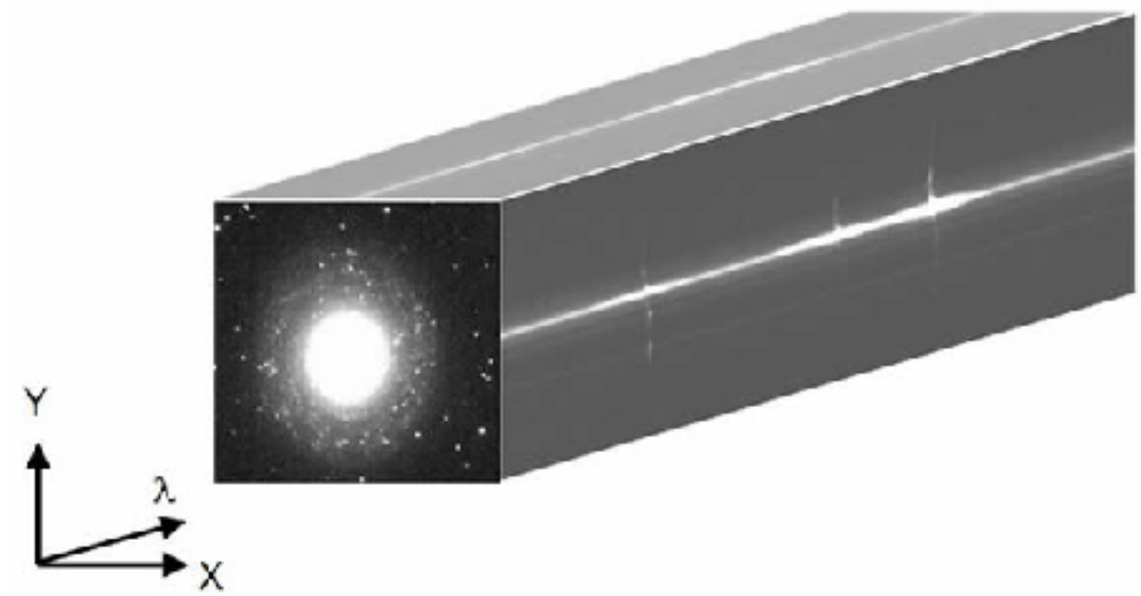
Spectral Mapping in the Mid-Infrared

and assorted recollections

JD Smith
University of Toledo
Max Planck Institute for Astronomy

What is Spectral Mapping?

- Image Slicer with Virtual Slit?
- Fiber Bundle Maps?
- Fabry-Perot Tuned Etalon?
- Long Slit Scan Mapping with Continuous Readout?
- “Step and Stare” with a Traditional Slit?



Which flavor is better?

✓Constrained Pixel Count?

✓Space Environment — no “sky” variability?

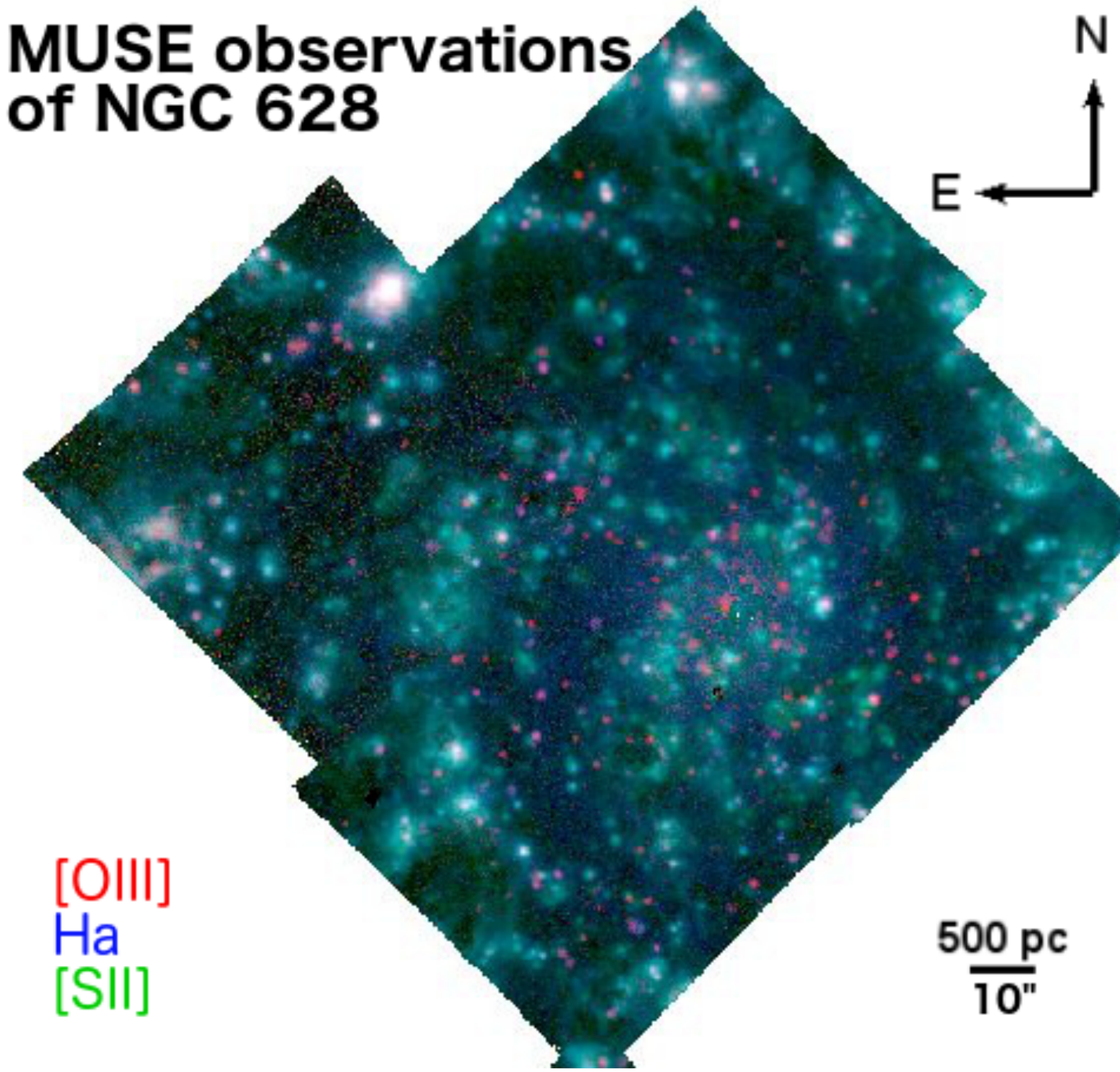
✓Low/no instrument variability?

✓Low/no stepping overhead?

✓No source variability over mapping duration?

