Aperture Array Developments at ASTRON

Stefan J. Wijnholds
e-mail: wijnholds@astron.nl

Phased Array Workshop
Provo (Utah), 3 May 2010

Outline

ASTRON

Main aperture array projects

- LOFAR
- EMBRACE

Concept design and subsystem studies

- OLFAR
- Path to the SKA

LOFAR – the Low Frequency Array

M. de Vos, A.W. Gunst and R. Nijboer, Proc. IEEE, 2009

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Phased array radio telescope consisting of

- 36+ Dutch stations with
  - 96 Low Band Antennas (LBA, 10 – 90 MHz)
  - 48 High Band Antenna tiles (HBA, 110 – 250 MHz)

    4x4 array -> total 768 HBAs / station
- 10+ international stations with 96 LBAs and 96 HBA tiles

Total:

- > 4400 LBAs
- > 43000 HBAs

LOFAR – Current status

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- 29 stations with CEP connection
- 22 stations validated
- Station calibration tables being produced
- Many “busy weeks”: focused pipeline efforts
  - Standard imaging pipeline
  - Pulsar pipeline
  - Transient detection pipeline
- **LOFAR opening: 12 June 2010**

LOFAR – Pulsar detection

Tom Hassall (PWG), AJDI 19 March 2010
Tom Hassall (PWG), AJDI 22 December 2009

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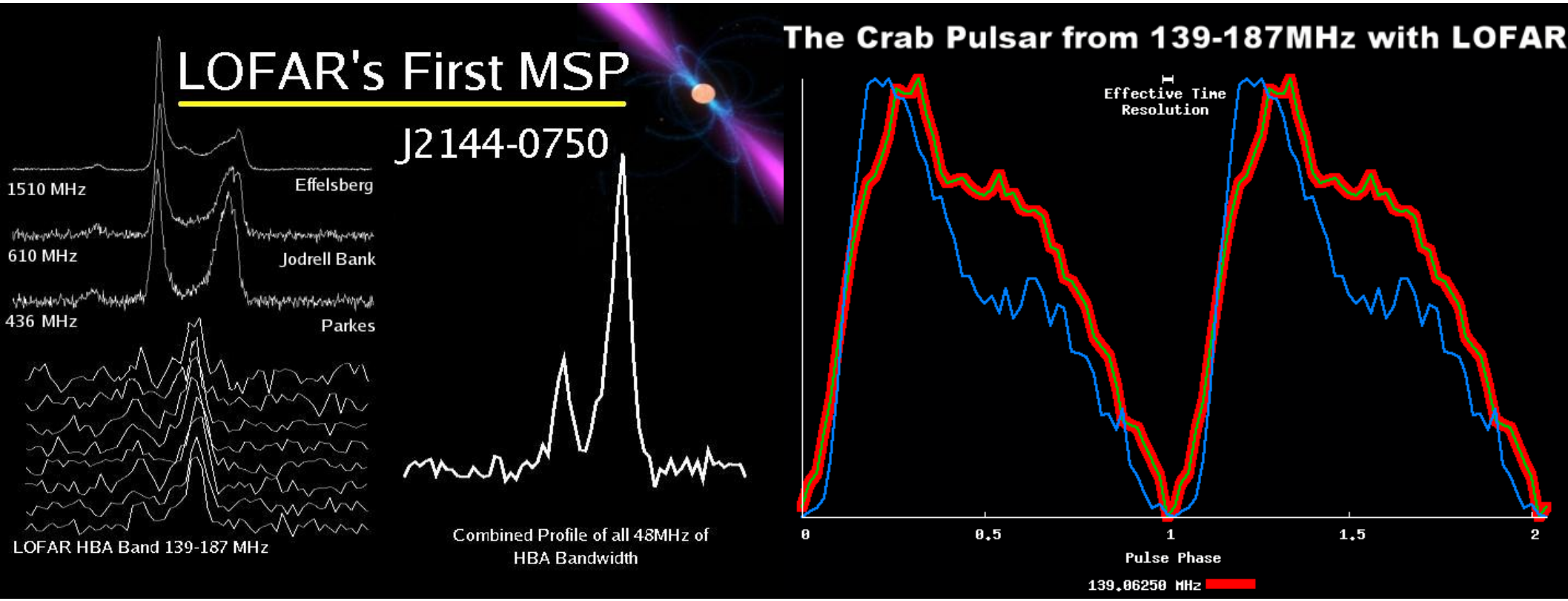

