

SMA Observations of Infall and Rotation around Class 0 & 0/I Protostars to Investigate Disk Formation at the Early Evolutionary Stage

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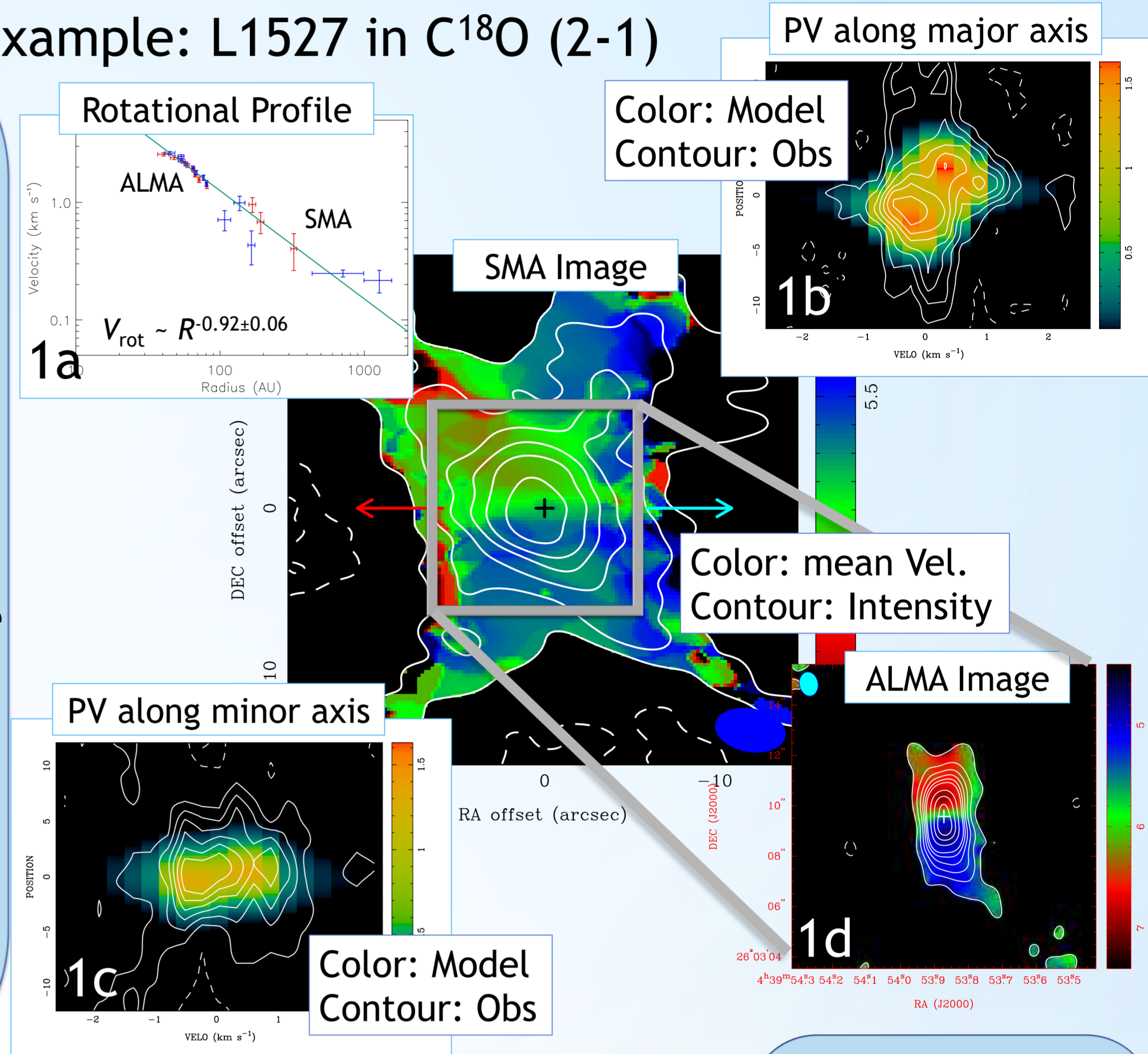
Background:

Circumstellar disks around young stellar objects are sites of planet formation. When and how these disks form during star formation processes are still controversial. Disks with outer radii >100 AU have been often observed around T Tauri stars and Class I protostars^{[1][2][3]}, suggesting disks are already well developed at the Class I stage. It is unclear whether the presence of such large-scale (100 AU) disks is common among Class 0 protostars. The goal of this project is to estimate disk sizes of a sample of Class 0 protostars with SMA observations.

