Magnetic fields at the onset of high-mass star formation

Henrik Beuther, MPIA
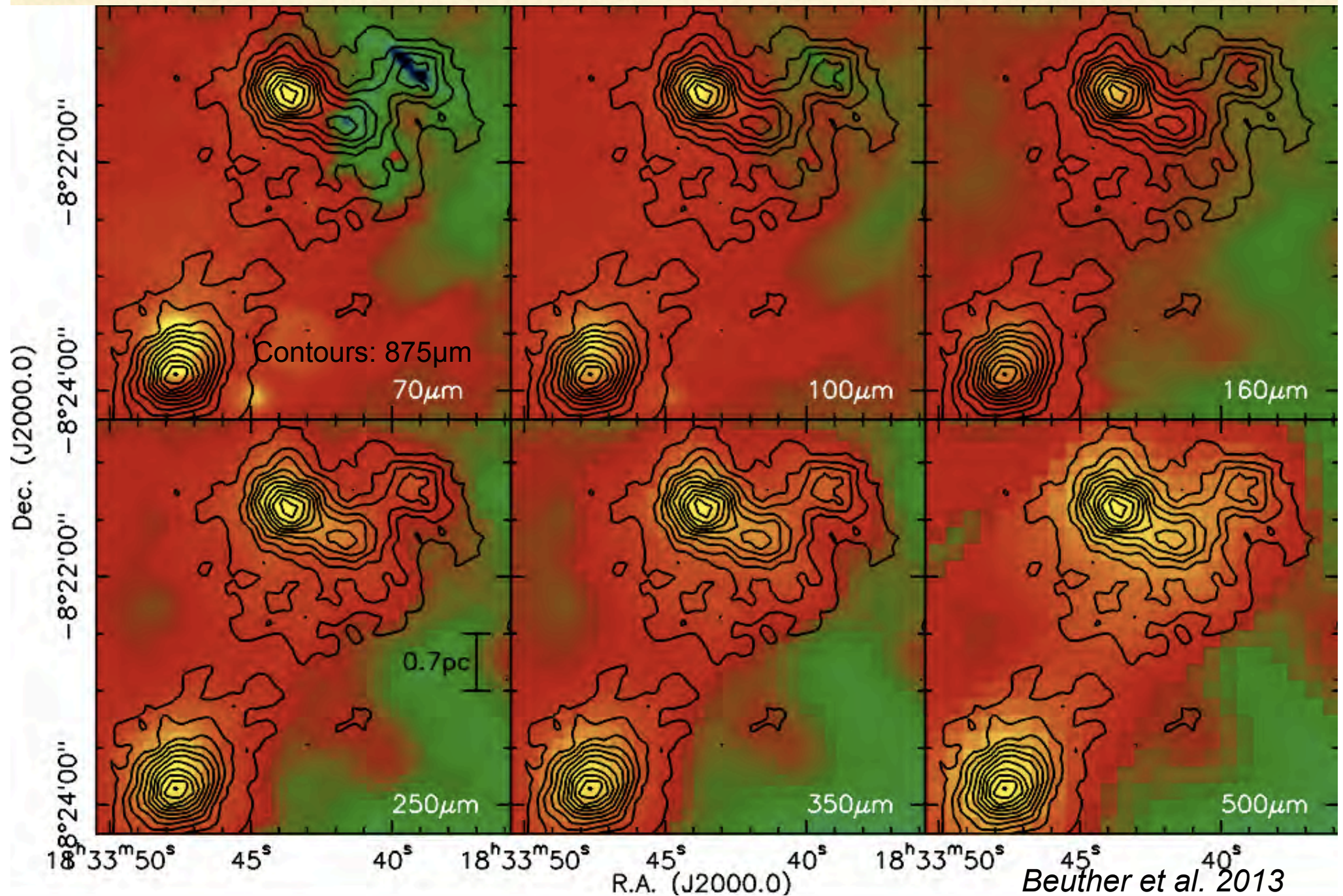
Co-Is: J. Soler, W. Vlemmings, H. Linz, Th. Henning, R. Kuiper, R. Rao, R. Smith, T. Sakai, K. Johnston, A. Walsh, and S. Feng

EPOS 2018

A very massive starless clump in IRDC18310-4
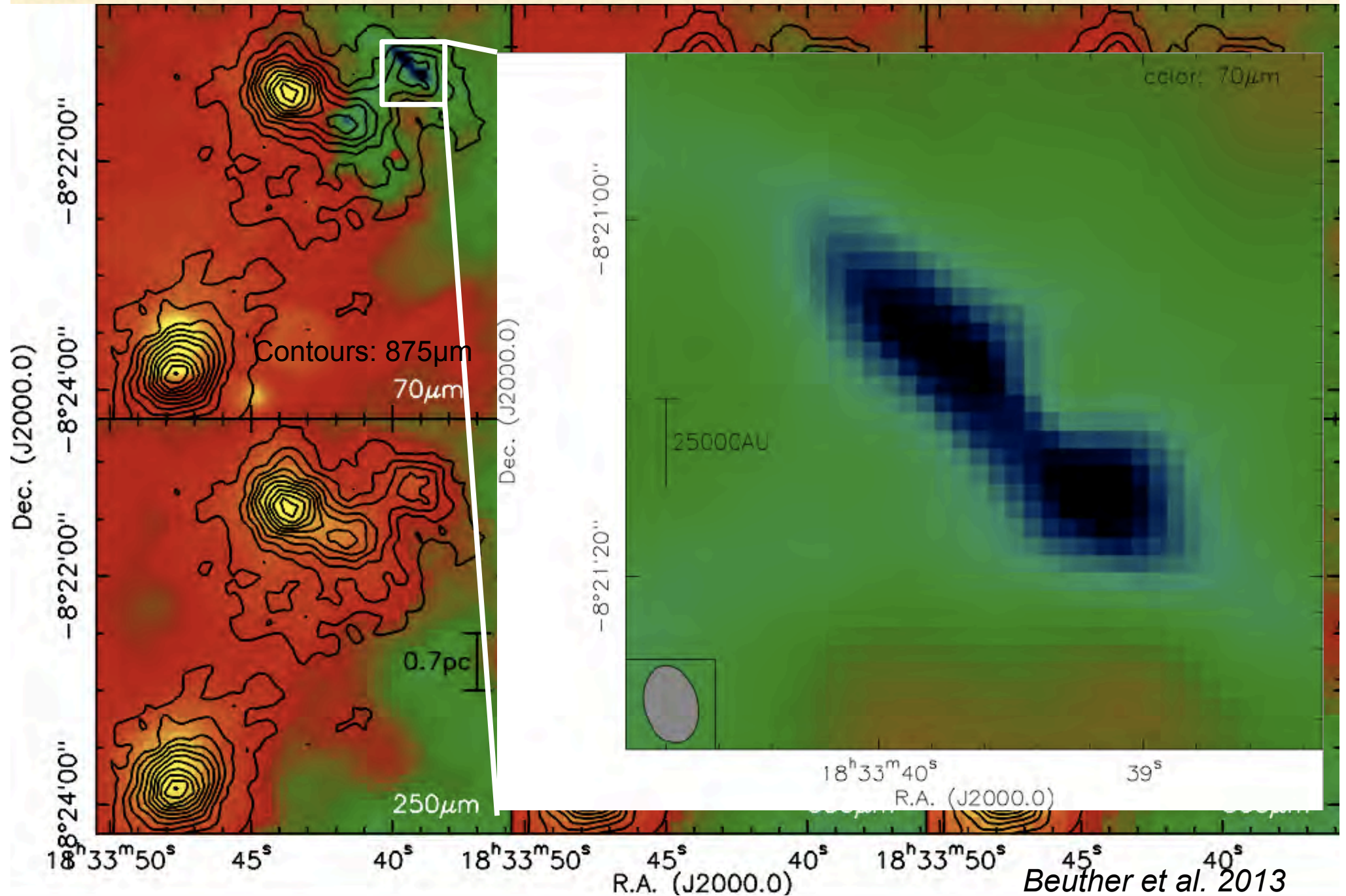
Beuther et al. 2013

A very massive starless clump in IRDC18310-4

Contours: 875μm

70μm

250μm

0.7pc

color: 70μm

25000AU

Dec. (J2000.0)

R.A. (J2000.0)

Beuther et al. 2013

A very massive starless clump in IRDC18310-4

Beuther et al. 2013

Hirarchical fragmentation

Beuther et al. 2015

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A very massive starless clump in IRDC18310-4

