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Experimental plan for improving the K-band Celestial Frame

ABSTRACT

A new K-band collaboration has been formed to reduce astrometric systematics and to complete sky coverage at K-band. Phase I will demonstrate fringes. The first observations were carried out on 23 August 2013 between telescopes in Australia, Korea and South Africa. From our initial observations we successfully detected fringes which demonstrates the feasibility of our experimental approach. Phase II of our plan will include 24 hour observations and a bigger network of telescopes to observe a larger number of sources and for imaging of source structure. The Korea South Africa baselines will extend K-band celestial reference frame (CRF) coverage down to about -45° declination. Observations between Australia and South Africa will extend coverage to the south polar cap and thus gain full sky coverage for the K-band CRF. We discuss the potential baselines, their mutual spatial and frequency coverages and the implications for K-band CRF work.

BACKGROUND

We present a new collaboration to densify the CRF at 22 GHz (K-band), with specific emphasis on the Southern hemisphere where K-band CRF coverage is weak.

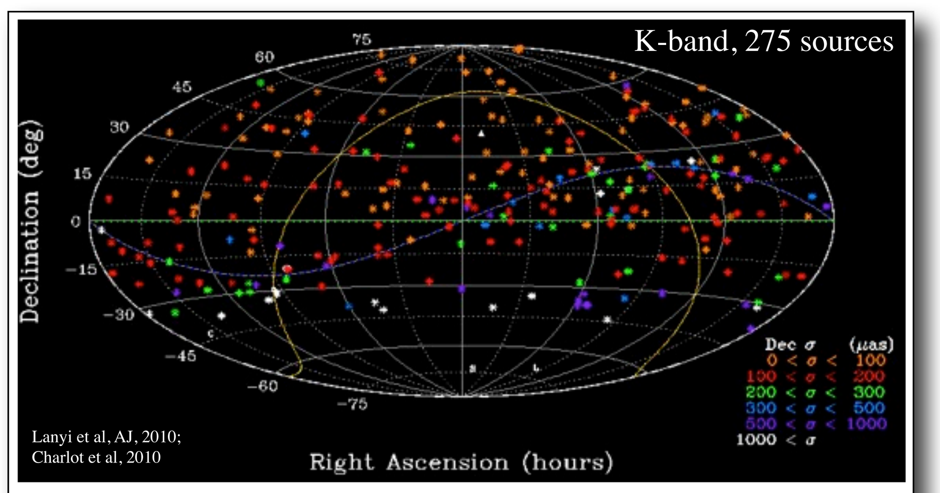

Fig. 1 The distribution of CRF sources at 24 GHz, showing a rapid drop in source density at declinations south of −30°

- Relative to the standard S/X observing bands, at K-band sources are expected to exhibit more compact source morphology (see e.g. Figure 2) and reduced core shift.
- This reduction of astrophysical systematics should be advantageous in tying the VLBI radio frame to the Gaia optical frame.

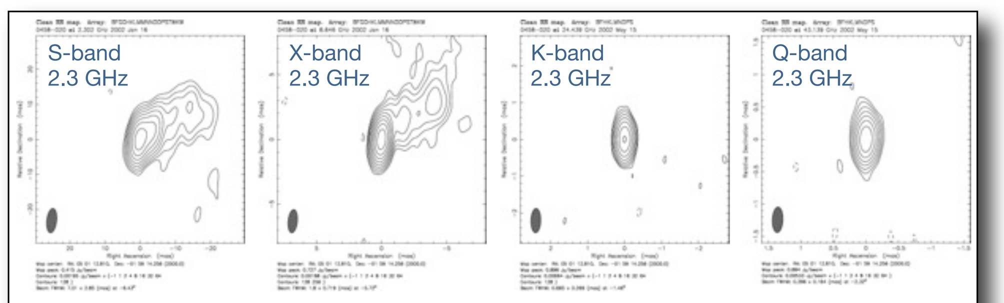

Fig. 2 Source structure (compactness of source) vs. frequency
Image credit: P. Charlot et al, AJ, 139, 5, 2010

Observational plan for extending the K-band celestial reference frame.

- We have developed a collaboration amongst the telescopes of the Korea VLBI Network (KVN), HartRAO, South Africa and Tidbinbilla and Hobart in Australia (see Figure 5).

Phase I observations:
- Demonstrate fringes.
- Succeeded 23 August 2013.

Phase II observations:
- 24 hour K-band observations to observe a larger number of sources.
- **Goal: more than 500 sources within the next year, with precision of < 70 μas.**
- A bigger network of telescopes for imaging of source structure.

