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faculty of mathematics and natural sciences
kapteyn astronomical institute
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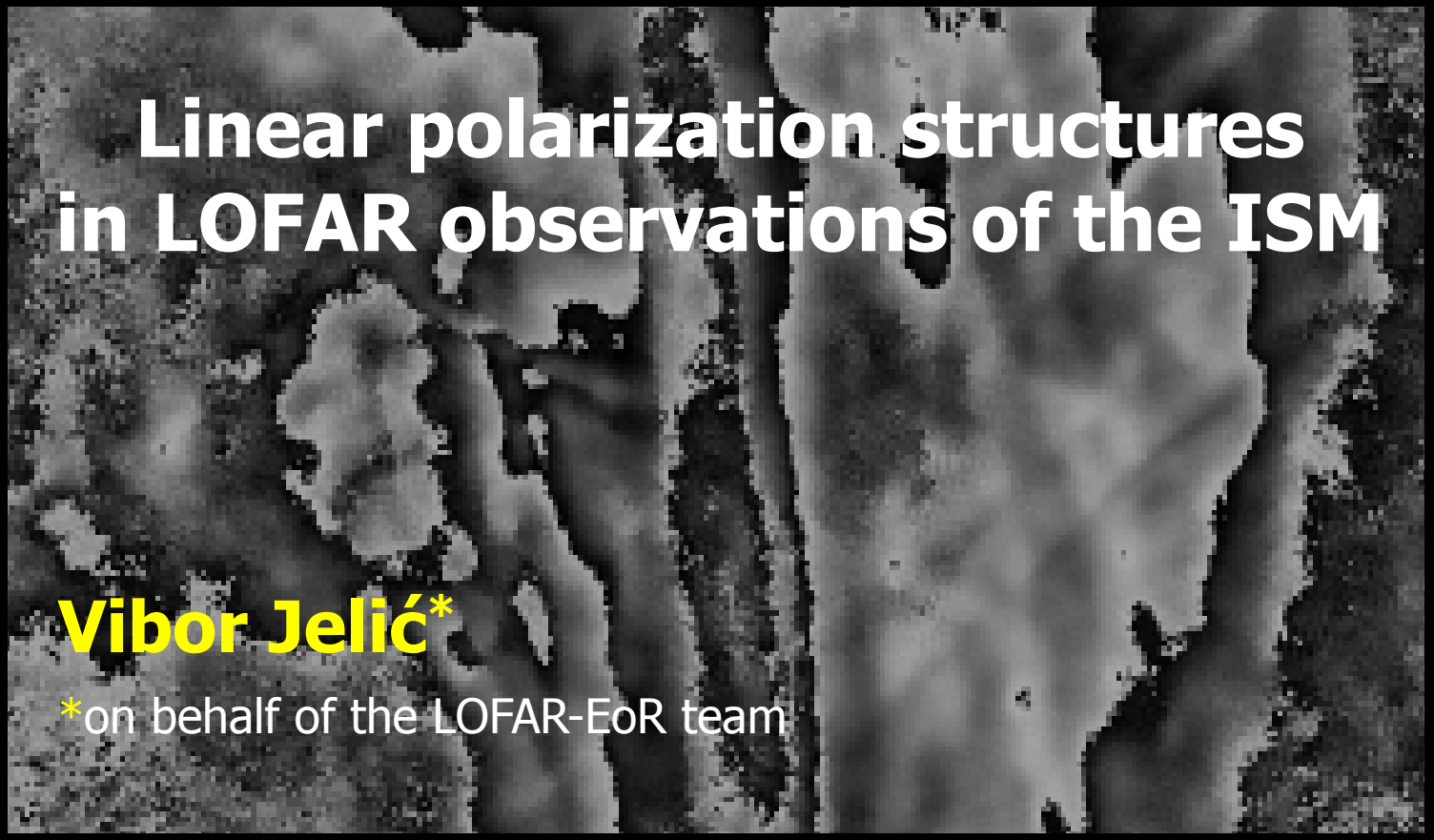
LOFAR

