Update on the LOFAR EoR project

Ger de Bruyn, for the EoR collaboration (~ 35 persons)

Outline:

Recap of goals of the project

Some areas of study:
- calibration (sagecal)
- ionospheric structure function, speckle noise
- polartization, leakage, sagecal a
- RM selfcal
- Reliable construction of power spectra (2-D and 3-D)

Some results: primary and ancillary science

Organization, Management and new appointments

Developments in resources: HW/SW

Current 'processing' and analysis efforts:

Sagecal calibration effects:
  - # clusters/directions and solver noise - Patil, de Bruyn, Yatawatta, Zaroubi, Koopmans
  - uv-range for calibration and imaging: de Bruyn, Yatawatta,…
  - faint RFI near NCP - Offringa

Polarization calibration and leakage   - Khan, Jelic,..

Ionospheric screen fitting and other effects – Mevius, Vedantham/Koopmans

Simulations to support all of the above (many)

ML inversion of data   - Ghosh, Koopmans

Brainstorming on all of the above (many)

New hardware, software

Pandey: design new ERC-funded processing cluster → CIT/RuG   (Jan-April 2015)

(5x faster single precision, 15x faster double precision than current EoR cluster)

Pandey: Backup/buffer storage at ASTRON, 2 new fast servers (dec 2014) , 10 Gbps/link

Yatawatta: 'Broadband' sagecal (see Sarod's talk at recent LSM)

Offringa: WSClean imager:

EoR structure on large scales (10'-30' can not be modelled (below noise!)
Hence do not include baselines in calibration process where they are visible

GAUSSIAN sources
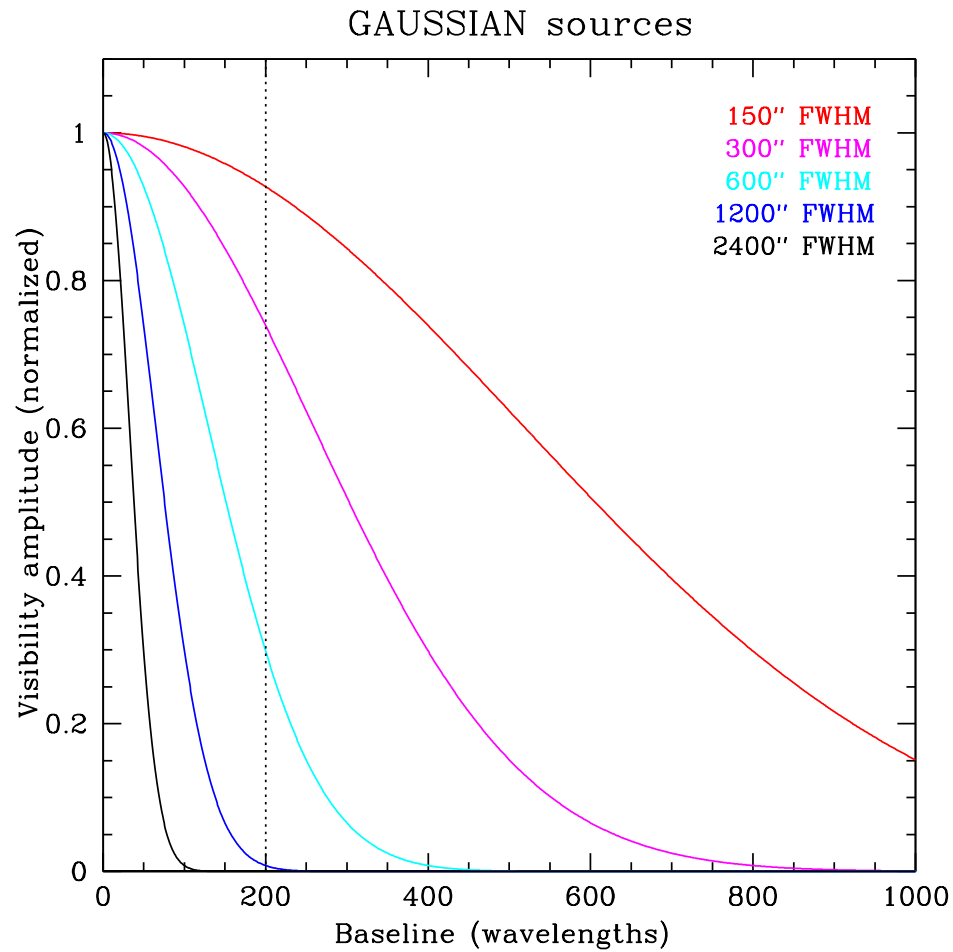
Computer simulation of the evolution of HI in the Universe

Andrej Mesinger(2013)

Redshift	z
the neutral fraction	$< x_{HI} >$
The intensity of the signal	$< \delta T_b >$

HI Power Spectrum

$z = 119.60$
$\langle x_{HI} \rangle = 1$
$\langle \delta T_b \rangle = -40$

750 Mpc

δT_b (mK)

