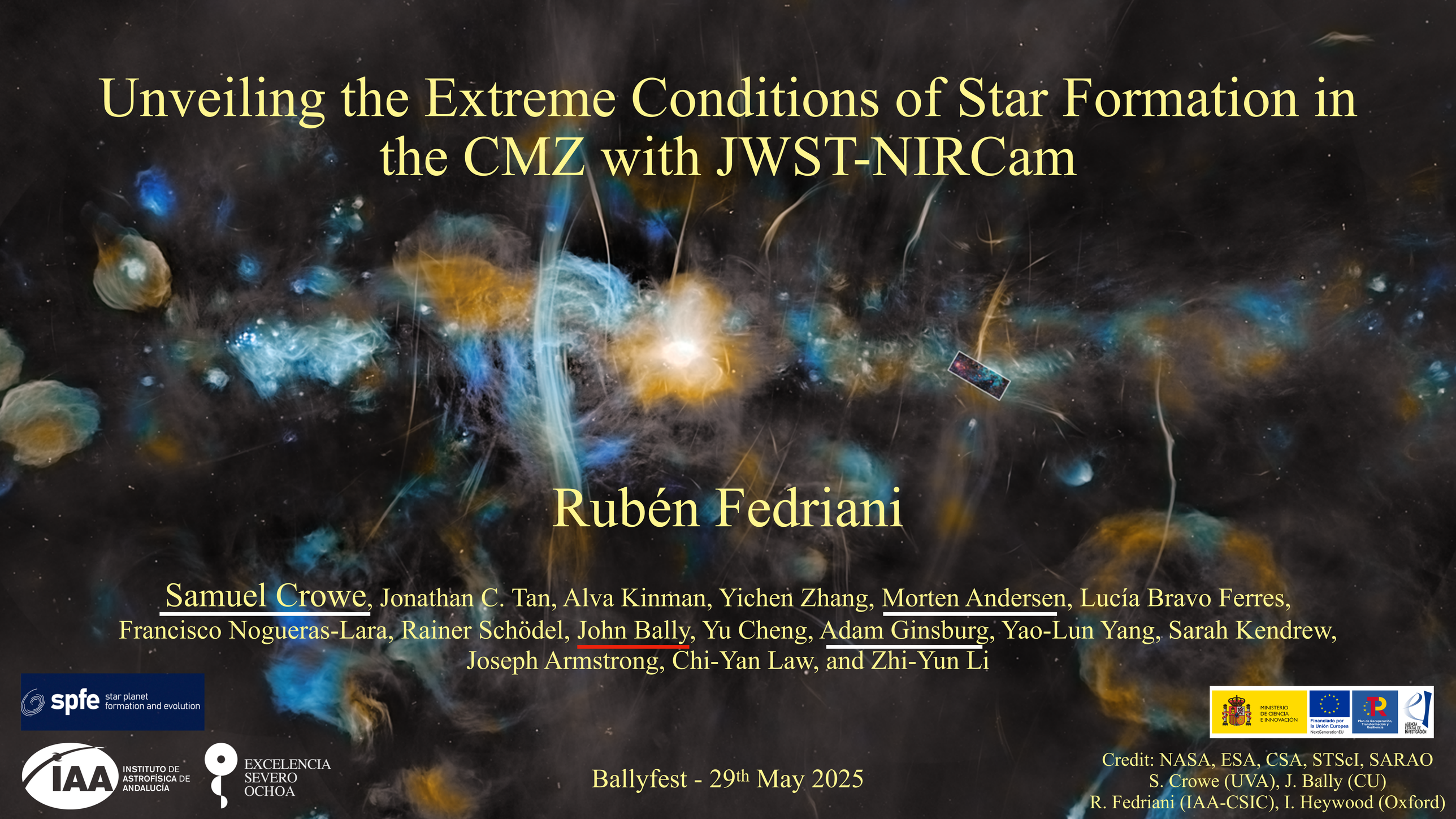
Unveiling the Extreme Conditions of Star Formation in the CMZ with JWST-NIRCam



Rubén Fedriani

Samuel Crowe, Jonathan C. Tan, Alva Kinman, Yichen Zhang, Morten Andersen, Lucía Bravo Ferres, Francisco Nogueras-Lara, Rainer Schödel, John Bally, Yu Cheng, Adam Ginsburg, Yao-Lun Yang, Sarah Kendrew, Joseph Armstrong, Chi-Yan Law, and Zhi-Yun Li

spfe star planet formation and evolution

IAA INSTITUTO DE ASTROFÍSICA DE ANDALUCÍA

EXCELENCIA SEVERO OCHOA

MINISTERIO DE CIENCIA E INNOVACIÓN

Financiado por la Unión Europea NextGenerationEU

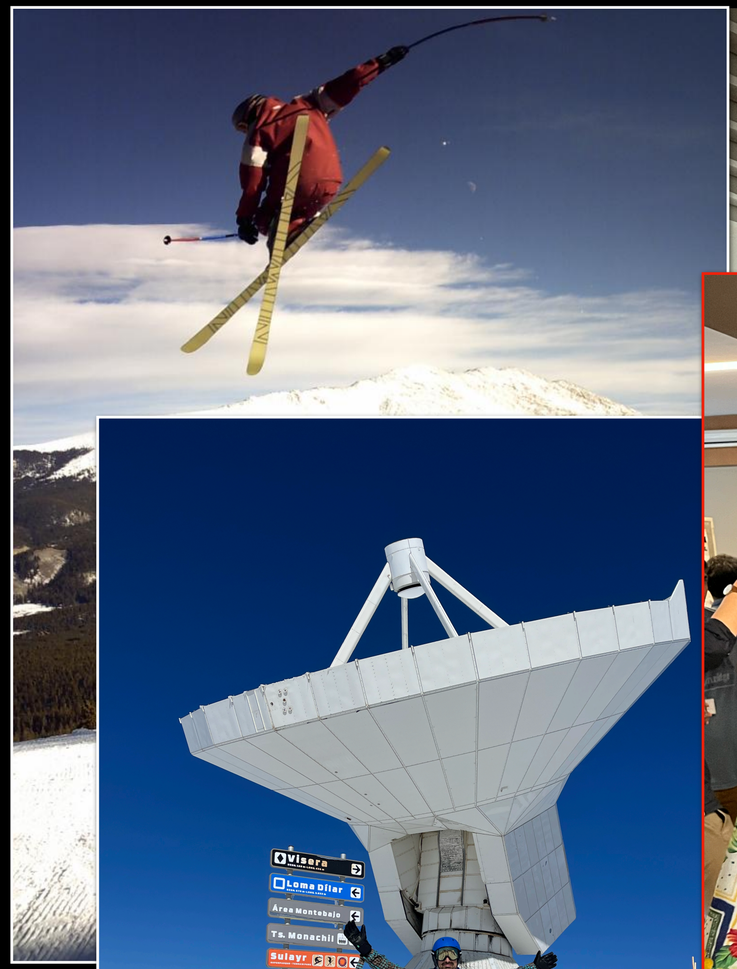
Plan de Recuperación, Transformación y Resiliencia

AGENCIA ESTATAL DE INVESTIGACIÓN

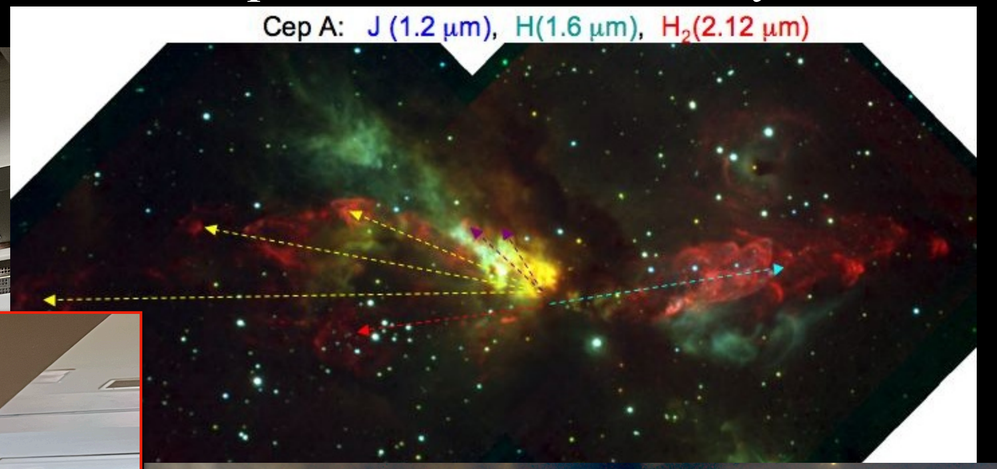
Ballyfest - 29th May 2025

Credit: NASA, ESA, CSA, STScI, SARAO
S. Crowe (UVA), J. Bally (CU)
R. Fedriani (IAA-CSIC), I. Heywood (Oxford)

Apache Point Observatory



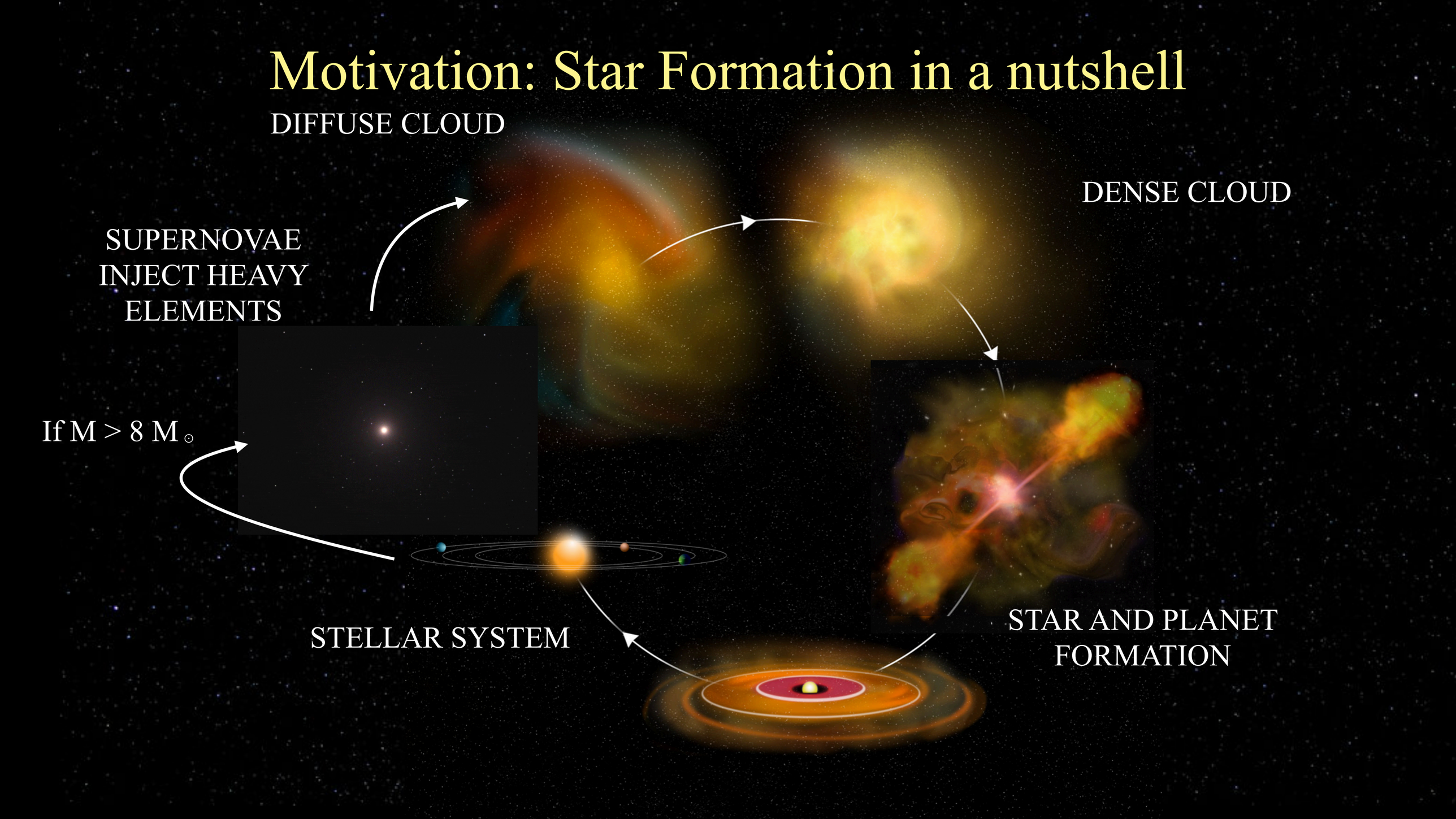








Motivation: Star Formation in a nutshell



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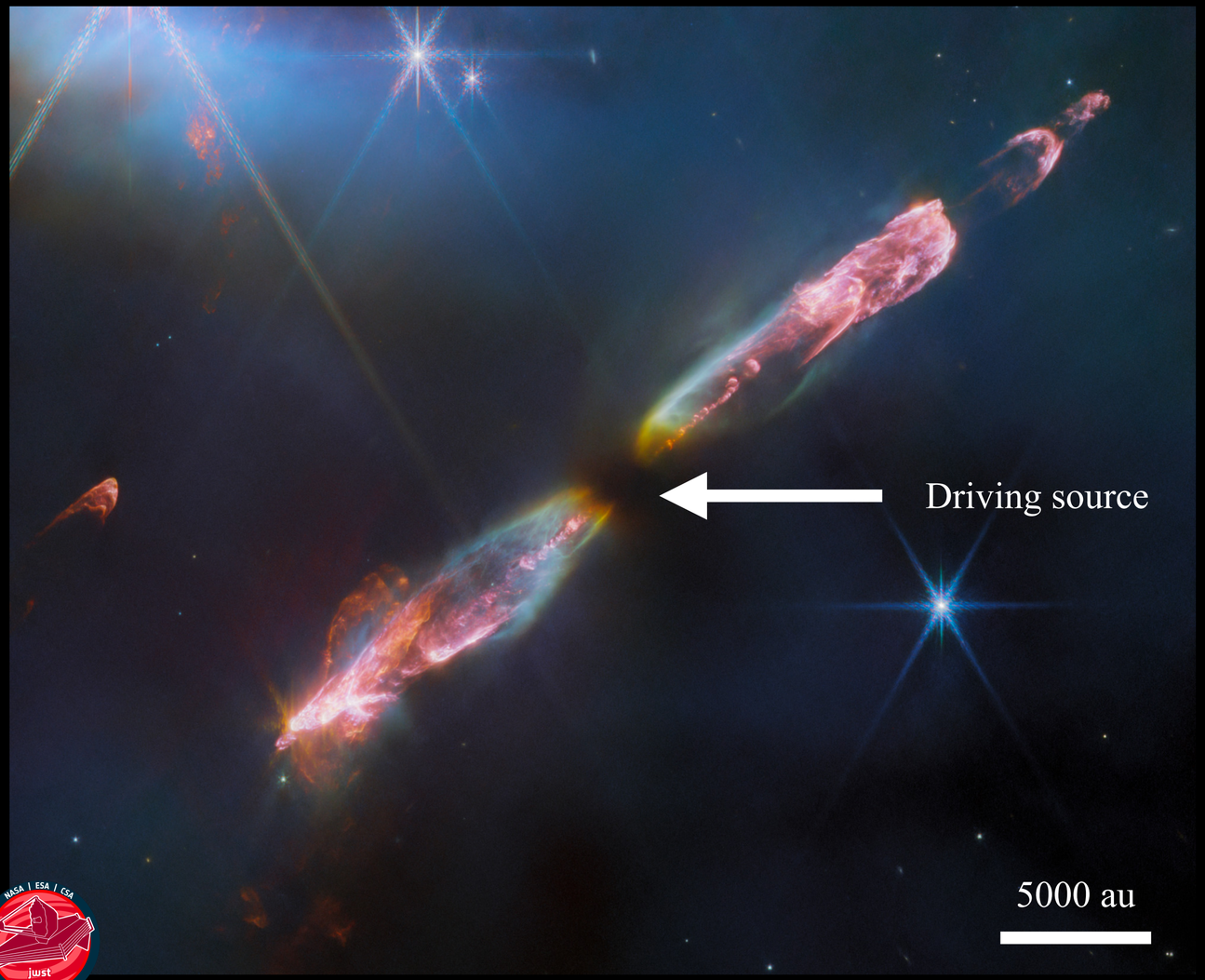
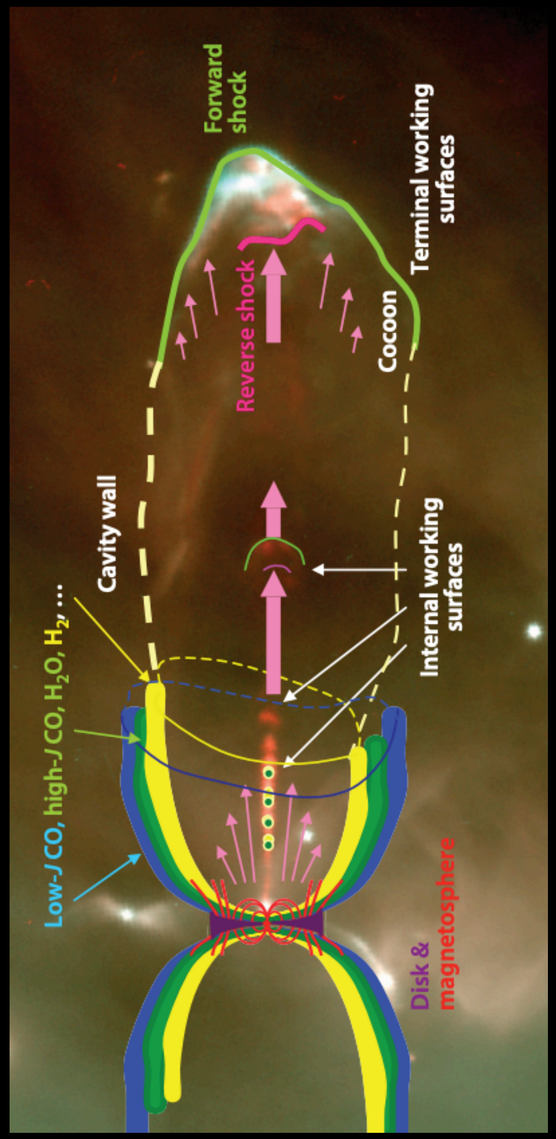


Ray et al. (2023)



See, e.g., the zillion of John's papers and Bally (2016)

Motivation: Star Formation in a nutshell

John Bally: “Give me an accreting, magnetised, rotating object, and I’ll give you its associated outflow”



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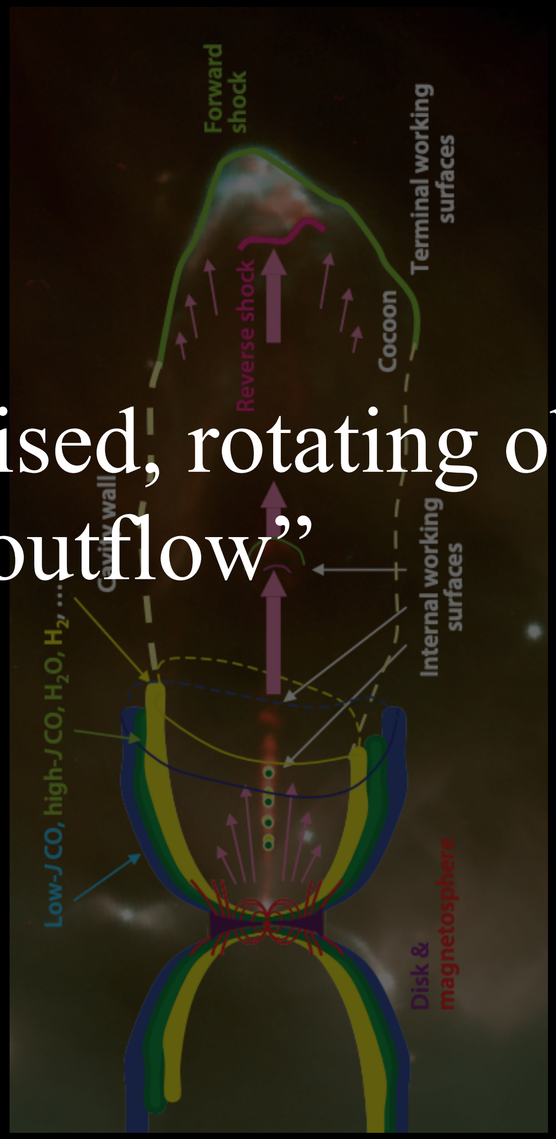

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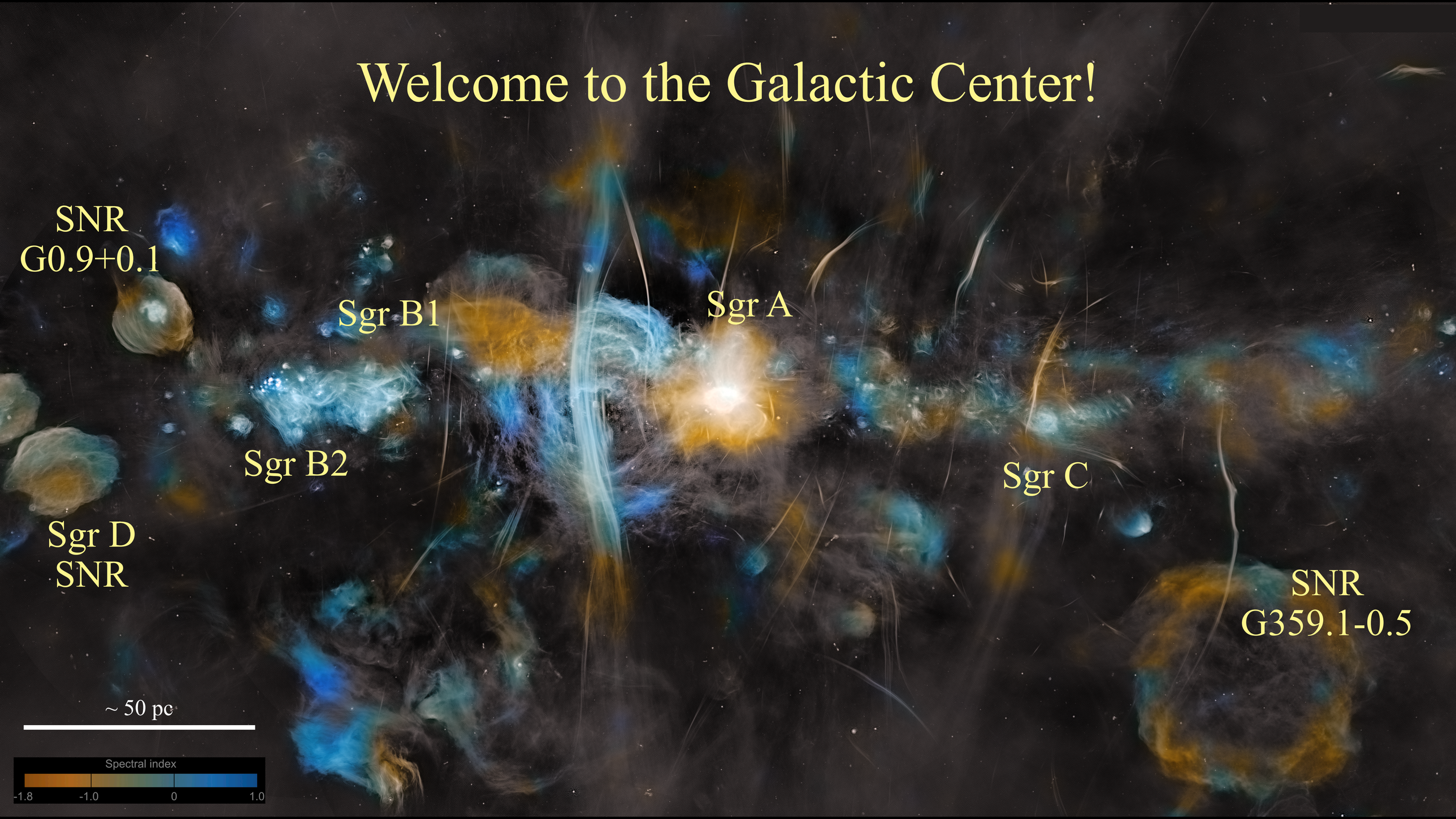
Welcome to the Galactic Center!

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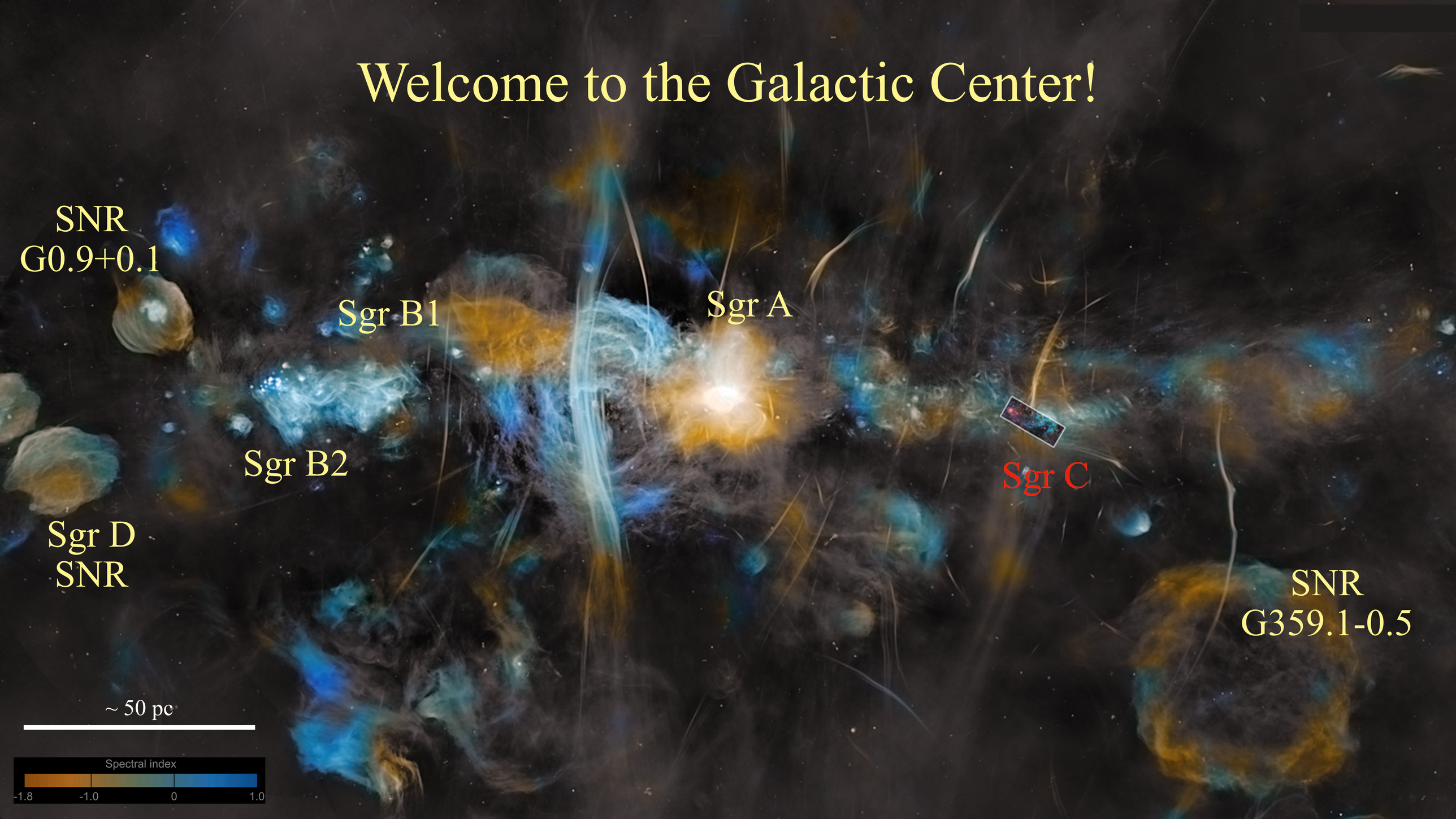
SNR G0.9+0.1
Sgr B1
Sgr A
Sgr B2
Sgr C
Sgr D SNR
SNR G359.1-0.5
~ 50 pc
Spectral index
-1.8
-1.0
0
1.0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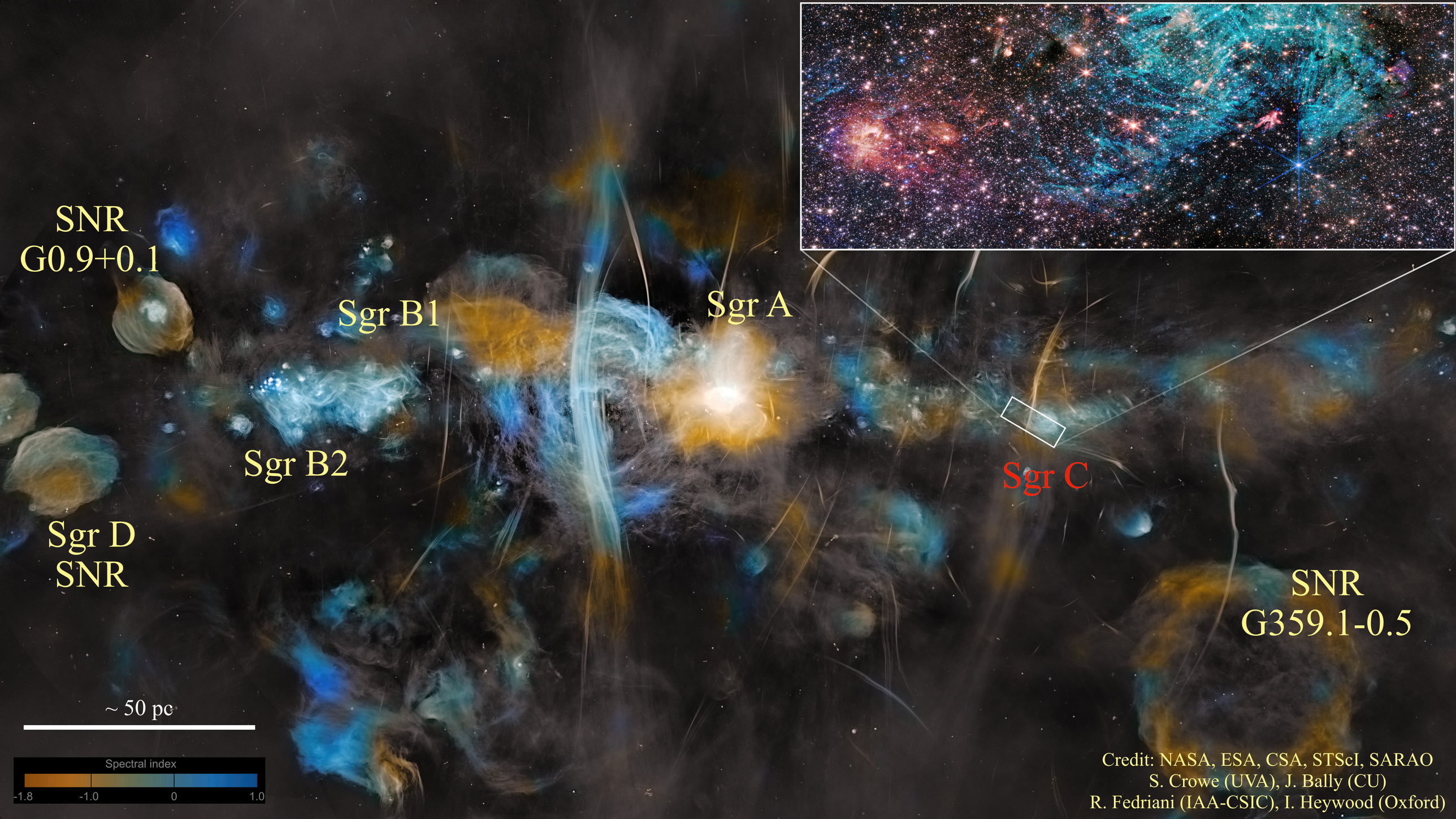