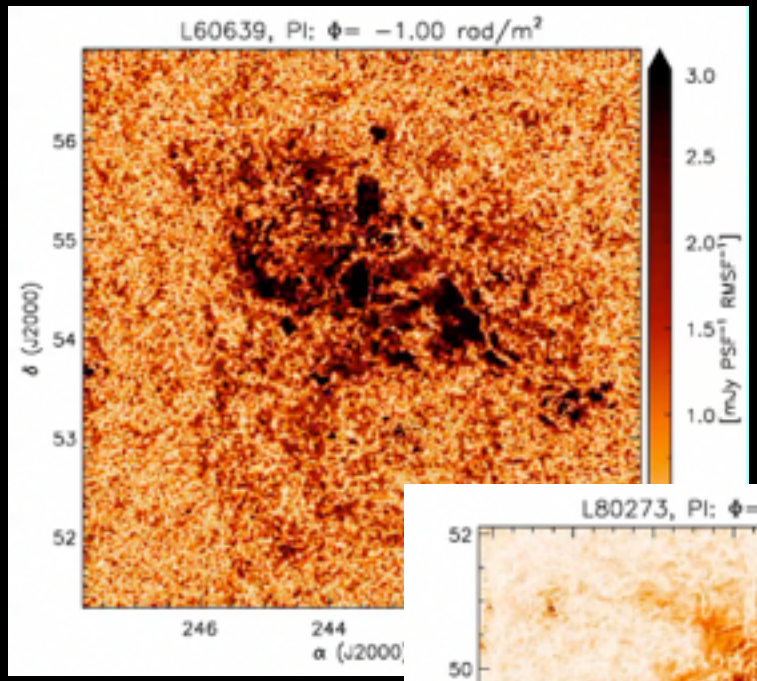


Linear polarization structures in LOFAR observations of the ISM

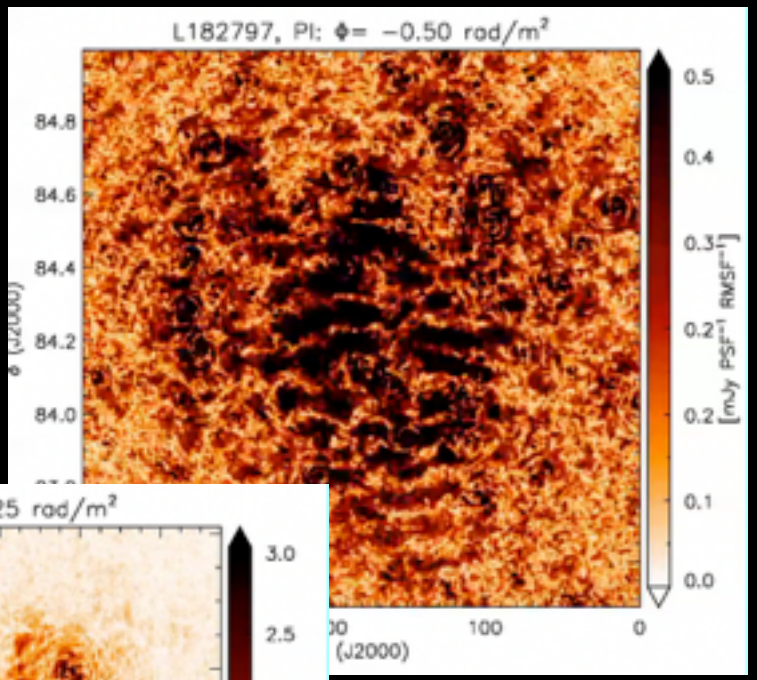
Vibor Jelić*

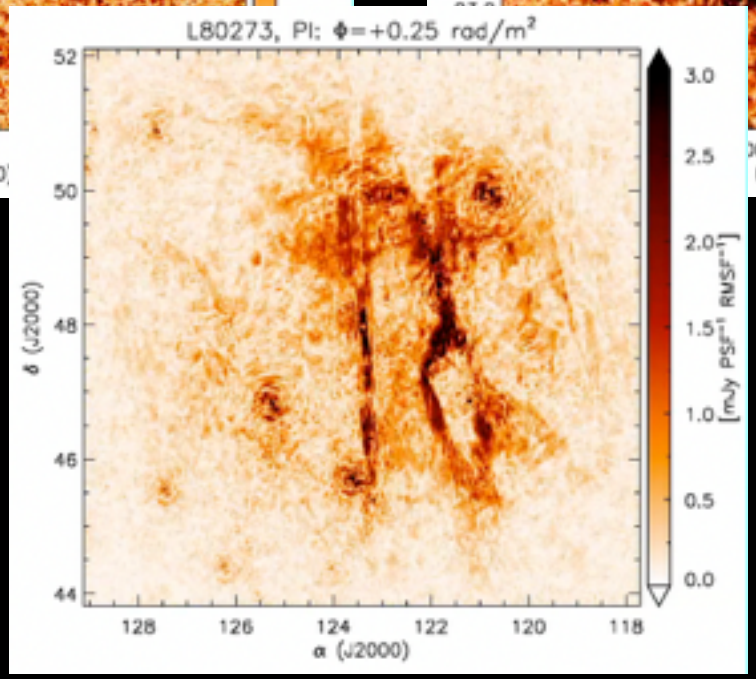
*on behalf of the LOFAR-EoR team

ELAIS-N1 field
from -10 to +13 rad/m^2
brightness temperature: 1 - 4 K



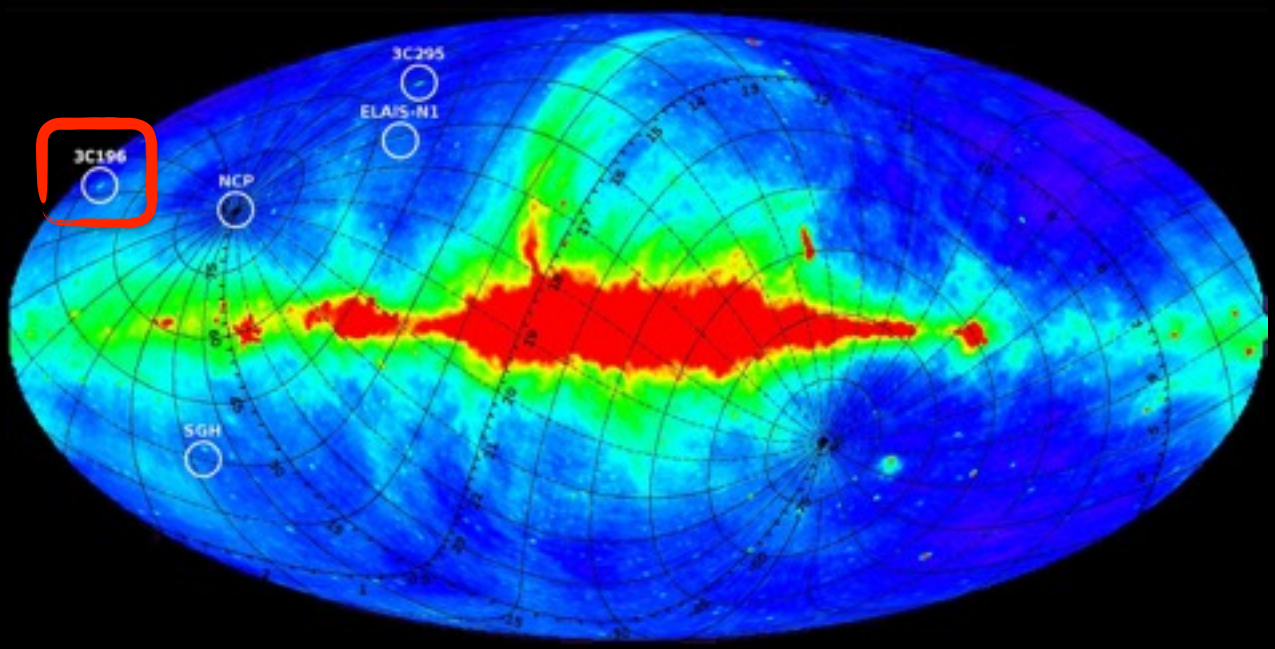
NCP field
from -45 to +5 rad/m^2
brightness temperature: mK to a few K





3C196 field
from -3 to +8 rad/m^2
