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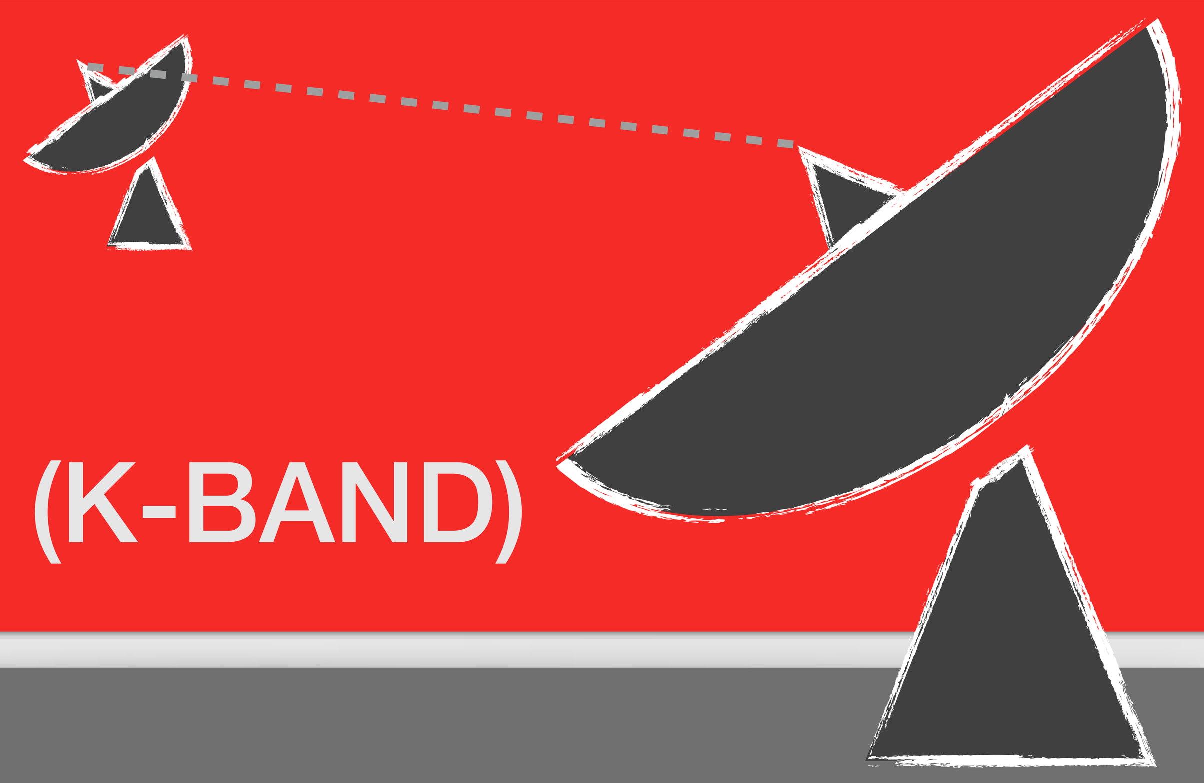

A CELESTIAL REFERENCE FRAME AT 22 GHZ (K-BAND)

ABSTRACT

Relative to observations at the standard S/X observing bands, at higher radio frequencies sources that make up the international celestial reference frame are expected to exhibit more compact source morphology and the effect of core-shift is expected to be smaller. This reduction in astrophysical systematics should allow for a more well-defined and stable reference frame at higher frequencies, and also be advantageous in tying the VLBI reference frame to future optical reference frames such as Gaia. Astrometric and imaging observations by Lanyi et al. (2010) and Charlot et al. (2010), provided a foundation for the development of a reference frame at 22 GHz (K-band). However, the current K-band frame consists of only 279 sources with weak coverage in the southern hemisphere and several localised regions with no sources, especially near the ecliptic and galactic planes. We present an overview of our plans to improve the accuracy and coverage of the K-band celestial reference frame and present ongoing results from our observational efforts. Specifically, dedicated high-resolution imaging and astrometric observations are currently underway to complete sky coverage in the south using South Africa to Australia baselines and to improve the K-band celestial reference frame in the North using the VLBA to densify the spatial coverage of sources. Our goal is to achieve a frame of at least 500 sources.

