Bundesamt für
Kartographie und Geodäsie

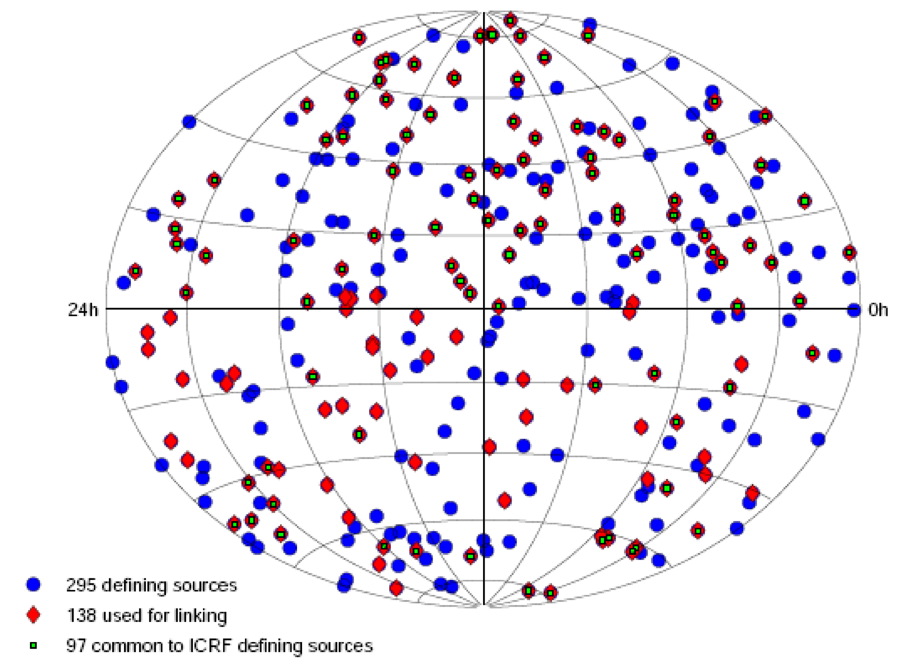
Cartography in Space Geodesy
Mapping of Extraterrestial Radio Sources

Method: Very Long Baseline Interferometry (VLBI)

Radio sources in the universe are observed with very high sensitive directional antennas, so called radio telescopes. If two or more radio telescopes point simultaneously to the same radio source in space it is possible to apply interferometric technique to the observed and recorded flux densities. The radio interferometry technique consists of the cross correlation (combination) of the received signals of the same radio source. Astrometrists transform the interferometric amplitude and phase into an image of the radio source.

The details of the source image are determined by the angular resolution which depends on the observed wavelength λ and the baseline distances B between the co-observing radio telescopes, as ~ 1.22 λ/B. The longer the baseline and the shorter the wavelength (the higher the frequency) – the better the resolution of the radio source maps and the more details of far away objects can be detected.

The Very Long Baseline Interferometry (VLBI) network is composed by independent radio telescopes which are located at different continents. The longest possible VLBI baseline corresponds to the diameter of the Earth (~12000 km), and the highest resolution can reach the submilliarcsecond level (Example: for λ= 4 cm and B= 12 000 km, the resolution is about 0.8 mas). VLBI technique is the most accurate technique to measure positions of radio objects in space.

