A Comparison between Magnetic Field Directions Inferred from *Planck* and Starlight Polarimetry toward Gould Belt Clouds

(*Gu & Li 2019, ApJL, 871, 15*)

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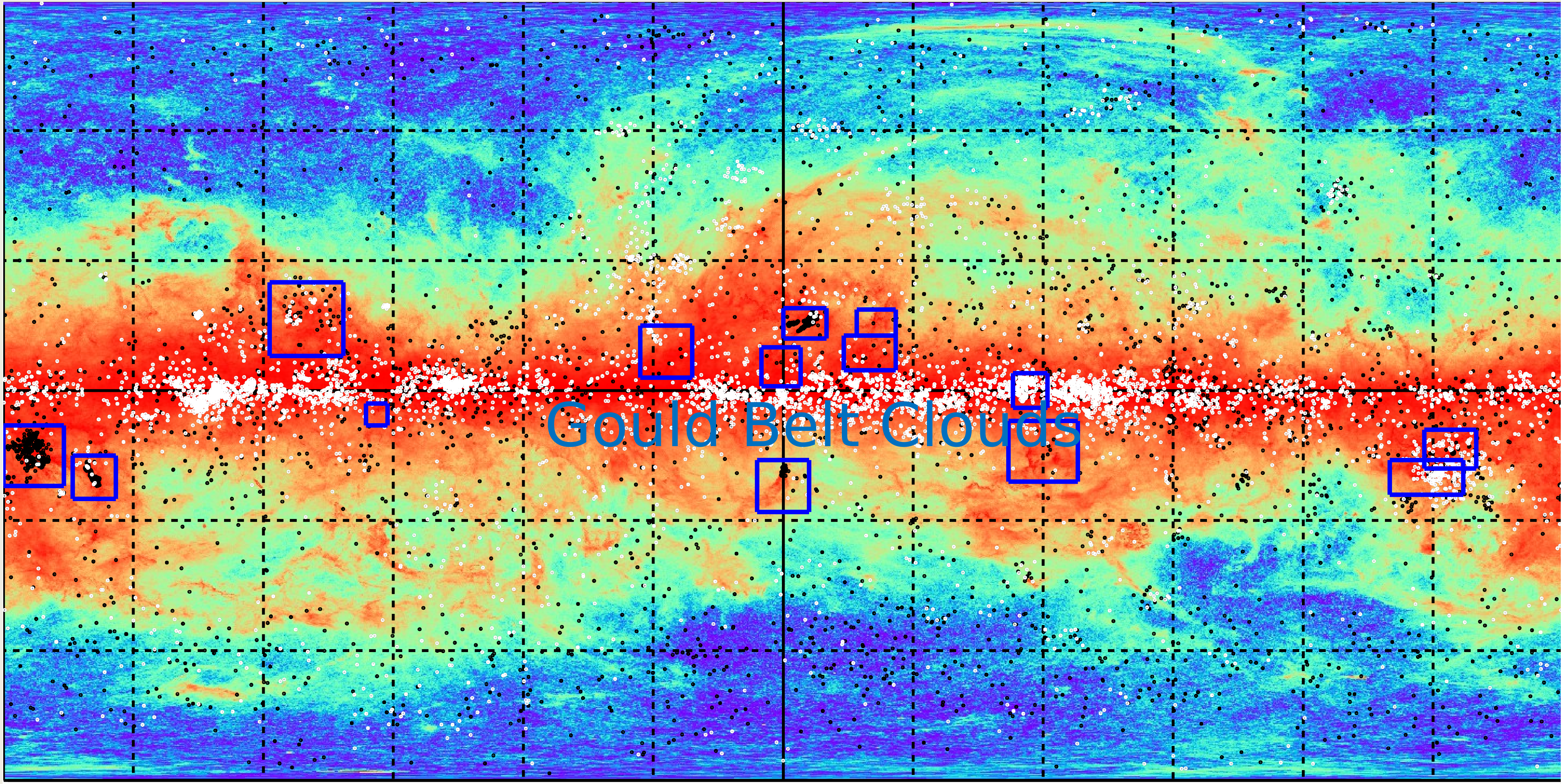
Outline

- Data Sources
- Results
  - *Stellar vs. Planck Inferred B-field Directions*
  - *Stellar vs. Planck in the Cloud-field Alignment toward Gould Belt Clouds*
  - *Connection between two alignment studies*
- Summary

Data Sources

- 353 GHz Thermal Dust Polarization from *Planck*
  - *Initially at 4.8’ and smoothed to 10’ for high S/N*
- Starlight Polarization
  - *From Heiles (2000), 5747 of 9286 stars with S/N $p/\sigma_p > 3$*