Contours: 875µm

70µm

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Beuther et al. 2013

A very massive starless clump in IRDC18310-4

Contours: 875μm
70μm
0.7pc
250μm

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white: 3mm
red: N_2H^+

25000AU

Beuther et al. 2013

A very massive starless clump in IRDC18310-4

color: 70μm
white: 3mm
red: N₂H⁺

Contours: 875μm

70μm

25000AU

Δv₁−1.2km/s   v₁(peak)−86.4km/s
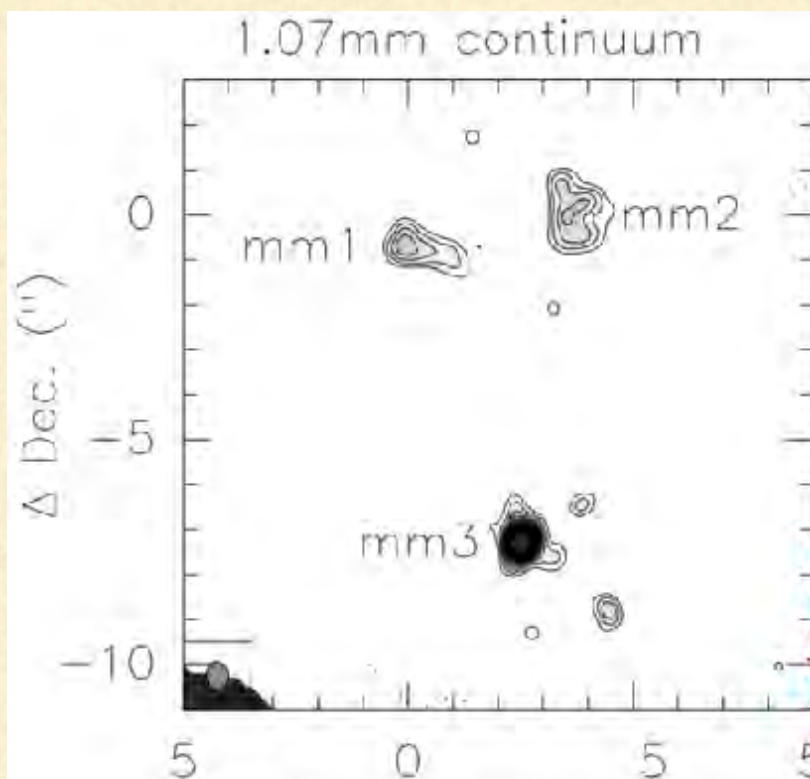Δv₂−1.7km/s   v₂(peak)−89.1km/s
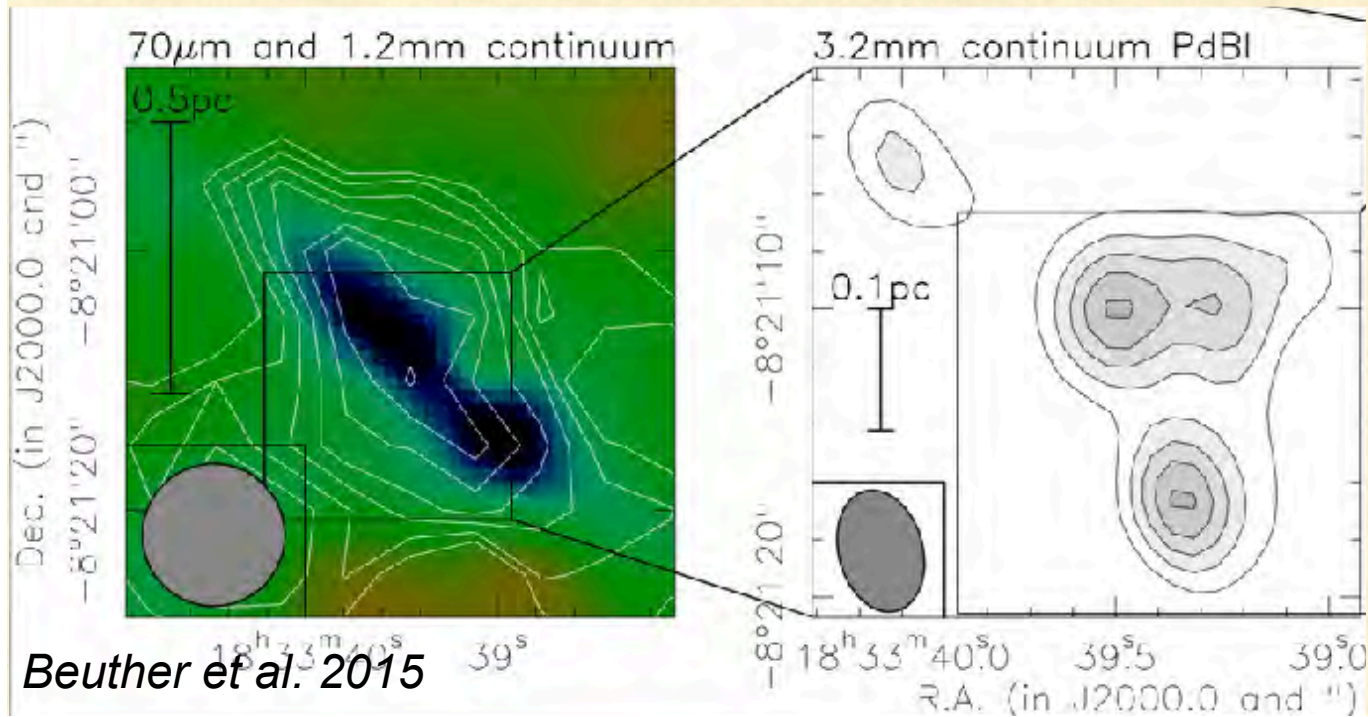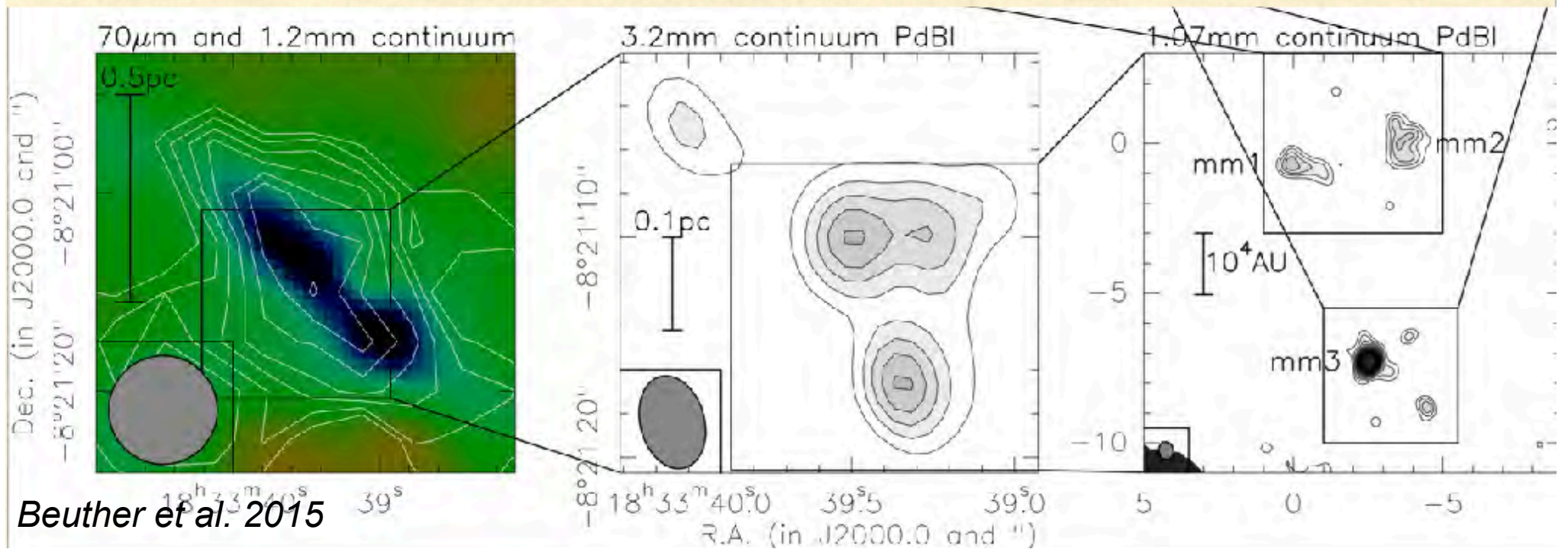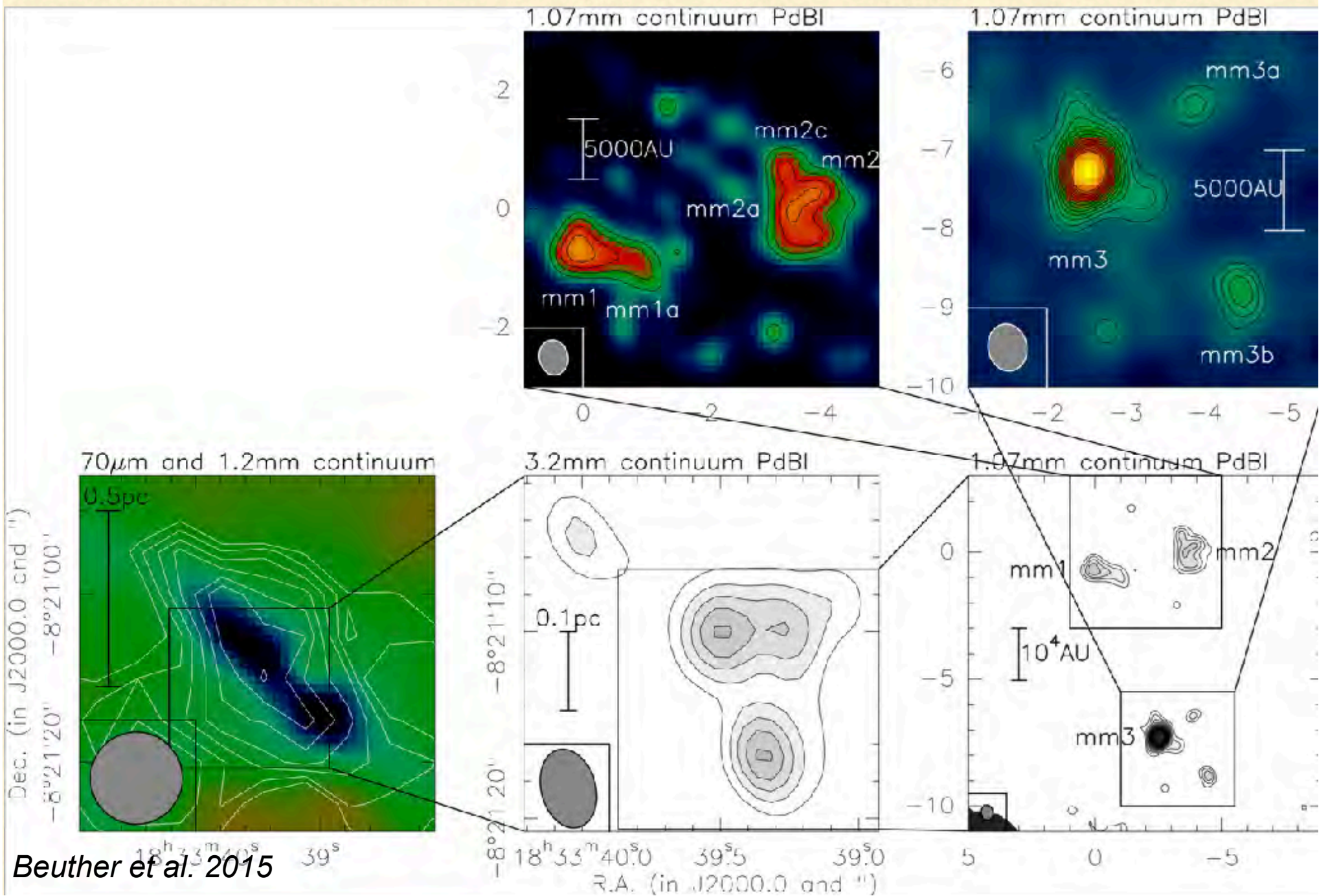