LMT/AzTEC 1.1 mm Survey of Dense Cores in Monoceros R2

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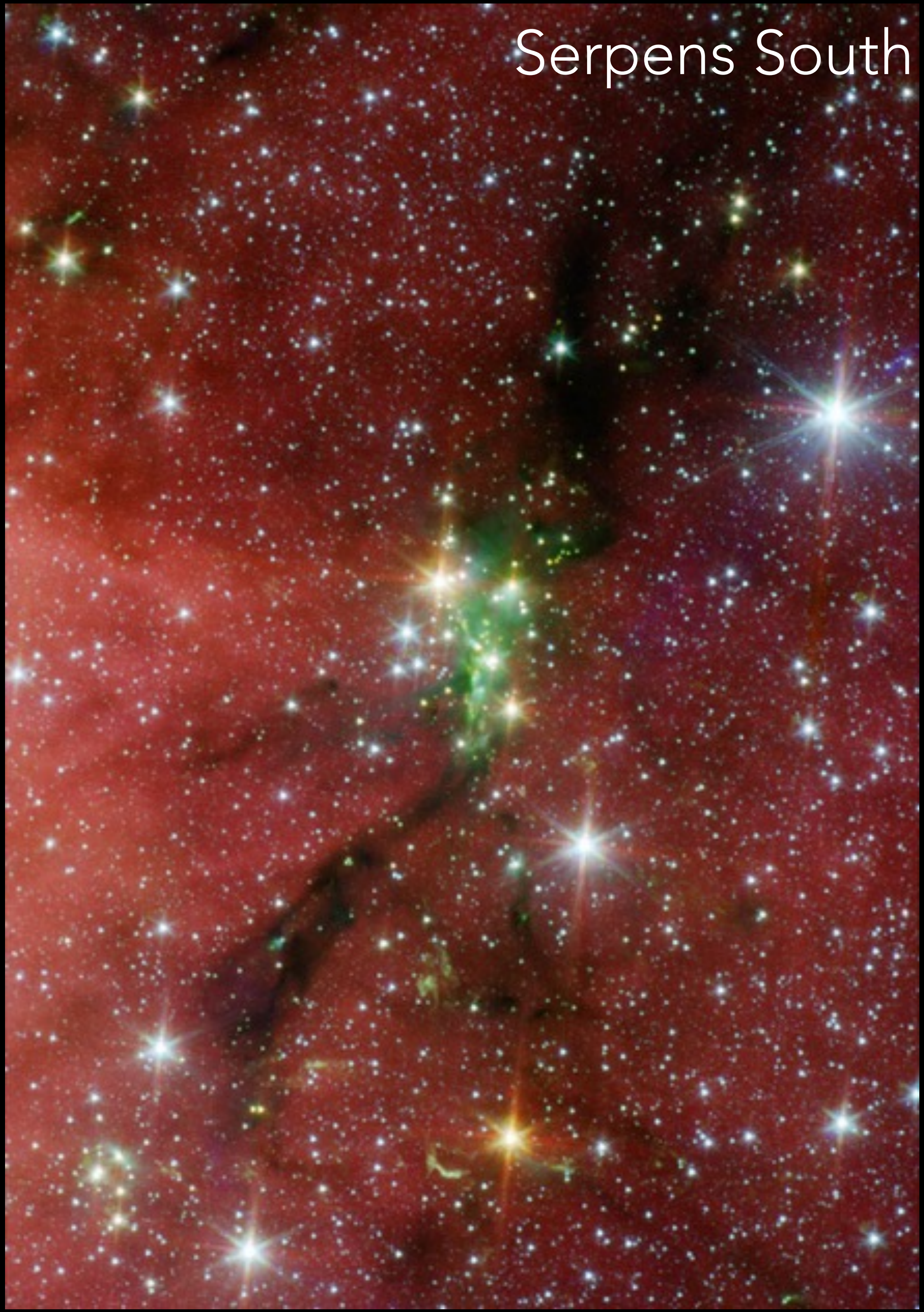
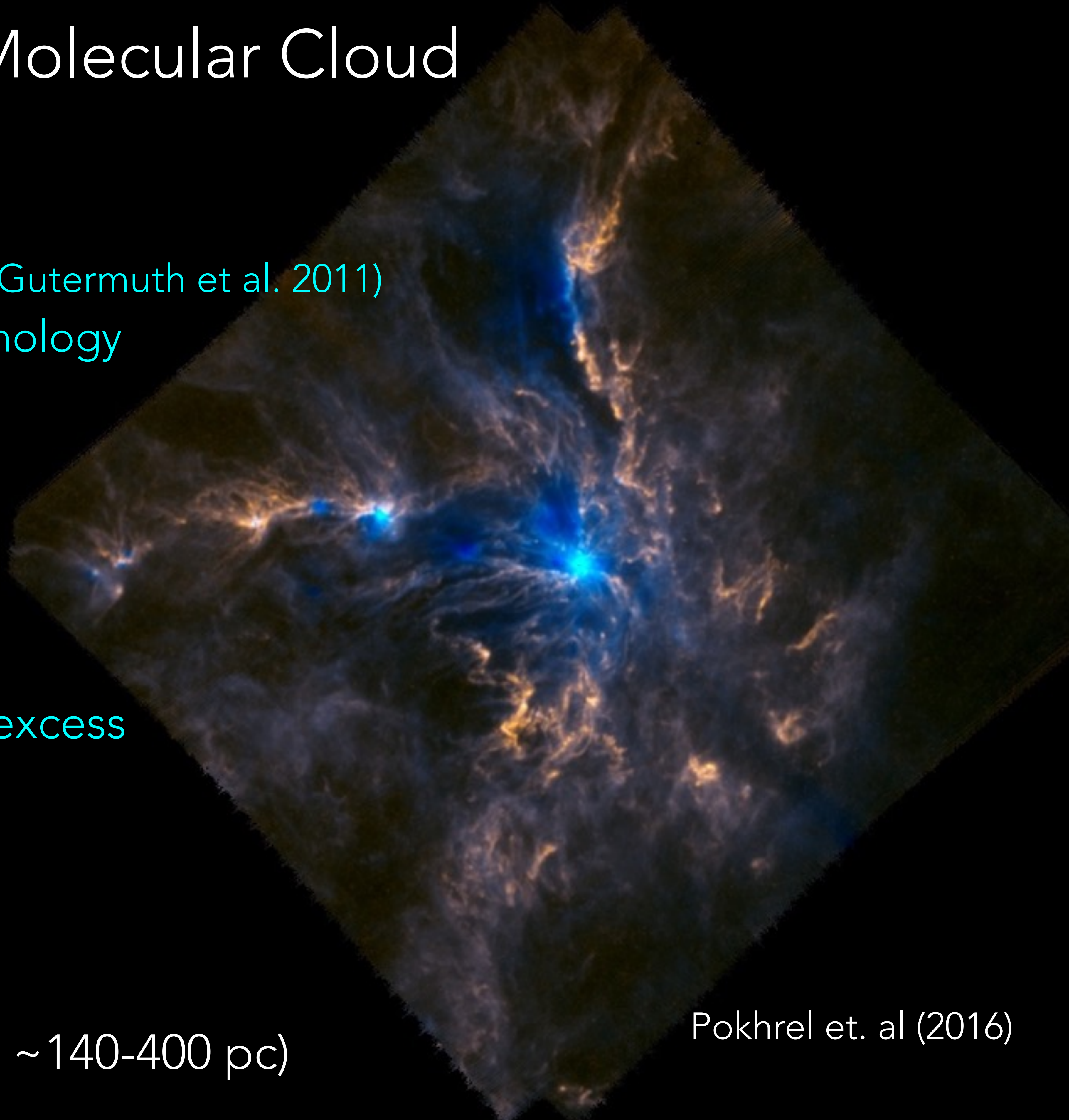
Why study dense gas cores?

- Majority of star formation occurs in clusters, what physics sets this clustering?
- YSO surveys suggest link between star and gas density at pc scales (Gutermuth et al. 2011)
- Dense gas cores are the formation sites of individual stars
- Do cores cluster like stars?
- How efficiently do cores form in molecular clouds?



