Measuring B-mode polarization foregrounds with neutral hydrogen

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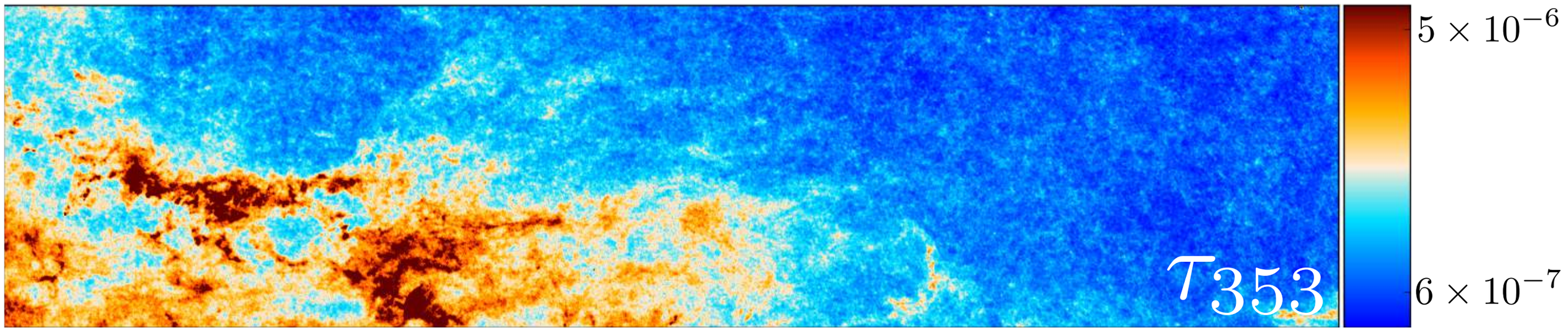
Dust opacity and neutral hydrogen (HI) column trace one another.



HI: GALFA-HI
Dust: *Planck*

e.g. Burnstein & Heiles 1982

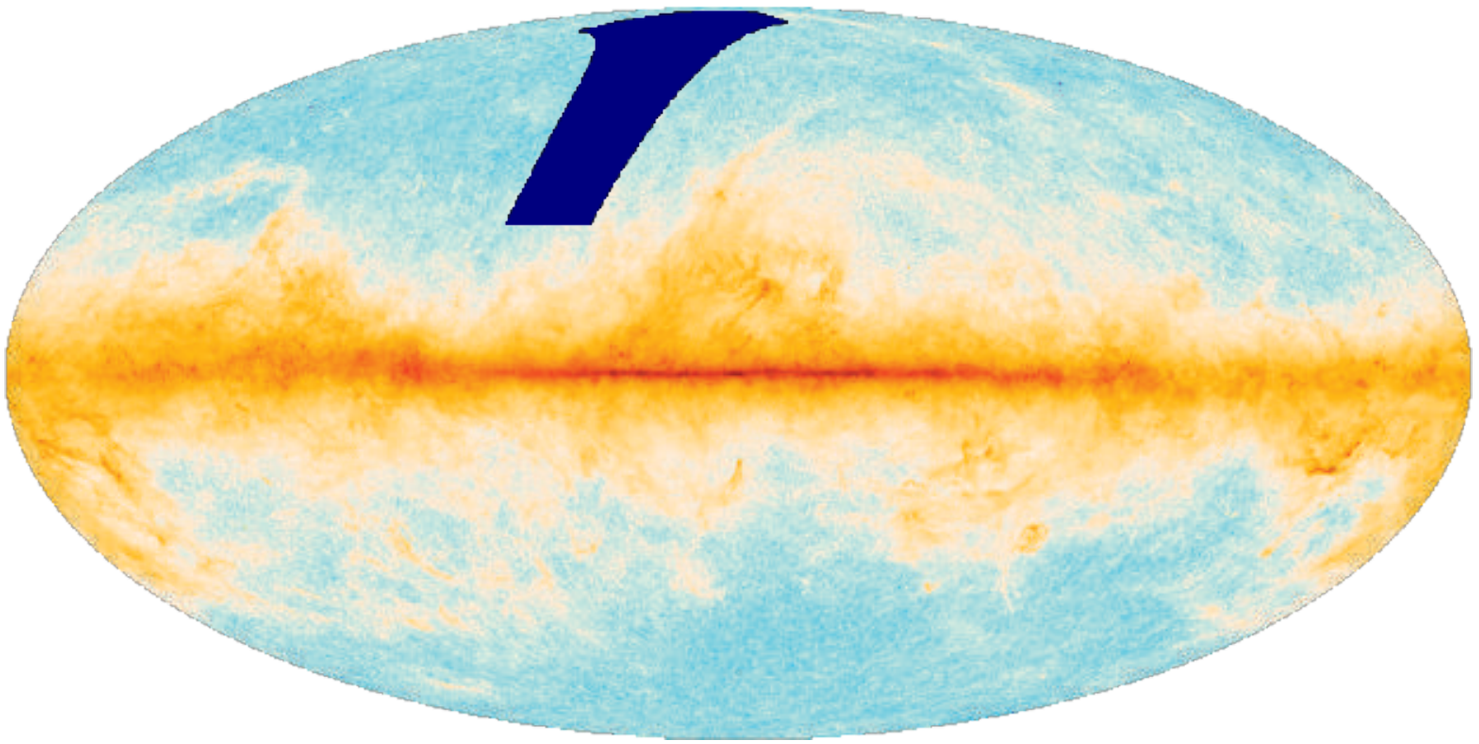
Spectrally binned HI reveals fine linear structure.

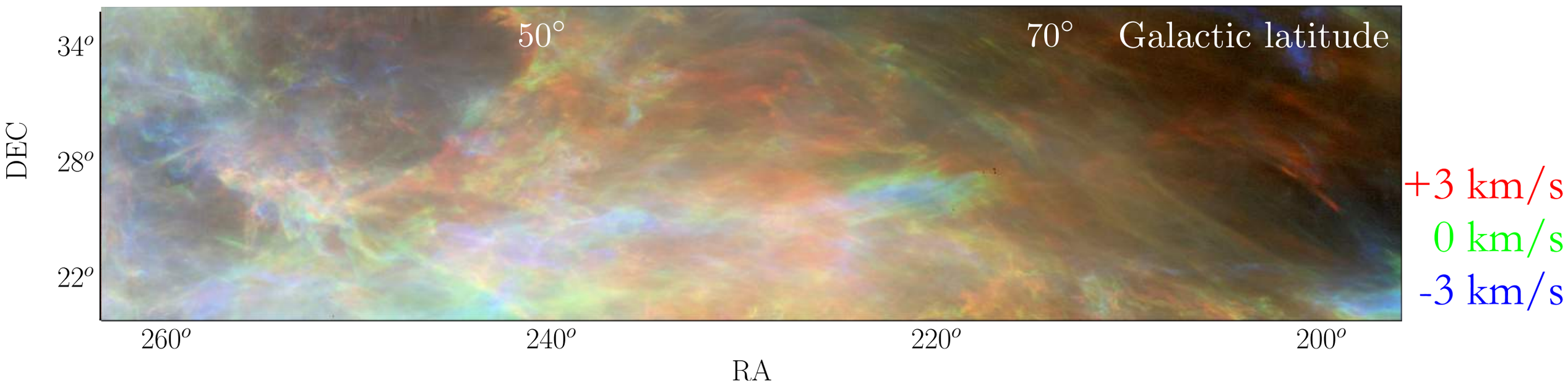
Arecibo Observatory, 4′ resolution

GALFA-HI: Peek+ 2011

We analyze a region of sky at high Galactic latitude.

