Mass Segregation and Young Stellar Groups

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with
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Introduction

- How small can a cluster be while still dominated by same processes for formation & evolution? (following Testi et al 1999)

→ Do small groupings of stars share similar (scaled-down) properties with clusters?
(see Kirk & Myers submitted)

- In this talk: Does mass segregation (a common feature of clusters) appear in smaller systems?

Mass Segregation

- Mass segregation observed (to varying extents) in many young clusters, e.g., ONC1 (Hillenbrand & Hartmann 1998), NGC 3603 (Stolte et al 2006), MonR2 (Carpenter et al 1997)

- Ascenso et al (2009) argue observational biases are responsible for these measures, particularly in largest, most distant systems

- What about in smaller stellar groups, where crowding & completeness issues raised by Ascenso et al are not a problem?

Young Stellar Groups

We considered YSO catalogs where:

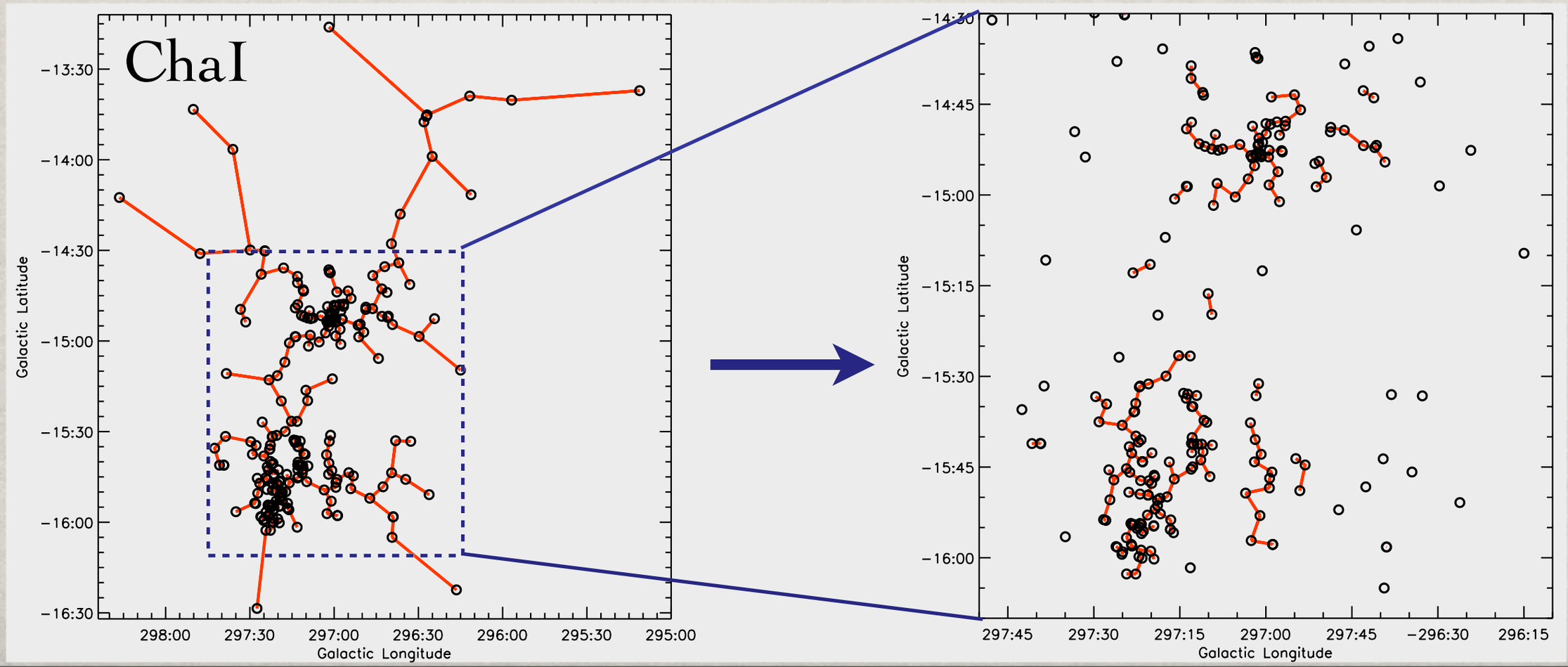
- Age ~1Myr
  - young enough so that ~ same location as formed
  - old enough (un-embedded enough) to allow for spectral classification
- Distance <300pc
  - close enough for deep catalogs (~all members)
- Spectral completeness >90% (~M8-M9)
  - for unbiassed mass estimation

The Dataset

- Catalogs exist for four nearby star-forming regions which satisfy our criteria :
  - Taurus (Luhman et al 2010, Rebull et al 2010)
  - Lupus3 (Comeron et al 2008)
  - ChaI (Luhman 2007)
  - IC348 (Muench et al 2007, Lada et al 2006)
- Advantages:
  - all have similar age, distance, (spectral) completeness
  - no source confusion
  - little/no contamination
- Note:
  - dataset does not include youngest YSOs (class 0, some class I) which best reflect primordial distribution

Identification of Groups

- in 4 regions, groups identified using Minimal Spanning Tree algorithm (Gutermuth et al 2009)
  - all stars connected to their nearest neighbour (the MST structure)
  - stars connected by branches less than the 'critical length' form groups
  - for N > 10, 14 groups identified :
  - 8 - Taurus, 1 - Lupus3, 3 - ChaI, 2 - IC348
  - Masses estimated assuming 1Myr, combination of stellar models



