Non-thermal radio emission from the jet associated with an intermediate-mass protostar

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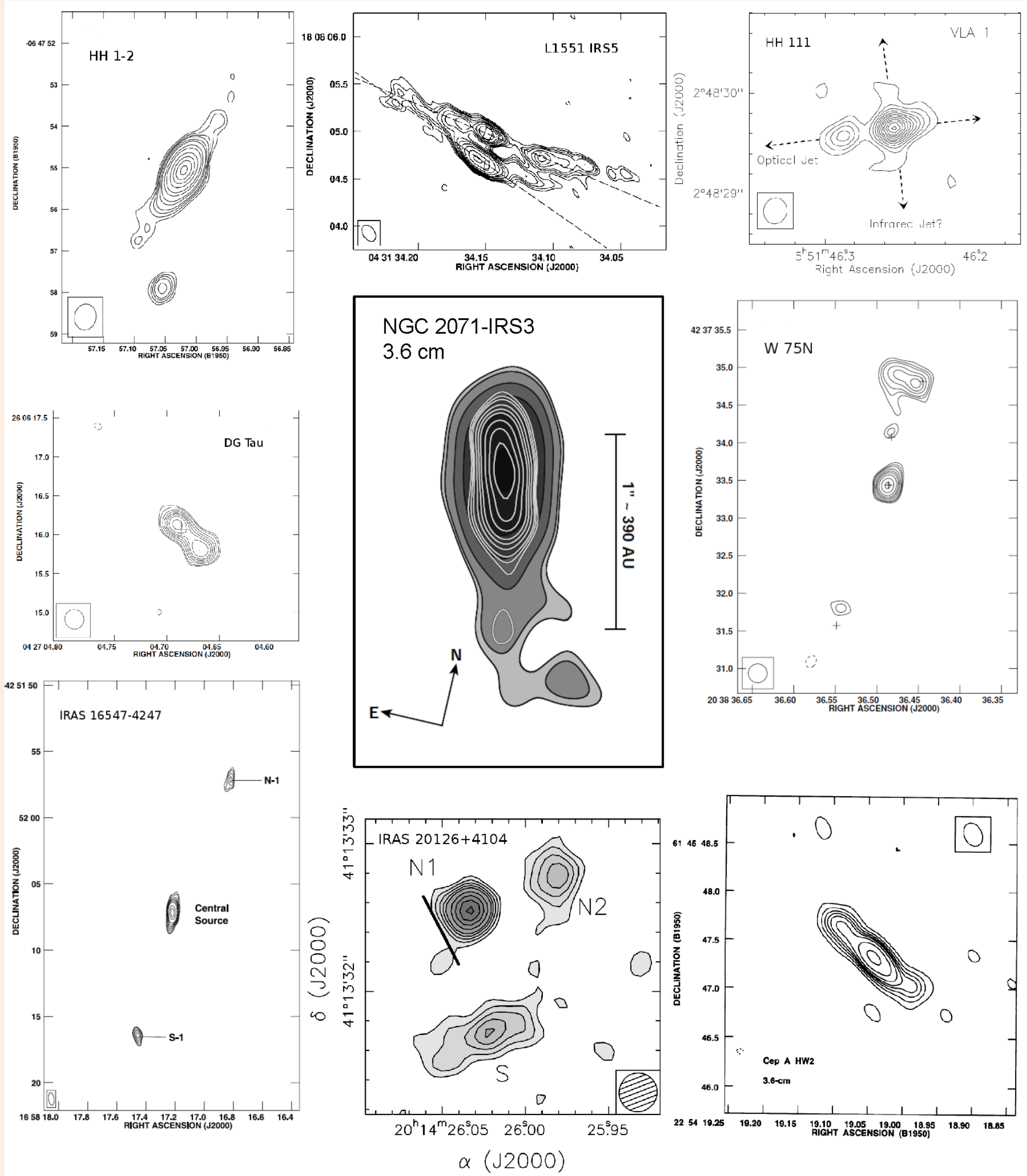
Radio jets around YSOs



Characterized by **thermal** free-free cm emission very close to the star.

-0.1 < spectral index < 2

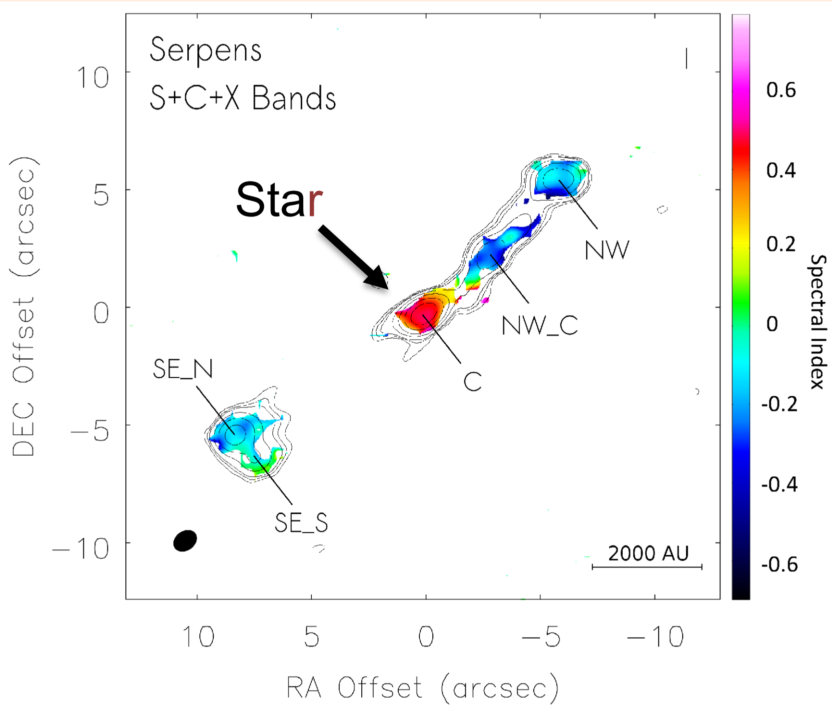
Typically: α = 0.4-0.7 (Anglada et al. 2018)

