

Observing the heart of IRAS18162-2048.

The driving source of HH80-81 revisited in the near-IR

Rubén Fedriani



5th May 2026

DSS optical RGB image



Star-forming region
IRAS 18162-2048.
Main source GGD27,
i.e., the driving source
of HH80-81

distance ~ 1.4 kpc

jet length > 10 pc

5 arcmin



DSS optical RGB image



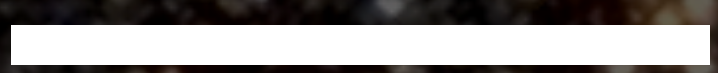
Star-forming region
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Gyulbudaghian et al. (1978)

5 arcmin



2MASS NIR RGB image

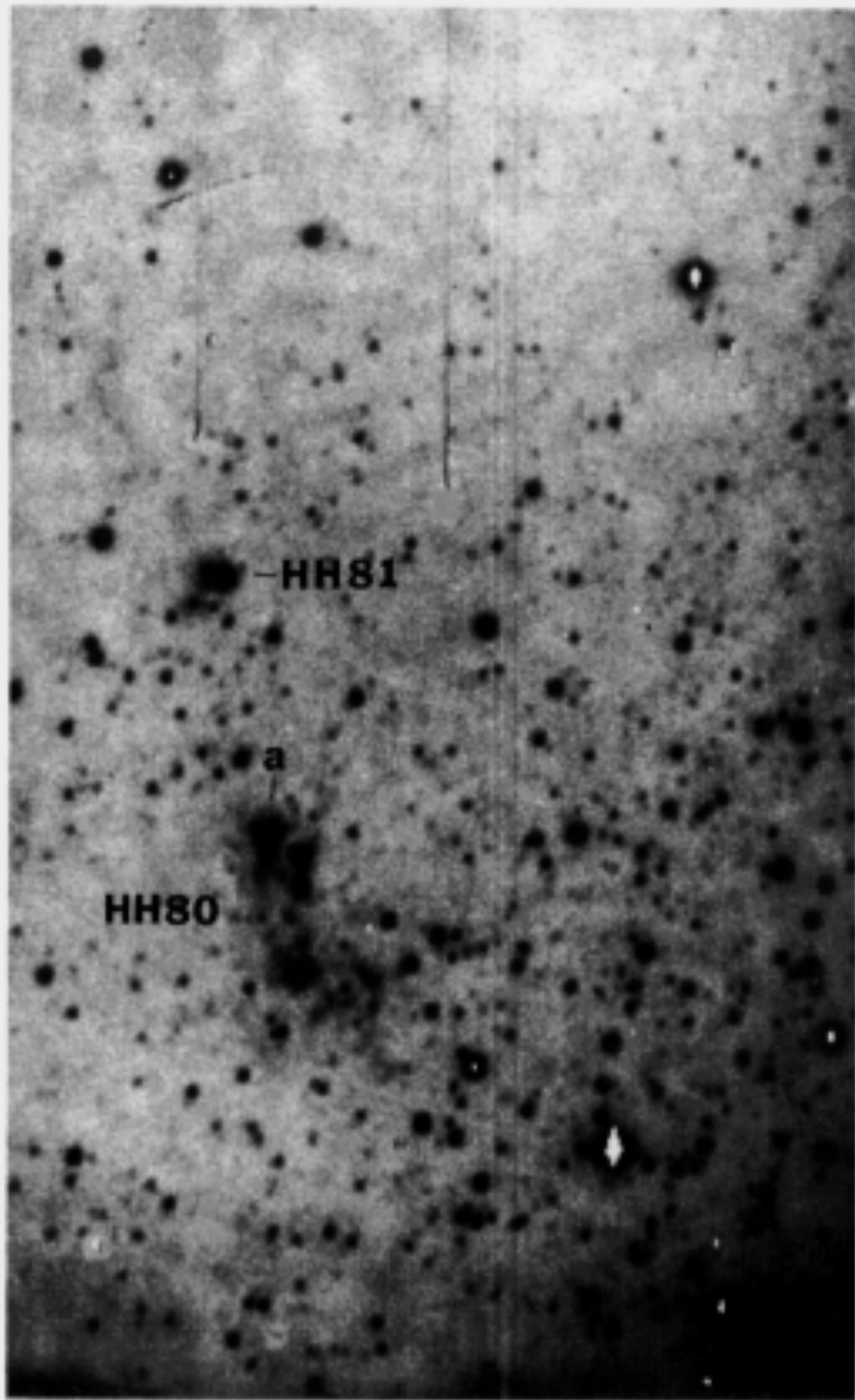


Fig. 25. The region of HH 80/81 in [S II] light. Exposure time 60 min. The field is 2'.5 x 4'



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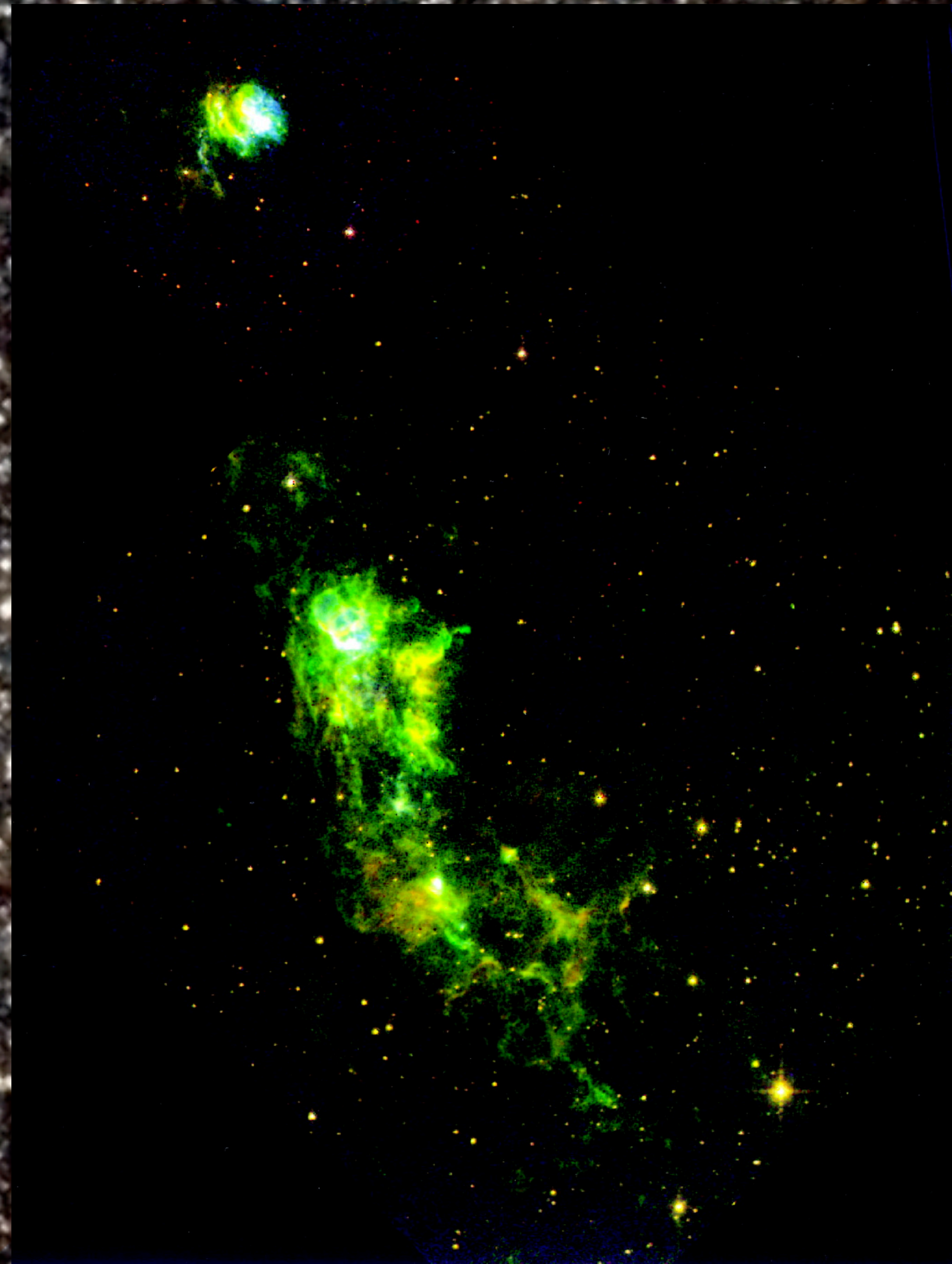
jet length > 10 pc

Gyulbudaghian et al. (1978)

Reipurth & Graham (1988)

5 arcmin





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IRAS 18162-2048.
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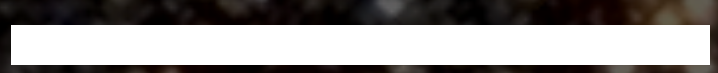
jet length > 10 pc

Gyulbudaghian et al. (1978)

Reipurth & Graham (1988)

Heathcote et al. (1998)

5 arcmin



2MASS NIR RGB image



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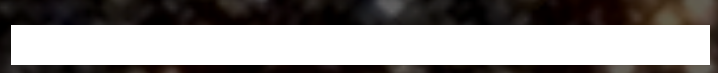
jet length > 10 pc

Gyulbudaghian et al. (1978)

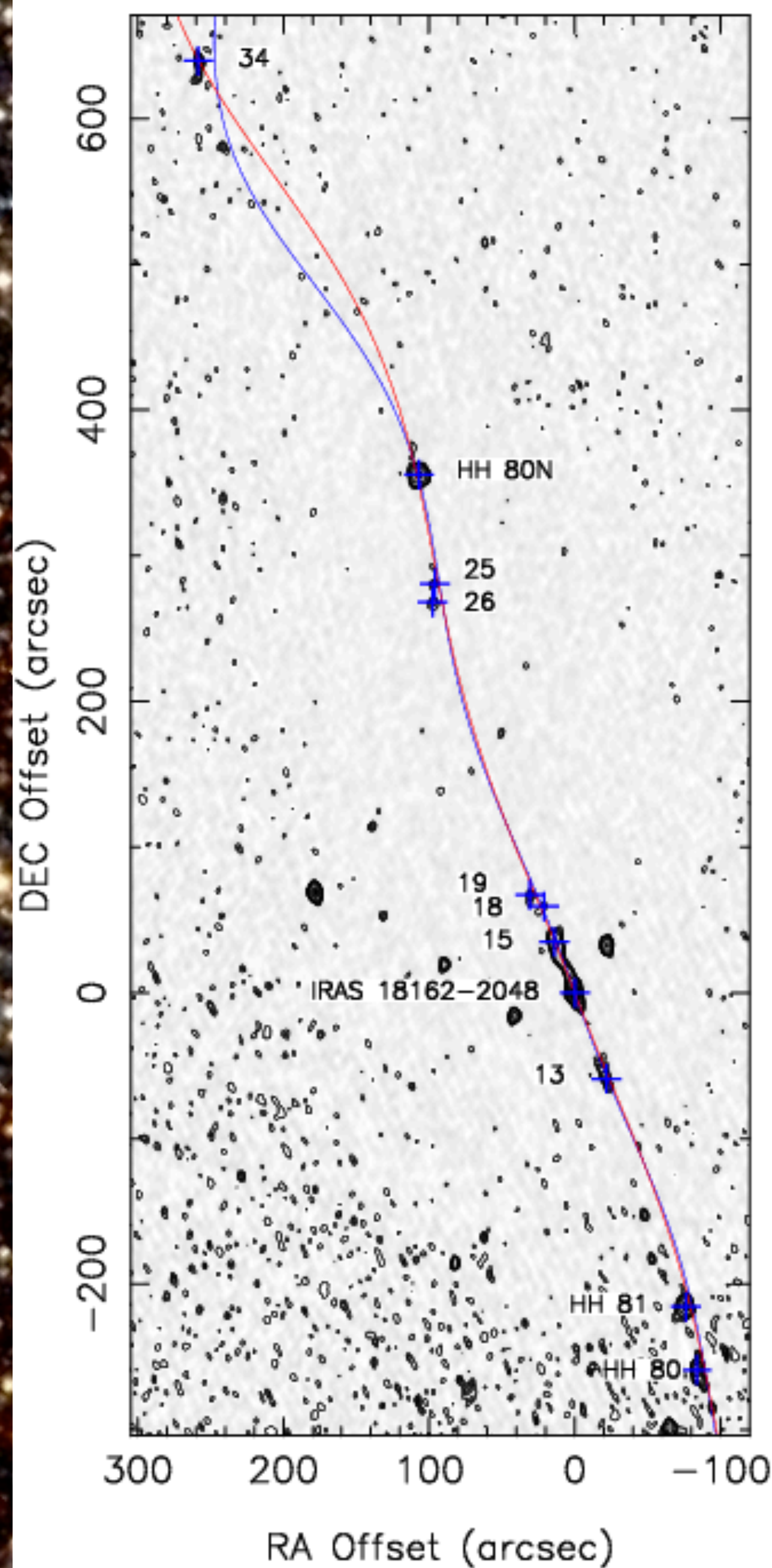
Reipurth & Graham (1988)

Heathcote et al. (1998)

5 arcmin



2MASS NIR RGB image



Star-forming region
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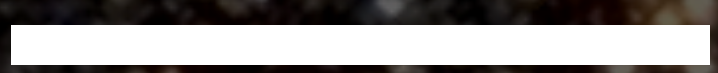
Gyulbudaghian et al. (1978)

Reipurth & Graham (1988)

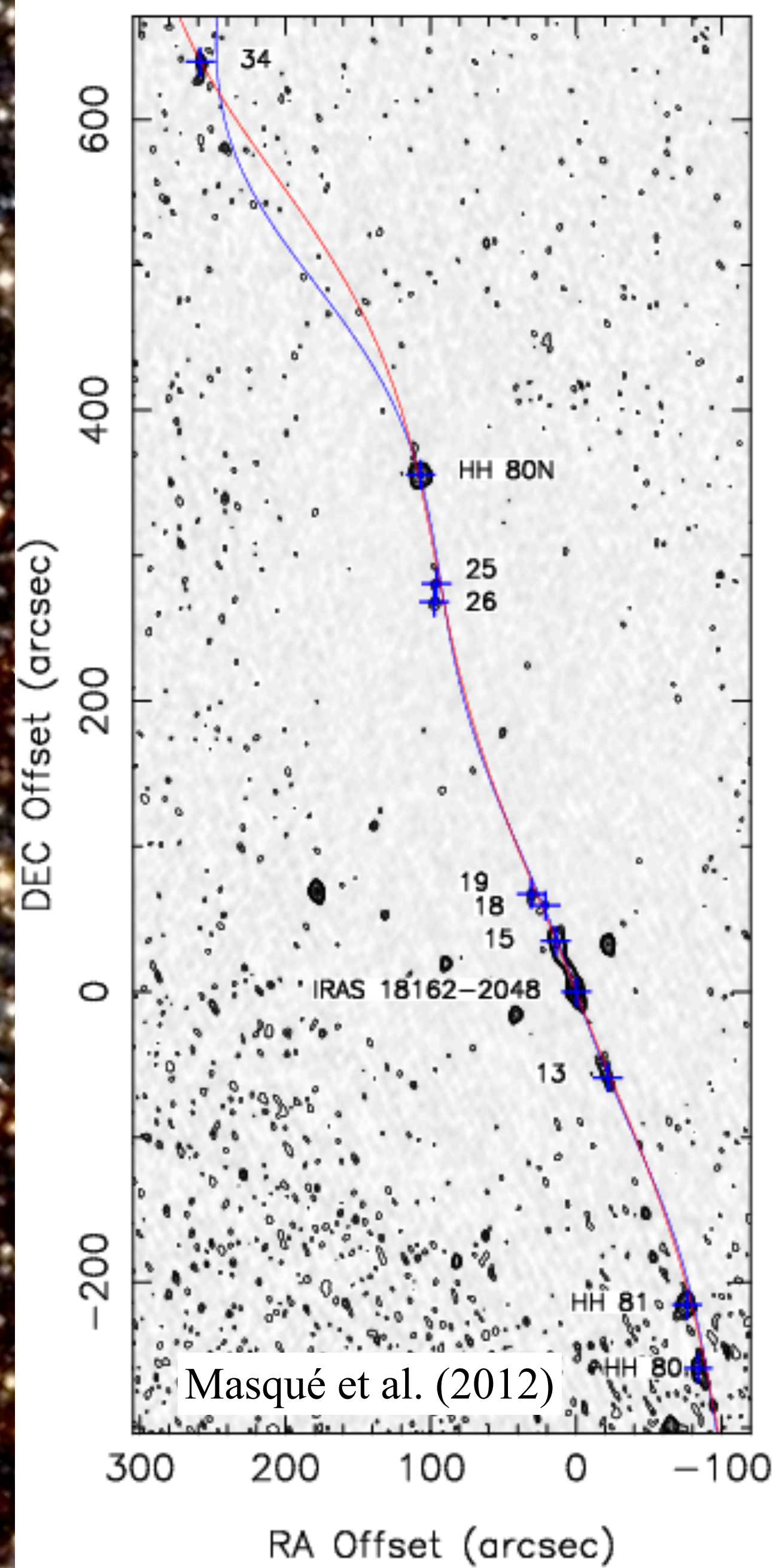
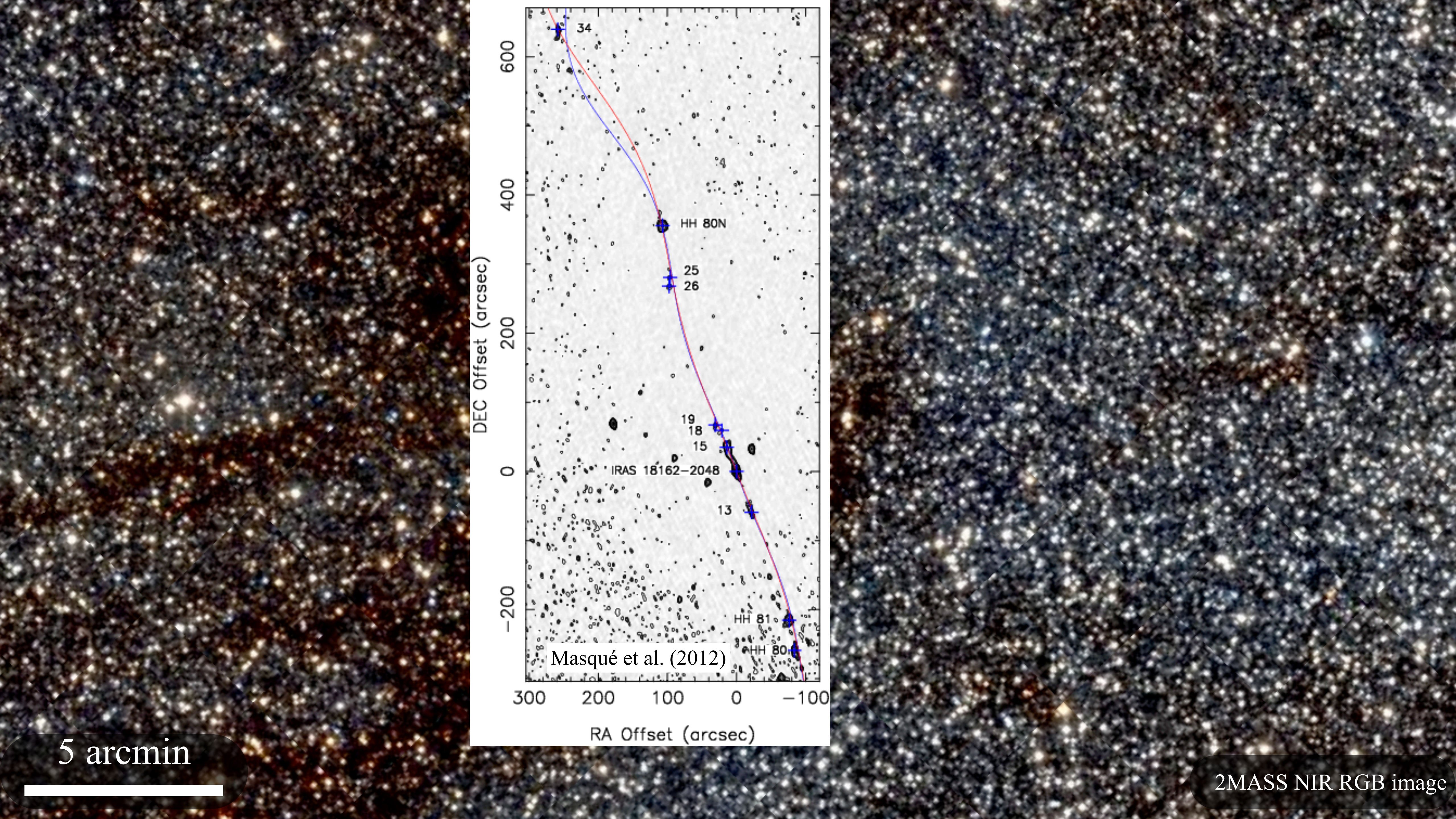
Heathcote et al. (1998)

Martí et al. (1993, 1995)

5 arcmin



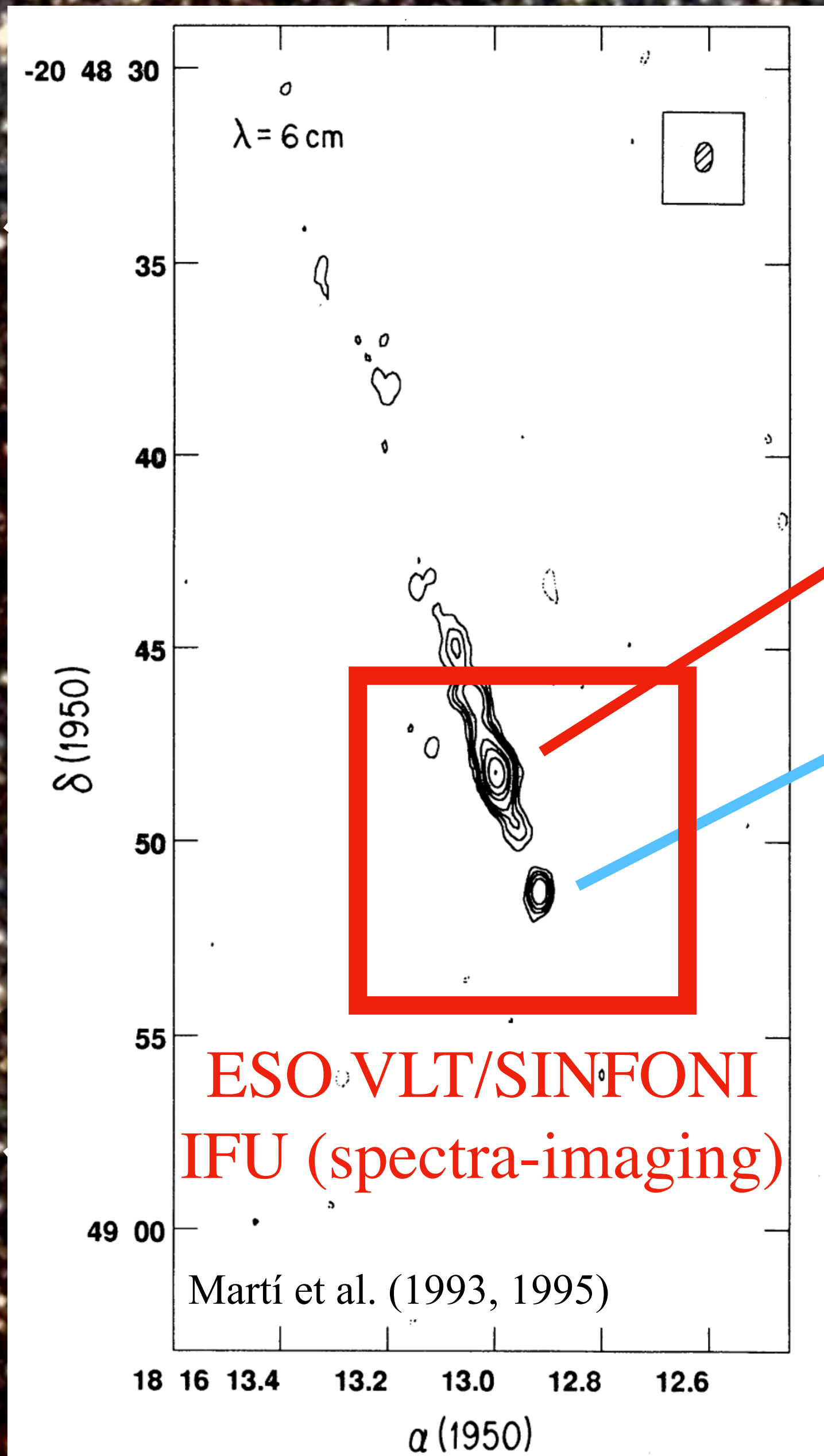
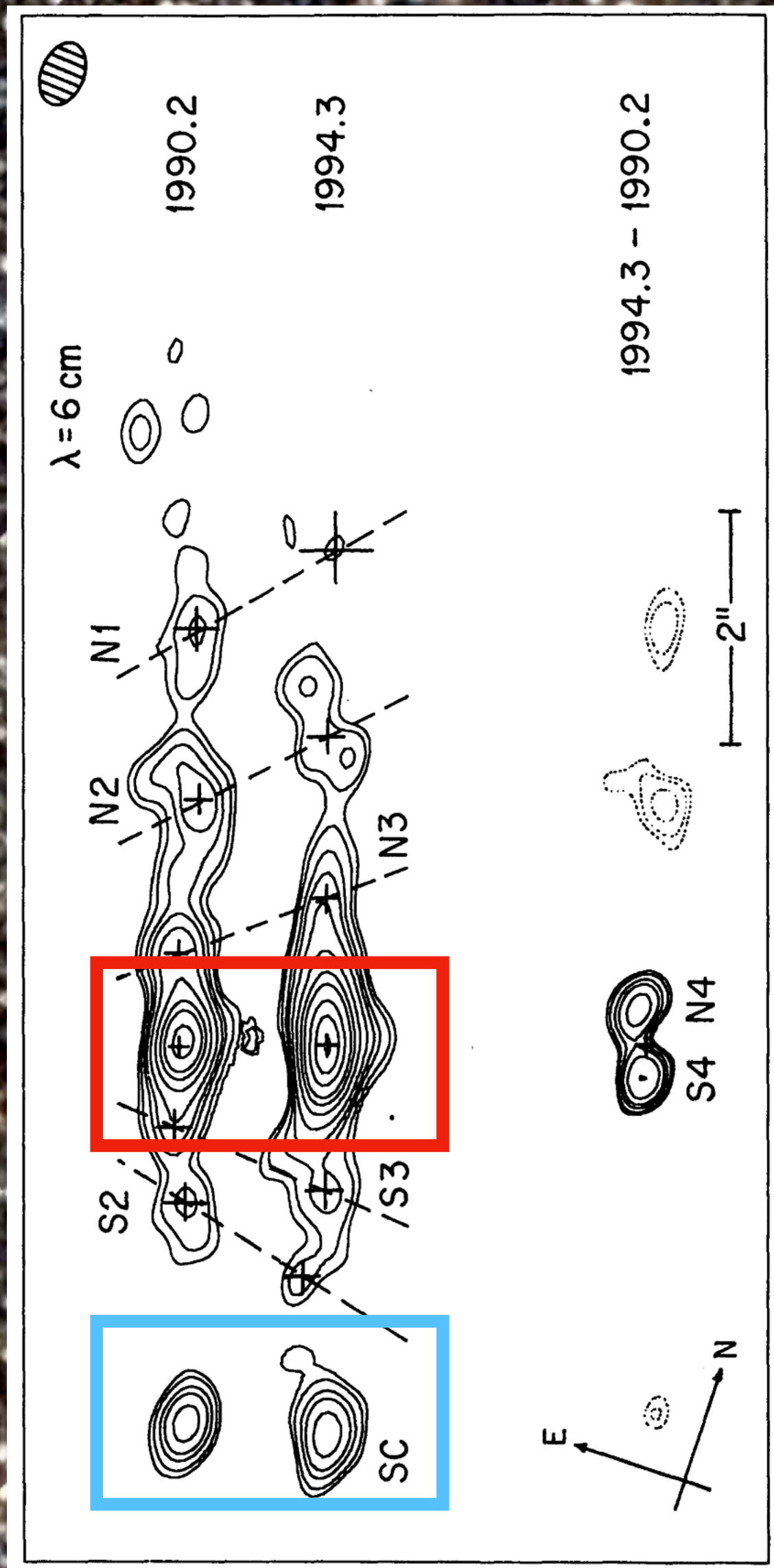
2MASS NIR RGB image



