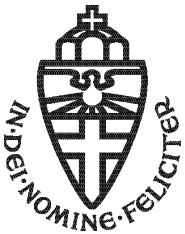
LOFAR Science Workshop 2015 - Summary



Radboud University Nijmegen

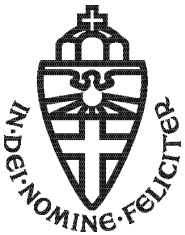
Heino Falcke

(Chair of the ILT Board)

Radboud University Nijmegen

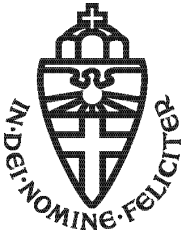
ASTRON, Dwingeloo

Science Output



- Refereed commissioning papers (2014 →2015)
  - 15→27 (→524 cites)
  - Top Cited:
    - van Haarlem 2013 (LOFAR): 53→174 cites
    - Stappers 2011 (pulsars): 67→ 90 cites
    - Hermsen et al. 2013 (psr mode switch): 37 cites
  - High Impact: 1x Science (Hermsen) + 1x Nature??
- Papers mentioning LOFAR:
  - 747→852 papers with 4869→6242 cites
  - Top 10: 8xEOR, 1xSRV, 1xCR (all promises)

LOFAR Top 10 (commissioning) papers



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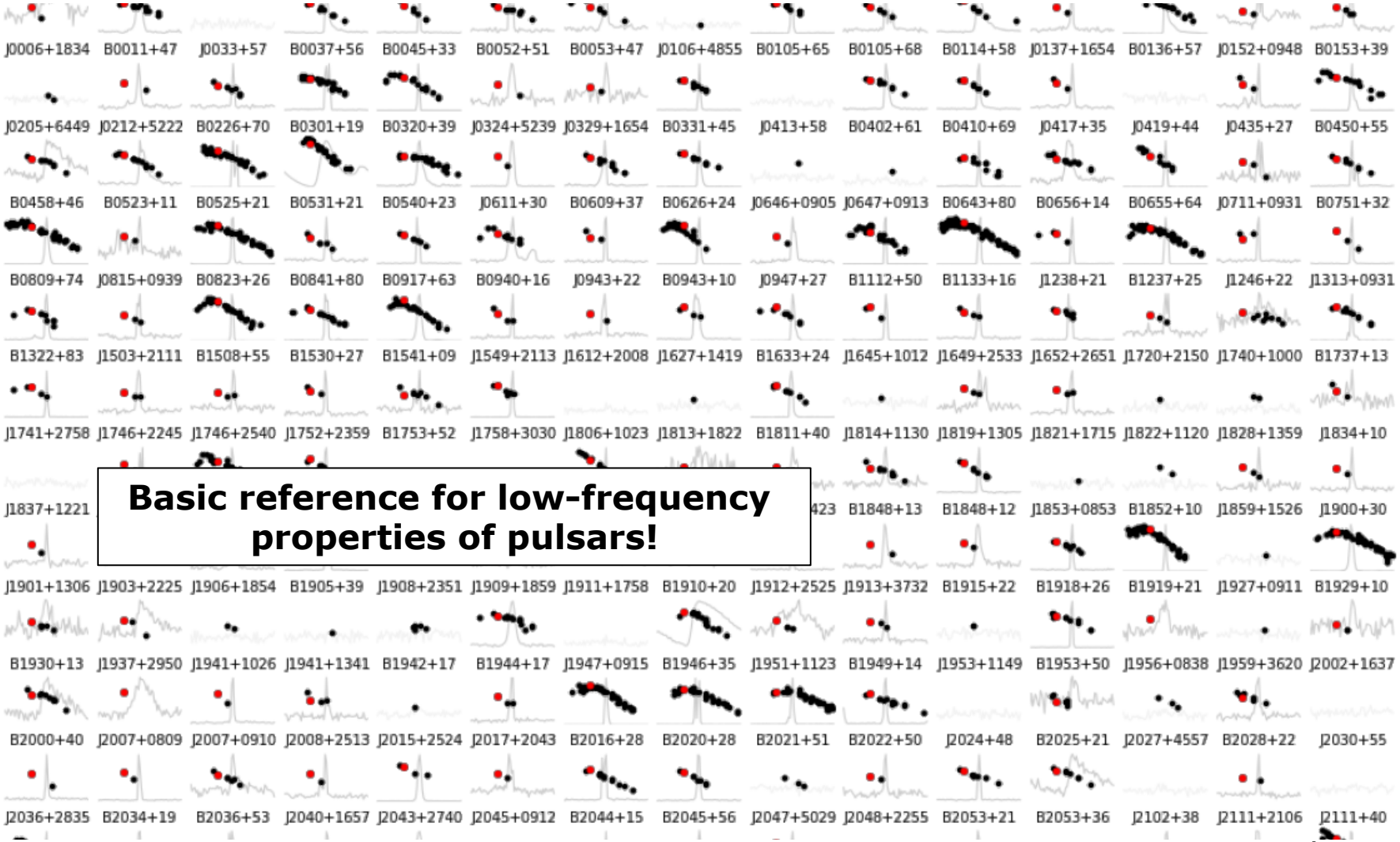
- van Haarlem, M. P., and 200 colleagues 2013. LOFAR: The LOw-Frequency Array. Astronomy and Astrophysics 556, A2. (**174 cit.**)
- Stappers, B. W., and 93 colleagues 2011. Observing pulsars and fast transients with LOFAR. Astronomy and Astrophysics 530, A80. (**90 cit**.)
- Hermsen, W., and 88 colleagues 2013. Synchronous X-ray and Radio Mode Switches: A Rapid Global Transformation of the Pulsar Magnetosphere. Science 339, 436. (**39 cit**)
- Yatawatta, S., and 88 colleagues 2013. Initial deep LOFAR observations of epoch of reionization windows. I. The north celestial pole. Astronomy and Astrophysics 550, A136.
- van Weeren, R. J., and 84 colleagues 2012. First LOFAR observations at very low frequencies of cluster-scale non-thermal emission: the case of Abell 2256. Astronomy and Astrophysics 543, A43.
- Hassall, T.E., and 93 colleagues 2012. Wide-band simultaneous observations of pulsars: disentangling dispersion measure and profile variations. Astronomy and Astrophysics 543, A66.
- de Gasperin, F., and 94 colleagues 2012. M 87 at metre wavelengths: the LOFAR picture. Astronomy and Astrophysics 547, A56.
- Offringa, A. R., and 95 colleagues 2013. The LOFAR radio environment. Astronomy and Astrophysics 549, A11.
- Sotomayor-Beltran, C., and 79 colleagues 2013. Calibrating high-precision Faraday rotation measurements for LOFAR and the next generation of low-frequency radio telescopes. Astronomy and Astrophysics 552, A58.
- Schellart, P., and 104 colleagues 2013. Detecting cosmic rays with the LOFAR radio telescope. Astronomy and Astrophysics 560, A98.

Pulsar Census



Basic reference for low-frequency properties of pulsars!

Pulsar Census: Galactic B-Field

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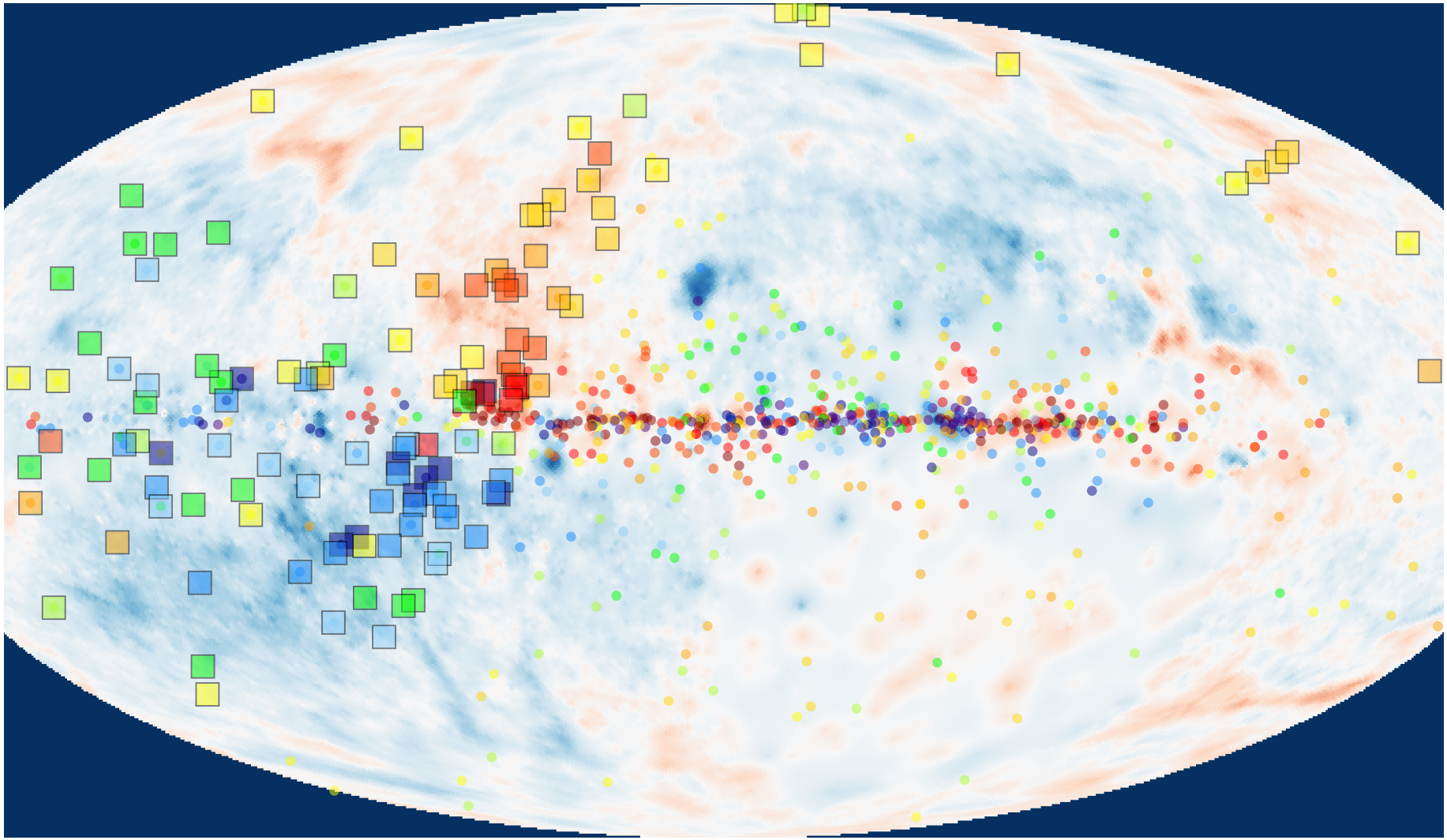

