Ambipolar diffusion and polarized thermal dust emission

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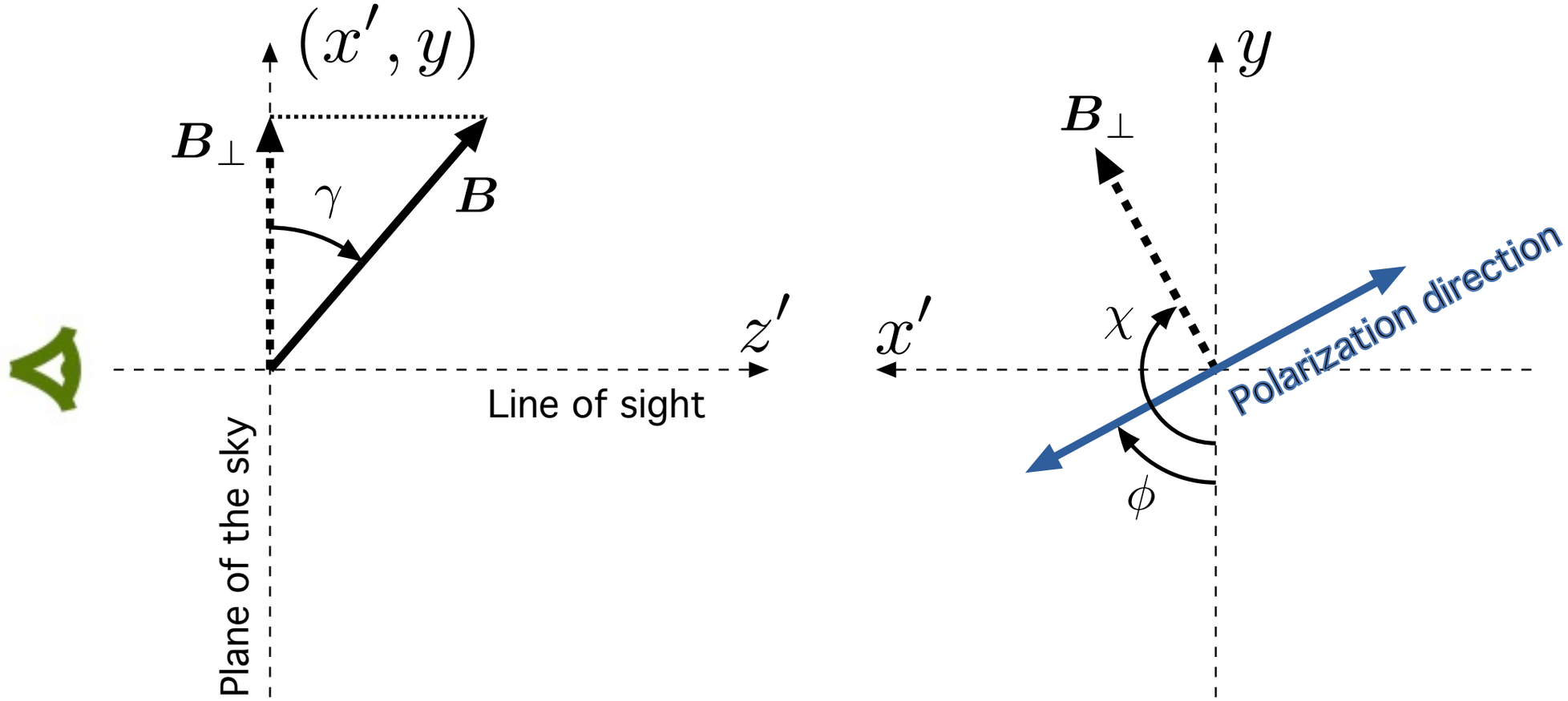
ISM Jamboree 30/01/2014

Simulating polarized thermal dust emission



$$I = \int S_\nu e^{-\tau_\nu} \left[1 - p_0 \left(\cos^2\gamma - \frac{2}{3}\right)\right] \mathrm{d}\tau_\nu$$

$$Q = \int p_0 S_\nu e^{-\tau_\nu} \cos(2\phi) \cos^2\gamma \mathrm{d}\tau_\nu$$

$$U = \int p_0 S_\nu e^{-\tau_\nu} \sin(2\phi) \cos^2\gamma \mathrm{d}\tau_\nu$$

Intrinsic dust polarization

$p_0 = 0.2$

Opacity at 353 GHz (Planck Collaboration XXXI, 2014)