$b > 30°$





What is the relationship between linear HI structures and the *Planck* magnetic field?

The Rolling Hough Transform

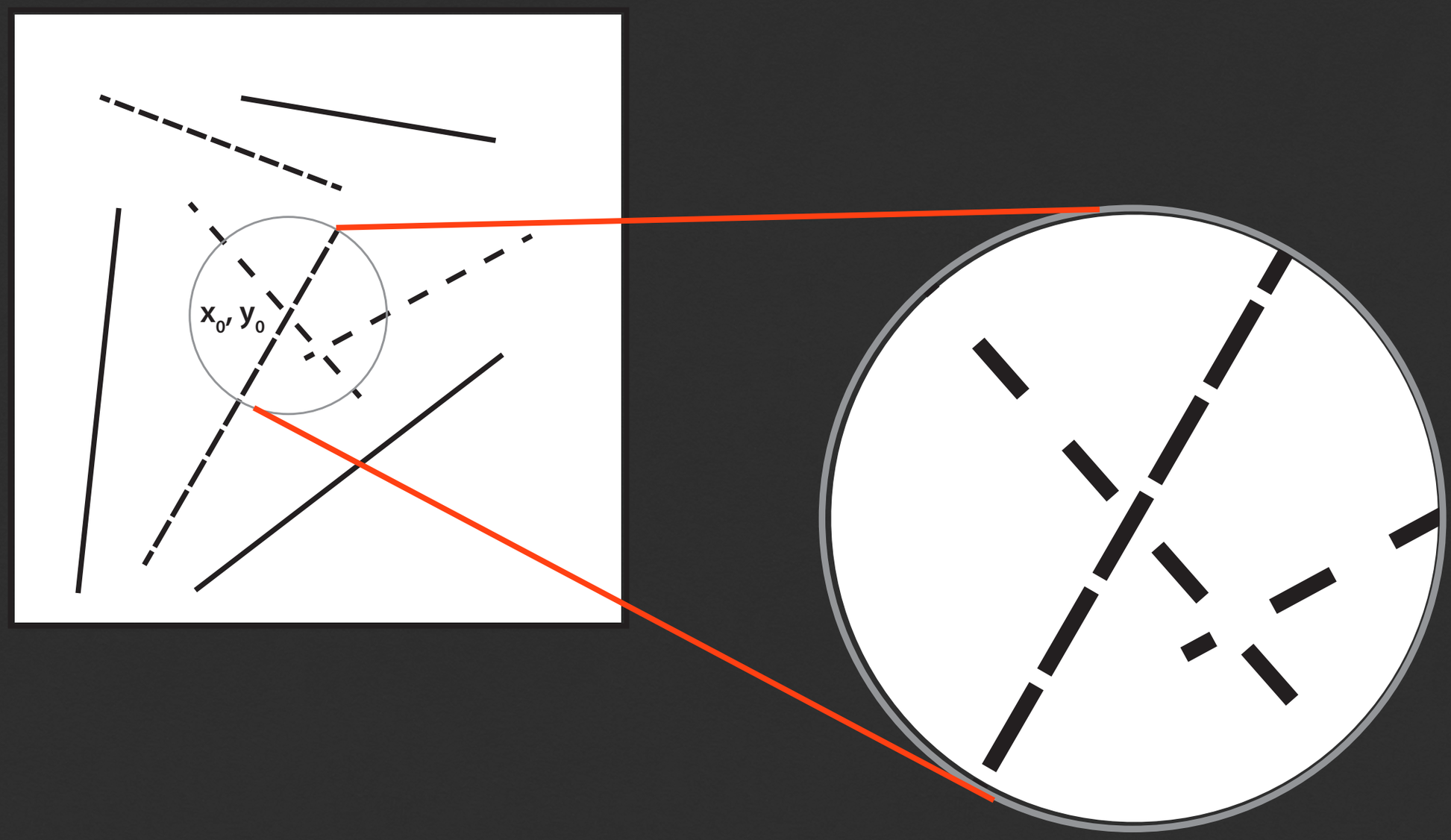
Clark+ 2014, ApJ 789, 82

github.com/seclark/RHT

Smooth and unsharp mask the image data.

Clark, Peek, & Putman 2014

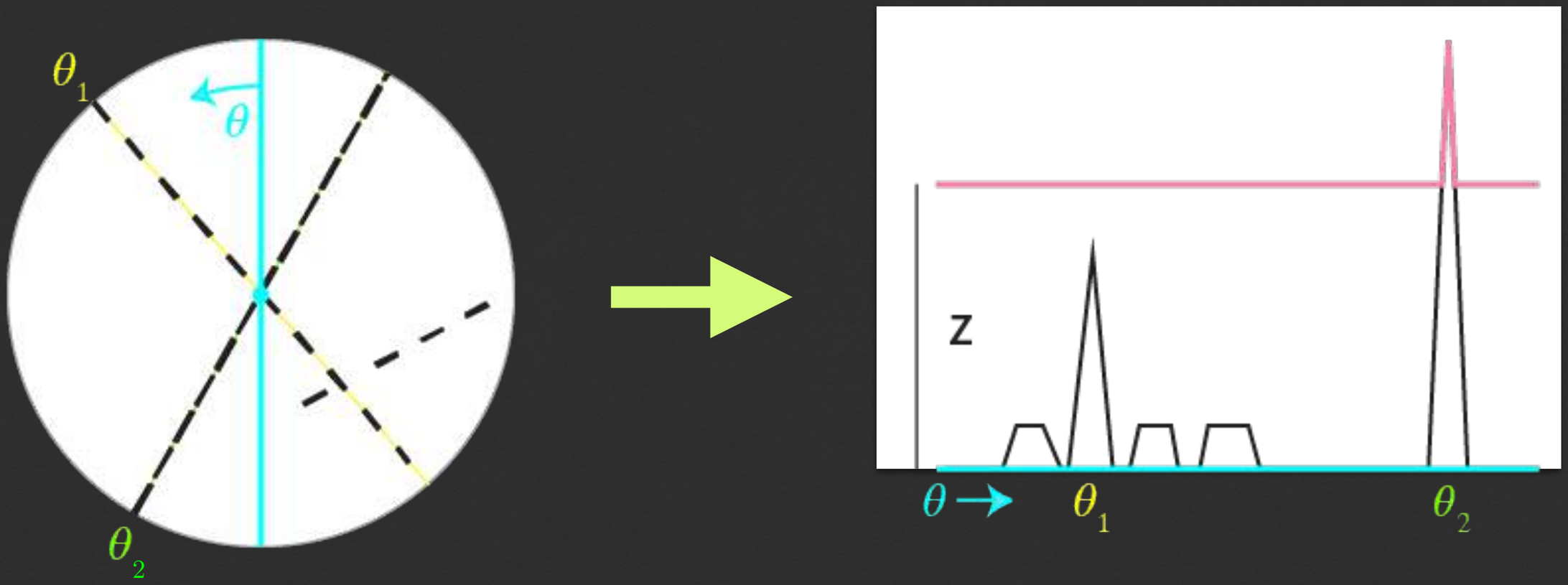
Roll through the data,
selecting a circular window around each pixel.



