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The IVS in the Southern Hemisphere: New Zealand Perspectives

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Abstract

Efforts to build a radio astronomy capability in New Zealand took a big step forward with the first successful VLBI experiment between New Zealand and Australia. The 1.6 GHz observation of PKS 1921-293 took place in late July, between a 6 m telescope in New Zealand and the Australia Telescope Compact Array (ATCA), with the data being correlated on the Swinburne University of Technology's supercomputer. This result follows 6 months of intense development and testing of the systems with the support of a number of institutions. Plans for the future development of New Zealand VLBI, as well as the reasons for New Zealand involvement in the IVS are discussed.

1. Introduction

In 2005 Auckland University of Technology (AUT) became a new affiliated member organization of the IVS.

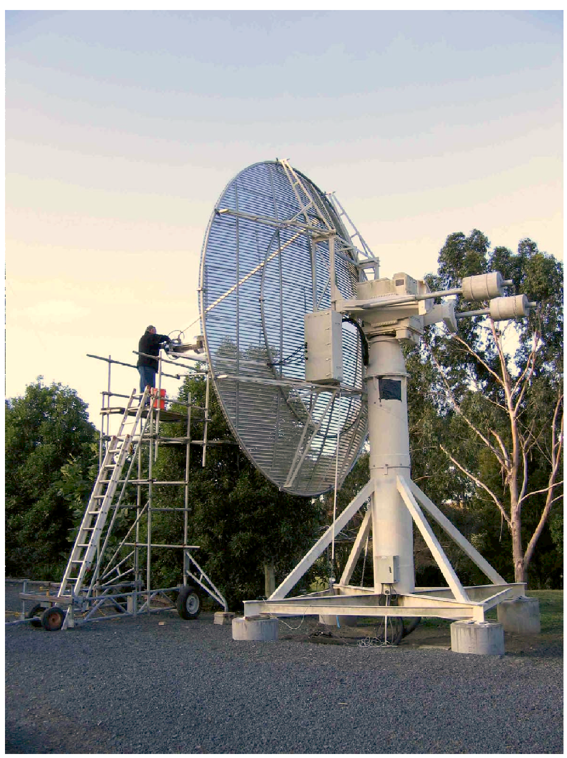

Figure 1. 6m radio telescope near Auckland (New Zealand).

The IVS has set itself the goal of achieving 1mm positional and 1mm/year velocity precision for the ITRF [1]. It is generally agreed that attaining as homogeneous a distribution of IVS sites on the Earth's surface as possible must form a vital part of the strategy to realise this goal. The current map of sites indicates a very heavy weighting in favour of the Northern Hemisphere [2]. A New Zealand site would be ideally placed to redress this imbalance (figure 2). It would provide an opportunity for extended and more continuous observation of sources and ionospheric effects. "Gaps" in coverage that currently limit achievable precision of the ITRF and EOP measurements would be reduced.

Recently New Zealand changed from Geodetic Datum 1949 (NZGD1949) to NZGD2000 [3]. The NZGD1949, which served the cadastral system of New Zealand for the last 50 years, had internal distortions of up to 7 m due to the limitations of the survey technology used to define it and the effects of earth deformation. The new datum NZGD2000 closely matches the ITRF, and the ellipsoid chosen is the Geodetic Reference System 1980 (GRS80).

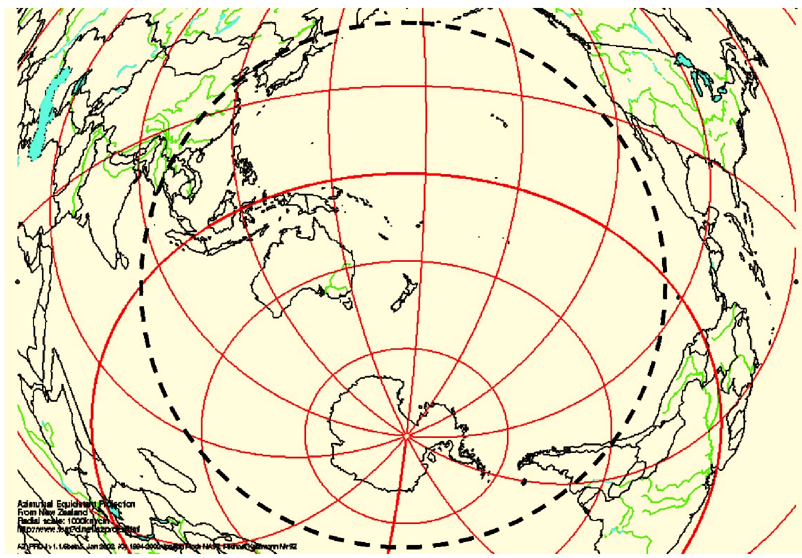

Figure 2. New Zealand's strategic location in the Southern Hemisphere. New Zealand is in the centre of the map. Radius of the dashed circle is 10,000 km along a great circle, which corresponds to a 9,000 km baseline. (Projection: Azimuthal equidistant.)

