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The University of Manchester

OCRA: The One Centimetre Receiver Array

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OCRA Collaboration: University of Manchester, Torun Centre for Astrophysics & University of Bristol

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What is OCRA?

- One Centimetre Receiver Array
- Multi-pixel array of continuum detectors
- 1 cm wavelength (30 GHz)
- Three receivers planned: OCRA prototype, OCRA FARADAY and OCRA Centi
- Proposed in Browne et al. (2000)

OCRA collaboration

- University of Manchester: R. Battye, I. Browne, R. Davis, S. Lowe, M. Peel and P. Wilkinson. Also E. Blackhurst, C. Baines, J. Edgley, J. Kitching, D. Lawson, J. Marshall and N. Roddis at JBO
- Toruń Centre for Astrophysics: R. Feiler, M. Gawronski, A. Kus, B. Pazderska, E. Pazderski
- University of Bristol: A. Azareedh, M. Birkinshaw, K. Lancaster

Why OCRA?

- Want to know point source fluxes at microwave frequencies for CMB experiments (Very Small Array, Planck, etc.)
- Useful datum in source spectra: can look for spinning dust, spectral behaviour of AGN, GLAST sources, etc.
- Measure the decrement from the Sunyaev-Zel'dovich effect in clusters of galaxies for cluster astrophysics, CMB foregrounds.

OCRA-p: What is it?

- OCRA prototype
- 2 beam receiver
- 27 to 33 GHz
- 72 arcsec resolution
- Nominal noise of 7 mJy $s^{-0.5}$
- Similar to Planck LFI receiver chain
- "Traditional" components

