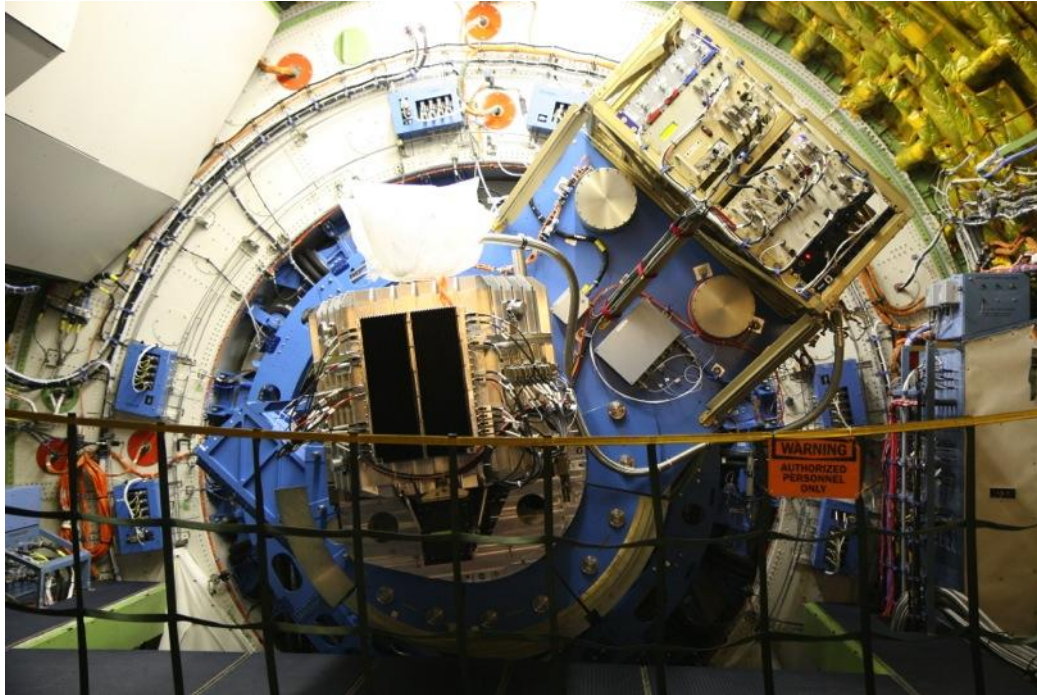


# FIFI-LS First Science



Leslie Looney  
(U of Illinois)  
+ FIFI-LS Team





# The Team



S. Beckmann A. Bryant S. Colditz  
C. Fischer F. Fumi N. Geis R. Hönle  
R. Klein A. Krabbe L. Looney A. Poglitsch  
W. Raab S. Ragan F. Rebell M. Savage

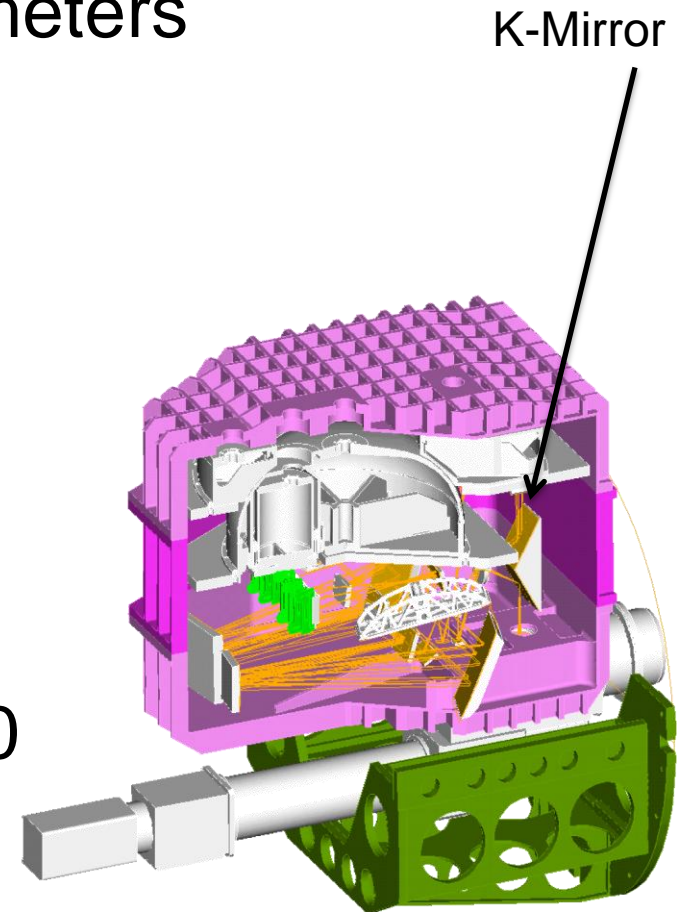
Special Guests:  
Bill Wohler (NASA)  
Erick Starman (USRA)  
Christof Iserlohe (Köln)

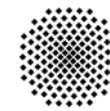




# FIF- LS: the Field-Imaging Far-Infrared Line Spectrometer

- Two parallel far-infrared spectrometers
  - Blue 50-110  $\mu\text{m}$   
5x5 pixel field of view: 6" pixels
  - Red 110-200  $\mu\text{m}$   
5x5 pixel field of view: 12" pixels
- Imaging spectrometer concept
  - 16 spectral pixels per spatial pixel
- Spectral resolution:  $R=1000-3000$



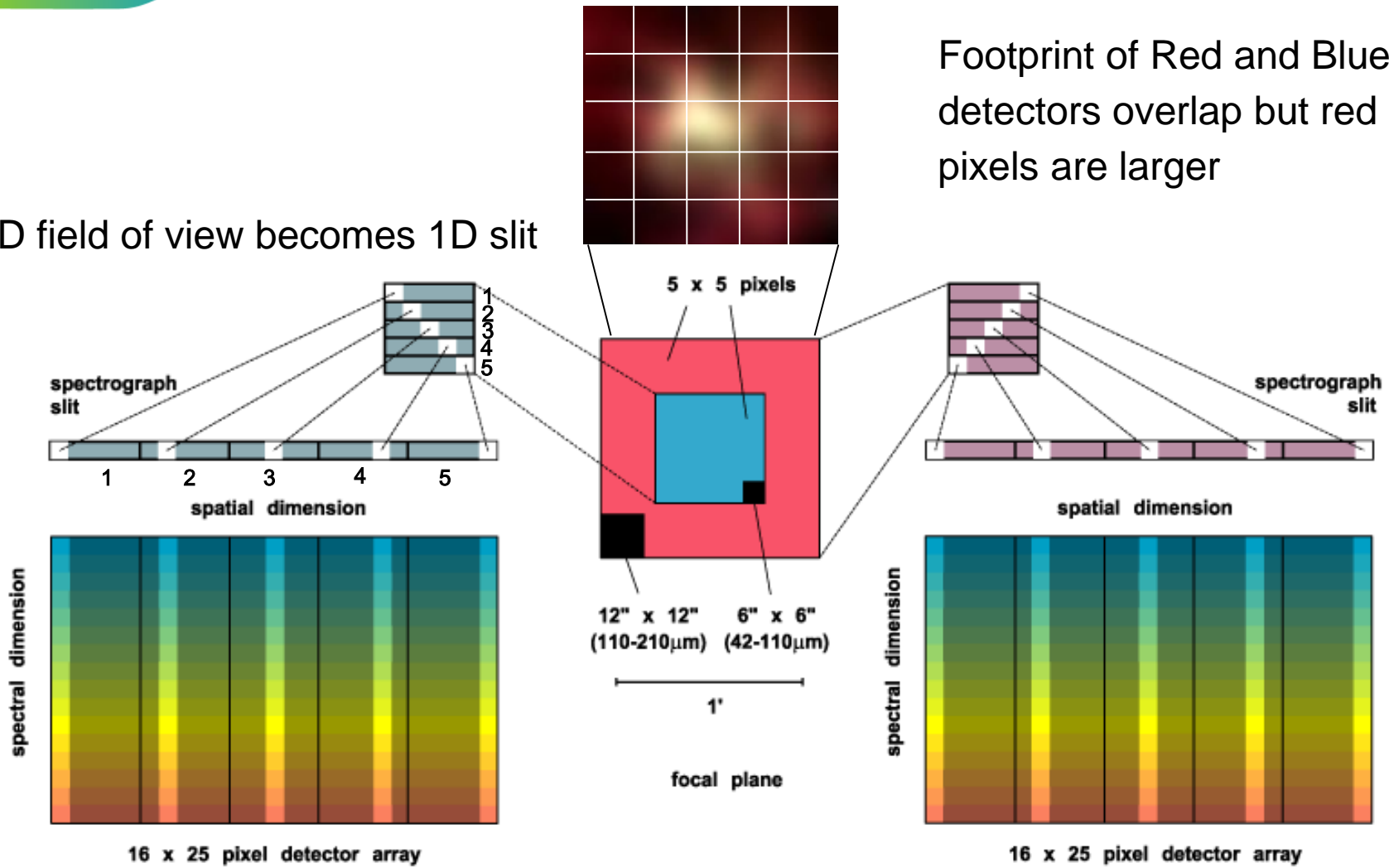


Getördert durch:  
 Bundesministerium  
 für Wirtschaft  
 und Technologie  
 aufgrund eines Beschlusses  
 des Deutschen Bundestages

# Integral Field Concept

Footprint of Red and Blue detectors overlap but red pixels are larger

2D field of view becomes 1D slit

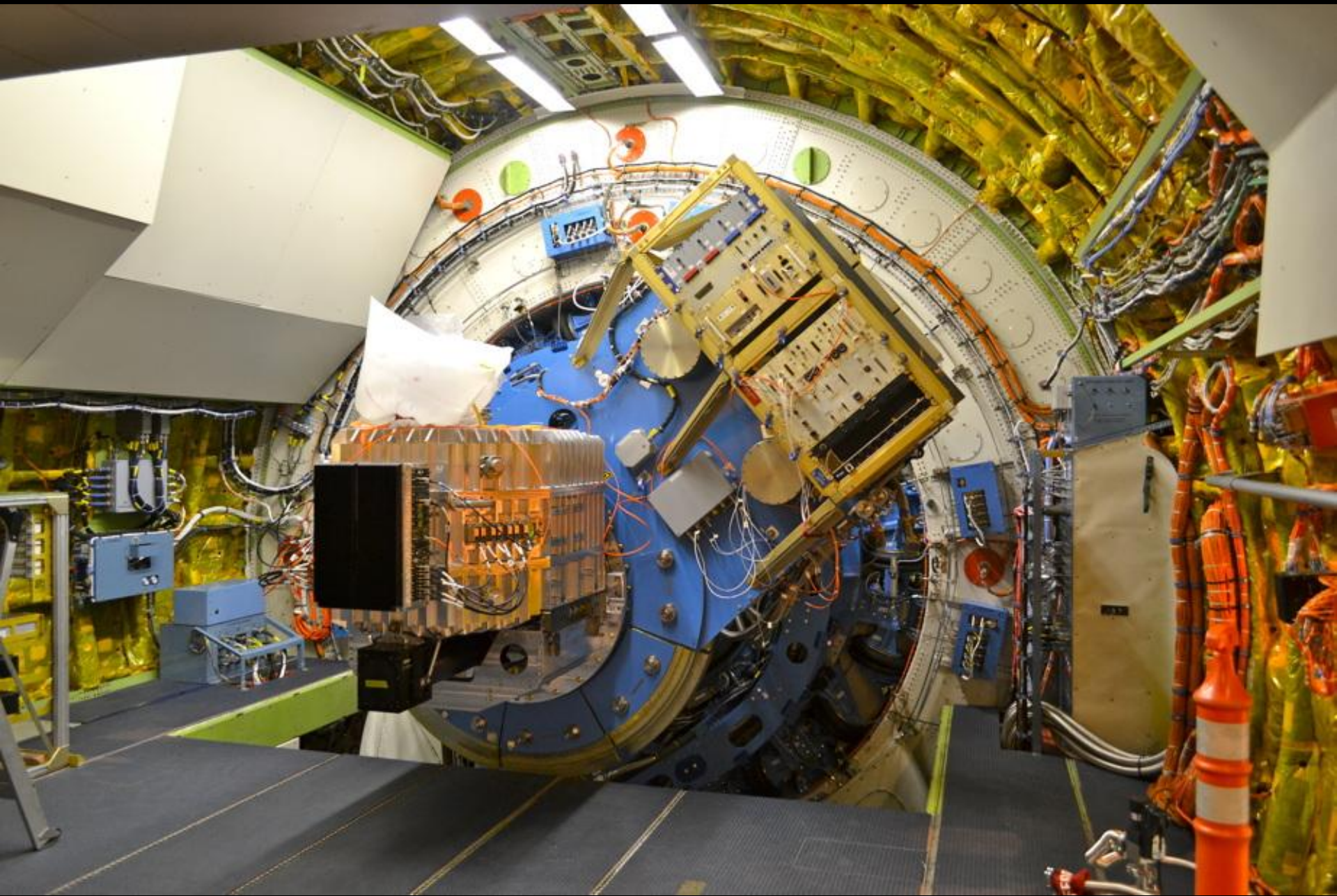


2D detector contains 3D data cube

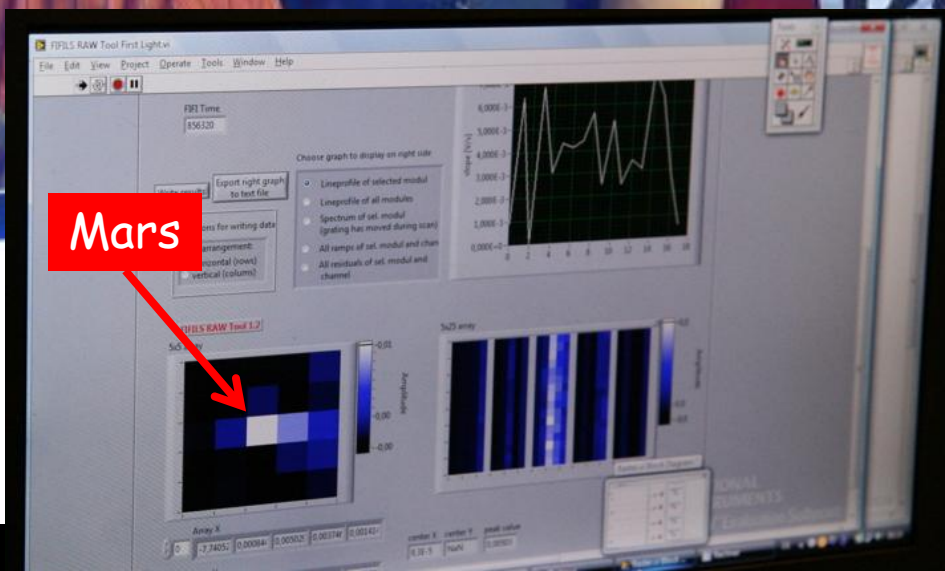
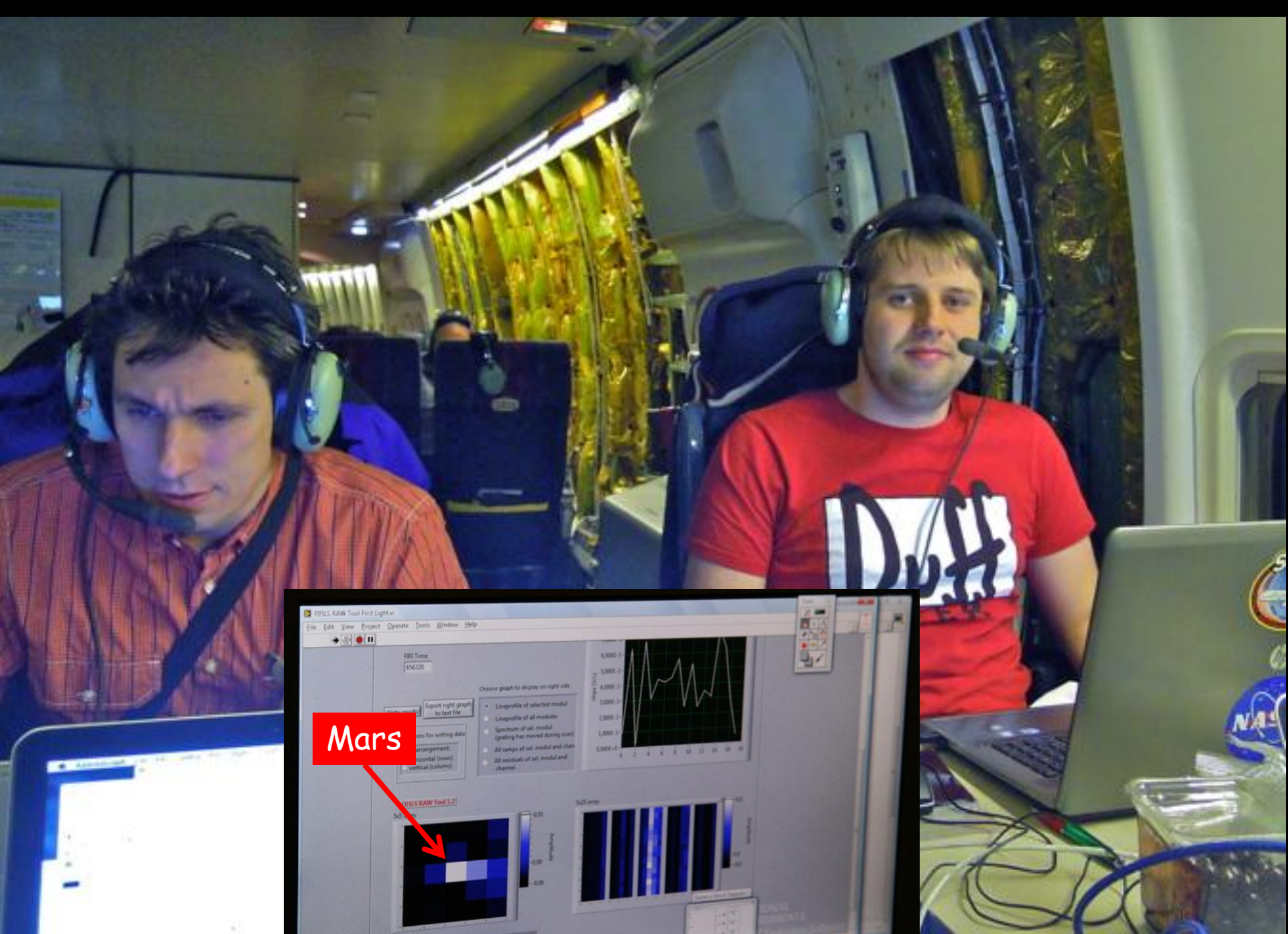








