From Rorschach to Reality:
on the interpretation of Faraday cubes of diffuse Galactic synchrotron emission

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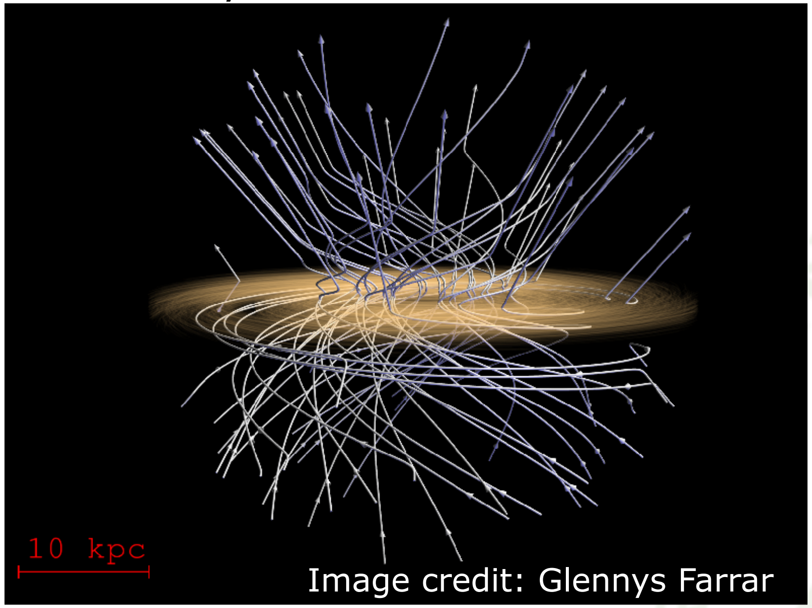
Magnetic fields in the Milky Way

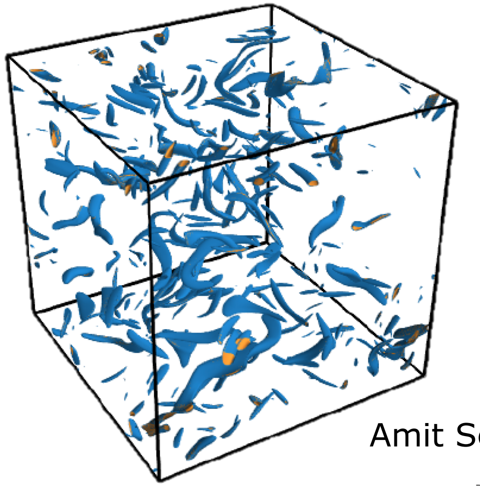
Global, coherent fields



+ Local Bubble fields

unpublished data

+ small-scale, turbulent fields

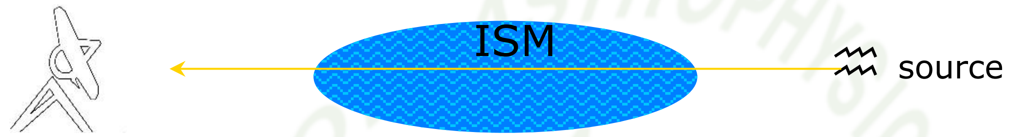


Amit Seta et al (2017)

Marta Alves et al (in prep)