$-200 \quad -160 \quad -120 \quad -80 \quad -40 \quad 0 \quad 40$

$\langle \delta T_b \rangle^2 \, \Delta_{21}^2(k) \, (mK^2)$

$k \, (Mpc^{-1})$
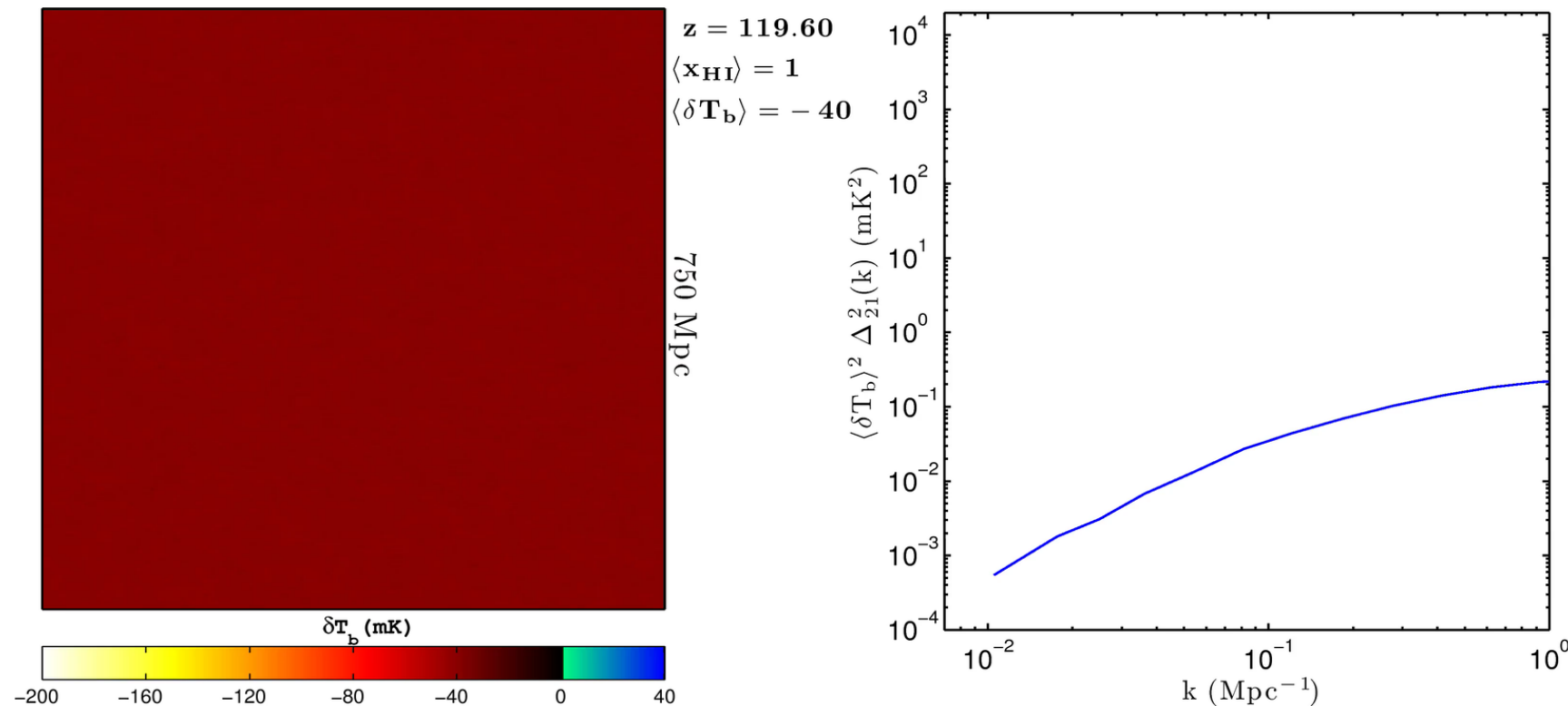
$k = 2\pi/\lambda$ = wavenumber in (comoving)Mpc

LOFAR deep low resolution (3' PSF) image of the NCP
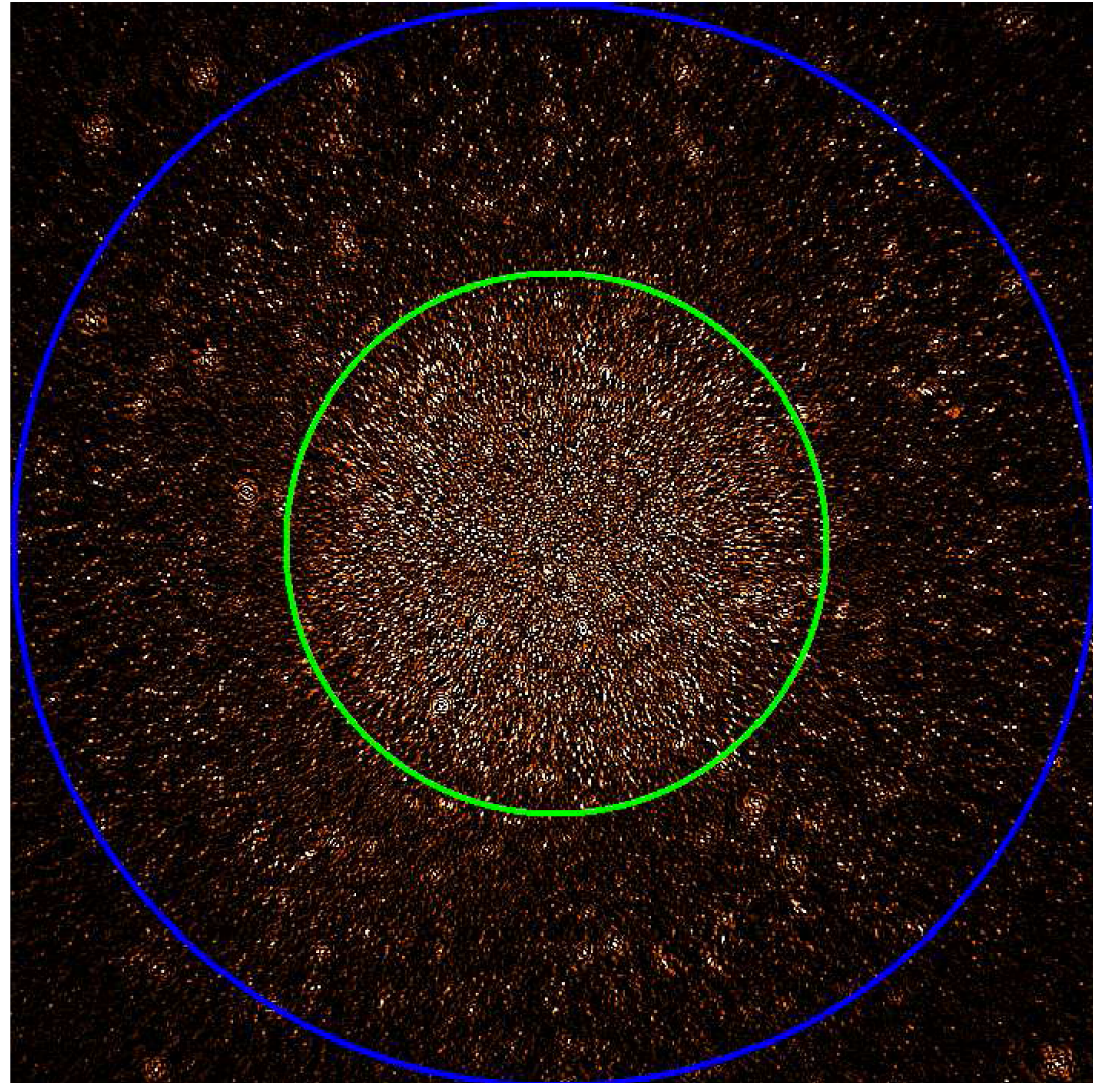
First null 10 deg. diameter, second null 20 deg. diameter

