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Interstellar magnetic fields and filaments hosting cold clumps

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E. Falgarone, F. Levrier, E. Abdikamalov

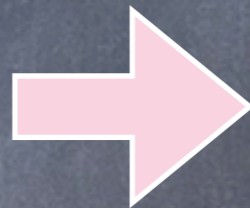
Introduction

- Context: yesterday's and today's talks
- Planck Collaboration papers
- Magnetic field (also) matters in structuring the ISM

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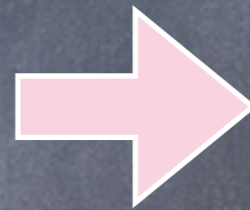
Gravity
Turbulence
B field



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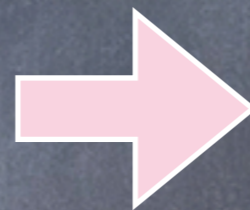


- Environment
- Evolutionary stage?
- Filaments/clumps?

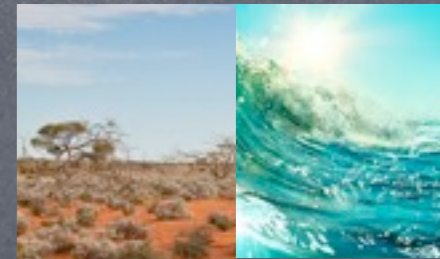
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Gravity
Turbulence
B field



- Environment



- Evolutionary stage?



(c) NGe

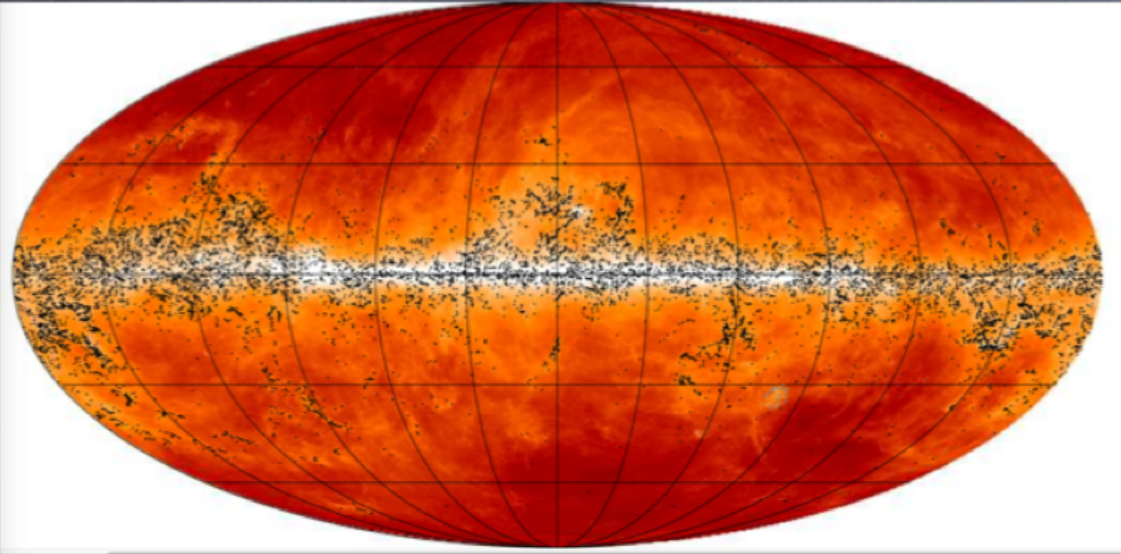
- Filaments/clumps?



(c) Gmaps

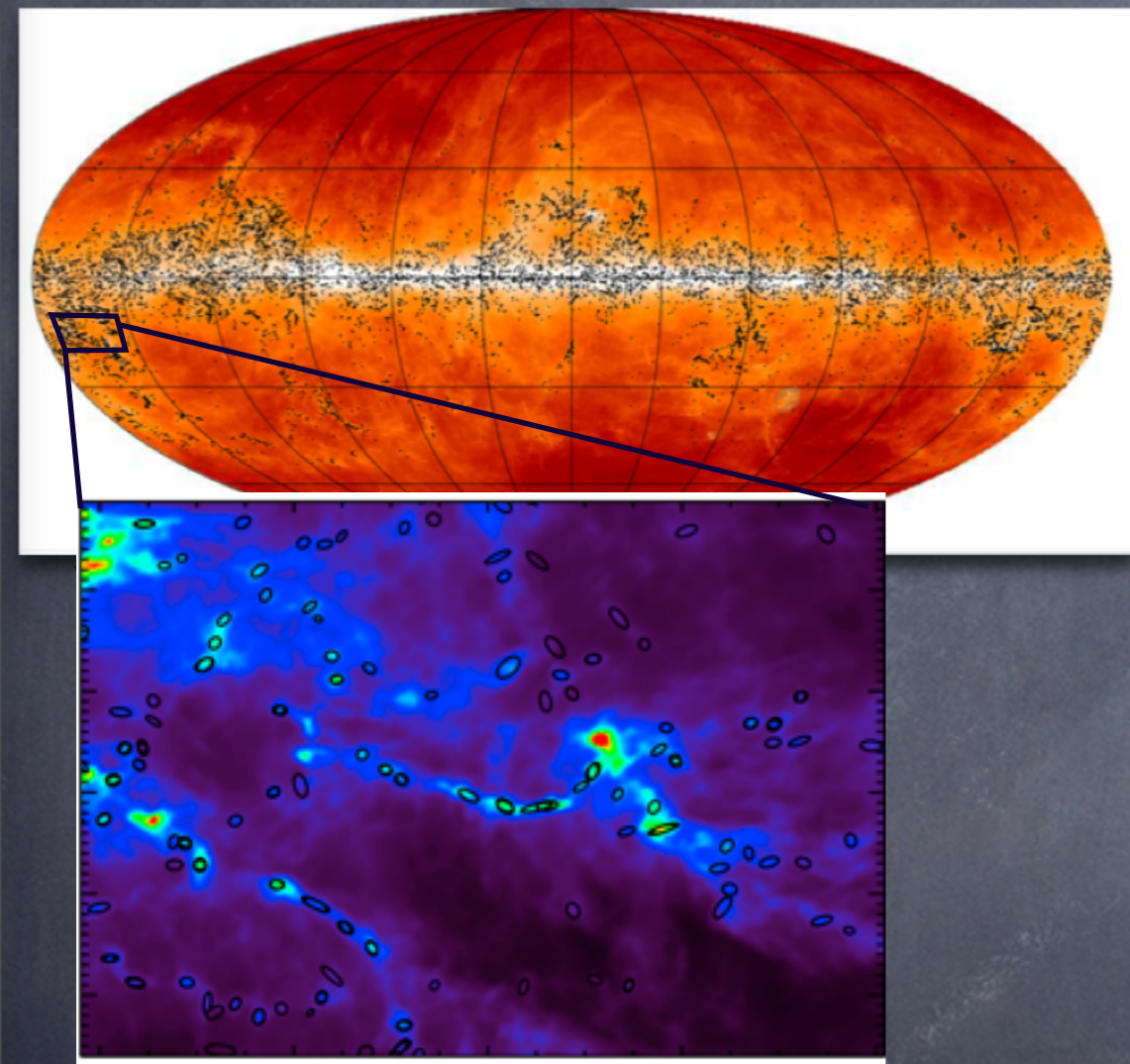
Method

PGCCs



Method

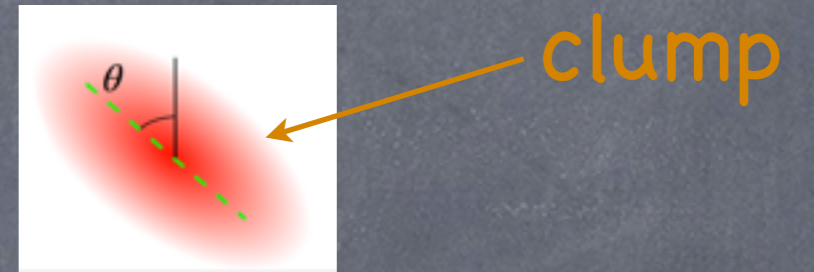
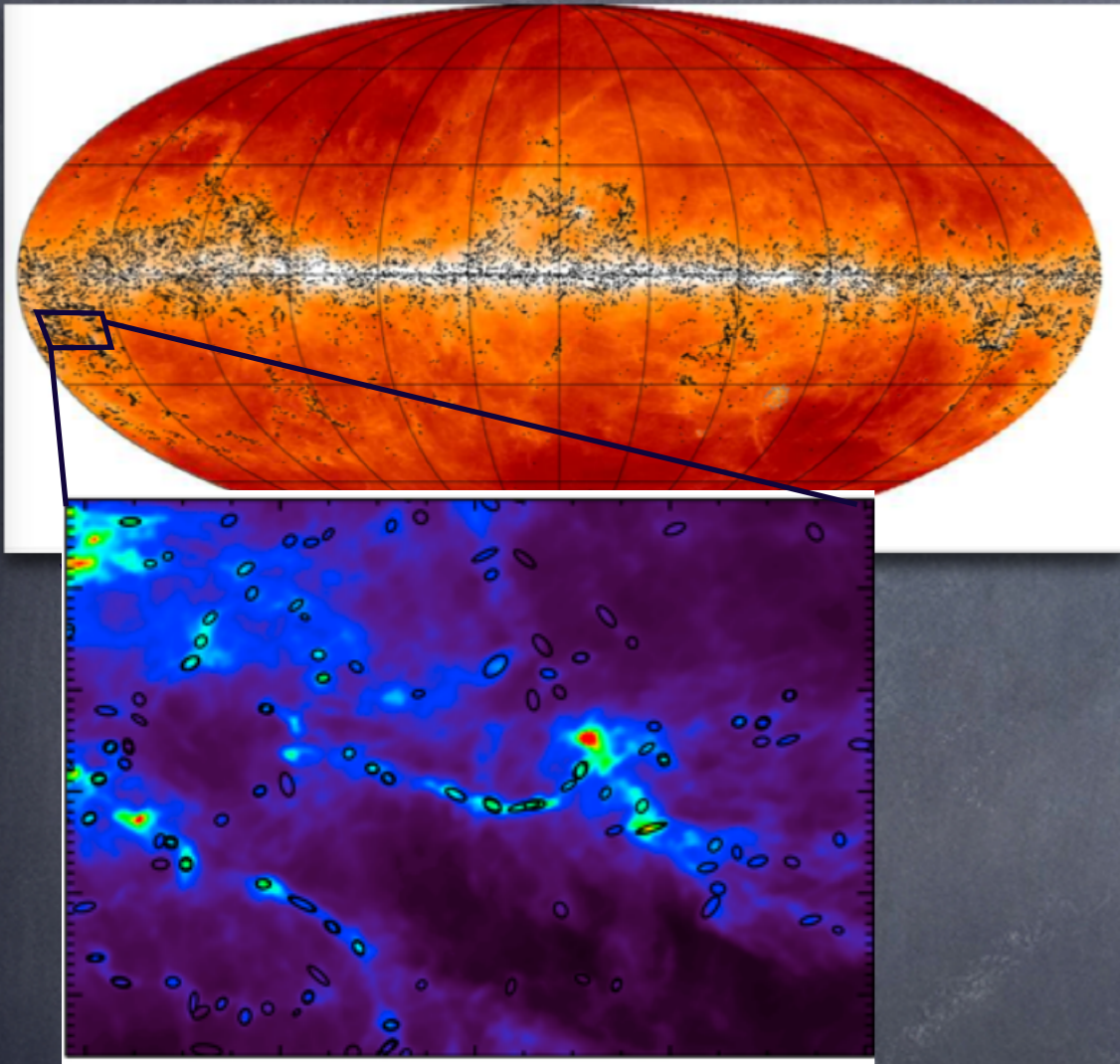
PGCCs