BGR=3.6, 4.5, 8.0 micron
Gutermuth et al. 2008

The Mon R2 Molecular Cloud



Why Mon R2 is of interest:
clean star-gas correlation (Gutermuth et al. 2011)
want to explore gas morphology

Large cloud: 40 x 40 pc

Mass: 4 x 10^4 $M_\odot$

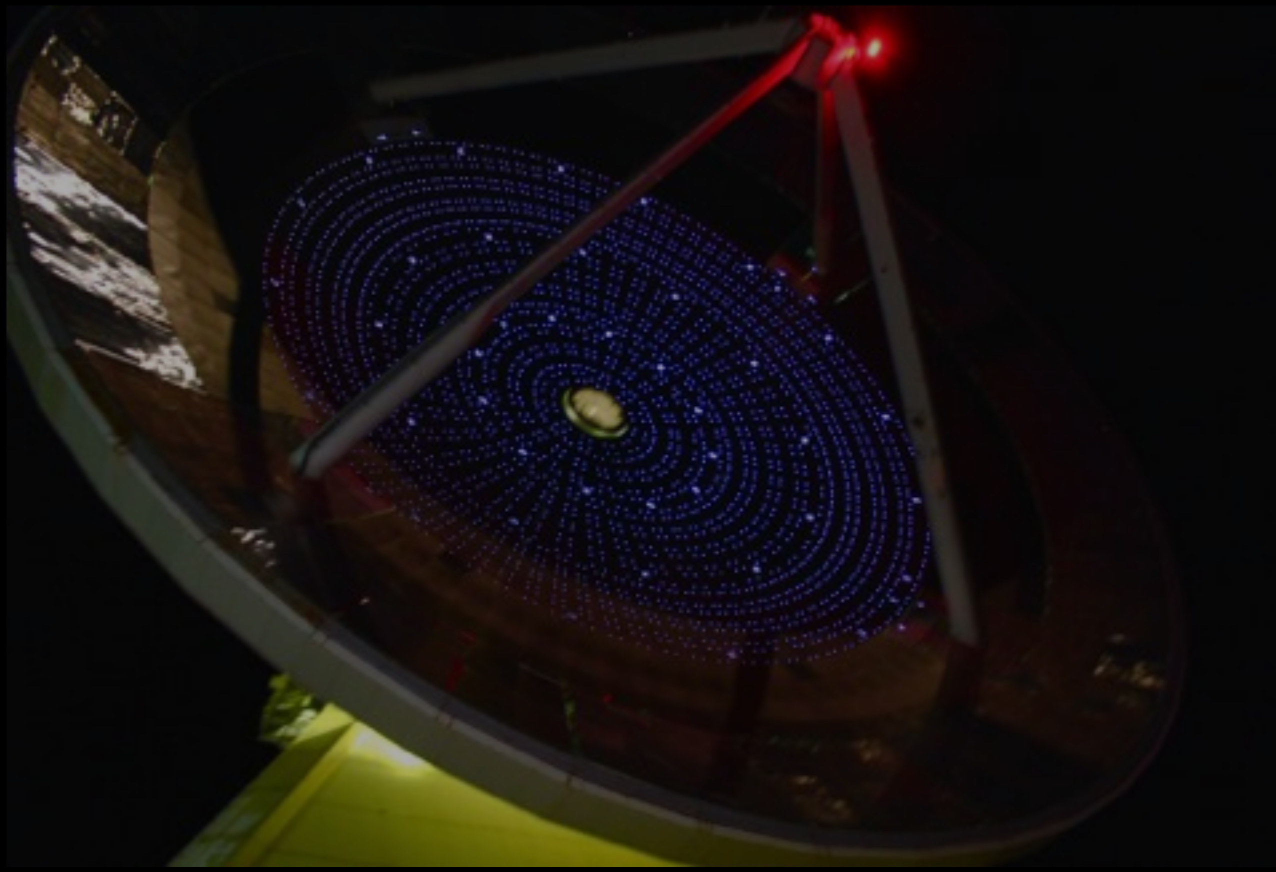
Stars: 1000 YSOs w/ IR excess

Distance: 830 pc

(Gould's belt distances ~140-400 pc)

Pokhrel et. al (2016)

OBSERVATIONS:
LMT/AzTEC 1.1 mm Survey

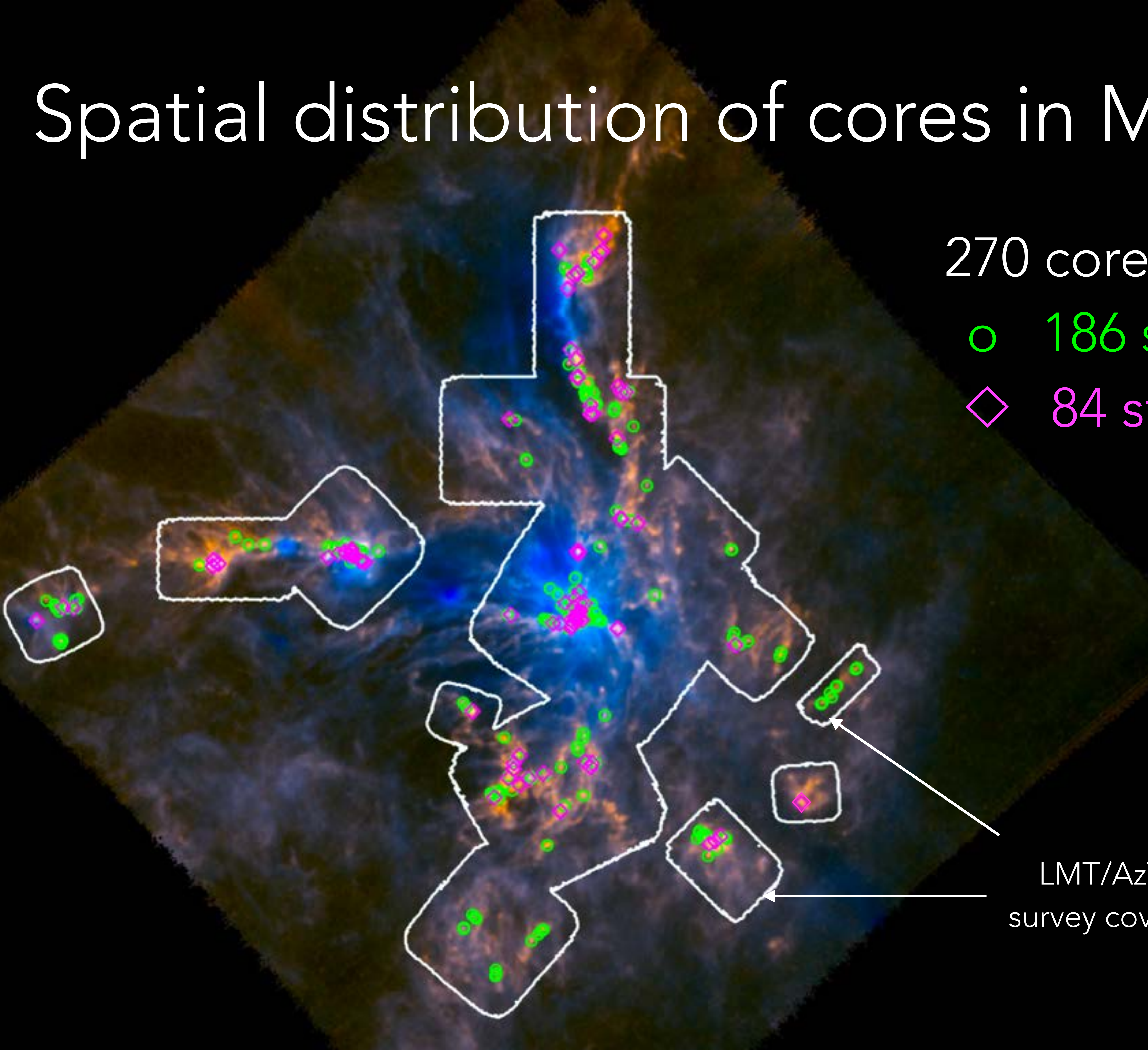


- Dense Cores (10^5 cm^{-3}): ~ 0.05 x 0.05 pc^2 (Enoch+2008)
  - LMT/AzTEC 1.1 mm (@32m) ~ 0.03 pc @ 830 pc
  - Herschel SPIRE 500 ~ 0.14 pc @ 830 pc

    dense structures beam diluted :(

- Shallow LMT Mapping: RMS 5 mJy/beam
  - AzTEC yields finer structures while Herschel maps out larger scale gas in more detail than Av maps