α = 0.6 for a conical jet (Reynolds 1986)

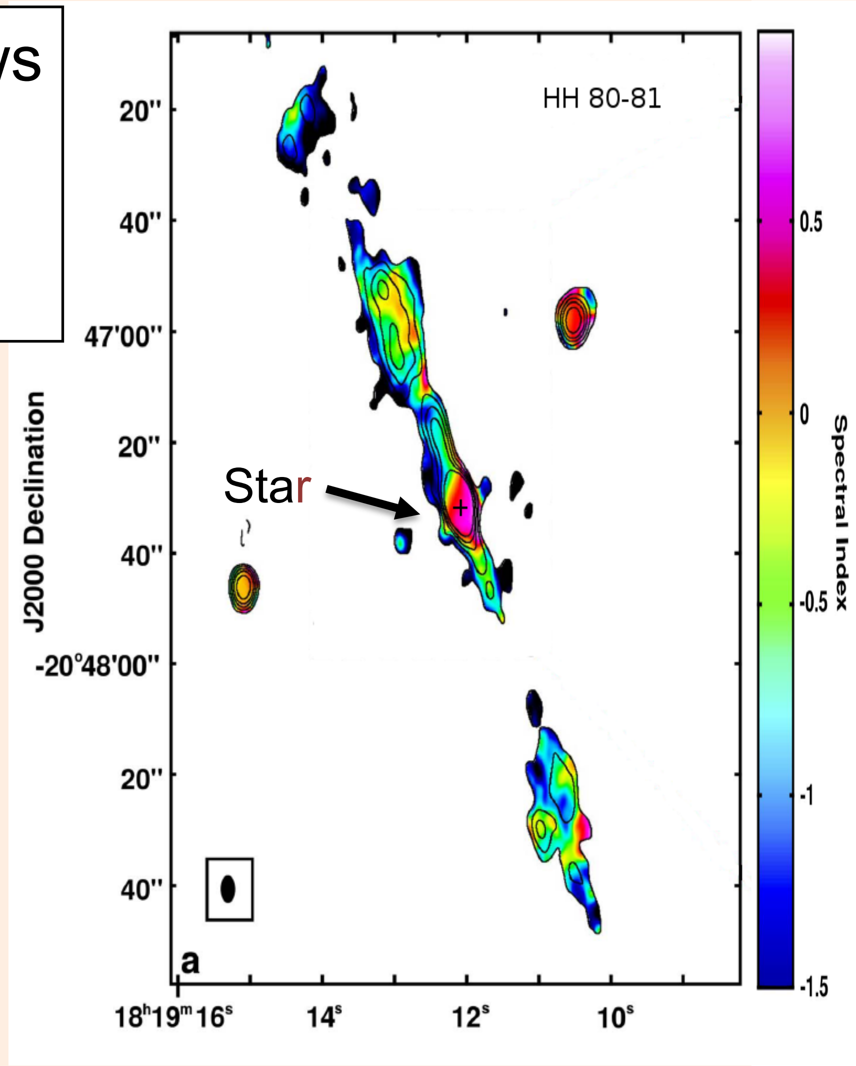
(Anglada et al. 2018)

Non-thermal radio jets

In some cases, the radio jet shows a thermal core (positive or flat spec index) and **non-thermal lobes** (negative spec index)

