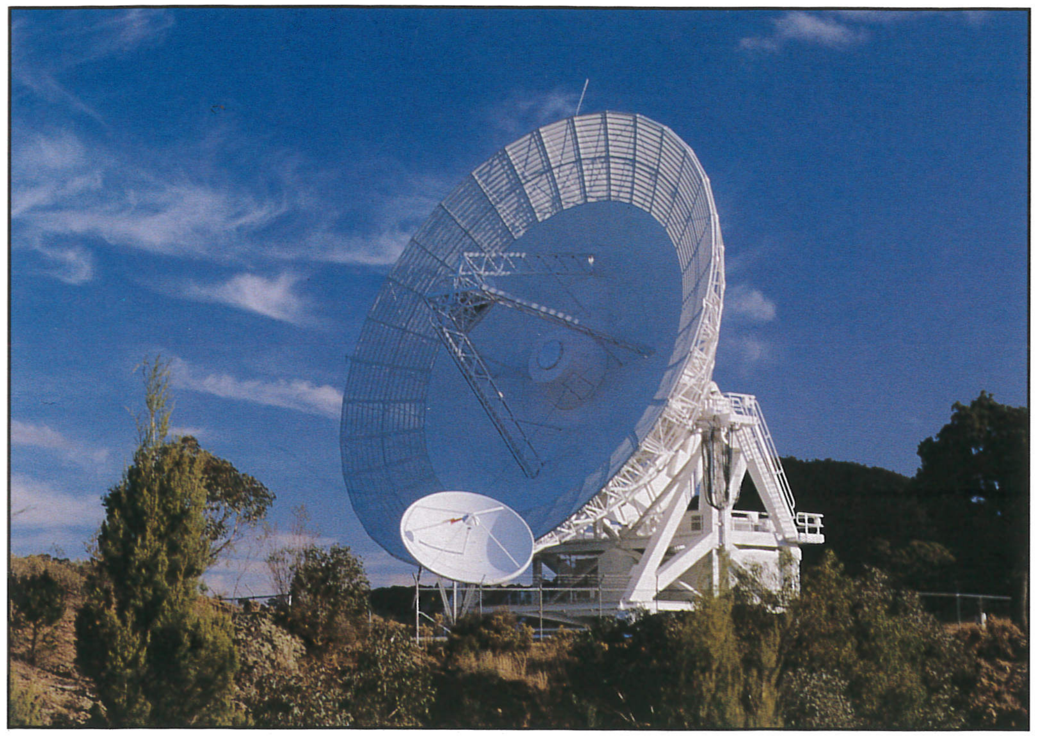
AUSTRALIA TELESCOPE NATIONAL FACILITY



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This is the annual report of the Steering Committee of the CSIRO Australia Telescope National Facility, for the year November 1991 to November 1992.

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Cover: A 22-m diameter antenna of the Australia Telescope near Coonabarabran, NSW, Australia.

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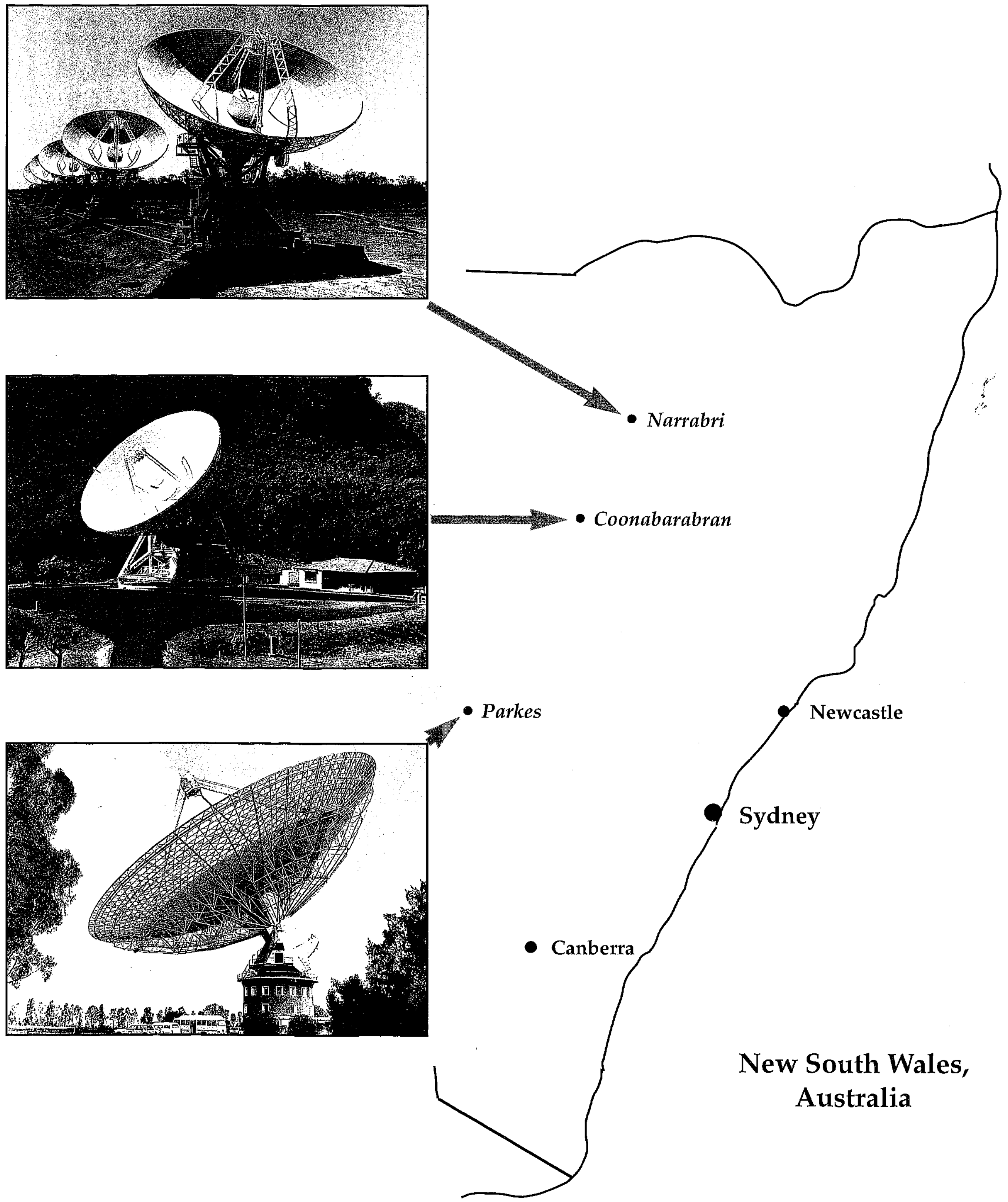
Contents

FIGURE 1

Locations of the Australia Telescope antennas



WHAT IS THE AUSTRALIA TELESCOPE NATIONAL FACILITY?

The Australia Telescope National Facility: an organisation to support astronomy

The Australia Telescope National Facility (ATNF), run by CSIRO, is an organisation that supports research in radio astronomy. It operates the Australia Telescope, a group of radio telescopes, which are used to observe those objects in the Universe which emit radio waves - galaxies, gas clouds between the stars, the remains of dead stars, and so on. The Australia Telescope is a *national facility* - it is open for use by astronomers from all Australian institutions, not just CSIRO. It is also used by overseas astronomers.

The ATNF's Headquarters is at the CSIRO Radiophysics Laboratory in Sydney, a site shared with the CSIRO Division of Radiophysics and the Anglo-Australian Observatory. The major computing network used for processing observations obtained with the Australia Telescope is located on this site.

The Australia Telescope: an instrument for doing astronomy

The Australia Telescope (AT) itself consists of eight antennas (radio-receiving dishes) at three sites in New South Wales. Each antenna collects radio signals from space. The signals are then brought together and processed to make a detailed picture of the object being studied. (These pictures are equivalent to photographs, but made from radio waves instead of light.)

Six of the Telescope's eight antennas are at the Paul Wild Observatory near Narrabri, NSW. They are spread along an east-west line of railway track. Five of them can be moved up and down a three-kilometre stretch of track to different observing positions, while the sixth antenna lies a further three kilometres to the west. Each of these antennas has a dish 22 m in diameter. This group of six antennas is called the Australia Telescope Compact Array. It began operation as a National Facility on 2 April 1990.

The Australia Telescope's two other antennas are the 64-m Parkes radio telescope and a new 22-m diameter antenna near Coonabarabran, NSW.

When the eight antennas are combined they form the Australia Telescope's Long Baseline Array (LBA). This simulates the power of a radio telescope 320 km in diameter, able to make very detailed (high resolution) pictures of small regions of the sky. Some of the Telescope's antennas are occasionally incorporated, together with other Australian and overseas telescopes, into large networks, to make even more detailed pictures. The technique used is called *very long baseline interferometry (VLBI)*. (See page 16.)

As well as being used in arrays, the Parkes telescope is still used as an independent instrument. The Coonabarabran antenna will be used too in this way, but mainly at higher frequencies.

The Australia Telescope is used to study many and varied cosmic objects, ranging from ones in our own Galaxy - such as radio-emitting stars, remains of exploded stars, and regions where stars are forming - to very distant galaxies at the far reaches of the Universe.

FIGURE 2

Publications, 1992 (derived from Appendix K)

WHAT IS THE AUSTRALIA TELESCOPE USED FOR?

The observing programs carried out with the Australia Telescope (AT) in 1992 are listed in Appendix A. Most of the Telescope's research falls into a limited number of categories, and these are described below. Figure 1 shows a breakdown of the research published in 1992 that arose from observations with one or more antennas of the Telescope, or from aspects of the Telescope itself.

• **Galaxies and quasars** are one of the most important areas of the AT's research. This is a very broad category, covering everything from the gas clouds found within galaxies to radio jets - long, thin structures that emit radio waves (and which are believed to be powered by black holes). Observations have been made of the fine-scale jets in the closest radio galaxy, Centaurus A; these are described on page 8. The AT has been used for several studies of the two galaxies nearest to our own, the Large and Small Magellanic Clouds, which are only visible from the Southern Hemisphere.

• **The Australia Telescope** itself was the subject of several publications. A compendium of papers on the Telescope was contained in the July 1992 issue of the *Journal of the Electrical and Electronics Engineers, Australia*, a special issue devoted to the AT. The contributions dealt with aspects of the Telescope's construction, from the initial design to the first radio observations.

• Several AT studies were related to specific regions in **our Galaxy**: phenomena associated with the Galactic Centre region, the dense, giant, gas clouds in which stars are being formed, and the regions ('HII regions') of hot ionized gas that mark the sites of recent star formation in these clouds. A study of arcs of polarized radio emission near the Galactic Centre is discussed on page 6, and another unusual object found near the Centre is described on page 9.

• Several types of **stars** have been studied. Some special kinds of stars, which produce a particular kind of radio emission ('maser' emission) can be used in making estimates of distances within the Galaxy; how this is done is described on page 11. Other kinds of radio emission associated with individual stars were also studied.

• **Pulsars** are the collapsed cores of old stars. They spin while sending out a beam of radio waves, in the way a lighthouse sends out a beam of light. The Parkes telescope is being used in a large search for millisecond pulsars - pulsars which make hundreds of rotations every second. The recent discovery of the brightest known millisecond pulsar is described on page 8. Some of the recent Australia Telescope studies concern the association of pulsars with supernova remnants (see below).

• **Supernovae** are exploding stars - and **supernova remnants** are what they leave behind. The remnants are a large class of important and generally strong radio sources. Matter blasted out by the explosion interacts with magnetic fields and other material in space around the original star, and this produces radio waves. Recent work has focused on the magnetic fields in supernova remnants: these fields influence the movement of the charged particles that produce the radio waves, and so are thought to influence how the supernova remnant evolves. The evolution of Supernova 1987A, discussed in the ATNF's 1991 Annual Report, is being monitored by regular AT observations.

• The **'other'** category in Figure 1 covers a wide range of topics. These include: studies of the cosmic background radiation (left over from the Big Bang); a program to search for extraterrestrial signals; astrometry (defining a reference frame for determining positions); and survey programs.

The Australia Telescope tracks masers to their hiding places

Look at a photograph of a spiral galaxy and what you see are the bright young stars that trace out the spiralling arms. These stars have been born in giant clouds of dust, called molecular clouds because they are thick with various kinds of atoms and molecules. The atoms and molecules tumble around within these stellar nurseries, gathering energy as they collide with each other or receive radiation from nearby stars. Then at some point they may shed this excess energy by radiating it away in the form of radio waves at characteristic frequencies. Many of these frequencies can be detected by radio telescopes, and they can tell us about the composition and physical properties of the clouds of molecules.

