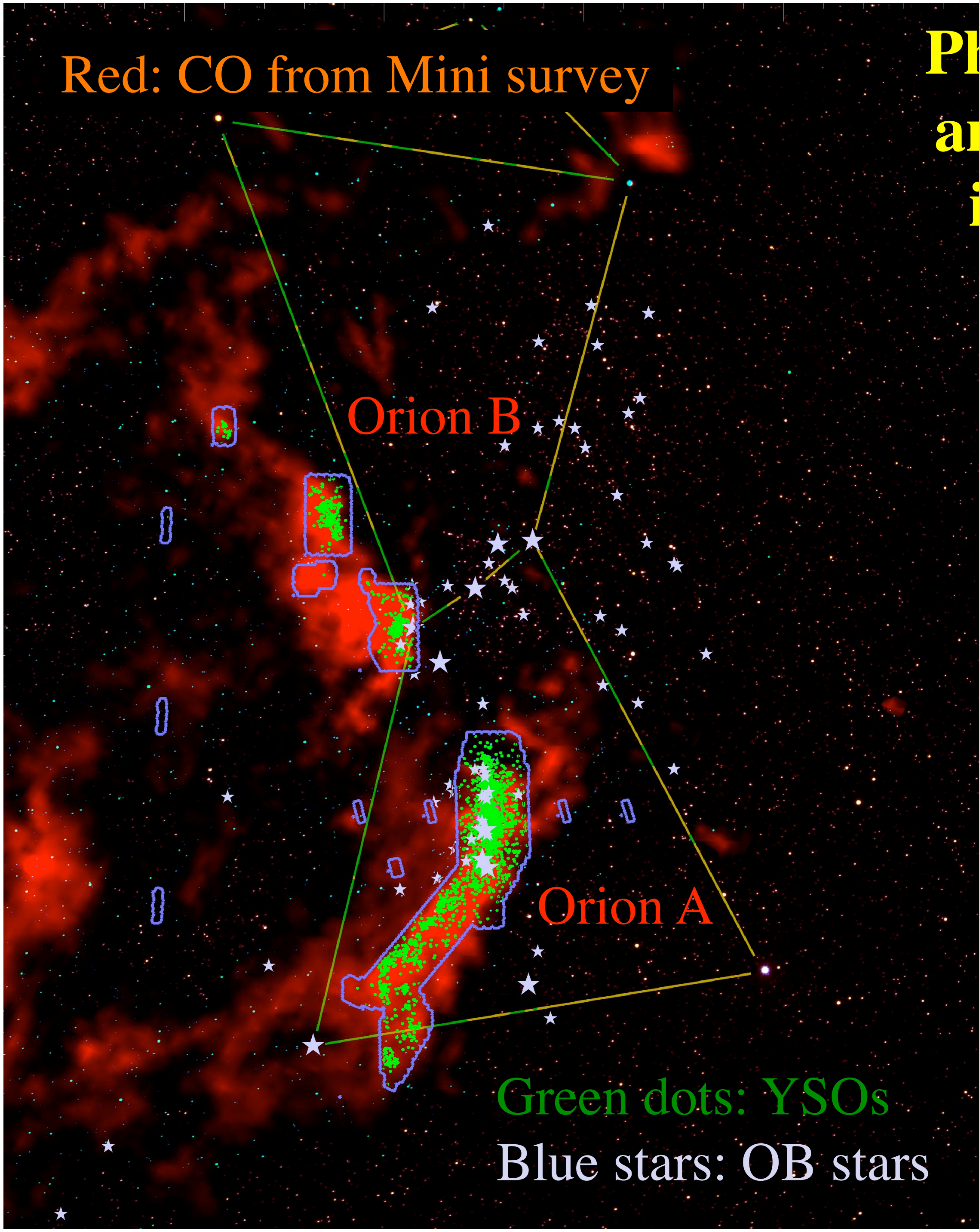
Philamentary Structure and Velocity Gradients in the Orion A Cloud



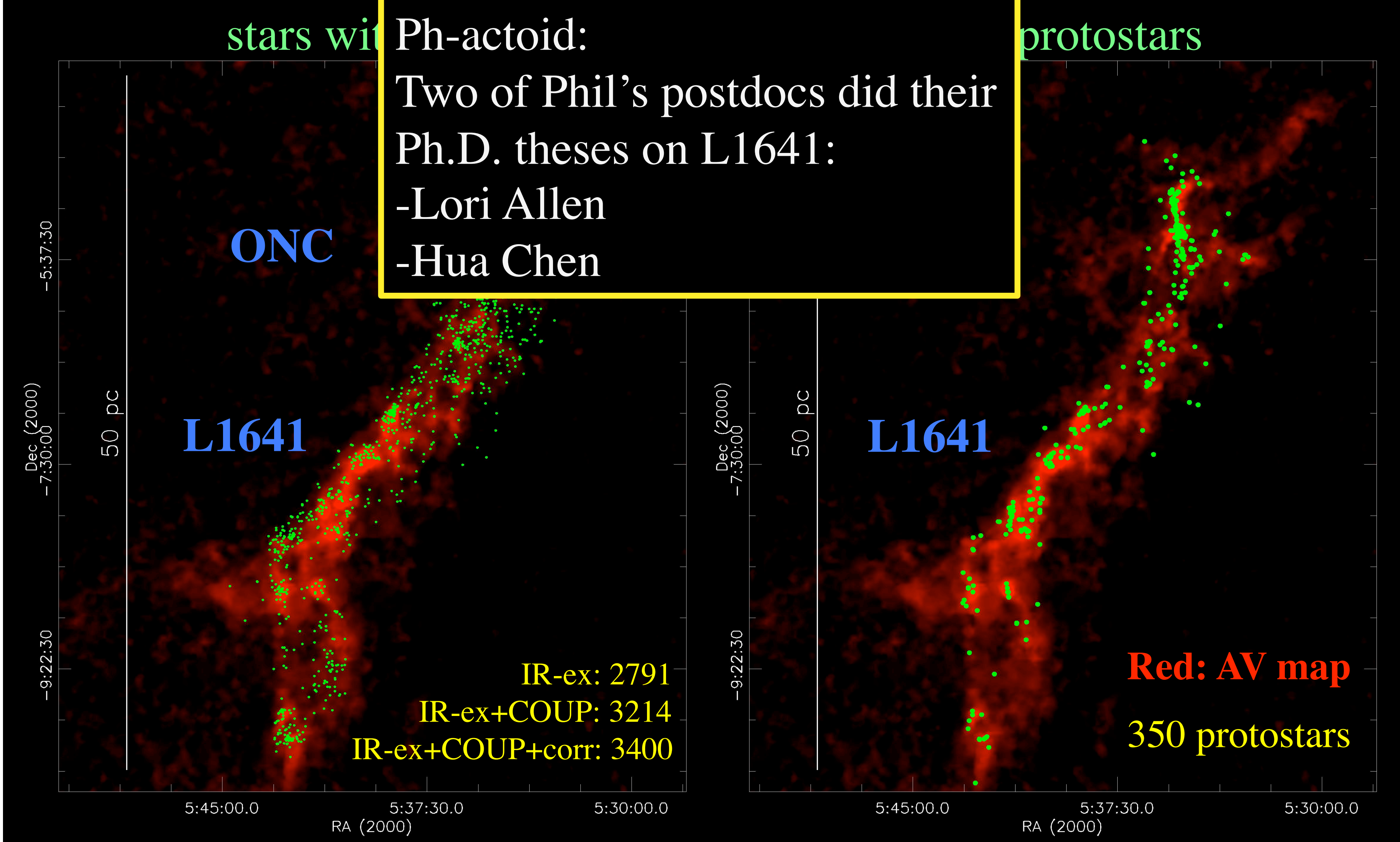
Spitzer Orion Cloud Survey:

10 sq. degrees in Orion A and Orion B mapped between 2004-2009

IR-ex: 3352
IR-ex + coup: 3845
IR-ex + coup + corr: 4300

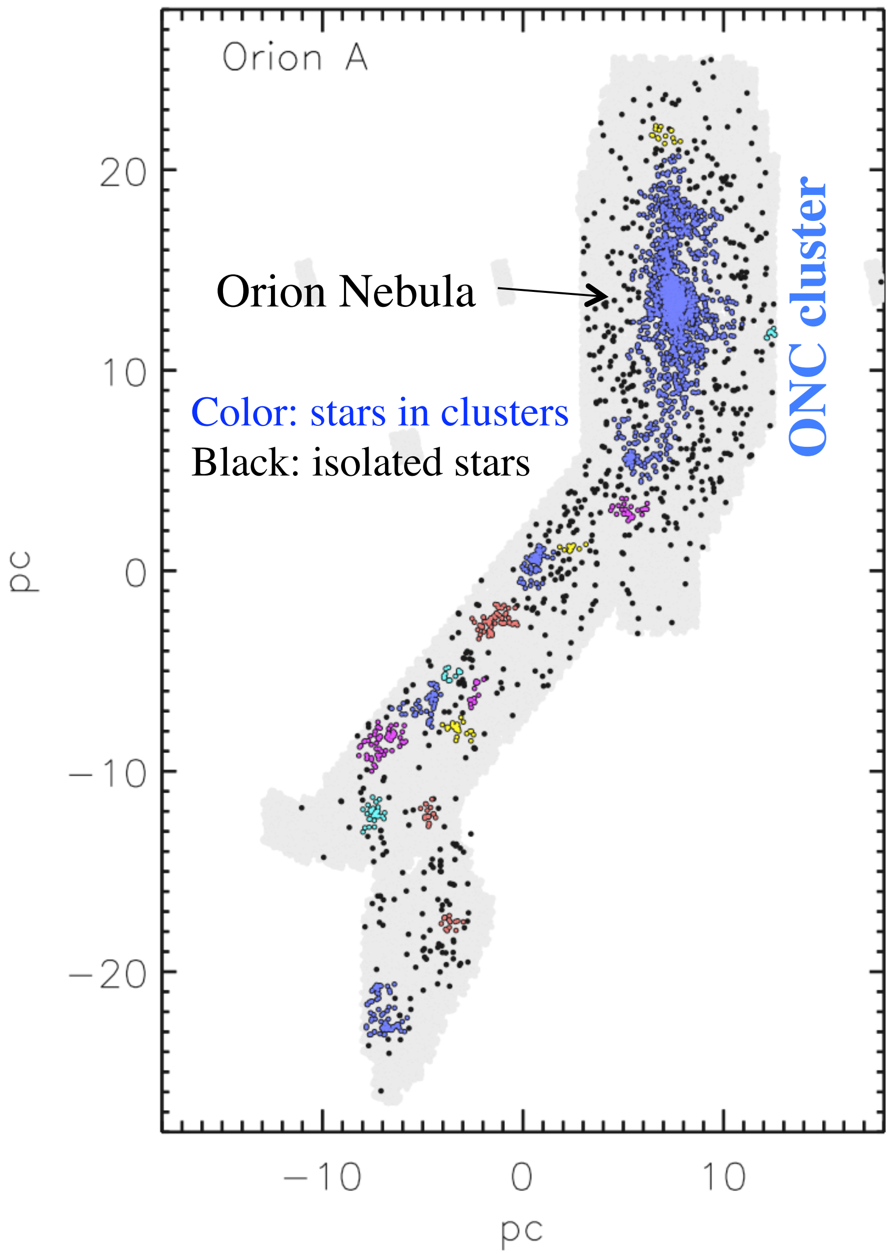
Megeath et al. (y+1)
y = current year

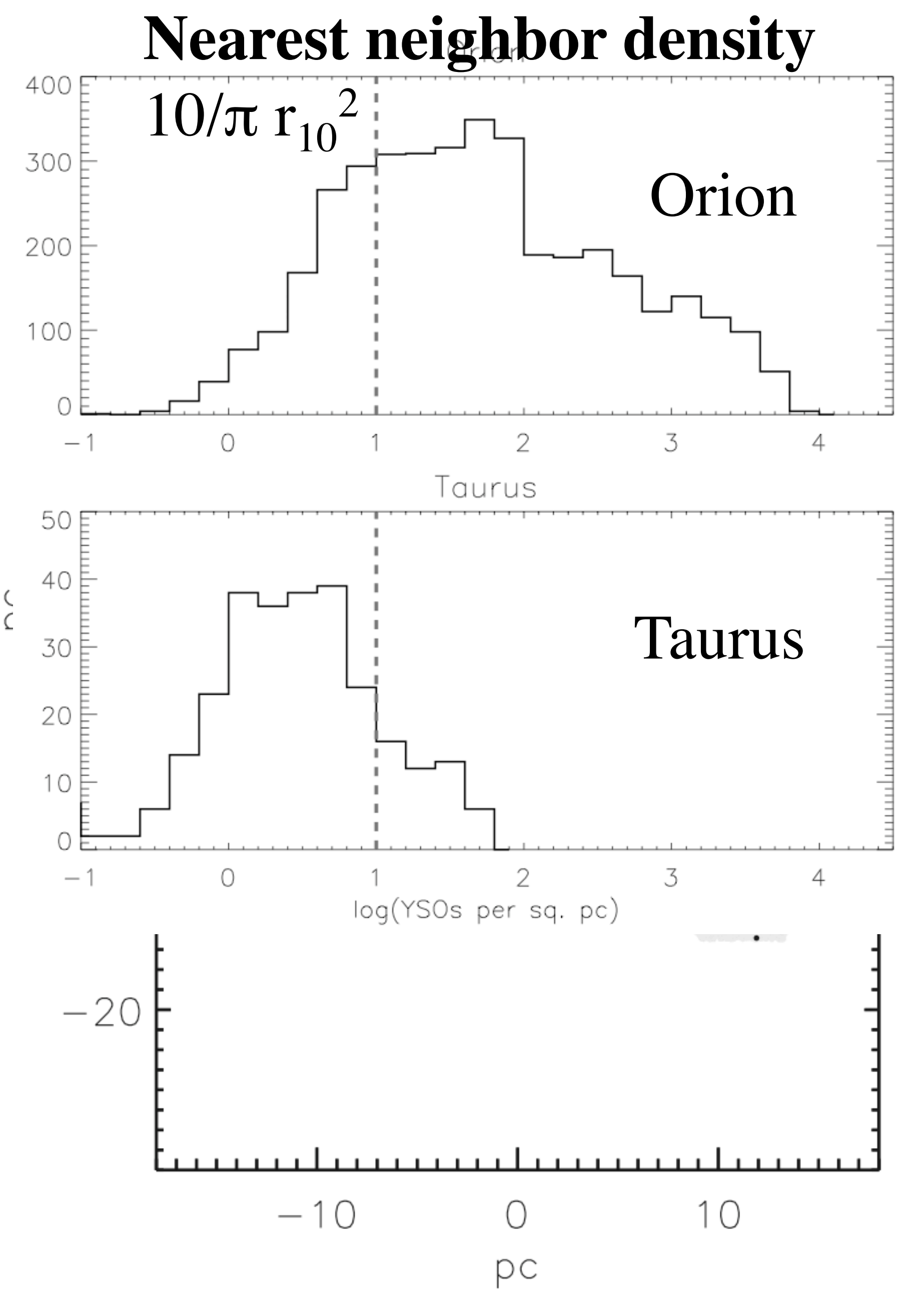
Orion A: A 50 parsec Long Star Forming Filament



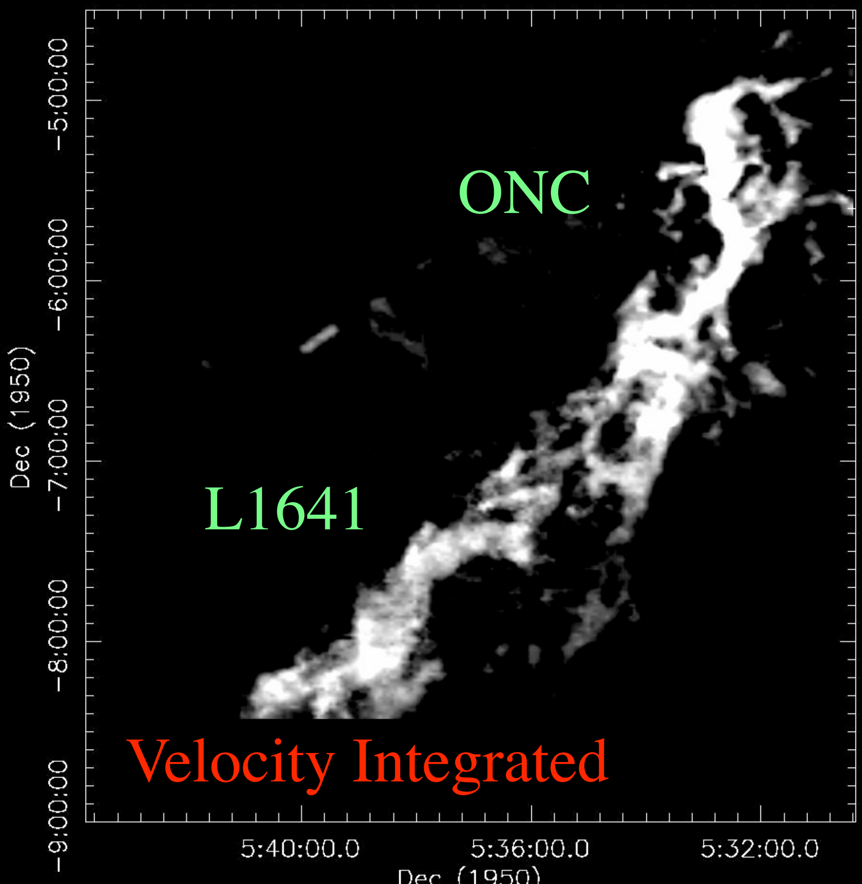
Ph-actoid:
Two of Phil's postdocs did their Ph.D. theses on L1641:
-Lori Allen
-Hua Chen

