ow to distinguish between jets and HCHIIR?

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Ionized jets and HCHIIR

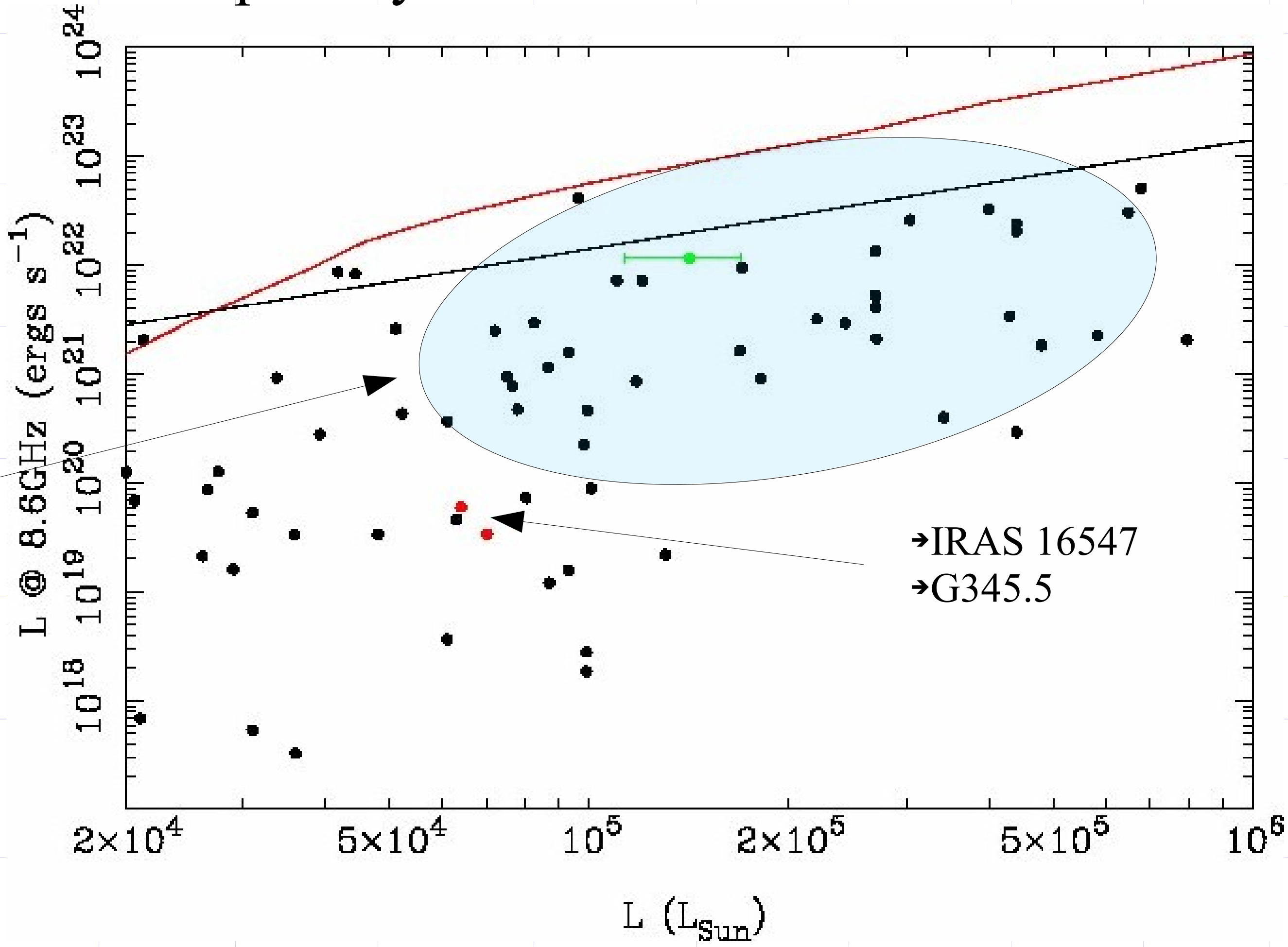
- Both are related to very early stages of high mass star formation

- They share similar characteristics when observed in cm radio continuum

- They will be confused in some degree depending on which criteria we used to identify young stellar objects