Under special conditions, some of the molecules emit intense radio emission in very narrow frequency ranges: this is 'maser' emission, which is the radio counterpart of laser light. Although we still don't understand how maser emission is produced by molecular clouds, it seems to pinpoint the dense regions within the clouds where stars are forming, or are about to form.

One molecule, methanol (CH_3OH), produces radio waves at many frequencies, but most of the emission is faint, or at high frequencies beyond the reach of most radio telescopes. However, a couple of years ago it was found that many methanol masers were pumping out radio waves at a frequency of 12 GHz. Radio astronomers became very excited: this looked like a frequency they could do something with.

In 1987 the ATNF started a study of this 12-GHz emission. The first finely detailed images of the masers producing this radiation have been made by the AT and other southern hemisphere radio telescopes, working together. Surprisingly, the masers within a given molecular cloud tend to lie along curved lines. This suggests that they might be forming in material flowing out from young stars, or in disks of material around embryonic stars.

In 1991 even stronger radio emission was detected from methanol masers, but this time at a frequency of 6.7 GHz. This was both tantalising and infuriating, as this frequency was outside the receiving range of most radio telescopes – even, on paper, the Australia Telescope. But test observations in early 1992 showed that the AT could 'see' the strongest of these masers, and in February proper images of them were made. They could now be fitted into a map which located all the other masers and regions of ionised hydrogen gas that are found in star-forming regions. In one such region (called Sagittarius B2) it seems that the the masers and regions of ionised gas mark a line where two dense clouds of dust and gas are colliding.

In many instances the 6.7 GHz methanol masers have been found in almost exactly the same places as the 12 GHz masers. This suggests that the same process is creating both kinds of emission. Both types of masers are now being observed with VLBI networks. (See page 16.)

Masers are popping up in all sorts of places. Observations made with the Parkes 64-m telescope have turned up, for the first time, masers in another galaxy – the Large Magellanic Cloud, our nearest neighbouring galaxy.

What's going on in there? Opinions are polarised

The centres of galaxies are often quite lively places. For instance, many galaxies have radio jets (long, thins jets of radio-emitting material) shooting out from their cores. The centre of our own Galaxy is a good deal quieter, but still active. Unfortunately, we are still in the dark (literally!) about exactly what goes on there, because the region is shrouded by clouds of dust, impenetrable by light. Radio waves, however, can get through, and so we know that at the heart of the Galaxy is a radio source called Sagittarius A*, where lurks some very massive object, or objects, and huge clouds of gas containing many kinds of molecules. Nearby are a number of radio-emitting structures of varying shapes and sizes – 'plumes', 'the Arc', 'the Bridge' – all presumably connected in some way. Large scale surveys have shown up these general features, but we are still unsure as to what physical processes have caused them.

With synthesis telescopes (such as the Australia Telescope's Compact Array) we can now make quite detailed images of the Galactic Centre. However, these only cover a very small region of the sky (a fraction of a degree in diameter at most). Because the Galactic Centre is relatively close to us, and because of the kinds of processes we suspect are going on, there should be effects observable on scales of a few degrees around the Centre. Single-dish telescopes such as the Parkes 64-m telescope are more suitable for surveying larger regions of this type.

Astronomers of the ATNF and the Max-Planck-Institut für Radioastronomie, Bonn, have been studying the centre of our Galaxy with the Parkes telescope, and have found structures, not detected before, that emit polarised radio waves. These structures shed yet a little more light on what's going on in the Galactic Centre. The direction of the polarisation of the radio waves is a guide to which way the magnetic fields in that region run.

The survey found three new arcs of polarised radio emission, two to the west and one to the east of Sagittarius A at the Galactic Centre. The arc to the east had been seen before, but the new observations show it to be much more extensive than previously thought.

How can these features be explained? Perhaps some of them are what's left of an expanding shell of material – the remains, perhaps, of a supernova (an exploded star) ? Another possibility is that the arcs and spurs are (largely) determined by the presence of magnetic fields that run perpendicularly to the plane of the Galaxy (i.e., skewering it through the centre). It might also be that some of the arcs now apparent are all parts of loop structures running around the Galactic Centre. In any case, these explanations will only be further sorted out and refined by further surveys.

The supernova remnant that wasn't

Recent observations by the Australia Telescope have helped to clear up a case of mistaken identity – turning what was thought to be a supernova remnant (the remains of an exploded star) into something quite different.

About ten years ago, a group of astronomers at the US Very Large Array radio telescope decided to look for the youngest supernova remnant in our Galaxy. They had some clear ideas about what such a thing would look like, a hundred years or so after the explosion, and set to work, making radio 'snapshots' of the sky with the VLA. They found fourteen objects. One by one, these candidates were discarded – most of them were found to be regions of ionised hydrogen gas – until only one was left: an object called G25.5+0.2.

This radio source had some properties that might apply to either a supernova remnant or a region of ionised hydrogen gas. But what was not detected was the kind of radiation that is typical of regions of ionised gas – so-called 'recombination lines' (radio waves produced when atoms recapture lost electrons). On the strength of this, G25.5+0.2 was dubbed a supernova remnant. It was estimated to have an age of less than 100 years, which would probably have qualified it as the youngest supernova remnant in the Galaxy. Nevertheless, some astronomers still had a sneaking suspicion (on the basis of its infrared spectrum) that G25.5+0.2 was really something else.

In March this year the AT detected radio recombination lines from G25.5+0.2 that had escaped the scrutiny of the Very Large Array. Infrared observations had shown an infrared source close to G25.5+0.2 – close enough, in fact, to be the same object, within the limits of observational error. An infrared image made with the Anglo-Australian Telescope revealed a hot, luminous central star, surrounded by a shell of ionised hydrogen, this region of gas corresponding closely to the radio image of the object.

The central source of G25.5+0.2 is now thought to be a massive star which, about ten thousand years ago, kicked out a lot of gas at a very high rate. It is probably a 'luminous blue variable', an unstable kind of star that periodically sheds some of its mass in attempts to become more stable. Further searches have turned up only one other object that resembles G25.5+0.2, which suggests that G25.5+0.2 is a very rare object, perhaps unique in the Galaxy.

Centaurus A shows a change of heart

Centaurus A (NGC 5128) is one of the most striking galaxies in the southern sky and, at a distance of about ten million light-years, the closest example of a galaxy which spews out vast amounts of radio energy. Because it is close, it gives us our best chance to have a good look at the centre of such a galaxy – where the action is. Now a largely Australian group has observed the first signs of the galaxy's core changing its structure.

Large-scale radio pictures of Centaurus A show that it has two giant radio-emitting regions ballooning out into space on opposite sides of the galaxy. But when you look closely, it seems that the radio jet that 'feeds' these regions is one-sided: that is, instead of two jets shooting out from the central core of the galaxy, we can only see one.

To zoom into the core of a distant galaxy in this way you need a system that can make finely detailed (high resolution) images. To do this, radio astronomers use a technique called very long baseline interferometry (VLBI), which relies on a network of widely separated telescopes. (See page 16.) One VLBI group that the ATNF has been closely involved with is the Southern Hemisphere VLBI team, SHEVE. The Australian members of SHEVE are the ATNF and the Universities of Adelaide, Sydney, Tasmania, Western Australia and Western Sydney. Further afield, the Hartebeesthoek Radio Astronomy Observatory, South Africa, also takes part in SHEVE, while the major US input comes from the Jet Propulsion Laboratory, Pasadena.

The SHEVE team has been observing Centaurus A since 1982, using various frequencies and combinations of telescopes. Observations made at a frequency of 8.4 GHz have shown that both the strength and the structure of the radio source at the galaxy's centre have changed since that time. The core has increased approximately five-fold in radio strength between 1982 and 1991. Also, recent detailed images of the core show that over a nine month period it has become longer, apparently lengthening at a rate of about a quarter of the velocity of light. But it is not clear exactly what this means. Is the known jet becoming longer? Or is a counterjet – a second jet in the opposite direction – beginning to emerge from the core? Time, and further observations, will tell.

Five down, how many to go?

Pulsars are the collapsed cores of stars, and send out regular 'pulses' of radiation, typically radio waves. It would be feasible to use them as a time standard because millisecond pulsars are more regular timekeepers than our best atomic clocks.

A team using the Parkes radio telescope is part-way through one of the most comprehensive searches ever made for millisecond (very fast) pulsars. This search, covering the whole southern half of the sky, is a collaboration between three institutions: the ATNF, the Istituto di Radioastronomia CNR, Bologna, and the Jodrell Bank Observatory, UK. If the observers find as many pulsars as they hope to, they will bring forward the day when pulsars will become the world's primary time standard.

The search complements other, similar searches that are being done with telescopes in the northern hemisphere. It is a massive undertaking: the Parkes telescope is being pointed at fifty thousand patches of sky, and it takes three minutes to observe each patch.

This search differs from previous pulsar searches in that the observers are looking specifically for millisecond pulsars. To date, most millisecond pulsars have been found in globular clusters, balls of a hundred thousand or so stars that are found on the fringes of our Galaxy. But the present search is looking for millisecond pulsars that might lie in the main part of our Galaxy. The search is using a very high sampling rate (approximately one million bits per second) to pick up millisecond pulsars, and not just the common-or-garden pulsars with longer periods. Less than one percent of the southern sky has previously been sampled in this way. The survey will show where the millisecond pulsars are scattered in space and tell us about their spin rates – data which should have some bearing on current ideas about how millisecond pulsars evolve.

So far about 35% of the total survey has been completed. Five new millisecond pulsar have turned up, and the observers are confident of finding at least fifteen in all. This is quite a large number considering that only six galactic millisecond pulsars had been found before.

One on the doorstep

One of the new pulsars is the closest one ever found – and it is by far the strongest in signal, at least ten times stronger than any other known millisecond pulsar. The signal is strong because the pulsar is so close to us, only about 500 light-years away – in astronomical terms, practically on the doorstep. The pulsar (PSR J0437-4715) appears to be a perfectly typical millisecond pulsar, with a period of 5.7 milliseconds. It orbits a low-mass companion star, which is probably a white dwarf (a small, degenerate star) once every six days, in an almost completely circular orbit. The pulsar signal is never eclipsed during the orbit, which means that the orbital plane does not lie perfectly edge-on with respect to us but is slightly tipped. The pulsar's position has been determined by the Australia Telescope Compact Array to within 0.1 seconds of arc.

Because the pulsar is so close we can measure many of its characteristics extremely well. Its pulses can be seen at every frequency between 400 MHz and 5 GHz, which is unusual. Its pulse period is known to 14 decimal places and the period of its orbit is measured to within 60 milliseconds. In fact we can count every pulse it makes. The companion star is not bright enough to show up on existing optical plates, but new observations may reveal it. It is also being checked for signs of X-ray or gamma ray emission; this has never been seen before in a millisecond pulsar, but might show up in one so close.

This and other millisecond pulsars could form the basis of a world time standard, replacing the current atomic clocks. A single pulsar would not be enough to constitute a time standard: probably at least a dozen would be required, and they would have to be observed for a number of years before they could be incorporated into a time standard. (A good time standard would require stability of at least one part in 10^{18}).

Apart from their potential as timekeepers, millisecond pulsars could be used to put an upper limit on the 'strength' and rate of occurrence of gravity waves. Just as water waves spread out from a stone dropped into a pond, theory predicts that gravity waves – ripples in space-time – propagate outward from events involving massive cosmic objects. If such a ripple flowed through a region where there was a pair of stars orbiting each other – a binary system – then it would disturb their orbits. Most millisecond pulsars are in binary systems, so by looking at their orbits we might be able to pick up signs of a passing gravity wave.

The Snake: a knotty problem

Observers from the University of Sydney, the ATNF and the National Radio Astronomy Observatory, USA, have been studying a peculiar long, thin radio source near the centre of our Galaxy. This structure, christened 'the Snake', is similar to other radio sources in the region, but unlike them it has kinks along its length.

The central region of our Galaxy is structurally complex, containing radio-emitting features of varying shapes and sizes – 'plumes', 'the Arc', 'the Bridge'. Here is found a radio source called Sagittarius A: from this emerges two long, thin radio-emitting structures called 'threads', which both curve and change in brightness smoothly along their lengths. The Snake is similar, but is a fair distance from Sagittarius A, and differs from the 'threads' in possessing kinks. It is the longest isolated linear feature in the Galactic Centre region.

All of the long, thin structures in this region are thought to have a common origin. Just what that is, however, has been open to speculation, with suggestions ranging from the unremarkable (compressed magnetic field lines) to the exotic (cosmic strings). None of the current suggestions explains the kinks in the Snake. The most prominent kink lies near the brightest part of the Snake, which suggests that whatever is causing the kink is responsible for the radio emission from the whole object.

