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Multi-tracers analysis of the Faraday tomographic data

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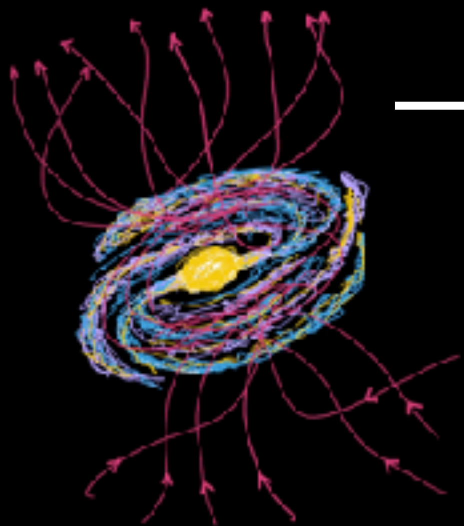
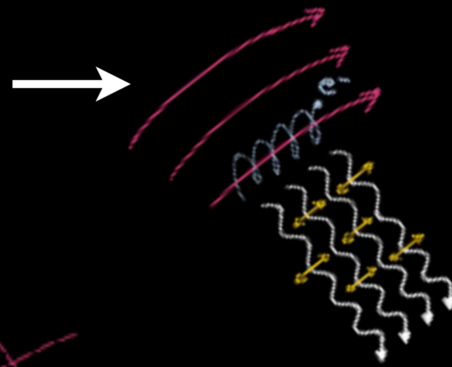


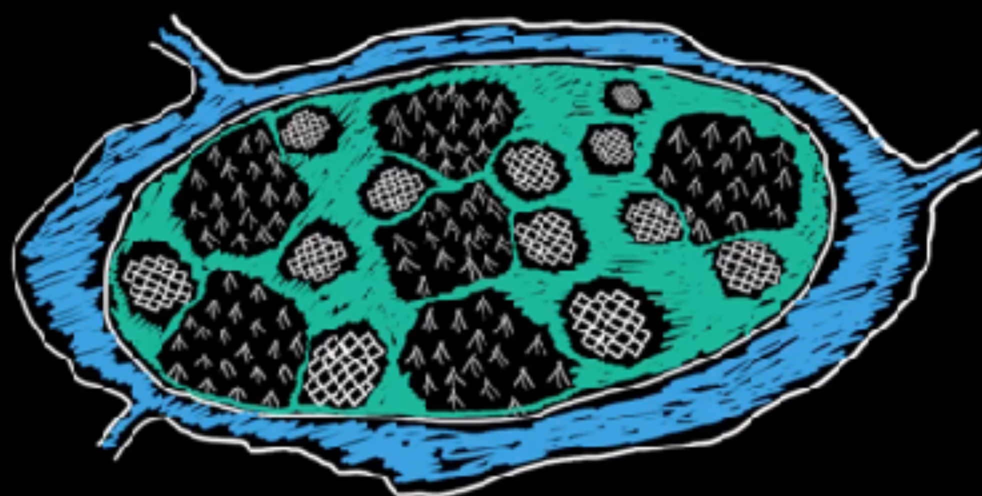


Faraday rotation

$$\Delta\theta = \lambda^2 \left(\text{const.} \int_0^d n_e \mathbf{B} \cdot \mathrm{d}\mathbf{l} \right)$$

synchrotron emission

$$I_\nu \sim n_{CR} B_\perp^{\frac{p+1}{2}} \nu^{-\frac{p+3}{2}}$$



The Low Frequency Array (LOFAR)

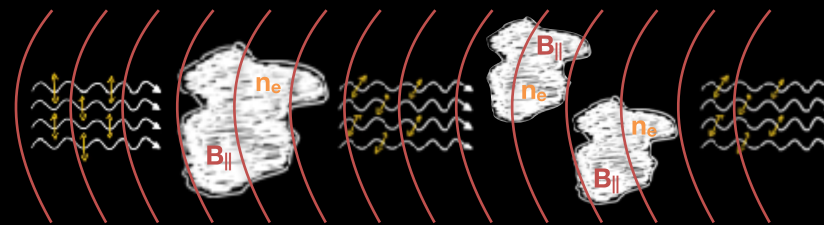
van Haarlem et al. 2013

10 - 240 MHz

LINEAR POLARIZATION
Stokes Q, U

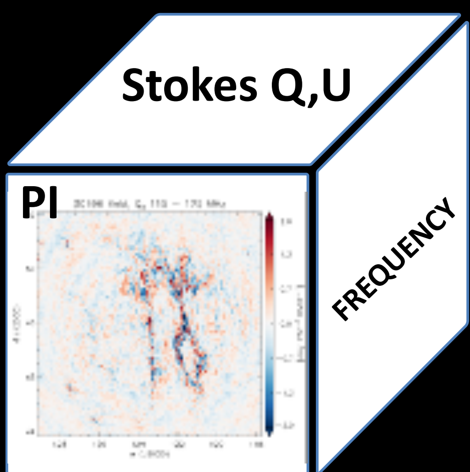
$$Q = PI\cos\theta \qquad PI = \sqrt{Q^2 + U^2}$$

$$U = PI\sin\theta \qquad \theta = \frac{1}{2}\tan^{-1}\frac{U}{Q}$$



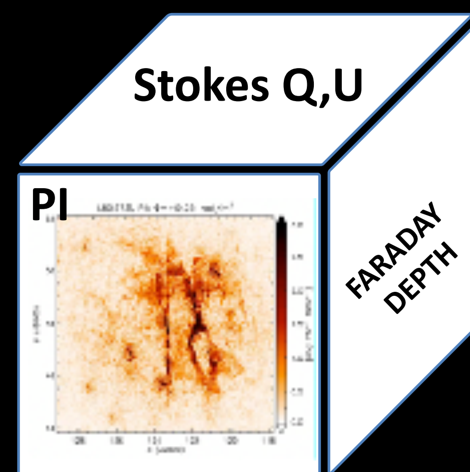
$$\theta = \theta_0 + \lambda^2\left(\text{const.}\int_0^d n_e\mathbf{B}\cdot d\mathbf{l}\right)$$

