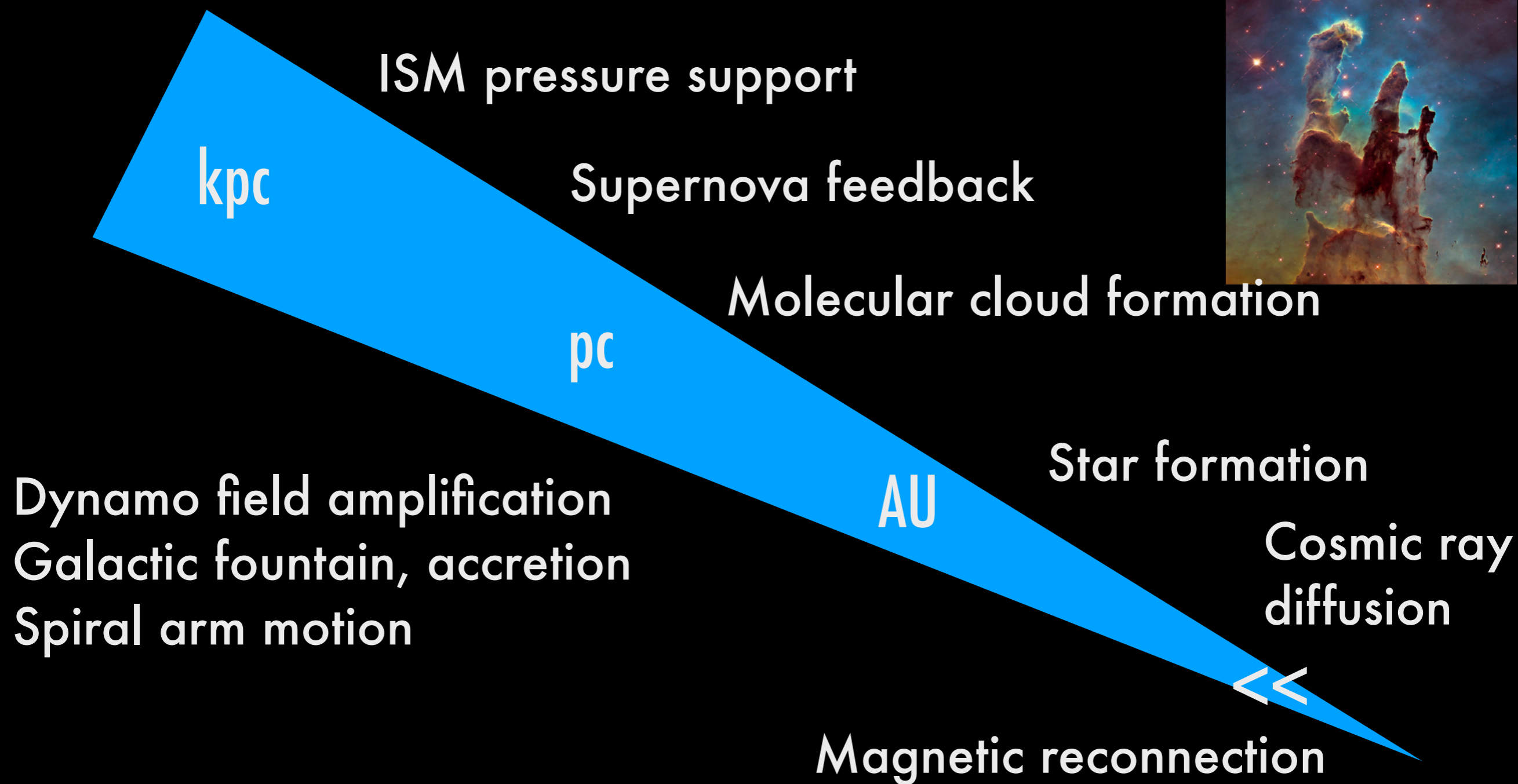


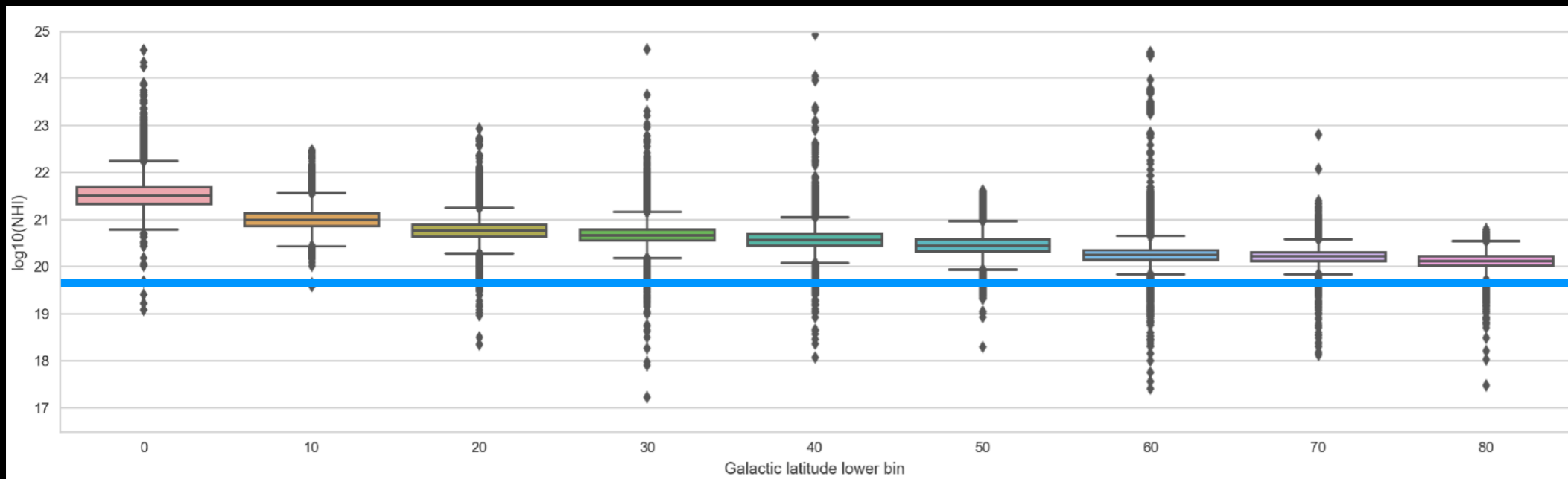
# The PICO Diffuse ISM Science Case

Susan E. Clark  
Hubble Fellow, IAS

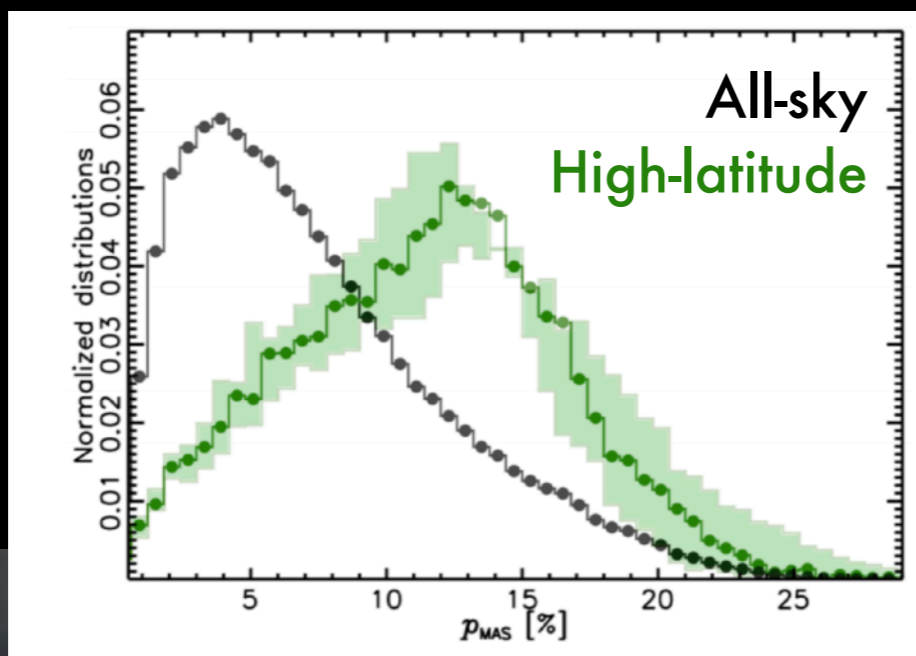
# Diffuse ISM: a laboratory for multi-scale physics