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JWST/NIRCam observations of the SgrC region





Samuel Crowe (UVa)

Angular resolution from 0.03″ to 0.15″

Crowe, Fedriani, Tan et al. (2025)

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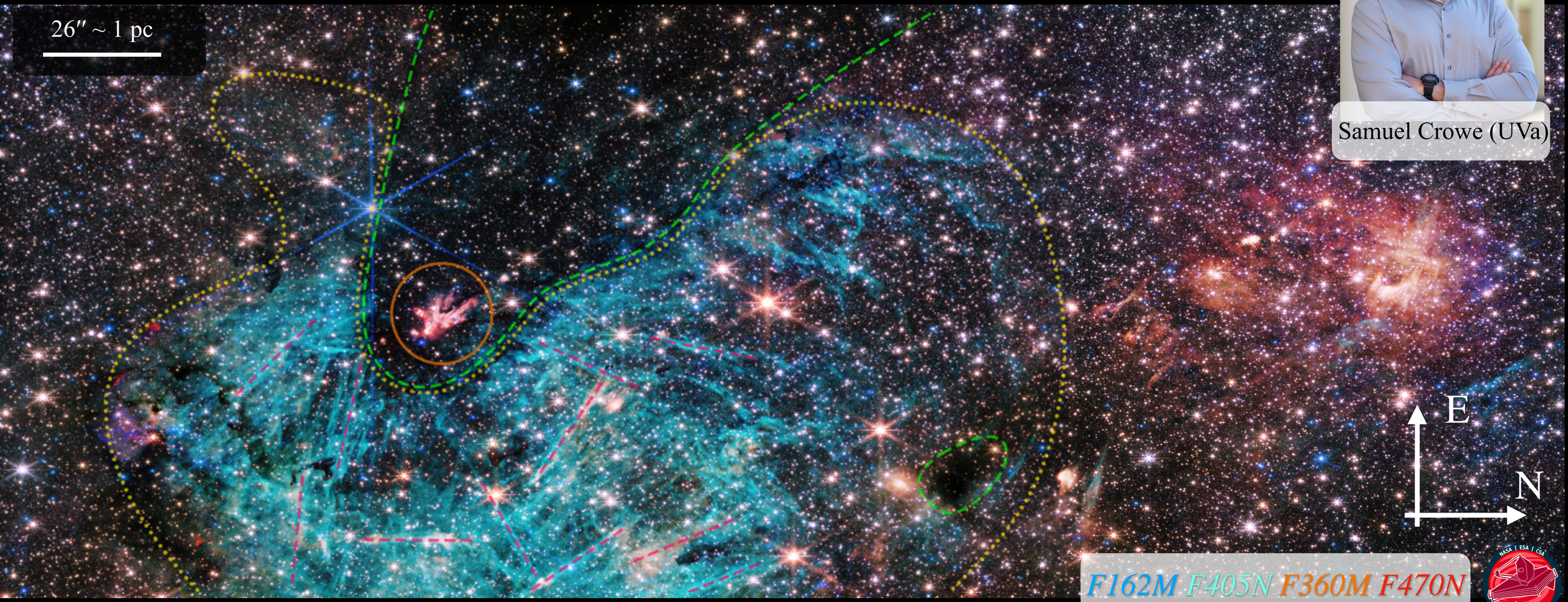



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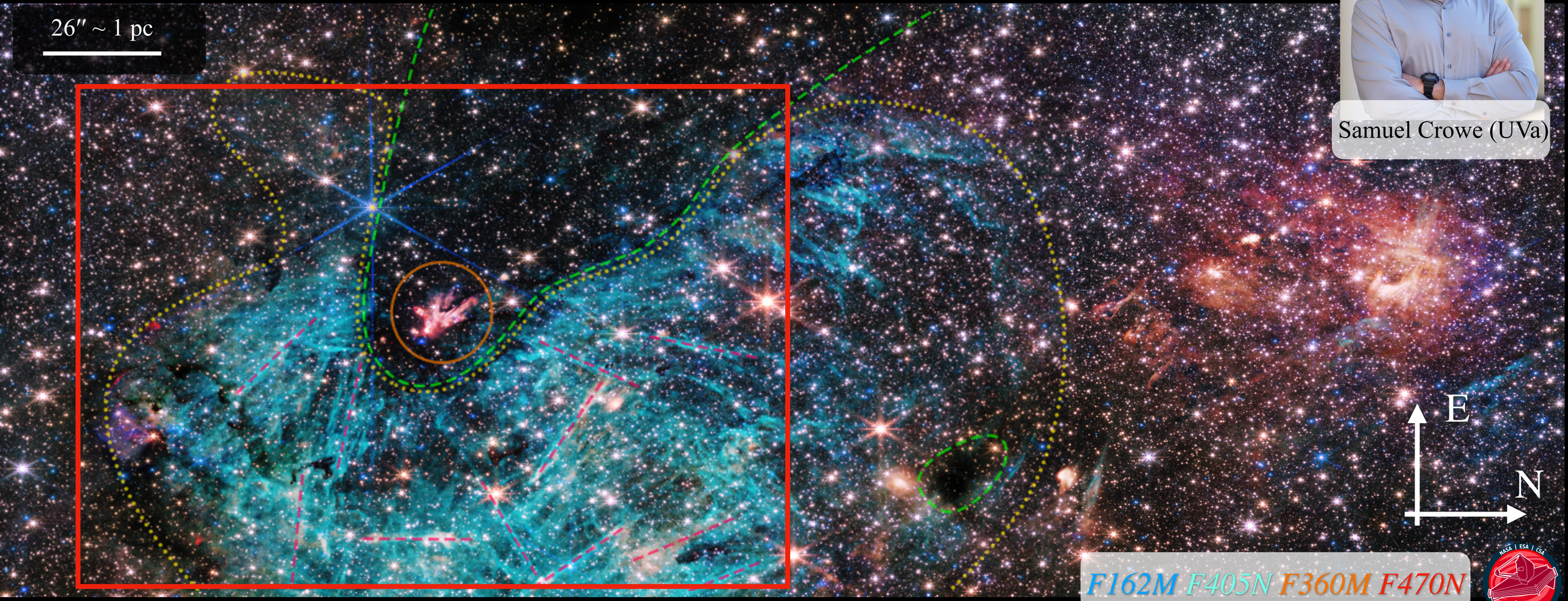



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This talk → Crowe, Fedriani, Tan et al. (2025)

Sam's talk → Bally, Crowe, Fedriani et al. (2025)

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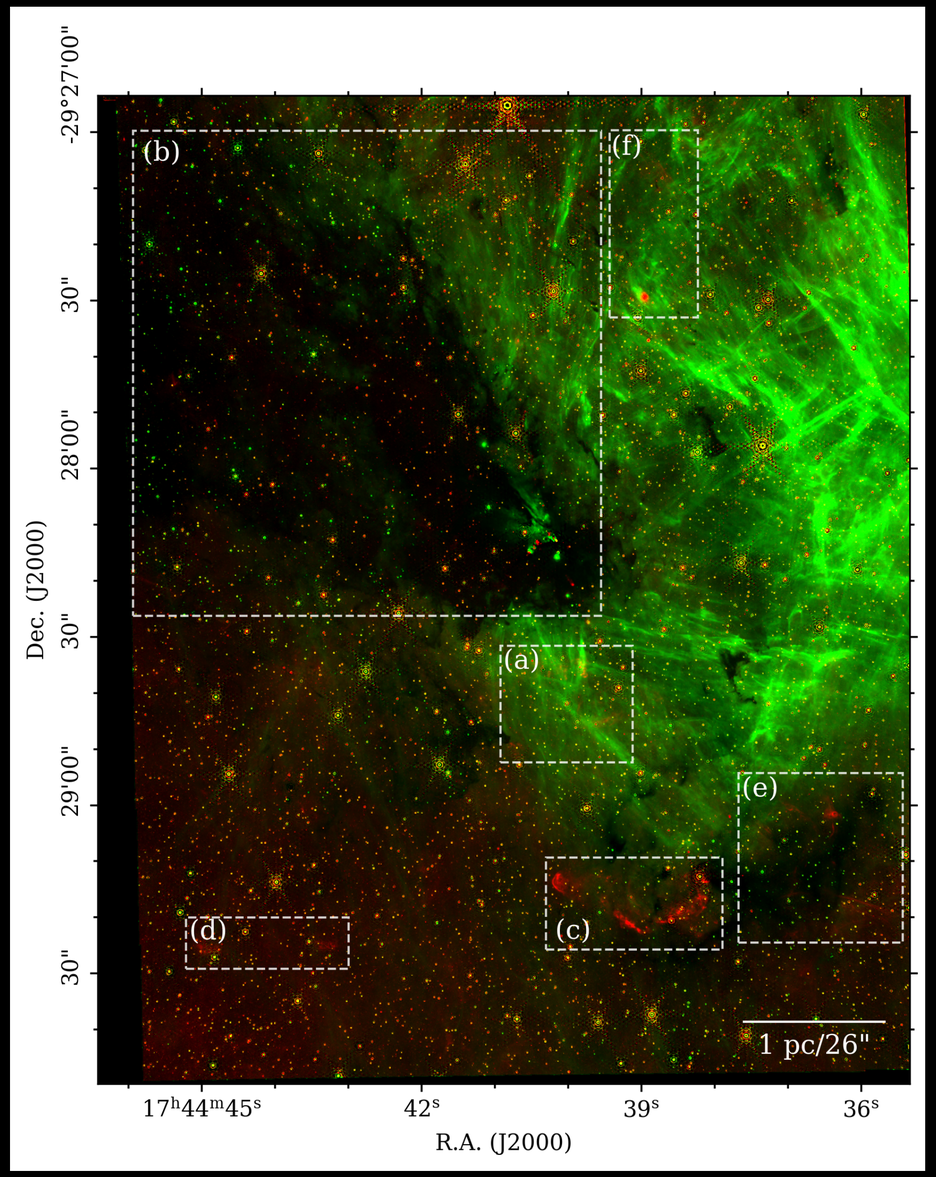

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F405N-cont (Brα)

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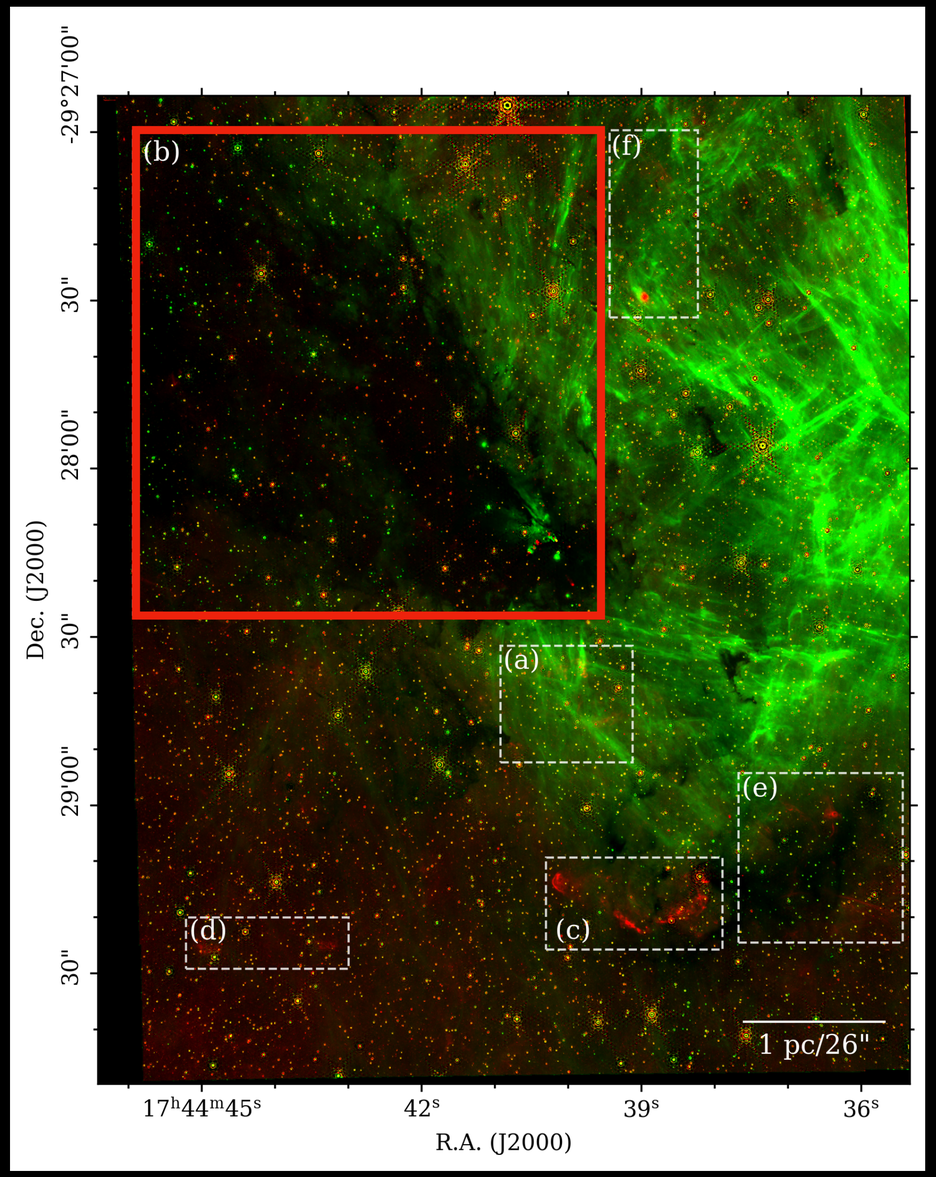

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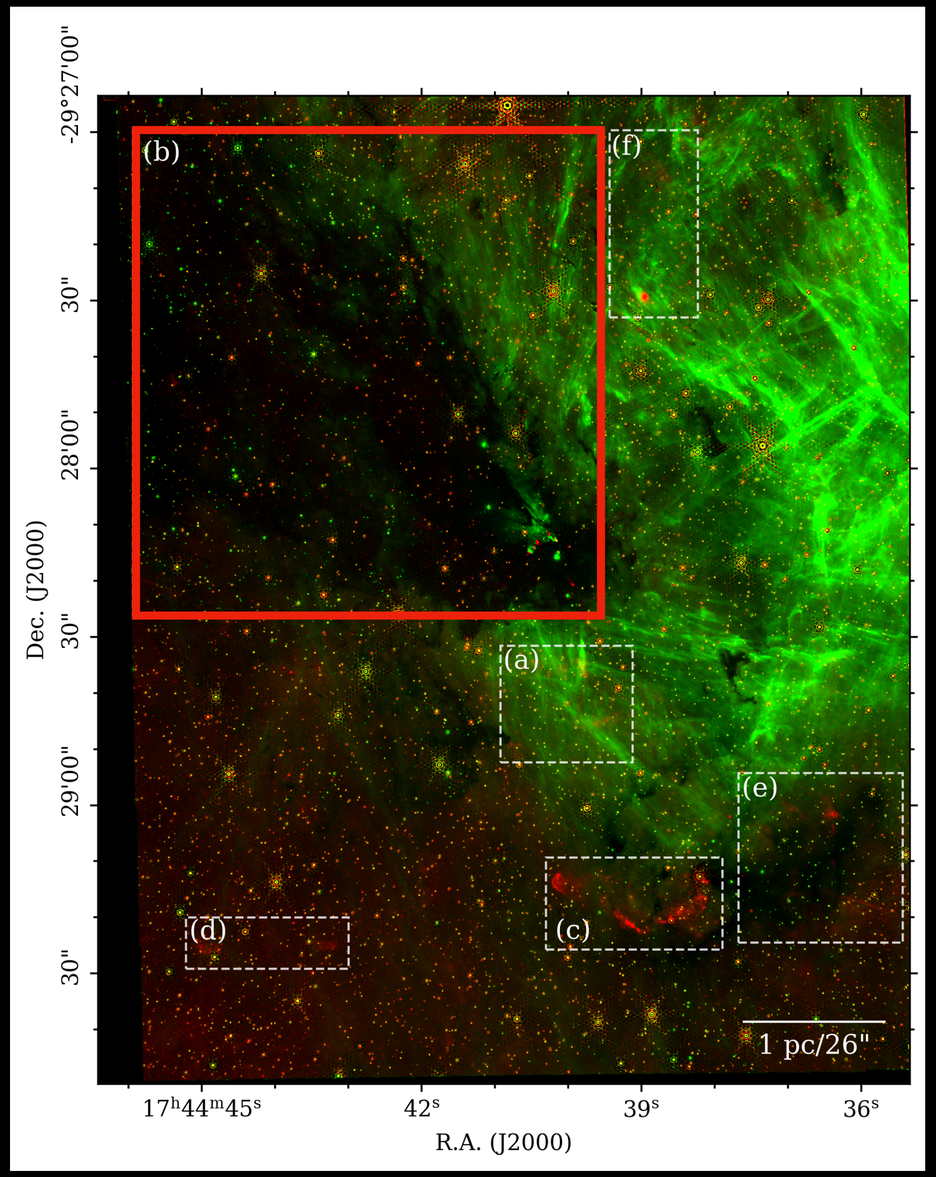

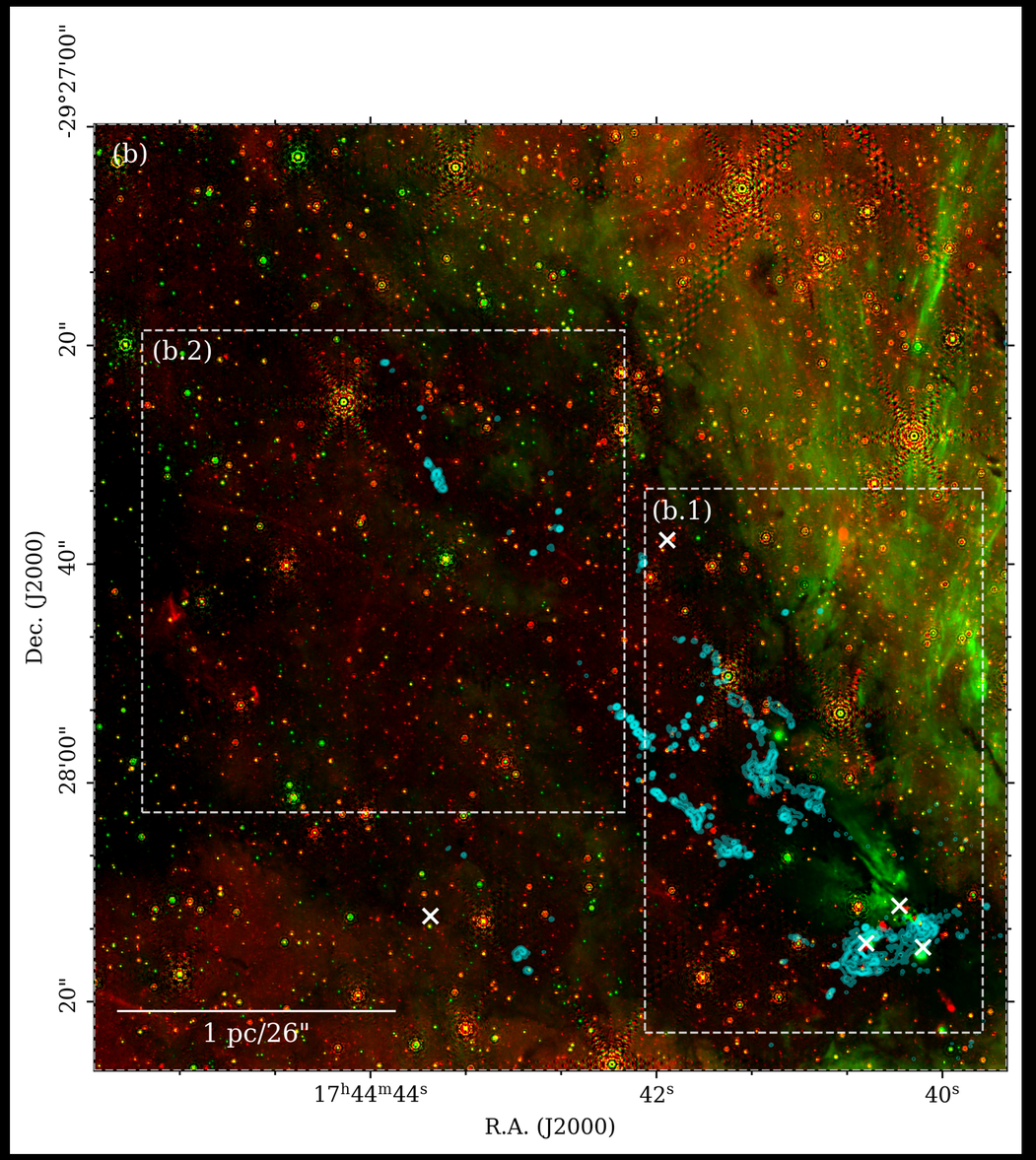

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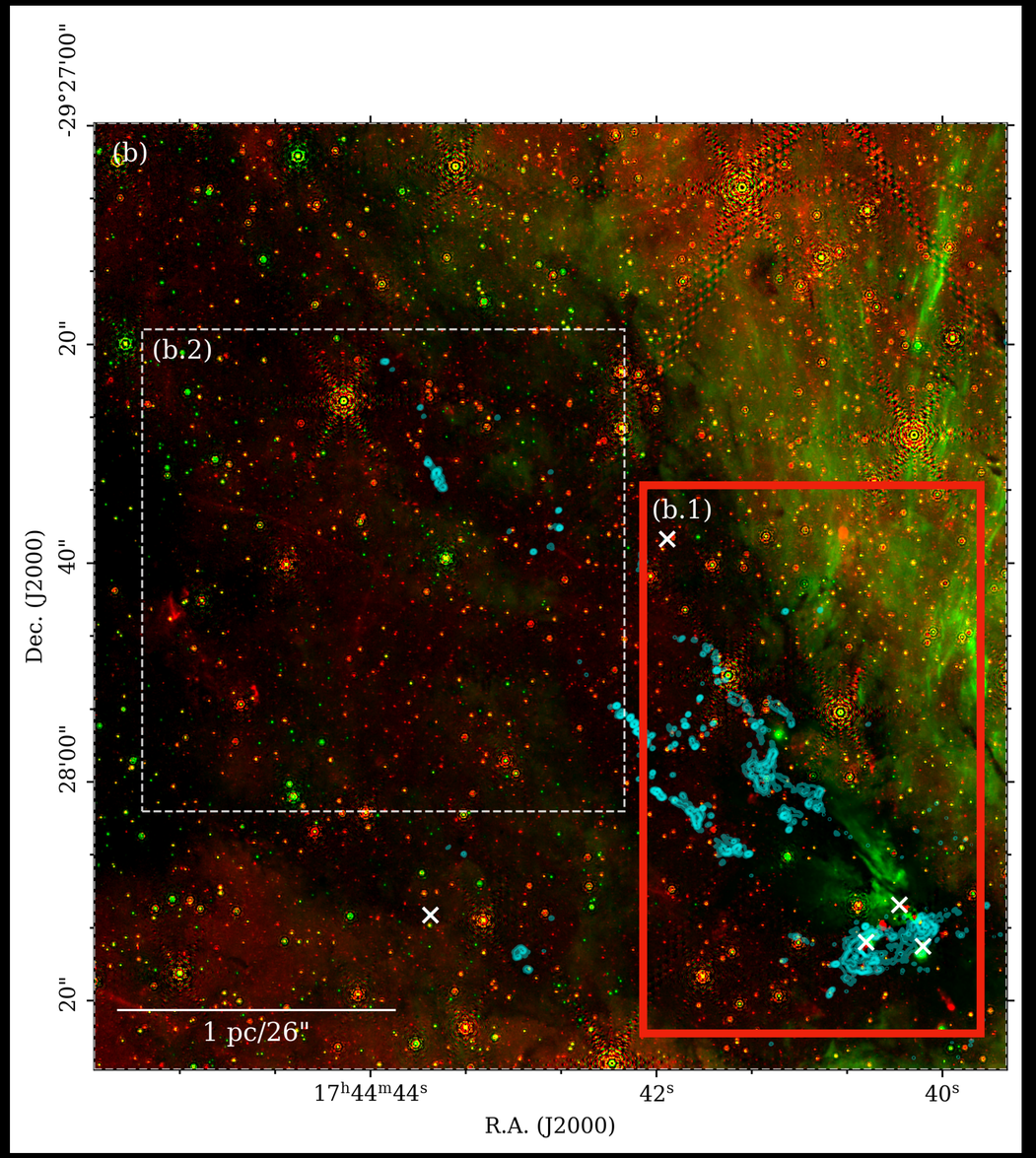

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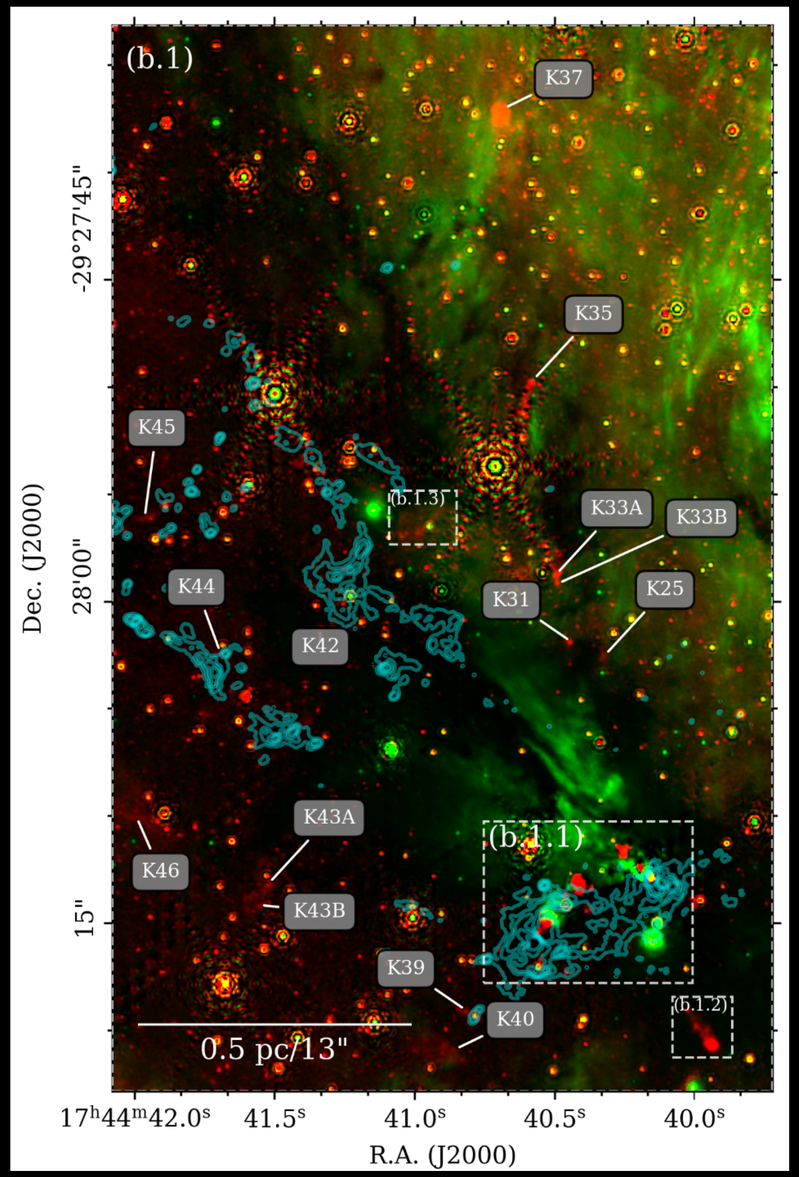

