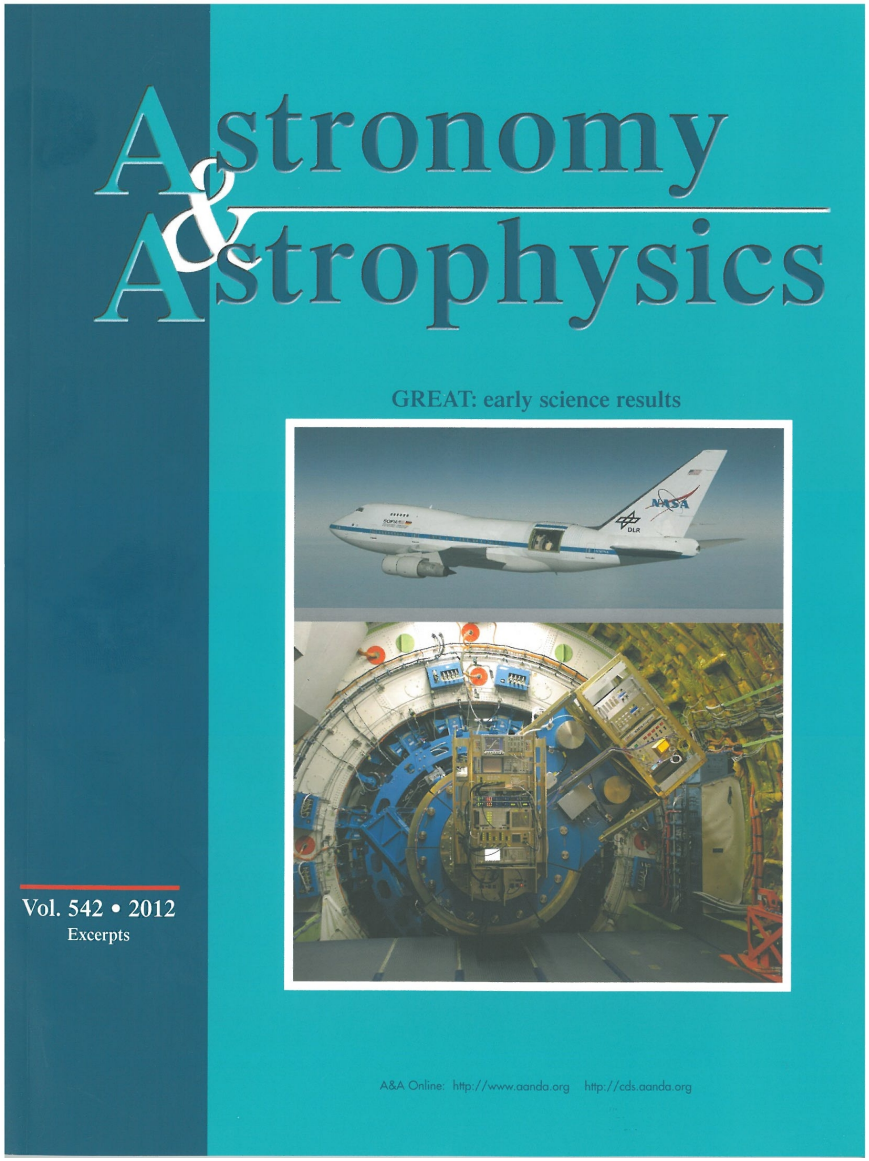
SOFIA observations of S106: Dynamics of the warm gas

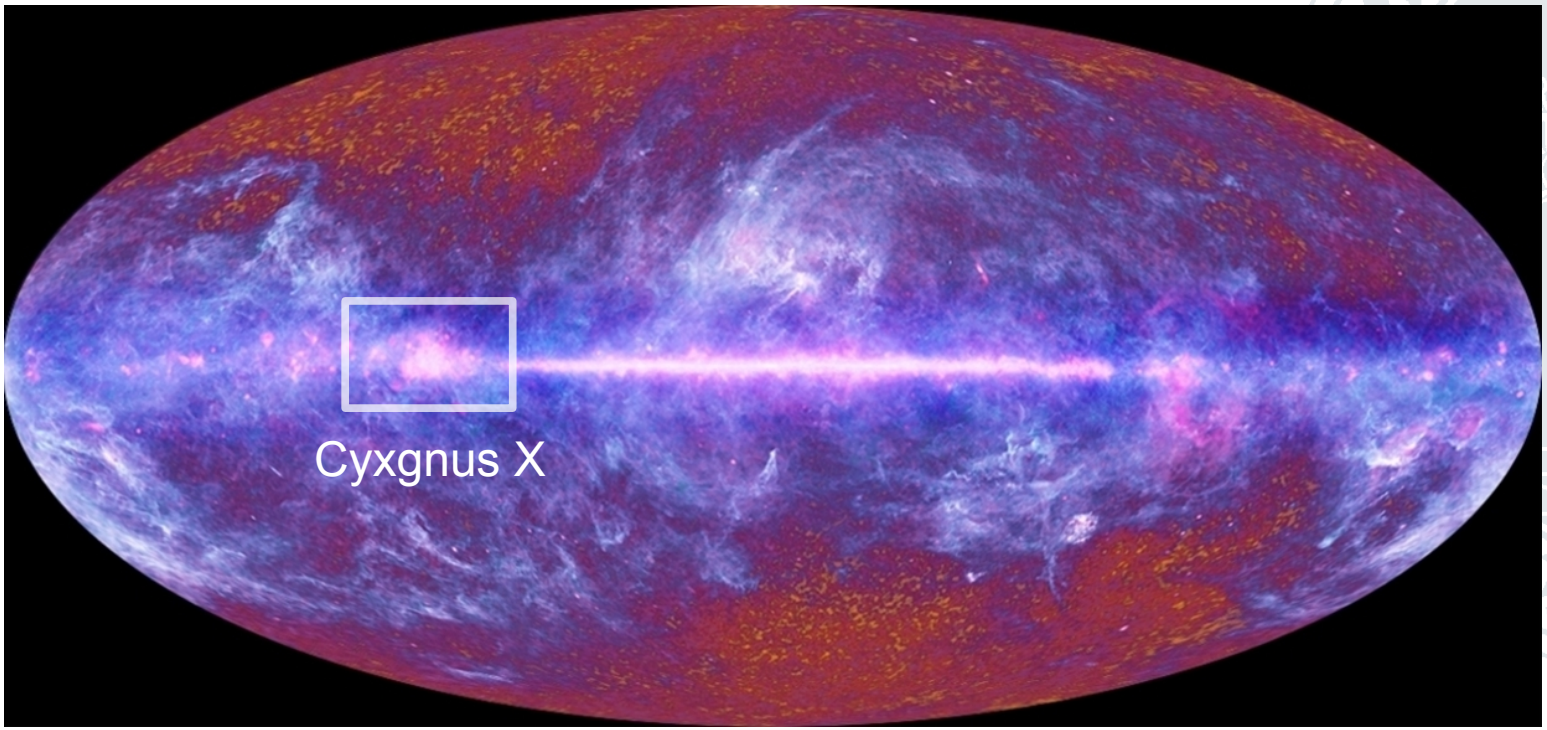
Robert Simon, Nicola Schneider, Jürgen Stutzki, Rolf Güsten, Urs Graf,
Paul Hartogh, Xin Guan, Johannes Staguhn, Dominic Benford



Letter in A&A special issue 542, L12 (2012)