BACKGROUND

At the standard S/X frequencies, many ICRF radio sources exhibit spatially extended structure that may vary in both time and frequency, degrading the accuracy of estimated source positions.

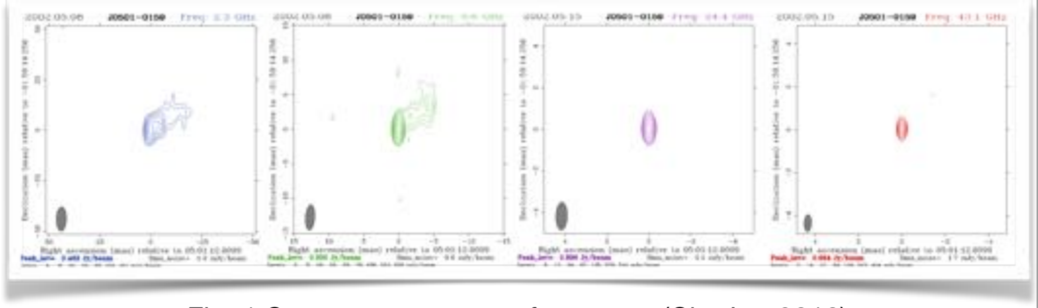

Fig. 1 Source structure vs. frequency (Charlot, 2010)

On VLBI scales sources tend to become more compact and show reduced core-shift at shorter wavelengths (higher frequencies).

Both these improvements allow for a more well-defined and stable reference frame at higher frequencies, such as 22 GHz (K-band).

This will be particularly advantageous in tying the VLBI reference frame to future optical reference frames such as Gaia.

Astrometric and imaging observations by Lanyi et al. (2010) & Charlot et al. (2010) provide a foundation for the development of a reference frame at K-band.

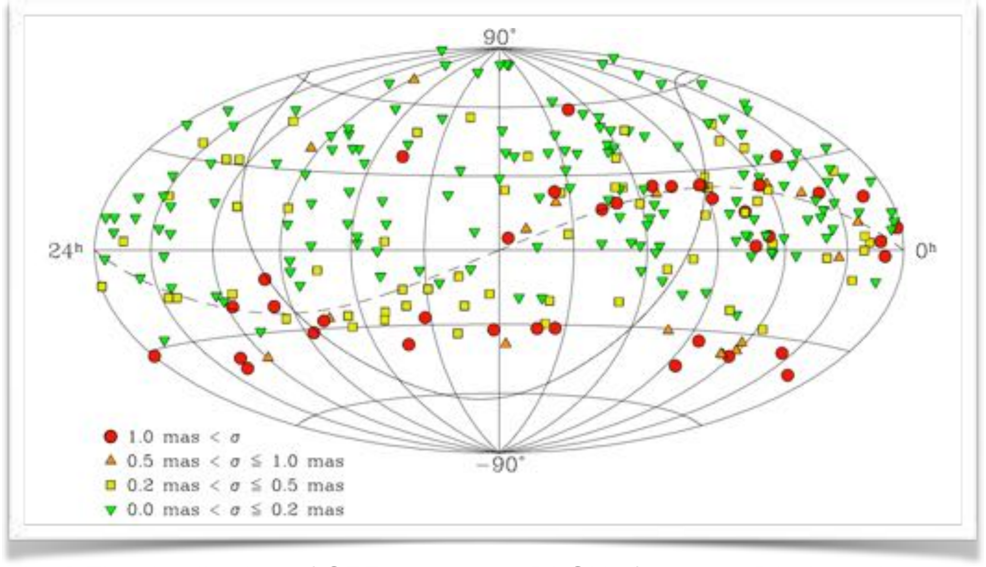

Fig. 2 The distribution of CRF sources at 24 GHz from ten, 24 observing sessions with the VLBA (Lanyi et al., 2010).

The current K-band catalogue (see Fig 2.) consists of only 279 sources with weak coverage in the Southern Hemisphere, several localised regions with no sources, and uncertainties in source positions at the ~100 microarcsecond level.

