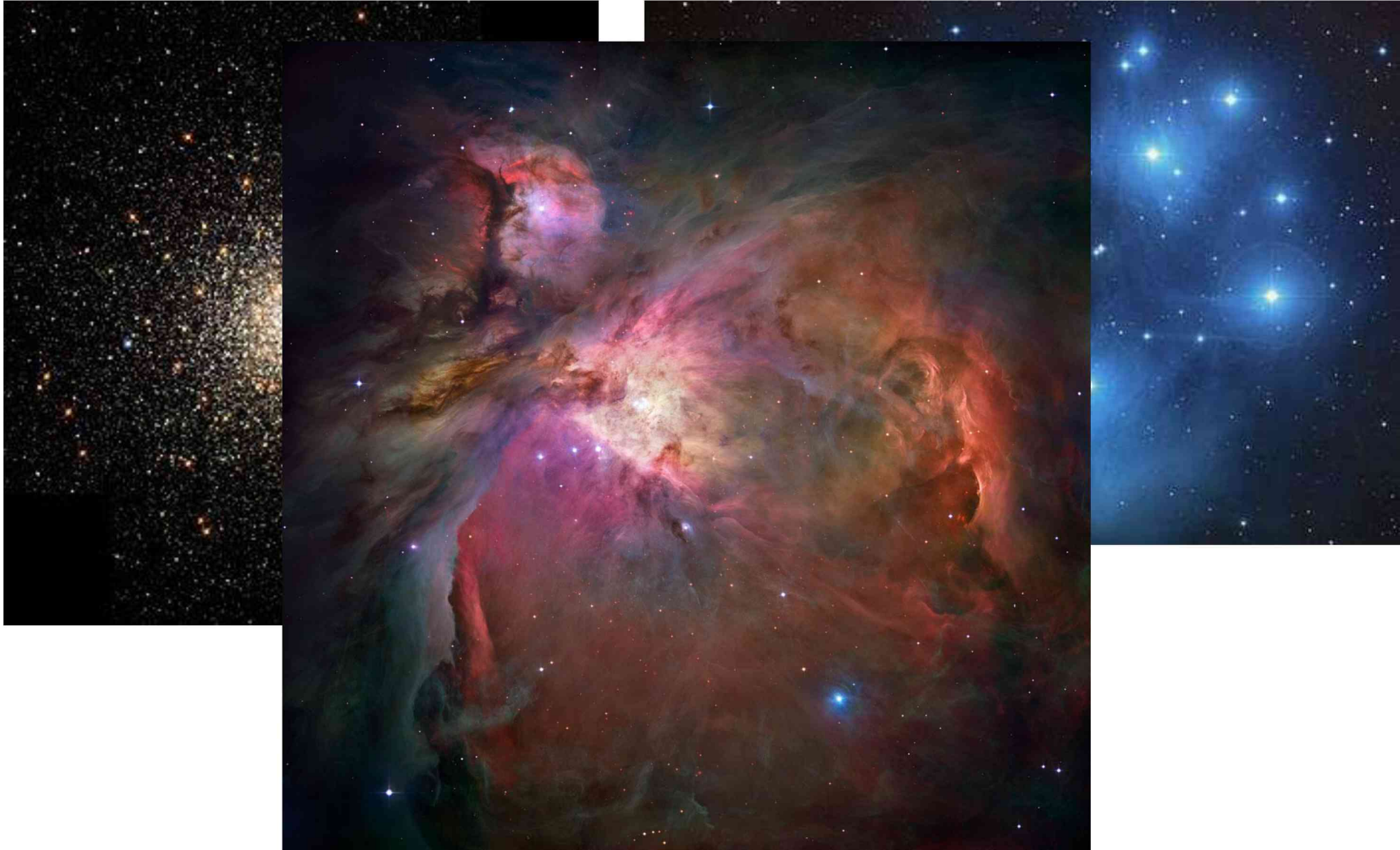


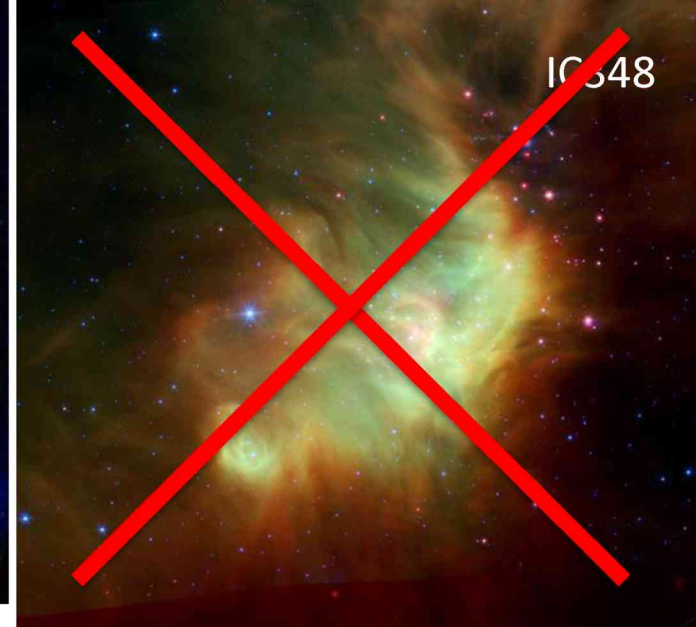
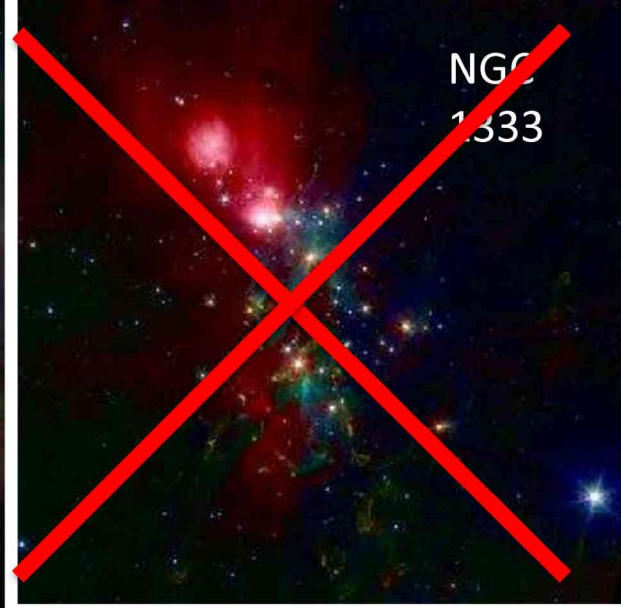
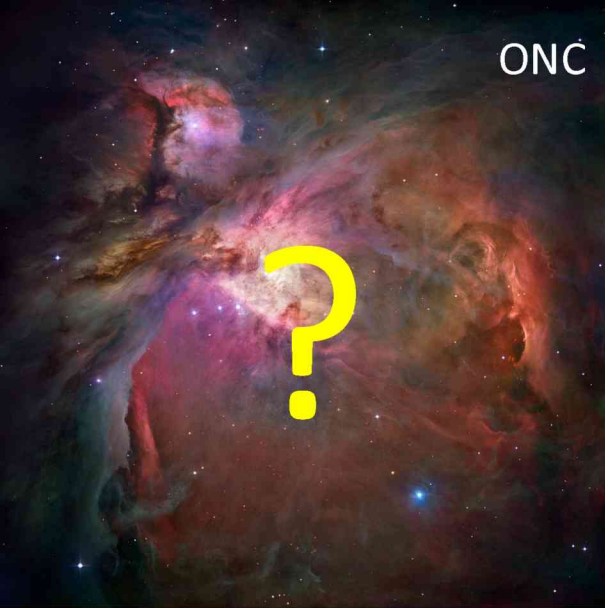
# Untangling the Galaxy

Marina Kounkel

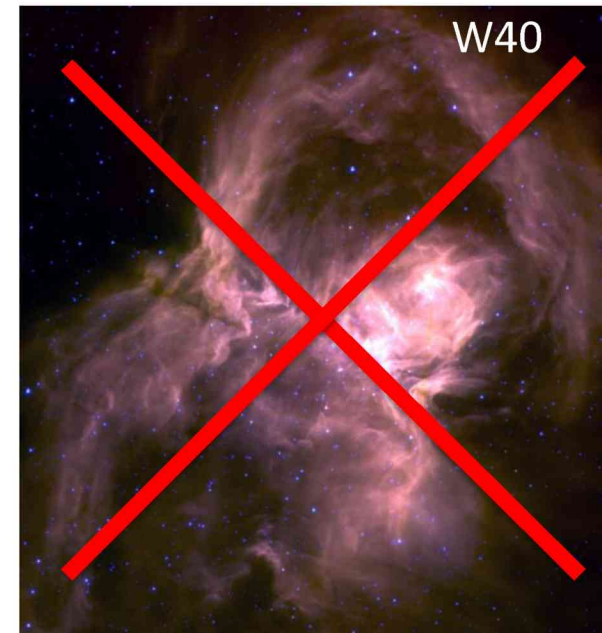
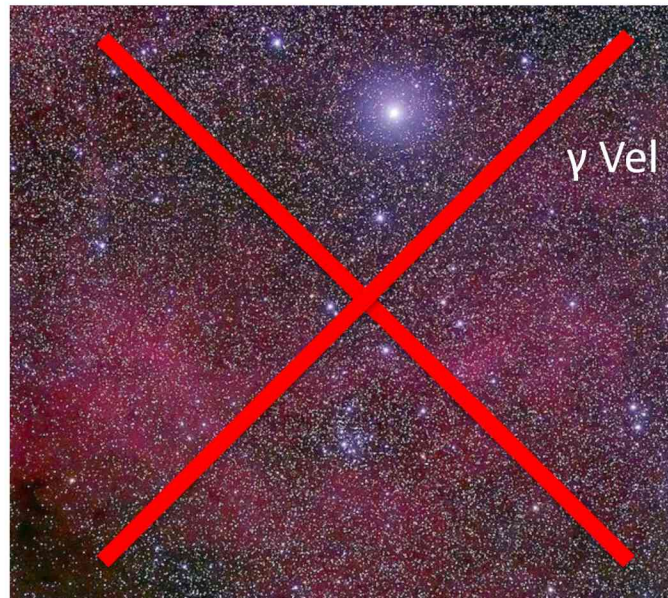
Western Washington University

# What are clusters?





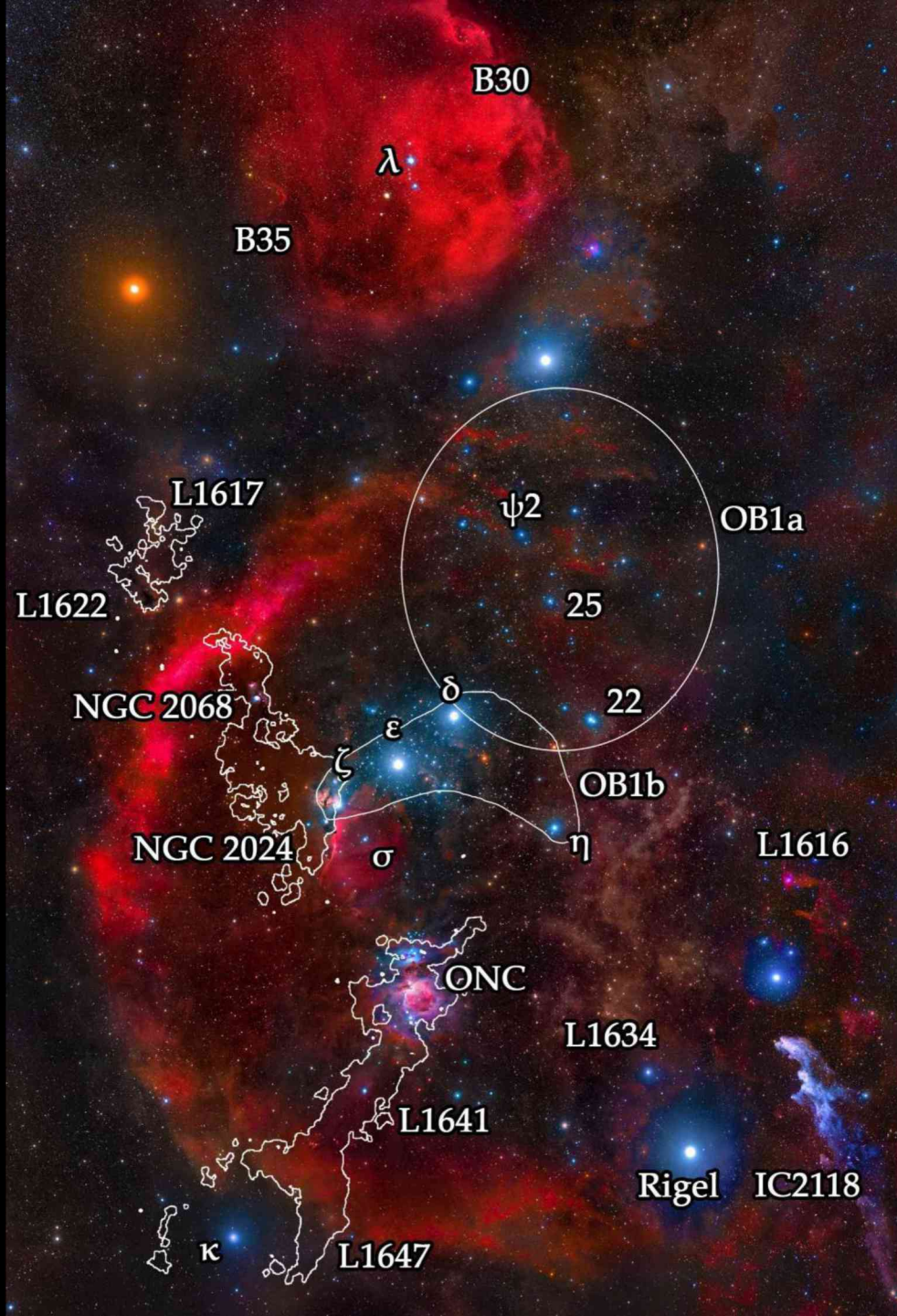
Most clusters do not survive past 10 Myr  
Few make it to 100 Myr