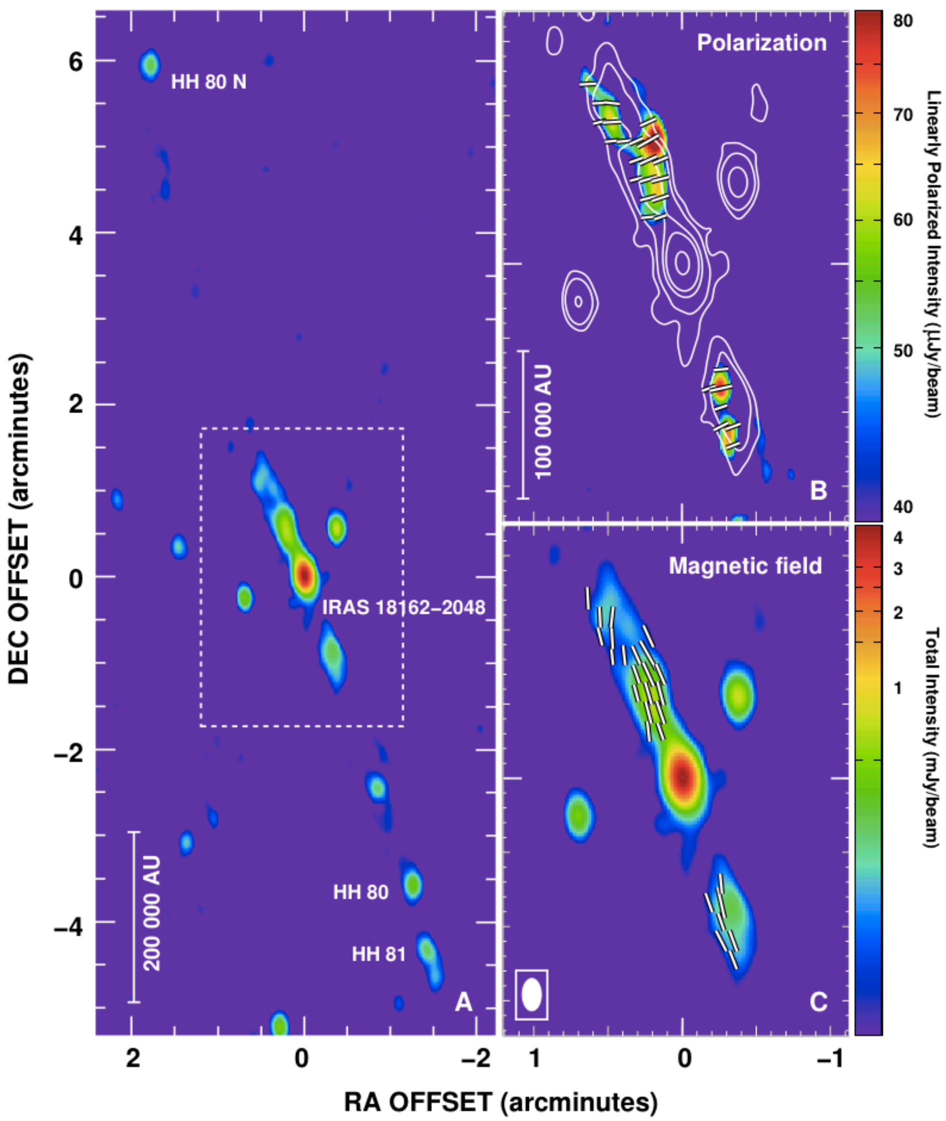


(Rodriguez-Kamentzki et al 2015)



(Rodriguez-Kamentzki et al 2018)

Synchrotron emission in the HH80 radio jet



(Carrasco-Gonzalez et al 2010)

Discovery of **linearly polarized** radio emission in the lobes of the HH80 radio jet (Carrasco-Gonzalez+2010)

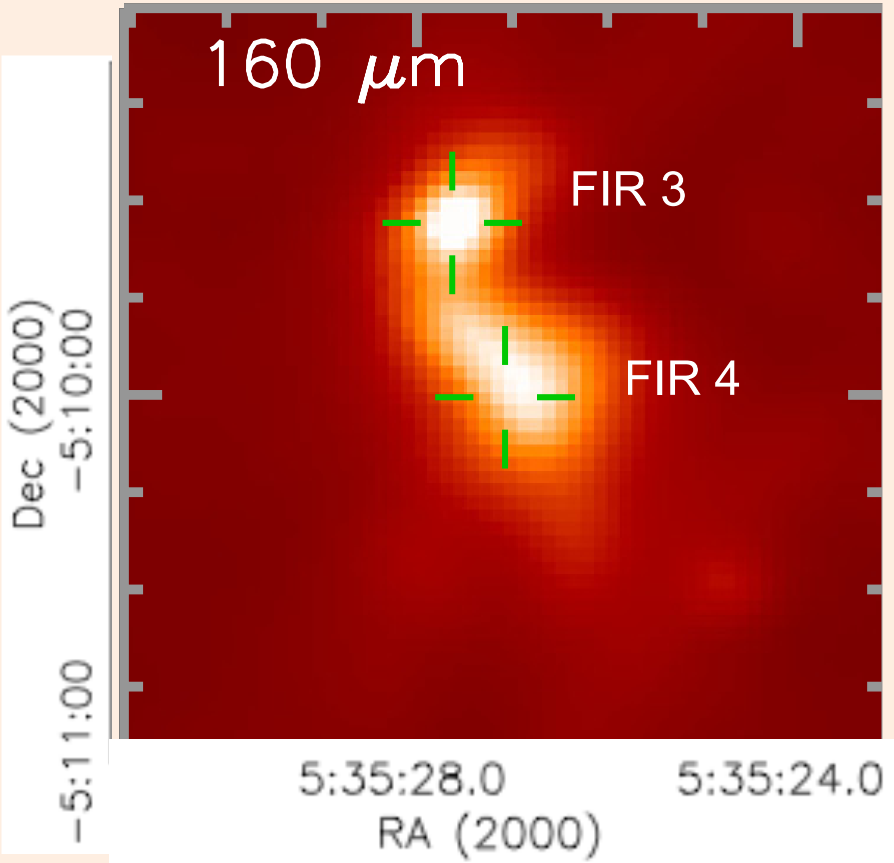
➔ **synchrotron emission**

➔ relativistic electrons

Mechanism:
Diffusive Shock Acceleration (DSA) mechanism (Drury 1991) that can work in the strong shocks produced by YSO jets.

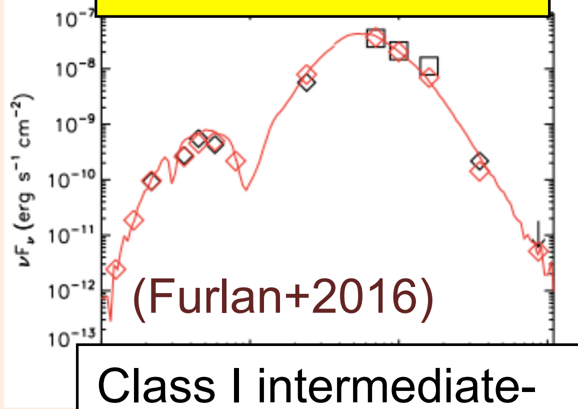
Confirmed by models (Araudo+2007, Padovani+2016)
=> Source of cosmic rays?

