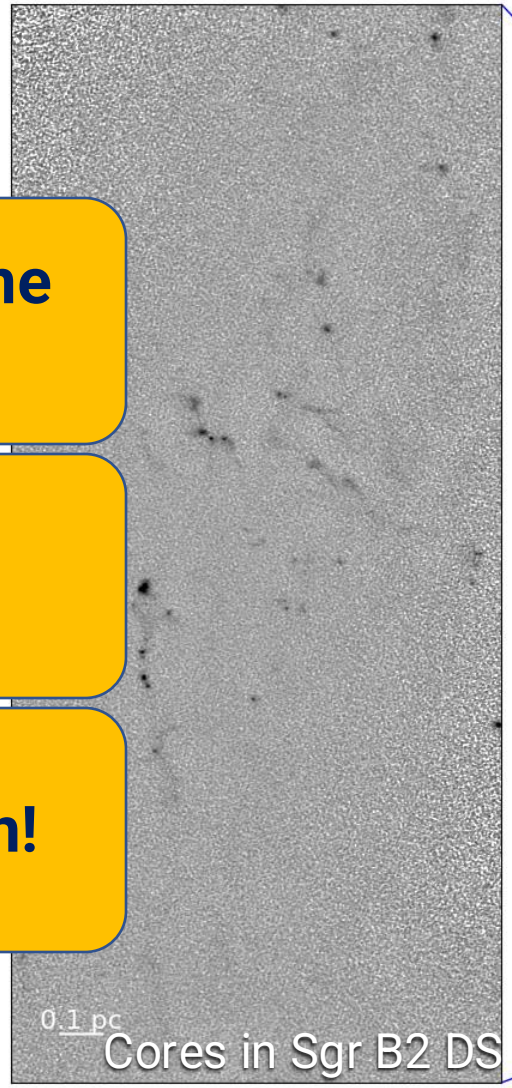
Sagittarius B2

<1% of the CMZ volume
(5×10^4 pc^3)

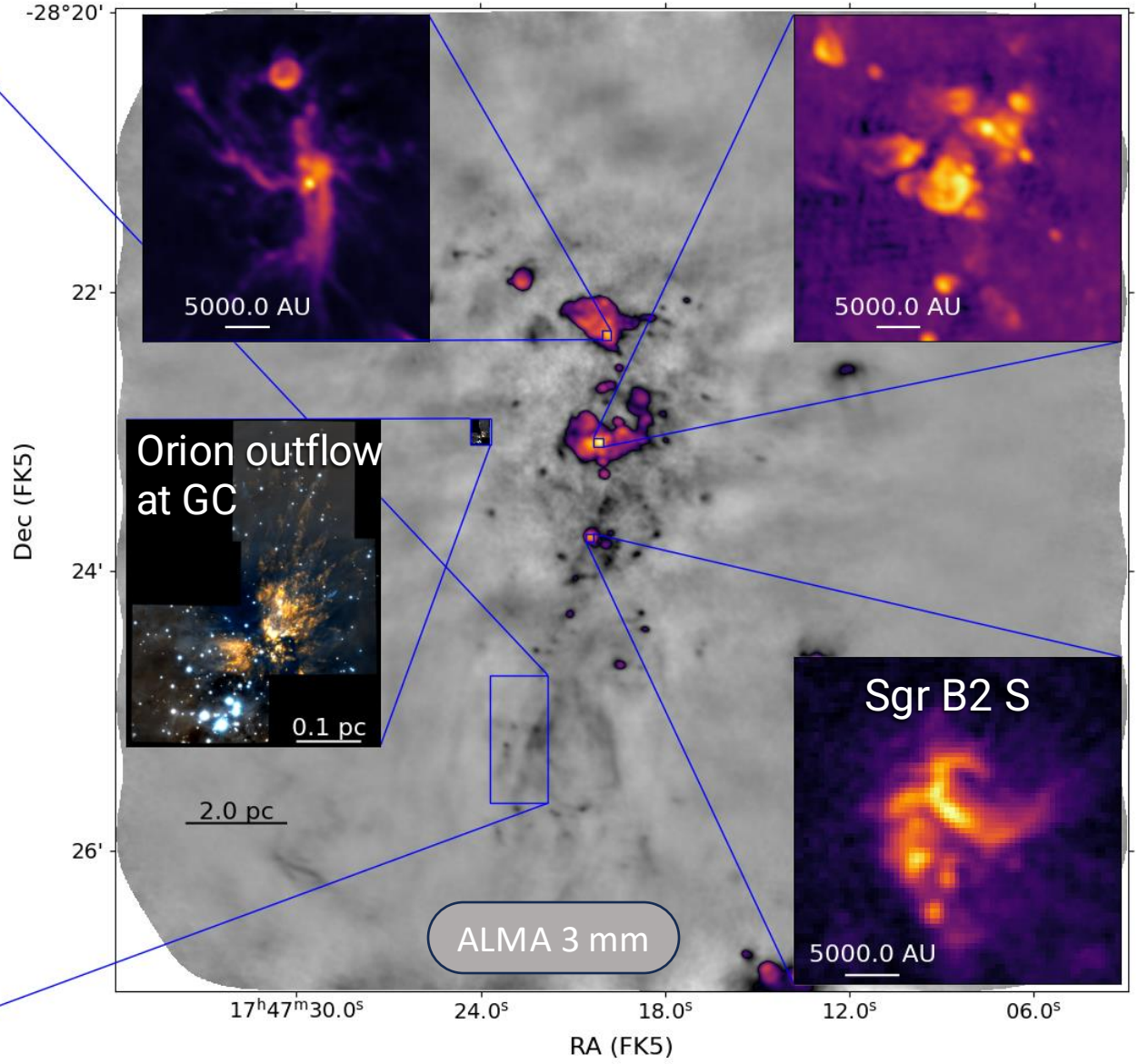
$\sim$10% of the mass
($8 \times 10^6 M_\odot$)

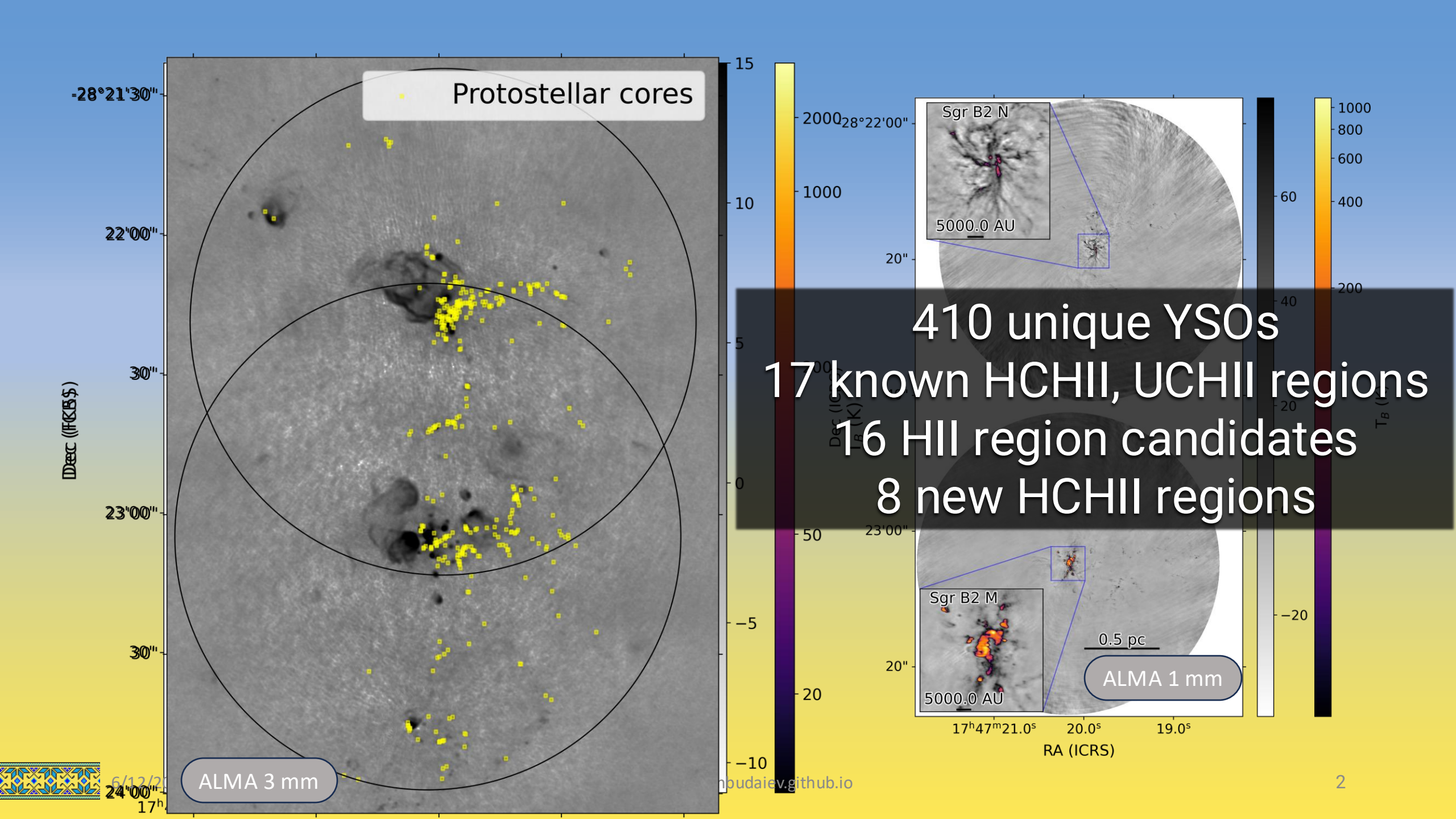
50% of star formation!

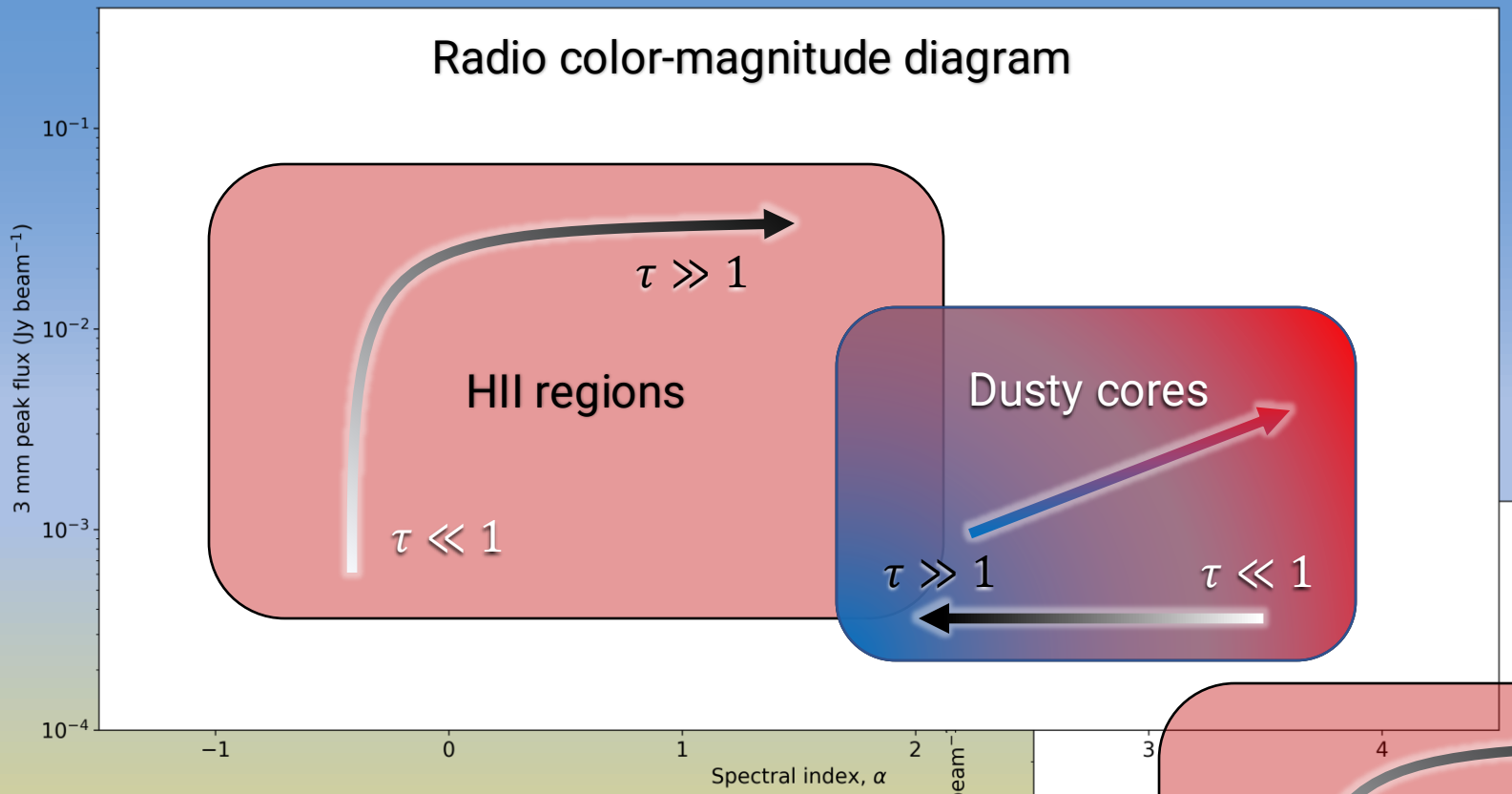


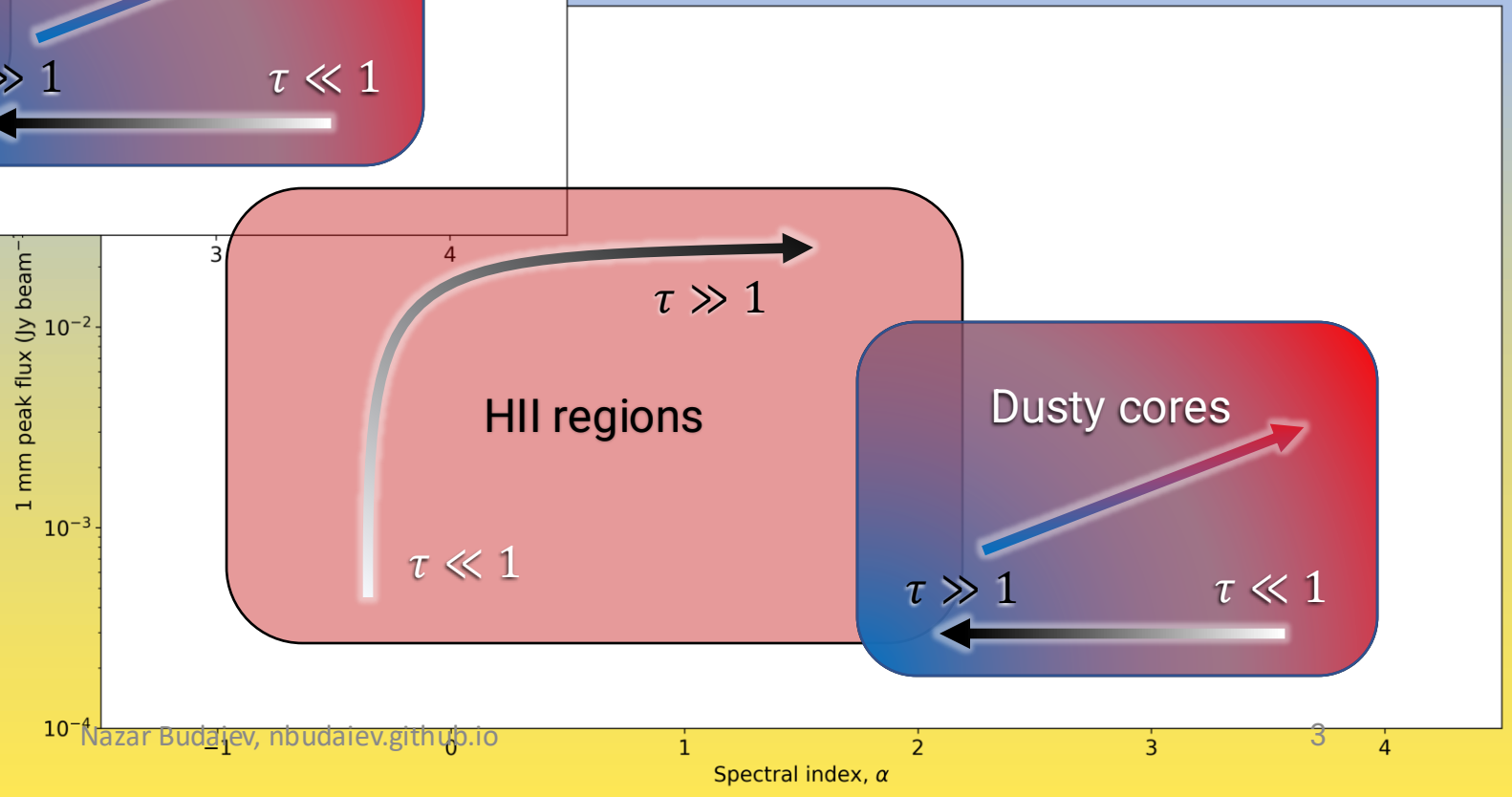
Sgr B2 N protocluster

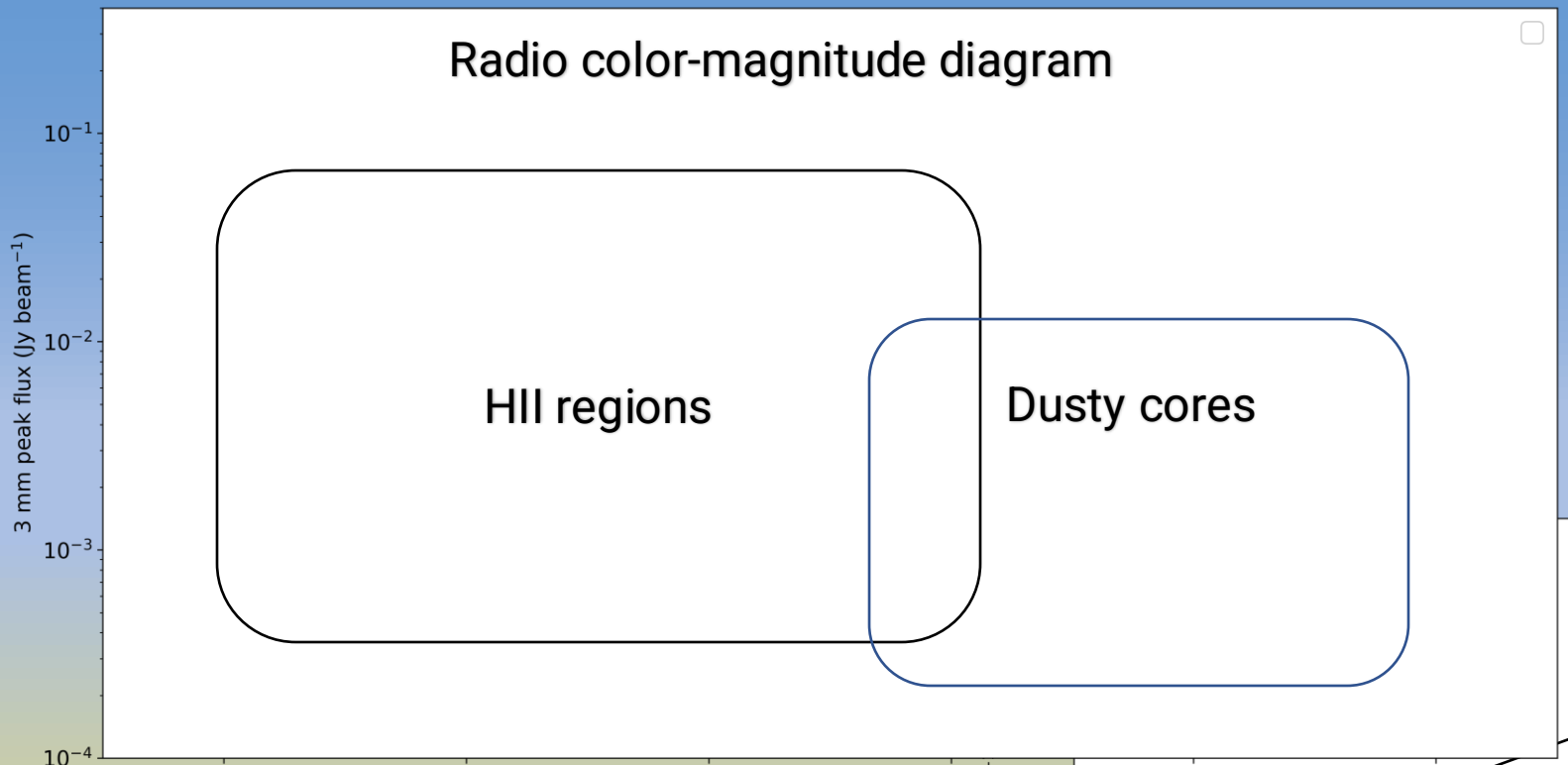
Sgr B2 M protocluster

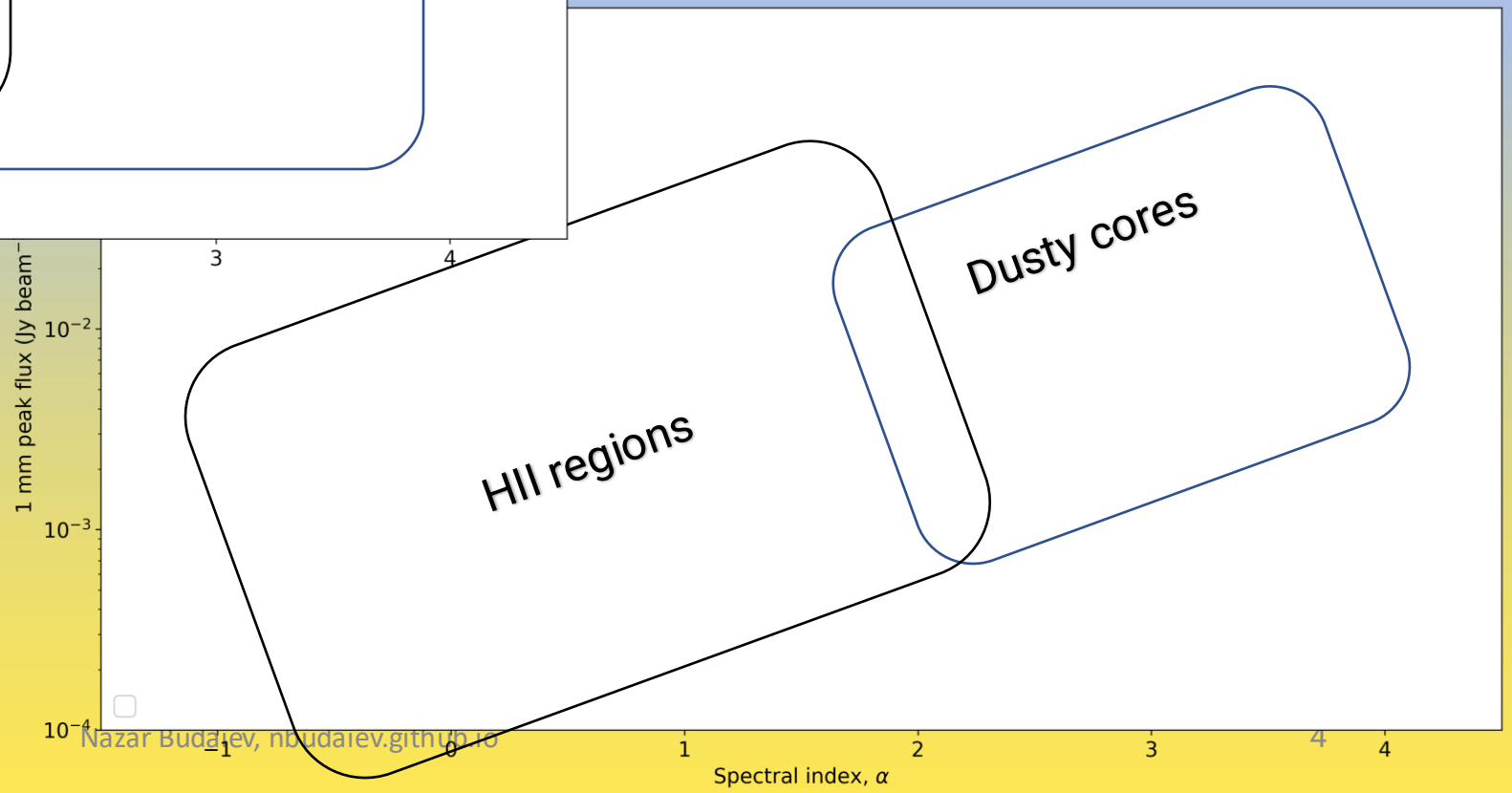


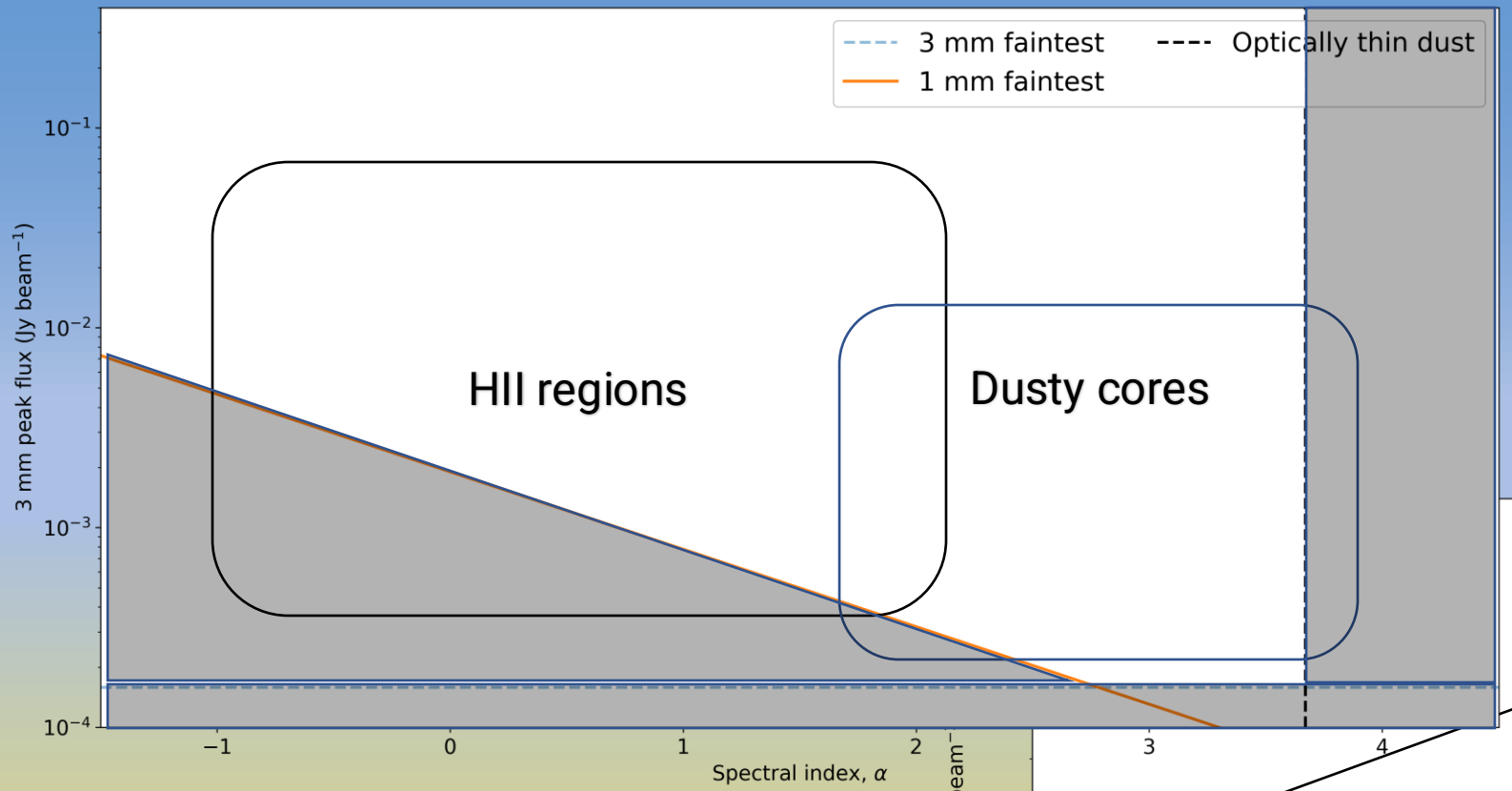

Protostellar cores
ALMA 3 mm
Sgr B2 N
5000.0 AU
Sgr B2 M
5000.0 AU
0.5 pc
ALMA 1 mm
RA (ICRS)
410 unique YSOs
17 known HCHII, UCHII regions
16 HII region candidates
8 new HCHII regions

