The distribution of magnetic field strength in Orion A region

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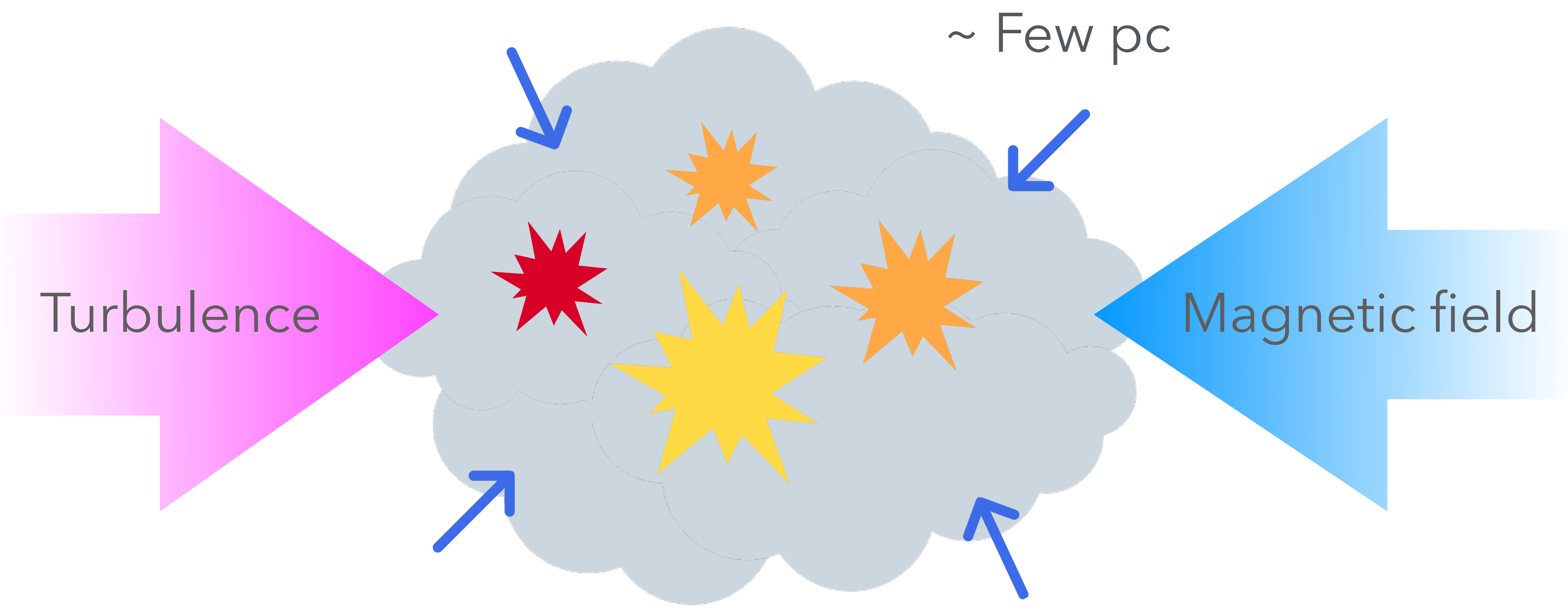
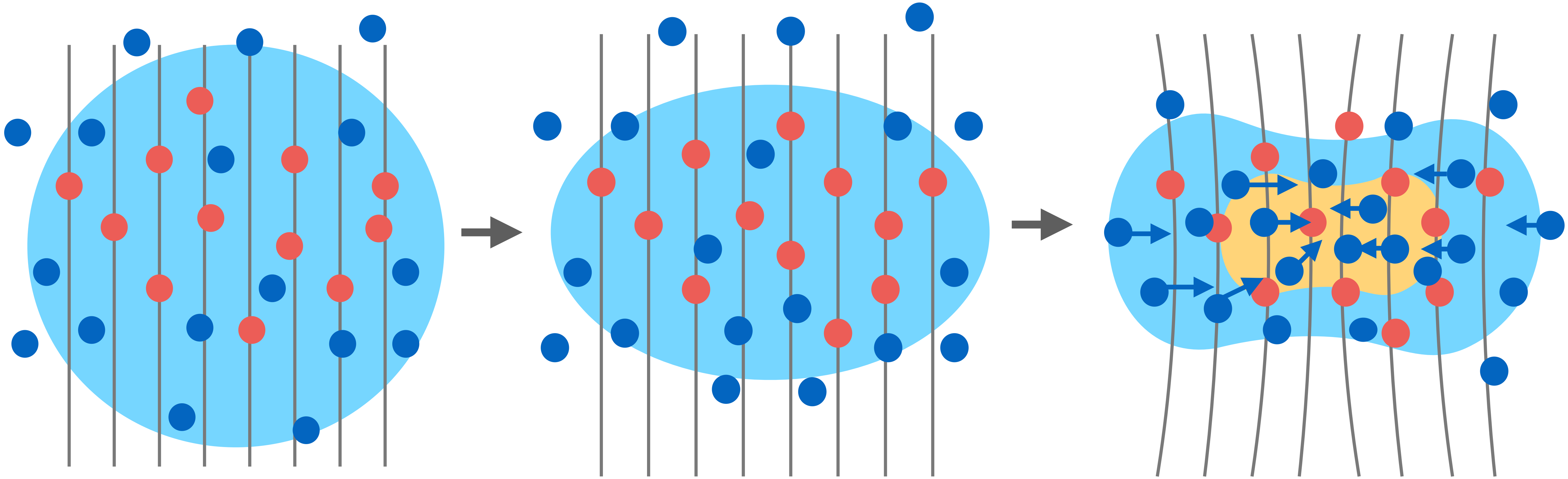
INTRODUCTION

- Star formation scenario



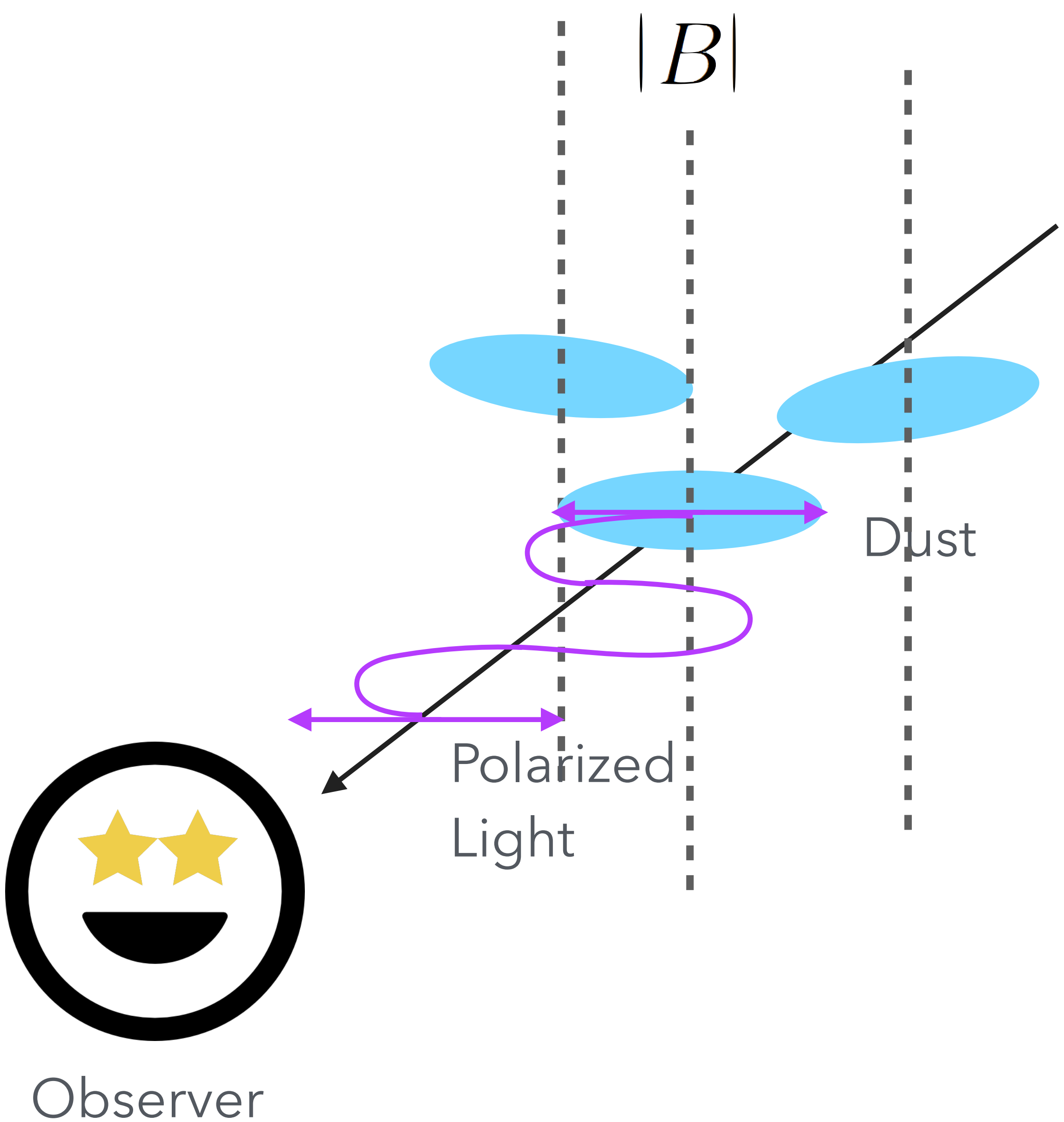
Strong field model - Ambipolar diffusion

