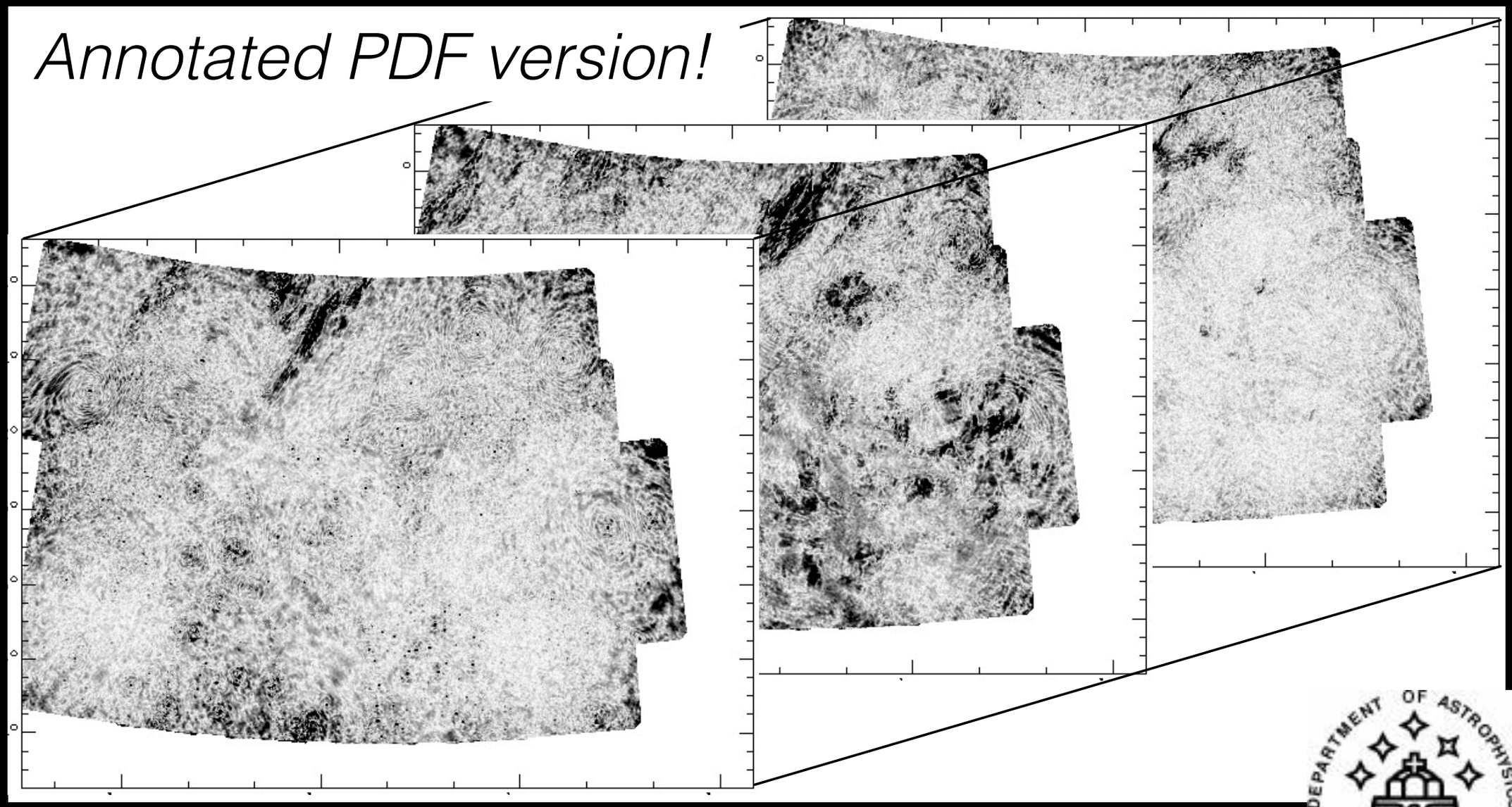
Faraday Tomography of the local ISM with LOFAR



Cameron Van Eck

4 April 2017

Detecting Magnetic Fields

Here's the processes involved:

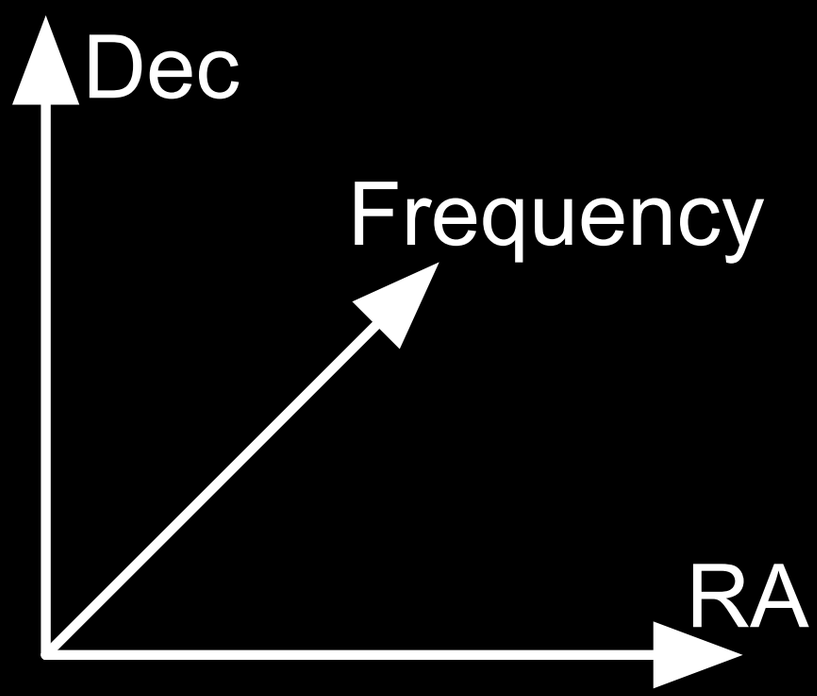
- cosmic rays + magnetic field =
  polarized synchrotron emission

