

NASA/SOFIA/Hankins et al.; JPL-Caltech/S.Stolovy;  
ESA ESA/Herschel/PACS, SPIRE/Hi-GAL Project

# The SOFIA/FORCAST Galactic Center Legacy Survey

*Matt Hankins, Caltech*

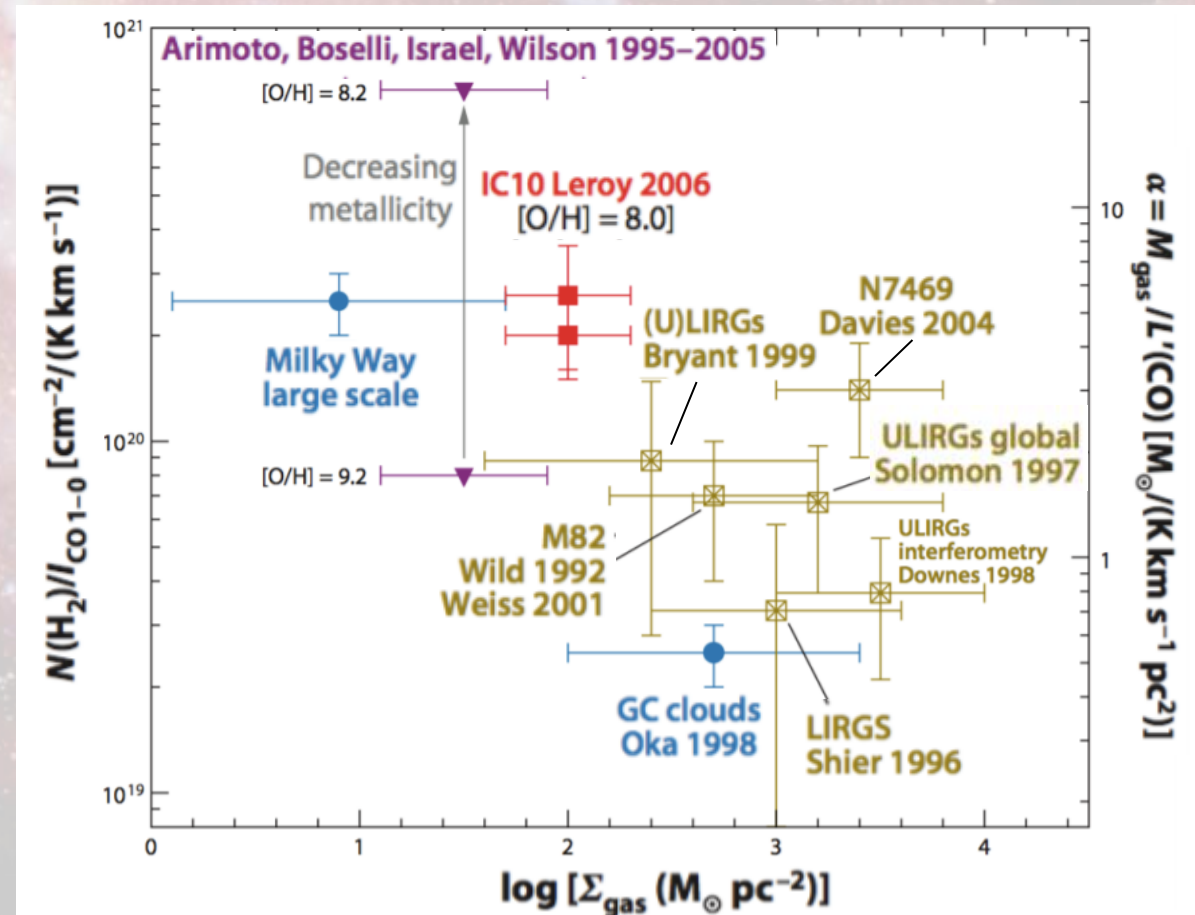
*SOFIA Tele-talk*

*May 6, 2020*



# Why Study the Galactic Center (GC)?

- Unique star formation environment within our own Galaxy:
  - high gas density
  - large turbulent motions
  - high temperatures
  - Strong and complex magnetic fields
  - deep gravitational potential well



# Testing Theories of GC Star Formation

Representation of Kruijssen+ 2015 Orbital Model

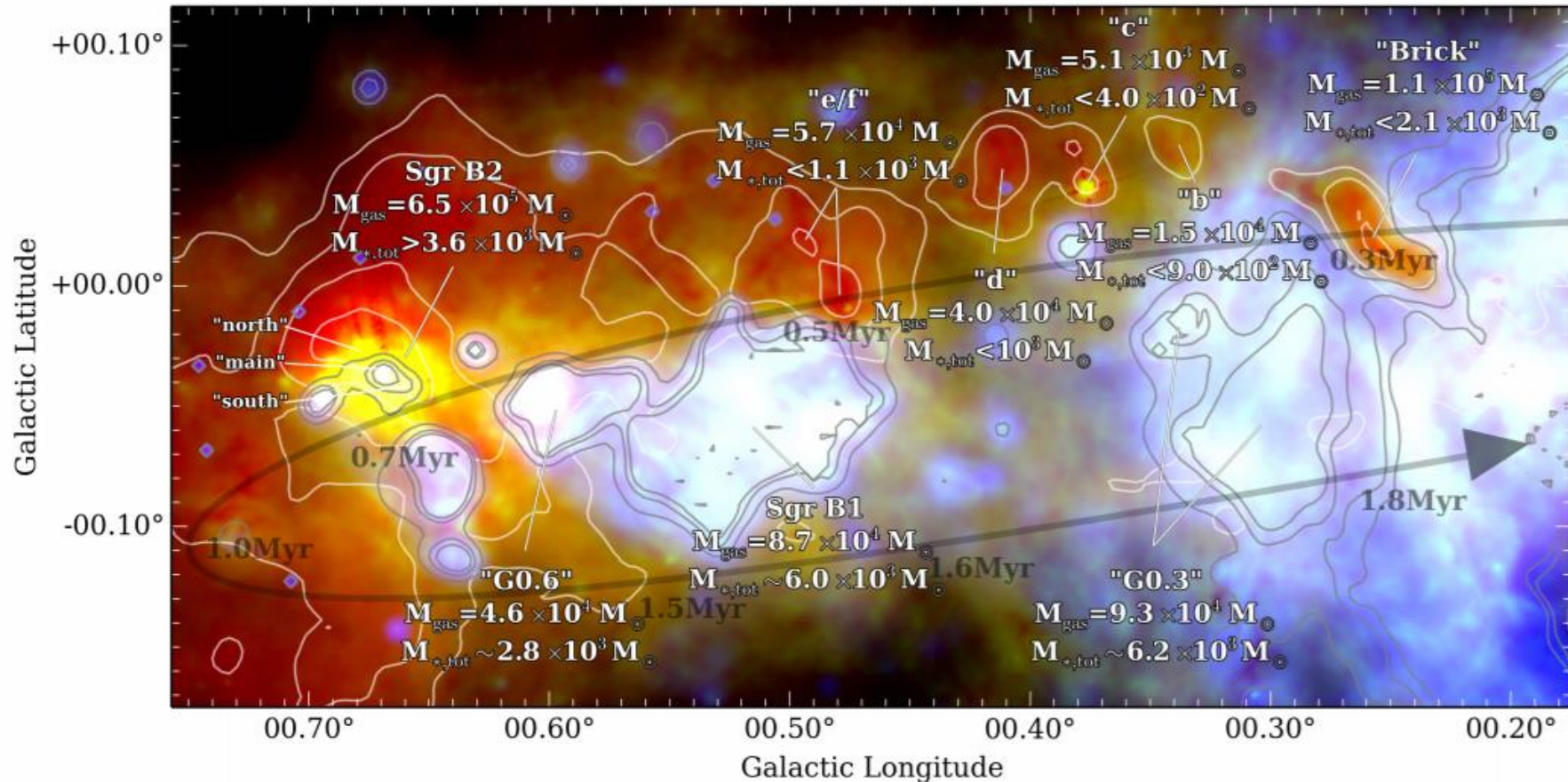
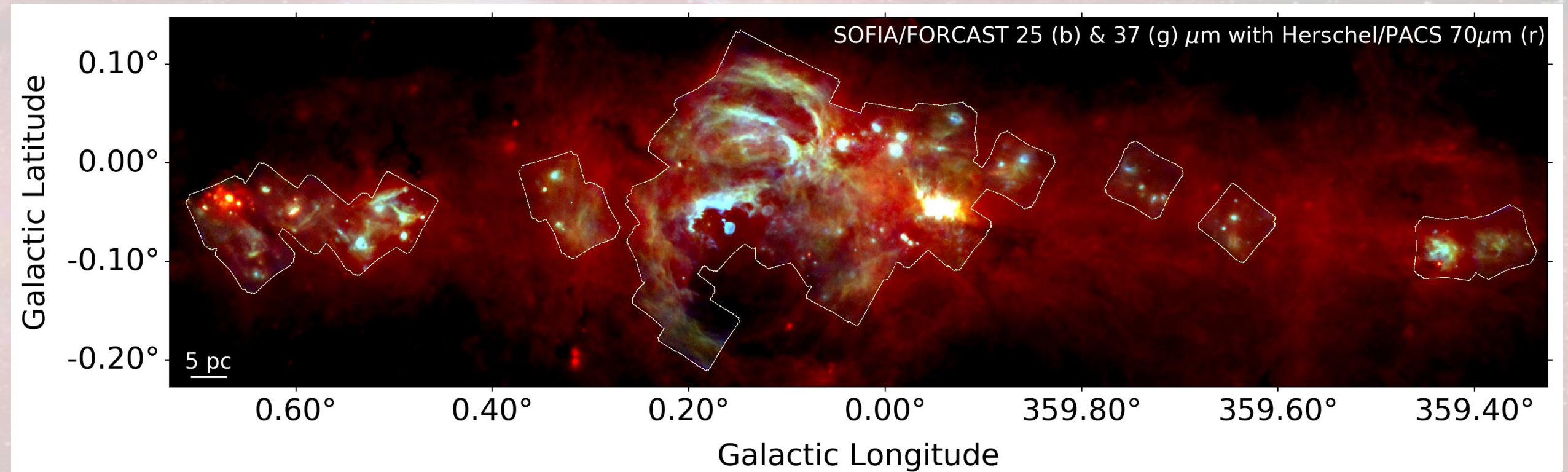


Figure from Barnes+ 2017

- Rich in dense molecular gas:  $\sim 10^7 M_{\text{sun}}$
- Global GC Star formation rate:  $\sim 0.1 M_{\text{sun}} \text{ yr}^{-1}$
- What suppresses star formation in the region?

# The SOFIA/FORCAST Galactic Center Survey:

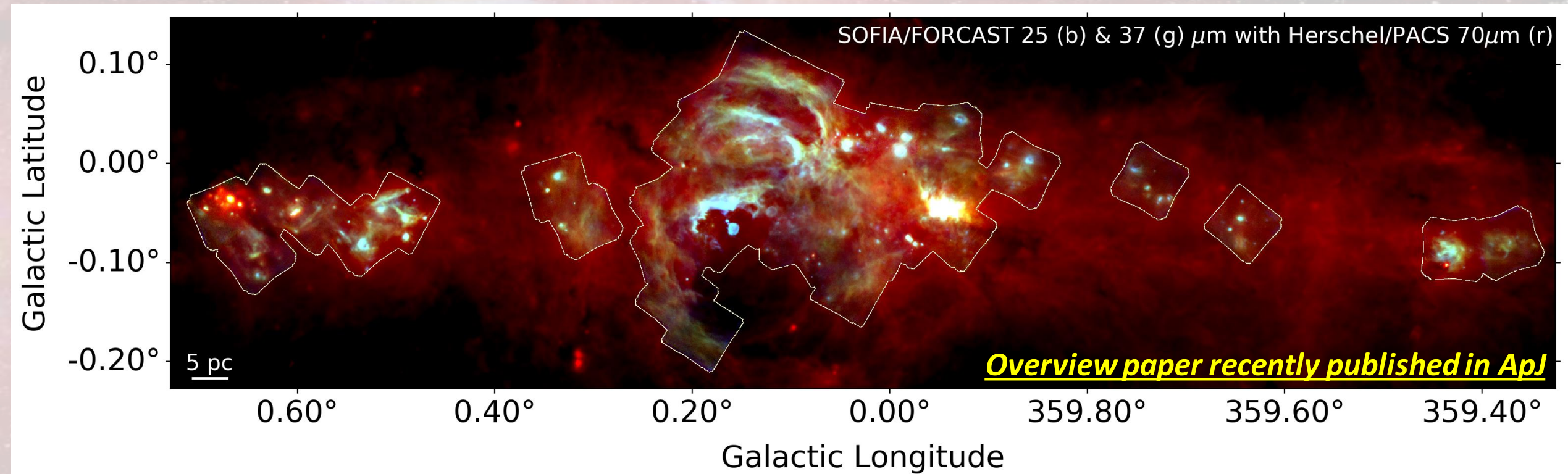
*Mapping the most active portions of the GC at 25 and 37  $\mu\text{m}$*



**Project Team:** Matt Hankins (PI, Caltech), Ryan Lau (JAXA), Angela Coteria (SETI), Mark Morris (UCLA), James Radomski (SOFIA/USRA), Betsy Mills (Univ. Kansas), Daniel Walker (ALMA/NAOJ), Ashley Barnes (Univ. Bonn), Janet Simpson (SETI), Terry Heter (Cornell Univ.), Steven Longmore (LJMU), John Bally (UC Boulder), Mansi Kasliwal (Caltech), Nadeen Sabha (Univ. Innsbruck), Macarena Garcia-Marin (ESA)