The nature of FIR 3 and FIR 4 in OMC-2



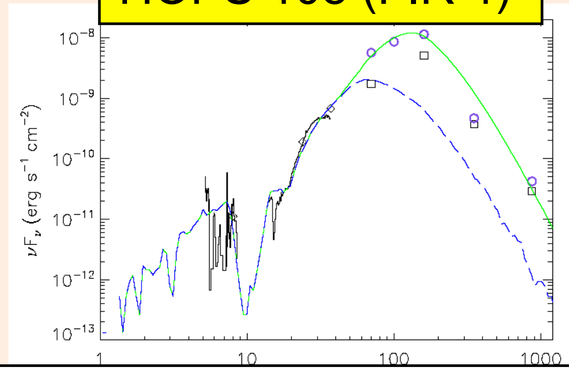
(Furlan et al. 2014)

HOPS 370= FIR 3



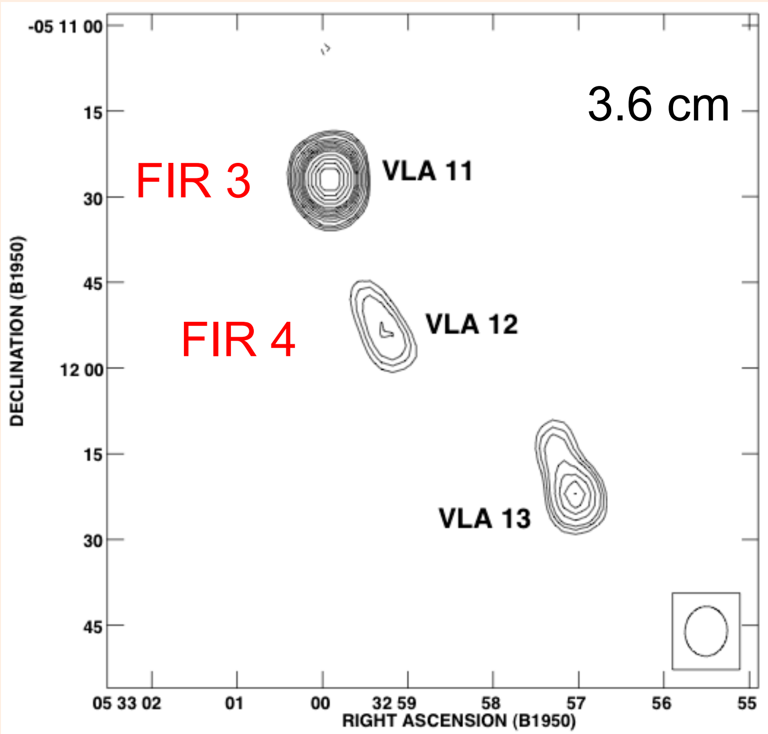
Class I intermediate-mass star L~500Lsun

HOPS 108 (FIR 4)



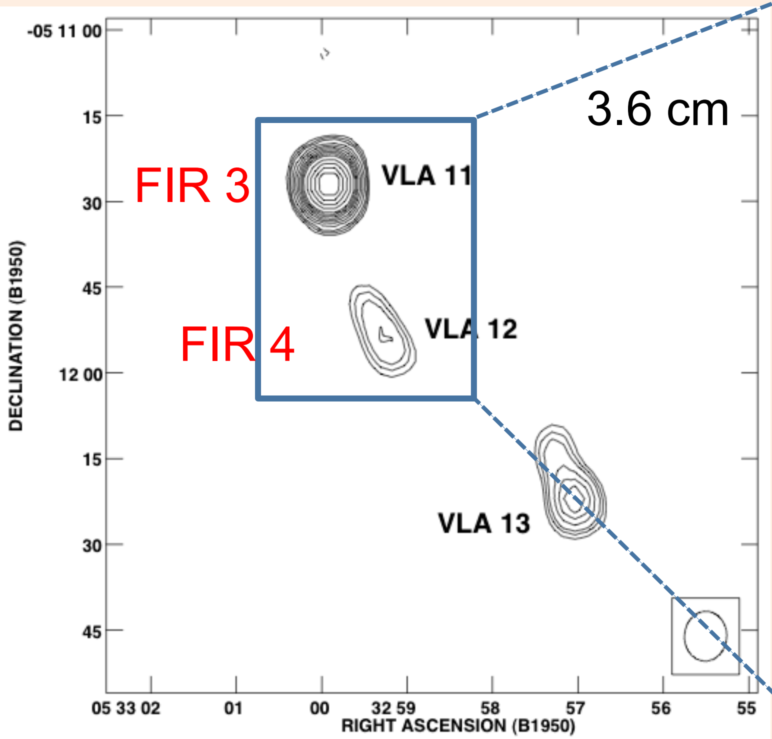
Complex region: protostellar model + clump of externally heated dust. L< 120Lsun