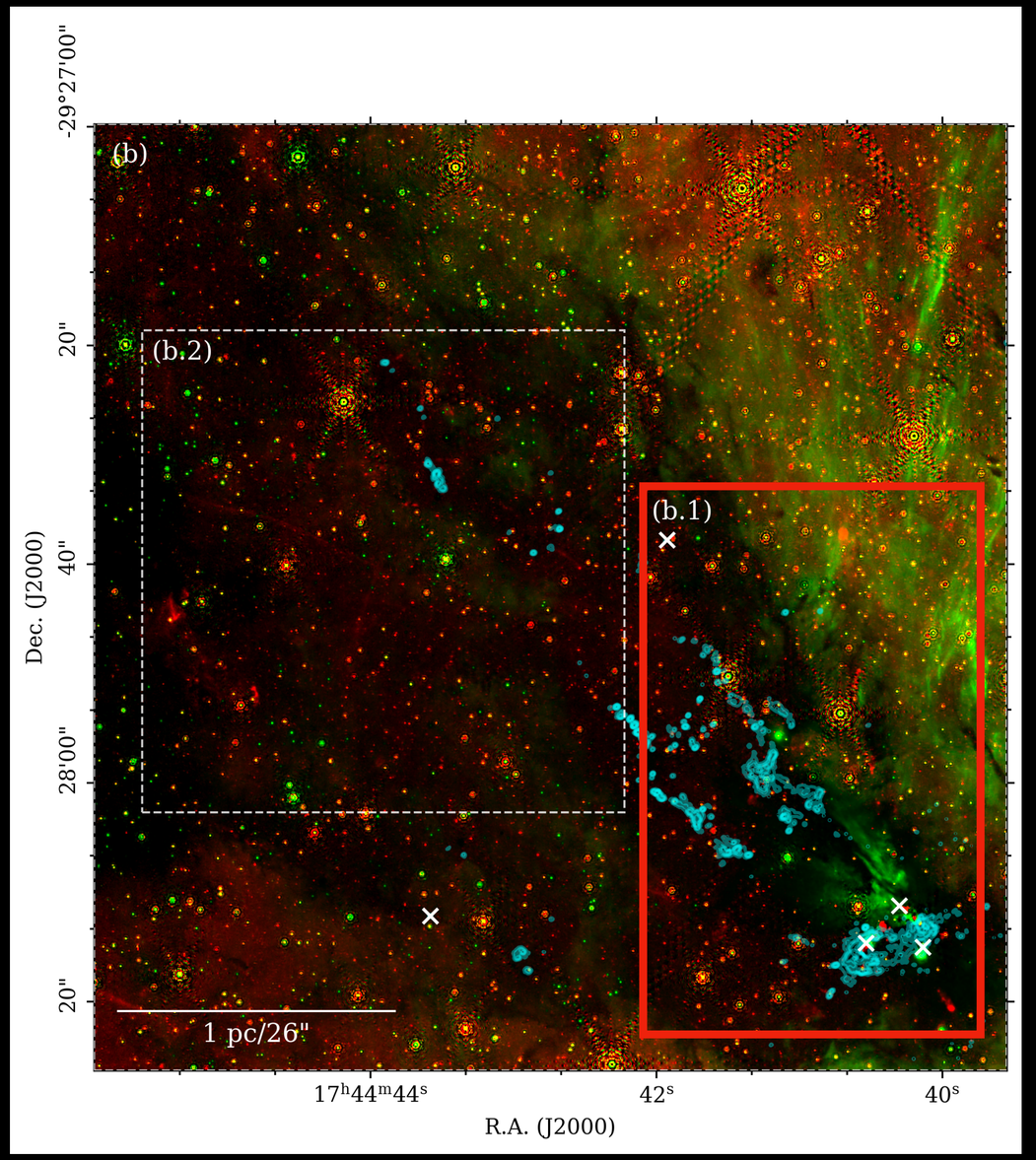

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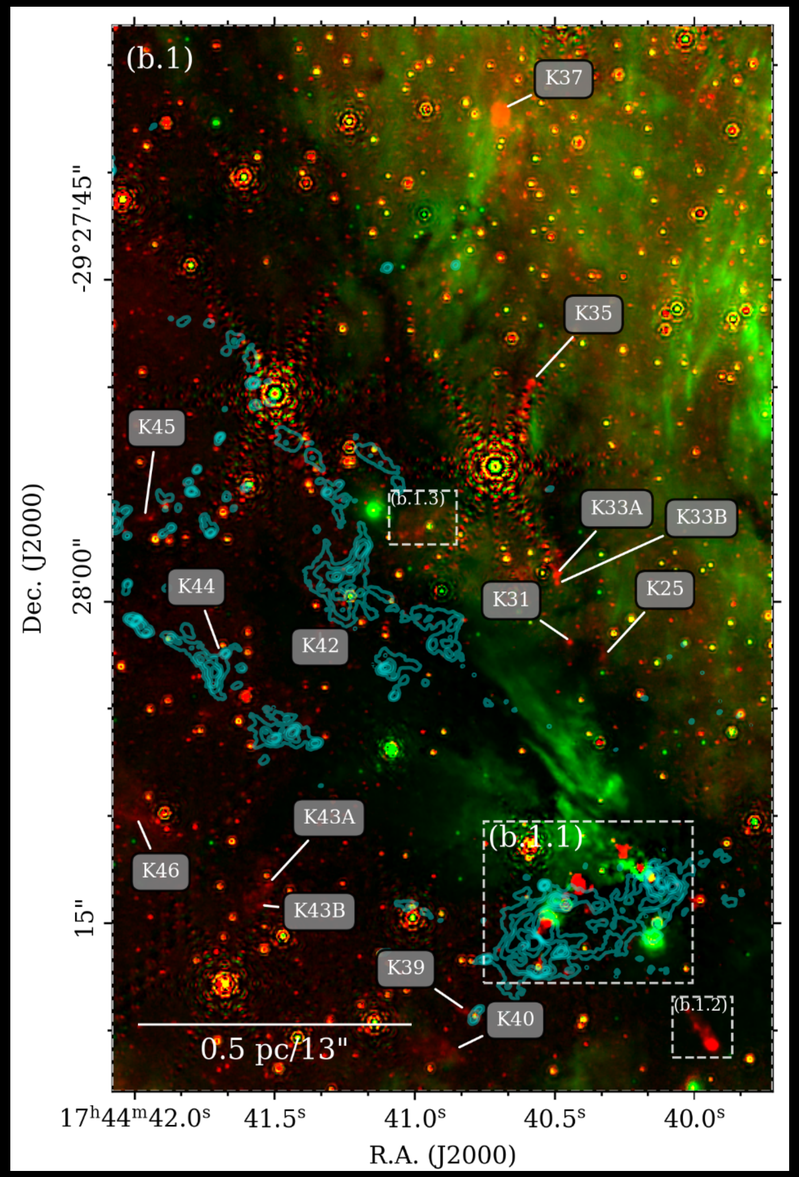

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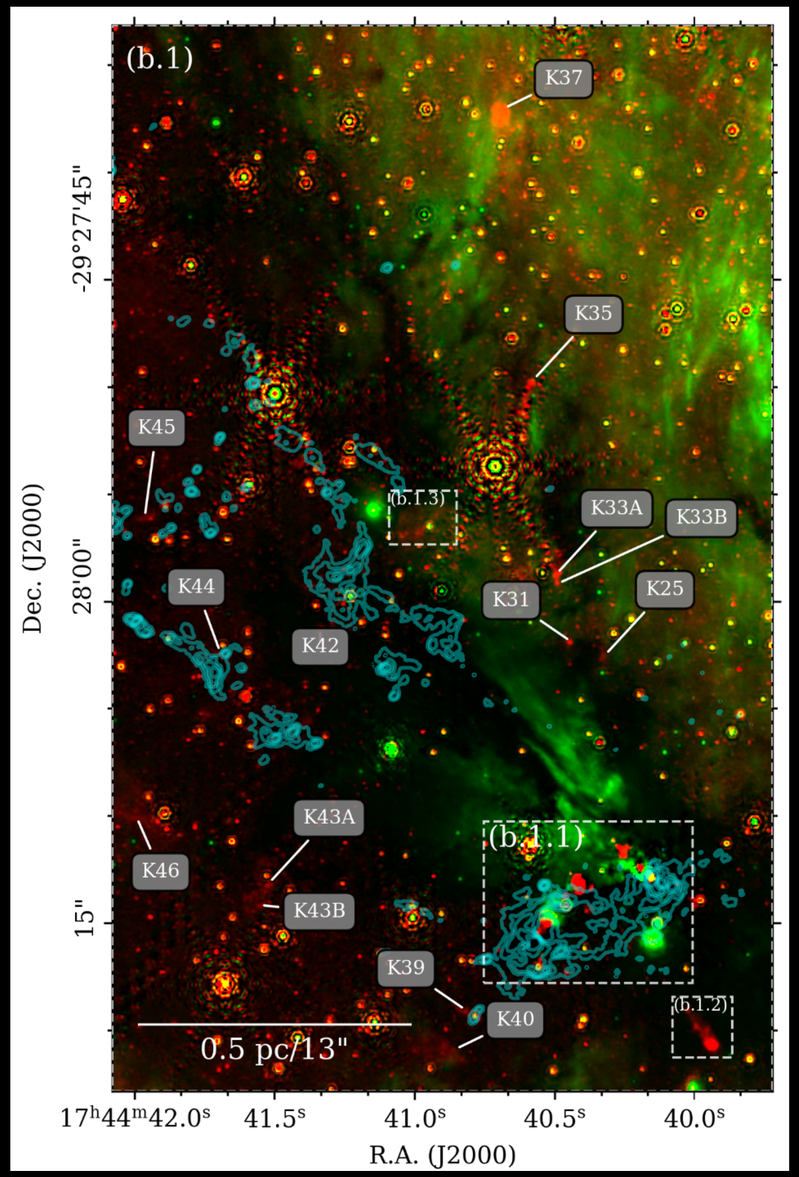
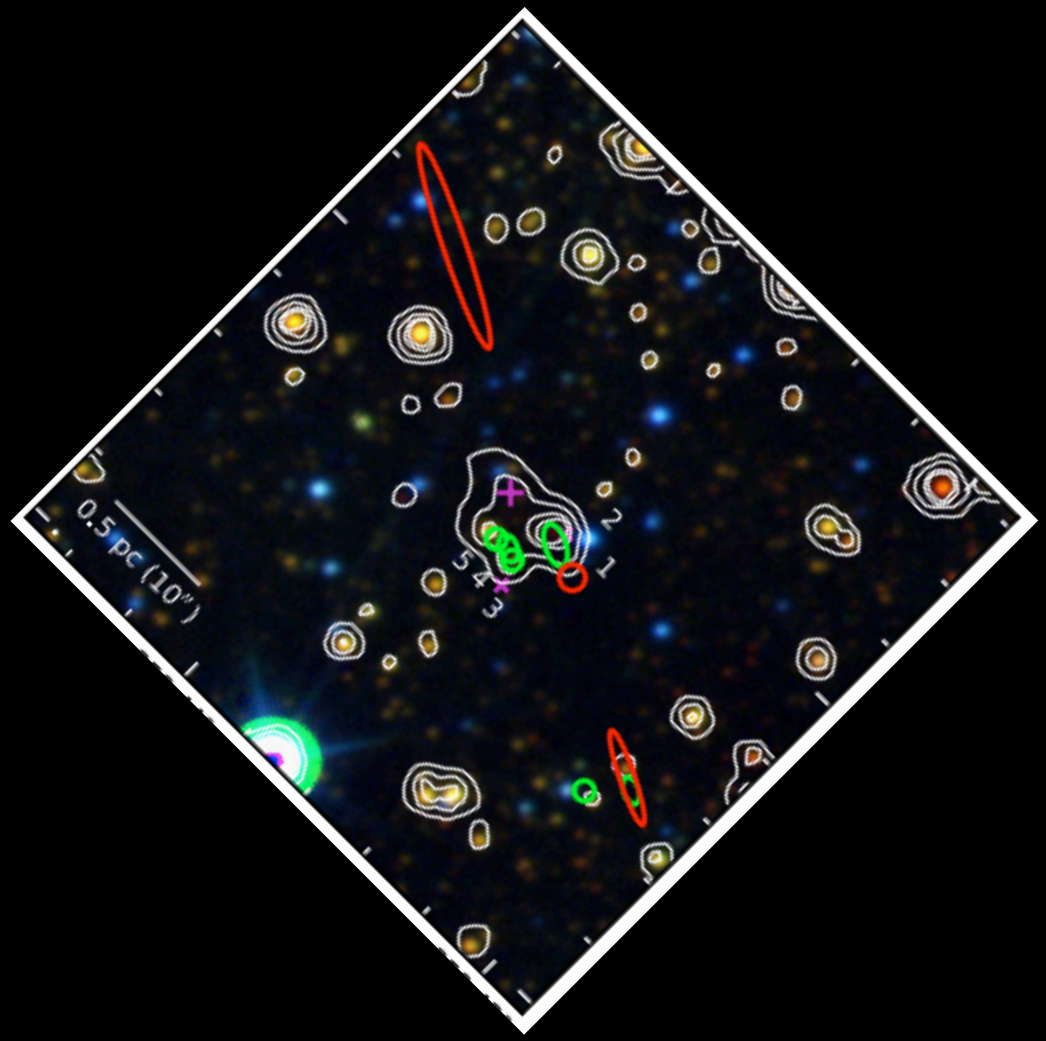
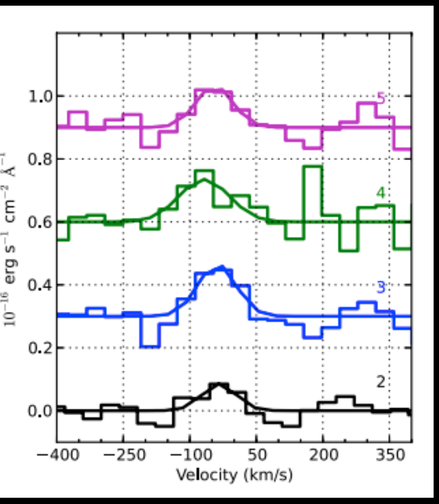




Spectra for H_2 emission lines



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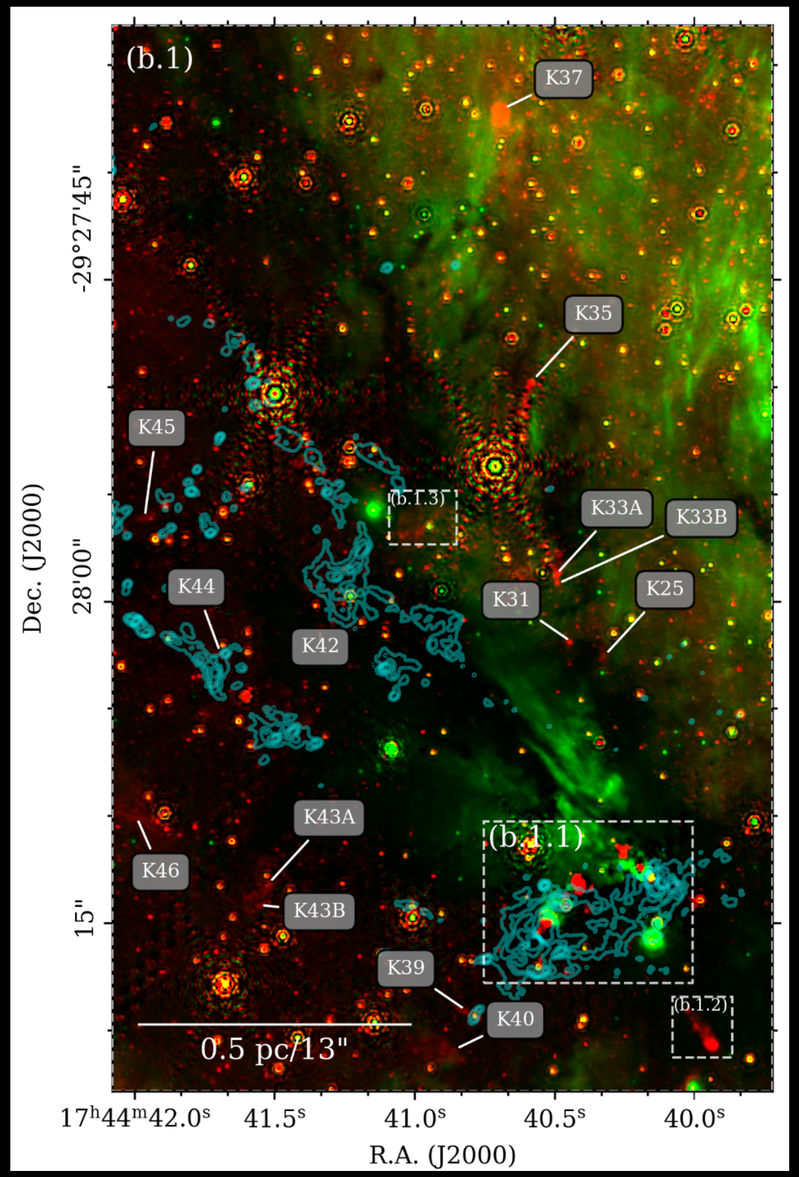

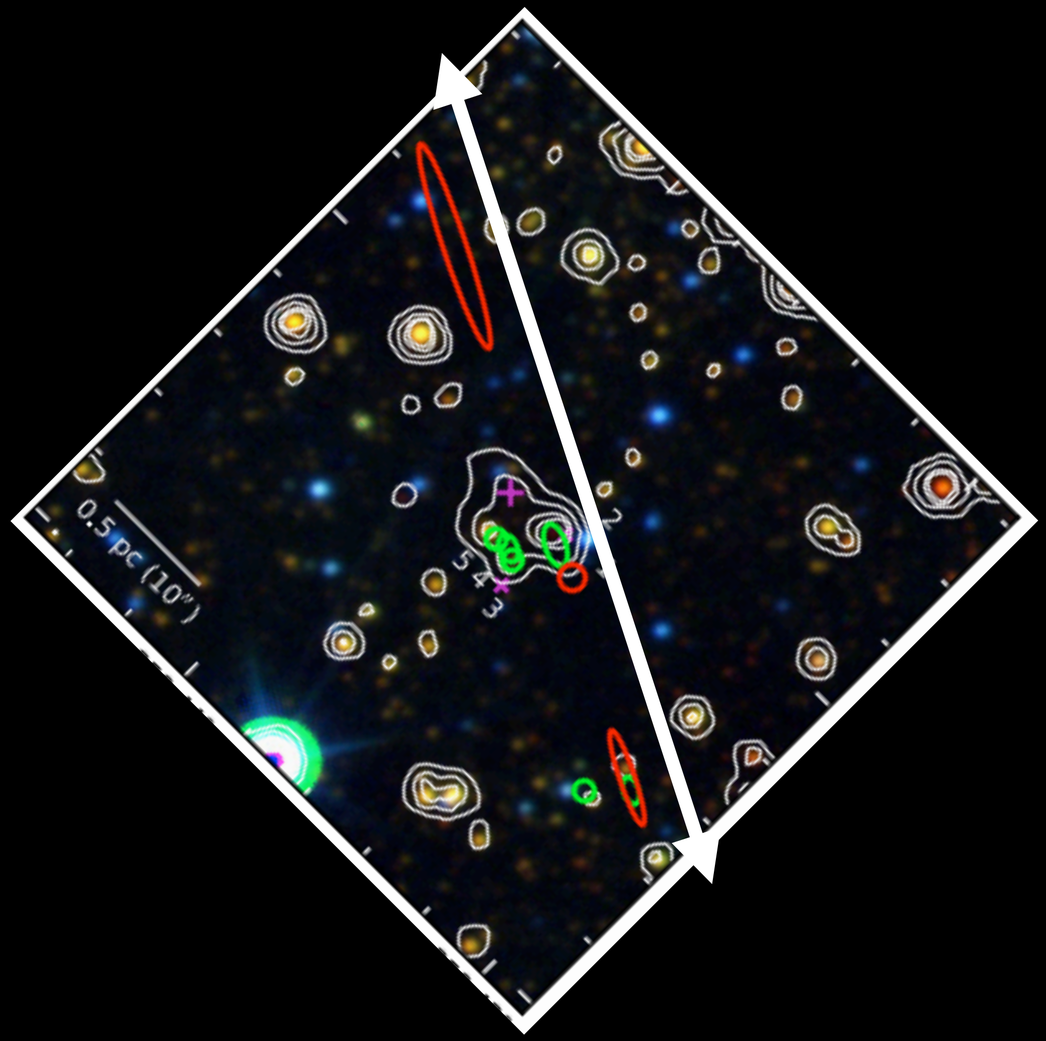

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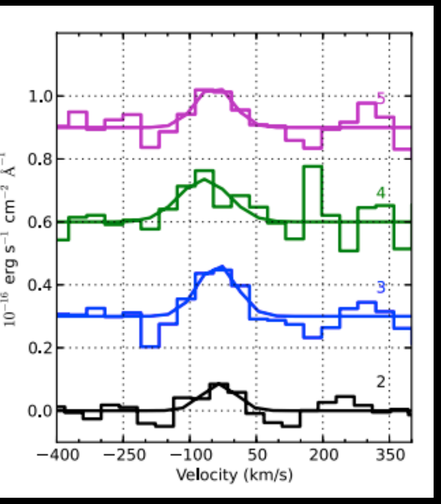

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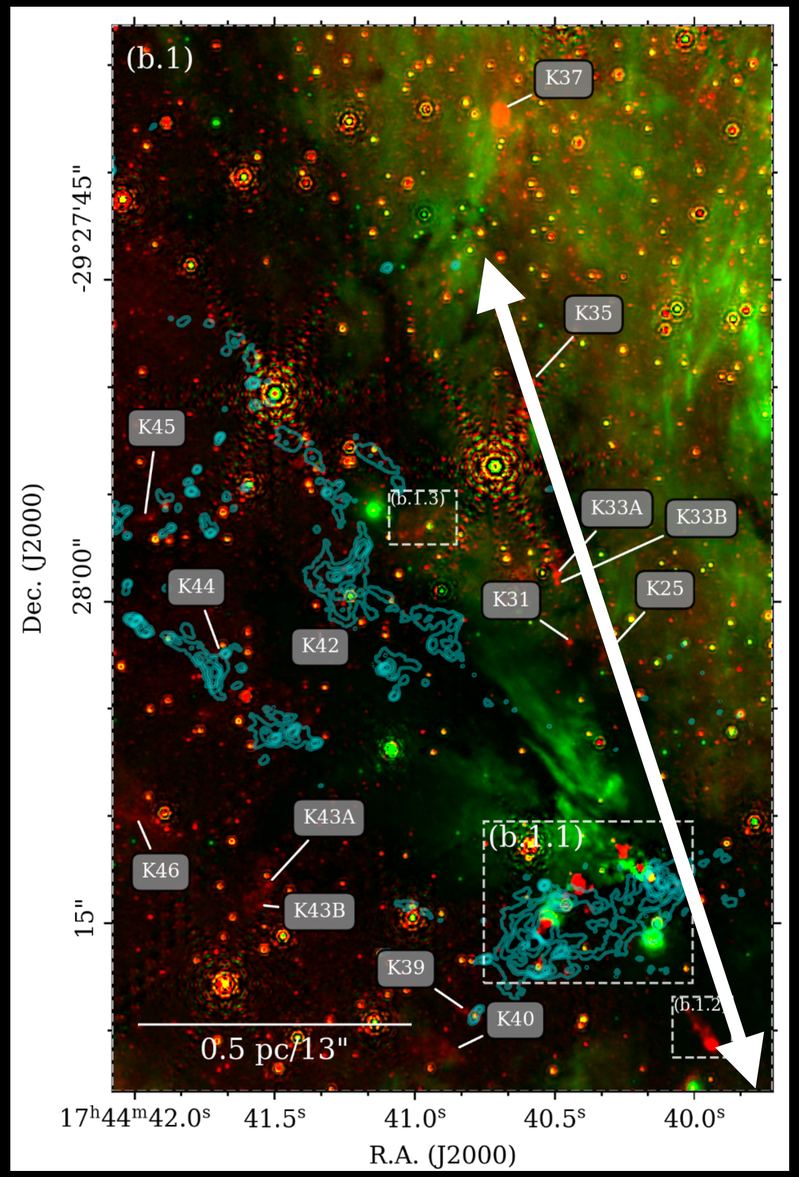

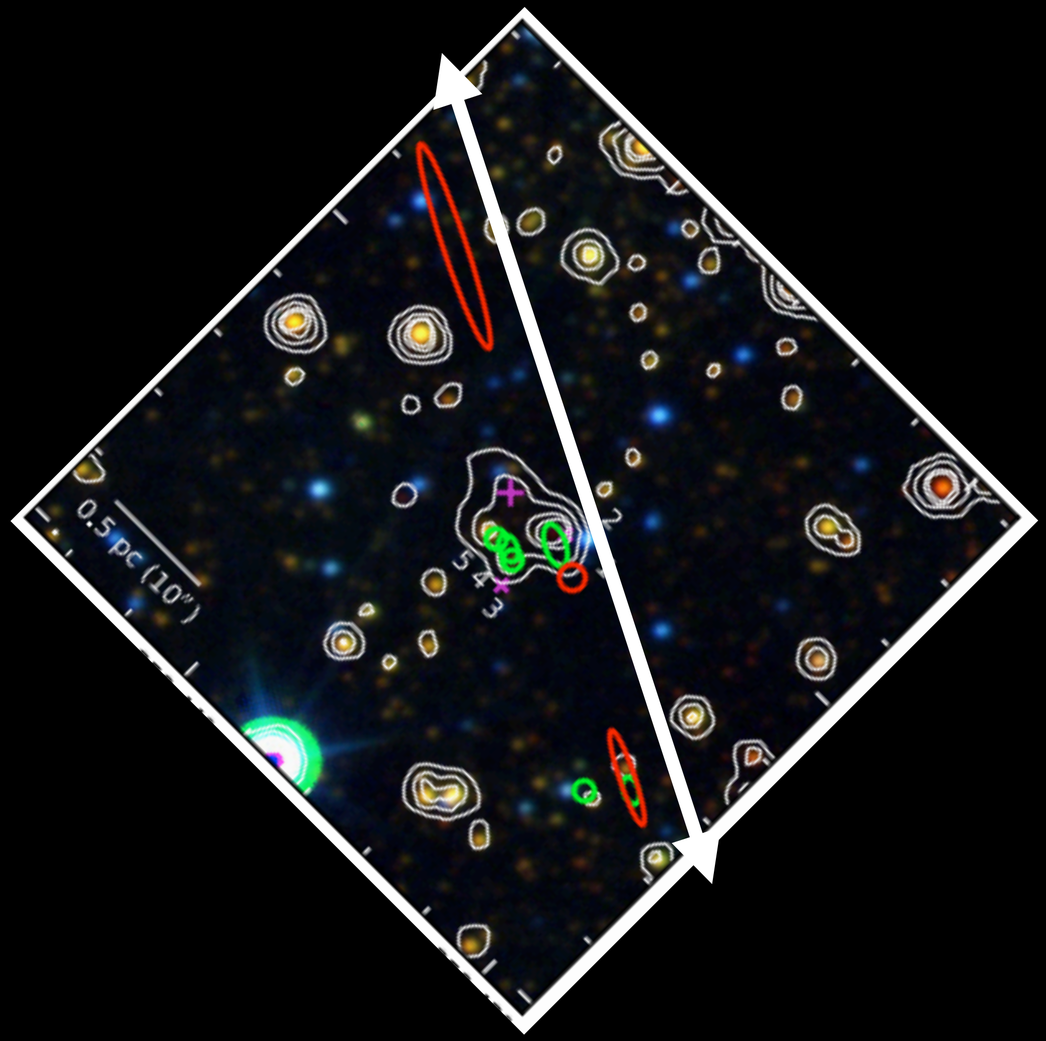

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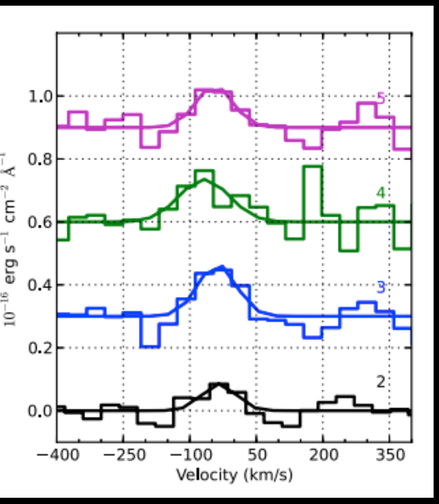

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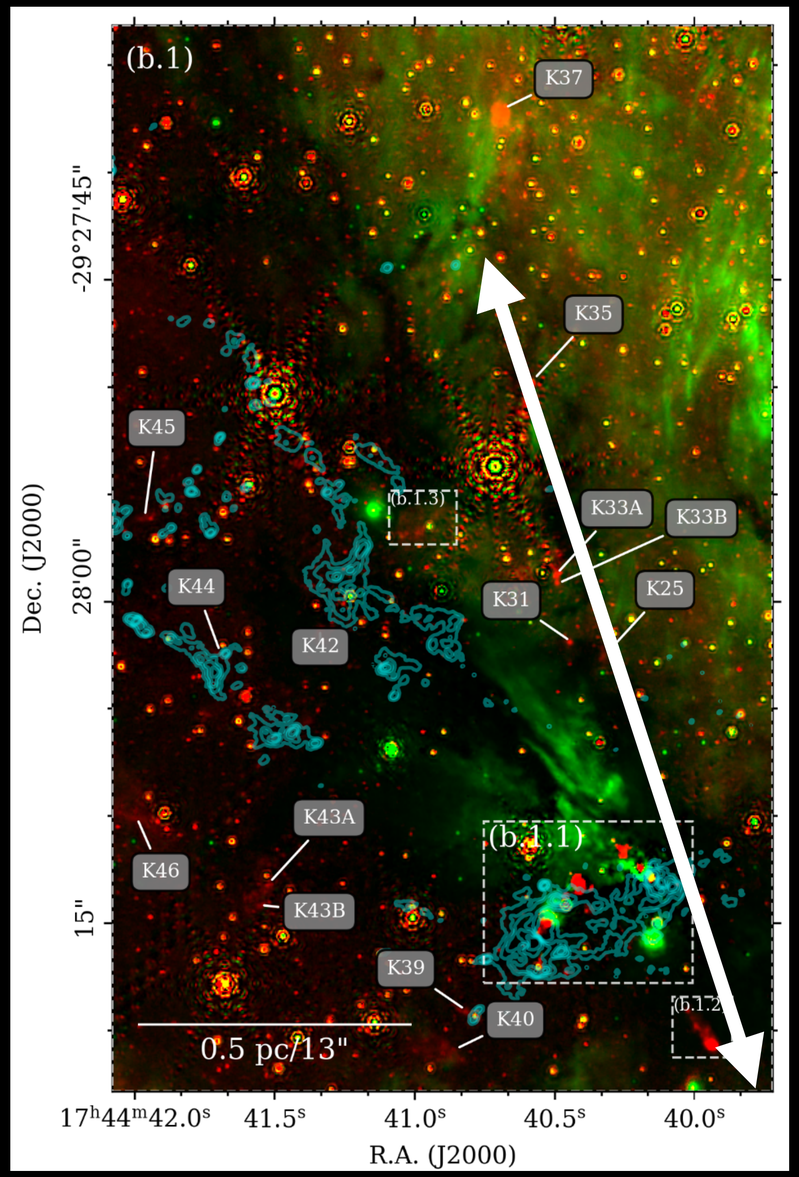

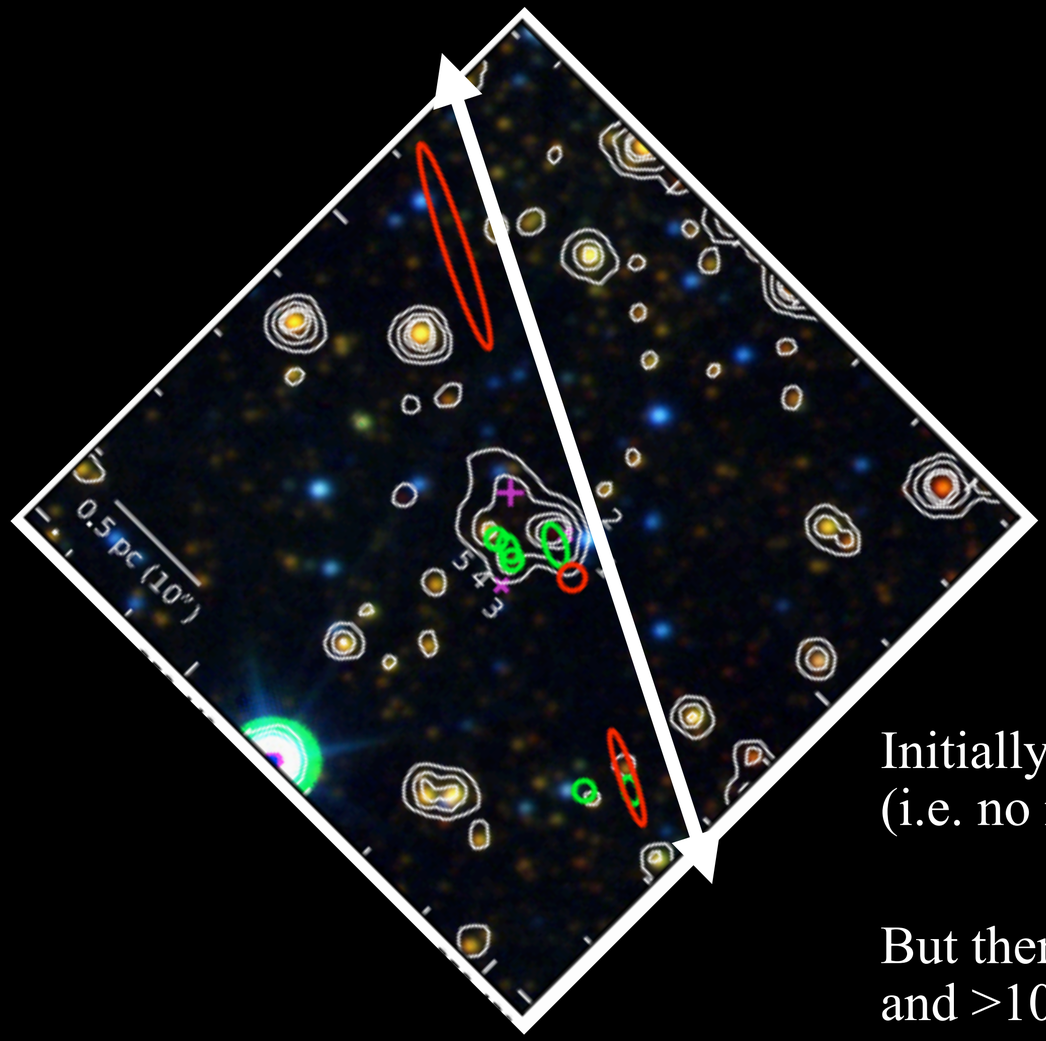

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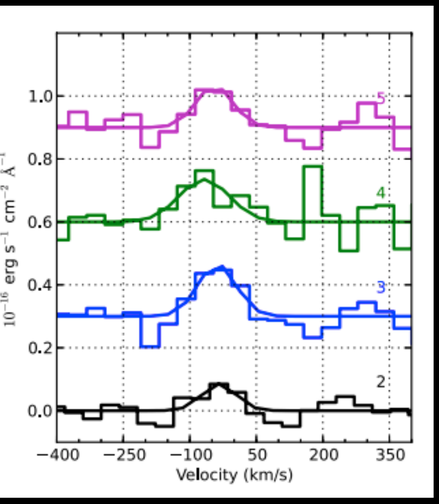

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Initially thought to be quiescent (i.e. no much star formation)

But there are >80 outflow knots and >100 mm cores

(i.e. plenty of star formation!!)