# PICO target sensitivity



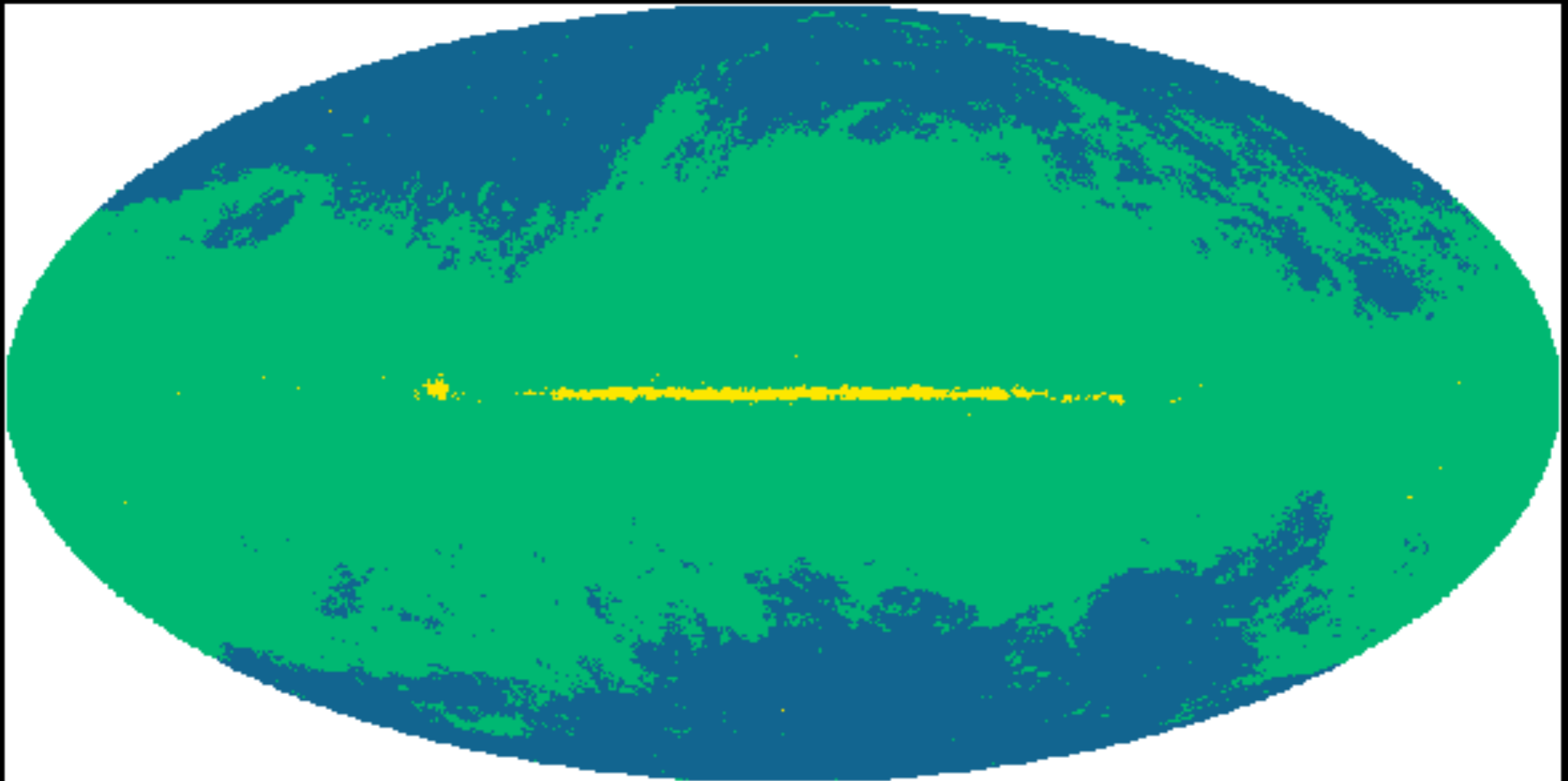
Target column:  
 $N_{\text{HI}} = 5 \times 10^{19}$



Detections with  $S/N > 3$  for polarization values of 1.2% at the 1.1 arcminute resolution of the 799 GHz channel

Planck Int  
XLIV

# A significant improvement over Planck in sensitivity & resolution over the whole sky



Planck 353 GHz, 5' resolution,  $\sigma_p < 0.33\%$   
PICO 799 GHz, 1' resolution,  $\sigma_p < 0.33\%$   
PICO 799 GHz, 5' resolution,  $\sigma_p < 0.33\%$

# Measure magnetic field strength

- We do not measure field strength directly – infer via Chandrasekhar-Fermi method + other techniques

- In individual clouds & as a function of spatial scale

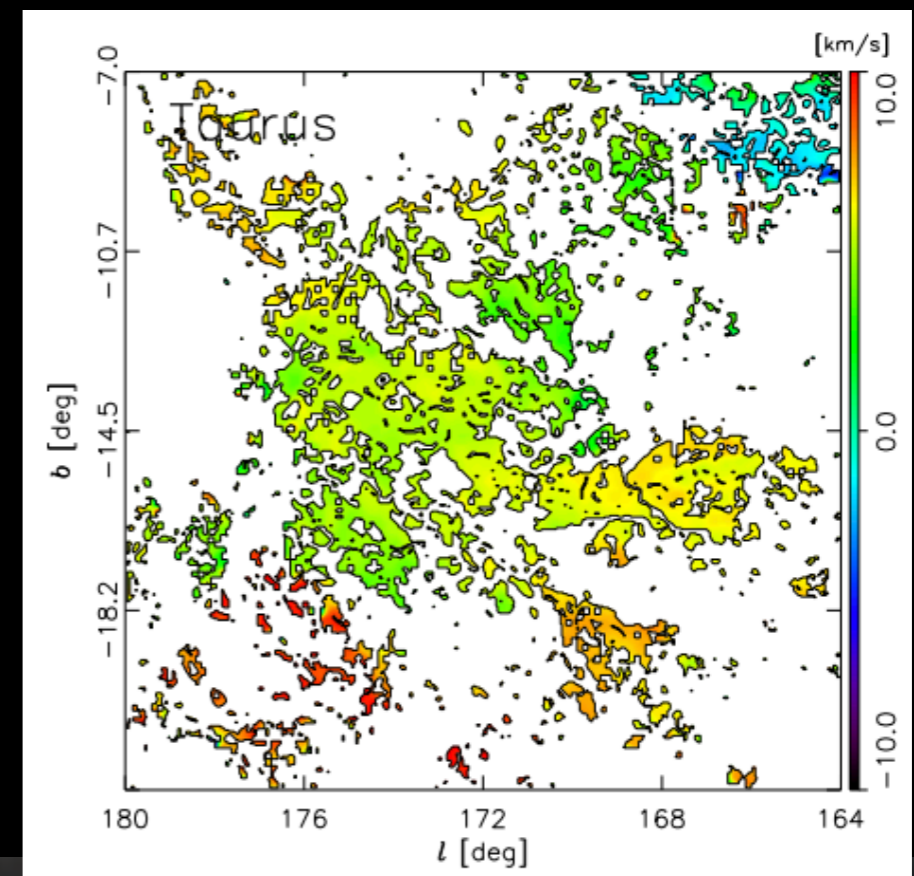
$$B_{\perp} = \sqrt{4\pi\rho} \frac{\sigma_{v_{\parallel}}}{\sigma_{\delta\psi}}$$

