Statistical analysis of the interplay between magnetic fields and filaments hosting PGCCs

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GCC meeting in Besançon

(remotely from Astana)

Star formation: gravity, turbulence, magnetic field, ...

- Weak

Turbulence conducts to overdensities & also provides support (with gas pressure) against gravity

- Strong

Gravitation

Gravitational contraction is guided by the field lines (Nakamura & Li 2008): filamentary structures ⊥ B

Turbulence

Matter is elongated along the field lines (Stone et al 1998): filamentary structures ∥ B

(some) Observational results

- using Planck data
  - PIP XXXII: diffuse ISM, Hessian analyis ∥ relative orientation ∥ + ⊥ in 2 MCs

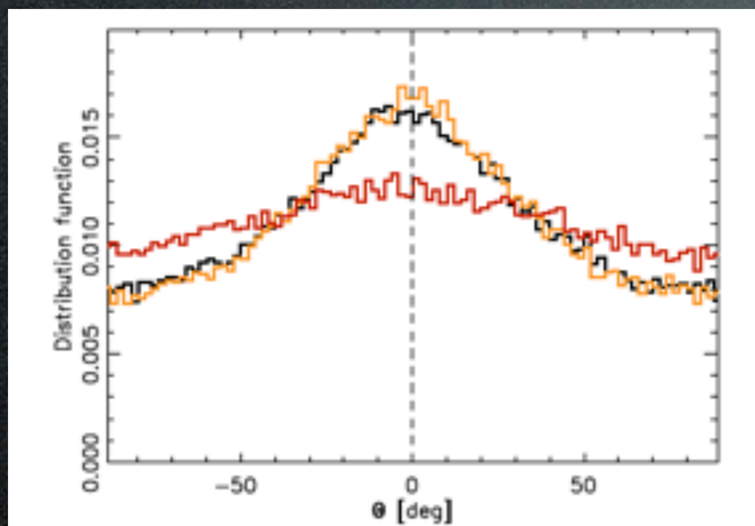
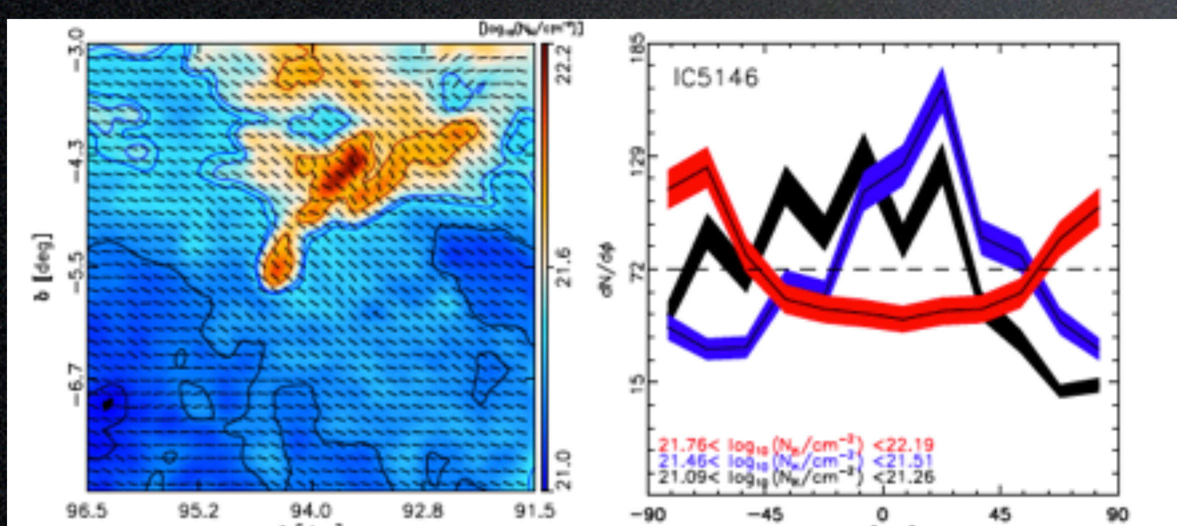


Fig. 10. Distribution function of Θ, the difference between the inferred orientation angle of the magnetic field and that of the ridges,

  - PIP XXXV: 10 GB MCs, HRO (N_H contours), from ∥ to ⊥ with ↗ NH



- using other data
  - SMA, Zhang et al 2014: both ∥ and ⊥

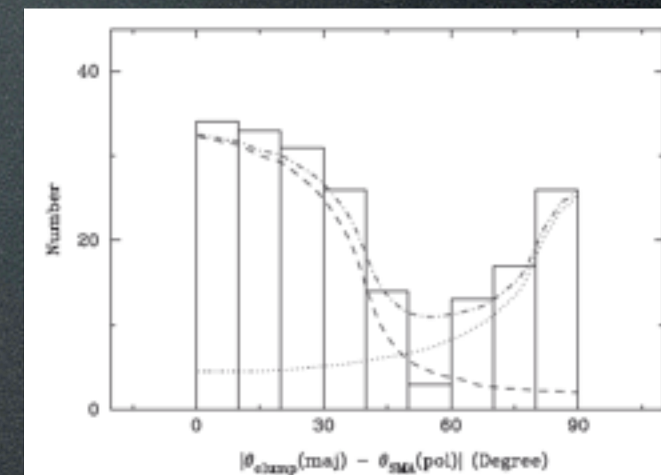
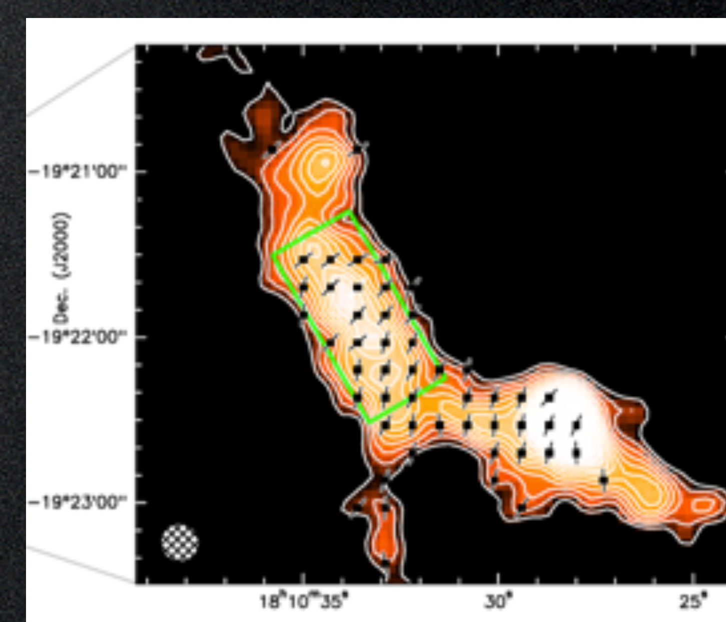


