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The PASIPHAE optopolarimetric survey: capabilities, timeline, and science potential

Konstantinos Tassis

What is PASIPHAE?

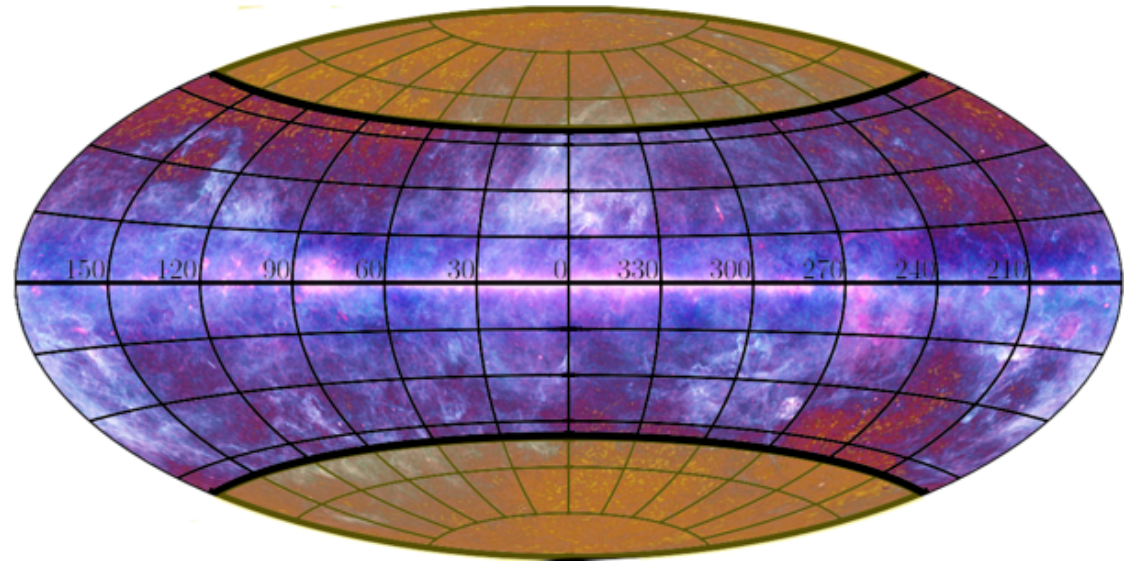


Polar-Areas Stellar Imaging in Polarization High Accuracy Experiment

The PASIPHAE survey

➤ Will measure polarization down to 0.3% at 3σ for all stars with $R_{\text{mag}} \leq 16.5$

➤ Survey will run concurrently in north (Skinakas 1.3m telescope) and south (South African Astronomical Observatory 1m telescope) over 4 years (2019-2022)



➤ Will cover the sky at $|b| \geq 50^\circ$ over 9,000 sqdeg

➤ **Will deliver over 10^6 confident polarization measurements**

Who is PASIPHAE?

The PASIPHAE Collaboration



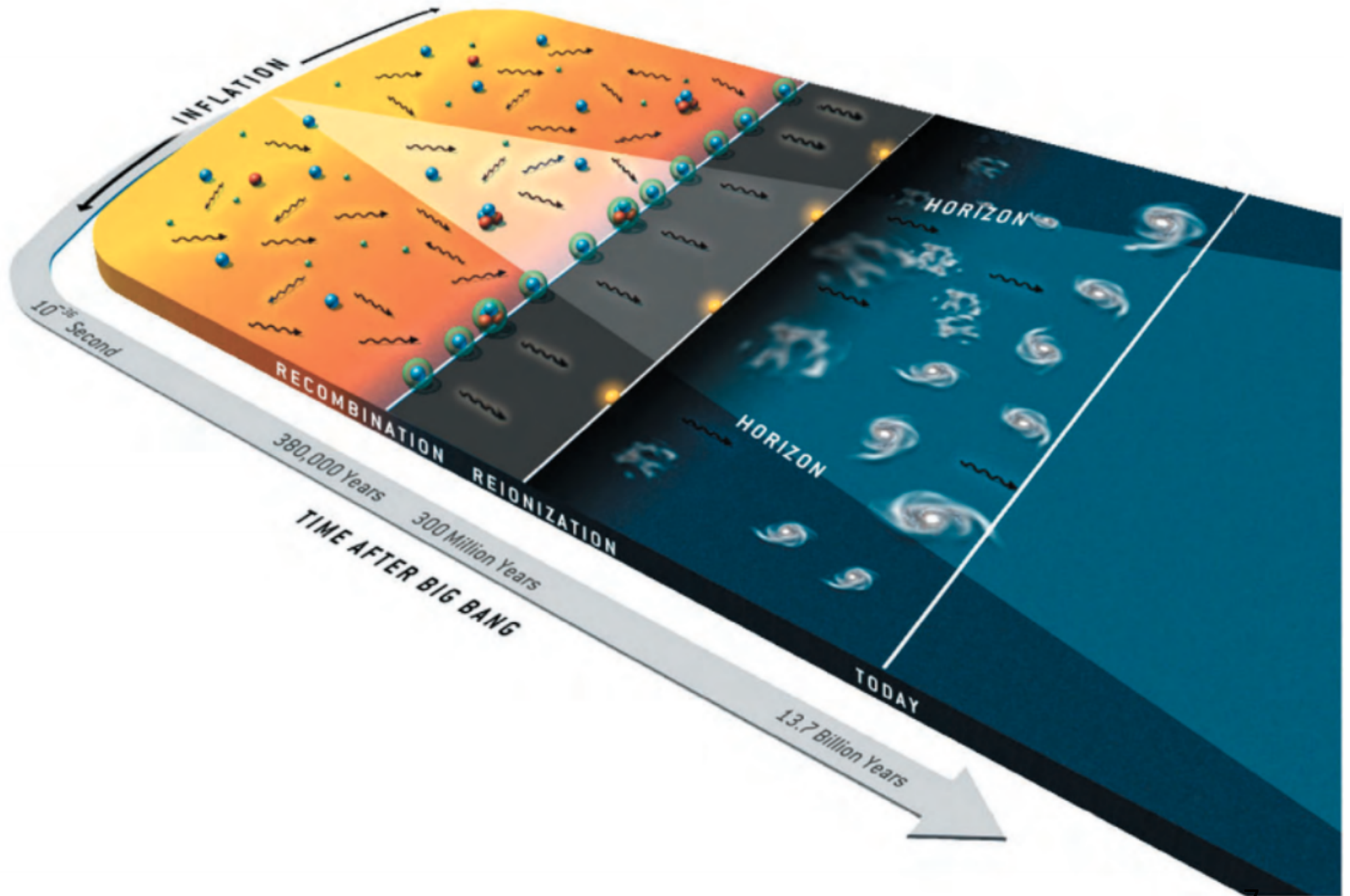
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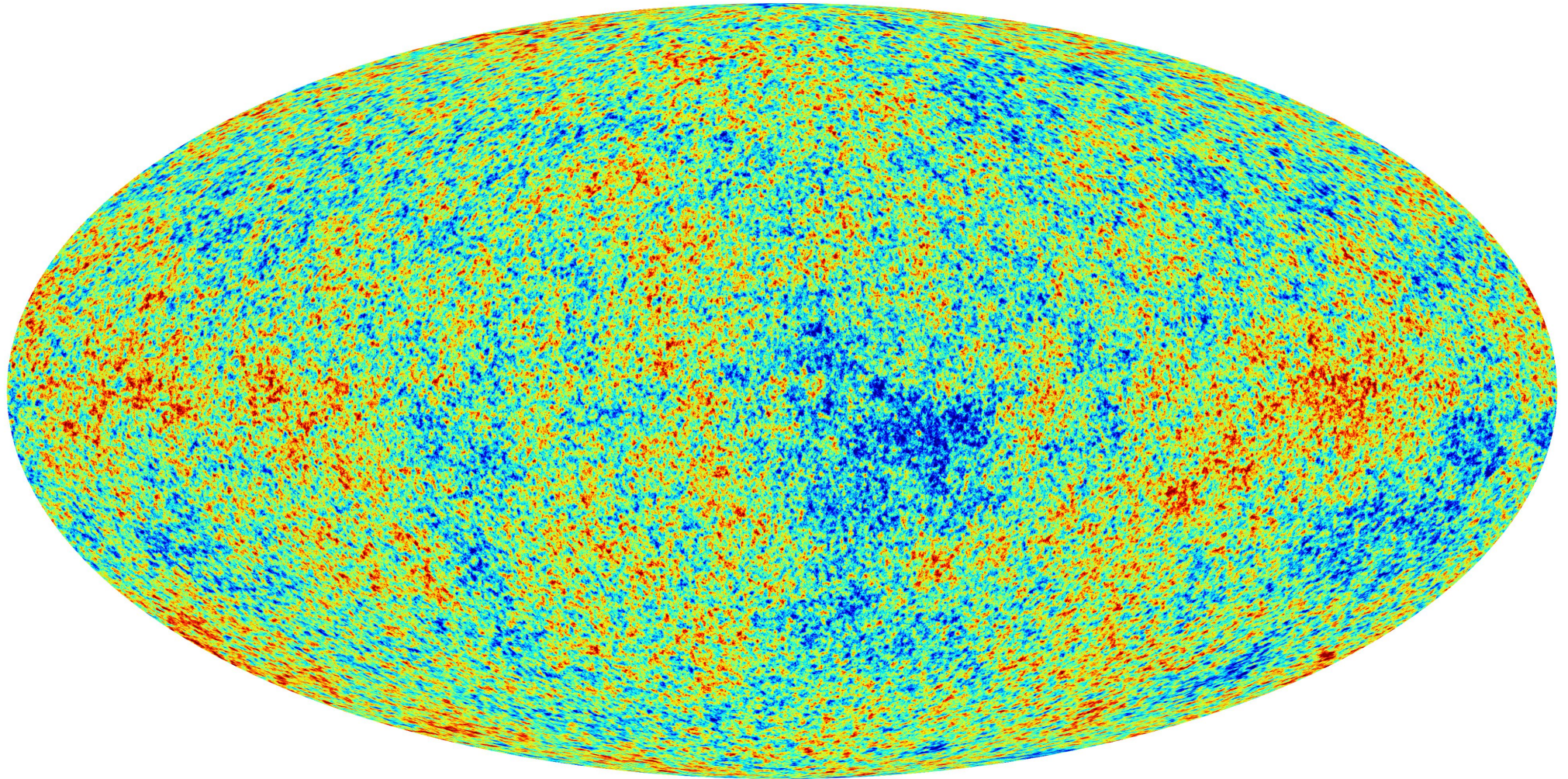


Why ?