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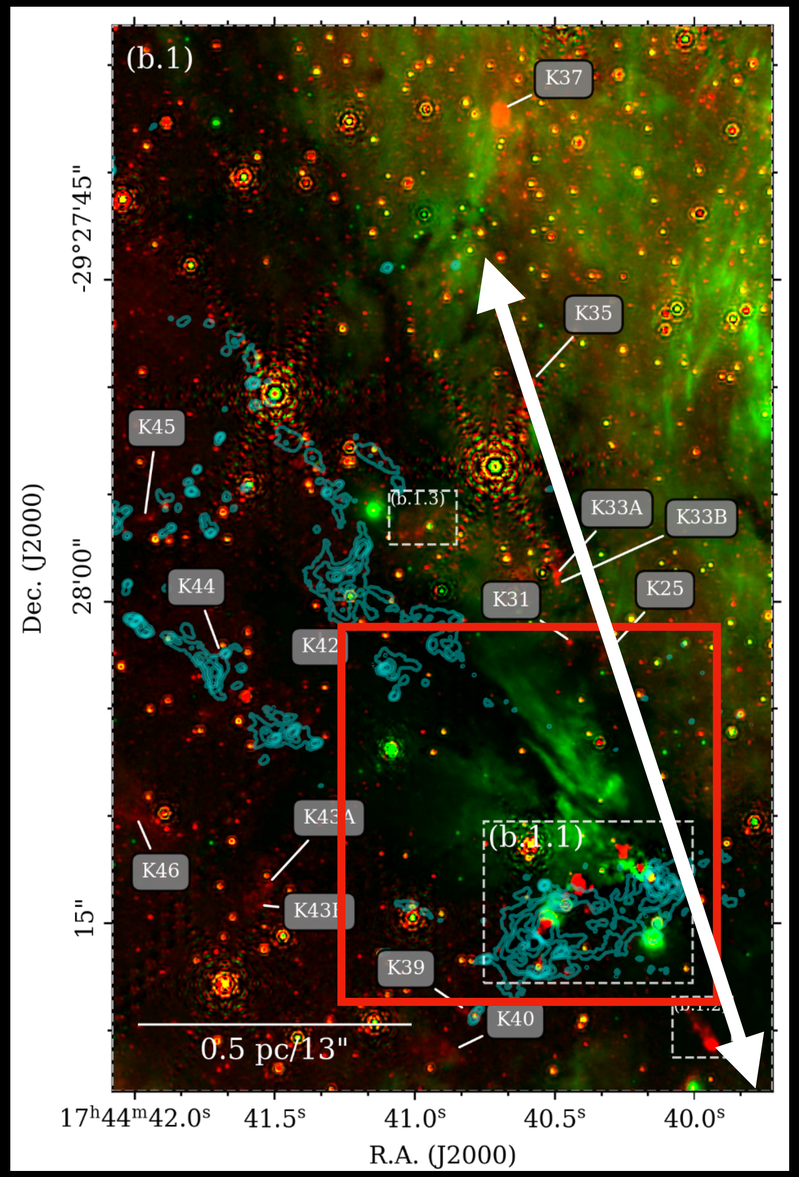

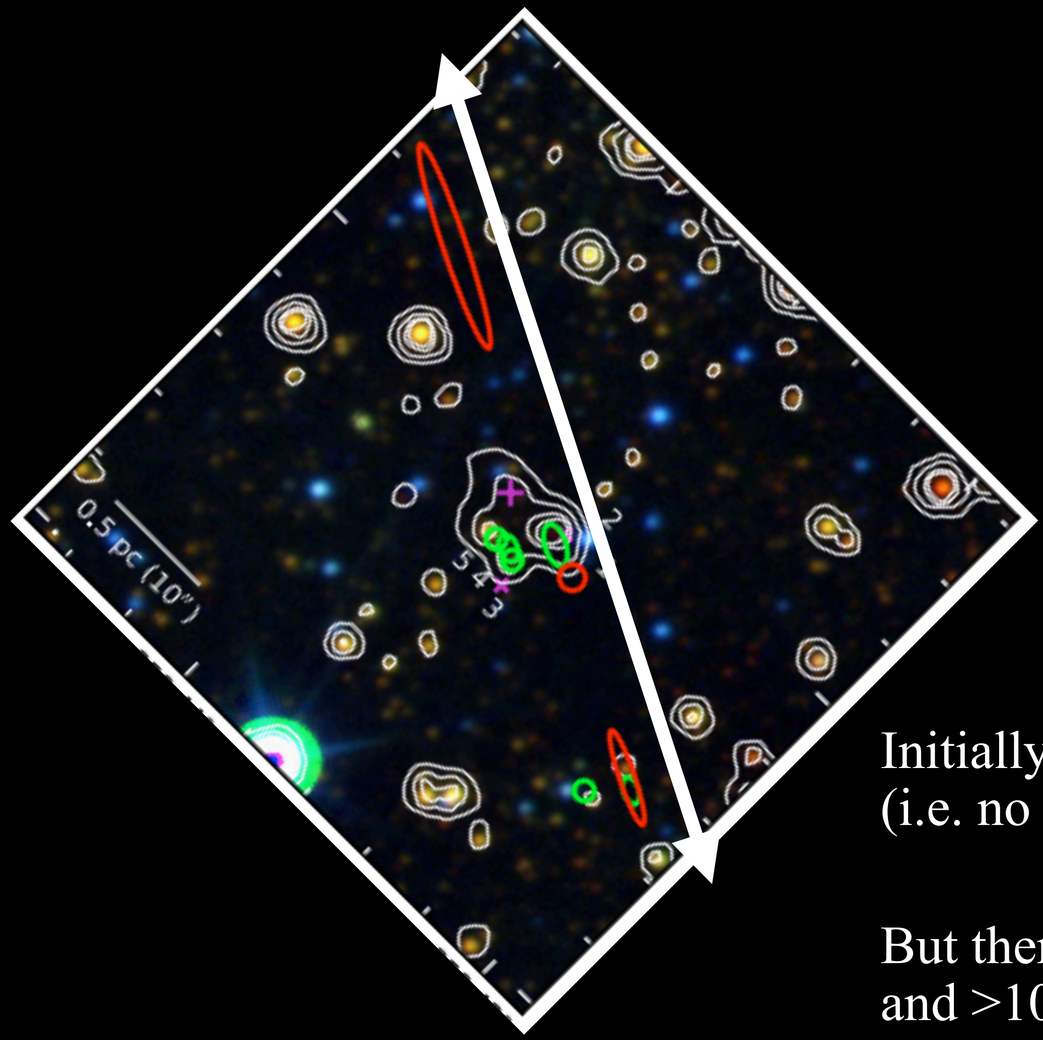

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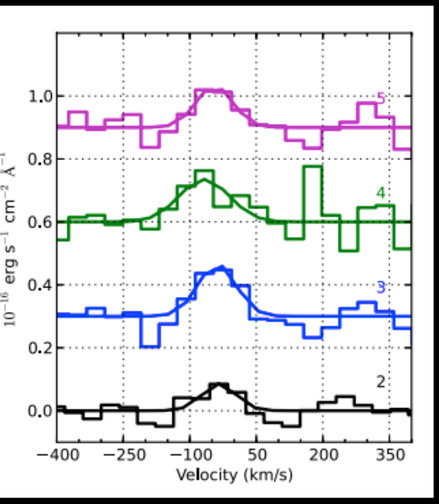

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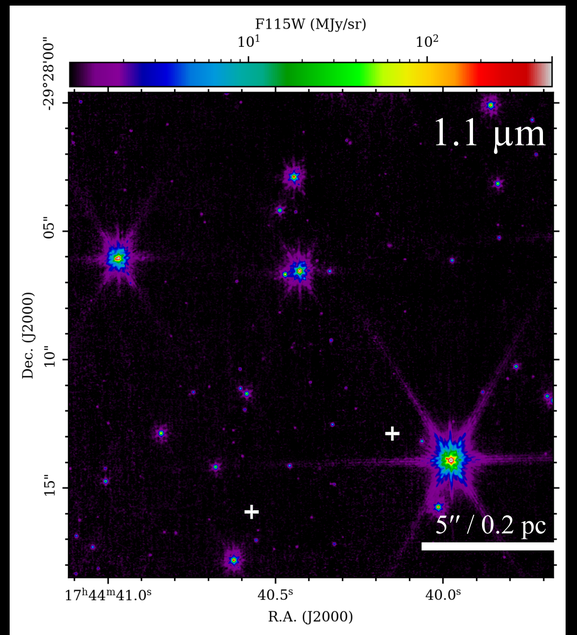

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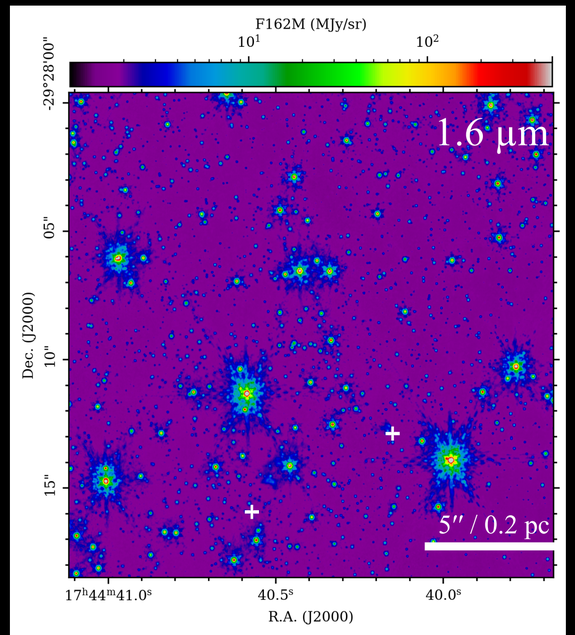

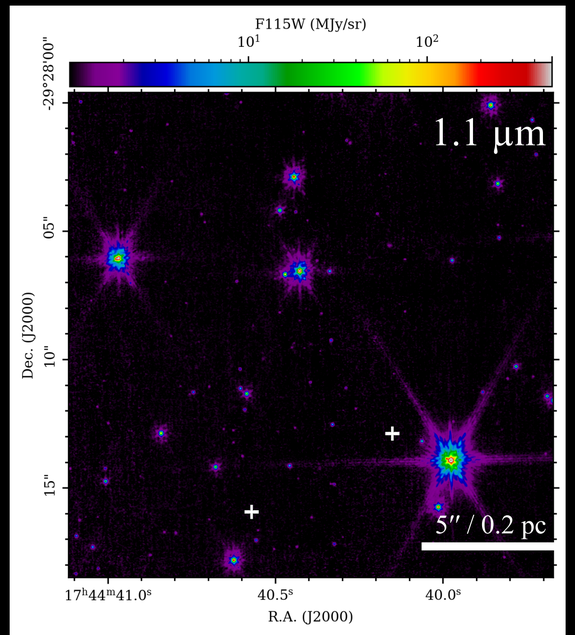

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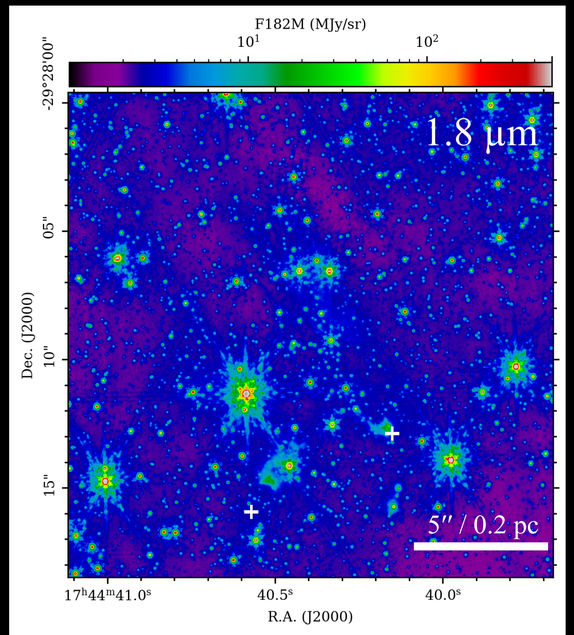

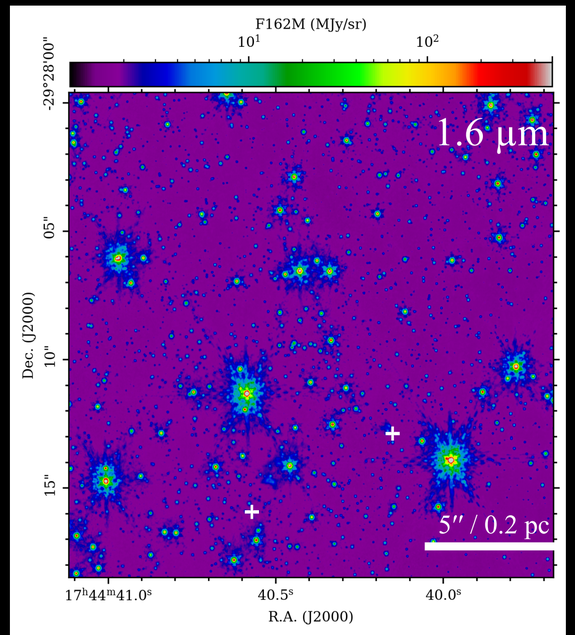

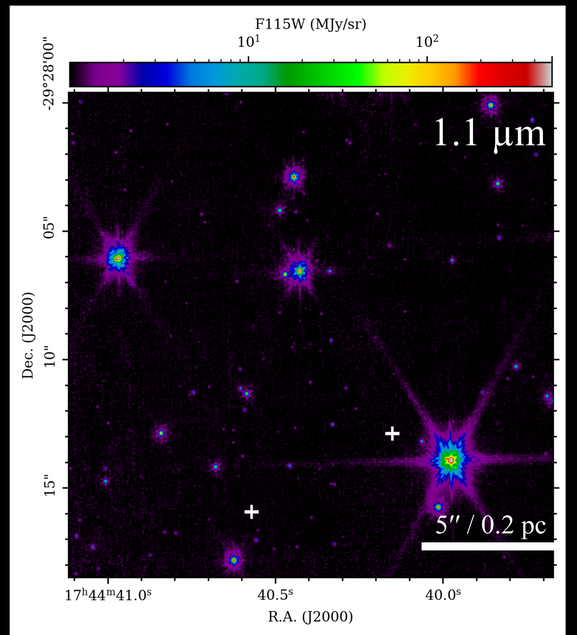

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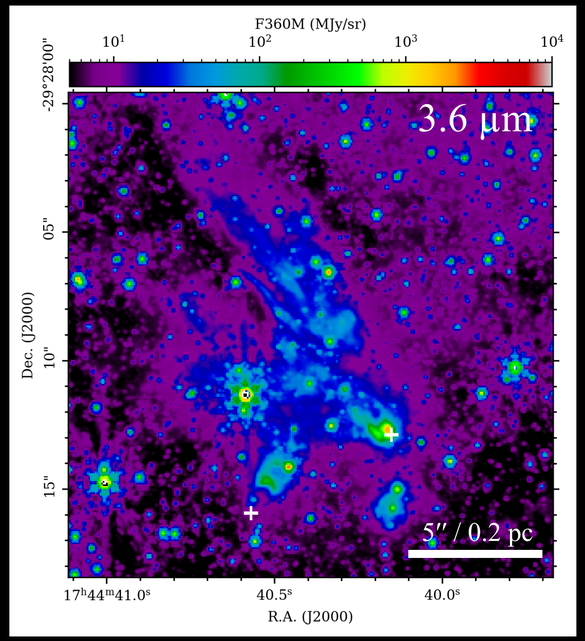

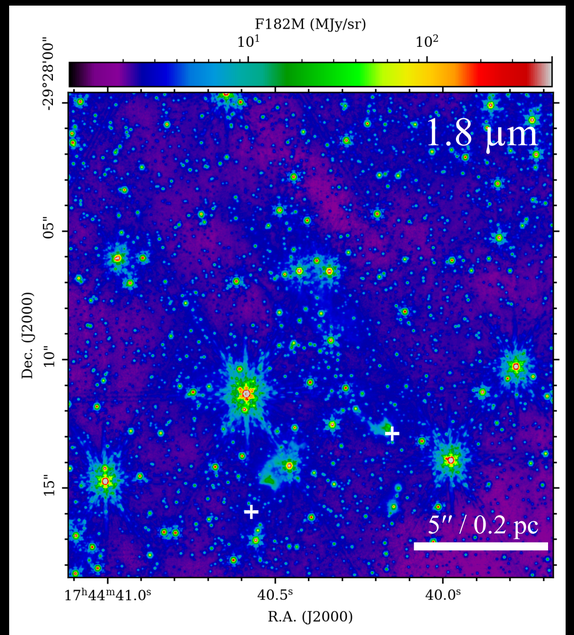

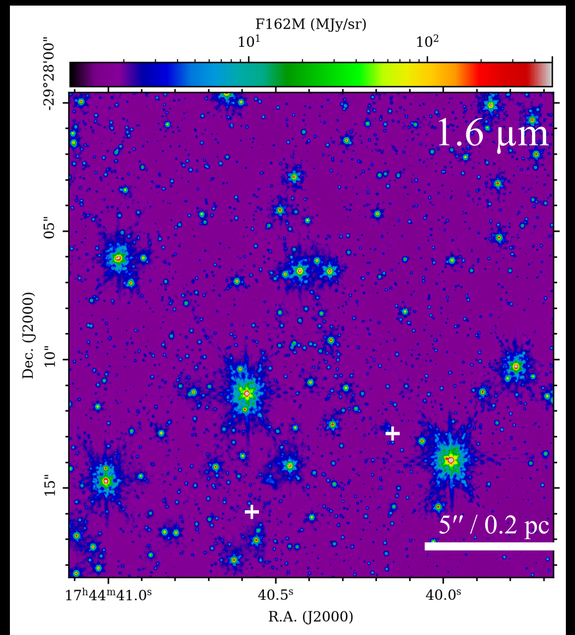

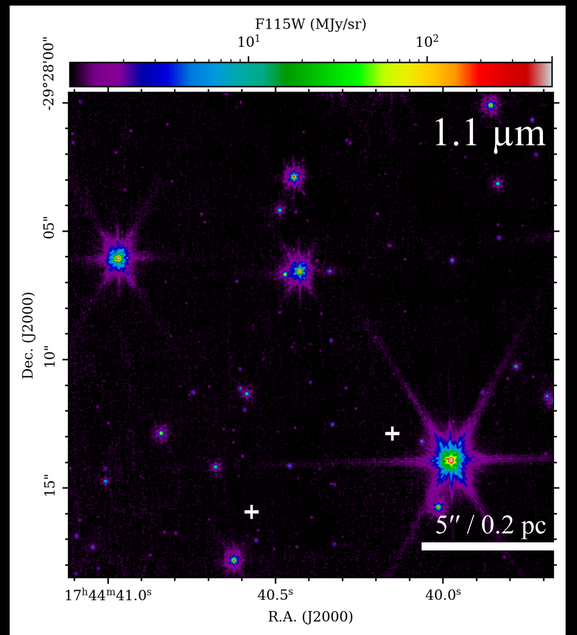

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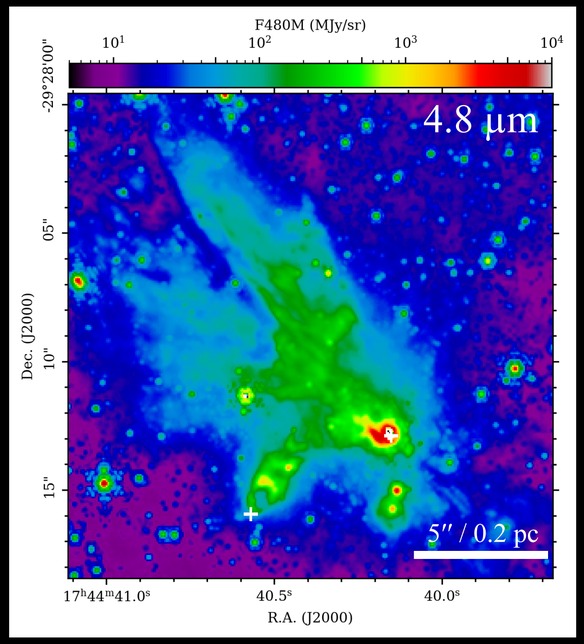
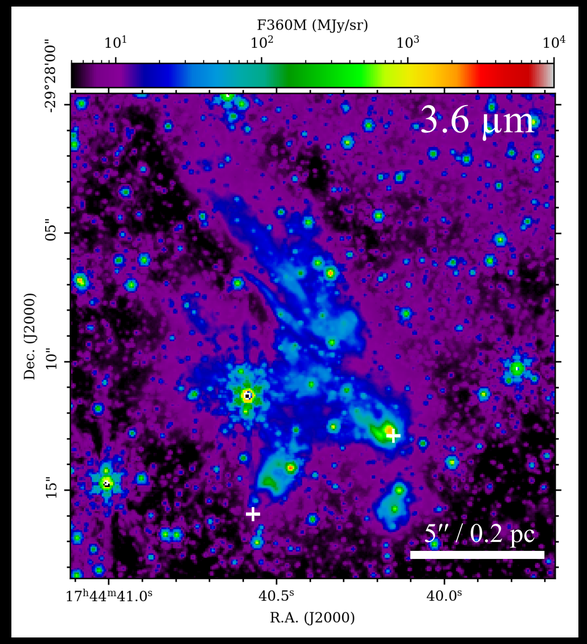
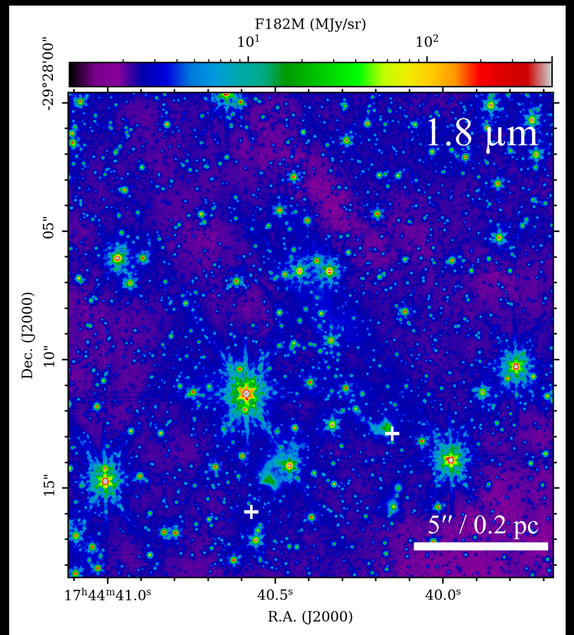
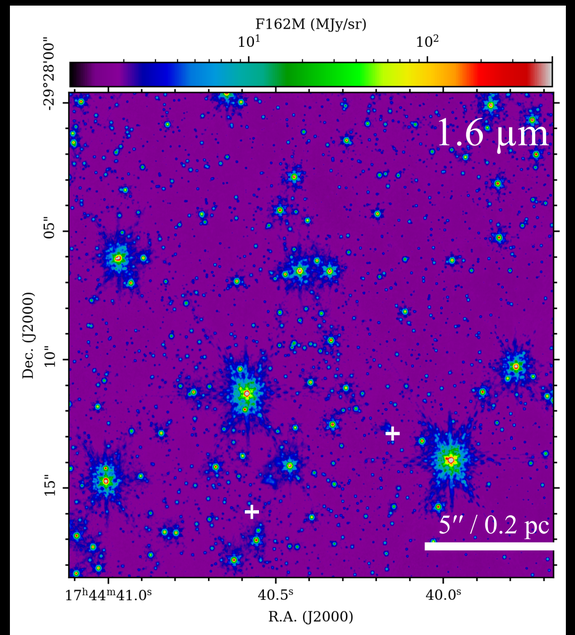
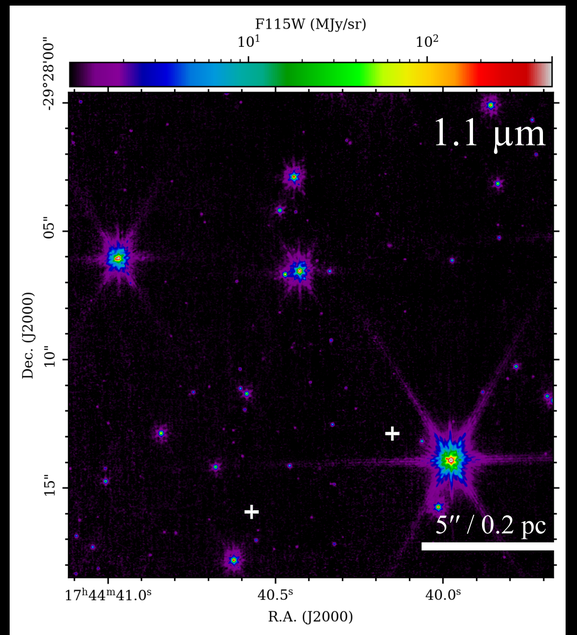






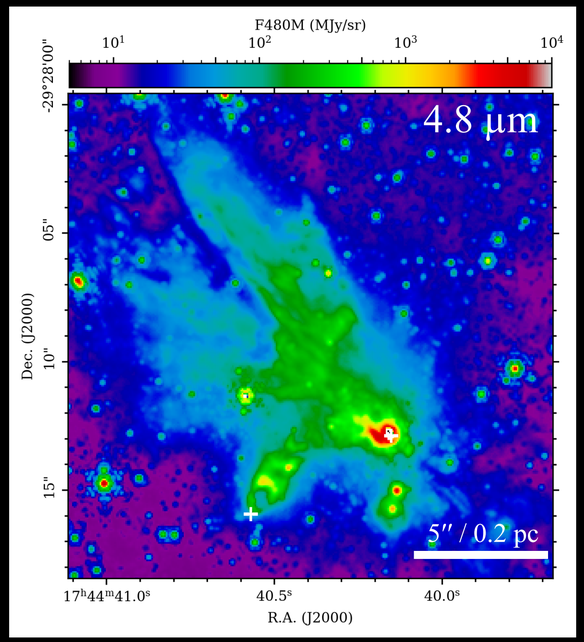


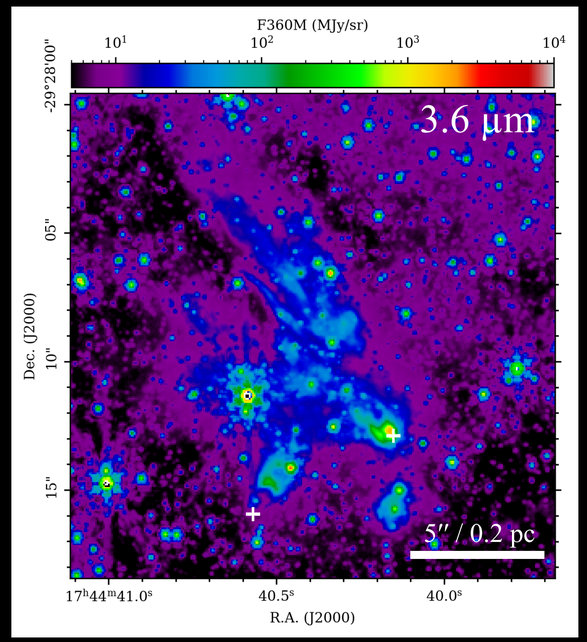


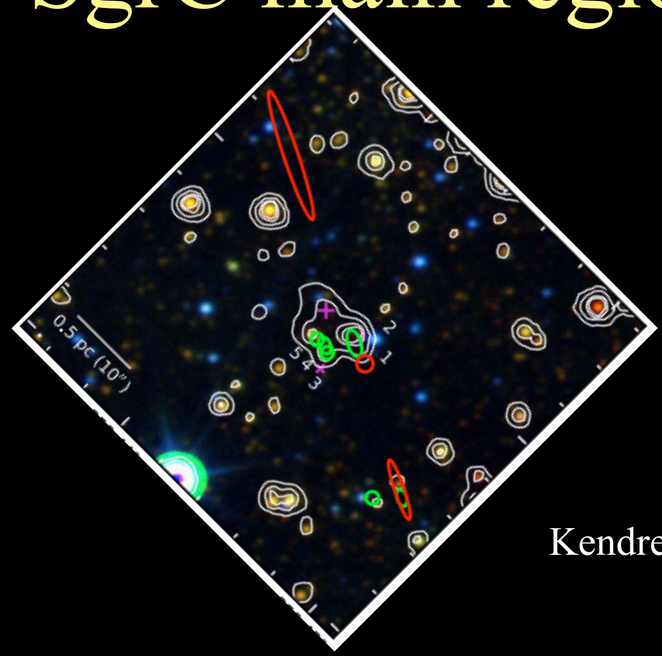
White crosses are ALMA band 6 (1.3 mm) peak emission for the two massive protostars (Lu et al. 2019a)

