ALMA Observations of the Large Magellanic Cloud: Molecular Filament Collisions Causing Massive Star Formation in N159 West

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Paper: High-mass star formation triggered by collision between CO filaments in N159 West in the Large Magellanic Cloud (submitted)

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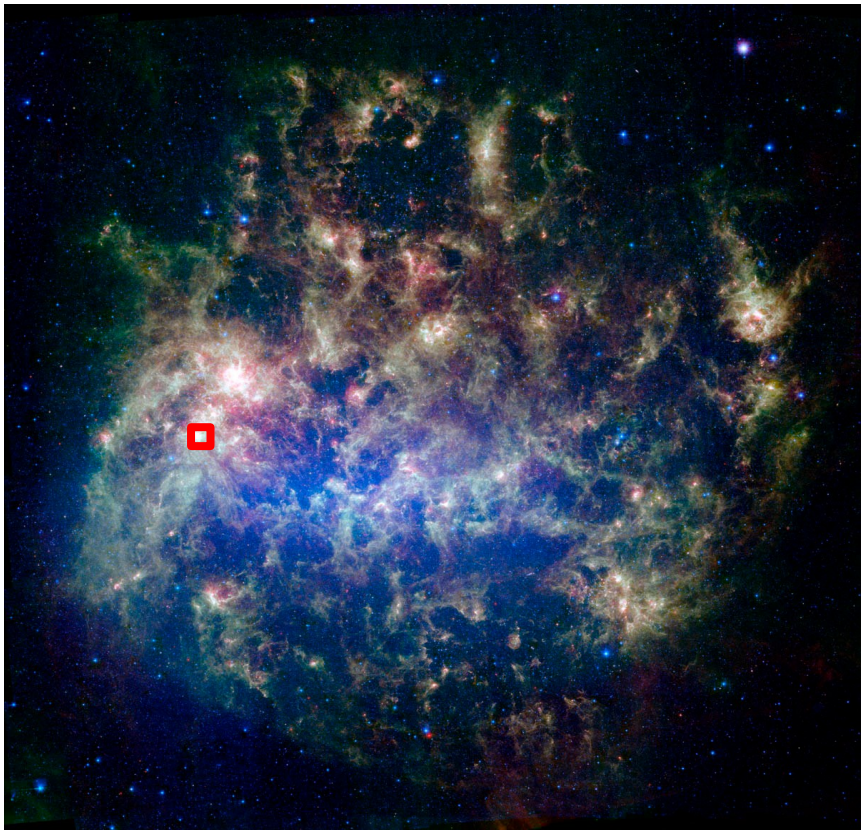
Why Study the Large Magellanic Cloud?

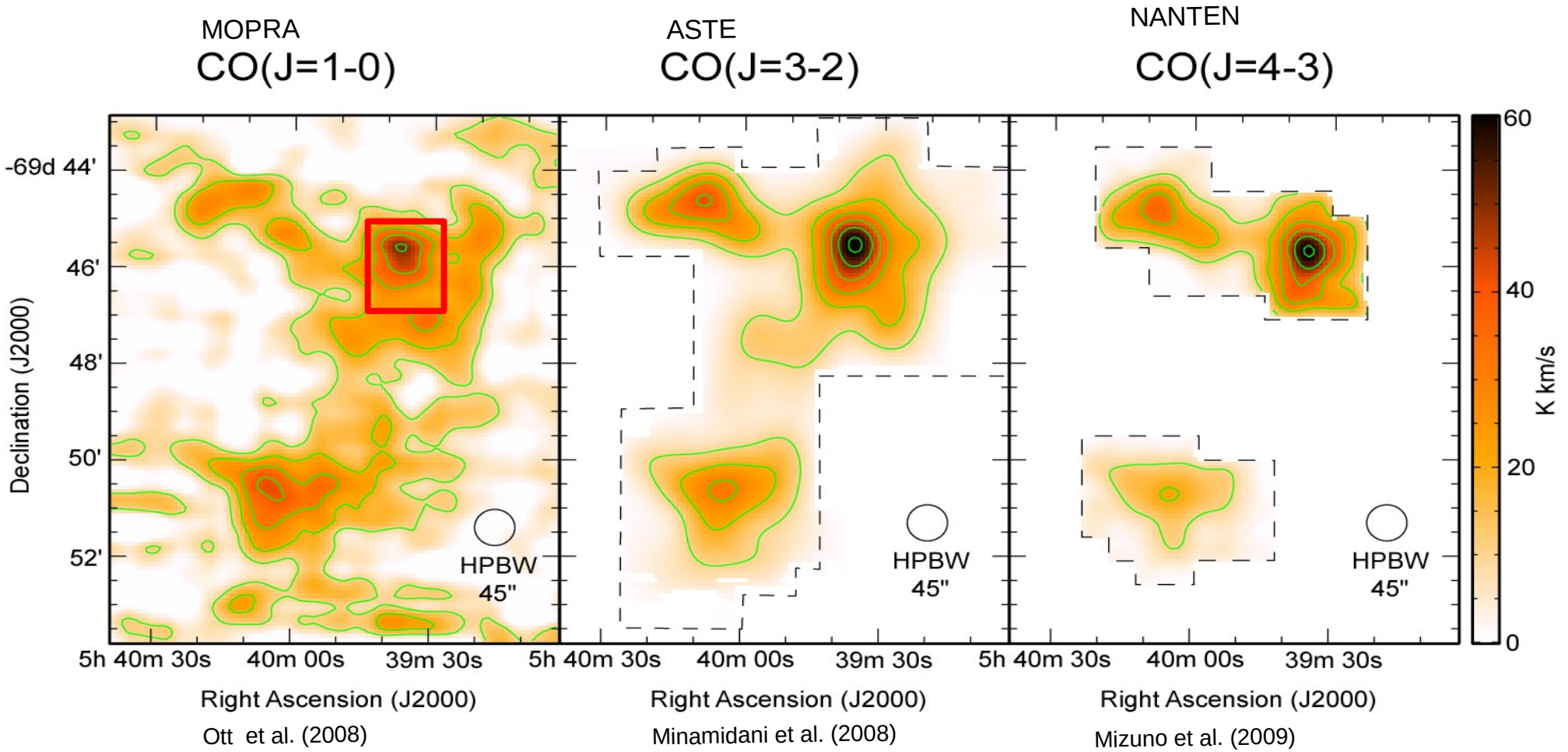
- Distance ~ 50 kpc (one of the nearest)
- Face-on view
- Active Star Formation
  - Massive star formation
  - SAGE survey (Meixner et al. 2006) used to find YSOs
- Different environment than Milky Way
  - Low dust-to-gas ratio (1/3 of MW)
  - Low metallicity (0.5 solar)
  - SFR of 0.1 solar mass/year
- Unbiased Survey