Spatial distribution of cores in Mon R2



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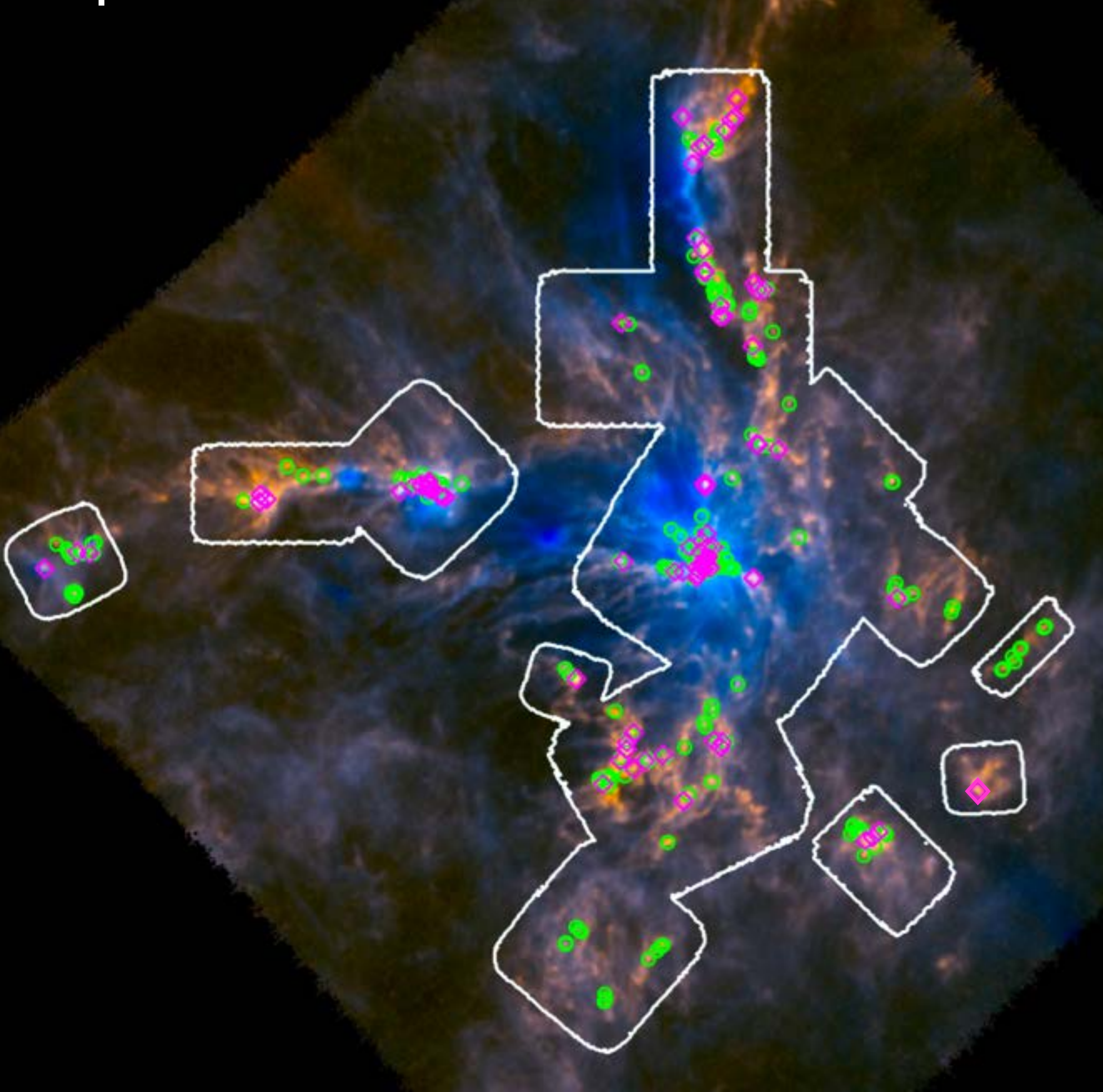


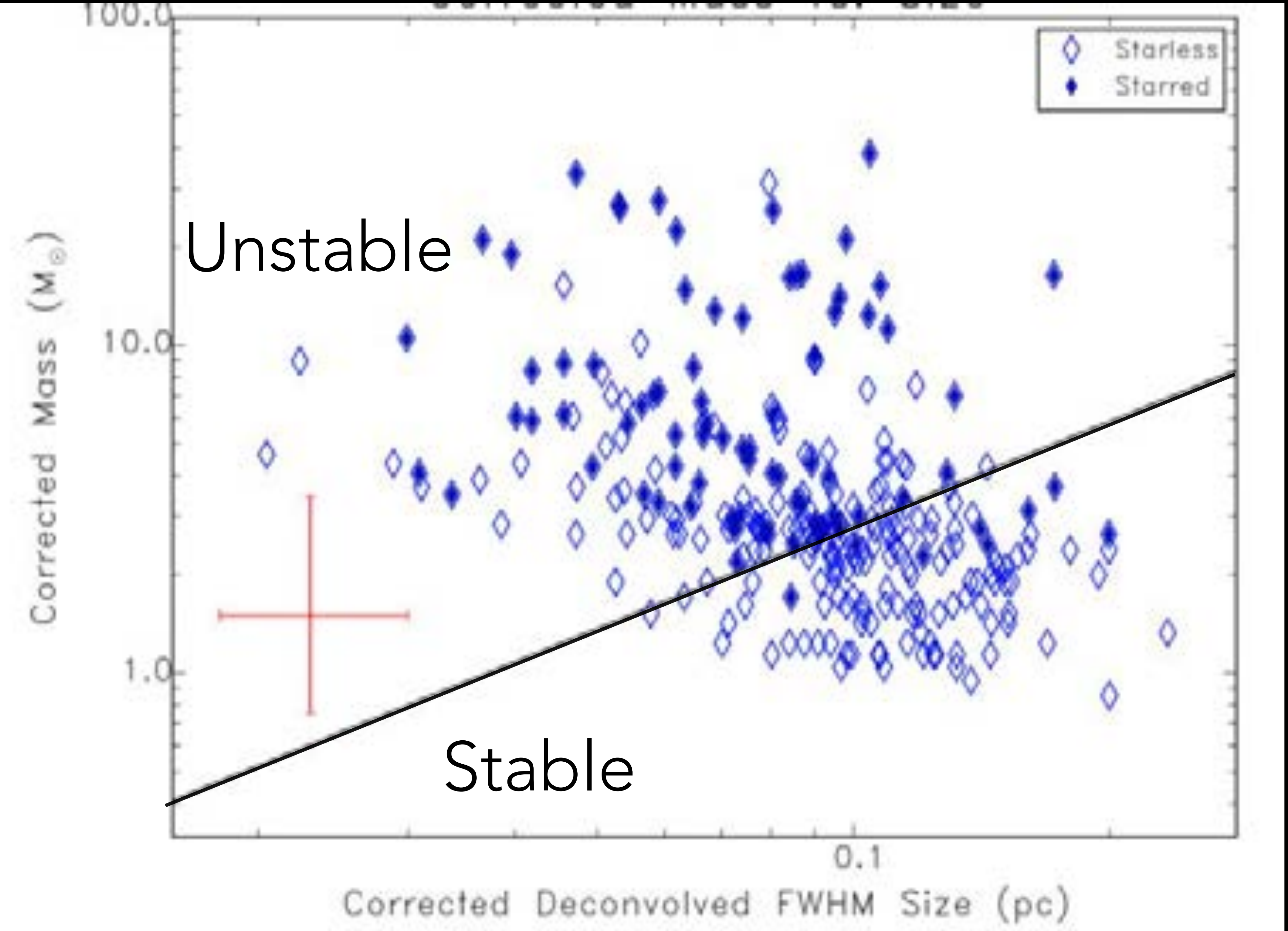
Goals:

1. Mass and size properties of spatially resolved cores

2. Relationship to surrounding gas

3. Efficiency of core formation

Mass vs. Size



58% above line: unstable to further collapse

93% of cores below are starless

*masses are derived from total flux: greybody emission (T~12K, gas/dust =100, emissivity models at ν = 1100 microns)

