Millimeter line observations of Class 0 protostars

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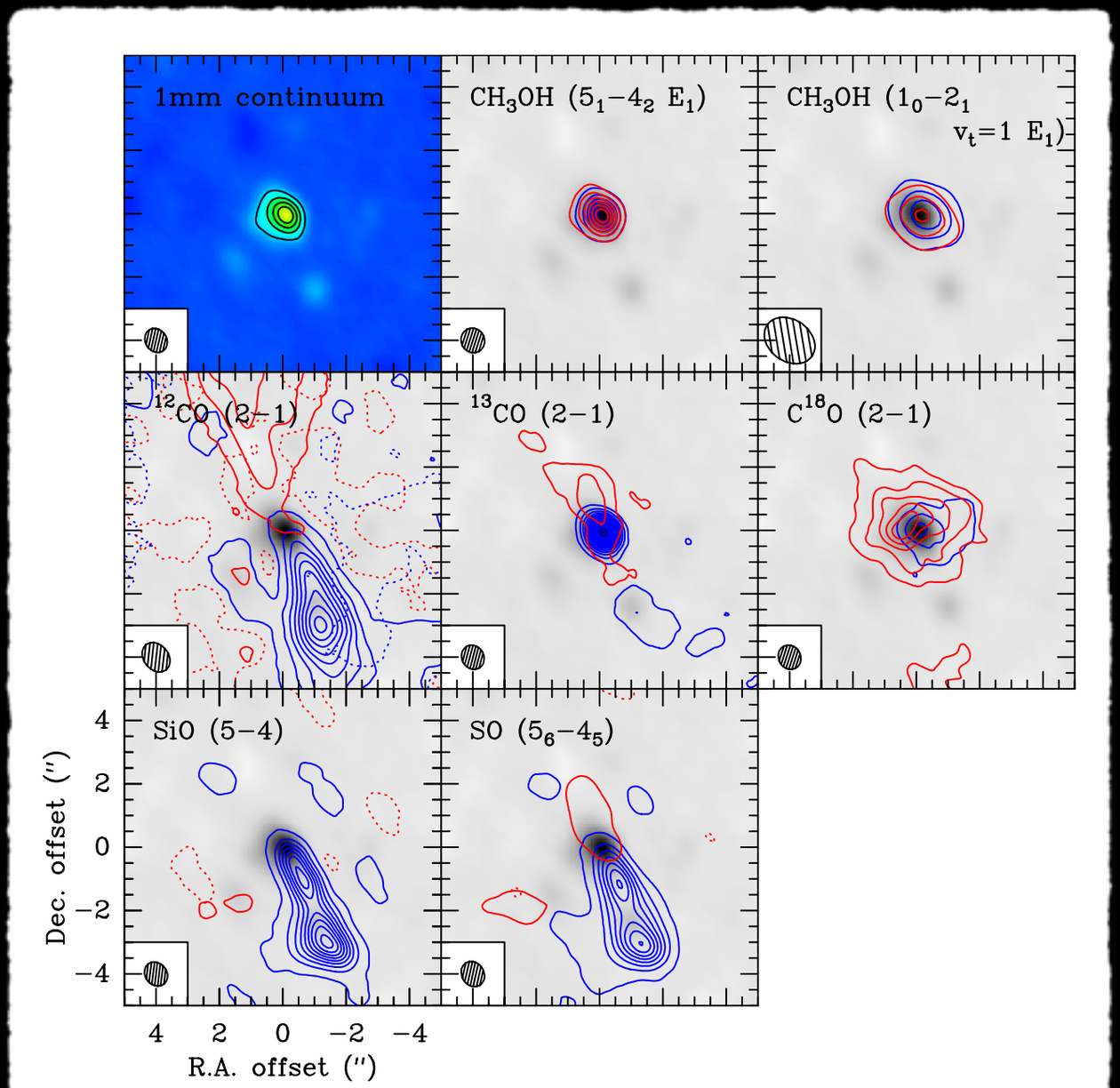
Why studying Class 0 protostars?