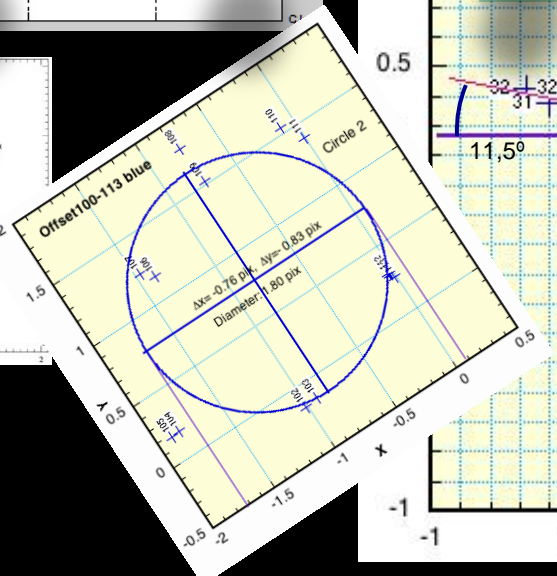
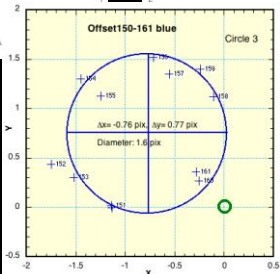
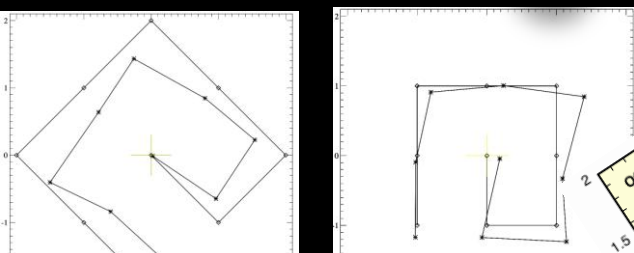
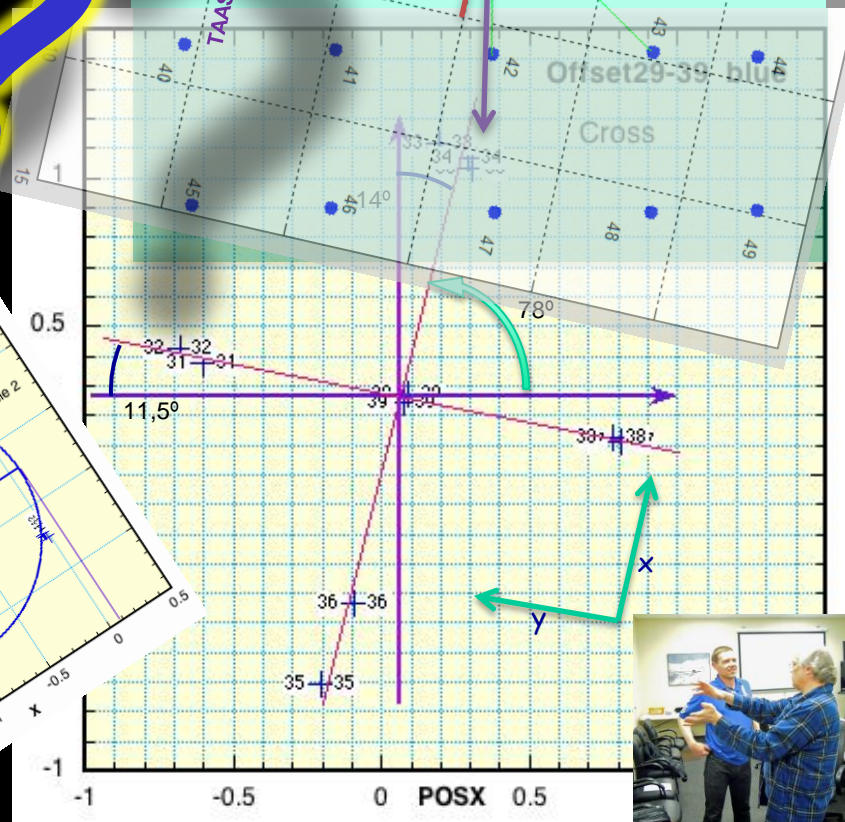
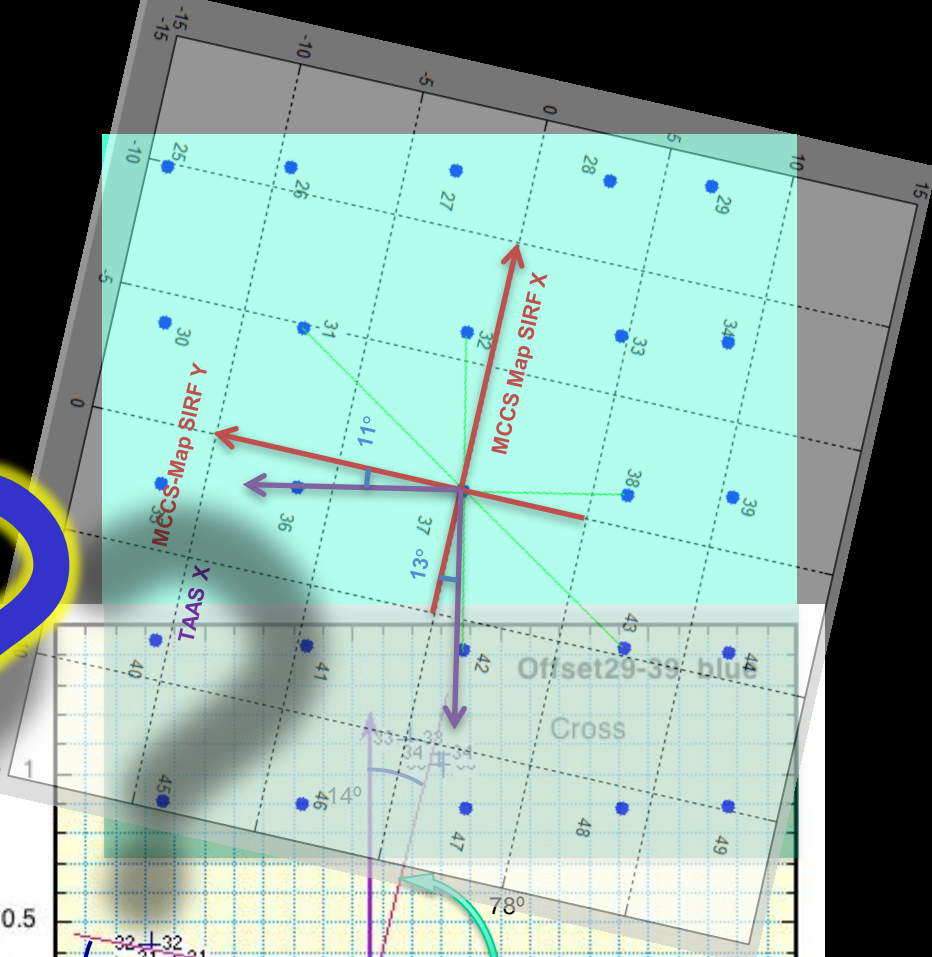
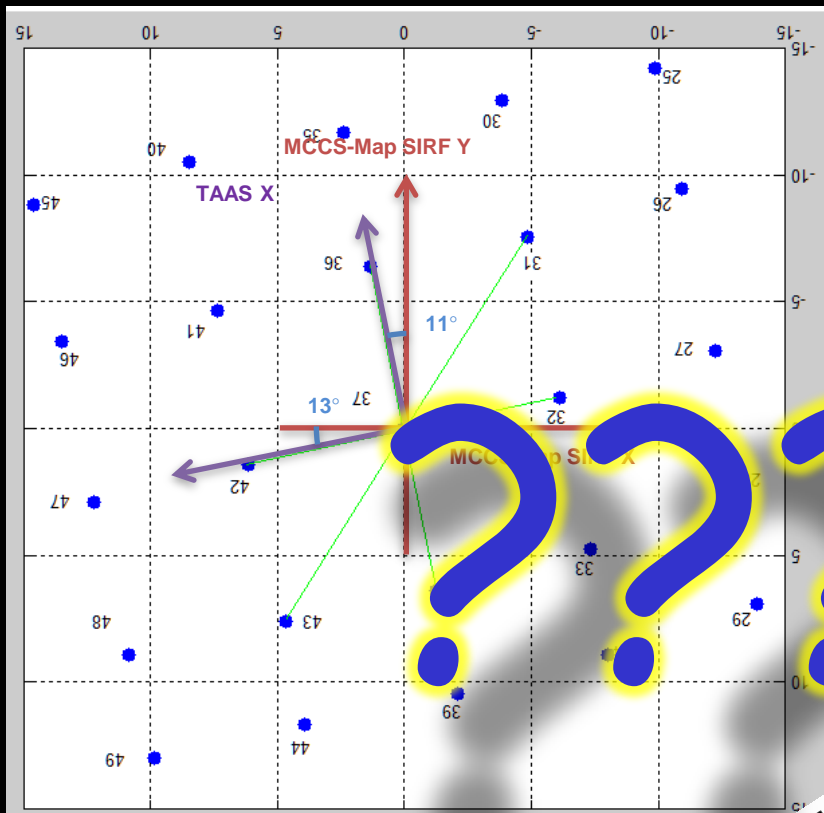






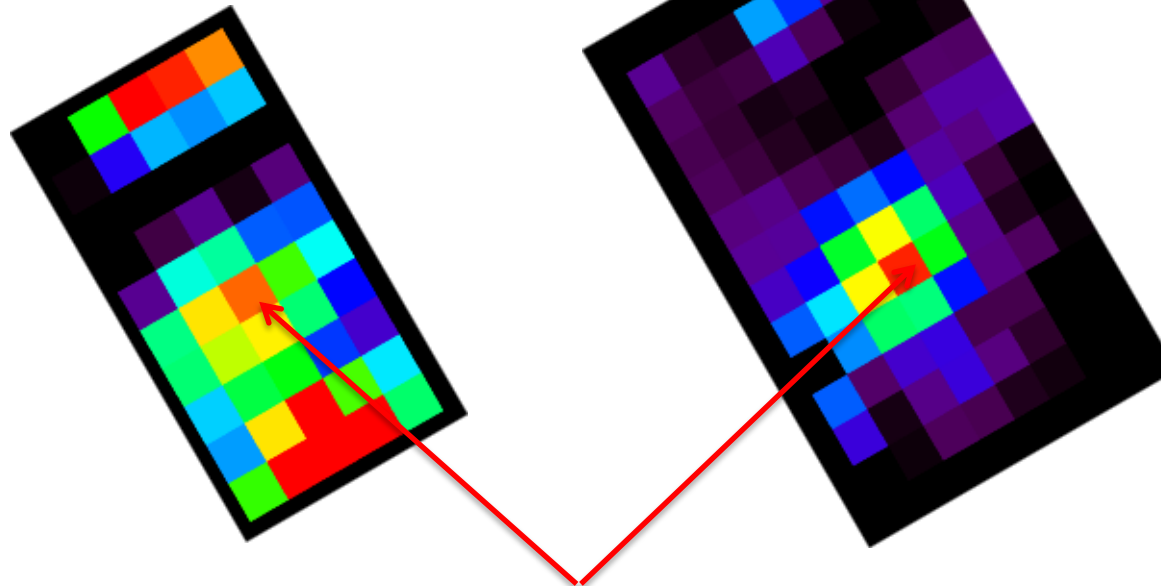
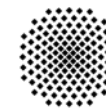








# [OIII] 52 $\mu$ m Line emission in NGC1569



Reference Pixel

Partial dataset 2014  
Initial Quicklook  
as of 2014

Full dataset 2014  
2x integration time  
Reduction as of March 2015

The improvement between the images is  $\sim 4$  S/N. A factor of  $\sqrt{2}$  accounts for the difference in integration time. The remainder is from the improved reduction.