Dedicated observations to improve the precision and spatial coverage of the K-band CRF are currently underway !

K-BAND CRF IN THE SOUTH

Astrometric Observations:

Astrometric Test Observations (4 hours), 23 Aug 2013

> 20 sources south of -20° declination and > 500mJy.
> Hobart 26m, Tamna 21m & HartRAO 26m telescopes.
> Data Corellation: DiFX software correlator in Bonn.
> Demonstrate fringes to all stations.

Astrometric Trial Observations (24 hours), 21 Dec 2013

> 106 sources south of -20° declination and > 500mJy.
> Included also the Tidbinbilla 70m telescope.
> Demonstrated that data taken with the the Tamna, KVN digital backend and the Tidbinbilla DVP backend system can be successfully correlated with DiFX.

Astrometric Trial Observations (24 hours), 04 May 2014

> 106 sources south of -20° declination and > 500mJy.
> Hobart 26m, HartRAO 26m & Tidbinbilla 70m telescopes.
> Successfully tested the newly installed cryogenically cooled K-band receiver on the HartRAO 26m antenna, that replaced the experimental ambient receiver.

> Astrometry data analysis in progress.
> Improvements in instrumental calibration at HartRAO provides hope that significant progress progress in the Southern Hemisphere is achievable in the next one or two years!

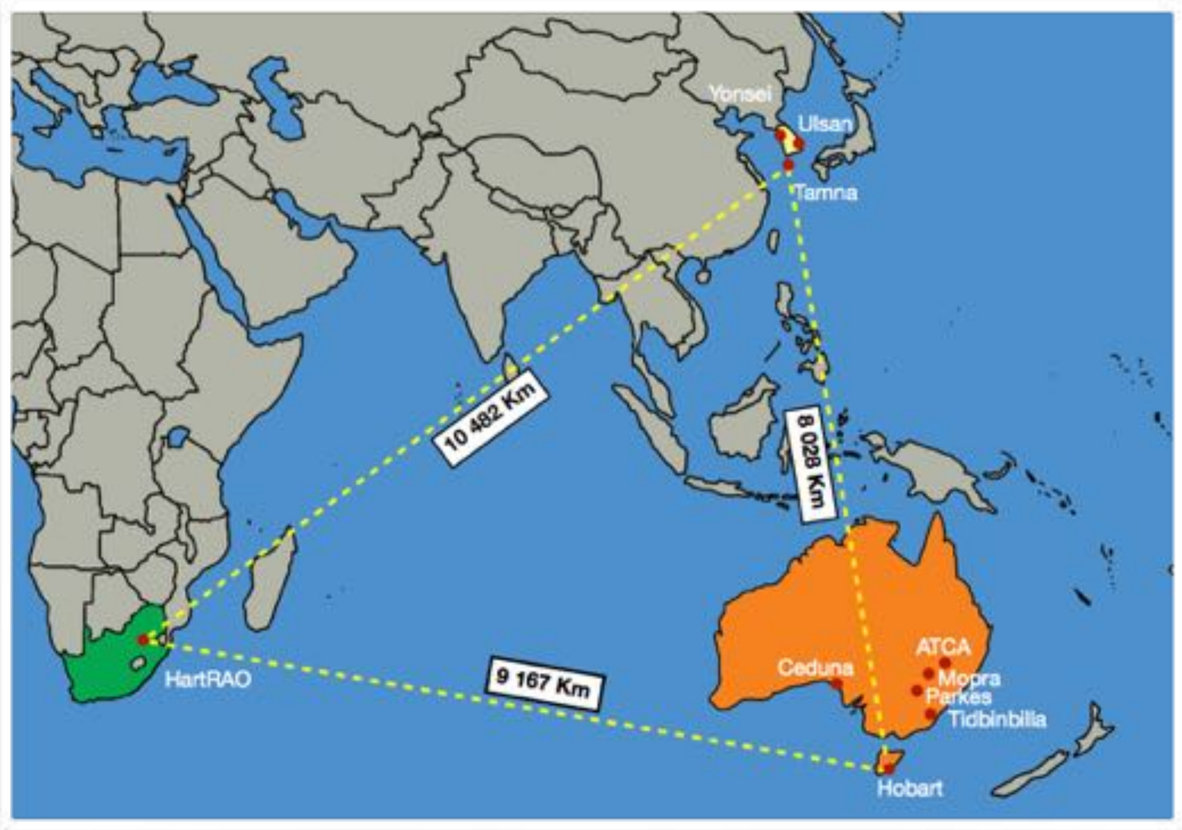

Fig. 3 A map showing the telescopes that was used for the Southern Hemisphere, K-band astrometric and imaging observations.