brightness temperature: 5 - 15 K

3C196 field



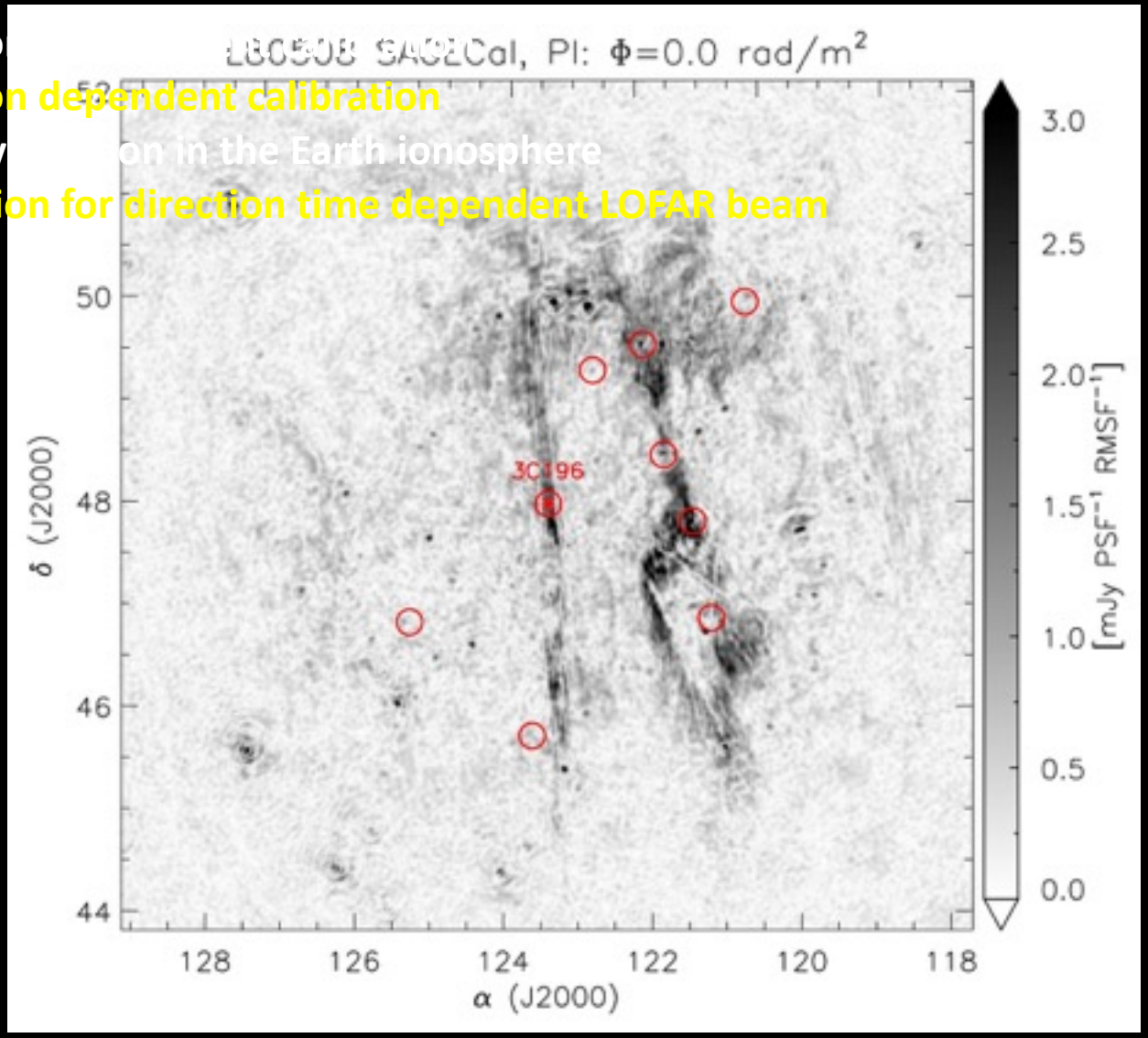
Observation ID	Start Time [UTC]
L79324	06-Dec-2012 22:41:05
L80273	12-Dec-2012 22:17:30
L80508	16-Dec-2012 22:01:46
L80897	21-Dec-2012 22:42:46
L192832	15-Dec-2013 23:06:40
Phase centre (J2000.0)	$08^h13^m36.07^s$, $+48°13'02.58''$
Frequency range	115 – 189 MHz
Spectral resolution	3.2 kHz
Integration time	2 s
Observing time	8(6) hours in 2012 (2013)