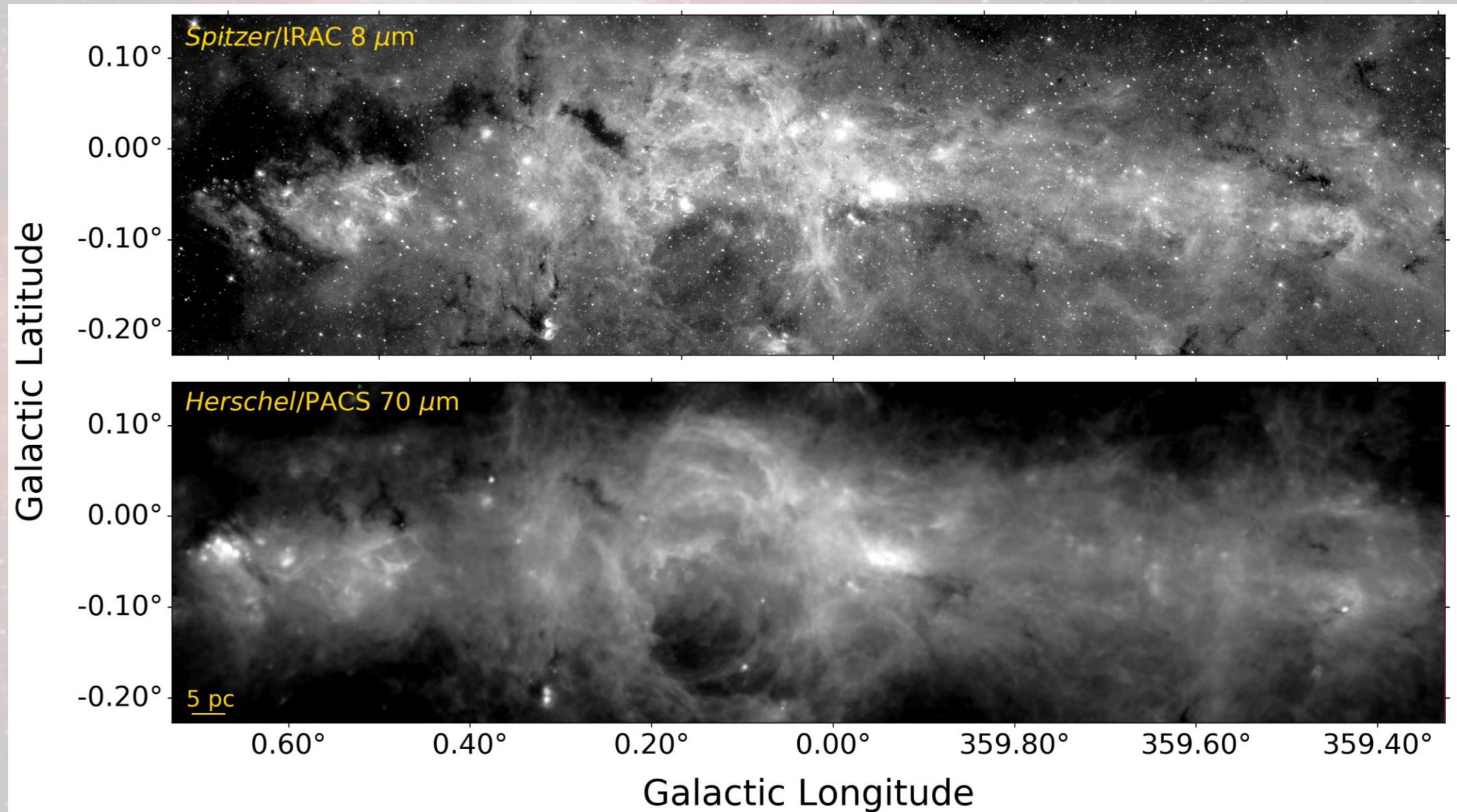
# The SOFIA/FORCAST Galactic Center Survey:

*Mapping the most active portions of the GC at 25 and 37  $\mu\text{m}$*

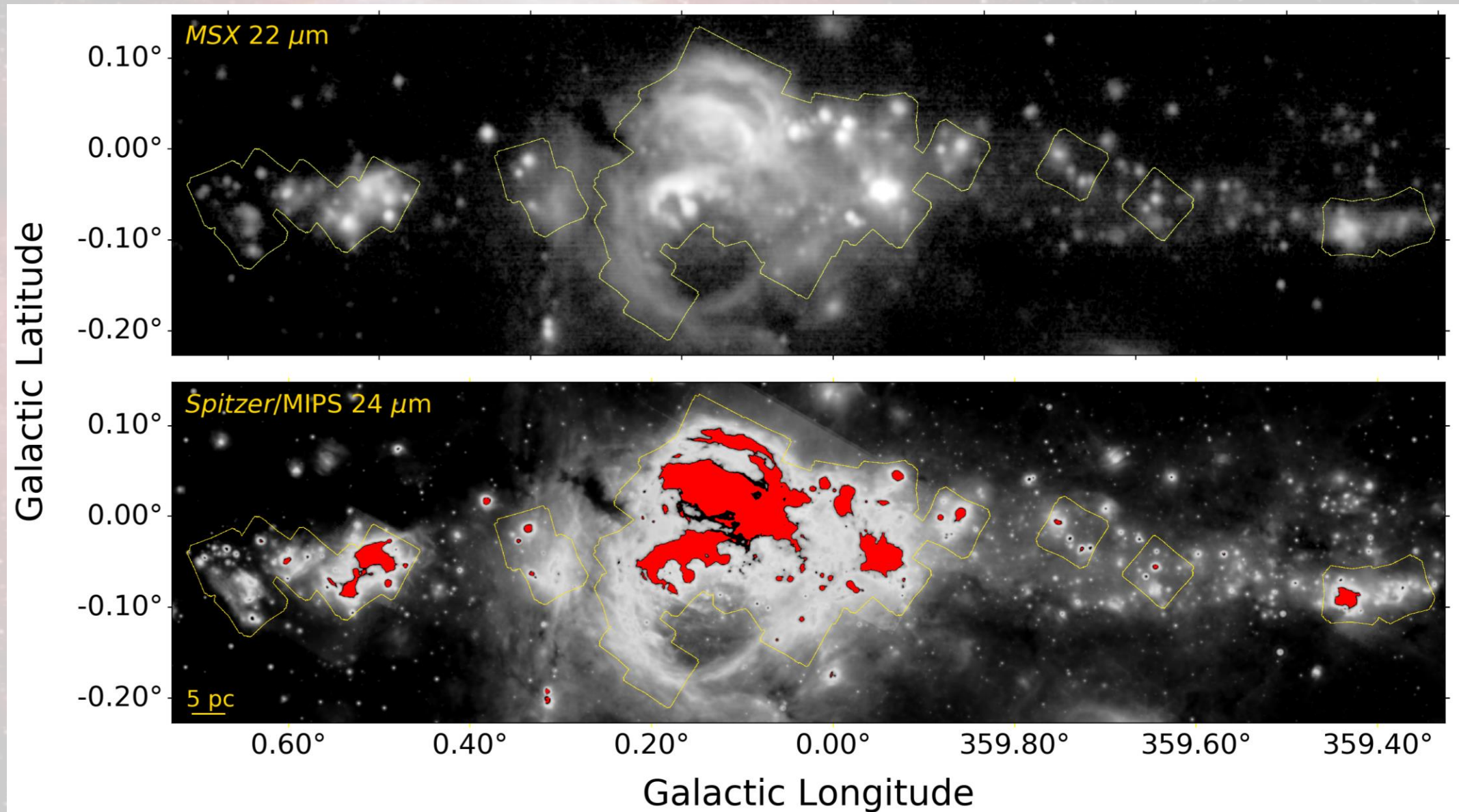


- Total of 42 fields: 35 observed in cycle 7 with 7 additional fields from earlier cycles
  - Covers 403 arcmin<sup>2</sup> (2180 pc<sup>2</sup>) including Sgr A, Sgr B, and Sgr C
  - Angular resolution: 2.3" ( $\sim 0.07$  pc) at 25  $\mu\text{m}$  & 3.4" ( $\sim 0.1$  pc) at 37  $\mu\text{m}$
  - Nominal point source sensitivity:  $\sim 250$  mJy at 25  $\mu\text{m}$  &  $\sim 400$  mJy at 37  $\mu\text{m}$

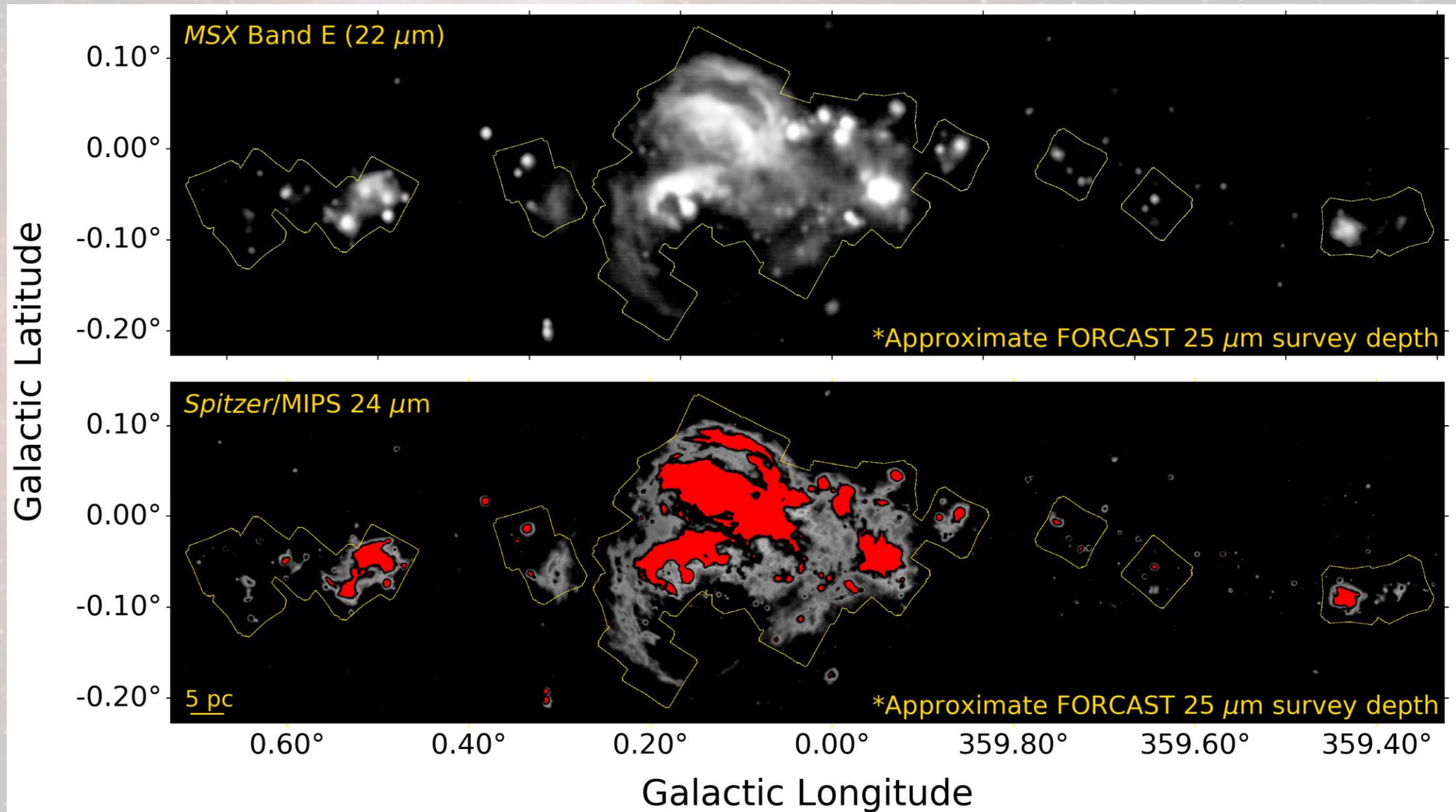
# The Galactic Center at IR Wavelengths



# Warm Dust Emission in the Mid-IR



# Warm Dust Emission in the Mid-IR





# FORCAST

## Faint **O**bject inf**R**ared **C**amera for the **S**ofia **T**elescope

### Dual-Channel Camera

- Short Wave: 5-25  $\mu\text{m}$
- Long Wave: 25-37  $\mu\text{m}$

### Camera Properties

- FOV: 3.2' x 3.2'
- Plate Scale: 0.768"x0.768"

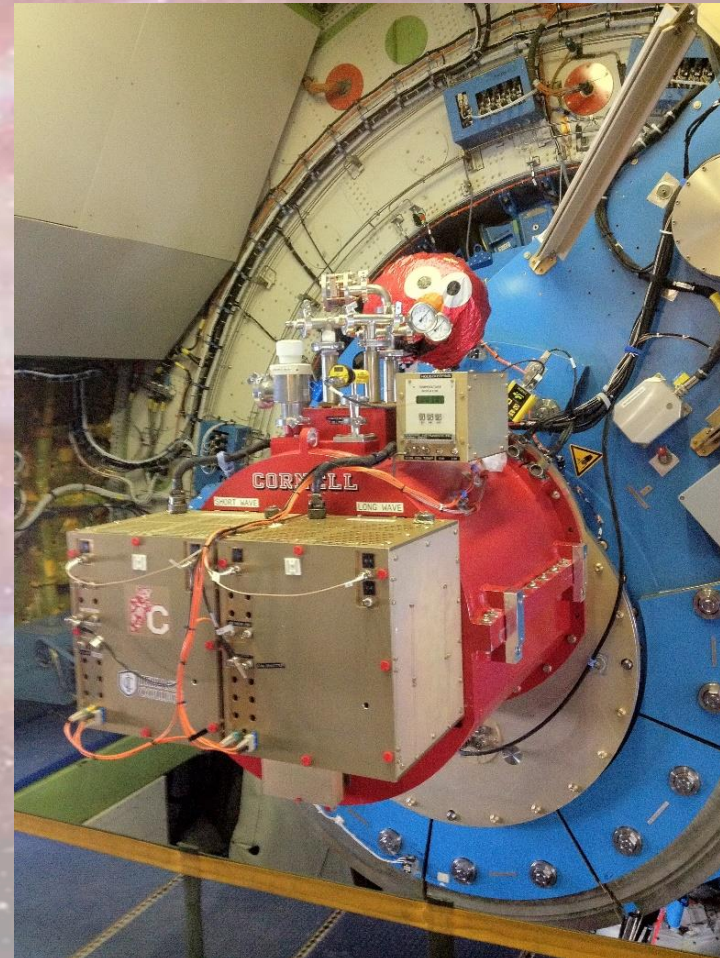


Photo Credit George Gull

# Star Formation in the GC: A Tale of Two Clouds

SOFIA/FORCAST 25 & 37  $\mu\text{m}$  with Herschel/PACS 70  $\mu\text{m}$



# Star Formation in the GC: A Tale of Two Clouds

SOFIA/FORCAST 25 & 37  $\mu\text{m}$  with Herschel/PACS 70  $\mu\text{m}$



The 'Brick'

Dense but little star formation!

