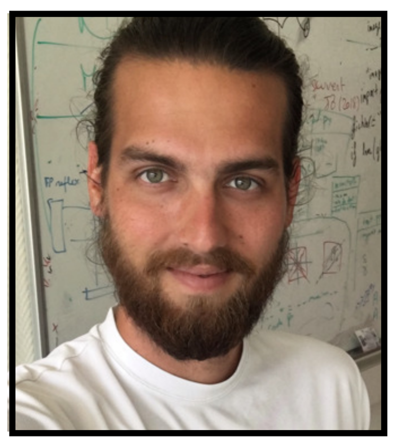
# Planck/Herschel analysis of correlations between filamentary structures and magnetic fields in star forming regions

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## Abstract


Pre-stellar cores form in the dense interstellar medium, mostly within filamentary structures. Magnetic fields are believed to play a key, albeit poorly understood, role in the whole sequence of structure formation, from interstellar filaments down to stars. It is, therefore, instructive to study the correlation between magnetic fields and filaments hosting cold cores in star forming regions under various conditions (ambient density, star formation efficiency, and core evolutionary stage). This can be investigated by combining column density maps from Herschel with magnetic field orientation maps from Planck. For this purpose, we have developed a method, based on an improvement of the Rolling Hough Transform code, for the detection and extraction of filamentary structures. This new method allows us to analyse the relative orientation between filaments and the local magnetic field over a broad range of density, from striations to dense filaments. We present the results obtained for a sample of Herschel fields from the 'Galactic Cold Cores' project, analyse the relative orientation between filaments and the local magnetic field over a broad range of density, from striations to dense filaments. We present the results obtained for a sample of Herschel fields from the 'Galactic Cold Cores' project, probing different Galactic environments. In order to separate the different emitting components in a given field and locate them along the line of sight, we use 12CO and HI (l, b, v) cubes. We also investigate whether the star formation efficiency is linked to the relative orientation between filaments and the local magnetic field.

*Carrière et al. in prep*


## Scientific context

***Filaments***
Filamentary structures are ubiquitous in the diffuse ISM and in star-forming molecular clouds.

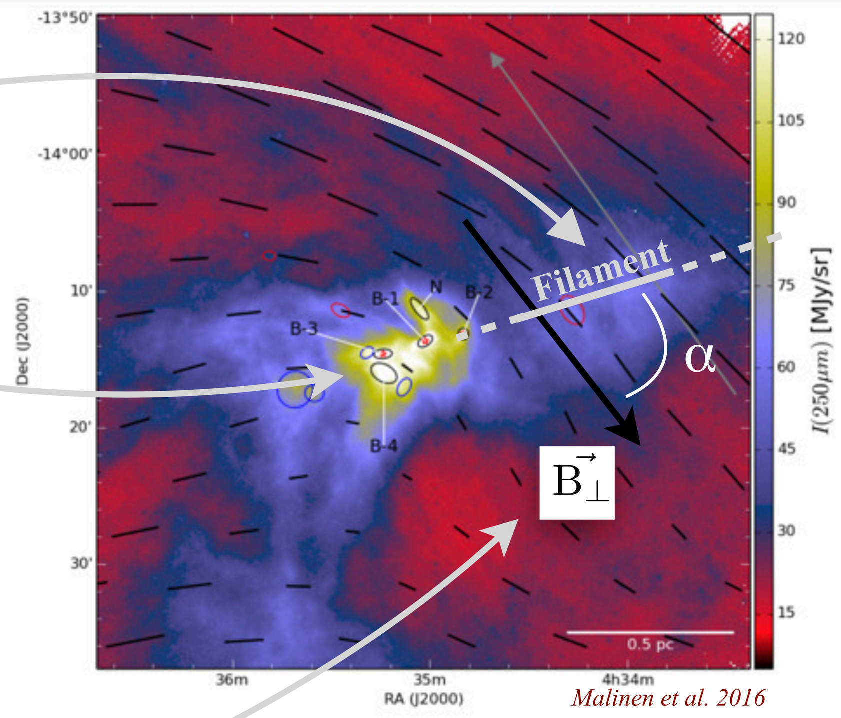
**Prestellar cores are preferentially located in the densest filaments**. The question of the **origin** and **evolution of dense cores** is **strongly connected to the filaments.**

**The physical mechanisms regulating star formation remain poorly understood.**

Different processes are involved :

Gravity — Turbulence — Magnetic field (Complex interplay)

Their actual **roles** and **interplay** has to be investigated. For this purpose, **different scales** must be probed, from molecular clouds through filaments and down to cold clumps and prestellar cores.