$\tau_{353}/N_\mathrm{H} = 1.2 \times 10^{-26}\,\mathrm{cm}^{-2}$

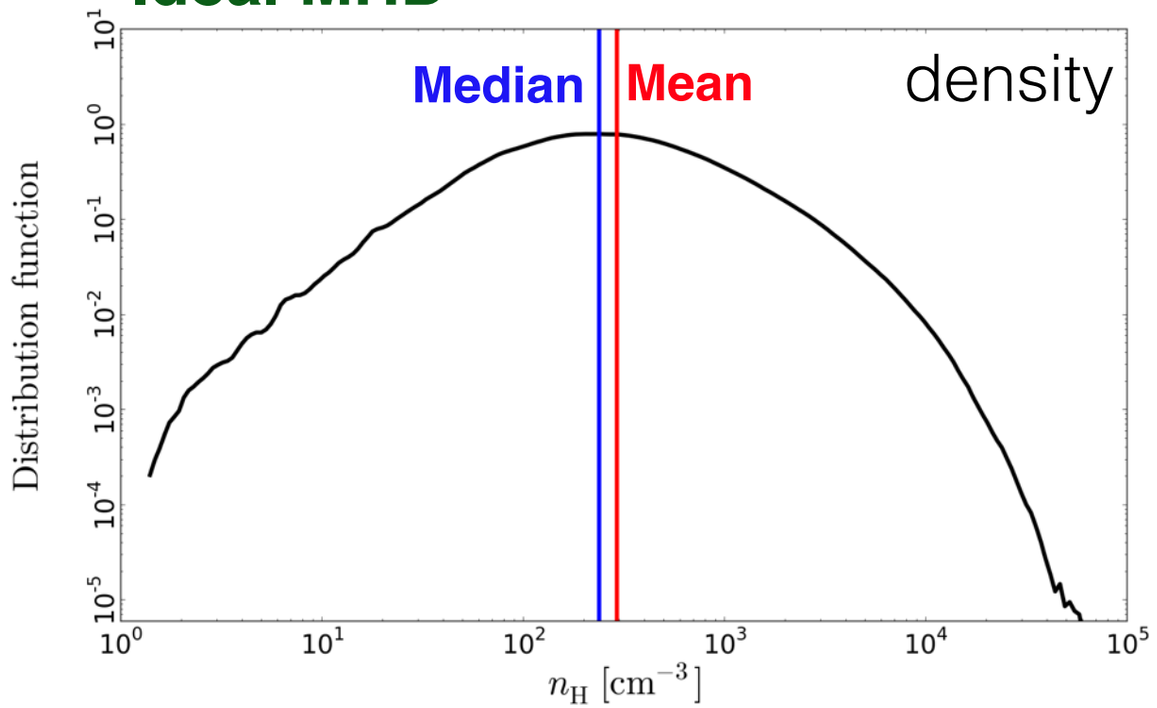
Dust temperature

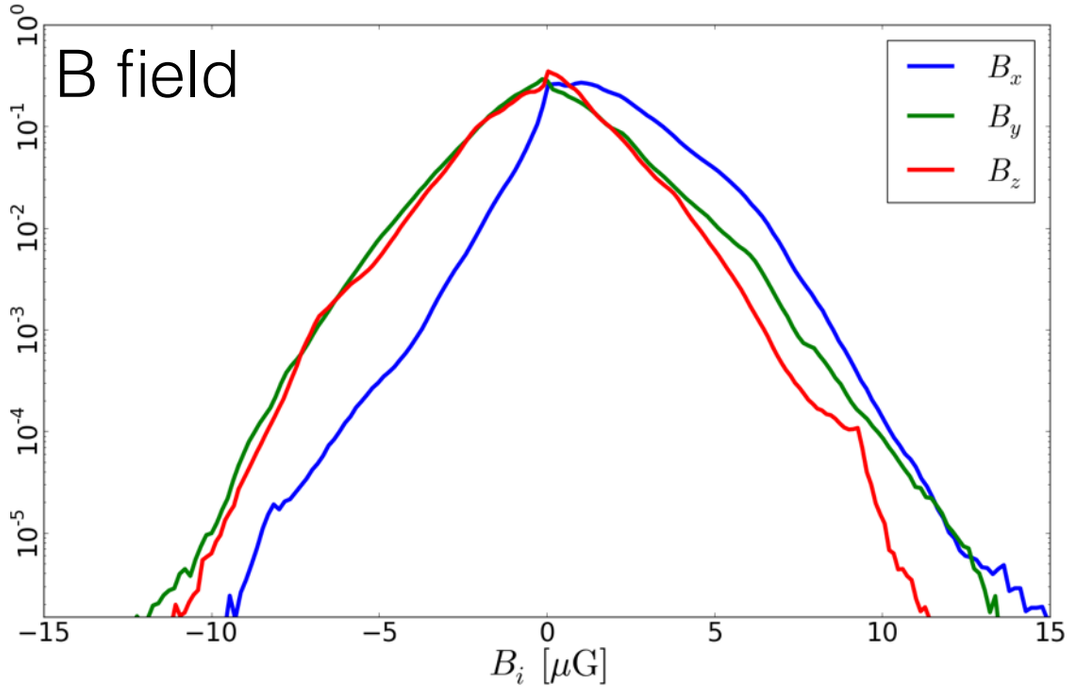
$T_d = 18\,\mathrm{K}$

Following Lee & Draine 85 and others…

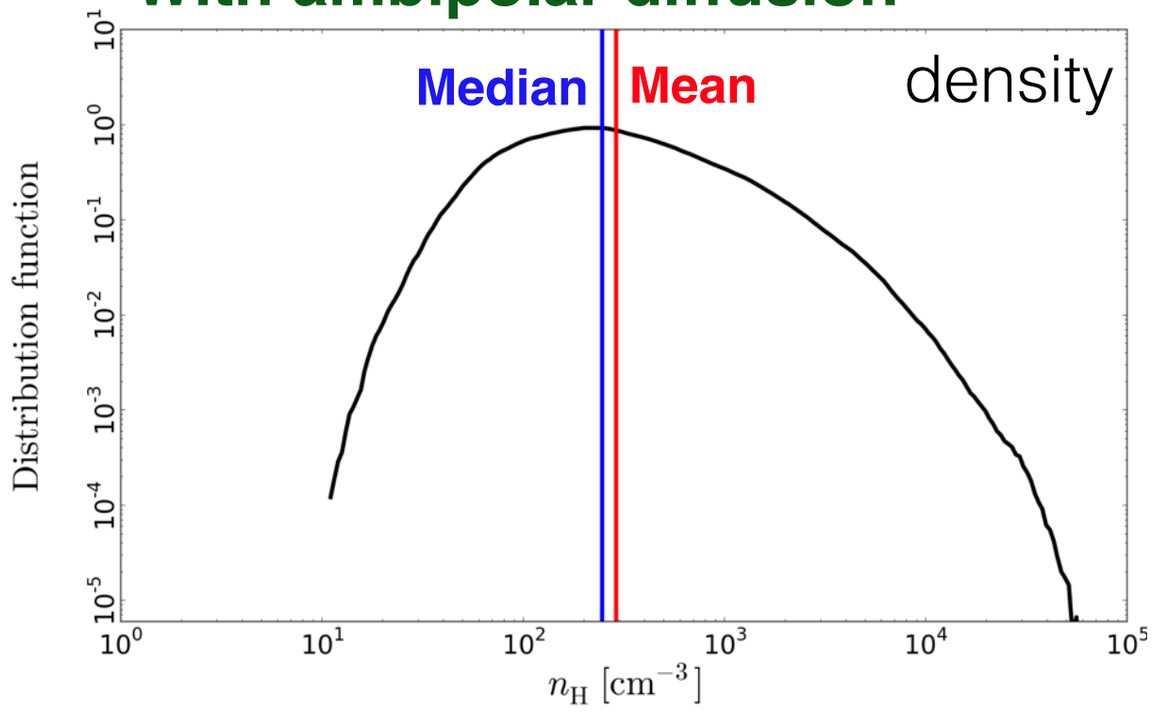
Simulations with and without AD

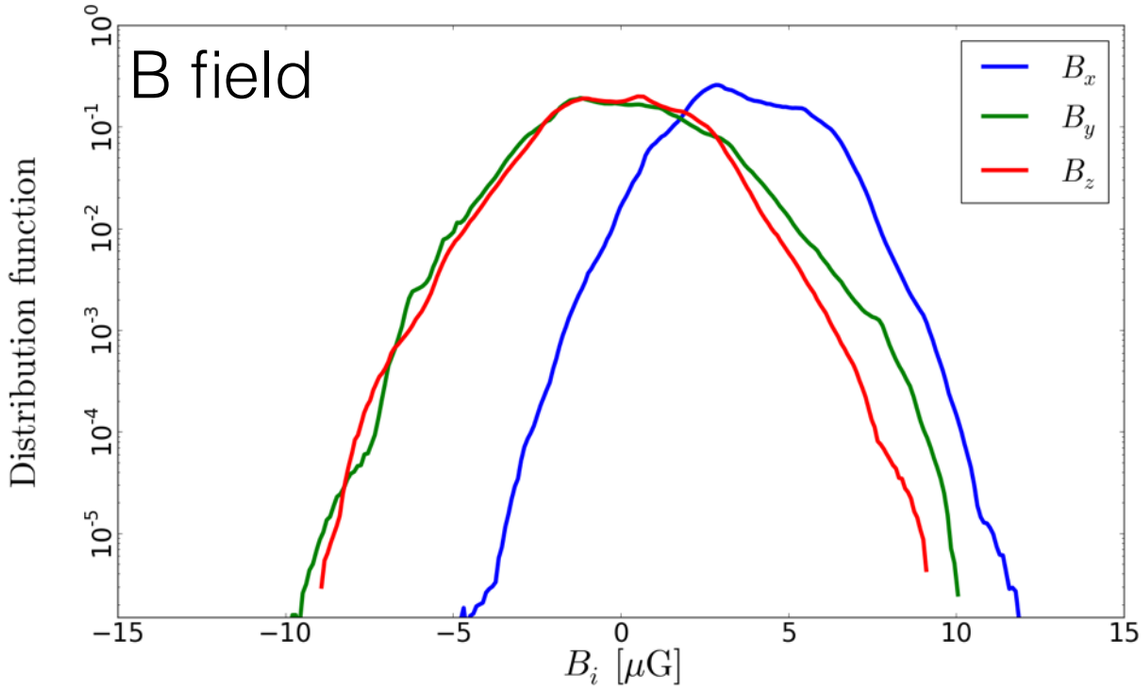
Ideal MHD





With ambipolar diffusion

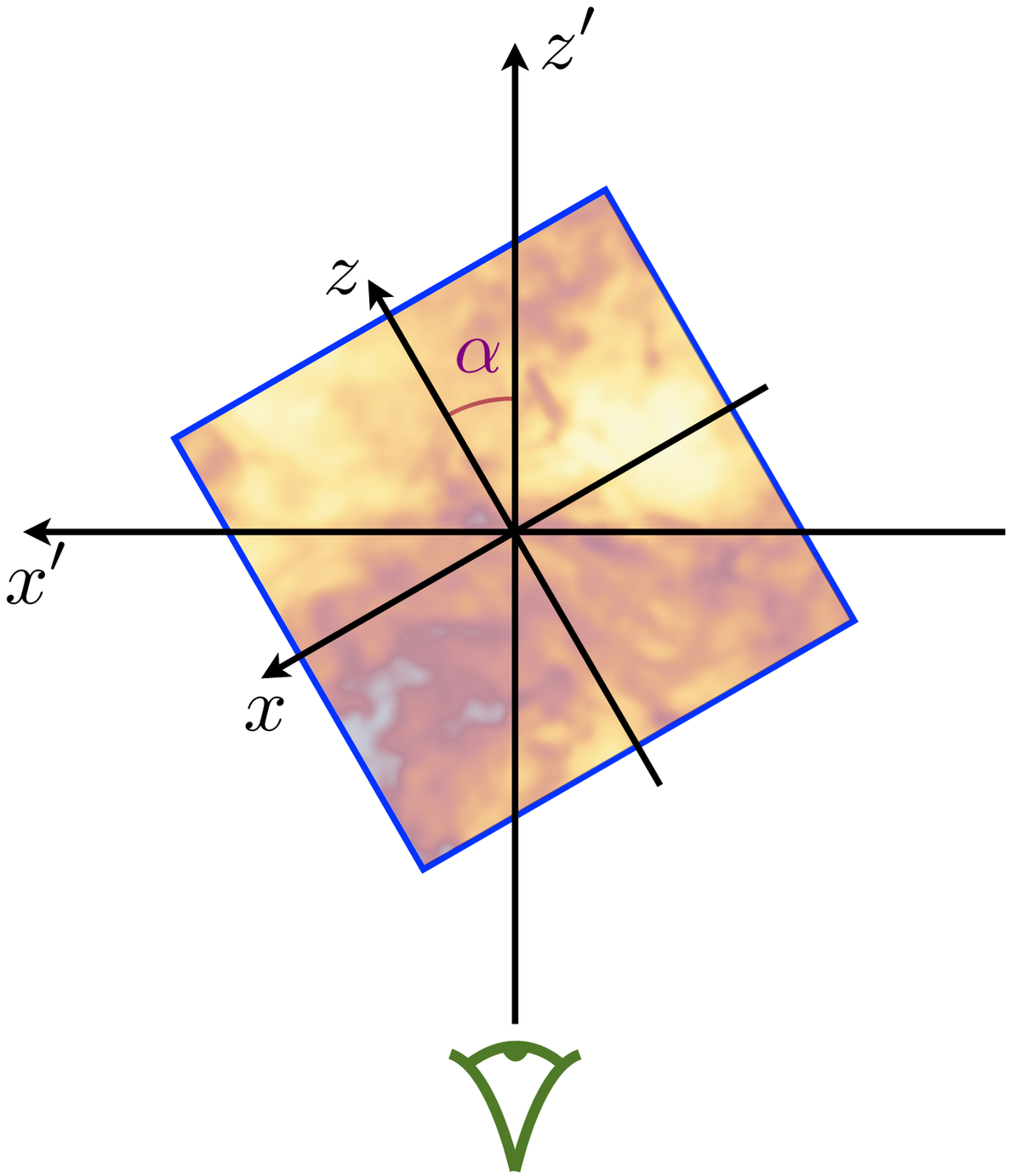


