Power Scales of Star Formation

Clump Formation Efficiency Maps

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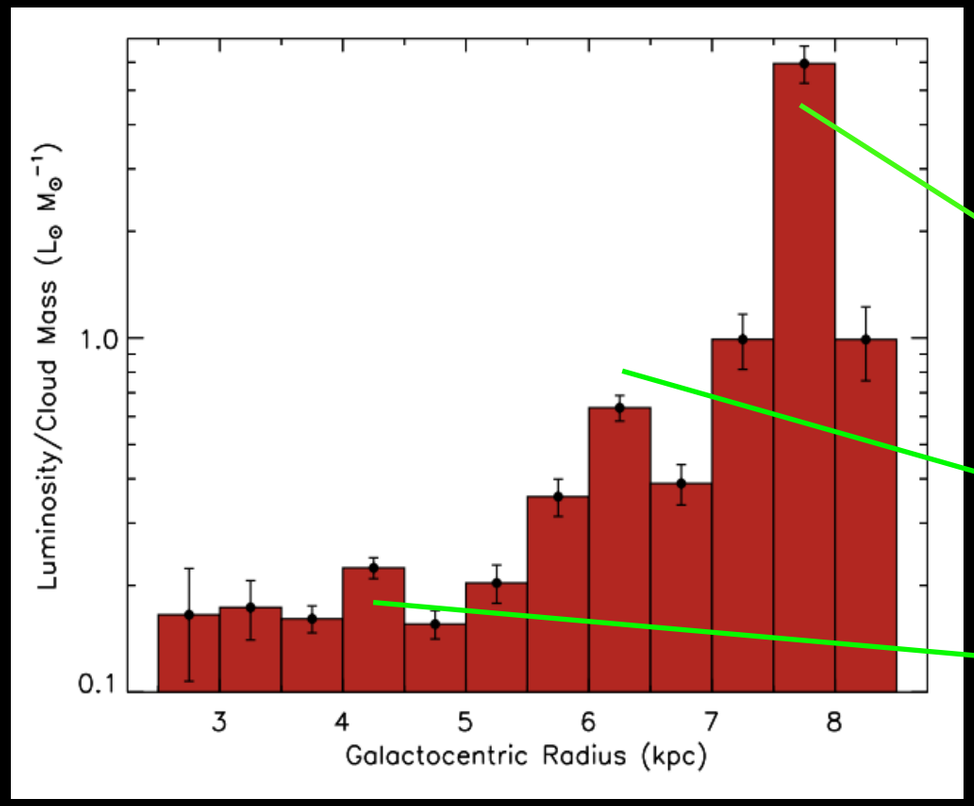
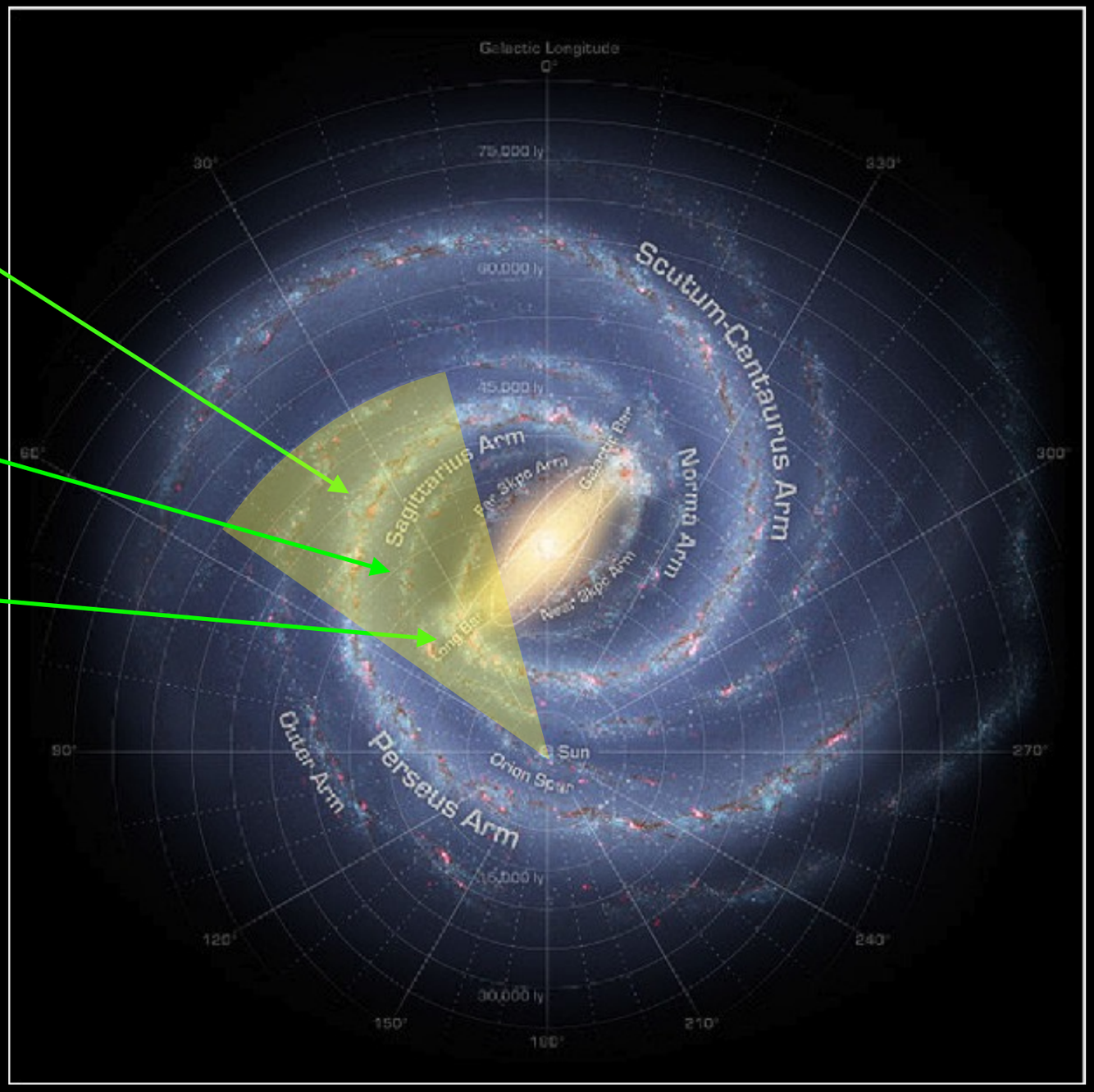
Outline

- Determining the scale of star formation
- Data and methodology
- Simulations of the method
- Column Density Maps
- Power Spectra Analysis