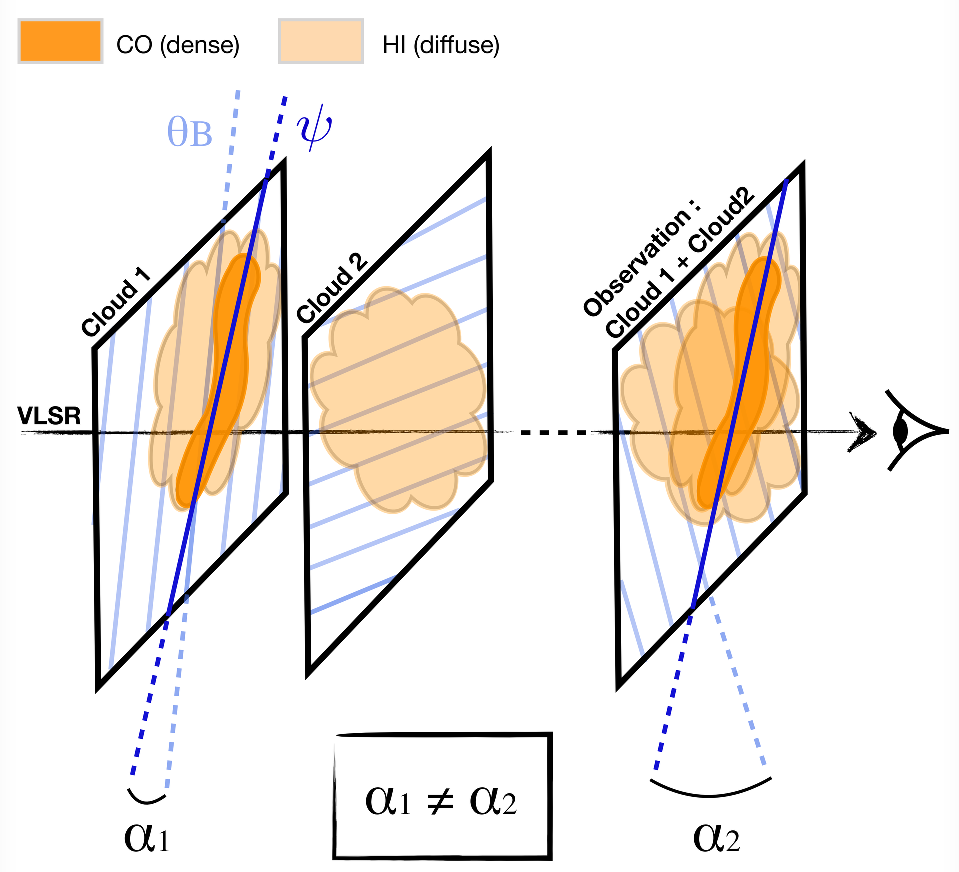



*L1642 high-b cloud : Herschel 250um emission (color) + Planck B⊥ orientation (black headless vectors)*

Study the relative orientation between filaments and the sky-projected magnetic field B⊥

We need to identify filaments and extract their relative orientations (angle α) to B⊥

### LOS confusion




The ***observed*** relative orientation (angle $\alpha_2$) between the filament (angle $\psi$) and B⊥ (angle $\theta_B$) is different from the ***actual*** relative orientation (angle $\alpha_1$)

### Objectives

**Study the properties of B⊥ (Planck) toward cold cores / clumps and their surrounding filaments (Herschel)**

- Separate the **different (HI[1] & CO[2]) velocity components** along the LOS and determine their associated B⊥ orientation (3D approach)
- Identify **filaments** over a broad range of densities and study their **relative orientations** to the local **B⊥**
- Link these relative orientations to the **cold core evolutionary stage**[3]

[1] *HI4PI Collaboration 2016*
[2] *Dame et al. 2001*
[3] *Montillaud et al. 2015*