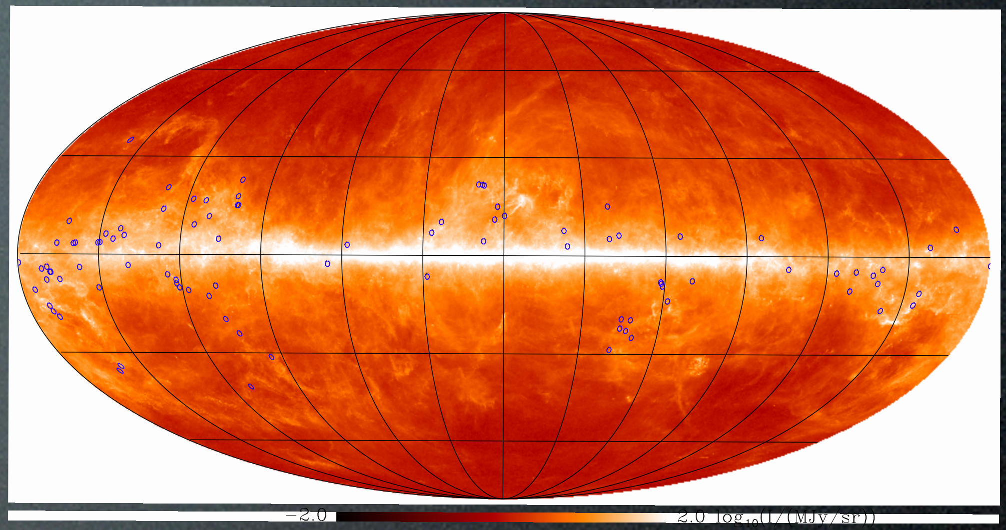
Figure 3. Difference between the major axis of the clump and dust polarization at the core scale. When the angle difference is 0°, the magnetic field is

  - ScuPol (JCMT), Pillai et al 2015: ∥ in diffuse and ⊥ in dense part of an IRDC



Aim: statistics + clumps

- Filaments hosting PGCCs
- Clump/Filament geometrical separation
- Dependence on (N_H) environment and relative density



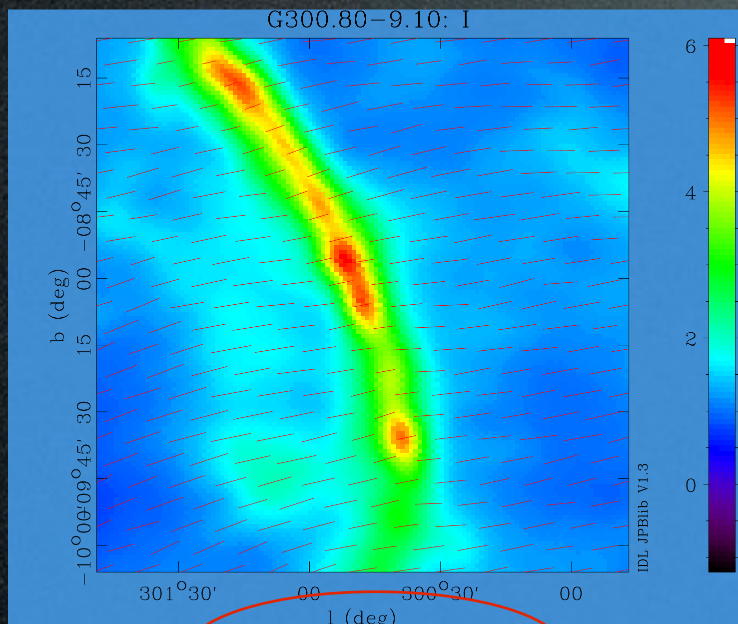
- Detection method: SupRHT
  - Kernel size: 31’ length, 6’ width
  - additional constraints on curvature