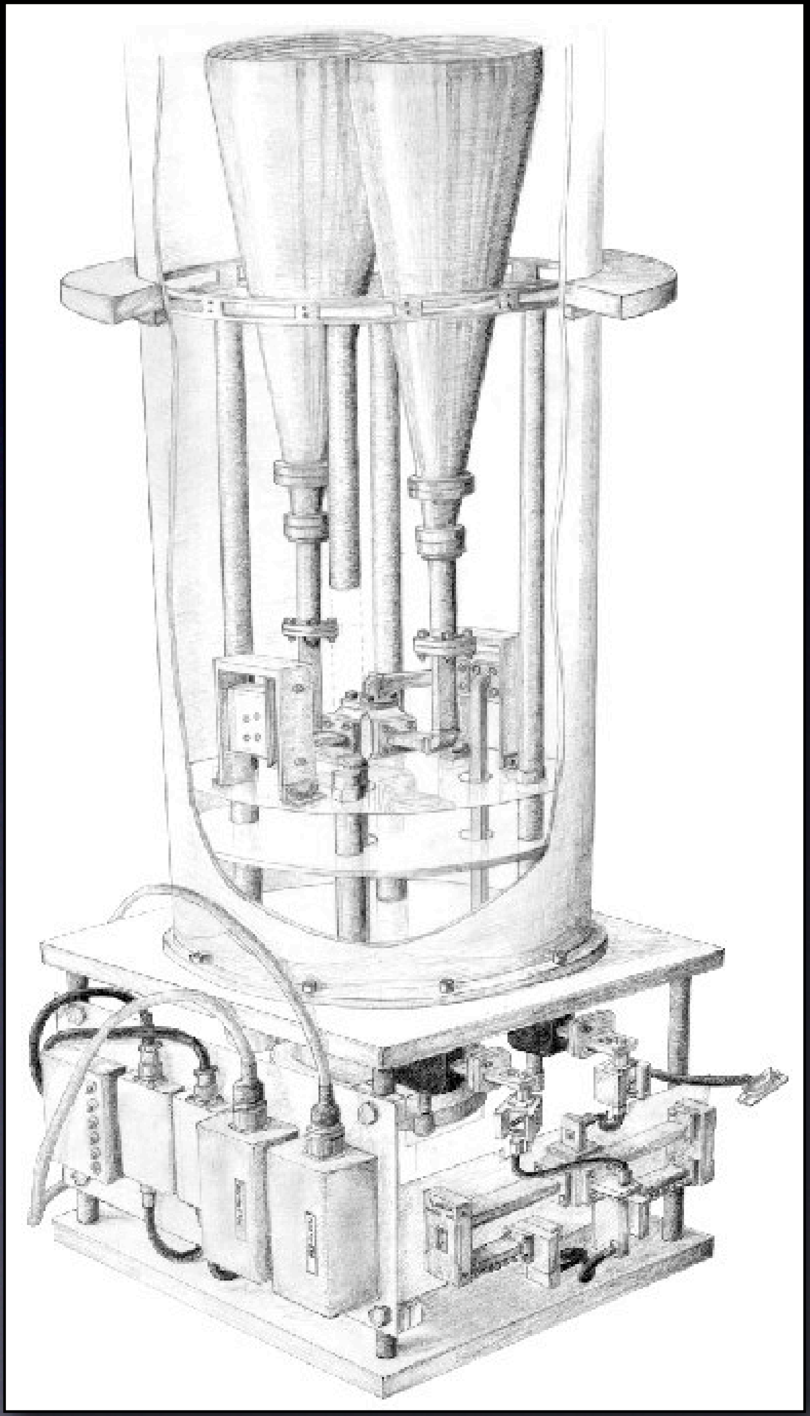


Image credit: S. Lowe

OCRA-p: Where is it?

- RT4 telescope at Toruń Centre for Astrophysics, Poland
- 32m dish, accurate to 0.4mm rms. Aperture efficiency 45%
- Pointing accuracy currently 10 to 15 arcseconds
- Better weather than Manchester!

OCRA-p: How do we use it?

- Use NGC 7027 as primary calibrator
- Various secondary calibrators: strong sources near observations
- Calibration and strong (>50mJy) sources measured using cross-scans
- Weaker sources measured with on-off measurements

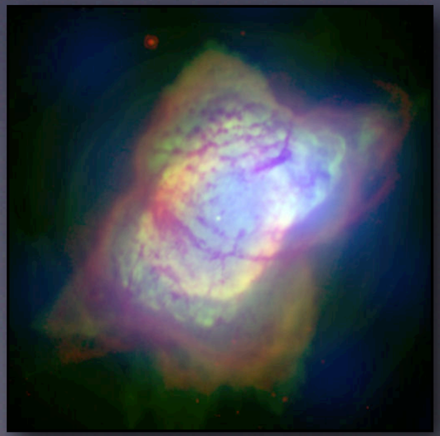


Image credit: NASA/Chandra (X-ray)

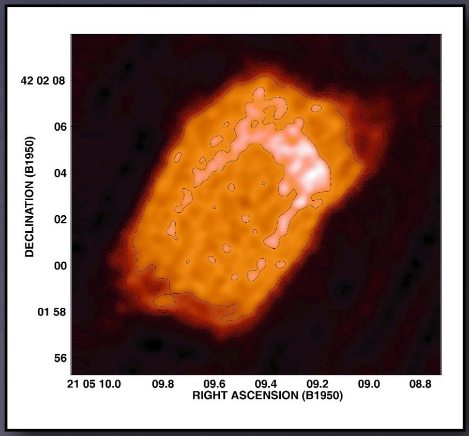
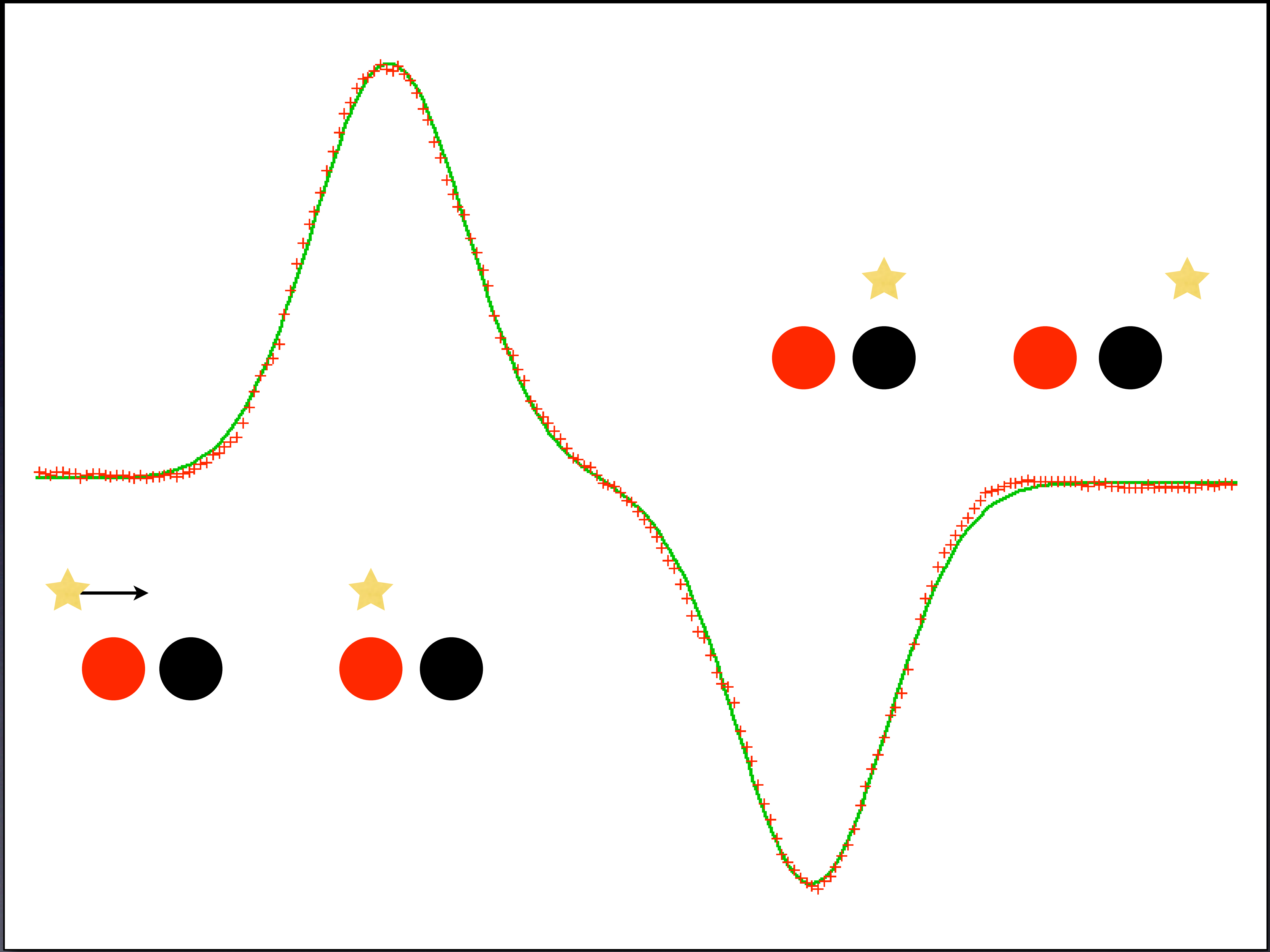