FARADAY DEPTH



RM synthesis

Burn et al. 1966
Brentjens & de Bruyn 2008

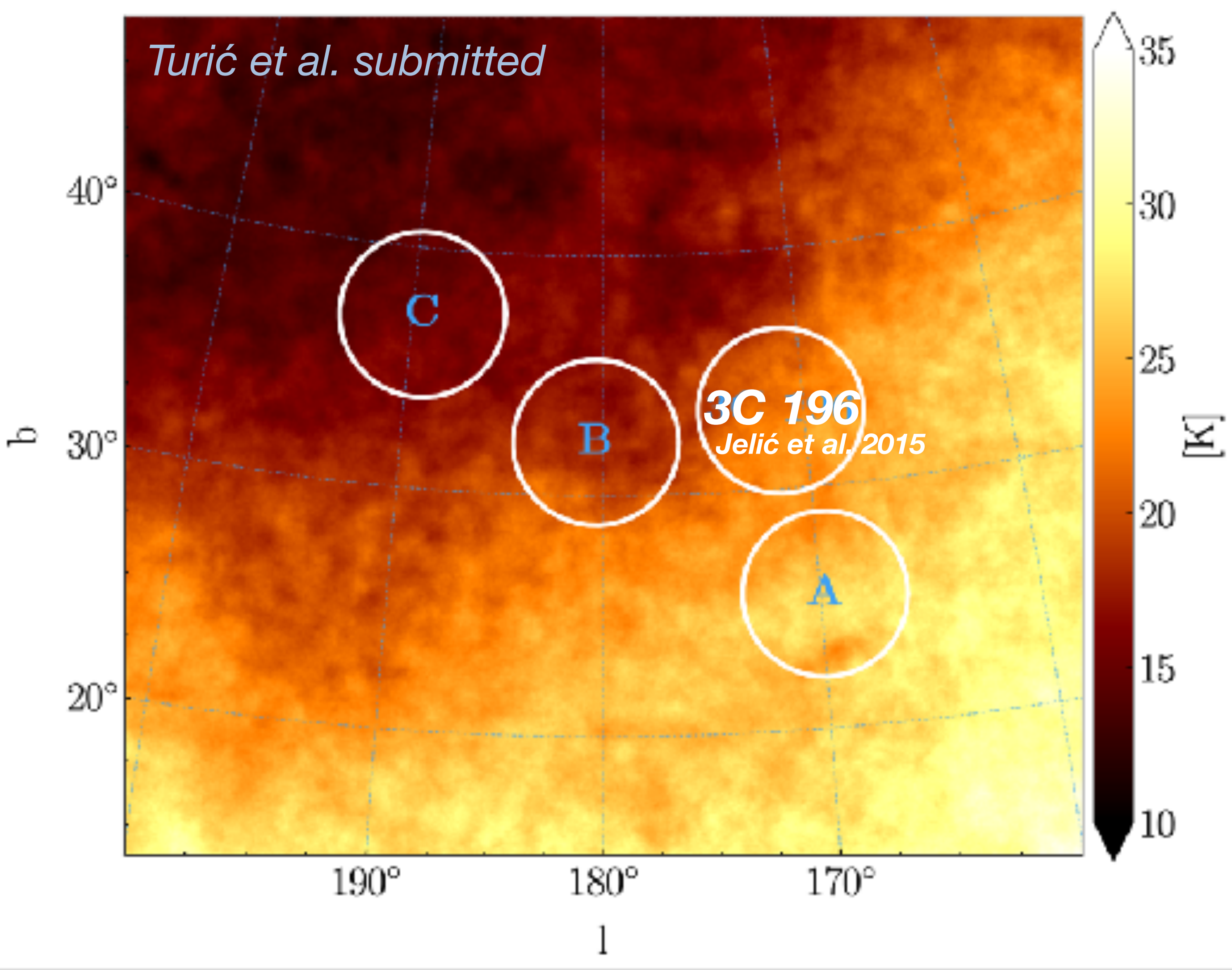


$$\mathbf{P}(\lambda^2) = \mathbf{Q}(\lambda^2) + i\,\mathbf{U}(\lambda^2)$$

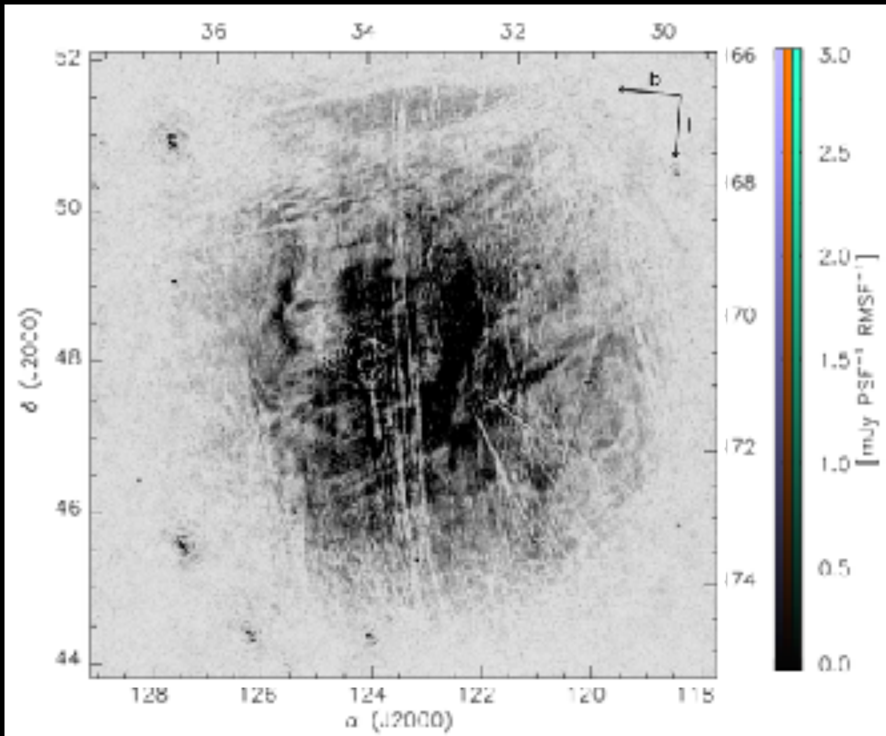
$$F(\Phi) = \int_{-\infty}^{+\infty} W(\lambda^2)P(\lambda^2)e^{-i2\Phi\lambda^2}d\lambda^2$$

Faraday tomography

- LOFAR - HBA observations, 1 night, 6h (115 - 175 MHz, 183 kHz)
- Q,U and PI images, $8.3^0 \times 8.3^0$, 3.5 arcmin
- $\delta\Phi$ = 1-2 rad/m^2