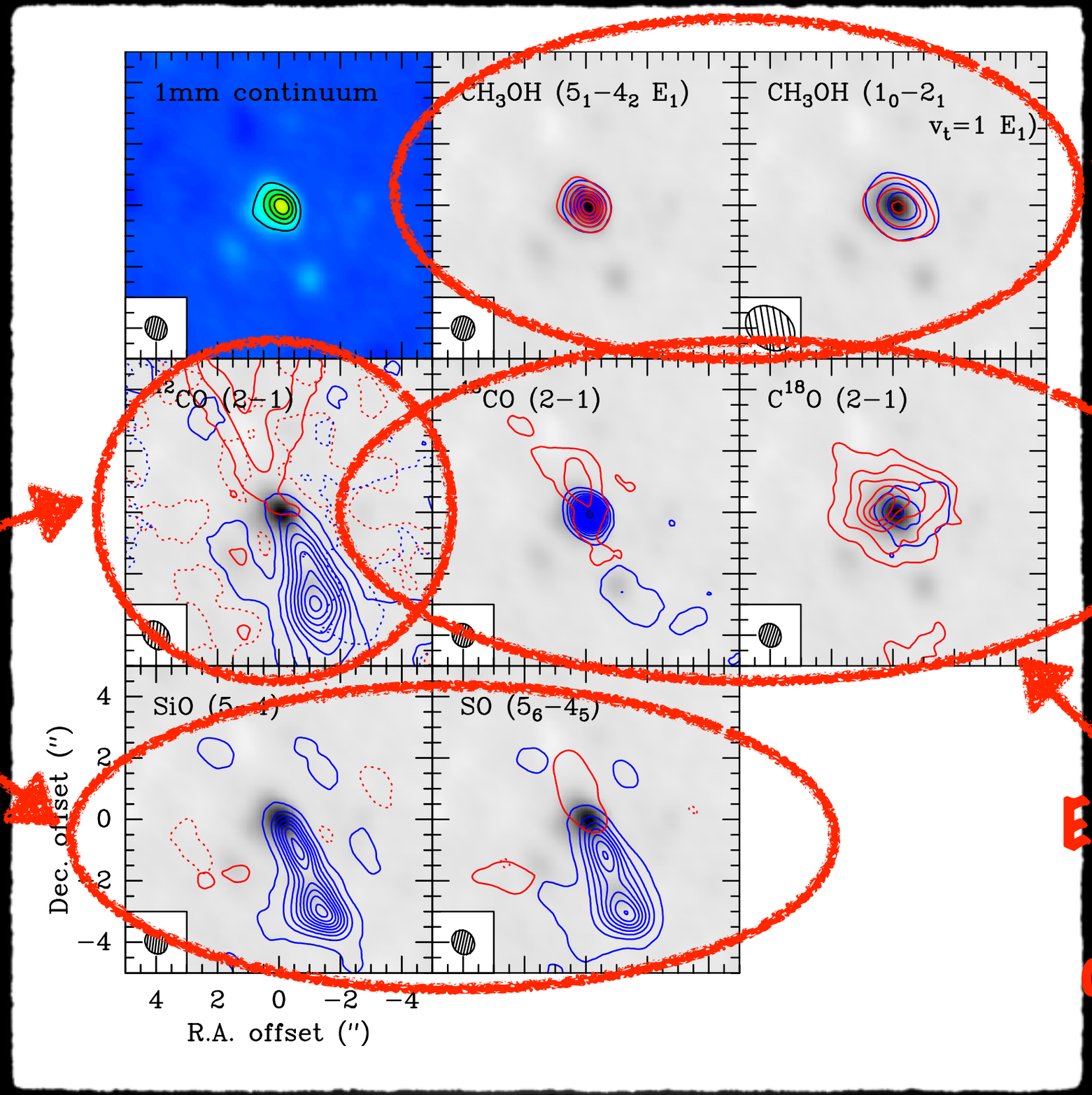
- Youngest protostars: initial conditions for star formation
- Crucial phase for the future evolution of the star: final mass, formation of the protoplanetary disk
- Their structure on 100 AU scales is poorly known; interferometric observations are needed to study them
- In this talk, I will focus on line observations obtained as part of the CALYPSO survey (P.I. P. André, c.f Anaëlle's talk)

NGC1333-IRAS2

- Class 0 protostar located in Perseus (235 pc)
  - $L_{bol} \simeq 20\,L_{\odot}$
  - $M_{env} \simeq 1.7\,M_{\odot}$
- Observed with the Plateau de Bure interferometer at 0.8” resolution (~200 AU)



Maret et al.; Maury et al.; Codella et al. (2014)