Image credit: MERLIN/VLA (1.7GHz)

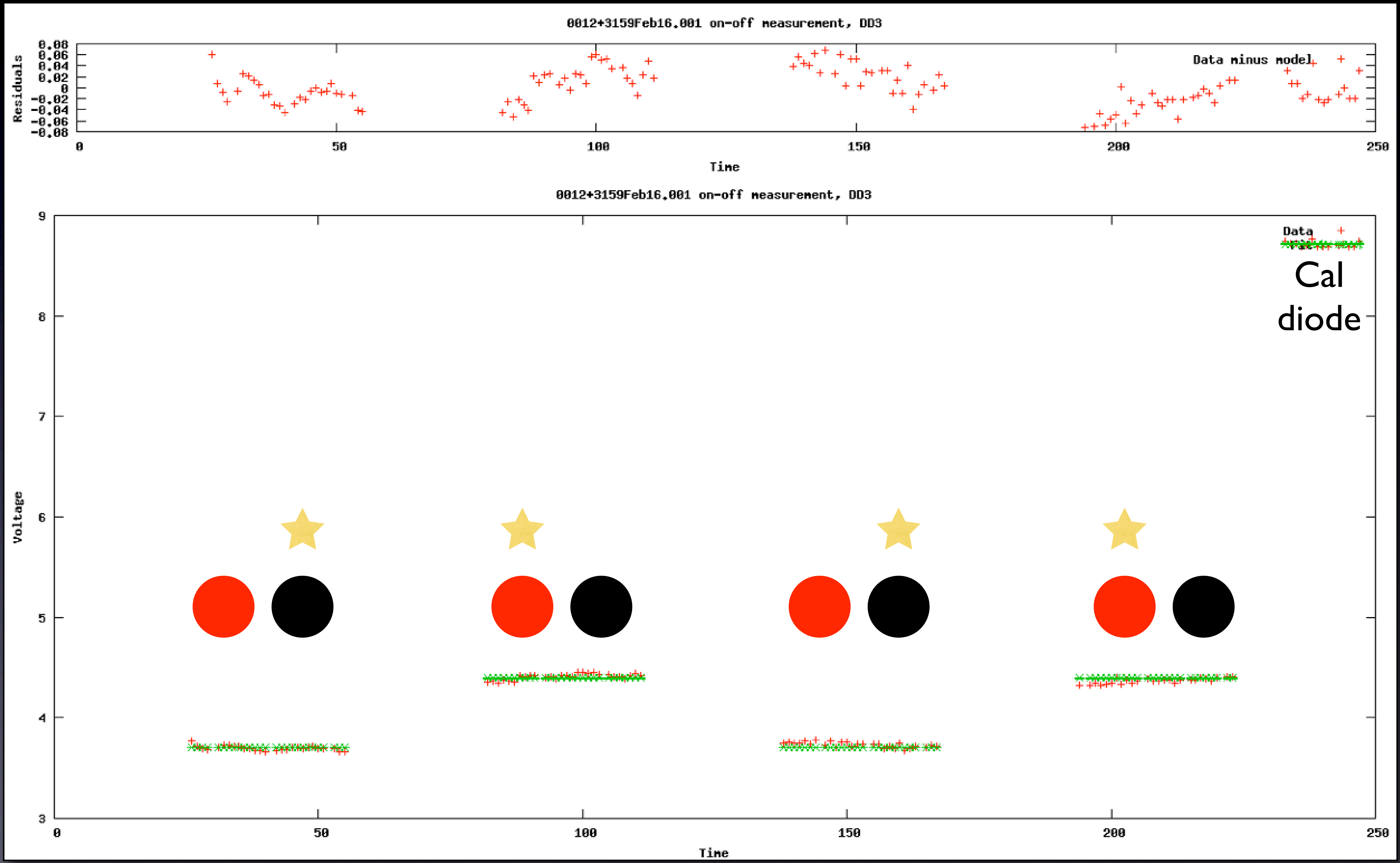
OCRA-p: How do we use it?