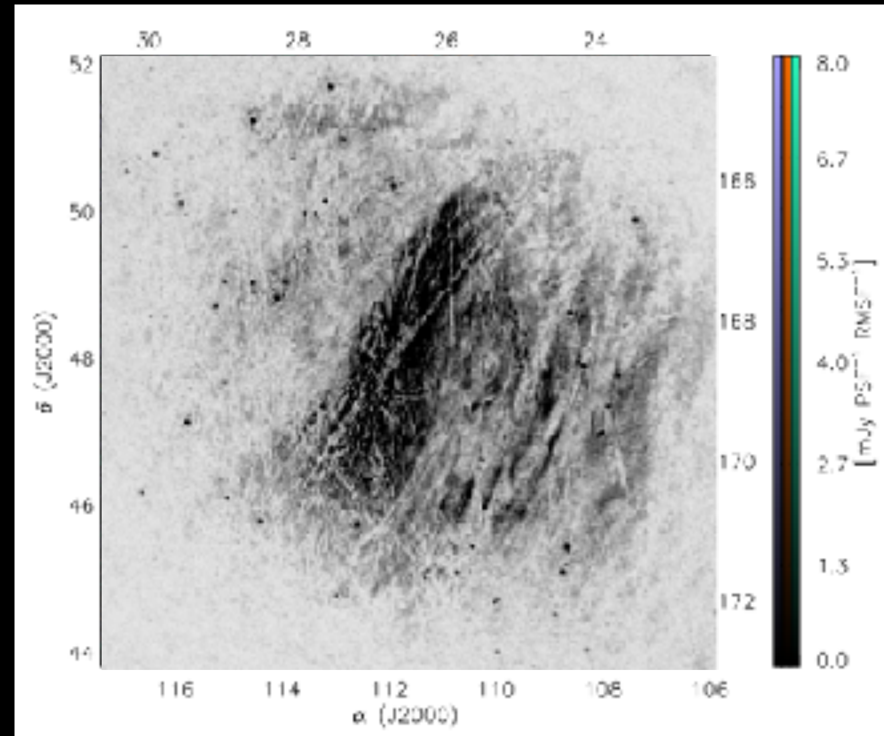


3C 196 field



Jelić et al. 2015

Field A



Truić et al. submitted

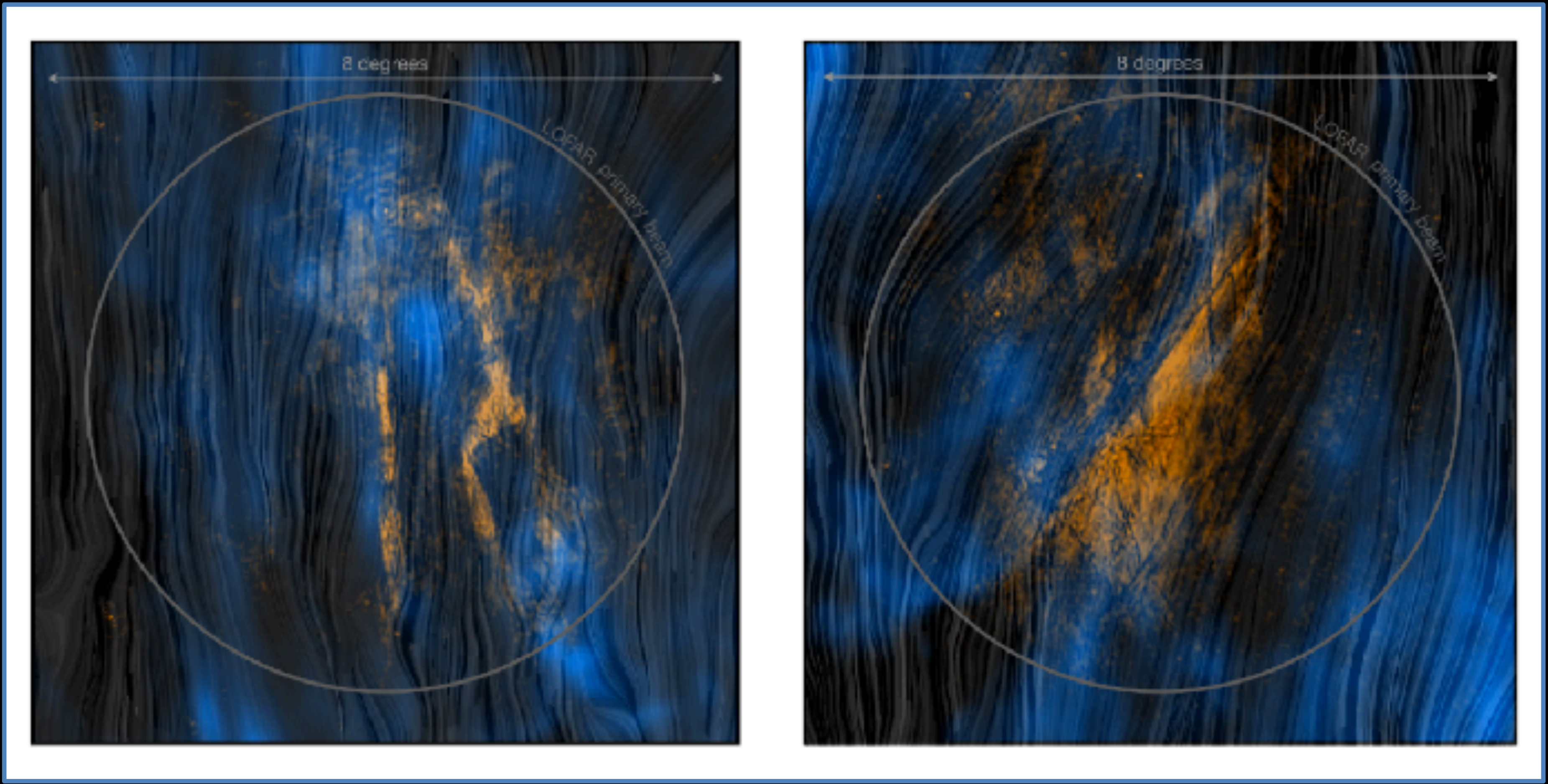
What drives morphology of the observed Galactic polarized synchrotron emission ?

Where does the observed emission originate from ?

What makes depolarisation canals so straight ?