Most of the clumps are located in
filaments

Method

PGCCs

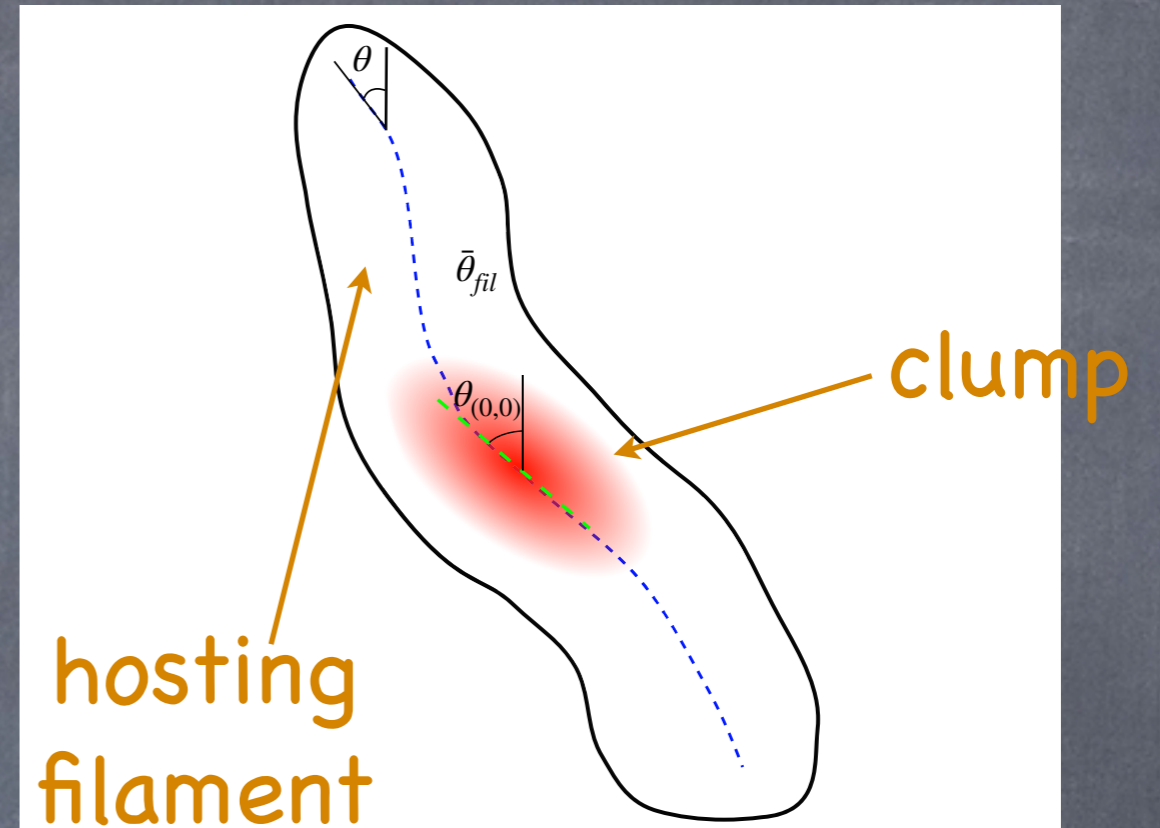
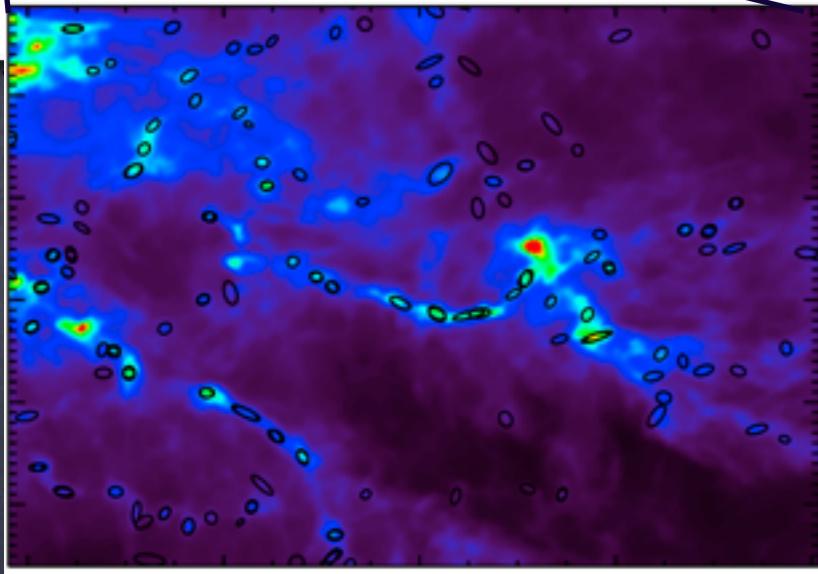
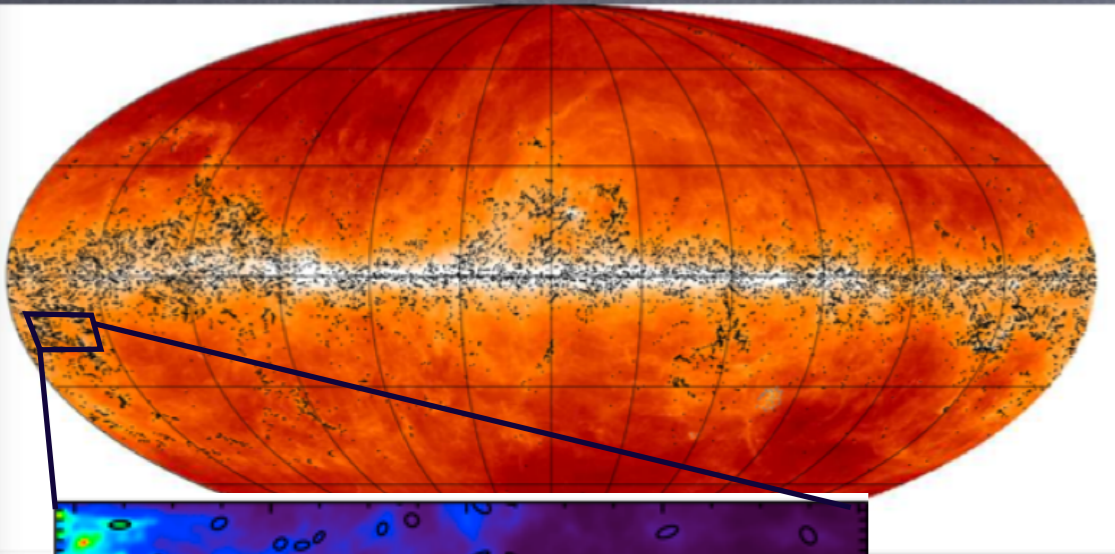


Most of the clumps are located in filaments

Method

RHT : Rolling Hough Transform (Clark2014) modified
Filaments associated with the PGCCs