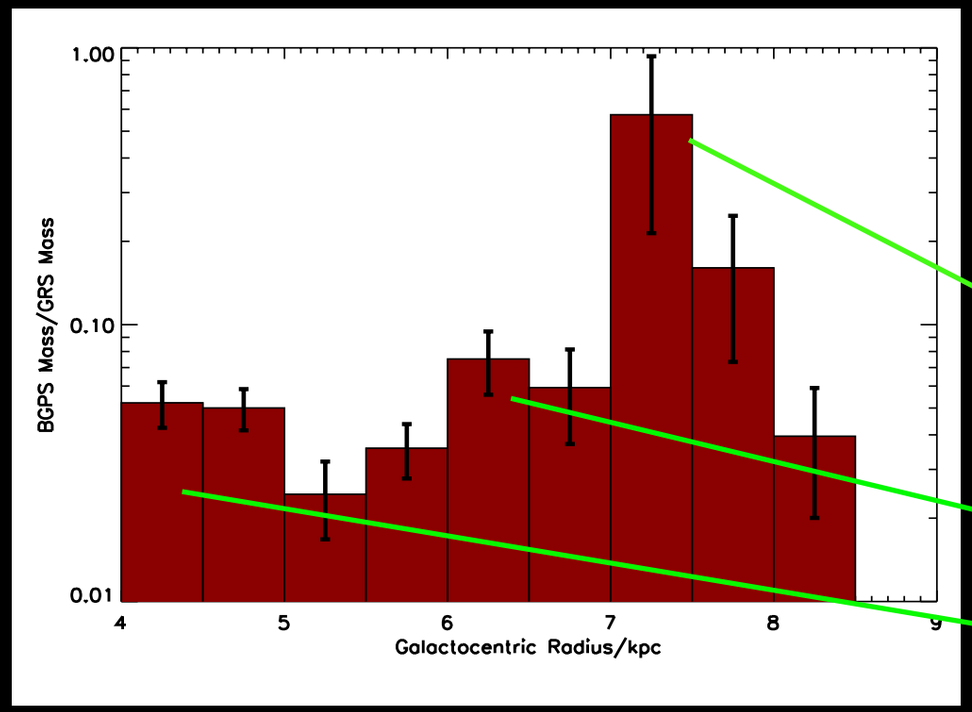
Scales of Star Formation



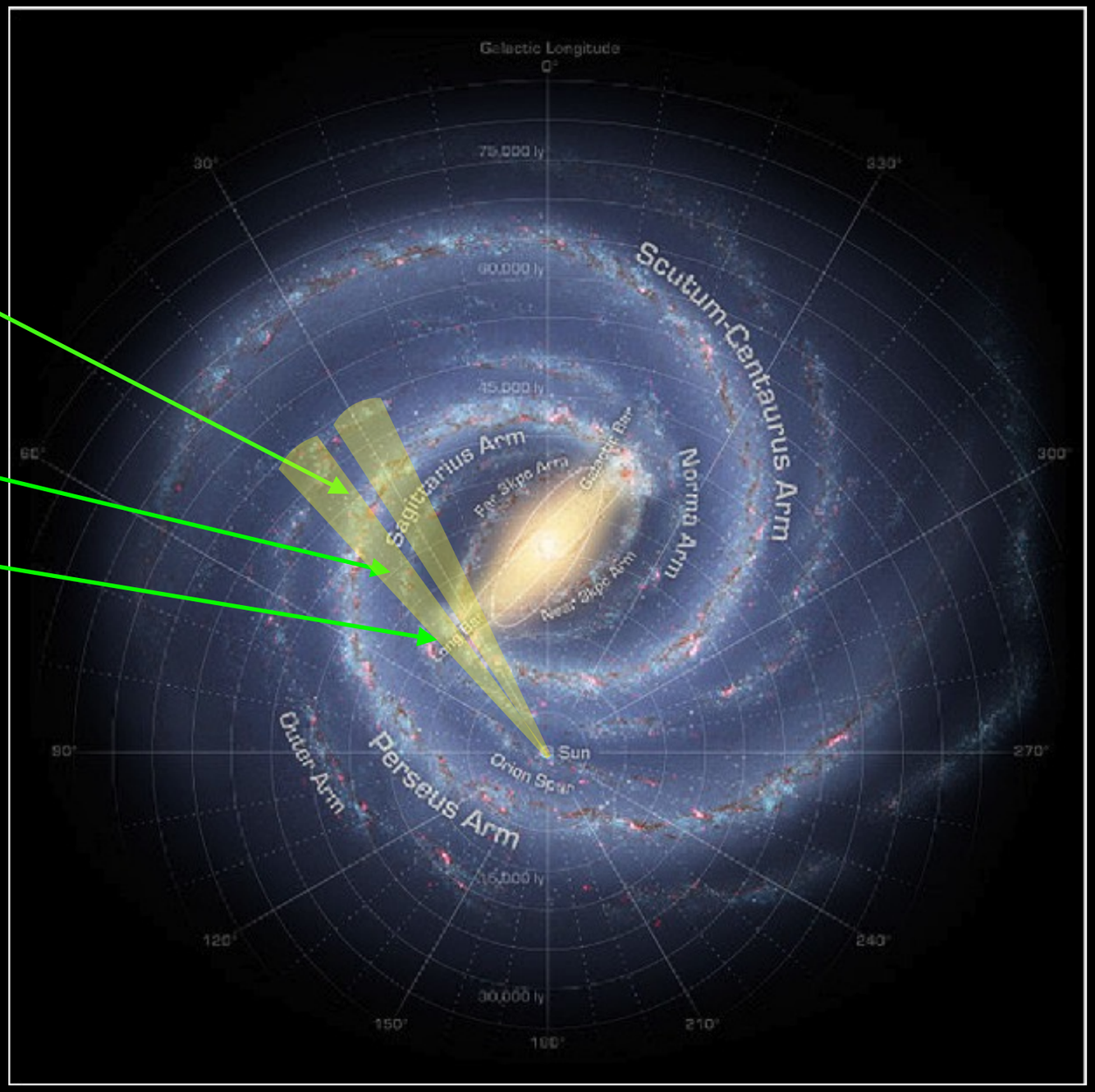
Moore+ (2012)



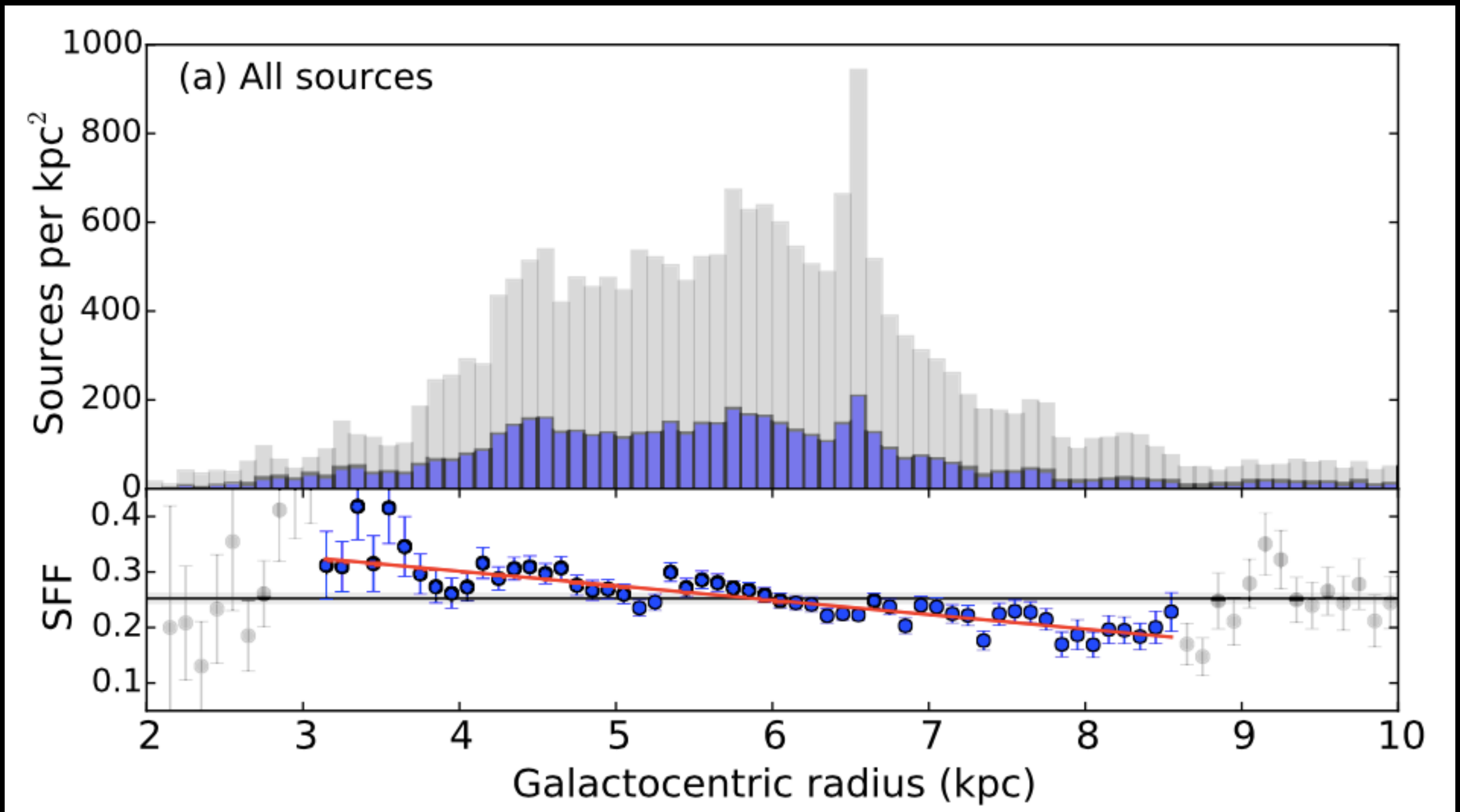
Scales of Star Formation



Eden+ (2013)