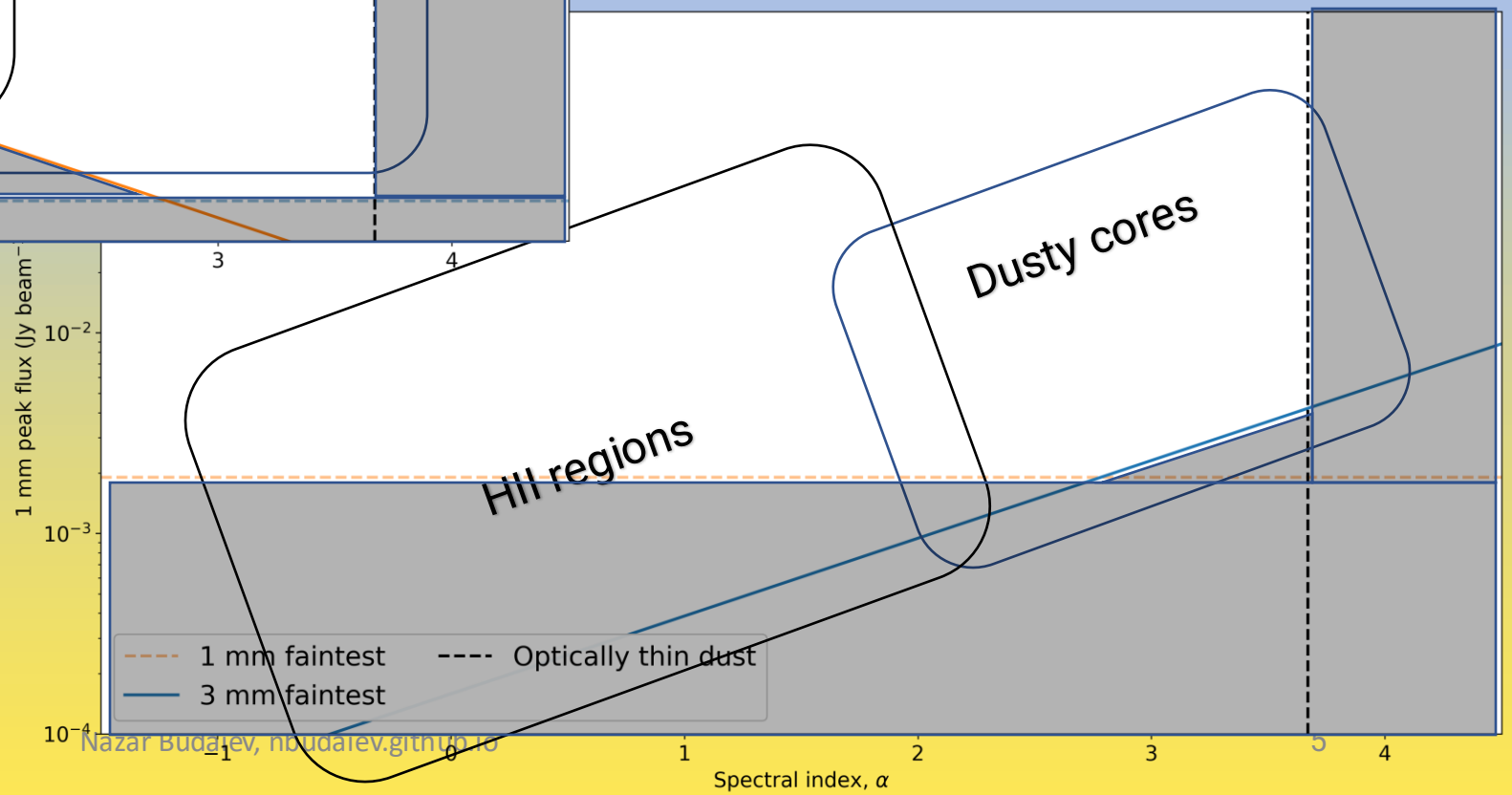

Radio color-magnitude diagram
HII regions
$\tau \gg 1$
$\tau \ll 1$
Dusty cores
$\tau \gg 1$
$\tau \ll 1$
3 mm peak flux (Jy beam^{-1})
Spectral index, α

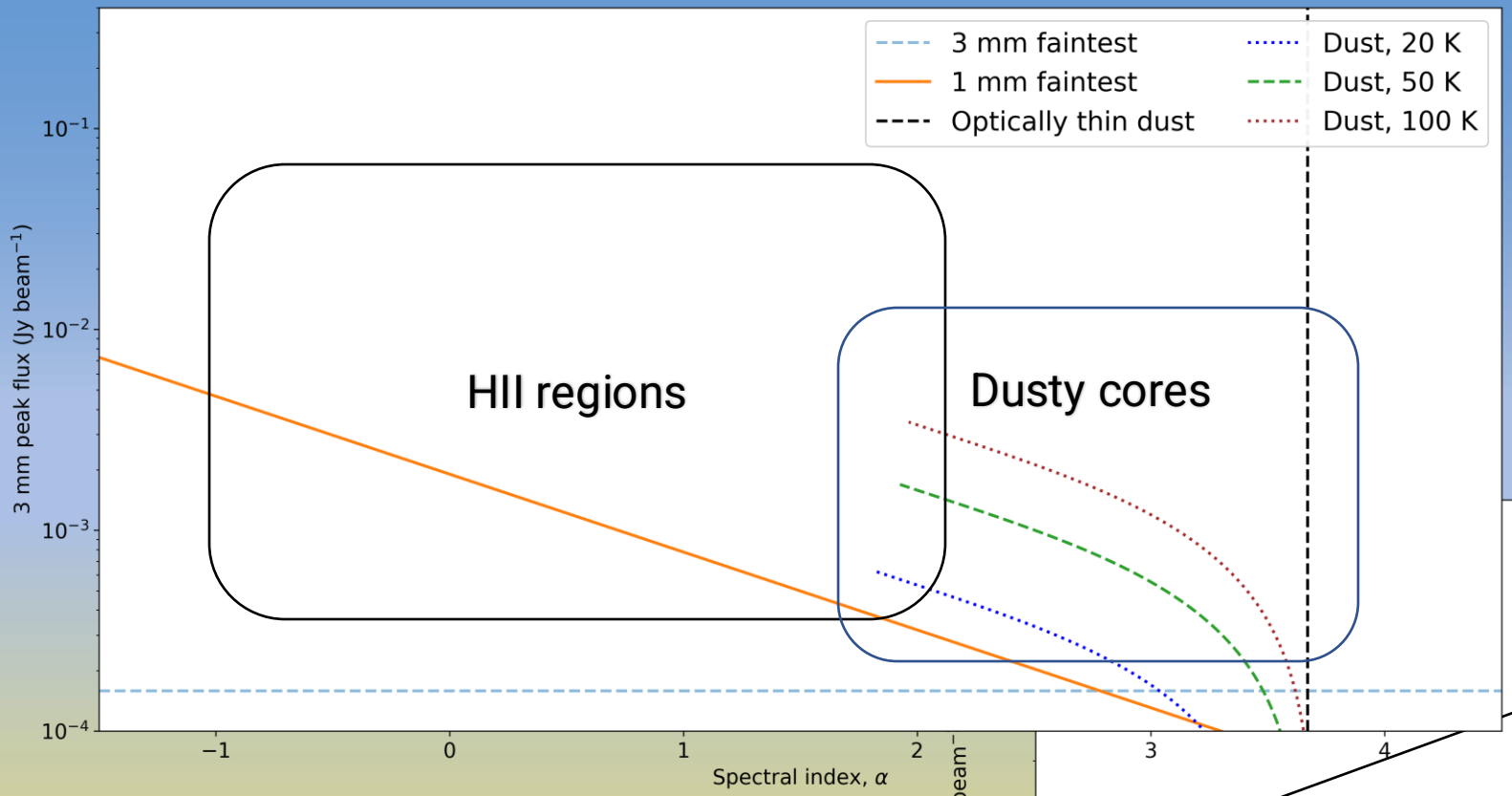

HII regions
$\tau \gg 1$
$\tau \ll 1$
Dusty cores
$\tau \gg 1$
$\tau \ll 1$
1 mm peak flux (Jy beam^{-1})
Spectral index, α

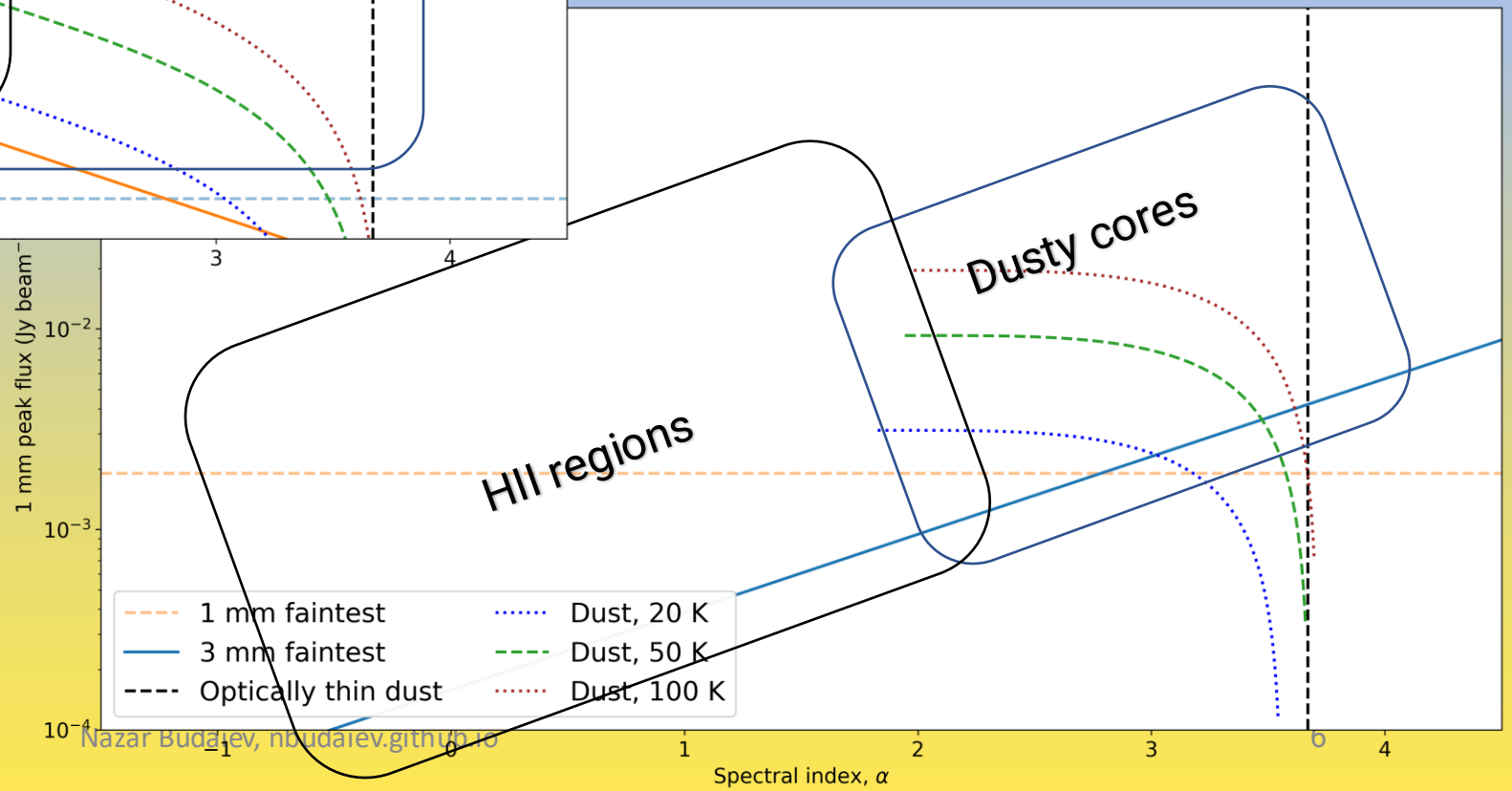

Radio color-magnitude diagram
HII regions
Dusty cores
3 mm peak flux (Jy beam^{-1})
10^{-1}
10^{-2}
10^{-3}
10^{-4}
−1
0
1
2
3
4
Spectral index, α

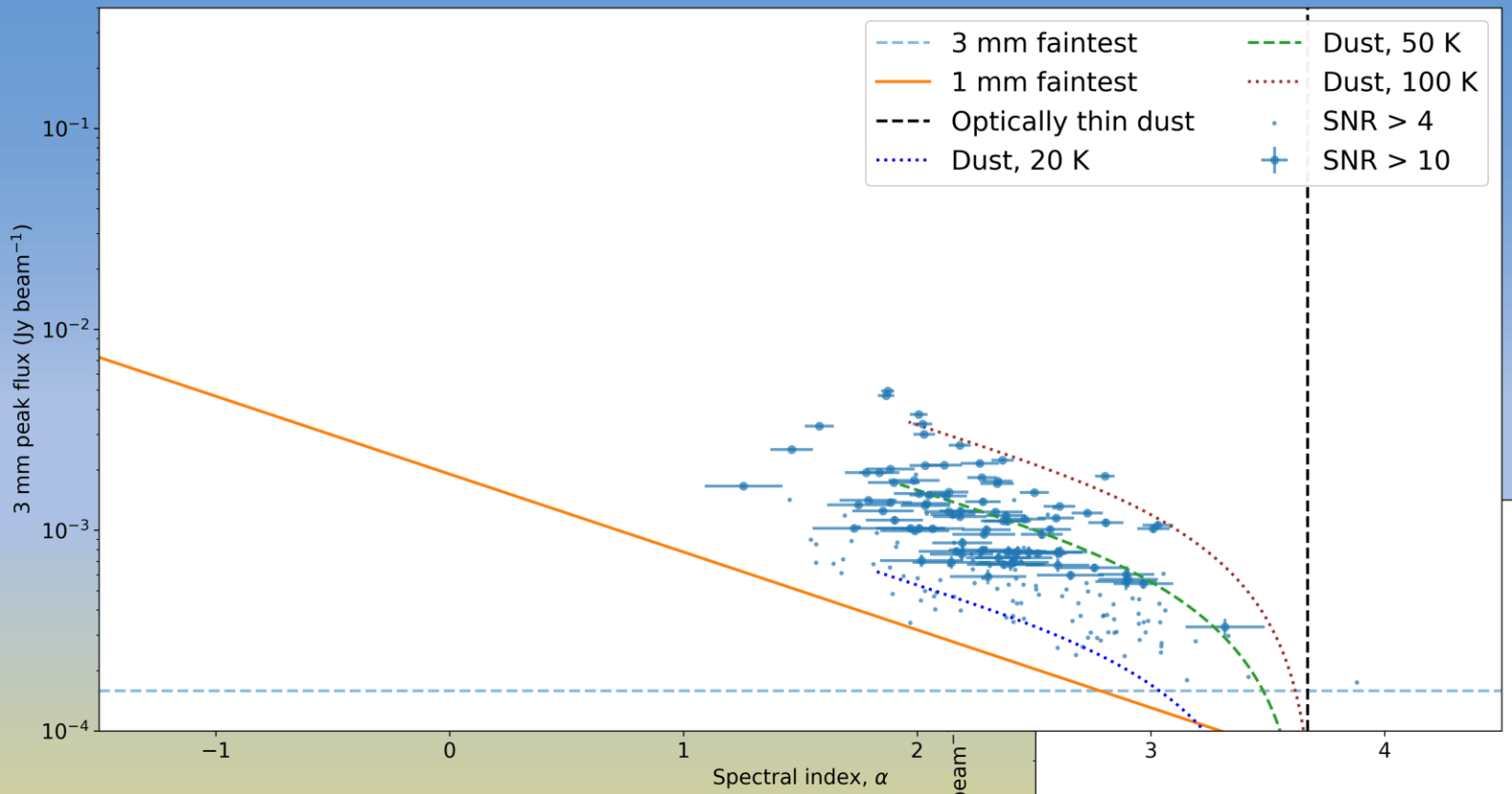

HII regions
Dusty cores
1 mm peak flux (Jy beam^{-1})
10^{-2}
10^{-3}
10^{-4}
−1
0
1
2
3
4
Spectral index, α

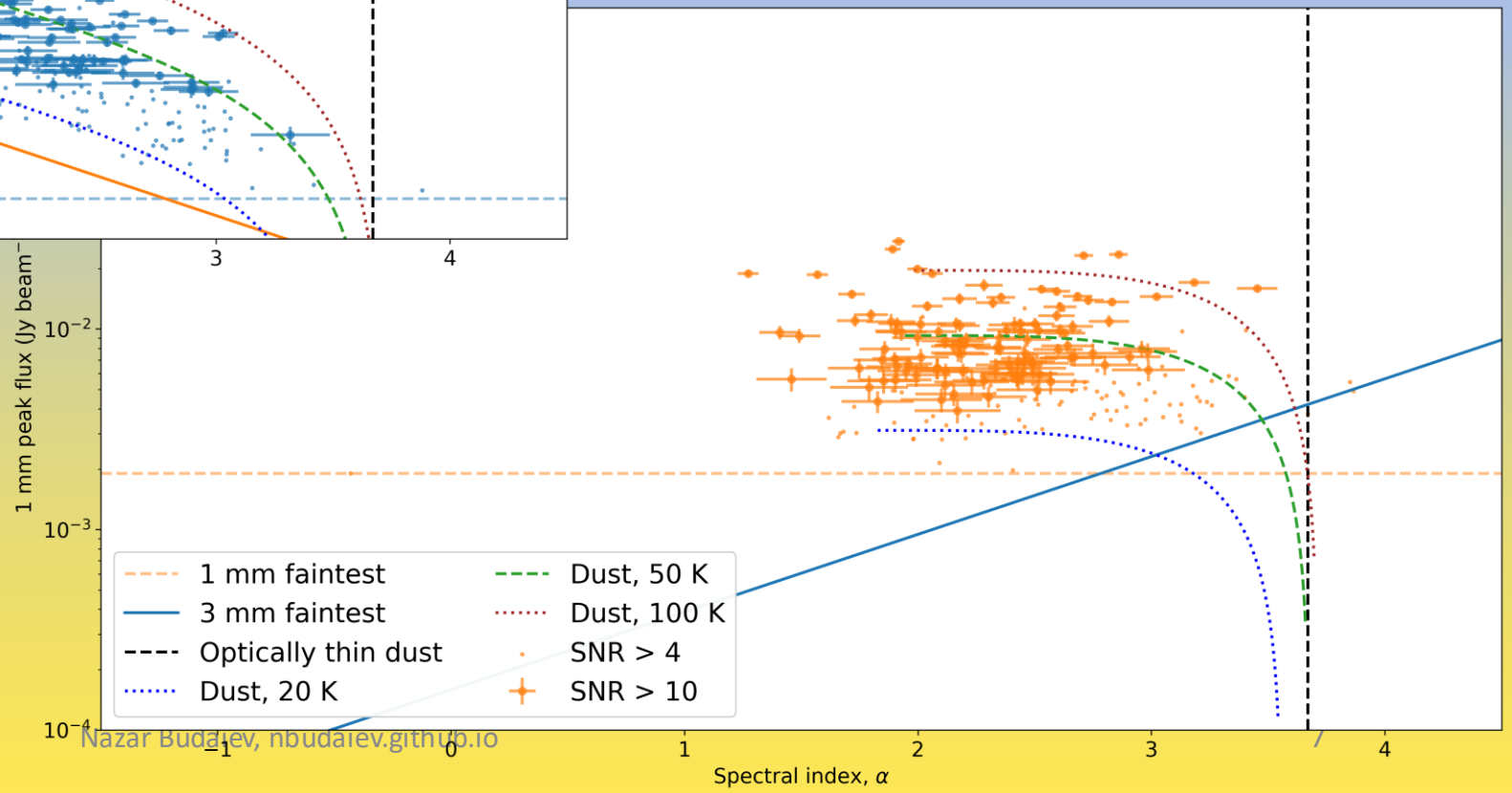

3 mm faintest
1 mm faintest
Optically thin dust
HII regions
Dusty cores
3 mm peak flux (Jy beam⁻¹)
Spectral index, α

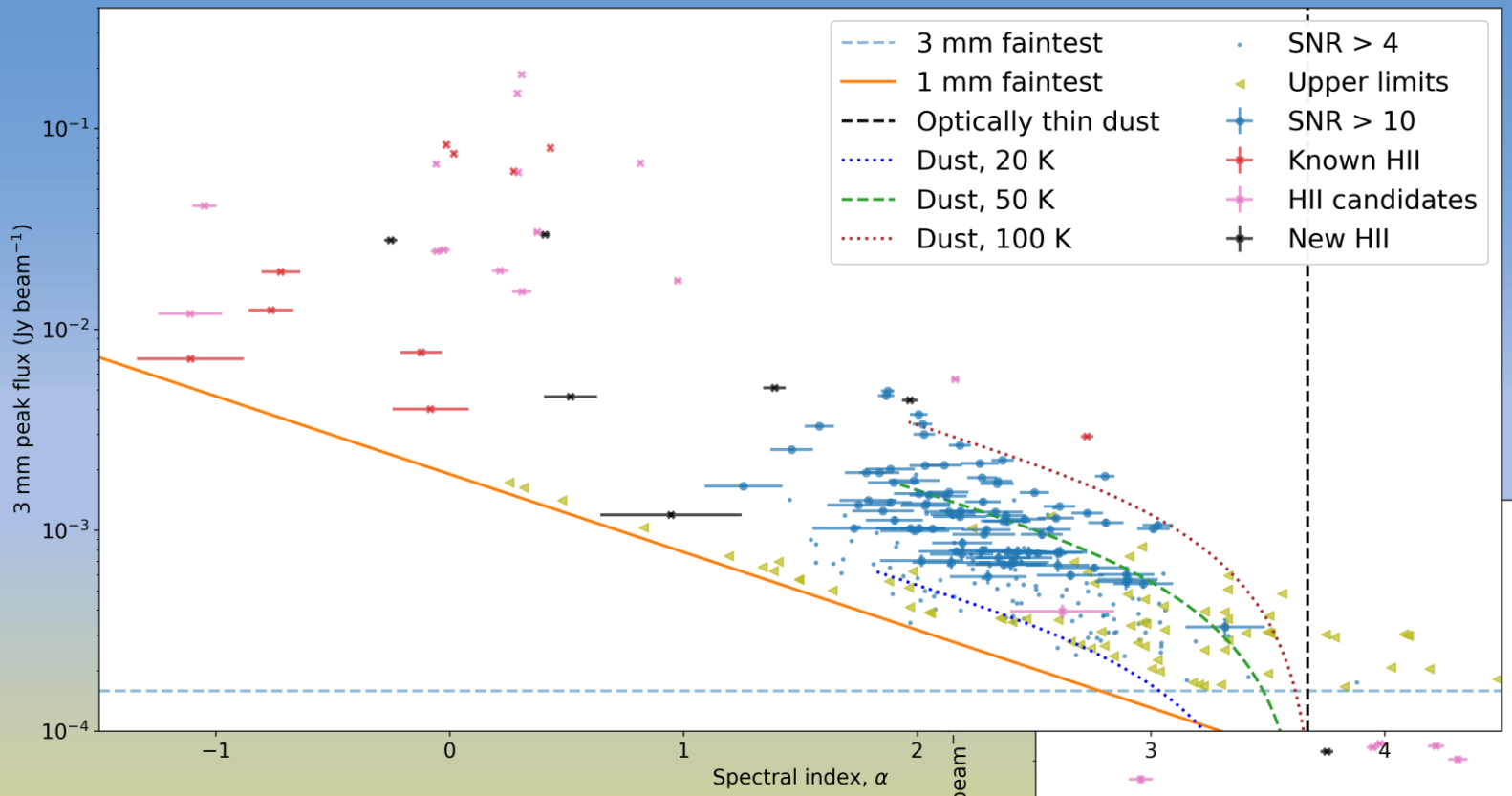

HII regions
Dusty cores
1 mm peak flux (Jy beam⁻
1 mm faintest
3 mm faintest
Optically thin dust
Spectral index, α

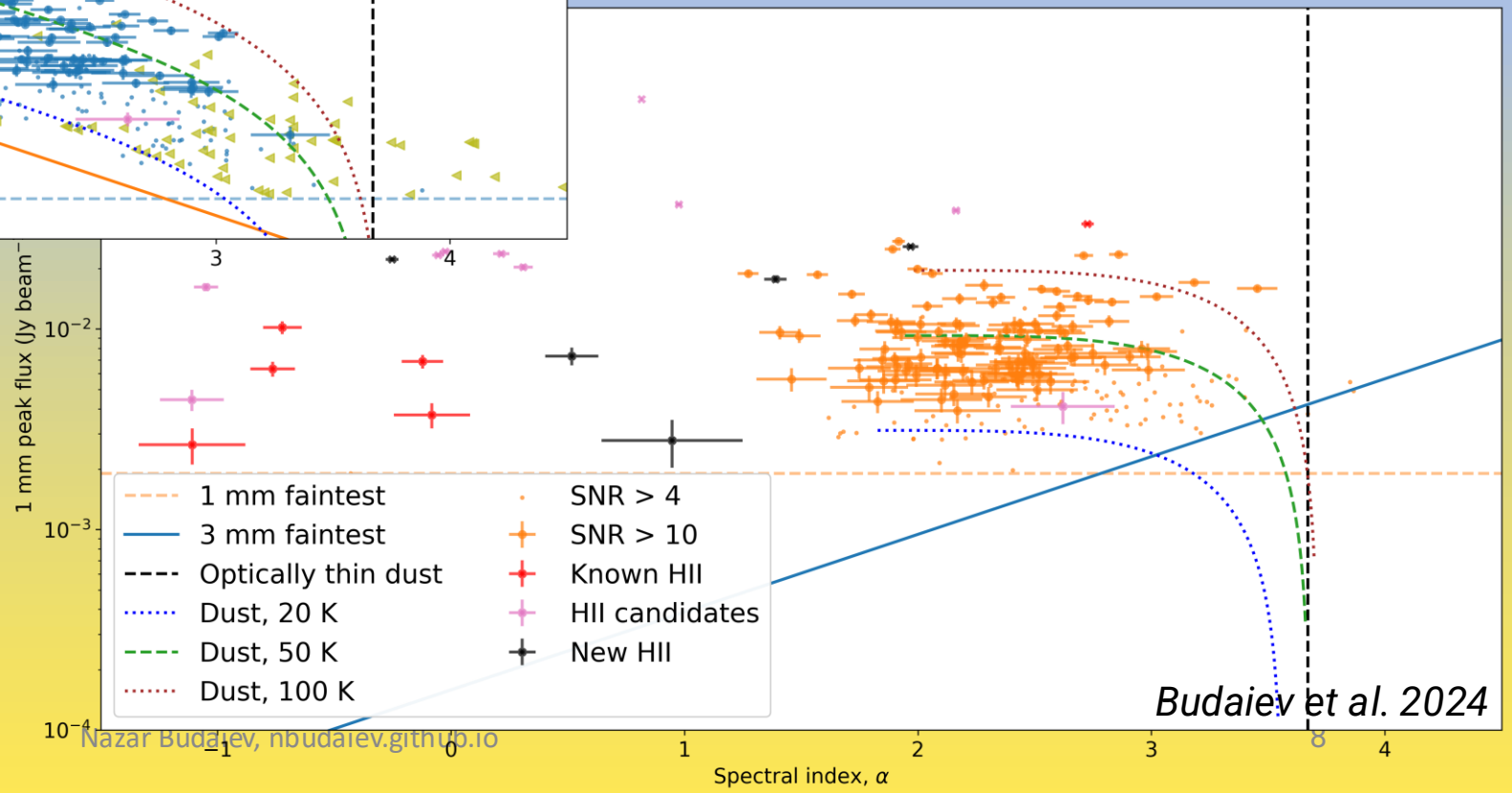

3 mm faintest
1 mm faintest
Optically thin dust
Dust, 20 K
Dust, 50 K
Dust, 100 K
HII regions
Dusty cores
3 mm peak flux (Jy beam⁻¹)
Spectral index, α


1 mm faintest
3 mm faintest
Optically thin dust
Dust, 20 K
Dust, 50 K
Dust, 100 K
HII regions
Dusty cores
1 mm peak flux (Jy beam⁻
Spectral index, α

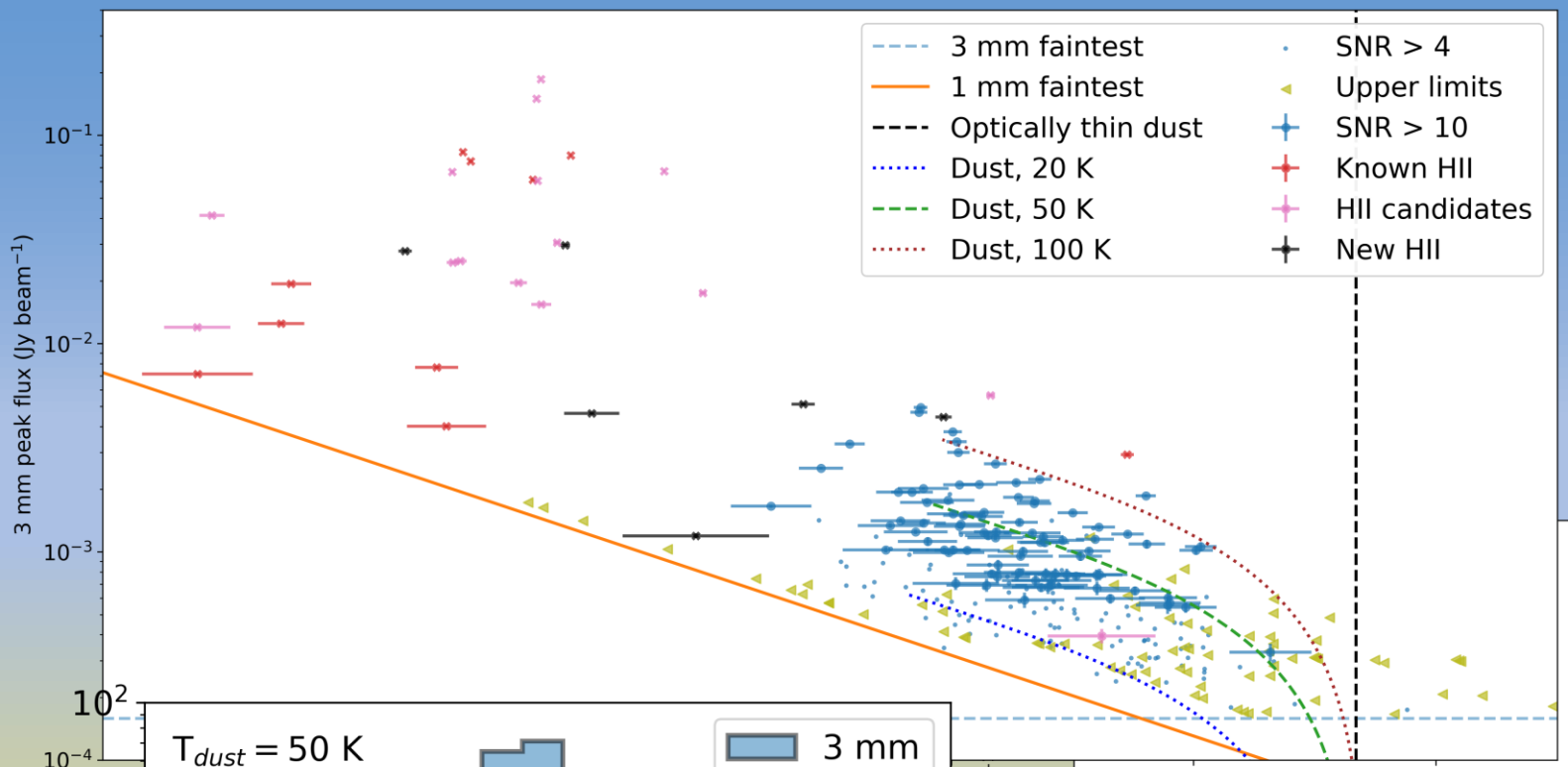

3 mm faintest
1 mm faintest
Optically thin dust
Dust, 20 K
Dust, 50 K
Dust, 100 K
SNR > 4
SNR > 10
3 mm peak flux (Jy beam^{-1})
Spectral index, α