Imaging Observations:

Imaging Observations (21 hours), 22 Sept 2014

> 106 sources south of -20° declination and > 500mJy.
> Hobart 26m, HartRAO 26m, ATCA, Parkes 64m, Ceduna 30m & Mopra 22m telescopes.
> Prelimnary imaging results are shown in Fig. 4.

> Proposal for additional imaging observations submitted !

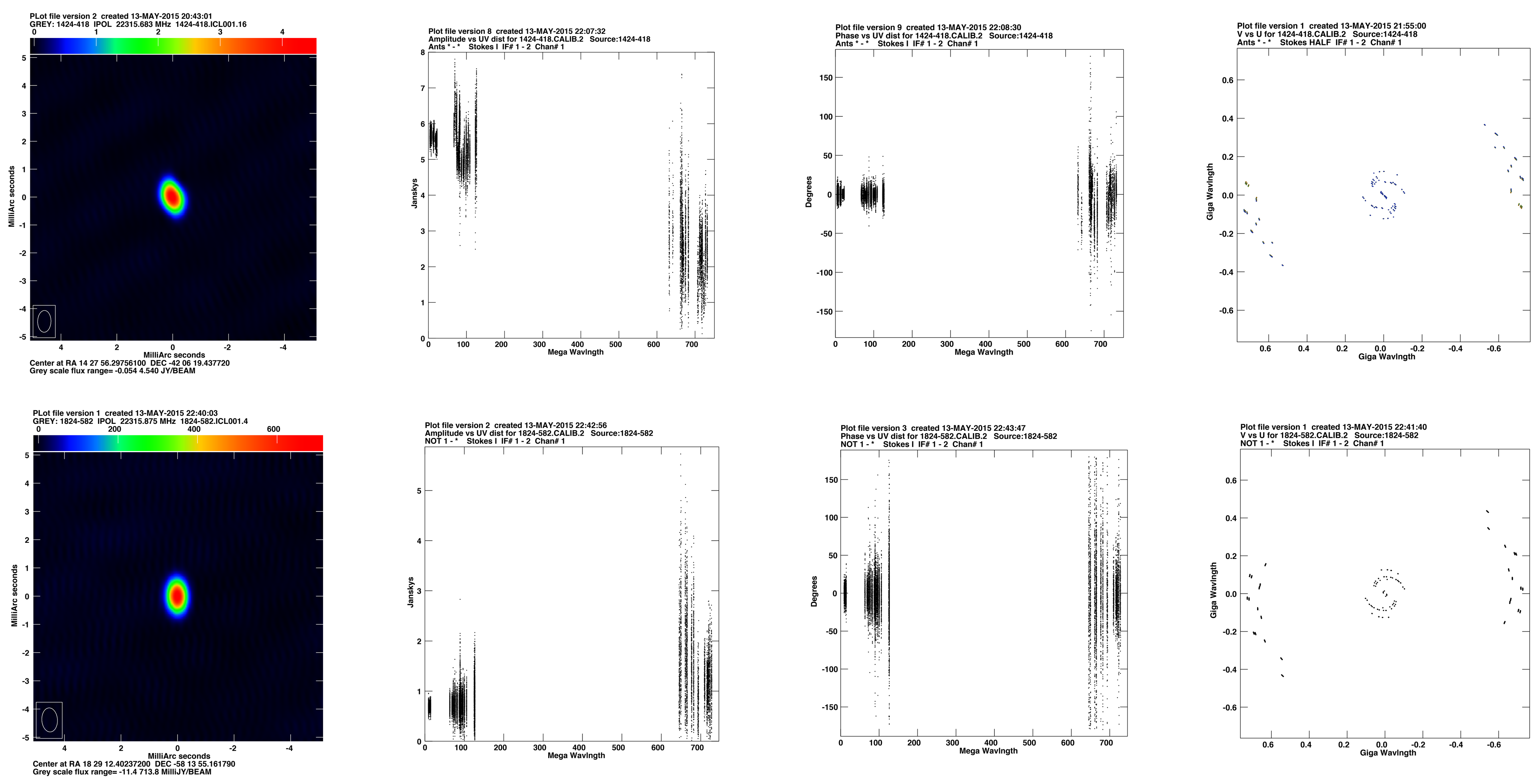

Fig. 4 Top panel: A map of the source J1427-4206 with peak flux density is 5.59 Jy, the rms noise is 17.8 mJy/beam. North is up and East is to the left. To the right the visibility amplitude vs uv-distance plot, the visibility phase vs. uv-distance plot and the uv-coverage. Bottom panel: A map of the source J1829-5813 with peak flux density is 0.69Jy, the rms noise is 3.08 mJy/beam. North is up and East is to the left. To the right the visibility amplitude vs uv-distance plot, the visibility phase vs. uv-distance plot and the uv-coverage.

GOALS

> The realisation of a full-sky, K-band celestial reference frame by 2018, in time for the Gaia optical reference frame.