Ionized jets and HCHIIR

1) First criterion for identifying early stages:
Less radio continuum than expected for a optically thin HIIR



Sewilo et al. 2004

→IRAS 16547
→G345.5

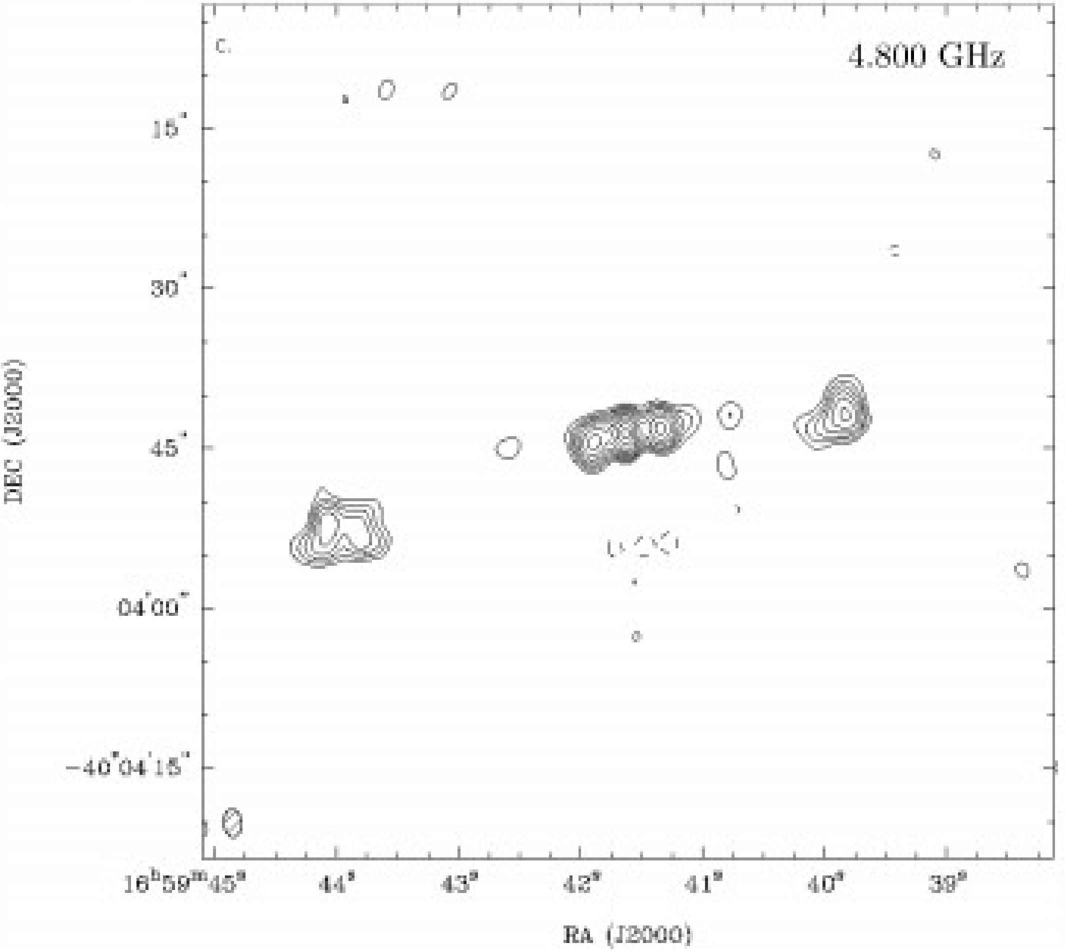
Ionized jets and HCHIIR

Under-luminous in radio because:

- Physical conditions of the ionized gas:
  - ➔ Optically thick HIIR, (young, maybe trapped)
- Physical conditions of the “protostar”
  - ➔ Less UV and Teff from young objects (puffed star)
- Physical process of ionization
  - In jets at least.

Ionized jets and HCHIIR

Table 1. Angularly Resolved Radio Jets.