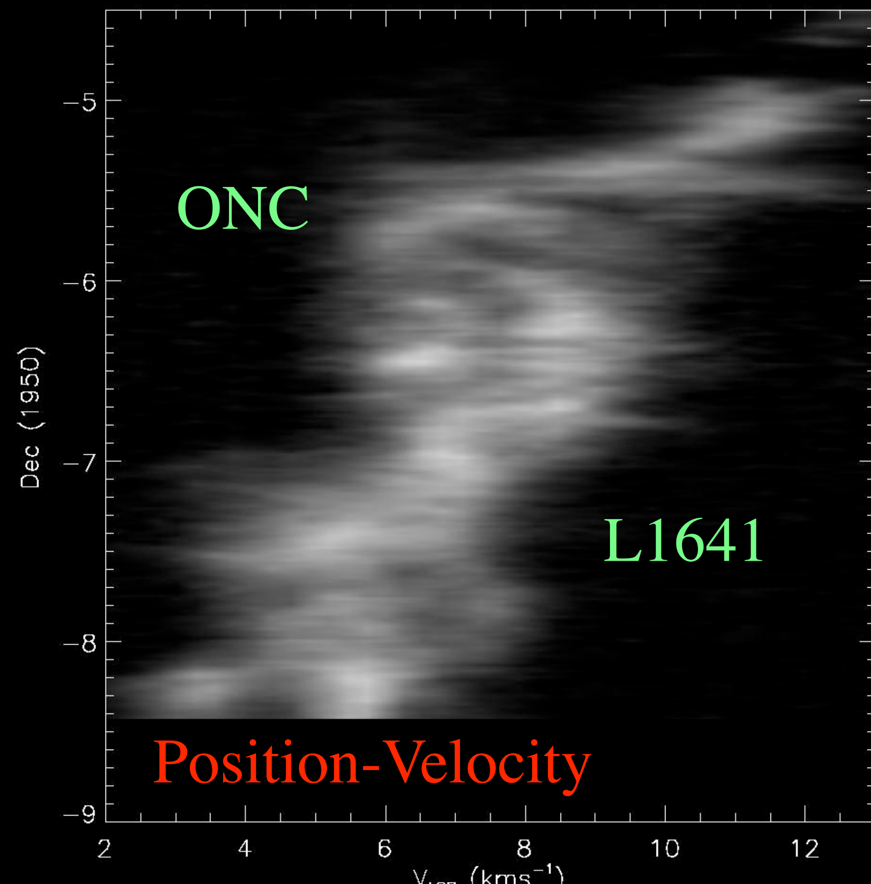
Clustering in the Orion Clouds





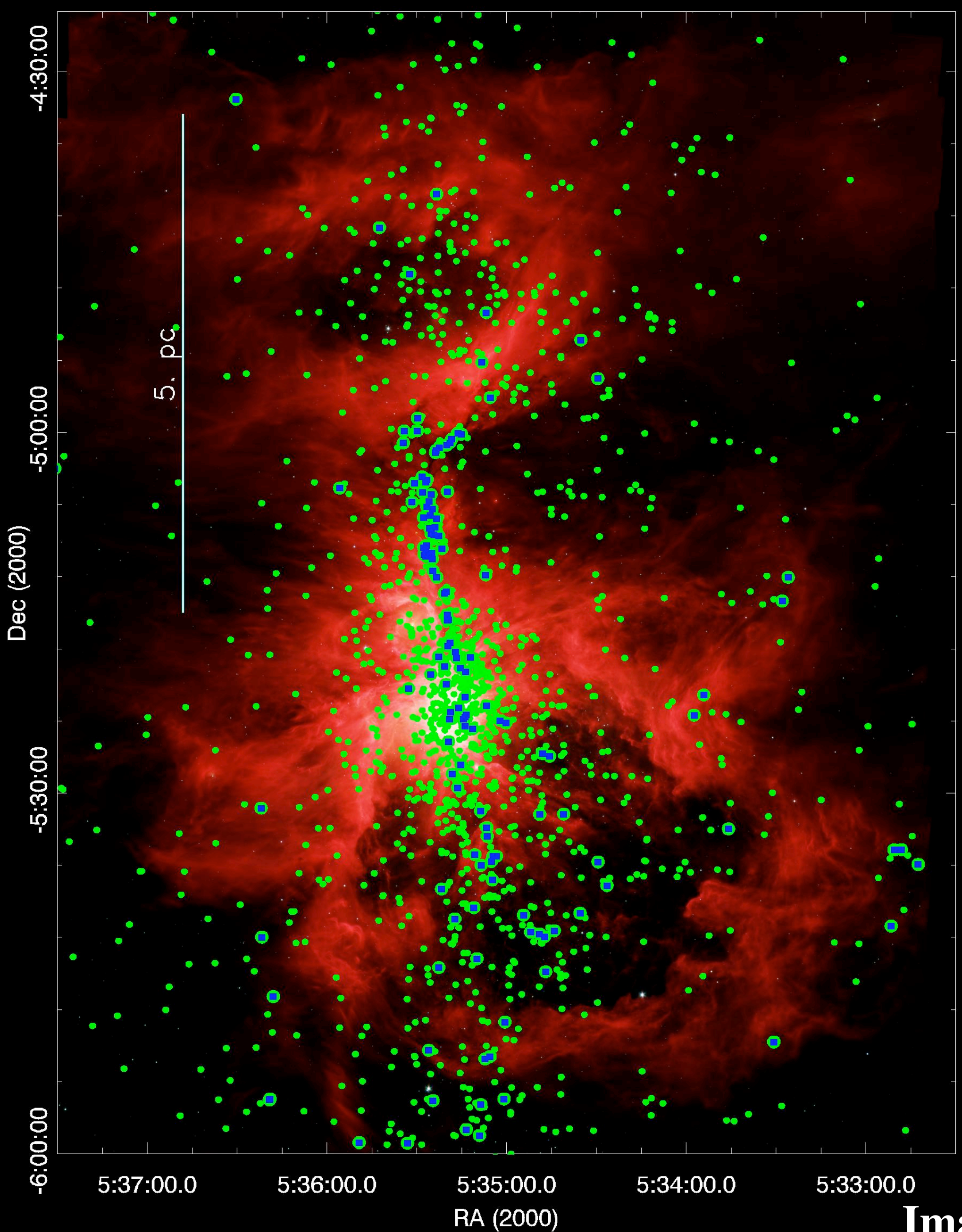
Velocity Structure of Orion A





Filamentary structure in the Orion Molecular Cloud
Bally et al. 1987

The Orion Nebula Cluster



12 pc long cluster

2232: IR-ex (corrected)

Highly elongated: 15 pc long
mean radius of 4.2 pc

The density peaks sharply in the center of the cluster in the Orion nebula.

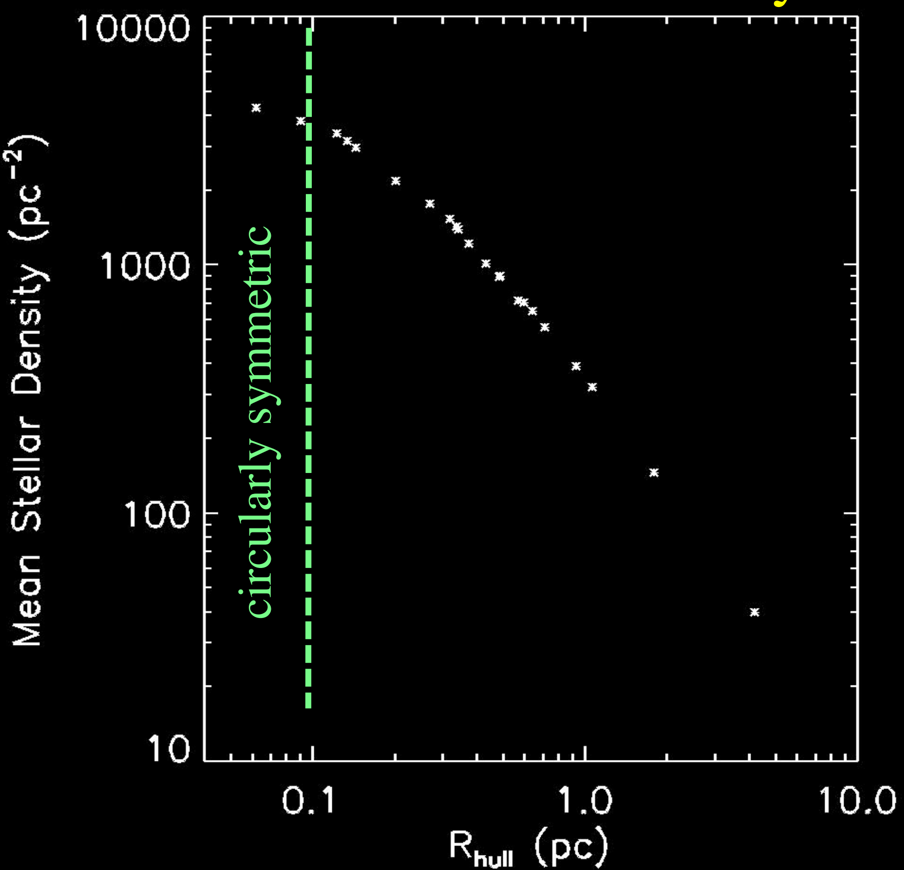
Rings show that massive stars are dispersing the gas.