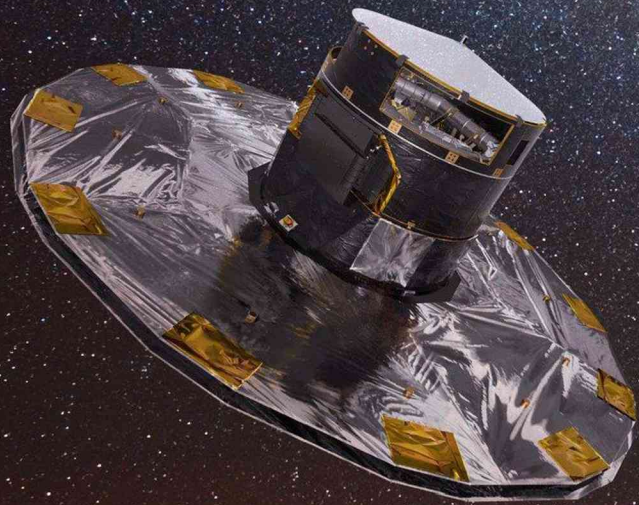


# Orion Molecular Cloud Complex

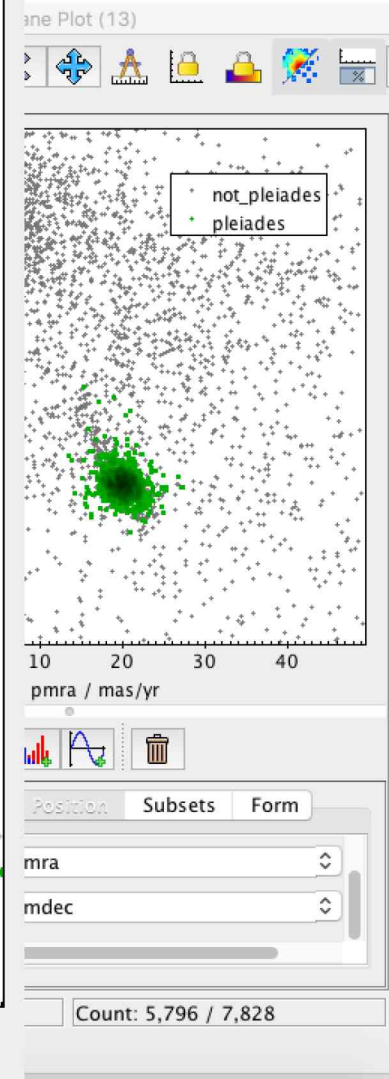
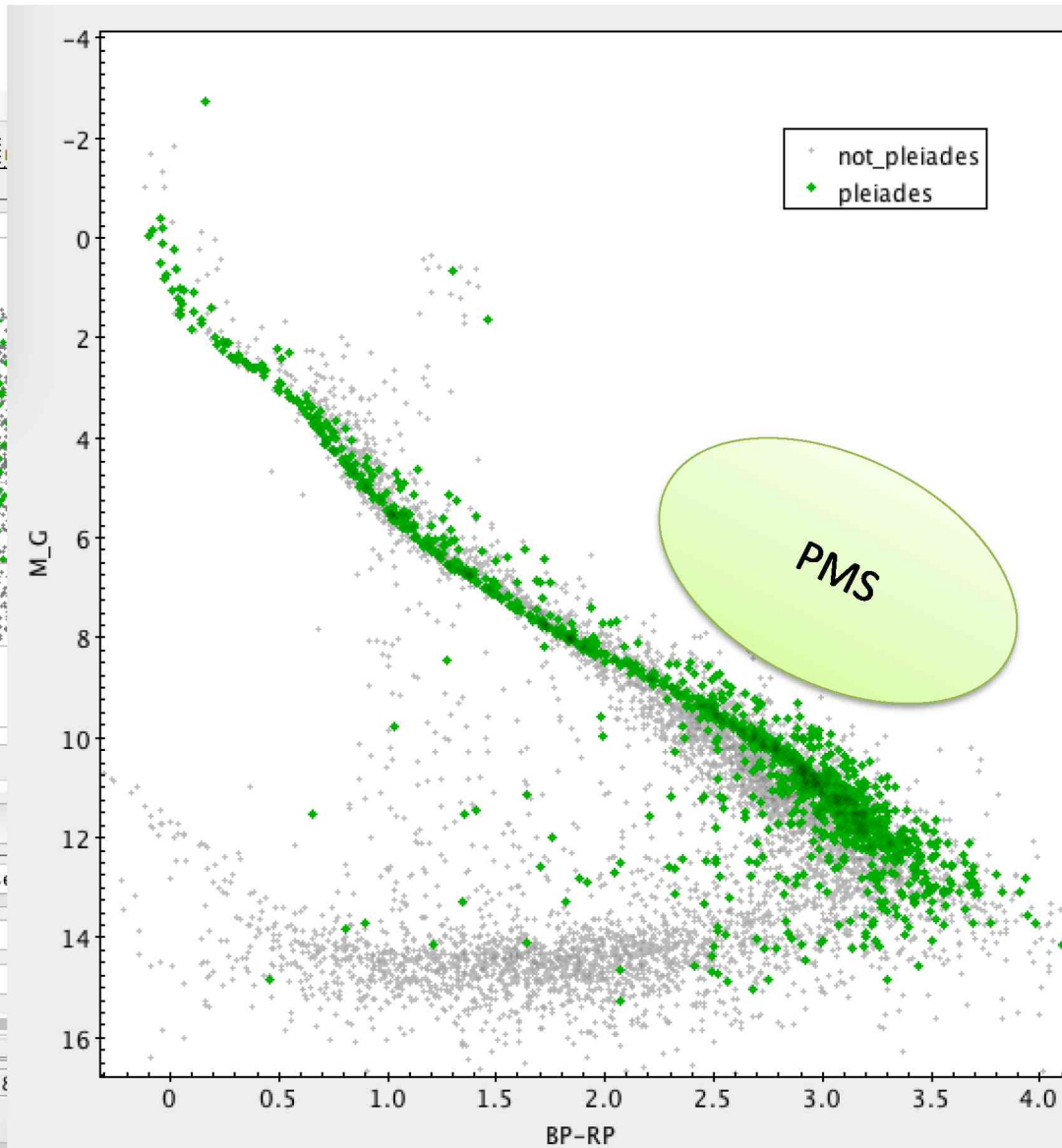
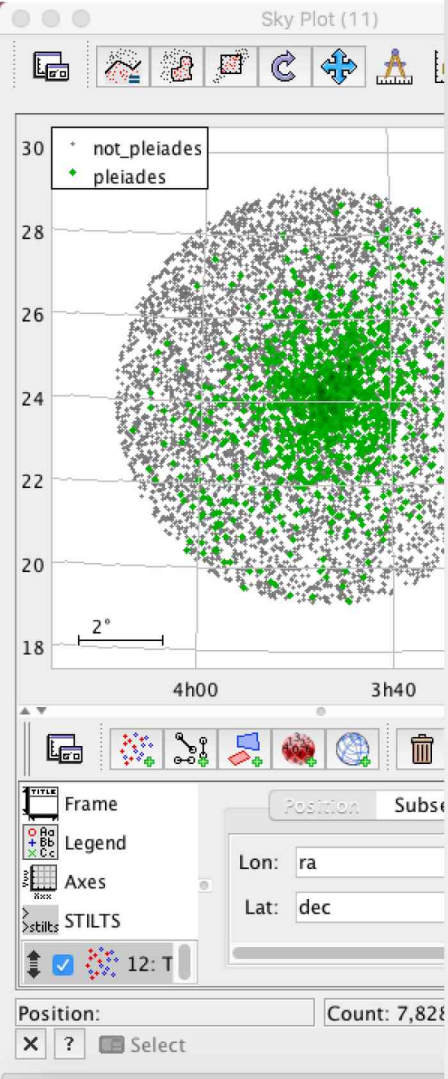
20°  
~150 pc

- Multiple stellar populations
- Age range from < 1 to >10 Myr

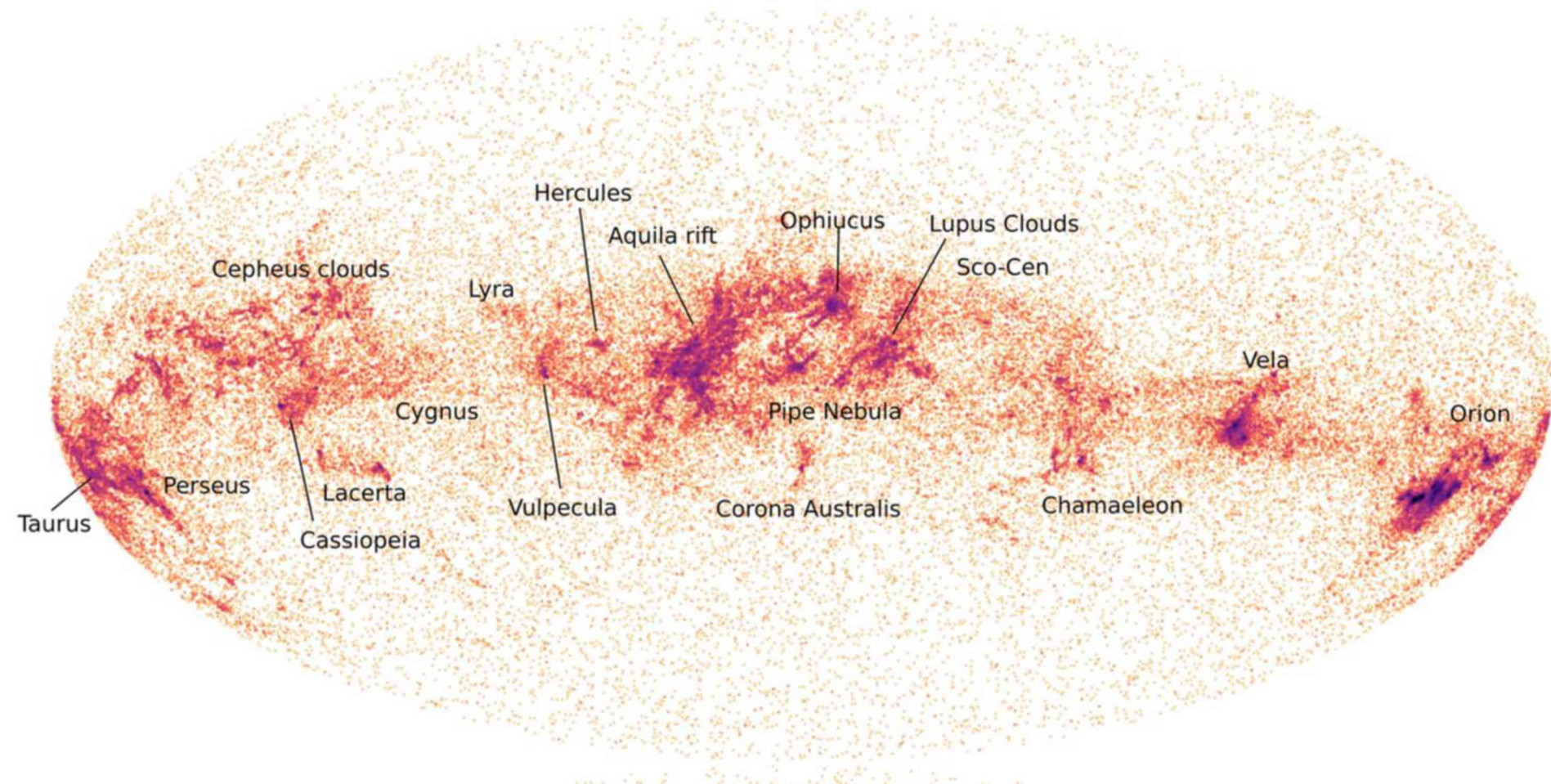




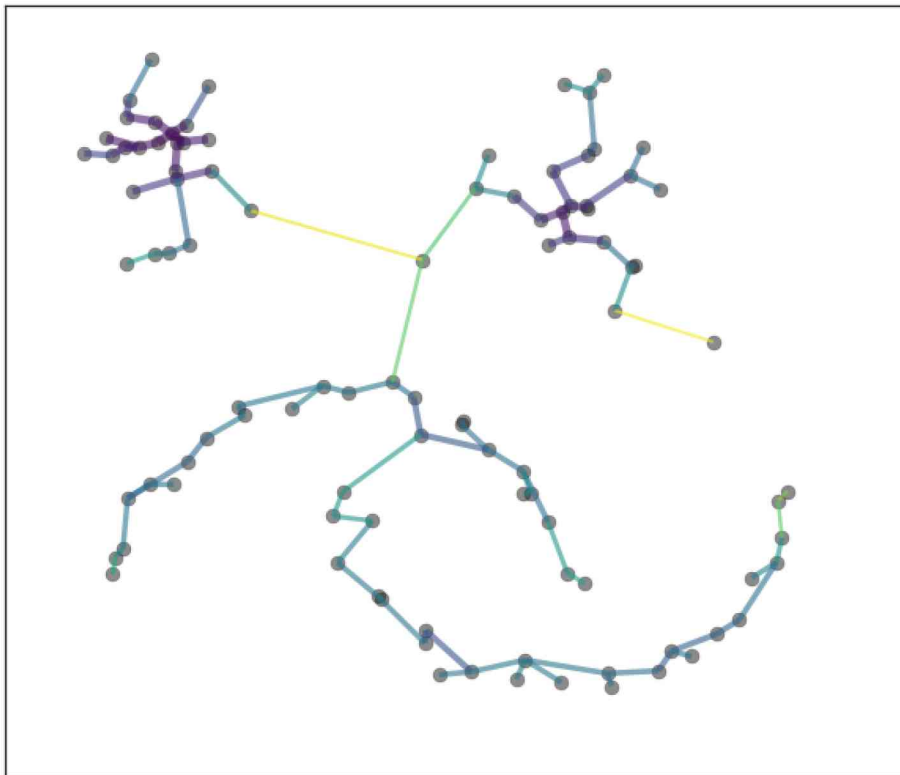
# Pleiades



# Low mass stars younger than 20 Myr



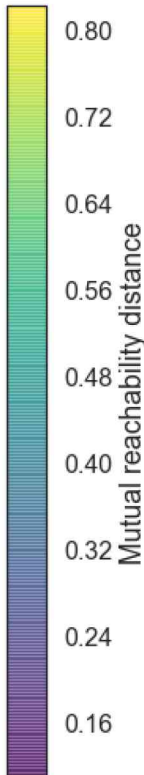
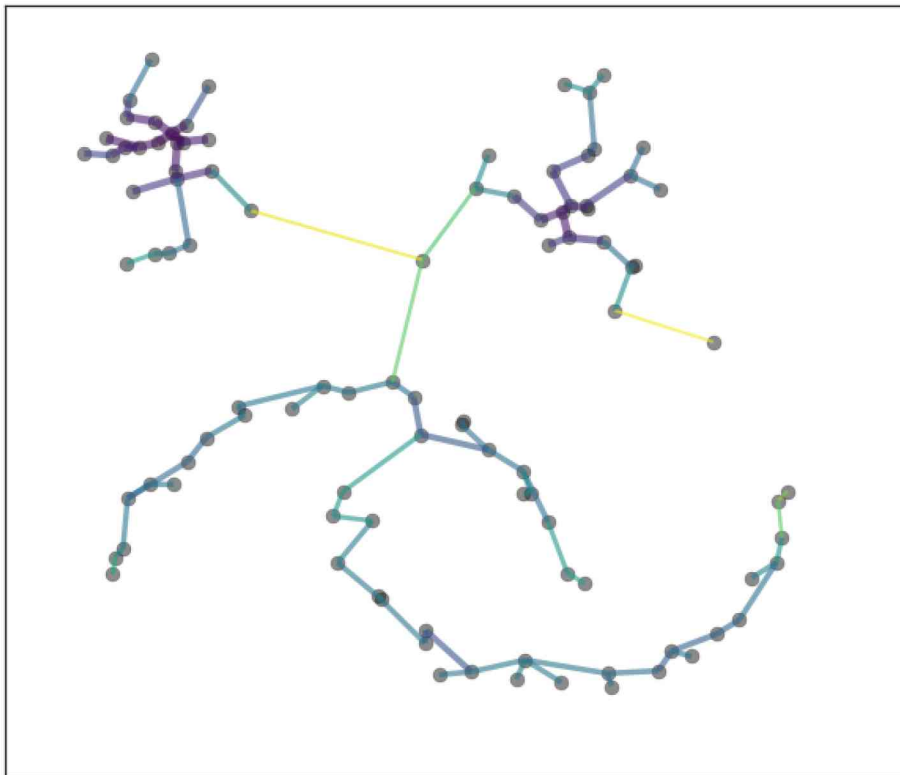
# Hierarchical clustering



- Measure distance between all points
- Construct a minimum spanning tree
- Determine the appropriate place to cut the branches

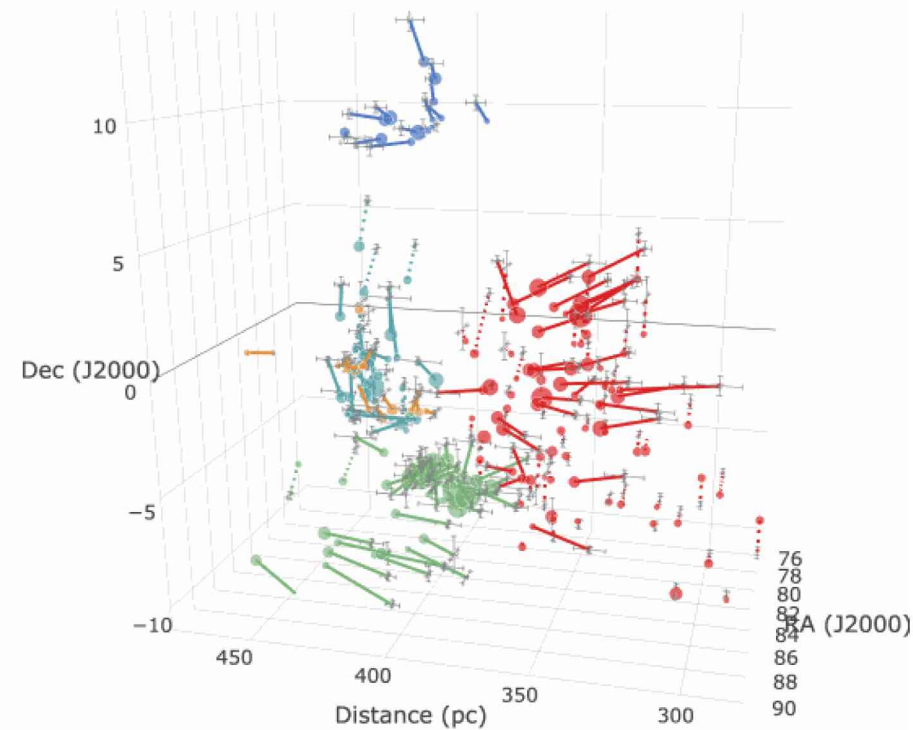
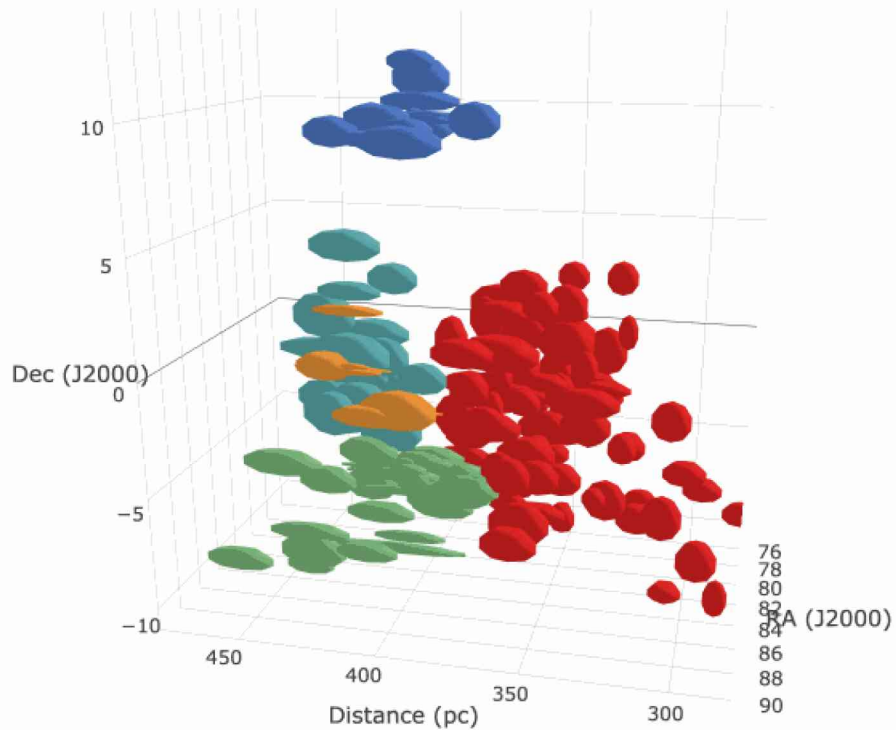


# Hierarchical clustering



- Different clustering algorithms may have differences in outputs, but trace the same underlying structure
- Data processed by the clustering algorithm  $\neq$  physical clusters are found

