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.

PHASE I OBSERVATIONS
Observational Details
- Stations: HartRAO => recorded with Mk5 & DBBC
- Tamna => recorded with KVN digital backend
- Hobart => recorded with Mk5 & DBBC
- Recorded bandwidth: 256 MHz
- 8 channels x 16 MHz x 2 sidesbands, 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 to Tamna.

Mutual Visibility
- Relative to the standard SX 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.

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

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

TELESCOPES
- HartRAO 26m Telescope
- Hobart 26m Telescope
- KVN TAMNA Telescope
- Tidbinbilla 26m Telescope
- HartRAO 70m Telescope
- Hobart 70m Telescope
- KVN 70m Telescope

Table 1. Telescope technical details

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

* Replacement of the HartRAO test receiver at K-band with a cryogenic receiver is in progress.

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.

Source: PKS J1427-4206

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

Charlot et al, 2010

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

Fig. 2 Source structure (compactness of source) vs. frequency

Fig. 3 Sky coverage plot 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. HartRAO and Tidbinbilla will not be able to observe higher than about +20° declination.

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

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 (Tama, Yoneai and Ukarait). Phase I observations included HartRAO, Hobart and Tamna.

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 not been observed with HartRAO and Hobart only.

Fig. 7 A4-DIFX correlation fringe fit output from the Phase I, K-band observations between HartRAO and Hobart for source J1427-4206.