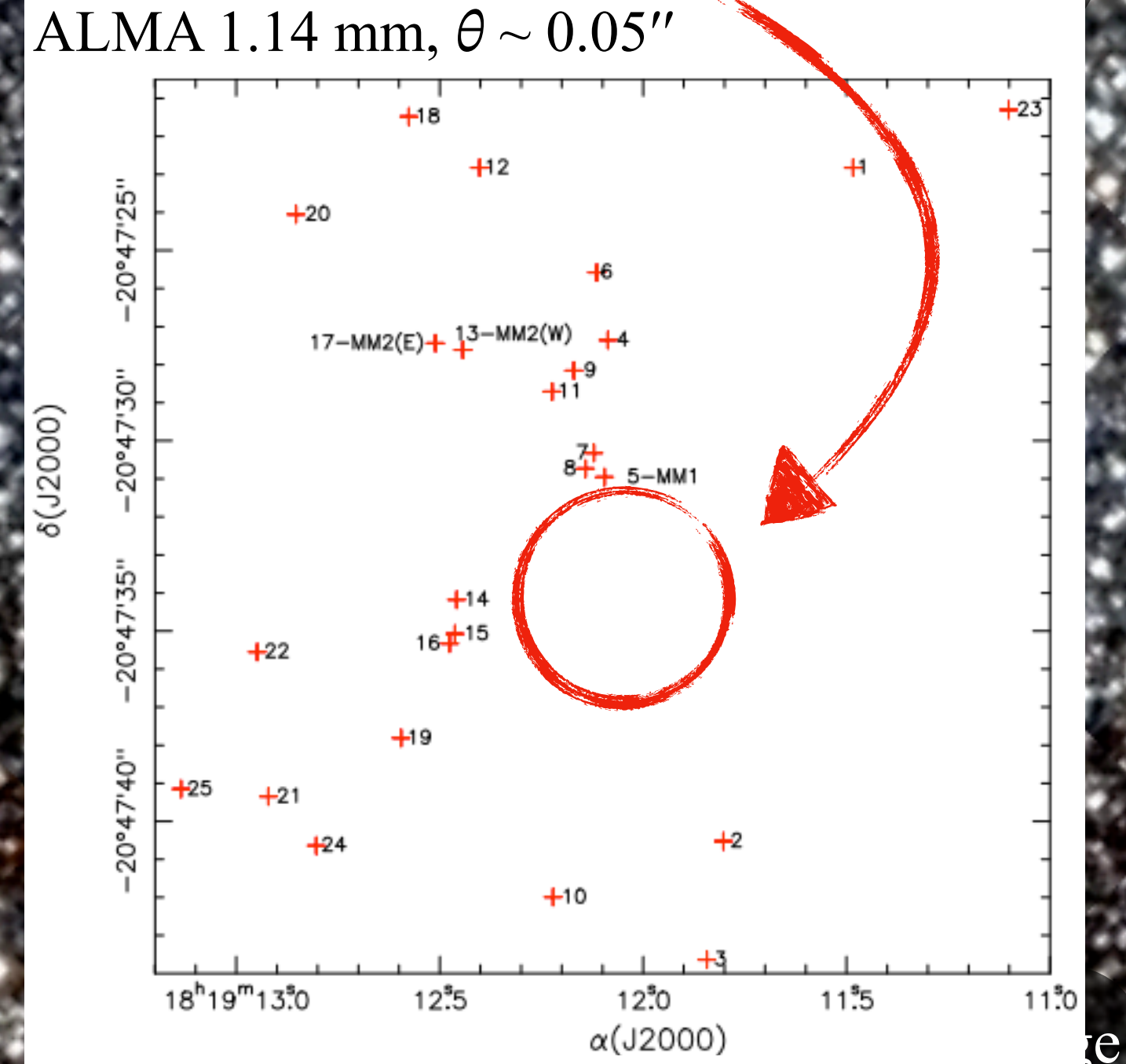
5 arcmin



2MASS NIR RGB image



GGD27 (or MM1)
SC
 (Stationary Condensation)
No detection at SC position

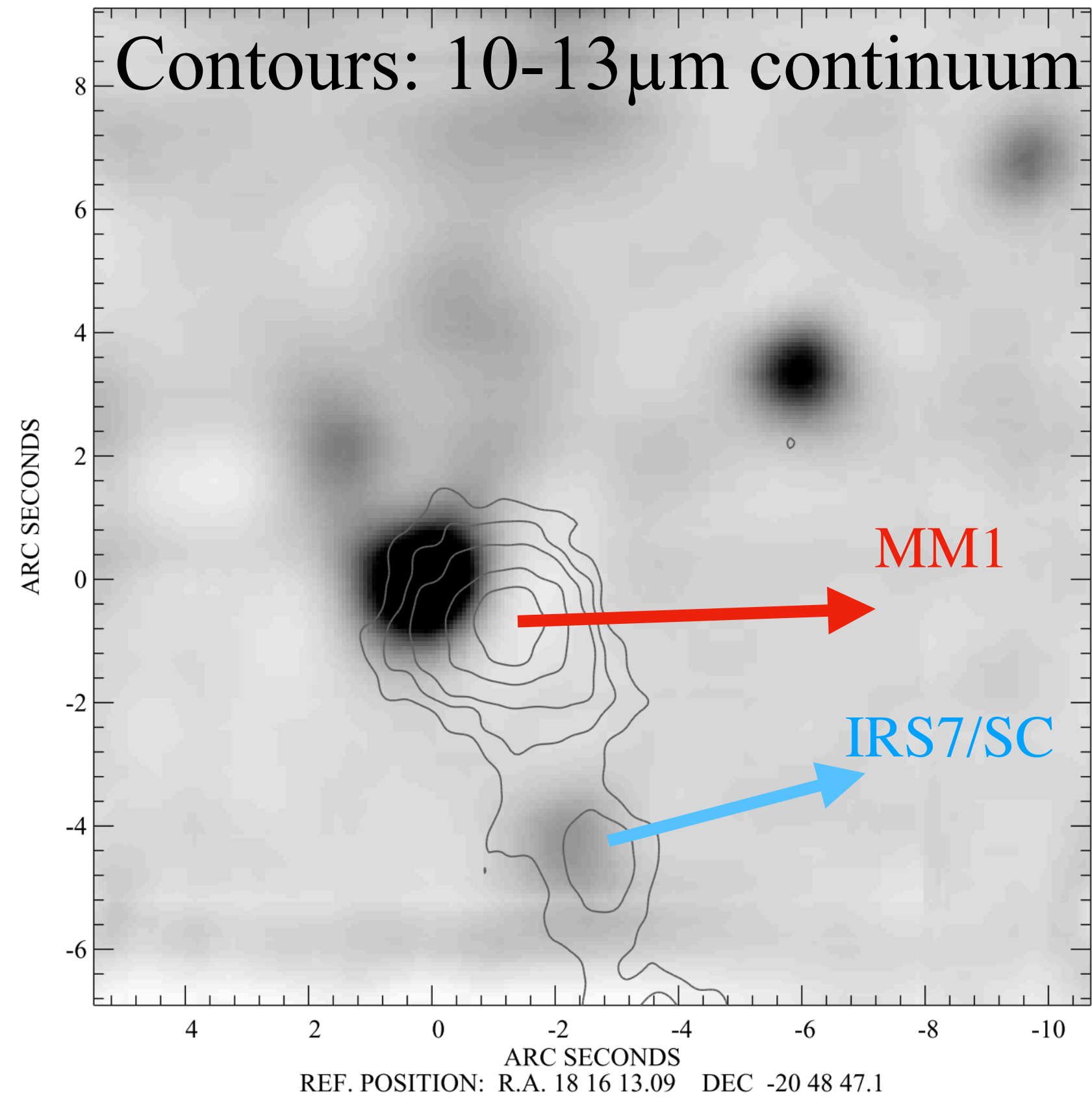
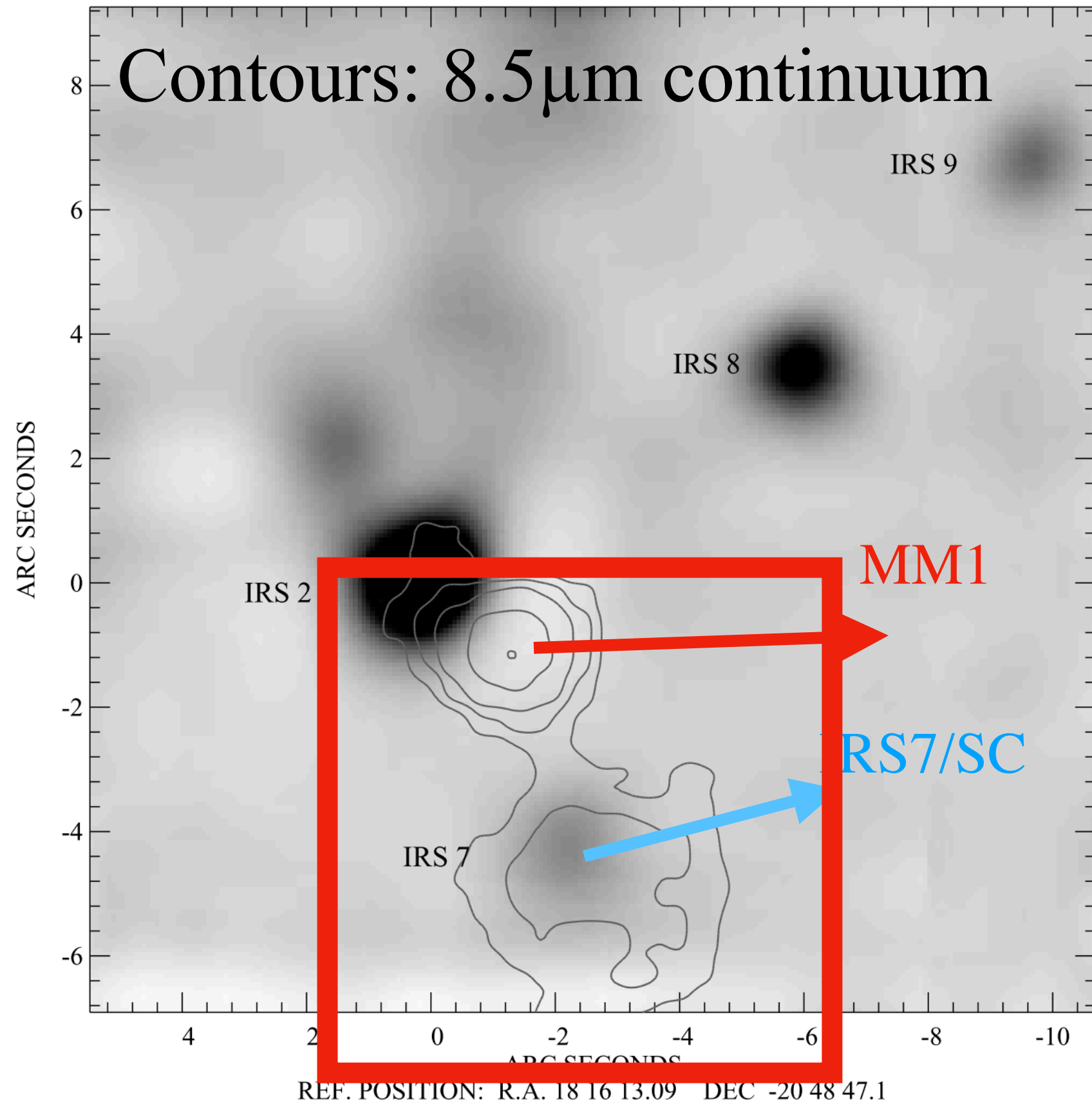


Busquet et al. (2019)

5 arcmin



What do we know about the central region in IR?



Star-forming region
IRAS 18162-2048
(near-IR and mid-IR)

Background image:
2 μm continuum

IRS2 \rightarrow may be the reflection
of IRAS18162 (MM1)

IRS7 \rightarrow strongly suggested to be
a YSO due to peaks in NIR and MIR

Stecklum et al. (1997)

5 arcmin

2MASS NIR RGB image

What do we know about the central region in IR?

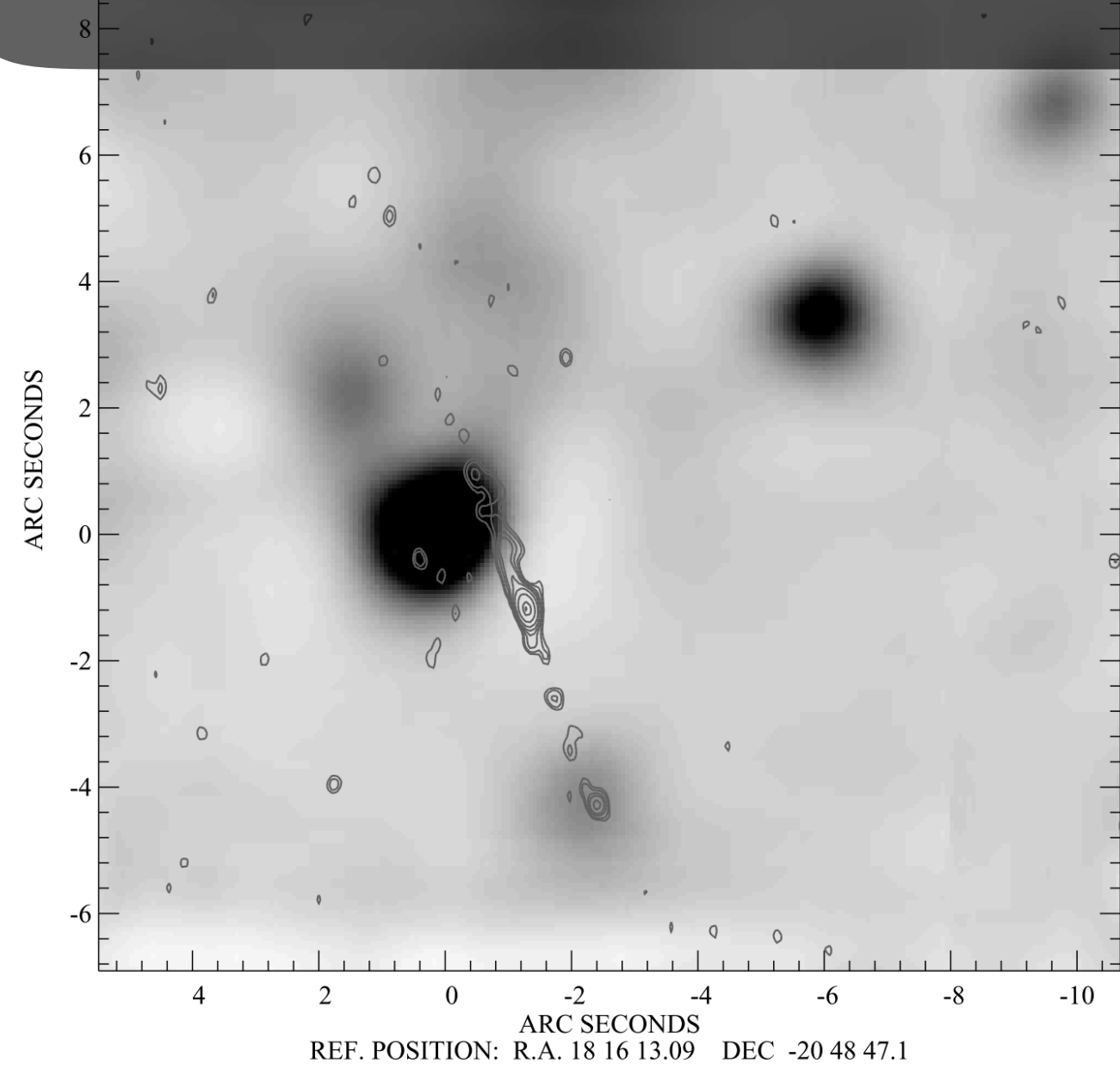


FIG. 3.—K-band image of GGD 27 IRS 2 again, this time superposed with 6 cm VLA contours by Marti et al. (1993). Contour levels are 3, 4, 6, 8, 12, 20, 40, 60, 80, and 100 times the 1σ level of 1.7×10^{-5} Jy.

becomes clear that it is presumably a stellar source. To confirm this hypothesis, we first estimate the rate of Lyman UV photons N'_e needed to maintain proper ionization for the observed radio flux using formulae (1) and (3) of Kurtz, Churchwell, & Wood (1994), which combine to

$$N'_e \geq 7.588 \times 10^{48} T_e^{-0.85} \times \left[\frac{1}{\alpha(\nu, T_e)} \left(\frac{\nu}{\text{GHz}} \right)^{0.1} \left(\frac{T_e}{\text{K}} \right)^{0.35} \left(\frac{S_\nu}{\text{Jy}} \right) \left(\frac{D}{\text{kpc}} \right)^2 \right]; \quad (1)$$

we get $N'_e \geq 3.15 \times 10^{44} \text{ s}^{-1}$, adopting $\alpha = 1$, $\nu = 5 \text{ GHz}$, the excitation temperature $T_e = 10^4 \text{ K}$, the integrated radio flux at 5 GHz $S_\nu = 0.95 \text{ mJy}$ (Marti et al. 1993), and a distance $D = 1.7 \text{ kpc}$ (Marti et al. 1995). According to model calculations by Panagia (1973), this implies that the exciting object is presumably a main-sequence B2 star.

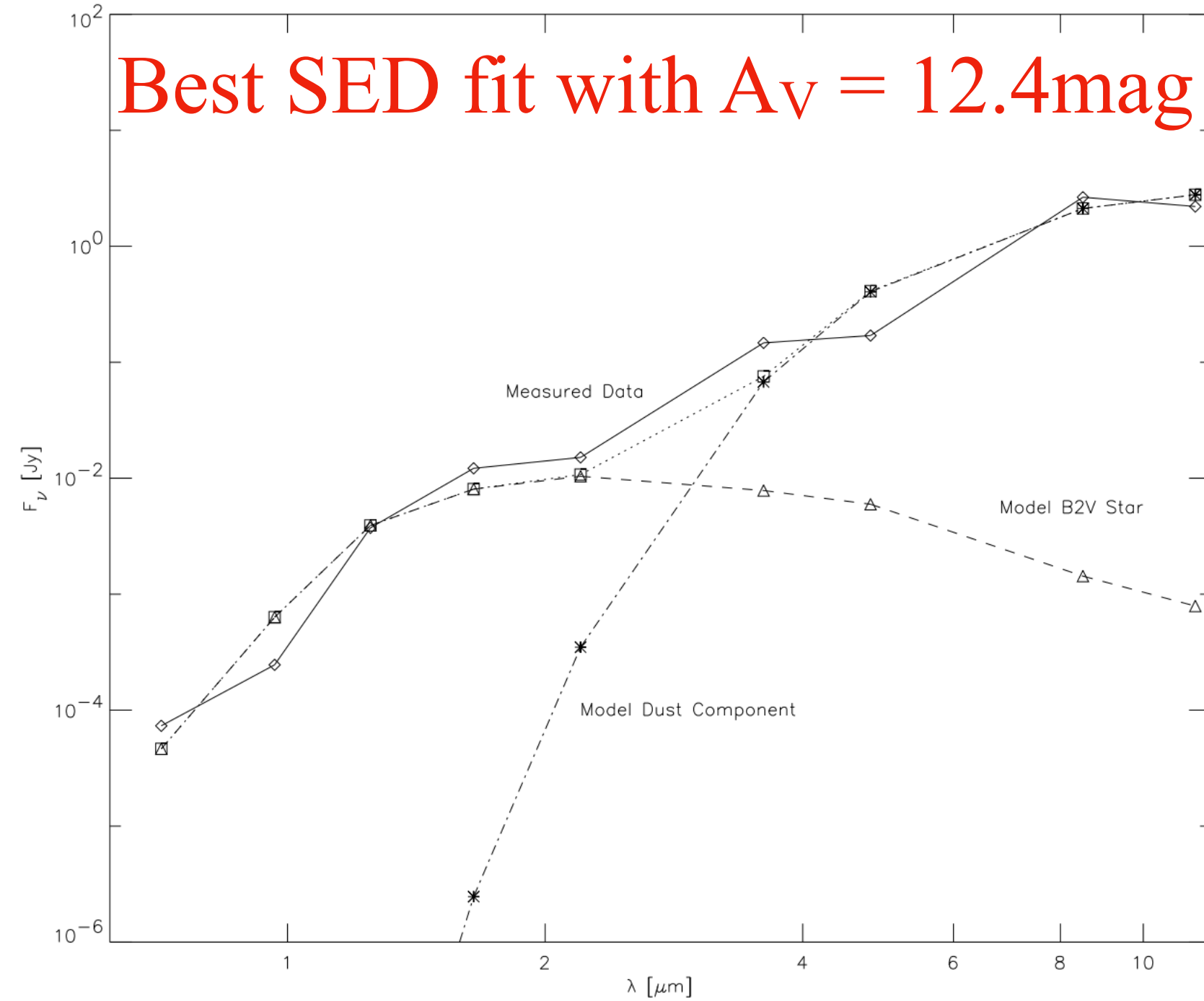


FIG. 7.—Spectral energy distributions of IRS 7 (diamonds and solid line) and a blackbody of 23,000 K (triangles and dashed line). Also shown is a distribution where a dust component (stars and dash-dotted line) has been added to the blackbody (squares and dotted line). The dust is represented by a single blackbody with $r = 1000R_*$ and a temperature of 400 K. IRS 7 fluxes for 0.7 and 0.9 μm are taken from Hartigan & Lada (1985); J , H , L' , and narrowband M fluxes are taken from Aspin et al. (1994). The K , $N1$, and 10–13 μm band fluxes are from the current data.

Star-forming region
IRAS 18162-2048
(near-IR and mid-IR)

Background image:
2 μm continuum

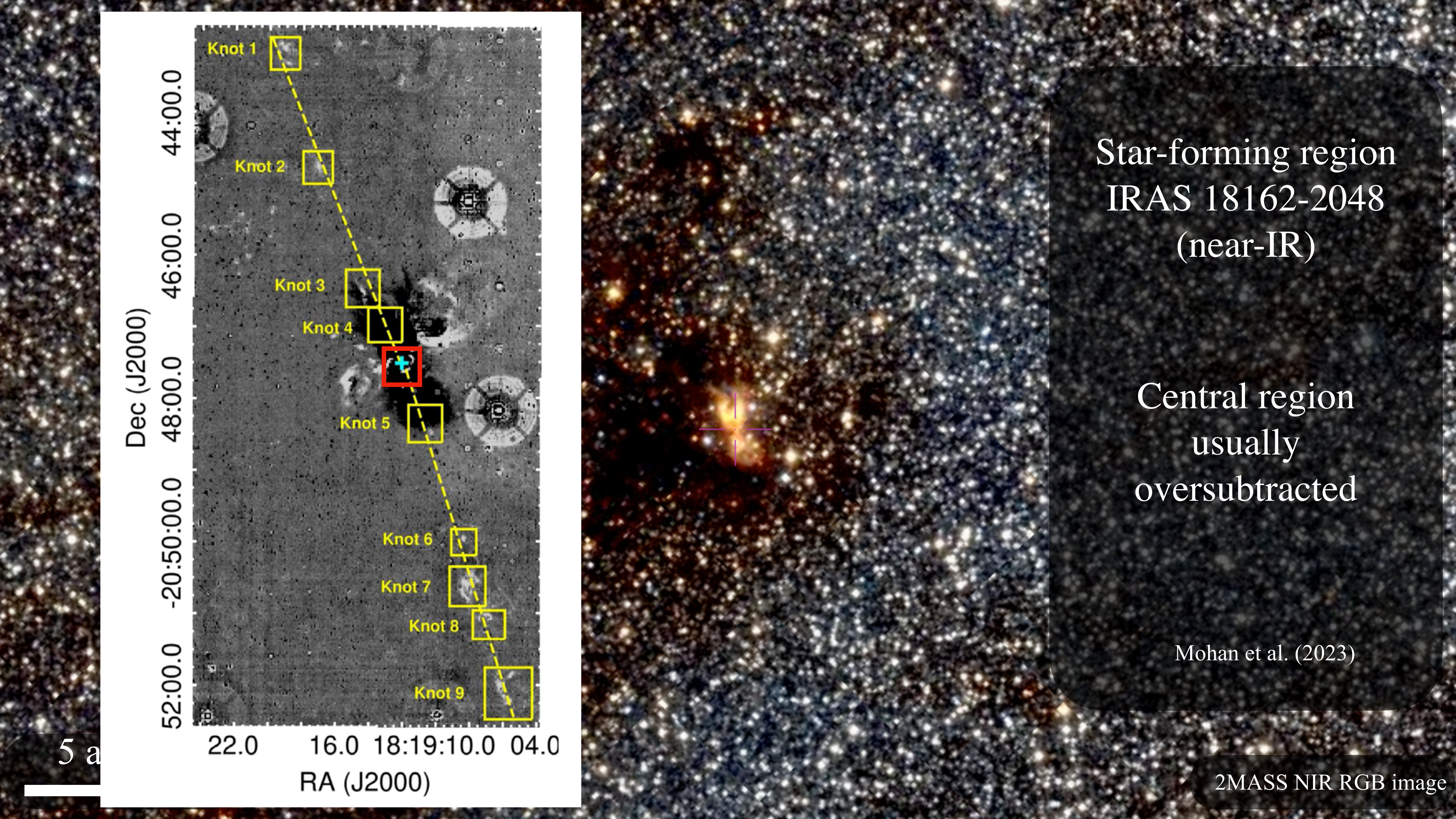
IRS2 \rightarrow may be the reflection
of IRAS18162 (MM1)

IRS7 \rightarrow strongly suggested to be
a YSO due to peaks in NIR and MIR

IRS7 \rightarrow radio continuum and
SED indicate a B2 SpT

Stecklum et al. (1997)

2MASS NIR RGB image



Star-forming region
IRAS 18162-2048
(near-IR)

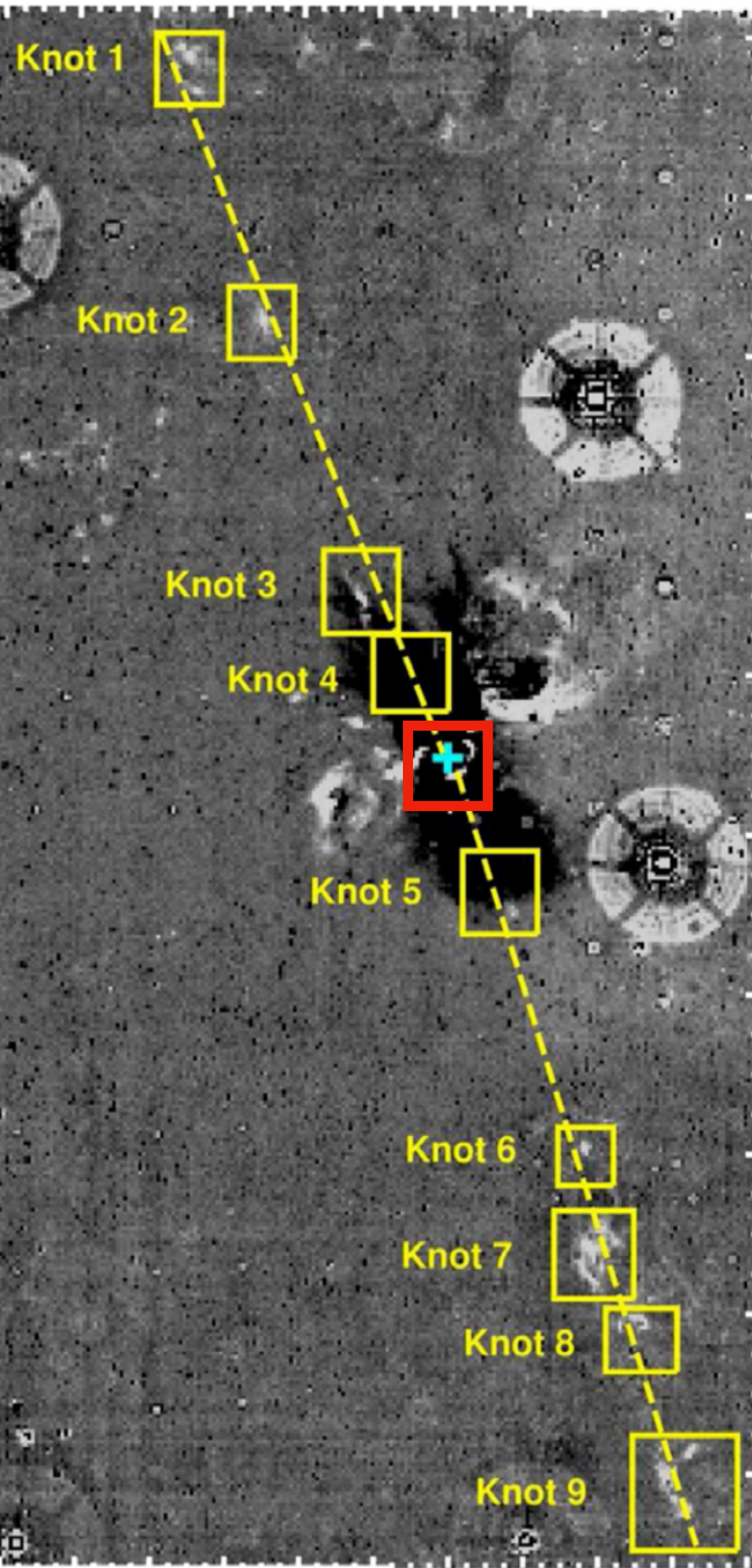
Central region
usually
oversubtracted

Mohan et al. (2023)

2MASS NIR RGB image

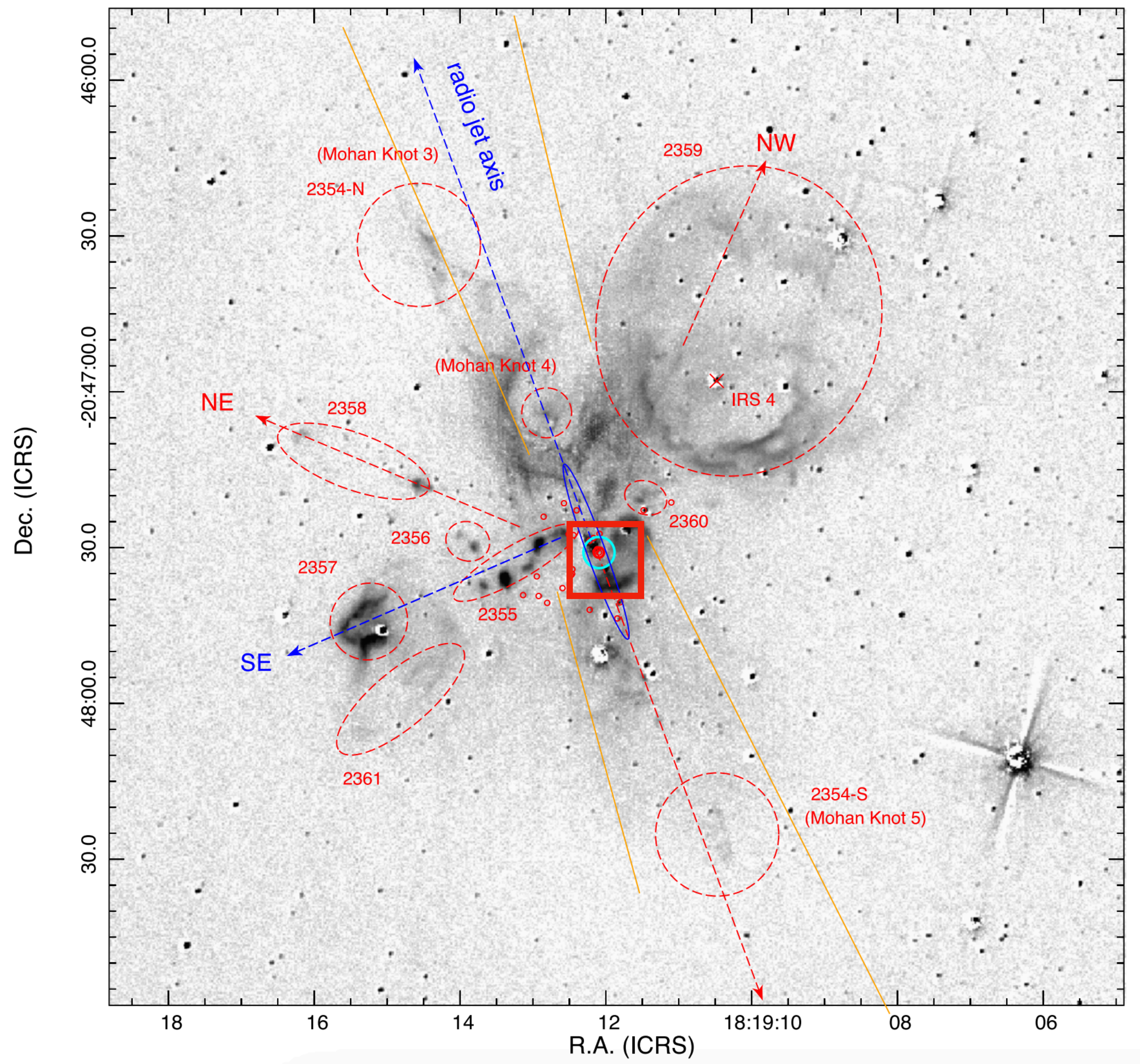
Dec (J2000)

44:00.0
46:00.0
48:00.0
50:00.0
52:00.0



22.0 16.0 18:19:10.0 04.0
RA (J2000)

5 a



Star-forming region
 IRAS 18162-2048
 (near-IR)

Lots of images, but
 no near-IR
 spectroscopy in the
 central region

Bally and Reipurth (2023)

2MASS NIR RGB image

Near-IR view of the central 10000 au of IRAS18162-2048 — continuum and line emission

A&A, 708, A11 (2026)

<https://doi.org/10.1051/0004-6361/202558460>

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**Astronomy
&
Astrophysics**

Diverse stages of star formation in the IRAS 18162-2048 region

Emergence of UV feedback

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G. Blázquez-Calero¹, A. F. Placinta-Mitreá¹, A. Sanna⁸, **R. Cesaroni⁹**, L. Moscadelli⁹, T. P. Ray¹⁰,
D. Coffey¹¹, and G. A. Fuller^{12,13}



European Organisation for Astronomical Research in the Southern Hemisphere

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APPLICATION FOR OBSERVING TIME

PERIOD: 101A

Important Notice:

By submitting this proposal, the PI takes full responsibility for the content of the proposal, in particular with regard to the names of CoIs and the agreement to act according to the ESO policy and regulations, should observing time be granted.