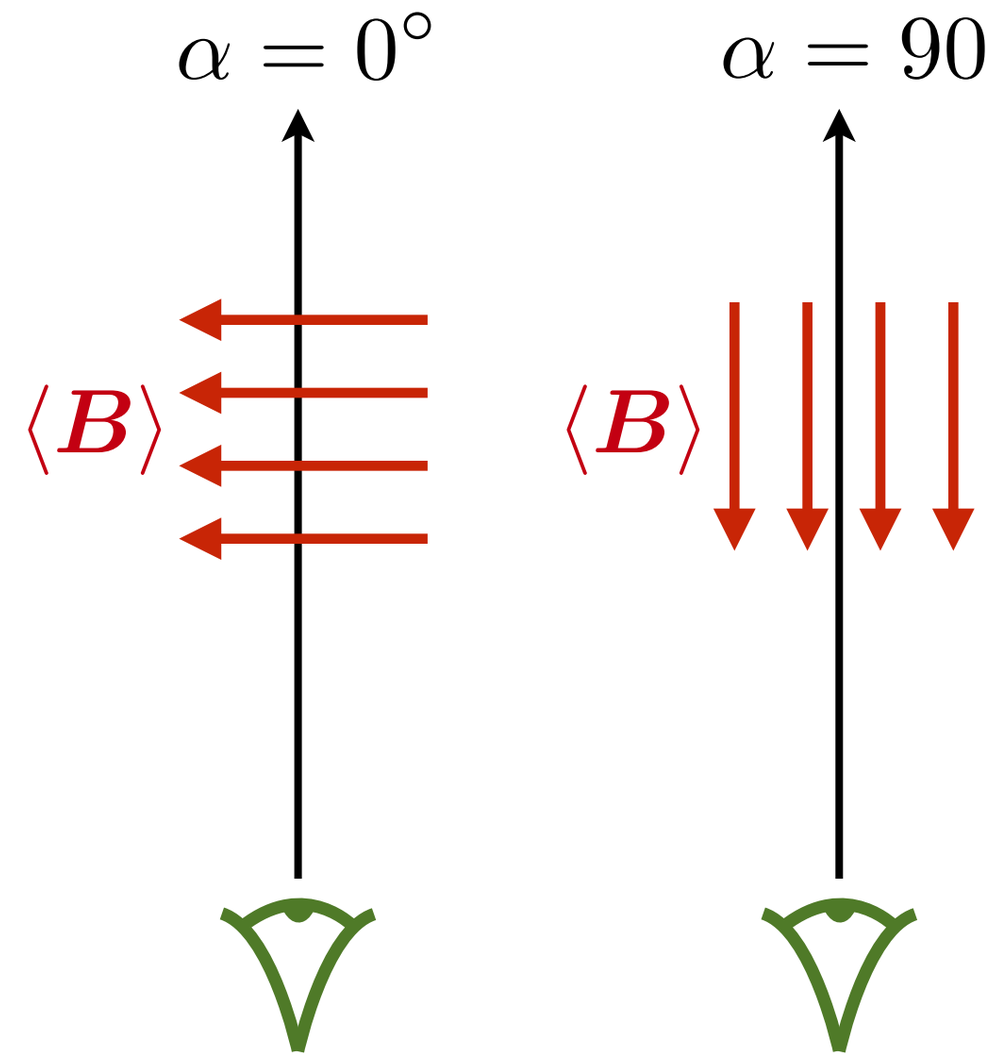


Simulations by E. Ntormousi & P. Hennebelle

L=1pc, l_{max}=11

Rotating the anisotropic input cubes



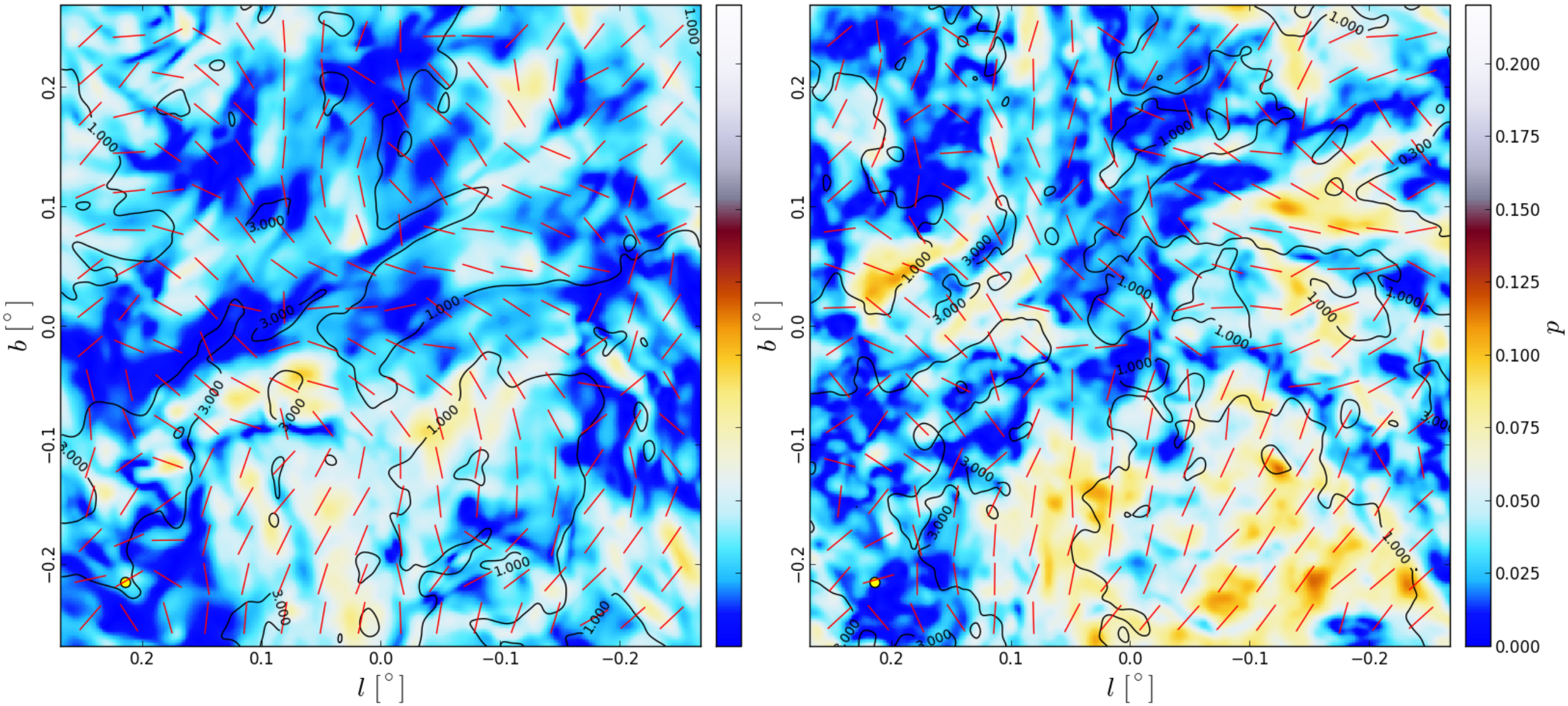


Regular gridding at *N*=512 : 2 mpc pixels

Simulated polarization fraction maps

With ambipolar diffusion

Ideal MHD



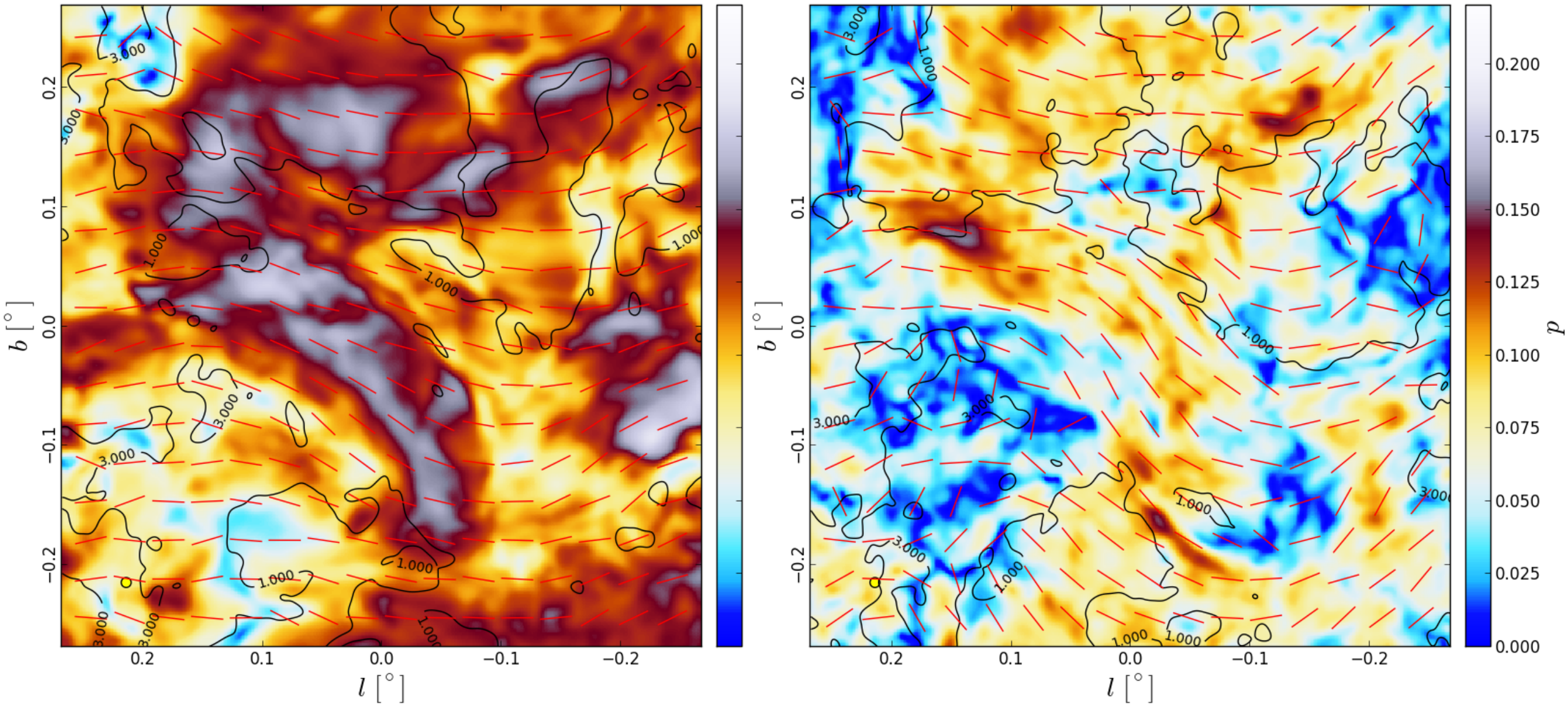
$$\alpha = 90°$$

Distance : 100 pc
Instrumental beam : 30 arcsecs FWHM corresponding to 15 mpc
No noise…