- polarization + free electrons + magnetic field =
  Faraday rotation

$$\text{Change in polarization} \propto \lambda^2 \underbrace{\int_0^d n_e \vec{B} \cdot \vec{dl}}_{\text{Faraday depth, } \phi}$$

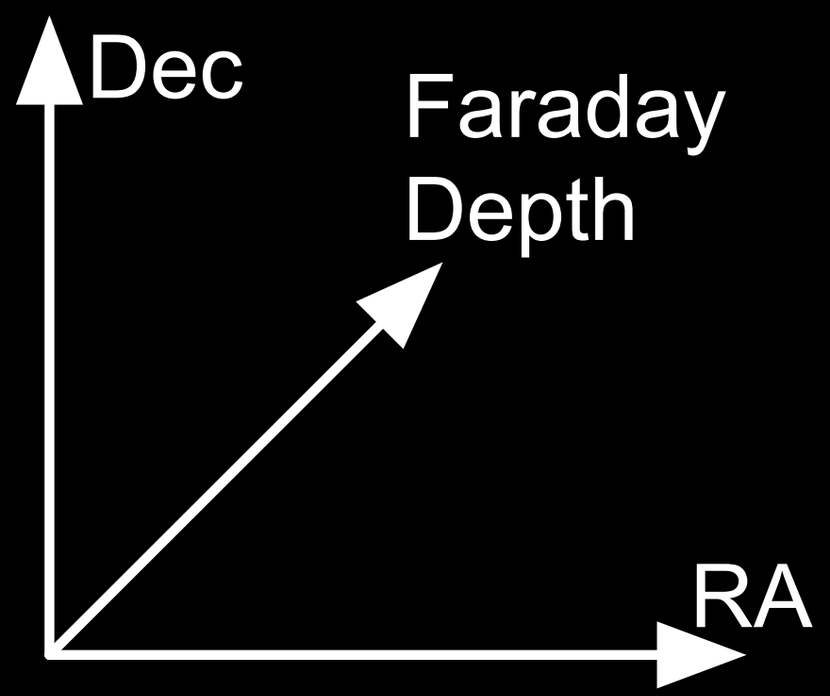
Faraday Tomography

- Broad-band radio polarization cubes can be transformed into Faraday depth cubes:



$$P(\lambda^2) \xrightarrow{\mathcal{F}} P(\phi)$$

We can look at the polarized signal at different Faraday depths!

