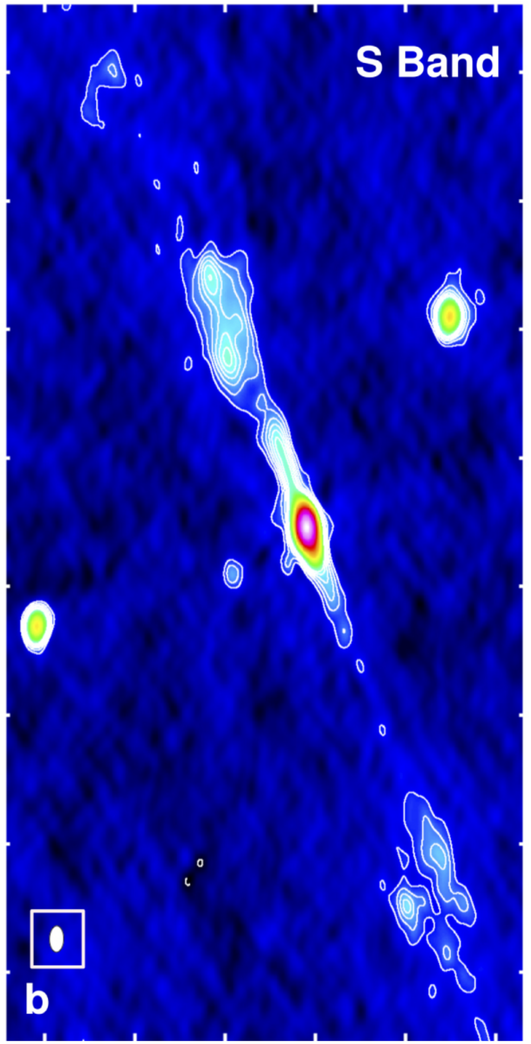
Protostellar Jets as Particle Accelerators

The case of HH 80-81



Siena
28th-31st October
TOSCA 2024

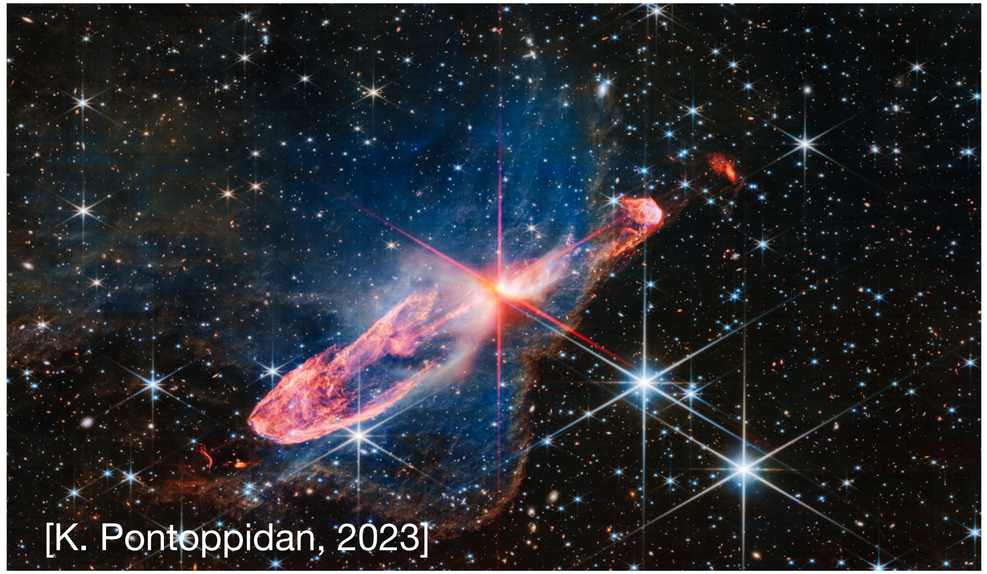
IAA INSTITUTO DE ASTROFÍSICA DE ANDALUCÍA
EXCELENCIA SEVERO OCHOA
CSIC
Javier Méndez-Gallego

Oct. 2024

MYSOs & Jets

- Massive young stellar objects (>8$M_\odot$).
- Collimated jets in a dense medium.
- Particle acceleration via **DSA**.