The Australia Telescope is a good instrument for observing the Snake (and the centre of our Galaxy in general), as this part of the sky. Of the radio telescopes that can view this object, the Australia Telescope is best able to make high-sensitivity images of the Snake.

A supernova discovered in retrospect

Serendipity seems to be operating as strongly as ever in astronomy. On a search for something quite different, astronomers from the ATNF, Mount Stromlo and Siding Spring Observatories, and the Anglo-Australian Observatory turned up an unusual object which seems to be a supernova (exploded star) that was not spotted when it blew up in 1978. If so, this is a good, close example of an unusual kind of supernova. The fact that it was missed before suggests that there may be many more of them around.

In 1991 and 1992 the Australia Telescope was being used to study the movement of hydrogen gas in the galaxy NGC 1313. But the observations also revealed a strong radio source on the galaxy's outskirts. The radio source coincided with the position of an object already known from optical studies. That object had been considered to be a *nova* - a star that undergoes an explosive outburst but lives to explode again another day. But a nova would not be a strong radio source such as this. Clearly, the object found by the AT was something else.

A bit of detective work among a series of archival plates made by the Schmidt Telescope of the Anglo-Australian Observatory made it possible to reconstruct a rough 'light curve' for the object, showing how its brightness had changed over a number of years. Archival data - optical, radio, X-ray and infrared - were drawn together from a number of sources and then new observations were made with the Anglo-Australian Telescope and the Australia Telescope Compact Array.

From the old data it seems that in mid 1978 the object had become very much brighter, and soon after began to put out increased amounts of radio waves and X-rays. So why wasn't it noticed at the time? Perhaps there were several reasons: one was simply that in 1978 there were few organised programs to search for supernovae.

But was it really a supernova? There are some oddities to be explained. For one thing, the object was almost as bright after the outburst as it was before. As well, if the object was a supernova, it is now putting out an unusual amount of radio and X-ray emission for this stage of its career. There is an alternative interpretation - that the object was an unstable giant star that had experienced one of the sporadic eruptions that these stars are prone to. But the balance of evidence points the other way: the light curve, the optical spectra, the strength and size of the present radio source, and the X-ray data all suggest that the object is almost certainly an unusual kind of supernova. The International Astronomical Union has recognised it as such, and it has now been christened, retrospectively, Supernova 1978 K. It is now being monitored regularly with the Australia Telescope, to see how it evolves over time.

The existence of SN1978K shows that we still have something to learn about the life processes of stars. The fact that it, and similar supernovae, could be so easily missed (even in nearby galaxies) suggests that they may be far more common than previously thought. Indeed, such 'invisible' supernovae might fuel the activity in 'starburst' galaxies. A follow-on program, to search for more of these objects, has been proposed.

Our place in space - OH/IR stars help to define it

It's a long, long way to Tipperary ... and even further to the Galactic Centre. But exactly how far, is difficult to determine. Measuring distances is a significant problem in astronomy, even for regions which are virtually our own backyard, such as our Galaxy. A program now being carried out with the Parkes telescope should give us a better sense of the size of our Galaxy, through refining the distances to certain stars and to the Galactic Centre.

Since 1988 astronomers from the ATNF, Mount Stromlo and Siding Spring Observatories, and the University of Sydney, have been using the Parkes telescope to observe 95 stars of a special kind, called OH/IR stars. These stars produce both infrared radiation (IR) and a certain kind of radio emission (from the OH molecule). Both kinds of radiation come from a shell of material that lies around the star (a circumstellar envelope). The OH radiation can be detected by radio telescopes, and observing it can tell us two things: the linear (that is, real) size of the circumstellar shell, and its angular size (how big it appears on the sky). By combining these two measurements we can get a good estimate of the distance to the star.

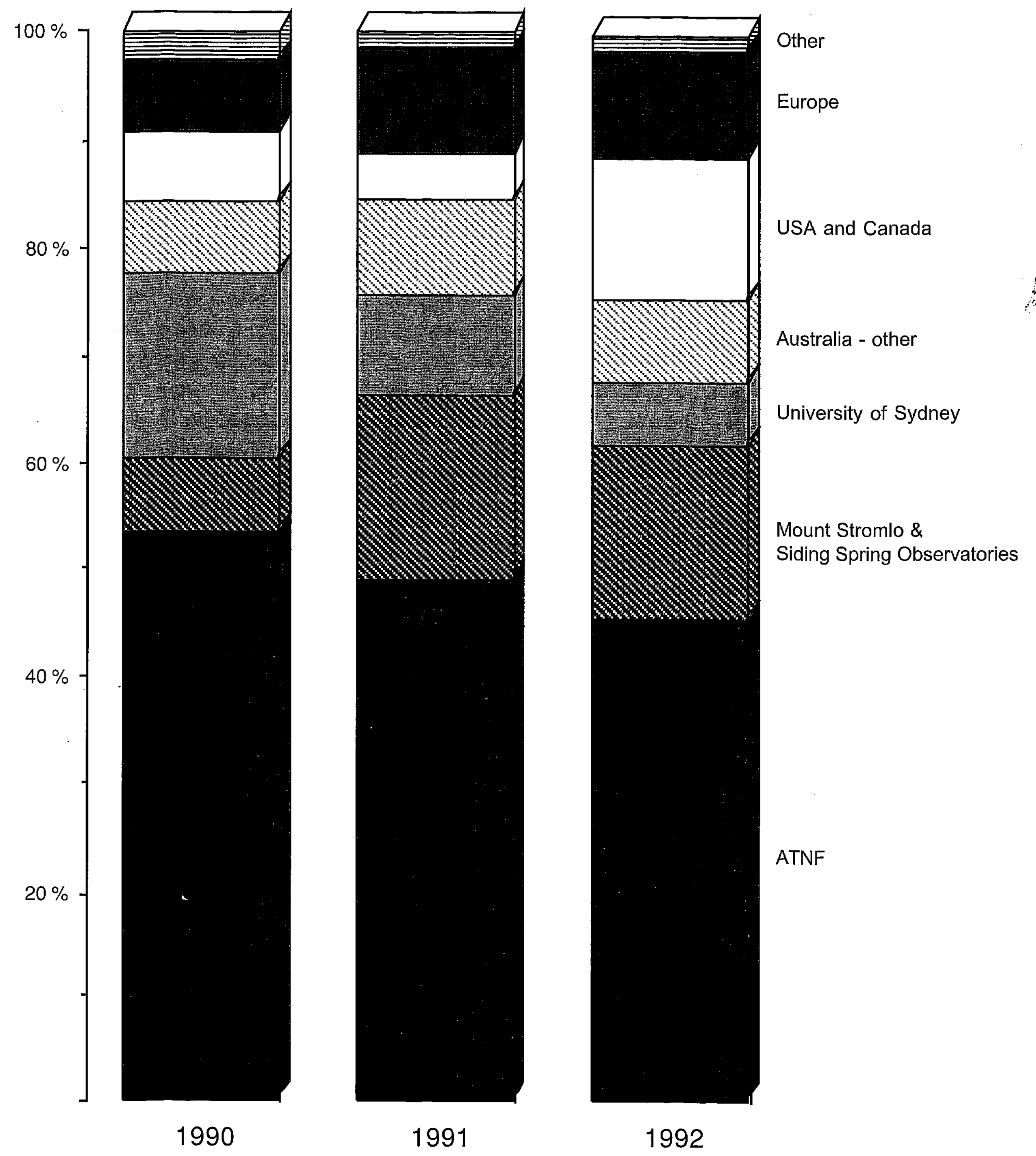
How are these measurements made? If we observe the star with a radio telescope such as Parkes, most of the OH radiation that we pick up has been emitted from the circumstellar shell that surrounds the star. The circumstellar shell is expanding, which means that, relative to the star, the back of the shell is moving away from us, while the front is moving towards us. The net result of this is that the radio emission reaching us from the front of the star is at a different frequency from that coming from the back of the star (because the two have undergone different Doppler shifts). In other words, we can easily tell the two apart.

This would not be much use except for the fact that the strength of the OH emission as a whole varies in a regular, almost sinusoidal, pattern over time. The period of this variation is quite long, greater than 300 days in most cases. The radiation from the front of the star peaks some days before the radiation coming from the back. These variations are caused by pulsations in the star itself, and the time lag is the amount of time that radiation from the back of the envelope takes to reach the front of the envelope. This can be converted into the distance between the front and back of the circumstellar envelope. For instance, a phase lag of three days corresponds to a linear size of about 80 thousand million kilometres. (For comparison, the Sun is only 1.4 million kilometres in diameter.) Most of the stars observed in this program have phase lags of between five and fifty days.

Once we have our linear sizes, what next? The angular sizes of the stars will be measured over the next few years by observations made with the MERLIN array of radio telescopes in the UK, the Very Long Baseline Array in the USA, and the Australia Telescope Long Baseline Array (all eight of the Australia Telescope antennas working together). Although the OH/IR stars are large objects in an absolute sense, they are quite small in angular size, and will be measured with the high-resolution technique of VLBI (see page 16). Armed with both the linear and angular sizes of the stars, we can calculate how far away they are. From this - and making some assumptions as to how the stars are distributed around the Galactic Centre - we can make a better estimate of our distance from the Galactic Centre.

FIGURE 3

Percentage of successful observing proposals, by origin of principal investigator



USER SUPPORT

In 1992 the ATNF was visited by eighty-nine people, from forty-nine institutions.

Visitors using the AT, particularly those from overseas, can draw on several forms of assistance. After observing-time has been scheduled, the AT User Support Group contacts observers who have not used the Facility before, to see what help they require. The User Support Group helps overseas visitors to plan their travel and can also provide some assistance with accommodation: the Parkes, Coonabarabran and Narrabri sites have living-quarters for observers, and accommodation is available at the Radiophysics Laboratory for international AT observers, invited guests, students working at the Laboratory and staff from the Telescope sites.

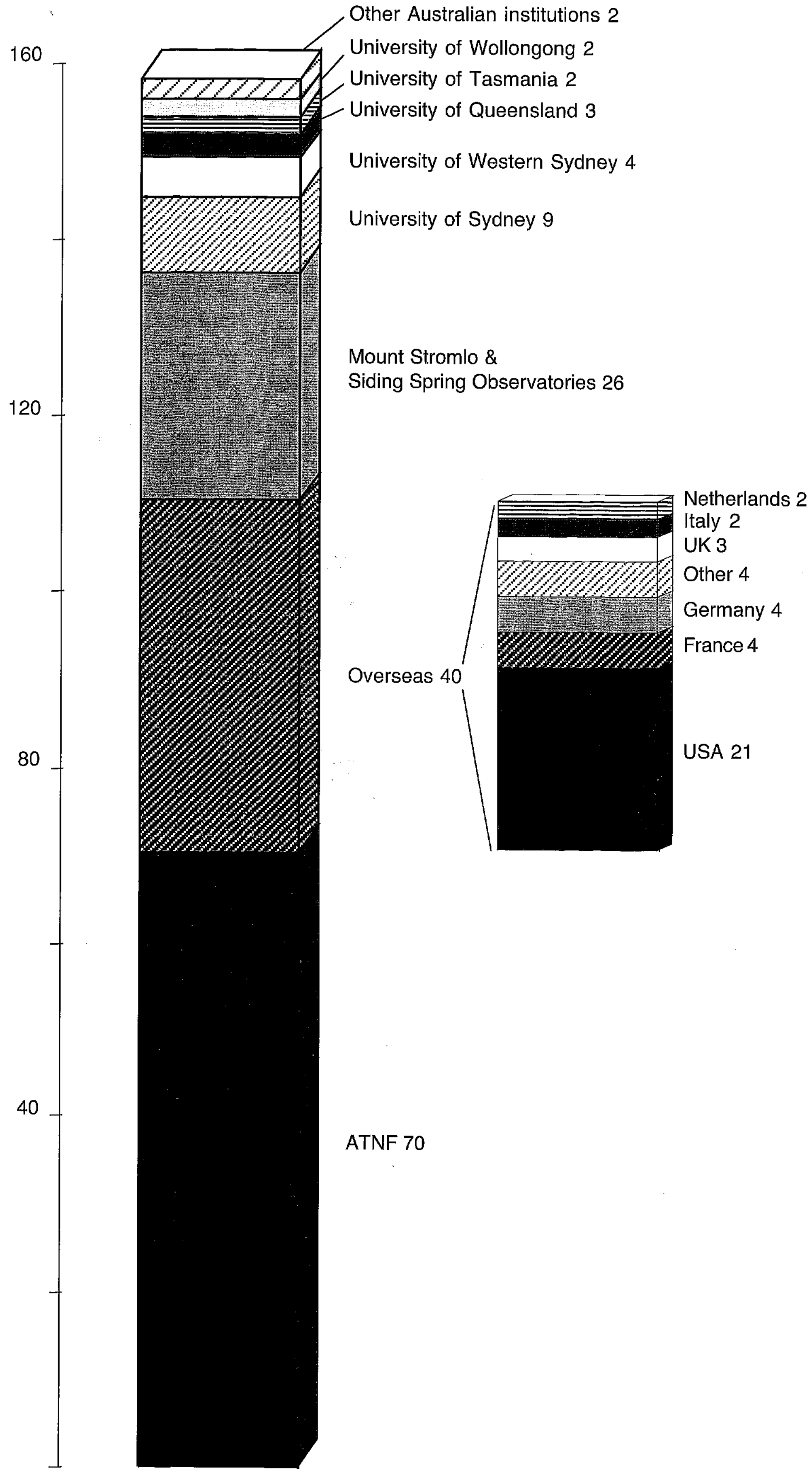
If an observer requests advice or collaboration the ATNF will suggest another AT user who has the required expertise. When visitors are ready to observe, rostered ATNF 'duty astronomers' at the Telescope sites help them to set up and run their observing sessions. At the Radiophysics Laboratory in Sydney, the User Support Group sets up computer accounts for visiting astronomers, and arranges assistance for them to process their data.