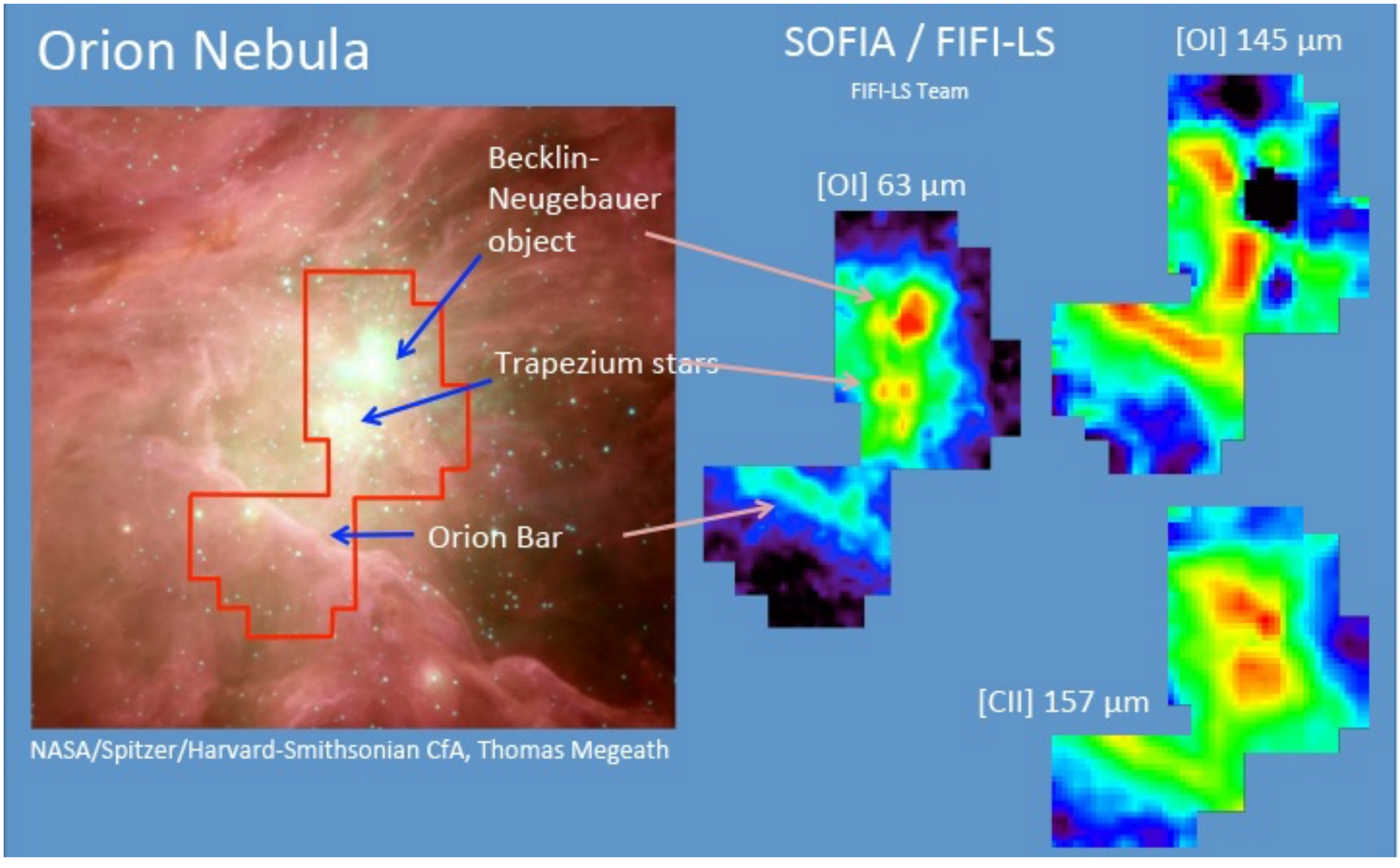
~Identical

Spectral Mapping Now Everywhere

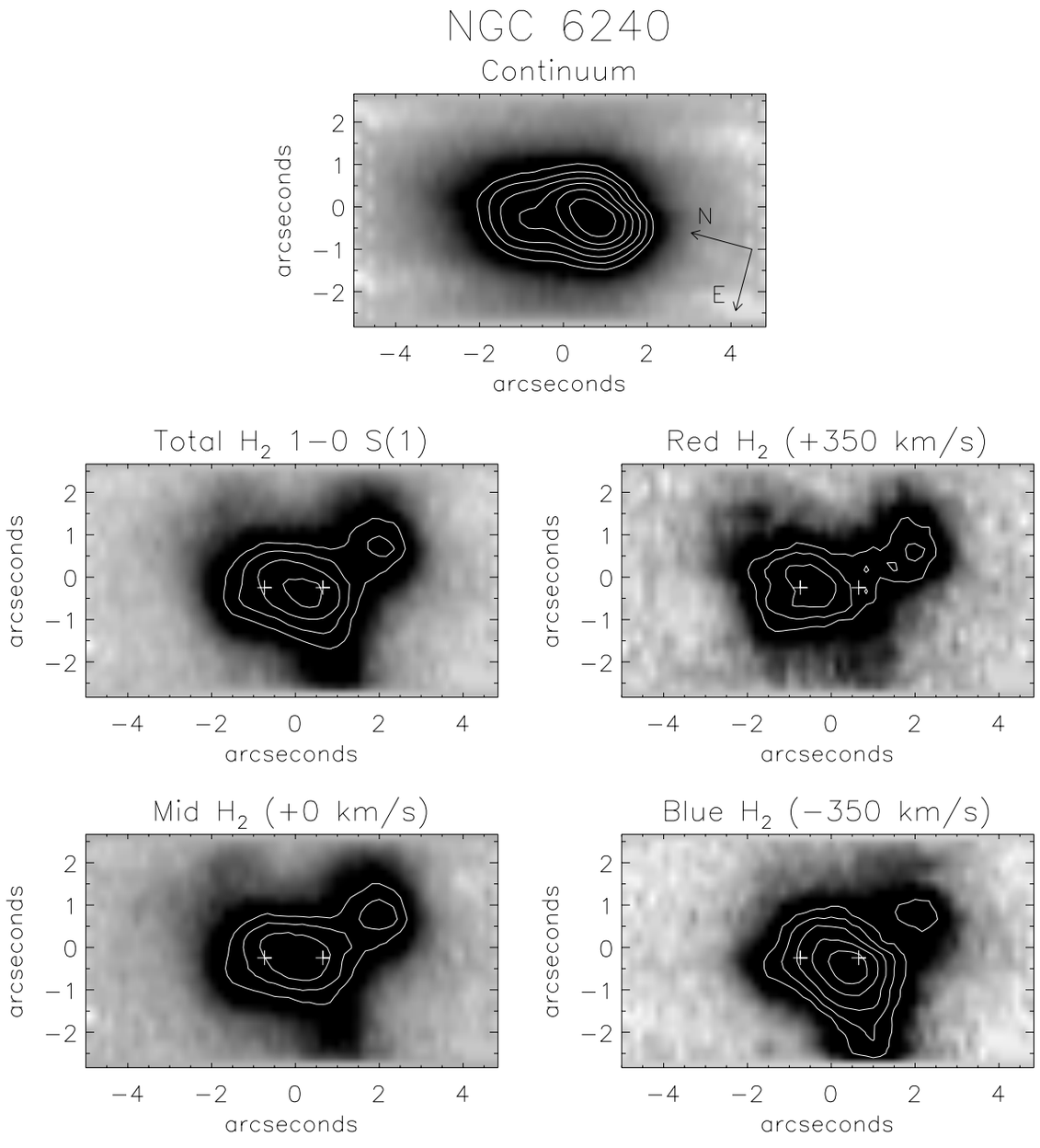


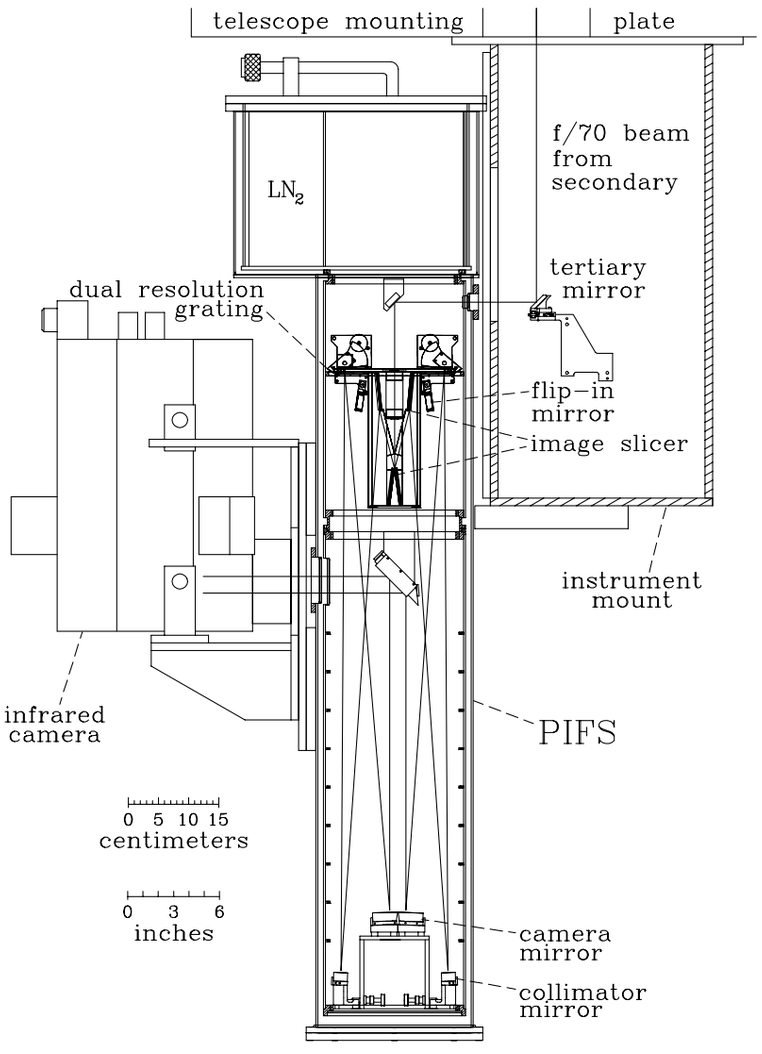
Kreckel+ 2017

SOFIA/FIFI-LS



Early NIR Spectral Mapping

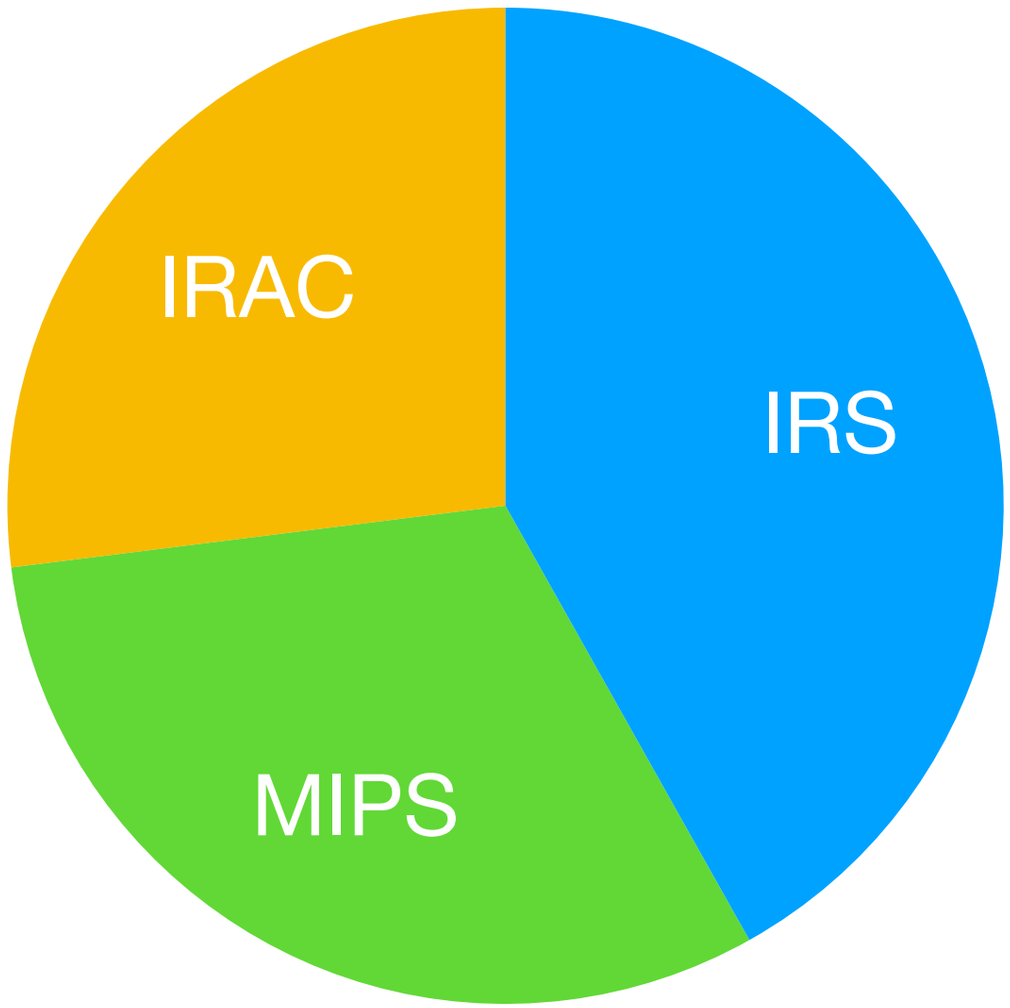




Murphy, Matthews, & Soifer, 1999

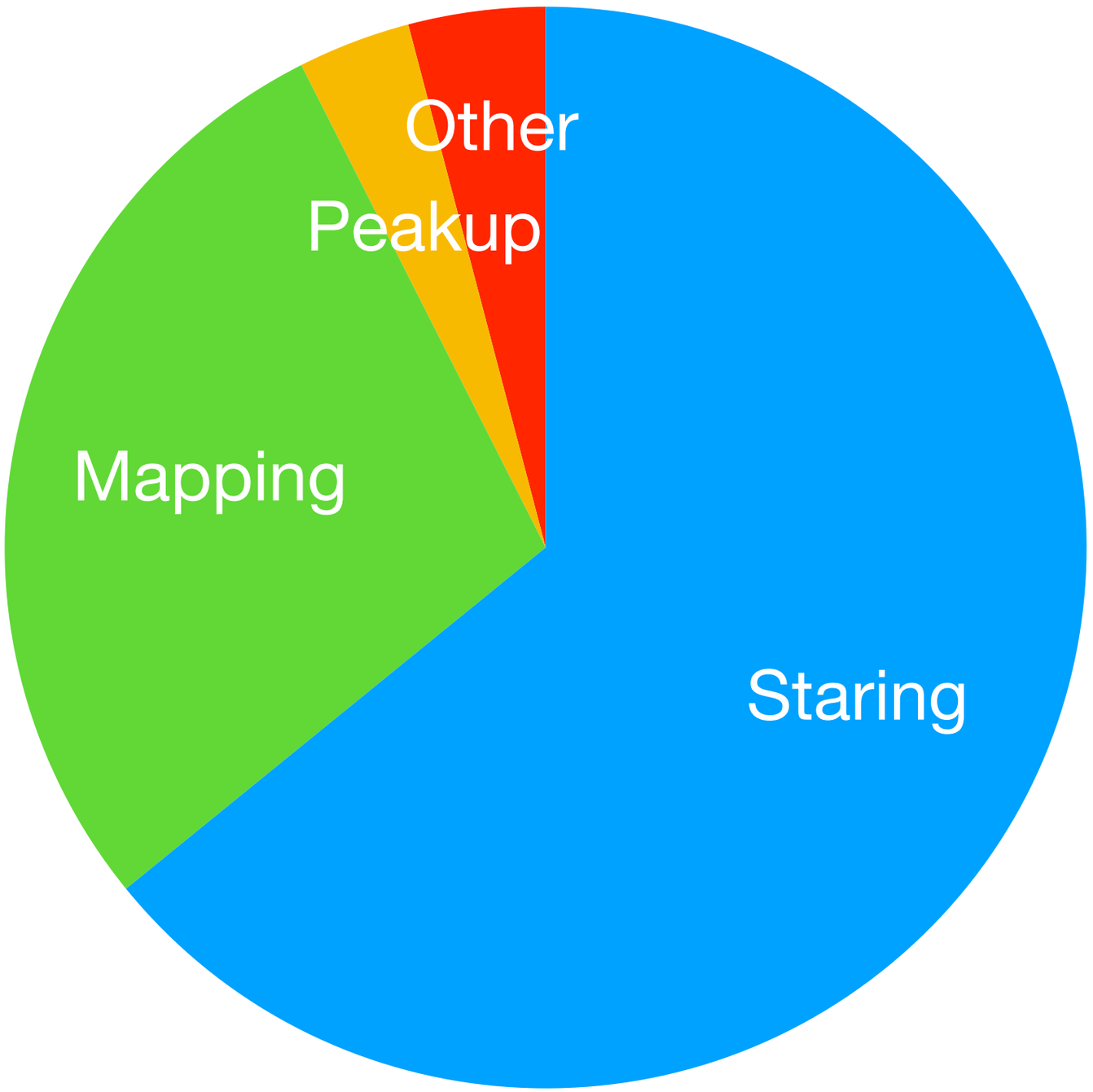
Putting IRS Mapping in Context

```
irs :          17769.8 hrs (41.9%)
  irsstare -   11396.3 hrs (64.1%)
     irsmap -   5047.5 hrs (28.4%)
        irs -    726.7 hrs ( 4.1%)
 irspeakup -     599.3 hrs ( 3.4%)

mips:          13232.4 hrs (31.2%)
  mipsphot -    6017.0 hrs (45.5%)
  mipsscan -    5936.2 hrs (44.9%)
      mips -     751.7 hrs ( 5.7%)
    mipssed -    459.8 hrs ( 3.5%)
     mipstp -     67.7 hrs ( 0.5%)

irac:          11454.3 hrs (27.0%)
   iracmap -   10459.8 hrs (91.3%)
      irac -     994.2 hrs ( 8.7%)
    iracpc -       0.3 hrs ( 0.0%)
```



(Cold Mission)

Putting IRS Mapping in Context



IRS Spectral Mapping History

- 1996: Joined Jim's group
- 1997 **SCORE** deployed at Palomar
- 2000: Renewed discussions of IRS "Scan Mapping" ⇛ "**Step & Stare**"
- 2002: Joined SINGS team at Arizona, developed **CUBISM**
- 2003, December: **First IRS Spectral Cube**
- 2003, Christmas Day: **First "Real"** IRS Cube produced: Galaxy NGC7331
- 2004: **First IRS Cubes published**

SIRTF

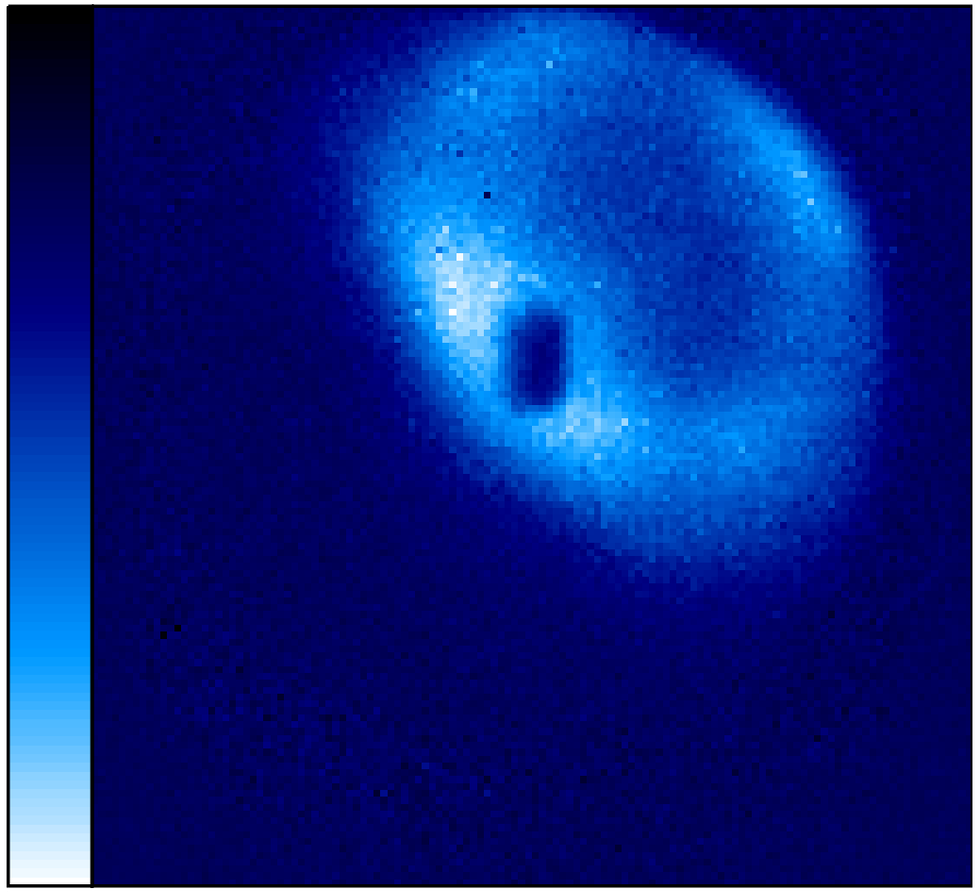
FREE FLYER PHASE A SYSTEM CONCEPT DESCRIPTION