Charlotte Sobey

LOFAR Pulsar Survey

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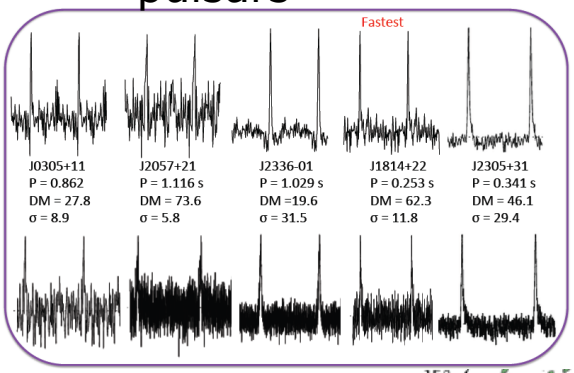
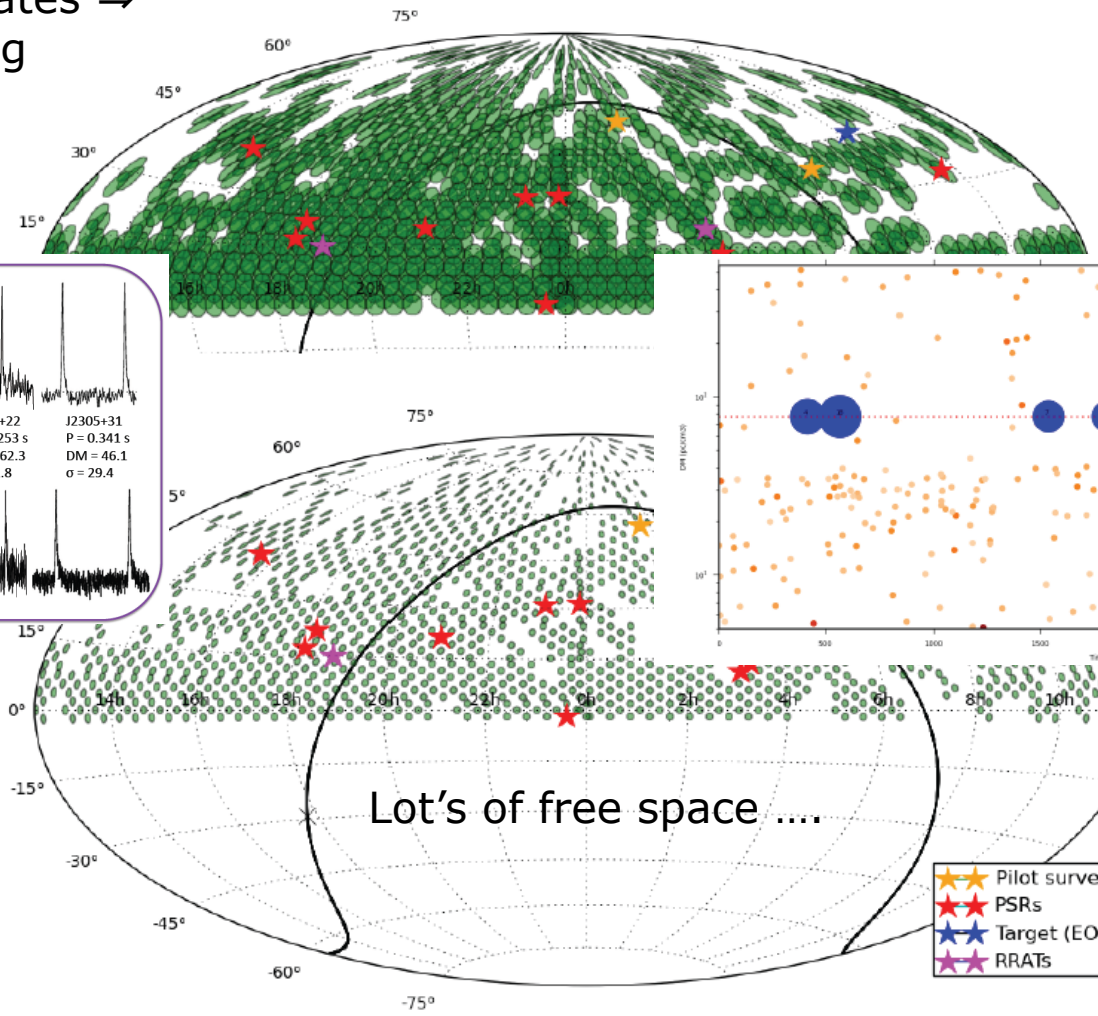
5 Million candidates ⇒ machine learning

15 new pulsars





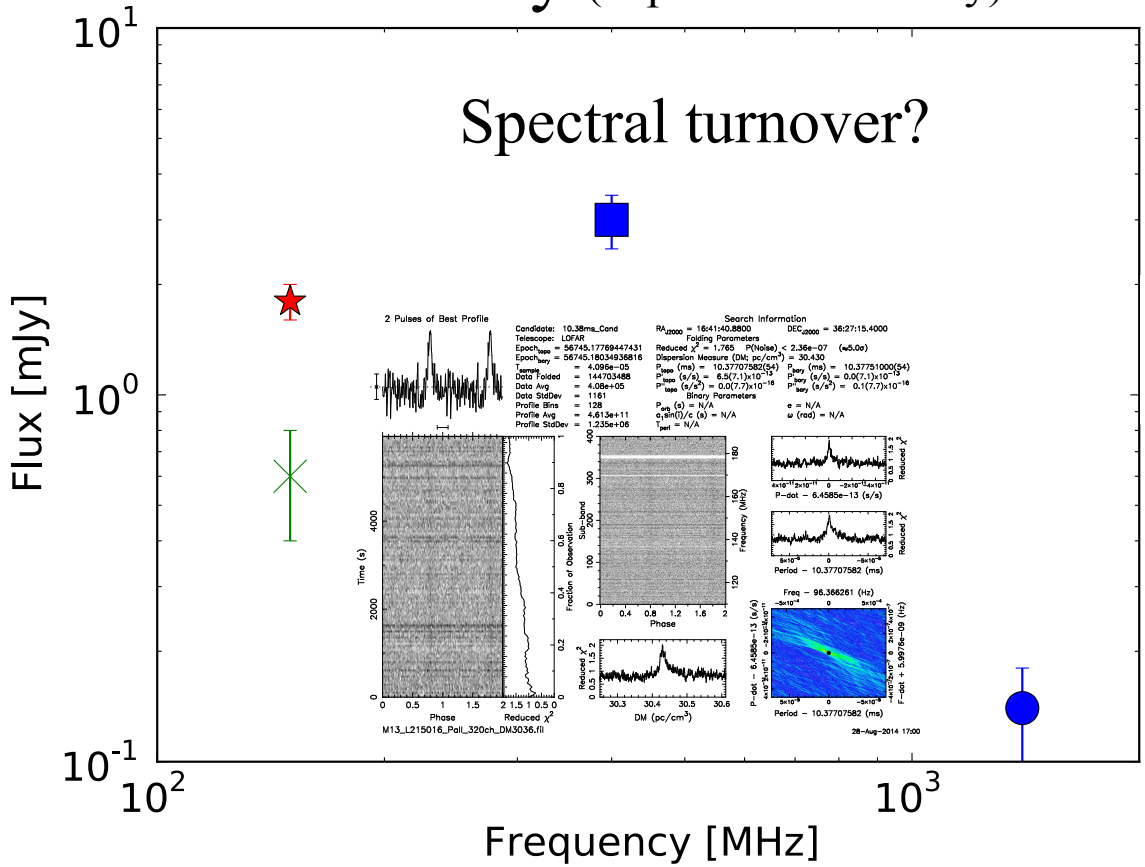
including 2 RRATs

Sally Cooper

Globular Cluster Pulsars: Detection of M13A – turnover?

Radboud University Nijmegen

1.8 mJy (expected 12-18 mJy)



Hessels et al. '07

Kulkarni et al. '91

LOFAR measured

LOFAR corrected

Where are the others? Can we trust our fluxes?

Sander ter Veen

Fast transients

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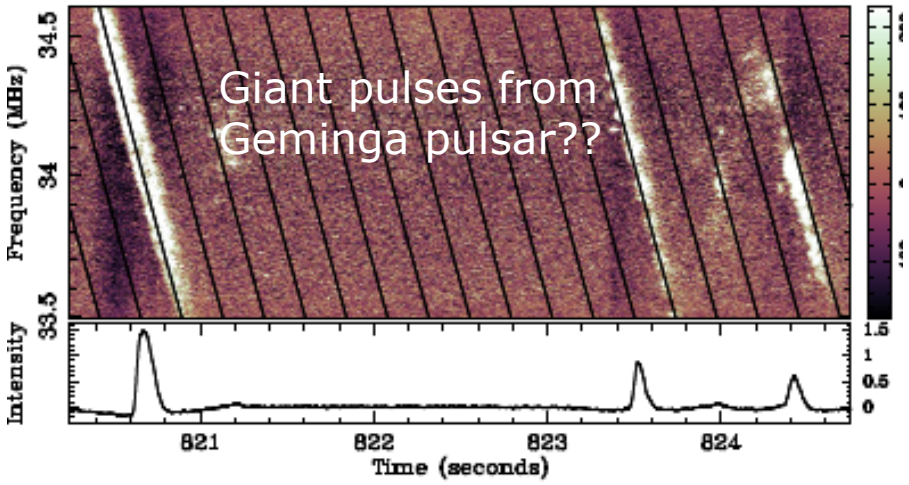
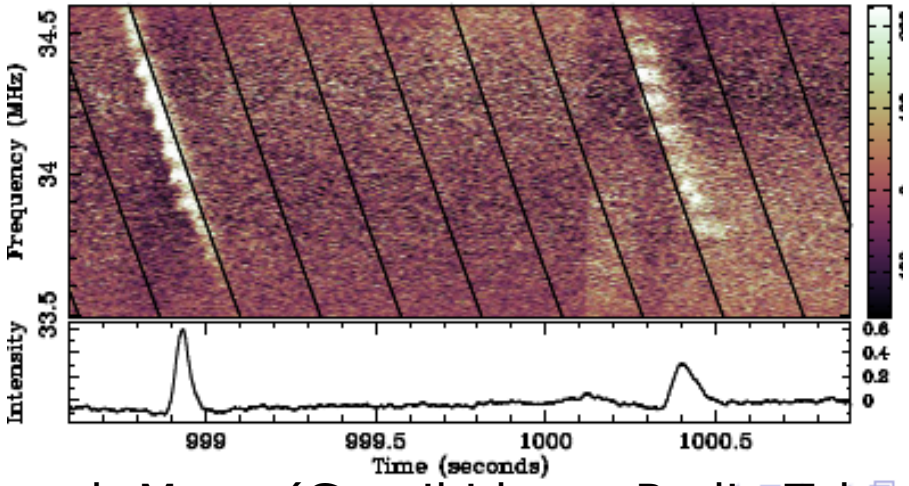
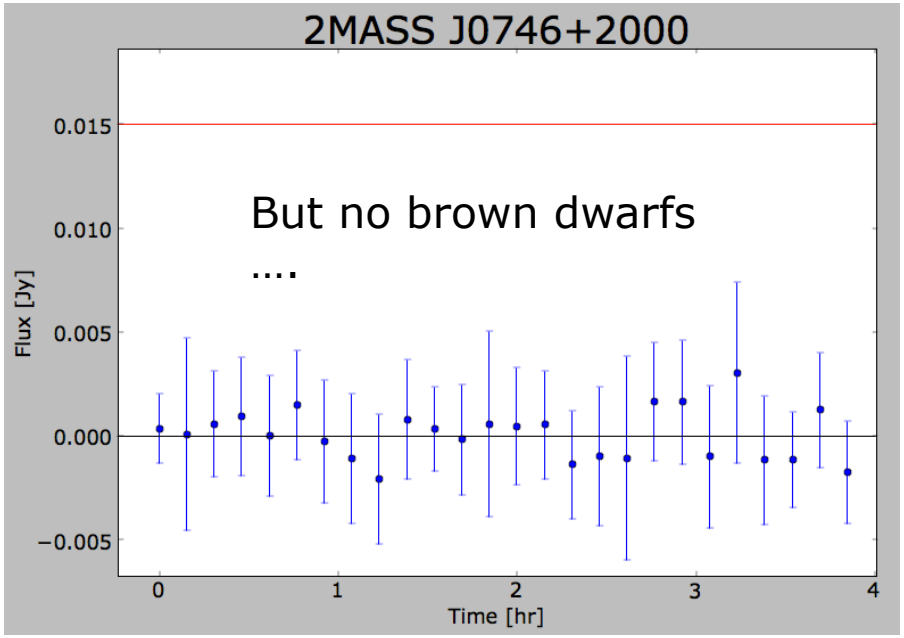






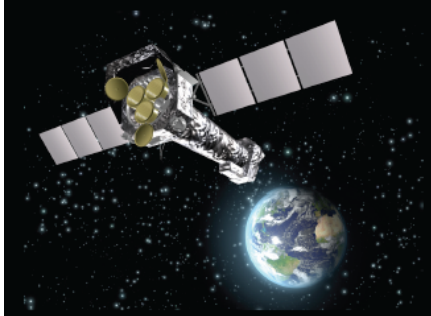
Emilio Enriquez

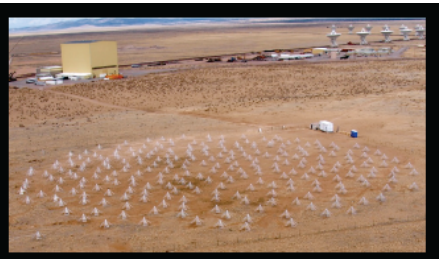
Yogesh Maan (Gauribidanur Radio Telescope)

The LOFAR Toolbox

Radboud University Nijmegen

Main Telescopes + People





XMM-Newton
Wim Hermsen (SRON/UvA)
Lucien Kuiper (SRON)
Sandro Mereghetti (IASF)

LWA
Kevin Stovall (UNM)