# Targets

## Team:

- Orion
- M82
- NGC 1569
- Antennae
- Galactic Center

## Community Proposals

- Dark Clouds (also Team)
- Massive YSO w/ jet
- SNR
- Binary merger



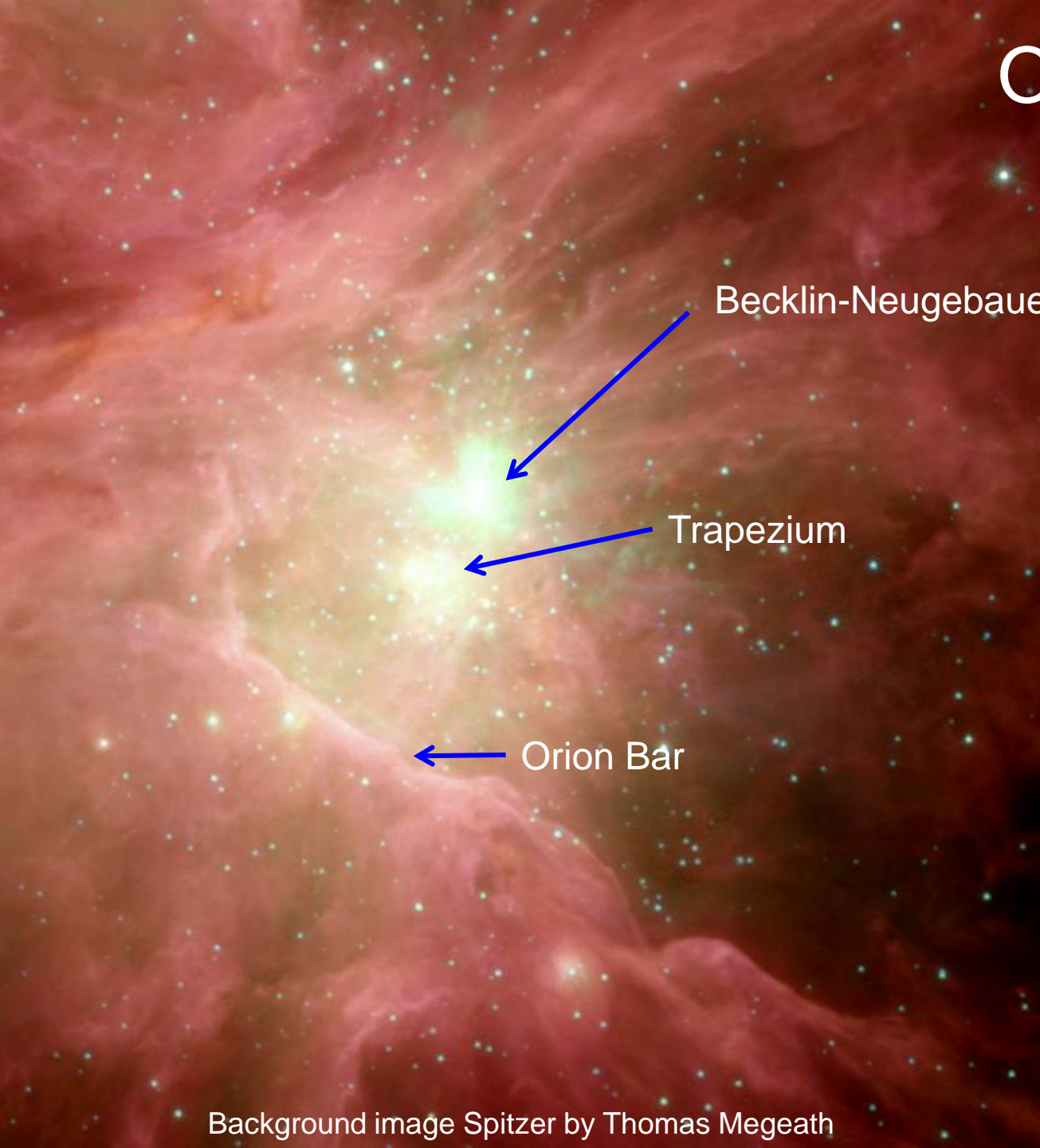


# Orion Nebula

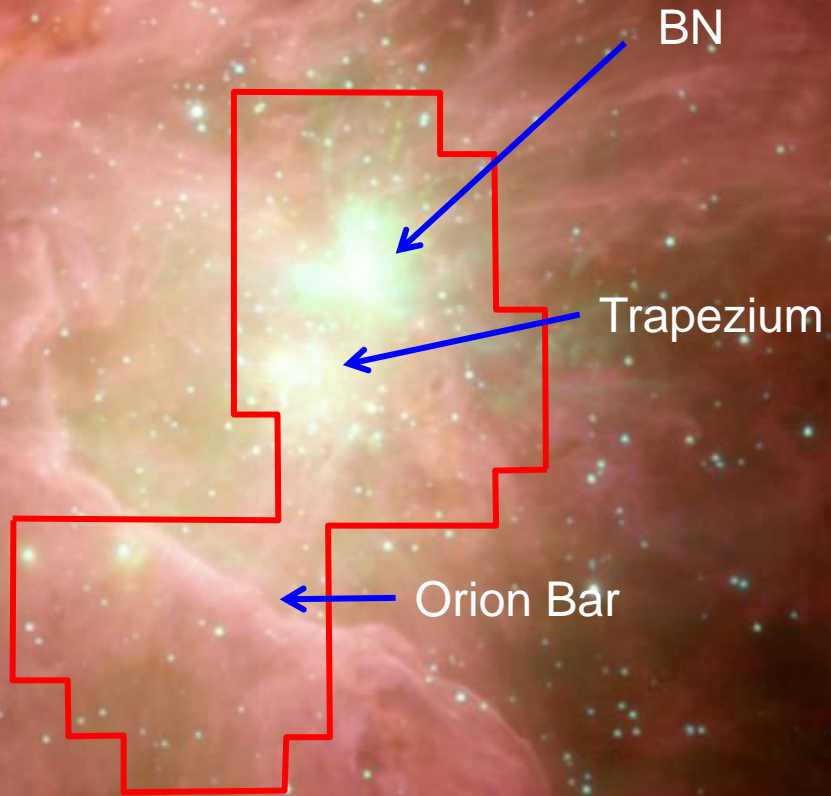
Becklin-Neugebauer Object

Trapezium

Orion Bar



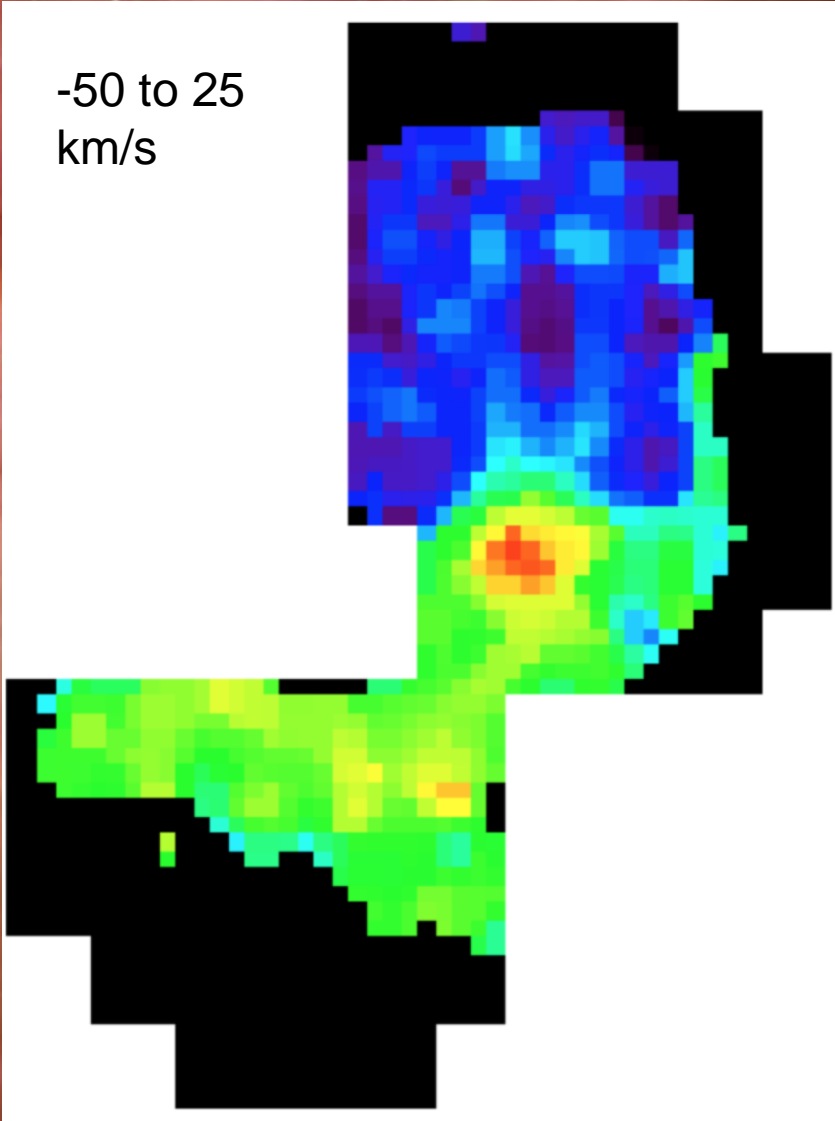
# Orion Nebula





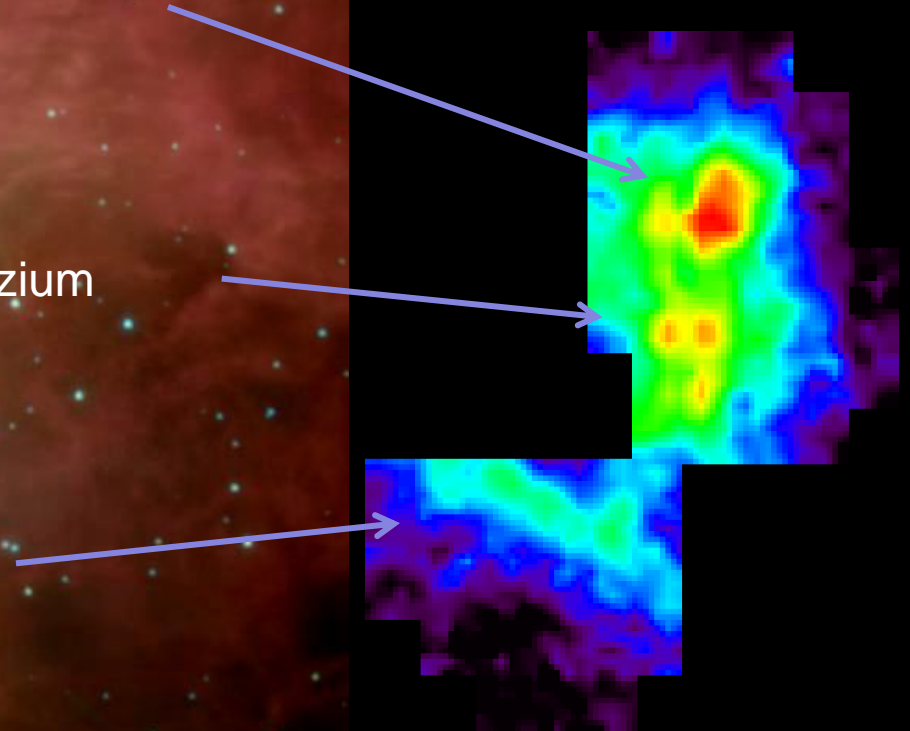
# Orion Nebula

-50 to 25  
km/s



zium

63  $\mu\text{m}$  [OI]

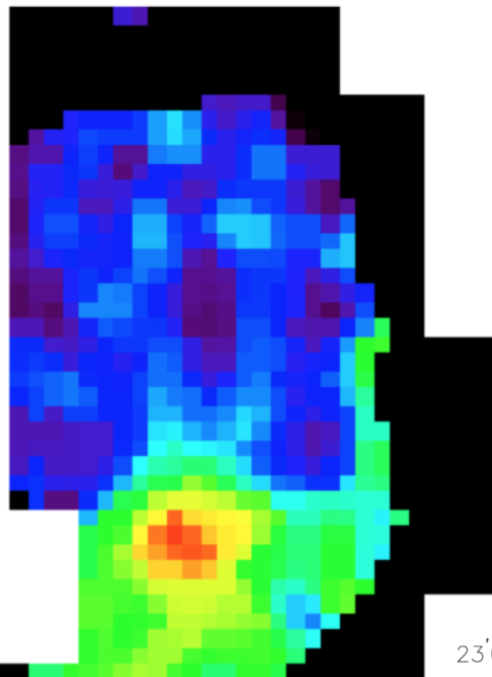


SOFIA &  
FIFI-LS

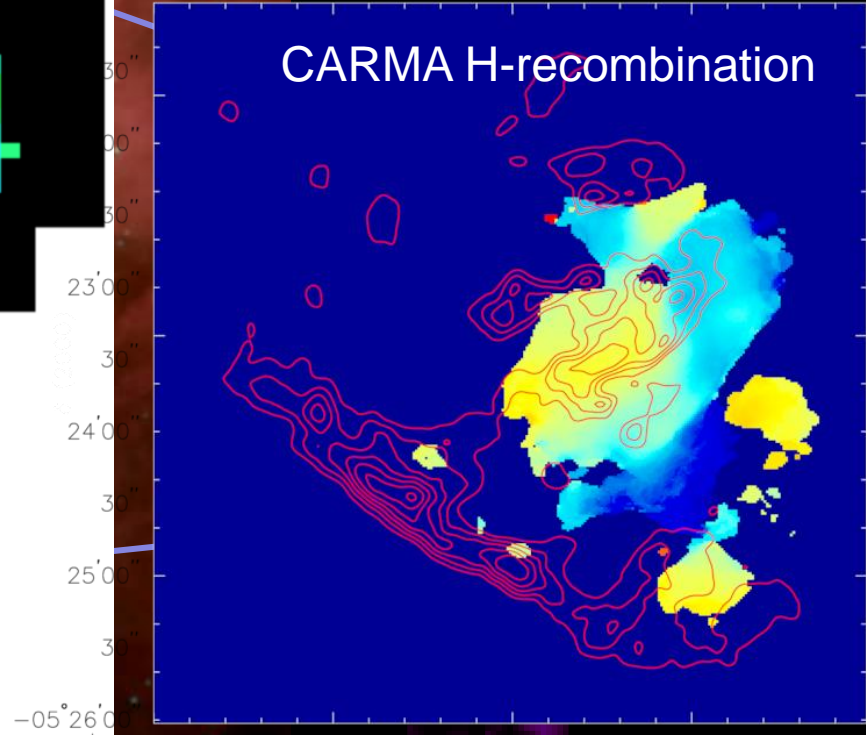
# Orion Nebula

63  $\mu\text{m}$  [OI]

-50 to 25  
km/s

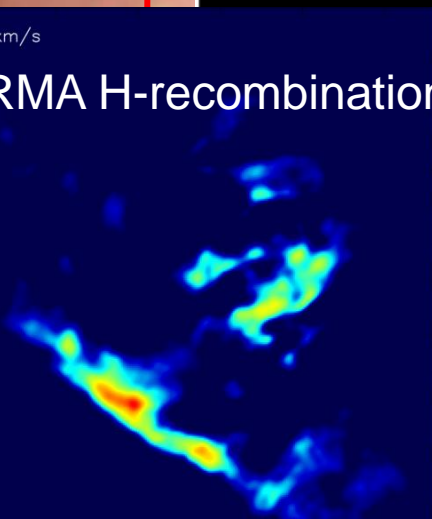


CARMA H-recombination



-25.37 km/s

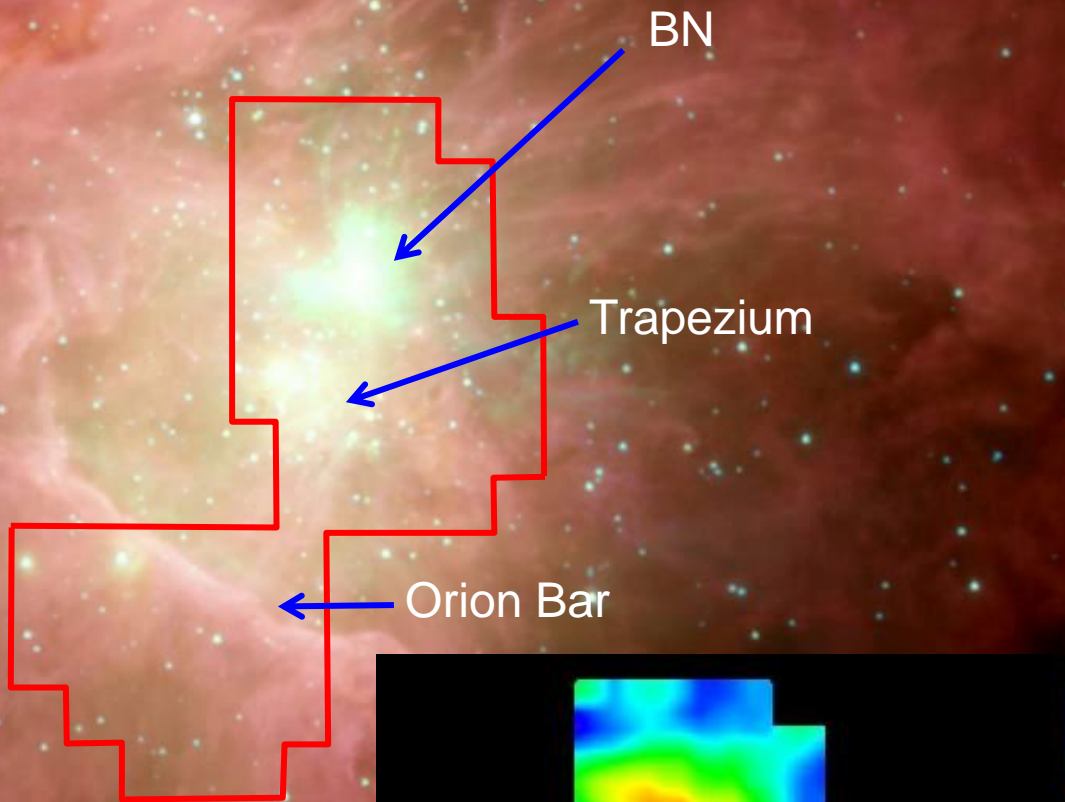
CARMA H-recombination



$\alpha$  (2000) **SOFIA & FIFI-LS**



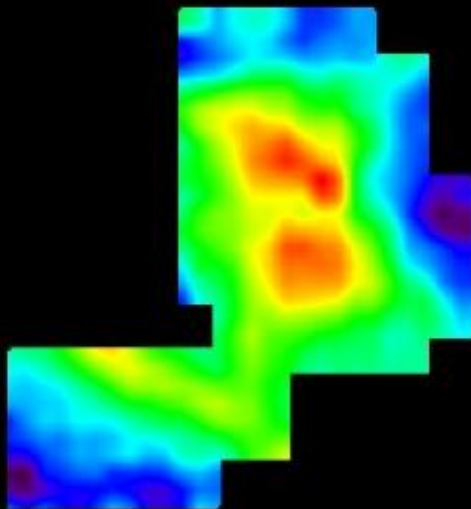
# Orion Nebula



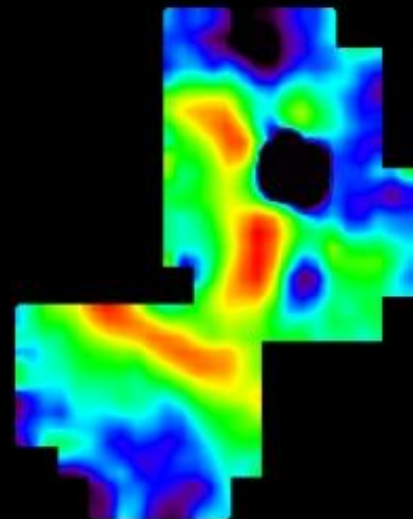
CO 22-21 @ 118  $\mu\text{m}$



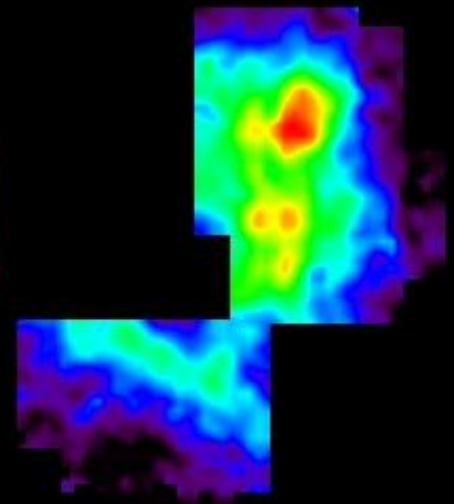
SOFIA &  
FIFI-LS



[CII] @ 157  $\mu\text{m}$

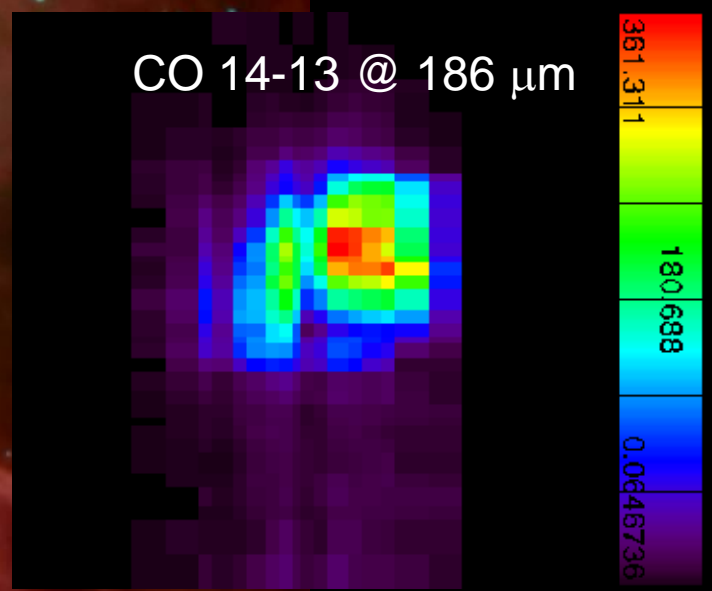
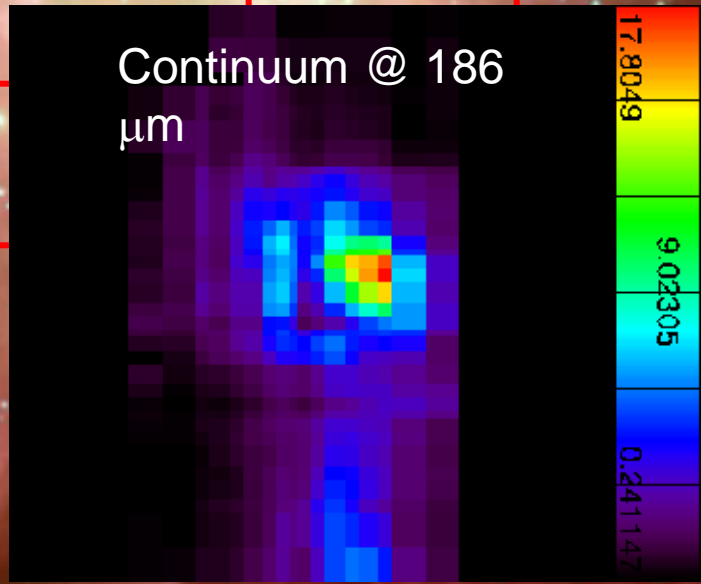
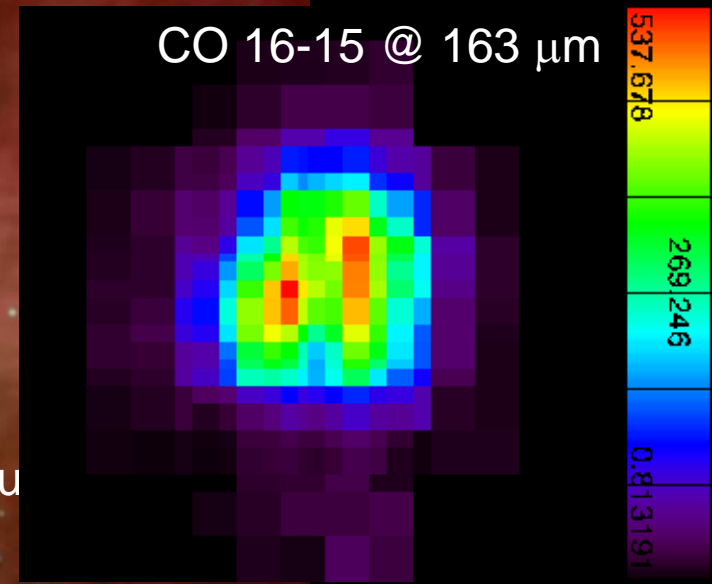
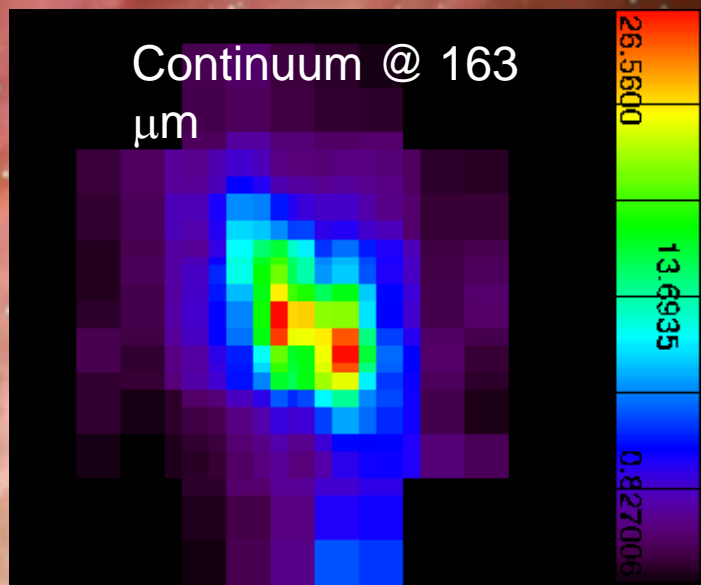


