

# A VLBA Survey at 327 MHz:

*A catalogue of E-LoFAR calibrators*

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# Outline

- LoFAR
- E-LoFAR → motivation
- VLBA
- The Project ■
- Calibrators
- Sources at 327 MHz
- Conclusion



# LoFrequency ARray (LoFAR)

(briefly)

Currently two operational stations:

- ASTRON, Dwingeloo, The Netherlands → CS1 (Exloo)
- MPIfR, Effelsberg, Germany (IS-DE1)
- A minimum of 36 stations in The Netherlands
- Each stations has a total of 96 antennas
- Main aim is to study the low frequency universe => 30 – 80 & 120 - 240 MHz.



Low band antennas 30 -80 MHz



High band Antennas 120 -240 MHz



MPIfR LOFAR station

## E-LoFAR



- European expansion of LoFAR
- Other countries (UK, France, Sweden, Italy and Poland) are expected to take part.
- Longest baseline extended from a few 100 km to a few 1000 km.
- Providing sub-arcsecond resolution, in the highest observing frequencies (~200 mas).
- Main concern → is there a sufficient density of compact sources to act as calibrators.

We propose to address this problem by exploiting the public archive of 327 MHz observations made by the VLBA.

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# Very Long Baseline Array – VLBA

## a brief intro



- 10 25-m diameter Radio Telescopes
- Observations at 90cm (327 MHz) to 7mm (42 GHz).
- From Mauna Kea, Hawaii to St. Croix, U.S. Virgin Islands.
- • Longest baseline is 8611 km.
- Resolution:
  - 90 cm => 26 mas
  - 7 mm => 0.2 mas

# The Project

## The Aim

to create a list of E-LOFAR calibrators/early targets at 327 MHz with sub-arcsecond resolution.



## How?

Calibrating, Fringe-Fitting, and imaging ~ 50 sources observed by the VLBA at 327 MHz from 2003 – 2007.



# The Project

(cont'd)

So far ...

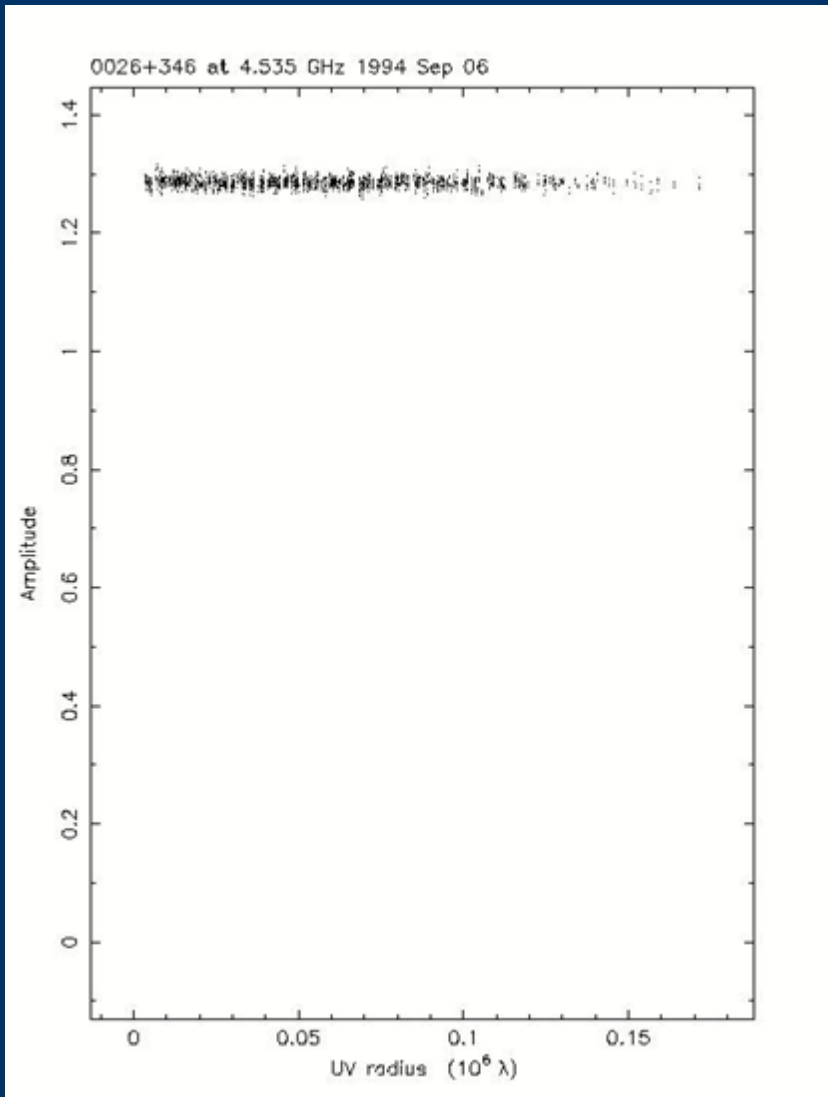
the data have been calibrated, fringe fitted and preliminary imaged via an automatic pipeline.