Guzman et al. 2010

t_{dyn} (yr)	Refs.	Notes[a]
1	1, 2, 3	B
3	4, 5, 6, 7, 8	B
2	9	B, P
5	10, 11, 12	A, P, N
7	13, 14, 15	A, P, E
3	16	A
2	17	M
4	16	B
3	16, 18	
1	19	
10	20	
1	21	
4	22	
3	16, 23, 24	
6	25, 26, 27	
3	28	
300	22, 29	
1	29, 30	
1	30	
1	30	

Anglada, 1996

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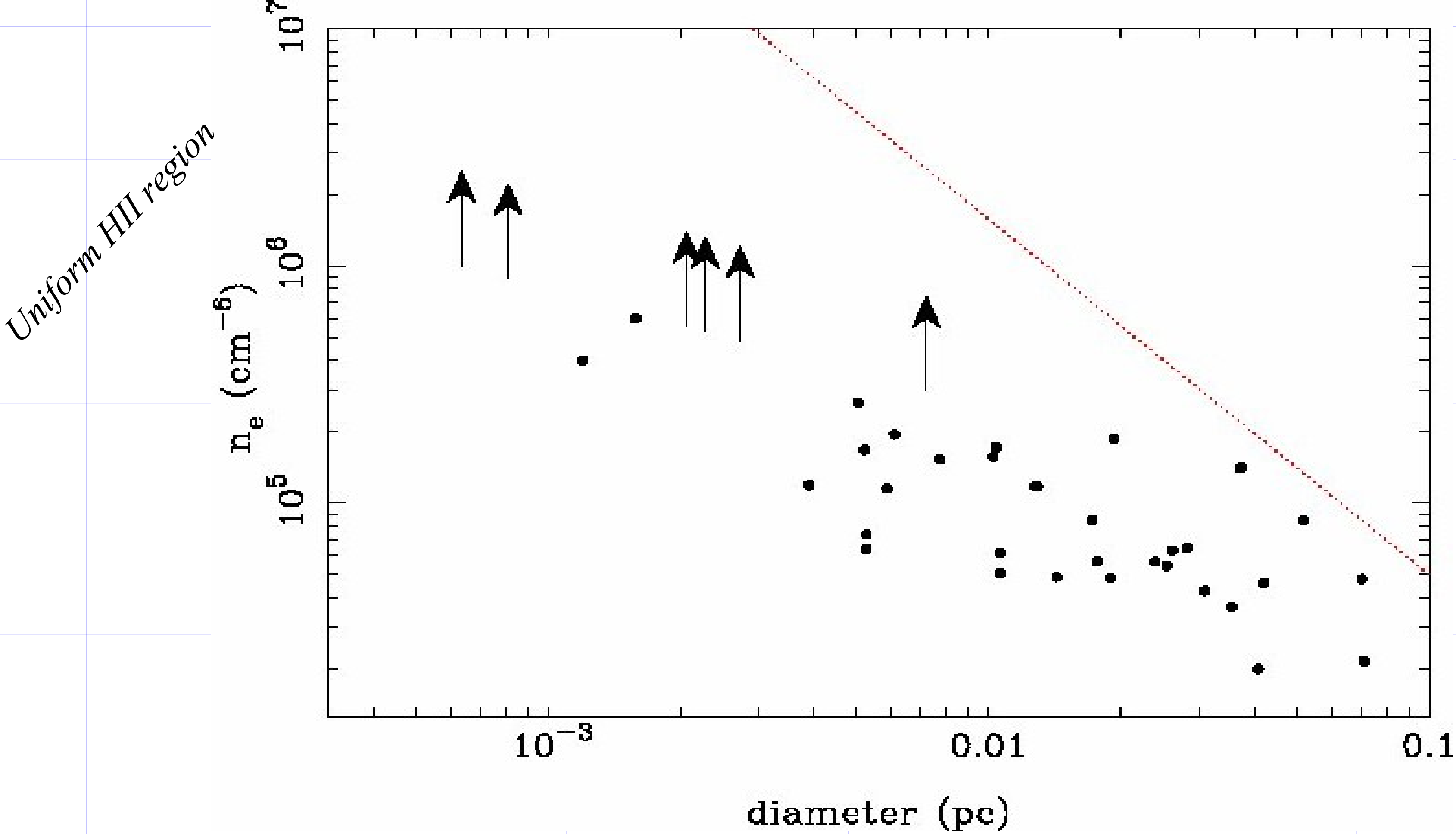
2) Second criterion: Density estimation using radio continuum. (Spectral index)



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3) Third criterion: Radio continuum spectrum.