[OI] @ 145  $\mu\text{m}$



[OI] @ 63  $\mu\text{m}$

# Brand New Data: Orion Nebula



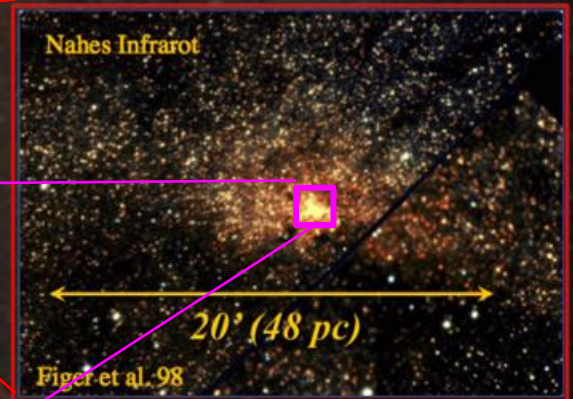


# FIFI-LS First Results: Galactic Center



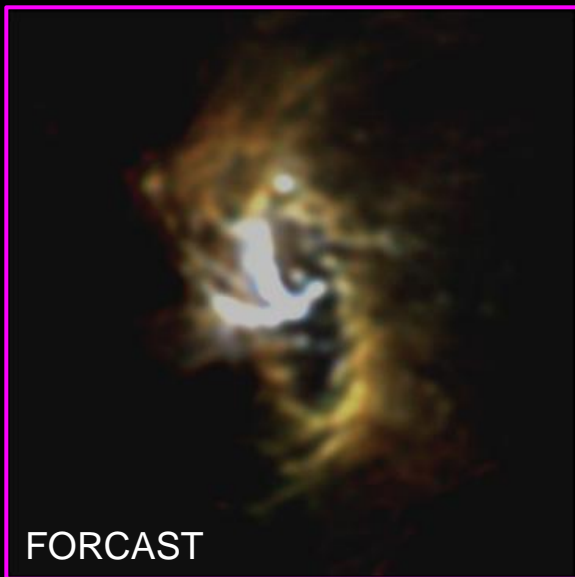
FORCAST 37μm Continuum

Lau et al. 2013



What is the connection between the circumnuclear disk and the black hole?

# FIFI-LS GC

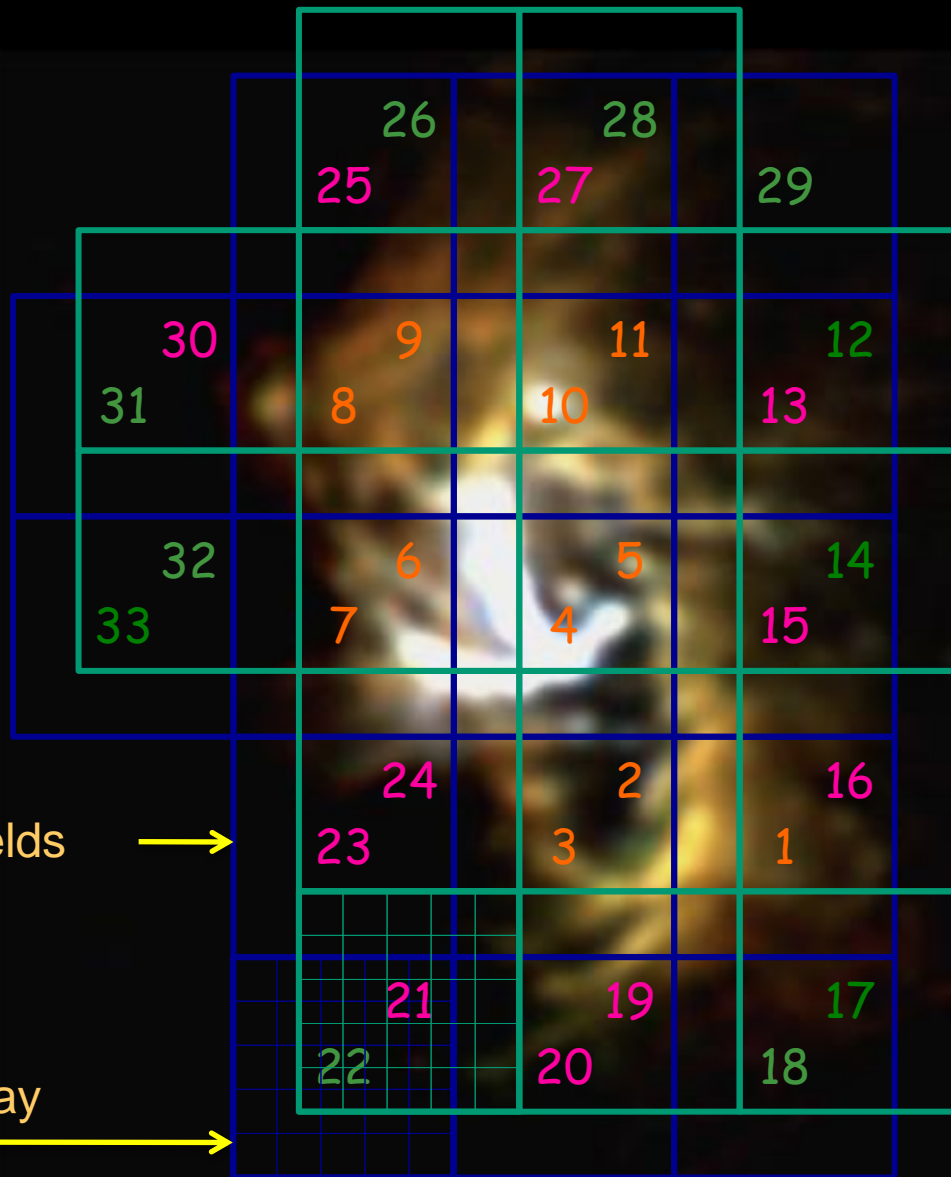


- 52  $\mu\text{m}$  [OIII]
- 57  $\mu\text{m}$  [NIII]
- 63  $\mu\text{m}$  [O]
- 88  $\mu\text{m}$  [OIII]
- 145  $\mu\text{m}$  [OI]
- 153  $\mu\text{m}$  CO 17-16
- 157  $\mu\text{m}$  [CII]
- 186  $\mu\text{m}$  CO 14-13

33 mosaic fields



FOV blue array



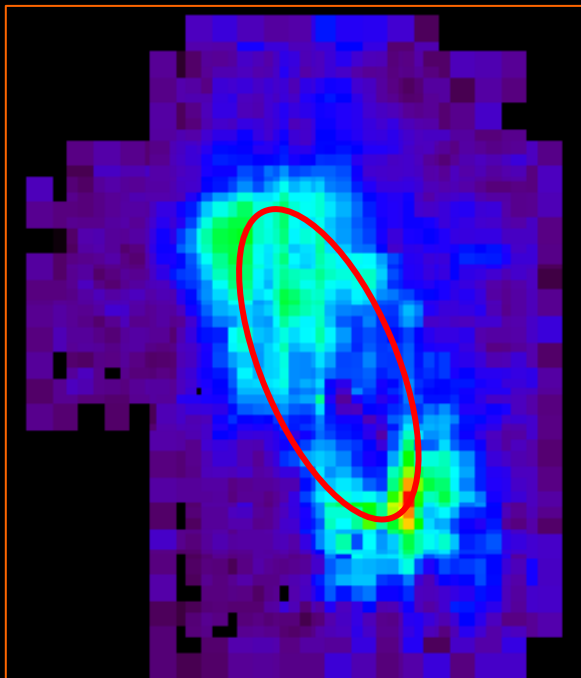
FIFI-LS mosaic



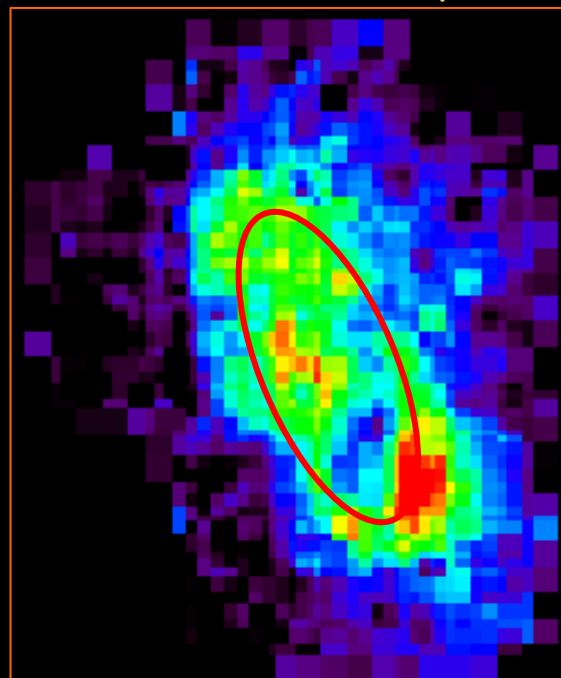
# FIFI-LS GC



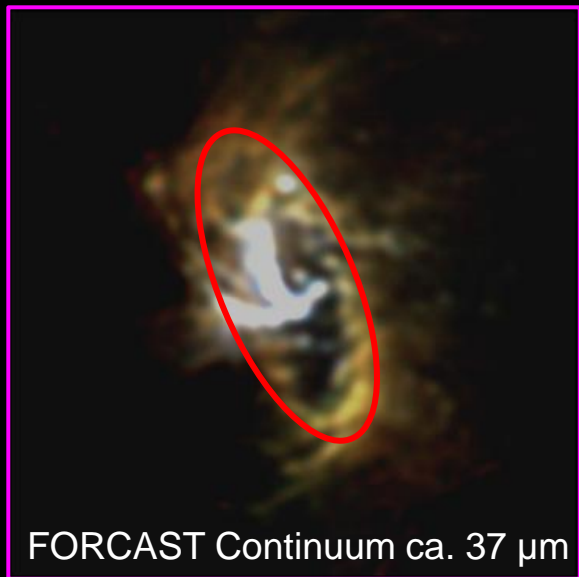
[OI] @ 63  $\mu\text{m}$



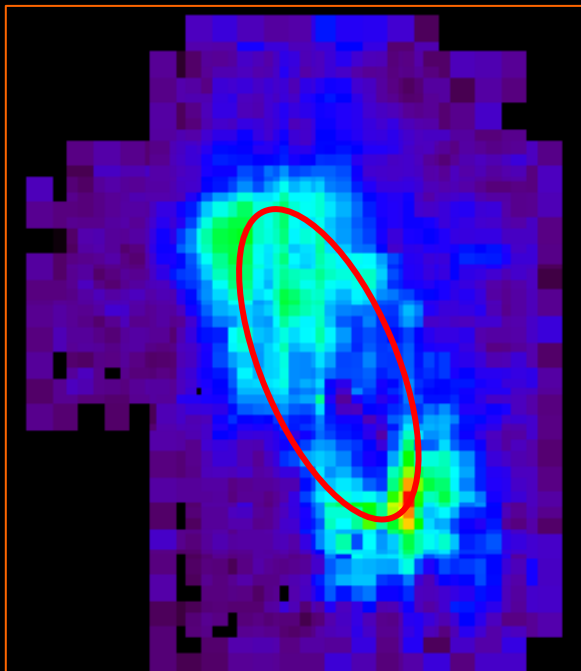
Continuum @ 63  $\mu\text{m}$



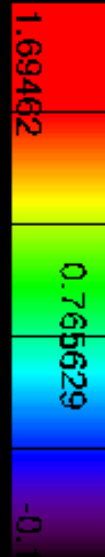
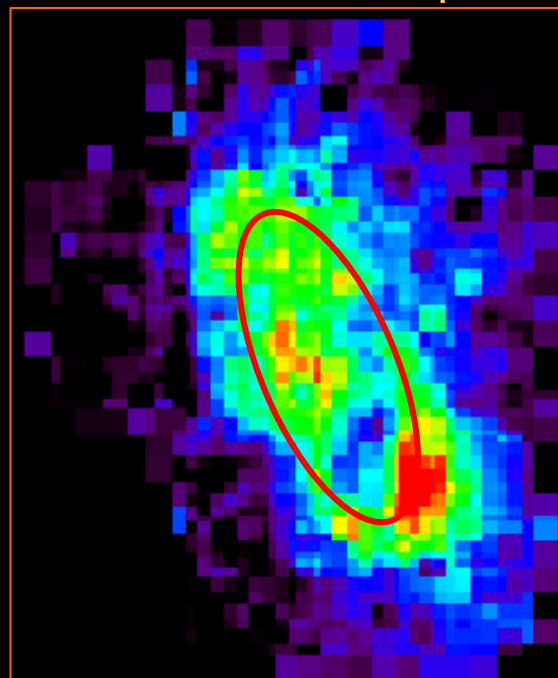
# FIFI-LS GC



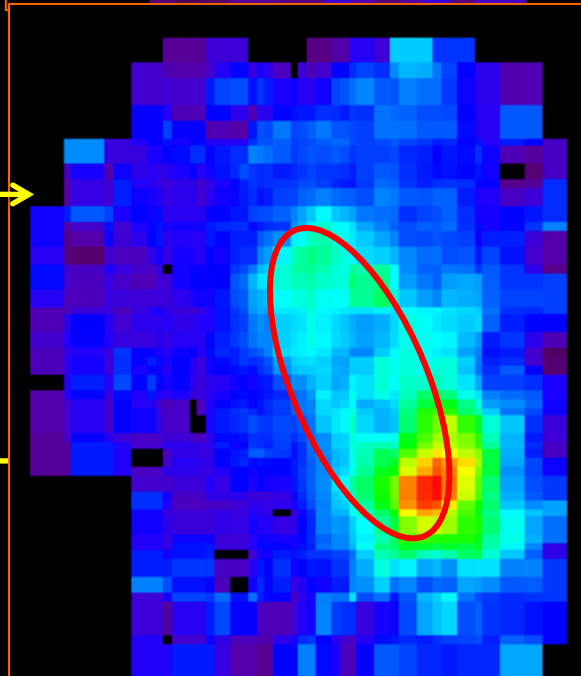
[OI] @ 63  $\mu\text{m}$



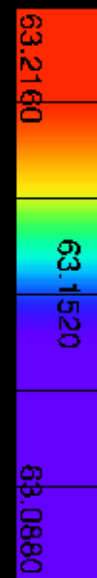
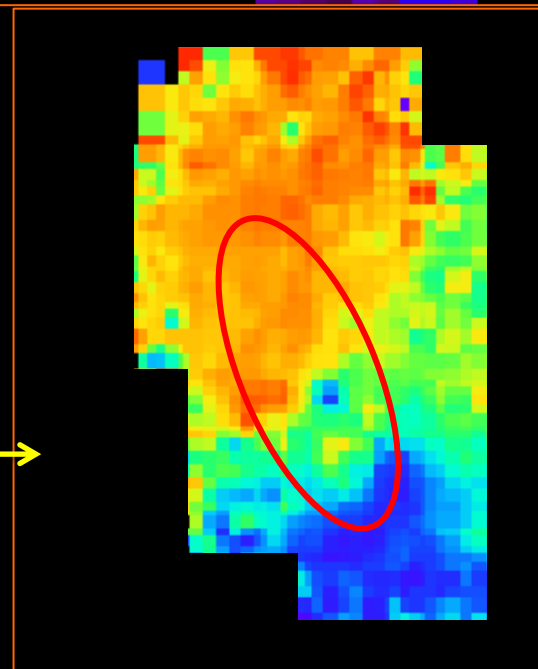
Continuum @ 63  $\mu\text{m}$