Spatial distribution



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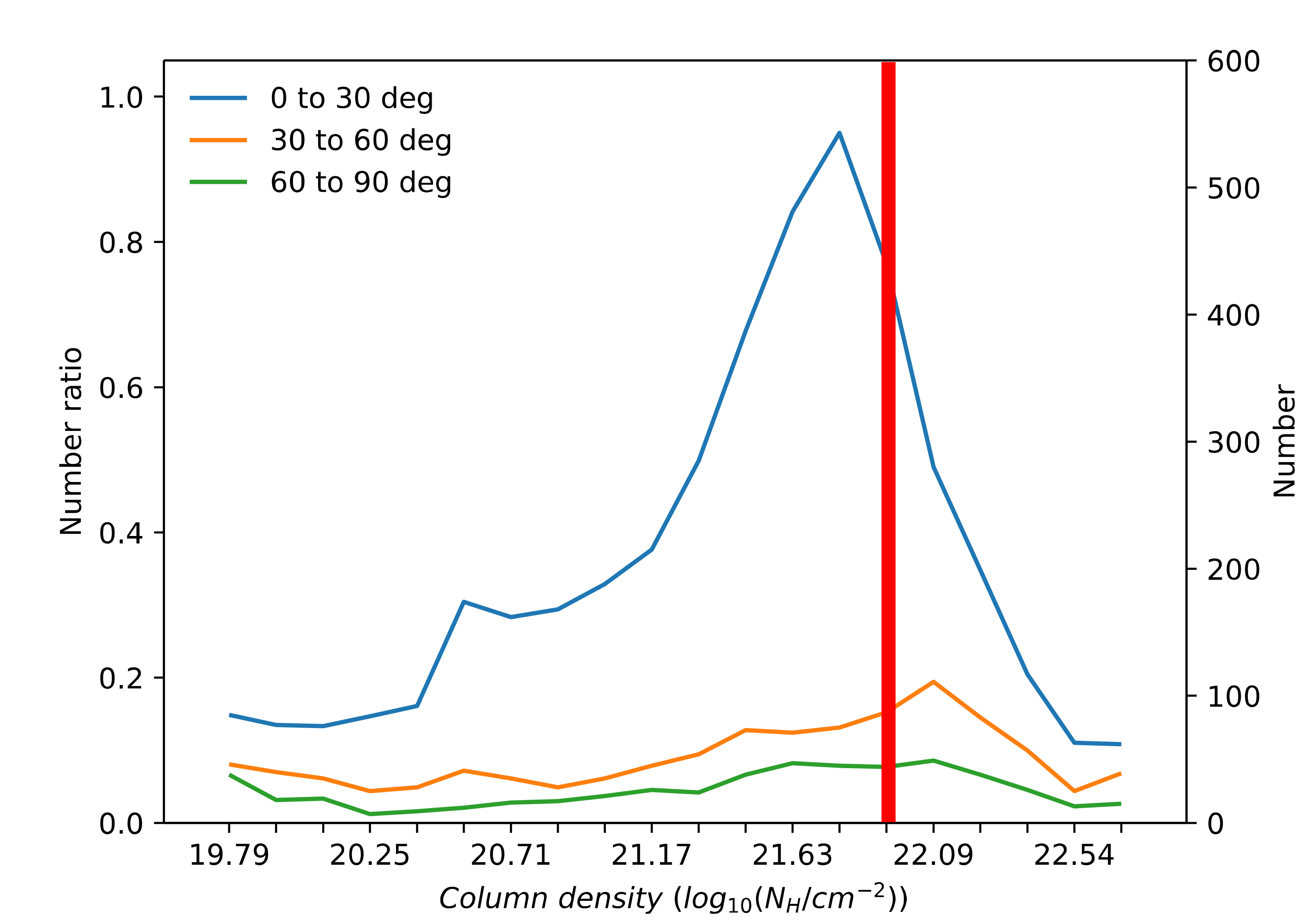
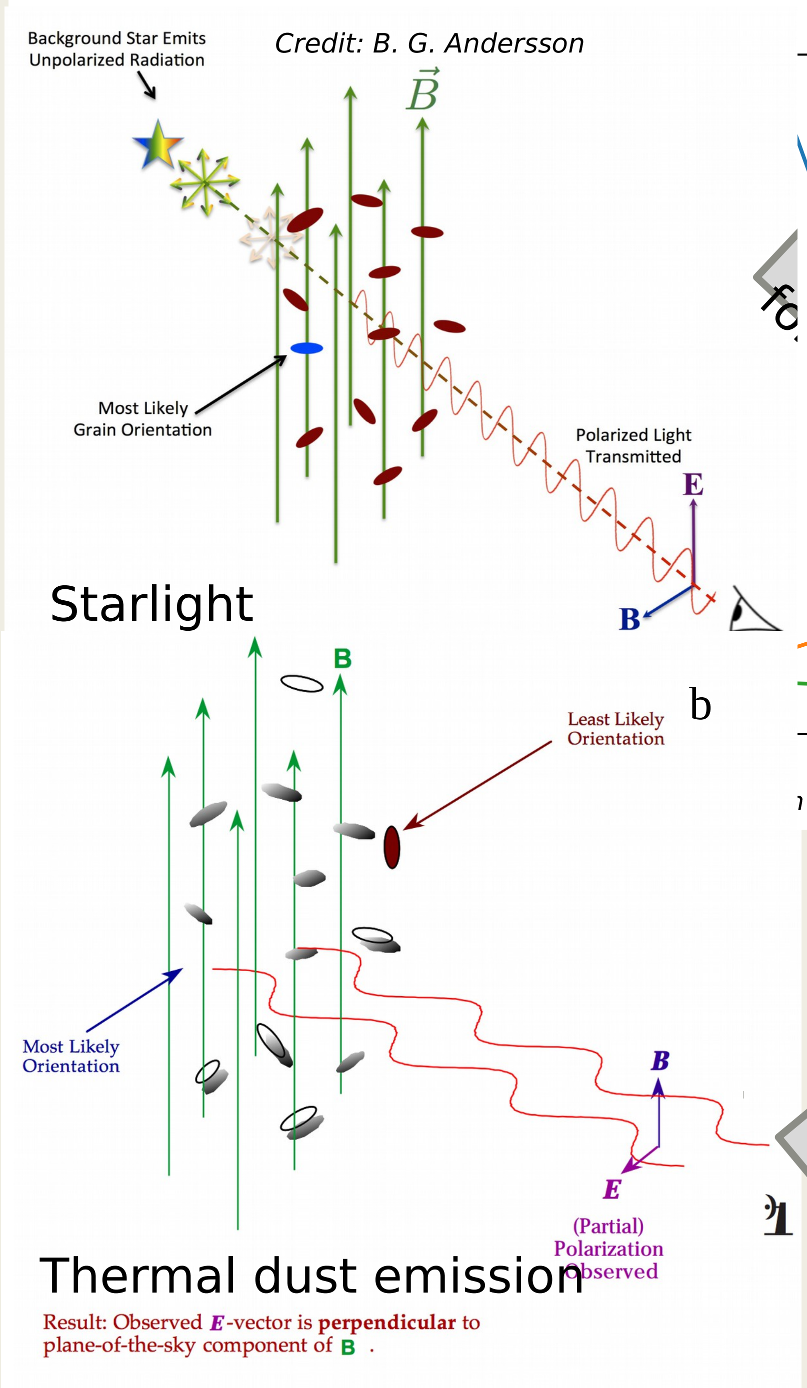
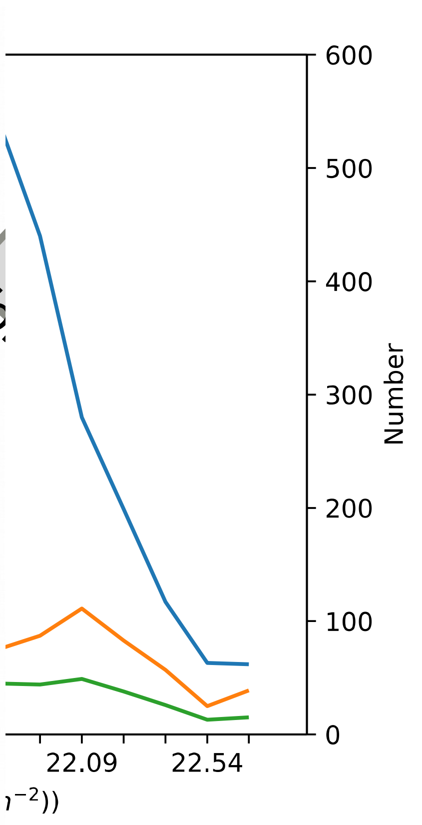
Planck-starlight inferred B-field orientation offsets with increasing N_H



In general, the angle difference between starlight and *Planck* is small, mostly below 30º.

Overall trend: firstly decrease and then increase with increasing N_H.
(Turning point: $N_H \sim 10^{22}$ cm^{-2})





erlap
round) is
weighted
en N_H
increases

Trace entire LOS

When N_H is so high, the background stars become invisible and the visible stars are mostly in the foreground so the overlap decreases. Stellar feedback will also contribute to grow the offsets

