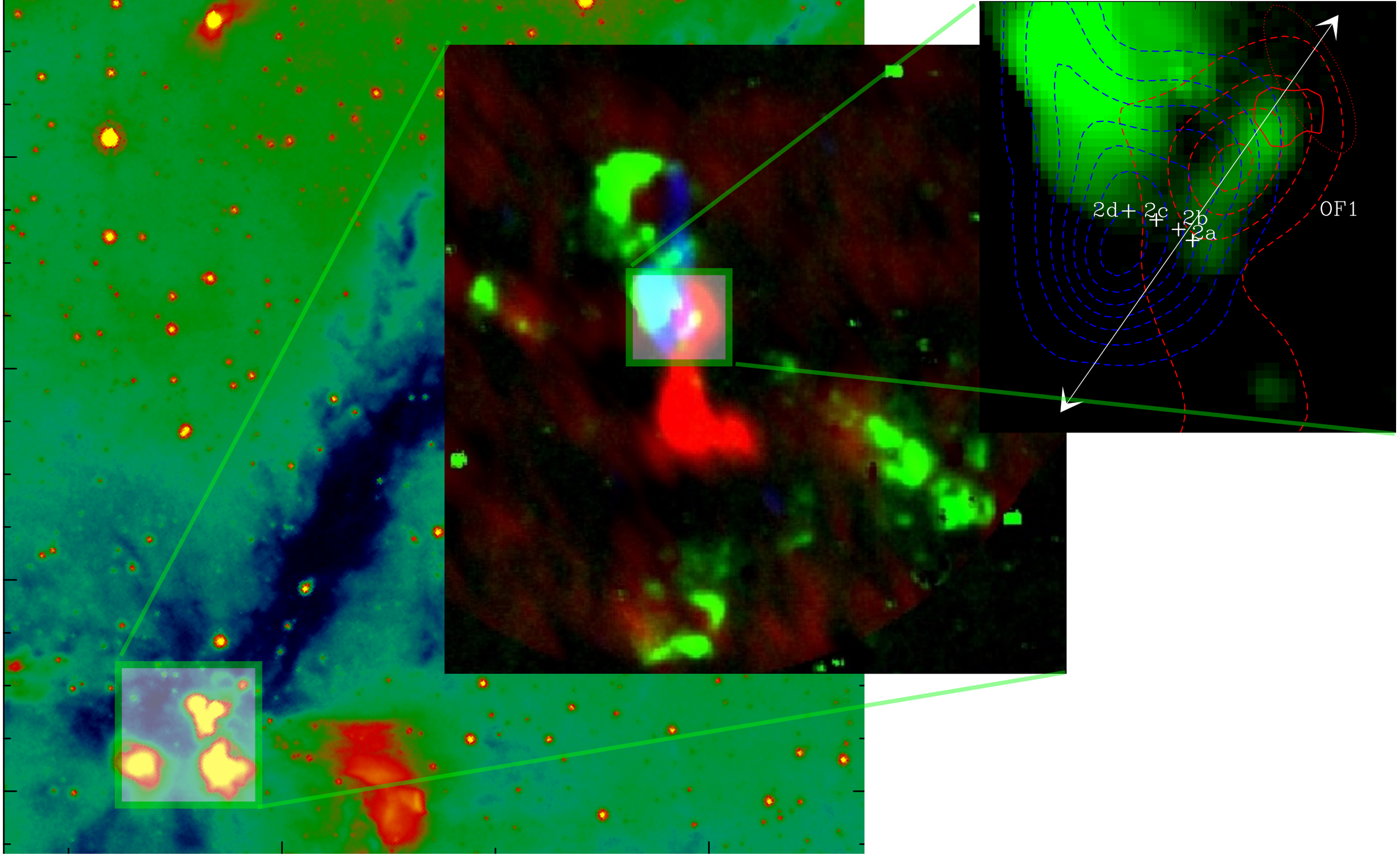
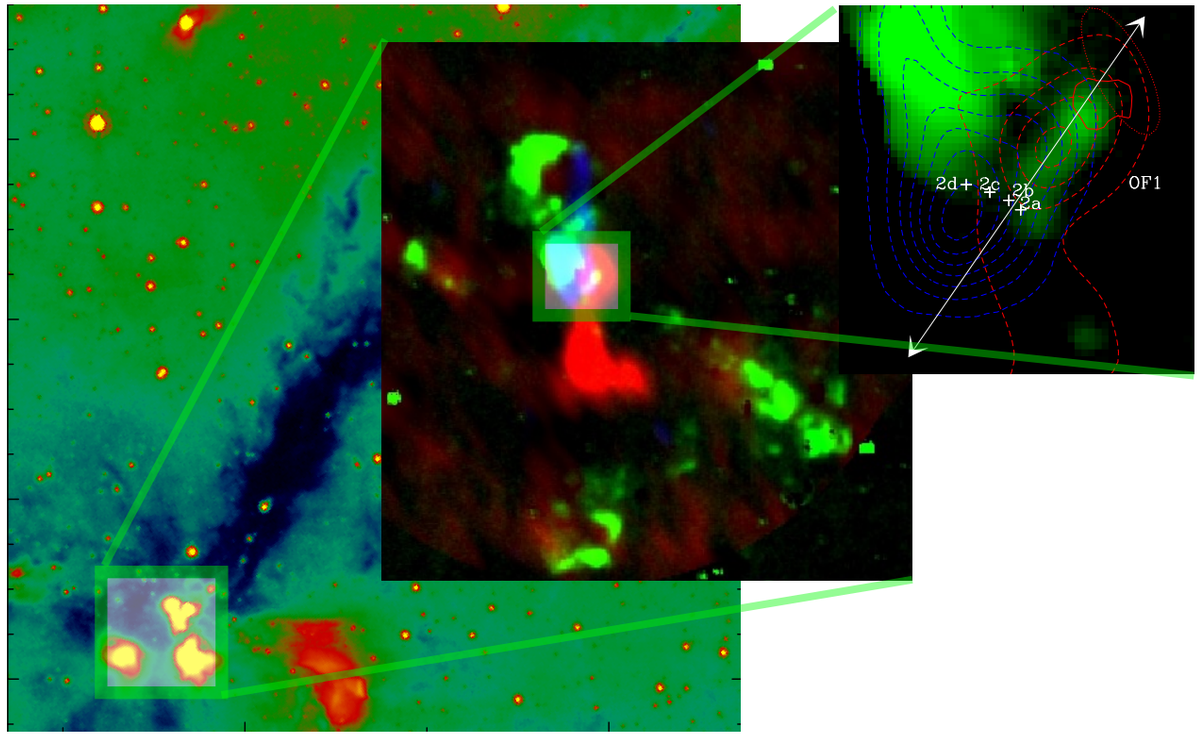


IRAS17233-3606: a close view of outflow multiplicity in a massive proto-cluster

Silvia Leurini (MPIfR)
Claudio Codella (INAF-Arcetri), Antoine Gusdorf (LESMA-Paris), Friedrich Wyrowski (MPIfR), Leonardo Testi (ESO)