[OI] @ 145  $\mu\text{m}$

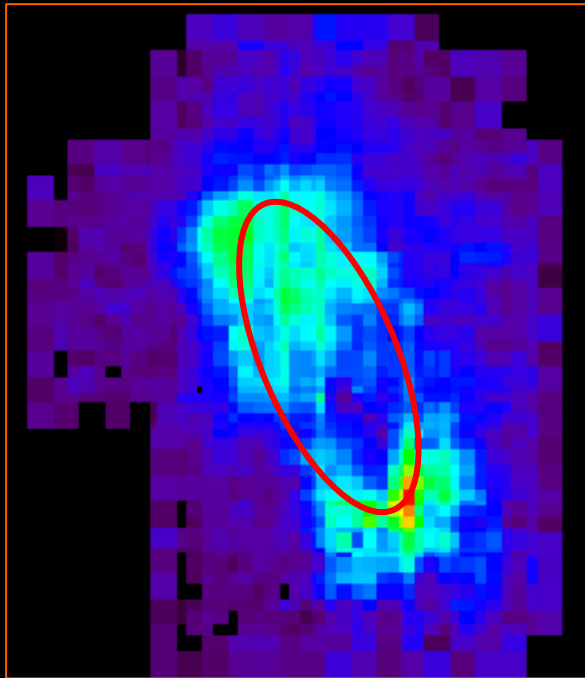


[OI] @ 145  $\mu\text{m}$   
velocity

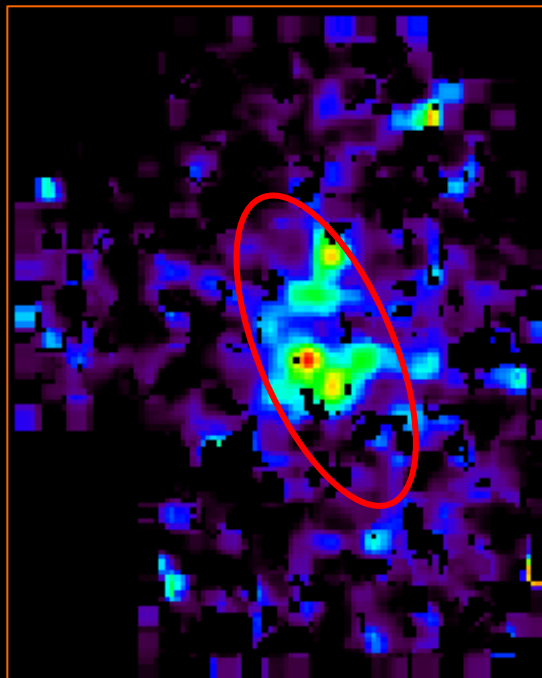




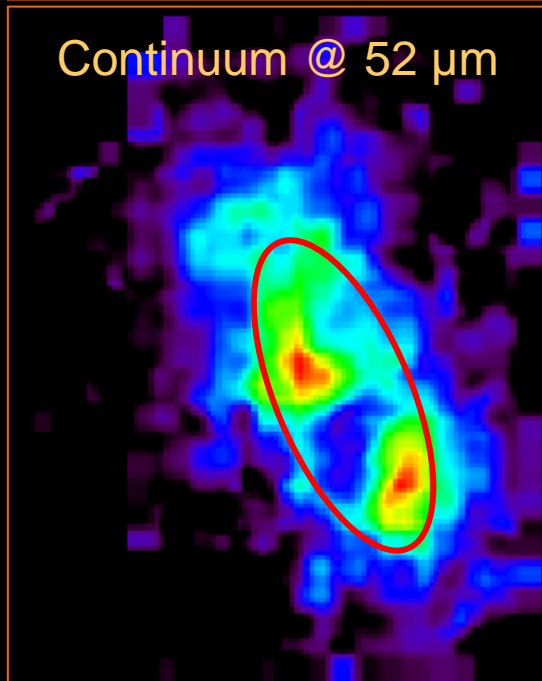
[OI] @ 63  $\mu\text{m}$



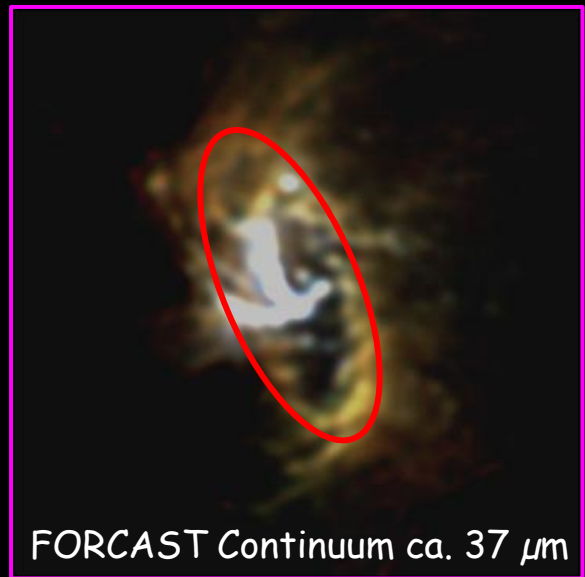
[OIII] @ 52  $\mu\text{m}$



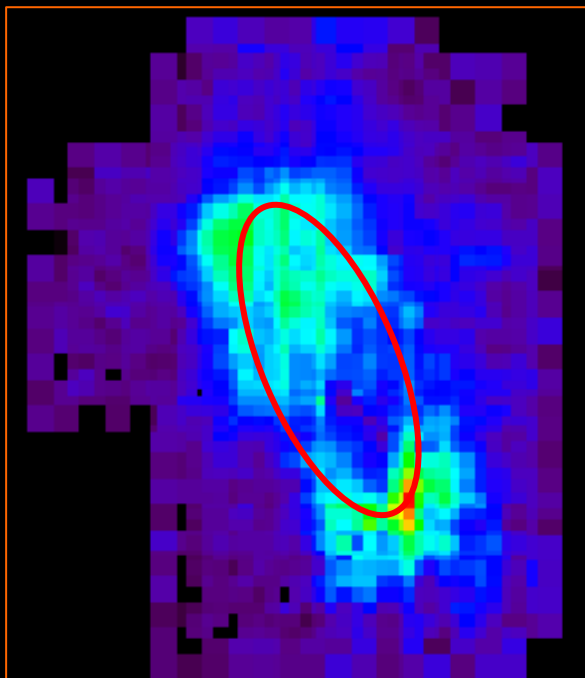
Continuum @ 52  $\mu\text{m}$



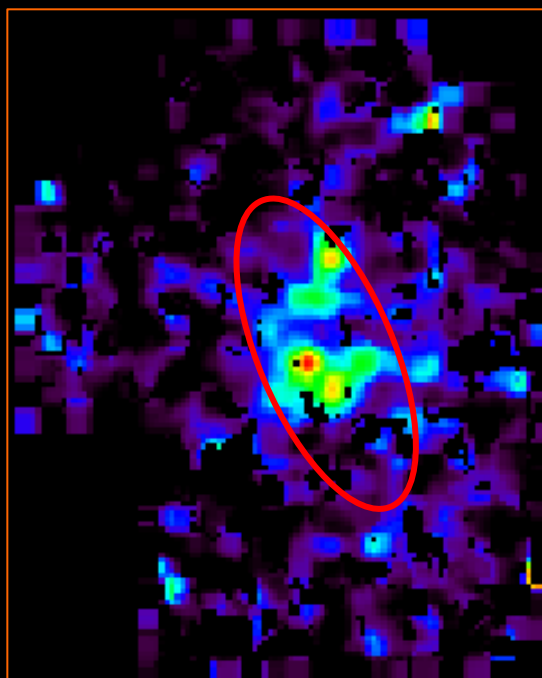
FORCAST Continuum ca. 37  $\mu\text{m}$



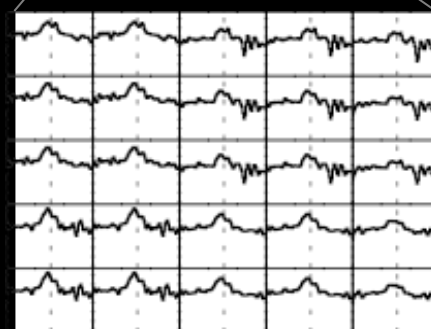
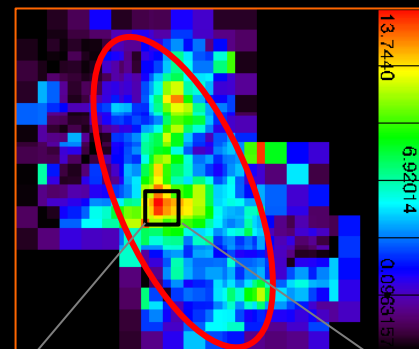
[OI] @ 63  $\mu\text{m}$



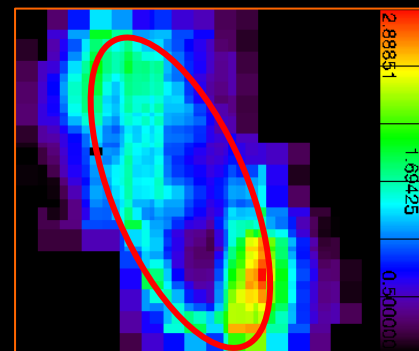
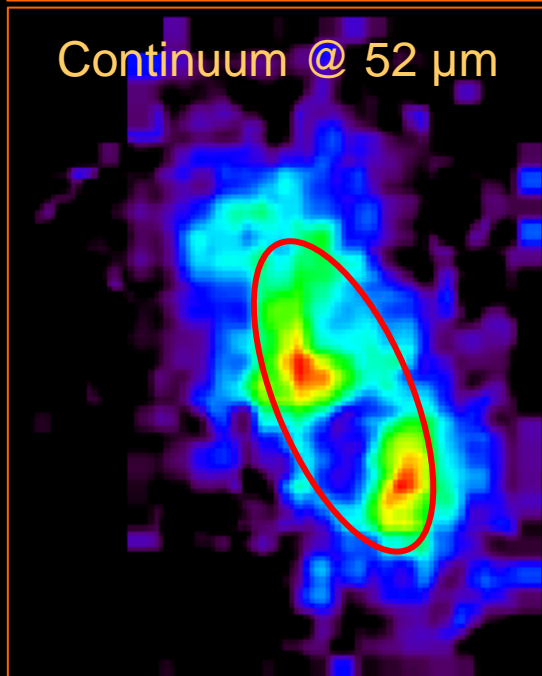
[OIII] @ 52  $\mu\text{m}$



[OIII] @ 88  $\mu\text{m}$



Continuum @ 52  $\mu\text{m}$



Continuum @ 88  $\mu\text{m}$

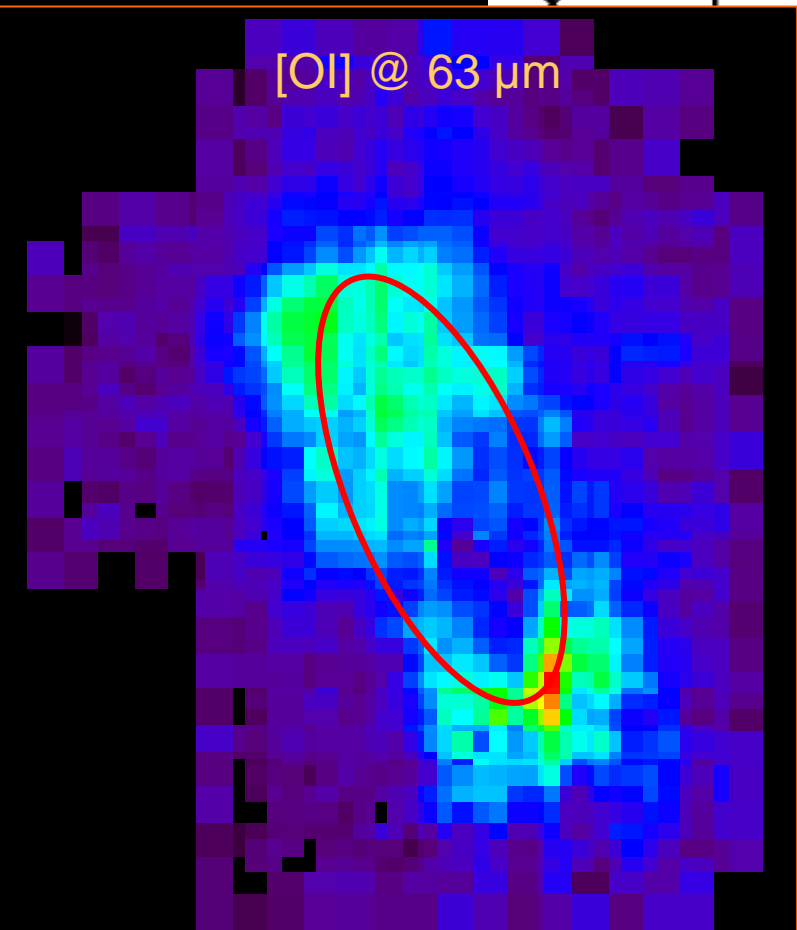
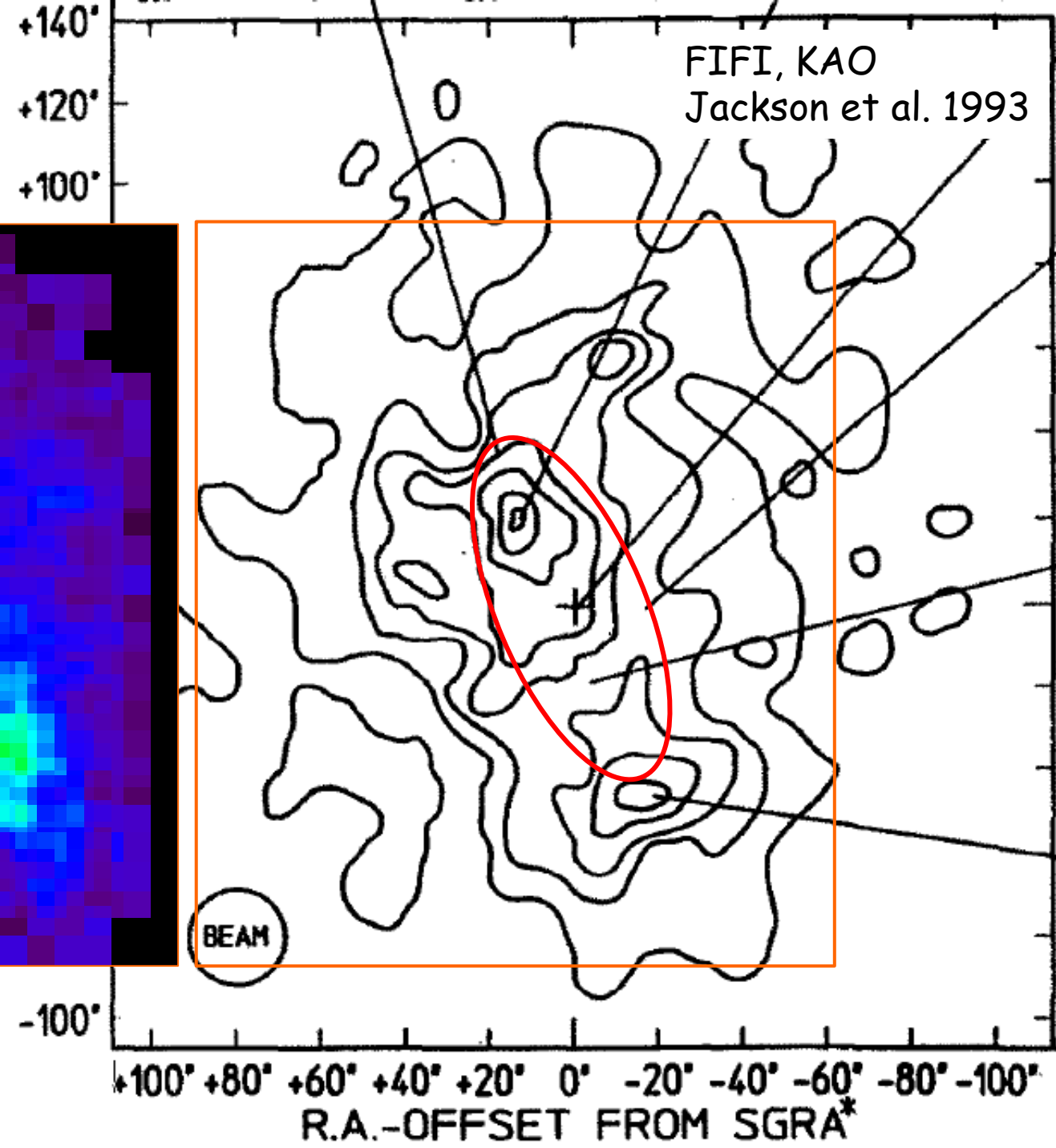
FORCAST Continuum ca. 37  $\mu\text{m}$