TELESCOPES

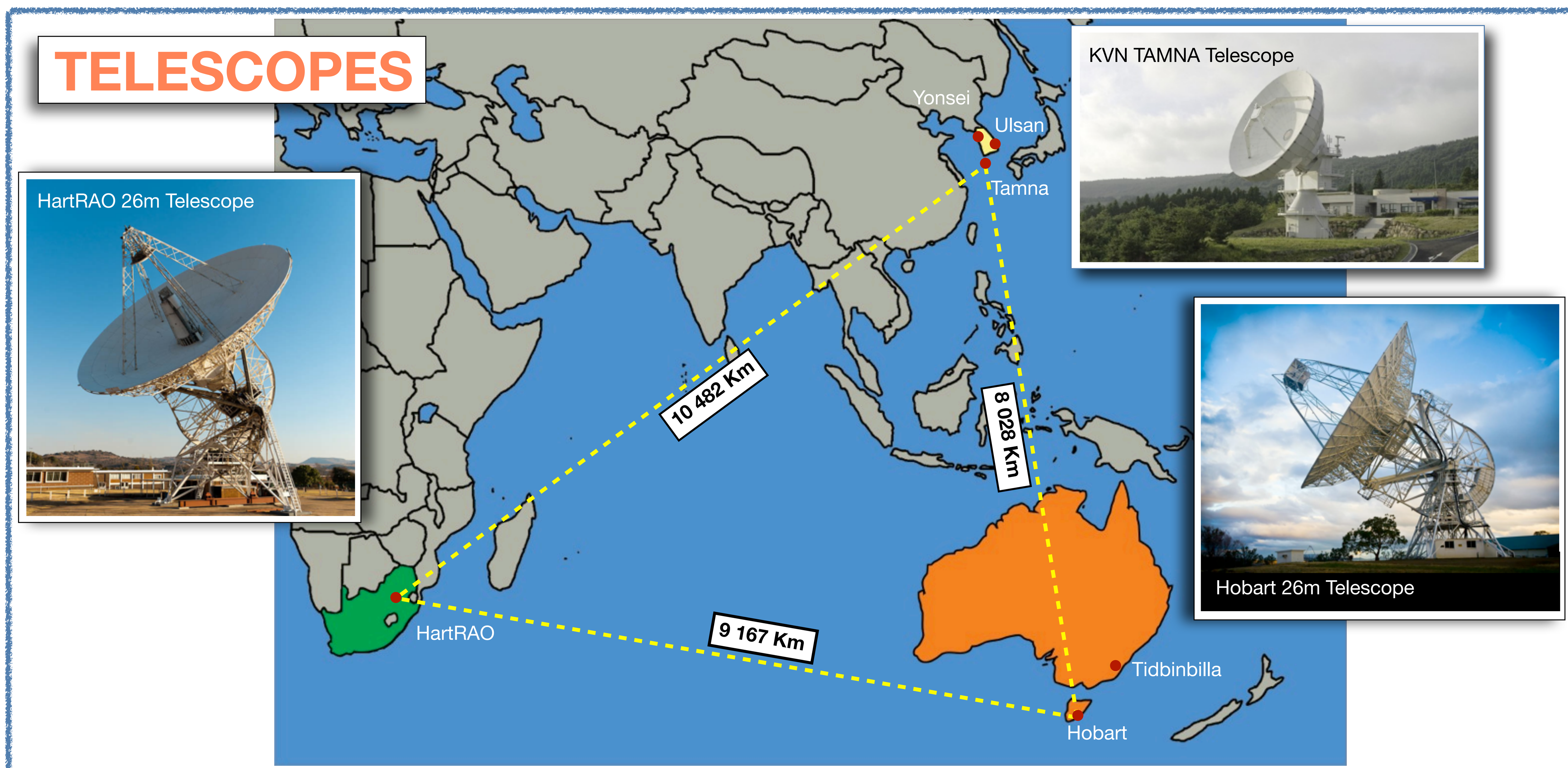

Fig. 5 A map showing the proposed telescopes for the K-band project. HartRAO in South Africa, Hobart and Tidbinbilla in Australia and the KVN telescopes (Tamna, Yonsei and Ulsan) in Korea. Phase I observations included HartRAO, Hobart and Tamna.