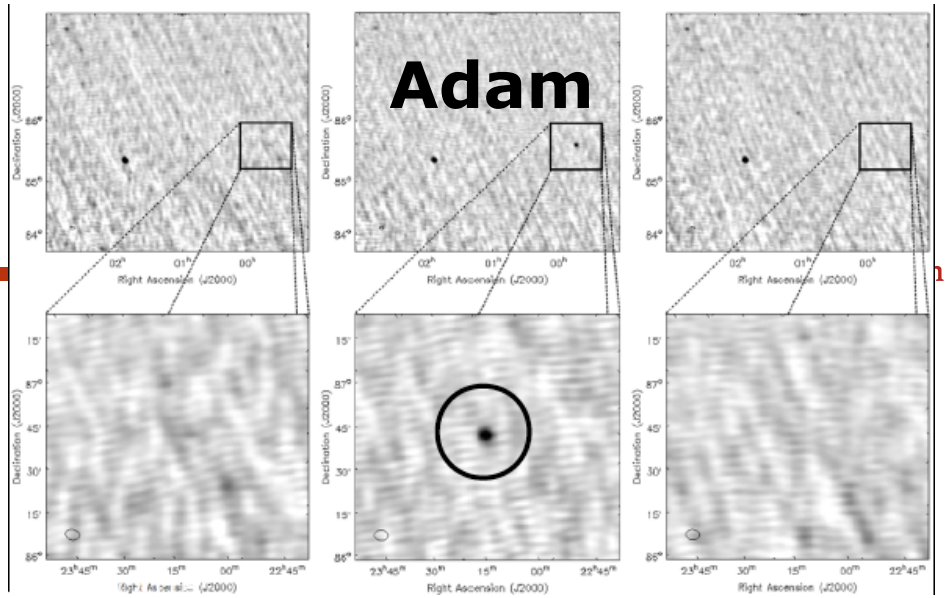
LOFAR (international)
Jason Hessels (ASTRON/UvA)
Stefan Oslowski (U. Bielefeld)
Maciej Serylak (UWC)

Arecibo
Joanna Rankin (U. Vermont)
Andrea Possenti (OAC)

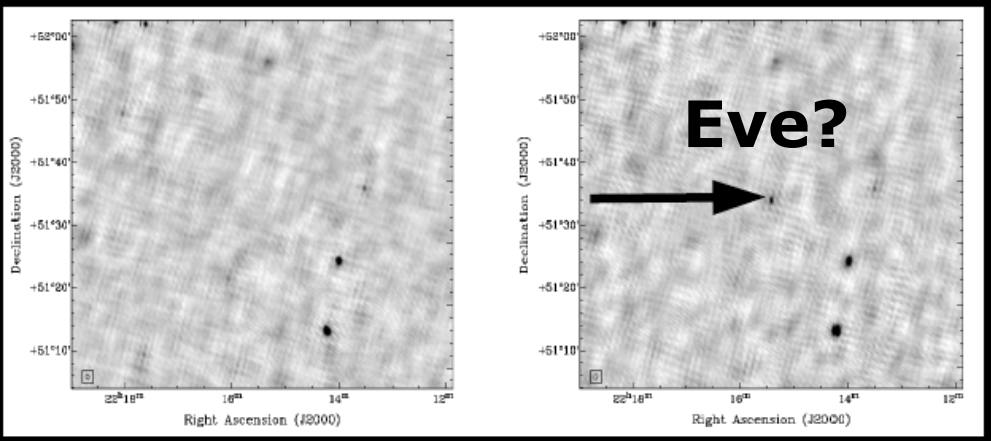
"Some science just takes time"

Transients

But, what's next?