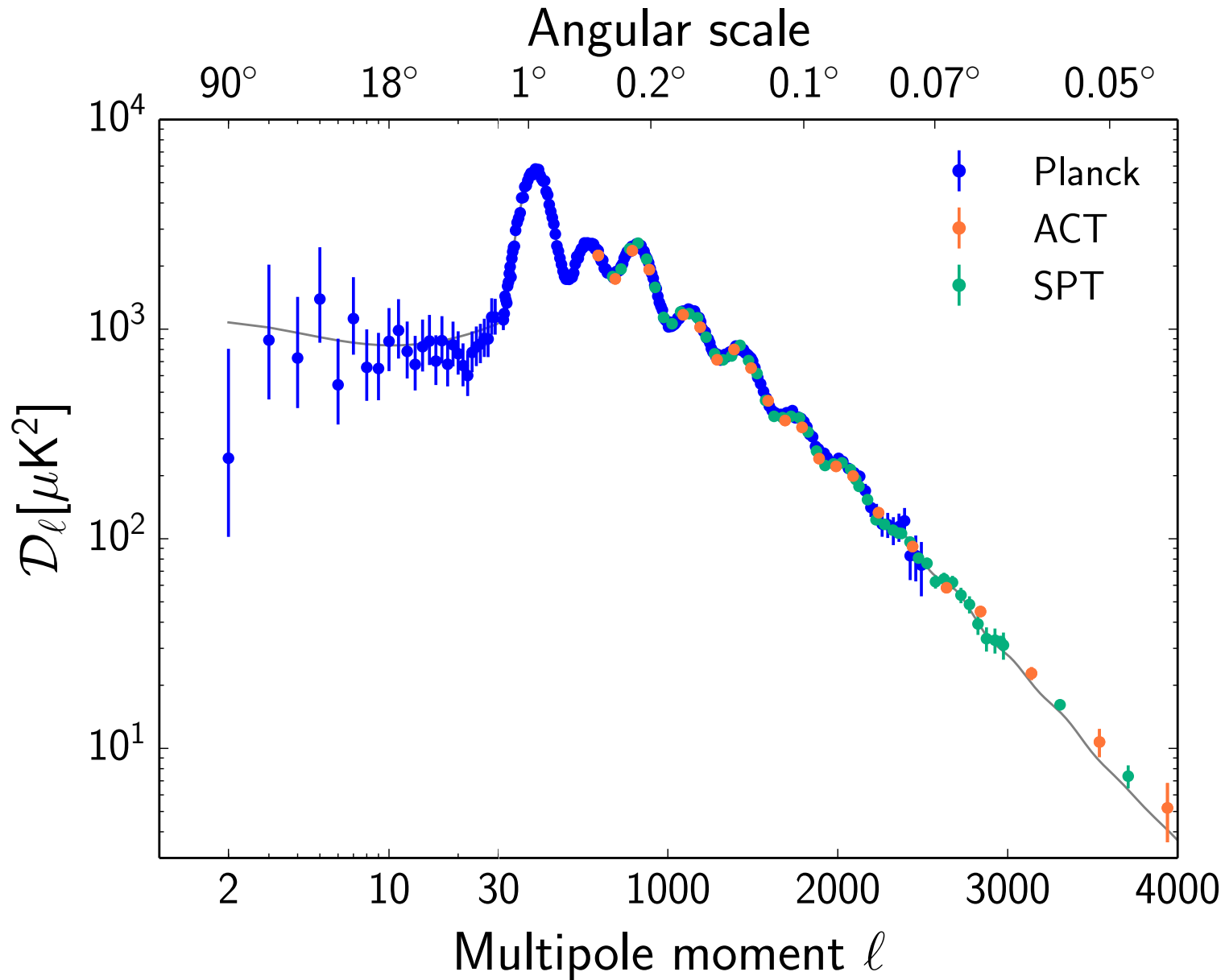
Credit: Hu & White 2004 SciAm

Planck's Map



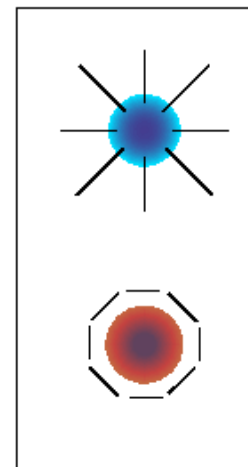
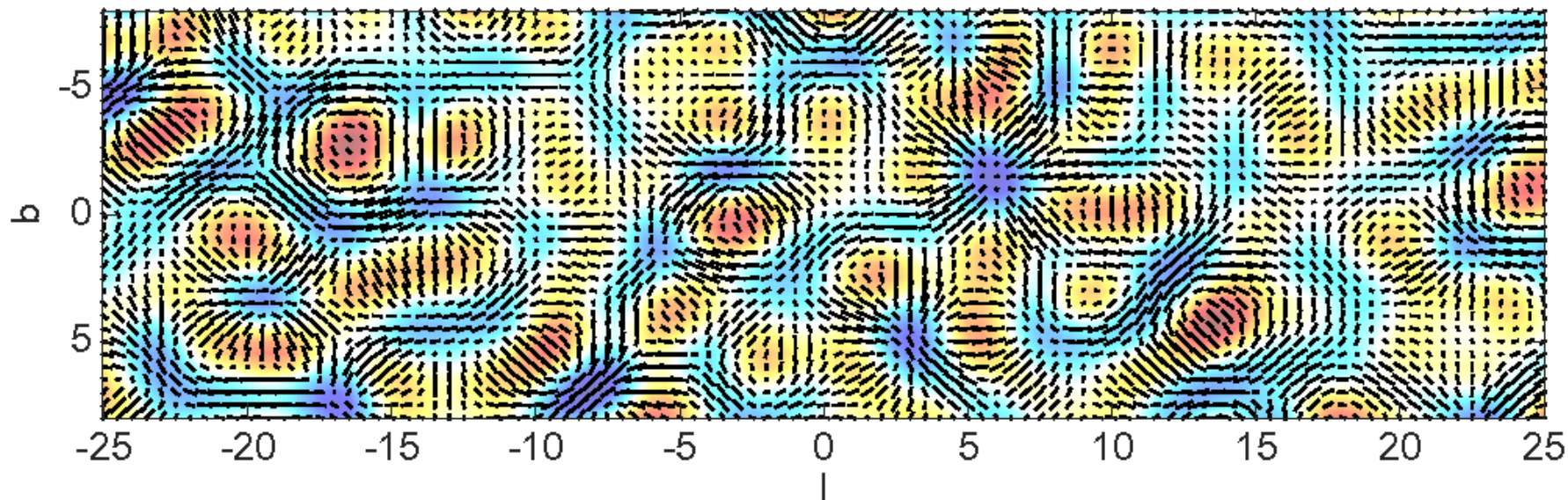
-300 μK  +300 μK

CMB Power Spectrum

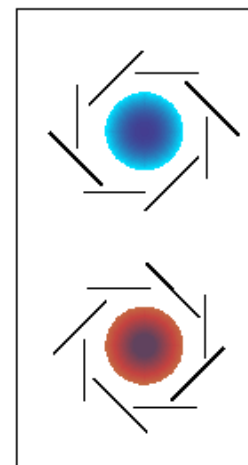
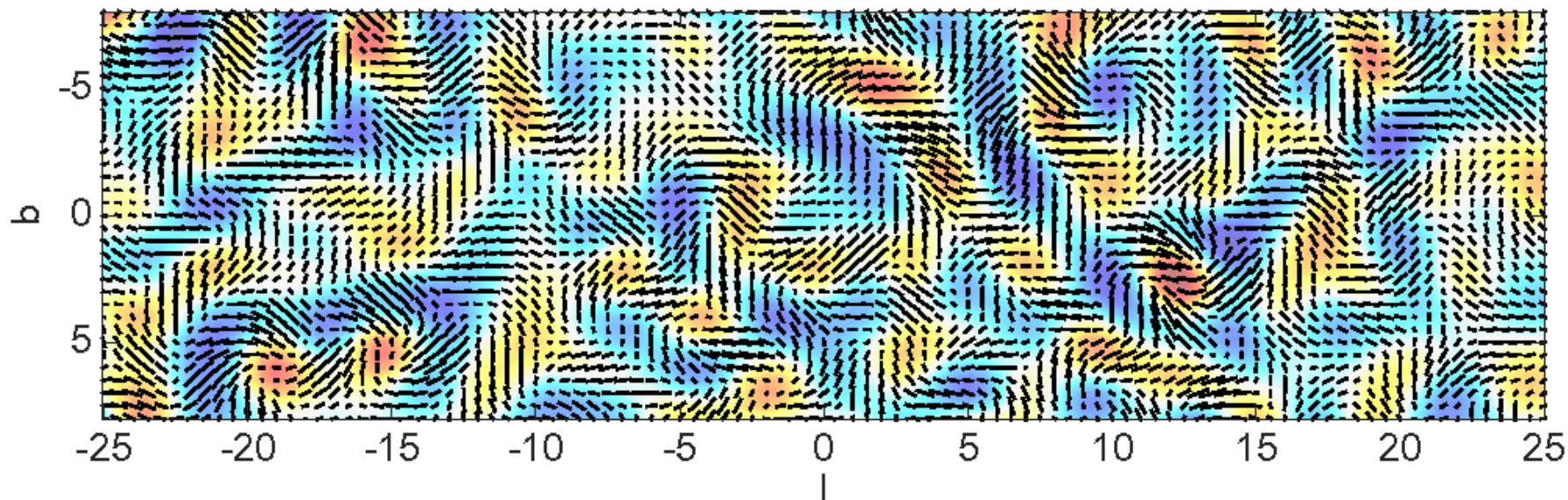