The User Support Group also prepares and distributes observing schedules and site information for visitors, and a variety of other documents such as preprints, annual reports and user manuals. Every four months it produces the AT Newsletter, which reports on any significant projects involving the ATNF, and keeps AT users up-to-date on the operations of the Facility.

The last stage in the observing process is publishing a paper. The Radiophysics Laboratory Editor (shared by the ATNF and the Division of Radiophysics) arranges from papers to be internally reviewed, then edits and prepares manuscripts to the requirements of the journals to which they will be submitted. She also prepares for publication larger works, such as a collection of papers arising from a symposium.

Figure 4

Principal investigators, by origin



Working with Others

Most of the observing teams that use the Australia Telescope have members from outside the ATNF: Figure 4 shows the origins of the principal investigators in each team. There is extensive collaboration between members of the ATNF and other institutions. In 1992, ATNF members and non-ATNF observers worked together in teams for 96 of the 157 observing programs involving the Compact Array or the Parkes radio telescope. Several of the collaborations are long-term, structured programs of research, and examples of these are given below; a significant proportion are partly or fully supported by funds from the Department of Industry, Technology and Commerce (DITAC). The ATNF works with other institutions not only in observing programs but also to develop instrumentation. Overall, collaboration is an effective way to spread skills and experience, share resources and promote the exchange of ideas.

Some of the ATNF's larger collaborations are listed below.

Stellar Atmospheres

The ATNF, six Australian universities and the US Joint Institute for Laboratory Astrophysics have a program to study the 'atmospheres' of stars with both radio and optical telescopes. This program is being supported by DITAC.

The Magellanic Clouds

The Large and Small Magellanic Clouds are the nearest galaxies to our own, and are visible only from the Southern Hemisphere. The ATNF has teamed up with the University of Sydney, Mt Stromlo and Siding Spring Observatories (Australian National University), and the Max-Planck-Institut für Radioastronomie, Bonn, for a six-year study of the Magellanic Clouds and the stream of gas extending through them, the Magellanic Stream. This study is partly funded by DITAC.

The Magellanic Clouds are rich in neutral hydrogen gas, and there is considerable interest in mapping the distribution and movements of this gas. The Australia Telescope is being used for this purpose by a group of collaborators from the ATNF, Meudon Observatory and IAS Orsay (France), Kapteyn Laboratory (Holland), and Universidad de Chile, with (Australian) financial support provided by DITAC.

Instrumentation for the Coonabarabran 22-m antenna

In a project partly funded by DITAC, the ATNF and the Max-Planck-Institut für Radioastronomie, Bonn, are collaborating to provide an acousto-optical spectrograph on this antenna which will make it possible to observe broad molecular lines in other galaxies.

The ATNF is also working with the US National Radio Astronomy Observatory on the design and construction of a 70-117 GHz low-noise dual-polarization receiving system operating at 4 K, to be used initially on the Coonabarabran antenna.

A search for millisecond pulsars

A new southern search for millisecond pulsars (described on pages 8 and 9) is being undertaken with the Parkes 64-m radio telescope, by the ATNF in collaboration with Jodrell Bank (UK) and the University of Palermo (Italy). The search has been very successful so far, finding many young millisecond pulsars along the Galactic plane, the first pulsar in a binary orbit with a non-degenerate companion star, and several 'recycled' pulsars in globular clusters. The project is supported by the DITAC-ATNF-Jodrell Bank Collaborative Program.

A 5-GHz survey of radio sources in the southern sky

The ATNF, the Massachusetts Institute of Technology, and the US National Radio Astronomy Observatory have been running a joint survey of radio sources in the southern sky (observing at a frequency of 5 GHz). The survey, begun in 1990, has been carried out using the Parkes radio telescope with a special receiving system able to sample seven different positions on the sky simultaneously.

About 20,000 radio sources have been detected, many ten times fainter than those found in previous southern surveys. The results of the survey are being published in a series of five papers in the *Astronomical Journal*.

Very Long Baseline Interferometry (VLBI)

VLBI is a technique used to make images of radio sources with very high detail. It is inherently collaborative because VLBI observations require networks of radio telescopes separated by large distances. Australia has been carrying out VLBI experiments since the early sixties, when the technique was first developed. The ATNF has many VLBI collaborations:

• The ATNF, the US Naval Observatory and the Hartebeesthoek Radio Astronomy Observatory, South Africa, have been doing high-precision astrometry of southern radio sources (that is, determining their positions precisely).

• Collaboration has started among a network known as the Asia-Pacific Telescope: this includes telescopes of the ATNF, Shanghai Radio Observatory (China), Nobeyama Radio Observatory and Kashima Space Research Centre (Japan), Hartebeesthoek Radio Astronomy Observatory (South Africa), and the Ussuriisk Telescope (Russia).

• The ATNF is a leading member of the Southern Hemisphere VLBI experiment (SHEVE) group. The other institutions involved are the Jet Propulsion Laboratory (USA), Hartebeesthoek Radio Astronomy Observatory (South Africa), and Australian collaborators at the Universities of Tasmania, Western Australia, Sydney and Adelaide. SHEVE has existed for ten years and has an active program of observations. For instance, it produced the first high-quality, high-resolution images of radio sources located far south in the sky: in recognition of this, NASA recently presented it with a Group Achievement Award.

In 1992 the ATNF constructed a 4.8-GHz low-noise amplifier and converter system for the Gnangara antenna near Perth (which is operated by the Australian and Overseas Telecommunications Corporation). It also provided the University of Tasmania with the necessary components for a similar converter system. These actions were to support VLBI observations, begun in November 1992, that are using several Australian antennas.

• The ATNF has a joint program with the Japanese Communications Research Centre, supported by Japan-Australia Bilateral funding, to measure precisely the Australia-Japan baseline and inter-plate motion of the Antarctic continent.

• The ATNF will take part in the forthcoming programs in Space VLBI. Russia plans to launch a 10-m diameter radio telescope (RadioAstron) into orbit around the Earth in 1996. This will be operated in conjunction with radio telescopes around the world, to make a large array of radio telescopes capable of making highly detailed images of celestial objects – images that are hundreds or even thousands of times more detailed than pictures from the Hubble Space Telescope. The Australia Telescope will form an important southern part of the ground-based network.

More than a dozen countries are participating in the RadioAstron project. Australia's participation is governed by the Memorandum of Understanding signed with the Space Research Institute of the USSR Academy of Science in 1987; Australians attending the twice-yearly project meetings are funded through the Australia-USSR Bilateral Agreement.

Collaborative projects with the Shanghai Observatory

In recent years Australia has negotiated a Bilateral Science and Technology agreement with China. Under this umbrella the ATNF is collaborating with the Shanghai Observatory on VLBI programs and a joint technical development program to build 22-GHz amplifiers for use in future space and ground-based VLBI projects. There will also be exchanges of scientific and technical personnel.

AIPS++, a new data processing package

Software is just as important for image production as hardware. The main processing system that the ATNF uses is AIPS (Astronomical Image Processing System). AIPS was developed at the US National Radio Astronomy Observatory (NRAO) and is now installed at over 150 institutions world-wide.

Although AIPS has been modified by the institutions that use it, it is now more than ten years old, and is increasingly unable to cope with new computer technologies, new imaging techniques, and new instruments such as the Australia Telescope. A new version of AIPS, called AIPS ++, is now being written by seven of the major institutions that use AIPS. The construction of AIPS++ began in January 1992, and it will effectively replace AIPS by the end of 1994.

As AIPS++ will be very important to the future of the ATNF, the organisation is giving significant resources to the project, up to the equivalent of three full-time people. AT users are canvassed for input, and informed of progress, by the ATNF AIPS++ project scientist.

CSIRO-University Collaborative Research Grants for 1992-93

CSIRO provides special funding for collaborative research between CSIRO Divisions and universities. CSIRO and the university concerned contribute equal funds to each joint project. Before 1992, the CSIRO side of the agreement was negotiated by the CSIRO Corporate Centre, but in 1992 the management of the program was devolved to Divisional level; this will allow alliances to be established more directly, more efficiently and more flexibly. This year the ATNF was able to offer full or partial support for nine of the ten project applications it received from universities.

NASA High Resolution Microwave Survey

For centuries people have speculated about the existence of intelligent life beyond Earth. Attempts to detect radio signals from possible extraterrestrial civilisations began in 1960. A number of groups observing with radio telescopes have found interesting, unexplained signals – but none of them has ever been repeated.

In October this year NASA began the largest SETI search ever undertaken - the High Resolution Microwave Survey. This search has two parts: an 'all-sky' survey, and a 'targeted search' for signals from about 1000 nearby solar-type stars. As part of this project, a contract is being negotiated between CSIRO and the Australian Space Office, representing NASA, to enable the NASA Ames Research Center to use their 10-million channel spectrum analyser on Australia Telescope antennas for part of the targeted search. The Parkes radio telescope will be used as the prime observing site for the Southern Hemisphere, and the equipment will be on the telescope for a period of approximately 20 weeks, beginning in August 1994. The search will cover the frequency range 1-3 GHz with a spectral resolution between 1 Hz and 30 Hz.

Megascience Forum

This year the OECD Committee on Scientific and Technological Policy established a 'Megascience Forum'. The intention was to help governments to coordinate the provision of large and expensive research facilities, through sharing experiences in the development of large facilities and information on future large programs and facilities to be jointly developed by several countries.

At the forum's first meeting in July, the scope of the forum was discussed and a tentative list of megascience projects was proposed – a megascience project being defined as a scientific effort of such scope and complexity as to require an unusually large-scale collaborative effort. Astronomy was one of the two areas selected for initial review. Australia's interests were represented by a member of DITAC and John Whiteoak of the ATNF.

In October a follow-up meeting was held to review international collaborations in astronomy. Again, DITAC presented Australia's potential involvement in collaborative projects, based on information compiled by the ATNF.

During 1992 the ATNF was host to meetings of various kinds that brought together members of the broader astronomical community and those interested in astronomy education.

Colloquia

This year the ATNF held twenty-five colloquia, on topics of general interest to astronomers. As a rule the speakers were visitors to the ATNF, speaking on their own areas of research. These colloquia were open to astronomers (and students) from any institution. The ATNF was also host to regular meetings of specialised astronomy working groups.

Australia Telescope Users Committee meetings

The Australia Telescope Users Committee (ATUC) is a group of about twelve people who represent the Australian users of the AT. (The current members of the Committee are listed in Appendix B.) This committee provides feedback to the ATNF Director on the operation of the Telescope. It meets in May and November each year to inform AT users of the current status and planned development of ATNF facilities and of recent scientific results. The meetings are also a forum where AT users can discuss any problems they may be experiencing and suggest improvements in AT operation or facilities.

At its meeting in May this year, ATUC endorsed the in-house production of a millimetre-wave receiver system for the Coonabarabran antenna. It also supported the decision to test the Narrabri site for the feasibility of doing millimetre-wave observations with the AT Compact Array. (The subject of the investigation is the quantity of atmospheric water vapour, which affects millimetre-wave observations.) Both of these actions are now under way. The community of AT users has since been polled for expressions of interest in using the Coonabarabran antenna for millimetre-wave observations.