Clark, Peek, & Putman 2014

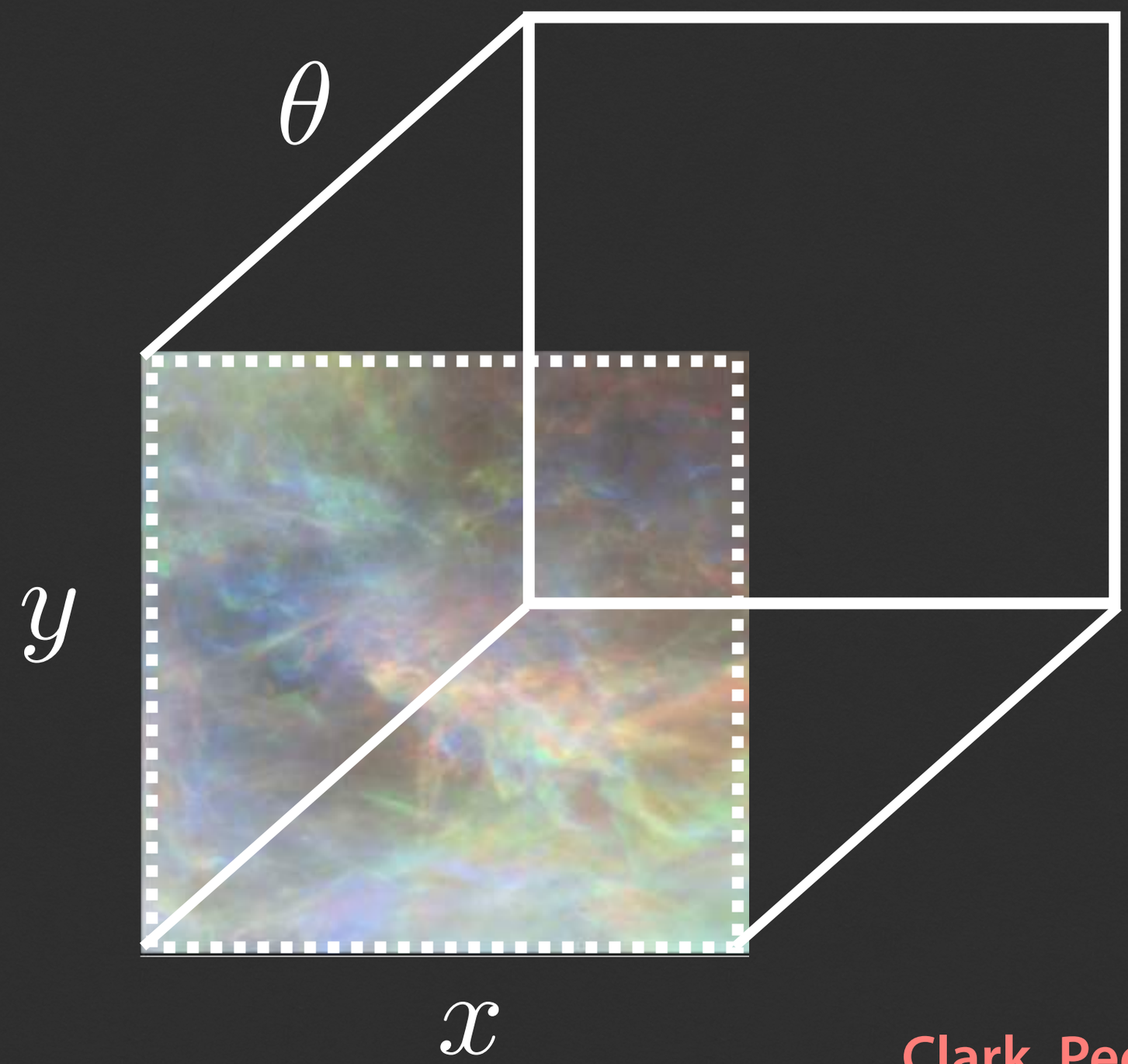
Measure intensity as a function of angle.

$$R(\theta, x, y)$$



Clark, Peek, & Putman 2014

Store intensity as a function of angle
for every image pixel.



Clark, Peek, & Putman 2014

We calculate HI and *Planck* magnetic field orientation.

HI orientation

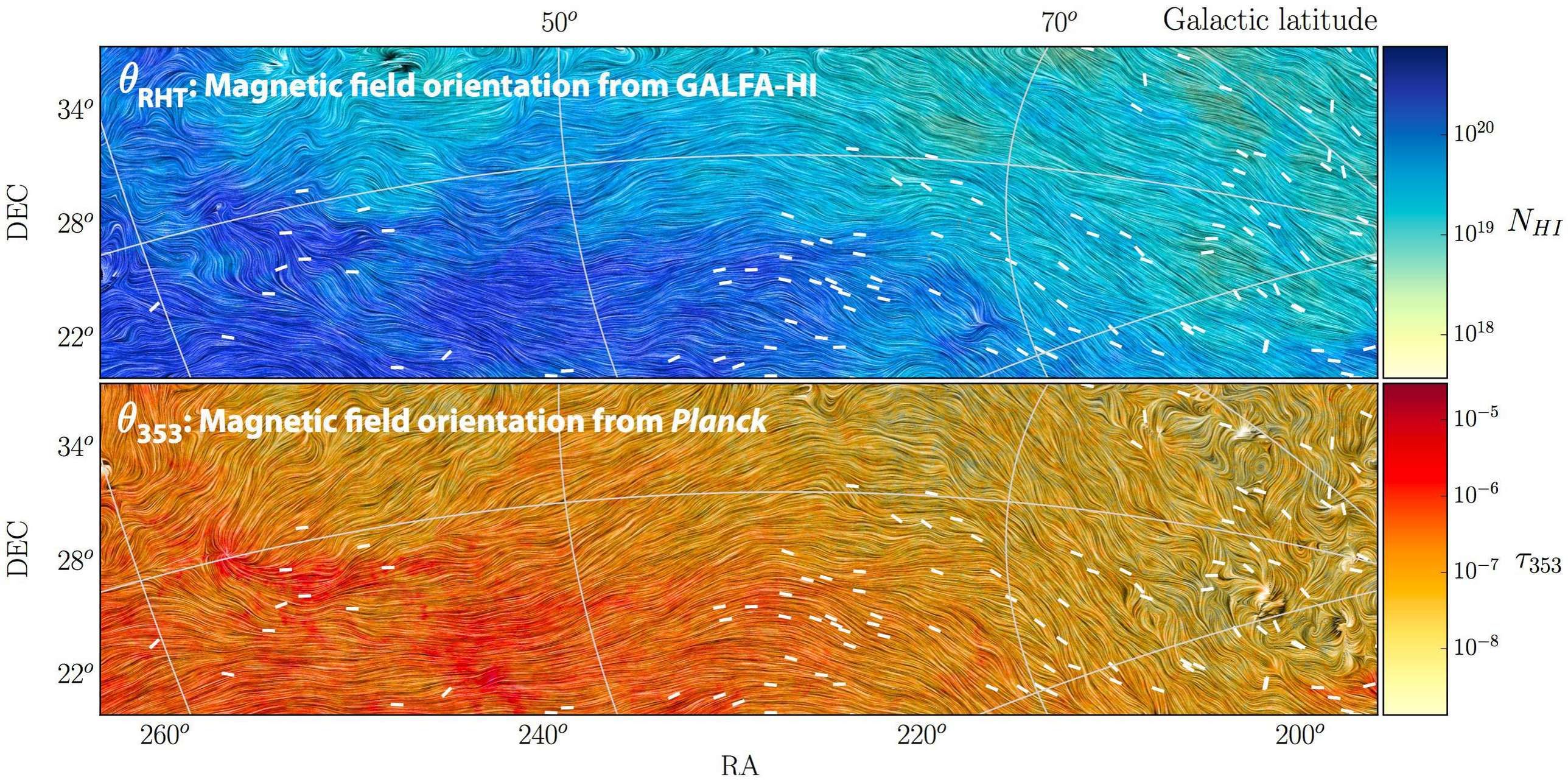
$$\theta_{RHT} = \frac{1}{2} \arctan \frac{U_{RHT}}{Q_{RHT}}$$

