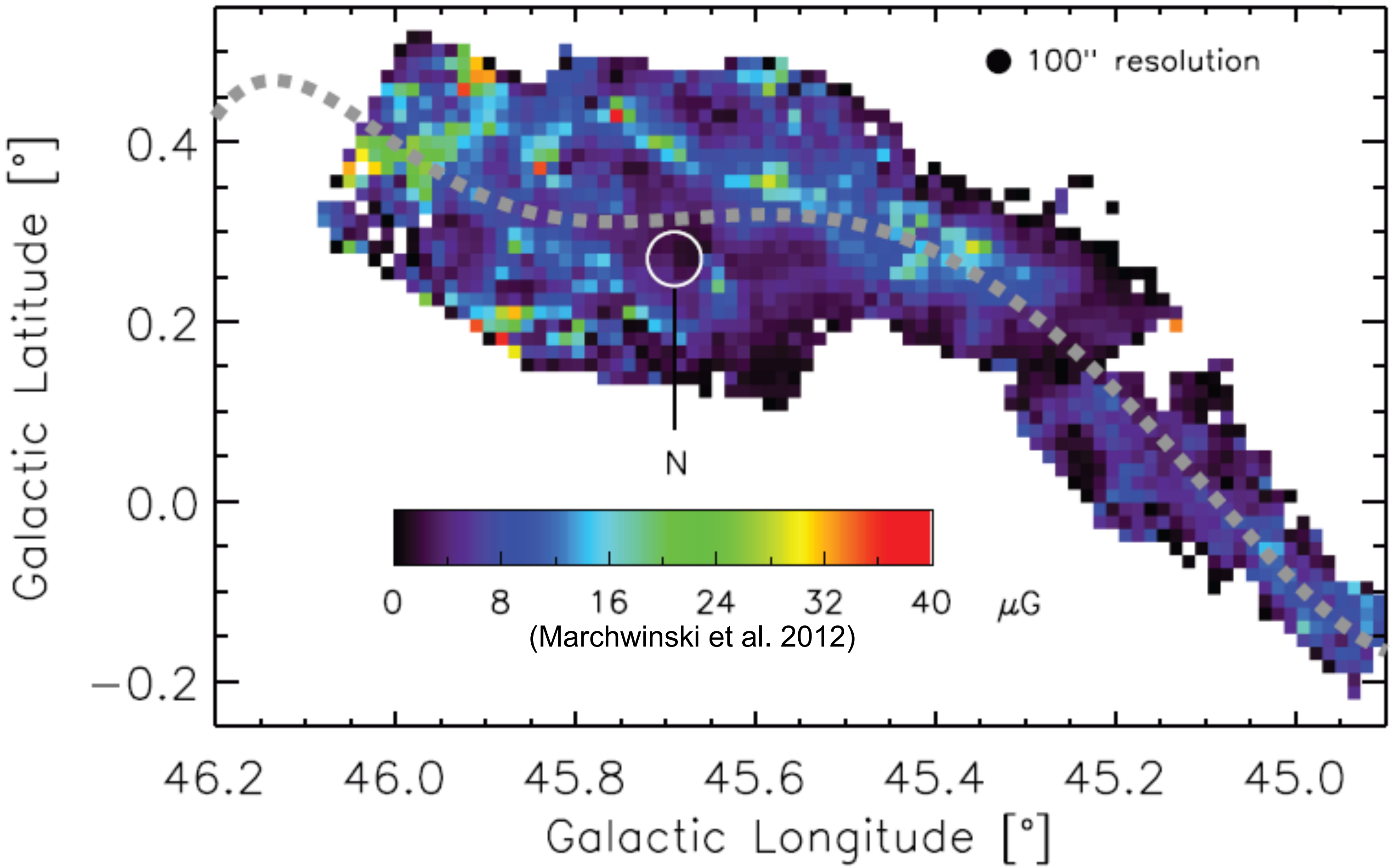
The Resolved Magnetic Fields of the Quiescent Cloud GRSMC 45.60+0.30



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Goal: Measure magnetic field strengths across a quiescent cloud.

Method: Combine

1) Starlight polarimetry (α)
2) ^{13}CO spectra (ρ, σ_v)
3) Chandrasekhar-Fermi method

to estimate the ***plane-of-the-sky*** magnetic field strength.

$$B = 0.5 \left(\frac{4}{3} \pi \, \rho \right)^{0.5} \frac{\sigma_v}{\alpha} \; [\mu\mathrm{G}]$$

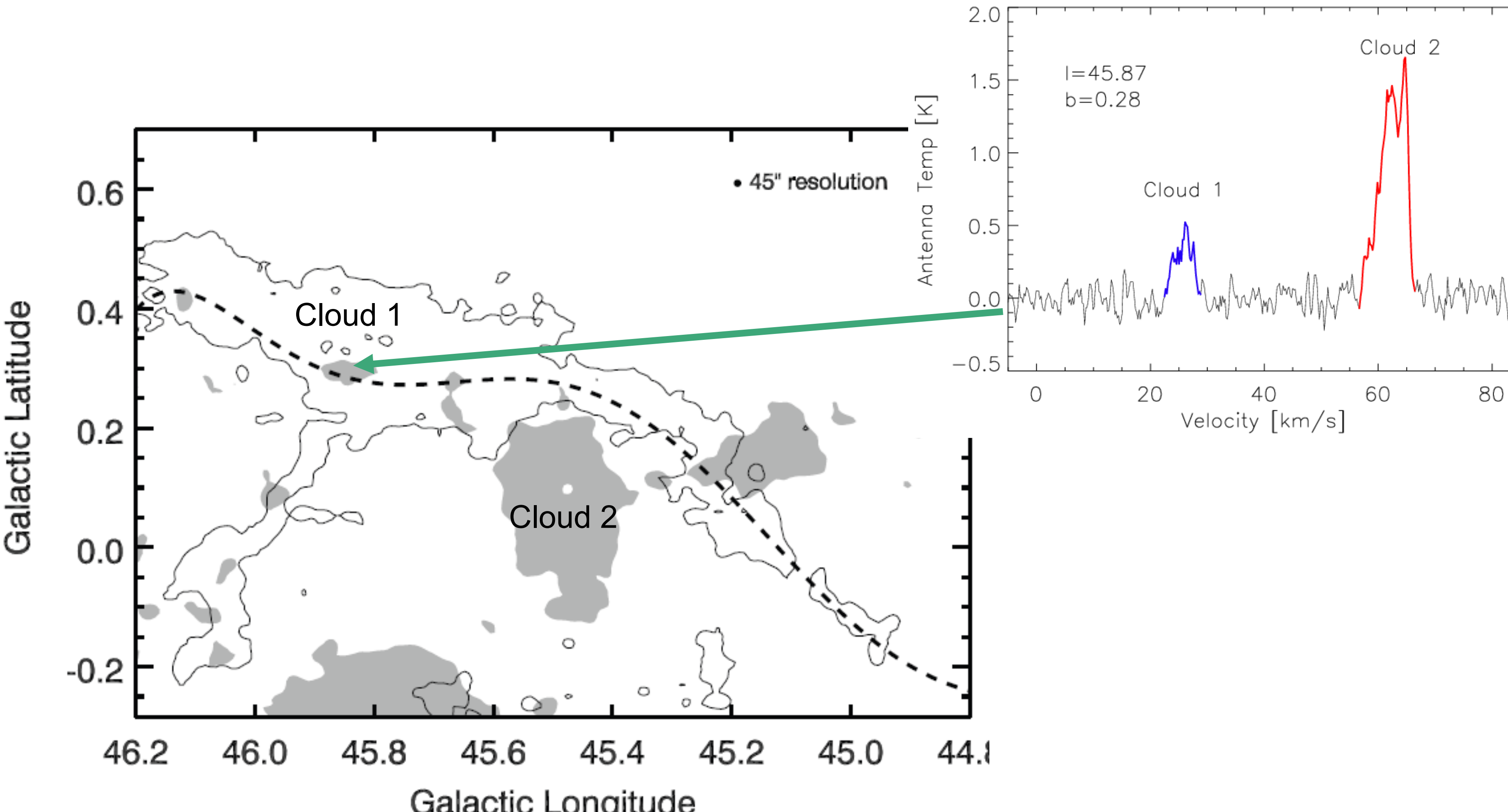
(Chandrasekhar & Fermi 1953b; Ostriker et al. 2001)