Cross scans



OCRA-p: How do we use it?

On-off measurements

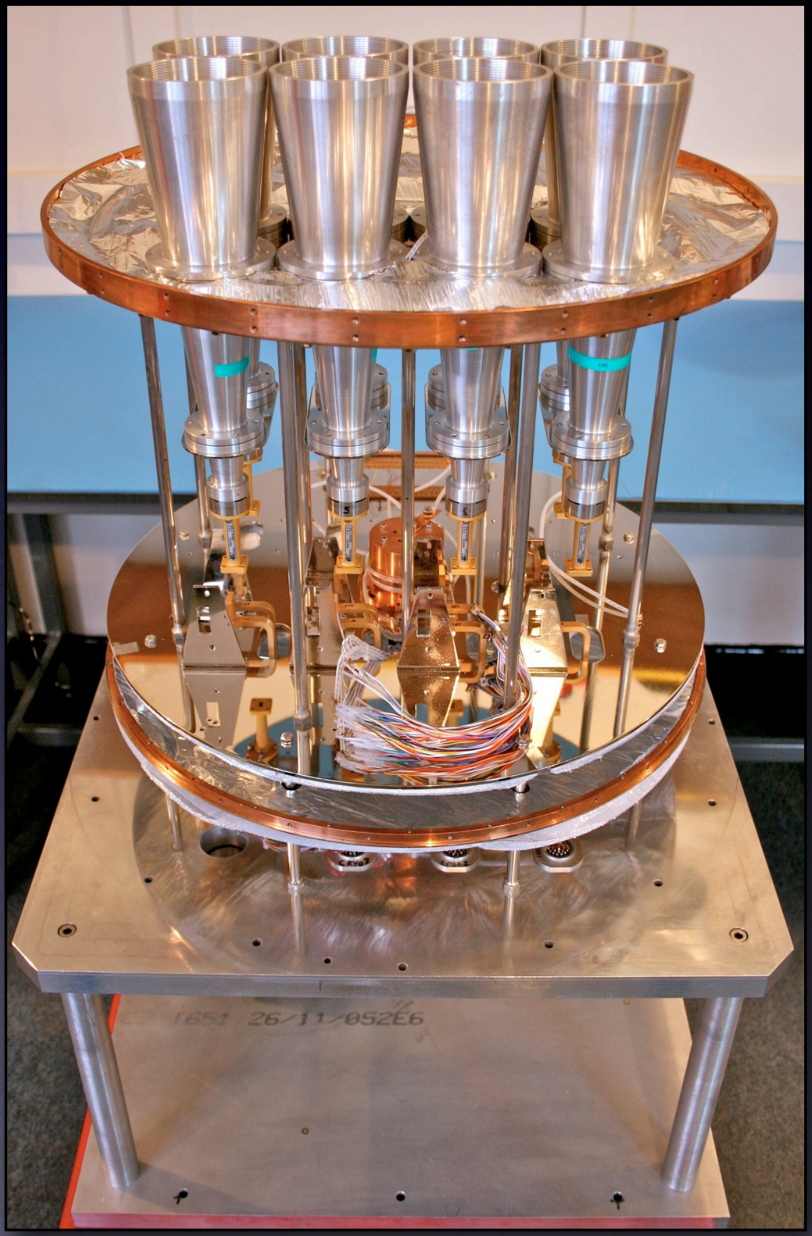


OCRA-p: What has it done?

