

Von einfachen Antennen
zum Radiointerferometer
per Software:
Das *Low Frequency Array* (LOFAR)

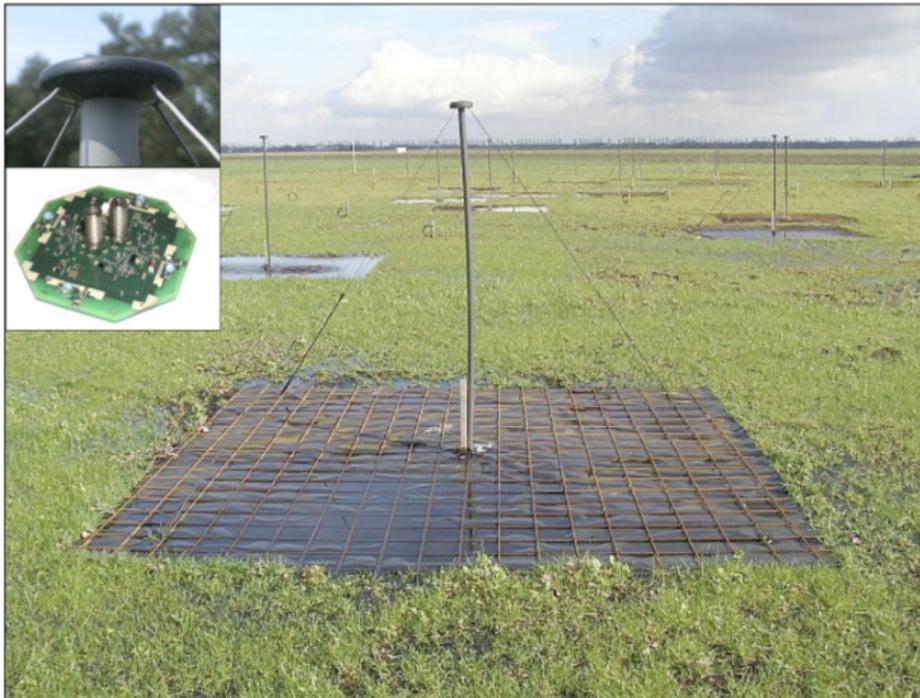


Low-Band und High-band Antennen

10 - 80 MHz
(25 - 4 m)

96 Antennen pro Station

(Bild: van Haarlem et al 2012)



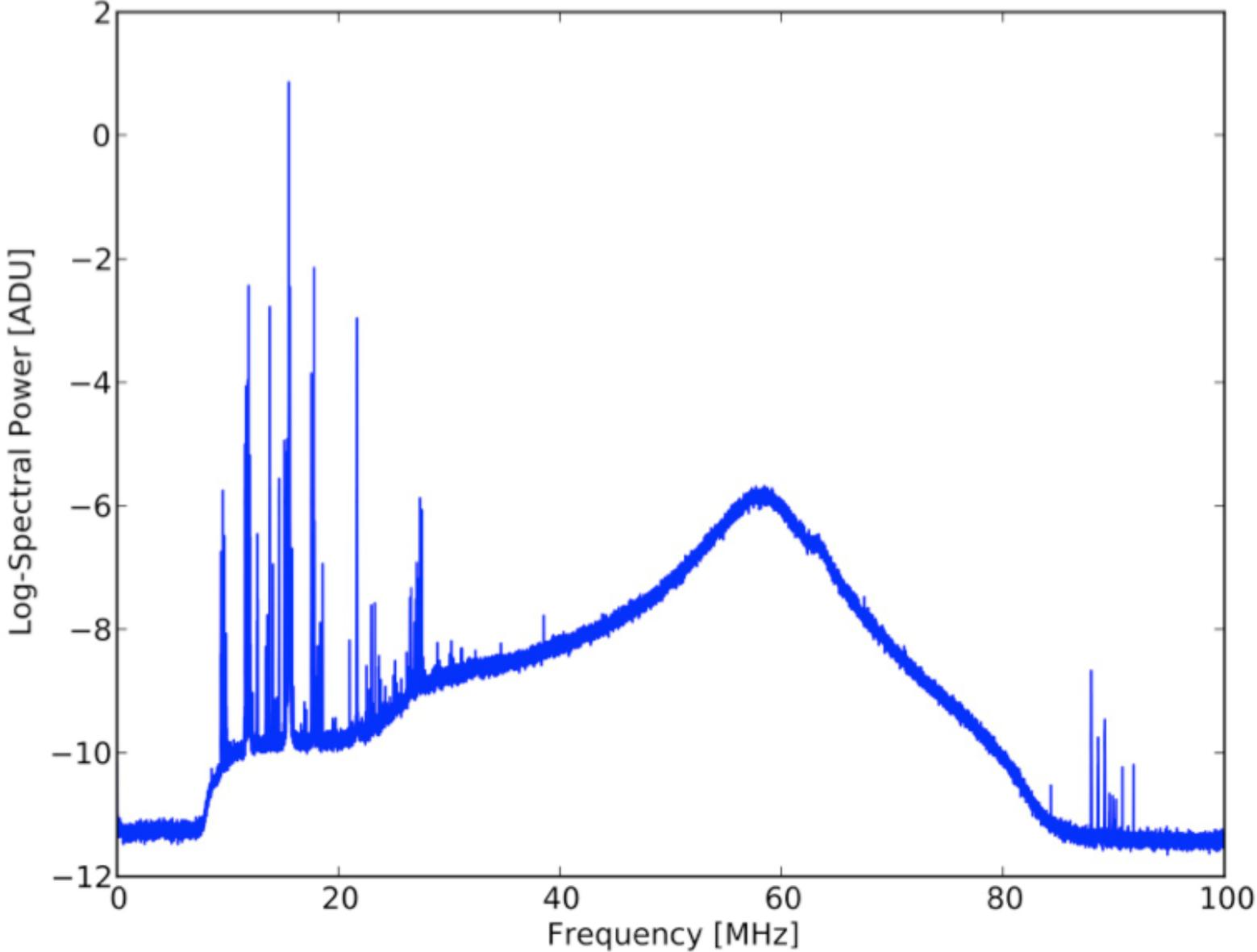
115 - 240 MHz
(3 - 1.2 m)

