Commissioning observations for EoR-project specific tests

Ger de Bruyn [1,2]
for the EoR KSP team

[1] ASTRON, Dwingeloo & [2] Kapteyn Institute, Groningen

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EoR ‘deep’ fields in commissioning time (Phase I)

The EoR (AND the calibration group, as well as the RO ?) propose to regularly observe three fields that were extensively observed as part of the WSRT-LFFE preparations for LOFAR (see Bernardi et al, 2009).

We know these fields very well and they can therefore help to optimize LOFAR calibration and serve as an excellent monitor of system performance when the rollout proceeds.

What is special about these 3 fields?

With 6x12h each they go very deep (0.5-0.7 mJy noise) in the 138-157 MHz range, with PSF ~2’ (2.7 km, ~ LOFAR core+1st ring.)

These 3 fields are:

FAN	0310 +66	bright diffuse polarization
3C196	0813 +48	very bright source
NCP	0400 +88	always up ! low fringe rates !

WSRT 150 MHz imaging (EoR project)

(red box=12°x12° but HPBW ~5°-7° and 'tile' beam ~ 22°)

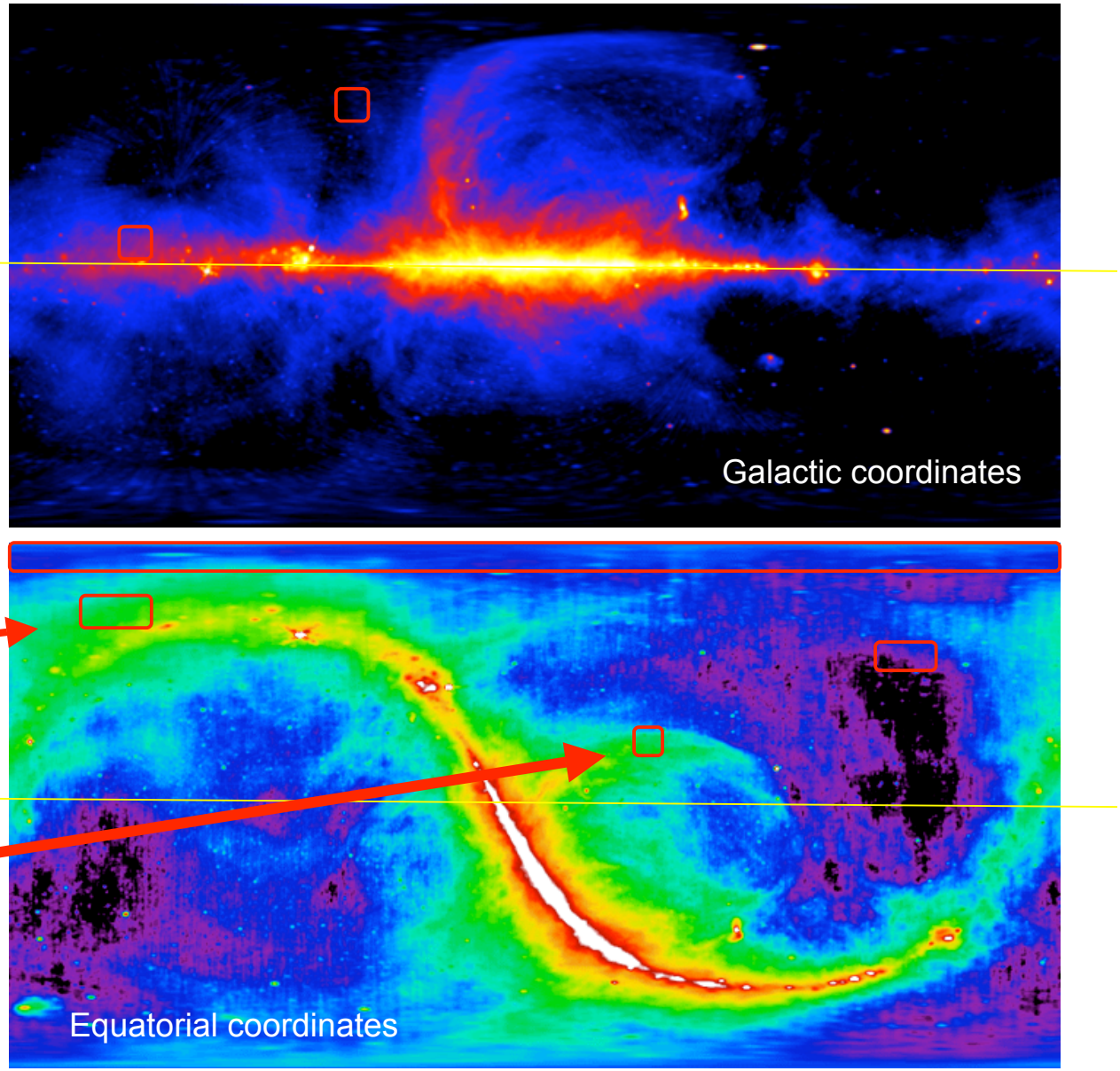
Location of 3 WSRT LFFE-fields (Nov07)