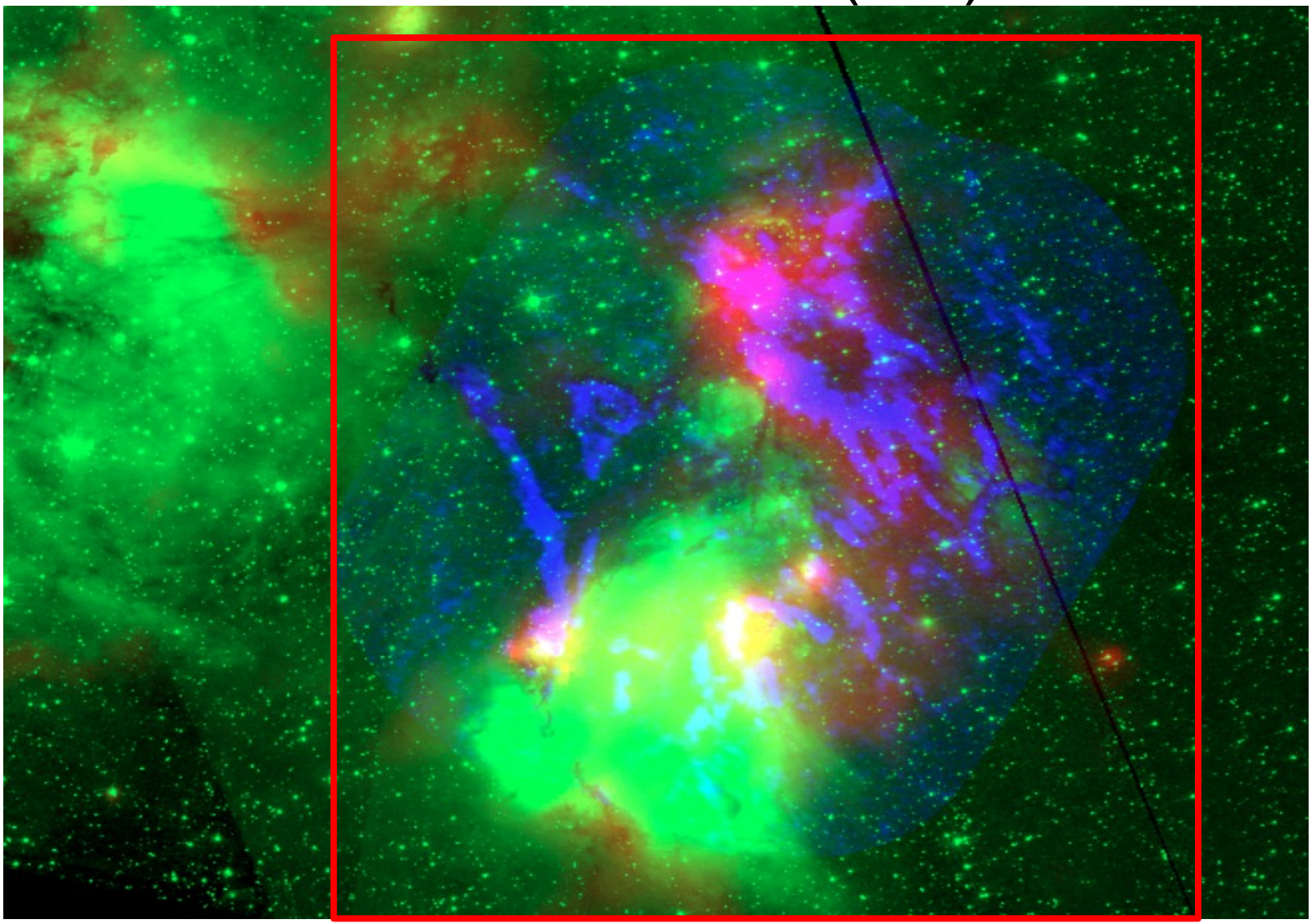
Meixner et al. (2006)
R: MIPS 24, G: IRAC 8.0, B: IRAC 3.6

Why study the N159 GMC?