CMB Polarization

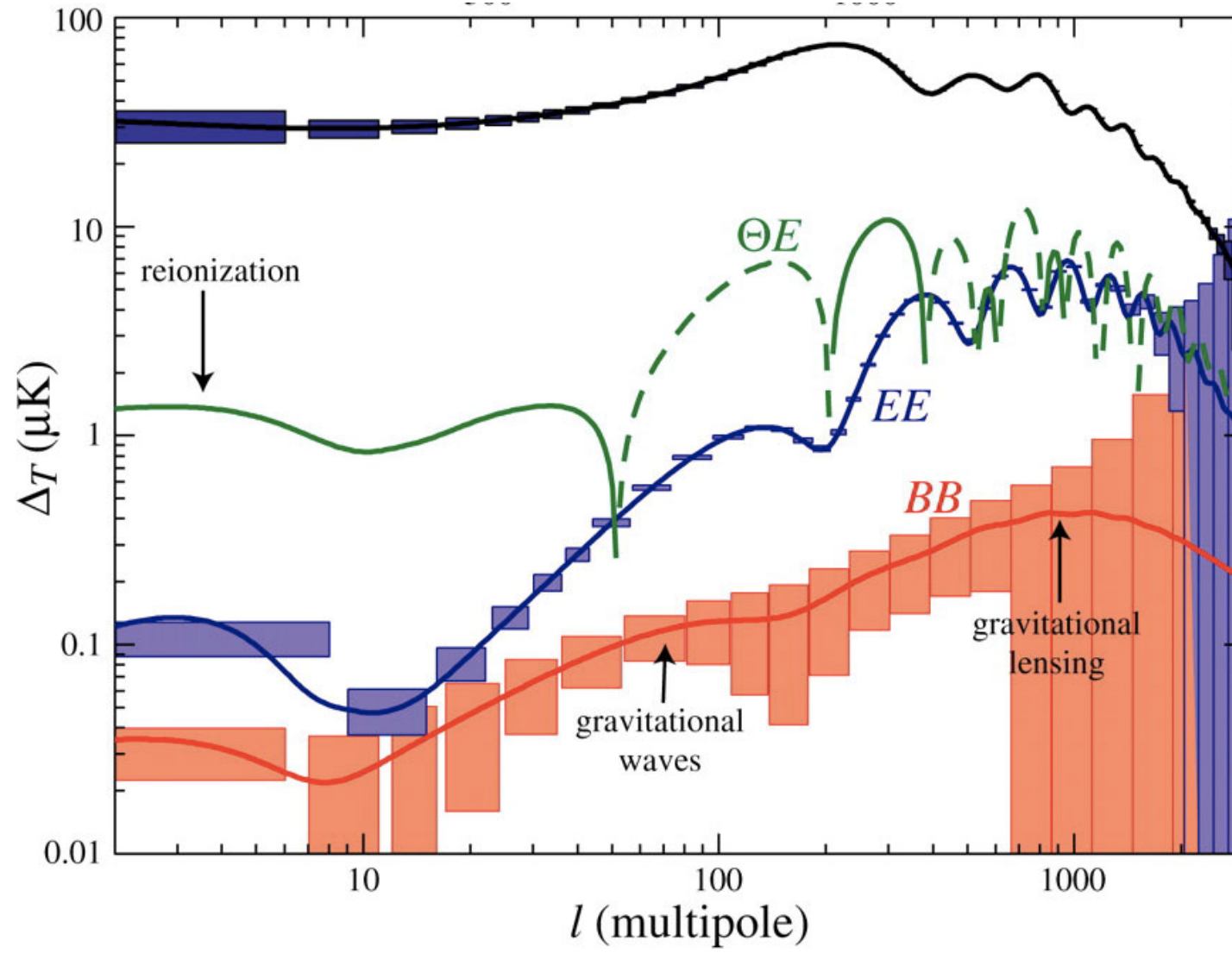
E-mode Polarization



B-mode Polarization



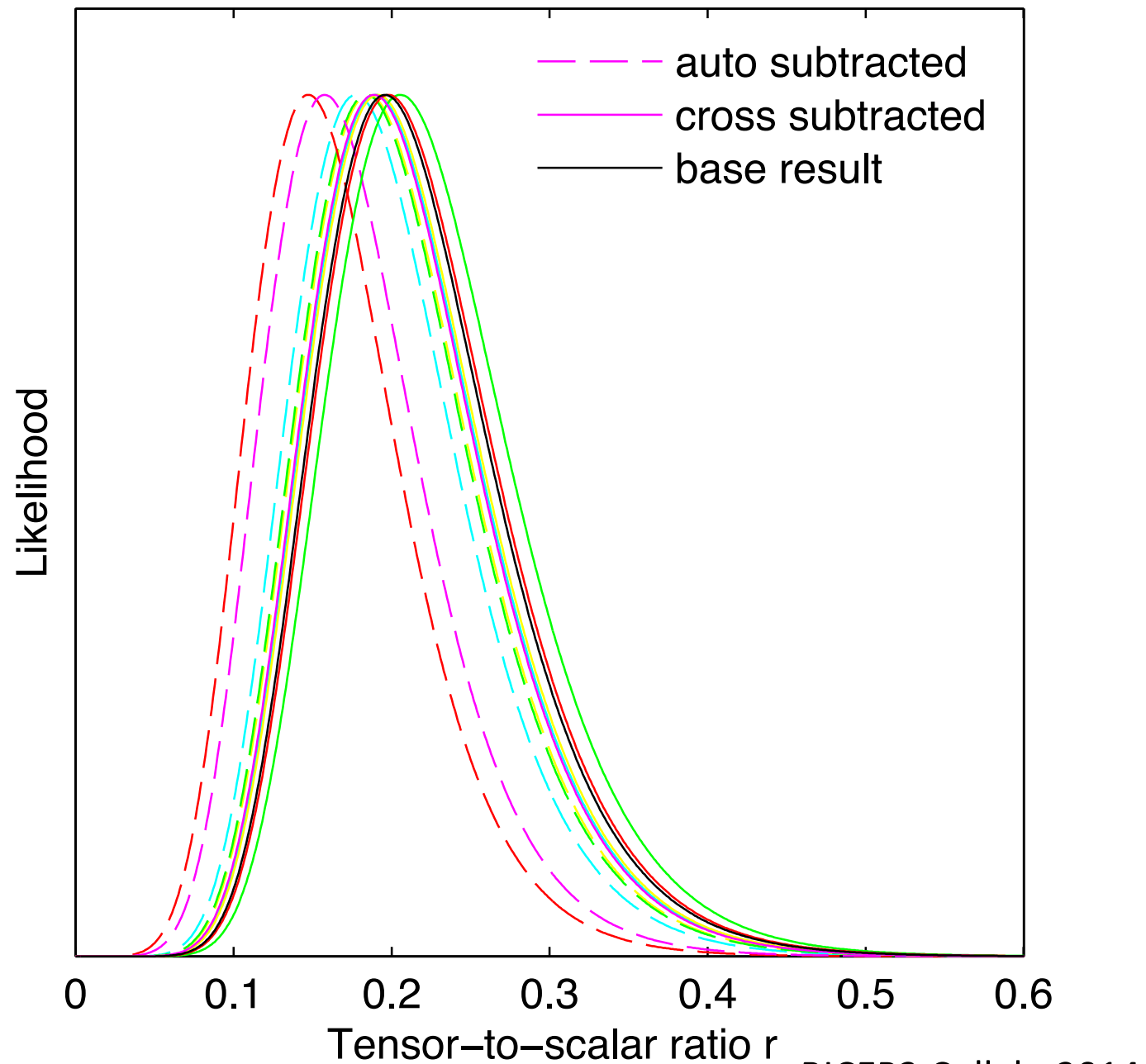
CMB Polarization



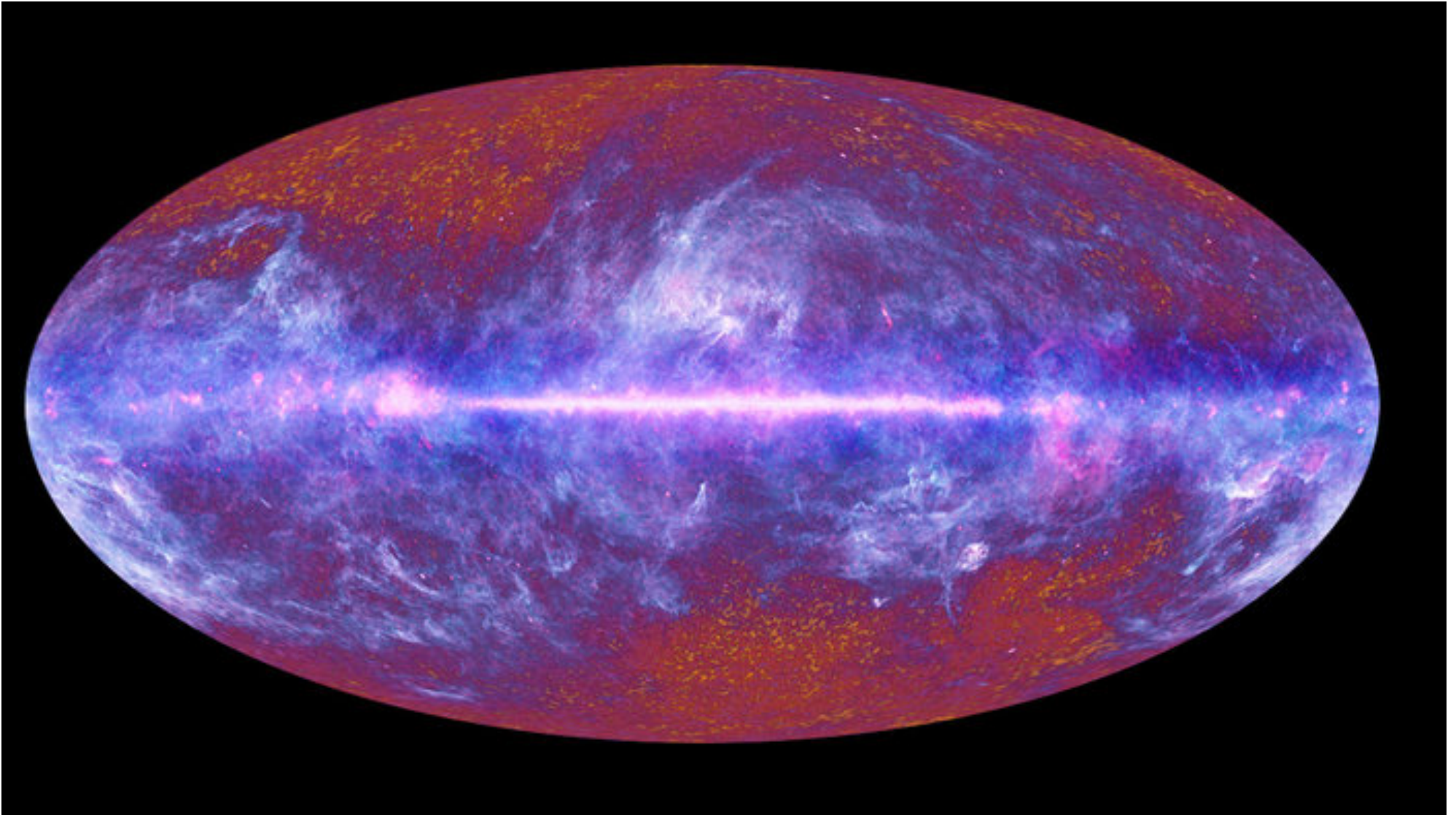
BICEP2



BICEP2

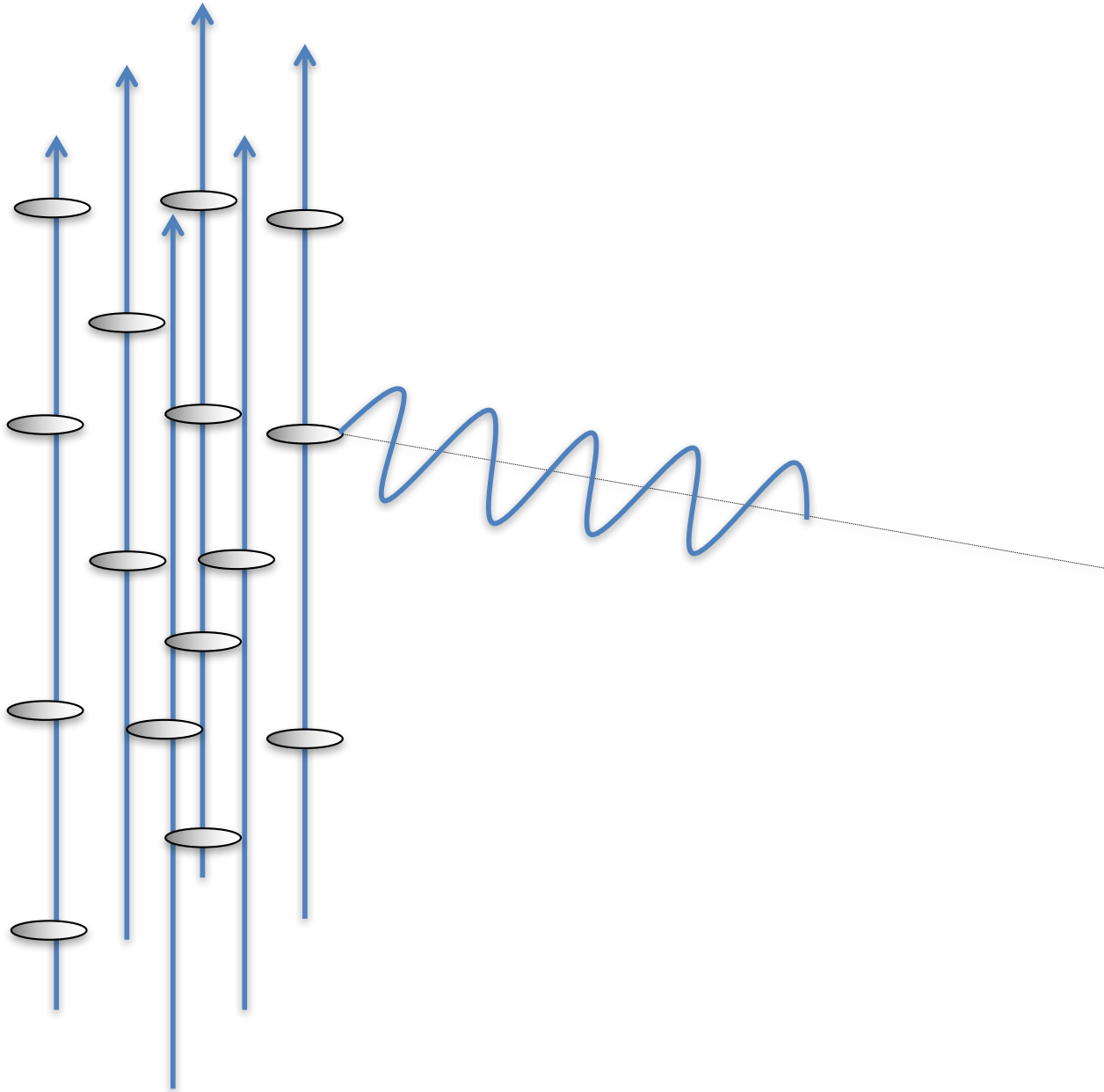


Interstellar Dust in the Galaxy