ATUC has input not only into specific development issues but also into the ranking of items listed for future development. The priorities given to those items by the User Committee are reflected in the future development plans given in Appendix C.

Forum of Continuing Astronomical Liaison - FOCAL

The greatest concentration of professional observatories in Australia lies within the borders of NSW. In June this year the ATNF convened the first meeting of a group of staff from the visitor and tourist centres associated with these observatories, who have a common interest in promoting their institutions and communicating astronomy to the public. The meeting was held at Parkes, and jointly sponsored by ATNF and the Parkes Shire Council.

Space Frequency Coordination Group meeting

In late October this year, the first Australian meeting of the Space Frequency Coordination Group was held in Canberra and Sydney. The meeting was jointly hosted by the Australian Space Office and the ATNF (acting on behalf of the CSIRO's Office of Space Science and Applications). It was attended by thirty-three overseas delegates and several representatives of CSIRO and the Australian Space Office.

The SFCG is an international group that represents the interests of national space agencies and organisations directly associated with space activities (e.g. ESA, NASA, NASDA) in many countries. Its activities are of interest to radio astronomers because passive space research and radio astronomy share several allocated bands in the radio spectrum, and both activities need these bands protected from interference. When space-VLBI projects are launched in the mid-1990s (see page 16) the links between the two areas will become even closer. The SFCG meeting also discussed another prospect that is further off in time, but of strong interest to radio astronomers: radio astronomy on the far side of the Moon.

The ATNF's training efforts extend beyond its own staff to the general astronomical community of Australia - and in particular, to the students who are on their way to becoming part of that community.

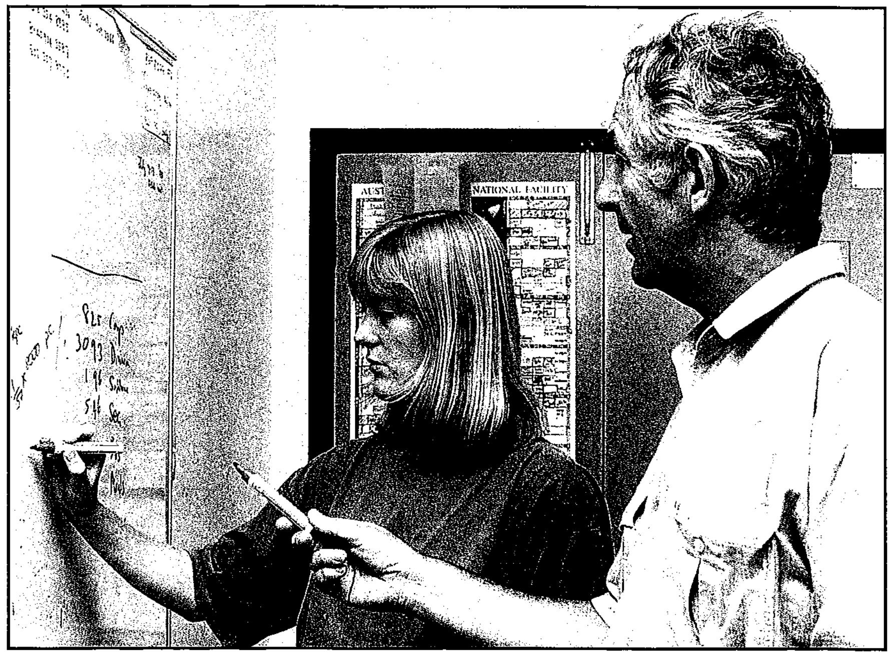
Joint supervision of PhD students

The ATNF allows students doing higher degrees the opportunity to have their work co-supervised by an ATNF staff member as well as a member of the student's university. By the end of 1992, twenty-two students from nine institutions were taking part in this scheme (a large increase over last year's figure of eight students). Their projects covered a diverse range of areas, from millimetre-wave imaging strategies to studies of the recently discovered methanol masers. Details of the students' projects and affiliations are given in Appendix D.

Summer vacation students

Each year the ATNF runs a summer vacation program at the Radiophysics Laboratory for undergraduate students who have completed at least three years of their degree. This program introduces students to a research environment, and arms them with some skills, contacts and (we hope!) the motivation to go on in the field. Each student is assigned a supervisor and a specific project on which he/she reports at the end of the vacation period.

In the period December 1991-February 1992 the ATNF chose seven students from a field of 169 applicants. The CSIRO Division of Radiophysics and the adjacent Anglo-Australian Observatory ran similar programs, employing a further seven and four students respectively; all the students benefited from some activities run jointly.



Sally Houghton, a student from the University of NSW, with Dr John Whiteoak of the ATNF.

The students participated in observing programs at Parkes and Narrabri, and collectively devised and carried out their own two-day observing project at the Parkes radio telescope. Many continued with their projects after the formal completion of the program, and one has developed her work into a project for her BSc Honours year.

'Sandwich' students

So-called 'sandwich' courses are tertiary-level courses in which a student alternates periods of full-time employment with blocks of full-time study. In 1991 the ATNF employed two sandwich students from the University of Technology, Sydney, who worked on correlator development.

Year 10 work experience

The ATNF is keen to acquaint junior school students with science and technology. In 1992 it offered a week's work experience at the Radiophysics Laboratory in Sydney to eight students (a further eight students worked at the Laboratory in areas shared by the ATNF and the Division of Radiophysics). The Parkes Observatory took a further eighteen year-10 students from NSW and Victoria, each spending two weeks at the site, and the Narrabri site gave work experience to ten students.

FIGURE 5

ATNF and associated staff, as of November 1992

DIRECTOR
R. Ekers

DEPUTY DIRECTOR
J. Whiteoak

ASSISTANT DIRECTOR
J. Brooks

PERSONAL ASSISTANT TO THE DIRECTOR
E. Pacey

PERSONAL ASSISTANT TO THE DEPUTY DIRECTOR AND ASSISTANT DIRECTOR
G. Manefield

ENGINEERING MANAGER
J. Brooks

Administration

P. Howson

S. Little
P. Cameron

User support, Communications, Publications

J. Whiteoak

L. Bedding**
D. Goddard**
G. Manefield
R. Otrupcek
B. Siegman
H. Sim

Computing

R. Norris

S. Amy*
J. Argyros
W. Brouw**
M. Calabretta
J. Deane
H. Eason
J. Gates*
R. Golding*
R. Gooch
M. Homsey
N. Killeen
S. Little*
H. May
R. Mercer
P. Mulhall*
L. Newton
R. Sault

* Position funded by the CSIRO Division of Radiophysics

** Position 50% funded by the CSIRO Division of Radiophysics

Astrophysics

R. Ekers

W. Brouw**
J. Caswell
J. Chapman
R. Duncan
P. Hall (Nar.)
R. Haynes
D. Jauncey (Cbr.)
S. Johnston
M. Kesteven (Nar.)
N. Killeen
R. Landau (Nar.)
R. Manchester
D. McConnell (Nar.)
V. Migenes (Cbr.)
D. Milne
G. Nelson (Nar.)
R. Norris
R. Otrupcek
J. Reynolds
R. Sault
L. Staveley-Smith
R. Stewart
A. Tzioumis
K. Wellington
J. Whiteoak
M. Wieringa (Nar.)
A. Wright (Pks)

Parkes

D. Cooke (OIC)

P. Buckett
J. Cole
G. Davis
H. Fagg
D. Fellows
G. Freeman
J. Glowacki
J. Hockings
S. Horner
A. Hunt
U. Knop
B. Lam
R. Lees
B. Livingstone
S. Magri
N. Mason
I. McGovern
M. Price
D. Scott
E. Troup
R. Twardy
T. Williams
A. Wright

Narrabri

G. Nelson (OIC)

D. Allman
R. Beresford
M. Bland
D. Campbell
A. Day
O. Dowd
H. Du
R. Edwards
C. Forbes
K. Forbes
T. Gordon
R. Gough
A. Grainger
J. Grenenger
P. Hall
M. Hayes
D. Hayne
G. Herbert
L. Kent
M. Kesteven
R. Landau
C. LeCornu
C. Leven
D. Loone
A. McConnell
D. McConnell
D. McKay
R. Novak
J. O'Brien
K. Redman
A. Spencer
G. Sunderland
D. Tibbits
R. Tomlinson
R. Wark
M. Wieringa
C. Wilson

Receivers

M. Sinclair

R. Bolton
G. Carrad
G. Gay
G. Graves
S. Hoyle
H. Kanoniuk
G. Moorey
P. Seckold
P. Sykes

Wirers

M. Chun
L. Gallardo

Electronics

W. Wilson

S. Ables
M. Anderson
K. Cambridge
E. Davis
R. Ferris
R. Gardyne
M. Leach
G. McCulloch
A. Tzioumis
M. Willing

Post-graduate students

D. Abbott (U. Syd.)
M. Anderson (UWS)
J. Bell (ANU)
D. Blank (U. Syd.)
S. Ellingsen (U. Tas.)
M. Filipovic (UWS)
R. Gooch (Mac. Uni.)
A. Gray (U. Syd.)
S. Houghton (UNSW)
V. Kaspi (Princeton)
L. Kedziora-Chudczer (U. Syd.)
E. King (U. Tas.)
A. Koekemoer (ANU)
H. Liang (ANU)
D. Lorimer (U. Manchester)
J. Lovell (U. Tas.)
S. Magri (UWS)
A. McPhail (Mac. Uni.)
M. Ott (MPIfR)
C. Robinson (U. Manchester)
A. Roy (U. Syd.)
N. Tasker (Mac. Uni.)

Honorary Fellows

O. B. Slee

Long-term Visitors

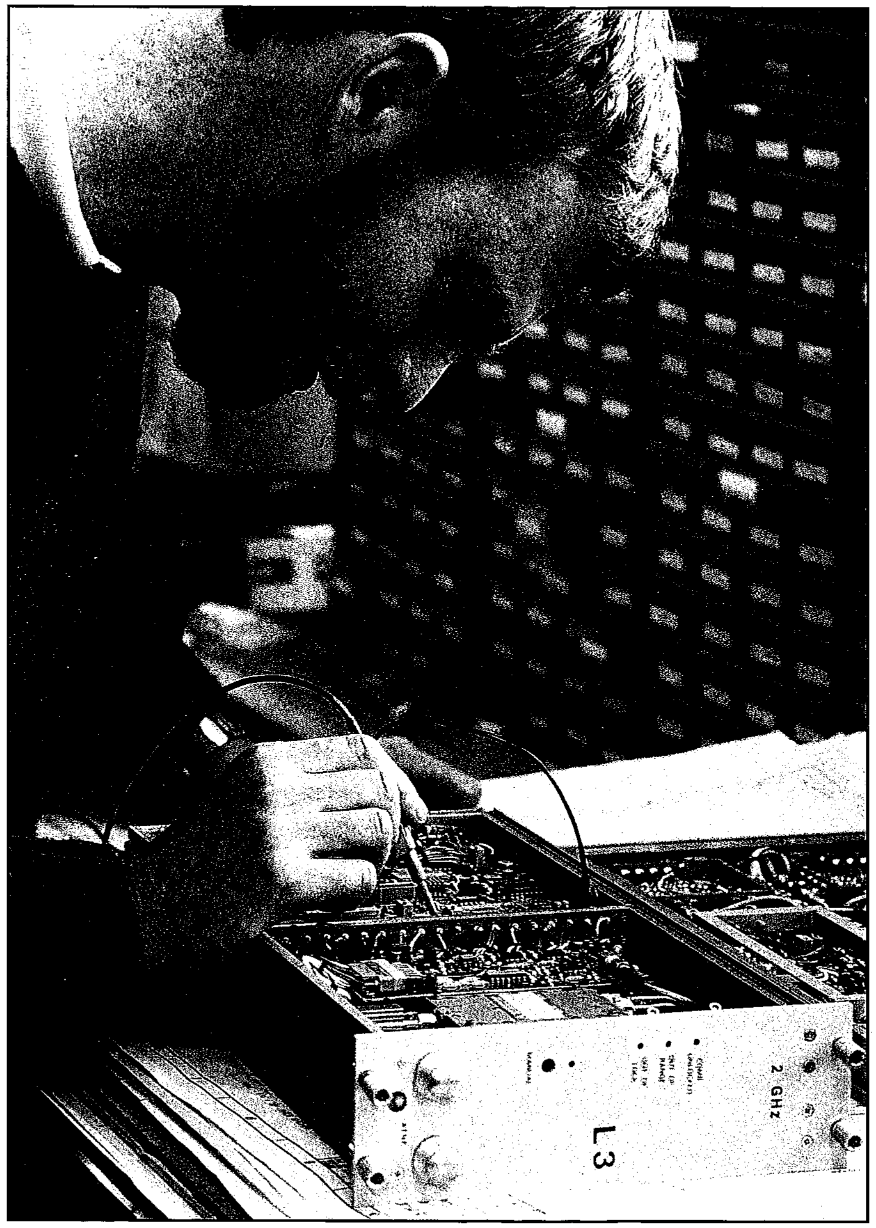
H. Dickel
J. Dickel

STAFF

As of November 1992 the ATNF had 138 staff (excluding students and visitors).