HH46/47. NIRCam@JWST

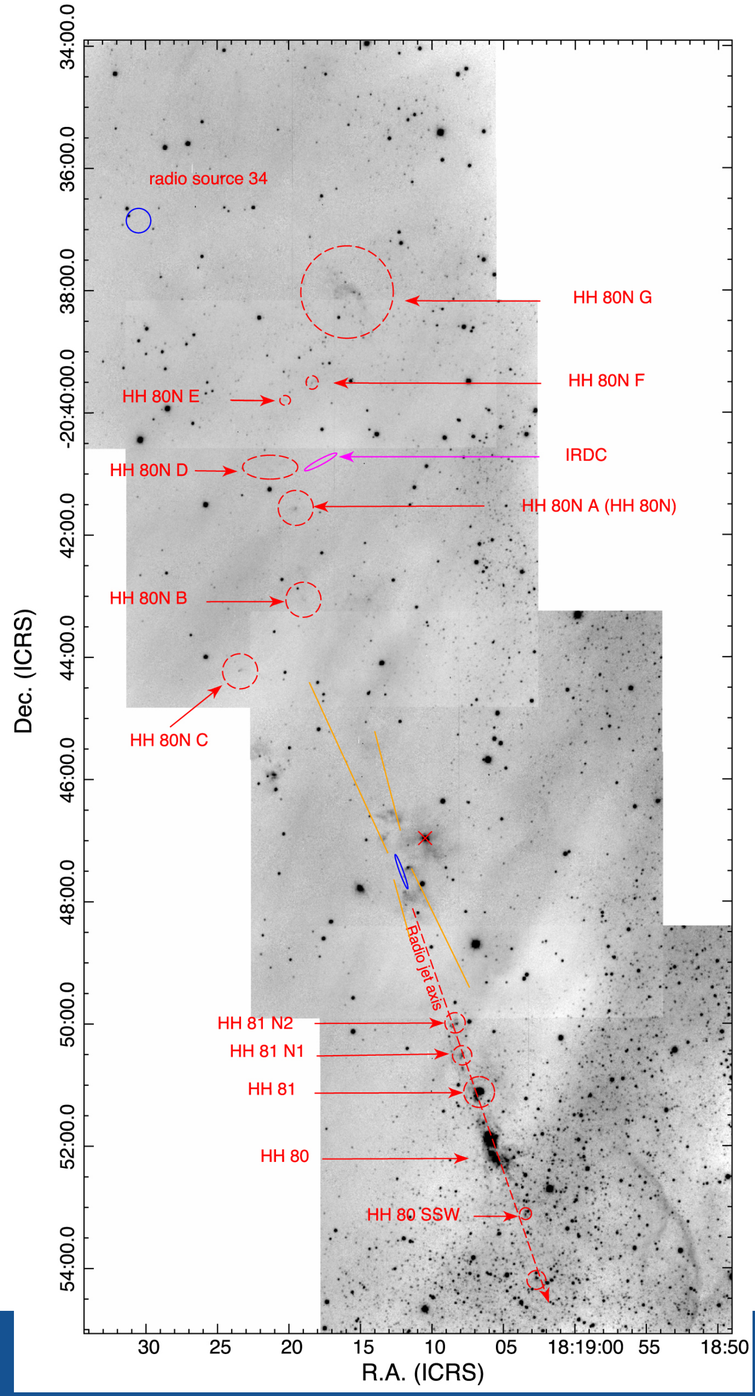


HH 211. NIRCam@JWST

[T. P. Ray et al., 2023]