# Star Formation in the GC: A Tale of Two Clouds

SOFIA/FORCAST 25 & 37  $\mu\text{m}$  with Herschel/PACS 70  $\mu\text{m}$



The 'Brick'

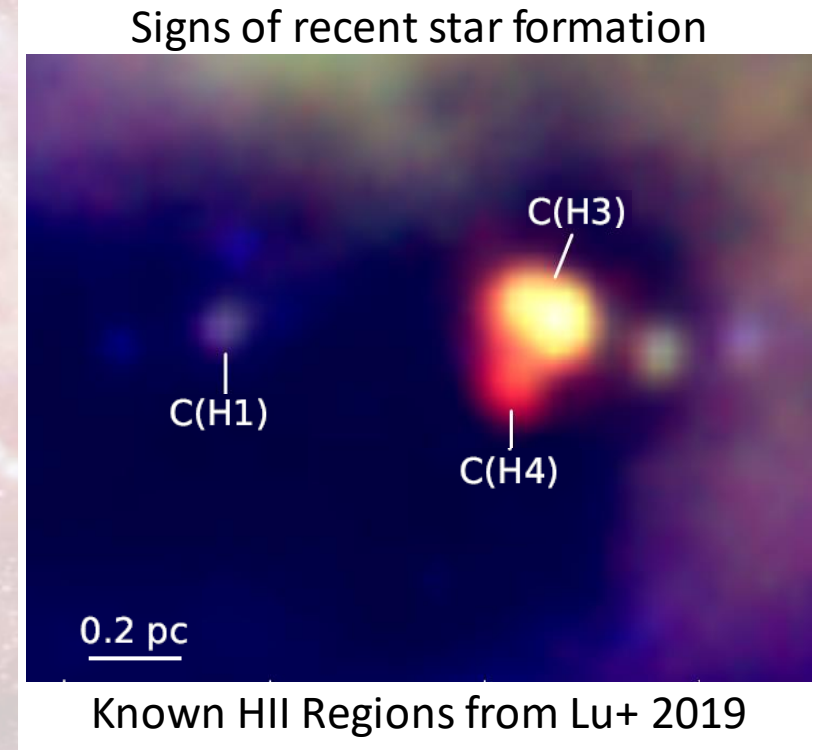
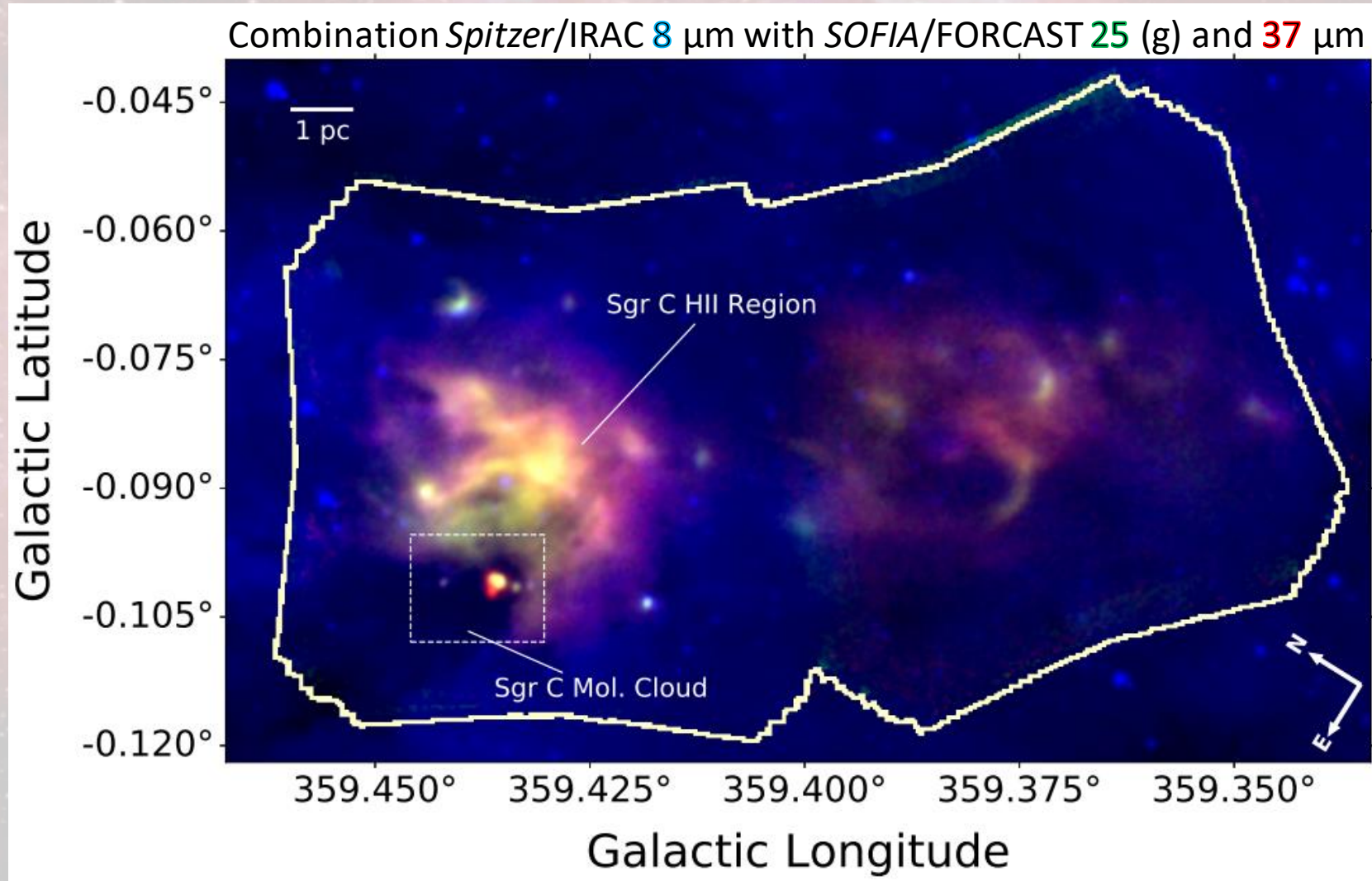
Dense but little star formation!

Sgr C

MYSOs

Molecular Cloud

# The Sgr C Complex

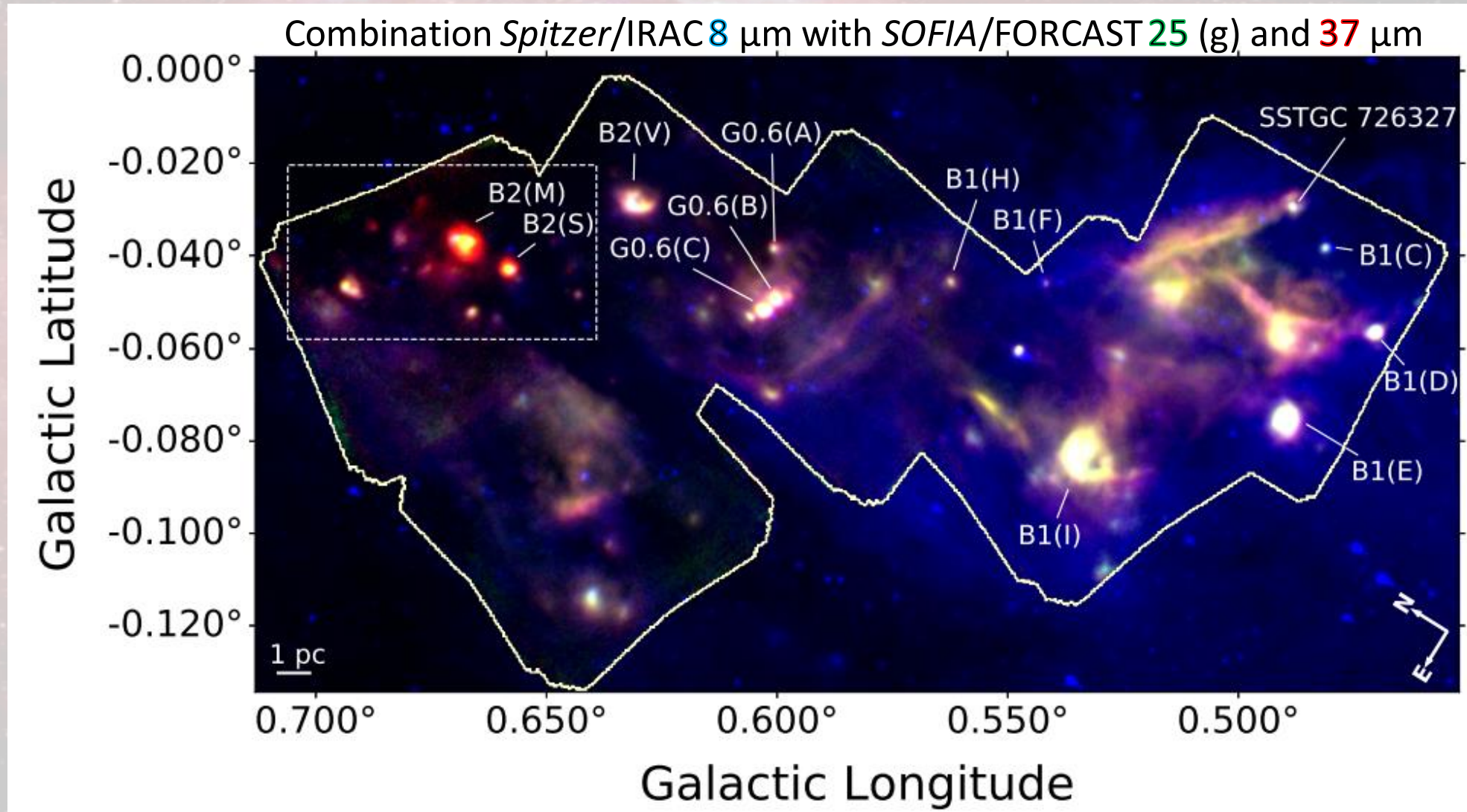


# Active Star Formation in the GC

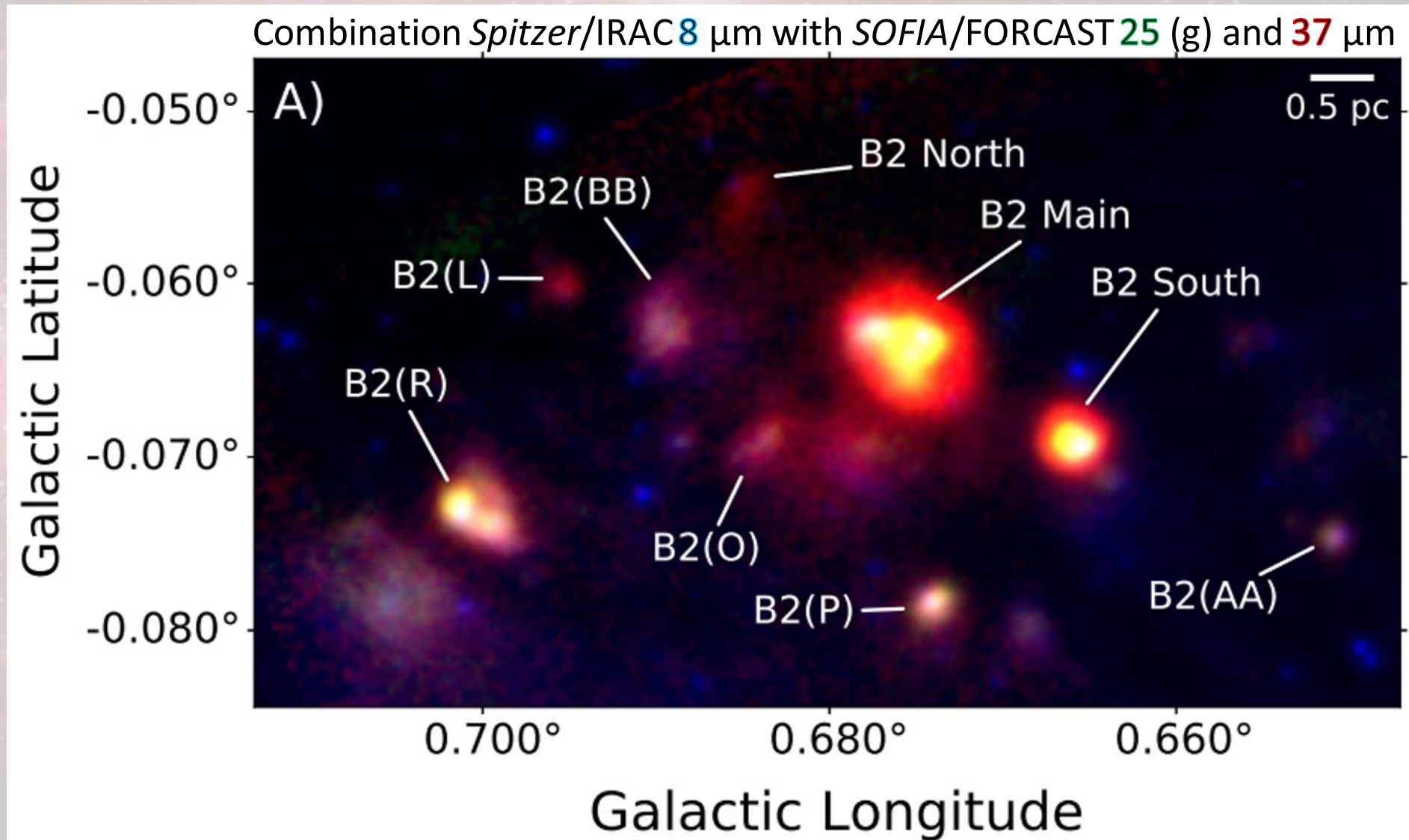
SOFIA/FORCAST 25 & 37  $\mu\text{m}$  with Herschel/PACS 70  $\mu\text{m}$