Jelic et al. , submitted to A&A

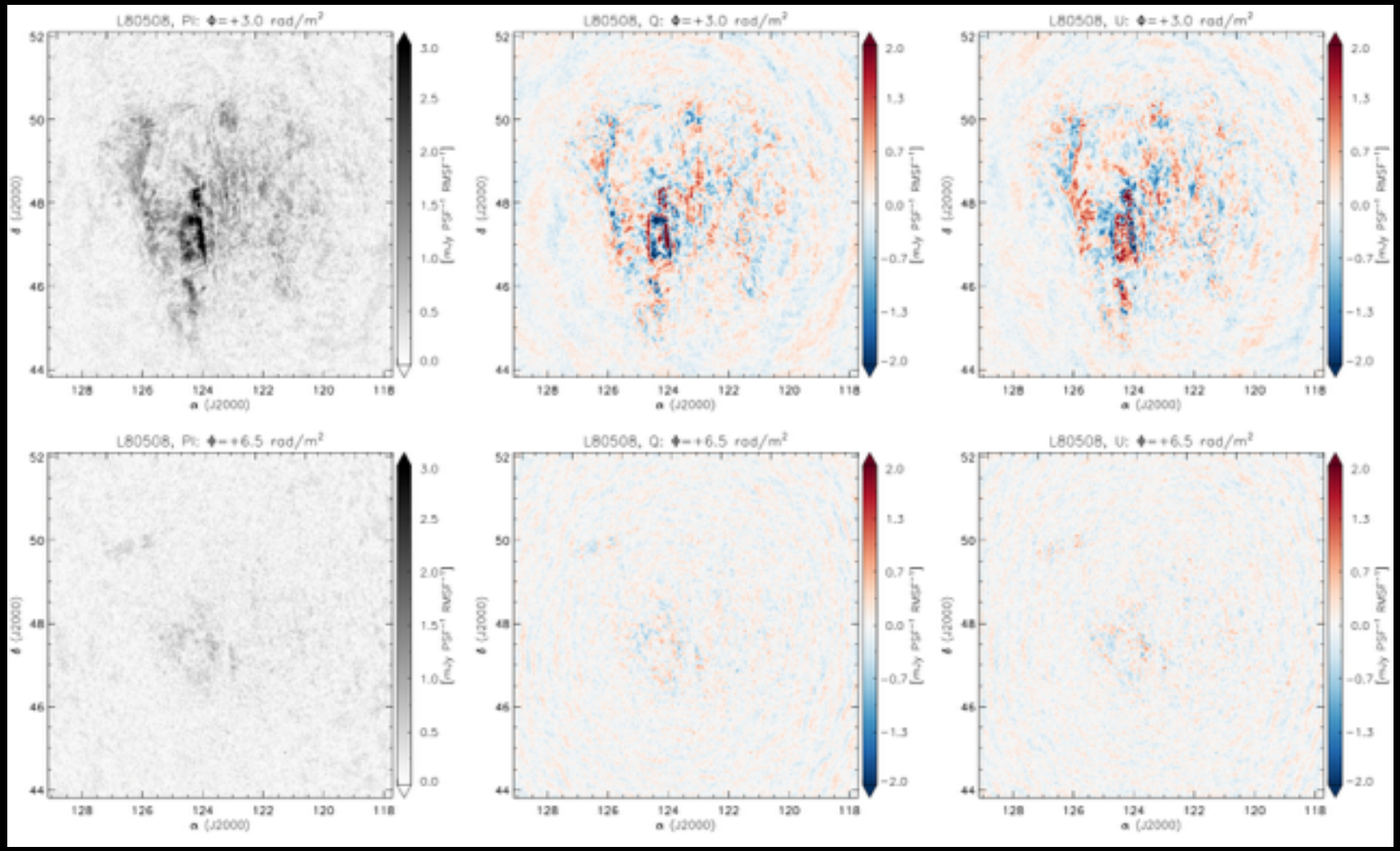
Observation ID	PI	Q	U
	[μJy PSF^{-1} RMSF^{-1}]		
L79324	83	123	127
L80273	67	101	102
L80508	70	111	105
L80897	75	118	114
L192832	73	111	115

