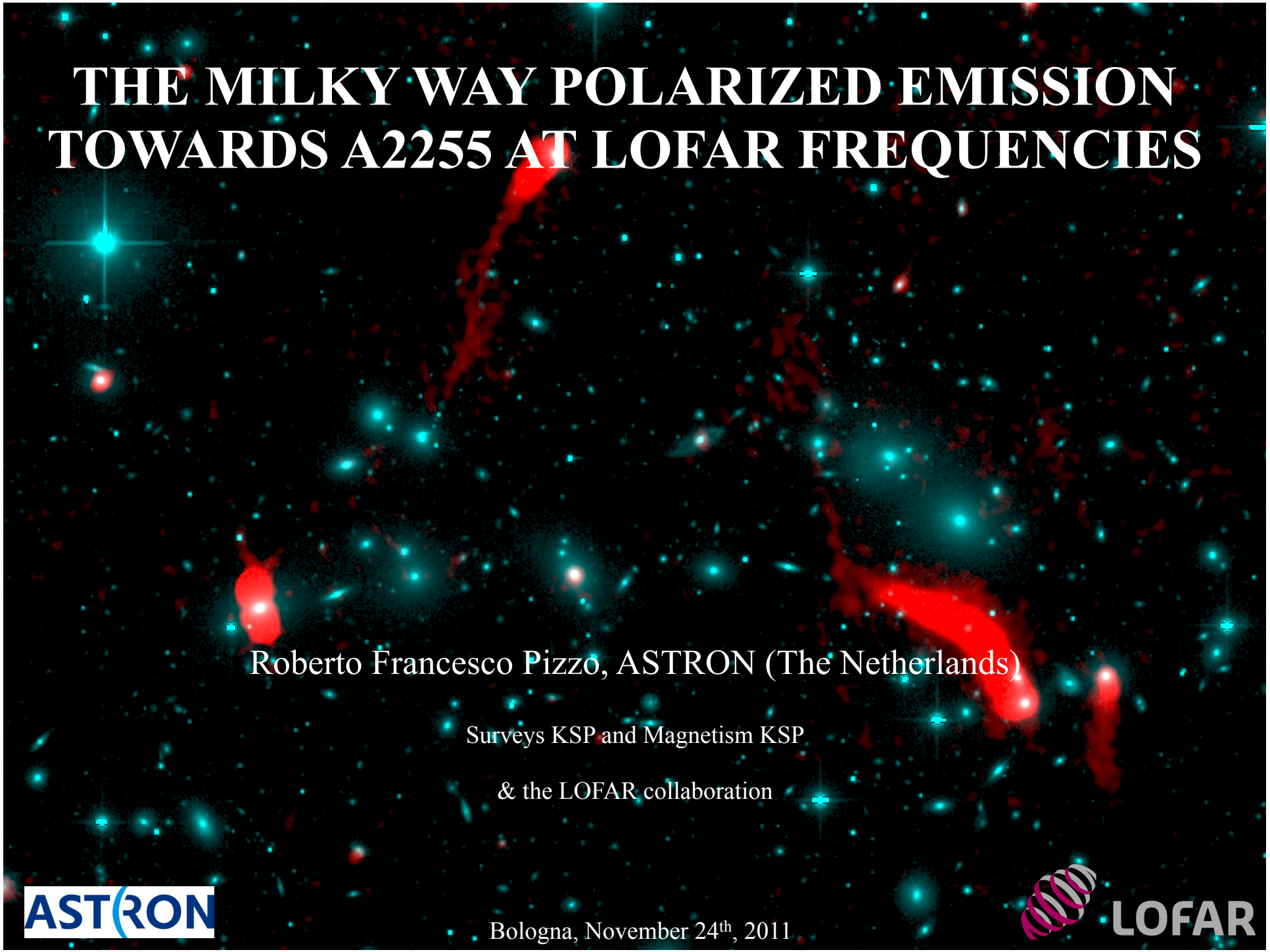
THE MILKY WAY POLARIZED EMISSION TOWARDS A2255 AT LOFAR FREQUENCIES



Roberto Francesco Pizzo, ASTRON (The Netherlands)