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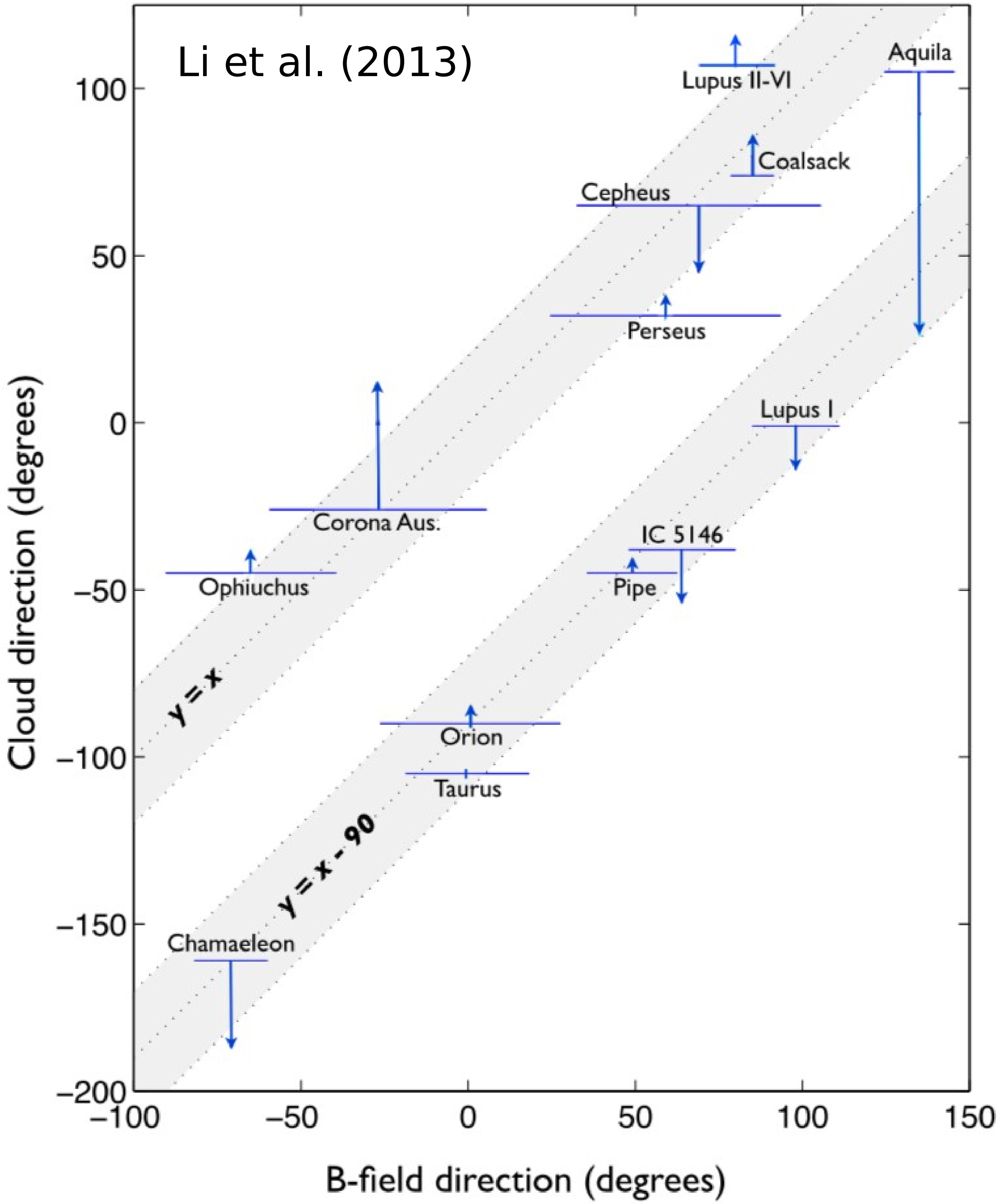
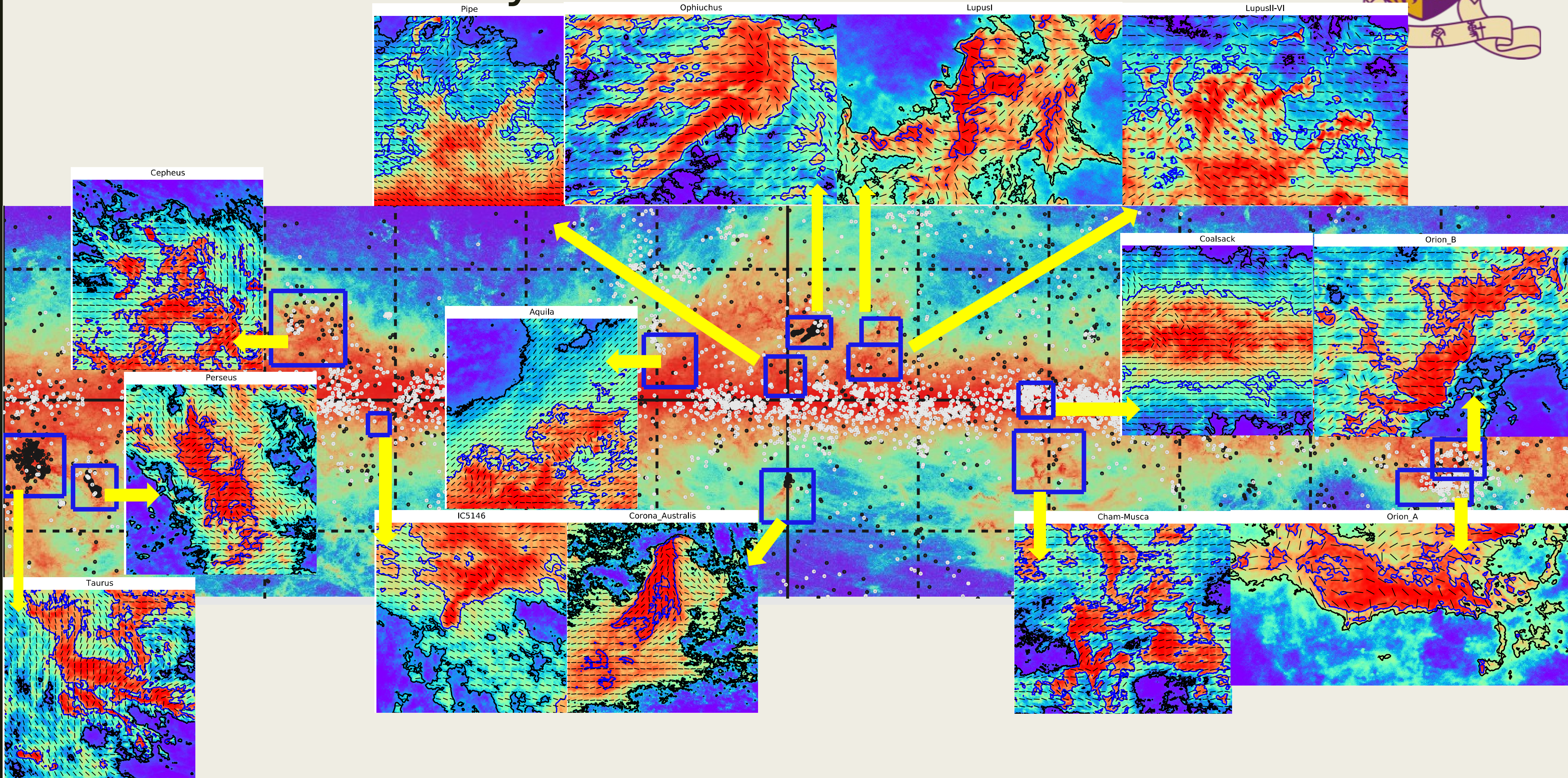
Bimodal distribution from *Li et al. (2013)*

Global cloud-field alignment (10 – 100 pc): mean B-field orientation and cloud orientation.

Clouds tend to be either parallel with or perpendicular to the mean B-field orientations.



