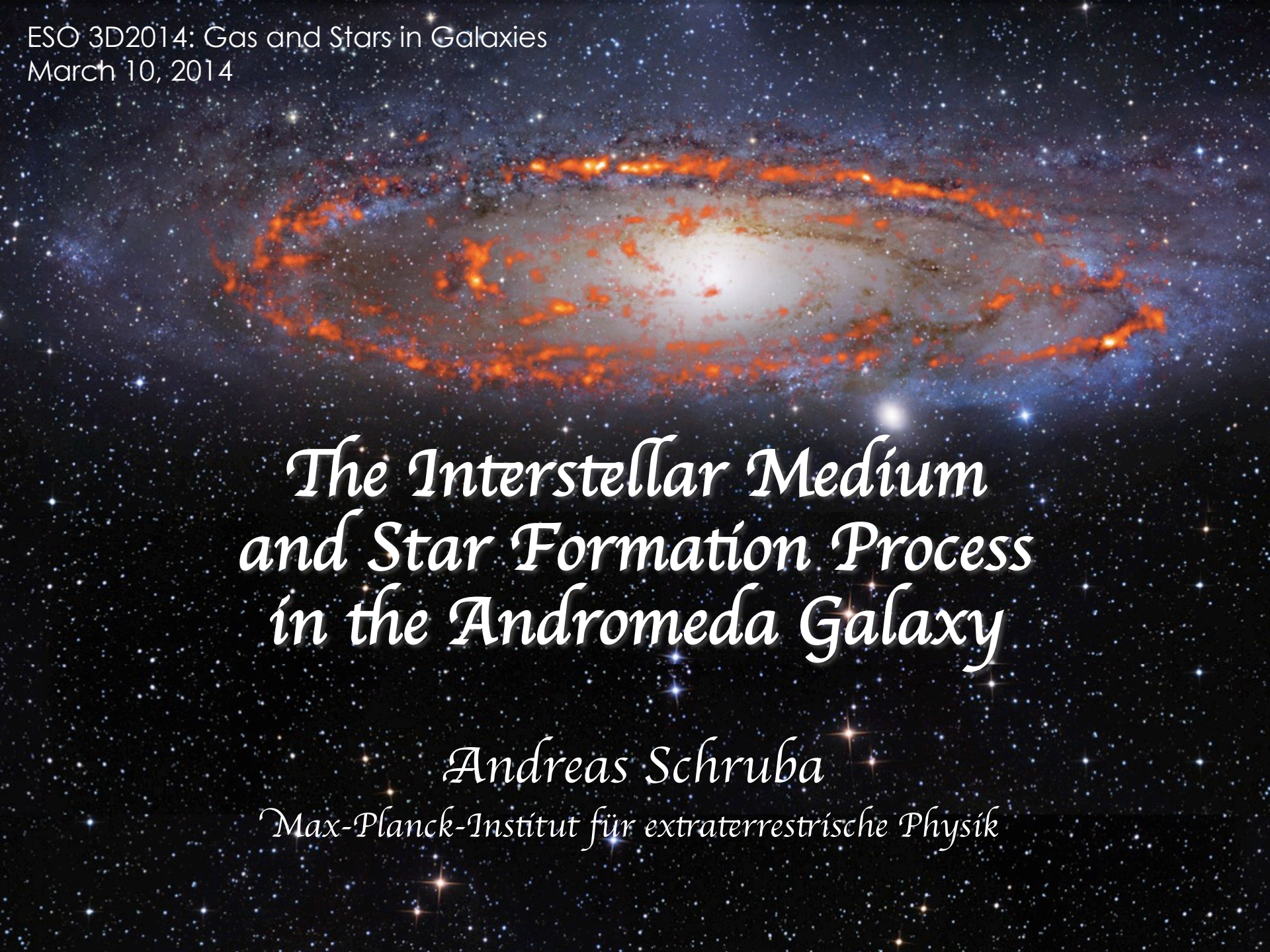
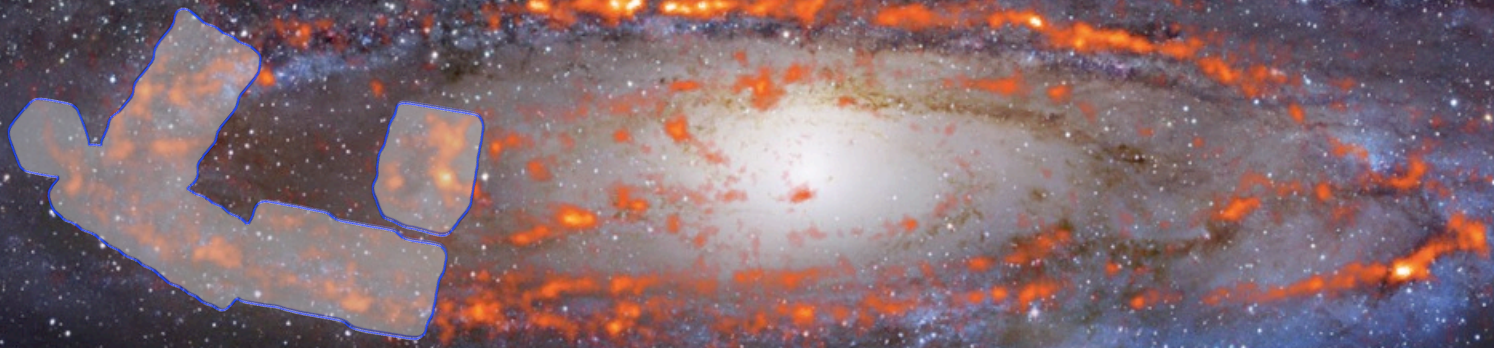
ESO 3D2014: Gas and Stars in Galaxies
March 10, 2014



The Interstellar Medium and Star Formation Process in the Andromeda Galaxy

Andreas Schruba
Max-Planck-Institut für extraterrestrische Physik

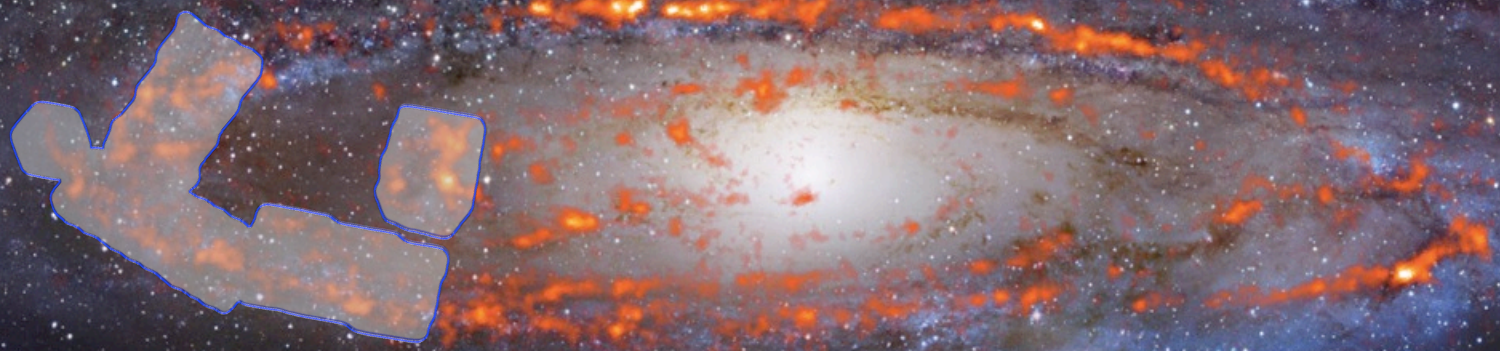
ESO 3D2014: Gas and Stars in Galaxies
March 10, 2014