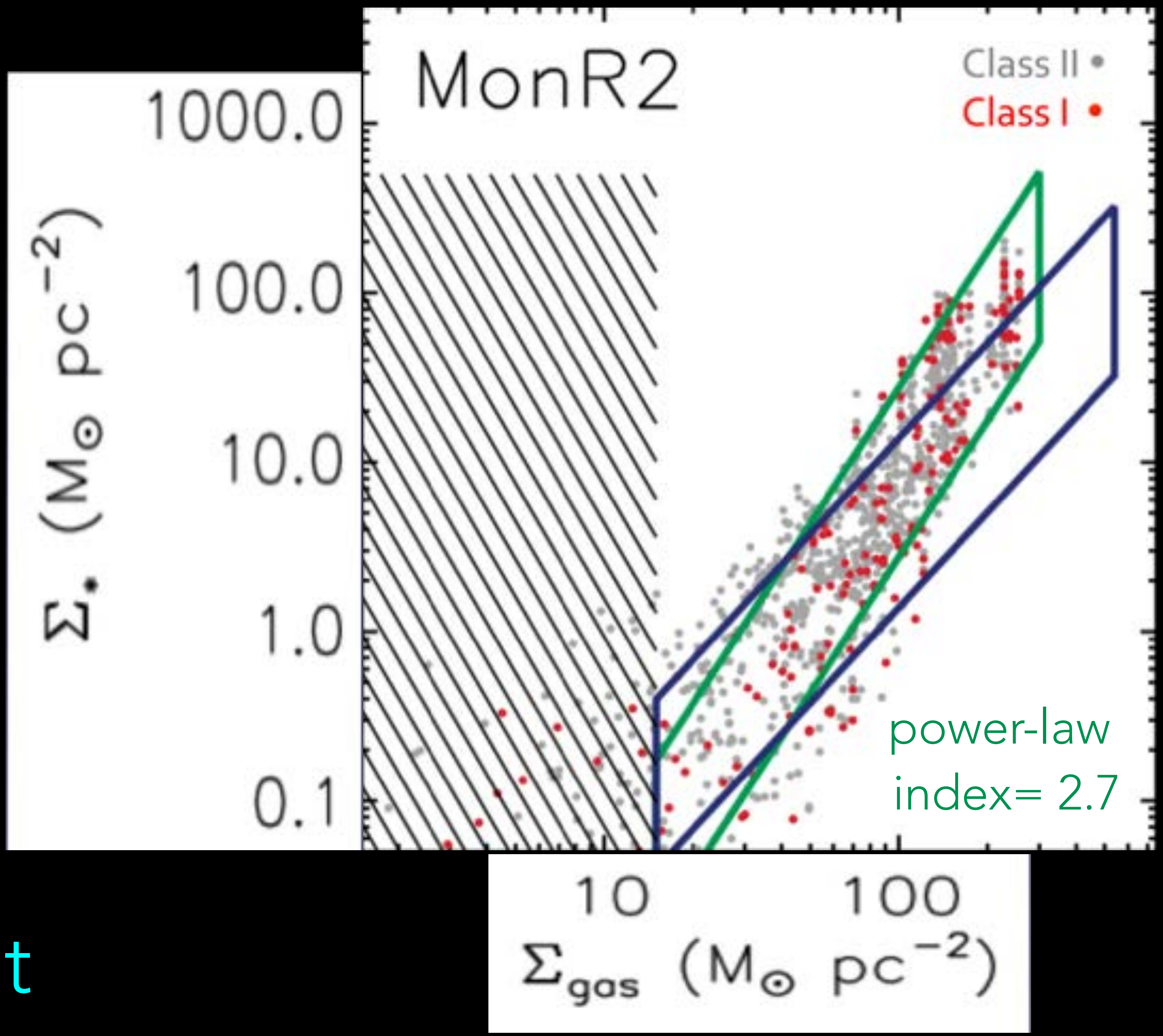
Relationship to gas column density

The motivation

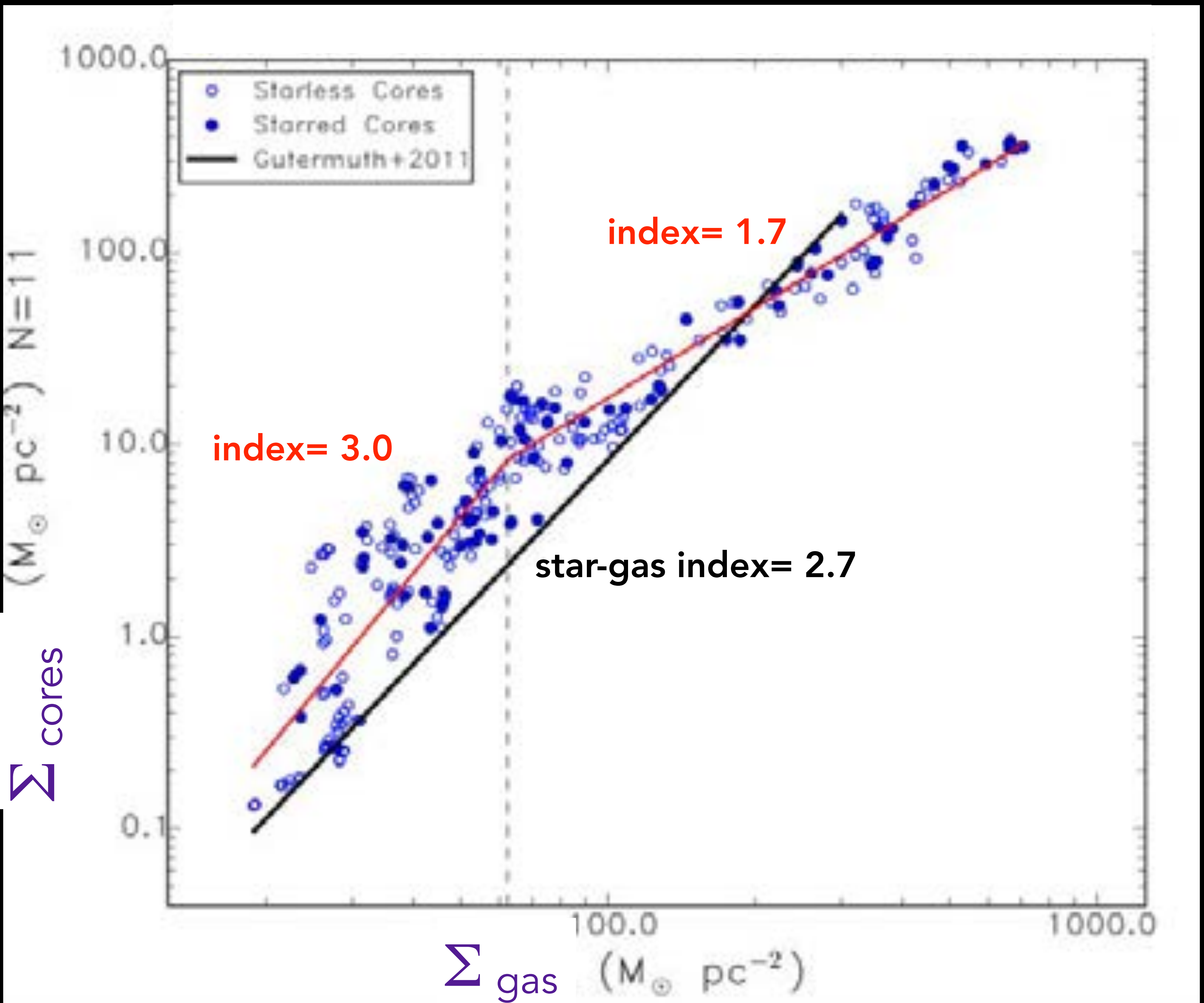
Mon R2 has clean star-gas correlation (Gutermuth et. al 2011)

Size scale ~ 1 pc

Is stellar clustering set by core clustering?



