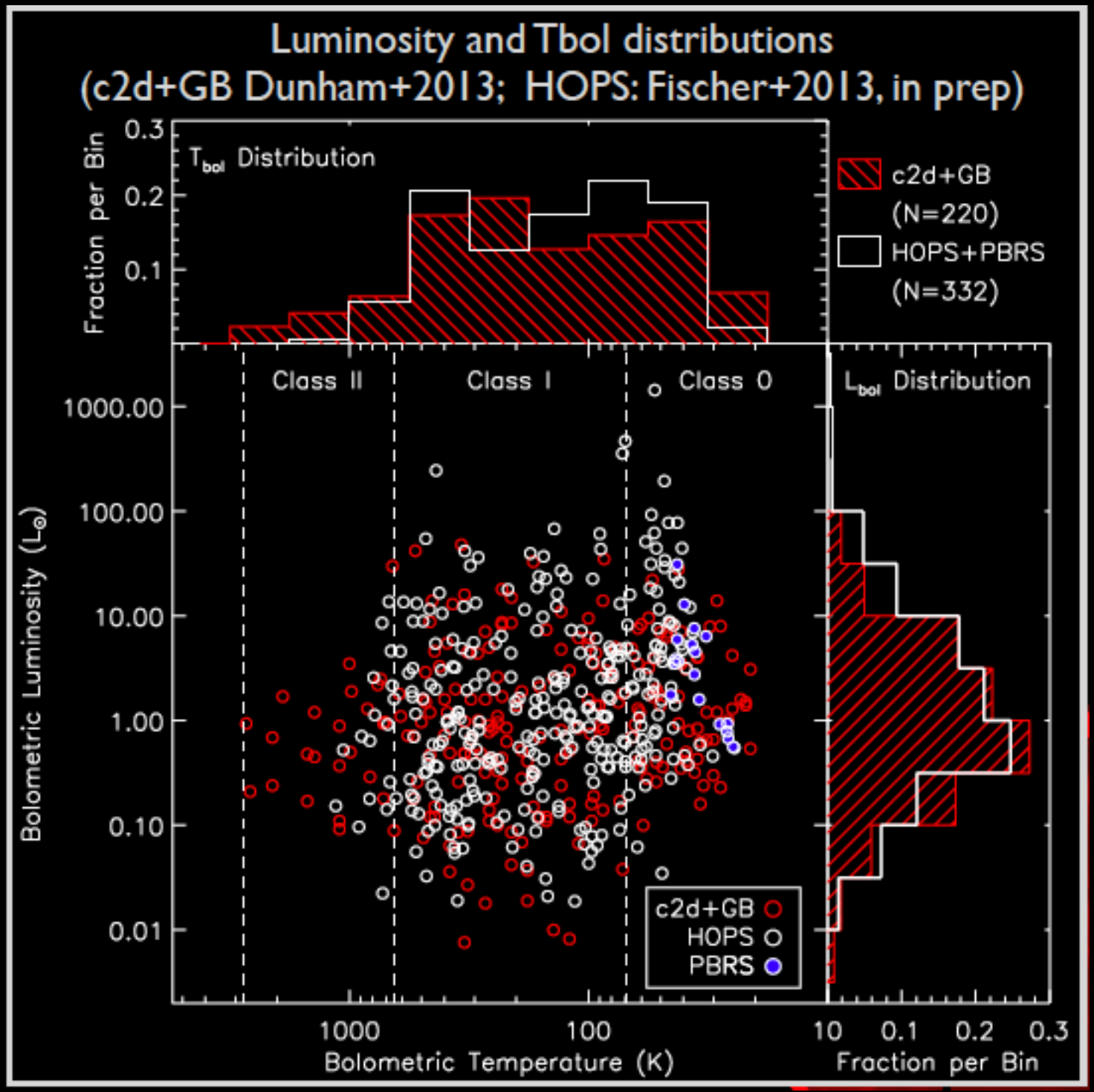

HOPS 86
HOPS 87
HOPS 88
HOPS 89
HOPS 90
HOPS 91
HOPS 92
HOPS 93
HOPS 94
HOPS 95
HOPS 96
HOPS 97



Luminosites from 1.5 to 50 Lsun

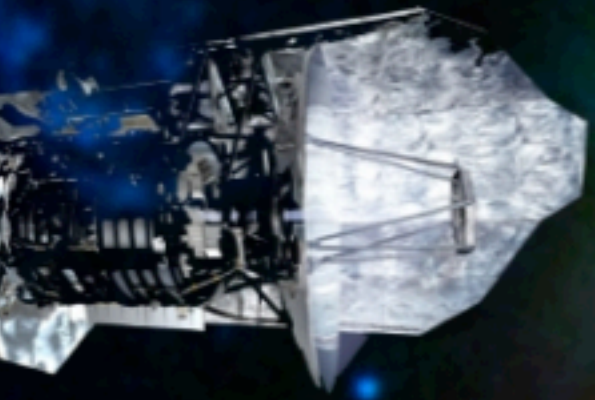
Mass Infall Rates from 10^{-6} to 10^{-4} Msun yr^{-1}


PBRS selection: log λFλ70 / λFλ24 > 1.65
New sources with 24 μm
New sources without 24 μm
HOPS protostars
Faint protostars
Other sources
PBRS selection
Class 0
Class I
A_K = 6
IRAS16293
VLA1623
CB244
CB68
B335
IRAM04191
CB130
L673-7
B1-bS
Per 58
Reliable newprotostars
Candidate protostars
Contamination
log (λFλ70)
log (λFλ70 / λFλ24)
−7
−8
−9
−10
−11
−12
−13
−1
0
1
2
3


Luminosity and Tbol distributions
(c2d+GB Dunham+2013; HOPS: Fischer+2013, in prep)
Fraction per Bin
0.3
0.2
0.1
T_{bol} Distribution
c2d+GB
(N=220)
HOPS+PBRS
(N=332)
Class II
Class I
Class 0
L_{bol} Distribution
Bolometric Luminosity ($L_\odot$)
1000.00
100.00
10.00
1.00
0.10
0.01
c2d+GB
HOPS
PBRS
1000
100
10
Bolometric Temperature (K)
0.1
0.2
0.3
Fraction per Bin

Ein Loch im Himmel

Hole in the Sky HOPS Stout



Maumee Bay Brewing Co.,
Toledo, Ohio