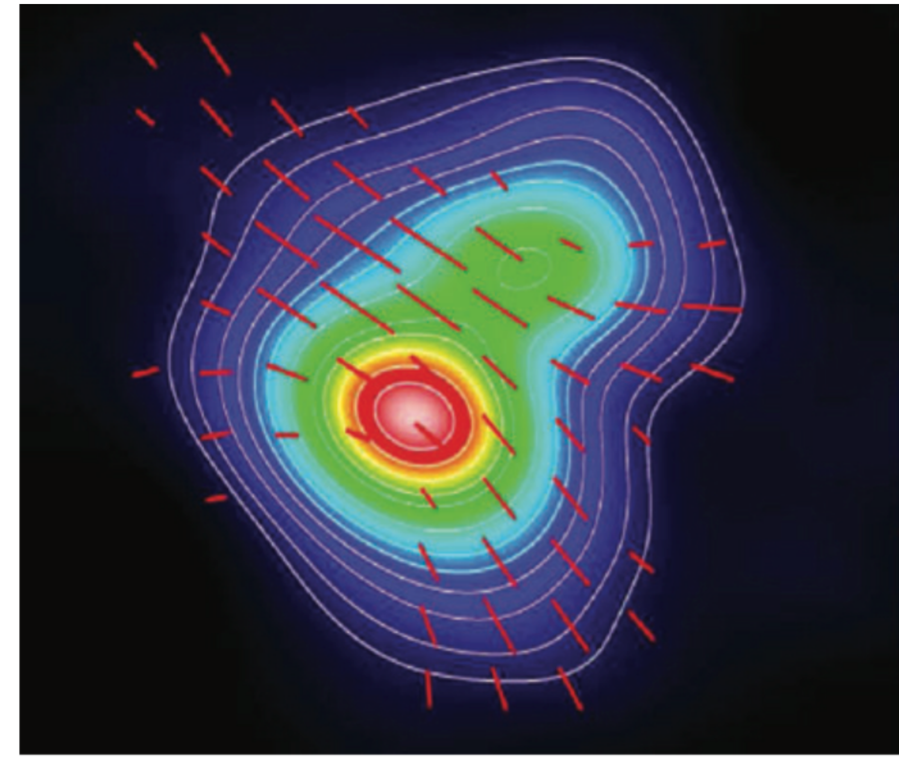
Mouschovias 1991, Mouschovias & Ciolek 1999