# A Plethora of Features in Sgr B



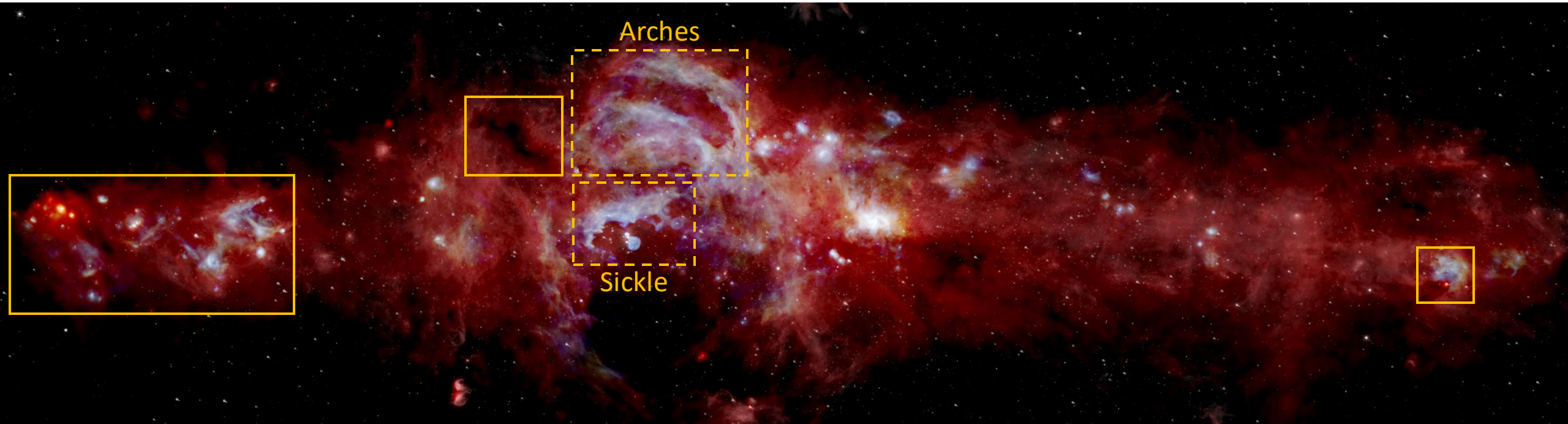
# Zooming in on Sgr B2



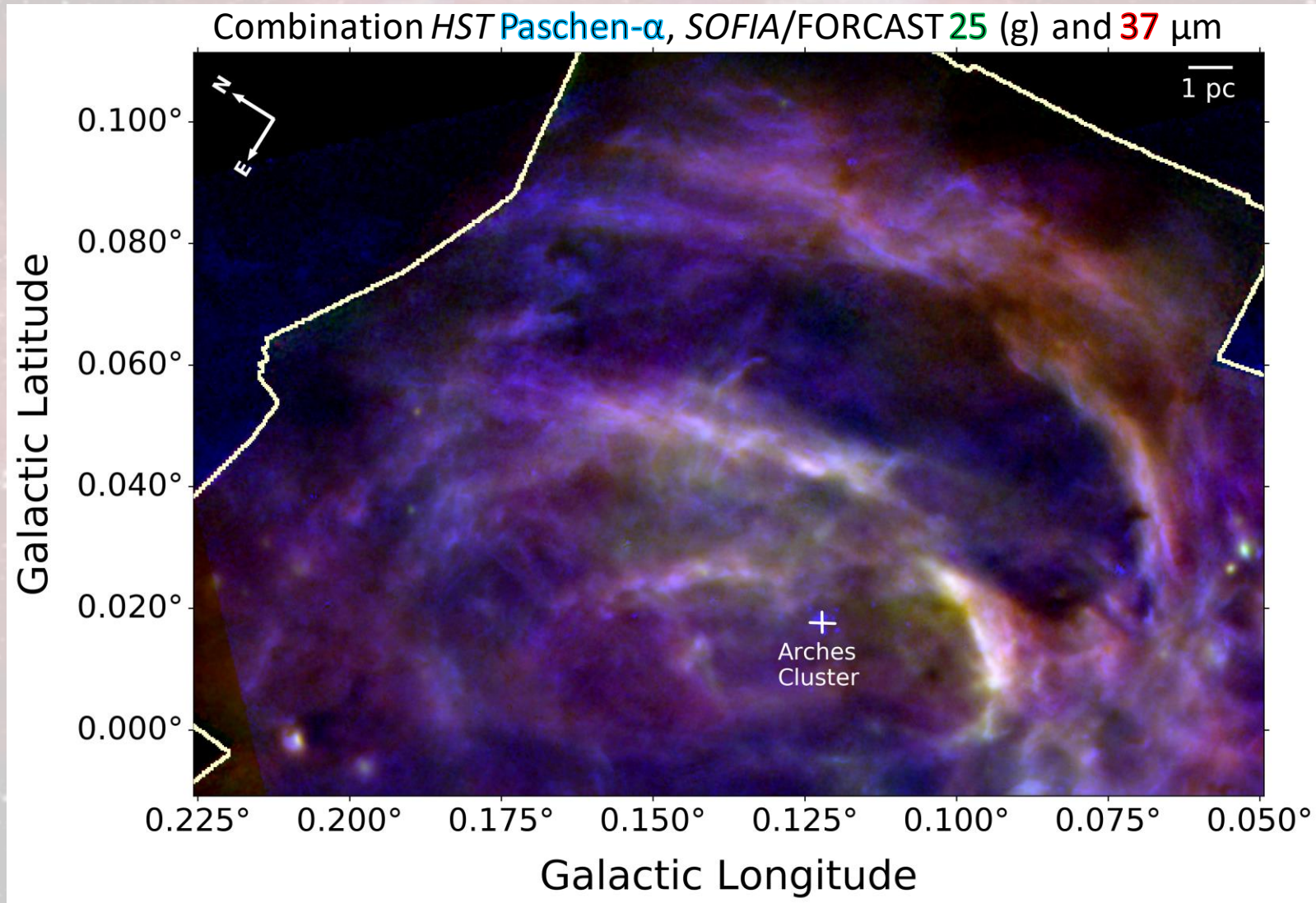


# Recent Star Formation in the GC

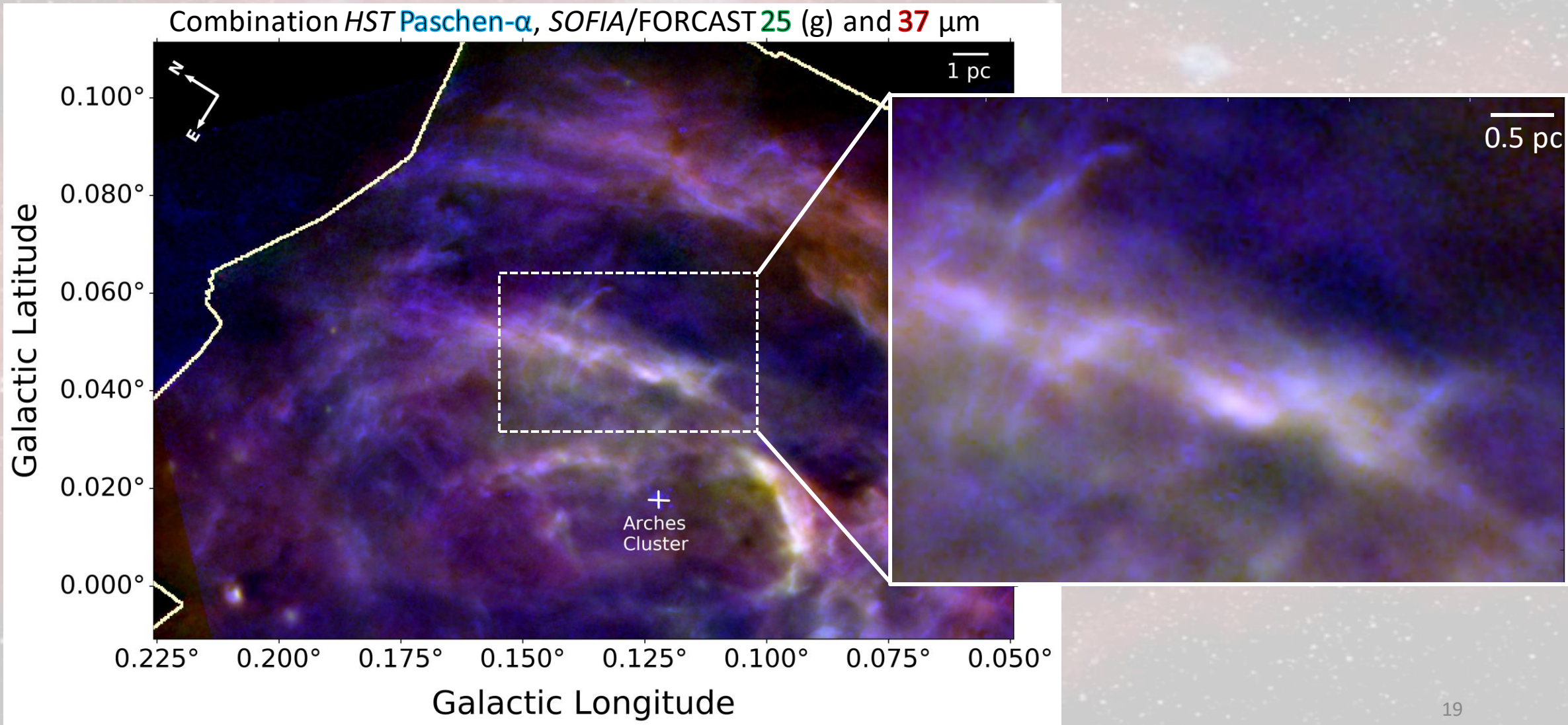
SOFIA/FORCAST 25 & 37  $\mu\text{m}$  with Herschel/PACS 70  $\mu\text{m}$