Modeled as spheres or cones with a power-law in density, both phenomena have transition regions where the emission is characterized by a spectral index between -0.1 and 2, depending on the density profile (beta):

$$\nu^{\gamma} \text{ with } \gamma = 2 - \frac{2.1}{\beta - 0.5}$$

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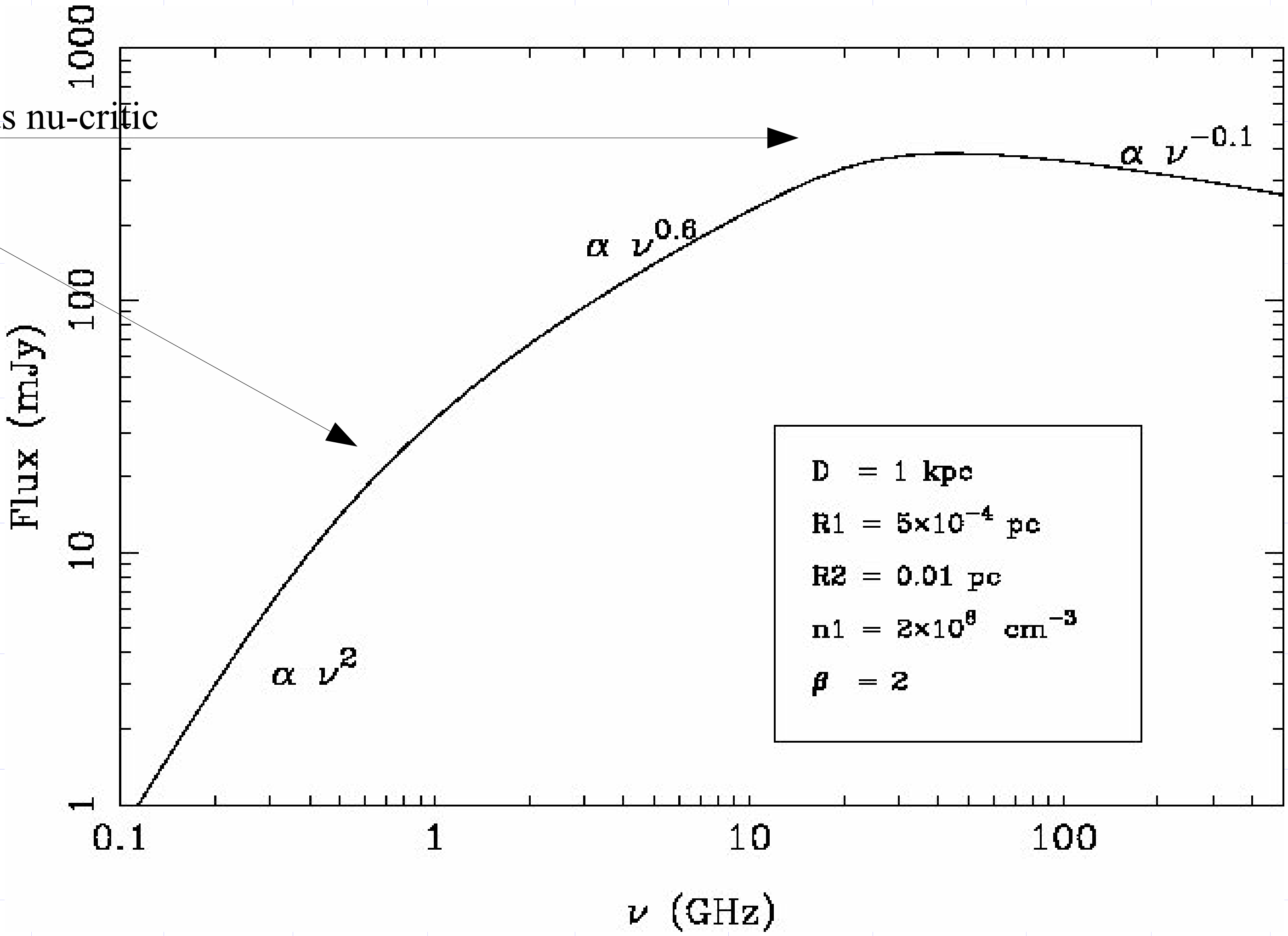
3) Ionized shell with power law index