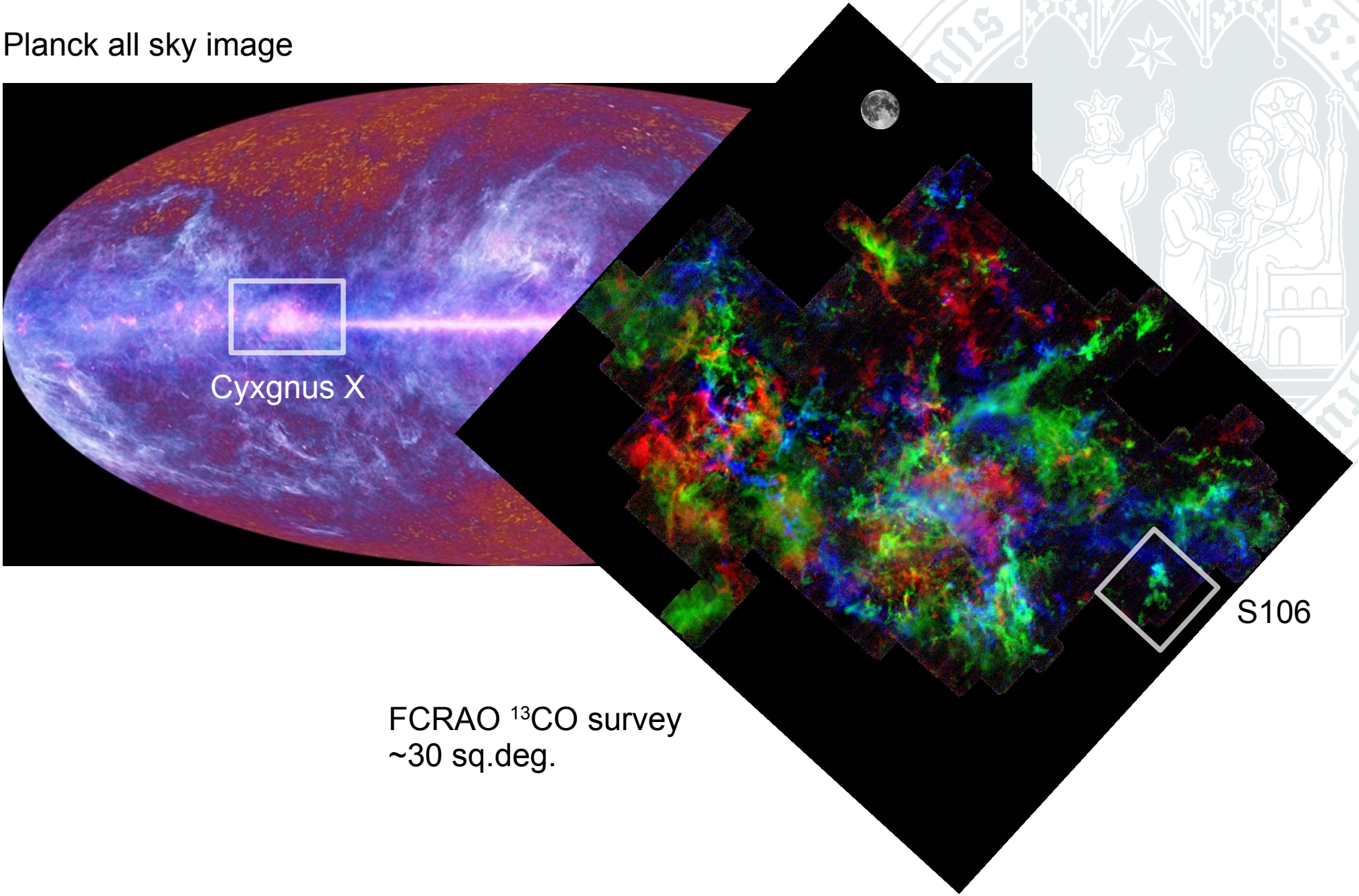
S106 in context

Planck all sky image



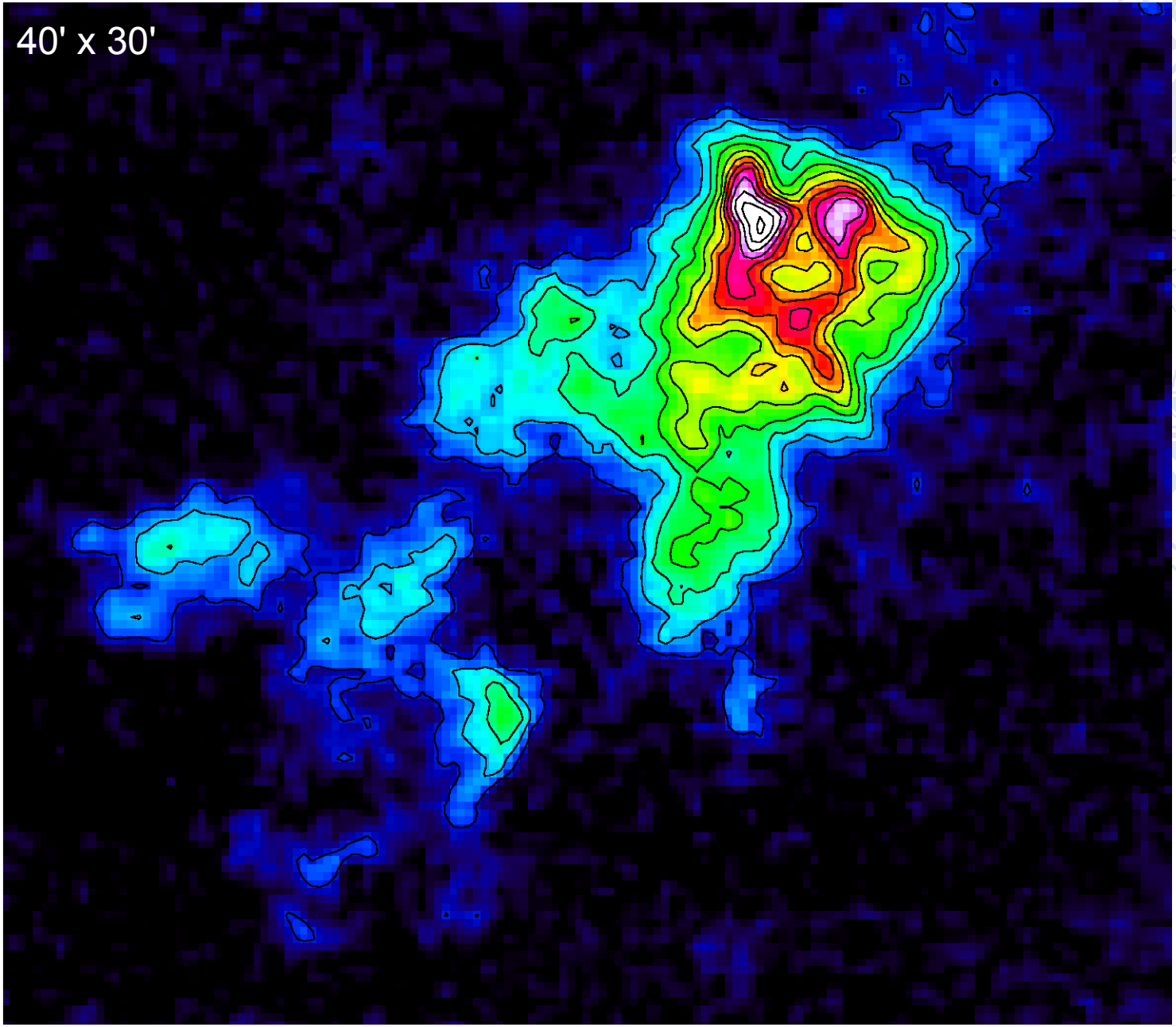
S106 in context

Planck all sky image



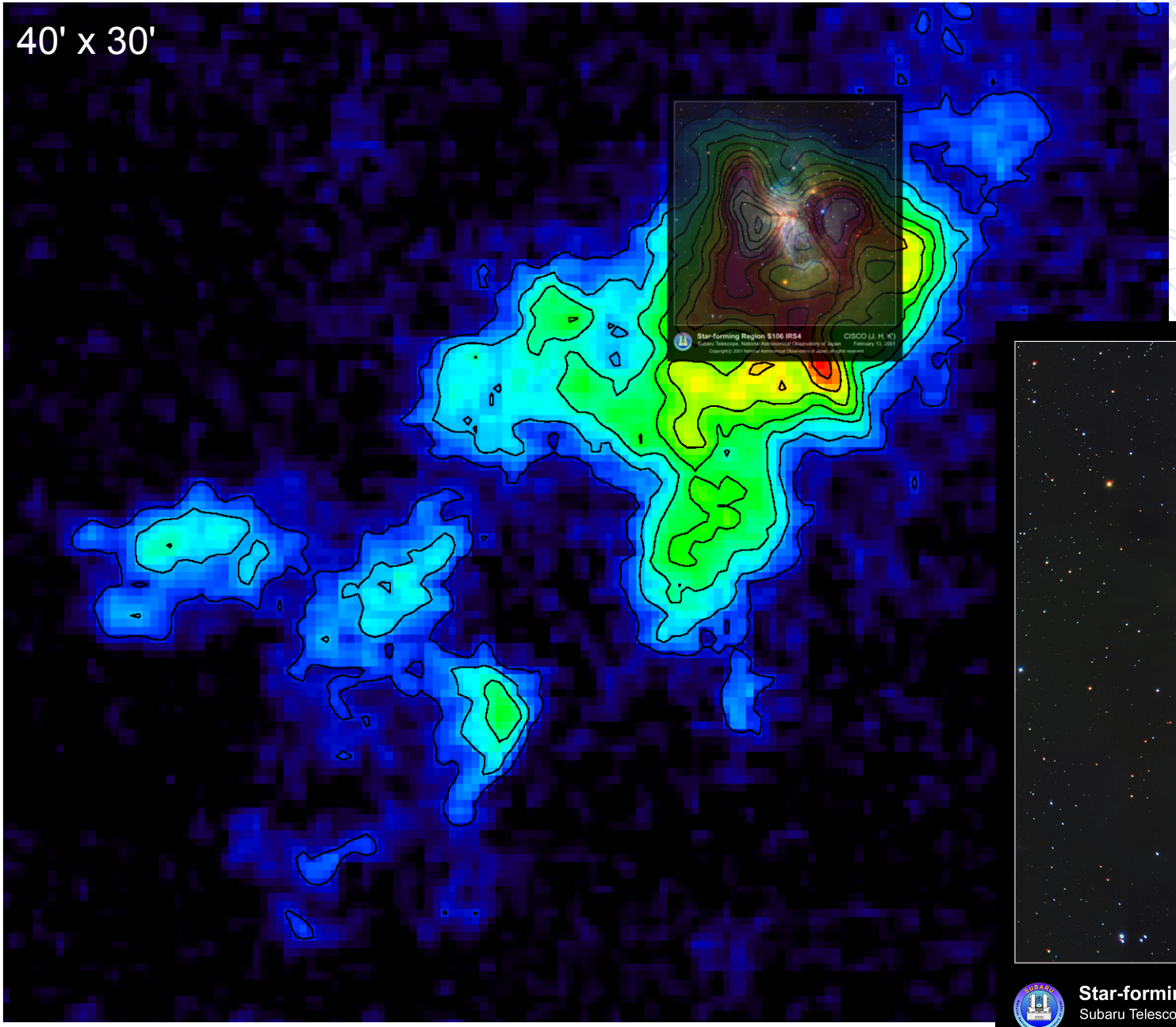
FCRAO ^{13}CO survey
~30 sq.deg.

S106 in context



FCRAO ^{13}CO survey

S106 in context



FCRAO ^{13}CO survey

Subaru near-IR

SOFIA observations of S106: Dynamics of the warm gas

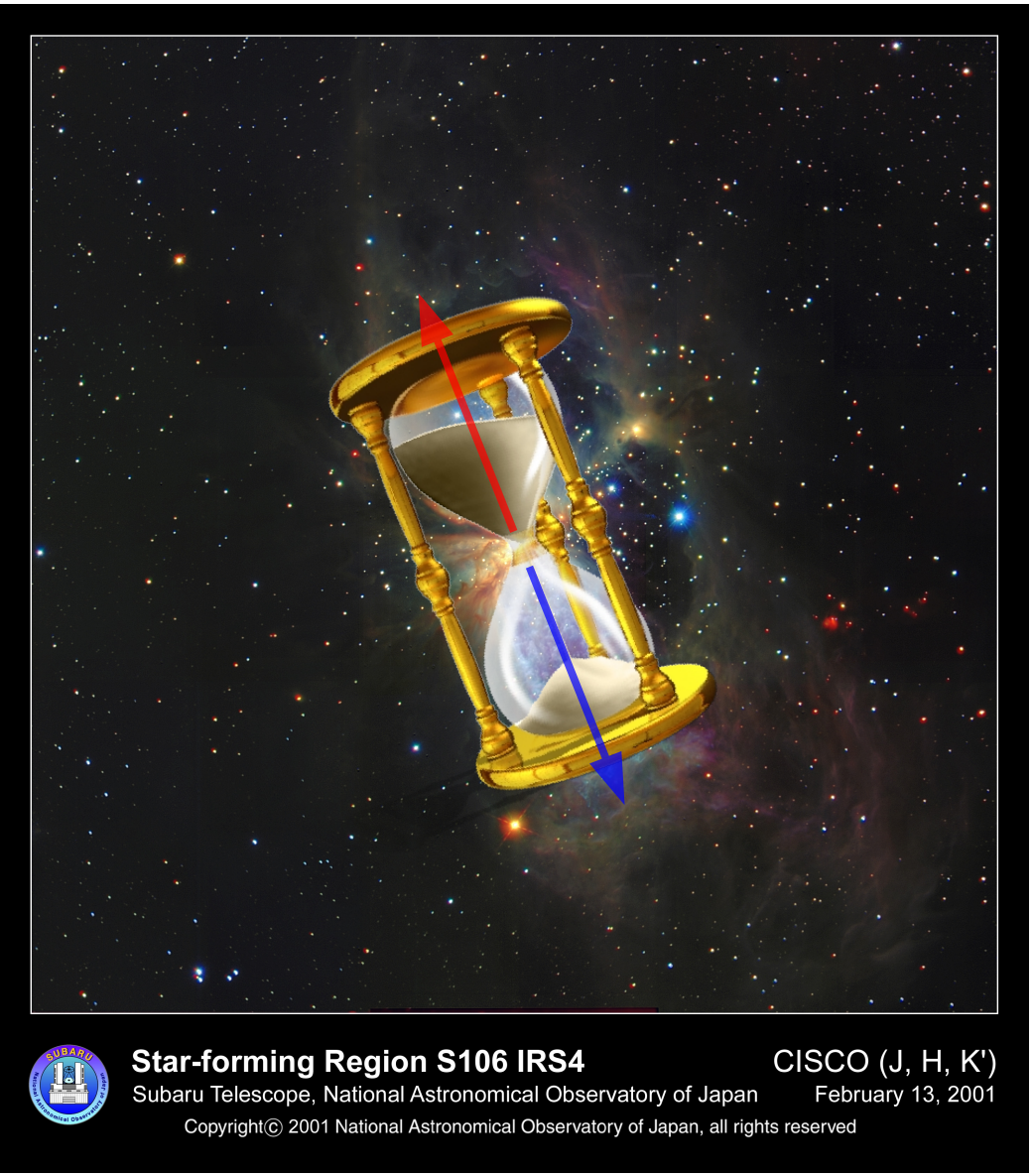
S106:
HII-region/PDR/molecular cloud complex
Single late-type O-star