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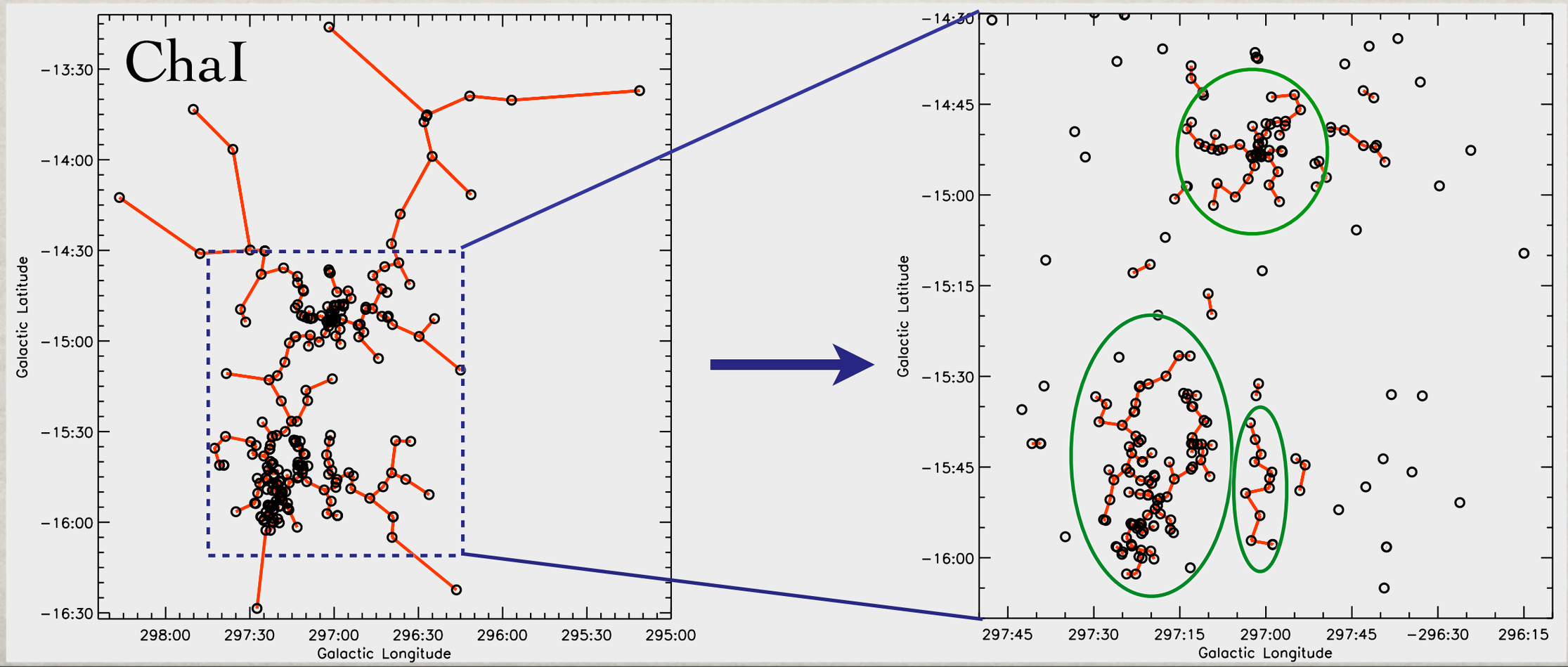
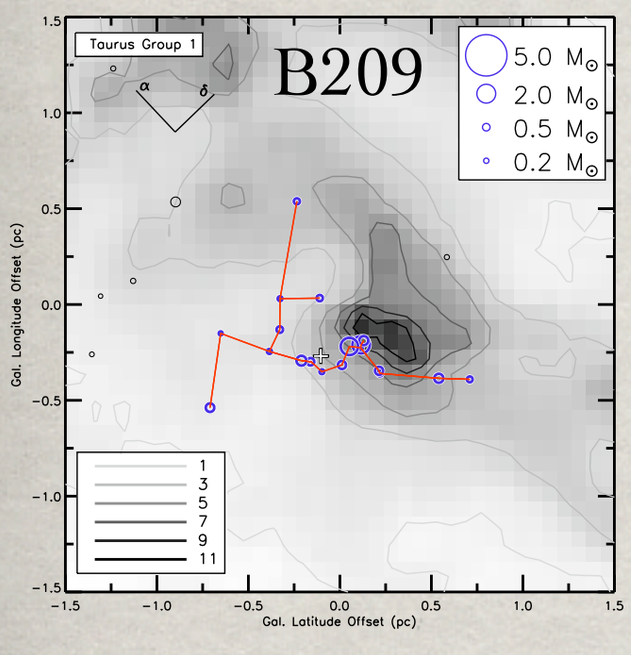
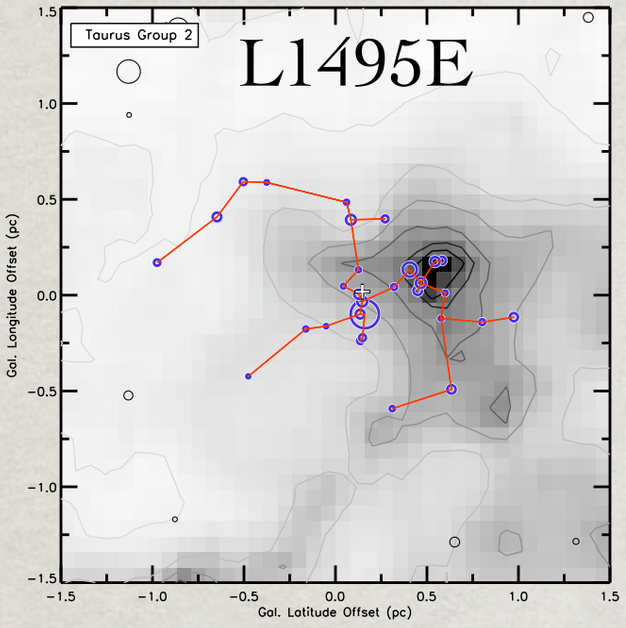
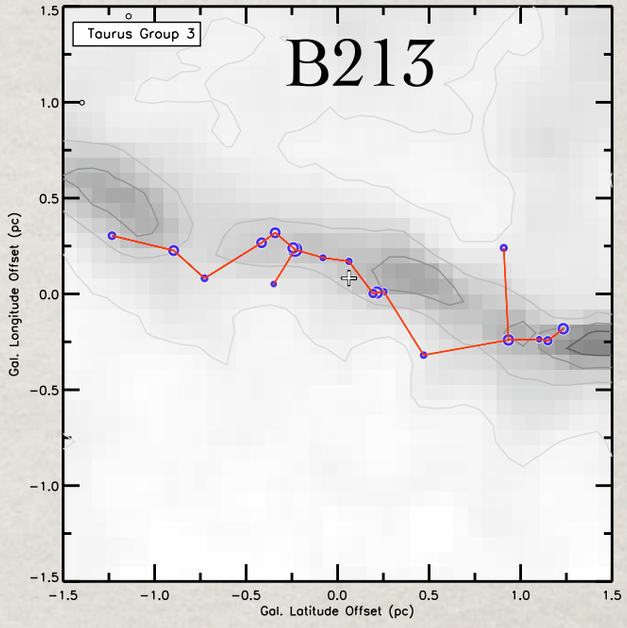
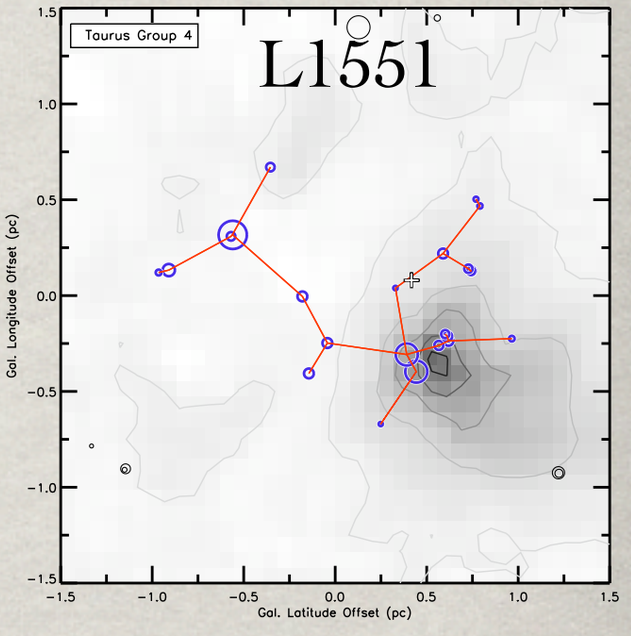