Inner radius nu-critic

Outer

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3) Ionized shell with power law index

- For beta<3/2 there is no transition region
- Most regions are well fitted by density profiles with beta>2
    - Recombination balance implies that most of theionizing photons are absorbed “nearby” the source.

Integral diverges if
Beta>3/2
& R1 → 0

$$4\pi \int_{R1}^{R2} (n(r))^2 r^2 \alpha_2 dr = N_*$$

Given a initial density,
beta>3/2 : arbitrarily small HIIR beta<3/2
:R2~RStromgren

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3) Spectral index of the deconvolved size
(radio continuum).

This is the first of the criteria that together with the *flux* spectral index could disentangle between jet and HCHIIR.

- Geometrical (and kinematical) “liberty” of the jet.

Width goes as r^epsilon (epsilon=1 → conical)

$$\Theta_\gamma \propto \nu^\delta \text{ with } \delta = -\frac{2.1}{2\beta - \epsilon}$$

$$0 < \epsilon \leq 1, \quad \beta > 3/2$$

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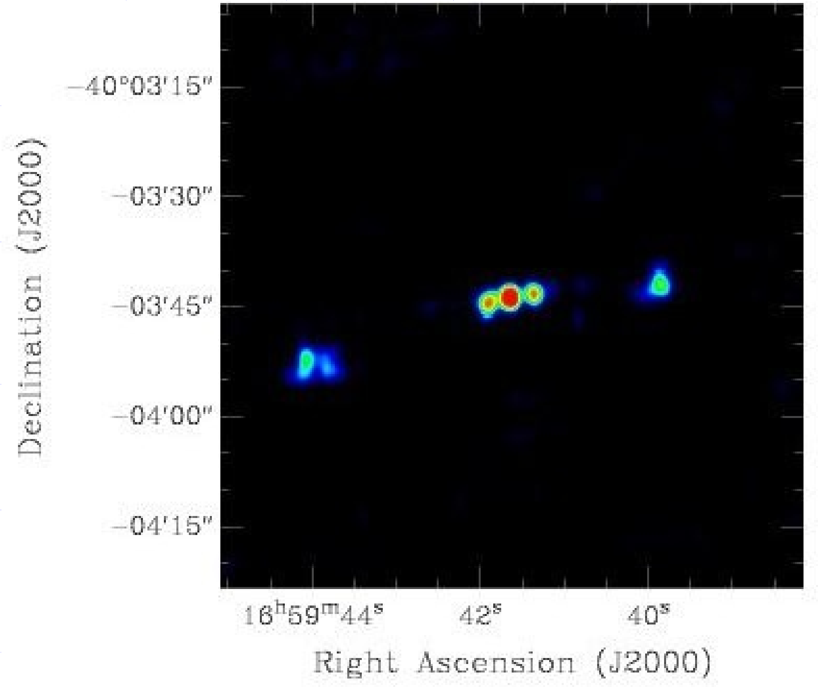
4) Presence of radio lobes: Emission from the shocked-ionized gas (not the jet itself)

These have been the confirmation of the jet phenomena. They also allow us also to estimate jet dynamics