NCP   250h
'deconvolved'

19'x22' area

noise ~ 35-40 µJy

7.2 Jy peak (outside
shown area)

1800 ± 200 sources /□°
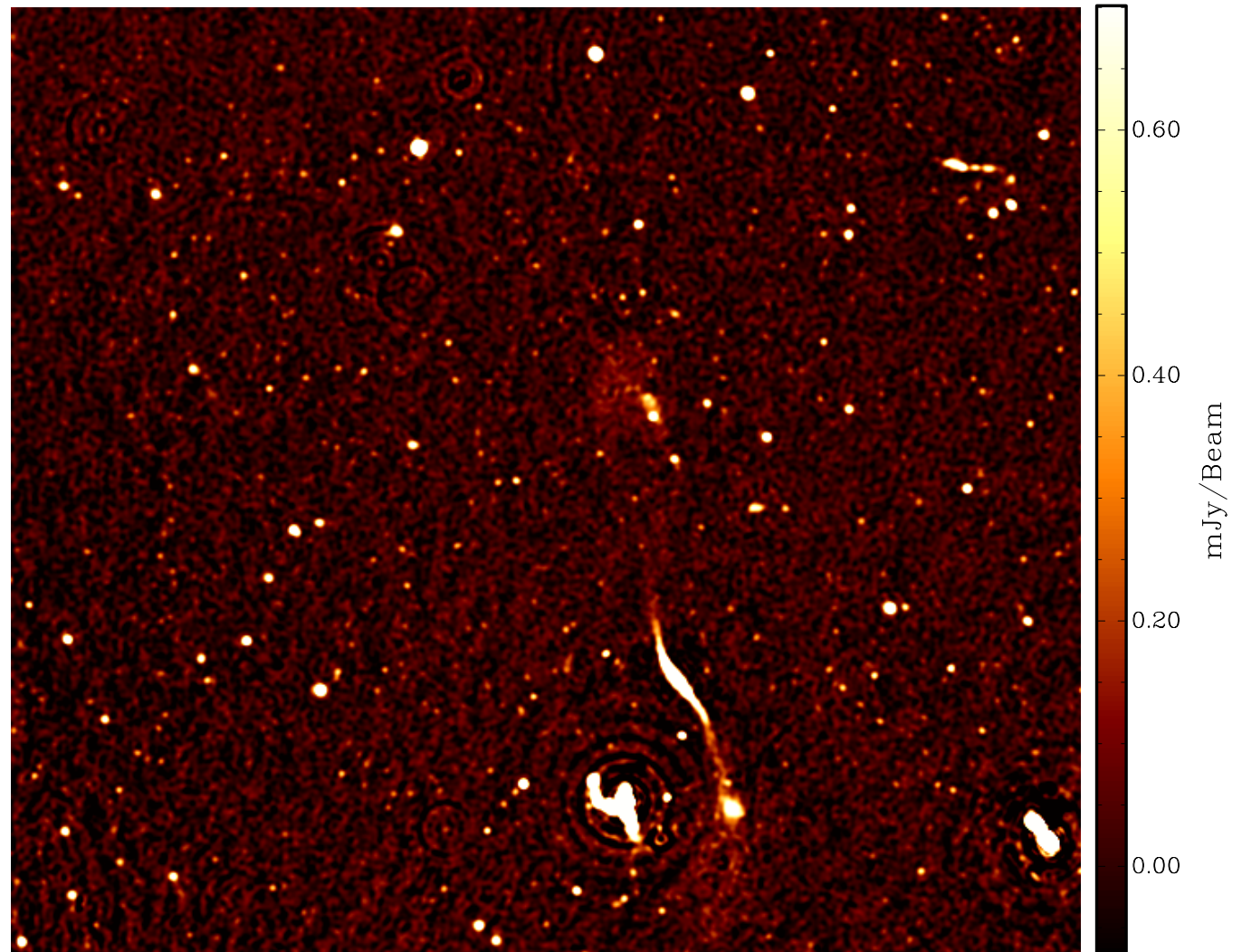