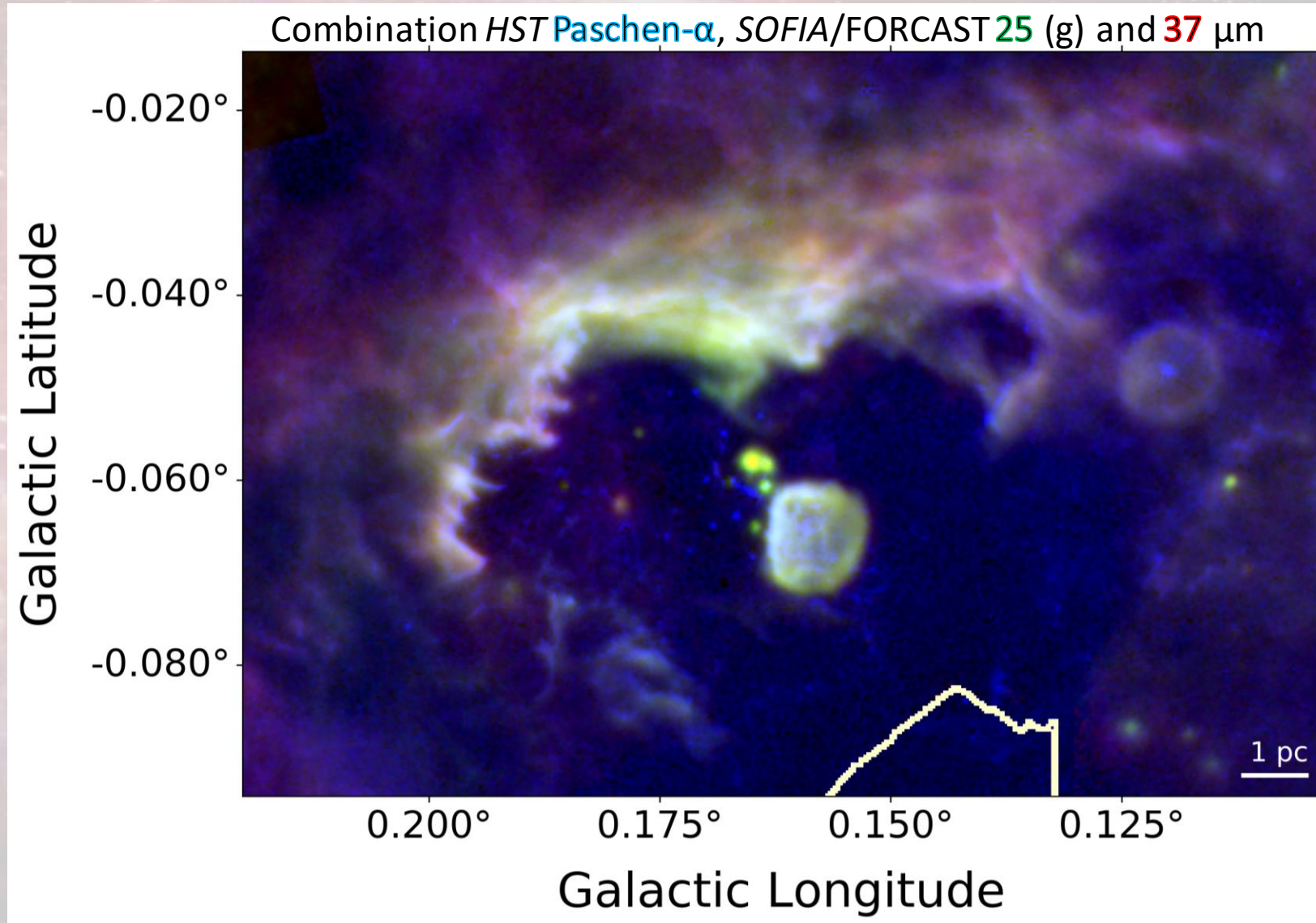
# The Arched Filaments HII Region



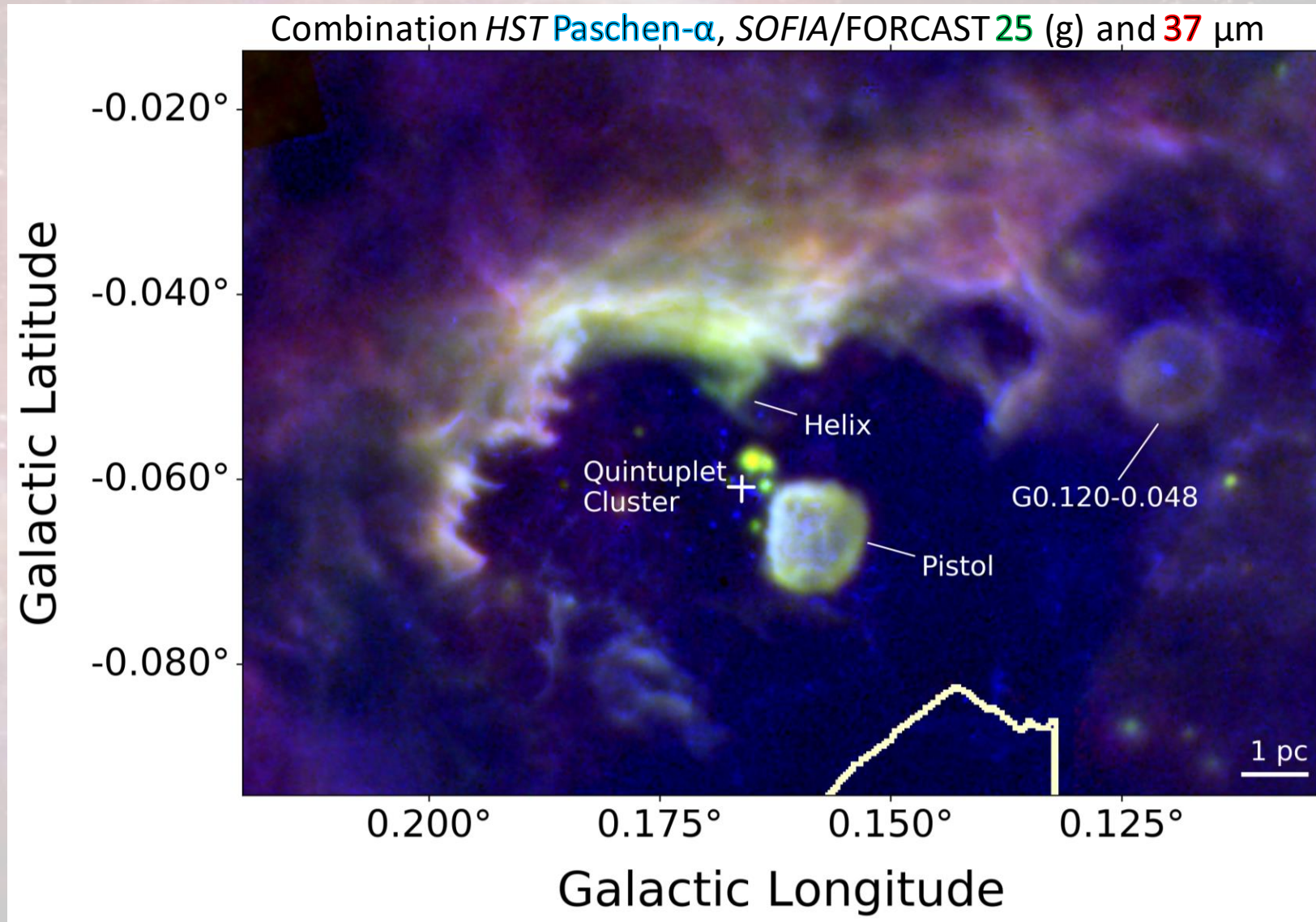
# The Arched Filaments HII Region



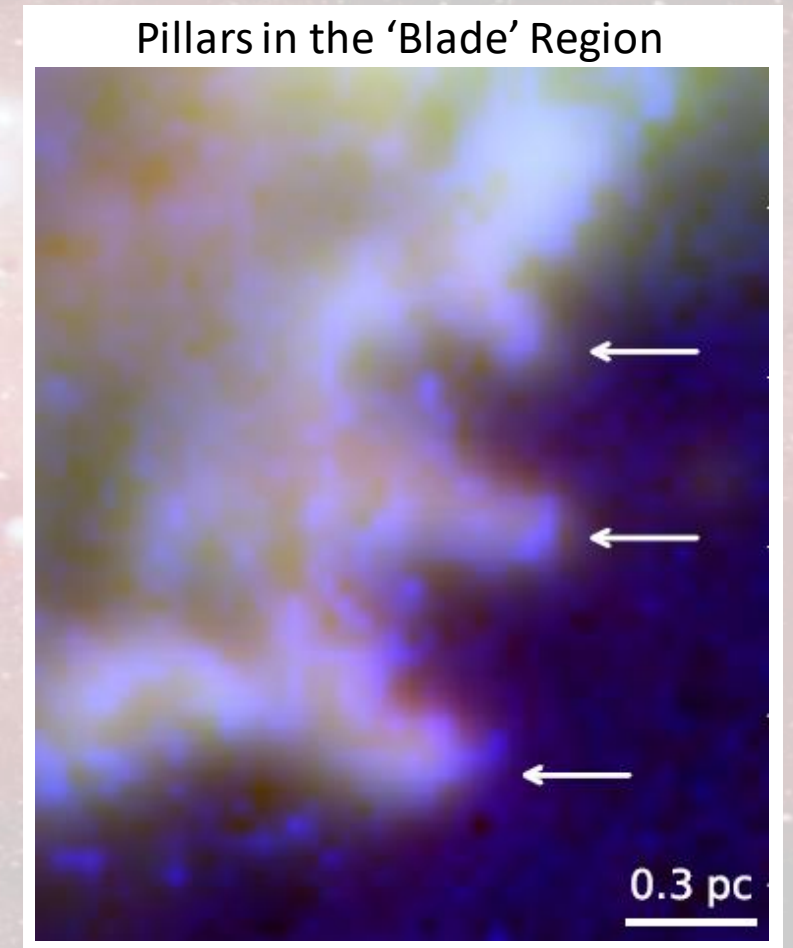
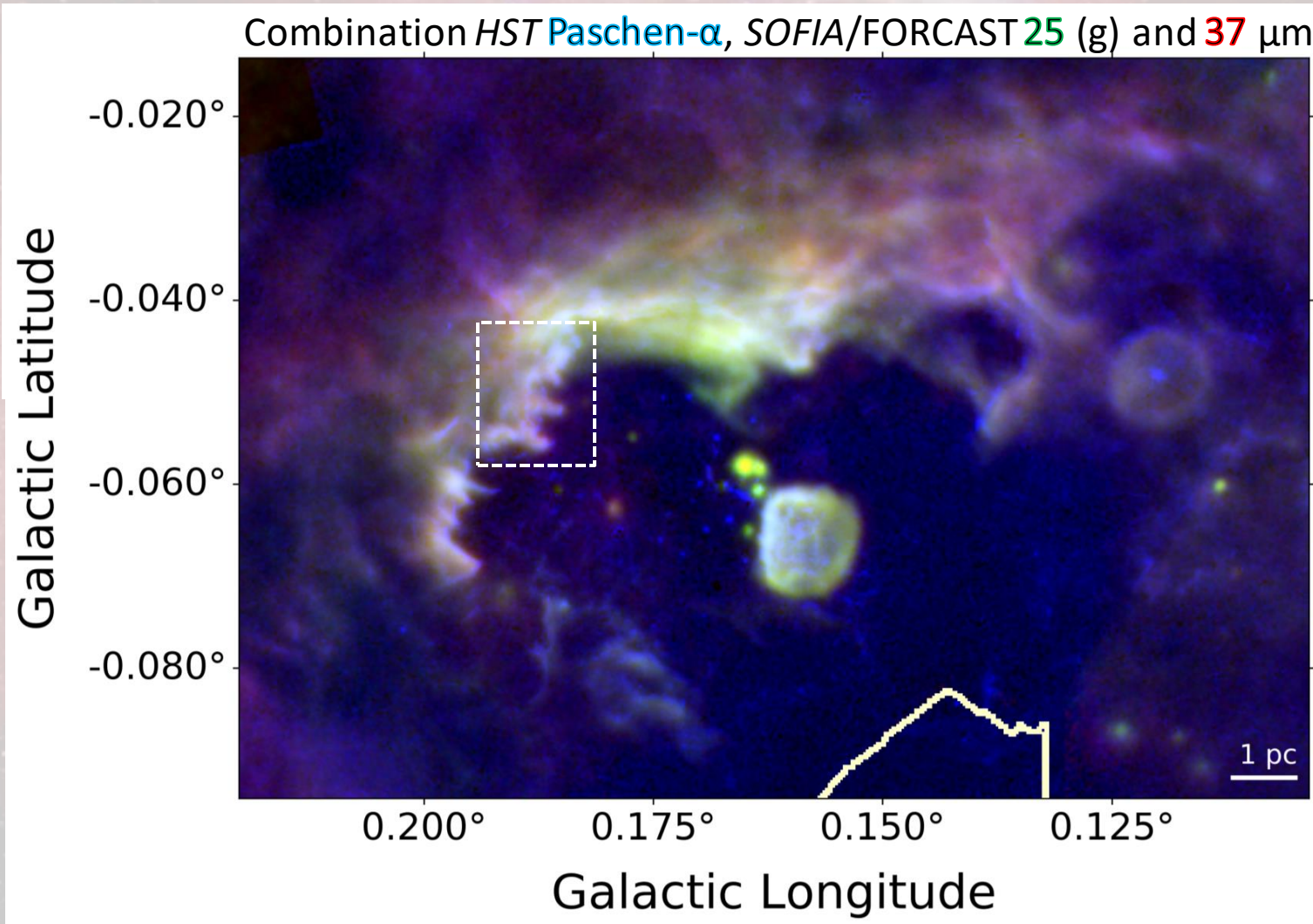
# The Sickie HII region



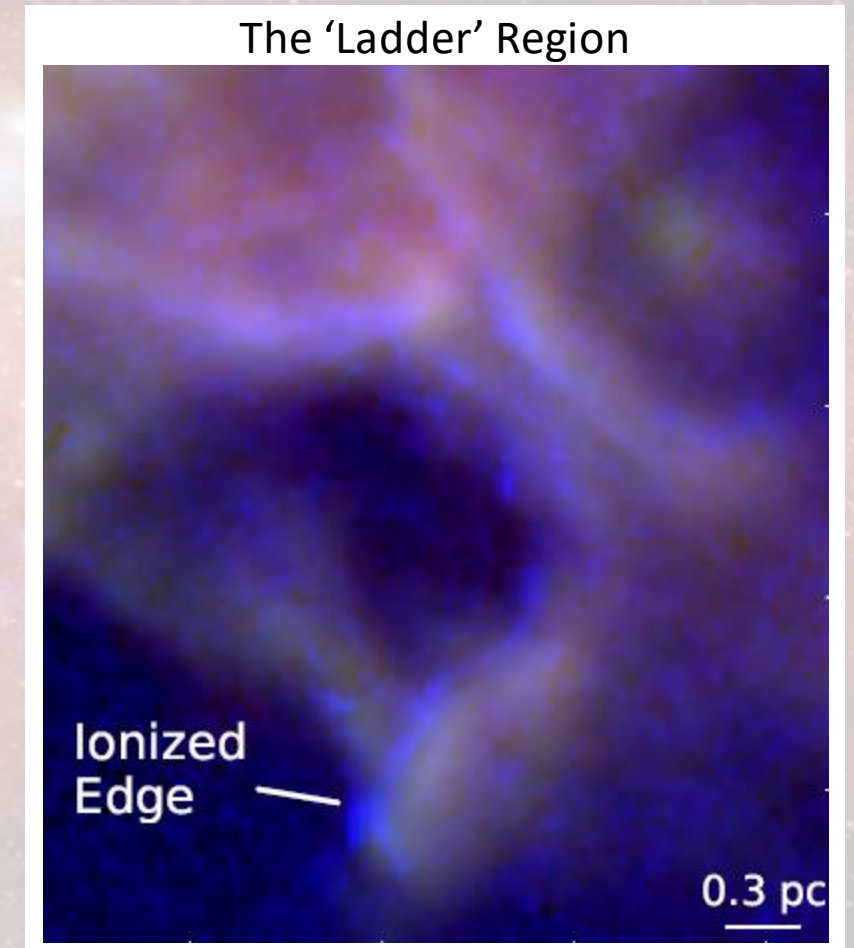
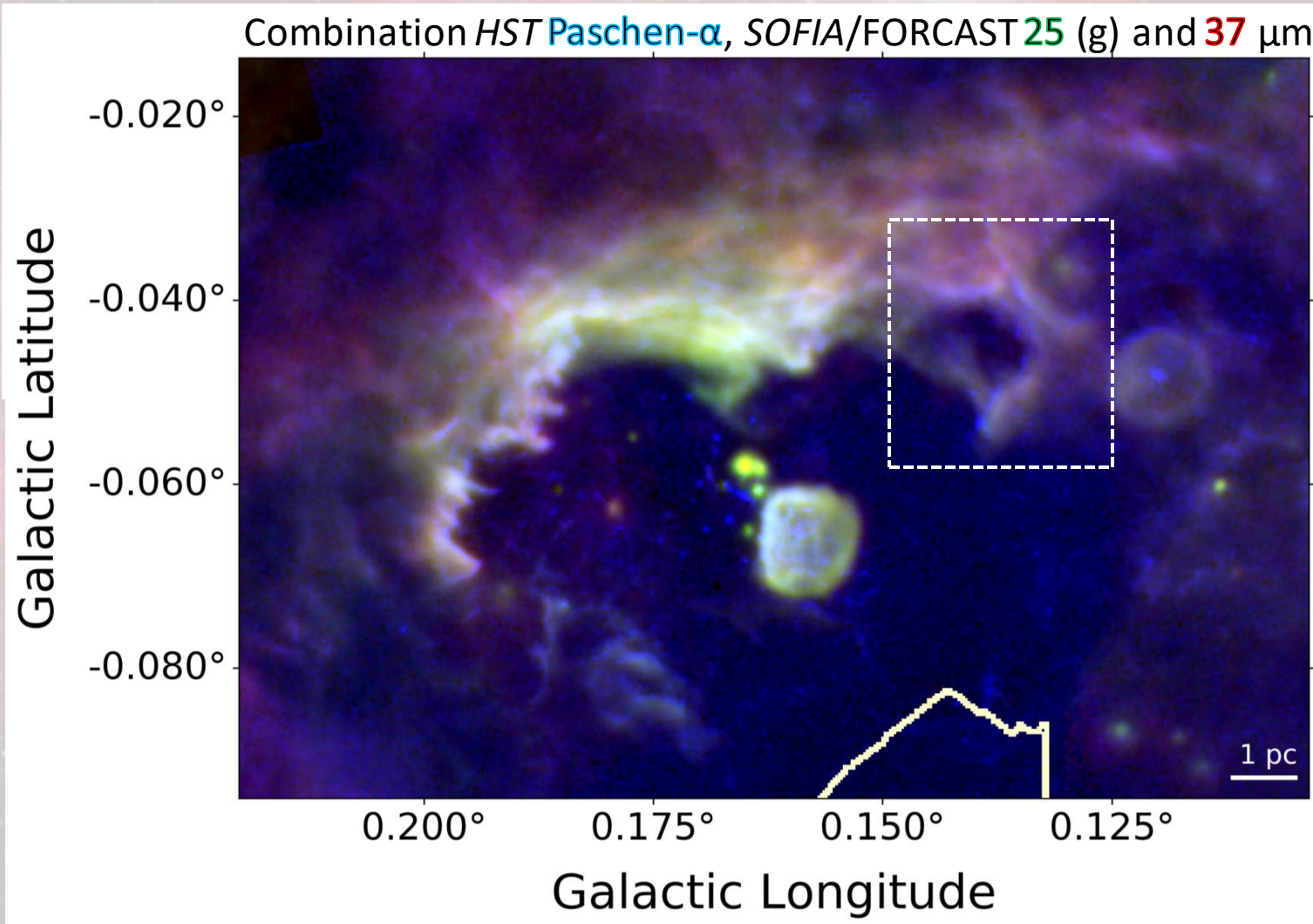
# The Sickie HII region