***Planck* magnetic field angle**

$$\theta_{353} = \psi_{353} + 90^o$$

Clark+ 2015, in press

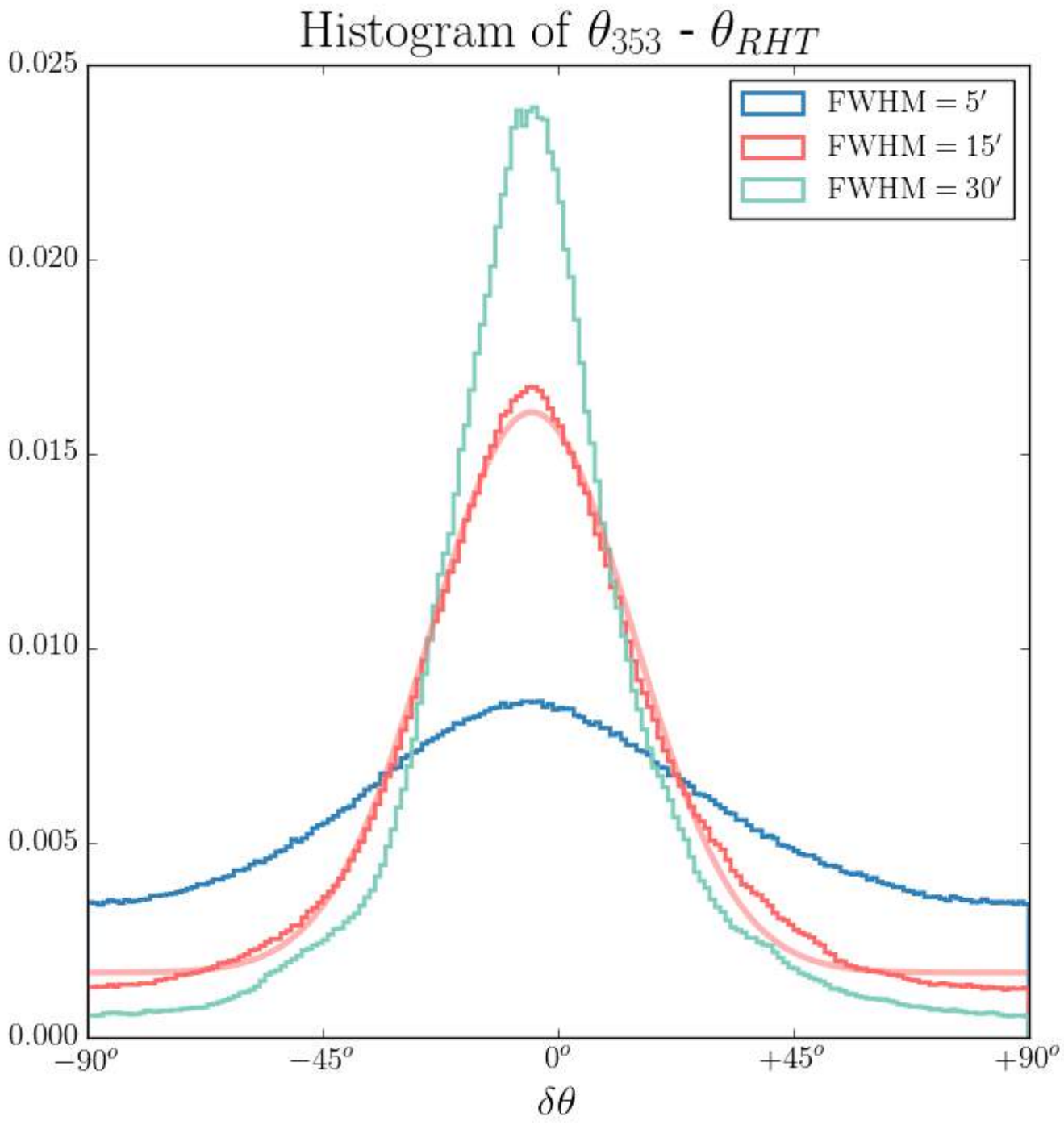
HI orientation traces *Planck* polarization angle.



stars: Heiles 2000

Clark+ 2015, in press
ArXiv:1508.07005

HI orientation traces *Planck* polarization angle.

