What the spatial distribution of stars can tell us about star formation

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N. Bastian, R. Gutermuth, and the GB, c2d, and Orion Spitzer team

SF occurs only in **clusters**?

Are there **different** modes of SF?

Comprehensive $\sum$ analysis of
Spitzer surveys (Bressert et al. 2010)

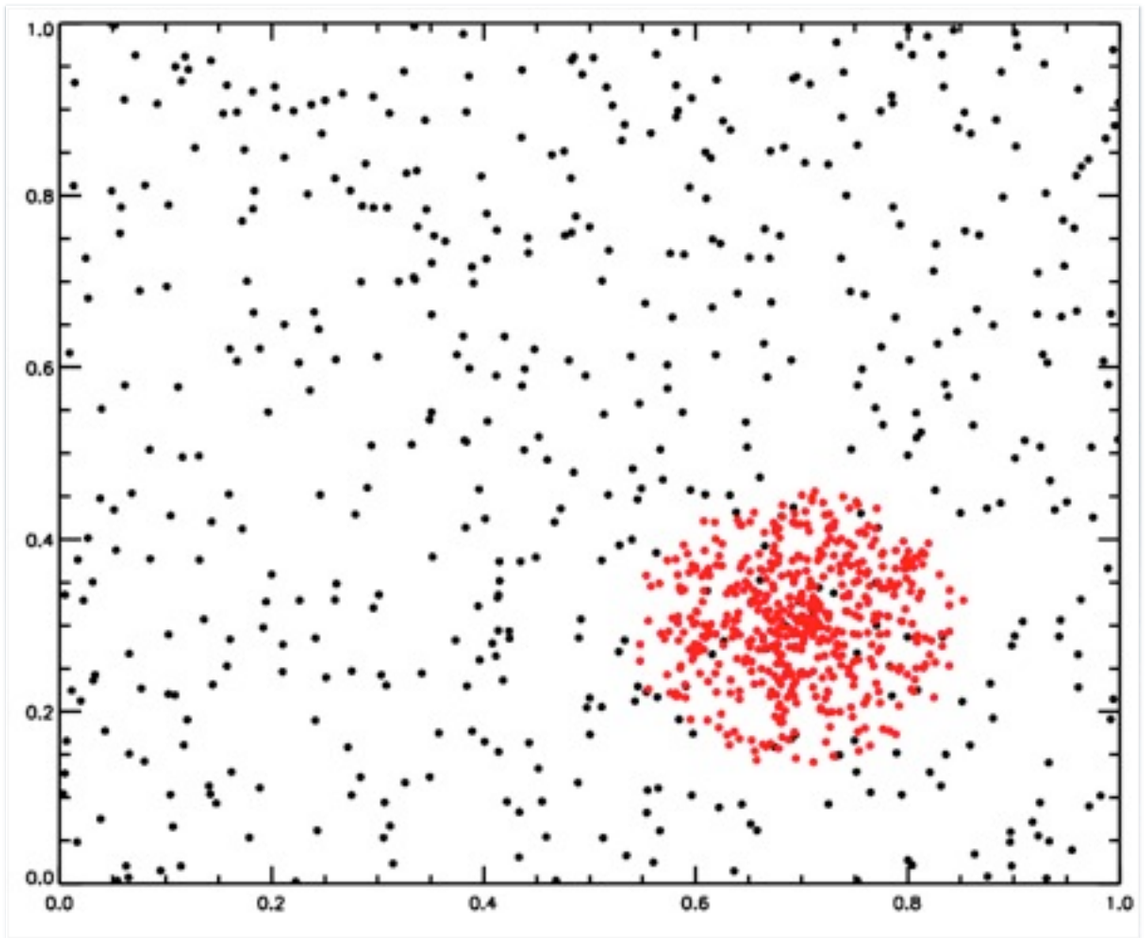
Isolated O-stars in the LMC

Conclusion

Credit: NASA/JPL-Caltech/CfA

MULTIPLE MODES

If there are multiple modes it should be apparent



$$\Sigma_* = \frac{j-1}{(\pi r_j^2)}$$

Casertano & Hut 1985

Clustered

Distributed

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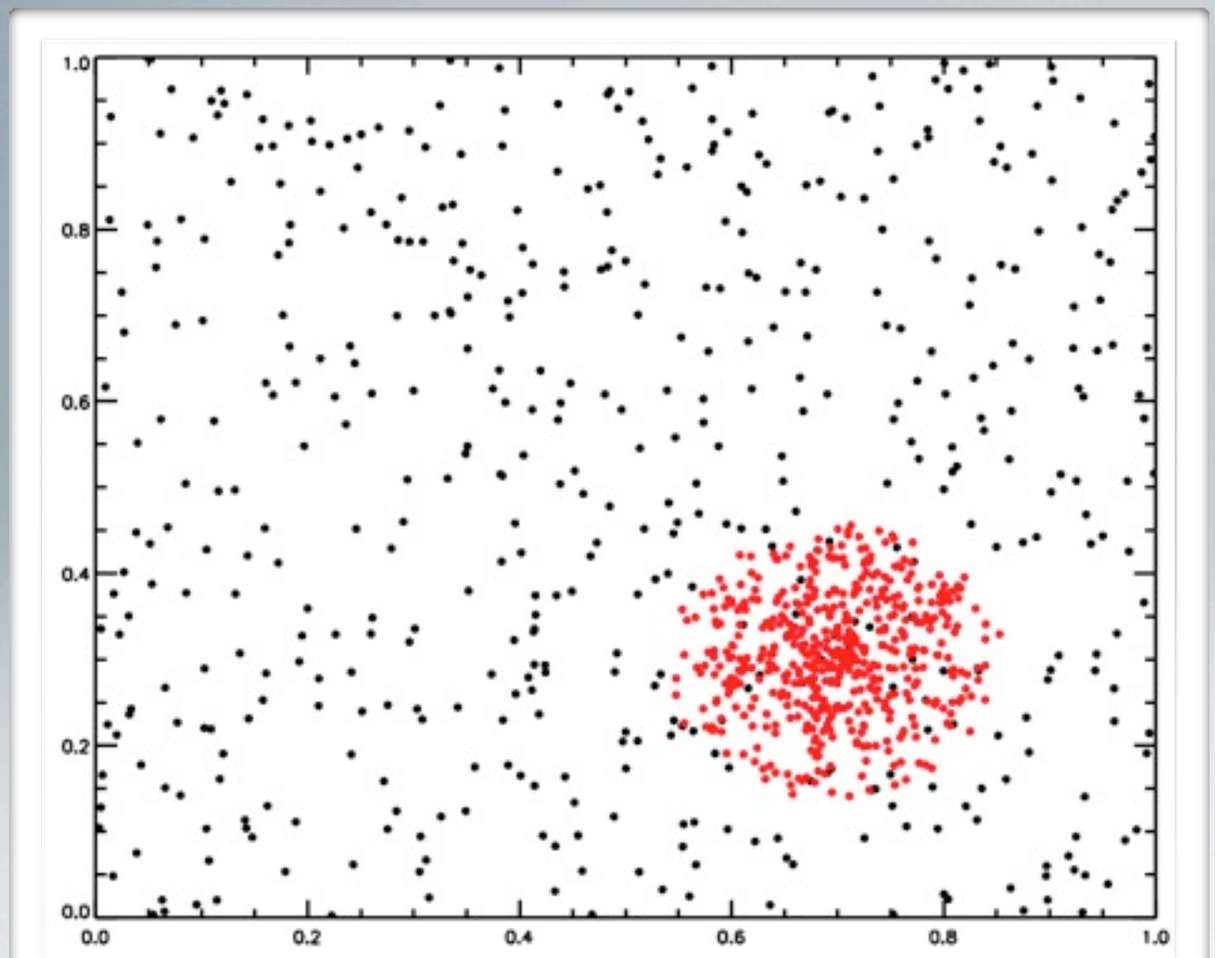

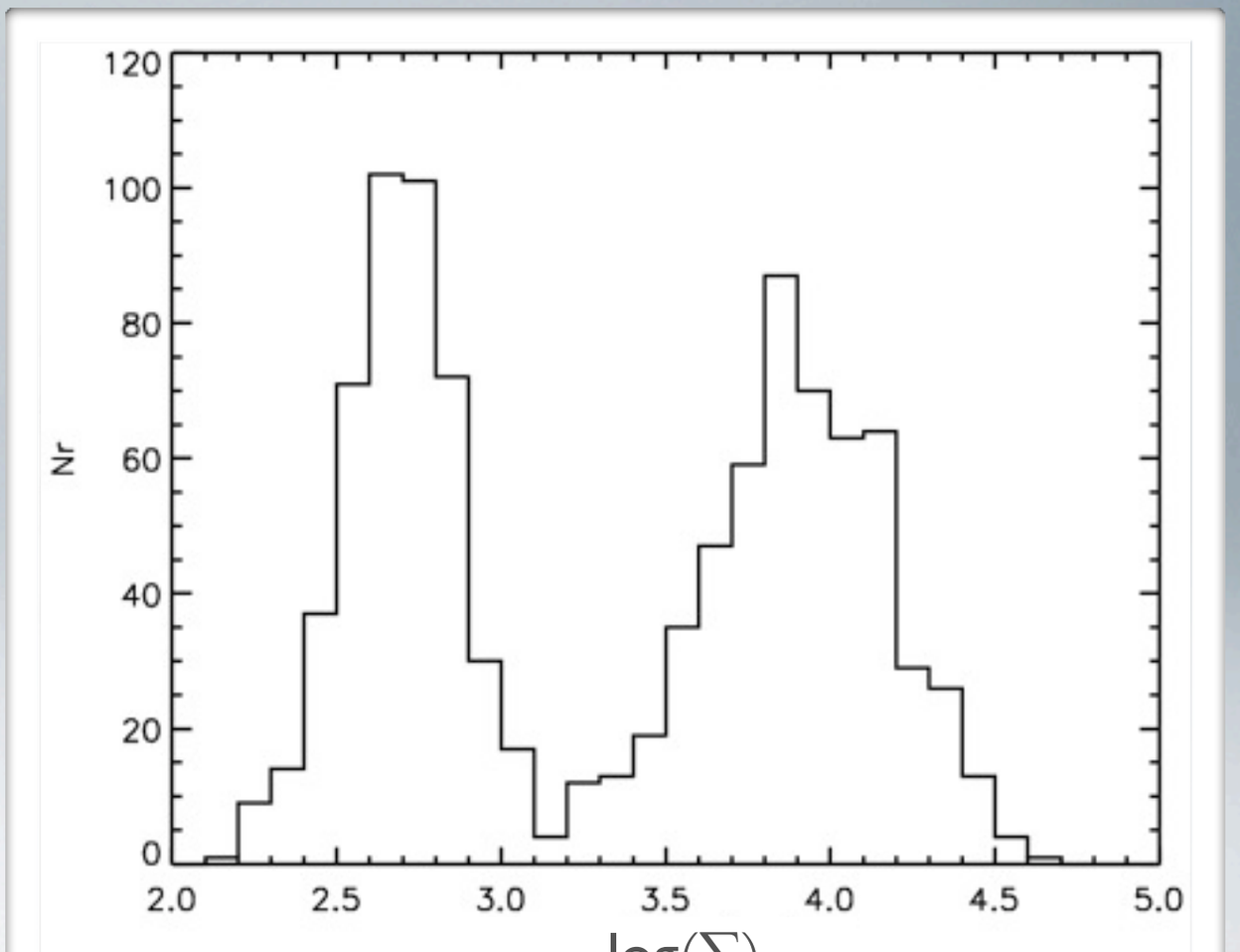

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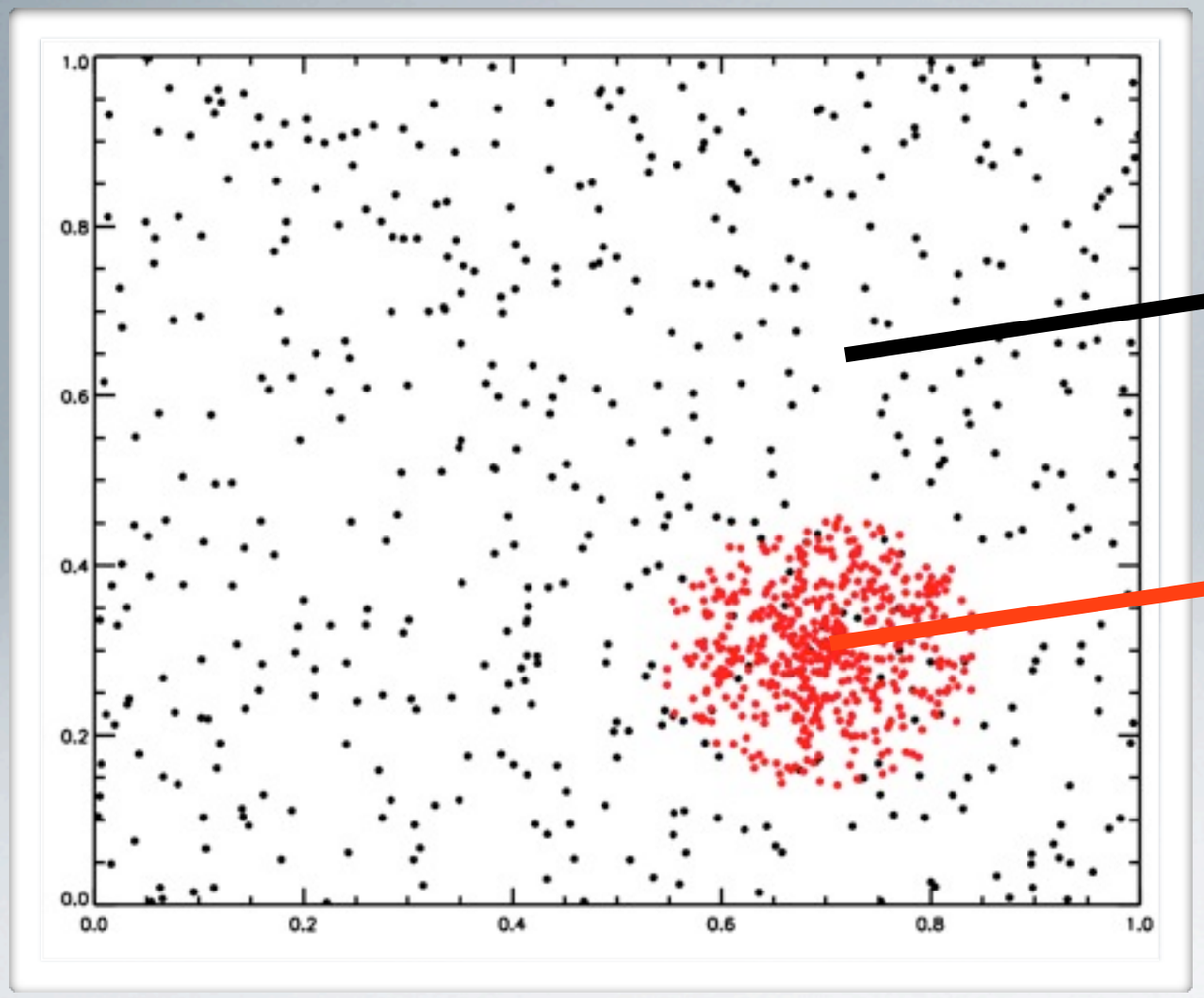