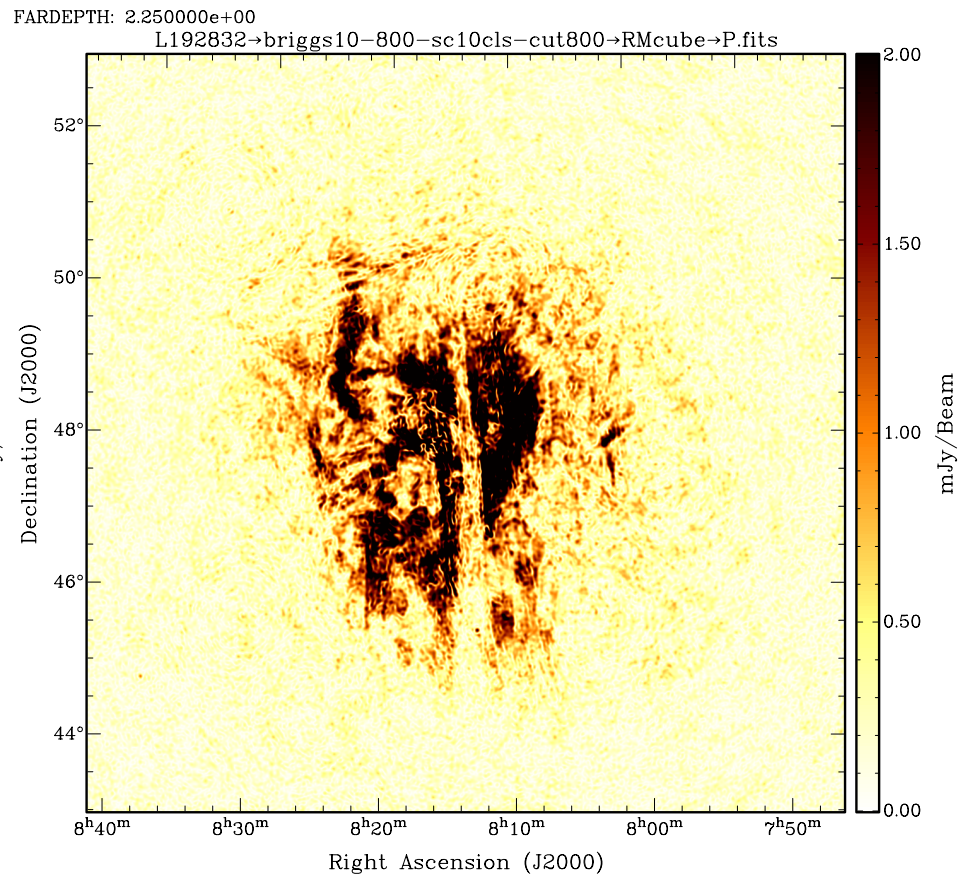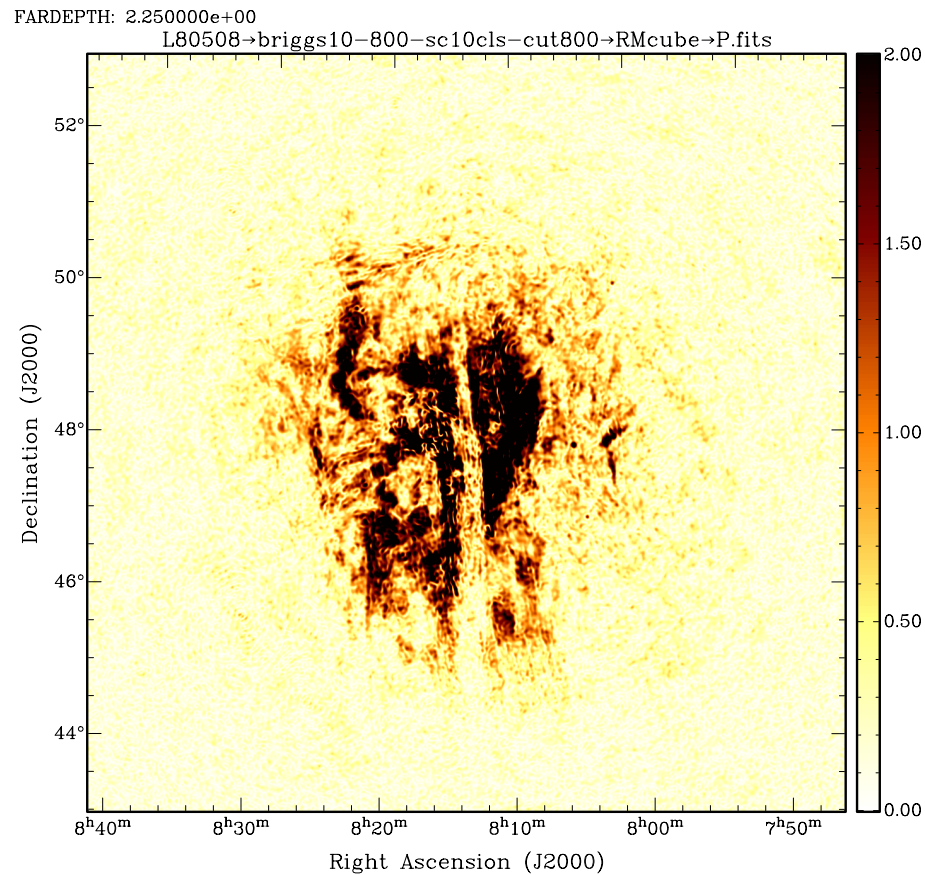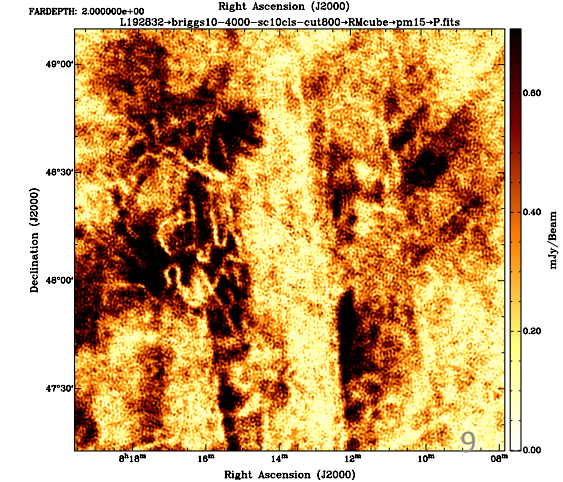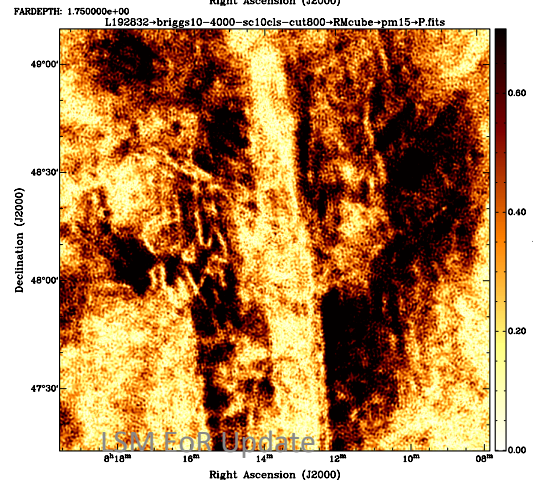# 3C196   3' PSF   RM frames at = +2.25 rad/m^2