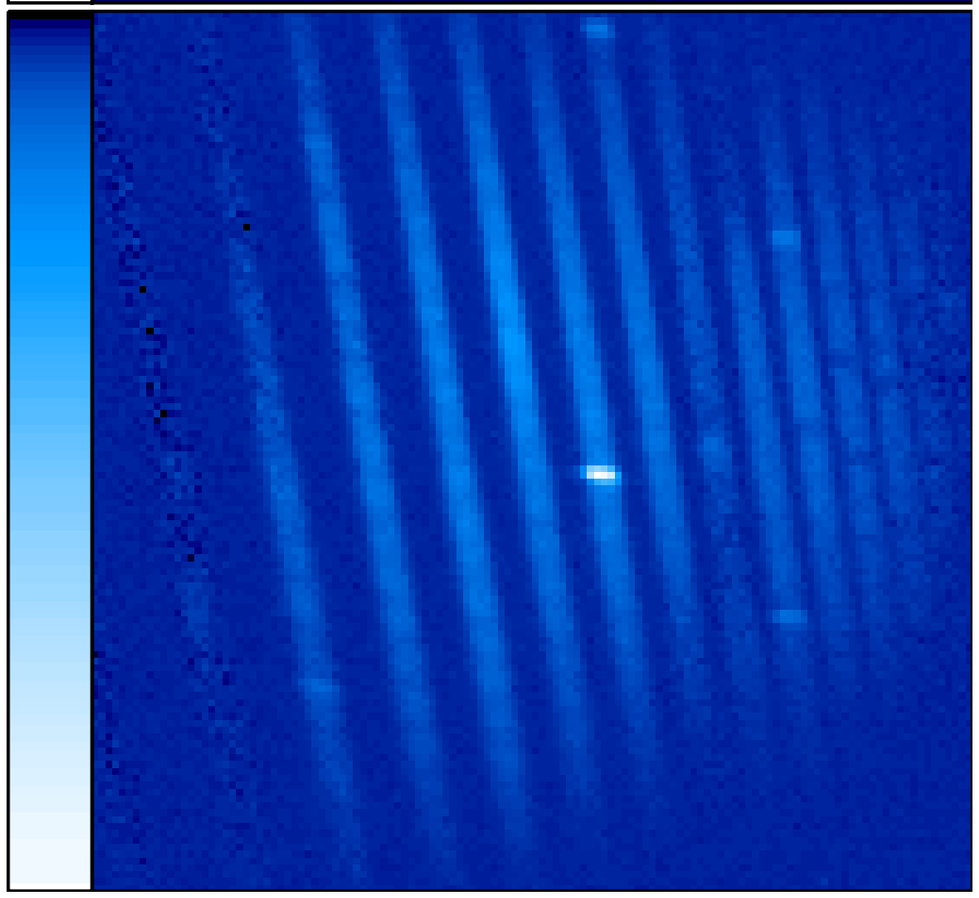
DOCUMENT NO. PD-1006 MAY 3, 1984

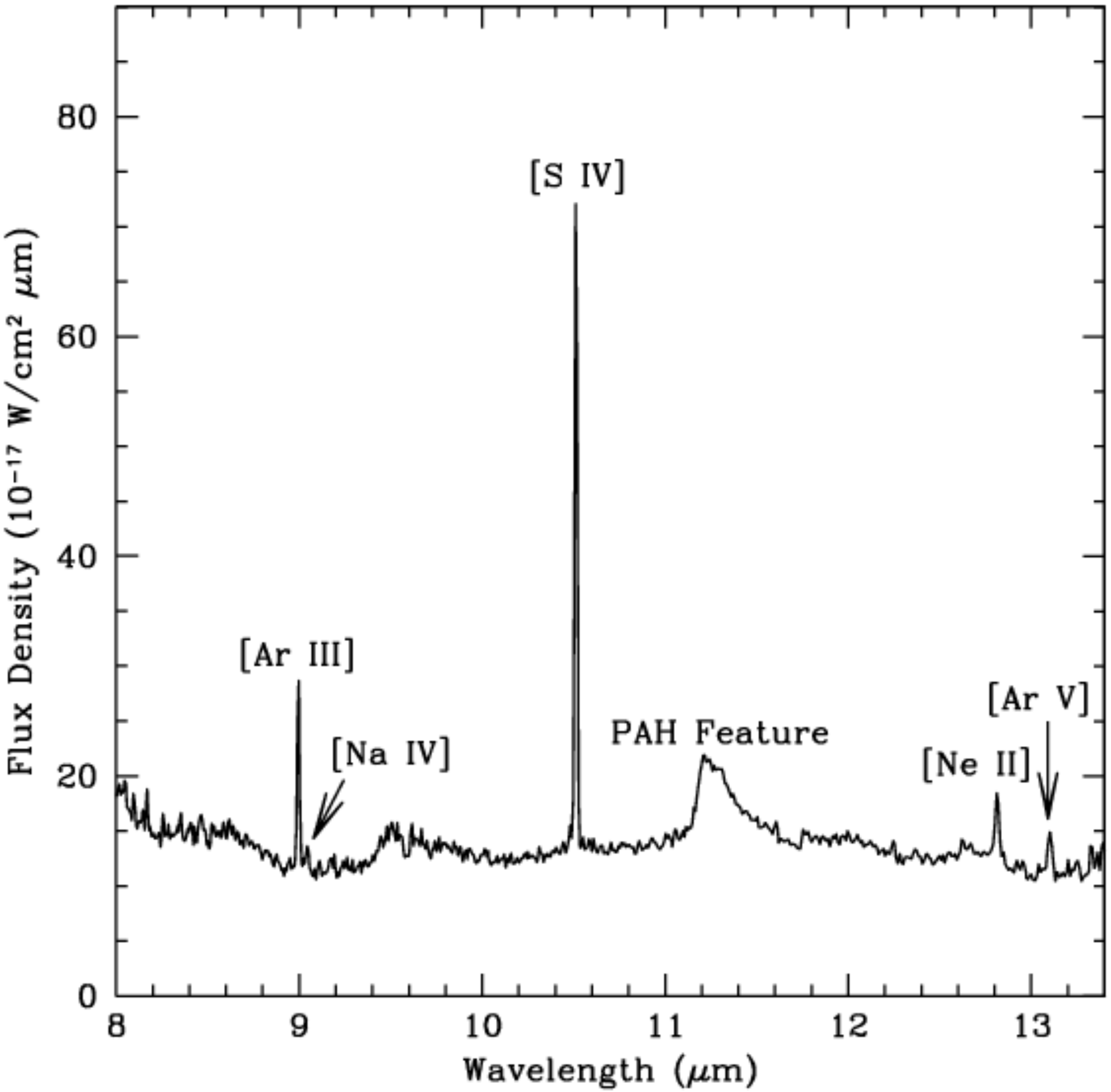
OBJECTS TO BE SEEN BY SIRTF

OBJECTS TO BE SEEN BY SIRTF	VELOCITY (RELATIVE TO THE SPEED OF LIGHT)	DISTANCE (LIGHT YEARS) OR TIME (YEARS AGO)
EDGE OF UNIVERSE	99.99%	17 BILLION
FORMING GALAXIES	99%	15 BILLION
QUASARS	60%	10 BILLION
DISTANT GALAXIES	1%	1 BILLION
LIFE CYCLES OF STARS	0.00001%	10^5
COMETS AND PLANETS	-	-

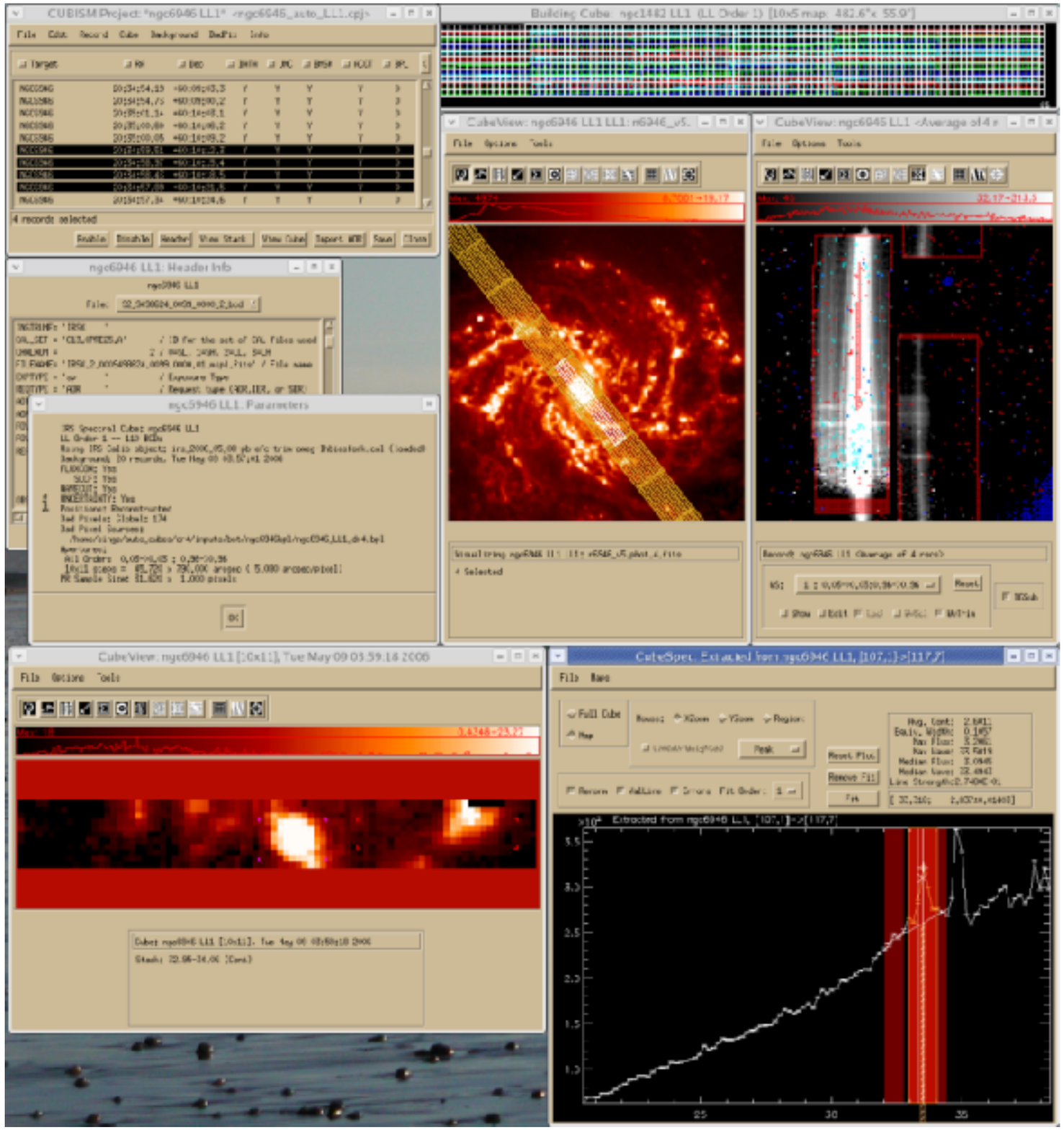
Space Administration
Ames Research Center
Moffett Field, California 94035






[S IV]
[Ar III]
[Na IV]
PAH Feature
[Ne II]
[Ar V]
Flux Density (10^{-17} W/cm^2 μm)
Wavelength (μm)
0
20
40
60
80
8
9
10
11
12
13