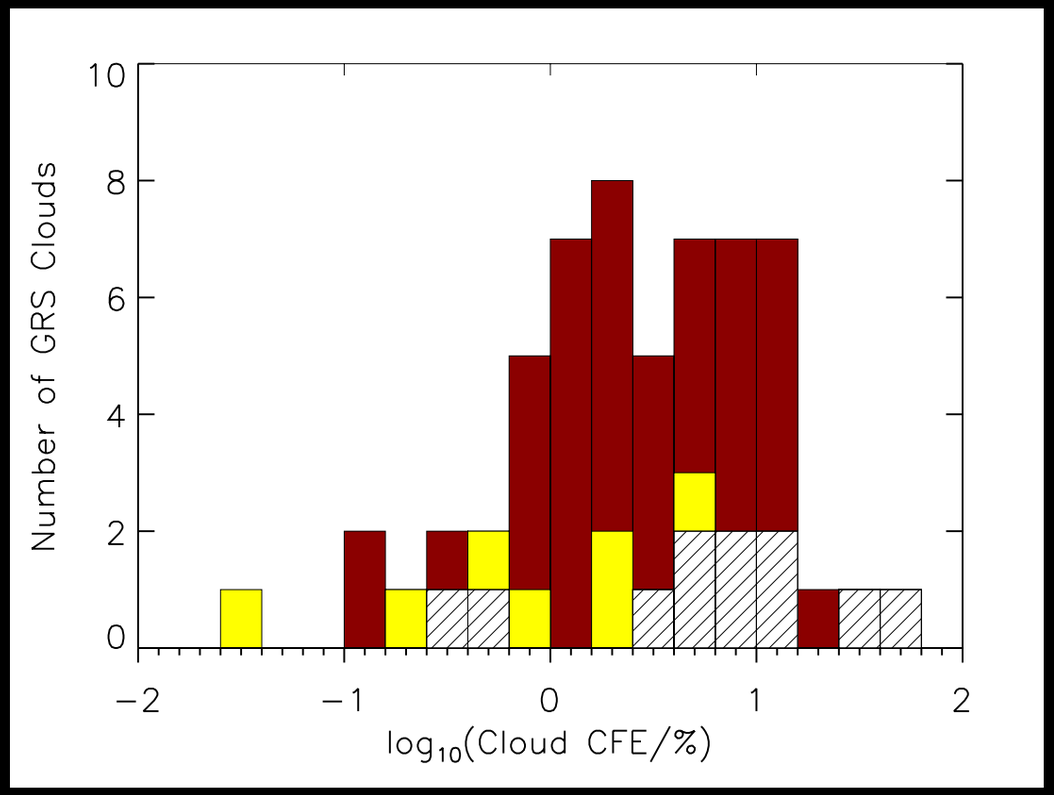


Scales of Star Formation

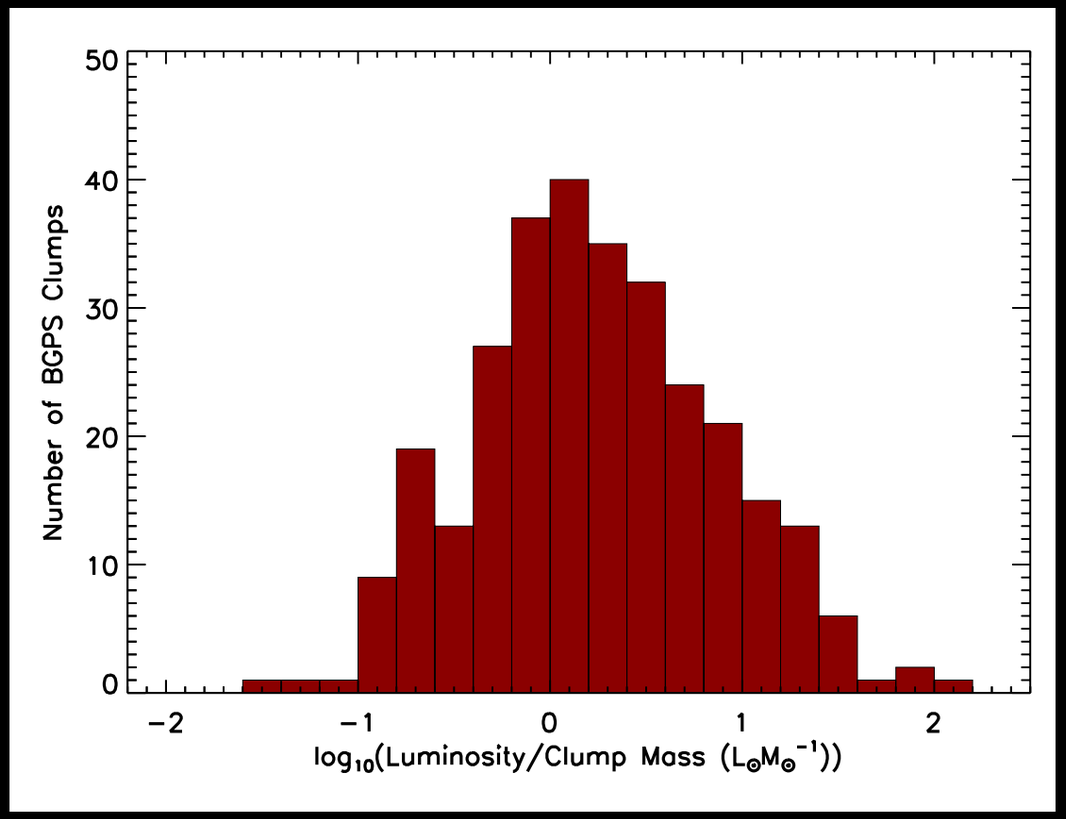


Ragan+ (2016)

Scales of Star Formation



Eden+ (2012)



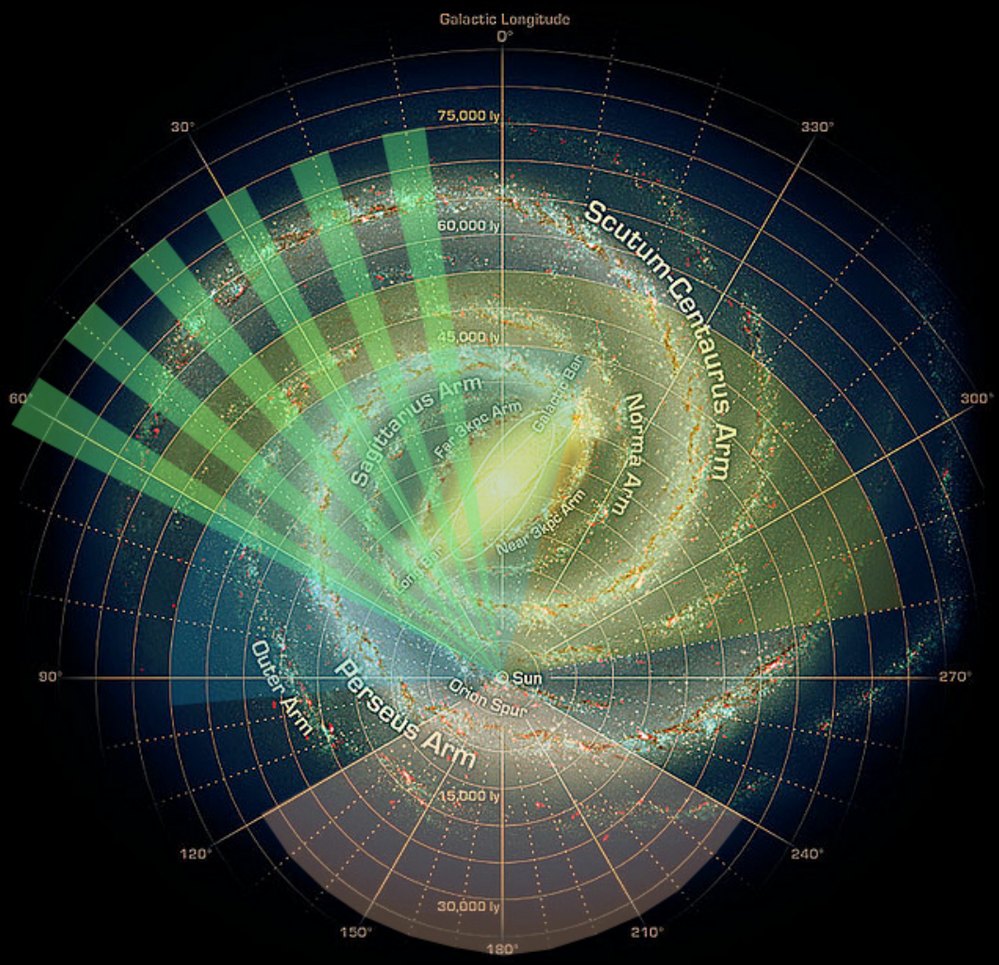
Eden+ (2015)

Data - JPS

JCMT Plane Survey (JPS)

450 hrs at 850 μm

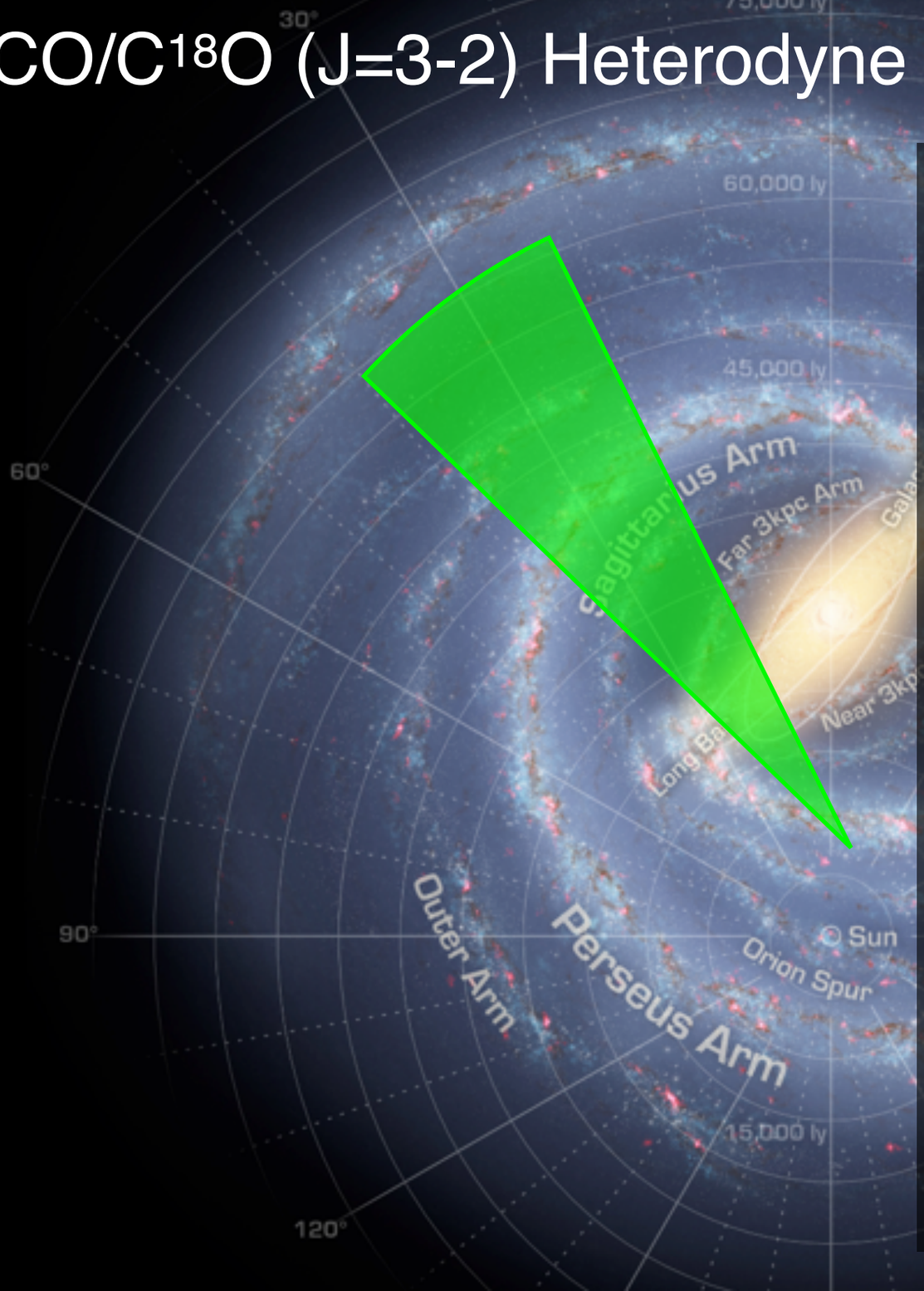
Band 3: $0.08 \leq \tau_{225\ \mathrm{GHz}} \leq 0.12$