# The Orion Complex



Orion A

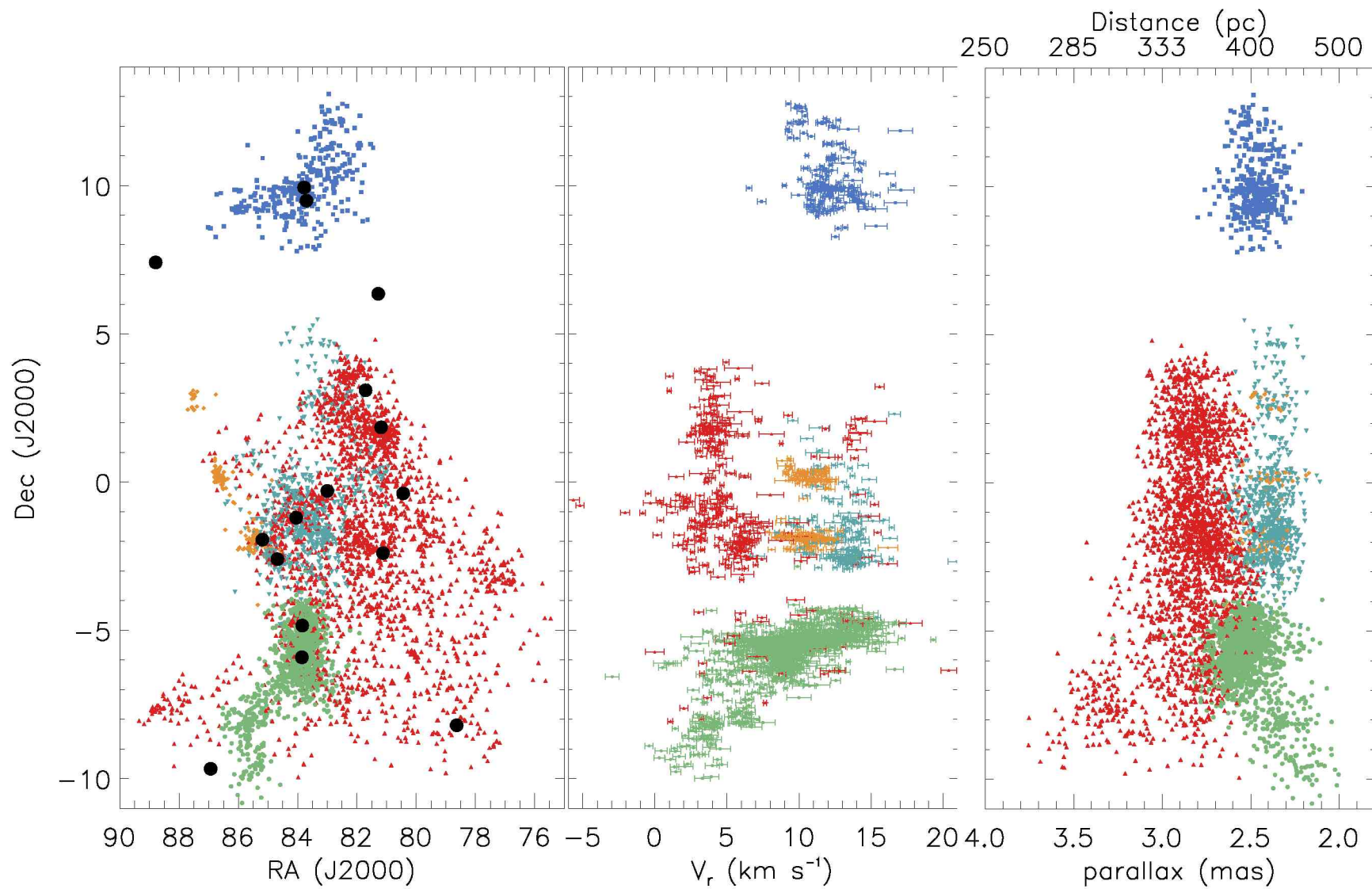
Orion B

Orion C

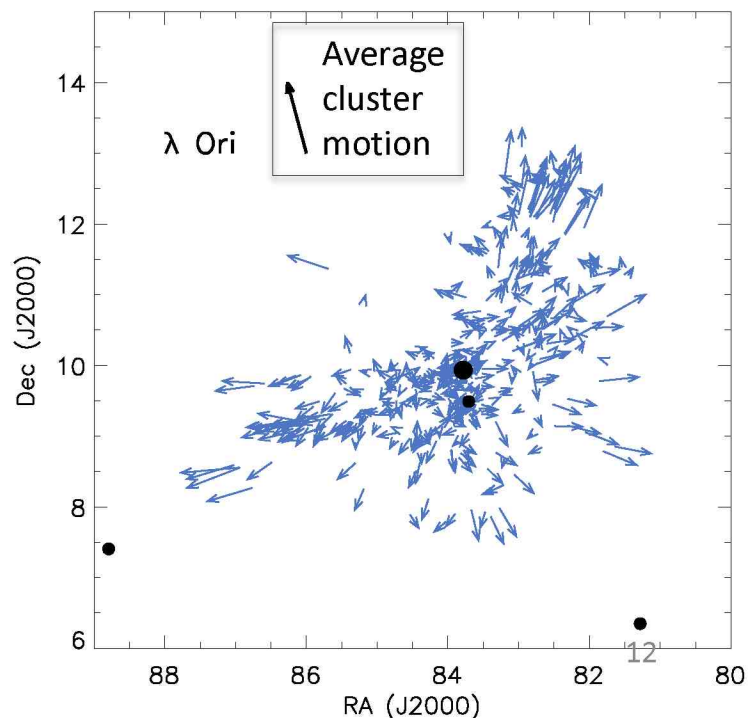
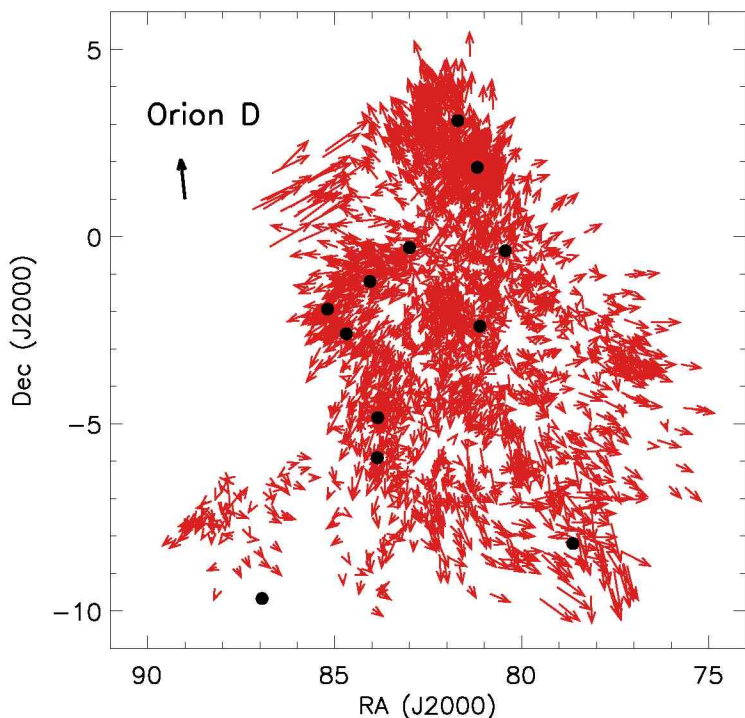
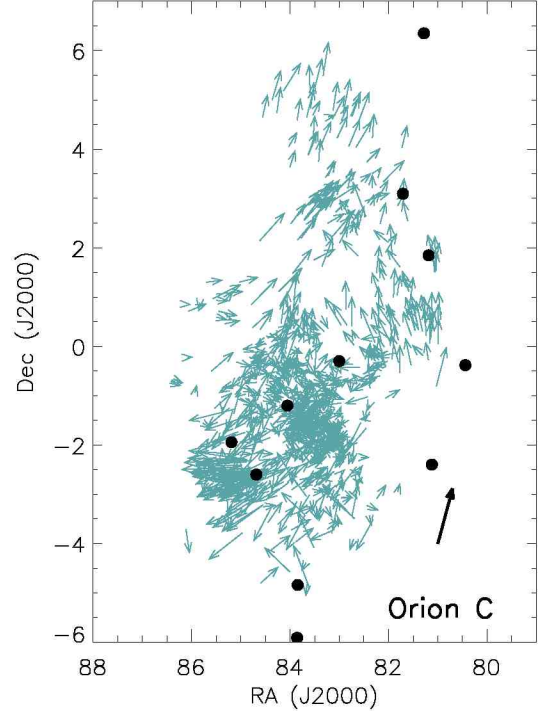
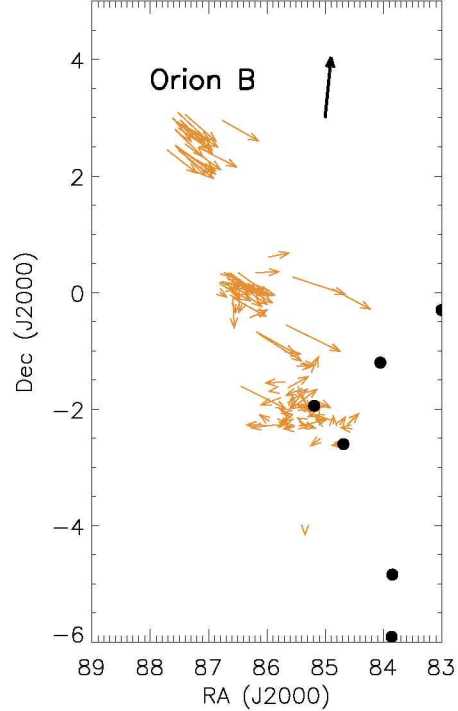
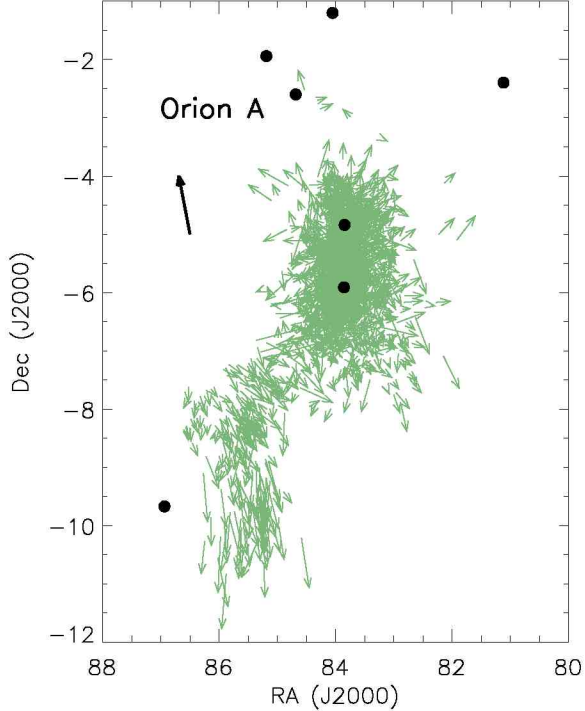
Orion D

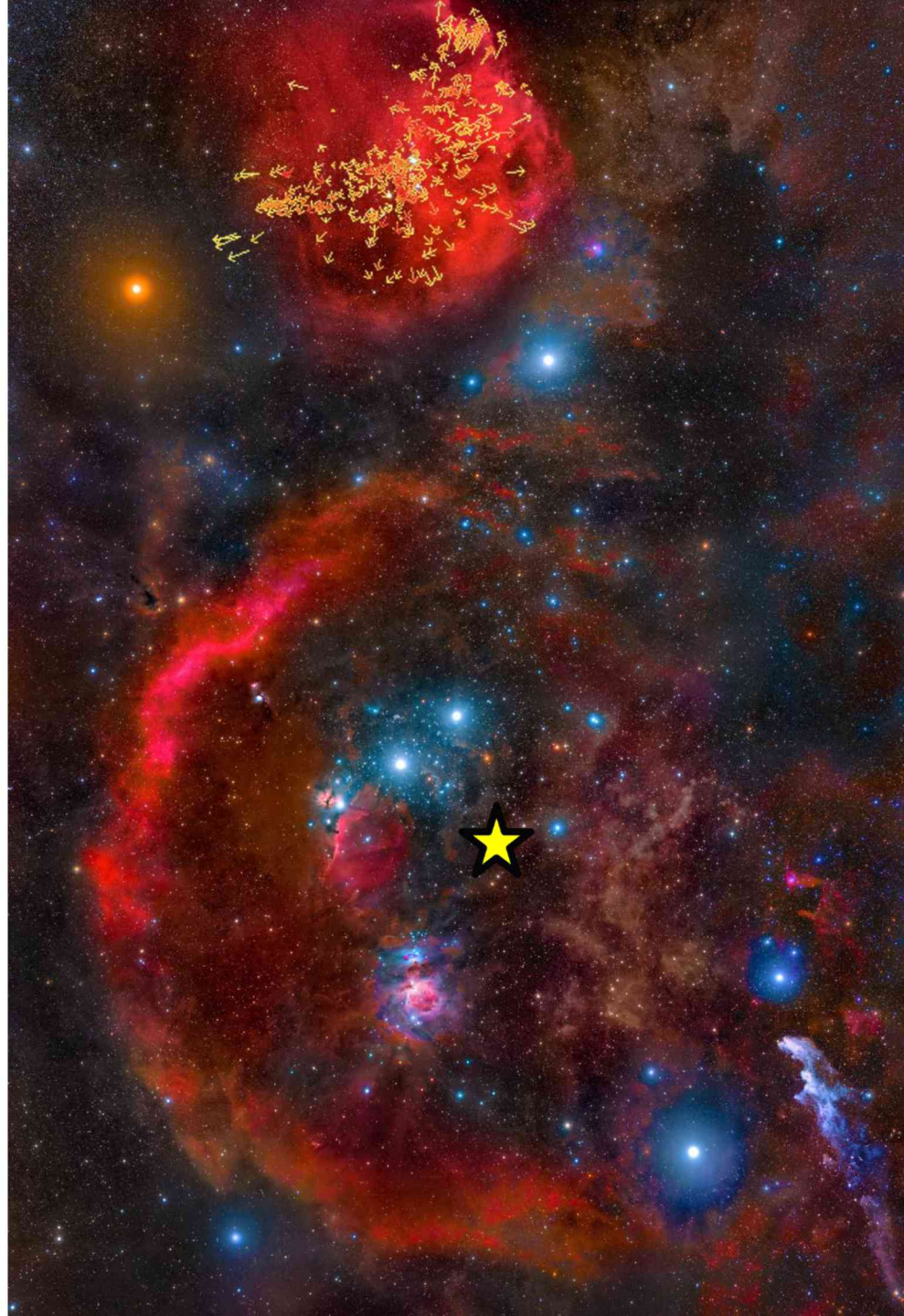
$\lambda$  Ori

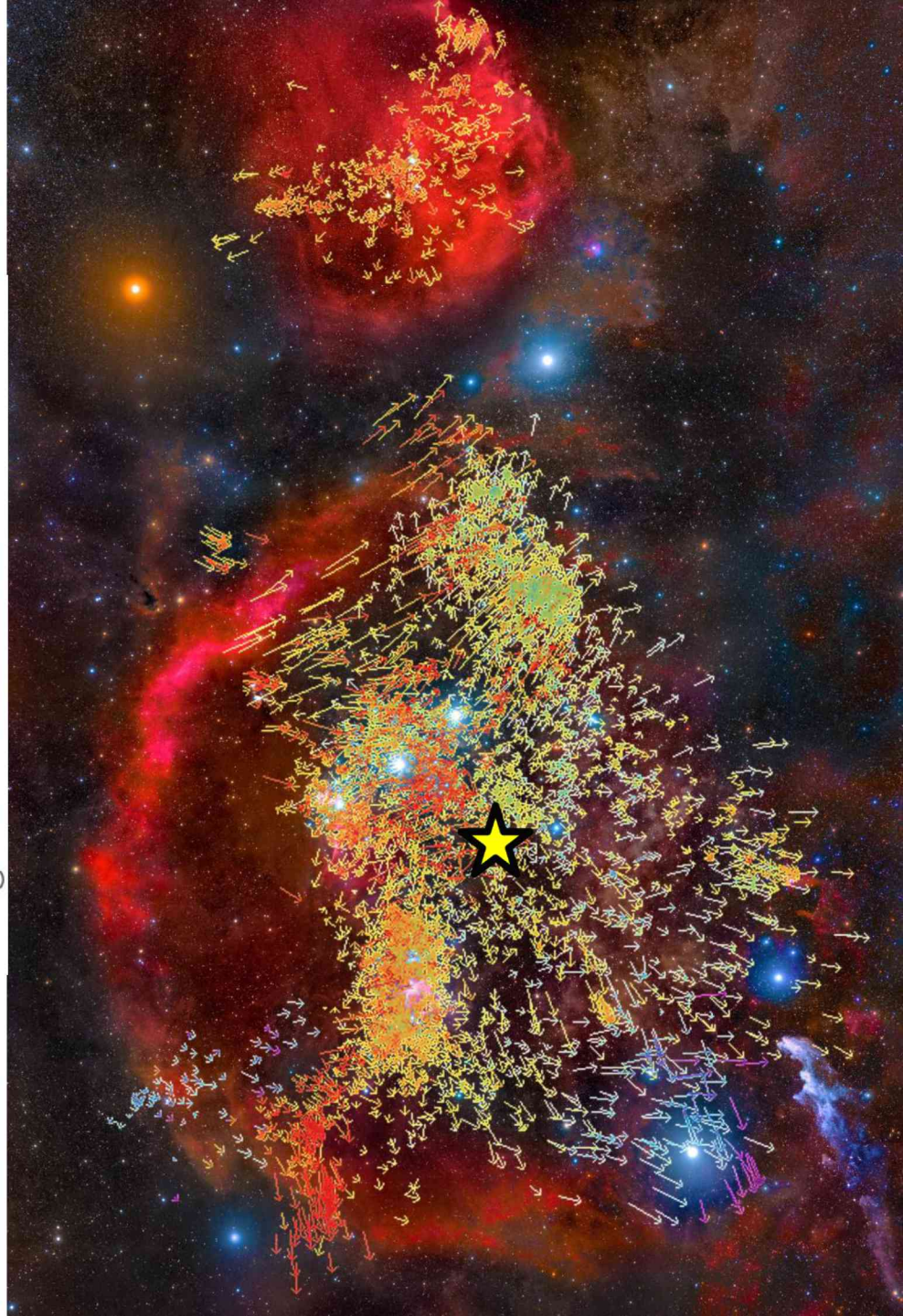
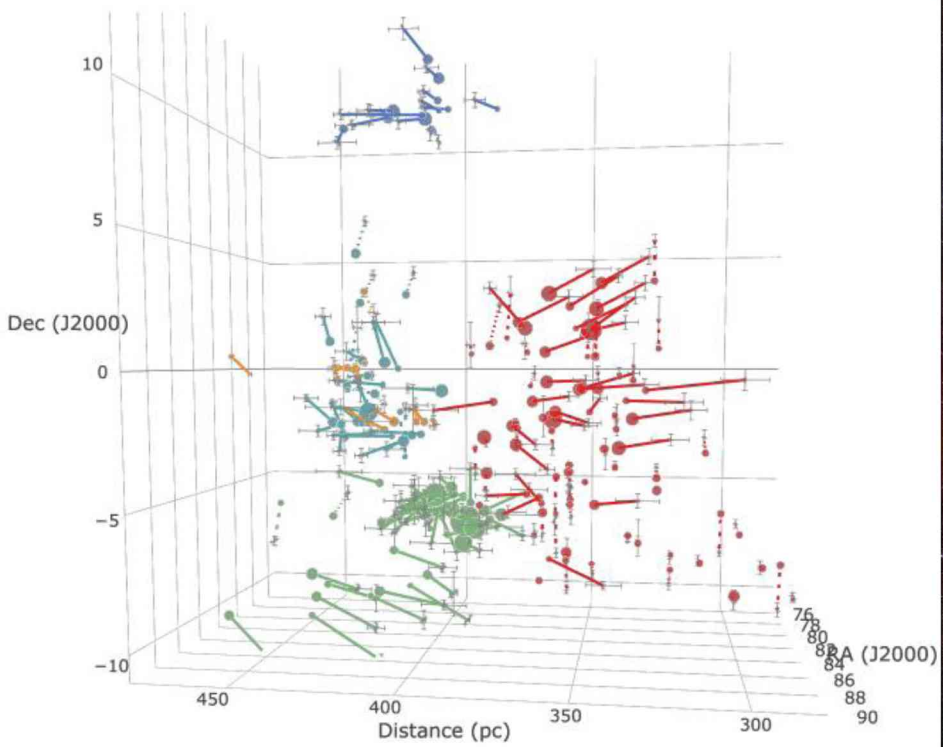
# Orion Complex