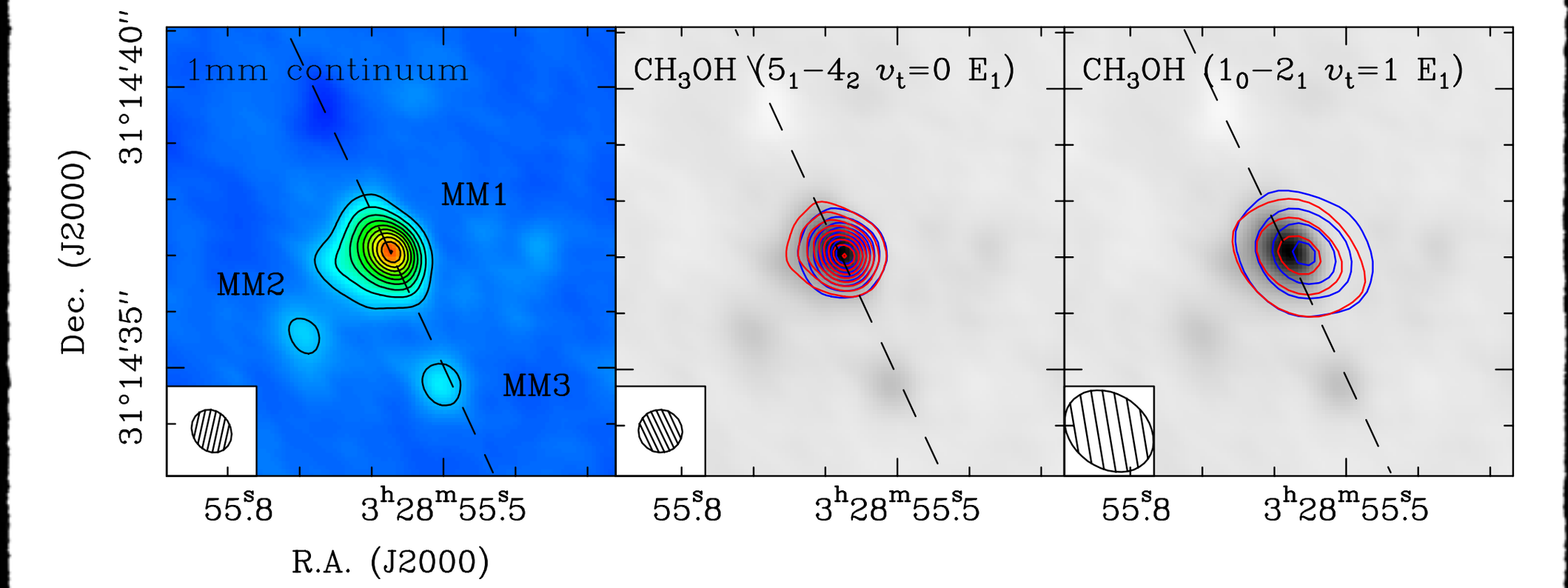


Outflow

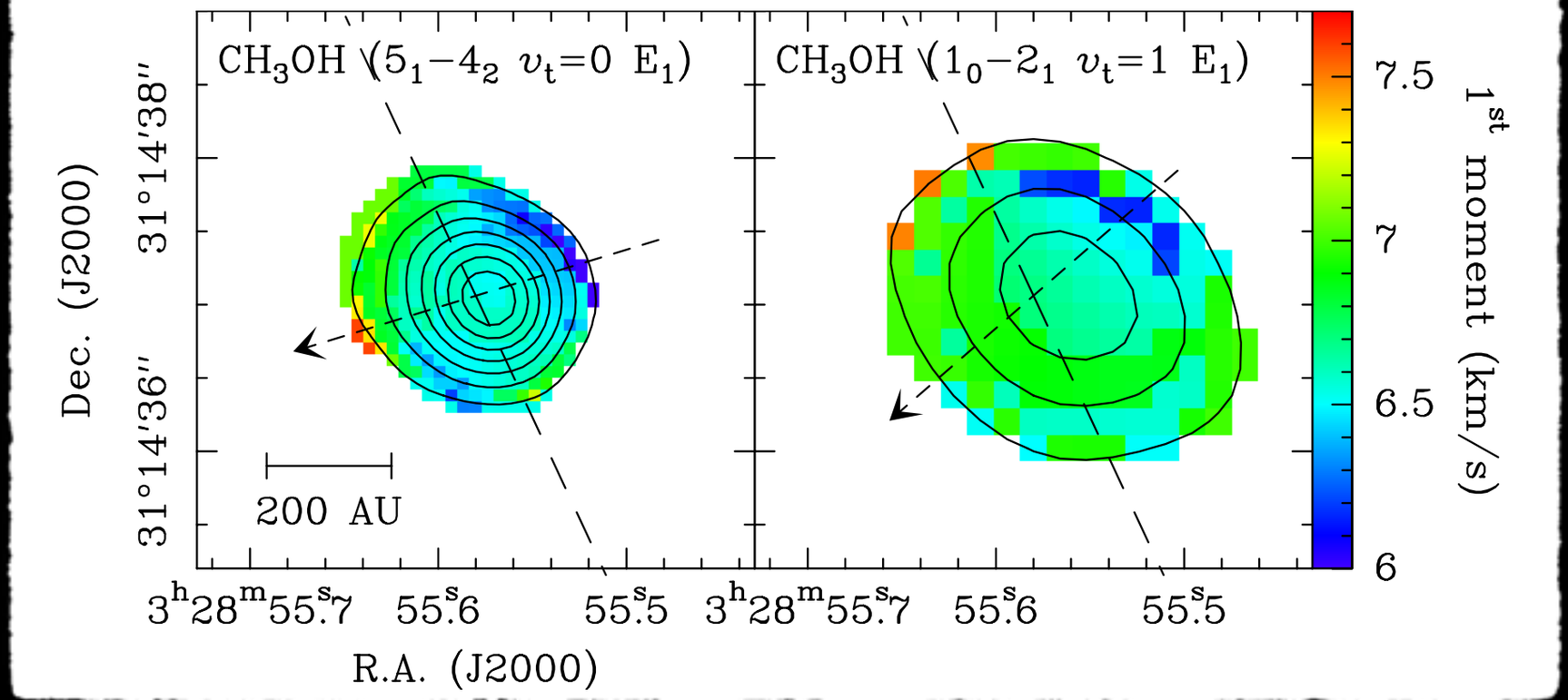
Inner envelope

Envelope and outflow

Methanol emission