LOFAR – ITS ('04) vs. CS10 ('08) image

S.J. Wijnholds, URSI GA, 2005
S.J. Wijnholds, Ph.D. Thesis, 2010

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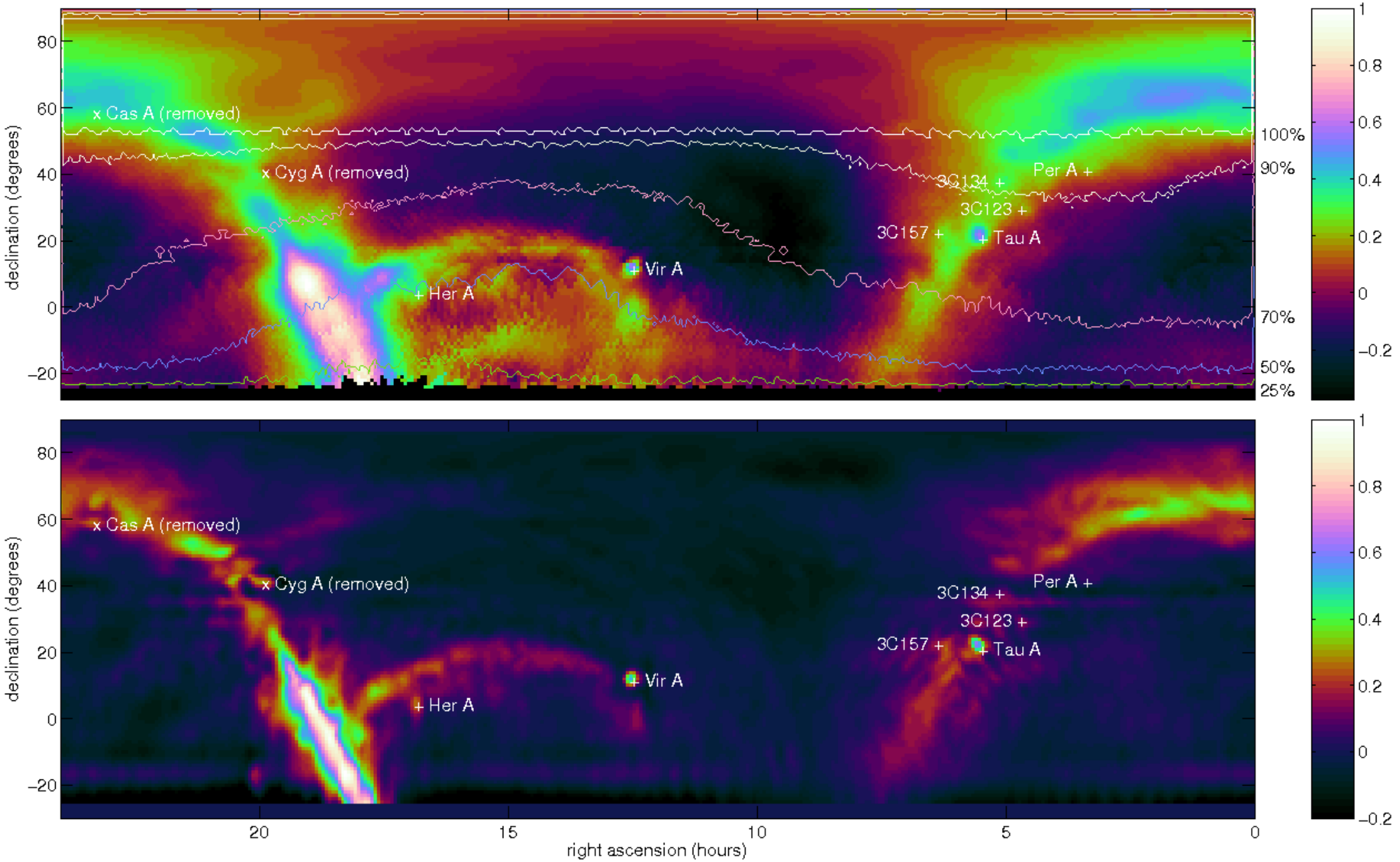