Test equipartition across environments  
in diffuse ISM

B power spectrum

Mass-to-flux ratios

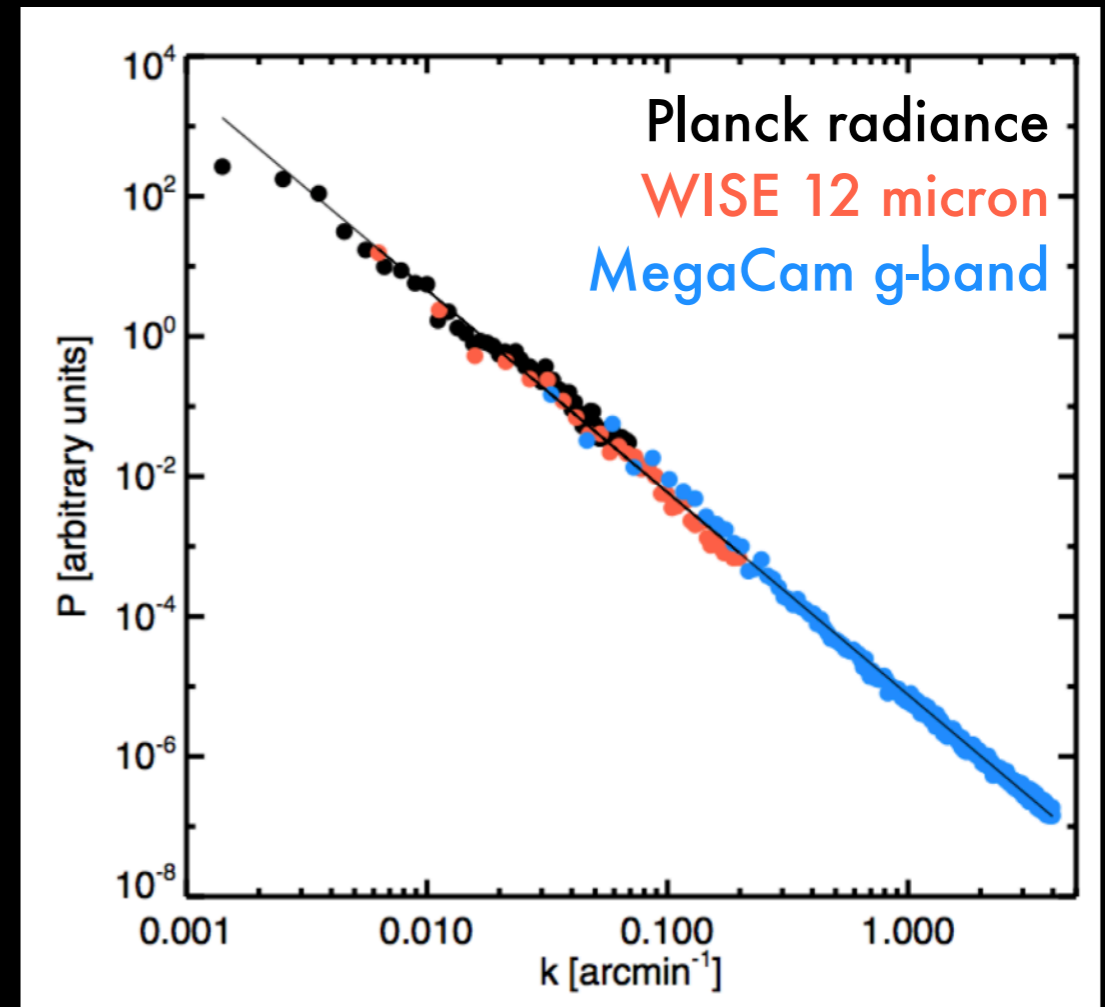
Comparison to simulations



Planck Int. XXXV, 2016

# Characterize turbulence in the diffuse ISM

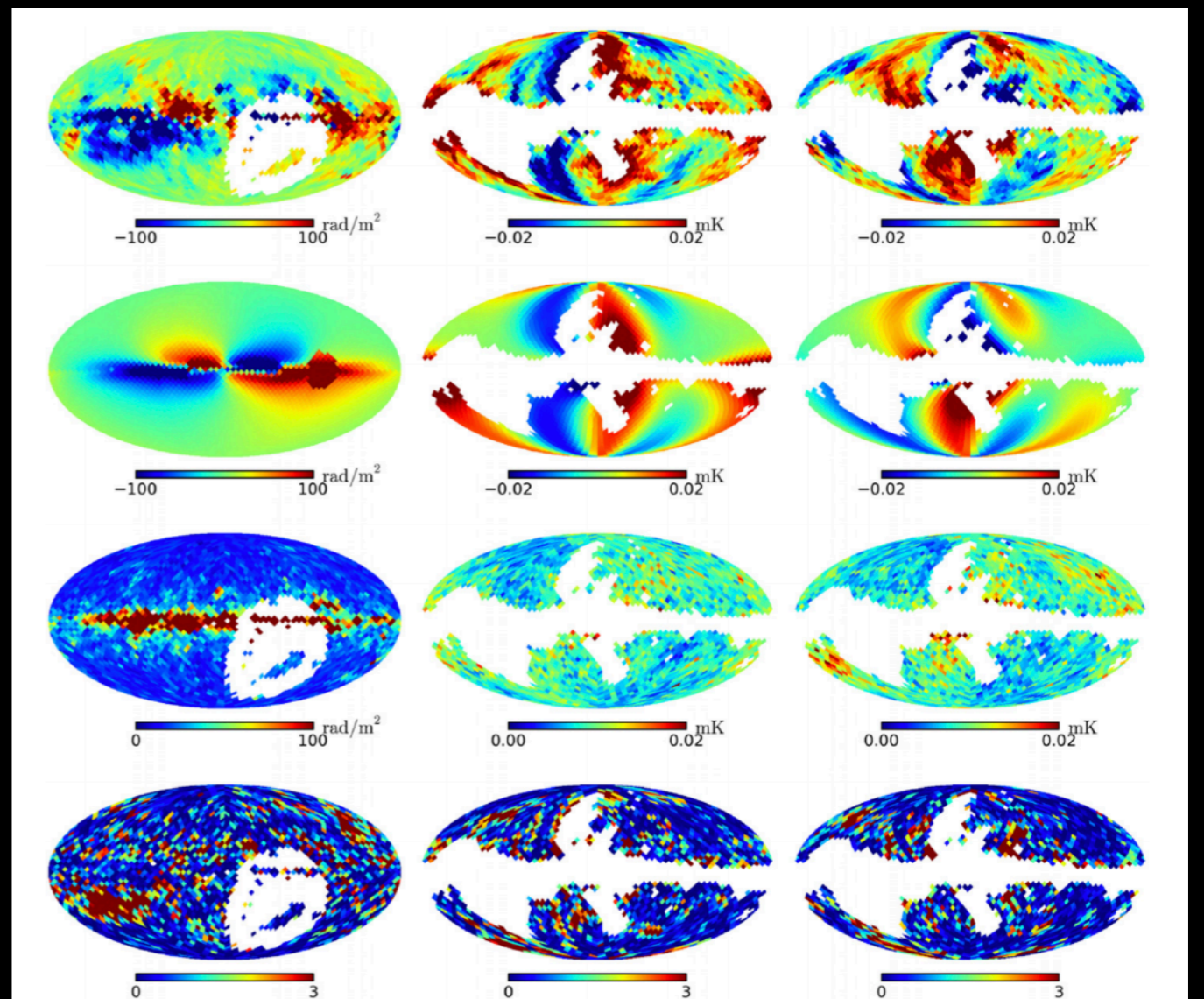
- What are the primary injection and dissipation scales in the ISM?
- Slope of turbulent power spectrum?
- Scale-dependent anisotropy?



Miville-Deschenes+ 2016

# Constrain Galactic Magnetic Field

- Polarized dust emission is fit with other data to produce global magnetic field models
- These are used to model CR propagation
- Low-ell dust polarization is especially useful for separating local structure contribution to observed field (e.g. Alves+ 2018)