The CARMA Survey of Andromeda

Today's largest (0.1 deg²) Interferometric Survey of CO(1-0) on Cloud Scale (20 pc x 1 km/s)

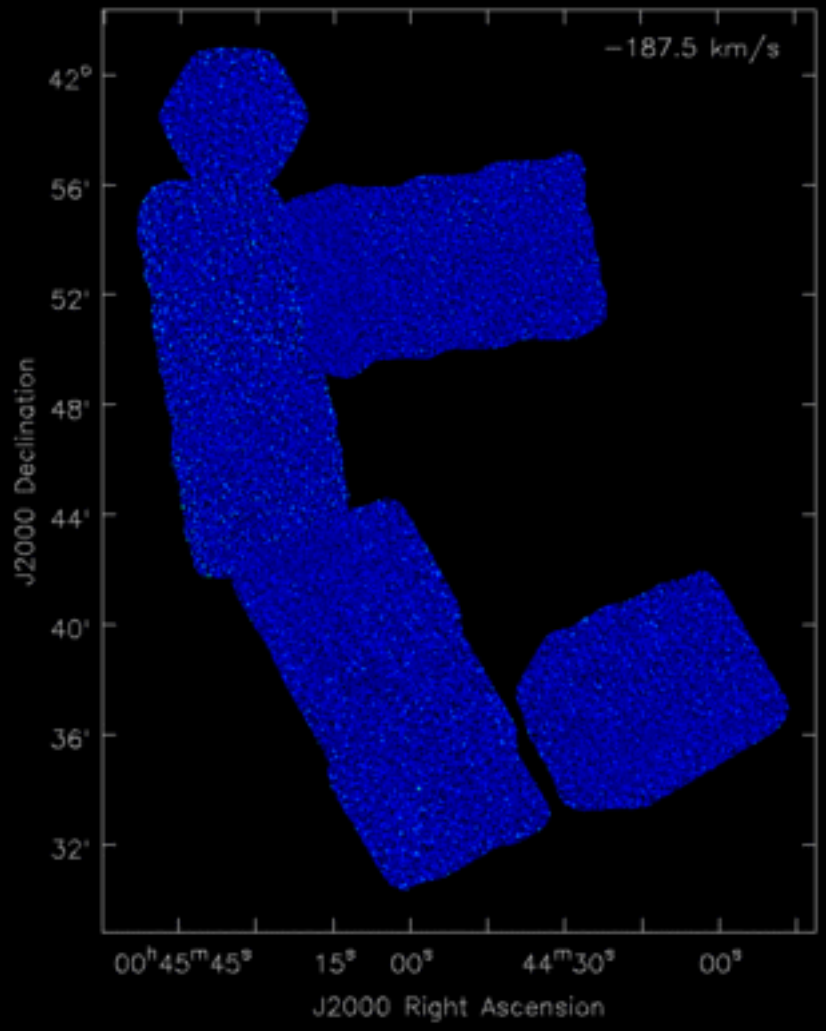
ESO 3D2014: Gas and Stars in Galaxies
March 10, 2014



1. Where is the Molecular Gas in a ‘normal’ Spiral?
2. What are the Properties of Molecular Clouds?
3. Is there Concordance of Cloud Properties?

1 Where is the Molecular Gas in a Spiral?

… a $3\mathcal{D}$ cloud-scale view of CO(1-0) in Andromeda

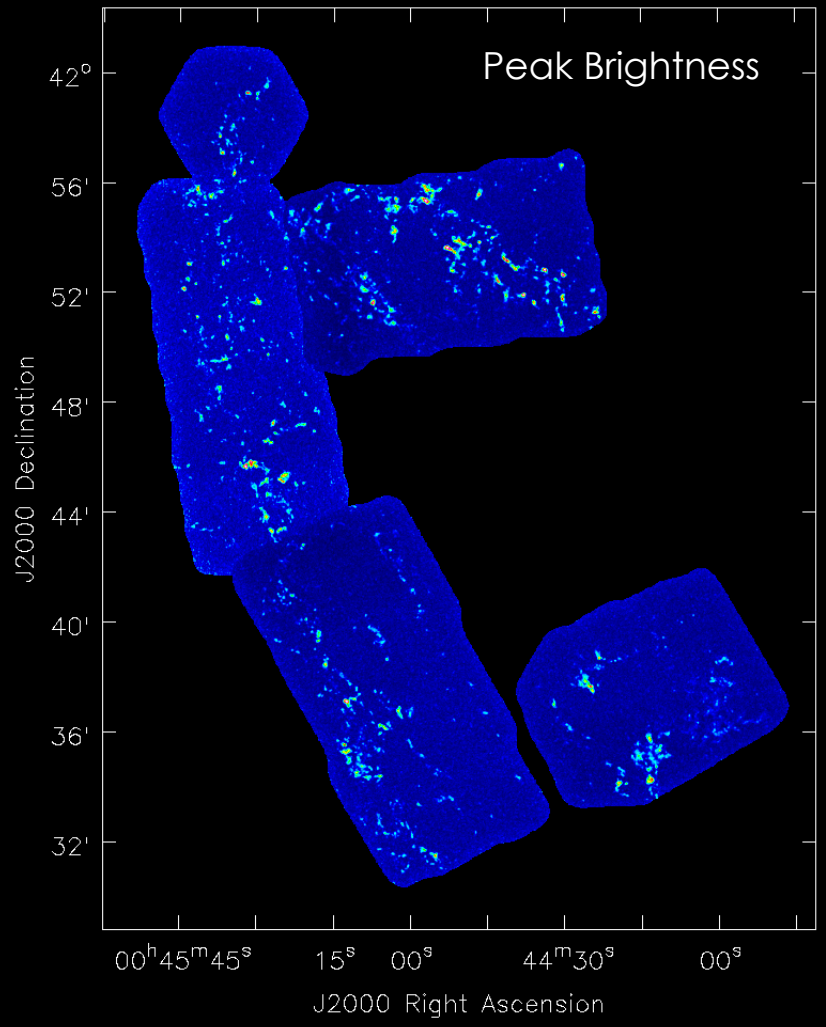


CARMA
Combined Array for Research in Millimeter-Wave Astronomy

SCHRUBA+ (IN PREP)