- One of the largest
  - Mass: $10^5 M_{sun}$
  - Size: $220\ pc^2$
  - Strongest CO peak
  - Actively forming stars



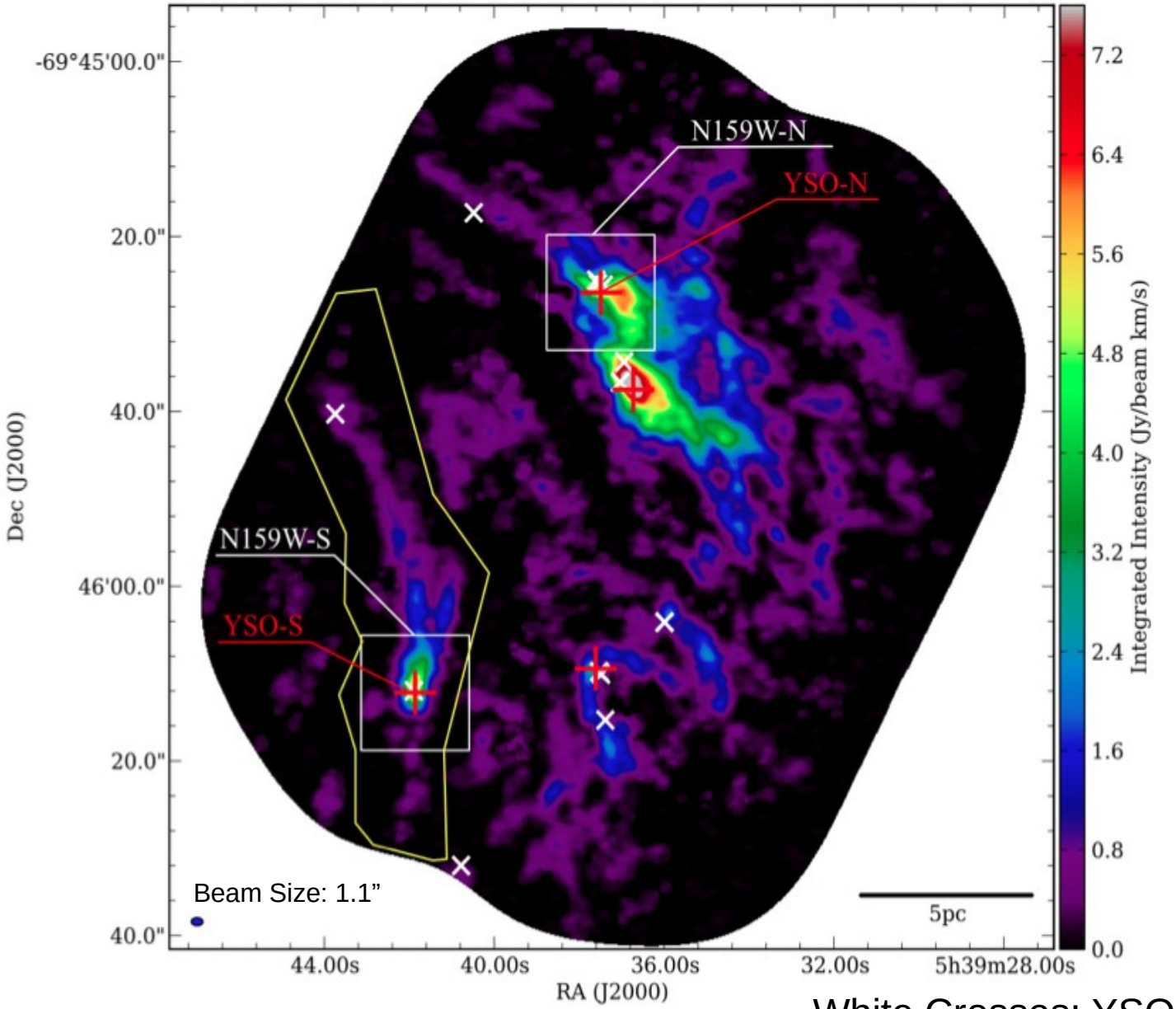
HST versus. ALMA 13 CO (2-1): Filaments!



R: Spitzer 8 micron, G: HST F555W, B: 13CO(2-1)

HST PI: R. Indebetouw
ALMA PI: Y. Fukui

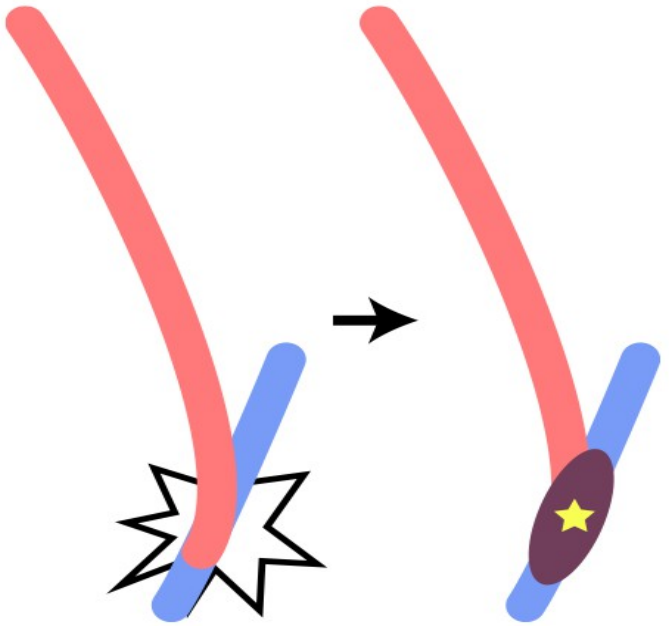
Filaments Revealed in ALMA 12 m Array 13CO (2-1)