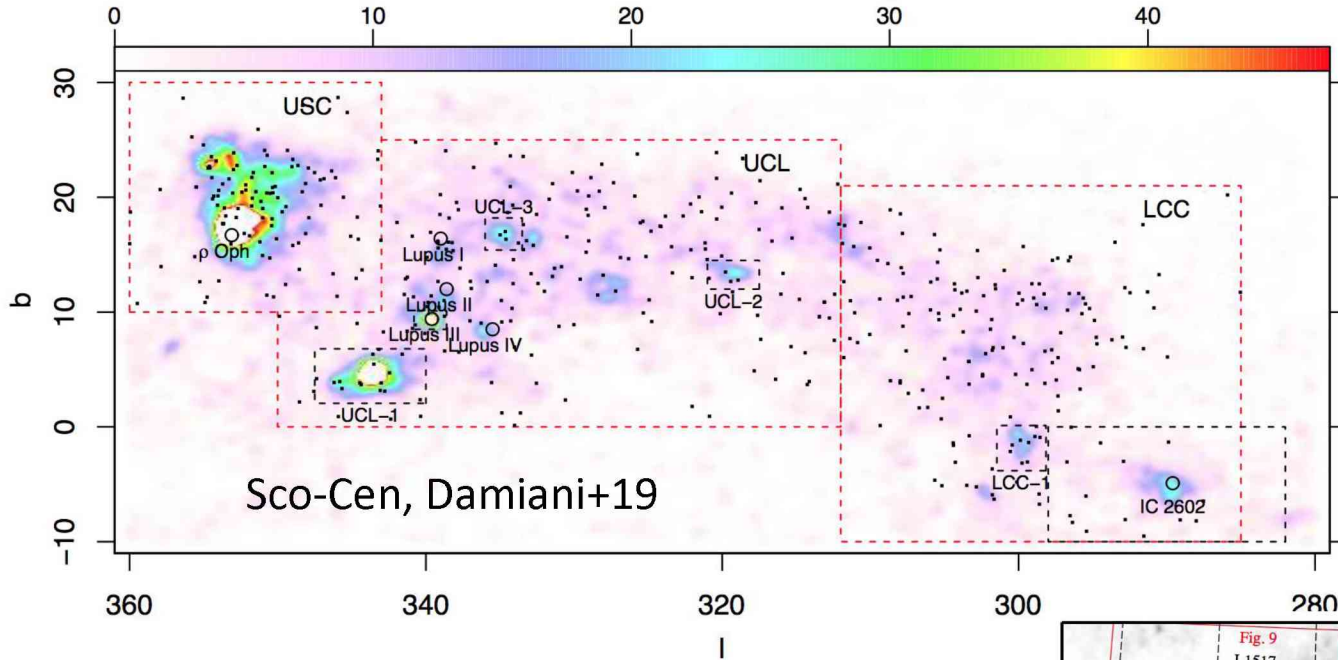


# Proper Motions

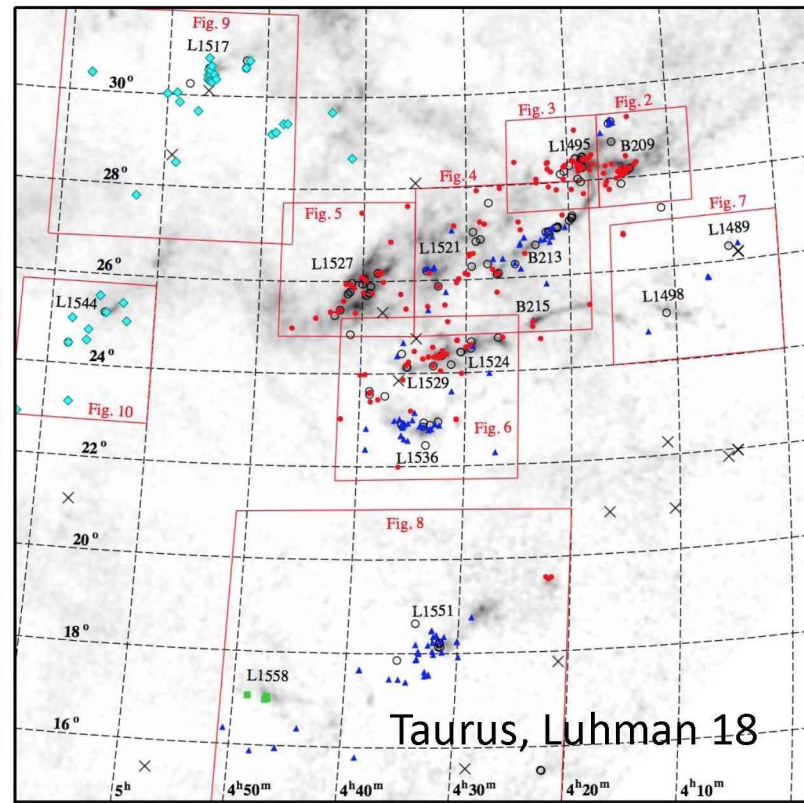
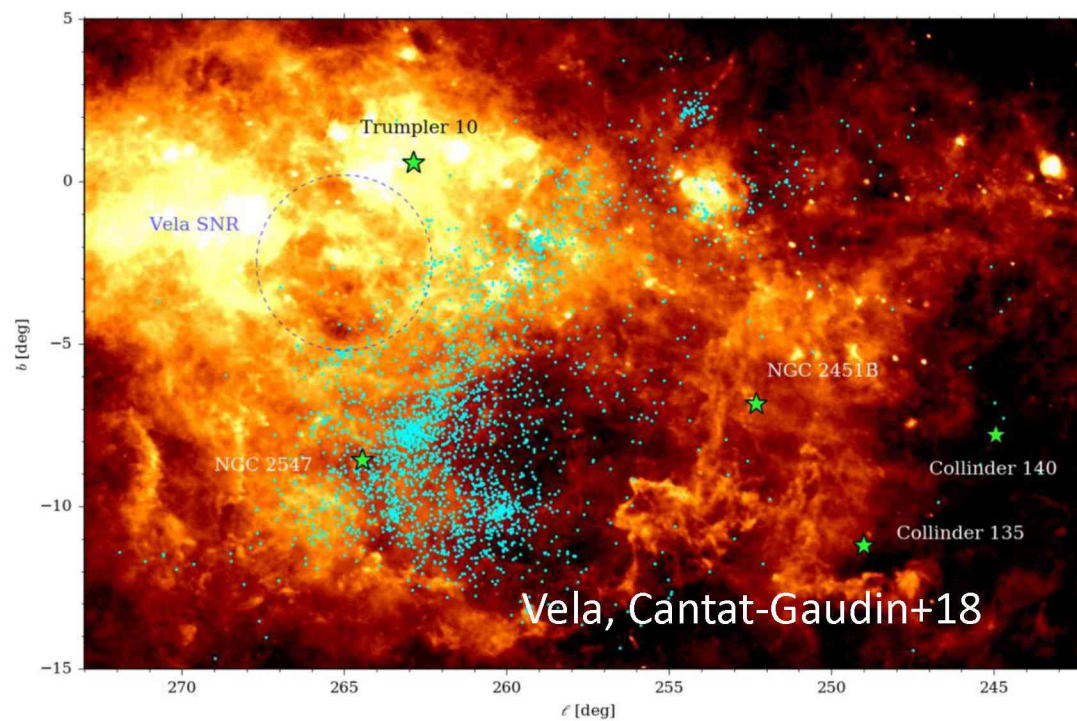




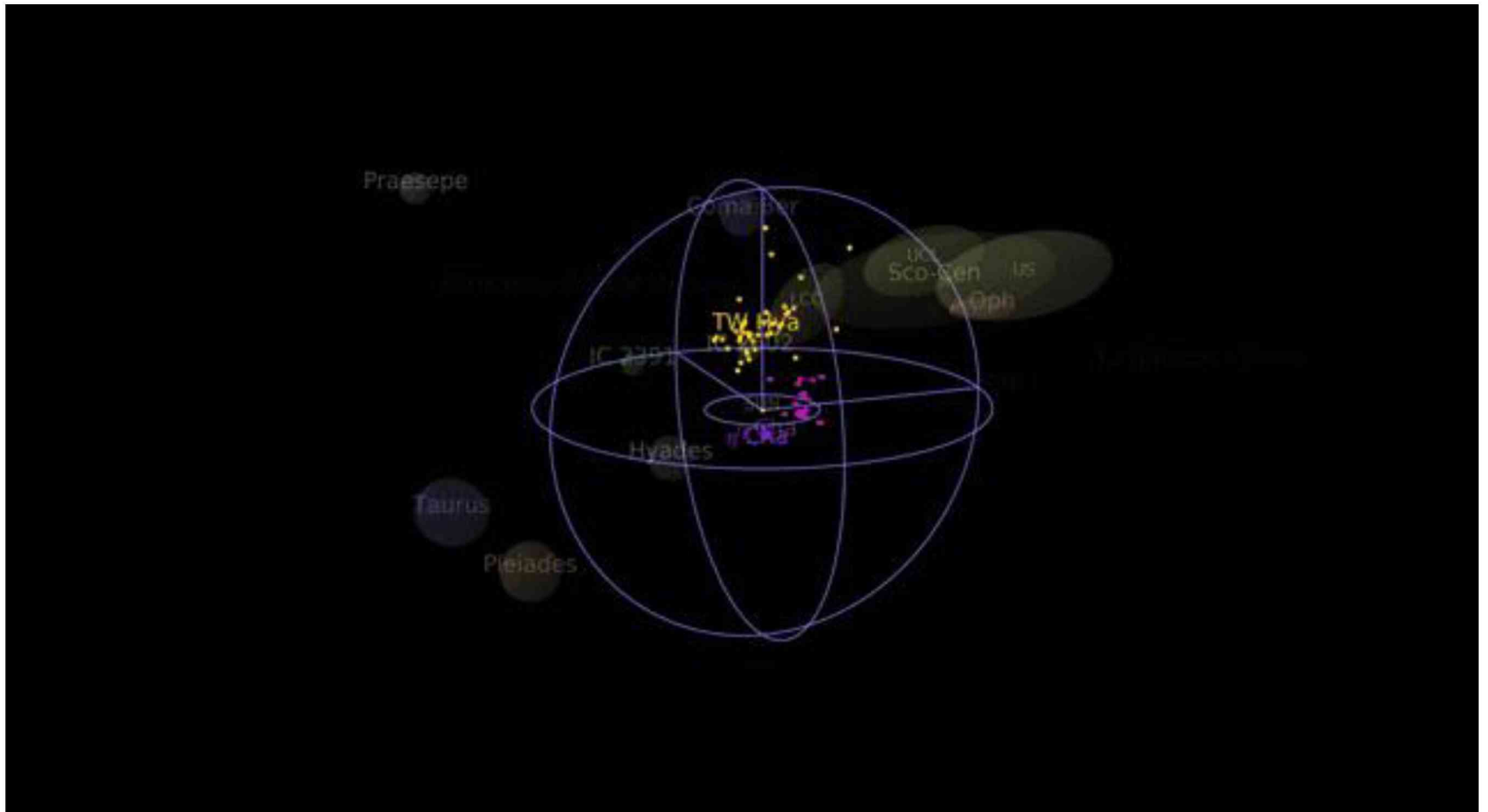




Most SFR are extended and dynamically cold

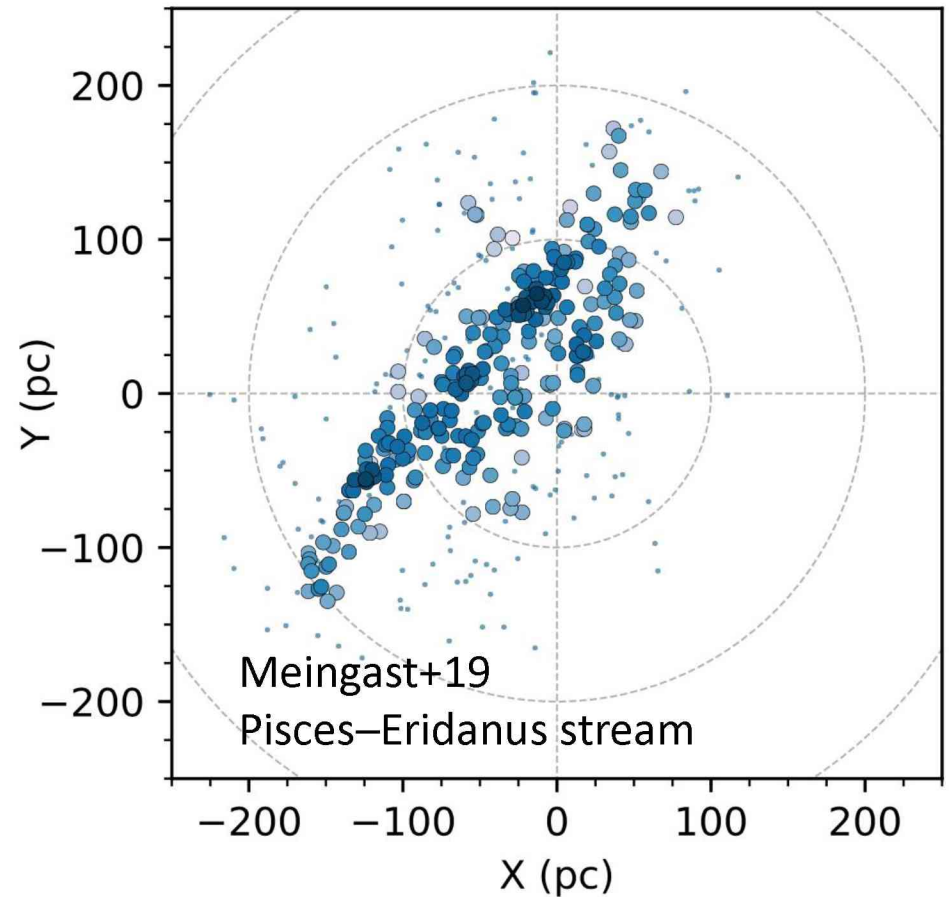
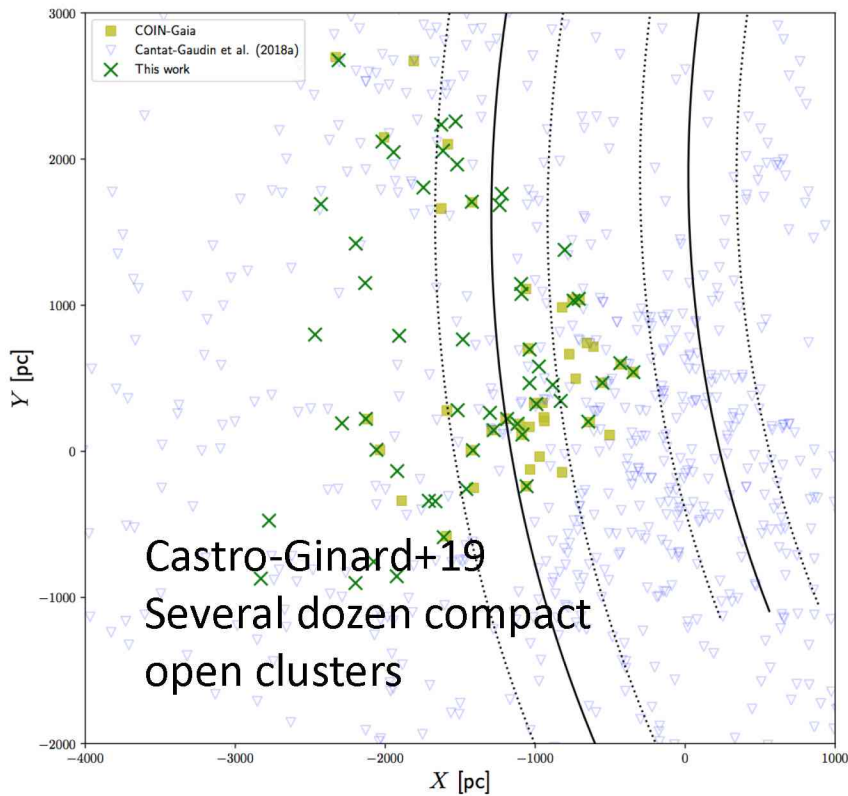