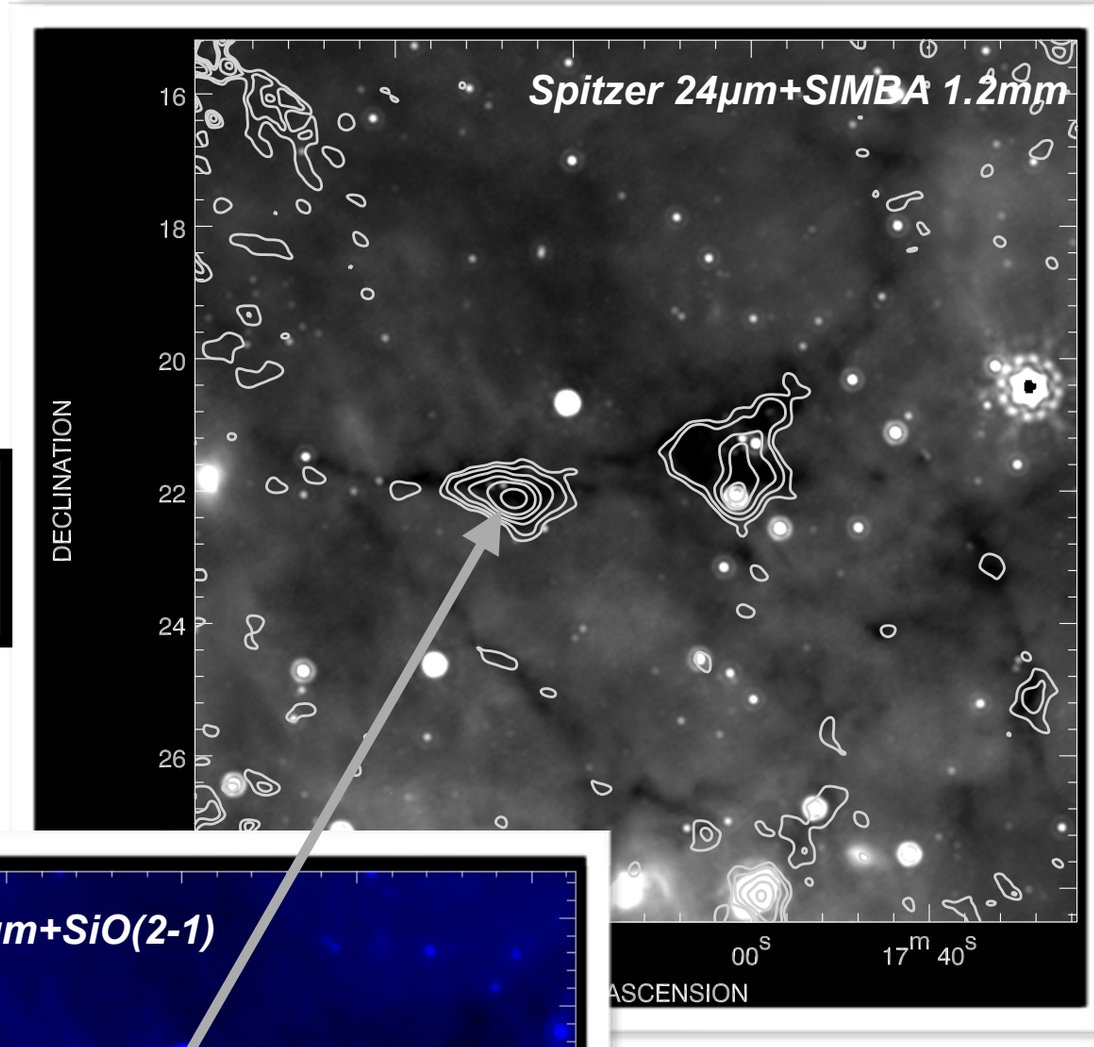
Content

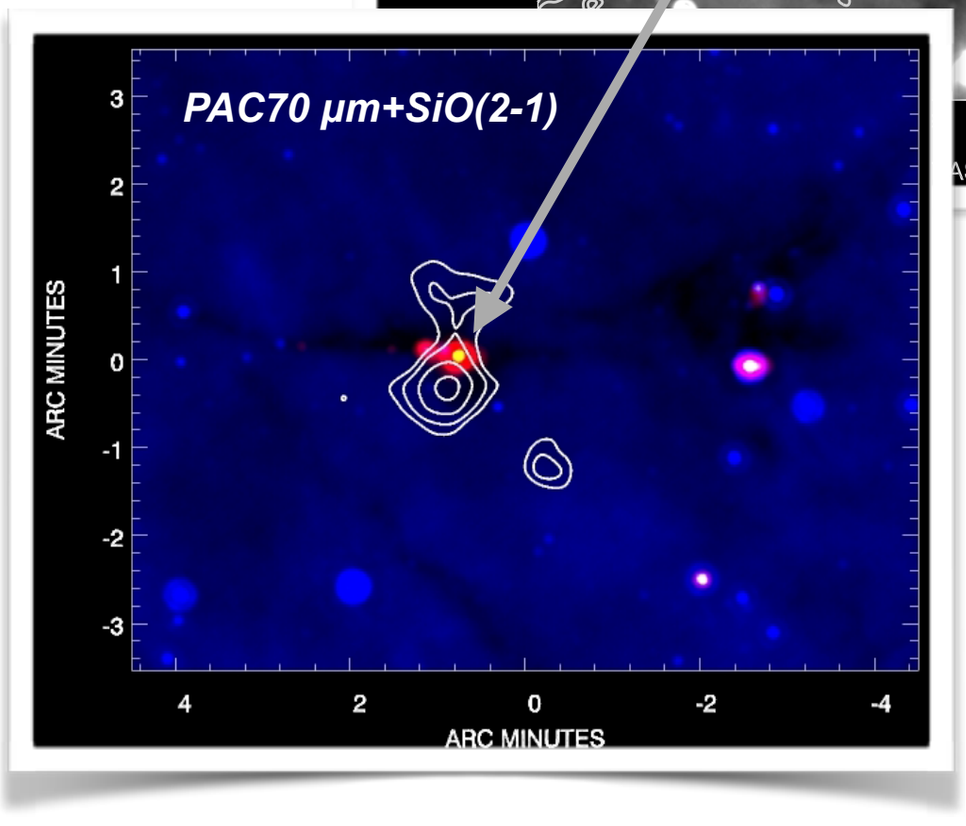


- The important of outflows/jets for SF
- IRAS 17233-3606: a case study
- Comparison with low-mass outflows
- Future perspectives