ATNF staff and associated staff are shown in Figure 3. Following the formal end of the Telescope's construction in 1991, the former Correlator and Signal Distribution groups were amalgamated into a single Electronics group.
The positions marked with an asterisk are funded by the Division of Radiophysics. There are other positions at the Radiophysics Laboratory (for example, some in the workshop) that are funded by the ATNF but are not shown here.

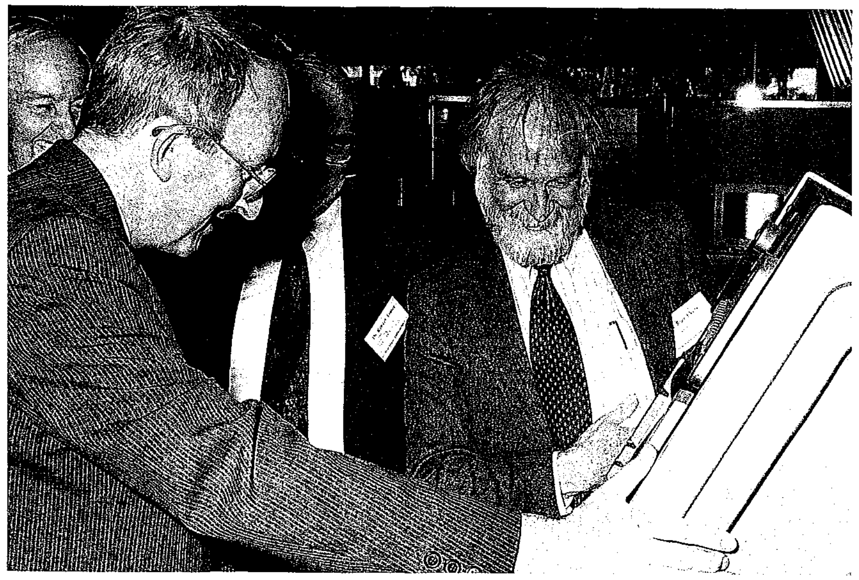
In 1992 six of the ATNF Astrophysics Group were recipients of post-doctoral fellowships, three supported by the ATNF and three by the Commonwealth Department of Industry, Technology and Commerce.



An ATNF staff member, Ross Gardyne, testing a 2 GHz local oscillator module of the Australia Telescope.

The ATNF is committed to informing the Australian public about its activities. Increasingly, it is doing this in collaboration with other organisations, through mechanisms such as the FOCAL group (see page 18) which was set up this year to promote the major professional observatories of NSW.

ATNF staff are frequently called upon to talk to astronomical societies, amateur astronomical groups, Rotary, Apex and Lions Clubs, and schools. They are also asked to speak on radio and television, either to comment on recent developments in astronomy in general or to speak on ATNF work in particular. Items of ATNF work considered to be of general public interest are publicised through media releases.



A 'hands on' display in the Visitors Centre at the ATNF's Narrabri site, attracting the attention of (left to right): the Minister for Science, the Hon. Ross Free; the Director of the CSIRO Institute of Information Science and Engineering, Dr Bob Frater; and the Director of the ATNF, Dr Ron Ekers.

As in previous years, the ATNF provided displays for a diverse range of events. It also hosted visits by a number of groups, including the 1992 Australian International Space School, organised by the Australian Science Teachers Association.

Visitors Centres

Both the Parkes and Narrabri sites have Visitors Centres that provide the public with an opportunity to learn about the activities of CSIRO, the ATNF in particular, and astronomy in general. The Centres are operated under the direction of the Officers-in-Charge of the associated ATNF sites, under the guidance of a Visitors Centre Advisory Committee.

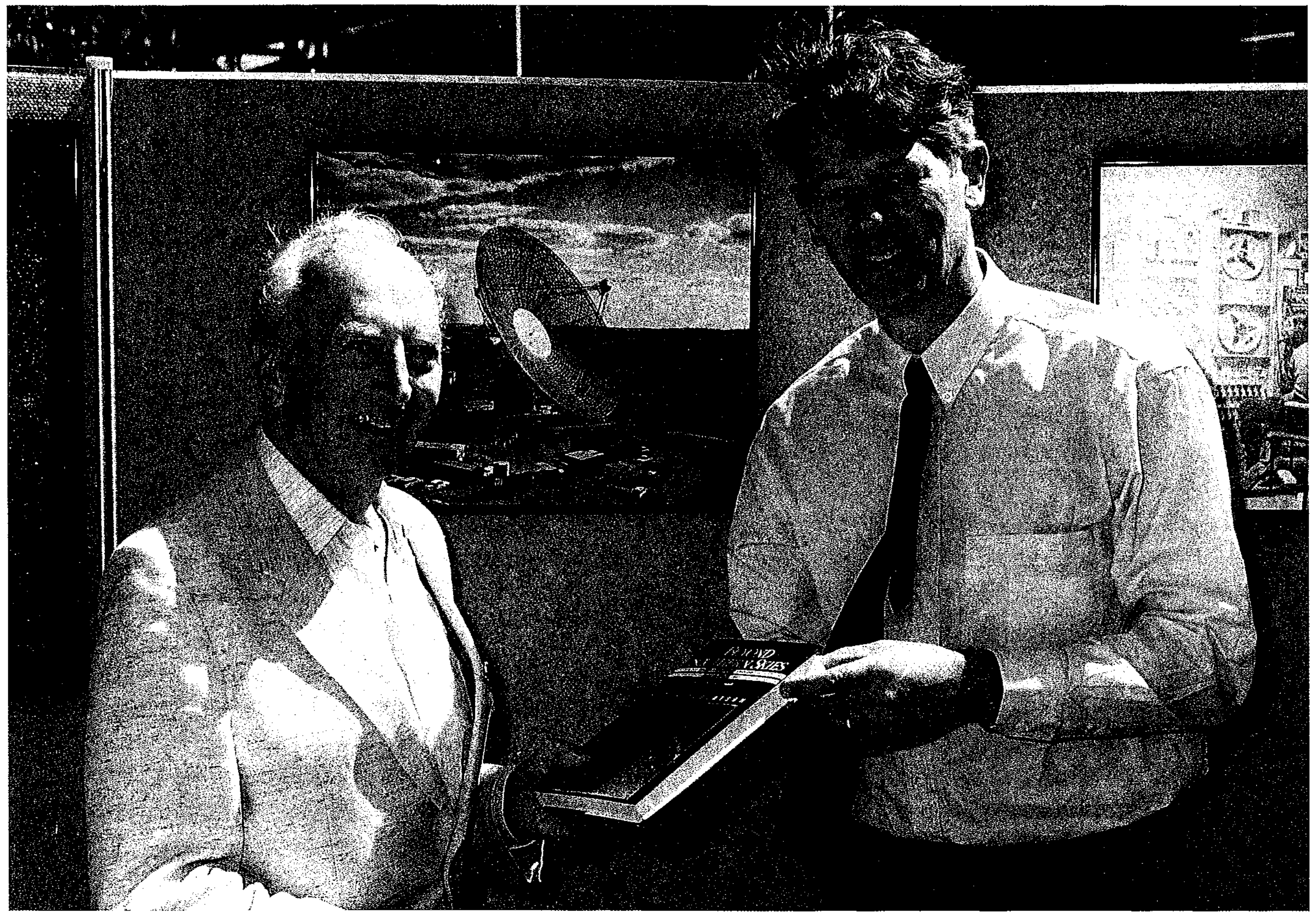
The Parkes Astronomy Education and Visitors Centre is staffed seven days a week. Over the past year it was visited by about 50 000 people, including 50 schools during the day and a further 20 for night-time observing sessions, and 100 coach tours.

The Narrabri Visitors Centre is now staffed full-time, Monday to Friday. The Centre was formally opened by the Minister for Science, the Hon. Ross Free, in April this year. Publicity gained by television coverage of the opening boosted visitor numbers to 2400 that month, the highest monthly figure to date. As in previous years, the Observatory held an 'open day' in October for the benefit of the local community.

To publicise the ATNF's Narrabri site and its Visitors Centre, a 'digital automatic tourist information system' has been installed near Narrabri. This consists of a continuous 1-watt transmission, at an FM frequency, of a 12-minute message about the Australia Telescope and other attractions in the Narrabri district. Billboards will be erected along the main highways to alert motorists to the broadcast. A similar system is planned for the Parkes Observatory.

Science prizes for Schools and TAFEs

As in past years, in 1992 ATNF presented awards to students at high schools and TAFE colleges in Parkes and Narrabri, for educational achievements in physics and technology studies.



Peter Robertson (right), the author of "Beyond Southern Skies", with Dr Harry Minnett, a former Chief of the CSIRO Division of Radiophysics and one who played a large role in the design of the Parkes radio telescope.

The Compact Array – the complete story

The design and development of the Compact Array is now open to public view, through the *Journal of Electrical and Electronics Engineering, Australia*, Volume 12, No. 2, June 1992 (a special issue on the Australia Telescope). This volume contains a general overview and system description, and chapters on the signal path through the antennas, feeds, receivers, sampling, optical fibre and delay systems, signal processing, Compact Array operations, and the first radio astronomy results.

Parkes – the definitive history

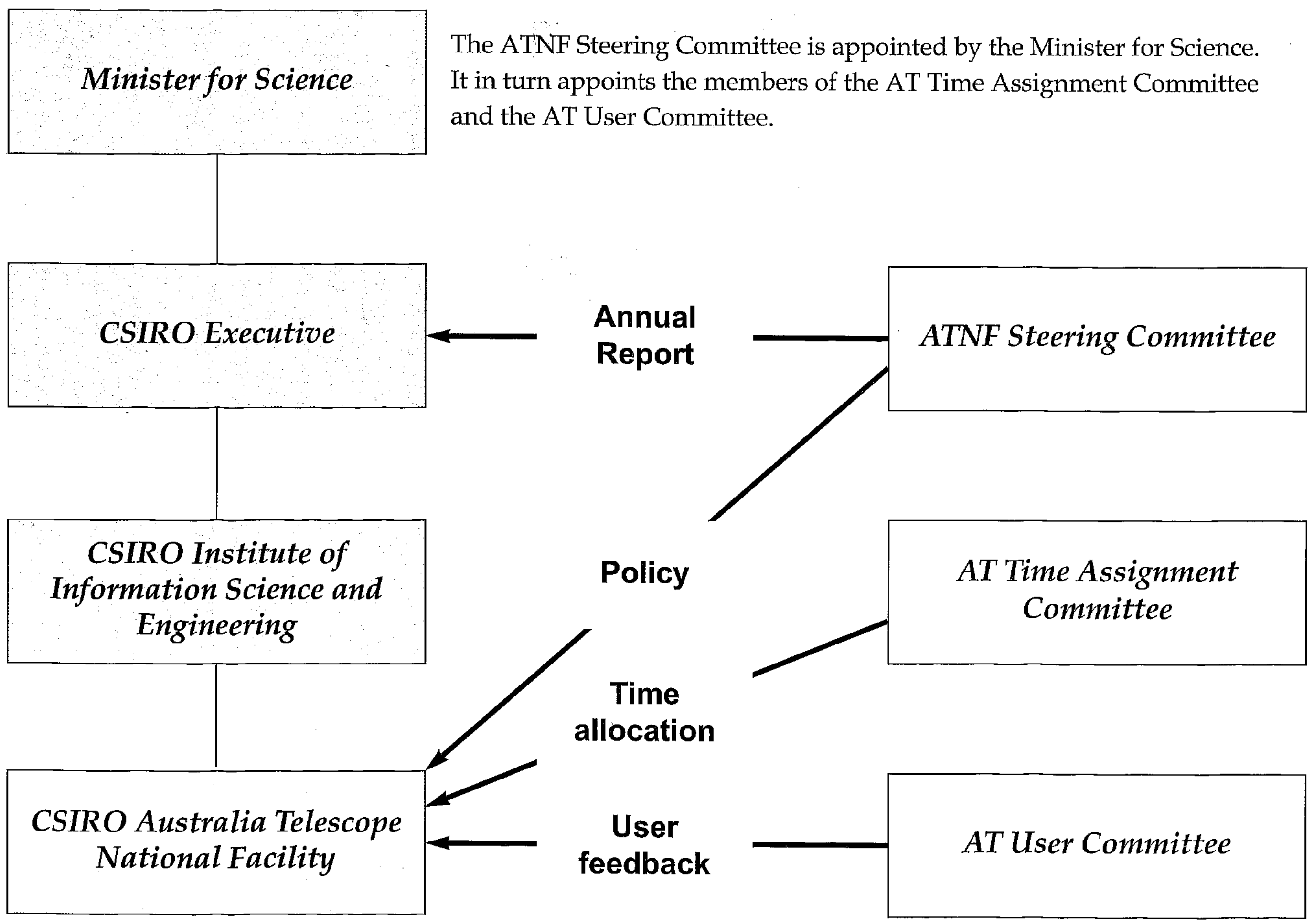
In October this year, *Beyond Southern Skies - Radioastronomy and the Parkes Telescope* was published by Cambridge University Press. Written by Peter Robertson, editor of the *Australian Journal of Physics*, it is a detailed history of the planning and construction of the Parkes radio telescope, and a survey of the telescope's achievements over the past thirty years. The book was formally launched in November 1992.