Simulated polarization fraction maps

With ambipolar diffusion

Ideal MHD



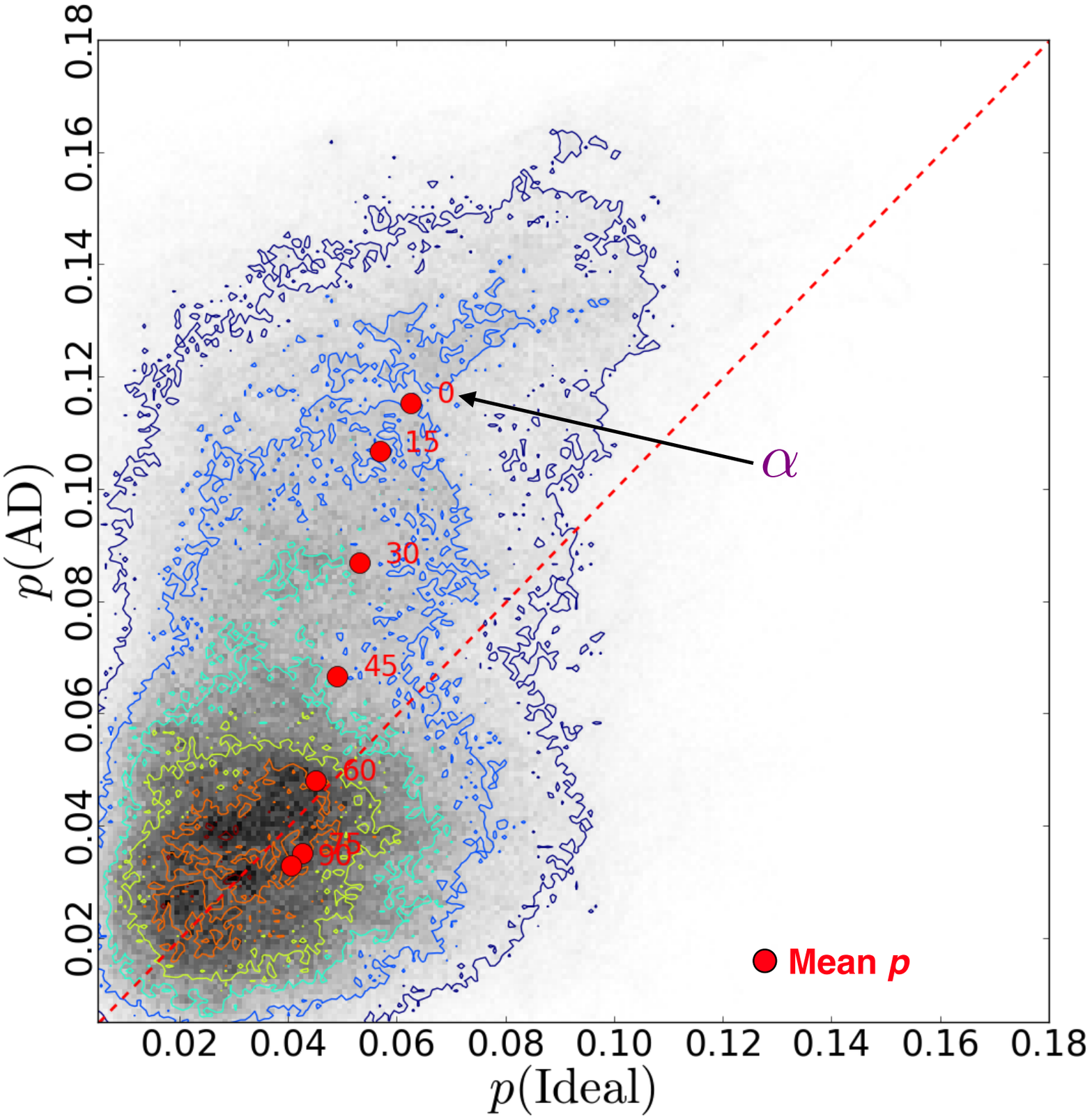
$$\alpha = 0^\circ$$

Distance : 100 pc

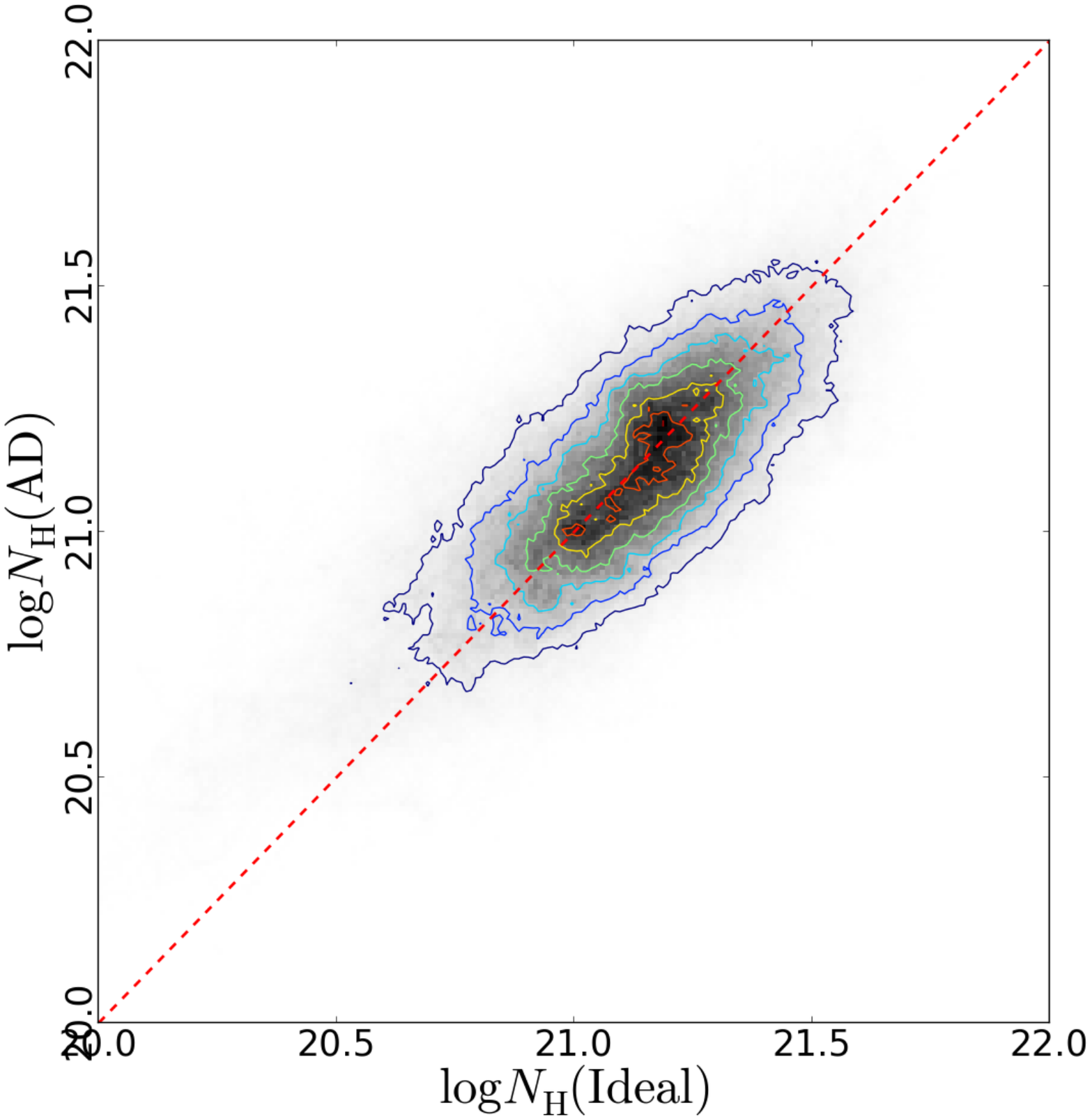
Instrumental beam : 30 arcsecs FWHM corresponding to 15 mpc