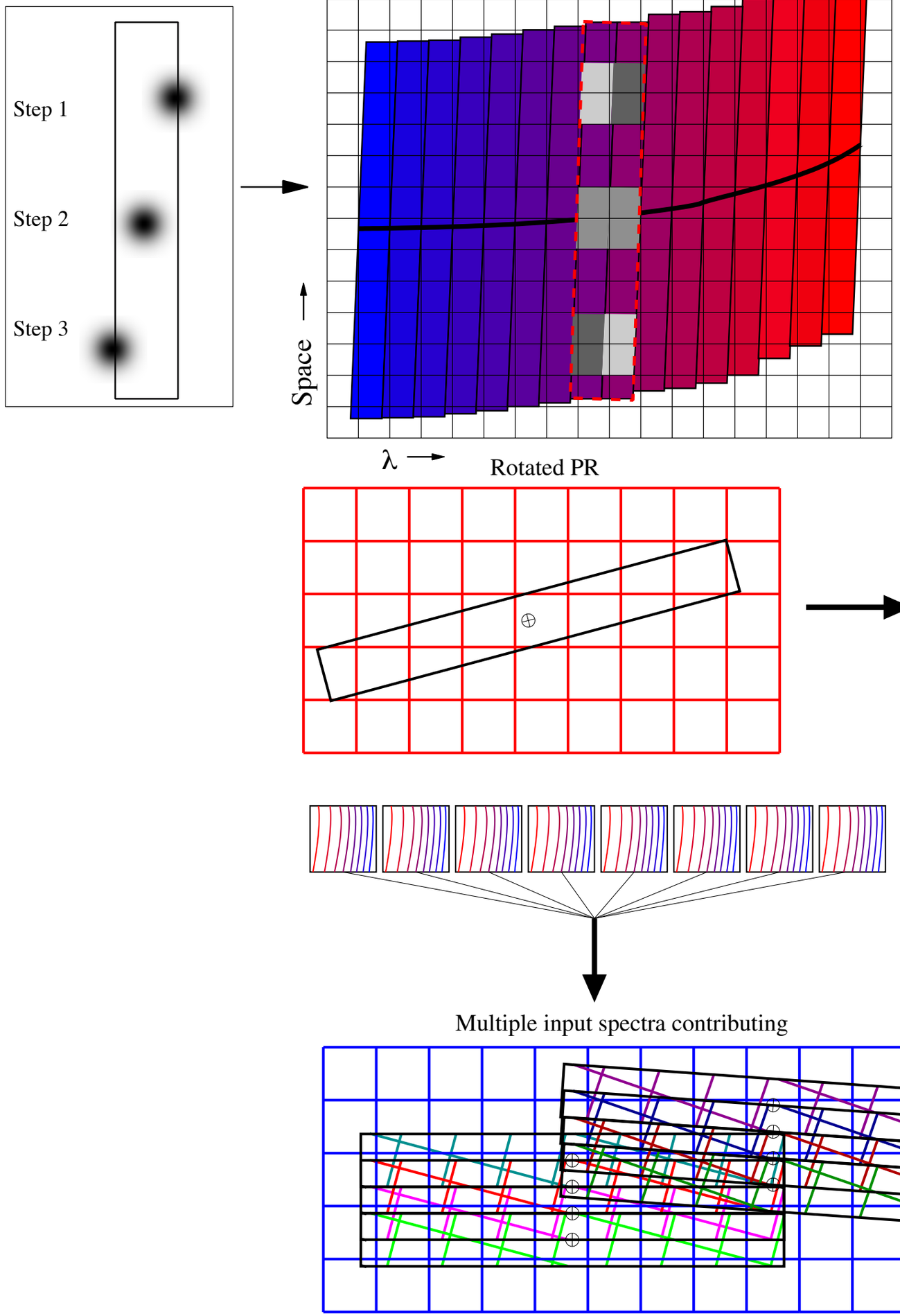
CUBISM



- Custom reduction and analysis tool for IRS Spectral Maps

Smith+ 2007

The guts of CUBISM



Smith+ 2007

First Ever Cube

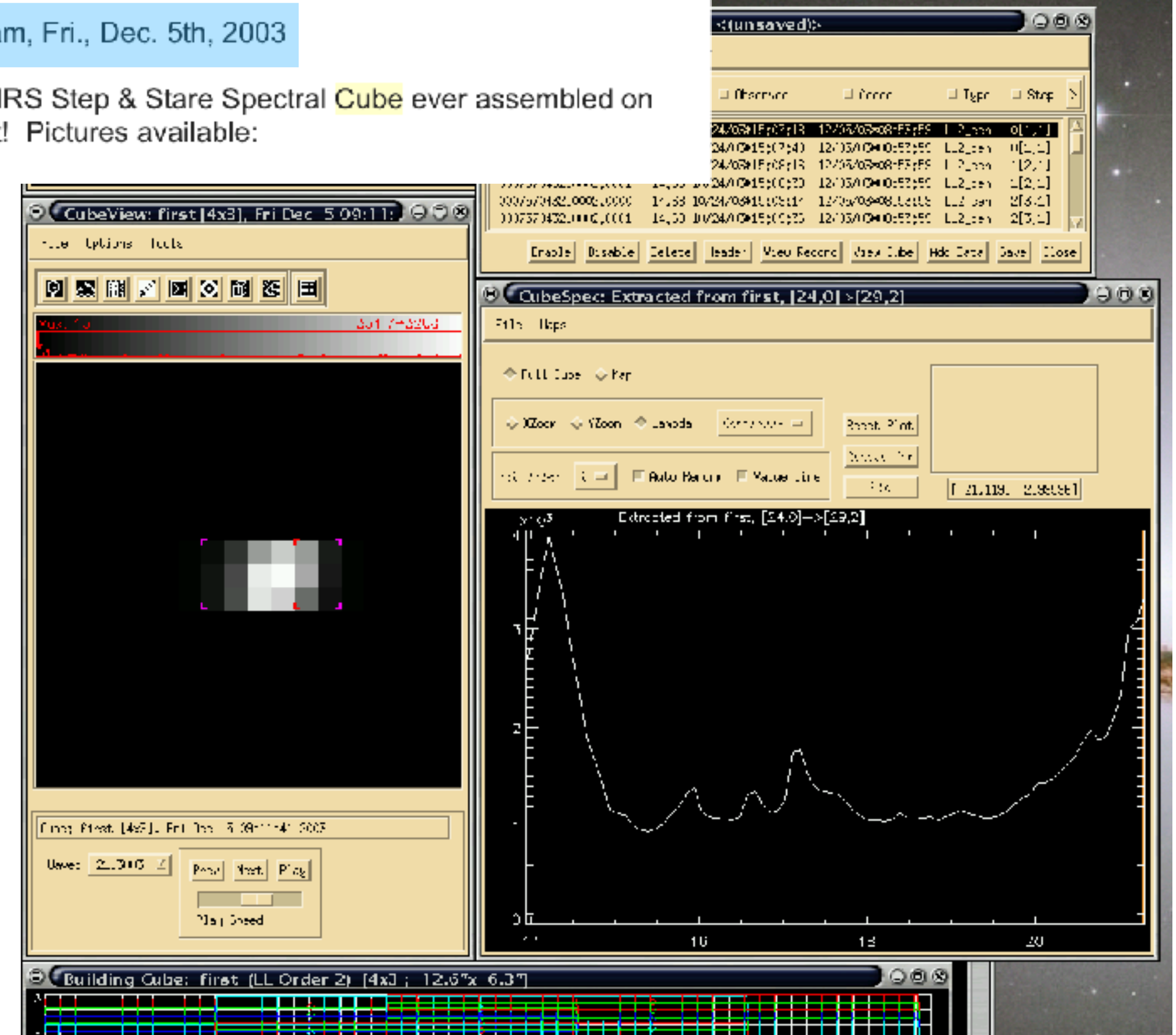
Archive Import x

JD Smith <jdsmith@as.arizona.edu> 12/5/03

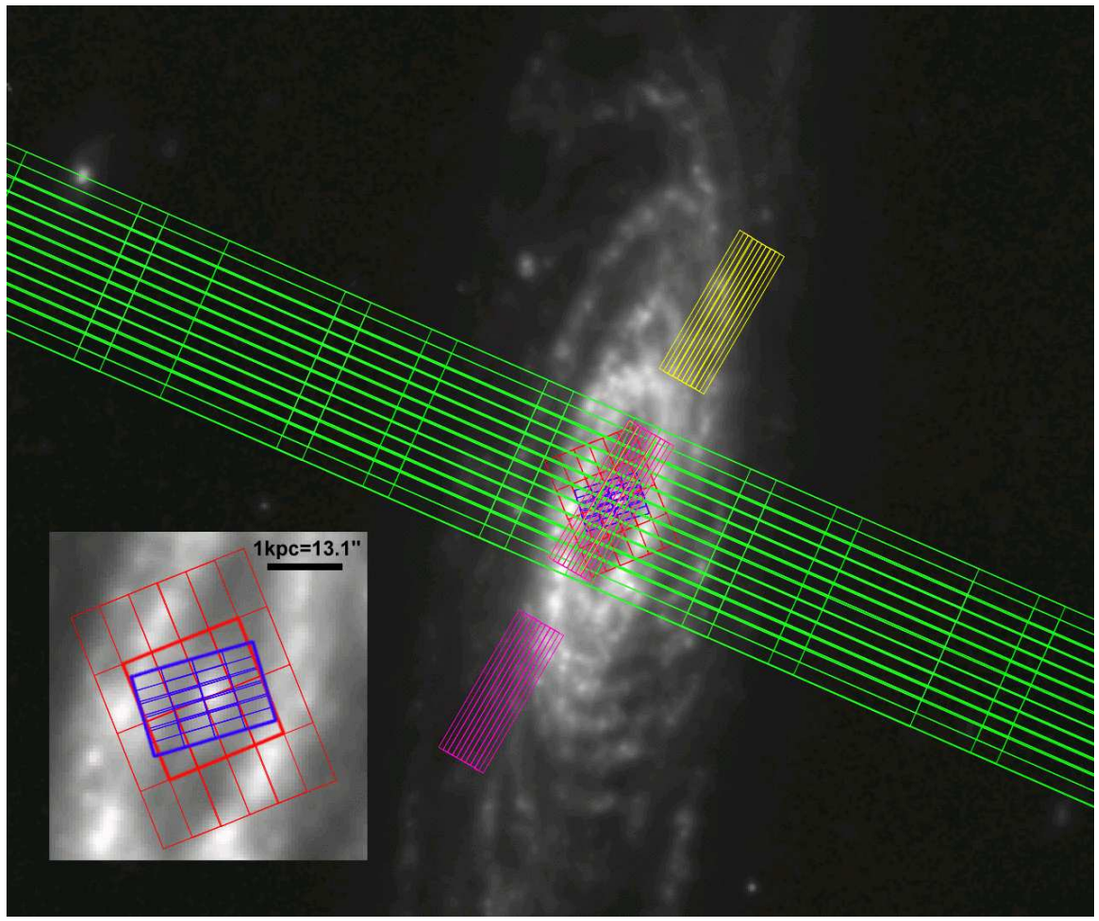
to Lee, George, Danny, Helene, Tom, Rob

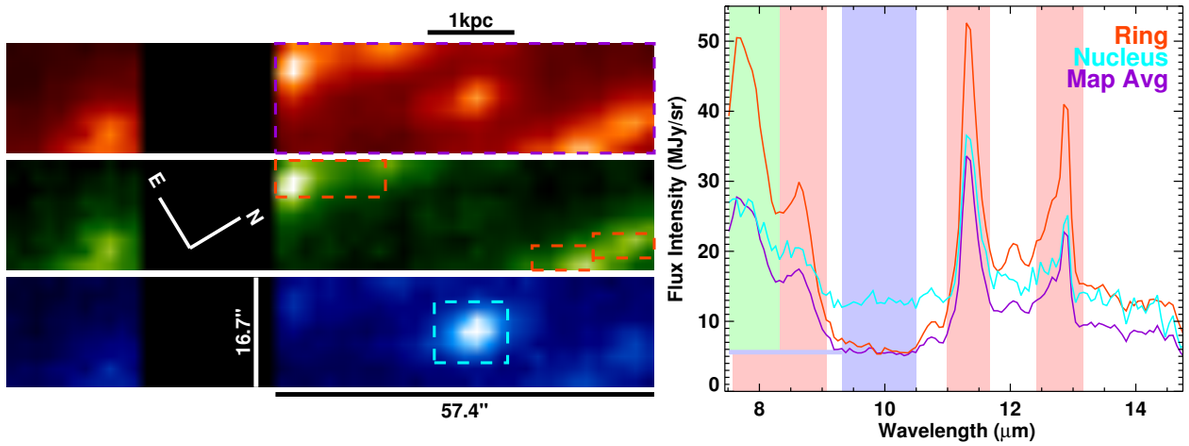
Cube Birth: 9:11:41 am, Fri., Dec. 5th, 2003

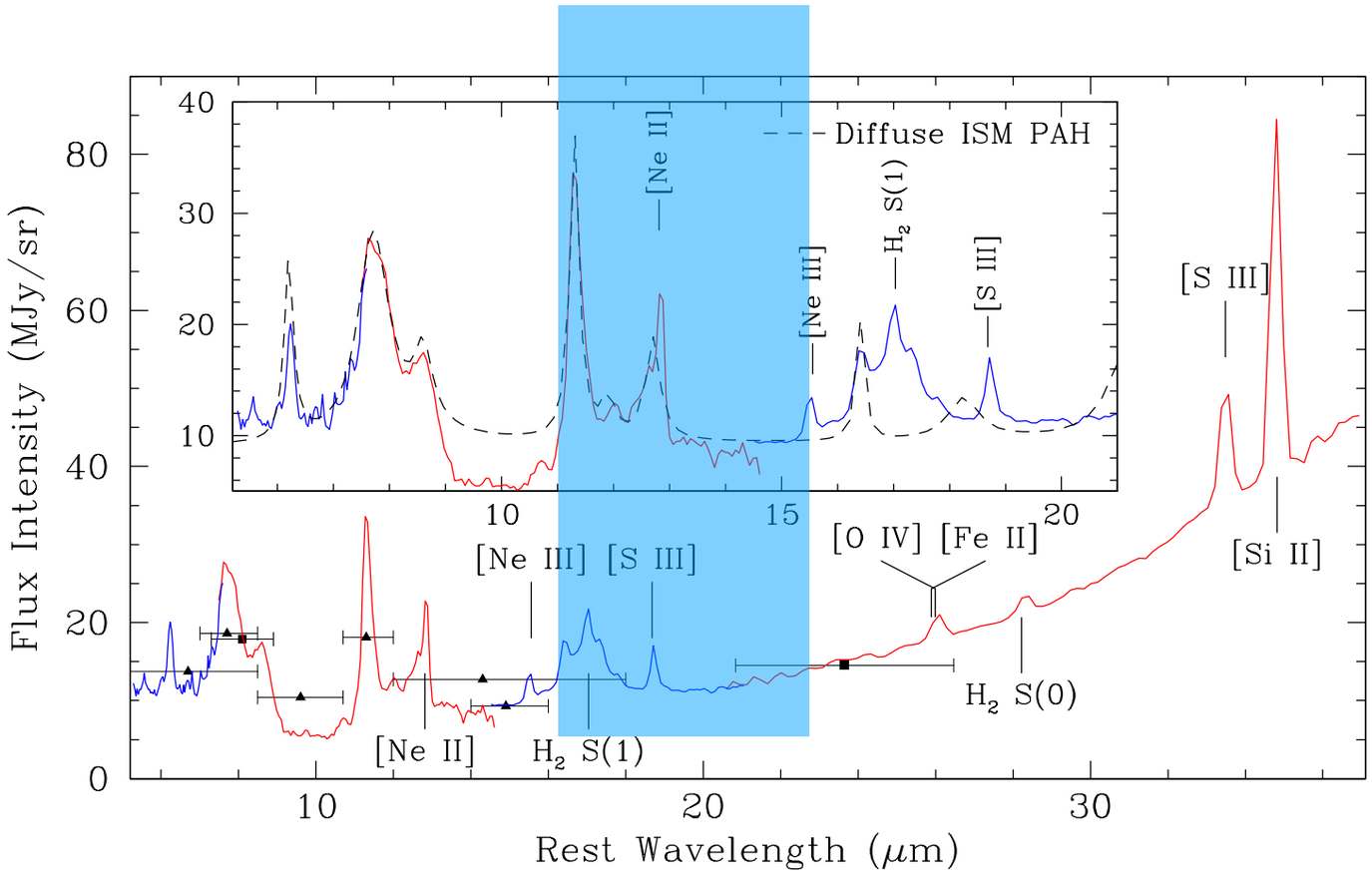
Announcing the first IRS Step & Stare Spectral Cube ever assembled on the face of the planet! Pictures available:



First real cube, and a new PAH

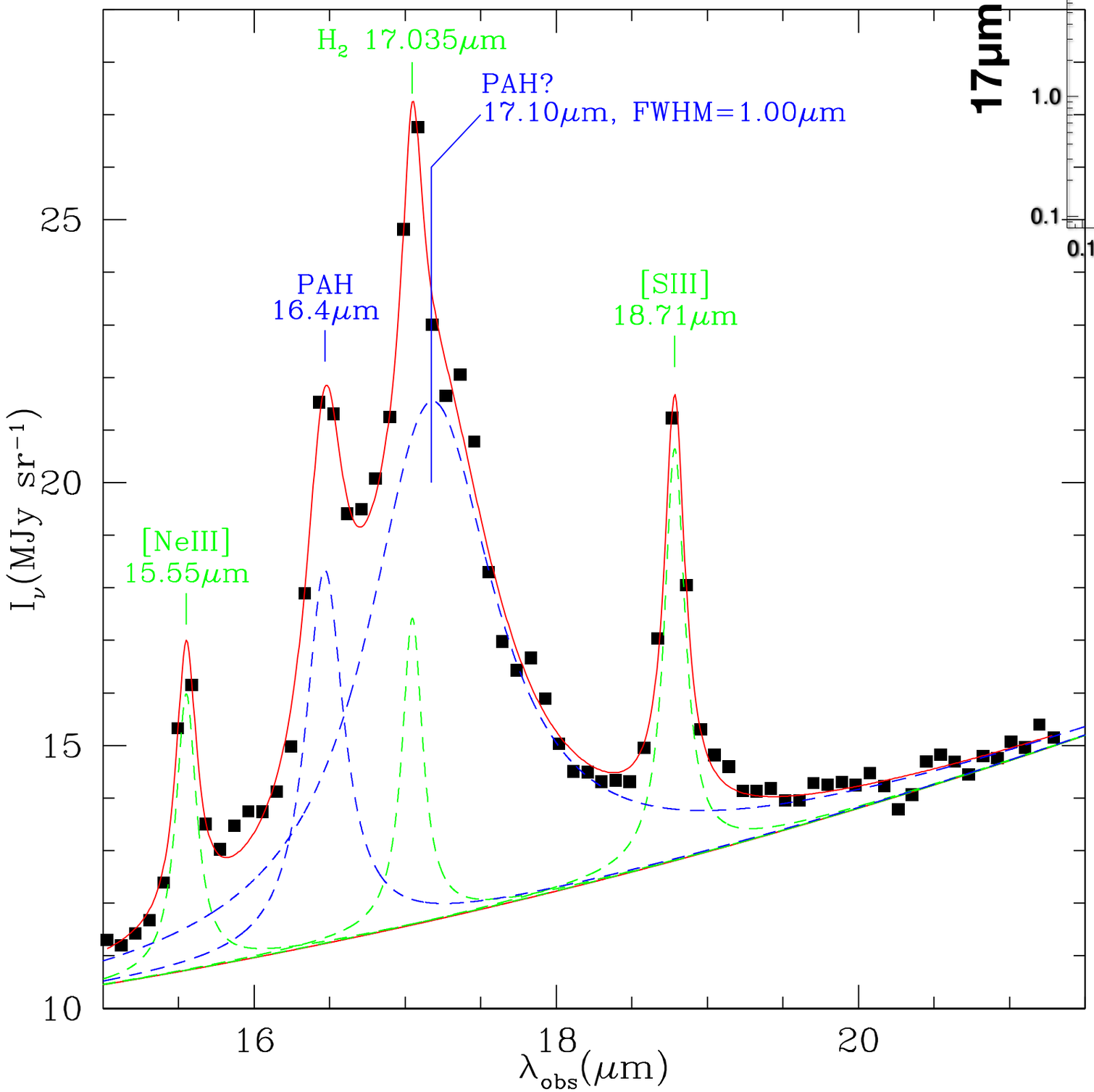


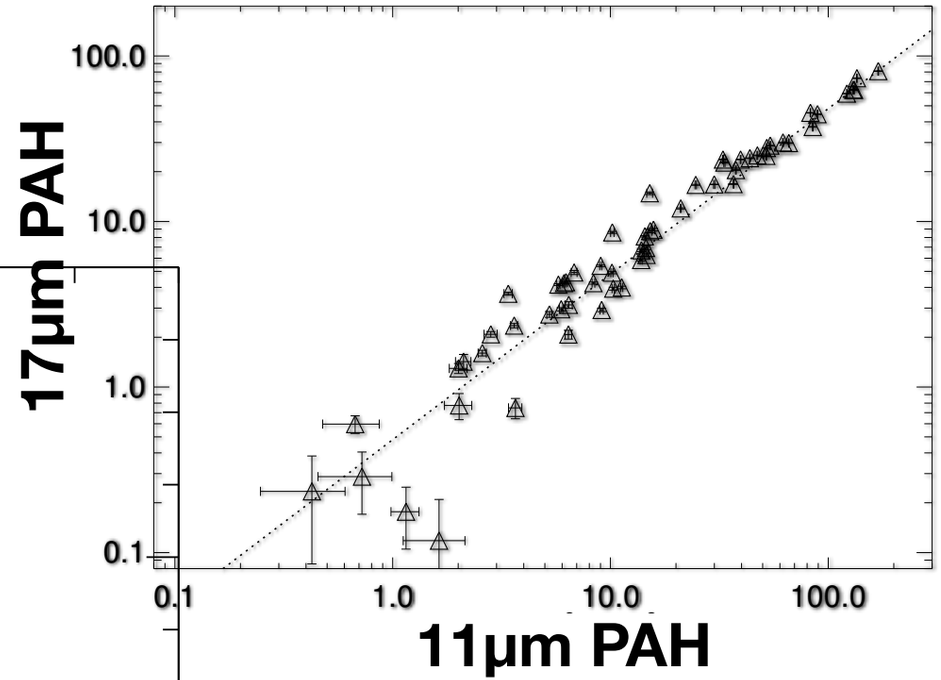




Smith+ 2004

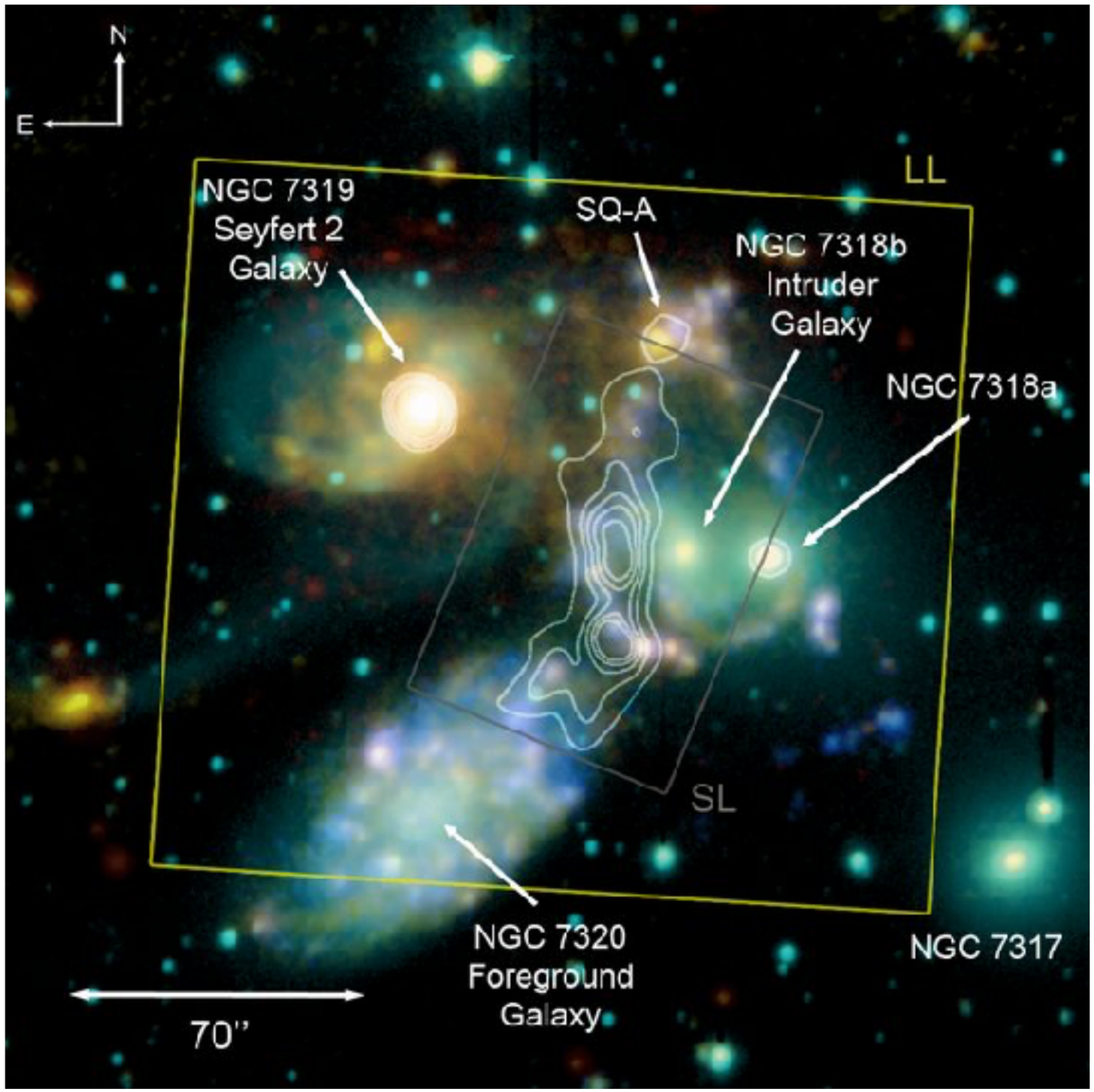
A new PAH





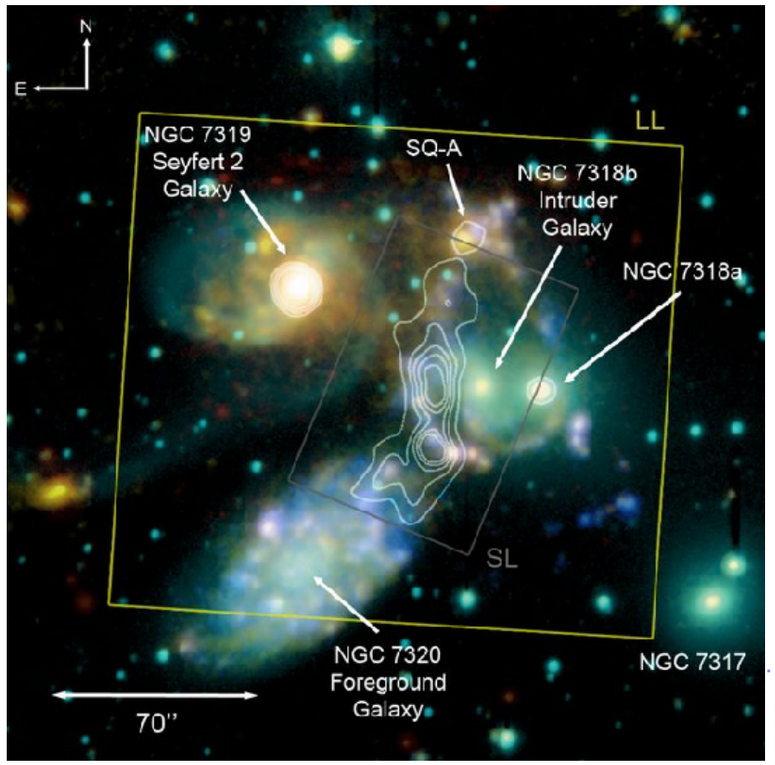
Smith+ 2004, 2007

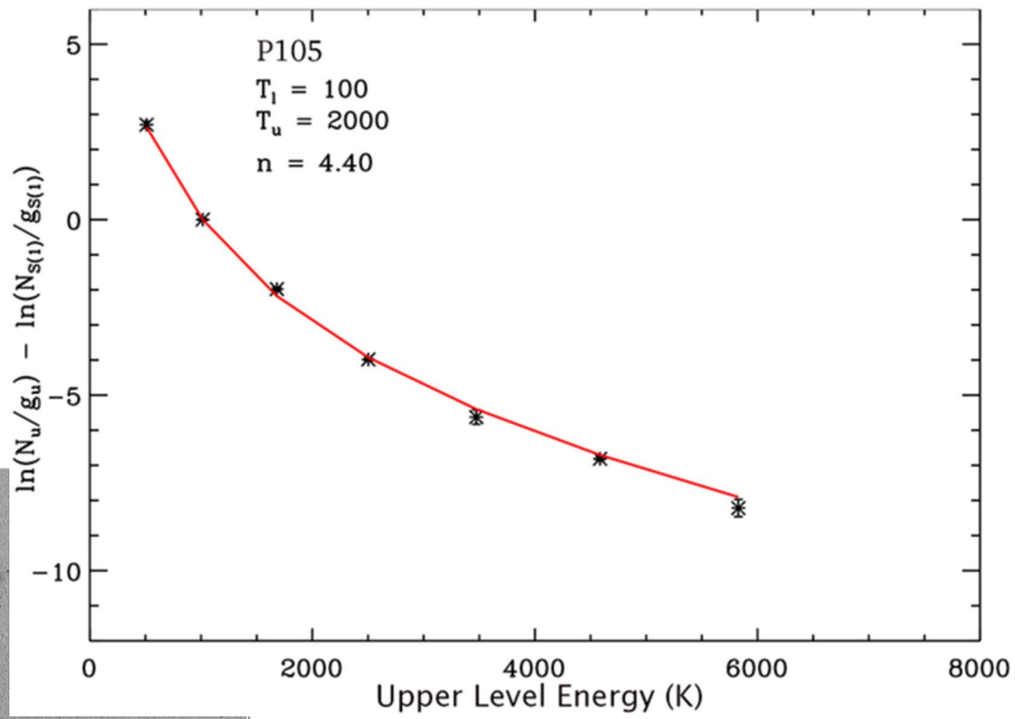
H_2 cooling in Stefan's Quintet

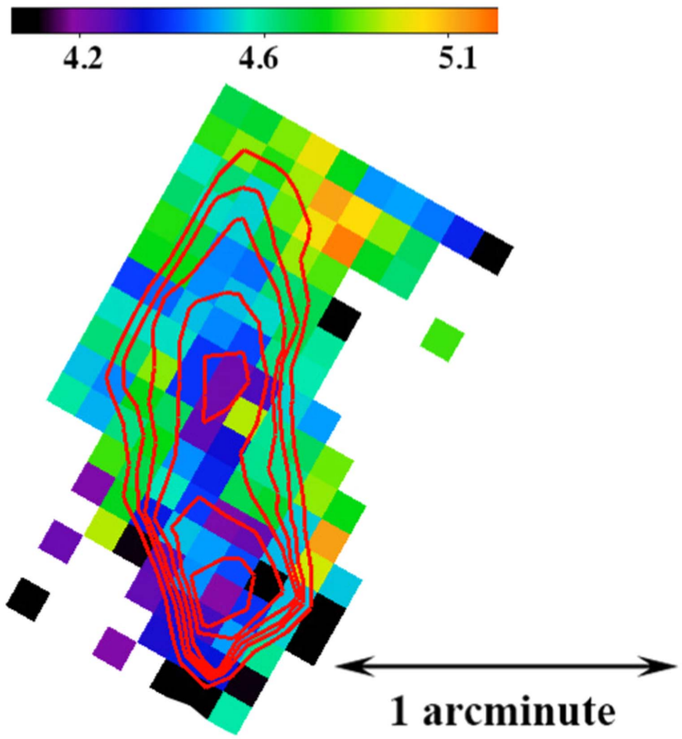