VLA radio observations of OMC-2 FIR 3 and FIR 4

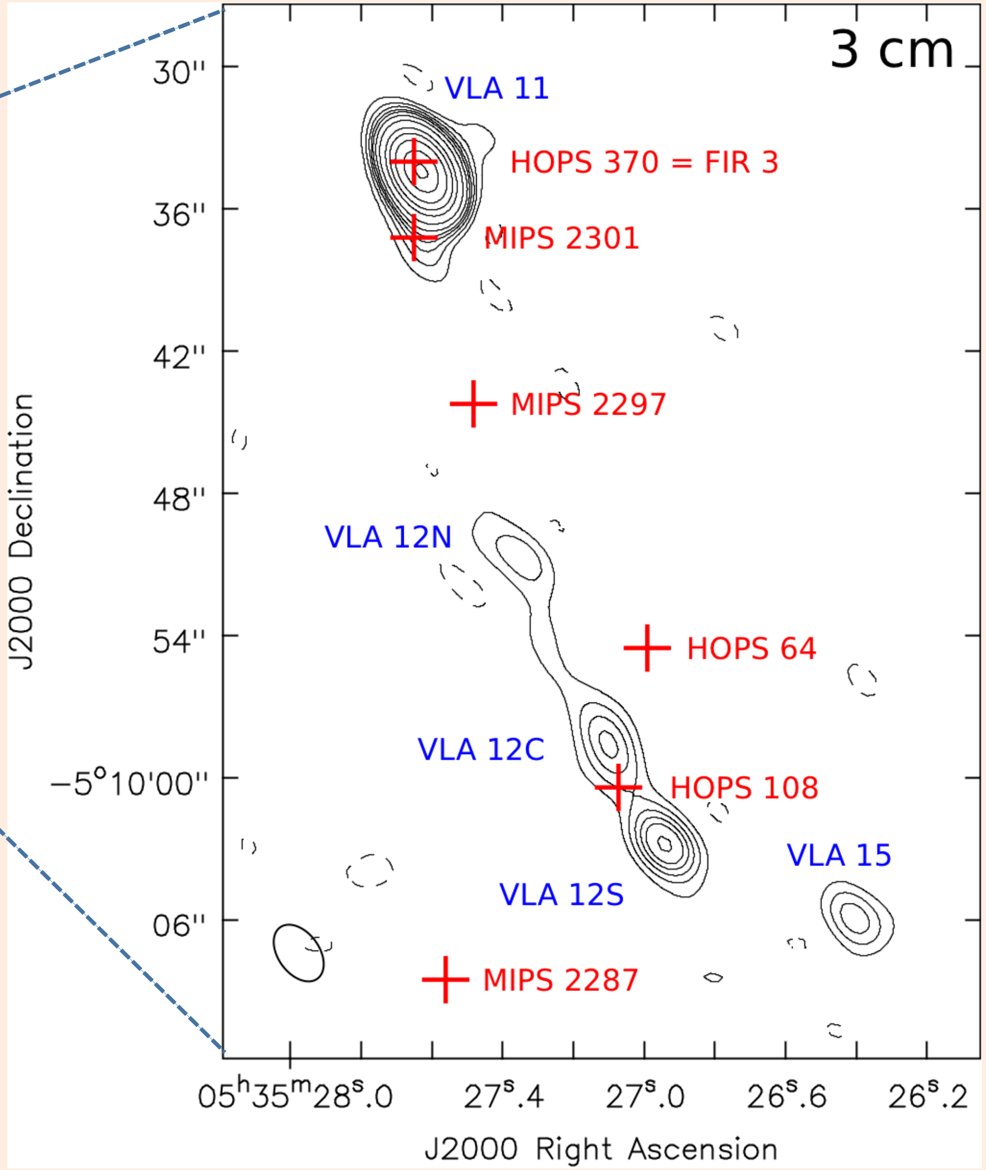


(Reipurth et al. 1999)