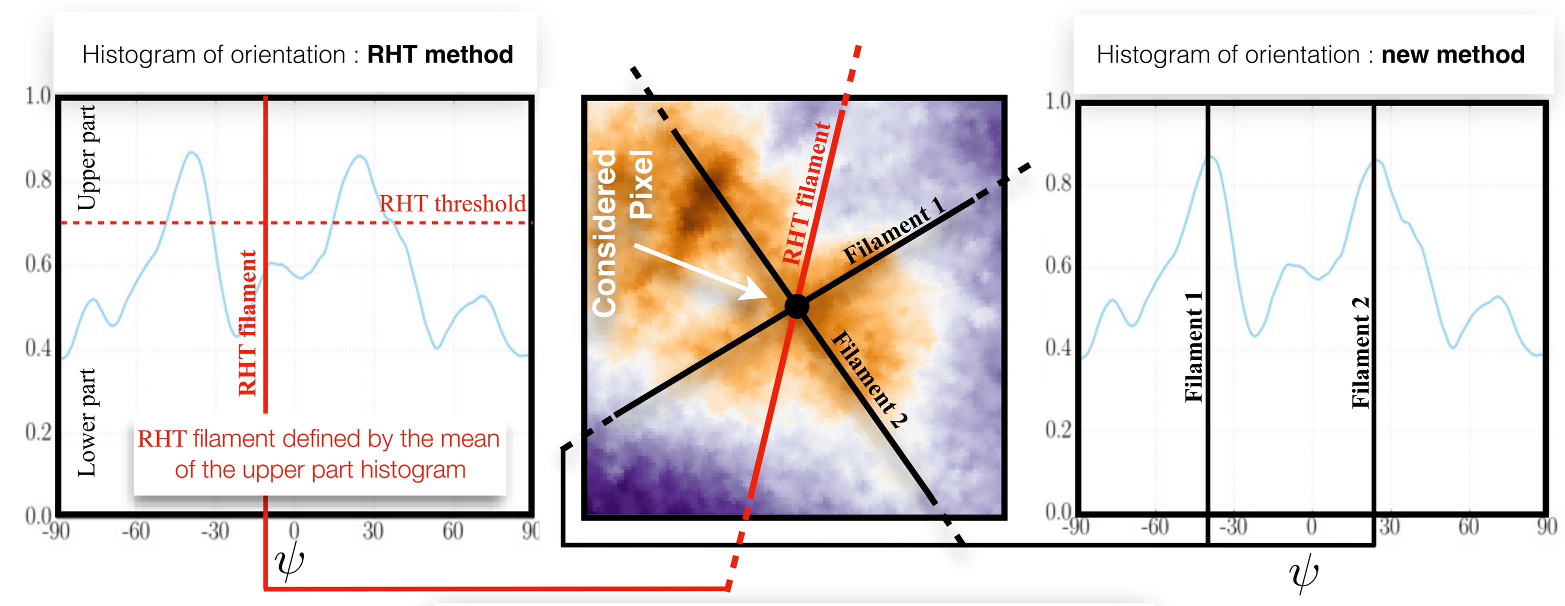
## Methodology for filament extraction

*Adapted from Rolling Hough Transform (RHT) Clark et al. (2014)*

Development of a **new method**