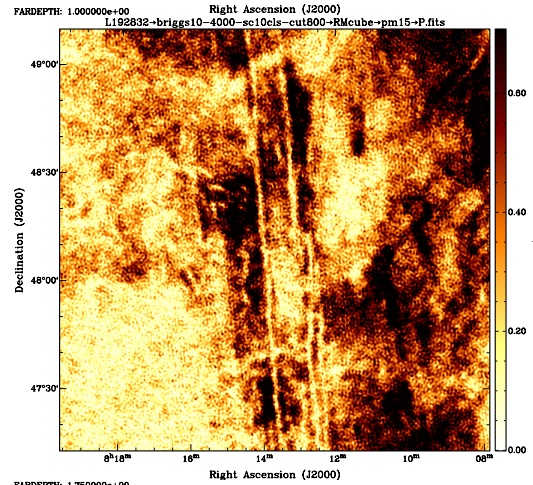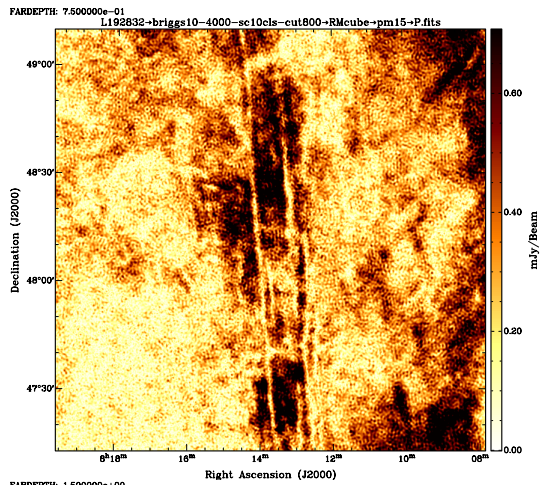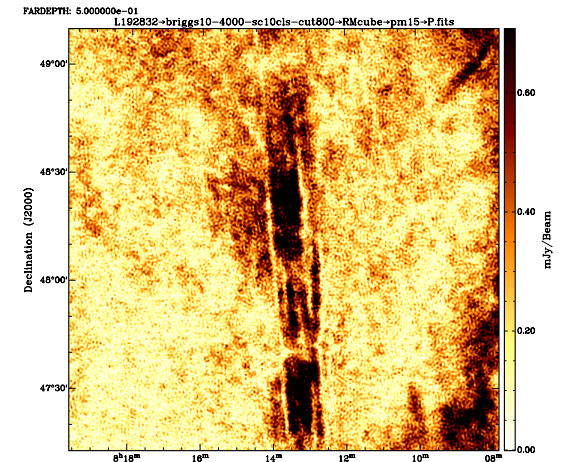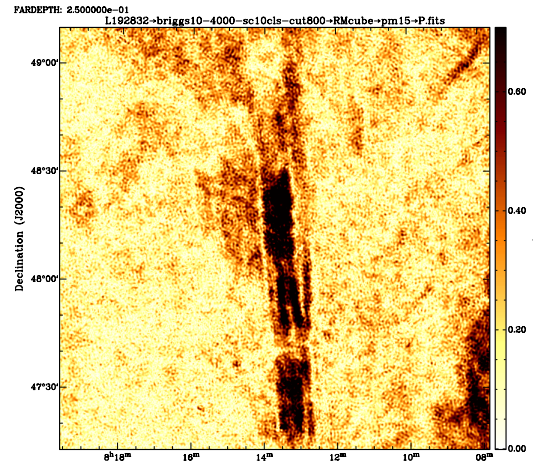## 16/17 Dec 2012   (6h)   15/16 Dec 2013

3C196   L192832   6h

15 Dec 2013

Calibration: sagecal 10 sources

Imaging : excon 2880x10" (8°x8°)