1 Where is the Molecular Gas in a Spiral?

… a $2\mathcal{D}$ cloud-scale view of CO(1-0) in Andromeda

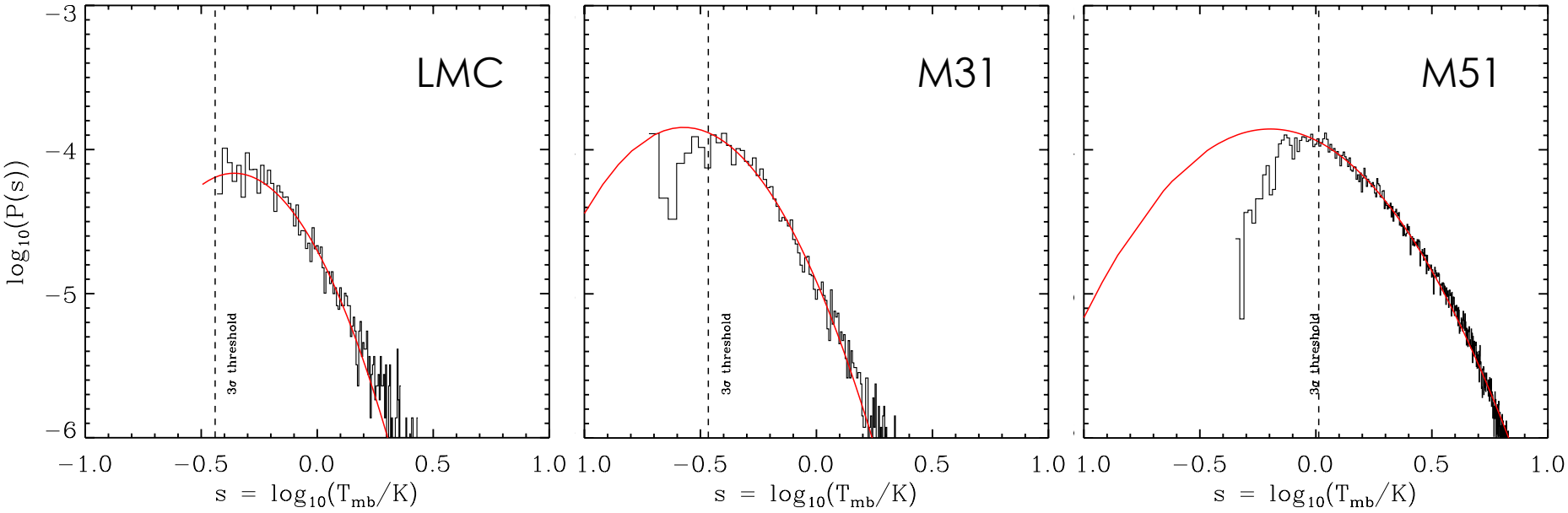


Combined Array for Research in Millimeter-Wave Astronomy

SCHRUBA+ (IN PREP)

1 Where is the Molecular Gas in a Spiral?

… PDFs of CO Pixel Brightness



~ 0.23 dex

Log width ~ 0.26 dex

~ 0.33 dex

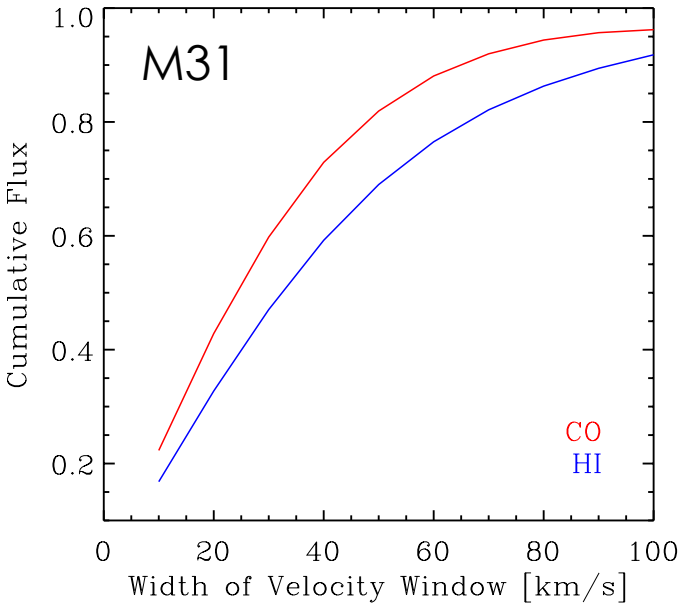
Most emission at low intensity (signal-to-noise) and thus often missed.

HUGHES+13; GRATIER+12

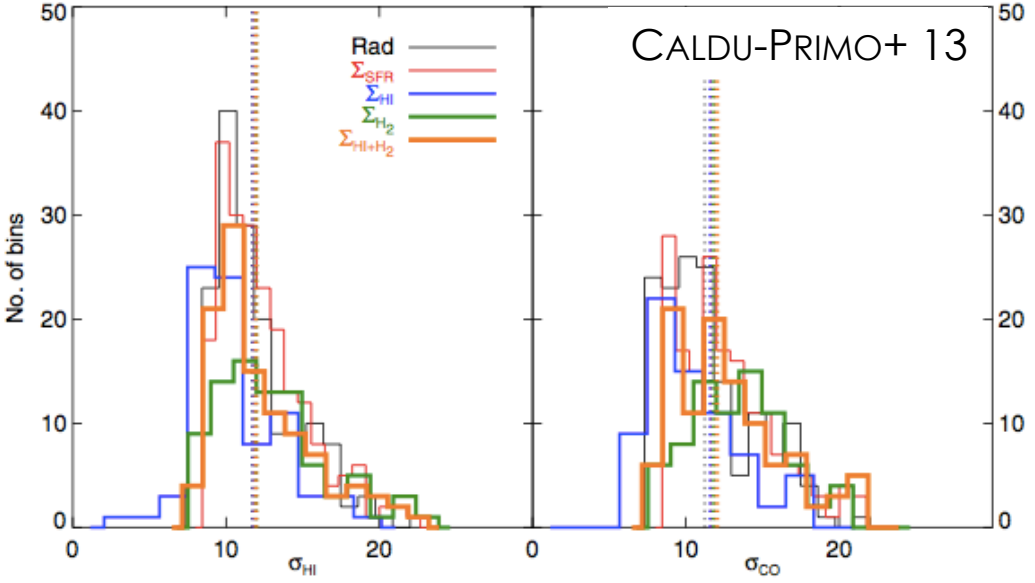
Data at Common Resolution of 50 pc x 5 km/s