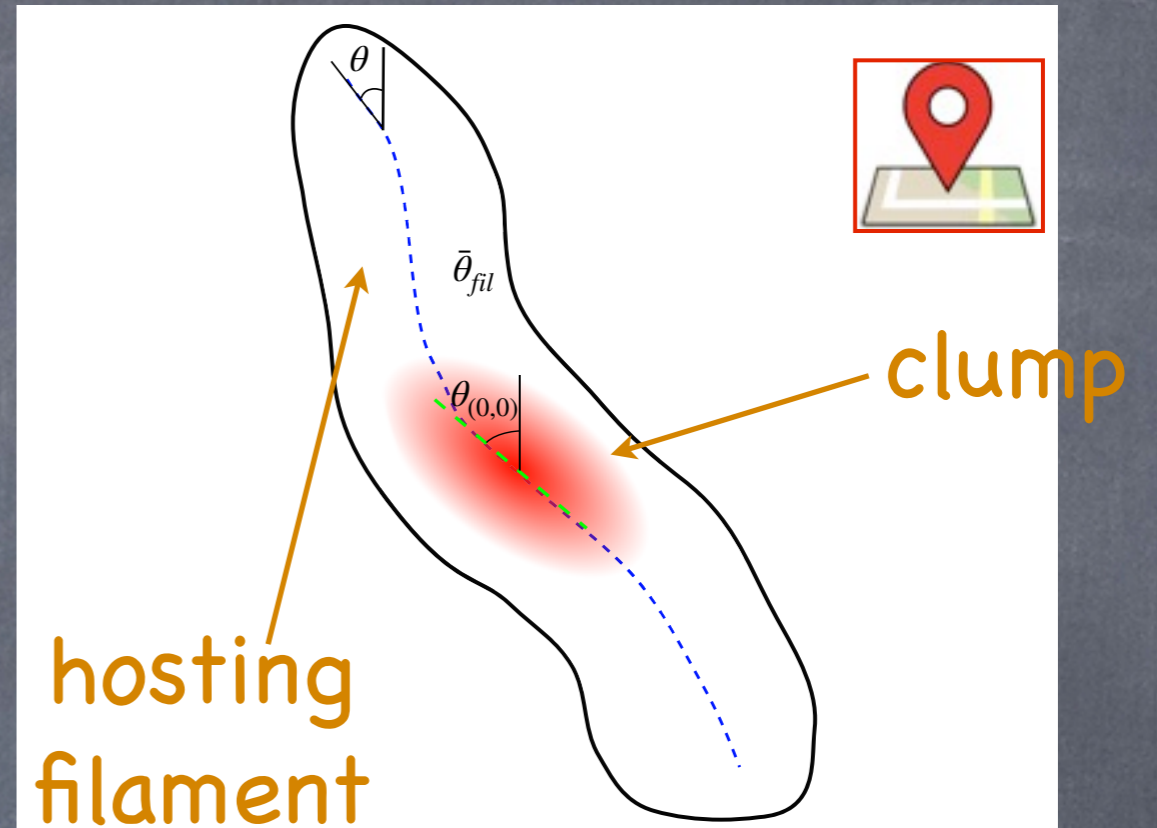
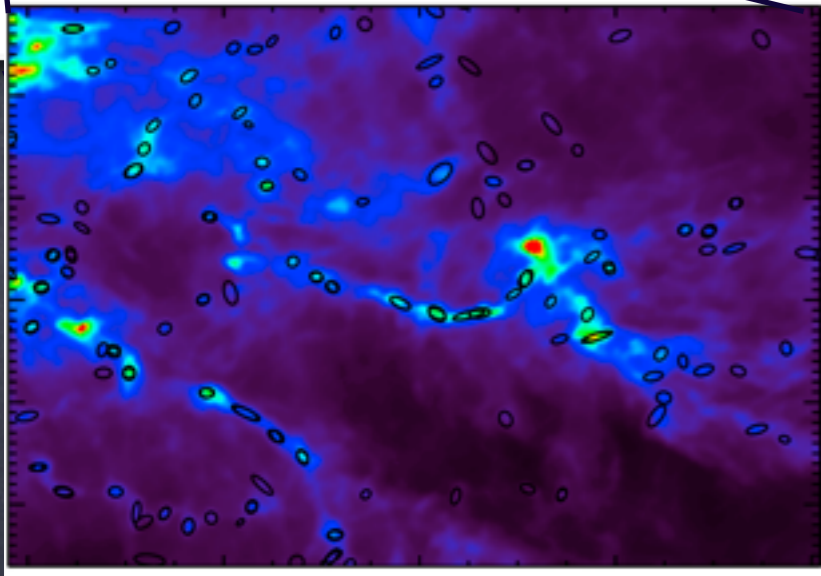
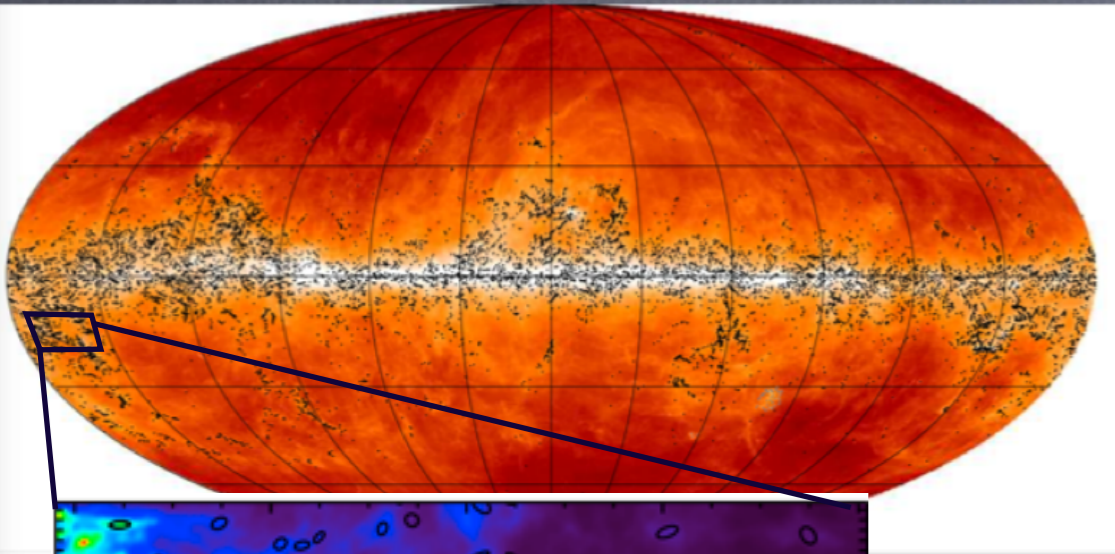
PGCCs



Method

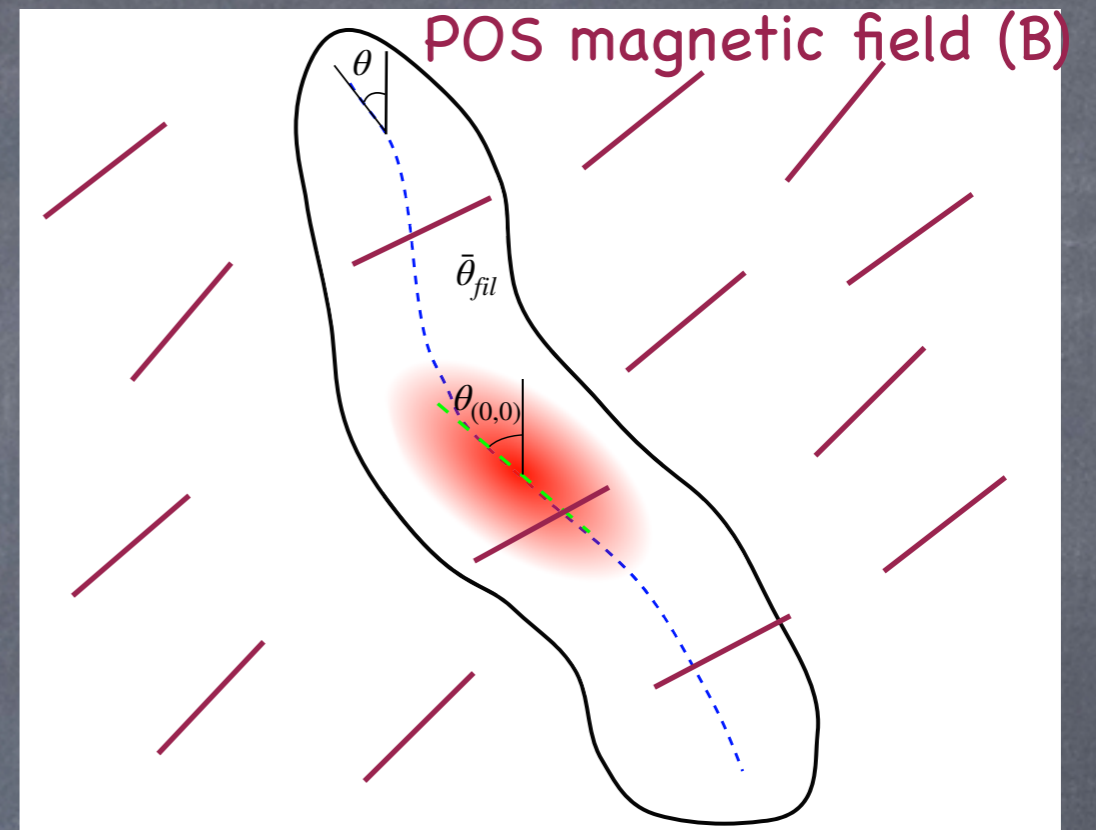
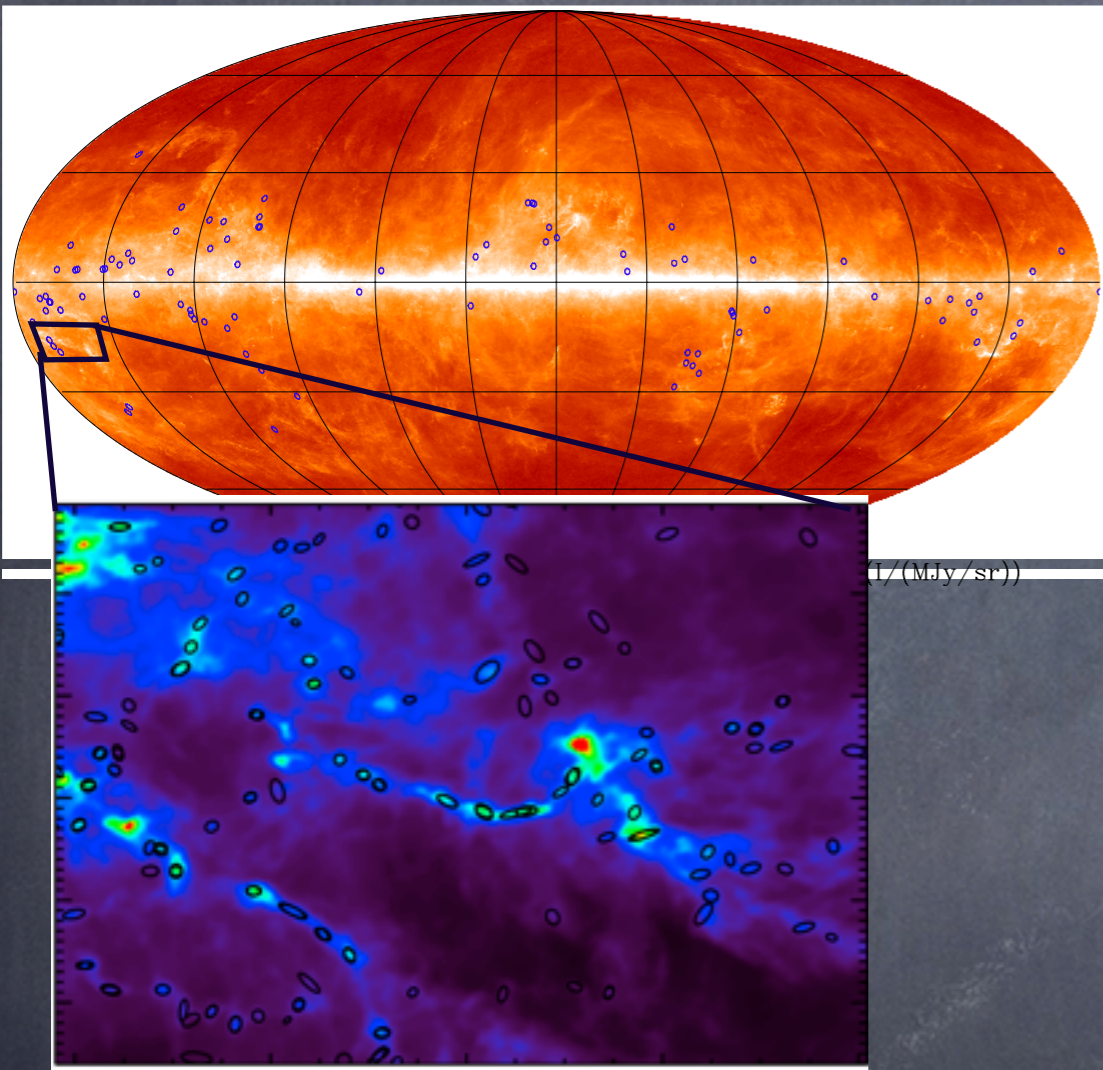
RHT : Rolling Hough Transform (Clark2014) modified
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PGCCs