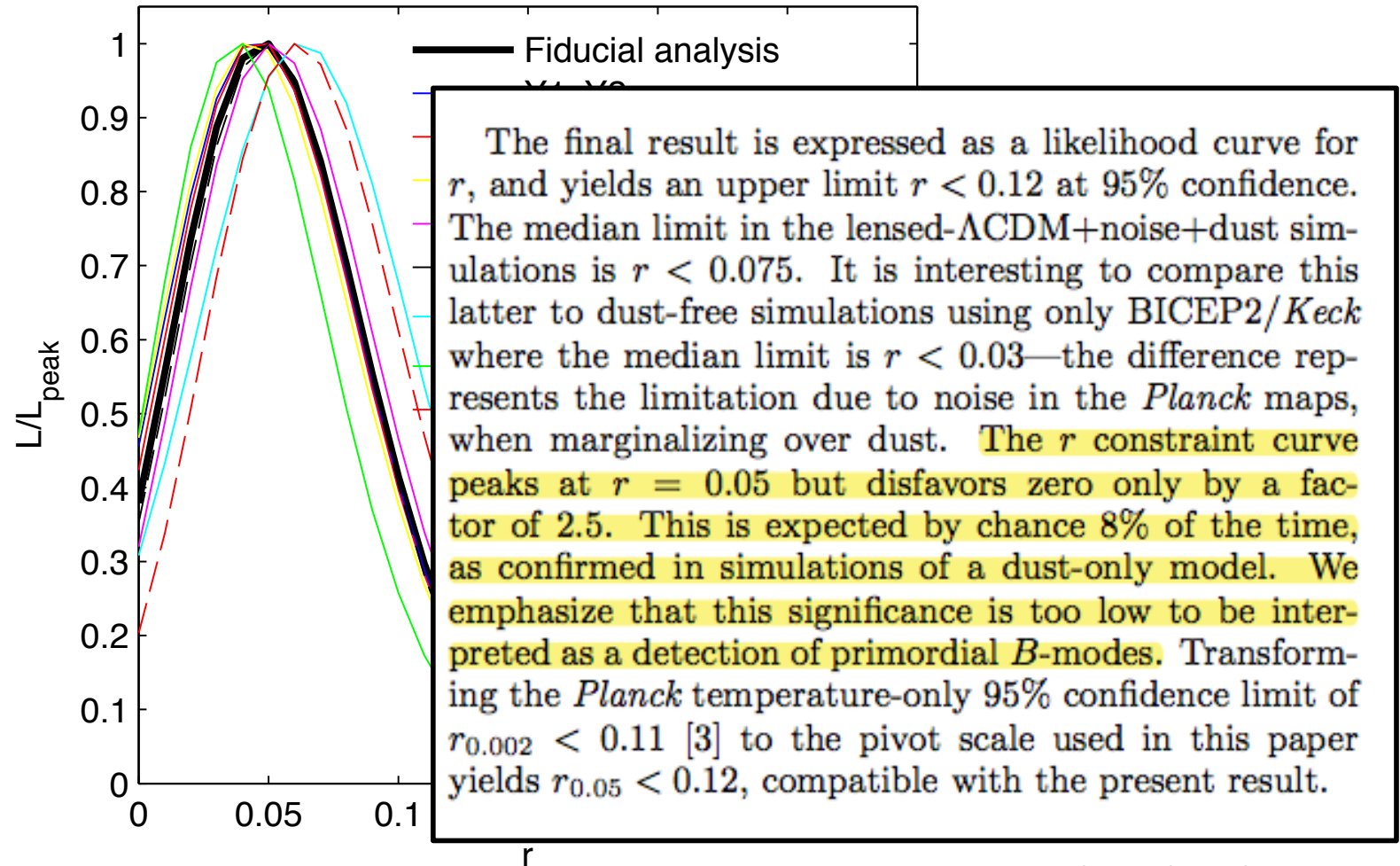


ESA/ LFI & HFI Consortia

Interstellar Dust Emits Polarized Light



BICEP2 + Planck

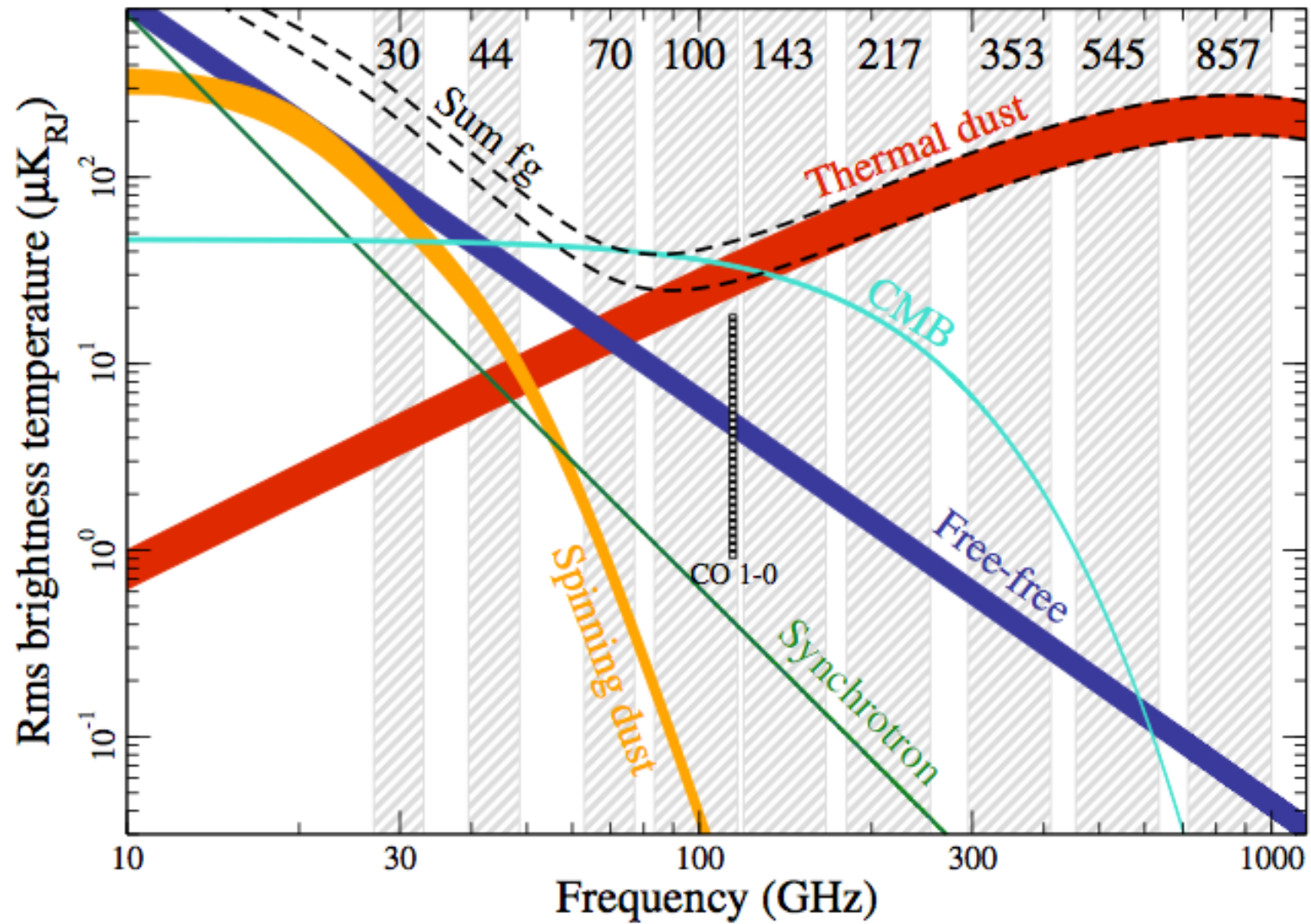


BICEP2 + Keck + Planck 2015

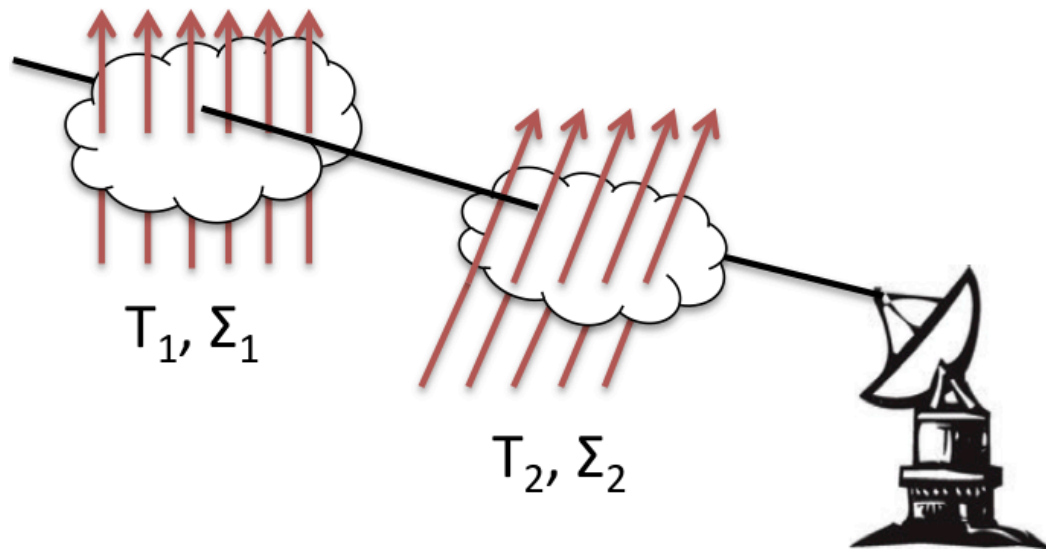
Interstellar dust cannot be avoided, no discovery yet...