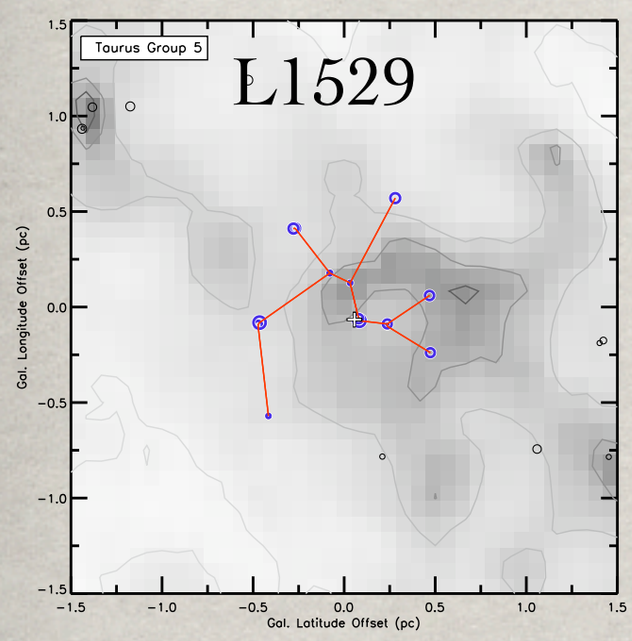
Taurus Groups

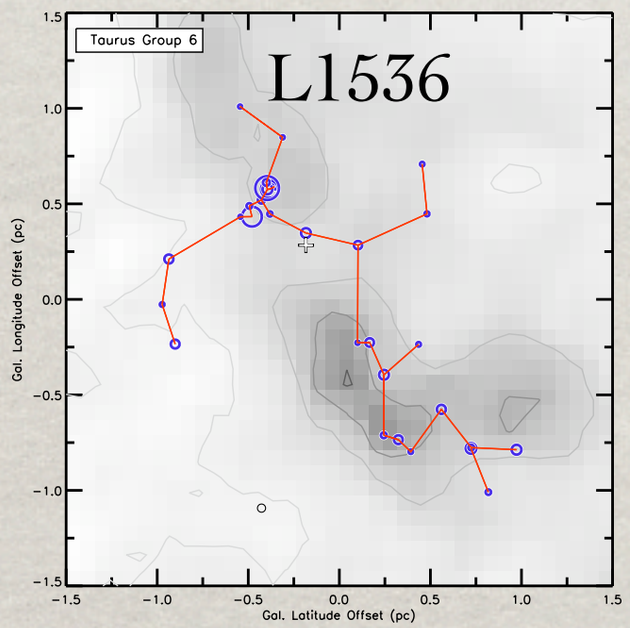


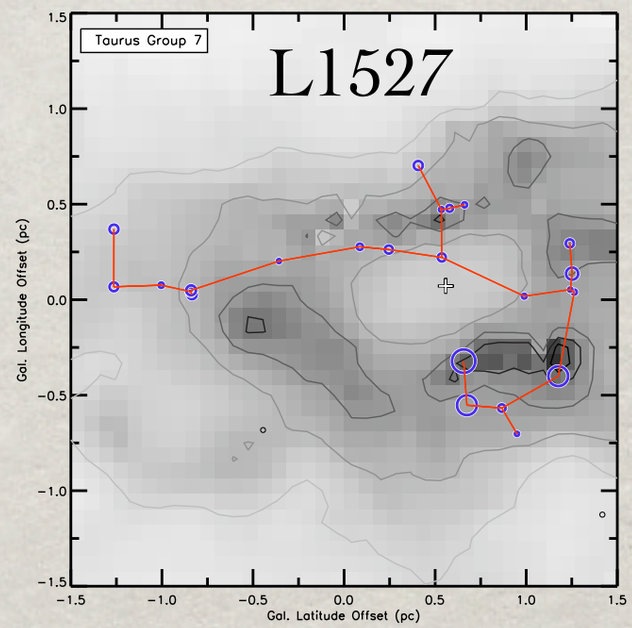


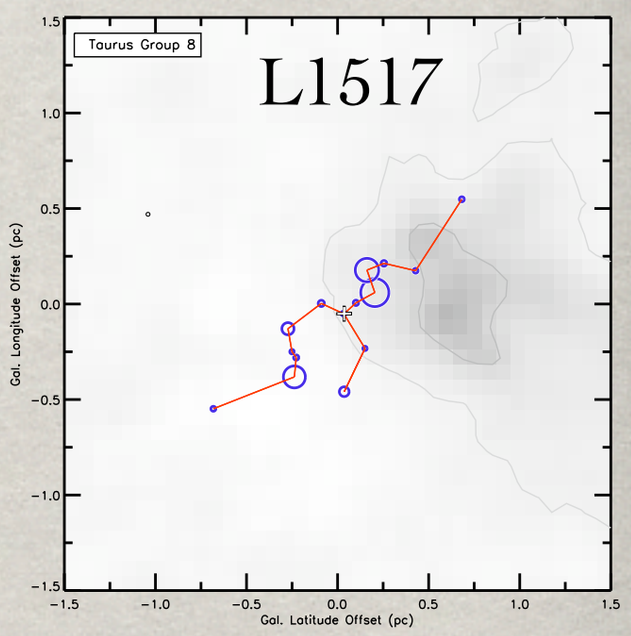








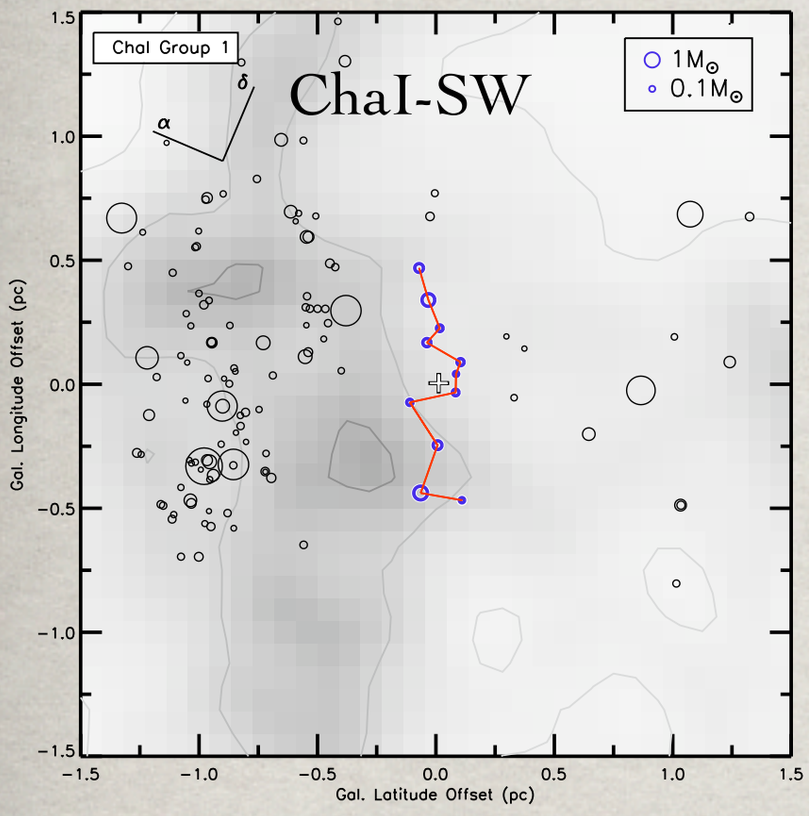


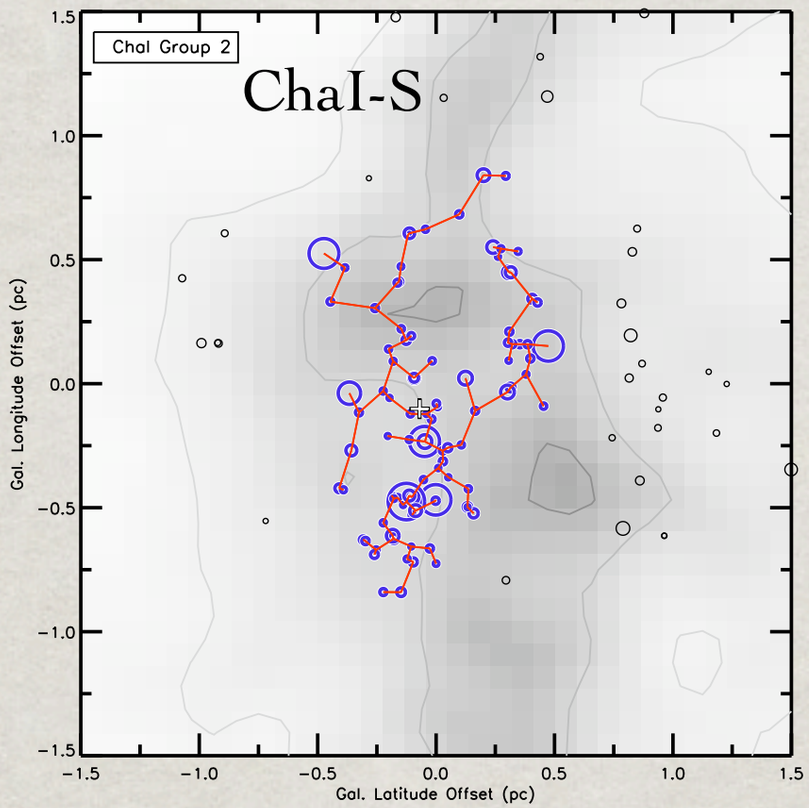