LOFAR – Beat NEWSTAR Project

Oleg Smirnov, SKA2010, 22-25 March 2010

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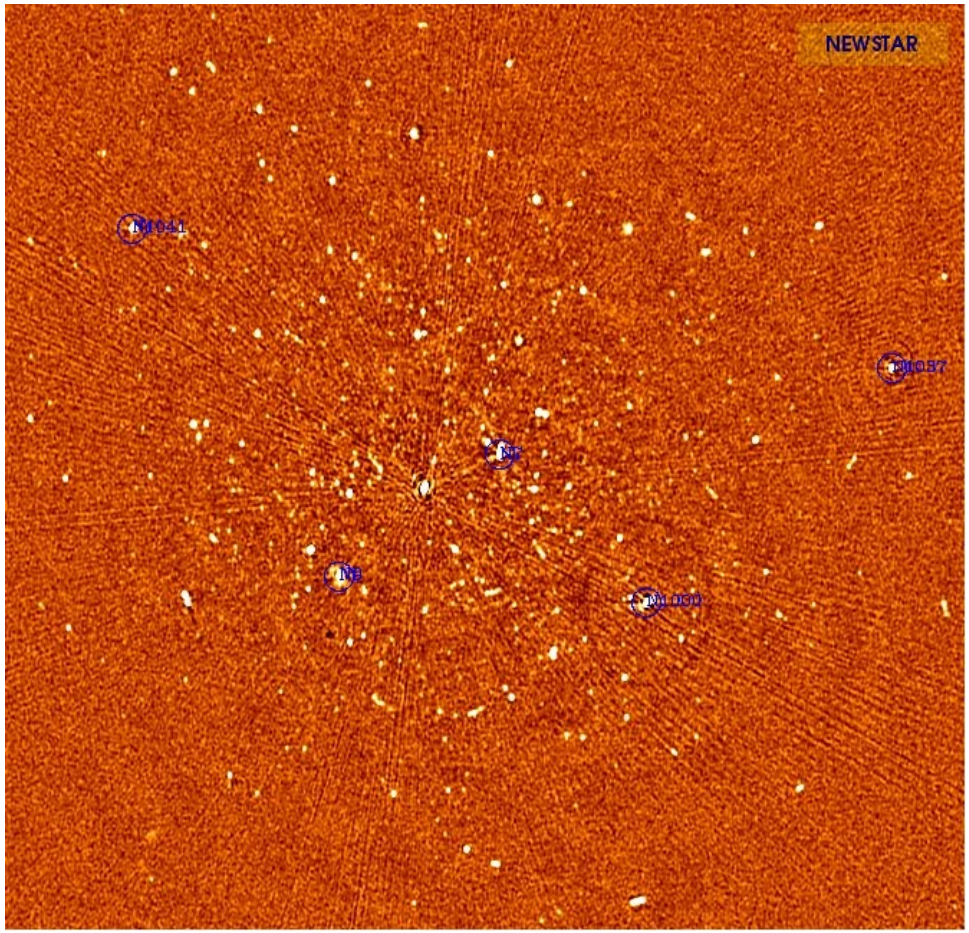