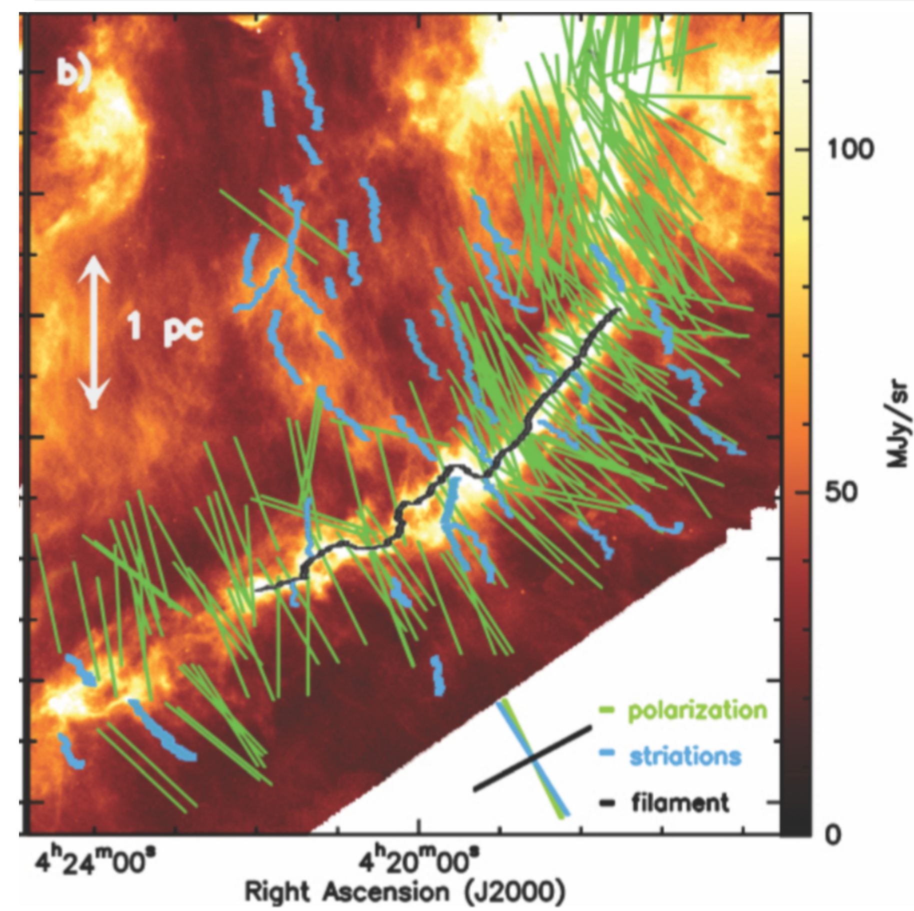


Charged particle (ion,electron..)   Neutral particle

Polarization





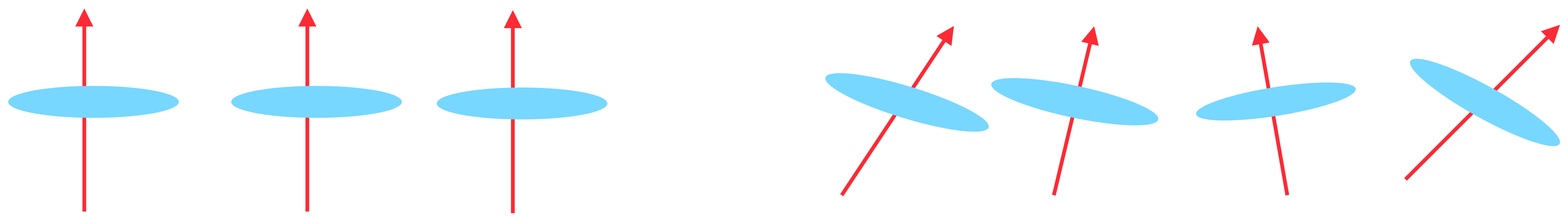


Girart, Rao & Marrone 2006
P. Palmeirim et al 2013

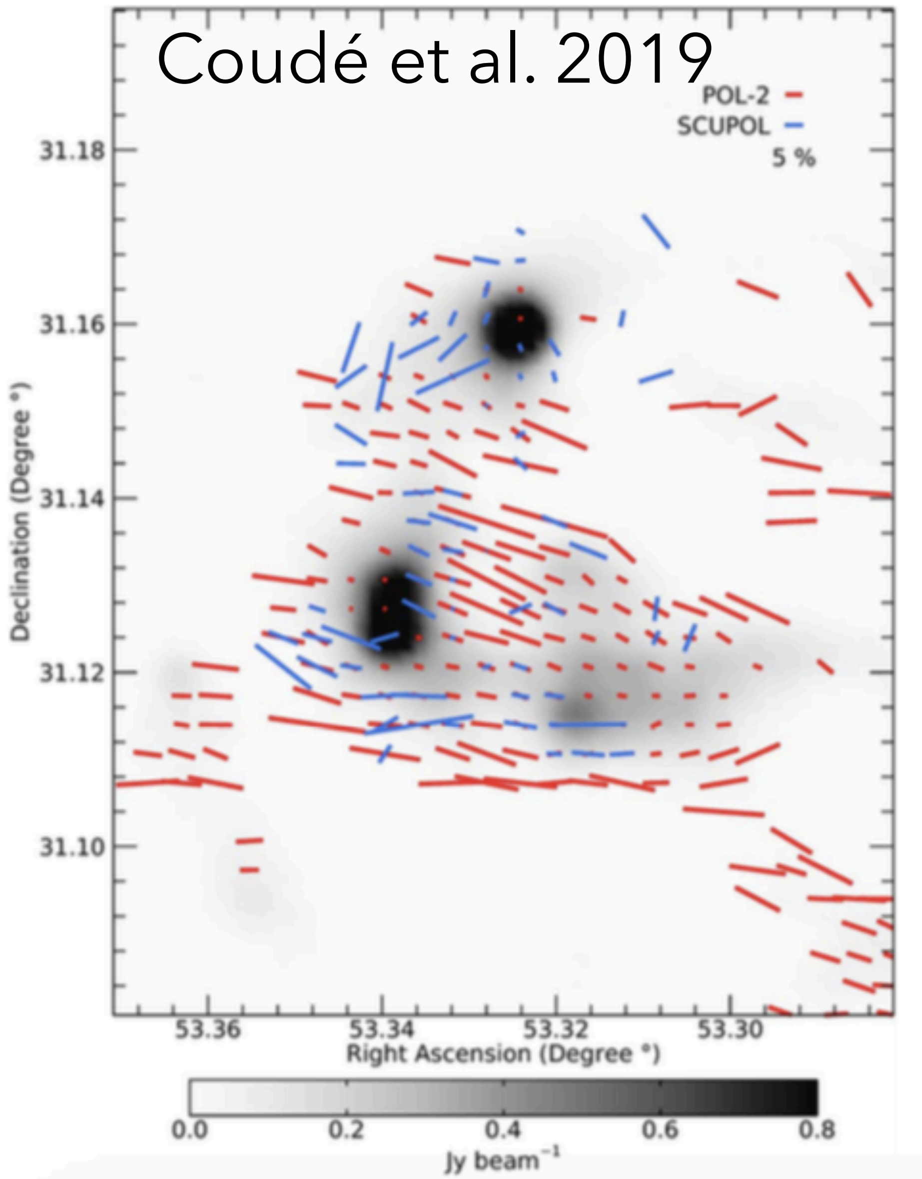
Chandrasekhar-Fermi (CF) method

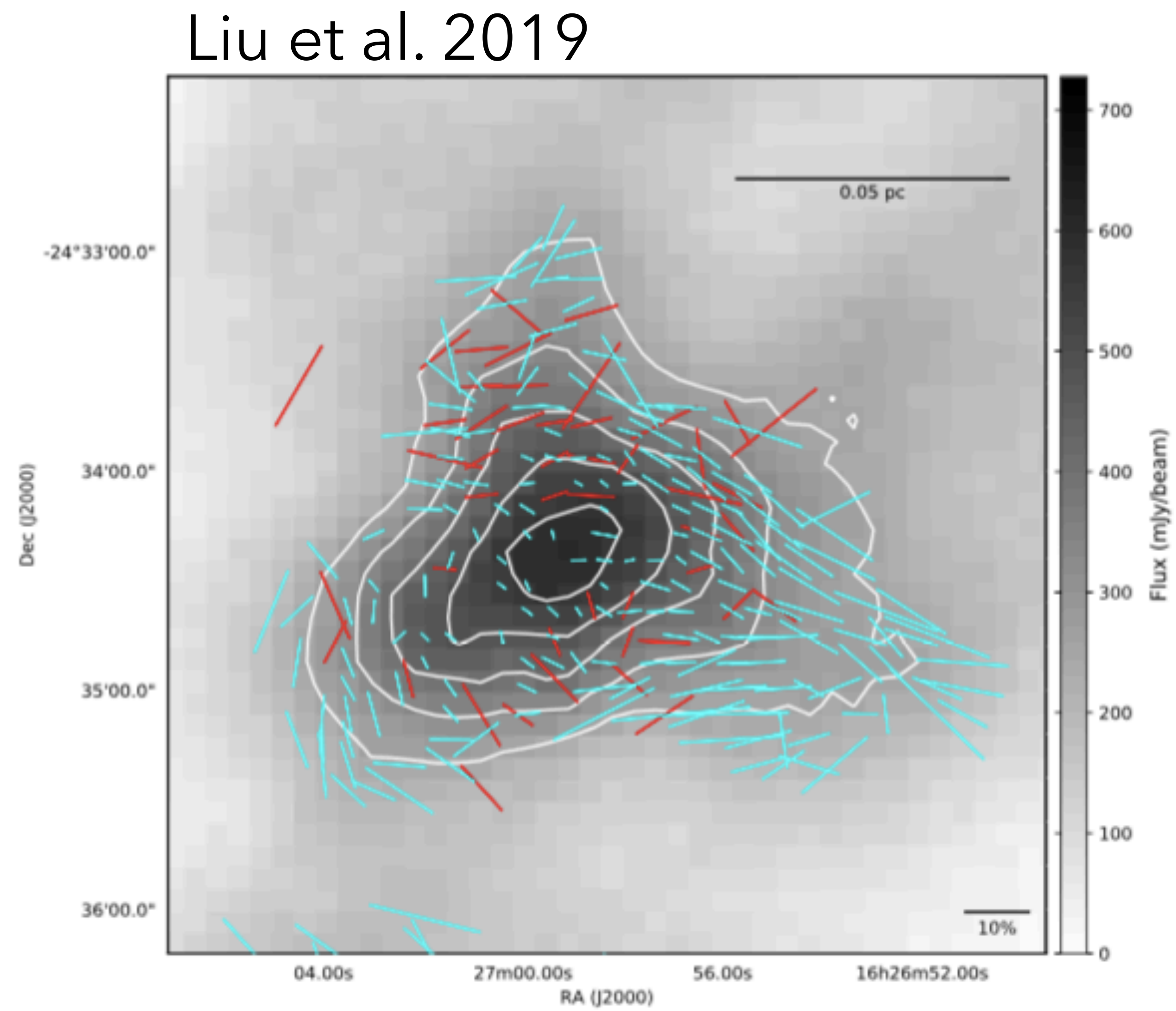
The dispersion of measured polarization angles is proportion to the distortion of magnetic field lines by turbulent motions of gas.

$$B_{pos} = 9.3\frac{\sqrt{n_{H_2}}\Delta V}{\delta\phi}$$



Chandrasekhar-Fermi (CF) method



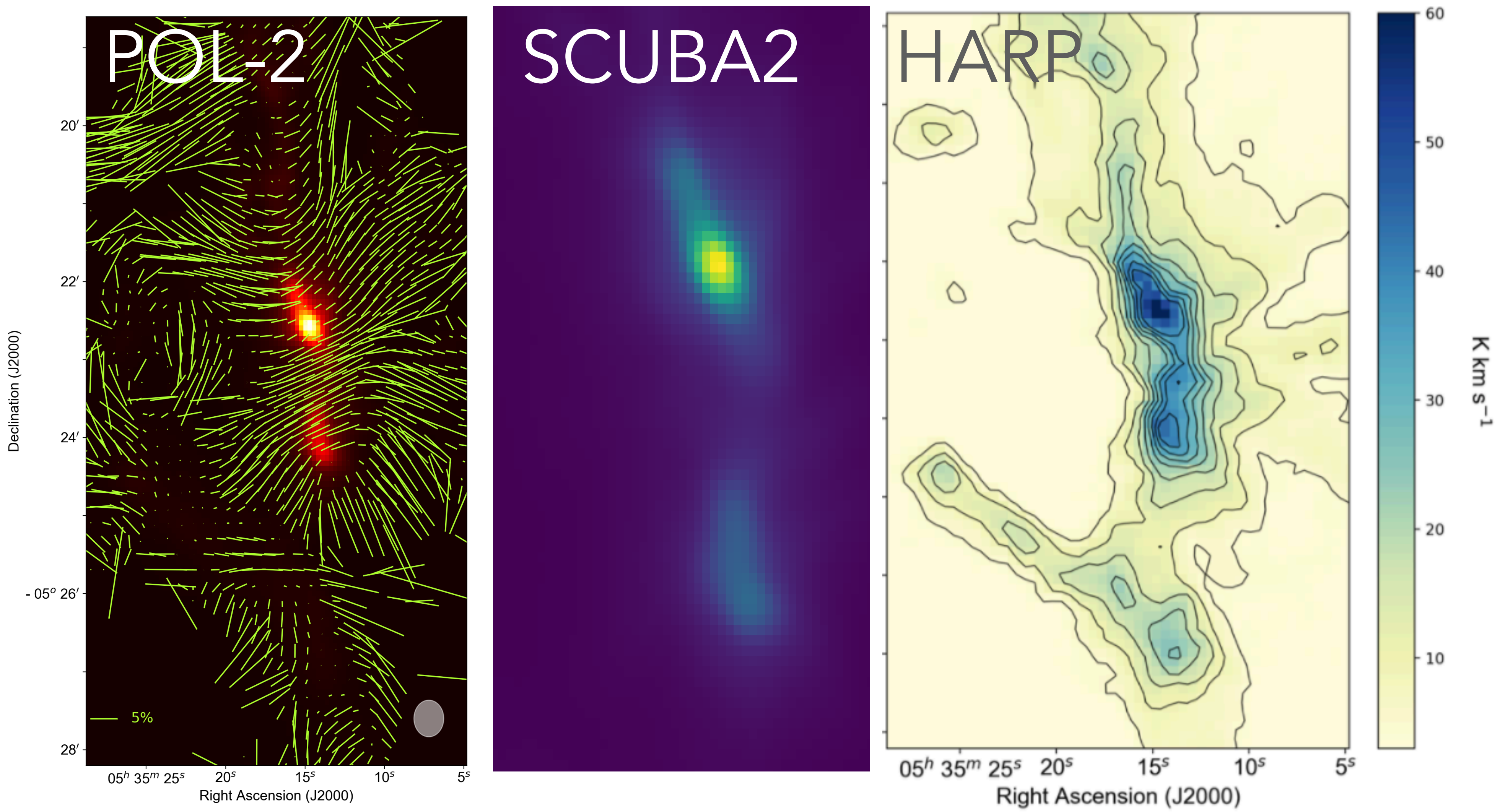


Previous studies obtained magnetic field strengths over the scales of molecular clouds or cores.