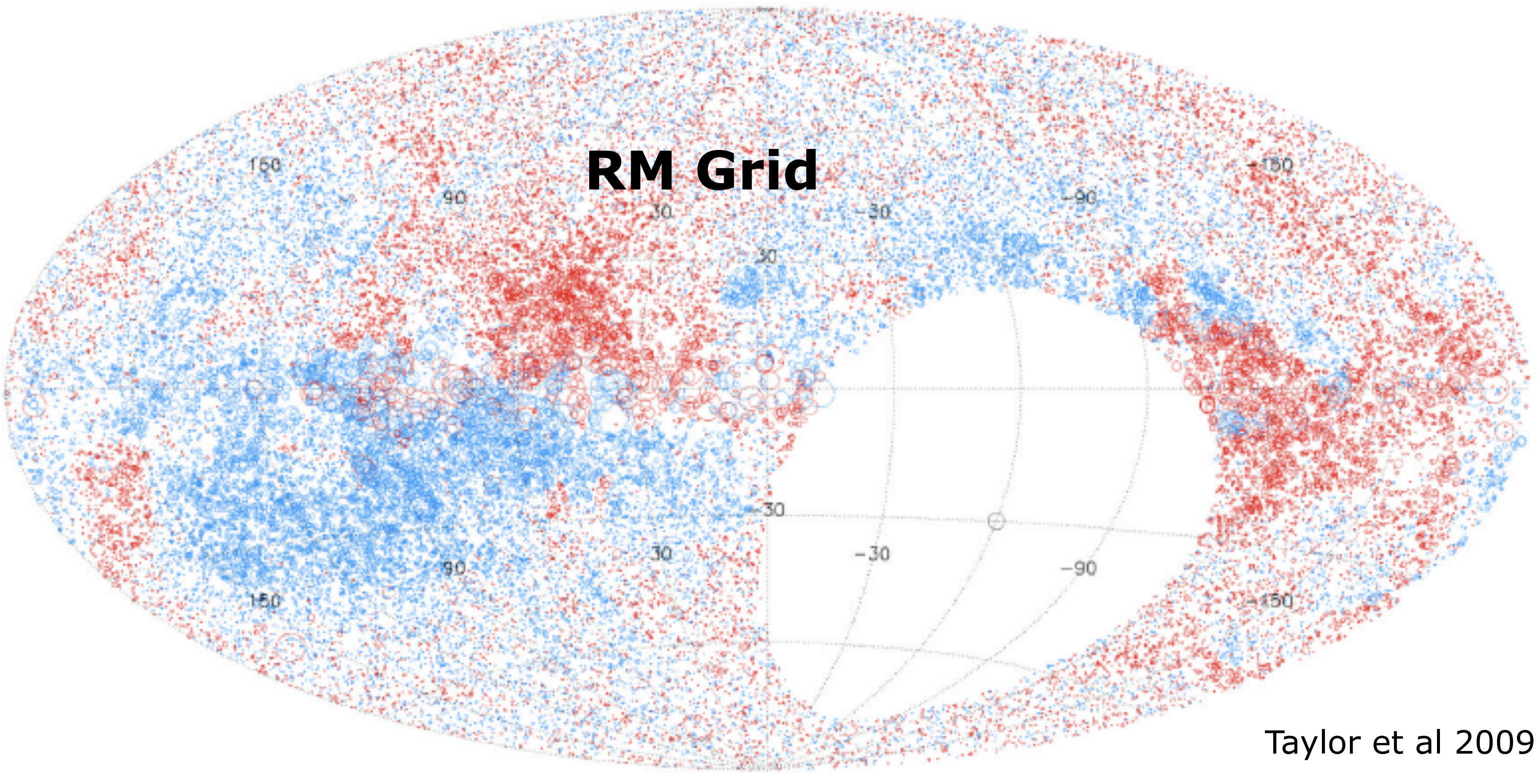
Faraday rotation

1 'Classical' :



Polarization angle rotates with observing wavelength λ: $\theta \propto \mathrm{RM}\,\lambda^2$

where rotation measure $$RM \propto \int_0^L n_e \vec{B} \bullet d\vec{l}$$



Taylor et al 2009

Faraday rotation

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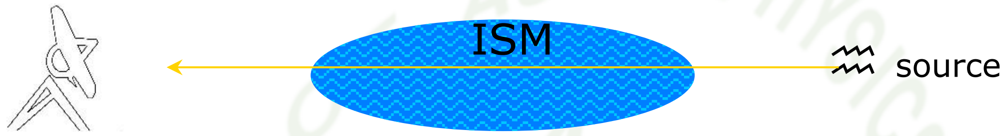

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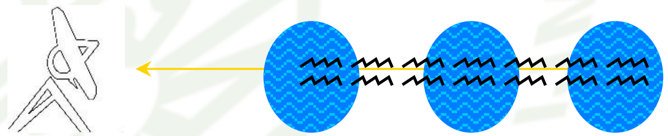
where rotation measure $$RM \propto \int_0^L n_e \vec{B} \bullet d\vec{l}$$

2 Rotation measure synthesis: (Burn 1966, Brentjens & de Bruyn 2005; Heald 2009)

Faraday depth $$\phi \propto \int_0^{l'} n_e \vec{B} \bullet d\vec{l}$$

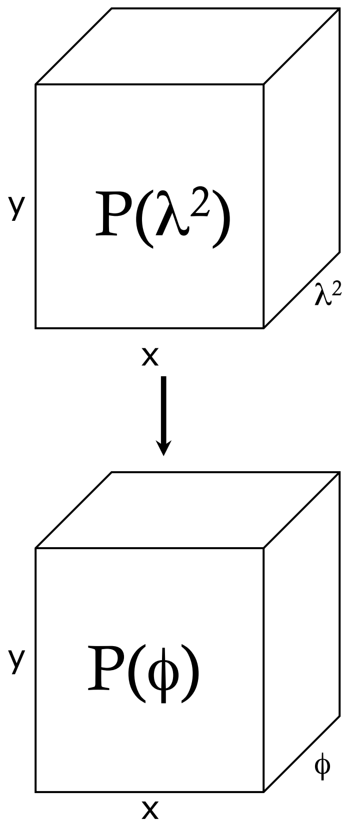


$$P_{obs}(\lambda^2) = W(\lambda^2) \int_{-\infty}^{\infty} F(\phi) e^{2i\phi\lambda^2}\, d\phi$$