B-field traced by *Planck* of Gould Belt Clouds

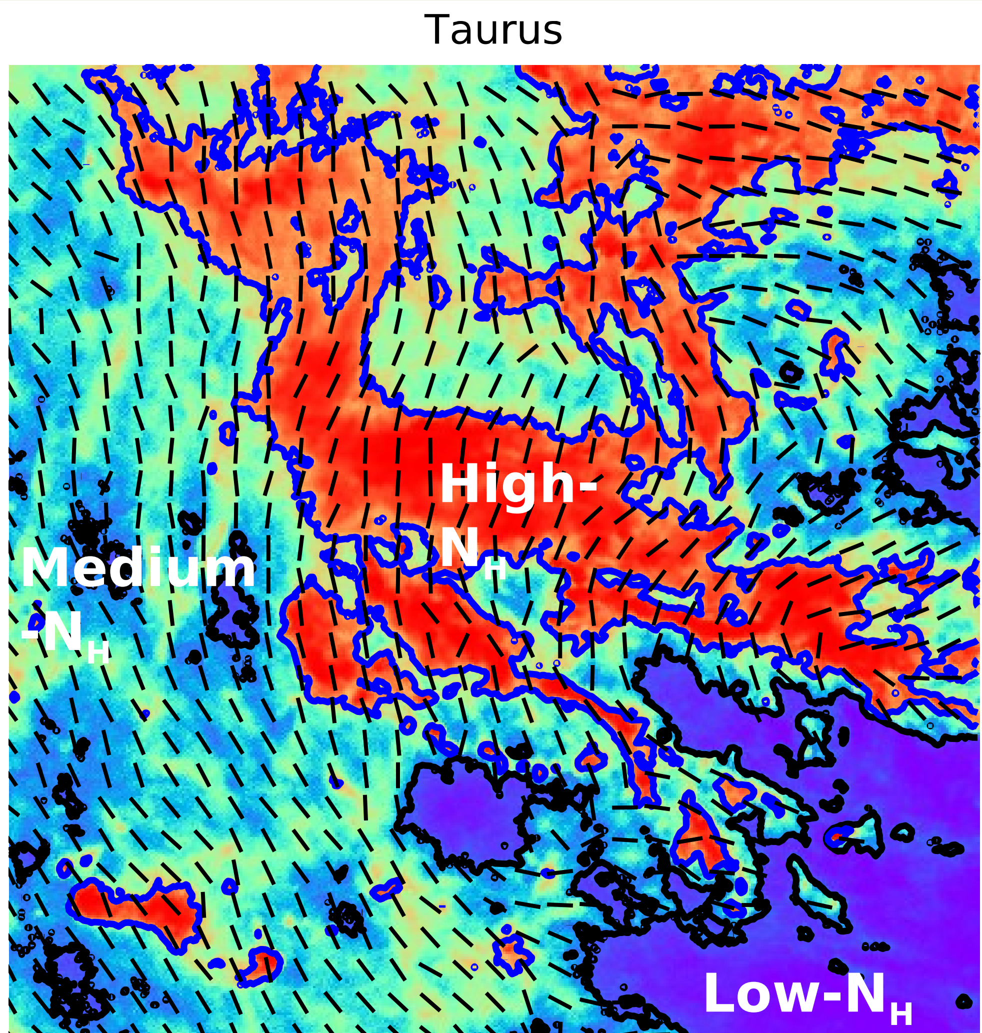


Stellar vs. Planck in the Cloud-field Alignment toward Gould Belt Clouds

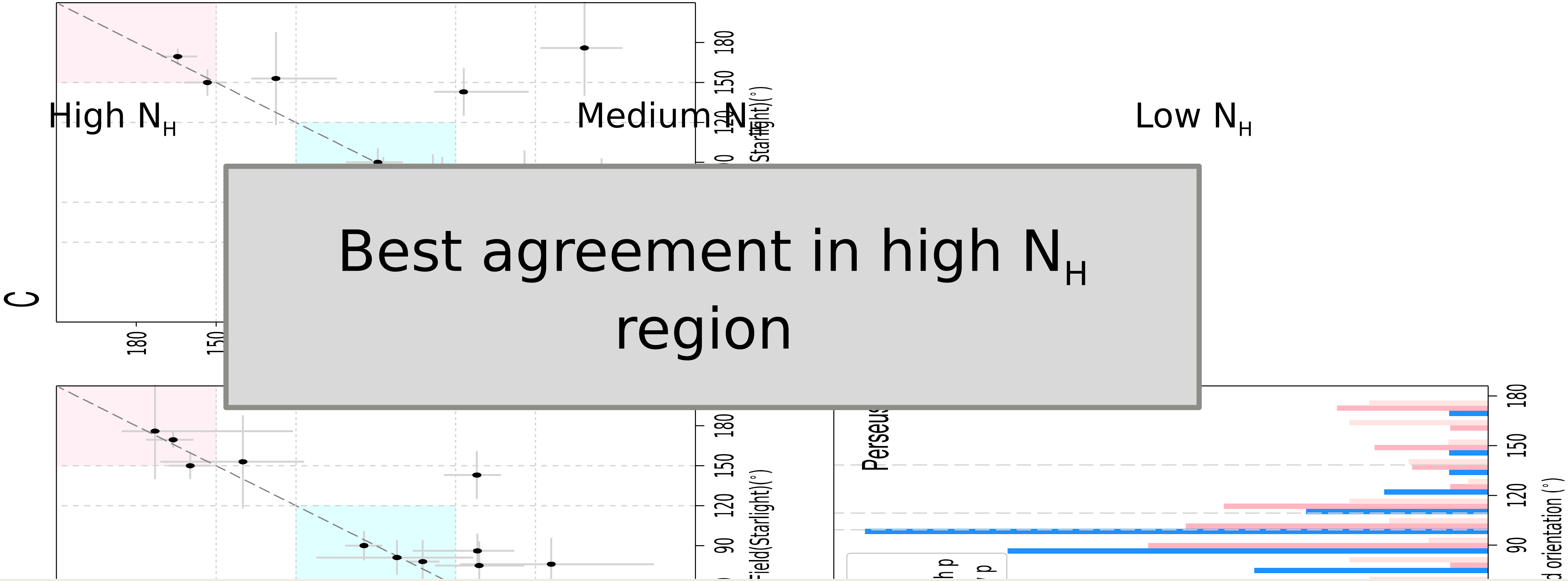
Divide each cloud into three parts with different N_H.

Use mean Q and U values of each part to derive corresponding mean B-field orientations.

Compare with cloud-field alignment resulted by Li et al. (2013).