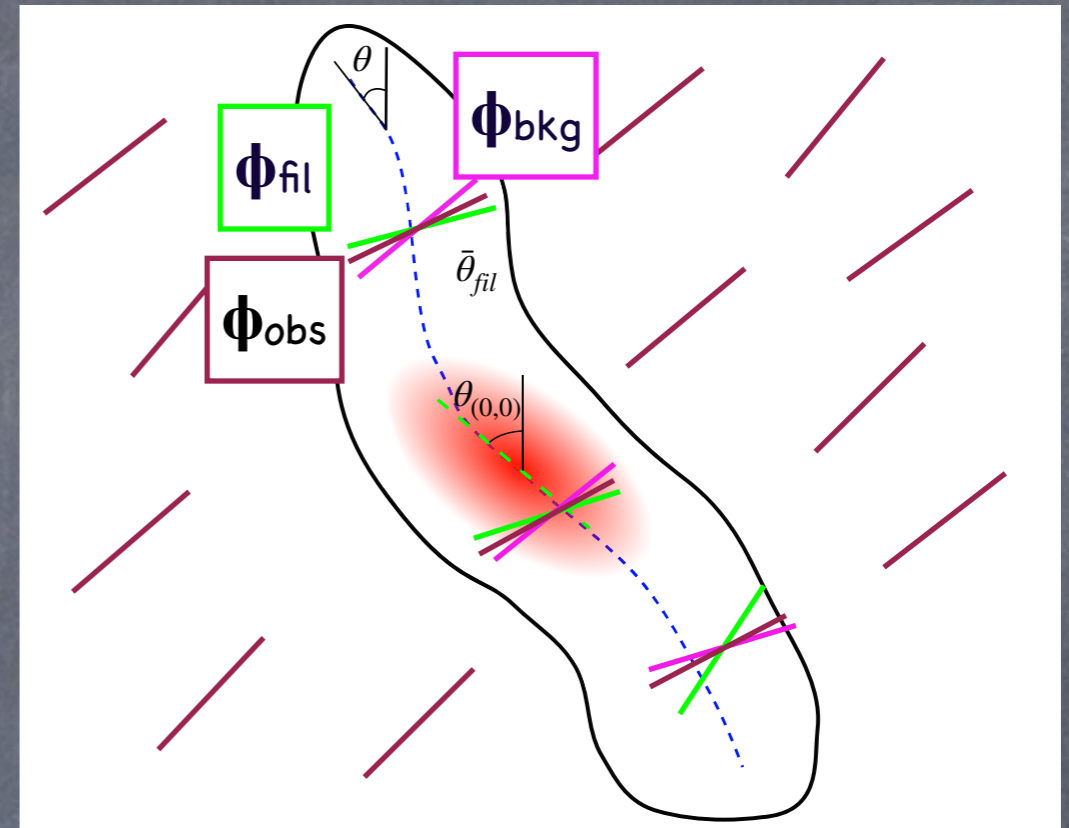


Method

90 filaments



Method

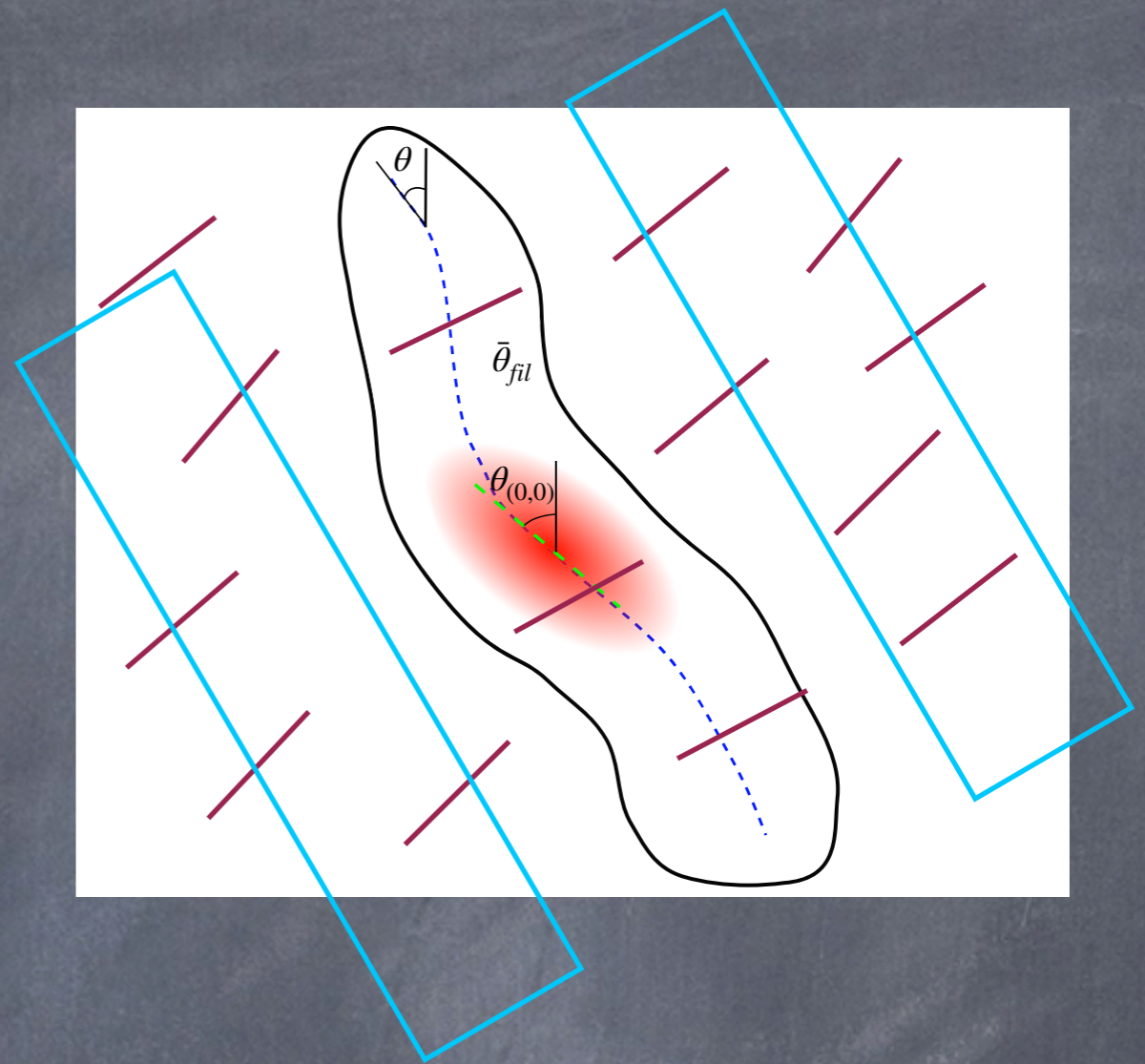


linear contribution

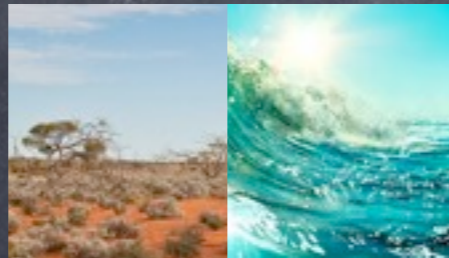
$$X = X_{fil} + X_{bkg}$$

$$X = \{I, Q, U\}$$

Method



- find uniform background regions
- indication of environment column density $N_H, \text{ bkg}$
- indication of column density contrast ΔN_H



Method: subsamples

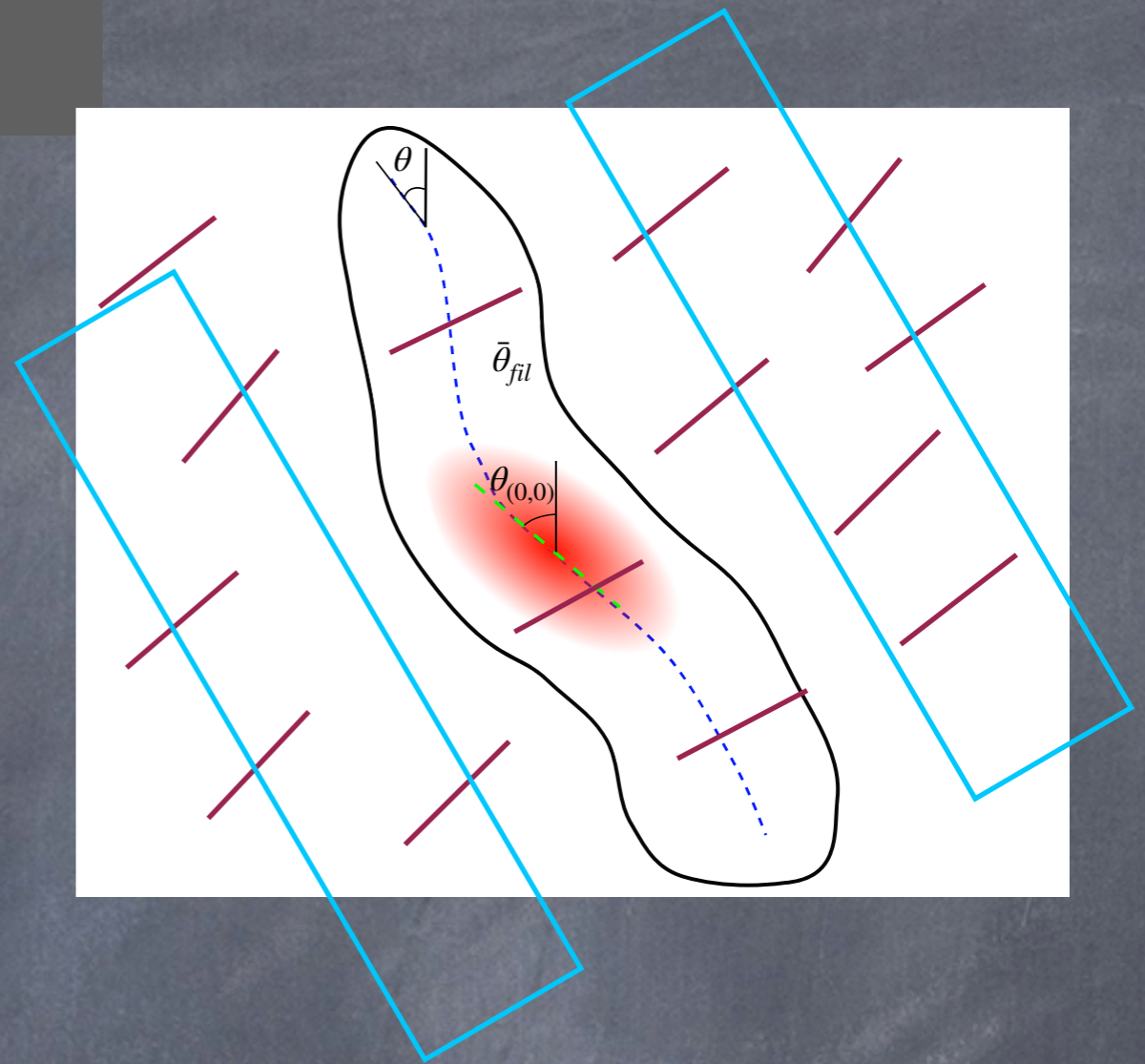
- Background (environment) column density