but maybe something there?

Foregrounds

Planck 2015 X



An Additional Hurdle: 3-d Structure of Dust



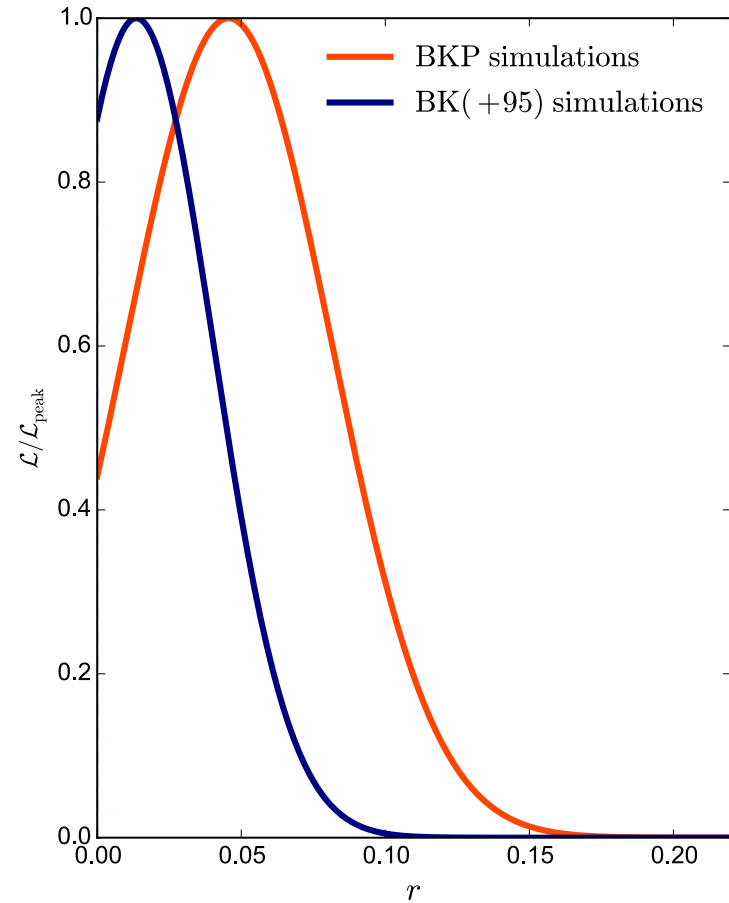
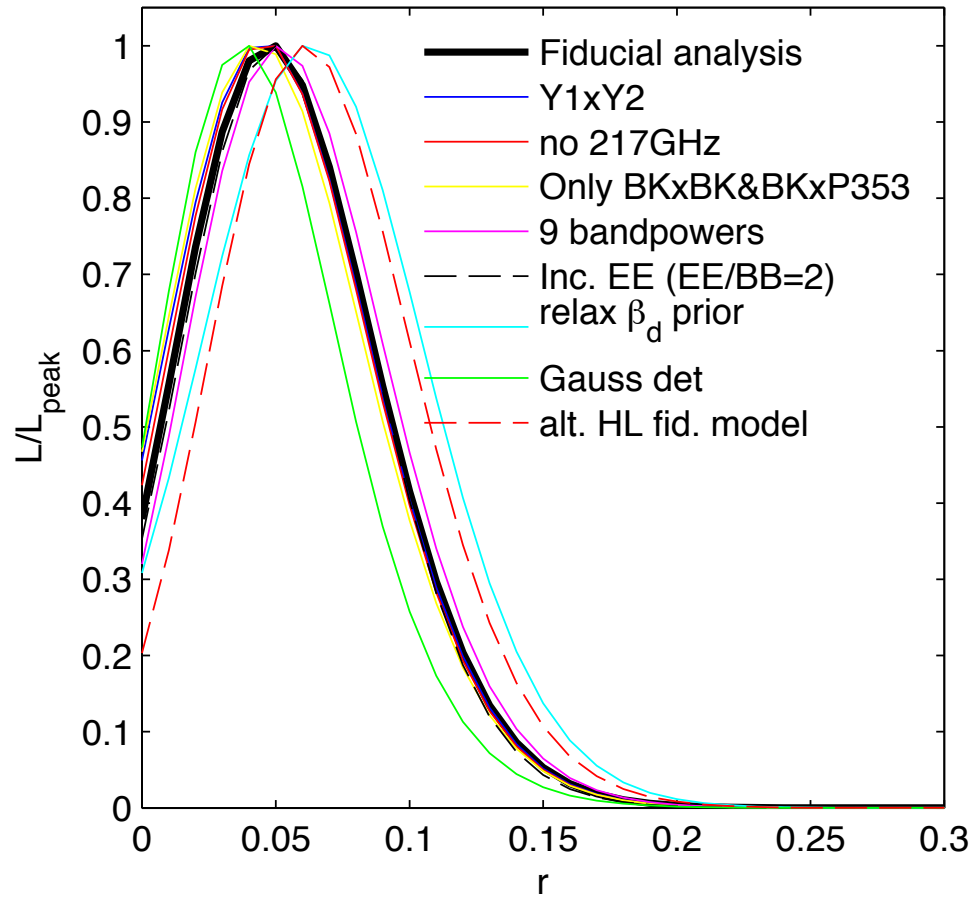
Multiple clouds along LOS induce *frequency dependence* of polarization