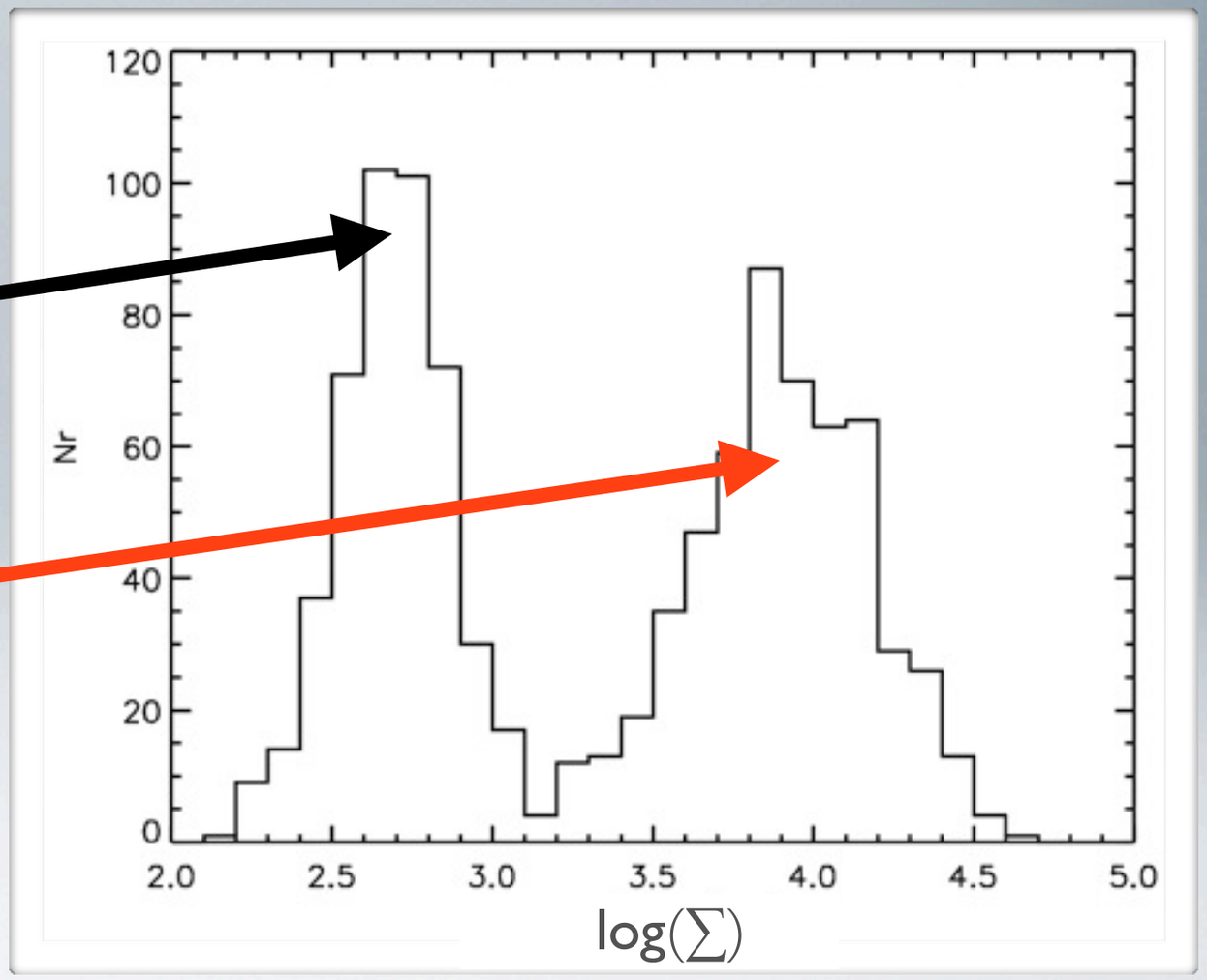

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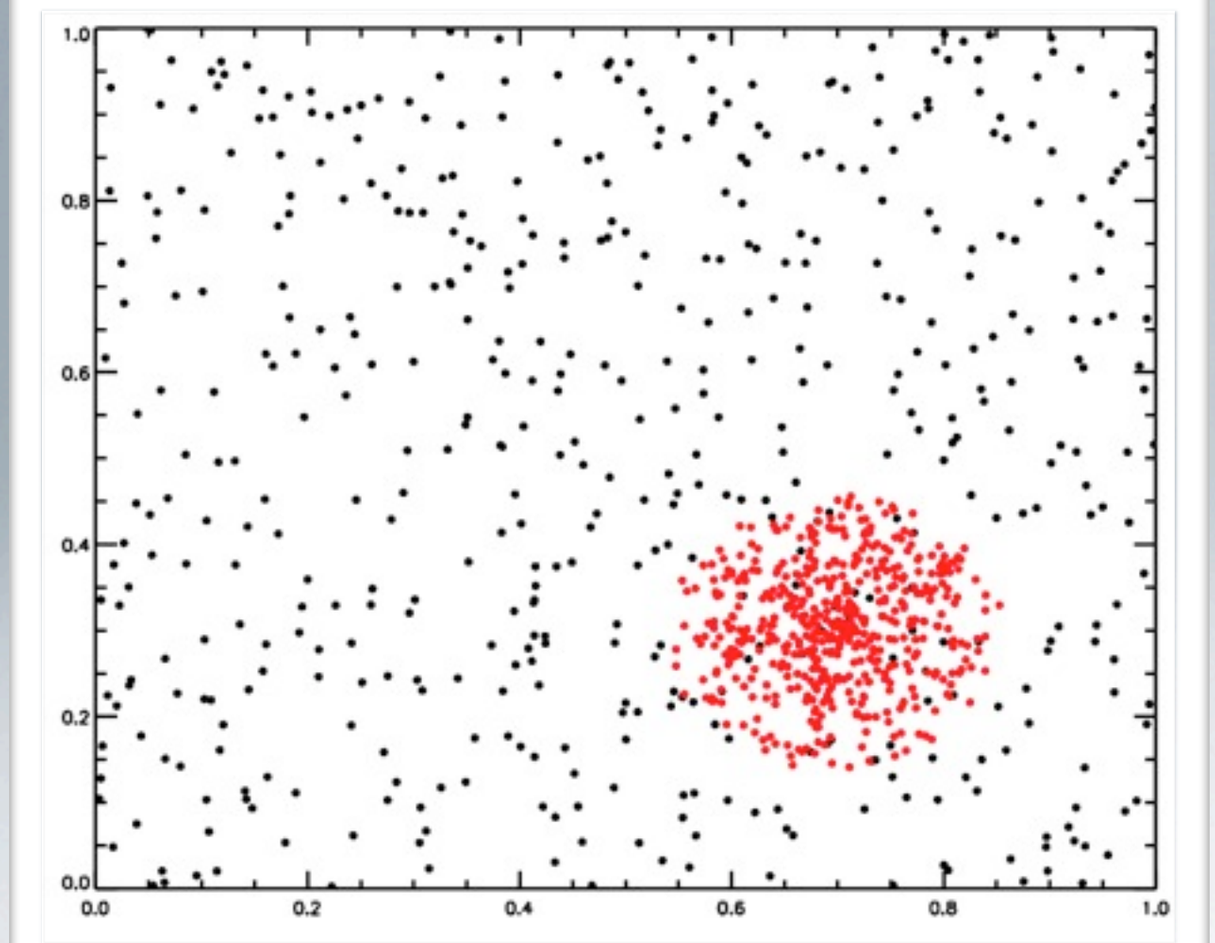

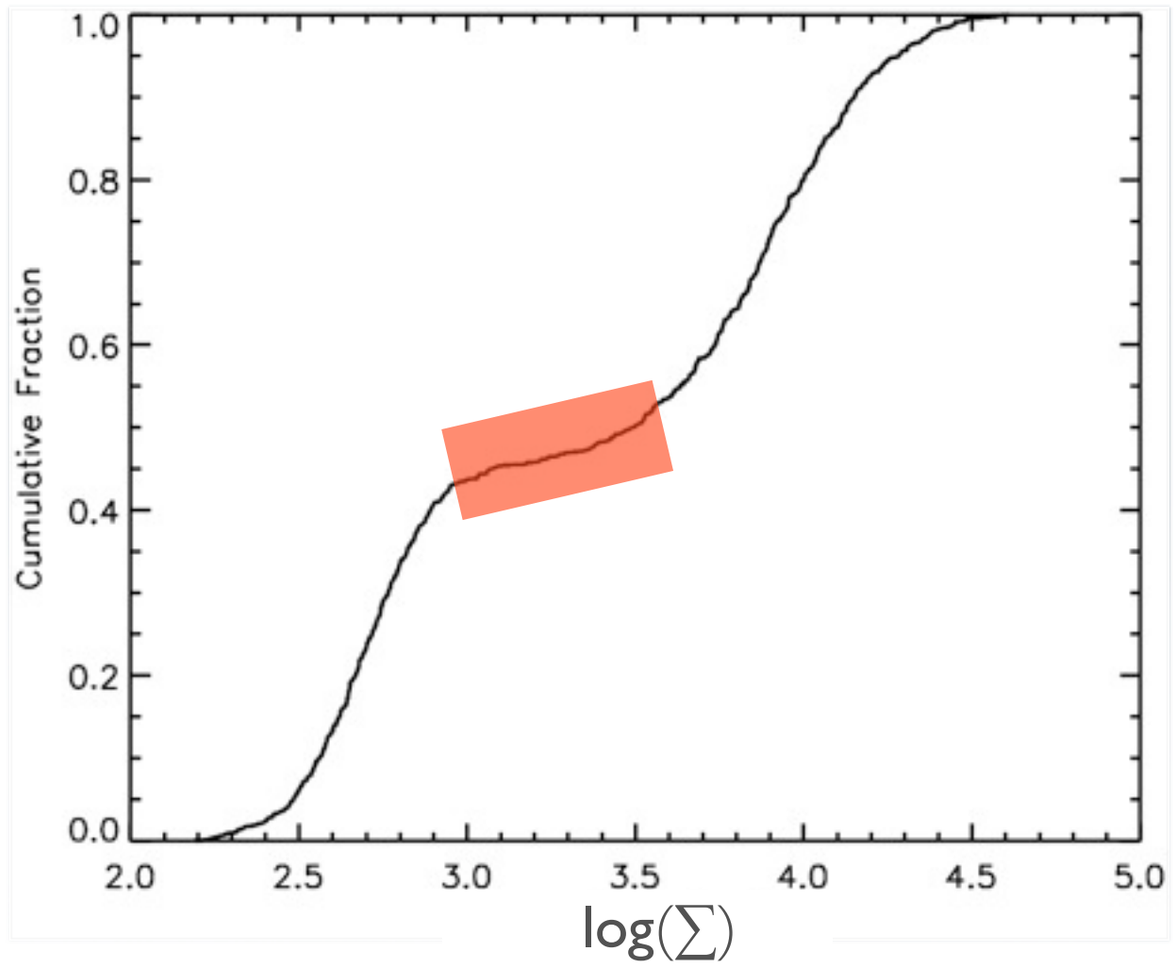

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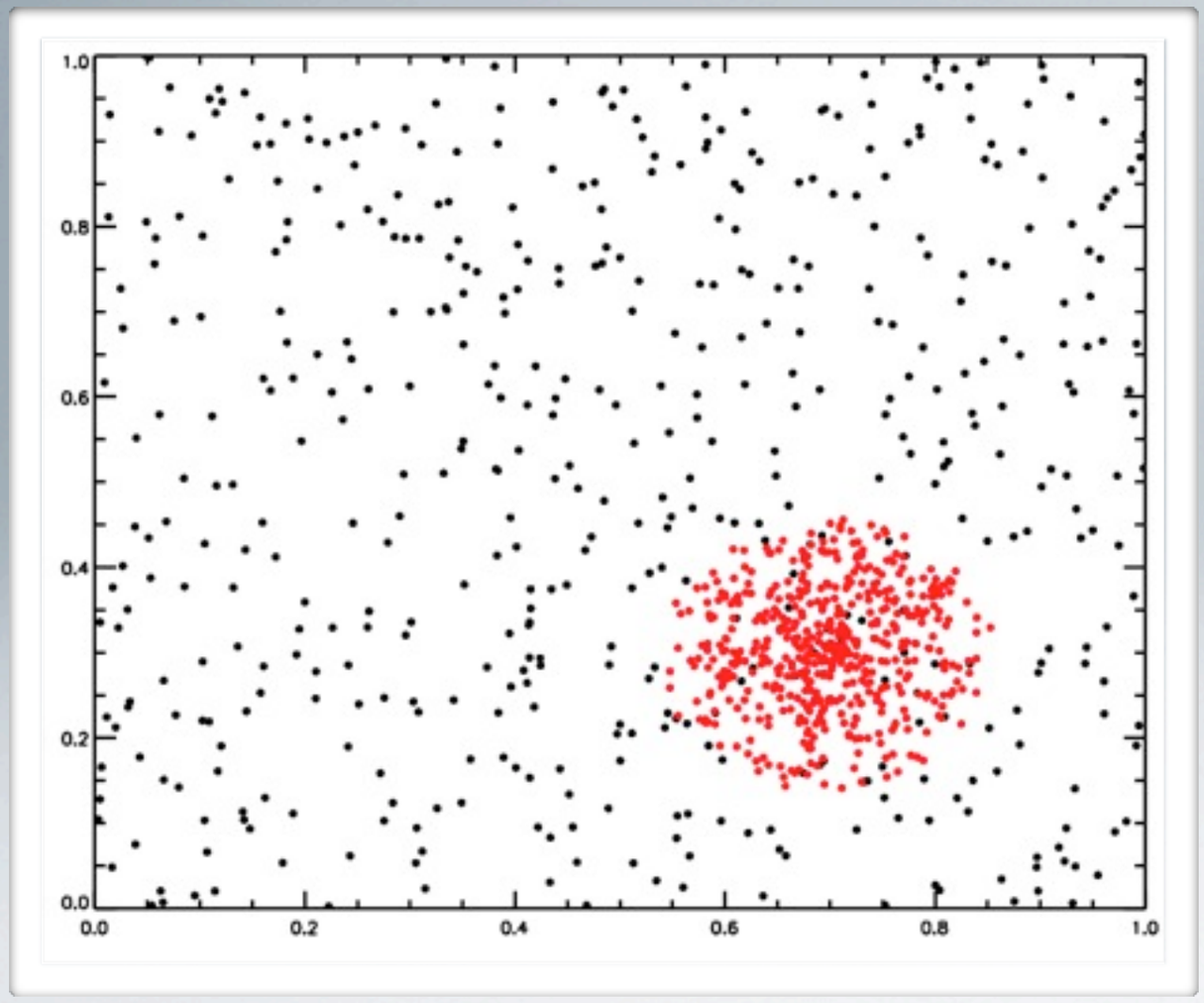