— NCP

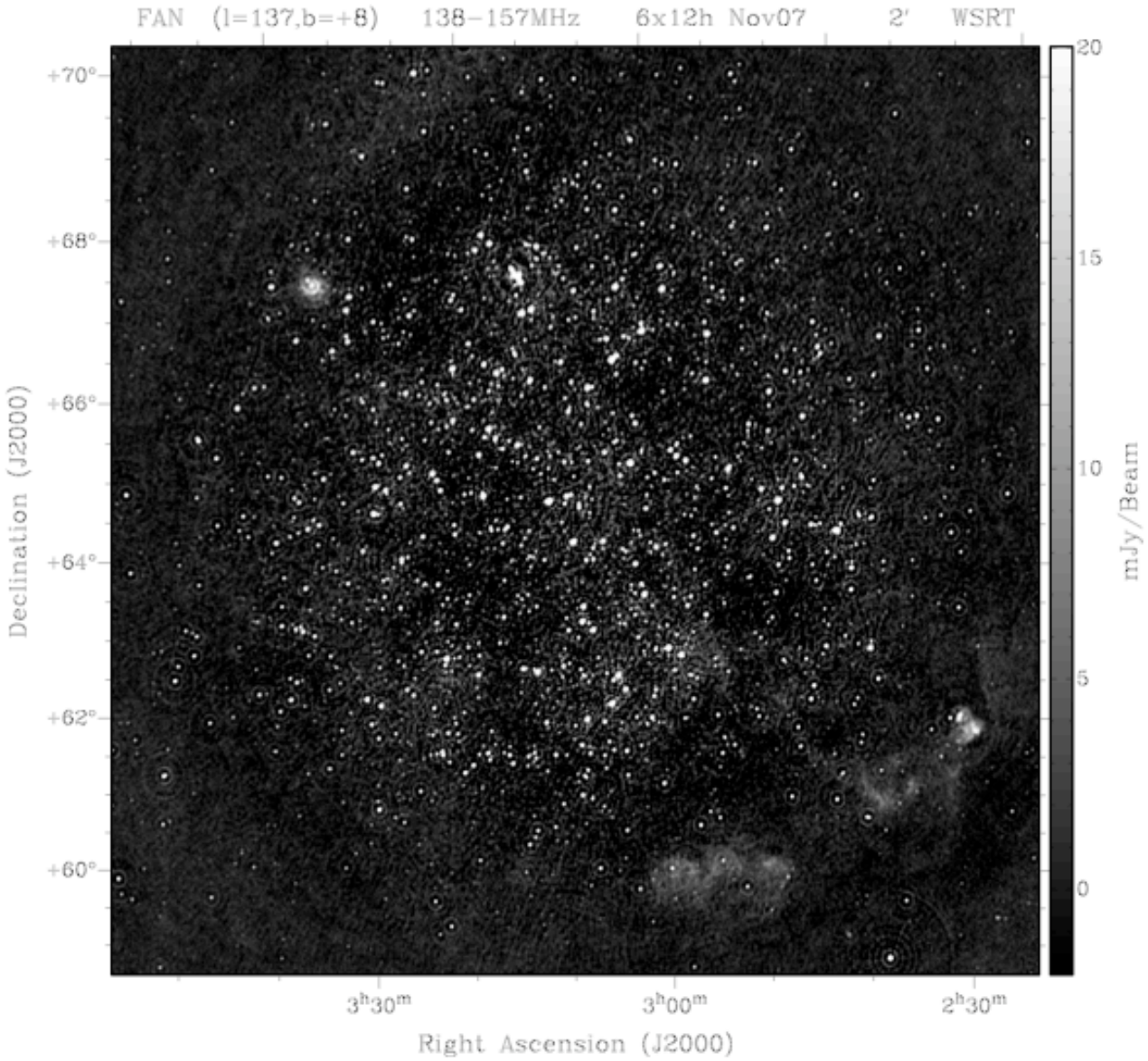
— 'FAN'

— 3C196

May 2009: NPS field !!