Crowe, et al. (2025)

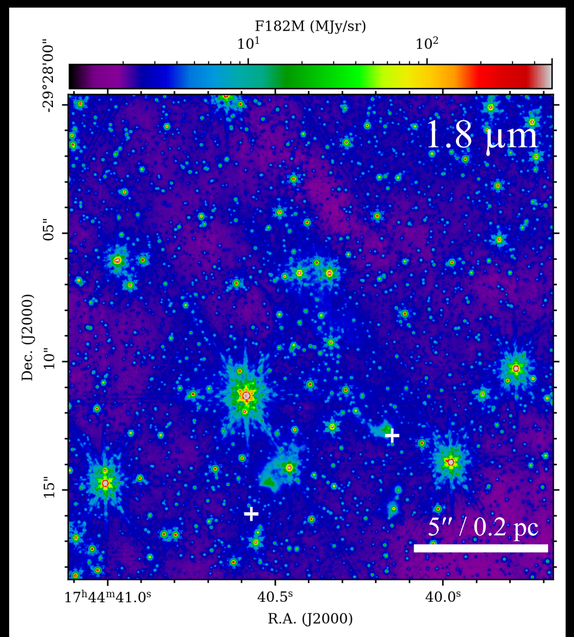
Closed-in view of the SgrC main region

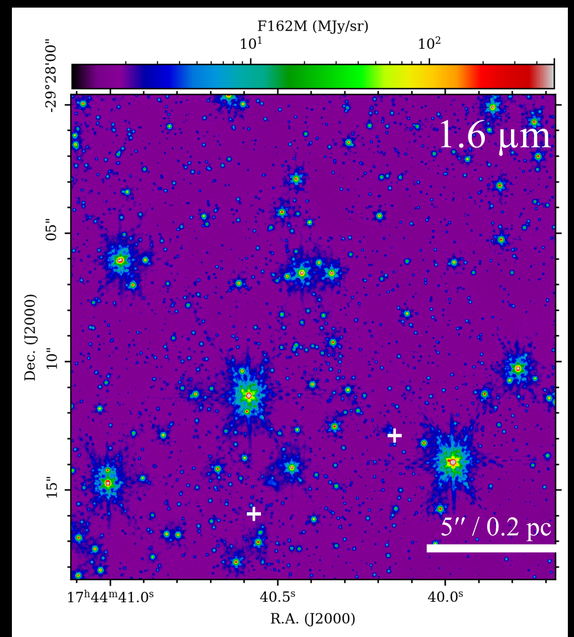


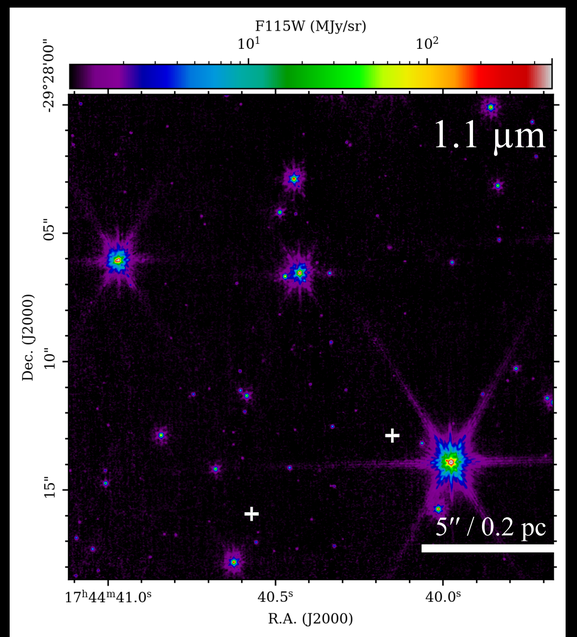




Kendrew, et al. (2013)







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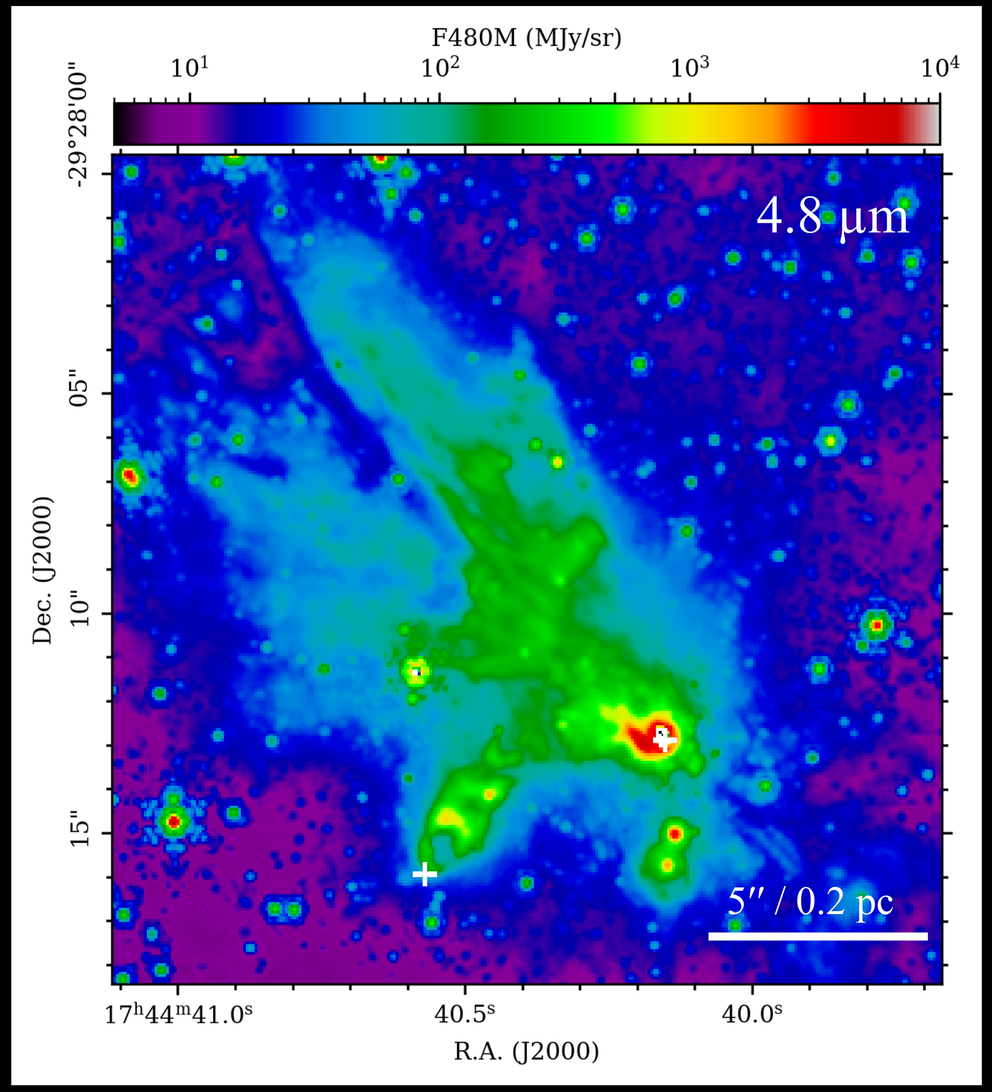
Closed-in view of the main massive protostars



Crowe, et al. (2025)

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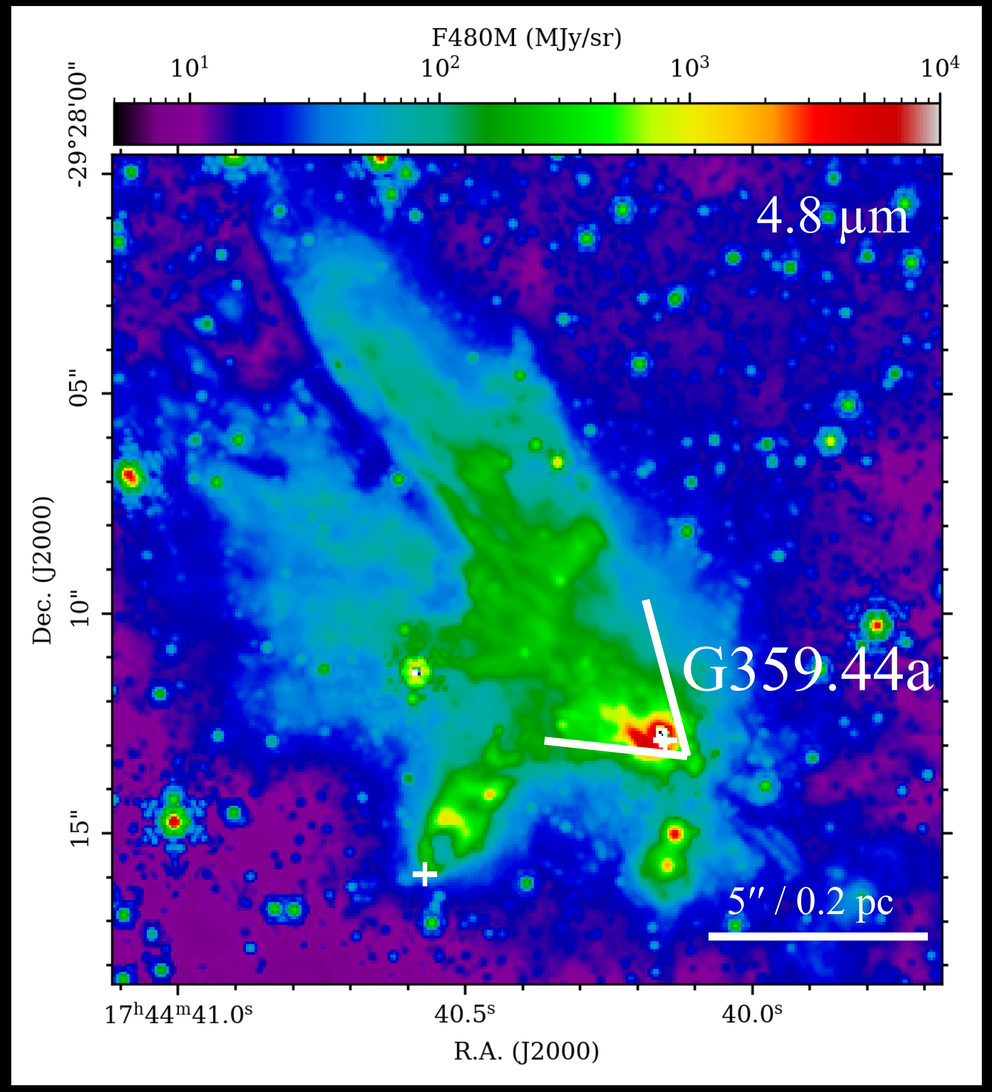

Crowe, et al. (2025)

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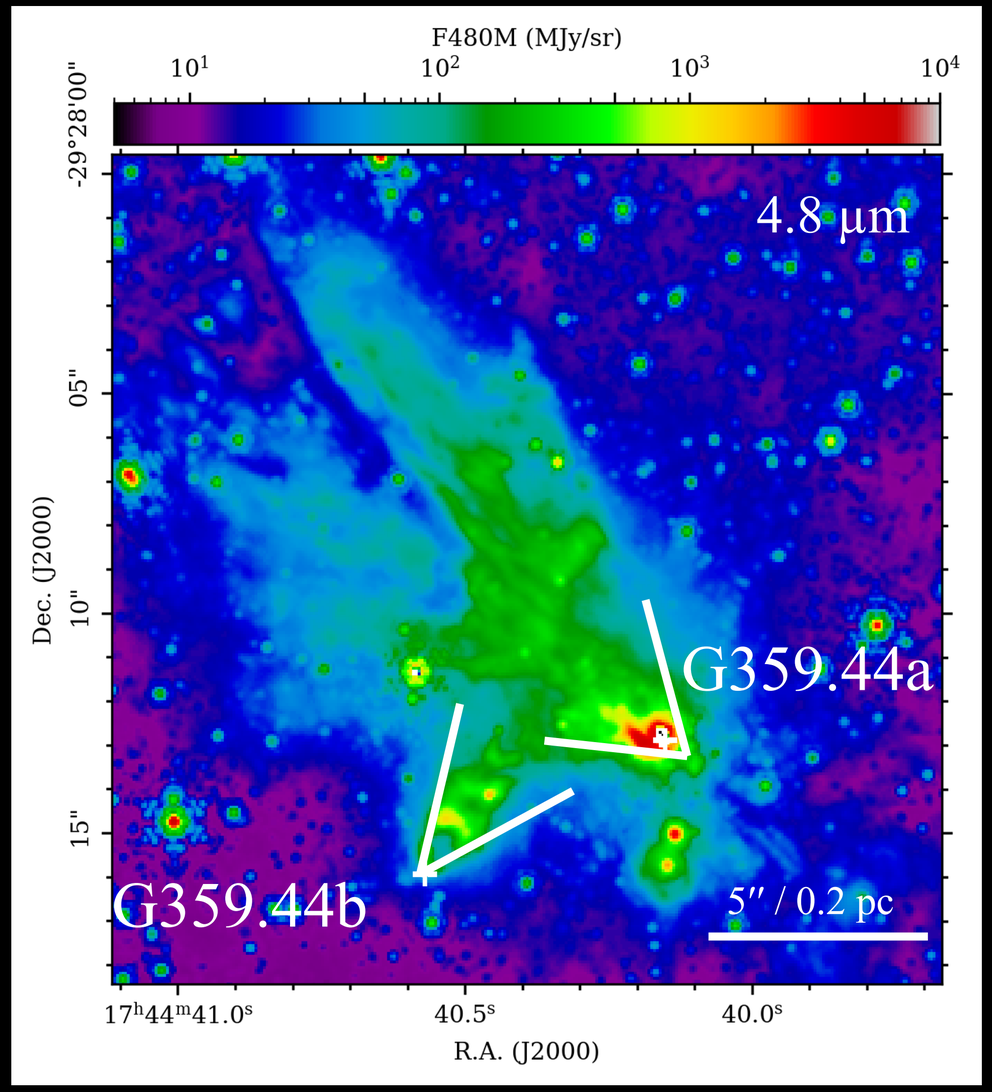

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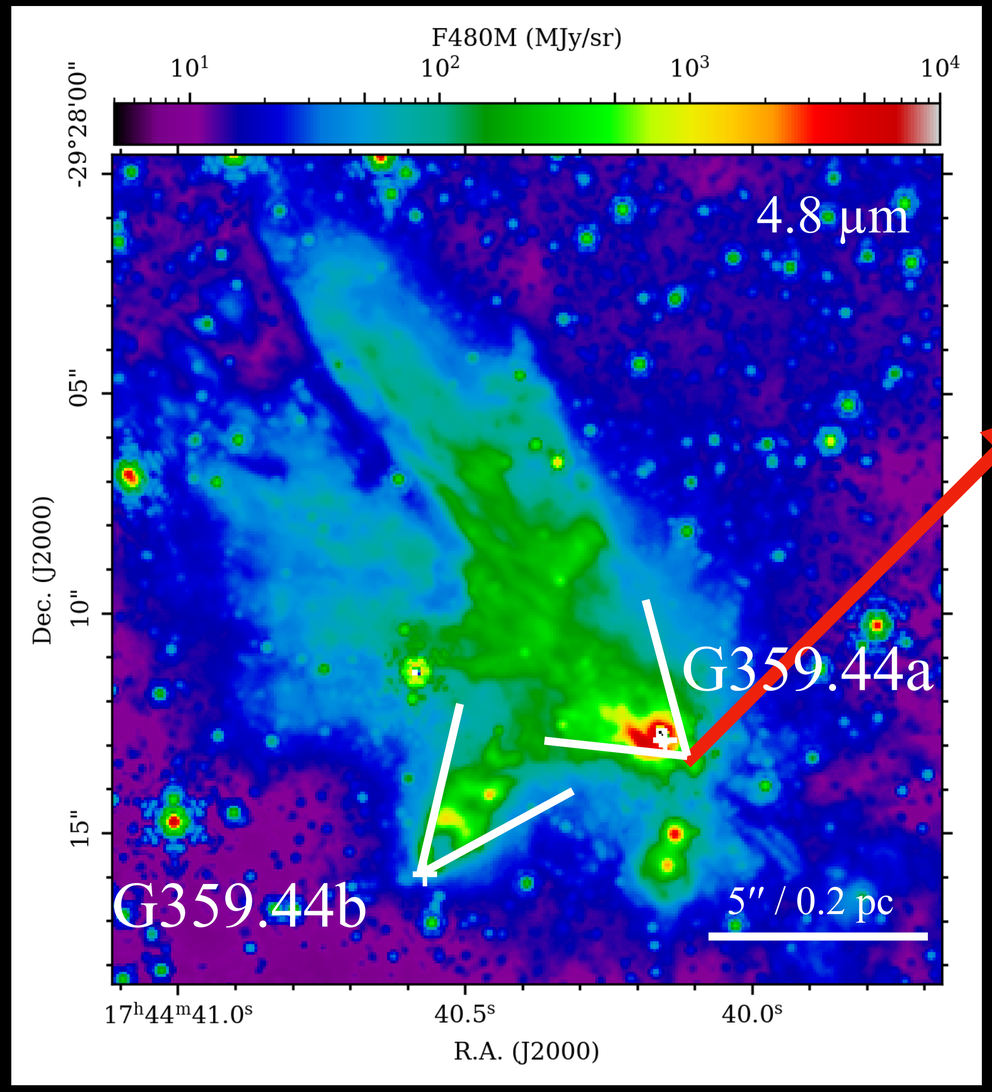
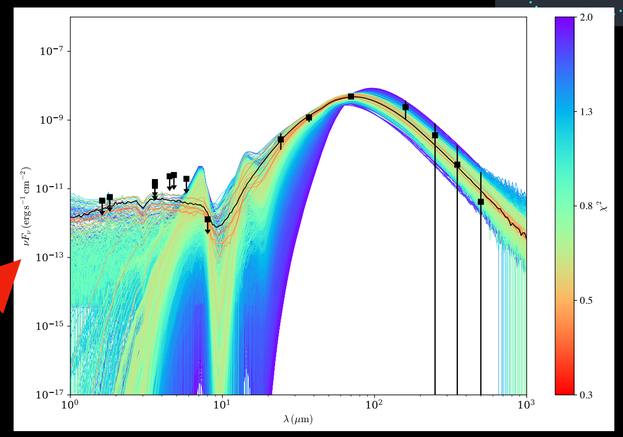


G359.44a



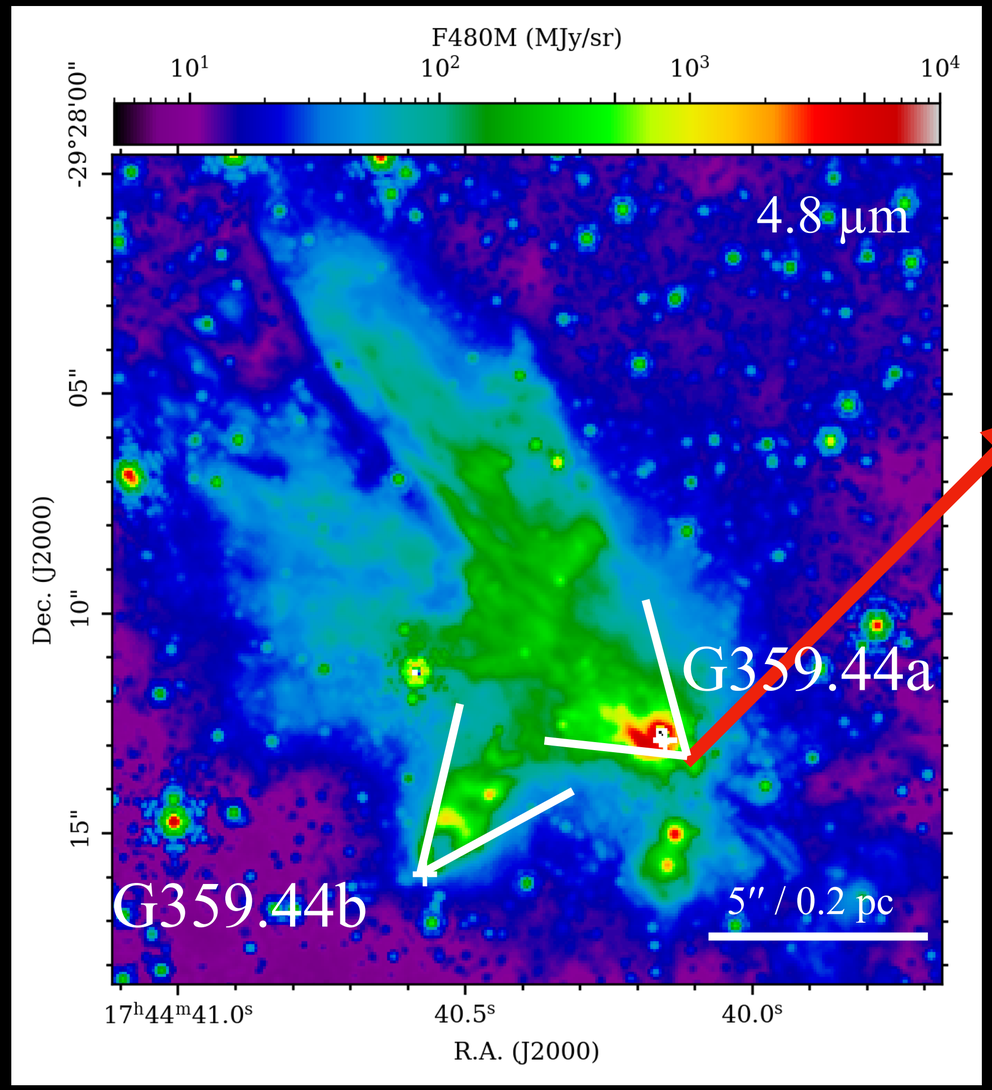
SED-fitted mass

~20M$_\odot$

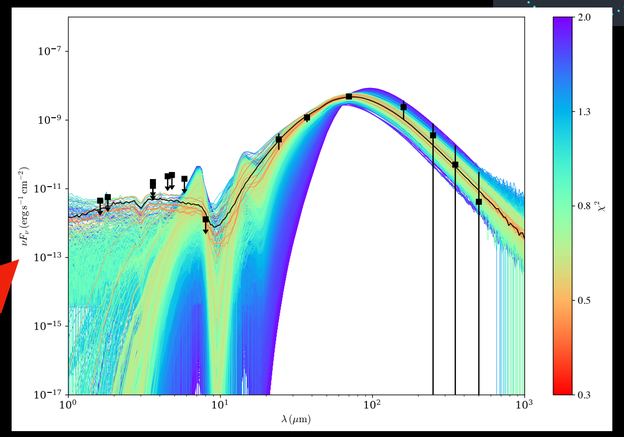
Fedriani, et al. (2023a)

Crowe, et al. (2025)

Closed-in view of the main massive protostars

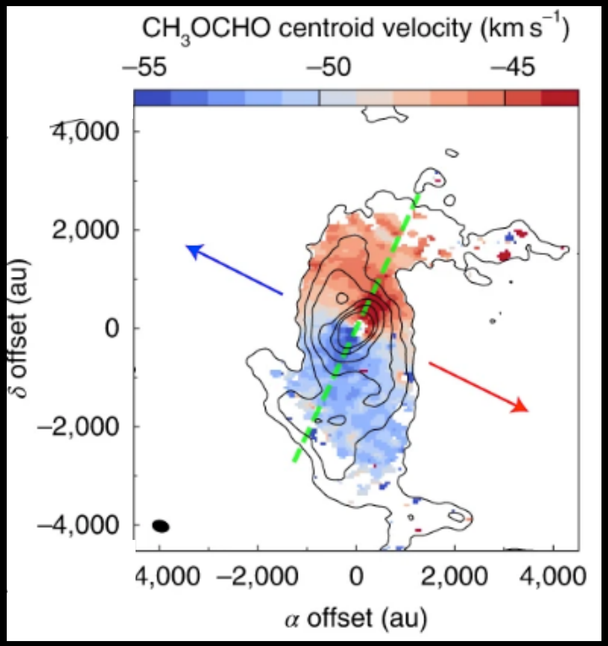


G359.44a



SED-fitted mass

~20M$_\odot$



Consistent with Keplerian rotation derived mass

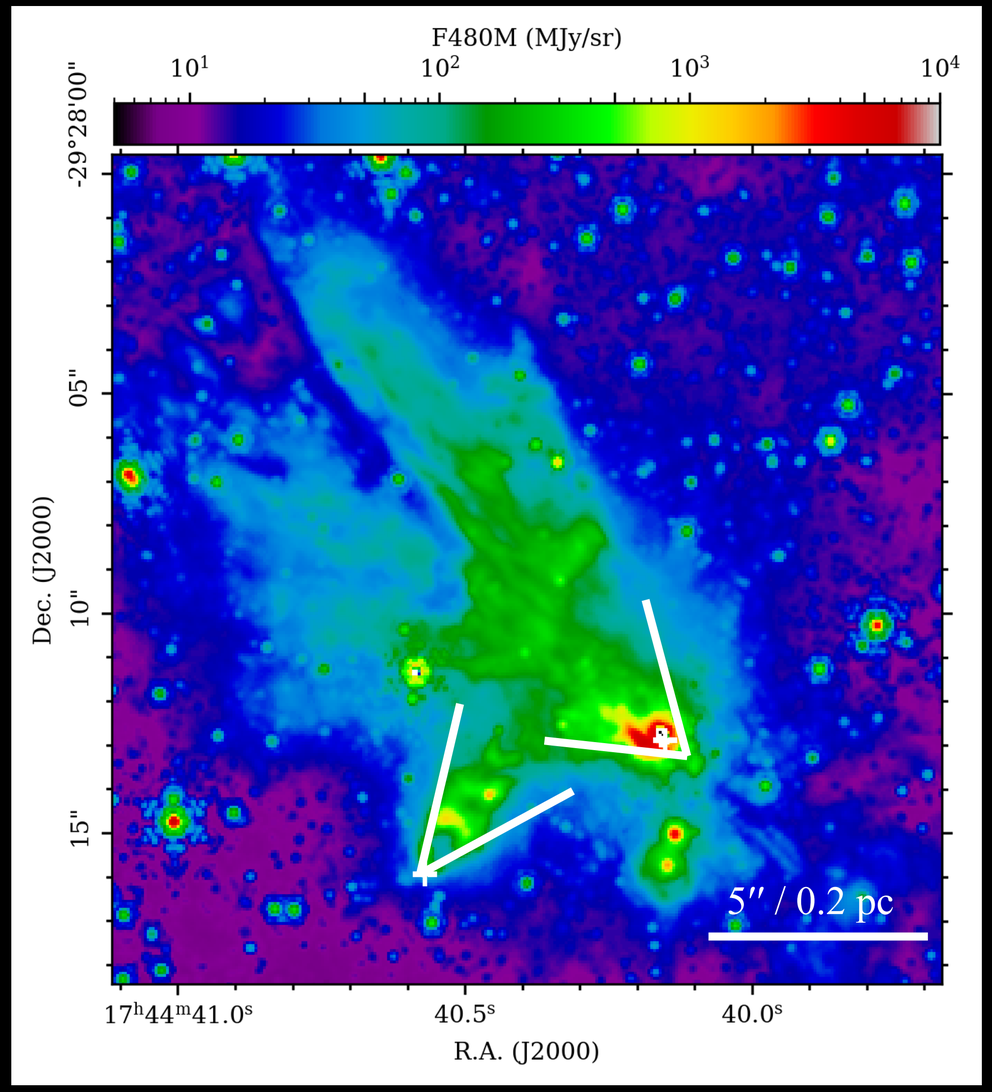
~25-35 M$_\odot$

Lu, et al. (2022)

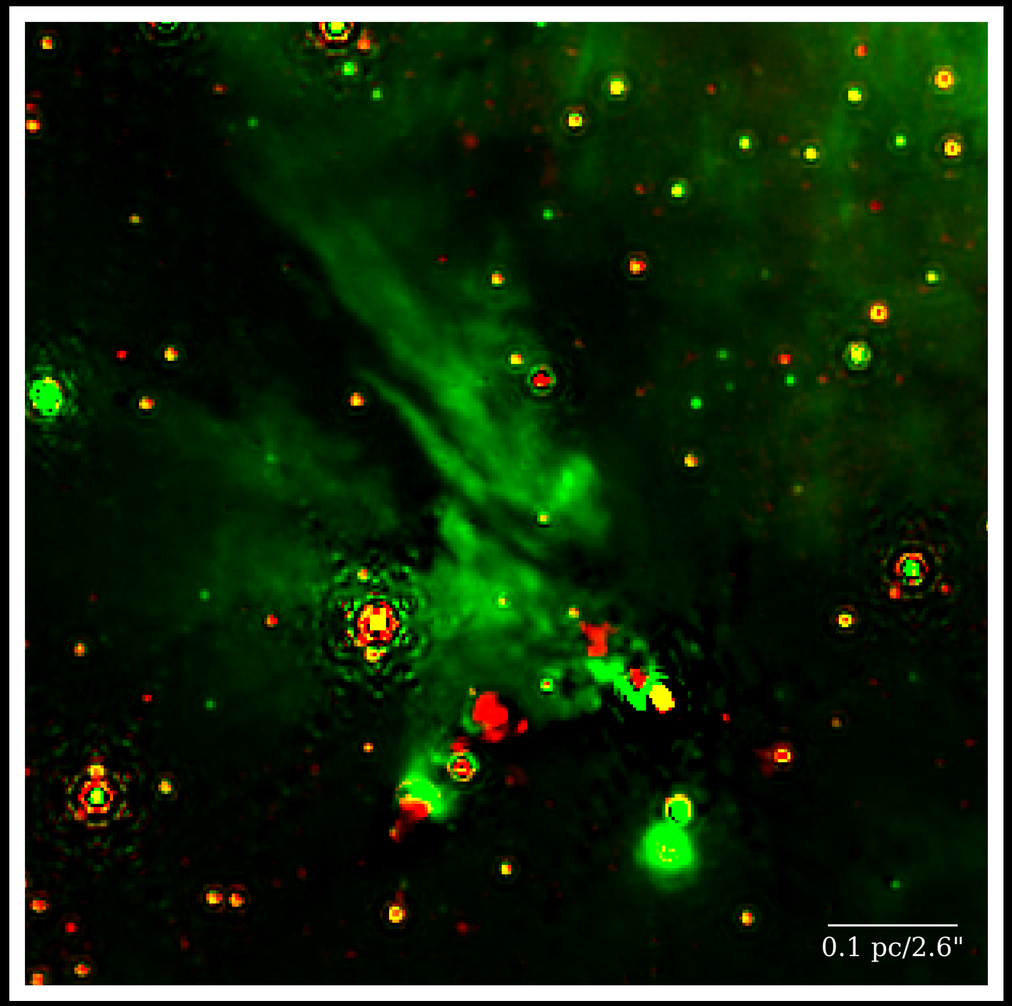
Fedriani, et al. (2023a)