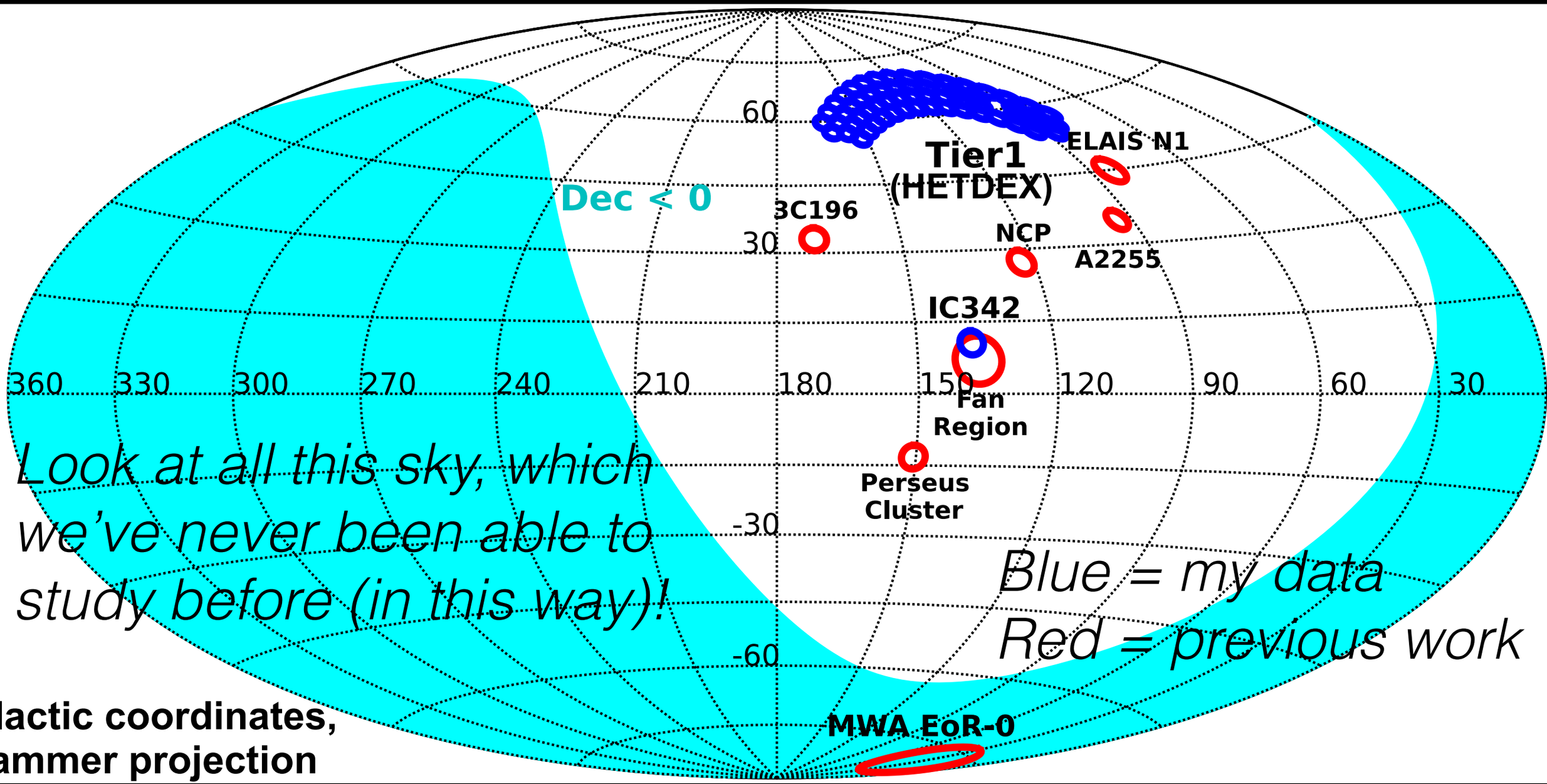


Polarization processing

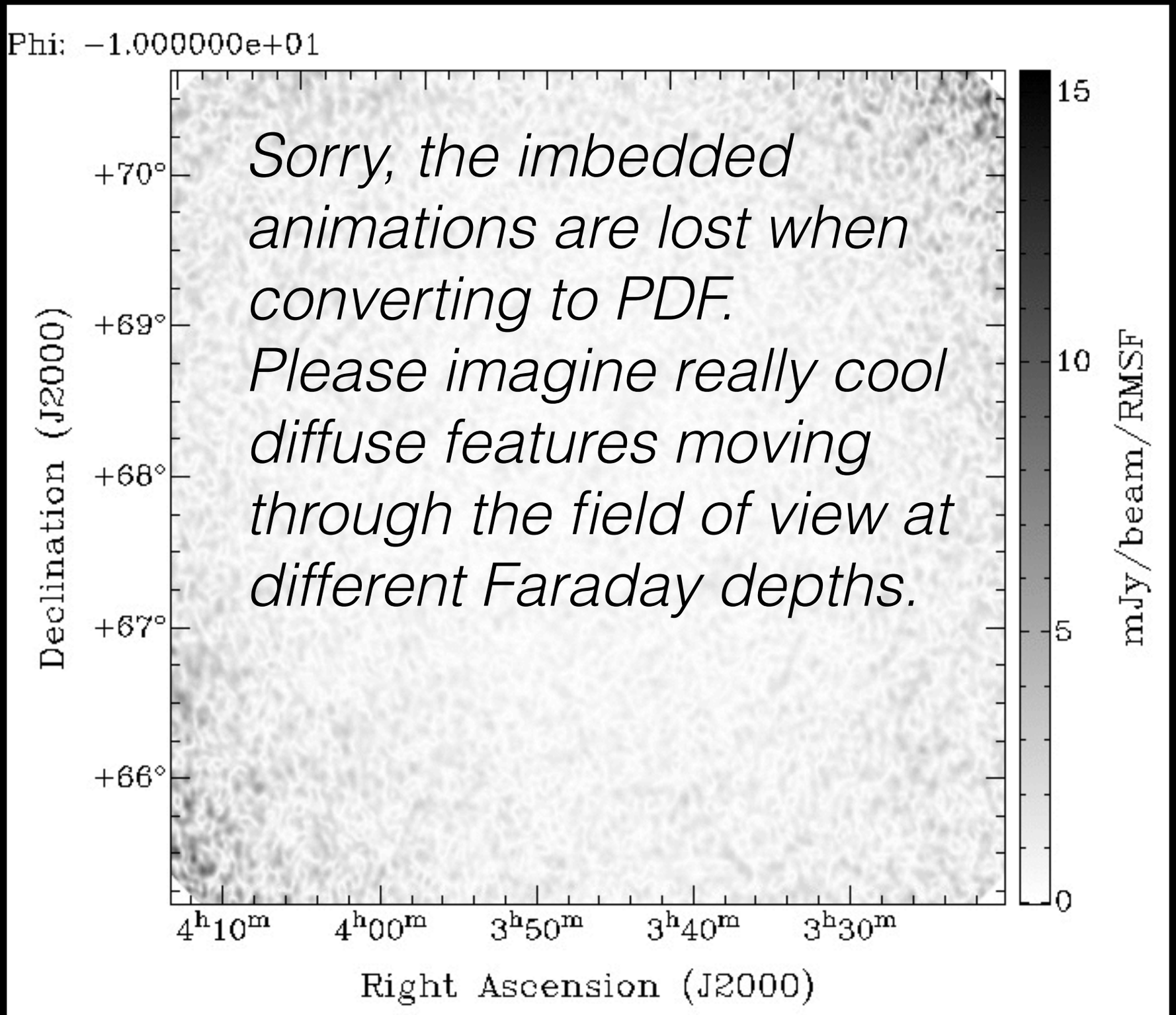
- Data requirements: 2+ channels/SB
- Apply correction for ionospheric Faraday rotation:
  RMextract (by Maaijke Mevius)
  + BBS/NDPPP Correct step
- Image Stokes Q/U for each channel
- RM synthesis: pyRMsynth

It's not that computationally intensive. Maybe your data is suitable? Ask me how to do it!