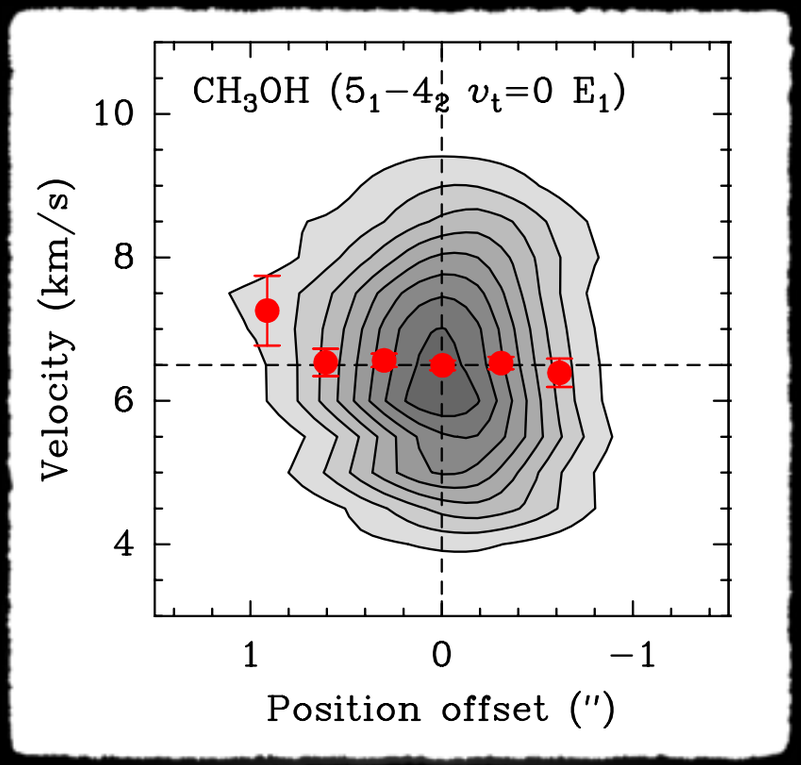
- Compact (0.4” i.e 90 AU) methanol emission centered on the main continuum source (MM1)
- Good probes of the inner envelope