HH 80-81

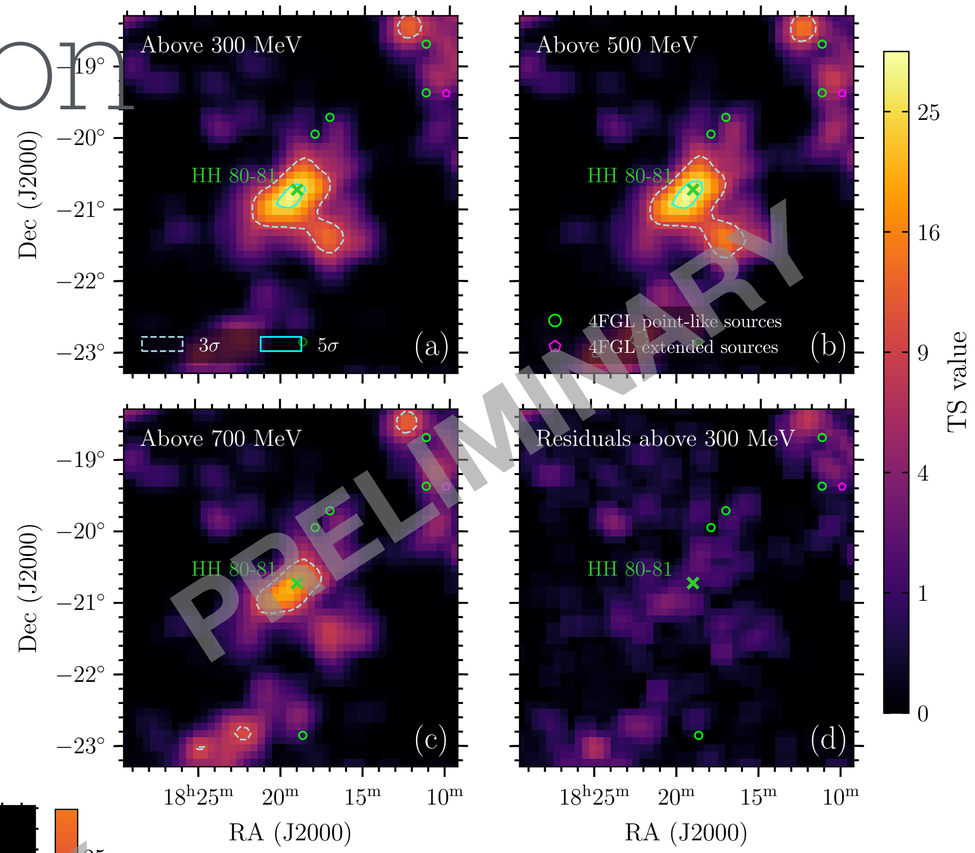
- Driven by **IRAS 18162-2048** (~20 $M_\odot$) at 1.4 kpc.
- Located in the L291 molecular cloud ($n \gtrsim 100$ cm^{-3}).
- Jet luminosity of 10^{37} erg/s.
- **Non-thermal emission** in radio and X-rays.

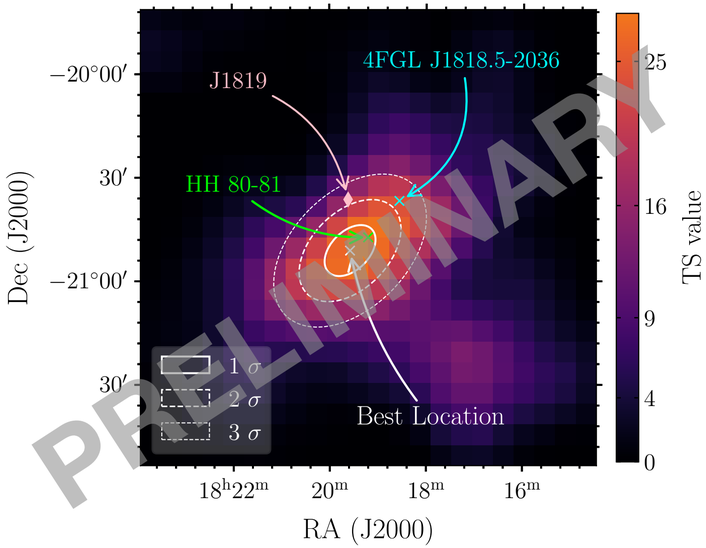


[J. Bally & B. Reipurth, 2023]

Detection and identification

- Yan+22 reported γ-ray excess in the region.
- **5.4σ detection** coincident with the protostar position.
- Only two candidates within the 3σ location area.
- **HH 80-81 is the most probable candidate** for explaining the γ-ray emission.