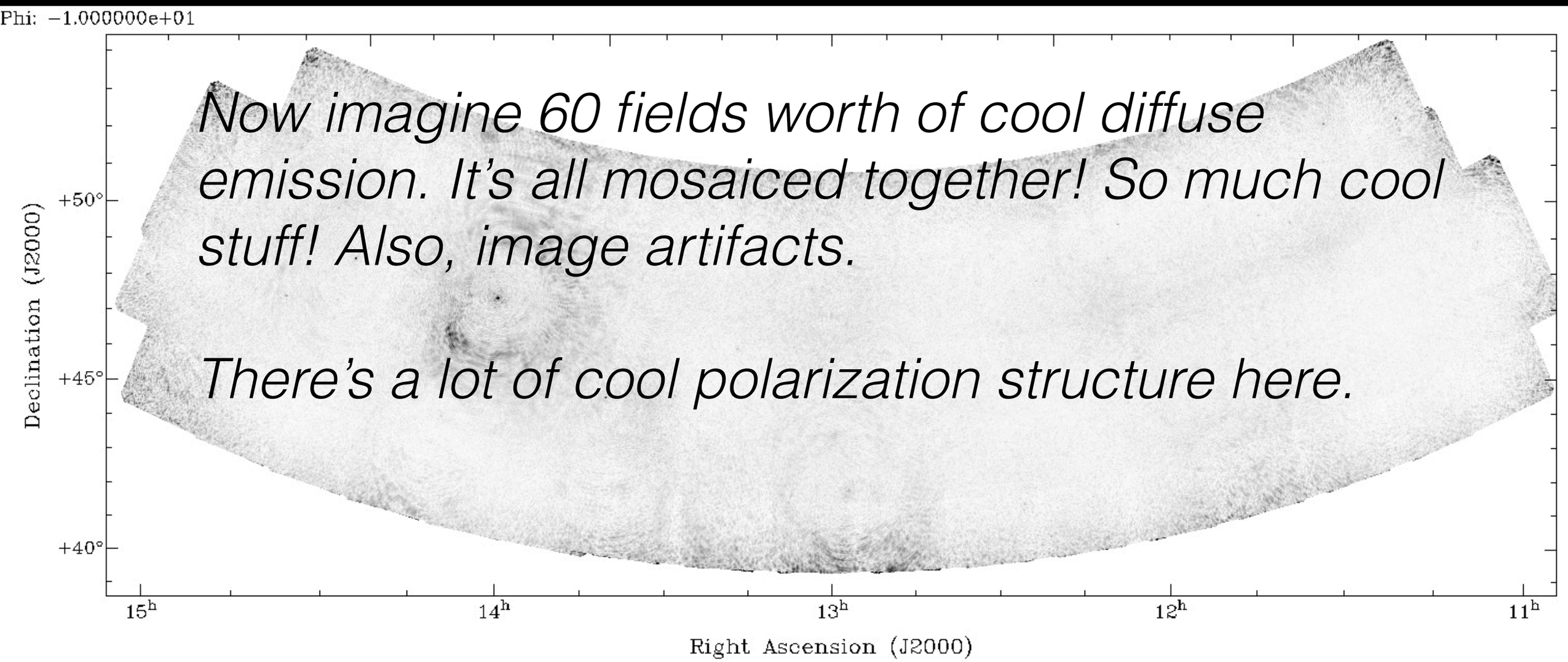
The (high-resolution) Faraday sky to date



