Shanghai Trip Report – Russell Gough

April 15 to May 3, 1996

As part of the Australia-China science agreement, the ATNF constructed a 12 mm band horn and cryogenically cooled HEMT receiver system for the 25 metre radiotelescope at Seshan, which is near Shanghai. Grahame Gay and I stayed at the site of the radiotelescope while we assembled, installed and tested the new receiver. The accommodation at the radiotelescope was basic, but the observatory staff had gone out of their way to make our stay comfortable.

On the morning of Wednesday, April 17, we attended a meeting with the head of the division, Jiang Dong-Rong, the astronomer responsible for the station, Liang Shi-Guang, the site engineer, Ren Xu, Jin Wei and others, to decide how we would assemble, install and test the new receiver. In the afternoon Jiang Dong-Rong and Jin Wei took us up a nearby hill to see the 1.56 metre optical telescope and the old observatory.

We had reassembled the receiver by Thursday and evacuated it overnight. On Friday the vacuum decay rate was 0.7 microns/min so we proceeded to cool the receiver. On Saturday we measured the noise temperature of the receiver using room temperature, and liquid nitrogen cooled, absorber. The receiver noise temperatures were 60 and 67 Kelvin. Details of the receiver noise temperature measurements are given in the attached technical report.

We reassembled and tested the receiver without any difficulty. This work was completed more quickly than expected because the receiver went together without any difficulty and because we could work on after the staff from Shanghai had gone home. If there had been any difficulties encountered while the receiver system has being assembled, cooled or tested, it may have taken quite some time overcome the problems, as the facilities available at the telescope were only modest. (The Chinese were having problems even phoning Shanghai from the observatory at Seshan.)

One difficulty encountered (which the observatory staff were well aware of before we arrived) was that there was a 650 mm diameter restriction through which the 500 mm square receiver frame would not fit. During the design phase we had been aware that the horn alignment ring was 650 mm diameter, but were not aware that this size constraint also applied to the receiver frame.

On Sunday, Dr. He and the observatory staff fixed this problem, with an angle grinder, while we were taken sightseeing in Shanghai. On Monday, April 22, the receiver and horn was carried into the basement of the antenna and was installed in the antenna without too much effort. After the paint had been removed from the horn alignment ring, it fitted perfectly. The receiver system temperatures were 95 and 102 Kelvin. Details of the receiver performance are given in the attached technical report.

The 0.5 - 1.0 GHz IF output of the receiver was mixed down with a 700 MHz LO so it could be fed into their continuum backend. On Tuesday and Wednesday nights Ren Xu checked receiver stability by plotting the total power output of the receiver. This is not a satisfactory way of checking receiver stability as the total power output changes with atmospheric conditions, and when birds fly in and out of the beam-waveguide system. On Tuesday, Liang Shi-Guang pointed the telescope at a few strong radio sources and plotted some drift scans. The consensus was that the telescope efficiency seemed to be about 30%. The Chinese were concerned that the low efficiency might be caused by poor pointing. On Wednesday more people came to look at the pointing, but I am not sure of their conclusions.

Thursday was a free day, so Grahame and I went for a short walk up one of the hills behind the telescope.

On Friday, April 26, a number of administrators from Bejing visited the telescope. Madame Ye had a look at the receiver and spoke the visitors from Bejing. We also met Yang Fumin, vice director of Shanghai Observatory, who was very apologetic about the difficulties encountered regarding payment for the receiver. In the afternoon we were taken to the Shanghai Convention Centre where we stayed for the rest of our visit.

While we were at the telescope at Seshan, they were fitting out the "Mobile VLBI" station which SHAO has built. The Mobile VLBI station has an antenna control room and backend, including S2 recorders and a maser, built into a medium sized van. The antenna, which we did not see, comes in another van/truck. They have done a very nice job for the military.

At the observatory, relatively little attention seems to be paid to maintenance beyond trimming the hedges and attending the fruit trees. It seems that it is much more difficult for the observatory to get funds for maintenance than for capital items. While were staying at the telescope, we saw their Russian built, single polarization, dual frequency S/X receiver which was still in pieces. They were waiting for some Russian technicians to come and assemble it.

On Thursday, May 2, Grahame Gay and I attended a technical discussion held in the Shanghai headquarters. The meeting was attended by Madame Ye and about ten people from Shanghai Observatory including Jiang Dong-Rong , Lian Shi-Guang, Ren Xu, Jin Wei, Dr. He and Lin Chuan-Fu, the maser engineer.