$$2° \leq l \leq 60°$$

$$\sigma_P = \sqrt{\sigma_Q \sigma_U} > 2$$

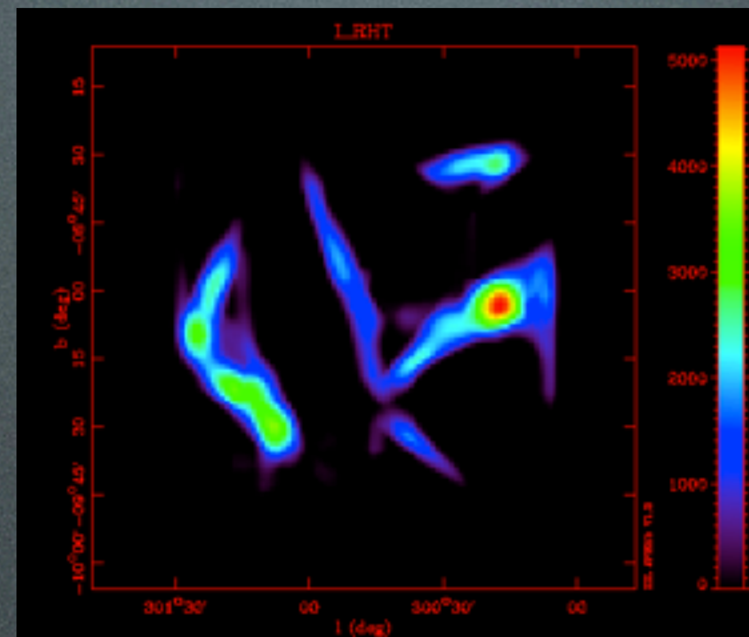
Example

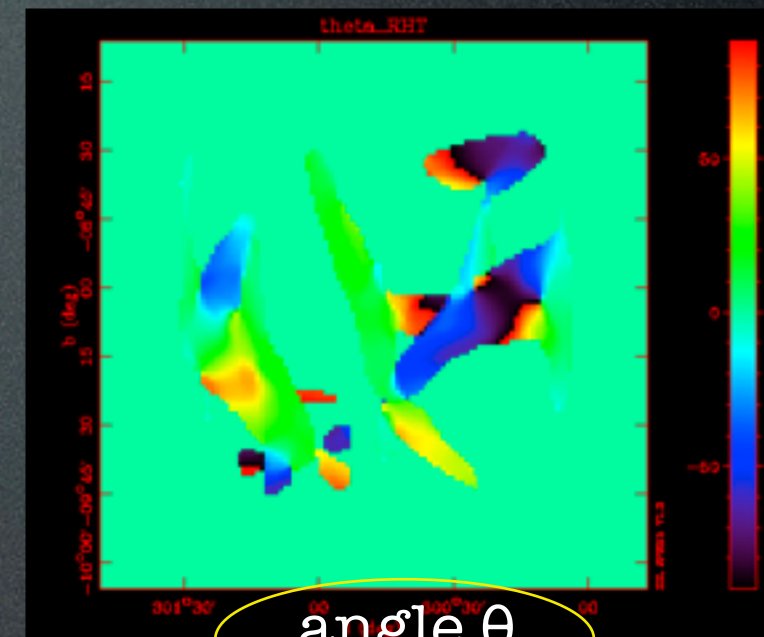
Input map: I_{353GHz}



angle φ

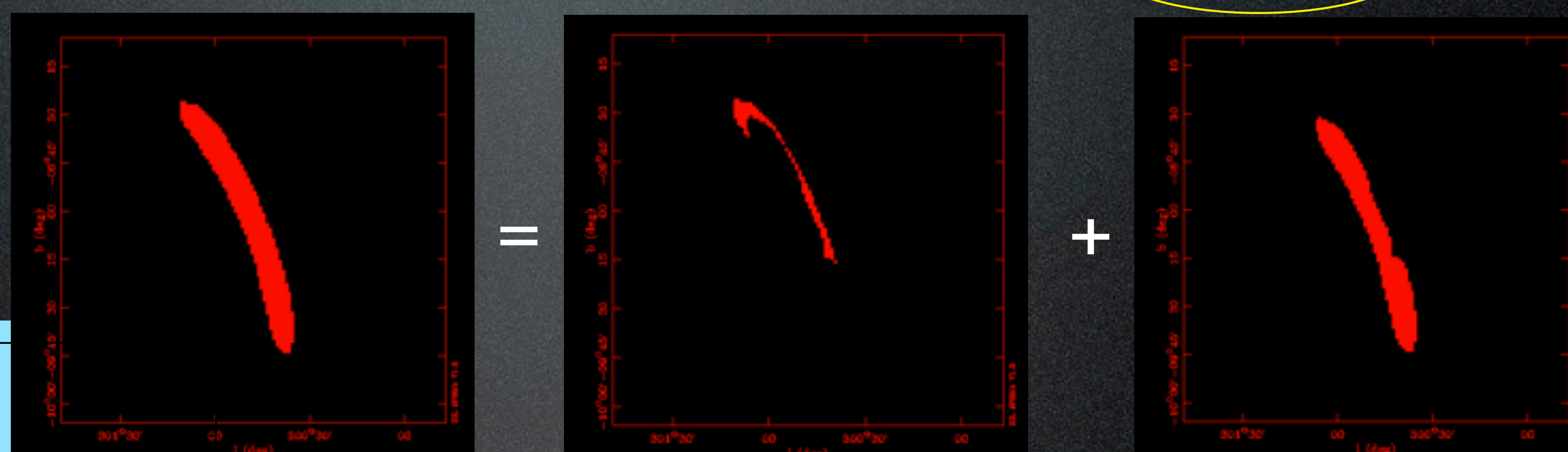
SupRHT output maps (+σ(θ))

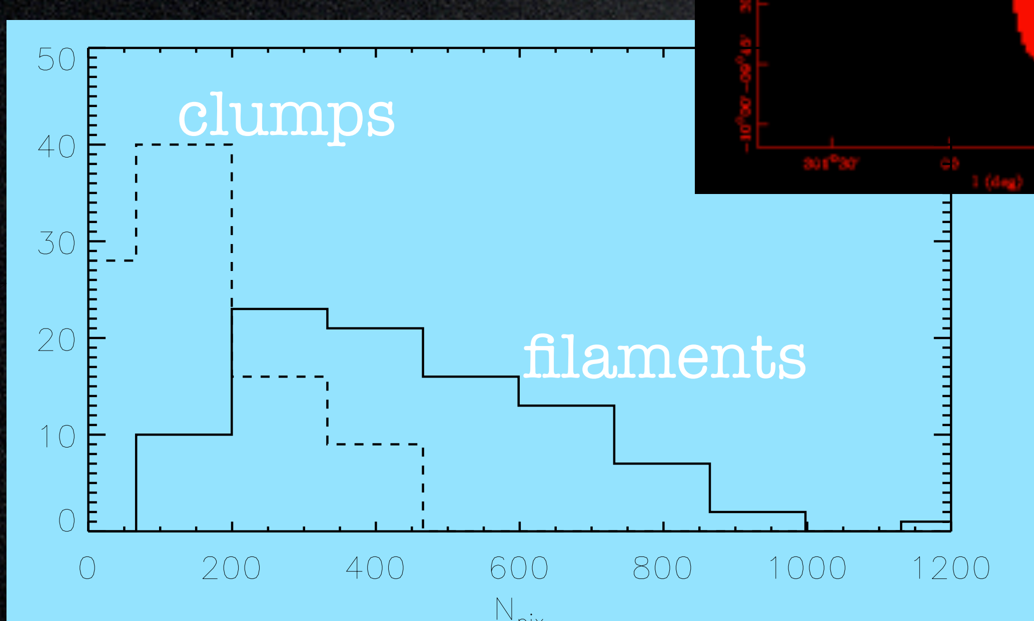




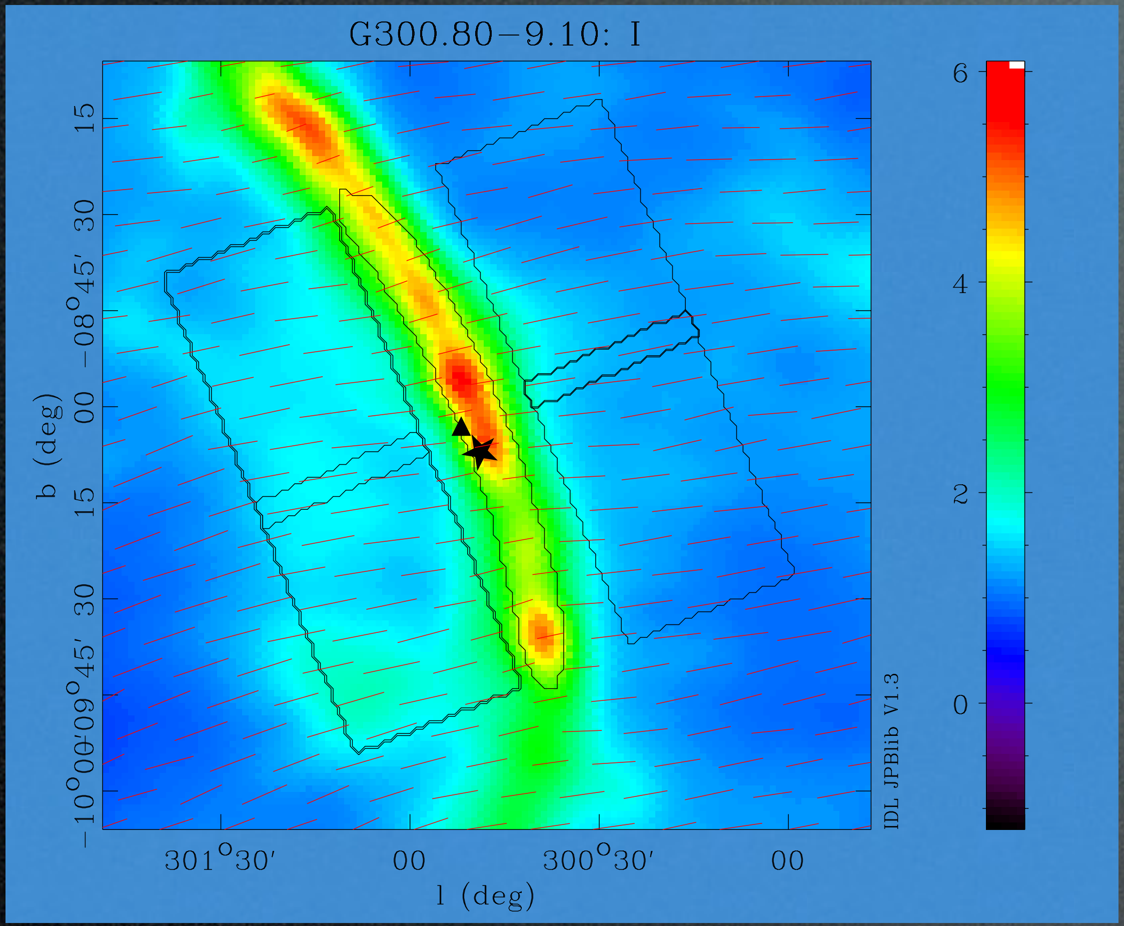
angle θ

Building masks:





Background (Q,U) subtraction

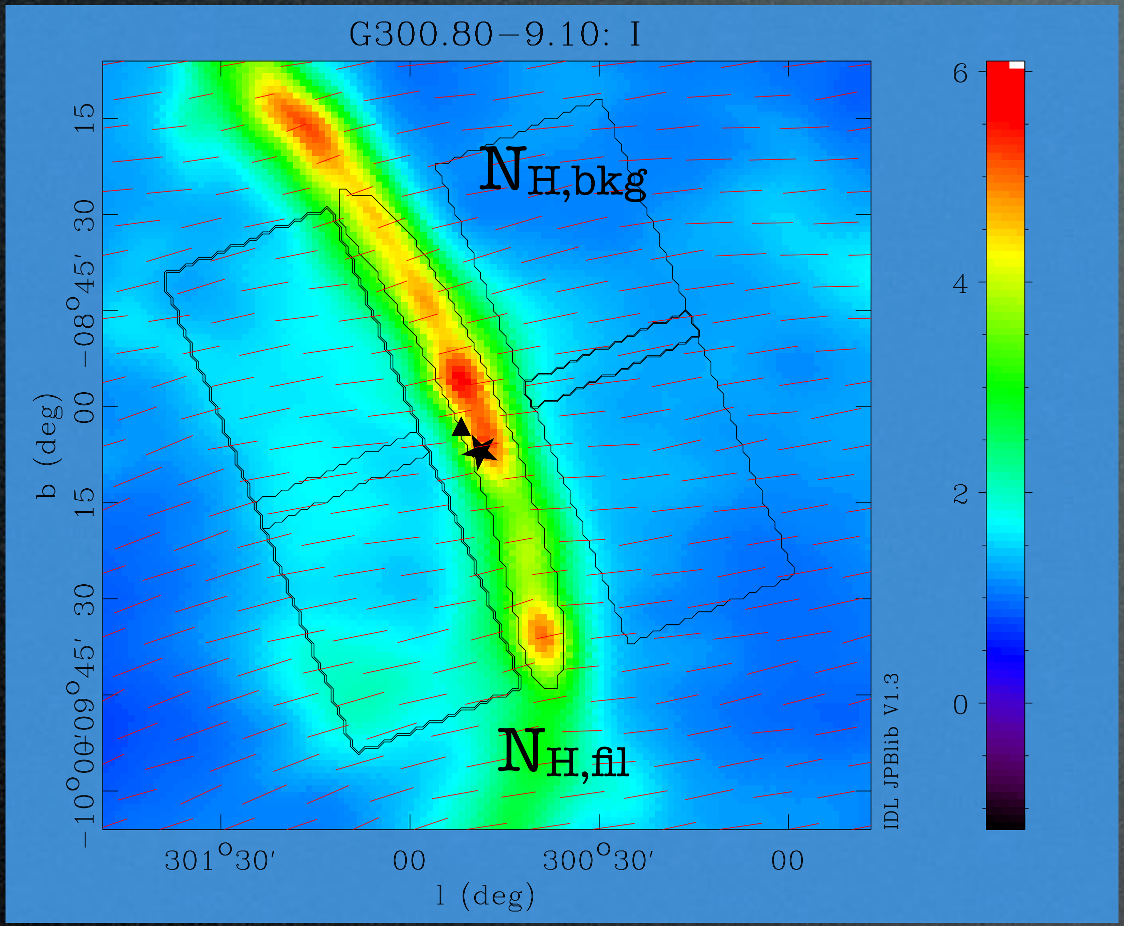


- Determine filaments with uniform background B angle (large rectangles): 92 out of 137
- Assume optically thin medium:

  $X = X_{fil} + X_{bkg}$, $X = \{Q,U\}$

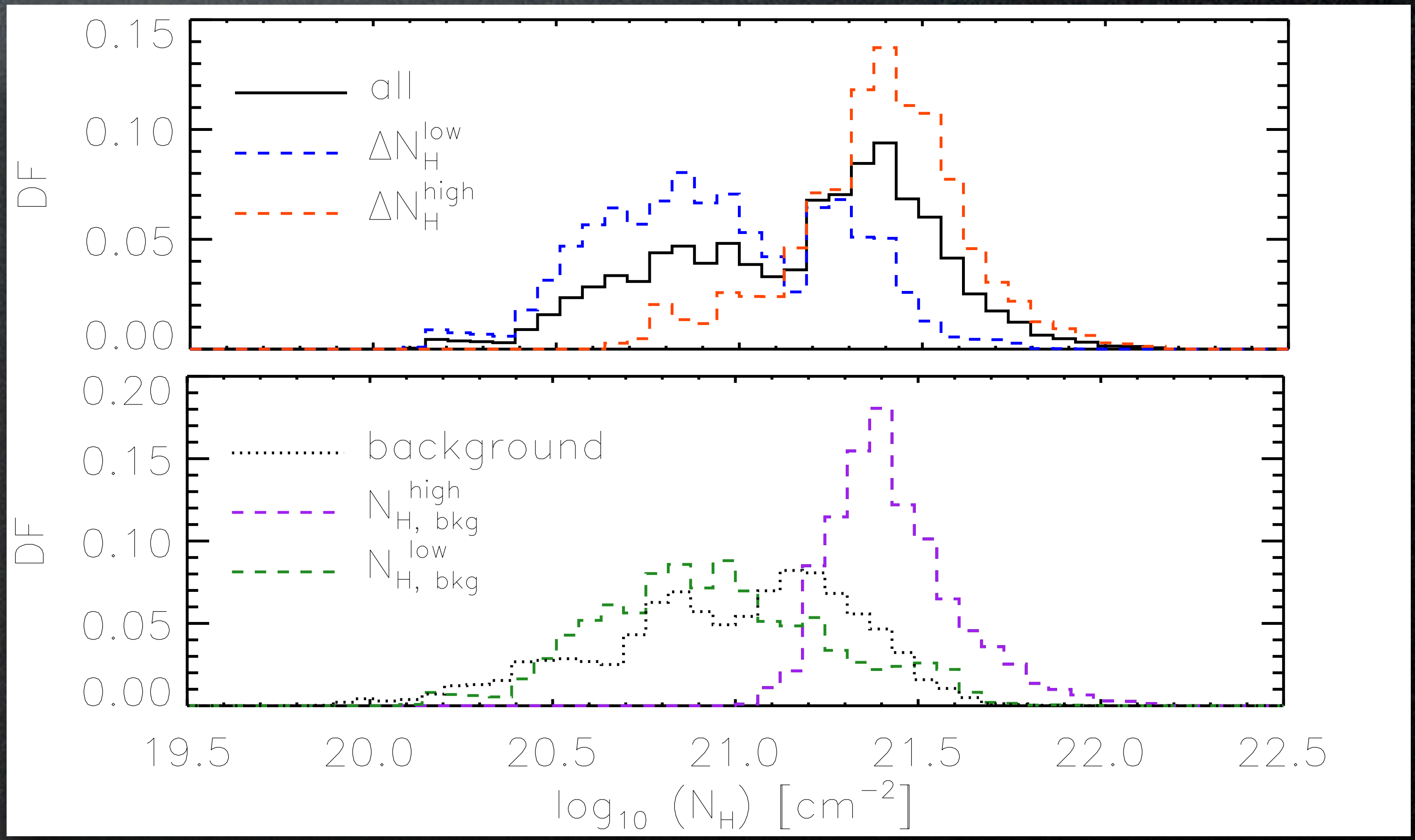
  X_{bkg} averaged over small parallelograms (cuts)