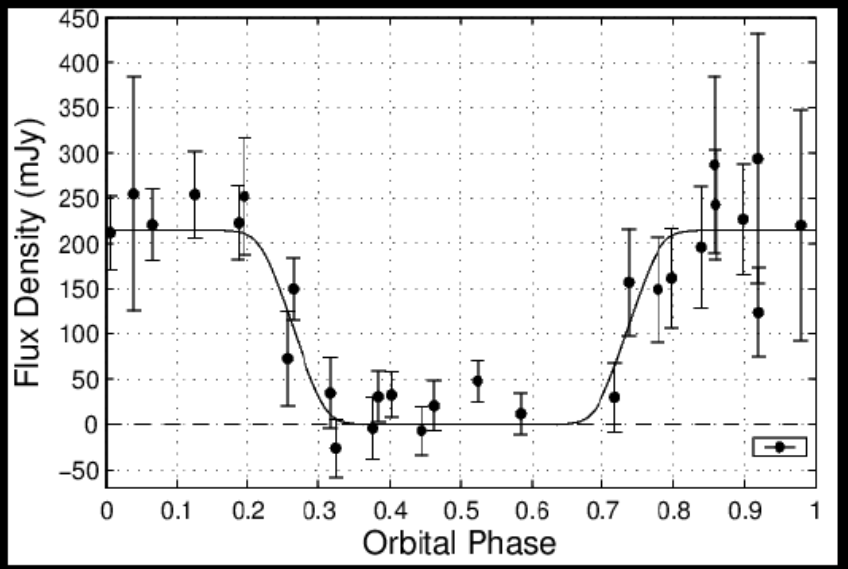


124 MHz observations



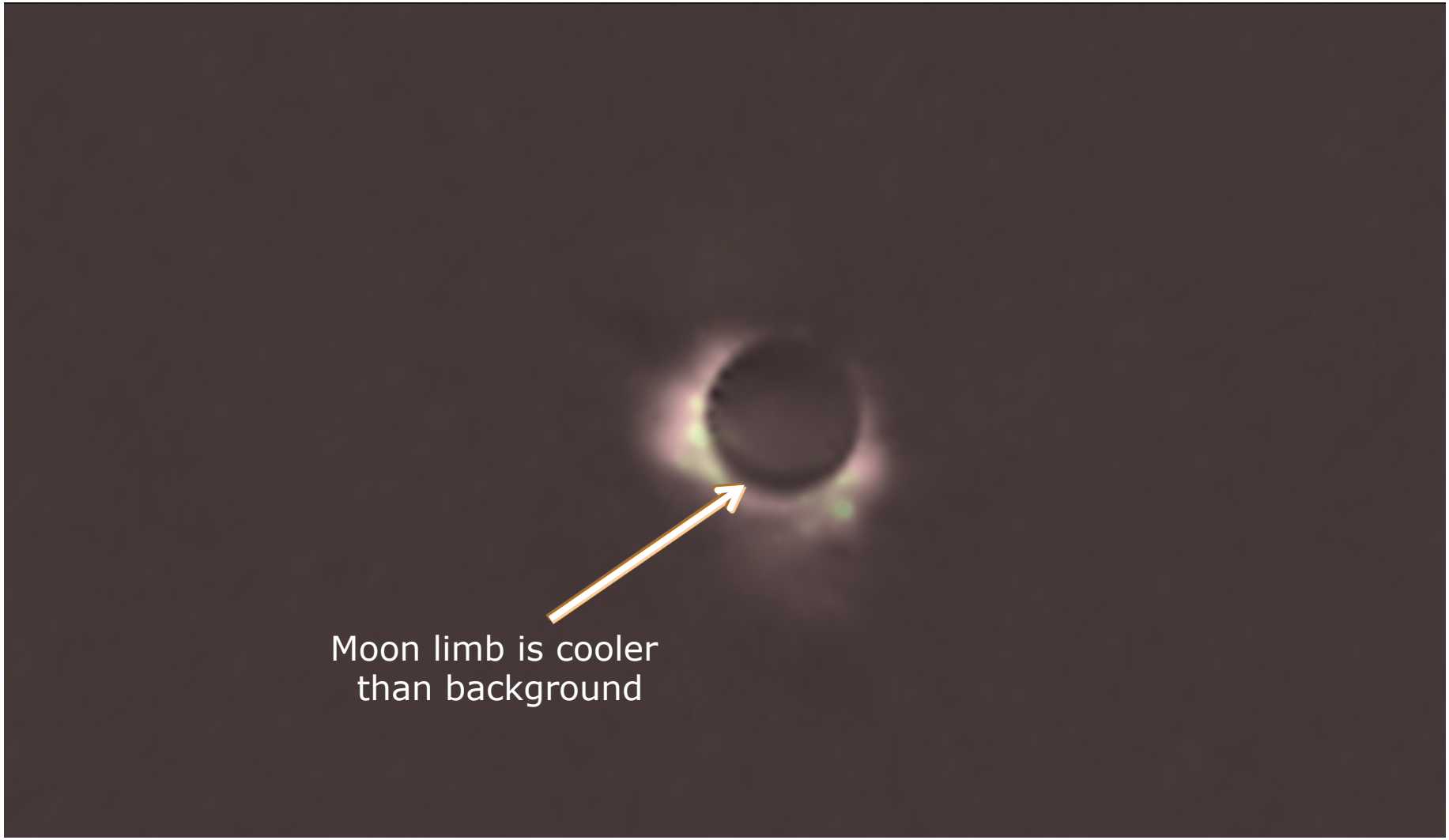
2013 February 10 2014 January 15

Dario Carbone, Assen – 02/06/2015



Full RSM dataset (e.g. 28 x 11 min images)
→ eclipses observed

Solar Eclipse Imaging



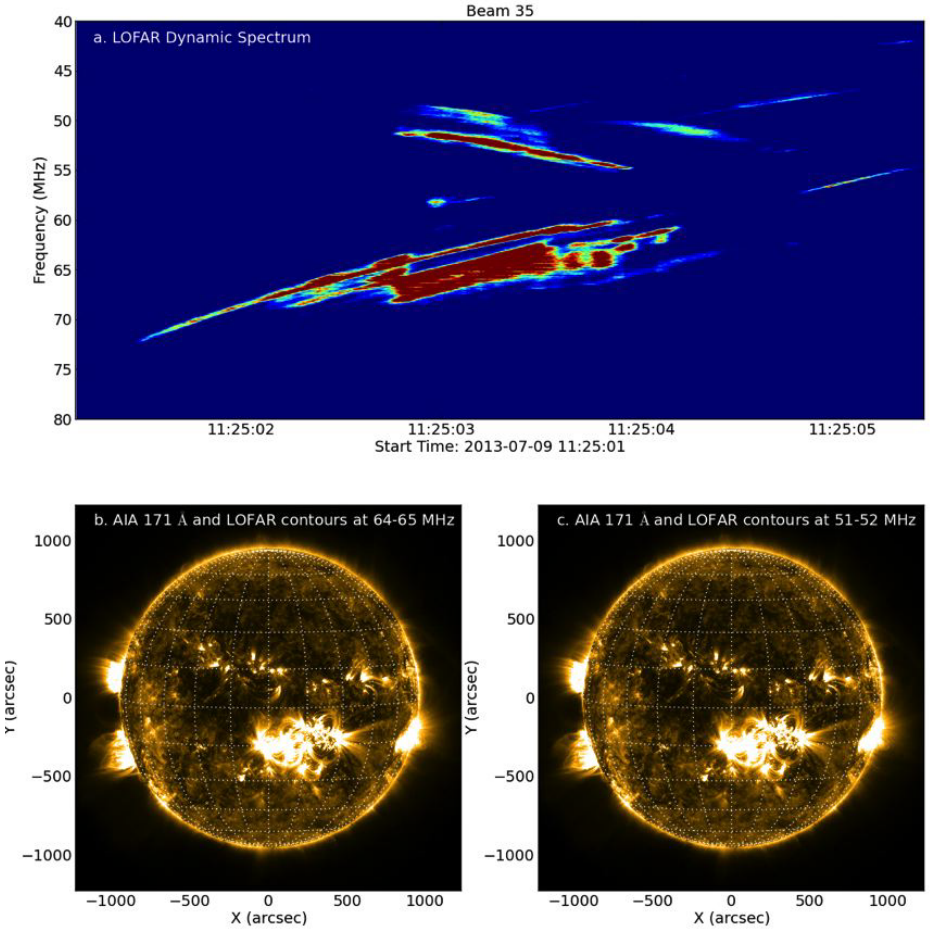
The Sun is bright

Radboud University Nijmegen

Brentjens

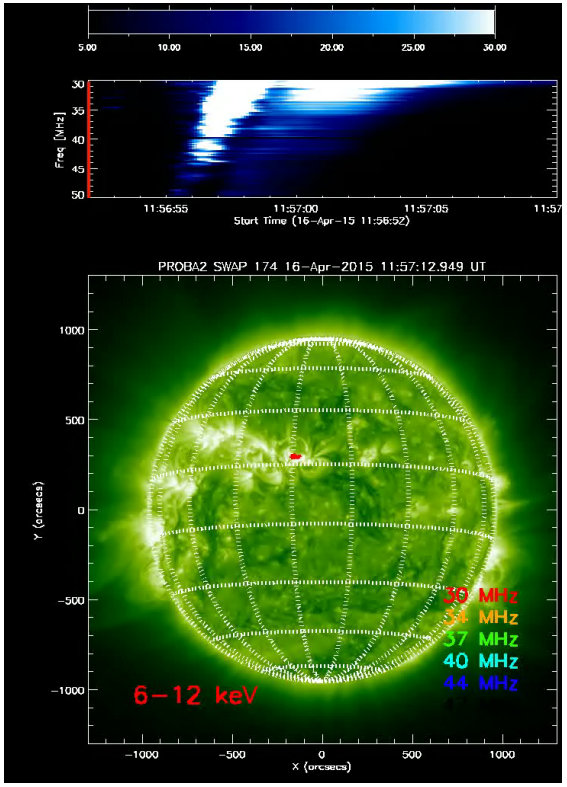
Happy Sunshine Movies

Radboud University Nijmegen



S-Bursts: Sun disguising as Jupiter

Diana Morosan



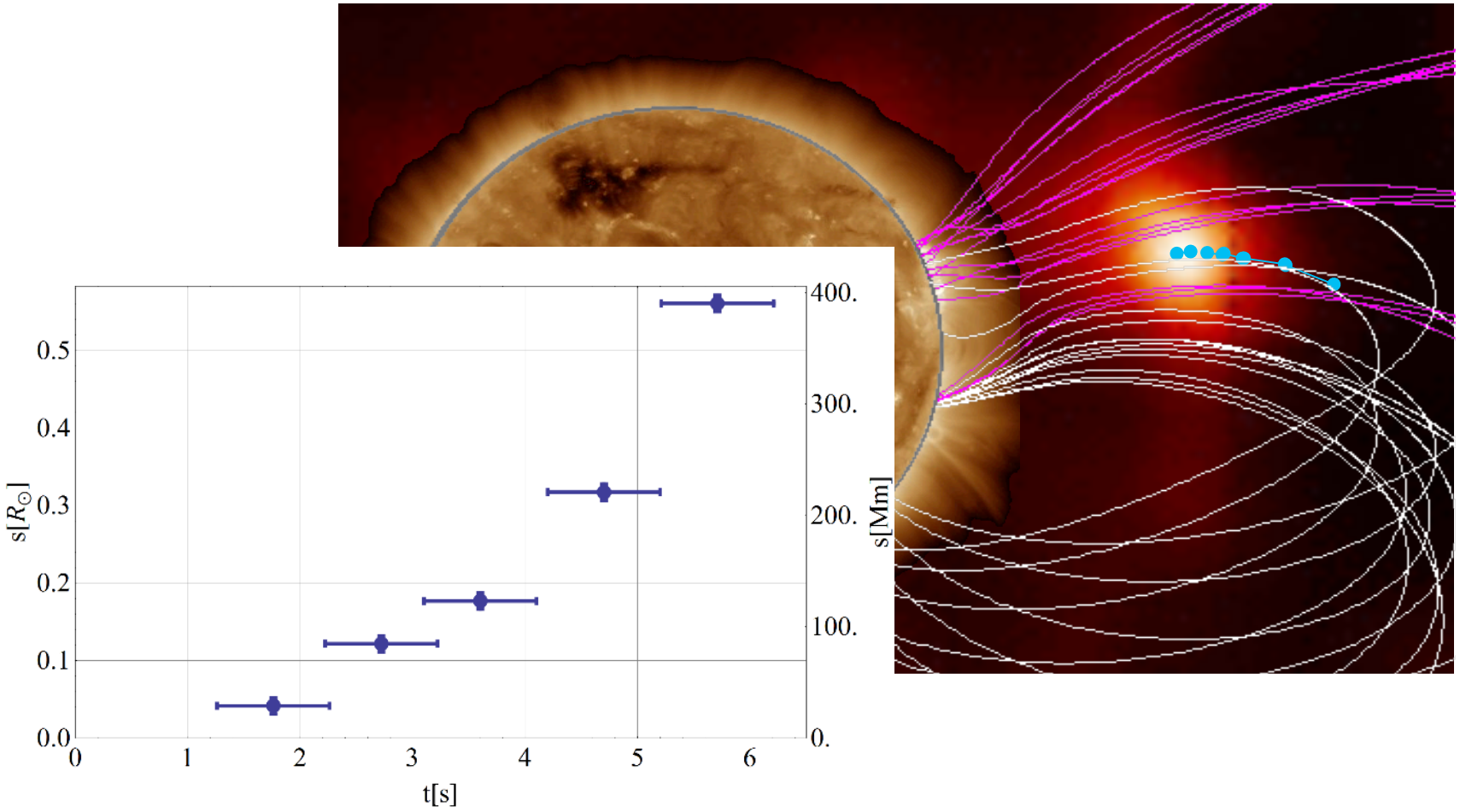
Frequency-dependent size and location of type III bursts

Hamish Reid

Happy Sunshine Movies

Radboud University Nijmegen

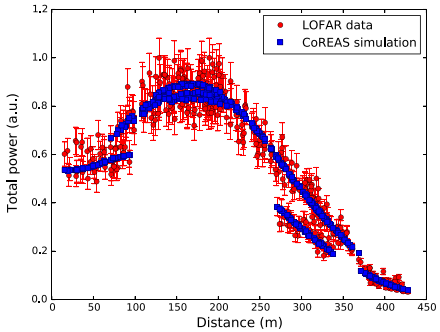
Turning Images into physics: Velocity and velocity distribution of electrons.

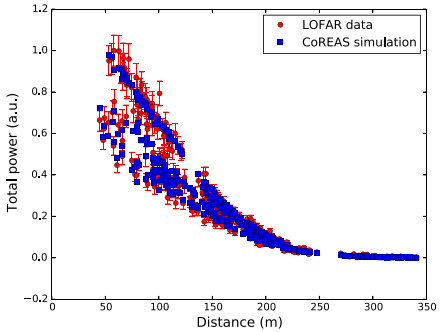


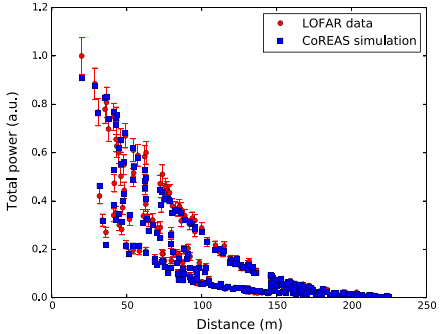
Gottfried Mann, Frank Breitling

Cosmic Ray Precision Composition Measurements

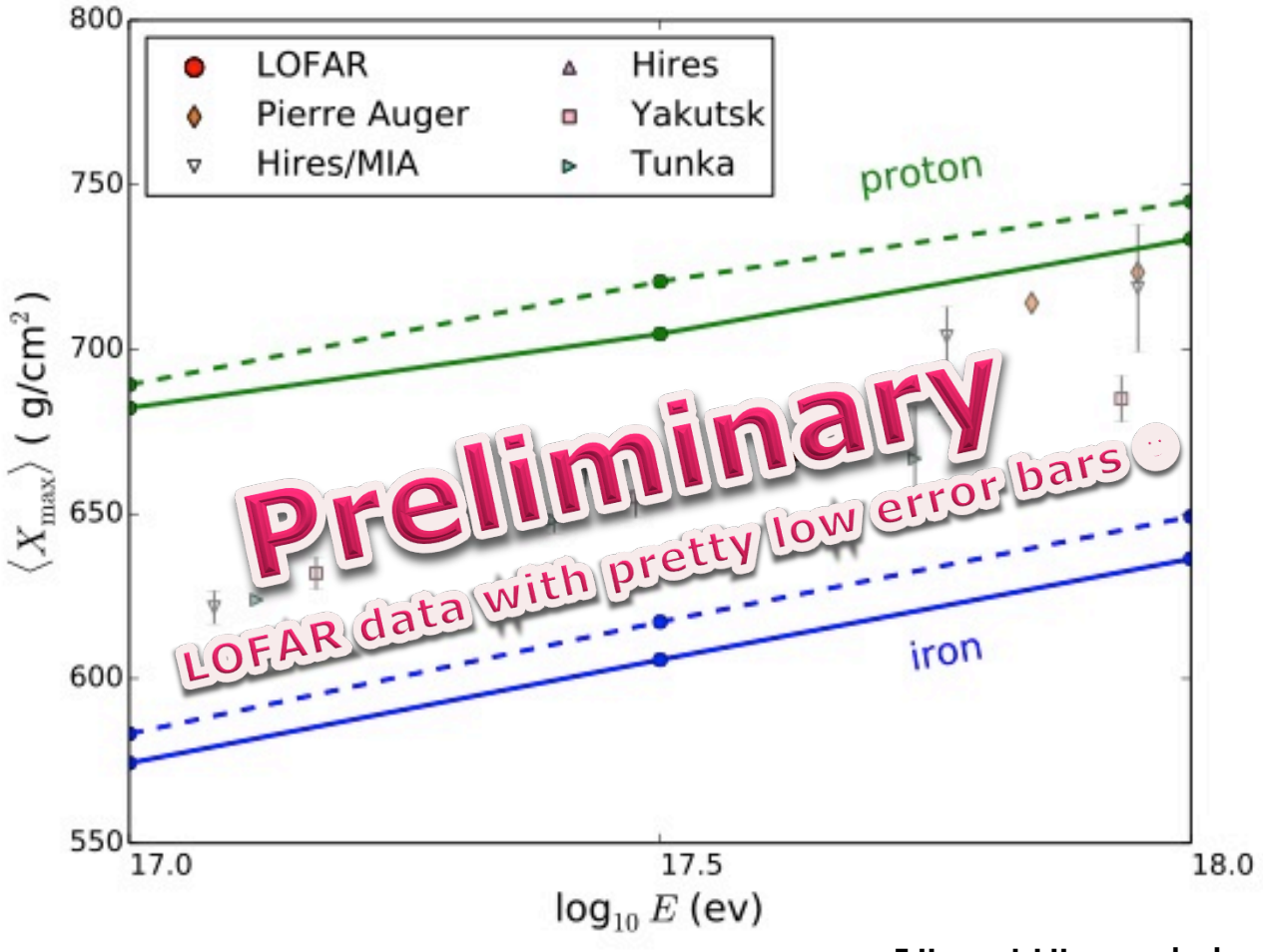
Radboud University Nijmegen







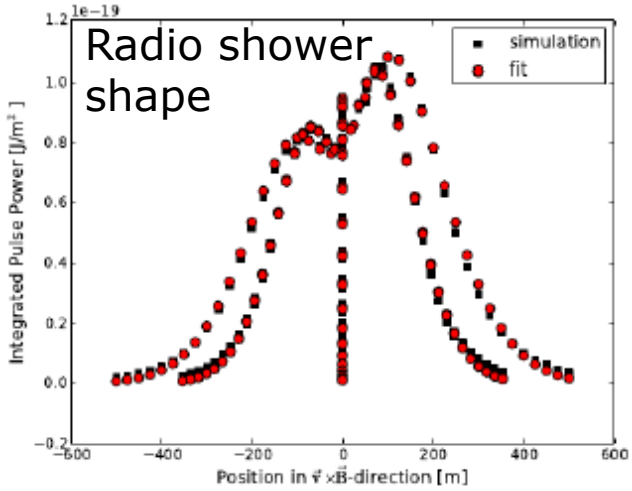
Most precise and probably most accurate CR composition measurements