Crowe, et al. (2025)

Closed-in view of the main massive protostars

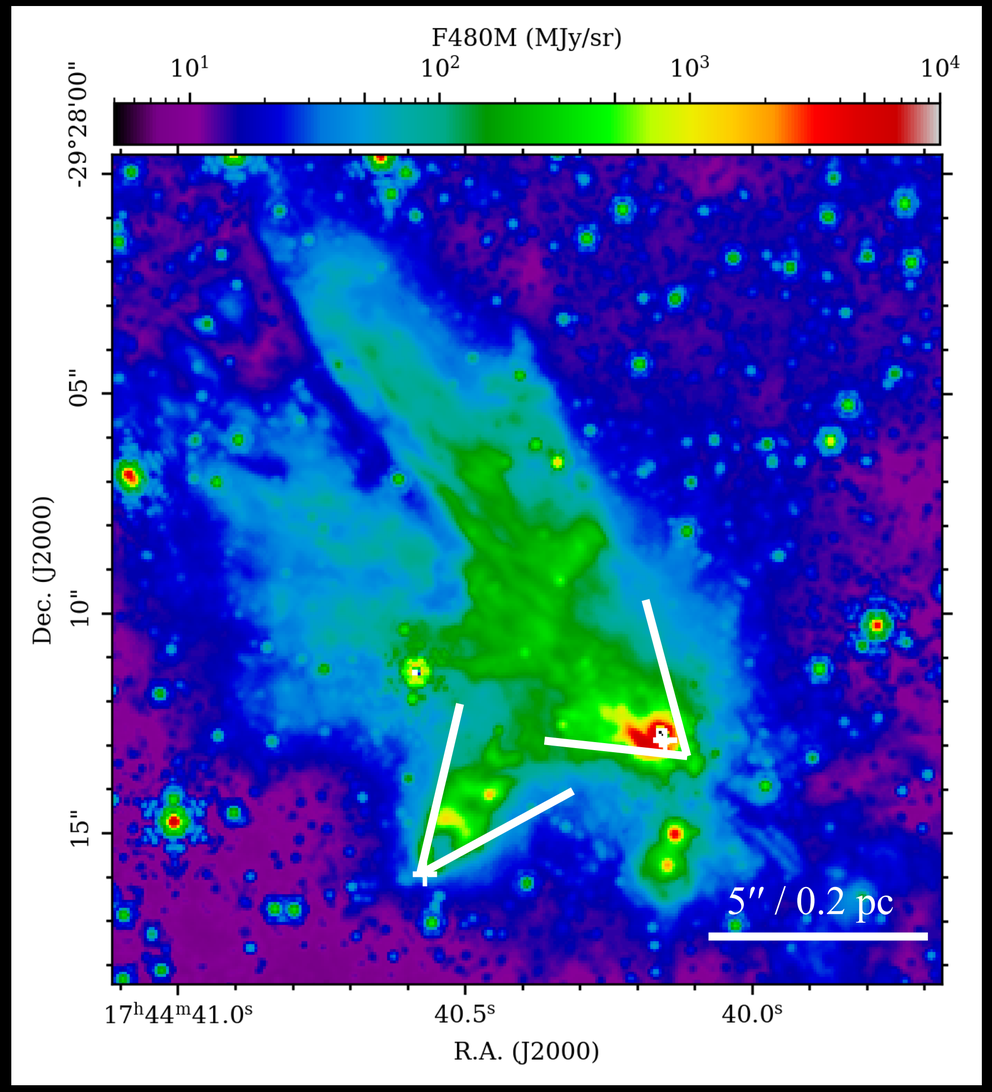


F470N-cont (H_2) *F405N-cont (Brα)* *ALMA 1.3mm*



Crowe, et al. (2025)

Closed-in view of the main massive protostars



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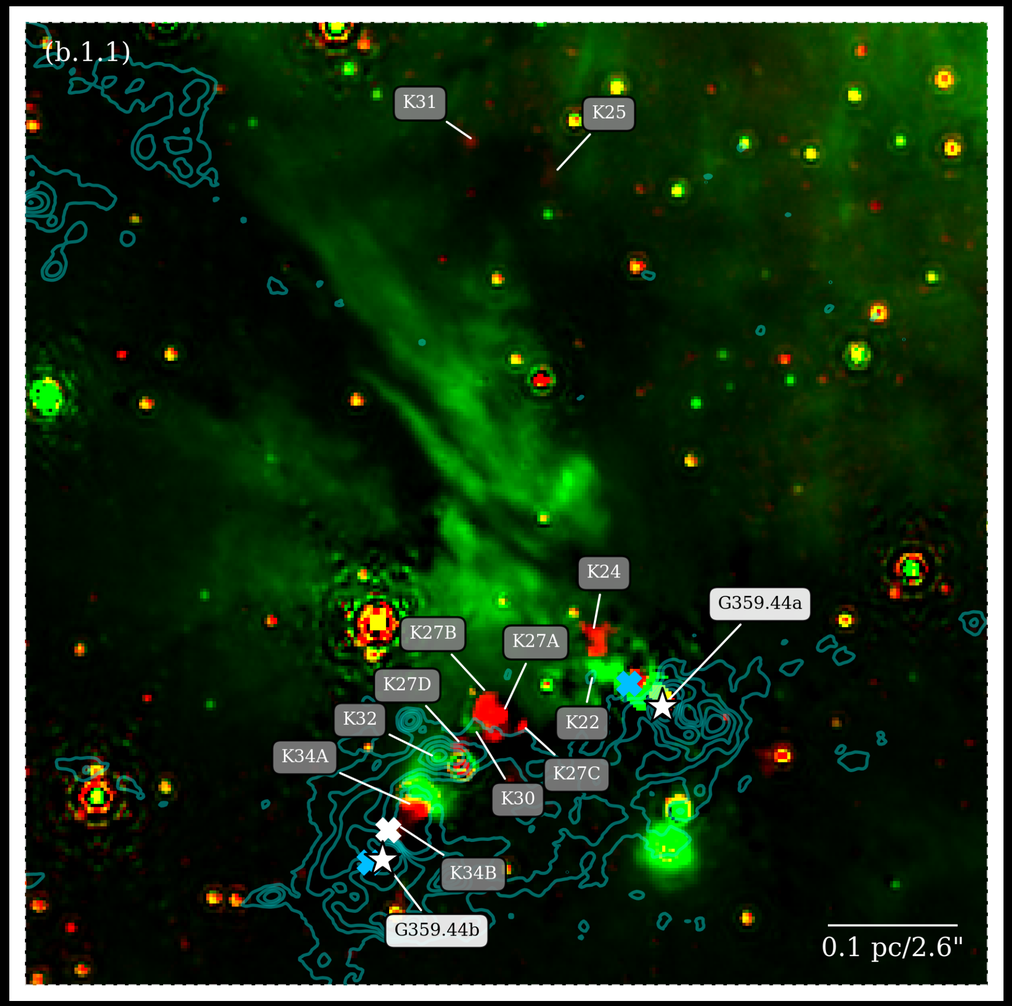

Crowe, et al. (2025)

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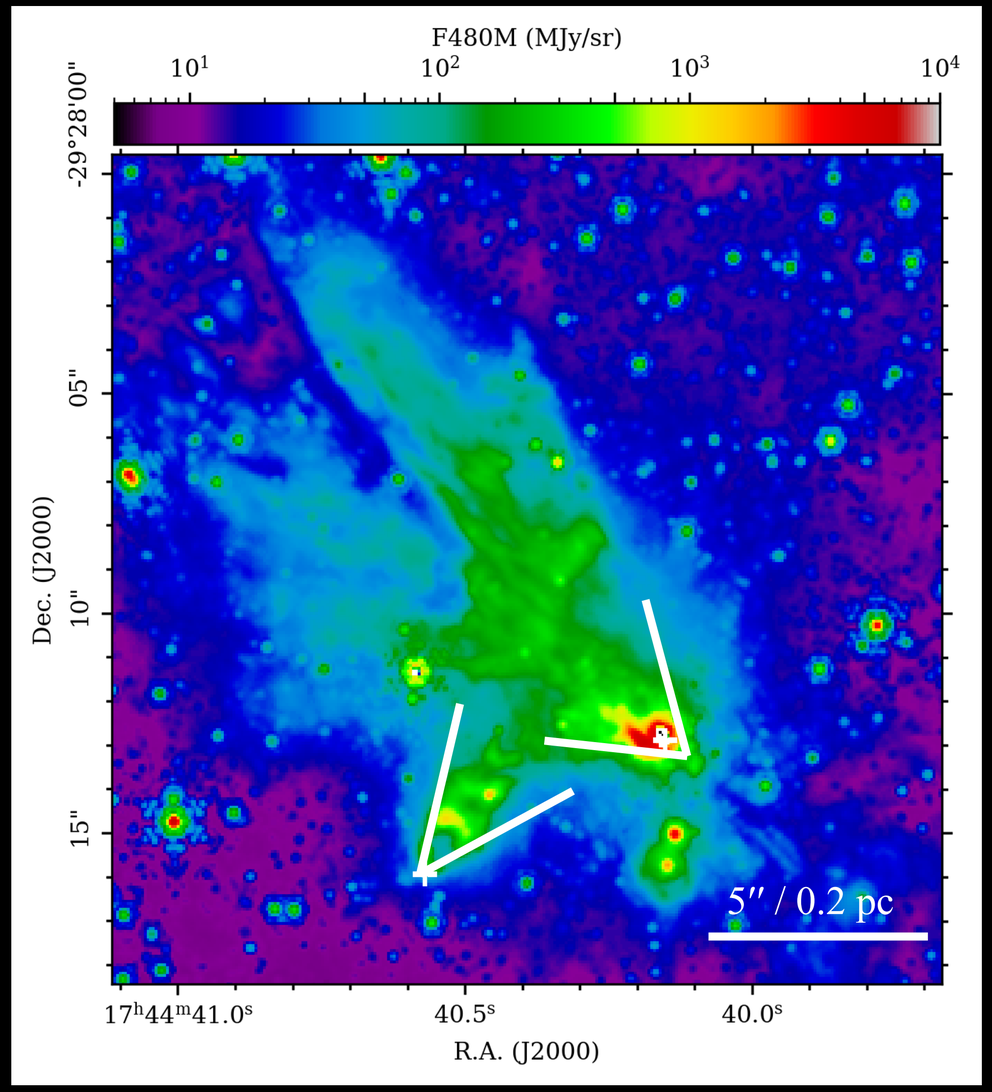

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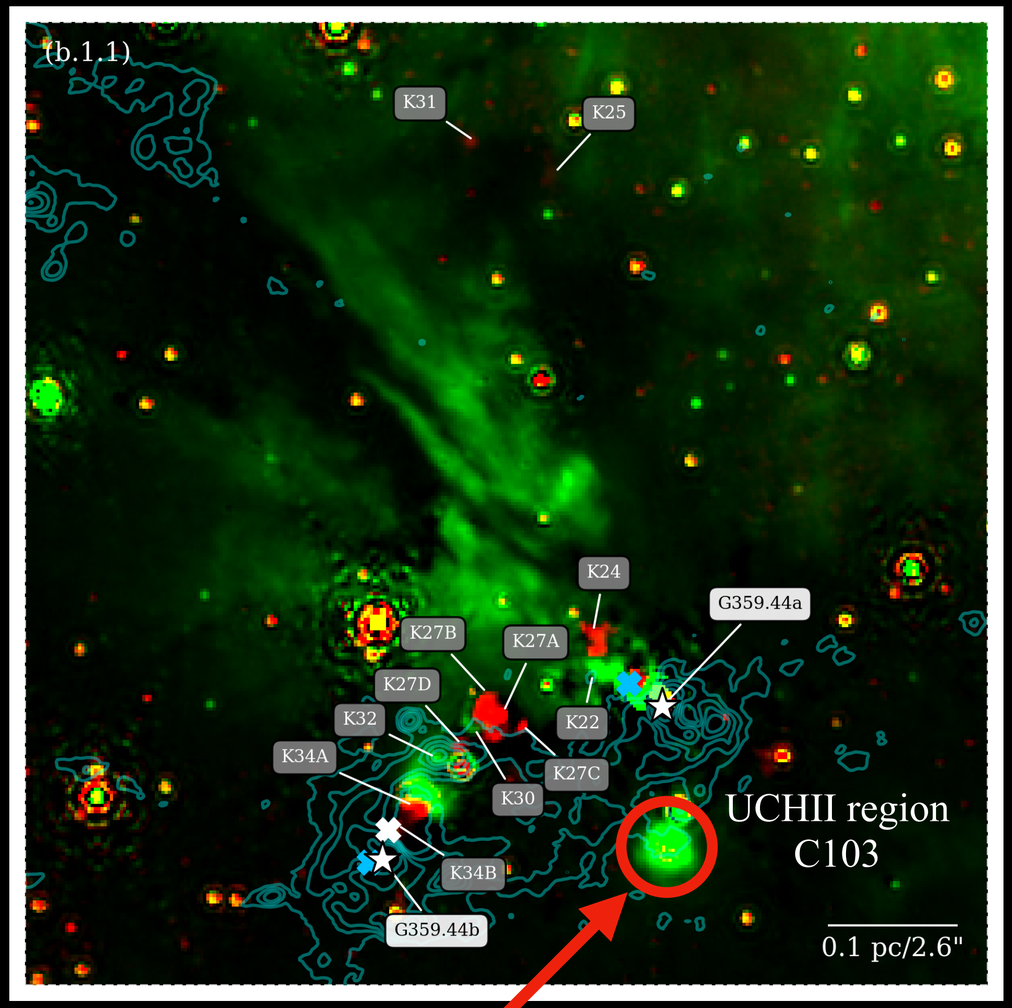


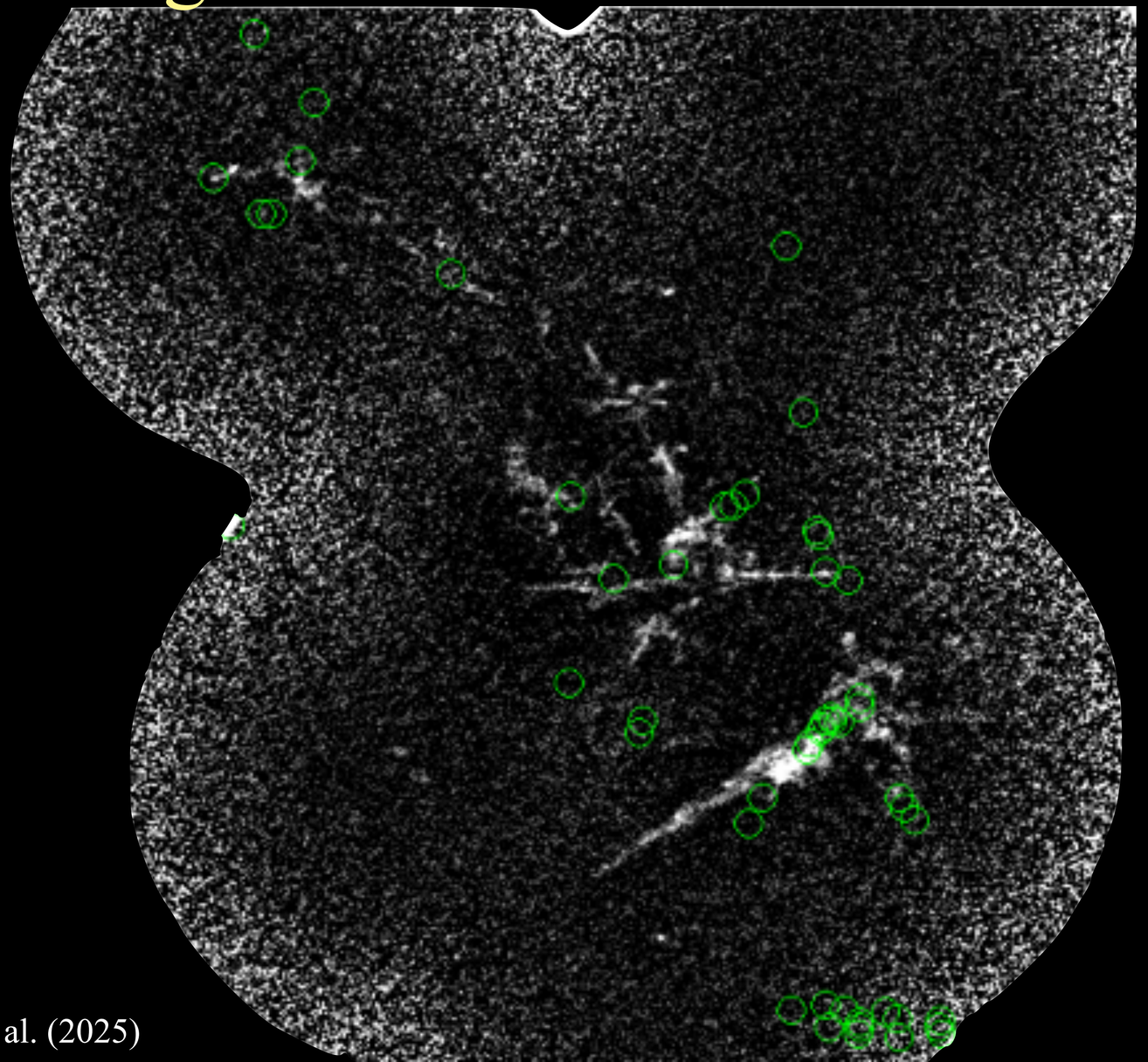
Match with VLA 6cm emission from Lu et al. (2019a)

Crowe, et al. (2025)

JWST+ALMA reveal shocks, jets, and cores throughout the SgrC cloud

Green circles are knots identified in the H_2 and Brα tracers

Background image SiO 5-4, which is also an outflow tracer (Lu et al. 2021)



Lu et al. (2021); Crowe, et al. (2025)

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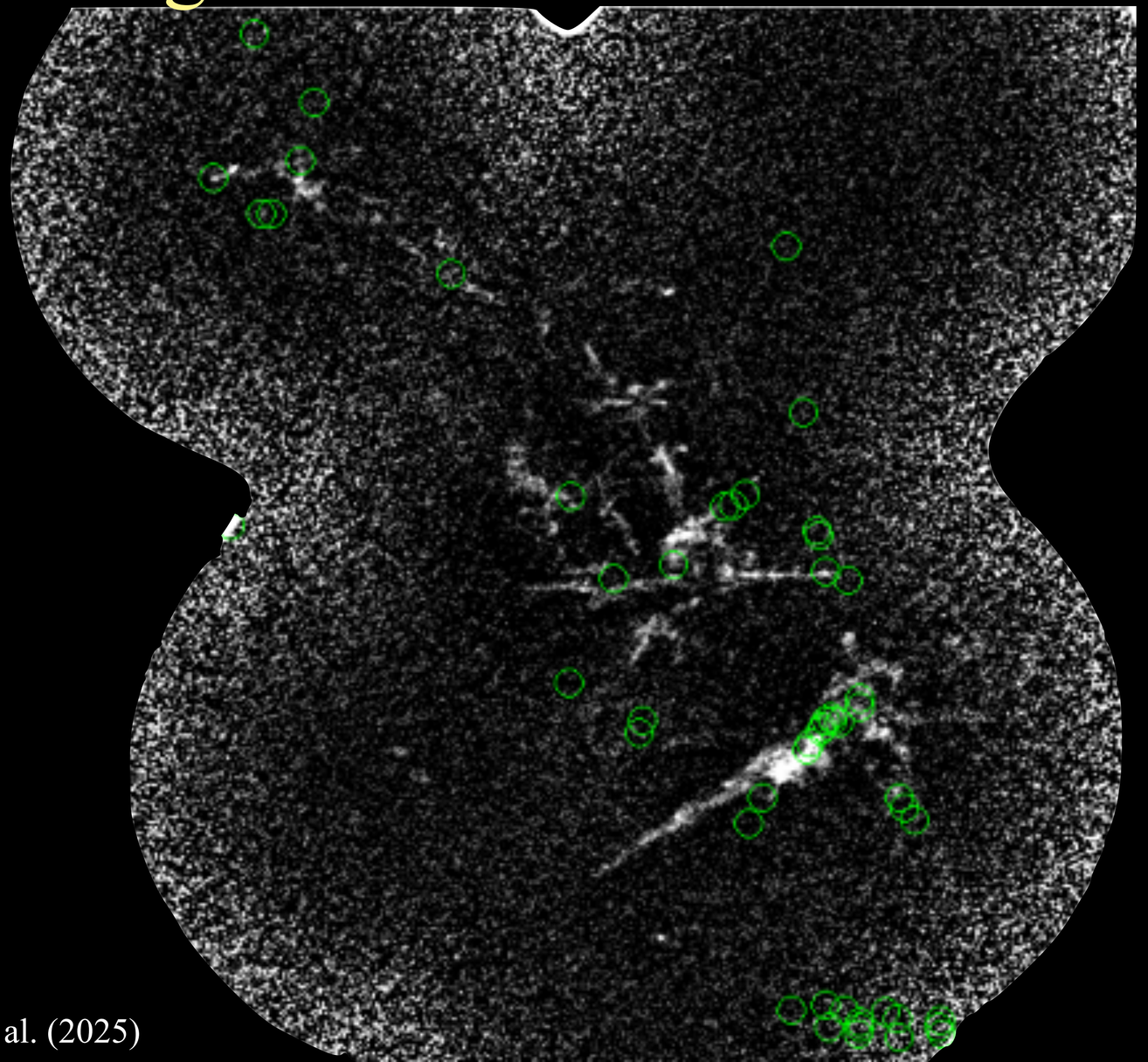
Outflow tracers in JWST and ALMA are strongly correlated



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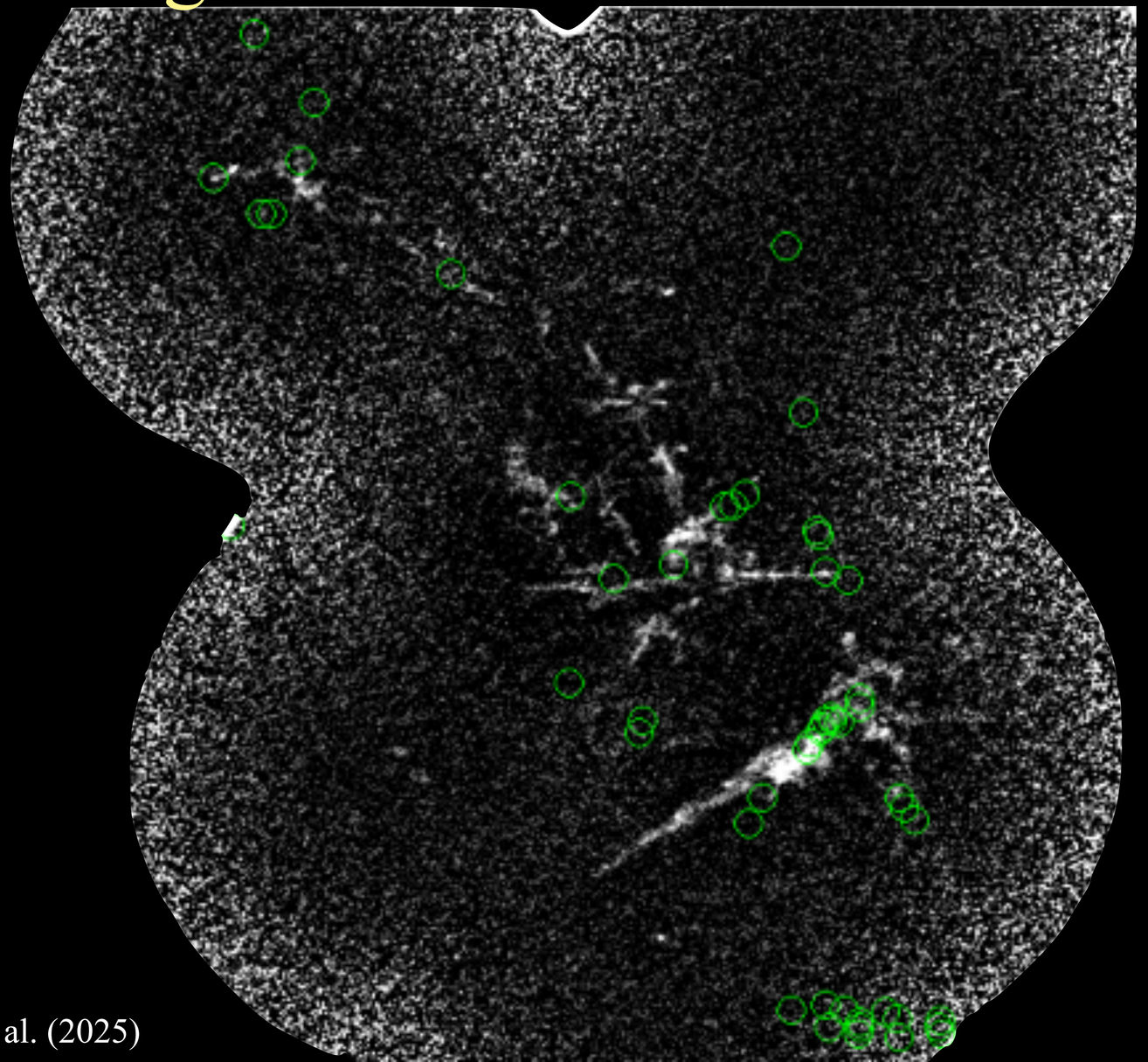
Conclusion: SgrC cloud is a clear stellar nursery!