ρ - volume mass density
σ_v - gas velocity dispersion
α - angular dispersion of the starlight polarimetry

Cloud Properties

Cloud Desig.	Identifier	Distance[a] (kpc)	$V_{\rm LSR}$ Range[b] (km s^{-1})	Extent (pc)	Mass[b] ($M_\odot$)
GRSMC 45.60+0.30	Cloud 1	1.88	22.0–30.0	45 × 22	17,000
GRSMC 45.46+0.05	Cloud 2	7.45	50.0–66.0	75 × 53	49,000

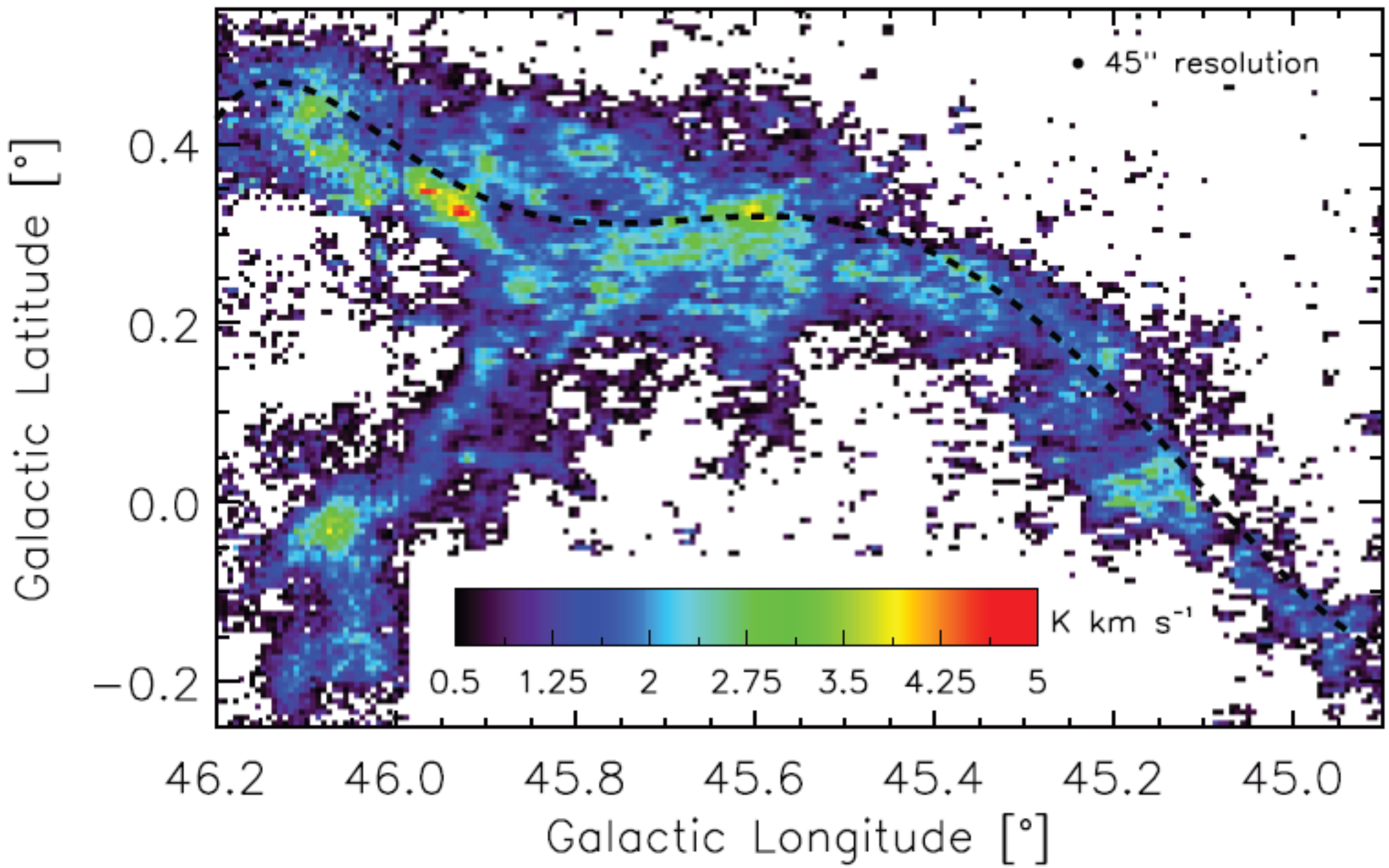
Notes.
[a] Roman-Duval et al. (2009).
[b] Simon et al. (2001).



Data from Galactic Ring Survey (GRS; Jackson et al. 2006)

Cloud 1 is quiescent:

- No GLIMPSE 4.5μm diffuse emission (EGO/Green Fuzzy)
- No BOLOCAM point sources
- No star formation activity seen in IRAS, MIPSGAL, MSX, or WISE