High N_H Medium N_H Low N_H



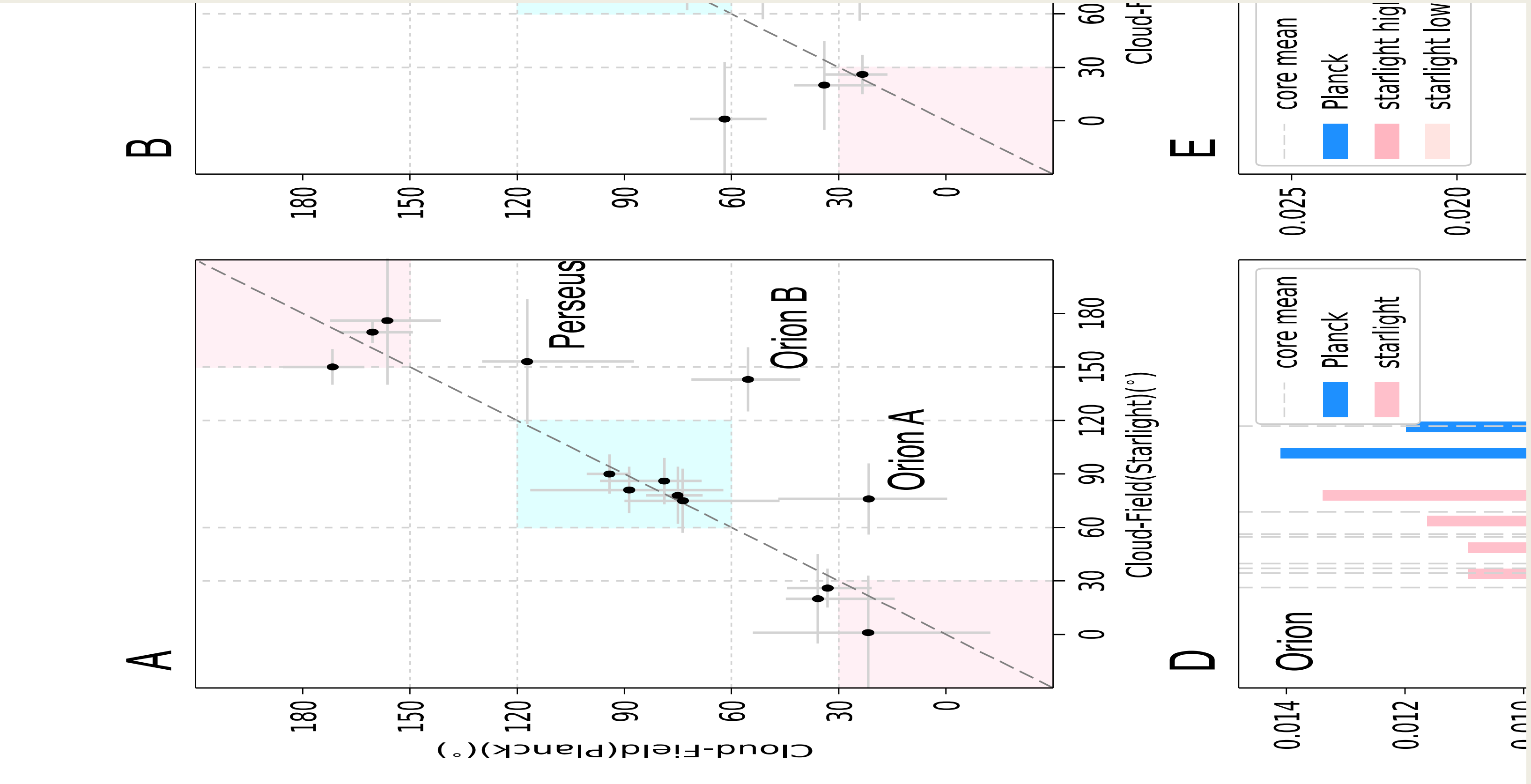
Best agreement in high N_H region

x-axis (Li et al. (2013)): B-field orientations derived from starlight method

y-axis (this work): B-field orientations derived from *Planck 353 GHz*

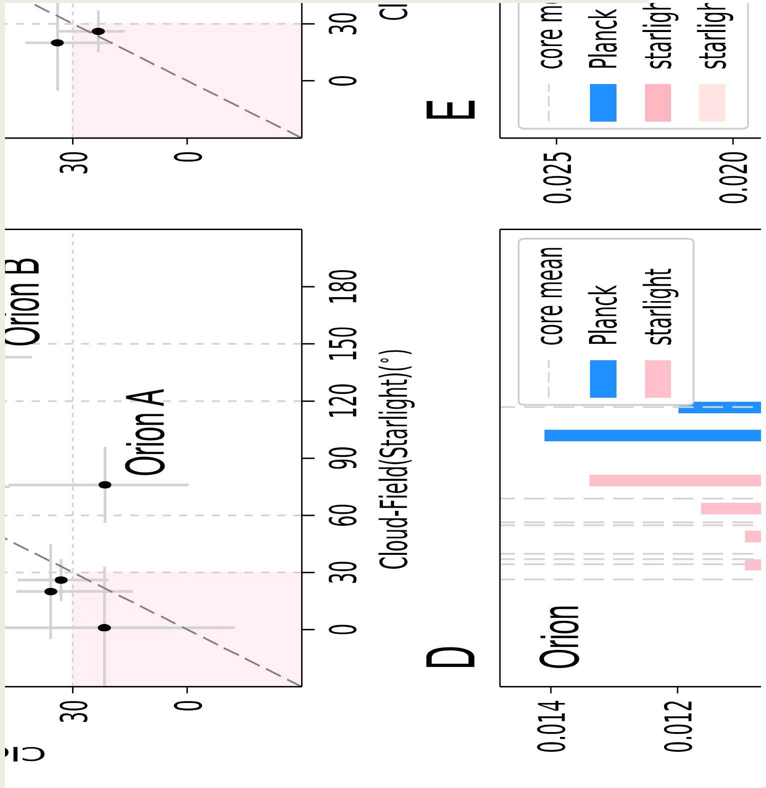
Outliers: Orion and Perseus

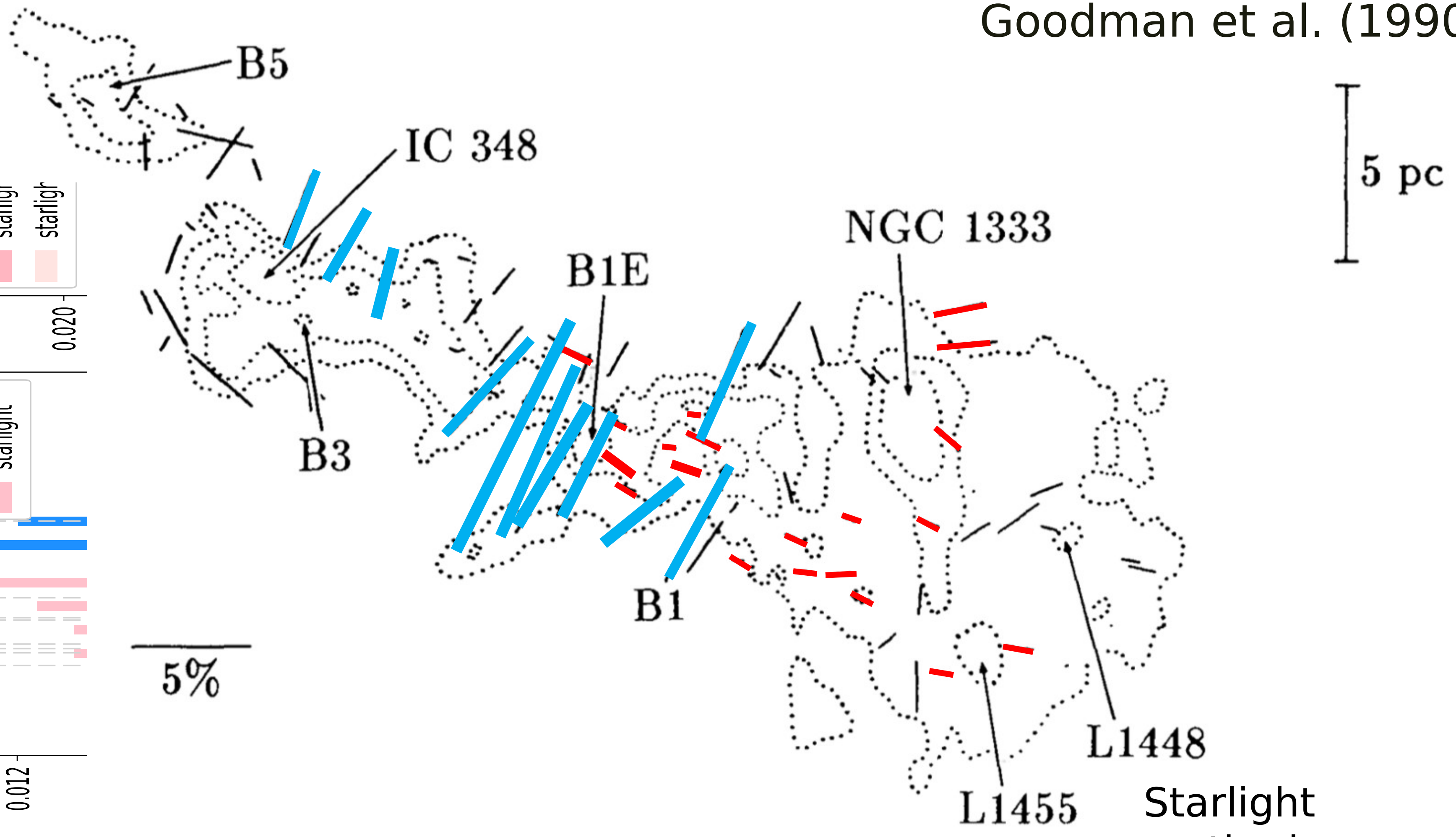
B-field orientations histogram



Perseus

Goodman et al. (1990



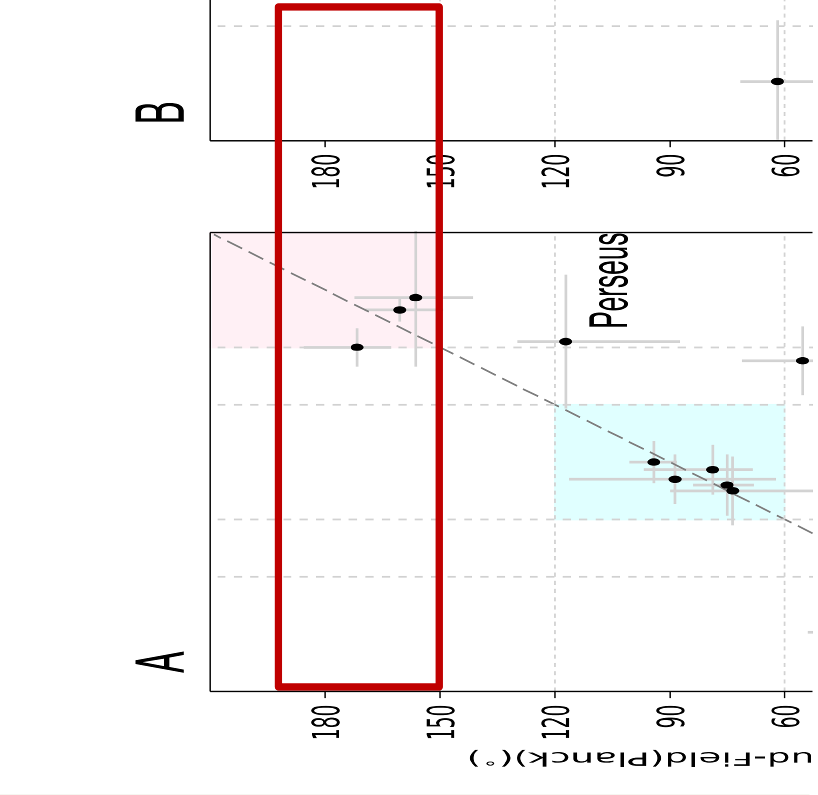


Starlight method