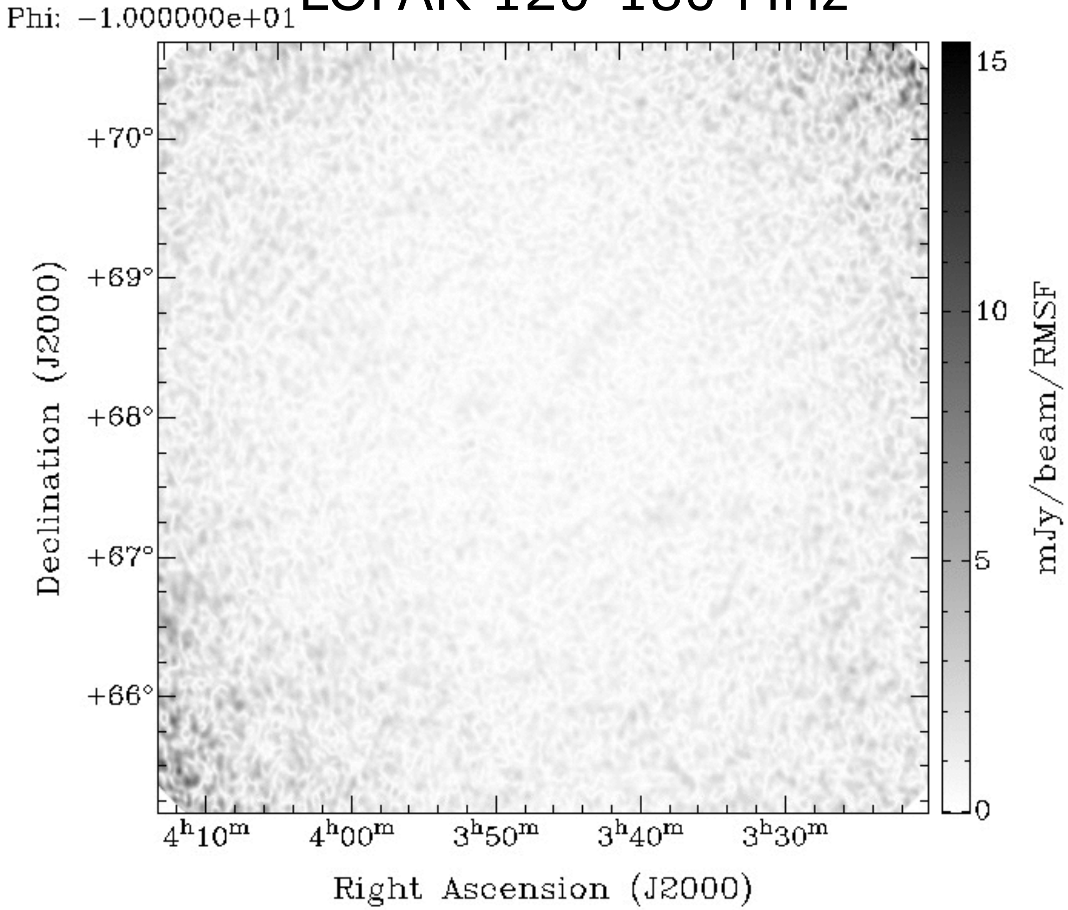
$$F_{obs}(\phi) = K \int_{-\infty}^{\infty} P_{obs}(\lambda^2) e^{-2i\phi\lambda^2}\, d\lambda^2$$

$$K = \left(\int_{-\infty}^{\infty} W(\lambda^2)\, d\lambda^2 \right)^{-1}$$

Example Rotation measure synthesis:



LOFAR 120-180 MHz



Van Eck et al (2017)

Faraday depth

$\phi = 0.81 \int n_e \, \mathbf{B \cdot dl}$

How to interpret these structures?

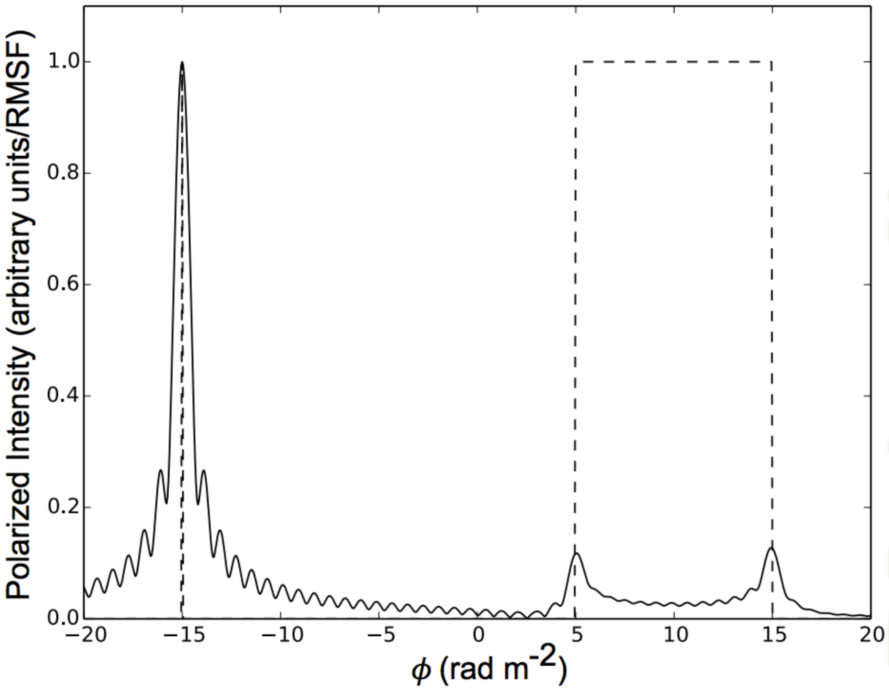
Challenges:

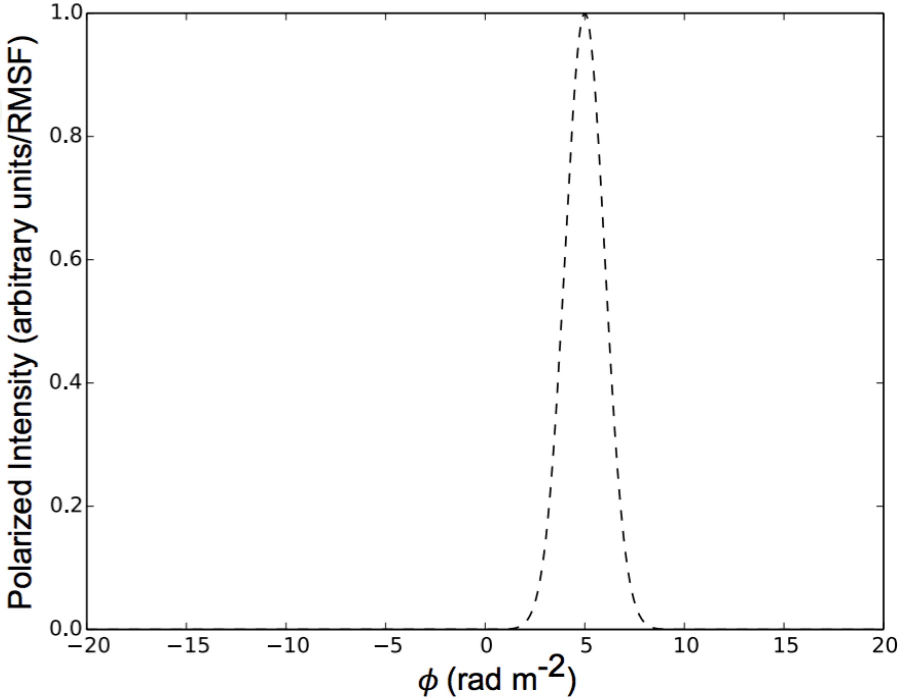
- No direct distance information: order in distance of structures is unclear
- Observational bias: e.g. insensitivity to Faraday-thickness, depolarization of distant structures

Solutions/first tries:

1. Understand biases through simulations
2. Find associations with other tracers
3. Get global picture: connect individual fields
4. Broader frequency coverage = more sensitivity

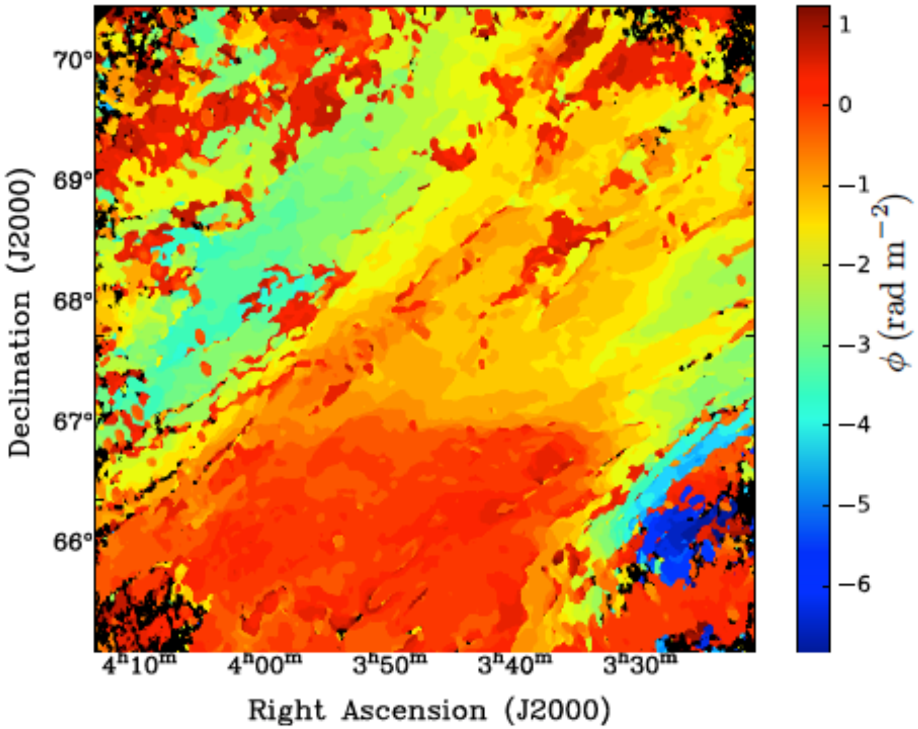
1. Understand biases through simulations