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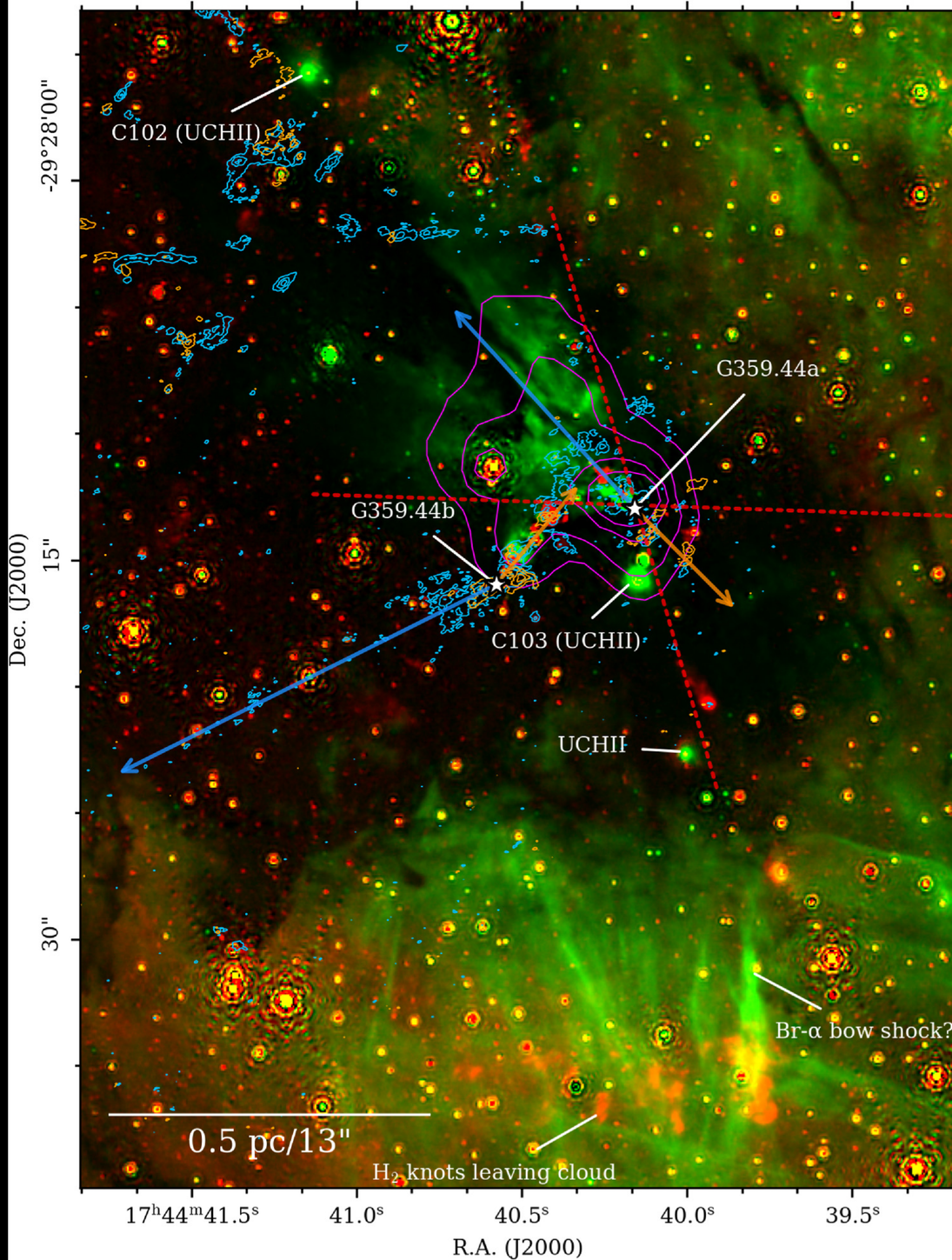
JWST+ALMA reveal shocks, jets, and cores throughout the SgrC cloud

F470N-cont (H_2) *F405N-cont (Brα)* ☆ *Main protostars*

ALMA Band 6 SiO 5–4 blueshifted (-80 to -51 km/s)

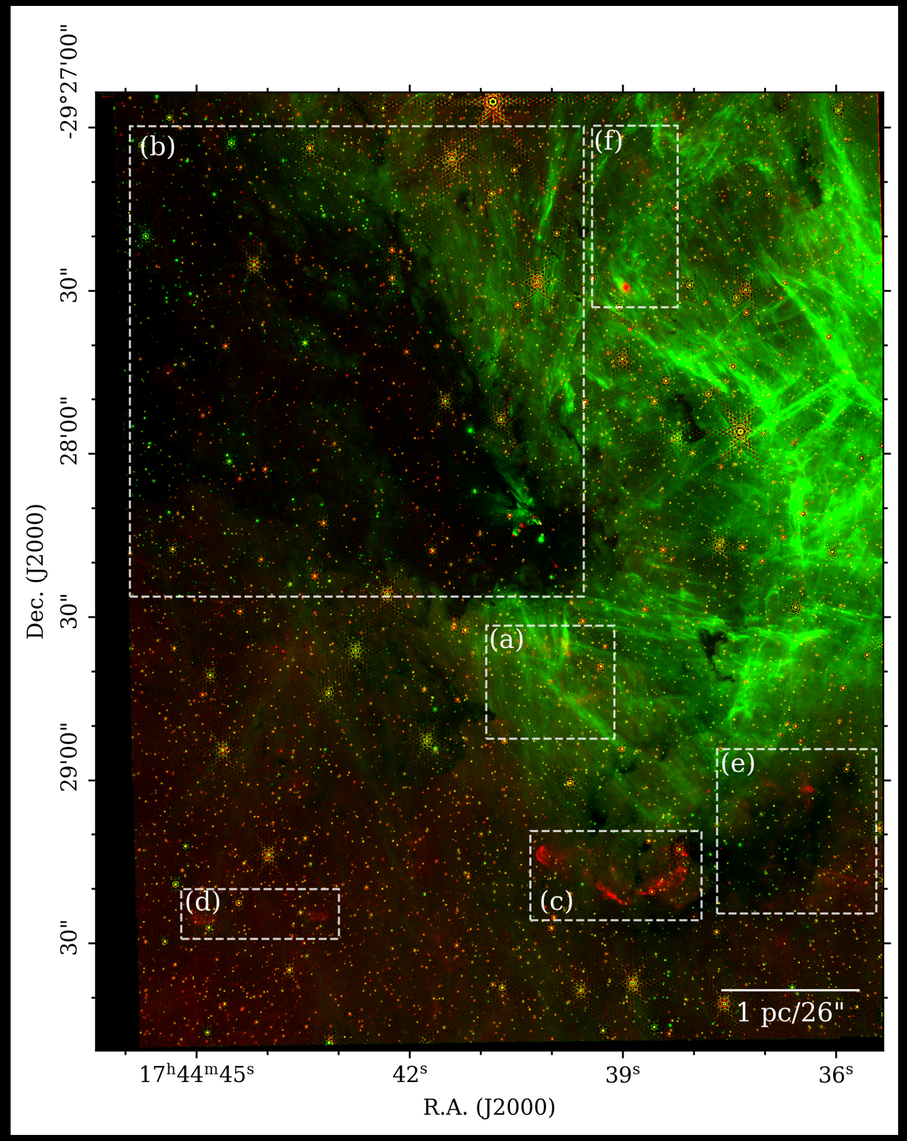
ALMA Band 6 SiO 5–4 redshifted (-48 to -25 km/s)

IRAC2 4.5μm



Lu et al. (2021); Crowe, et al. (2025)

Newly discovered star forming region - G359.42-0.104



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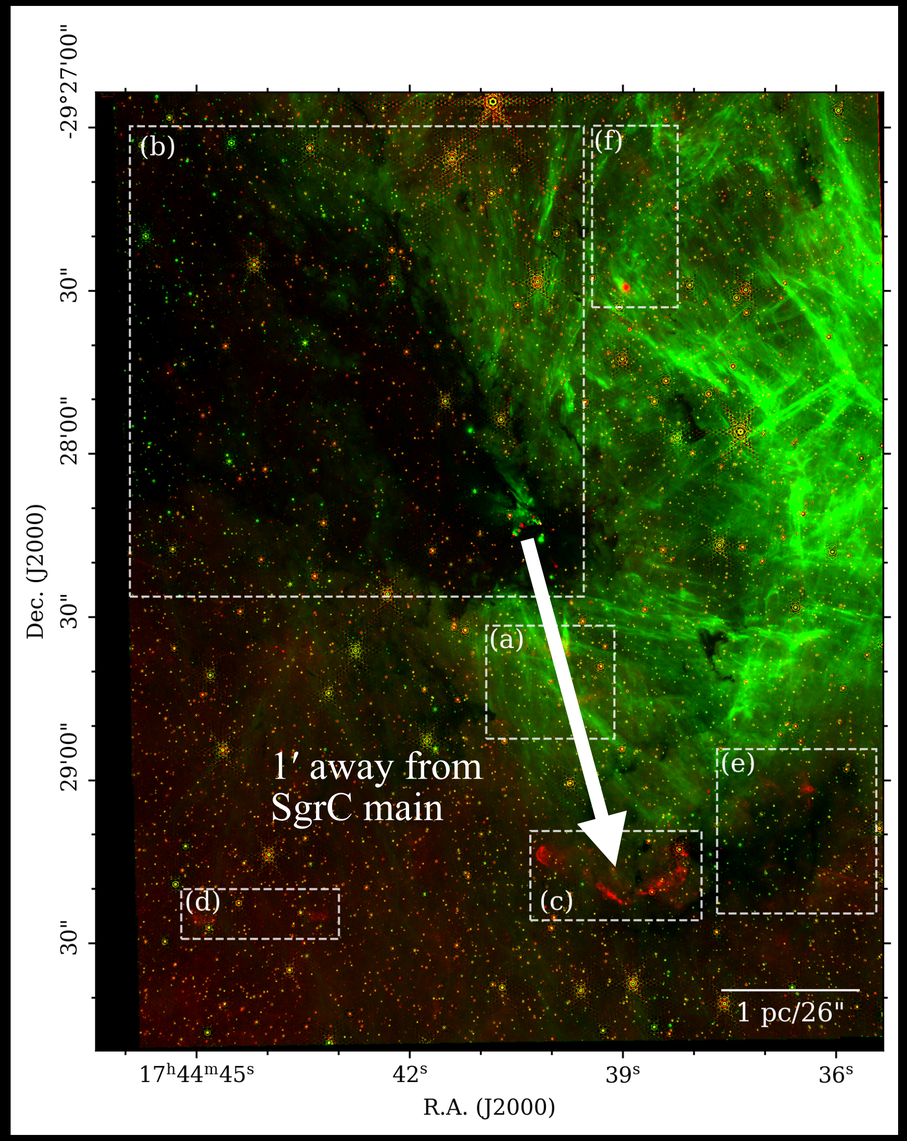

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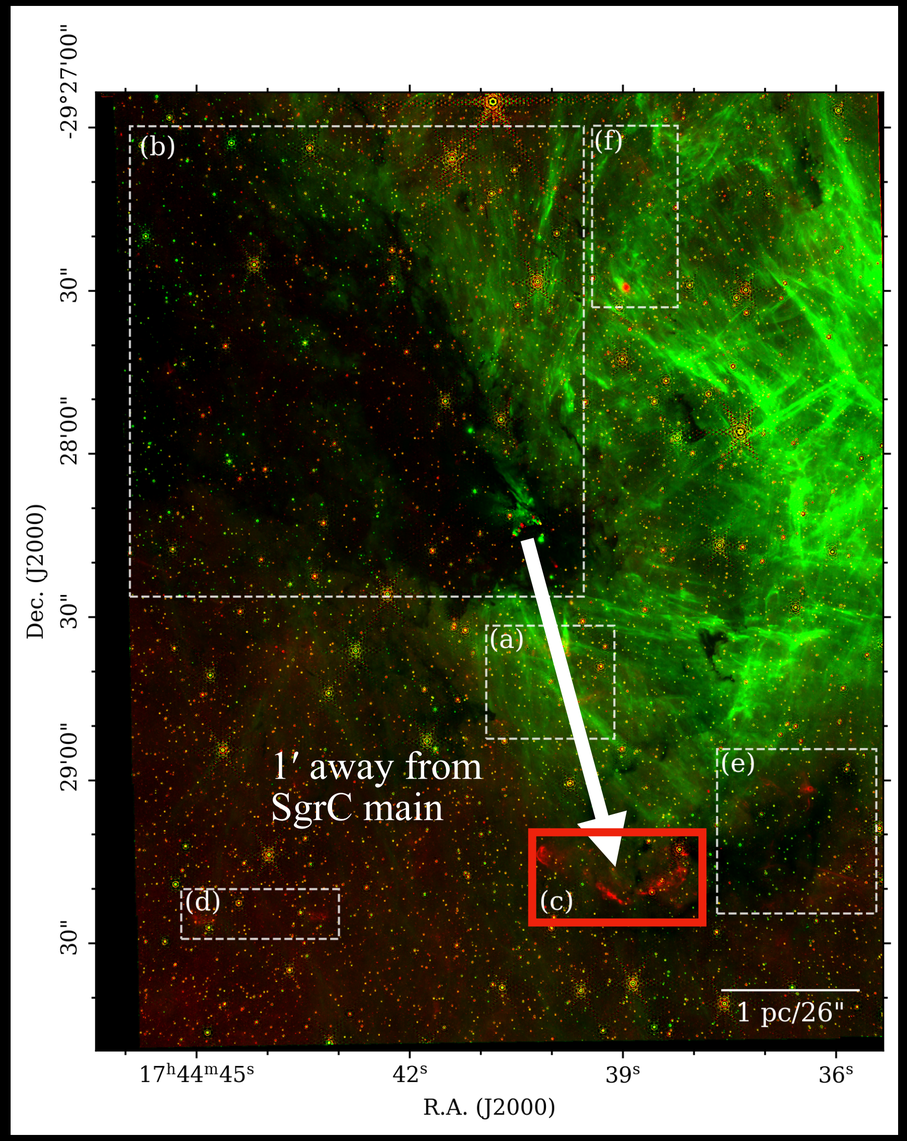

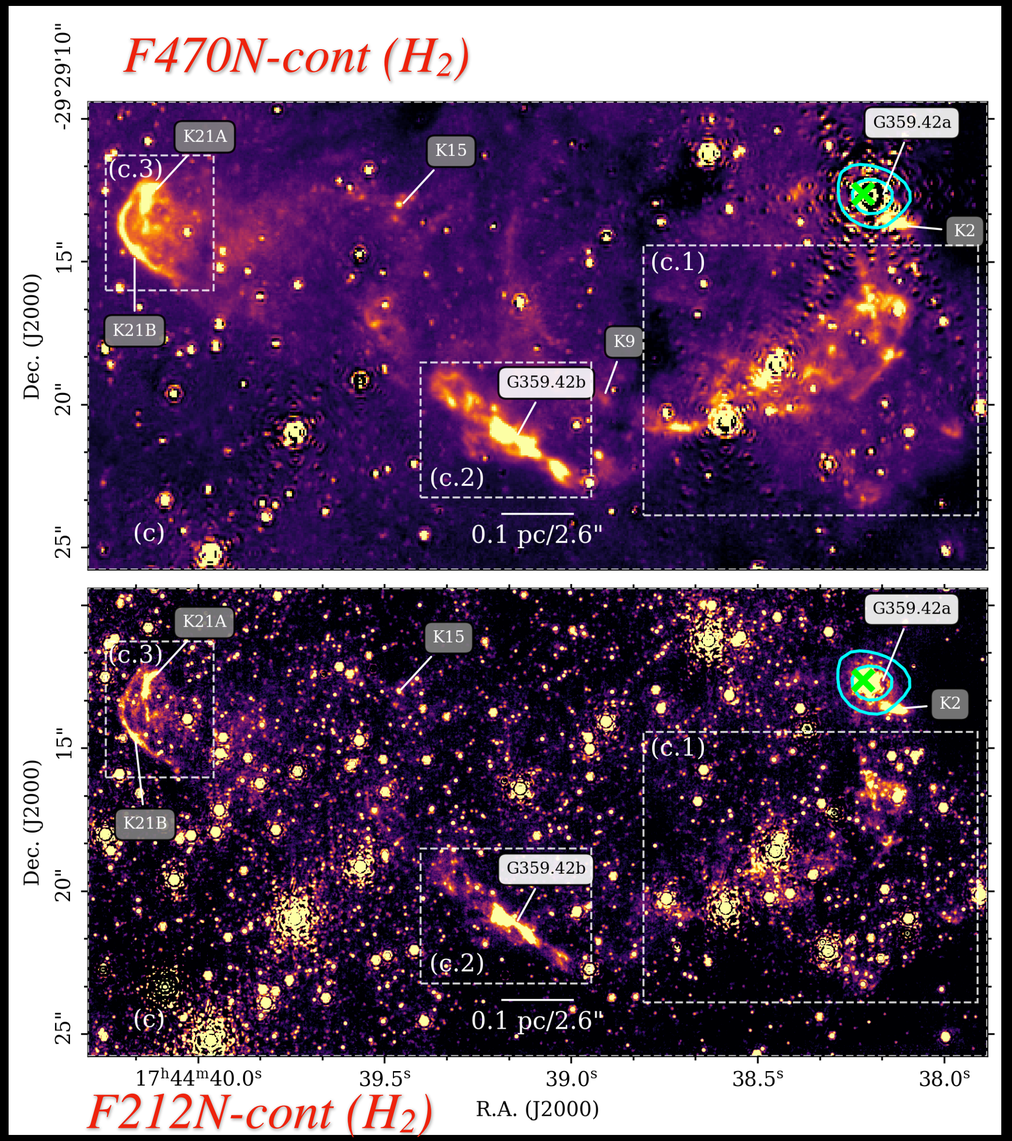

ALMA 3mm
(ACES Survey)

Crowe, et al. (2025)

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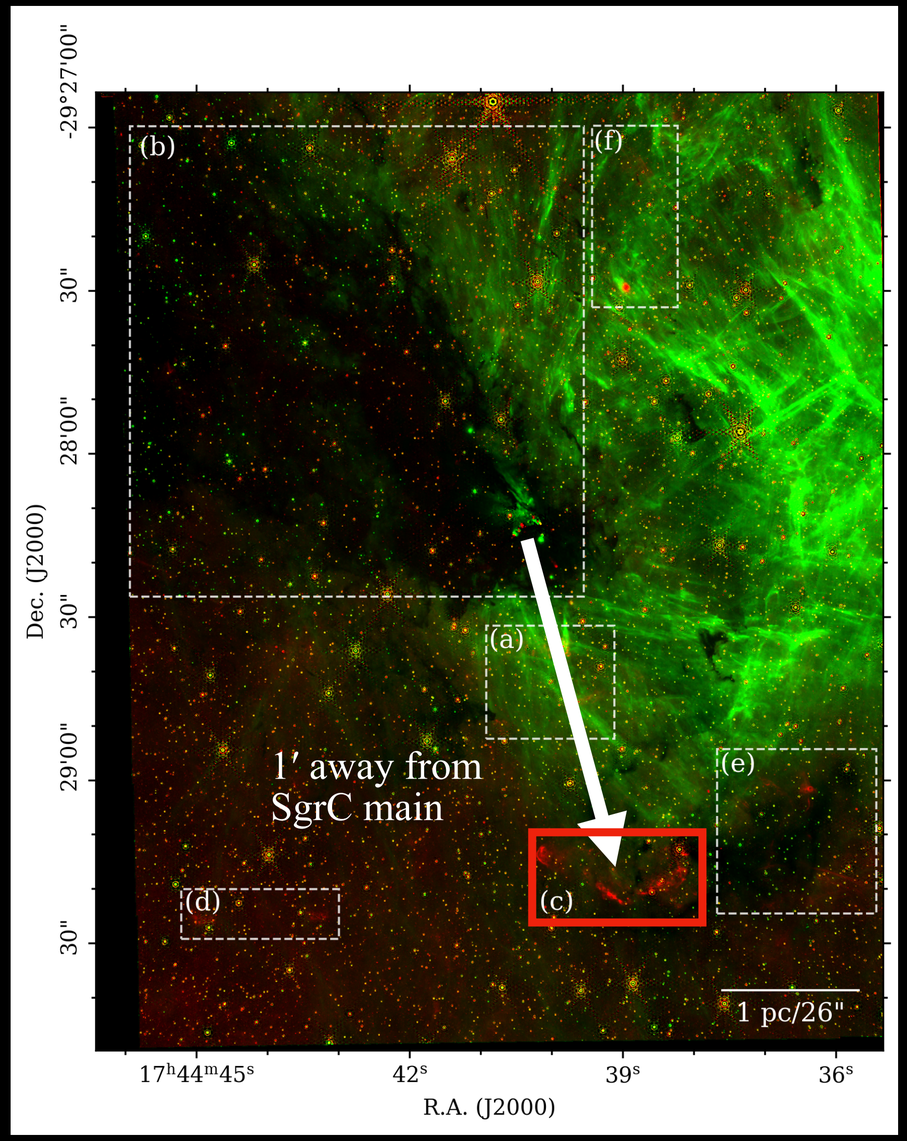

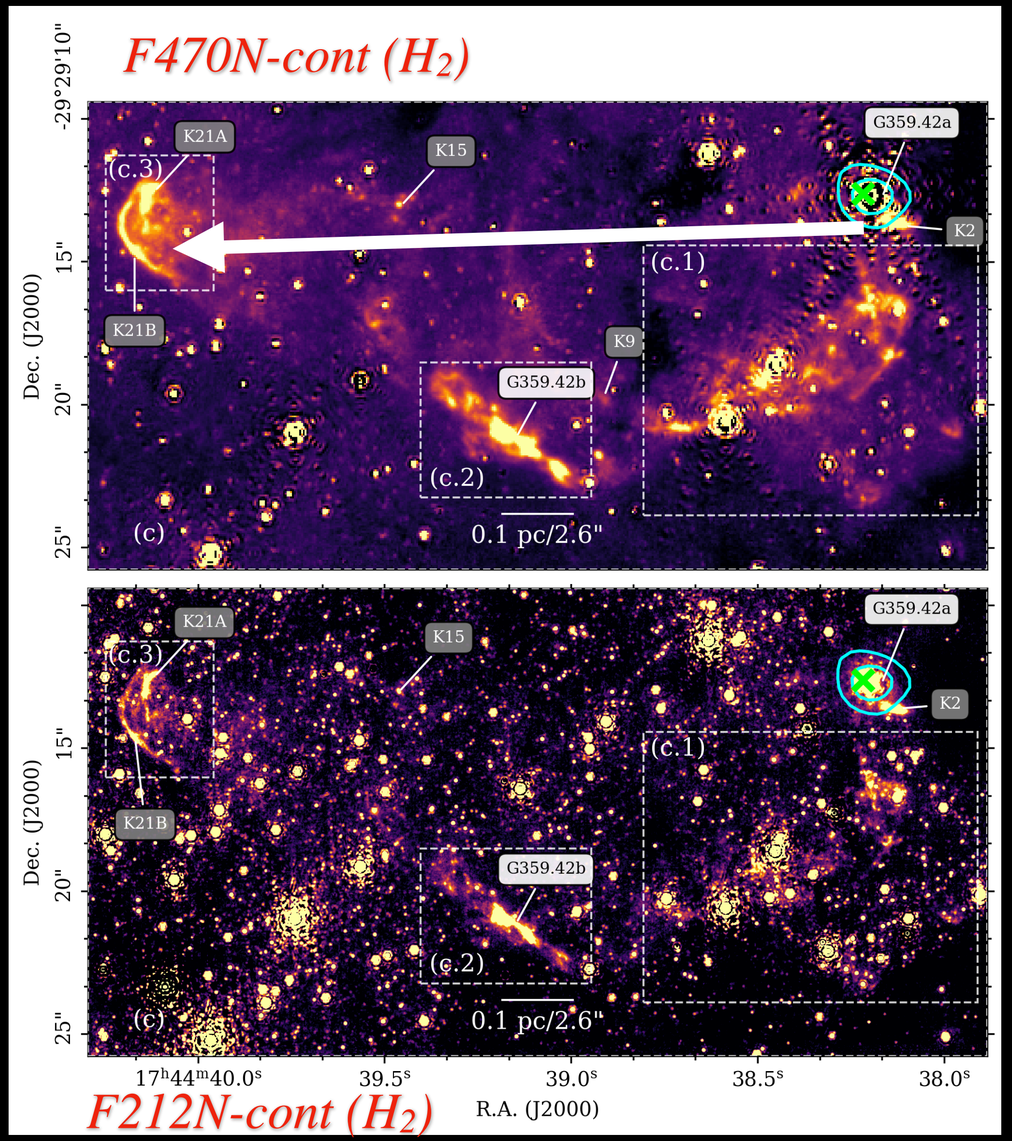

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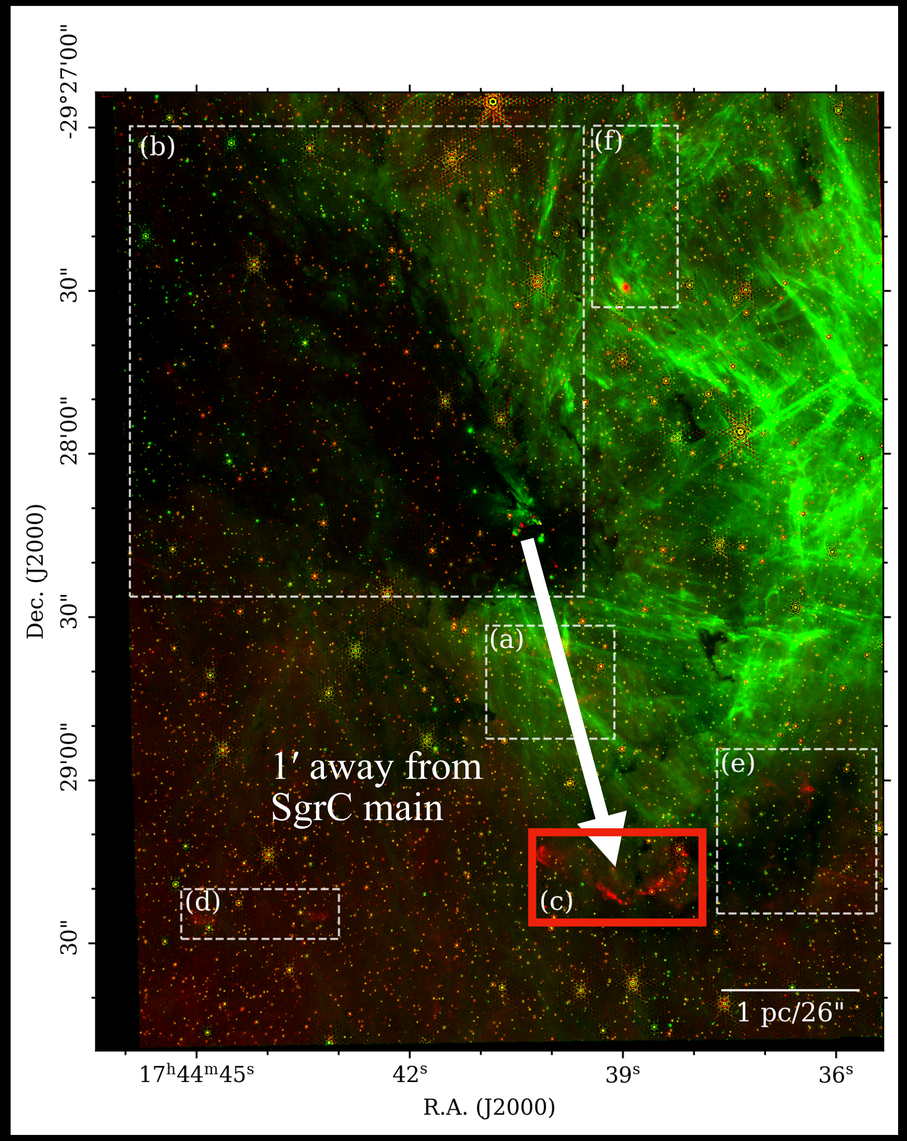

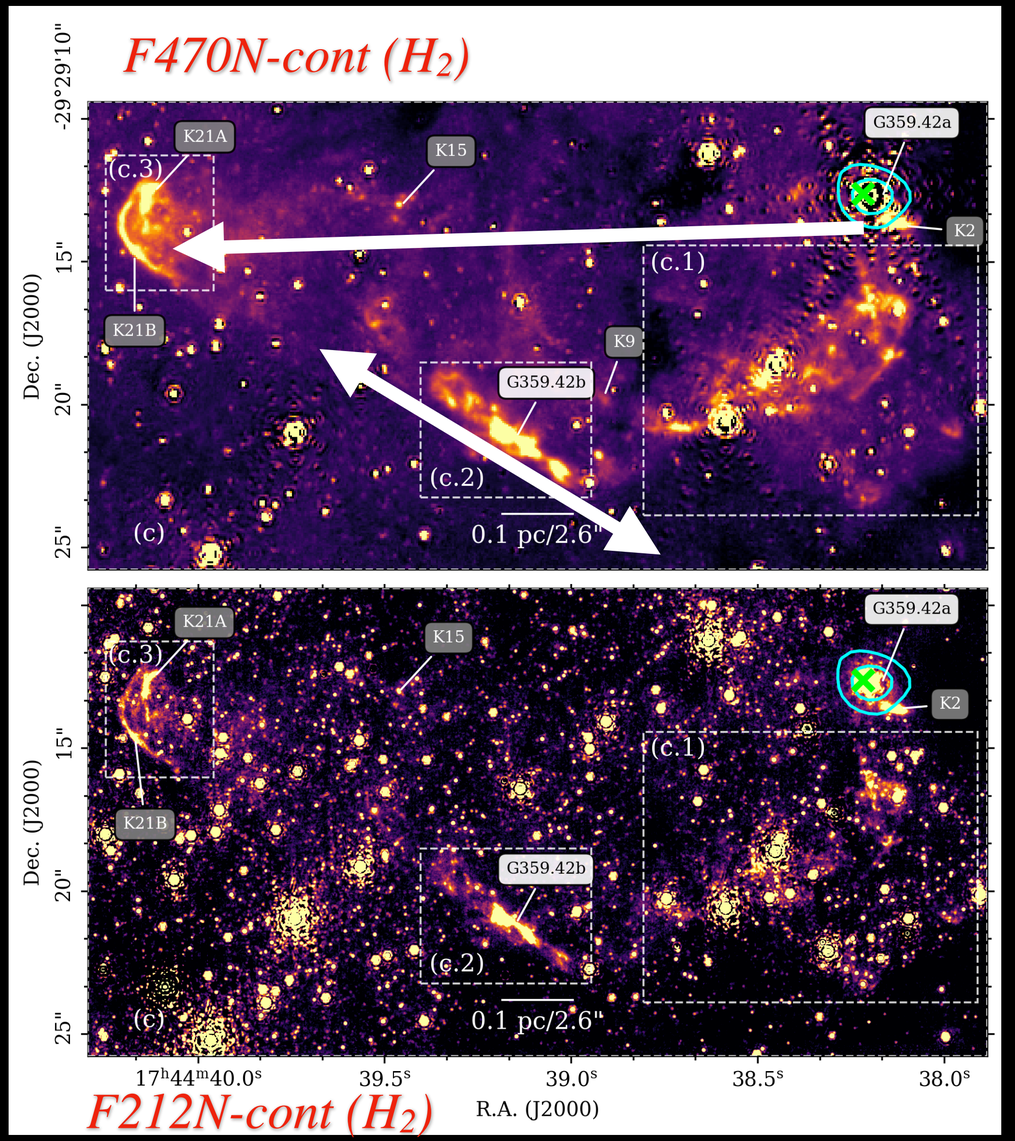

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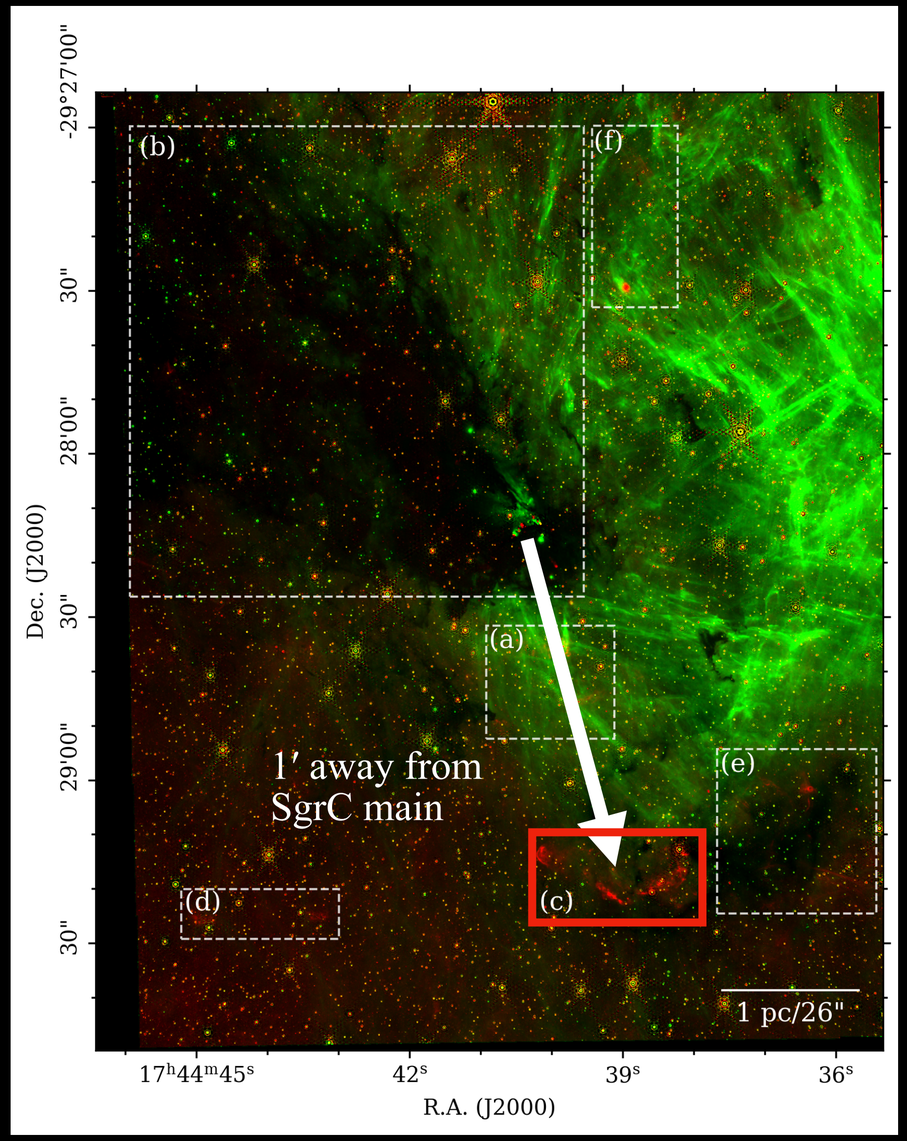