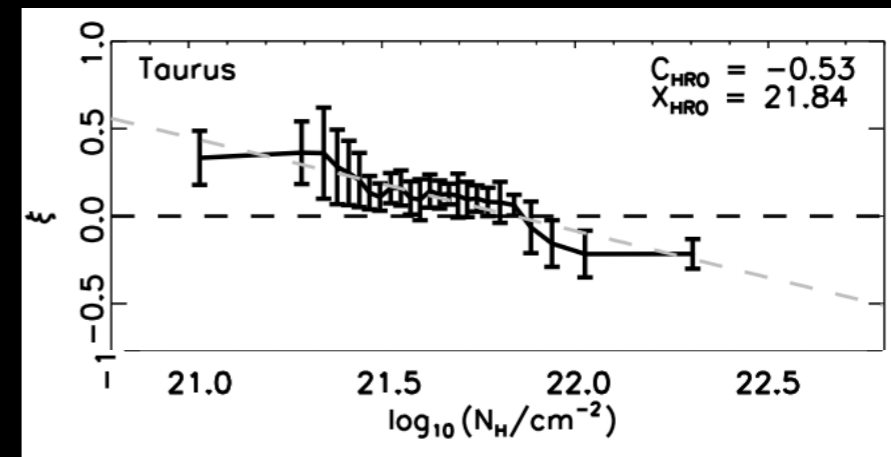
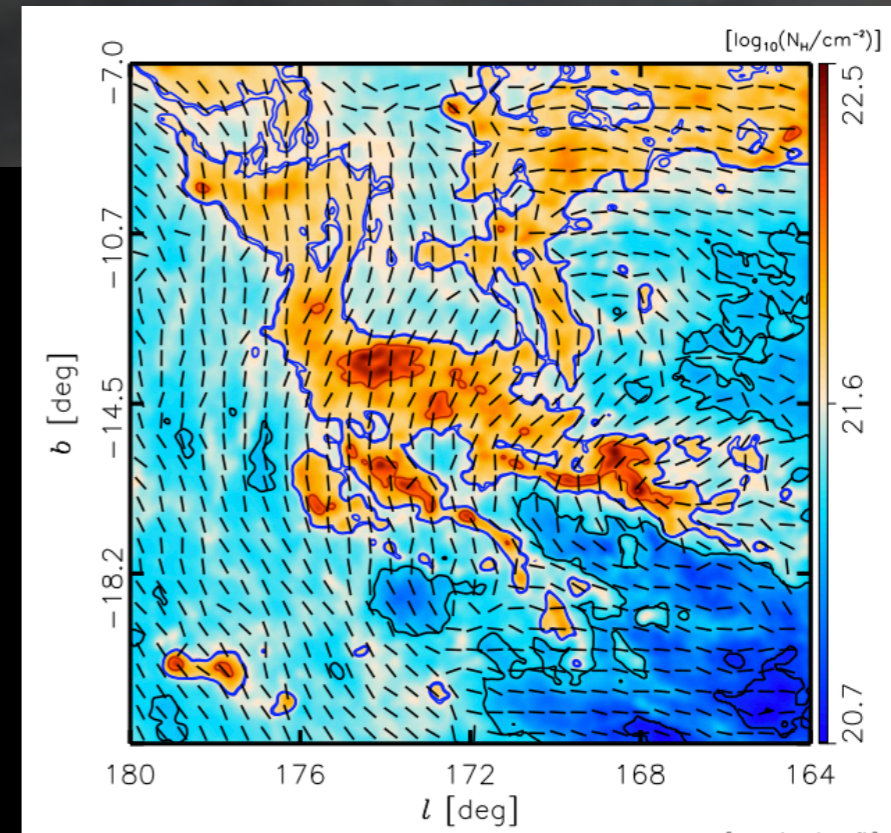
Jansson & Farrar 2012

# Molecular cloud formation (& star formation – Laura's talk)

Planck measured a change in the relative orientation of density structures & the magnetic field.

Implies magnetic field is dynamically important for cloud assembly on Planck scales.

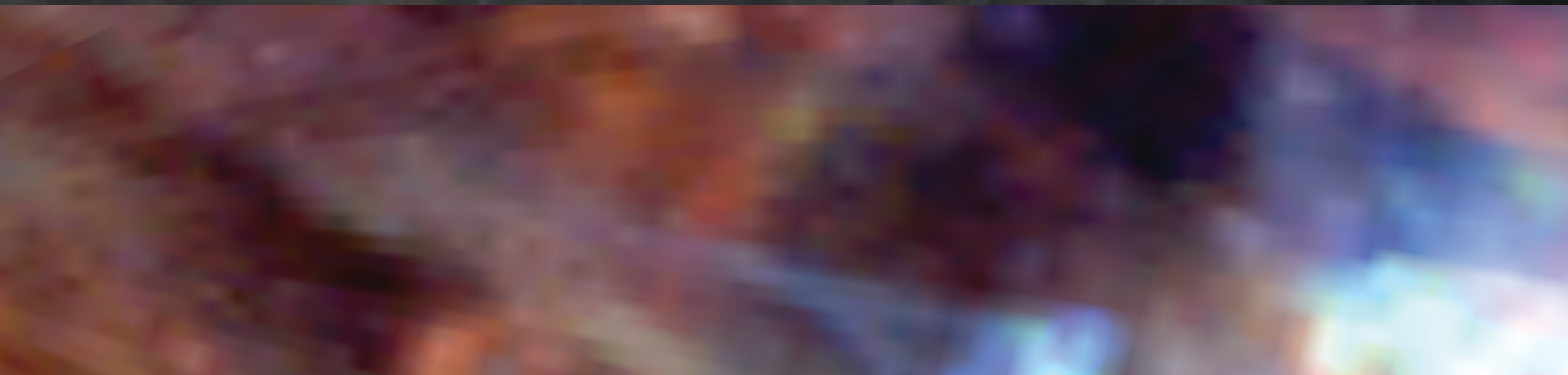
PICO will have much better statistics.  
Comparisons to simulations.



Planck Int. XXXV, 2016

$3^{\circ}$

$36'$



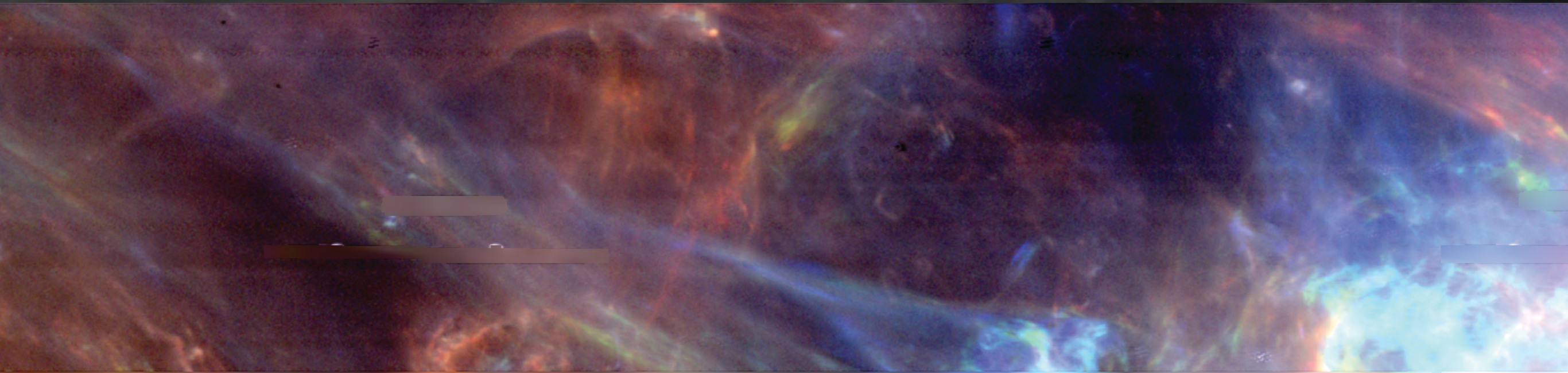
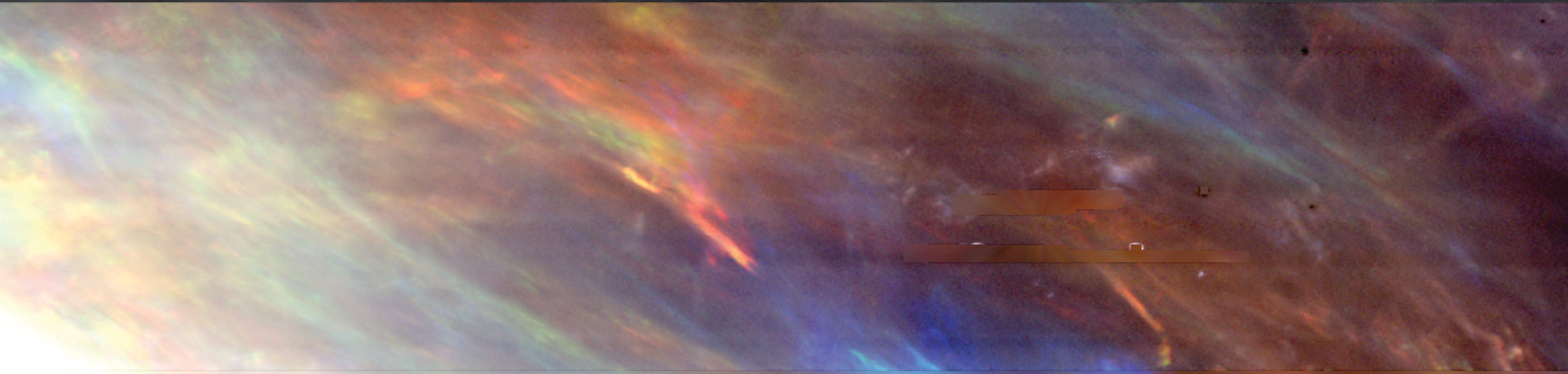
3°