1 A Thick Disk of (diffuse) Molecular Gas

M31: cumulative emission around local HI velocity



Velocity Dispersion of HI and CO in 12 spirals at low inclination



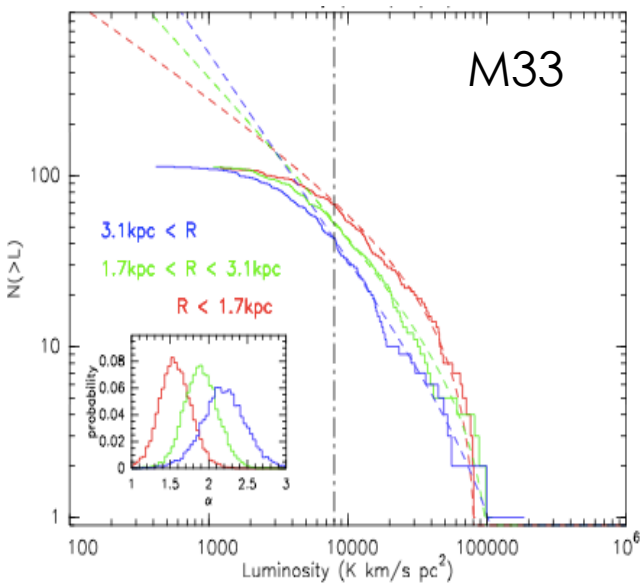
76% of flux within ~40 km/s
⇒ LOS dispersion ~18 km/s
… but M31 highly inclined

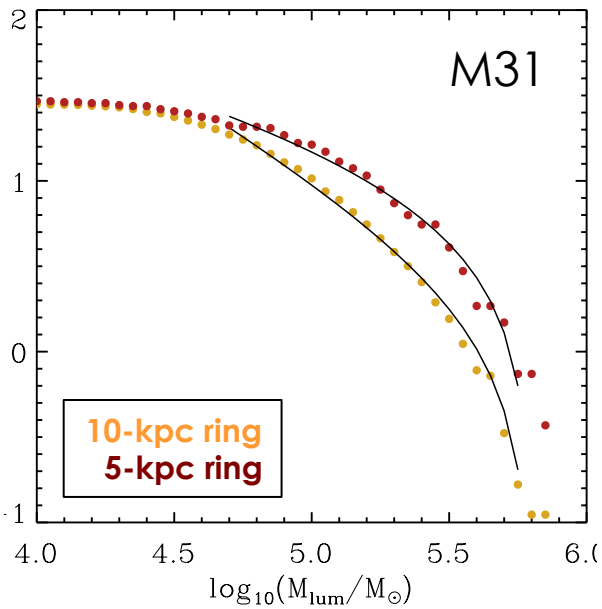
Line Width of HI and CO comparable
=> Evidence for thick disk of diffuse H_2

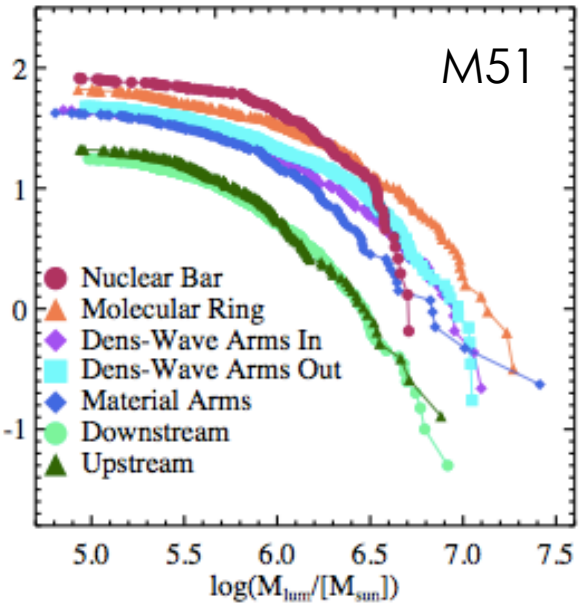
CALDU-PRIMO+13; PETY+13

2 Mass Spectrum of Molecular Clouds

… as described by truncated power-law







All data: γ = -2.0
range: -1.5 … -2.3

10-kpc ring: γ = -2.0
5-kpc ring: γ = -1.4

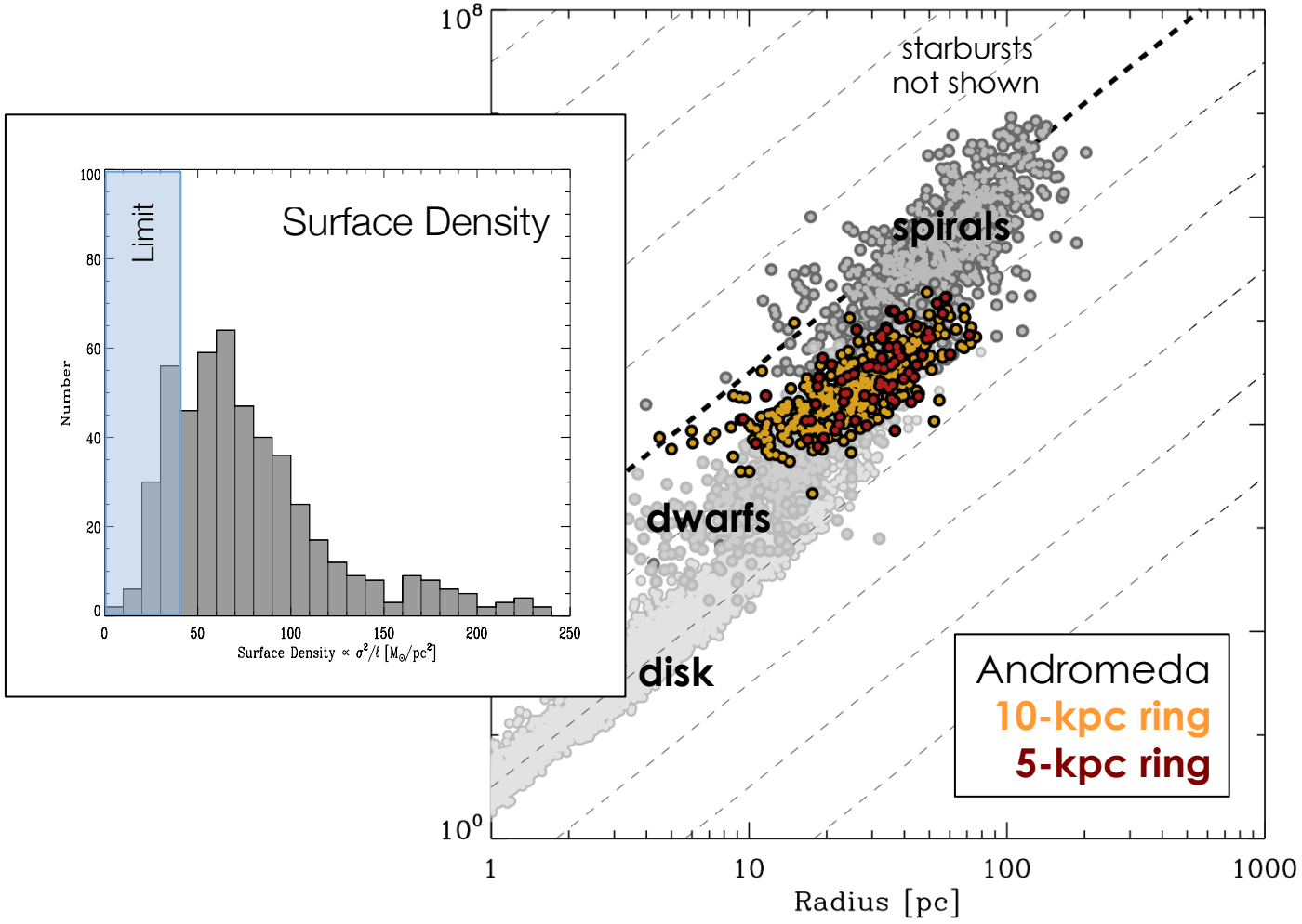
All data: γ = -2.3
range: -1.3 … -2.6

Cloud mass spectrum steeper in low-density then high-density environments,
… but cloud samples contain only ~50% of total mass, rest in diffuse phase