# Zooming into the Sickie HII region



# Zooming into the Sickie HII region



# Curious Isolated Mid-IR Sources

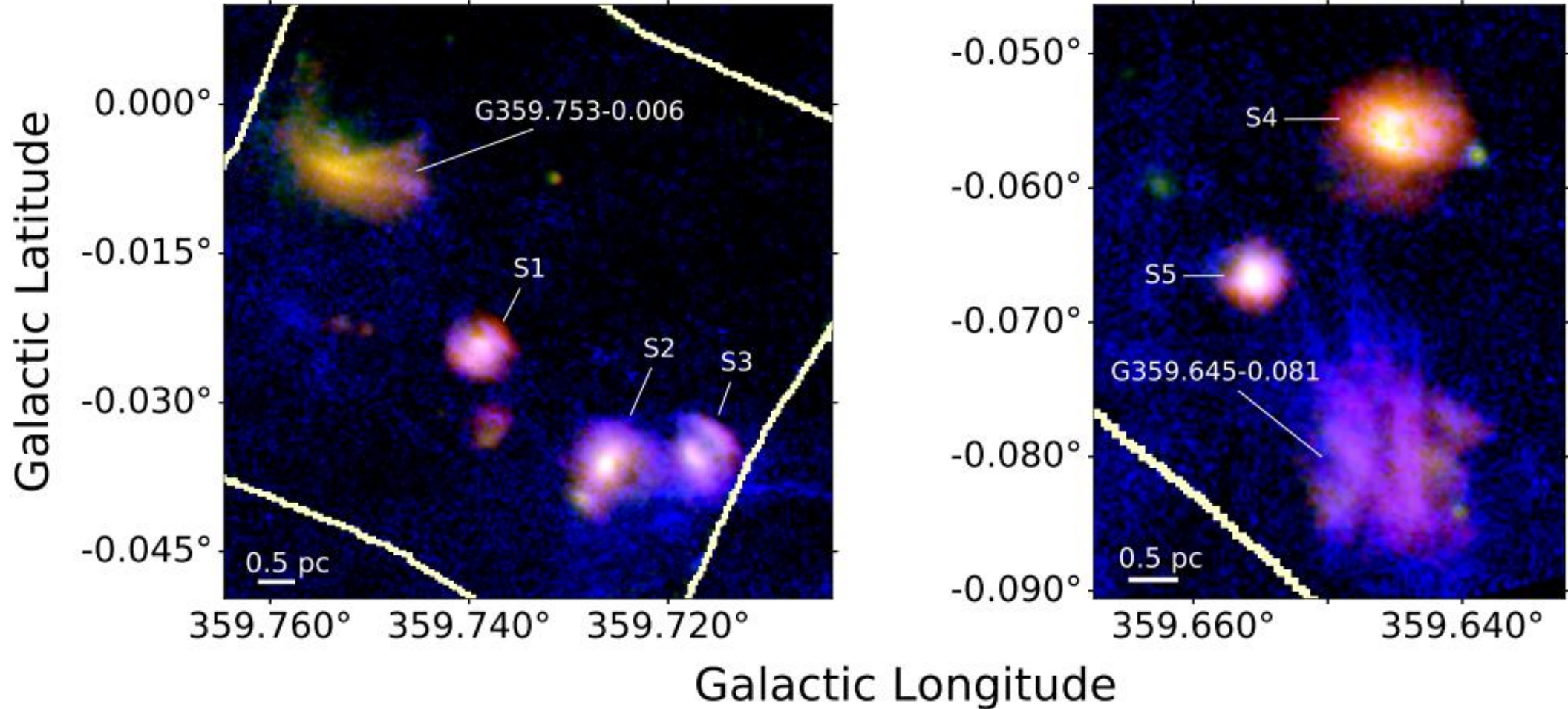
SOFIA/FORCAST 25 & 37  $\mu\text{m}$  with Herschel/PACS 70  $\mu\text{m}$





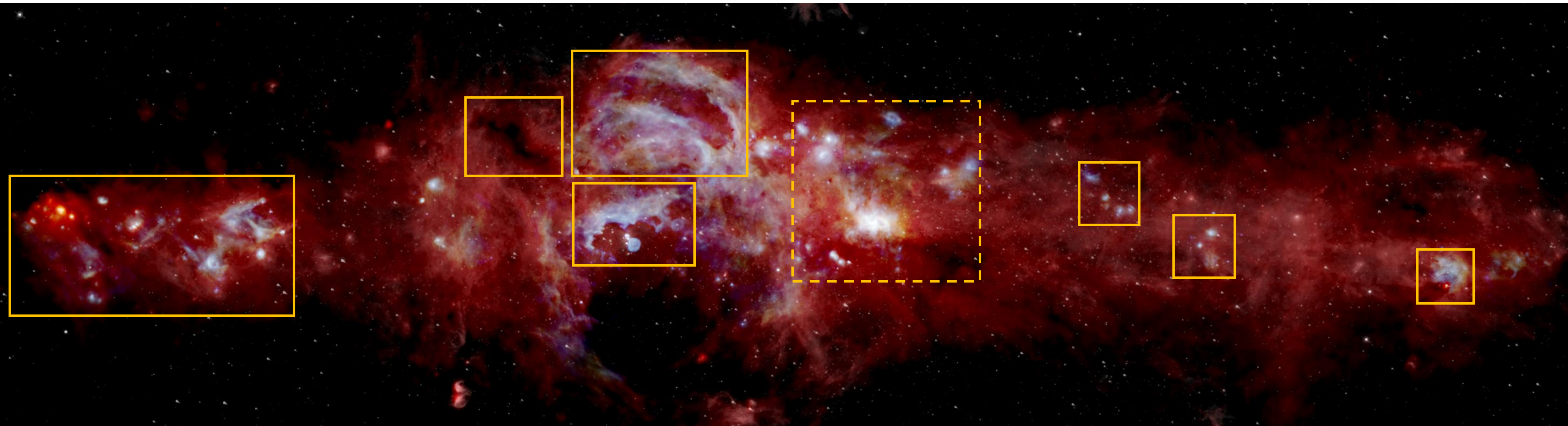
# Curious Isolated Mid-IR Sources

Combination *HST* Paschen- $\alpha$ , *SOFIA*/FORCAST 25 (g) and 37  $\mu\text{m}$  images

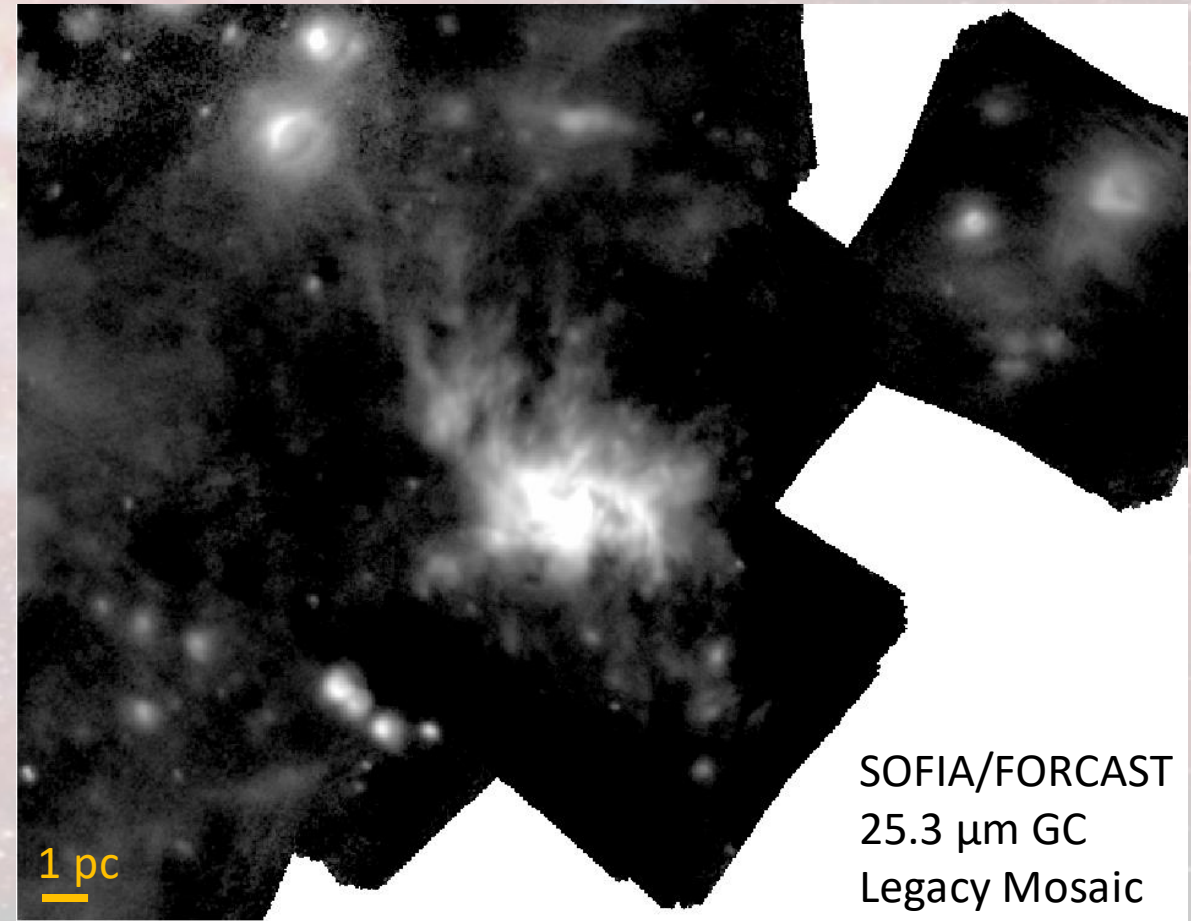
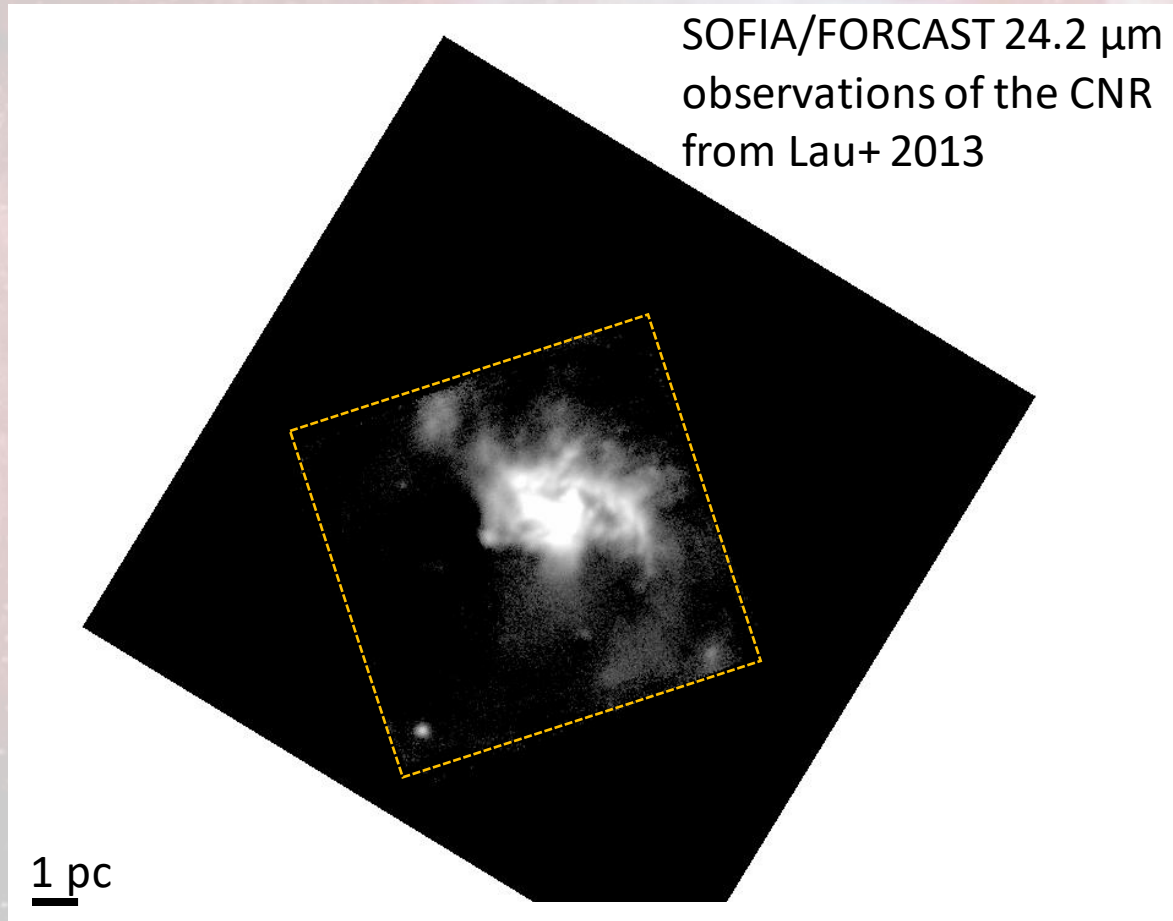