GALFA-HI DR1: 2011

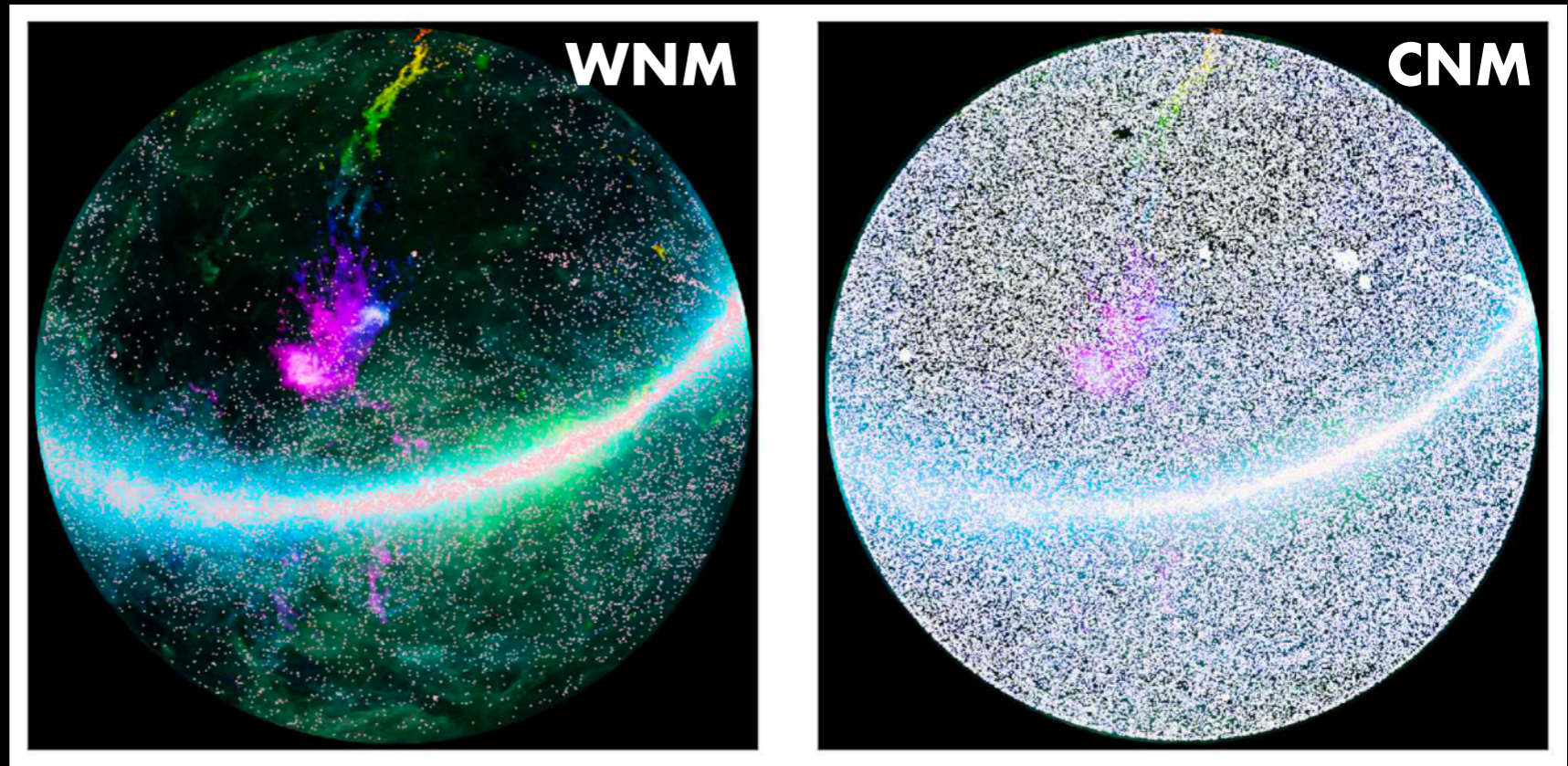
DR2: 2018

4'



# Diffuse ISM science & the SKA

1. All-sky spectral line survey (+1.4 GHz continuum)
2. Targeted plane & Magellanic system survey, 20" imaging



McClure-Griffiths+ 2015

- What is the temperature distribution of the neutral ISM?
- How does gas move within and between phases of the ISM?
- How do molecular clouds form?

**PICO: Role of the magnetic field**

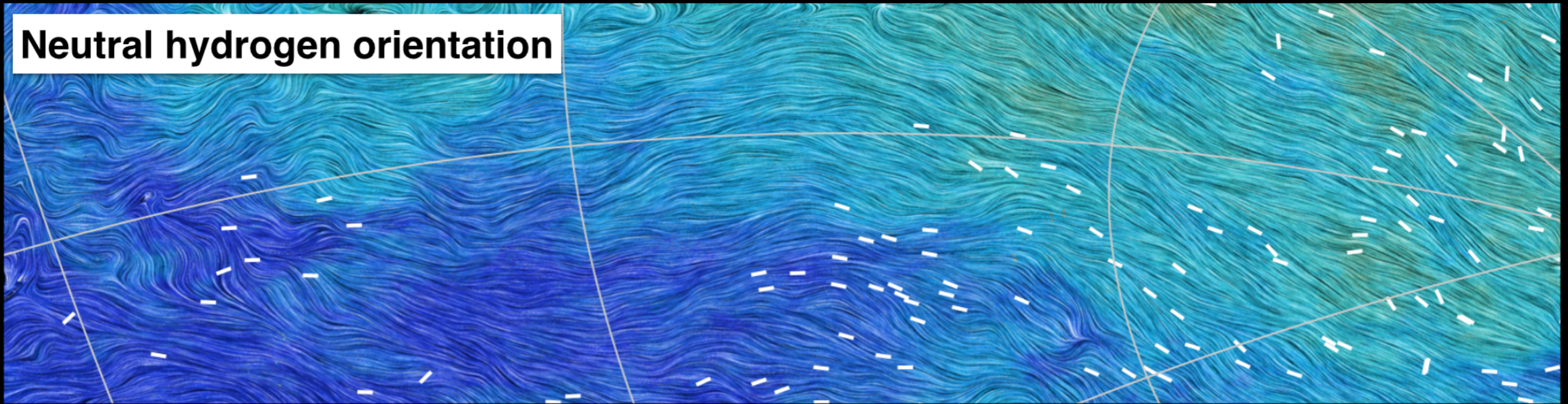
High-latitude GALFA-HI structures are aligned with the Planck magnetic field orientation.