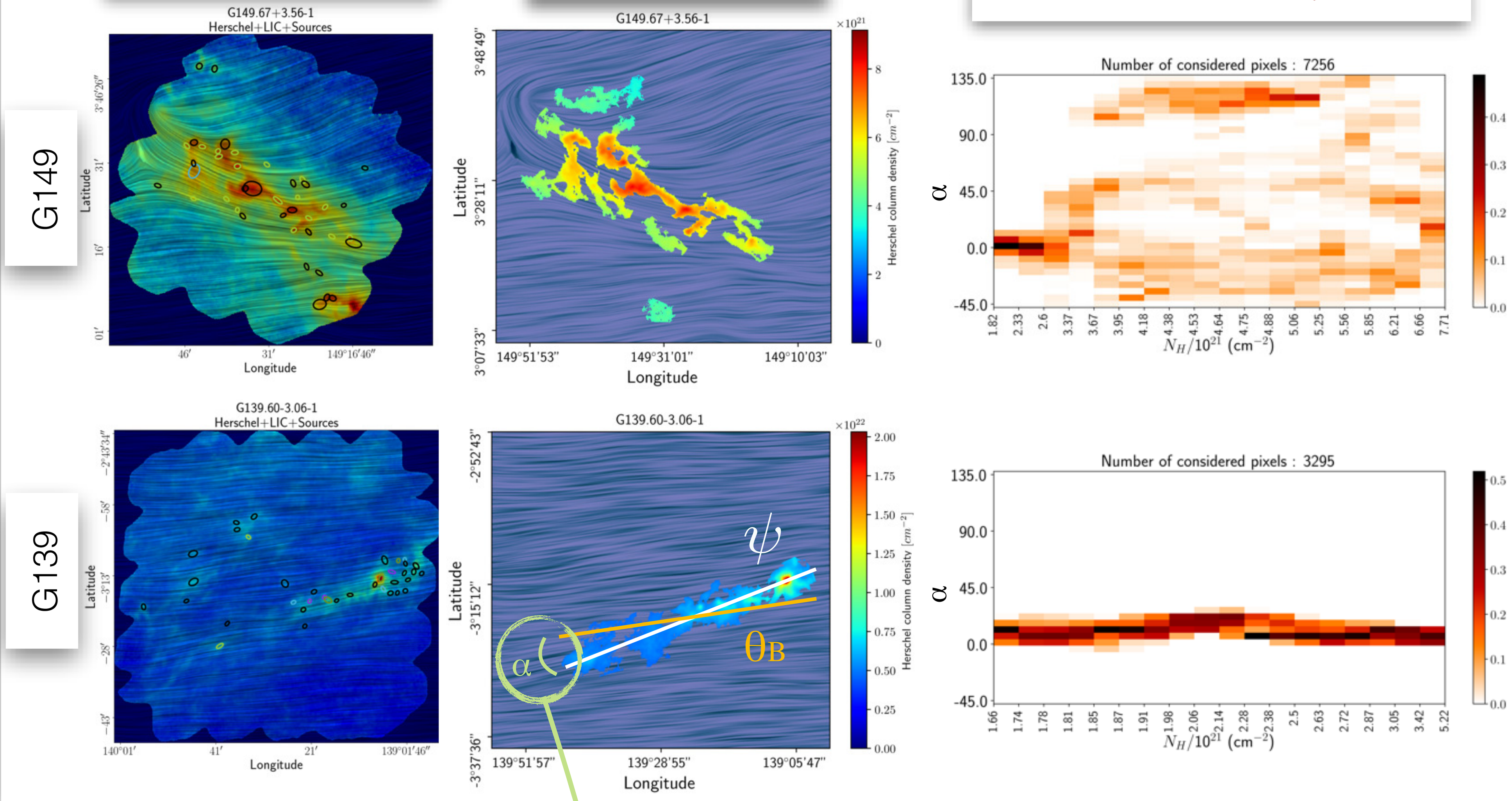
- **Allows** us to disentangle multi-scale filaments
- **Leads to**
  - Better control of filament size
  - Automatic definition of significance
  - Multi-peak detection