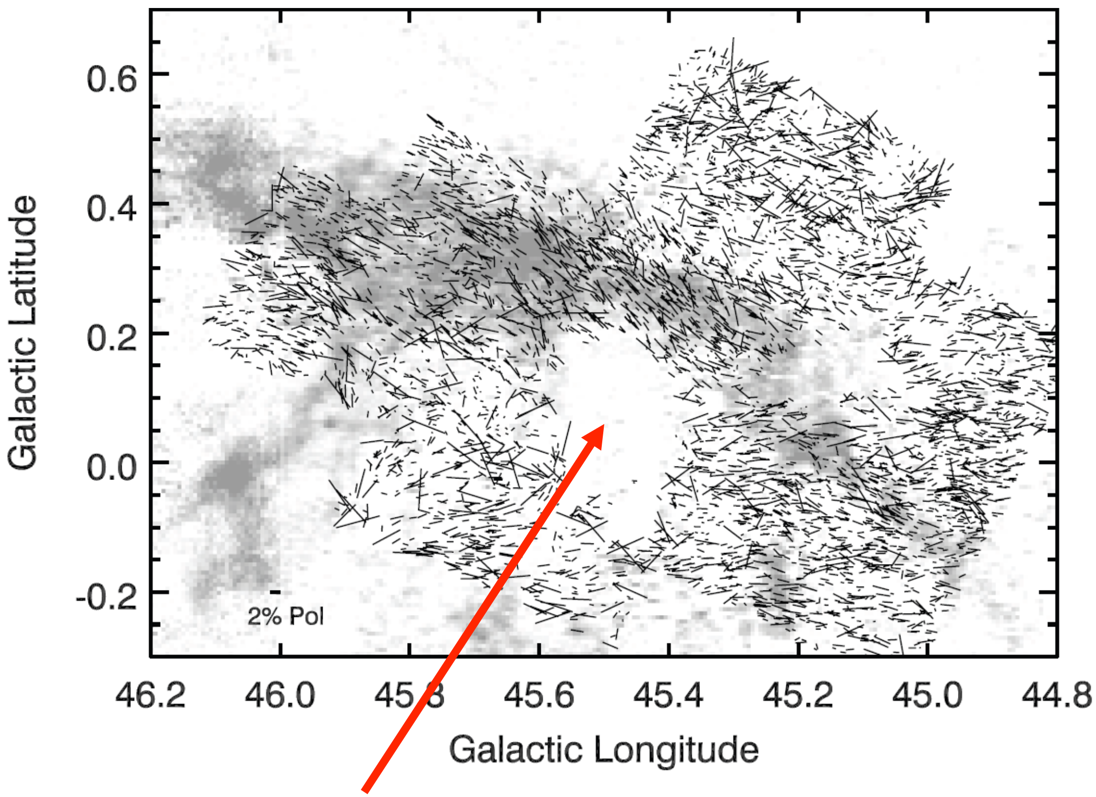


(13CO integrated intensity of cloud 1 from GRS)

H-band (1.6μm) starlight polarimetry

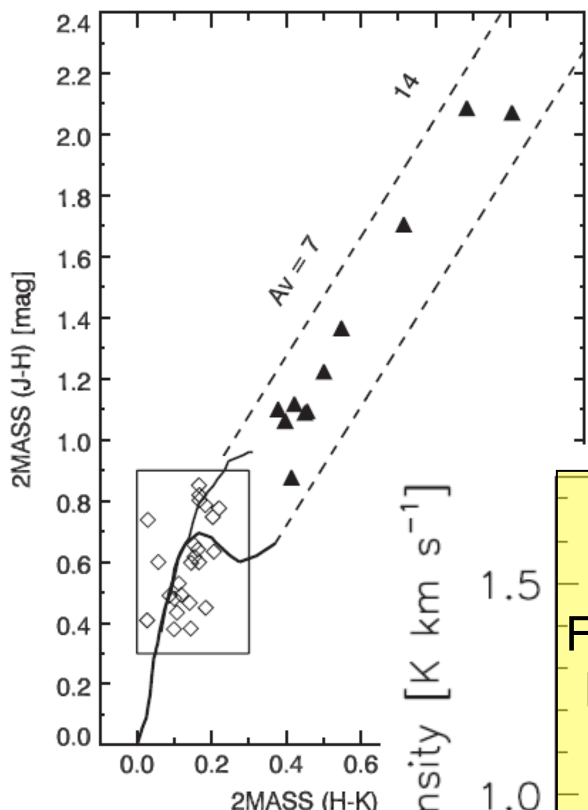
Galactic Plane Infrared Polarization Survey
(GPIPS; Clemens et al. 2012a,b,c)

Polarimetrically spans 7 < H < 12th mag



Stars overlapping with cloud 2 were removed to prevent contamination

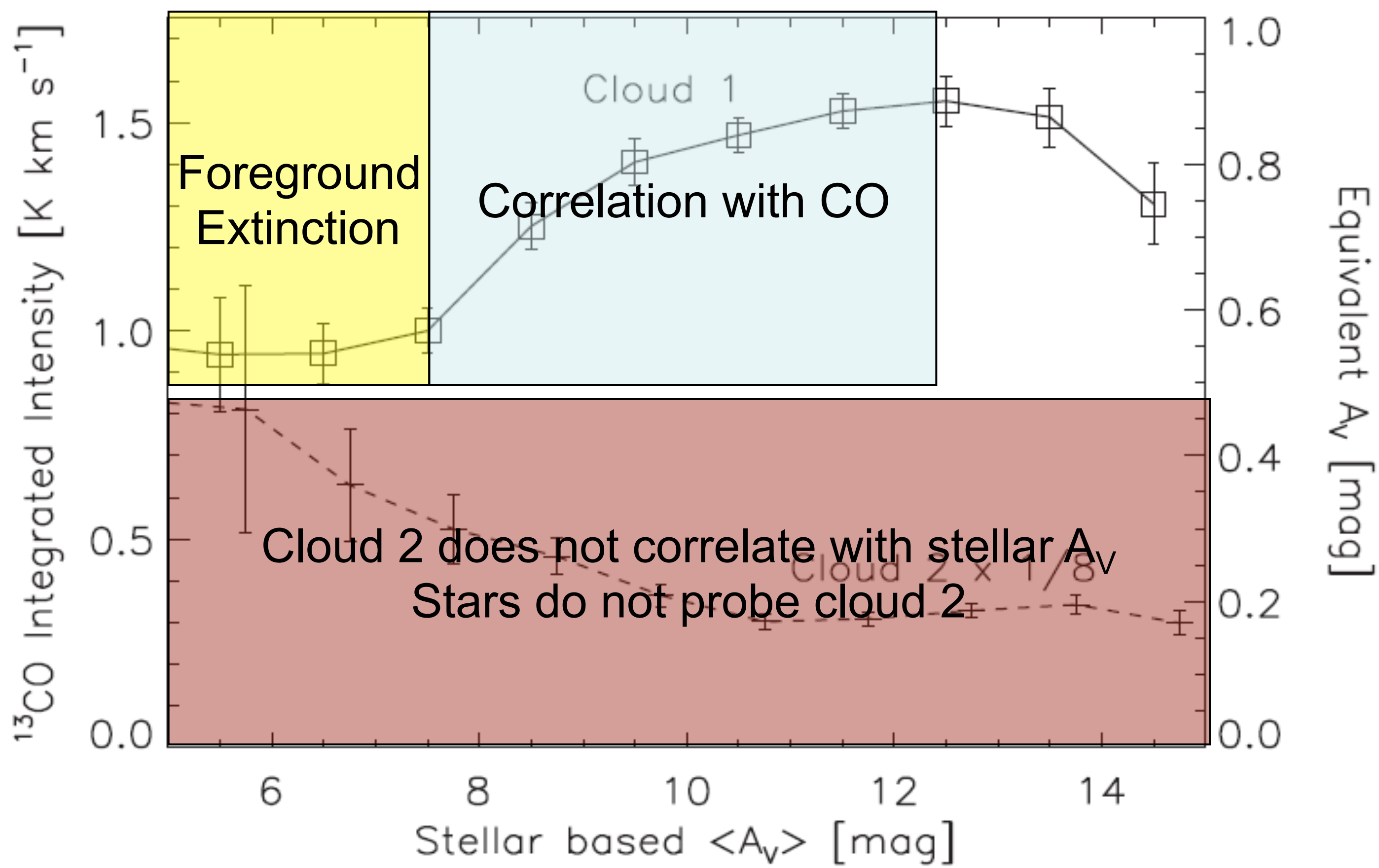
Cloud 1 Polarizes and Extincts Starlight