LOFAR-EoR observations

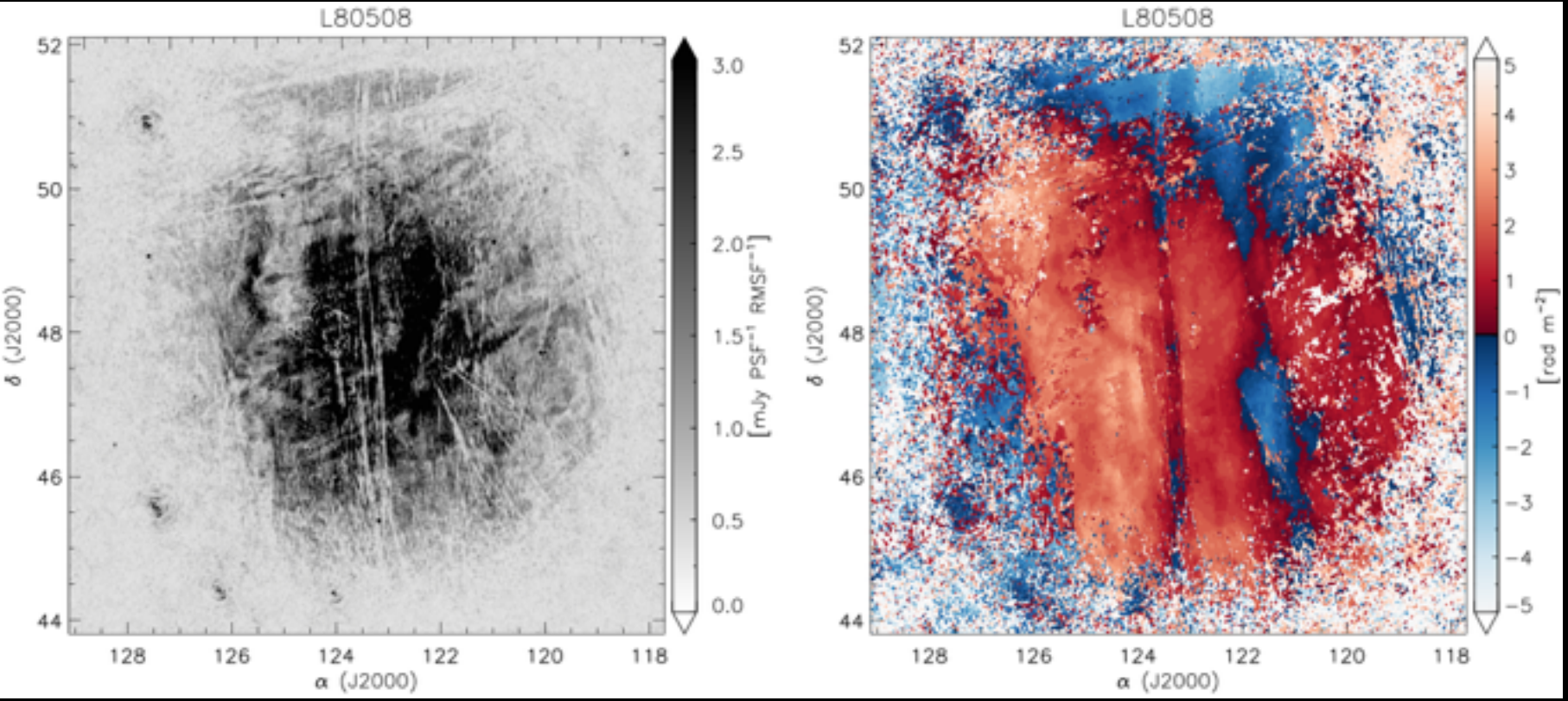
- direction
- direction dependent calibration
- Faraday on in the Earth ionosphere
- correction for direction time dependent LOFAR beam



3C196 field


L80508, PI: Φ=+3.0 rad/m²
L80508, Q: Φ=+3.0 rad/m²
L80508, U: Φ=+3.0 rad/m²
L80508, PI: Φ=+6.5 rad/m²
L80508, Q: Φ=+6.5 rad/m²
L80508, U: Φ=+6.5 rad/m²
α (J2000)
δ (J2000)
[mJy psf⁻¹ RMSF⁻¹]