Moore+ (2015), Eden+ (2017)

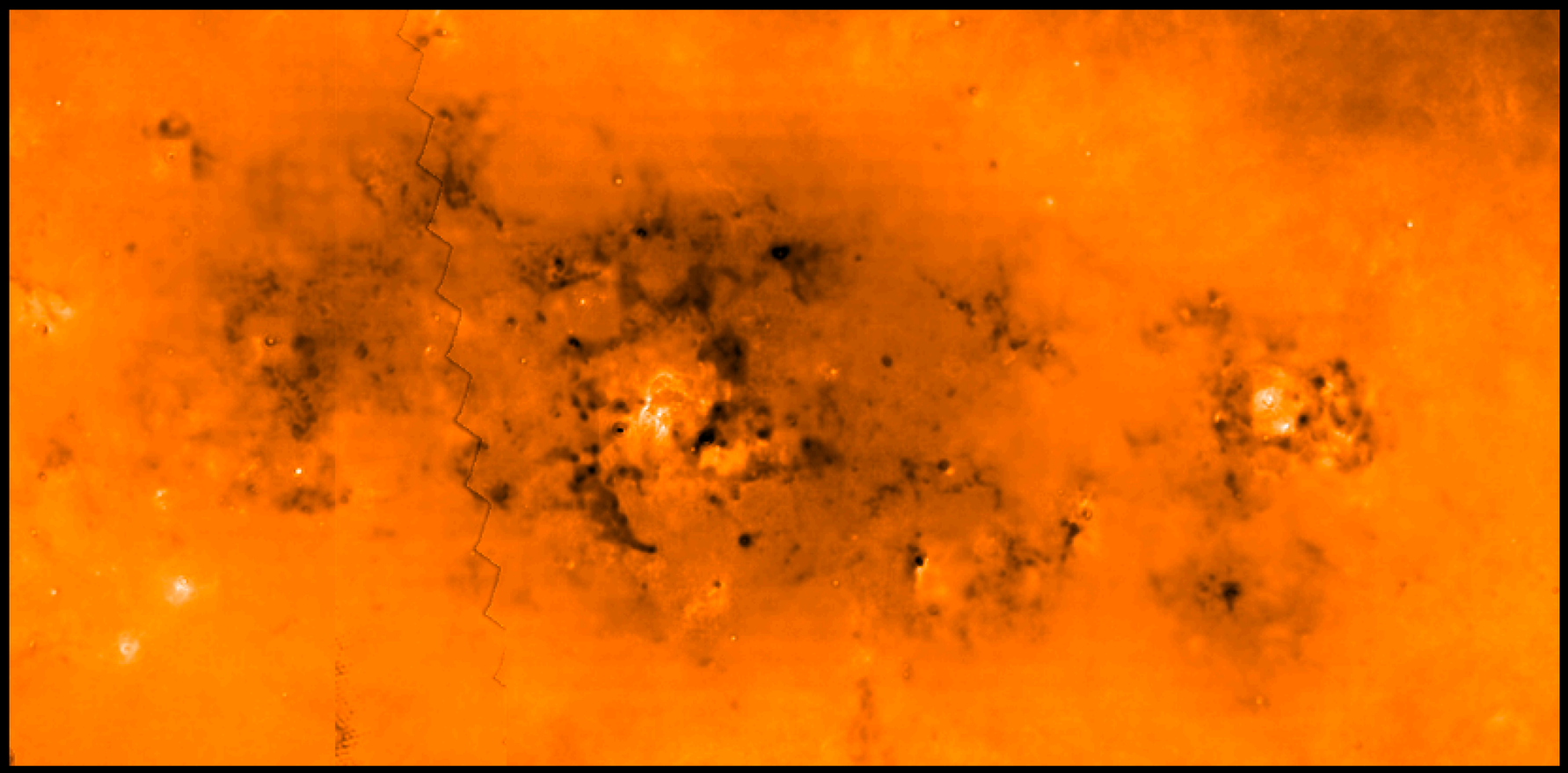
Data - CHIMPS

The $^{13}CO/C^{18}O$ (J=3-2) Heterodyne Inner Milky Way Plane Survey



- JCMT (15m) with HARP
  - ^{13}CO (3–2) & $C^{18}O$ (3–2)
  - Dense gas (n_{crit} ~ 10^4 cm^{-3})
  - High optical depth: cloud interiors
- $27.5° < l < 46.3°$ and $|b| < 0.5°$ (19 deg^2) spectral survey
- Spatial resolution ~ 15”
- Velocity resolution 0.5 km/s (raw channel width 0.055 km/s)
- 200 km/s coverage ~ -50–150 km/s
- Sensitivity σ (T_{mb}) < 1 K per channel
  - T_A^*~ 0.6 K/channel for ^{13}CO
  - T_A^*~ 0.7 K/channel for $C^{18}O$

JPS Column Densities

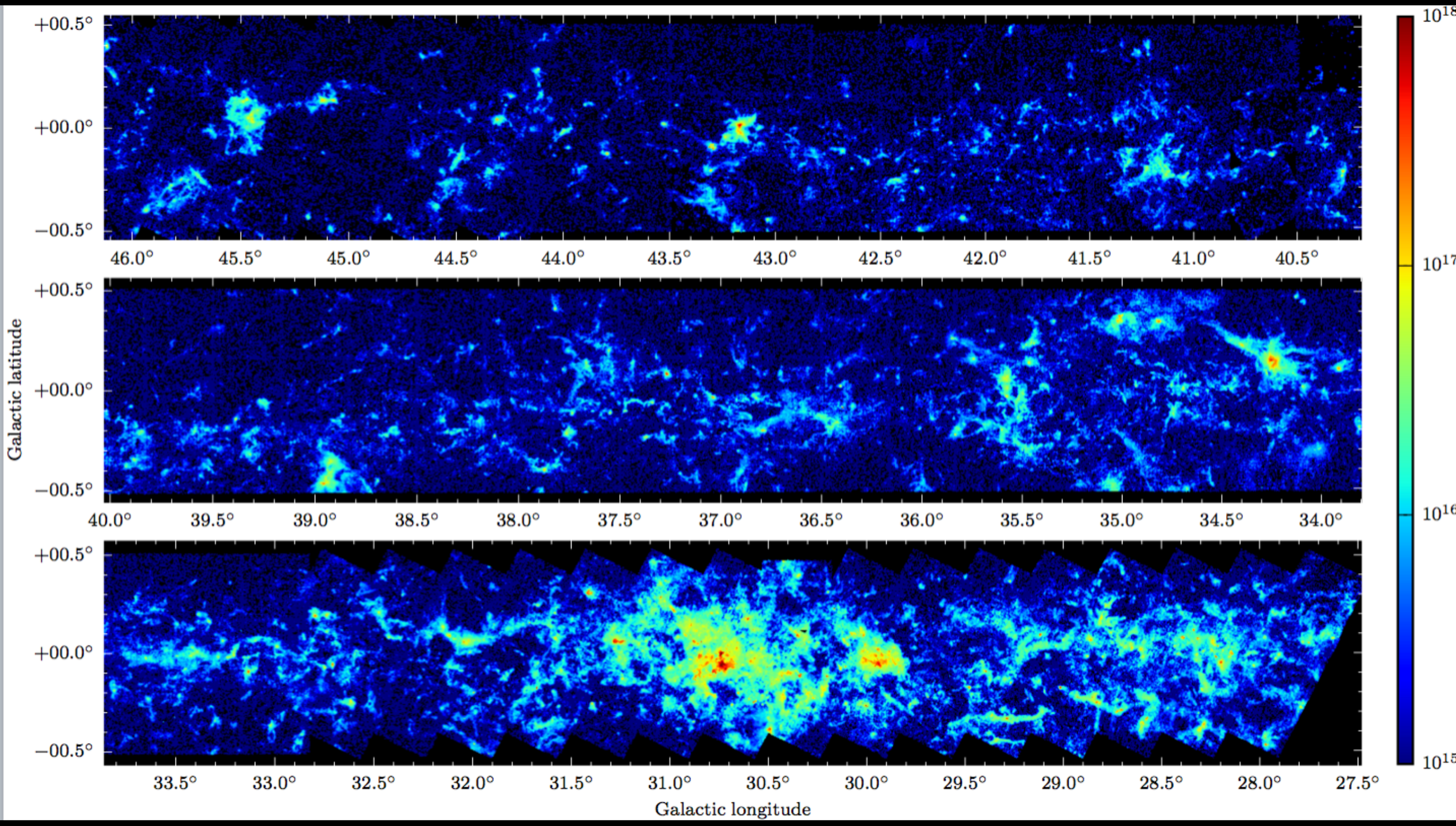


PPMAP temperatures using JPS data and 5 wavebands from Hi-GAL (Eden+, in prep)

$$N(H_2) = \frac{F_\nu R}{B_\nu(T_d)\Omega\kappa_\nu\mu_{H_2}m_H}$$

CHIMPS Column Densities

$N(H_2) \sim 10^{24}$ cm^{-2}



Rigby+ (2019)