$$N_{H,bkg}^{low} < 1.2 \times 10^{21} \text{ cm}^{-2} < N_{H,bkg}^{high}$$

- Differential column density between filaments and their background

$$\Delta N_H^{low} < 4 \times 10^{20} \text{ cm}^{-2} < \Delta N_H^{high}$$

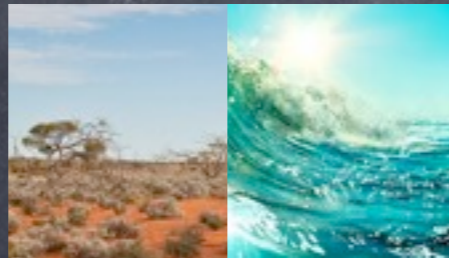
- Threshold are chosen at median values



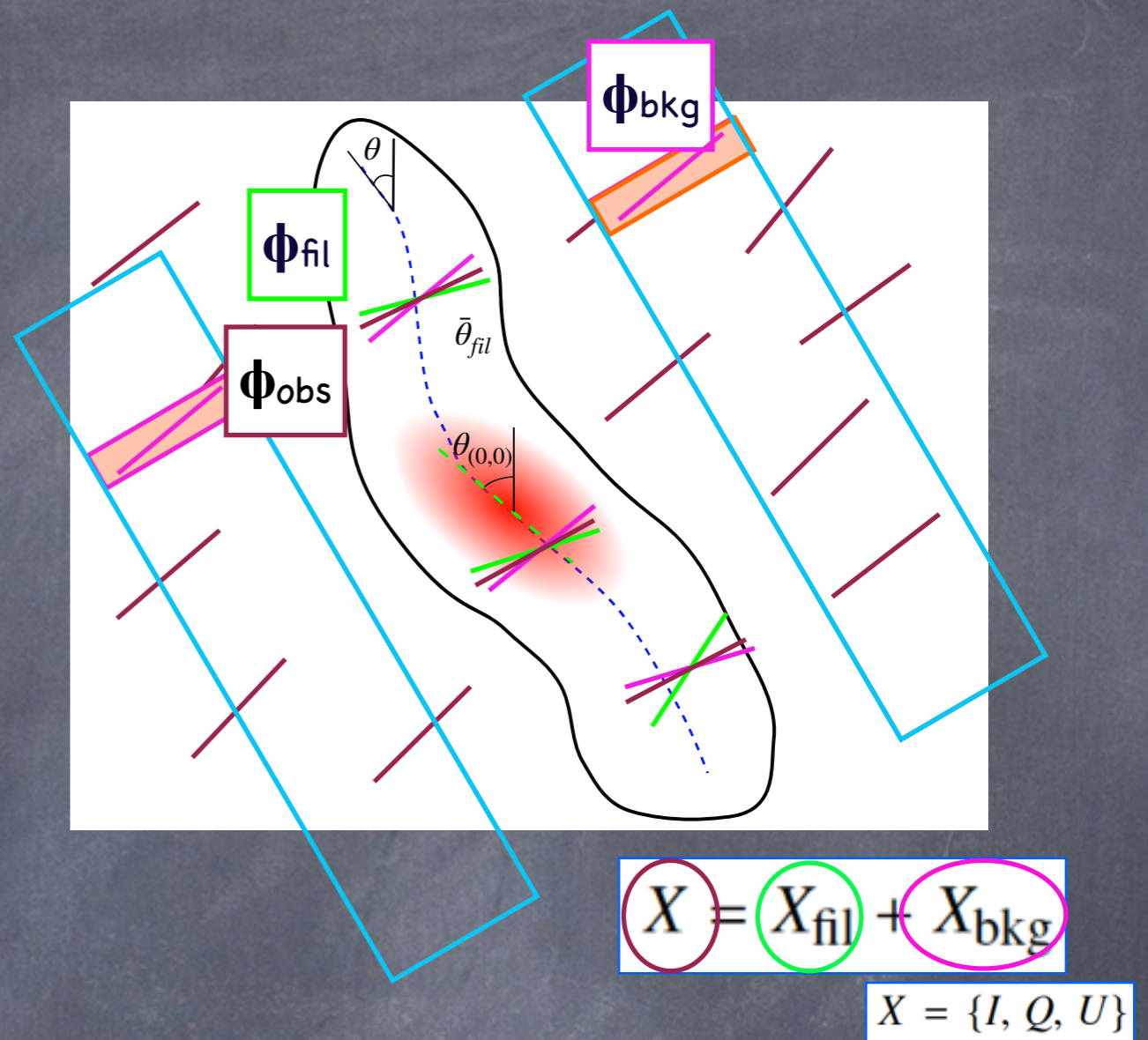
- find uniform background regions

- indication of environment column density $N_{H, bkg}$

- indication of column density contrast ΔN_H



Method



- determination of filament and background Q, U

Method

• Matter orientation angles: filament and clump