COLOMBO+13; GRATIER+12; WONG+11; ROSOLOWSKY+05; HEYER+01

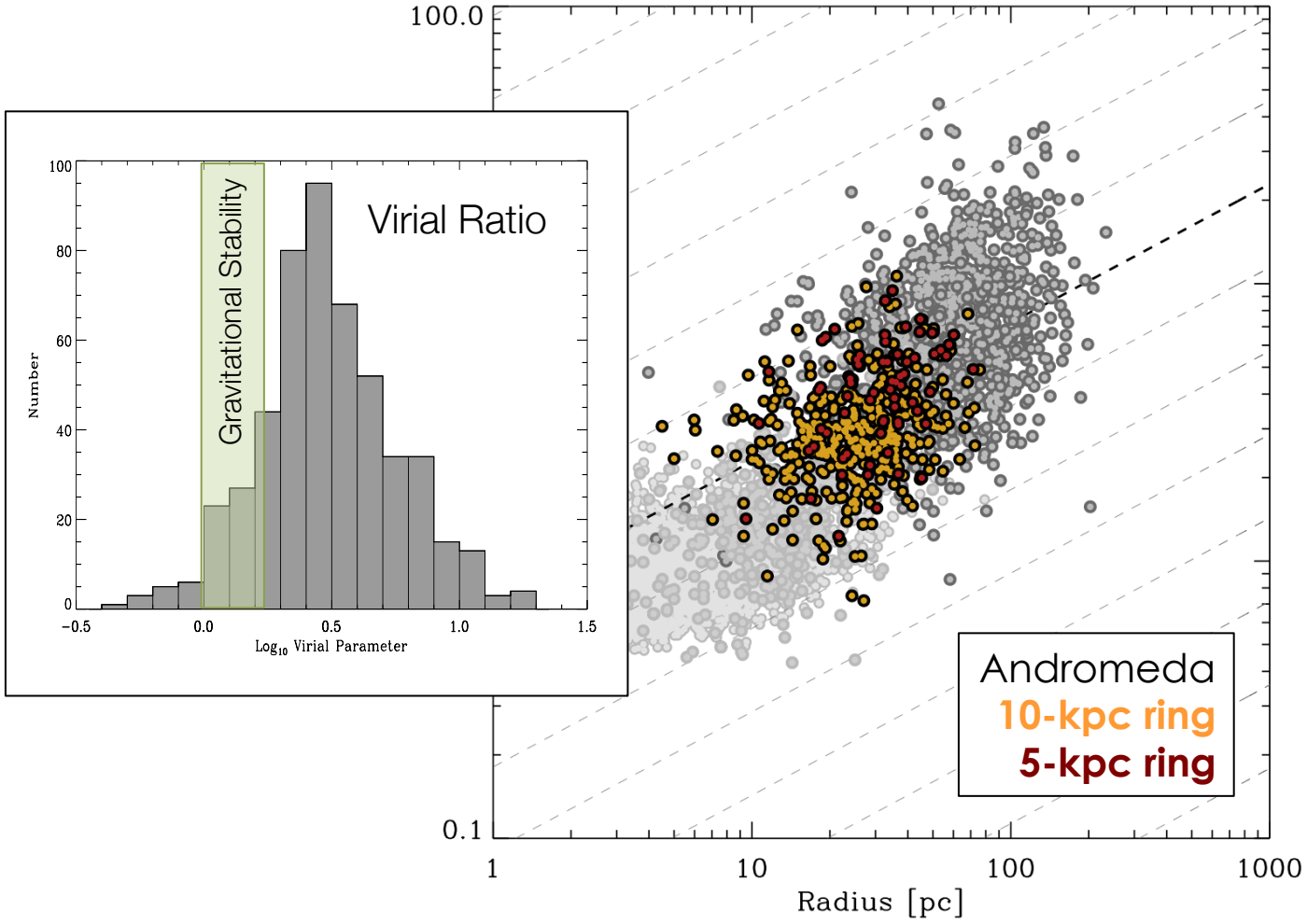
2 Surface Density of Molecular Clouds

… mass vs. radius for Milky Way and nearby SF galaxy clouds



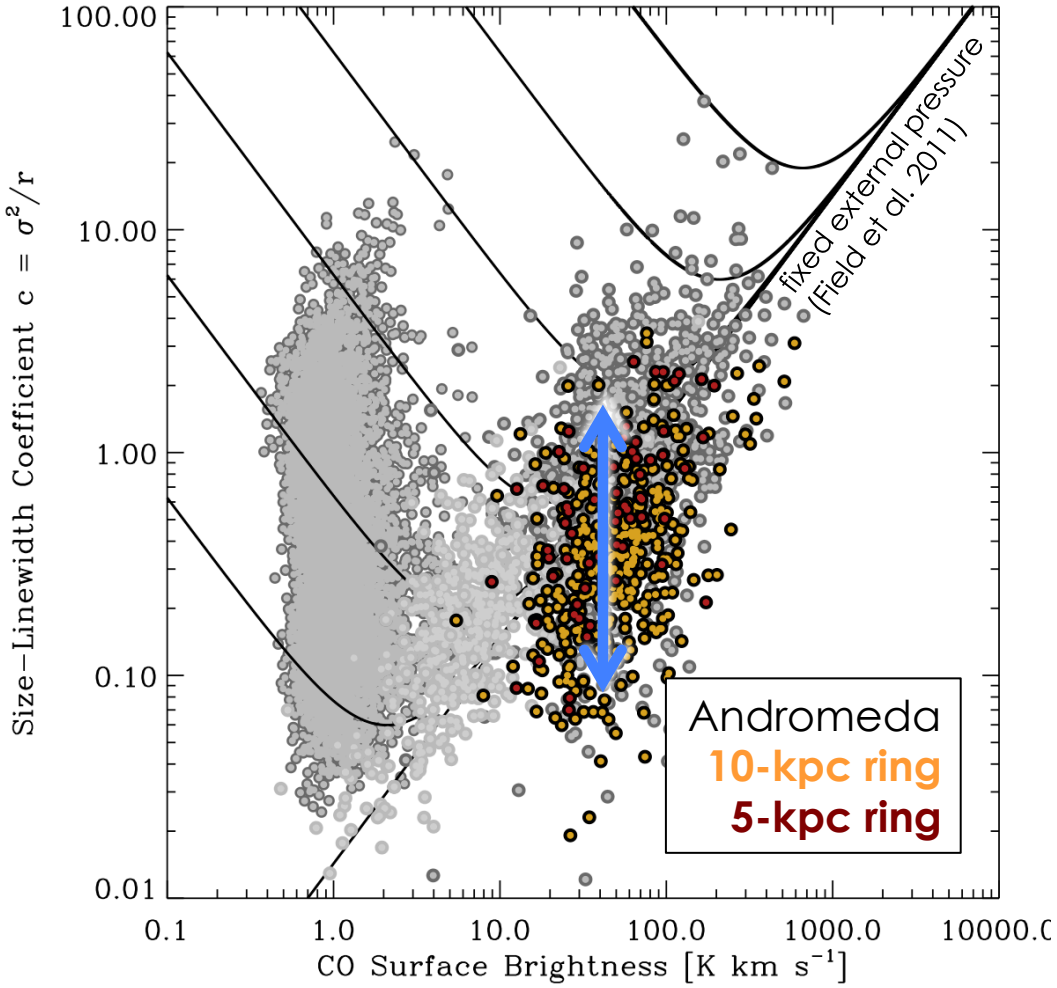
2 Turbulence of Molecular Clouds