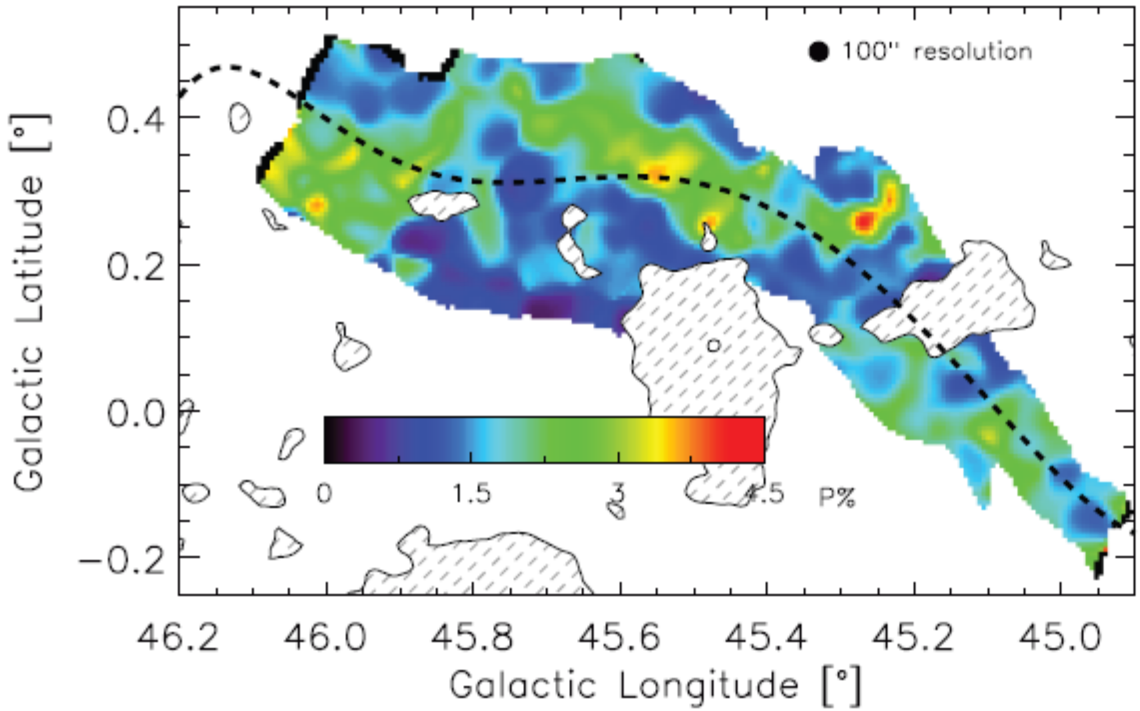


$$A_V \approx r' E(H-K)$$ r'~16 (Whittet et al. 1996)

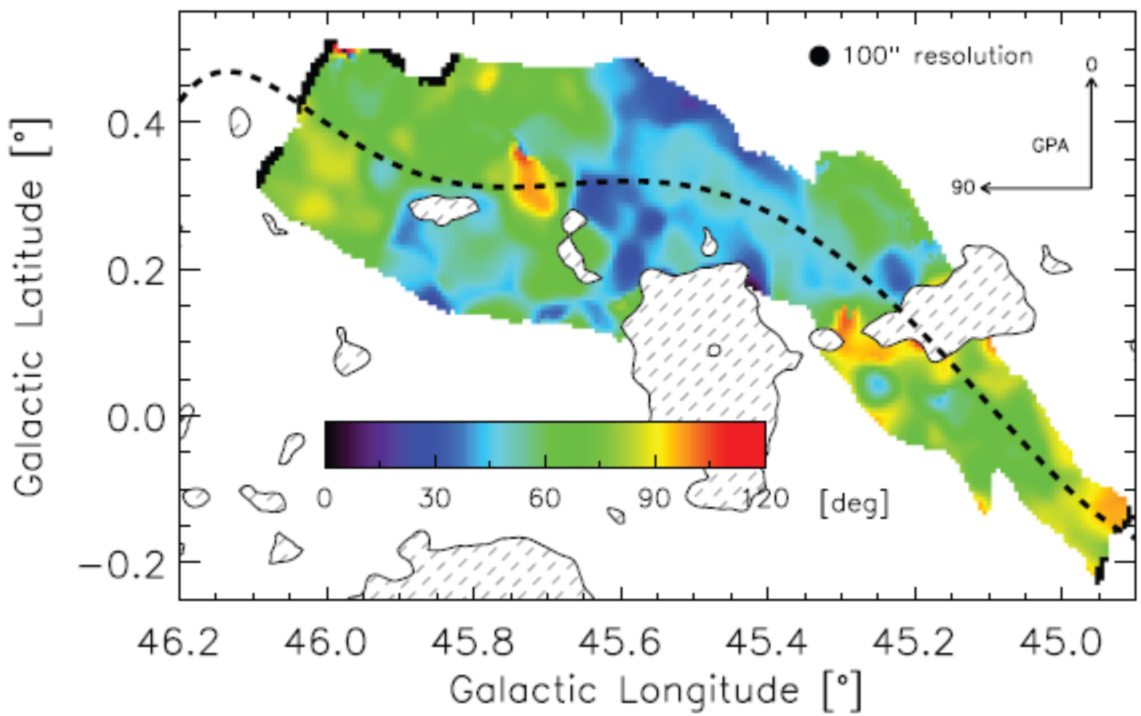
$$E(H-K) = (H-K)_{2MASS} - \langle (H-K)_{intrinsic} \rangle$$

$\langle (H-K)_{intrinsic} \rangle$ is 0.13 ± 0.01 mag (Lada et al. 1994)