Clouds of different T may *dominate emission* at different frequencies

Extreme case:
cloud 1 dominates at f_1
cloud 2 dominates at f_2

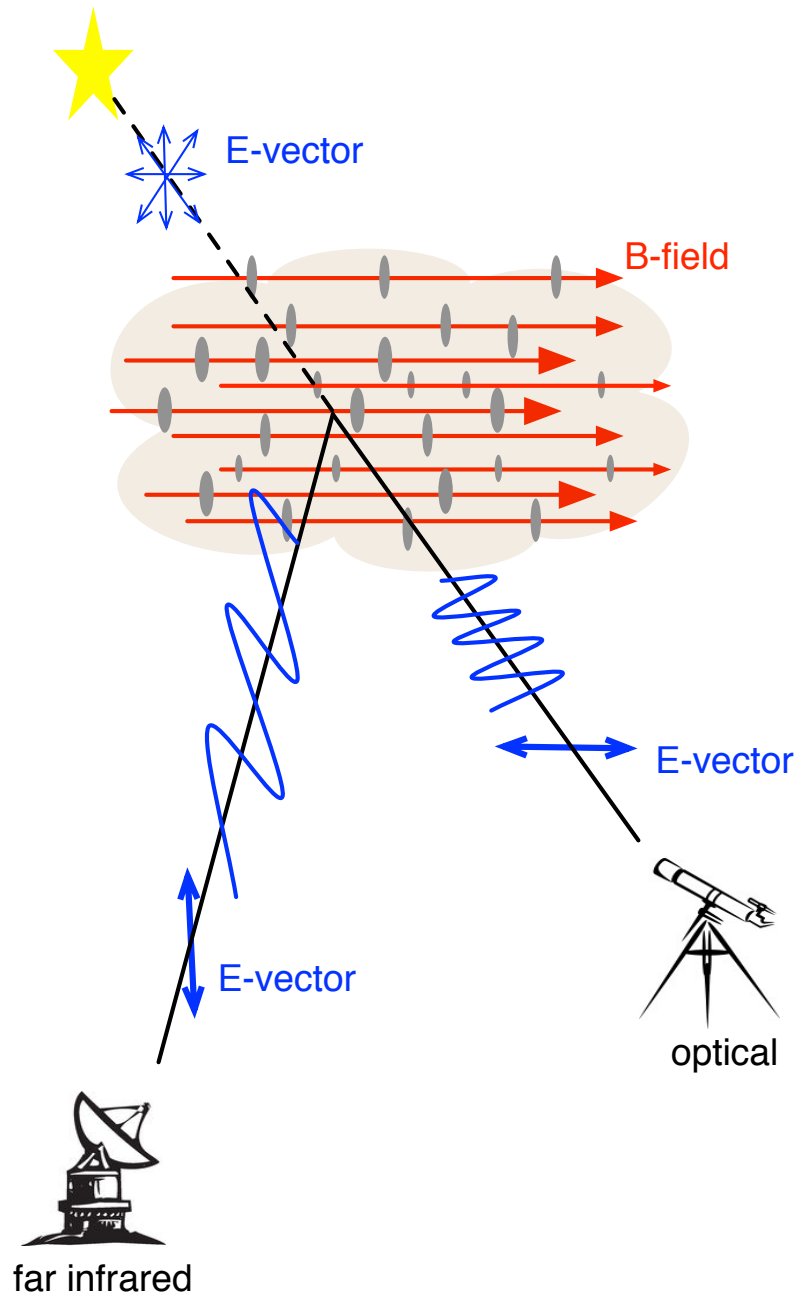
Tassis & Pavlidou 2015

3D Effects Important



Planck L 2016

Optopolarimetry of Starlight



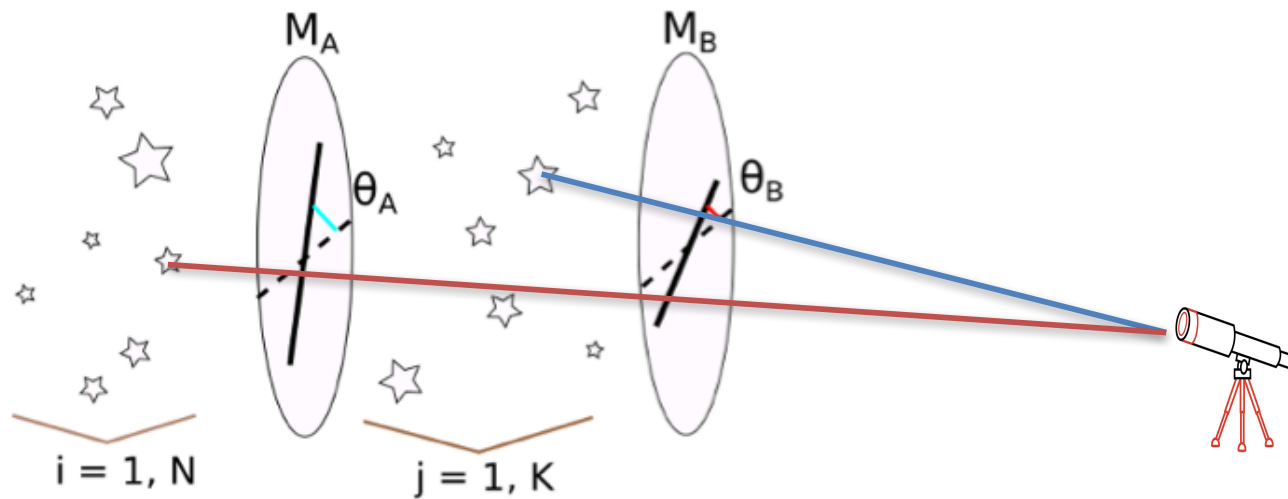
Dust absorption – induced polarization of starlight:

Common origin
with polarized dust emission

Unique handle
on 3-d structure of foreground dust
& B-field

Magnetic Tomography of Galactic Dust

Stars at different distances act as lampposts
only affected by dust and B-field ahead



Will we Know Enough Stellar Distances?

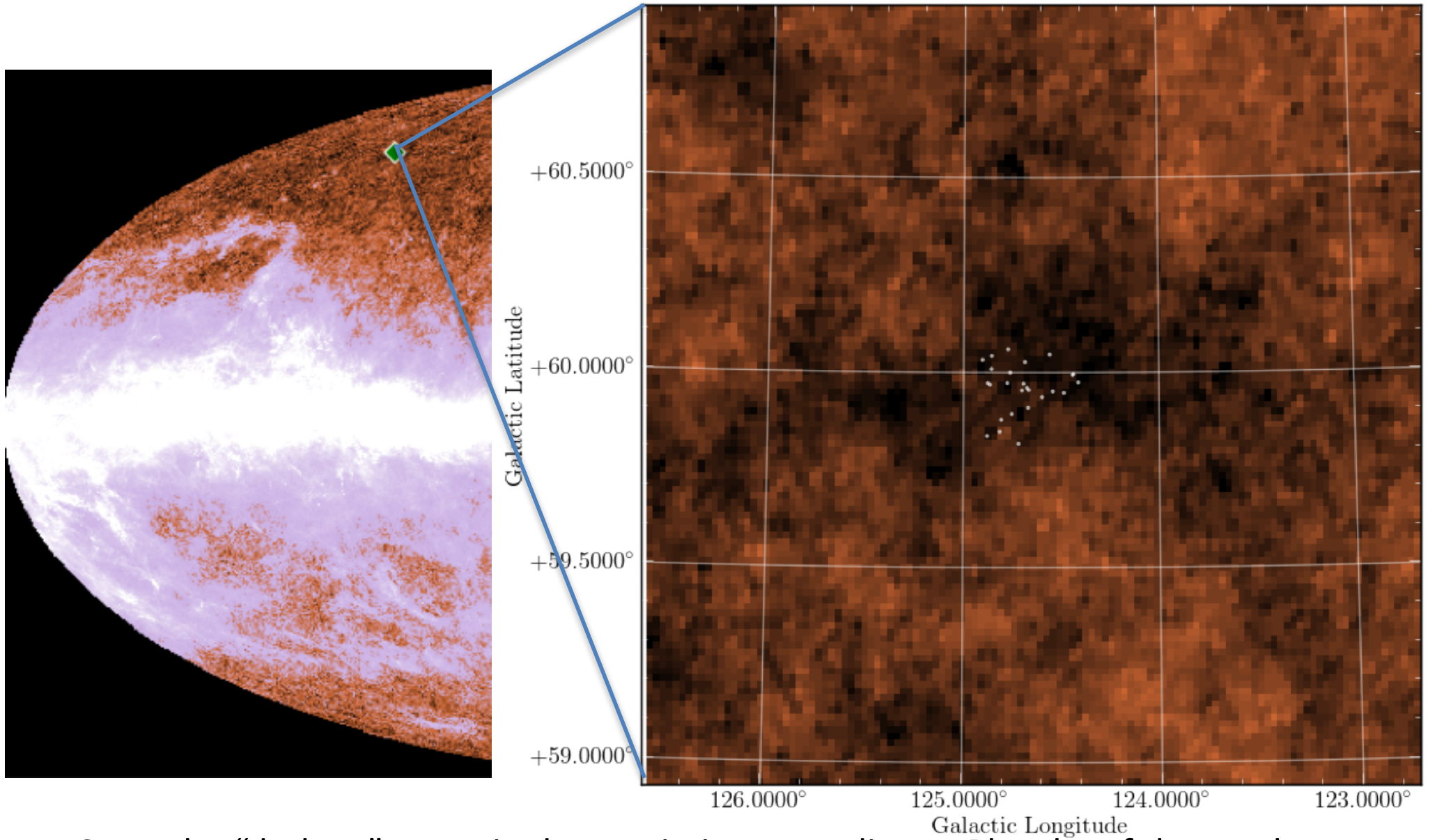


YES! -- Gaia

Distances for
a billion stars

10% out to 10kpc

Is Starlight Polarized Enough at High $|b|$?

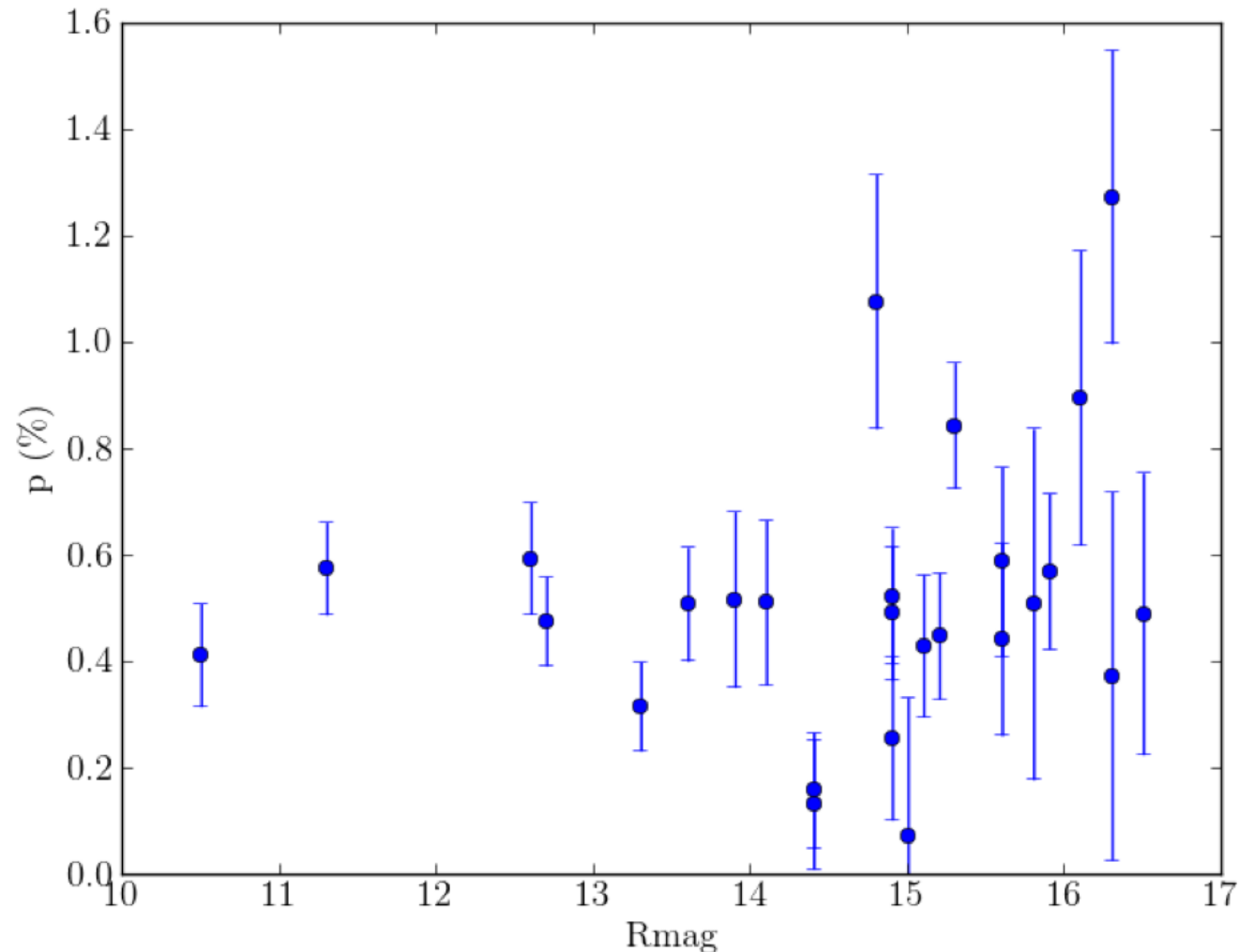


Go to the “darkest” spot - in dust emission according to Planck - of the northern sky and measure starlight polarization with RoboPol

Is Starlight Polarized Enough at High $|b|$?

YES!