The role of outflows and jets in understanding massive SF

1. *Outflows indicate whether a core is protostellar or prestellar;*

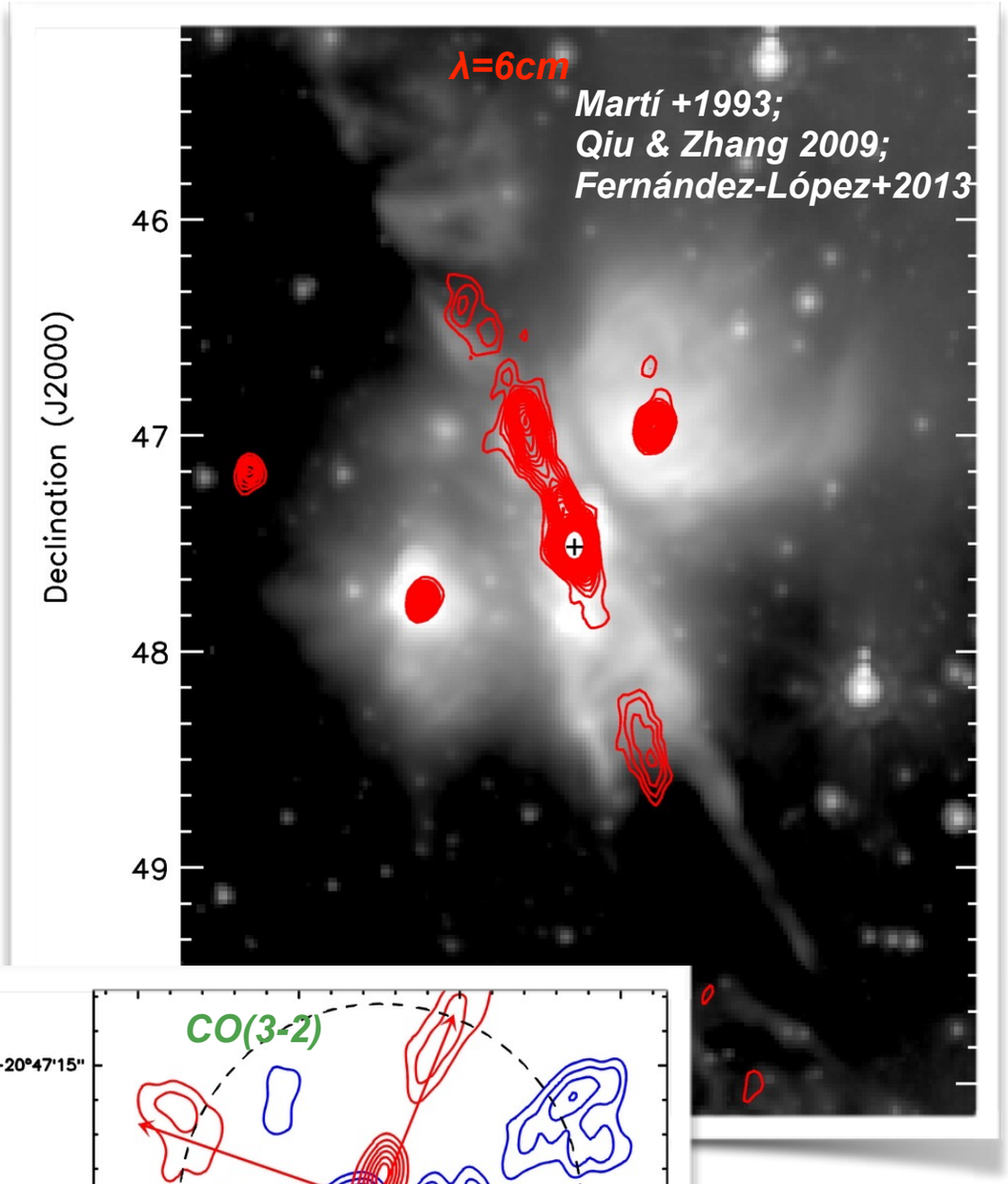


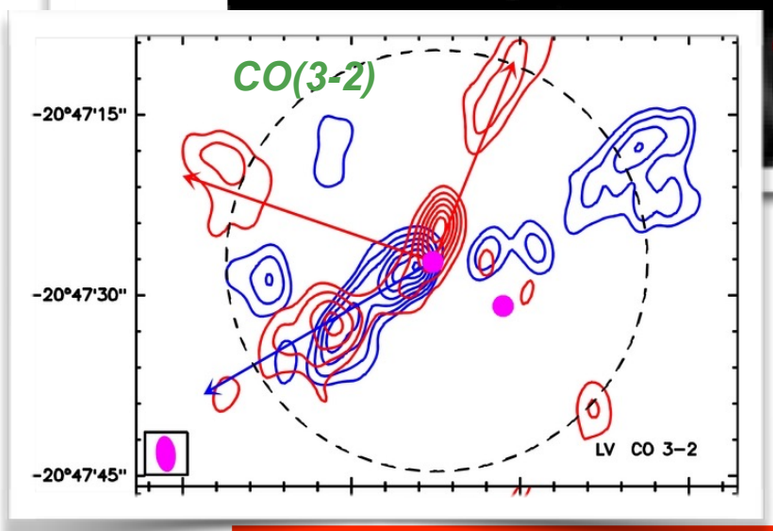


Vasyunina+2009; Linz+2013

The role of outflows and jets in understanding massive SF

1. Outflows indicate whether a core is protostellar or prestellar;
2. *Collimated outflows trace kinematics at very high-resolution and help to interpret gas kinematics at larger scales;*



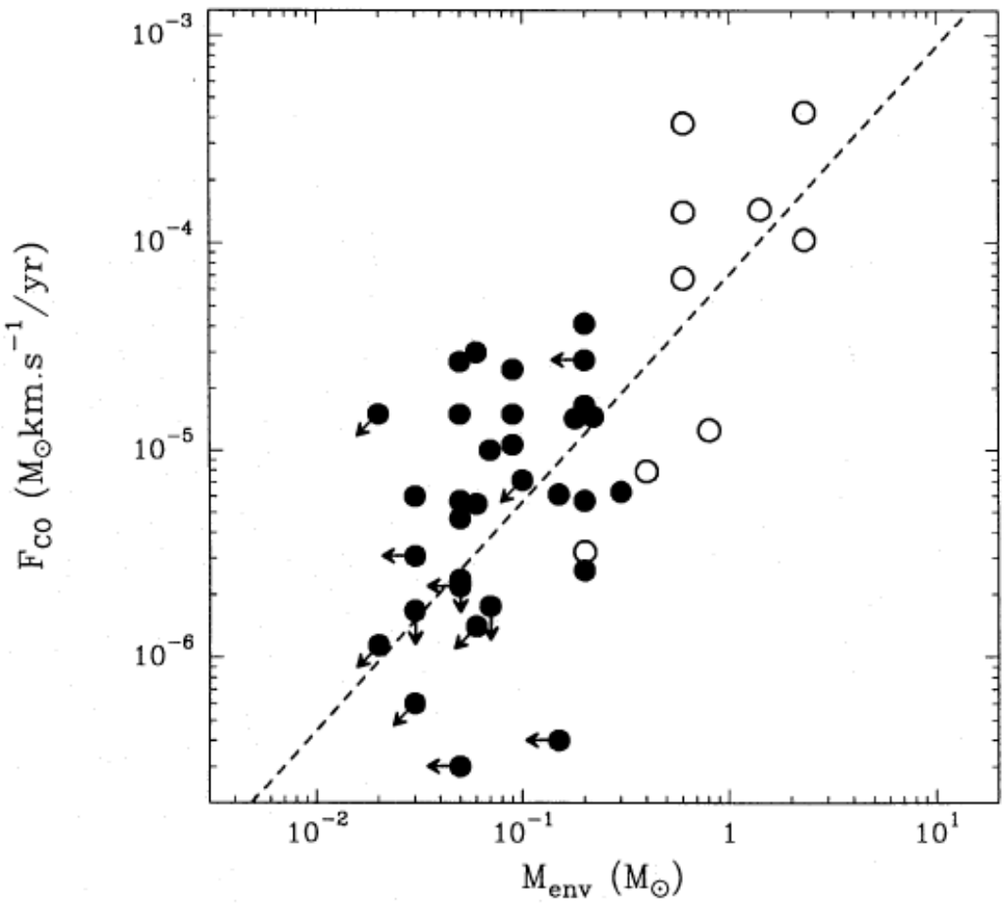


But NO CO emission on the radio jet at small scale!

The role of outflows and jets in understanding massive SF

1. Outflows indicate whether a core is protostellar or prestellar;
2. Collimated outflows trace kinematics at very high-resolution and help to interpret gas kinematics at larger scales;
3. *Outflow flux–core mass relations could indicate a switch to a different SF mode if they break at some core mass;*

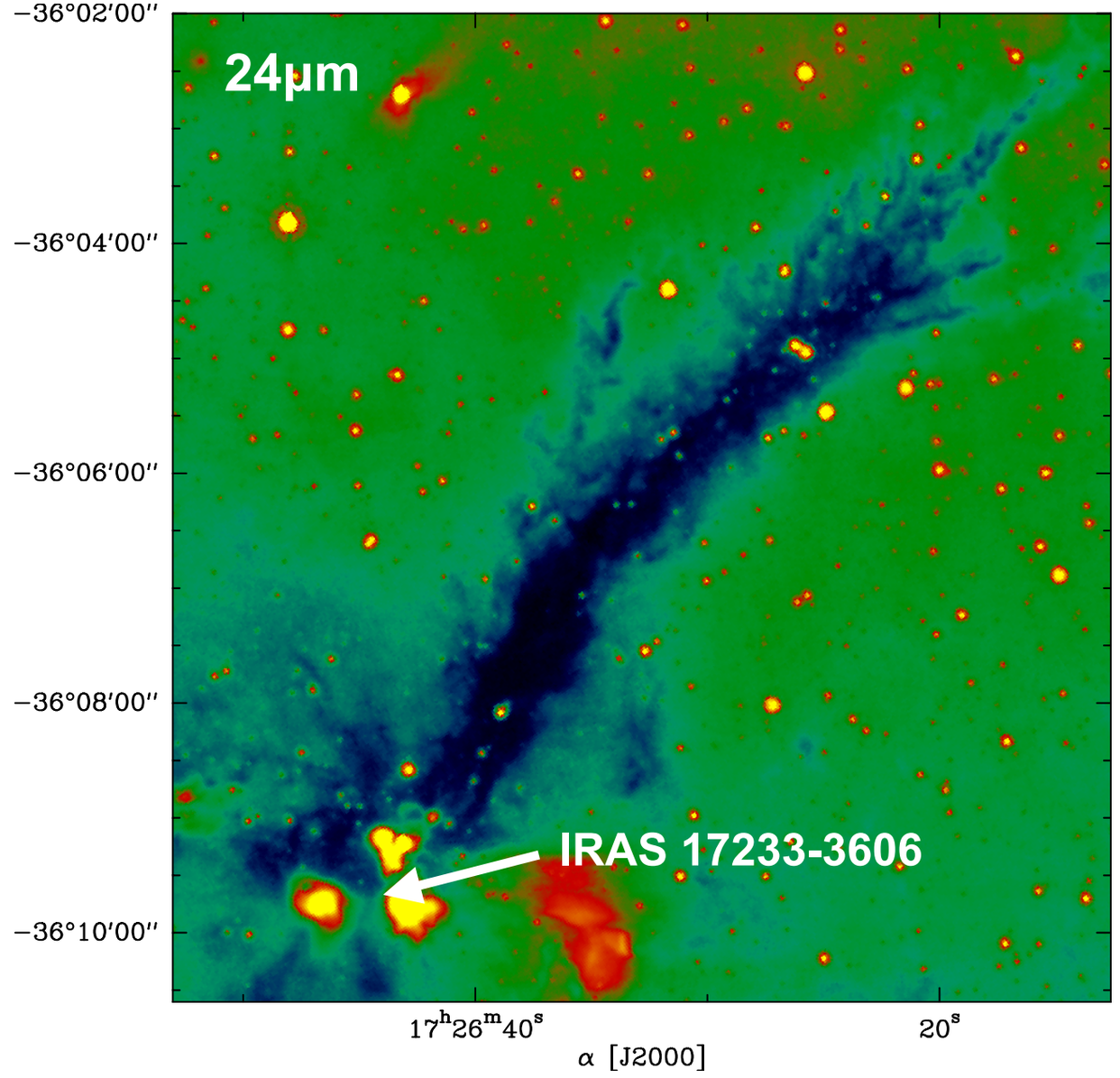
Bontemps et al. 1996



IRAS 17233-3606: a laboratory for high-mass SF

Some facts:

- the 10th strongest ATLASGAL massive clump
- closeby, d≤1kpc
- $L = 2\ 10^4\ L_\odot$
- early phase of evolution, still accreting material
  - rich molecular spectrum
  - large scale bipolar outflow
  - still dark at 8μm



Observations:

1. SMA CO(2-1), 5”× 2” resolution
2. SMA SiO(5-4), 3”× 3” resolution
3. UKIRT H_2 map, 0.5” resolution
4. VLA maps, down to 0.3” resolution

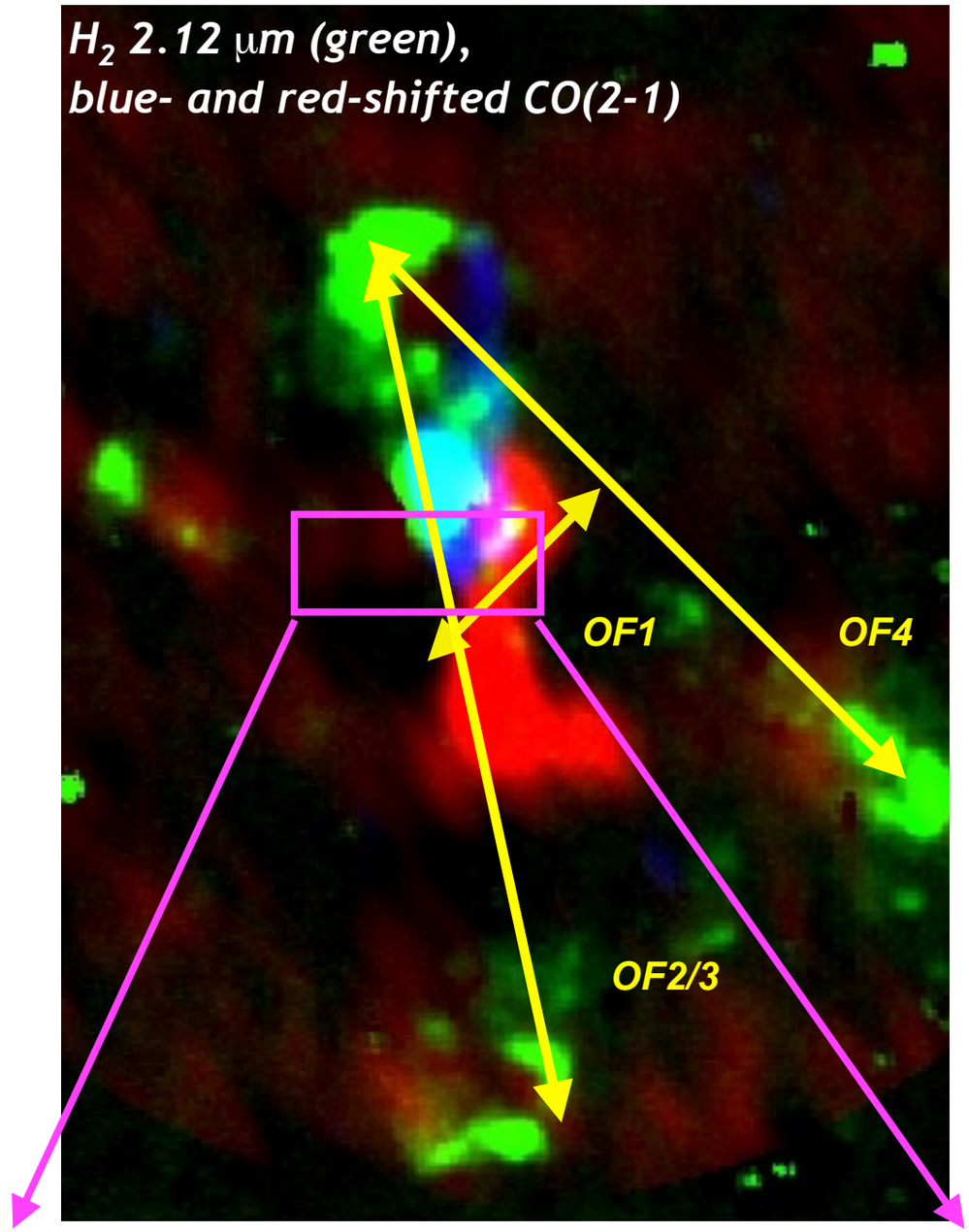
Outflow multiplicity in IRAS 17233-3606

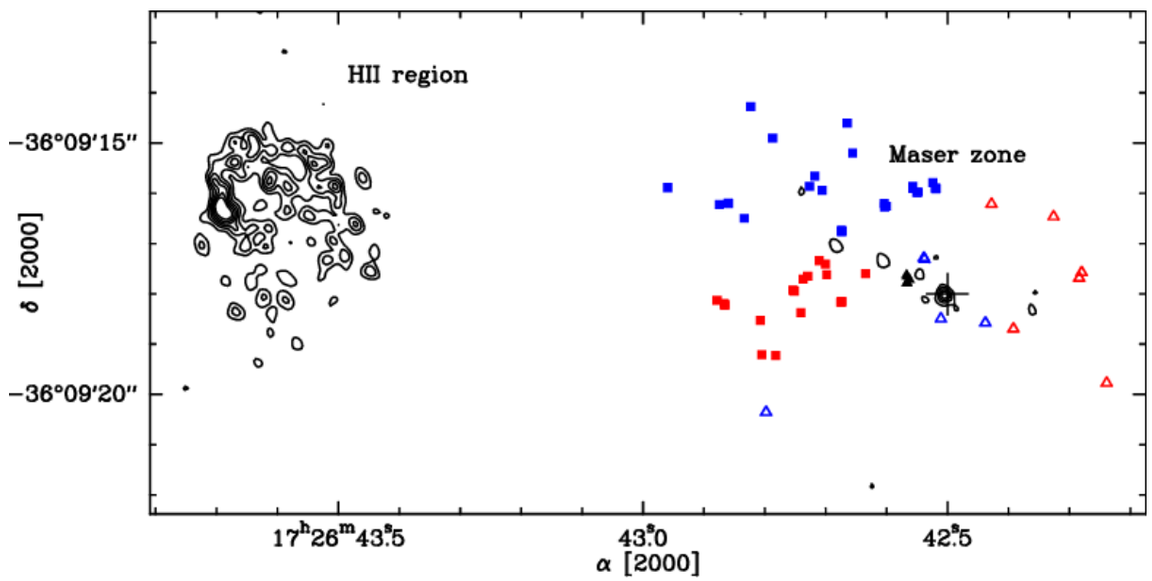
Zapata+2008; Leurini+2009, 2011, 2013

- four compact cm continuum sources in within 0.5”;
- the large scale molecular outflow splits in to up three/four flows seen in CO and SiO;
- the flows have very high collimations, and masses and energetics which point to early B YSOs;

Observations:

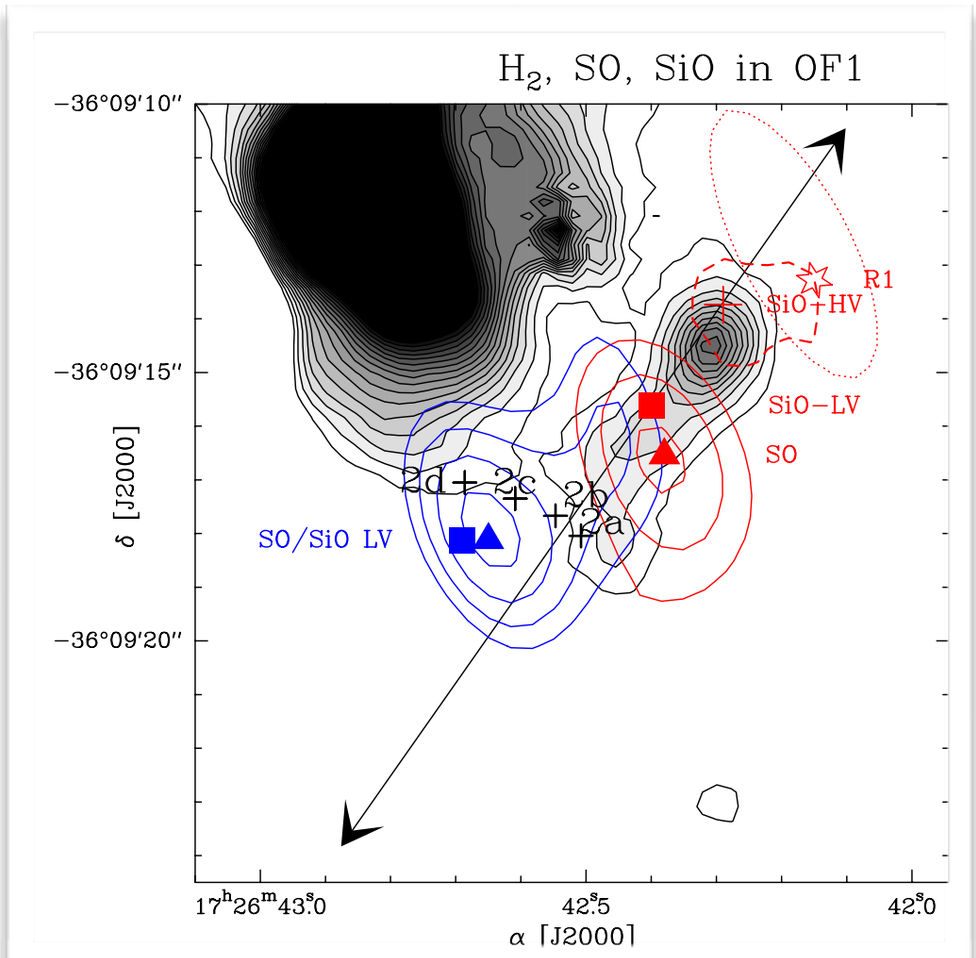
1. SMA CO(2-1), 5”× 2” resolution
2. SMA SiO(5-4), 3”× 3” resolution
3. UKIRT H_2 map, 0.5” resolution
4. VLA maps, down to 0.3” resolution