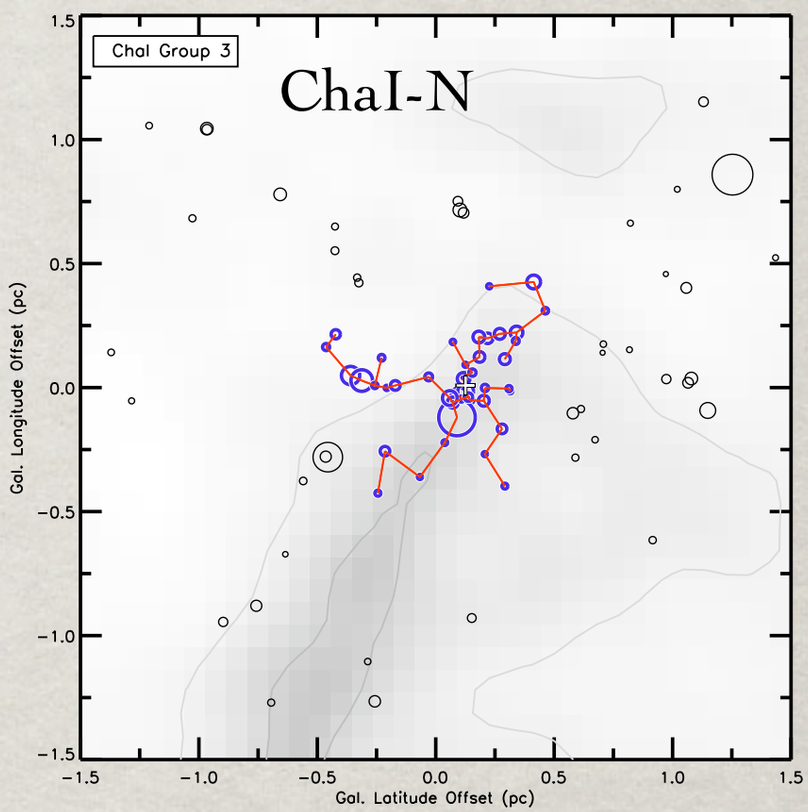
background extinction: Froebrich et al (2007)

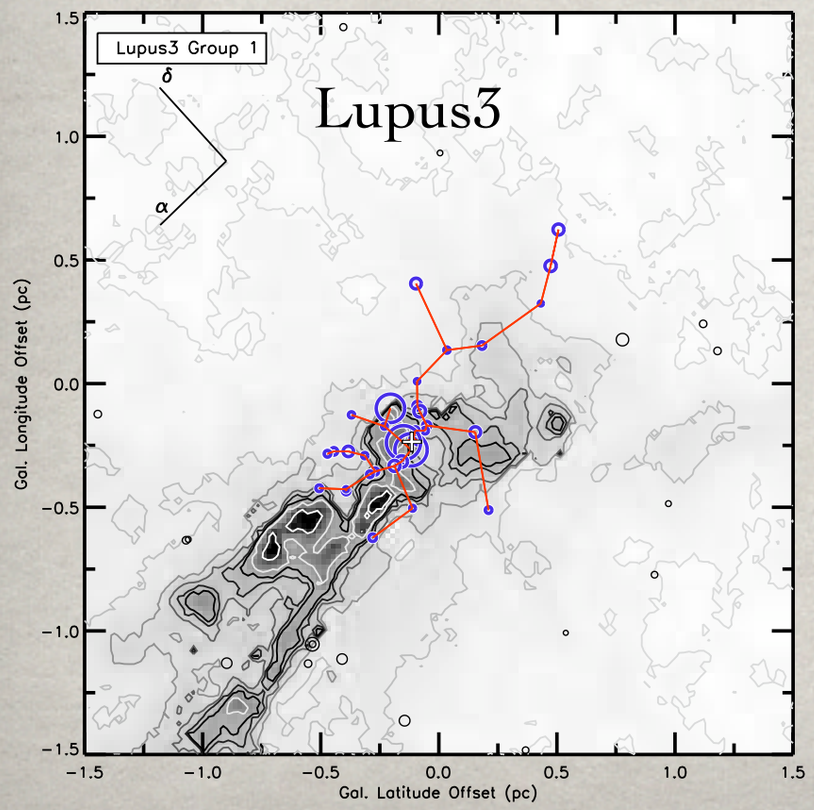
next page: ChaI - Dobashi et al (2005); Lupus3 - Teixeira et al (2005) + Rowles & Froebrich (2009); IC348 - Rowles & Froebrich (2009)