Telescope	Diameter	Latitude	Longitude	Slew rate	K-band receiver	K-band SEFD	Frequency range
HartRAO	26 m	25.89° S	27.69° E	0.50 deg/sec	uncooled *	5000 Jy	22 - 24 GHz
Hobart	26 m	42.81° S	147.44° E	0.67 deg/sec	cryogenically cooled	3400 Jy	18 - 25 GHz
KVN	21 m	26.29° N	126.46° E	3.00 deg/sec	cryogenically cooled	1200 Jy	21.25 - 23.25 GHz
Tidbinbilla	70 m	35.40° S	148.98° E	0.25 deg/sec	cryogenically cooled	60 Jy	18 - 26.5 GHz

Table 1. Telescope technical details
* Replacement of the HartRAO test receiver at K-band with a cryogenic receiver is in progress.

PHASE I OBSERVATIONS

Observational Details

- **Date & Time:** 23 August 2013, 06:30 - 10:30 UT
- **Stations:**
  HartRAO => recorded with Mk5 & DBBC
  Hobart => recorded with Mk5
  Tamna => recorded with KVN digital backend
- **Recorded bandwidth:** 256 MHz
  8 channels x 16 MHz x 2 sidebands, RCP only
- **Spanned bandwidth:** 350 MHz, centered on 22304 MHz
- **Rates:** Bits/sample = 2, Data rate = 1024 Mb/s
- **Data correlation:** DiFX software correlator in Bonn. The data was electronically transferred from HartRAO and Hobart and via courier from Tamna.

Source Selection

- 23 compact sources from VLBI global solution rfc_2013c catalogue (http://astrogeo.org).
- X-band flux > 600mJy
- Goal SNR ≥ 20 in 2 min integration

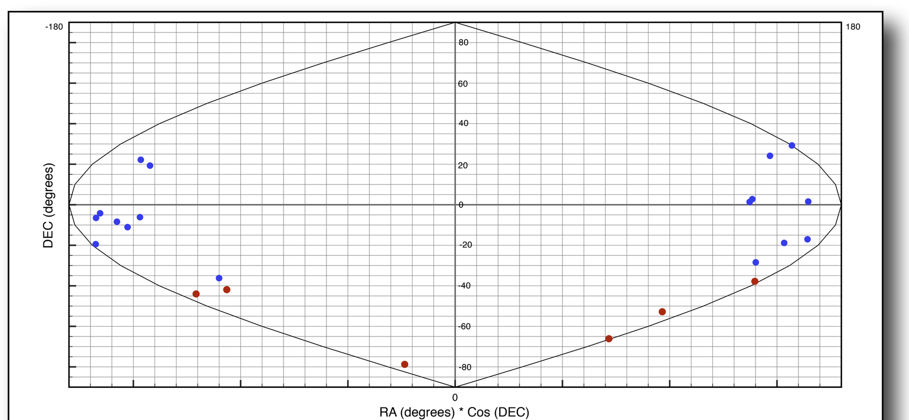

Fig. 6 Distribution of the 23 sources selected for the fringe demonstration on 23 August 2013. Sources in blue have been observed with HartRAO, Tamna and Hobart. Sources in red have been observed with HartRAO and Hobart only.

MUTUAL VISIBILITY

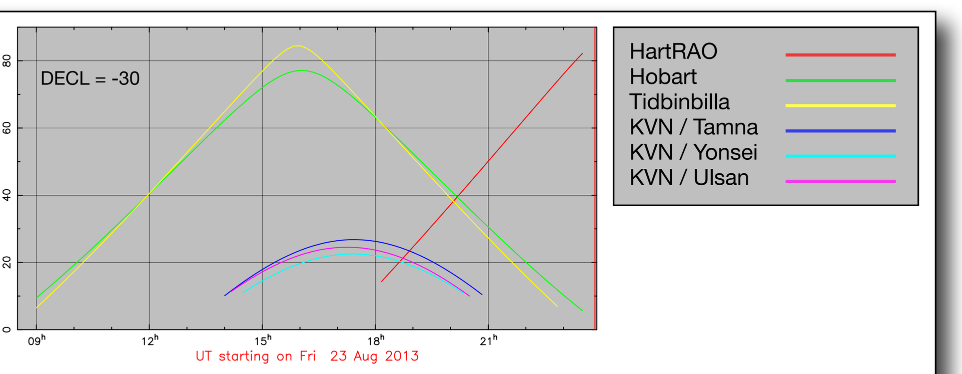

Fig. 3 Sky coverage plots for a source at -30° declination. Observations between the KVN telescopes and HartRAO is limited to about ±45° declination, and less than 4 hours of mutual visibility. Hobart and Tidbinbilla will not be able to observe higher than about +20° declination.