B-field orientations traced by starlight has bimodal distribution: vectors with low fraction are mostly parallel with the cloud while those with high fraction are mostly perpendicular to the cloud. (Goodman et al. (1990))

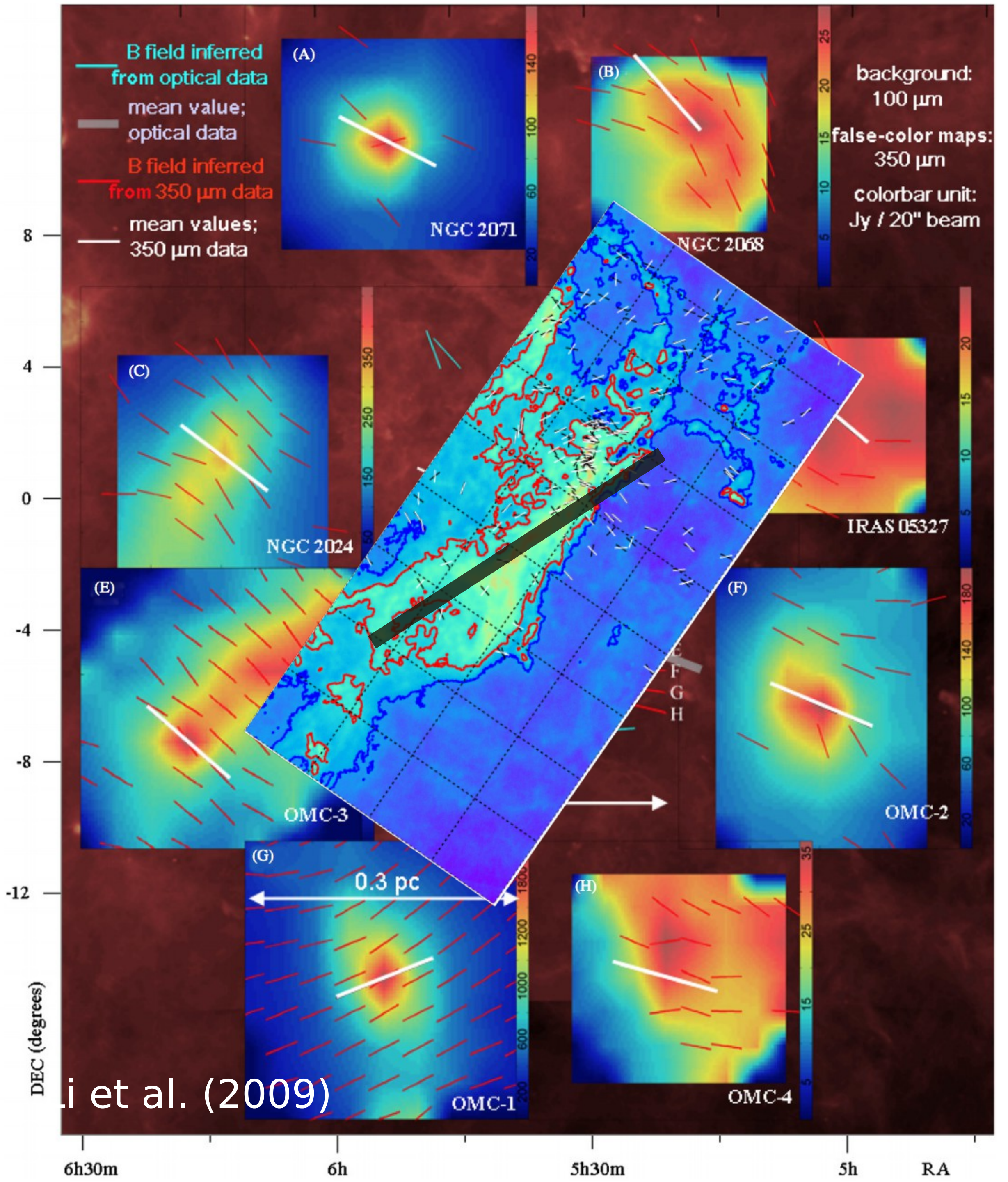
Possible reasons:
1. Low fraction group has more starlight data;
2. *Planck* (thermal dust emission) favors region with high polarized flux;
3. High fraction group shaped by stellar feedback (Goodman et al. (1990)).