Surveys KSP and Magnetism KSP

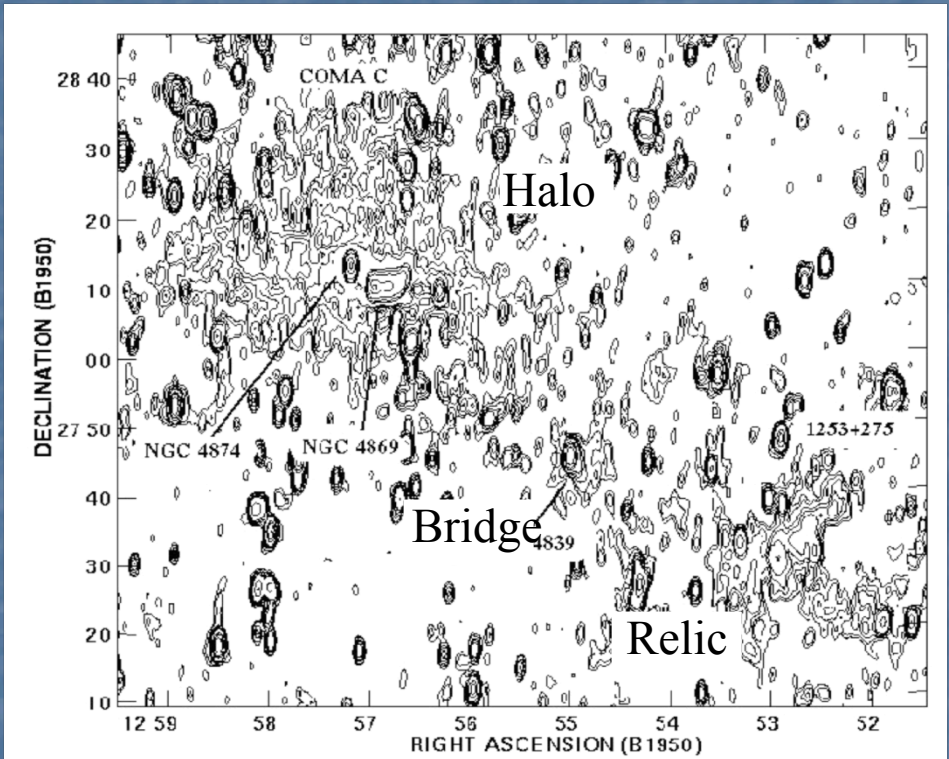
& the LOFAR collaboration

ASTRON

Bologna, November 24th, 2011

LOFAR

RADIO EMISSION FROM CLUSTERS: RADIO GALAXIES, HALOS, AND RELICS

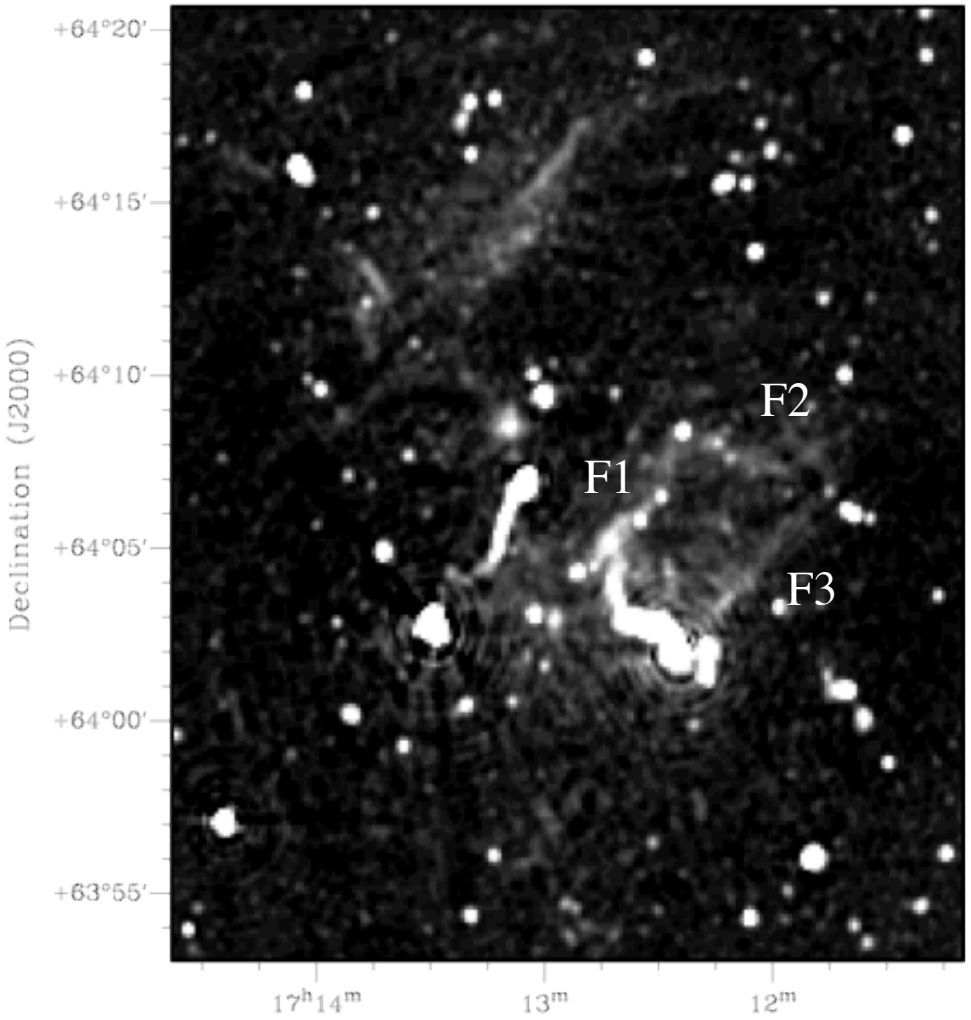


Coma cluster (92 cm, WSRT) Kim et al. 1989

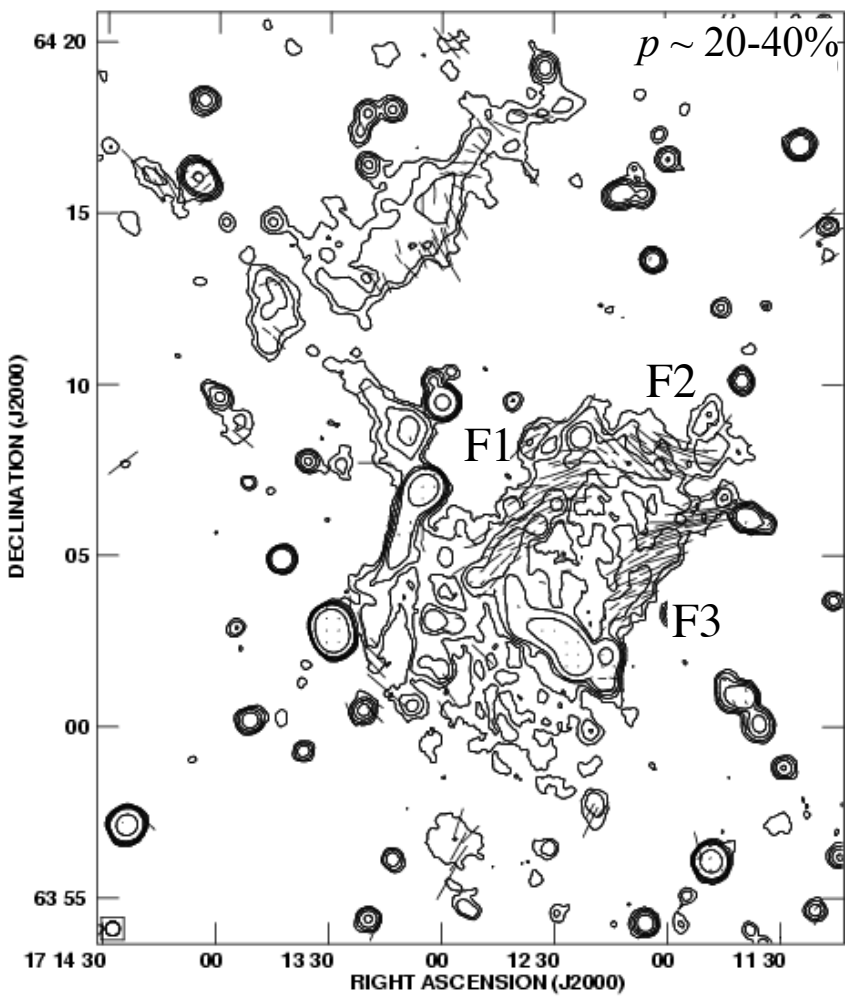
HALO:
- at the cluster center
- regular morphology
- steep spectrum ($\alpha < -1$, $S(\nu) \propto \nu^{\alpha}$), flattening towards the halo center
- unpolarized (< 10%)

RELIC:
- peripheral source
- elongated shape
- steep spectrum ($\alpha < -1$)
- highly polarized (20-40%)

SCIENCE CASE: ABELL 2255 (z = 0.08)



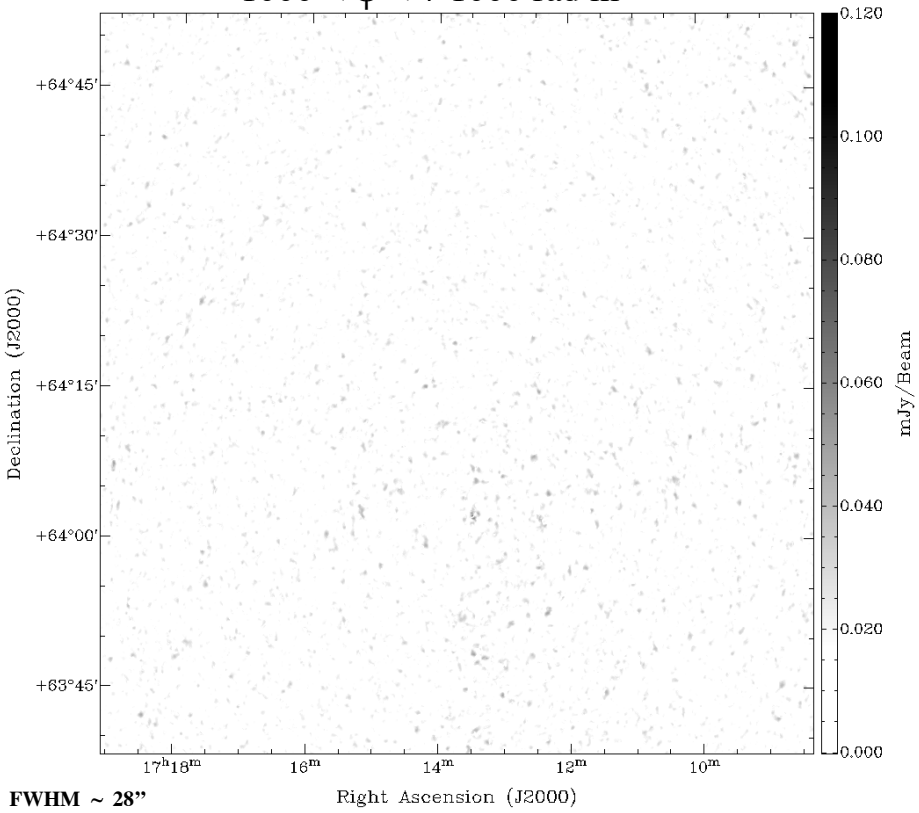
WSRT, Pizzo & de Bruyn 2009 ν = 1.2 MHz



VLA, Govoni et al. 2005 ν = 1.4 MHz

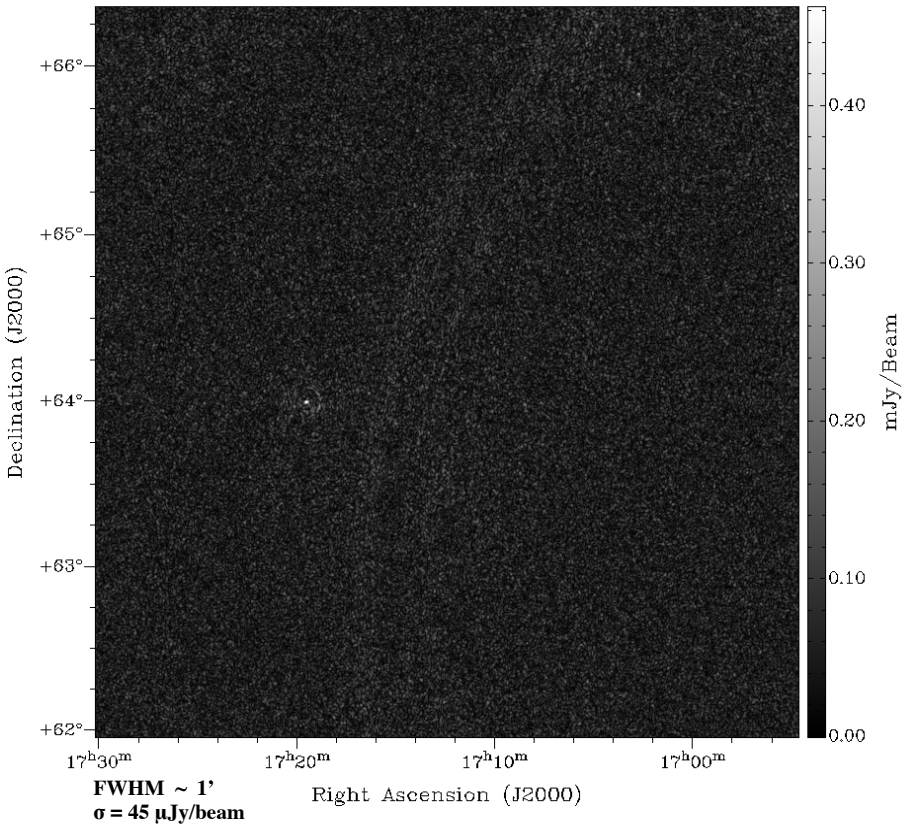
POLARIMETRIC RESULTS (WSRT)

ν= 1200-1400 MHz,
- 1000 < ϕ < + 1000 rad m^{-2}



FWHM ~ 28”
σ = 10 μJy/beam

ν= 350 MHz,
- 200 < ϕ < + 200 rad m^{-2}



FWHM ~ 1’
σ = 45 μJy/beam

- 1.2 – 1.4 GHz RM cube: the halo is not polarized. The 3 bright filaments at the edge of the halo are located in the foreground of the cluster (Pizzo et al 2011).
- 350 MHz RM cube: most of the polarized emission detected towards A2255 at low frequency has a Galactic origin (although emission from A2255 very clearly seen)