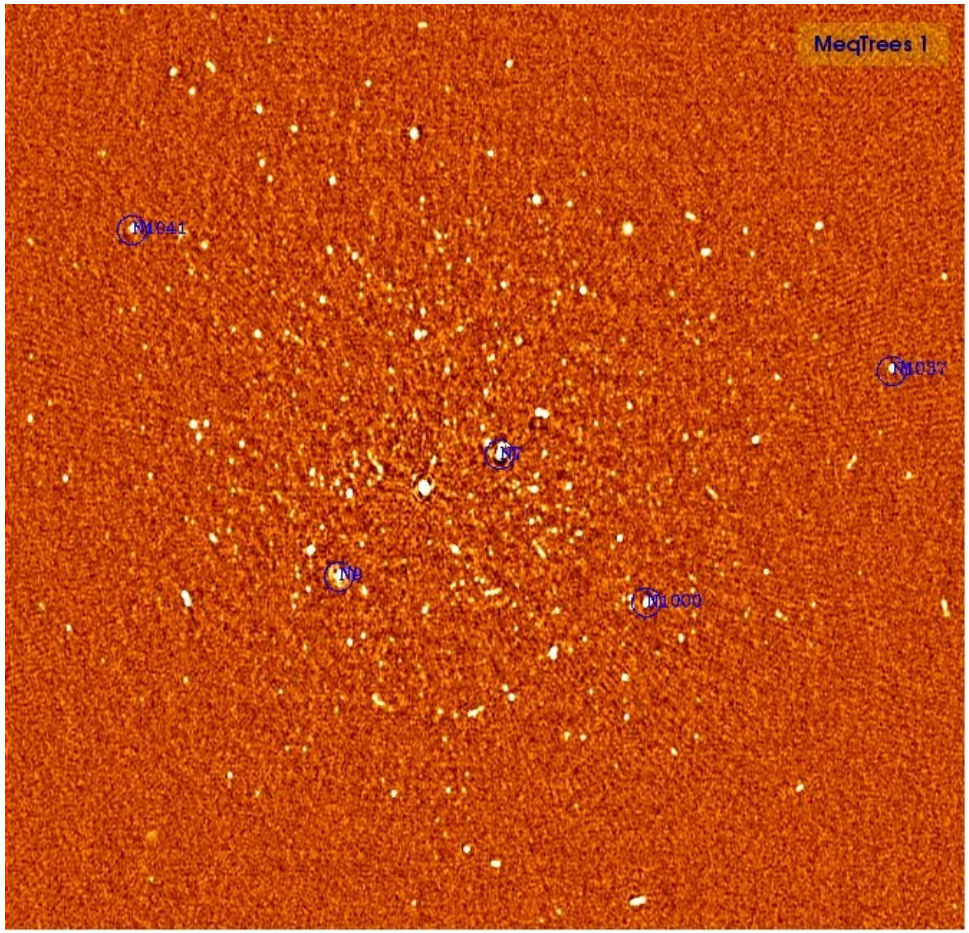
- Goal: beat DR on 3C147 obtained by De Bruyn ($2 \cdot 10^6$)
- Main challenge: direction dependent effects (DDEs)