The molecular outflow OF1

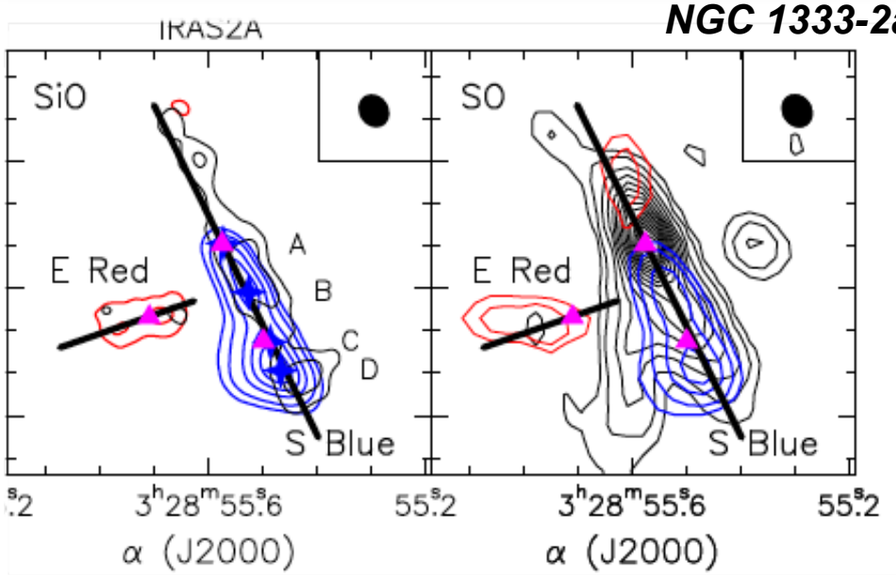
Leurini+2009, 2013

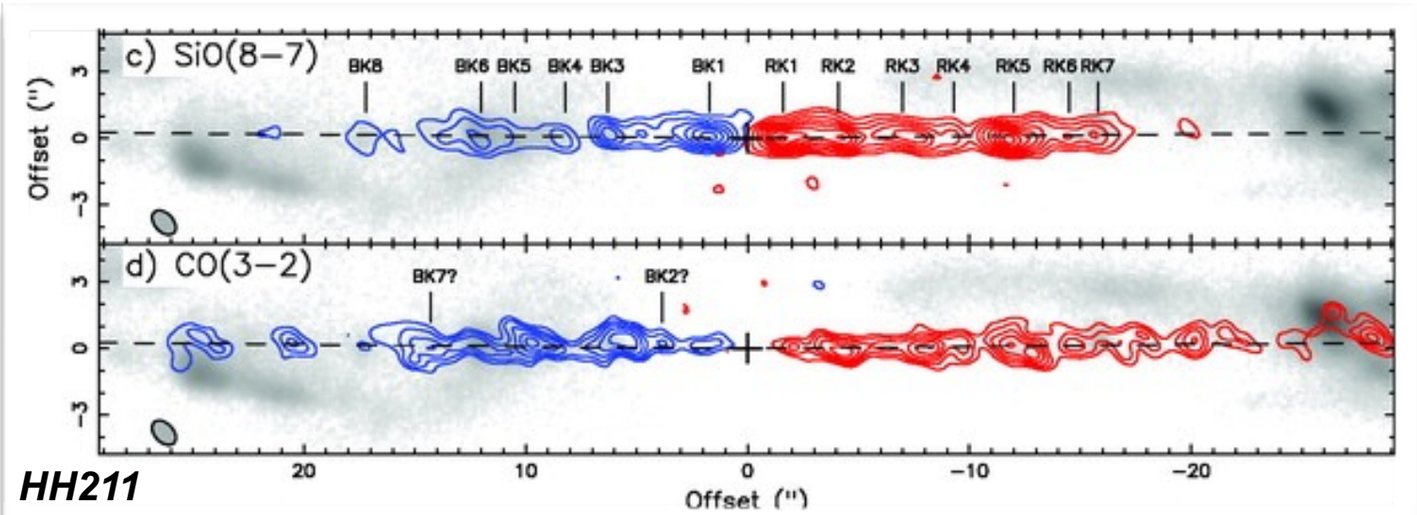


- H_2 highly collimated emission
- SiO closely follows the highly collimated H_2 jet
- SO and SiO show a very similar morphology
- Kinematical pattern: LV SiO and SO, HV SiO, EHV CO

similar to prototypical low-mass class 0 outflows
(HH212, NGC 1333-2a, HH211; e.g. Codella+2007, 2014;Lee+2007)