N_H subsamples



Subsamples:

	$N^{low}_{H,bkg}$	$N^{high}_{H,bkg}$	total
ΔN^{low}_{H}	30	15	45 (17)
ΔN^{high}_{H}	15	30	45 (9)
total	45 (9)	45 (17)	



$\Delta N_H = N_{H,fil} - N_{H,bkg}$

limits: $N_{H,bkg} = 1.2\ 10^{21}$ cm^{-2},

$\Delta N_H = 4\ 10^{20}$ cm^{-2}

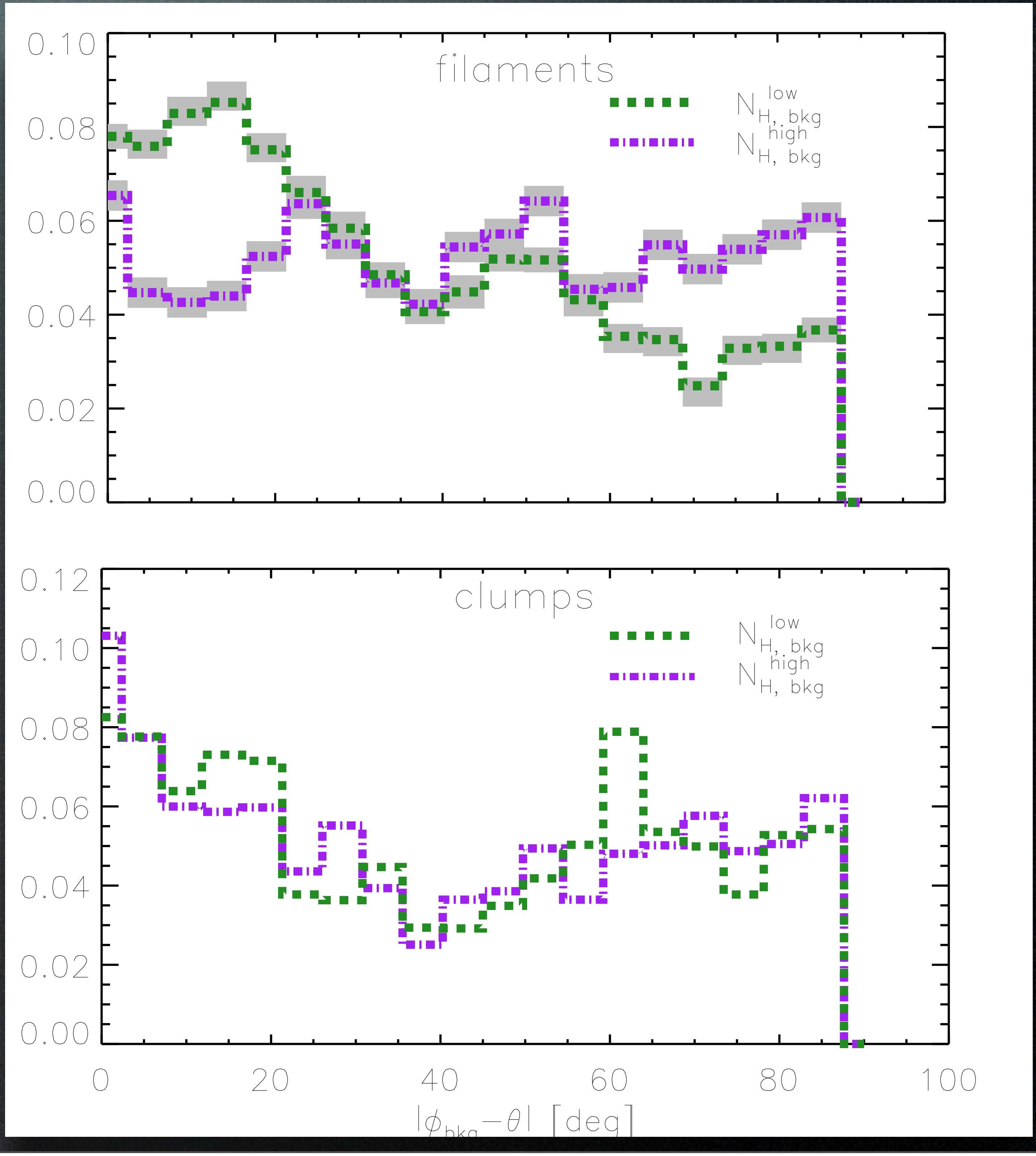
Filament vs B (background): $|\theta - \varphi_{bkg}|$

background N_H subsamples

- DFs over pixels (not filaments)
- Mostly aligned for low $N_{H,bkg}$ filaments
- Random for high $N_{H,bkg}$ filaments

  Mann-Whitney & Kolmogorov tests give ≃0

- Clumps: similar DFs (MW probability 21%)