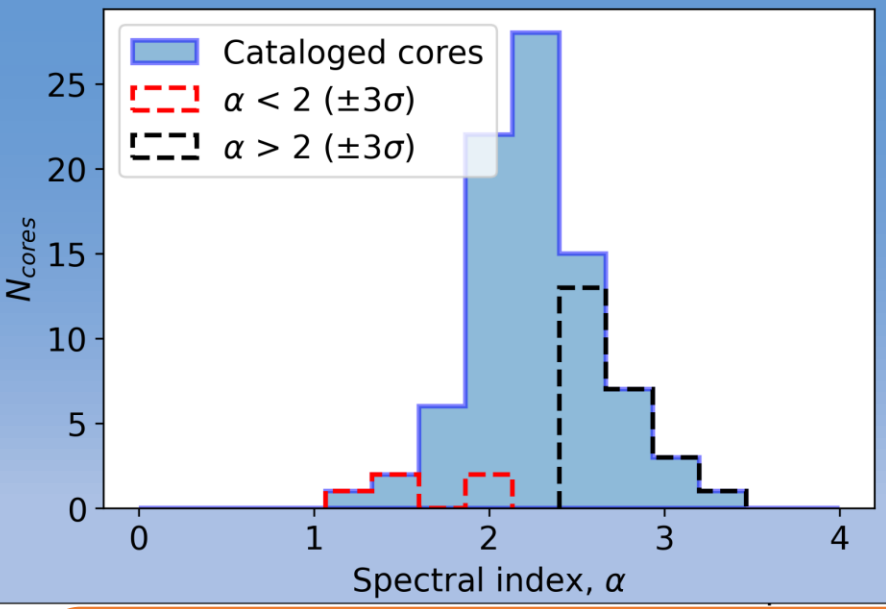

1 mm faintest
3 mm faintest
Optically thin dust
Dust, 20 K
Dust, 50 K
Dust, 100 K
SNR > 4
SNR > 10
1 mm peak flux (Jy beam^{-1})
Spectral index, α



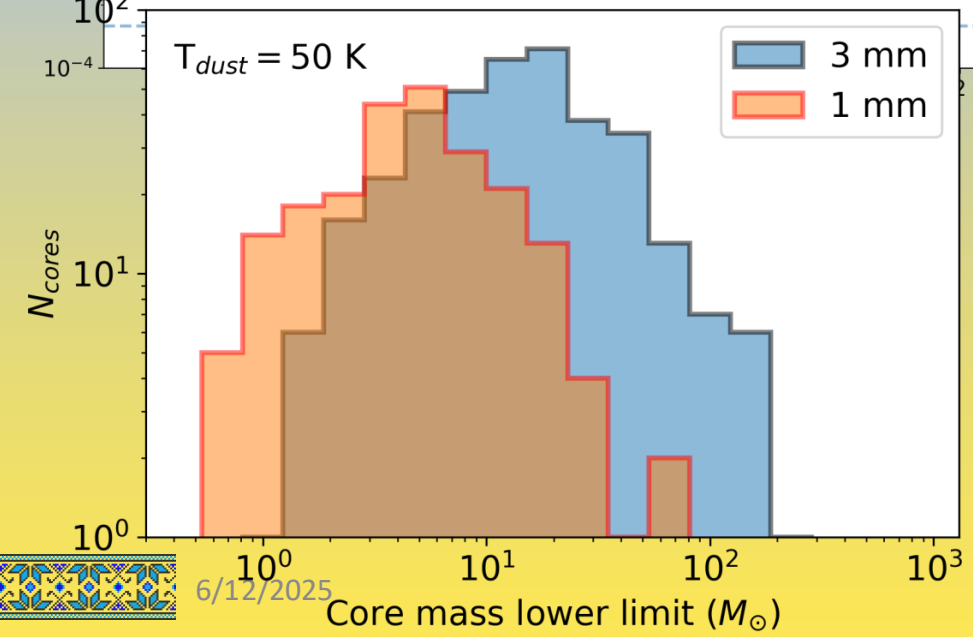


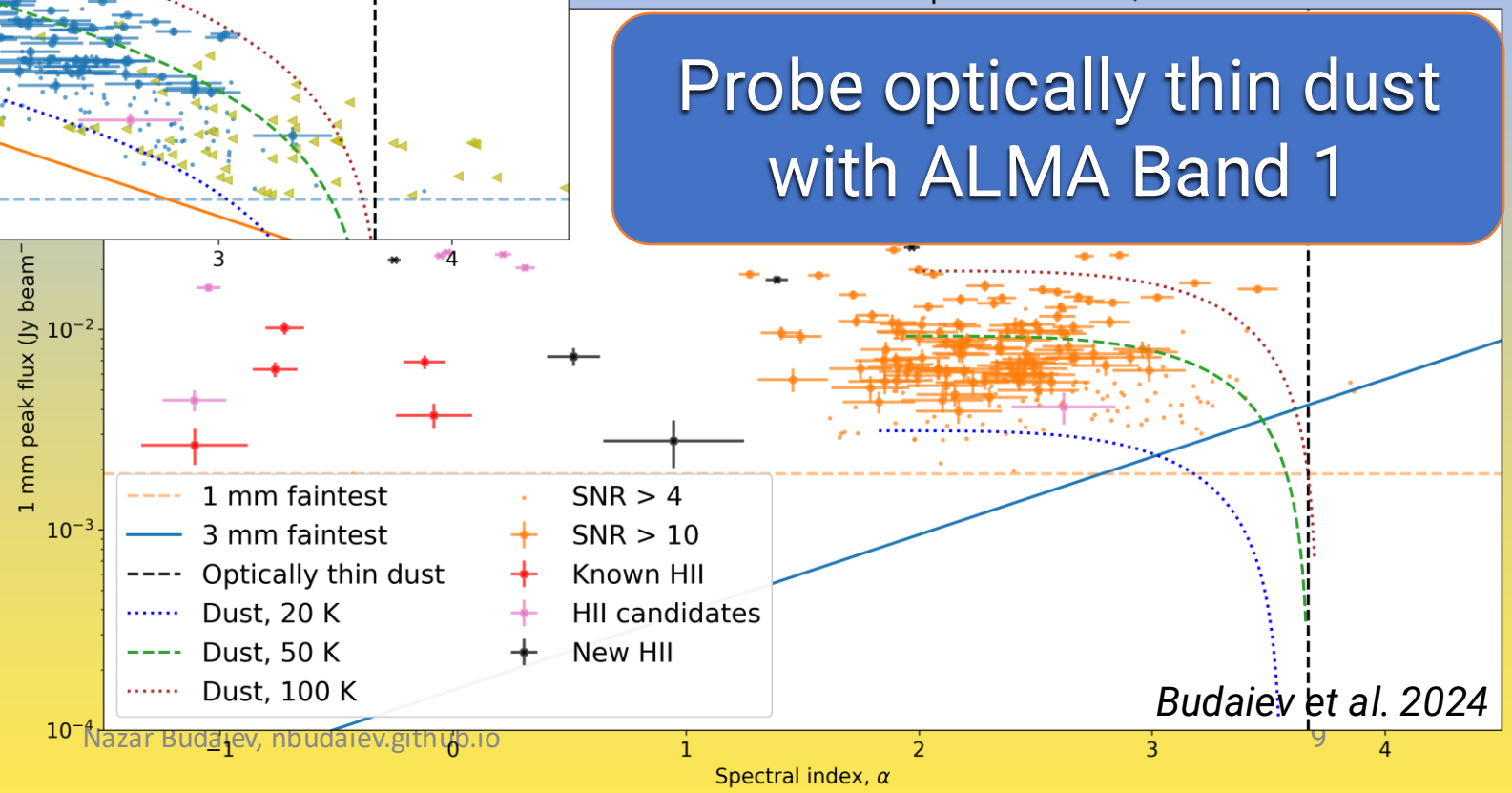
Budaiev et al. 2024





Probe optically thin dust with ALMA Band 1





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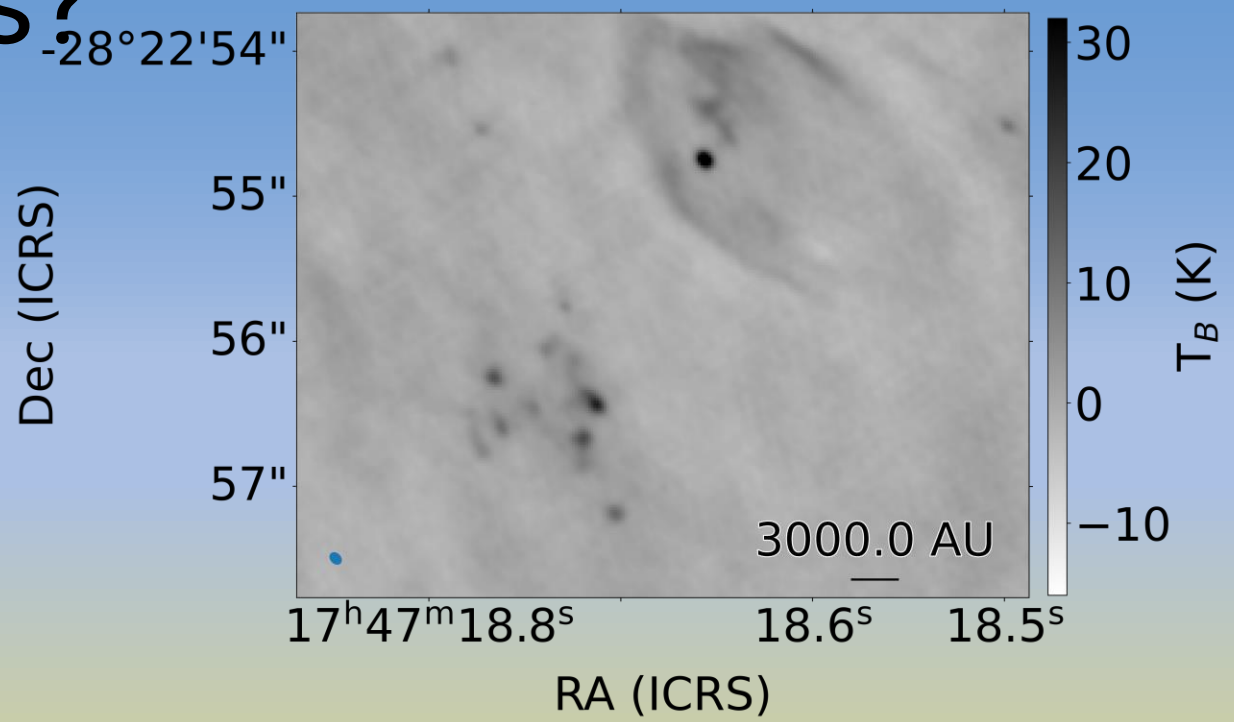
What are our sources?

Stage 0/I YSOs:

- Compact dusty sources
- Rotationally supported
- 200-1000 AU
- 50 K



Prestellar cores?

$$t_{ff} = \sqrt{\frac{3\pi}{32G\rho}}$$

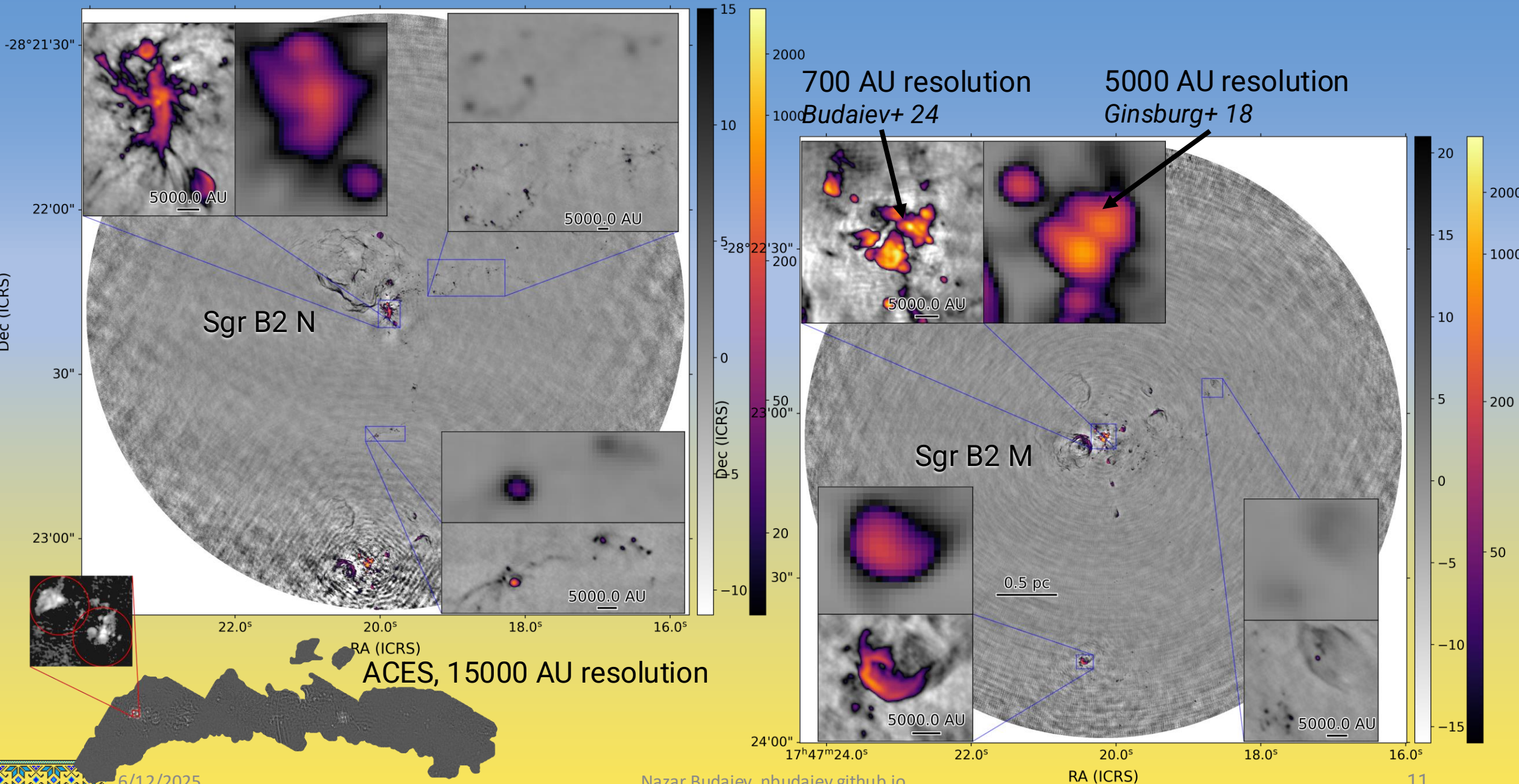
~1200 years at 1 Msun

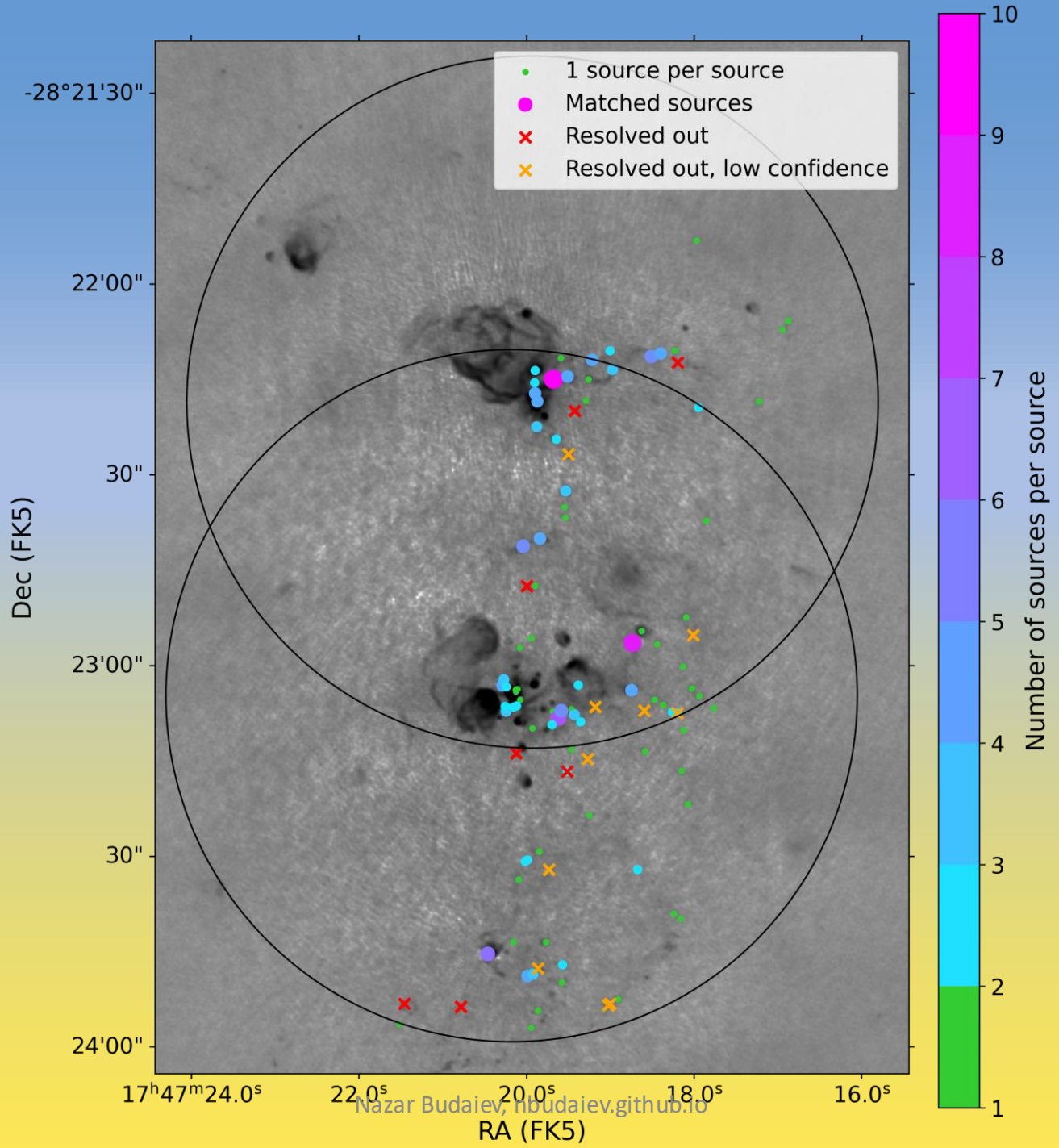
Stage II YSOs?

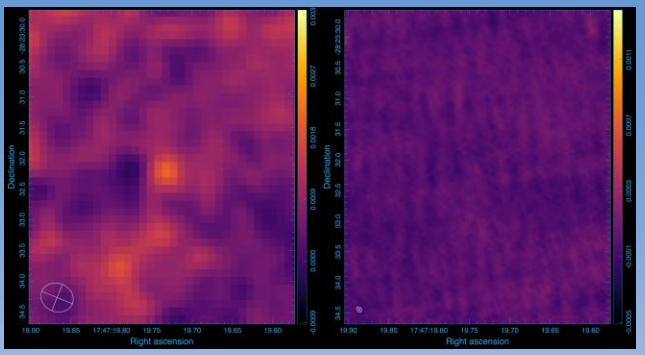
Faintest source ->
30 Msun central star

HII regions?

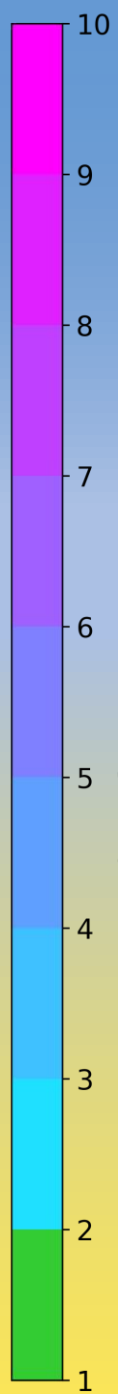
Only optically thick,
30-80 AU in diameter

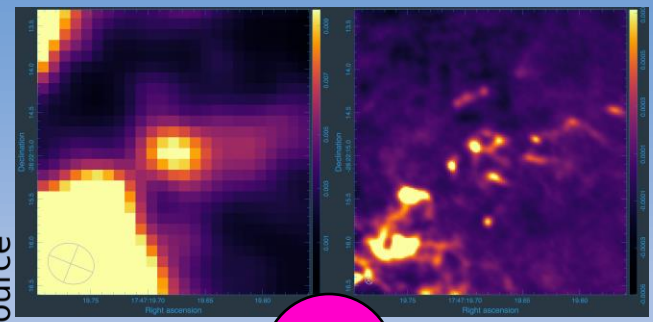

700 AU resolution
Budaiev+ 24
5000 AU resolution
Ginsburg+ 18
Sgr B2 N
Sgr B2 M
ACES, 15000 AU resolution
5000.0 AU
0.5 pc
Dec (ICRS)
RA (ICRS)
T_B [K]

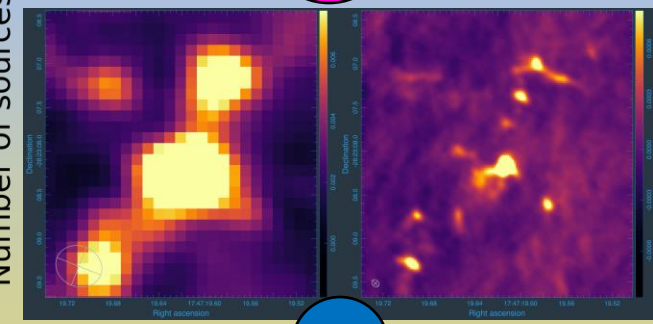

1 source per source
Matched sources
Resolved out
Resolved out, low confidence
-28°21'30"
22'00"
30"
23'00"
30"
24'00"
Dec (FK5)
17h47m24.0s
22.0s
20.0s
18.0s
16.0s
RA (FK5)
Number of sources per source
10
9
8
7
6
5
4
3
2
1

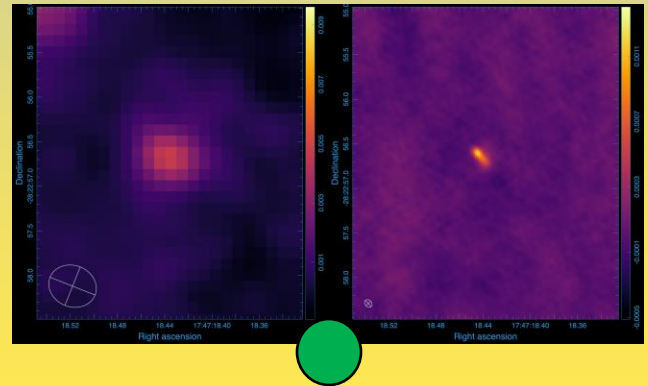


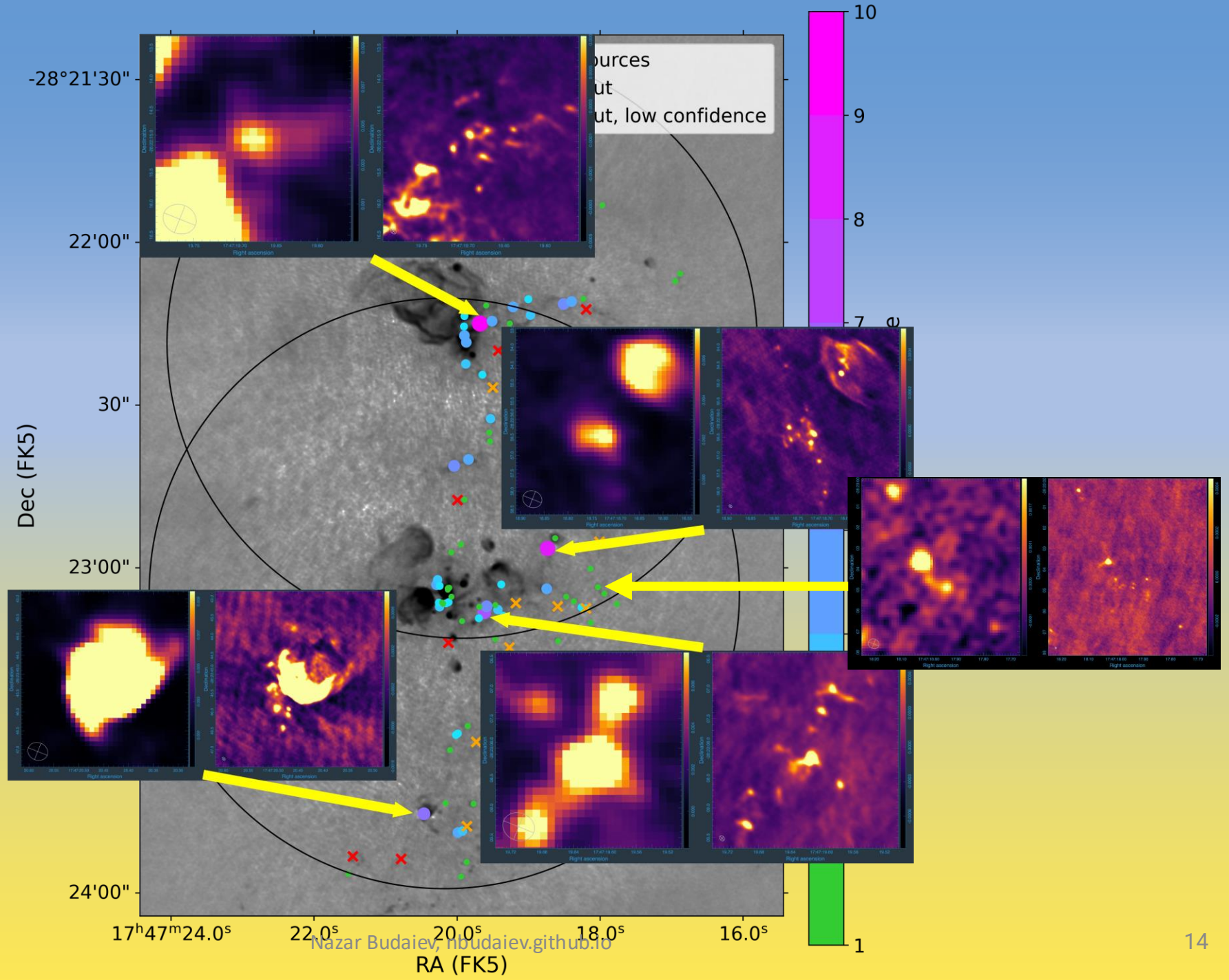
1 source per source
Matched sources
Resolved out
Resolved out, low confidence
-28°21'30"
22'00"
30"
23'00"
30"
24'00"
Dec (FK5)
17h47m24.0s
22.0s
20.0s
18.0s
16.0s
RA (FK5)

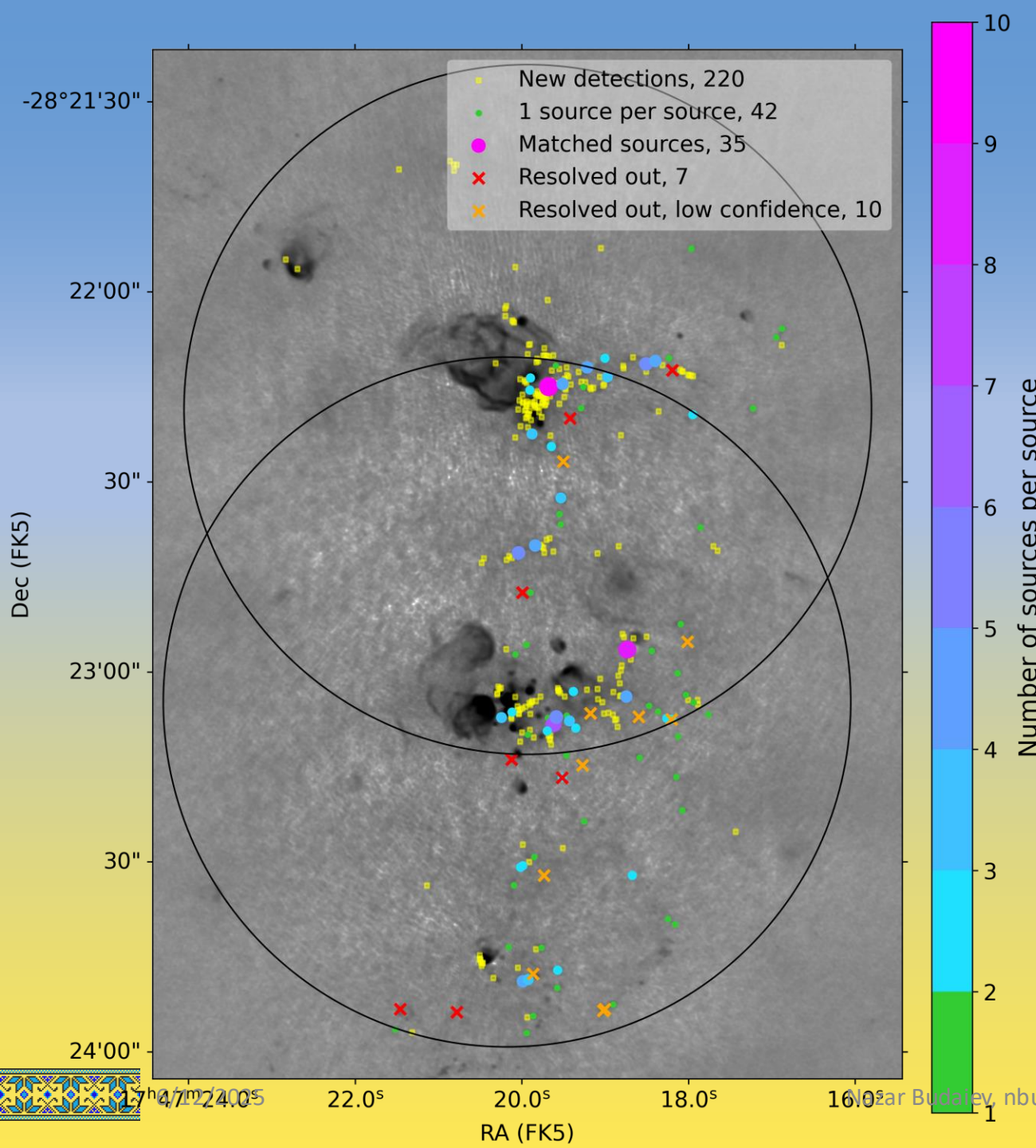

10
9
8
7
6
5
4
3
2
1
Number of sources per source

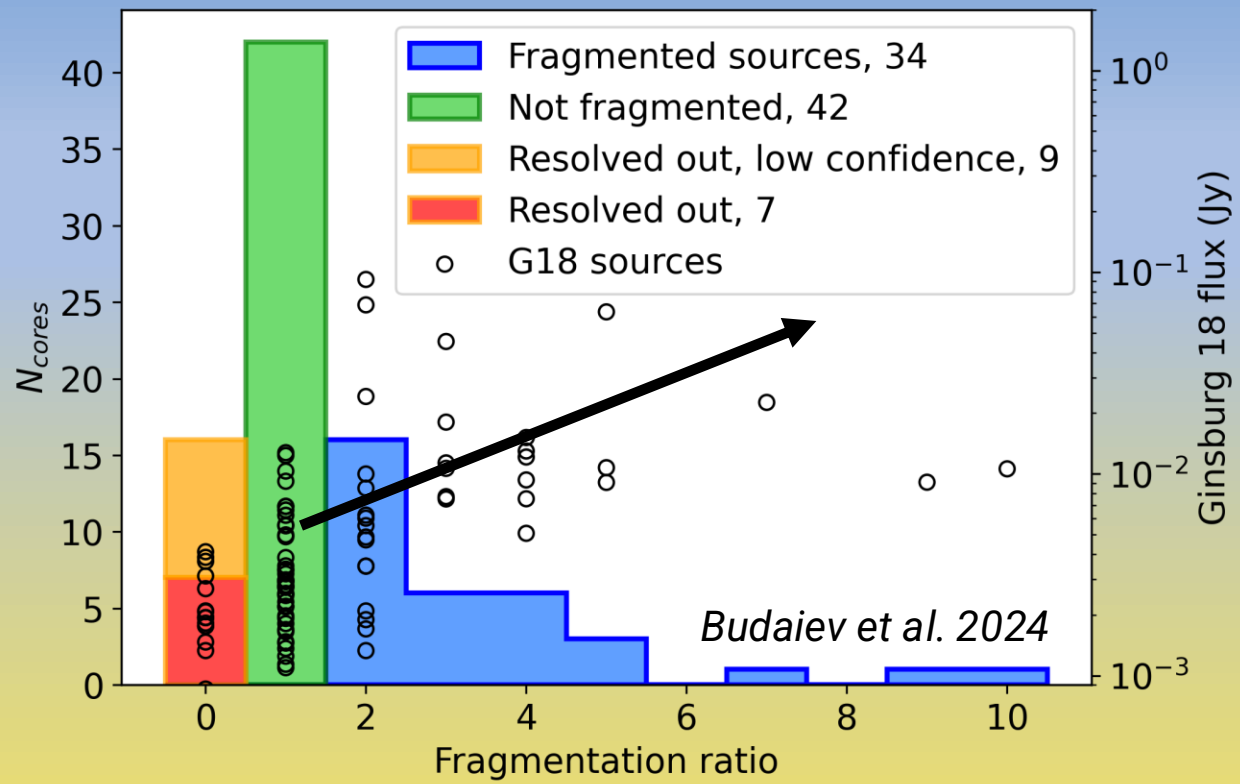







ources
ut
ut, low confidence
-28°21'30"
22'00"
30"
23'00"
24'00"
Dec (FK5)
17h47m24.0s
22.0s
20.0s
18.0s
16.0s
RA (FK5)
10
9
8
7
1