3C 196 field
LOFAR 0 rad/m², EBHIS -5 km/s

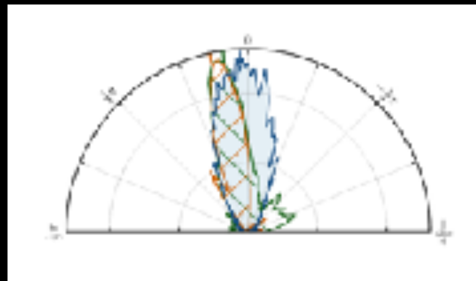
Field A
LOFAR -1.25 rad/m², EBHIS +1.4 km/s



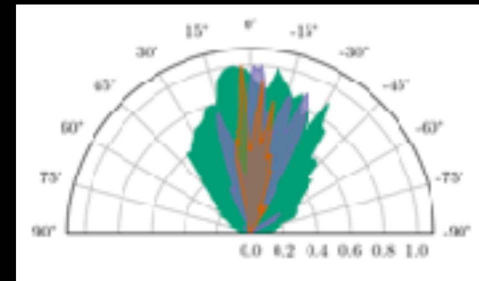
Zaroubi, Jelić et al. 2015, Kalberla & Kerp 2016,
Bracco et al. 2020

- observed correlation between Faraday structures, magnetic field probed by polarised dust emission and neutral hydrogen (mostly CNM and LNM)