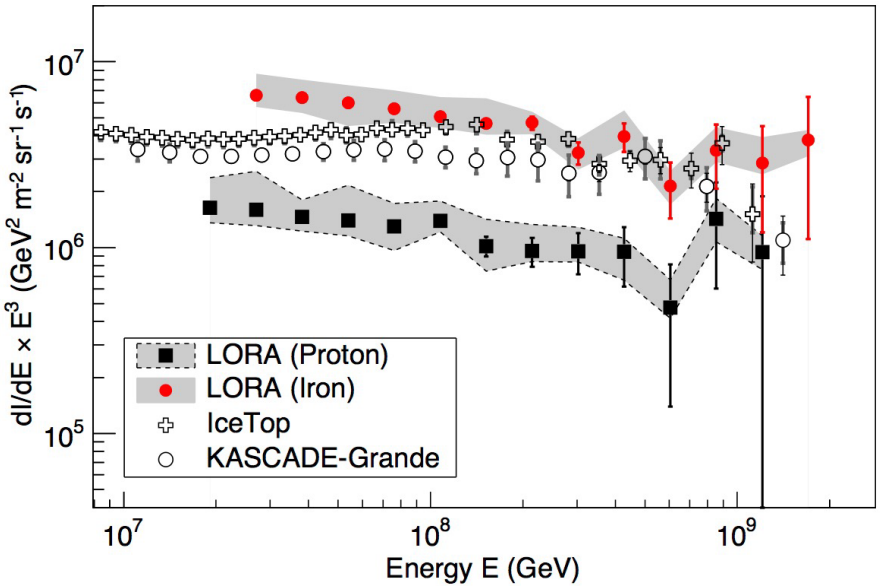


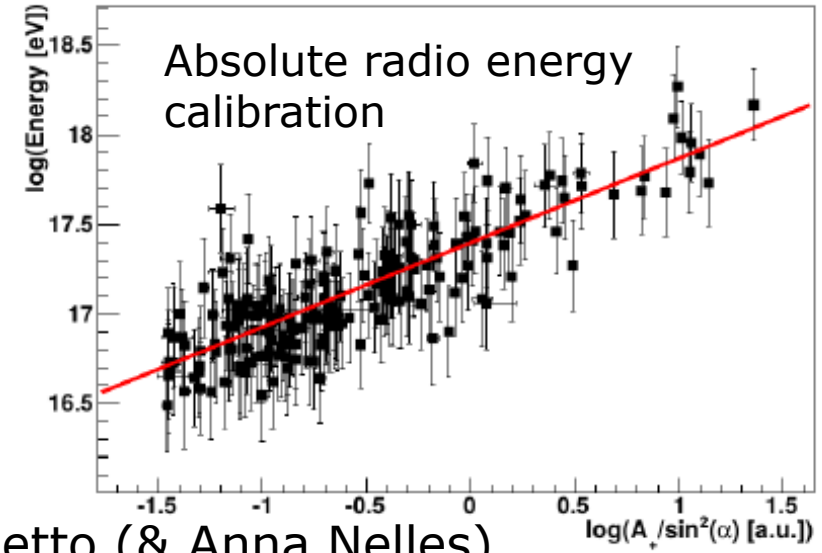
Jörg Hörandel

Cosmic Ray measurements

Radboud University Nijmegen





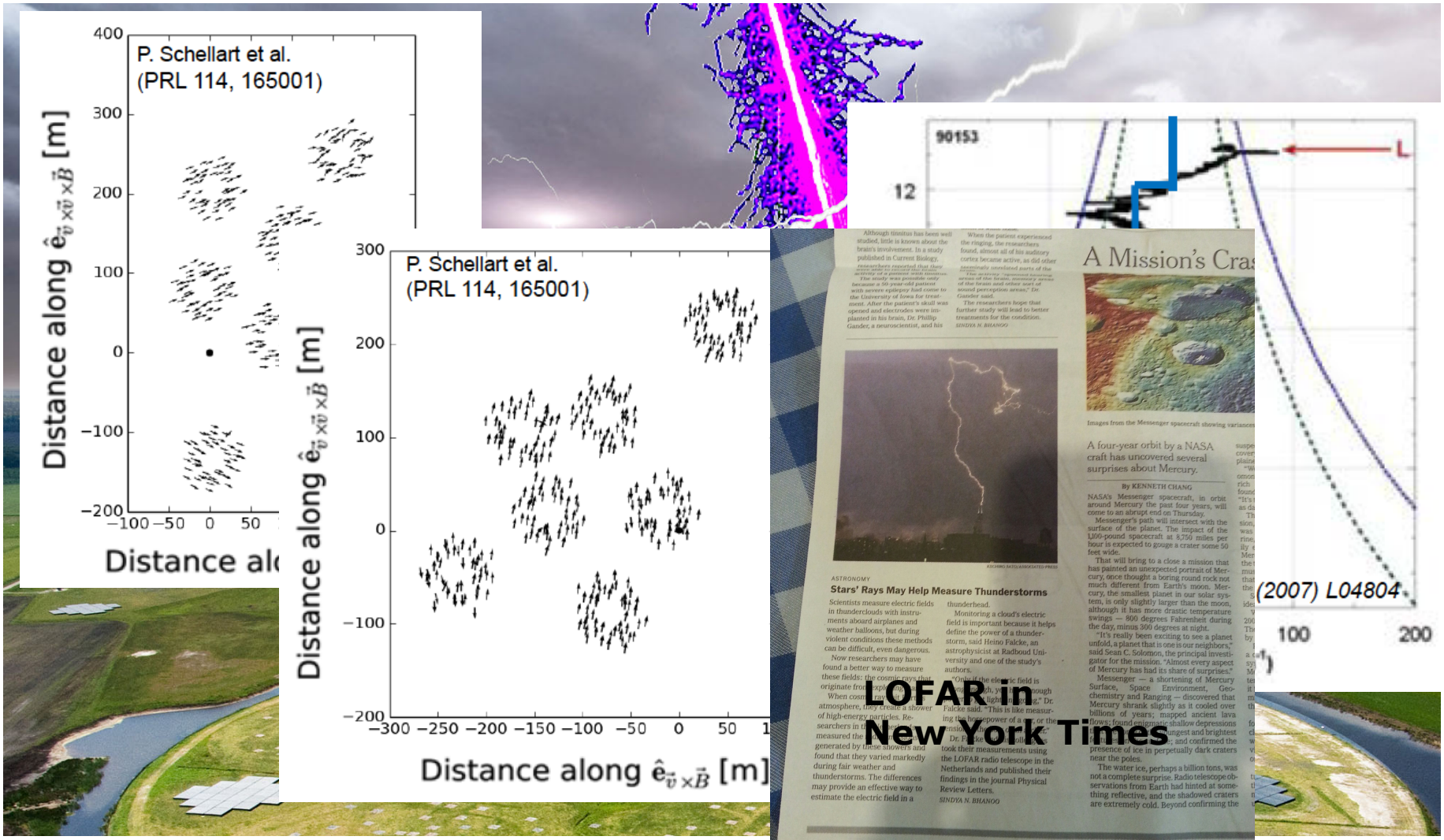


Satyendra Thoudam

Laura Rosetto (& Anna Nelles)

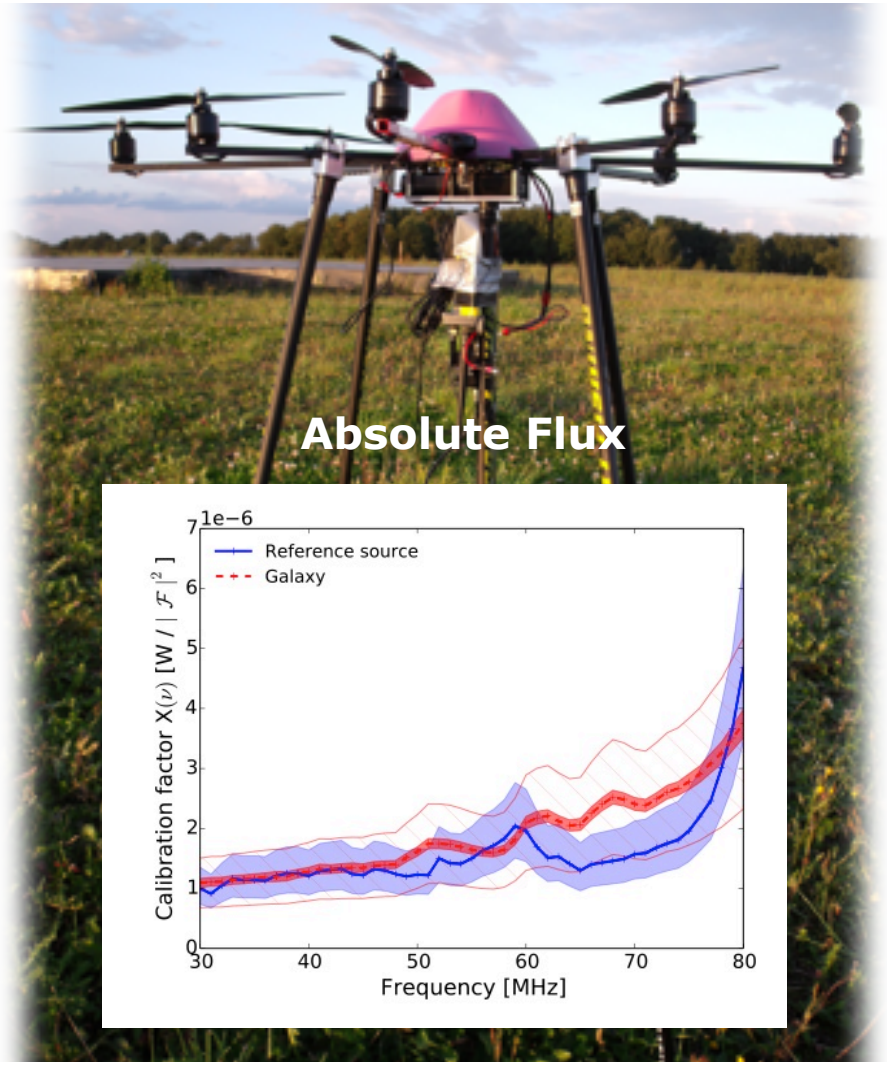
Lightning & CRs: Astroparticlegeophysics