We will estimate the distribution of magnetic field strength within a molecular cloud, OMC 1.

OBSERVATIONS

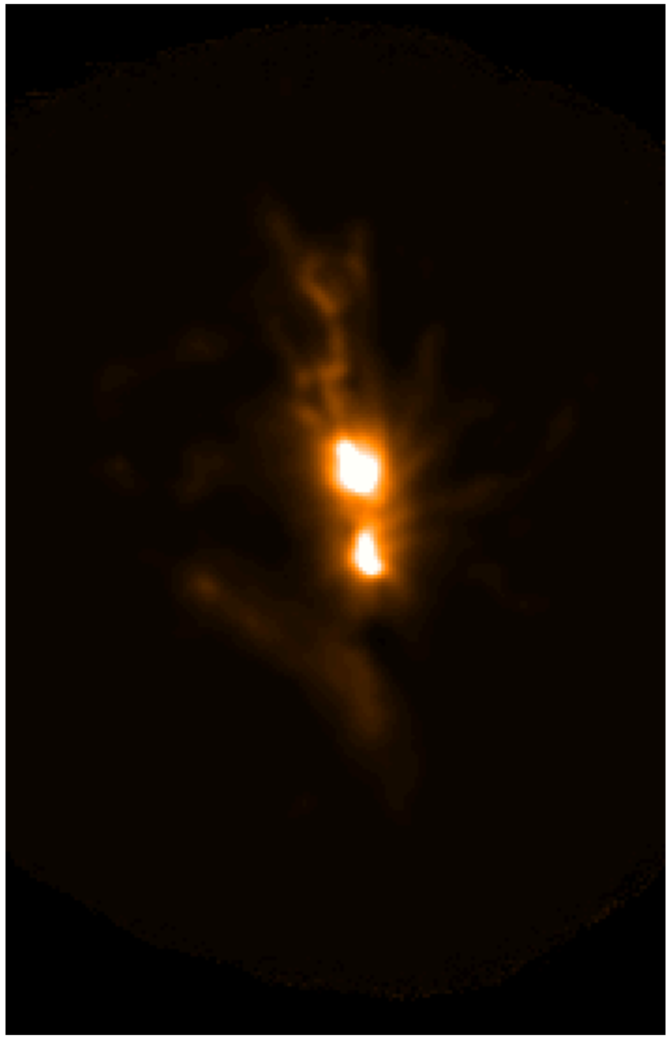
- JCMT (James Clerk Maxwell Telescope)



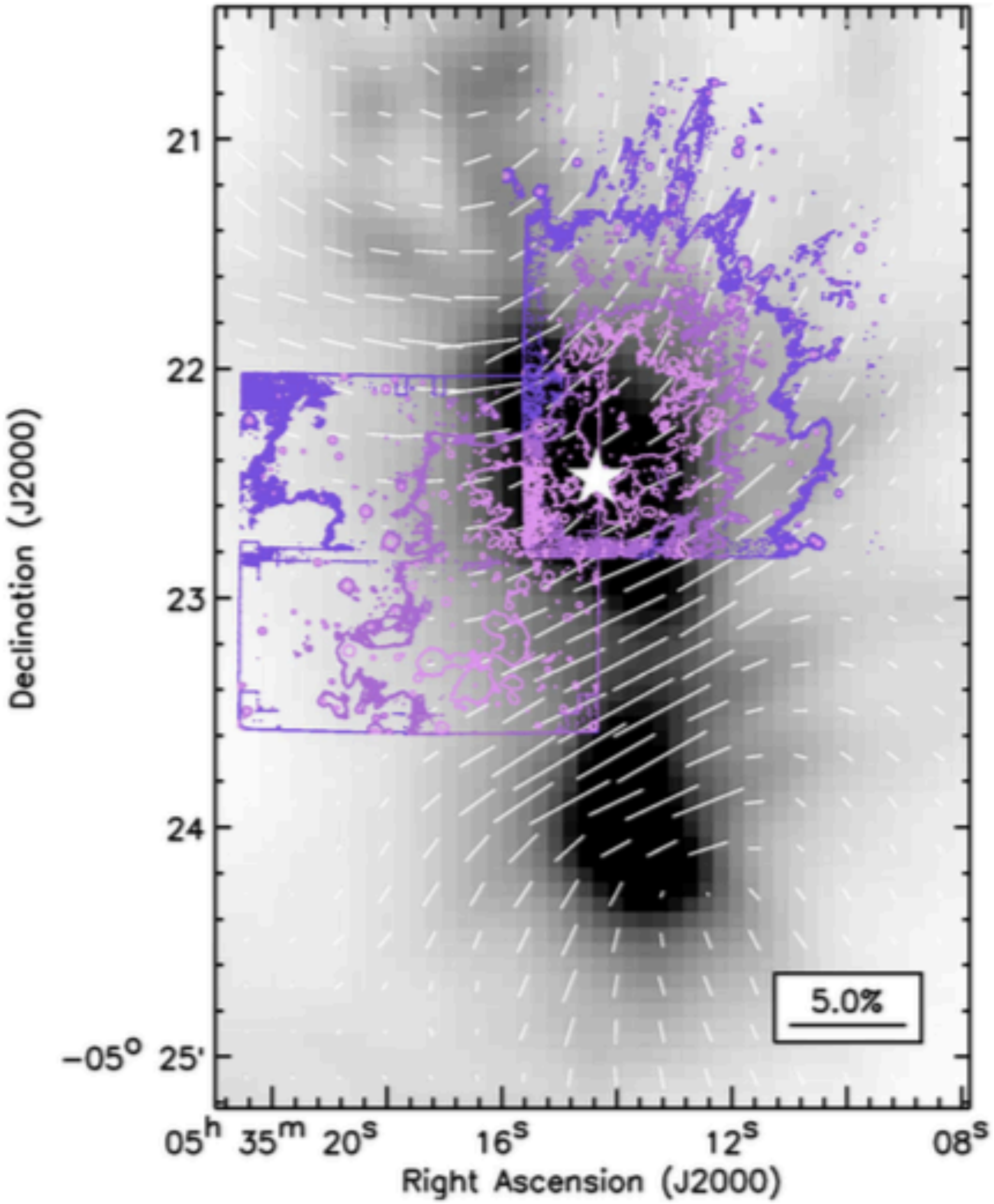
BISTRO (B-field In STar-forming RegiOns), Gould Belt Survey , POL2 commissioning data

Orion A region - OMC 1

388 ± 5 pc (Kounkel et al. 2017)
High-mass star-forming region
BN/KL & S clumps
Explosive outflow