VLA radio observations of OMC-2 FIR 3 and FIR 4

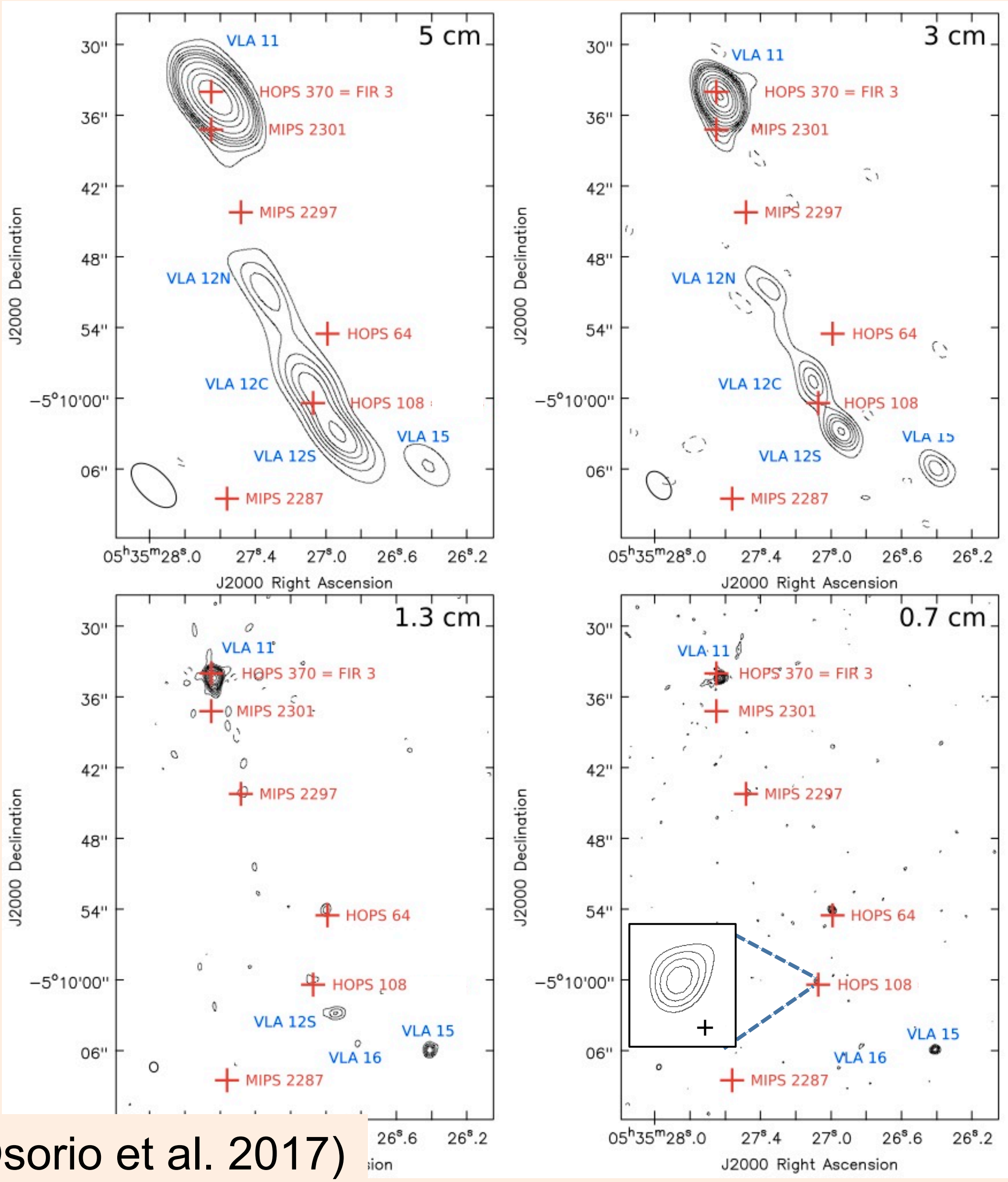


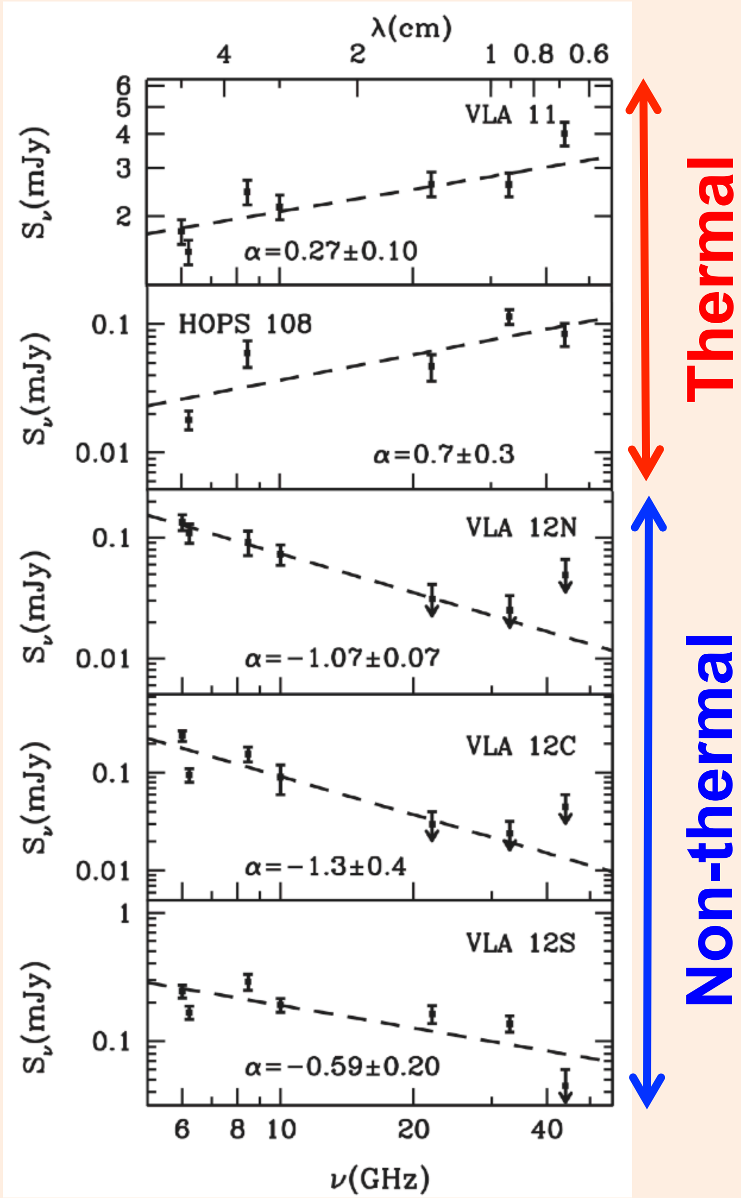
(Reipurth et al. 1999)



(Osorio et al. 2017)