> To obtain comparable density and accuracy in the south to that obtained from the astrometry that was done with the VLBA in the north.

> Further densification of the K-band celestial reference frame in the north using the VLBA.

> Our ultimate goal is to reach accuracies better than 70 µas to match the Gaia predicted accuracy for V=18 visual magnitude quasars.

K-BAND CRF IN THE NORTH

Astrometric and Imaging Observations (4 x 24 hours), using the Very Long Baseline Array (VLBA), in progress.

> 246 sources north of about -30° declination.
> The source list is based upon the X/Ka catalogue (Jacobs, 2014) and the flux cut-off is set to be 100 mJy.

> Additional VLBA observations to improve K-band precision and spatial coverage in the north.

Towards a full sky CRF at K-band

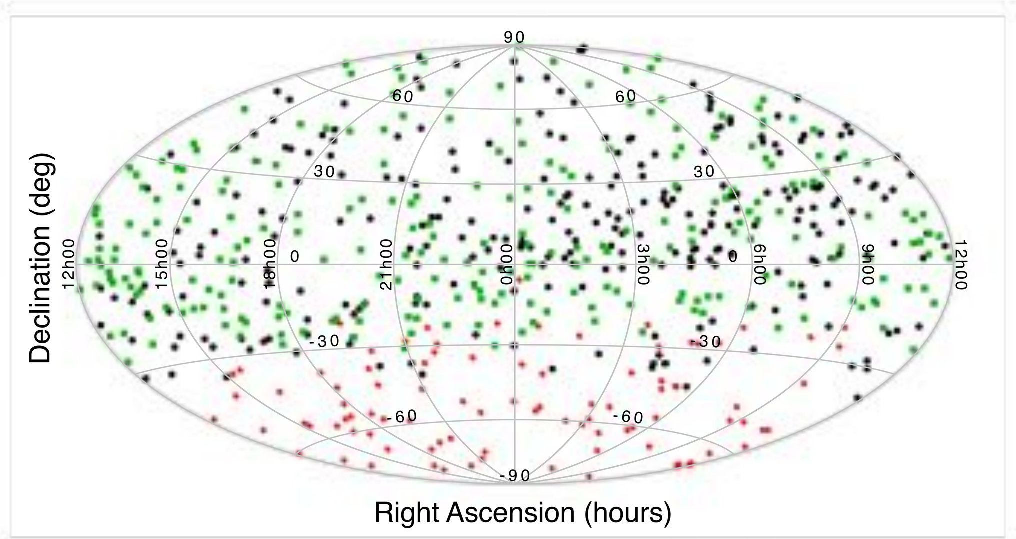

Fig. 5 The 279 sources from Lanyi et al. (2010) & Charlot et al. (2010) are shown in black. The 106 sources from the southern astrometric observations are shown in red. The 246 sources to be observed using the VLBA are shown in green.

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