The IC342 field



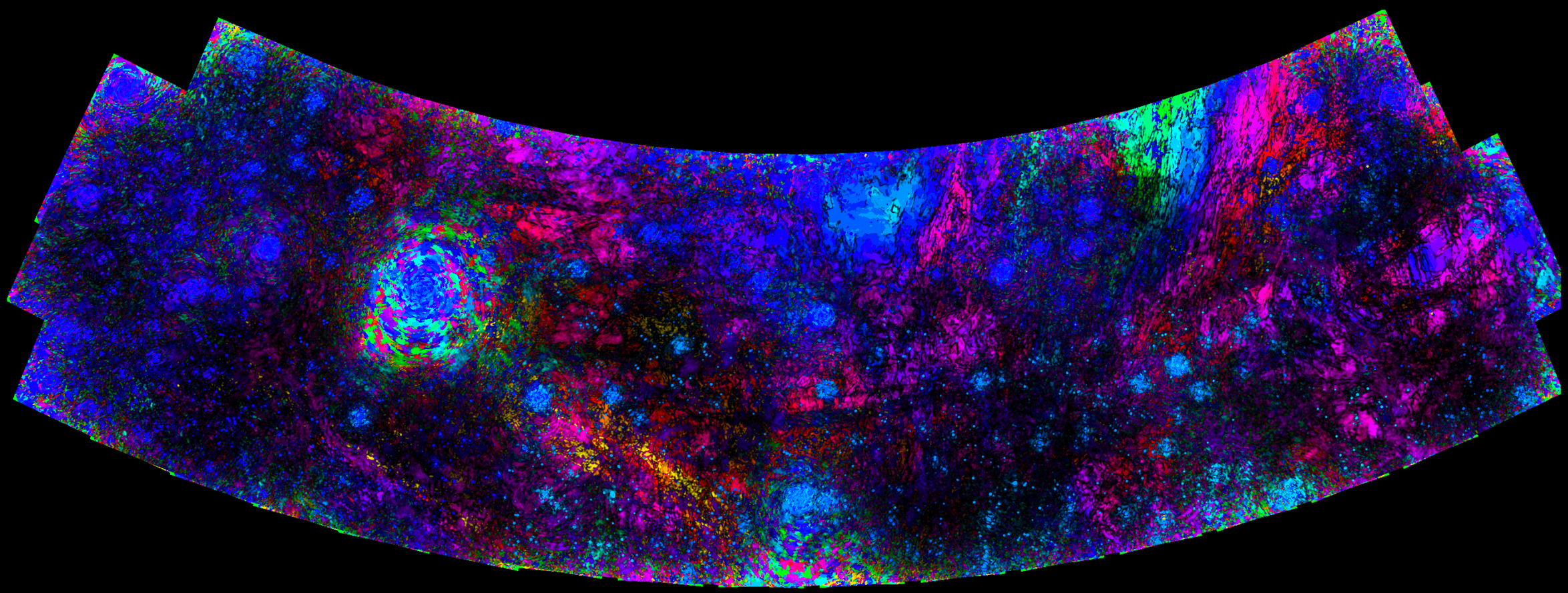
Tier 1 HETDEX



Now imagine 60 fields worth of cool diffuse emission. It's all mosaiced together! So much cool stuff! Also, image artifacts.

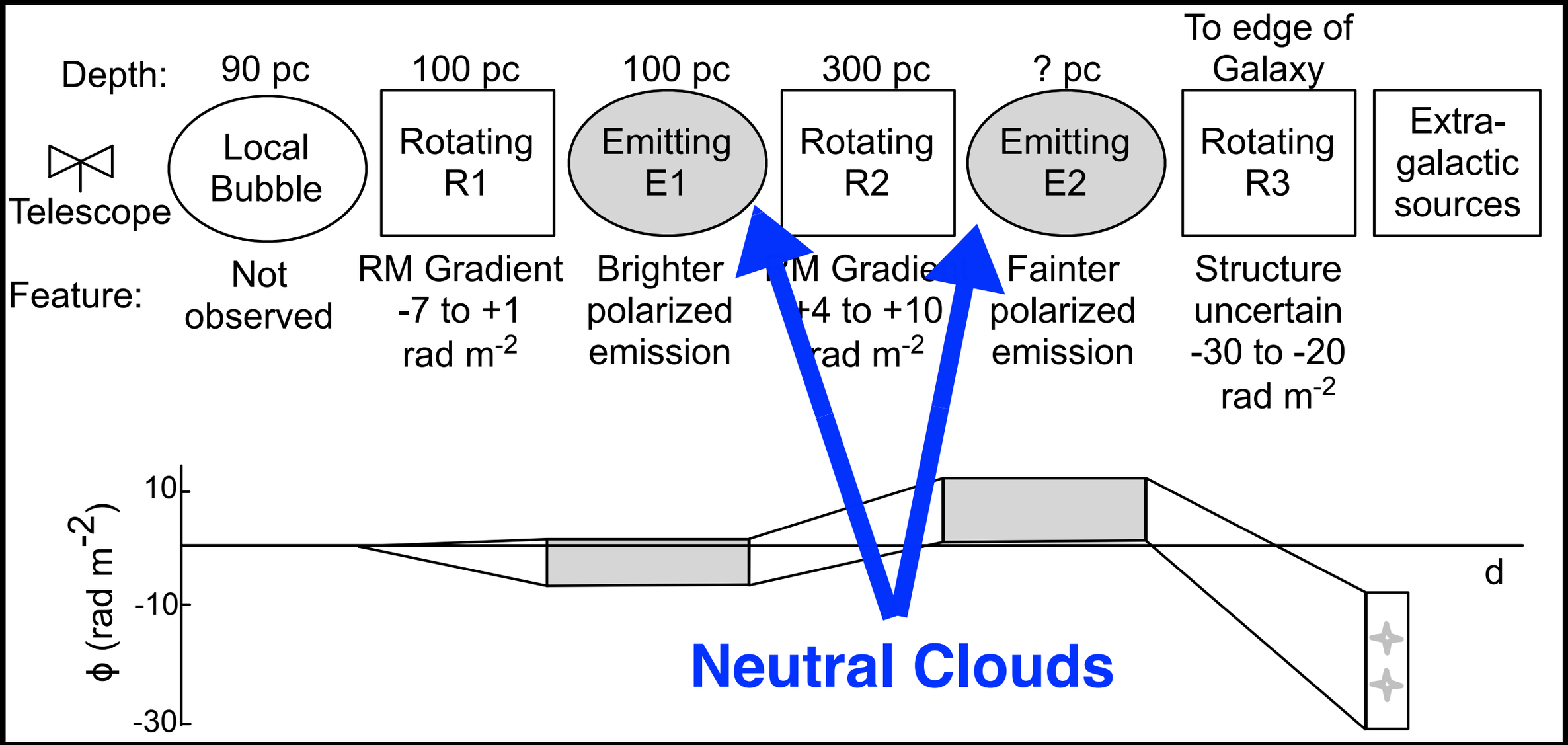
There's a lot of cool polarization structure here.