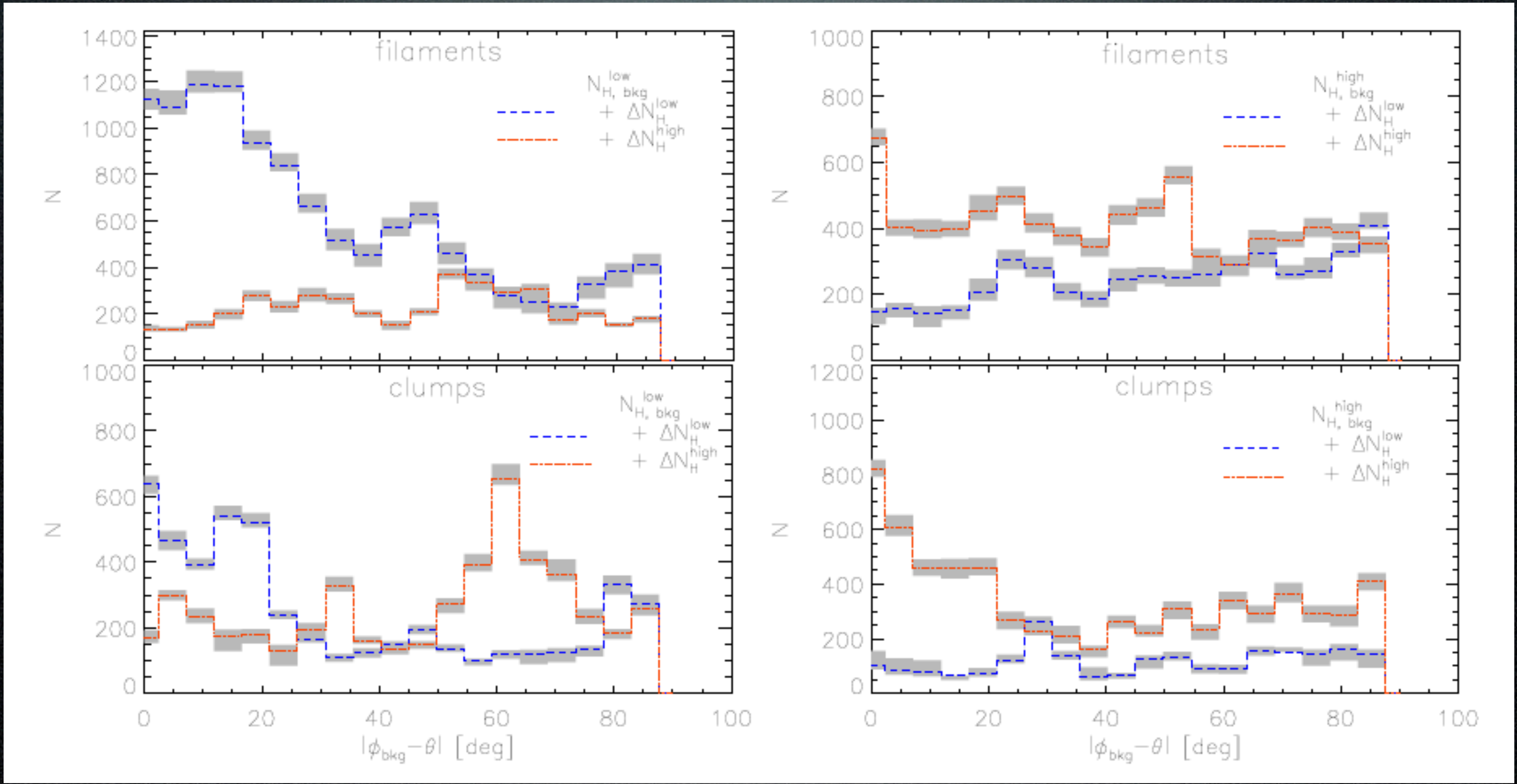


Filament vs B (background):