Blue dots: protostars
Green dots: stars with disks

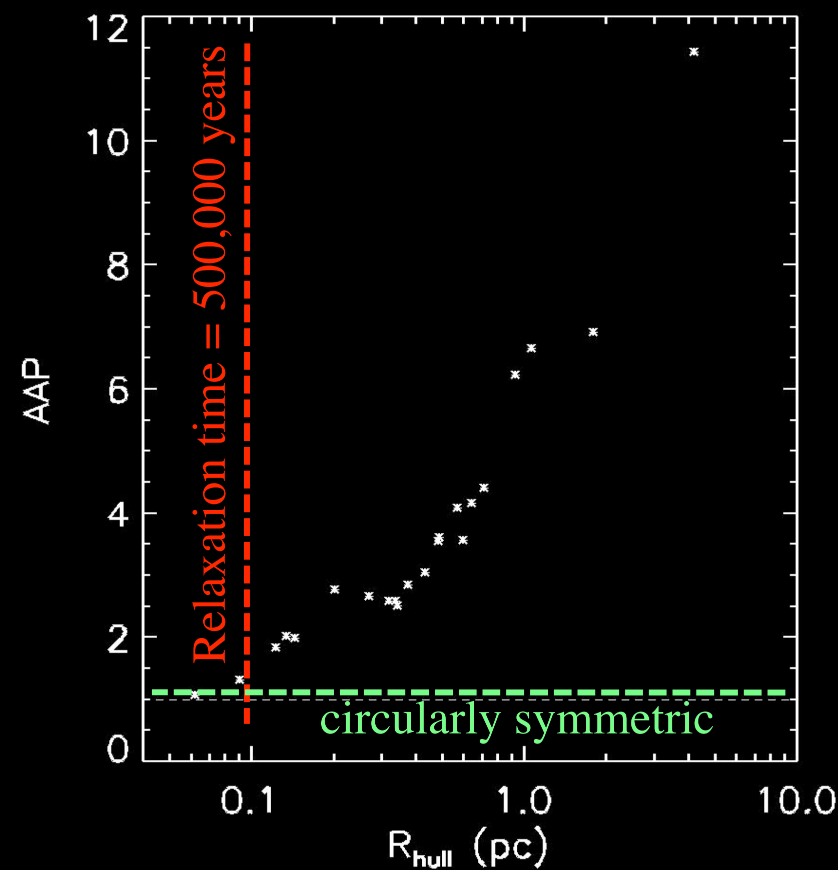
Image: Blue 3.6 µm, green 4.5 µm, red 8 µm

Properties of the ONC

Stellar Surface Density



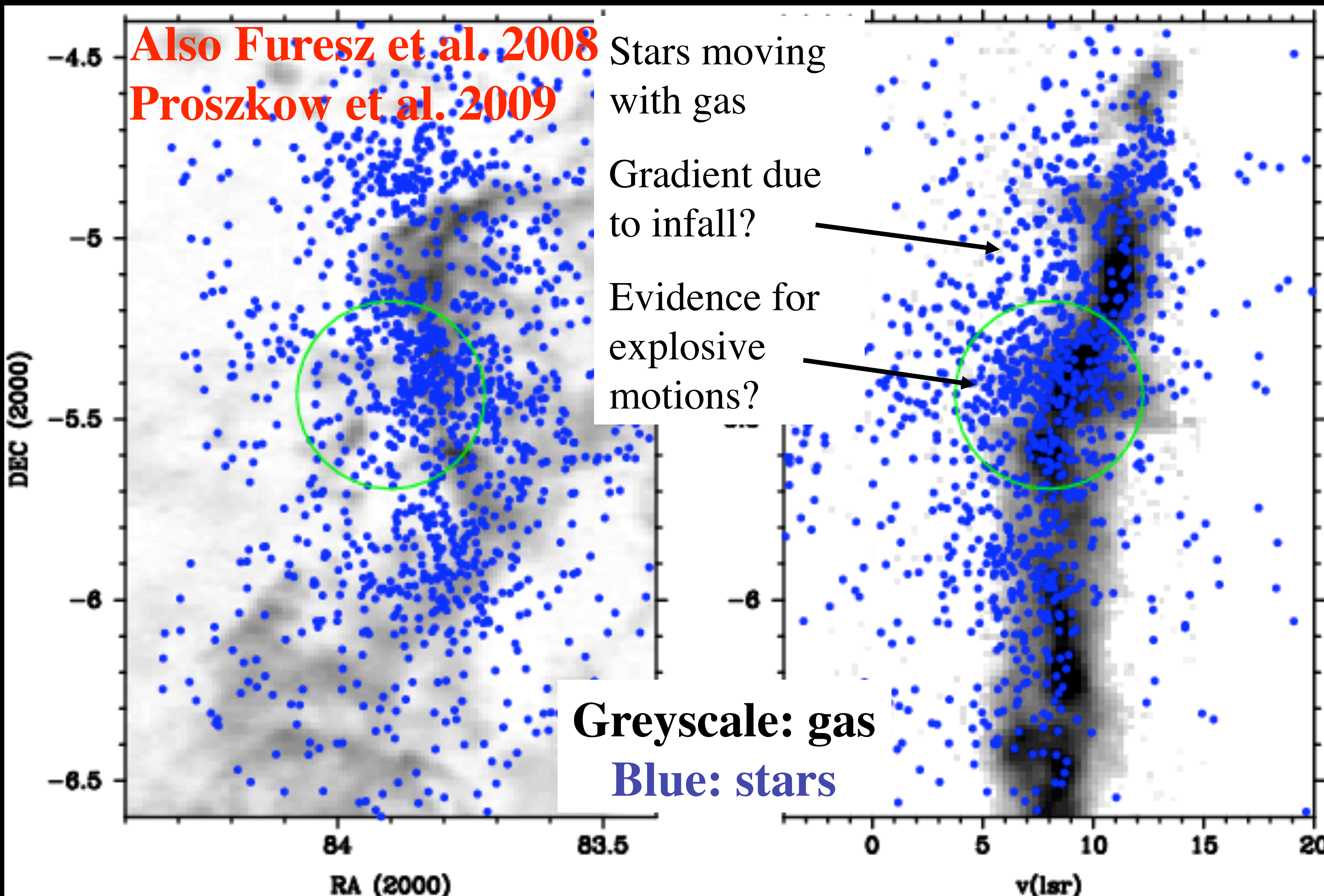
Degree of Asymmetry



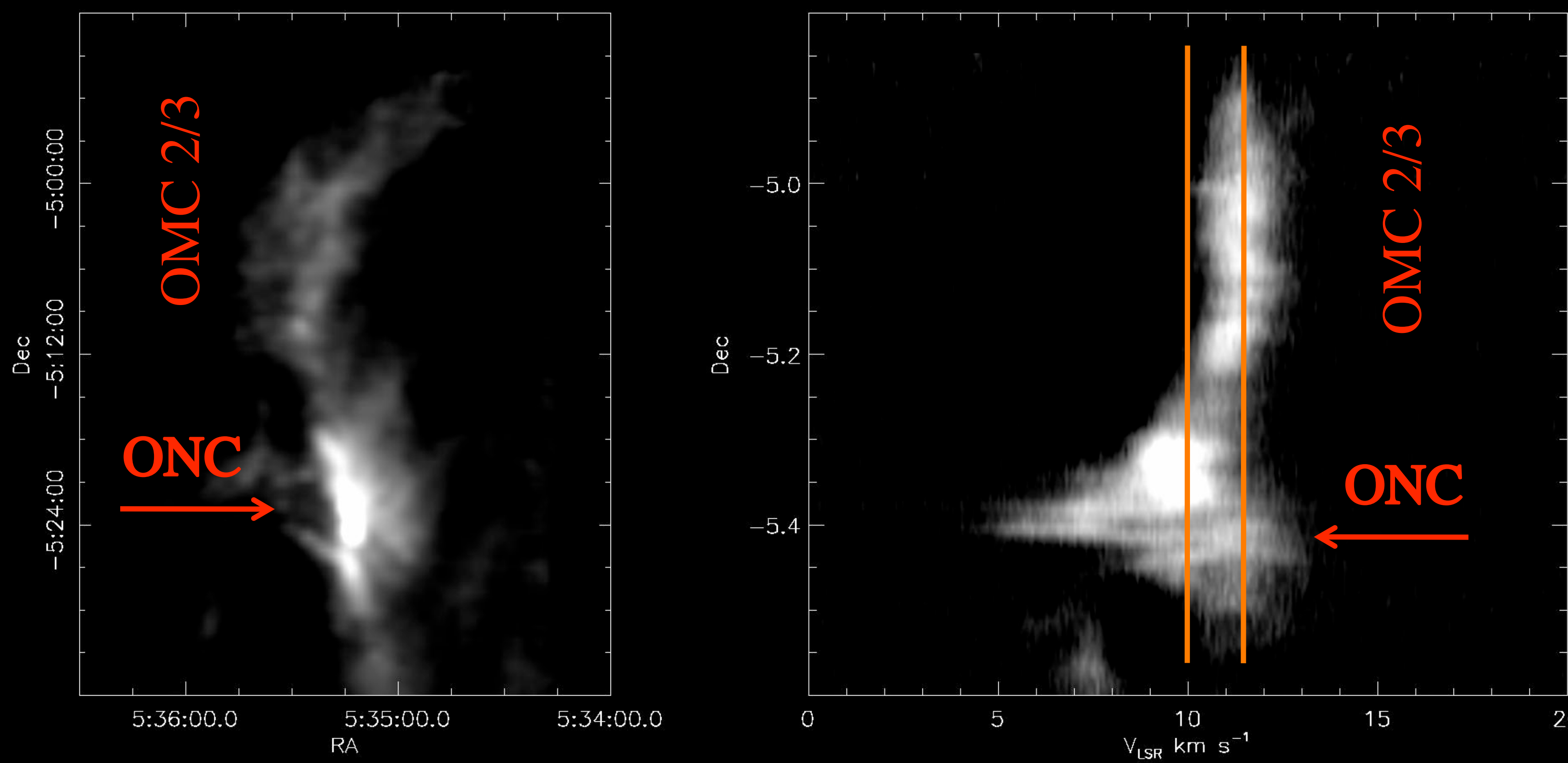
Azimuthal Asymmery Parameter
(Gutermuth et al. 2005)