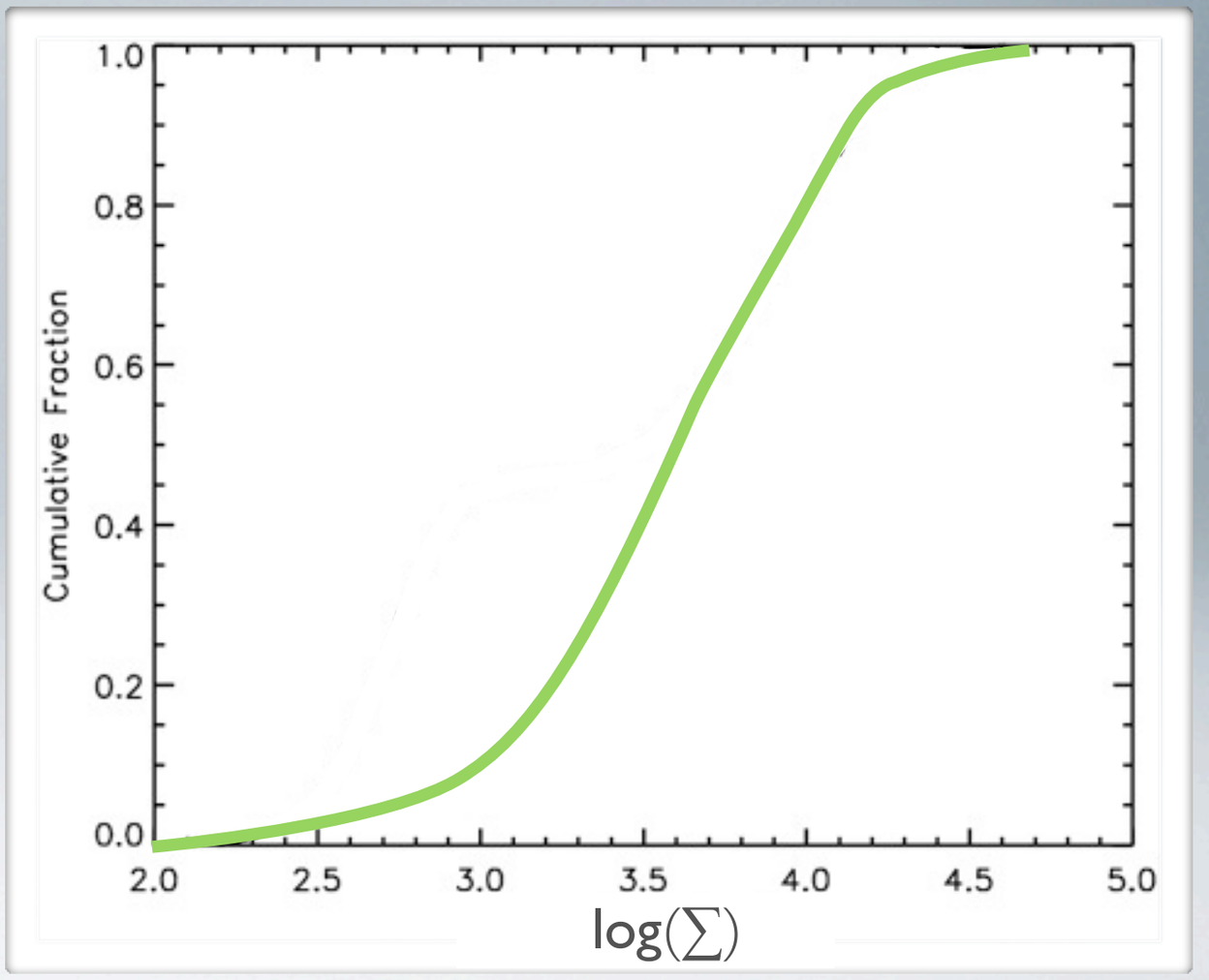

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Distributed

OBSERVATIONS

Before

NIR Imaging

At low YSO surface densities, associated members is **highly uncertain**

NIR only studies on low $\sum$ are incomplete

Now

Spitzer surveys

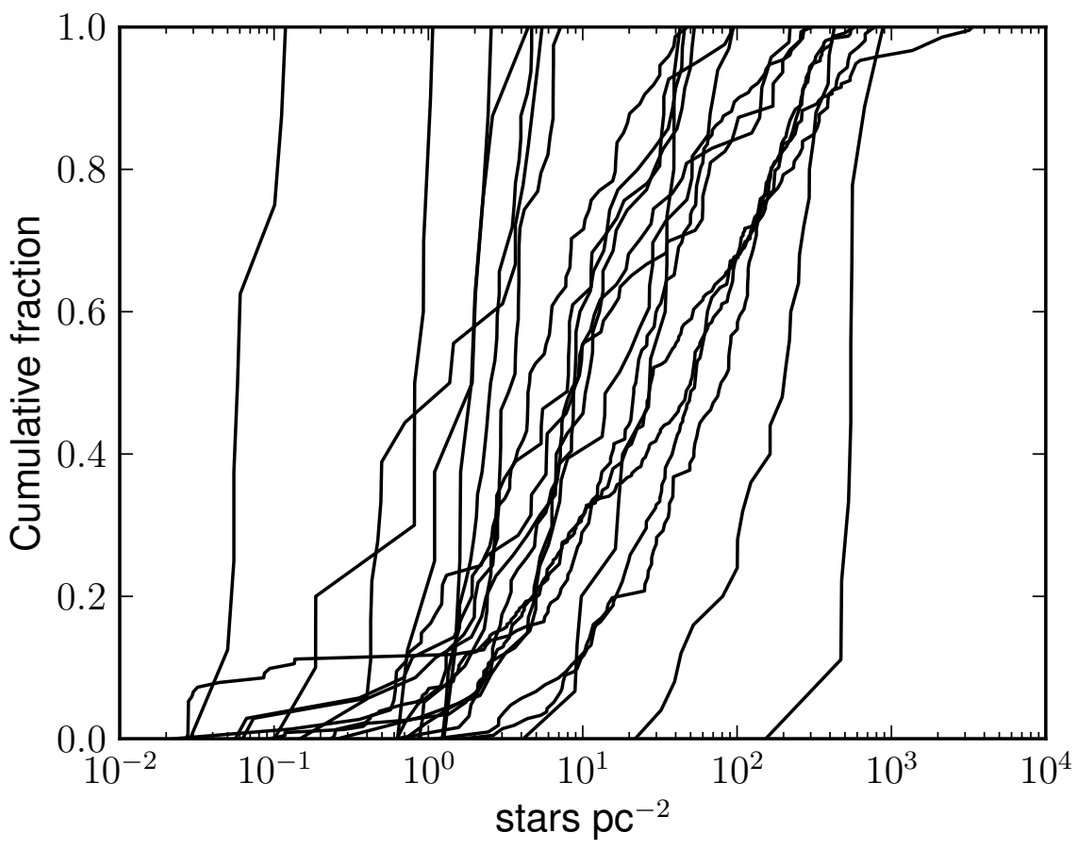
More **robust** and less contamination

Provides **global** outlook of low to high $\sum$

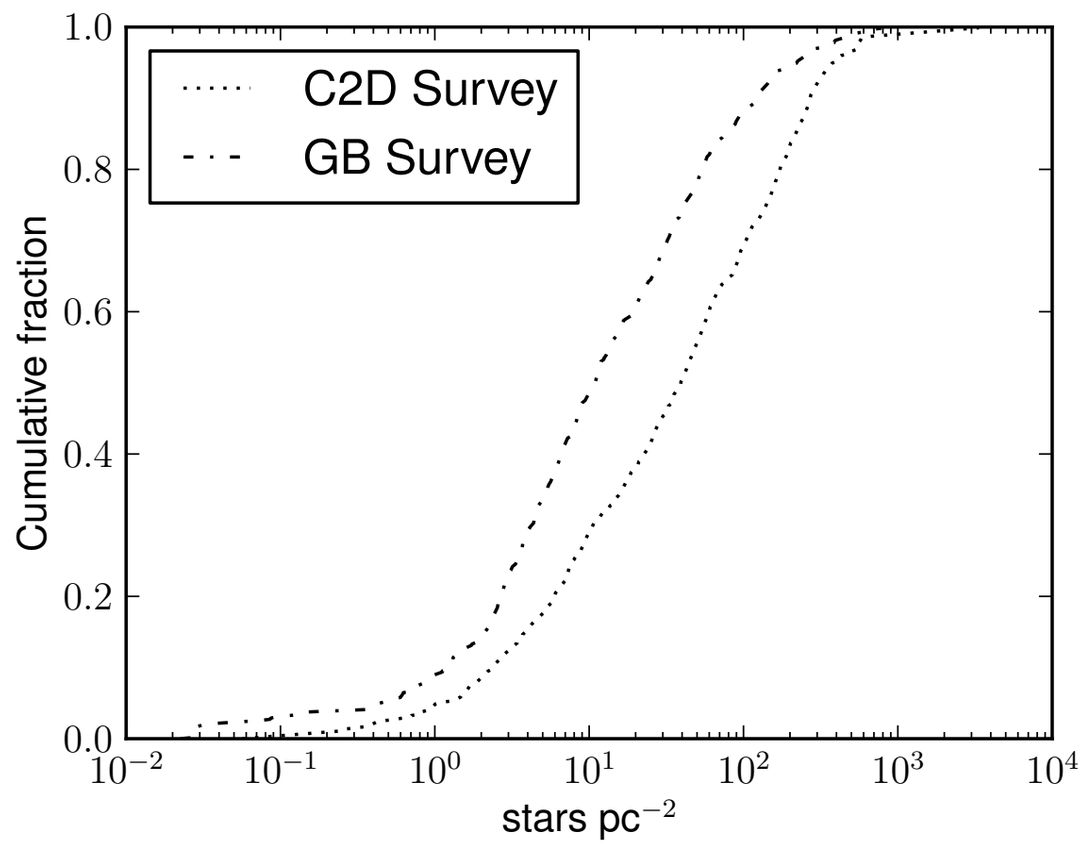
Large FoV Surveys
GB, c2d, Taurus, and Orion

GB & C2D

Separate Regions



Combined Regions



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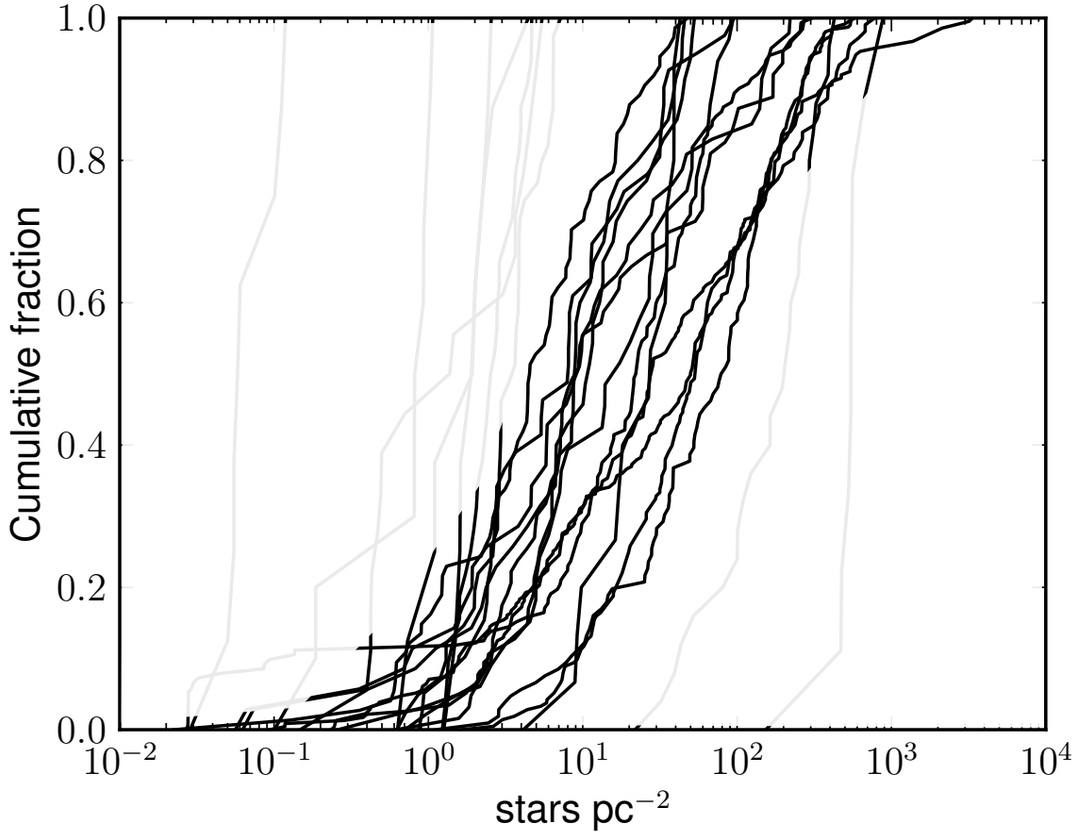