White Crosses: YSOs (Chen et al. 2010)
Red Crosses: 1.3mm continuum peak

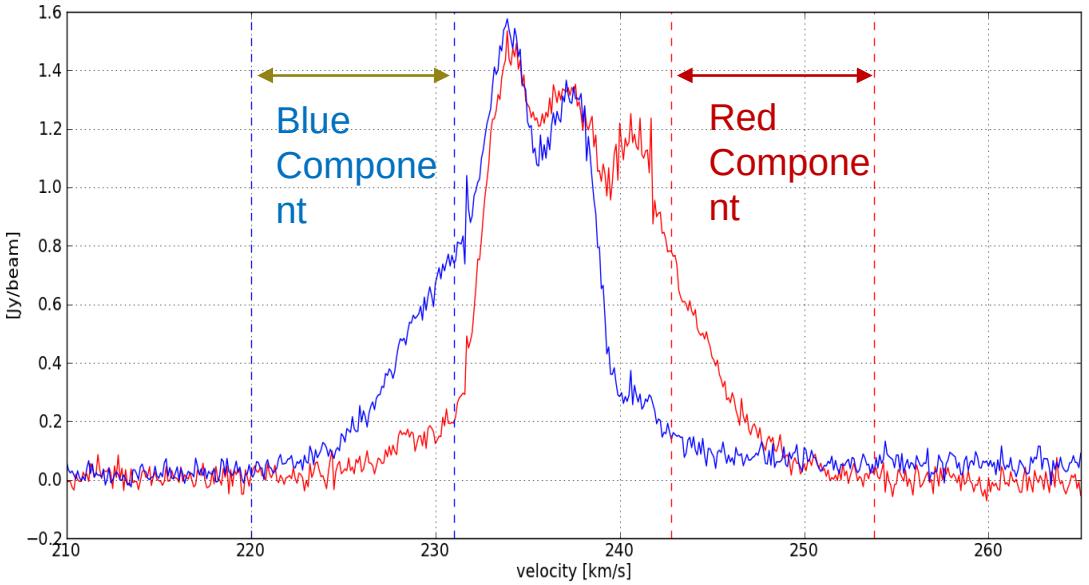
Formation of Massive Cores

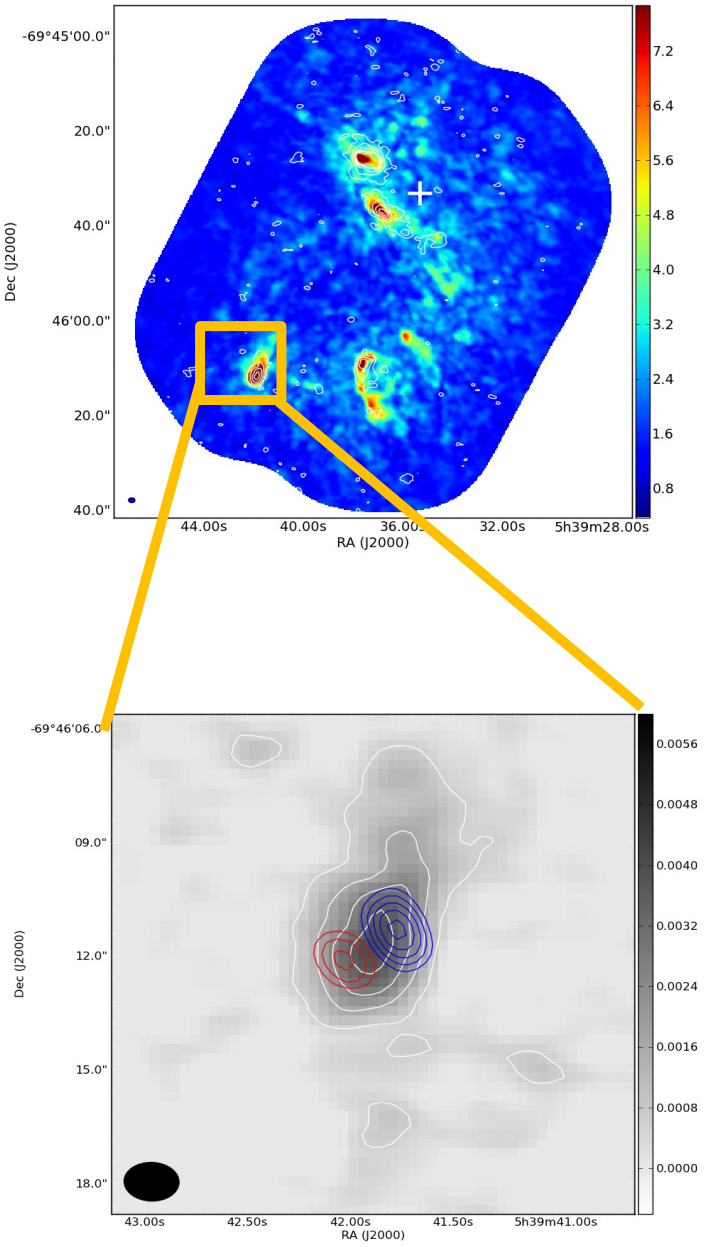
- Filamentary collisions lead to massive star formation