$$\mathrm{AAP_{raw}} = \frac{\sqrt{\sum_{i=1}^{m}\left[(n_i - |n|)^2\right]/(m-1)}}{\sqrt{|n|}}.$$

Spectroscopic Survey of ONC with Hectoshell and Mike (Tobin et al. 2009)

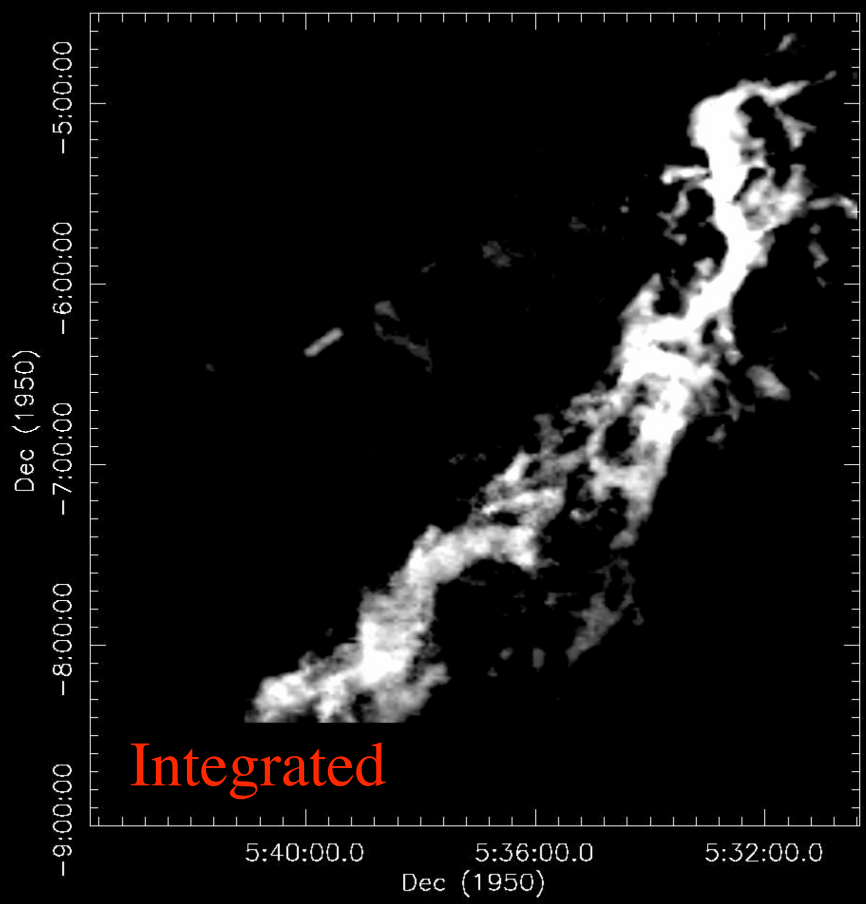


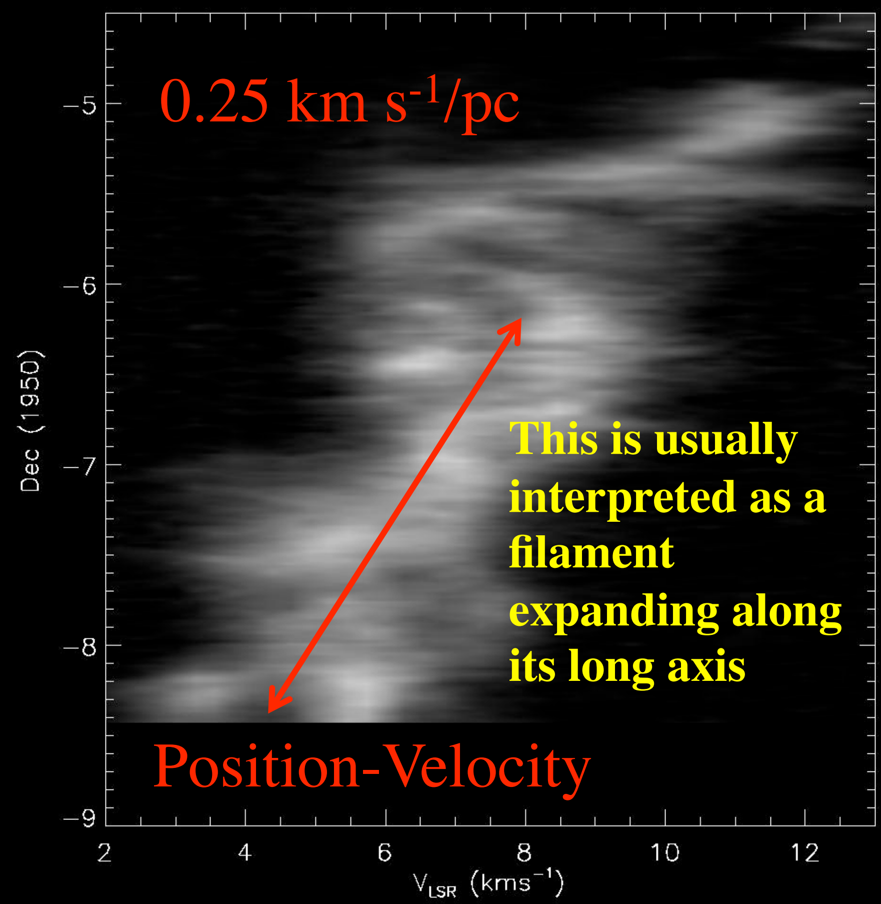
CS (2-1) Data of the ONC Region



Acceleration consistent to material falling from 1.5 parsecs onto a 500 solar mass object

Velocity Structure of Orion A





Filamentary structure in the Orion Molecular Cloud
Bally et al. 1987

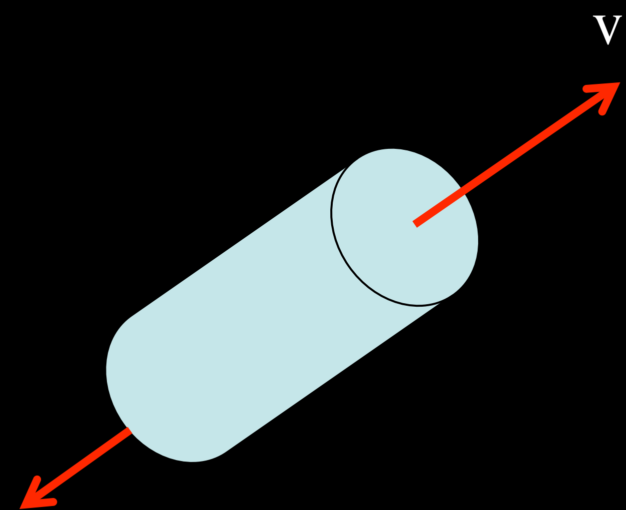
Motivation

Consider an expanding filament with a linear velocity gradient

Does gravity or kinetic energy win?

