Searching small circumstellar disks in Cygnus X

Xing Pan[1,2] (xing.pan@cfa.harvard.edu), Keping Qiu[2], Qizhou Zhang[1]

[1] Center of Astrophysics | Harvard & Smithsonian, USA

[2] School of Astronomy and Space Science, Nanjing University, China

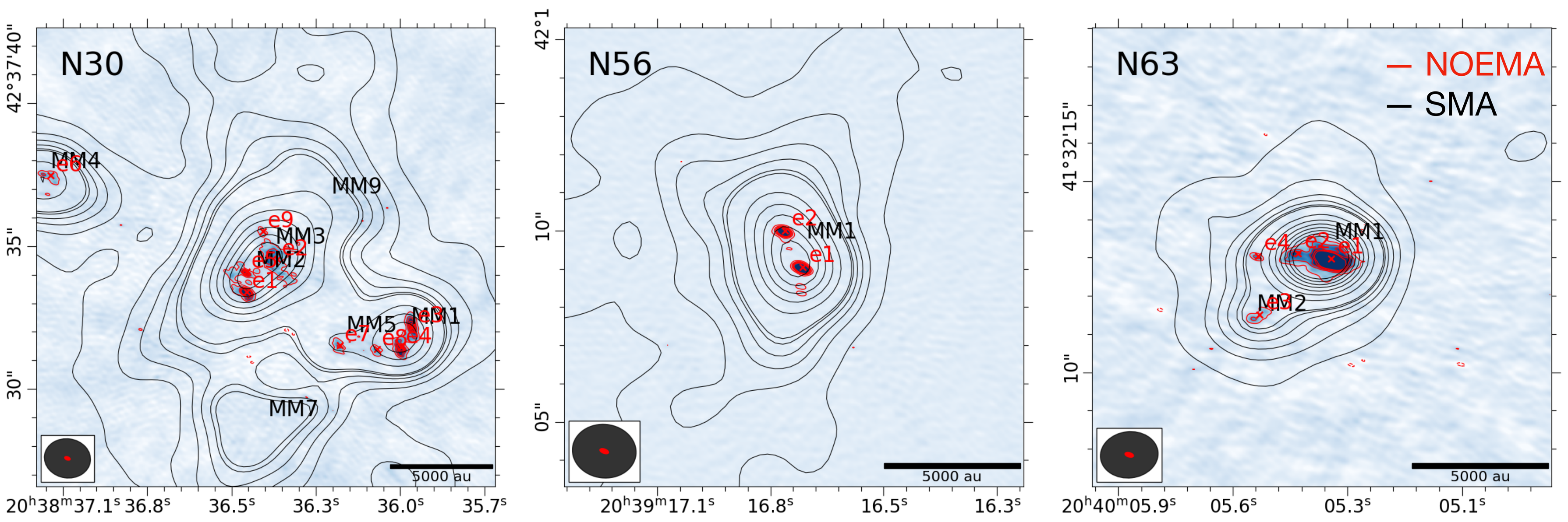
Introduction

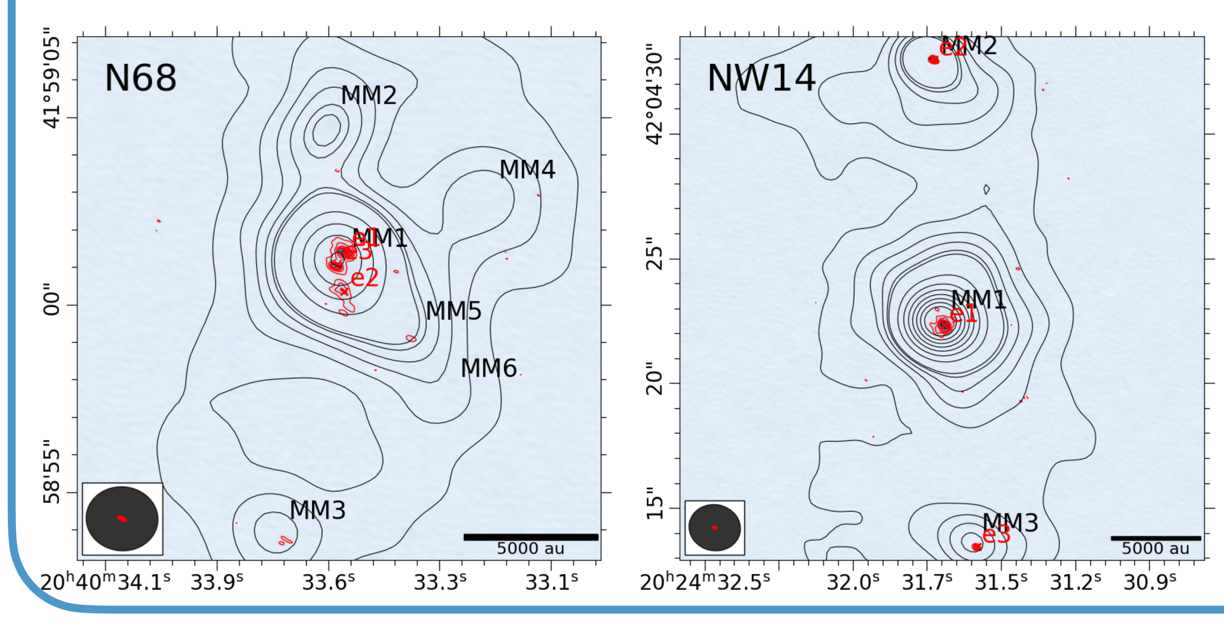
Disk accretion is widely regarded as the primary mechanism driving star formation across various mass ranges. However, unlike low-mass stars, only a limited number of circumstellar disks have been observed around massive protostars. Previous disk candidates were identified based on rotational signatures, but most of these structures are massive, large (exceeding 2000 AU) [1], and likely unstable against gravitational collapse. Such large structures are more plausibly interpreted as rotating envelopes or toroids surrounding the embedded accretion disk. Recent observations with ALMA have revealed several stable, Keplerian-like disks with sizes around 100 AU, suggesting that true accretion disks may be significantly smaller.