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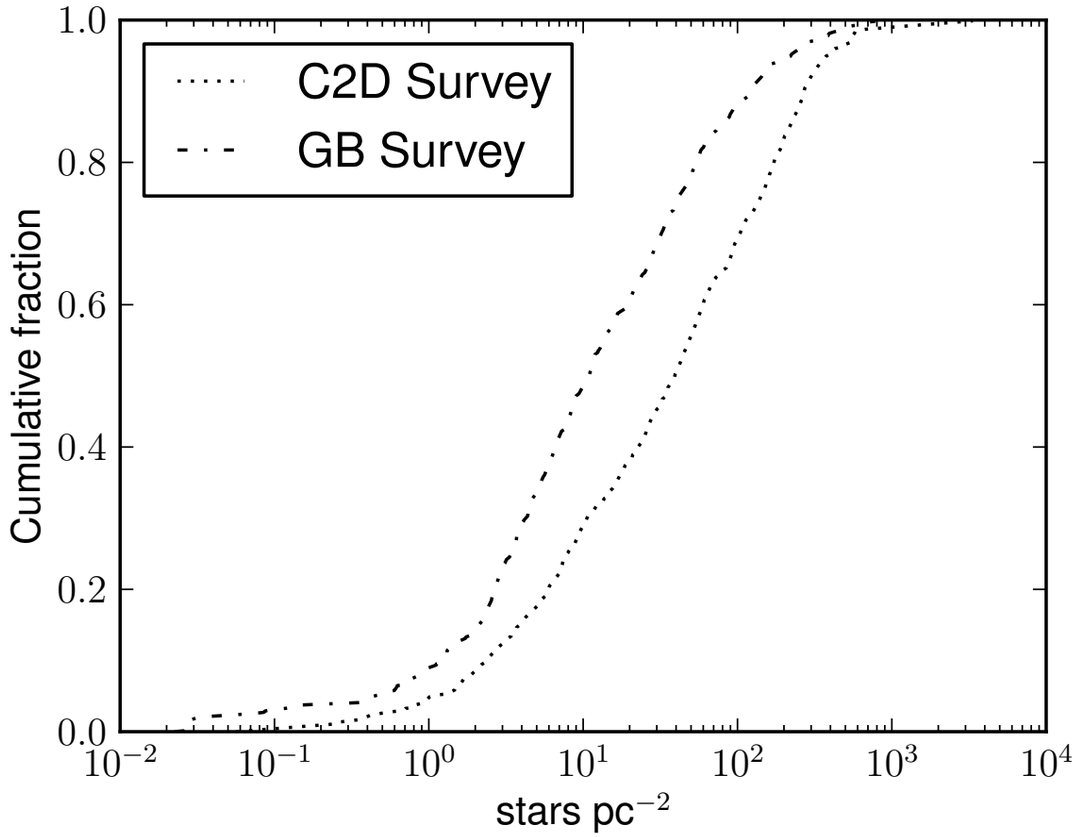

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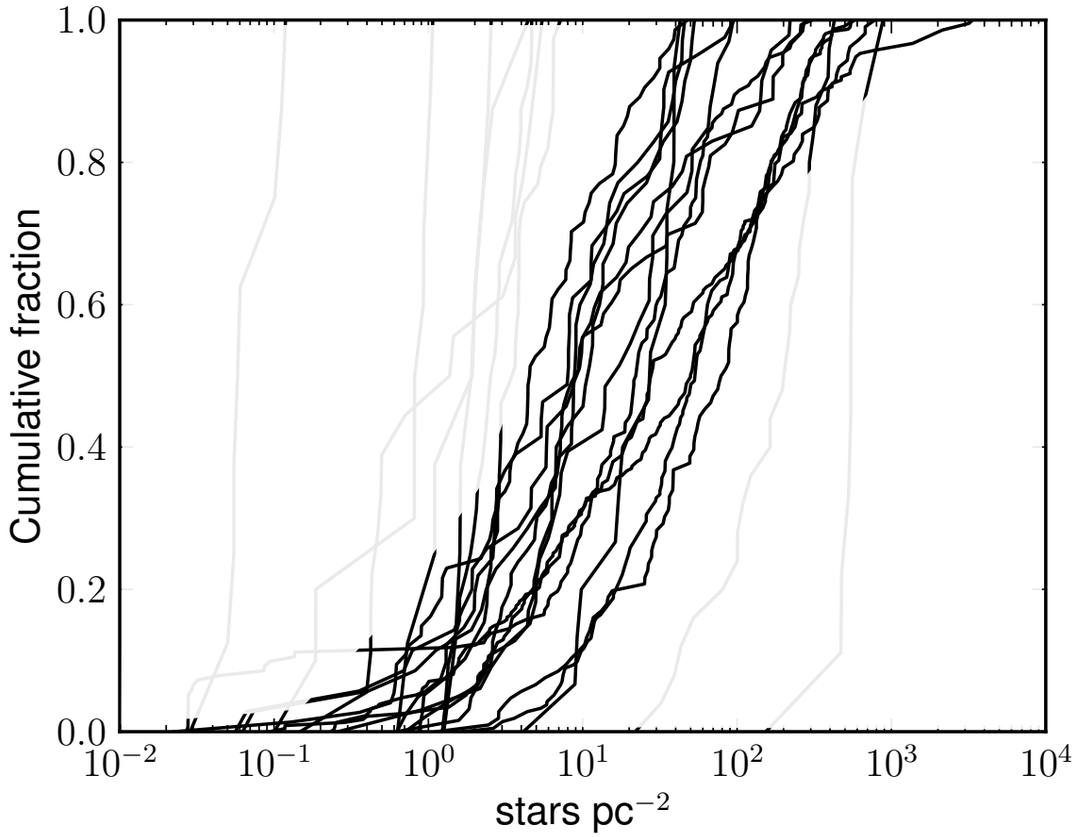
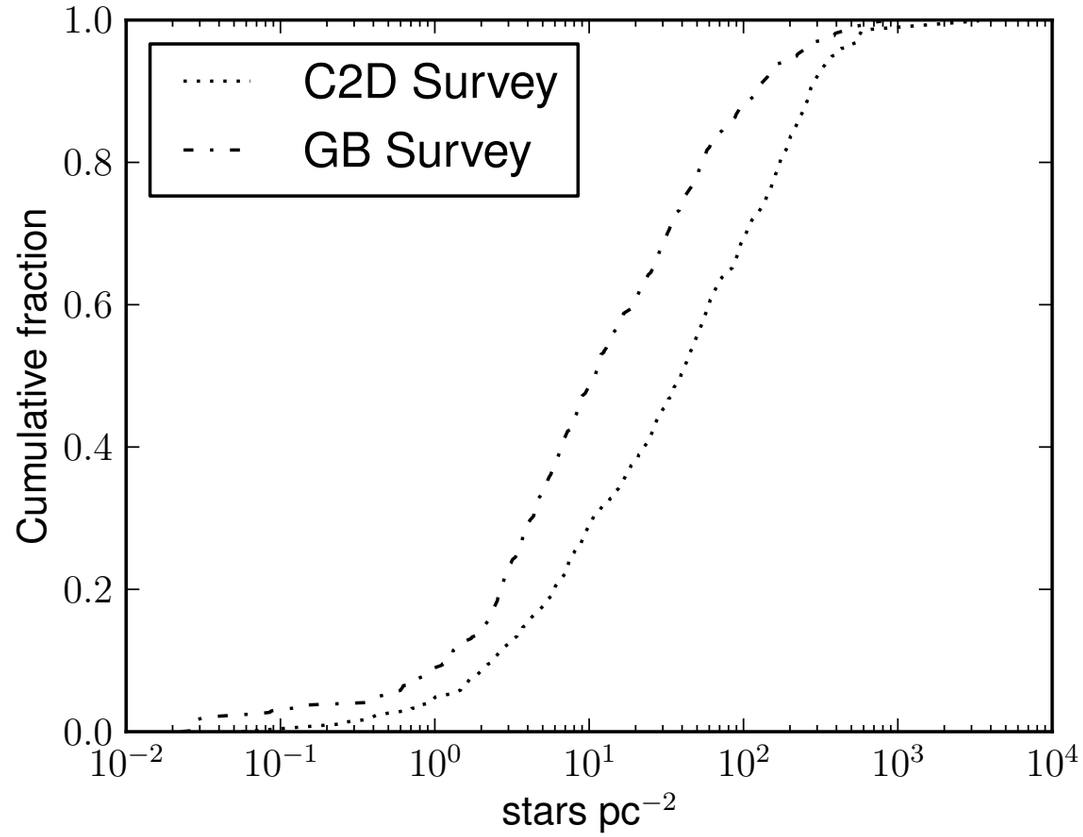


Combined Regions

Smooth profiles



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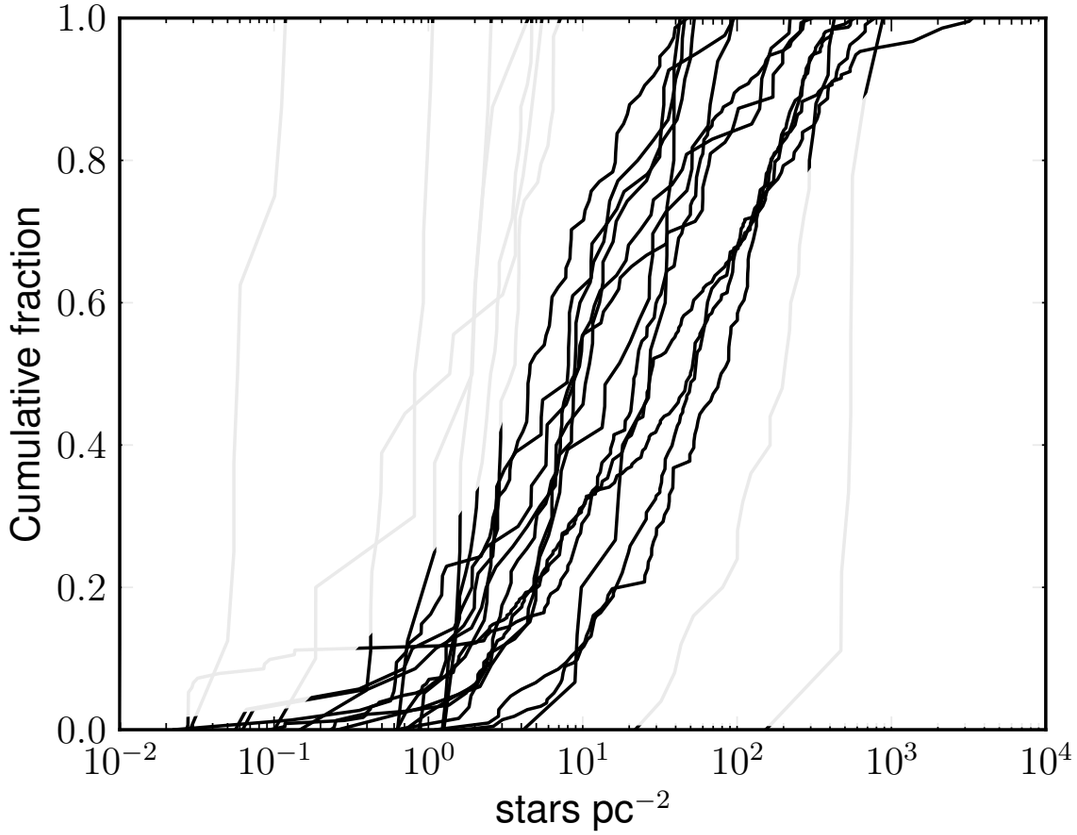