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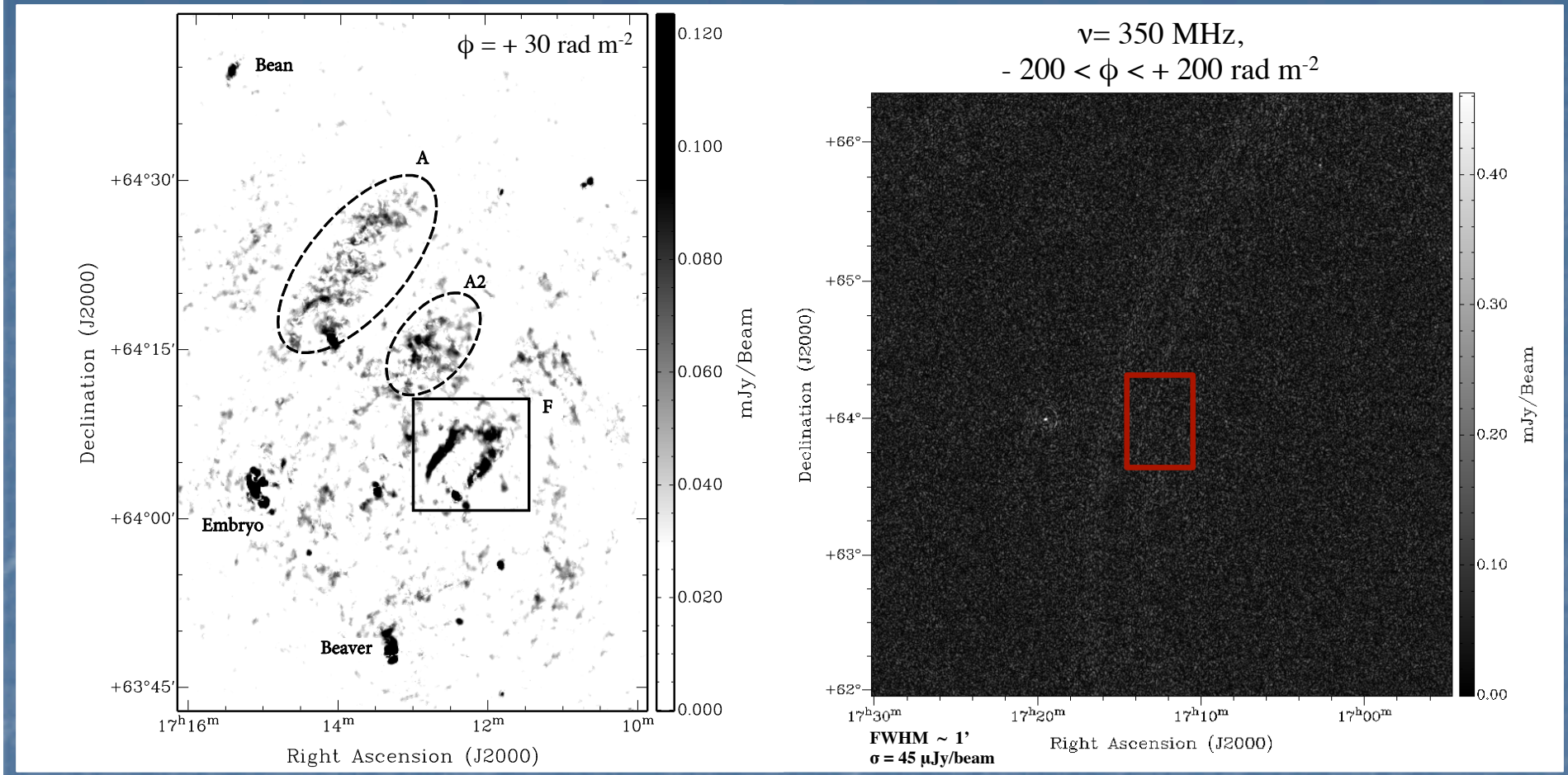

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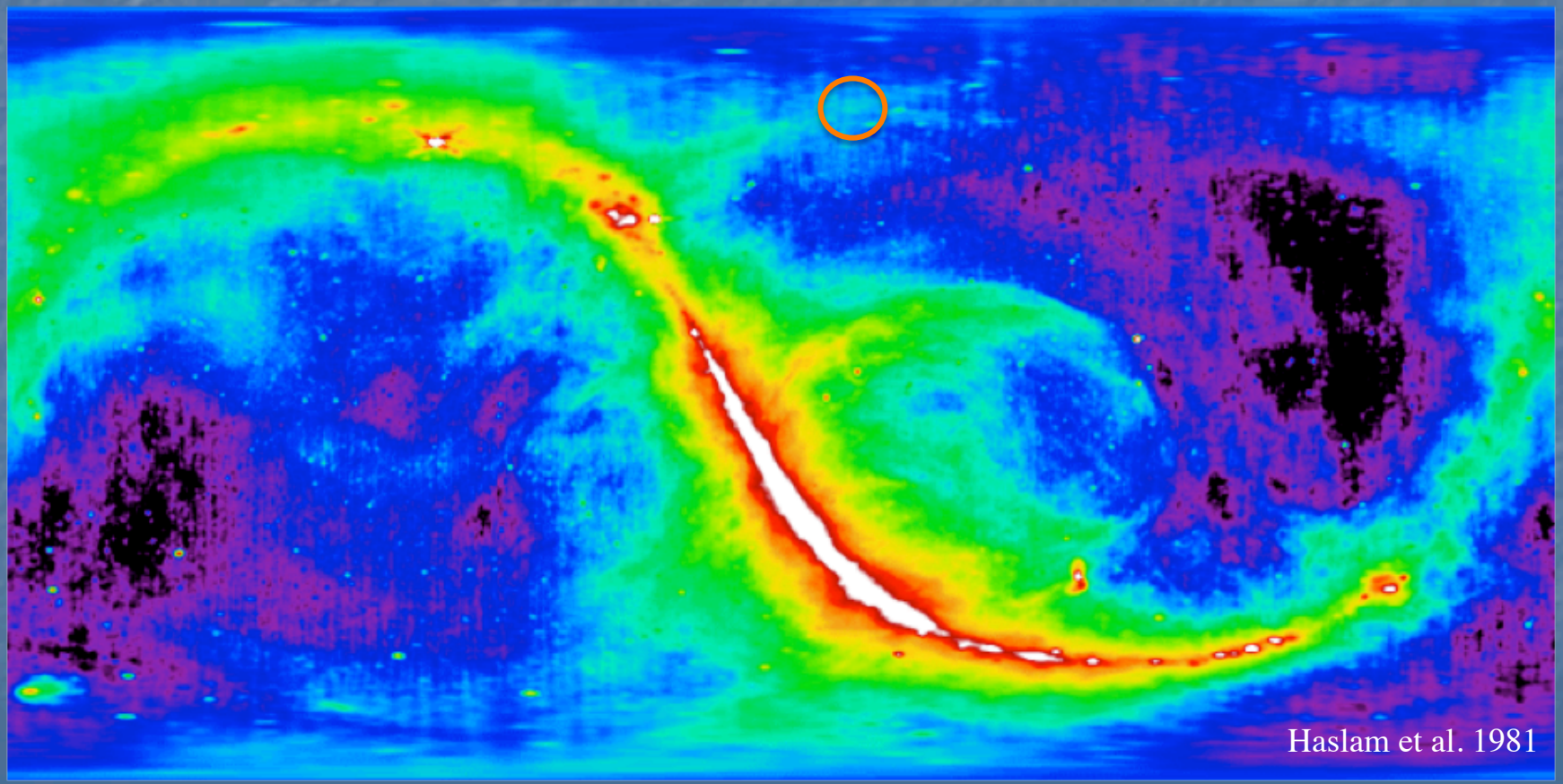
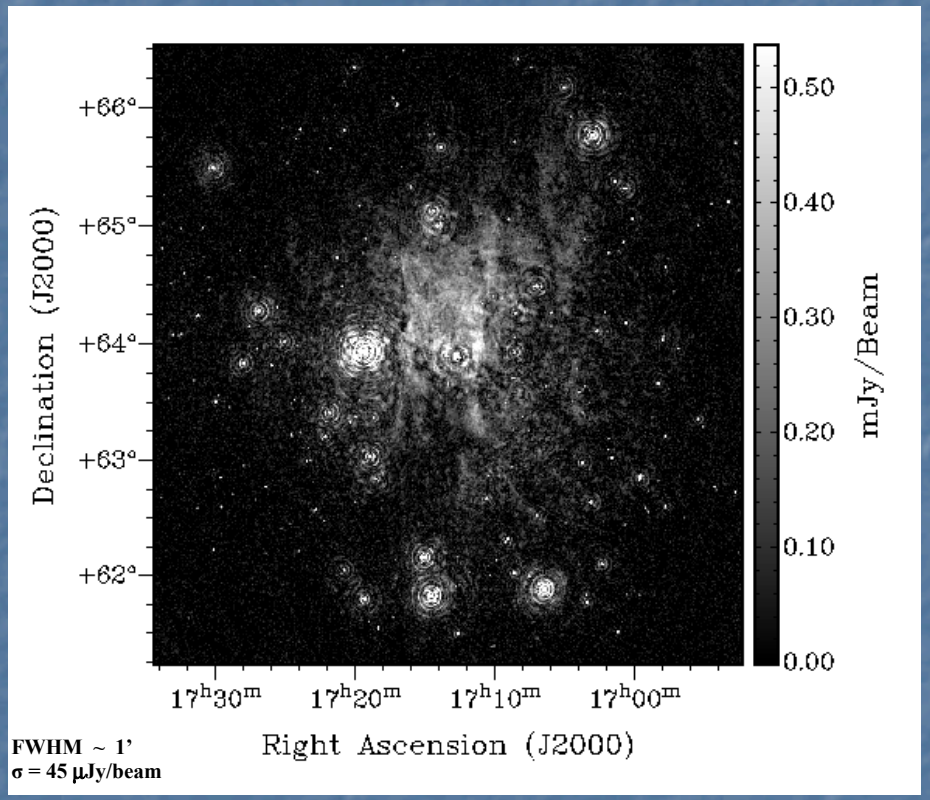
THE GALACTIC LOCATION OF A2255