27.4” resolution

$N(H_2) \sim 10^{21}$ cm^{-2}

Method

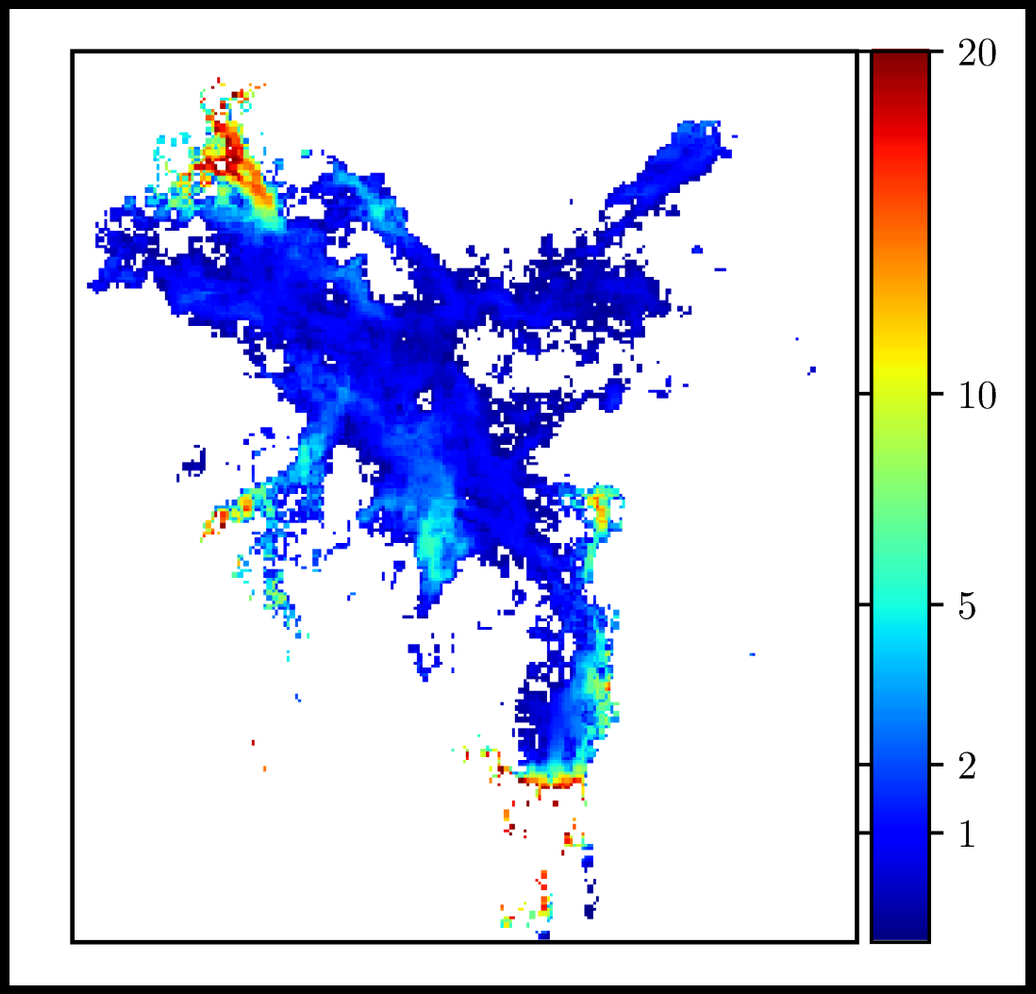
The CFE, or DGMF, is defined as the ratio of the dense, star-forming clump mass to the molecular cloud mass.

If at the same distance and with the same beam size, the ratios of column densities can be used.

The JPS data are spatially filtered and preferentially detect star-forming material, whereas the CHIMPS data detect the ambient material.

Two potential pitfalls: The use of CO 3-2, as opposed to 1-0 and the use of the CHIMPS data as the tracer of the ambient gas.

Simulated CFE Maps



Eden+ (in prep)

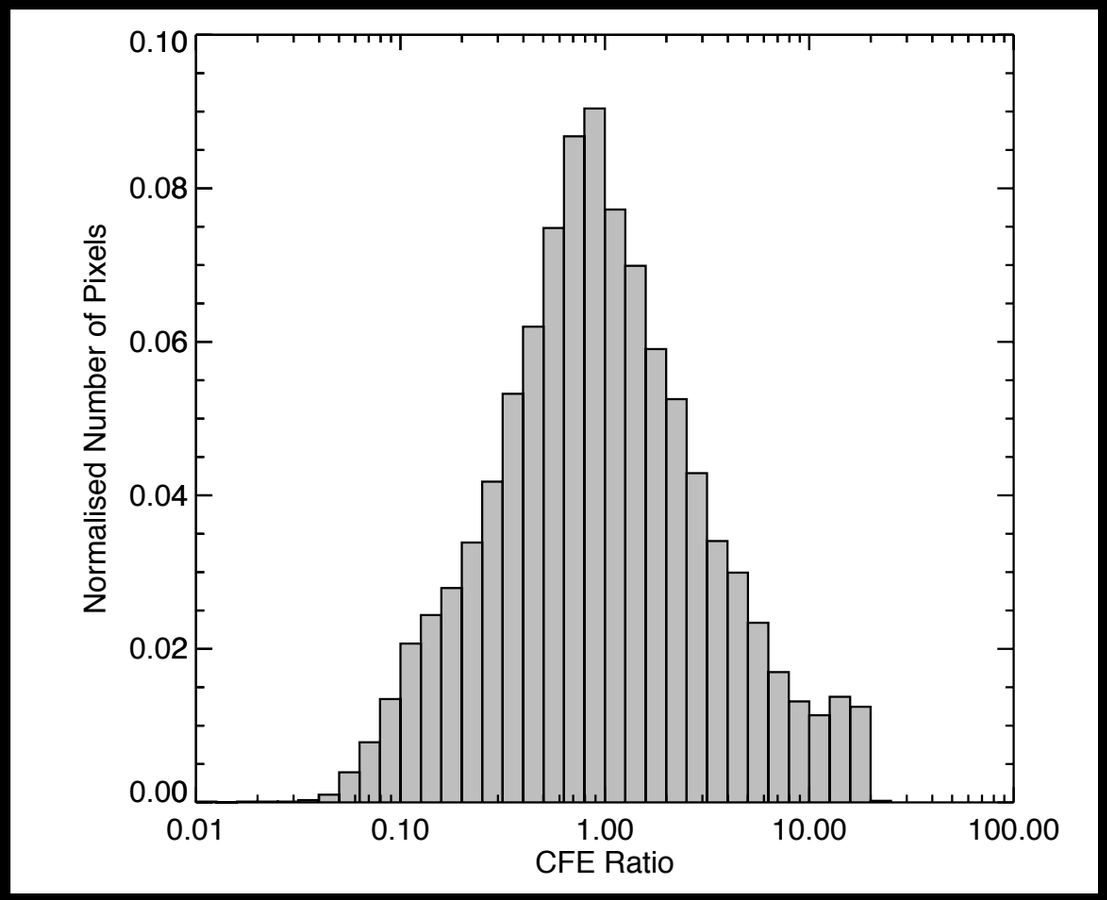
Produced two CFE maps using the simulated molecular cloud of Penaloza+ (2017).

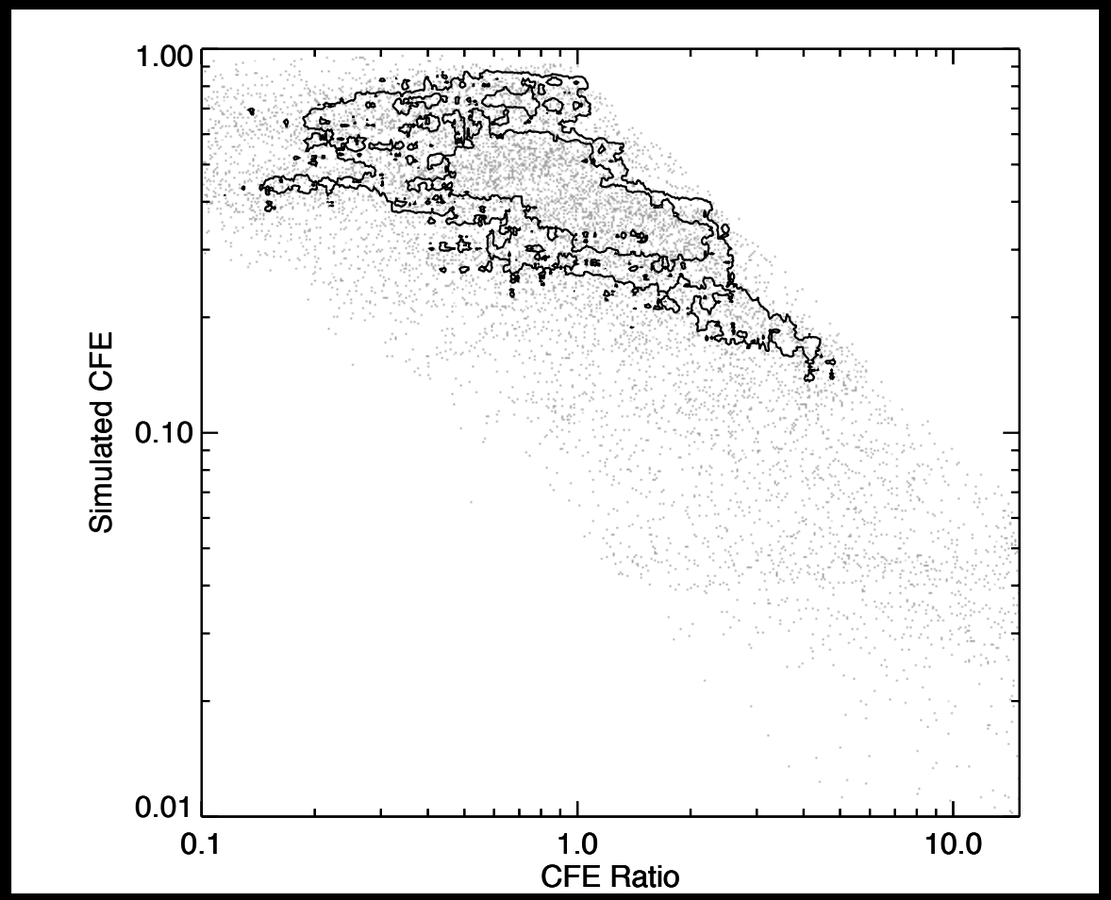
Map 1: Simulated the observations.
JPS data - smoothed with large-scale structure removed.