Clark, Hill+ 2015, PRL

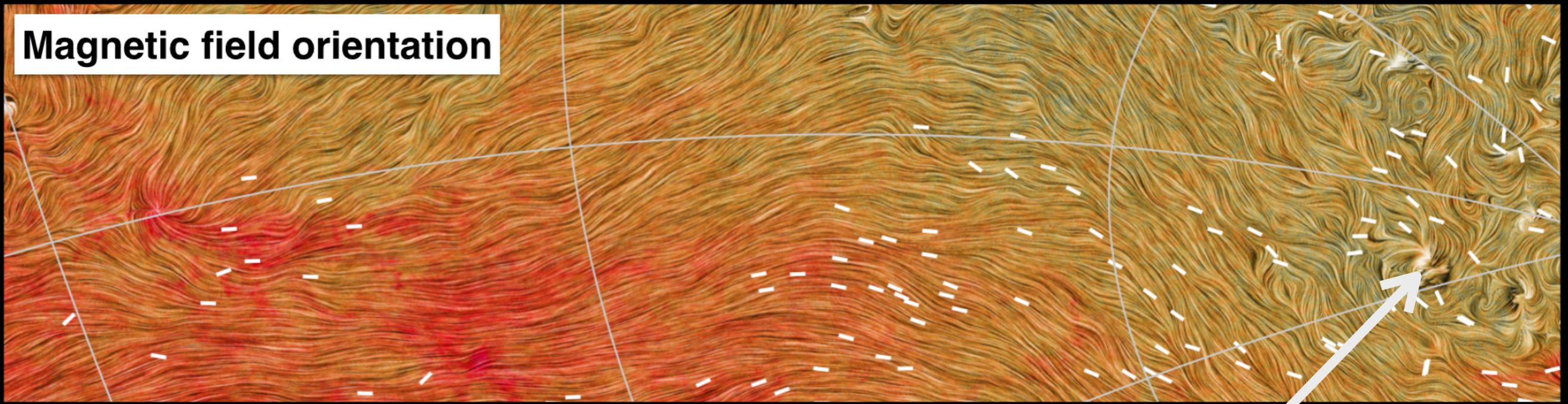
50°

70° Galactic Latitude

Neutral hydrogen orientation



Magnetic field orientation



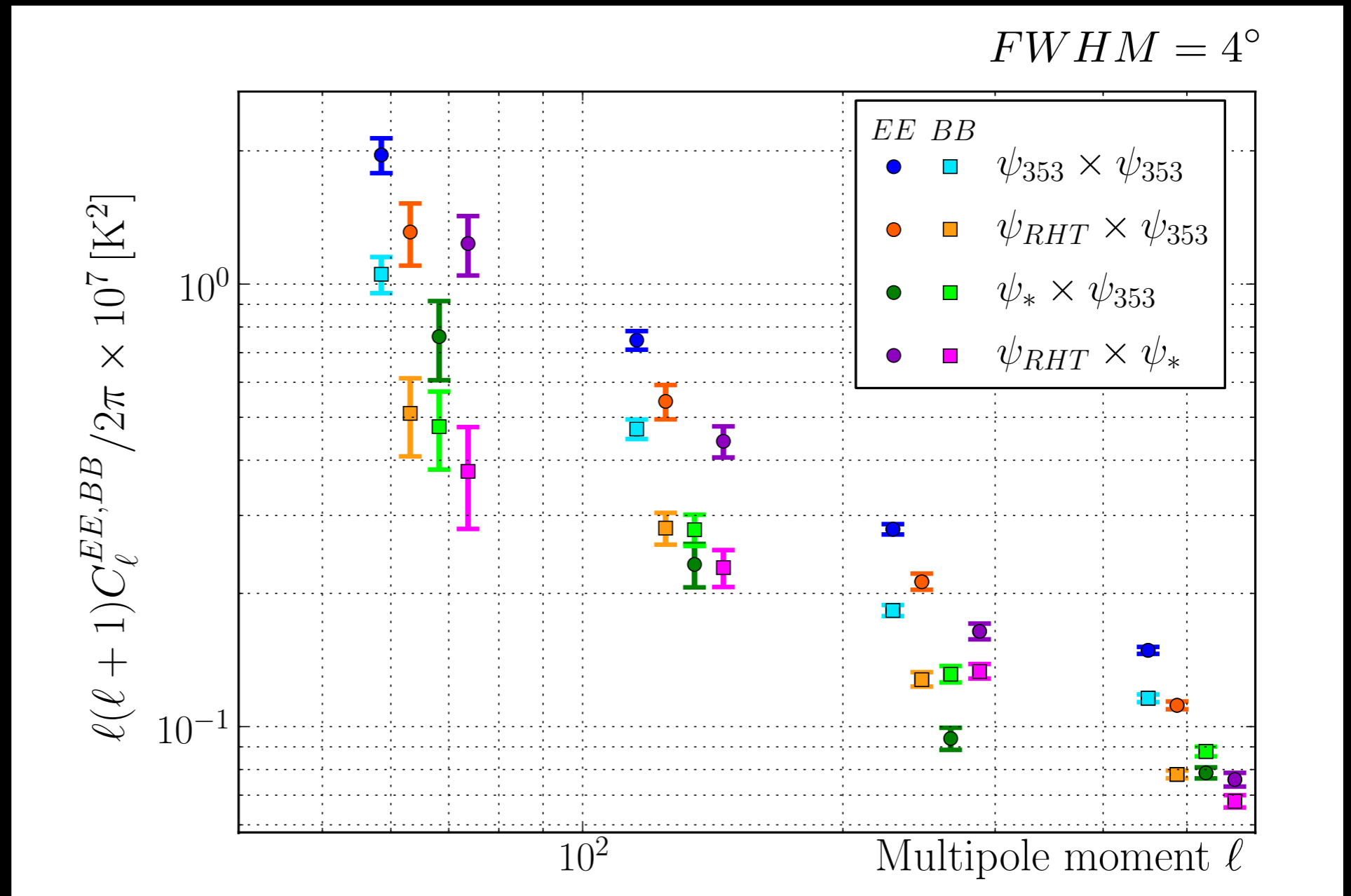
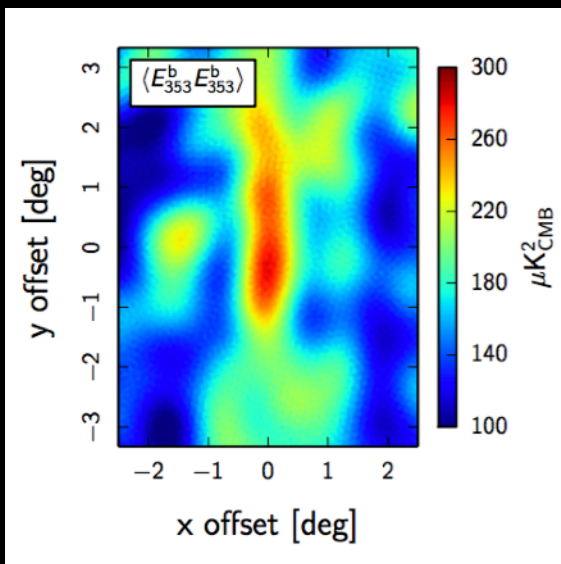
Starlight polarization: Heiles 2000

S.E. Clark, IAS

Planck is noise-dominated!

PICO Collaboration Science Meeting

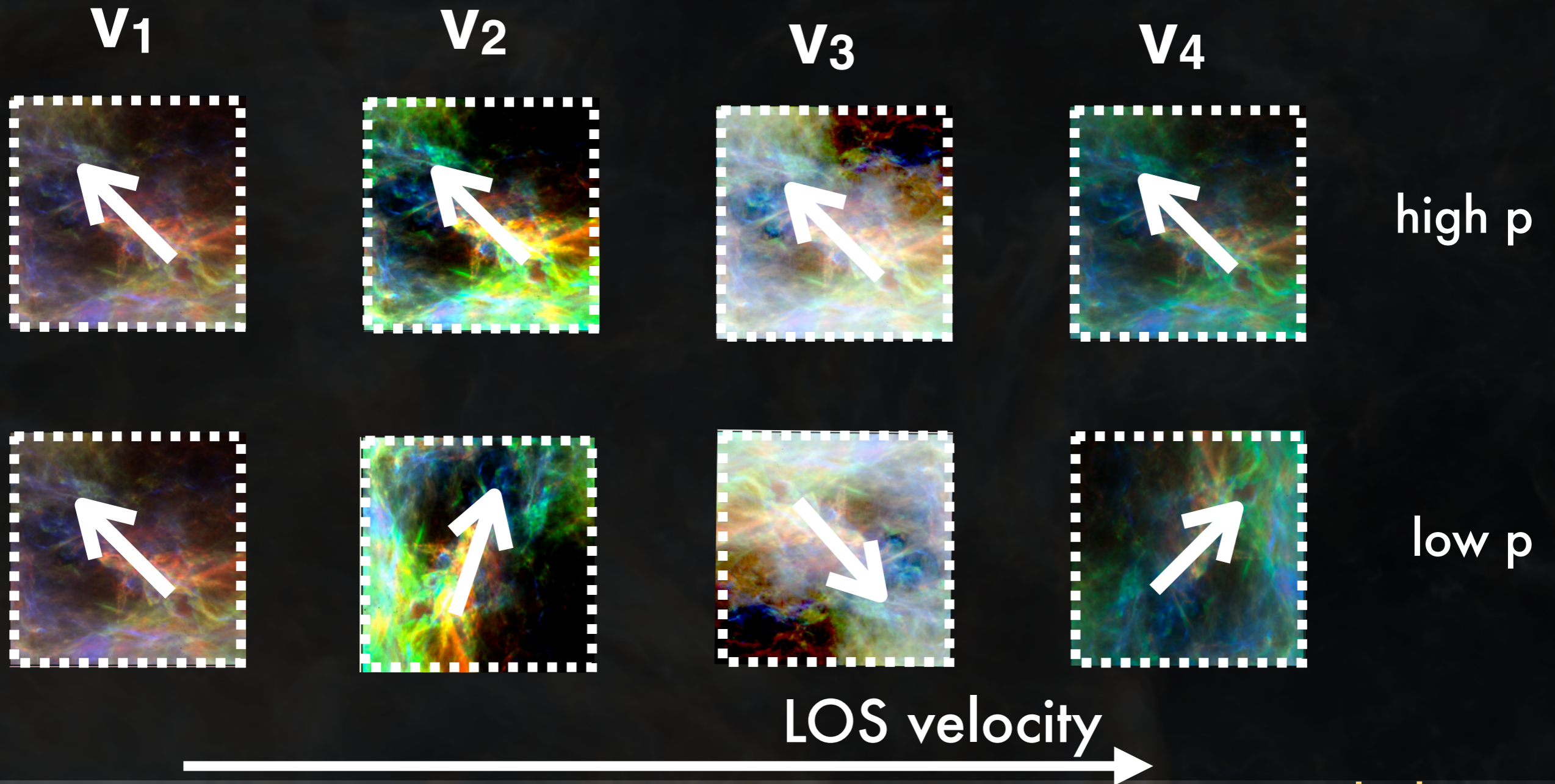
We detect strong cross-correlations between HI, 353 GHz, and starlight polarization angles.