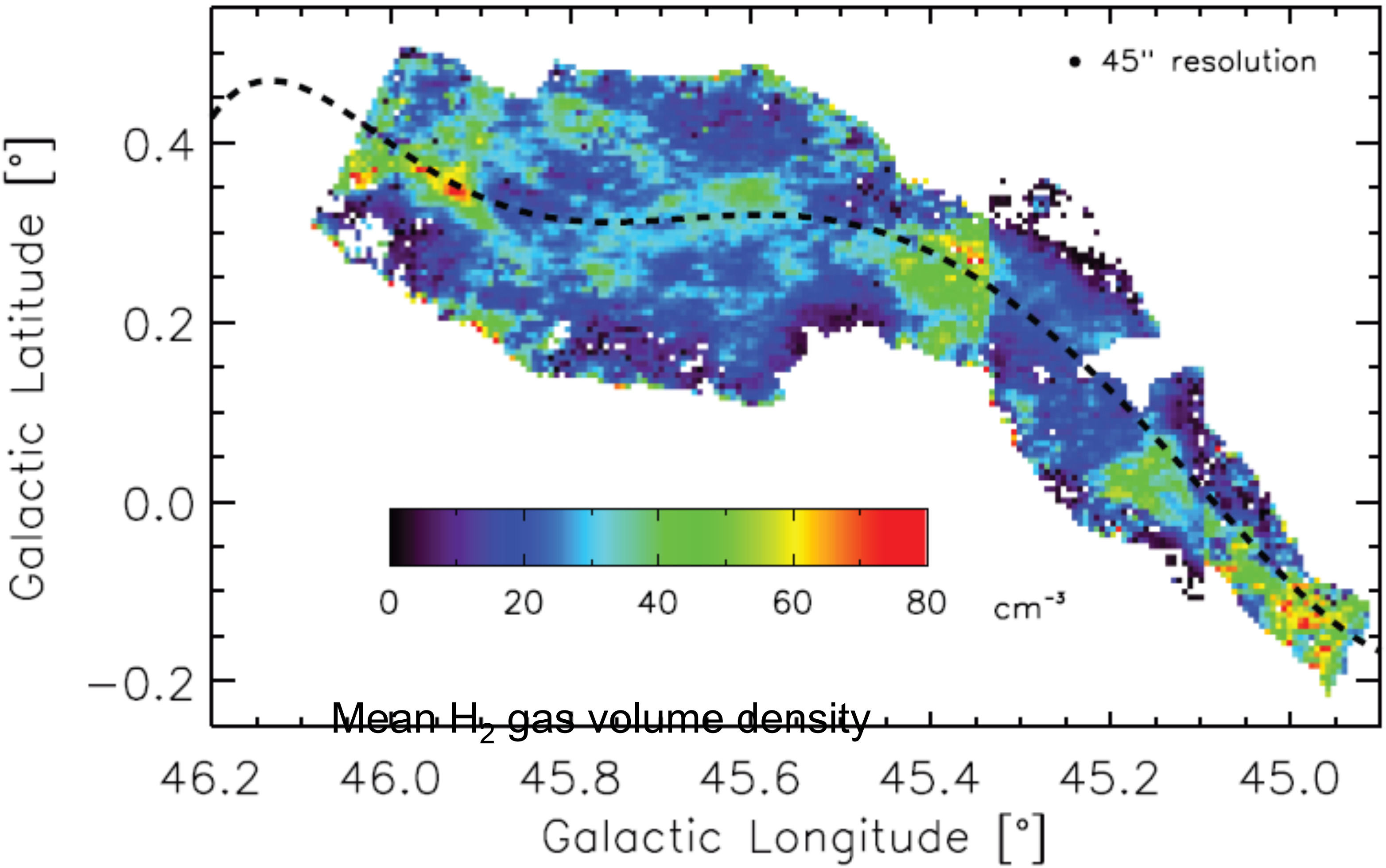
Mean Polarization



Mean polarization
Galactic Position Angle

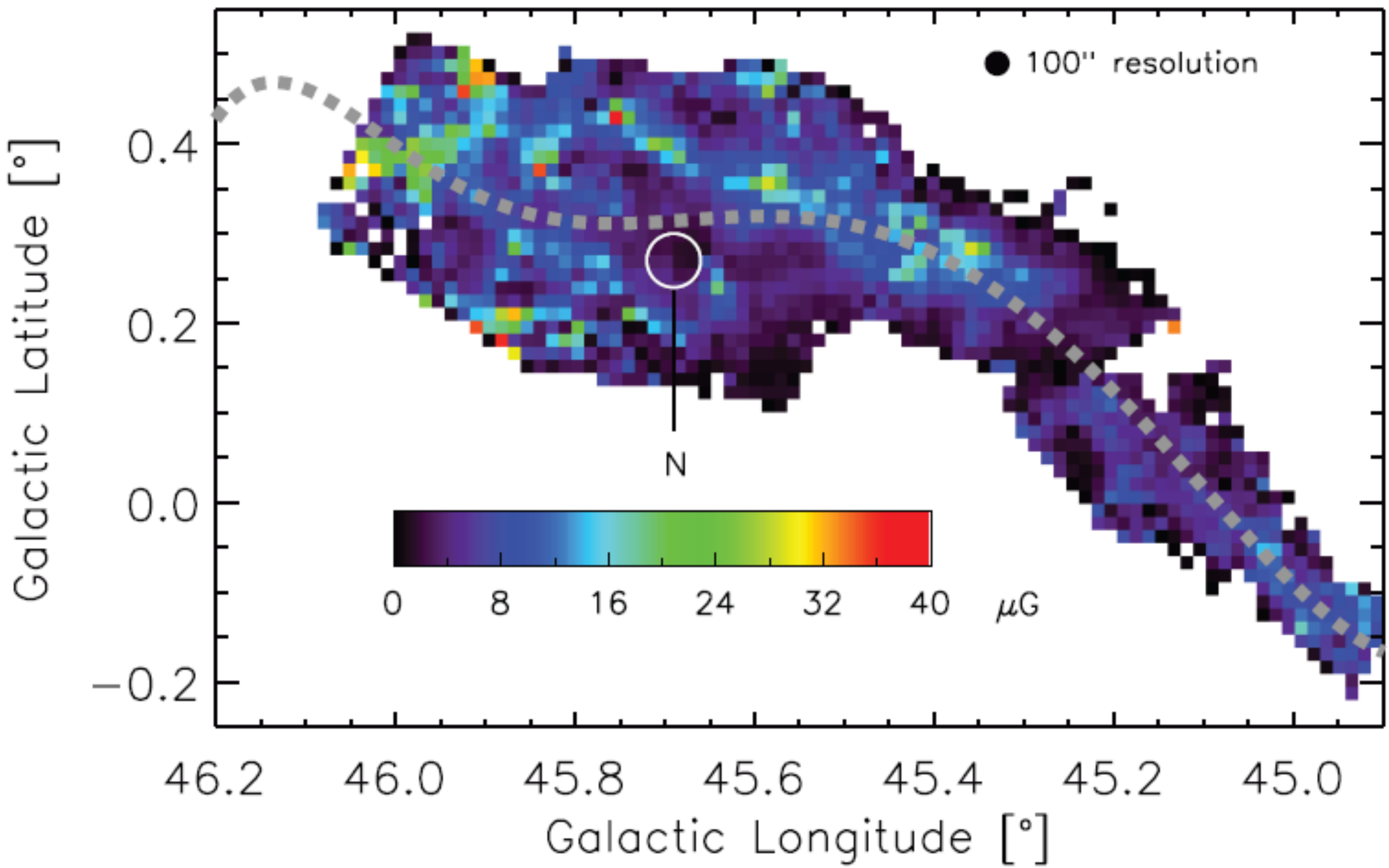
Mean cloud density is 26 cm^{-3}

Total mass of H_2 + He is 15,700 solar masses

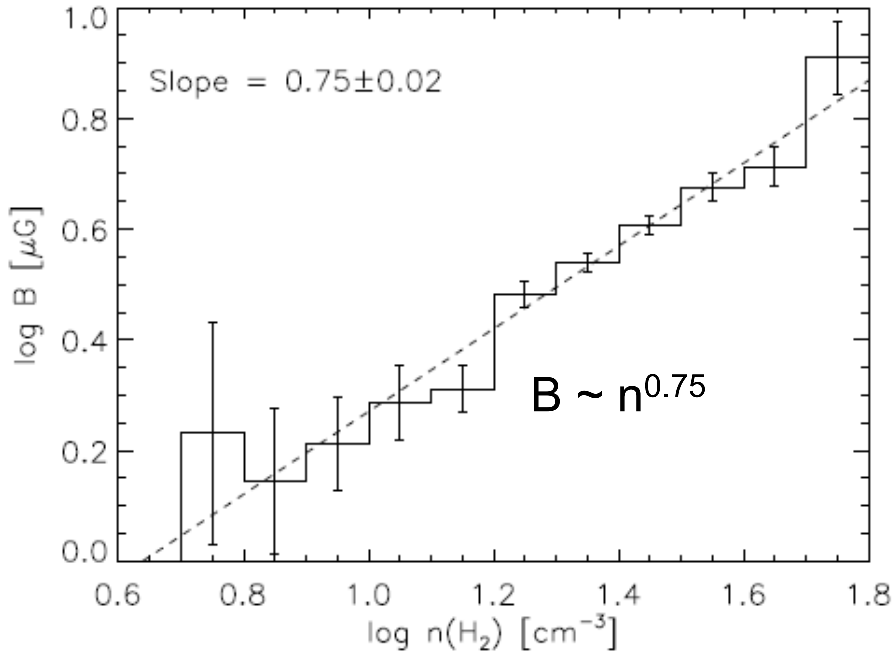


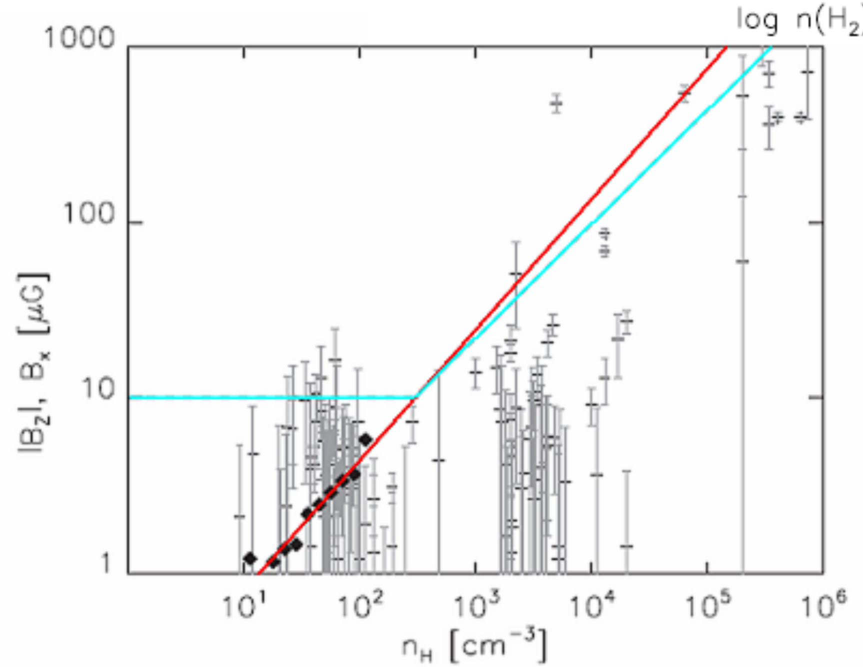
Mean H_2 gas volume density