FAN: classical confusion limited: 2.7 km 2' PSF



range

-3, 30 mJy

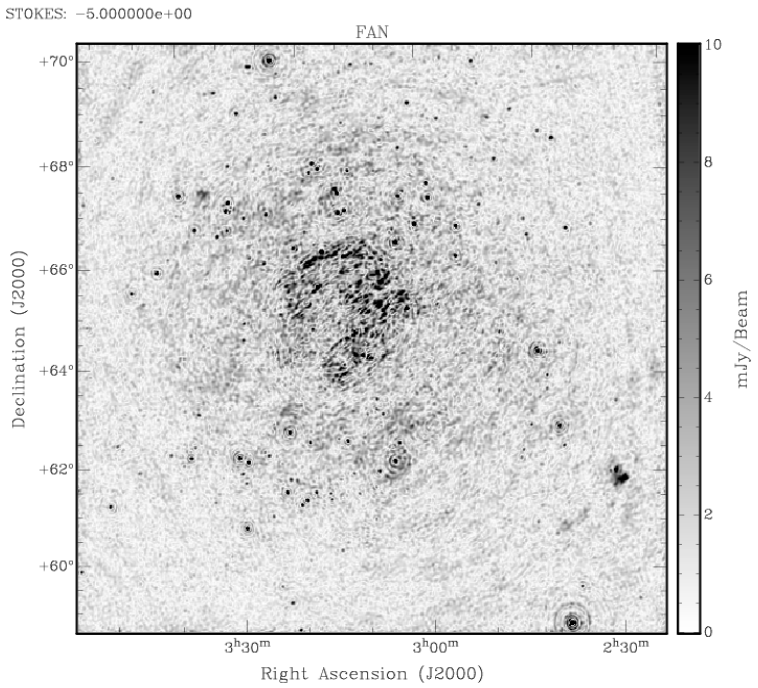
0.7 mJy thermal noise

3 mJy confusion noise (inner part)

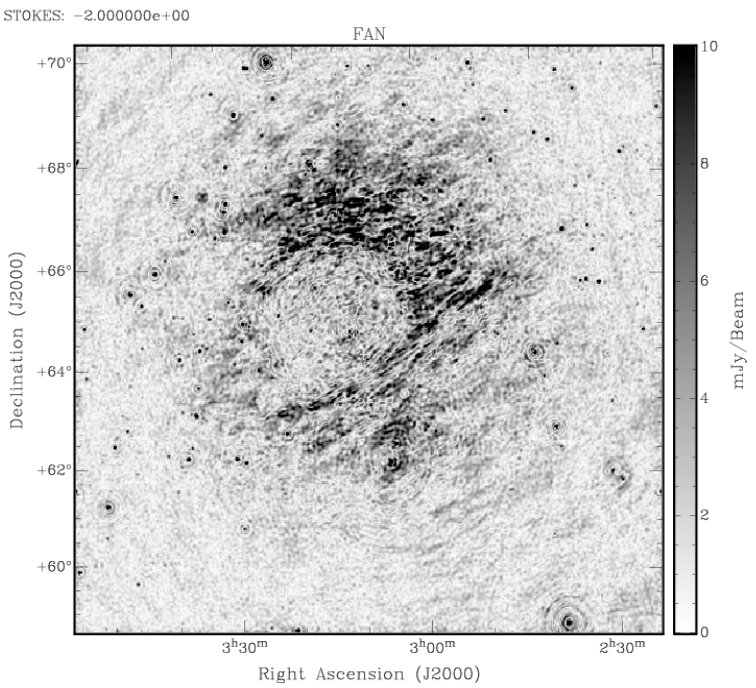
> 2000 sources !