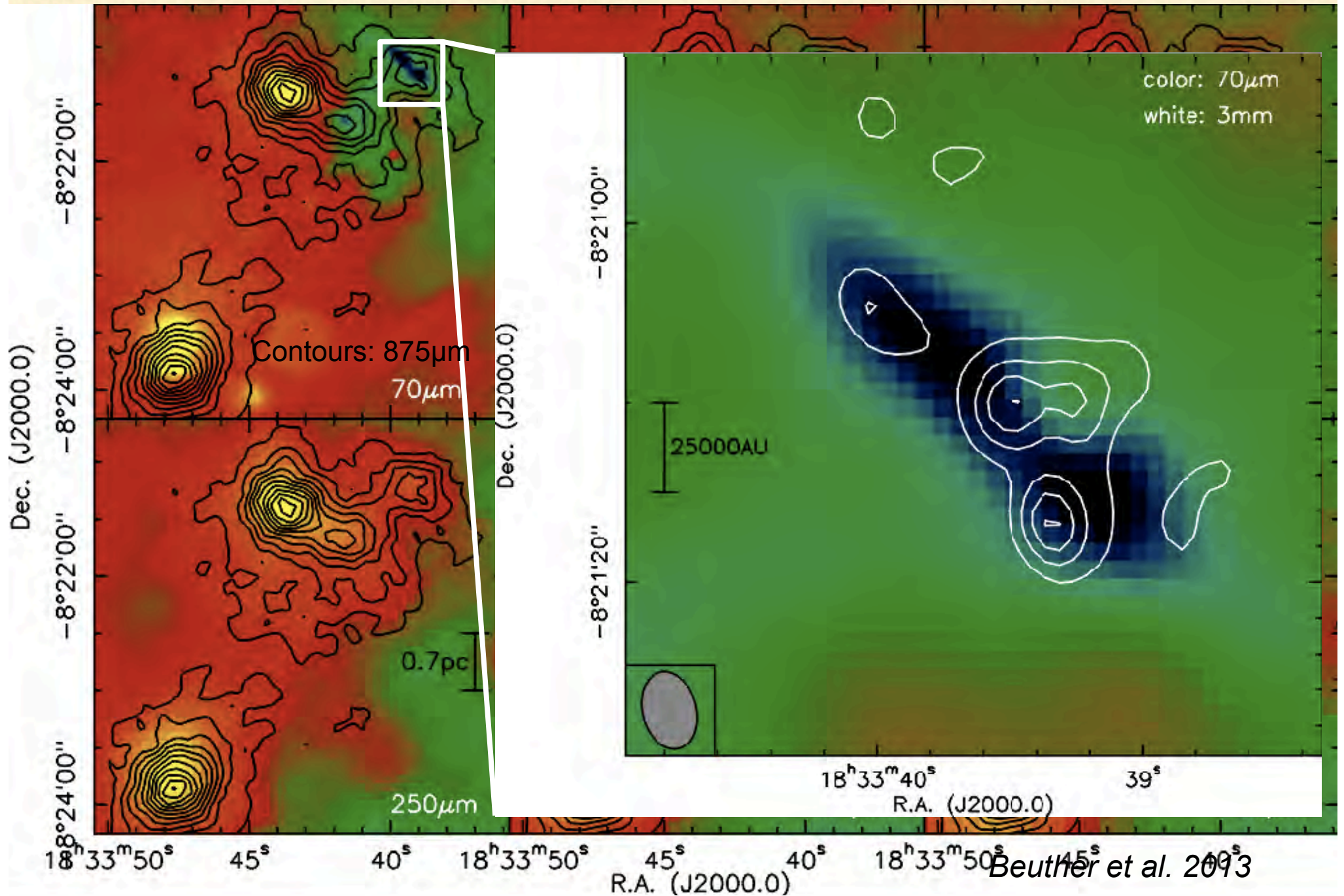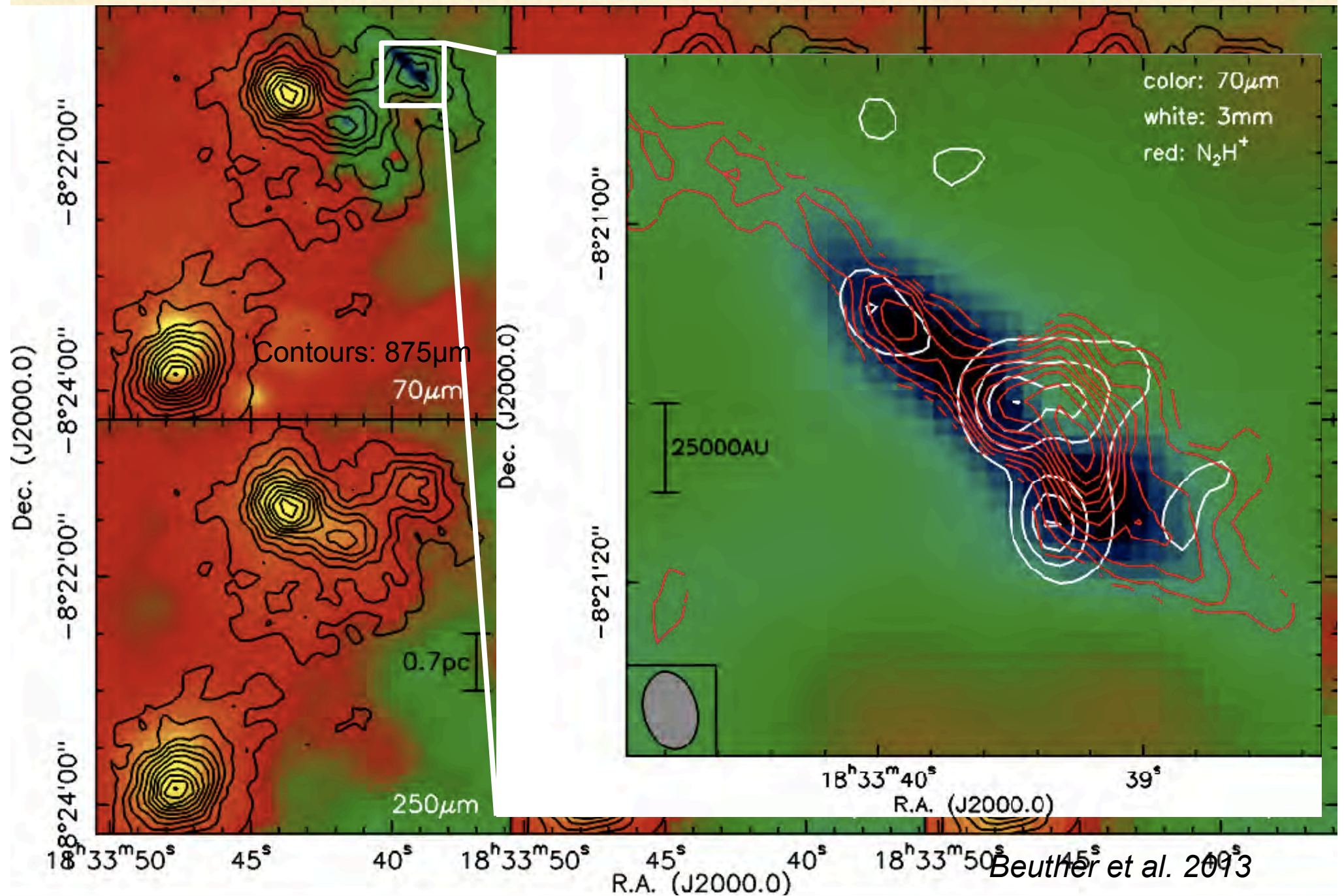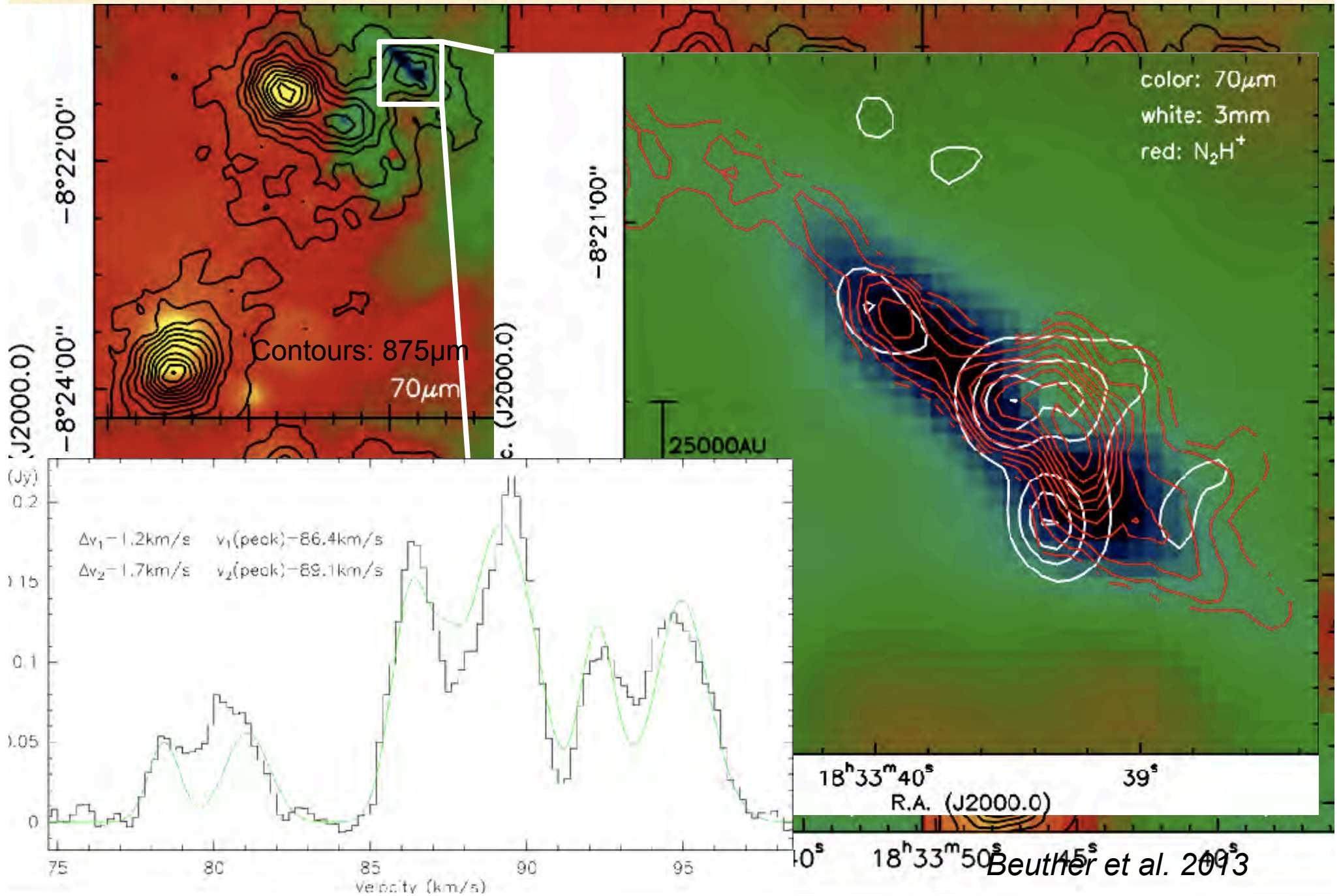
Beuther et al. 2013
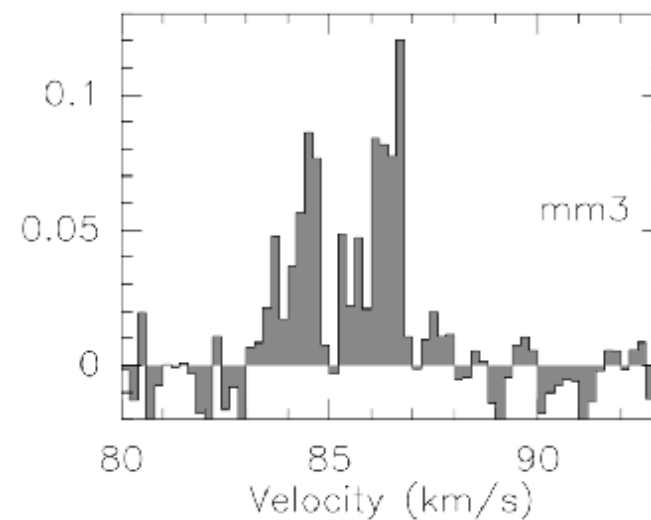
Multiple velocity components
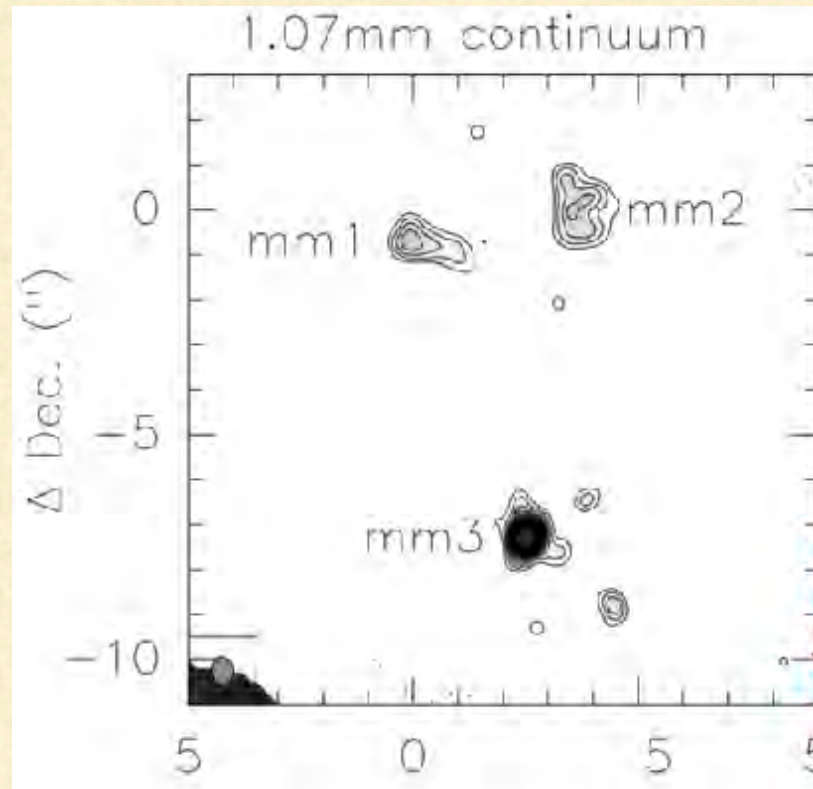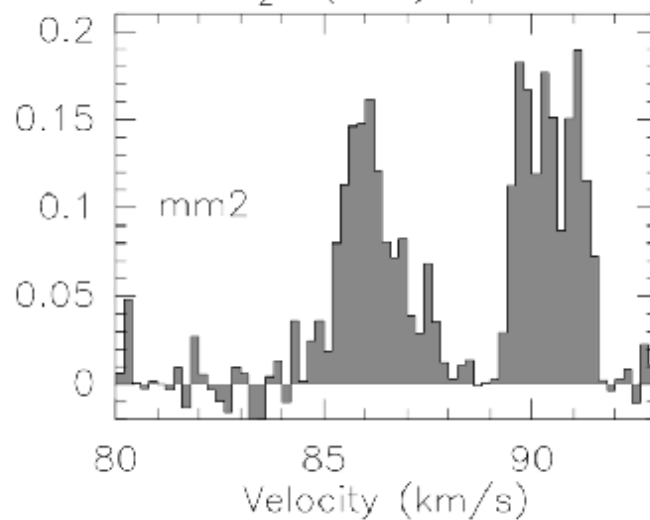