Electronic Multi-Beam Radio Astronomy Concept

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EMBRACE-WSRT

- 144 single pol. tiles
- A-beam: 144 signal paths
- B-beam: 36 signal paths
- 72 tiles installed
- 192-input LOFAR backend

EMBRACE Nancay

- 72 single pol. tiles
- 20 signal paths per beam

EMBRACE – Backend

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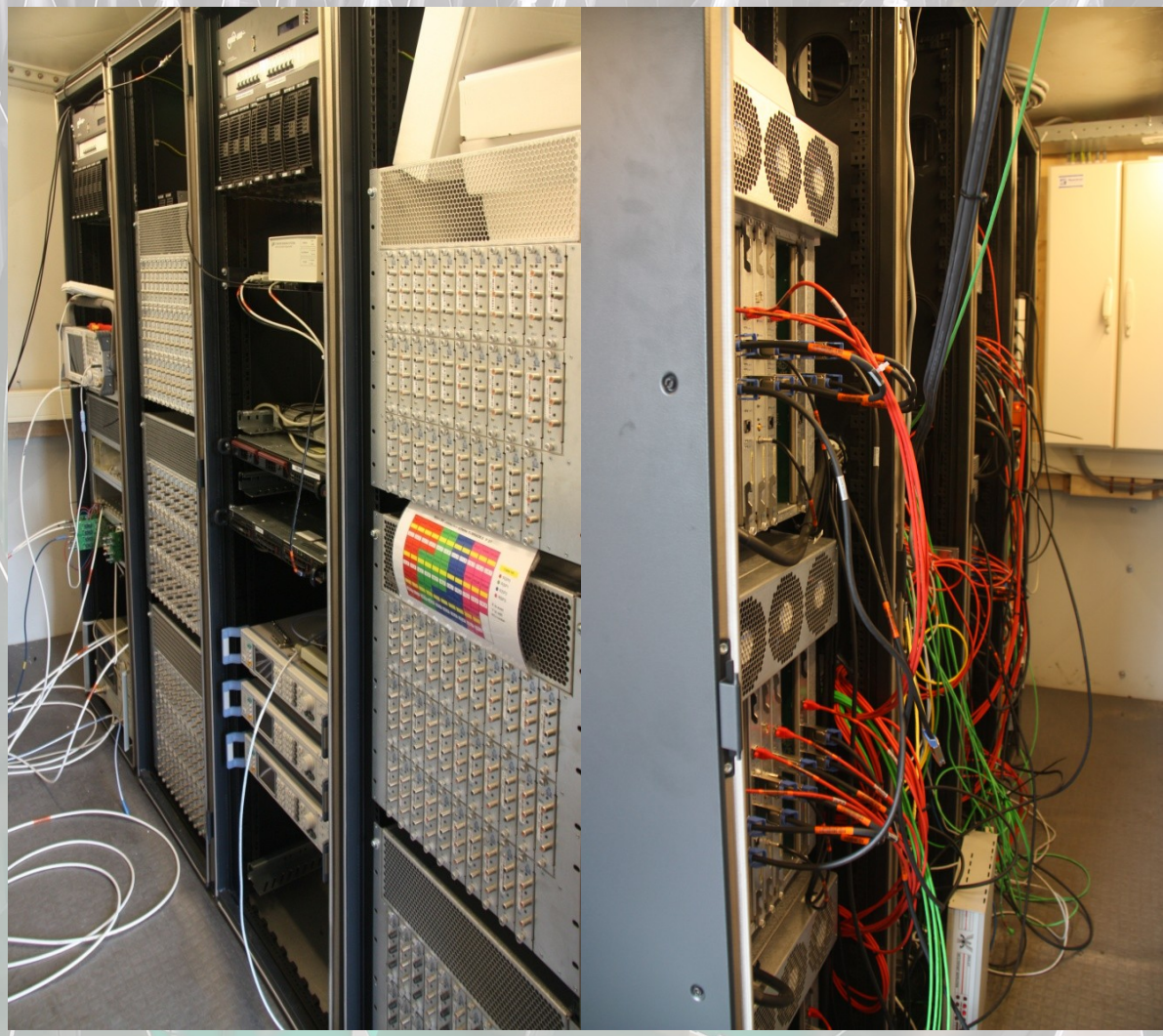
180 CDCs (LO dist.)

192 RCUs

- 110-190 MHz band
- 12 bit 200 MHz ADCs

digital processing

- 195 kHz subbands
- autocorrelations
- visibilities



EMBRACE – Solar fringes

S.J. Wijnholds et al., SKADS conference, 4-6 November 2009
G.W. Kant et al., IEEE TrAP, in revision, 2010