Polarized intensity distributions in/around ‘the ring’

RM = - 5 rad/m^2



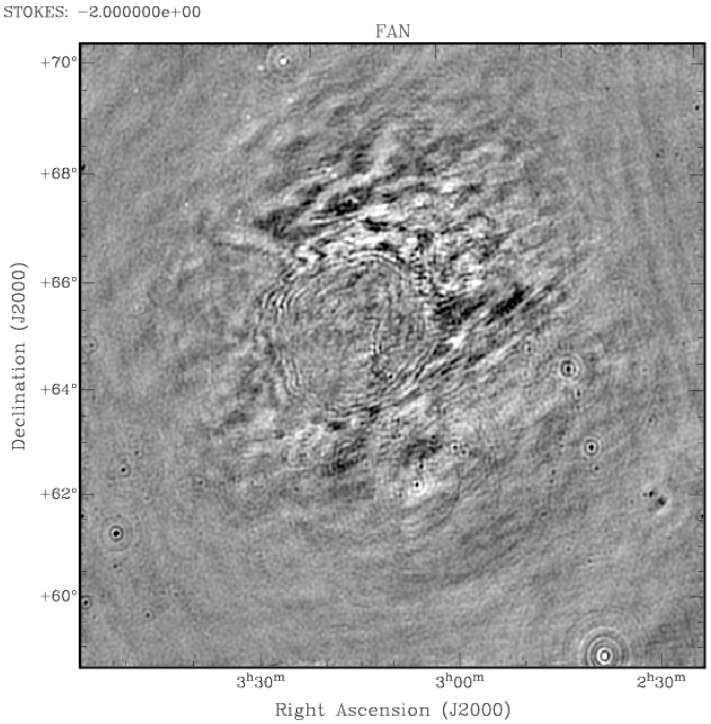
RM = - 2 rad/m^2

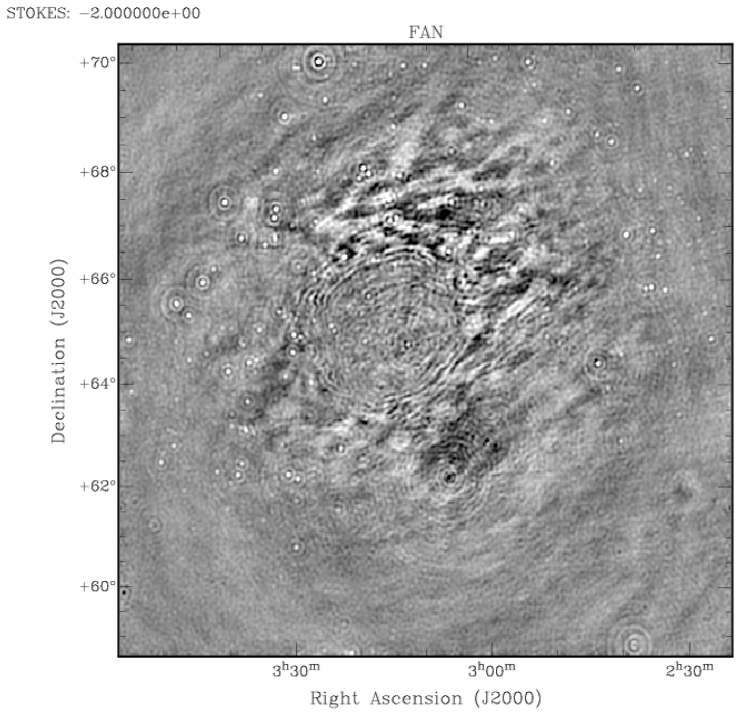


Brightness temperatures ~ 15 K !