NGC 1333-2a



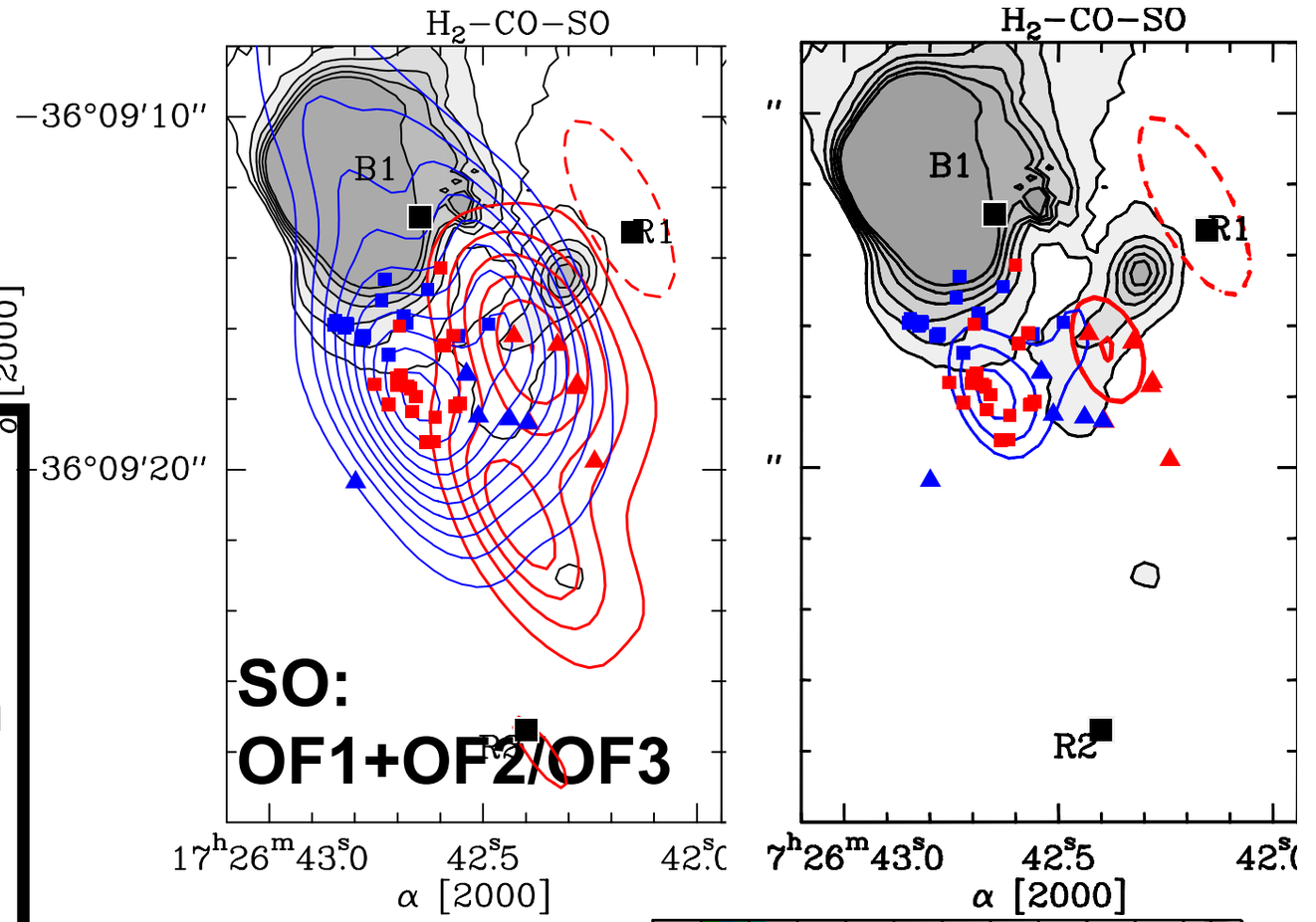


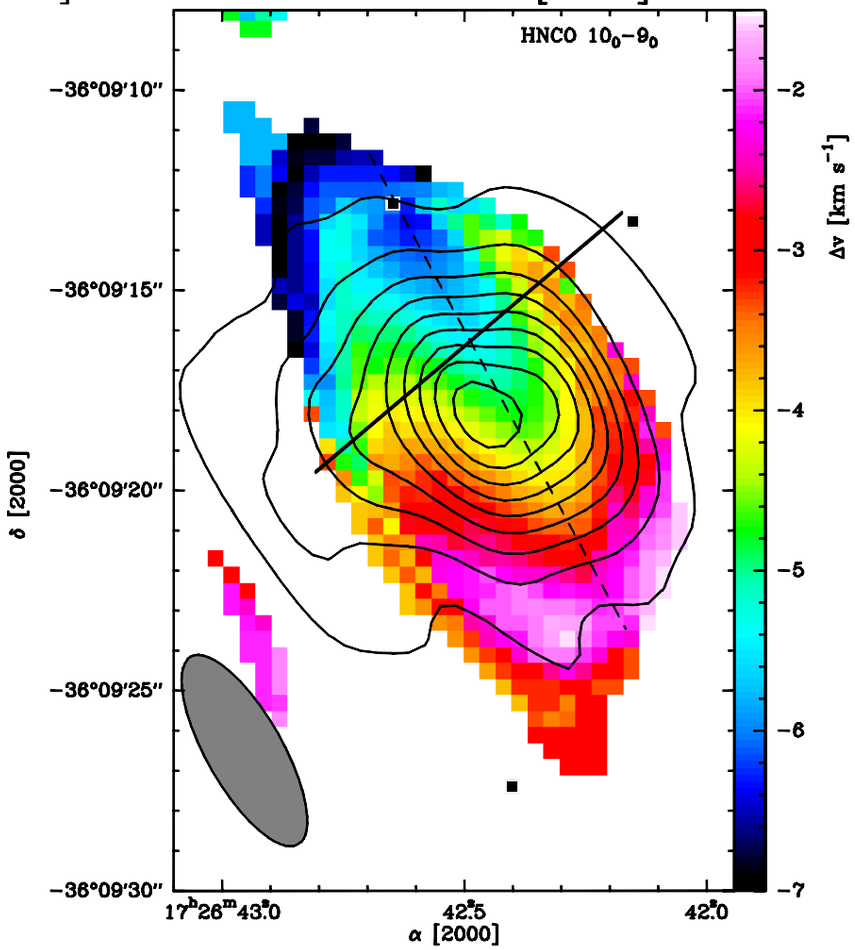
HH211

The inner region of IRAS 17233-3606

Zapata+2008; Leurini+2009, 2011, 2013

- four compact cm continuum sources in within 0.5";
- the large scale molecular outflow splits in to up three/four flows seen in CO and SiO;
- the flows have very high collimation, and masses and energetics which point to early B YSOs;
- complex chemistry detected in the entrained gas: SO, HNCO, CH_3OH, CH_3CN;
  - ✦ OF1 and OF2/OF3: CH_3OH, CH_3CN, SO
  - ✦ OF2/OF3: HNCO

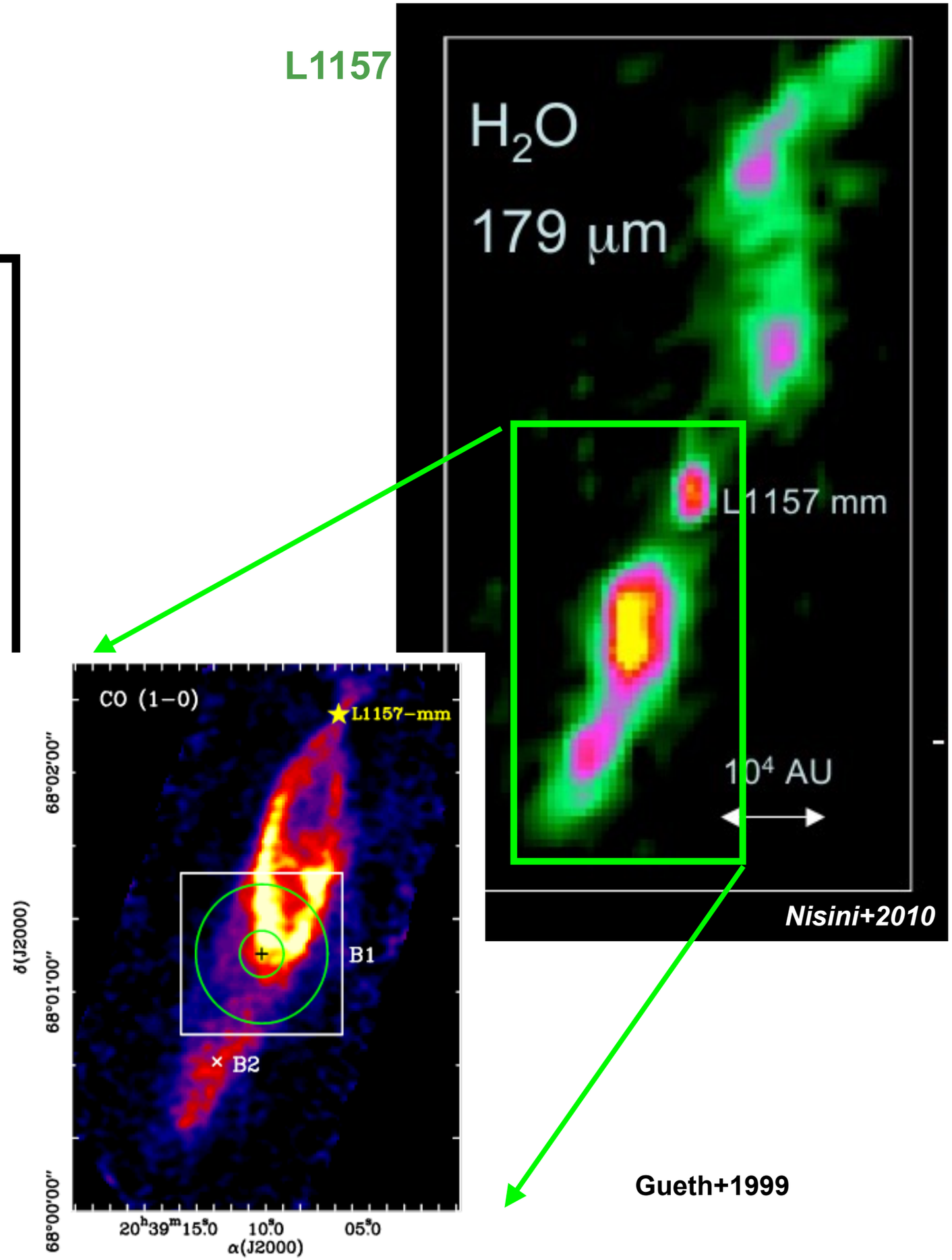




Chemistry of low-mass outflows

Some facts:

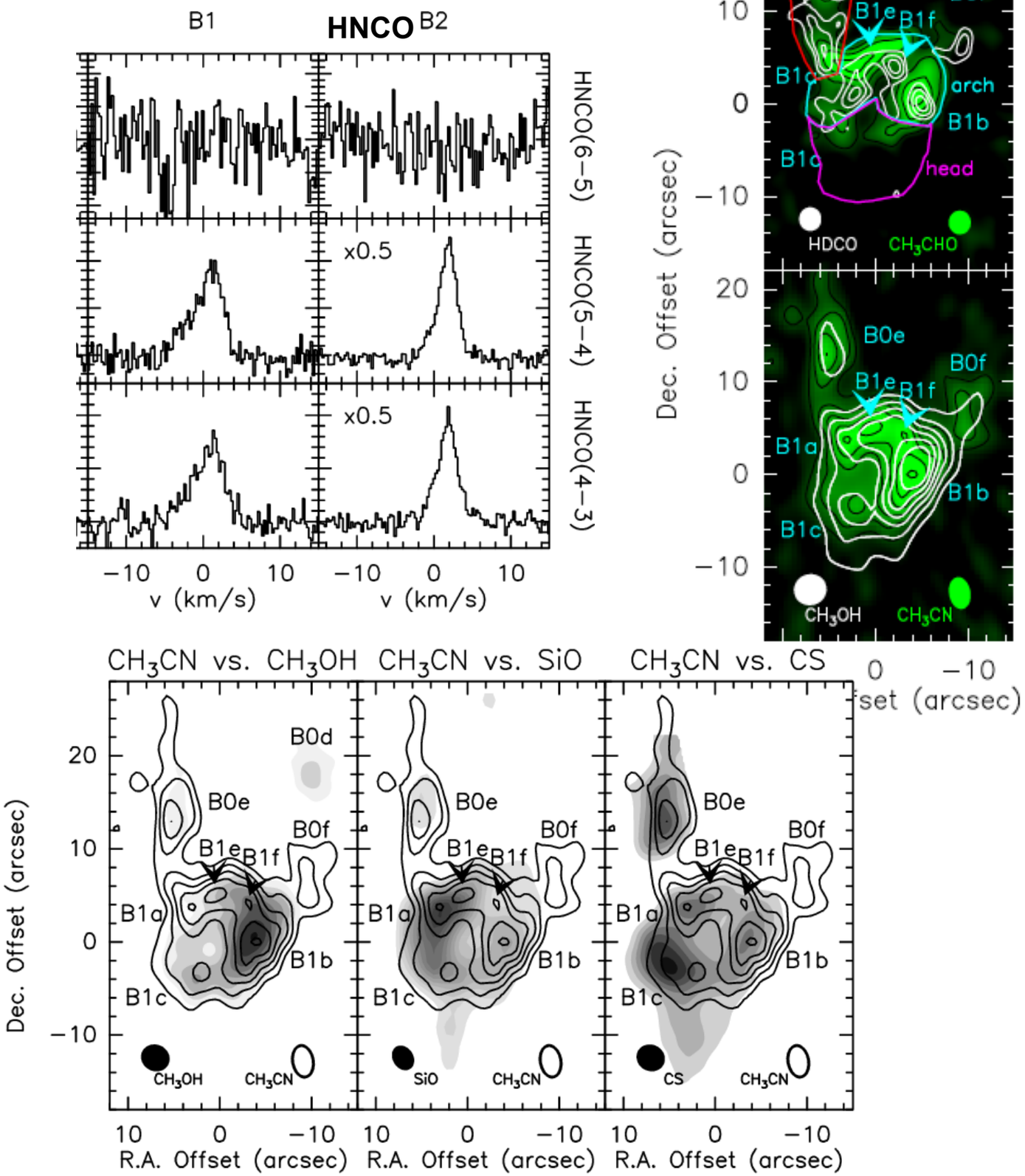
- powered by a class 0 YSO;
- d = 250 pc;
- southern lobe consists of 2 cavities created a precessing, highly collimated jet;
- B1 is the brightest shock episode at the apex of the second cavity;



Chemistry of low-mass outflows

Some facts:

- powered by a class 0 YSO;
- d = 250 pc;
- southern lobe consists of 2 cavities created a precessing, highly collimated jet;
- B1 is the brightest shock episode at the apex of the second cavity;
- *chemically active outflow:* more than 20 molecules detected, some first detection in shocks:
  - shock tracers: e.g. SiO
  - hot-core tracers: CH_3CN, ***HNCO***, ***CH_3CHO***
  - deuterated species: HDO, HDCO, and CH_2DOH



Codella+2009, 2015; Fontani+2014;Rodríguez-Fernández+2010

IRAS 17233-3606

The exceptional close distance (d≤1kpc) of IRAS 17233-3606 and the favourable geometry allow to:

I. reach high linear resolution with relatively low beam (5”× 2”);
II. detect H_2 very close to the inner region;
III. resolve the large scale outflow in 3-4 collimated flows;
IV. associate complex molecules to entrained gas from different outflows;

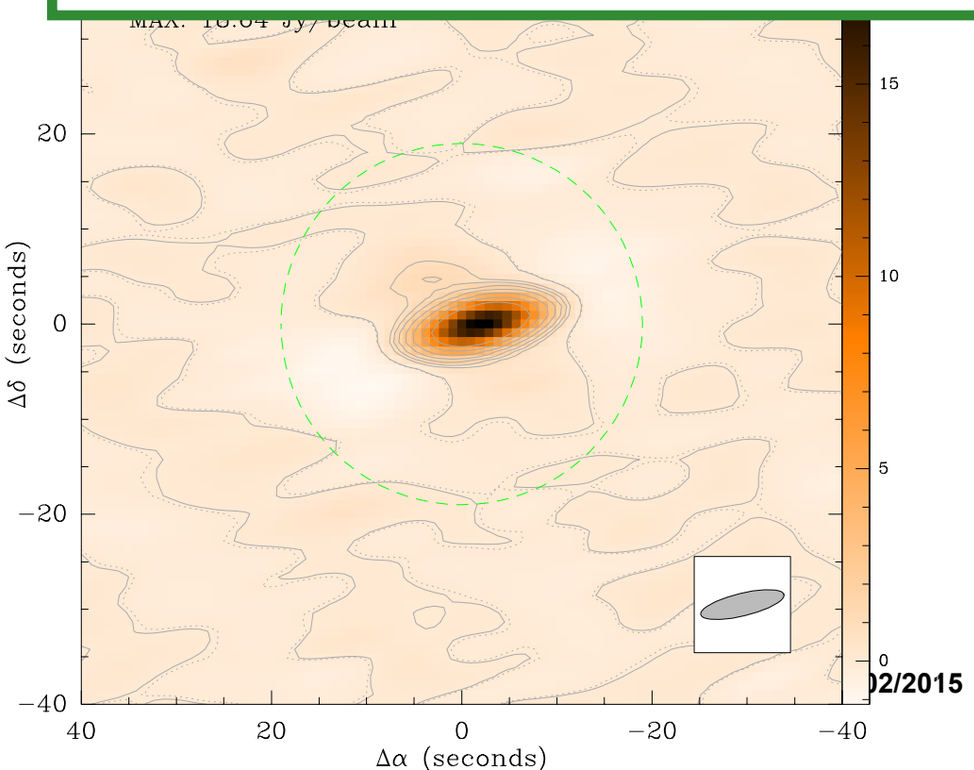
Open questions:

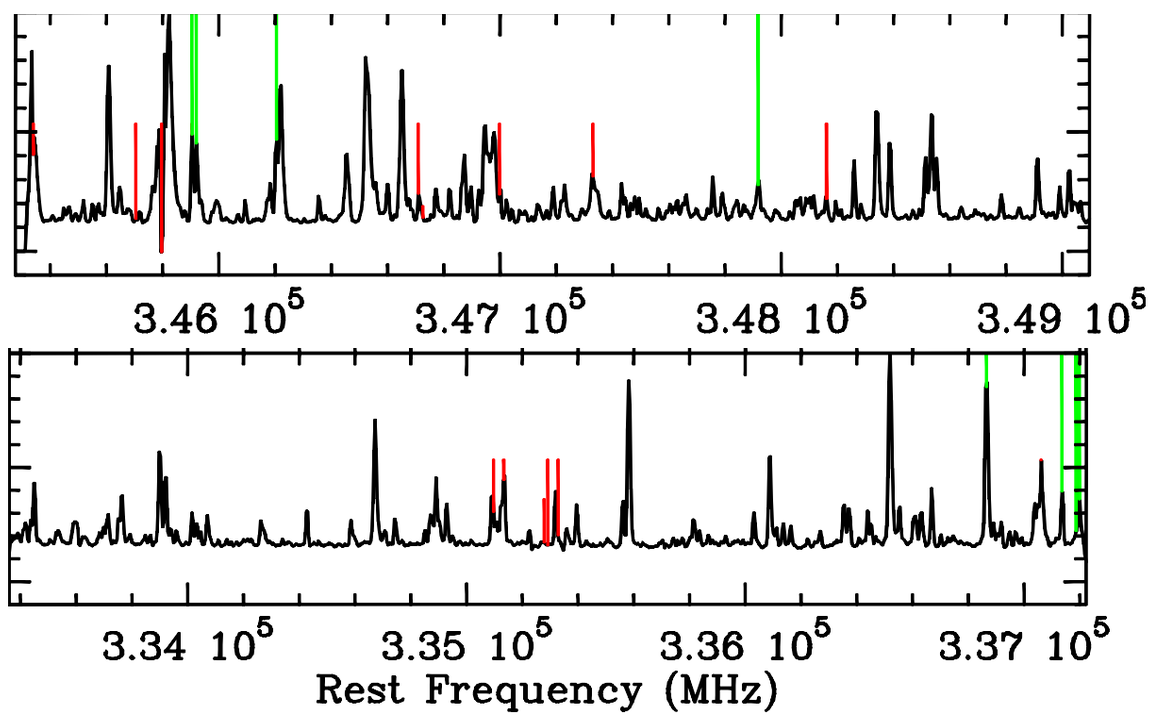
1) power sources are unidentified (4 VLA objects in ~1”);
2) relations flux/momentum-core properties;
3) kinematics of the EHV gas;