Orion



B-fields from starlight and Hertz (CSO) show agreement (Li et al. (2009)), but show disagreement with that from *Planck.*

Possible reason:
Planck traced an LOS dimension much larger than a core while CSO's beam is smaller than a core and for starlight the LOS scale could be controlled by stellar distance.



Li et al. (2009)

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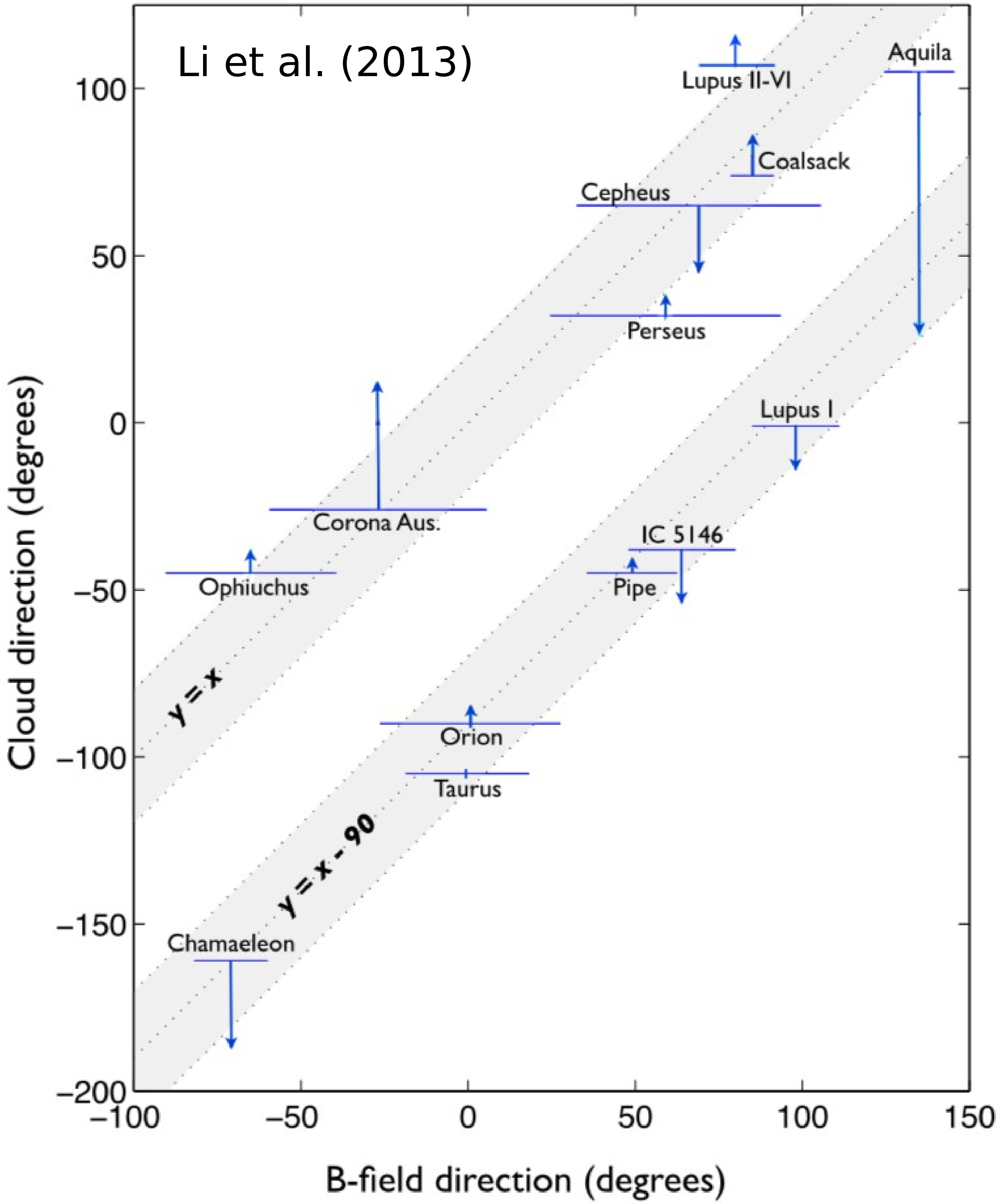


Structure-field alignment relation in *Planck XXXV*

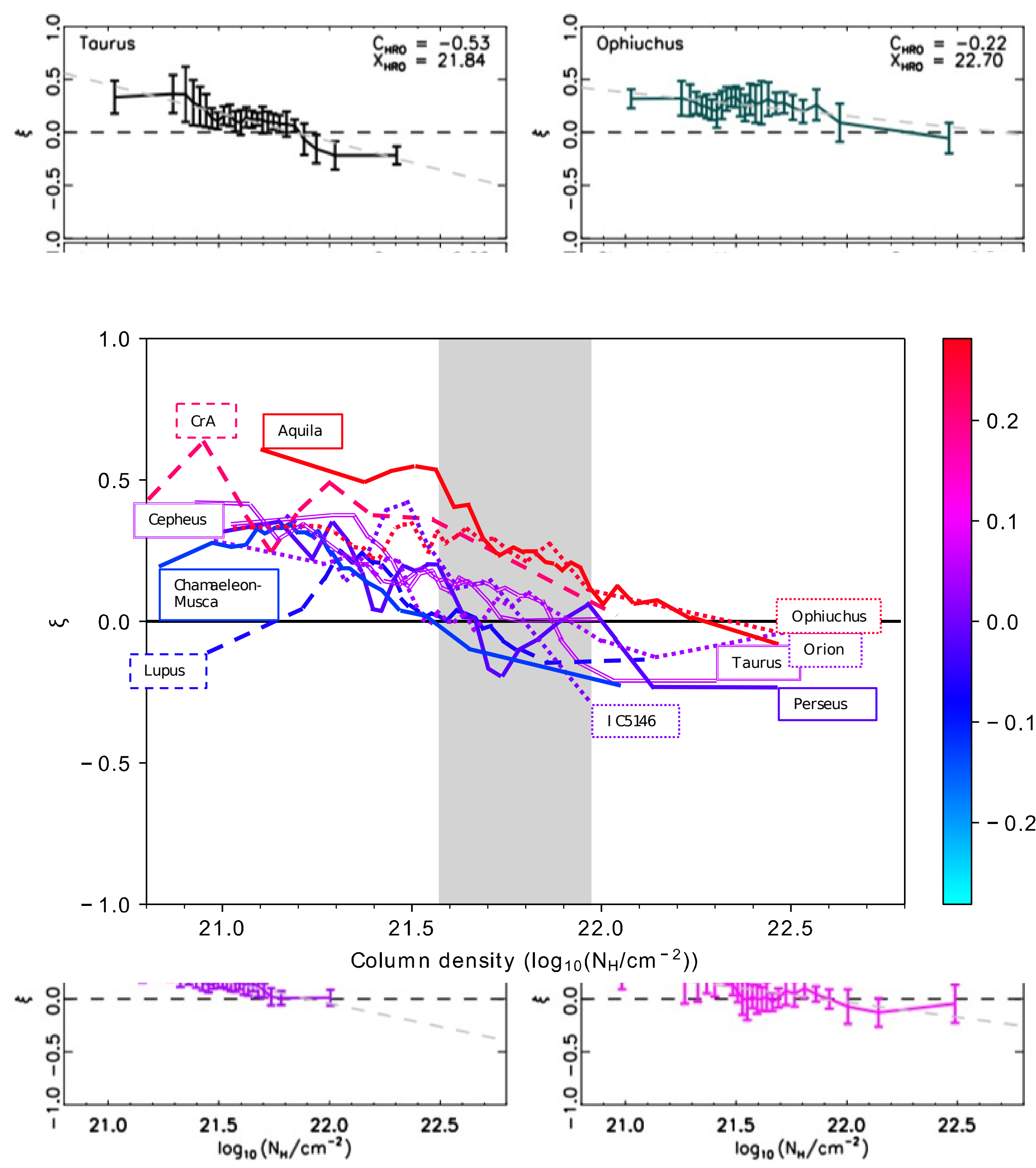
Pixel size (0.1 – 1 pc): shows relation of local B-field orientation and local N_H contour.