Integrated over several Faraday depth components

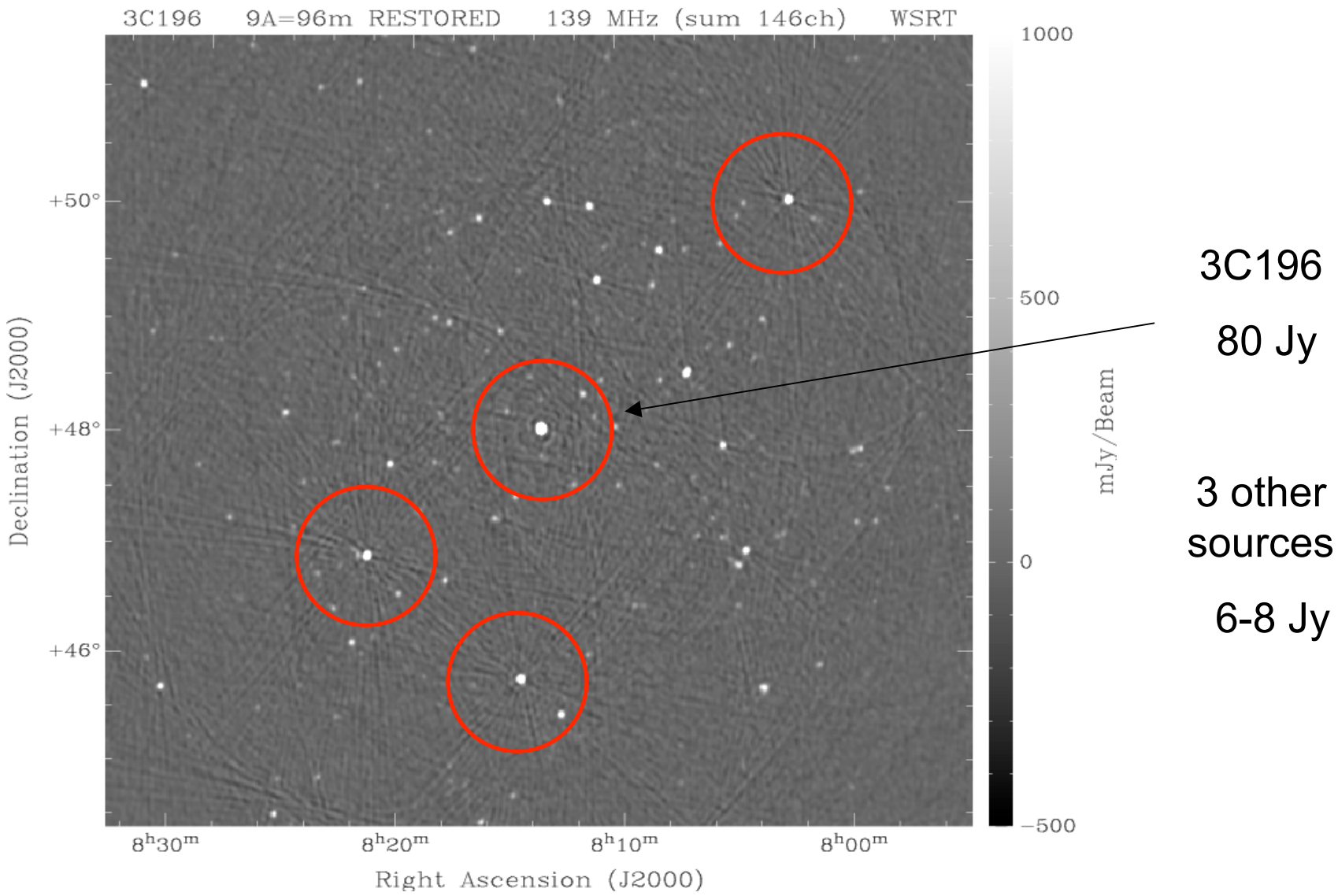
Stokes Q and U images at RM = - 2 rad/m^2





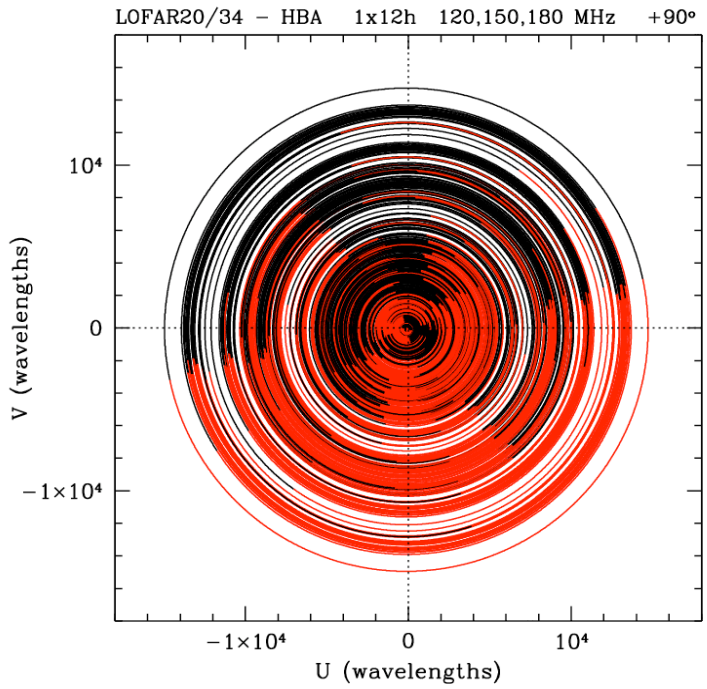
Note the large polarization angle gradients at the edge of ‘the ring’