50% of stars polarized at $> 0.4\%$

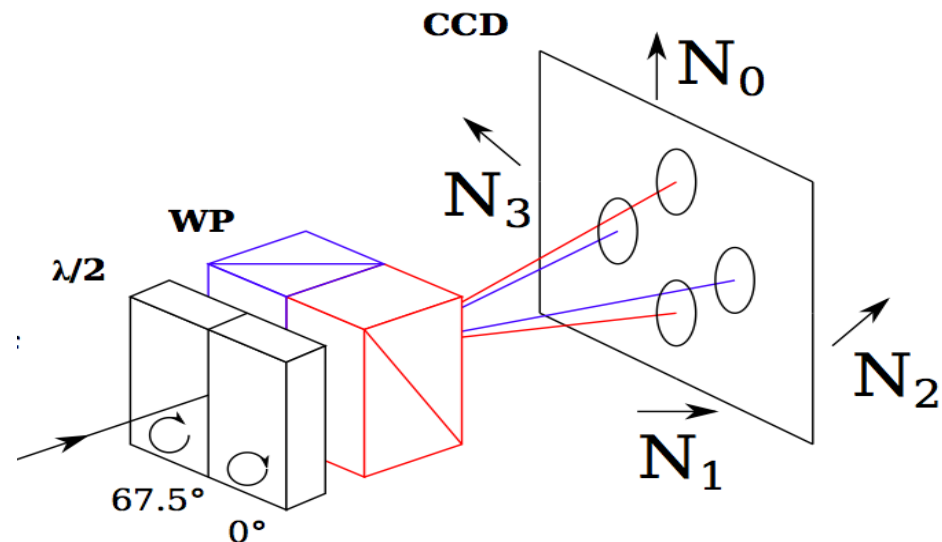
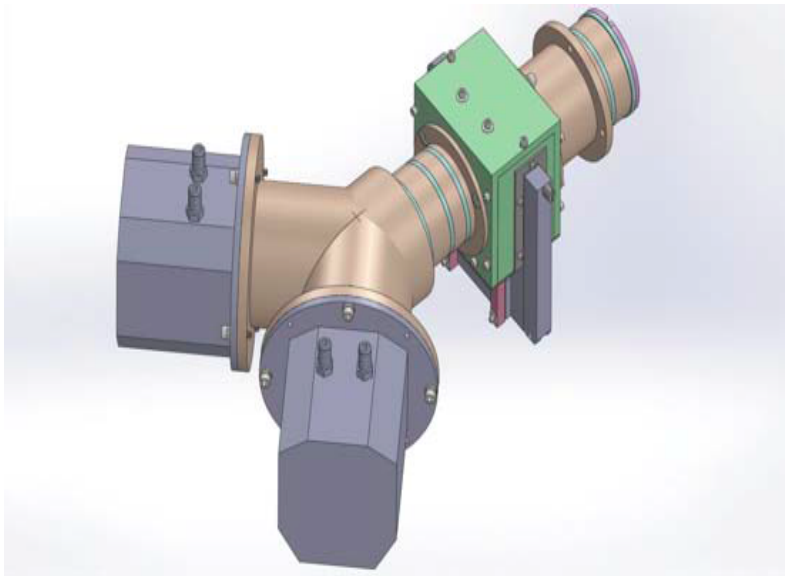


How ?

PASIPHAE's WALOPs: Innovative Design

For each point source:

- Split light in 4 linear polarization states differing by 22.5° .
 - Project each state in a different CCD
 - Combine to obtain Stokes Parameters
-
- Technology successfully tested with RoboPol, expanded to wide FoV

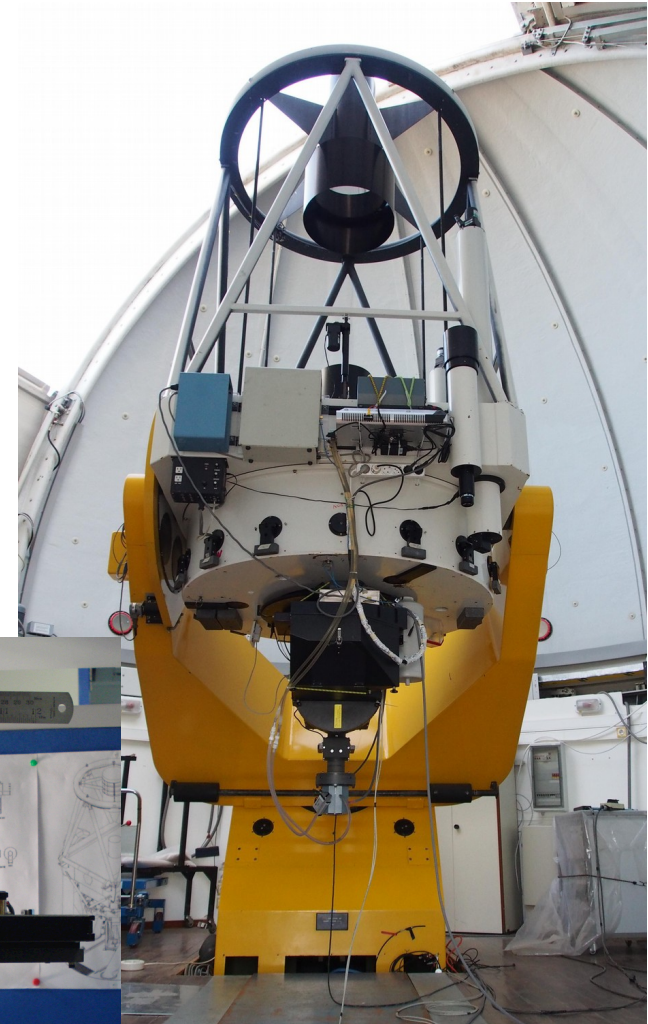
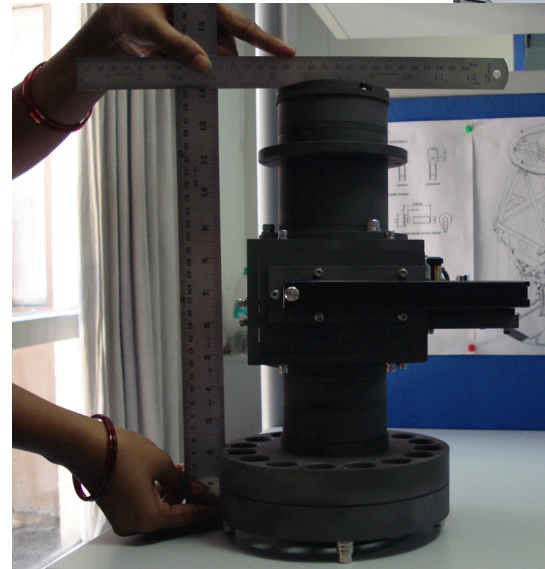
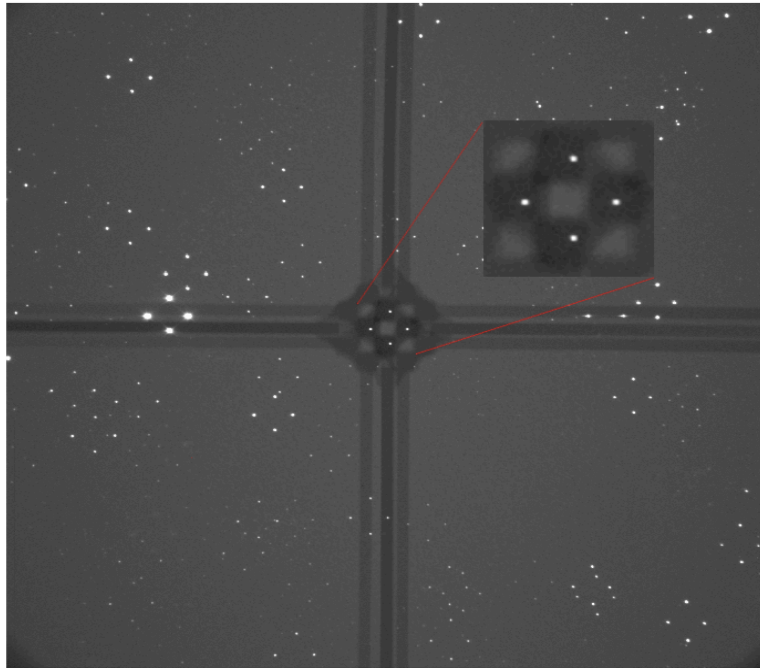


$$q = \frac{N_0 - N_1}{N_0 + N_1} \quad u = \frac{N_2 - N_3}{N_2 + N_3}$$

RoboPol

RoboPol polarimeter used successfully at Skinakas since 2013 for blazar monitoring and interstellar medium mapping