3C196 field

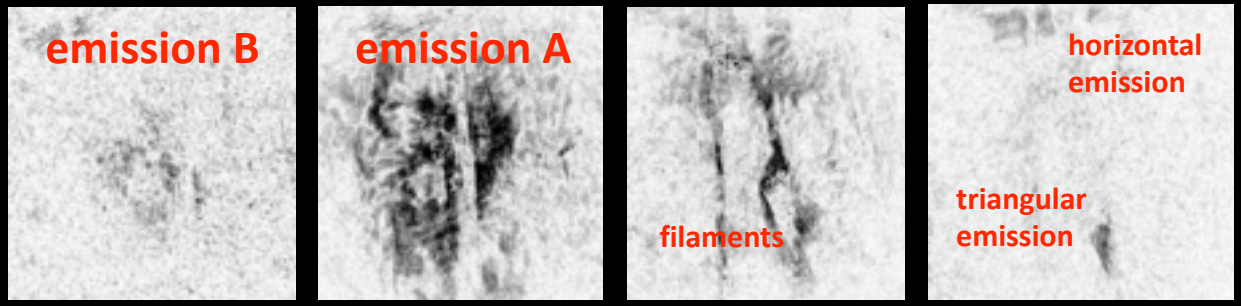


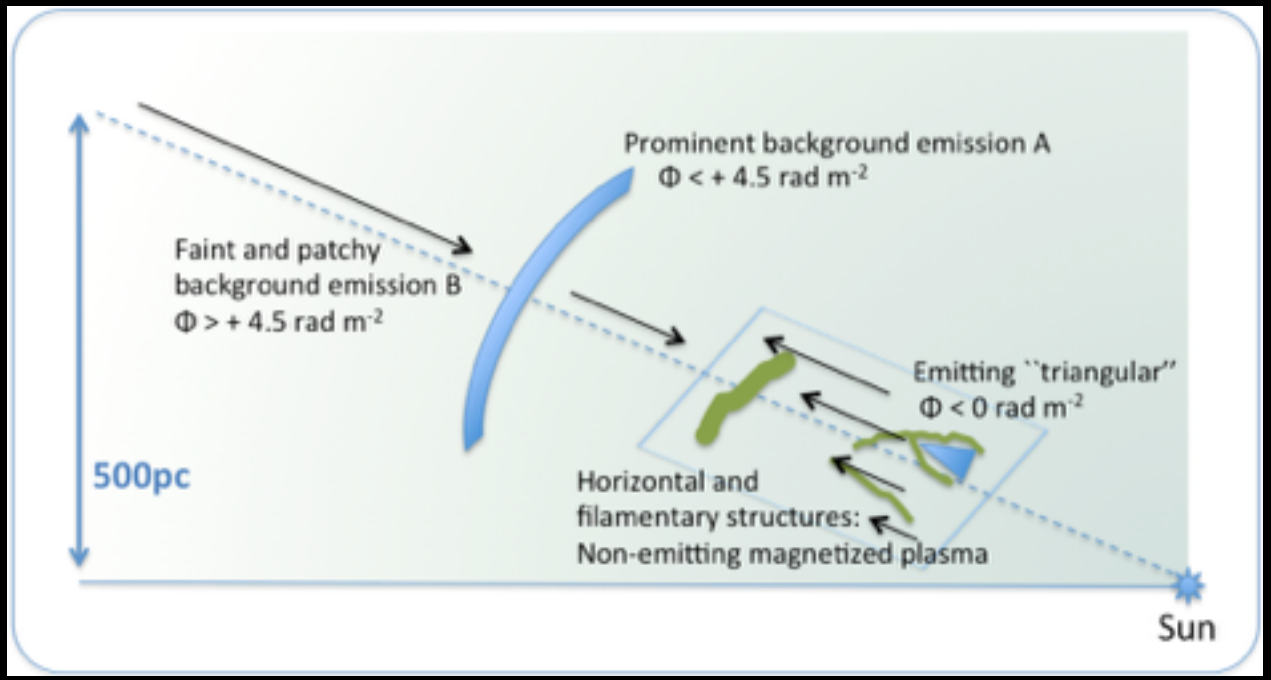
from -5 to +5 rad/m²

brightness temperature: 1-10 K

What do we see ?!

3C196 field: cartoon





3C196 field: constrains on $B_{||}$

PULSAR 434 ms; +2.7 rad/m^2; 11.3 pc cm^{-3}
(J. Hessels & V. Kondratiev)

$$\frac{\langle B_{\parallel} \rangle}{[\mu\mathrm{G}]} = \frac{\mathrm{RM\ [rad\ m^{-2}]}}{0.812\ \mathrm{DM\ [pc\ cm^{-3}]}}$$

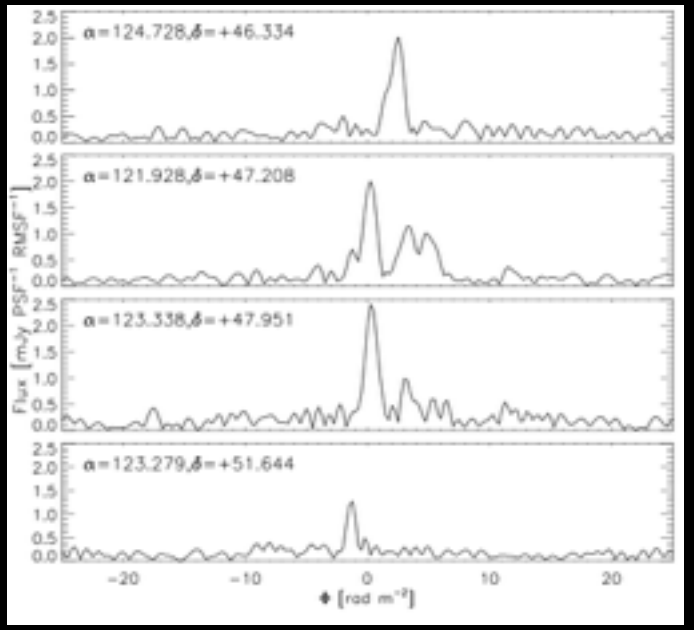
$$\langle B_{\parallel} \rangle = 0.3 \pm 0.1\ \mu\mathrm{G}$$