The first Galaxy-scale hunt for the earliest phases of the formation of the most massive stars

ALMA+ACA+APEX cycle 2 project, P.I. T. Csengeri

42 massive YSOs at 0.5”: CO, SiO, and other outflow tracers

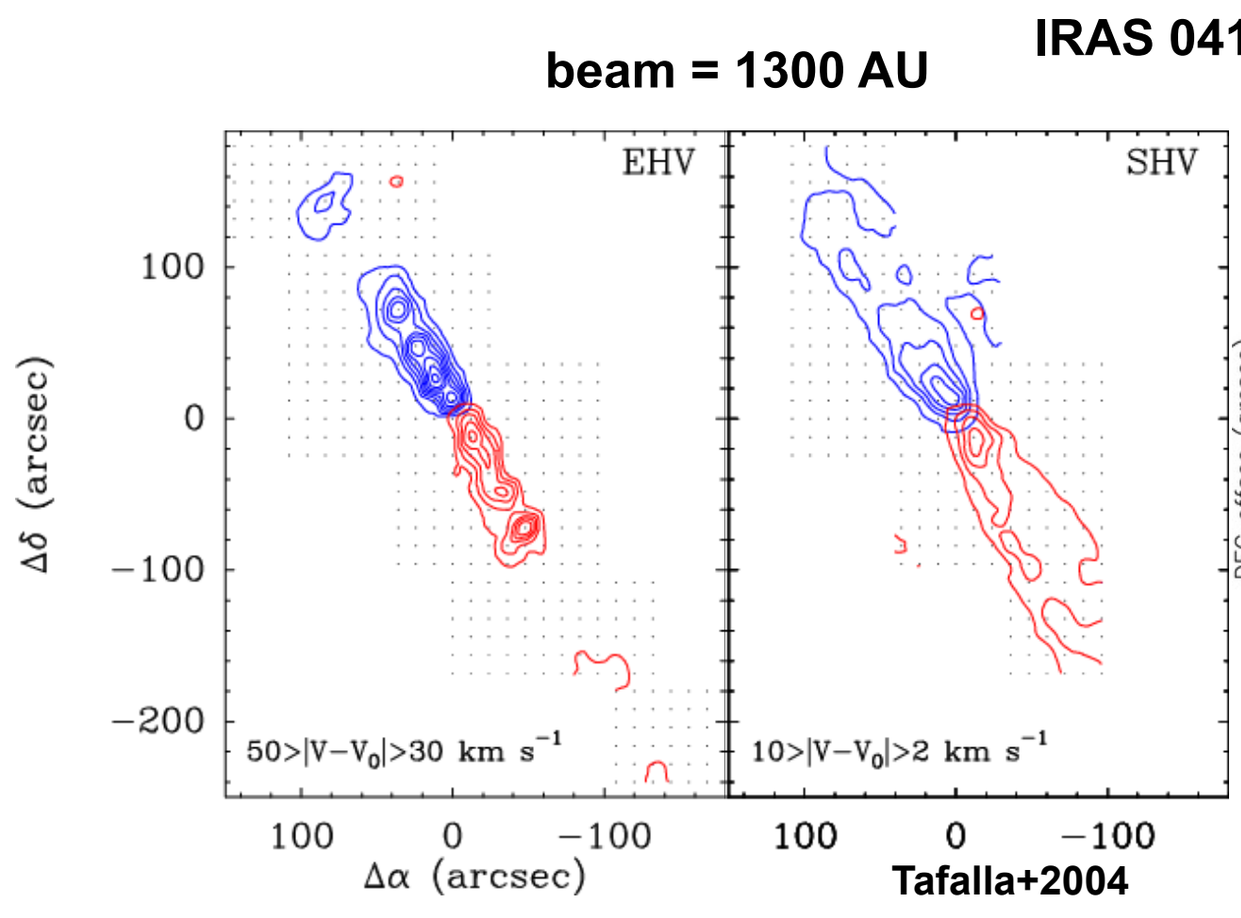




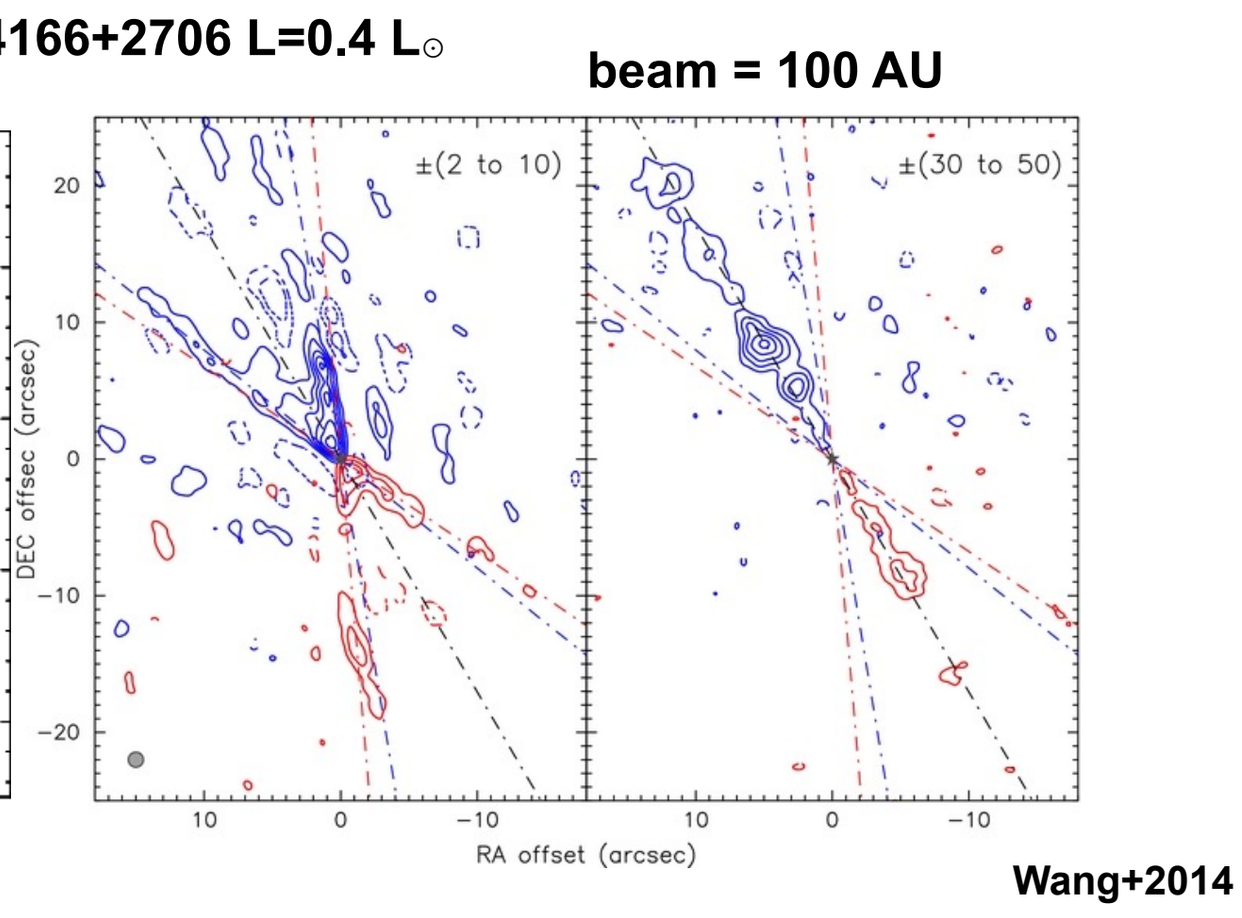
Future perspectives

ALMA sensitivity and resolution will:

I. show if IRAS 17233-3606 (and L1157) are *special cases;*
II. allow more complete view of outflows through detection of more species;
III. allow a safer determination of outflow multiplicity in high-mass clumps;
IV. allow detection of EHV (weak) emission and to verify whether high-mass outflows show the same kinematics as their low-mass counterpart;
V. allow to study outflow-flux envelope relations as for low-mass YSOs;



Tafalla+2004



Wang+2014