- In order to probe the gas kinematics, we have computed first order moment maps (mean velocity)

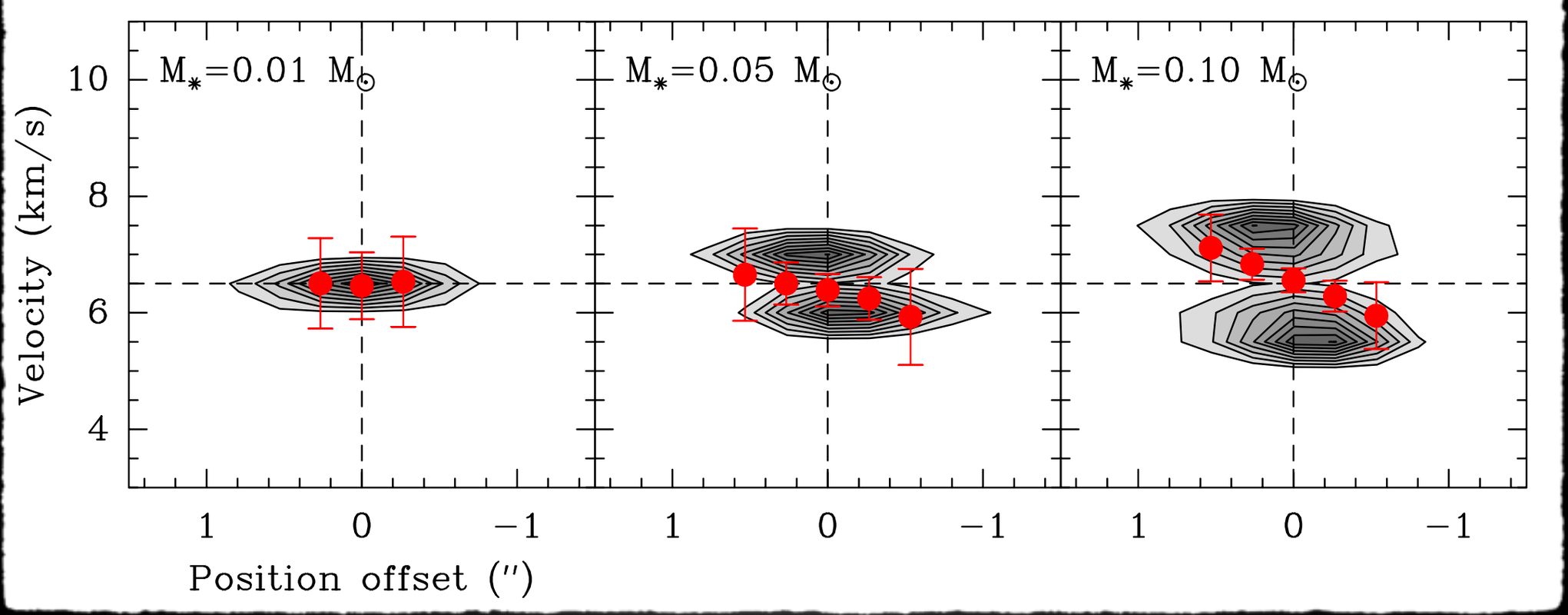
- No clear pattern, but a fit reveals a marginal velocity gradient, oriented perpendicularly to the outflow, as one would expect for a disk

Observations



- Position-velocity cut along the direction of the gradient
- Observations are **not consistent with a Keplerian disk**
- The lines probably originate from the infalling (and perhaps rotating) inner envelope

Disk toy model



Why not all Class 0 have disks?