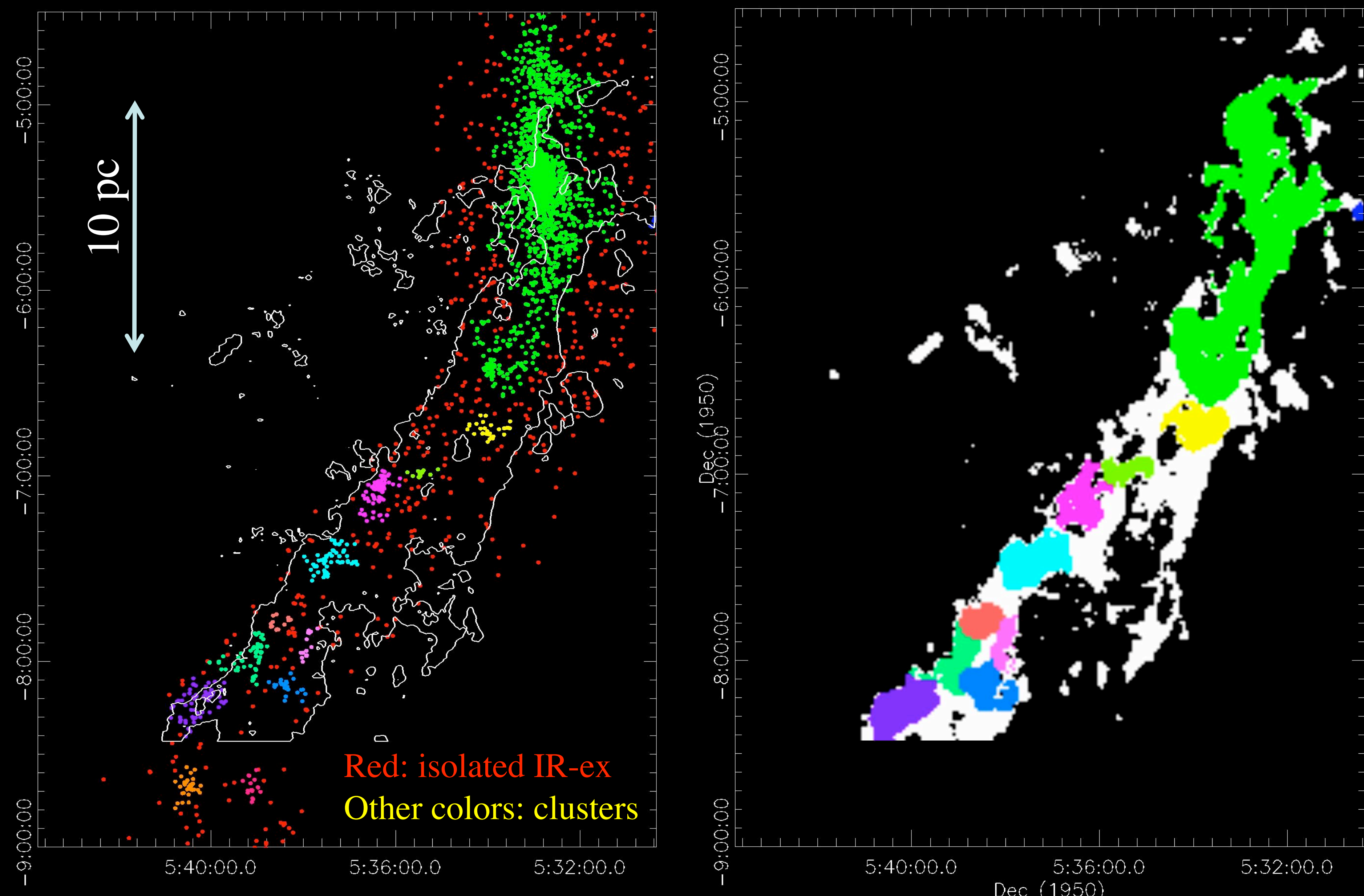
What is the dominant form of kinetic energy: thermal, turbulent or large scale velocity gradient?

You can derive a length, at which velocity gradient wins.

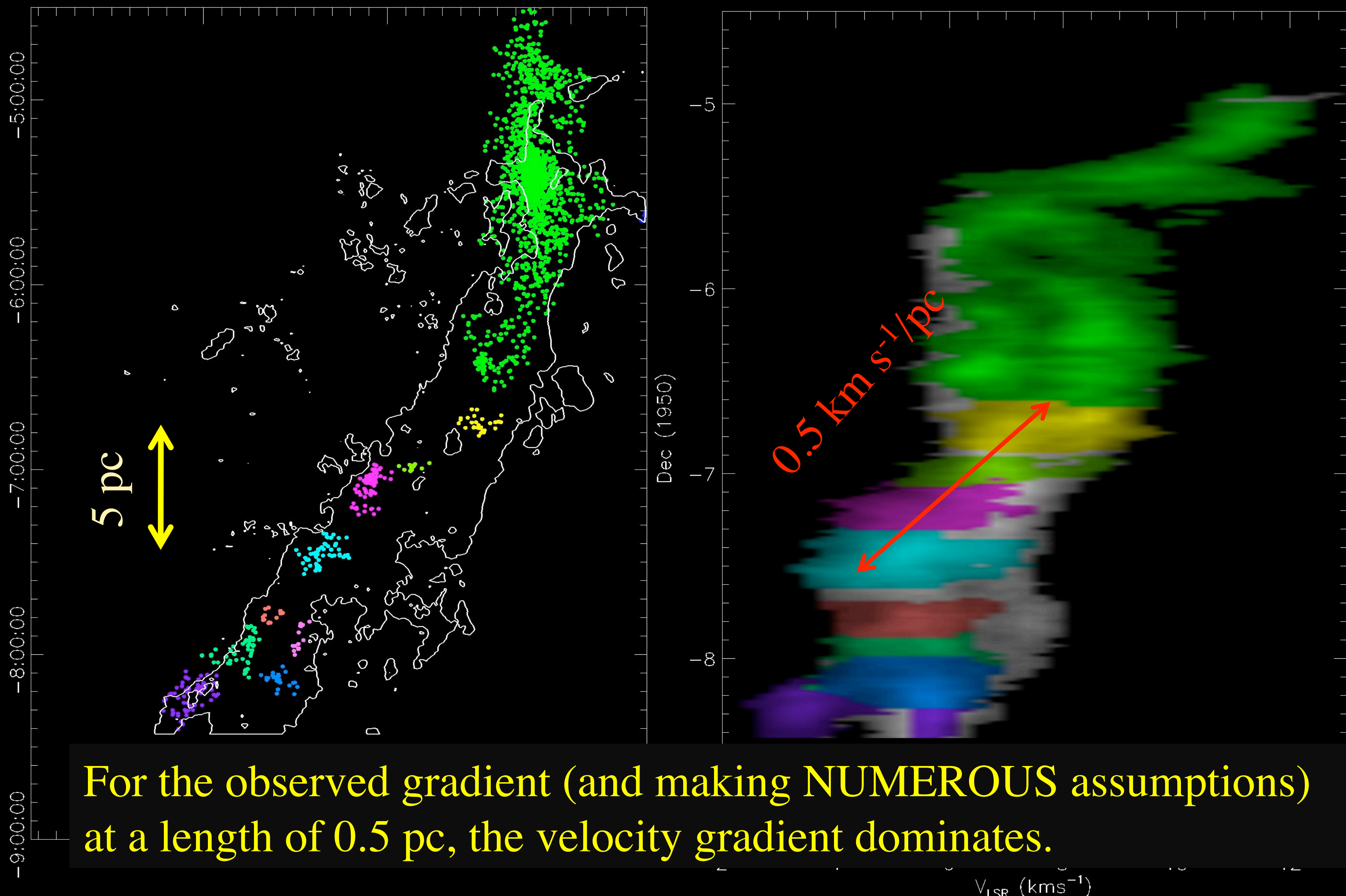


Length *prop* 1/velocity gradient

Breaking up the Orion A Filament by Cluster



Breaking up the Orion A Filament by Cluster



For the observed gradient (and making NUMEROUS assumptions) at a length of 0.5 pc, the velocity gradient dominates.

Where to go next

Filaments show complicated and significant velocity structure.

•Some evidence for infall along filament

•Expansion may help define clusters and separation between clusters

Need to understand motions more: what is driving velocity gradients?

Need to find more examples: are such gradients common?

Need to simulate star formation in filaments with velocity gradients

Need to ask Phil what he thinks!