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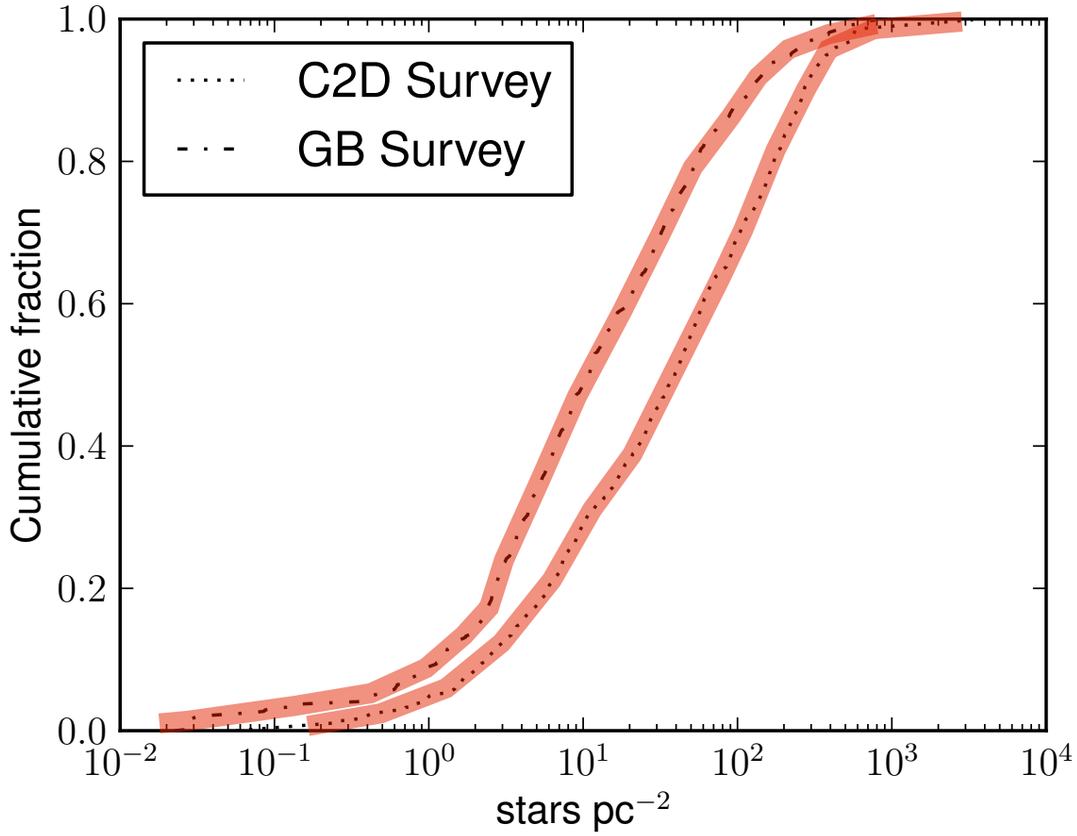
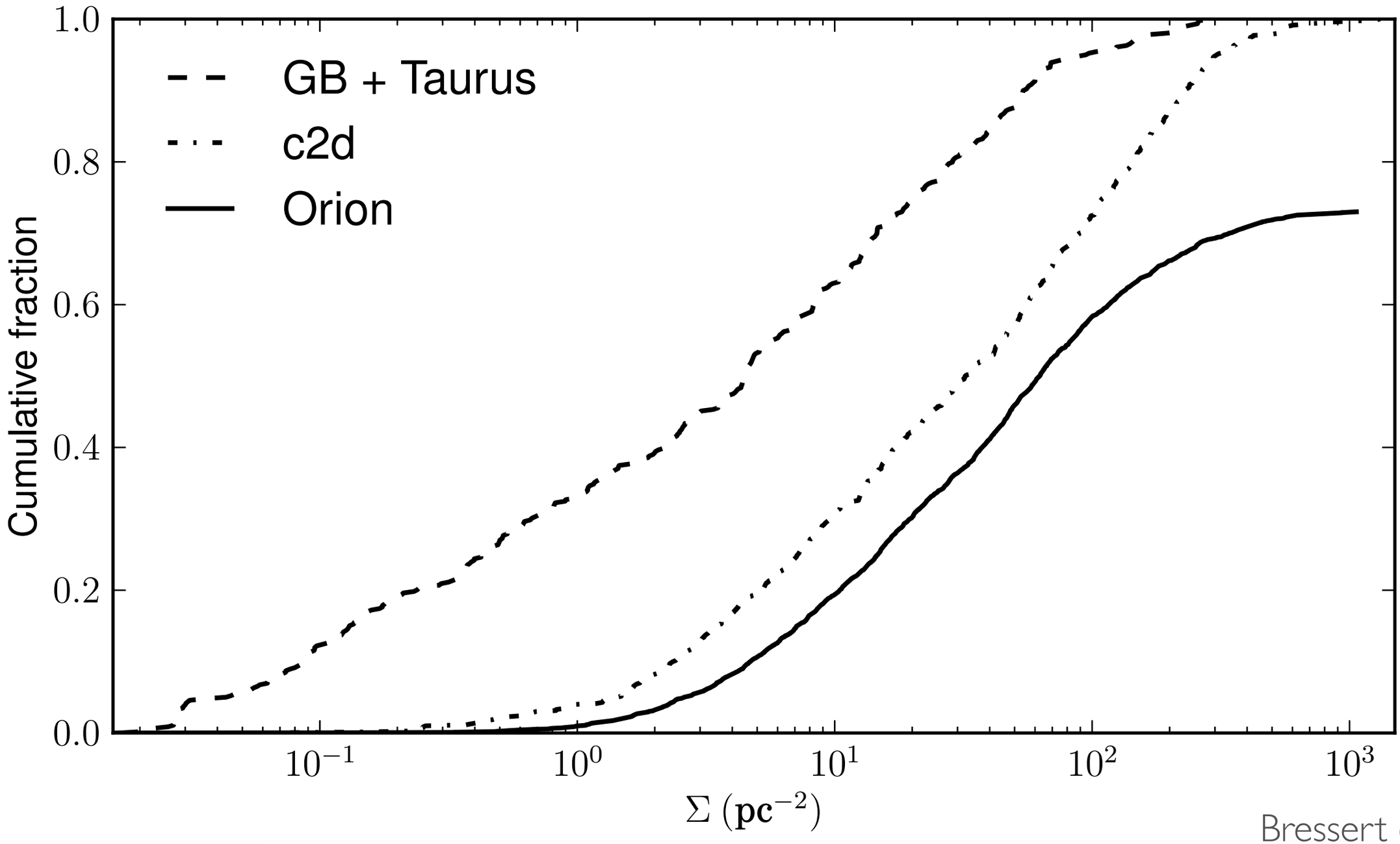
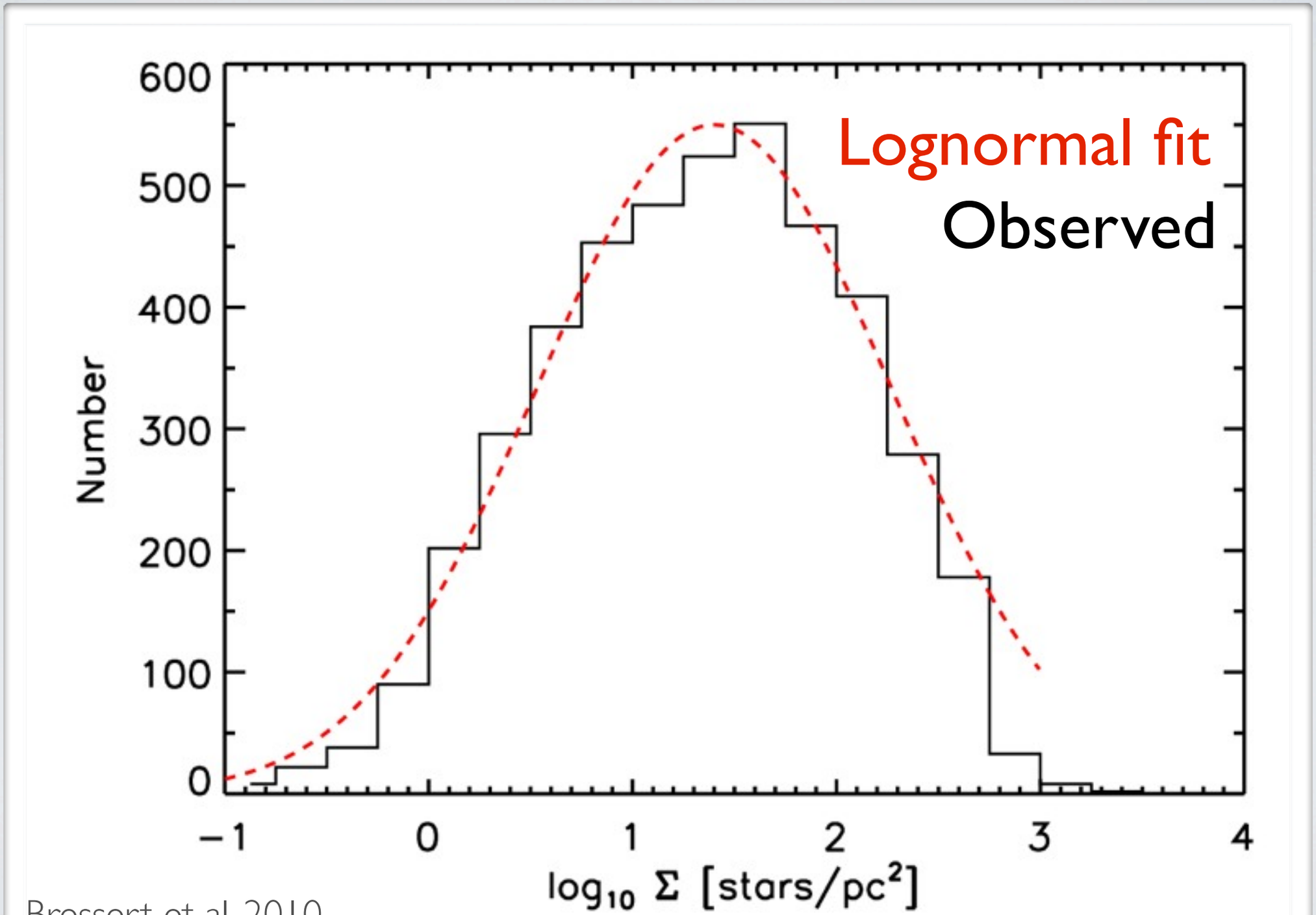


COMPARISON



Bressert et al. 2010

LOGNORMAL FIT



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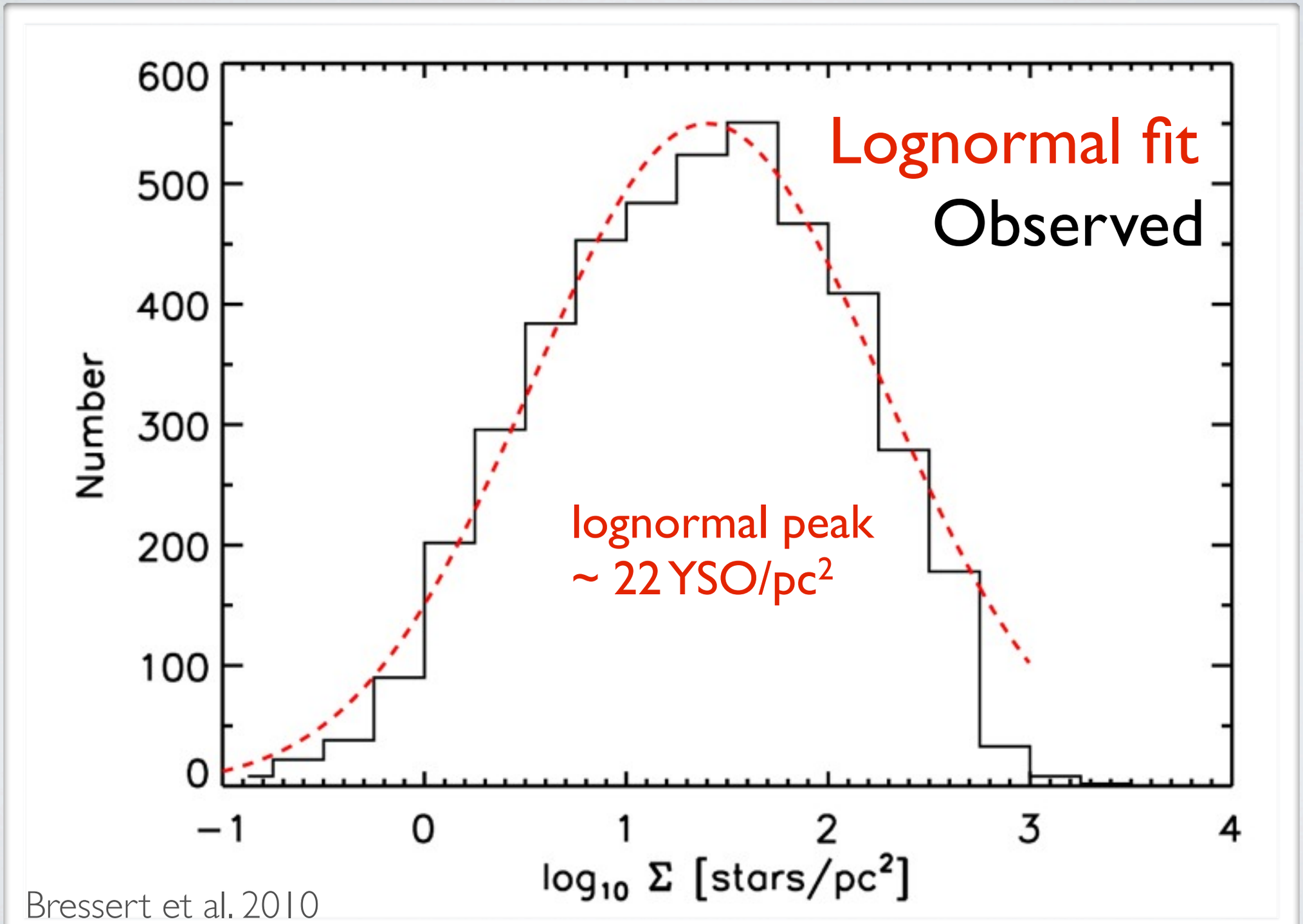

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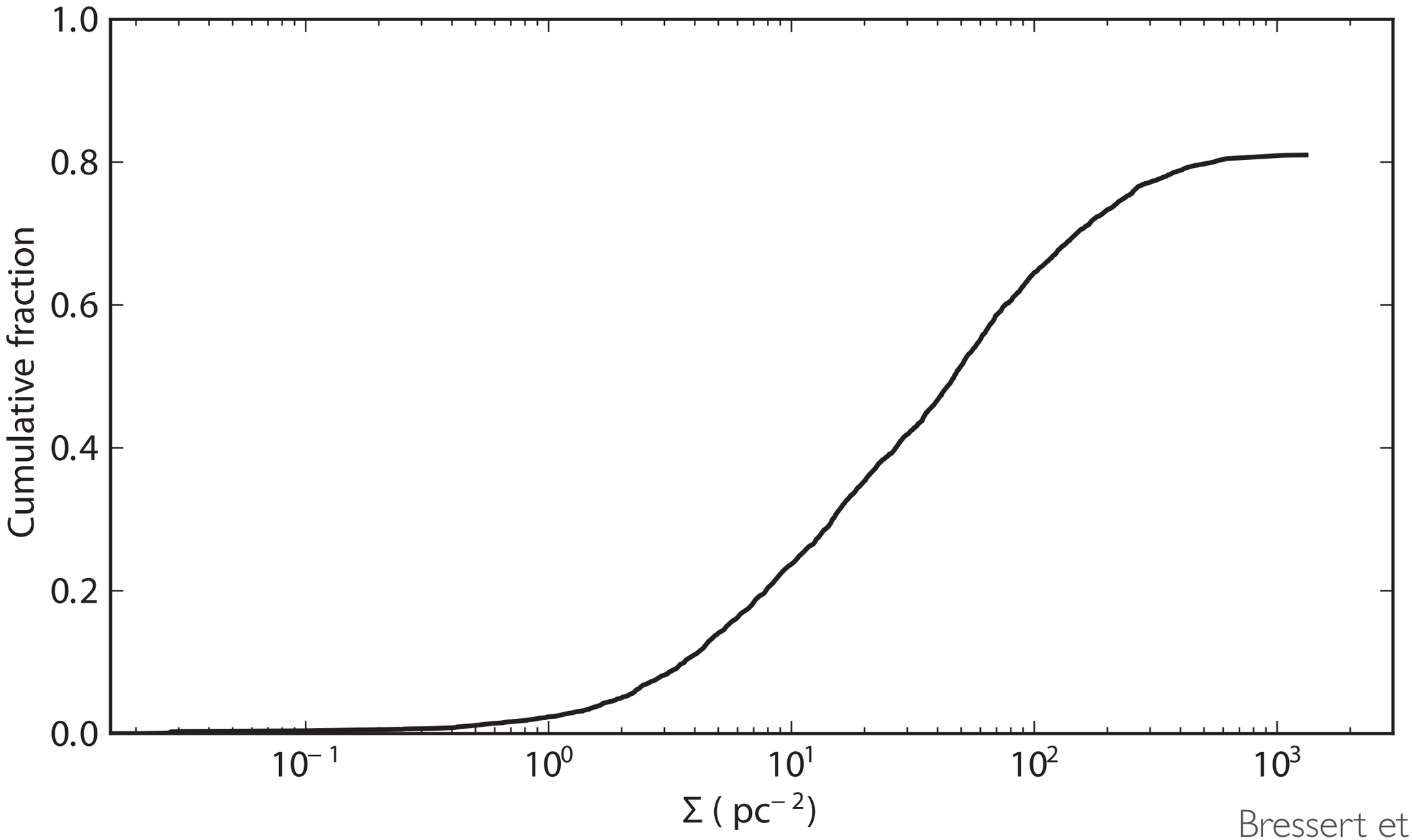
CLUSTERS REVISITED