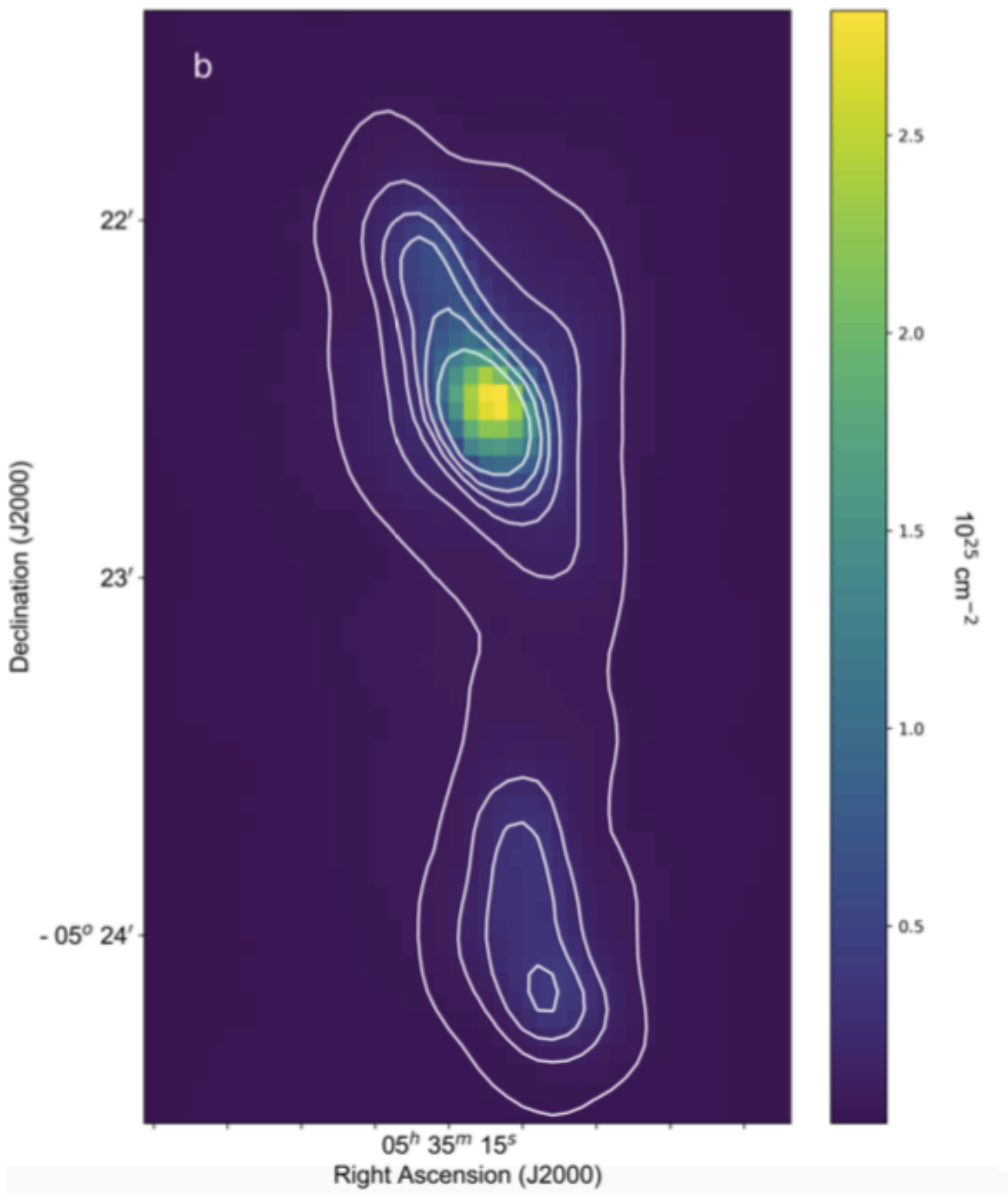
JCMT 850 μm
dust continuum



Pattle et al. 2017

RESULTS

- Column density map



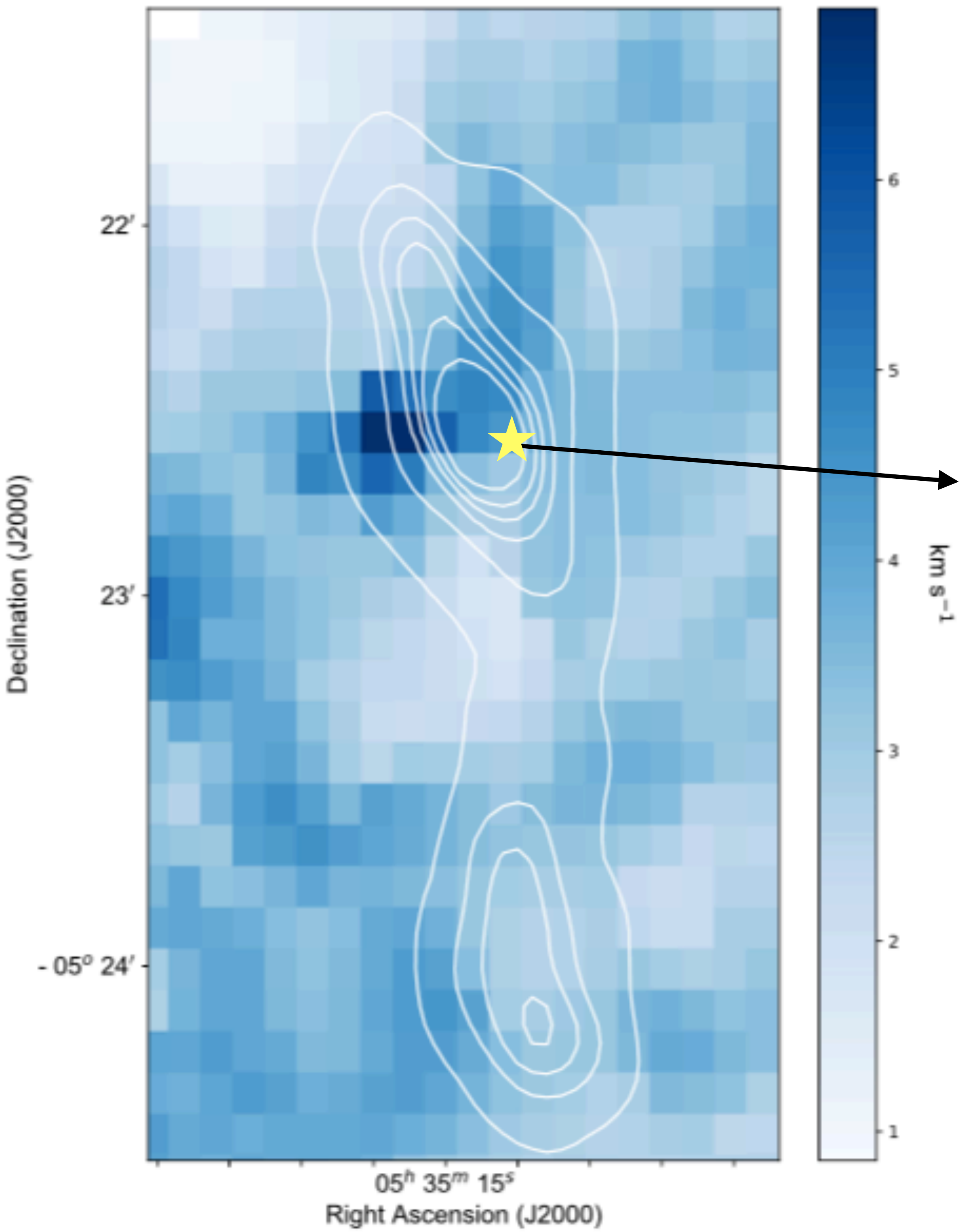
$$\frac{I_{850}}{I_{450}} = \left(\frac{\nu_{850}}{\nu_{450}}\right)^{3+\beta} \times \frac{e^{\frac{h\nu_{450}}{k_B T}} - 1}{e^{\frac{h\nu_{850}}{k_B T}} - 1} \qquad \beta = 2$$

$$I_\nu = \mu m_H \kappa(\nu) N(H_2) B_\nu(T)$$

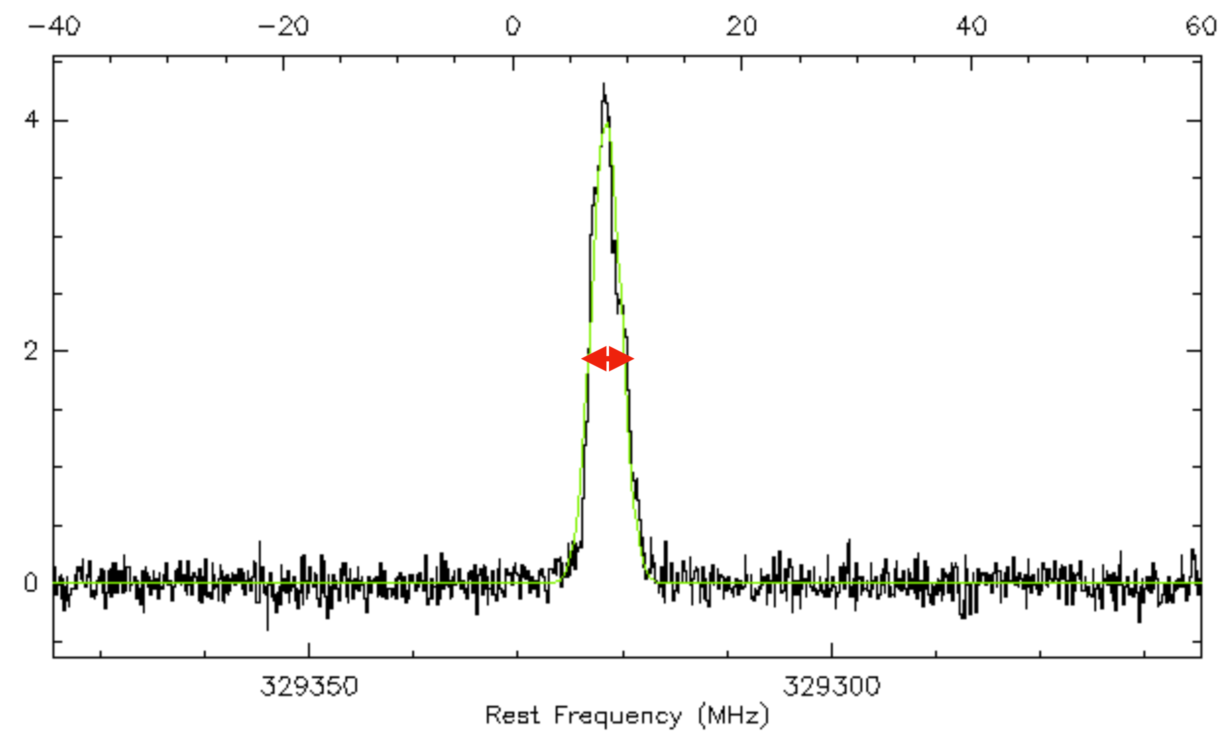
$$\kappa(\nu) = \kappa_{\nu_0}\left(\frac{\nu}{\nu_0}\right)^\beta$$