Tier 1 HETDEX



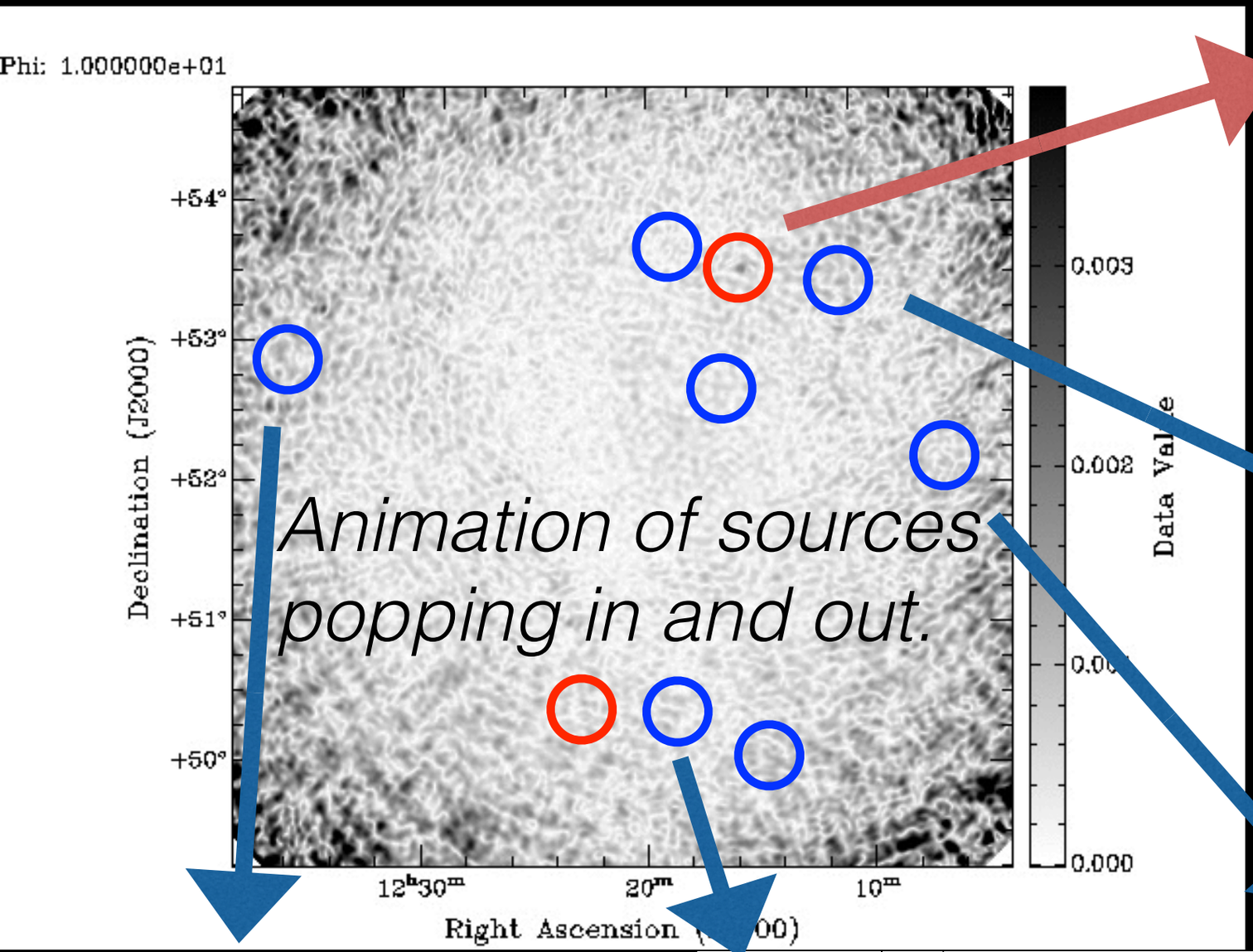
Colourized! Hue = Faraday depth, brightness = flux
That green-to-purple gradient is very interesting.