The new datum definition is frozen at the specified epoch (2000.0) and does not include time dependencies, such as station velocities, rates of change for transformation parameters, etc. In reality, such changes will occur in the future: e.g. large coordinate jumps may be required in geologically dynamic New Zealand as a result of earthquakes or localised mark movement. Therefore, monitoring of changes between the datum as a whole and the global reference frame (ITRF) is essential. While a GPS station network allows building a relative local velocity model, only VLBI is able to directly link this (local) model to the ITRF. Development of a New Zealand VLBI service for geodesy is one of the central tasks in sustaining the New Zealand Geodetic Datum 2000 in the future and maintaining its link to the ITRF.

There is also a need to consider the continuing effects of ground deformation and the requirements of New Zealand's national height datum for the foreseeable future. VLBI is required for vertical datum development in New Zealand.

2. Current Work

Current work in Radio Astronomy is centred on the newly formed Centre for Radiophysics and Space Research (CRSR) located at AUT (Auckland University of Technology). AUT has undertaken the task of developing VLBI facilities in New Zealand. This work is being conducted in collaboration with Swinburne University of Technology (Melbourne) and with the support of the Australia National Telescope Facility and the University of Tasmania at Hobart in Australia.

A grant of NZ$300,000 was obtained from the New Zealand Ministry of Economic Development (MED) to support this work. The MED sees VLBI activity as a potential user of the Advanced Network, which in turn forms a vital component of the government's Digital Strategy.

A self contained radio astronomy receiving and recording system for VLBI was constructed (see details in [4]). The major items of equipment include:

- Receiver operating at 1.658 GHz centre frequency, 16 MHz bandwidth.
- An 8 bit sampler / digitiser based on a Maxim 1448 ADC.
- Disk based recording system constructed from a Dell Poweredge 1600SC fitted with a Metsahovi VSIB interface card.
- Stanford Research Systems FS725 Rubidium Frequency Standard.
- Trimble Thunderbolt precision GPS oscillator.

Feed and downconversion system are locked to the Rubidium frequency standard. A 2.5 hour loop time constant was used to discipline the FS725 to the 1 PPS signal produced by the GPS unit. This combination provided sufficient control of the long term drift of the Rubidium without being too detrimental to its short term stability. The Rubidium was calibrated with the use of Hydrogen masers (in Hobart and Parkes). It proved to be stable to $\approx 10^{-12}$.

Signals from the prime focus of the telescope were collected by a circular waveguide with simple scalar choke ring and a single linear polarisation pickup.

The whole package was designed as a portable system for use on different radio telescopes, since the one thing that New Zealand lacks at the moment is ready access to a large collecting area, fully steerable antenna.

We are exploring possibilities arising from collaboration with Australia. A number of Trans-Tasman tests have been conducted in 2005 between the AUT system installed on a 6 metre dish located at Karaka, South Auckland, and the Australia Telescope Compact Array in Narrabri, Australia. This work has been successful, with fringes located from the recorded data and high resolution image of the quasar PKS1921-293 obtained for the first time (figure 3).

These measurements form the beginning of monitoring geographic location of the New Zealand RT with respect to the LBA (Australia) antennas. The geographic location of the 6m RT is:

$\phi = -37^o05'53.4183$"
$\lambda = 174^o49'43.6518$"E
Ellipsoid height= 58.492 m
Geoid height= 32.935 m

The geocentric coordinates of the 6m RT are:

$X = -5072744.194$ m
$Y = 459085.7453$ m
$Z = -3826123.922$ m

The distance between the ATCA at Narrabri and New Zealand 6m dish was found from the first VLBI test to be 2398483.72 ± 0.01 m.