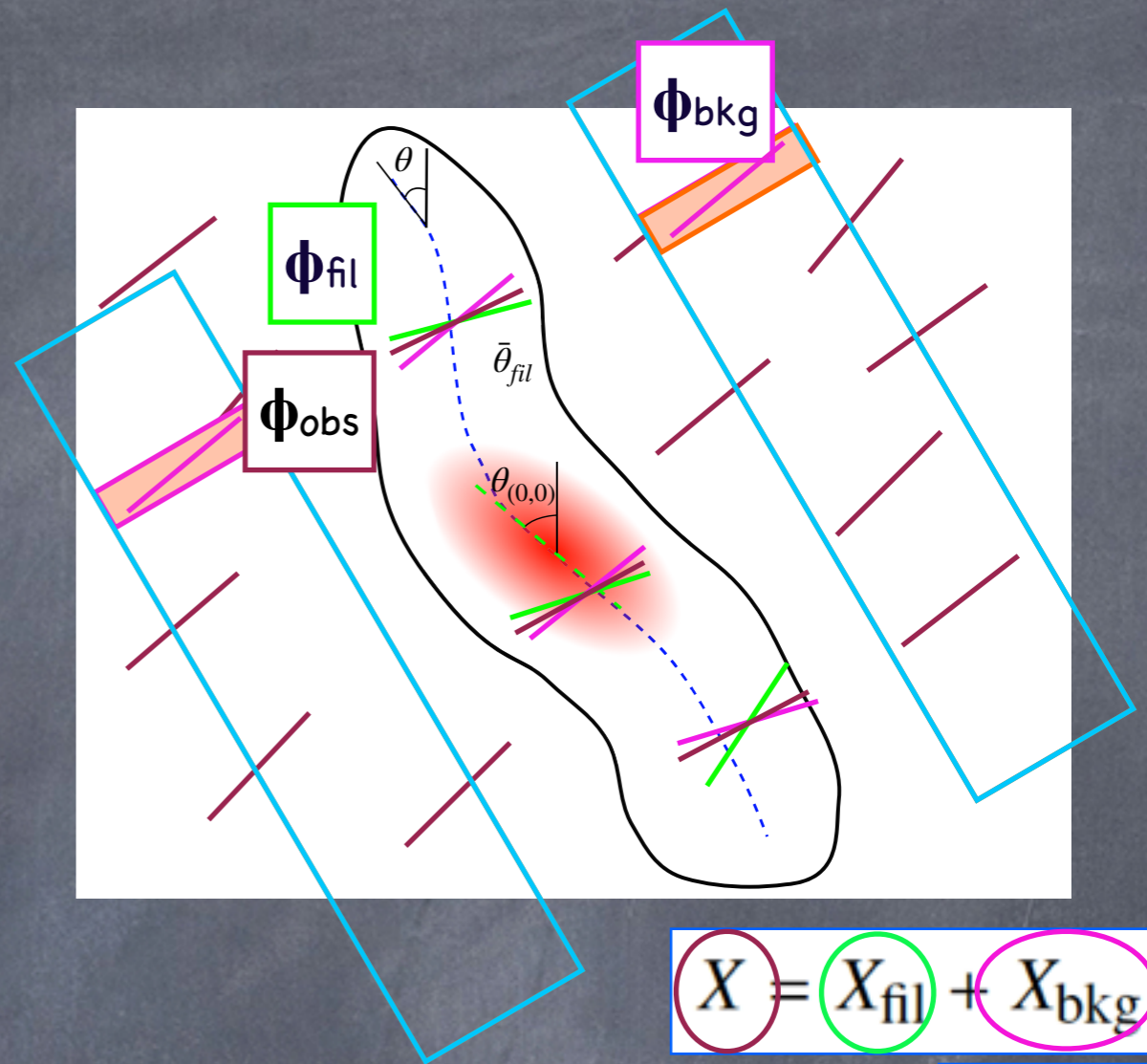
$$\theta_{fil}$$

$$\theta_{cl}$$

• B angles: filament and background

$$\phi_{fil}$$

$$\phi_{bkg}$$

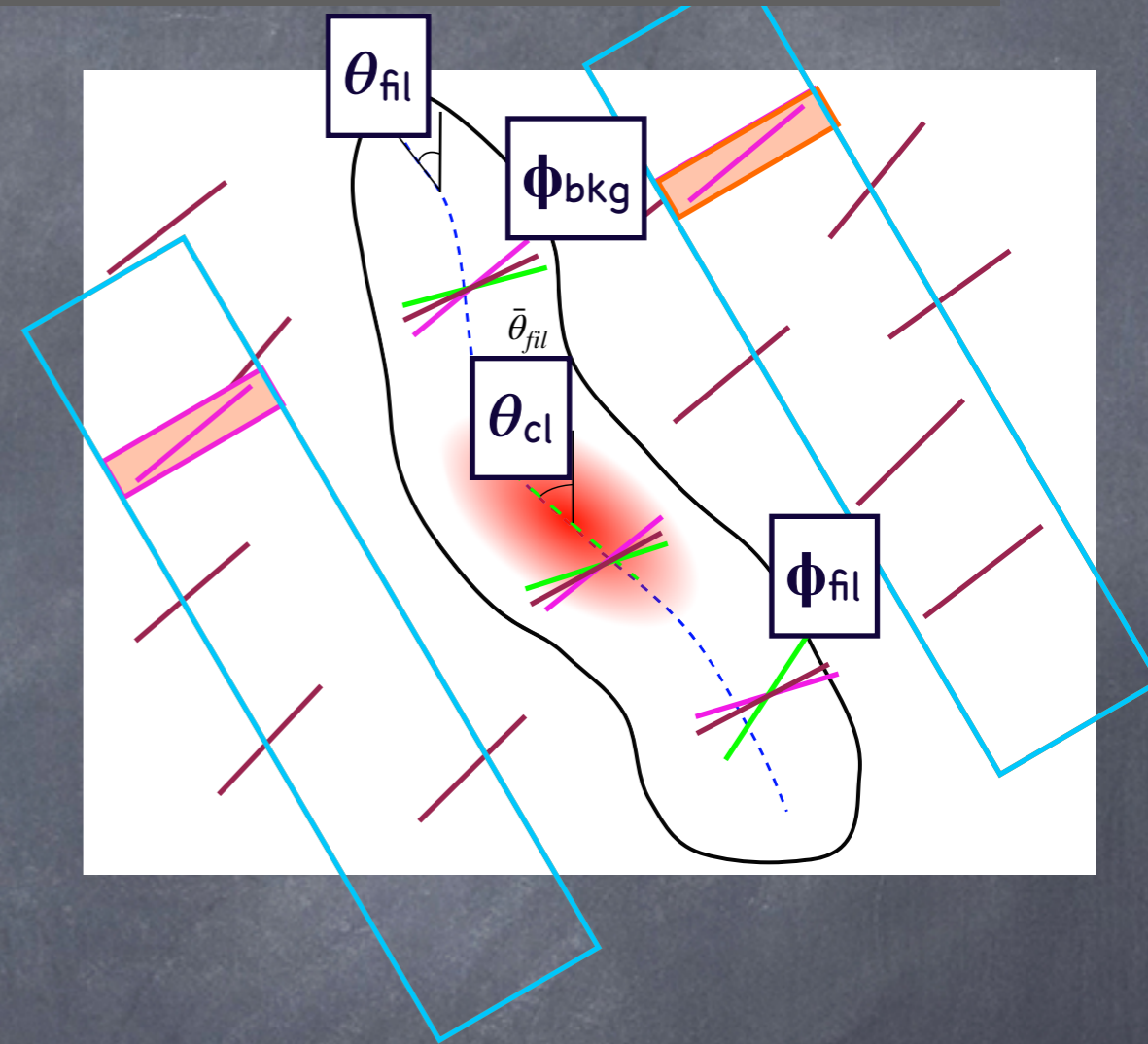
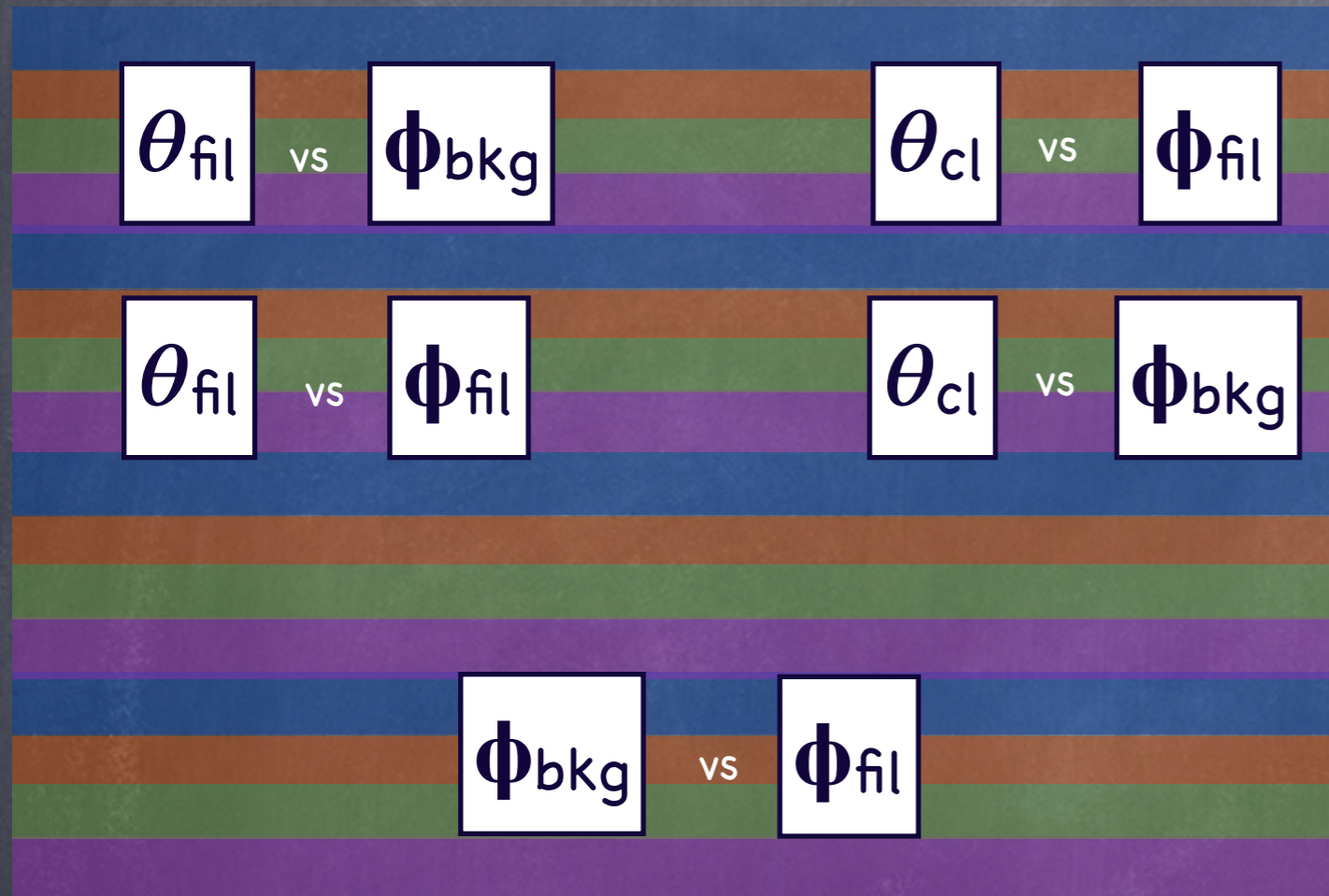


$$X = X_{fil} + X_{bkg}$$

$$X = \{I, Q, U\}$$

• determination of filament and background Q, U

Method: relative orientation in subsamples

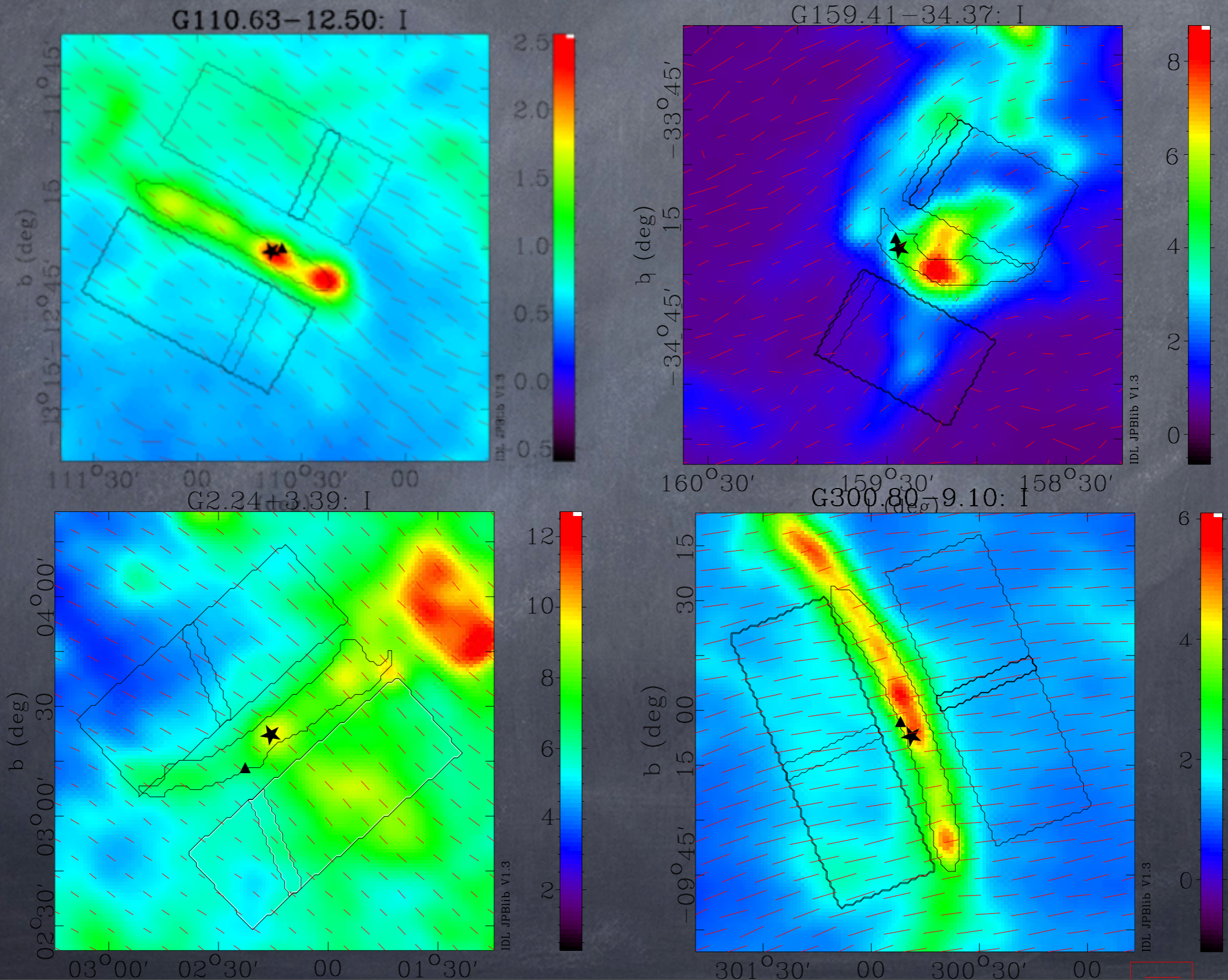


$$\Delta N_H^{low} < 4 \times 10^{20} \text{ cm}^{-2} < \Delta N_H^{high}$$

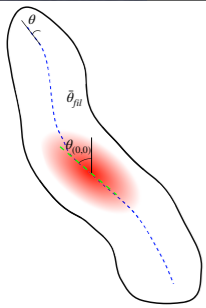
$$N_{H,bkg}^{low} < 1.2 \times 10^{21} \text{ cm}^{-2} < N_{H,bkg}^{high}$$