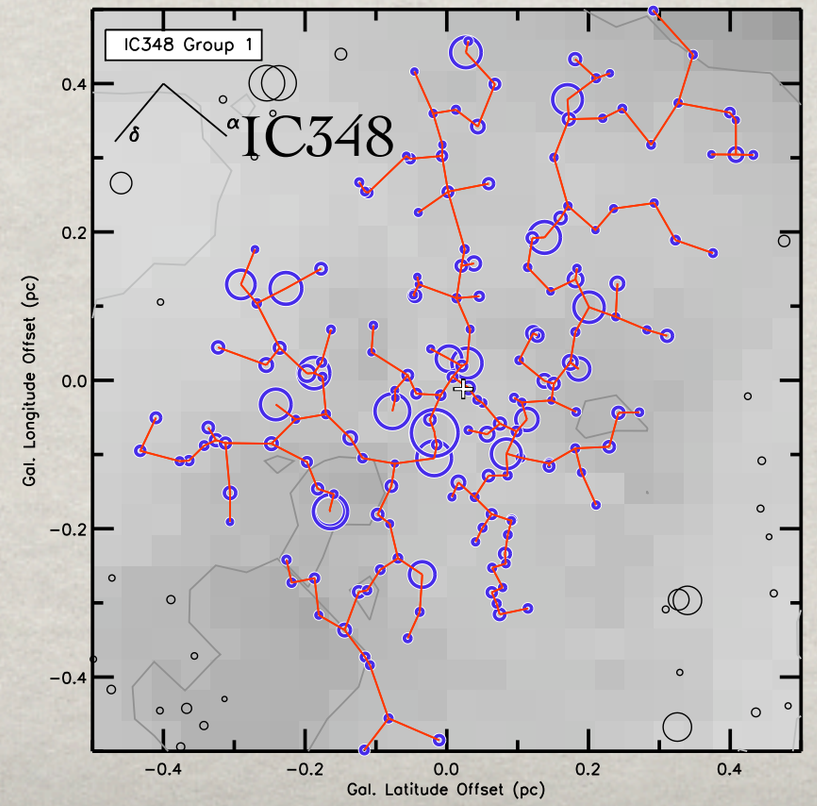
Other Groups

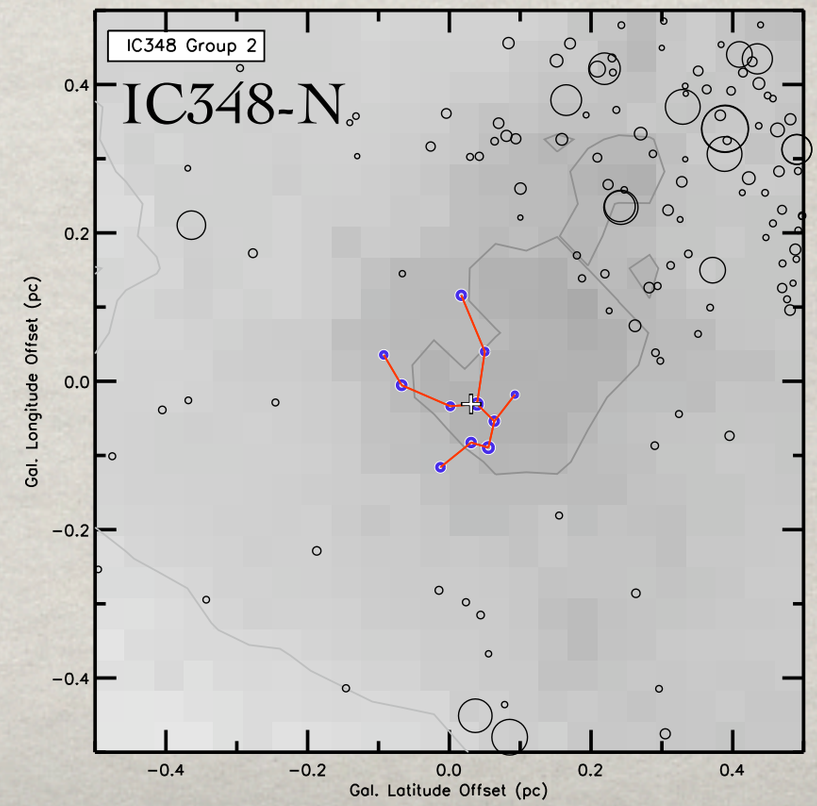






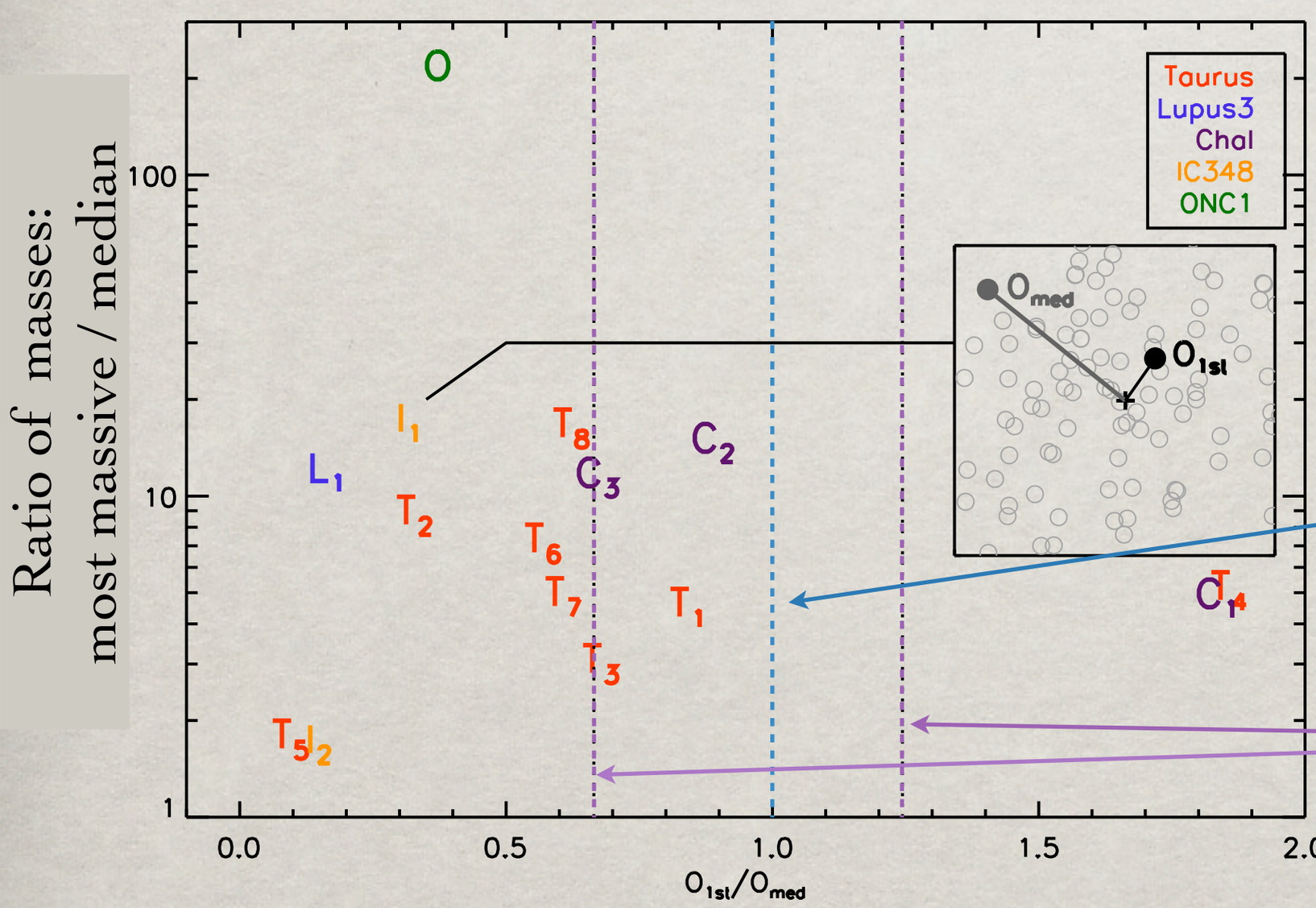






Massive YSO Location

- Most massive YSO in group tends to be near center, much closer than expected from random locations