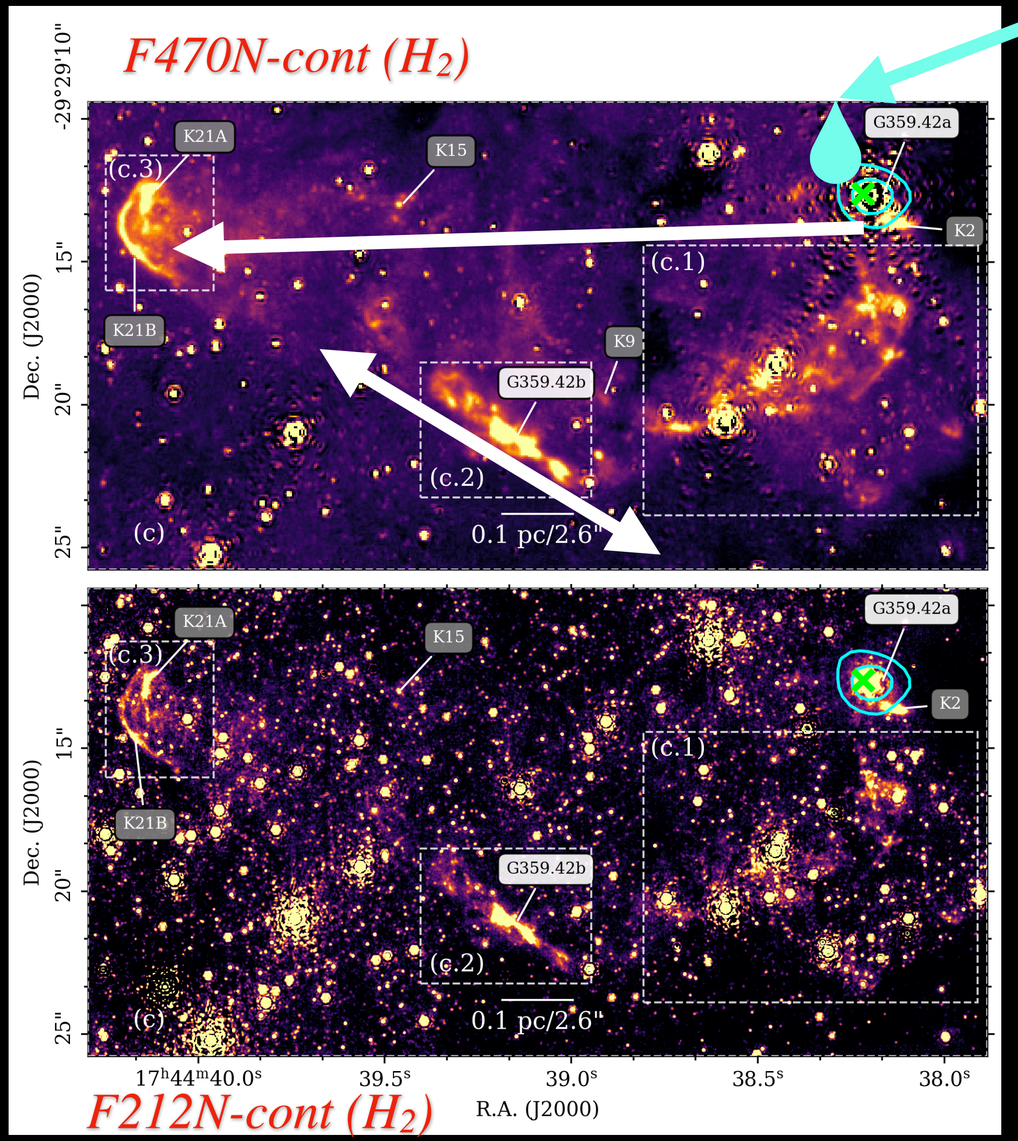

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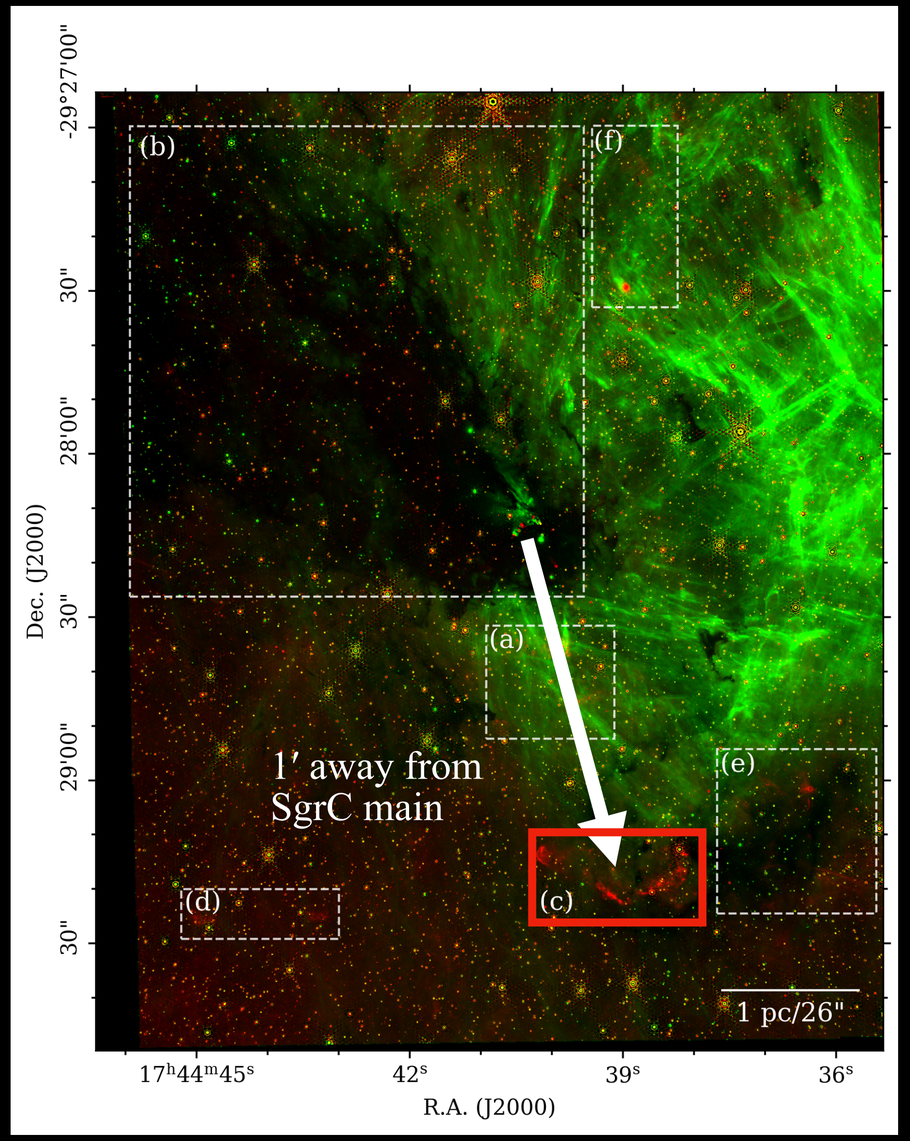

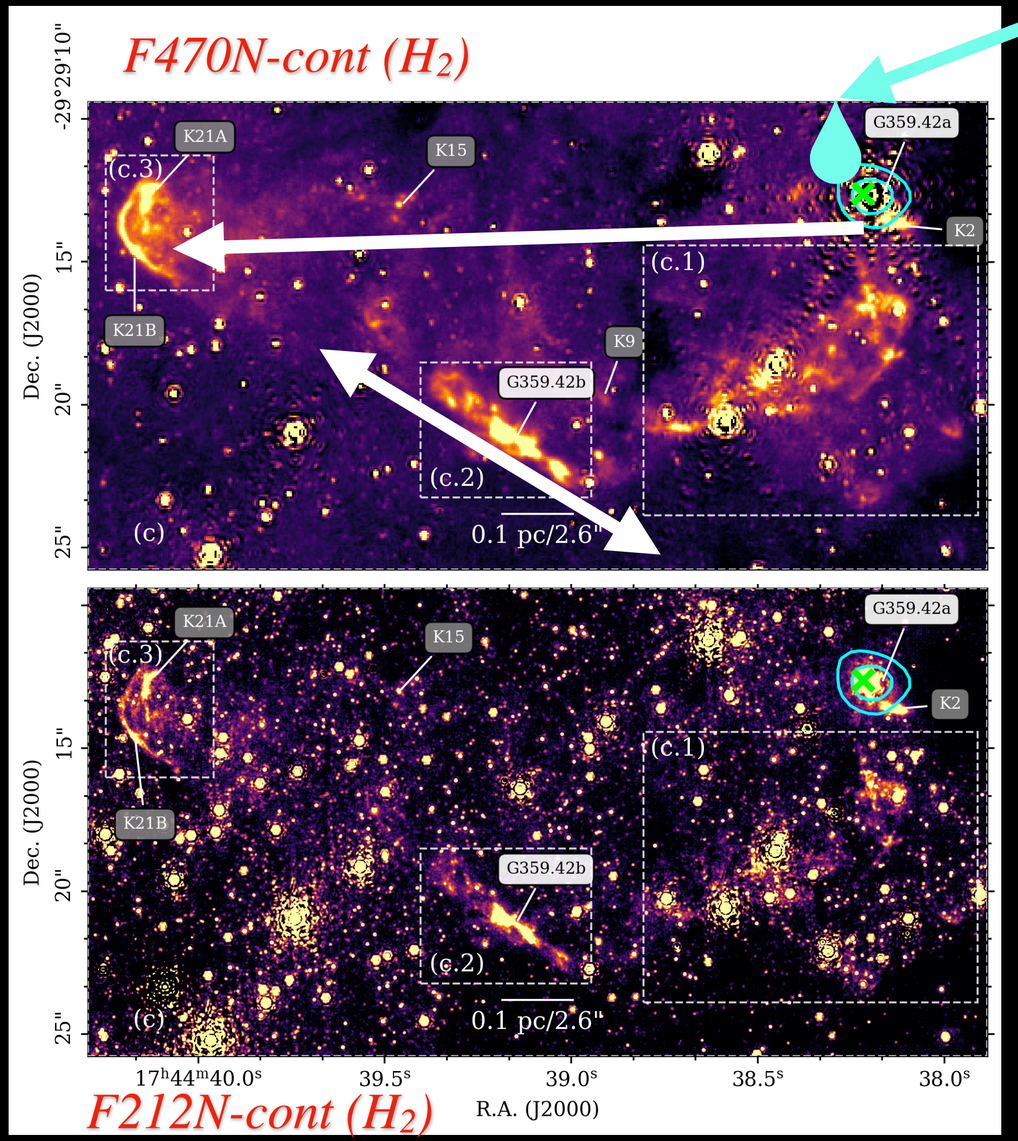

Lu, et al. (2019a)

ALMA 3mm (ACES Survey)

SED-fitted mass

~8 $M_\odot$

Crowe, et al. (2025)

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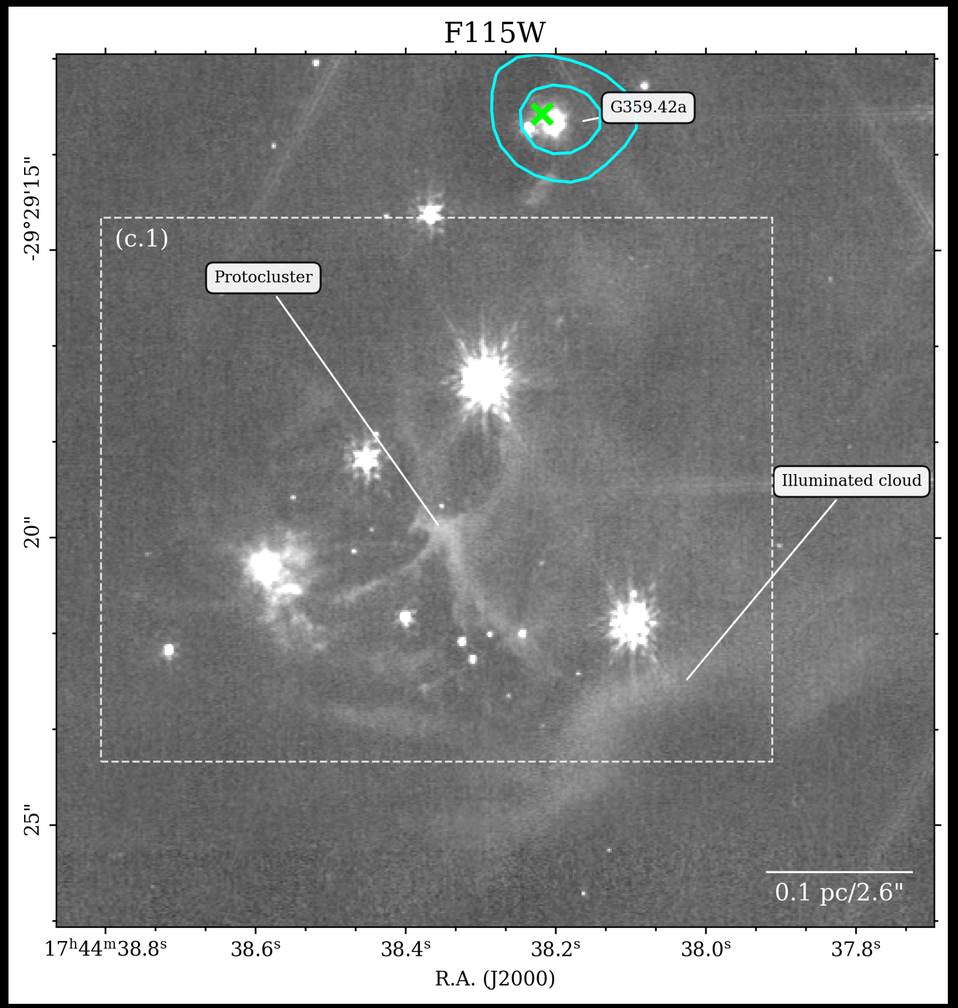

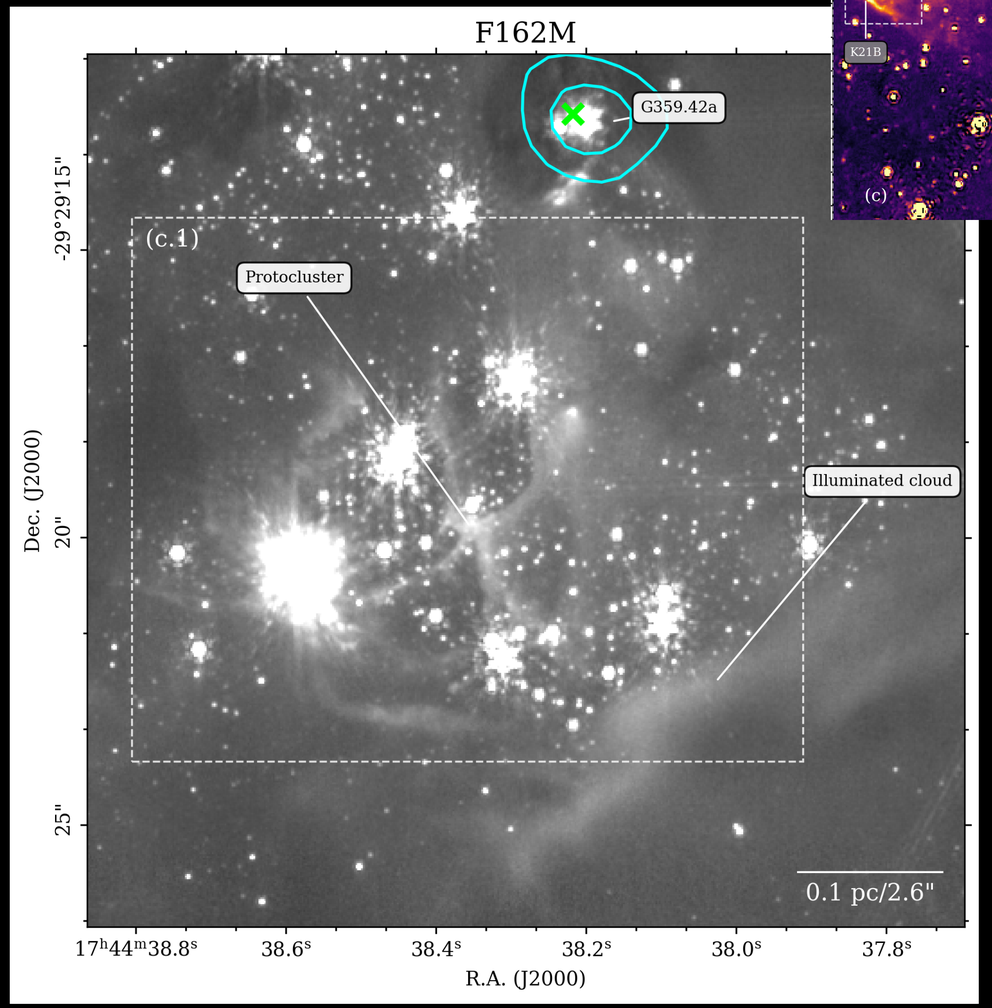

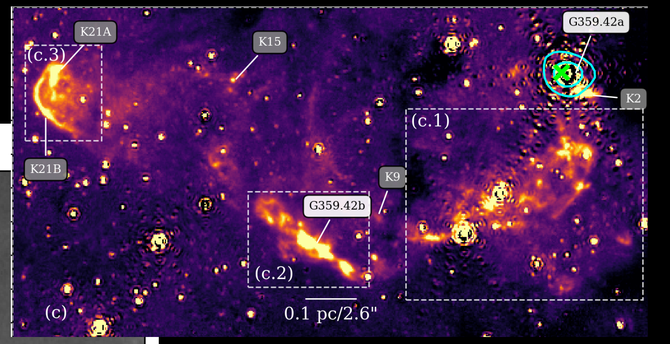

Crowe, et al. (2025)

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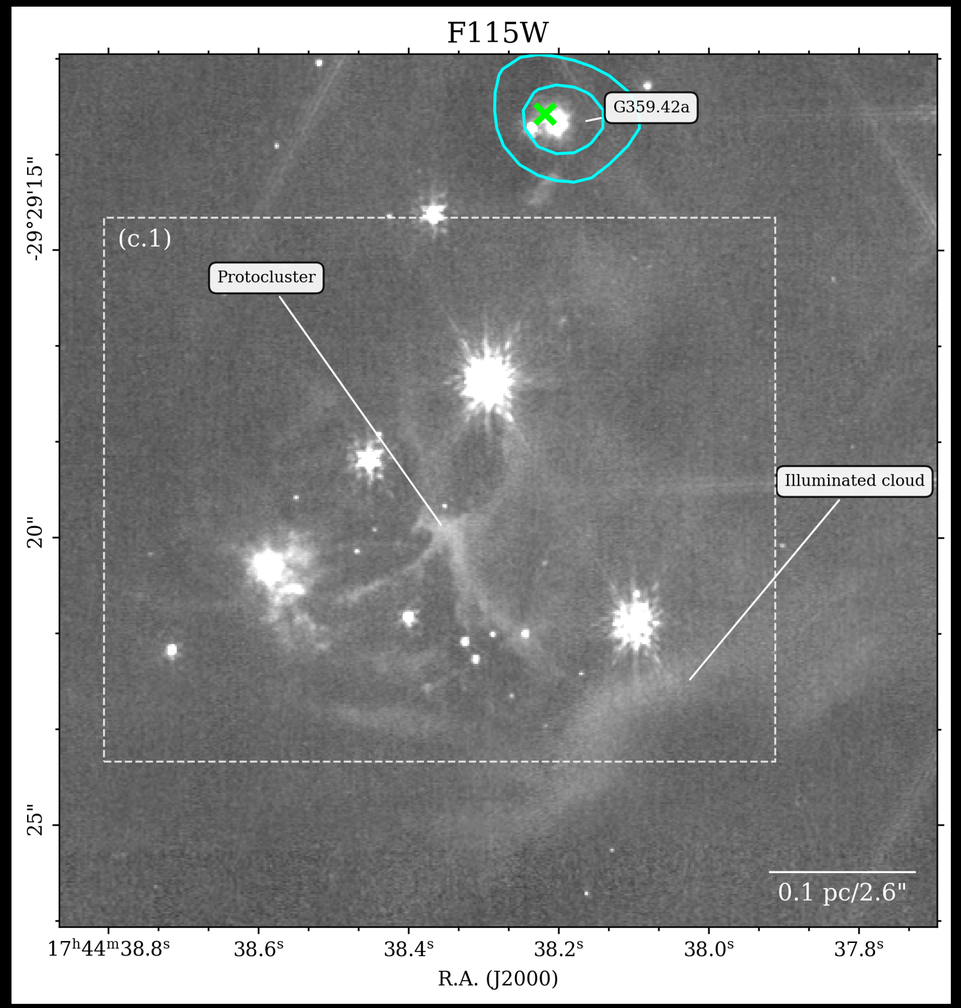
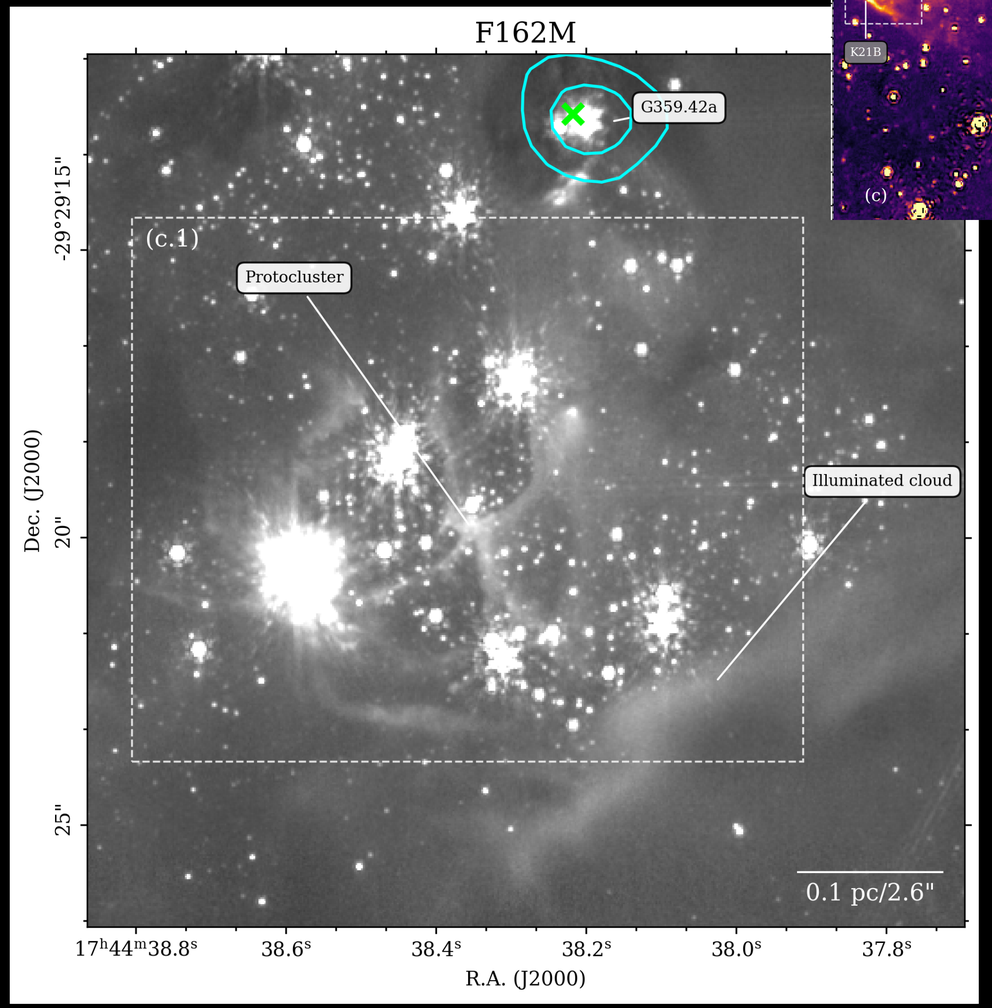
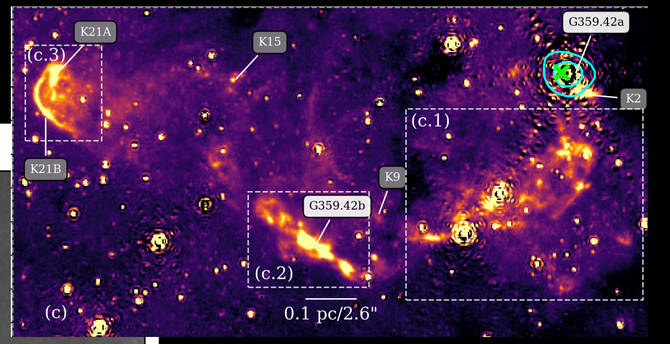






ALMA 3mm (ACES Survey)

Crowe, et al. (2025)

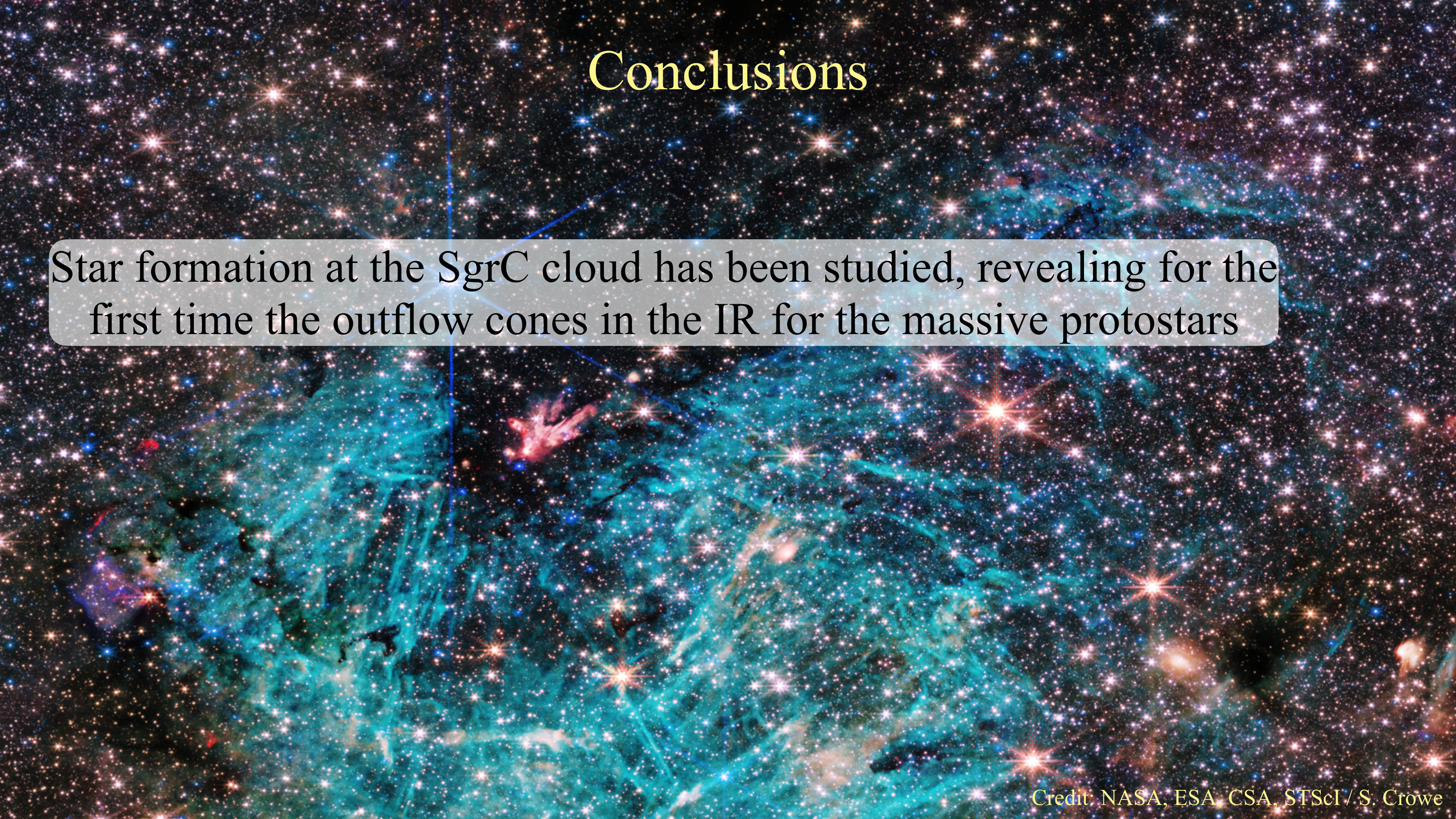
Conclusions



Credit: NASA, ESA, CSA, STScI / S. Crowe

Conclusions

Star formation at the SgrC cloud has been studied, revealing for the first time the outflow cones in the IR for the massive protostars



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A new star-forming region at 1′ to the south of SgrC main has been discovered via its outflow activity

Credit: NASA, ESA, CSA, STScI / S. Crowe

Conclusions

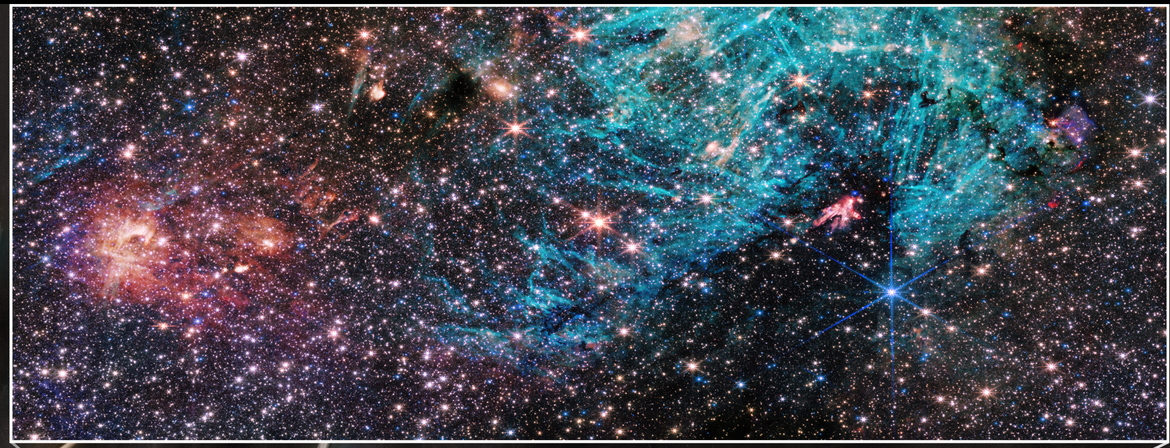
Star formation at the SgrC cloud has been studied, revealing for the first time the outflow cones in the IR for the massive protostars

A new star-forming region at 1′ to the south of SgrC main has been discovered via its outflow activity

The star formation in SgrC at the CMZ seems to proceed similarly as in the rest of the galaxy

Credit: NASA, ESA, CSA, STScI / S. Crowe

Thanks!



Credit: NASA, ESA, CSA, STScI, SARAO
S. Crowe (UVA), J. Bally (CU)
R. Fedriani (IAA-CSIC), I. Heywood (Oxford)