# Nearby Moving Groups





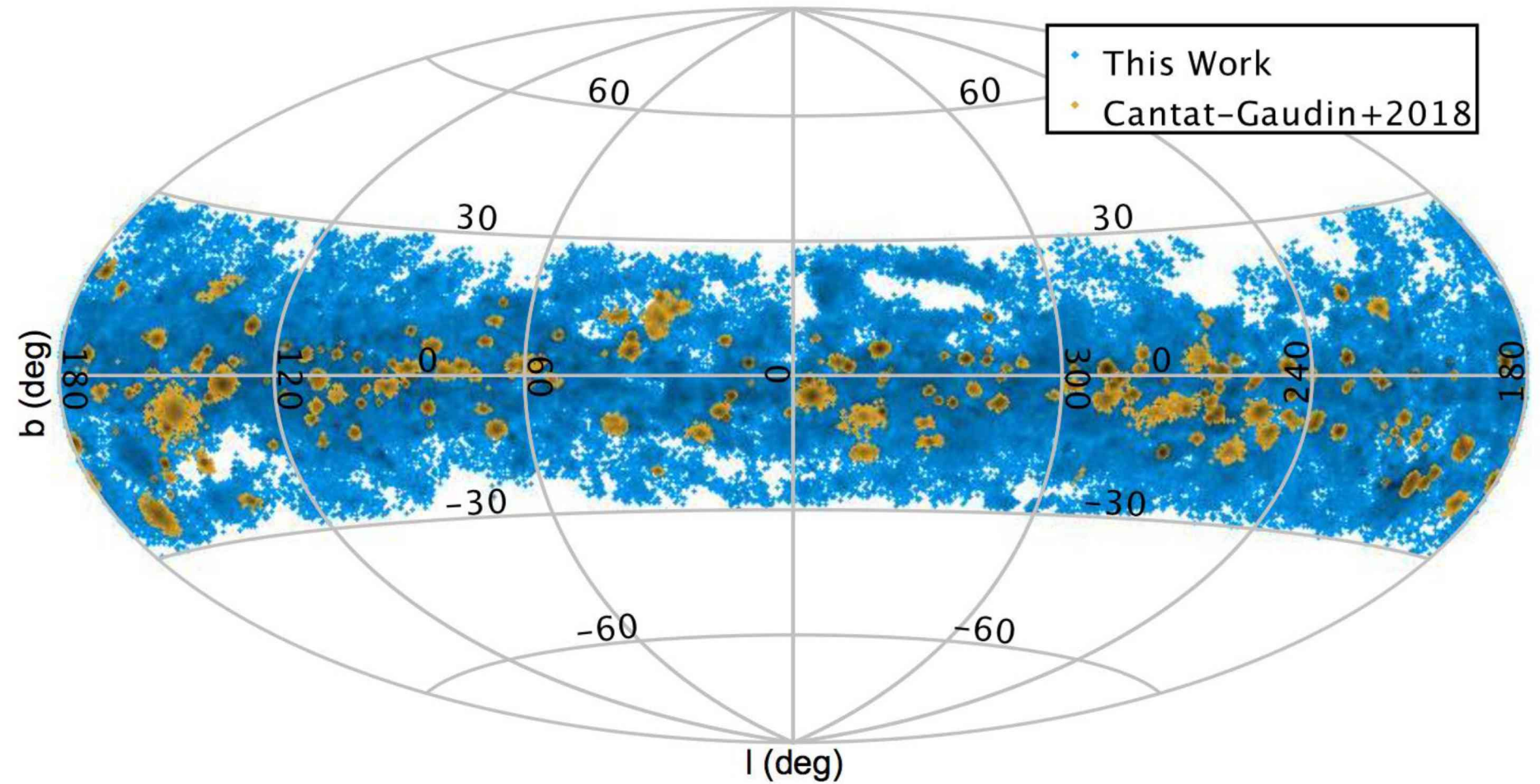
# New structures found with Gaia



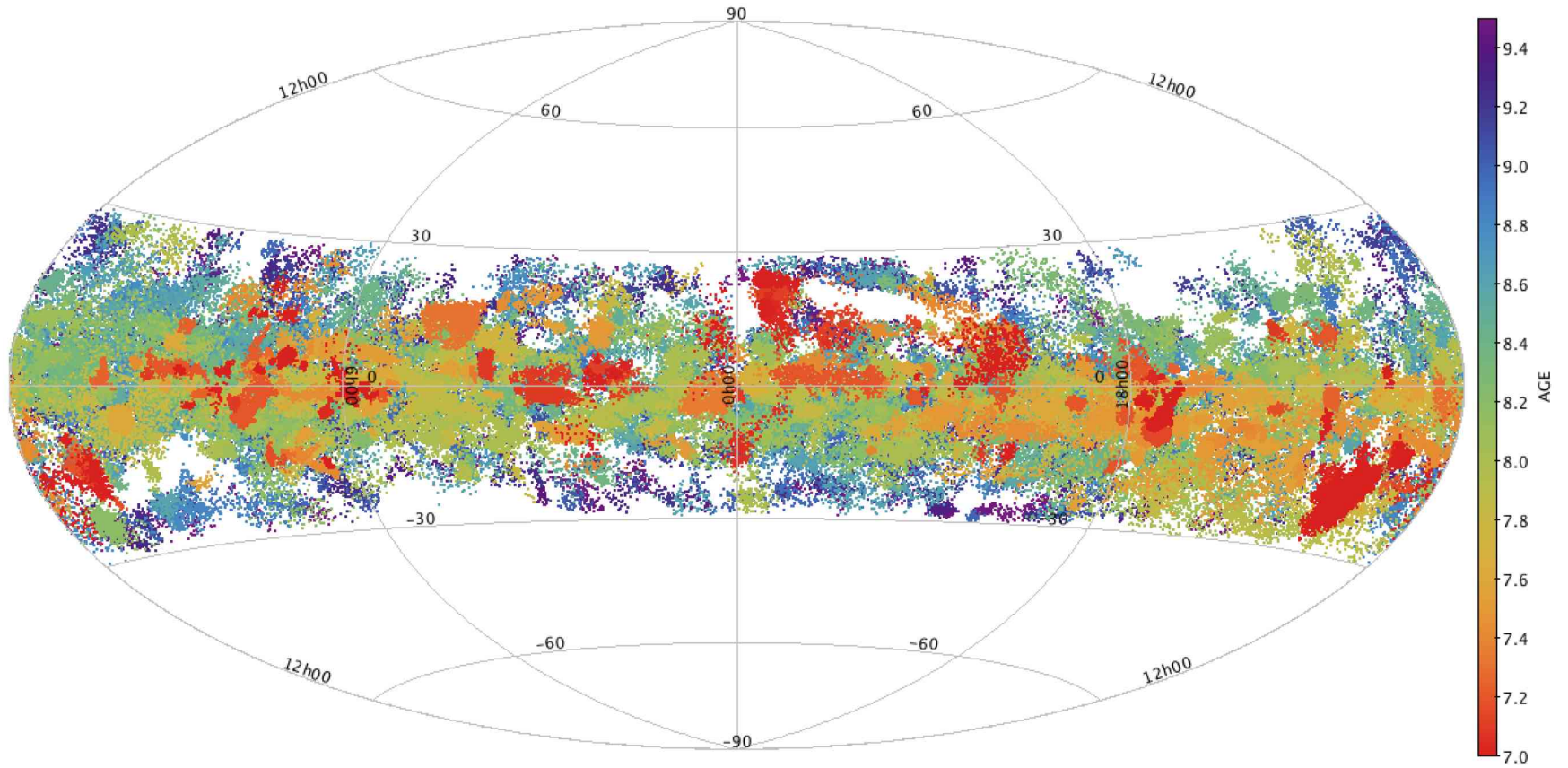
# HDBSCAN

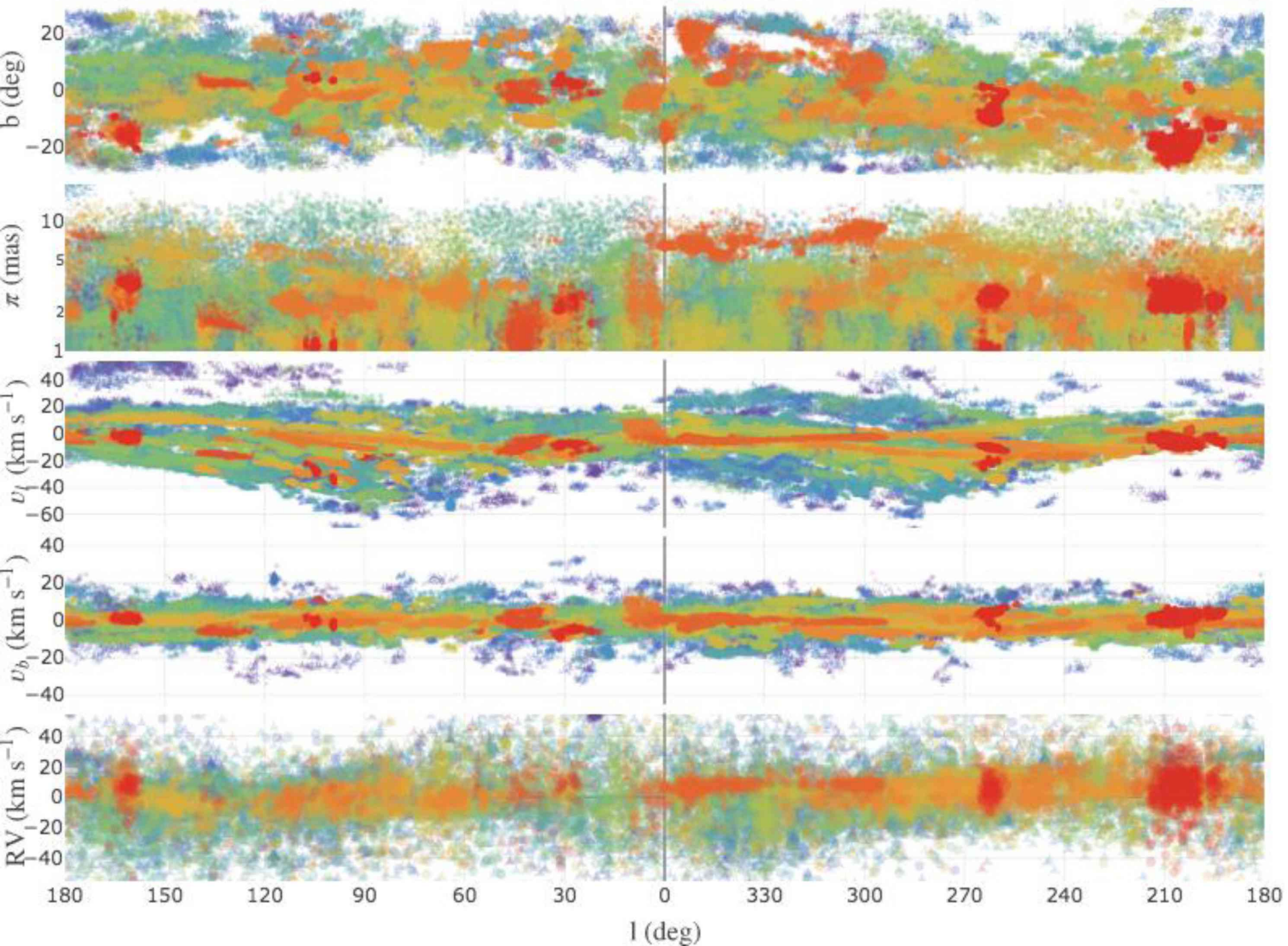
- Clustering in 5d space ( $l, b, \pi, v_\alpha, v_\delta$ )
- Proper motions in lsr and in units of km/s
- Clustered in various distance slices and stitched together