Ratio of offsets from centre:
most massive member / median

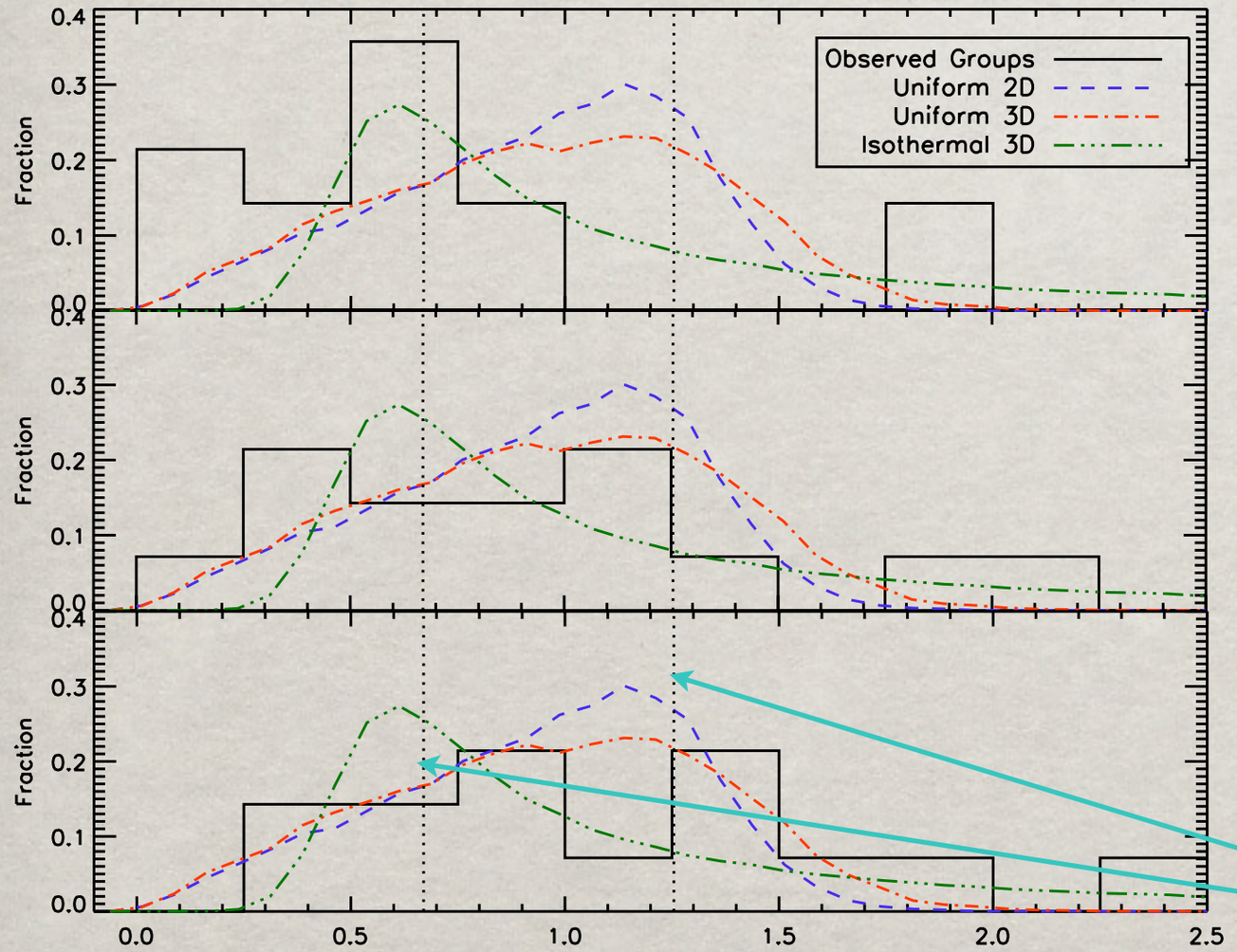
Details:
- group center = median position
- median masses typically 0.1-0.2 $M_\odot$
- offset << than for random

Ratio for random distribution is > 1 approx. 50% of the time

1st & 3rd quartile for 3D random uniform distribution

More General Mass Segregation?

- The trend seen for the most massive group member sometimes extends to the second or third most massive member, but never more



Most massive member

2nd most massive member

3rd most massive member

1st & 3rd quartile values for random distribution

More General Mass Segregation?

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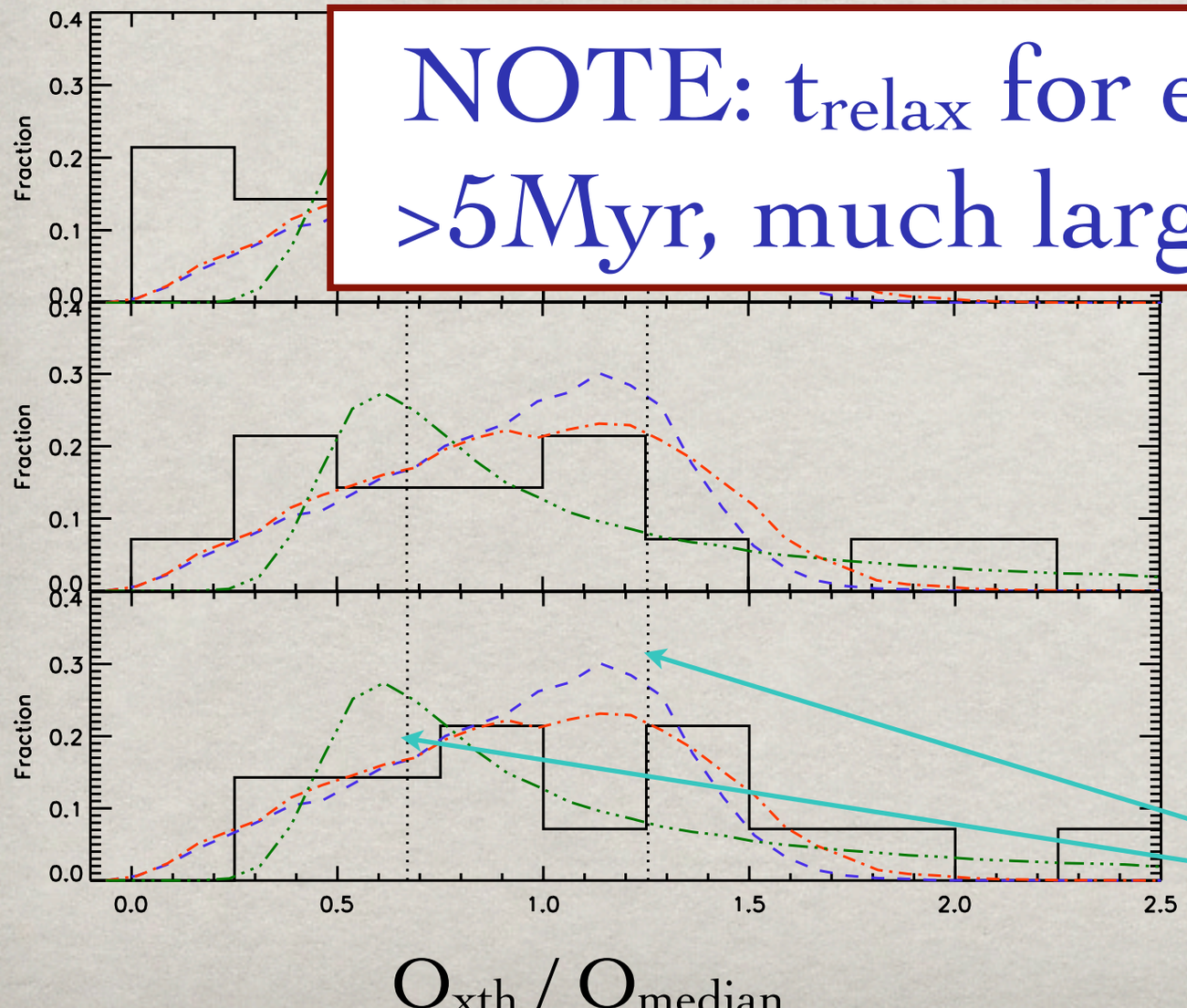
NOTE: t_{relax} for each group is >5Myr, much larger than t_{group}