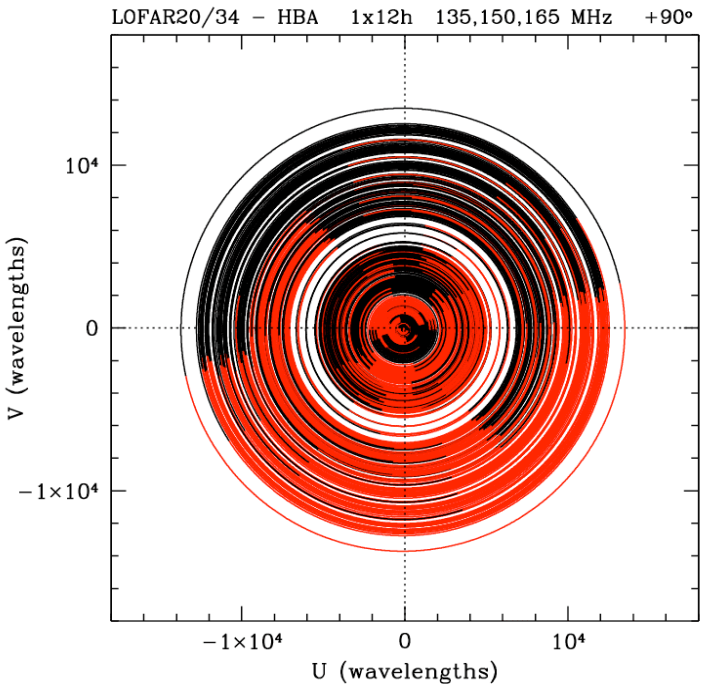
3C196 in ‘worst’ night: some nonisoplanaticity !



LOFAR20/34 HBA uv-coverages

broadband/MFS 12h +90º





Frequency band-edge issues

What/How ?

Testing noise and stability of the lower and upper edges edges of the HBA (2d Nyquist zone, 200 MHz clock).

Adjacent and interleaved combs of 110-190 MHz in 2 x 40 MHz combs.
Adjacent and interleaved combs of 115-185 MHz in 2 x 35 MHz combs.
Observations will also be used to determine system stability and RFI occupancy

Why ?

The EoR KSP wants to observe from z= 6 to z=11.5 but should not waste time on data that ultimately will not be very useful (e.g. 110-115 MHz). We also need data in '21cmline-free' frequency ranges. If these lie in the 180-190 MHz (z=6.9-6.5) band we do not have to go to 160 MHz sampling (170-230 MHz)

When ?

Whenever the major bugs in the system have been cured. August ?

Who ?

EoR team

Rapid switching procedures and overhead

What /How ?

Rapid switching (position or frequency mozaicing) observation sequences with both analog and digital digital beam changes. Fields to be selected. One of them is probably 3C196. Do this a few times for a few hours following scheduling/correlating improvements.

Why ?

For ionospheric calibration we may have to switch rapidly between sources over an area of about 25^{o} (tile FOV). For a ground array of 50 km this will dissect a huge ionospheric volume for tomographic reconstruction (e.g. multiple layer identification). How efficient is this and how do we store and process such data efficiently ?

When ?

As soon as there are ~ 10 stations.

Who ?

EoR and SRV teams ?

Stability and Redundancy tests

What/How ?

Regular observations on the quality and repeatability of the visibility data. The comparison of redundant baselines allows a first measure of the fidelity of the visibility data. LOFAR will have many redundant baselines within the core. An example is the 129m baseline between the 24-tile sub-stations (which come in 3 different orientations). Total time limited but under well controlled conditions.

Why ?

The quality of data is crucial for the LOFAR EoR project. It will observe several windows on up to 100 nights. The stability of the instrument is therefore important. Redundant baselines provide a good diagnostic tool to learn about the stability/quality of the data.

When ?

Regular sequences whenever there are a few new stations handed over

Who ?

EoR and other commissioning teams

Ionospheric Faraday rotation and TEC-modeling

What/How ?

We want to commence regular observation of the 3 well-known polarized pulsars (PSR1937,PSRJ0218, PSR0531) in day and night. So we would like to start this a.s.a.p. and continue for 6 months to cover all conditions. These observations can be started even with a single baseline ! They are to be accompanied with Differential Ionospheric Refraction Monitoring. Typically they could be 15m observations.

Why ?