3C 196 field



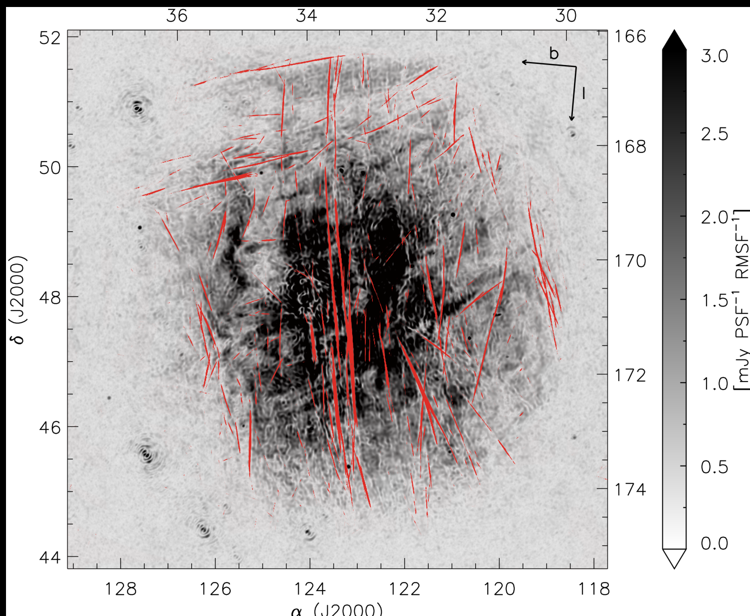
Field A



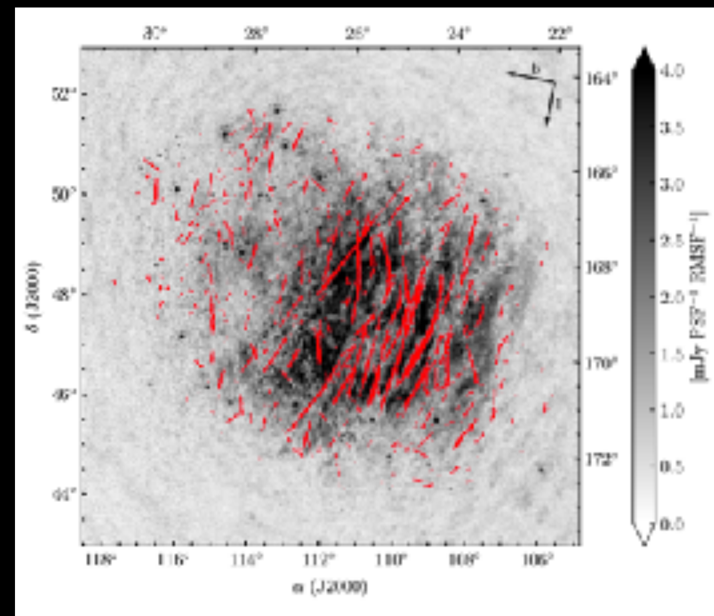
LOFAR data

EBHIS data

Planck data



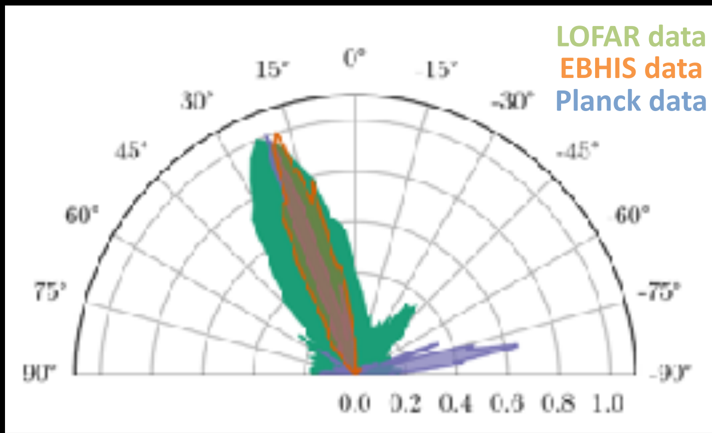
Jelić et al. 2018

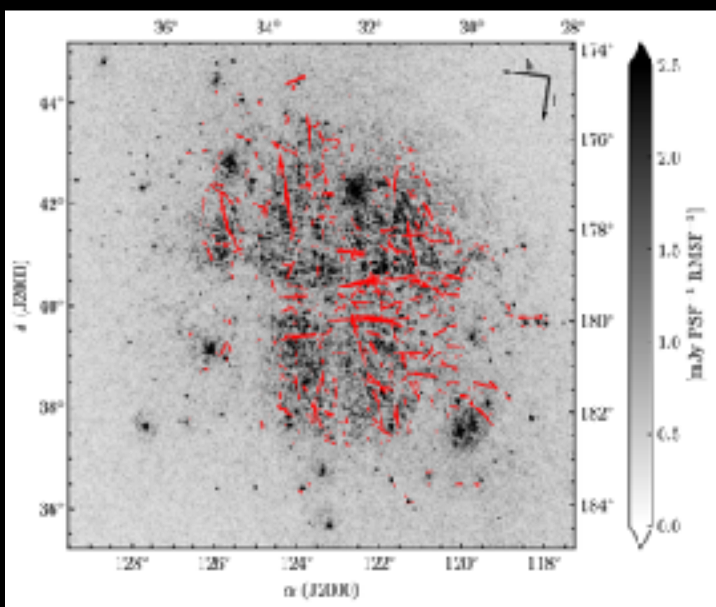


Turić et al. submitted

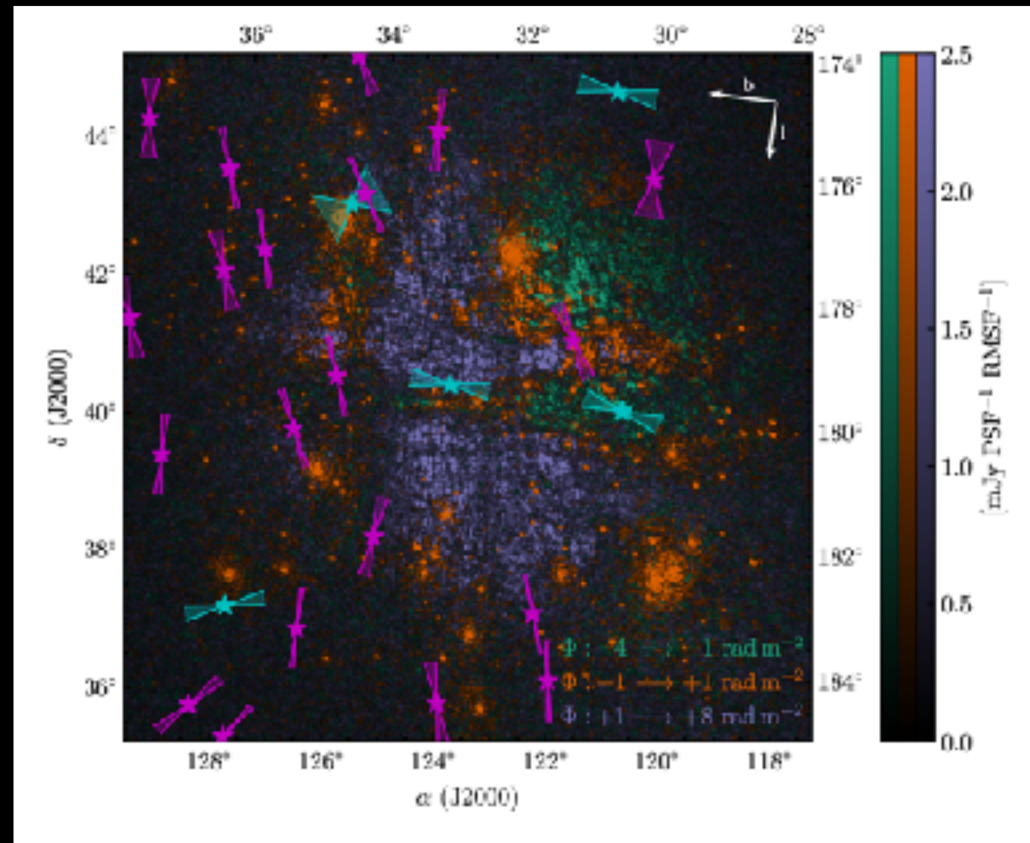
- analysis of straight depolarisation canals using Rolling Hough Transform (**RHT**, *Clark et al. 2014*)
- *an alignment between three tracers of the local interstellar medium, driven by a very ordered local magnetic field in the plane-of-the-sky*