Salji et al. 2015; Pattle et al. 2017

Velocity dispersion map

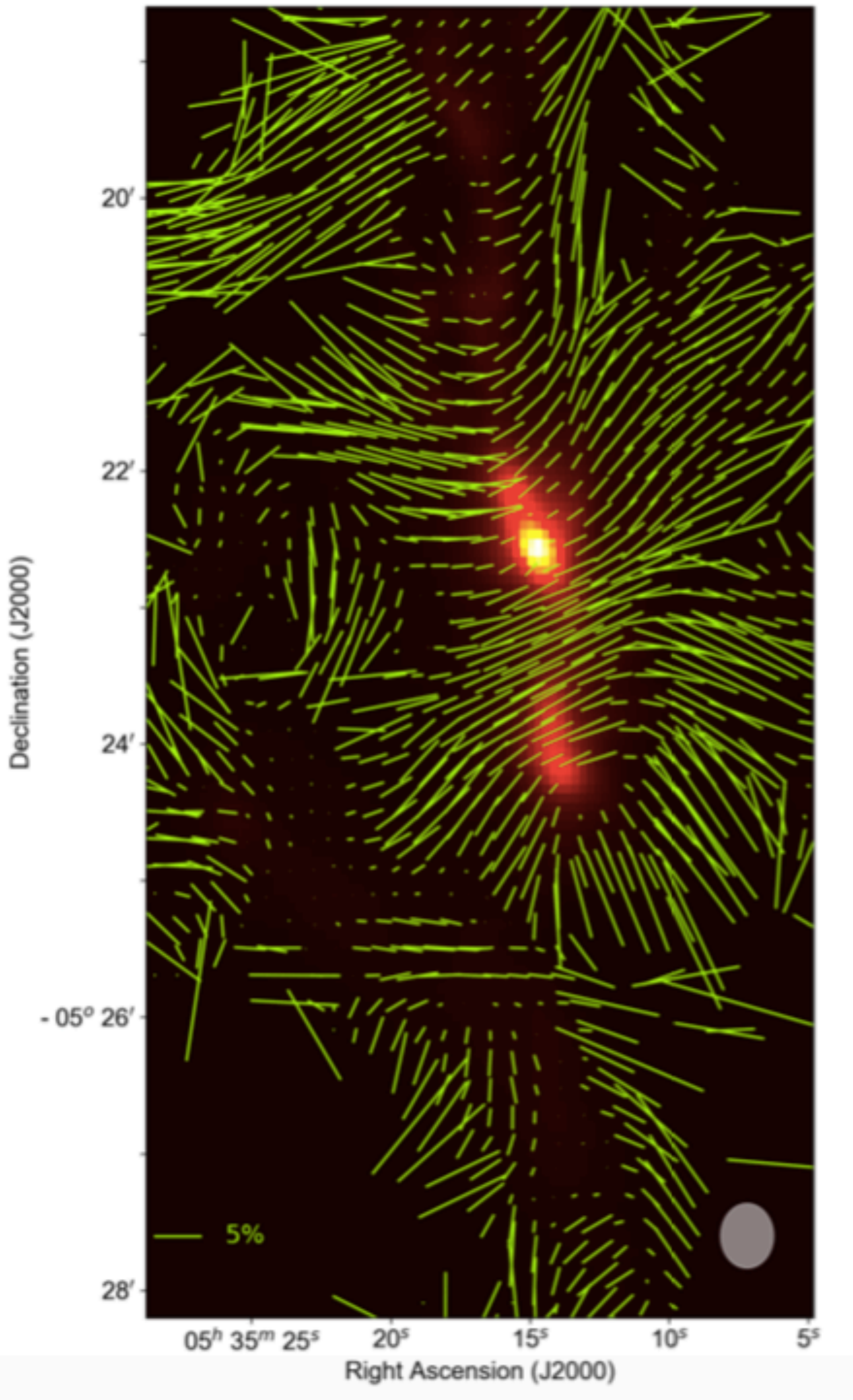


HARP



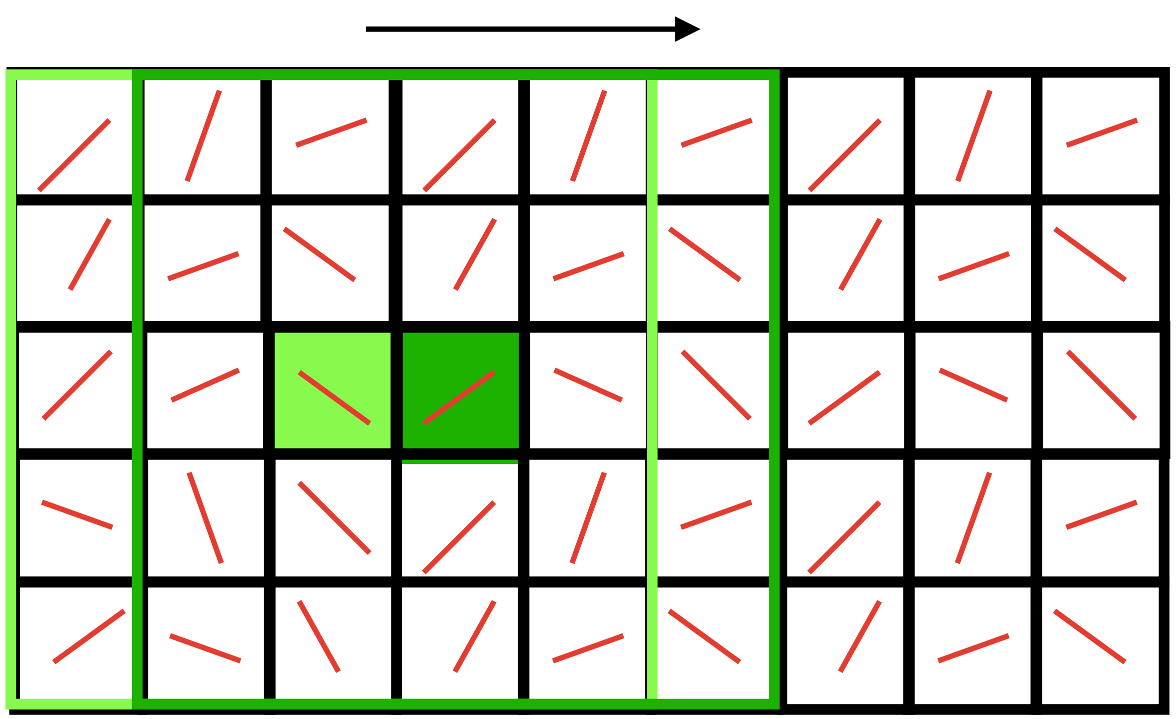
Measure the Full Width at Half Maximum of $C^{18}O$