SOFIA/GREAT observations:
[CII] and CO 11-10

Complementary data:
Submm continuum (350 μm) SHARC-II
Low-J CO lines IRAM 30 m
Various continuum images

SUBARU near-IR image (Oasa et al. 2006)

SOFIA observations of S106: Dynamics of the warm gas



S106:

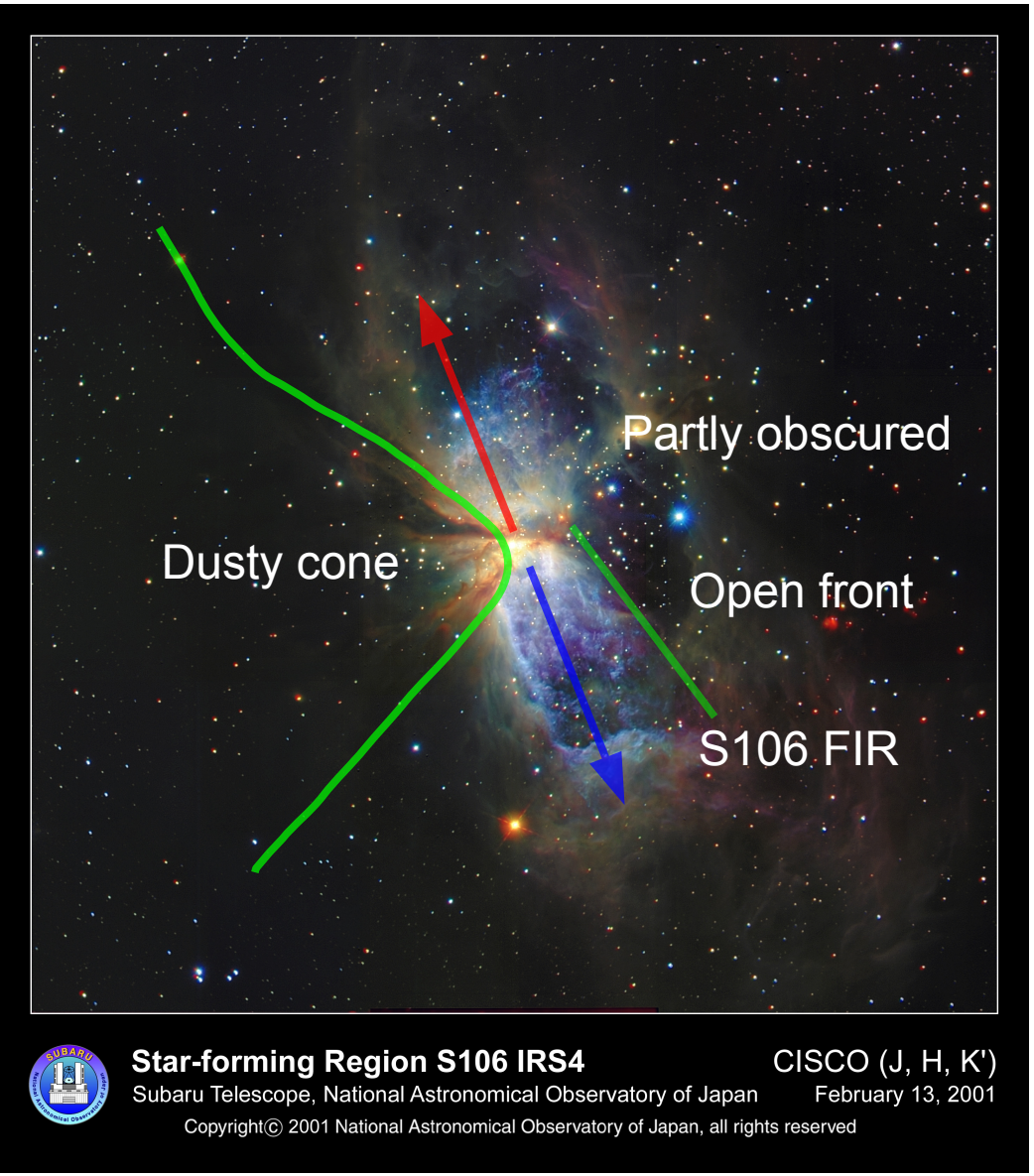
HII-region has an hour glass shape

Small inclination angle

Cavity walls partly eroded

SUBARU near-IR image (Oasa et al. 2006)

SOFIA observations of S106: Dynamics of the warm gas



S106:

HII-region has an hour glass shape

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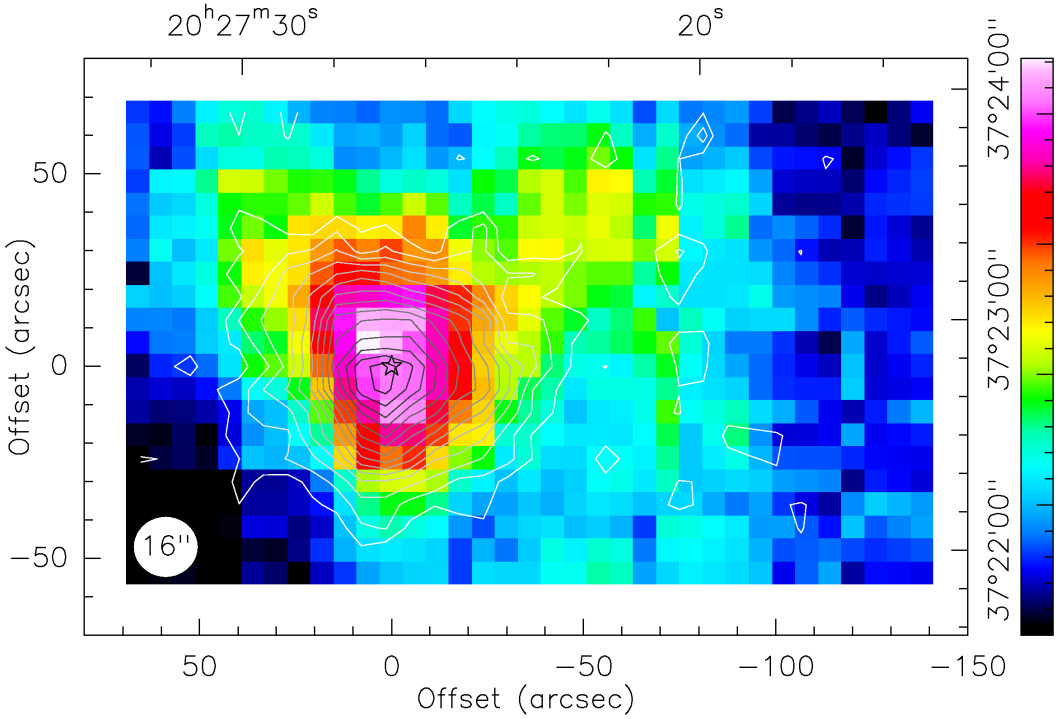
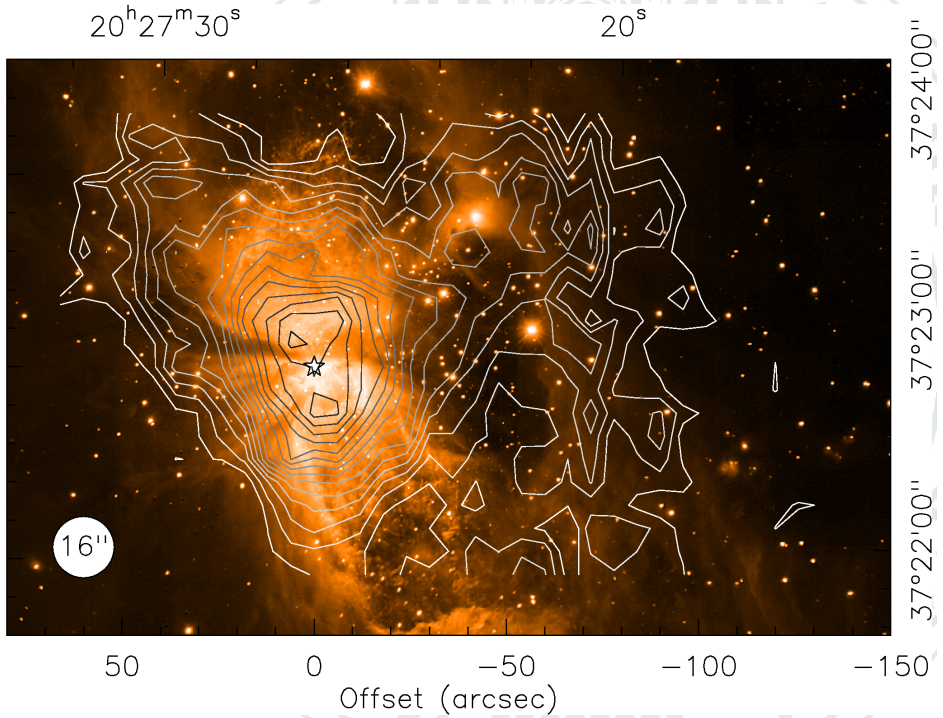
SUBARU near-IR image (Oasa et al. 2006)