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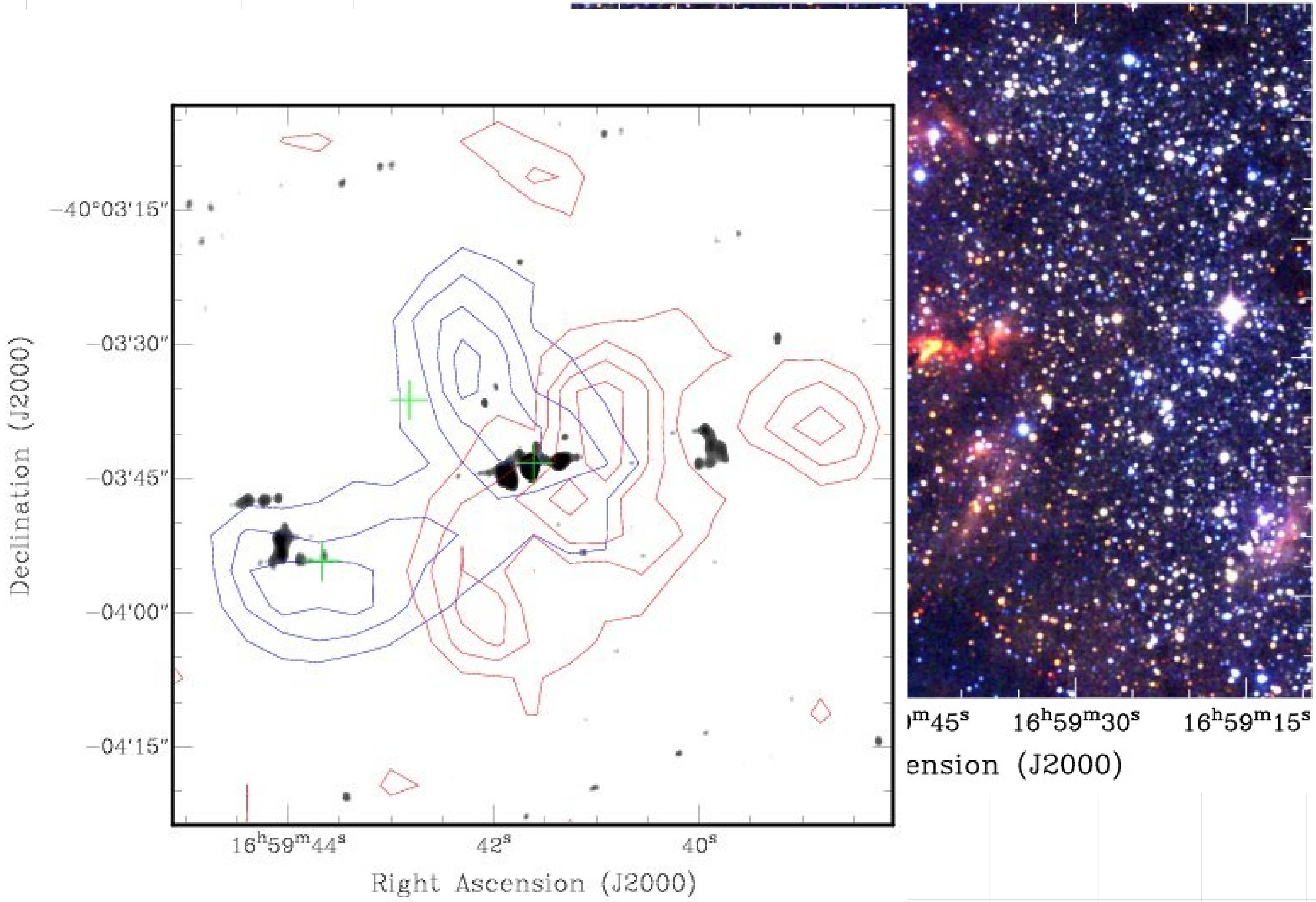

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6) Velocity broadening of hydrogen RRLs

Until now, the velocity width of hydrogen RRLs of regions classified as HC rarely goes above 100 km/s.
Estimations of massive-protostars-jet-velocities (Ceph A, HH80-81, IRAS16547, G345.5) all range between 300-1000 km/s
→RRLs peak ~ 1 to 5% of the continuum