40" PSF, 70 μJy noise

RMSF 1.0 rad/m²

8 Faraday-depth frames
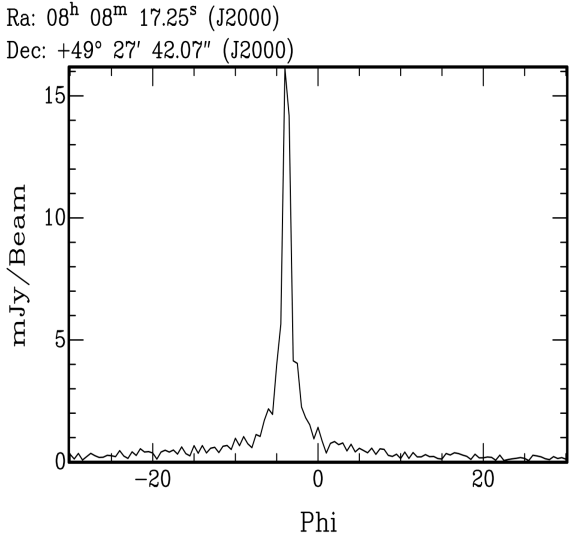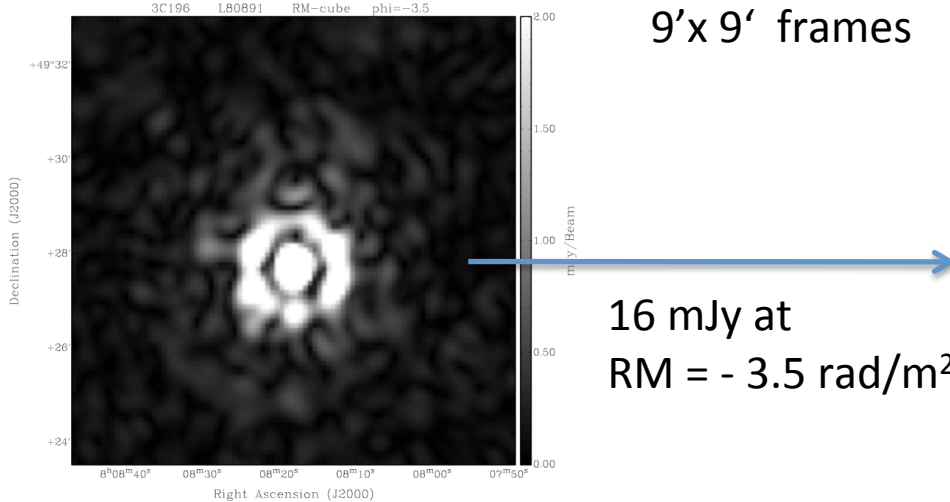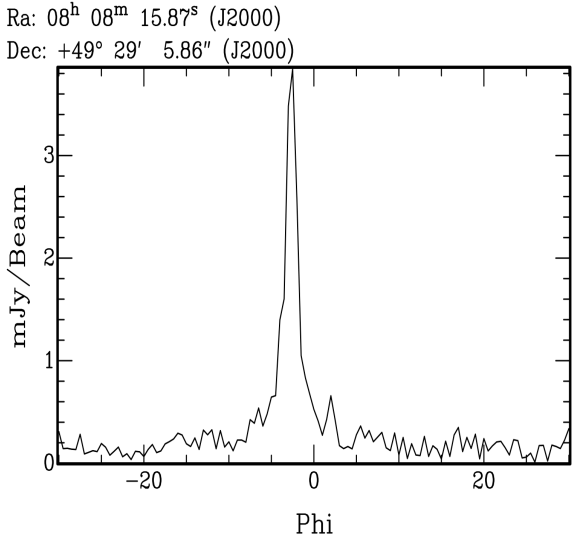at   0.25 (0.25) 2.00 rad/m²
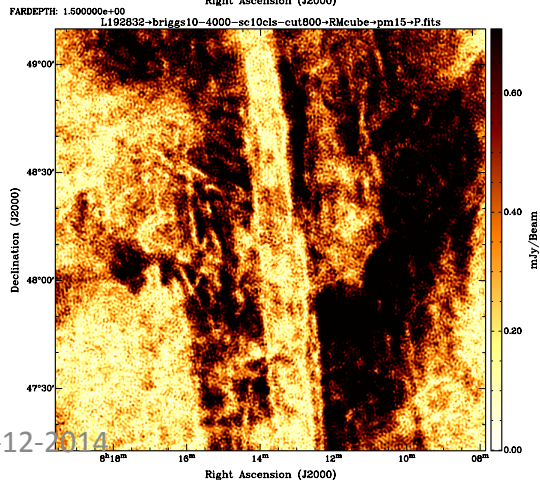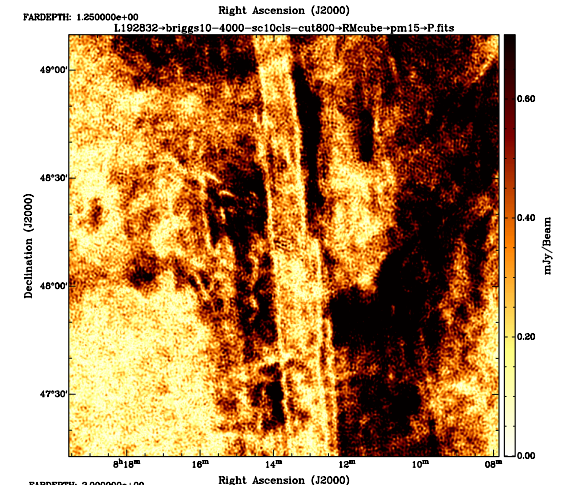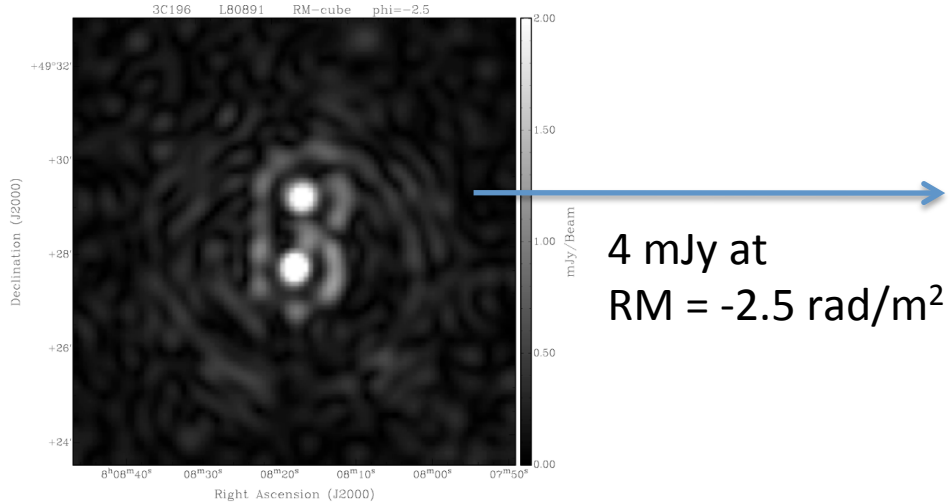
Polarization in giant/double radio sources