Local Core-Gas Correlation

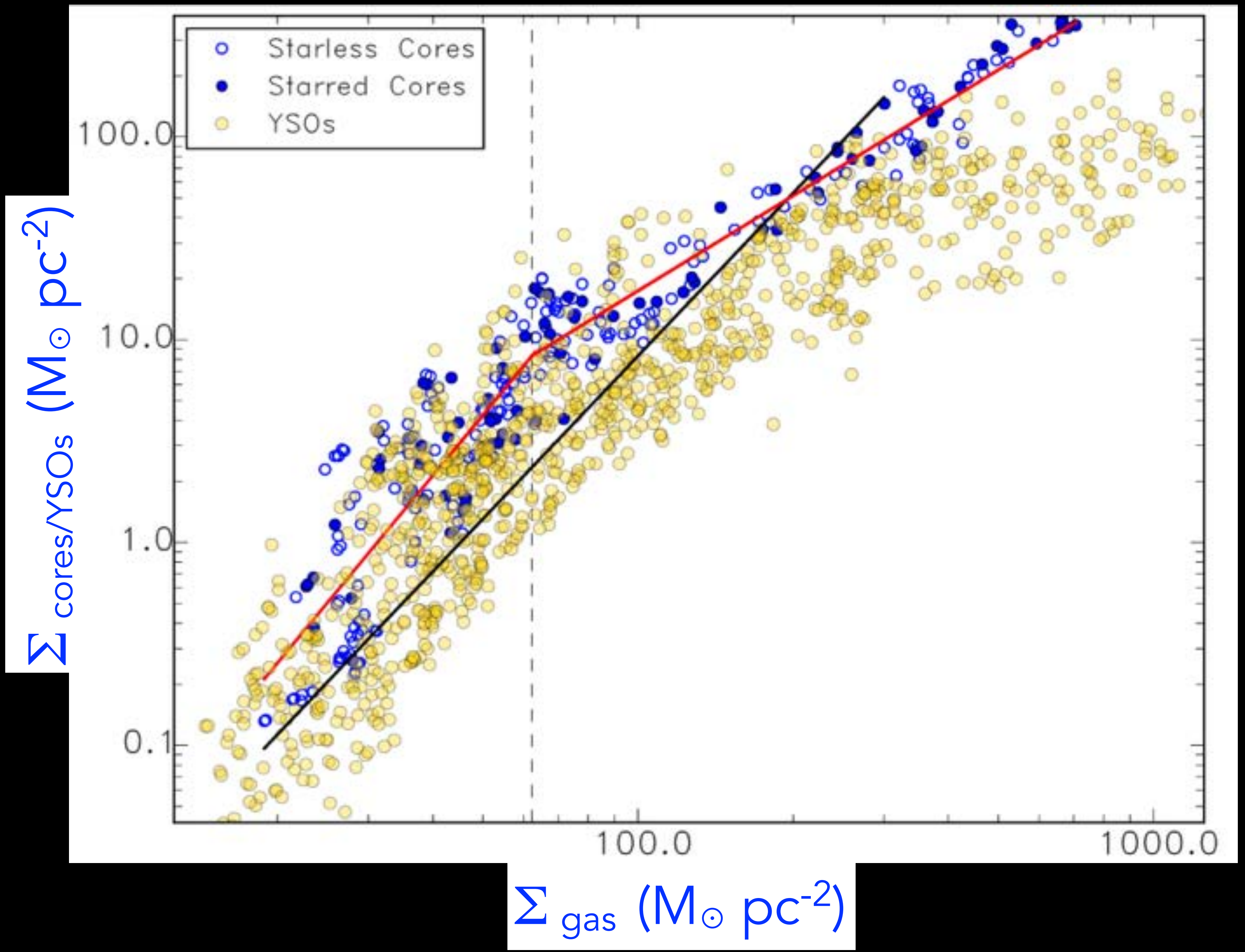


Clustering:
N=11 nearest neighbors using mean mass of groupings

Gas:
Herschel-derived column density

What can the core-gas correlation tell us?

We recreated the star-gas correlation with Herschel column densities



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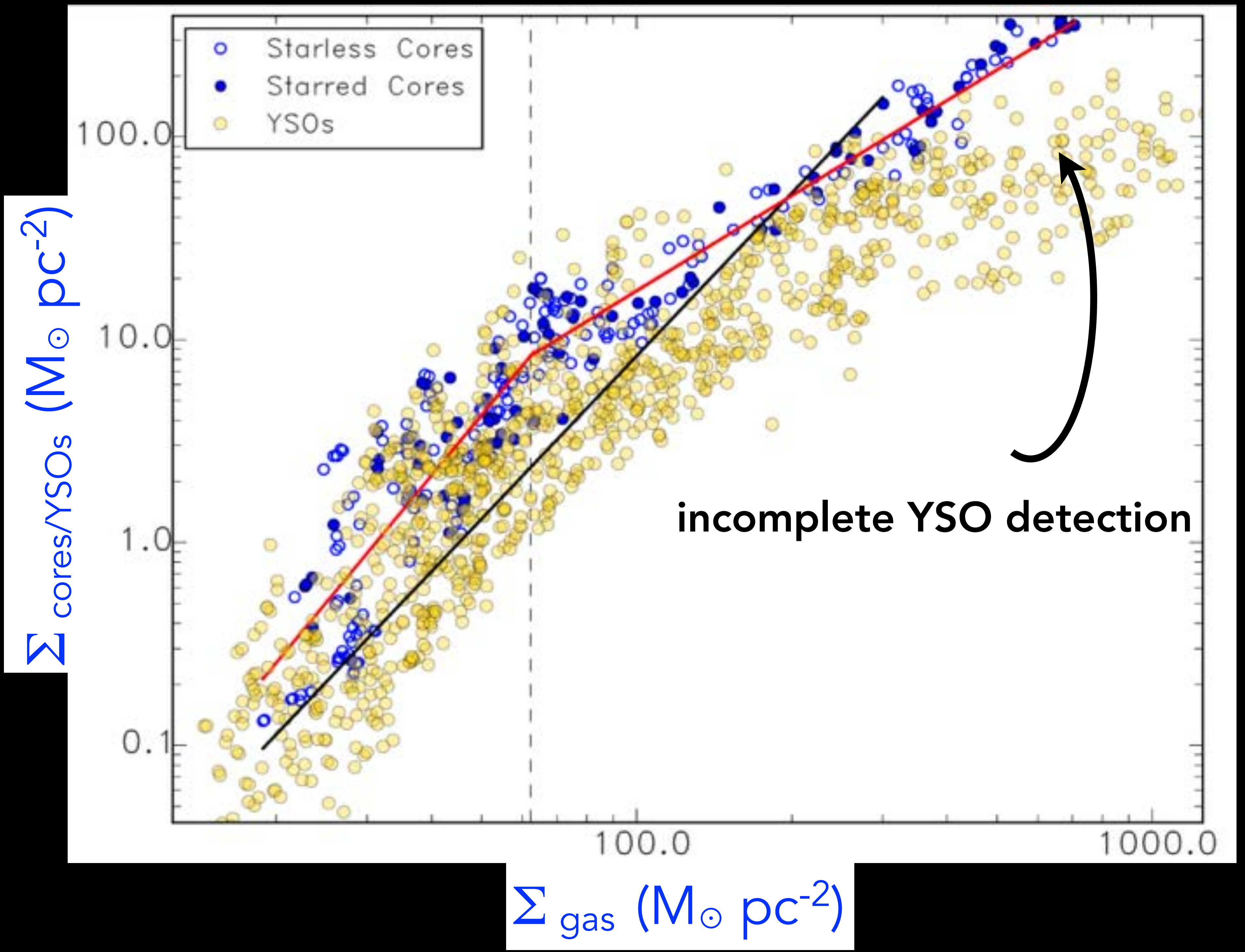

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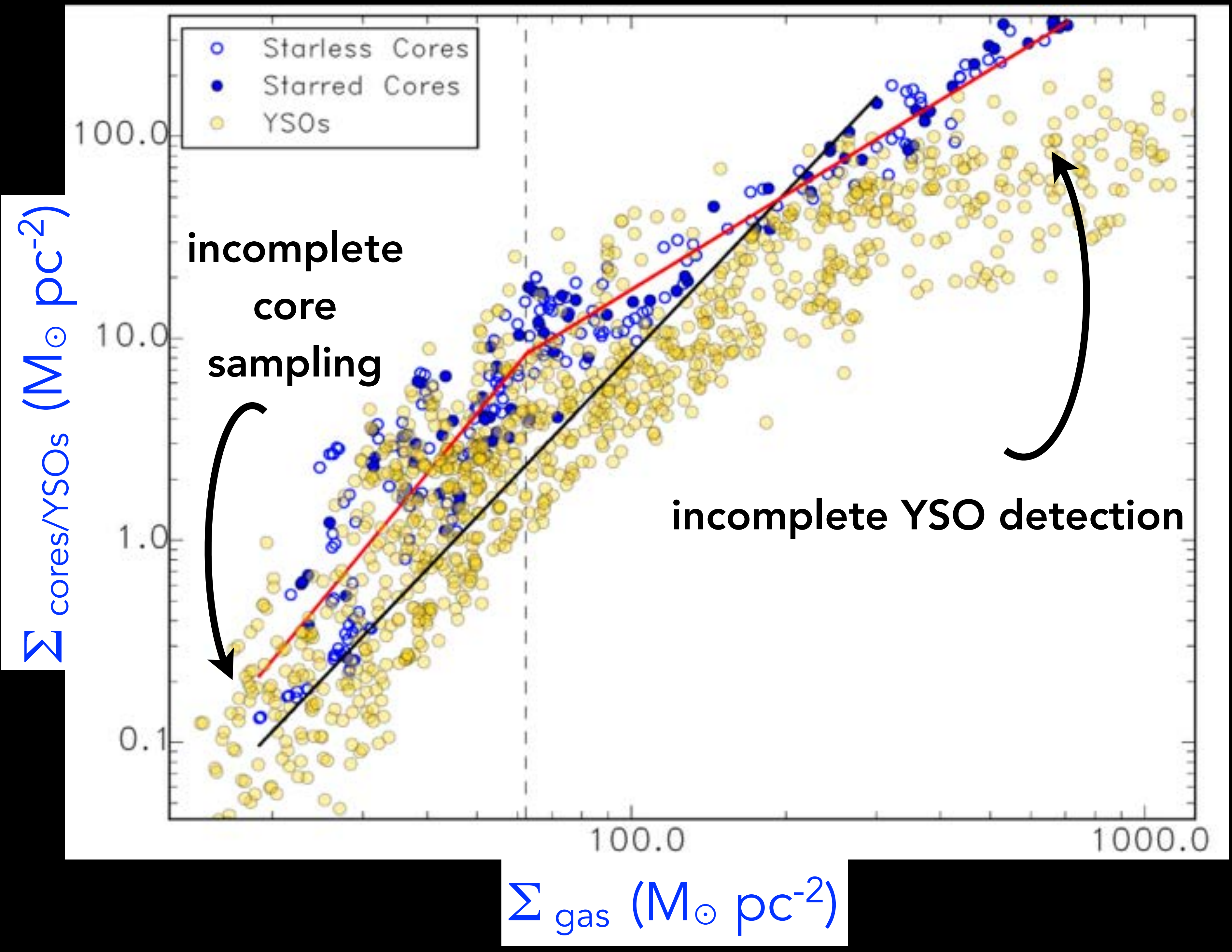