# Identified Structures

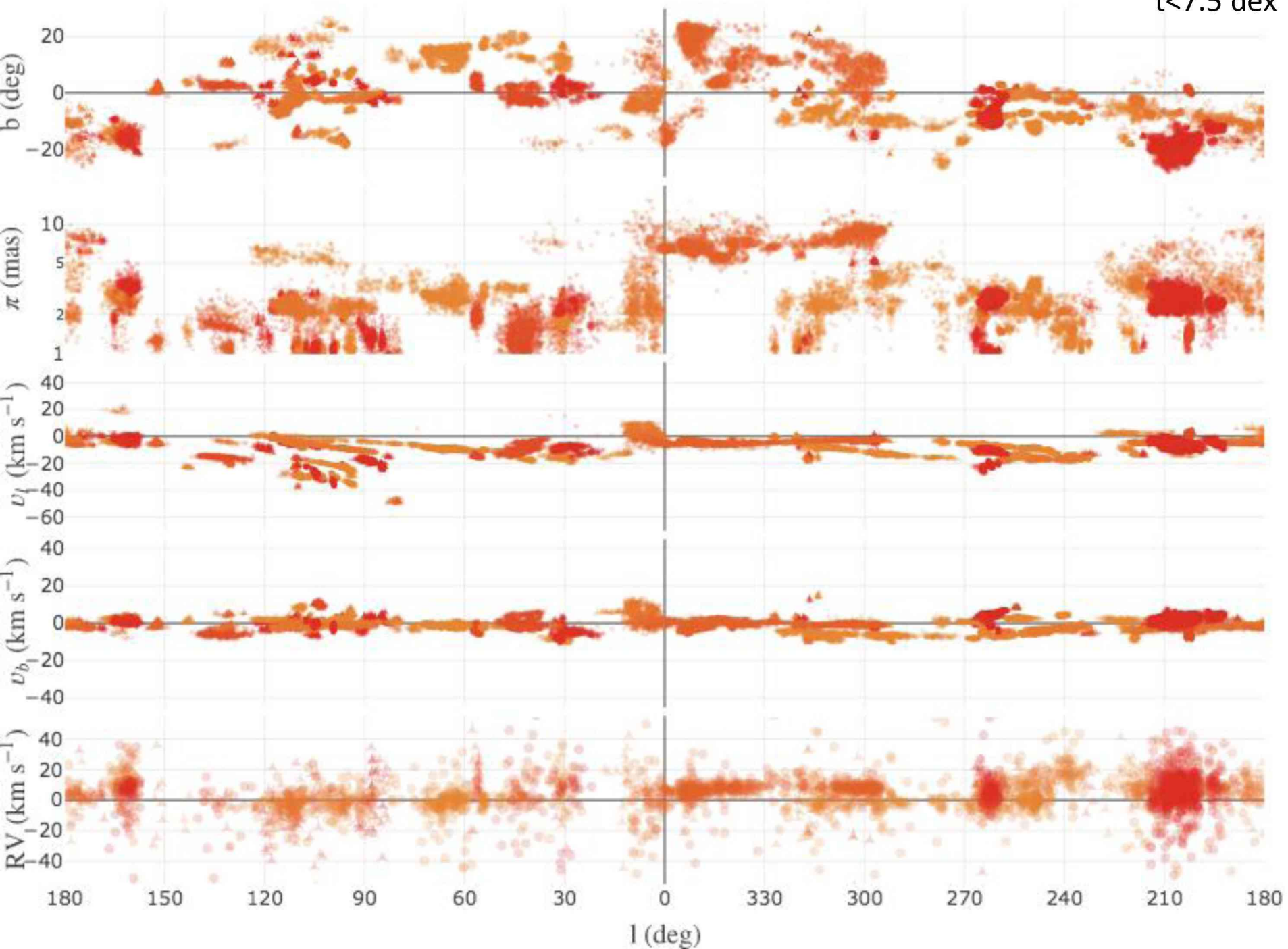


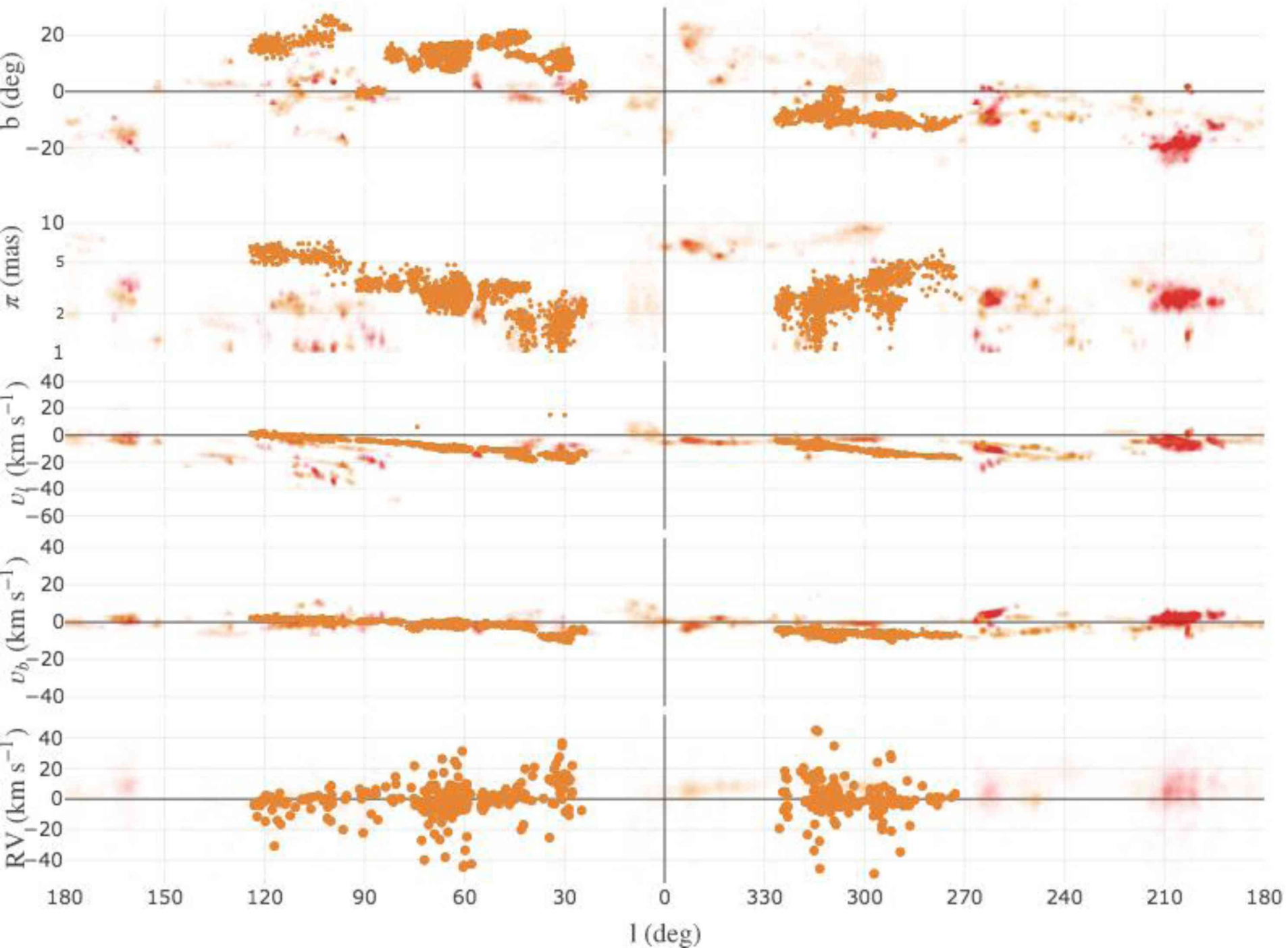
# Ages



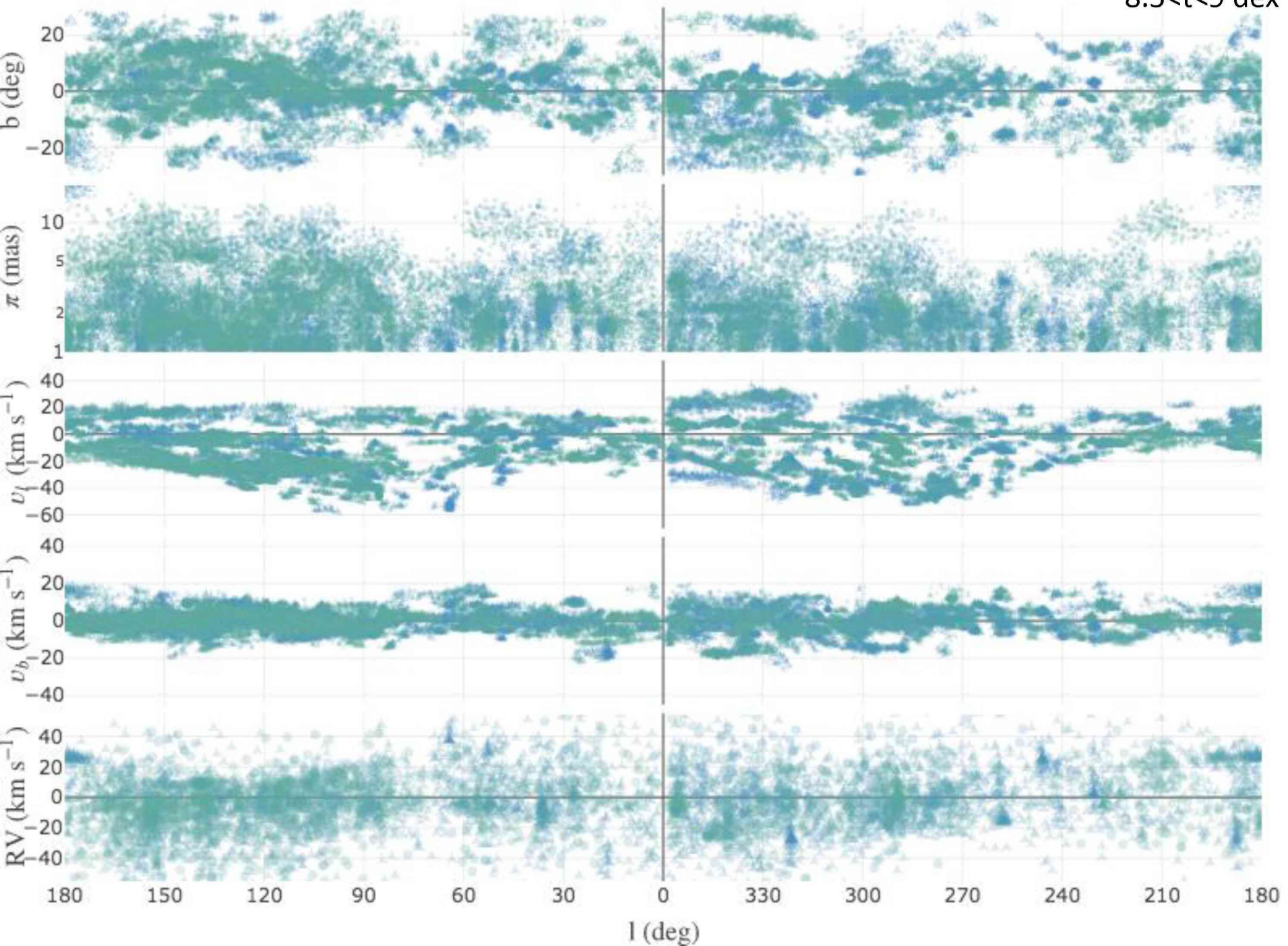


$t < 7.5$  dex



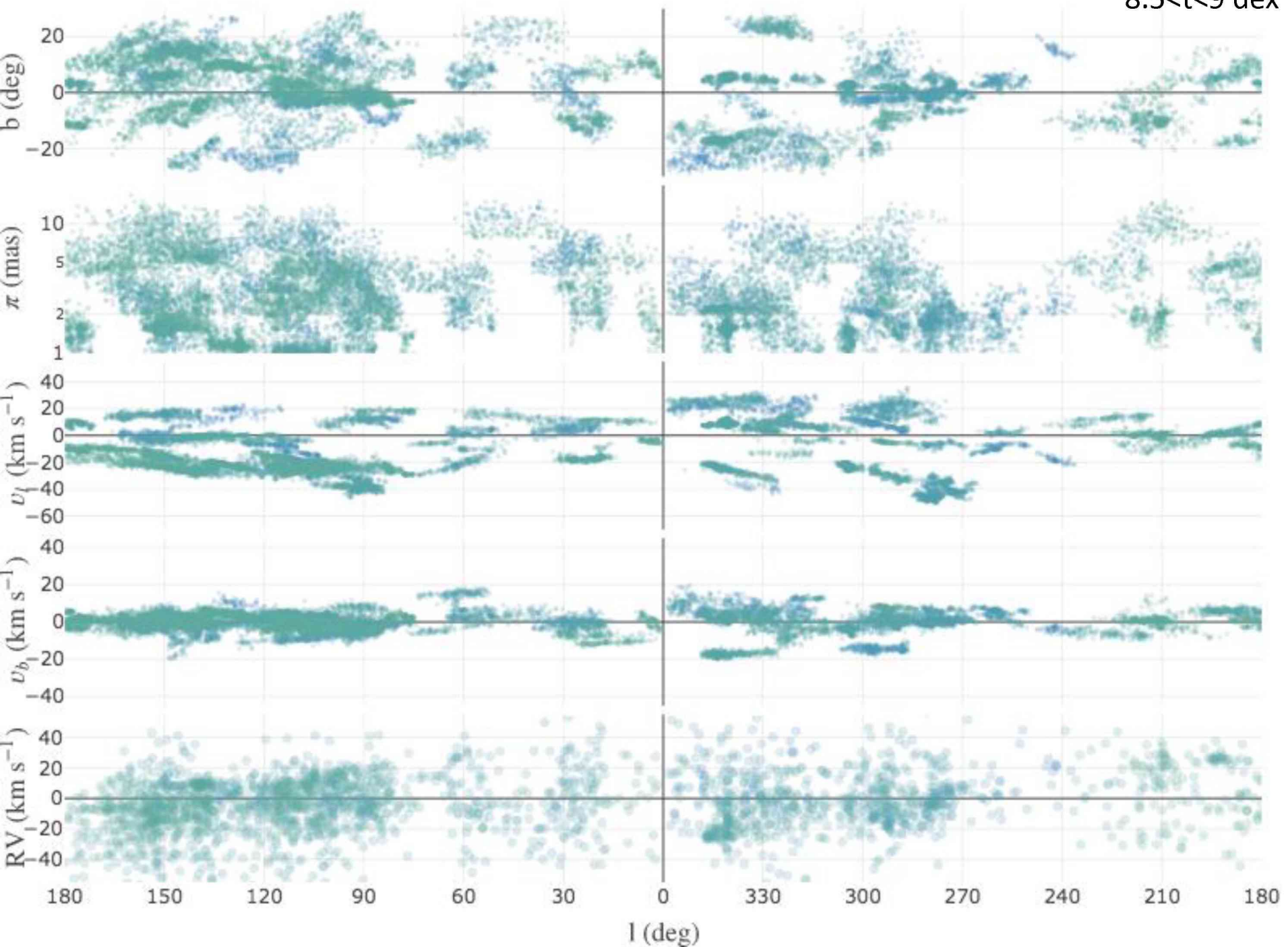


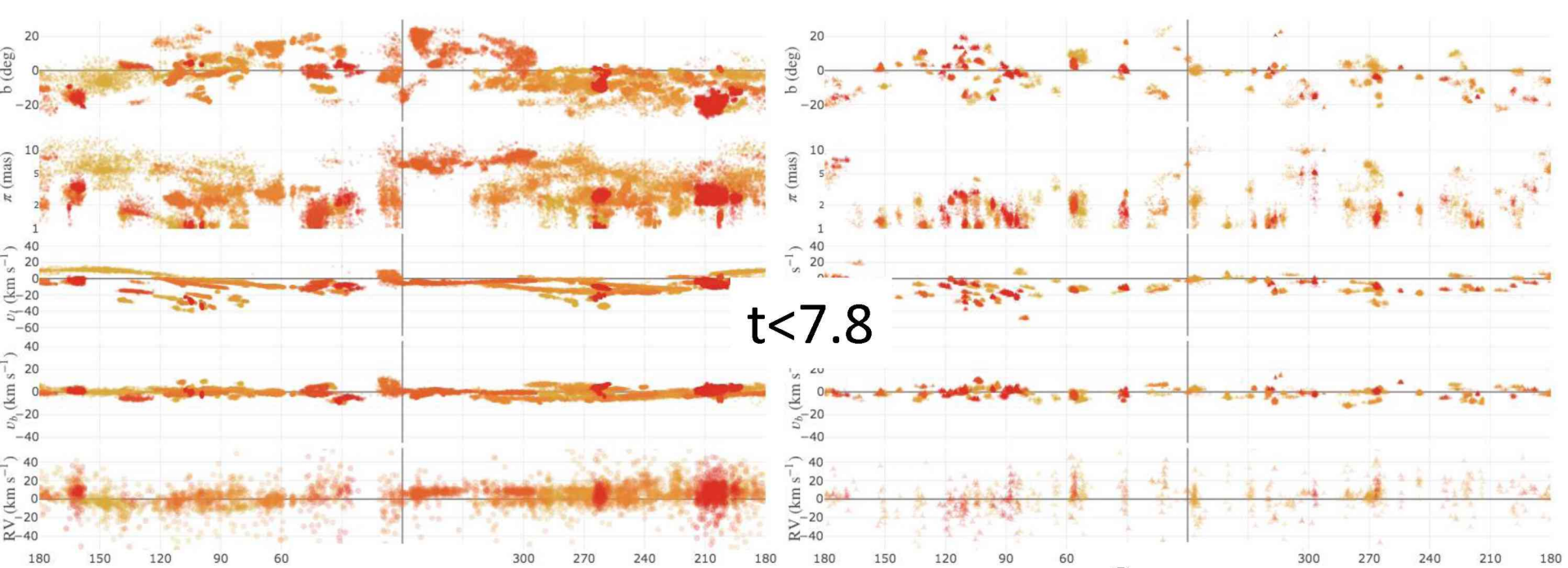
8.5 < t < 9 dex





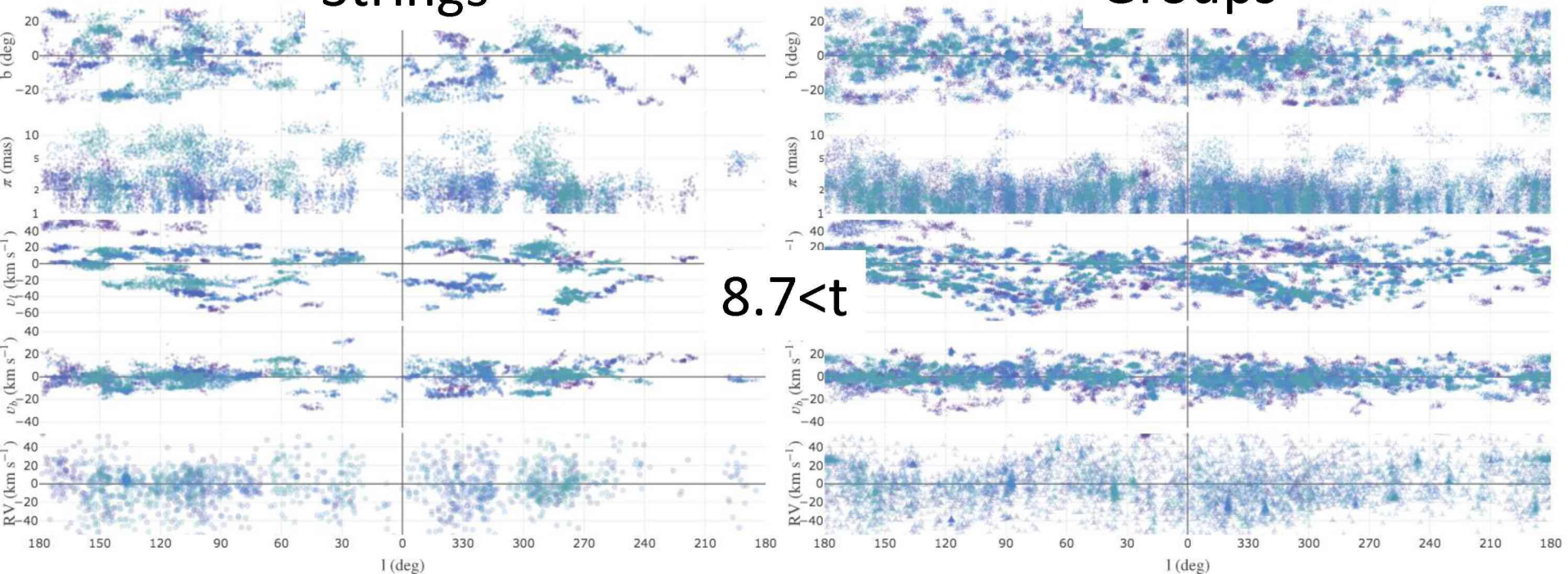
8.5 < t < 9 dex





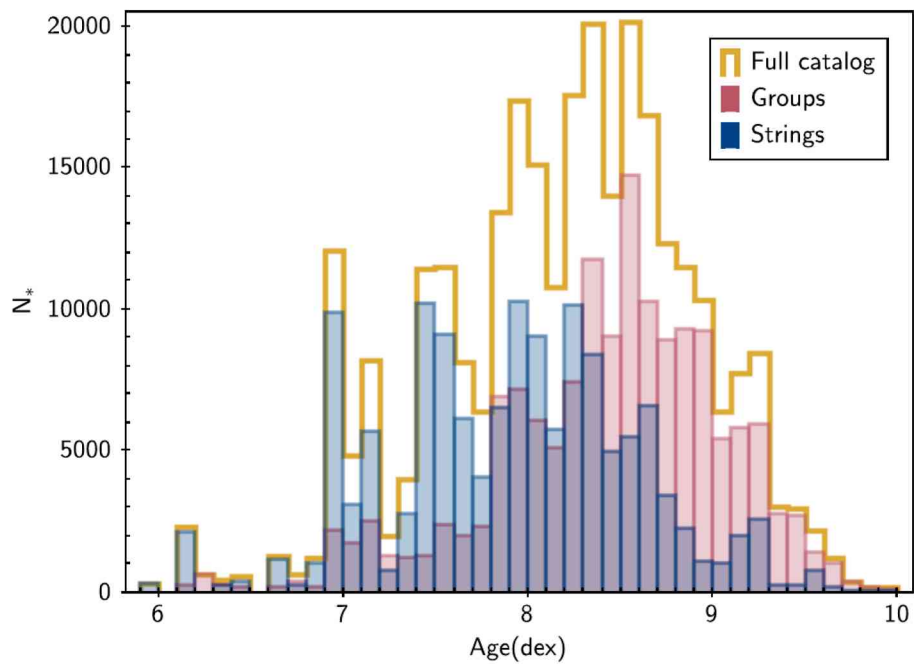
Strings

Groups

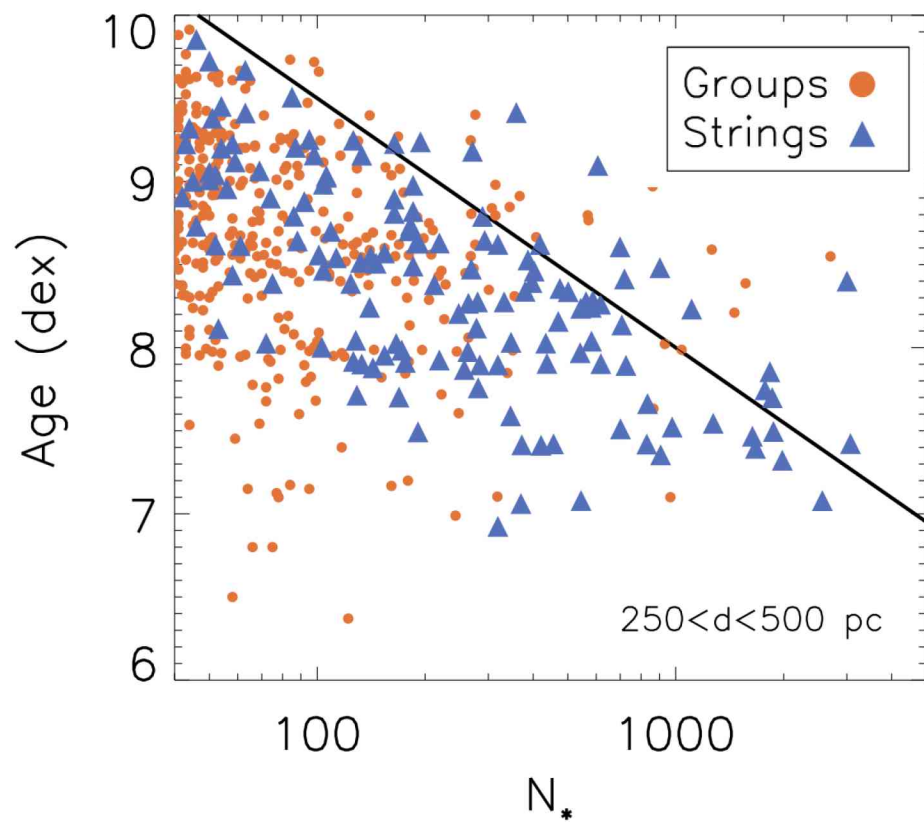


$8.7 < t$

## Distribution of ages

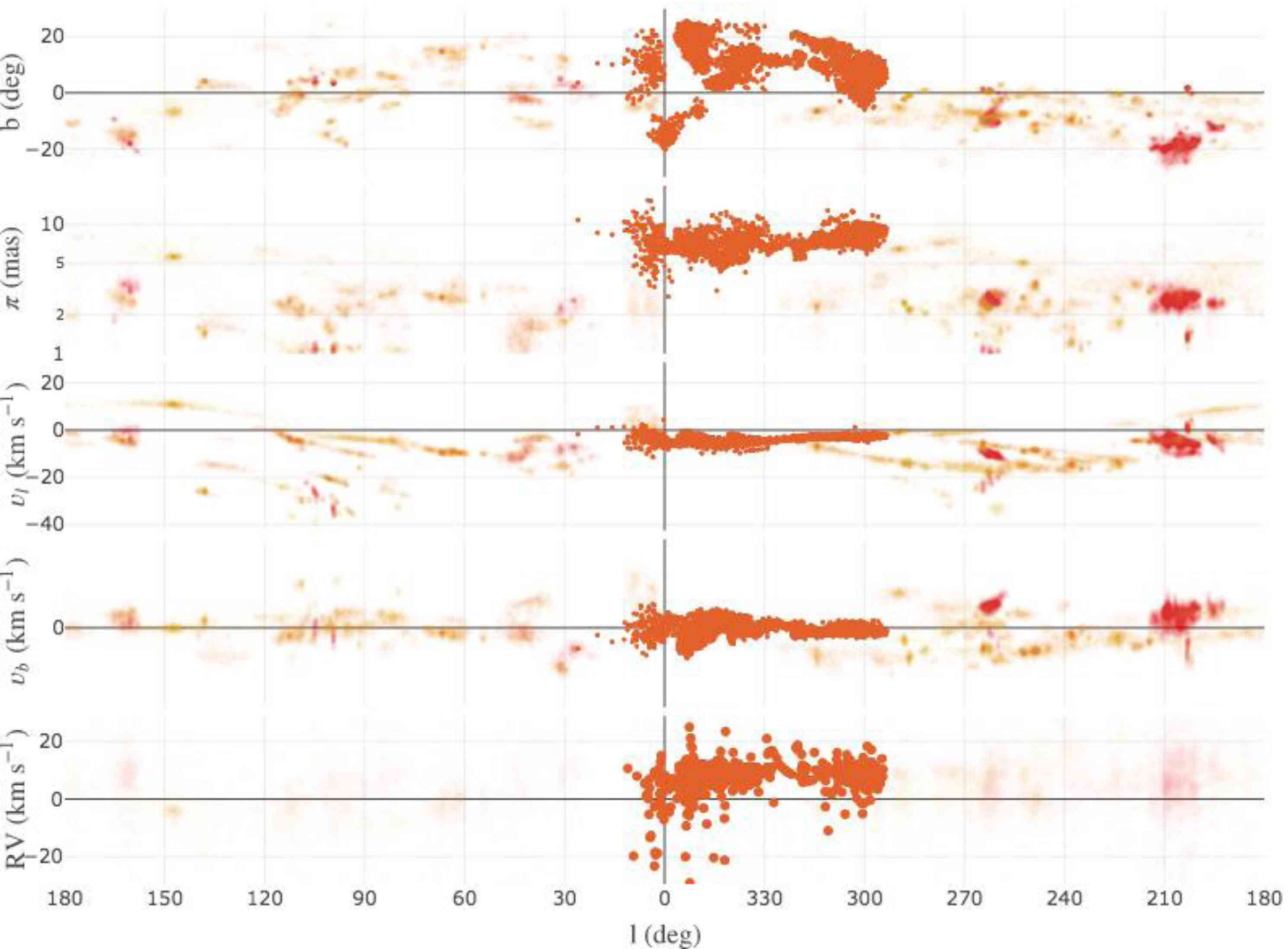