… line width vs. radius for Milky Way and nearby SF galaxy clouds

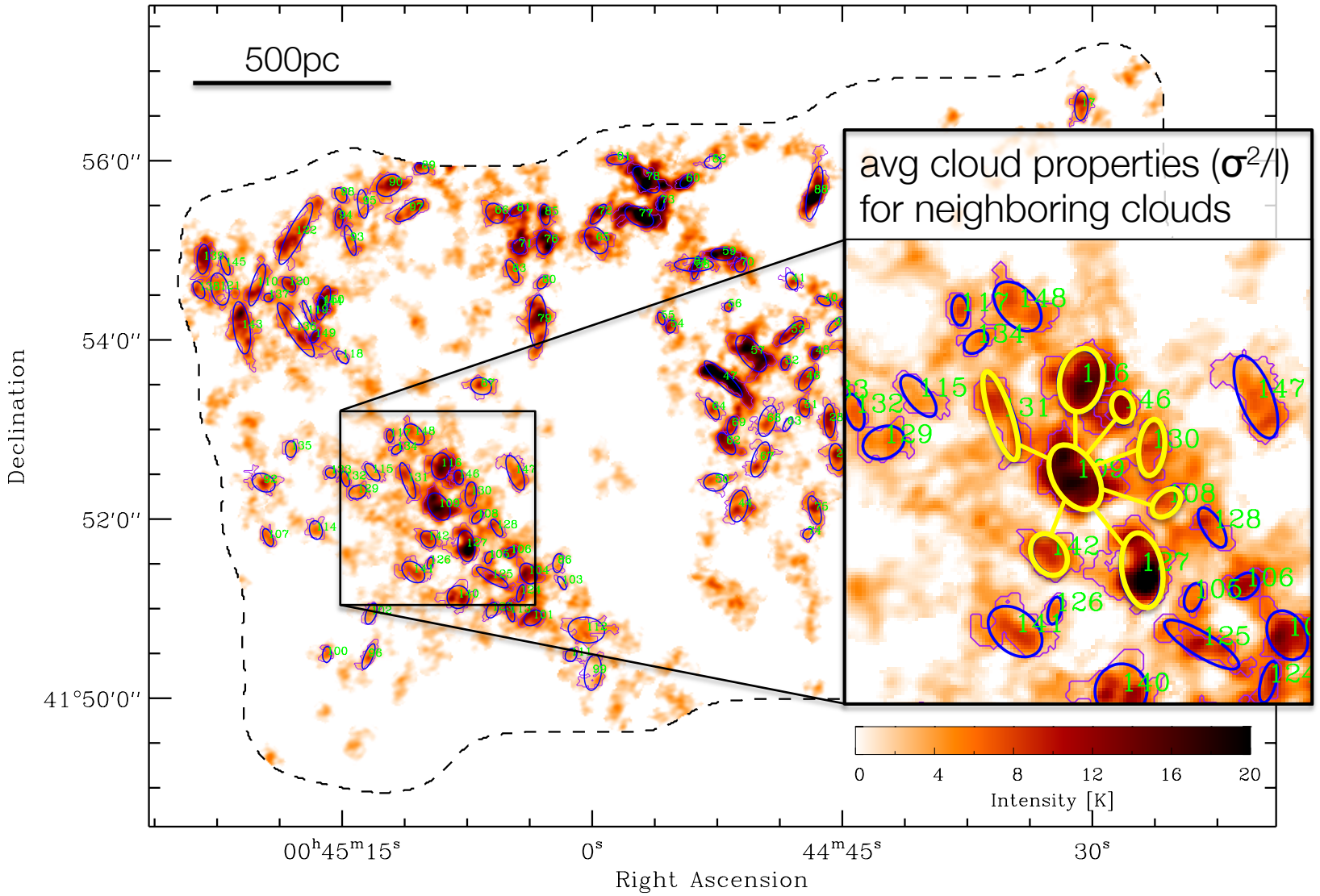


2 Turbulence of Molecular Clouds

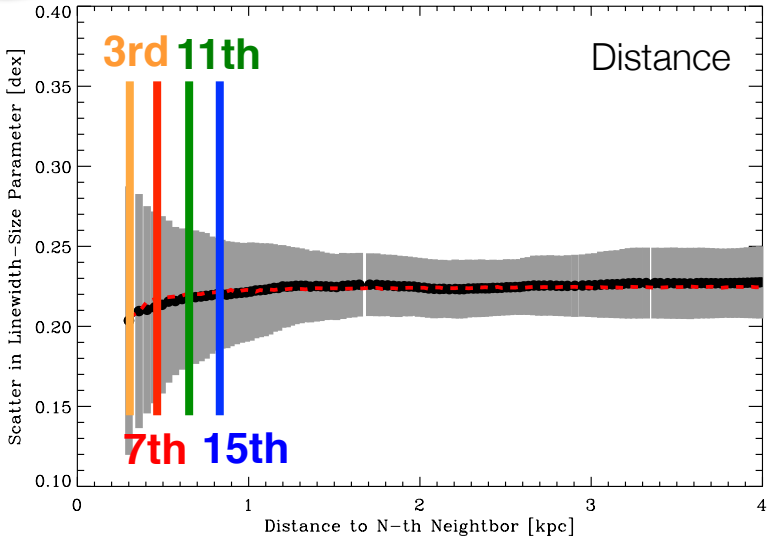
… concordance of properties (ie offsets) of neighboring clouds?