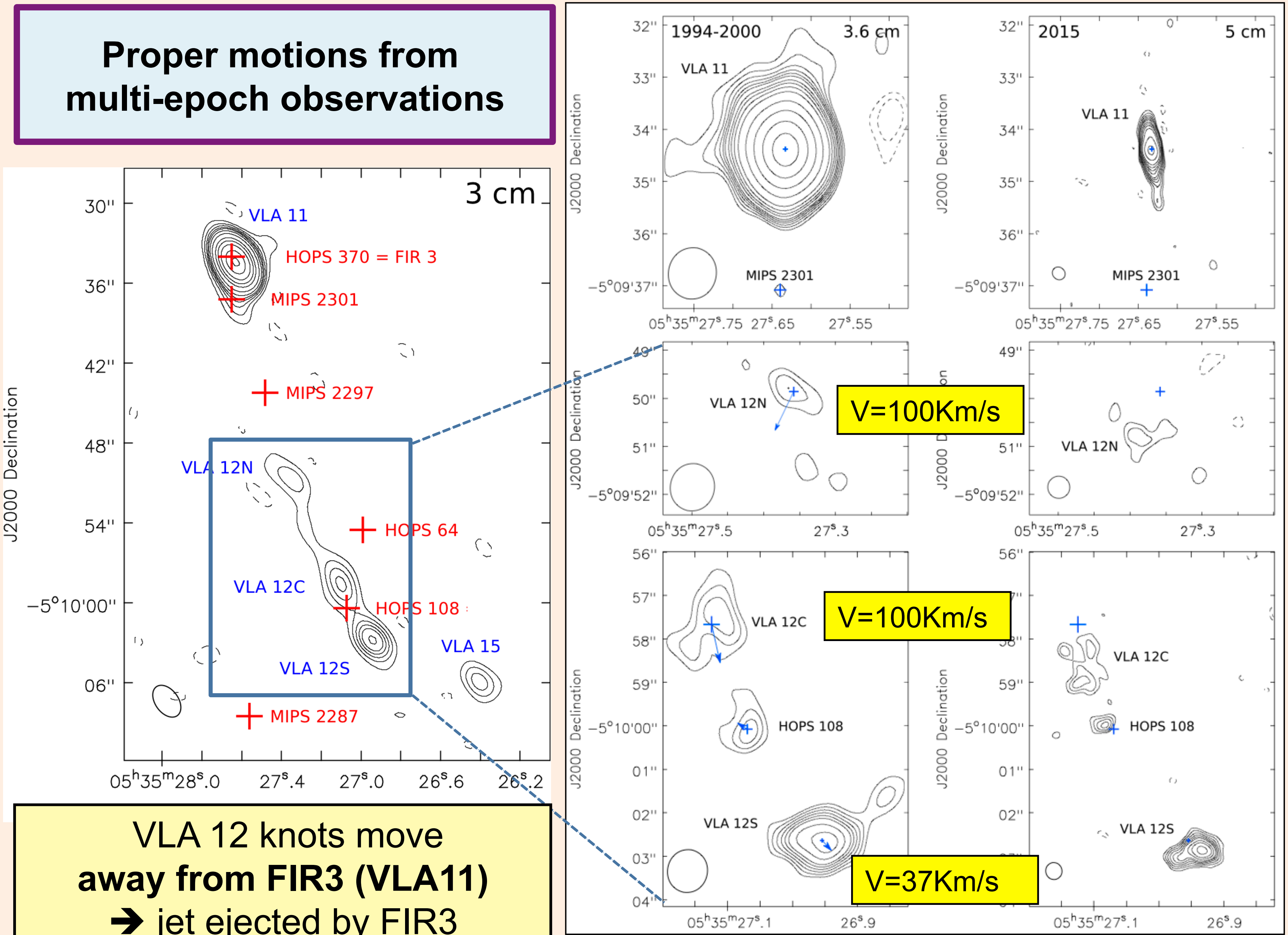
Multiwavelength observations of FIR 3 and FIR 4





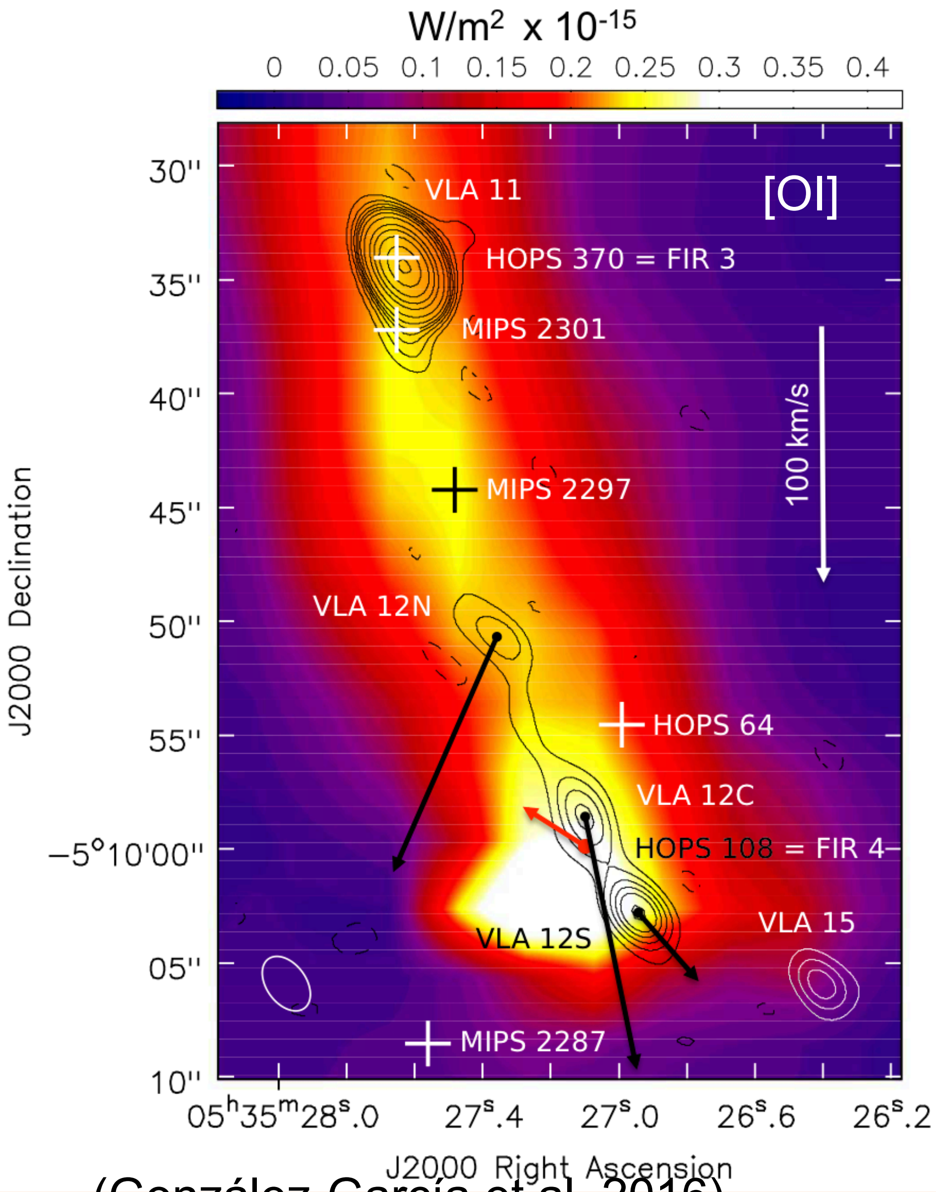
(Osorio et al. 2017)