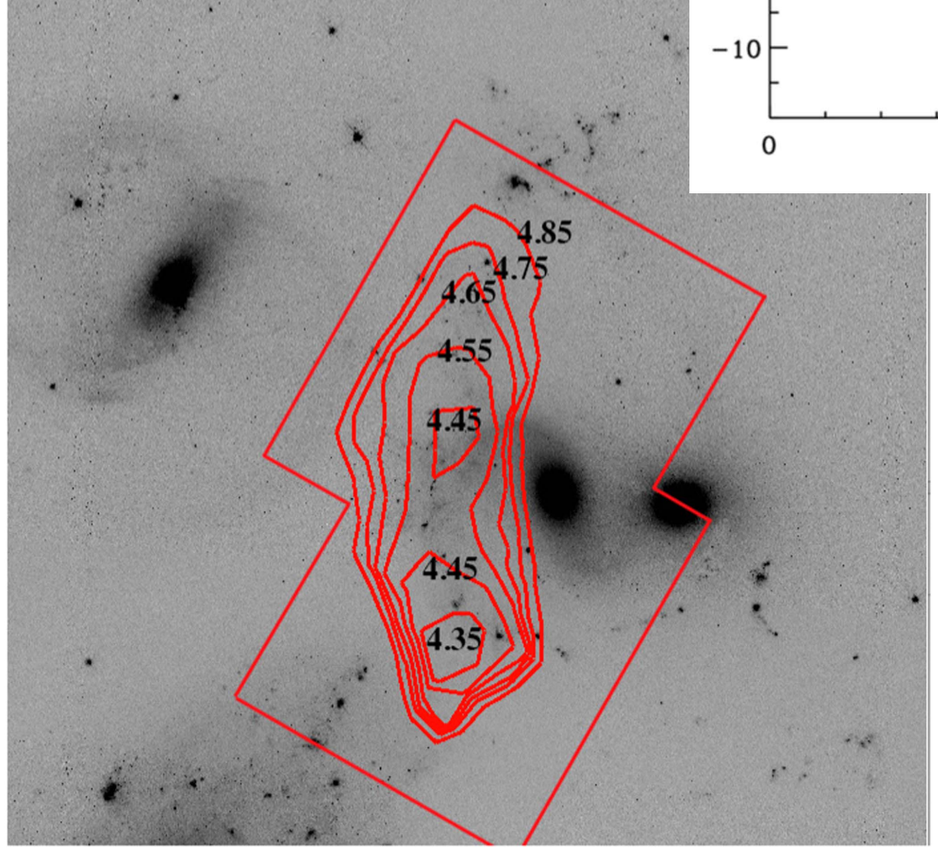
Cluver+ 2010

H_2 cooling in Stefan's Quintet



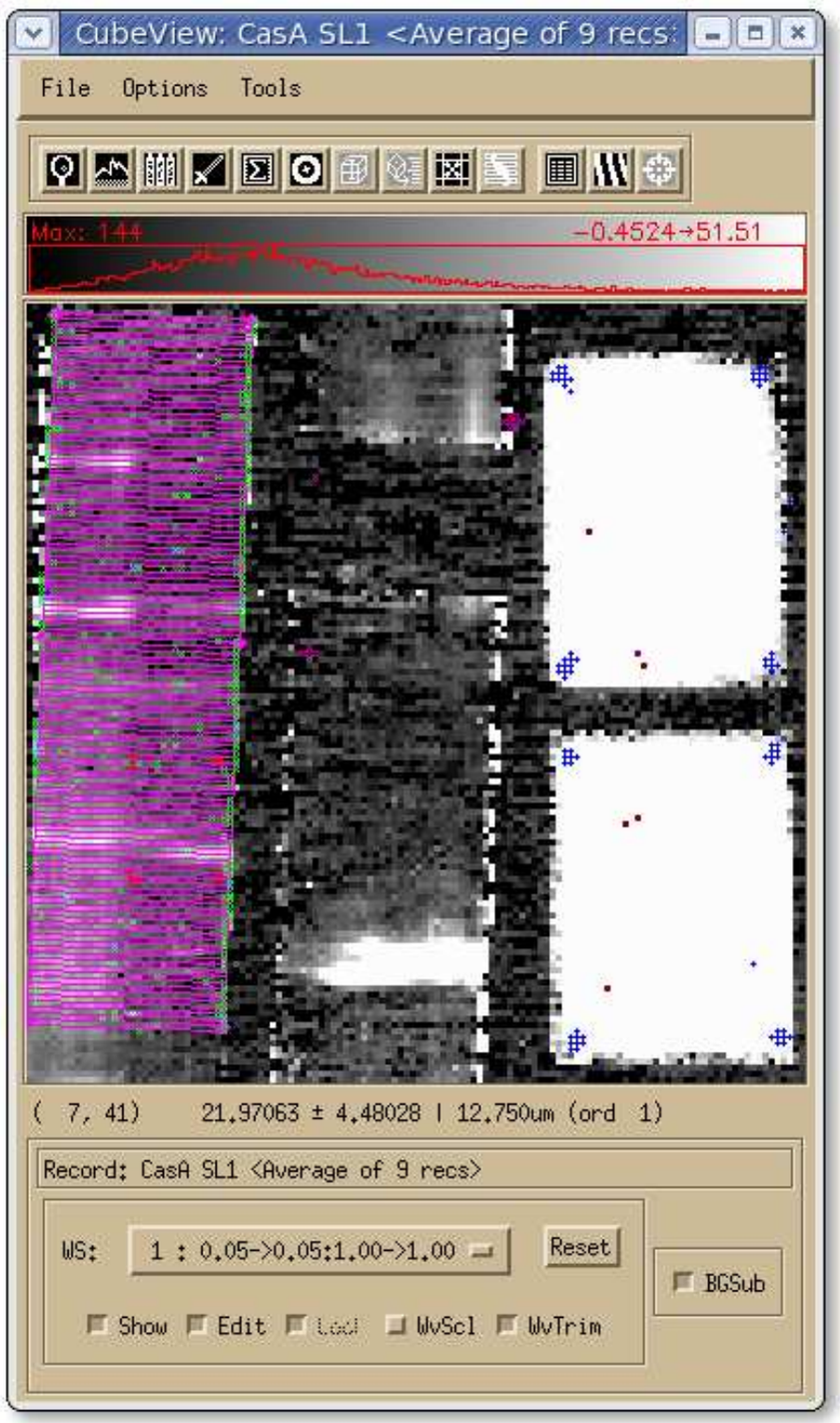


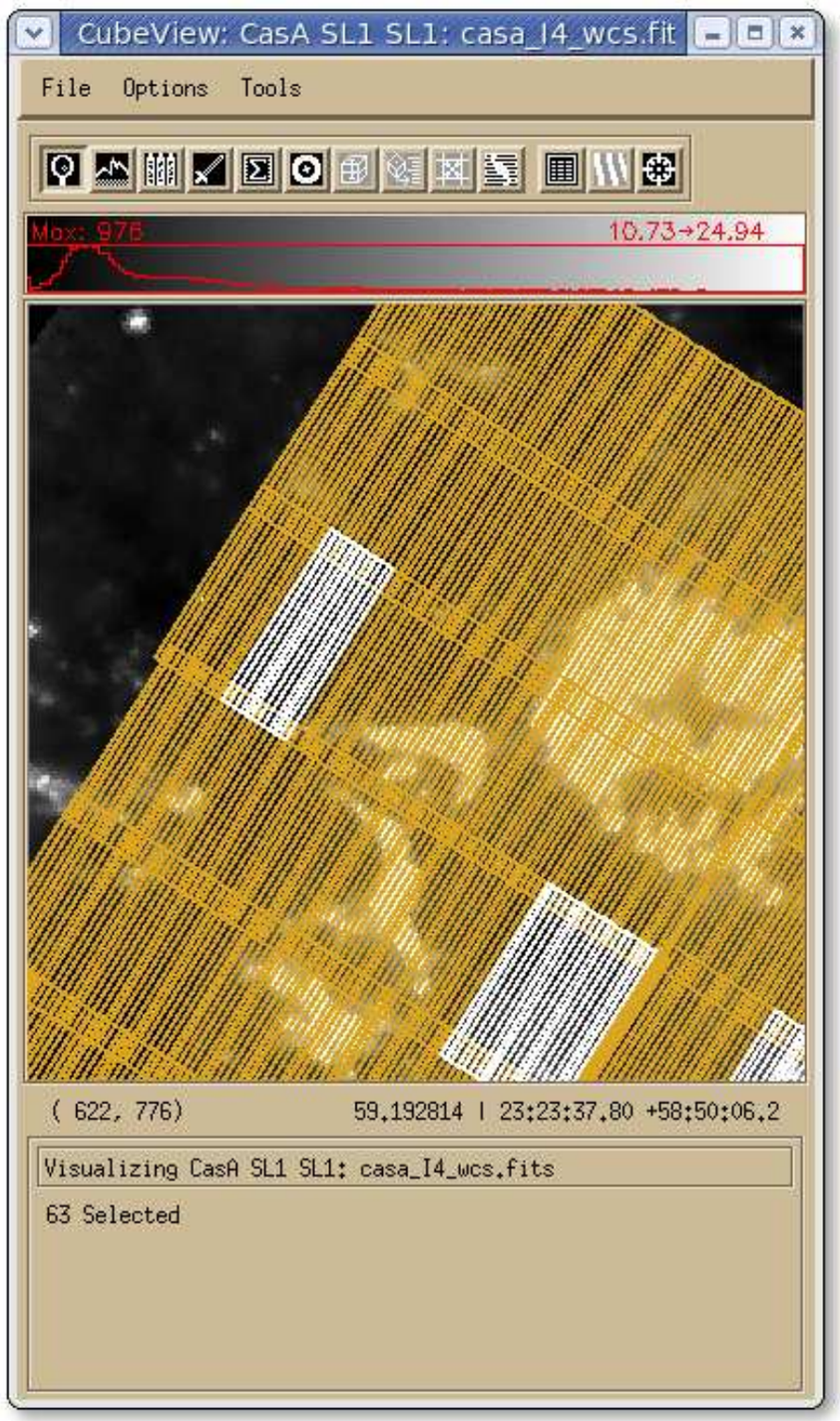


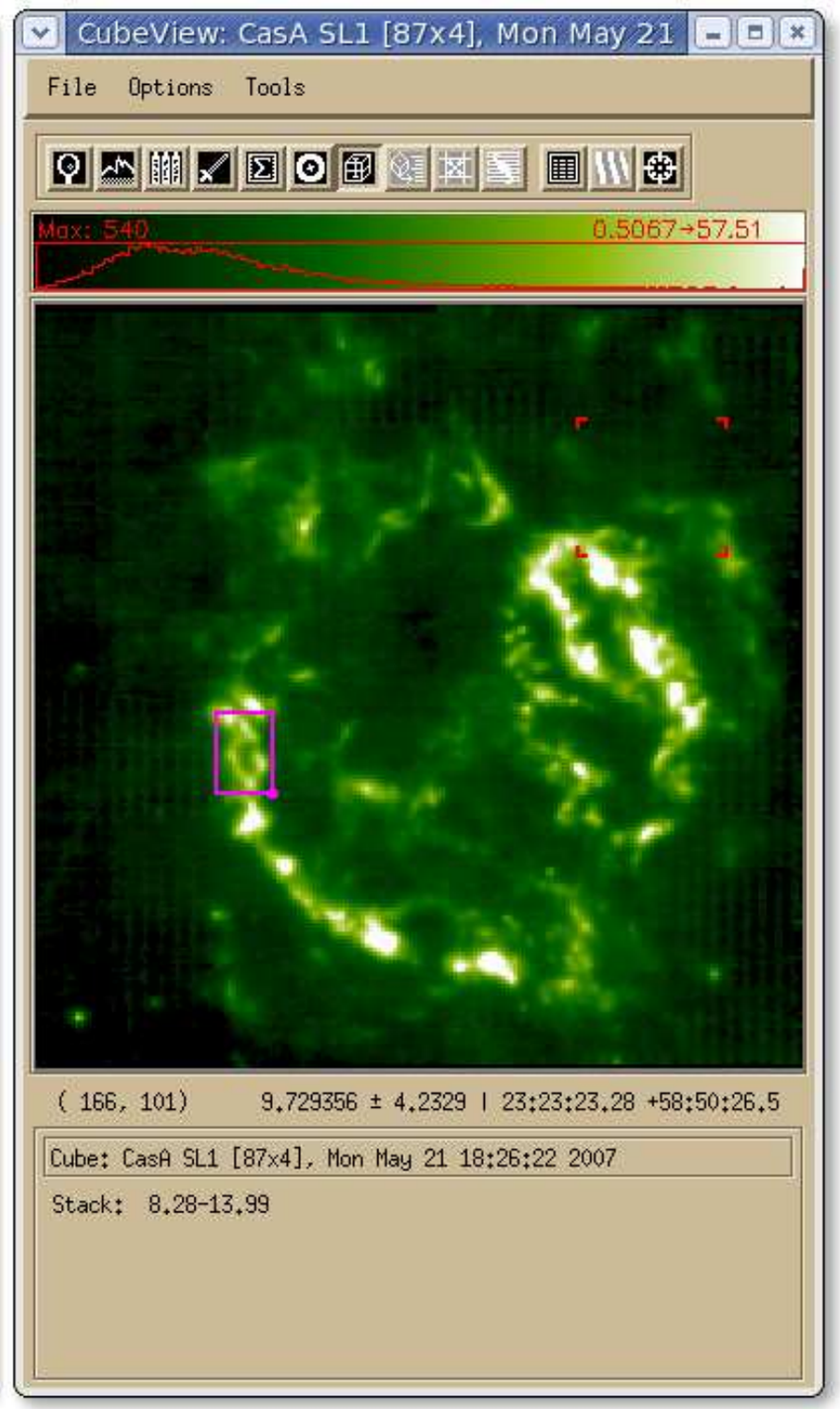


Appleton+ 2017

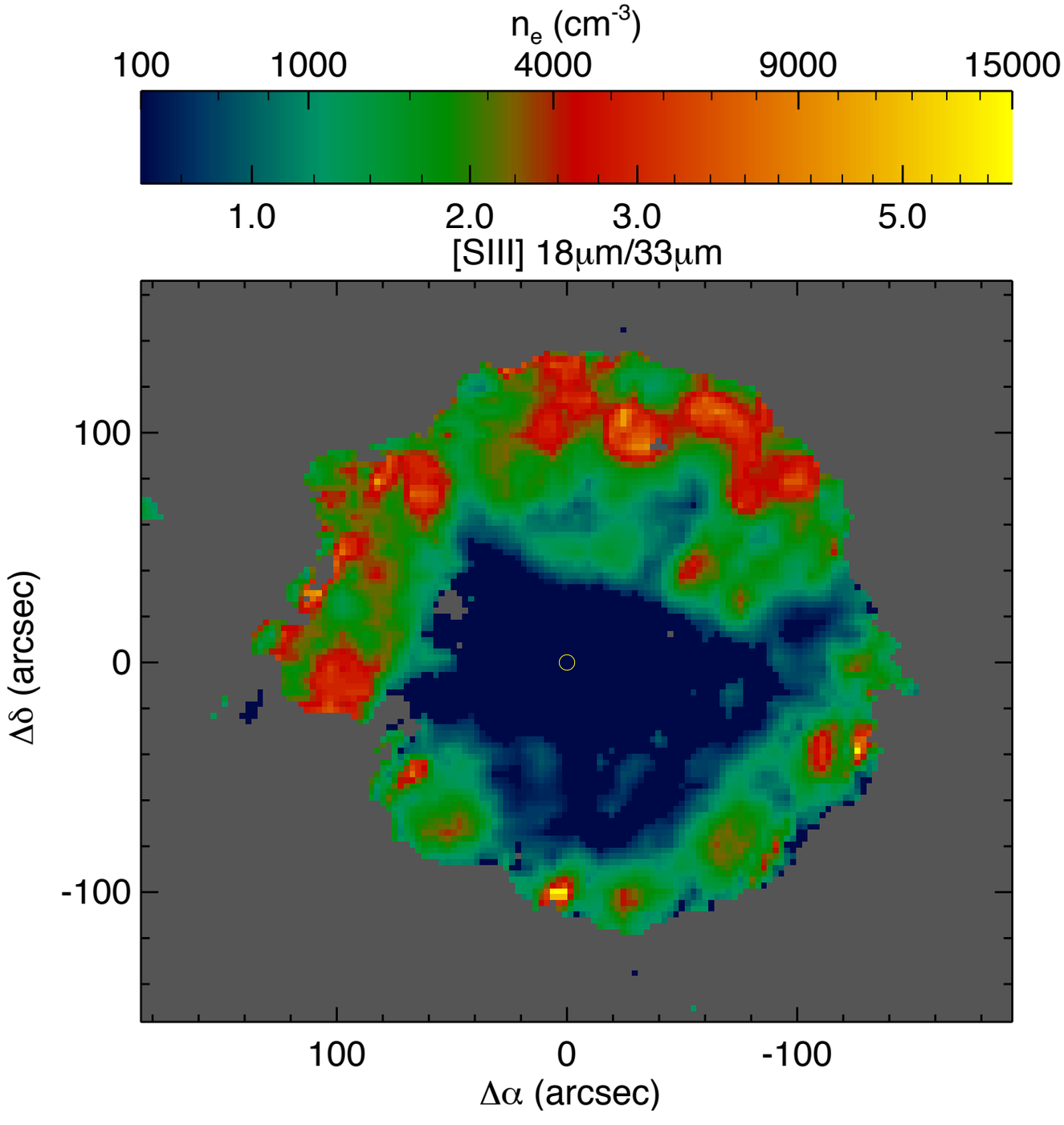
Cassiopeia A

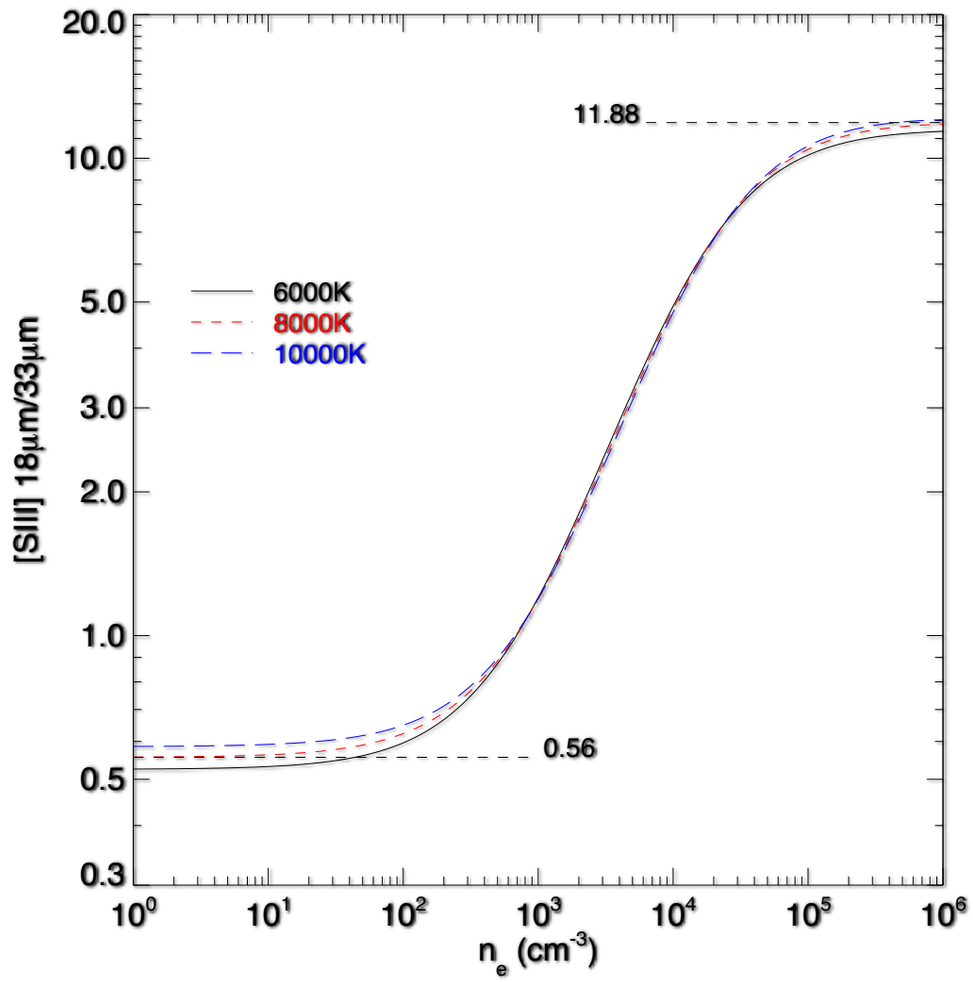