New detections, 220
1 source per source, 42
Matched sources, 35
Resolved out, 7
Resolved out, low confidence, 10
-28°21'30"
22'00"
30"
23'00"
30"
24'00"
Dec (FK5)
17h24m24.0s
22.0s
20.0s
18.0s
16.0s
RA (FK5)
Number of sources per source
10
9
8
7
6
5
4
3
2
1


Fragmented sources, 34
Not fragmented, 42
Resolved out, low confidence, 9
Resolved out, 7
G18 sources
Budaiev et al. 2024
N_{cores}
Fragmentation ratio
Ginsburg 18 flux (Jy)
0
5
10
15
20
25
30
35
40
0
2
4
6
8
10
10^{0}
10^{-1}
10^{-2}
10^{-3}

ALMA 1 mm

Sgr B2 DS

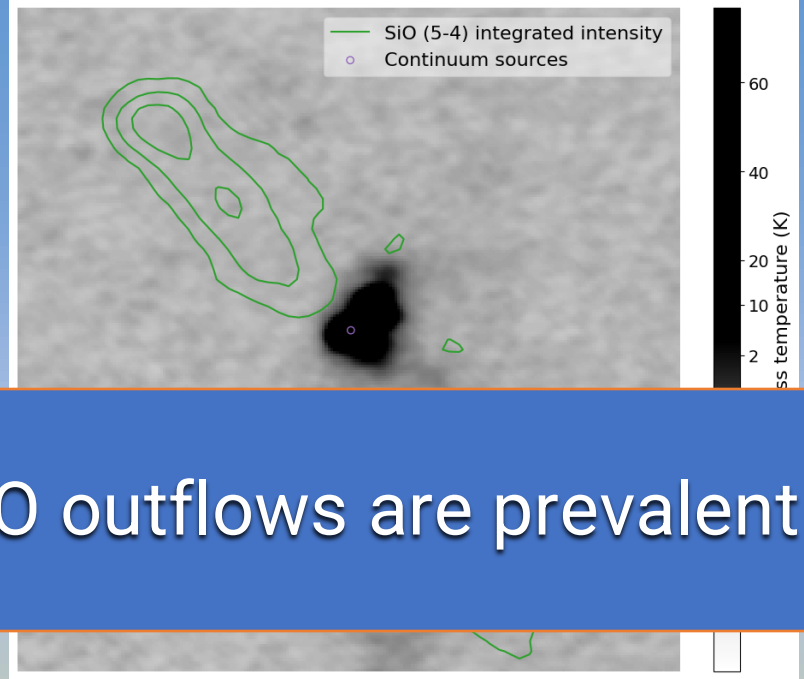
SiO (5-4) integrated intensity
Continuum sources

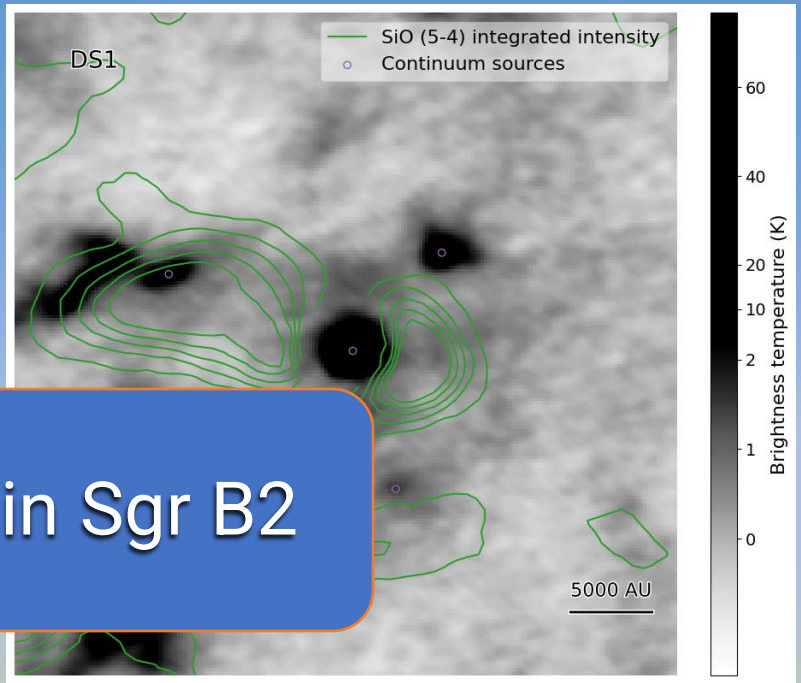
Dec (ICRS)
RA (ICRS)
1 pc

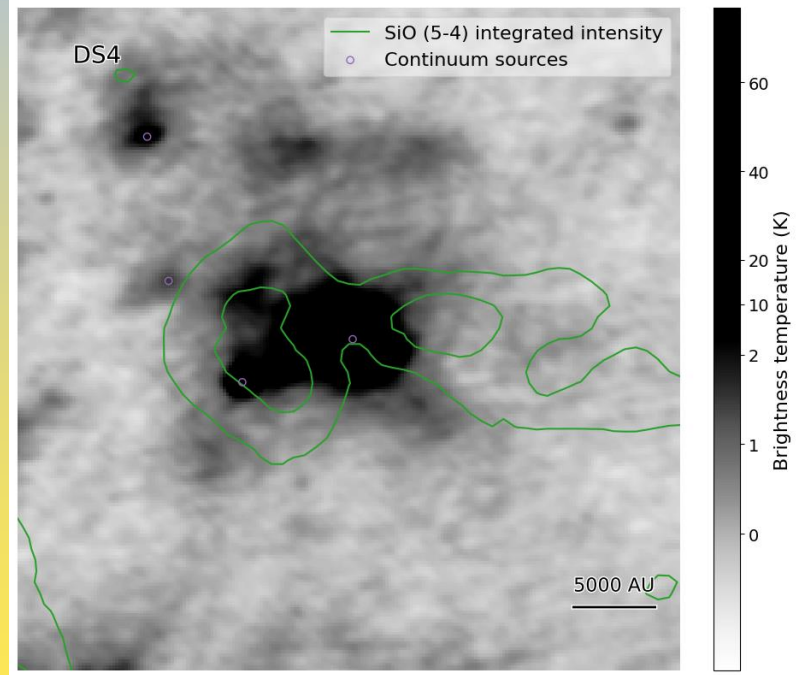
Cataloged 350+ YSOs in Sgr B2 DS

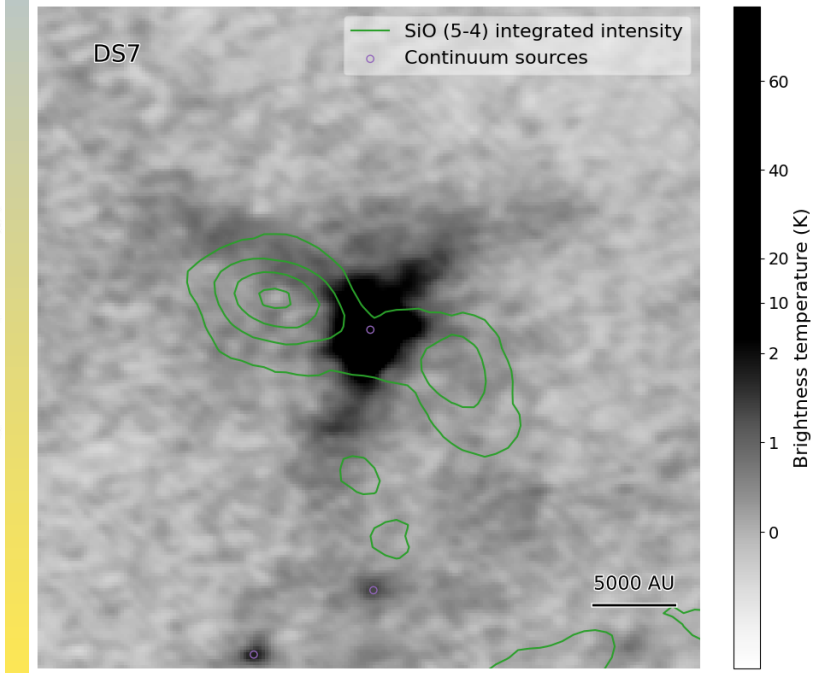
Mario (Antonio) Daley
UF undergrad

SiO outflows are prevalent in Sgr B2

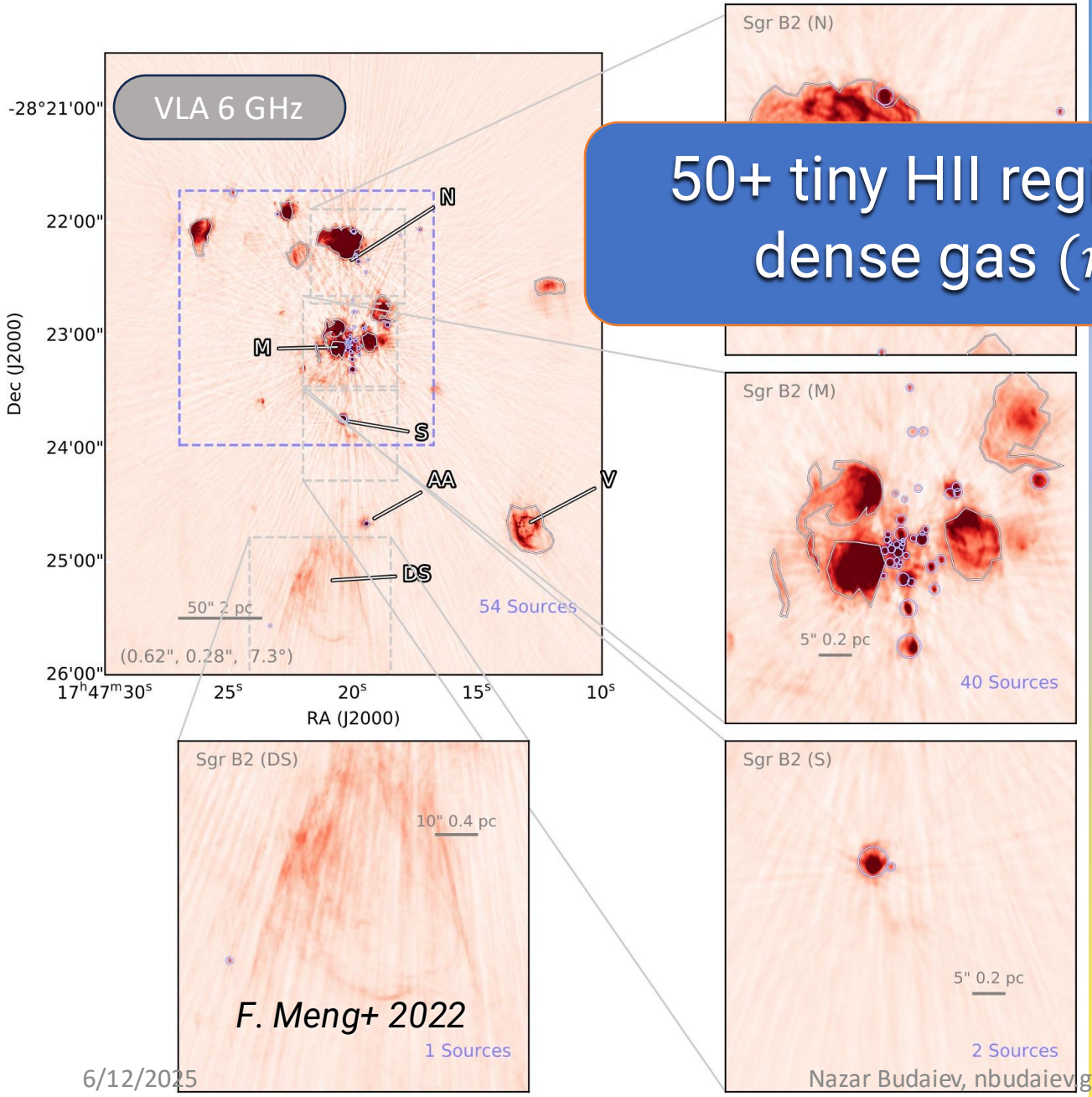


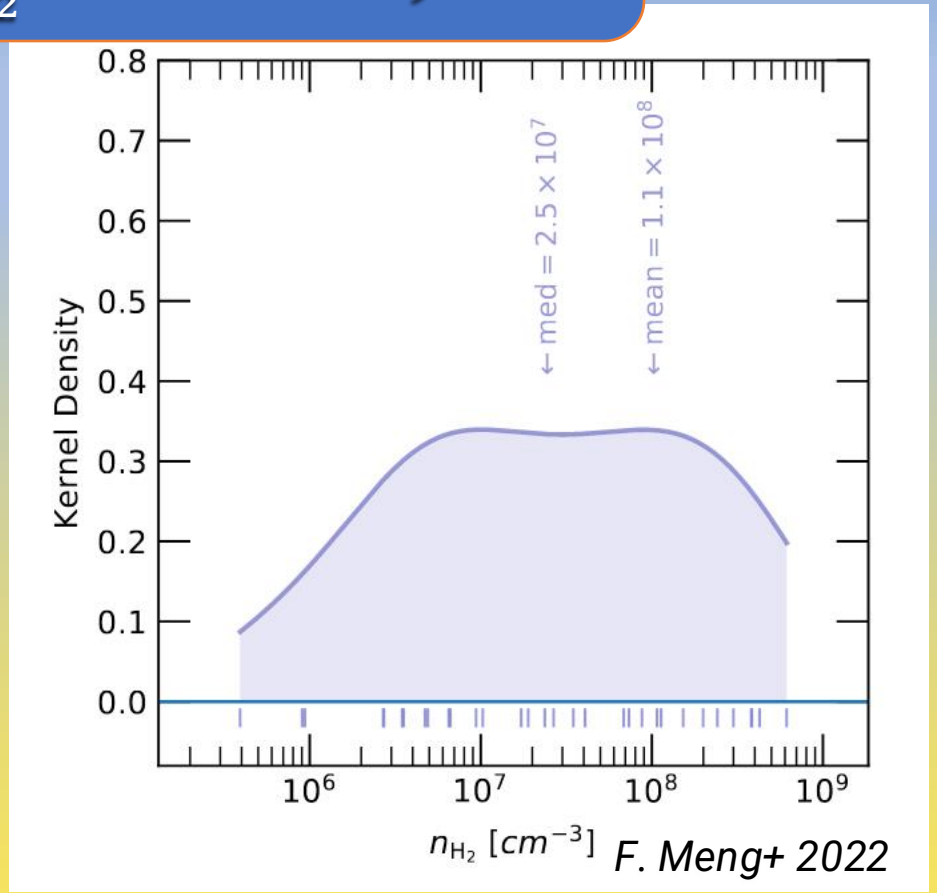






50+ tiny HII regions surrounded by dense gas ($n_{\mathrm{H}_2} > 10^7 \mathrm{cm}^{-3}$)





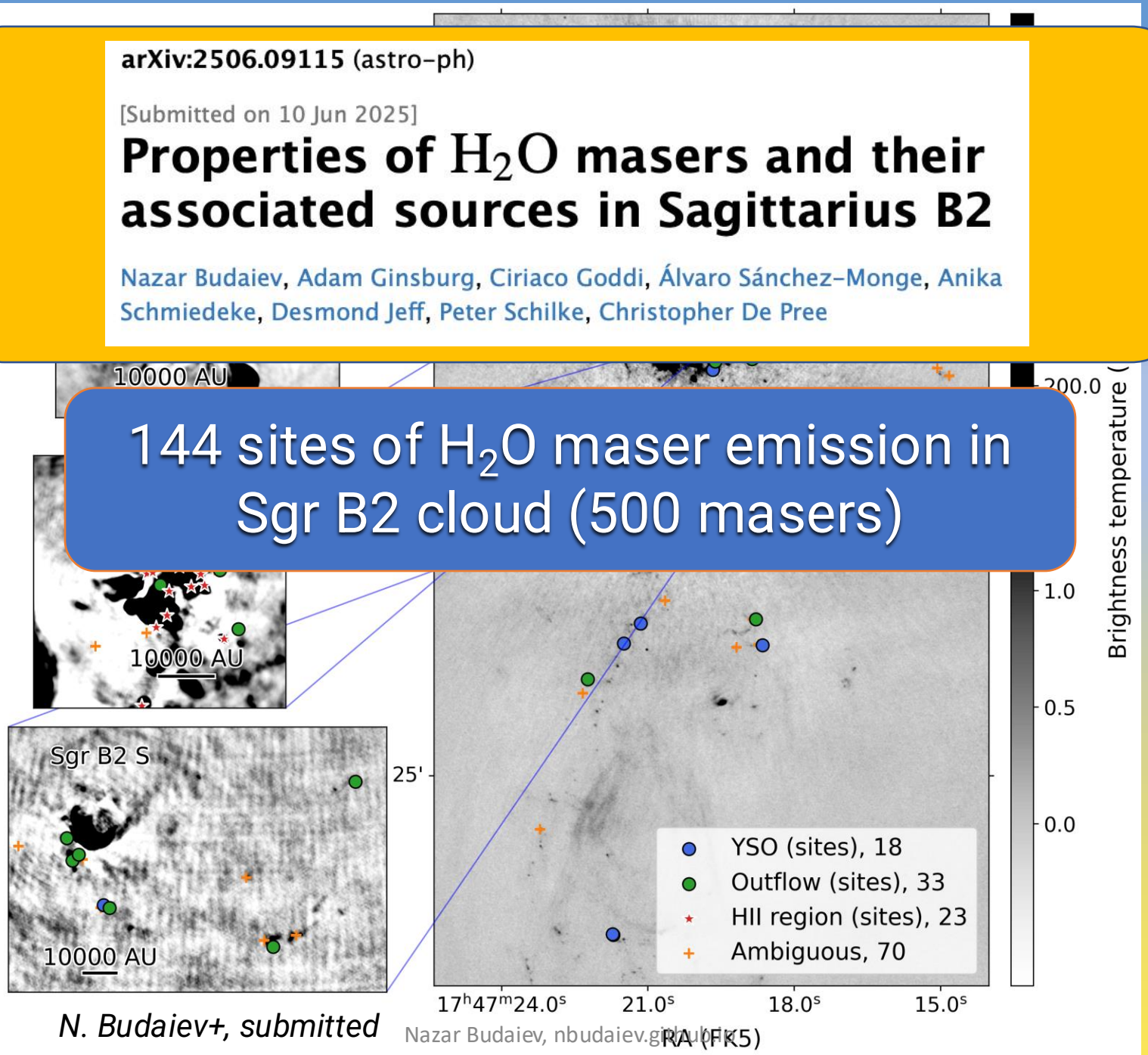
arXiv:2506.09115 (astro-ph)

[Submitted on 10 Jun 2025]

Properties of H_2O masers and their associated sources in Sagittarius B2

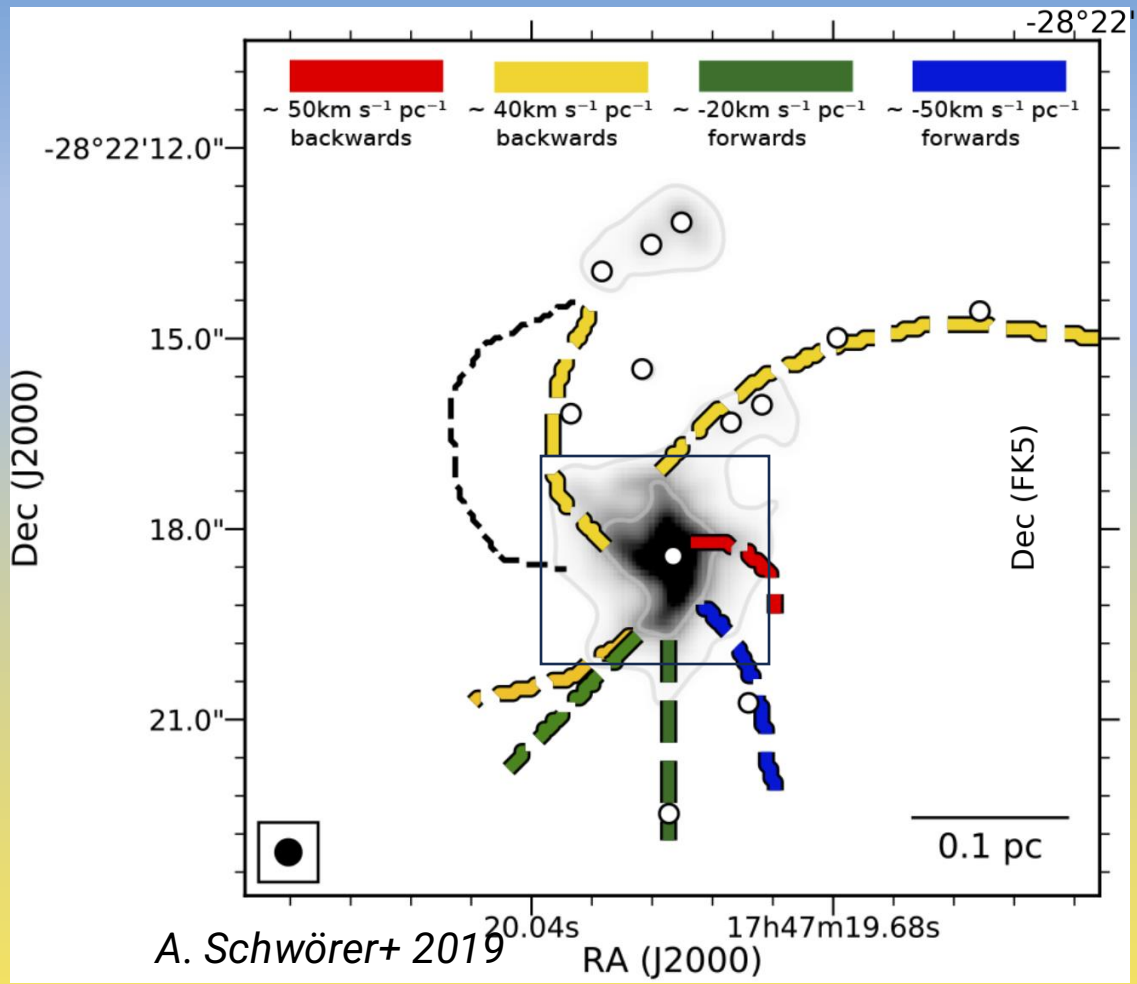
Nazar Budaiev, Adam Ginsburg, Ciriaco Goddi, Álvaro Sánchez-Monge, Anika Schmiedeke, Desmond Jeff, Peter Schilke, Christopher De Pree

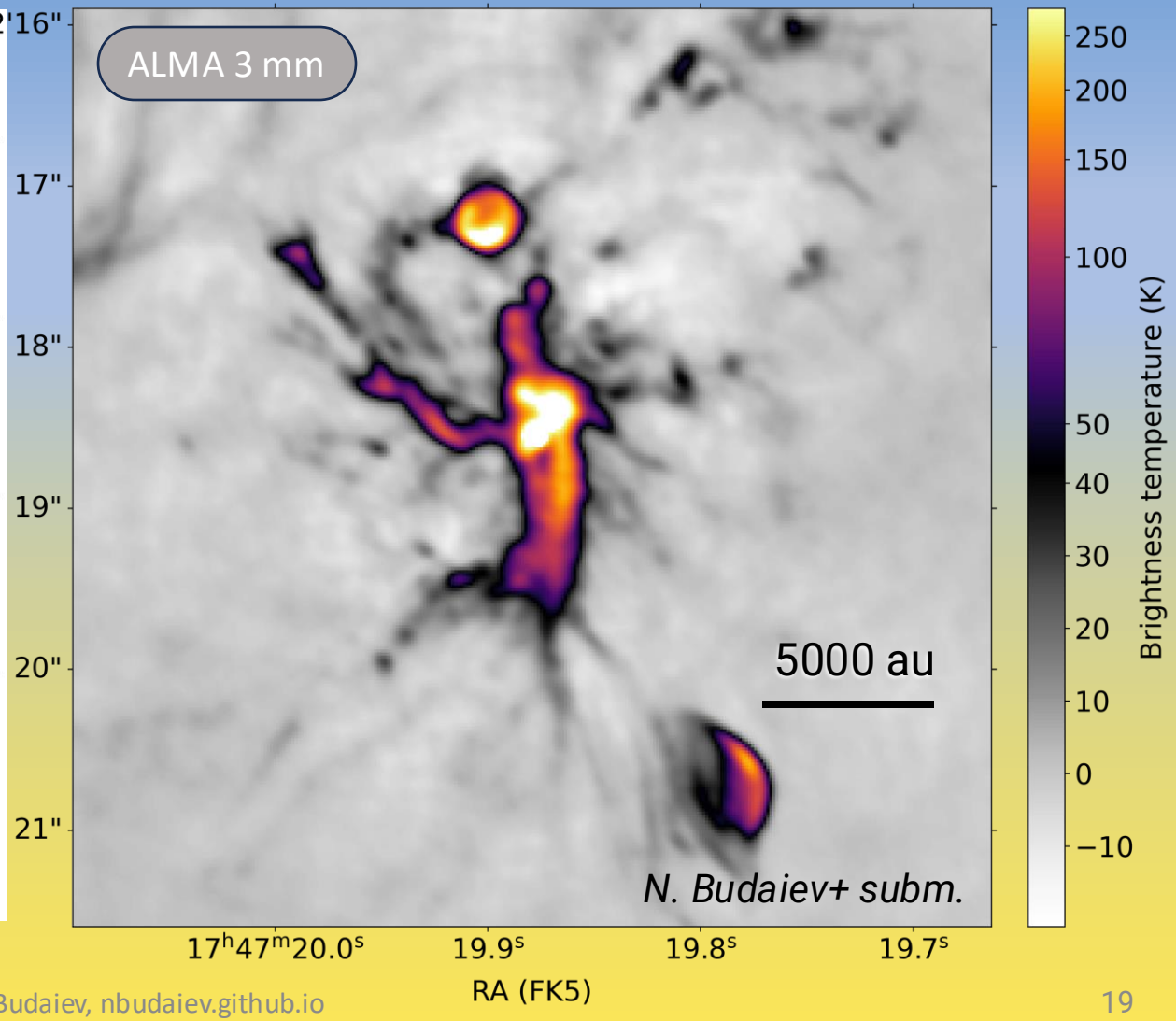
144 sites of H_2O maser emission in Sgr B2 cloud (500 masers)