Radboud University Nijmegen



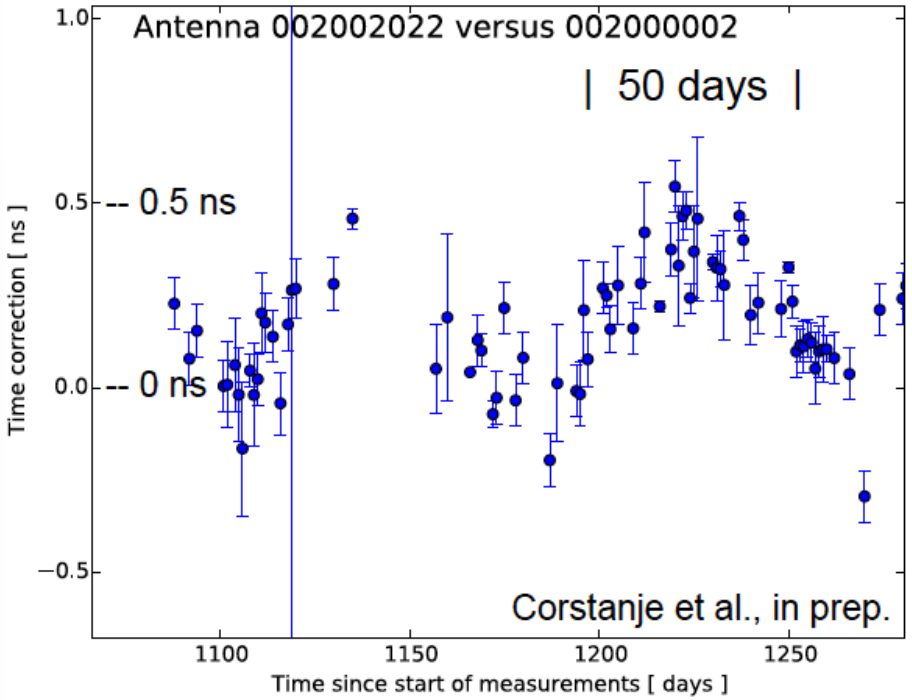
Calibration of LOFAR

Radboud University Nijmegen



Jörg Hörandel

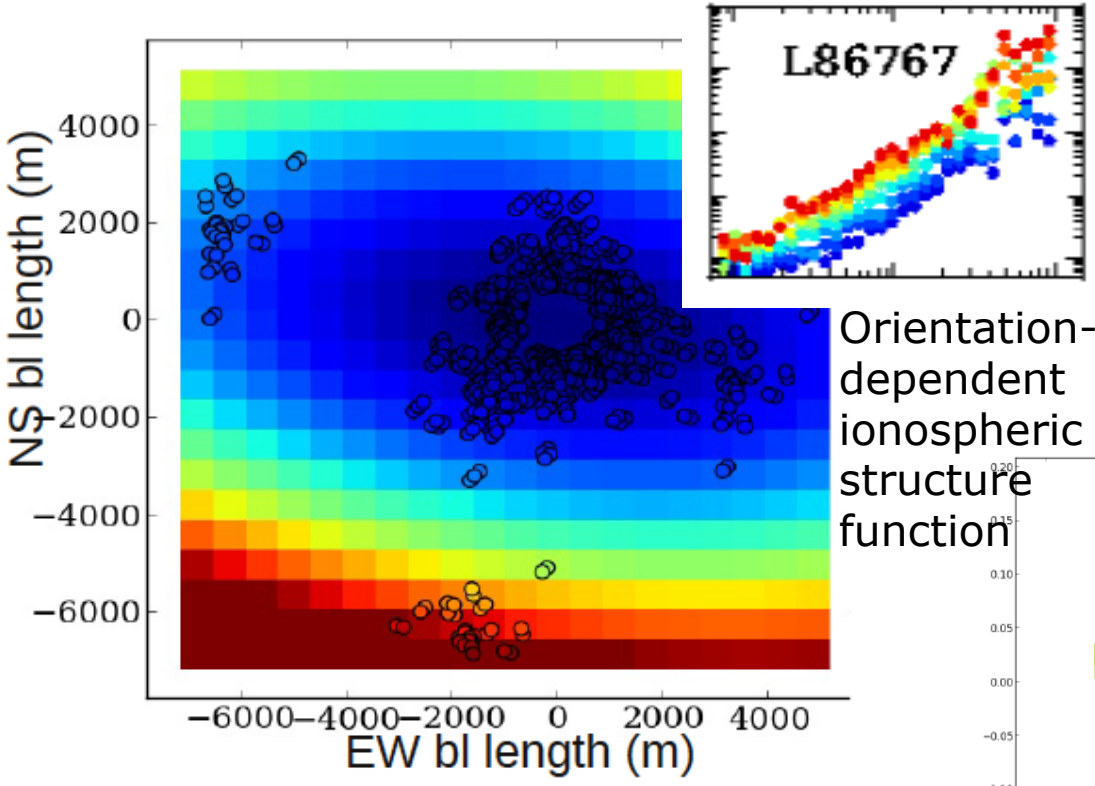
Timing



Arthur Corstanje

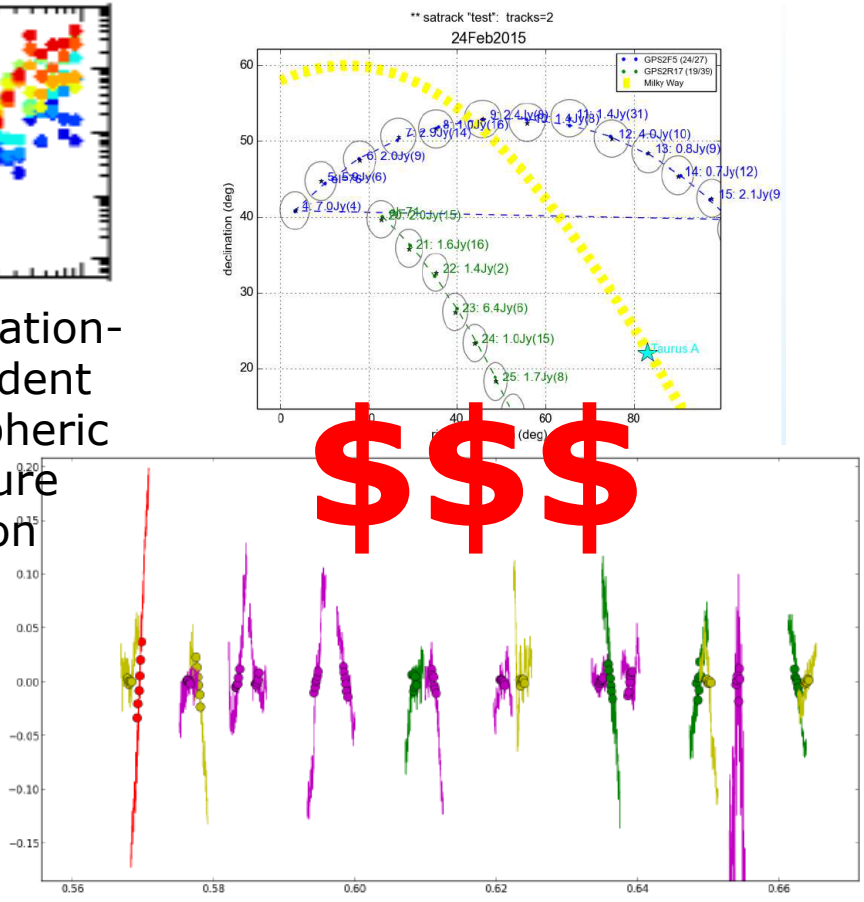
Dissecting the Ionosphere

Radboud University Nijmegen



Orientation-dependent ionospheric structure function

2D Structure of Ionosphere aligned with geomagnetic field
Maaike Mevius



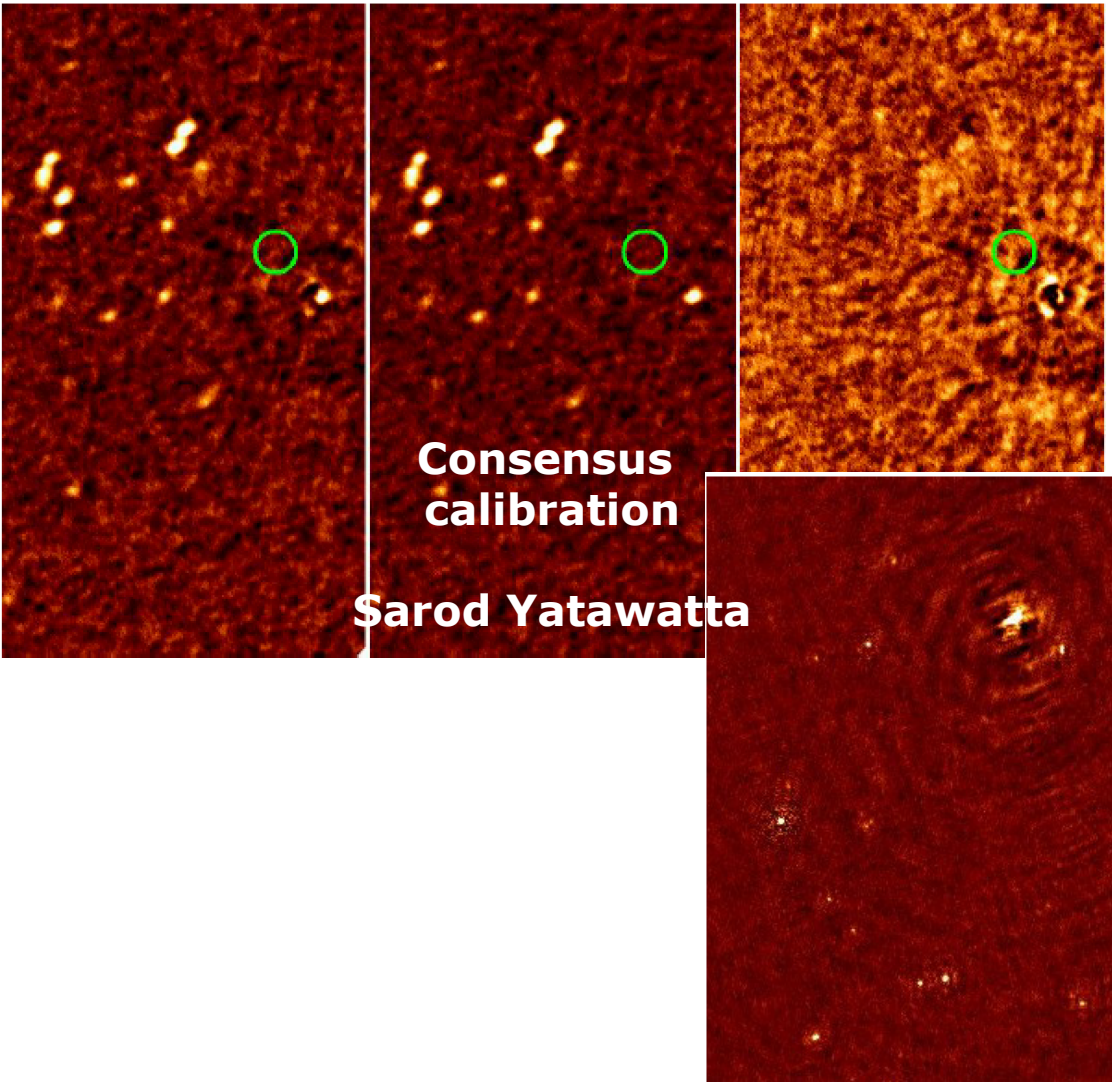
Improving Galileo GPS with LOFAR?
Bas van der Tol

See also Richard Fallows' Christmas present

WOW Imaging

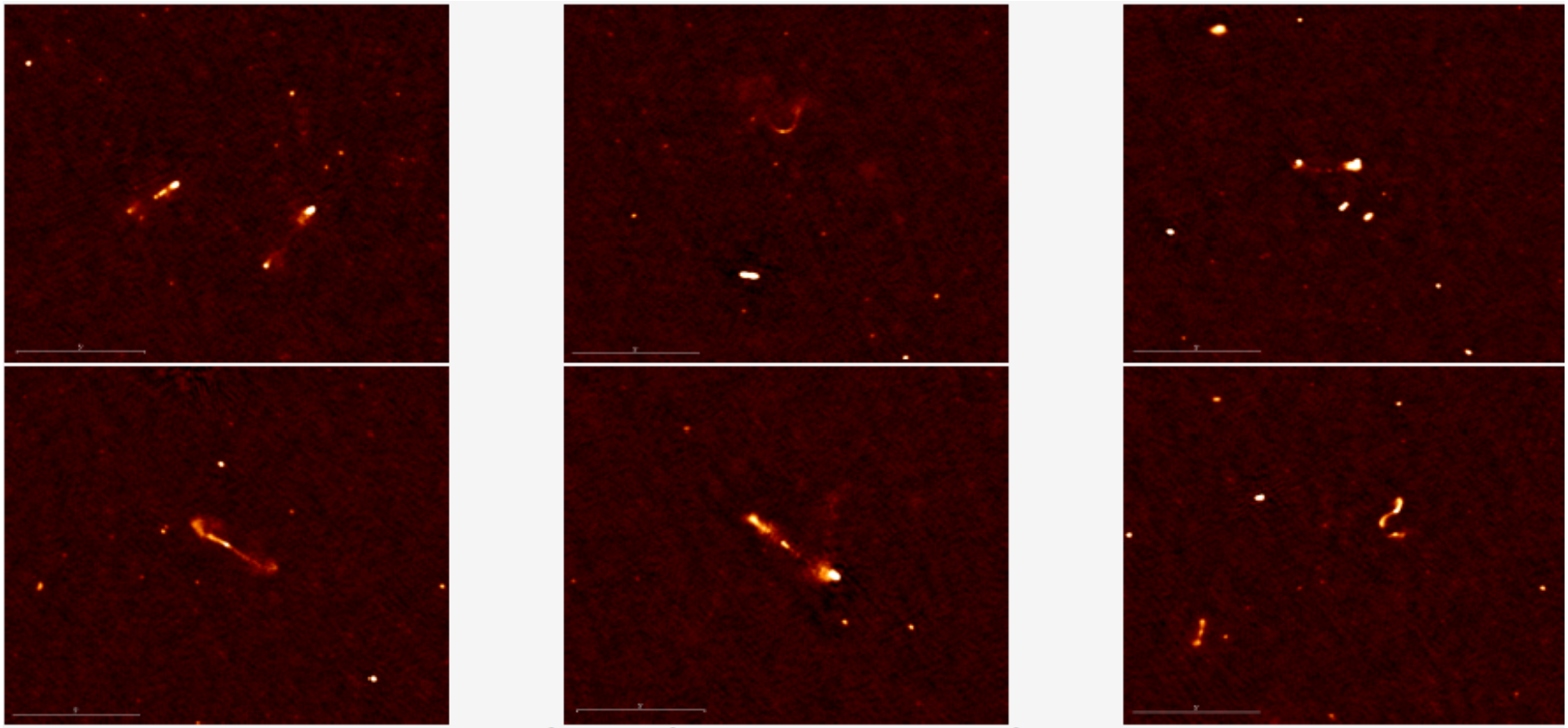
Wonders of Widefield Imaging

Radboud University Nijmegen



WOW Imaging Facet Calibration

Radboud University Nijmegen

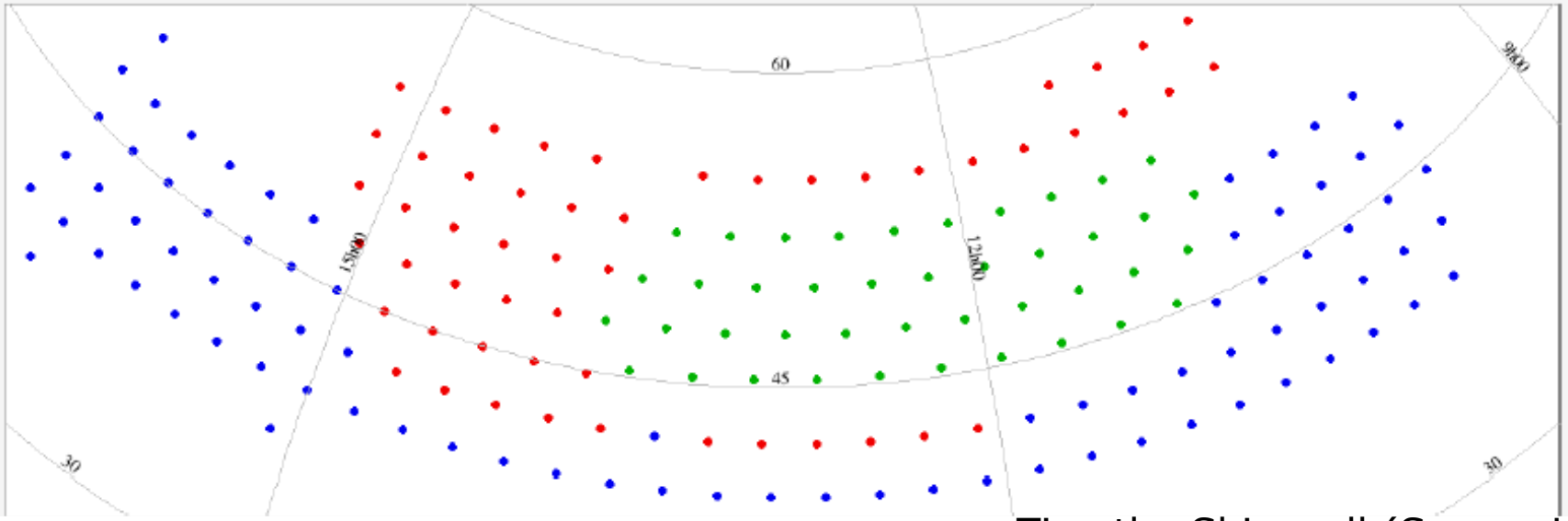


120μJy and 5x7arcsec resolution.