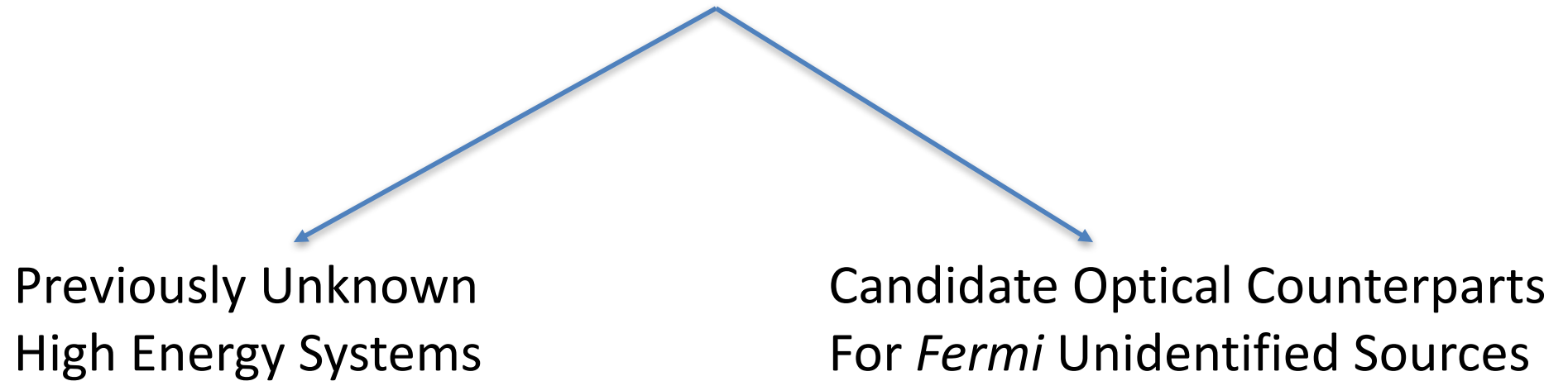
Actual RoboPol Image



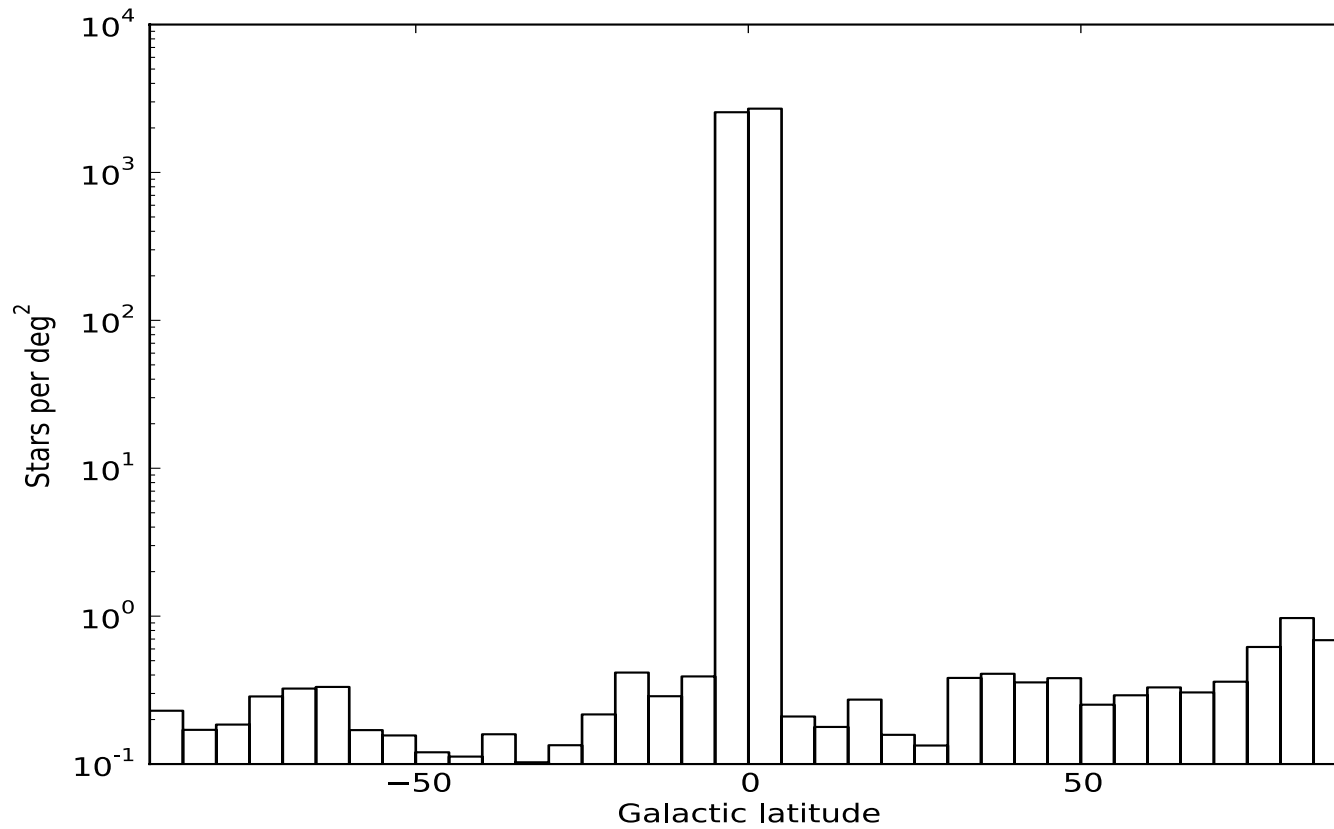
Relevance to high energy polarimetry?

Survey Mode

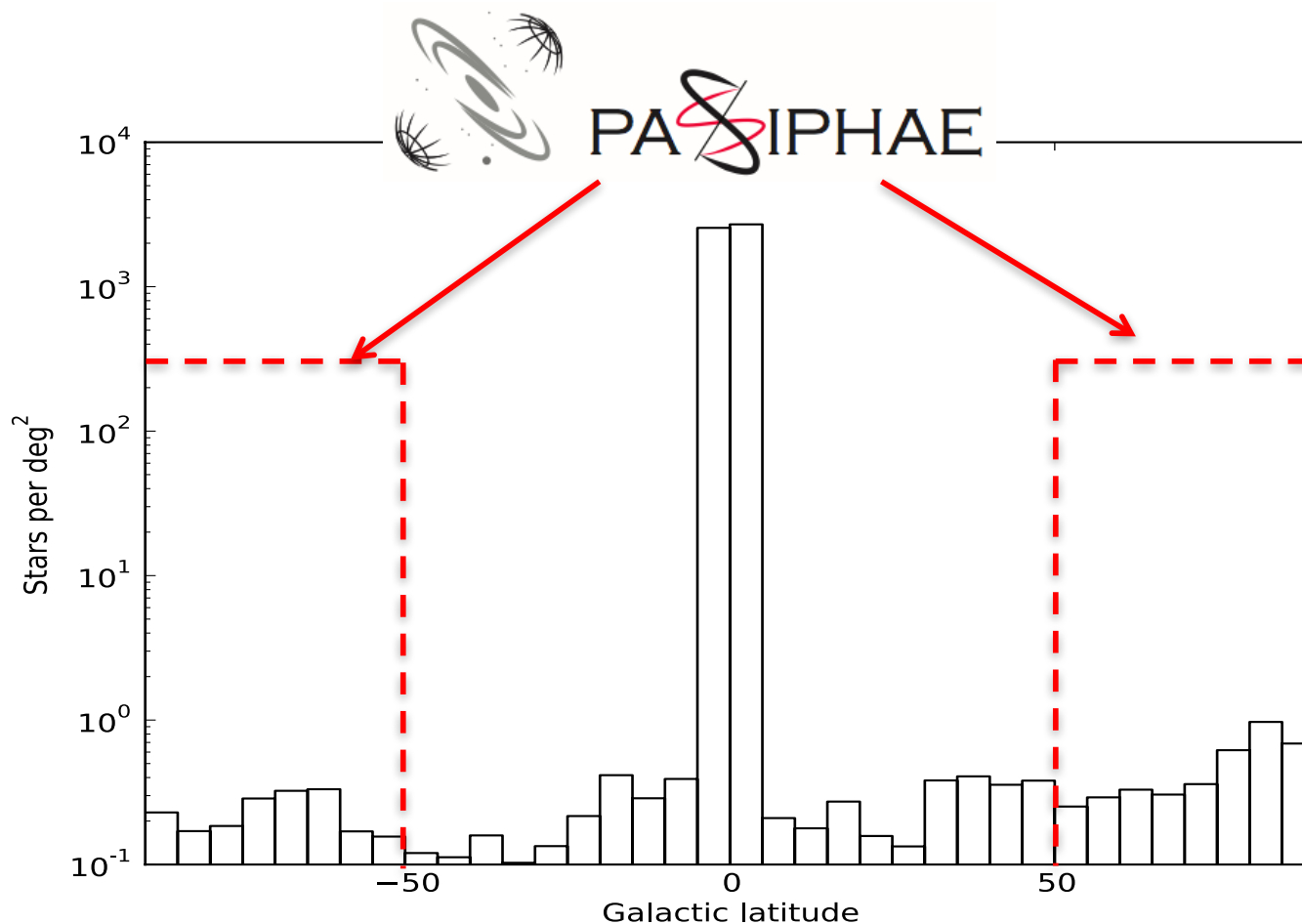
PASIPHAE will identify high optical polarization point sources



Current Opto-Polarimetric State of the Art at High $|b|$?

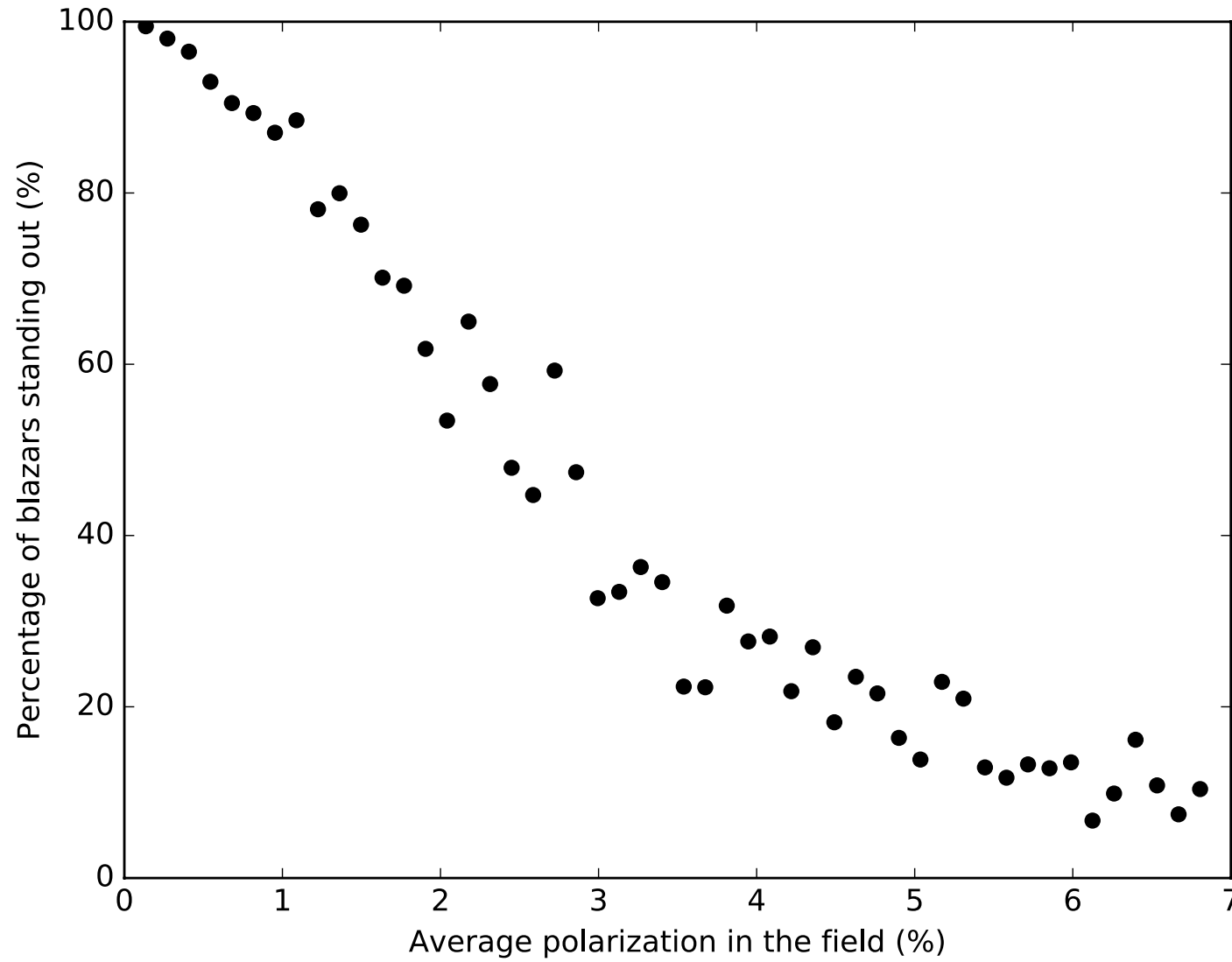


PASIPHAE's Improvement of the State of the Art



**PASIPHAE will increase the # of starlight polarizations
at high Galactic latitudes a 1000-fold!**

Blazars Stand Out on Polarization Maps

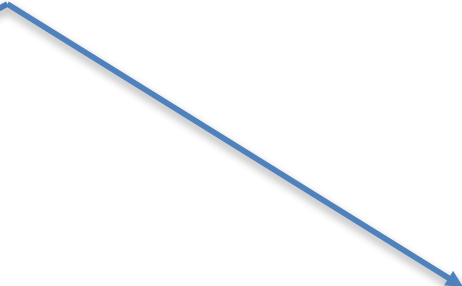


TOO Mode

WALOPs have



a lot of
telescope time



wide field
of view

Thank you