- Caltech-Jodrell flat spectrum sources at 30GHz (Lowe et al. 2007)
- Sunyaev-Zel'dovich effect in small sample of galaxy clusters (Lancaster et al. 2007)
- Sources in the Very Small Array super-extended array fields (Gawronski et al. 2008, in prep)
- Fluxes of Planetary Nebulae at 30GHz (Pazderska et al. 2008, in prep)
- More observations ongoing

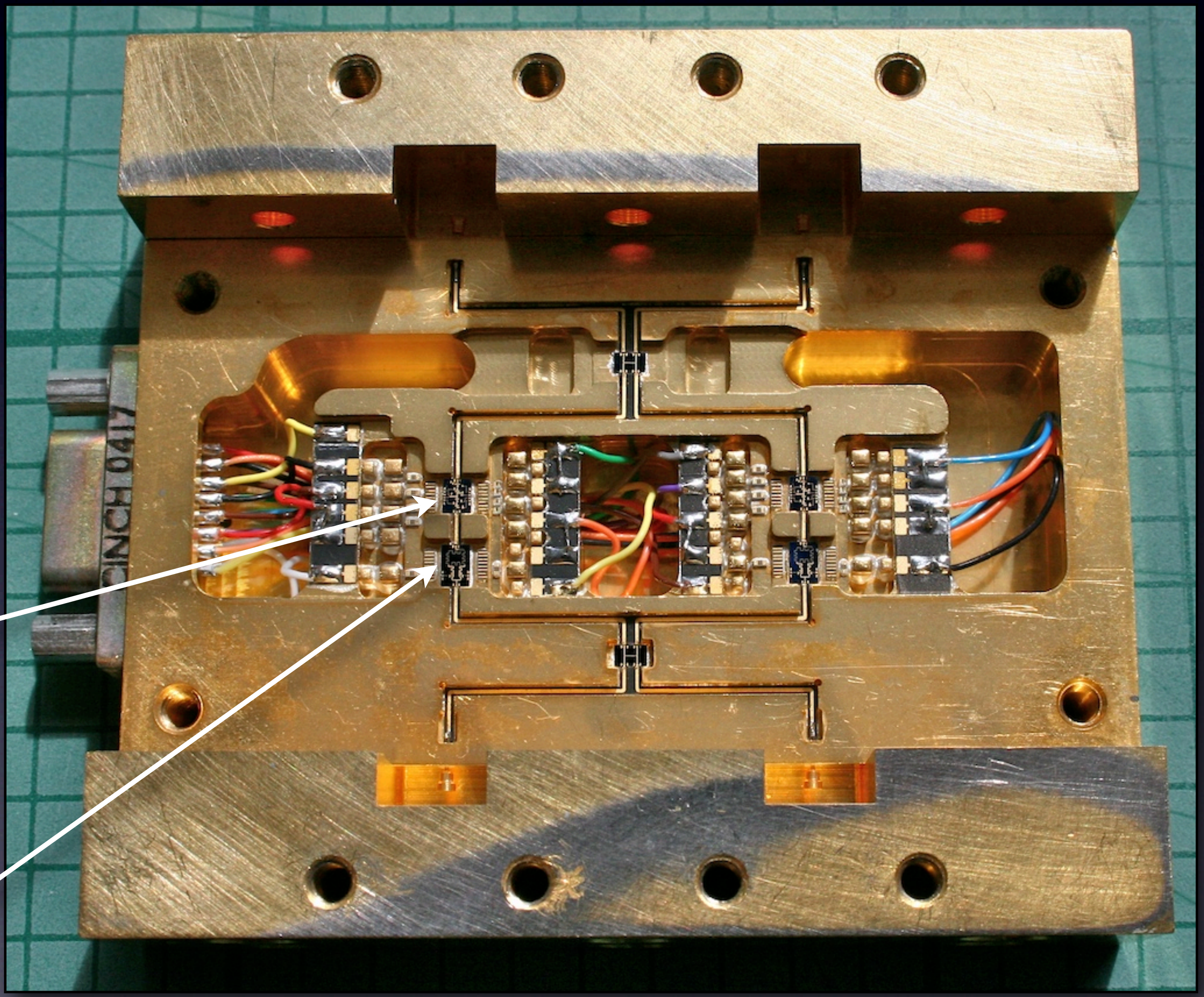
OCRA-F: What is it?