Circumstellar disks in Cygnus X

Cygnus X is the most massive giant molecular cloud within 3 kpc of the Sun. It hosts numerous star formation activities. Using 1.8" (~3000 au at a distance of 1.4 kpc) SMA observations, We found nine condensations (~0.01 pc) showing evidence of rotating disk within 48 massive dense cores (MDCs, ~0.1 pc) in the Cygnus-X cloud. Among them, we selected four MDCs (N30, N56, N63, NW14) exhibiting clear disk evidence to resolve the underlying accretion disk inside them and one MDC (N68) without disk evidence as a comparison. ***Here we confirm two stable, Keplerian-like disks (N30 e1, NW14 e1) with a radius of about 500 au out of former disk candidates using NOEMA high-resolution (~0.2") observations.***

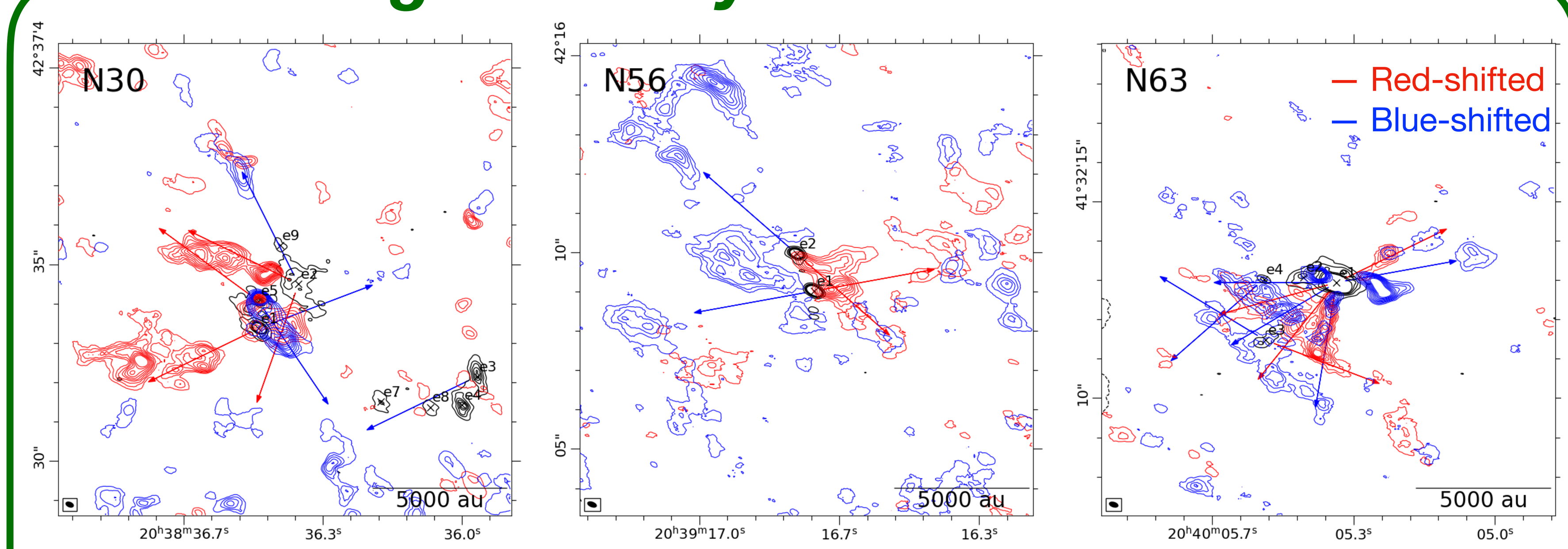
1.3 mm Continuum & Fragmentation

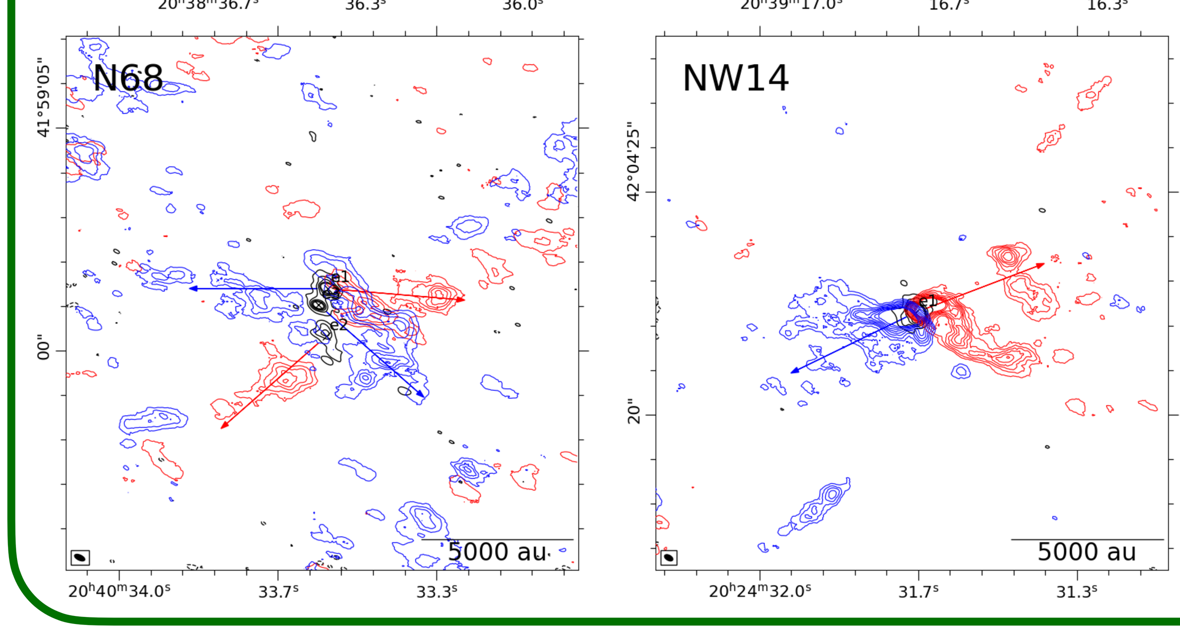




- NOEMA @0.2" vs SMA @1.8"
- Different fragmentation levels
- $S_{\rm frag}$:250-800 au