Compression in Reverse Shock

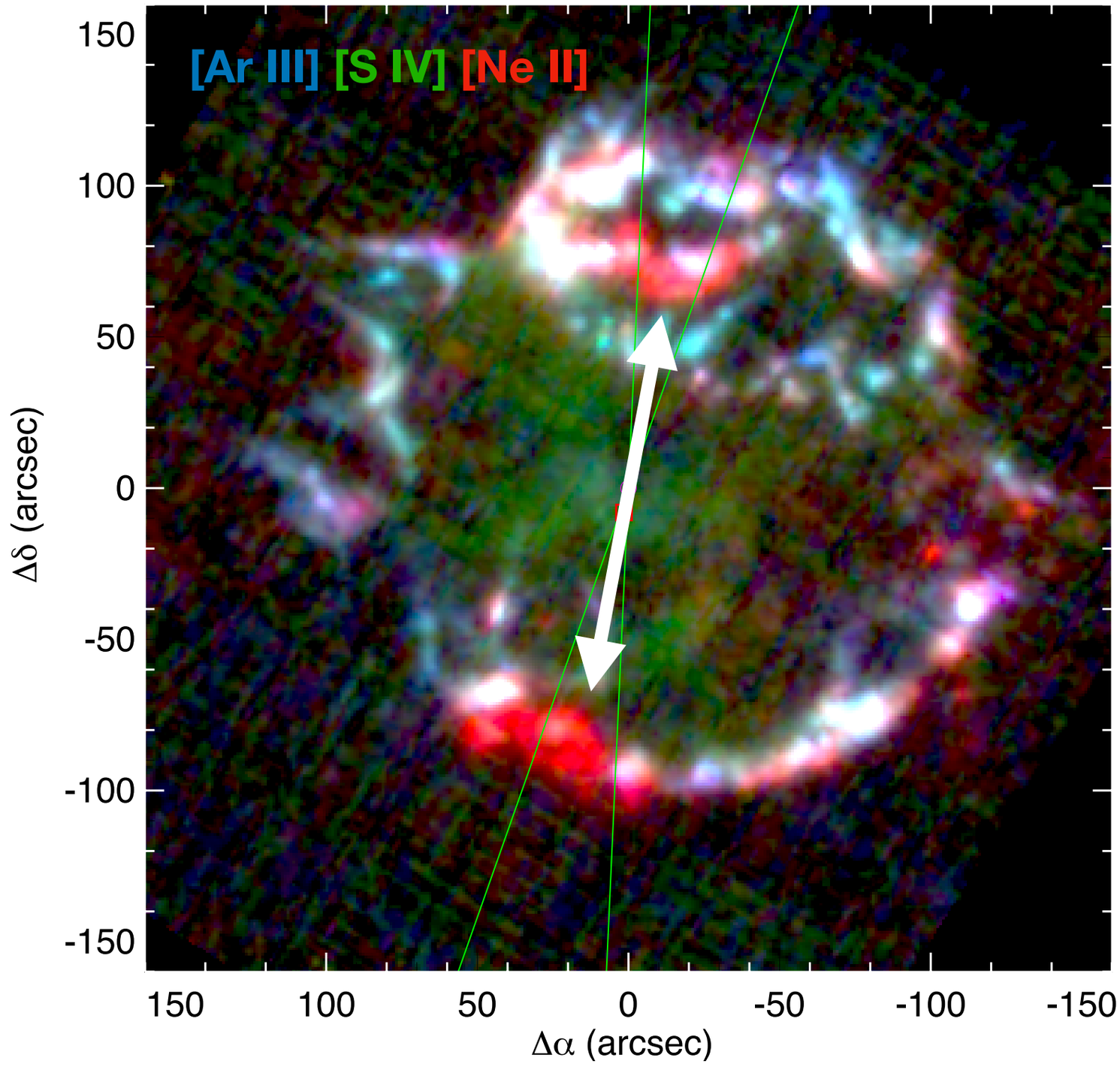




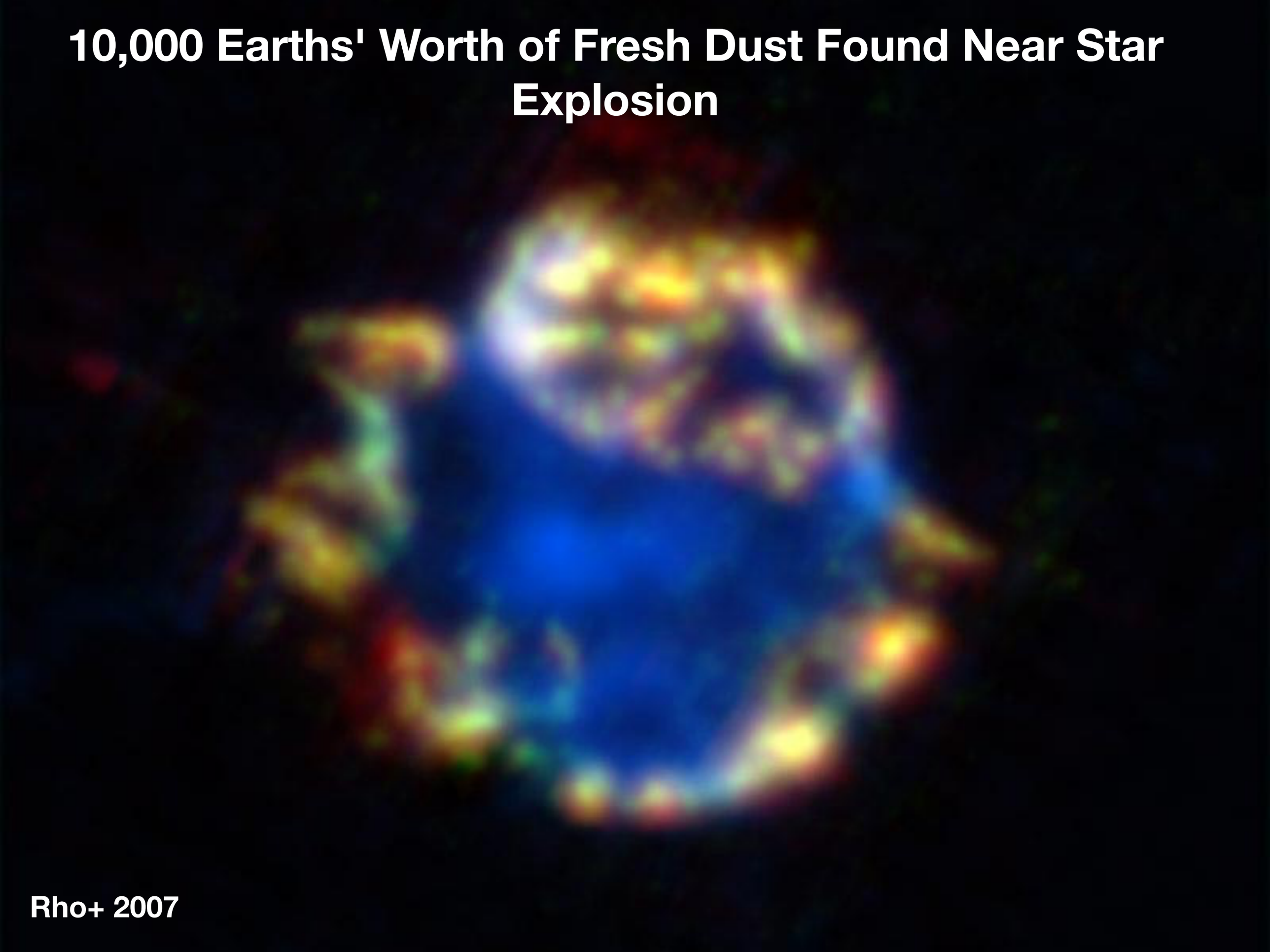
Smith+ 2009

A Symmetric Supernova Asymmetry?

- Pure Ne/O lobes along NS kick direction.

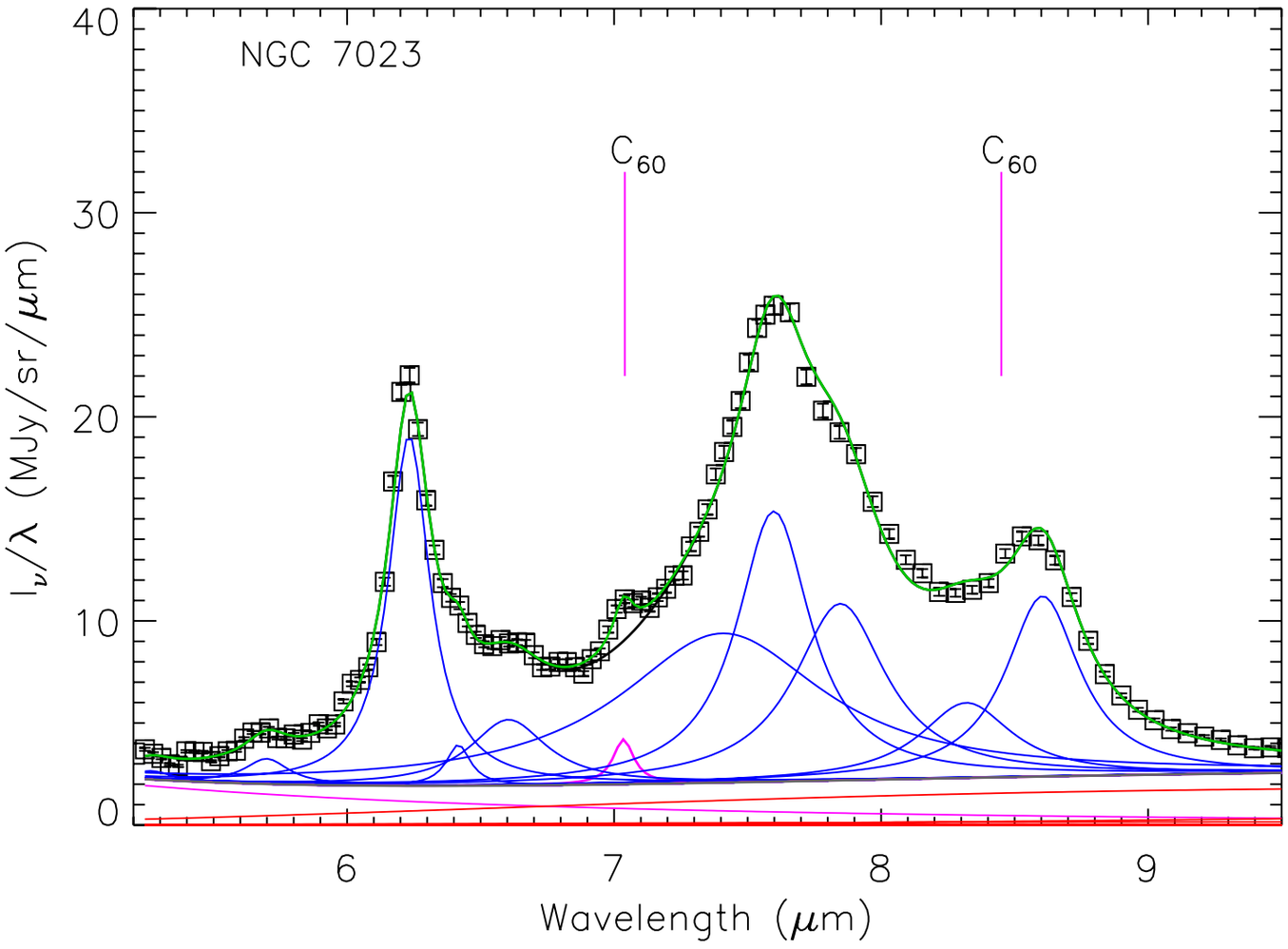


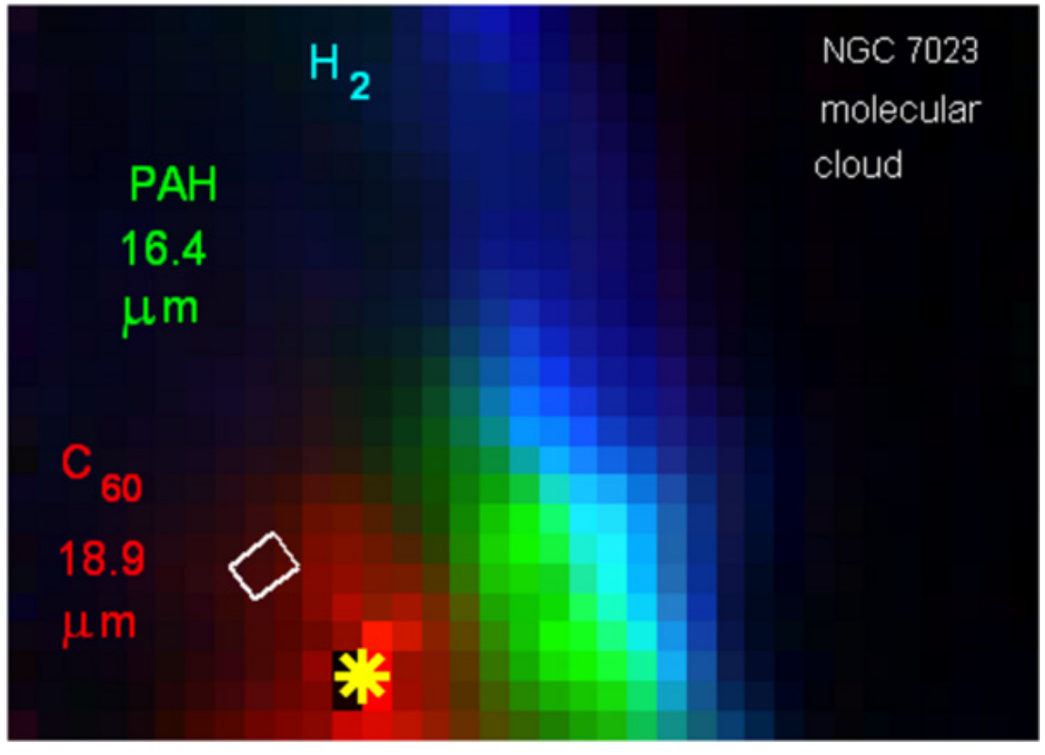
10,000 Earths' Worth of Fresh Dust Found Near Star Explosion