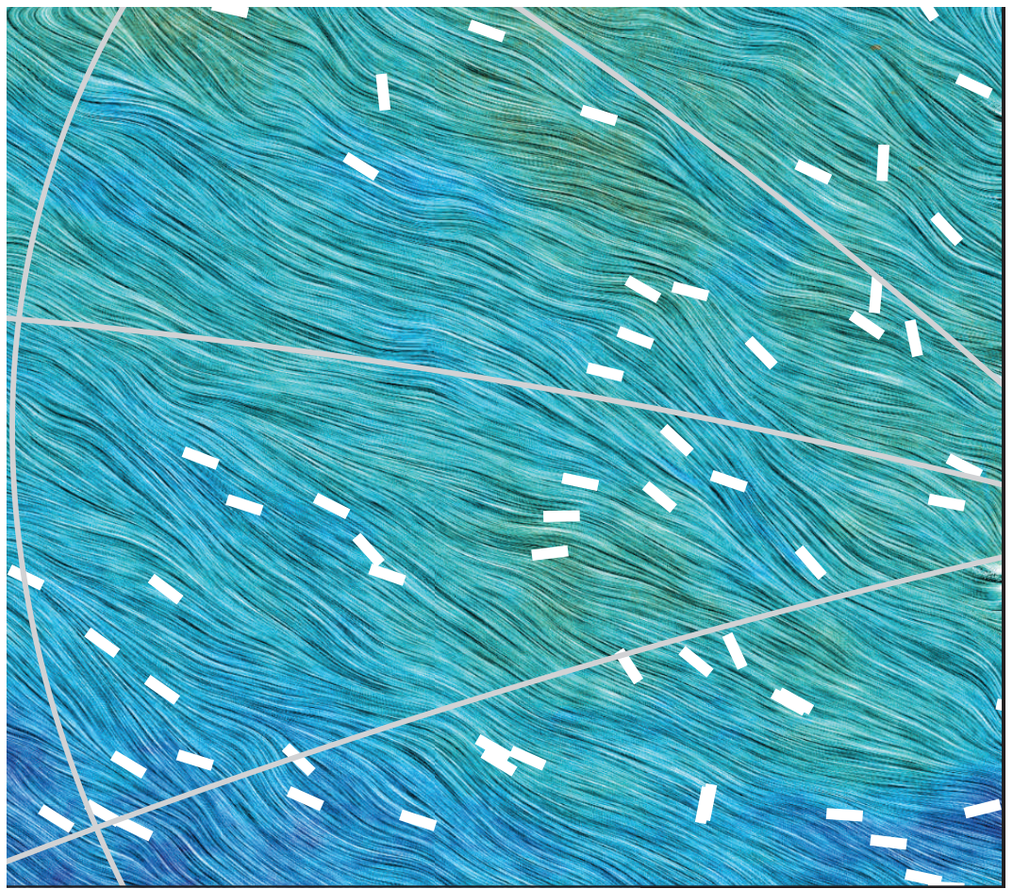


Clark+ 2015, in press

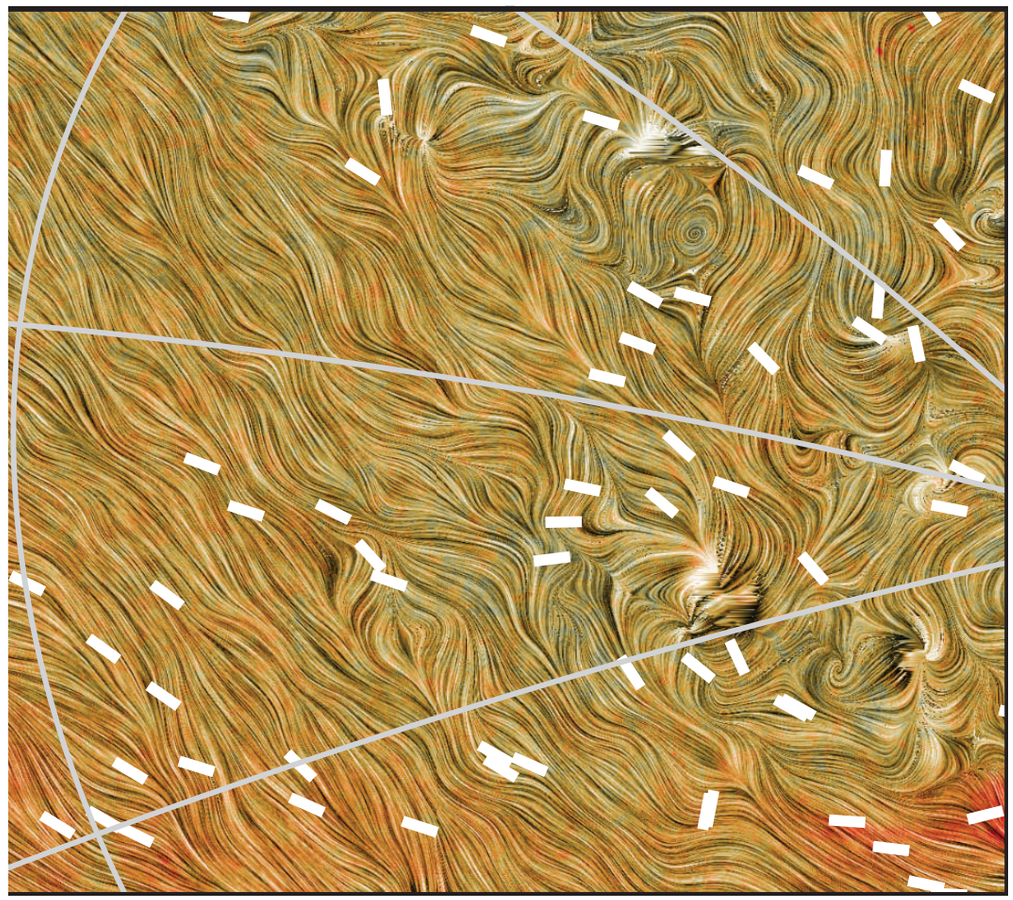
At high Galactic latitudes, *Planck* data are noise-dominated.