ξ-function:
- > 0 for parallel relation
- = 0 no preferred relative orientation
- < 0 for perpendicular relation

Overall trend of moving away from parallelism to perpendicularity with increasing N_H.

PDF of N_H turns from log-normal to roughly a power law where gas turns gravitational bounded.

Gray region: $2 < A_v < 5$ (Kainulainen et al. (2009)), ξ lines are colored by the gray area above ξ = 0 (blue for negative, red for positive).



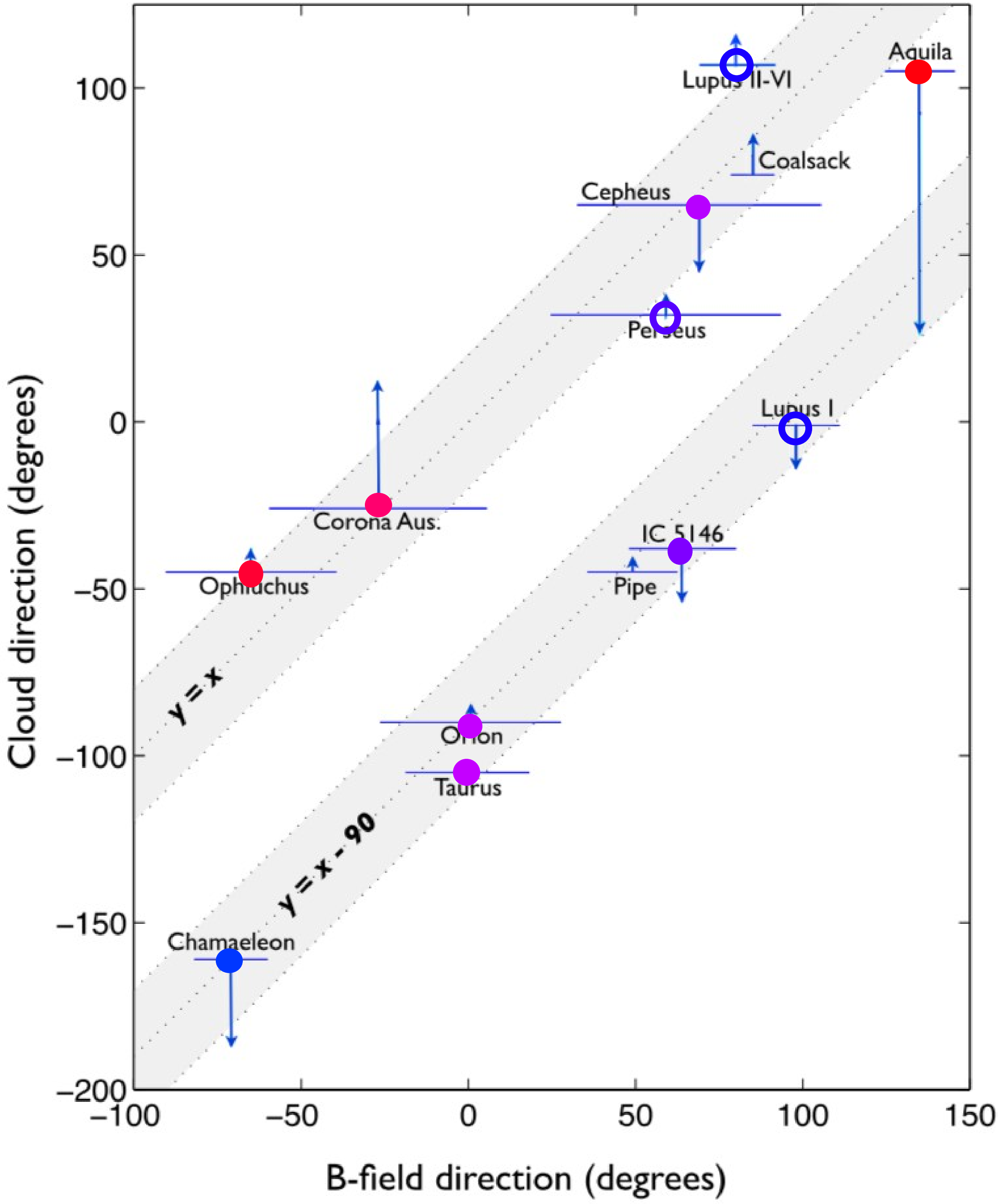
Planck Collaboration Int. XXXV (2016)

Connection between two alignment studies

hollow symbols are not suitable for the comparison: Lupus is divided into Lupus I and Lupus II-VI in Li et al. (2013)

y = x panel: redder
y = x – 90 panel: bluer

Two studies don't conflict with each other but show some agreements.



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Summary

- In general, B-field directions inferred from two methods agree well. The slight disagreement in low and extremely high N_H regions can be explained by: (a) the overlap of the LOS traced by two methods is more weighted with higher foreground N_H; (b) visible stars in extreme high N_H LOS are mostly in the foreground, which decreases the overlap of two methods; (c) stellar feedback affects the denser regions more.
- Based on *Planck* 353 GHz thermal dust polarization data, we repeat the global cloud-field alignment study carried out by *Li et al. (2013)* and find a good agreement with high-N_H data
- In the range of cloud contraction threshold density, $2 < A_v < 5$, where N_H PDFs turn from log-normal to roughly a power law, the local cloud-field alignment observed by *Planck XXXV* shows some agreements with the study of the global cloud-field alignment.

Time for questions and dinner!