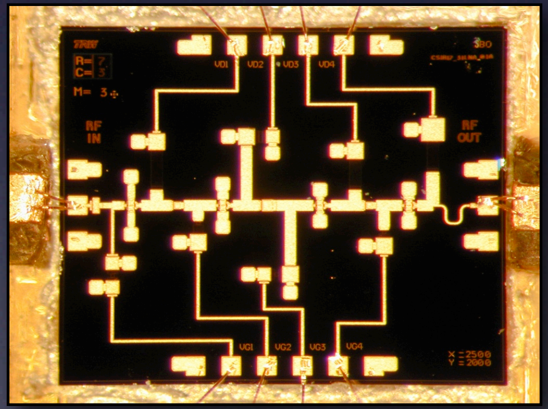
- OCRA FARADAY
- 8 (later 16) beam receiver
- 26 to 36 GHz band
- 72 arcsec resolution
- Nominal noise of 7 mJy $s^{-0.5}$
- Monolithic Microwave Integrated Circuits instead of "traditional" components

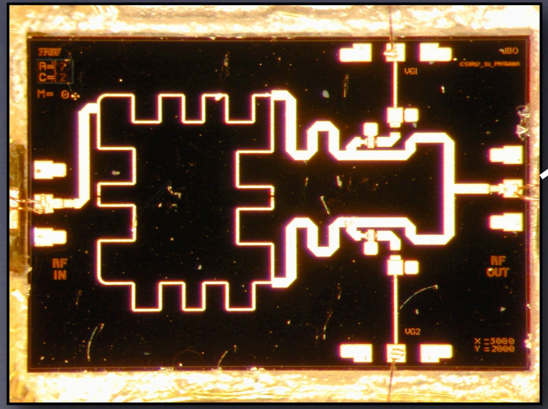


OCRA-F: What is it?

- MMIC-based hybrids, amplifiers, phase switches
- Modular front and back ends







OCRA-F: Where is it?

- Jodrell Bank Observatory
- Original test cryostat dismantled January 08
- Following 6 months spent assembling it into final configuration
- Testing of amplifiers in cryostat started June 08
- Will be superseding OCRA-p on 32m Toruń telescope when complete (Autumn 08)

OCRA-F: What will it do?

- Point sources:
  - Blind surveys
  - Follow up GLAST sources
- SZ effect
  - Follow up Planck clusters
  - Mapping galaxy clusters?
  - Blind SZ surveys?
- Will start observing in early 2009