Polarized foregrounds are of interest (as well as a 'nuisance') for the EoR project. They are also interesting for Galactic halo studies by MKSP group members. We need to monitor the VTEC and the resulting ionospheric Faraday rotation to allow adequate correction and calibration procedures to be developed.

When ?

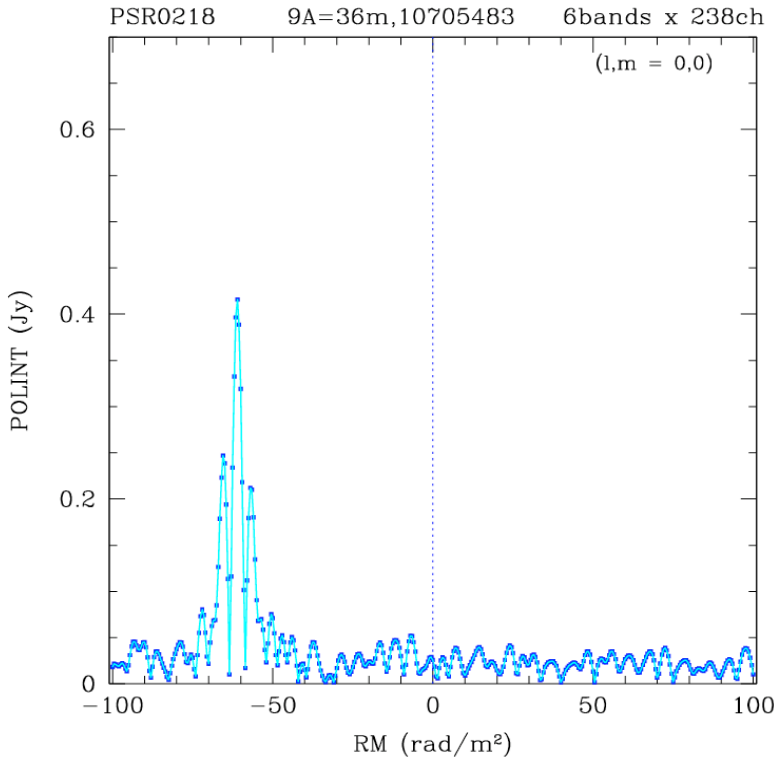
As soon as possible and well into MSSS to cover all ionospheric phases.

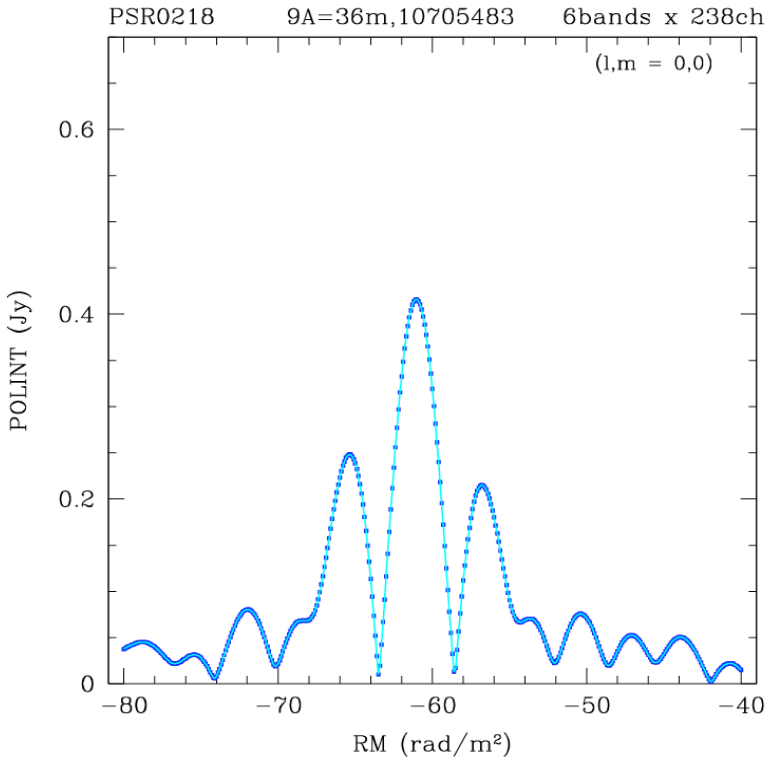
Who ?