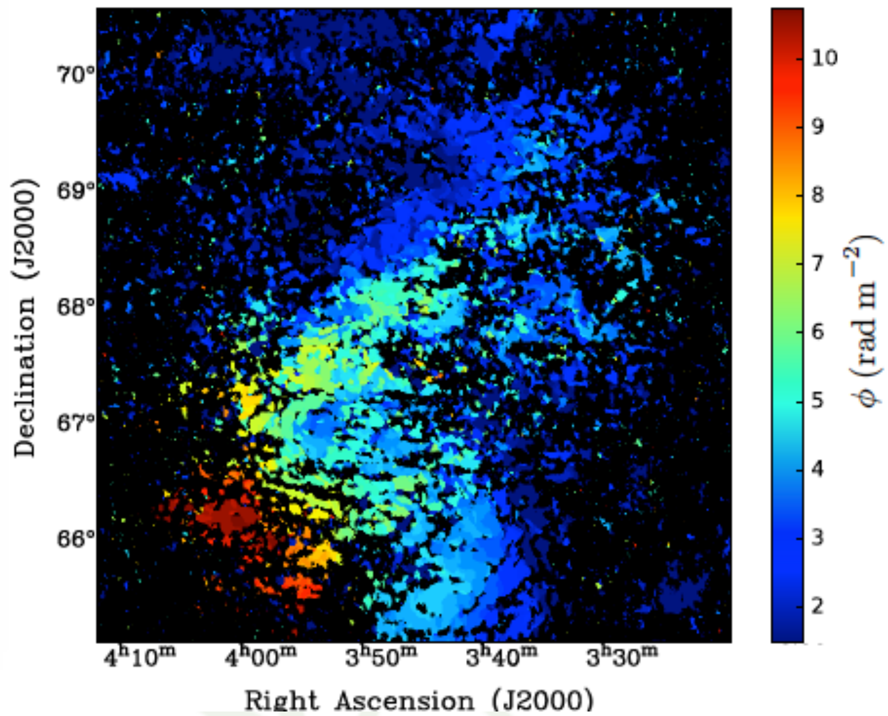




Van Eck et al, 2017

2. Find associations with other tracers: synchrotron emission components ←→ neutral clouds