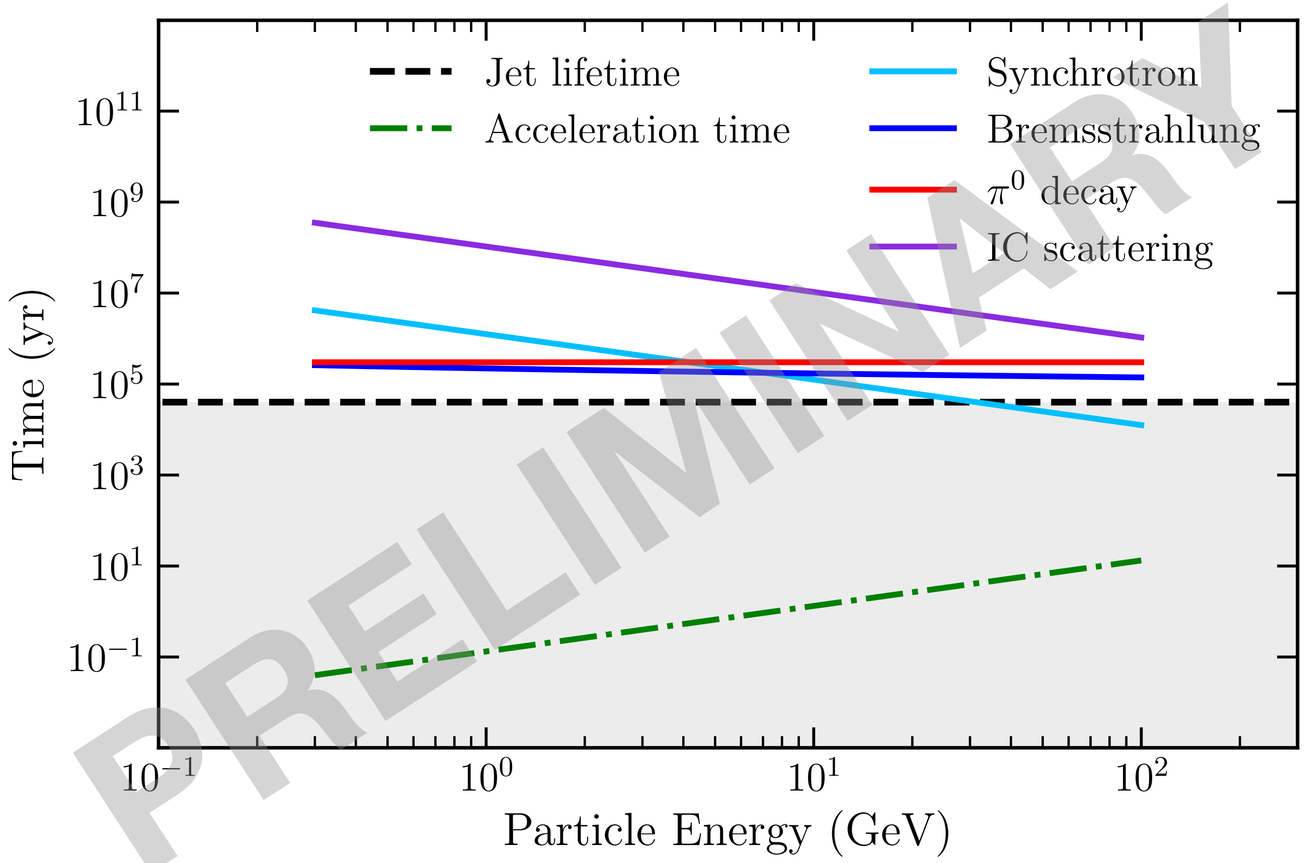




γ-ray origin

Two possible radiative mechanisms:

- **Electrons**: Bremsstrahlung emission.
- **Protons**: π^0 decay.