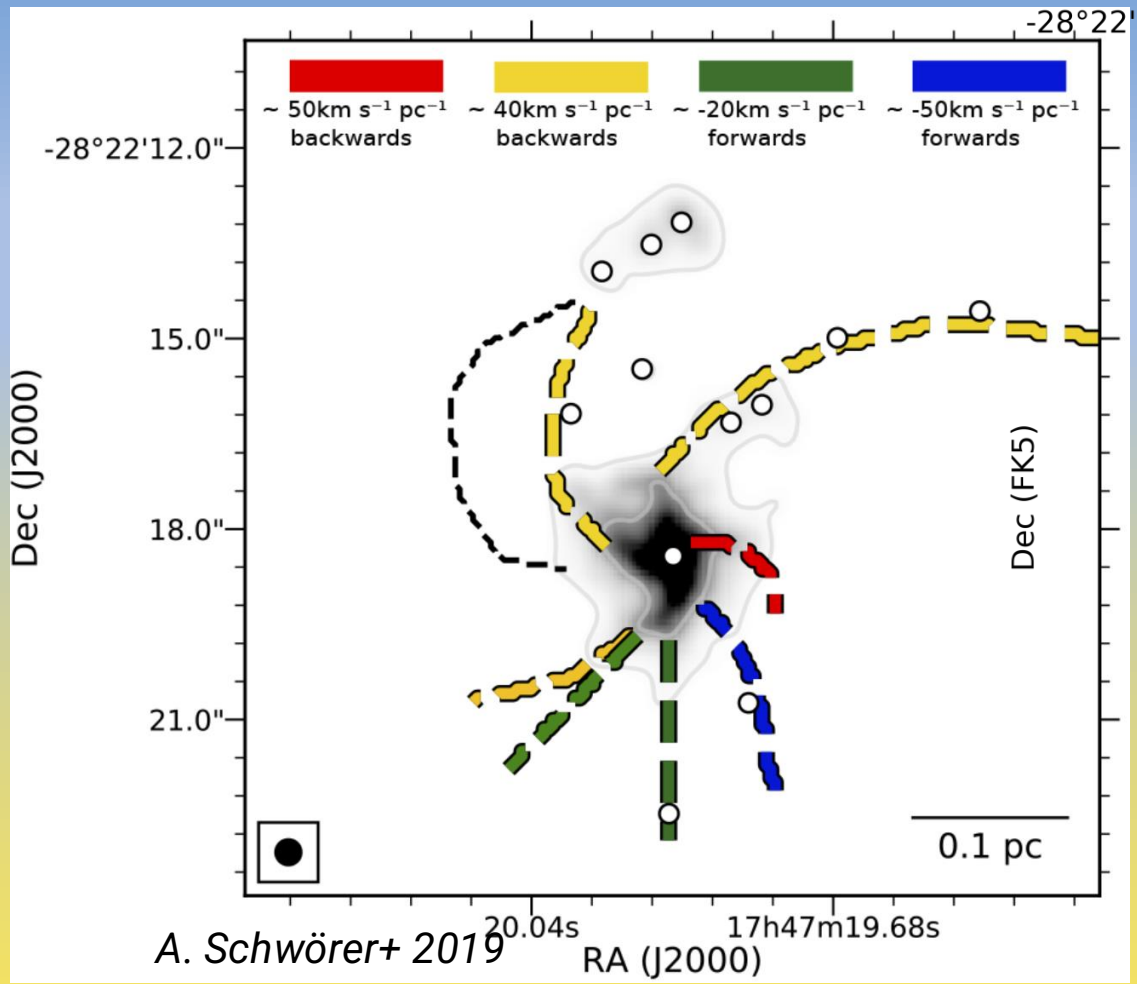
N. Budaiev+, submitted

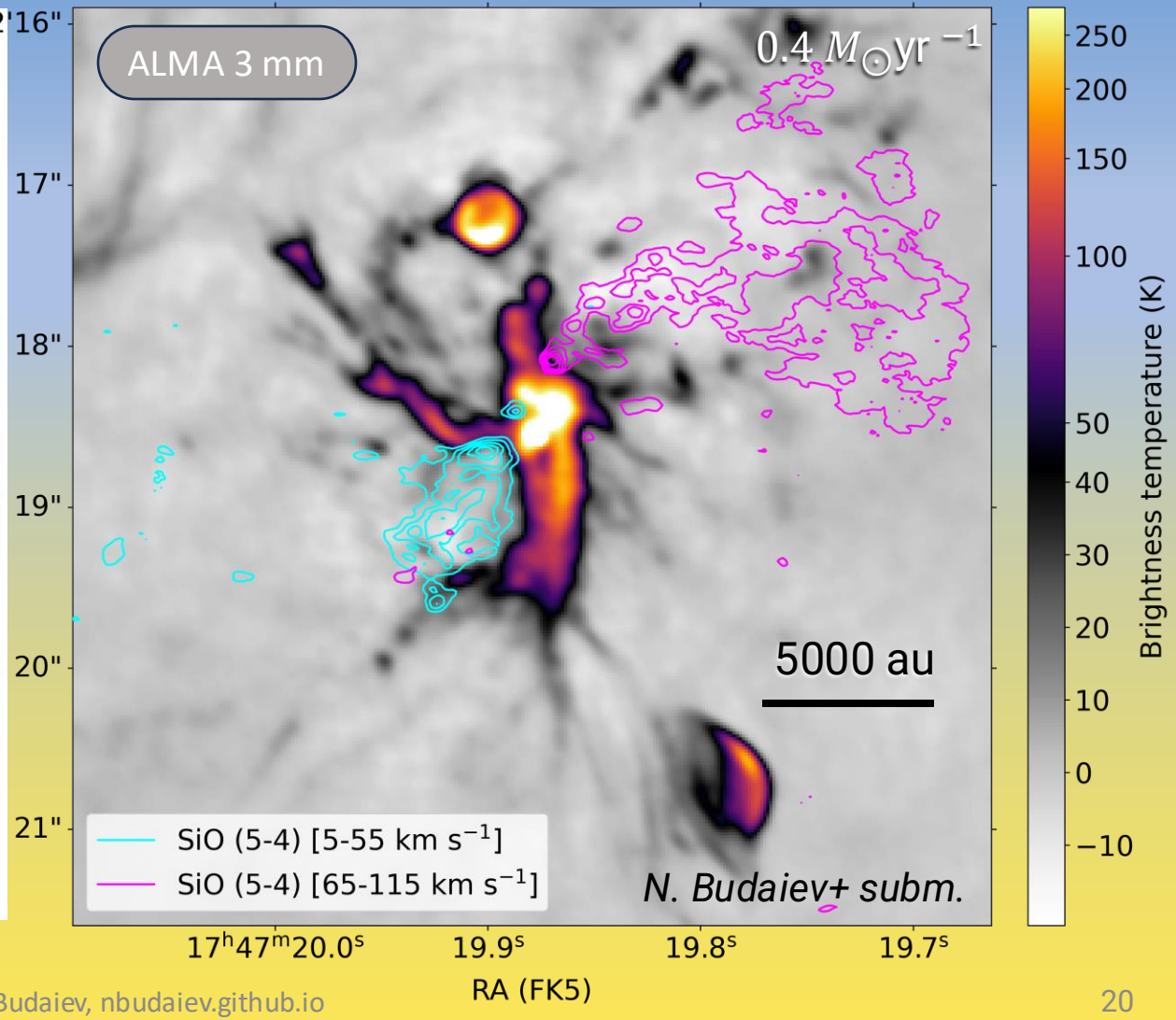
Large-scale material flow in Sgr B2 N





Large-scale material flow in Sgr B2 N

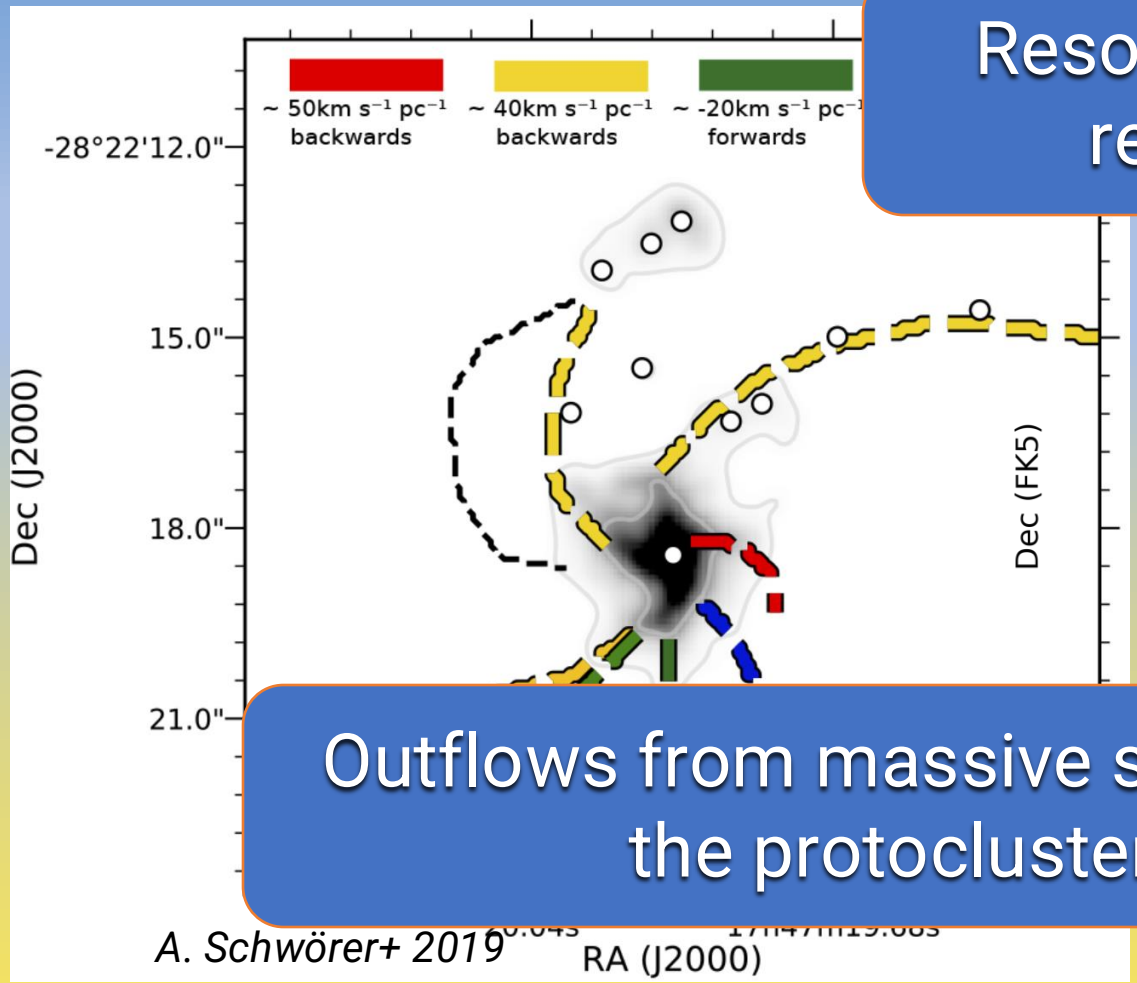


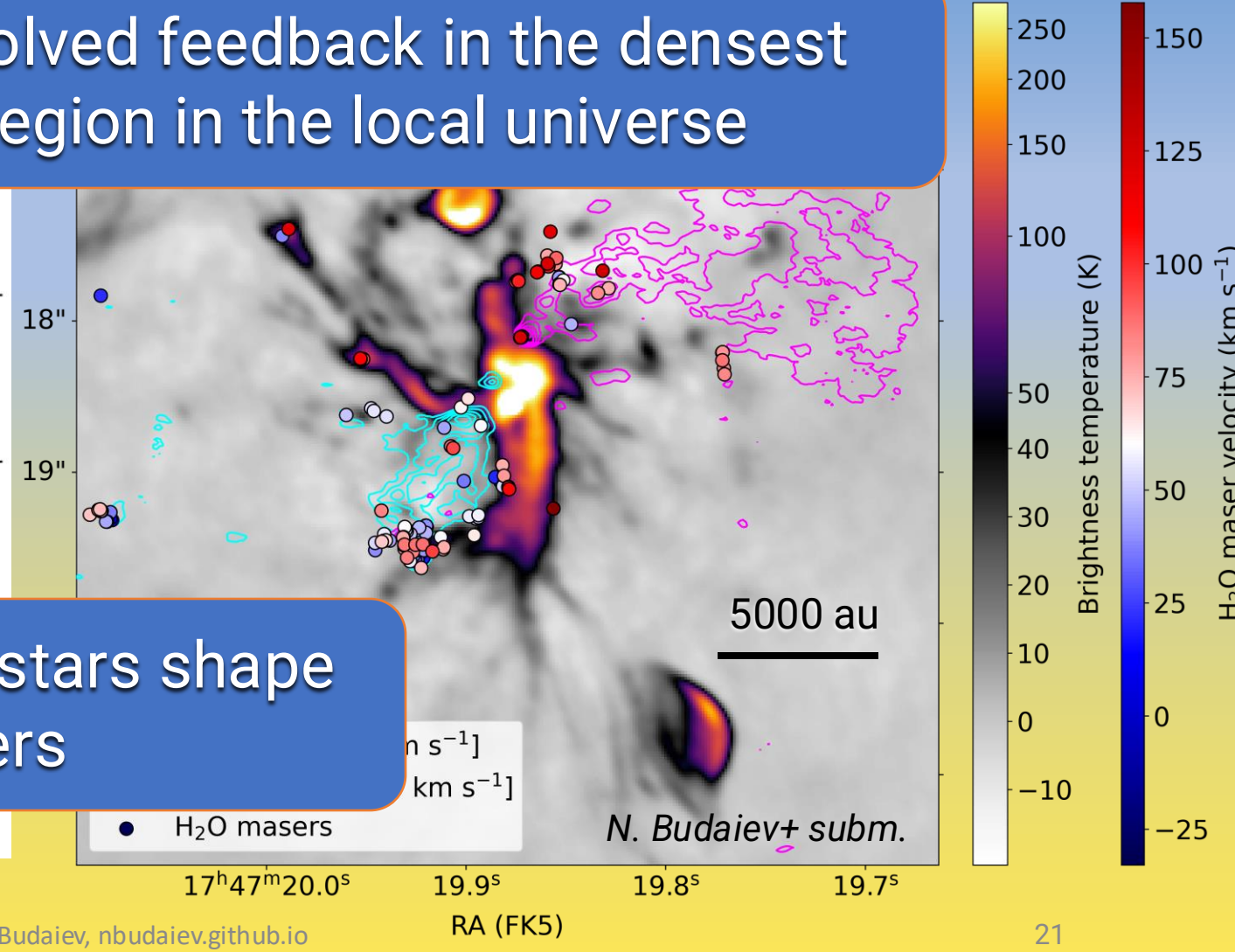


Large-scale material flow in Sgr B2 N

Resolved feedback in the densest region in the local universe

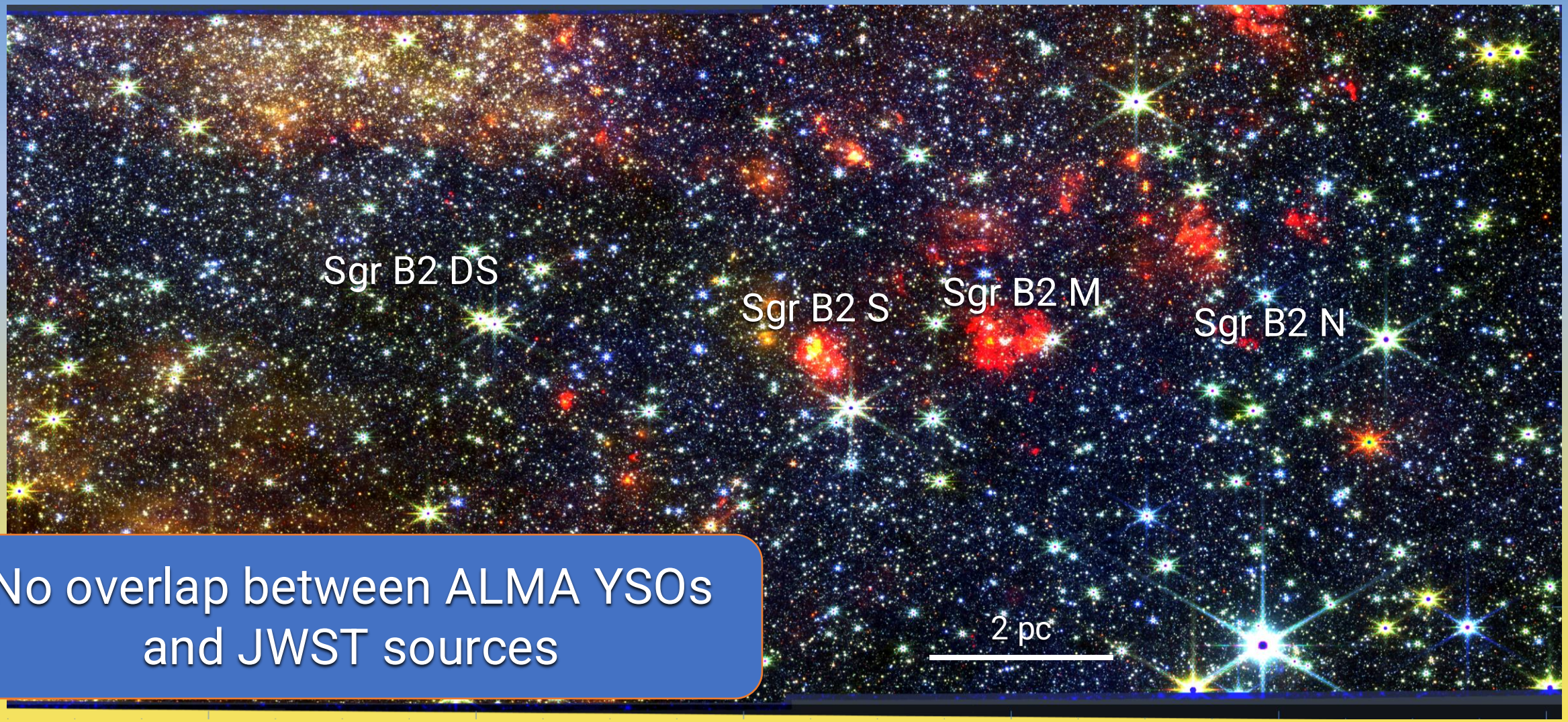
Outflows from massive stars shape the protoclusters





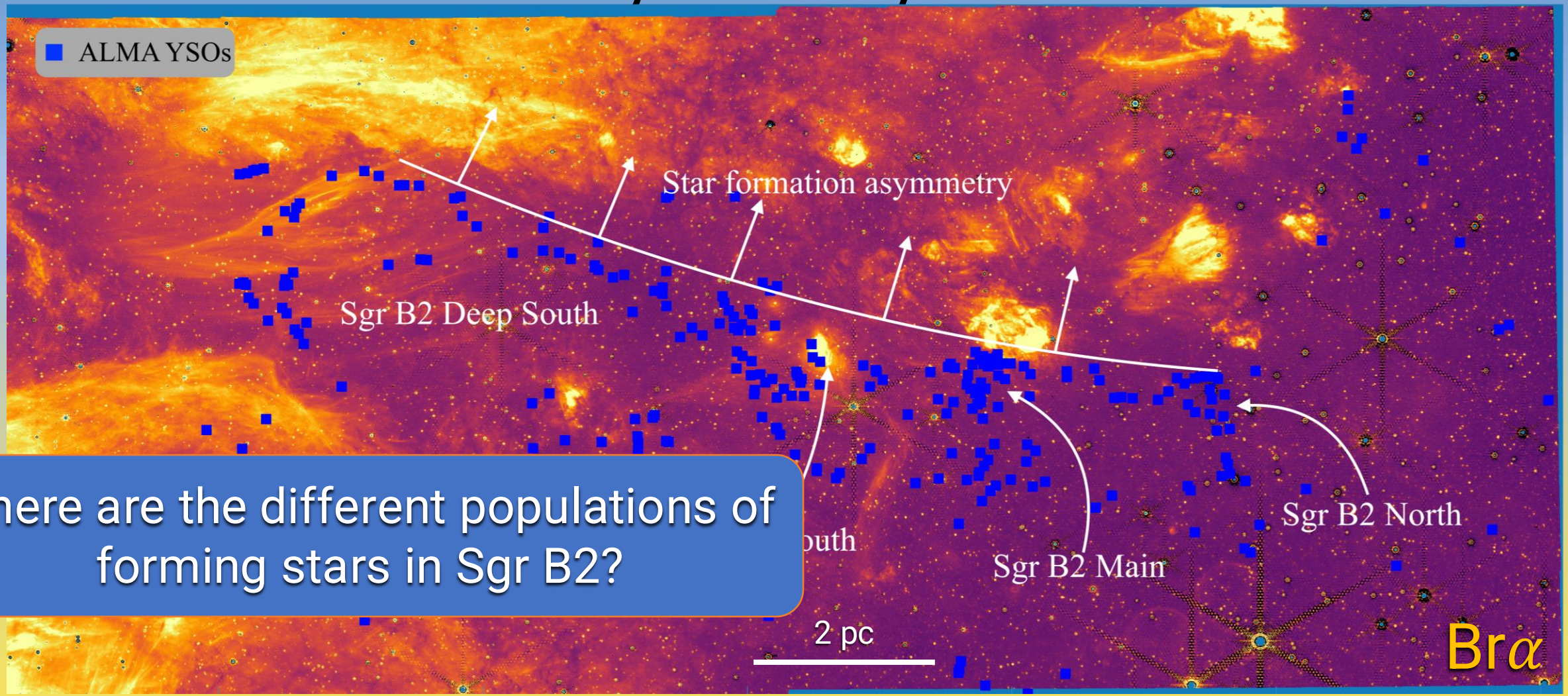
Evolved YSOs

F480M + F360M + F182M

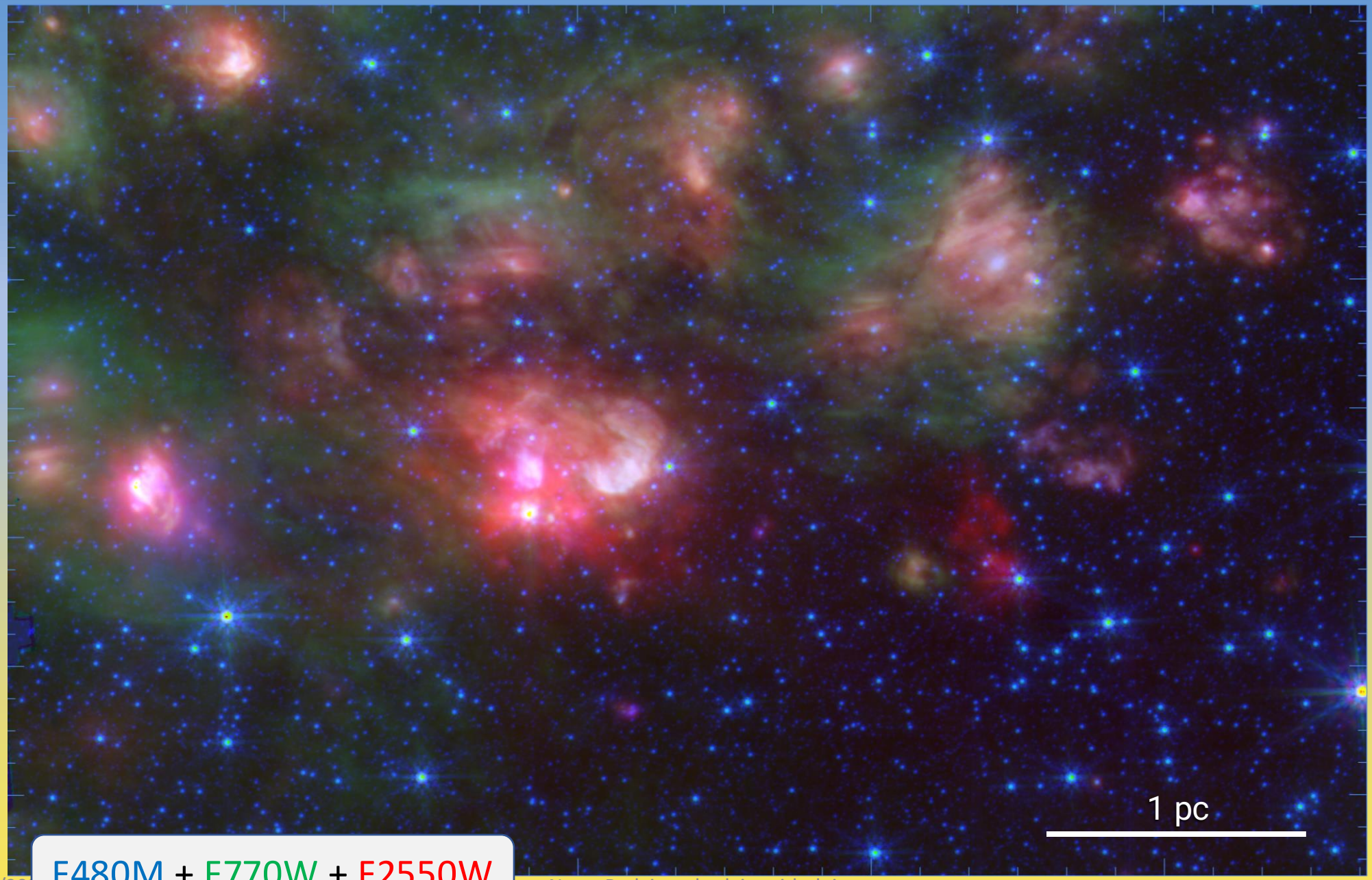


No overlap between ALMA YSOs and JWST sources

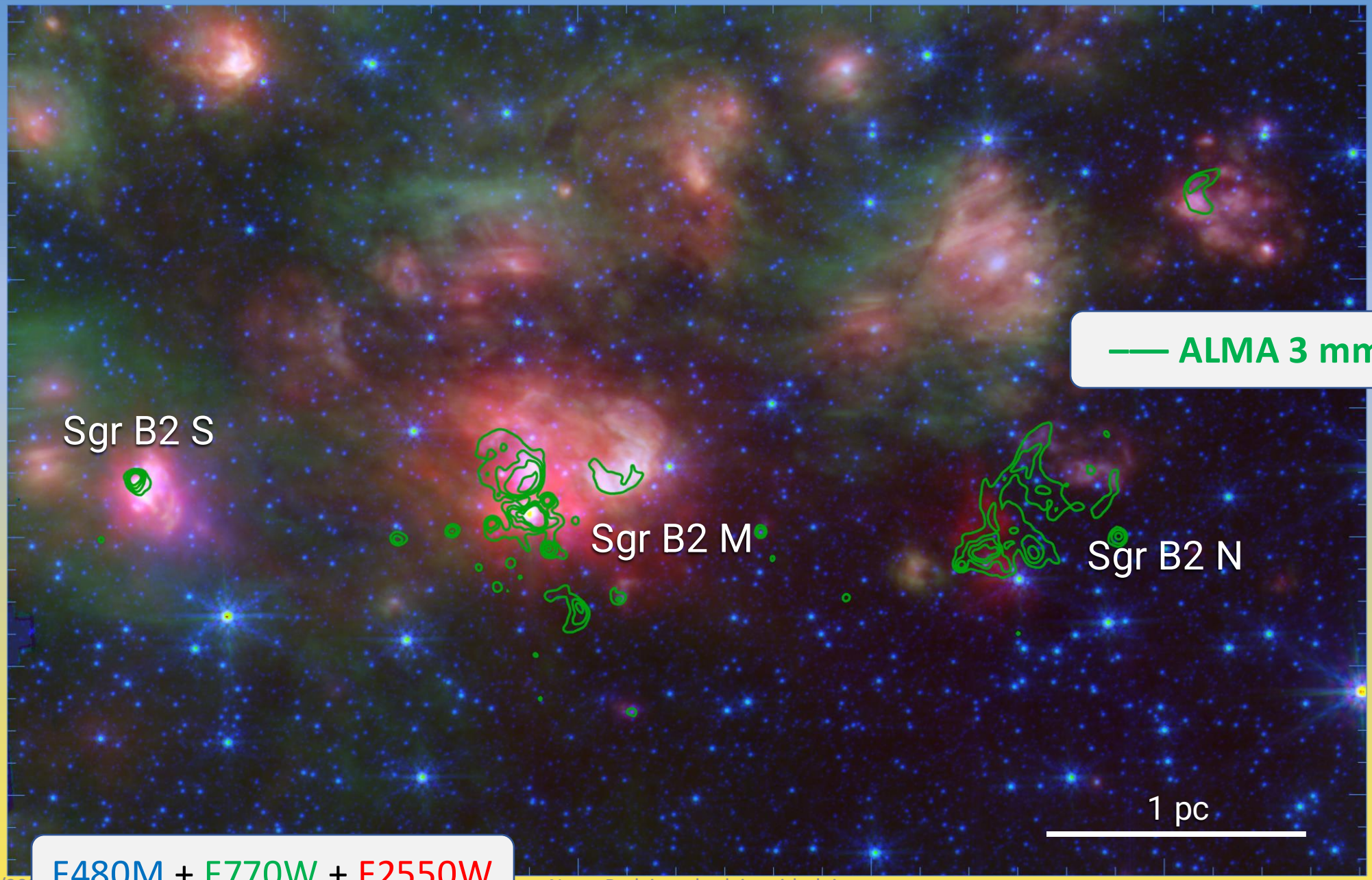
Star formation asymmetry



Where are the different populations of forming stars in Sgr B2?