Field B



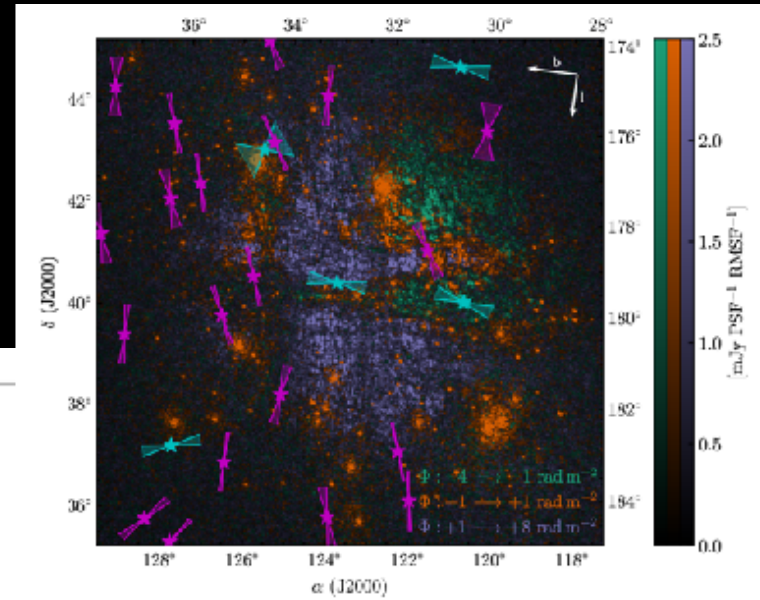


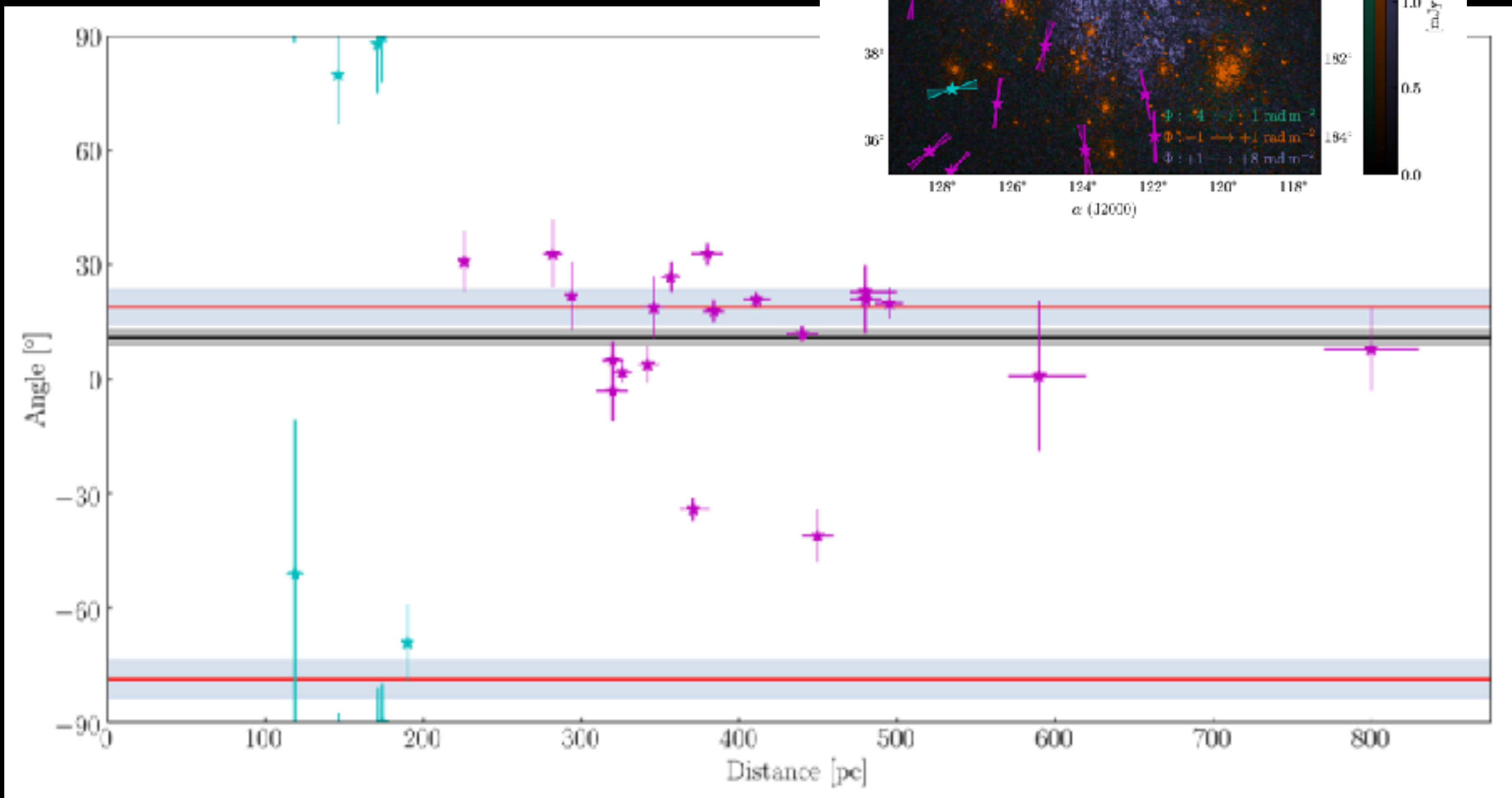
Turić et al. submitted



- available starlight polarization data (*Heiles 2000; Berdyugin, A. et al. 2001; Berdyugin, A. & Teerikorpi, P. 2002; Bailey et al. 2010; Berdyugin, A. et al. 2014*) with their distances from the Bailer-Jones catalogue (*Bailer-Jones et al. 2018*), which is based on Gaia Data Release 2 (*Gaia Collaboration et al. 2018*)

- polarized synchrotron emission observed at different Faraday depths originates from different distances:
    - 100 - 200 pc (-4 —> 0 rad/m²)
    - 250 - 800 pc (0 —> +8 rad/m²)