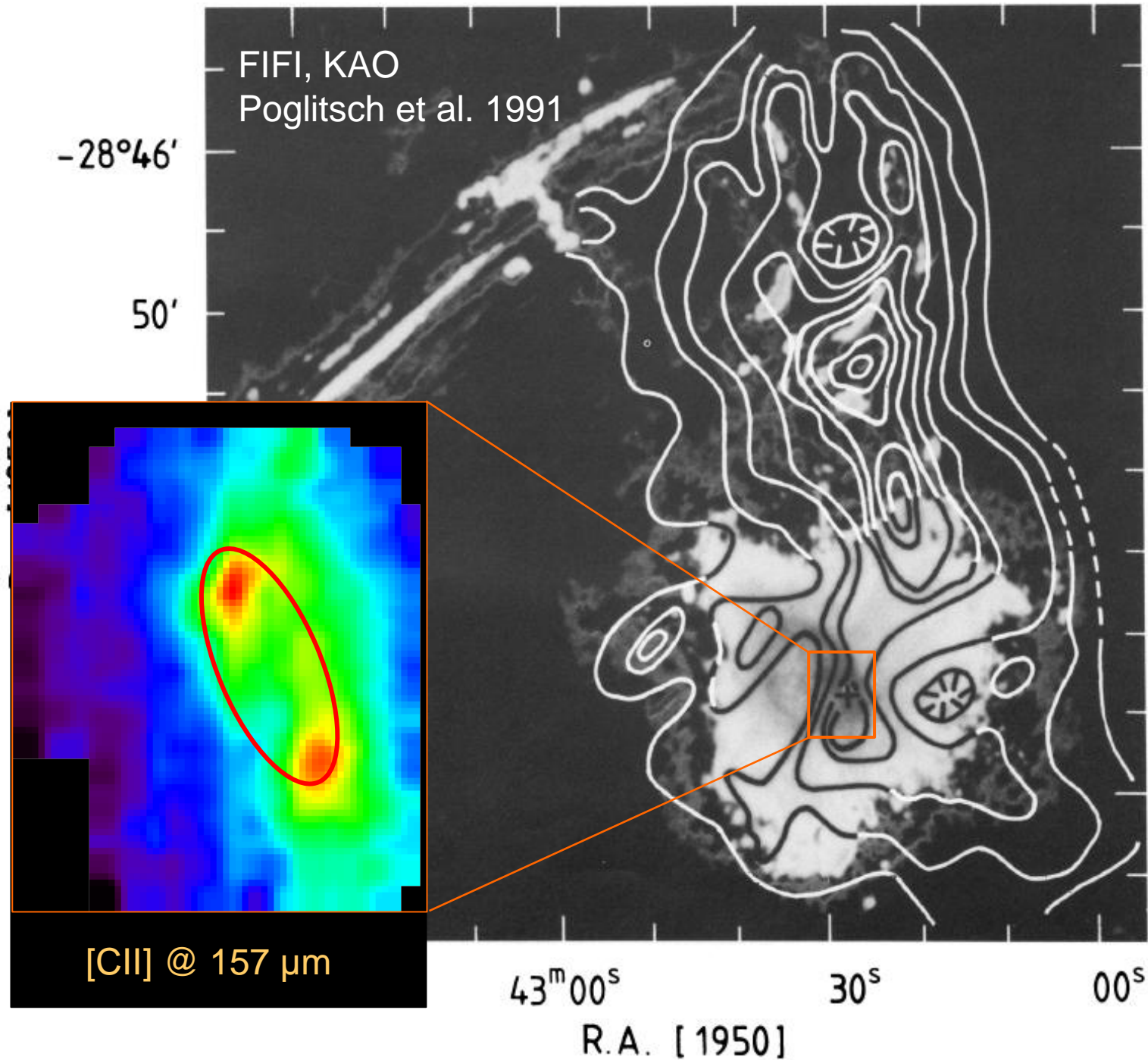


FIFI, KAO  
Jackson et al. 1993

[OI] @ 63  $\mu\text{m}$

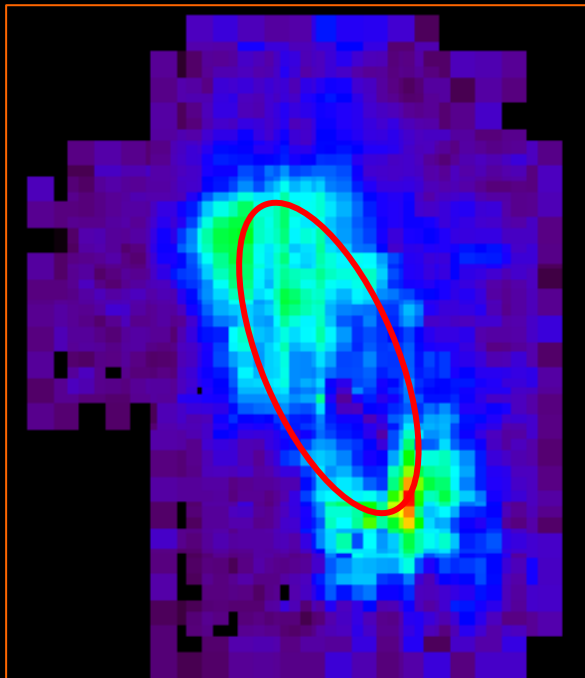


FIFI-LS GC

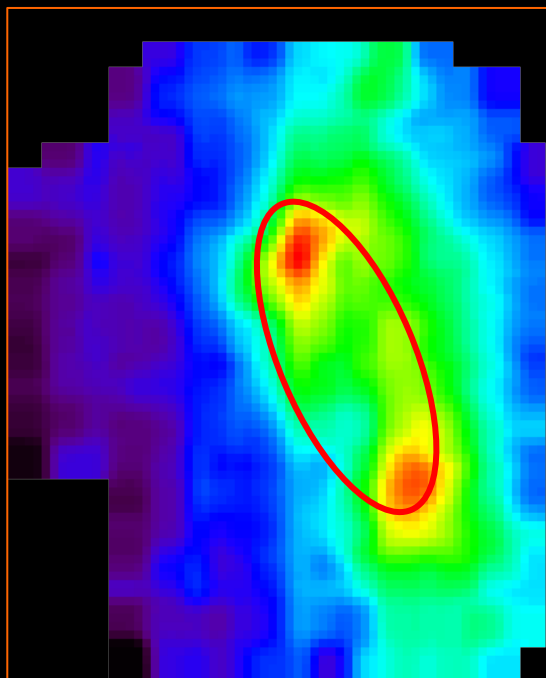




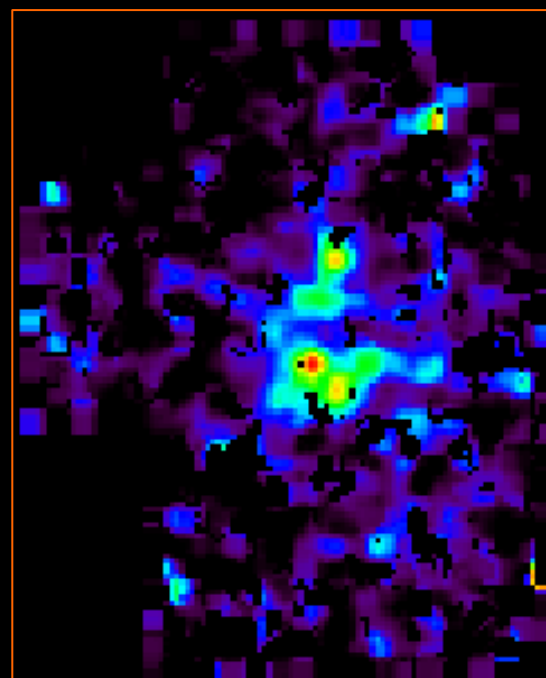
[OI] @ 63  $\mu\text{m}$



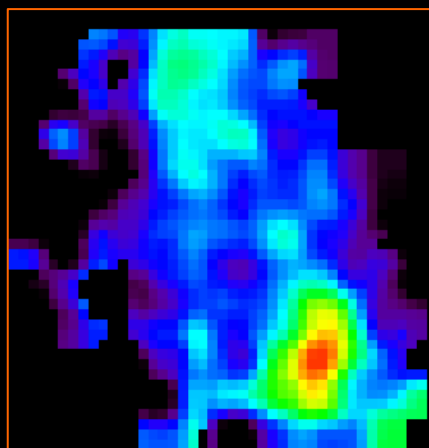
[CII] @ 157  $\mu\text{m}$



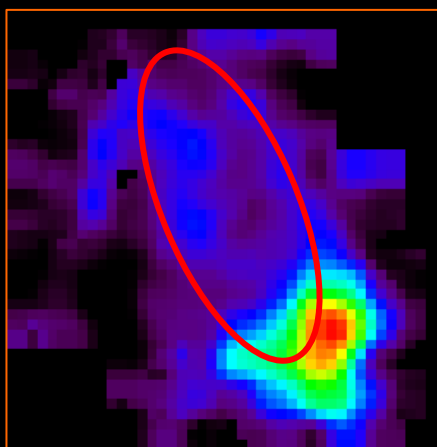
[OIII] @ 52  $\mu\text{m}$



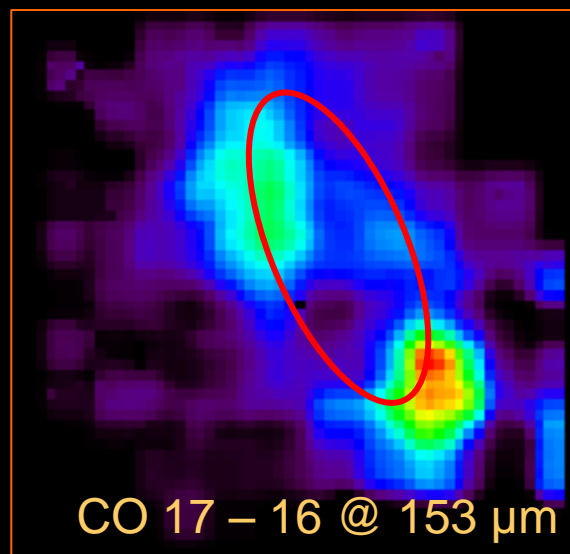
Continuum @ 186  $\mu\text{m}$



CO14 – 13 @ 186  $\mu\text{m}$

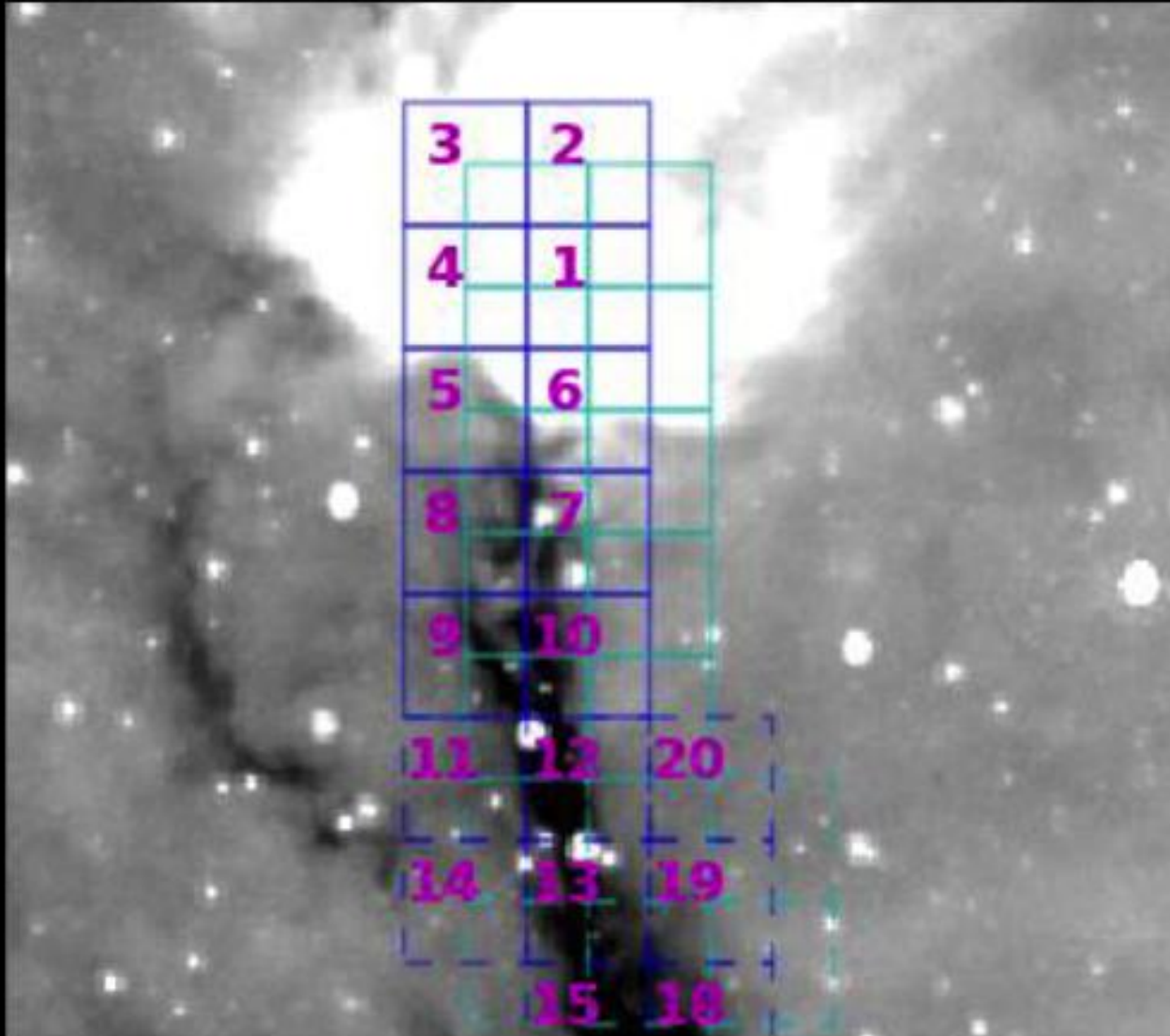