Van Eck et al, 2017

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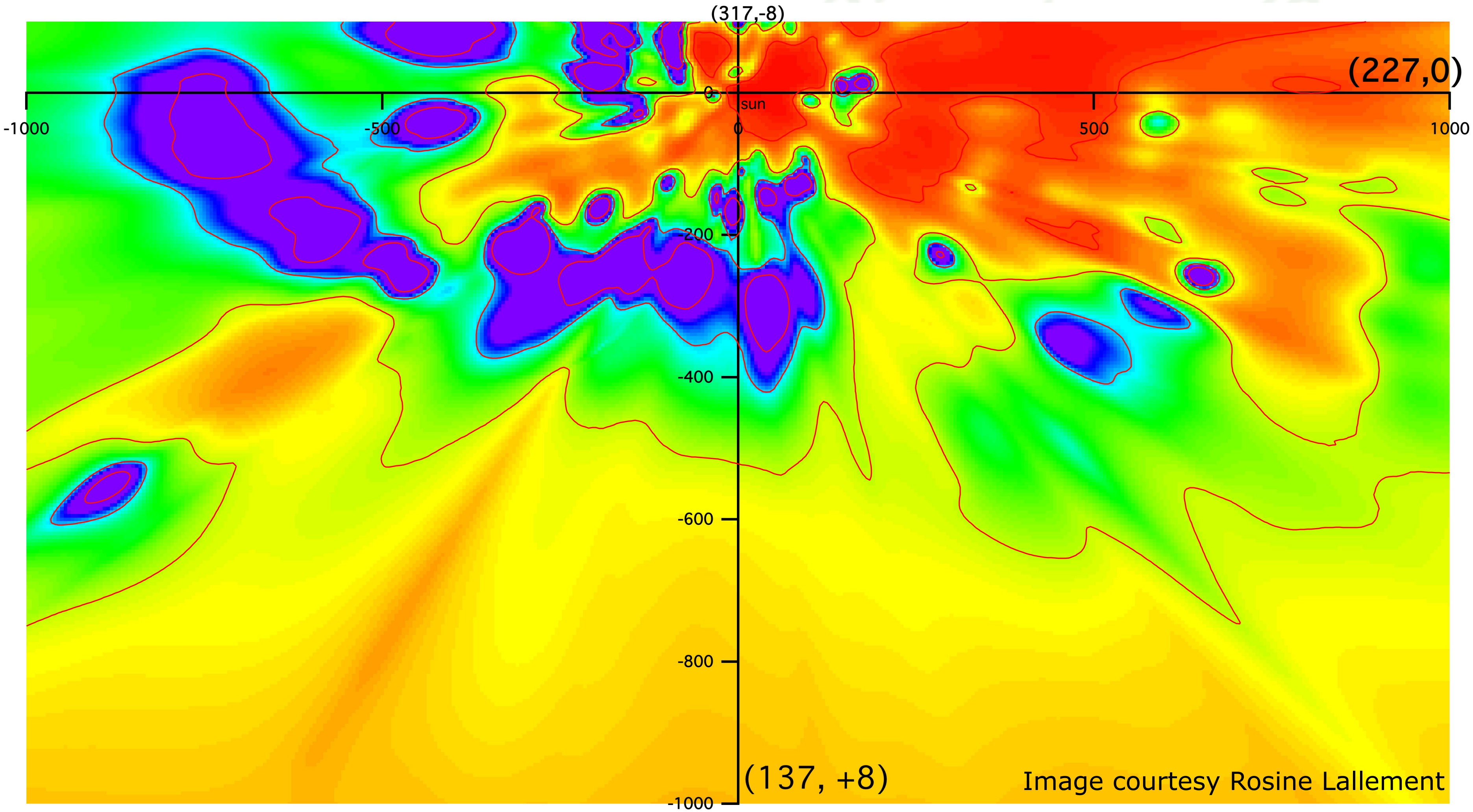
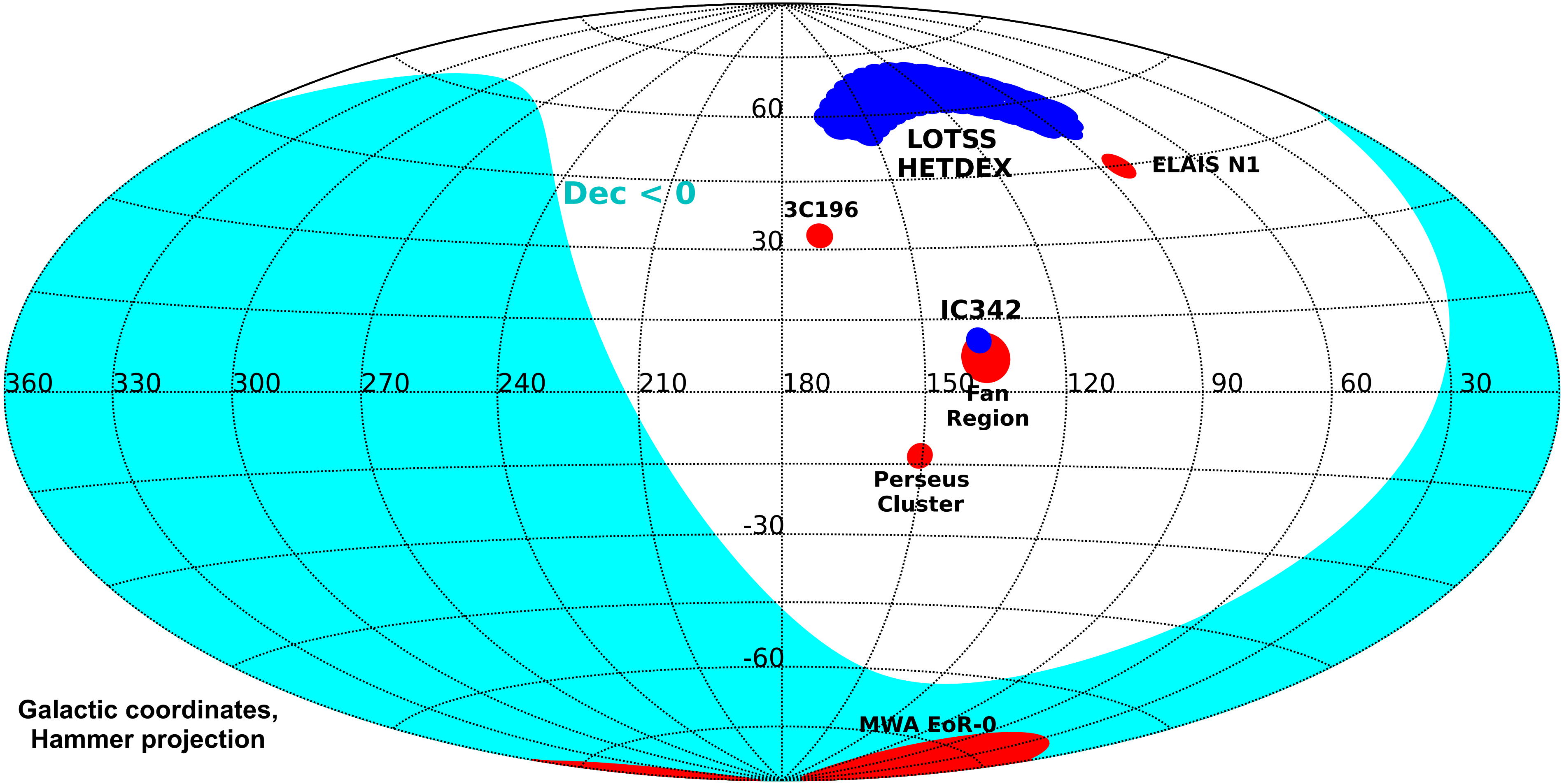