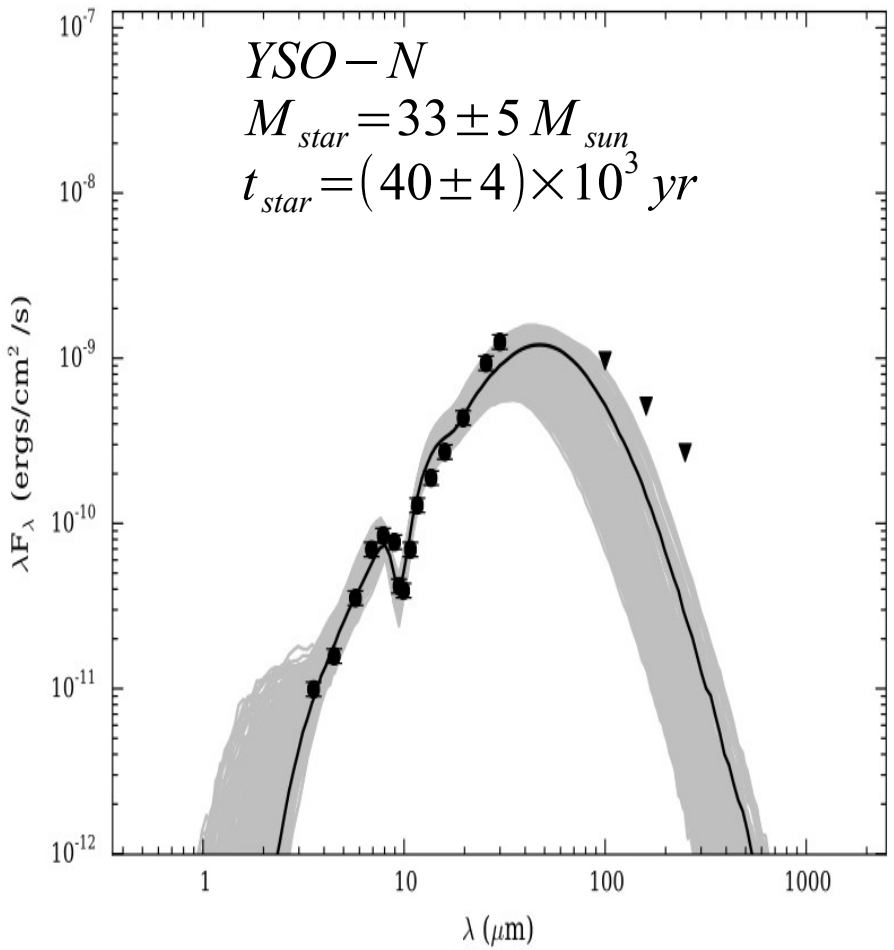
First Extragalactic Outflows Detected

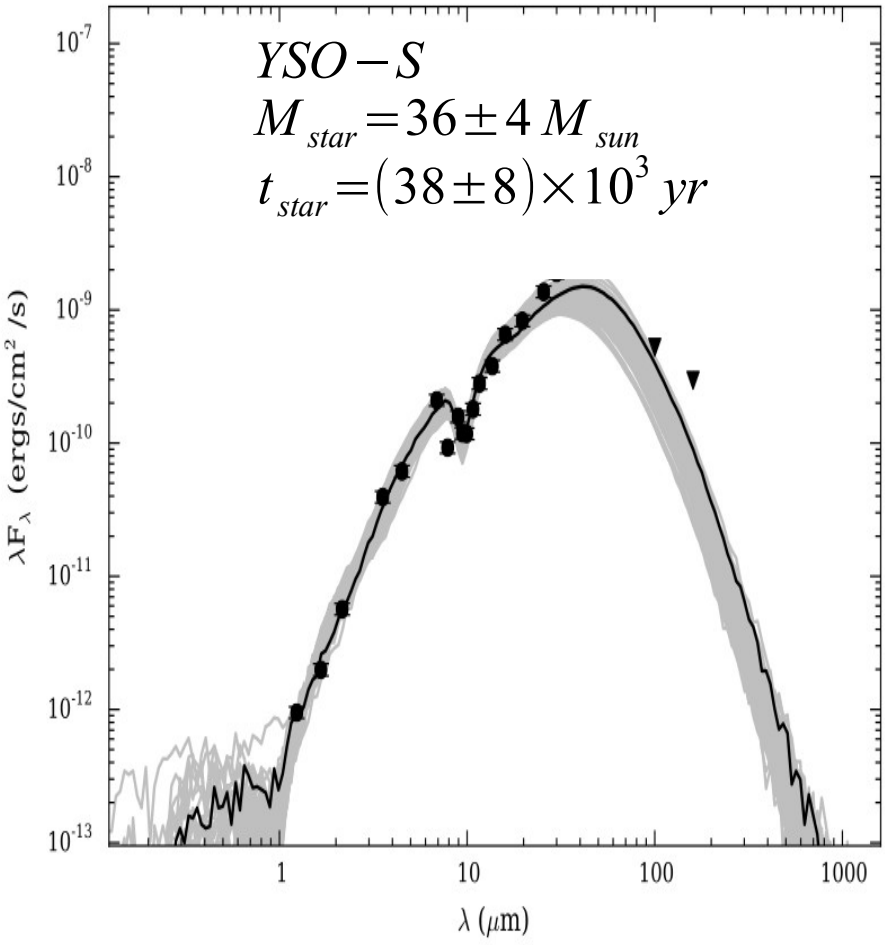
- Colliding Filaments
  - Velocity difference: 2-5 km/s
- Massive YSO in the center of collision