Integrated intensities

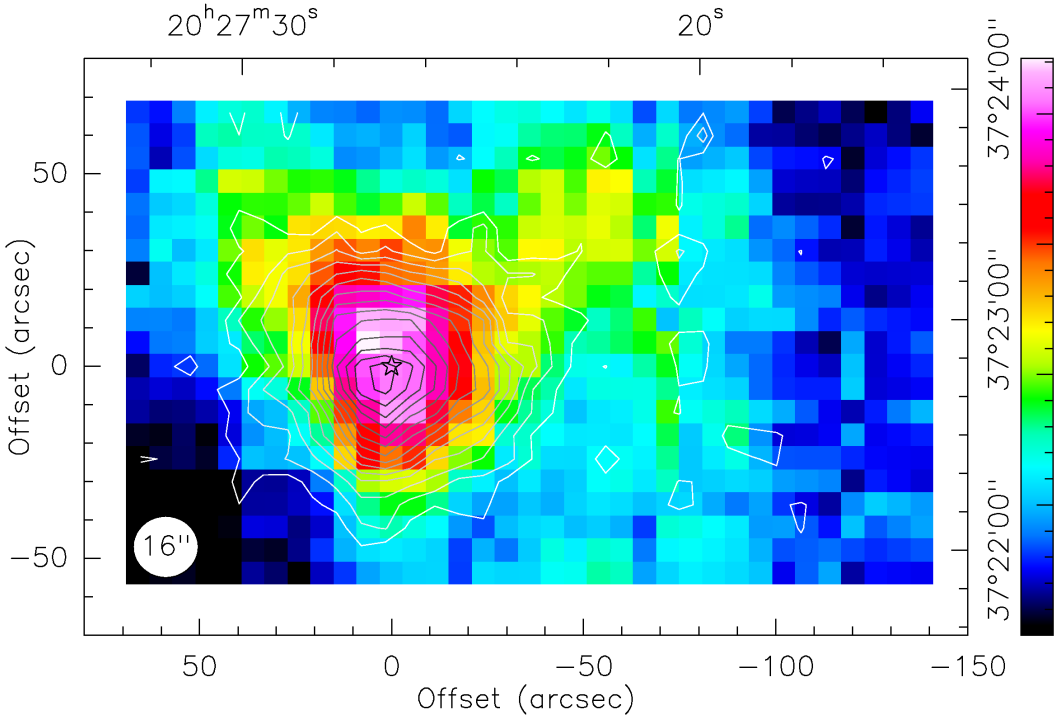


Color: [CII]
Contours: CO 11-10

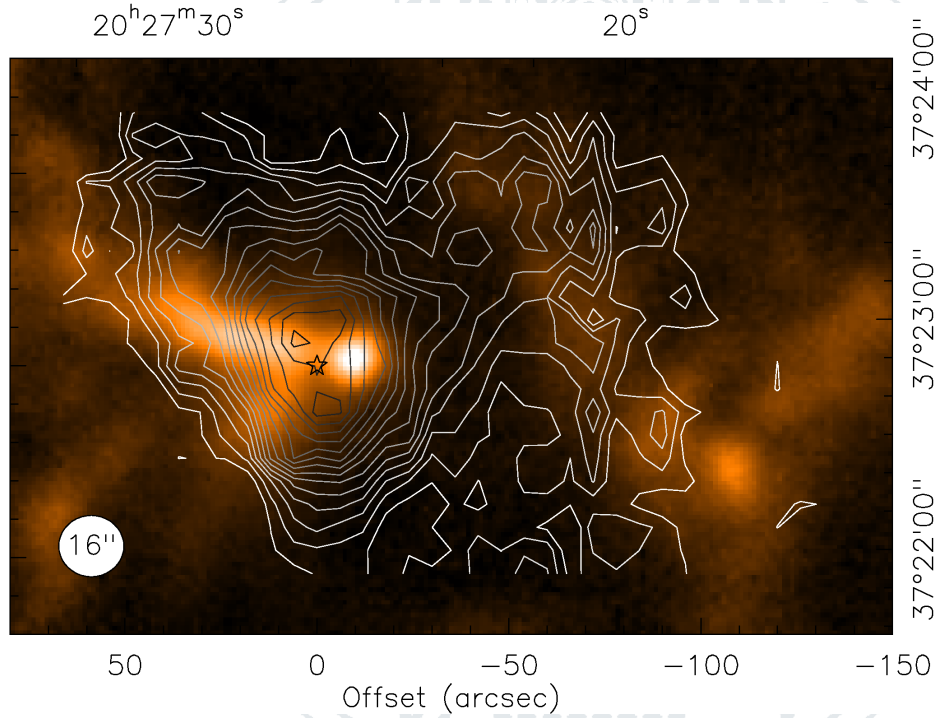


Color: near-IR, SUBARU
Contours: [CII]

Integrated intensities



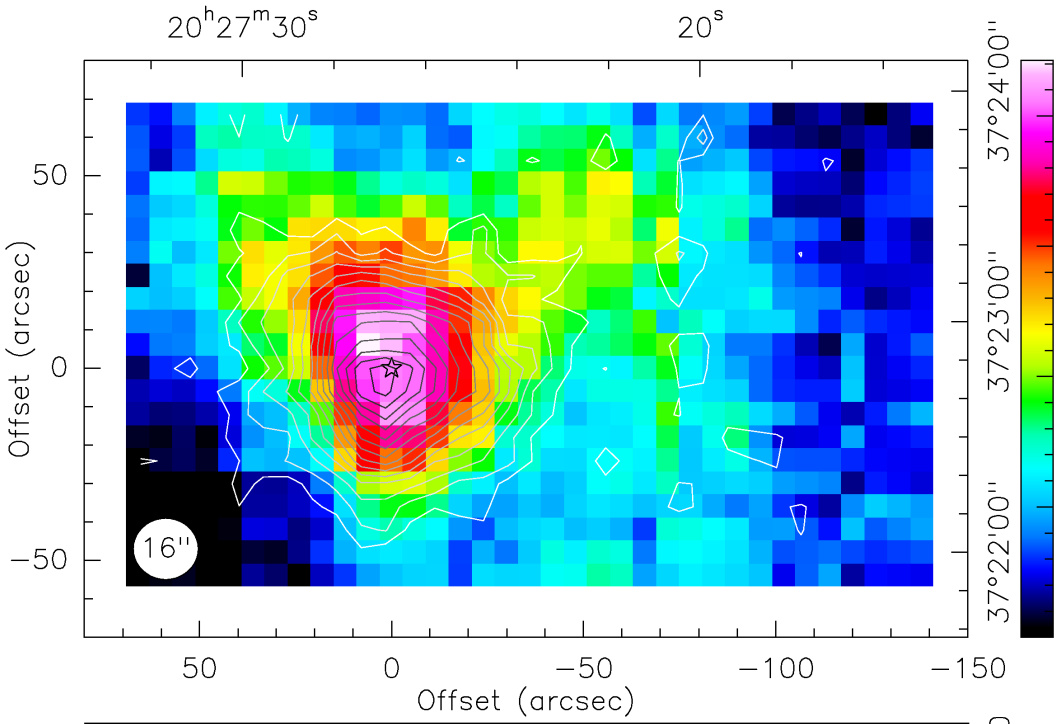
Color: [CII]
Contours: CO 11-10

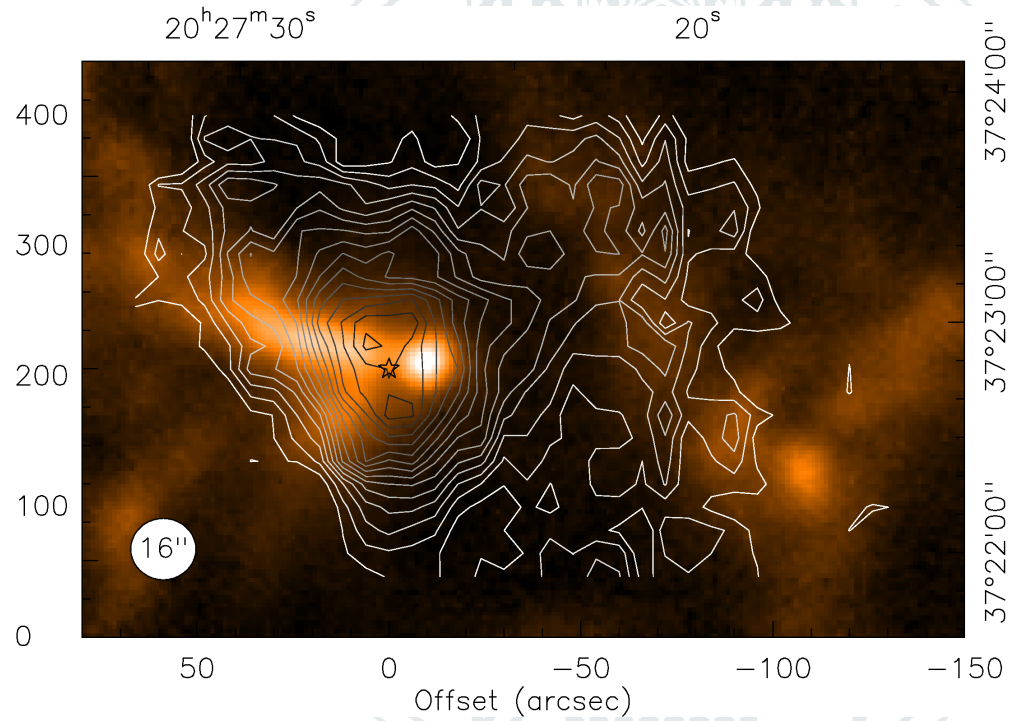


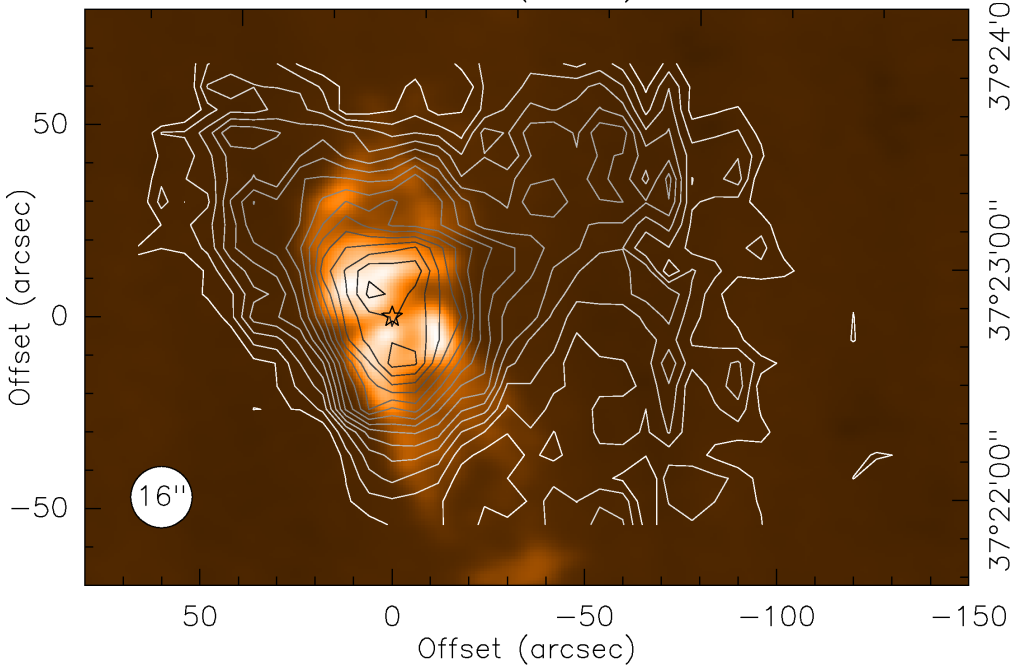
Color: 350 µm continuum, SHARC-II
Contours: [CII]