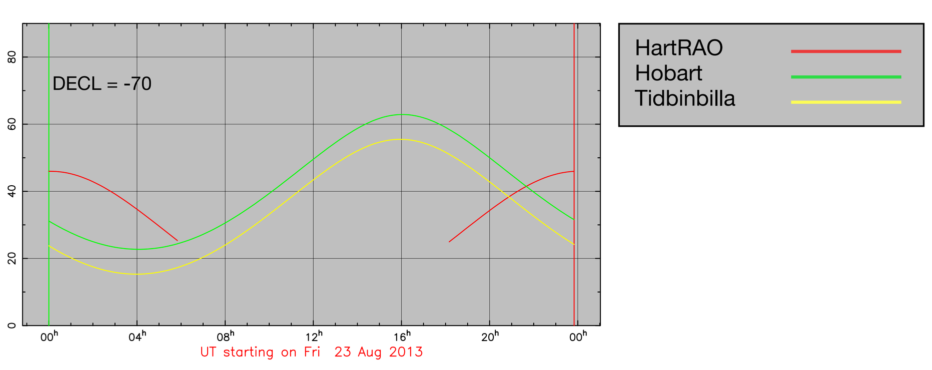

Fig. 4 Sky coverage plots for a source at -70° declination. The gap in the HartRAO sky coverage is due to the polar mount of the telescope.

Results from Phase I observations

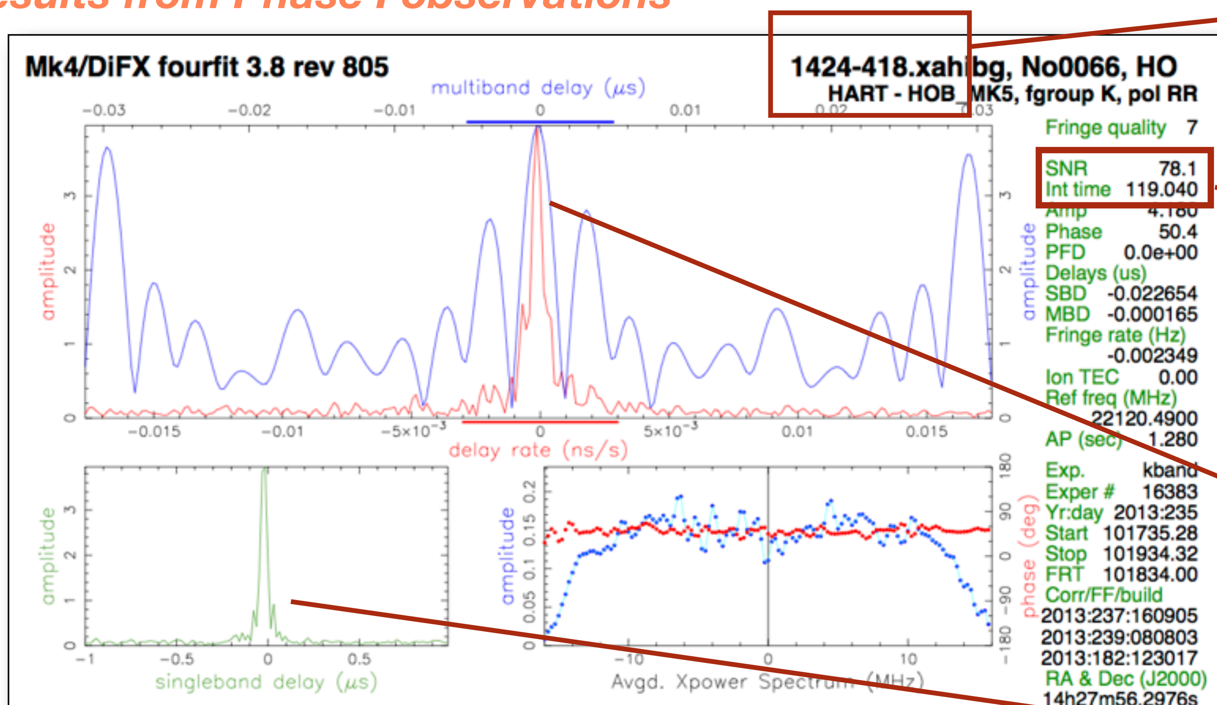

Fig. 7 Mk4/DiFX correlator fringe fit output from the Phase I, K-band observations between HartRAO and Hobart for source J1427-4206.

Baseline: HartRAO – Hobart26
Source: PKS J1427-4206
Flux density: 1.6 to 2.8 Jy at K-band

SNR ~ 78 in 120 seconds

The data has been fringe fitted and manual phase calibration applied.

Multi-band delay (MBD) in μs: The location of the peak of the MBD spectrum gives the residual MBD solution

Single-band delay (SBD) in μs

NRF HartRAO · Max Planck Institute for Radio Astronomy · igg · NASA · UTAS · KASI · CSIRO