Method: examples

90 filaments

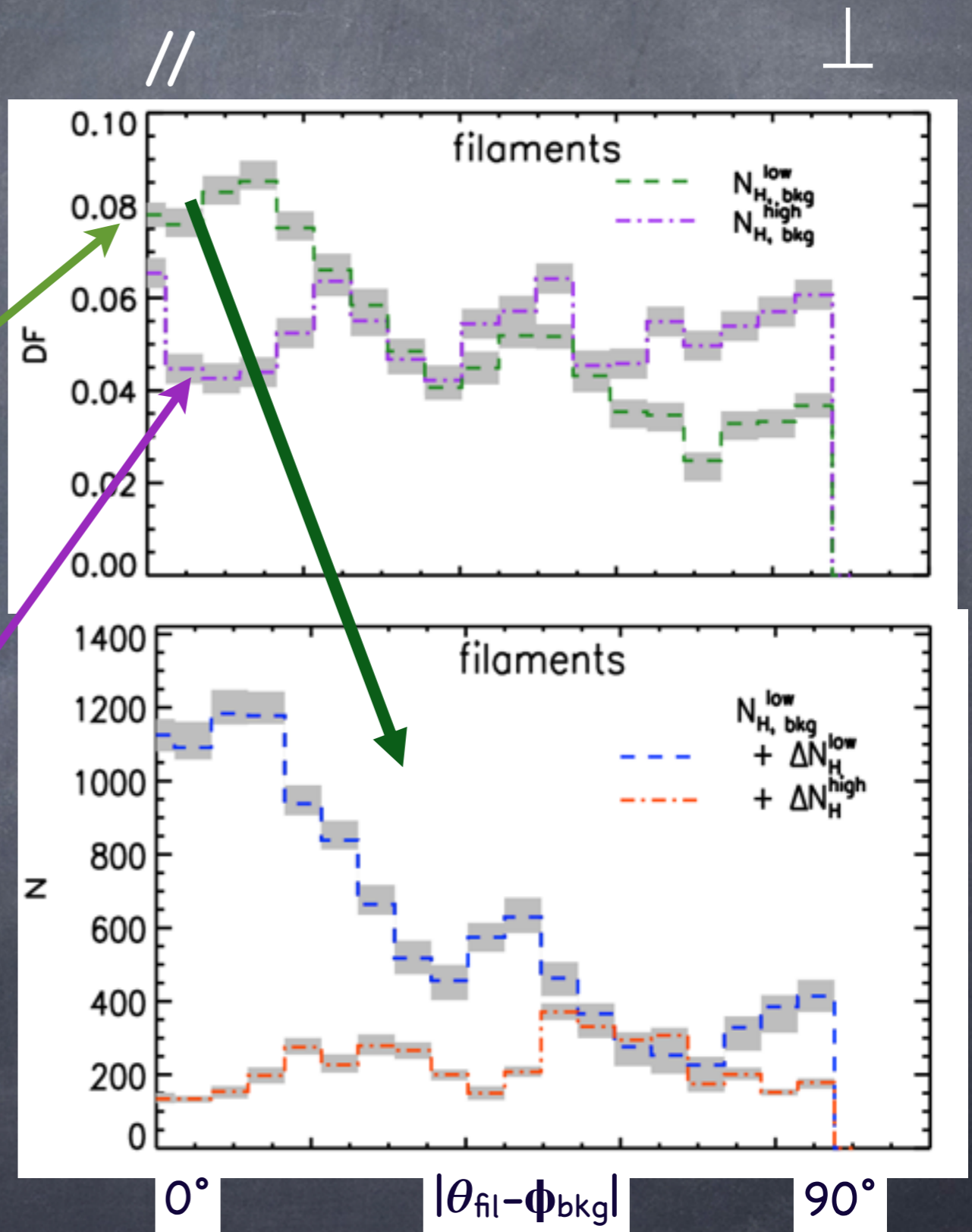


Results: filaments vs B_{bkg}

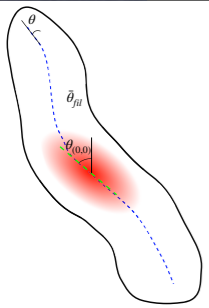


θ_{fil} vs ϕ_{bkg}

- Preferential parallel alignment in low $N_{\text{H, bkg}}$
- All relative orientations in high $N_{\text{H, bkg}}$

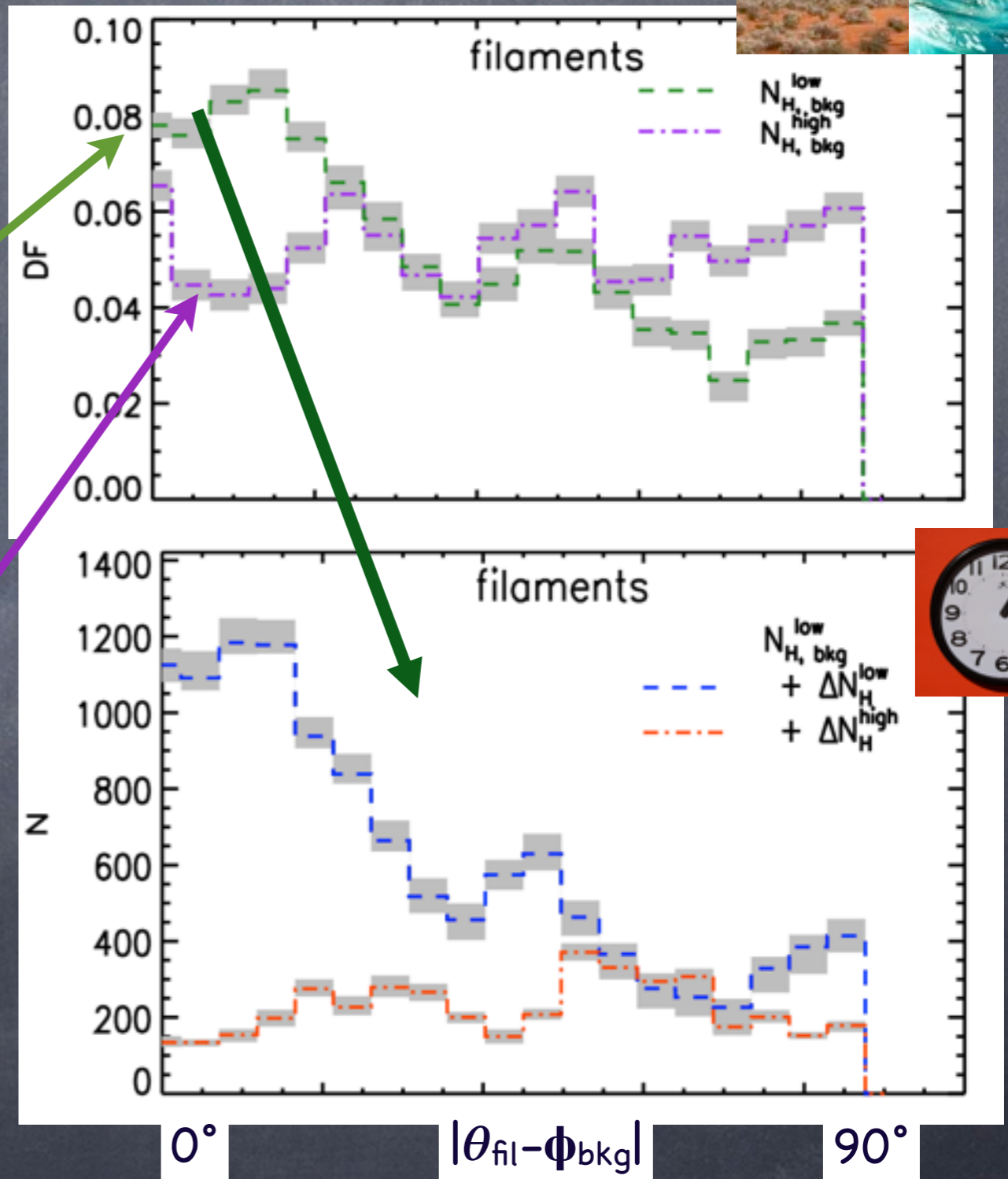
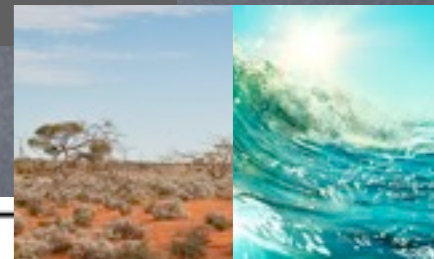


Results: filaments vs B_{bkg}

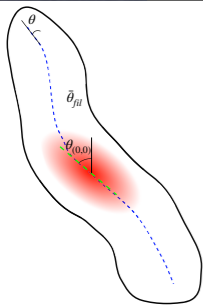


$$\theta_{fil} \text{ vs } \phi_{bkg}$$

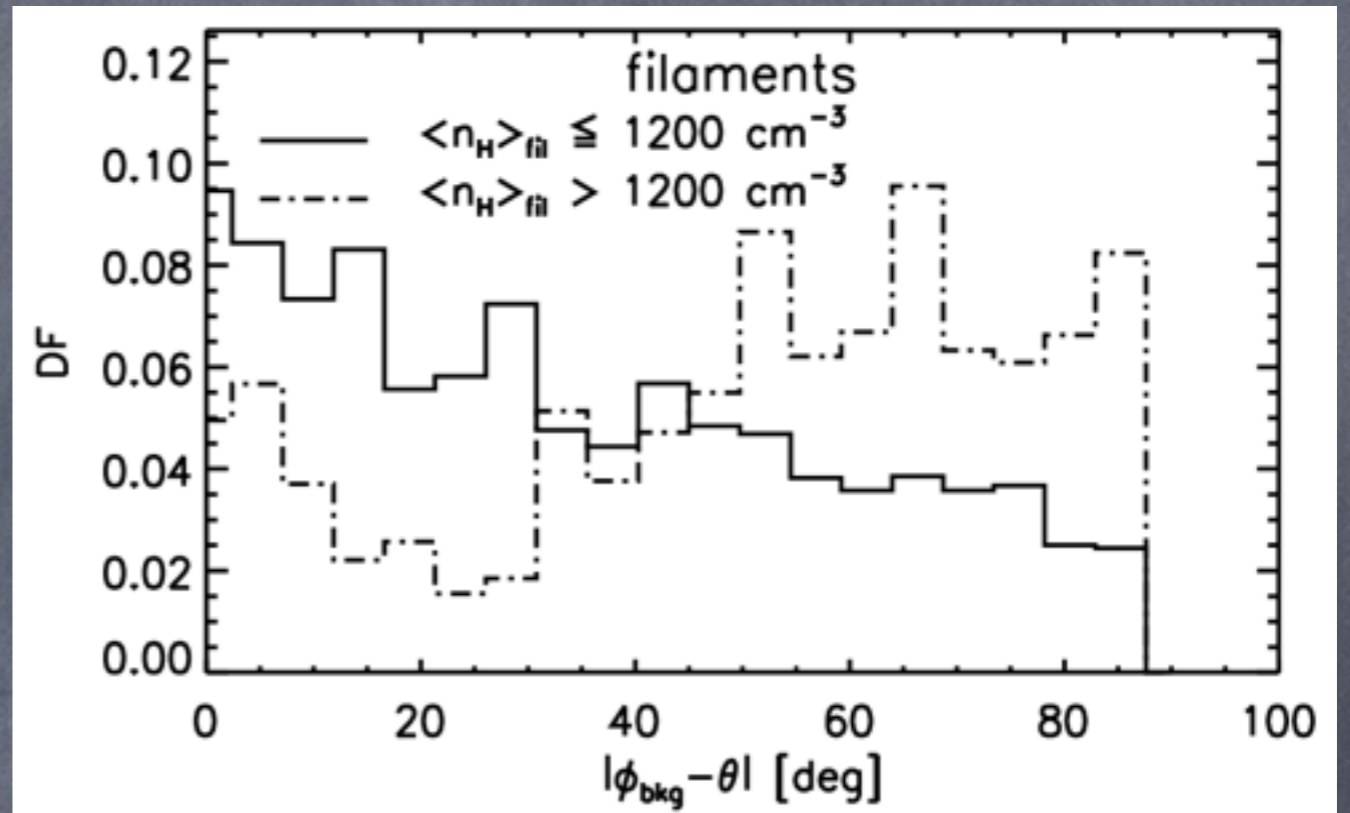
- Preferential parallel alignment in low $N_{H, bkg}$
- But disappears for high-contrast filaments
- All relative orientations in high $N_{H, bkg}$