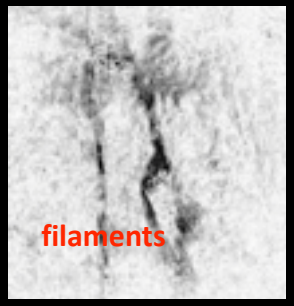
H alpha map (Finkbeiner 2003)

$$\sigma_{\langle B_{\parallel} \rangle} = \sqrt{\left(\frac{\sigma_{\langle \mathrm{RM} \rangle}}{0.81\,\langle n_e \rangle L}\right)^2 + \left(\frac{\langle \mathrm{RM} \rangle\,\sigma_{\langle n_e \rangle}}{0.81\,\langle n_e \rangle^2 L}\right)^2}$$

$$\sigma_{\langle B_{\parallel} \rangle} \simeq 0.2\ \mu\mathrm{G}$$

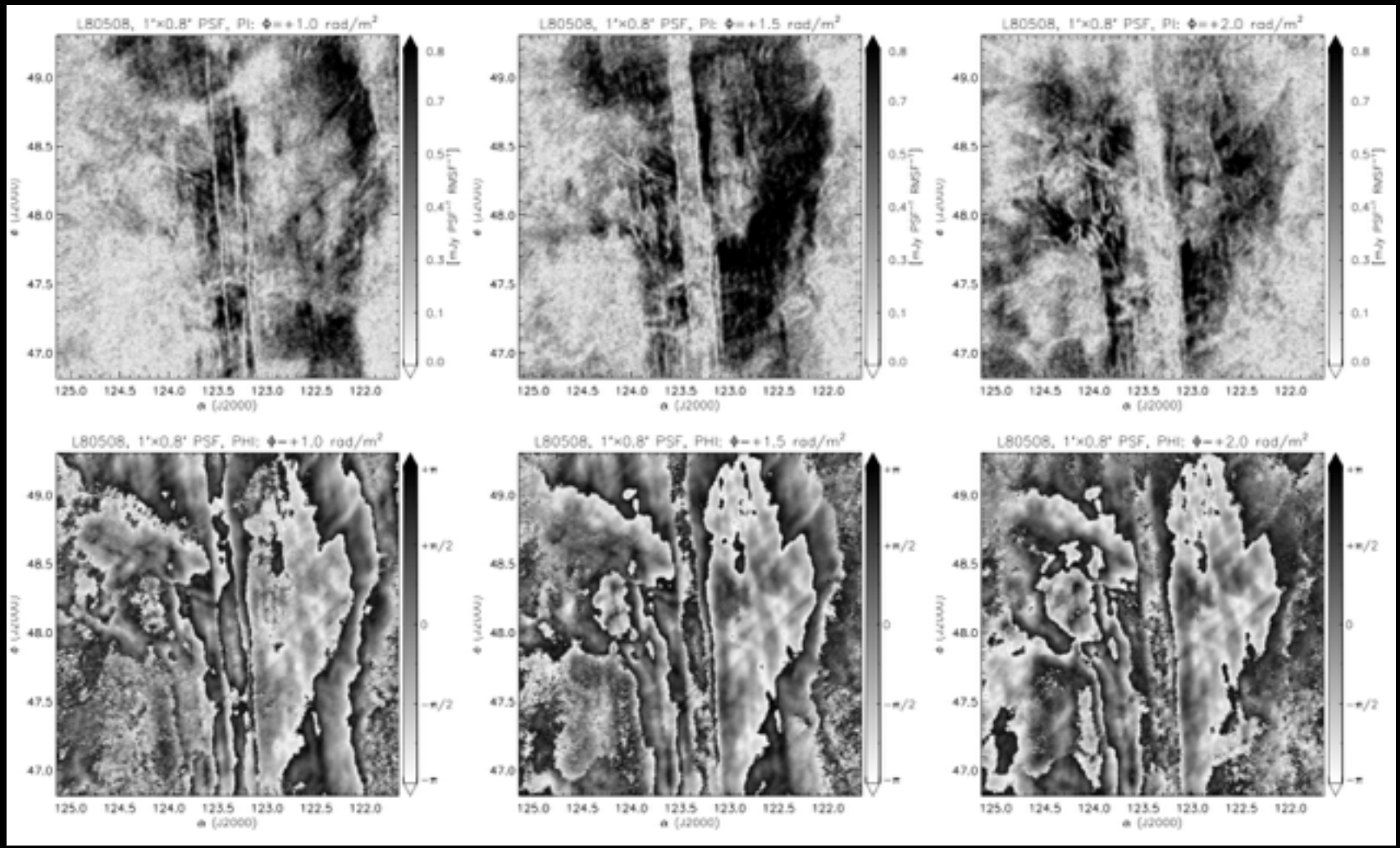
magnetic field reversal(s)