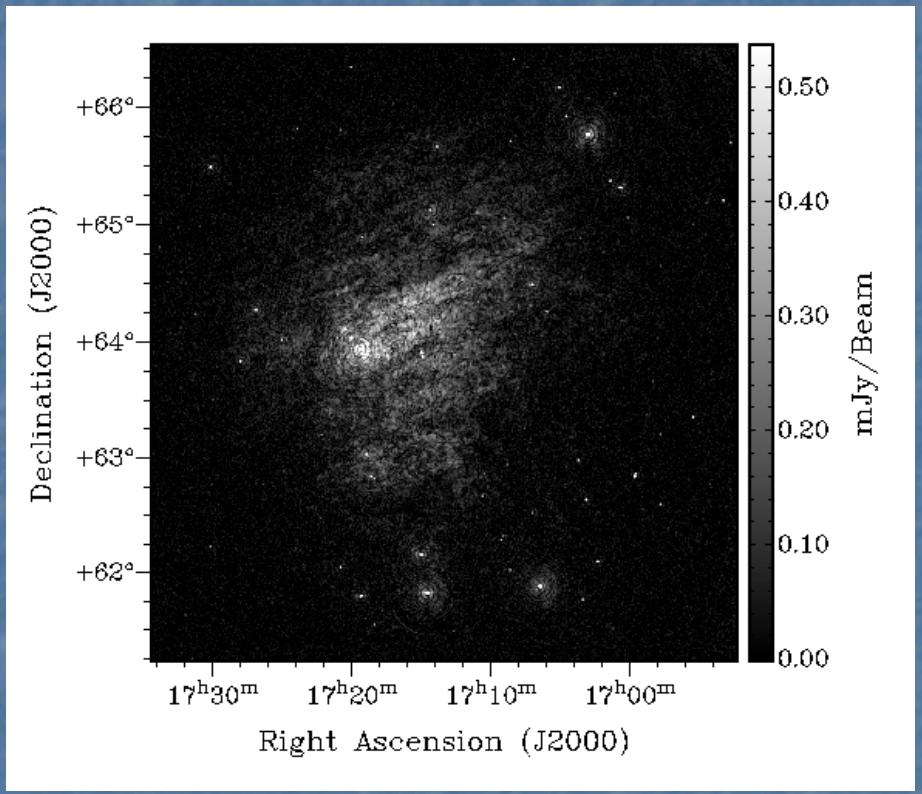
The Galactic region towards A2255 covers the range in Galactic coordinates $l = 93^{o} – 96^{o}$, $b = 33^{o} – 36^{o}$. The cluster lies in the direction of Loop III, a spur of the Galactic synchrotron emission (Berkhuijsen et al. 1971)



THE GALACTIC FOREGROUND: 2 MAIN COMPONENTS

(de Bruyn & Pizzo, to be submitted)





"Sheet"

$-4 \text{ rad m}^{-2} < \phi < +8 \text{ rad m}^{-2}$

"Filamentary"

$+20 \text{ rad m}^{-2} < \phi < +36 \text{ rad m}^{-2}$

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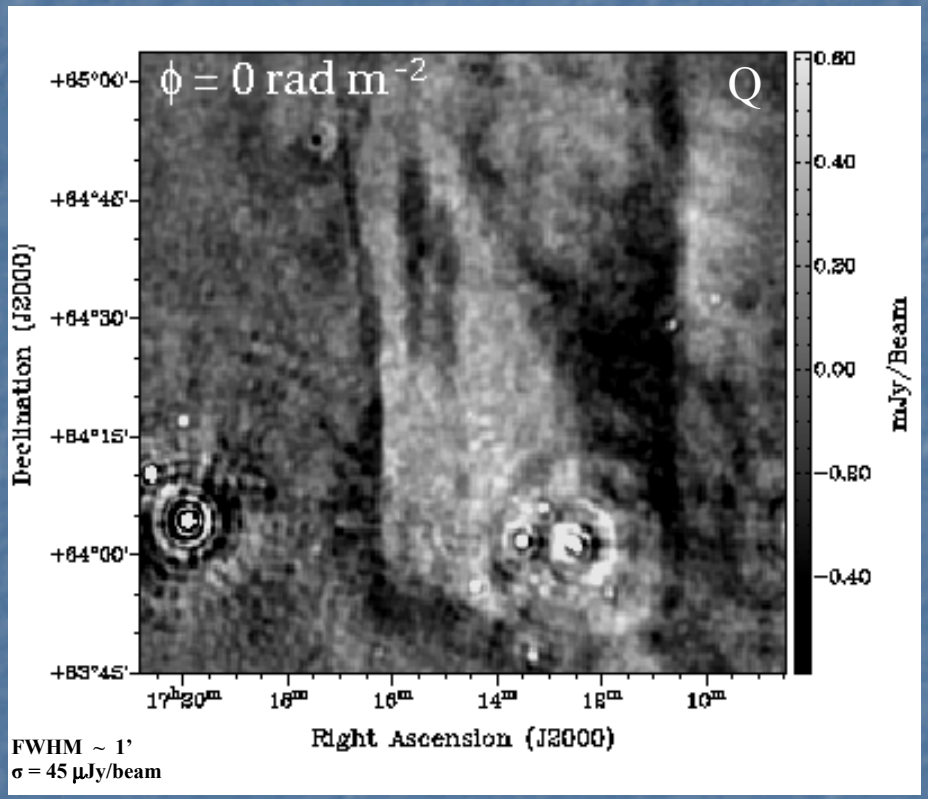
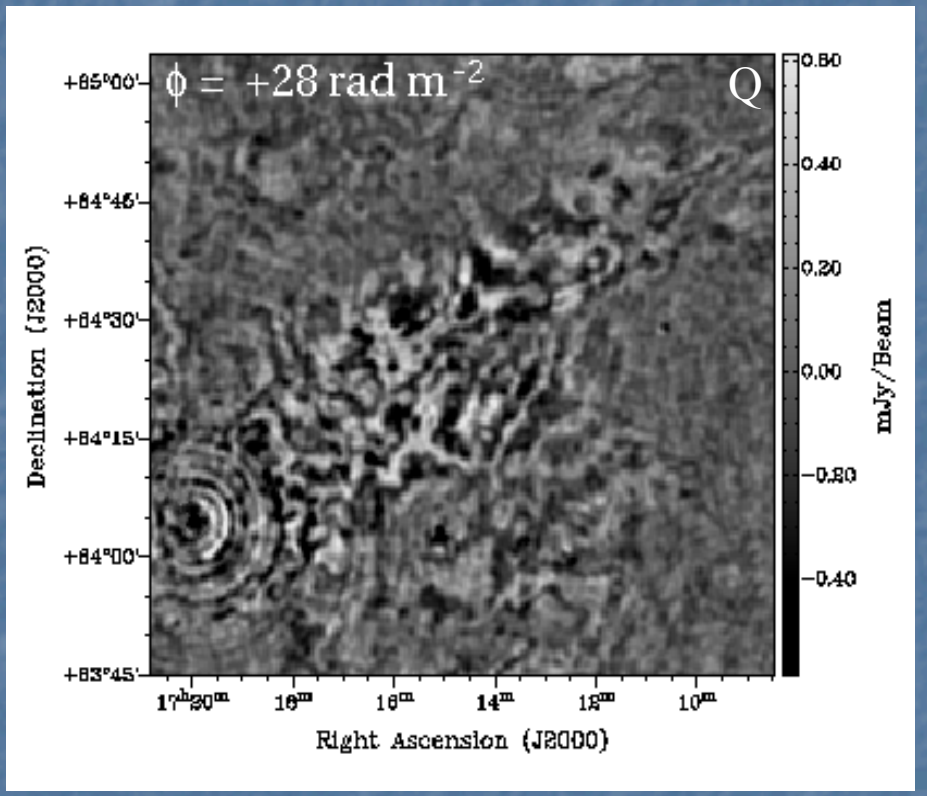


FWHM ~ 1'
σ = 45 μJy/beam



"Sheet"

-4 rad m^{-2}< ϕ < +8 rad m^{-2}

"Filamentary"