Madame Ye was particularly keen to take up John Brooks suggestion of collaboration between Shanghai Observatory and ATNF to upgrade the electronics of the SHAO maser. They are worried about the sidebands of the 21.6 GHz phase-locked oscillator which are only 20 to 30 dB below the carrier. When I suggested that we may be short of manpower since the MNRF proposal has been approved, Madame Ye countered that we only need to redesign (or advise on the redesign) of the electronics, and SHAO would manufacture the electronics. The Chinese seem to think that once you have the circuit diagram, you have all the information you need to build the circuit. They don't realise that the board layout - grounding, isolation etc. - are important aspects of circuit design.

While we were in Shanghai we were well looked after. We taken on sightseeing trips to two museums, to the famous gardens in Suzhou and to the Shanghai acrobats.

Russell Gough
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THE AUSTRALIA TELESCOPE NATIONAL FACILITY

PERFORMANCE OF THE 12 mm RECEIVER ON THE SHANGHAI 25 metre RADIOTELESCOPE

Russell Gough

The performance of the receiver and horn was measured at the observatory at Seshan before it was installed in the telescope. The measurement was made using hot and cold loads at the horn flange. The loads were pieces of microwave absorber, one at room temperature, and one which had been placed in liquid nitrogen. The ratio of the output powers of the receiver, Y, is

$$Y = \frac{T_{receiver} + T_{hot}}{T_{receiver} + T_{cold}} \tag{1}$$

where $T_{receiver}$ is the noise temperature of the receiver, T_{hot} is the temperature of the room temperature absorber and T_{cold} is the temperature of the absorber which had been placed in liquid nitrogen. We can calculate the receiver noise temperature using

$$T_{receiver} = \frac{T_{hot} - Y \cdot T_{cold}}{Y - 1} \tag{2}$$

Table 1 shows the measured Y factors and corresponding receiver noise temperatures, calculated using eq (2), with T_{hot} = 290.7 Kelvin and T_{cold} = 80 Kelvin.

Polarization	Y(dB)	Y	$T_{receiver}$ (K)
RCP (A)	4.00	2.51	59.4
LCP (B)	3.86	2.43	67.2

Table 1

After the receiver and horn were installed in the telescope, the system temperature was measured in a similar manner. The system temperature, T_{sys}, is

$$T_{sys} = T_{background} \cdot L_{atmosphere} + T_{atmosphere} + T_{antenna} + T_{receiver} \tag{3}$$

where $L_{atmosphere}$ is the loss in the atmosphere, and $T_{background}$, $T_{atmosphere}$, $T_{antenna}$ and $T_{receiver}$ are the noise temperatures of the cosmic background, the atmosphere, the antenna and the receiver respectively.

We measured the ratio, Y', of the output power of the receiver when it was installed in the telescope and the output power when the horn was covered with microwave absorber at room temperature.

$$Y' = \frac{T_{receiver} + T_{hot}}{T_{sys}} = \frac{T_{receiver} + T_{hot}}{T_{background} \cdot L_{atmosphere} + T_{atmosphere} + T_{antenna} + T_{receiver}} \quad (4)$$

where T_{hot} is the temperature of the room temperature absorber. The system temperature can then be calculated using

$$T_{sys} = \frac{T_{receiver} + T_{hot}}{Y'} \quad (5)$$

Table 2 shows the measured Y factors and corresponding system temperatures, calculated using eq (5), with T_{hot} = 290 Kelvin and $T_{receiver}$ as given in Table 1.

Polarization	$T_{receiver}$ (K)	Y'(dB)	Y'	T_{sys} (K)
RCP (A)	59.4	5.68	3.70	94.6
LCP (B)	67.2	5.42	3.48	102.5

Table 2

We can calculate $T_{antenna}$ using

$$T_{antenna} = T_{sys} - T_{background} \cdot L_{atmosphere} - T_{atmosphere} - T_{receiver} \quad (6)$$

where $T_{background}$ is 2.7 K. When the system temperature measurements were made, the atmospheric temperature was 17.3°C and the relative humidity was 45%. At 22 GHz the loss in the atmosphere, at zenith, is expected to be 0.4 dB, and the noise contribution from the atmosphere is expected to be 26 Kelvin.

The contributions to the system temperature are summarised in Table 3. Notice that the noise contribution from the antenna, calculated using eq(6), is very similar for the two polarizations.

Polarization	$T_{background} \cdot L_{atmosphere}$ (K)	$T_{atmosphere}$ (K)	$T_{antenna}$ (K)	$T_{receiver}$ (K)	T_{sys} (K)
RCP (A)	2.5	26.0	6.7	59.4	94.6
LCP (B)	2.5	26.0	6.8	67.2	102.5

Table 3