Timothy Shimhwell (Wendy Williams) -> Apply to deep survey
Sarrvesh S. Sridhar - > NGC 5775

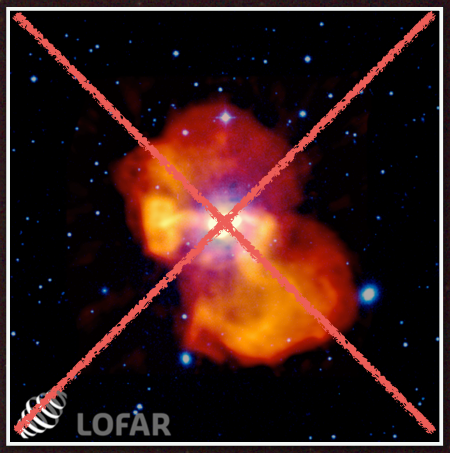
Continuum Survey possible

- $\approx 100 \times 8$ hr pointings have been observed and 80 are scheduled.
- 48 MHz bandwidth (from 120 MHz to 168 MHz) towards each pointing
- Always using core and remote stations (40 m to 120 km) in HBA-dual-inner mode and ≈50% of the time also using the international stations.



WOW Imaging

Wonders of Widefield Imaging



M87 at Low-Band!!!!

Francesco de Gasperin

Virgo A
LOFAR LBA (46 MHz)
rms: 30 mJy/b
beam: 16”x17”
dyn range: 7500

Expected flux: 3120 Jy
Measured flux: 3004 Jy

Picking out interesting sources – blobby universe

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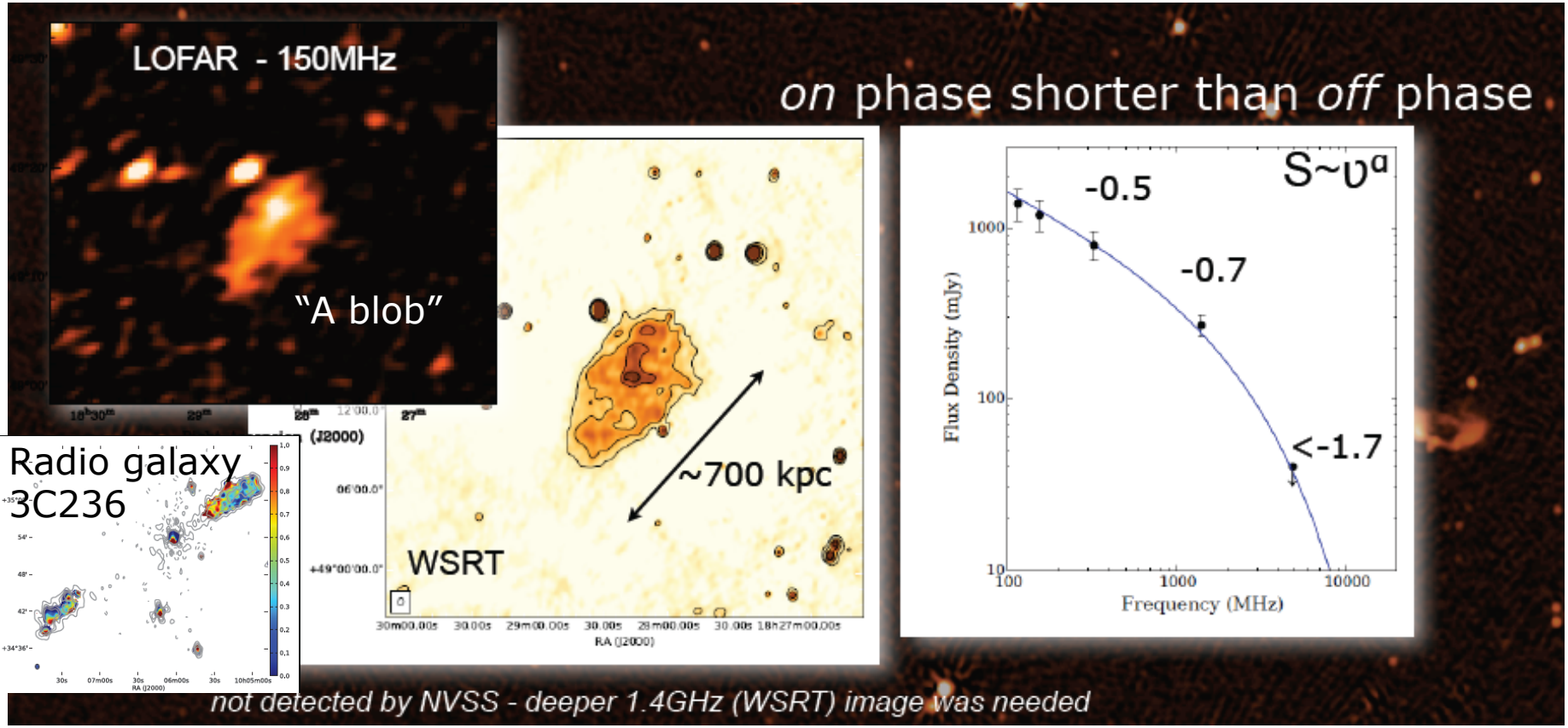
Structure and spectral index info adds a lot of new information facilitated by LOFAR



Raffaella Morganti, Marisa Brienza, Aleksandar Shulevski

"LOFAR getting so deep, that you need very deep high-frequency follow-up!"

A cluster of clusters

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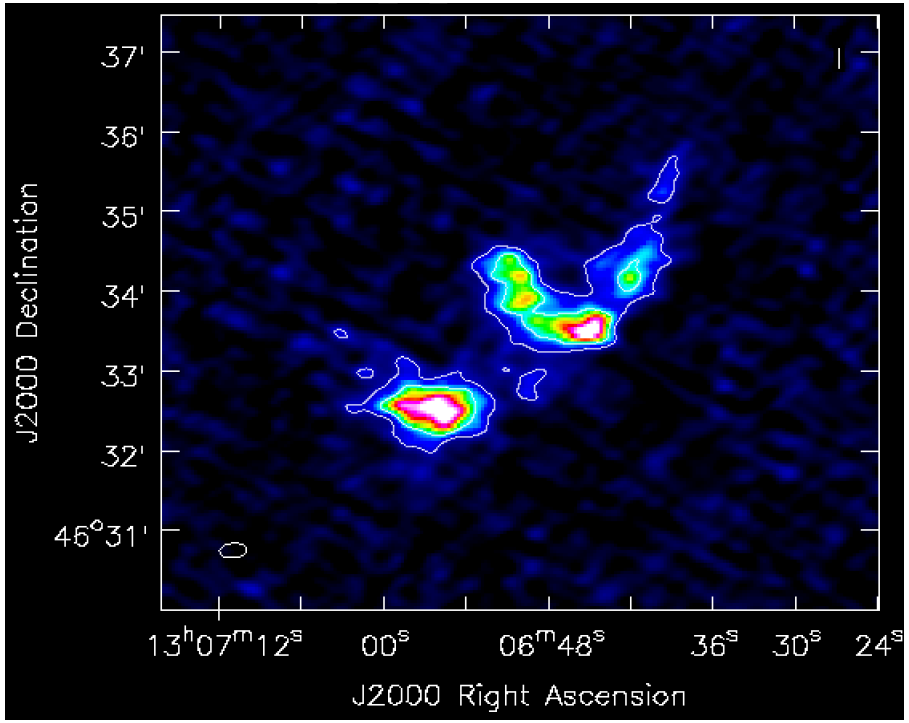
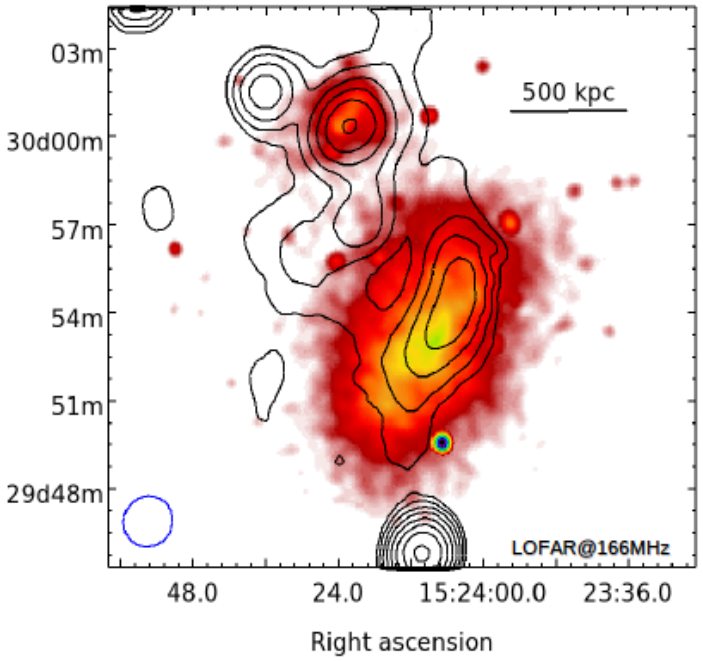