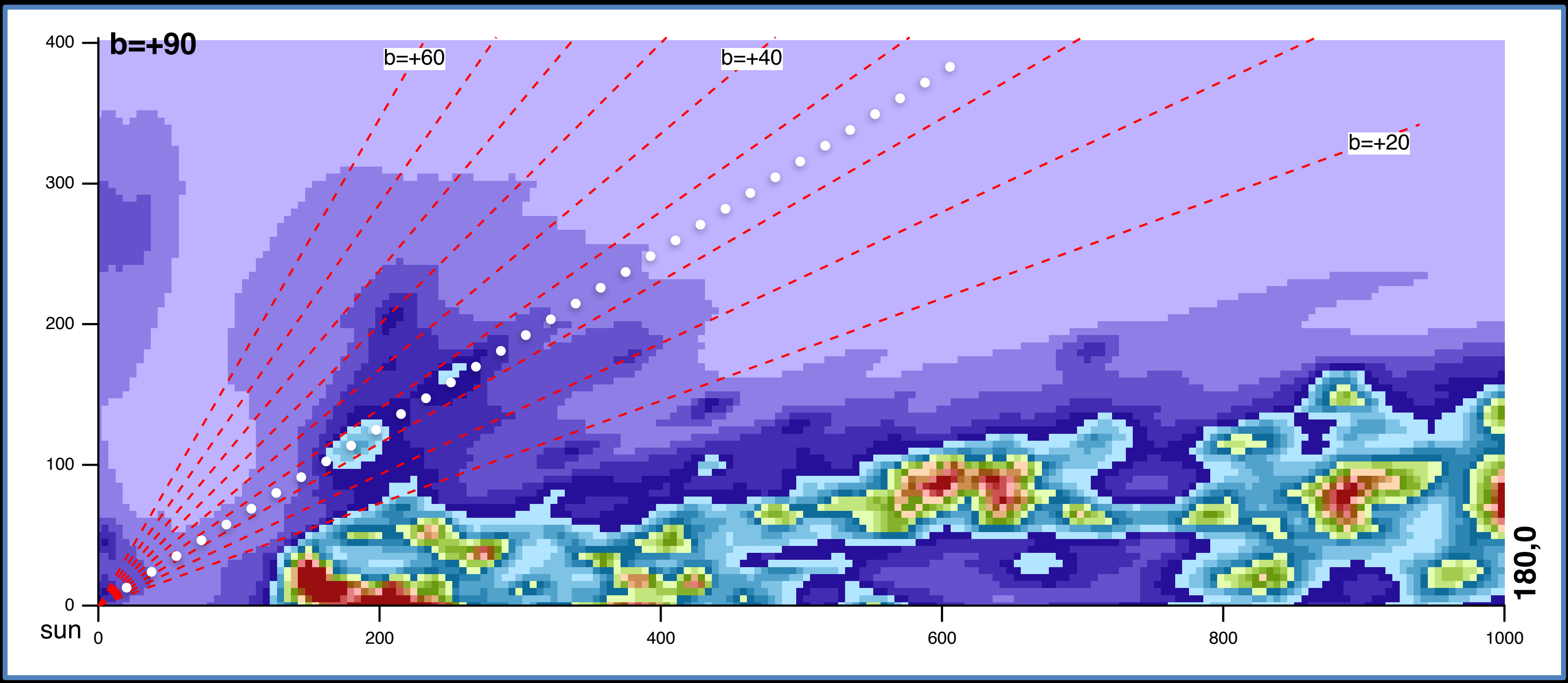




Turić et al. submitted

Field B

3D map of the local ISM

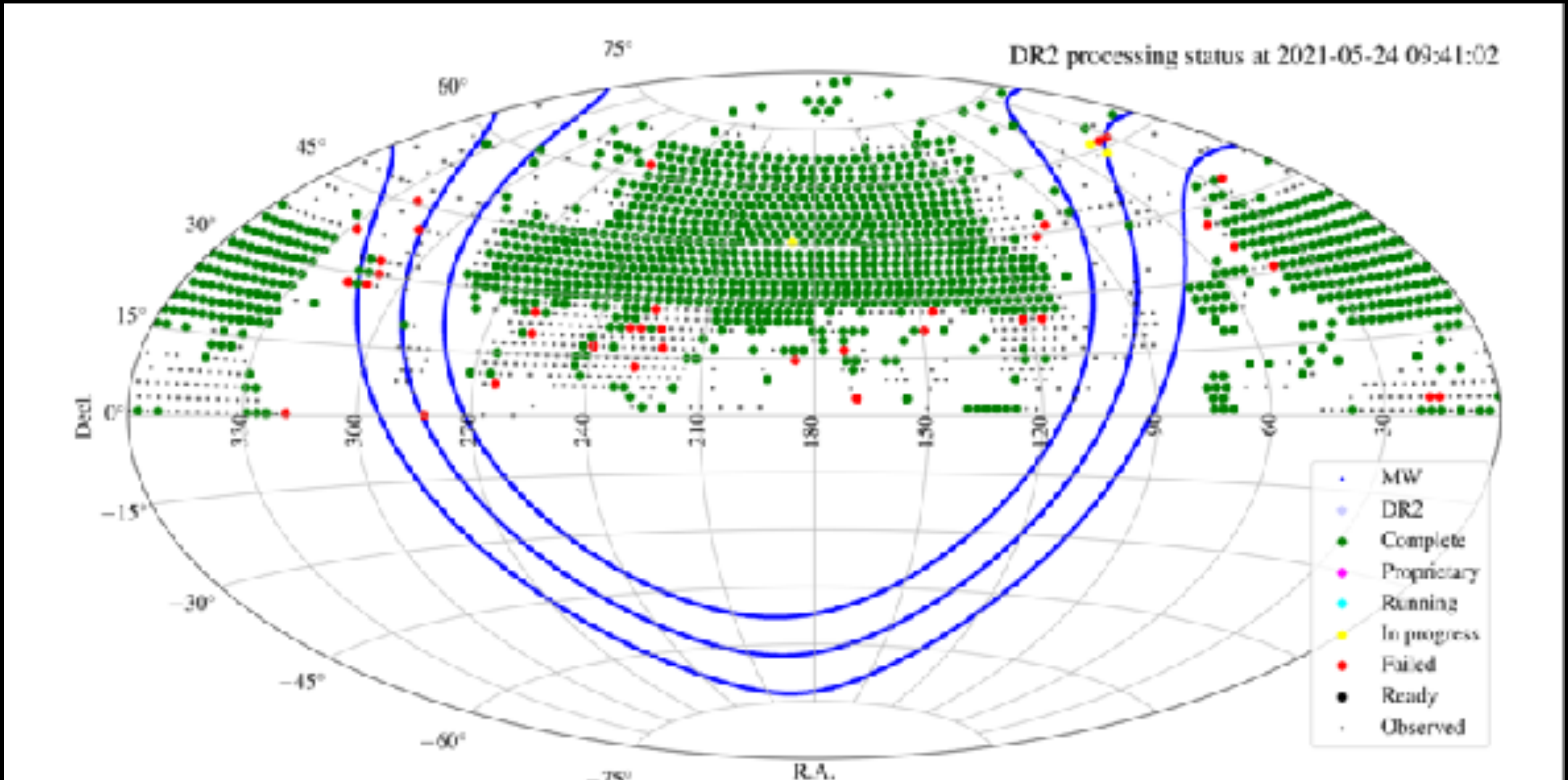


Lallement et al., 2014
Capitanio et al. 2017

LoTSS - LOFAR Two-metre Sky Survey

https://lofar-surveys.org

Shimwell et al. 2017, 2019



Faraday tomography of the LoTSS preliminary DR - *Van Eck et al. 2019*

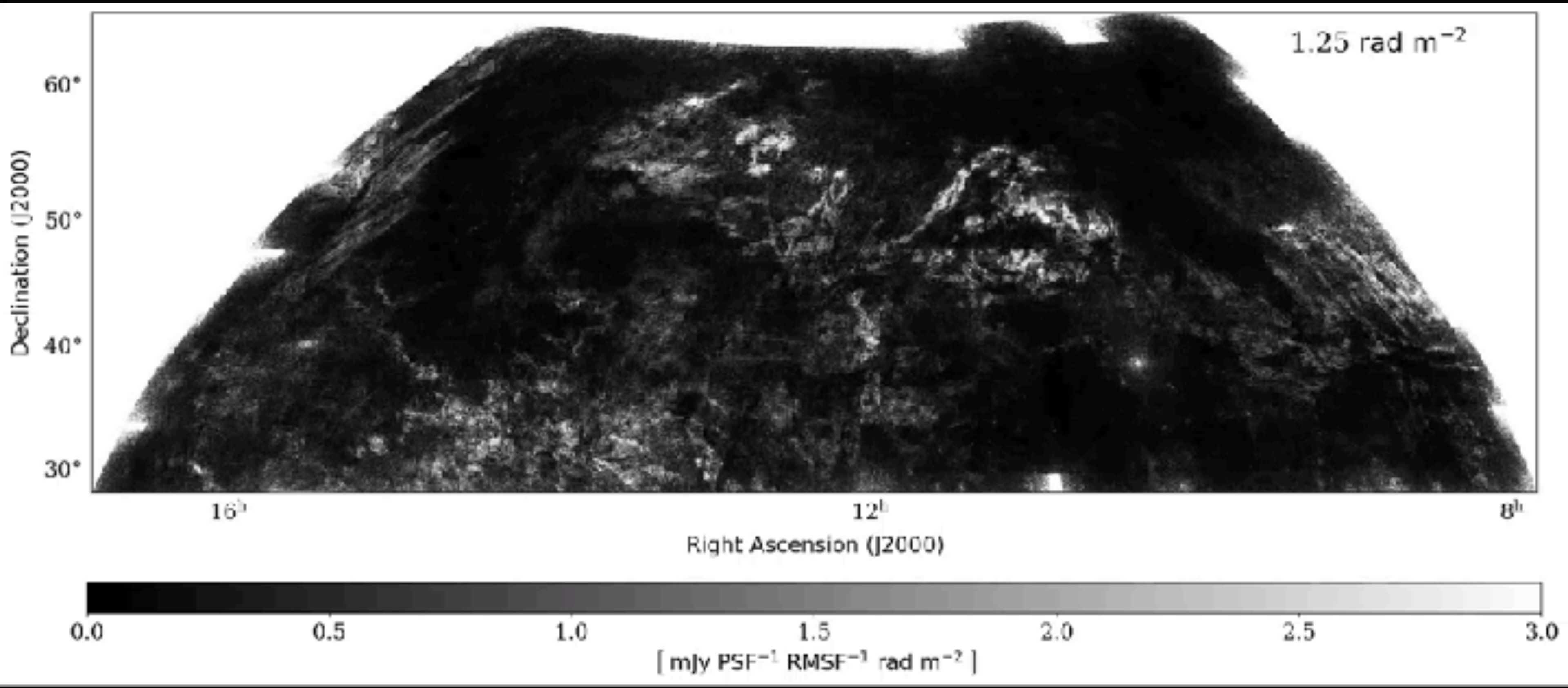
Faraday tomography of the LoTSS DR2 data