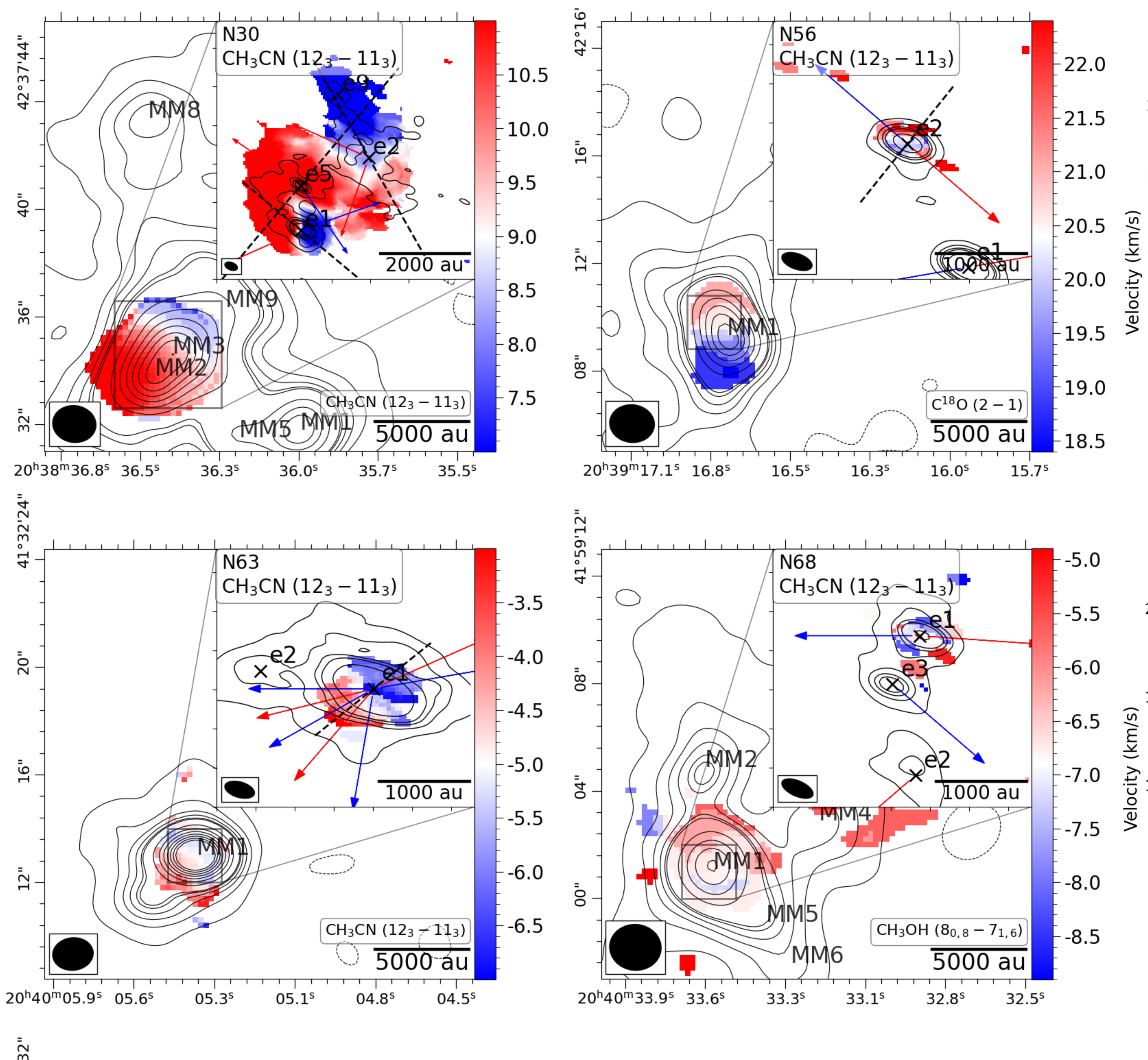
High Velocity CO Outflow

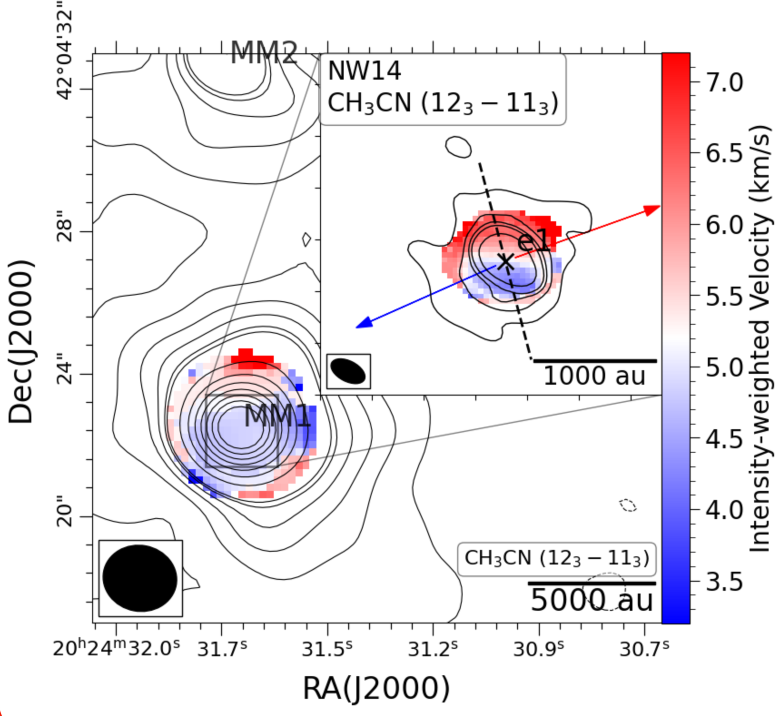




- $|v - v_{\rm sys}|$>3 km/s
- Resolve outflow substructures
- 10 bipolar outflows, 8 unipolar outflows.