Proper motions from multi-epoch observations



VLA 12 knots move
away from FIR3 (VLA11)
➔ jet ejected by FIR3

Additional evidence of shocks



(González-García et al. 2016)

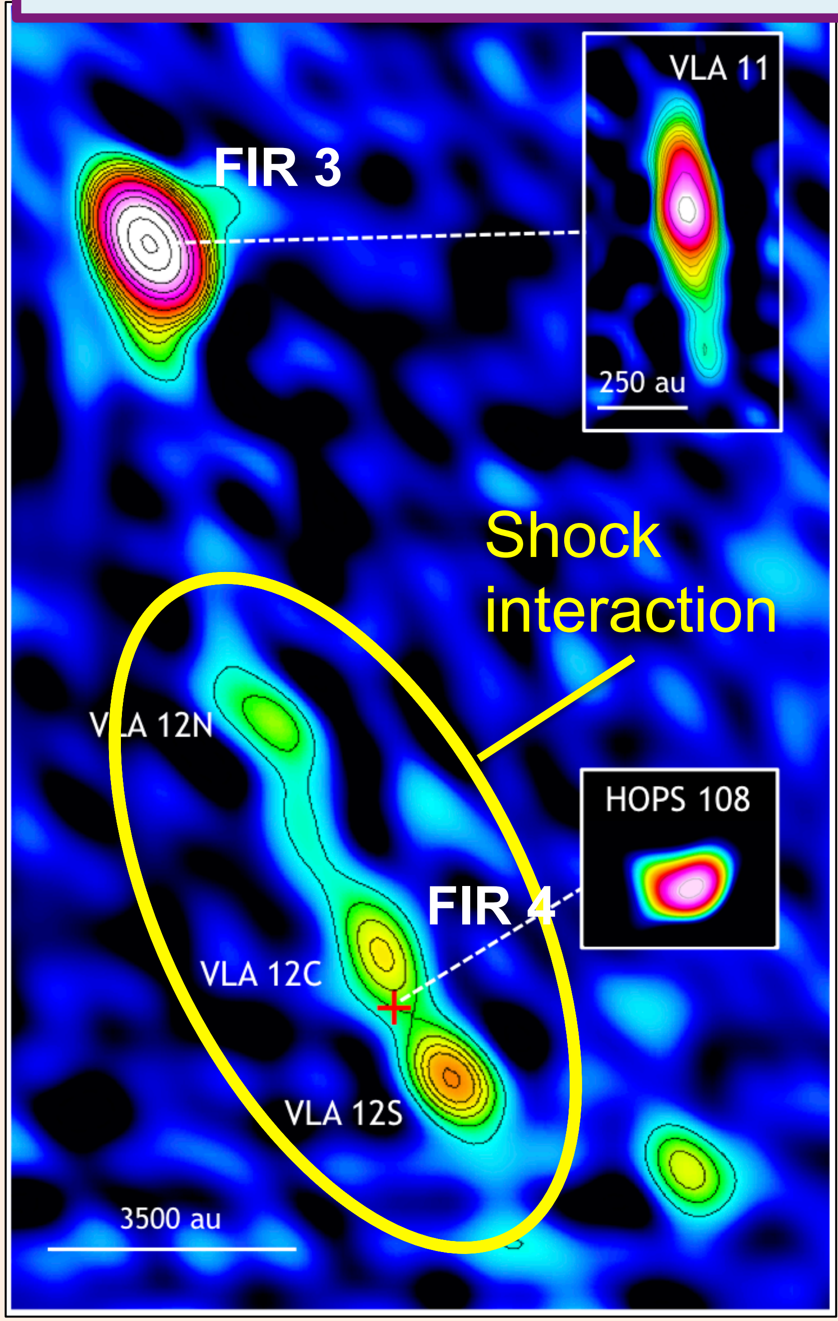
*The jet has been imaged in [OI], a shock tracer (González-García+2016). **The [OI] emission is brighter in the proximity of FIR4.**

*Other FIR shock tracers: high excitation CO, H_2O, OH lines near FIR3 and FIR4 (Manoj+2013, 2018).

*Shimajiri+2008,2015 found morphological, kinematical, and chemical evidence of shocks near FIR4.

*The impact of the jet with an ambient cloud may have triggered the formation of the HOPS 108 protostar (Osorio +2017).

The non-thermal jet from FIR 3: a possible source of CRs



FIR 3 drives a non-thermal radio jet.
A strong shock interaction is taking place at the region of its non-thermal lobe.
This is a source of relativistic particles and possible CRs.

Other shock tracers support this strong interaction (Shimajiri+ 2018, 2015 Manoj +2014, Gonzalez-Garcia+2016).

Some authors (Ceccarelli+2014, Fontani +(2017) have found evidences of a high cosmic-ray ionization rate at the position of FIR 4.

Padovani+ (2016) proposed that jet shocks could be strong accelerators of CR protons, which can be boosted up to relativistic energies. **We believe that the jet driven by FIR 3 is the responsible of these CRs.**

Thanks!