γ-ray origin

Two possible radiative mechanisms:

- **Electrons**: Bremsstrahlung emission.
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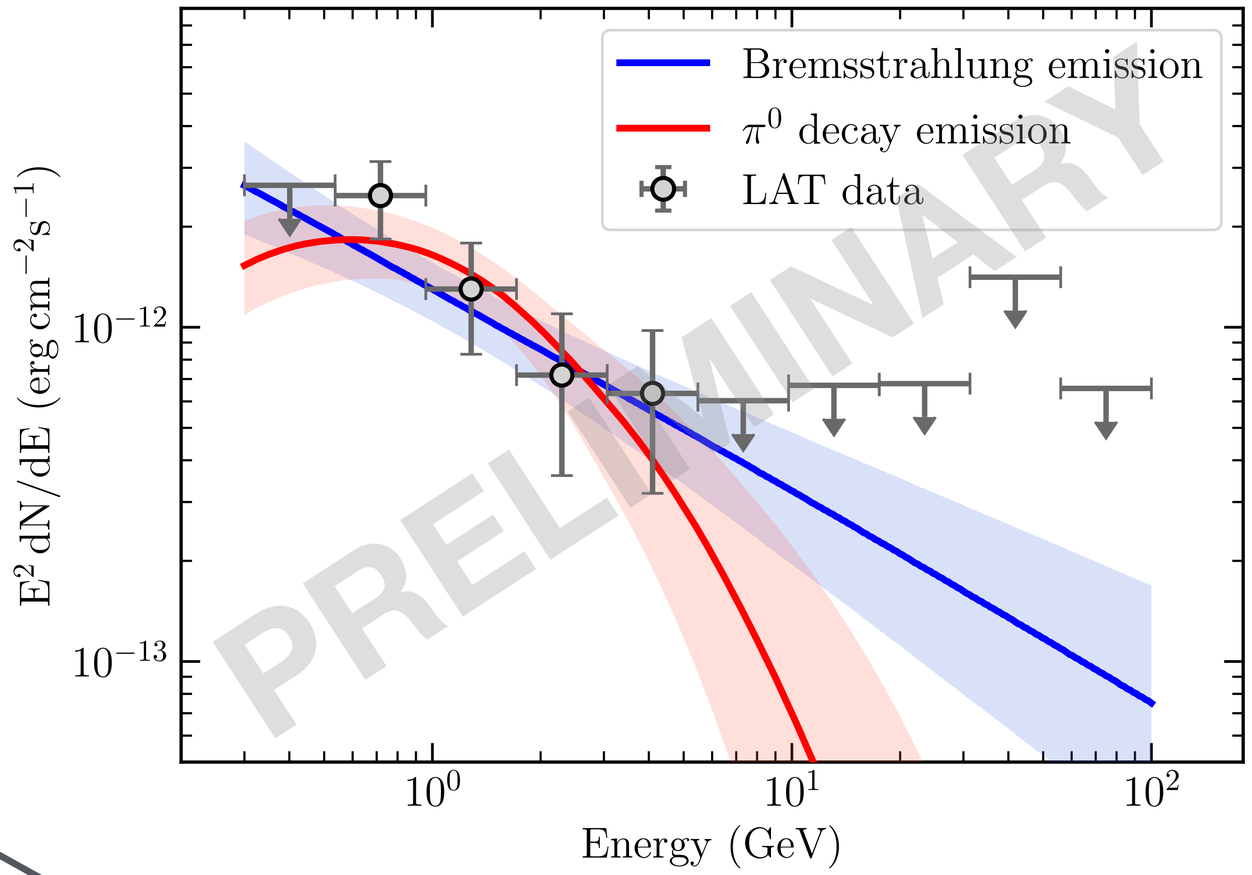
Model	Energy (erg) $\left(\times \frac{n}{100\,\mathrm{cm}^{-3}}\right)$	Injection time (yr)
Bremsstrahlung	$(1.5 \pm 0.4) \times 10^{46}$	$(9.5 \pm 2.3) \times 10^2$
Pion decay	$(2.1^{+1.2}_{-0.7}) \times 10^{47}$	$(1.3^{+0.7}_{-0.4}) \times 10^4$