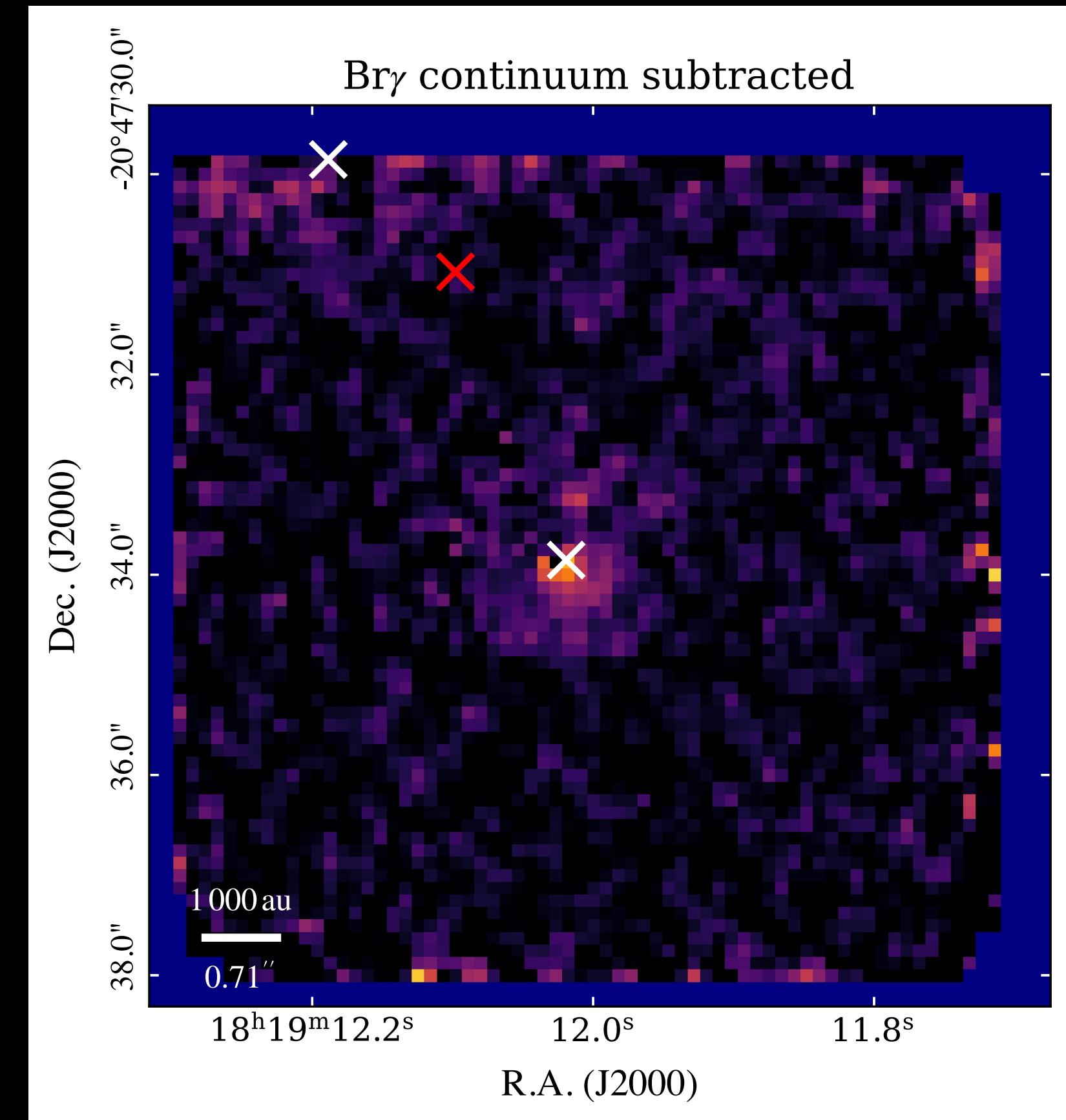
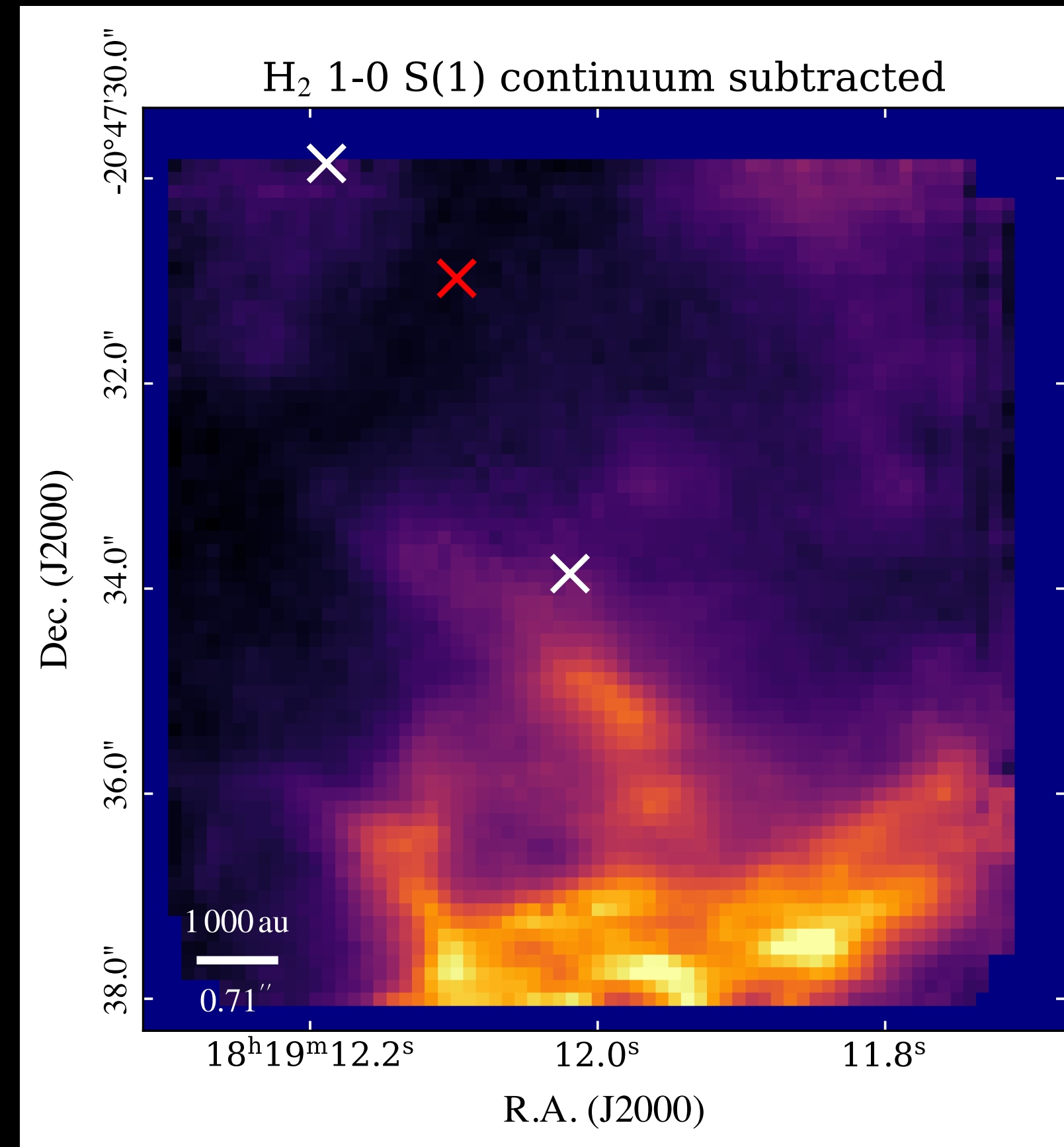
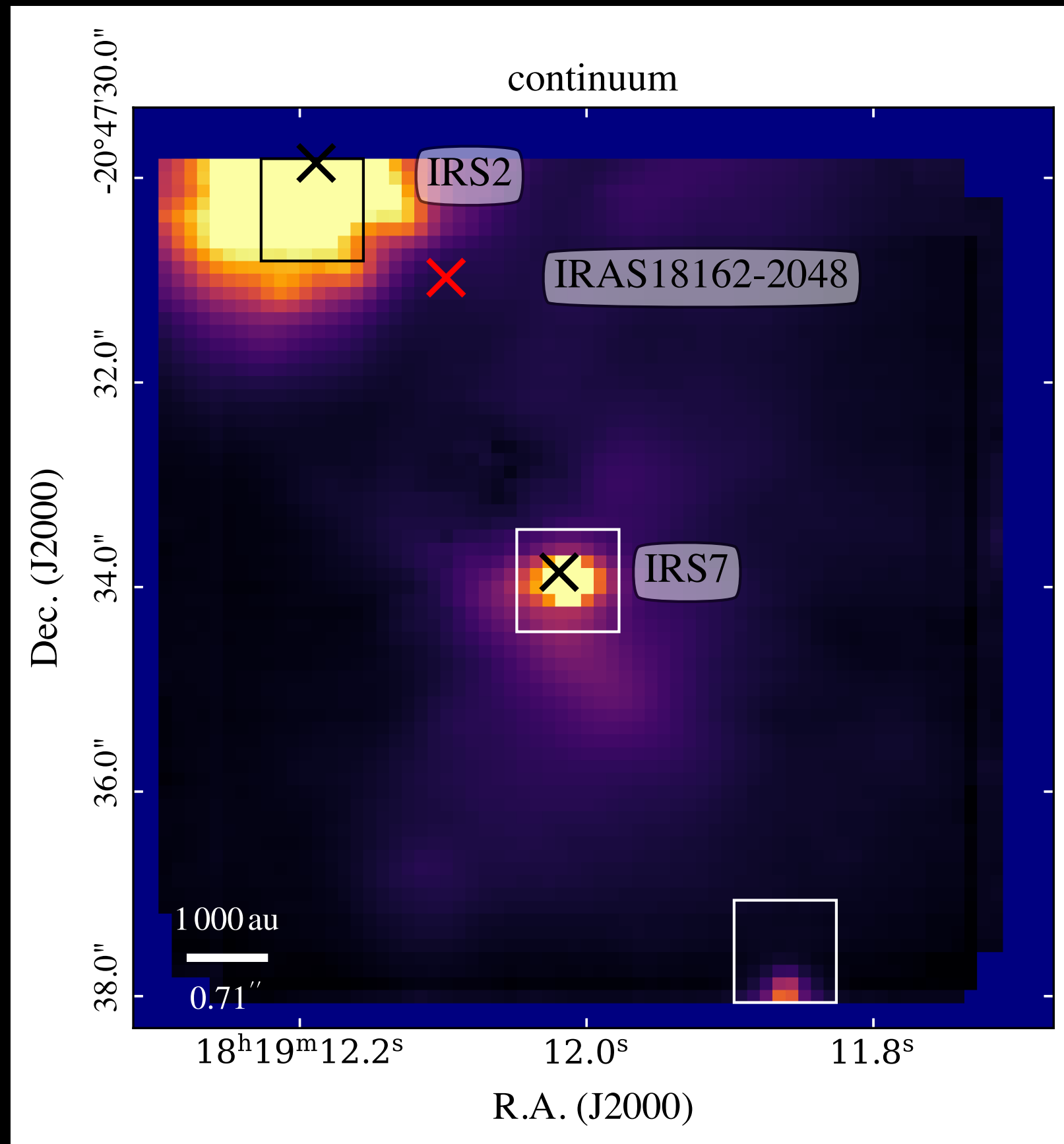
1. Title Category: **C-5**
Revealing the dominant component in High-Mass Young Stellar Objects primary jets.

6. Principal Investigator: Ruben Fedriani, fedriani@cp.dias.ie, IE, Dublin Institute for Advanced Studies,

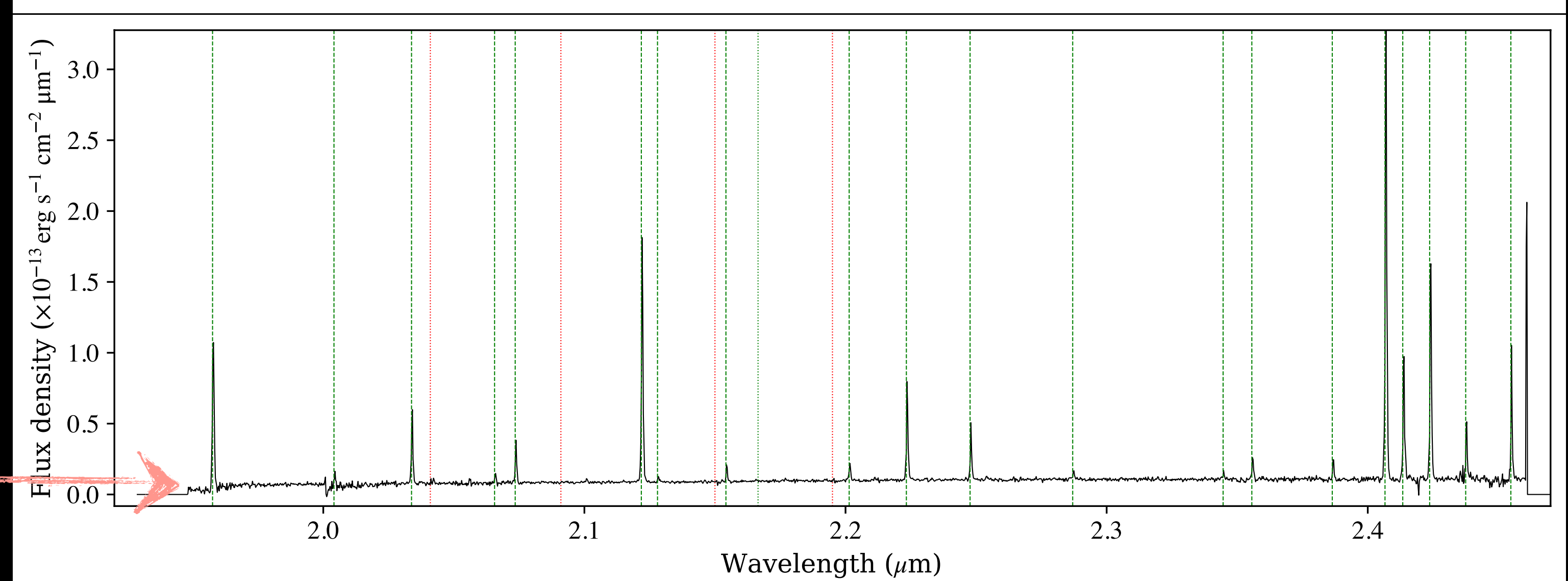
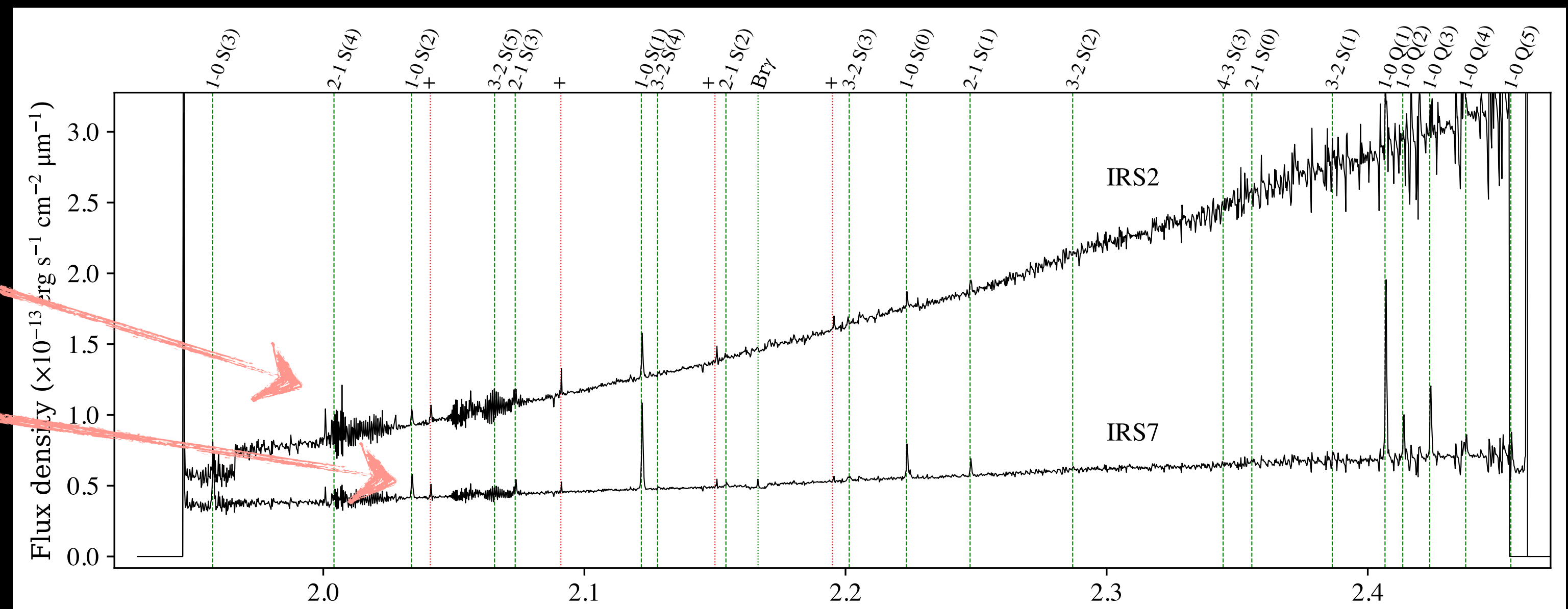
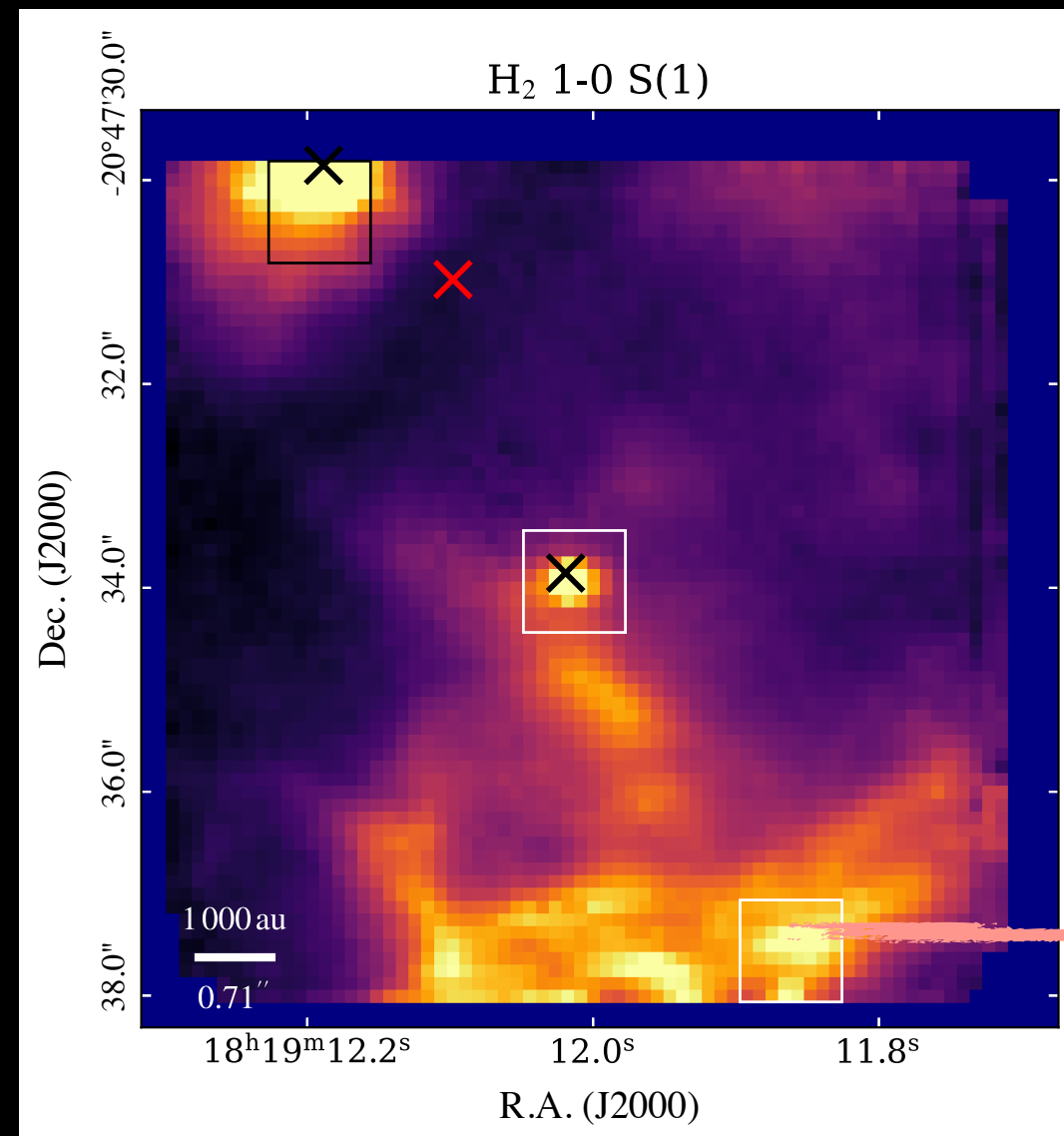
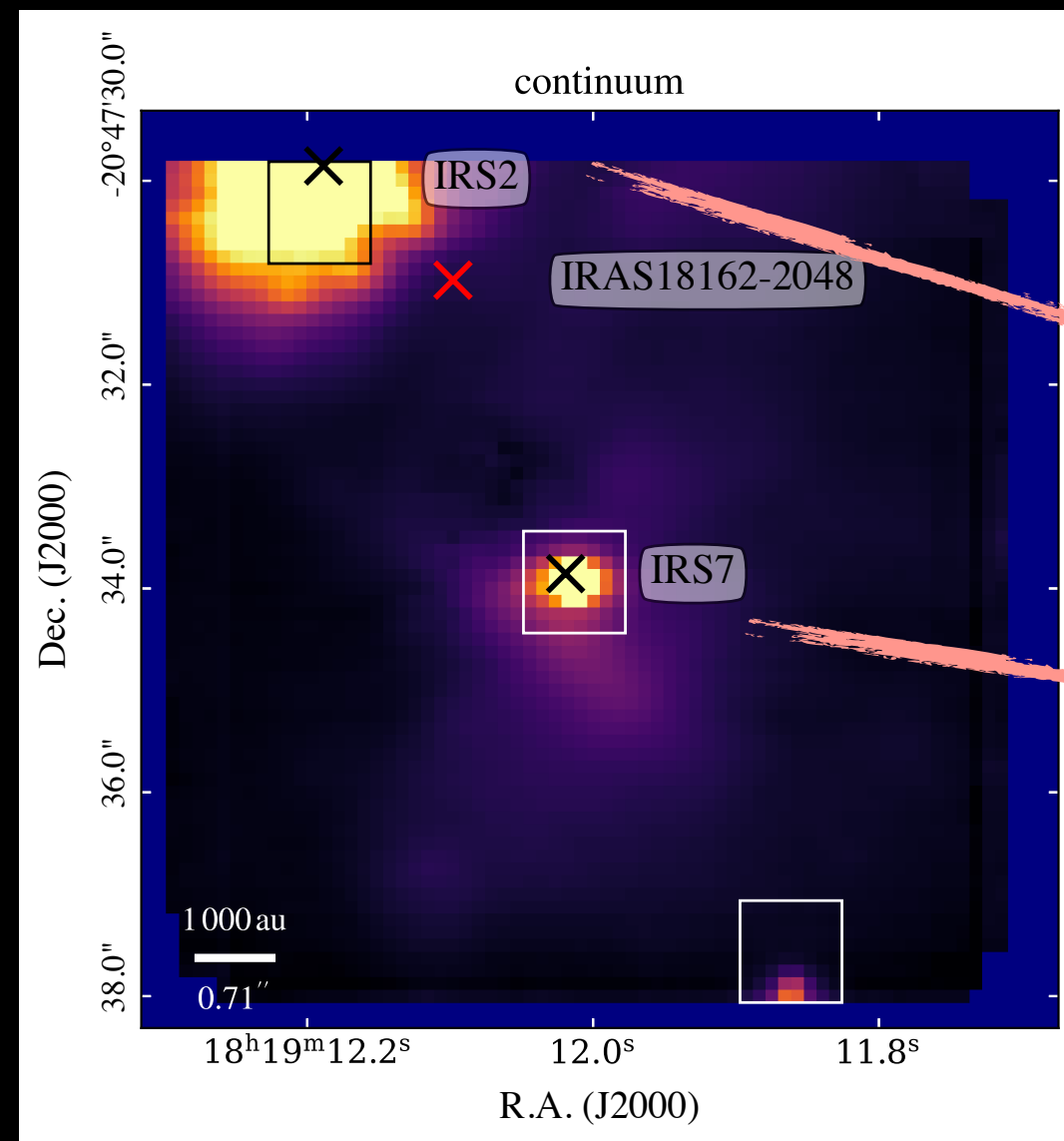
6a. Co-investigators:

A.	Caratti o Garatti	Max Planck Institut fuer Astronomie,D
D.	Coffey	University College Dublin,School of Physics,IE
B.	Stecklum	Thueringer Landessternwarte Tautenburg,D
R.	Garcia Lopez	Max Planck Institut fuer Astronomie,D
R.	Cesaroni	INAF - Osservatorio Astronomico di Arcetri,I
T.	Ray	Dublin Institute for Advanced Studies,,IE
L.	Moscadelli	INAF - Osservatorio Astronomico di Arcetri,I
A.	Sanna	Max Planck Institut fuer Radioastronomie,D

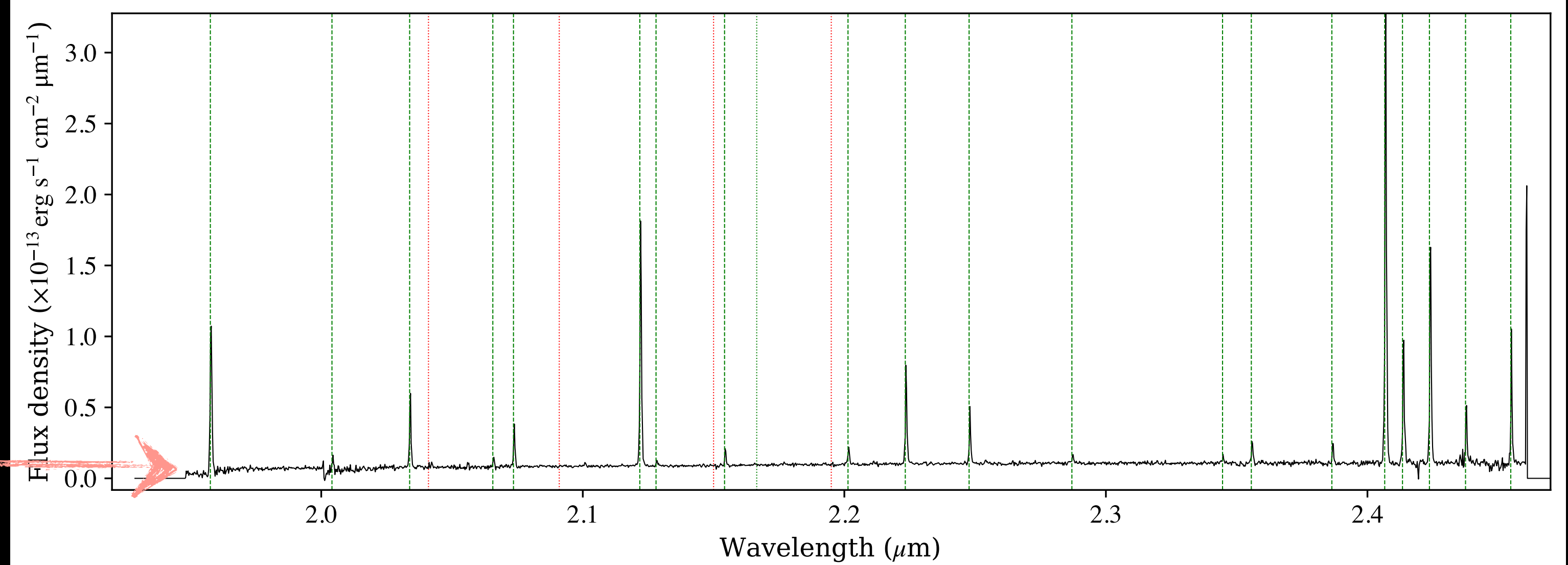
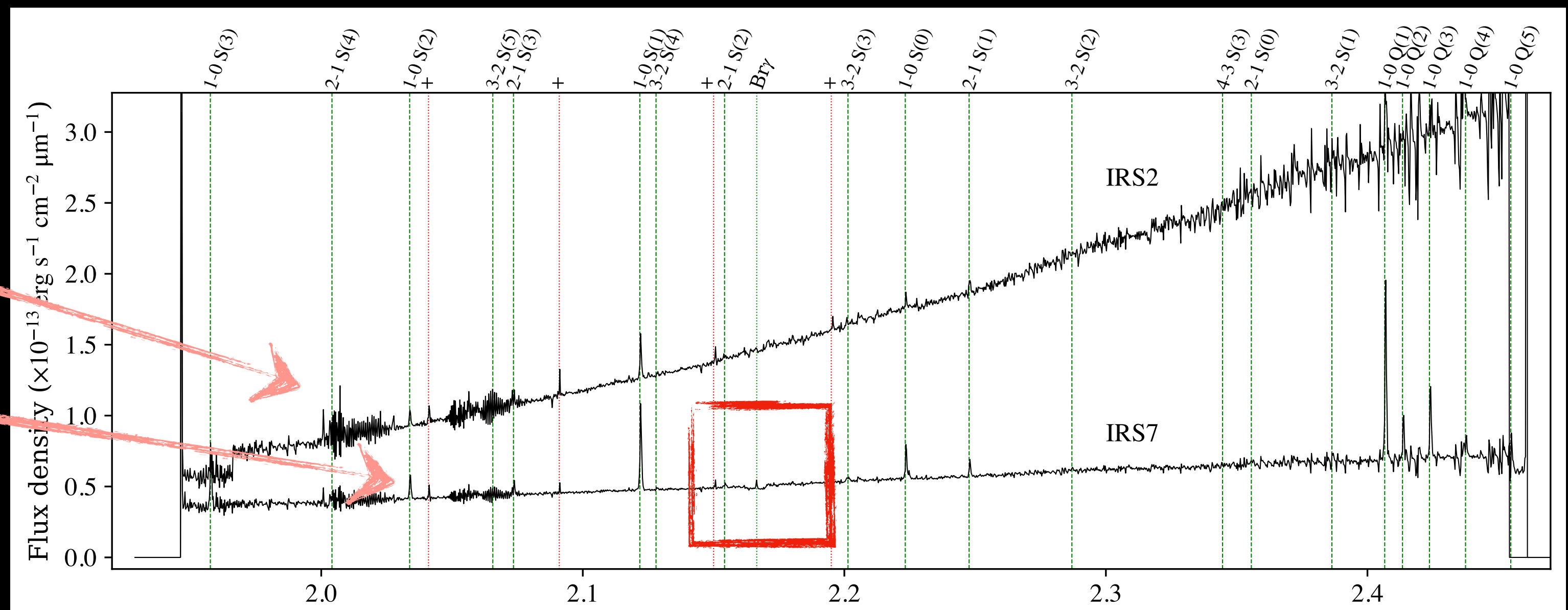
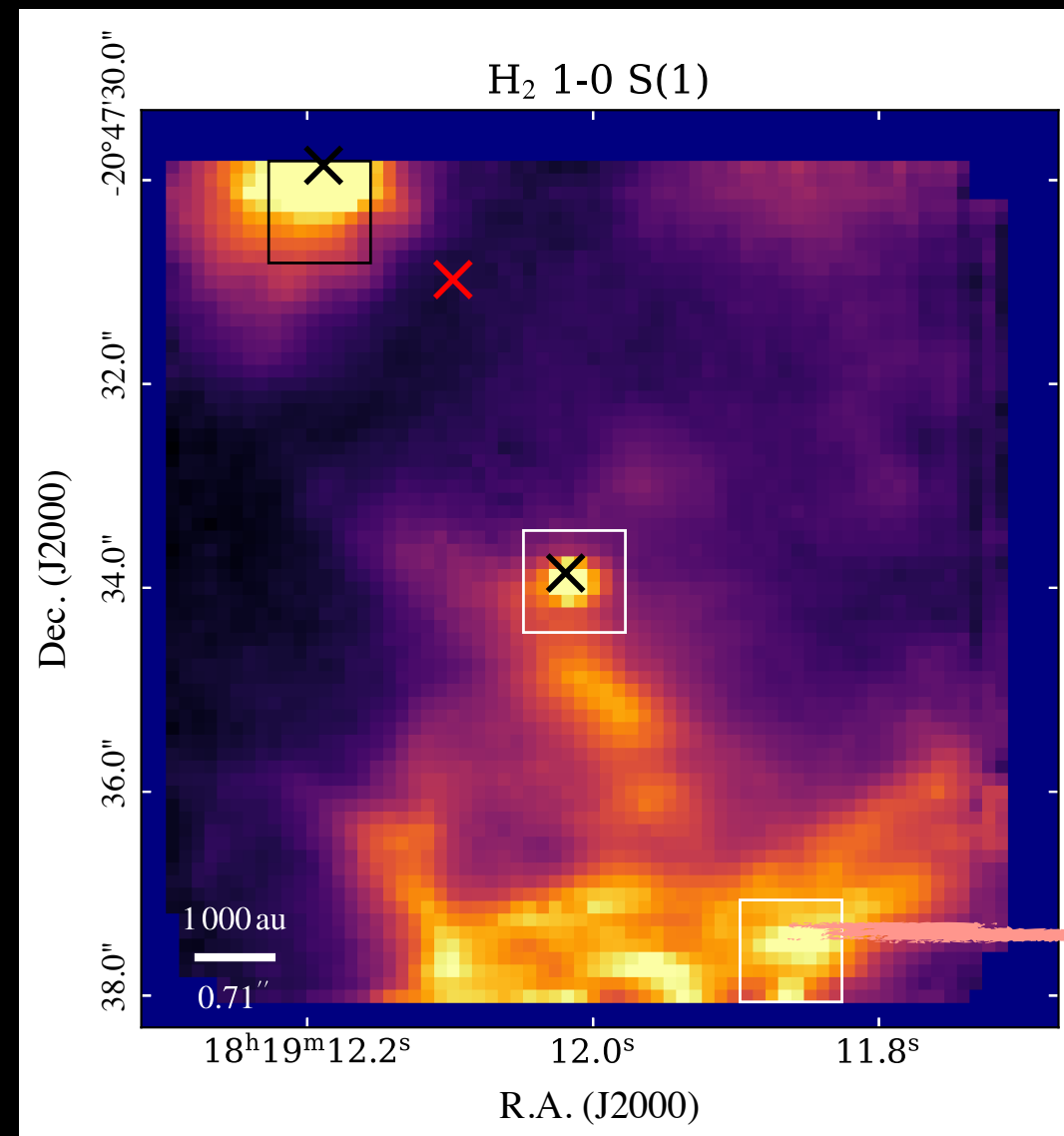
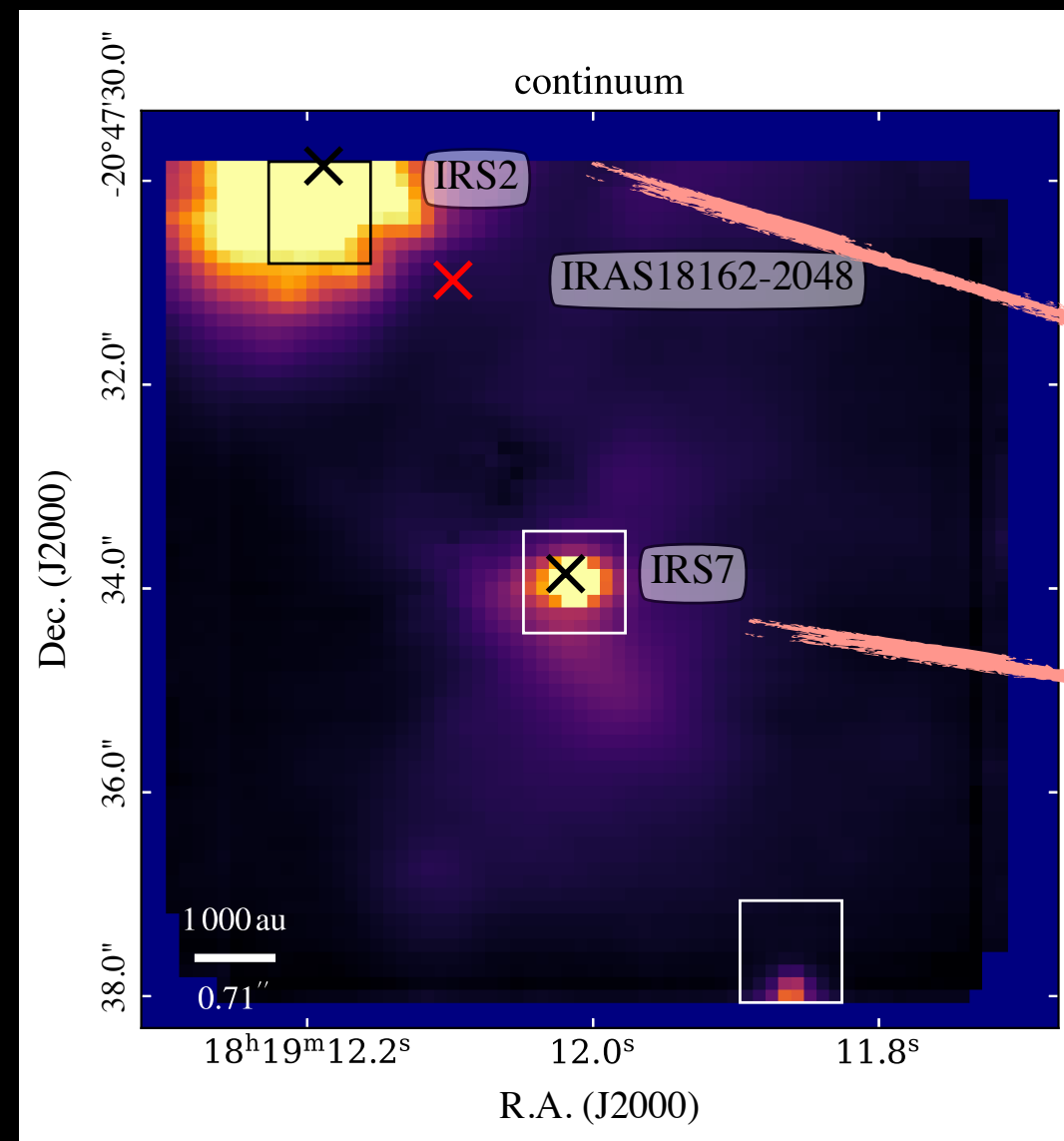
Near-IR view of the central 10000 au of IRAS18162-2048 — continuum and line emission