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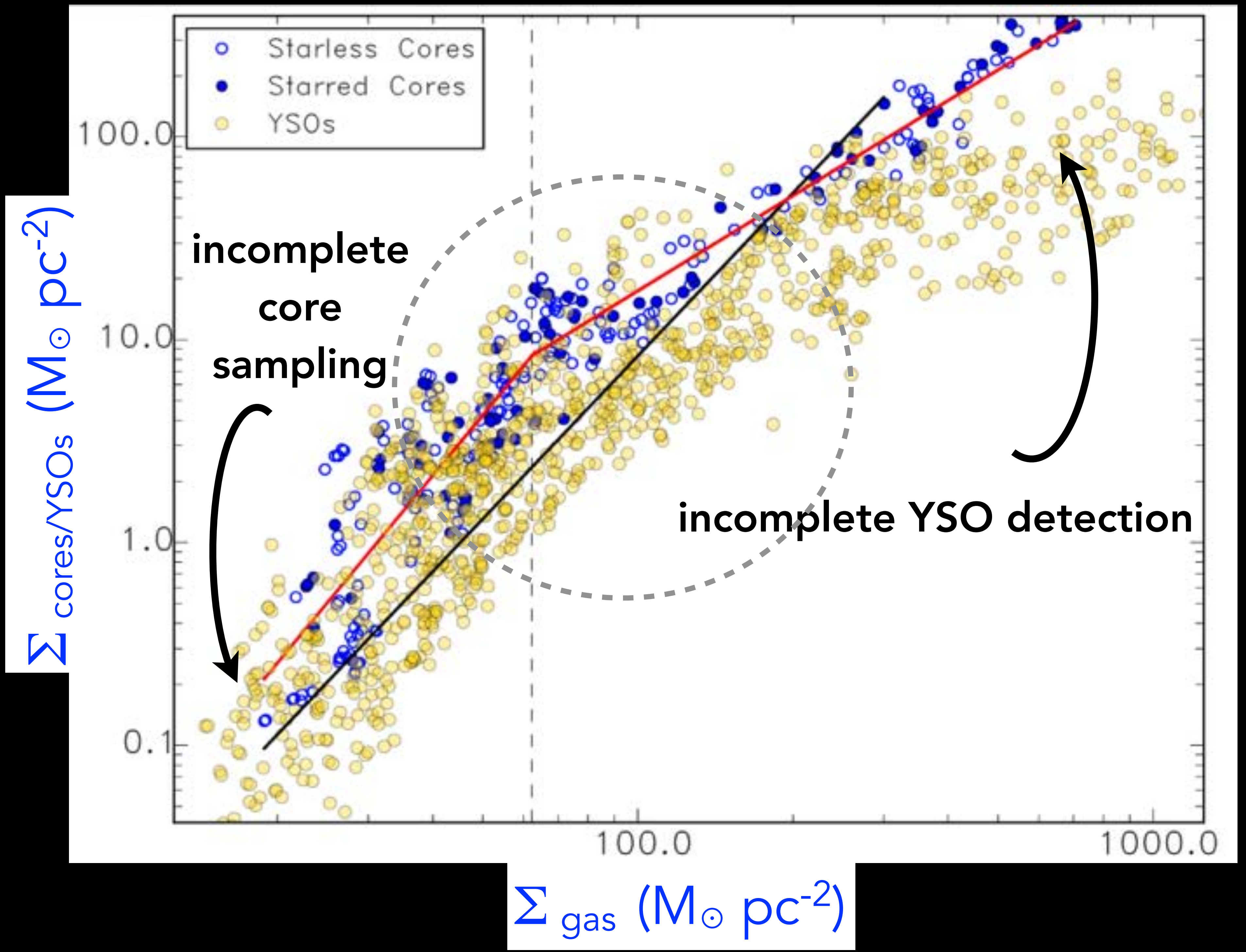
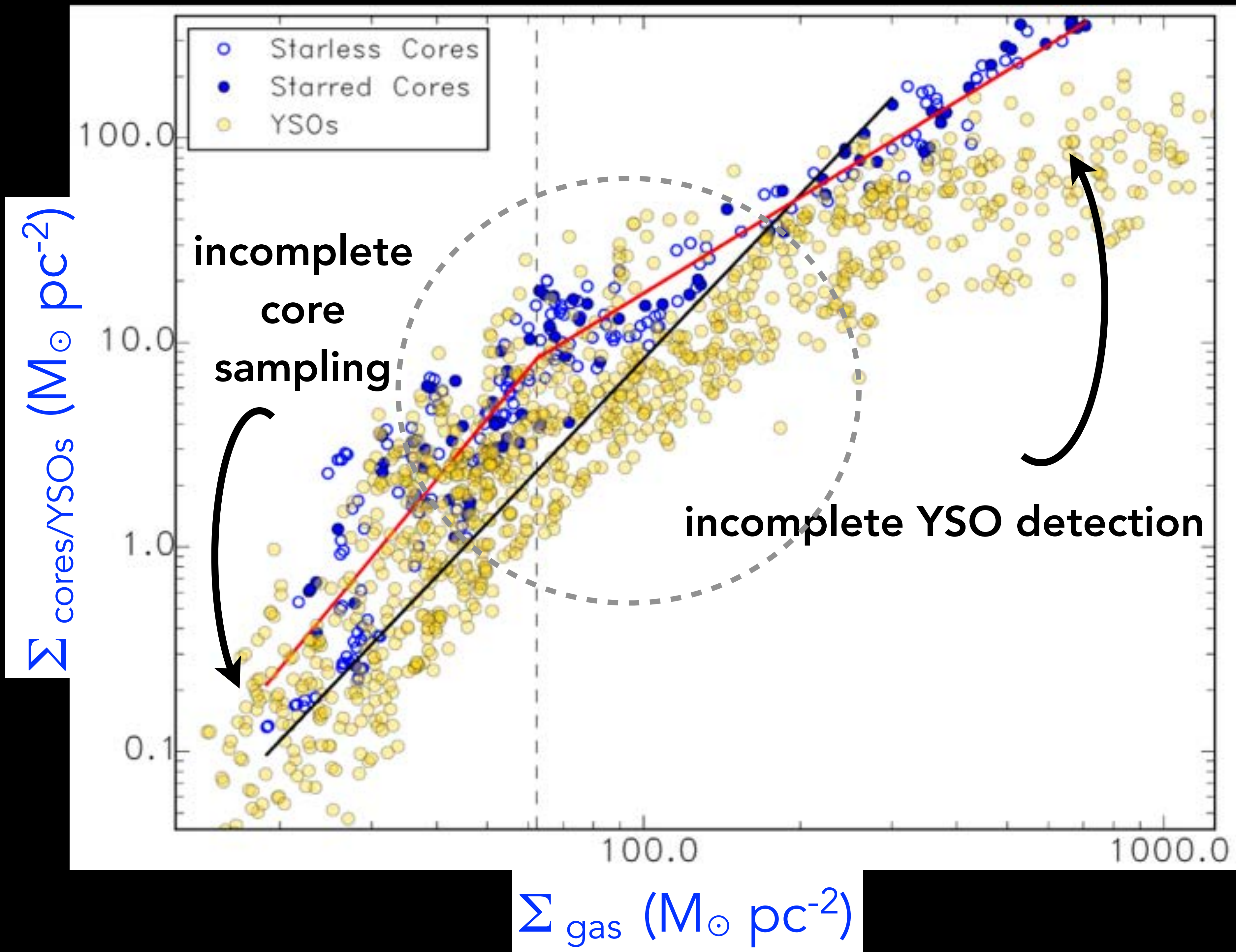
Approx 2.5x shift



What can the core-gas correlation tell us?