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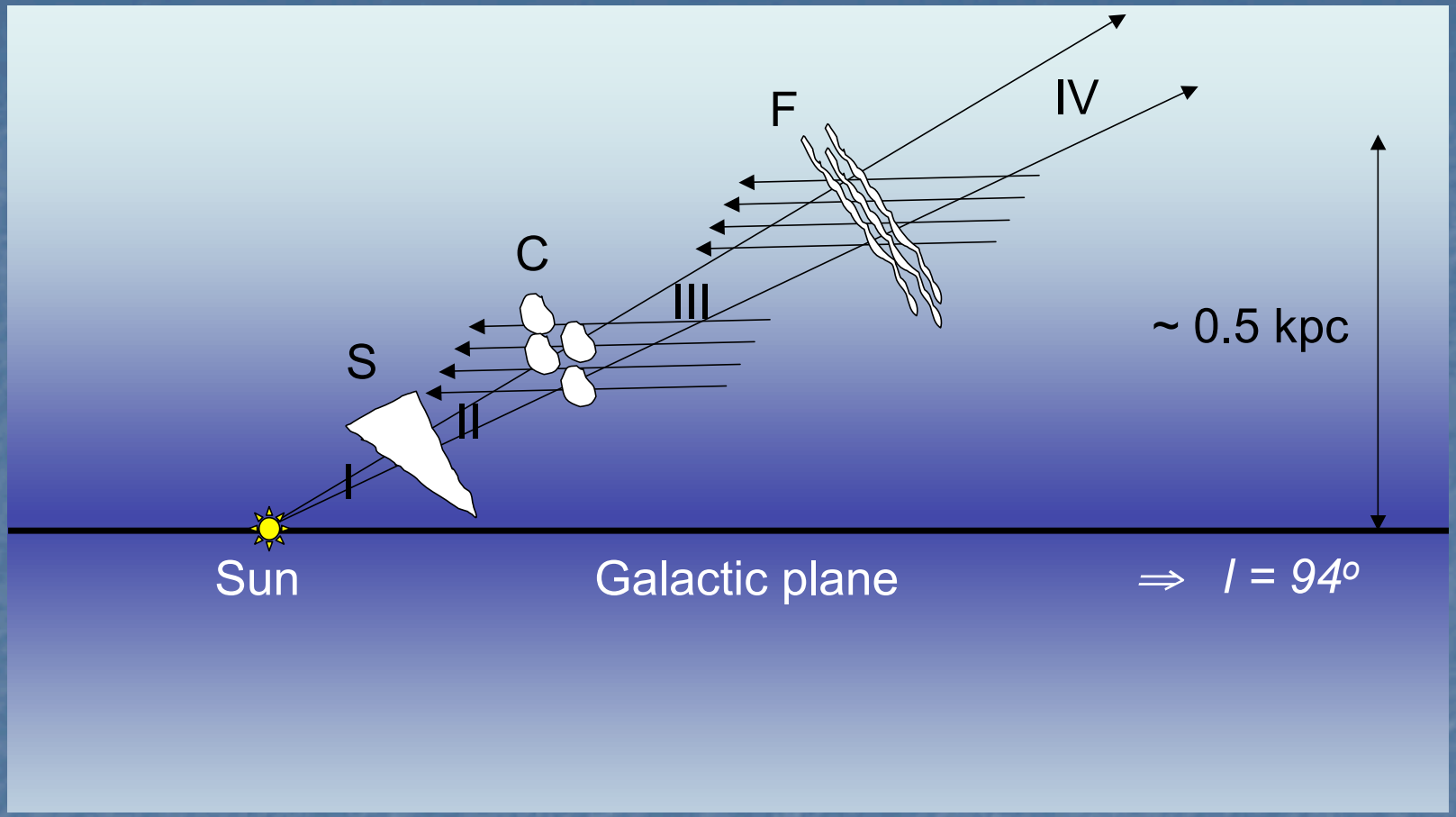
A SIMPLE PHYSICAL MODEL (de Bruyn & Pizzo, to be submitted)

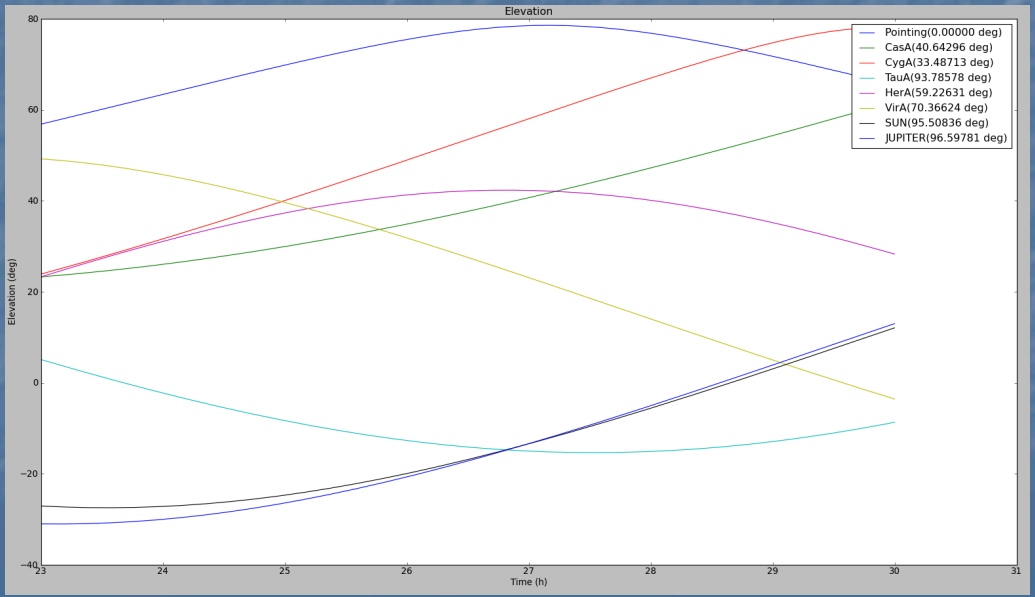


- Multiple regions of synchrotron emission, where the polarized signals are built up, separated by Faraday rotating regions (screens) that create the imprint at specific Faraday depths.

- A2255 lies near the upper part of Loop III, modeled by Spoelstra (1972) as a local SNR, located at a distance of only 150 pc from the Sun. Regions C and S are even closer! Most of the Galactic polarized emission is produced within a few hundreds kpc from the Sun.

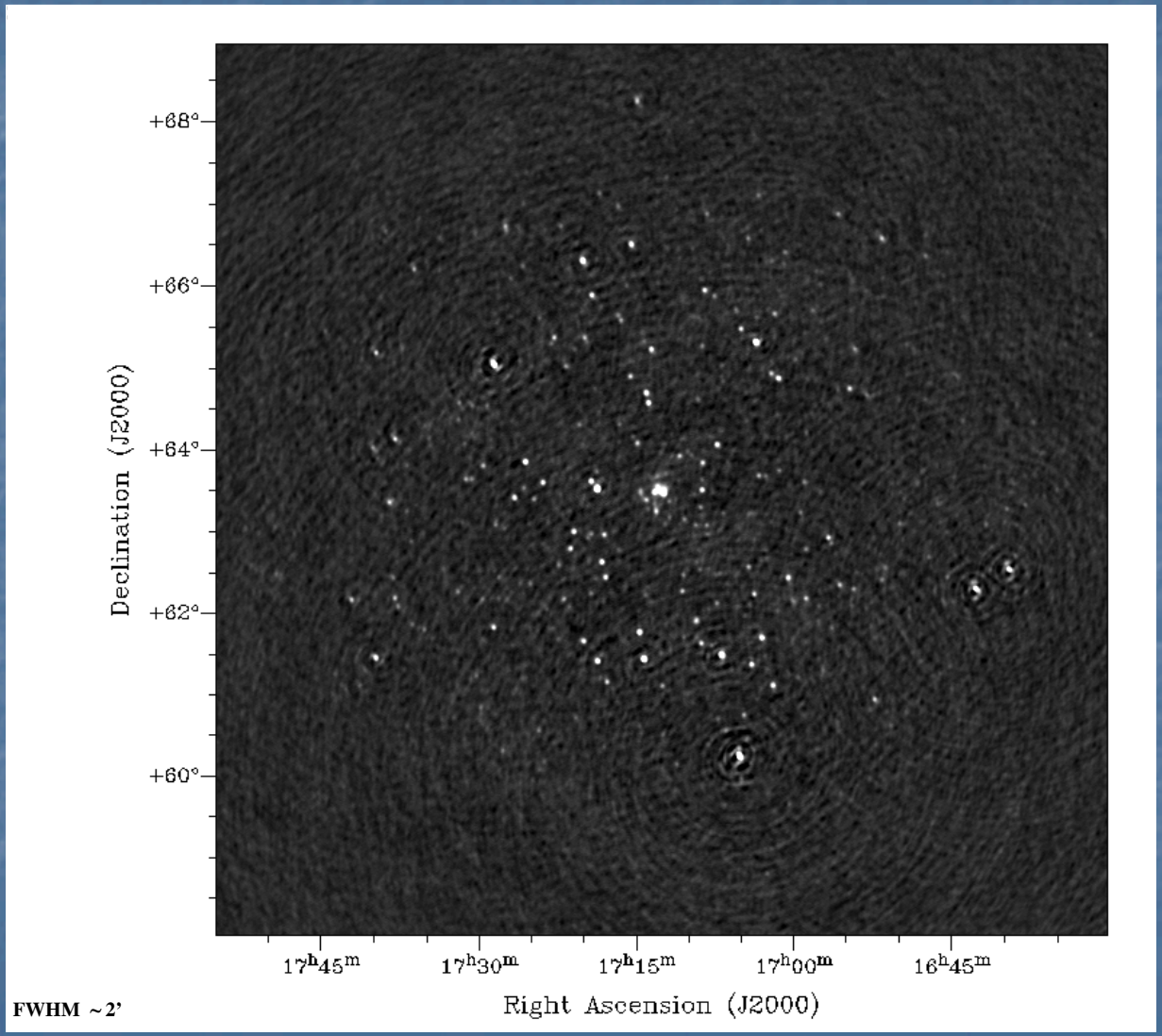
LOFAR OBSERVATIONS: HBA

- HBA LOW (110-190 MHz), 15-16 Apr 2011, 23 pm – 6 am, 7 hours
- HBA DUAL, 45 stations, 38 CS + 7 RS
- 244 sub bands, 64 channels, 2 seconds integration
- The A-team:



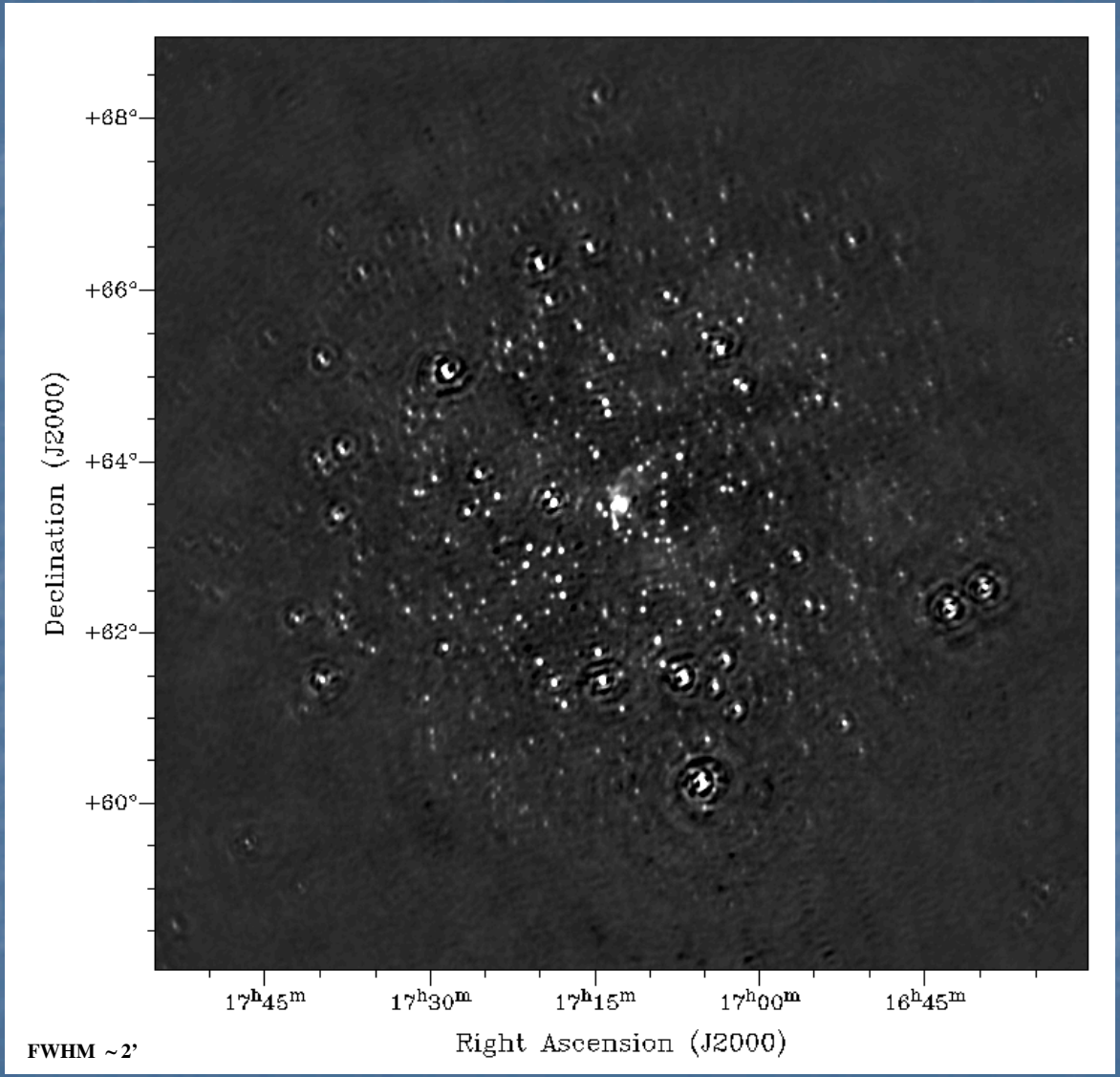
Cas A and Cyg A nearby (<40°) and at high elevation !

STOKES I CUBE (189 SBs)

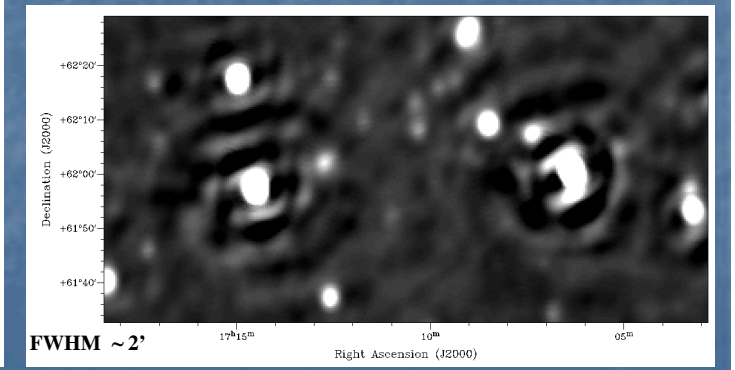


- ✓ 189 frames from 110 to 190 MHz
- ✓ Global calibration applied; model extracted from WENNS (350 components)
- ✓ Residual low level RFI left after clipping after the calibration (still need to be investigated)
- ✓ Primary beam effect clearly visible
- ✓ Off-axis errors at the location of strong off-axis sources (probably due to not correct beam computation)

THE FINAL MAP (189 SBs)



- ✓ Dynamic range ~ 3000
- ✓ σ = 1.5 mJy/beam (15 x σ_{therm})
- ✓ Thousands of sources detected in the field
- ✓ RS still need to be included. Imaging is in progress
- ✓ Off-axis problems still need to be taken care of