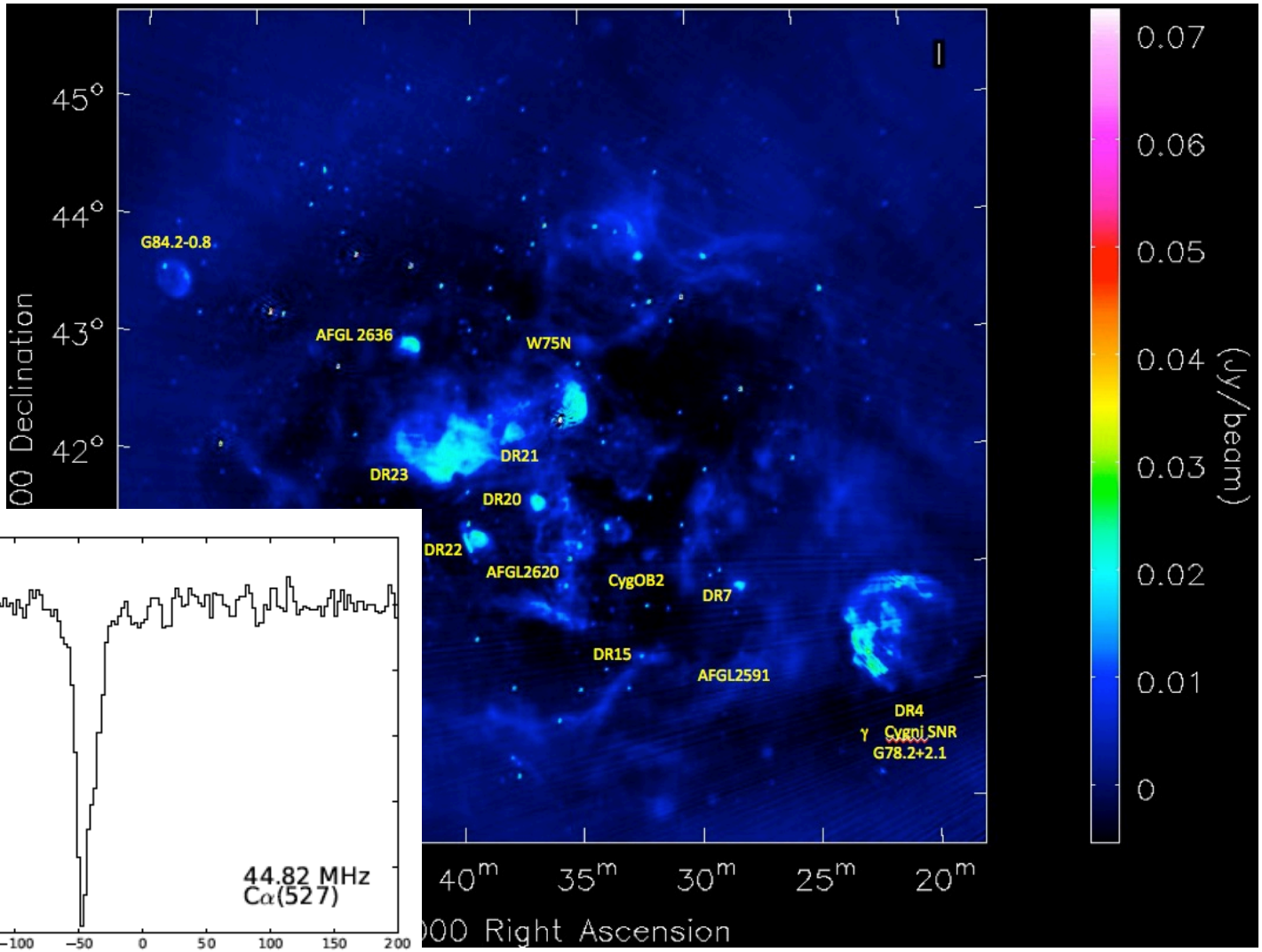
AA1682
Alex Clarke



A2069
Alexander Drabent

Galactic WOW Imaging Bonanza

Radboud University Nijmegen

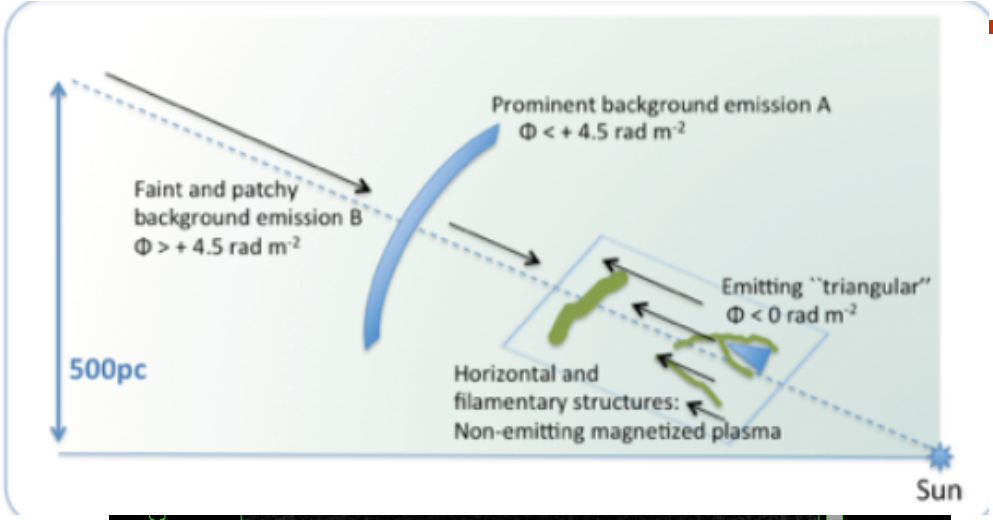


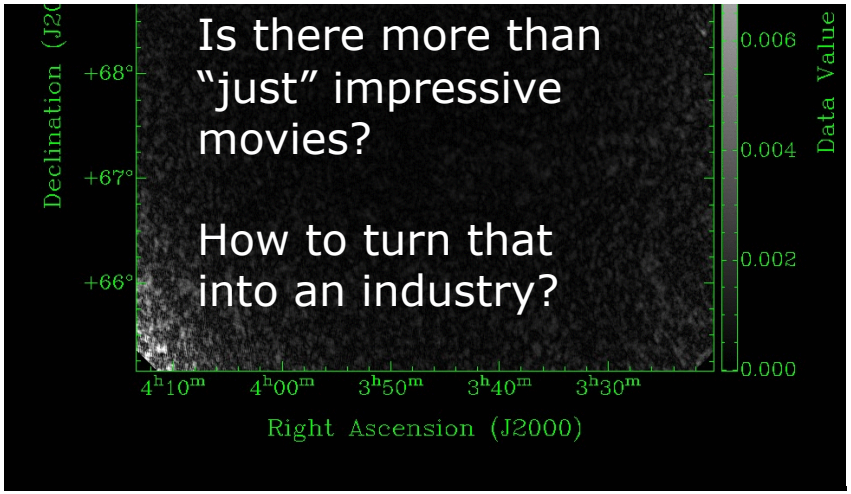
Pedro Salas

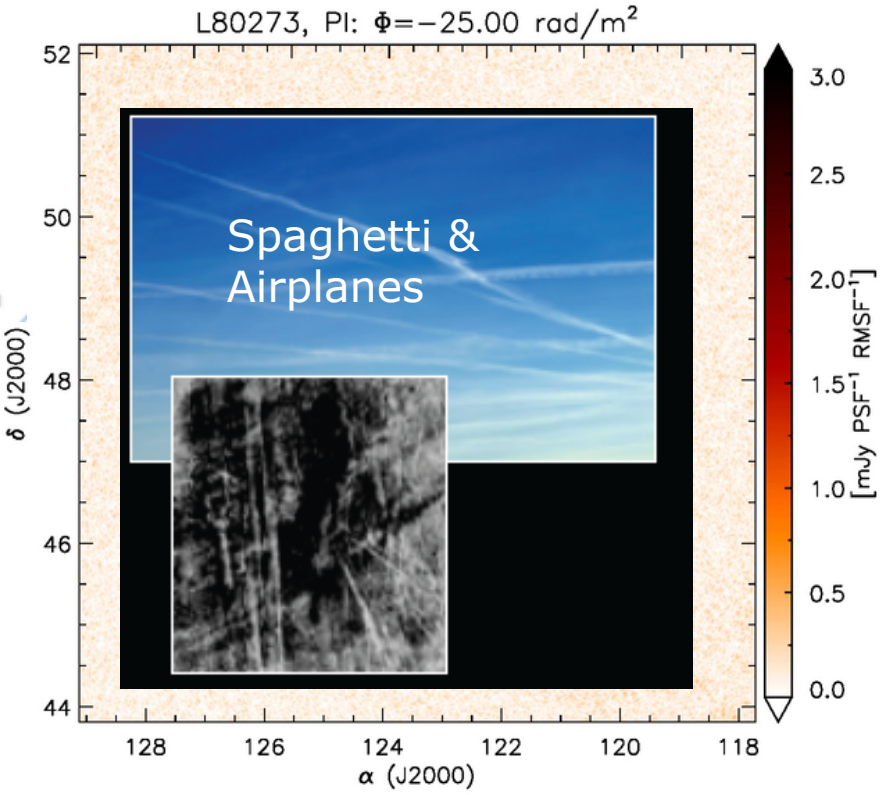
Glenn White

Galactic WOW Foregrounds

Radboud University Nijmegen



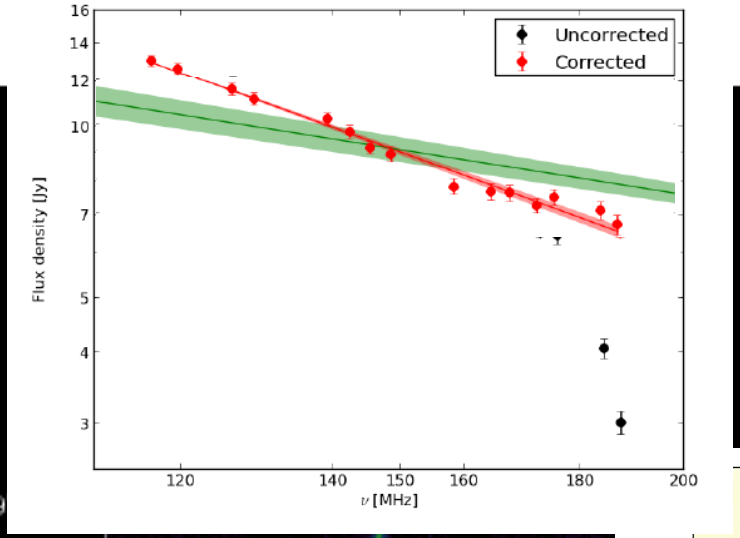




Cameron van Eck

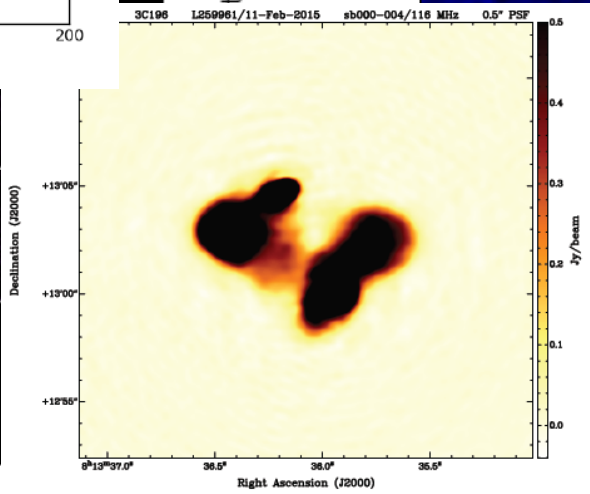
Vibor Jelić

Long Baselines becoming more common place



LOFAR 150 MHz

Javier Moldon



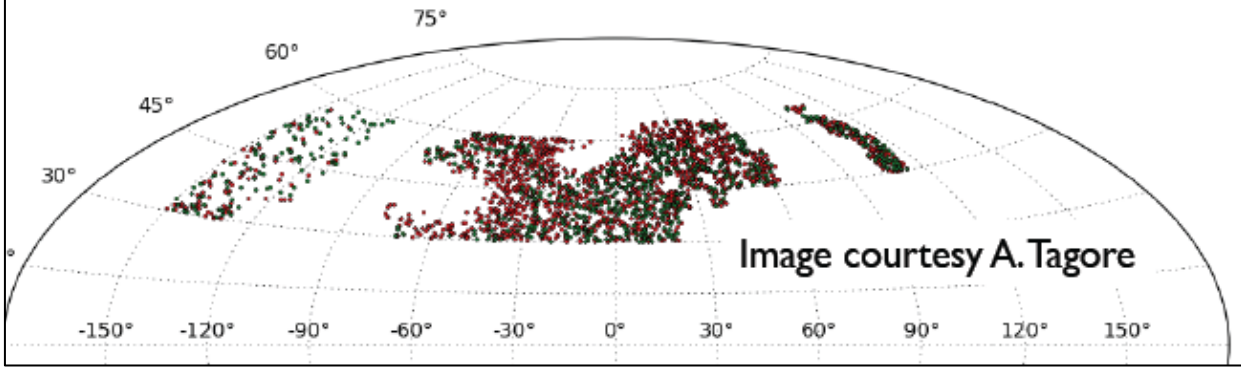
EOR can use long baselines as well!
Ger de Bruyn

Leah Morabito

Long Baselines

Long Baselines will become bread & butter science soon – any surprises expected?

- 31 hours (>7,000 sources) observed, about half reduced
  - Big thanks to RO+Michiel: much manual work!
  - Detection rate >30%
  - Data has been affected by incorrect BBS parset which reduced sensitivity (now fixed)



Meeting flavor

- Refreshingly “boring”: people discuss **published** papers!!
- Family meeting with remarkably little dirty laundry but a lot of hard and successful efforts to make LOFAR work!!
- Occasionally smiling PostDocs and PhD students …
- Evolutionary phases of LOFAR Science meetings:
  - → Fantastic promises (2002 - 2011)
  - → Nothing works – complete frustration (2012)
  - → frantic experimentation (2013)
  - → some victories & unpublished world records (2014)
  - → normal science programs (like ALMA …) (2015)
  - → fundamental discoveries (unlike any other tel) …

What to expect?

- High-profile papers, unique LOFAR science (2015+)
  - CR lightning paper (Phys. Rev. Lett.)
  - CR composition paper & Solar KSP paper in "negotiations" with high-profile journal
  - First MSSS papers (➞ reprocessing)
  - First EOR upper limit
  - A Fast Radio Burst with LOFAR … ?
  - Interesting new pulsar, new transients, deep survey object?
- Deep understanding on how to do radio astronomy today
  - SKA will never work if LOFAR doesn't work (but we will make it work!)
  - SKA will never work if it doesn't learn from LOFAR (will they?)

Work to be done

- Major progress in imaging, incorporate extreme/ facet peeling in standard processing (and other options seem promising too!)
- Flux-calibration, beams shape, in-band spectral index, phasing stability
- Rapid response: TBB modes & real-time triggers, real-time transients, piggybacking incoherent beam searches
- Fix-up some remaining long-baseline issues.

LOFAR 2.0

- Develop a vision – start thinking and discussing now!
  - Make LBA more useful, more signal paths, improved/ more antennas, parallel observing with HBAs
  - More LOFAR stations in core and a few to fill gap at 100 km range
  - Long baselines and LBA will remain a very unique selling point of LOFAR
  - …?

Conclusion

- LOFAR is about to start for real only now! The top of the hill is in sight.
- Big thanks to all who have made this possible over the years!
- Still, we need to finish the job - looking forward to new discoveries in 2016!