CHIMPS data - binned to the same velocity resolution with the same detection threshold applied.

Map 2: True CFE map
Using the critical density of the 3-2 line, calculated the ratio of dense gas in each line of sight.

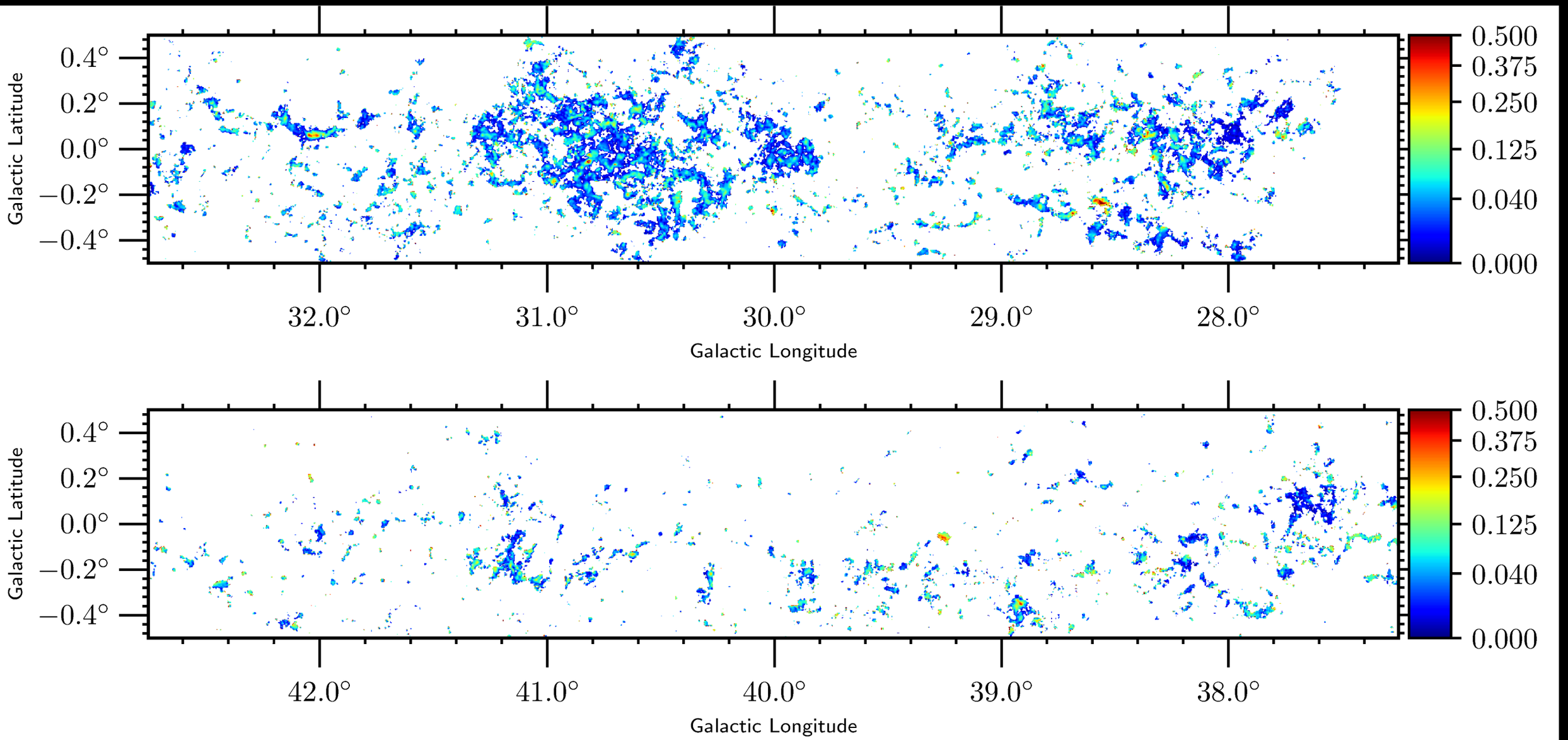
Simulated CFE Maps





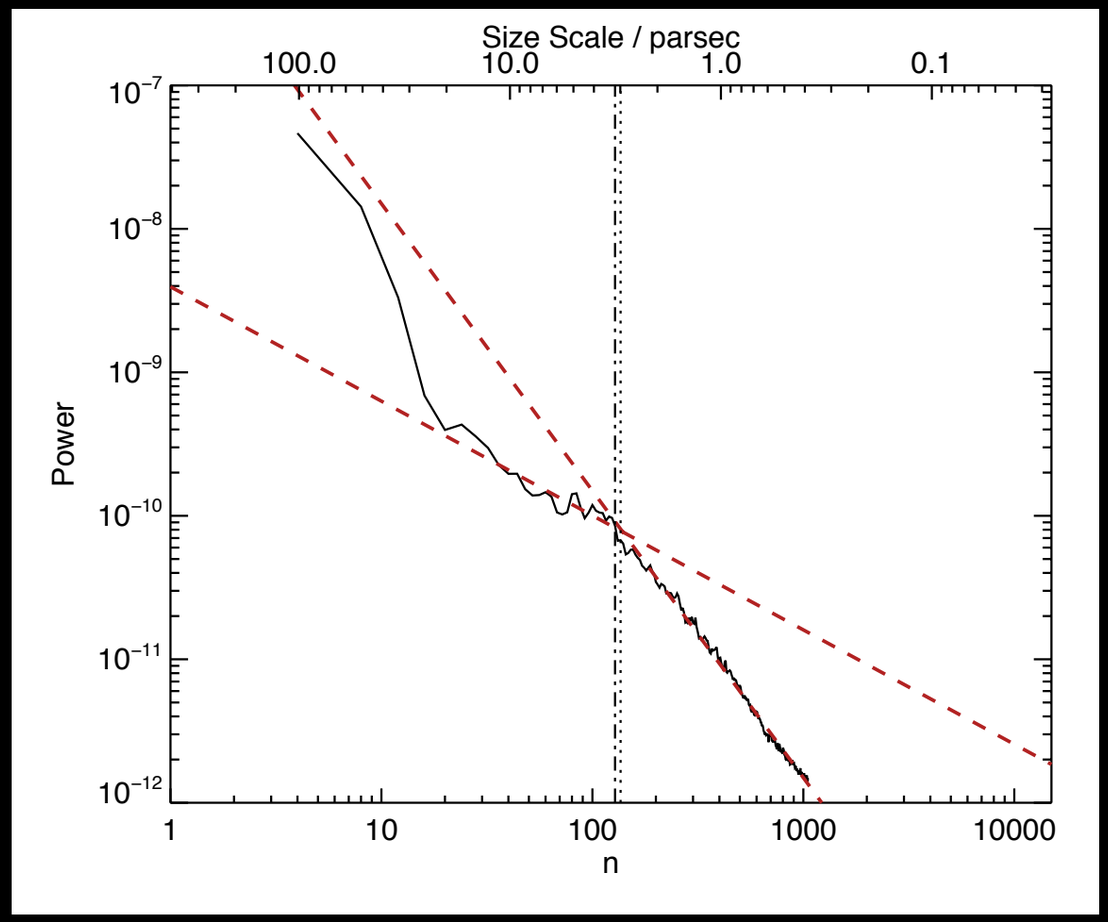
Eden+ (in prep)

CFE Maps

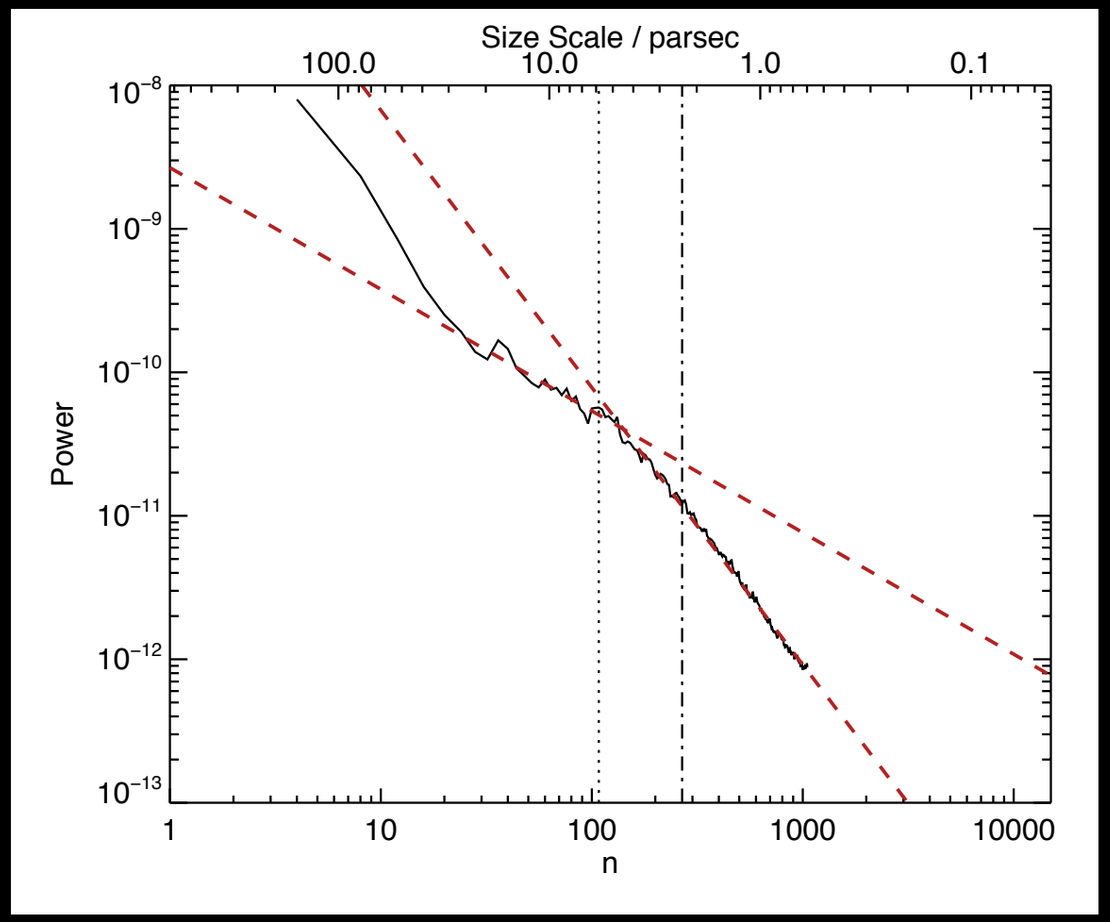


Eden+ (in prep)