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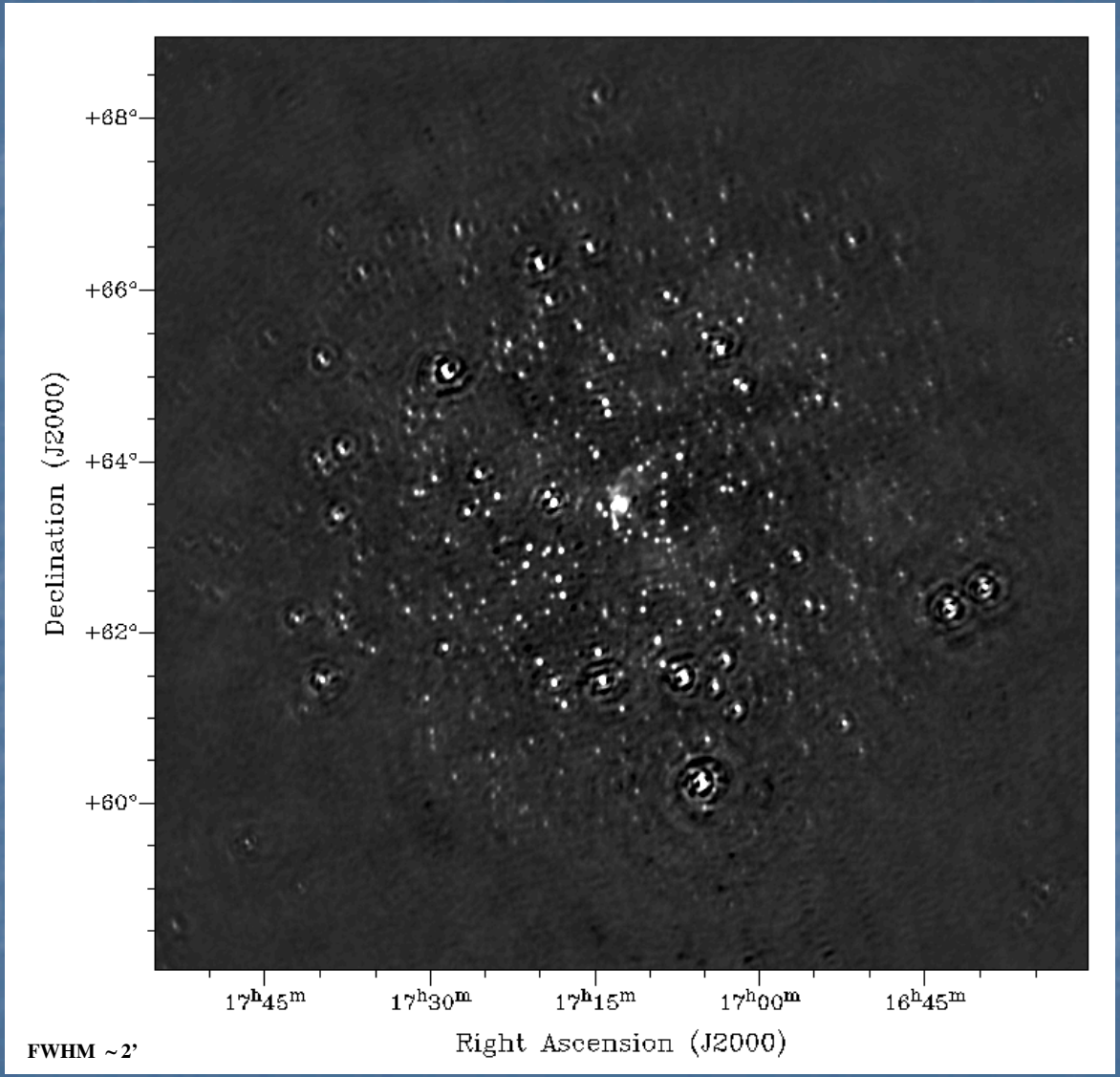
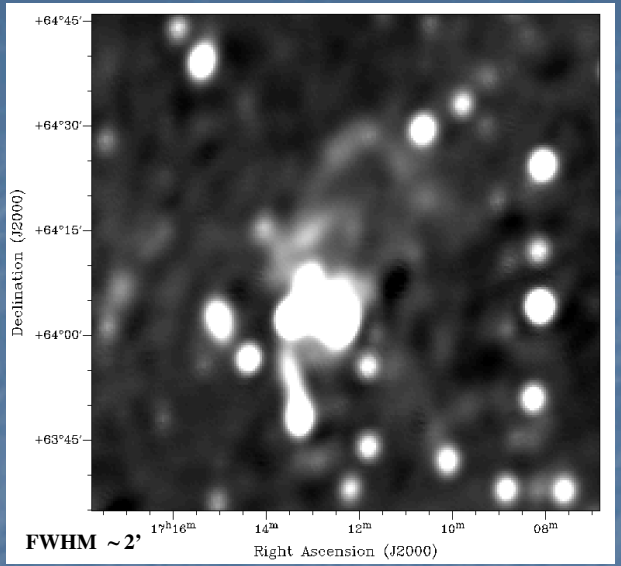
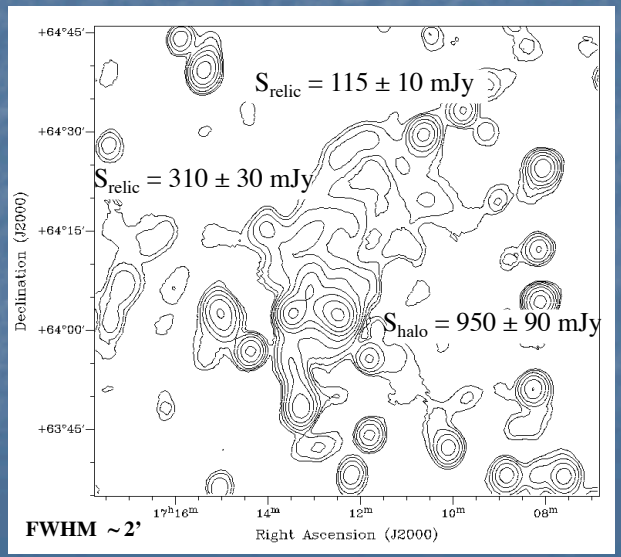
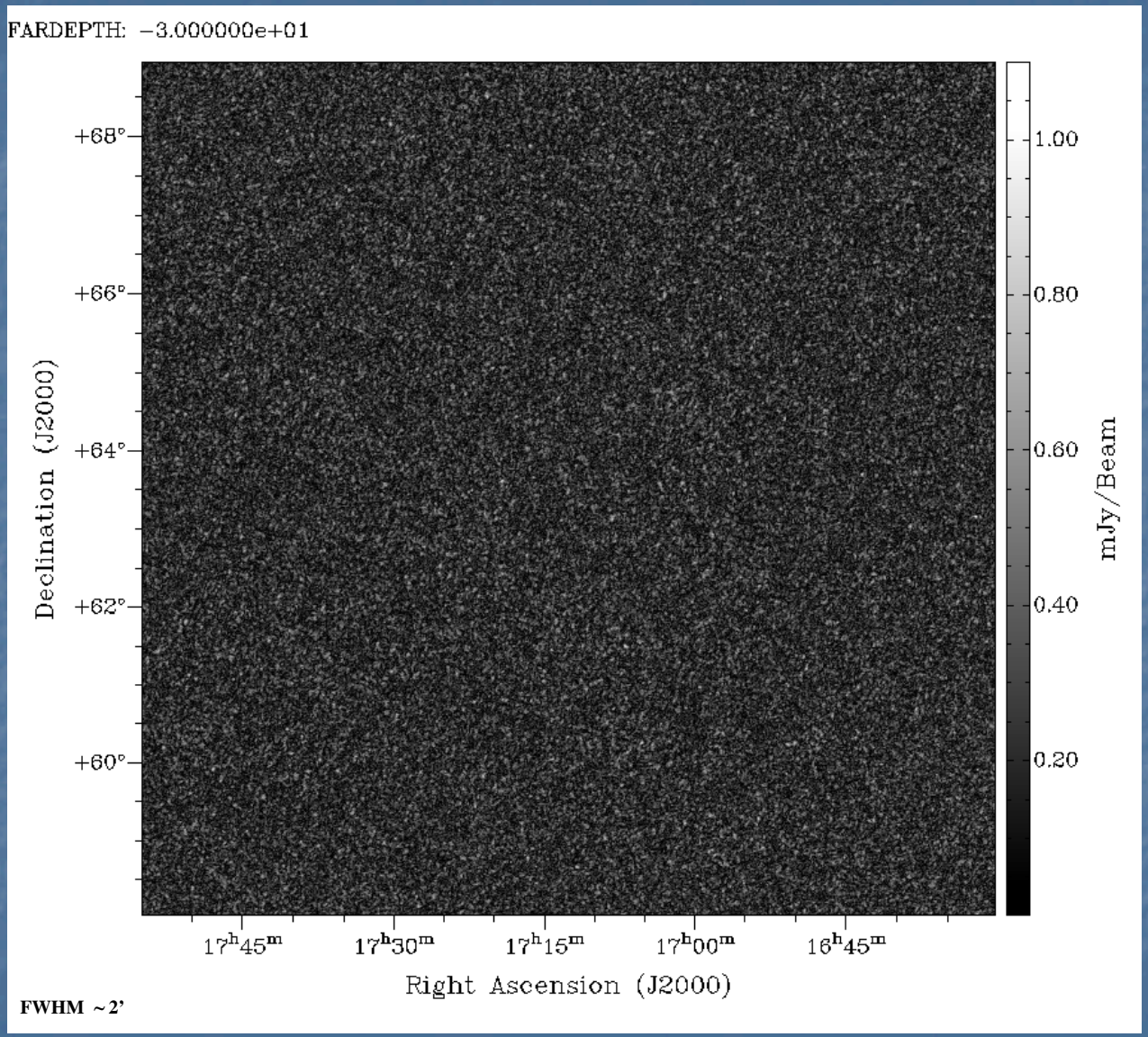