Fitting the SED to Derive Stellar Parameters of Stage 0/I YSOs



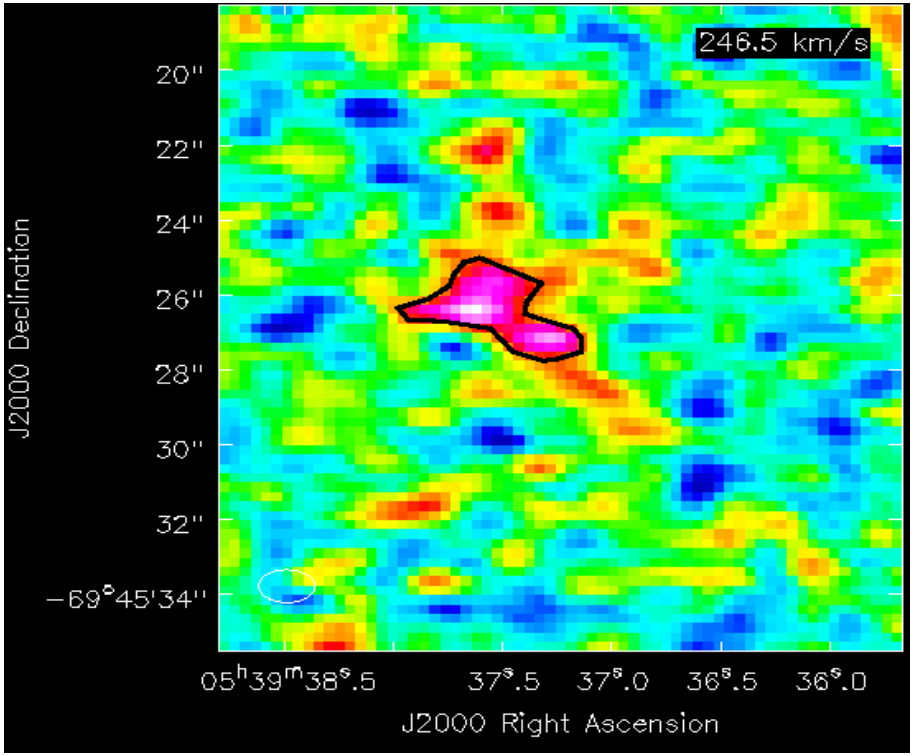


Photometry From : IRSF JHK, Spitzer IRAC, Spitzer MIPS, Herschel PACS, and Herschel SPIRE

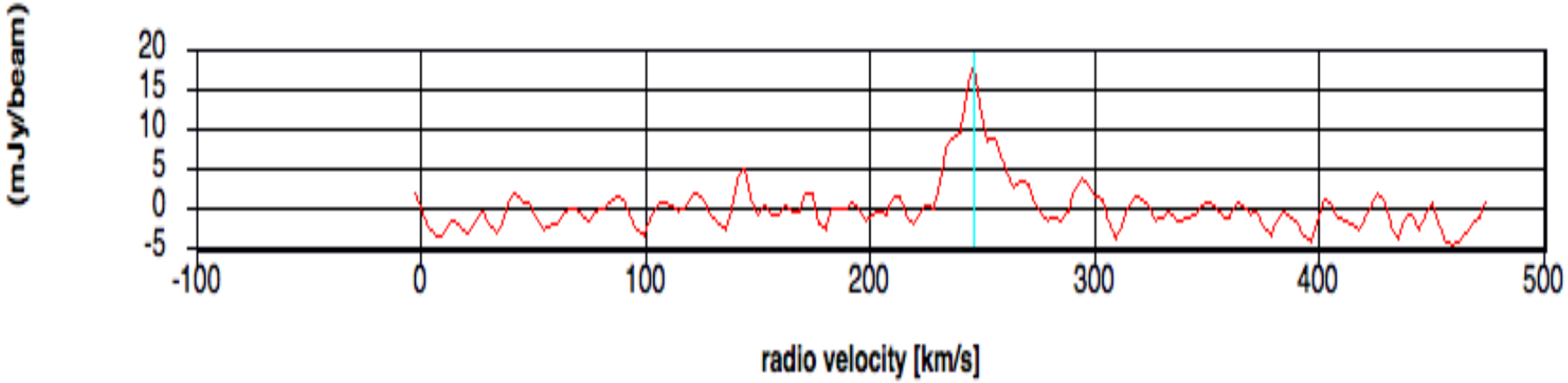
Other photometric points extracted from Spitzer IRS spectrum

SED fitter by Robitaille et al. (2006, 2007)