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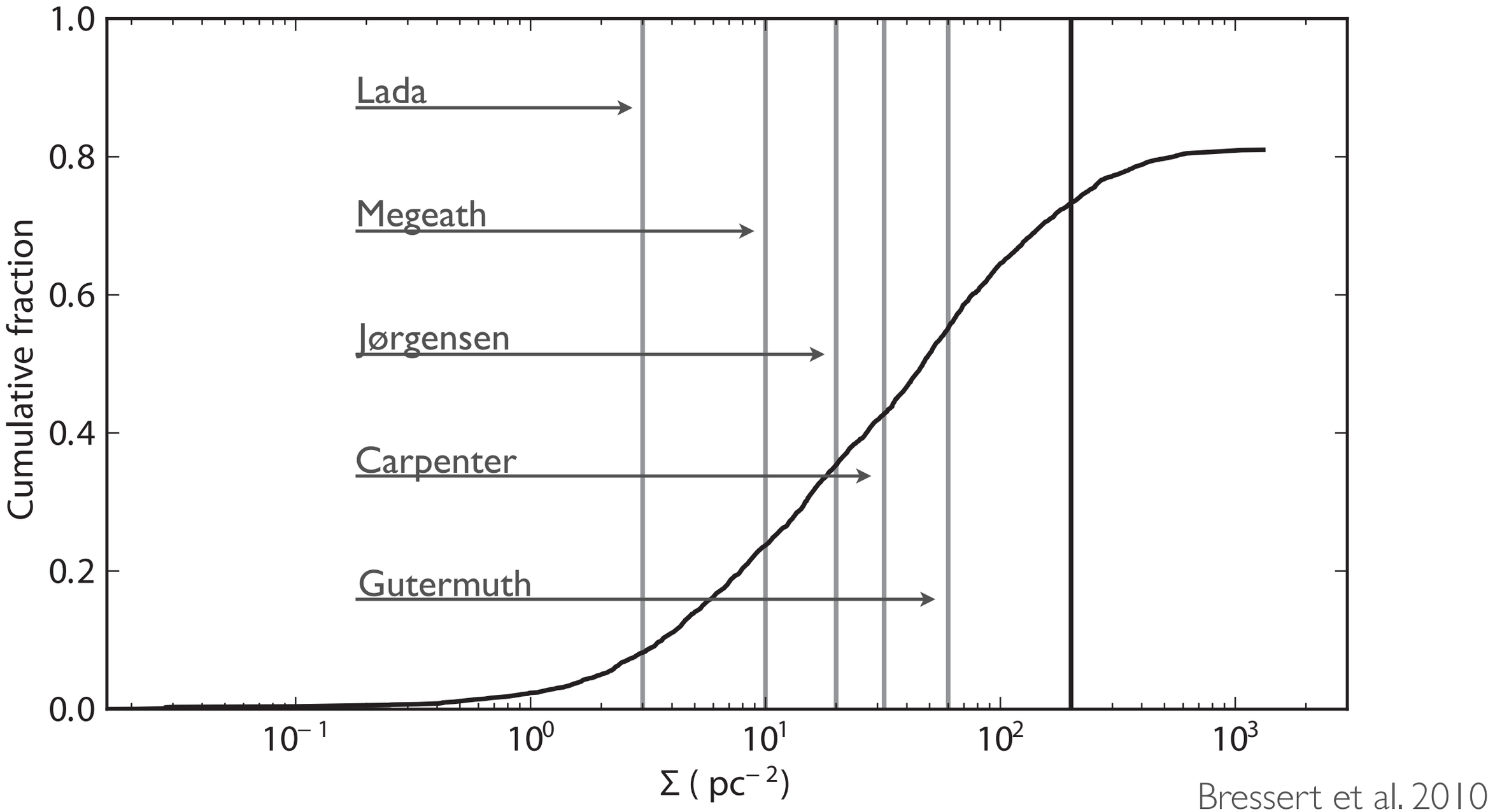

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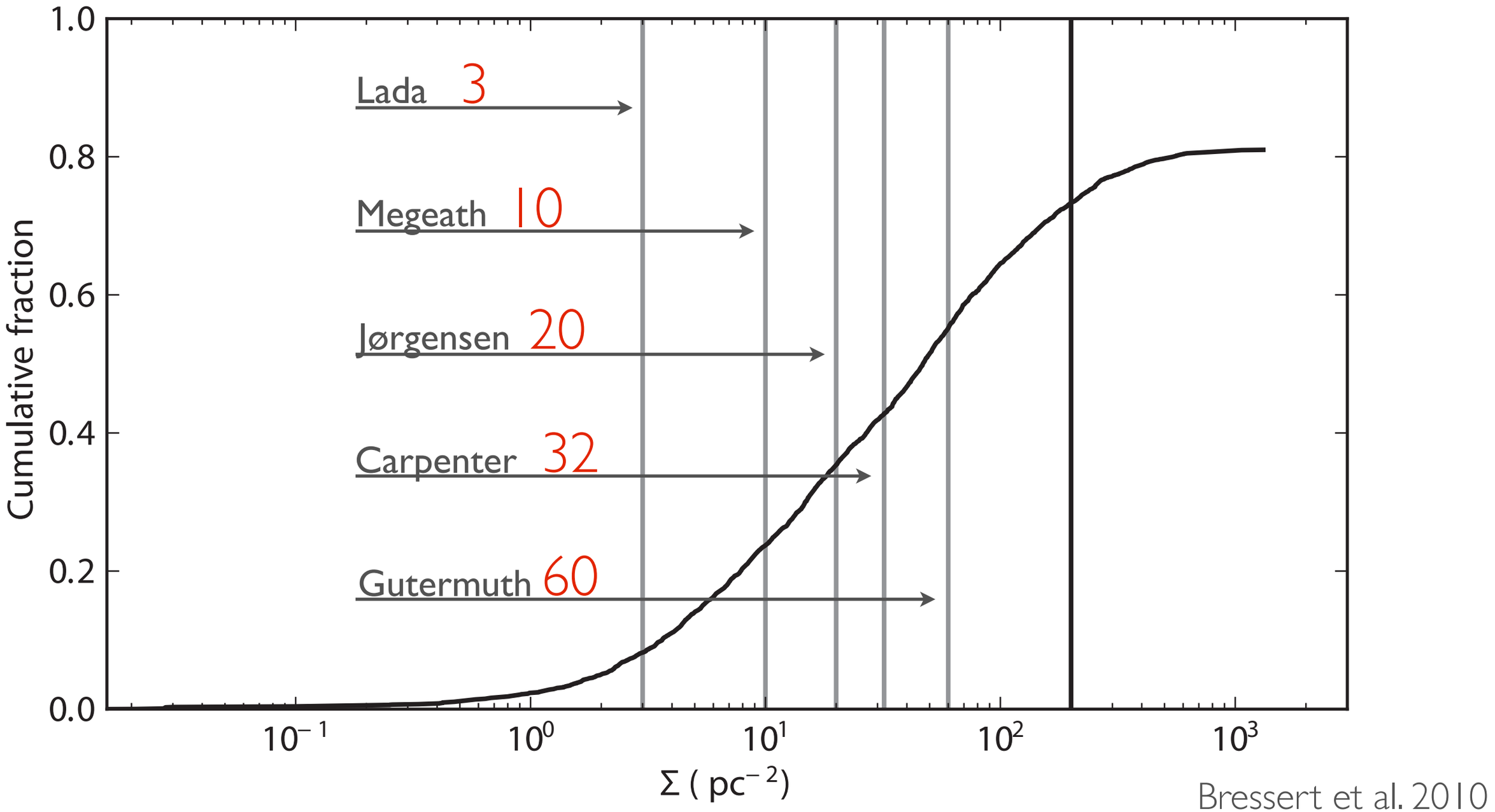

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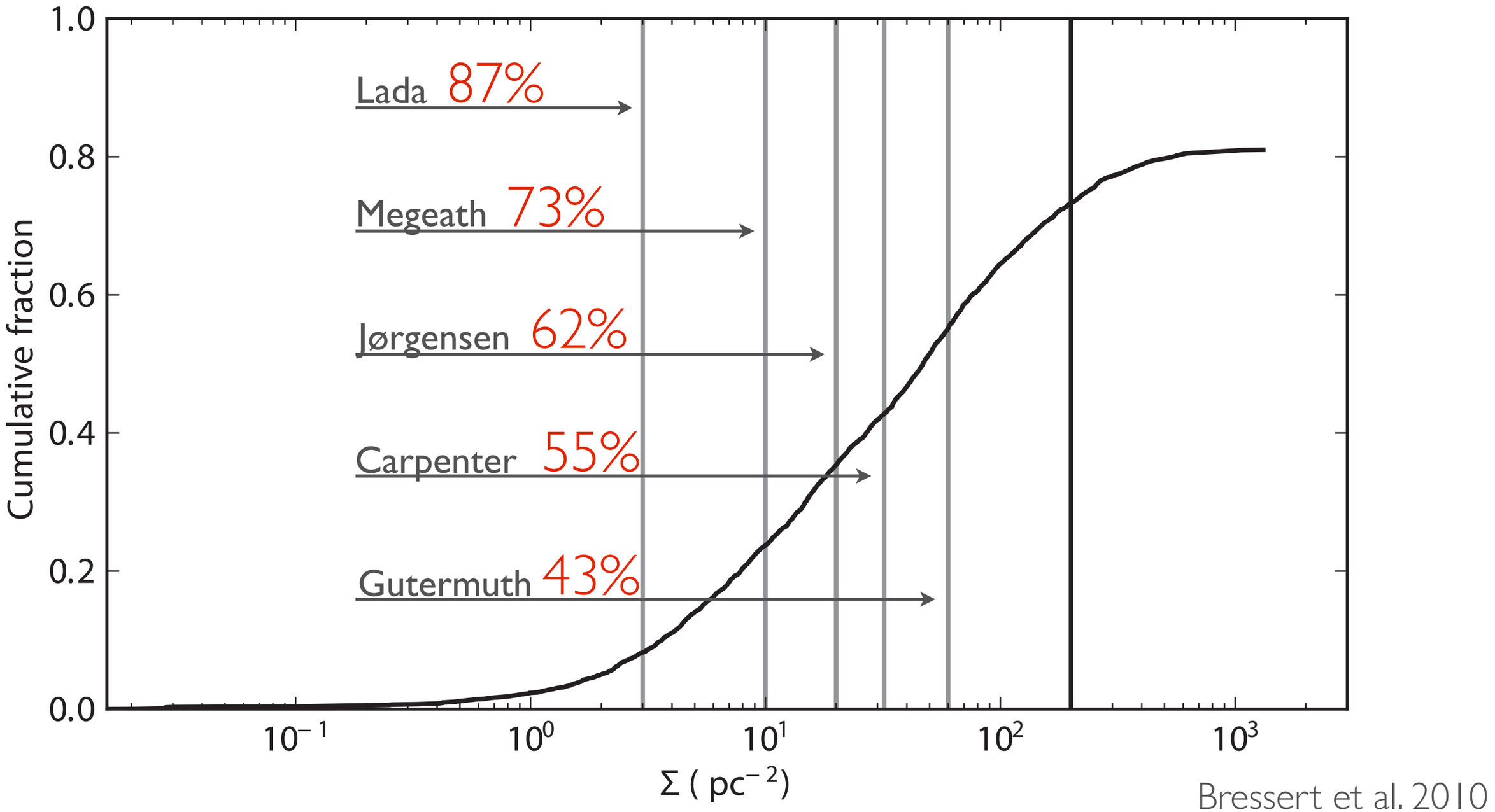

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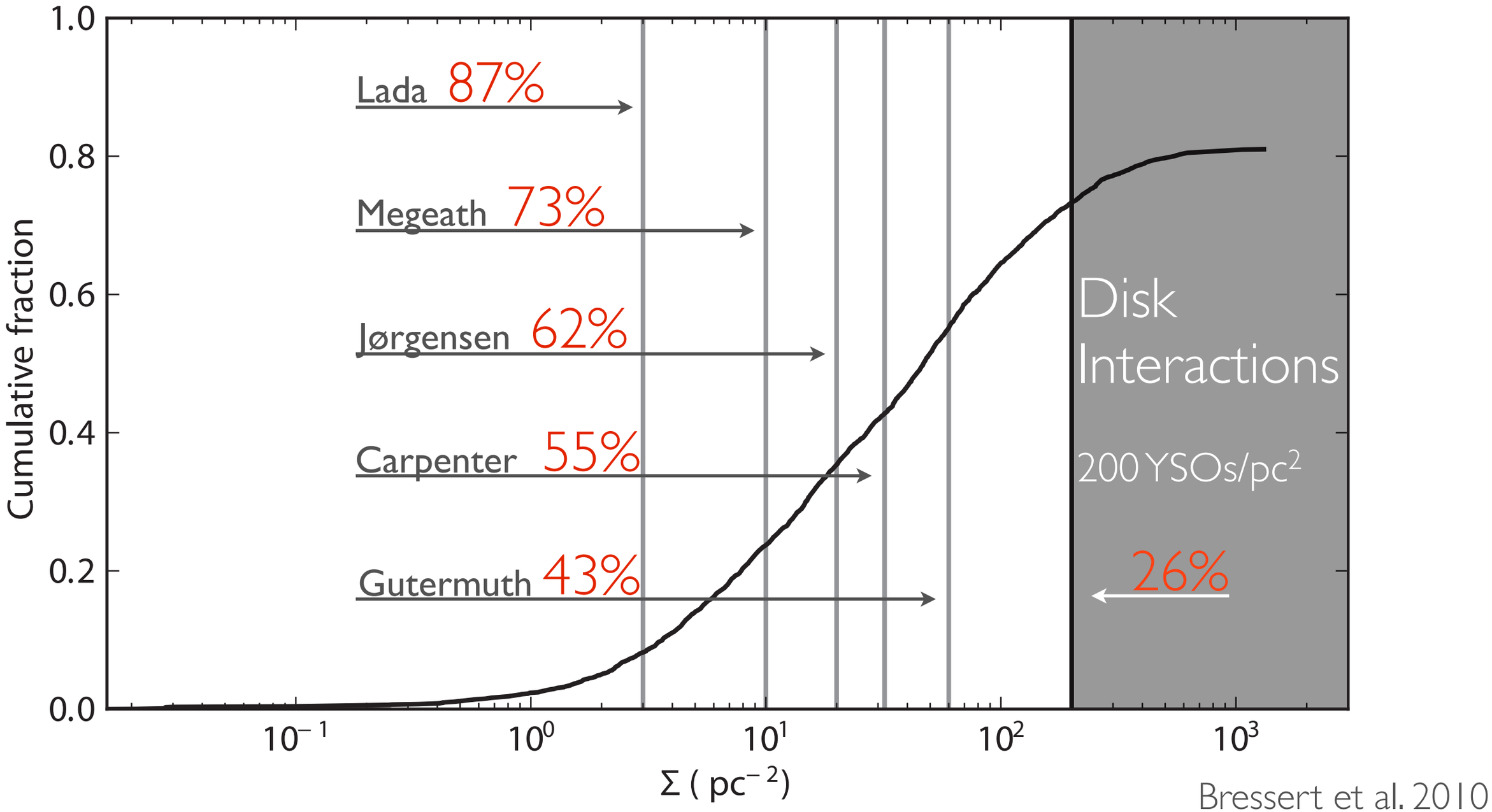


Bressert et al. 2010

What fraction of stars form in clusters?