ember

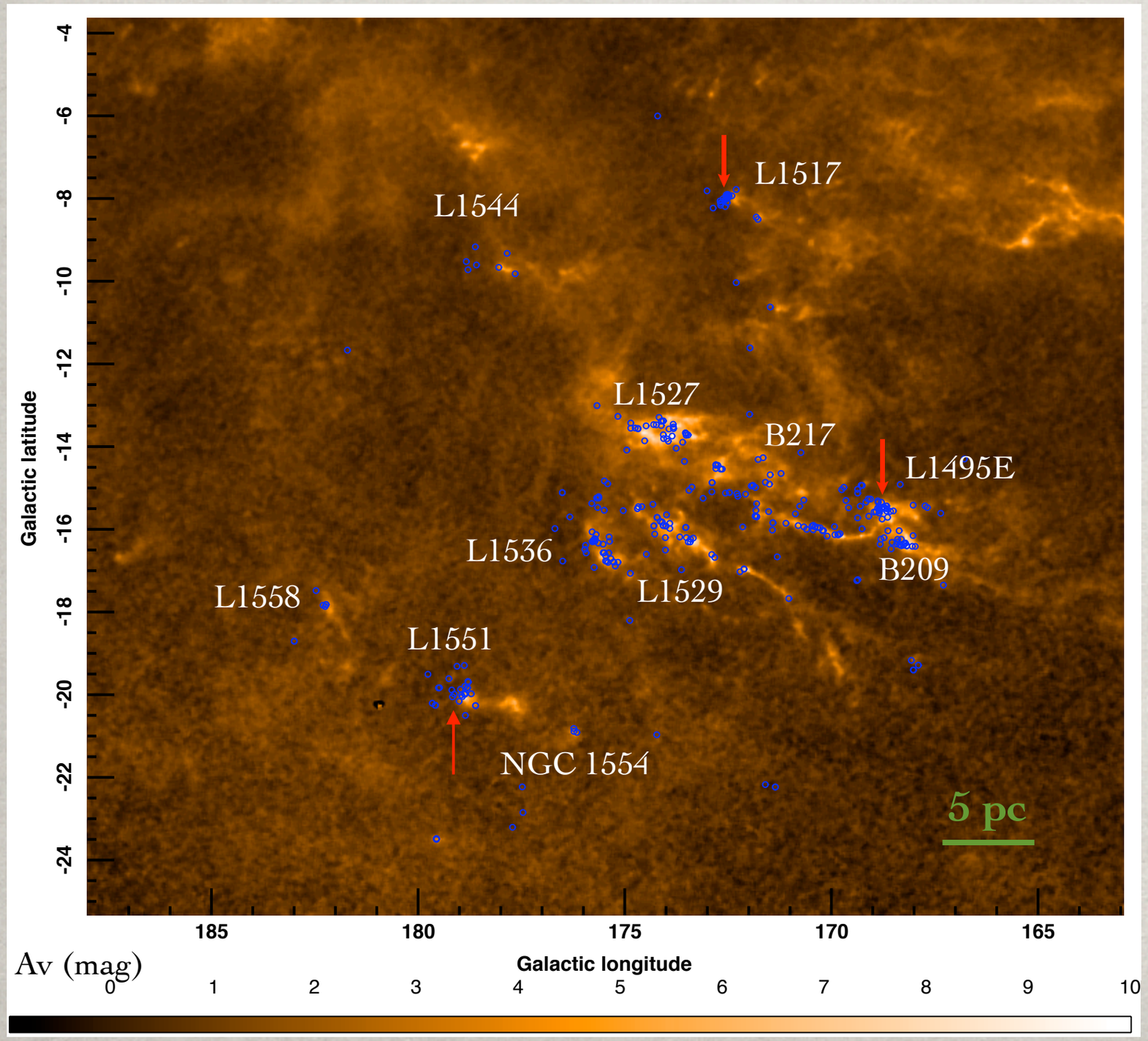
2nd most massive member

3rd most massive member

1st & 3rd quartile values for random distribution

Aside: Taurus & Mass Segregation

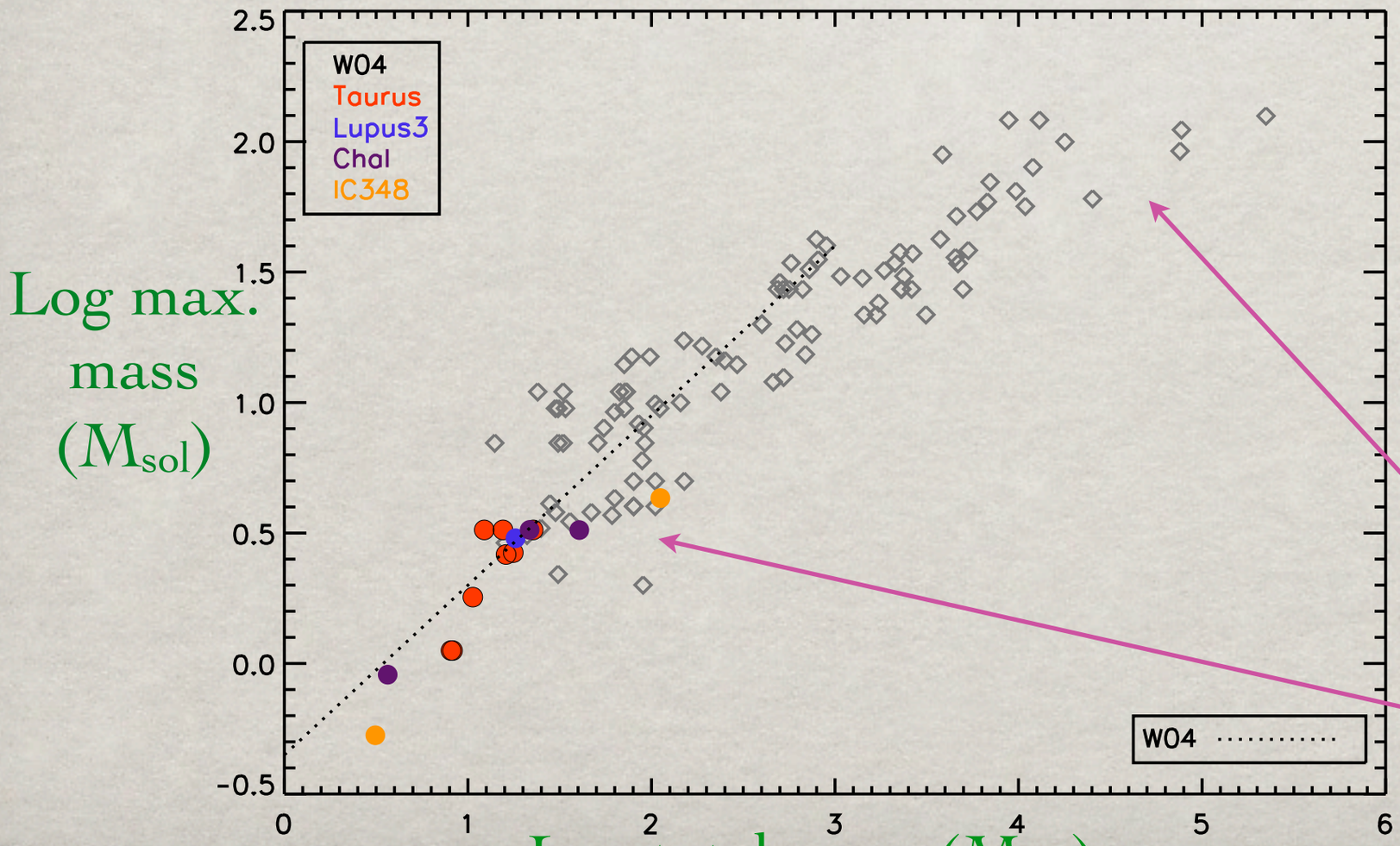
(Froebrich et al 2007 extinction map; Luhman et al 2010 YSOs)



- Four B9 stars in Taurus are located in groups near the periphery of the larger complex
- No conflict between our small-scale results and Richard Parker's results

Other Group Properties: Mass of Most Massive

- in clusters, mass of most massive member related to total cluster mass
- consistent with random sampling of IMF with max mass ~ 150 M_{sol} (Weidner et al 2004, 2010)



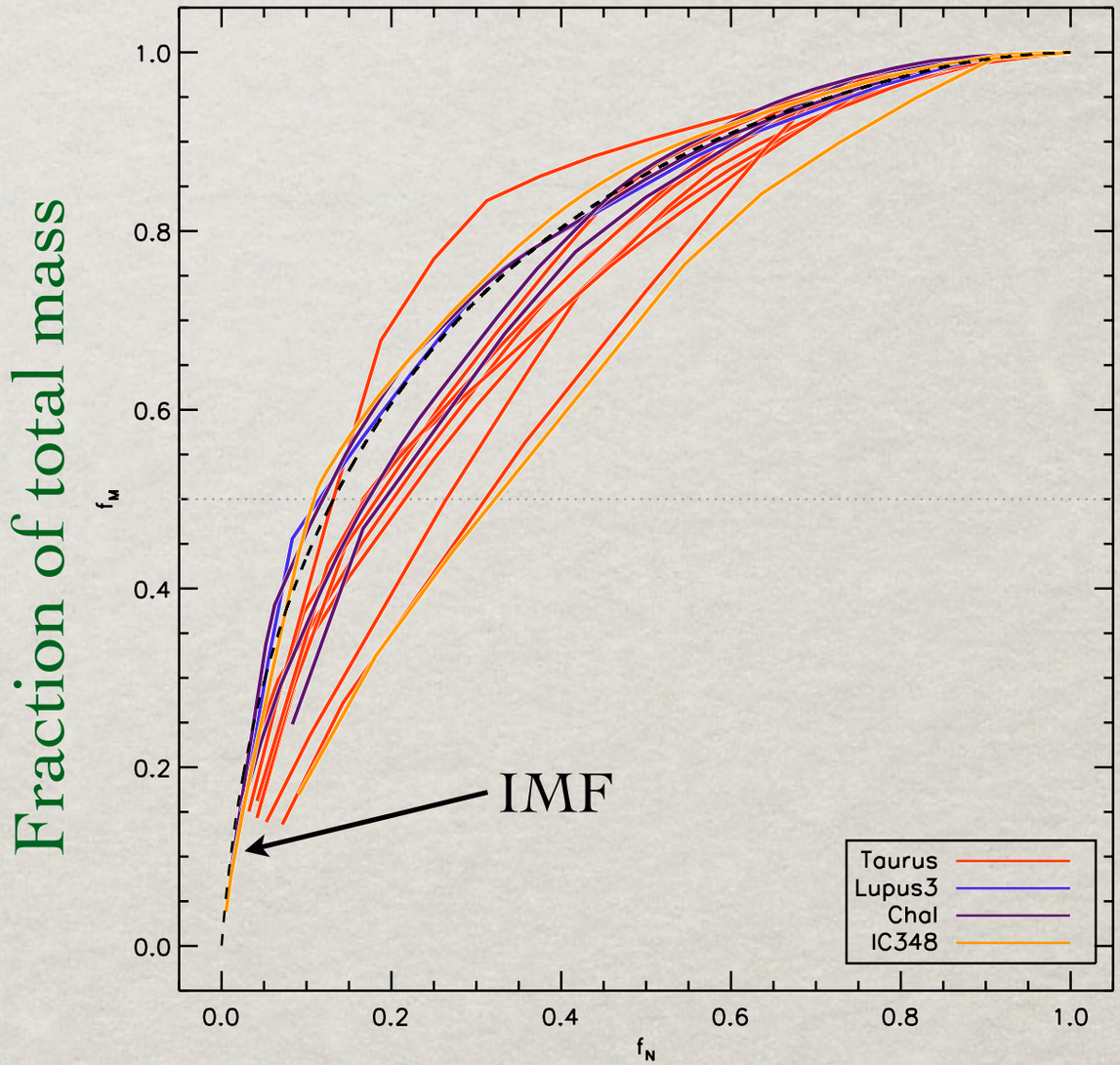
Our groups fall along same relationship as found by Weidner et al

turn-over at high masses due to maximum mass

linear at low masses due to power law IMF

Dominance of Most Massive

- Most massive few members contain a substantial fraction of the group's total mass
- Random sampling of IMF also implies substantial fraction of mass in few most massive members



Suggests most massive group members may play an important role in group!

Summary

- Nearby star-forming regions (e.g., Taurus) show evidence of scaled-down clustered star-formation
- Stellar groupings show central location of their most massive member, similar to mass segregation apparent in clusters
  - location not due to random sampling or dynamics
  - less crowding, better completeness eliminates potential for observational bias
  - max mass scales with total cluster mass
  - substantial % of mass in most massive members
- Can current models of clustered star formation extend to such small & sparse groups?

For more details, look for Kirk & Myers, ApJ submitted

Thank You!