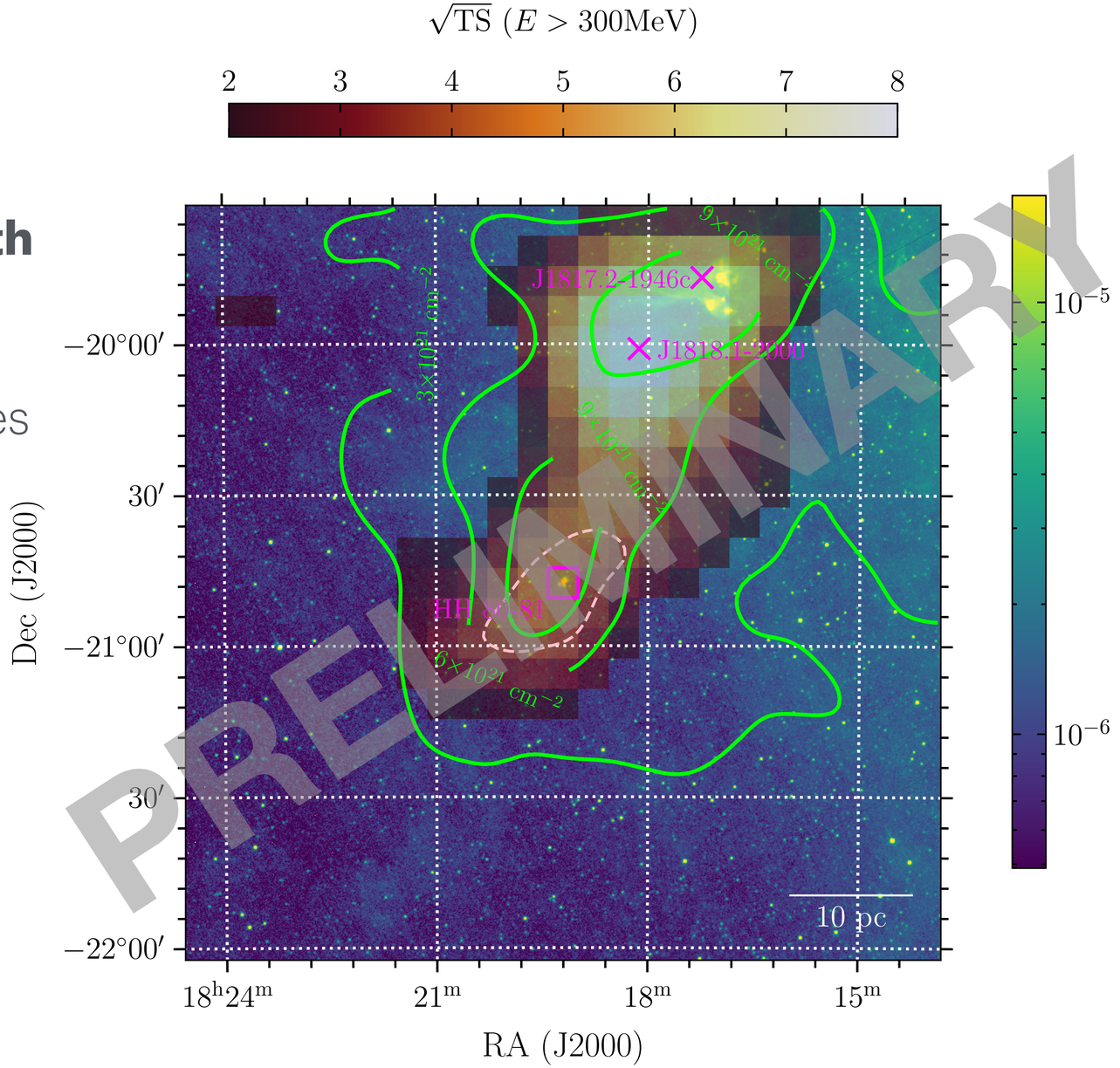
Jet lifetime ~4×10^4 yr

[Qui et al., 2019]

γ-ray origin

- γ-ray emission is **spatially coincident with the molecular gas density**.
- The combination of the three 4FGL sources of the region traces the molecular cloud.

Galactic origin!