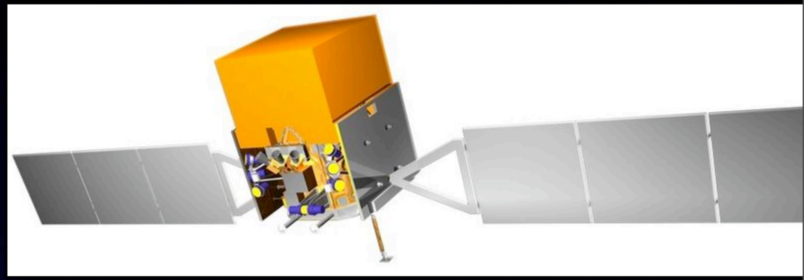
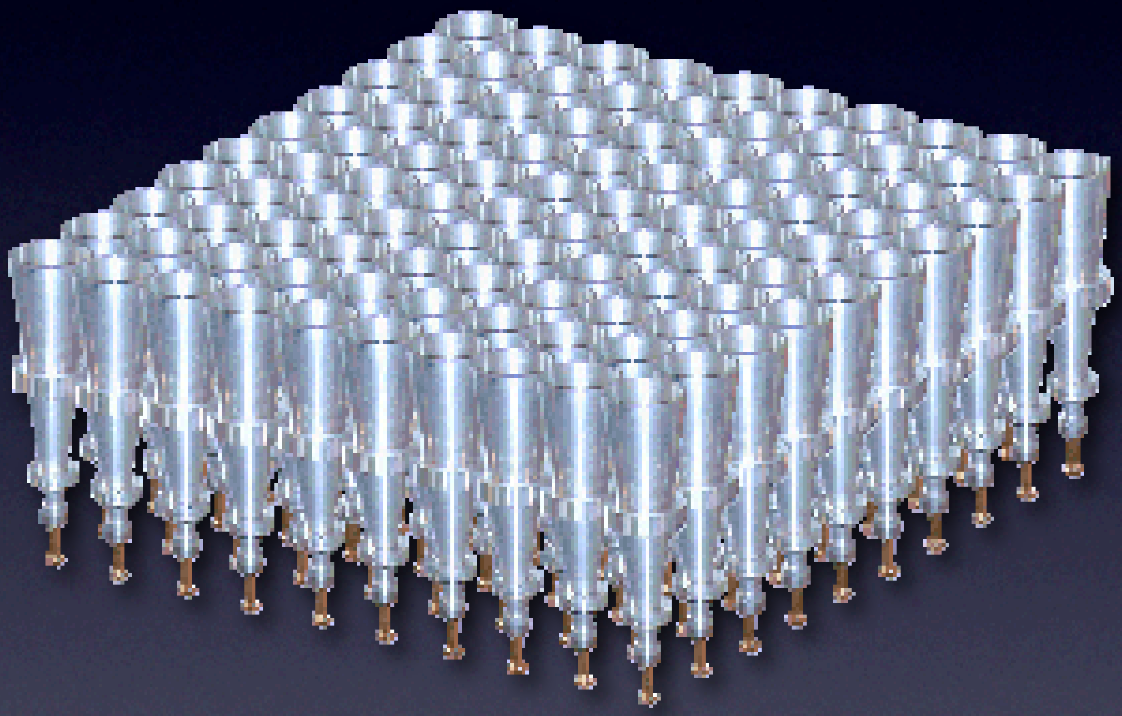


Image credit: SpectrumAstro

Image credit: ESA

OCRA-C: What is it?

- OCRA Centi
- 100 beam receiver
- 30GHz / 1cm
- Bandwidth and resolution to be decided
- Will combine continuum and spectrum measurements



OCRA-C: Where is it?

- Not started yet
- Technology to make it will be studied in "All Purpose Radio Imaging Cameras On Telescopes" (APRICOT) project
- EC Framework 7 RadioNet joint research activity with MPIfR Bonn, IRA Bologna, TCfA Torun, FG-IGN Madrid
- Peter Wilkinson leading this
- Starting January 2009

OCRA-C: What will it do?

- Point sources:
  - Large scale blind surveys at 30GHz
  - Galactic and extragalactic targets
  - Continuum and spectroscopy
- SZ effect
  - Map galaxy clusters
  - Large scale blind SZ surveys

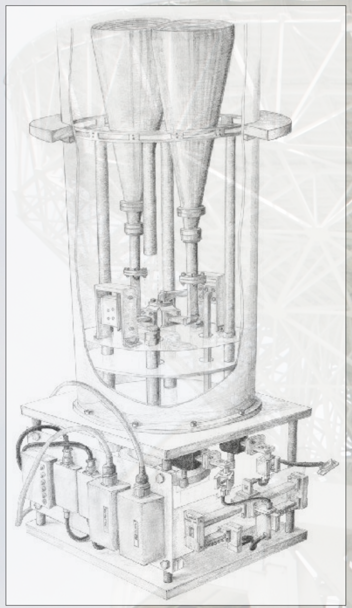
OCRA: The One Centimetre Receiver Array

M. Peel; the OCRA collaboration

Jodrell Bank Centre for Astrophysics, University of Manchester

The One Centimetre Receiver Array (OCRA) program is focused on developing multi-pixel arrays of continuum receivers at microwave frequencies. It currently has two receivers, OCRA-p and OCRA-F, both of which operate at a wavelength of 1 cm (30 GHz). OCRA-p is a 2-beam prototype currently located on the Toruń 32m telescope in Poland, and OCRA-F is an 8-beam receiver array due to start observing at the start of 2009 from the same location. The ultimate goal of the program is to construct a 100-beam receiver array.

OCRA-p



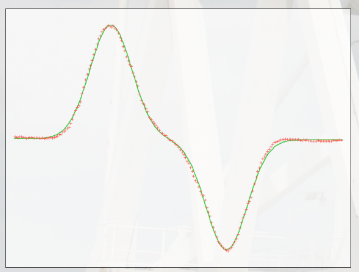
OCRA-p. Image credit: S. Lowe

The OCRA prototype is a two-beam pseudo-correlator receiver based upon the Planck LFI receiver chain, and is similar to the WMAP 23 GHz receiver.