4 mJy at
RM = -2.5 rad/m^2

9'x 9' frames

16 mJy at
RM = - 3.5 rad/m^2

Another giant (5') radio galaxy: J0801+4737

50" PSF

Φ = 3.25 rad/m2

Φ = 3.75 rad/m2
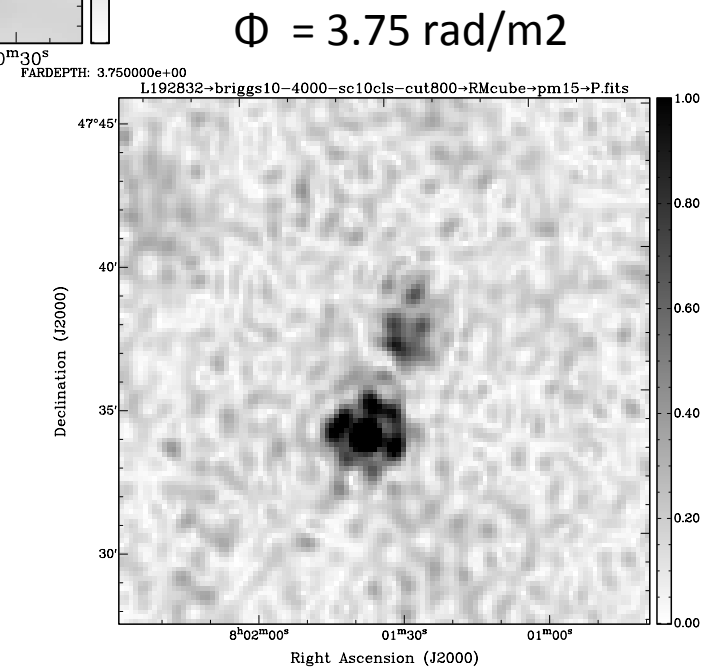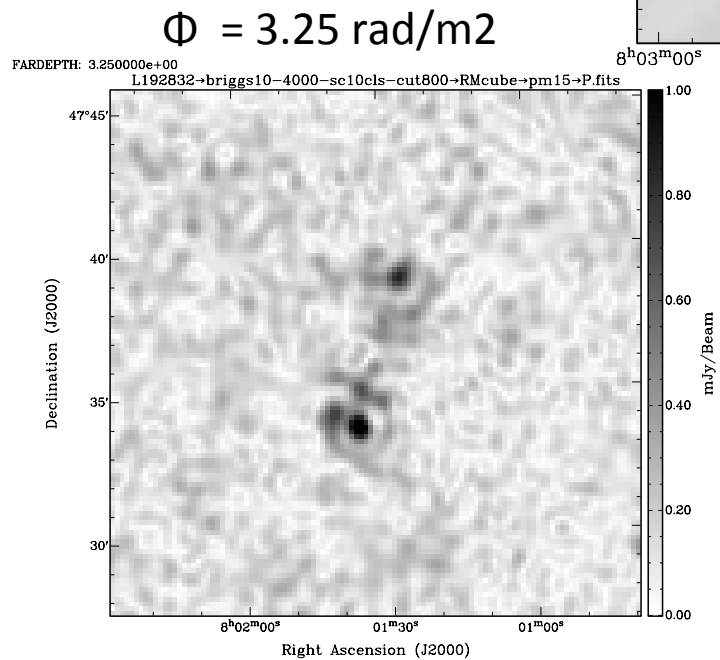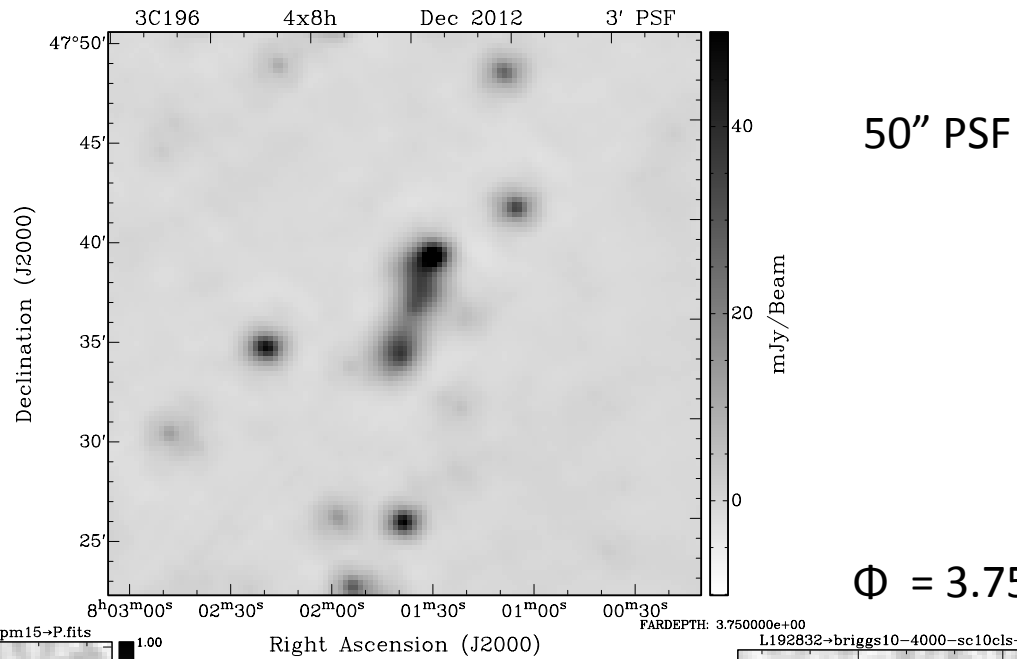
RM's of 15 polarized radio galaxies in the 3C196 window