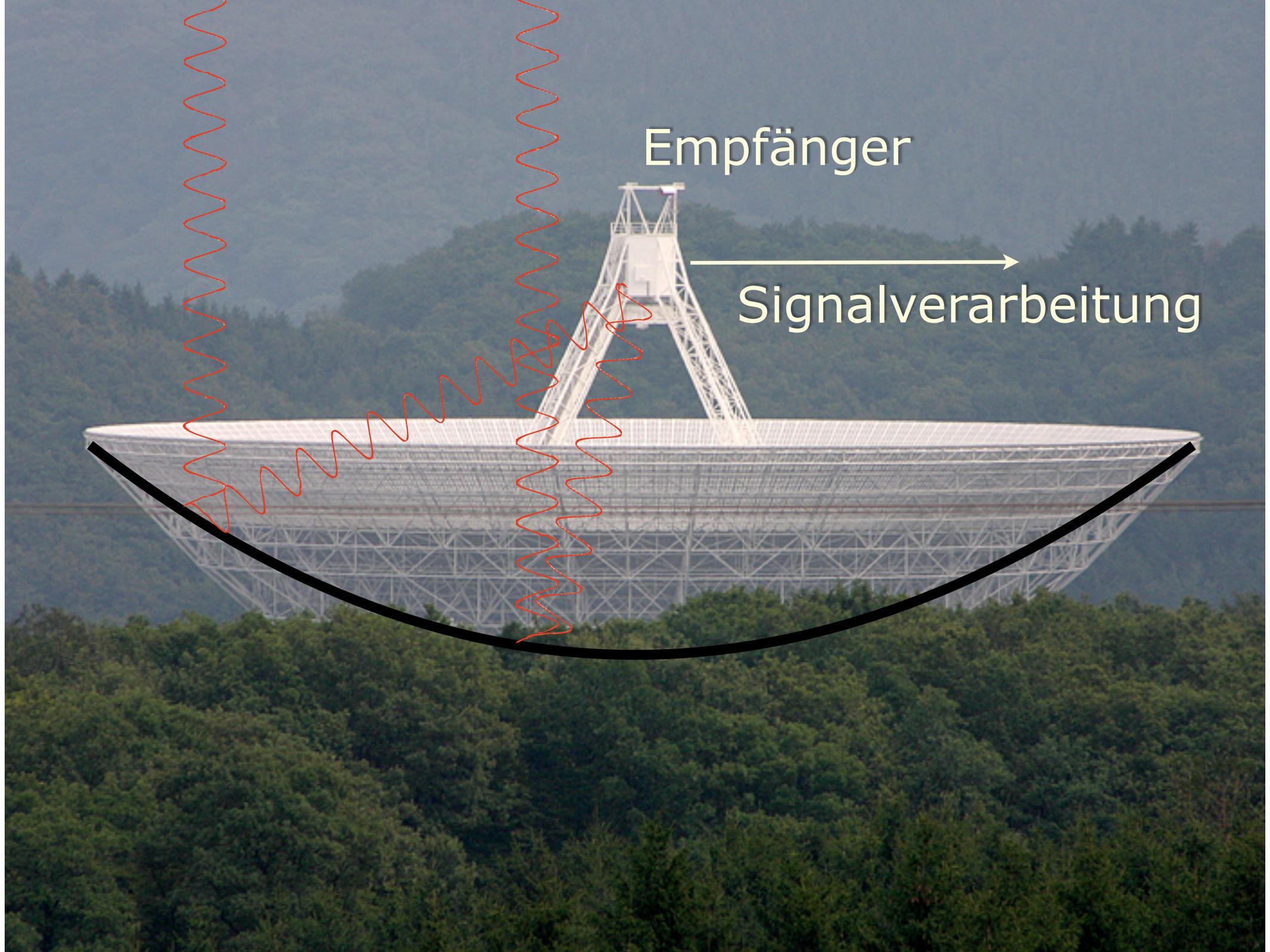
96 Tiles pro Station

(Bild: ASTRON)



Das Spektrum einer LBA-Antenne



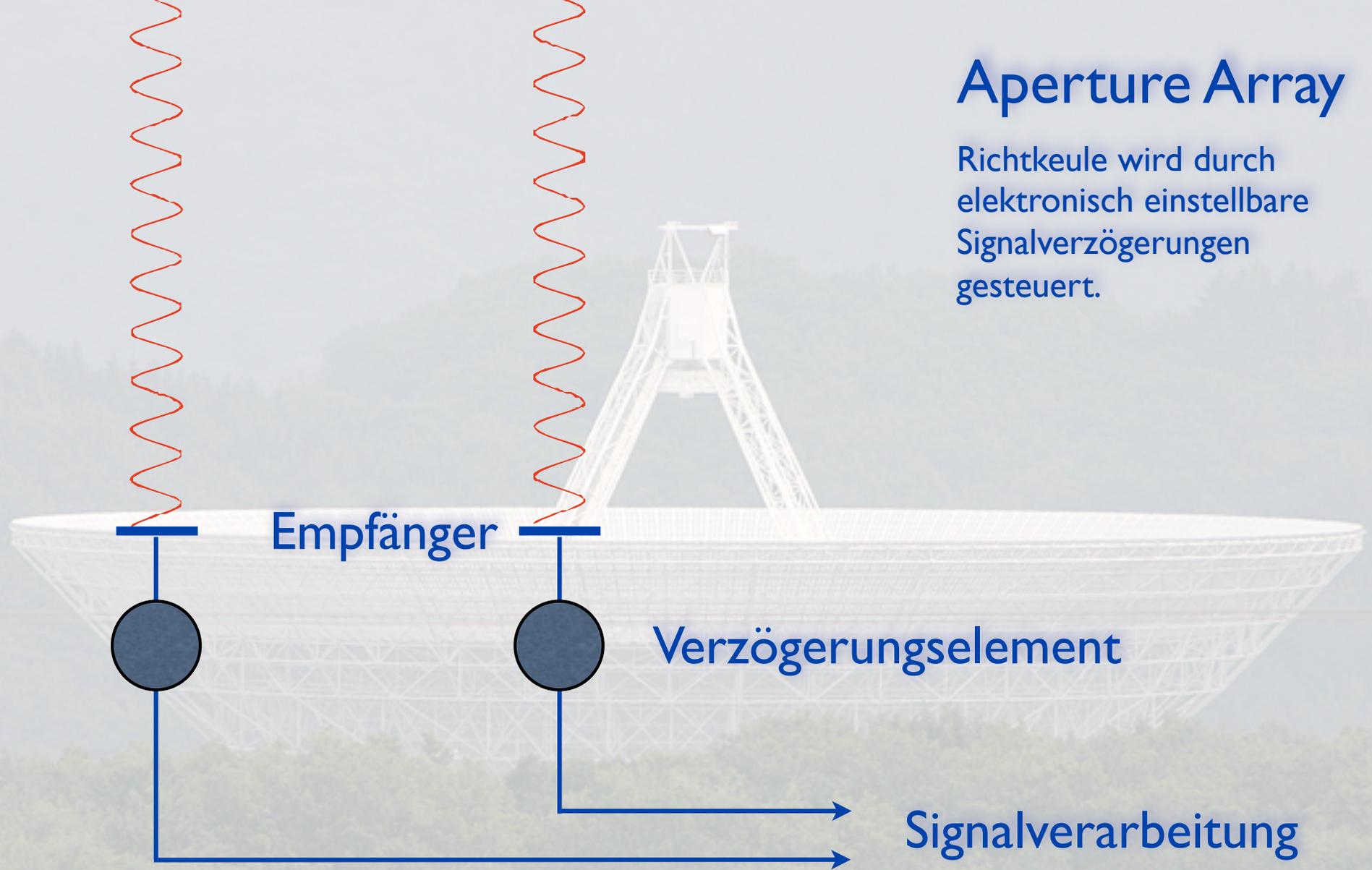


Empfänger

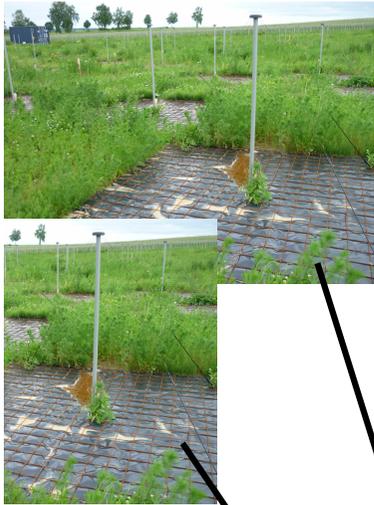
Signalverarbeitung

Aperture Array

Richtkeule wird durch elektronisch einstellbare Signalverzögerungen gesteuert.



Prinzip von LOFAR



Detektion der elektromagnetischen Wellen durch simple Antennen

Datenübertragung zu einem Zentralcomputer

Erst
heute
möglich



'Optik' durch geeignete Überlagerung der Signale der Antennen

LOFAR: Eine Herausforderung an Datenleitungen und Computer

Datenrate:

4 GB/s pro Station

Korrelator:

Supercomputer Blue Gene/P

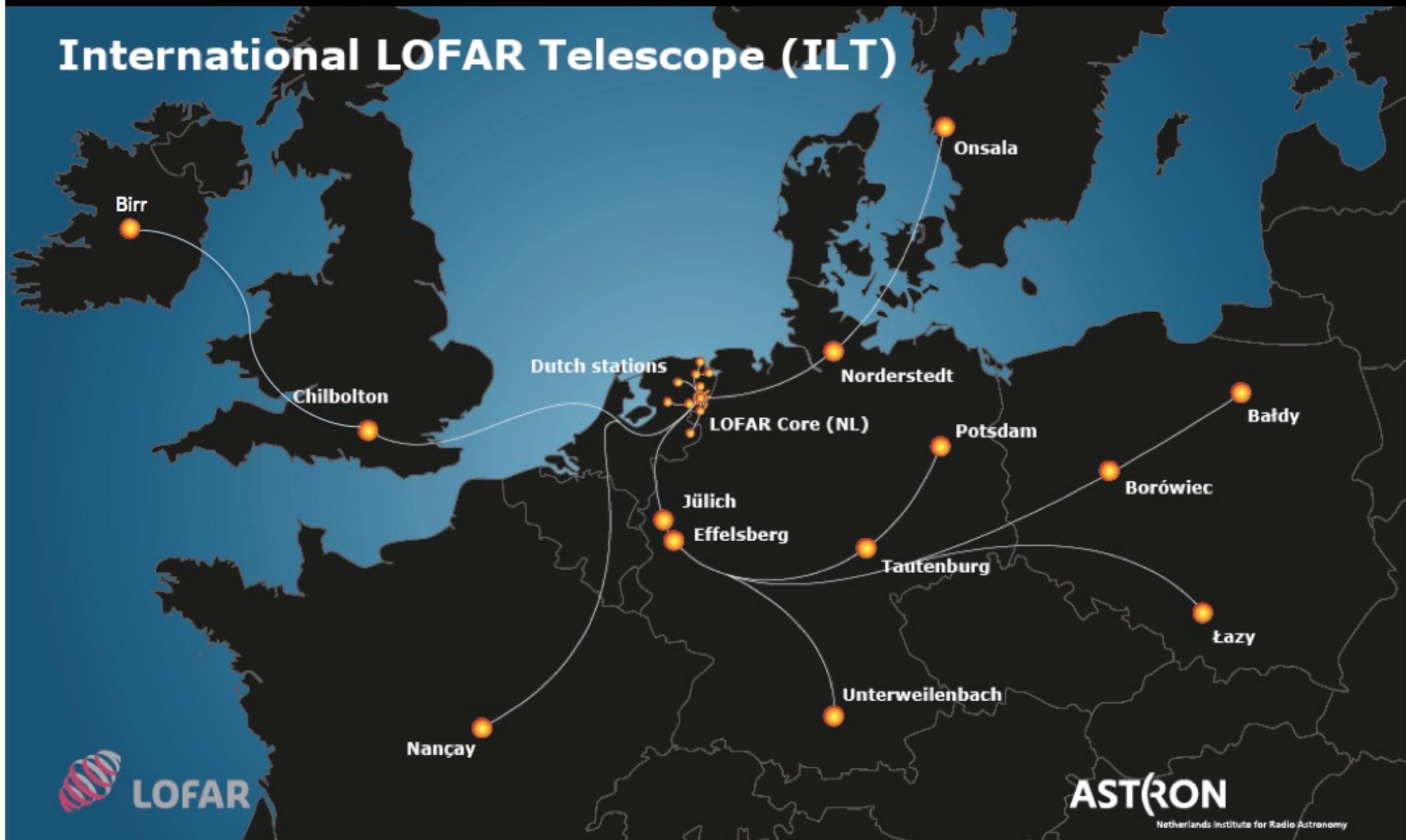
Datenvolumen nach der Korrelation:

$$\frac{t_{\text{obs}}}{t_{\text{int}}} \times N_{\text{baselines}} \times N_{\text{channel}} \times N_{\text{pol}}$$

Typische Größe der Datenprodukte:

einige 10 TB pro Nacht -> sofortige Weiterverarbeitung erforderlich

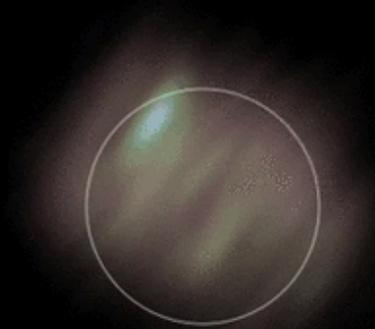
International LOFAR Telescope (ILT)



Science Highlights

ASTRON

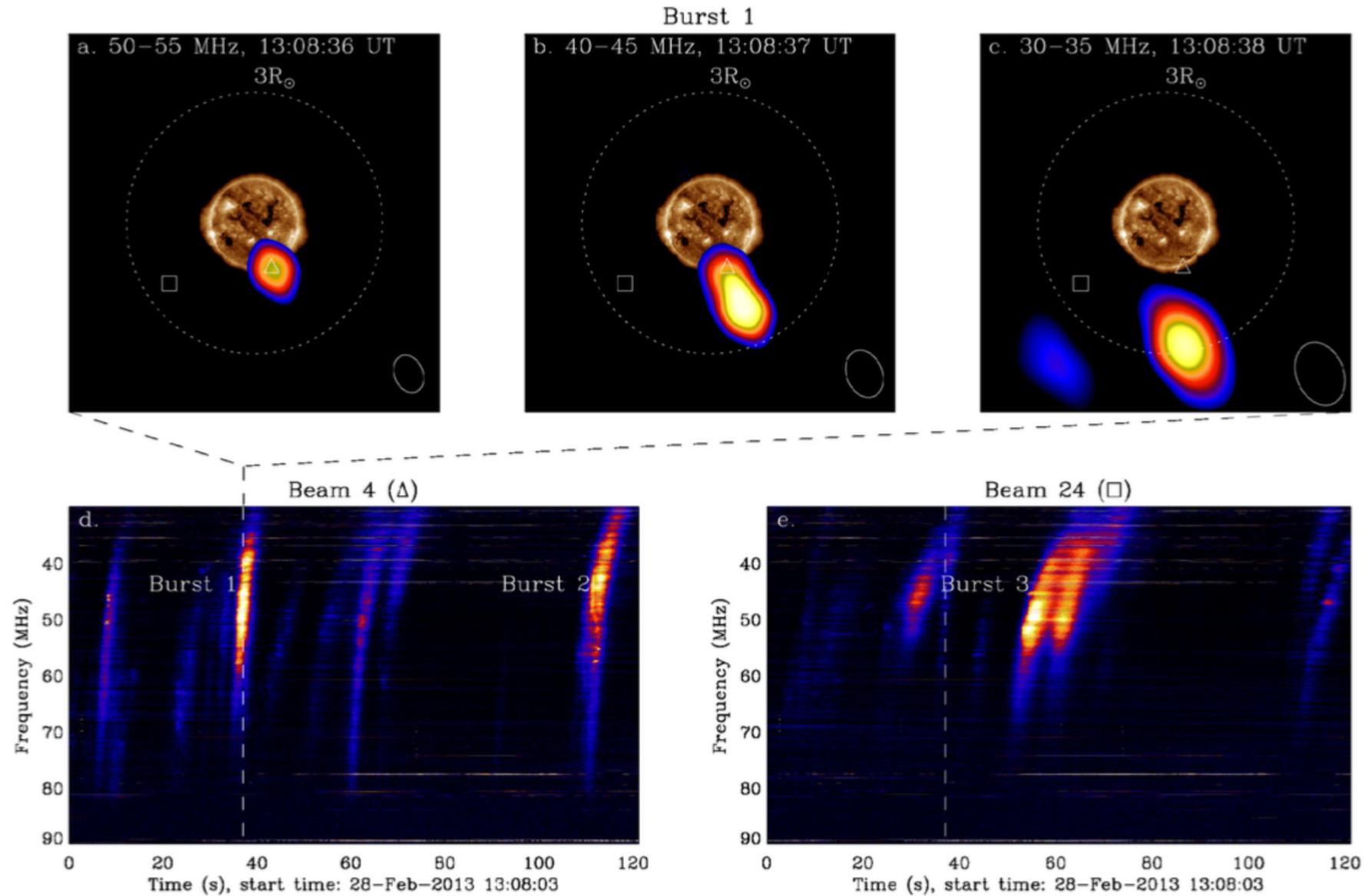
Netherlands Institute for Radio Astronomy



08:25 CET

20. März 2015, M. Brentjens (ASTRON)

LOFAR tied-array imaging of Type III solar radio bursts★



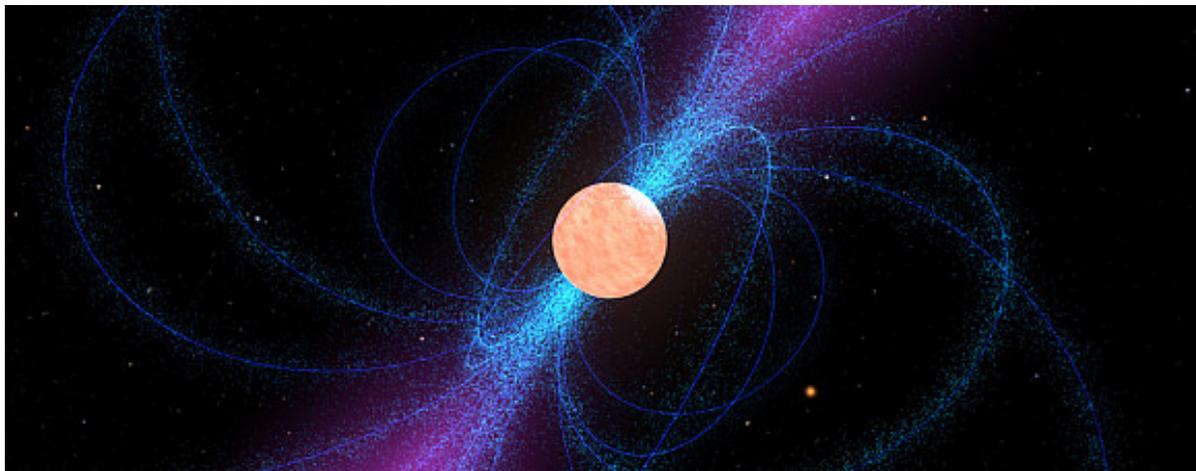
News | 19.04.2016 | [Drucken](#) | [Teilen](#)