Beuther et al. 2015

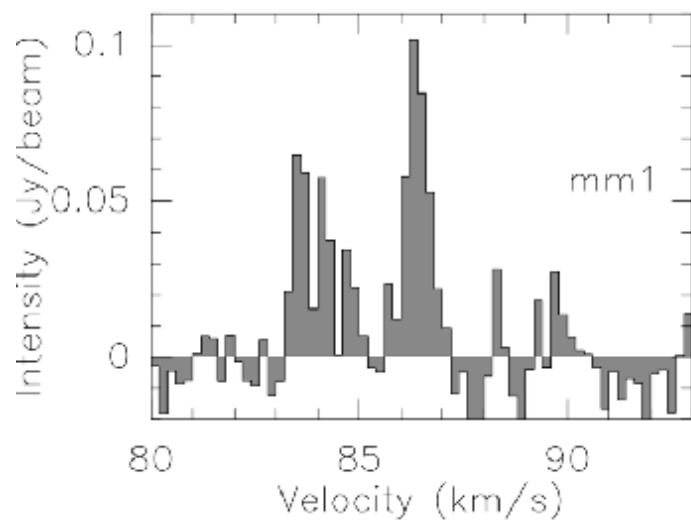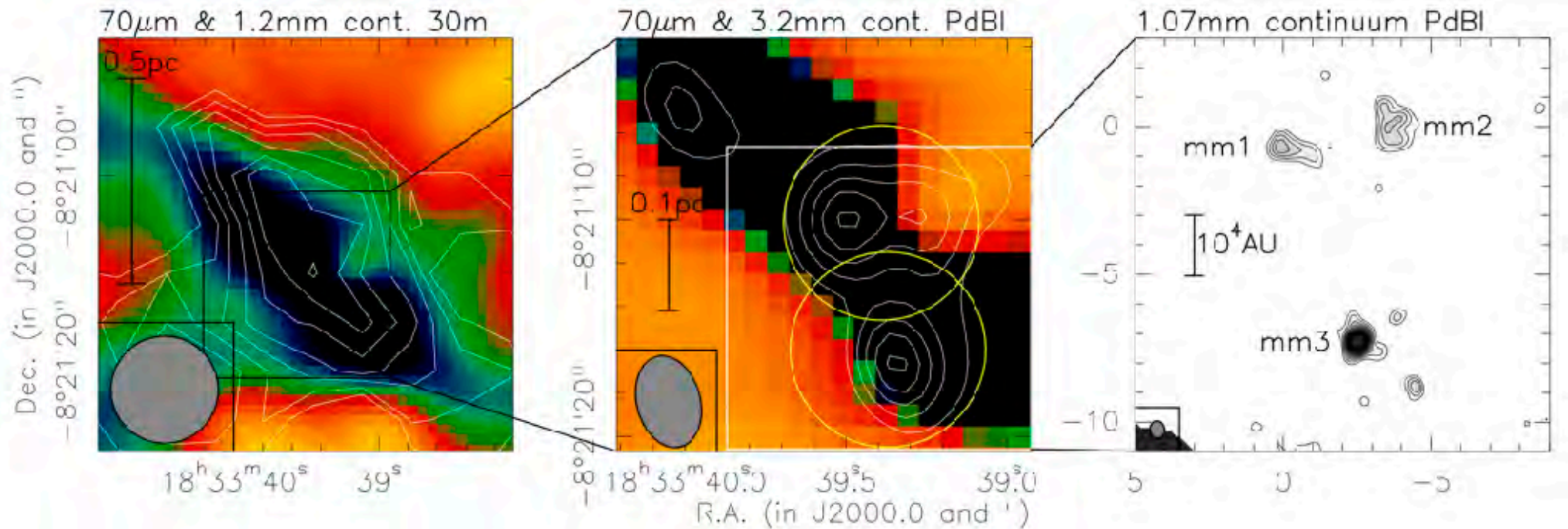# Multiple velocity components
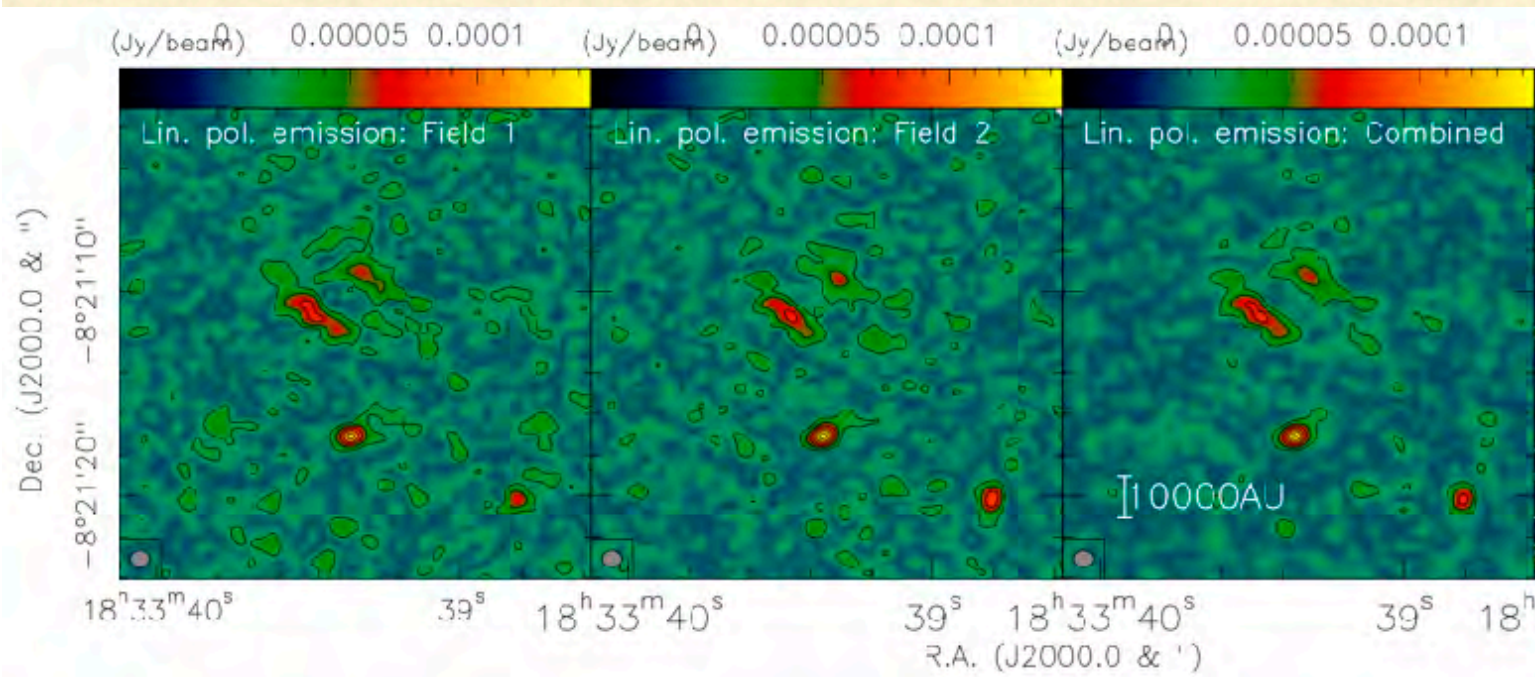

Beuther et al. 2015

Δv between
0.3 and 1.3km/s

ALMA polarization setup
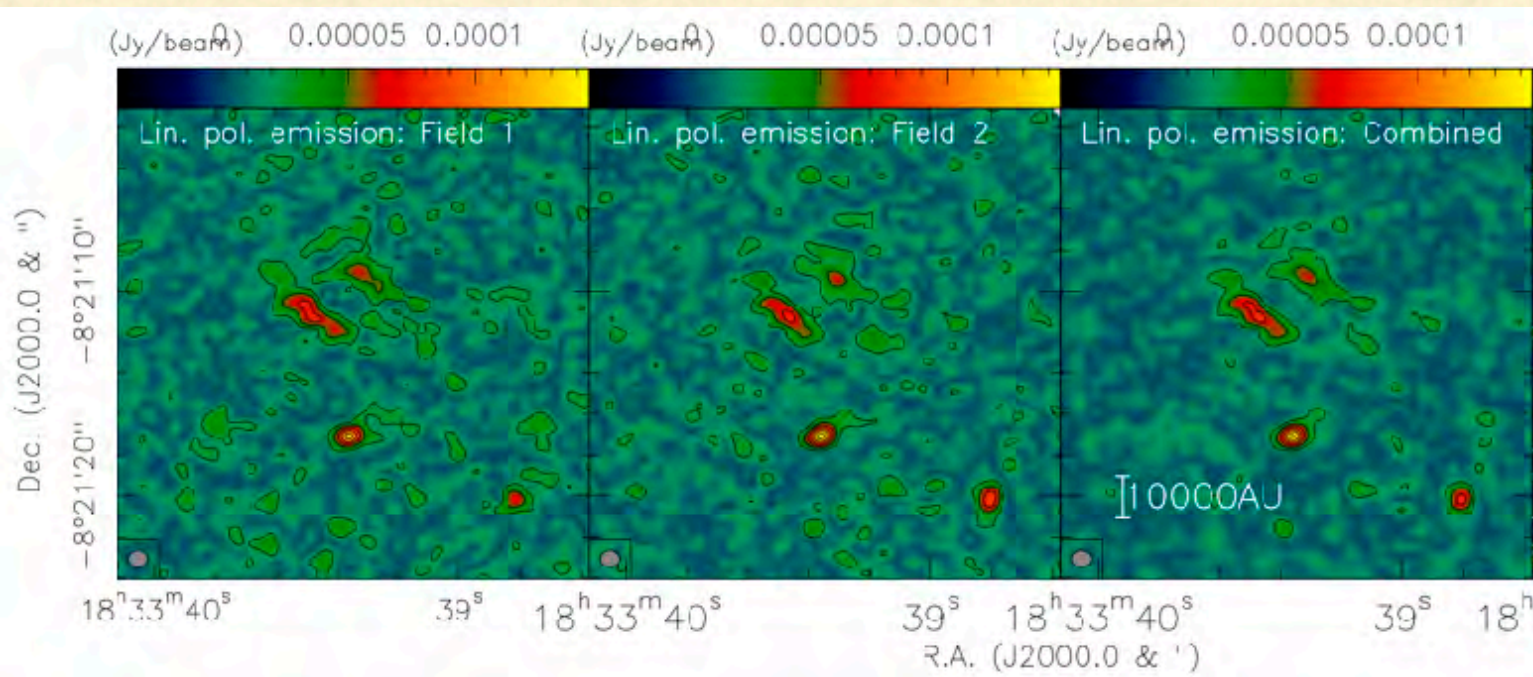
Beuther et al. 2018