No noise…

Comparison of polarization fractions



Comparison of column densities

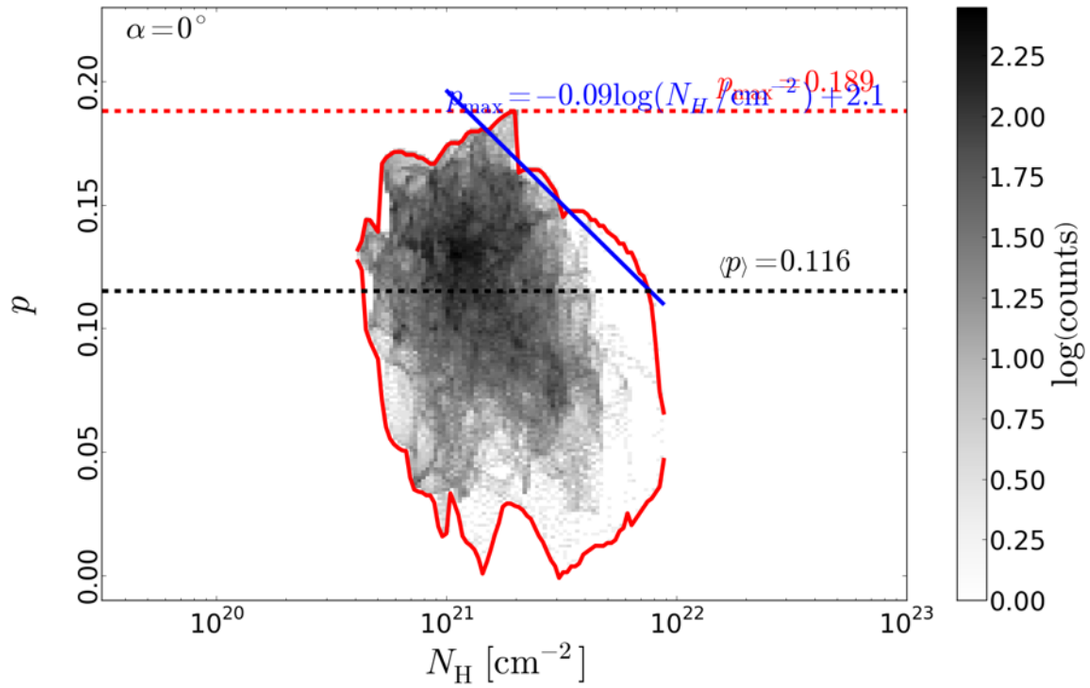


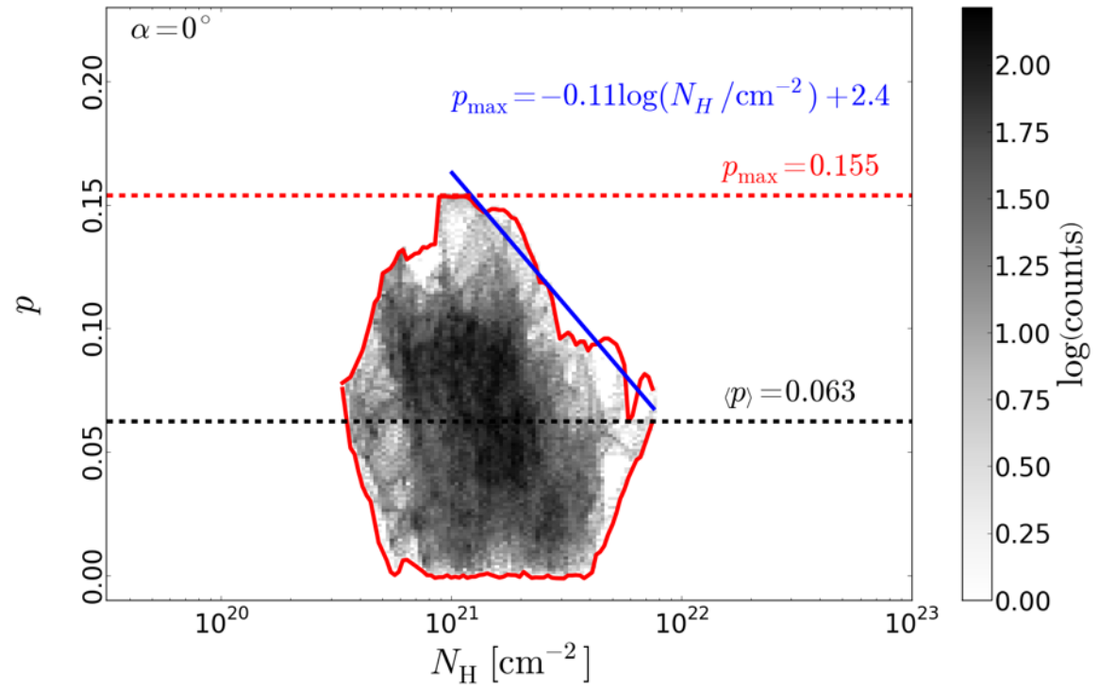
Polarization fraction vs. column density