(Dashed line represents the ‘spine’ of the cloud)



100'' resolution
N
0
8
16
24
32
40
μG
0.4
0.2
0.0
−0.2
Galactic Latitude [°]
46.2
46.0
45.8
45.6
45.4
45.2
45.0
Galactic Longitude [°]





Zeeman measurements from Crutcher et al. (2010)

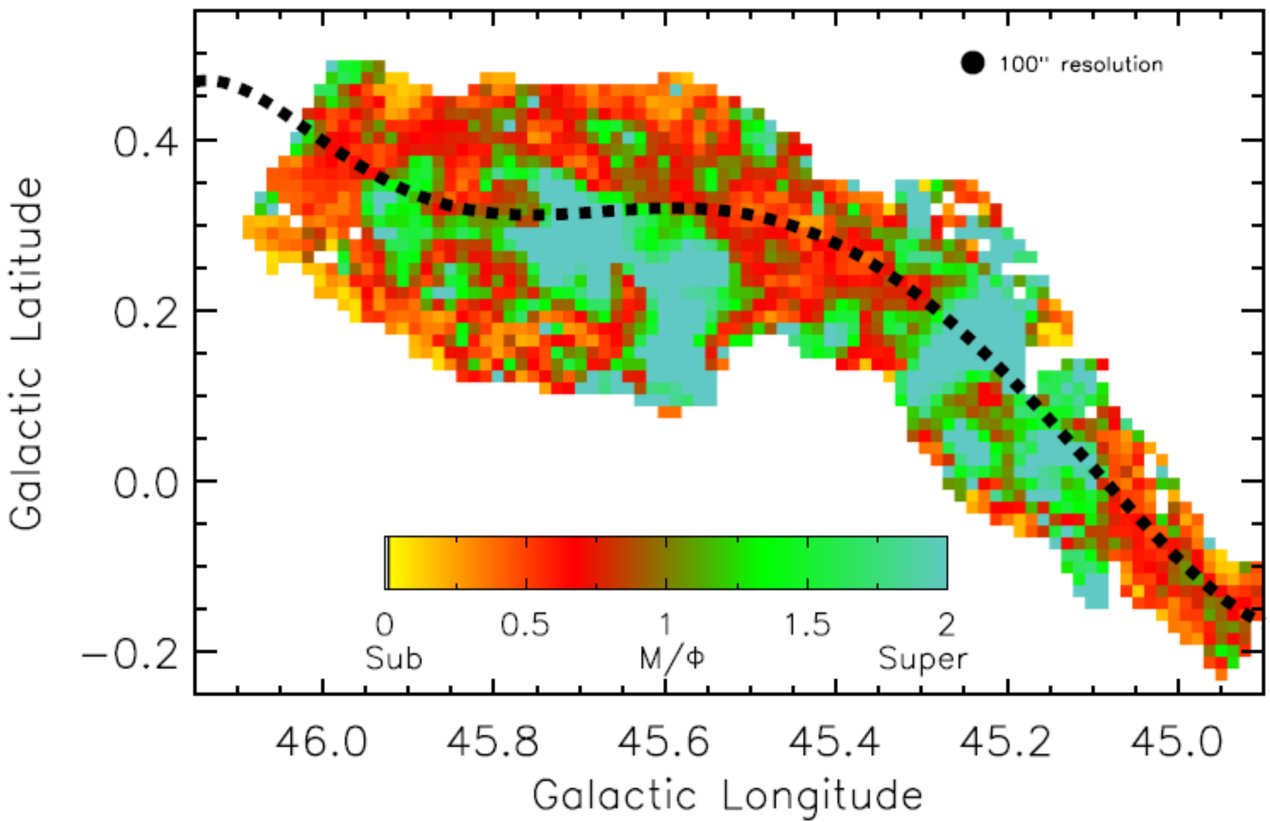
B-n_H is continuous over 5 orders of magnitude in gas density.