Polarization test

Beuther et al. 2018

Polarization test

$$Q_{res} = (Q_1 - Q_2)/2 \quad \& \quad U_{res} = (U_1 - U_2)/2$$

$$Mask = \frac{\sqrt{Q^2 + U^2}}{3 \times \sqrt{Q_{res}^2 + U_{res}^2}}$$

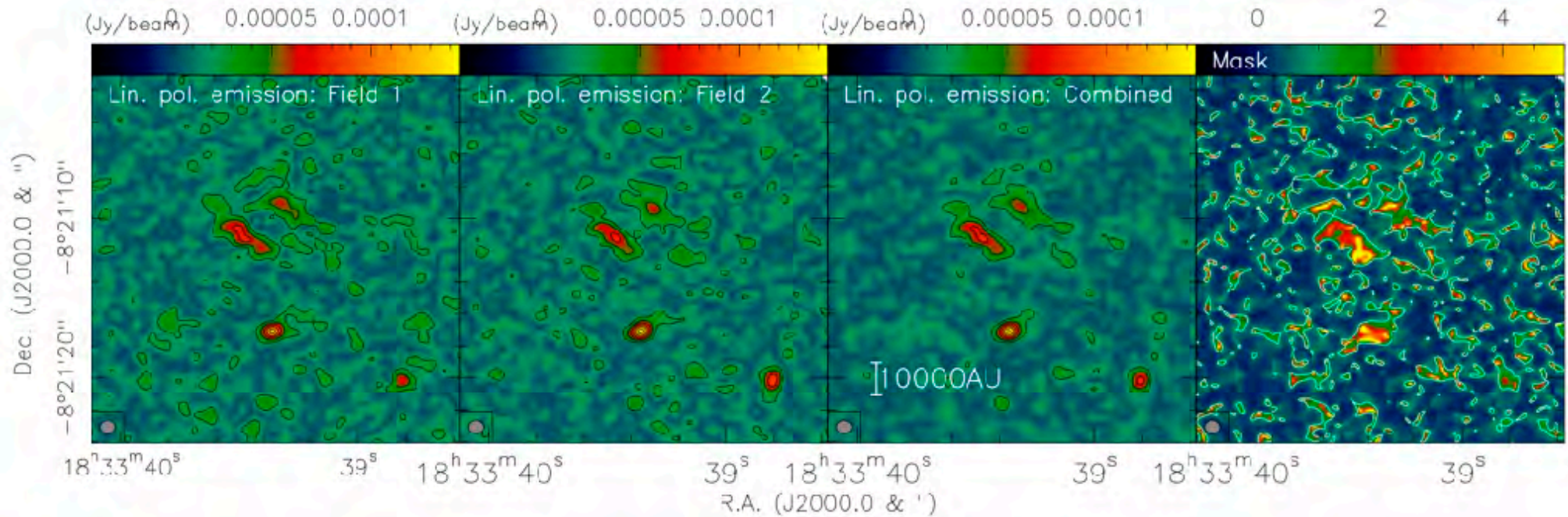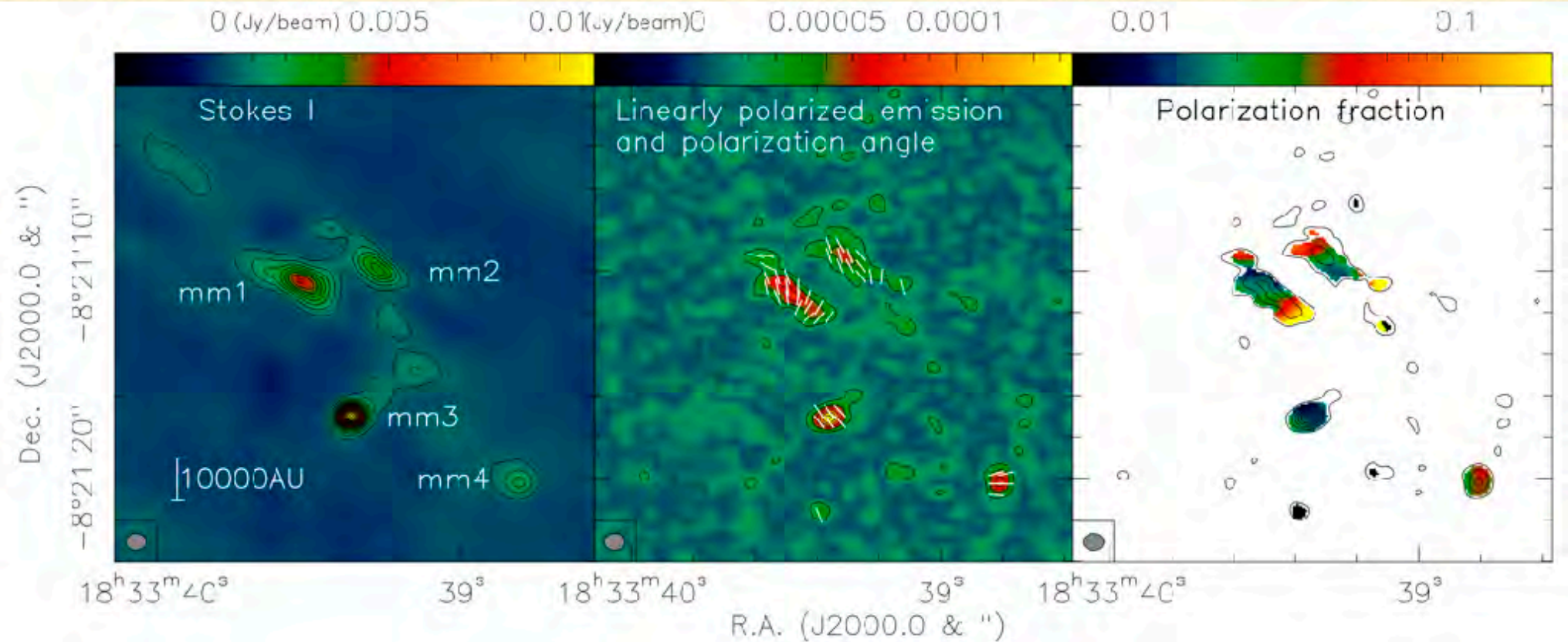*Beuther et al. 2018*

Polarization test

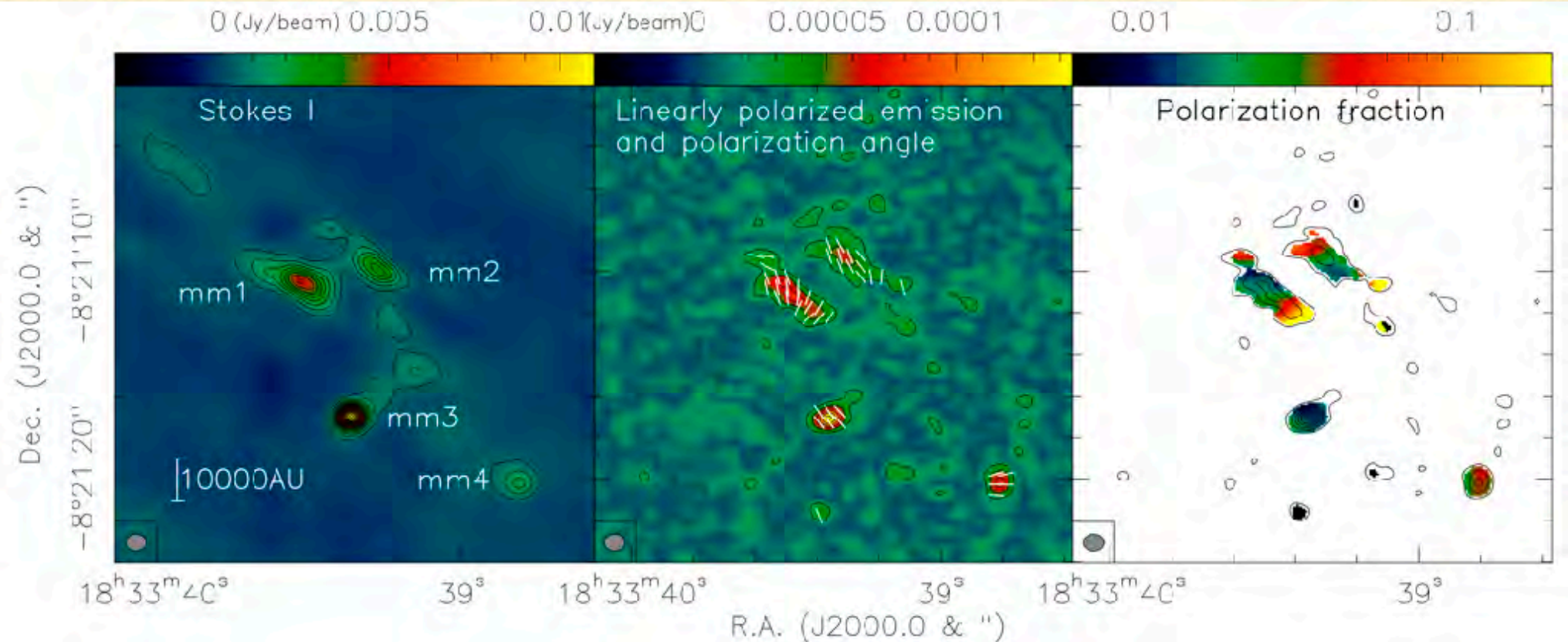
$$Q_{res} = (Q_1 - Q_2)/2 \quad \& \quad U_{res} = (U_1 - U_2)/2$$