EE/BB asymmetry:  
Planck Intermediate Results XXX,  
XXXVIII  
S.E. Clark, IAS

Clark, Hill+ 2015, PRL  
PICO Collaboration Science Meeting

# A new probe of LOS magnetic field tangling



Clark 2018

# A new probe of LOS magnetic field tangling

1

$$Q_v = I_v \cos(2\theta_{RHT})$$
$$U_v = I_v \sin(2\theta_{RHT})$$

Q, U templates weighted by local HI intensity

2

$$Q_{HI} = \int Q_v dv$$
$$U_{HI} = \int U_v dv$$

Integrate over HI velocity

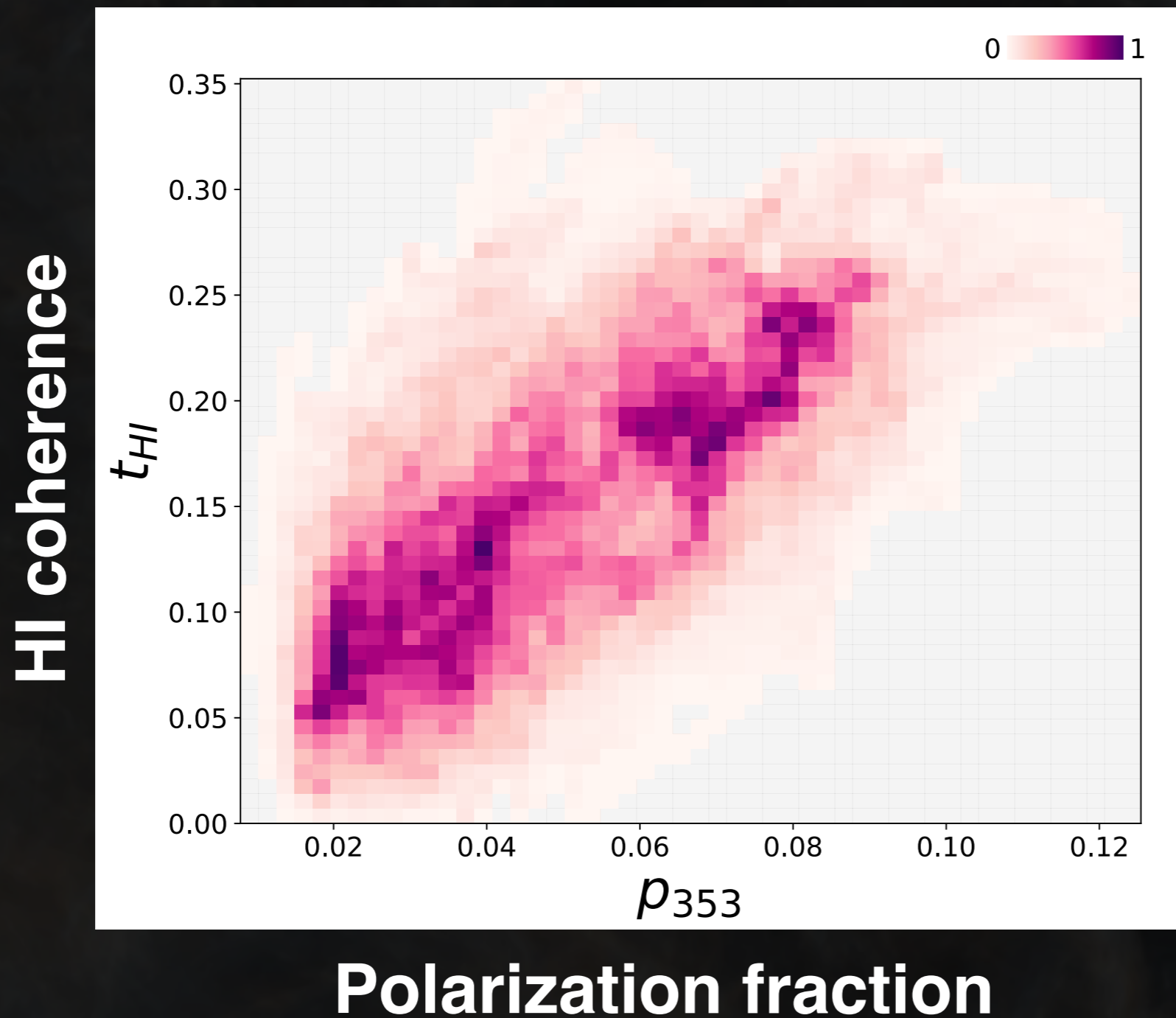
3

$$t_{HI} = \frac{\sqrt{Q_{HI}^2 + U_{HI}^2}}{I_{HI}}$$

HI coherence parameter

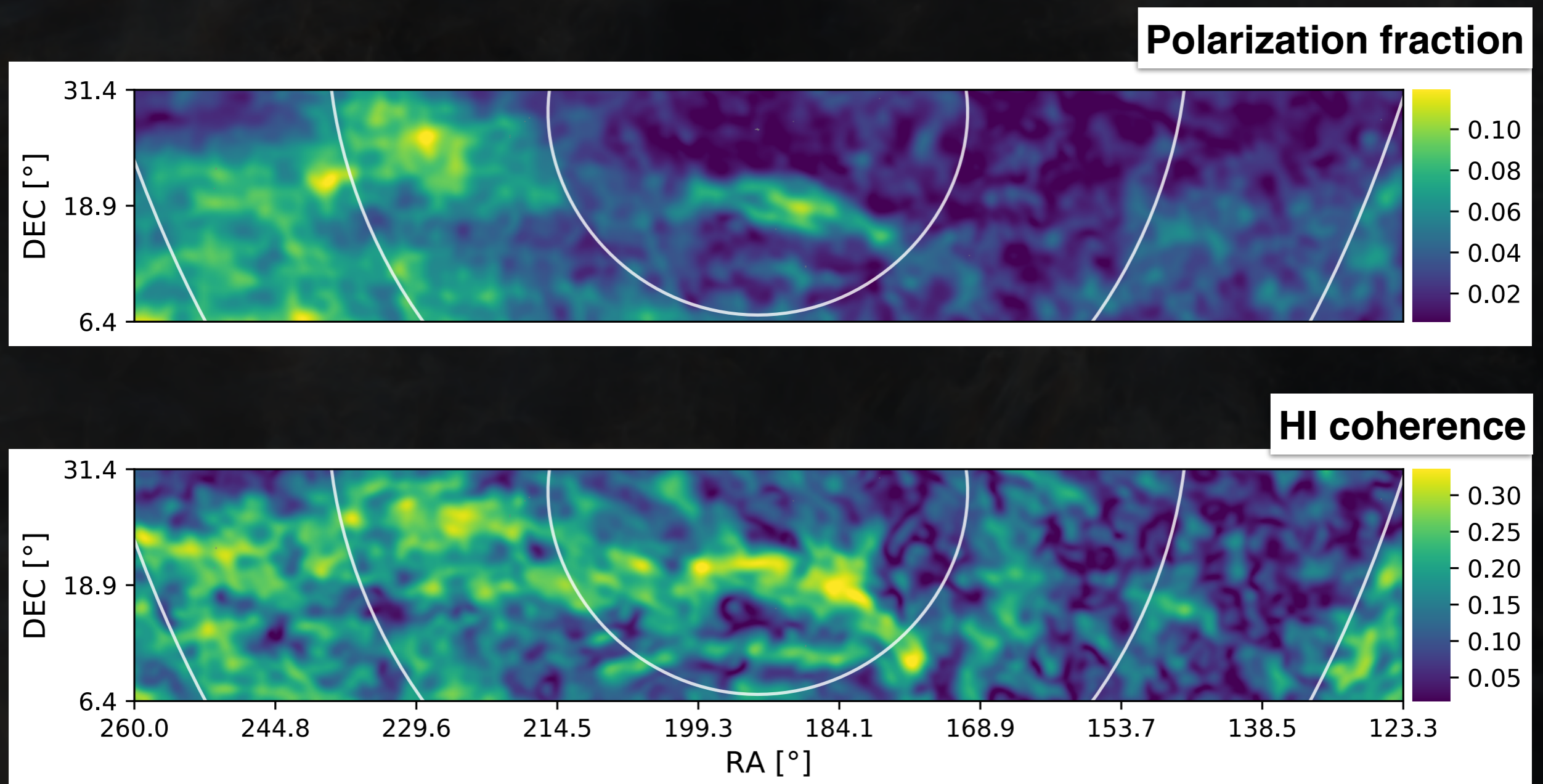
Clark 2018

# The dispersion of HI orientation traces LOS depolarization.



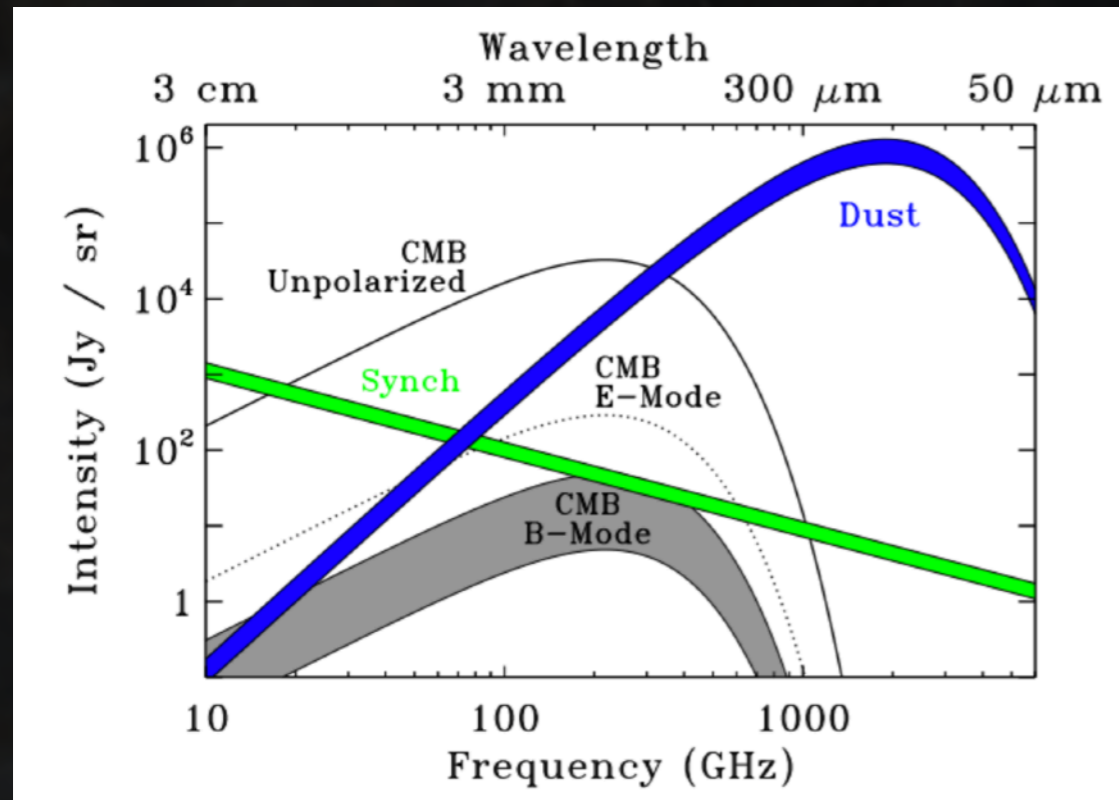