What fraction of stars form in clusters?

What fraction of stars will form clusters?

What can the spatial distribution of high mass stars tell us about star formation?

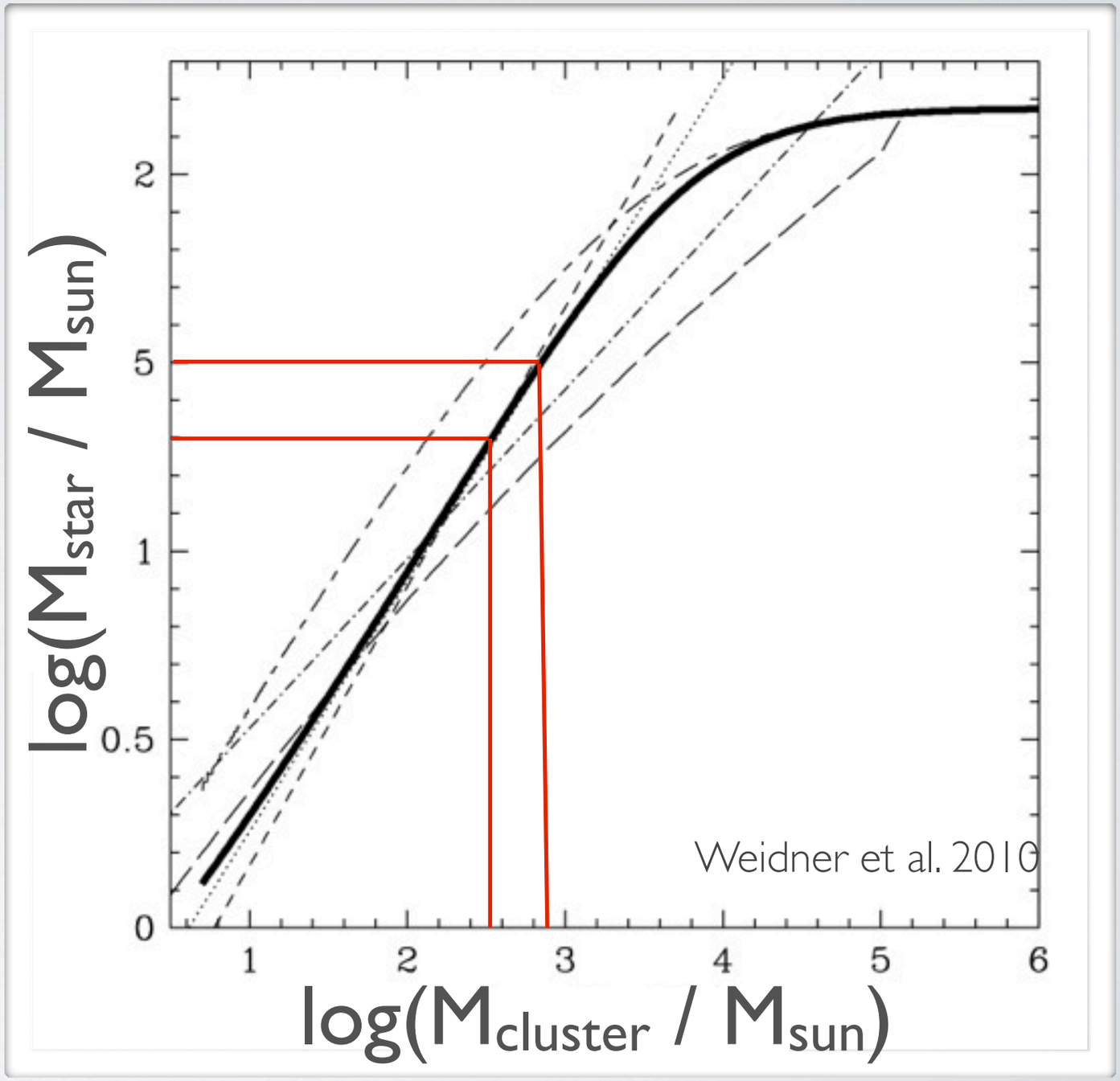
ESO/M.-R. Cioni/VISTA Magellanic Cloud survey

ISOLATED MASSIVE STARS?

Or do they only form in clusters?
(e.g. Vanbeveren 1984; Weidner & Kroupa 2006)

Frequent studies searching for isolated forming O-stars
(e.g. de Wit et al. 2004, 2005)

Either will have effects or confirm on star formation theories (e.g. Tan, Bonnell) and the IMF

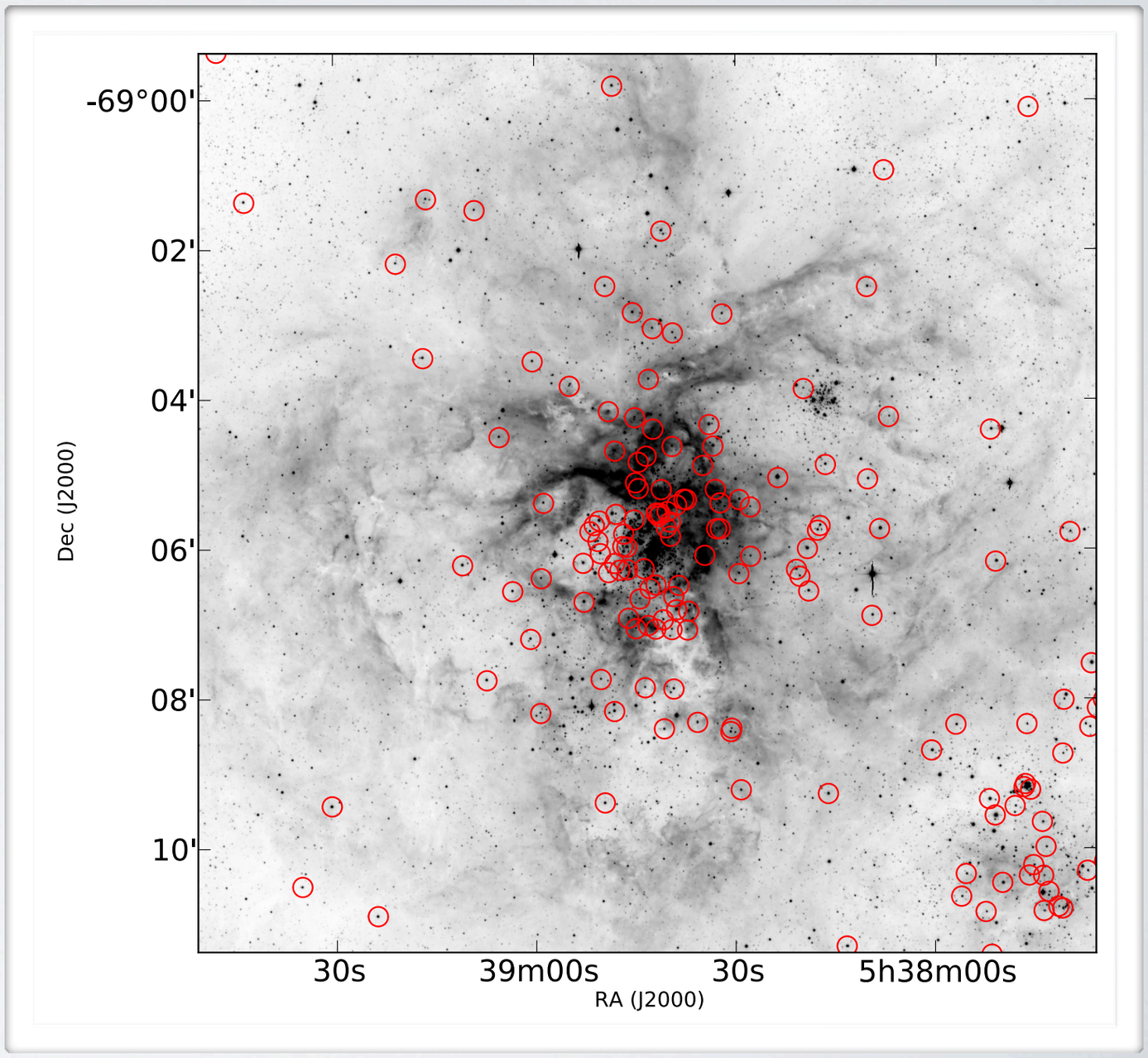


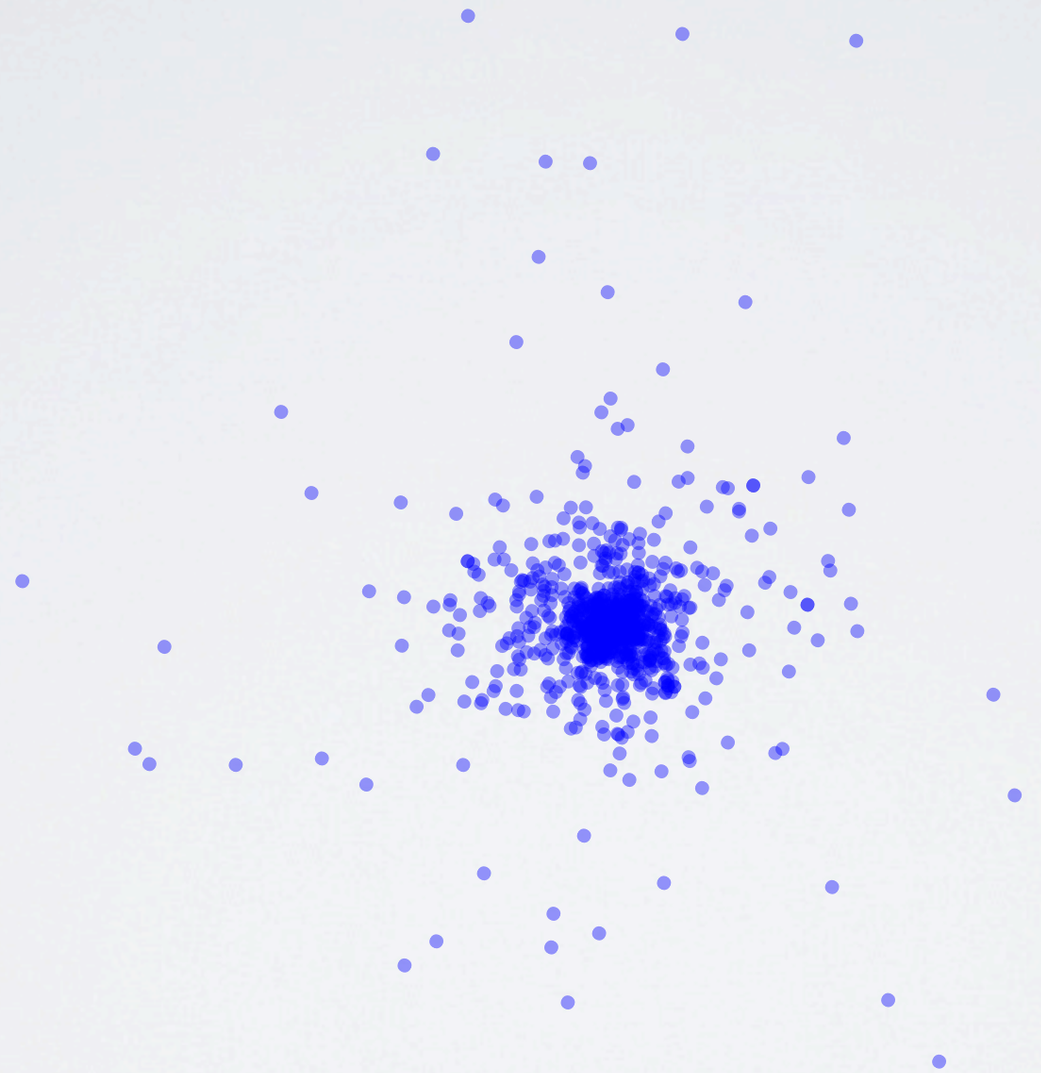
O-STARS IN THE LMC

VLT FLAMES (PI: C. Evans)

~300 spectrally confirmed massive stars outside of R136

~170 are single massive star candidates





Rule out runaways

Rule out runaways

Radial velocities cut

New

Molecular filaments (MF)

Rule out runaways

Radial velocities cut

Molecular filaments (MF)

New

Rule out runaways

Probability of being a runaway massive star:

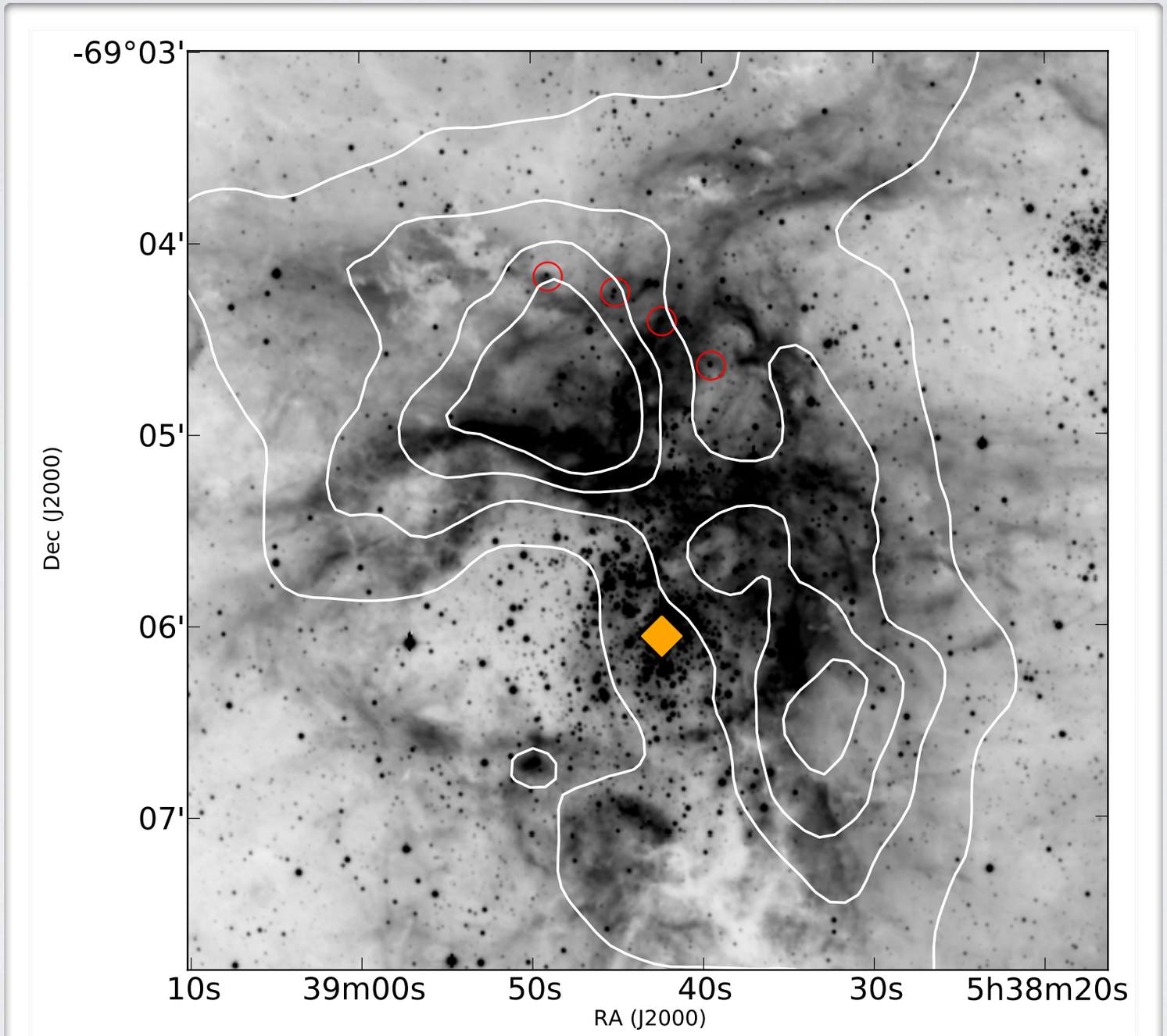
$$P(N(\bigstar) \in MF) << 1, \text{where } N \geq 3$$

In terms of probability we can rule out the chance of stars being runaways

Radial velocities cut

ISOLATED O-STARS?

Preliminary



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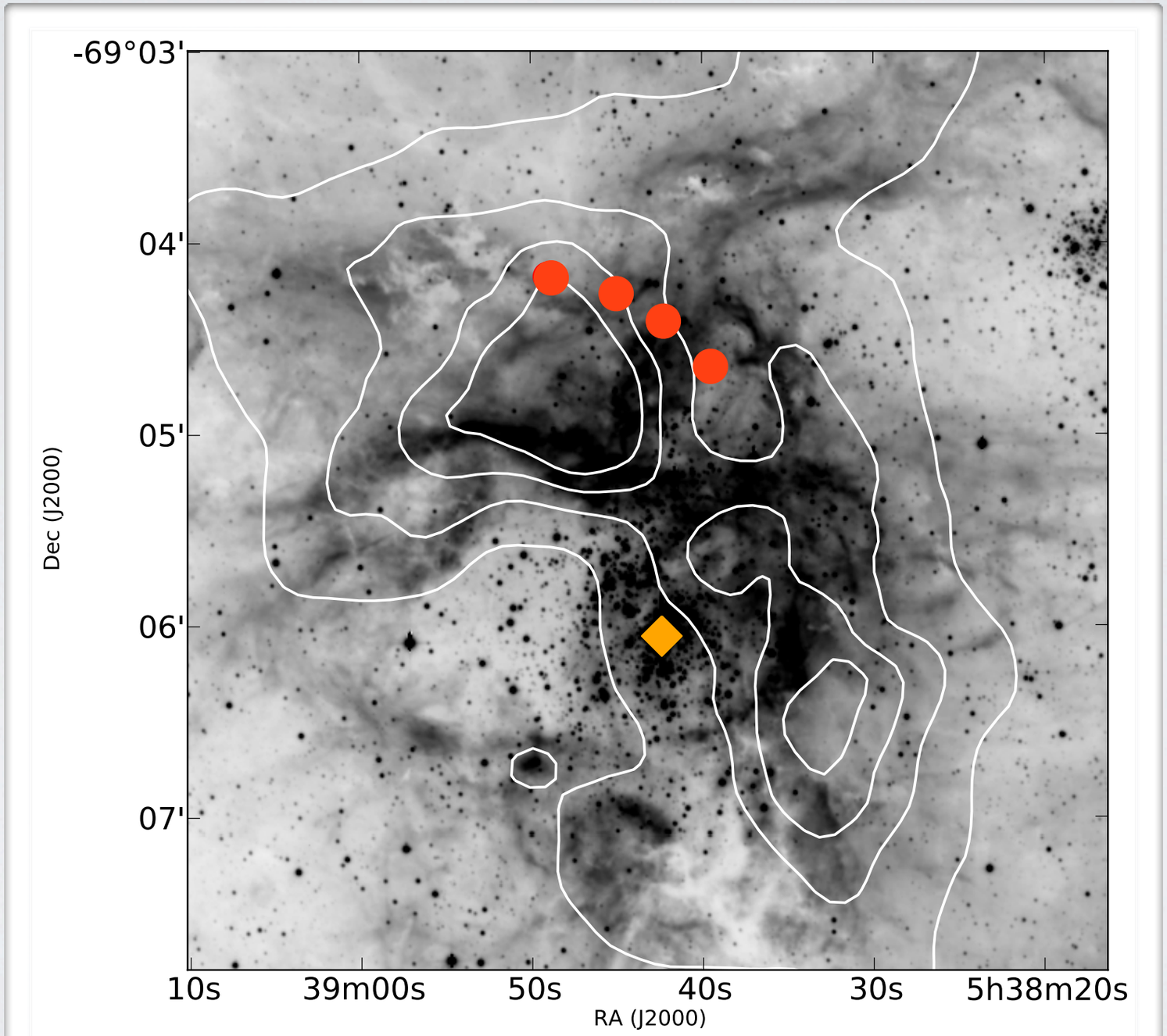

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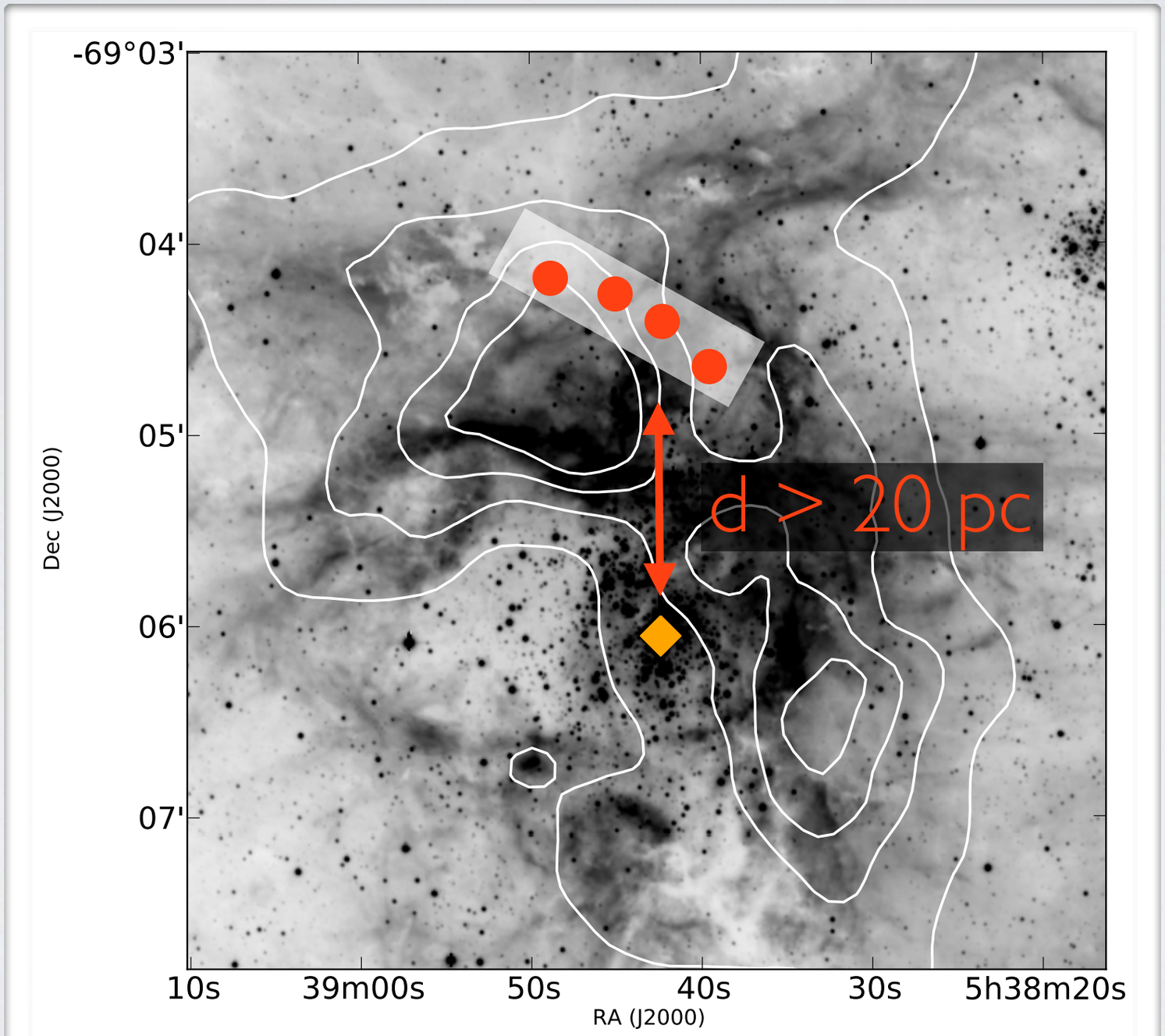

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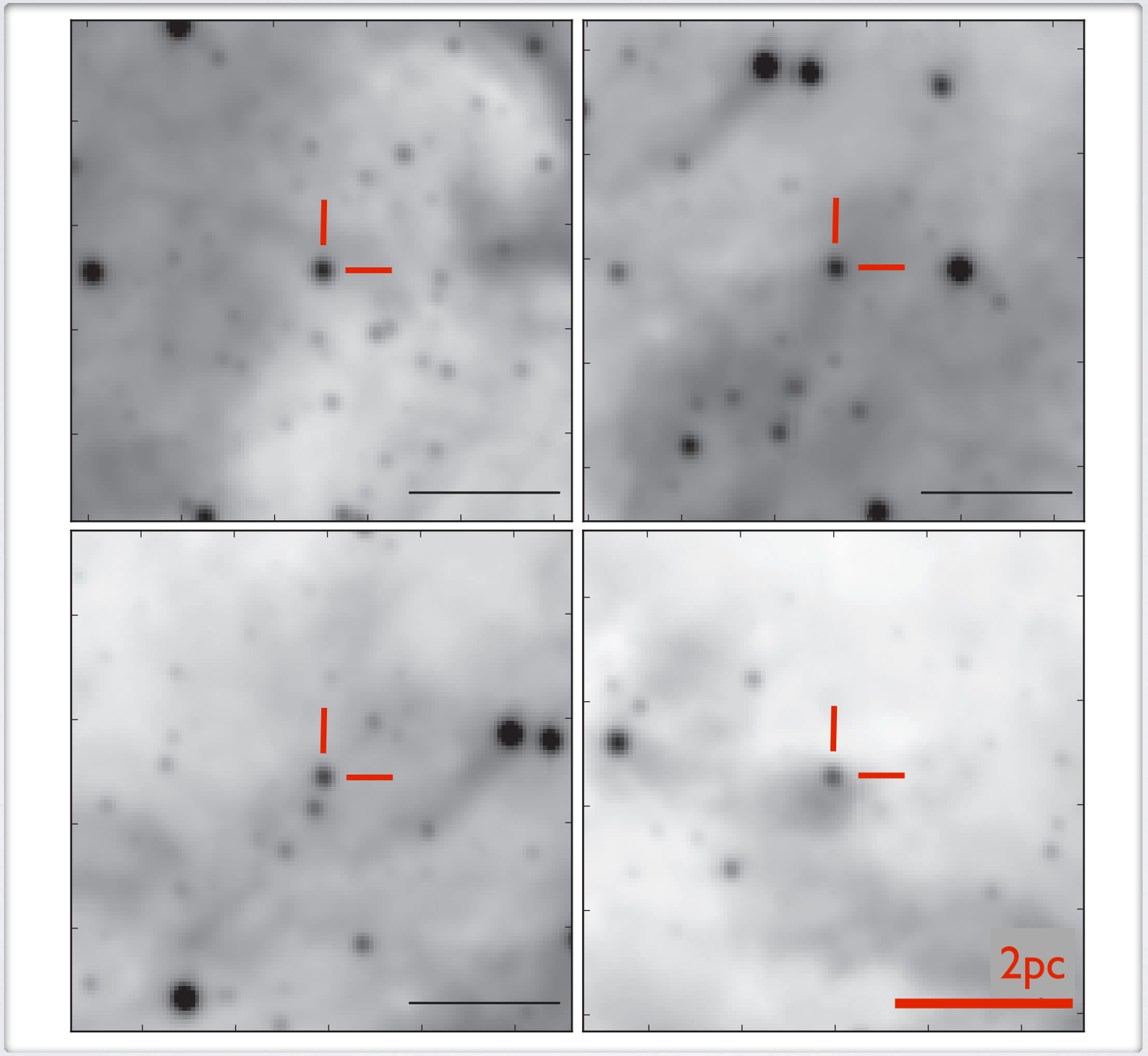

SUMMARY

Do all stars form in clusters? Local environment implies **no**

$\sum$ of YSOs is well fit by a lognormal with **peak** at 22 YSOs/pc^2

No evidence of different modes of SF

"Cluster" definitions are **arbitrary** for star forming environments

~25% of YSOs are found in dense environments

Preliminary results on **isolated O-stars** in the LMC