- *Erceg et al. in prep.* - the intermediate Galactic latitude in the outer Galaxy and Loop III
- *Gajović et al. in prep.* - the intermediate Galactic latitude in the inner Galaxy
- *Bracco et al. in prep.* - in Taurus region

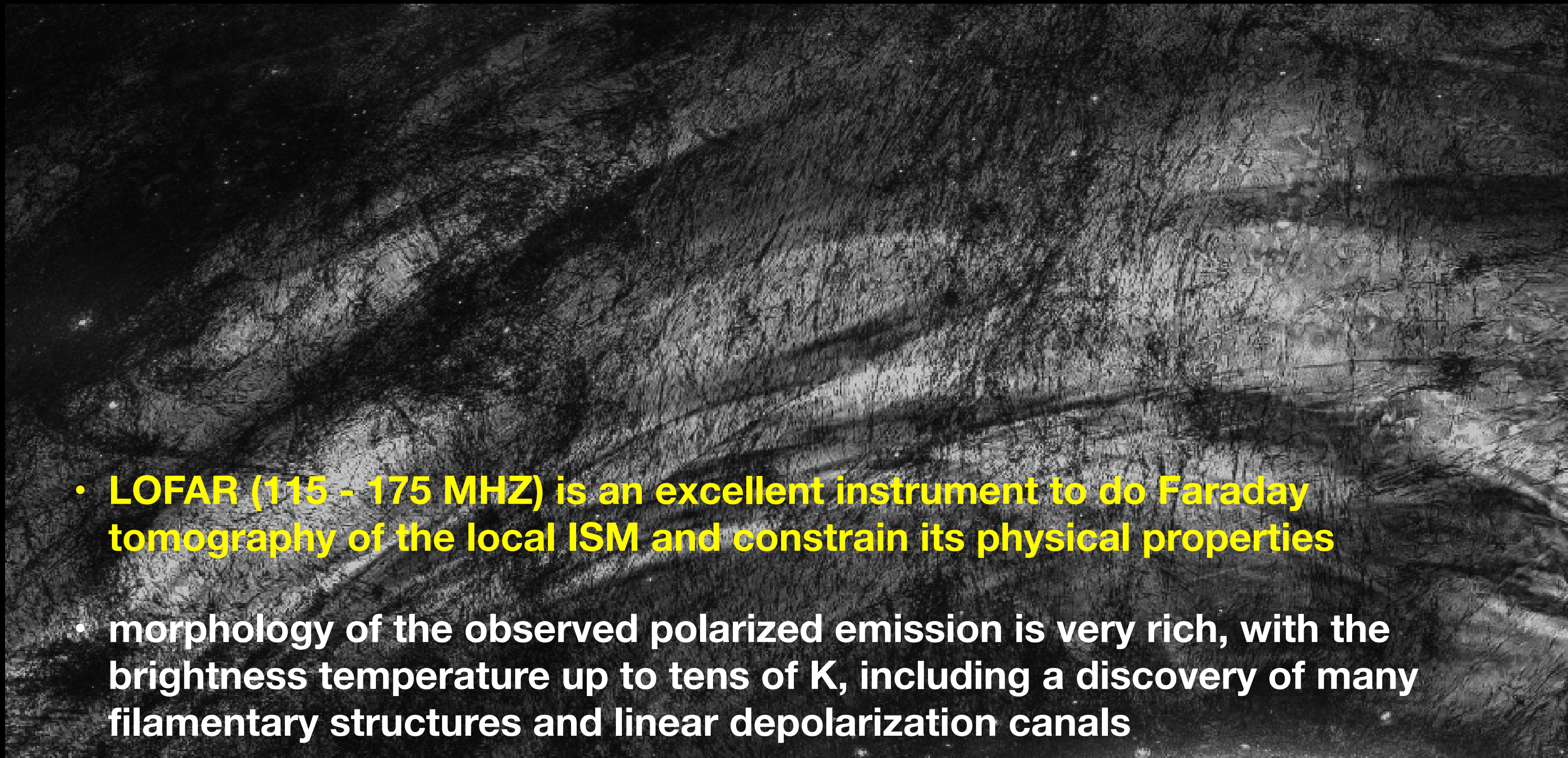
Faraday tomography of the LoTSS Deep Fields

- *Šnidarić et al. in prep.* - ELAIS-N1 Deep field

The intermediate Galactic latitude in the outer Galaxy



LoTTS Survey DR2: *Erceg et al. in prep.*



- LOFAR (115 - 175 MHZ) is an excellent instrument to do Faraday tomography of the local ISM and constrain its physical properties

- morphology of the observed polarized emission is very rich, with the brightness temperature up to tens of K, including a discovery of many filamentary structures and linear depolarization canals

- multi-tracer analyses of Faraday tomographic data are inevitable if one wants to constrain distances to the observed structures and understand the 3D nature of the magnetic field

- the magnetic field needs to be ordered with a dominant component in the plane of the sky to observe a correlation between different tracers of the multiphase ISM