$$Mask = \frac{\sqrt{Q^2 + U^2}}{3 \times \sqrt{Q_{res}^2 + U_{res}^2}}$$

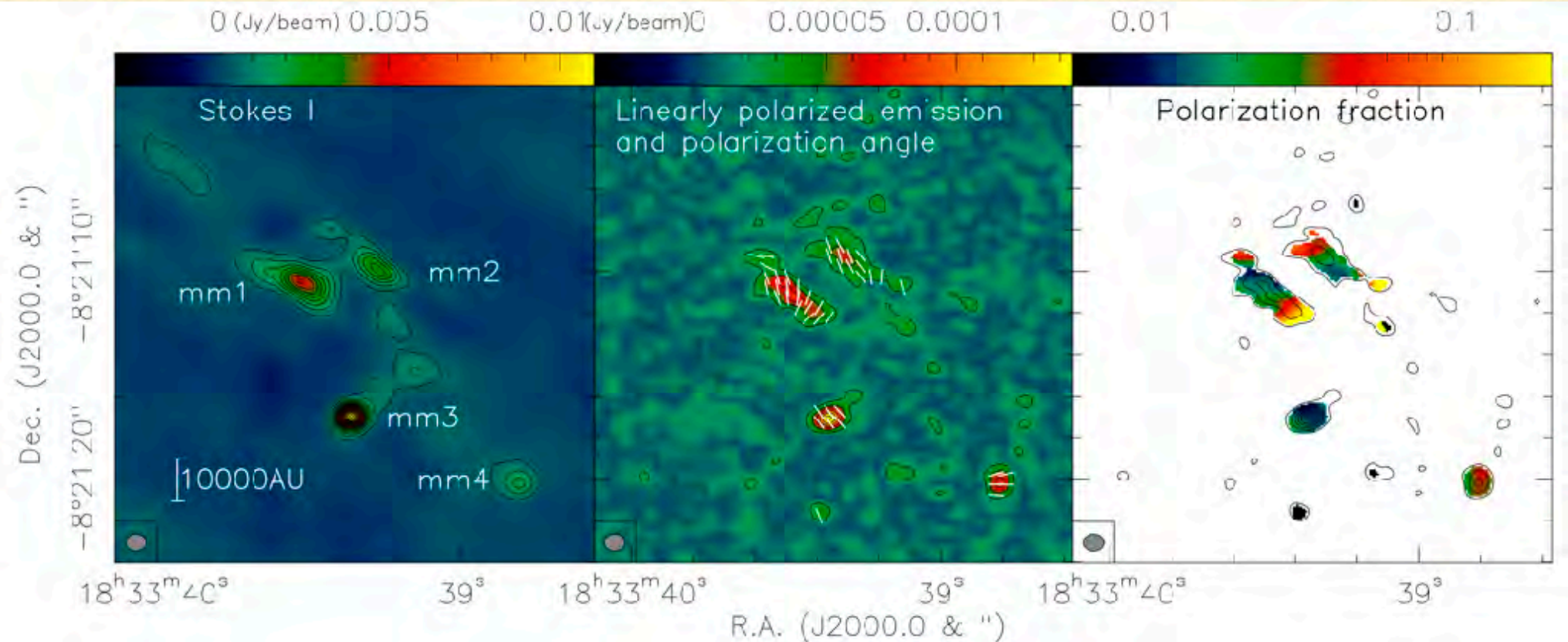*Beuther et al. 2018*

Polarization results

Beuther et al. 2018

Polarization results

$$B_\perp^{\text{DCF}} = \sqrt{4\pi\rho}\,\frac{\sigma_v}{\sigma_\psi}$$

Beuther et al. 2018

Polarization results

$$B_\perp^{\mathrm{DCF}} = \sqrt{4\pi\rho}\,\frac{\sigma_v}{\sigma_\psi}$$ —> magnetic field between 0.3 and 1.3mG

Beuther et al. 2018

Angle measurements

Beuther et al. 2018
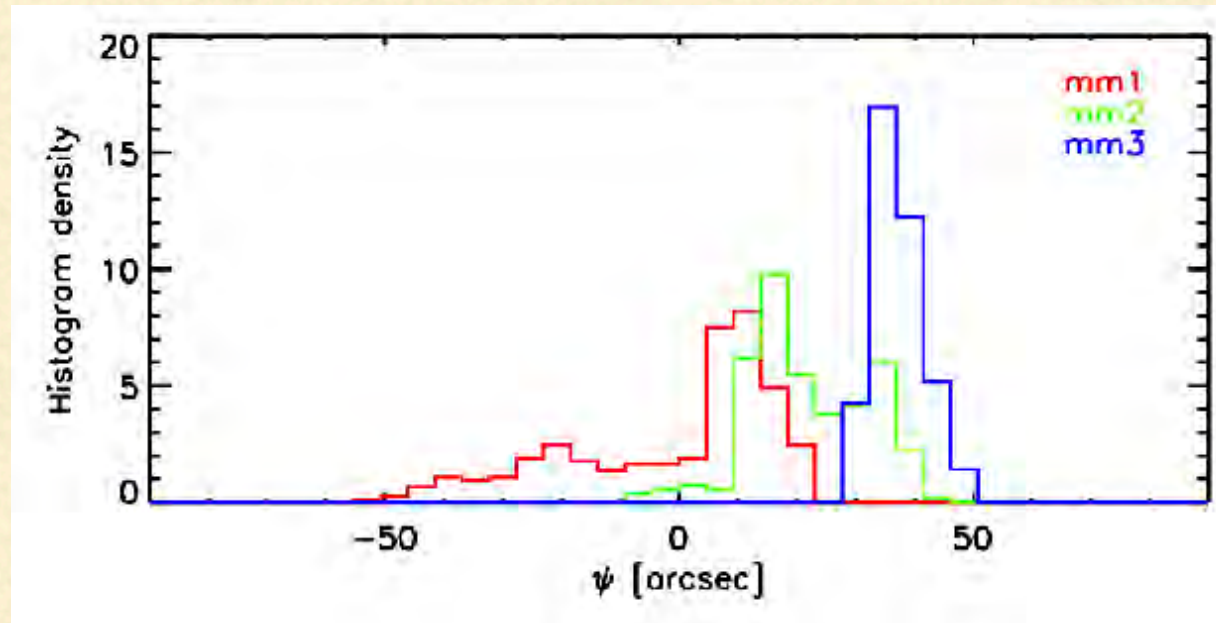
Angle measurements
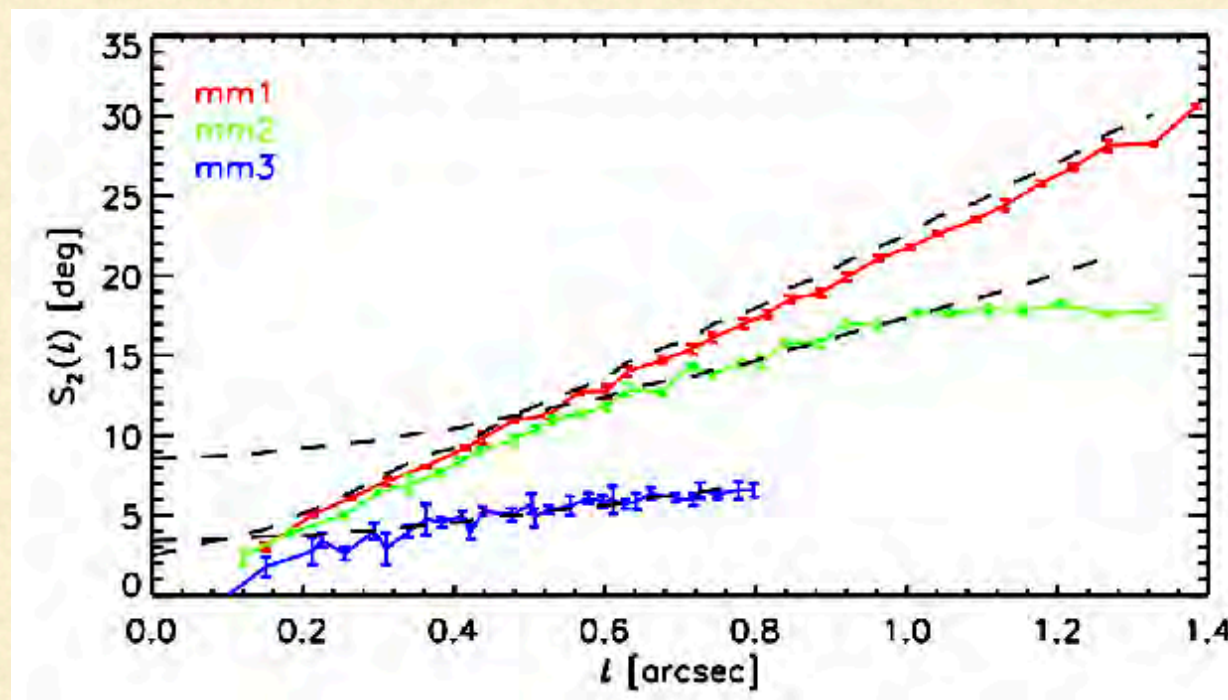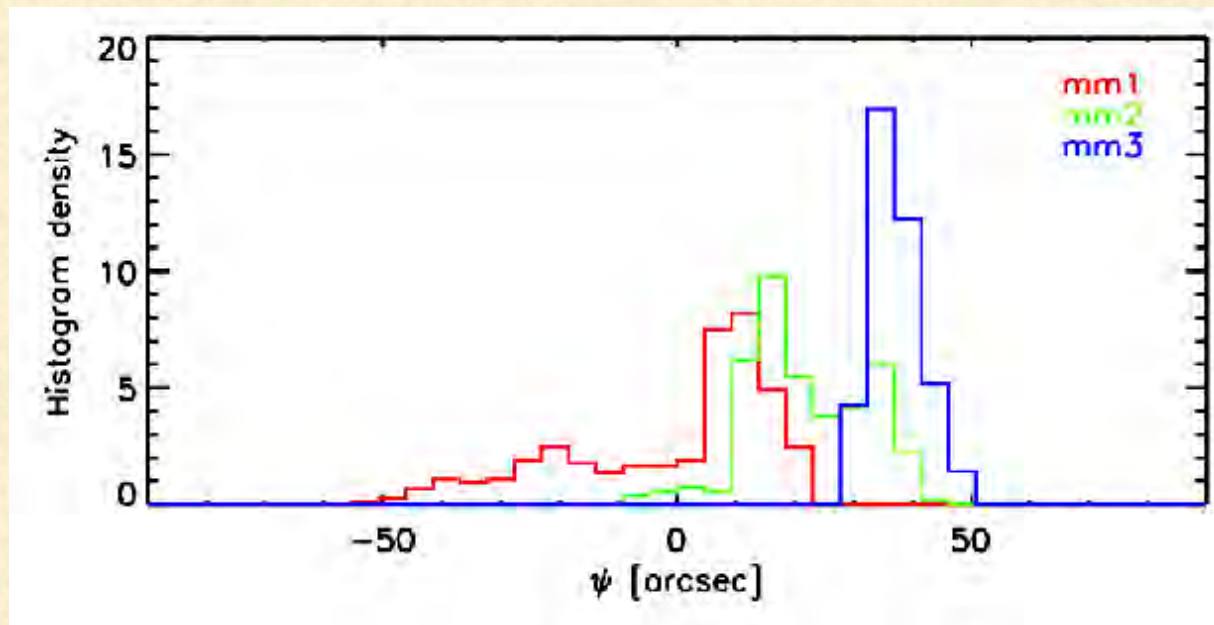
Beuther et al. 2018