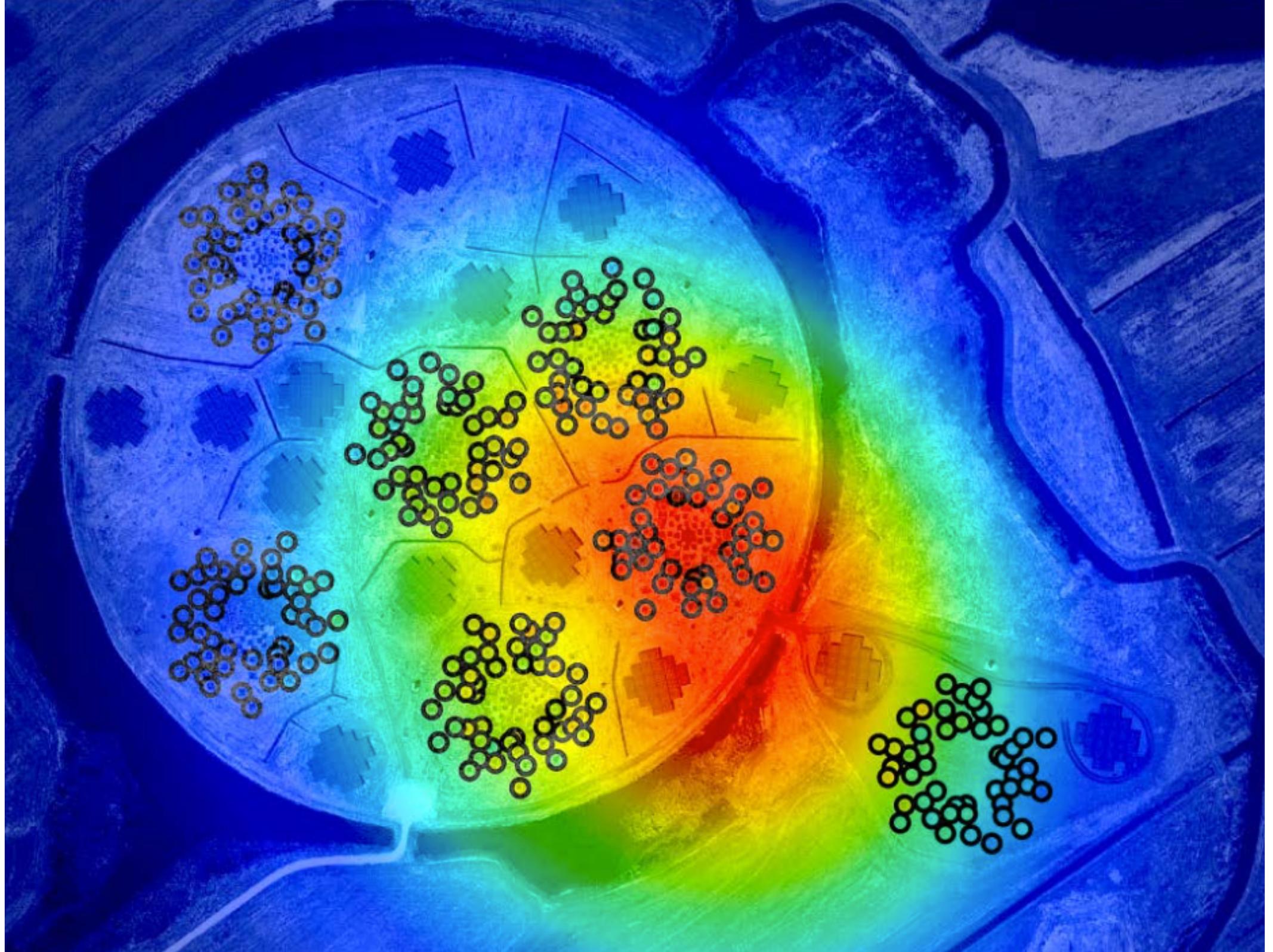
RADIOASTRONOMIE

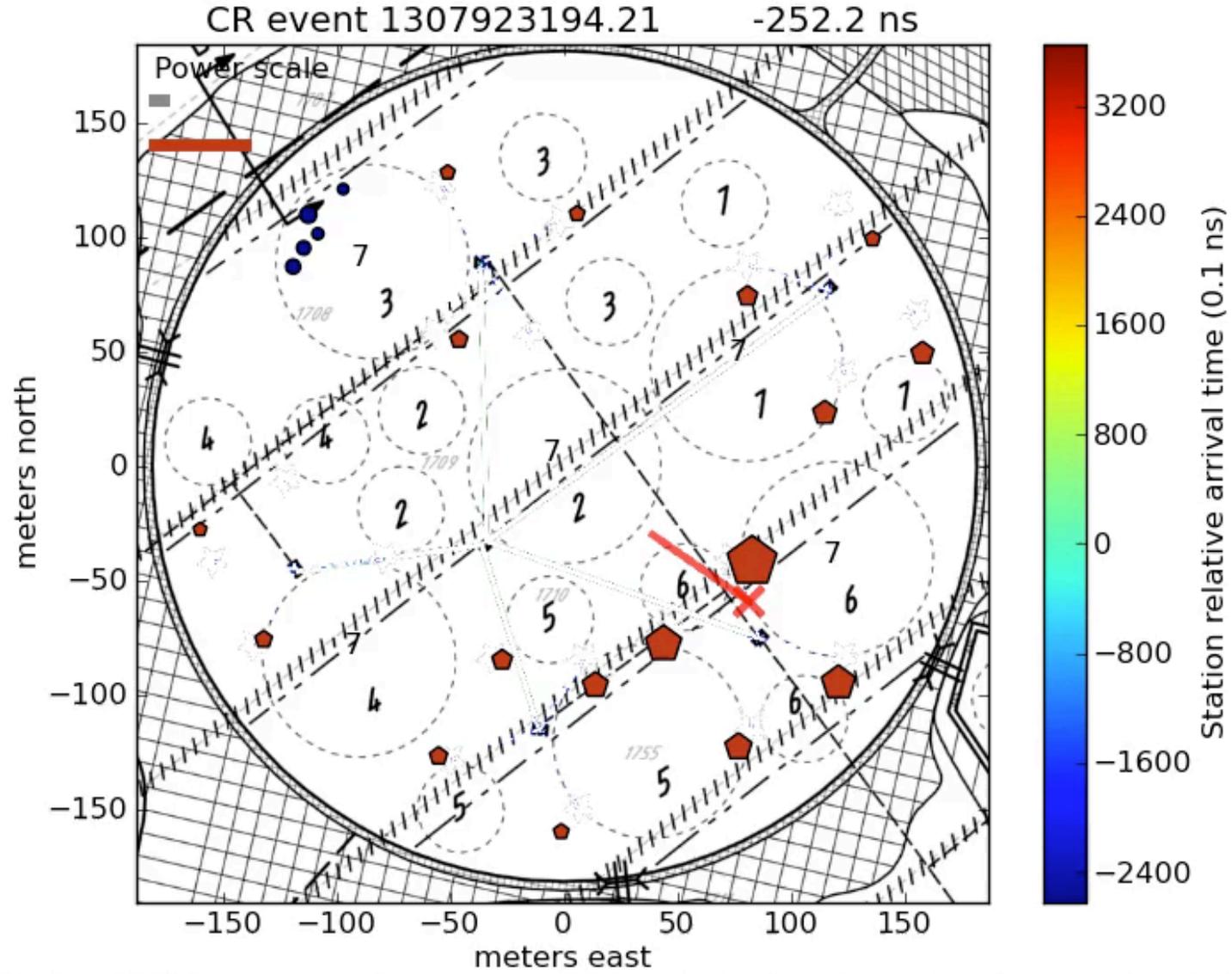
LOFAR findet ersten Millisekundenpulsar

Der internationale Teleskopverbund LOFAR spürte einen Radiopulsar mit einer Periode von 2,43 Millisekunden auf. Die Entdeckung gelang bei Nachbeobachtungen einer Gammastrahlenquelle, die der Satellit Fermi aufgespürt hat.

von [Tilmann Althaus](#)