CO 17 – 16 @ 153  $\mu\text{m}$



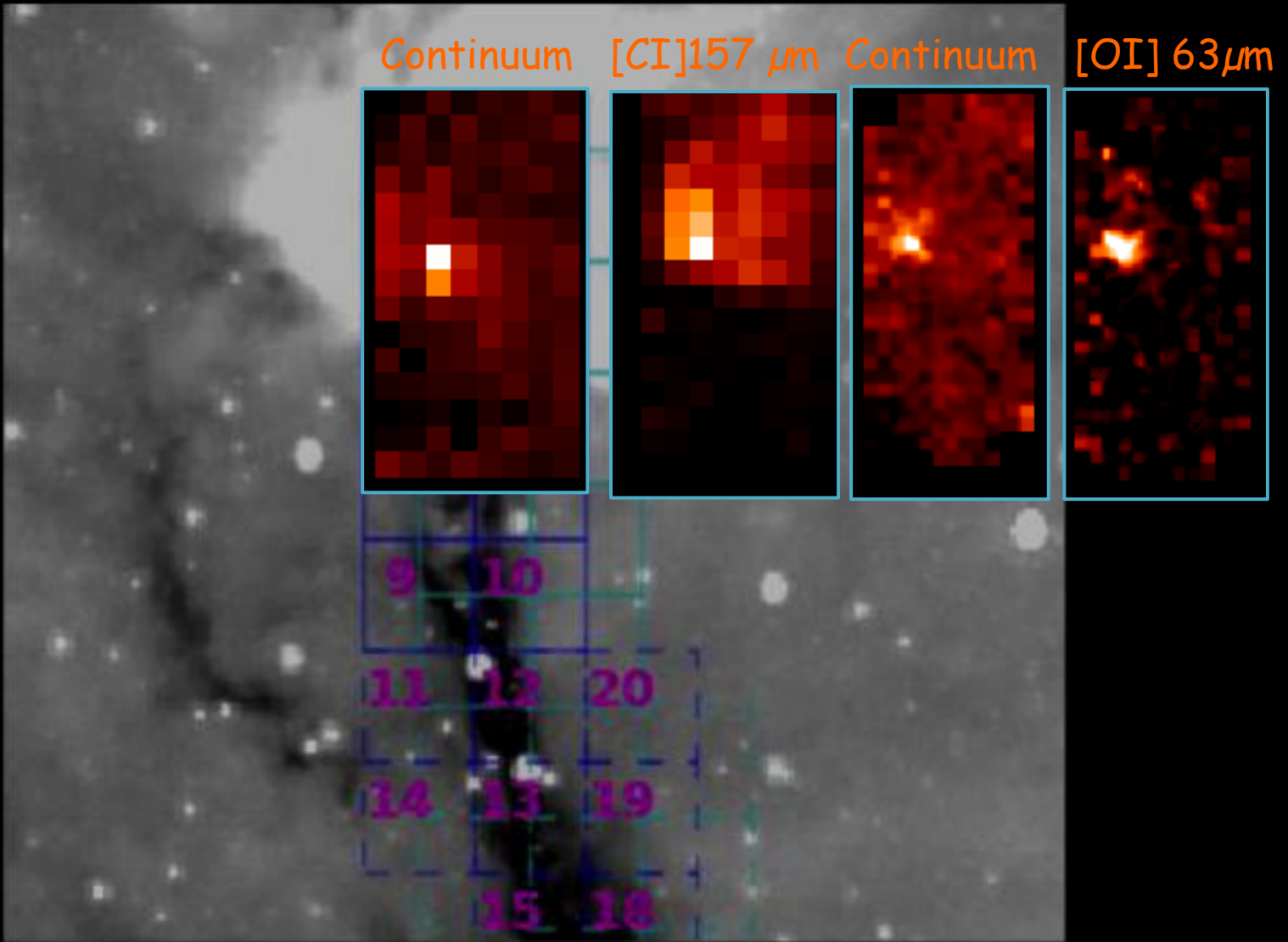
FIFI-LS GC

# Dark Cloud IRDC 18223

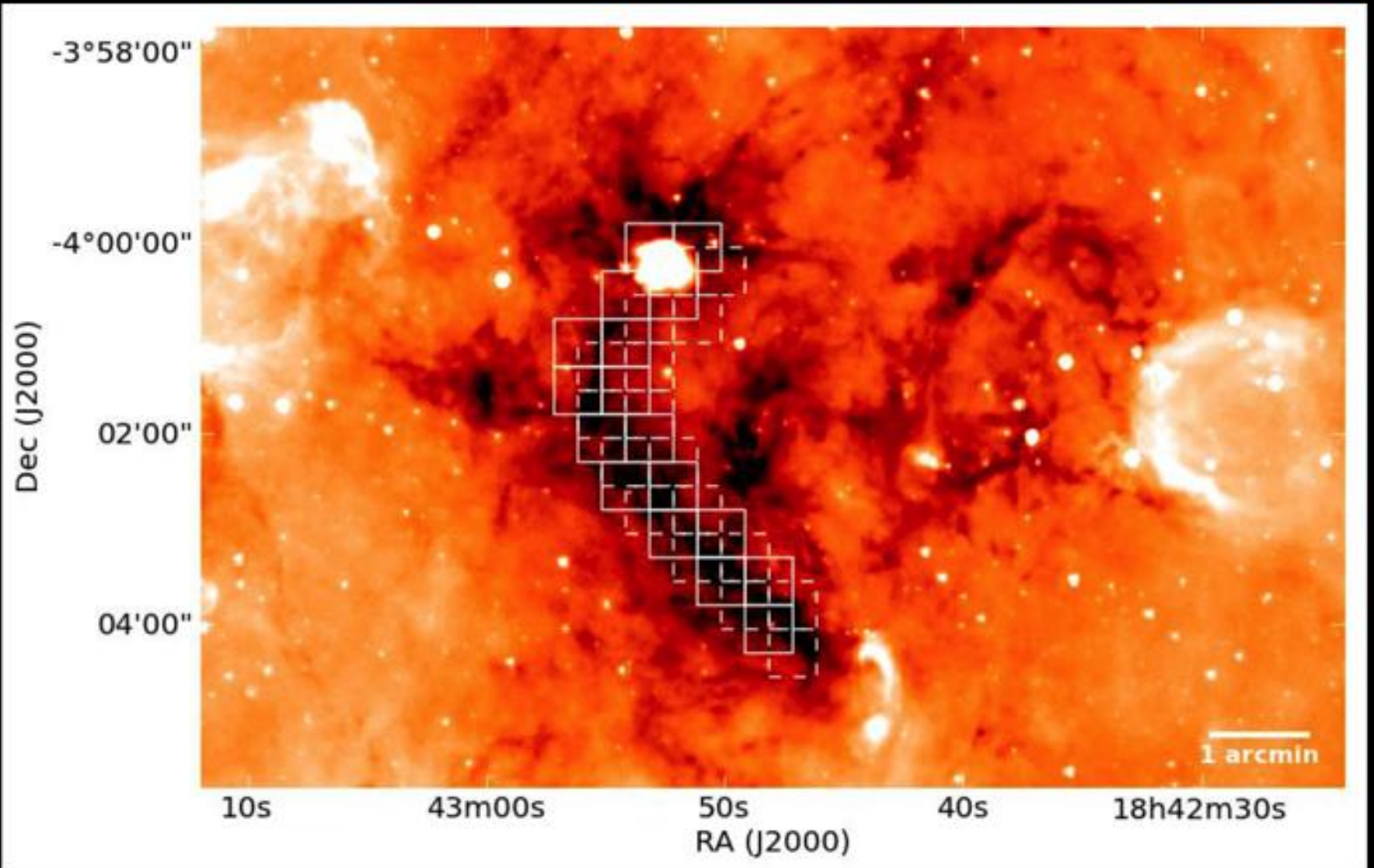




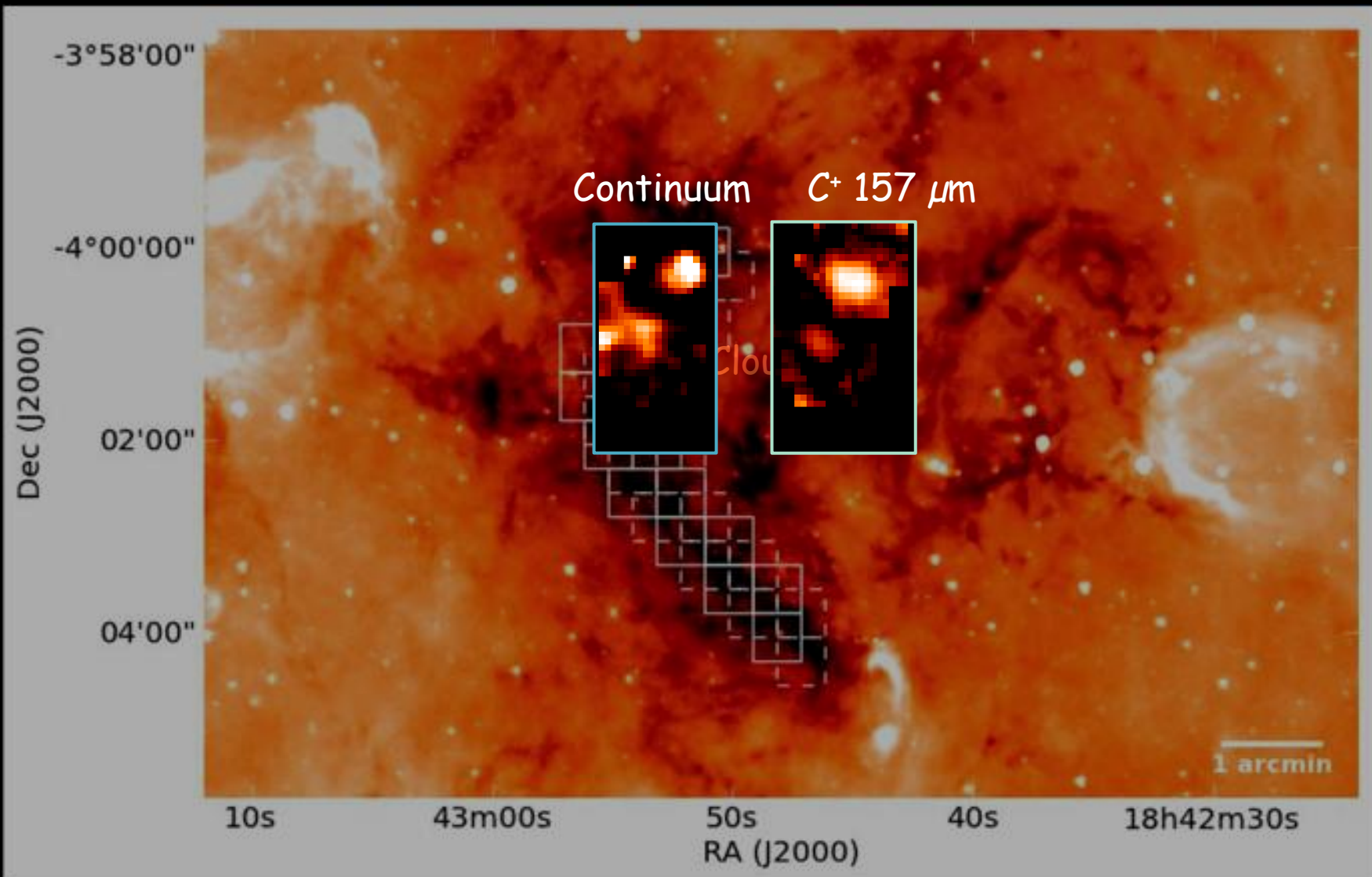
# Dark Cloud IRDC 18223



# Dark Cloud G28.34



# Dark Cloud G28.34

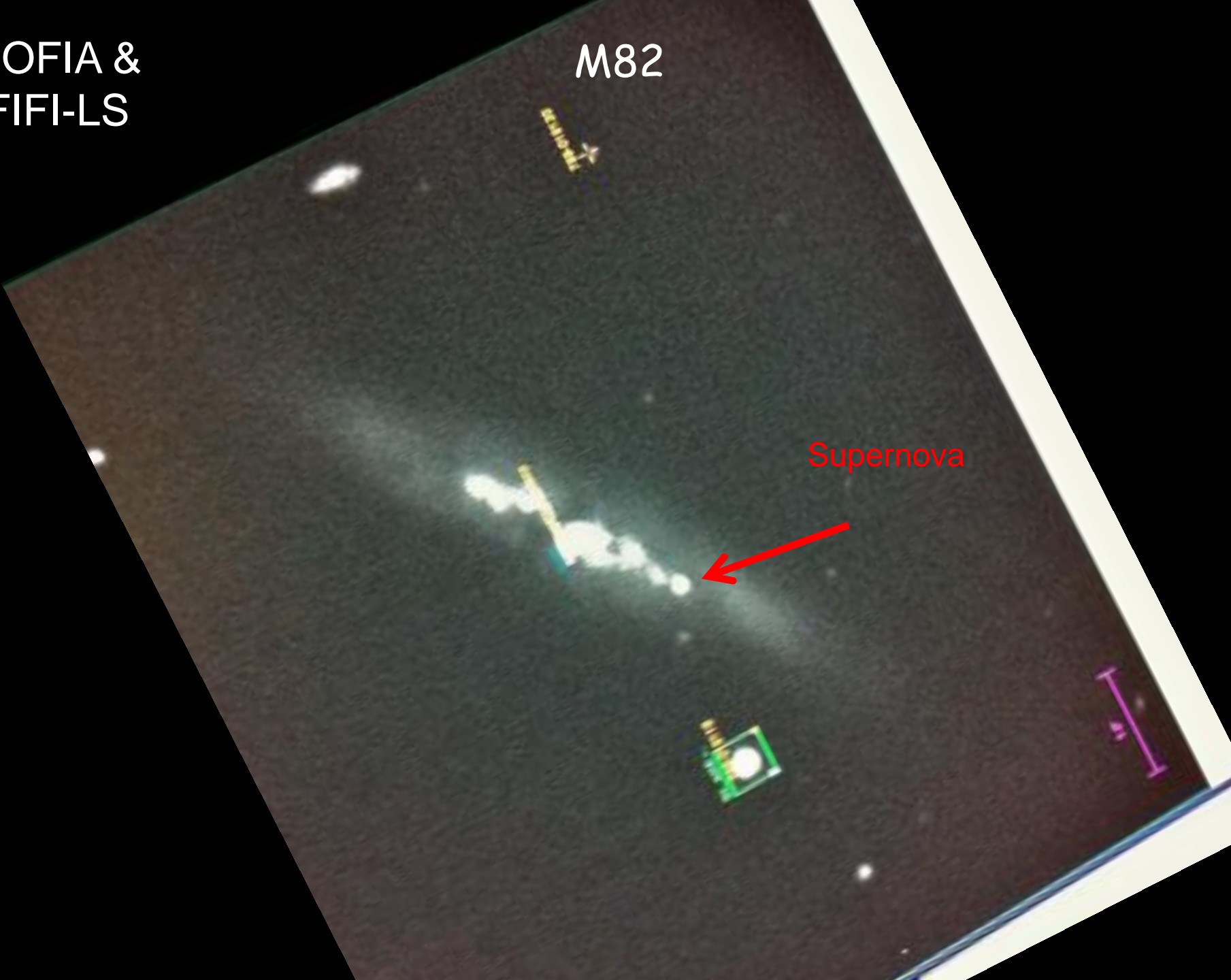




SOFIA &  
FIFI-LS

M82

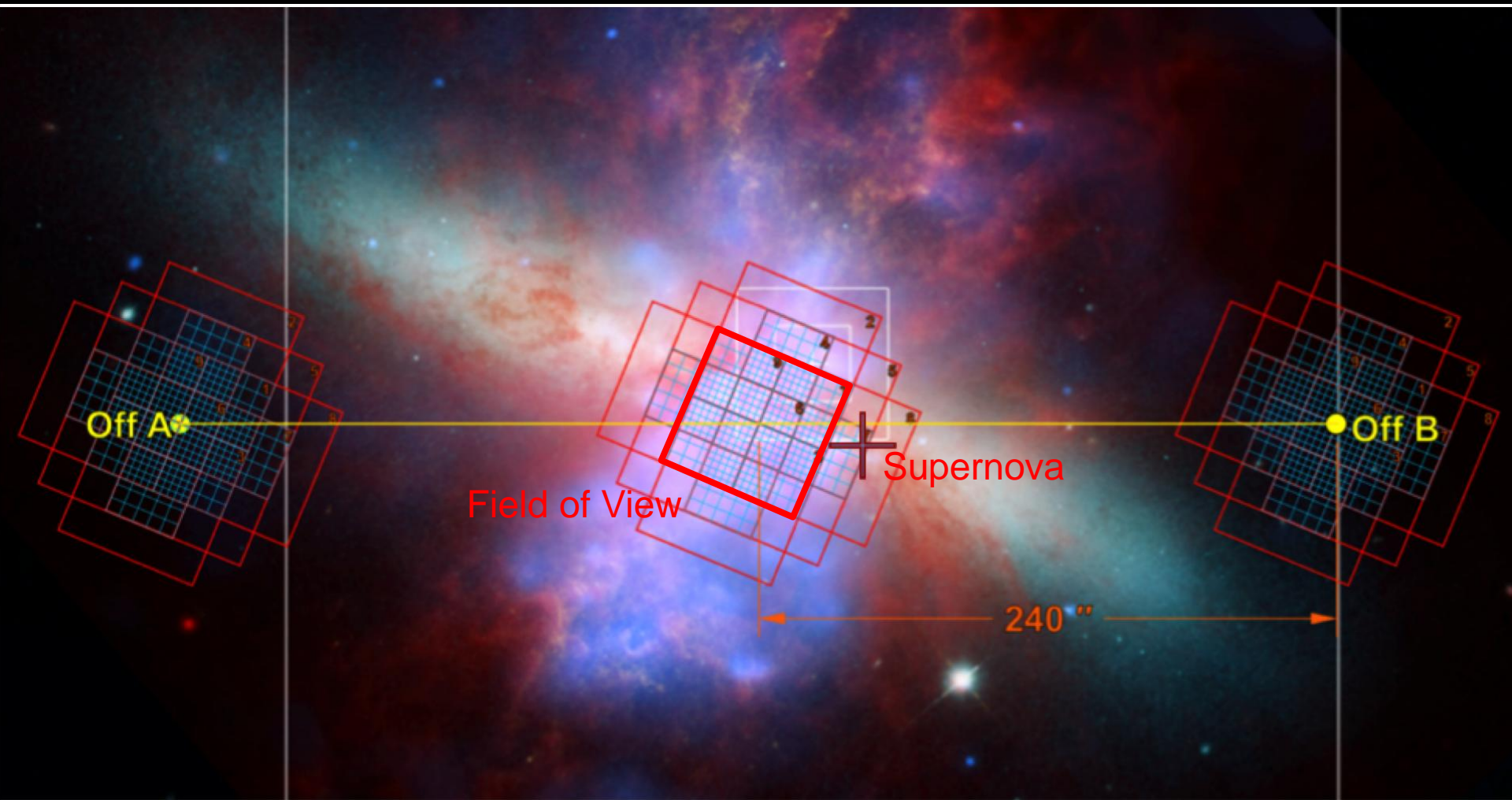
Supernova



SOFIA &  
FIFI-LS

M82 Galaxy

Ionized Carbon



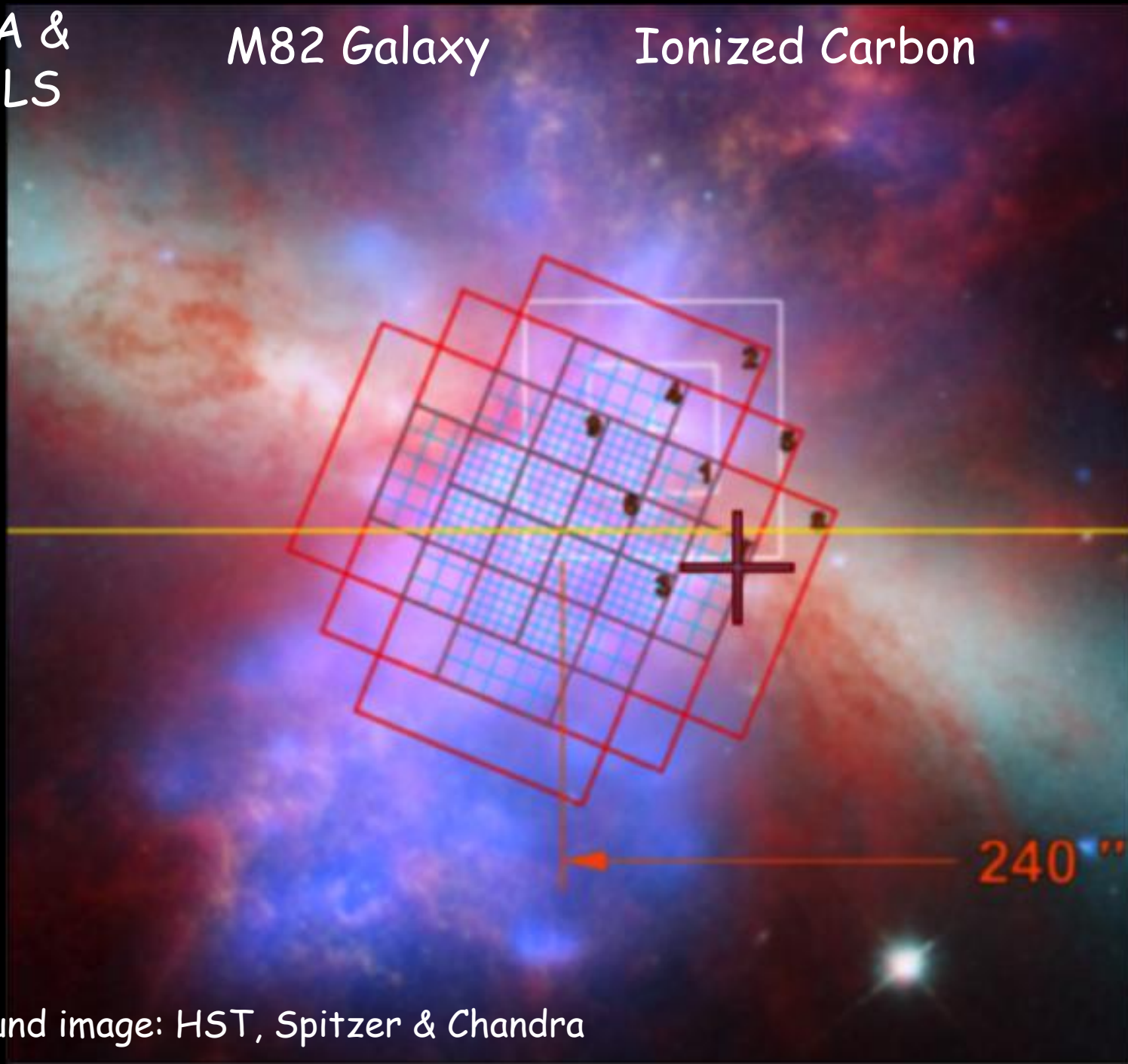
Background image: HST, Spitzer & Chandra