Power Spectra



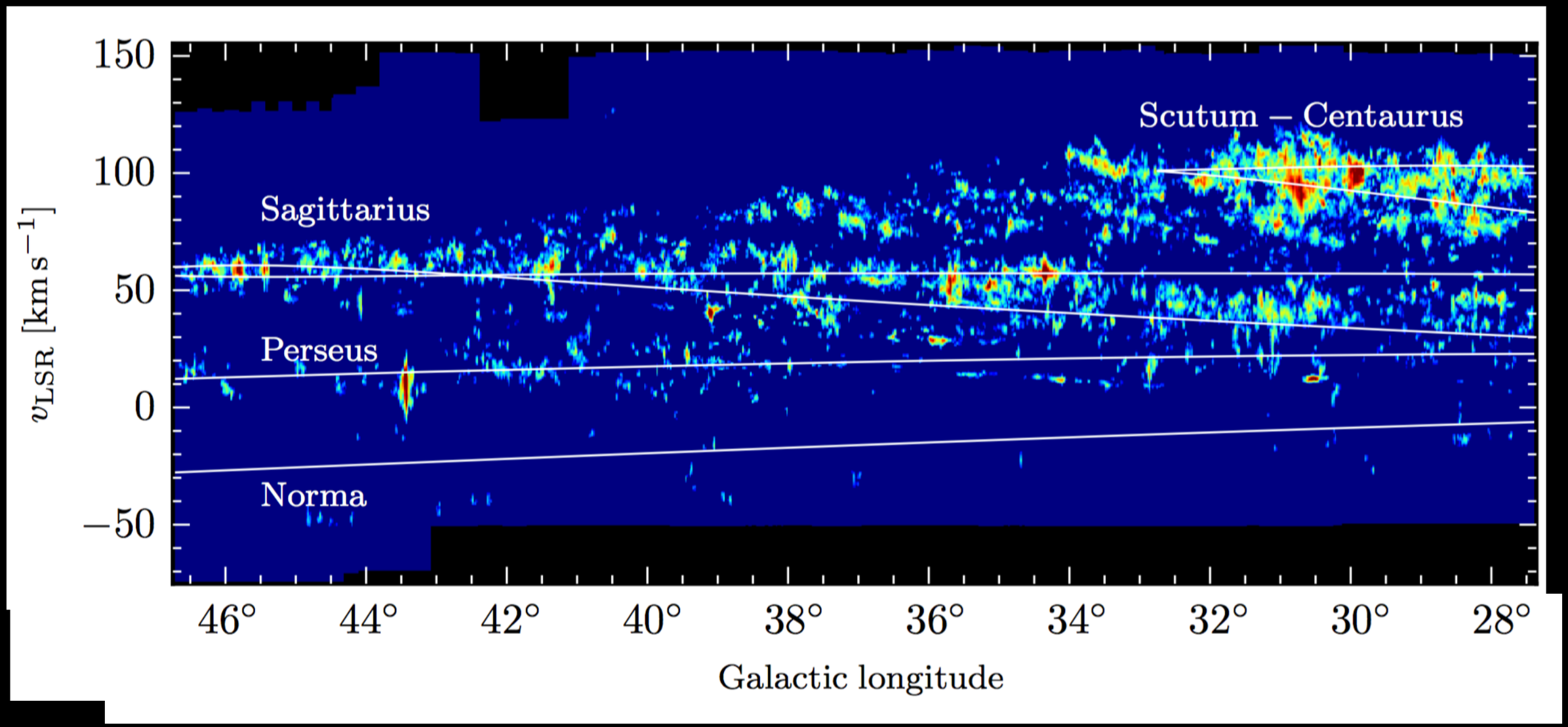
l=30°



l=40°

Eden+ (in prep)