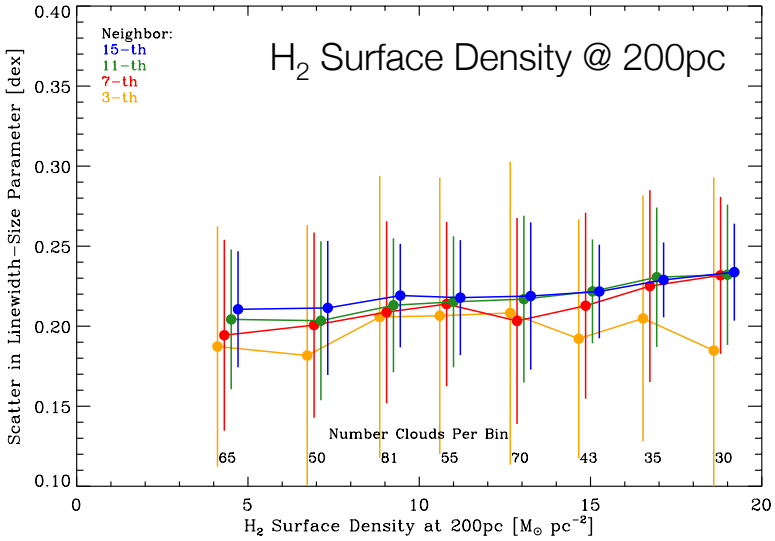


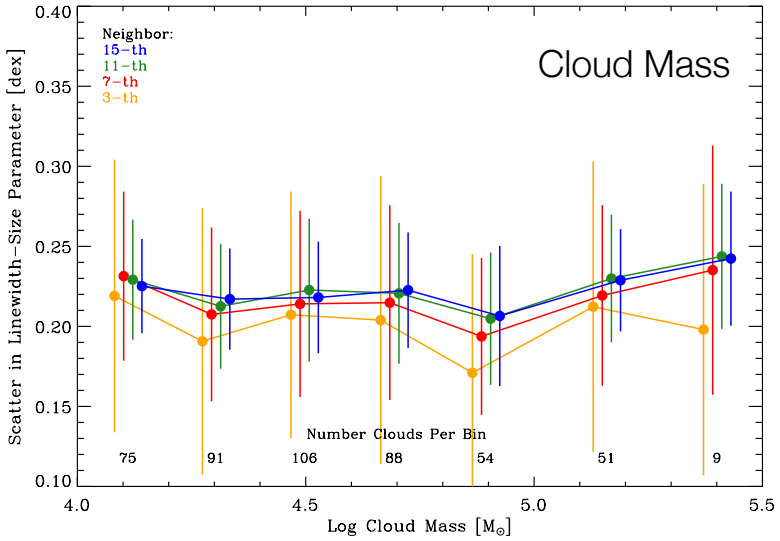
3 Concordance of Cloud Properties?