F480M + F770W + F2550W


—— ALMA 3 mm
Sgr B2 S
Sgr B2 M
Sgr B2 N
1 pc
F480M + F770W + F2550W

ALMA:

1000+ YSOs

-Fragmentation

-SiO outflows

-SF asymmetry

-Resolving feedback

-Hot cores (see Bonfand+19, Jeff+24, Belloche+25, Möller+25 etc)

VLA:

-50+ HII regions

-Dense gas

-140+ H_2O maser sites

-Kinematics of the cloud

JWST:

-No overlap with ALMA

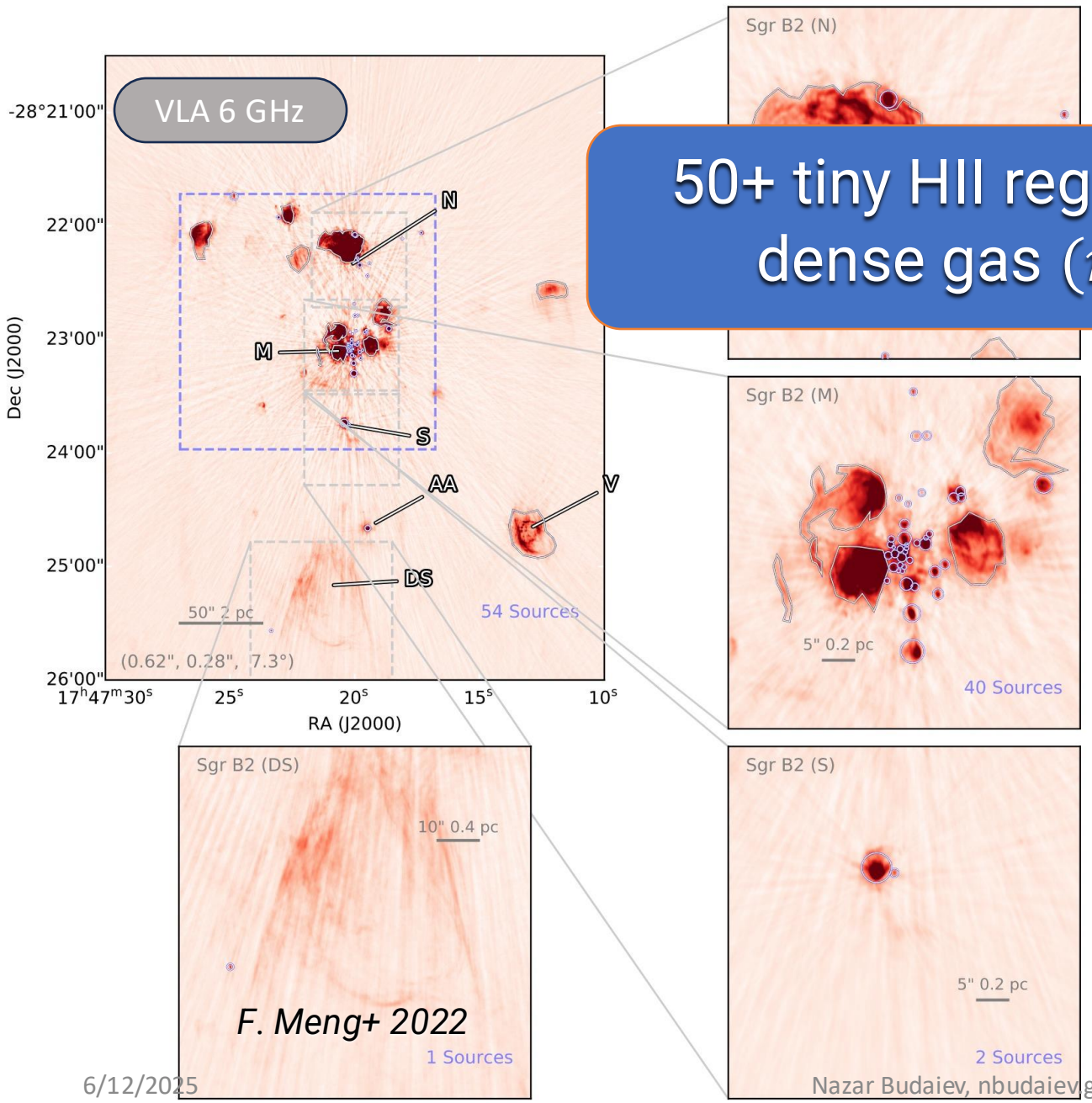
-100k NIRCam detections

-Extinction measurements

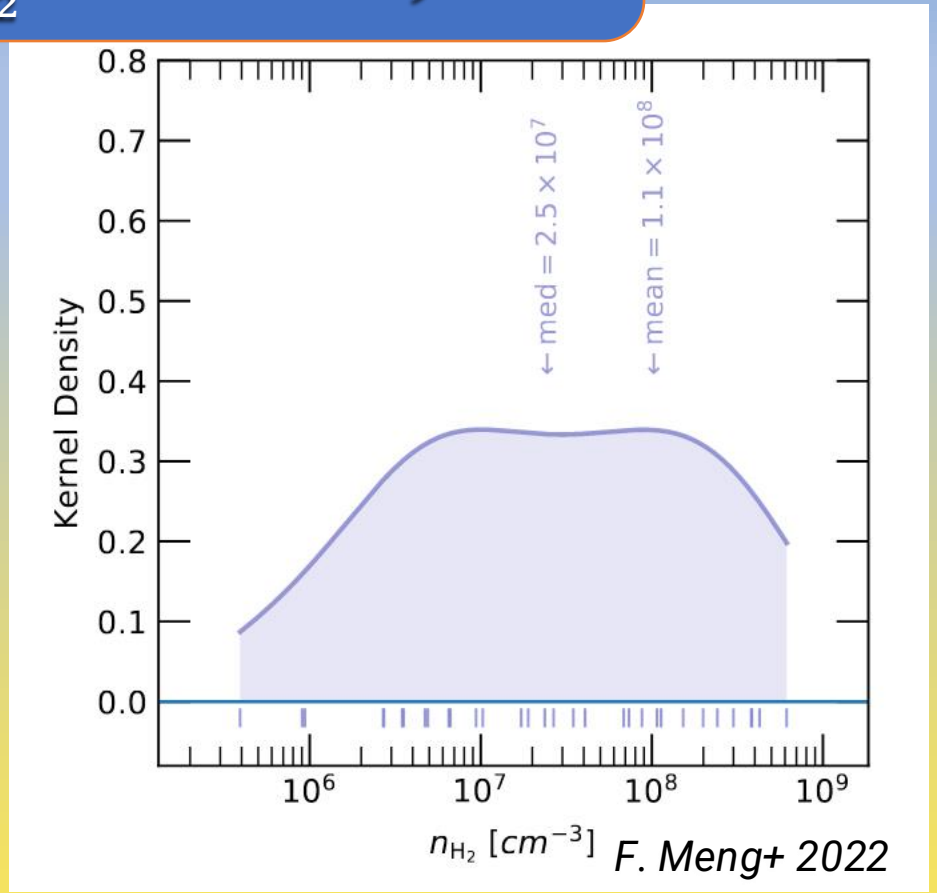
-Stage II/III YSOs

-Hint of tiny HCHII regions

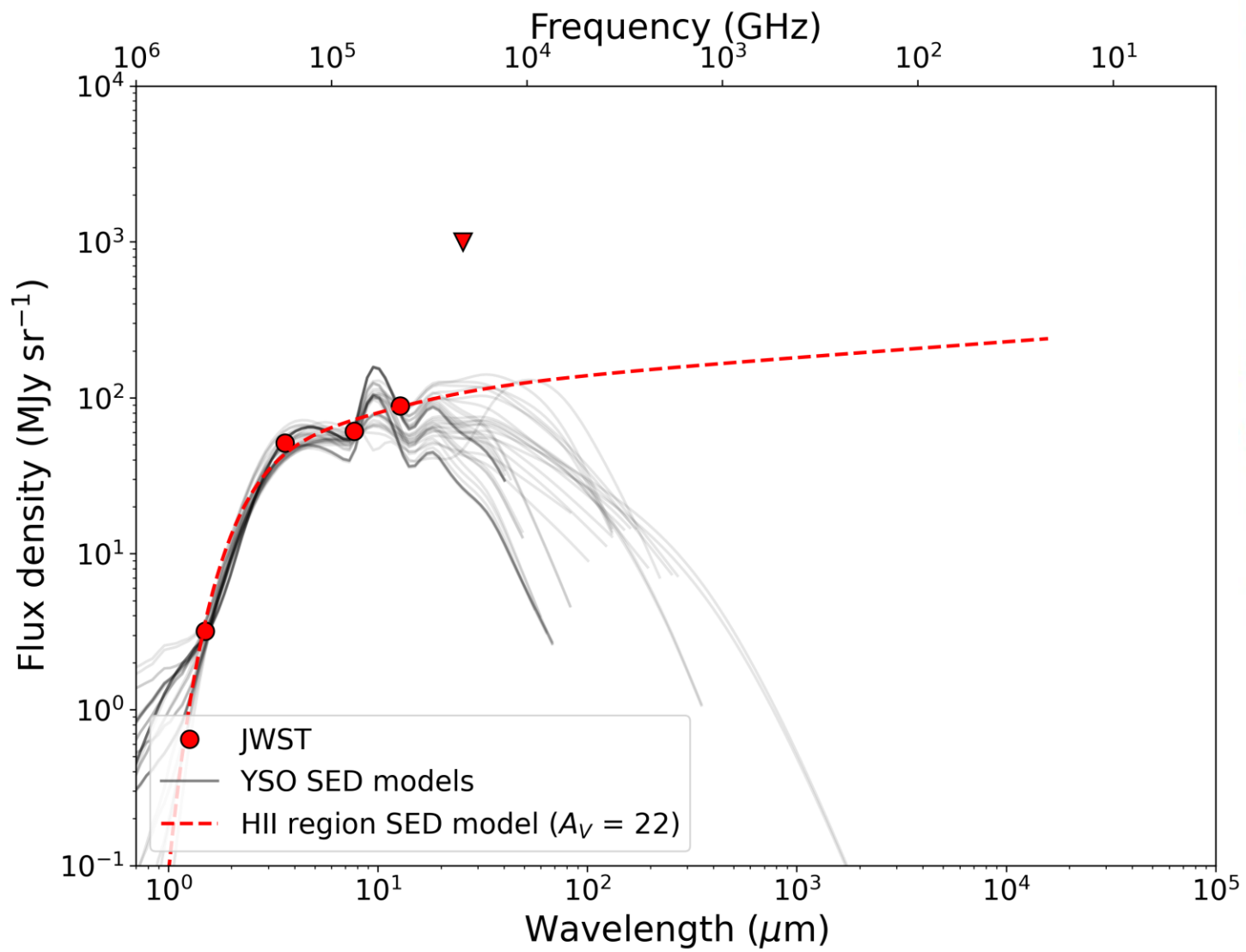
Extra slides

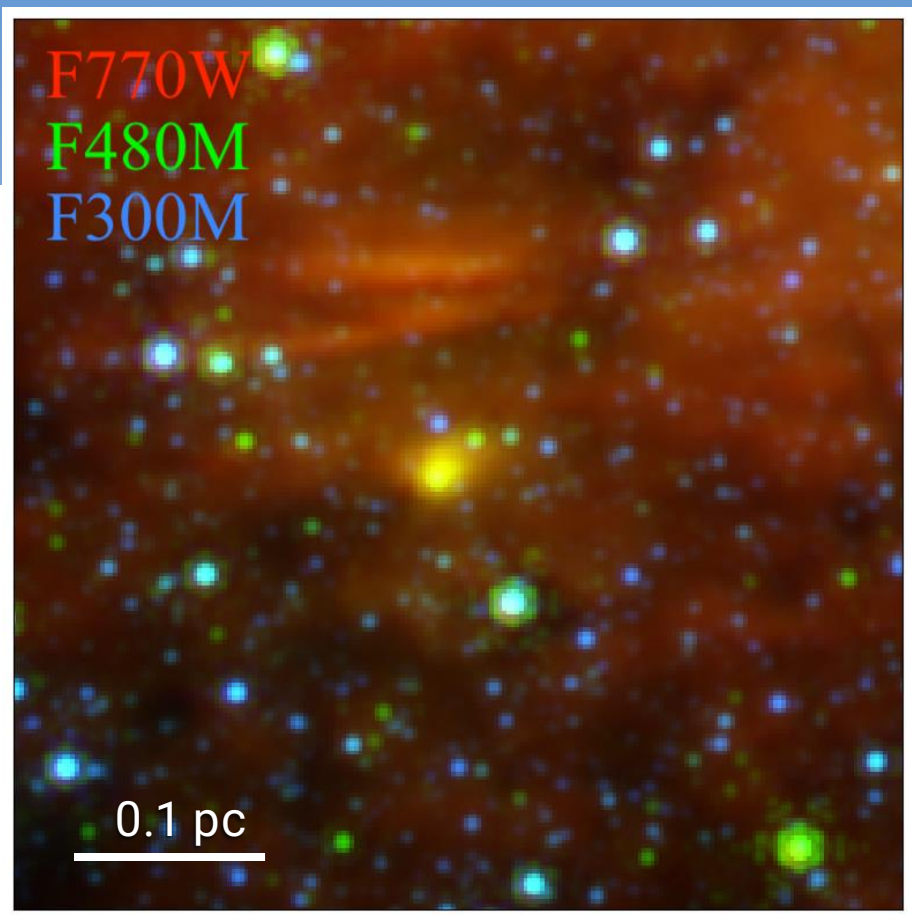


50+ tiny HII regions surrounded by dense gas ($n_{\mathrm{H_2}} > 10^7 \mathrm{cm}^{-3}$)