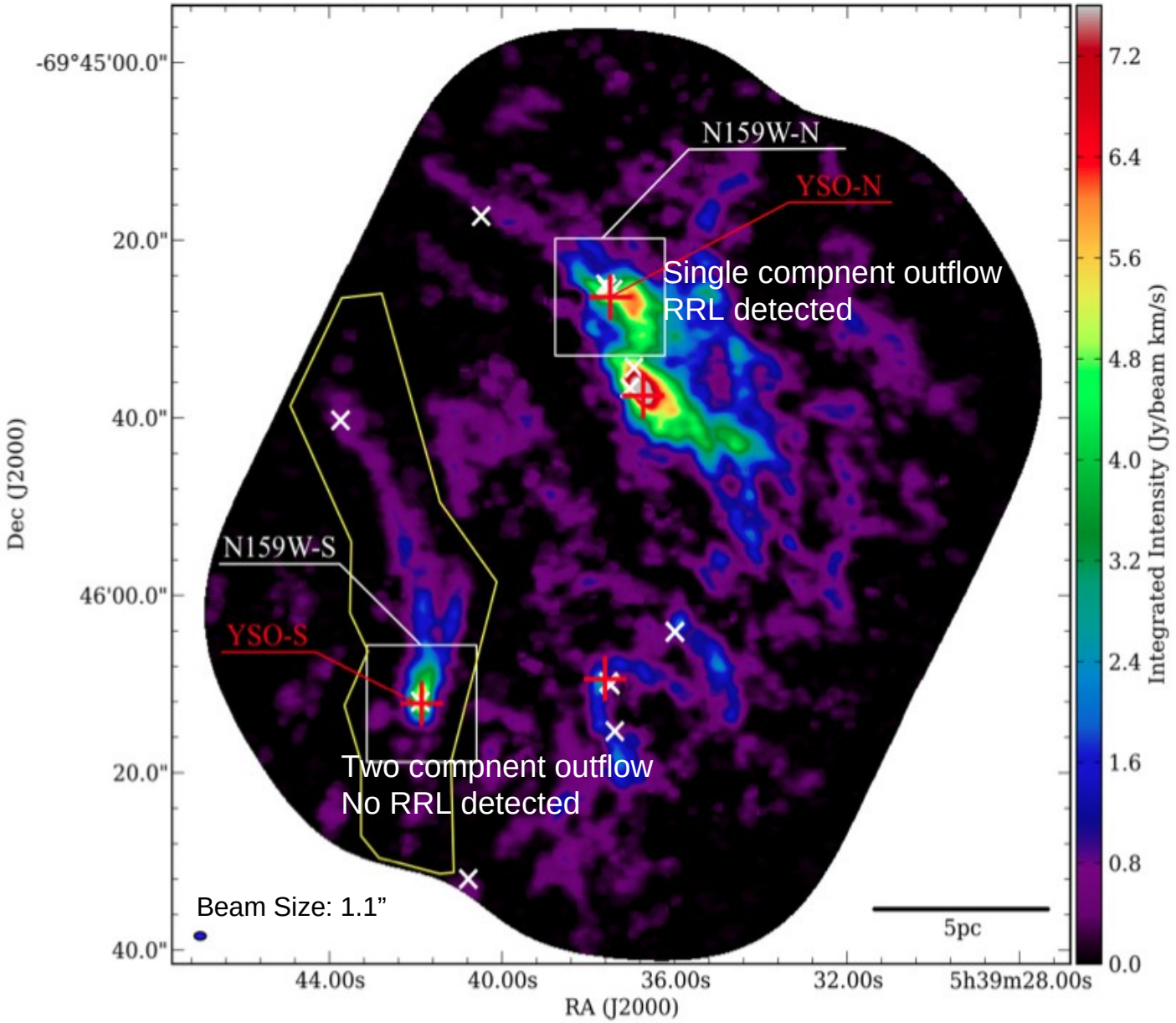
YSO-N is More Evolved



- Ne= $2.5\times10^{3}\,cm^{-3}$
- M(ionized)= $350\,M_{sun}$
- EM= $6.3\times10^{5}\,pc\,cm^{-6}$
- U= $170\times10^{3}\,pc\,cm^{-2}$
- Nc= $1.5\times10^{50}\,s^{-1}$
- Spectral Type= O3