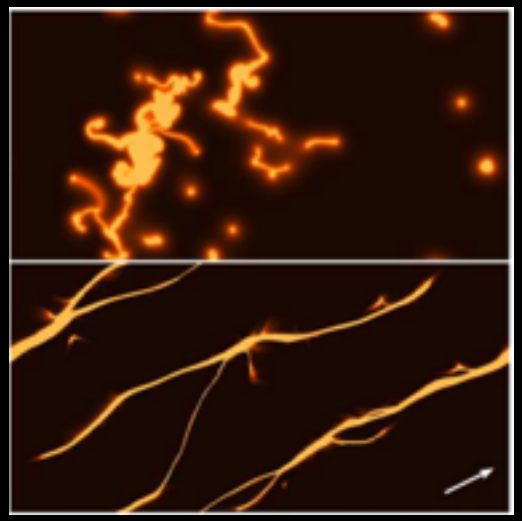


$$n_e B_{\parallel} > 6.2\ \mathrm{cm^{-3}}\,\mu\mathrm{G}$$

3C196 field: depolarization canals



3C196 field



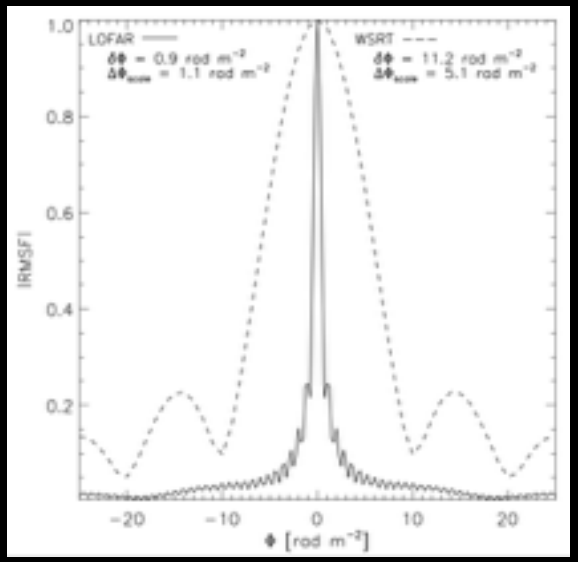
MHD simulations of ISM: thermal instabilities with (an)isotropic conduction (and weak magnetic field)

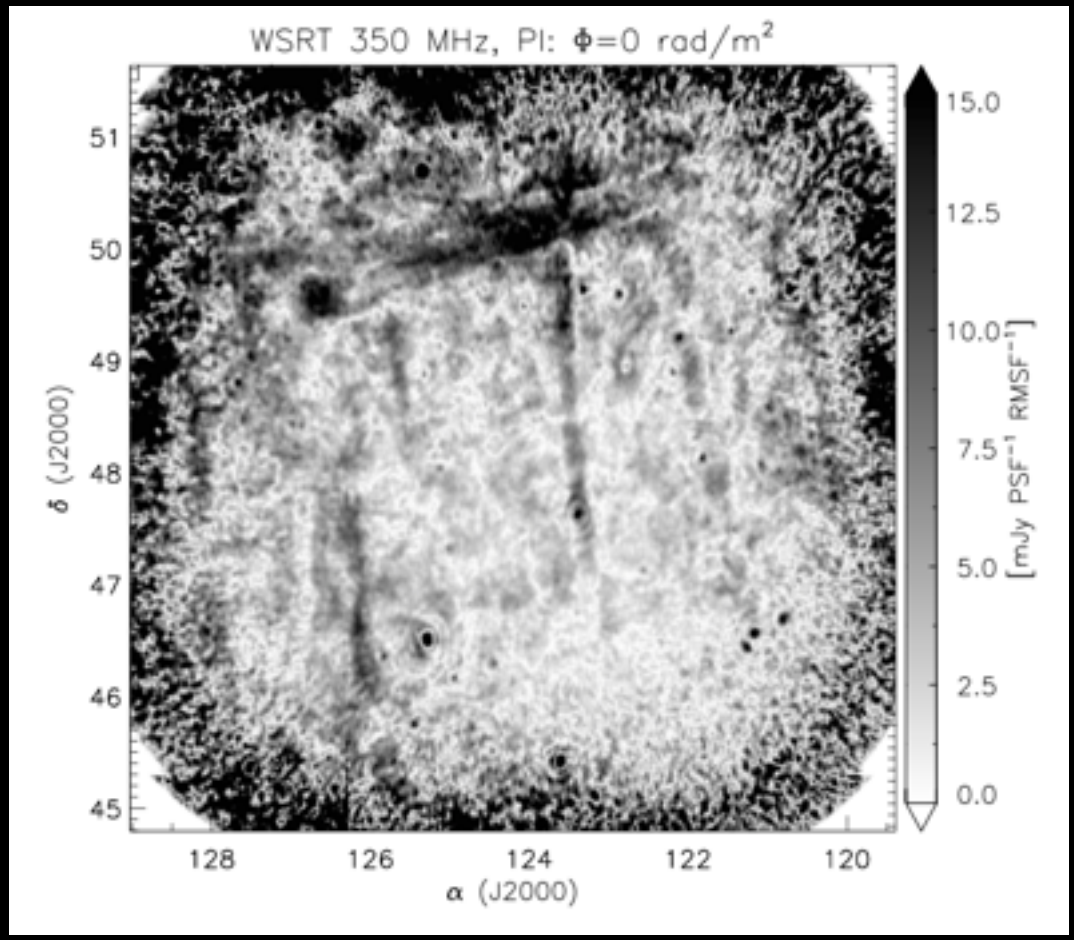
Choi & Stone (2013)

trails in the ISM caused by close-by fast moving stars

Observations at higher frequencies

WSRT @ 350 MHz


LOFAR
WSRT
|RMSF|
Φ [rad m⁻²]


WSRT 350 MHz, PI: Φ=0 rad/m²
δ (J2000)
α (J2000)
[mJy PSF⁻¹ RMSF⁻¹]

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LOFAR

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- rich morphology of polarized emission detected with LOFAR (115 - 175 MHZ)
- brightness temperature of emission much higher than expected (a few K)
- each field has different polarization horizon
- probed ISM mostly close by (<200 pc), within the Local Bubble
- discovery of many filamentary structures and linear depolarization canals (thermal instabilities with anisotropic conduction; trails of stars,…)
- LOFAR an excellent instrument to study ISM with an exquisite resolution in Faraday depth (1 rad/m^2)
  - to fully understand observed emission a multi-frequency study is needed combined with simulations

THANK YOU !