Polarization angle dispersion

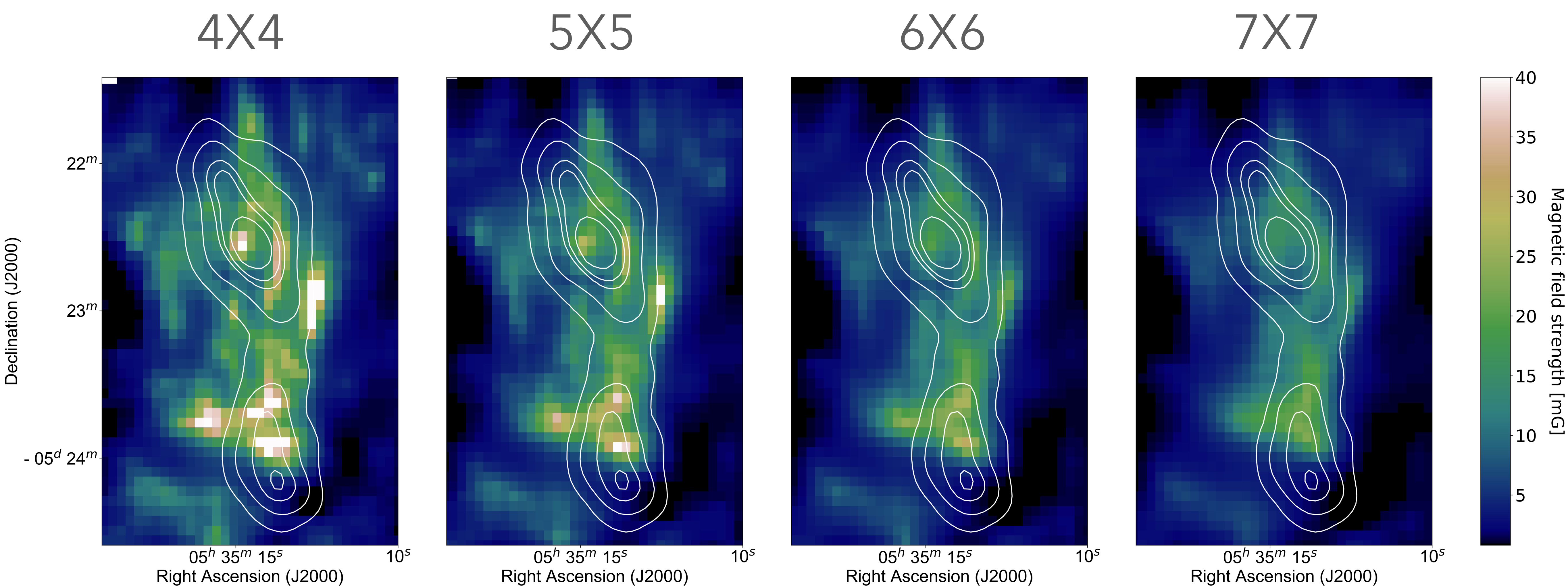


1 pixel = 4 arcsec.
Make moving boxes
(4x4, 5x5, 6x6, 7x7)
Determine angle dispersion at the center of a box

$$AD = \sqrt{\frac{\Sigma(\theta - \bar{\theta})^2}{N}}$$



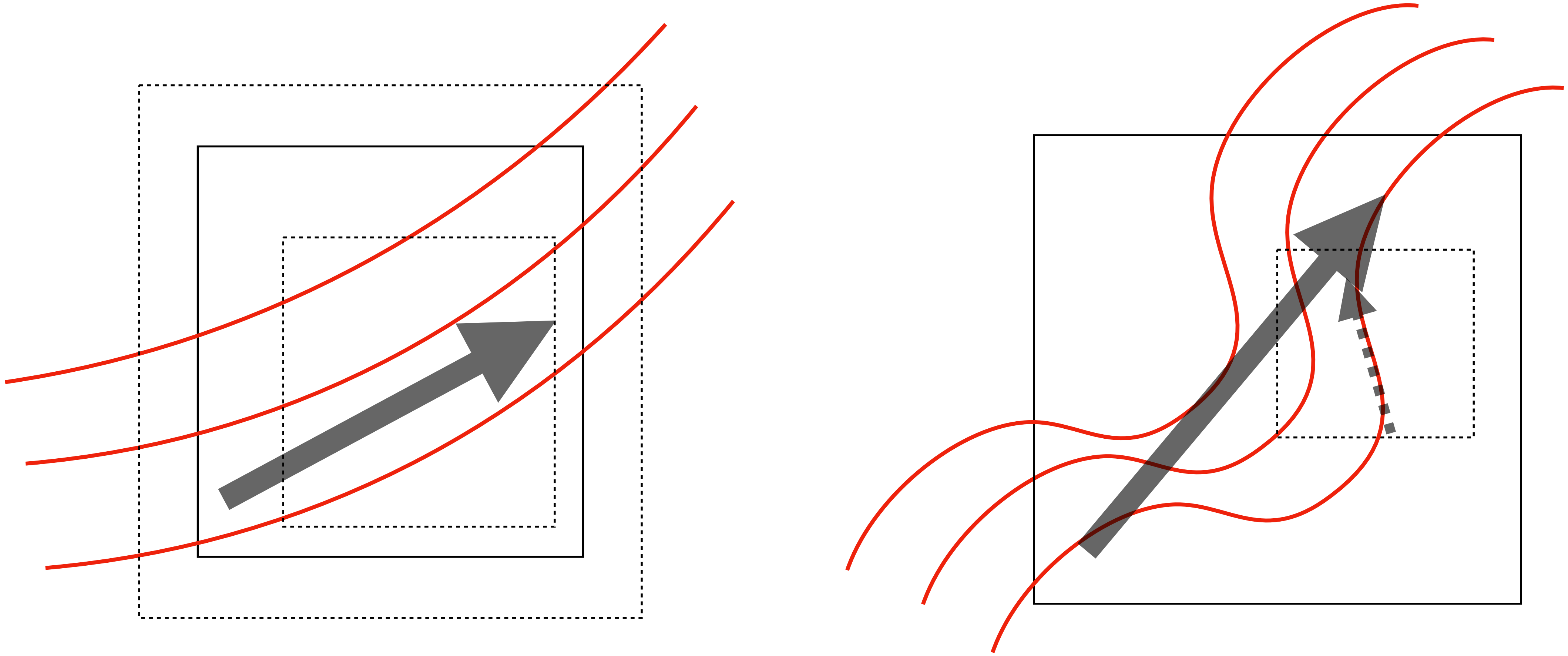
DISCUSSIONS



14.8 ± 6.7 12.1 ± 5.6 10.4 ± 5.0 9.3 ± 4.7 [mG]

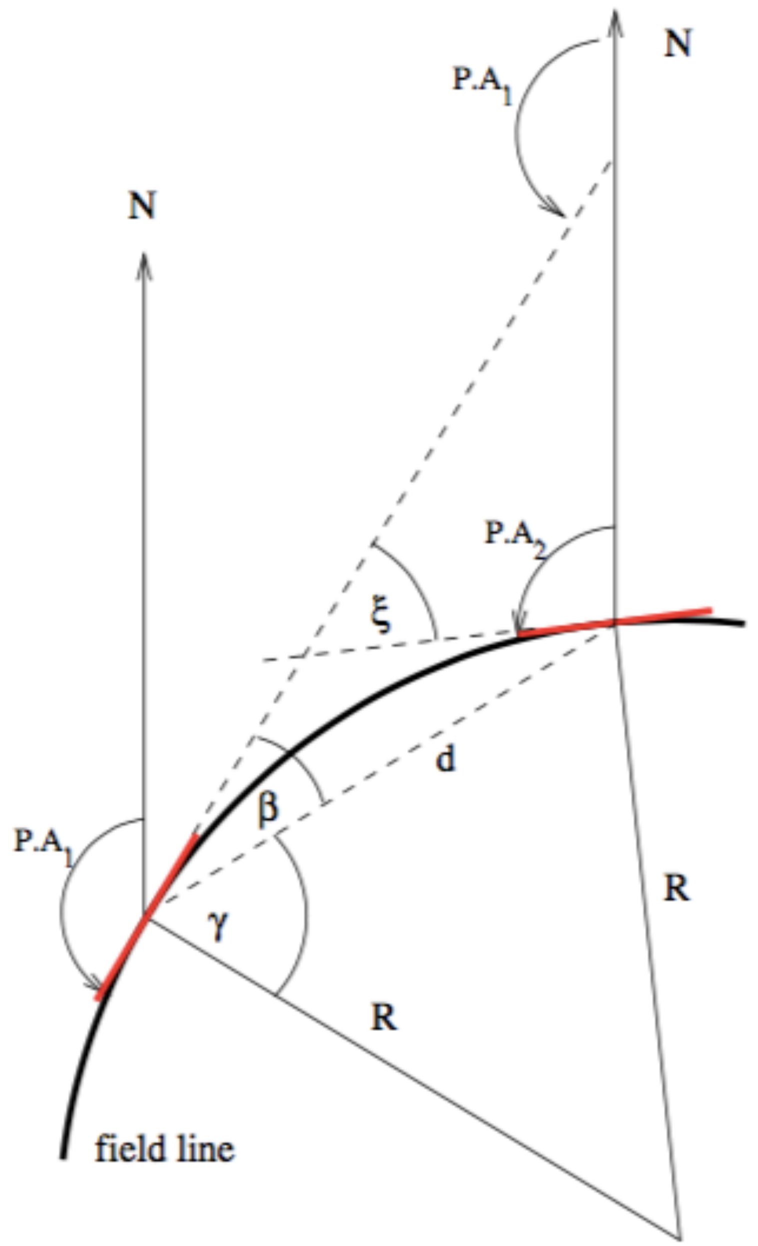
How to measure curvature

Assumption : A mean field direction in a box is uniform.