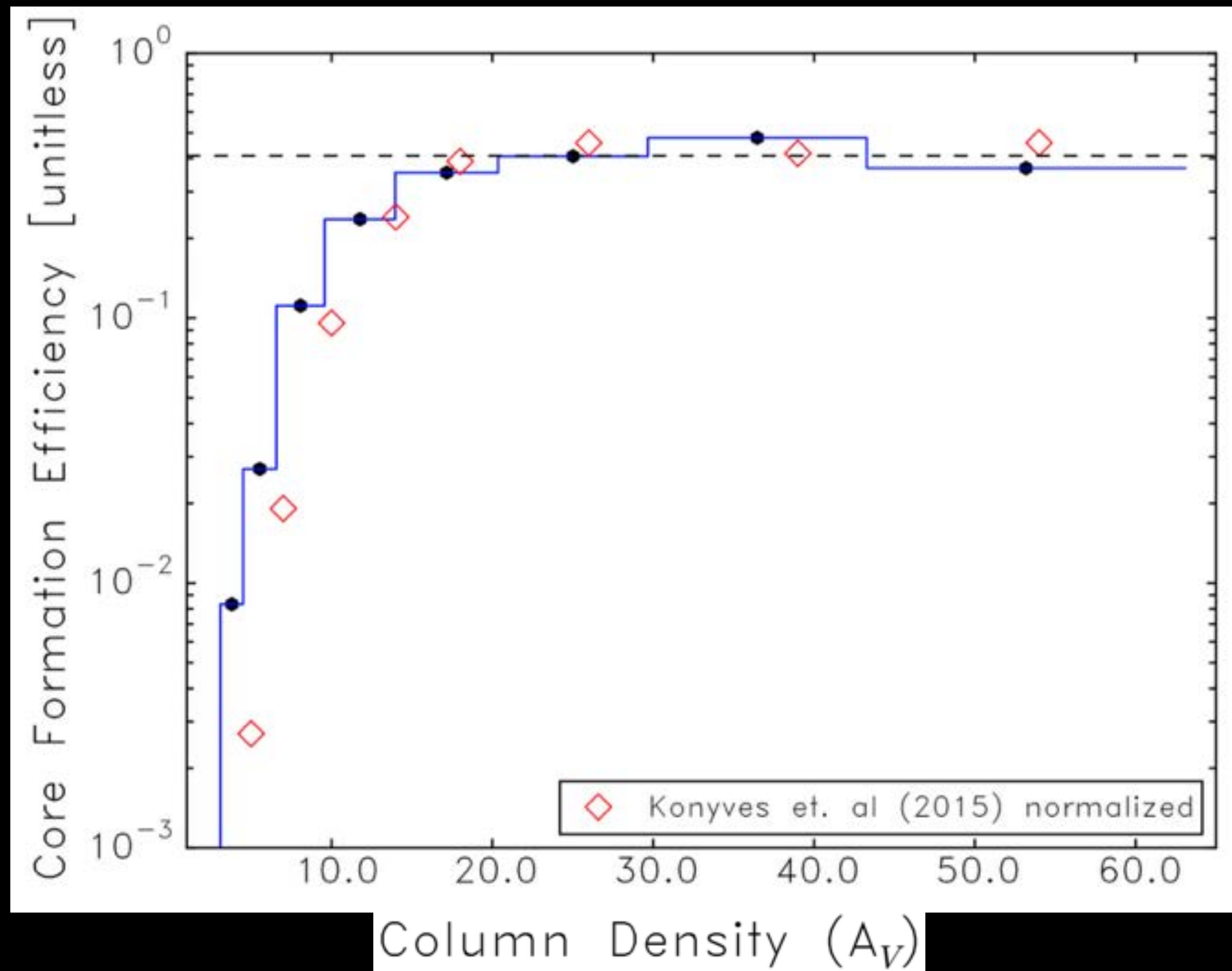
Approx 2.5x shift

Core clustering set by parsec scale cloud structure which also sets stellar clustering



Core Formation Efficiency (CFE): Global Scale

$$\mathrm{CFE_{global}} = \Delta M_{\mathrm{cores}}(A_{\mathrm{v}})/\Delta M_{\mathrm{cloud}}(A_{\mathrm{v}})$$



(1 Av= 15 $M_\odot$ pc^{-2})

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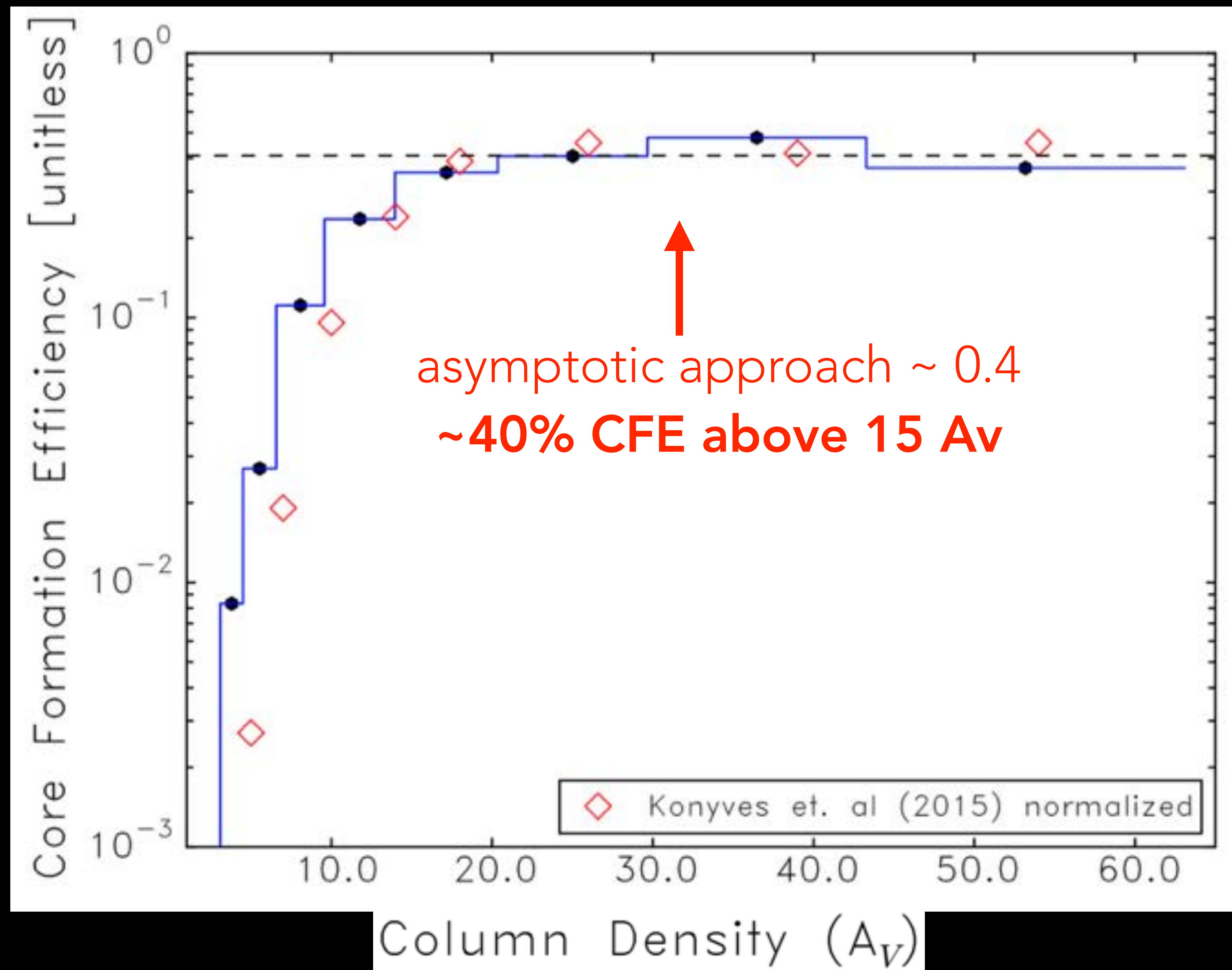