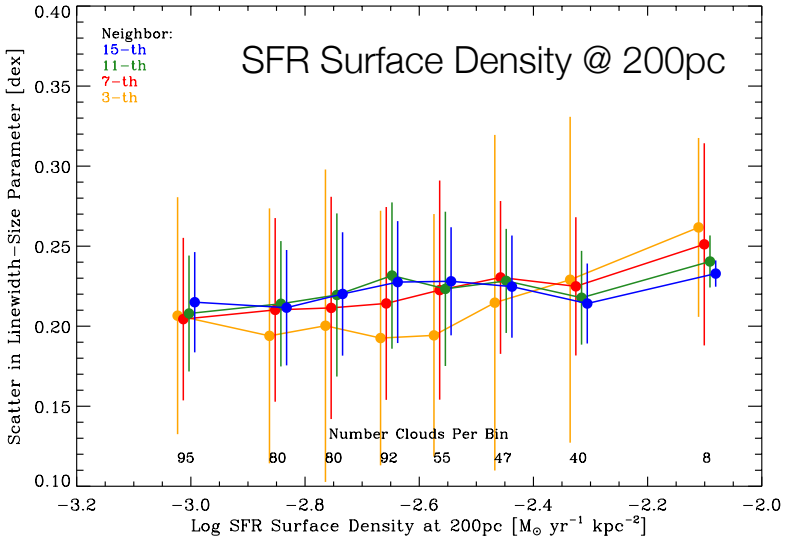


3 Concordance of Cloud Internal Properties?

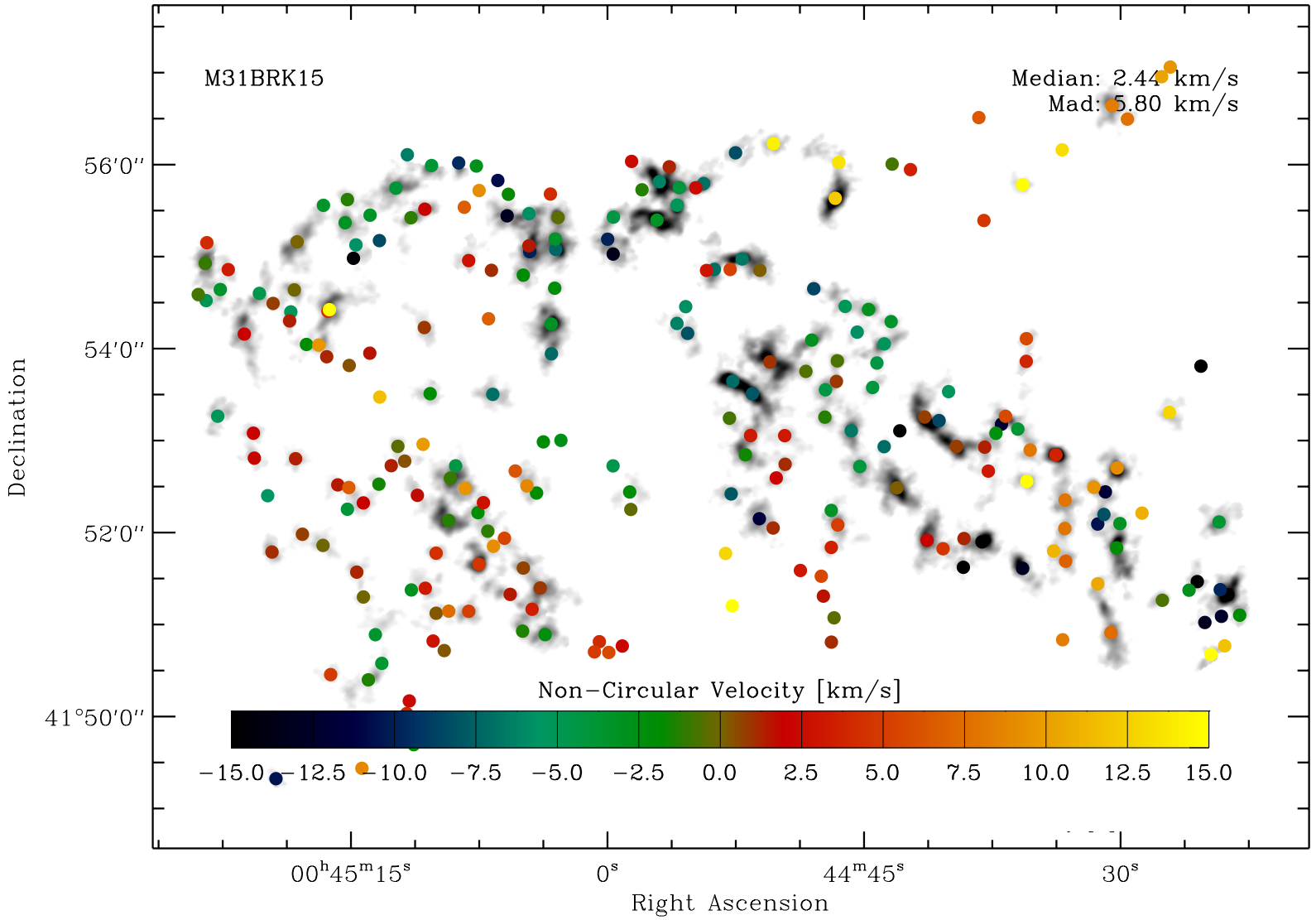




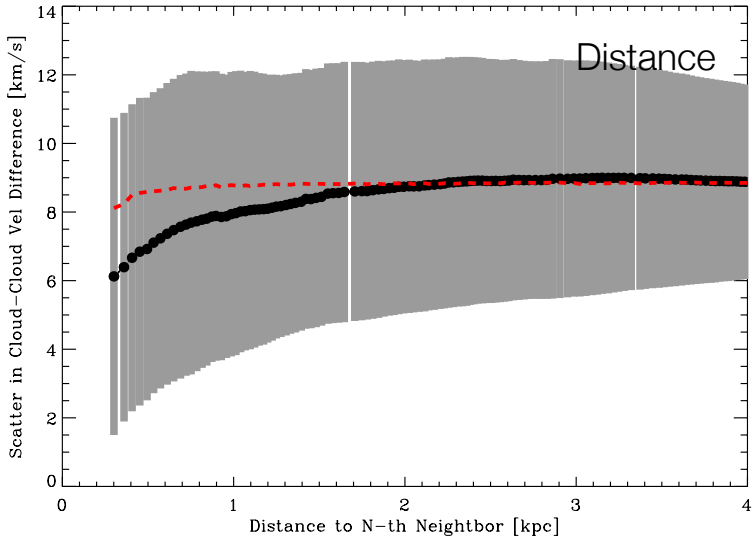


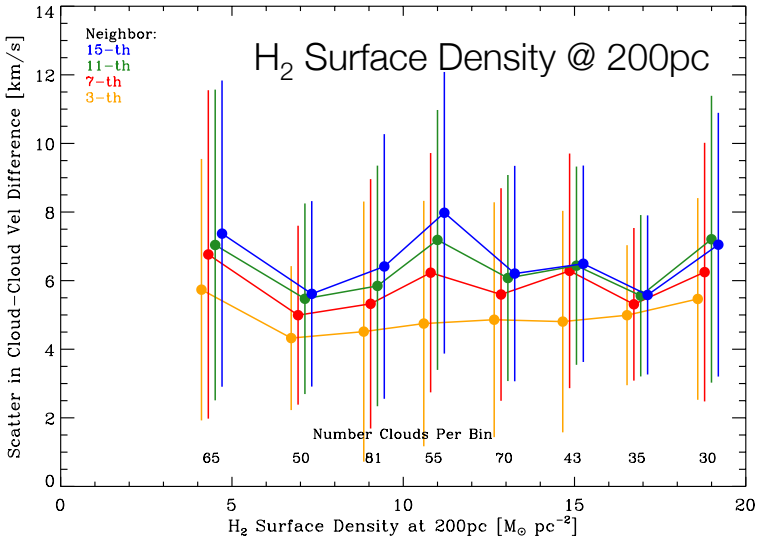


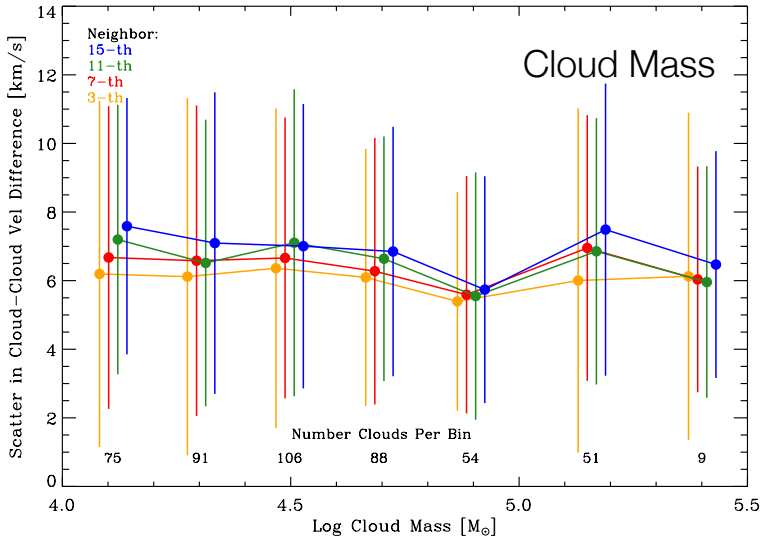
3 Concordance of Cloud-to-Cloud Motions?

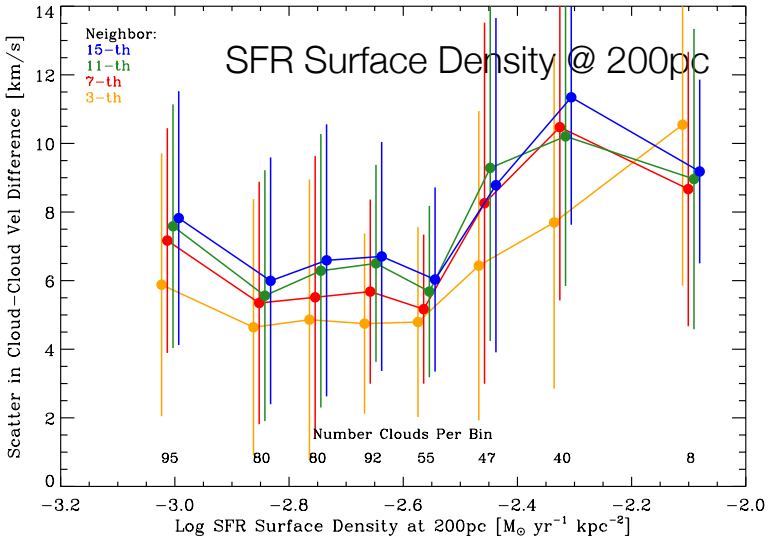


3 Concordance of Cloud-to-Cloud Motions?









A Short Summary

1. Evidence of diffuse molecular gas in thick disk
2. Molecular Clouds don't have uniform properties
3. Neighboring Clouds have uncorrelated properties