$b > 70°$

θ_{RHT}

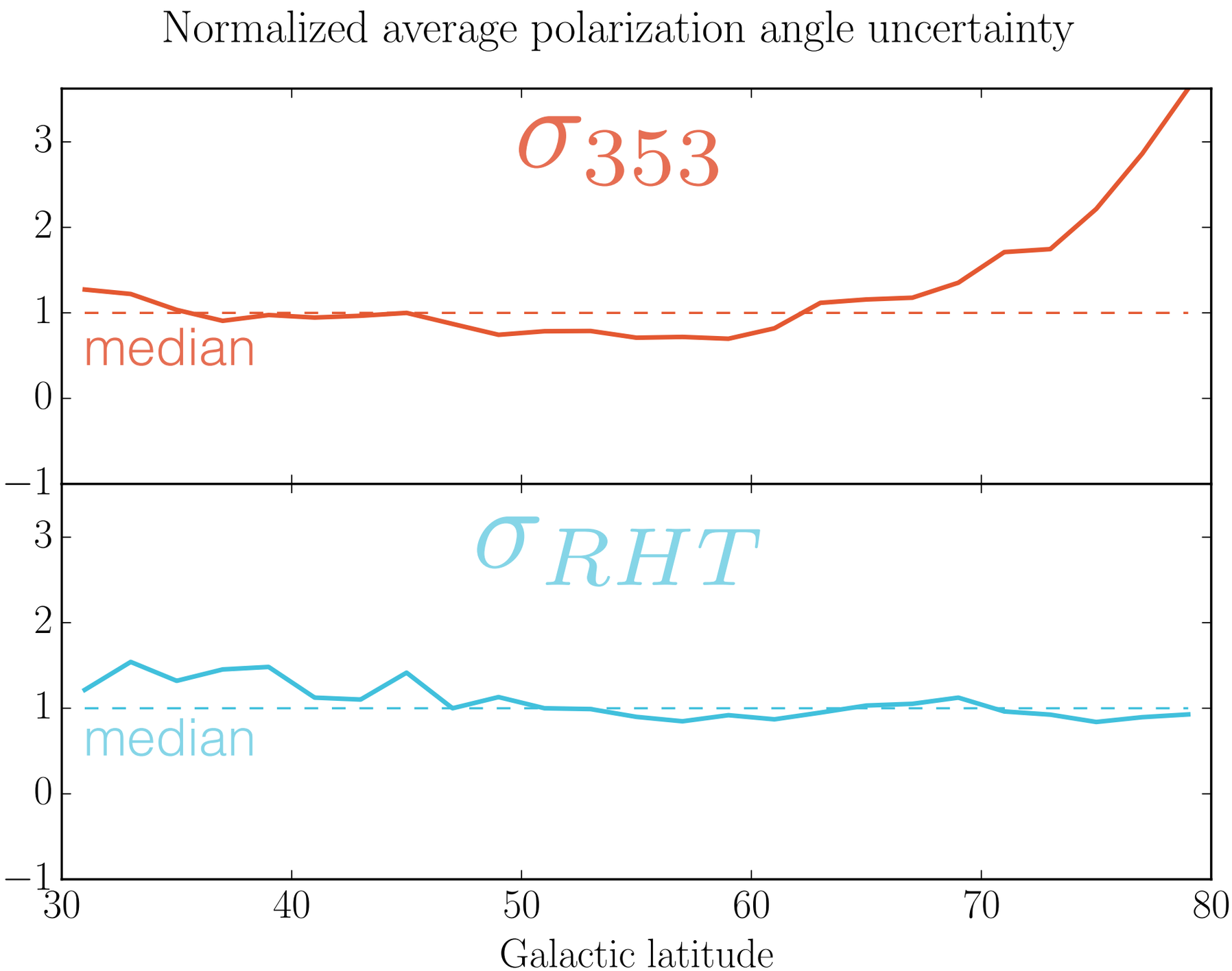


θ_{353}



Clark+ 2015, in press

RHT sensitivity remains fairly constant at high Galactic latitude.



Clark+ 2015, in press

We construct simple dust polarization template maps.

$$Q = P \cdot \cos\left(2\theta\right)$$

$$U = P \cdot \sin\left(2\theta\right)$$

$$P^2 = Q^2 + U^2$$

We fix the polarization fraction to unity
to isolate the angle information.

$$Q' = I_{353} \cdot \cos(2\theta)$$

$$U' = I_{353} \cdot \sin(2\theta)$$

$$\boxed{P = Ip}$$

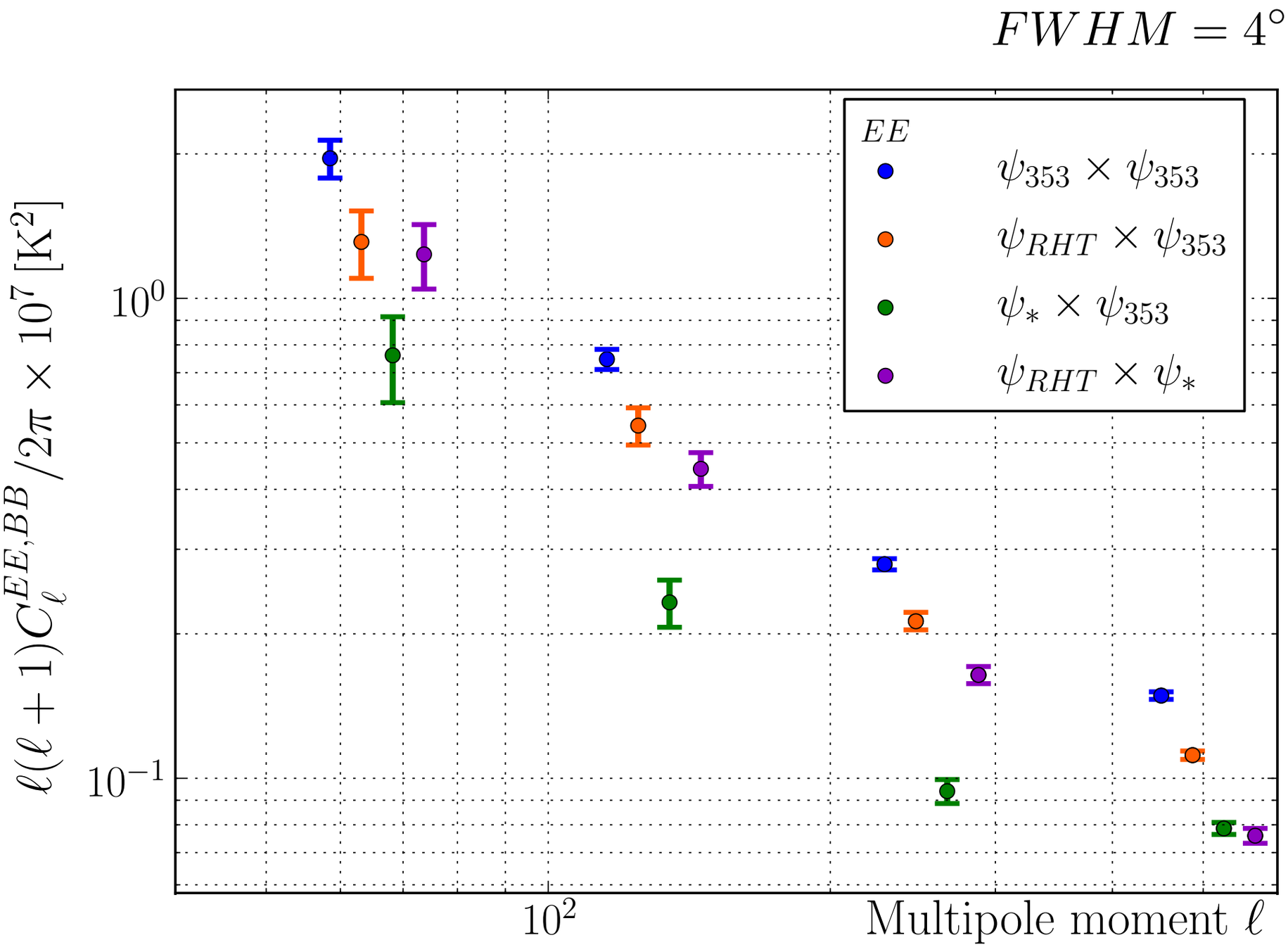
We analyze *Planck*, RHT, and starlight polarization angles.