Mass-to-Flux Ratio

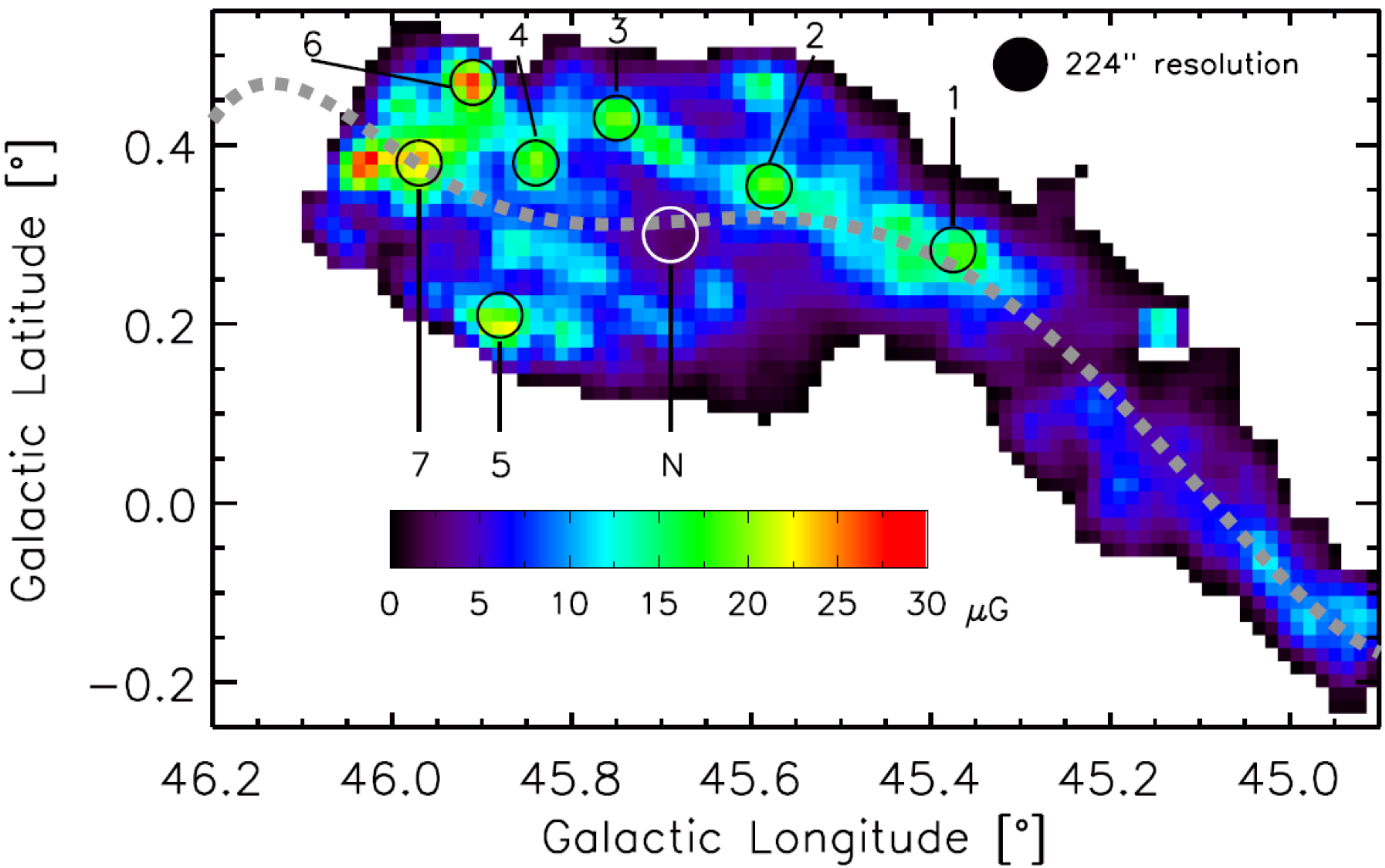
Is magnetostatic pressure able to resist gravitational collapse?

$$\frac{\mathcal{M}}{\Phi} = \frac{M/\Phi_B}{(M/\Phi_B)_{\rm crit}} = 1.0 \times 10^{-20} N(\mathrm{H}_2)/\,|B|$$ (Crutcher 1999)

MTF > 1 “supercritical” gravitationally-dominated
MTF= 1 “critical”
MTF < 1 “subcritical” magnetically-dominated