Emitting components correspond to neutral clouds

3. Get global picture:
spectro-polarimetry of the LOTSS survey



Galactic coordinates,
Hammer projection

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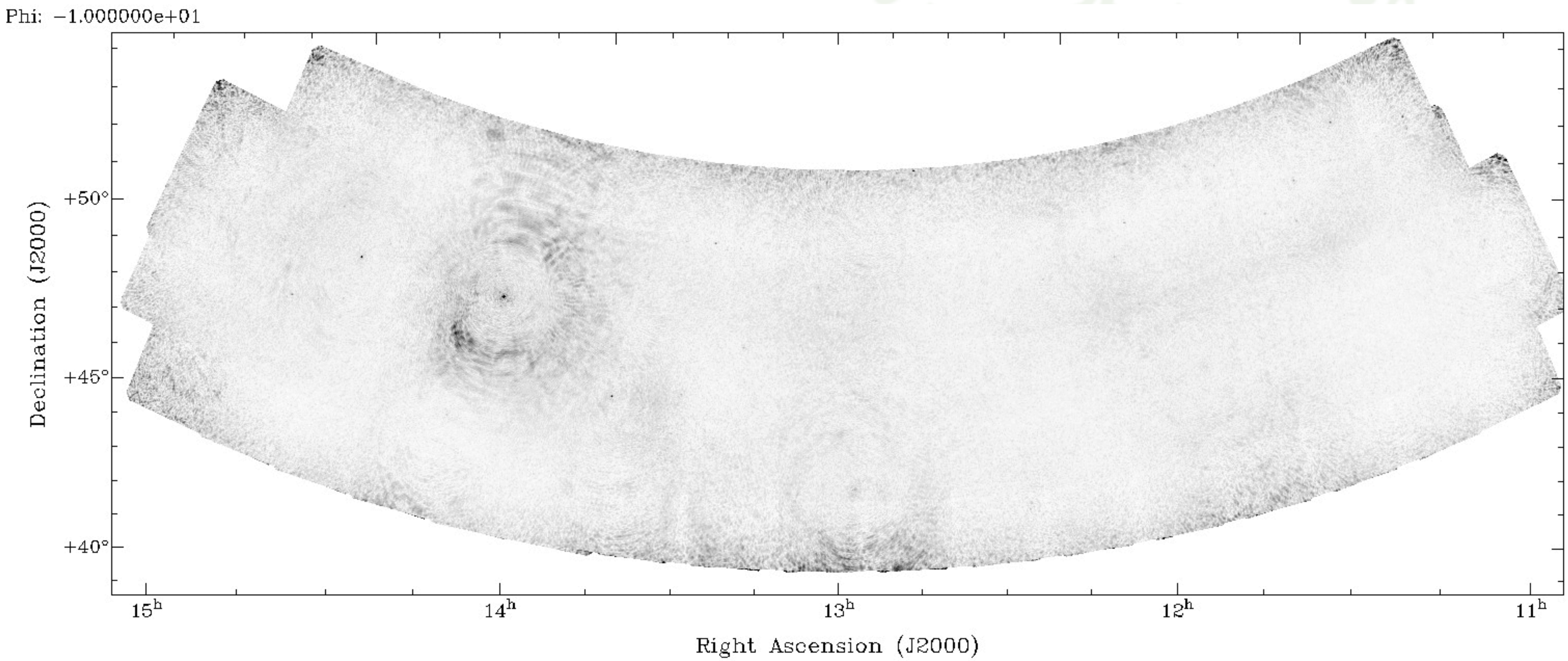

Van Eck et al (2018)