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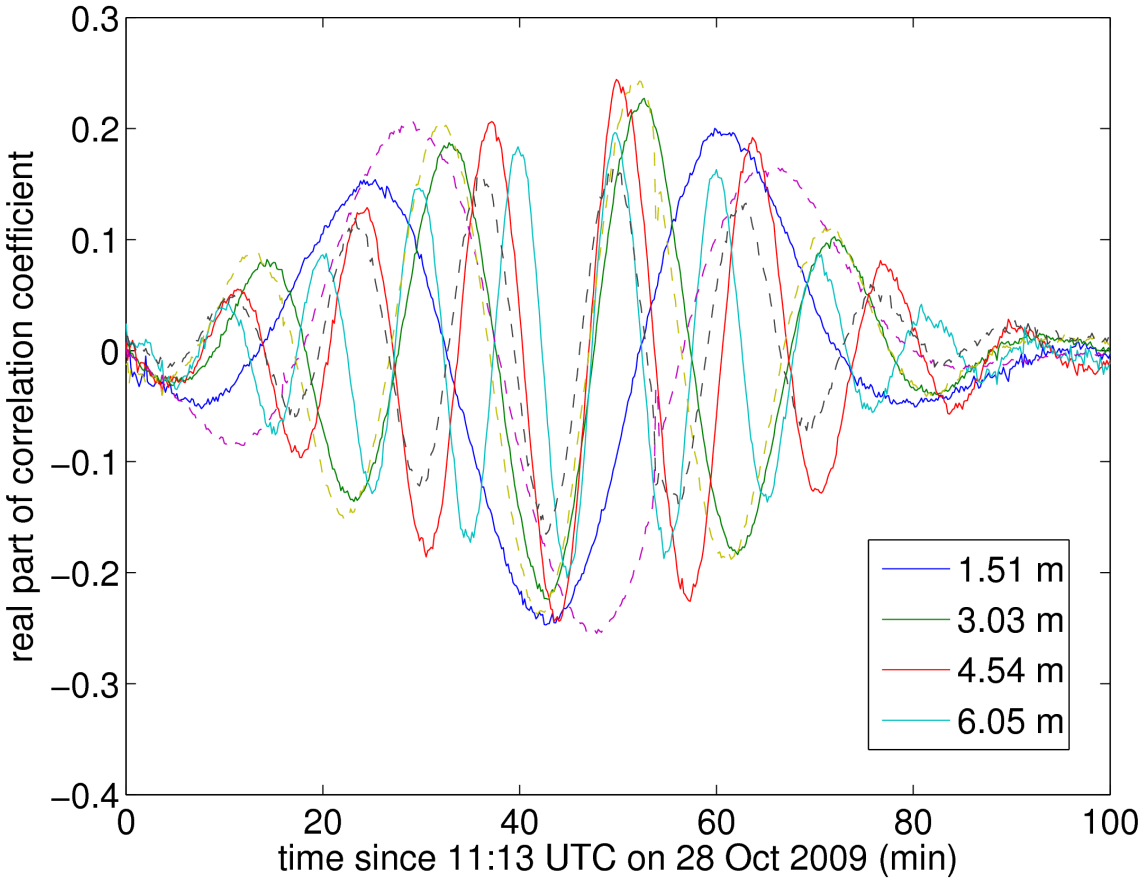
Interferometric measurement with 10 tiles

- two E-W ULAs
- frequency: 1179 MHz
- integration: 10 s
- bandwidth: 195 kHz

Initial performance est.

- A/T = $4.7 \cdot 10^{-3}$ (to sun)
- Tsys = 103-117 K (to zenith)