The ATNF's broad objective is to operate and develop the National Facility as a prestigious, world-class radio astronomy observatory, dedicated to the advancement of knowledge. The more specific objectives that flow from this are shown in the Operational Plan for 1992-93, which appears in Appendix E. Detailed development plans are given in Appendix C, and future directions are discussed more broadly on pages 31 to 32.

Plans for the ATNF's future development are determined by the ATNF Steering Committee, an independent committee appointed by the Minister for Science, with input from the AT Users Committee (which represents Australian users of the Telescope) and ATNF management.

FIGURE 6

Operational Arrangements for the ATNF



The development of the Australia Telescope is guided by an Operational Plan. Specific milestones reached in the 1991-92 Operational Plan are noted in Appendix H; general developments are discussed below.

1992 Development of the Compact Array (Narrabri antennas)

General operation

• Last year's development highlight for the Compact Array was the completion of the '6-km' antenna. This year attention has been directed to upgrading instrumentation, particularly the antenna control computers.

• The Array's 'down time' was reduced to less than 5% this year.

Simultaneous operation at two frequencies

• Dual polarizations can now be obtained at two frequencies in the same band, or in different bands in the 20-cm/11-cm and 6-cm/3-cm pairs. Filters with bandwidths of 4, 16 and 32 MHz have been installed in all antennas, complementing the existing 8-MHz filters. In practical terms this means that there is a greater range of frequency resolutions, making it possible to observe narrow spectral lines (such as those from masers – see page 6).

Antenna control computers upgraded

• Prior to 1992, each antenna was controlled by a PDP 11/73 processor with the actual antenna servo system controlled by a second subordinate computer. This year the PDP processor was provided with an interface for reading position encoders, the second computer was removed, and new, more efficient control software was written. The new system is much more robust and reliable than the old one.

• As part of the computer upgrade, the two VAX 8250 computers controlling on-line and off-line Compact Array operations have been replaced with MicroVAX 3100 units.

Receiver upgrade

• The 6-cm/3-cm receiver system is being upgraded. The 3-cm field-effect transistor (FET) amplifiers are gradually being replaced by high-electron-mobility-transistor (HEMT) units, which will halve the system temperature to about 40 K. At the same time, the 6-cm FETs are being replaced with wider band HEMTs: these will provide system temperatures of about 70 K at 6.7 GHz, the frequency of a recently discovered methanol maser transition. (The replaced units had been designed to a specified upper frequency of 6.0 GHz.)

Other developments

• A local-oscillator phase transfer system has been installed. This corrects for variations in the length of the local-oscillator reference cable during operation of the Array, and has greatly improved the instrumental phase stability.

• A 'switched correlator' configuration is being tested. This will enable more accurate polarization calibration and better interference suppression.

• The pointing characteristics of the 22-m antennas are being studied.

• So that the Compact Array may be used at millimetre wavelengths, atmospheric stability at the site is being measured, a millimetre-wave receiver is being built, and millimetre-wave optics are being designed.

• An Operations Coordinator has been appointed. He is responsible for user support and, during maintenance periods, for coordinating access to the antennas by local and visiting personnel.

1992 development of the Coonabarabran antenna

• The outfitting of the Coonabarabran antenna was finished last year, and this marked the formal end of the Australia Telescope's construction. This year the antenna was brought into regular operation. Members of the AT user community have been canvassed for proposals to use the antenna for millimetre-wave observations in the near future.

• This antenna is now outfitted with the same receiver systems that are available at Narrabri (including the 6-cm/3-cm HEMT upgrades).

• Several VLBI observations (see page 16) have taken place since the first successful run in November 1991.

• The antenna now has a correlator, containing only two blocks but based on the Compact Array design.

• A small antenna has been erected at the site. This will be used in long baseline interferometry projects (LBA, VLBI) to receive frequency reference signals from the communications satellite Optus B1.

• The ATNF is constructing a millimetre-wave receiver system for use on the Coonabarabran antenna: this will be installed in 1993. The ATNF's receiver group has analysed the optics and secondary focus area of the 22-m antennas, and produced a design covering the frequency range 80-115 GHz for both the Coonabarabran and Compact Array antennas. At the end of 1992 this project was proceeding on three fronts: dewar design, horn construction, and helium compressor development.

1992 development of the Parkes telescope

General operation

• One-person operation of the telescope has been instituted and appears to be successful. It is based on the use of a 'dead man's handle', an electronic timer and an alarm system. A telephone link with a second person is required for the operation.

• The Telescope's 'down-time' for the May-July and August-October quarters this year was unfortunately higher than average (12% and 17% respectively), due to a major computer breakdown in the first period and the failure of a 7-mm receiving system during the second.

Total quality management

As noted in last year's report, an ATNF team – one of four throughout CSIRO – was set up to evaluate the use of Total Quality Management techniques in the development of a scheme to train observers to operate the Parkes telescope. The team met ten times and the new training scheme was implemented at the beginning of July.

Correlator replaced

As mentioned in last year's report, the old Parkes digital correlator has been replaced by a system containing components designed for the Compact Array. The system was further refined this year in terms of bandwidth. It now provides bandwidths of 4, 8, 16, 32 and 64 MHz for two simultaneous inputs, with the number of associated channels ranging from 512 at 64 MHz, to 8192 (of which only 2048 can be stored) at 4 MHz. It is now necessary to change the operating system of the Parkes-Tidbinbilla Interferometer (an arrangement in which a 70-m antenna at NASA's Canberra Deep Space Communications Complex is linked to the Parkes telescope in real-time).

New 6.7-GHz/12.2-GHz receivers

A cooled dual-polarization 6.7-GHz/12.2-GHz system was installed on the telescope in December 1991. The average zenith system temperatures were 45 K at 6.7 GHz, and 80 K at 12.2 GHz. The system is intended primarily for observing two interstellar methanol transitions which produce strong, widespread maser emission. It has already provided the first detection of 6.7-GHz methanol maser emission in a galaxy other than our own (the Large Magellanic Cloud). (See page 6).

VLBI capability

A full VLBI capability (a MkIII recording system and a hydrogen maser) is now available at Parkes.

Parkes tested for involvement in NASA survey

NASA is conducting a search of nearby solar-type stars for possible signals from extraterrestrial civilisations. There are plans to use the Parkes telescope for part of this search (known as the High Resolution Microwave Survey) in 1994. (See page 17 for details) In April this year NASA staff used the Parkes telescope to investigate the radio interference occurring within the frequency bands covered by the telescope's 20-cm and 13-cm receiving systems. Except for occasional interference near 1.6 GHz from GPS and GLONASS satellites the interference from man-made transmitters was low, and would not hamper the planned 1994 observations.

1992 development of the Long Baseline Array

• Two Canadian S2 recording systems were tested in July. One system was connected to data streams originating from four of the Compact Array antennas, the other was installed at the Coonabarabran antenna. The recorded signals were correlated in Sydney; fringes were found for all baselines.

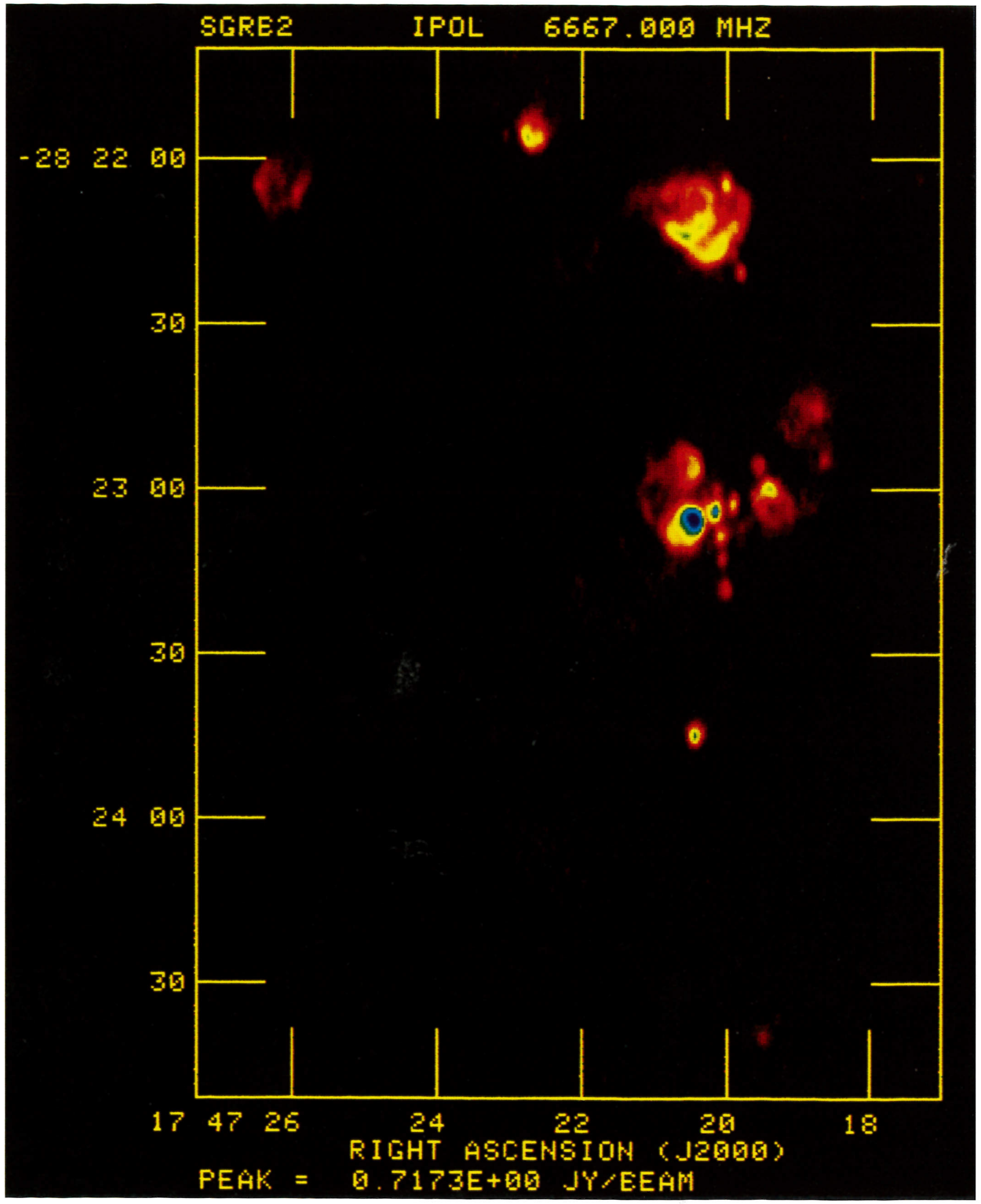
• Small antennas, installed at Parkes and Tidbinbilla, were used in November to test the phase-transfer system via the communications satellite Optus B1. These locations were chosen because both have access to maser frequency sources for comparative tests.