Quick Census: Embedded YSOs within 500 pc

Ophiuchus & Perseus

A_v cloud map: Complete

YSOs: IR-ex from Spitzer C2D

Taurus

A_v cloud map: Lombardi & Alves

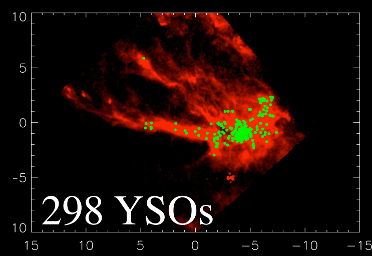
YSOs: all known from K Luhman

Orion

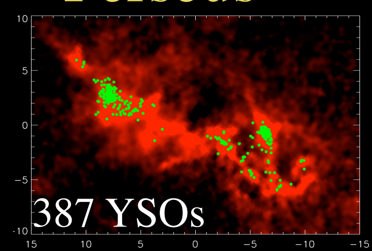
A_v cloud map: R. Gutermuth

YSOs: IR-ex from Spitzer Megeath in prep. + COUP

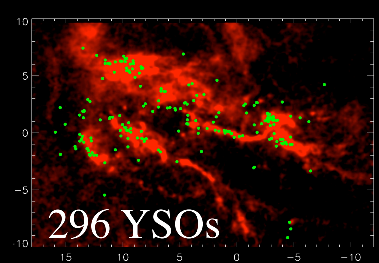
Ophiuchus

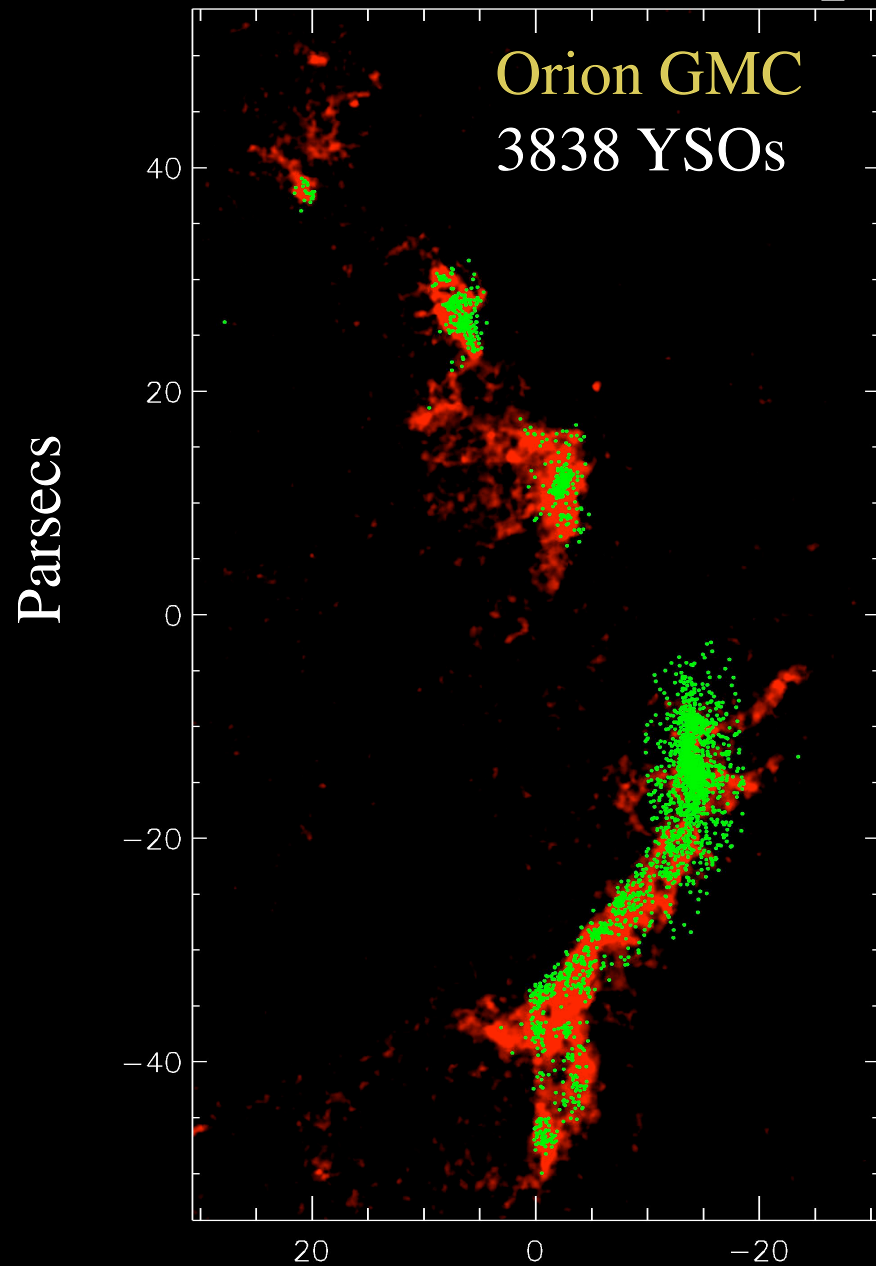


Perseus

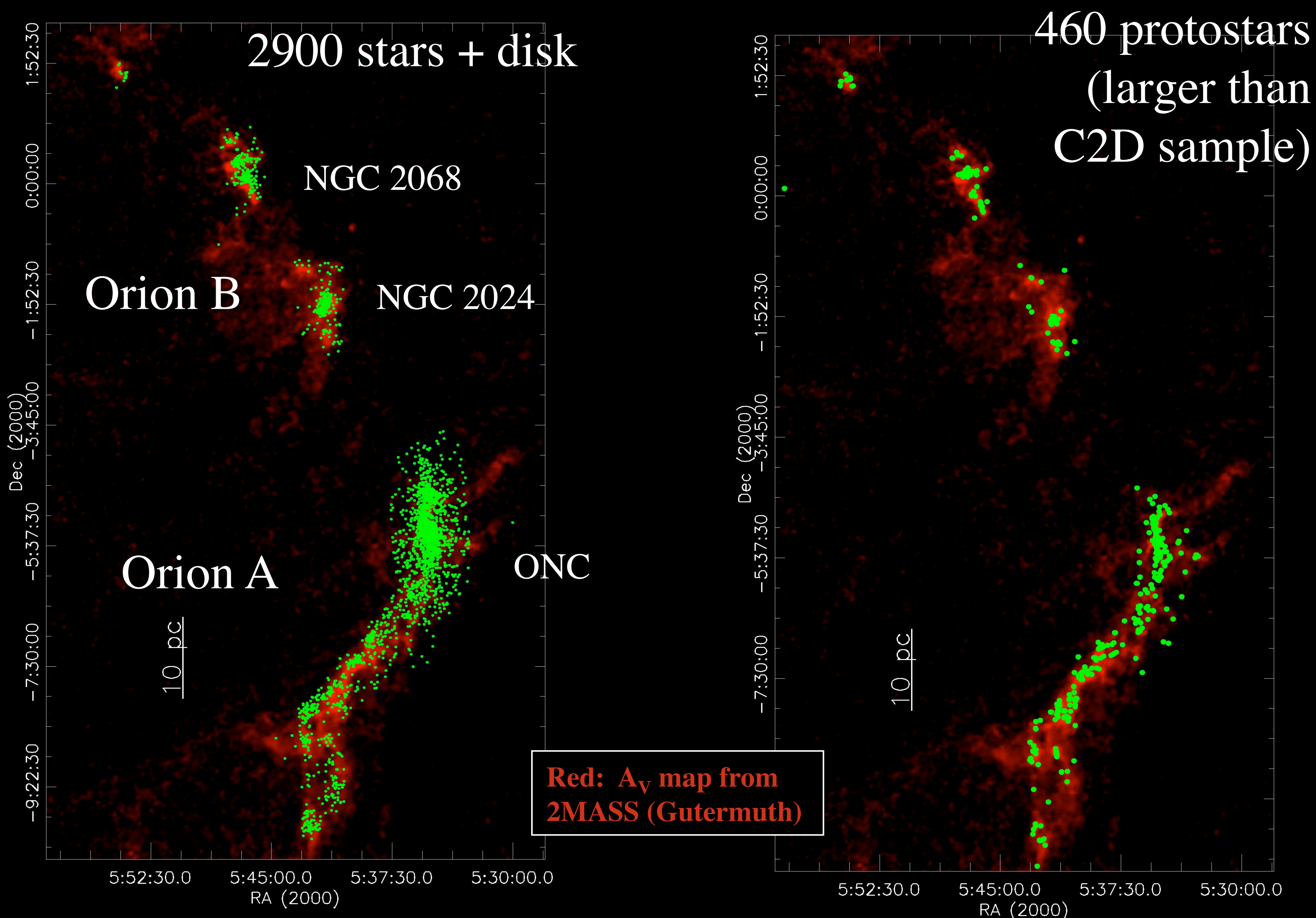


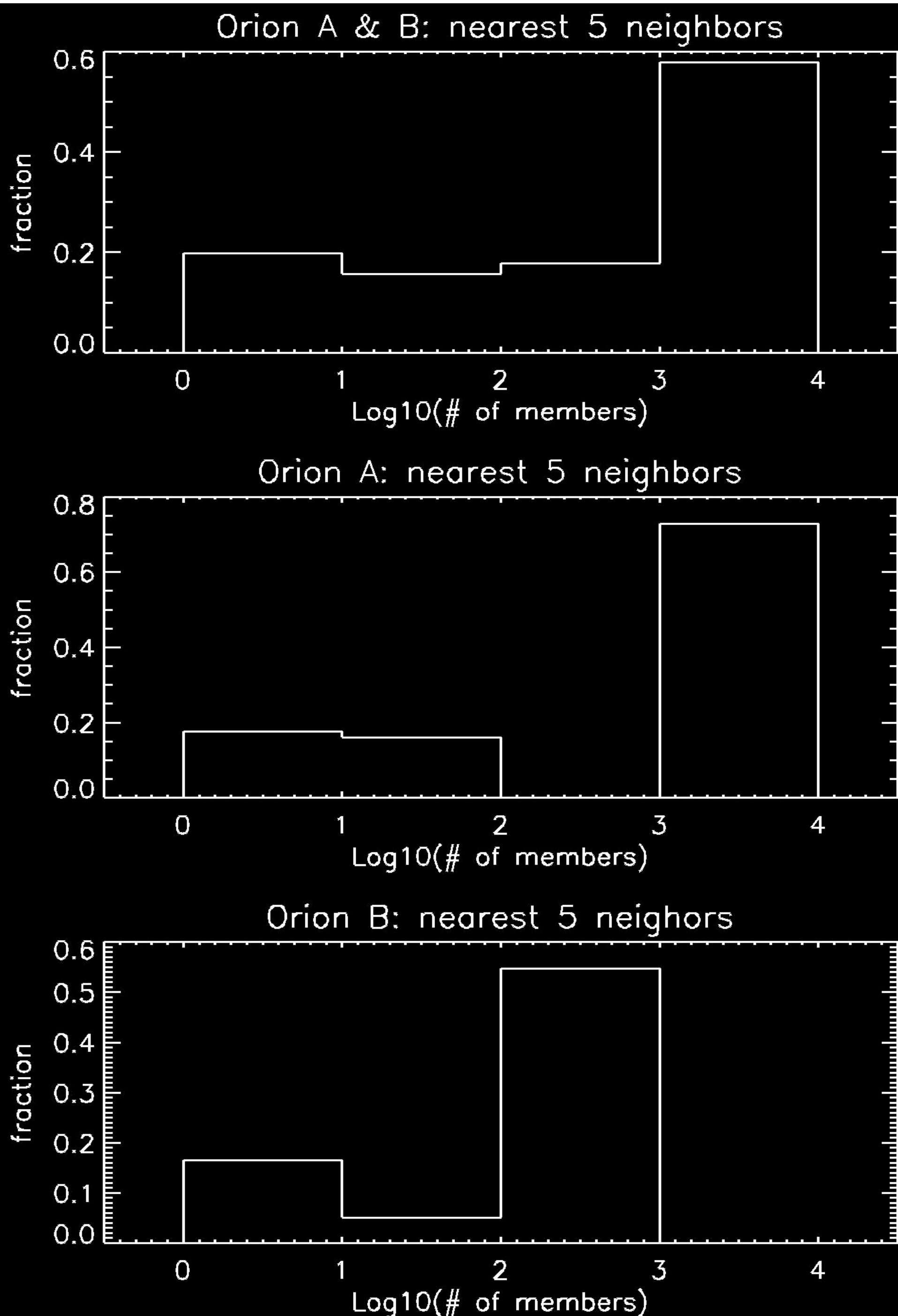
Taurus





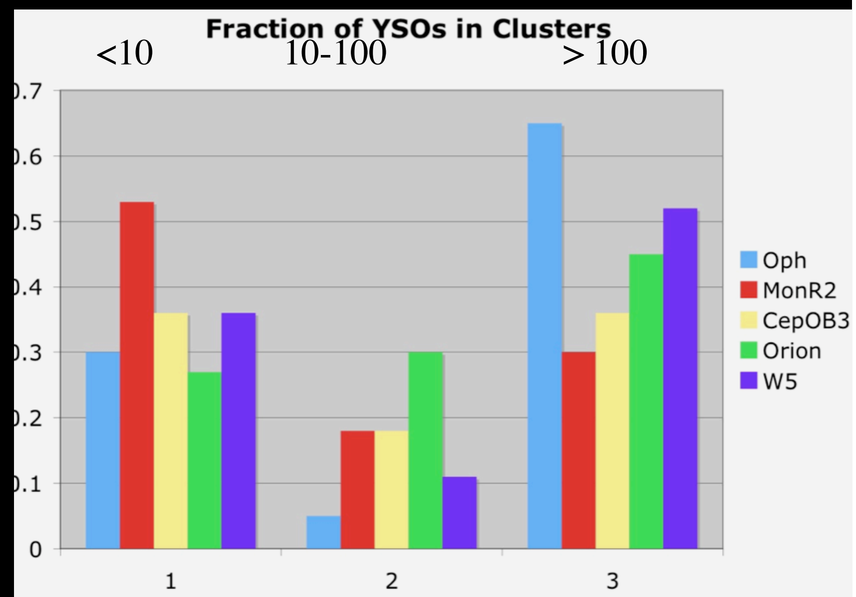
The Distribution of Stars Follows the Distribution of Gas





We find that all GMCs associated with massive stars contain significant numbers of low mass stars in small groups and relative isolation.

Even in GMCs containing young massive stars, many low mass stars are found in relative isolation, parsecs away from the hot OB stars.



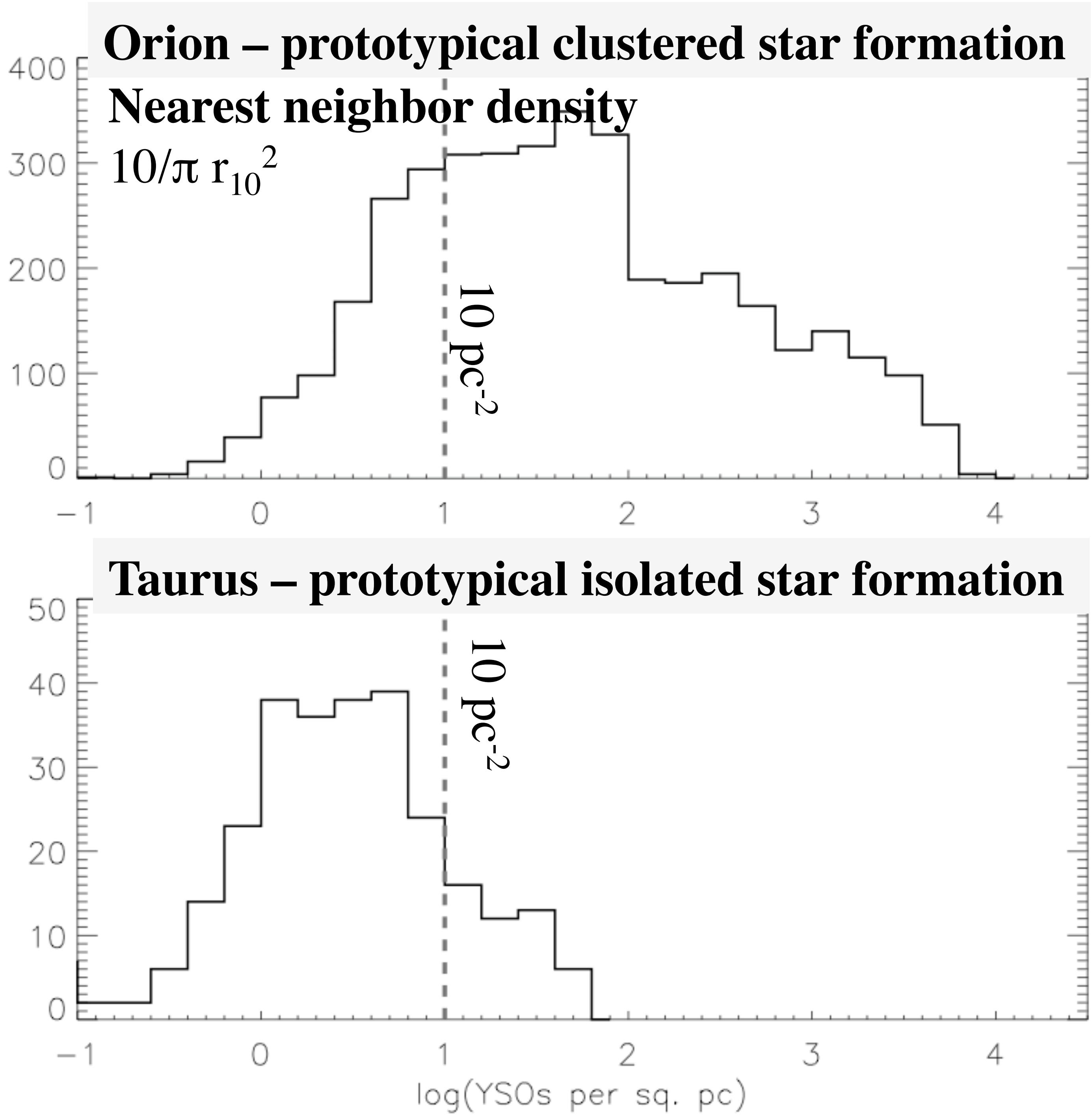
Orion-Like vs Taurus-Like Regions

2MASS Images

In the star formation literature, there are two archetypes for star forming regions:

The Taurus Molecular Cloud – the prototypical distributed star forming region

The Orion Molecular Clouds – the prototypical clustered star forming region



How do you identify clusters?

One approach is to use a surface density criteria.

For the following analysis, I adopt a threshold of $10\ pc^{-2}$

Processes Controlling Star Formation

Large Scale Motions in the ISM (creates molecular clouds)

Global Gravitational Collapse (collapse of clouds or large regions within clouds)

Jeans Fragmentation (forms ~stellar mass sized unstable fragments)

Small Scale Collapse of Fragments into Stars

Turbulence within Molecular Clouds (turbulent fragmentation creates fine scale structure needed for small scale collapse, resists global collapse)

Magnetic Fields (resists collapse, particularly on small scales)

Feedback from Stars (outflows, winds and UV radiation)

Dynamical Motions of Stars in Clusters (eject stars from cloud)

Comparing Clustered and Distributed Modes

Relative importance of clustered and distributed stars appears to be linked to the organization of gas in the clouds.

Taurus – spaghetti like filaments, no major clumps with large column densities.

Ophiuchus – star formation found in one large clump, perhaps the result of compression by Upper Scorpius association.

Does compression from external stars play role? Do magnetic fields inhibit the formation of clumps?