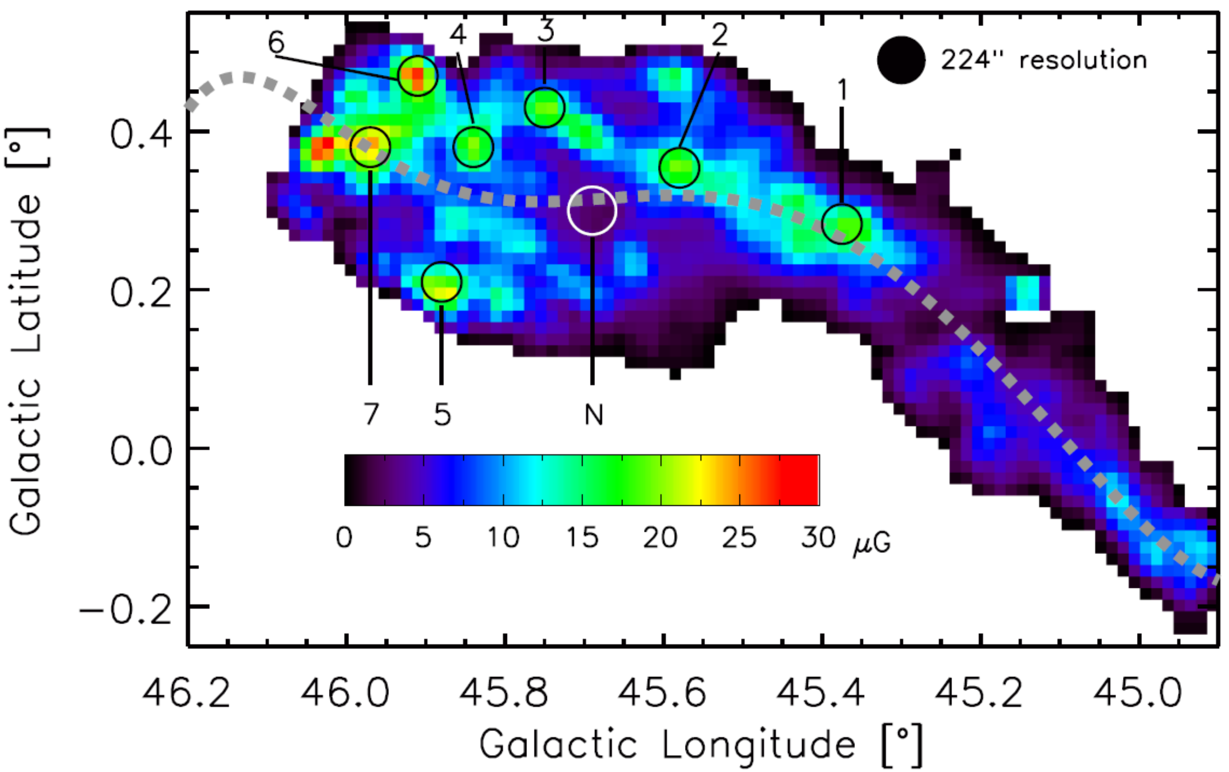
Magnetic Cores



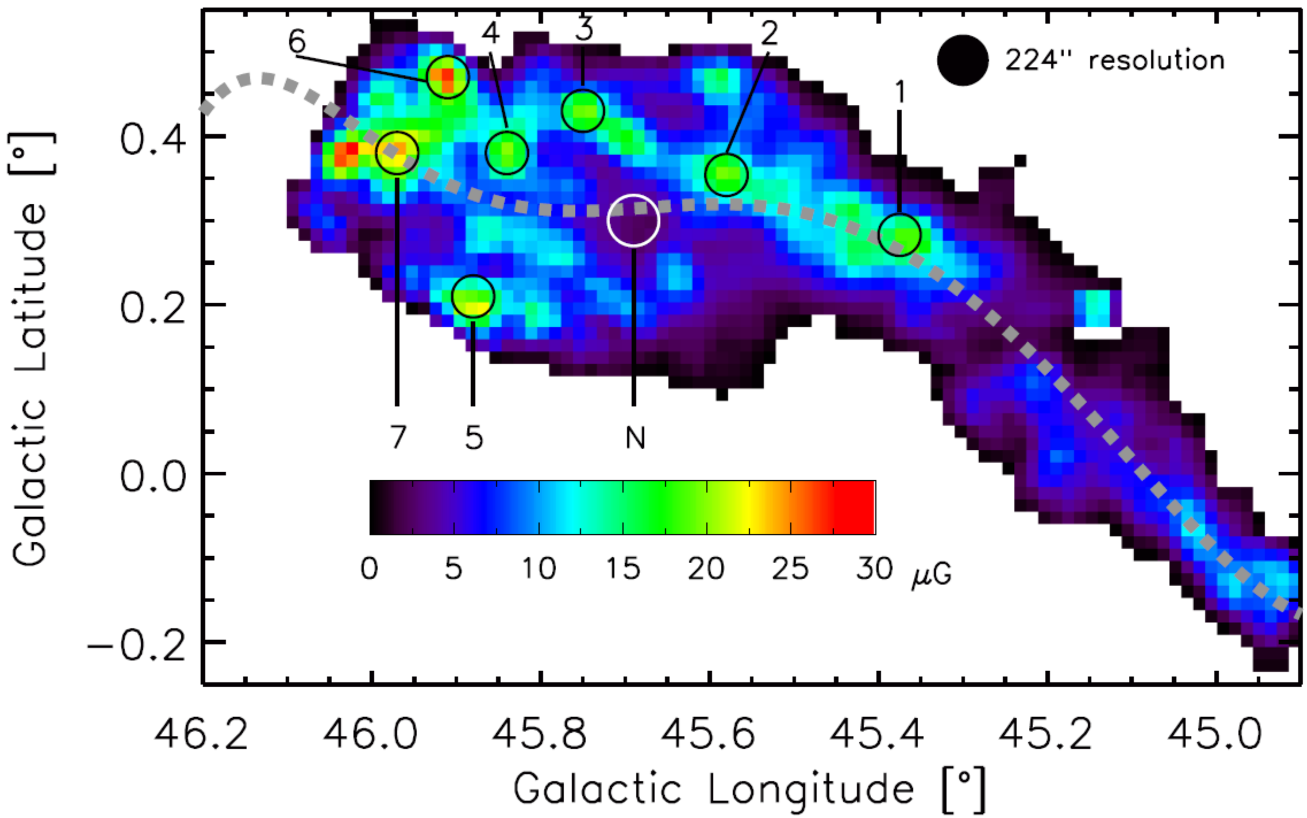
Core	ℓ (deg)	b (deg)	$\langle n_{H_2} \rangle$ (cm^{-3})	Mass ($M_\odot$)	B_{max} (μG)	$\langle B \rangle$ (μG)	Radius (pc)	$\overline{M/\Phi}$
1	45.38	0.24	44.8 ± 1.5	162 ± 3	30 ± 4	7.7 ± 0.2	1.77 ± 0.05	0.78 ± 0.04
2	45.60	0.32	33.5 ± 1.7	121 ± 2	30 ± 7	10.7 ± 0.4	1.14 ± 0.02	0.92 ± 0.06
3	45.75	0.39	27.6 ± 1.2	118 ± 3	42 ± 10	6.7 ± 0.2	1.45 ± 0.09	0.79 ± 0.07
4	45.85	0.35	26.2 ± 1.7	55 ± 2	37 ± 6	10.1 ± 0.6	1.02 ± 0.02	0.63 ± 0.07
5	45.89	0.17	40.5 ± 10.2	78 ± 2	38 ± 12	5.0 ± 0.3	1.72 ± 0.08	0.64 ± 0.07
6	45.92	0.42	29.0 ± 1.5	154 ± 3	35 ± 9	7.0 ± 0.3	1.95 ± 0.10	0.67 ± 0.04
7	45.99	0.35	38.9 ± 2.0	218 ± 5	32 ± 6	10.9 ± 0.3	1.85 ± 0.05	0.74 ± 0.06
Unweighted Means			34	129	35	8.3	1.6	0.74
Uncertainties			3	24	2	0.9	0.2	0.04

Magnetic cores are exclusively subcritical.

Since this B is a lower limit to total B, MTF is an upper limit and these results are robust.



Summary



- Resolved magnetic field strength mapping across a quiescent cloud using GPIPS
- B-n_H relationship extended to low (~10 cm^{-3}) densities
- Identification of magnetic cores coincident with column density peaks
- Magnetic cores are exclusively subcritical
    - Direct evidence for the role of magnetic fields in regulating star formation rates