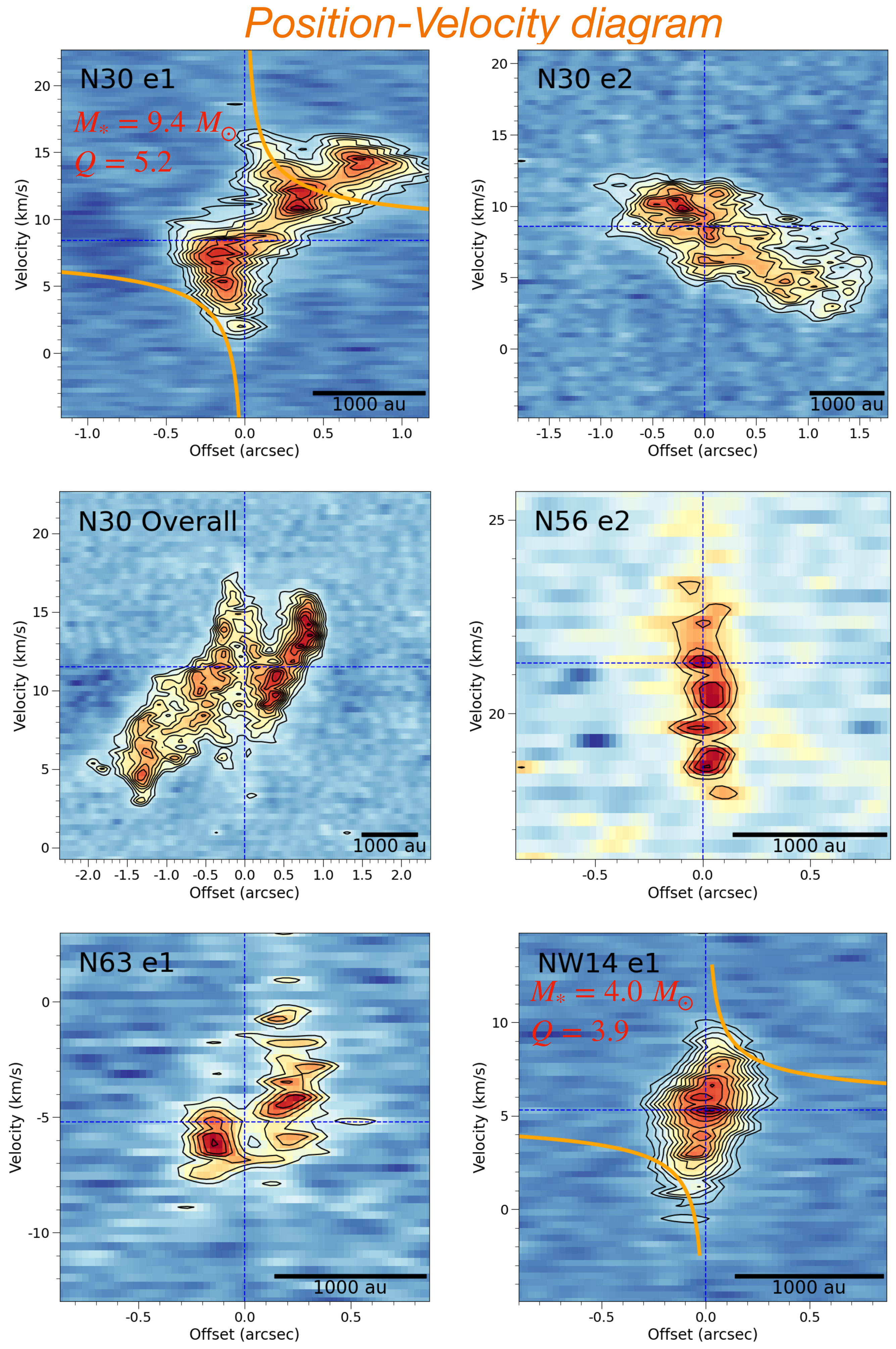
Multiscale Gas Kinematics





- NOEMA (Top right) vs SMA (Bottom left) gas kinematics.
- Most fragments show velocity patten similar to their parental structures, except fragments in N30 MM1.

Position-Velocity diagram



Stability of the disk, $Q = c_s \Omega / \pi G \Sigma$

Summary

- High resolution NOEMA data resolve 0.01 pc condensations from SMA observations into several 100 au scale fragments.
- Reveal gas kinematics at smaller scale. Most sources show similar velocity pattens with their parental structures, while fragments in N30 MM1 show two distinct velocity gradients.
- Confirm two stable, Keplerian-like disks (N30 e1, NW14 e1) out of four former disk candidates. These disks have radius about 500 au, suggesting previous large rotating structures are more likely rotating envelopes or toroids.

[1] Beltrán et al. 2016