Individual Spiral Arms



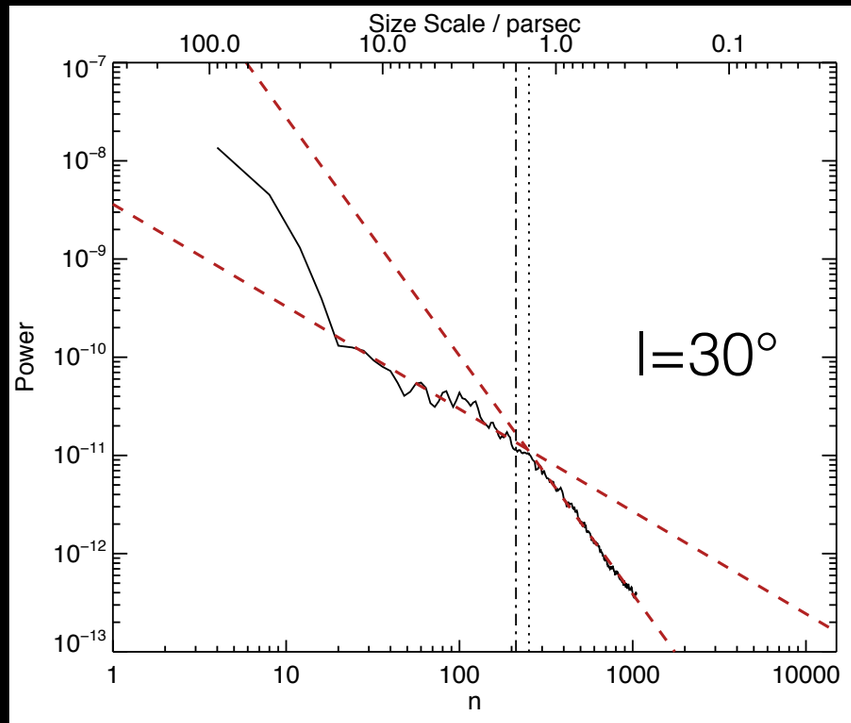
Rigby+16

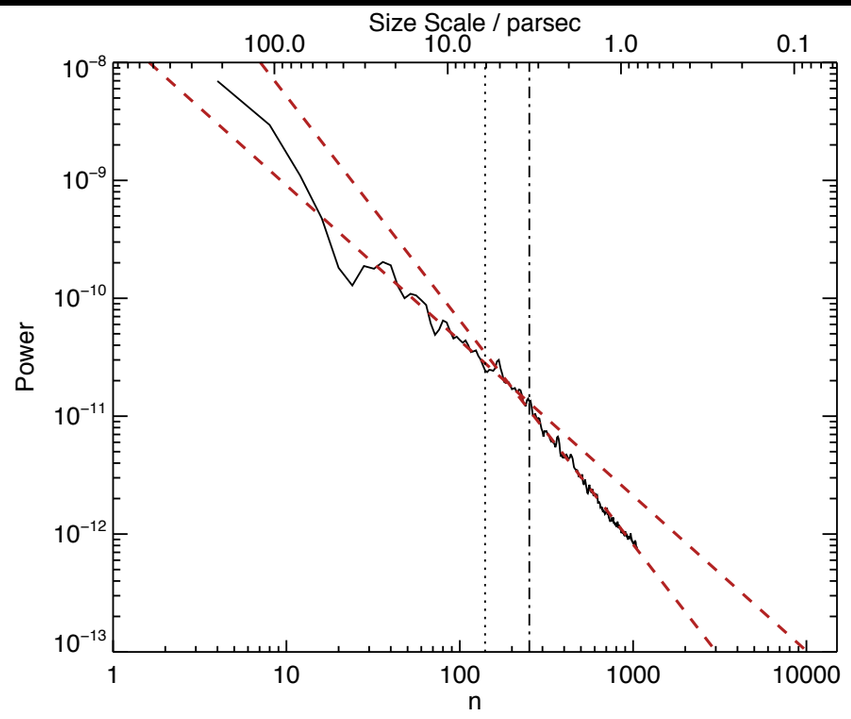
Individual Spiral Arms

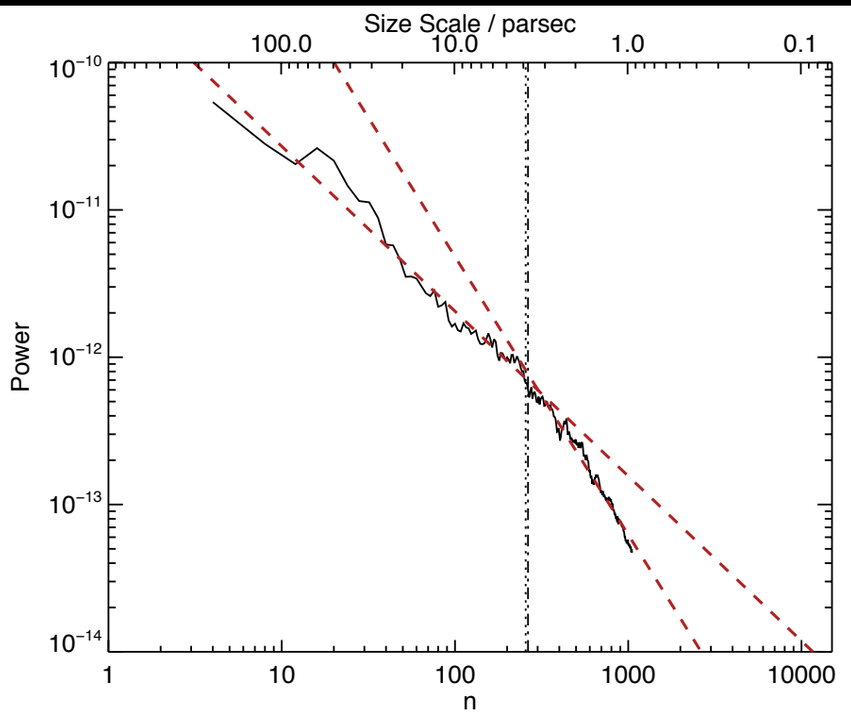
Scutum

Sagittarius

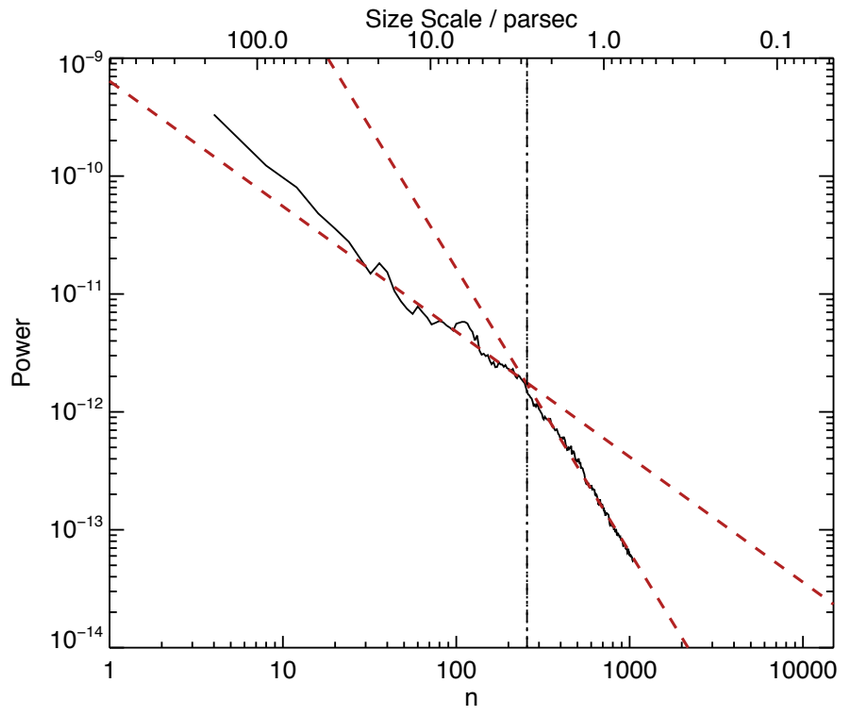
Perseus

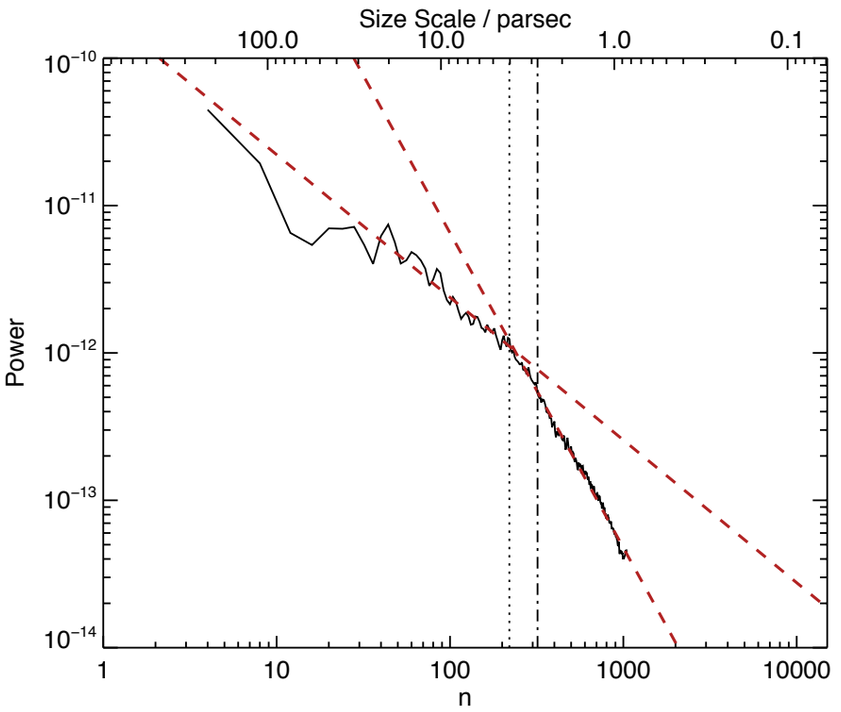






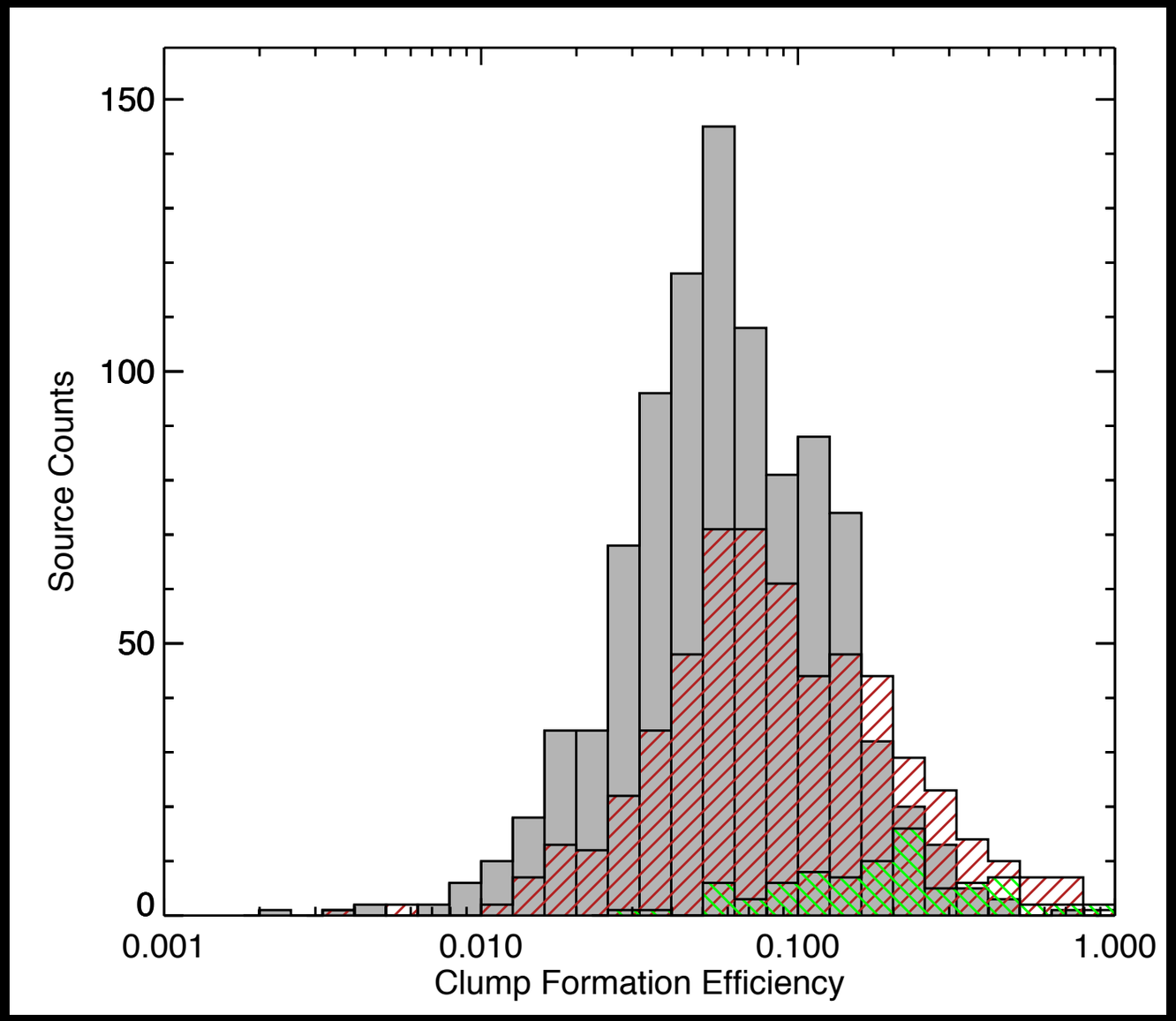
l=40°





Eden+ (in prep)

CFEs of individual clouds



Mean values

Scutum:	0.058 ± 0.001
Sagittarius:	0.081 ± 0.002
Perseus:	0.195 ± 0.013

Eden+ (in prep)

Conclusions

- Using the ratio of the continuum and CO 3-2 emission is a good proxy for the clump formation efficiency.

- CFE is at a background level of ~0.03, or 3 per cent

- Power spectra of individual spiral arms show that the breaks correspond to the molecular cloud scales, implying this is the characteristic scale of the clump formation.

- Evidence that the mean cloud CFE varies between the spiral arms.