Method:

We studied the gas motions around 17 Class 0 or 0/I protostars observed with SMA in C¹⁸O (2-1) at angular resolutions of 2"-8" and velocity resolutions of 0.14-1.2 km/s. We constructed simple models of infalling and rotating envelopes with a conserved angular momentum, which have been observed around several protostars with our recent observations (1a)^{[3][4][5]}, to reproduce the velocity gradients observed with SMA (1b & 1c), and estimated protostellar mass and size of Keplerian disks. Follow-up ALMA observations of L1527 (1d)^[5], directly revealing the disk, confirmed the SMA estimates, and the uncertainty of the SMA results is <50% of the measurements.

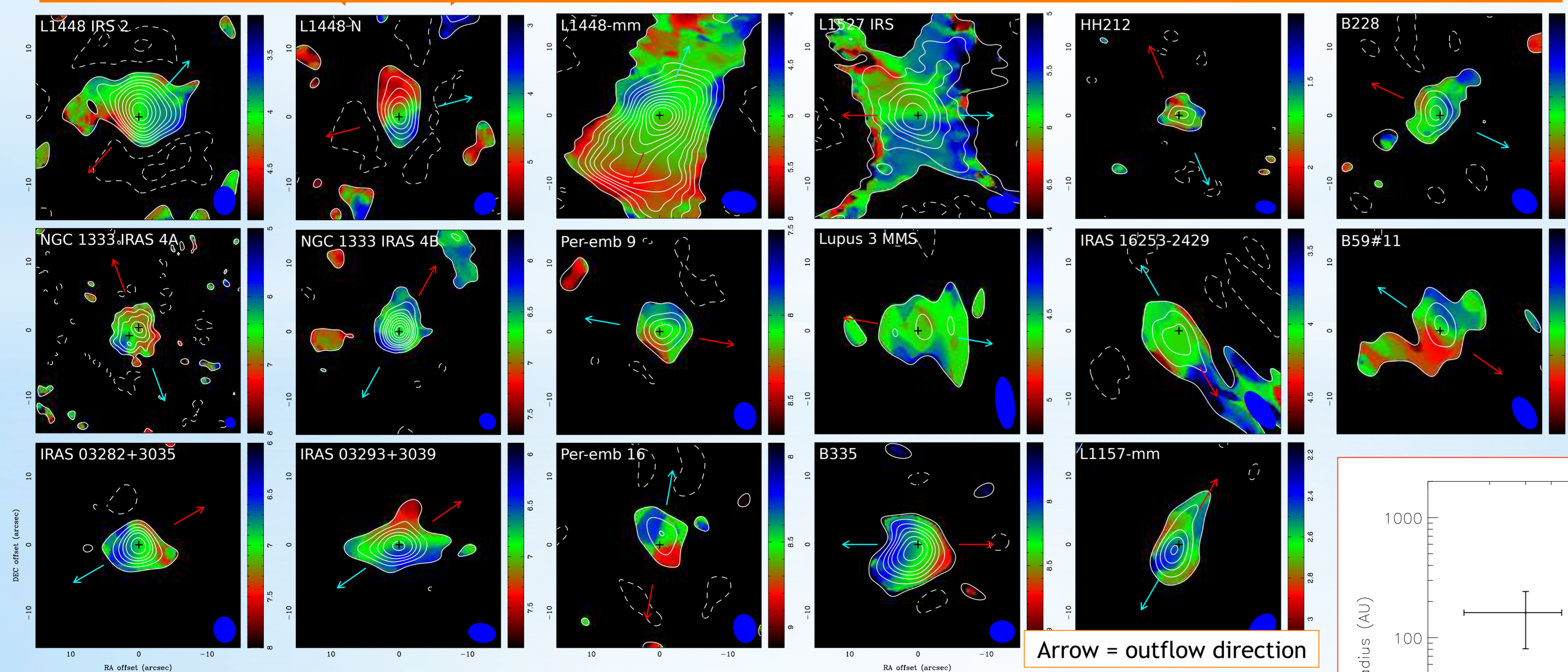
Example: L1527 in C¹⁸O (2-1)