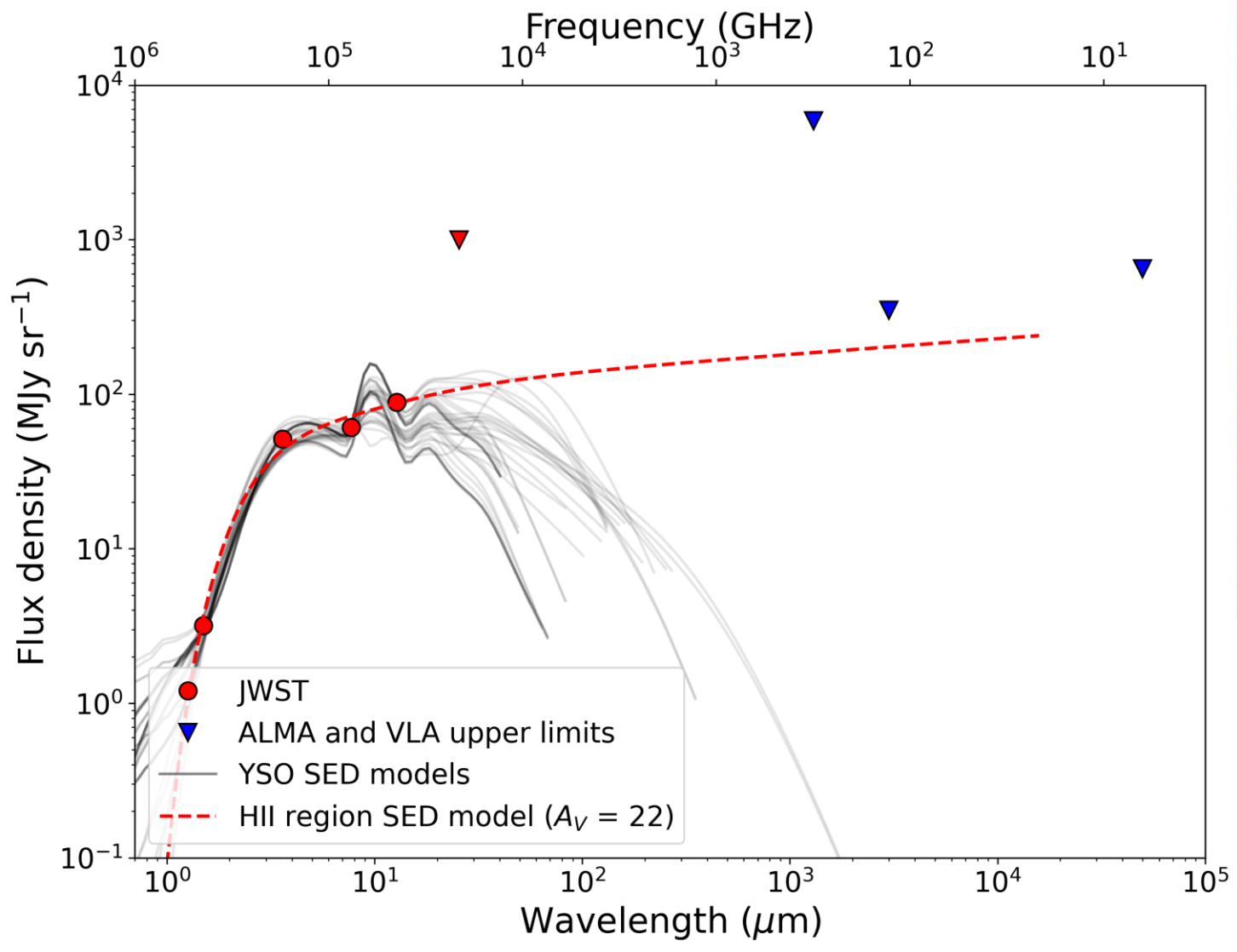


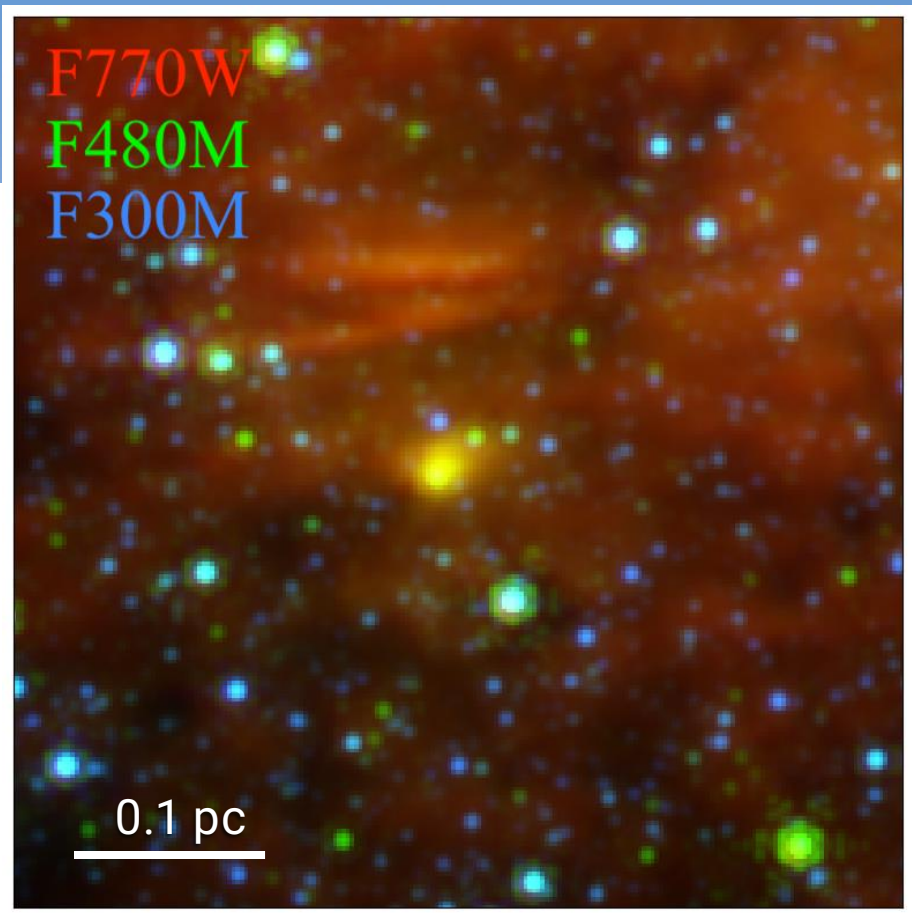
HCHII regions vs YSOs



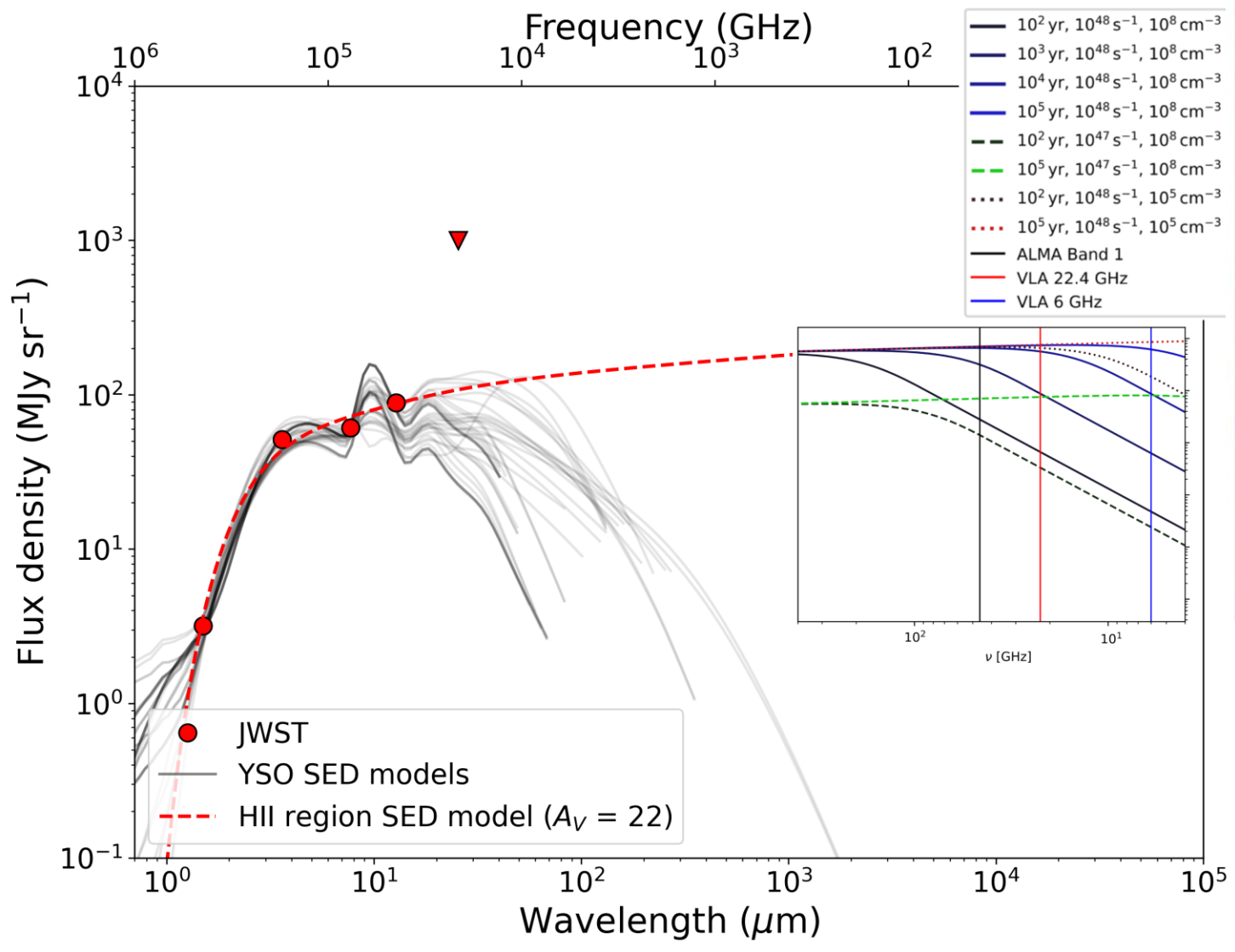


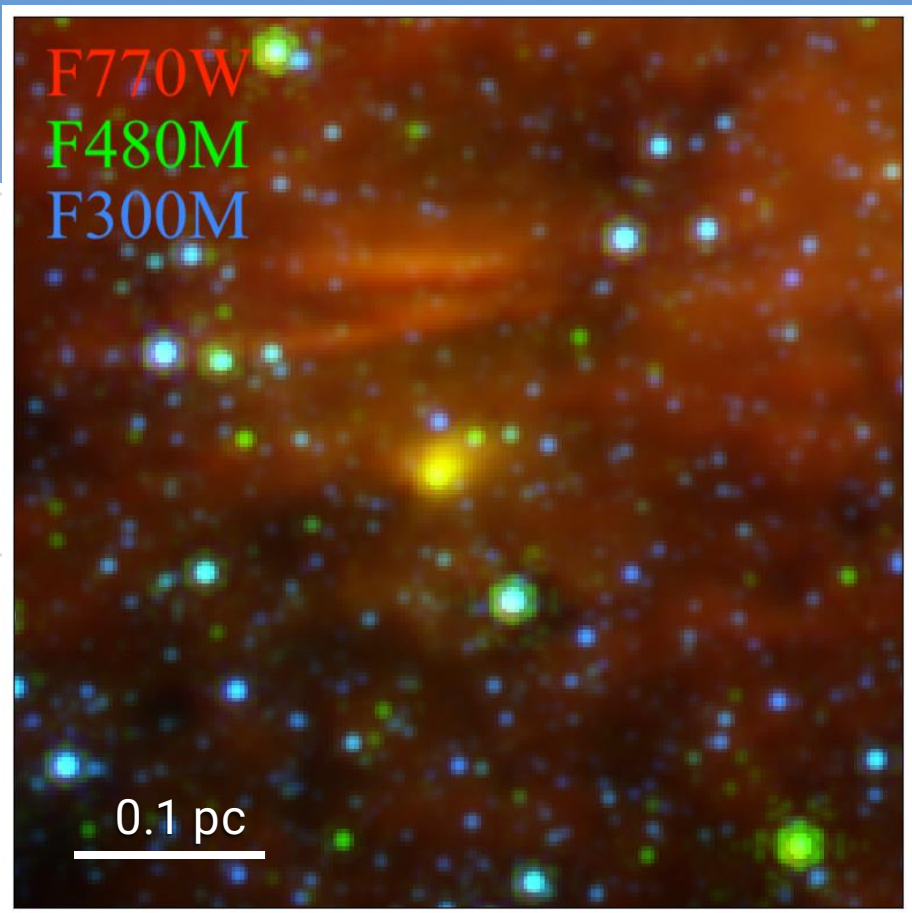
HCHII regions vs YSOs



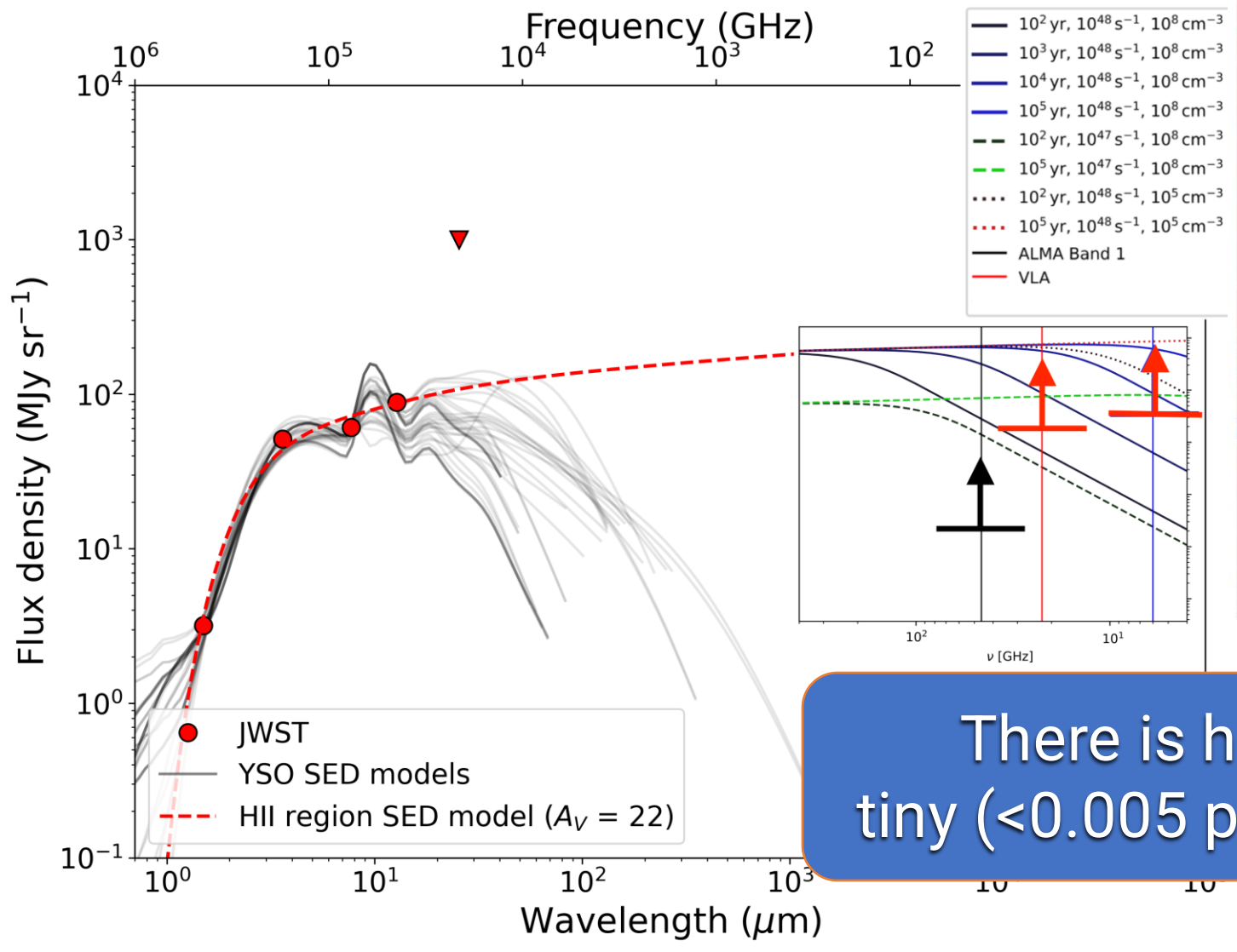


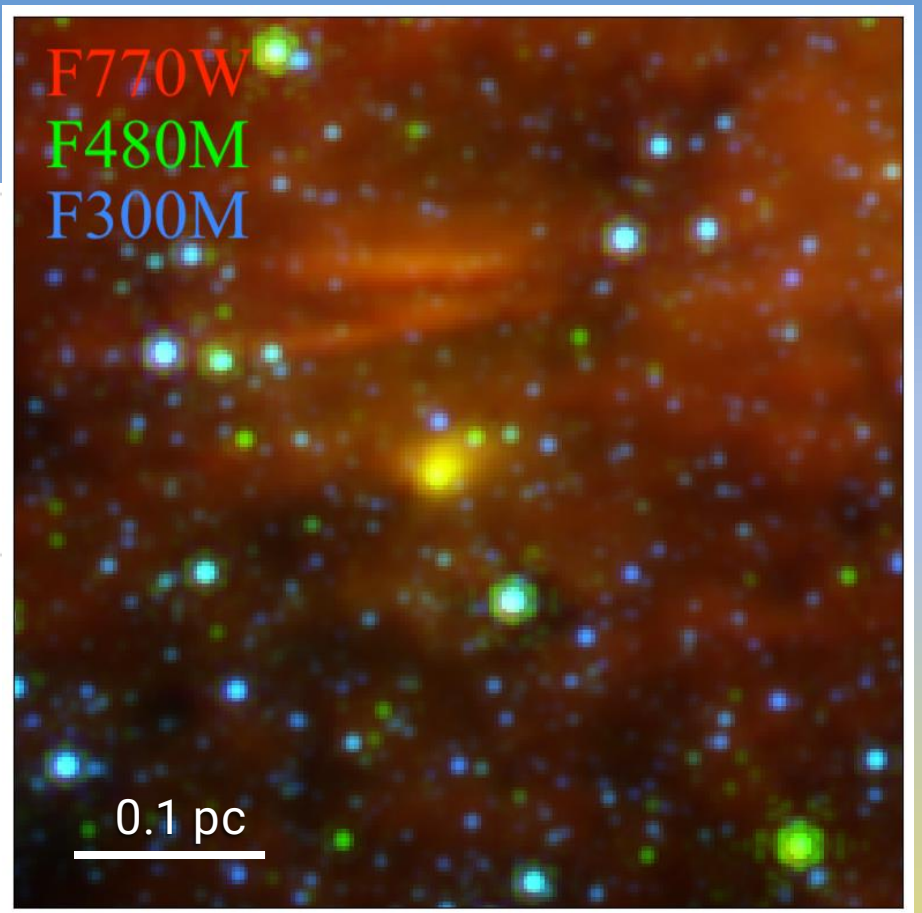
HCHII regions vs YSOs





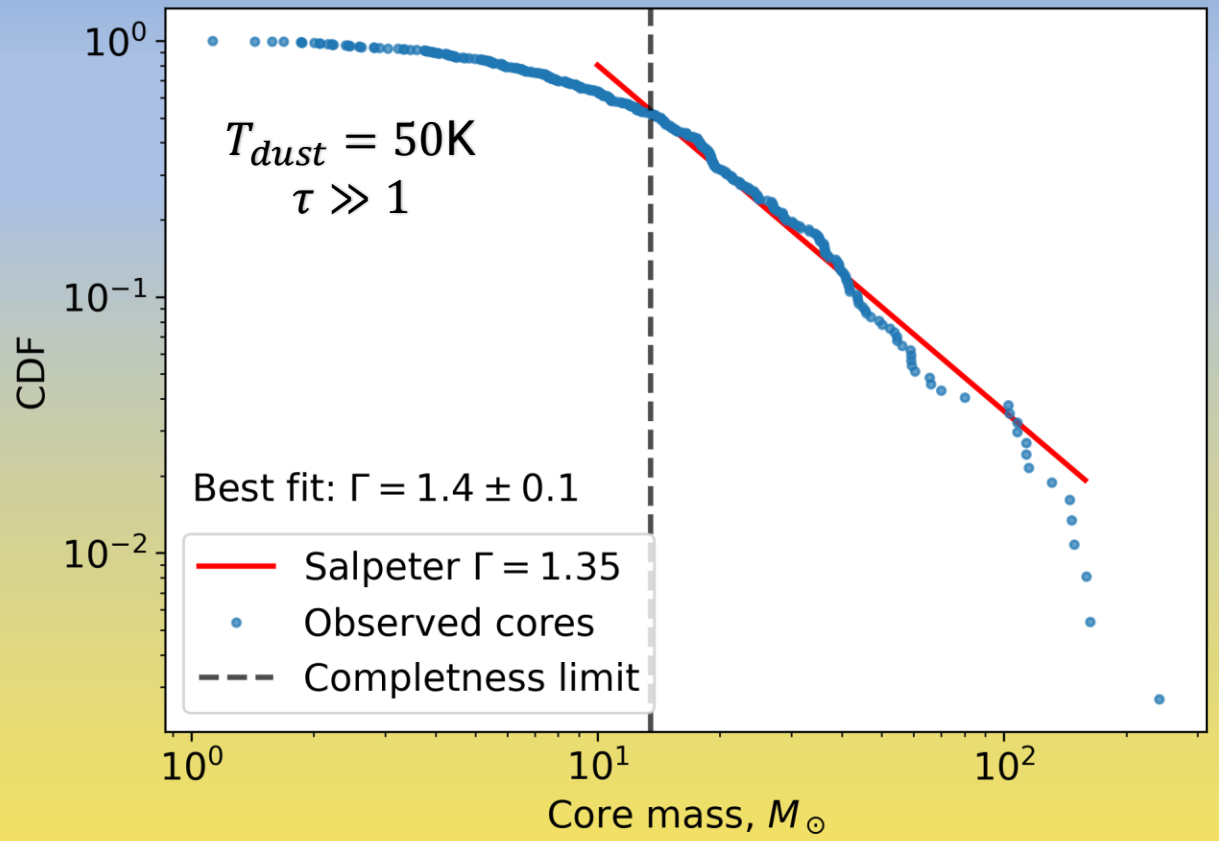
HCHII regions vs YSOs

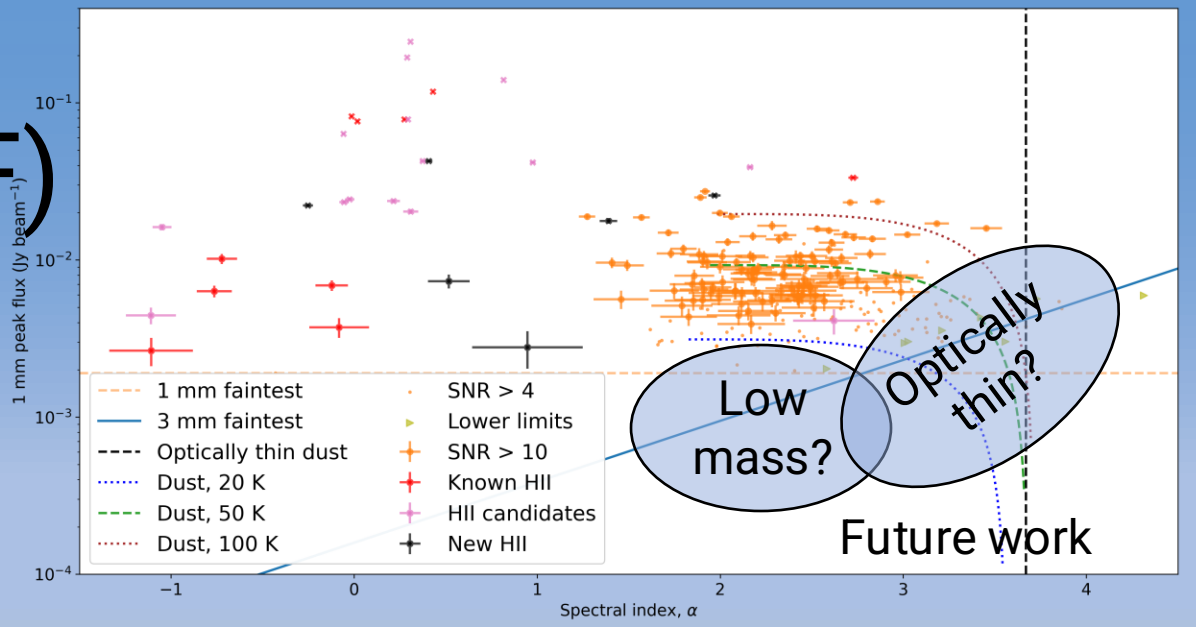


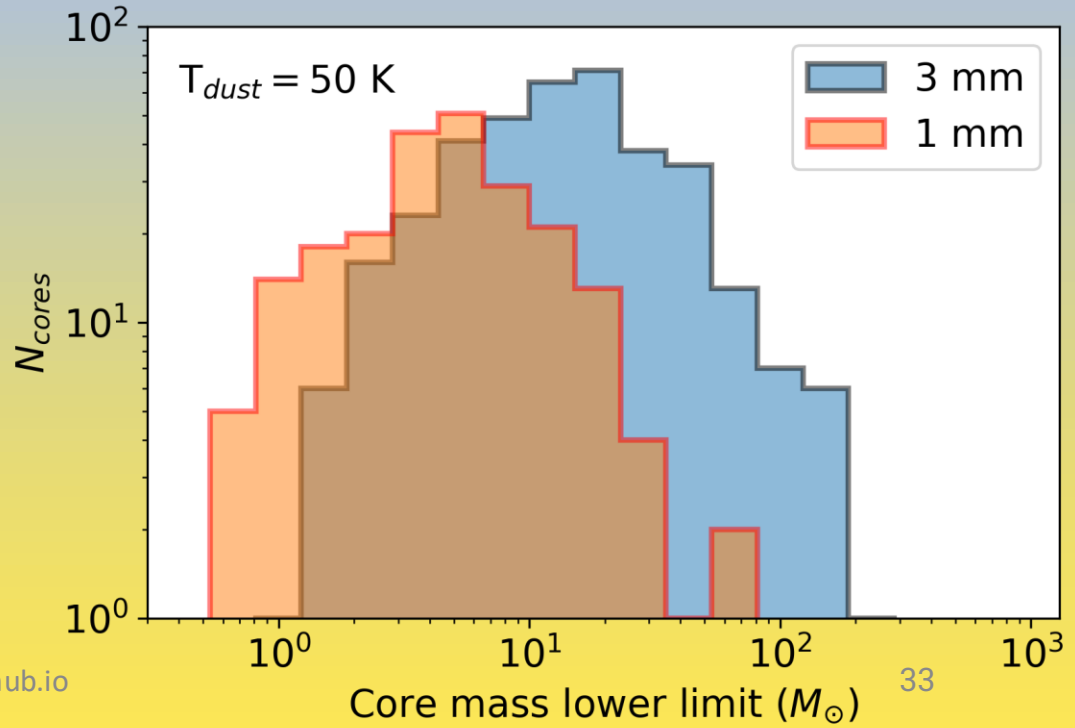


There is hidden population of tiny (<0.005 pc) HII regions in Sgr B2

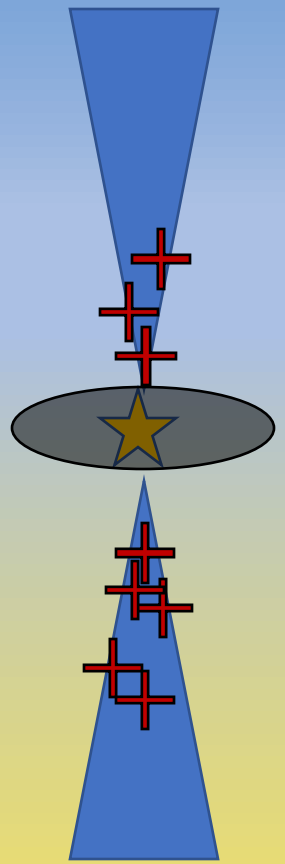
Core Mass Function (CMF)