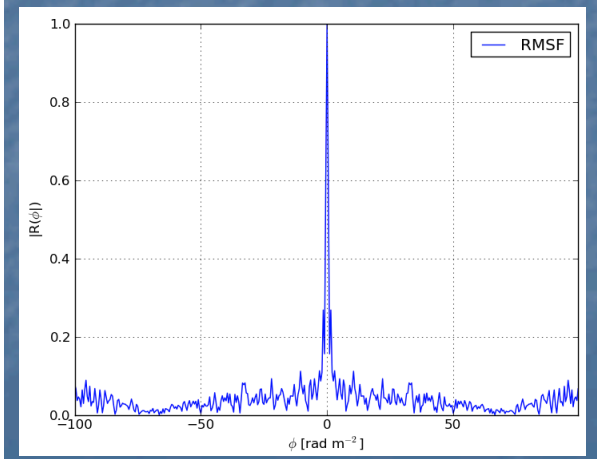




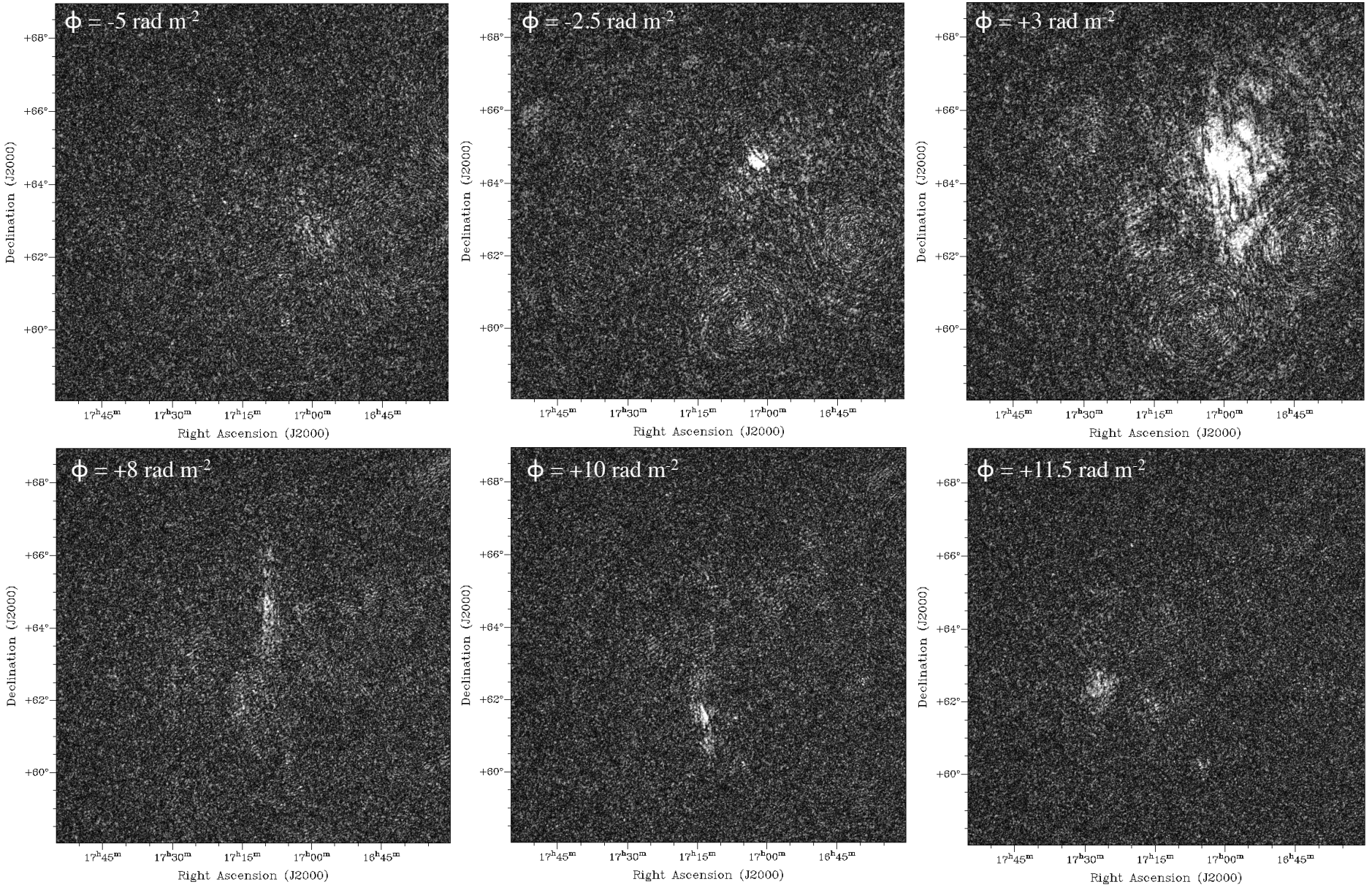
POLARIZED EMISSION: RM CUBE



- ✓ $-30 < \phi < +30$ rad m^{-2} with a step of 0.5 rad m^{-2}
- ✓ $\sigma = 0.2$ mJy/beam!!
- ✓ Polarized emission detected at $-5 < \phi < +15$ rad m^{-2}



POLARIZED EMISSION AT INTERESTING ϕ



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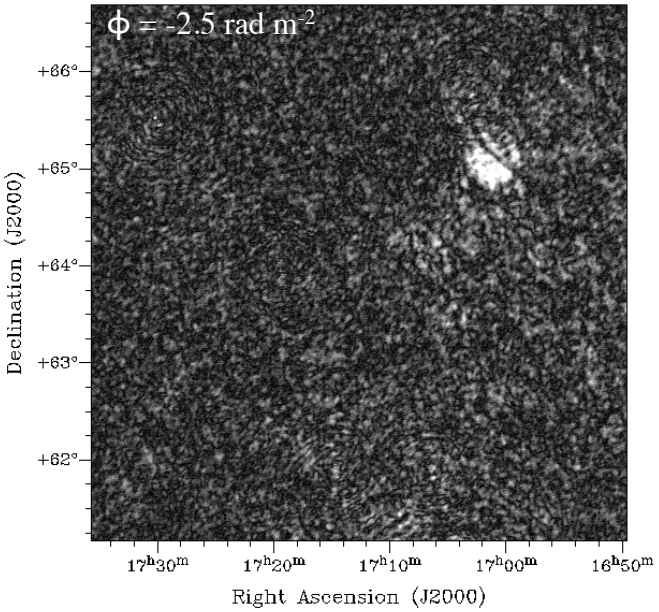
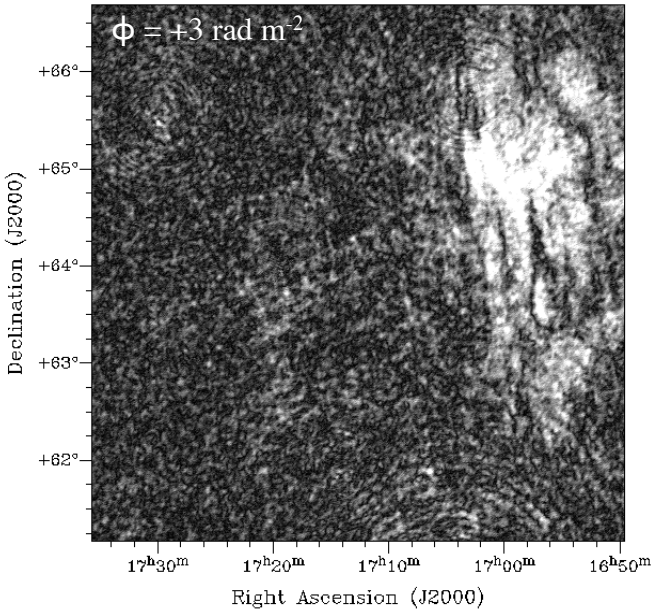
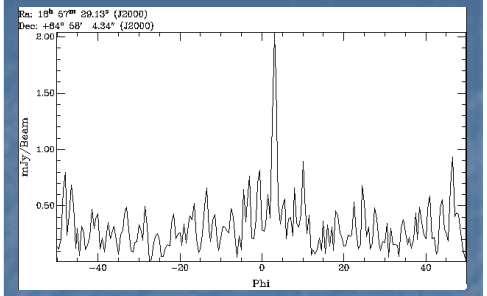
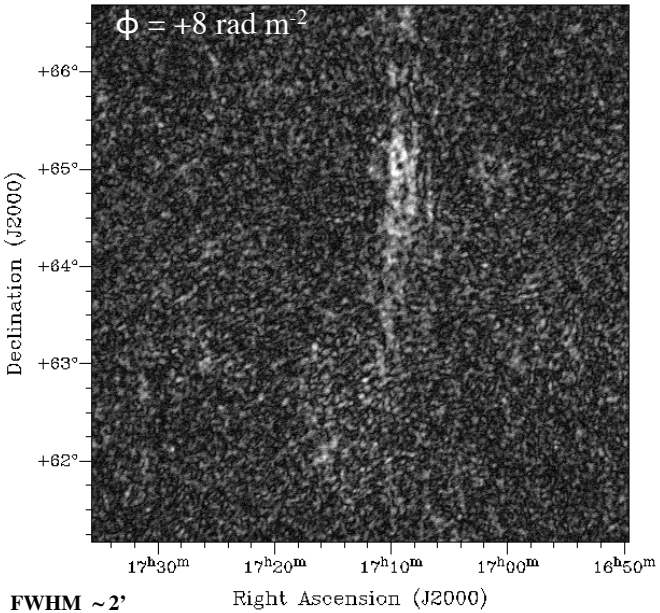
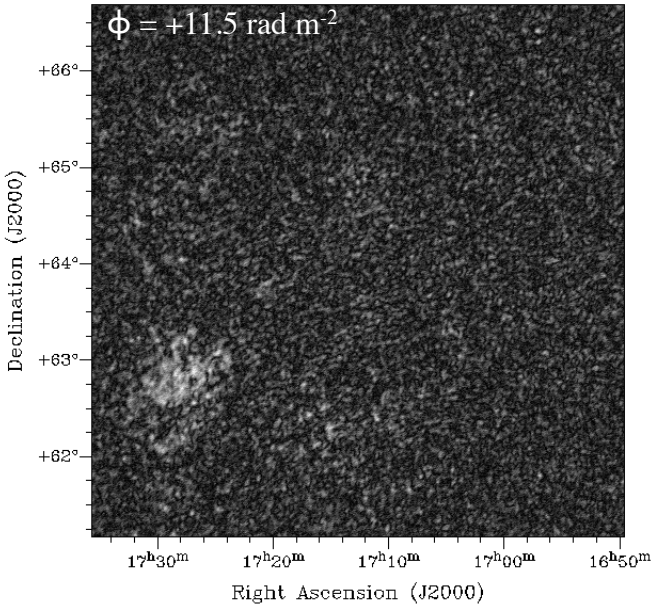








FWHM ~2'



- ✓ Various polarized features with no counterpart in Stokes I
- ✓ Brightness temperature ~ 4 K
- ✓ Instrumental origin unlikely, as they do not happen at $\phi = 0$ rad m^{-2} are not symmetric w.r.t this Faraday depth

SUMMARY AND FUTURE WORK

- ✓ A2255 represents a very interesting science case for LOFAR. Several open questions can be answered through the new sensitive high resolution data provided by this instrument;
- ✓ the preliminary results from HBA imaging show that the data are of very good quality;
- ✓ in Stokes I, the final map is more sensitive than the best available WSRT map (factor of 2);
- ✓ the emission from halo, relics and head-tail radio galaxies is fully recovered. More extended emission to the south of the cluster is detected;
- ✓ in polarization, the final RM cube is the most sensitive cube made with LOFAR data to date. Several extended polarized features are detected. They are likely associated with the Galaxy;
- ✓ following the interpretation given for the Galactic emission as seen in the WSRT cube, we think that the newly detected Galactic features are close to the observer;
- ✓ deeper HBA observations of this same field and nearby Galactic regions are needed to properly study the properties of our Galaxy along Loop III;
- ✓ performing RM synthesis on LOFAR data is compute intensive. 'Ad hoc' softwares need to be implemented to produce and properly display the naturally large LOFAR RM cubes

THANK YOU