DeLaney+ 2010

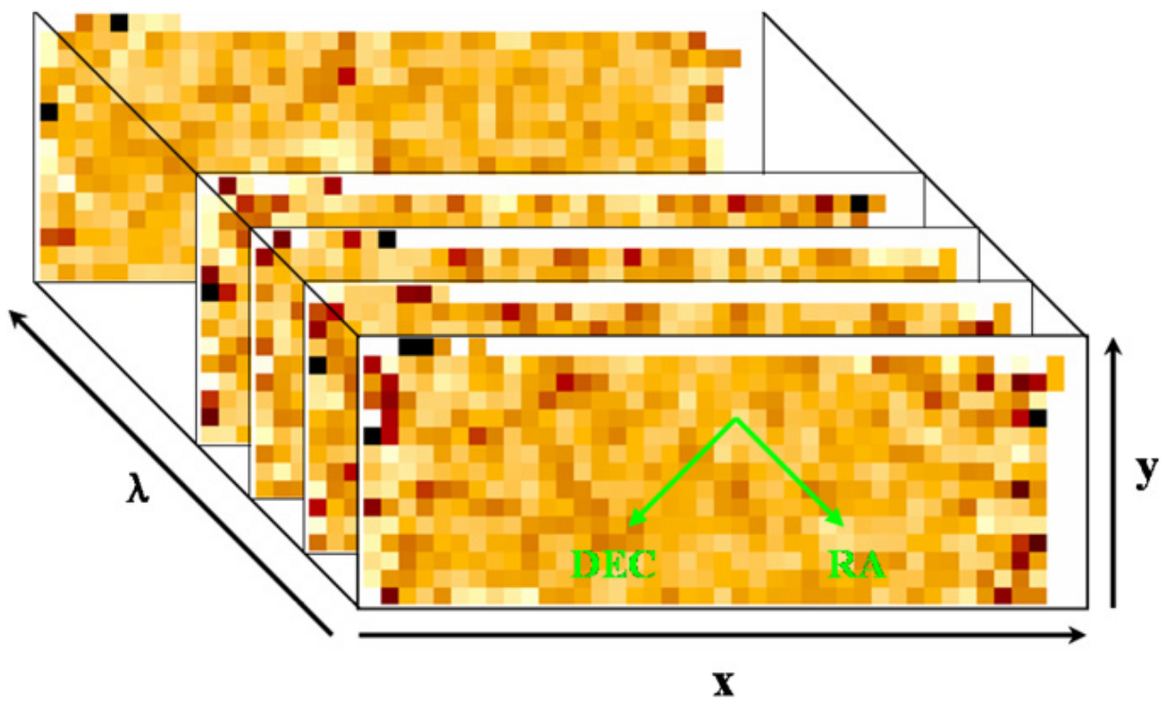
Interstellar C60 discovered

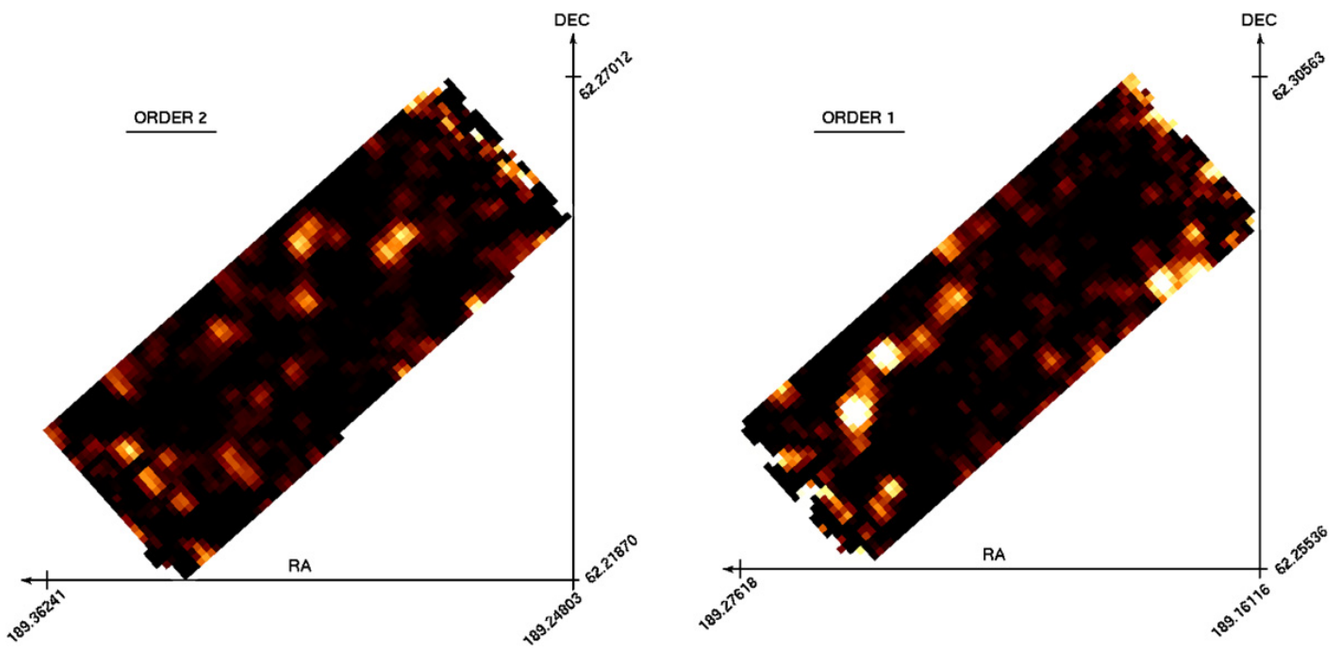




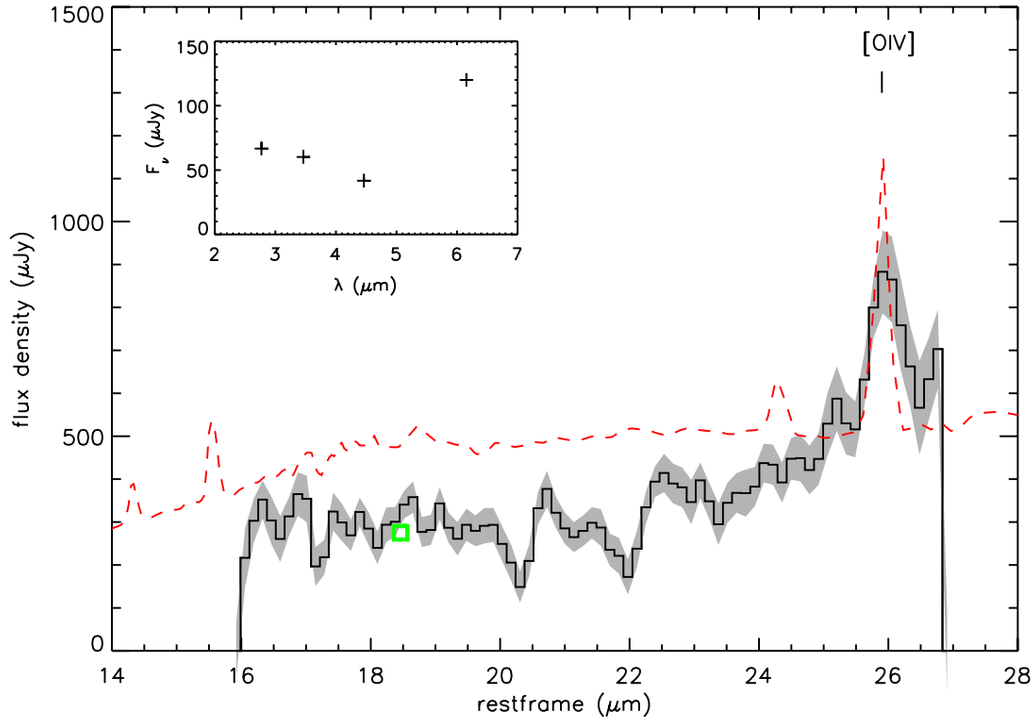
Sellgren+ 2010

Blind Surveys



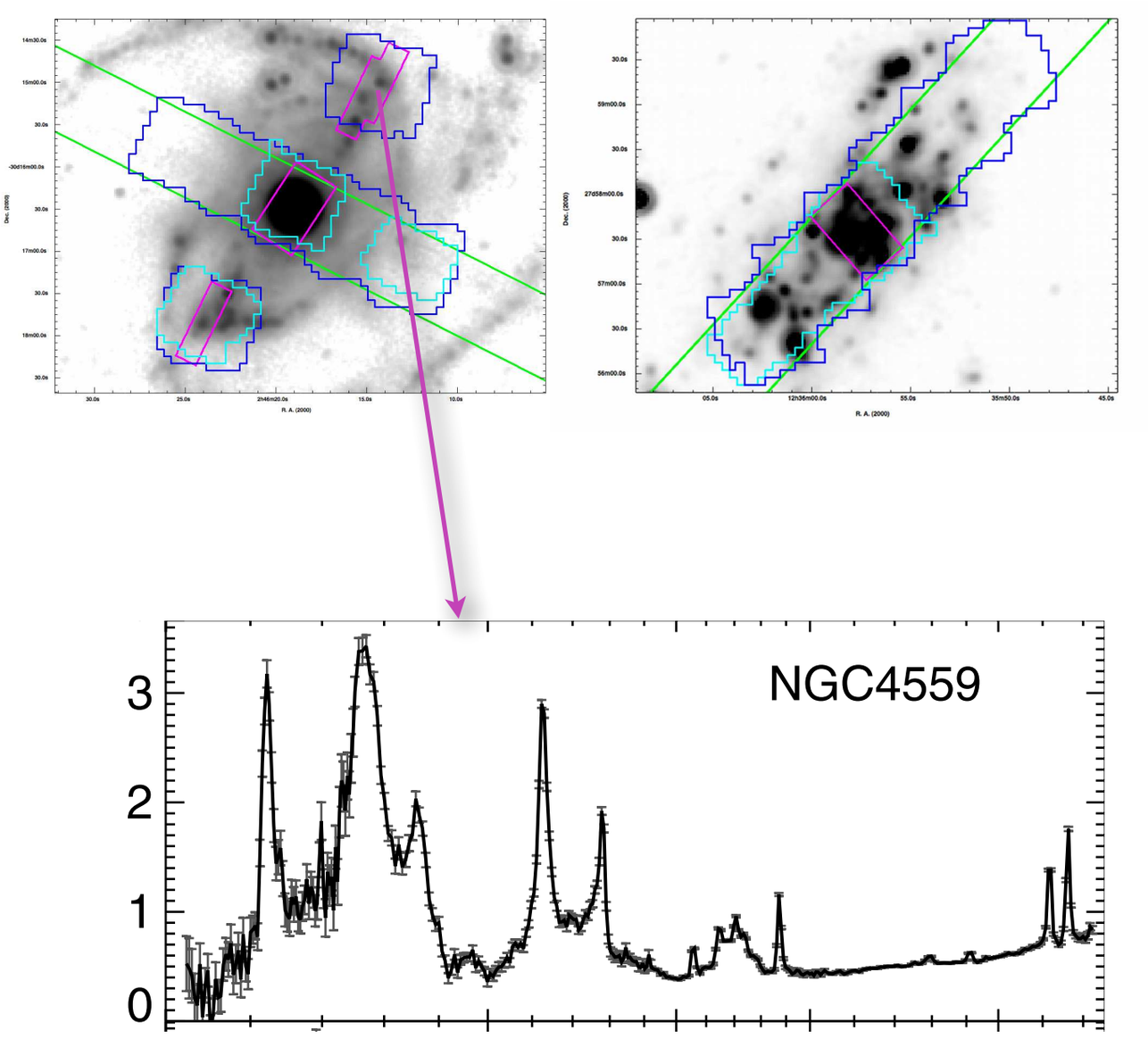


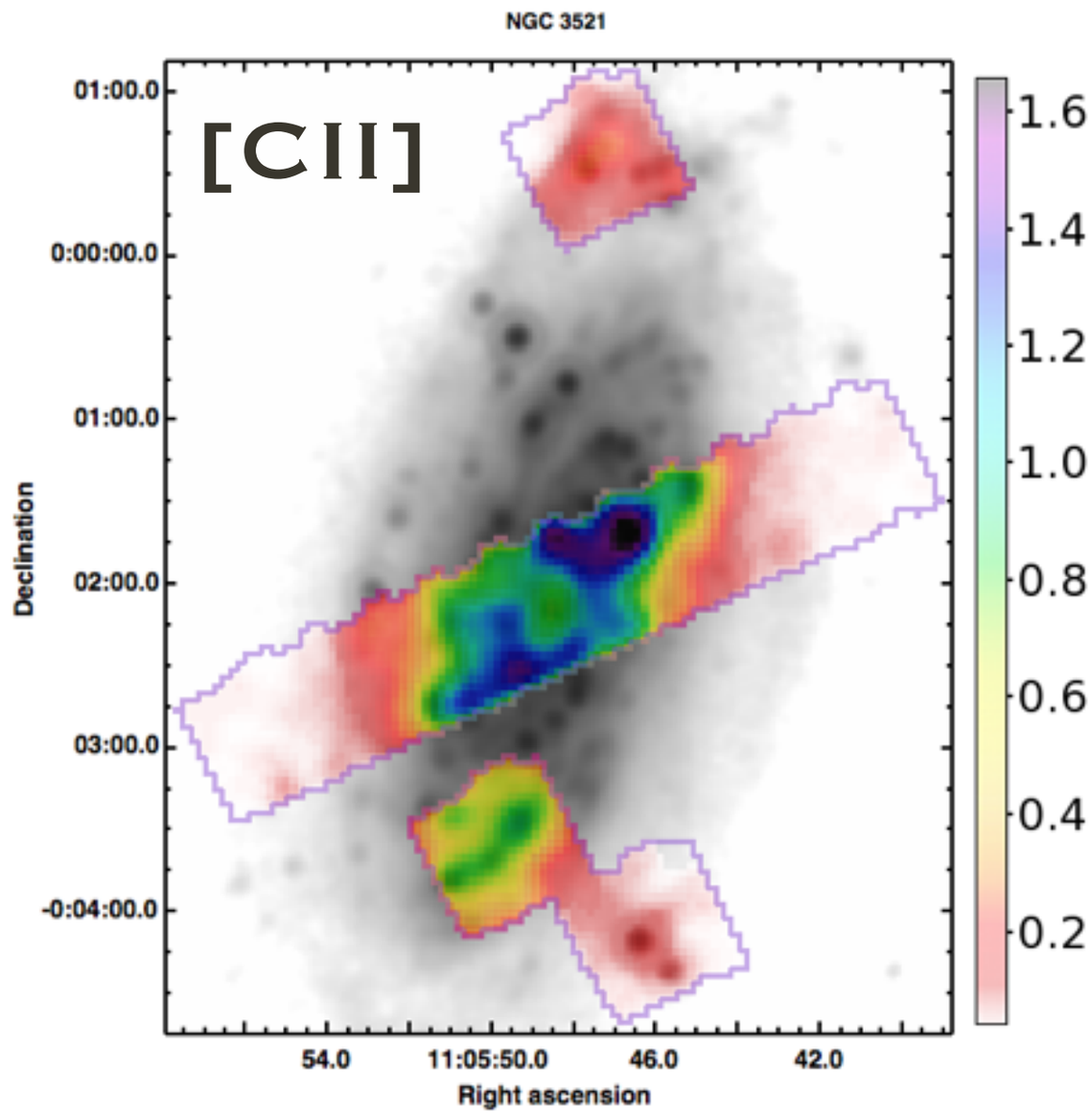
Bertincourt+ 2009



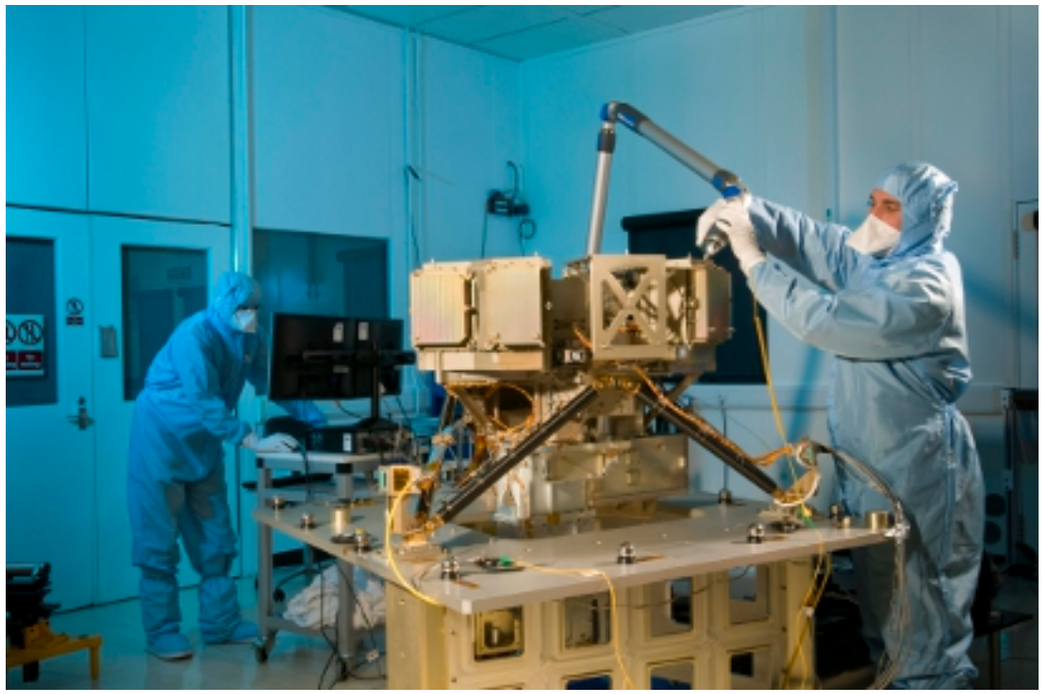
- Blind LL spectral mapping survey in the GOOD field.
- 45 sources, z=0.2–2.2
- A few very high line-to-continuum sources without GOODS counterparts.

IRS mapping inspirations

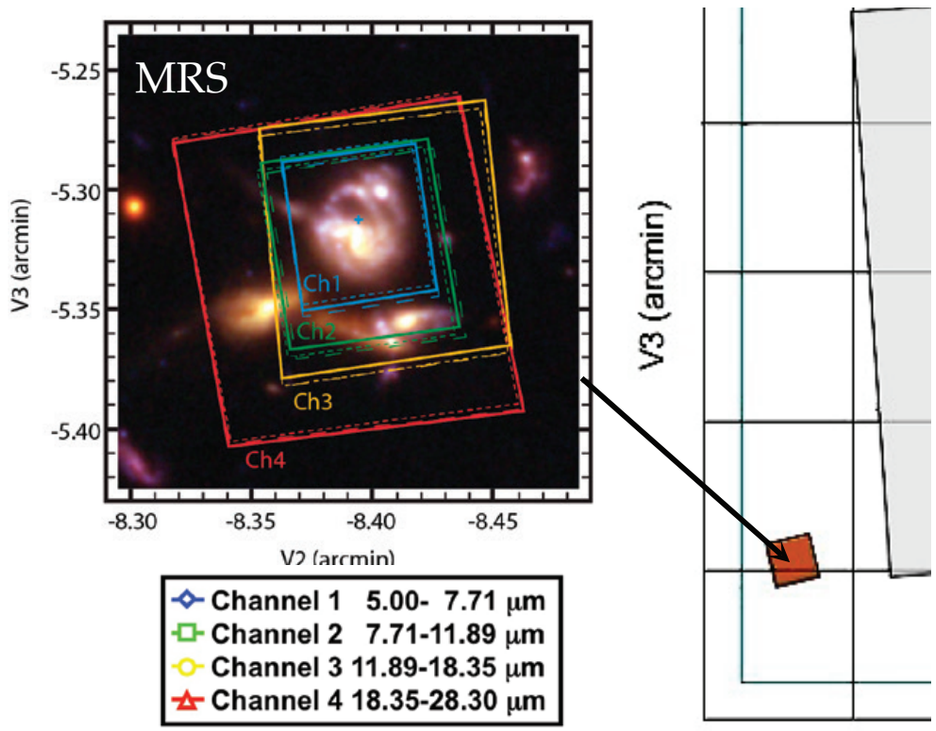


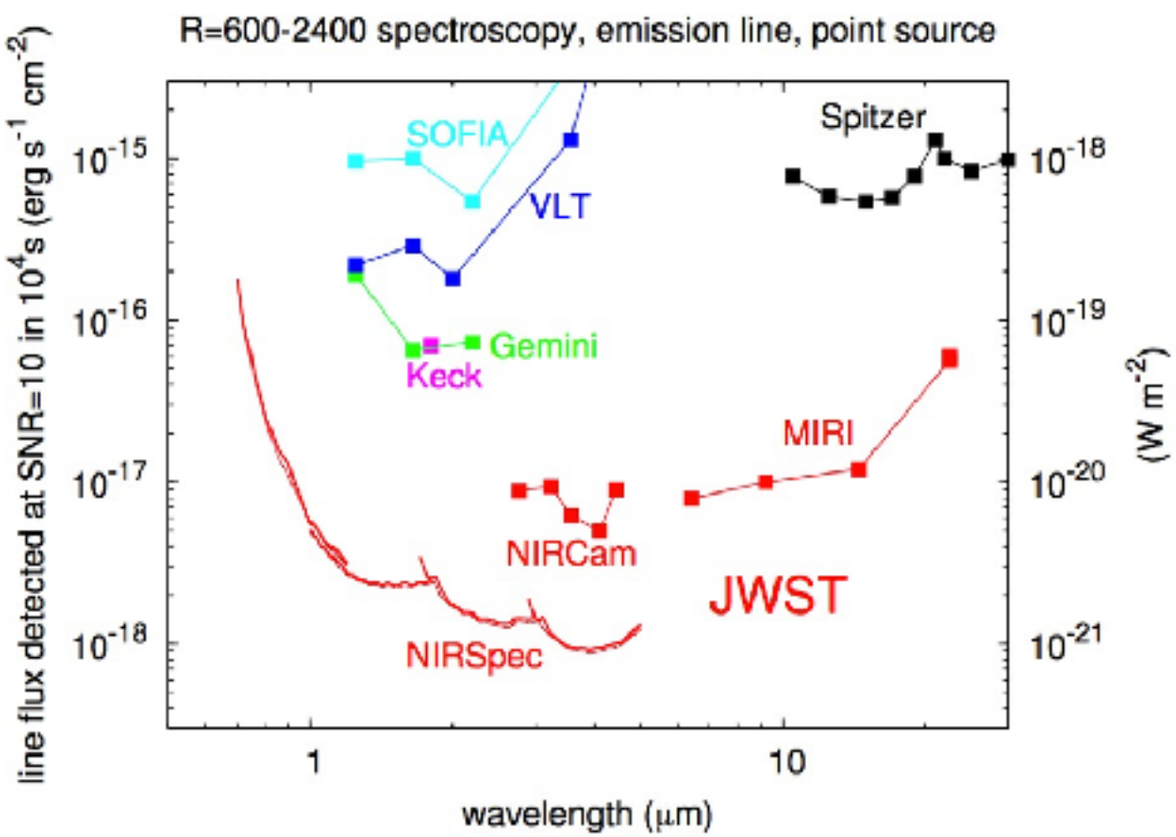


The Future of MIR Spectral Mapping



- MIRI on JWST





ELT/METIS