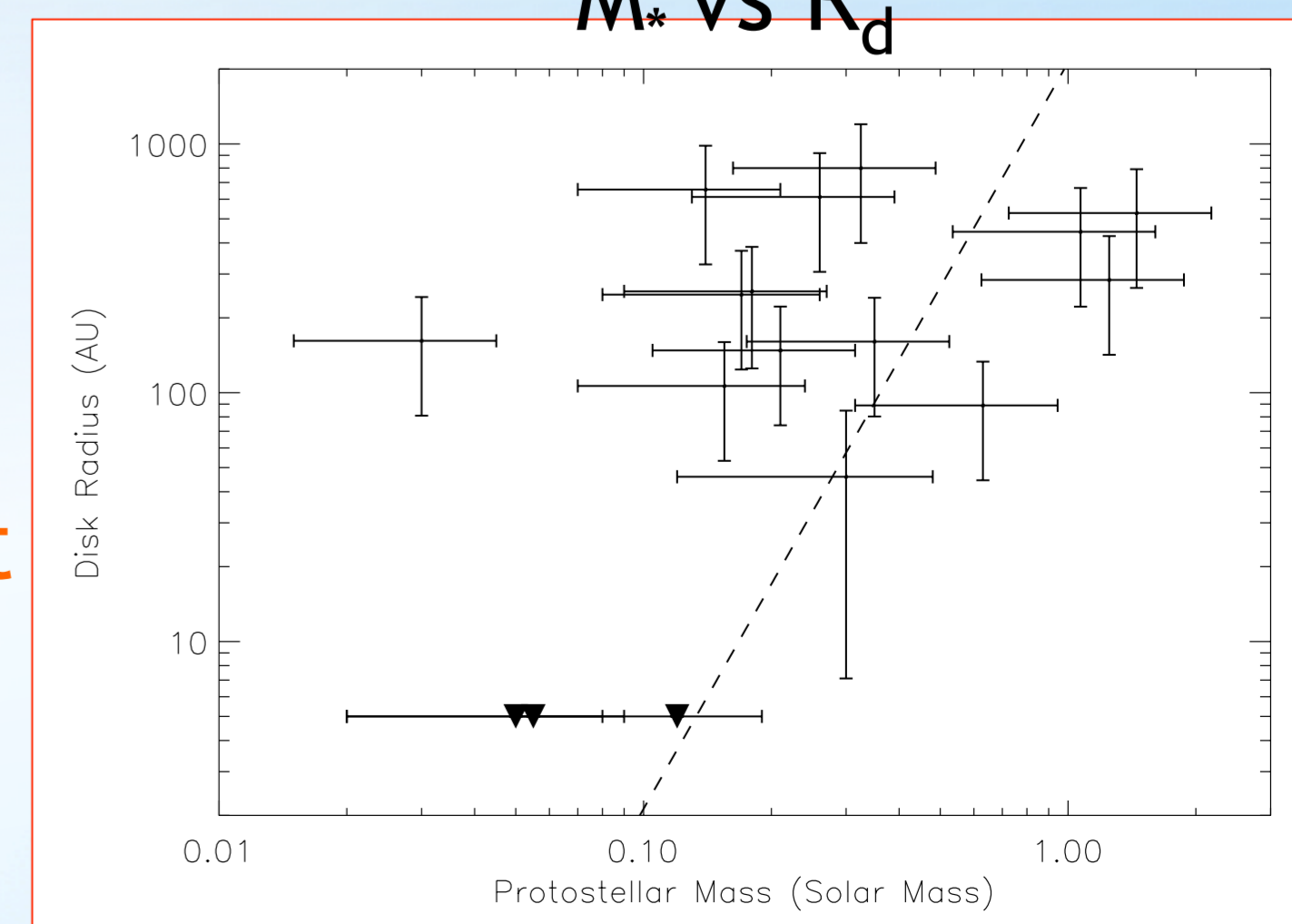
Reference:

- [1] Simon et al. 2000, ApJ, 545, 1034
- [2] Takakuwa et al. 2012, ApJ, 754, 52
- [3] Yen et al. 2013, ApJ, 722, 22
- [4] Yen et al. 2014, ApJ, submitted
- [5] Ohashi et al. 2014, ApJ, submitted

SMA C¹⁸O (2-1) Results of 17 Class 0 or 0/I Protostars



M* vs R_d



Wide ranges of magnitude and orientation of velocity gradient observed. Estimated disk radii range from <5 AU to >500 AU, suggesting that the Class 0 stage is likely the stage to build a large-scale disk. The small number of protostars exhibiting smaller disk (<100 AU) suggests that large-scale disks can be well developed in a short time scale, or that suppression of disk formation is not common among Class 0 protostars.