EMBRACE – Redundancy

S.J. Wijnholds et al., SKADS Conference, 4-6 November 2010

P. Noorishad et al., SKADS Conference, 4-6 November 2010

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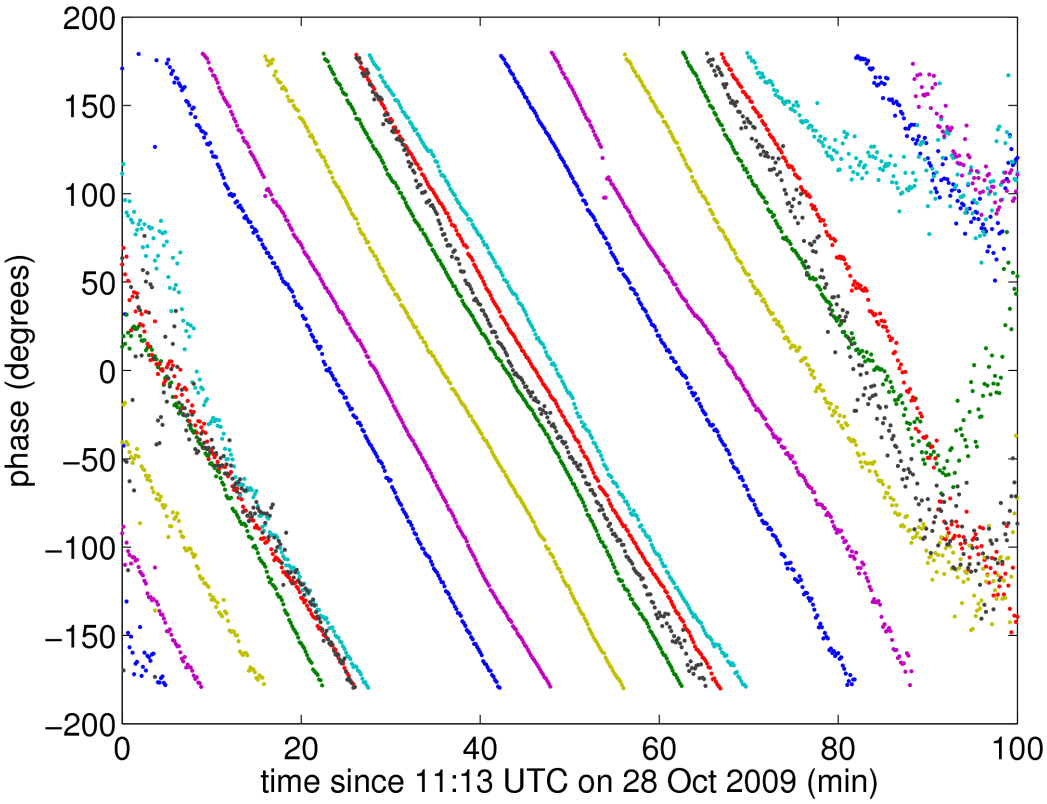
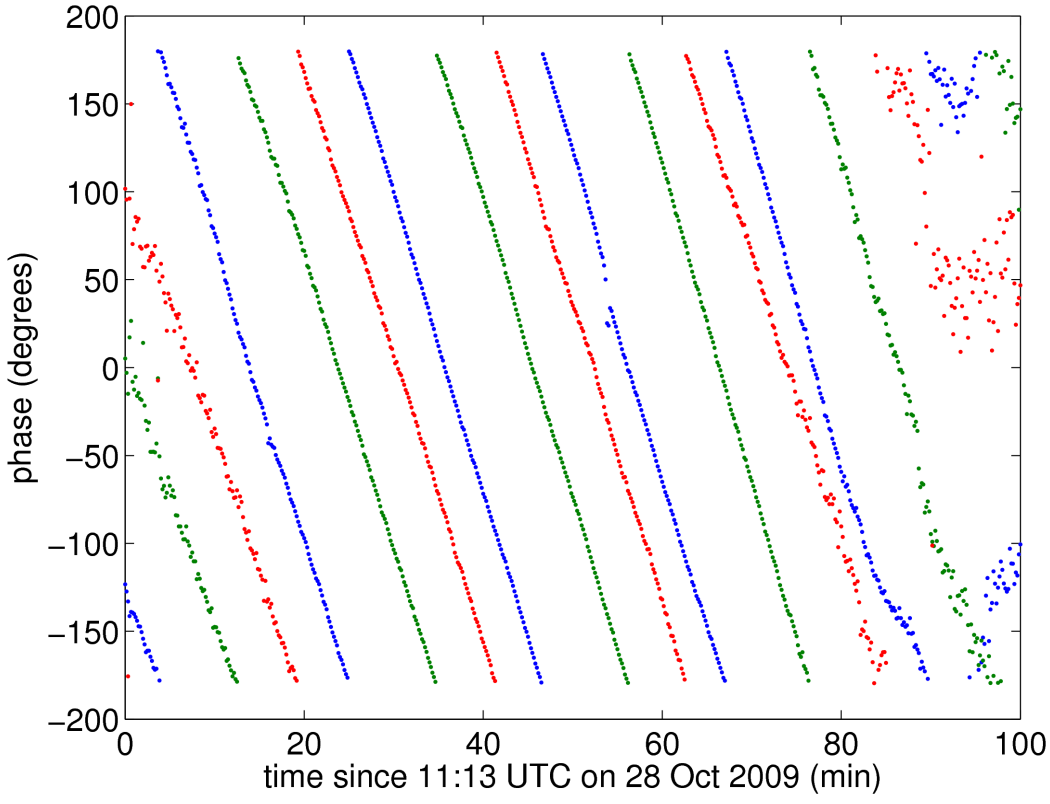
Redundant baselines produce redundant visibilities

Useful for calibration (under study by Parisa Noorishad)





EMBRACE – 40 dB DR Afristar image

S.J. Wijnholds (EMBRACE team), AJDI, 26 January 2010
G.W. Kant et al., IEEE TrAP, in revision, 2010