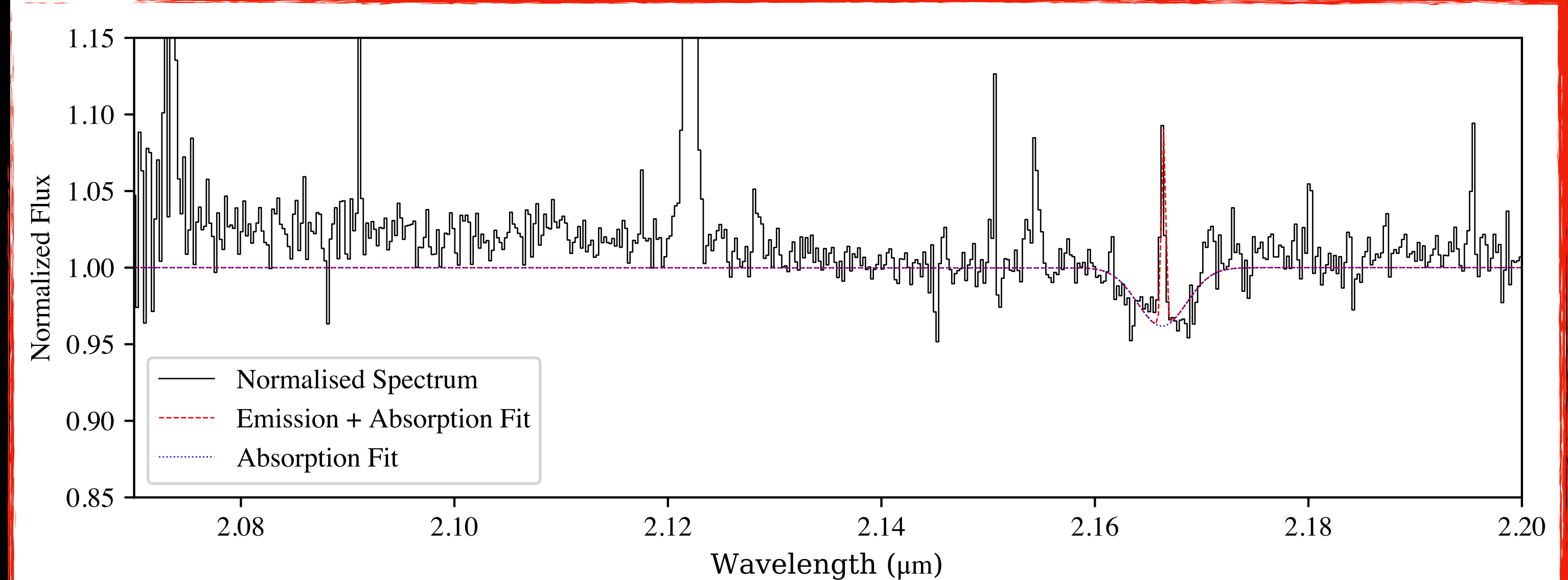
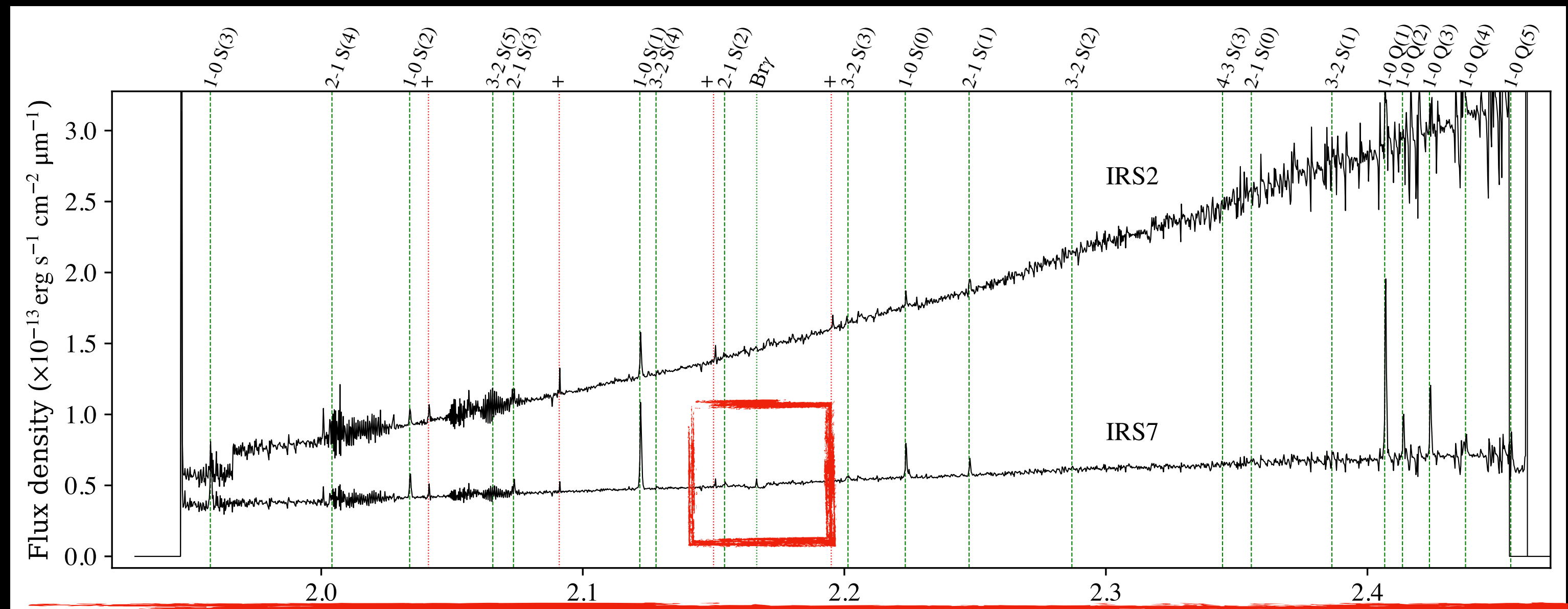
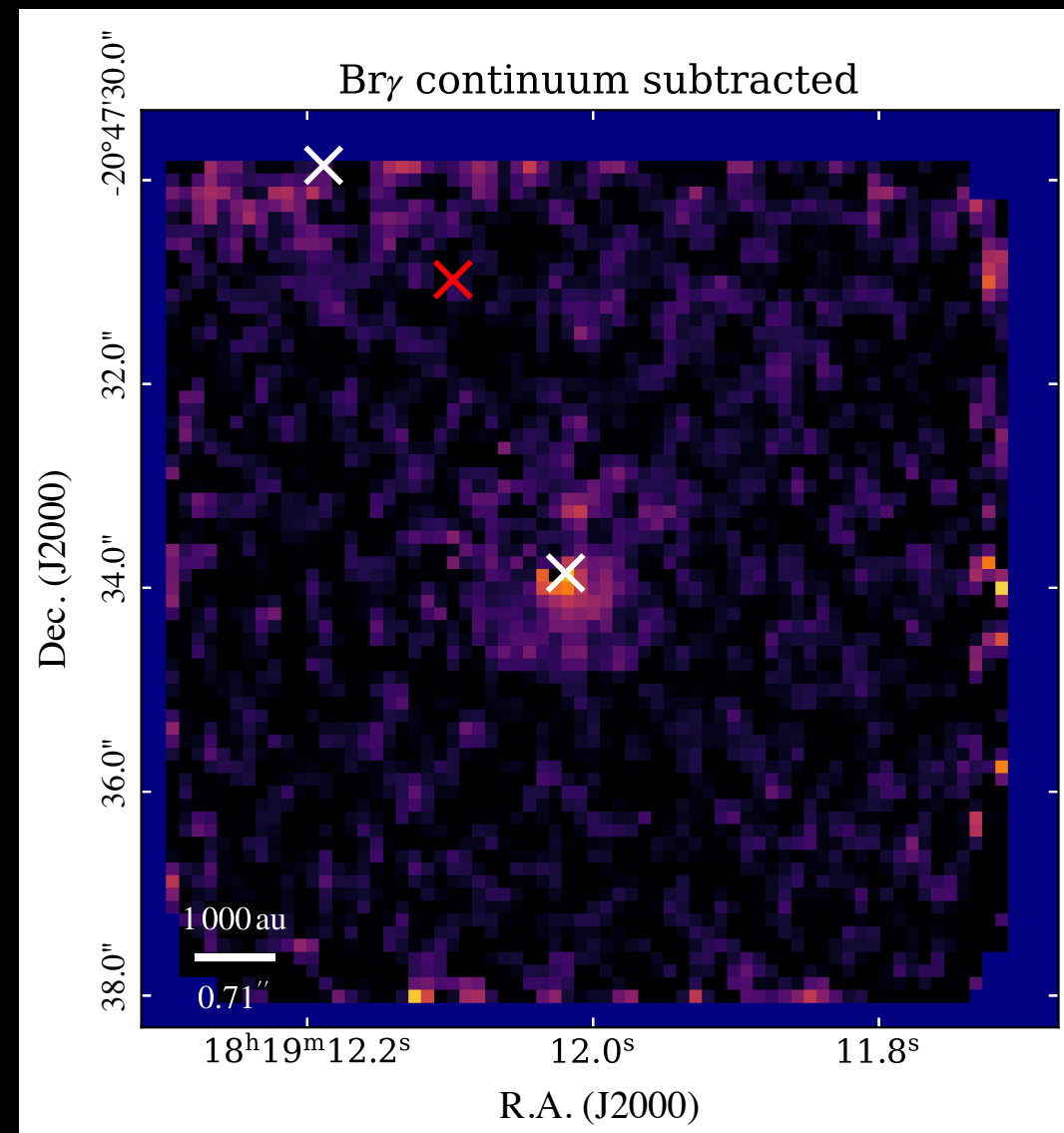
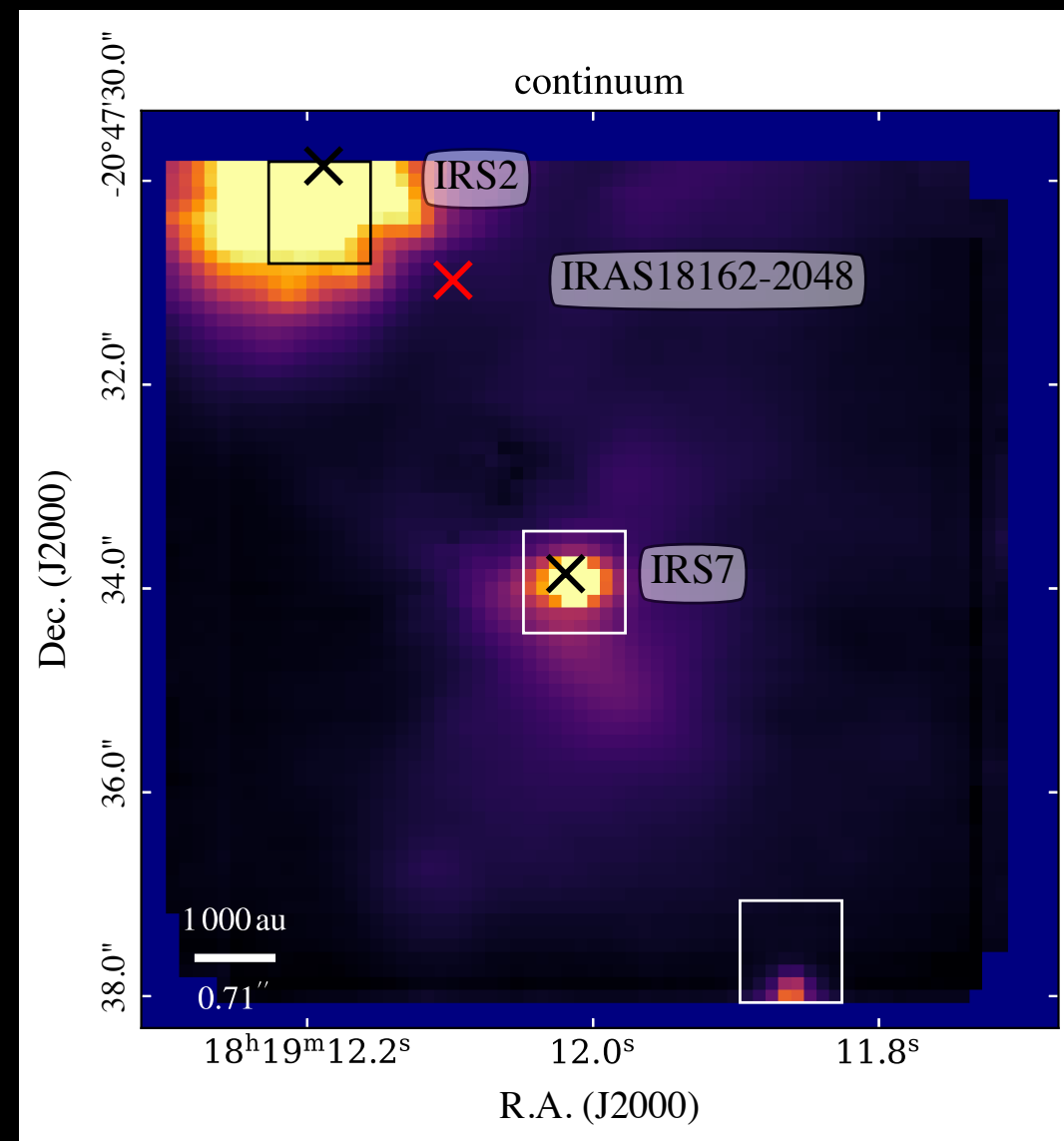
Near-IR view of the central 10000 au of IRAS18162-2048 — spectra



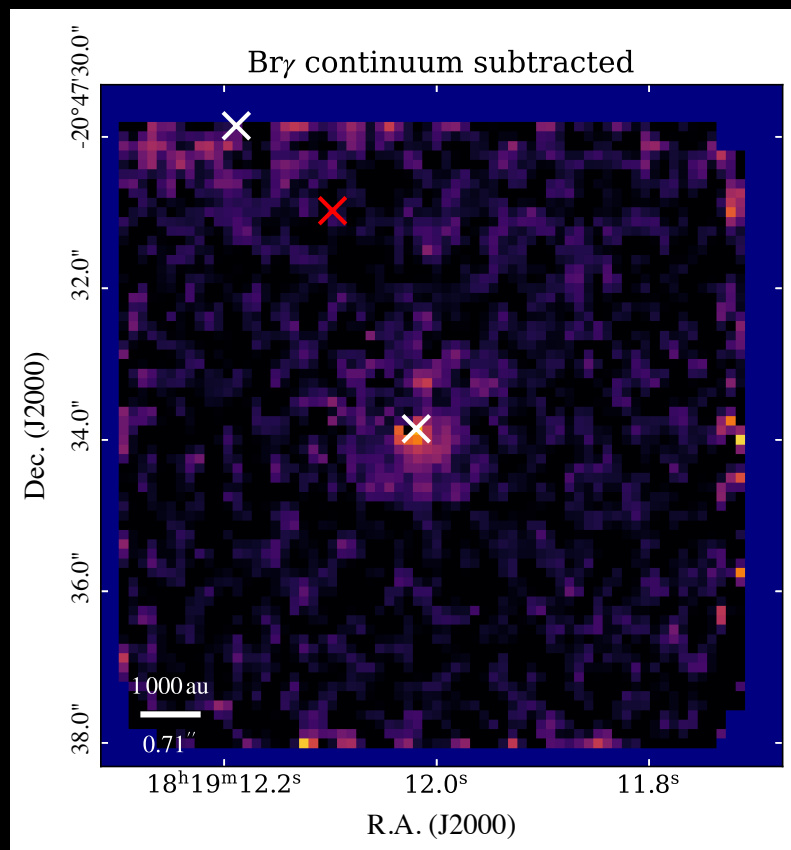
Near-IR view of the central 10000 au of IRAS18162-2048 — spectra



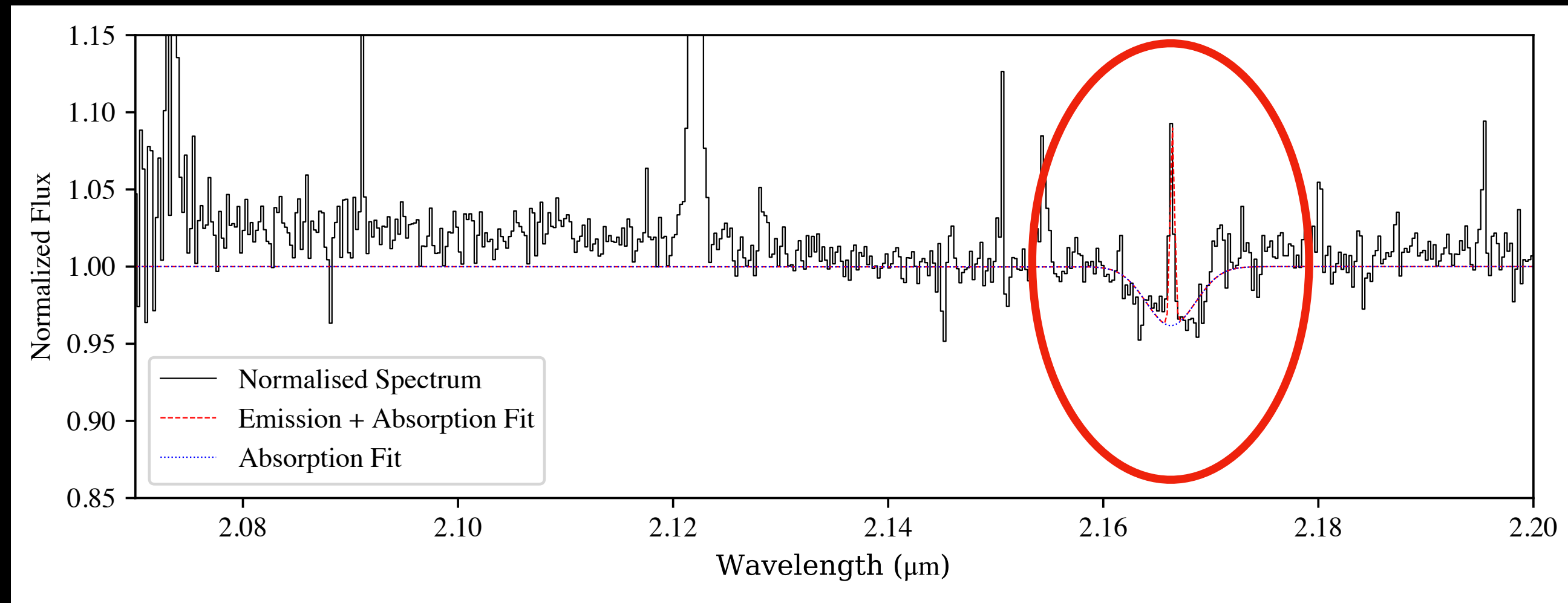
Near-IR view of the central 10000 au of IRAS18162-2048 — spectra at IRS7



IRS7 spectral classification — Bik et al. (2005) method



Conclusion:
From NIR spectrum
IRS7/SC is a B2/B3 ZAMS



No C IV
 No He I
 No N III
 Br γ
 No He II

These lines would imply O SpT

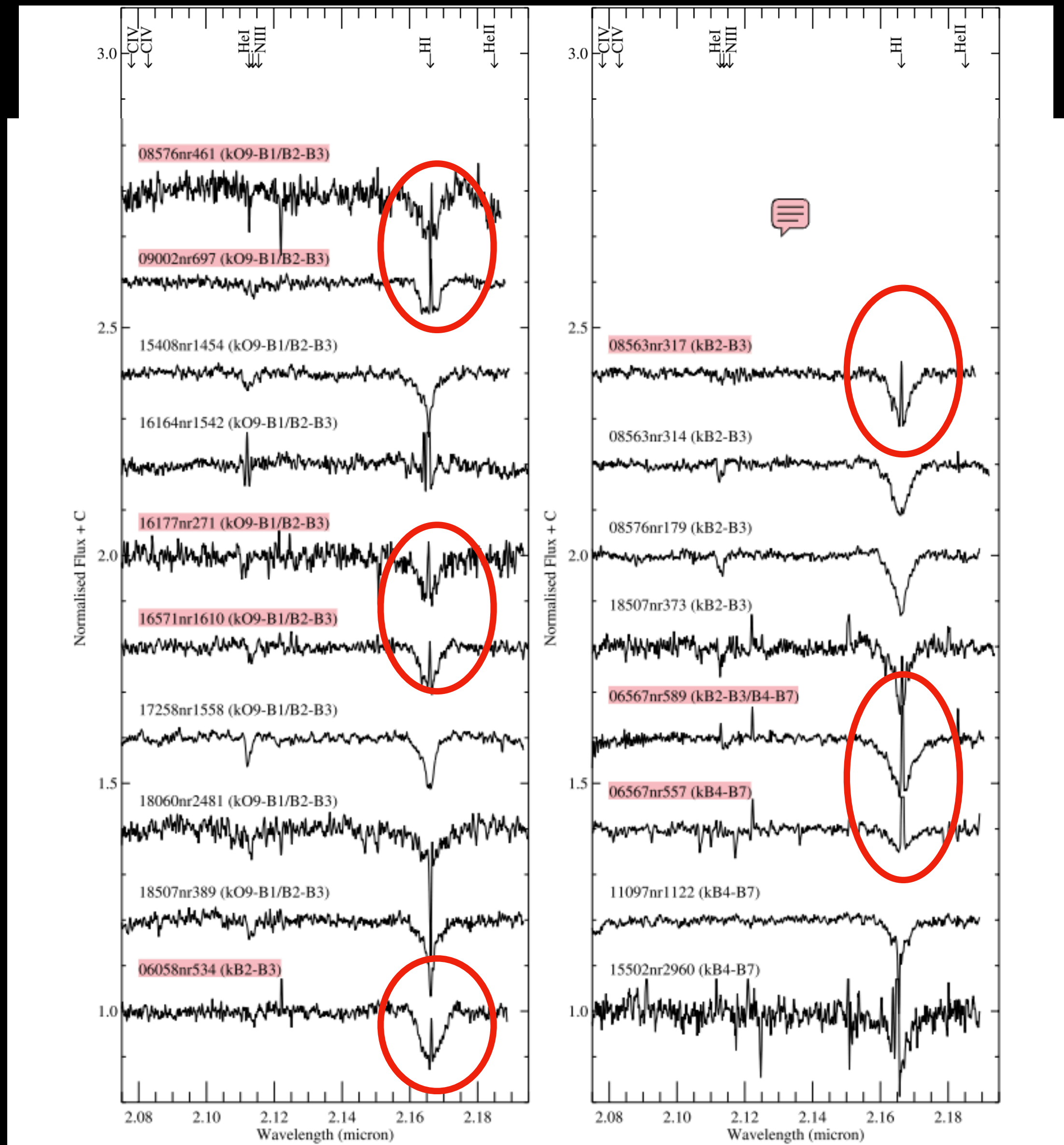
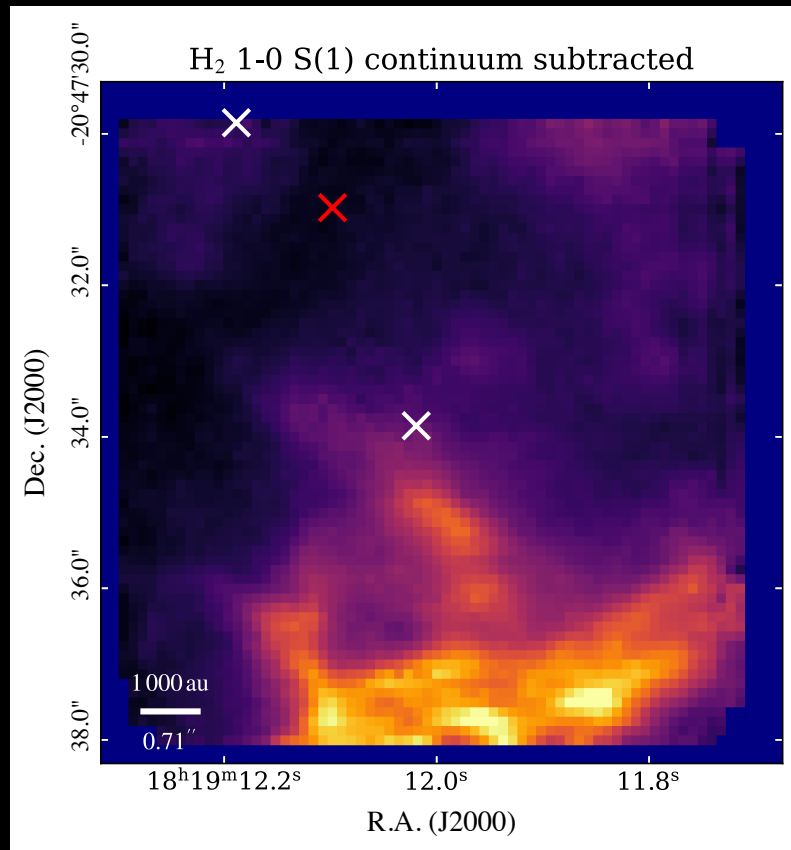


Fig. 5. K -band spectra of young OB stars deeply embedded in star-forming regions, continued. In this figure the B stars are plotted. In early-B stars, the He I line is still present (left panel), but in the mid-B stars the Br γ line is the only diagnostic line.