SOFIA &  
FIFI-LS

M82 Galaxy

Ionized Carbon

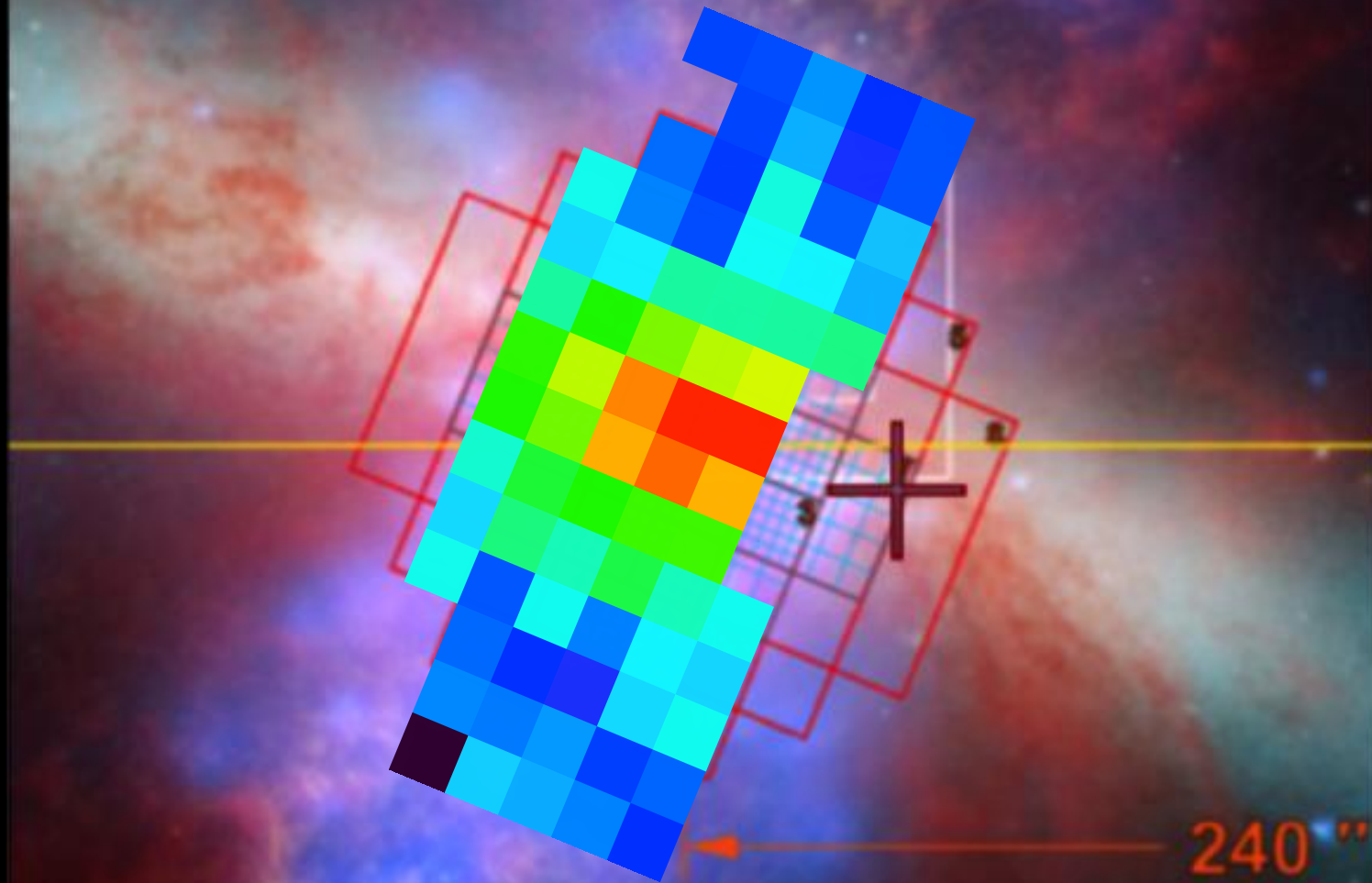


Background image: HST, Spitzer & Chandra



SOFIA &  
FIFI-LS

M82 Galaxy



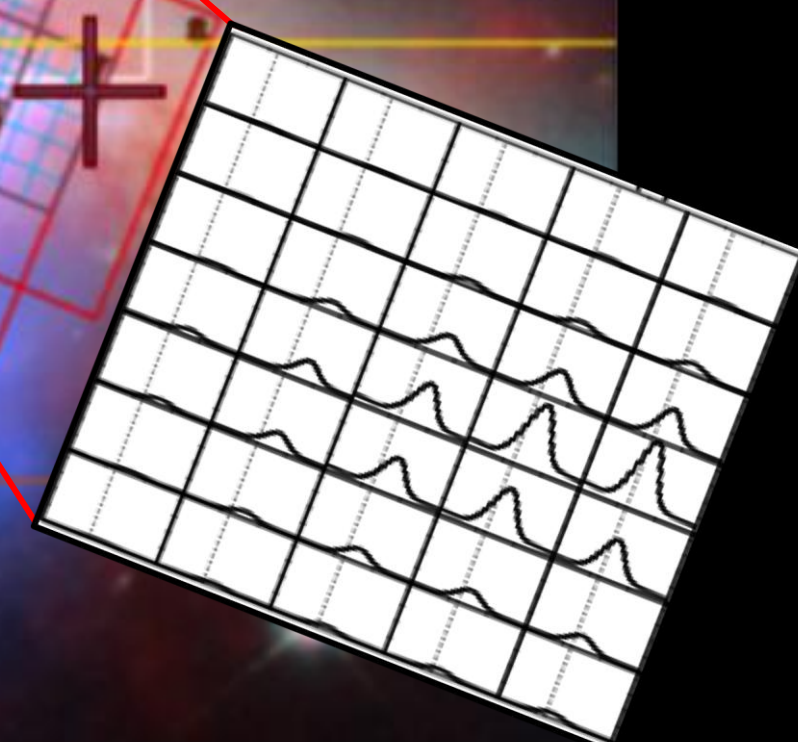
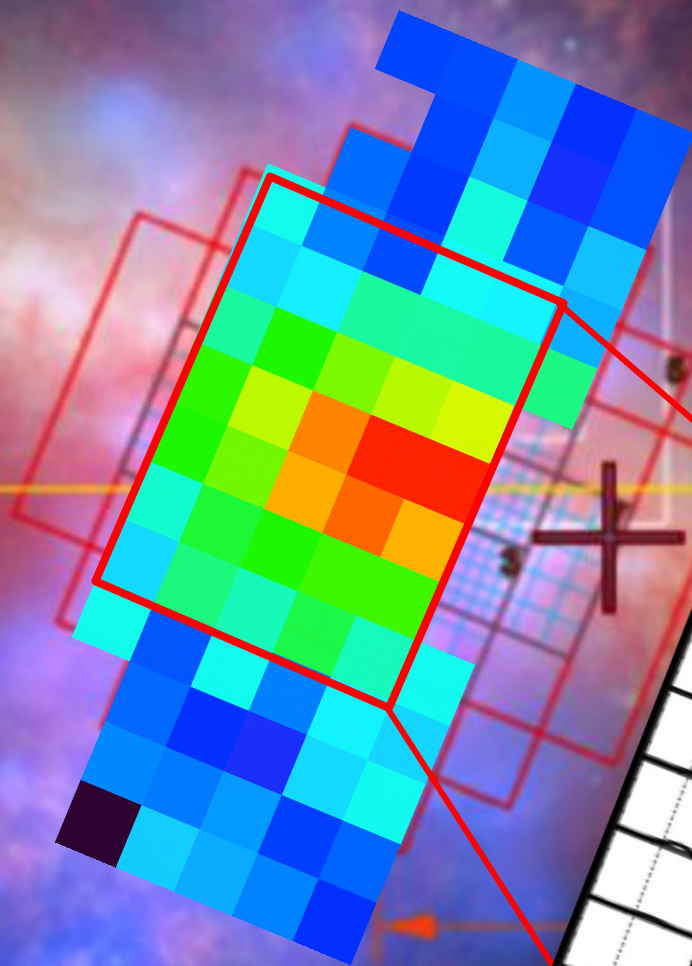
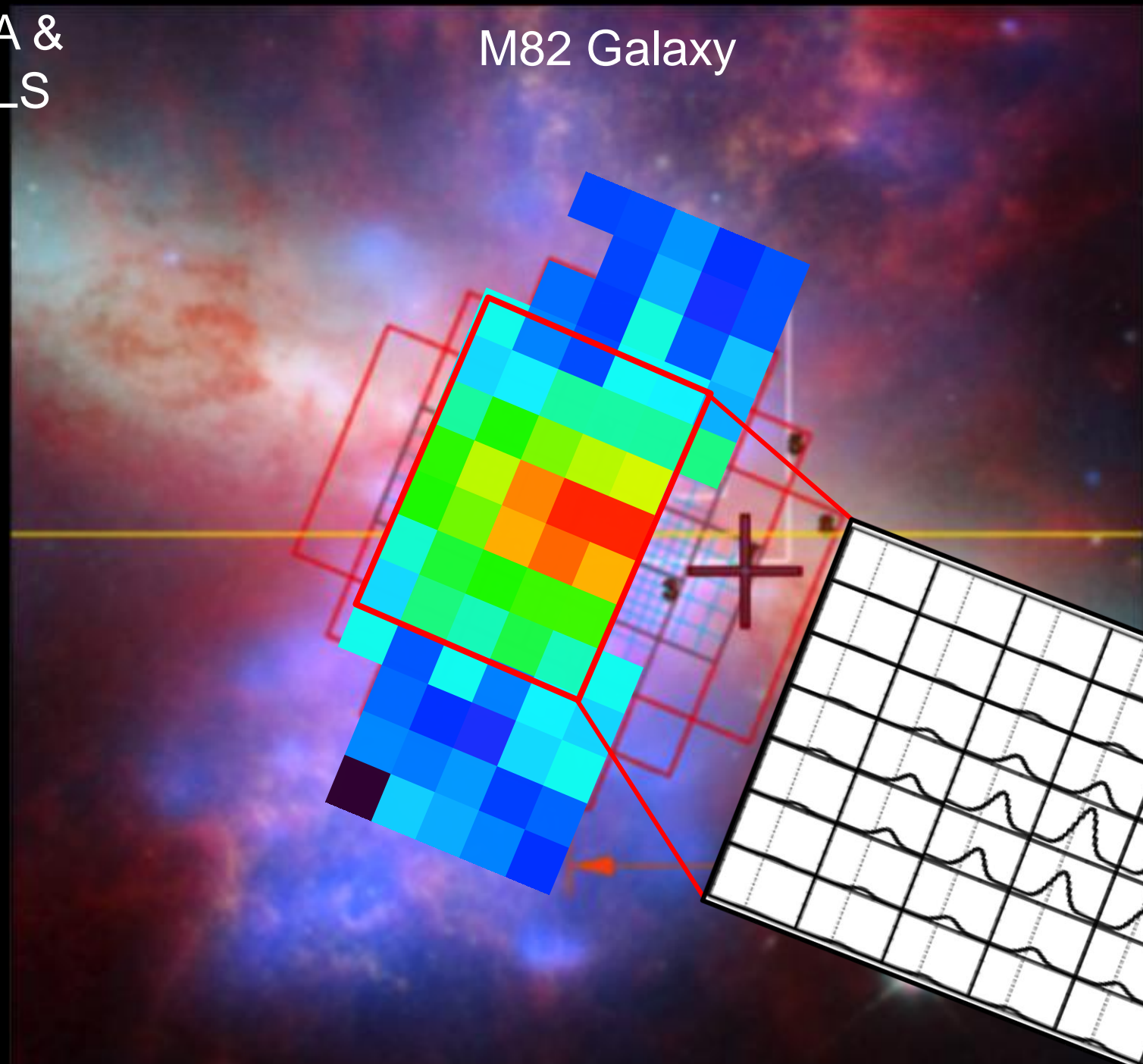
[CII] @ 157  $\mu\text{m}$

240''

Background image: HST, Spitzer & Chandra

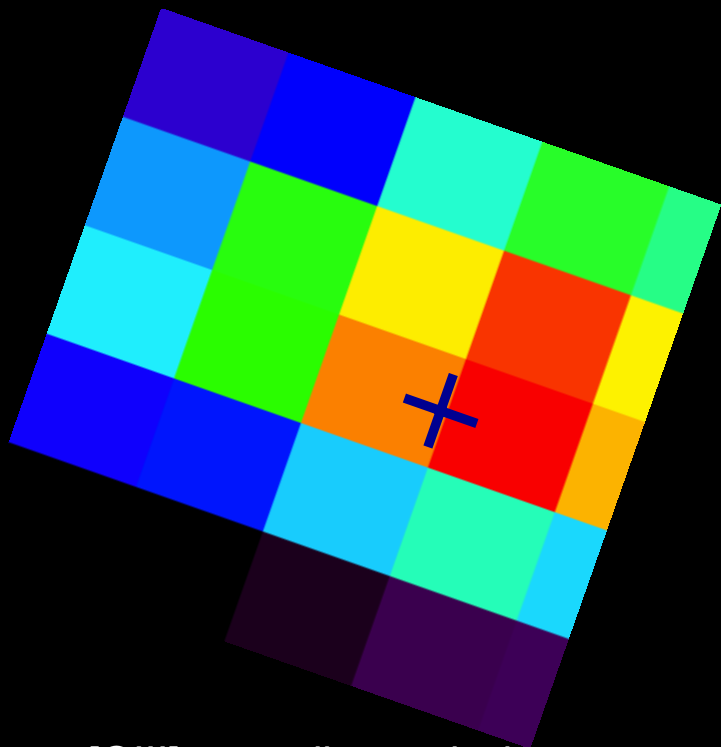
SOFIA &  
FIFI-LS

M82 Galaxy



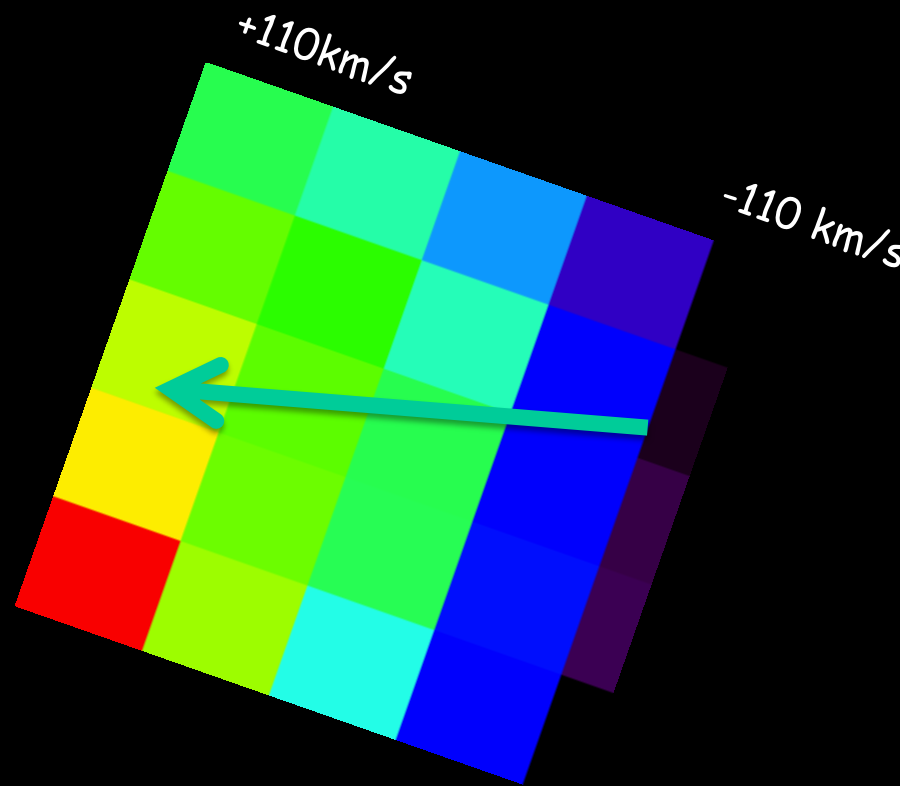
SOFIA &  
FIFI-LS

M82 Galaxy



[OIII] 52μm line emission

Intensity



[OIII] 52μm rotation speed

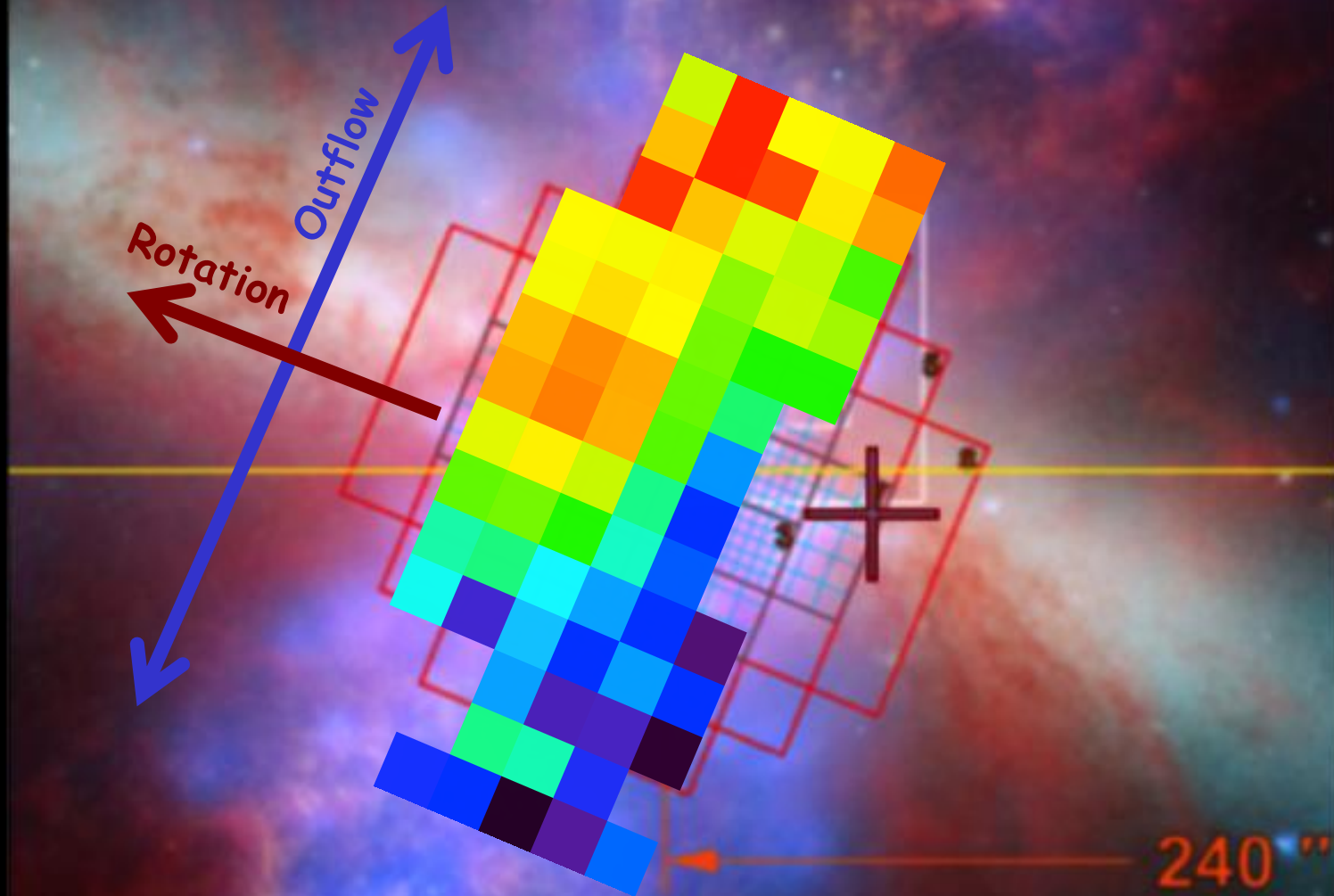
Velocity



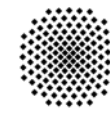
SOFIA &  
FIFI-LS

M82 Galaxy

Ionized Carbon



Velocity of ionized Carbon @ 157  $\mu\text{m}$   
from -130 km/s to +130 km/s



# Summary

FIFI-LS is flying and taking great data

Calibration is now optimized and will further improve with WVR measurements

Able to map large regions quickly, providing continuum and useful diagnostic lines

FIFI-LS beginning transition from PI-instrument to Facility instrument