With ambipolar diffusion

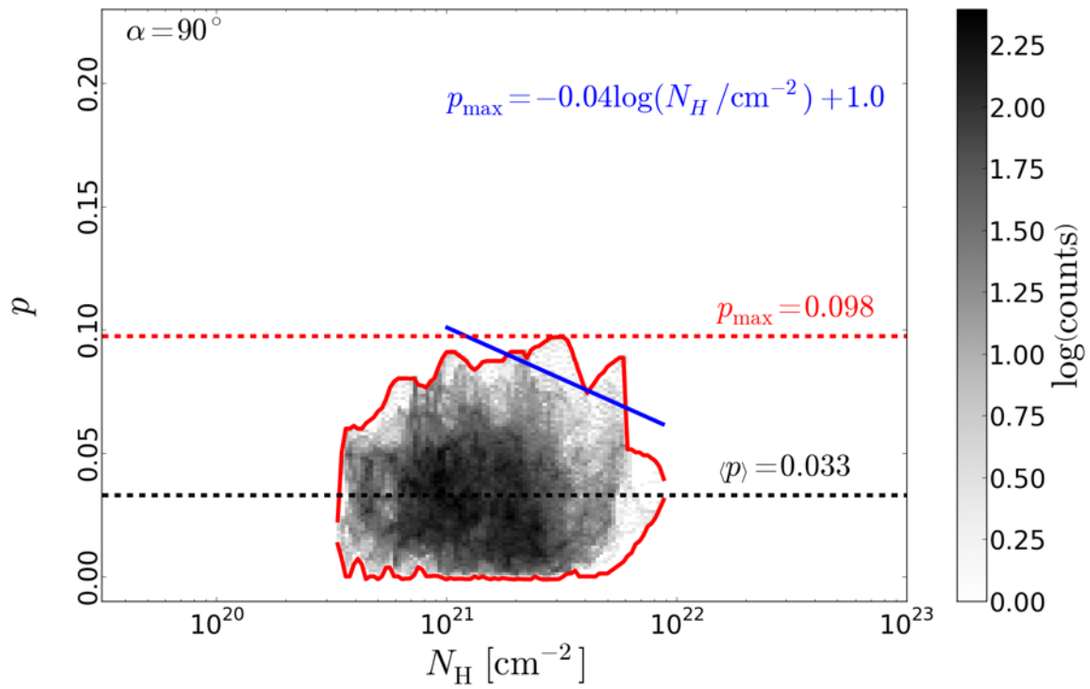
Ideal MHD

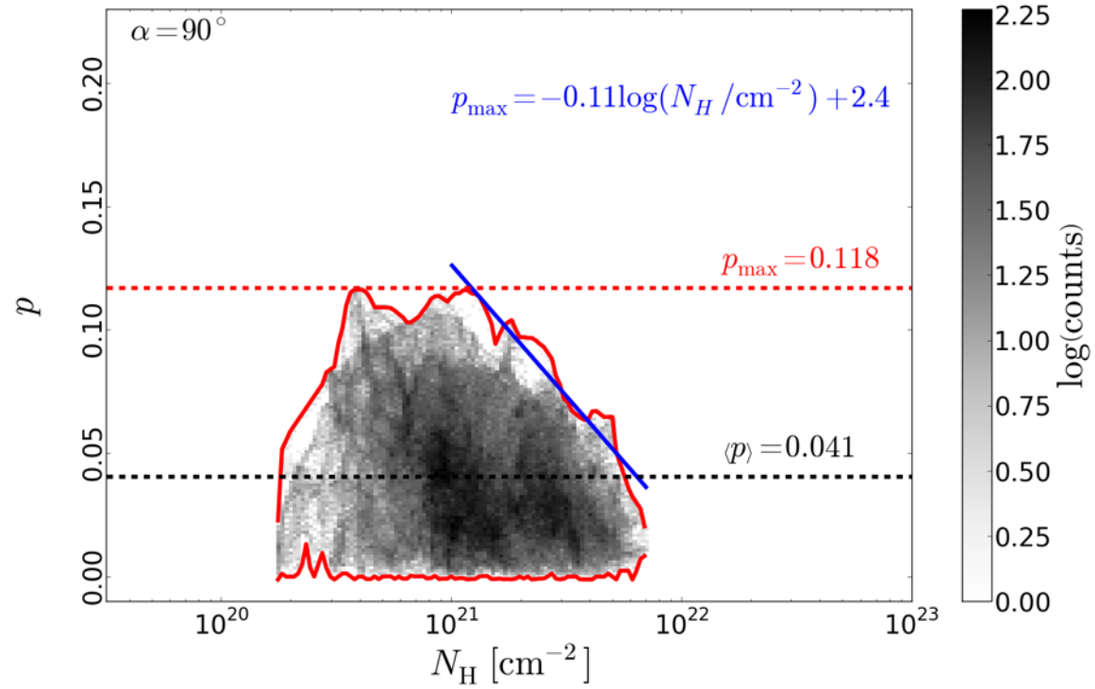
$\alpha = 0°$





$\alpha = 90°$



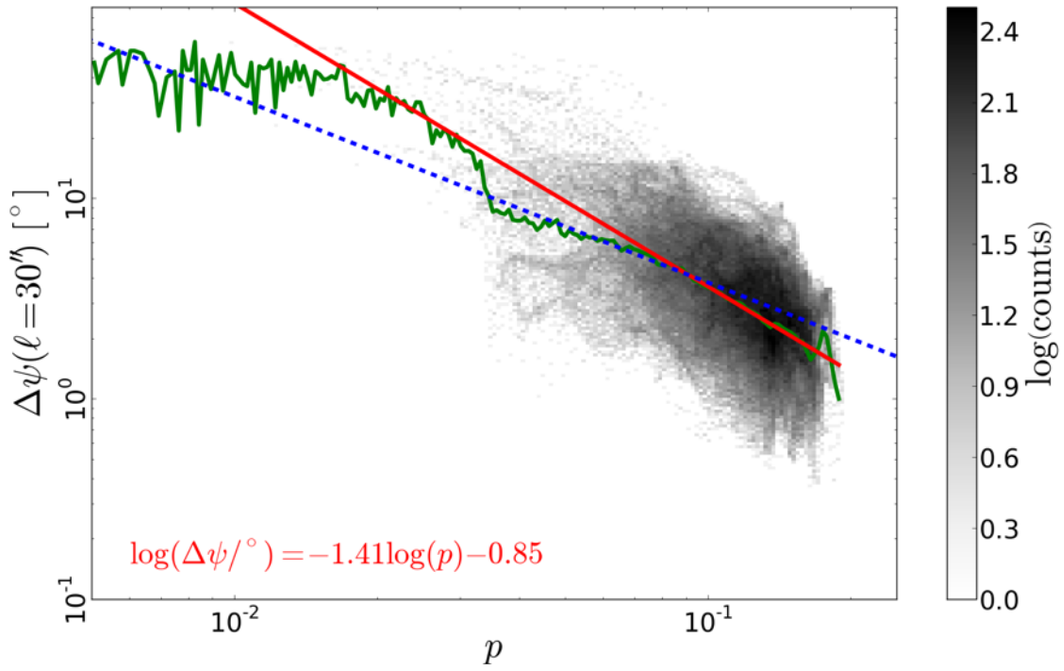


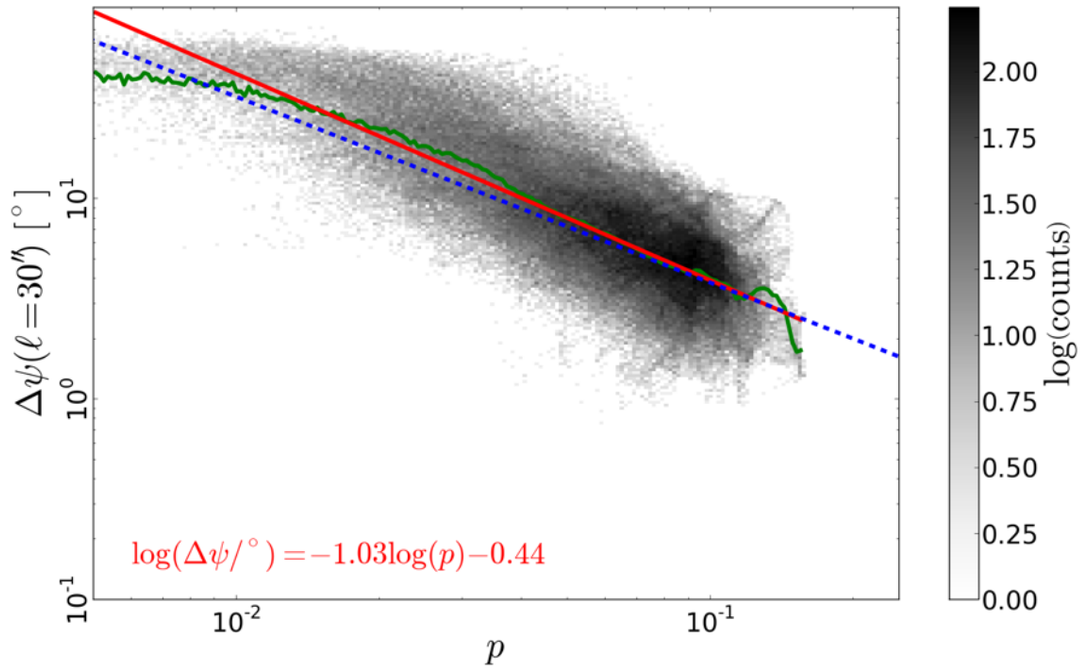
Angle dispersions vs. polarization fractions