# Sgr A Region

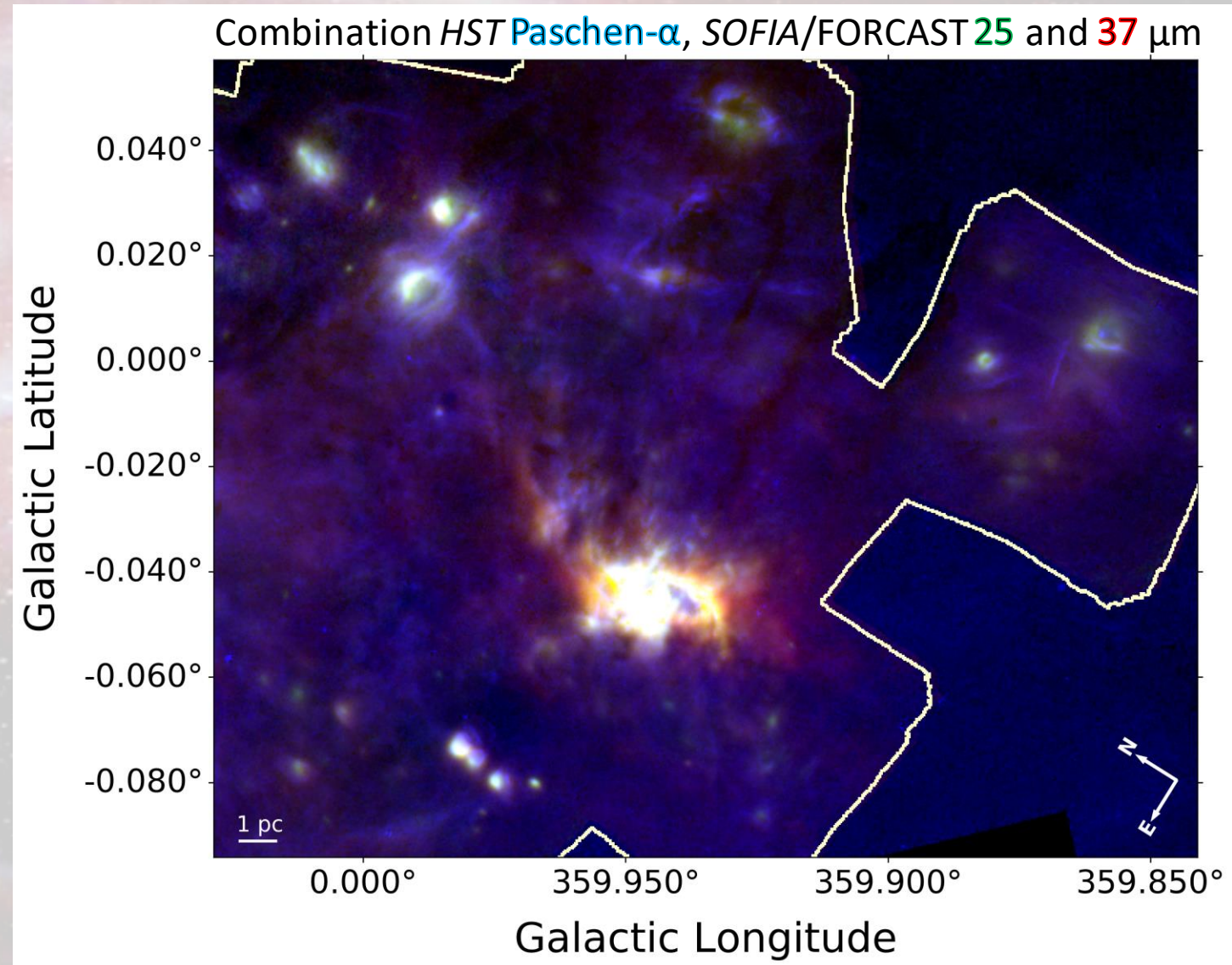
SOFIA/FORCAST 25 & 37  $\mu\text{m}$  with Herschel/PACS 70  $\mu\text{m}$



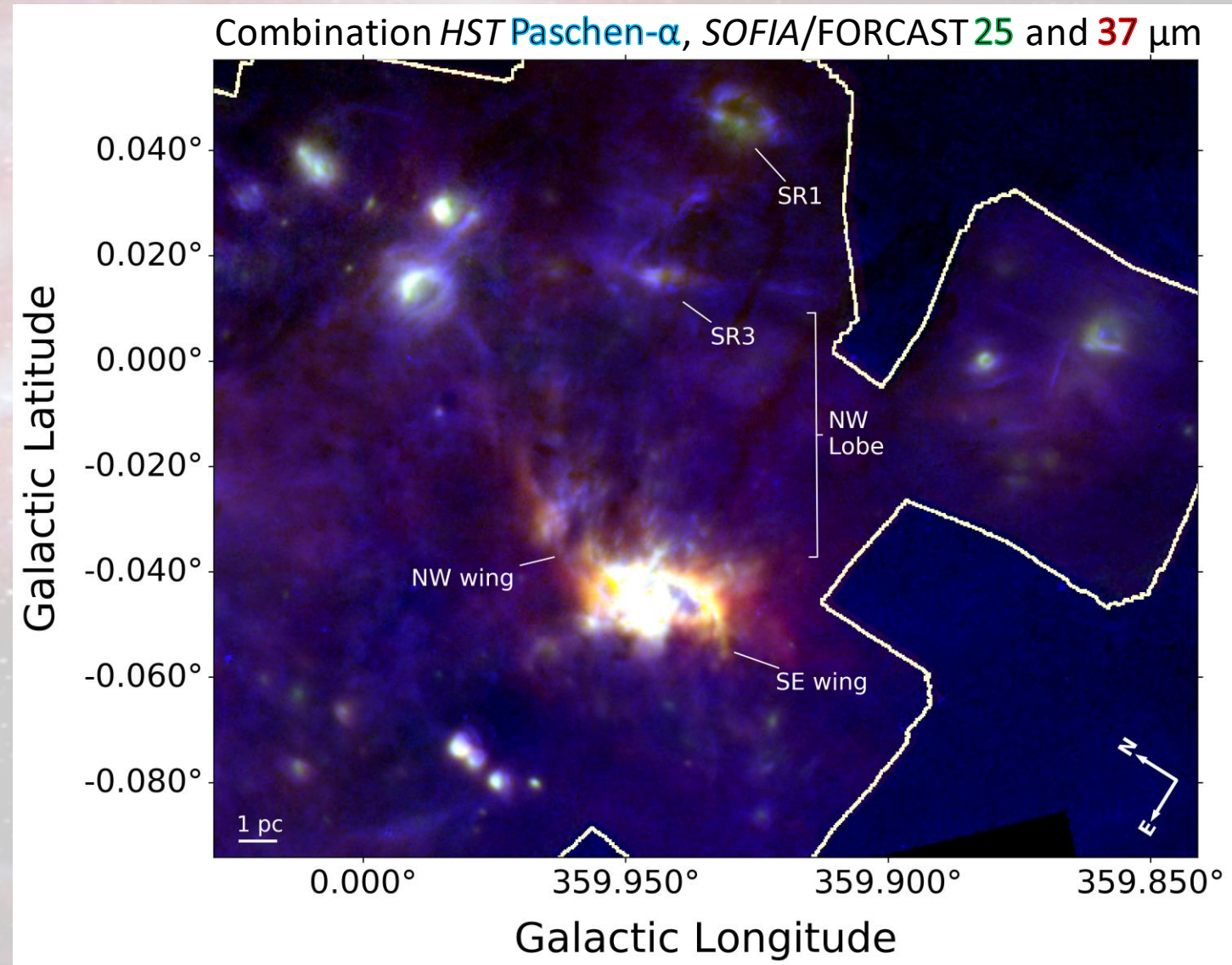
# Sgr A: Comparison with Prior Observations