Near-IR view of the central 10000 au of IRAS18162-2048 — the H₂ emission (diagnostics)

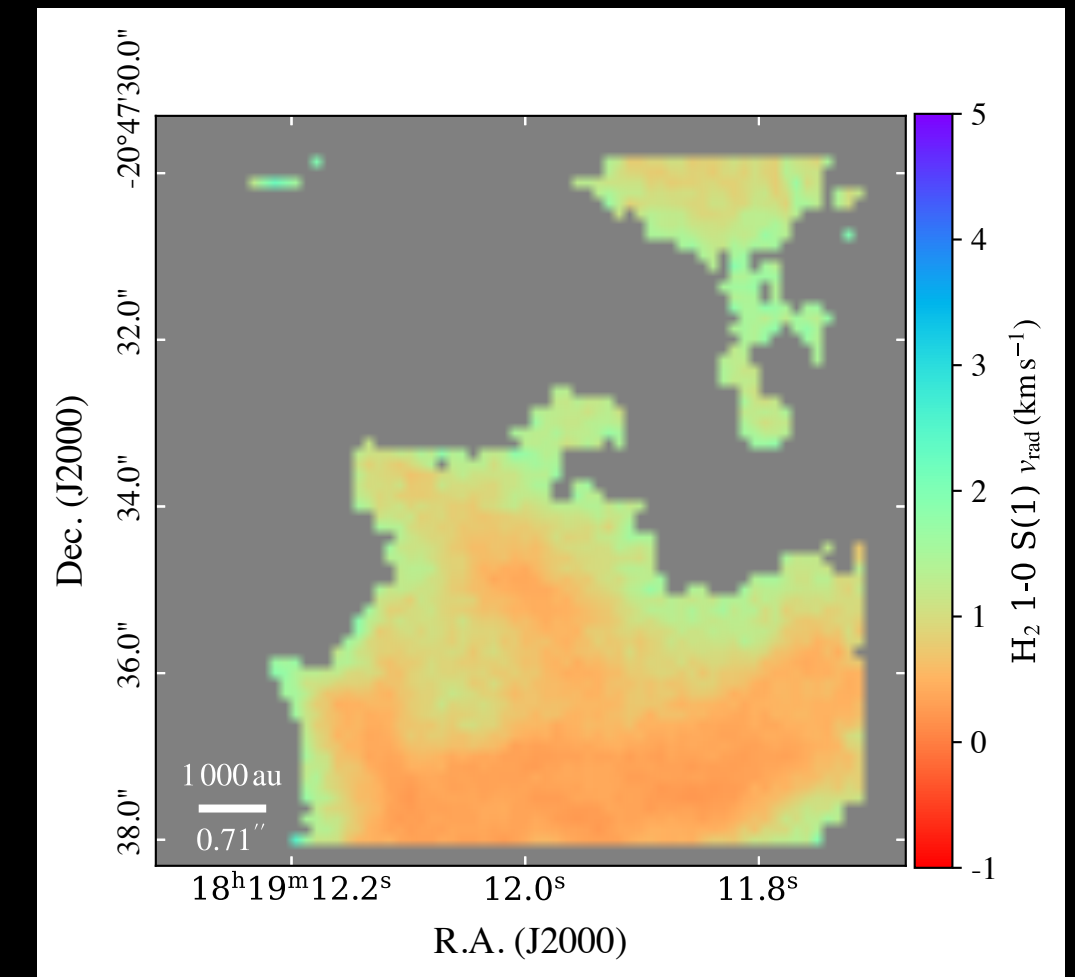
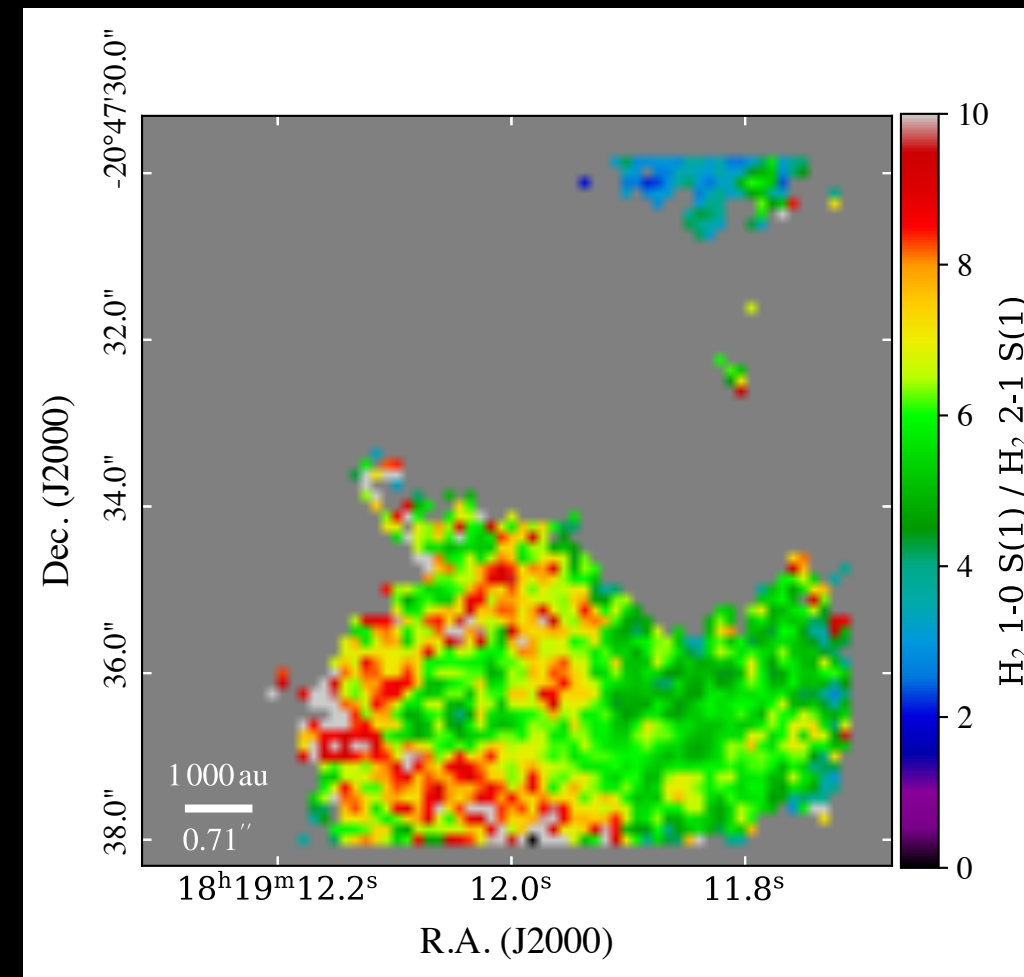
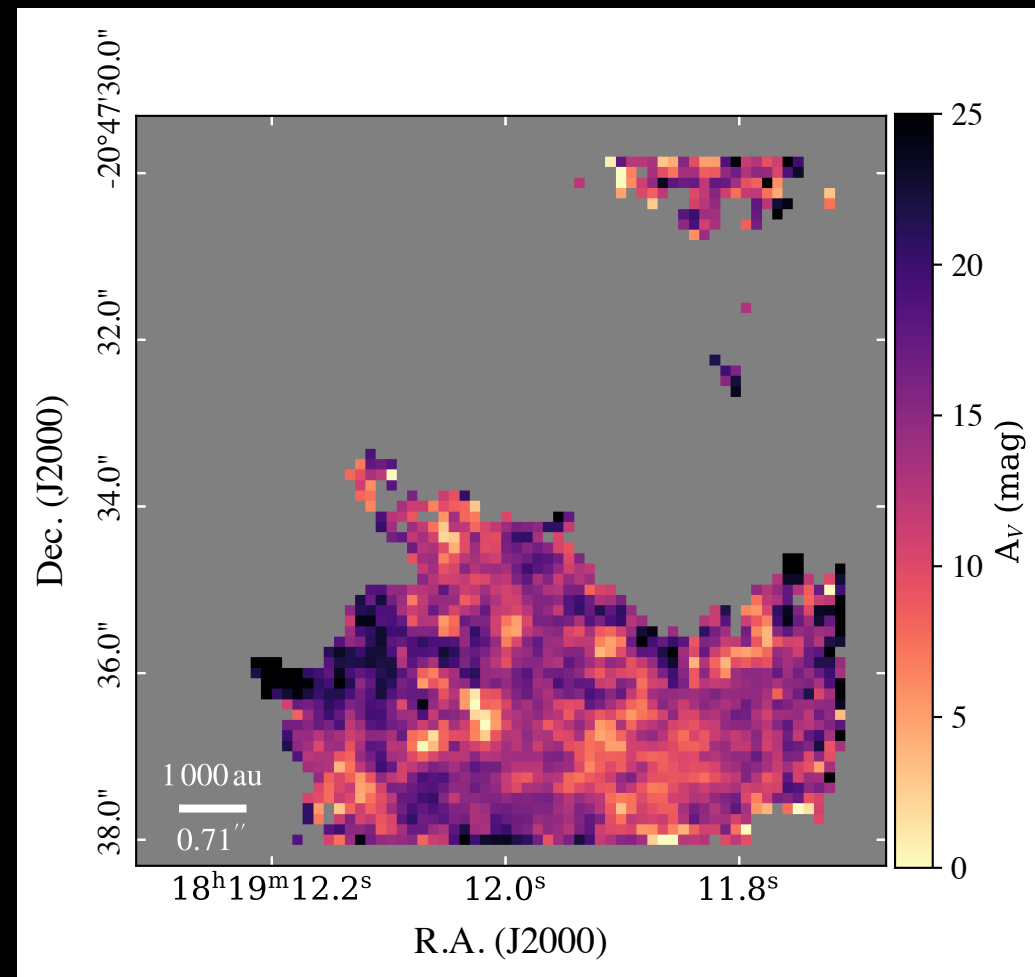


The H₂ arch seems to be a Photodissociation Region (PDR), i.e., supports photo-excitation as opposed to shocks

Extinction map
H₂ 1-0 Q(3) / 1-0 S(1)

Excitation map
H₂ 1-0 S(1) / 2-1 S(1)

Radial velocity map
H₂ 1-0 S(1)



A_V mean value ~ 12 mag

Ratio mean value ~ 5.9
consistent with UV-pumping

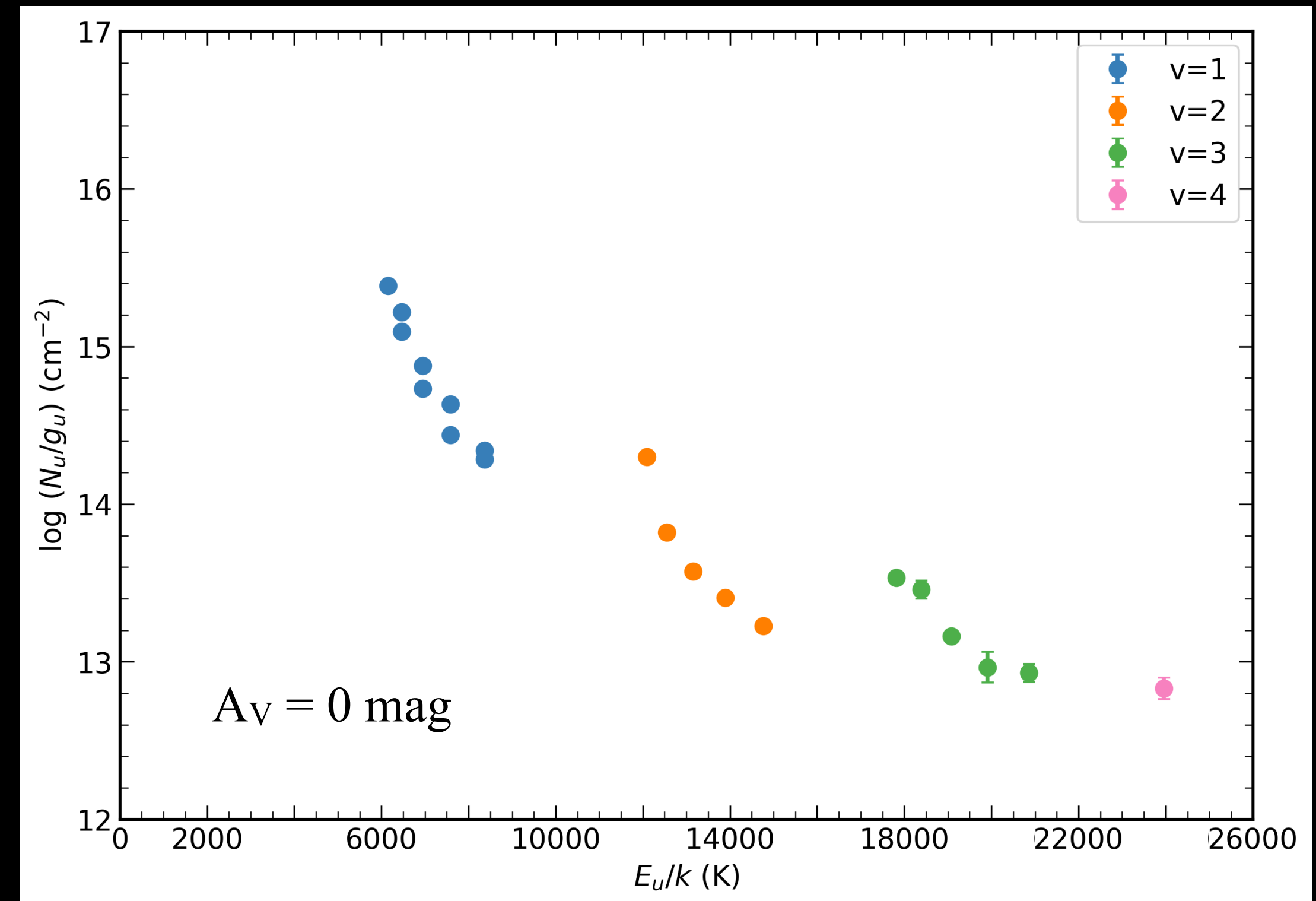
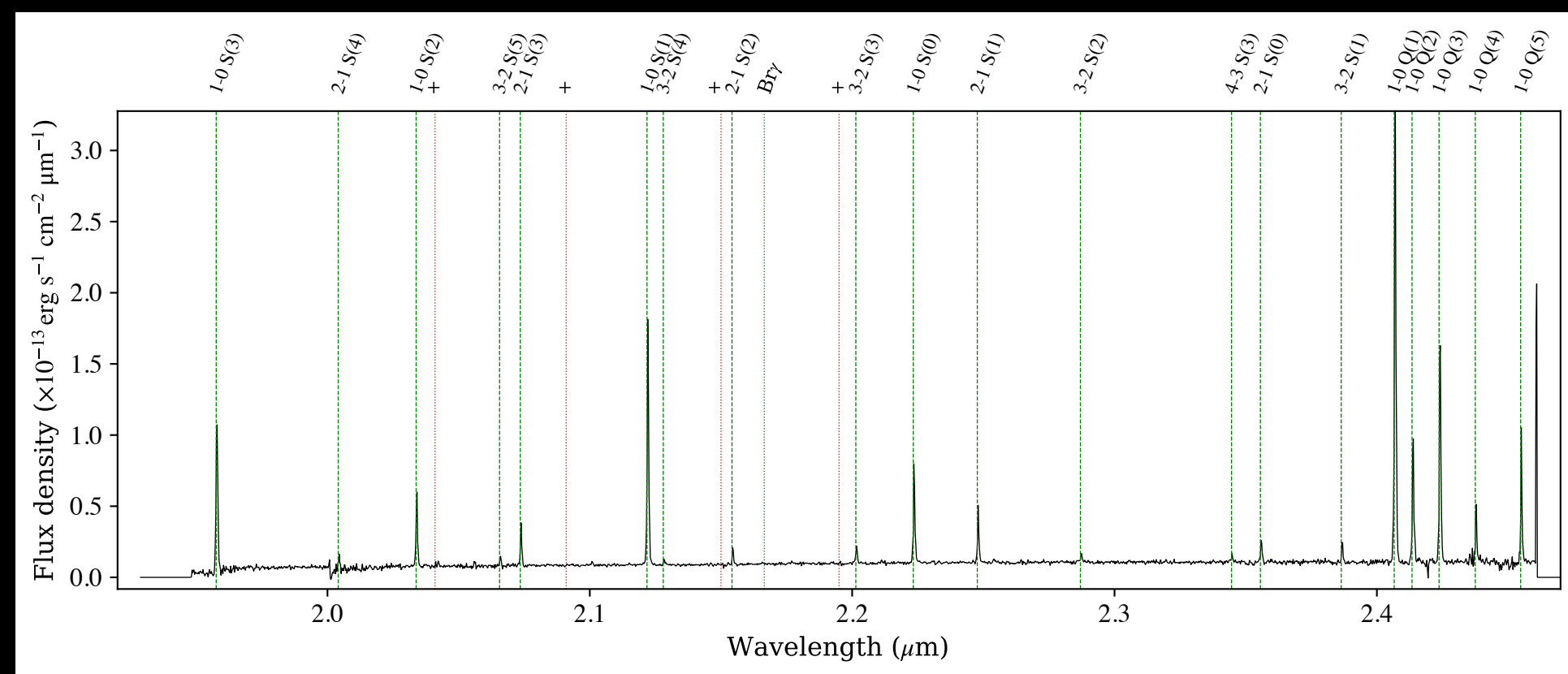
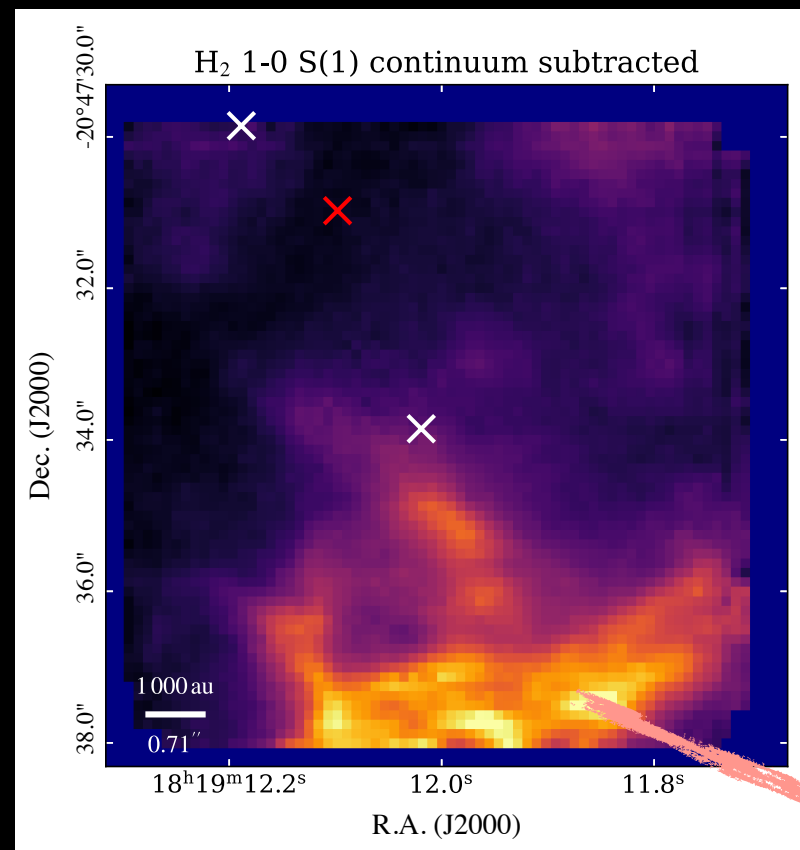
Bulk radial velocity ~ 0 km s⁻¹

Consistent with Stecklum et al (1997), 12.4 mag

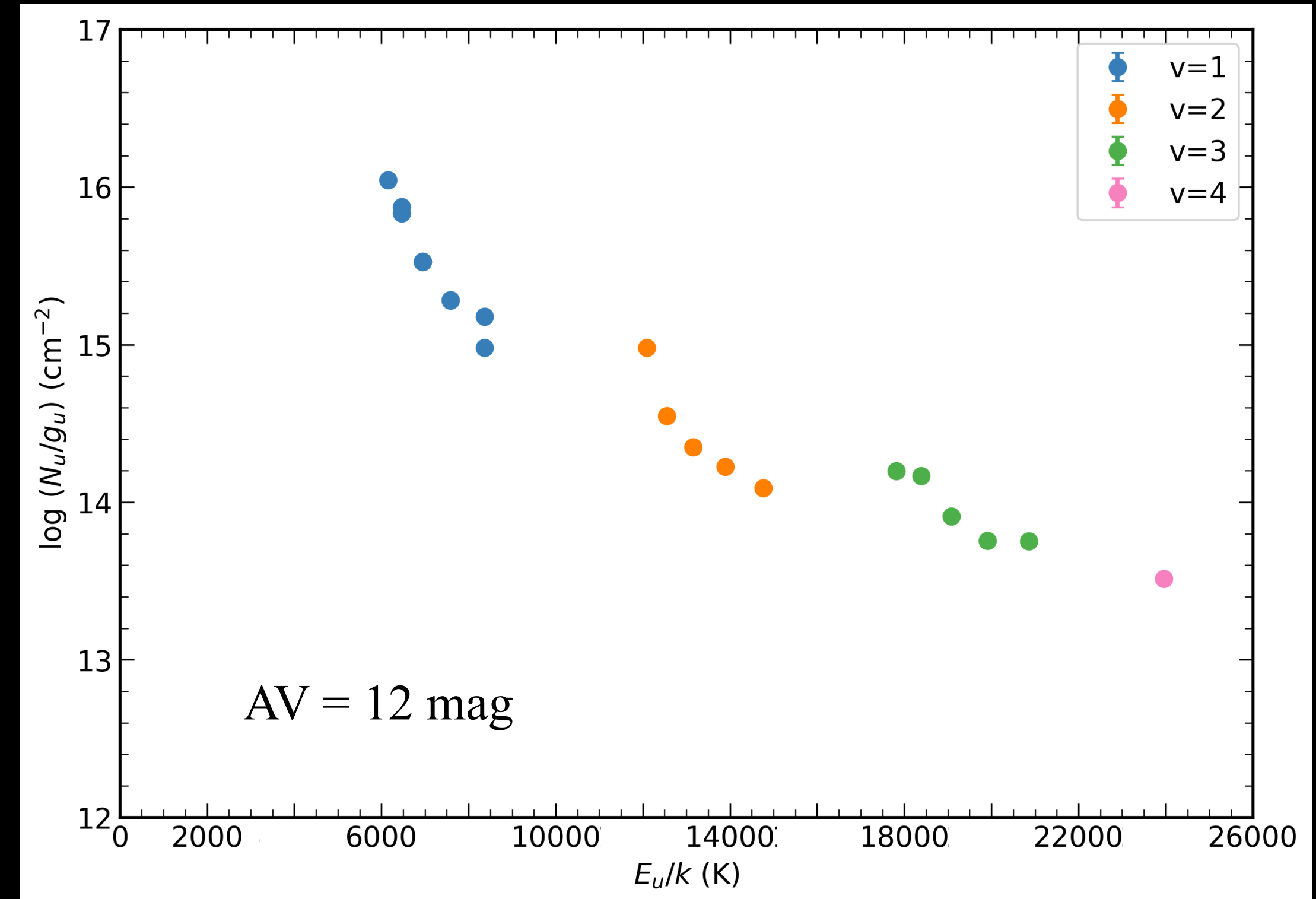
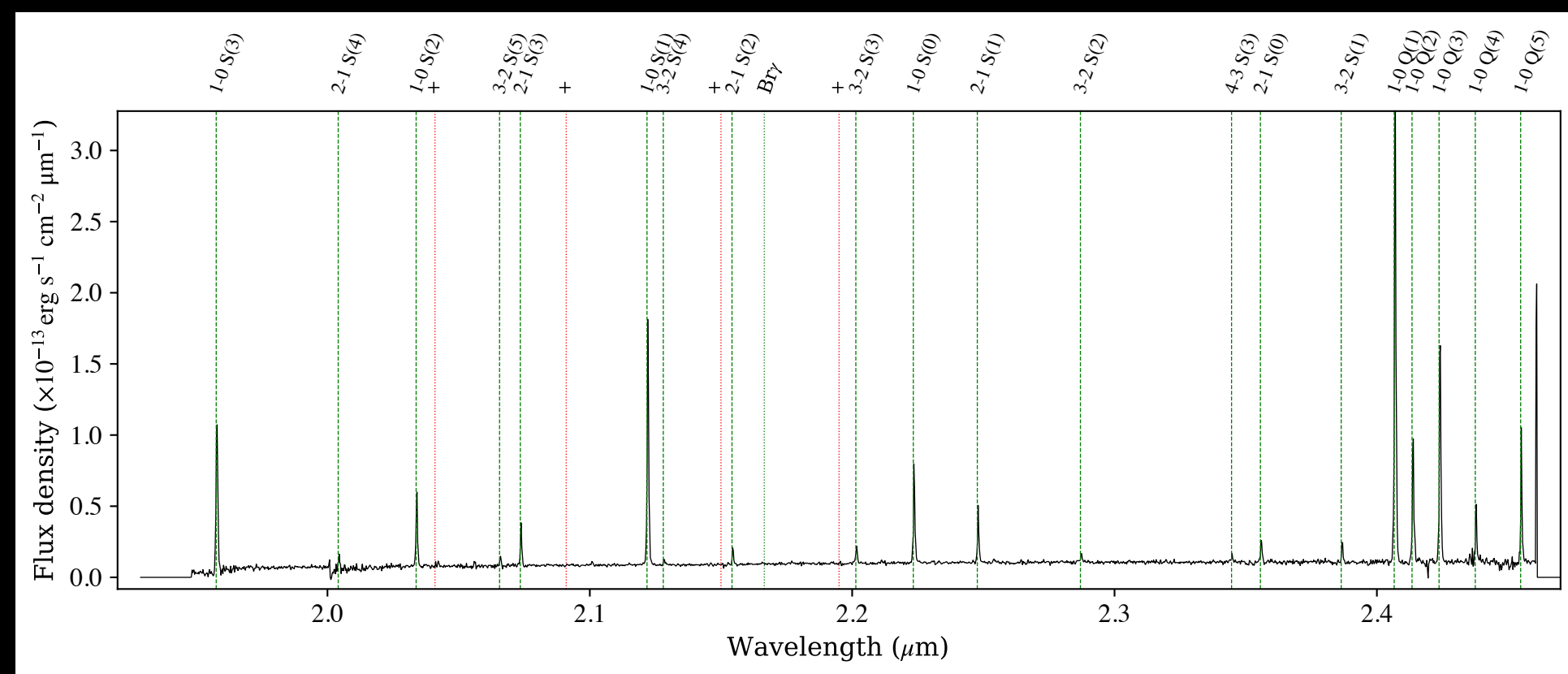
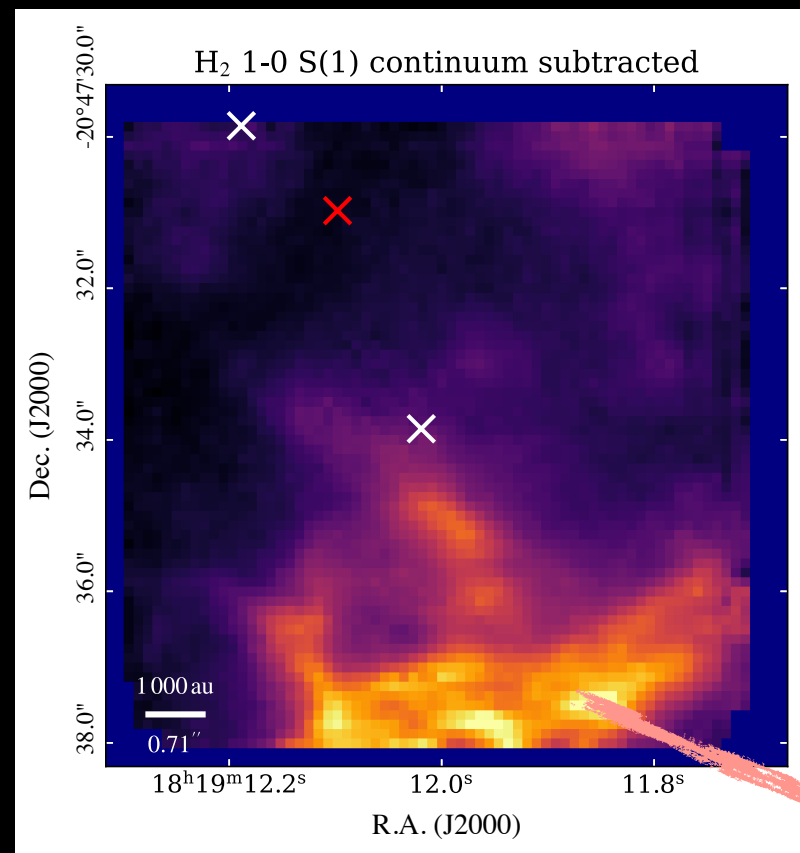
For shocks ratio > 10
e.g., Burton (1992)

For jets v_{rad} > 100 km s⁻¹

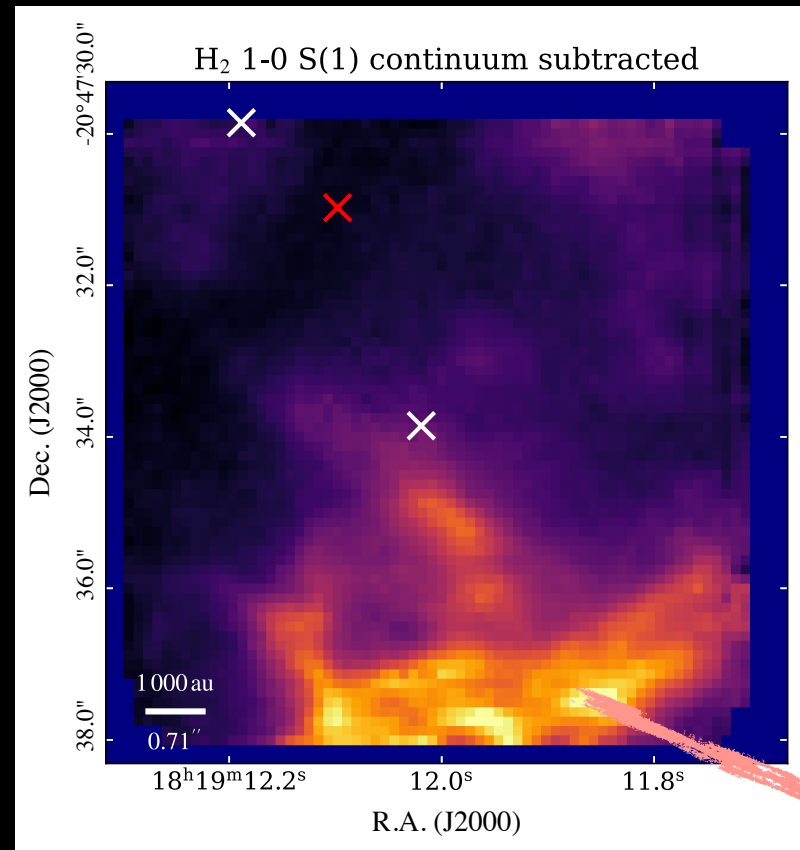
Near-IR view of the central 10000 au of IRAS18162-2048 — the H₂ emission (RV diagram)