Circles: LOFAR antennas, Pentagons: LORA particle detectors, size denotes signal strength

Lightning & Cosmic Rays: Astroparticlegeophysics



Artist's rendition

NATURE | LETTER



日本語要約

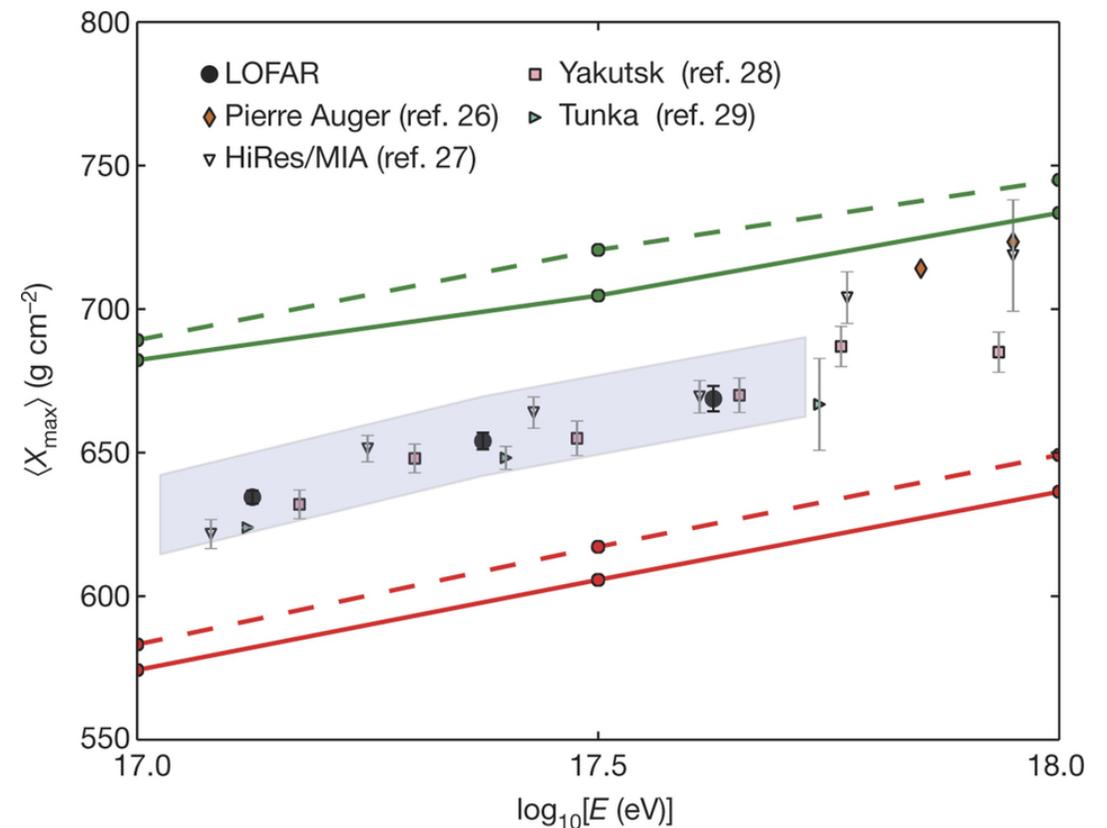
A large light-mass component of cosmic rays at 10^{17} – $10^{17.5}$ electronvolts from radio observations

S. Buitink, A. Corstanje, H. Falcke, J. R. Hörandel, T. Huege, A. Nelles, J. P. Rachen, L. Rossetto, P. Schellart, O. Scholten, S. ter Veen, S. Thoudam, T. N. G. Trinh, J. Anderson, A. Asgekar, I. M. Avruch, M. E. Bell, M. J. Bantum, G. Bernardi, P. Best, A. Bonafede, F. Breitling, J. W. Broderick, W. N. Brouw, M. Brügger, H. R. Butcher, D. Carbone, B. Ciardi, J. E. Conway, F. de Gasperin, E. de Geus, A. Deller, R.-J. Dettmar, G. van Diepen, S. Duscha, J. Eislöffel, D. Engels, J. E. Enriquez, R. A. Fallows, R. Fender, C. Ferrari, W. Frieswijk, M. A. Garrett, J. M. Grießmeier, A. W. Gunst, M. P. van Haarlem, T. E. Hassall, G. Heald, J. W. T. Hessels, M. Hoeft, A. Horneffer, M. Iacobelli, H. Intema, E. Juette, A. Karastergiou, V. I. Kondratiev, M. Kramer, [M. Kuniyoshi](#), G. Kuper, J. van Leeuwen, G. M. Loose, P. Maat, G. Mann, S. Markoff, R. McFadden, D. McKay-Bukowski, J. P. McKean, M. Mevius, D. D. Mulcahy, H. Munk, M. J. Norden, E. Orru, H. Paas, M. Pandey-Pommier, V. N. Pandey, M. Pietka, R. Pizzo, A. G. Polatidis, W. Reich, H. J. A. Röttgering, A. M. M. Scaife, D. J. Schwarz, M. Serylak, J. Sluman, O. Smirnov, B. W. Stappers, M. Steinmetz, A. Stewart, J. Swinbank, M. Tagger, Y. Tang, C. Tasse, M. C. Toribio, R. Vermeulen, C. Vocks, C. Vogt, R. J. van Weeren, R. A. M. J. Wijers, S. J. Wijnholds, M. W. Wise, O. Wucknitz, S. Yatawatta, P. Zarka & J. A. Zensus [Show fewer authors](#)

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Nature 531, 70–73 (03 March 2016) | doi:10.1038/nature16976

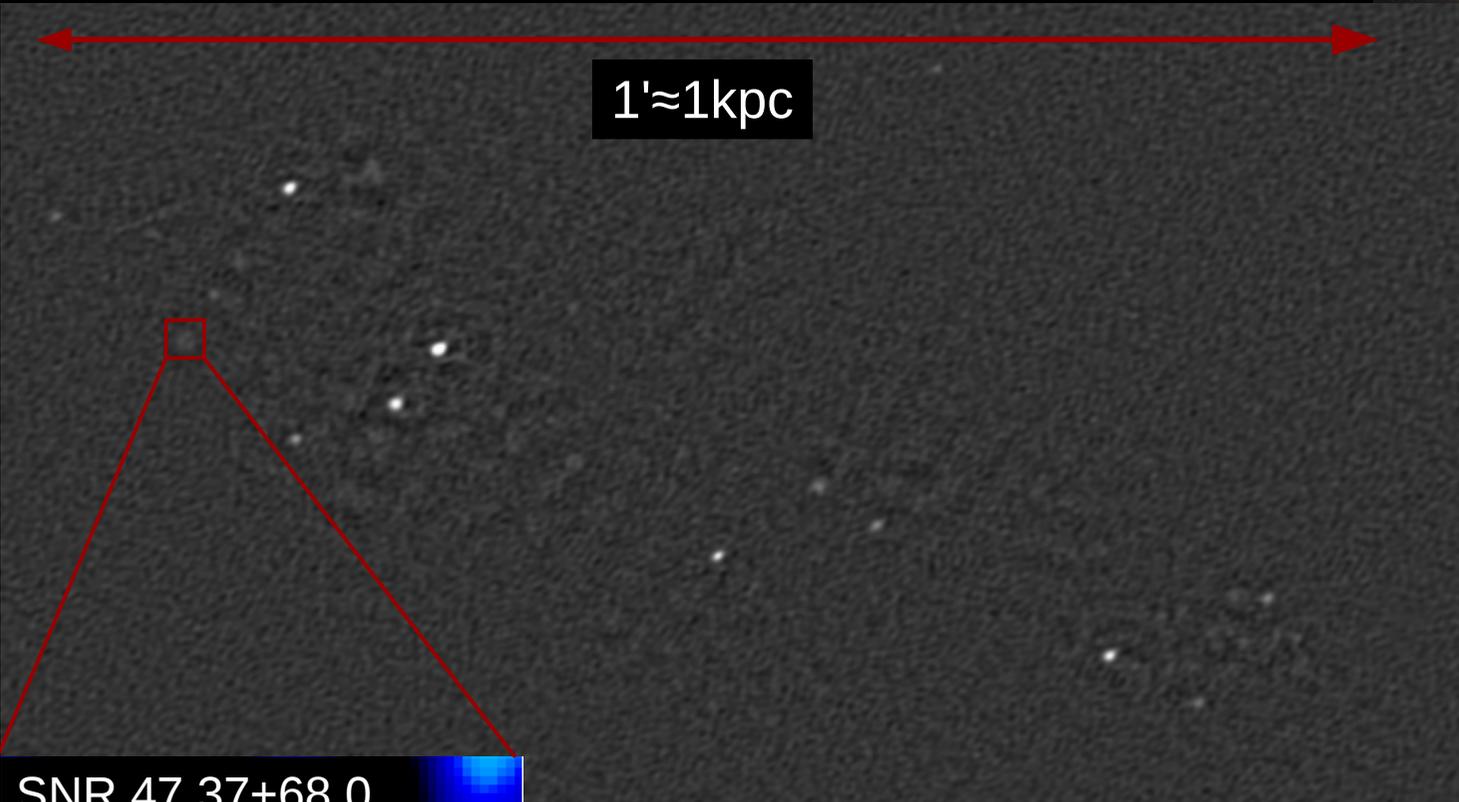
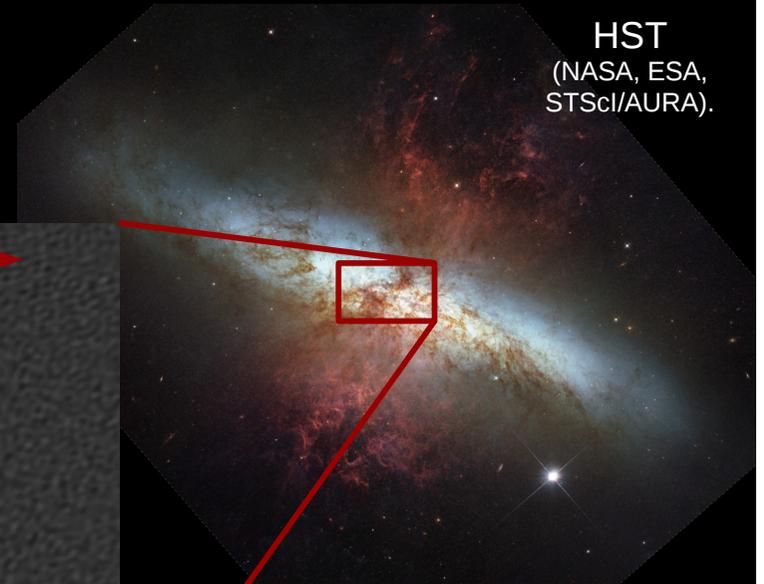
Received 19 March 2014 | Accepted 29 December 2015 | Published online 02 March 2016