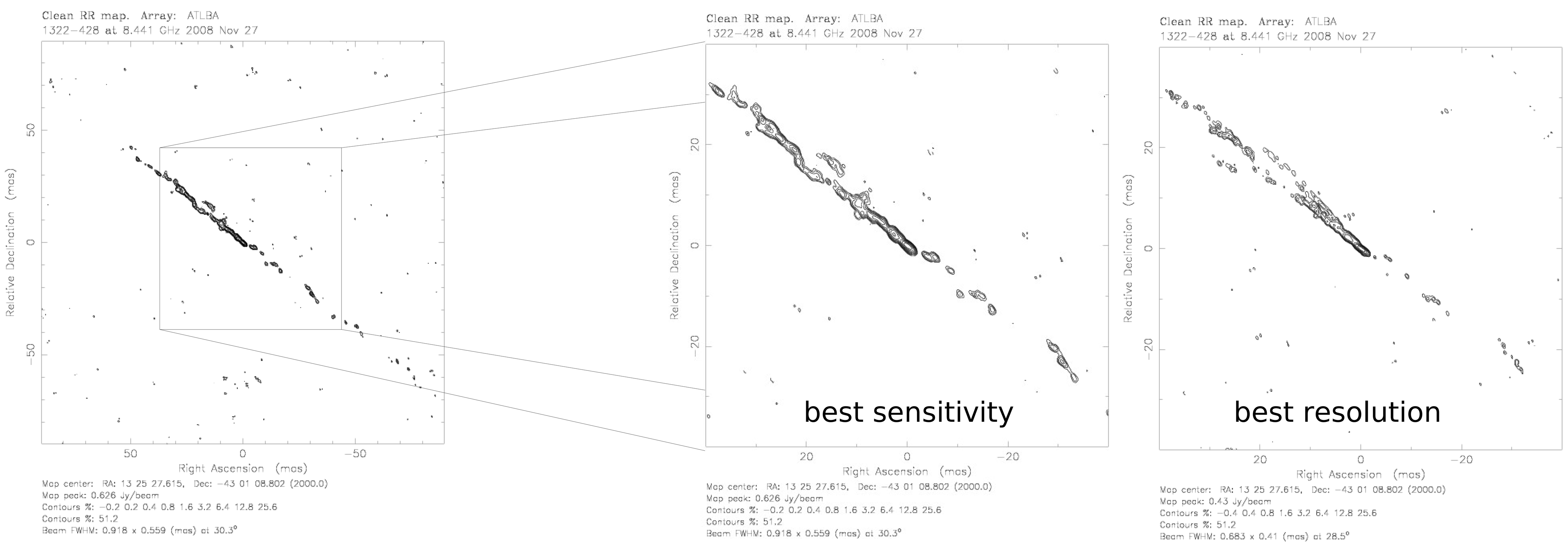


IERS Celestial Reference Frame 2

This picture shows radio source positions which form the most accurate and primary celestial reference frame ICRF2, which was adopted by the International Astronomical Union in August 2009.

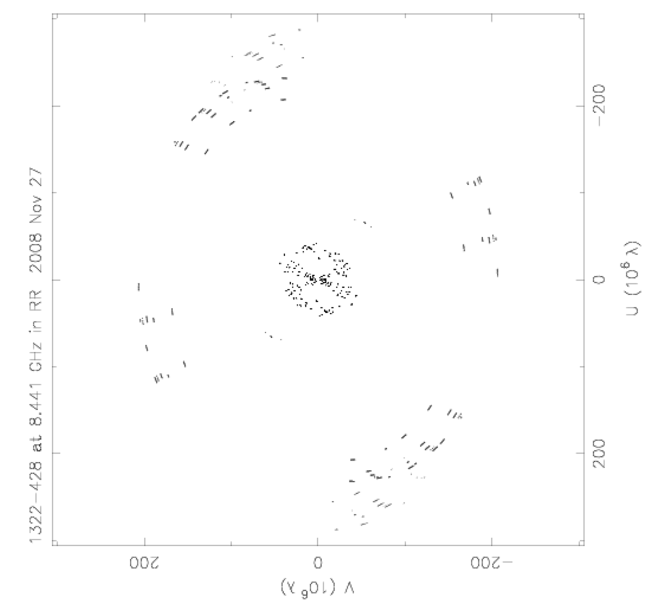
The best map of Centaurus-A @ 8.4 GHz

The maps below are based on VLBI observations within the TANAMI project by radiotelescopes in Australia, TIGO in Chile and O'Higgins in Antarctica which took place on November 28, 2008. The combination of short and long baselines shows in detail the radio source structure. These are so far the **most accurate maps** of Centaurus-A ever observed.