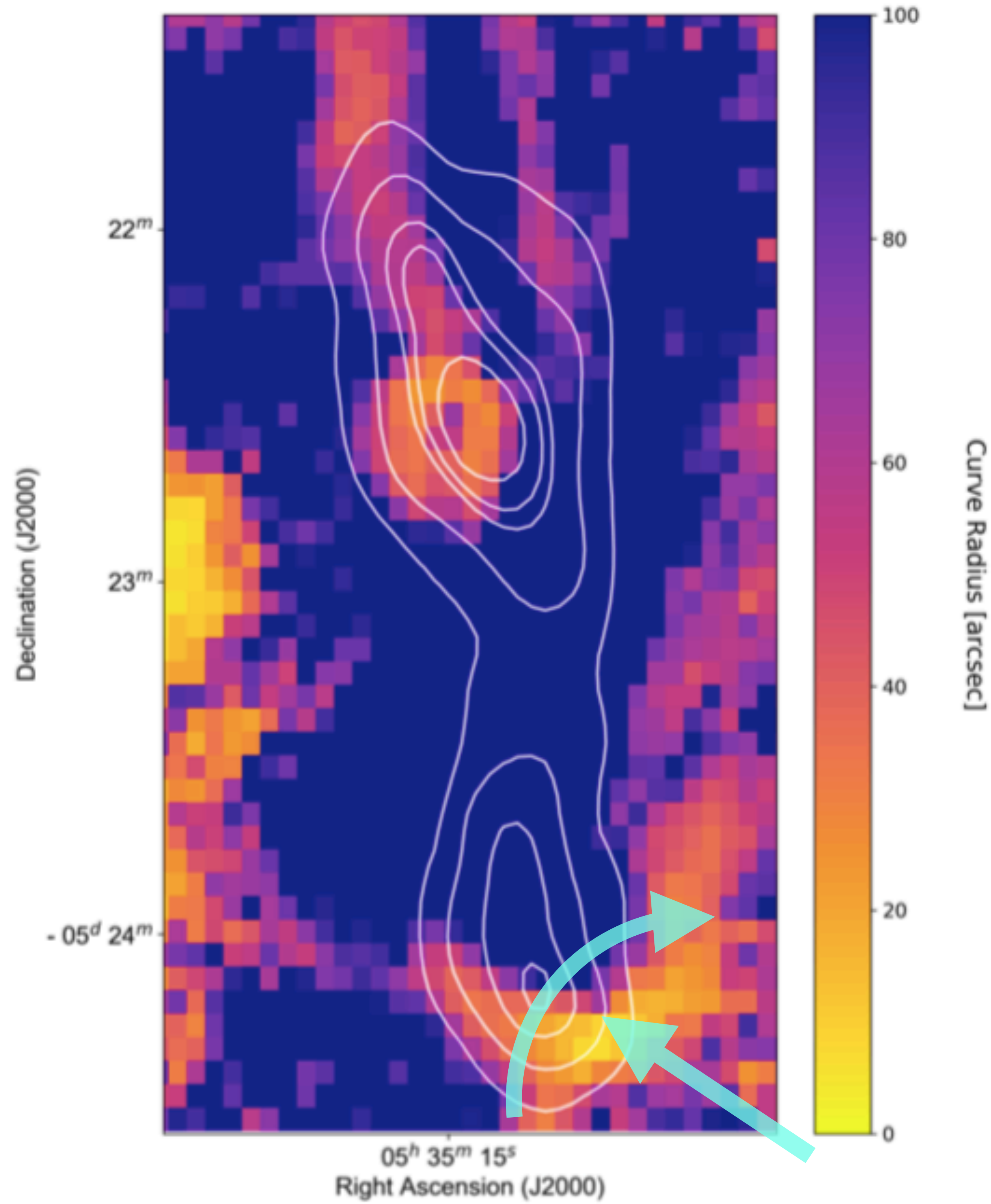
If we use a moving box whose size is larger than curvatures of magnetic field lines, then an angle dispersion of polarization segments (a magnetic field strength) within the box will be overestimated (underestimated).

Curvature Radius



$$C = \frac{1}{R} = \frac{2}{d} cos(\frac{1}{2}[\pi - \Delta P.A.])$$

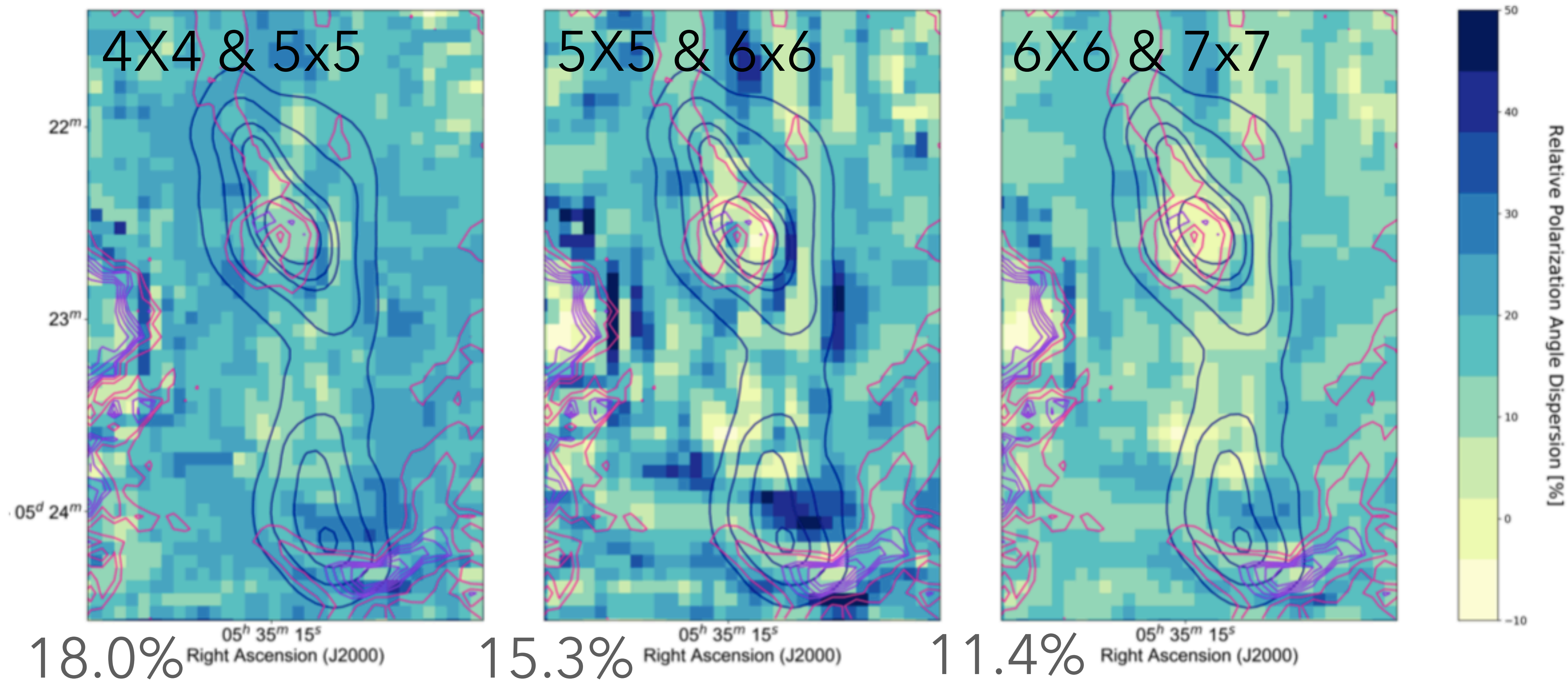
Koch et al. 2012



Relative polarization angle dispersion

$$\Delta AD = \frac{AD_L - AD_S}{AD_L} \times 100[\%]$$

AD_L angle dispersion in a large box
AD_S angle dispersion in a small box



The relative angle dispersion between 6x6 and 7x7 boxes is the smallest and uniform. The central part of BN/KL shows smaller curvature than 7x7 box, so we consider 6x6 box is appropriate to estimate the distribution of magnetic field strength in OMC 1.

SUMMARY

1) We developed a way to find a distribution of magnetic field strength using the CF method.

2) We obtained a map of magnetic field distribution with a pixel size of 4″ in OMC 1 region.
The maximum, minimum and mean field strengths obtained by 6x6 box are 0.5, 30.3, and, 10.4, respectively.

3) The size of a moving box should be determined in comparison with curvature of field lines.

Thank You