$|\theta - \varphi_{bkg}|$

background N_H subsamples

$+ \Delta N_H$ sub-subsamples

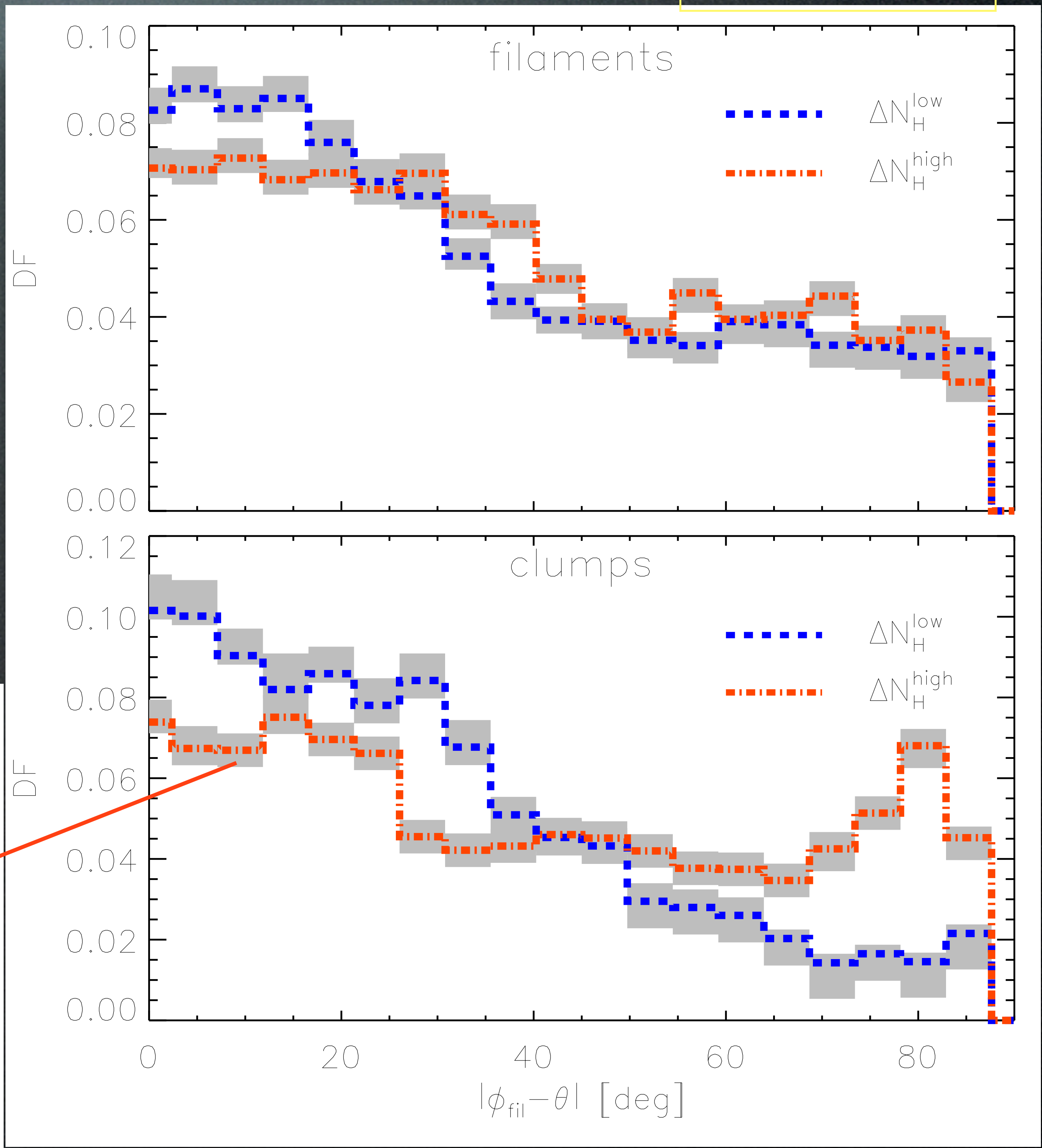


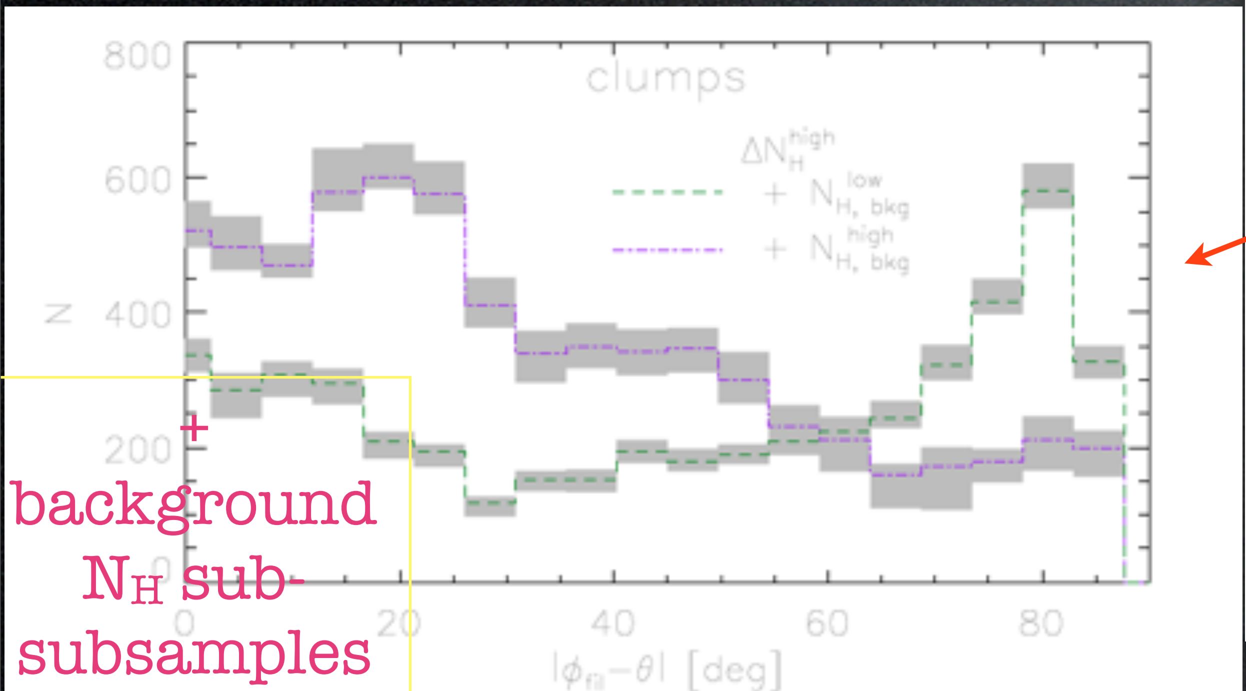
opposite behaviors ..?

Filament vs B (in the filament): $|\theta-\varphi_{fil}|$

differential N_H subsamples

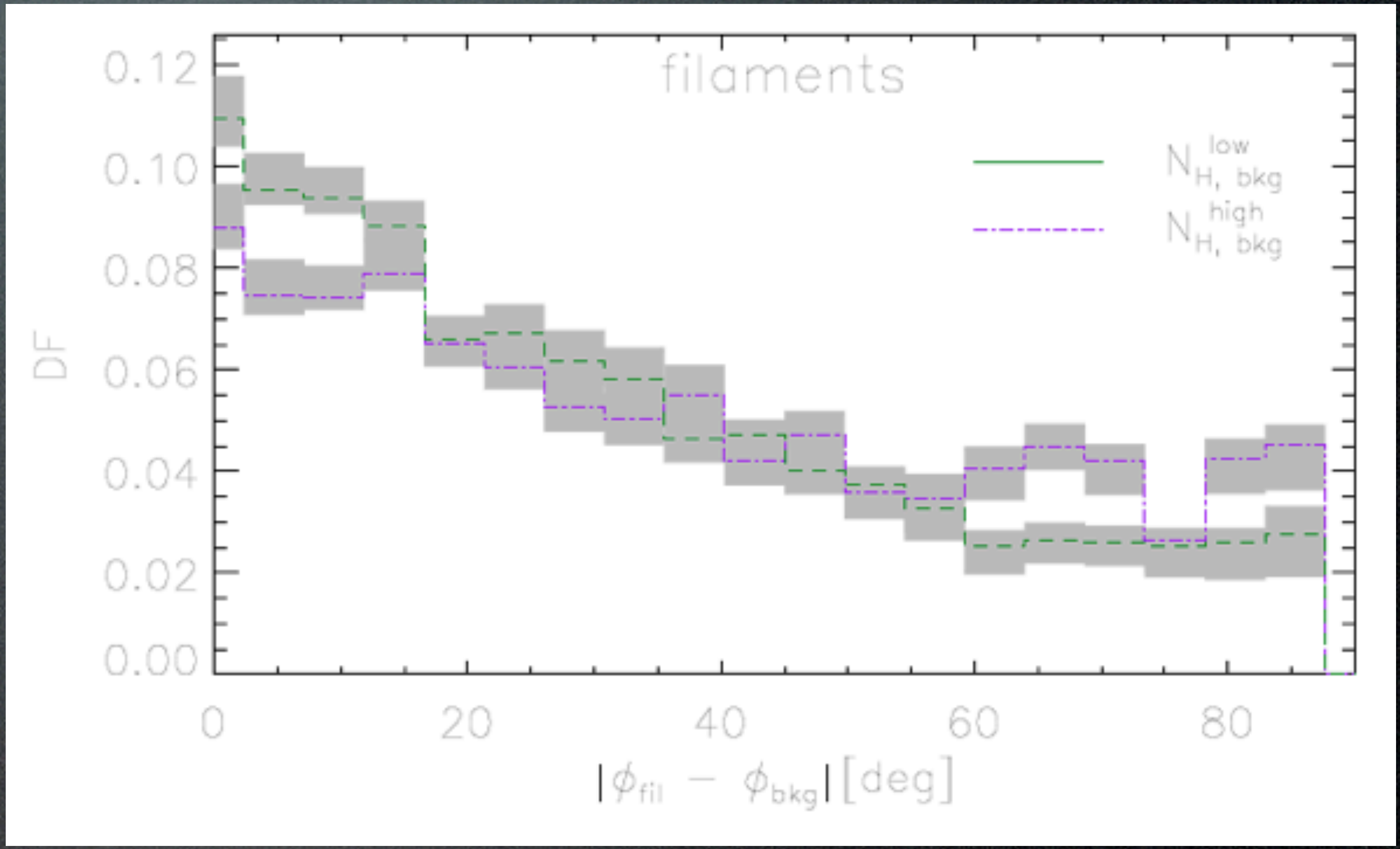
- filaments only: preferential alignment between matter and B (though projection effects)
- clumps only: clear difference between subsamples