$$Q' = I_{353} \cdot \cos(2\theta)$$

$$U' = I_{353} \cdot \sin(2\theta)$$

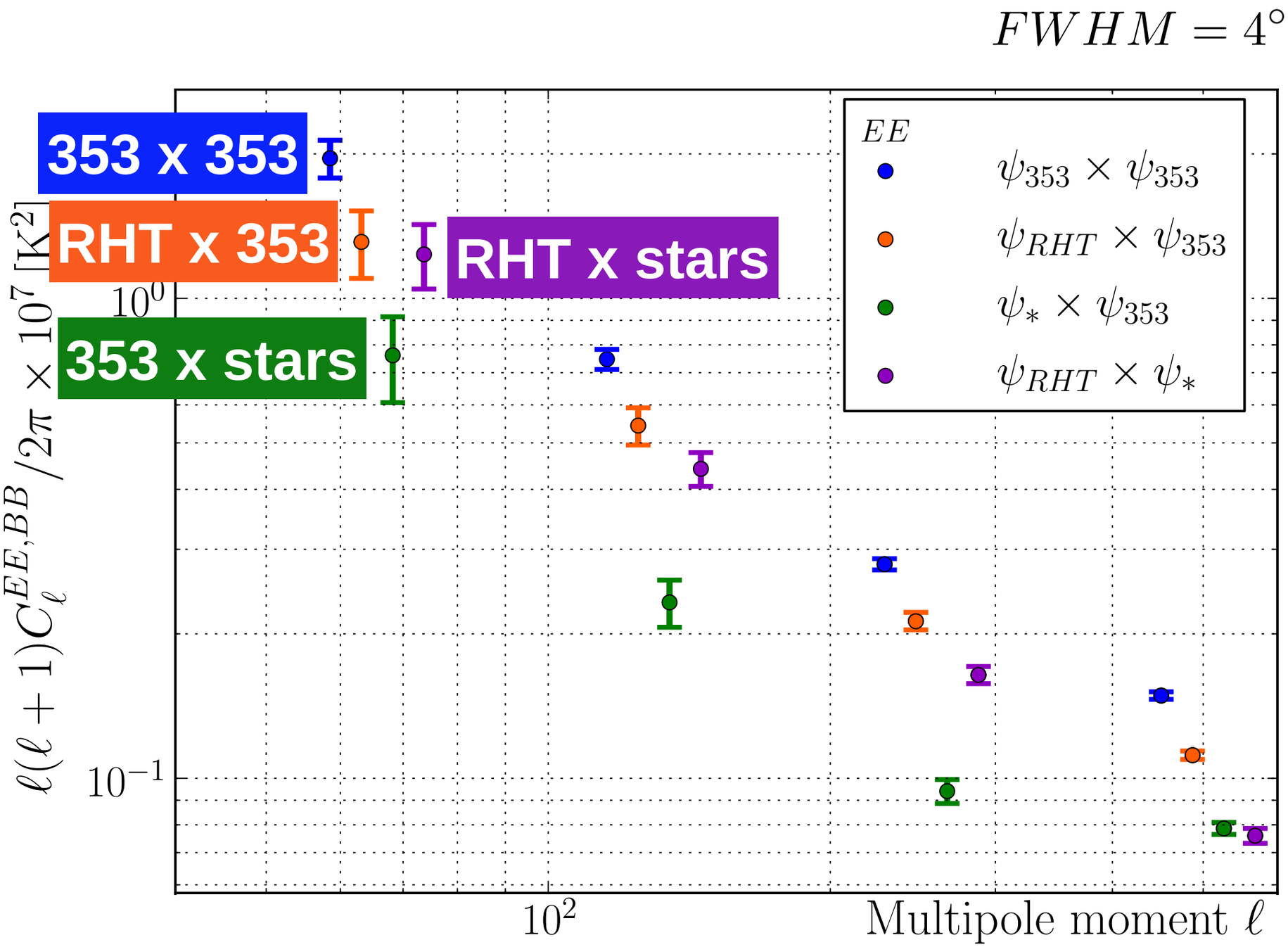
$$\theta_{RHT} \quad \theta_{353} \quad \theta_{\star}$$

We detect strong cross-correlations between the templates.



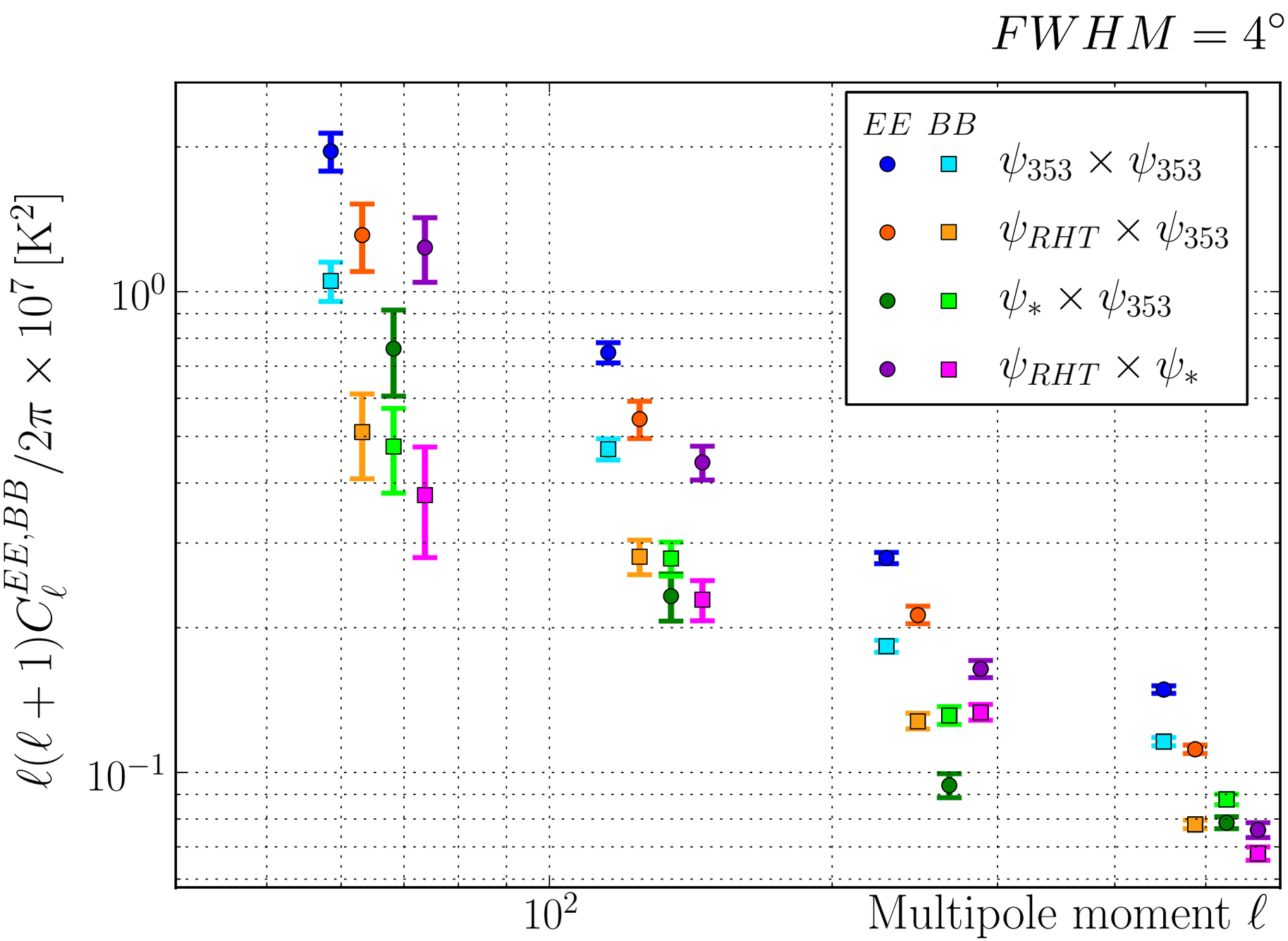
Clark+ 2015, in press

RHT angles correlate more strongly with *Planck* angles than starlight polarization angles do.