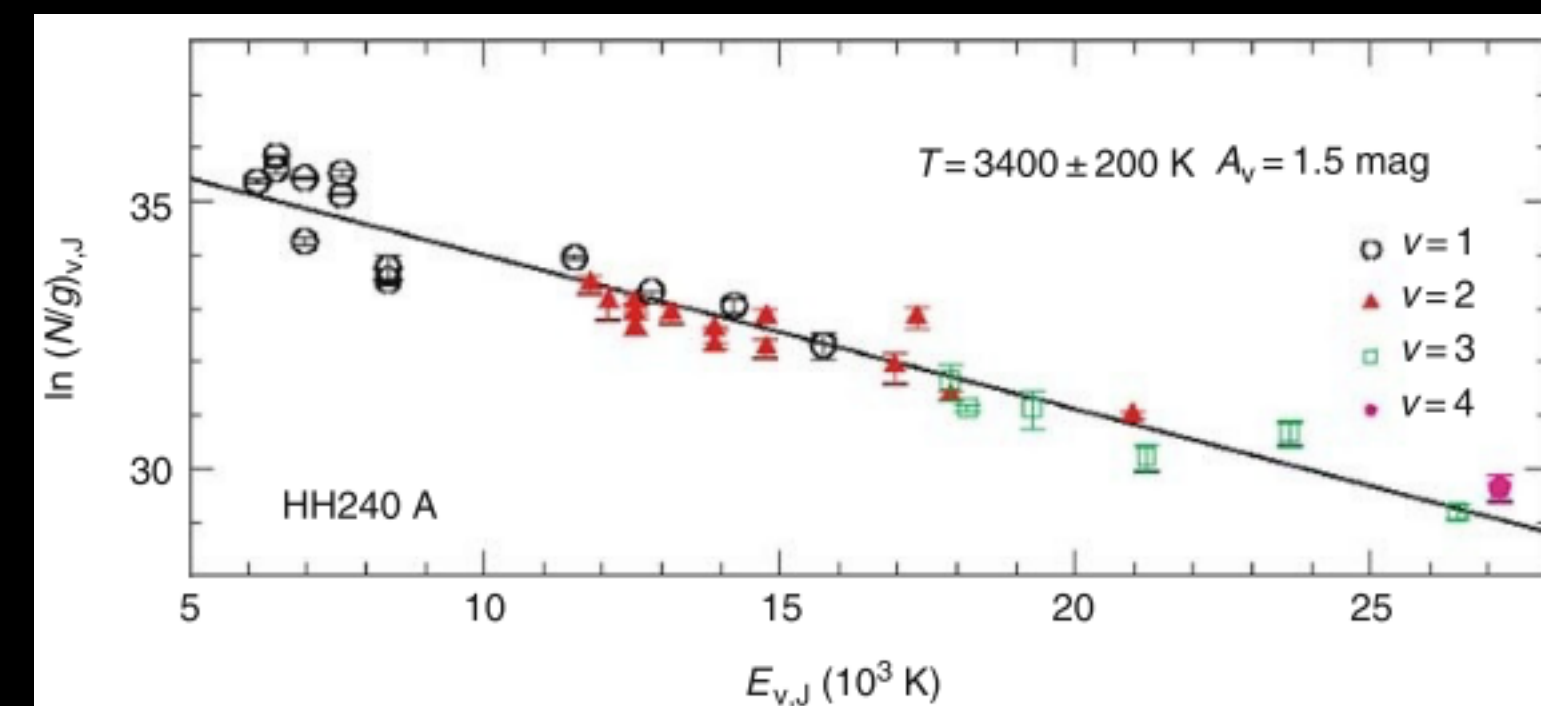
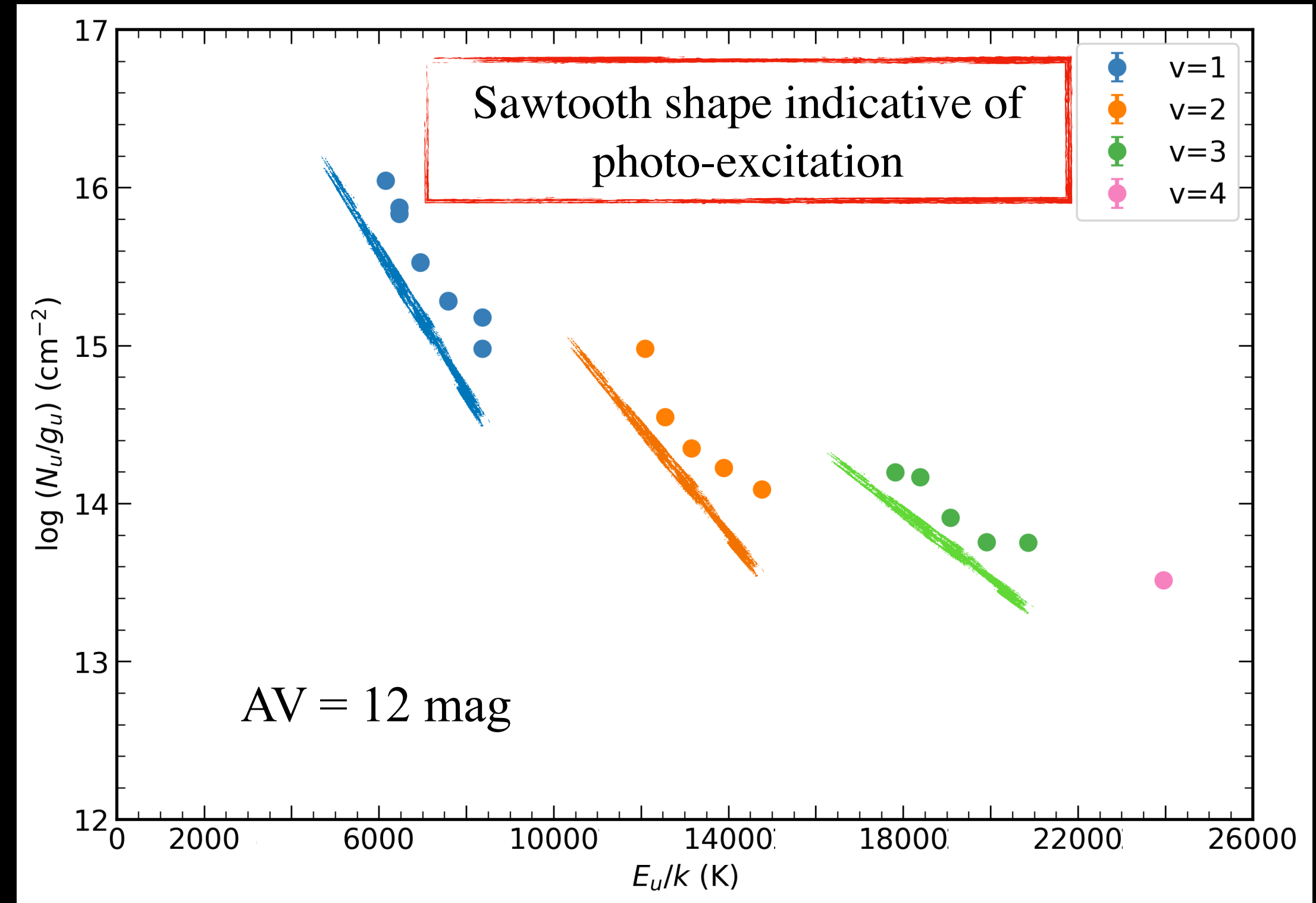
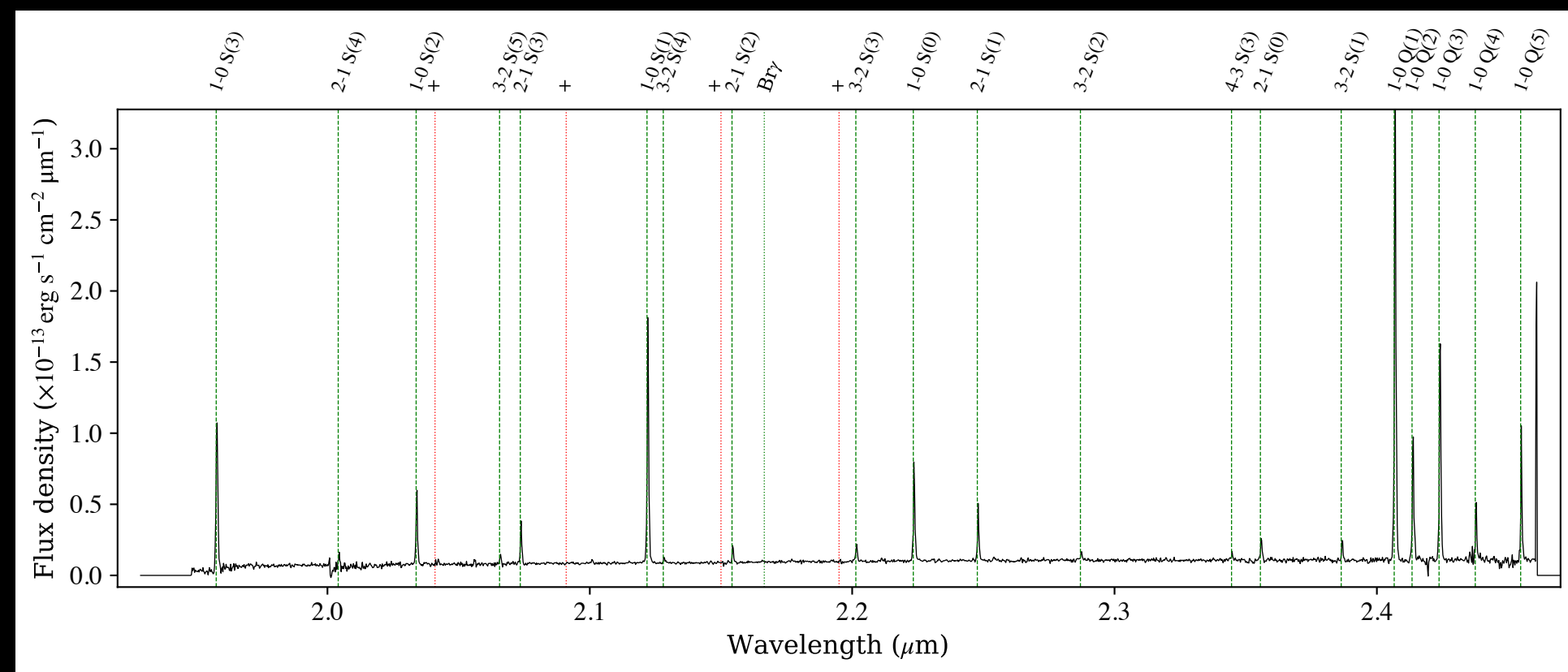
Near-IR view of the central 10000 au of IRAS18162-2048 — the H₂ emission (RV diagram)



Near-IR view of the central 10000 au of IRAS18162-2048 — the H₂ emission (RV diagram)



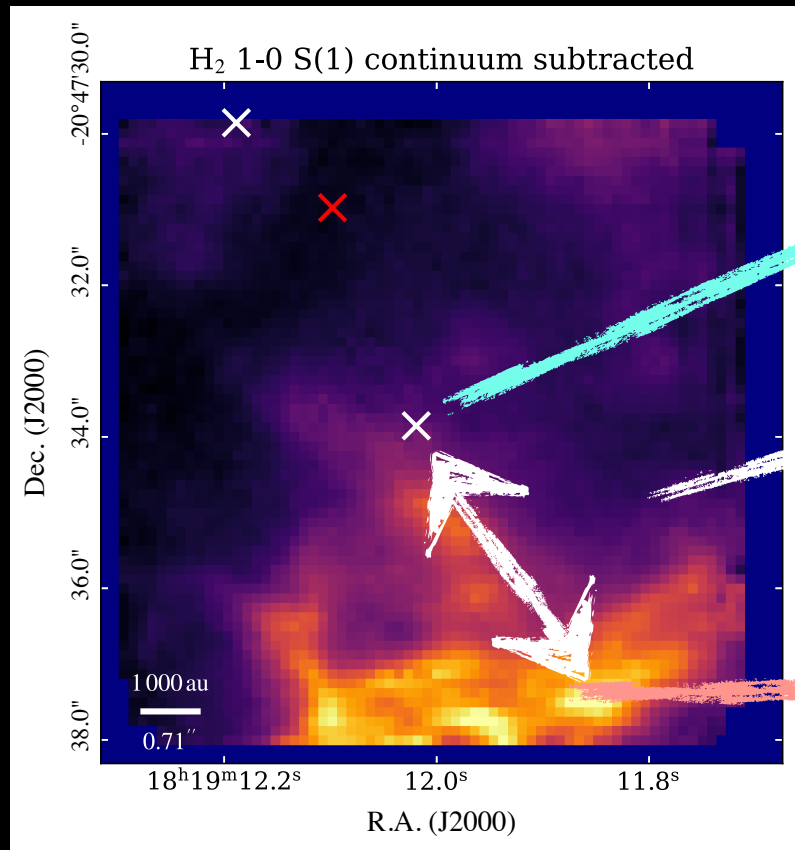
The H₂ ro-vibrational diagram supports the PDR scenario too



HH240A: LTE fit with H₂ thermalised due to shocks

Nisini et al. (2002)
See also Caratti o Garatti et al. (2015)

Near-IR view of the central 10000 au of IRAS18162-2048 — the H₂ emission (modelling)



IRS7: Ionising source B2/B3 star

Distance between ionising source and PDR is ~ 0.027 pc

PDR

Cloudy & Associates

Photoionization simulations for the discriminating astrophysicist since 1978

Ferland et al. (2013, 2017), Gunasekera et al. (2025)

Grid search over

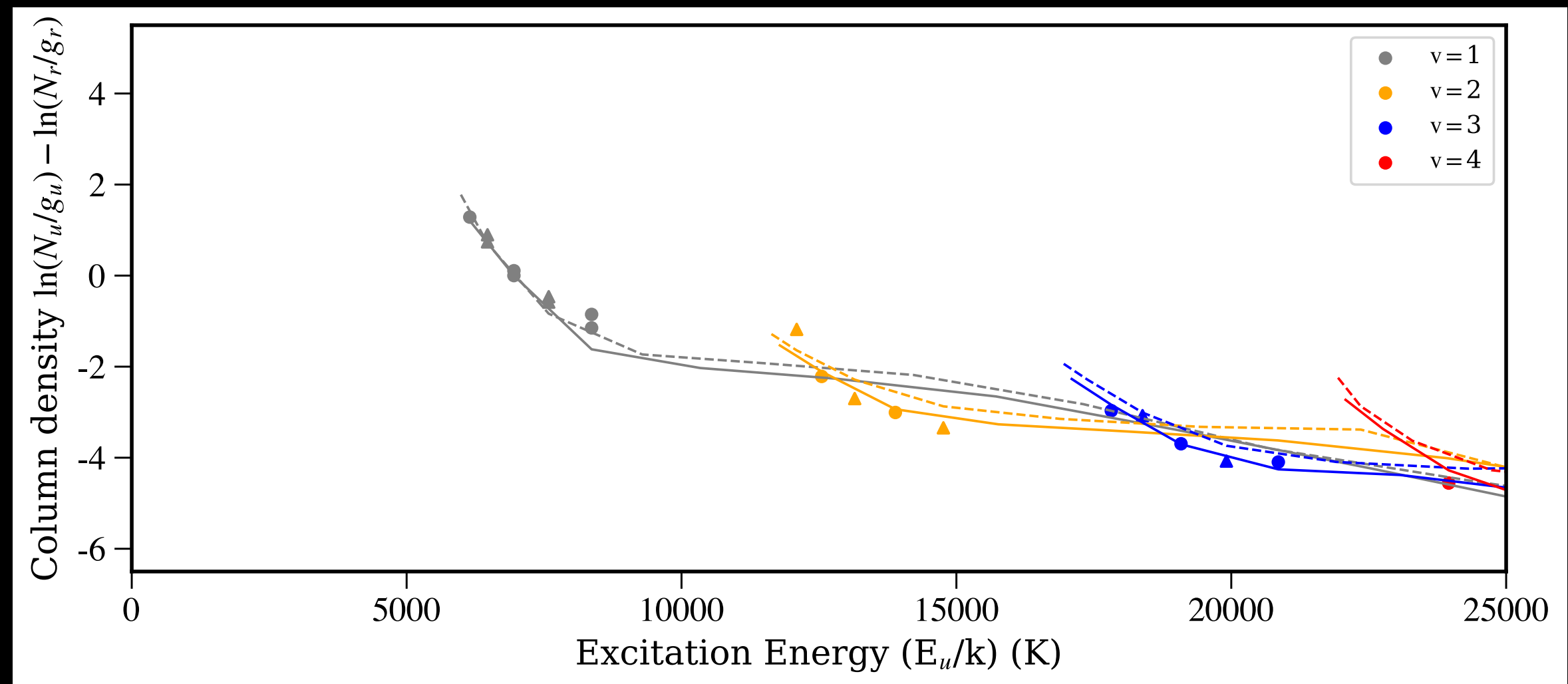
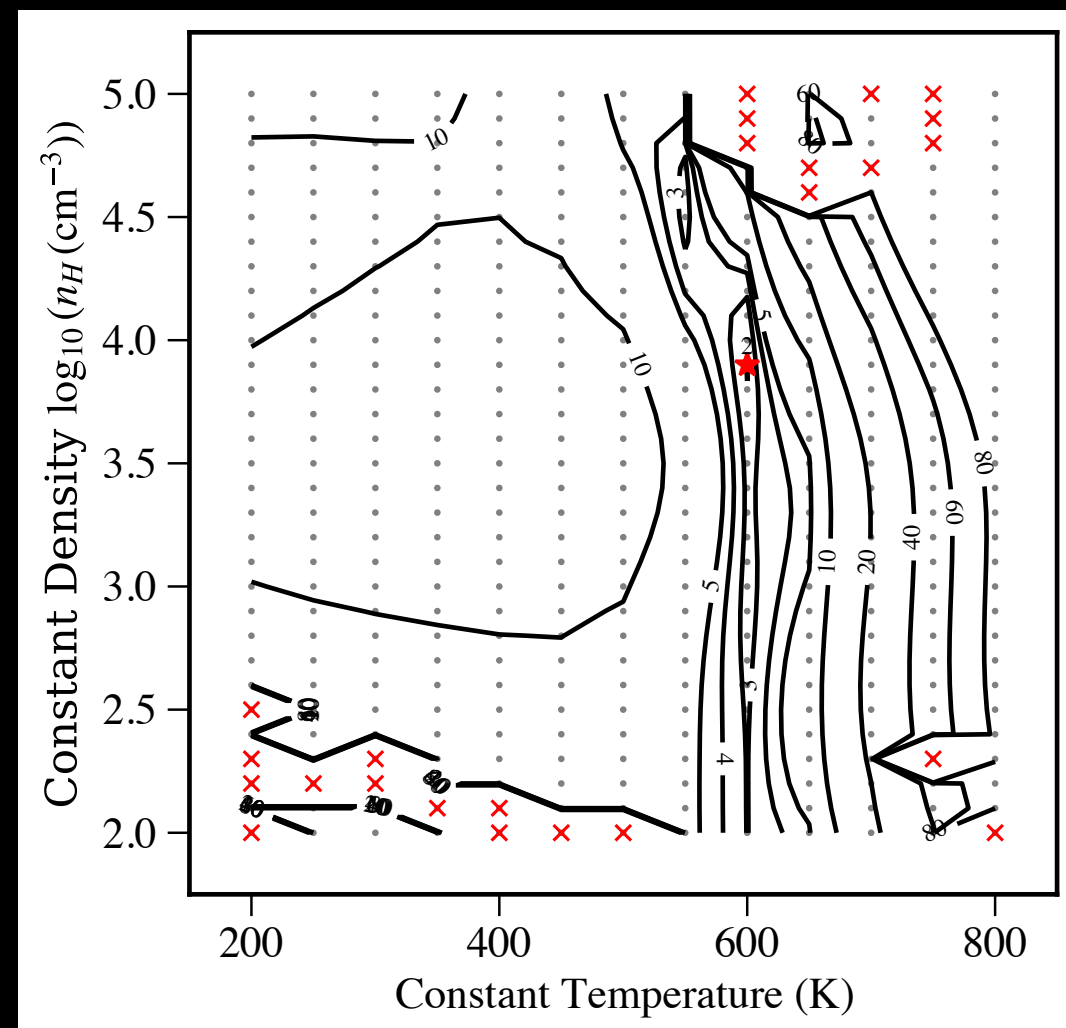
$$T \in [200 - 800] \text{ K}$$

$$n_{\text{H}} \in [10^2 - 10^5] \text{ cm}^{-3}$$

Best fit

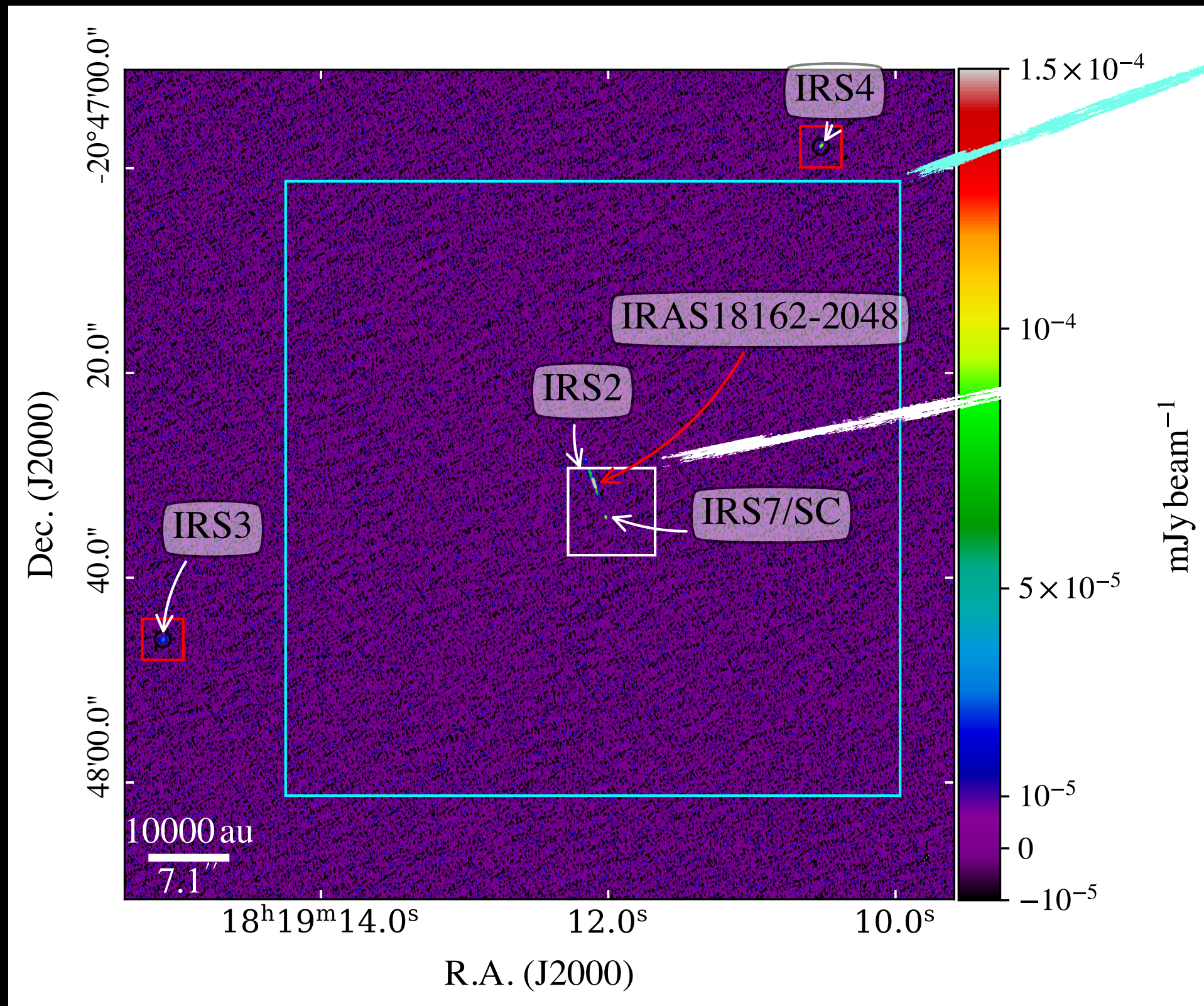
$$T \sim 600 \text{ K}$$

$$n_{\text{H}} \sim 8 \times 10^3 \text{ cm}^{-3}$$



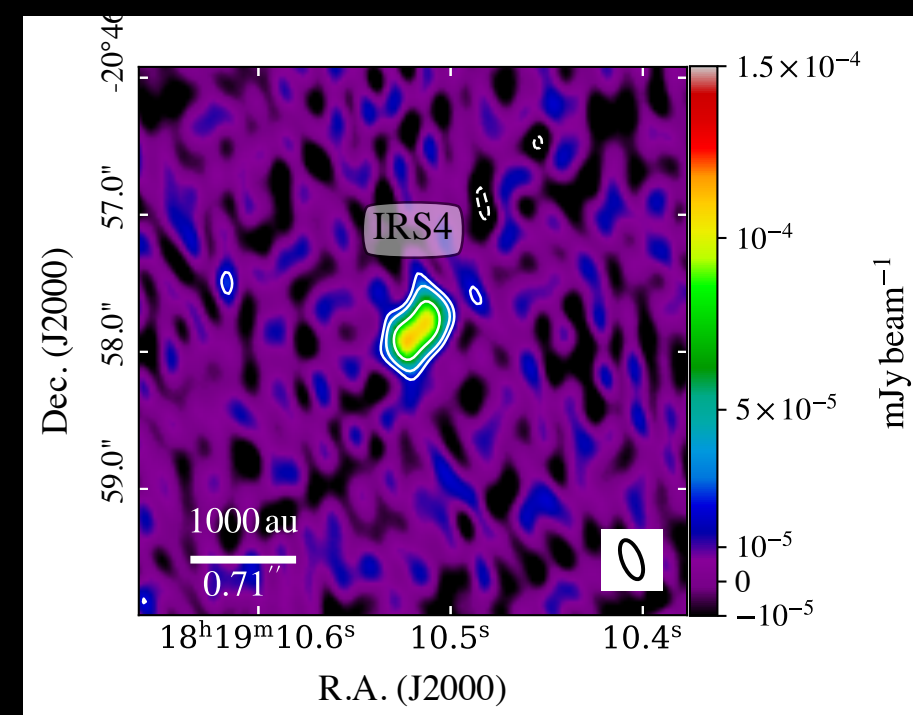
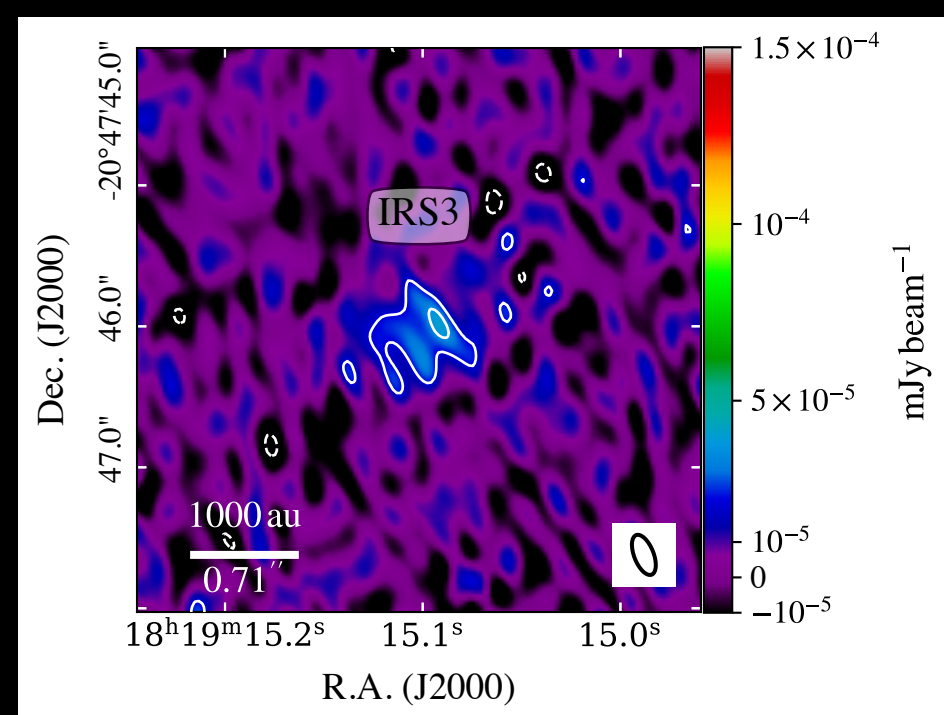
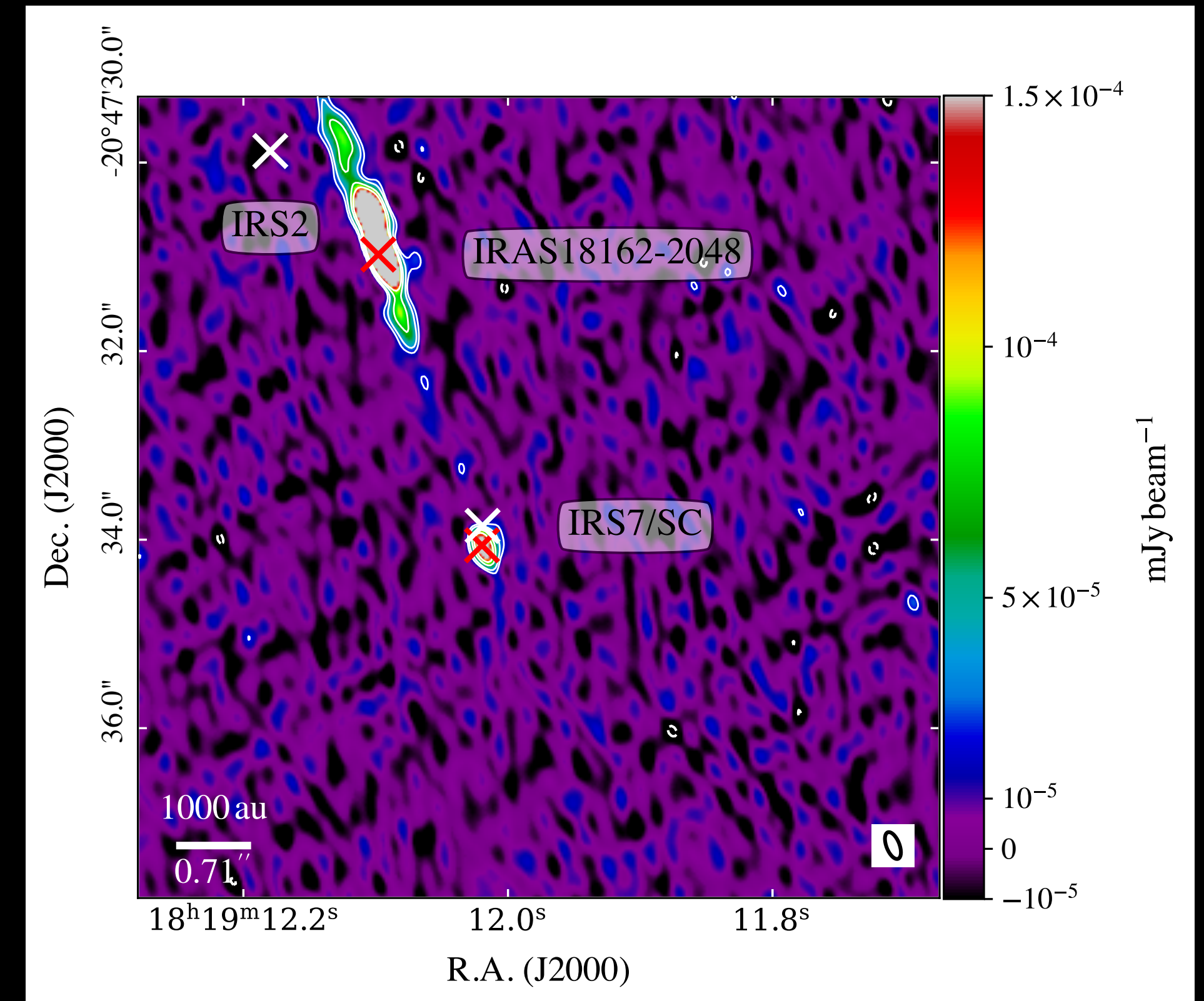
Near-IR view of the central 10000 au of IRAS18162-2048 — revisiting the cm emission

VLA X+C band (3-6 cm)



ALMA band 3 coverage

SINFONI FoV



x near-IR sources

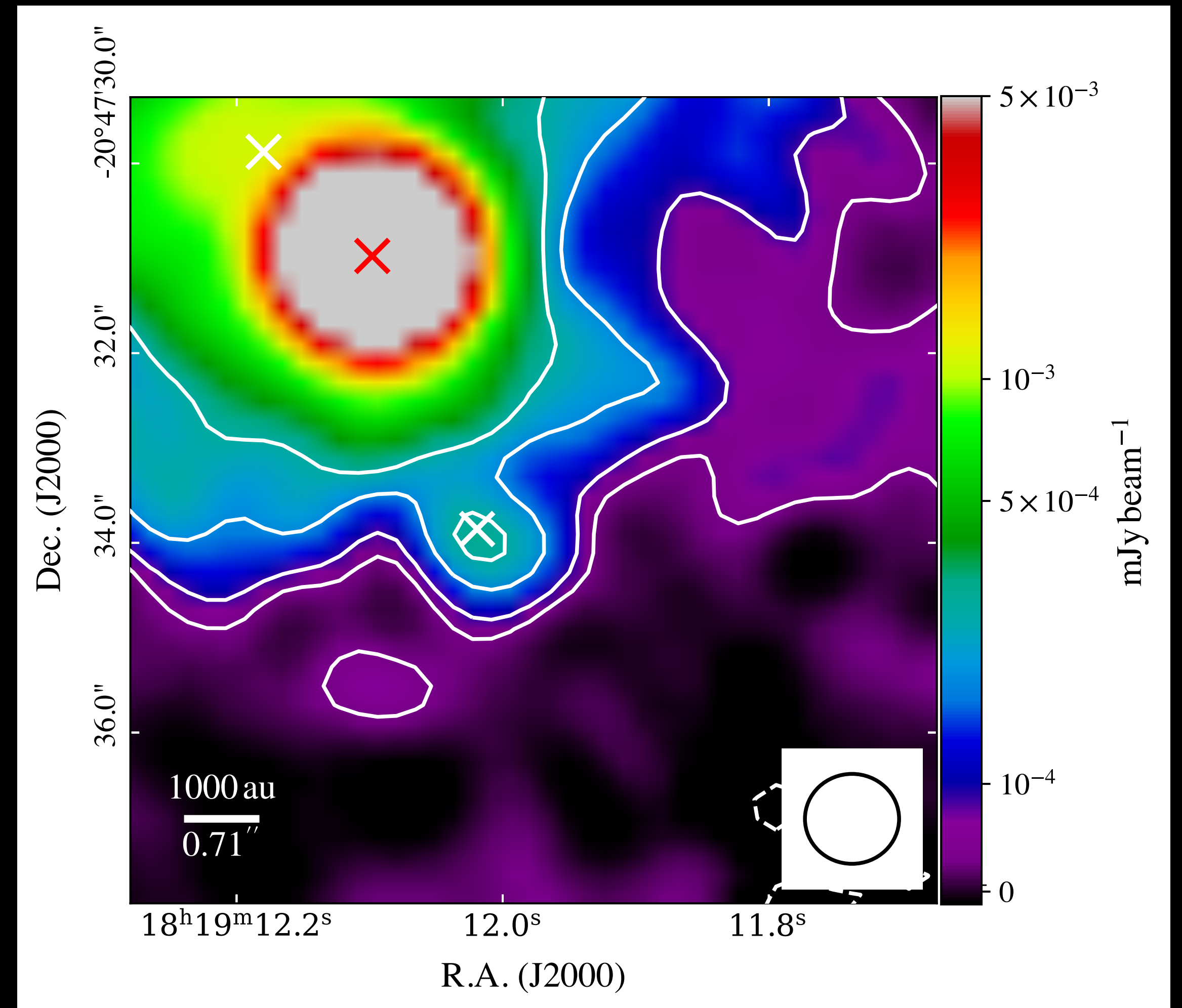
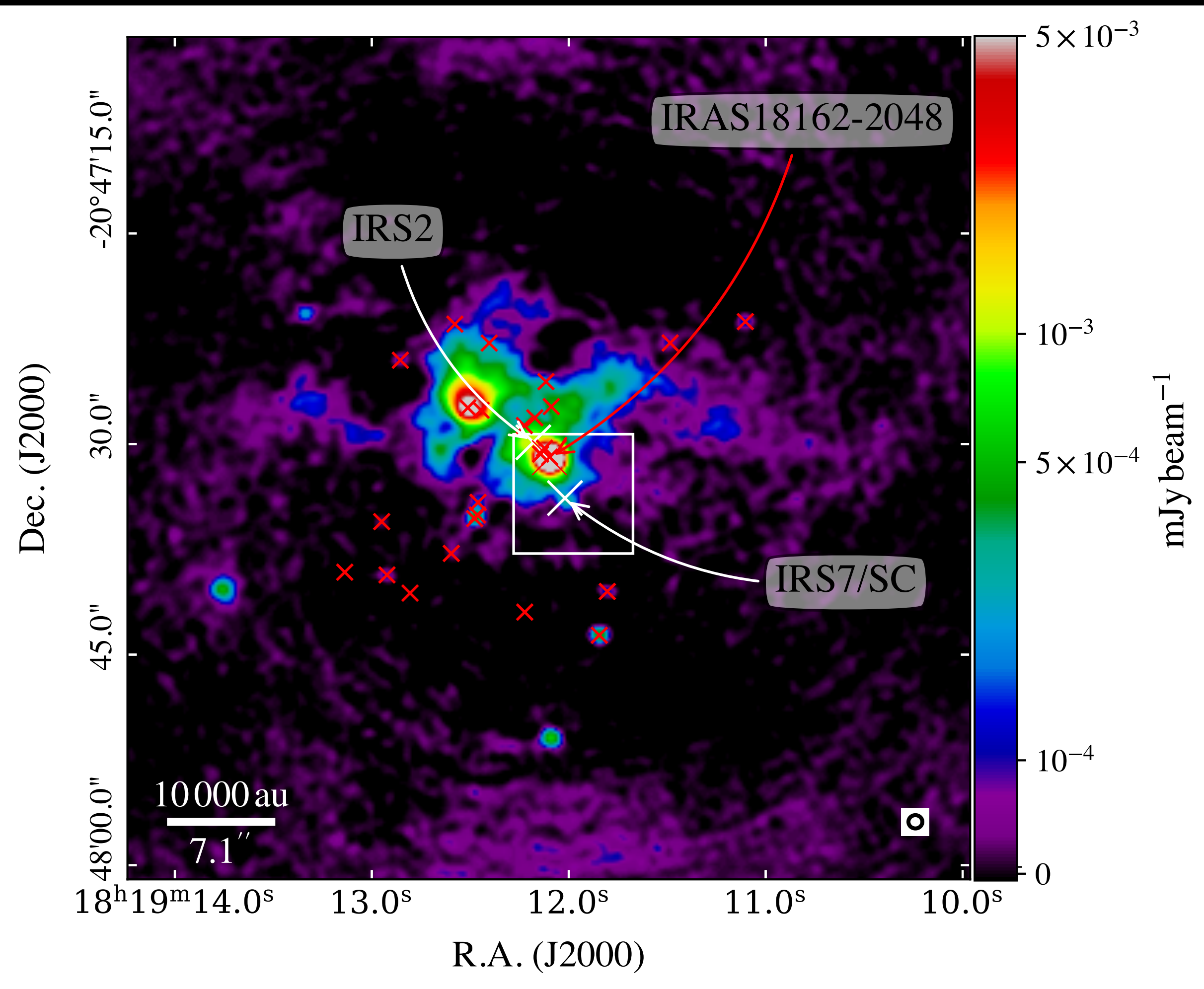
x cm sources

Restoring beam $\sim 0.30'' \times 0.14''$

Contours are $(-3, 3, 5, 10, 15) \times \sigma_{X+C}$,
where $\sigma_{X+C} = 7 \mu\text{Jy beam}^{-1}$.