Conclusions

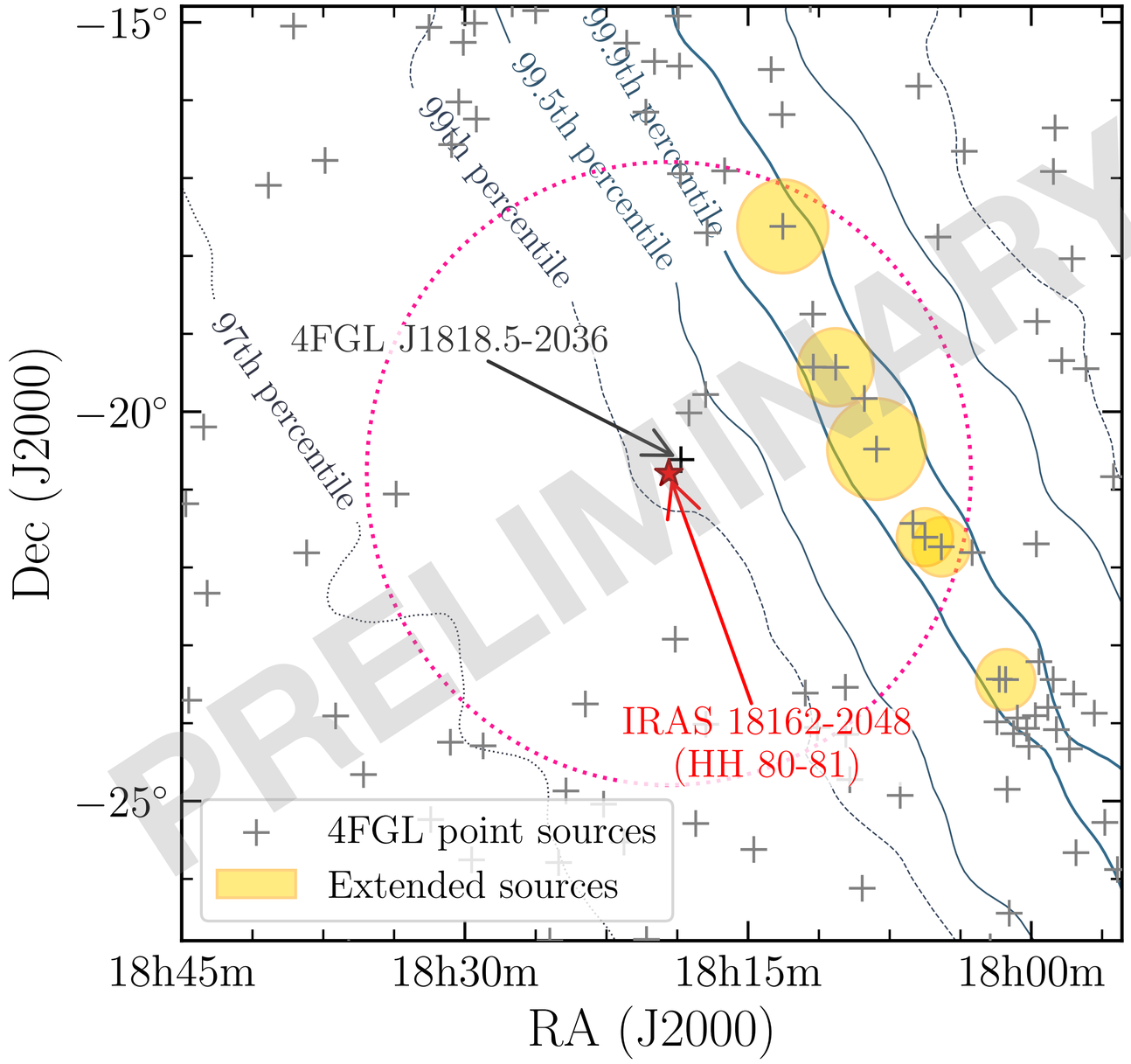
- We have performed a **source association** between the gamma-ray excess and the sources in the region based on positional arguments, concluding that HH 80-81 is the most probable counterpart for explaining our detection.

- Based on energetic arguments, **the leptonic or hadronic origin of the gamma-ray emission remains unclear**. In addition, both models are consistent describing the spectral shape of the source.