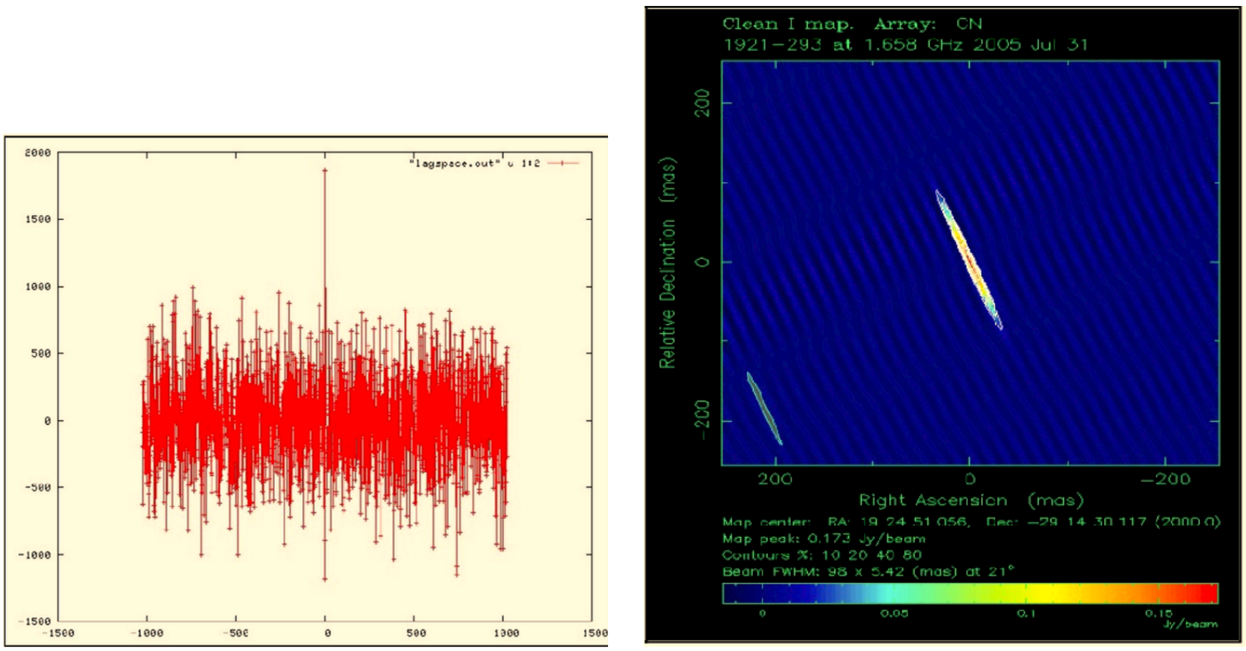

Figure 3. The first fringe and image of PSK1921-293 obtained from Australia–New Zealand VLBI. (From [4].)

3. Future Plans

The central task for New Zealand radio astronomy is to acquire a radio telescope with bigger collecting area and parameters determined in the IVS WG3 Report [1]. This development will most likely be conducted in the framework of the ongoing development with Geoscience Australia.

Venture Southland, a regional development group, has acquired an 11m dish for its site in Awarua and is working with AUT to prepare it for radio astronomy. A high-speed network linking New Zealand research institutions is expected to be up and running in the second half of 2006, and will facilitate an eVLBI system.

We plan to conduct further VLBI tests with Australia, to study the opportunity for establishing Trans-Tasman eVLBI, and as a medium-term goal to explore possibilities to work with other VLBI stations (e.g. with Japan).

We plan to further strengthen collaboration between the Centre for Radiophysics and Space Research (AUT) and leading New Zealand geoscience/geodesy institutions, such as Land Information NZ, and the Institute of Geological and Nuclear Sciences with the aim of sustaining the NZGD2000 and monitoring tectonic deformations.

A search for radio quiet sites for a New Zealand radio telescope facility is underway. New Zealand's geographic location makes it a natural place for possible extension of the planned Australian SKA from 3000 km to almost 6000 km baseline, increasing the spatial resolution of the SKA telescope. Four trial sites with favourable natural conditions, and well developed infrastructure and communications have been pre-selected as potential SKA sites. The level of RFI at the potential sites will be monitored in 2006. The New Zealand Ministry of Economic Development has granted $60,000 scholarship to an AUT postgraduate student to conduct this investigation.

4. Acknowledgements

We are very grateful to our colleagues from ATNF and the University of Tasmania who made our development possible.

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