Near-IR view of the central 10000 au of IRAS18162-2048 — revisiting the mm emission

ALMA band 3 (3 mm)



× near-IR sources

× 1.14 mm sources
(Busquet et al. 2019)

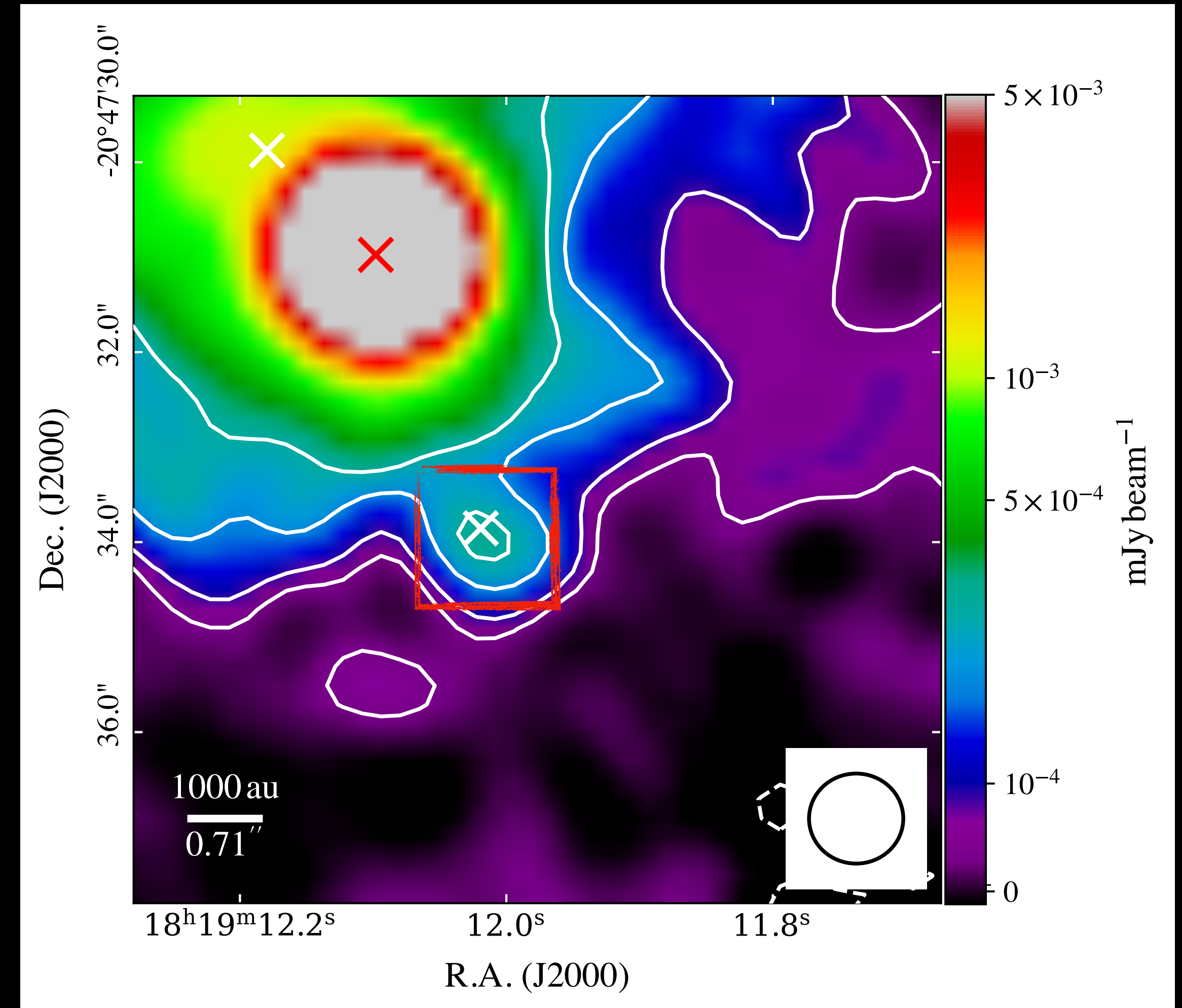
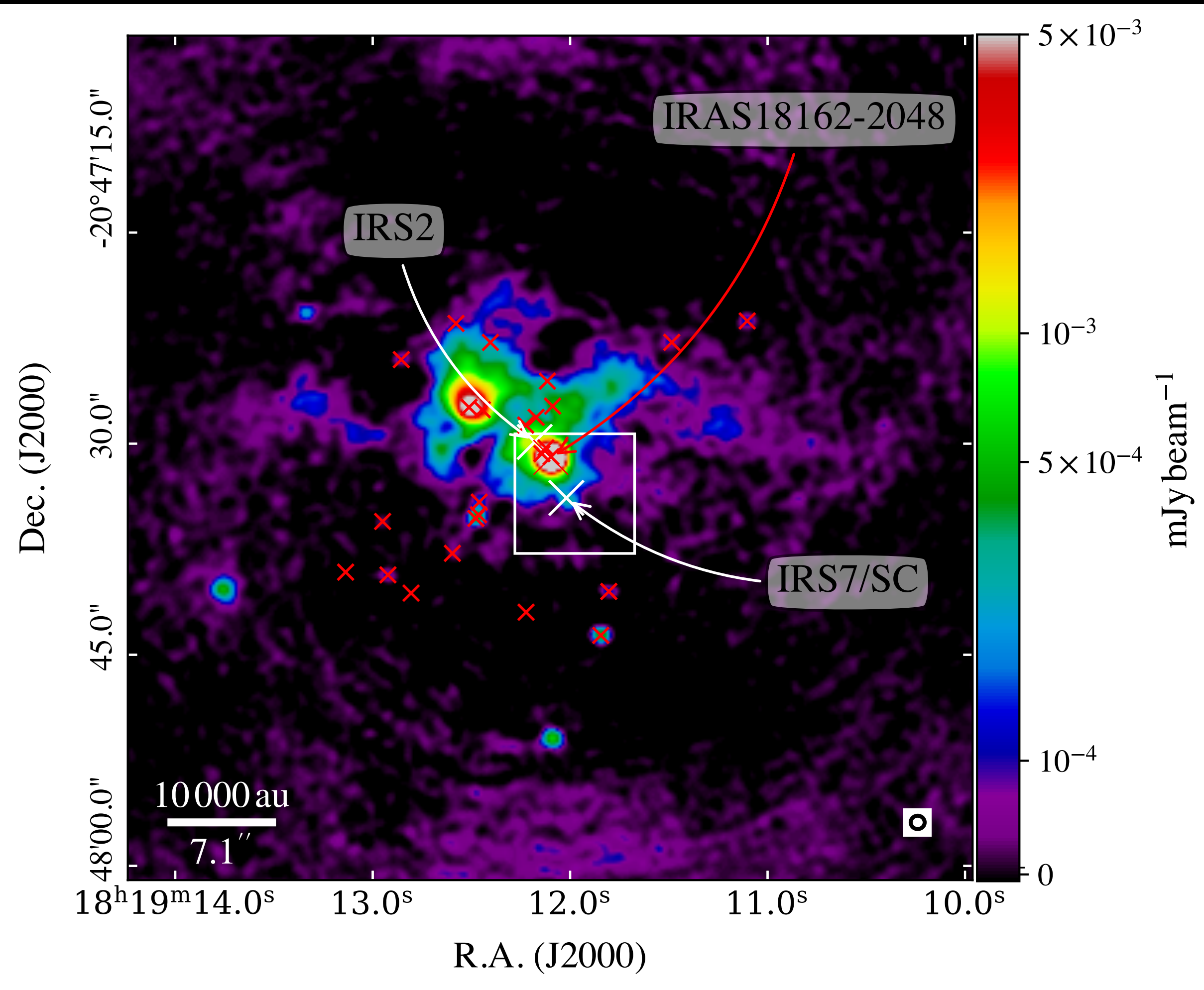
Beam $\sim 0.99'' \times 0.95''$

Contours are $(-3, 3, 5, 10, 15) \times \sigma_{3.3\text{mm}}$,
where $\sigma_{3.3\text{mm}} = 18 \mu\text{Jy beam}^{-1}$.

Near-IR view of the central 10000 au of IRAS18162-2048 — revisiting the mm emission

ALMA band 3 (3 mm)

IRS7 detected for the first time in the mm regime



× near-IR sources

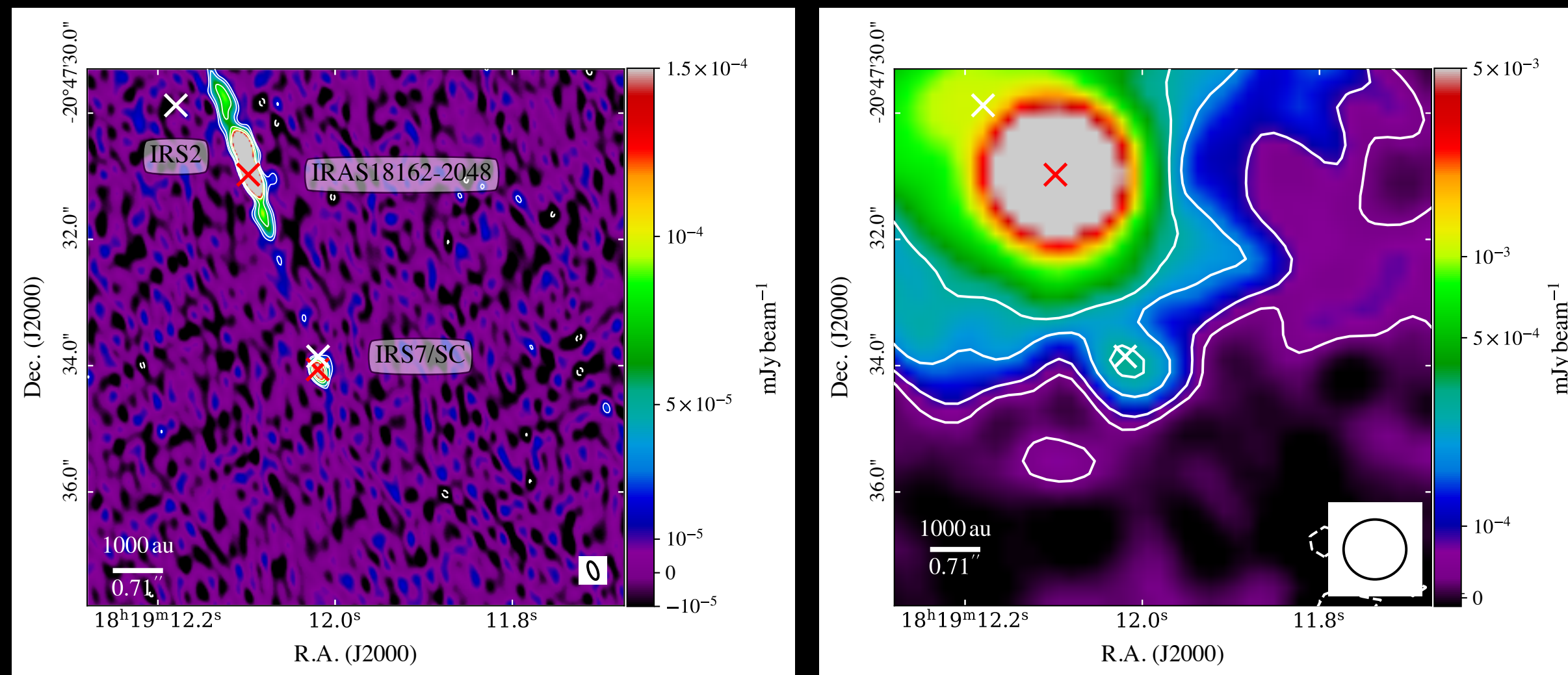
× 1.14 mm sources
(Busquet et al. 2019)

Beam $\sim 0.99'' \times 0.95''$

Contours are $(-3, 3, 5, 10, 15) \times \sigma_{3.3\text{mm}}$,
where $\sigma_{3.3\text{mm}} = 18 \mu\text{Jy beam}^{-1}$.

Near-IR view of the central 10000 au of IRAS18162-2048 — spectral index from IRS7

IRS7 is unresolved in both the VLA and ALMA data

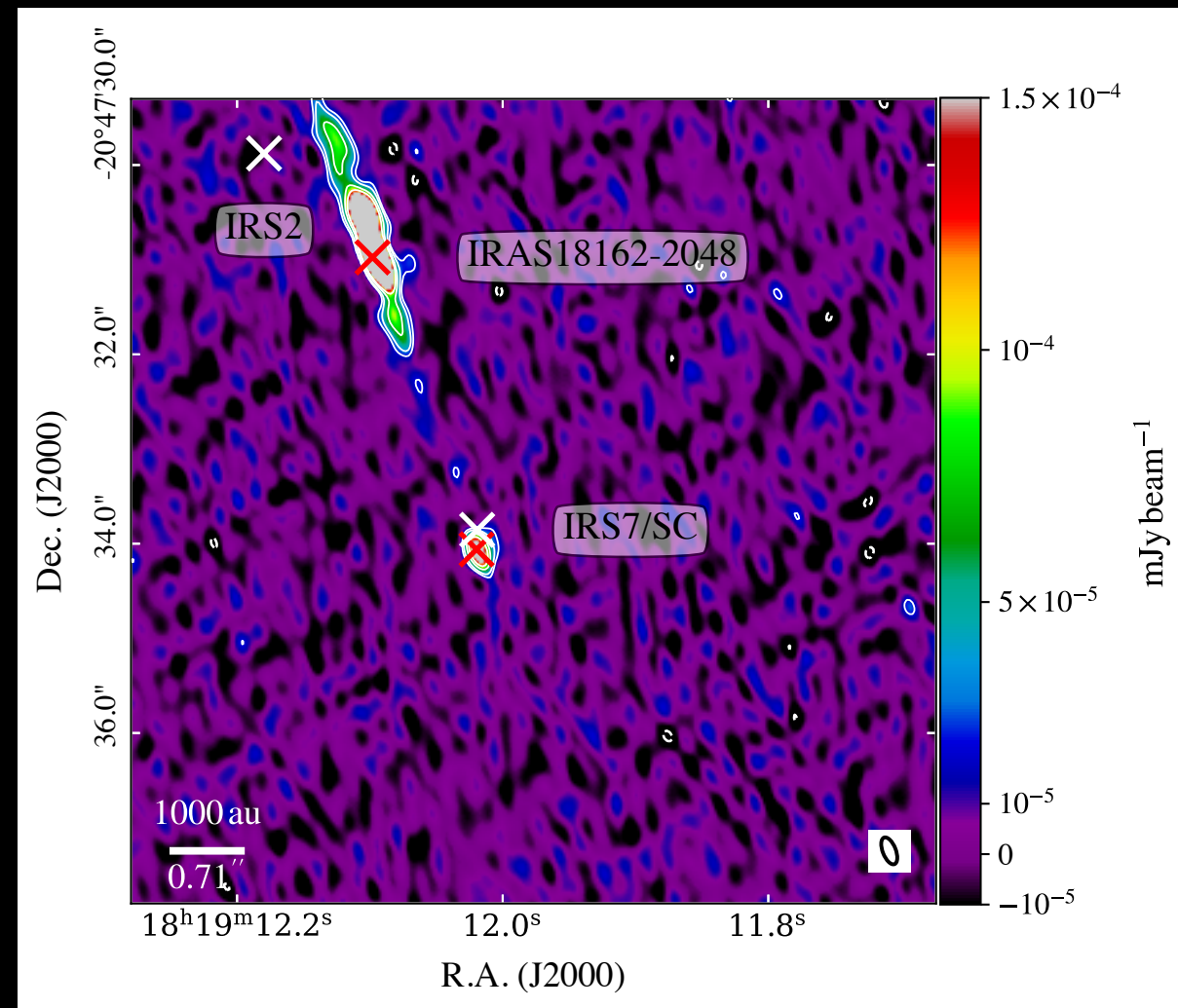


$$\alpha = \frac{\log_{10}(S_{\nu_1}/S_{\nu_2})}{\log_{10}(\nu_1/\nu_2)}$$

Consistent with optically thin free-free emission
i.e., not dominated by dust

$$\alpha = 0.19 \pm 0.27$$

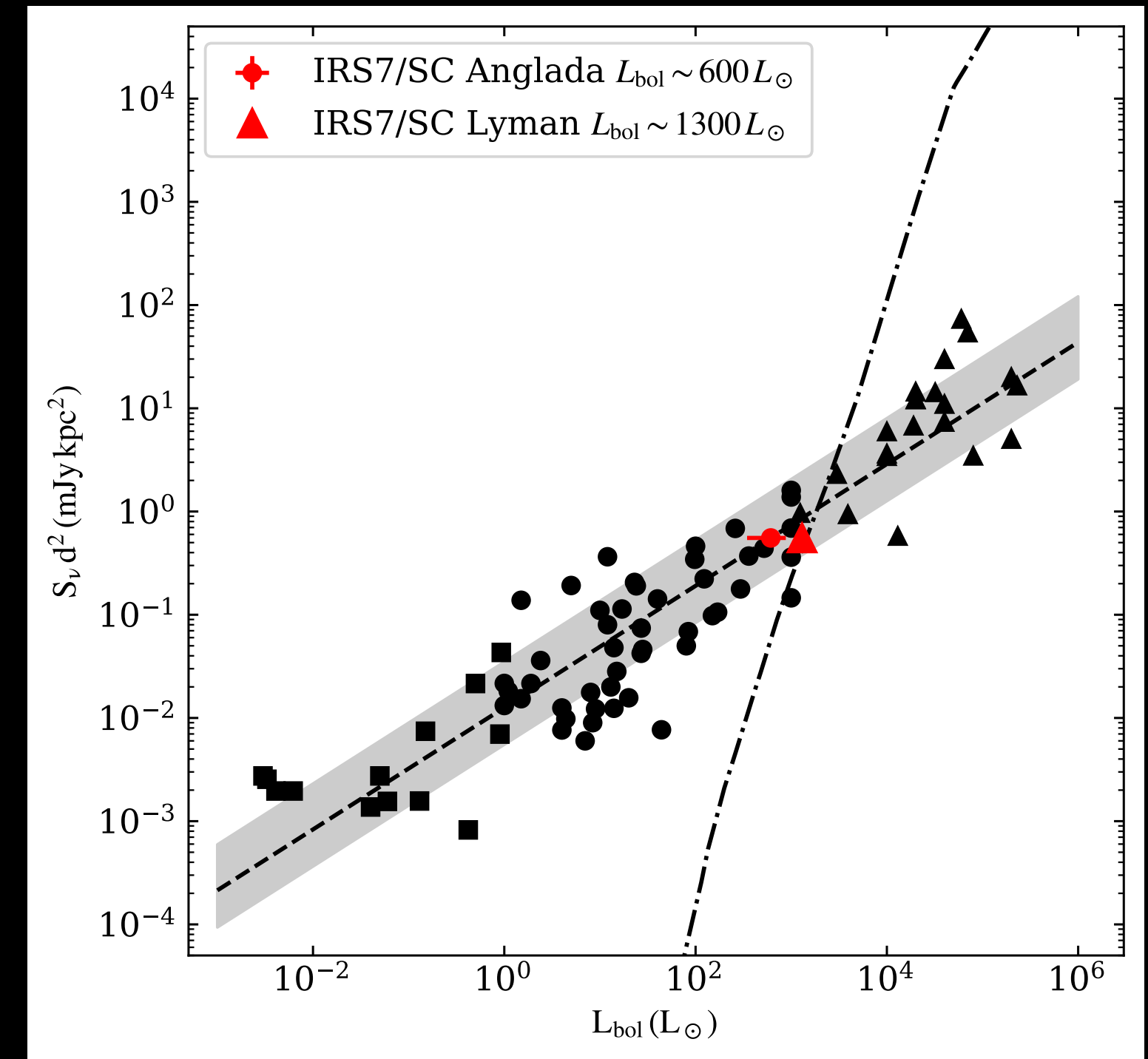
Near-IR view of the central 10000 au of IRAS18162-2048 — the Anglada plot



● Radio continuum from radio jet
 ▲ Radio continuum from Lyman

$\log(N_L) \sim 43.67$

L_{bol} vs radio continuum luminosity



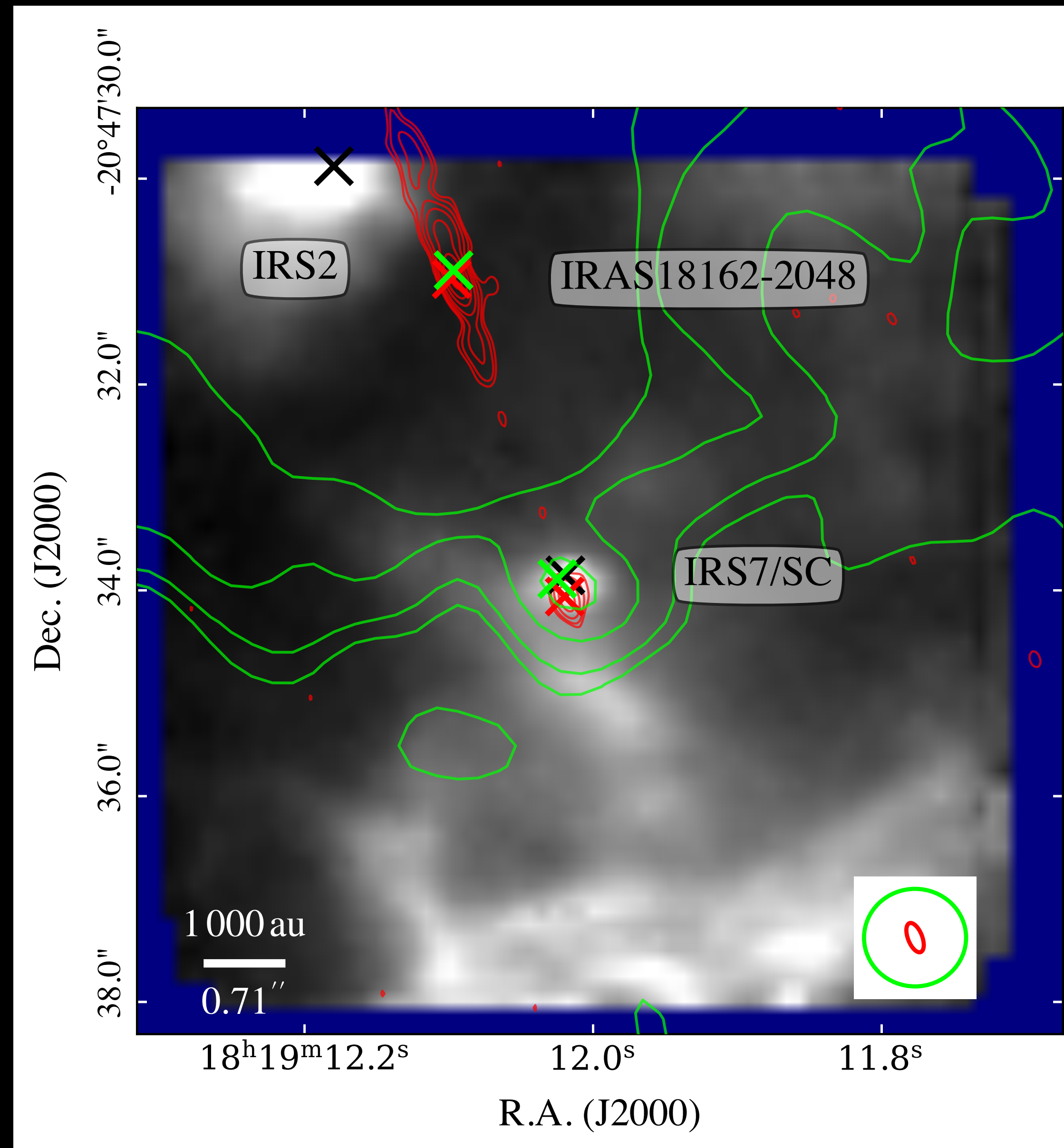
Adapted from Anglada et al. (2018)

TABLE II. Fluxes of Lyman Continuum Photons, Excitation Parameters, Fractional Energy of Lyman Continuum, and Ratio of Stellar Luminosity to Lyman-alpha Luminosity.

SP	$\log N_L$				U (pc cm ⁻²)				P ($\times 10^2$)			α_∞		
	ZAMS	V	III	I	ZAMS	V	III	I	ZAMS-V	III	I	ZAMS-V	III	I
O4	49.93	49.93	49.93	49.93	126	126	126	126	66	63	61	3.5	3.7	3.1
O5	49.62	49.71	49.71	49.77	99.3	106	106	111	60	57	56	3.9	3.9	4.8
O5.5	49.36	49.50	49.53	49.66	81.3	90.2	92.3	103	54	52	52	4.2	4.3	4.1
O6	49.08	49.24	49.34	49.55	65.6	75.0	80.4	94.2	46	46	46	5.0	4.7	4.5
O6.5	48.82	49.02	49.15	49.43	53.8	62.8	69.2	86.3	40	40	40	5.4	5.4	4.9
O7	48.62	48.86	49.05	49.37	46.3	55.6	64.1	82.1	35	35	37	5.7	6.0	5.3
O7.5	48.51	48.70	49.98	49.34	42.5	49.4	60.8	80.2	31	31	32	6.1	6.5	5.9
O8	48.35	48.59	48.90	49.30	37.4	45.0	57.0	76.9	27	27	25	6.9	7.3	6.7
O8.5	48.21	48.45	48.83	49.22	33.7	40.6	54.2	73.0	23	22	19	7.9	7.9	8.1
O9	48.08	48.32	48.78	49.12	30.1	36.2	52.3	67.9	20	19	13	9.2	8.6	10.3
O9.5	47.84	48.08	48.53	48.97	25.4	30.5	43.2	60.6	14	12	6	13.2	13.9	13.7
B0	47.36	47.63	47.94	48.53	17.6	21.7	23.9	43.2	7	4	<2	26.	29.	30.
B0.5	46.23	46.50	46.80	47.60	7.3	9.1	11.5	21.0	<2	<2	...	>100	>100	>100
B1	45.29	45.52	45.87	46.78	3.5	4.3	5.6	11.2	...	...	...	...	...	...
B2	44.65	44.89	45.25	46.18	2.2	2.6	3.5	6.6	...	...	...	...	...	...
B3	43.69	43.91	44.30	45.57	1.1	1.2	1.7	4.4	...	...	...	...	...	...