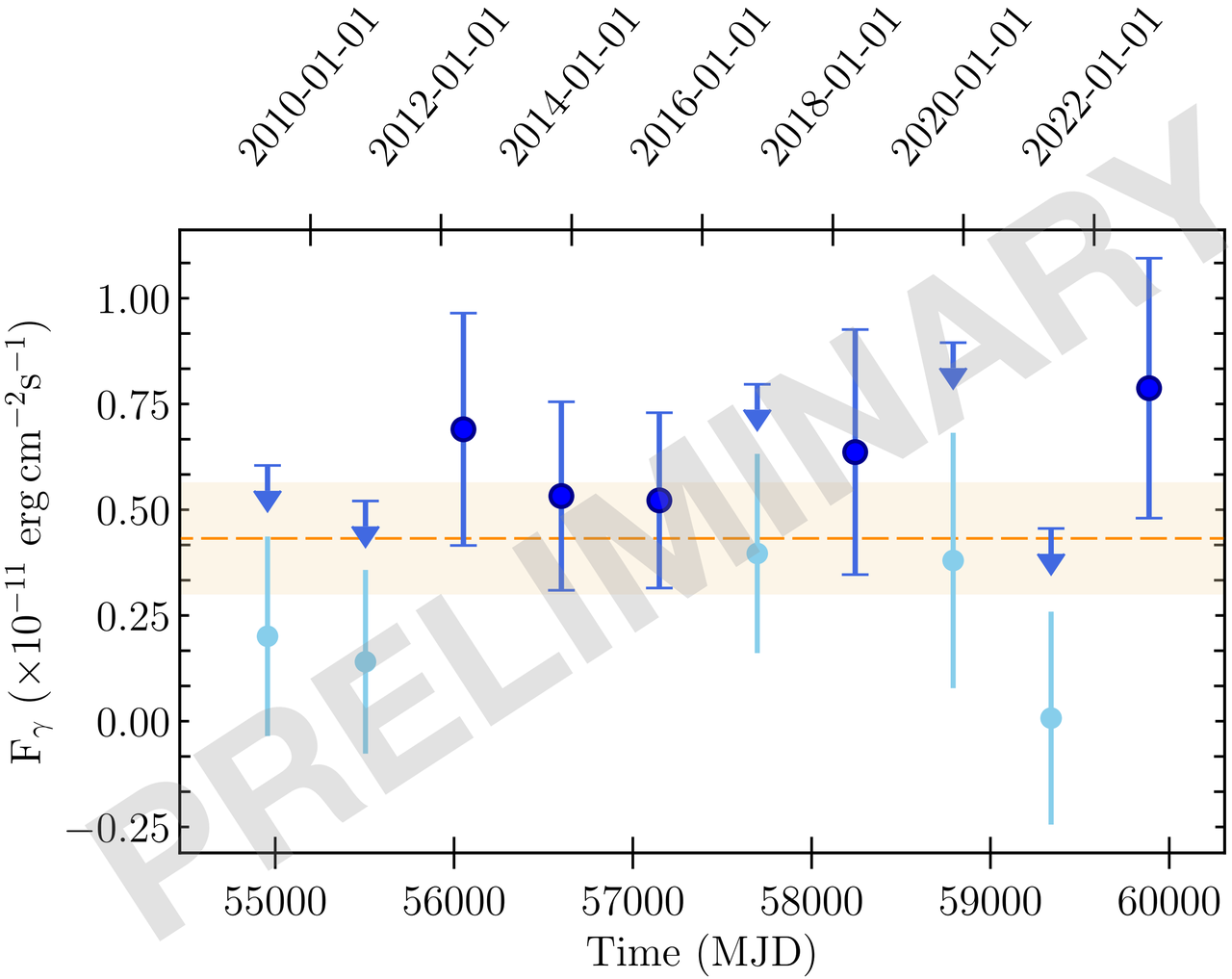
- Since the source emission is spatially coincident with L291, longer exposure times are required to perform significant studies to study the individual **morphology of HH 80-81** and the correlation with the ISM molecular clouds.

Thanks for your attention!

ROI


−15°
−20°
−25°
Dec (J2000)
18h45m
18h30m
18h15m
18h00m
RA (J2000)
99.9th percentile
99.5th percentile
99th percentile
97th percentile
4FGL J1818.5-2036
IRAS 18162-2048
(HH 80-81)
4FGL point sources
Extended sources
PRELIMINARY

γ-ray variability



γ-ray spectrum