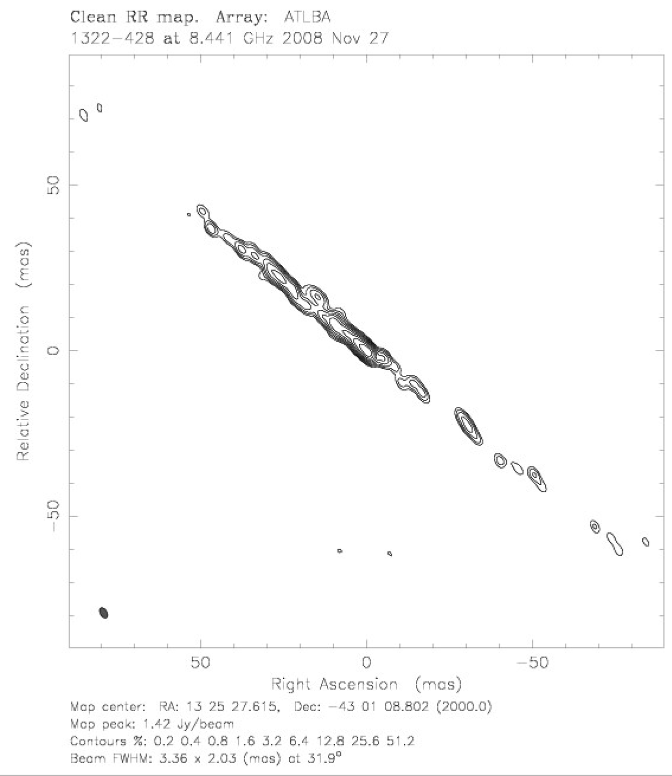
UV-Plane

The uv-plane characterizes how well the radio source is being mapped by the configuration of the radio interferometer. The location of each point in the uv-plane corresponds to one baseline between two telescopes measured in units of millions of wavelengths. It reflects also the Earth rotation during observation. The plot shows the uv-plane used for the maps on the left. The inner dots represent the shorter baselines in Australia.



Map of Centaurus-A @ 8.4 GHz

The map below is the result of using only Australian radio telescopes (LBA) – without the very long baselines to South America and Antarctica. Compared to the above map the resolution is substantially lower by a factor of ~4 and the fine structure of the jet system is not resolved.

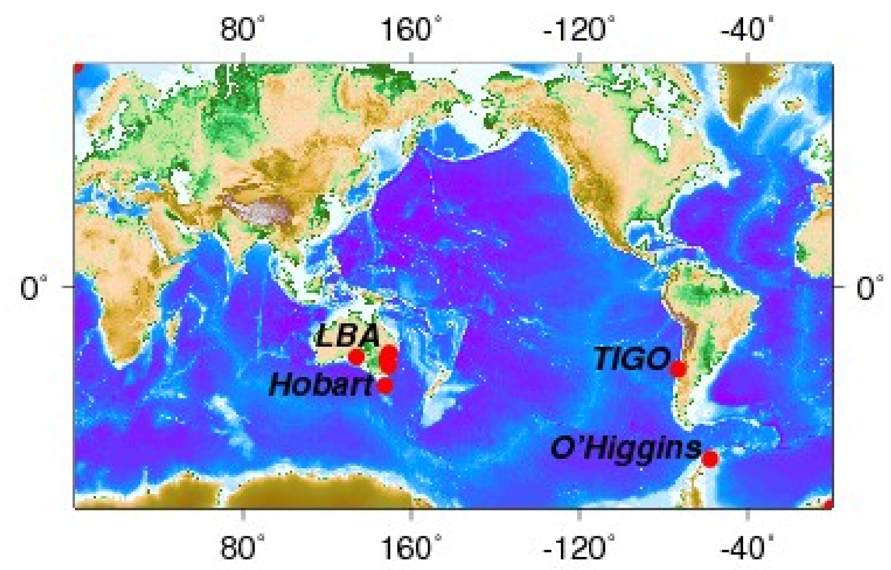


Ceduna, Australia

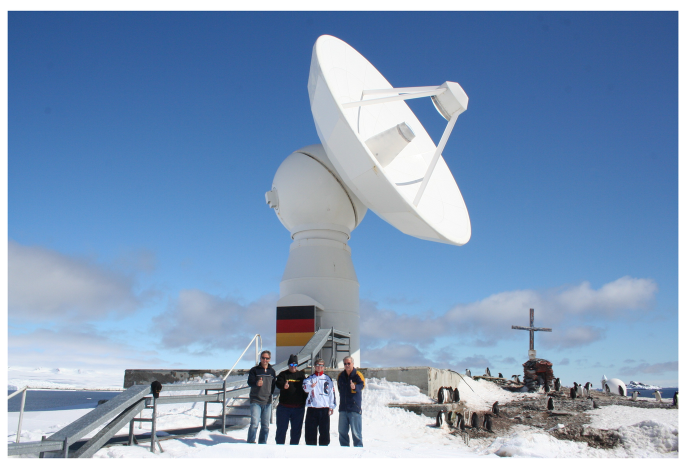
Parkes, Australia

Radio Telescope Network

The map of Centaurus A above was only possible with the radio telescopes network shown below. Currently it is the only network capable of observing radio sources at X-band (8-9 GHz) in the southern sky.



TIGO Concepción, Chile



GARS O'Higgins, Antarctica

Tidbinbilla DSS43
Australia

Mopra, Australia

ATCA Narrabri, Australia

Hobart Tasmania, Australia

Weiterführende Informationen

Acknowledgement: The presented maps are a cortesy of the Tanami-Project (http://pulsar.sternwarte.uni-erlangen.de/tanami).
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