Filament B vs background B

- Distribution is flatter for higher column densities

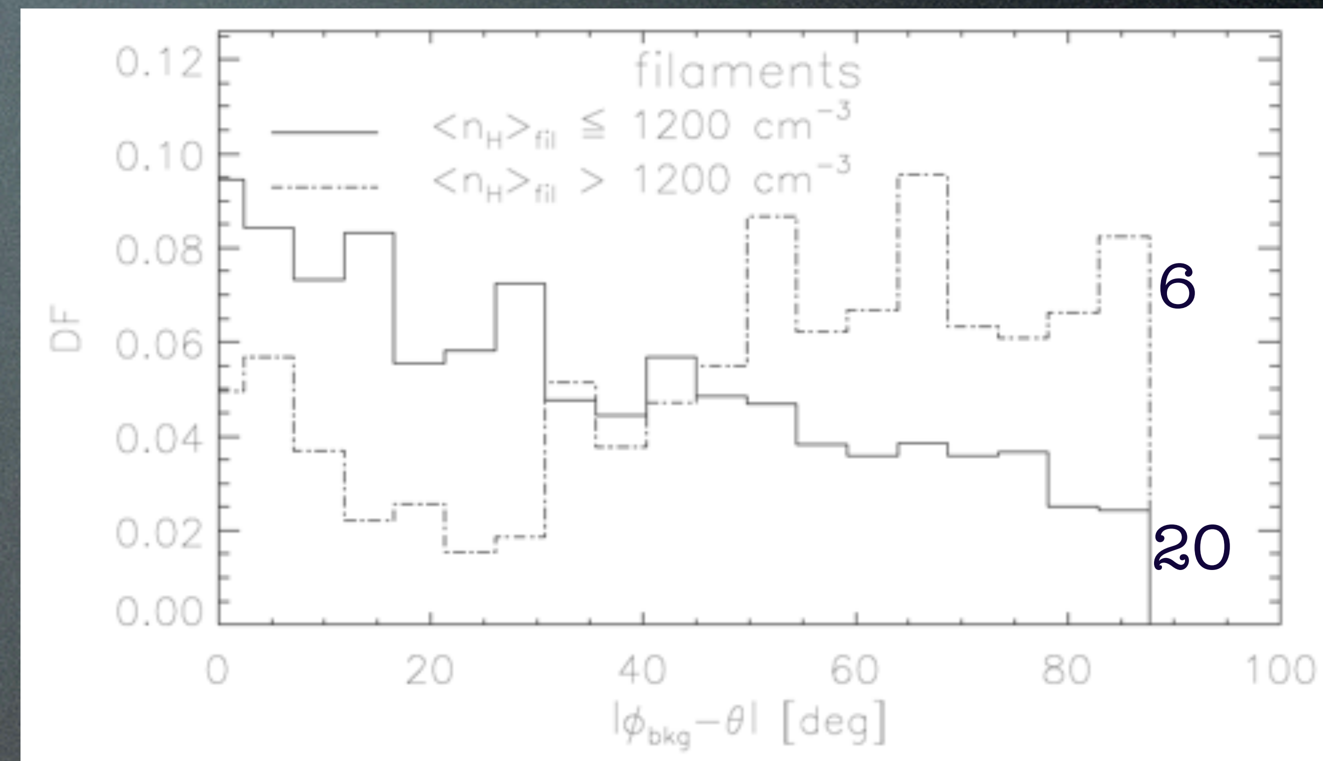


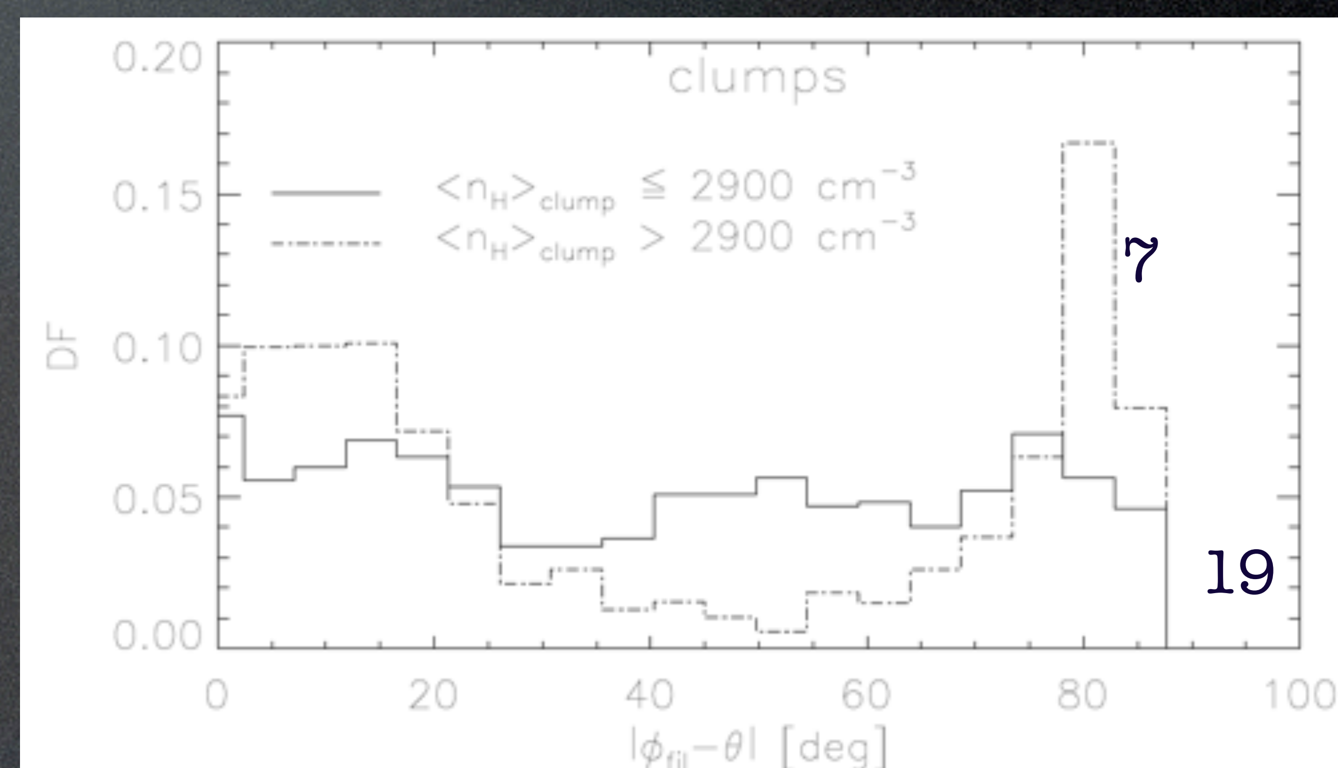
from N_H to n_H: 26 PGCCs

- d < 500 pc

$$\langle n_H \rangle_{clump} = \frac{3\,\langle N_H \rangle_{clump}}{4R}$$

$$\langle n_H \rangle_{fil} = \frac{\langle N_H \rangle_{fil}}{2dw}$$





Conclusions

- Bimodal distribution of the relative orientation between magnetic field and filamentary structures is observed at clump scales
- Relative variation between filaments and magnetic field depends on density and evolutionary stage