CII tends to avoid submm continuum

Integrated intensities







Color: 350 µm continuum, SHARC-II
Contours: [CII]

CII tends to avoid submm continuum

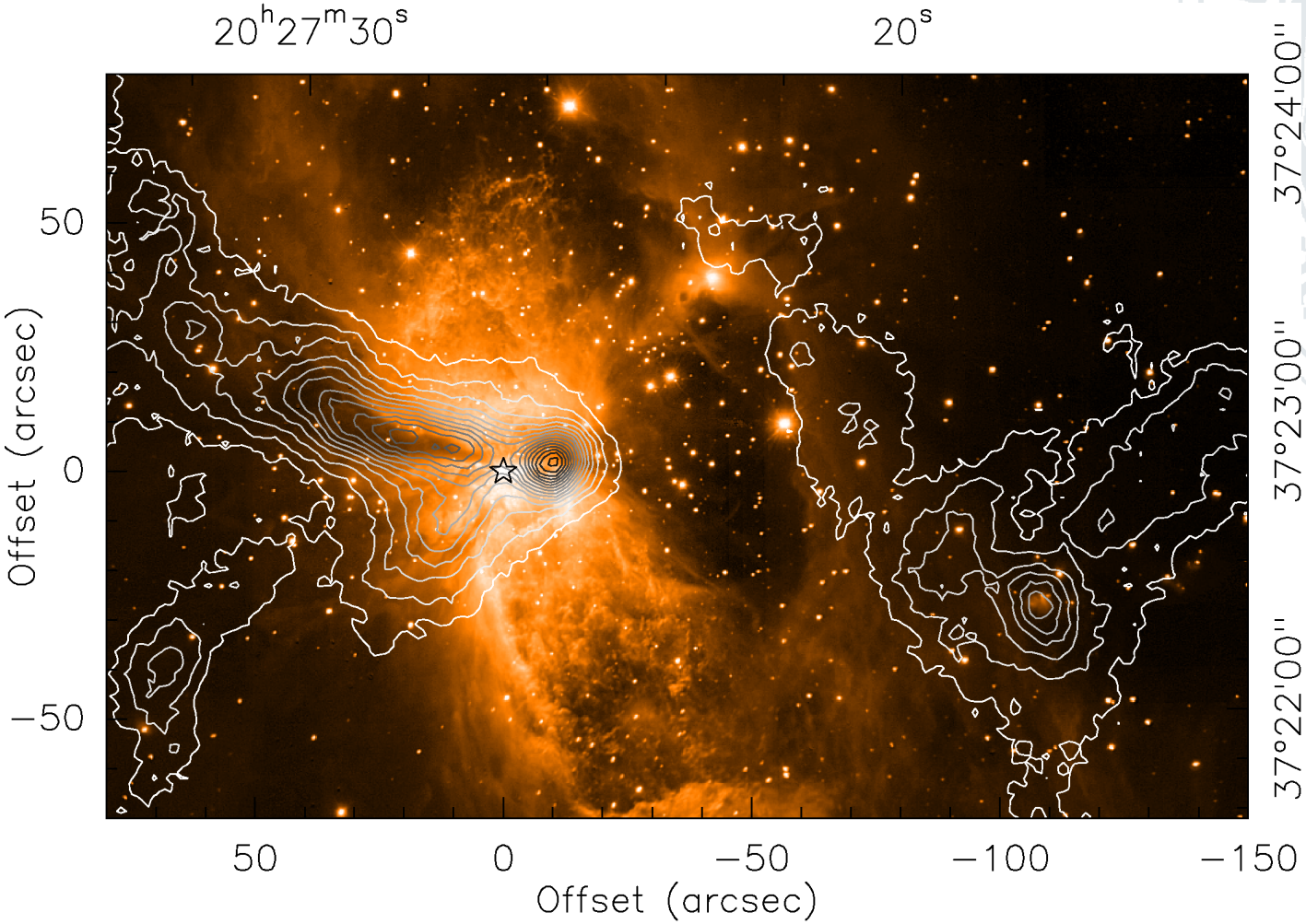
Better tracer of ionized gas

Color: 1.4 cm continuum, VLA
Contours: [CII]

The dark lane

Shadow of small scale disk?

Extinction in high column density gas?

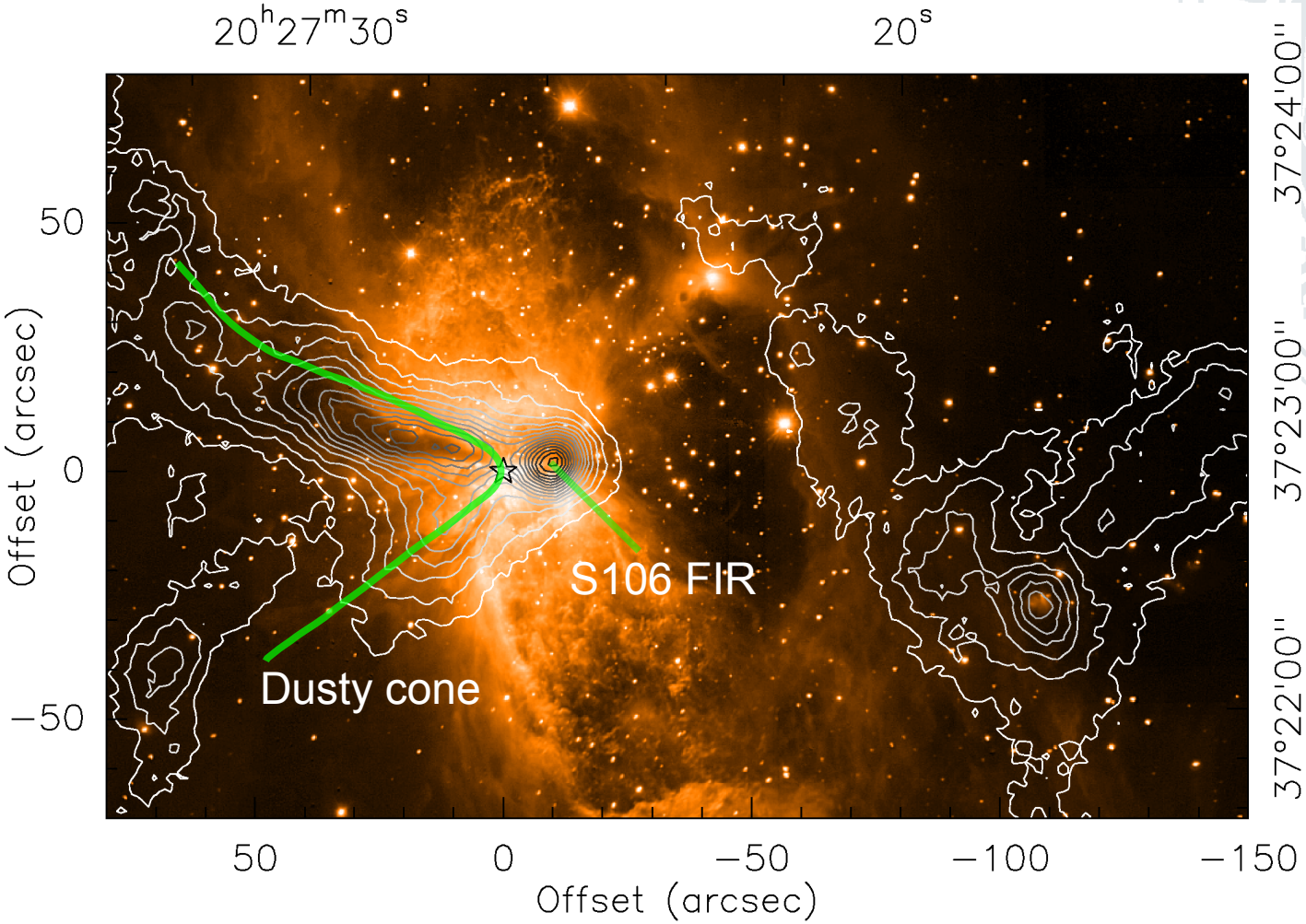


Color: near-IR, SUBARU
Contours: 350 µm continuum, SHARC-II

The dark lane

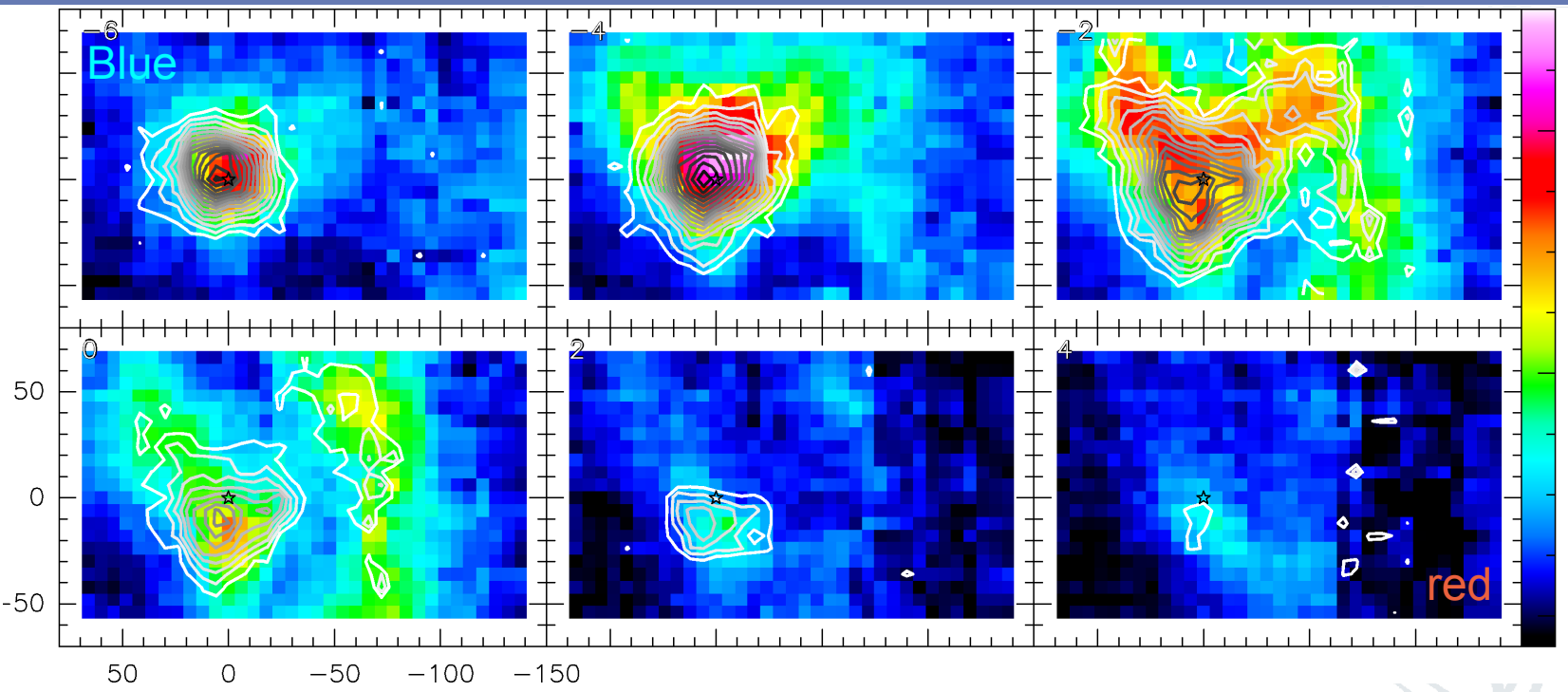
Shadow of small scale disk?