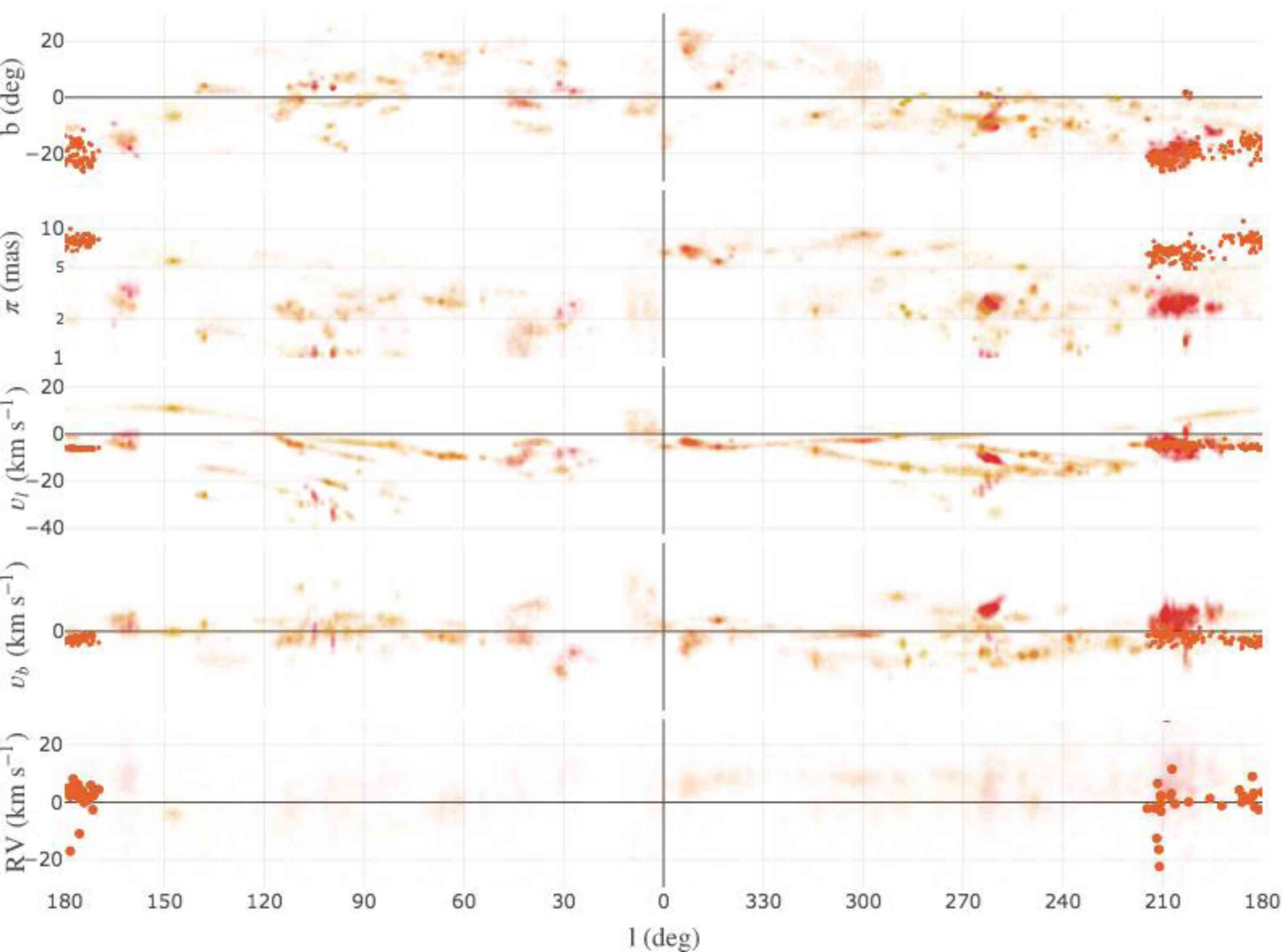
## Number of stars as a function of age

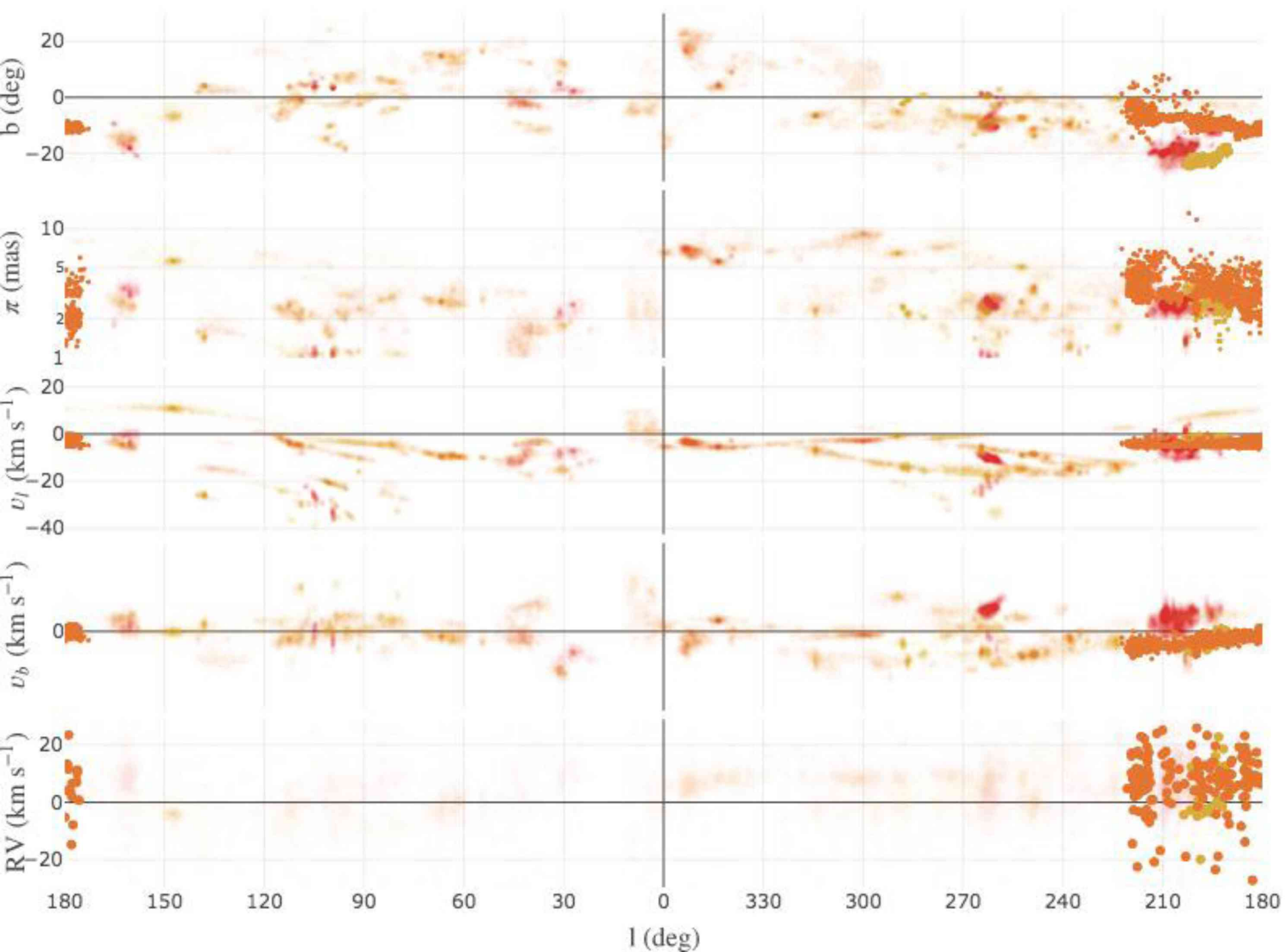


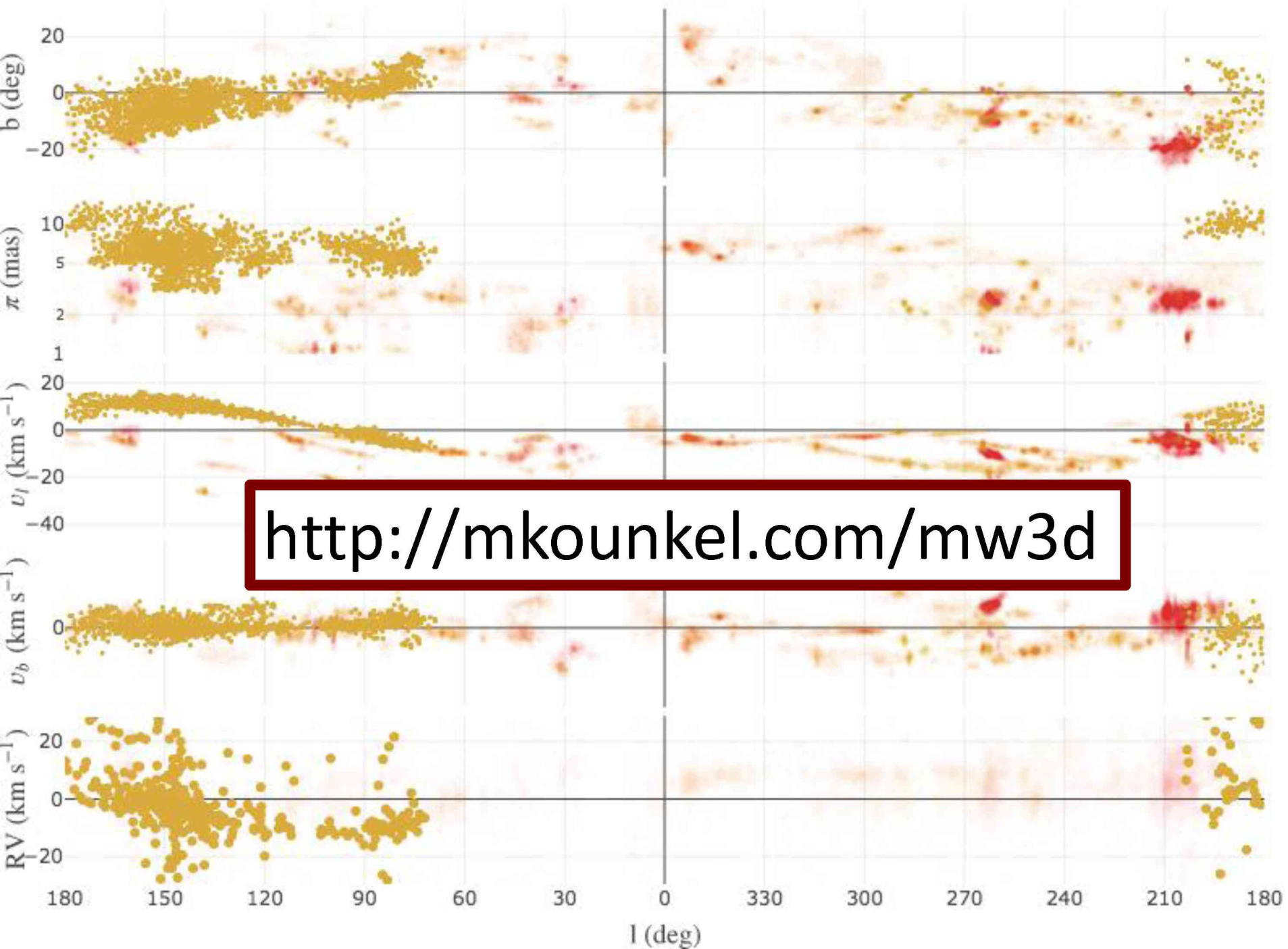
# Origin of extended structure

- Not tidal stretching
  - Present ubiquitously in younger regions
  - Frequently not associated with a cluster at a center
- Primordial!
  - Remnants of the filamentary molecular clouds
  - Slowly dissolving over time
  - Only those that have been incredibly massive to begin with will survive for more than a few hundred Myr