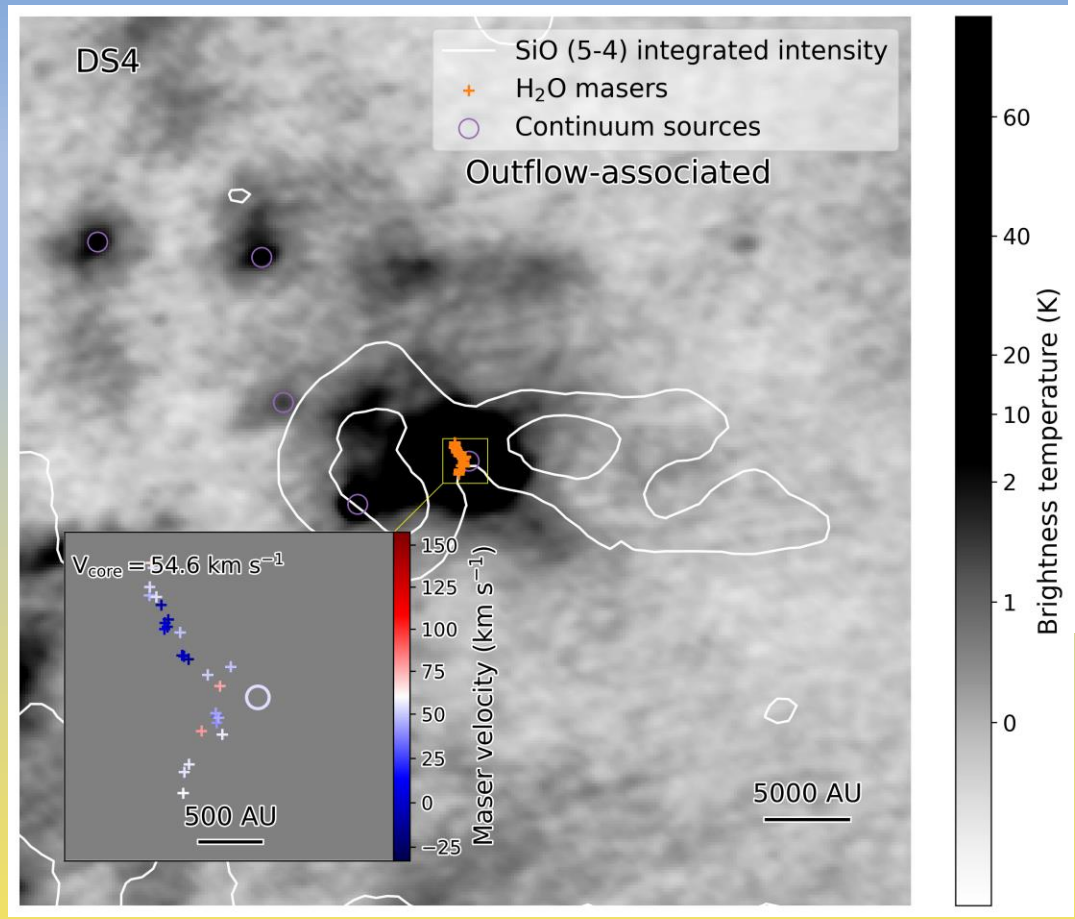


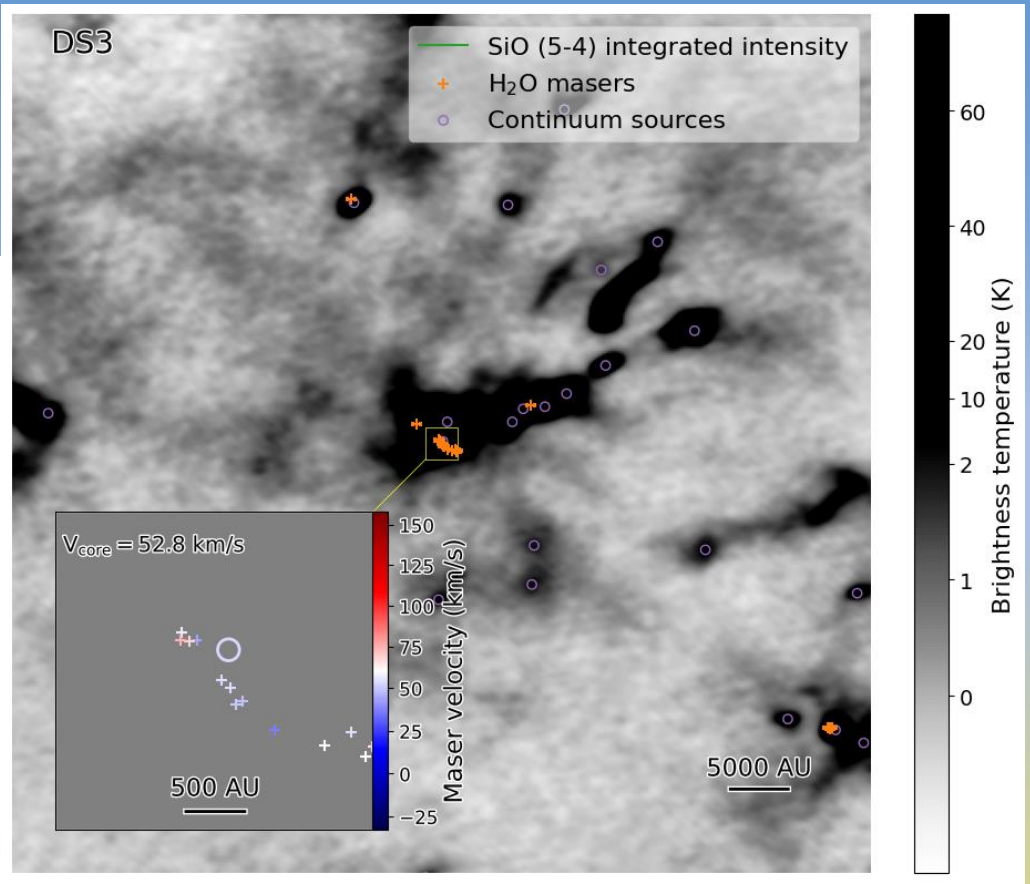




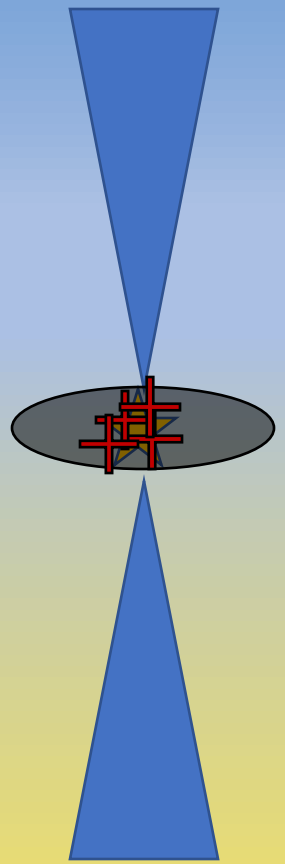
Outflow-associated

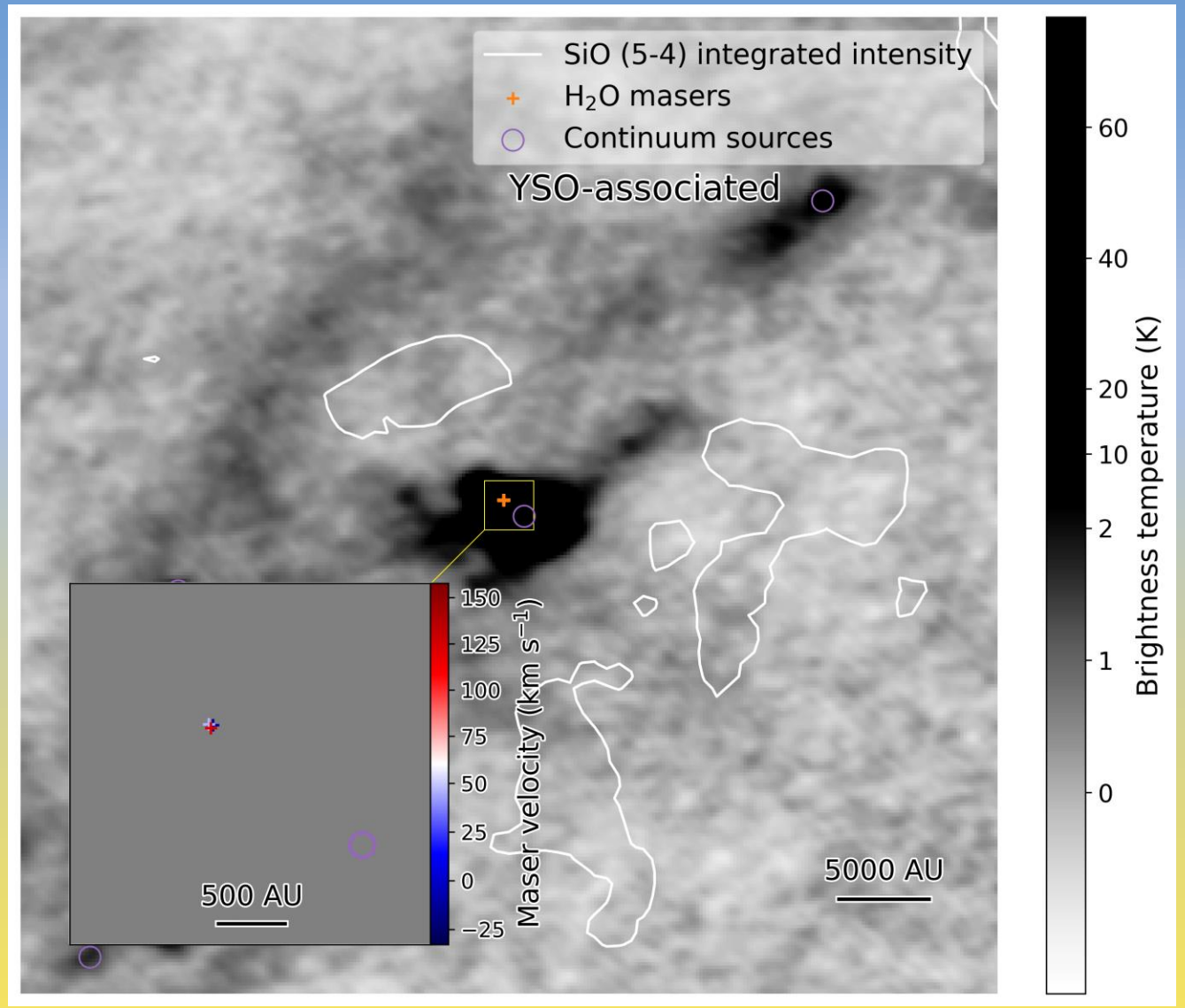




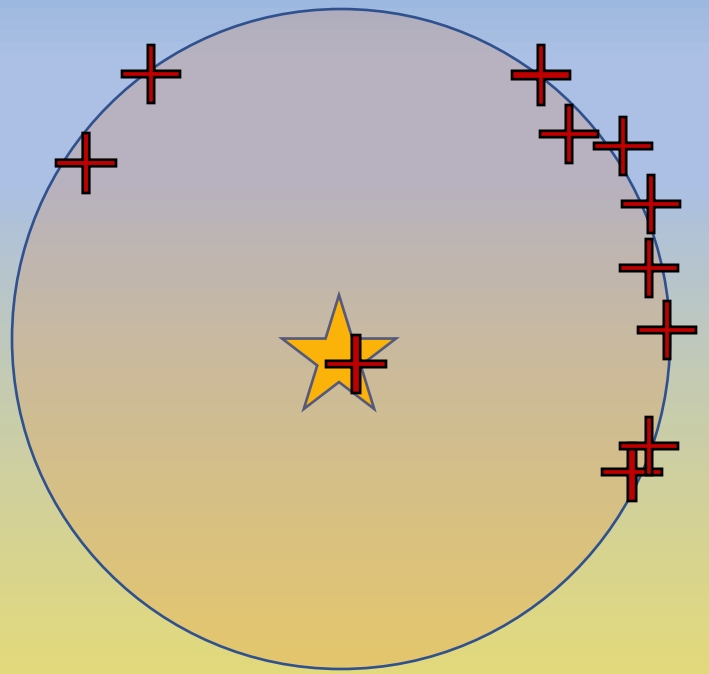


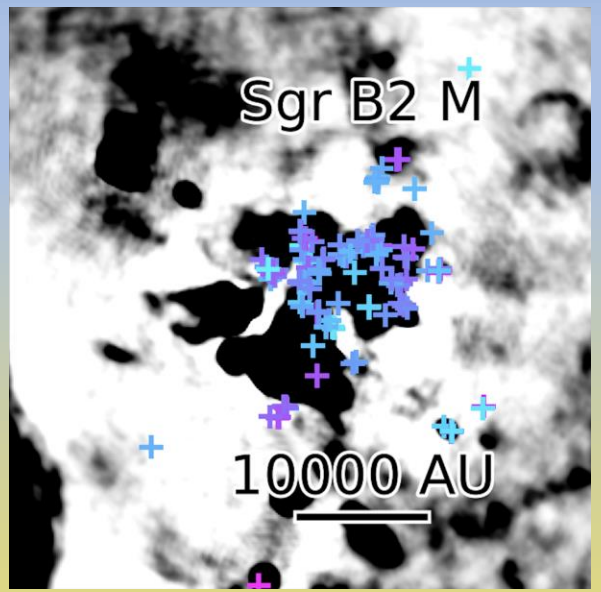
YSO-associated

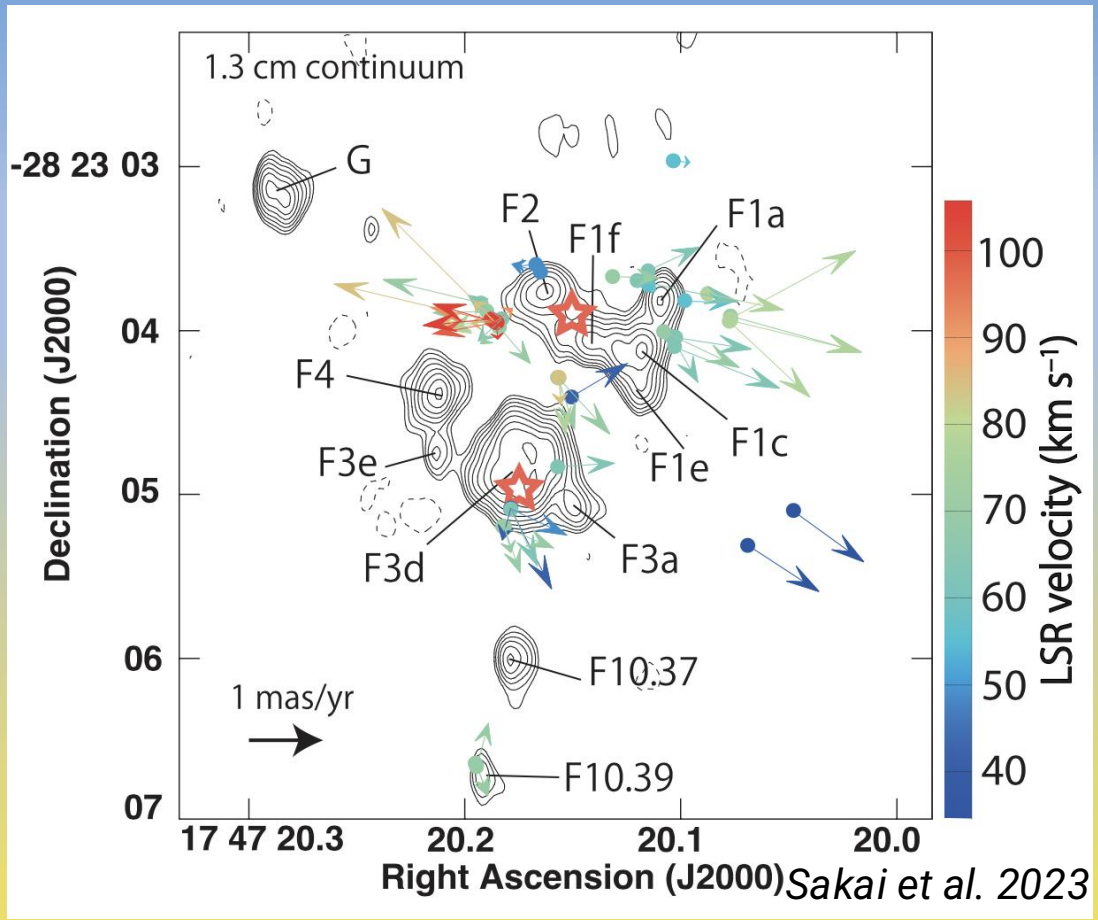




HII region-associated







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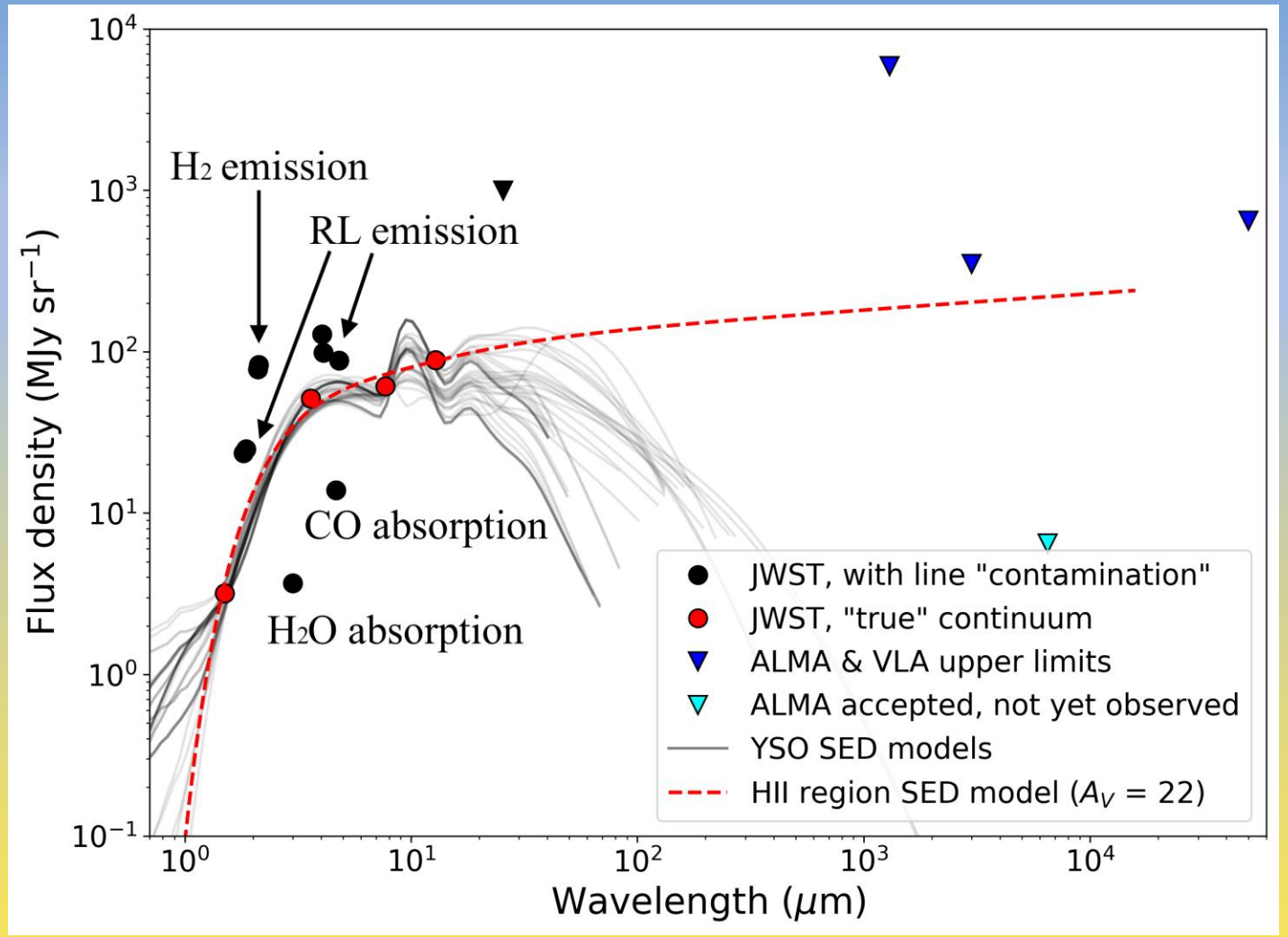
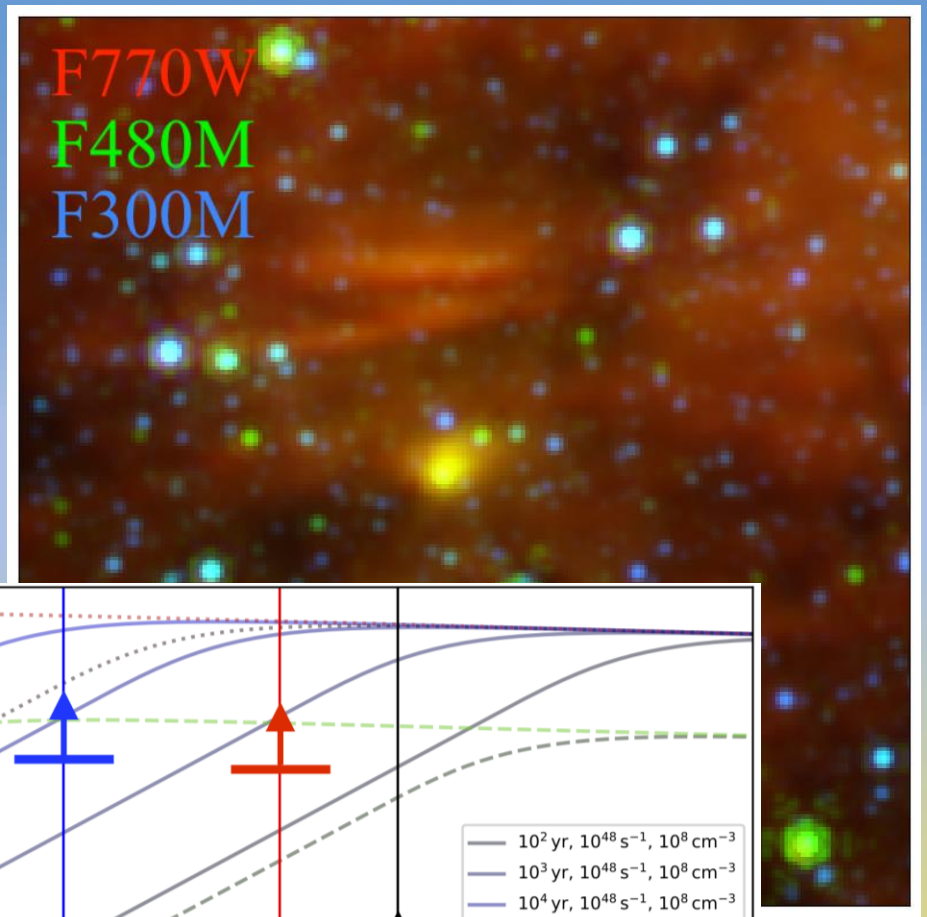
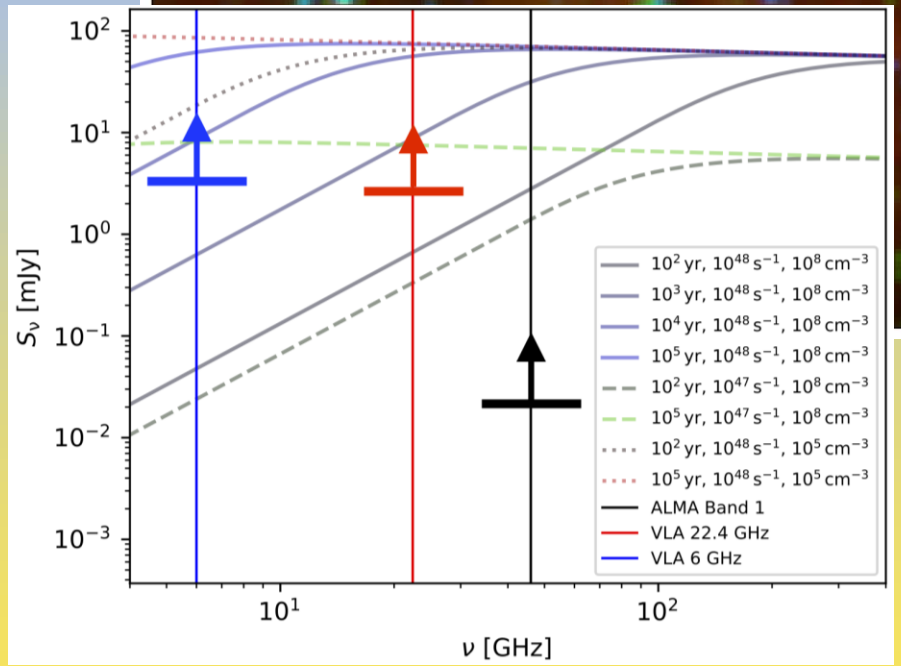
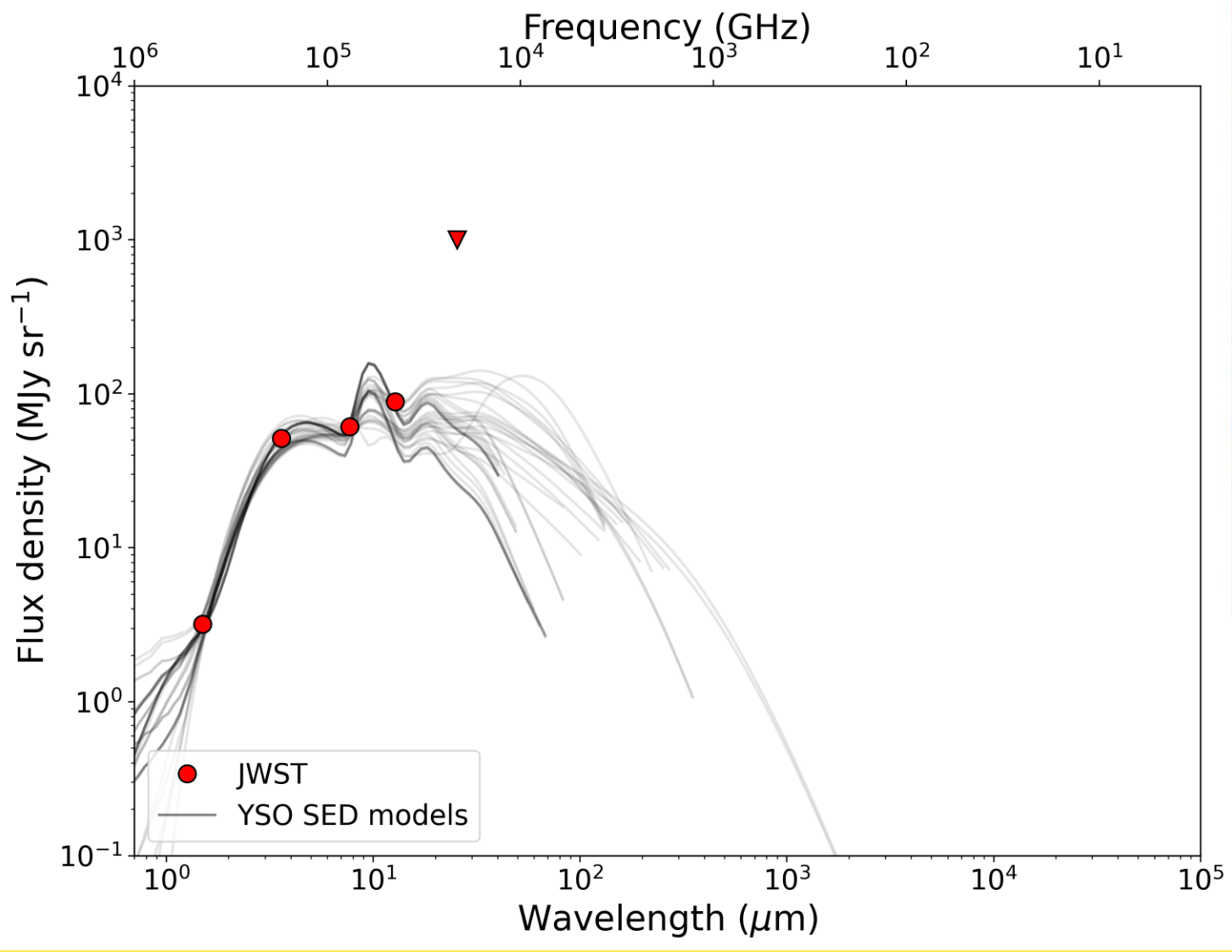
HCHII regions vs YSOs

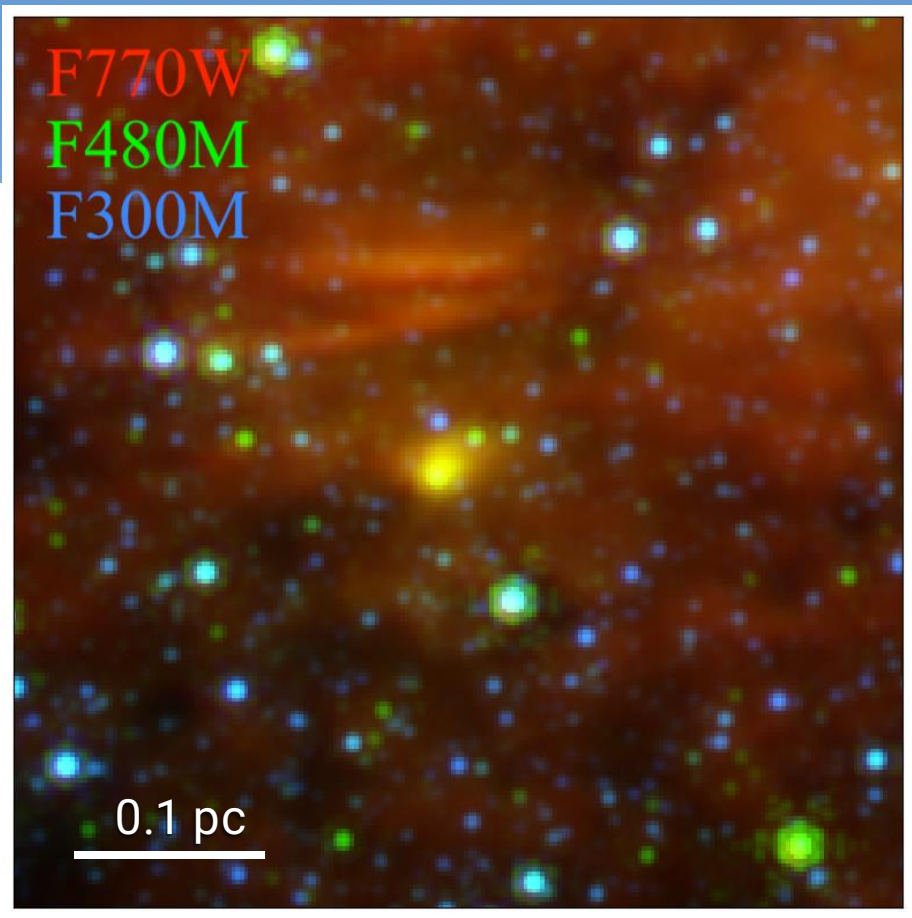






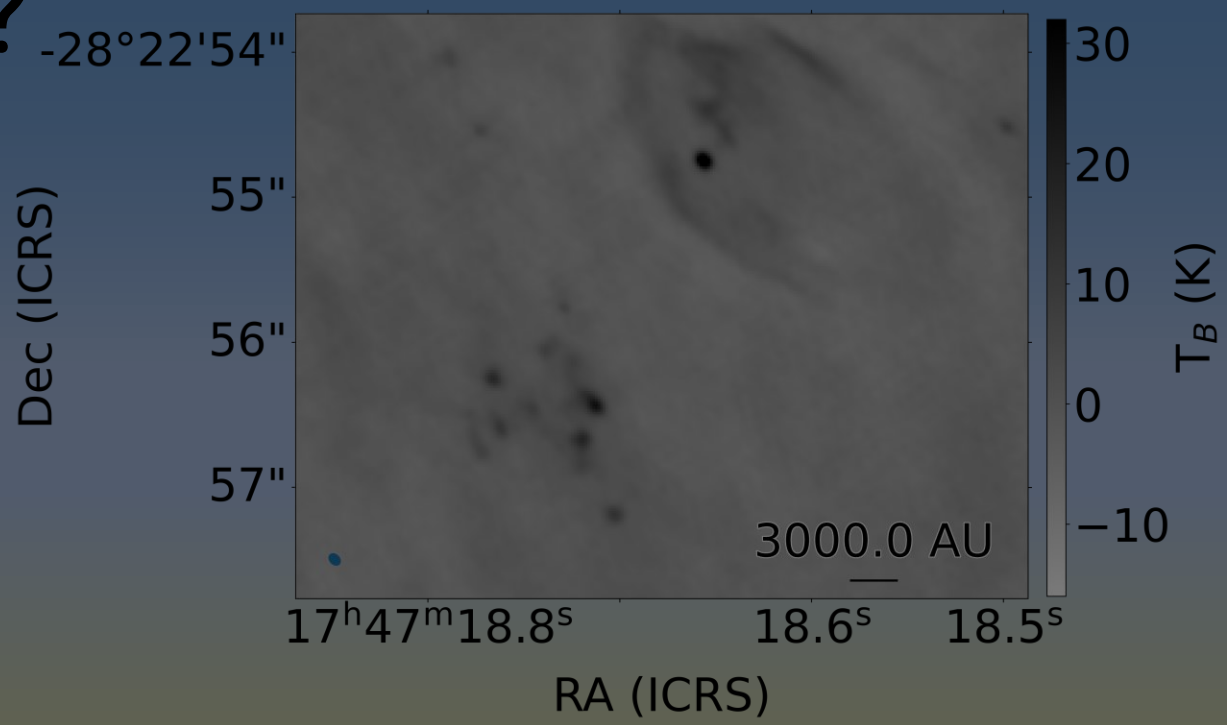
Evolved YSOs





What are our sources?

Stage 0/I YSOs:
- Compact dusty sources
- Rotationally supported
- 200-1000 AU
- 50 K



Prestellar cores?

$$t_{ff} = \sqrt{\frac{3\pi}{32G\rho}}$$

~1200 years at 1 Msun

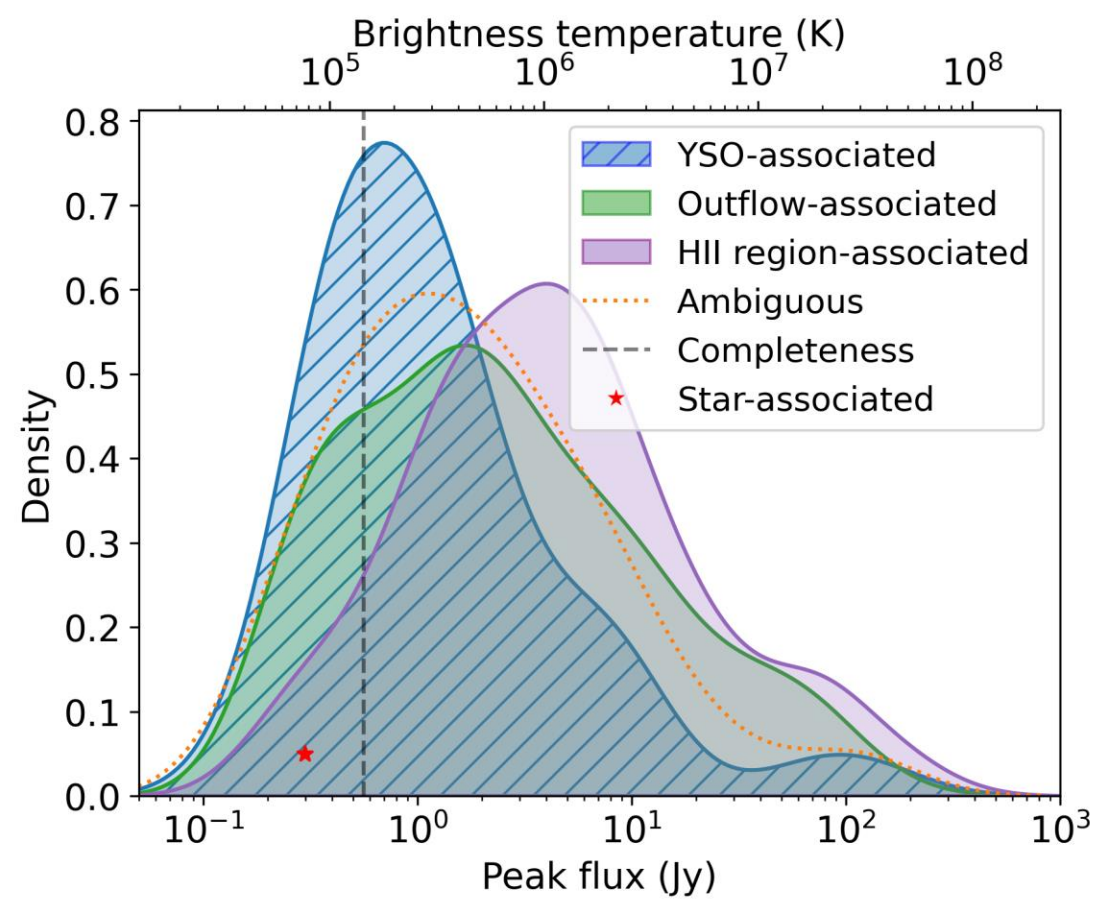
Stage II YSOs?

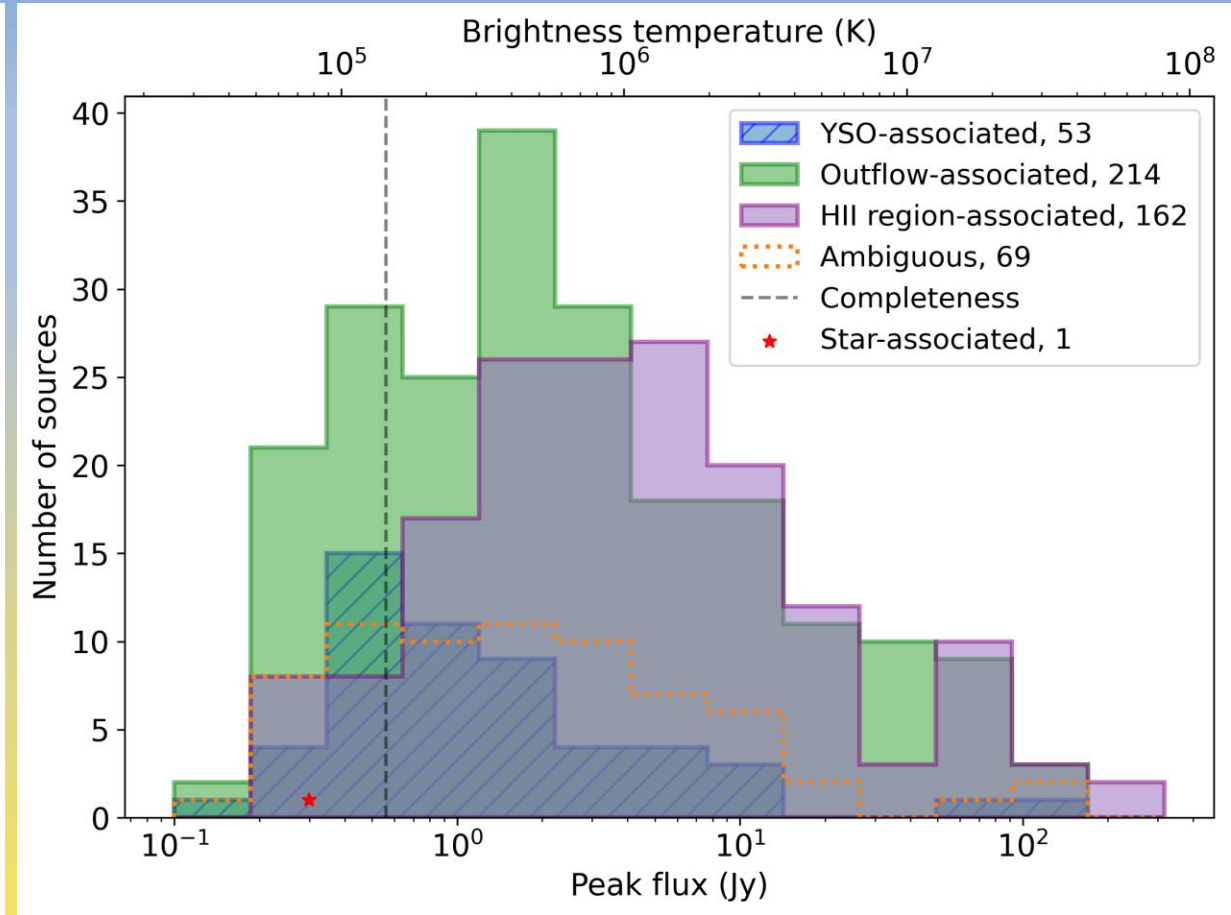
Faintest source ->
30 Msun central star

HII regions?

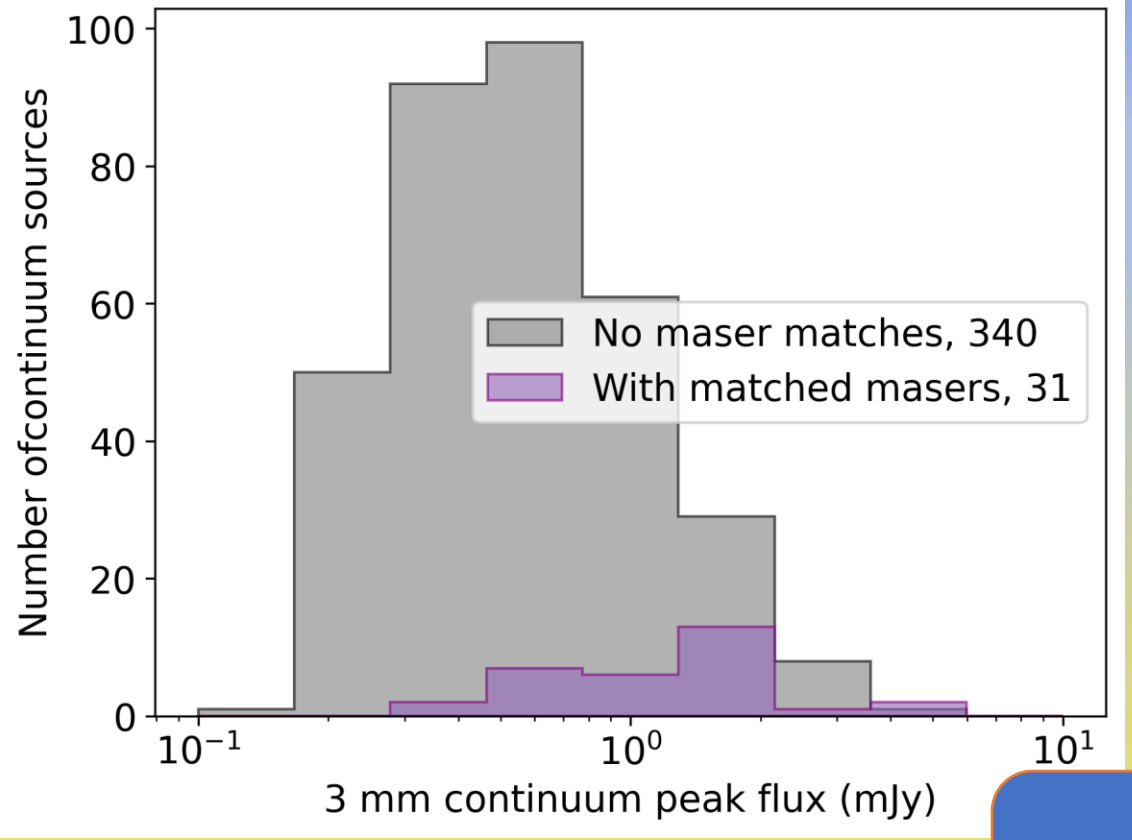
Only optically thick,
30-80 AU in diameter

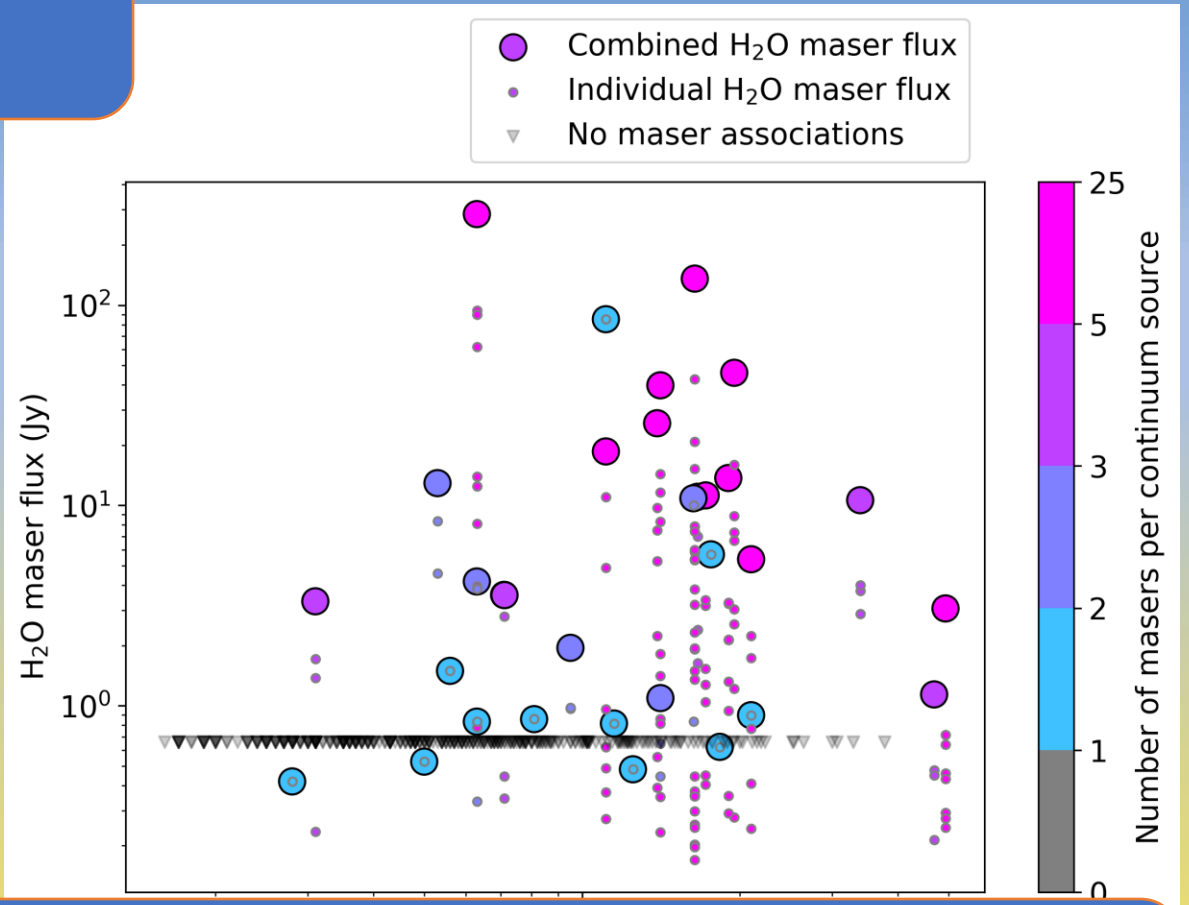
Interpretation for surveys





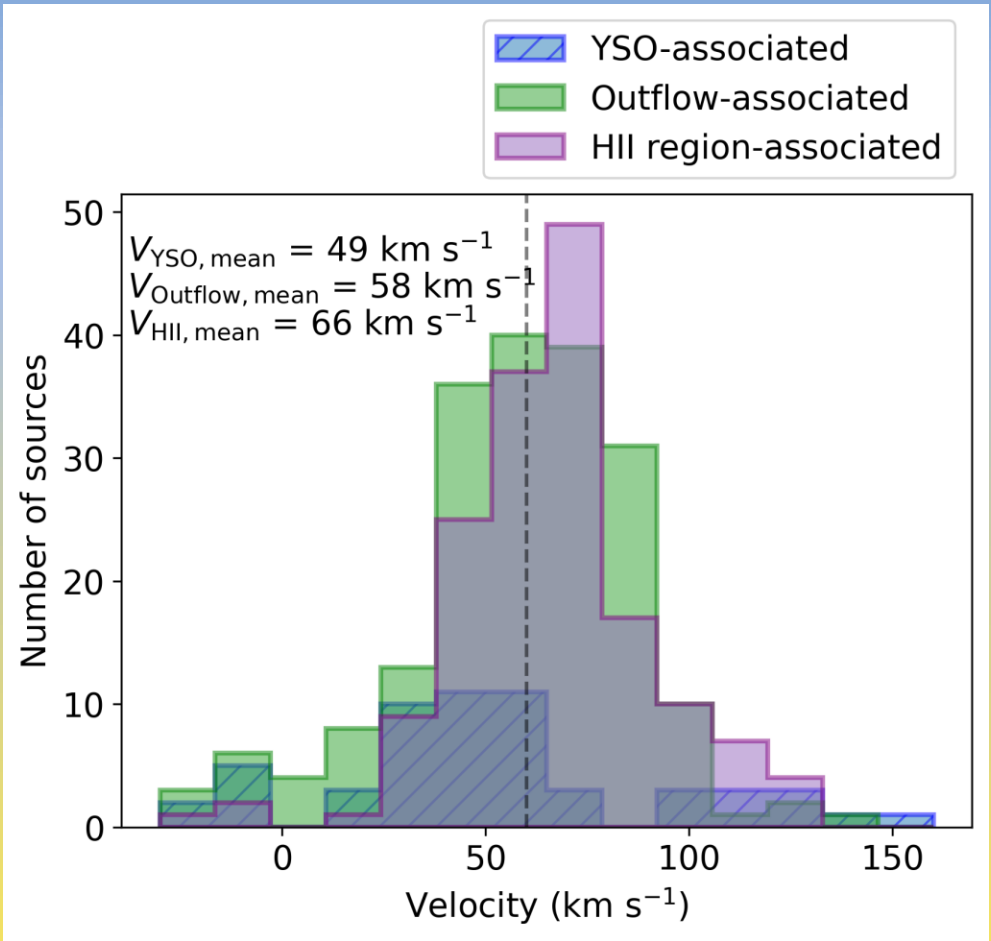
Dust continuum is brighter in the presence of H_2O masers

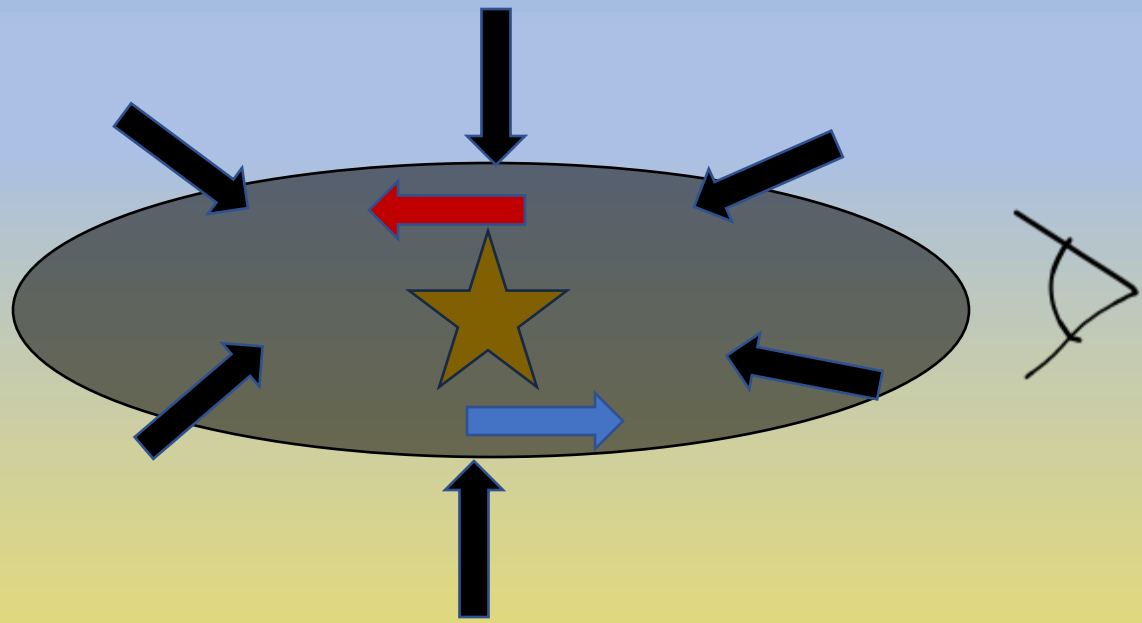




There is no strong correlation between maser and continuum fluxes

Maser velocity by source nature





Maser velocity by source nature