Extinction in high column density gas?



Color: near-IR, SUBARU
Contours: 350 µm continuum, SHARC-II

Velocity channel maps

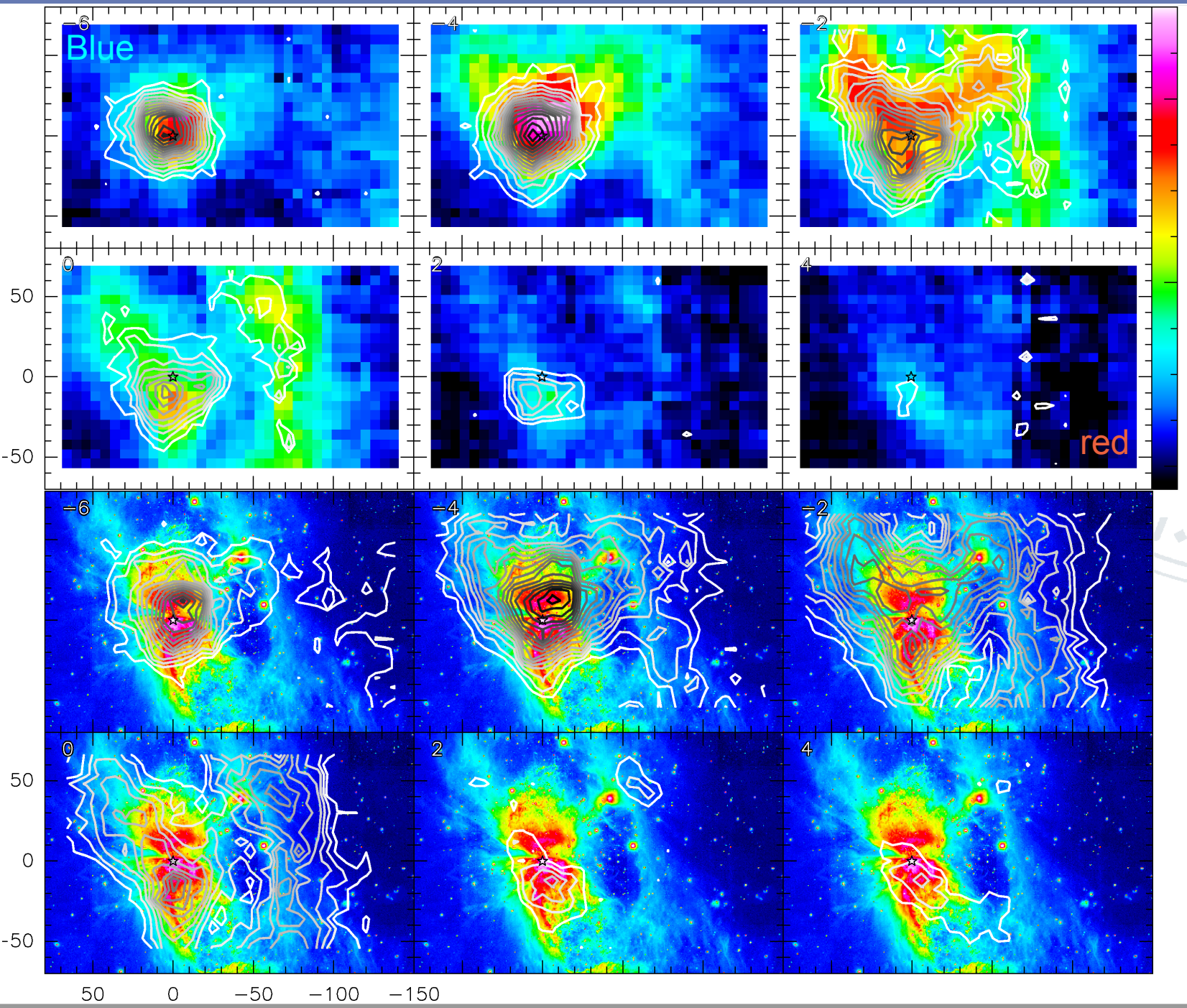


CO 11-10 cont. on

[CII] color

1. -6 to -3 km/s
2. -3 to 1 km/s
3. 0 to 4 km/s

Velocity channel maps



CO 11-10 cont. on

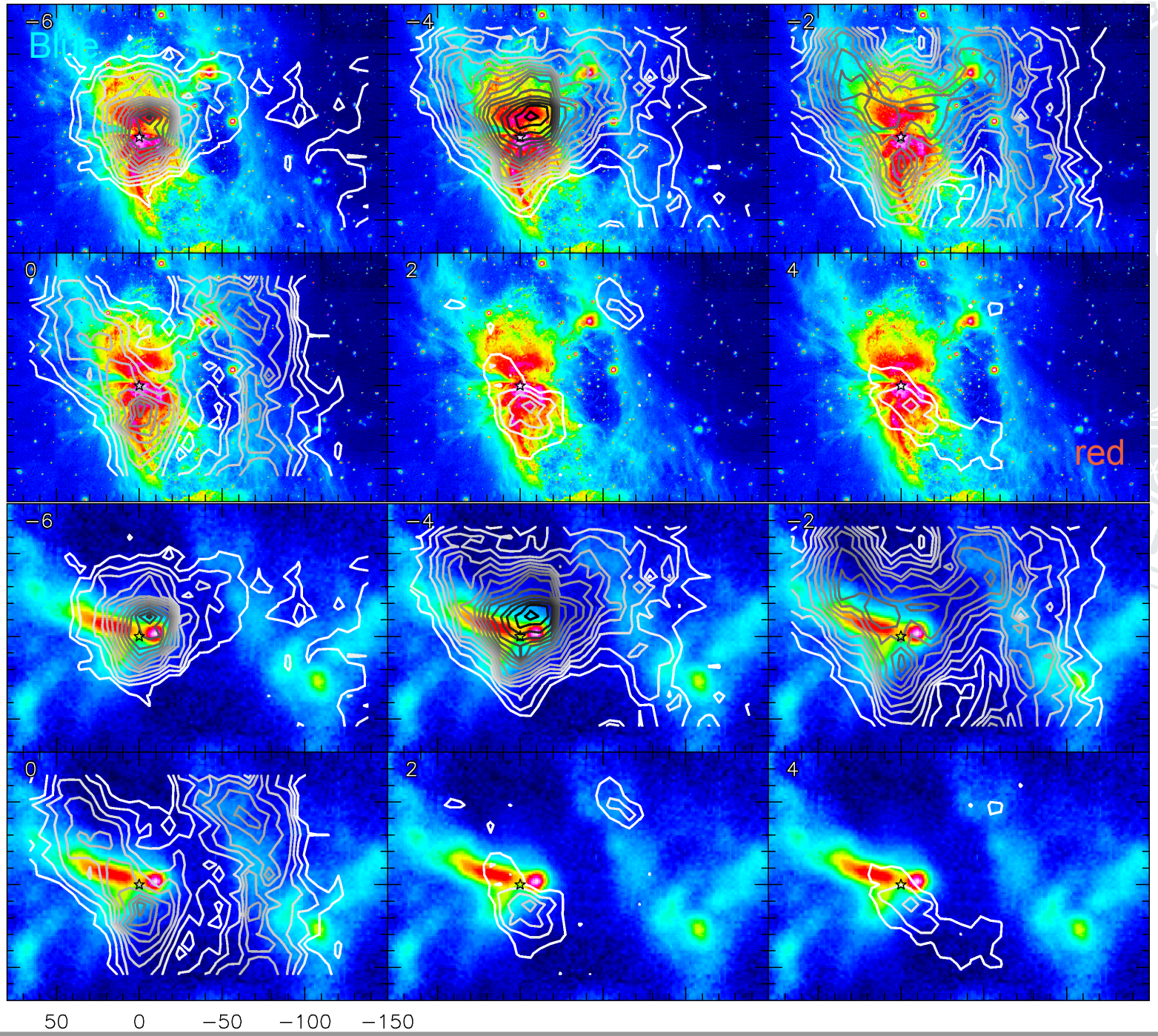
[CII] color

1. -6 to -3 km/s
2. -3 to 1 km/s
3. 0 to 4 km/s

[CII] contours on

SUBARU near-IR warm dust