Clark+ 2015, in press

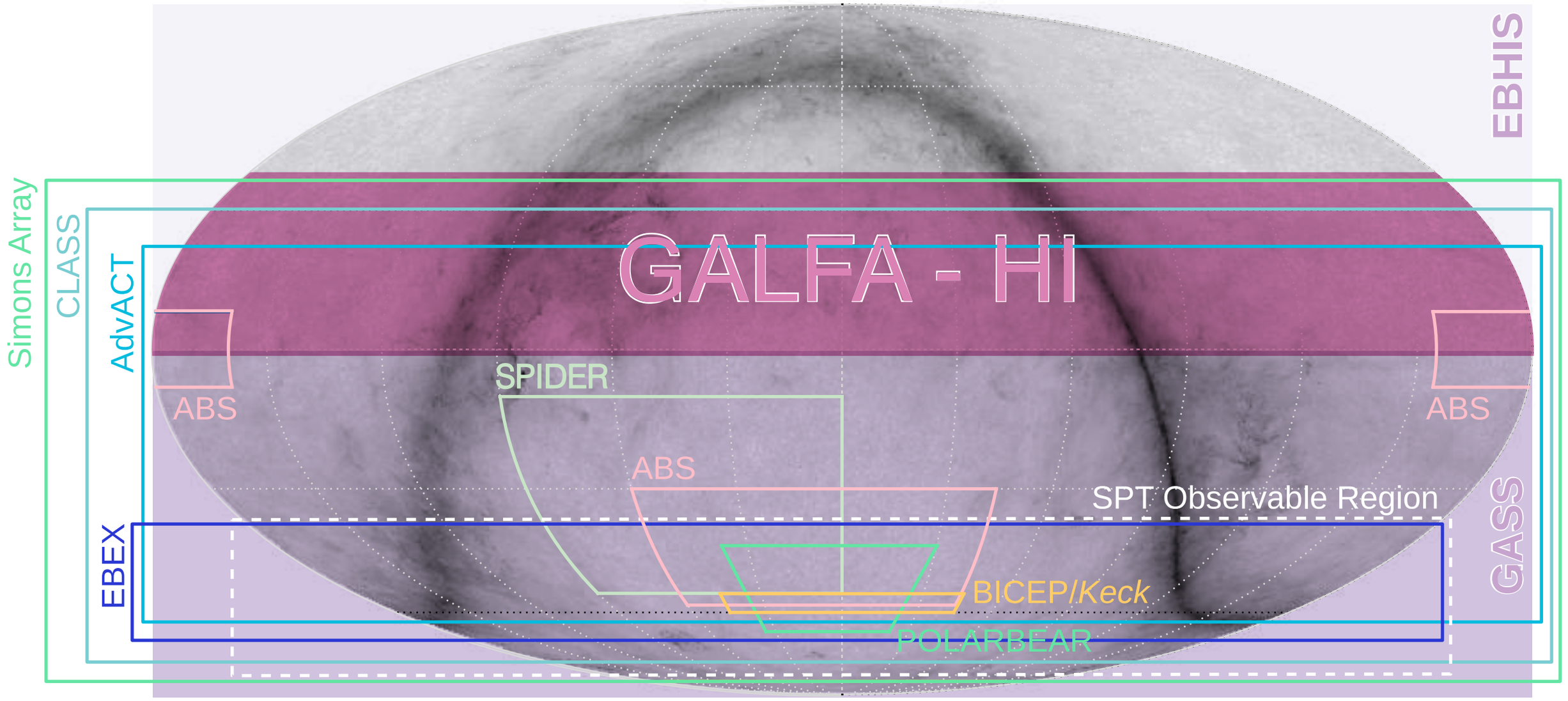
RHT x starlight correlations are fairly consistent with RHT x *Planck* correlations, but lie below *Planck* x *Planck*.



EE/BB asymmetry:
Planck Intermediate Results XXX, XXXVIII

Clark+ 2015, in press

The GALFA-HI Survey maps 13,000 square degrees.



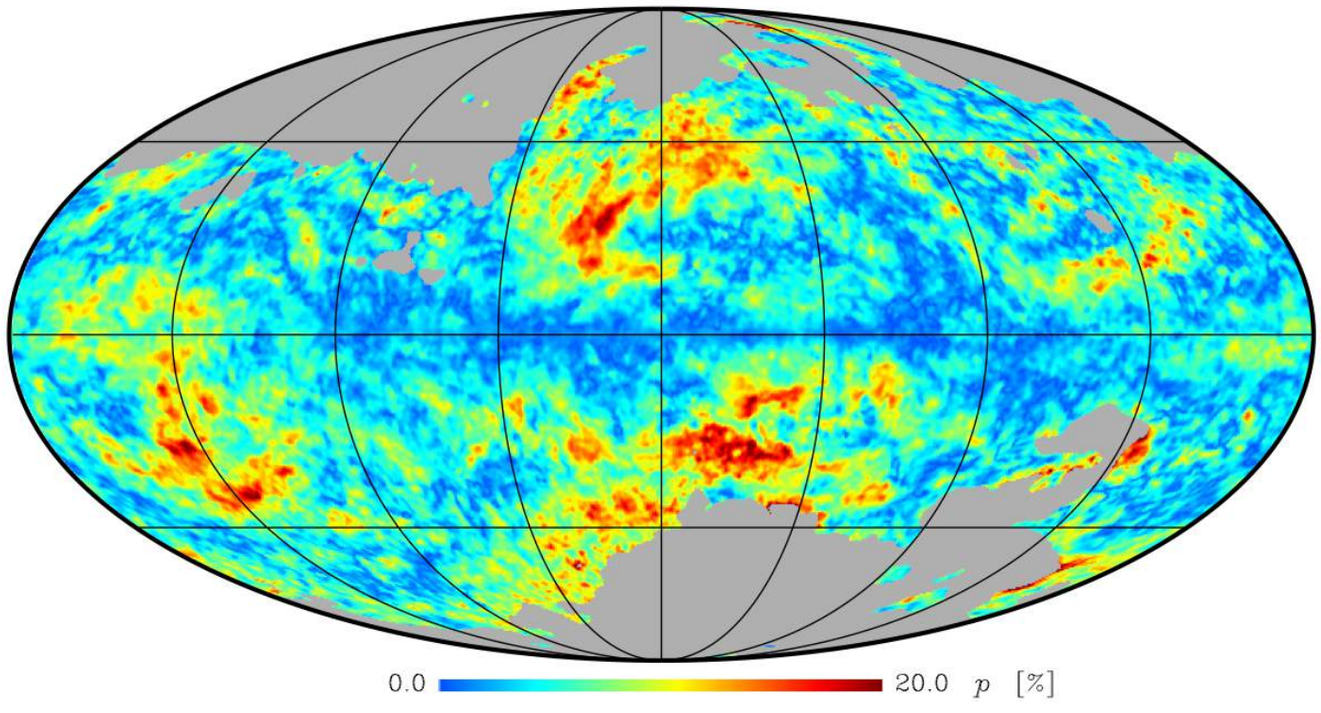
-6.17 -1.57

$\log_{10}$ (*Planck* 353 GHz Intensity [K])

Clark+ 2015, in press

HI orientation as a function of velocity may probe line-of-sight field tangling.

polarization fraction,
Planck Intermediate Results XIX



The orientation of HI is an independent predictor of *Planck* polarization angle.

We will combine these data with estimates of the polarized intensity to construct higher SNR polarized foreground templates, which are currently the limiting factor in primordial B-mode searches.

Clark+ 2015, in press
ArXiv:1508.07005