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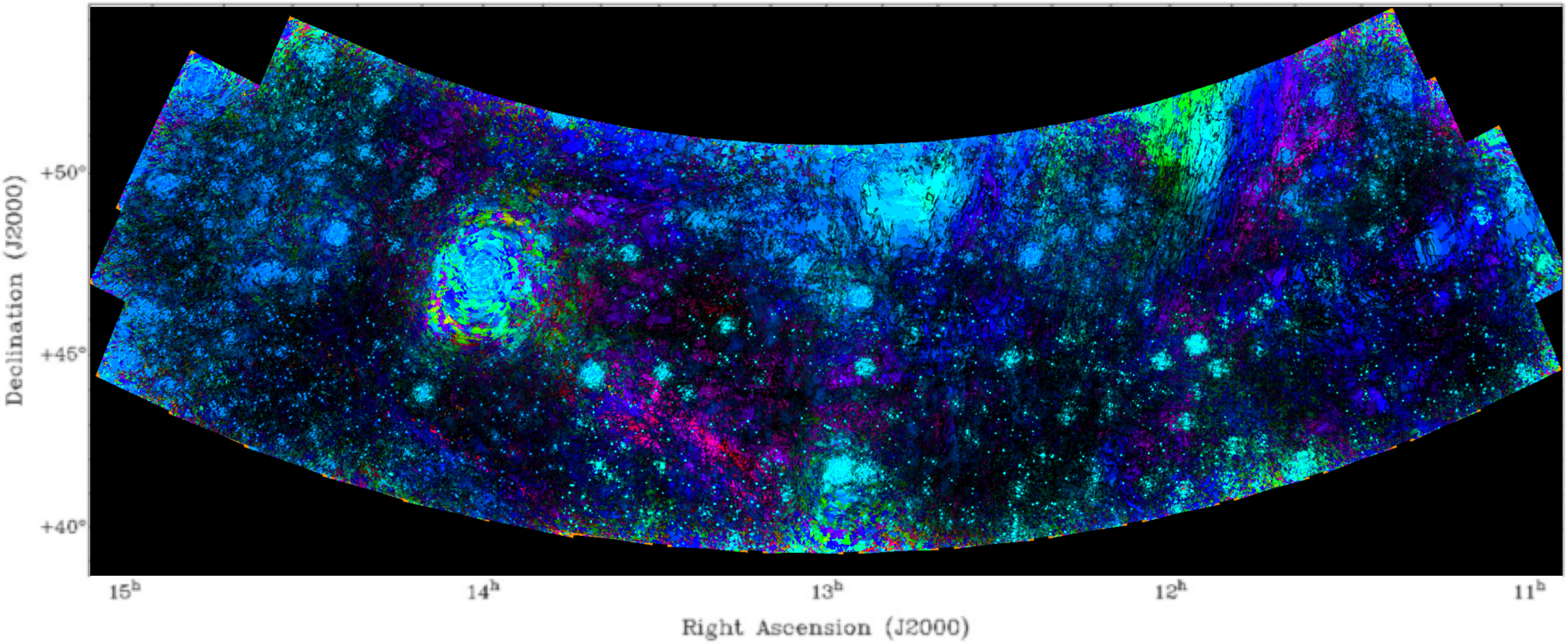
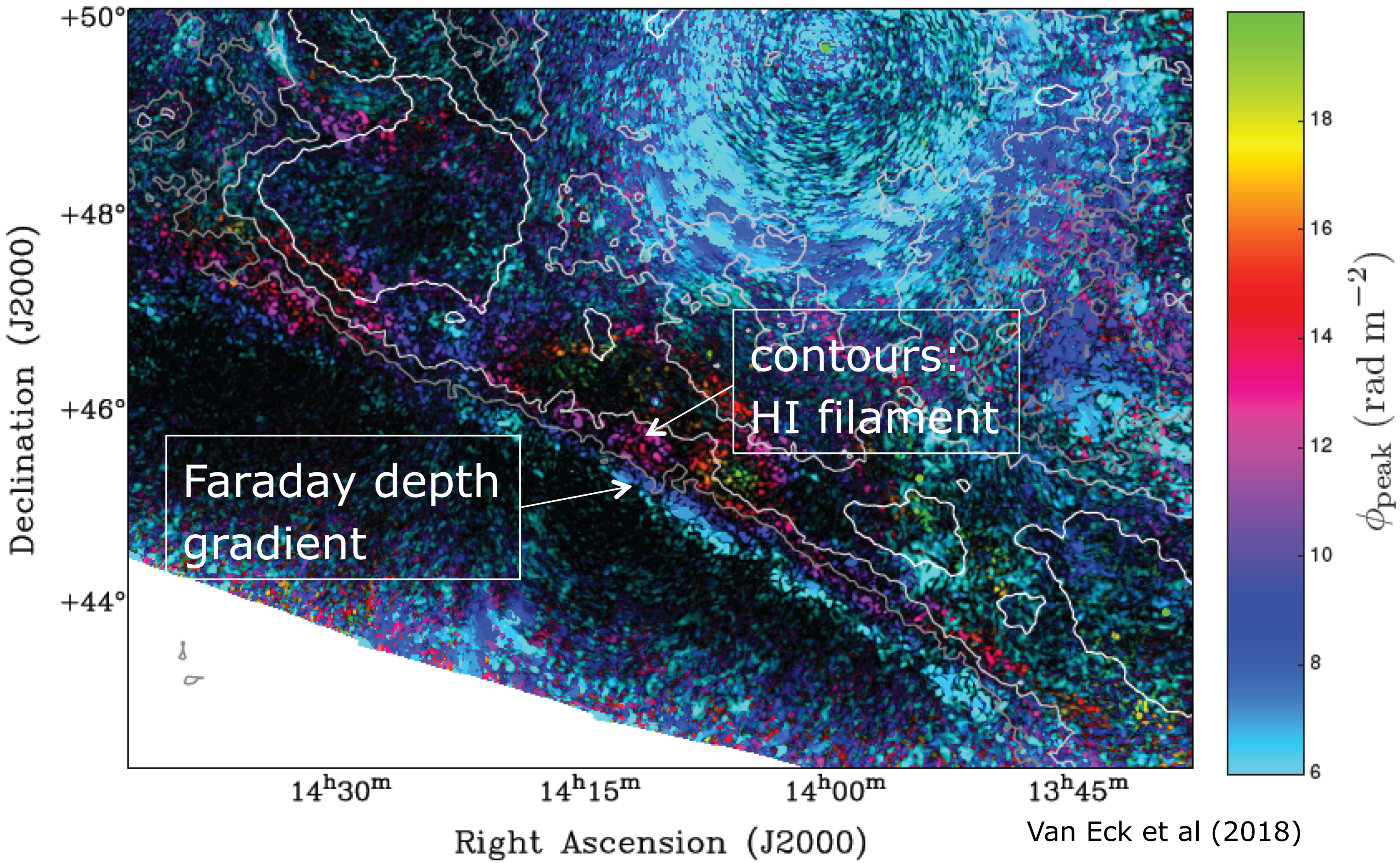


Van Eck et al (2018)

Neutral hydrogen filament with ionized edge?



Van Eck et al (2018)

Summary

- Faraday Tomography of low-frequency diffuse synchrotron radiation probes the **local Galactic magnetic field**
- Interstellar medium components seem **intricately connected** in detail: ionized medium, neutral medium and magnetic fields
- High-polarized emission regions at low frequencies come from **neutral gas clouds**

PhD and postdoc positions at Radboud University to be advertised soon:

Topics:

- extreme broadband Faraday Tomography of the Milky Way
- Bayesian modeling of the Galactic magnetic field
- using optical starlight polarimetry to probe turbulent Galactic magnetic fields
- 3D Galactic dust models

Interested? Talk to me!