Velocity channel maps



[CII] contours on

SUBARU near-IR

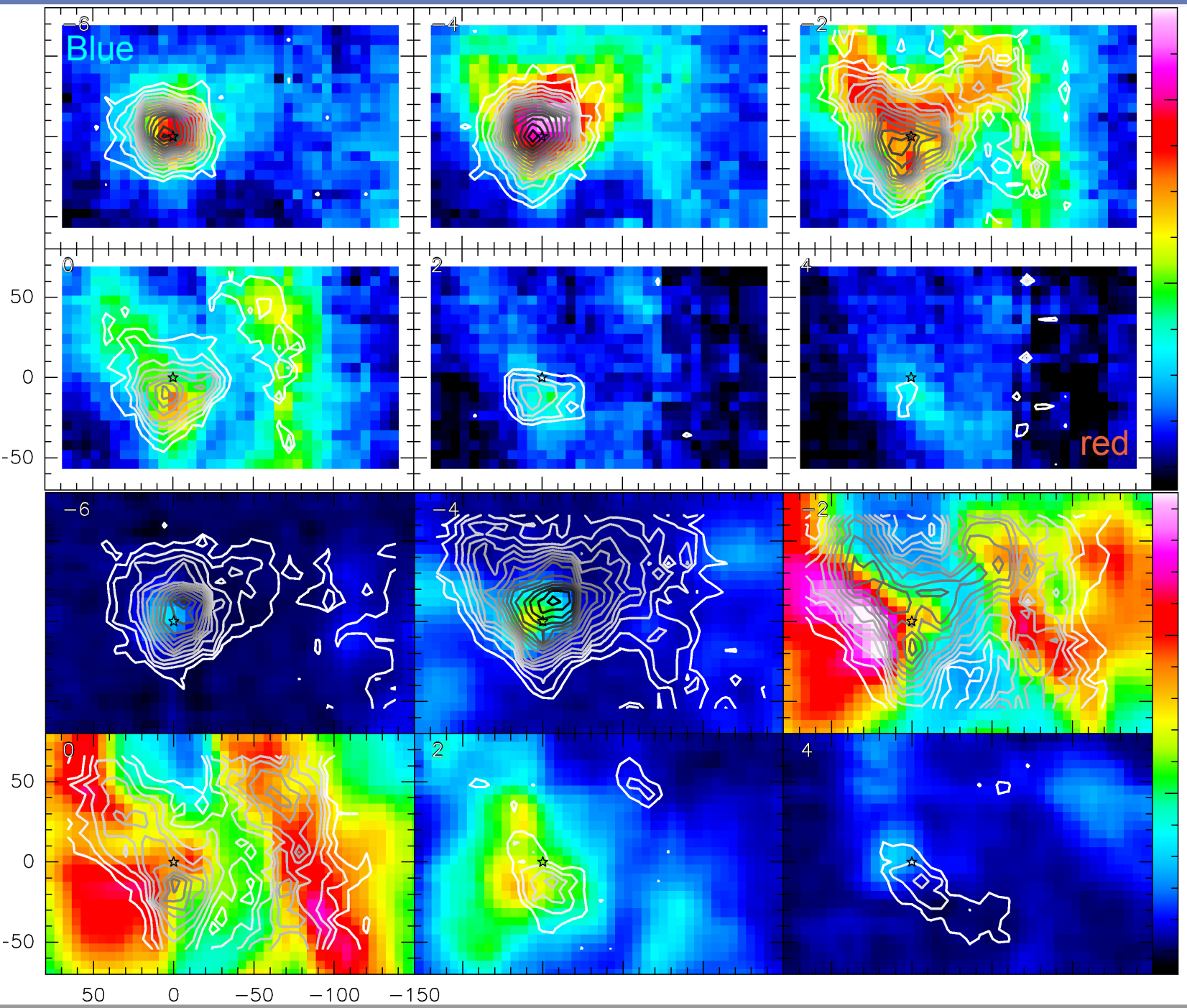
1. -6 to -3 km/s
2. -3 to 1 km/s
3. 0 to 4 km/s

[CII] contours on

Submm continuum cold dust

Evaporation or ablation of S106 FIR?

Velocity channel maps



CO 11-10 cont. on

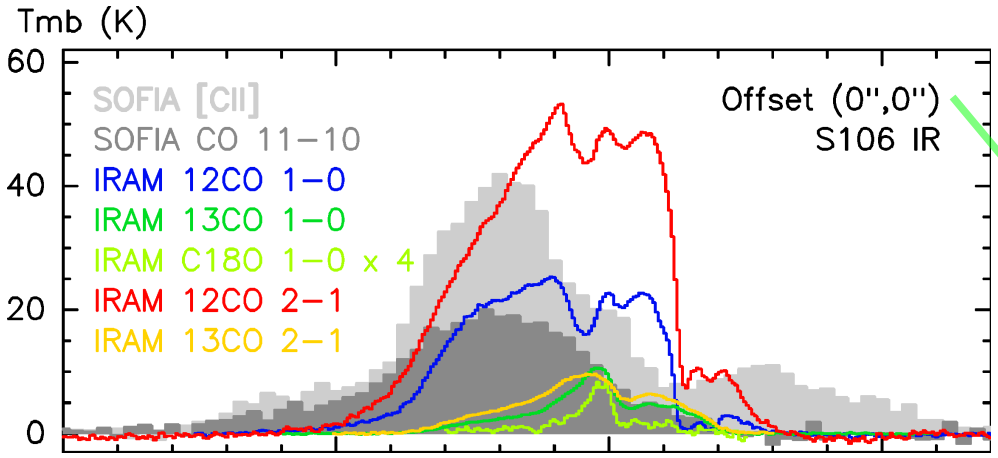
[CII] color

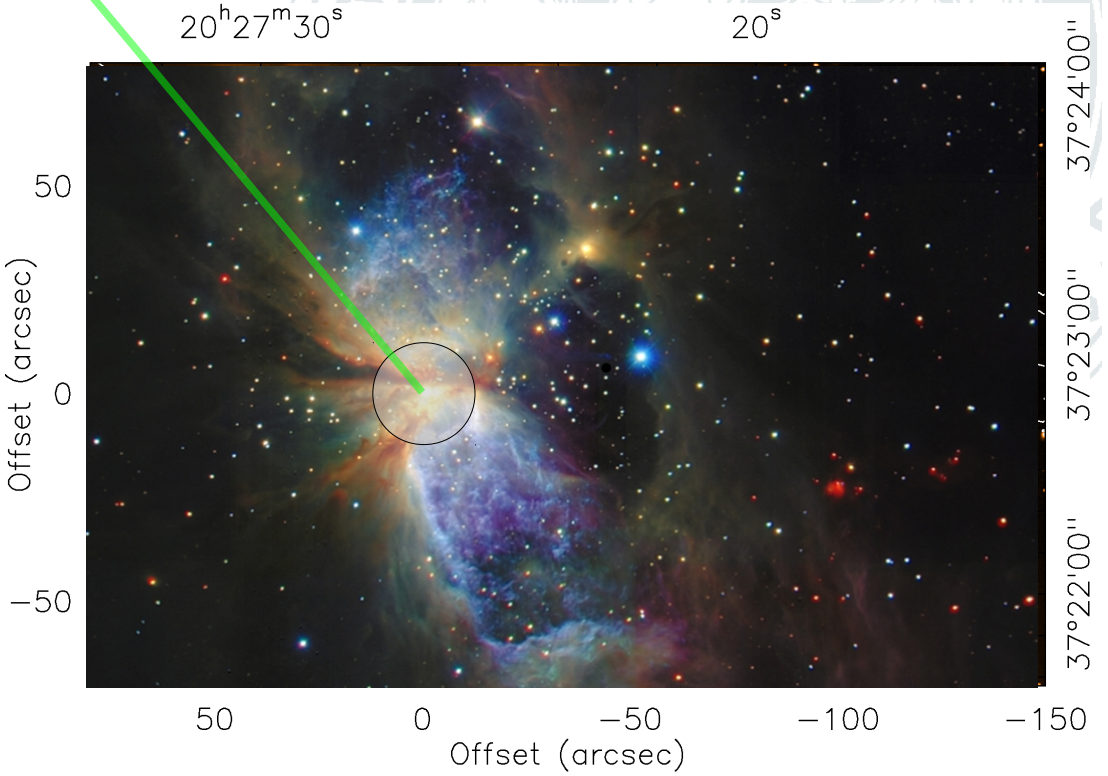
1. -6 to -3 km/s
2. -3 to 1 km/s
3. 0 to 4 km/s