3C196 polarized radio galaxies
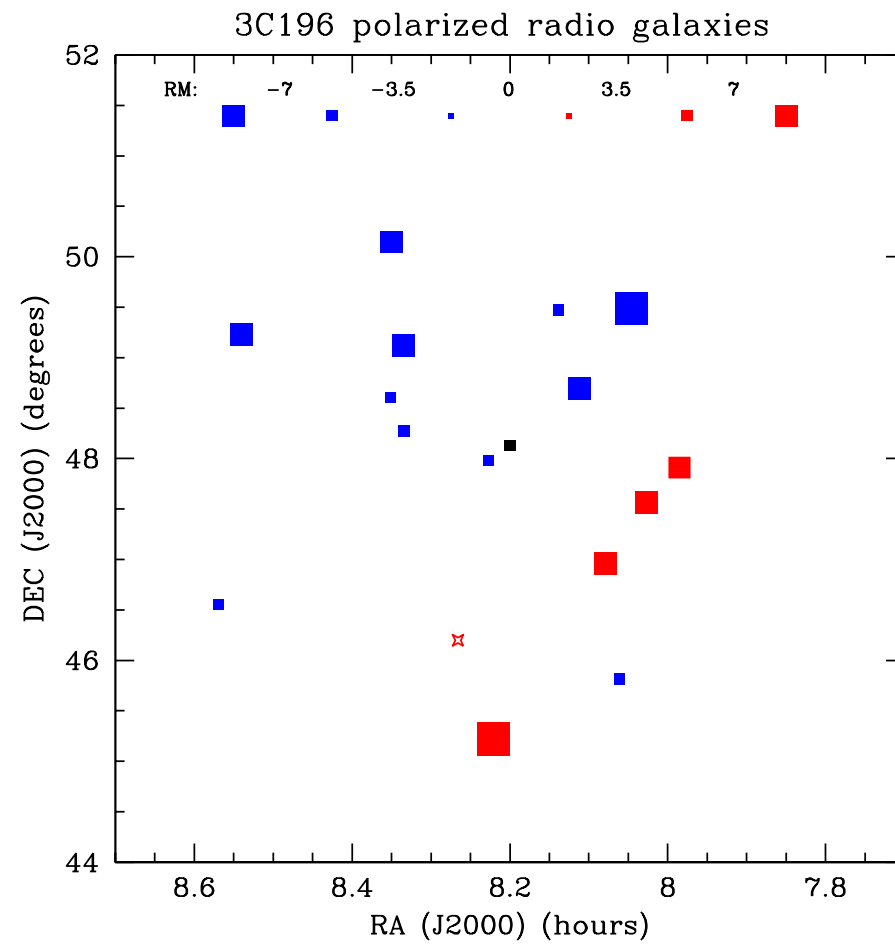
Recently published and (coming soon) papers

Vedantham et al: "Moon " (arXiv)

Vedantham-Koopmans: "Speckle noise" (arXiv)

Jelic etal: "Polarization in the 3C196 field"

Patil etal: "Solver noise and other calibration issues"

De Bruyn etal: "Project overview"

Khan et al: "Polarization leakage in the 3C196 field , and effects on EoR power spectrum"

Mevius et al: " Ionospheric structure functions.."

Zaroubi etal : "EoR Upper Limit Paper"

Organization and Management:

Group Meetings:
- MT (weekly, Groningen)
- Science group (weekly , Groningen)
- Processing group (weekly, ASTRON)
- Full group: bi-annual Plenary meeting (Italy, June; Groningen- December)

Current funding and staff:
- ERC Starting grant Koopmans
- ERC Advanced grant de Bruyn
- VICI – NWO Zaroubi

Recent appointments (since Oct 2014)
- Postdoc: Andre Offringa (ASTRON)
- PhD student: Arun M. (ASTRON)
- Datamanager: Medhi Hatef (ASTRON)
- PhD student: Robin Kooistra: (RuG)
- Postdoc: Marta Silva (RuG)
- …

Ancillary science with our EoR deep field image(cubes)
Collaborations with   MKSP, SKSP, TKSP

1) Galactic foreground polarization (Vibor, Ger,..   Marijke, Andrew, ….)

2) Source spectra (broad/narrow spectral structure) Pandey, Andre,..

3) Giant and DD radio galaxies, especially polarization → Ger, Vibor, Michiel, Abhik, …   Torsten Ensslin/Vacca,….)

4) Transients   (Fender/Wijers) → Ger, Ajinkya,….

5) Pulsars   (Hessels, Kondratiev etal) → Ger, Pandey, Vibor, Michiel

6) Exoplanets (Zarka + Soobash)

7) Deep source counts (Best …)

8) ?