International baseline imaging: M 82 at 150 MHz

LC0_026: 16 MHz bandwidth, 16 hours.

Resolution 0.3", rms noise 0.15 mJy/beam.



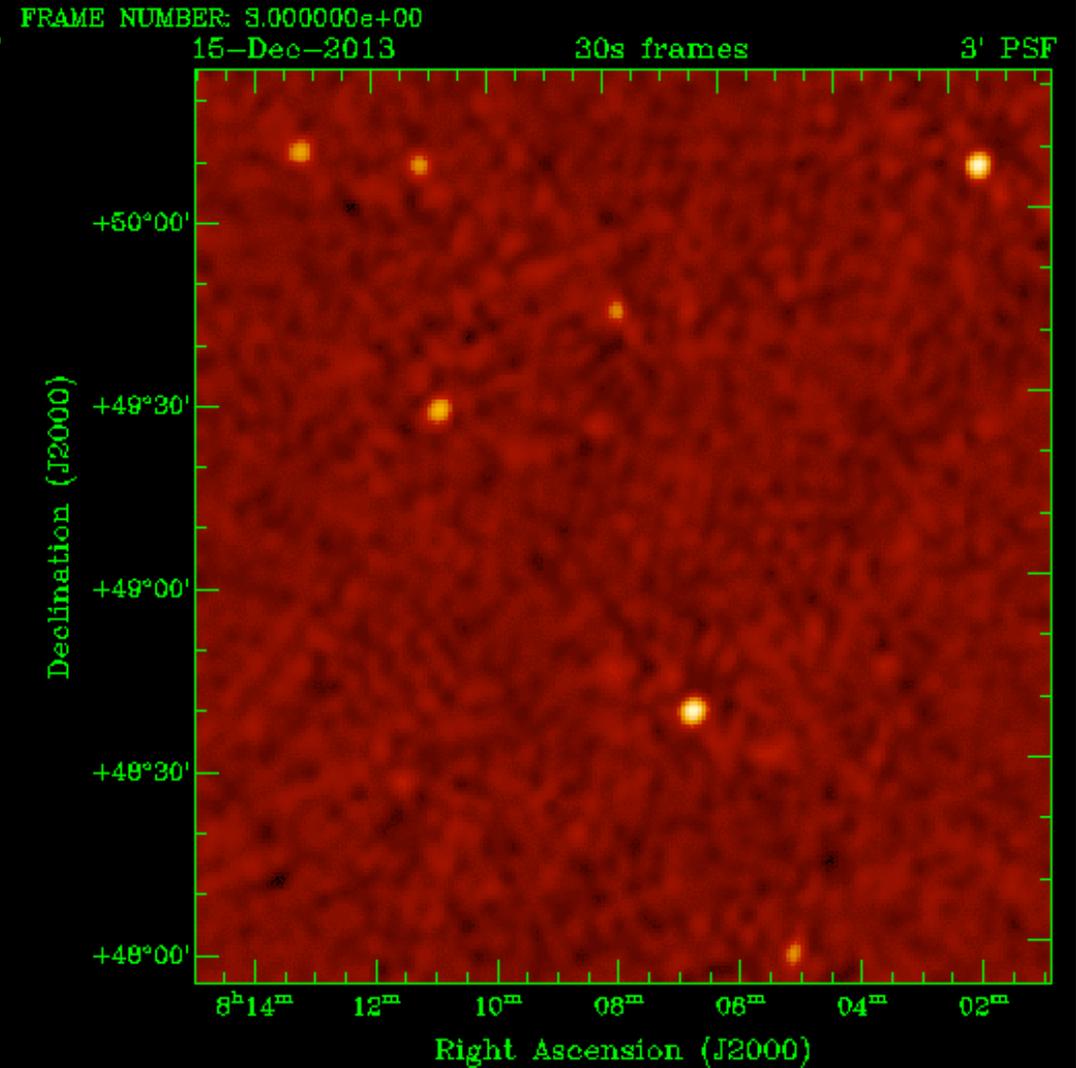
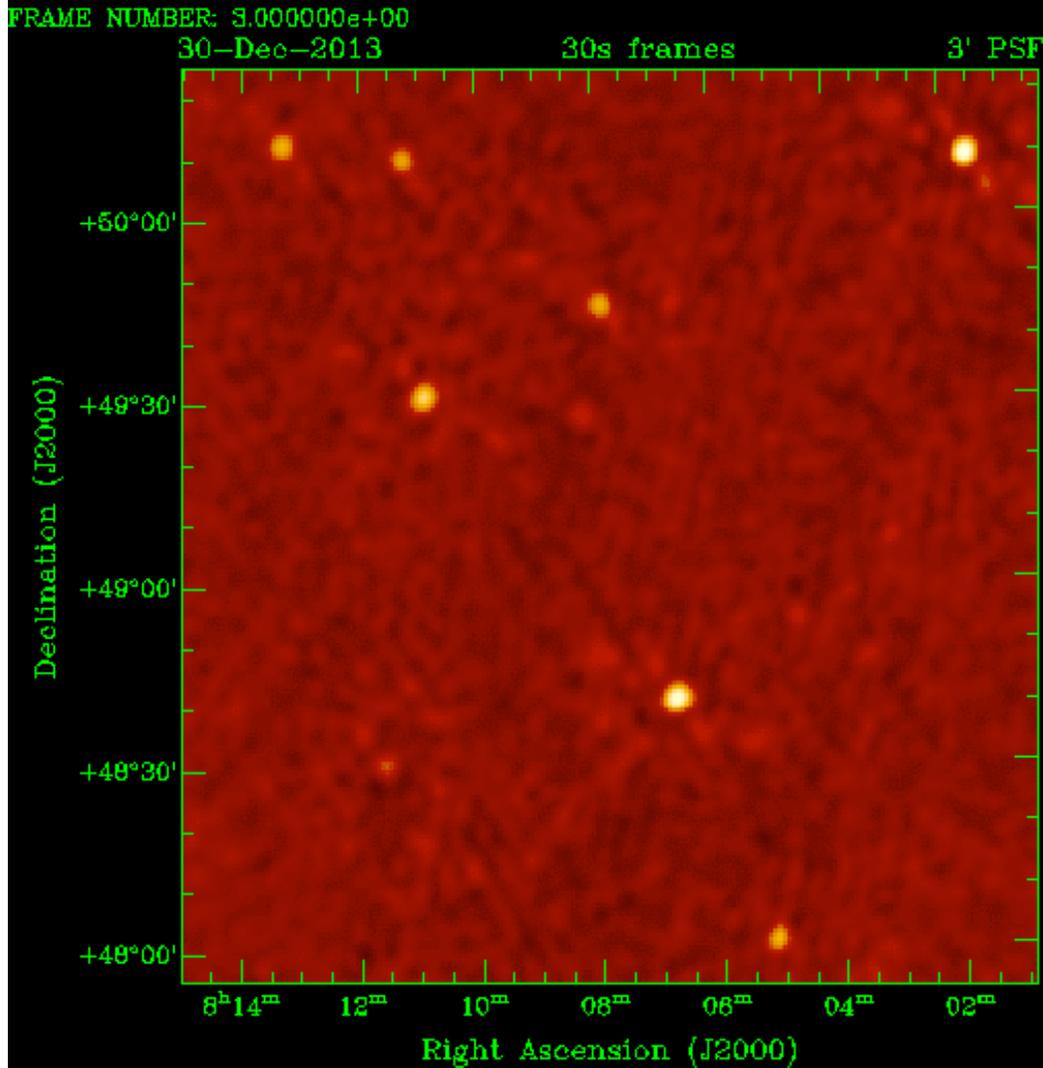
Results:

- Detect 16 objects (7 new)
- Resolve SNR shells

0.4" \approx 7pc

ruhige Ionosphäre

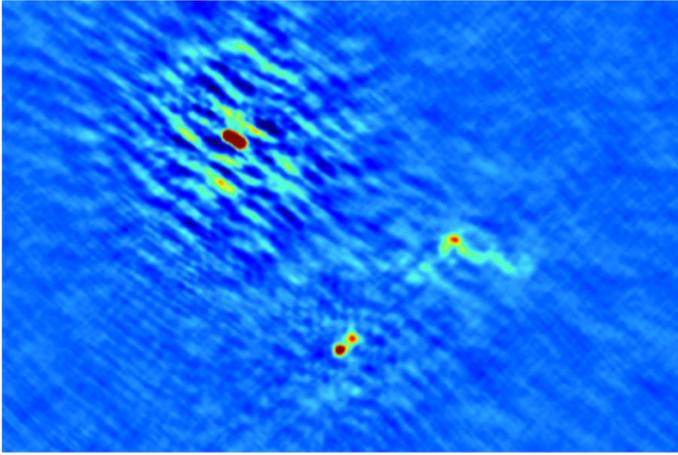
'turbulente' Ionosphäre



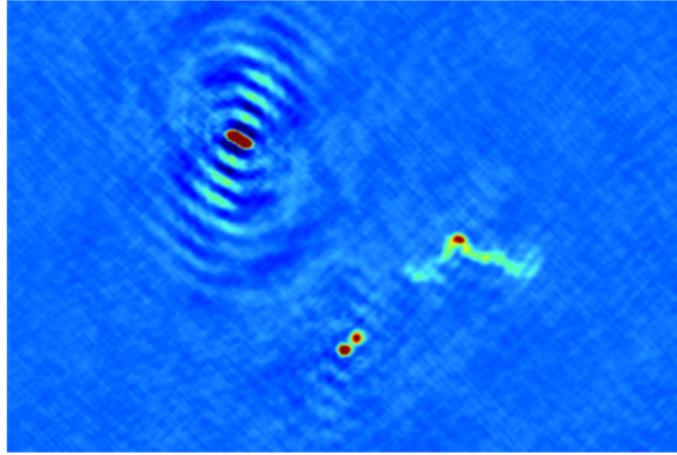
Note: these images have 3 arcmin resolution...

Ger de Bruyn & LOFAR EoR team

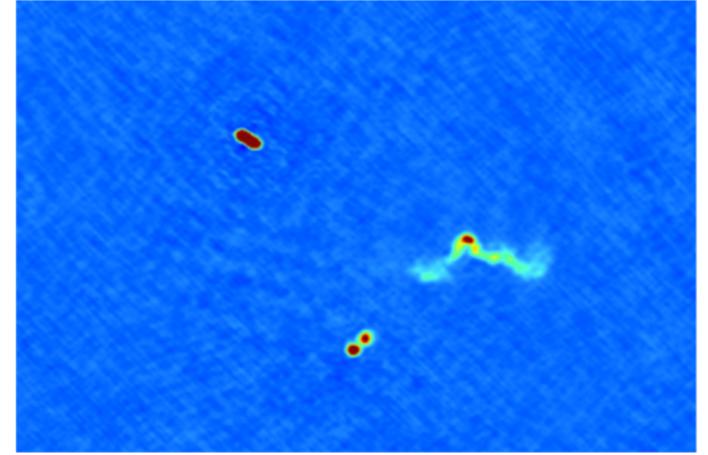
Kalibration in 'Facetten'