**Comparison between RHT and new method**




**RHT filament** is not tracing actual gas structure while our 2 filaments give much better representation

## Relative orientation : 2D approach

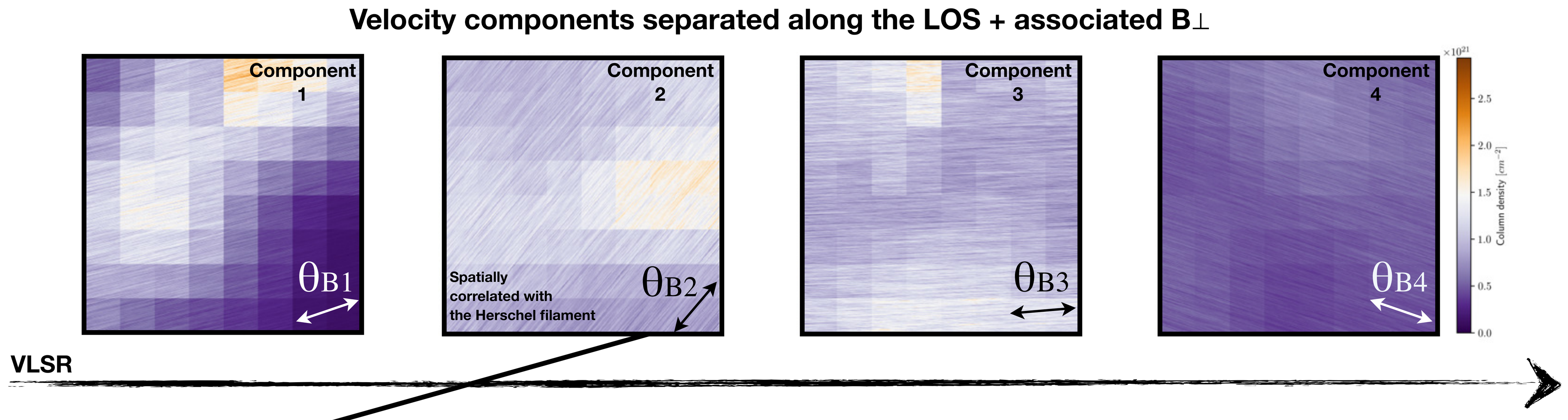


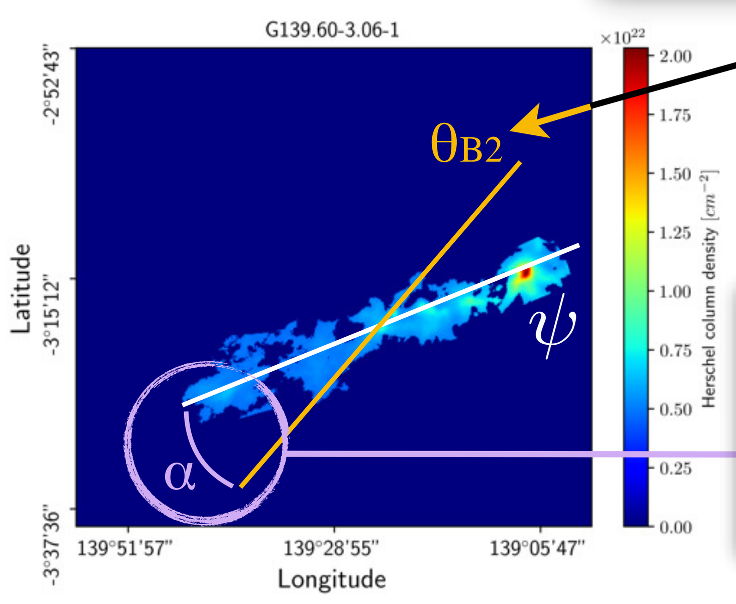

## Full 3D approach

**Velocity components separated along the LOS + associated B⊥**

**ROHSA** analysis to extract and separate HI & CO along the LOS

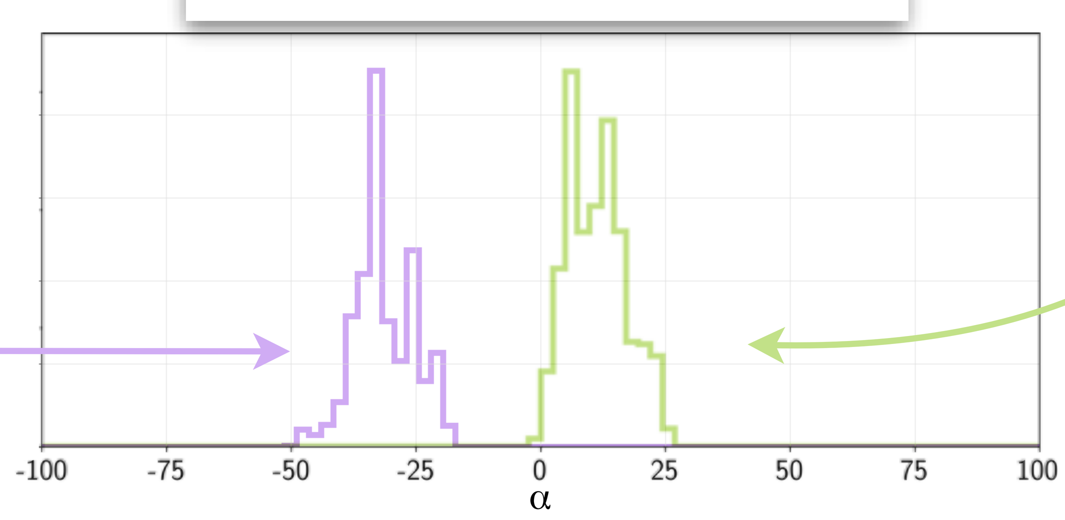
**MCMC** analysis to derive the B⊥ orientation angle $\theta_B$ associated with the different components




*Extracted filaments vs B⊥ from cloud separation*

*Histogram of relative orientation between B⊥ and filaments*




*Extracted filaments vs B⊥ from Planck*

## Conclusion & Perspectives

- **Combination of Herschel & Planck**
  - Detection of filaments down to striations
  - Comparison between filament and B⊥ orientations
- **Optimised version of RHT**
  - **Fast :** < 30min for 1 field (~1°x1°)
  - **User friendly** : only 2 free parameters
  - **More robust** : control of filament size, automatic significance, multi-peak detection
- **Development of the first 3D approach**
  - LOS velocity component separation in HI & CO cubes
  - Overcoming LOS confusion
  - Comparison with 2D results
- **To do next : Extension to larger sample[4] of molecular clouds**
  - Broad range of properties / sizes / morphologies
  - Including evolutionary stage of cores (starless, pre-stellar, proto-stellar)

[4] *Alina et al. 2019*