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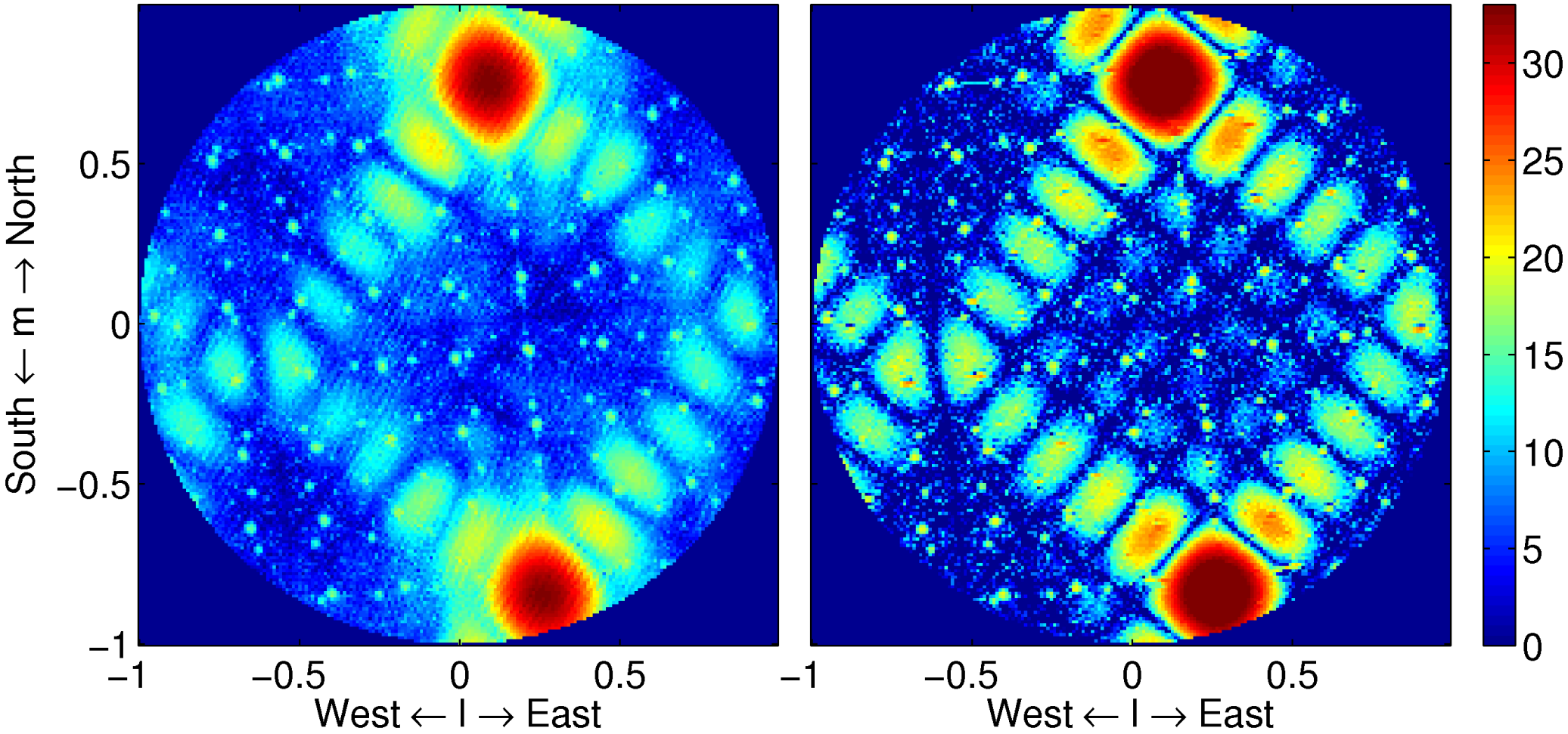
Measured (left) and simulated (right) array factor



OLFAR – Orbital Low Frequency Array

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Concept design study

Goal: low (< 10 MHz) frequency array in space

Concept

- Antennas on formation flying micro-satellite
- One mother ship with central processing and downlink
- Distributed signal processing

Partners: Delft University of Technology, Twente University, ALTRAN, Astrium, Radboud University Nijmegen

The path to the SKA

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Aperture Array Verification Program (AAVP)

- Verification of EMBRACE
- Design improvement (lower Tsys, mass production)

Other SKA studies (implicit and explicit)

- Virtual observatory: experience LOFAR and WSRT
- Calibration and imaging research
- Uniboard: generic digital signal processing board
- Photonic research: data transport, beam forming