The next step (and current) ■

to produce images and plots of the uv-data (AIPS) of the sample, listing their suitability as calibrators and publish the results ▲



# A Little info on Calibrators



- The best calibrators are point sources.
- For a point source the amplitude is constant over all baselines.
- A source can also be a good calibrator if it has a well defined structure – even a complex one.
- Provided it is also detected on long baselines.

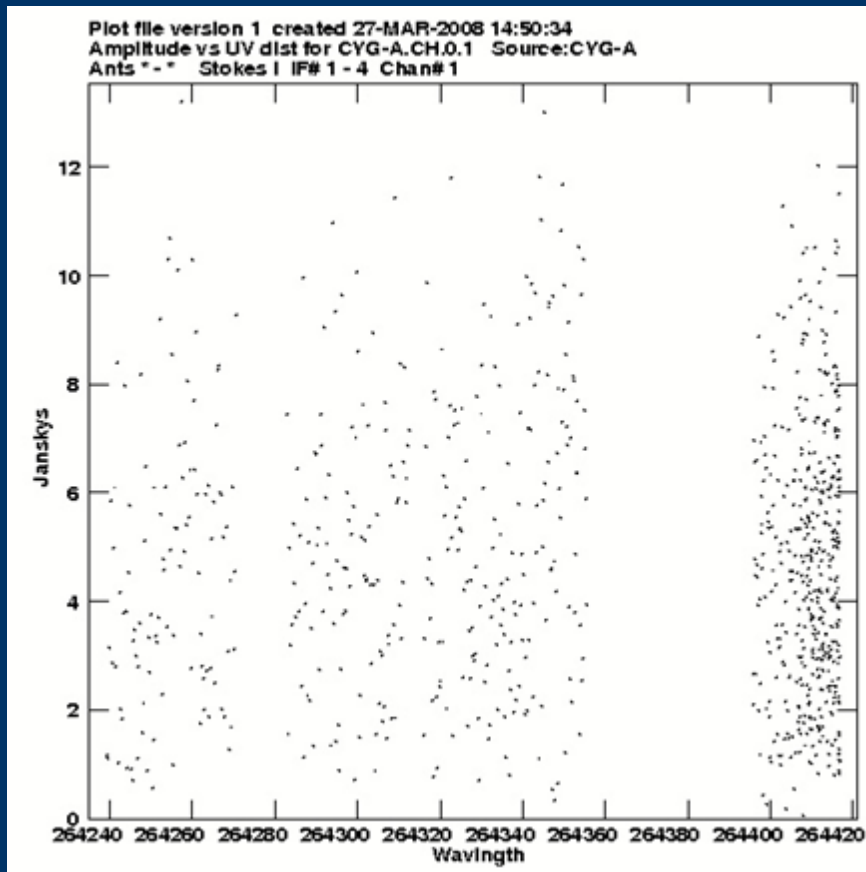
uv plot of the source J0029+349 at 6cm. Courtesy  
The VLA Calibrator Manual

## Sources at 327 MHz

- The properties of sources at low frequencies are almost unknown at sub-arcsecond scales.
  - Very little of this data have been published.
  - Many interesting targets that are easily detected at centimetre wavelengths are not detected at metre wavelengths - Cygnus-A.
  - Cygnus-A dominates the images made by the current LOFAR test array
  - But it is completely undetected by the VLBA at 327 MHz (Project BE032A\_PASS1)
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# Sources at 327 MHz

(cont'd)



- Plot of Cygnus-A uv data from VLBA 327 MHz.
- The baseline is 0.26 mega-wavelengths
- The total VLBA baseline at 327 MHz is 9 mega-wavelengths.
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- No indication of a detection.
- The randomness suggests noise

## Sources at 327 MHz

(cont'd)

- Many (all?) of the sources in our sample are resolved, some showing extended structure on scales  $\sim 10 - 100$ 's mas.
- Which however would be unresolved for E-LOFAR ( $\sim 300$  mas res)
- Bright sources ( $> 100$  mJy) can act as primary calibrators for E-LOFAR.
- But a much denser grid of fainter sources is required to be able to make deep images across the entire sky.

# Sources at 327 MHz

(cont'd)

## Lenc et al (2008)

have embarked on a deep, wide-field global VLBI 327 MHz survey using B0218+357 as an 'in-beam' calibrator.

mapped out ~ 270 sources in the field around this source



detecting about 10%

## This suggests

that a sufficient fraction of E-LOFAR source population, will be bright and compact enough to form a grid of calibrator sources across the sky.

## In Conclusion

- The archive survey we have embarked upon, also provides an opportunity to identify other sources to serve as in-beam calibrators so that this work can be further extended.
- This will also lead to a general study of the nature of the faint and transient radio source population at low frequencies.

### Further ...

(hope to) extend this work by embarking on a large 327 MHz survey of all sources above  $\sim 100$  mJy (in-beam calibrators ?)

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