Angle measurements
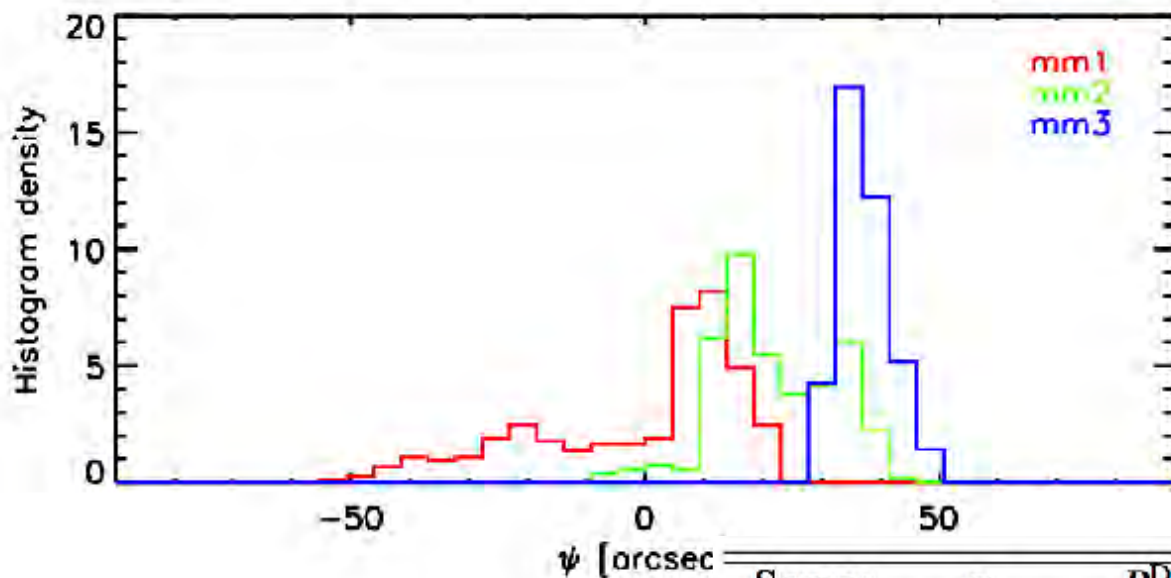
Source	σ_ψ [deg]	$B_\perp^{DCF}$ [mG]	$b(0)$ [deg]	$B_\perp^{SF}$ [mG]
mm1	23.1	0.3±0.1	1.6	3.7±1.3
mm2	9.8	0.6±0.2	8.8	0.6±0.2
mm3	4.3	1.3±0.4	3.3	1.7±0.6
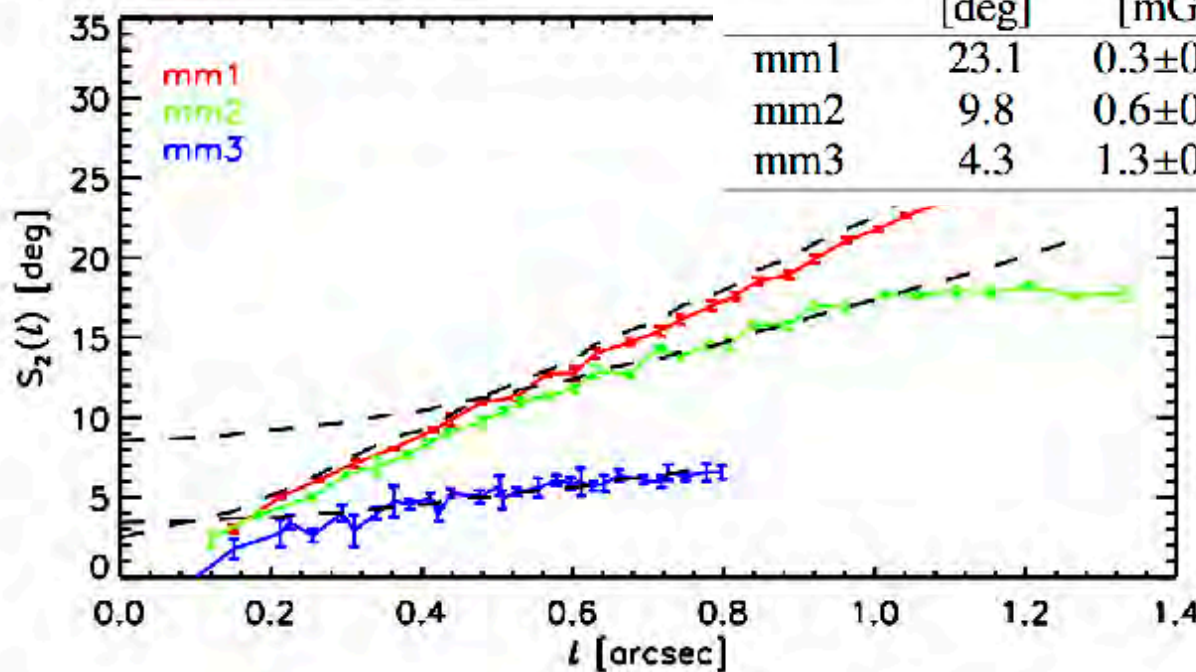
Beuther et al. 2018

Implications

Turbulent-to-magnetic energy: $\beta \sim 3(\sigma_v/\sigma_A)^2$
—> between 0.01 and 0.18
—> magnetic energy dominates over turbulent energy

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—> between 0.01 and 0.18
—> magnetic energy dominates over turbulent energy

mass-to-flux ratio: $M/\Phi_B \approx 7.6 \times 10^{-24} \frac{N_{H_2}}{B}$
0.5 for single-dish column density
3.1 for ALMA column density
—> on large scale close to critical, on small scales collapsing

Summary

- Magnetic field structure in high-mass starless core smooth

- Field strength on the order of mG

- Magnetic energy dominates over turbulent energy

- Likely at the verge of collapse.