- No disk detected in NGC1333-IRAS2
- Keplerian disks detected in L1527 (Tobin et al. 2012, Sakaï et al. 2014), and also VLA16293 (Murillo et al. 2013)
- Evolutionary effect or initial conditions?
- Comparison with simulations of magnetized collapse (c.f. Benoît's talk) are needed

Modeling the chemo-dynamical evolution of Class 0 protostars

- ANR young researcher project Chemodyn (P.I. S. Maret, 2013-2016)
- Approach: couple MHD simulations with chemistry and line radiative transfer to model the CALYPSO observations

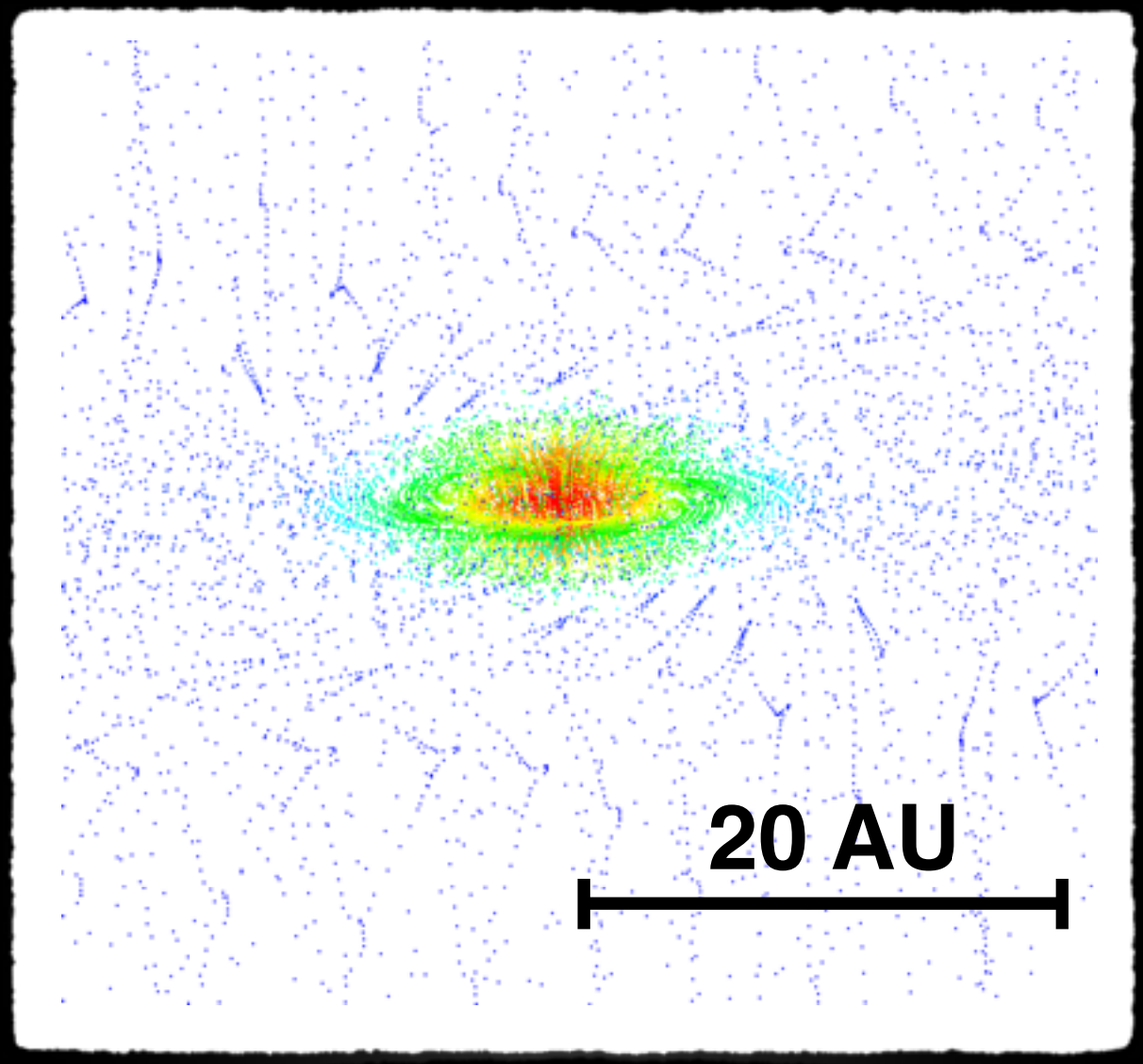


Figure courtesy of S. Anderl

Perspectives

- Surveys are needed to study the properties of Class 0 protostars (e.g. the presence of disks)
- Such surveys **can not** (yet…) be done with ALMA. The PdBI (and NOEMA) is essential for this
- Comparison with simulations should bring importants constraints on the formation and evolution of these objects
- It would be interesting to compare the properties of the newly detected Class 0 disks with that of Class II disks (c.f. Edwige talk)