The two beams are combined together using a hybrid, then combinations of the signals passed through two Low Noise Amplifiers (LNAs) and a pair of phase switches. The signals are then separated by another hybrid, futher amplified and square-law detected. The detected signals are subtracted from each other to get the difference in signal between the two beams. This reduces the effect of 1/f noise from the LNAs and the atmosphere.

Beams:	2
Resolution:	72 arcseconds
Frequency range:	27-33 GHz
System temperature:	40 K (all contributions)
Nominal noise:	7 mJy $s^{-0.5}$

OCRA-p has been used to observe radio point sources (the CJF sample; Lowe et al. 2007, and the Very Small Array fields; Gawronski et al. 2008), the Sunyaev-Zel'dovich (SZ) effect from clusters of galaxies (Lancaster et al. 2007) and planetary nebulae (Pazderska et al. 2008).

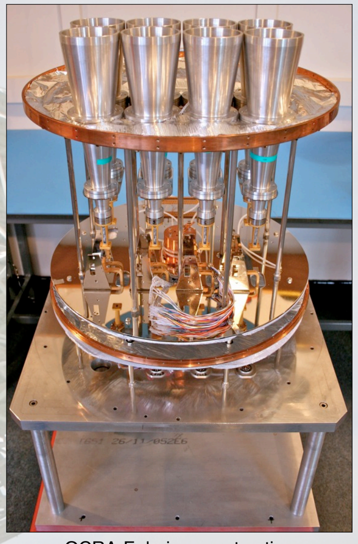


An example azimuth scan of NGC 7027

On the left is an example OCRA-p cross-scan of NGC 7027, a planetary nebula that is also a strong radio source. The red points are the one second data and the green line is a double gaussian fit, representing the 'positive' and 'negative' beams.

OCRA-F

OCRA FARADAY currently has 8 beams, with the space for expansion to 16 beams; these are arranged in pairs. The receiver builds upon OCRA-p, following the same receiver chain pattern but using Monolithic Microwave Integrated Circuits (MMICs) in place of traditional components (see Kettle & Roddis 2007).



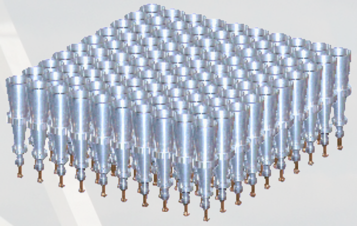
OCRA-F during construction

OCRA-F is currently being assembled and is expected to begin observing at the start of 2009, with an upgrade to 16 beams around 2010. OCRA-F will be used to do small scale blind surveys for point sources and the SZ effect, and will also be able to create maps of extended emission.

Beams:	8; later 16
Resolution:	72 arcseconds
Frequency range:	26-36 GHz
System temperature:	50K (all contributions)
Nominal Noise (per pair):	7 mJy $s^{-0.5}$

OCRA-C

The goal of the OCRA program is to construct a 100 beam array, which can then be used for large scale blind surveys of point sources and the SZ effect (Browne et al. 2000). The receiver technology required for such an instrument will be studied in the EC Framework 7 APRICOT (All Purpose Radio Imaging Cameras On Telescopes) project within RadioNet. The aim is to combine spectroscopic and continuum measurements in one receiver.



An impression of a 100-beam OCRA horn array. Image credit: S. Lowe

The OCRA collaboration consists of R. Battye, I. Browne, R. Davis, S. Lowe, M. Peel and P. Wilkinson at the Jodrell Bank Centre for Astrophysics; R. Feiler, M. Gawronski, A. Kus, B. Pazderska and E. Pazderski at the Toruń Centre for Astrophysics, and A. Azareedh, M. Birkinshaw and K. Lancaster at the University of Bristol. It also involves the engineering staff at Jodrell Bank Observatory, including C. Baines, E. Blackhurst, J. Edgley, D. Kettle, J. Kitching, D. Lawson, J. Marshall and N. Roddis.

Browne, I. et al. (2000), Proc. SPIE **4015**, 299
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- Lowe et al. (2007), "30 GHz flux density measurements of the Caltech-Jodrell flat-spectrum sources with OCRA-p", A&A 474, 1093
- Lancaster et al. (2007), "Preliminary Sunyaev-Zel'dovich observations of galaxy clusters with OCRA-p", MNRAS, 378, 673