[CII] contours on

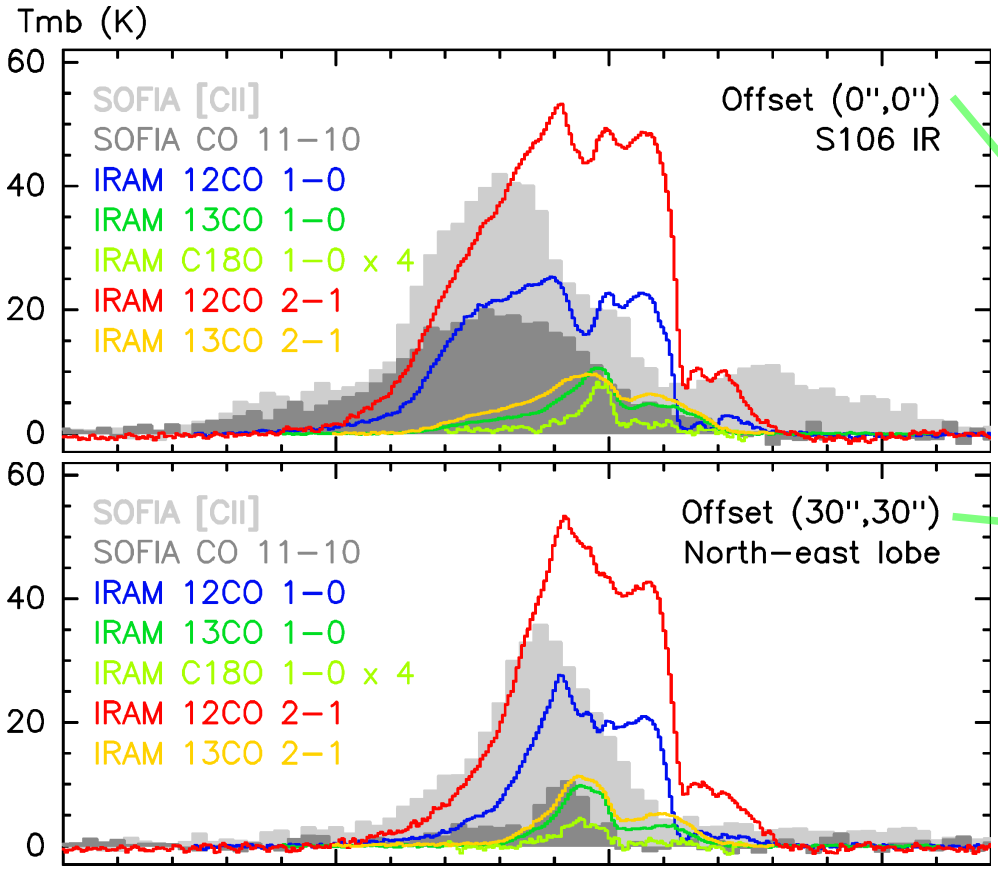
^{13}CO 2-1,
IRAM 30 m

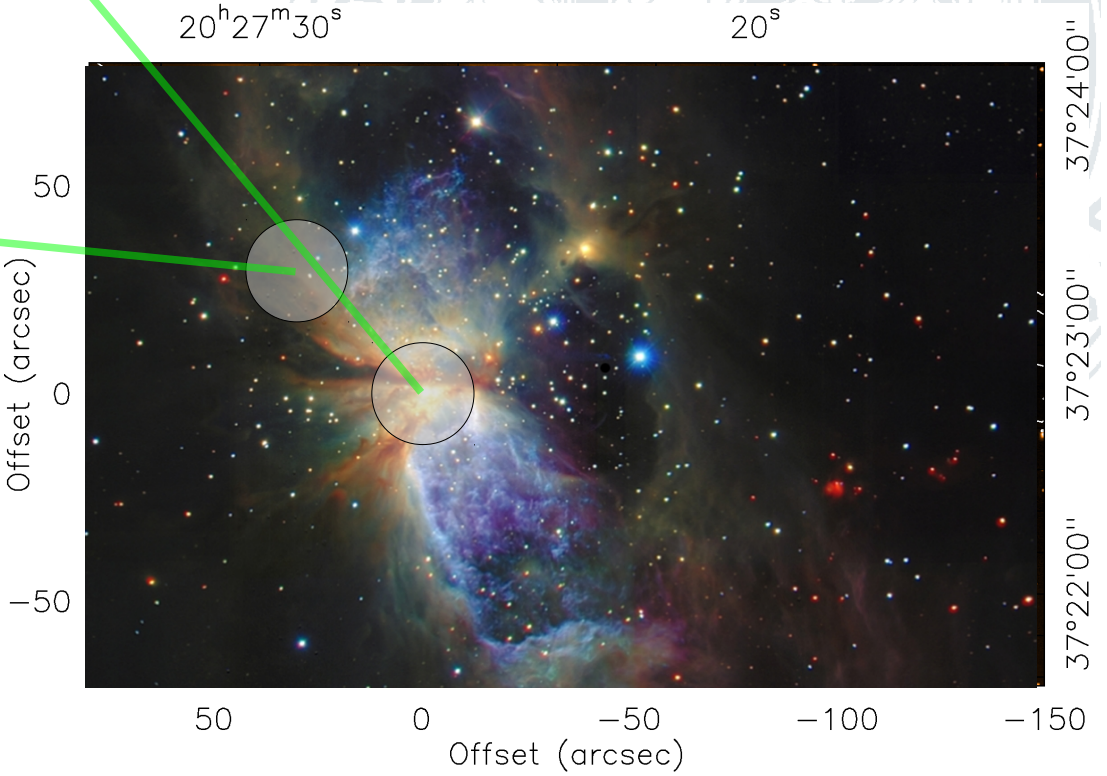
Spectra


Tmb (K)
60
40
20
0
SOFIA [CII]
SOFIA CO 11–10
IRAM 12CO 1–0
IRAM 13CO 1–0
IRAM C18O 1–0 x 4
IRAM 12CO 2–1
IRAM 13CO 2–1
Offset (0",0")
S106 IR

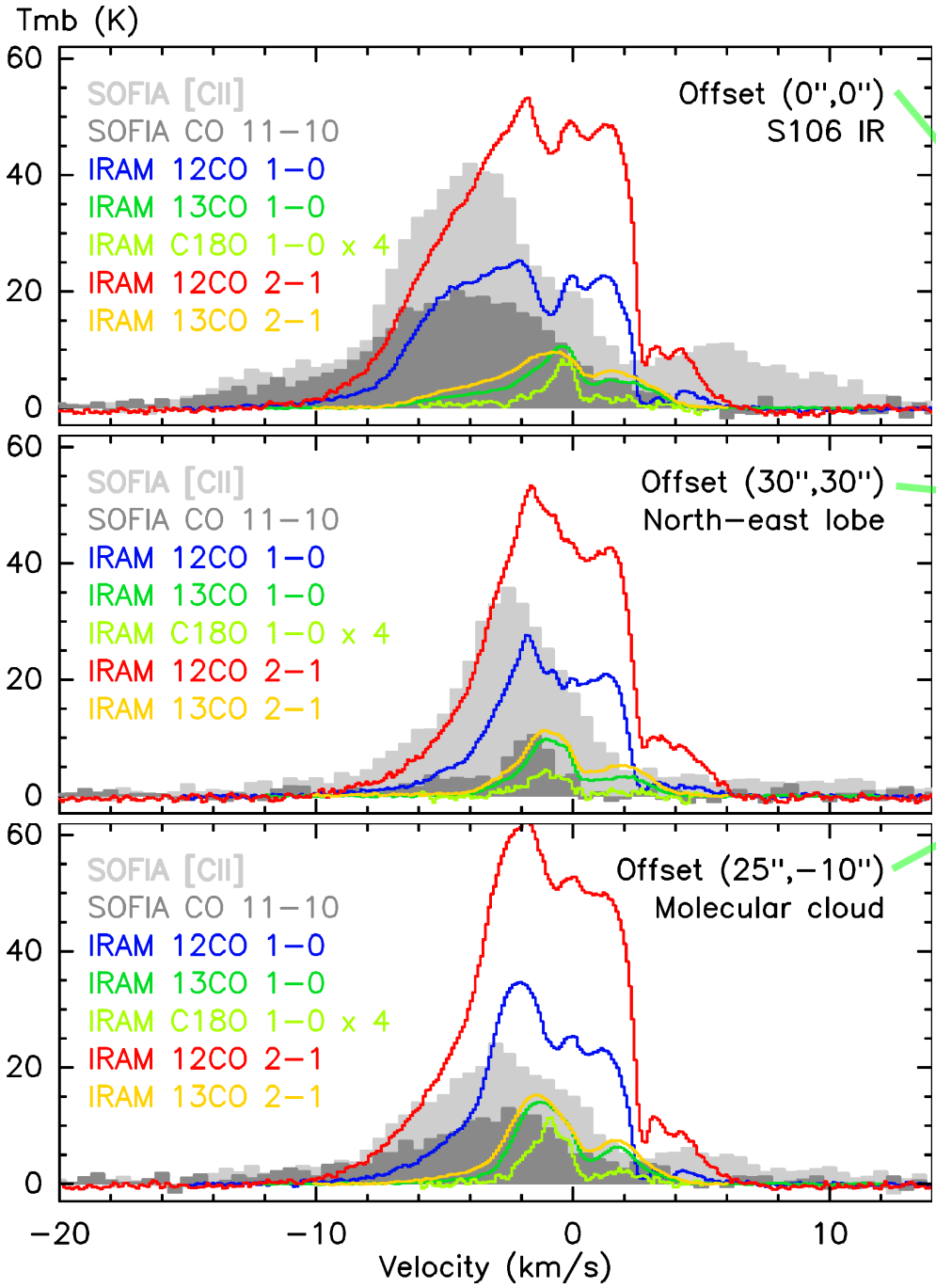

20h27m30s
20s
37°24'00"
37°23'00"
37°22'00"
50
0
−50
Offset (arcsec)
50
0
−50
−100
−150
Offset (arcsec)

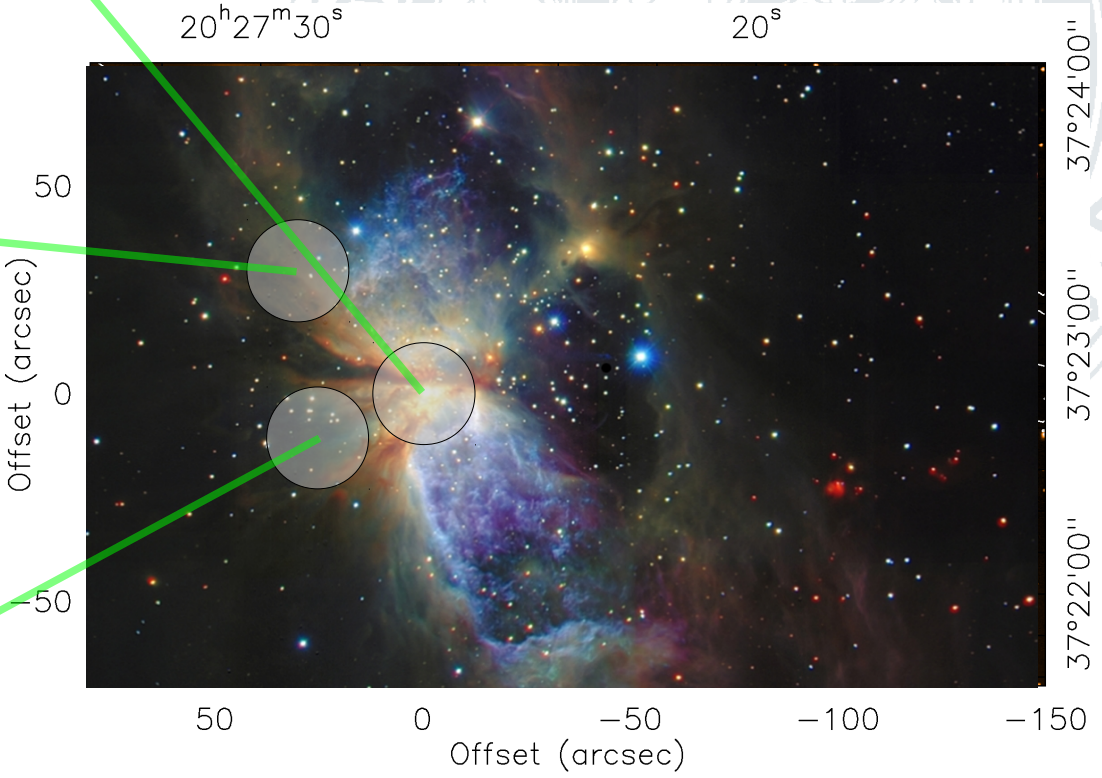
Spectra


Tmb (K)
60
40
20
0
SOFIA [CII]
SOFIA CO 11−10
IRAM 12CO 1−0
IRAM 13CO 1−0
IRAM C18O 1−0 x 4
IRAM 12CO 2−1
IRAM 13CO 2−1
Offset (0",0")
S106 IR
Offset (30",30")
North−east lobe


20h27m30s
20s
37°24'00"
37°23'00"
37°22'00"
50
0
−50
Offset (arcsec)
50
0
−50
−100
−150
Offset (arcsec)

Spectra


Tmb (K)
SOFIA [CII]
SOFIA CO 11−10
IRAM 12CO 1−0
IRAM 13CO 1−0
IRAM C18O 1−0 x 4
IRAM 12CO 2−1
IRAM 13CO 2−1
Offset (0",0")
S106 IR
Offset (30",30")
North−east lobe
Offset (25",−10")
Molecular cloud
Velocity (km/s)


20h27m30s
20s
37°24'00"
37°23'00"
37°22'00"
Offset (arcsec)
Offset (arcsec)

Summary

- Morphology and kinematics
  - Complexity only visible in channel maps, very important to gain better understanding of the nebula
  - [CII] bright, broad lines, tracing high velocity gas at the interfaces of HII region and molecular cloud
  - No counterpart in other line tracers
  - CO 11-10 more confined to the warmer, higher density gas
  - To disentangle contributions from HII region, shocks, and PDR requires modelling
- Dark lane
  - **Not** just the shadow of a small disk around the star, traces the warm, high column surface of the molecular cloud