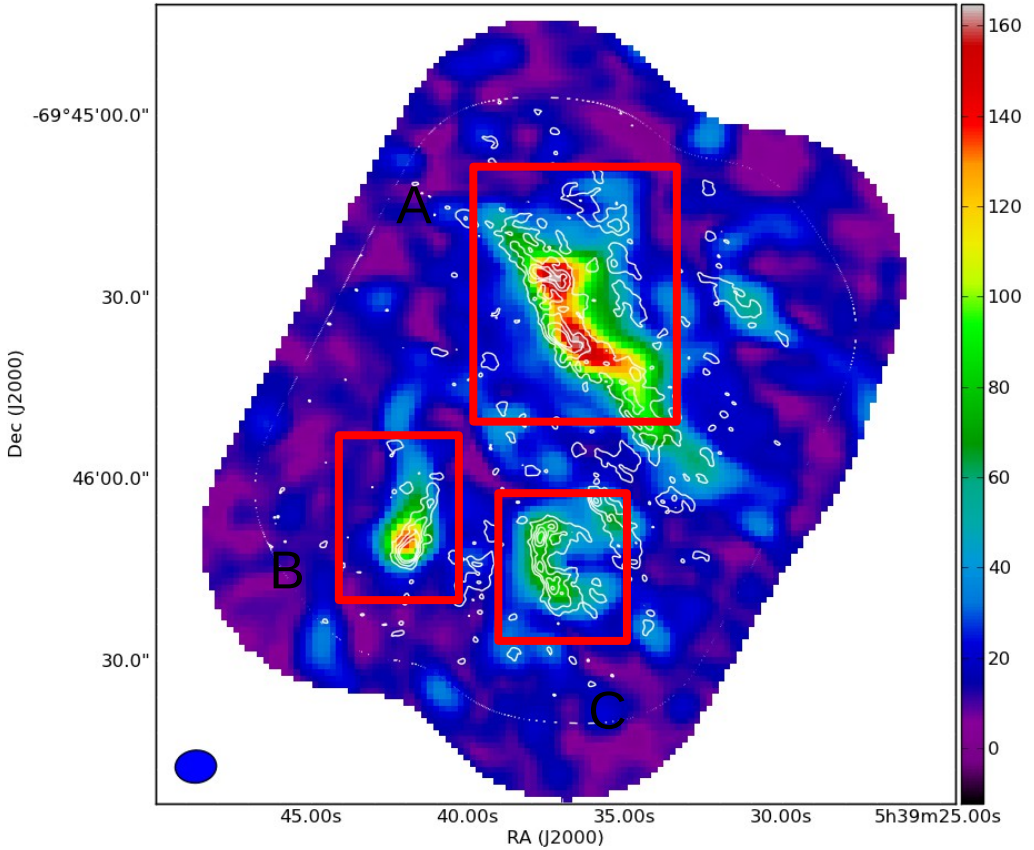
Evidence for Evolution of Environment



Conclusions

- We detect filaments
- Colliding filaments create massive stars
- We detect outflows associated with massive star formation for the first time outside our own Galaxy
- Difference between YSO-N and YSO-S shows evidence for evolution of environment
- Look for Fukui et al paper (coming soon)
- These are early results, more exciting things to come!

ALMA 12CO(2-1)



Color : 7m
Contour : 12m

Flux density (Jy km/s)

A	196	785
B	48.4	151
C	65.8	168

ALMA 12m Array Image of 13CO(1-0)

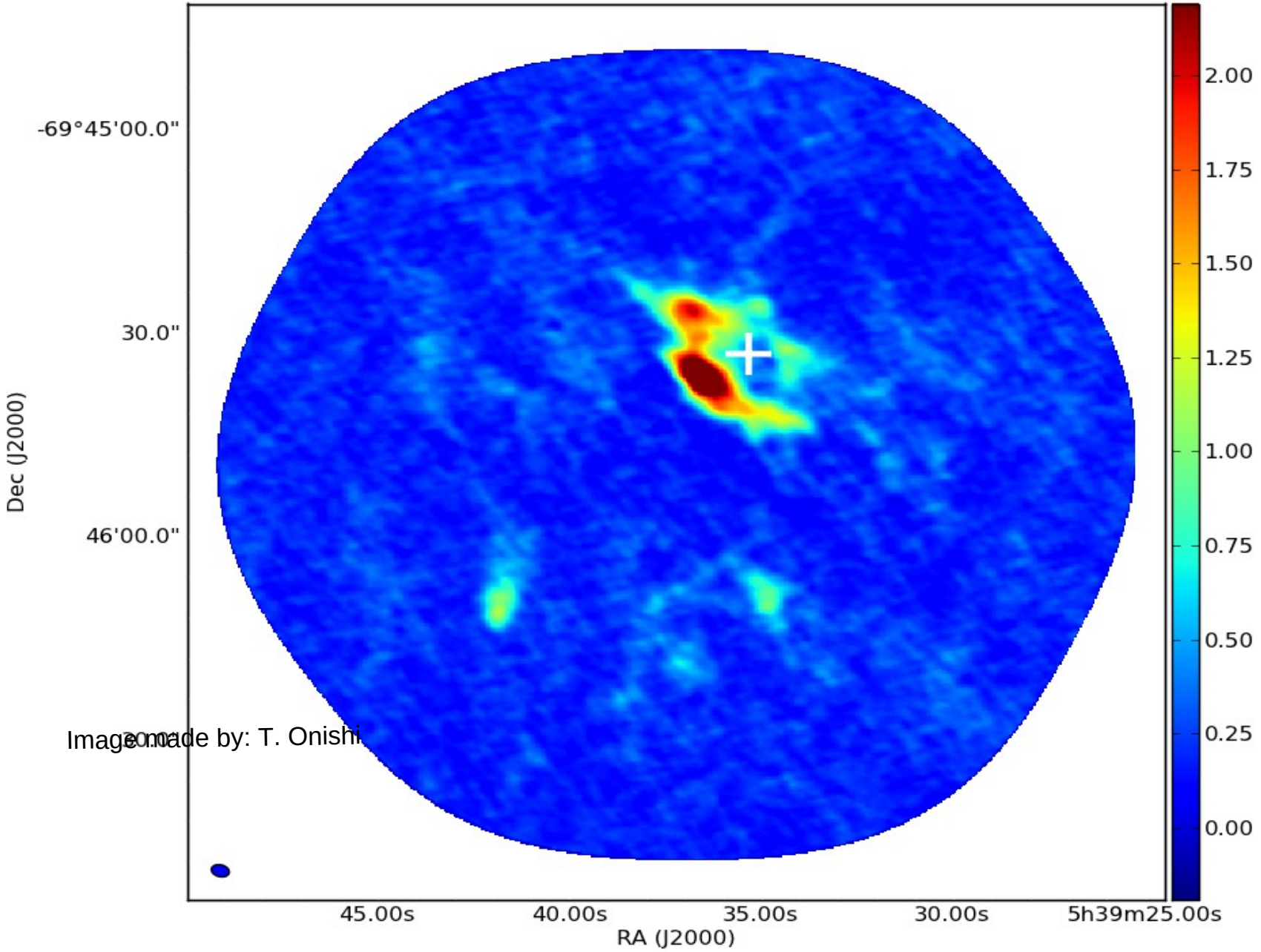


Image made by: T. Onishi