With ambipolar diffusion

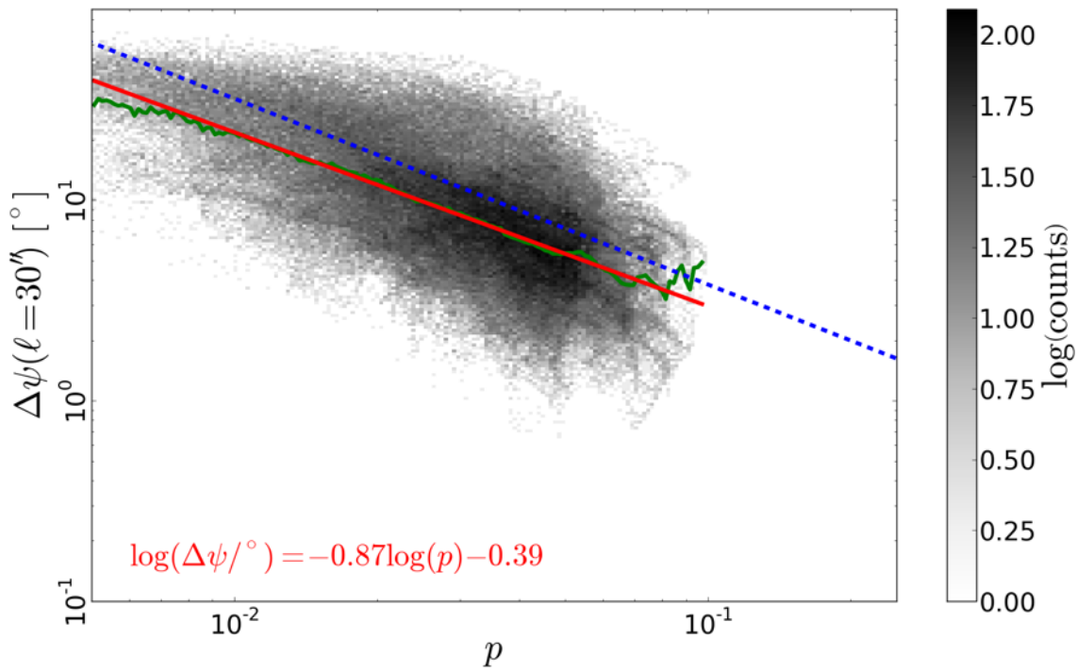
Ideal MHD

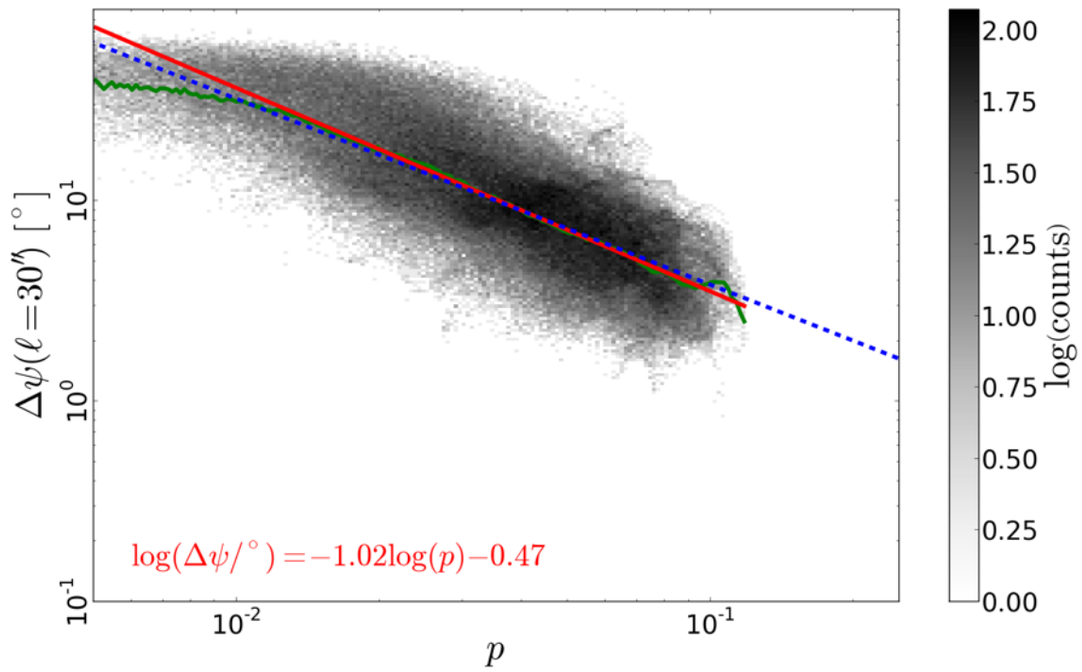
$\alpha = 0^\circ$





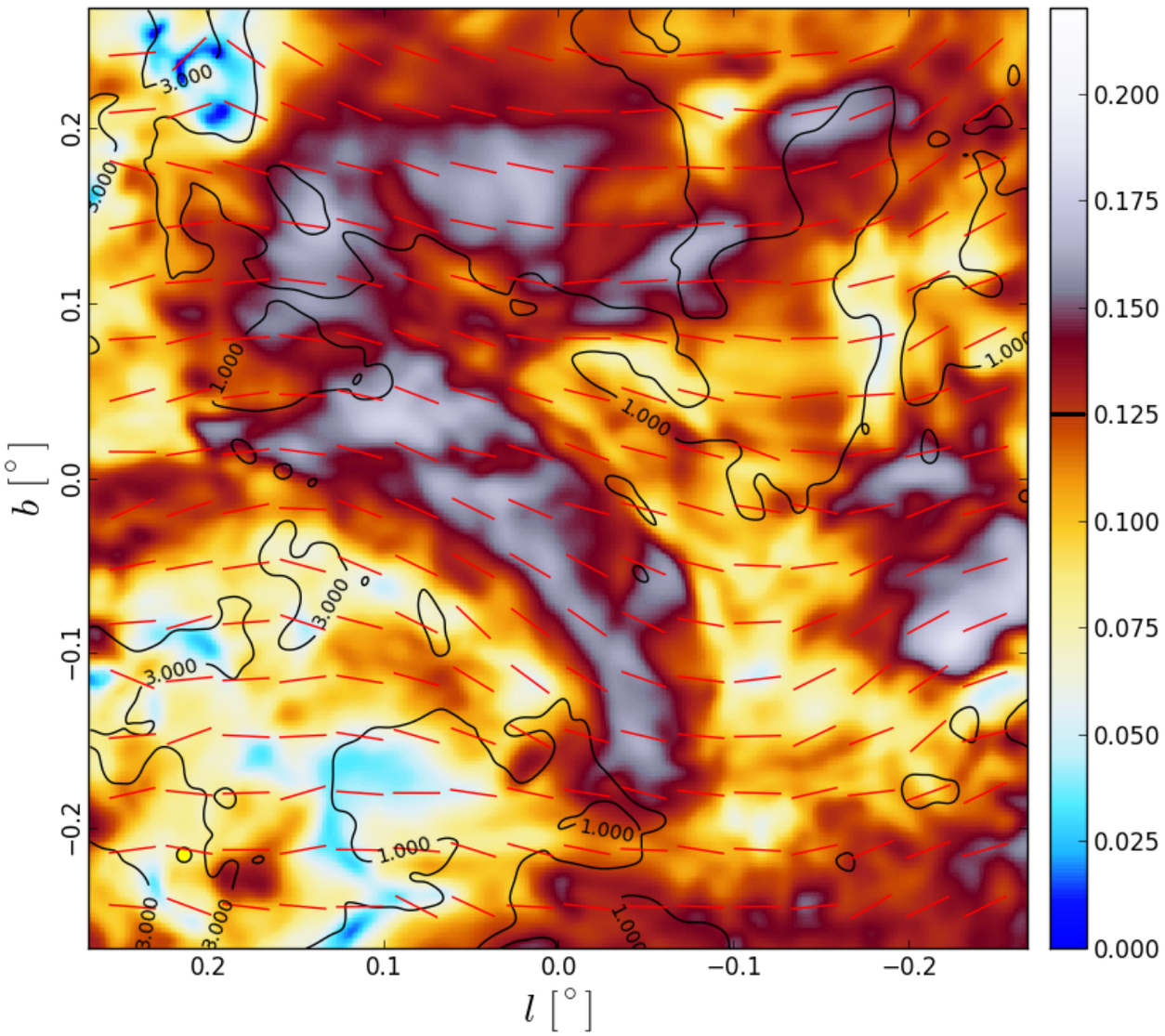
$\alpha = 90^\circ$



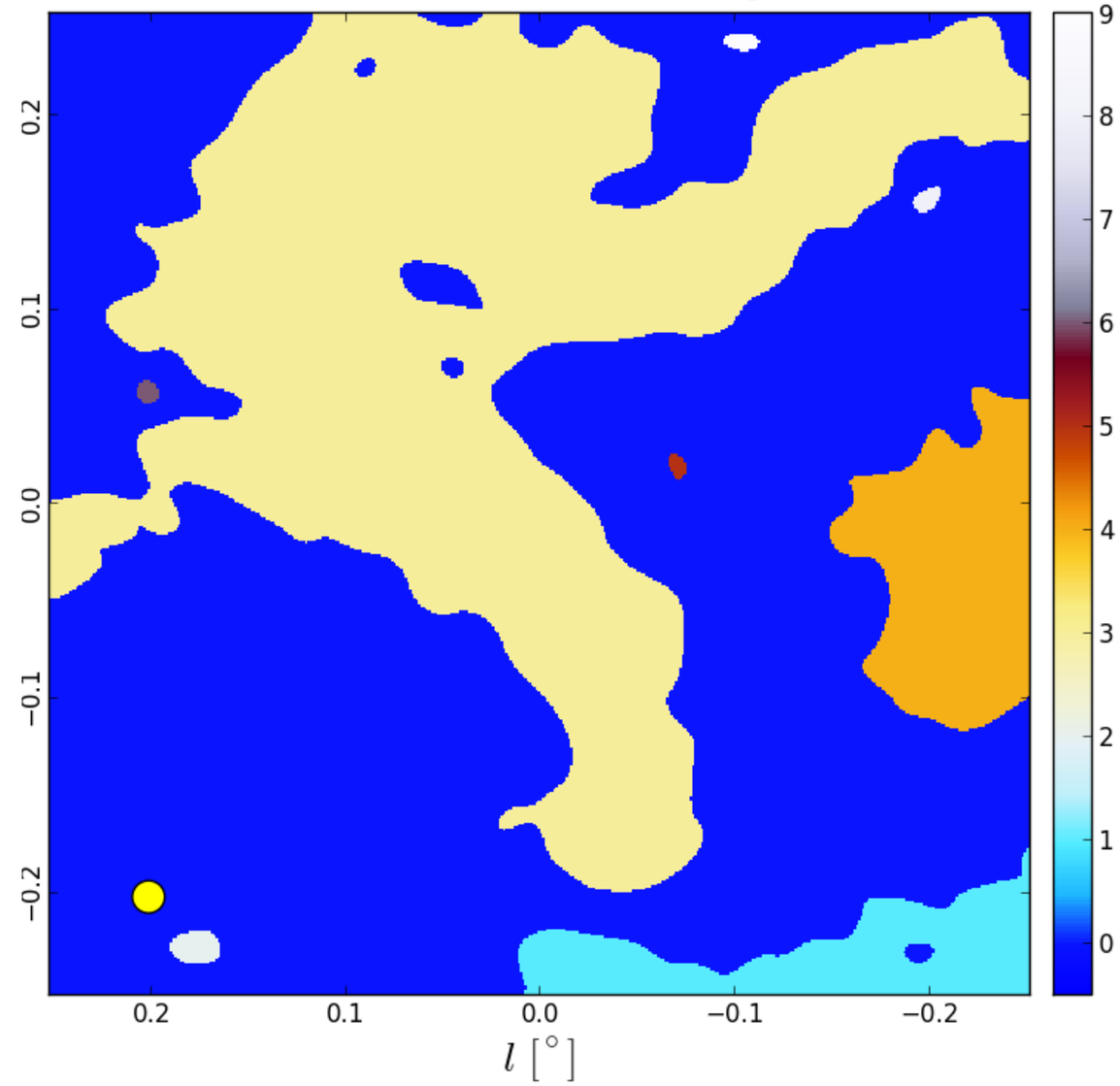


Small decrease of the angular dispersion from ideal MHD to AD MHD

Size of structures above a given p



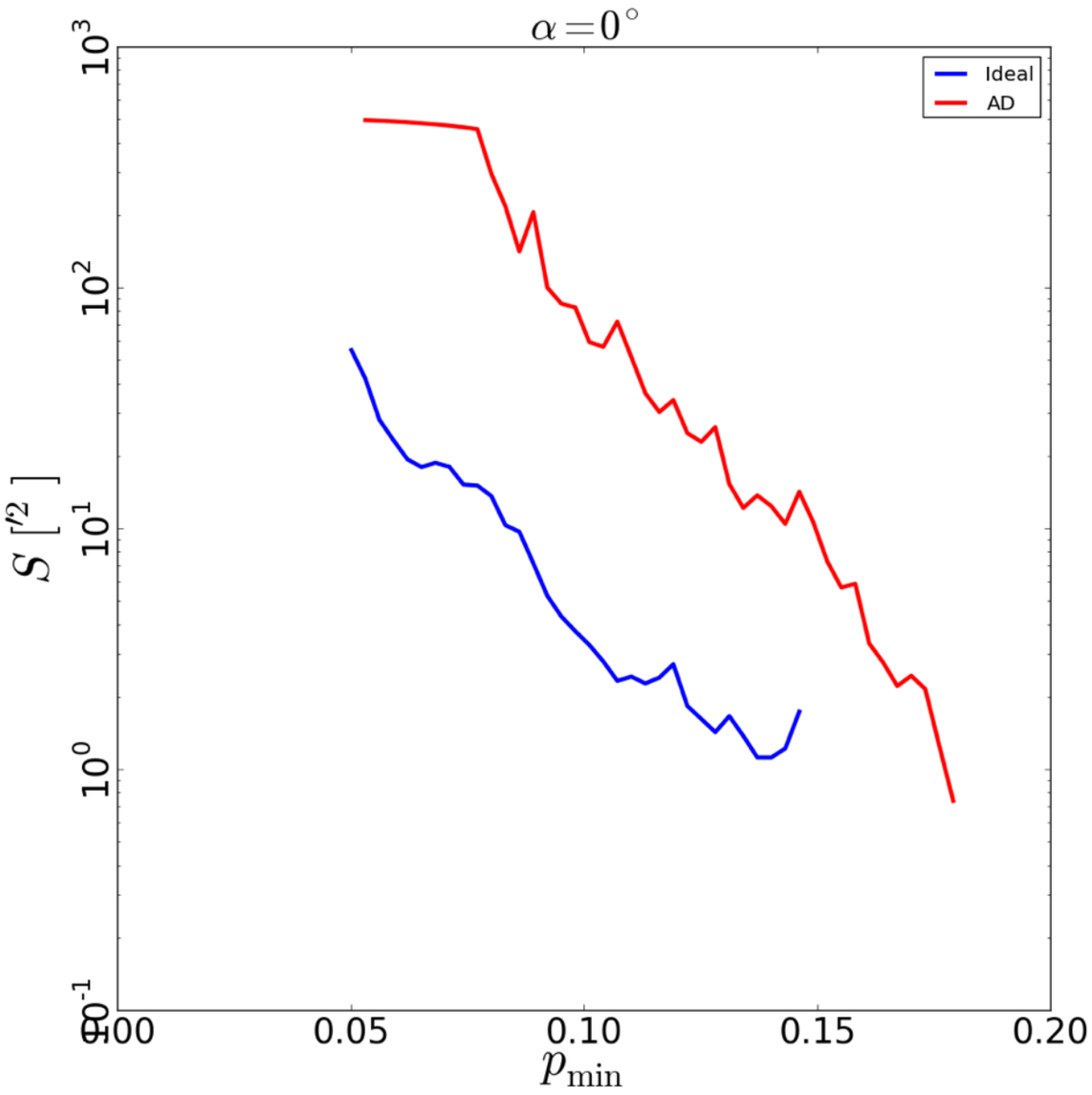
Structures above 12,5% polarization

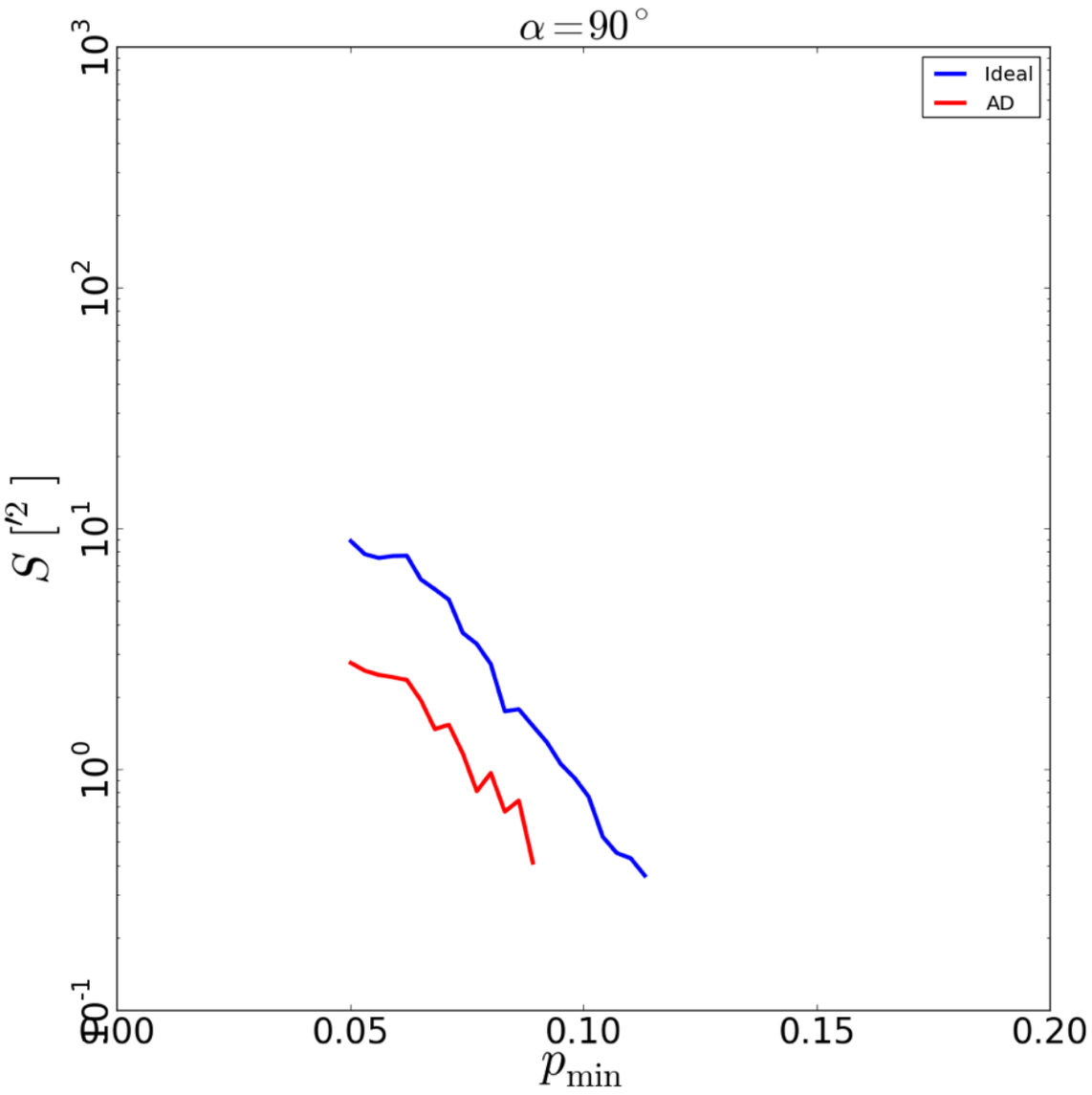


$$\alpha = 0^\circ$$

Thresholding of *p* maps
Identification of connected structures