Clark 2018

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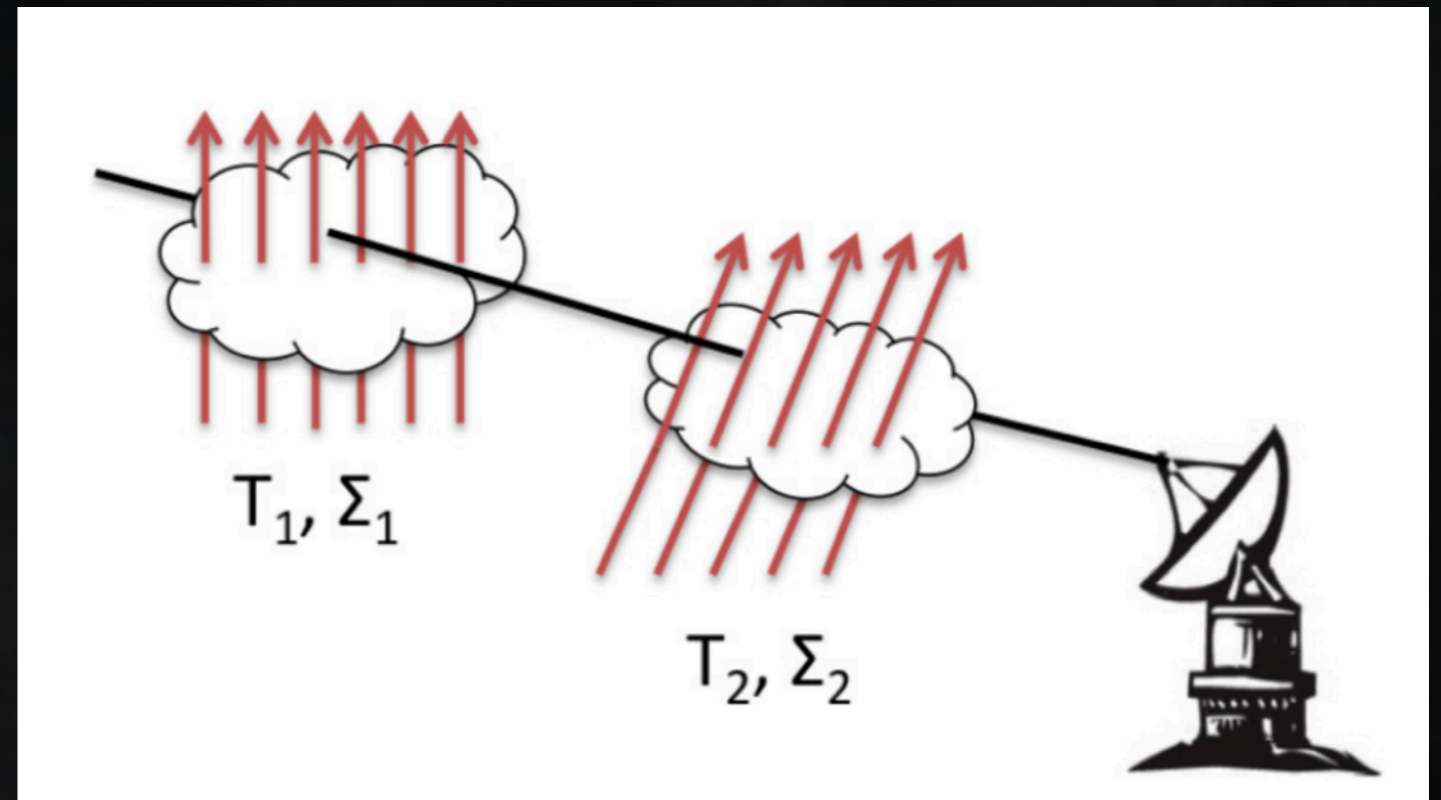


Clark 2018

# LOS magnetic field tangling causes frequency decorrelation.



Kogut & Fixsen 2016



Tassis & Pavlidou 2015

HI-based polarized dust models  
coming soon.

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Measure magnetic field strength

Constrain GMF

Characterize magnetic turbulence in the diffuse ISM

Power spectrum over large range of spatial scales

Probe role of magnetic field in molecular cloud

formation Sensitivity in diffuse regions

Synergies with SKA, HI science

Diffuse ISM science enables better foreground modeling.

New HI-based polarized foreground models in prep