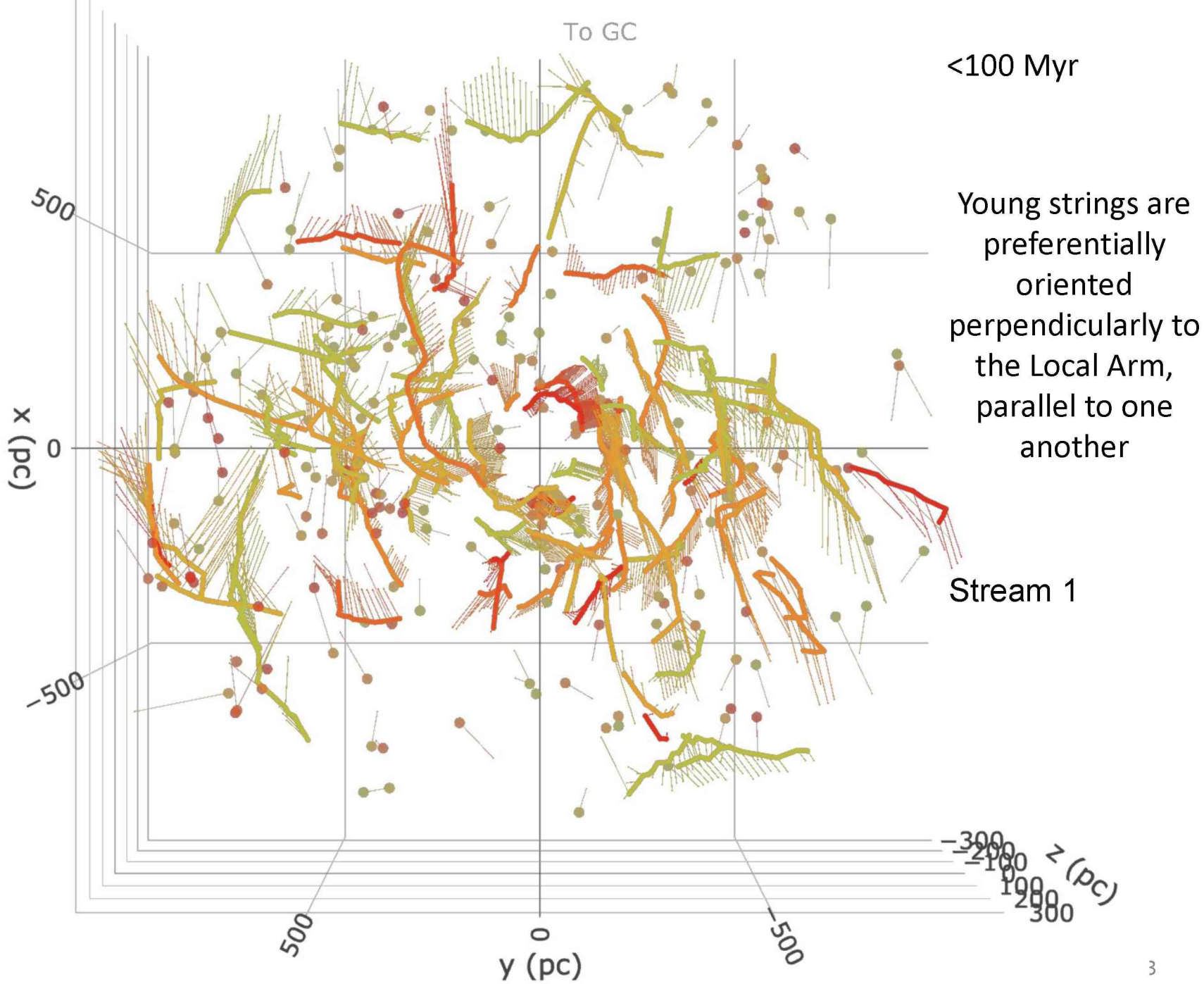






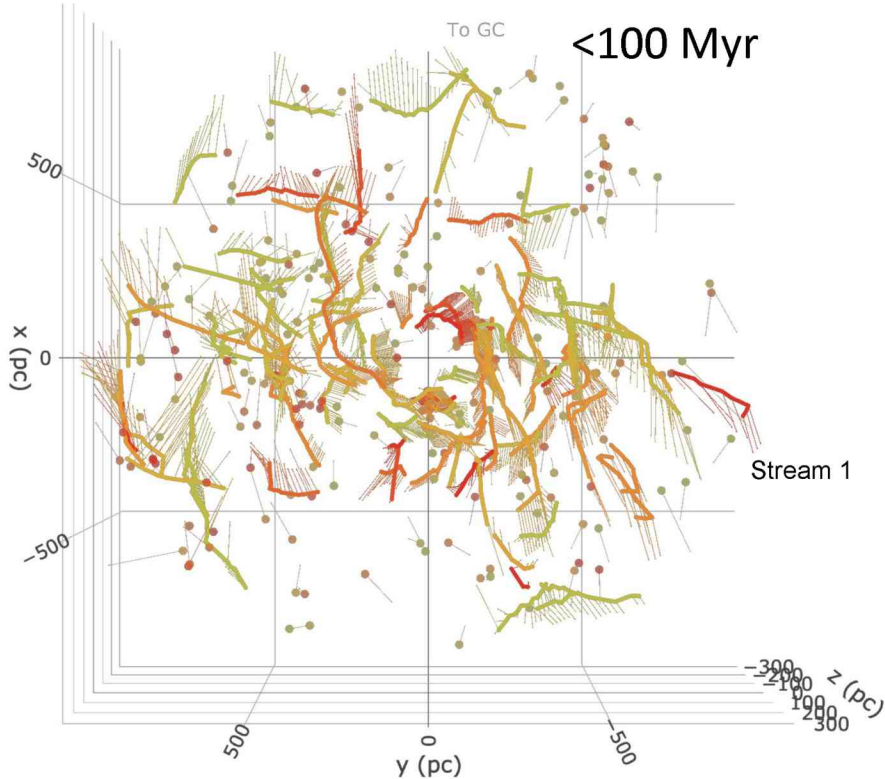




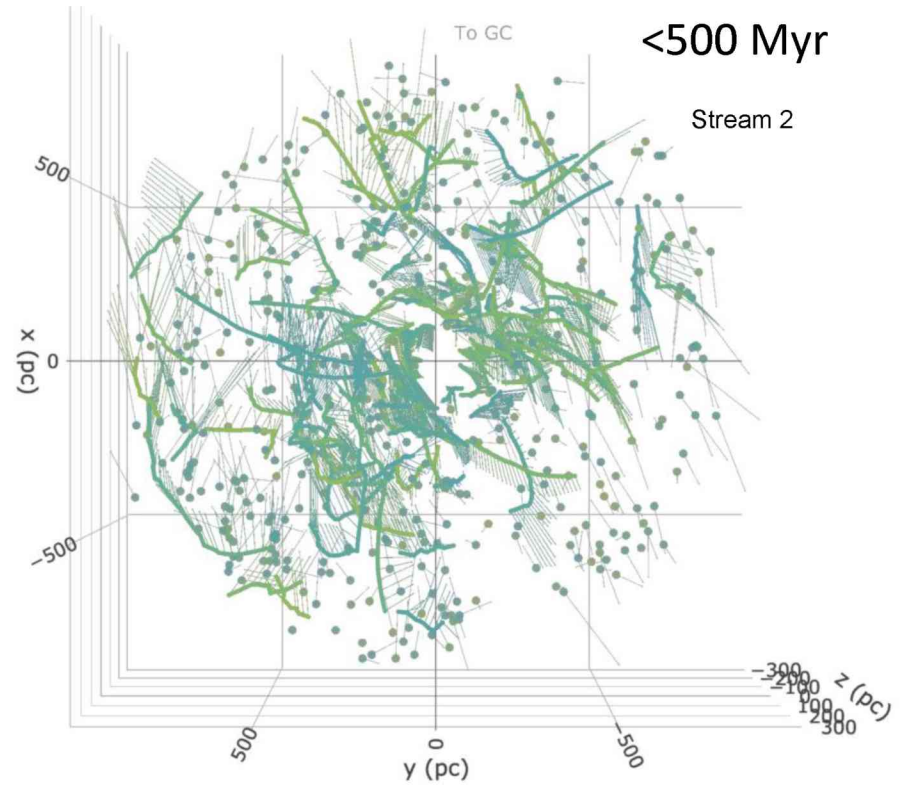
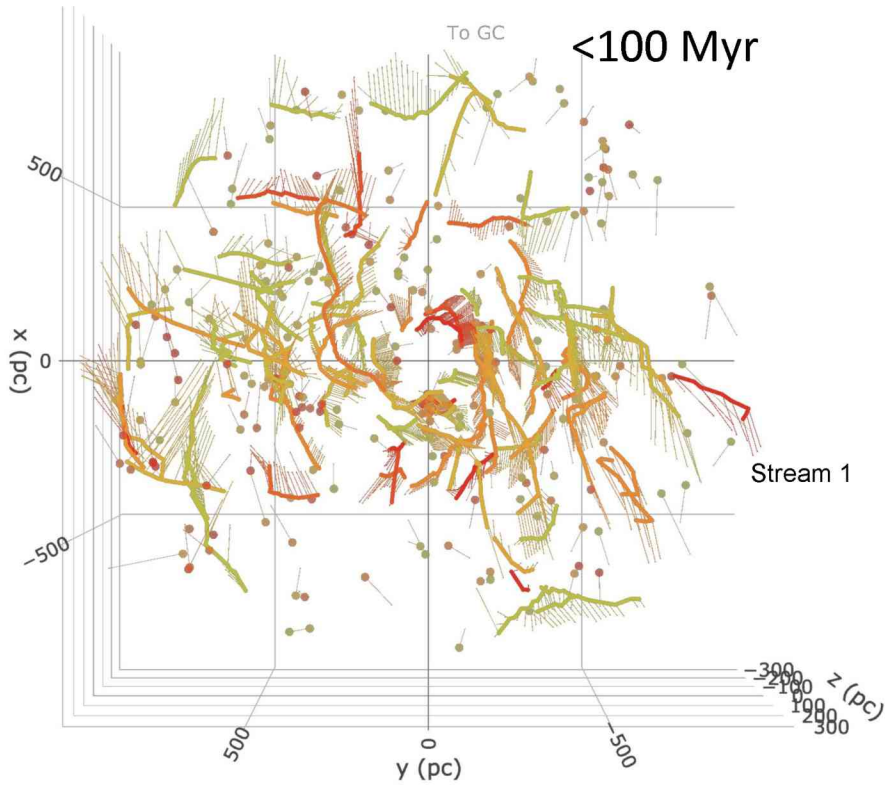


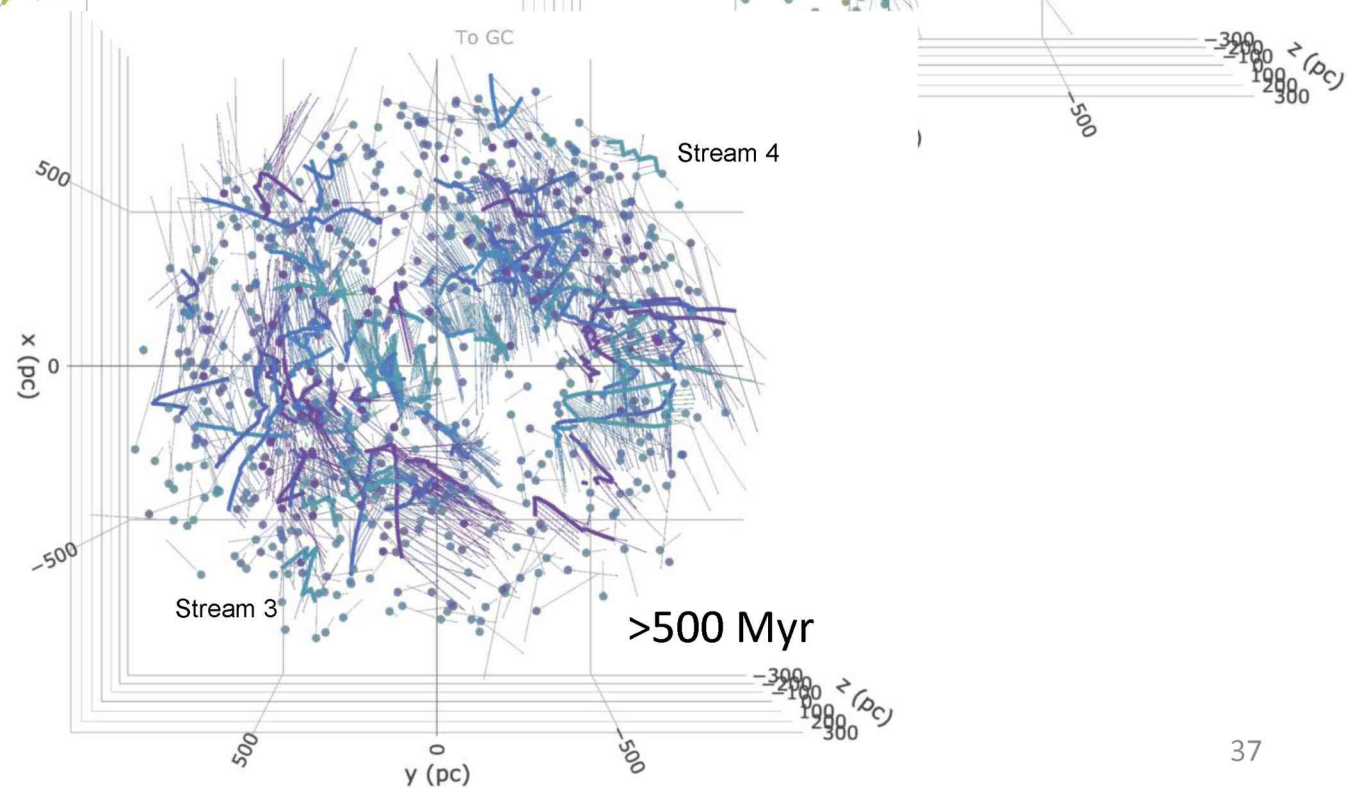
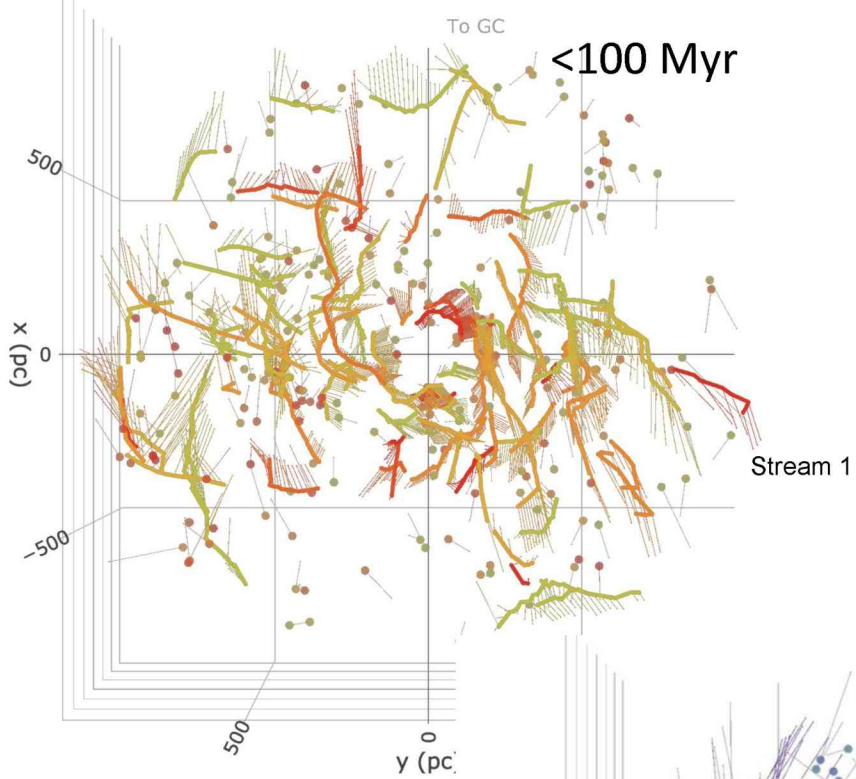


# Galactic view



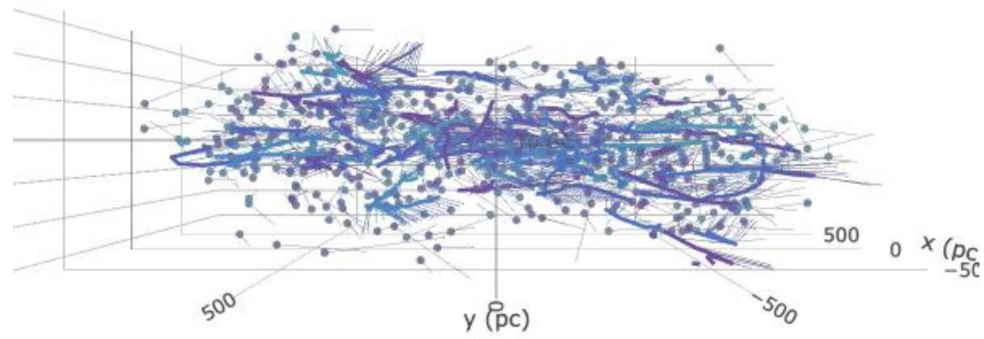
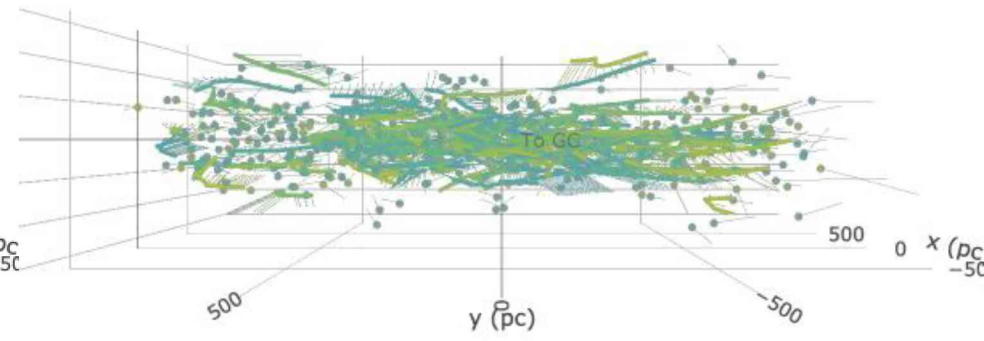
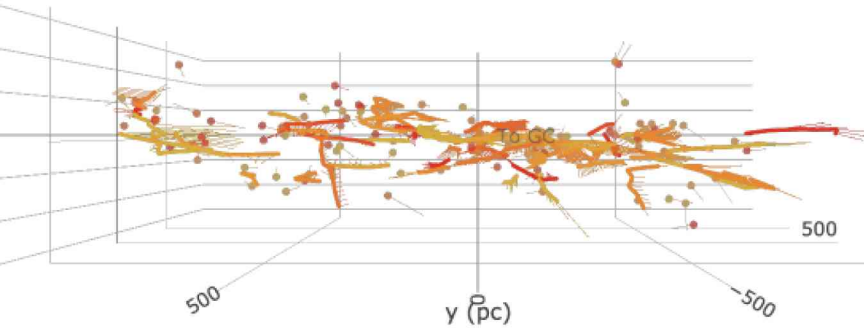
# Galactic view





<100 Myr

<500 Myr



>500 Myr

# Summary

- ~300,000 stars within 1 kpc with ages
- Stars commonly form in extended string-like structures, not just in clusters
- Some of the strings can remain coherent for >Gyr timescales
- Can be used as tracers of the evolution of the Galactic structure