Results: filaments vs B_{bkg}



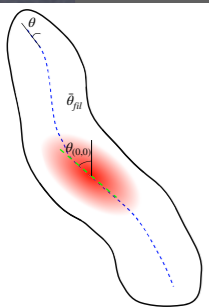
θ_{fil} vs ϕ_{bkg}



Alina et al. 2019

- Nearby MCs ($d < 500 \text{ pc}$)
- Relative orientation changes in dense gas

Results: filaments & clumps vs B_{fil}



$$\theta_{fil}$$

vs

$$\phi_{fil}$$

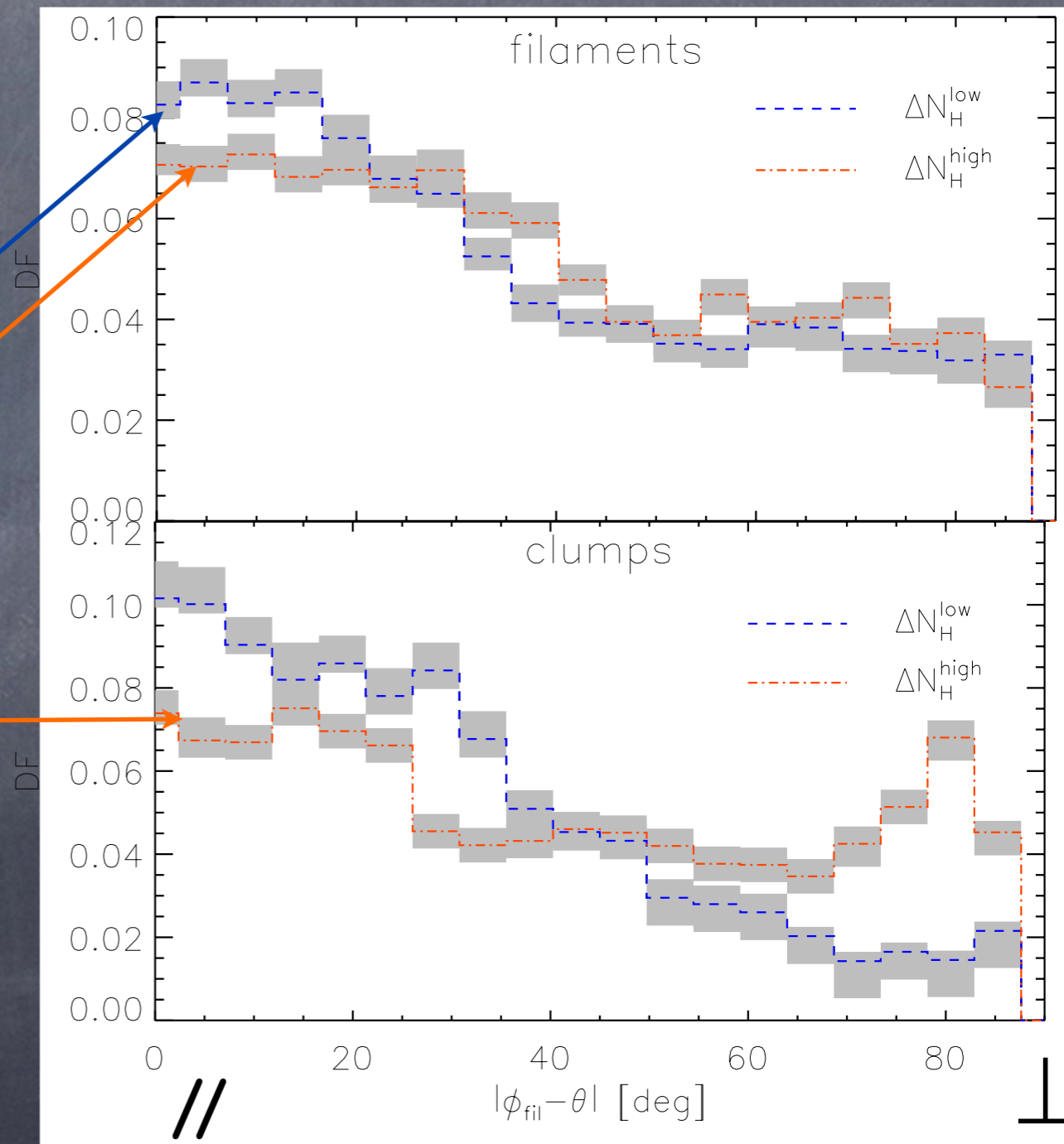
$$\theta_{cl}$$

vs

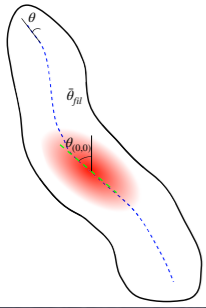
$$\phi_{fil}$$

Filaments are // to B_{fil}

Clumps are either // or \perp to B_{fil} in high contrasted filaments

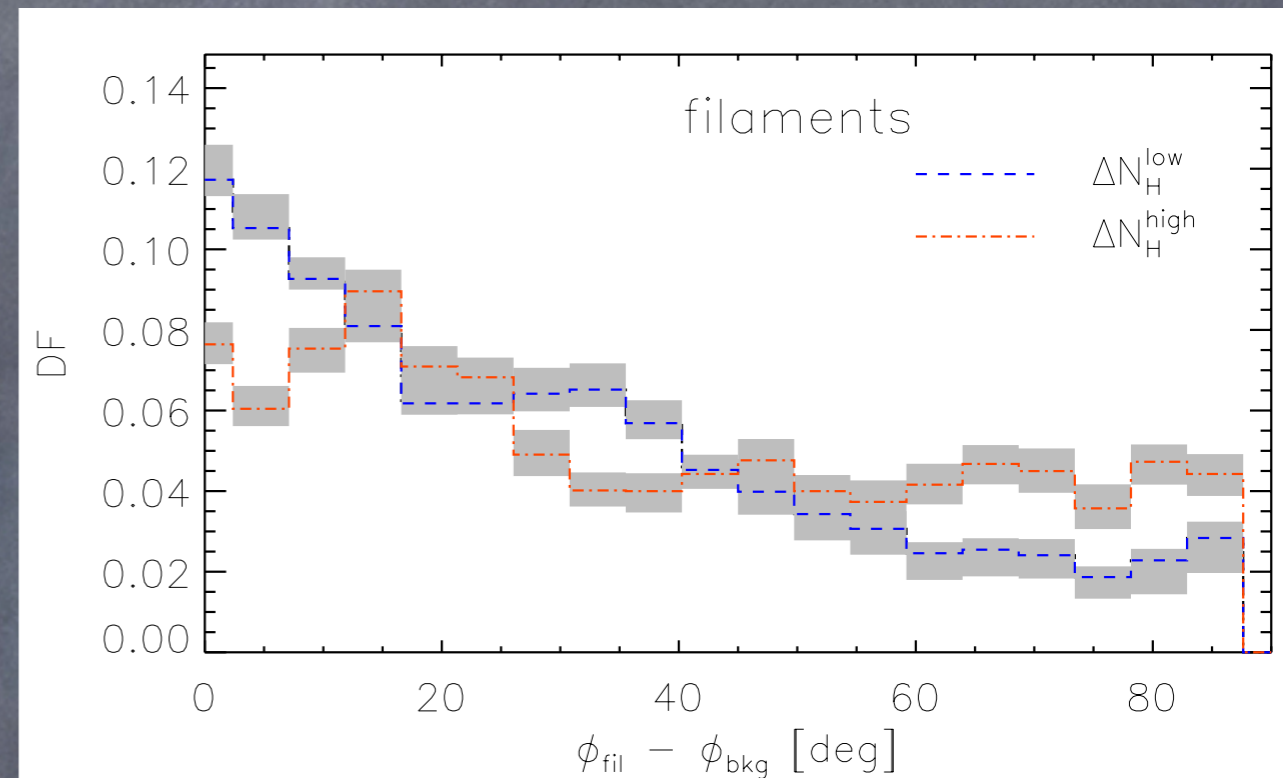


Results: B_{bkg} vs B_{fil}



$$\Phi_{\text{bkg}} \text{ vs } \Phi_{\text{fil}}$$

- low preferential alignment in high-contrast filaments
- results in three studied filaments are consistent with Planck XXXIII 2015



Alina et al. 2019

Gravity, Turbulence, B fields in filaments?



ΔN_H \ N_H bkg	Low	High
All	mostly //	no tendency
Low	mostly //	mostly \perp
High	no tendency	no tendency
n_H	mostly //	\sim mostly \perp



- High-density environment: Gravity is significant
- low contrasted (less evolved) filaments: + B fields
- high contrast (evolved) filaments: + turbulence



- Low-density environment: B fields & Turbulence
 - high contrast (evolved): gravity

Gravity, Turbulence, B fields in filaments?



ΔN_H \ N_H bkg	Low	High
All	mostly //	no tendency
Low	mostly //	mostly \perp
High	no tendency	no tendency
n_H	mostly //	\sim mostly \perp

in clumps?

- Clump areas should be taken into account in filament studies
- Things may be different in clumps



ΔN_H \ N_H bkg	Low	High
All	// + \perp	// + \perp
Low	mostly //	no tendency
High	mostly \perp	mostly //



Gravity, Turbulence, B fields in filaments?



Filaments vs B_{fil}

ΔN_H \ $N_{H \text{ bkg}}$	Low	High
Low	//	//
High	//	//

Clumps vs B_{fil}

ΔN_H	Low	High
	//	// + \perp

B_{bkg} vs B_{fil}

$N_{H \text{ bkg}}$	Low	High
Low	//	less //
High	less //	no tendency

- Coupling between magnetic field and matter in clumps and filaments during their evolution

Conclusions and perspectives

- At intermediate scales between molecular clouds and cores, Planck satellite reveals new insights on the role of B fields in evolution of ISM
- The interplay between the B fields and filaments, clumps is strong: however, need detailed analysis to determine the evolutionary stage
- Polarization data in clumps brings information on both the magnetic field structure and dust properties
- Further statistical observations are needed to characterize the range of scales and densities for which the magnetic fields have a significant impact