Computation of the area of each structure

Size of structures above a given p



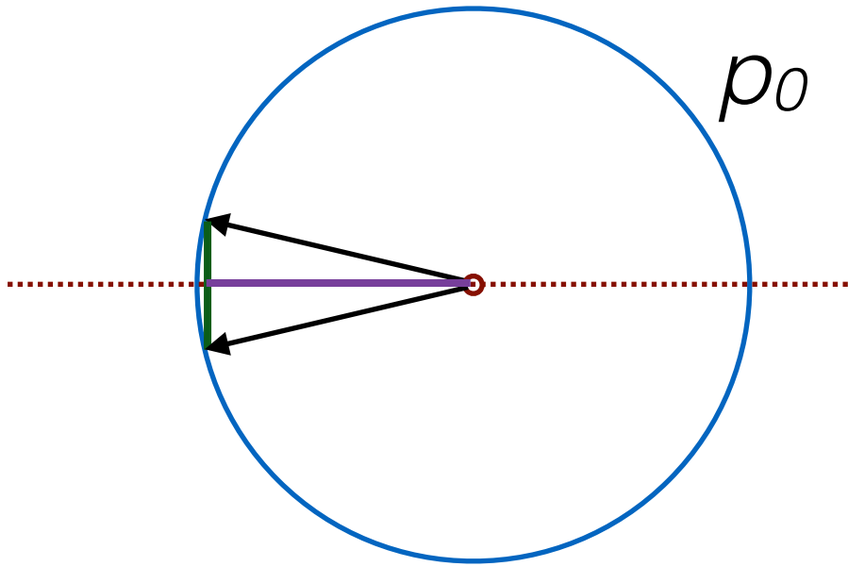


Statistical variance may be large
Structures cut by the edges of the map
Difference in overall *p* not taken into account

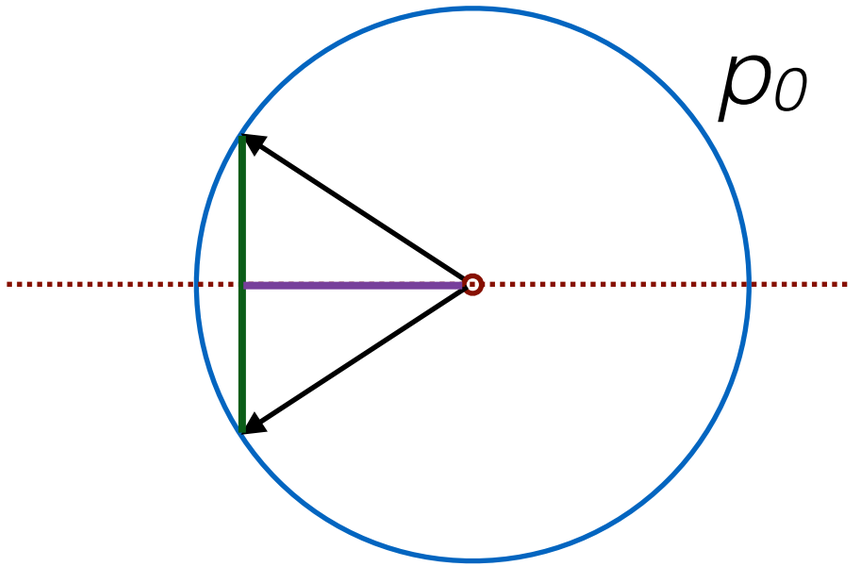
Temporary conclusions

Geometrical interpretation of the polarization fraction variations

With ambipolar diffusion



Ideal MHD



Small decrease of the angular dispersion from ideal MHD to AD MHD

Structures in AD MHD polarization simulations seem less « mottled » than in ideal MHD