Conclusion:
 From radio continuum flux
 IRS7/SC is a B2/B3 ZAMS

Near-IR view of the central 10000 au of IRAS18162-2048 — all pieces together

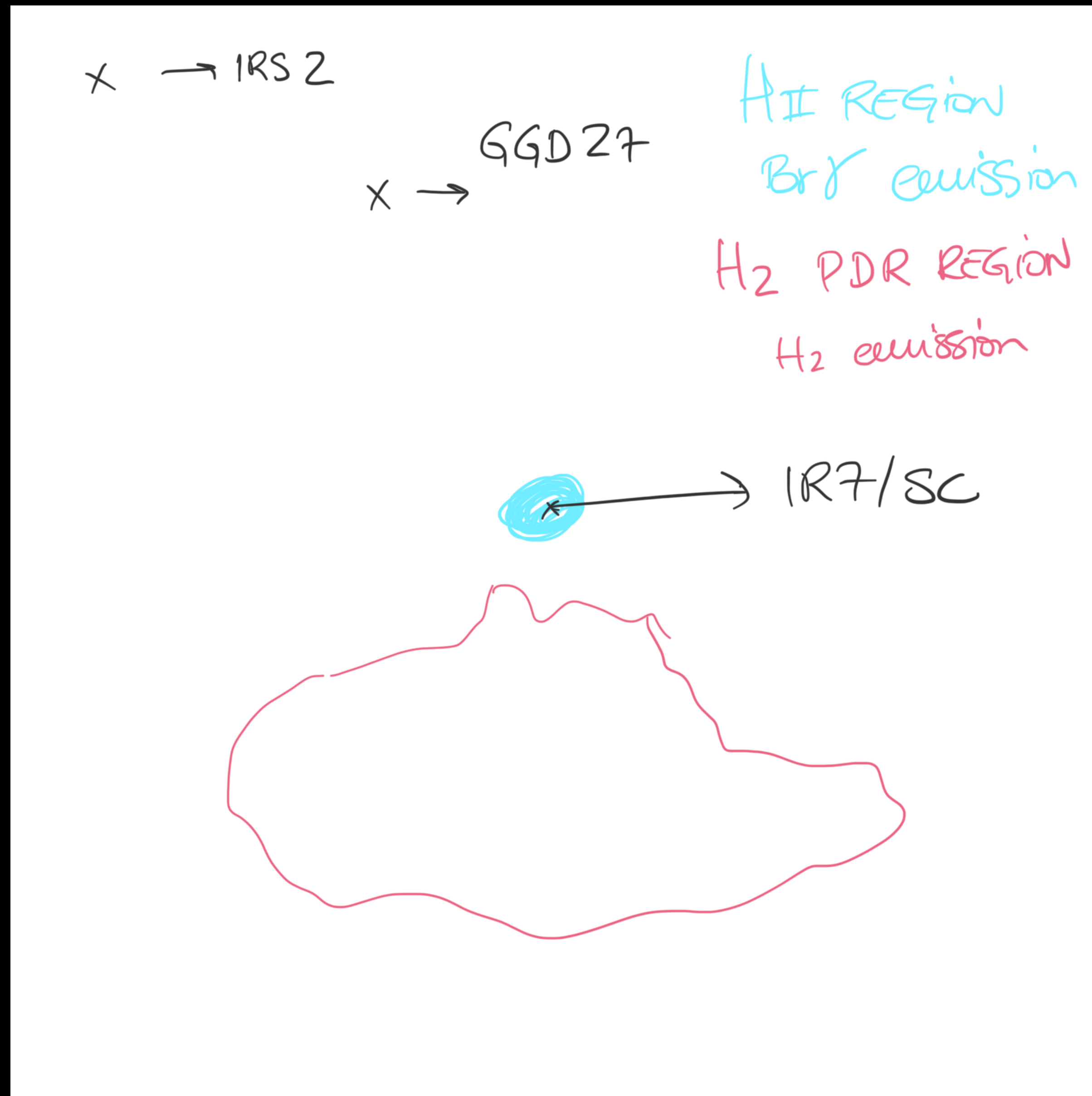


Gray scale image \rightarrow
2.12 μm H₂ emission

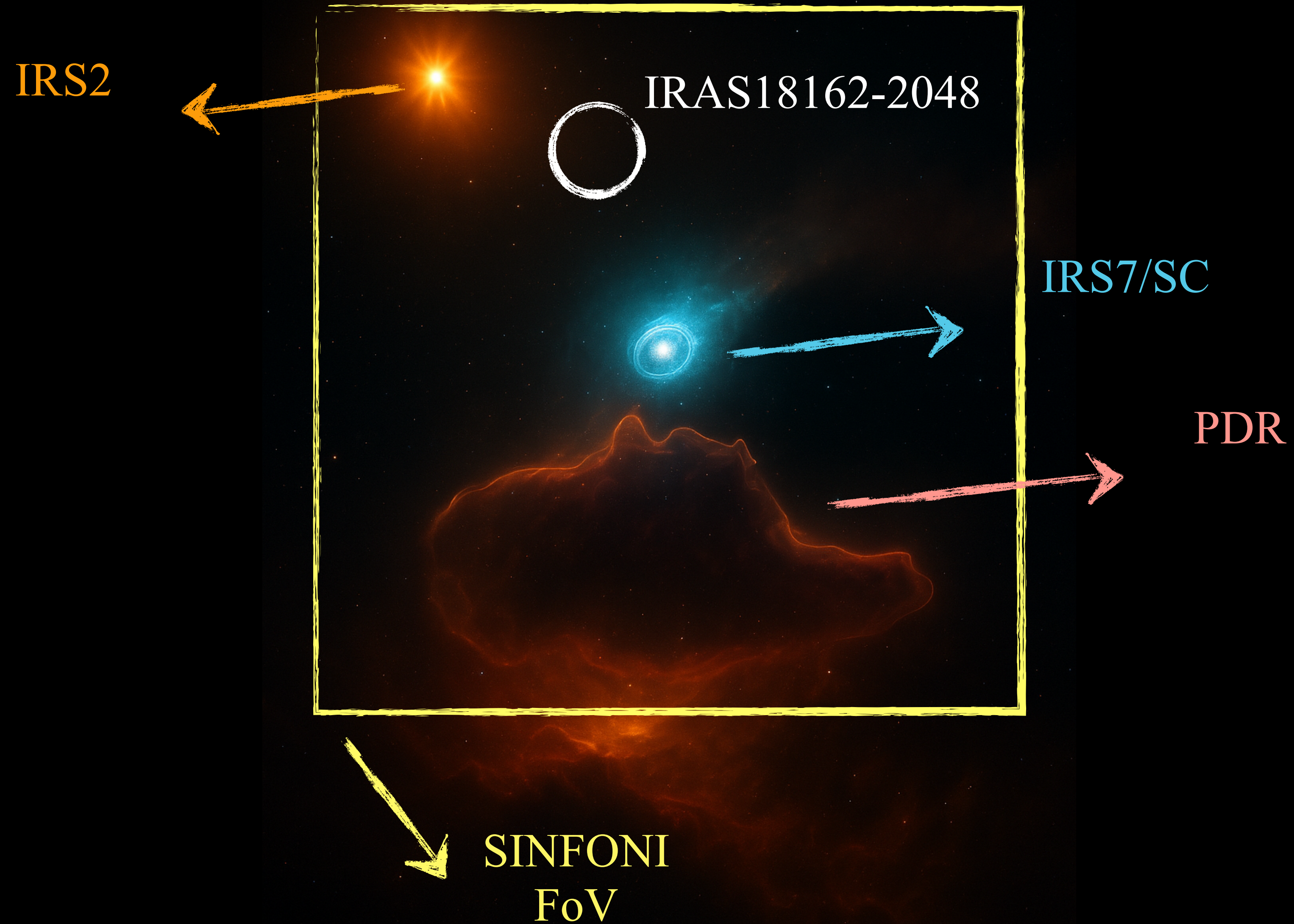
Red contours \rightarrow
VLA X+C band

Green contours \rightarrow
ALMA band 3

Near-IR view of the central 10000 au of IRAS18162-2048 — all pieces together

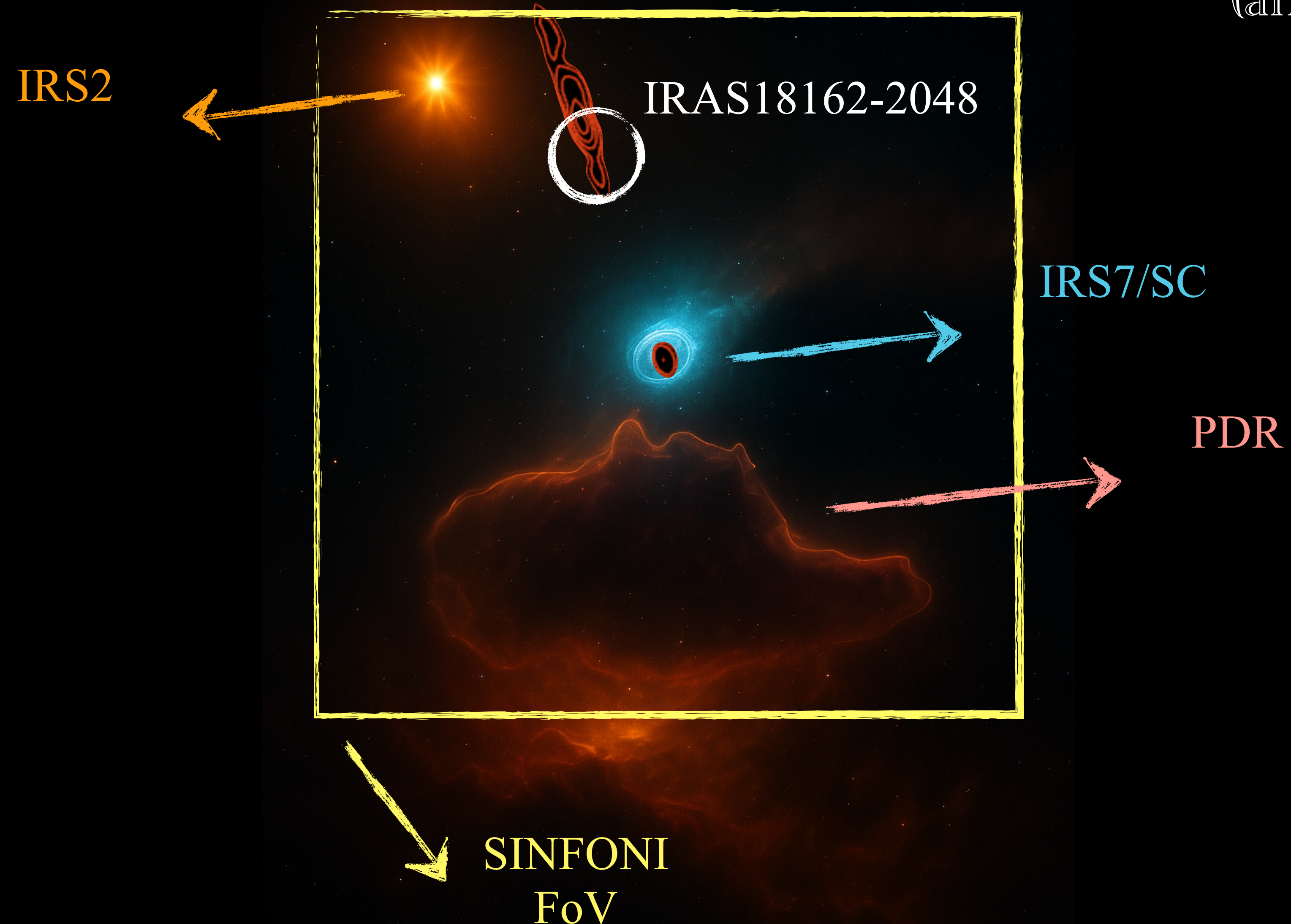


Artist impression (as seen in the near-IR)



Artist impression (as seen in the near-IR)

(and radio)



Artist impression (as seen in the near-IR)

(and radio)

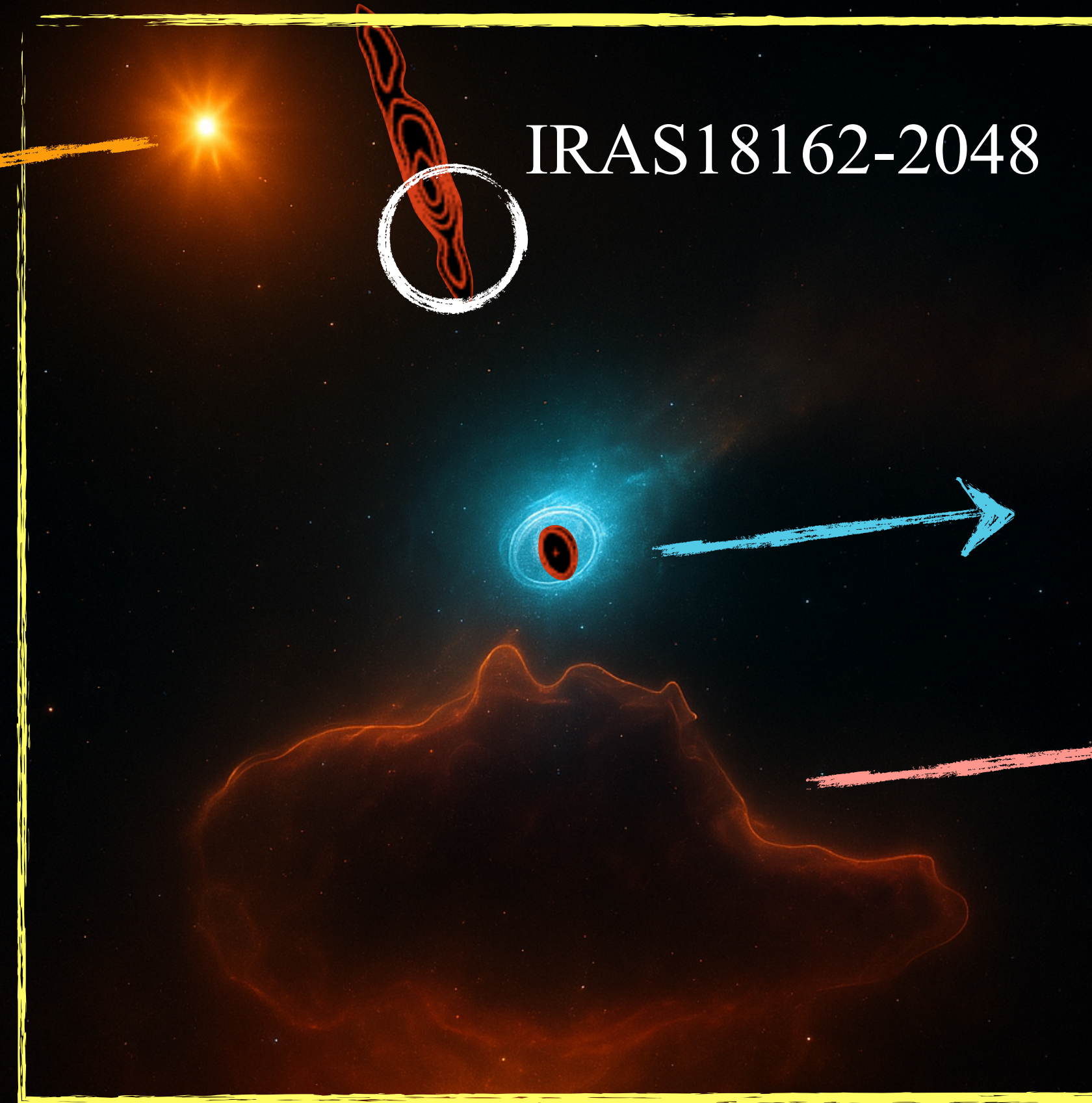
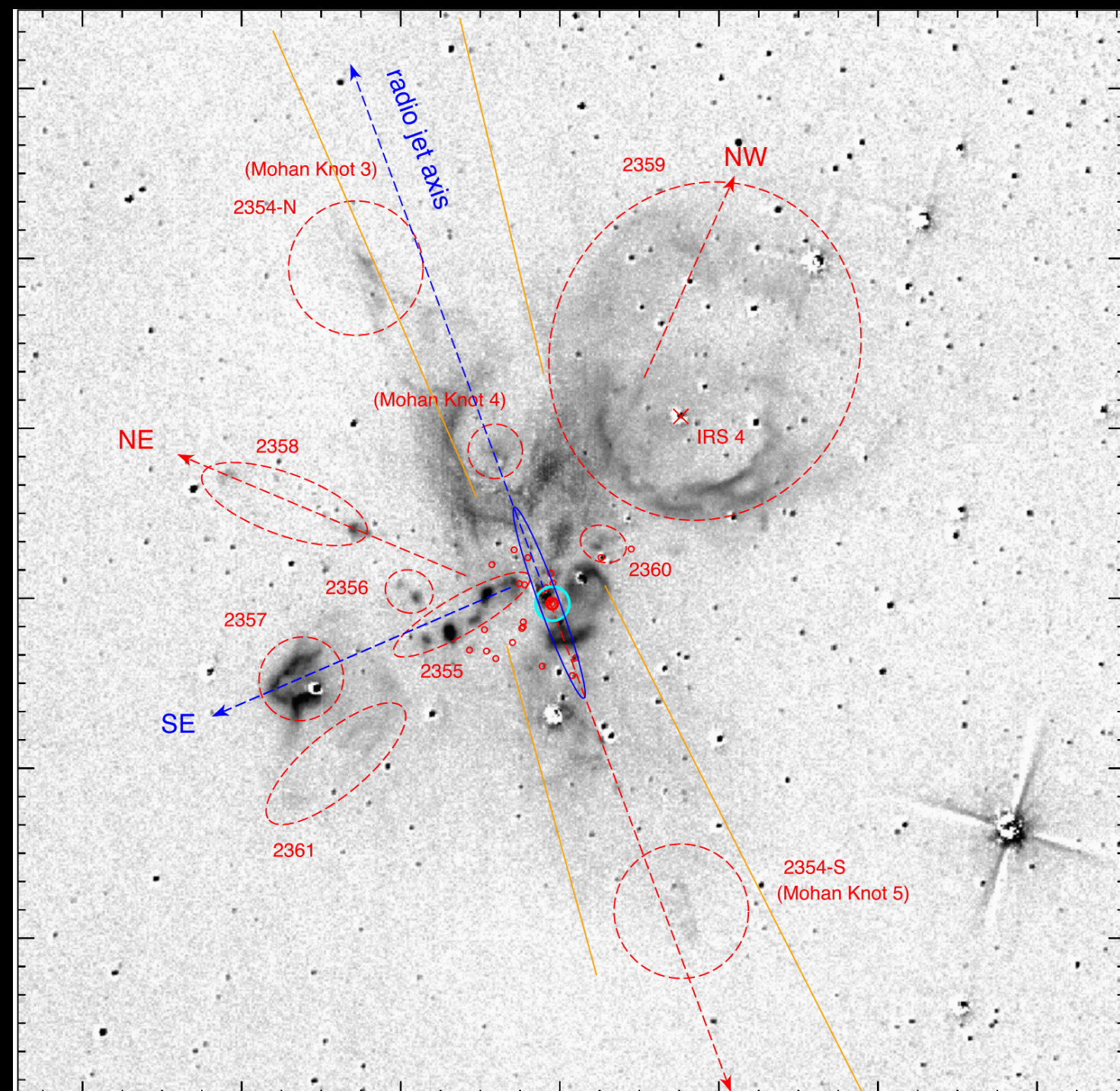
IRS2

IRAS18162-2048

IRS7/SC

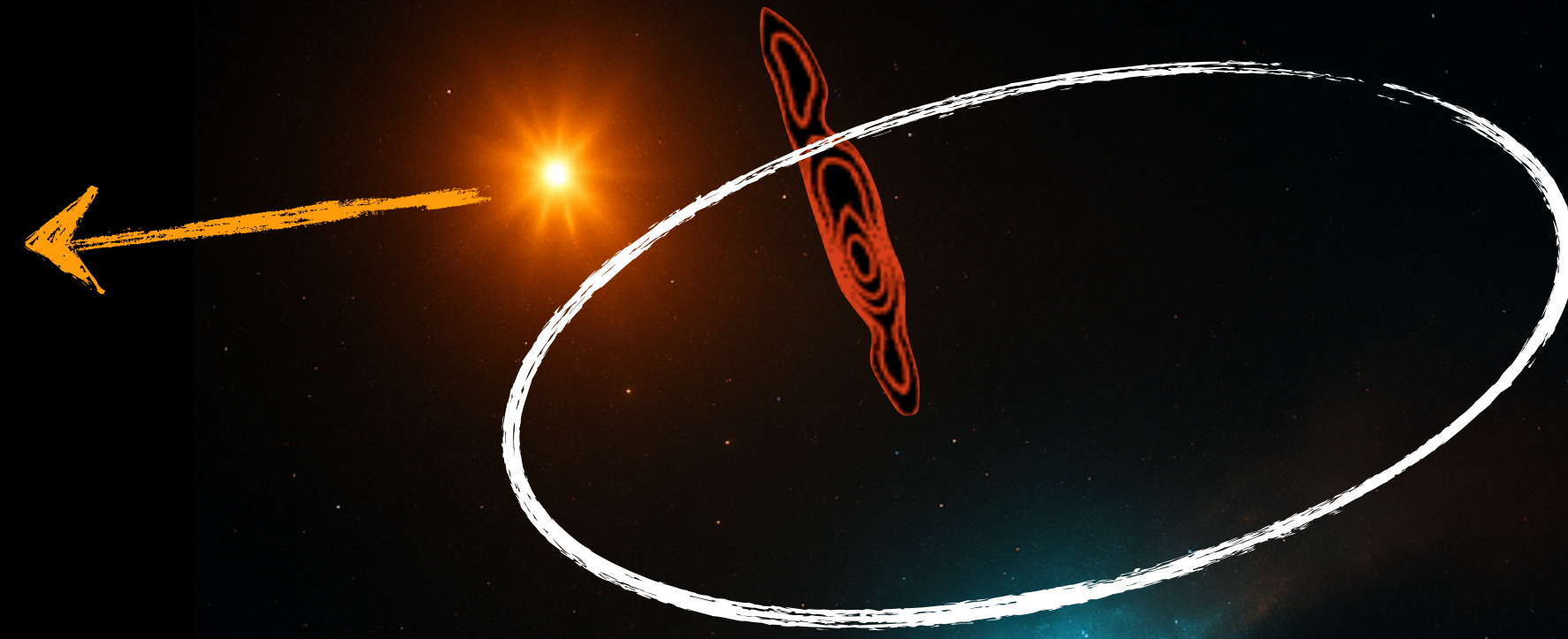
PDR

SINFONI
FoV



Summary

Young (proto)star
but older than the rest



This region is 'invisible' to
the near-IR due to high extinction,
including IRAS18162-2048

$> 13.6\text{eV}$ photons excites H_{II} region

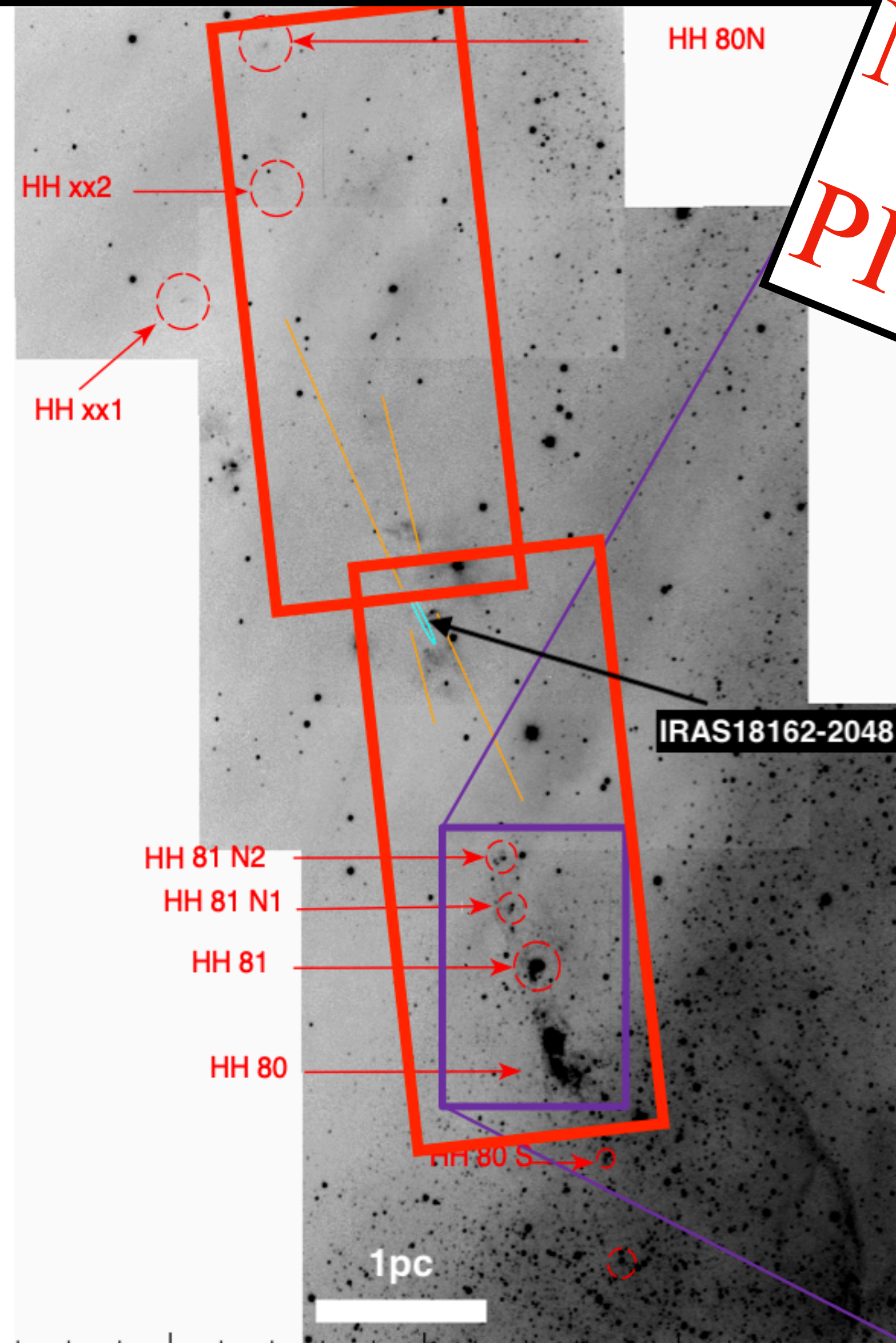
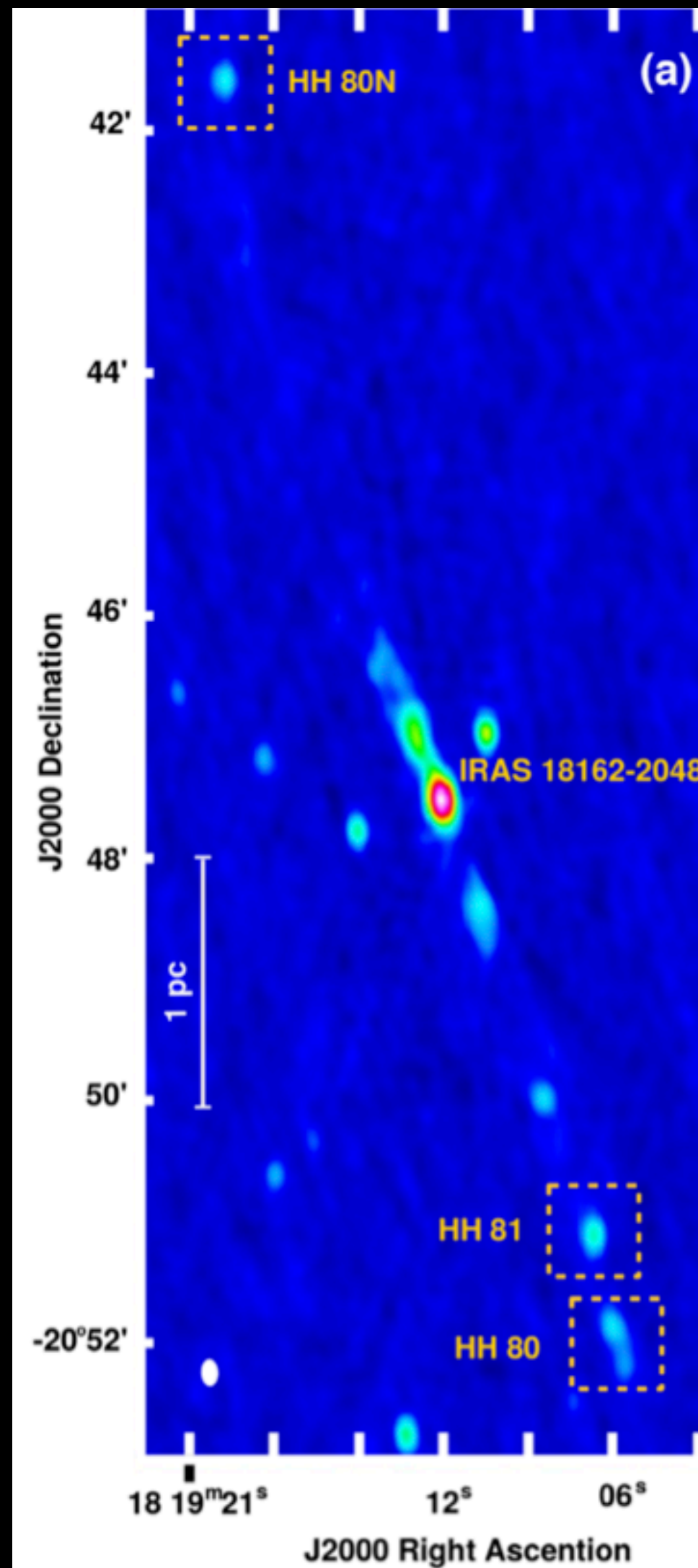
1. $\text{Br}\gamma$ absorption/emission line consistent with B2/B3 ZAMS
2. cm continuum consistent with B2/B3
3. IRS7/SC detected for the first time in the mm regime with ALMA band 3
4. α consistent with free-free optically thin emission (i.e., no dust)



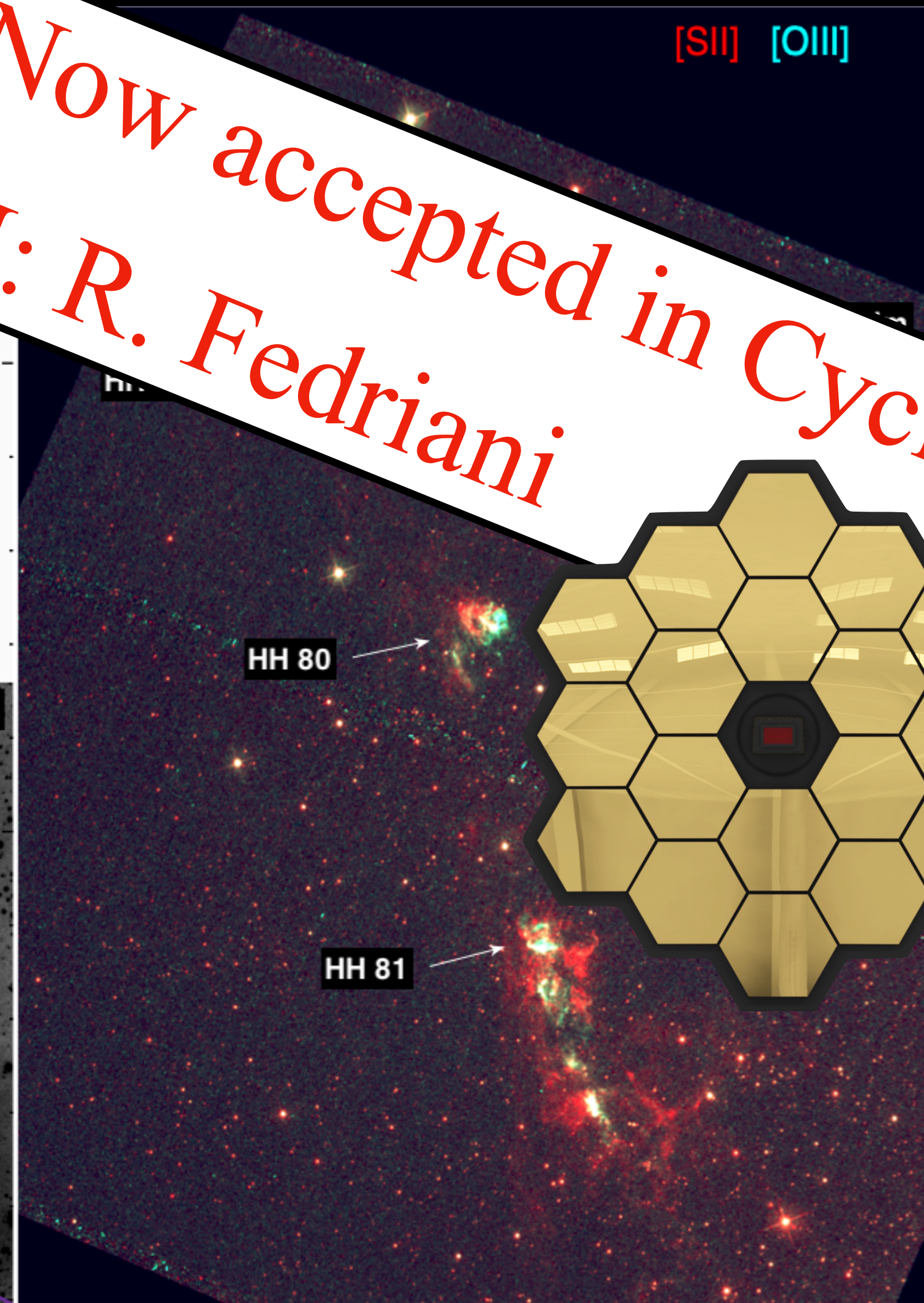
$10.3\text{eV} < \text{photons} < 13.6\text{eV}$
excites the PDR region

1. H_2 ro-vibrational diagram with PDR shape
2. H_2 1-0S(1)/2-1S(1) < 6
3. Bulk radial H_2 velocity $\sim 0 \text{ km s}^{-1}$

JWST follow up



Now accepted in Cycle 5!
PI: R. Fedriani



Thanks!



DSS optical RGB image