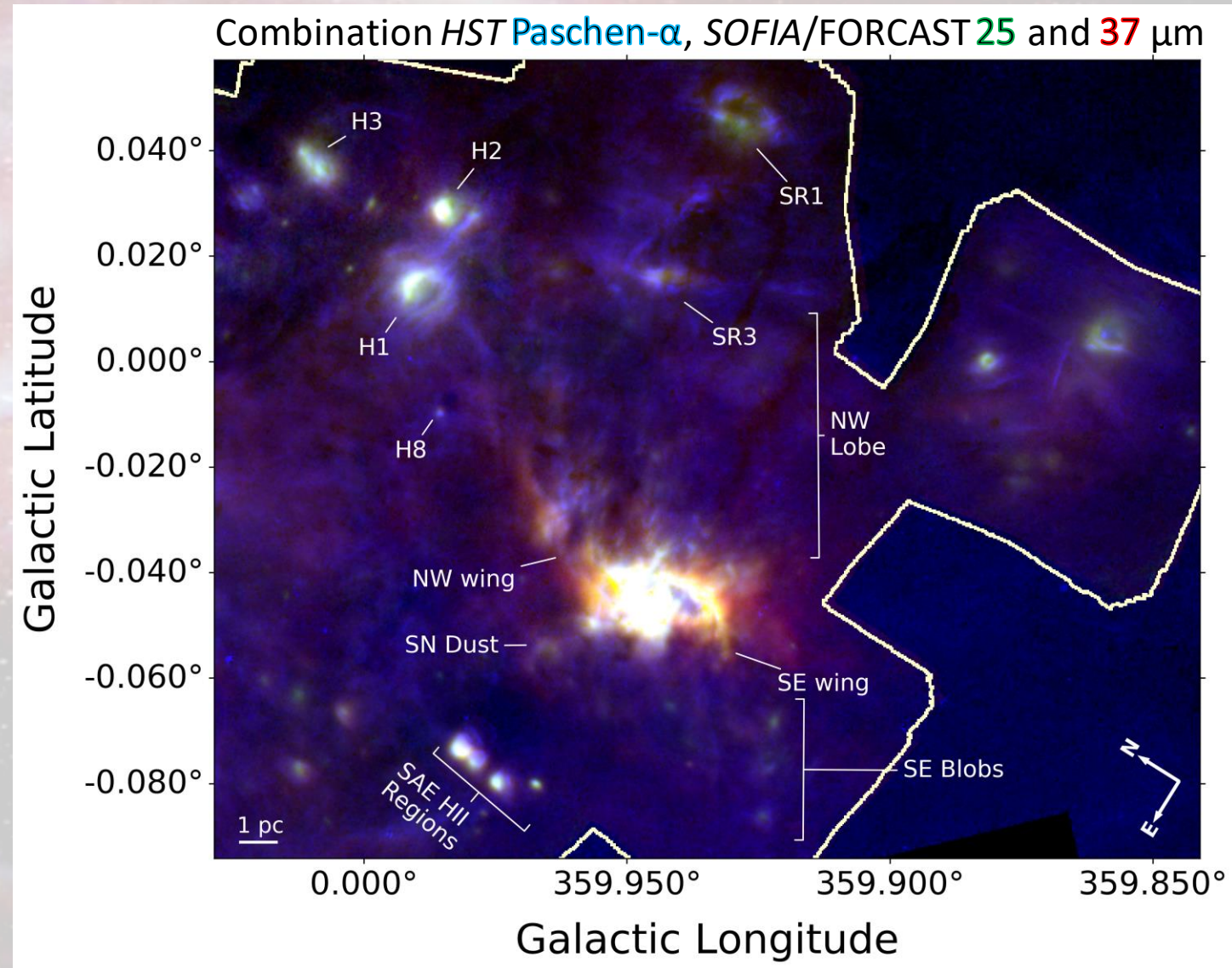
# Dissecting Sgr A in the Mid-IR



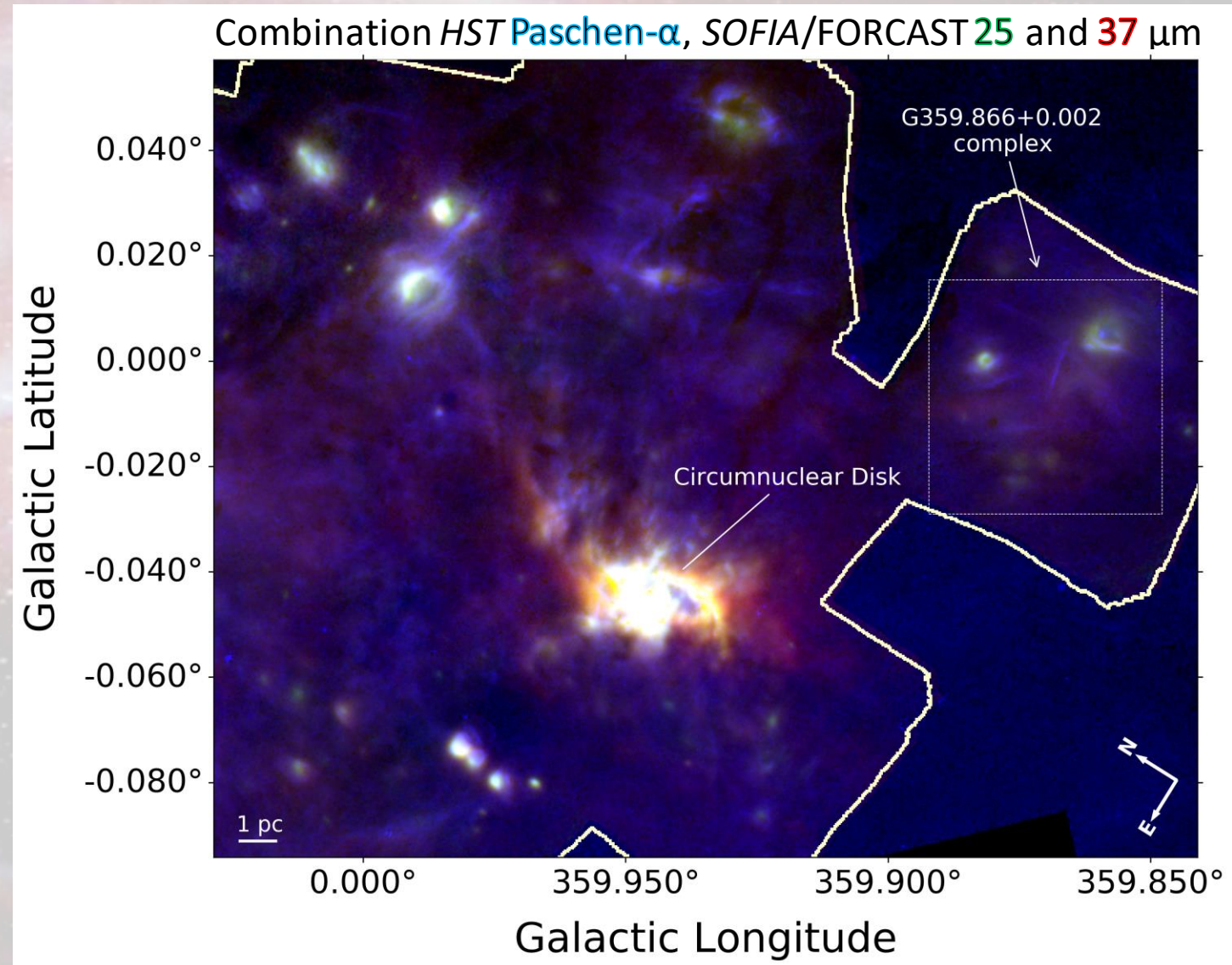
# Dissecting Sgr A in the Mid-IR



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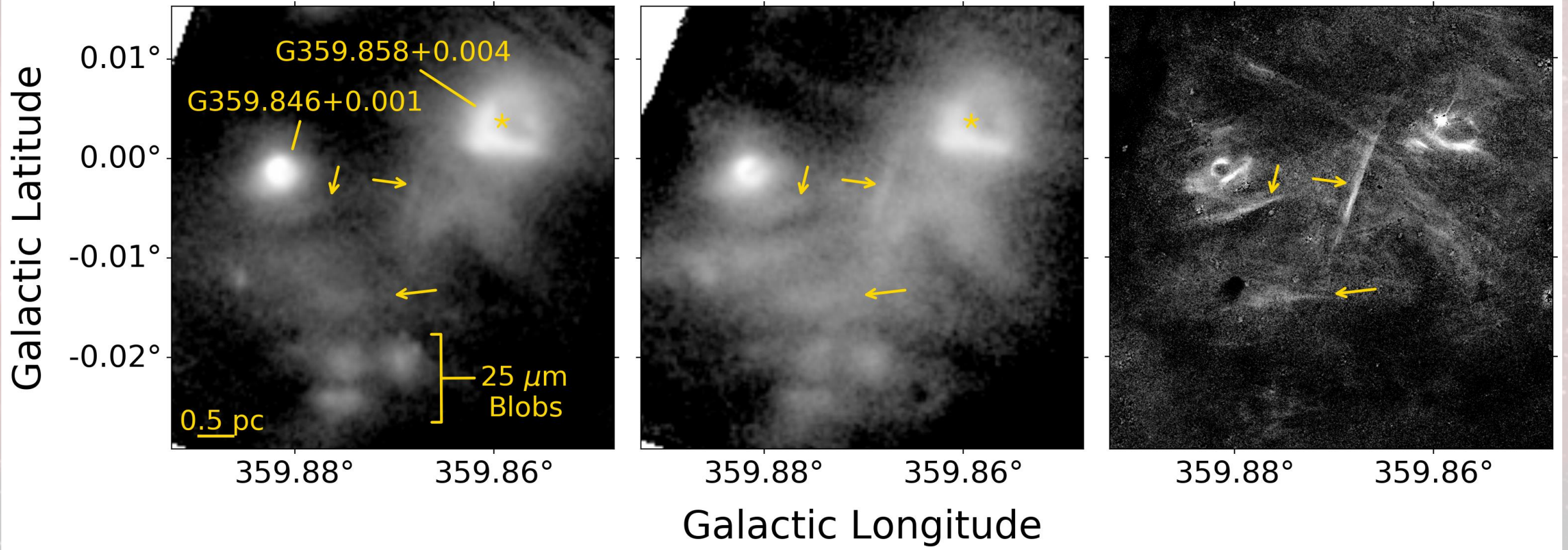


# The G359.866+0.002 Complex

SOFIA/FORCAST 25  $\mu\text{m}$

SOFIA/FORCAST 37  $\mu\text{m}$

HST Paschen- $\alpha$

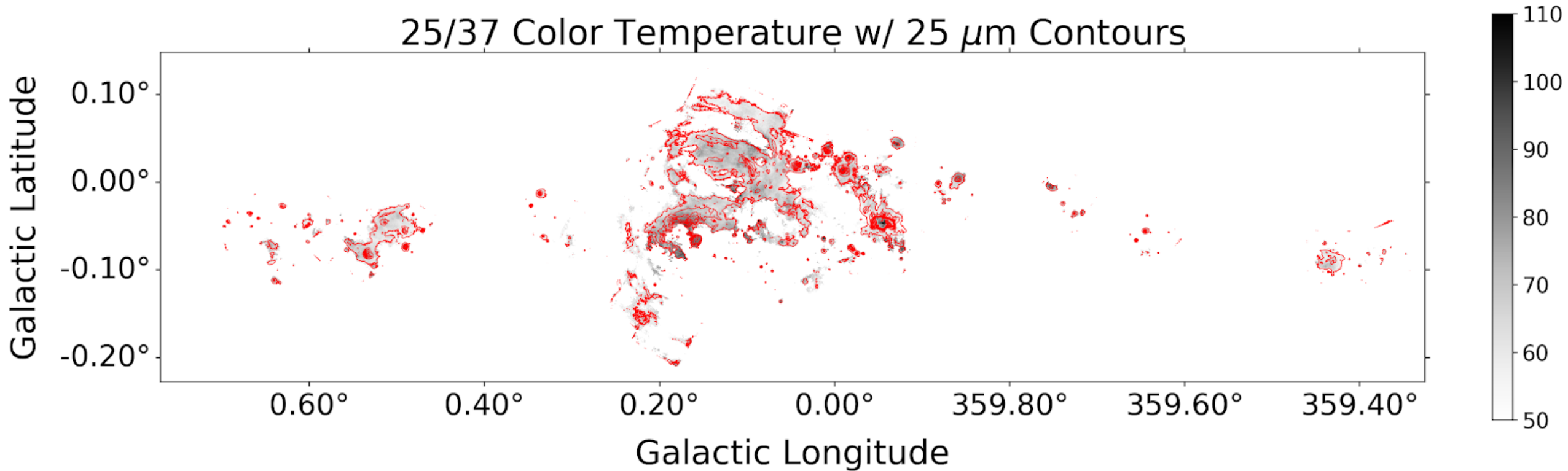




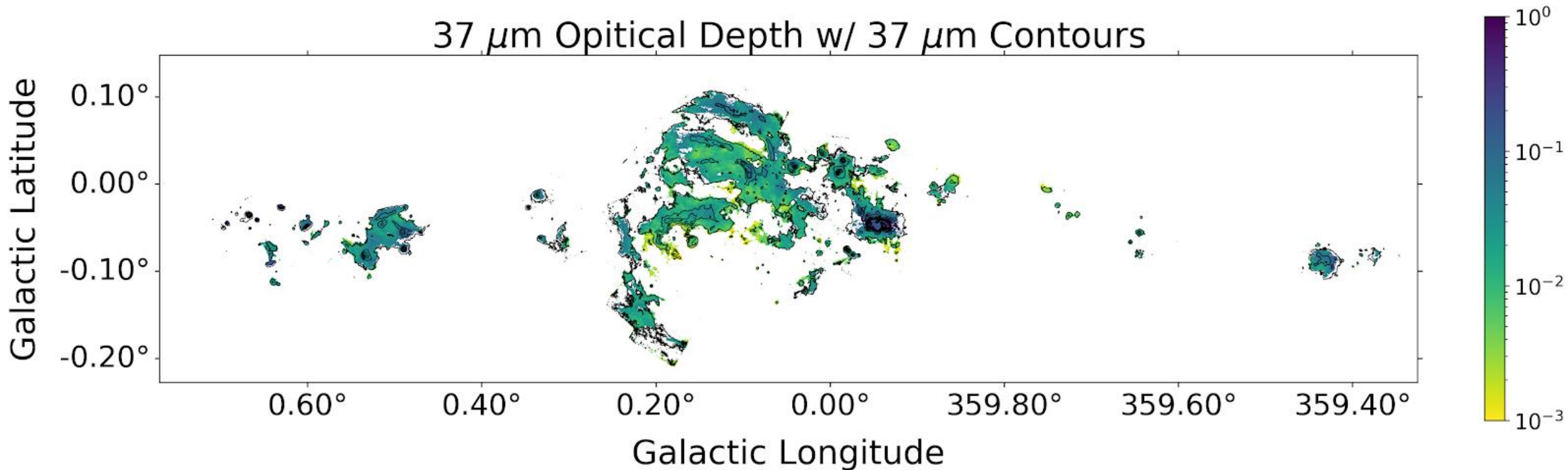
# Legacy Program Data Products

- Survey mosaics at 25  $\mu\text{m}$  and 37  $\mu\text{m}$ 
  - Initial versions available on SOFIA DCS & IPAC/IRSA
  - Stay tuned for revised versions with improved PSF uniformity
- 25/37 color-temperature and 37  $\mu\text{m}$  optical depth maps
  - Preliminary versions on next slides
- Compact Source Catalog
  - Preliminary version created, undergoing refinements
- Combined SOFIA/FORCAST 25  $\mu\text{m}$  and Spitzer/MIPS 24  $\mu\text{m}$  map
  - Work in progress

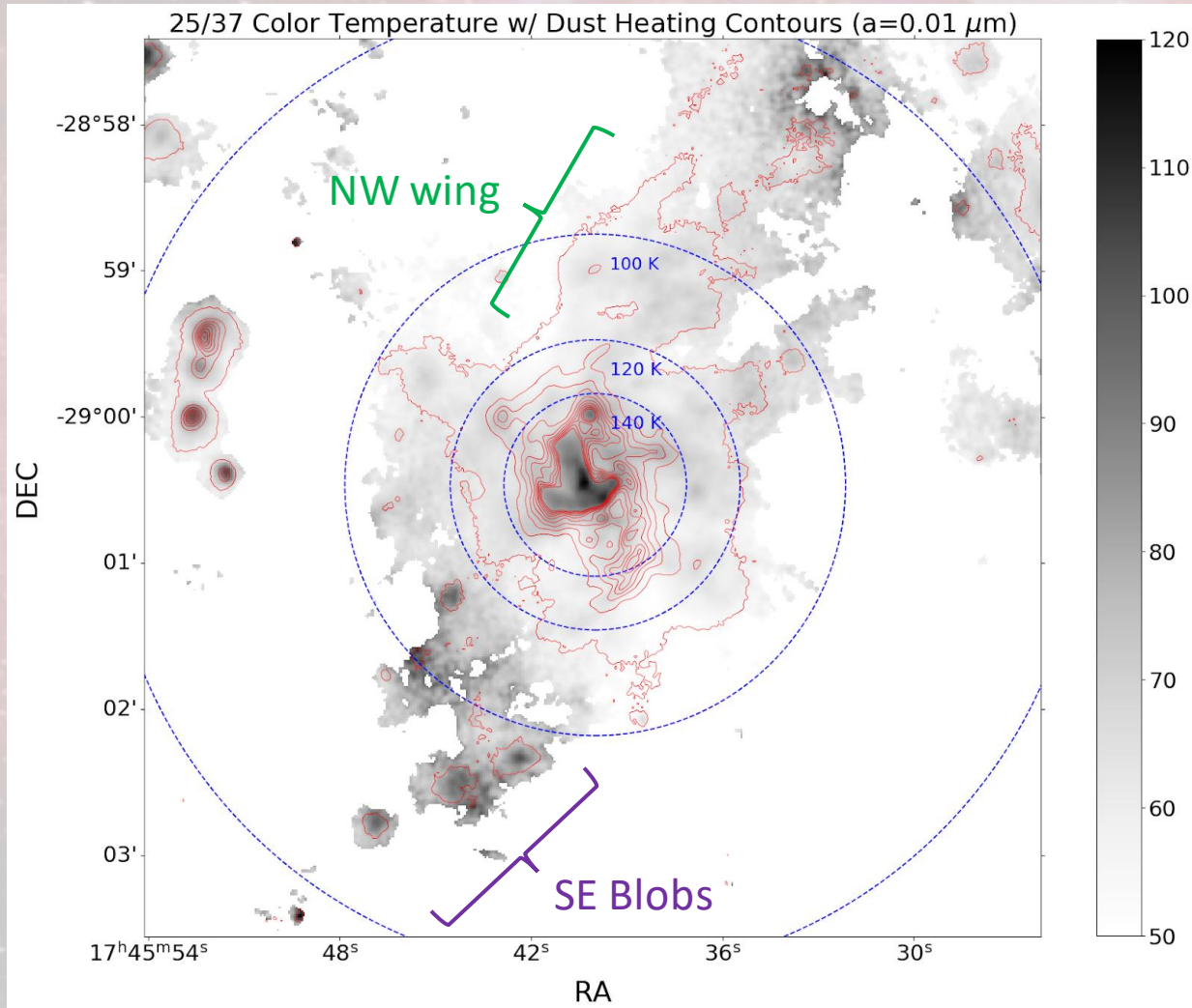
# Preliminary Dust Temperature Maps



# Preliminary Optical Depth Map



# What Comes Next?: A Preliminary Look at Sgr A



- Examine dust temperatures to examine potential heating sources
  - Dashed Contours are dust temperatures estimated from the central cluster
- The **SE blobs** appear to have a source of local heating
- The **NW wing** has no local 'hot spots'

# Summary

- SOFIA/FORCAST GC Legacy Program observed in cycle 7
  - Survey mosaics at 25  $\mu\text{m}$  and 37  $\mu\text{m}$  are available on SOFIA DCS & IPAC/IRSA
- Survey Overview paper describing data [published in ApJ](#) & available on [Arxiv](#)
  - Feature several known regions of interest with more work to be done
  - Stay tuned for updates & additional data products

# Thanks for listening!

## Questions?

Special thanks to SOFIA Mission Operations and all those that made the FORCAST program possible

Collaborators: Ryan Lau (JAXA), Angela Coteria (SETI), Mark Morris (UCLA), James Radomski (SOFIA/USRA), Betsy Mills (Univ. Kansas), Daniel Walker (ALMA/NAOJ), Ashley Barnes (Univ. Bonn), Janet Simpson (SETI), Terry Heter (Cornell Univ.), Steven Longmore (LJMU), John Bally (UC Boulder), Mansi Kasliwal (Caltech), Nadeen Sabha (Univ. Innsbruck), Macarena Garcia-Marin (ESA)