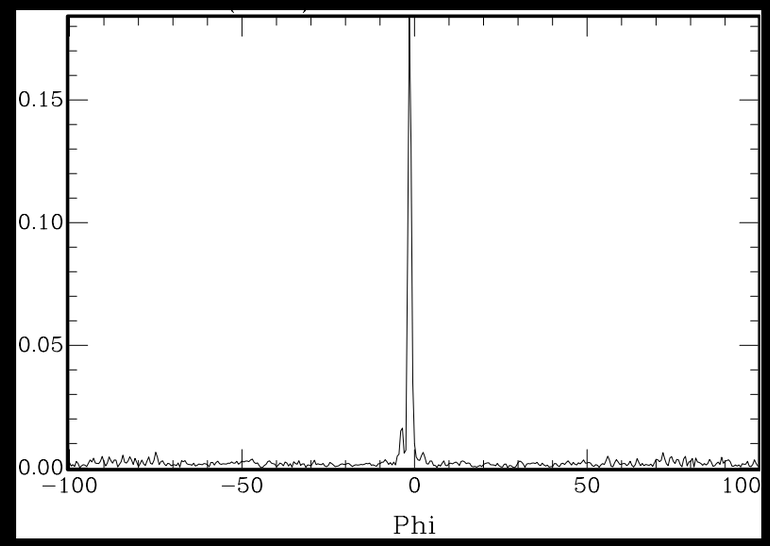
Modelling the IC342 field

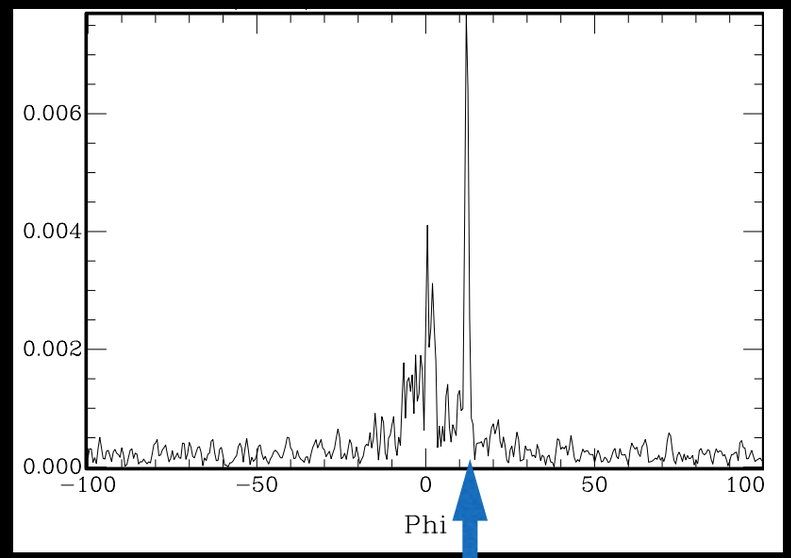


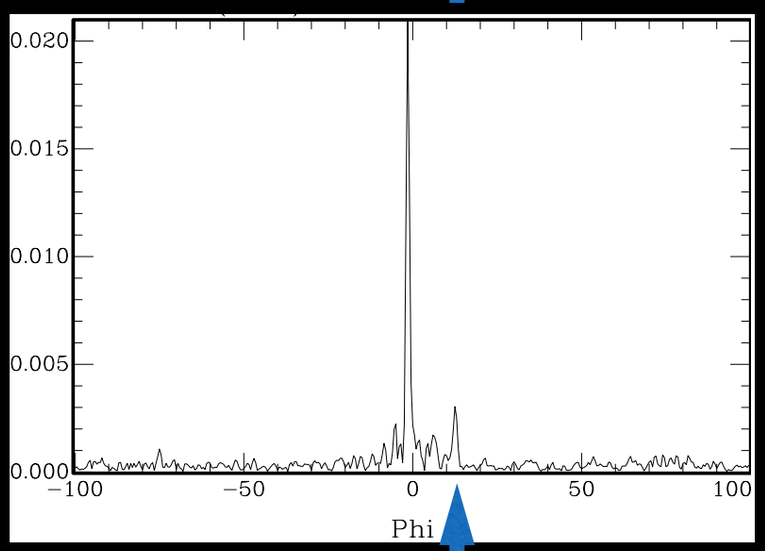
It's not just pretty, it's scientific. I did some modelling of the line-of-sight using the polarization data.