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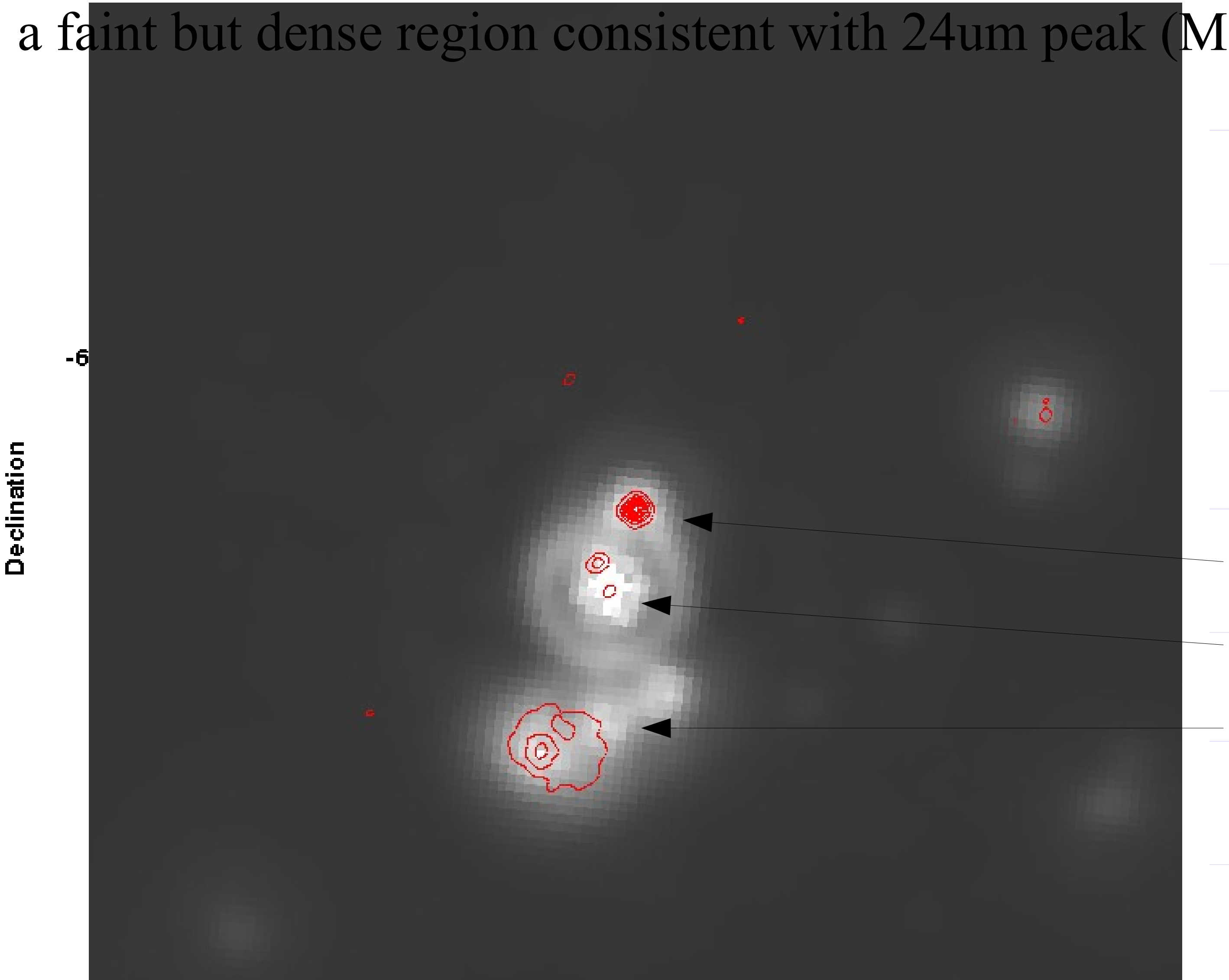
7) Consistent with FIR peak? We have an example of a faint but dense region consistent with 24um peak (MIPS)



UCHIIR

CHIIR

Ionized jets and HCHIIR

Final remarks and conclusions

- All these criteria and analysis should be useful in order to present a consistent physical context.
- Until now, HCHIIR have less “requirements” other than density or EM

Ionized jets and HCHIIR

	EM10^7	diampc	dens10^4	comment
G337	3.811	0.0266	3.7866	normal-dense
I13134A	0.197	0.032	0.7845	normal
I13134B	0.789	0.0064	3.5204	normal-dense
I13134C	19.5	0.0011	41.5	dense
17238	11.2	0.0197	7.51	dense
G345.01	18.9	0.0128	12.15	dense
G317	21.13	0.025	9.15	dense
G333.13	10.78	0.074	3.8	normal-dense