Follows similar form to Konyves et. al 2015 (Aquila cores, CFE~15%)

(1 Av= 15 $M_{\odot}$ pc^{-2})

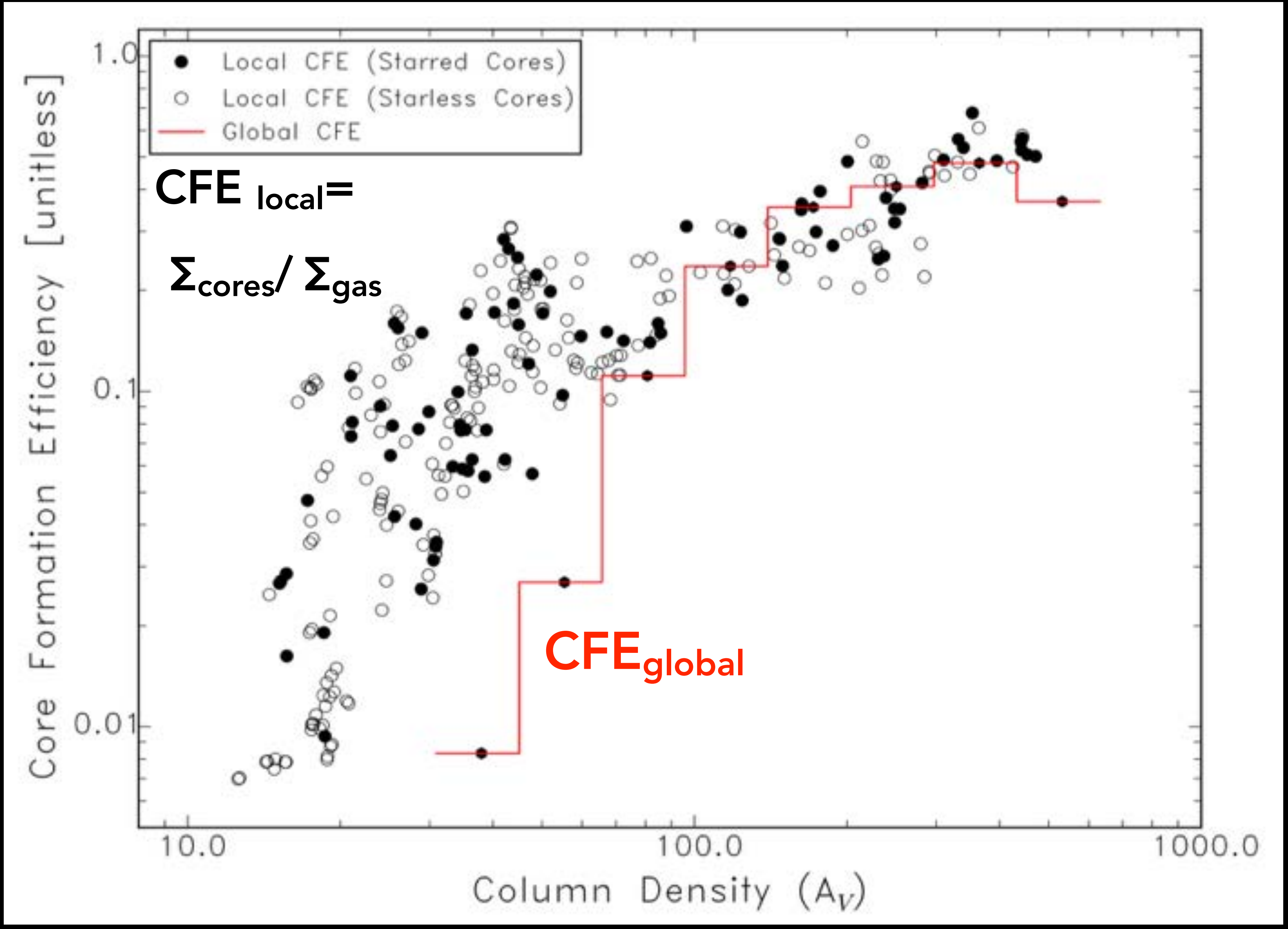
Local vs Global Core Formation Efficiencies

Projection effects might de-correlate column and volume density at low column

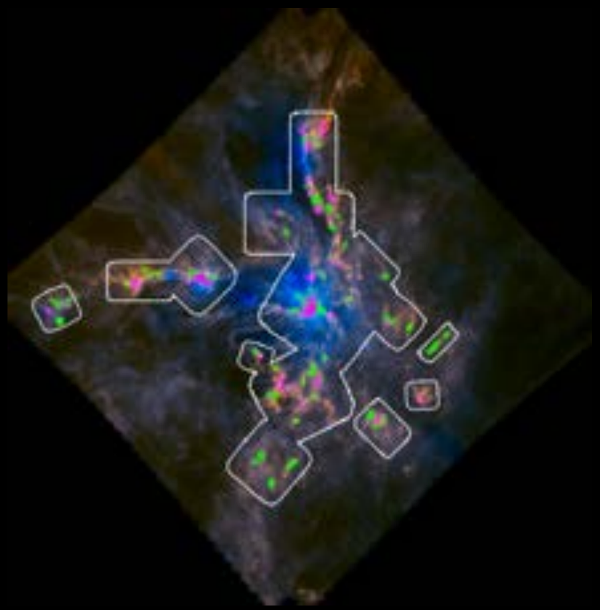
local points could trace elevated volume density

global measurements may have longer lines of sight

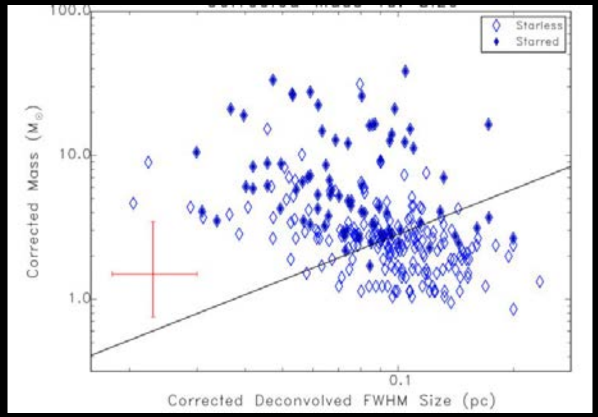
Local and integrated measurements differ!



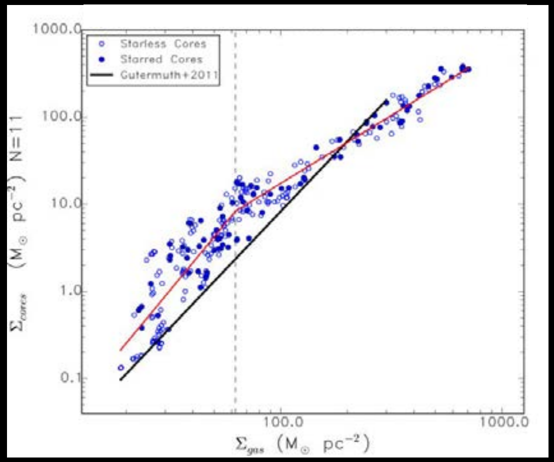
Summary



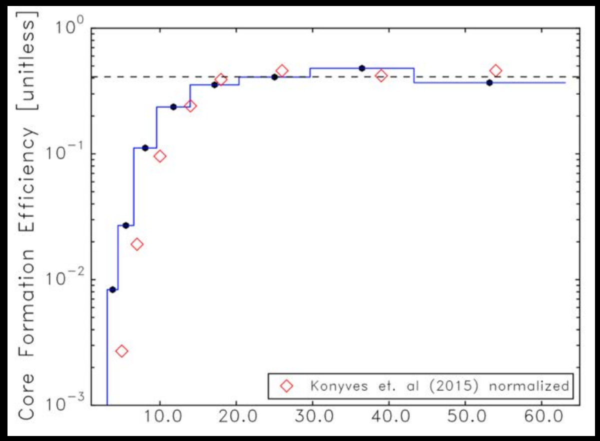
- 270 cores detected, 186 starless, 84 starred



- Flux and size corrections yield mass-radius relationship



- Local core-gas correlation with double-power law



- Stellar clustering set by core clustering and local gas morphology
- Global CFE ~ 40% above 15 Av