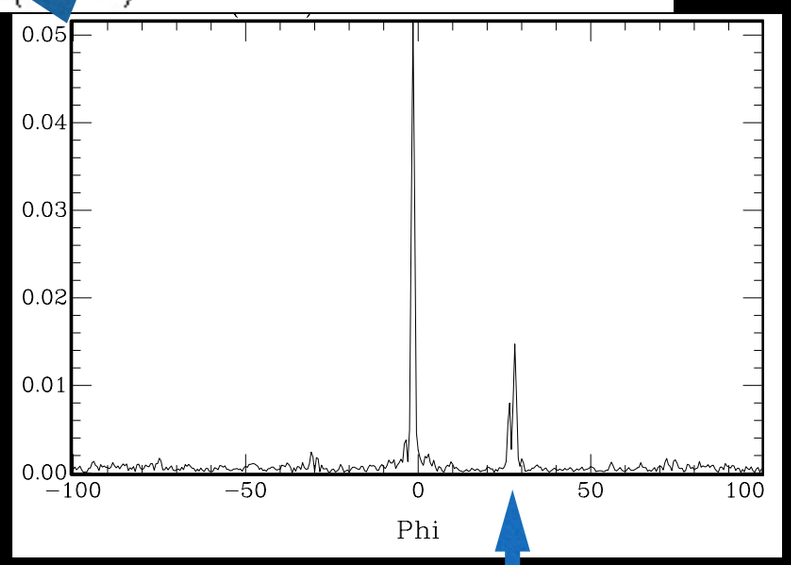
Point sources

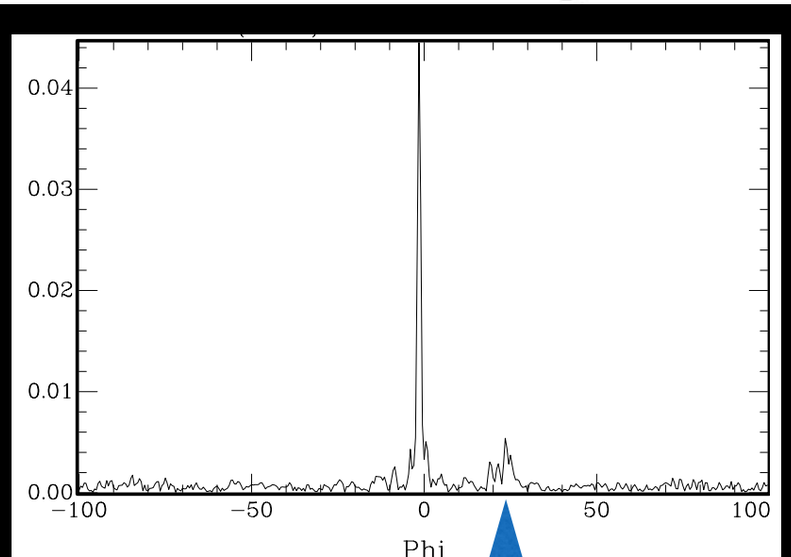












Take-home points

- LOFAR is amazingly sensitive to diffuse emission
- While polarization leakage is still unsolved, we can still get great polarization data out of LOFAR
- This is a very new way of exploring magnetic fields in our Galaxy, so there's still a lot to figure out.

For more information:

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Astronomy & Astrophysics

Faraday tomography of the local interstellar medium with LOFAR: Galactic foregrounds towards IC 342★

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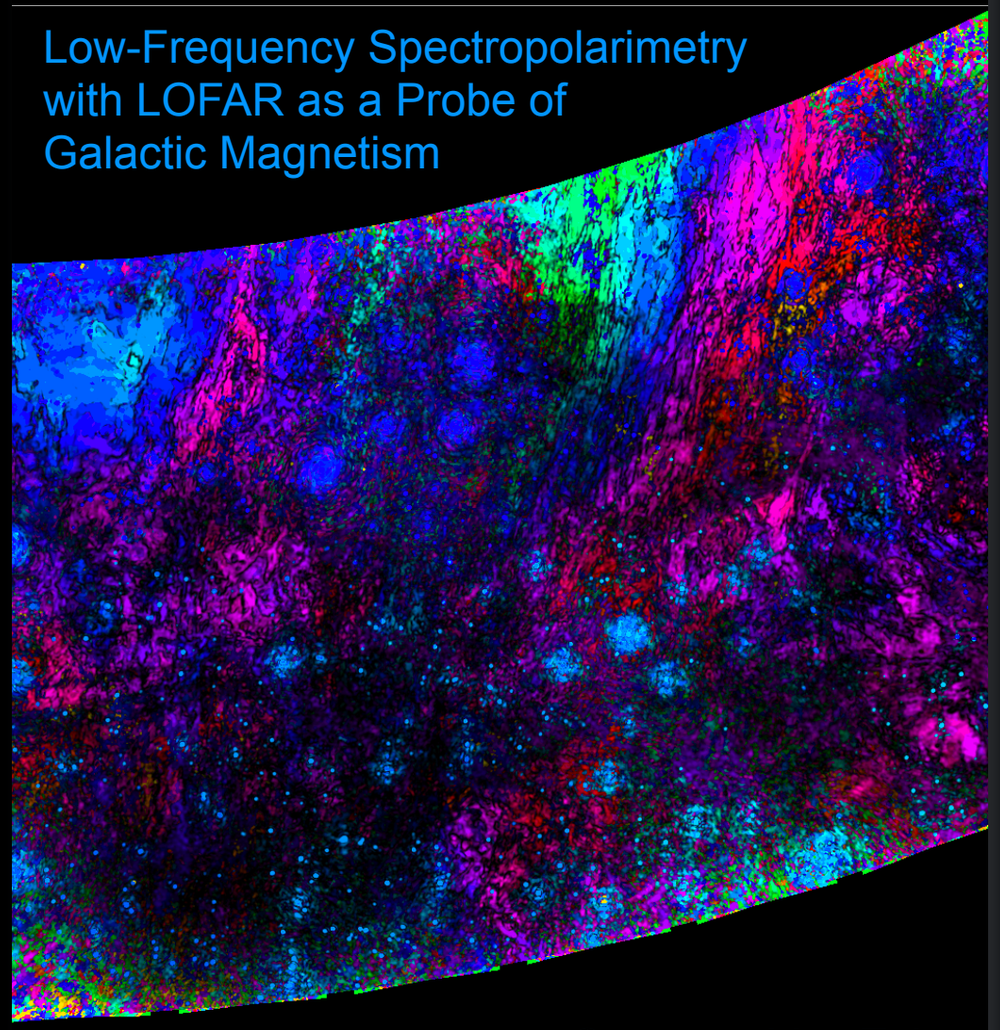
Exploring the Threefold Invisible Universe:

Low-Frequency Spectropolarimetry with LOFAR as a Probe of Galactic Magnetism



Cameron Van Eck

Coming this summer:
my PhD thesis