anfängliches Bild



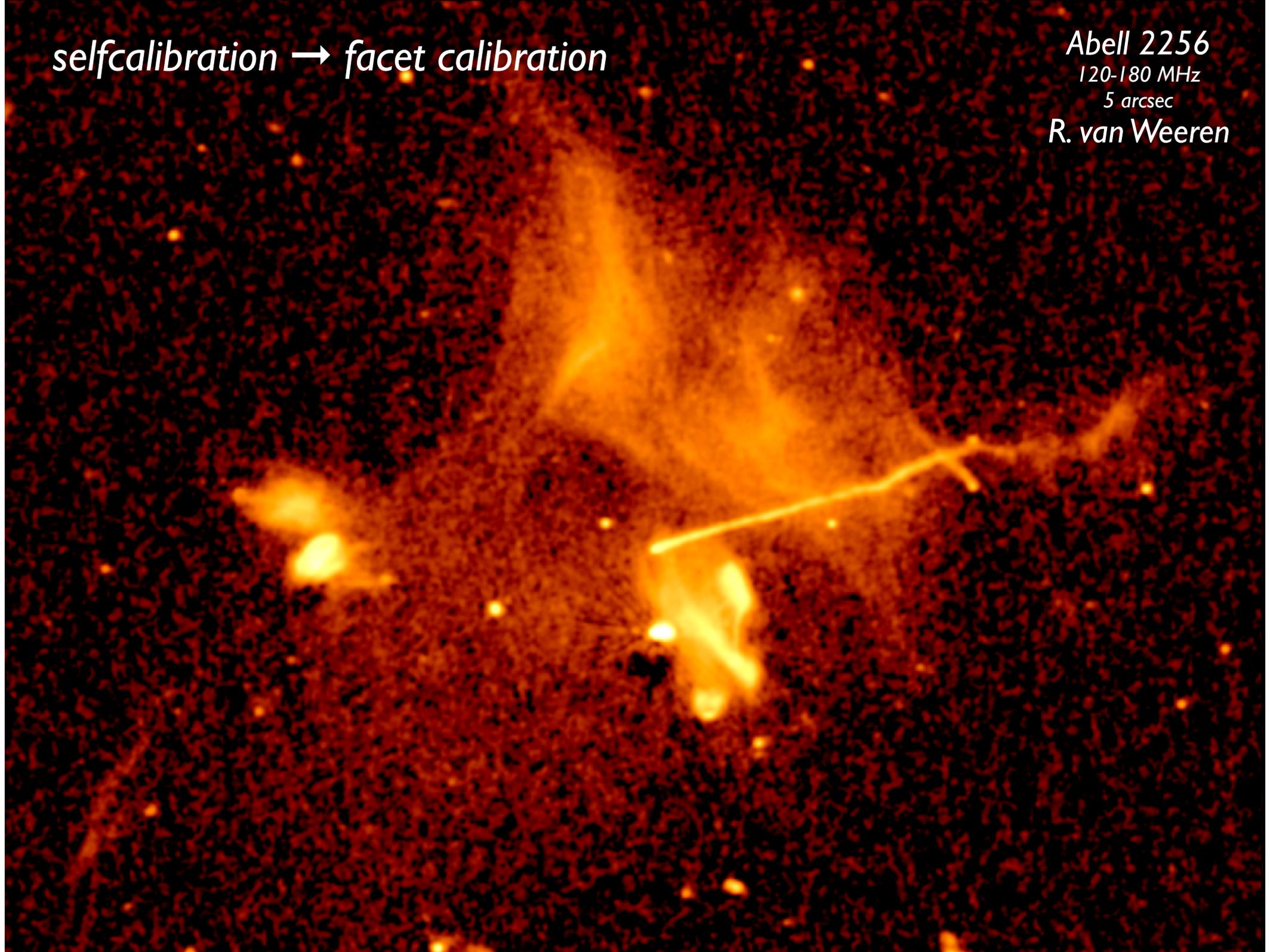
nach einer Kalibration

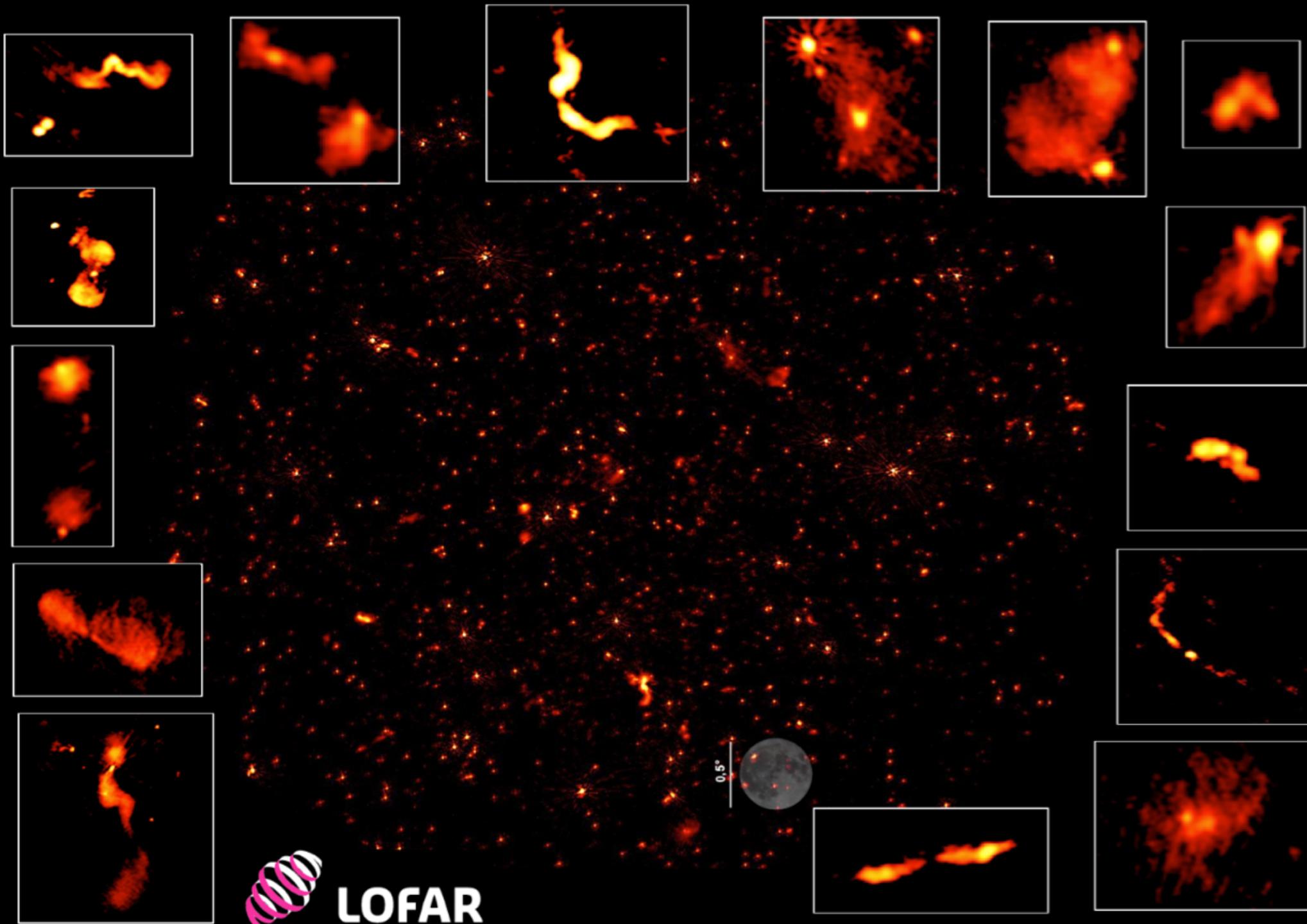


Ergebnis

selfcalibration → *facet calibration*

Abell 2256
120-180 MHz
5 arcsec
R. van Weeren

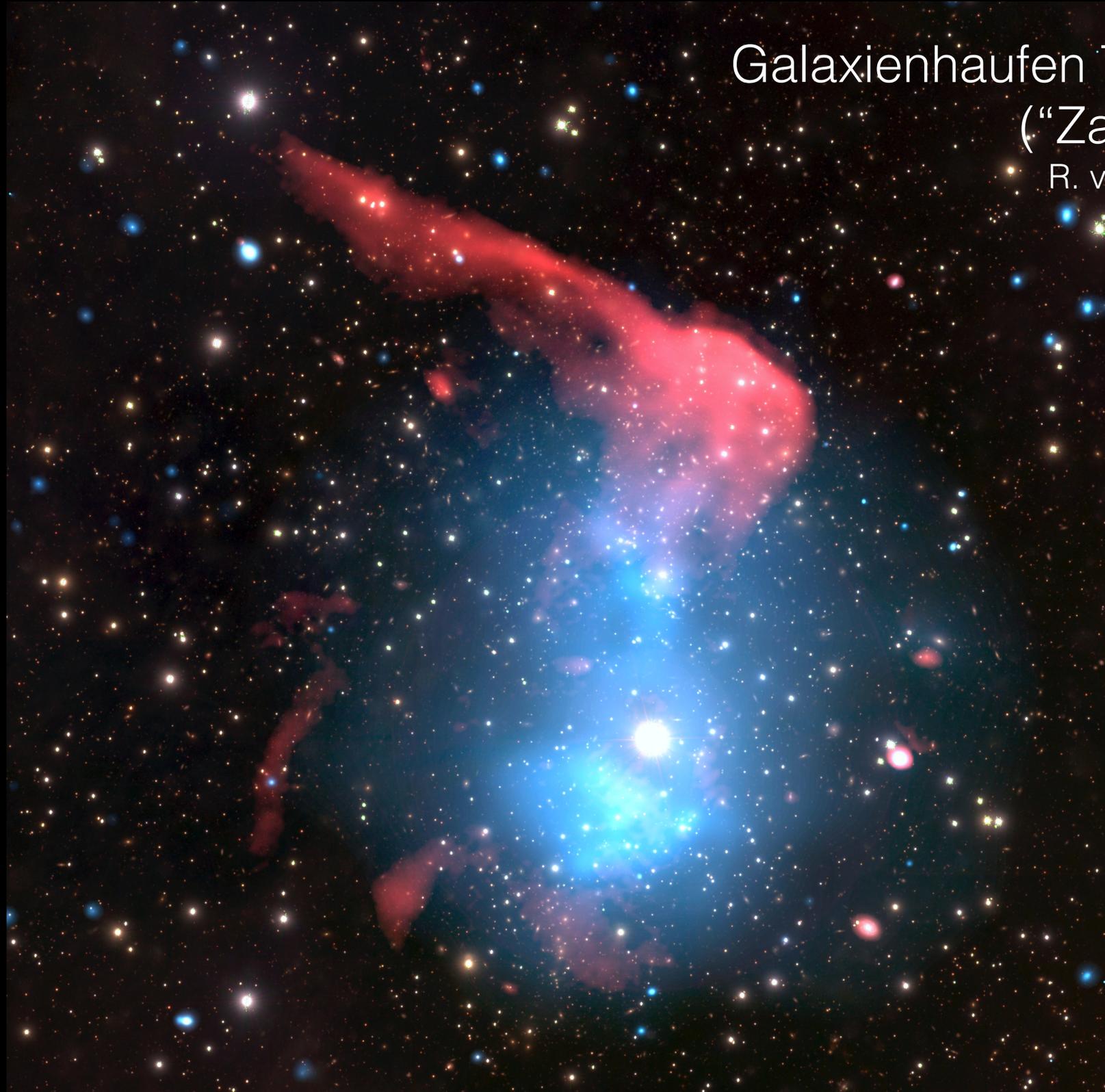




Galaxienhaufen Toothbrush ("Zahnbürste")

R. van Weeren et al.

ApJ 2016



optisch (weiss)
Röntgen (blau)
LOFAR (rot)