MKSP and EoR teams

Data on a (serendipitously discovered) pulsar

Navarro et al, 1995

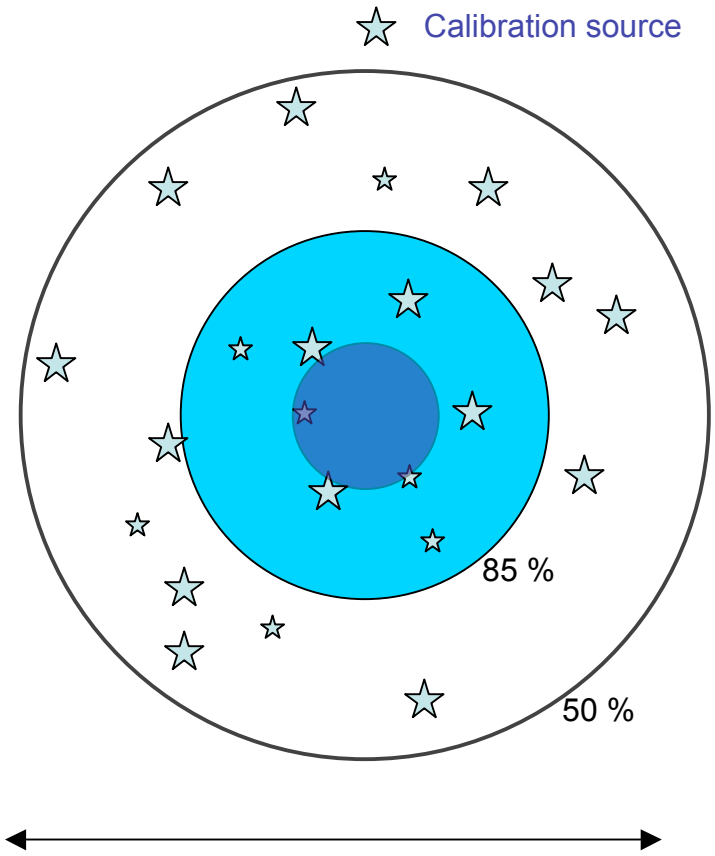




15^m of data on J0218+42 in frequency range 138-157 MHz. RM = - 61 rad/m^2 (accuracy +- 0.01 rad/m^2)

(NB high RMSF-sidelobes due to 4 MHz RFI gap in the middle)

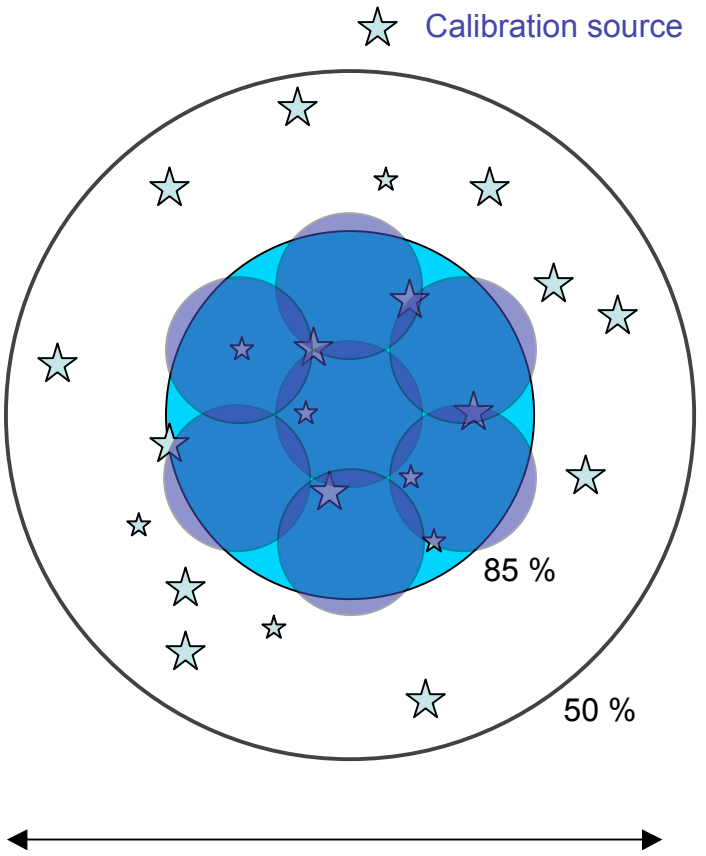
Dynamic ionospheric phase-screen mapping ?



tile beam 20-25^{o}

16-bit case

e.g. 1 beam x 48MHz



tile beam 20-25^{o}

4-bit case

e.g. 7 beams x 27 MHz