Finances

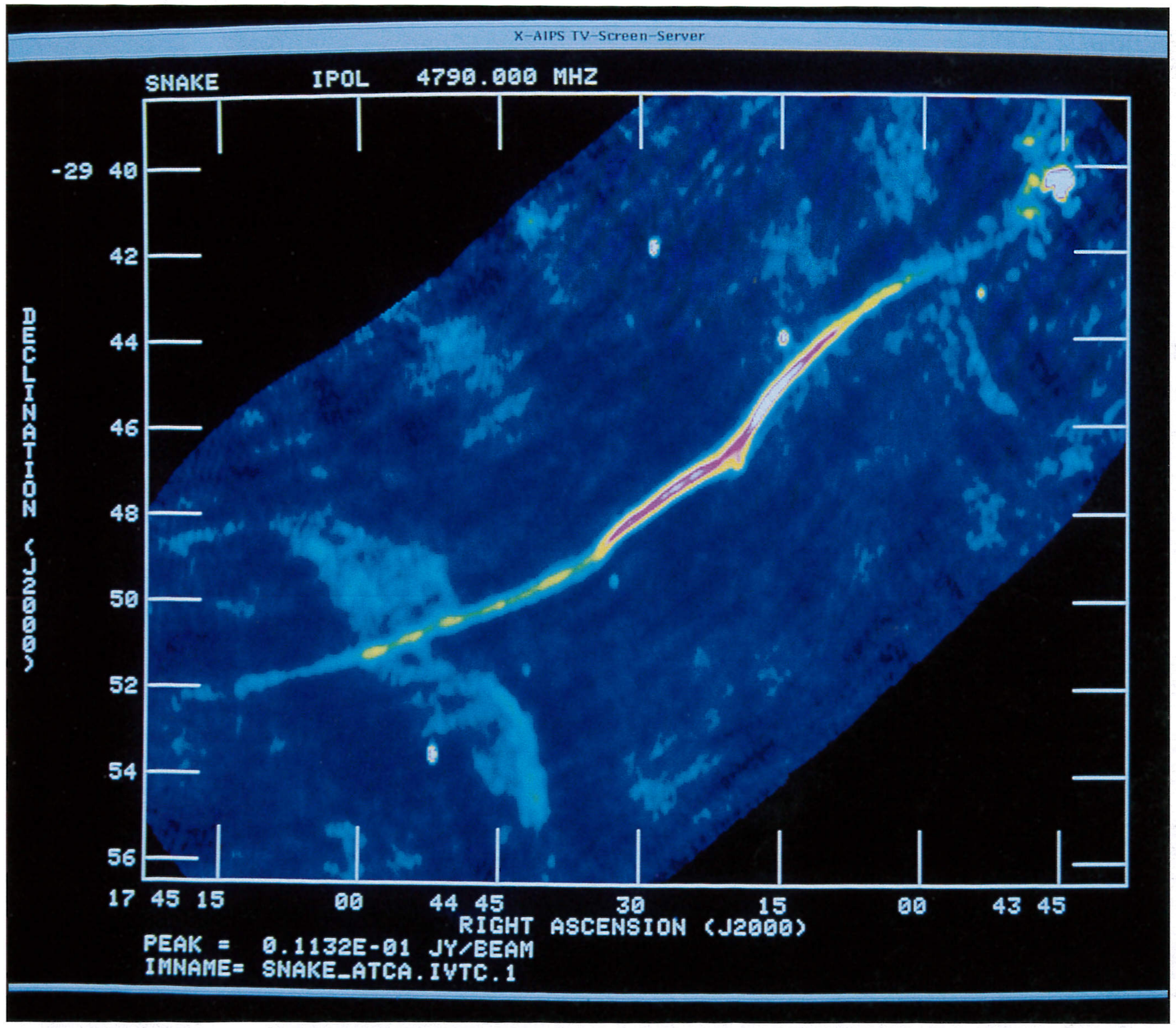
Appendix I lists details of the ATNF Operations Budget for the year 1991/92. The total amount is $10 398 000, containing $6 036 000 for salaries, $3 777 000 for operating, and $585 000 for development.

A construction budget of $625 000 is managed independently by the ATNF Engineering Manager, John Brooks. It is mainly for hardware associated with outfitting the antennas for use as the Long Baseline Array.

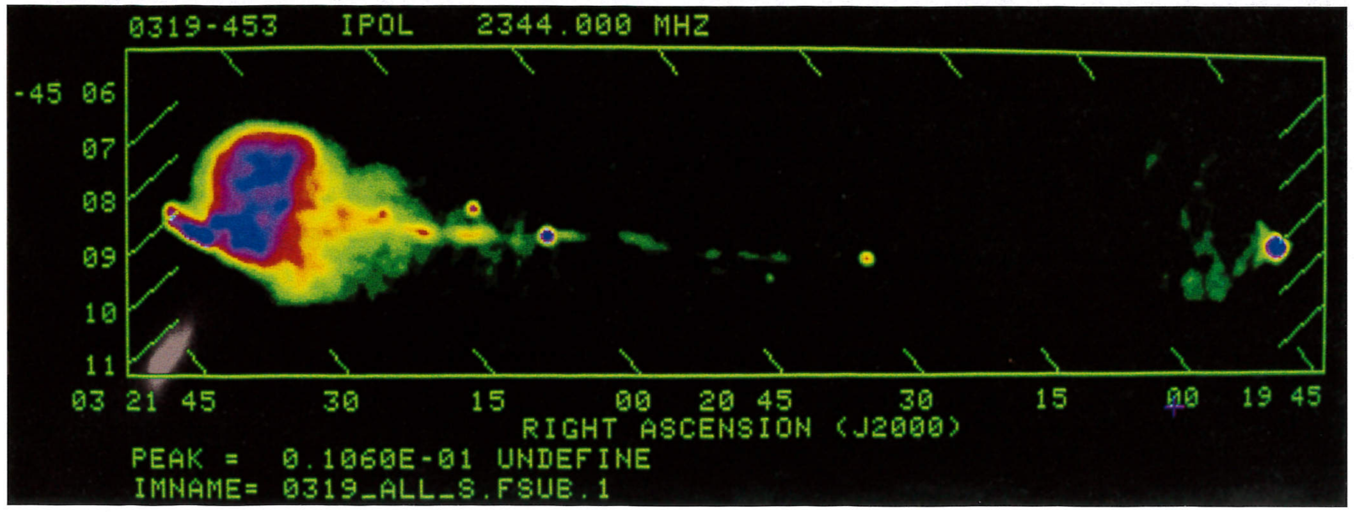
Appendix C shows the development budget associated with the ATNF's five-year plan.



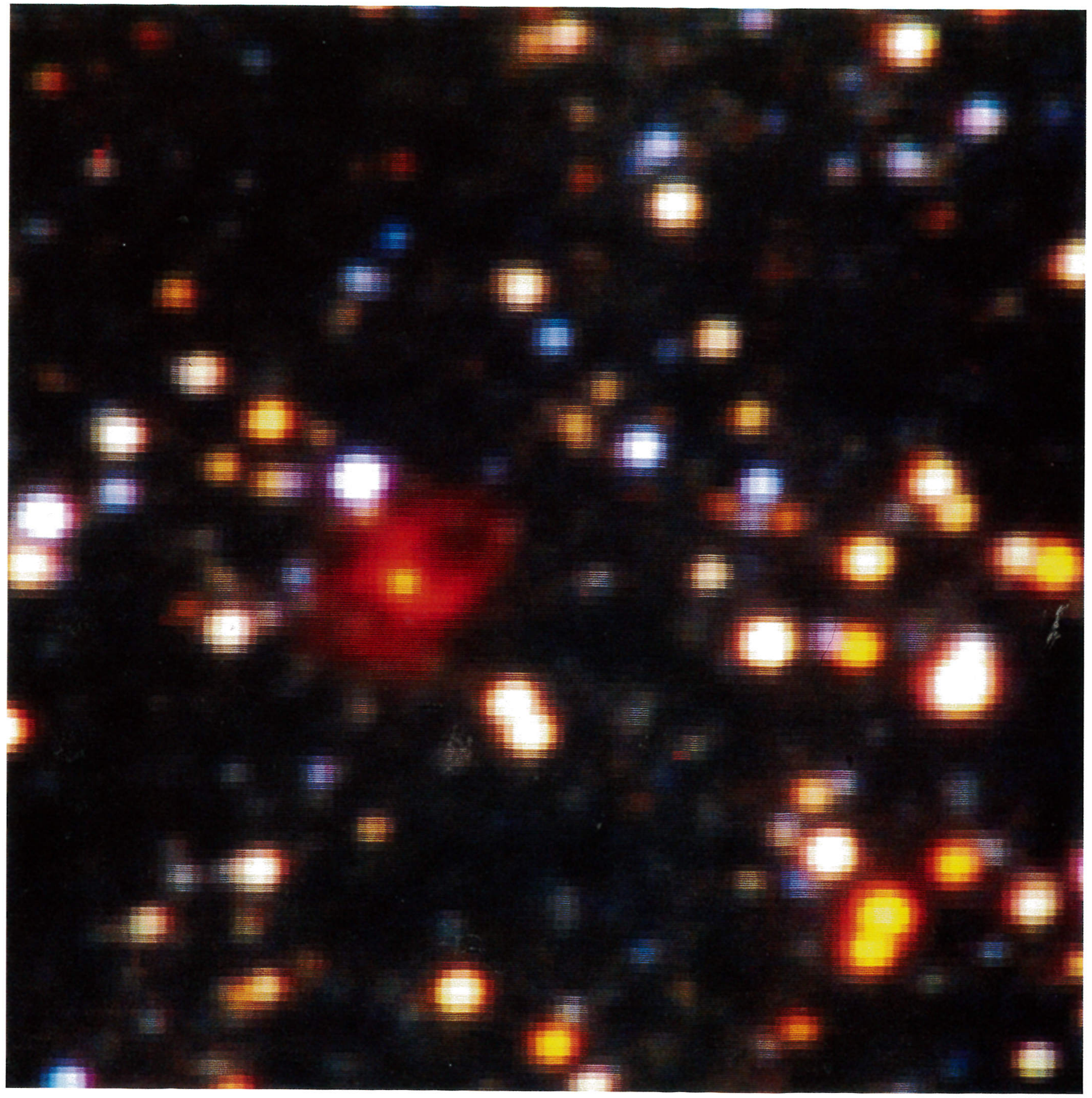
Small-scale regions of ionised hydrogen gas associated with the radio source Sagittarius B2 – a region where stars are forming. In this region there are extended, dense clouds of gas and dust. Within the clouds are methanol masers (not shown) which mark active regions of star formation. (See page 6.) Observers: John Whiteoak, Sally Houghton



Above: 'the Snake', an unusual long thin radio source near the centre of our Galaxy. (See page 9.) Observer: Andrew Gray



The longest 'radio jets' found so far. Some galaxies shoot out streams of radio-emitting particles, which are called 'radio jets'. This picture shows the radio galaxy 0319-453 as a small dot (between '15' and '00'), with radio jets extending to the left and right. The jet to the left ends in large radio-emitting region; the one extending to the right is much fainter. Radio jets are not uncommon, but these are the longest ones ever found: each is more than one-and-a-half million light-years long. These observations are the first clear case of twin jets (a jet and a counterjet) in a radio source of this type (FRII). Observers: Lakshmi Saripalli, Ravi Subrahmanyan, Dick Hunstead



An infrared image of the object G25.5+0.2, made with the Anglo-Australian Telescope (an IRIS image). Following observations with the Australia Telescope , Anglo-Australian Telescope and the Very Large Array (US), G25.5+0.2, whose nature was previously uncertain, appears be an extremely rare luminous blue variable star that has recently thrown off a large amount of matter. (See page 7.) Observer: David Allen. Image courtesy of the AAT Board.

Future Development

Appendix E shows the 1992-93 Operational Plan for the ATNF. The broad objective is to operate and develop the Facility as a prestigious and world-class radio astronomical observatory; more specific objectives are:

- to operate the Telescope as a National Facility;
- to pursue a program of research in astronomy and astrophysics that complements the national facility role;
- to develop the next generation of radio astronomy instrumentation, and to support and develop the computing facilities shared by the ATNF and the Division of Radiophysics;
- to promote the activities of the ATNF, and to provide information and educational resources.

The ATNF's development plans are a further refinement of these objectives. The details of the five-year plan, which is based on inputs from the user community and from ATNF astronomers and engineers, are given in Appendix C. Some future developments are discussed below.

Compact Array (Narrabri antennas)

Improved frequency coverage

The field-effect-transistor (FET) pre-amplifiers used in the 5.3-GHz/8.6-GHz dual-frequency system will be replaced by high-electron-mobility-transistor (HEMT) units. This will provide a much more sensitive 8.6-GHz receiver and, at the lower frequency, a wider bandwidth, resulting in a much-improved system performance at 6.7 GHz (the frequency of an important methanol maser).

At present the highest available frequency on the Array is 9.2 GHz, but the ATNF plans to install a receiving system for frequencies of 12-25 GHz. This will make it possible to observe several important molecular spectral lines, many of which cannot be observed with other radio telescope arrays. It will also give better spectral coverage and angular resolution when the 'continuum' emission of radio sources is being studied.

Greater frequency resolution

Higher spectral resolution would enhance studies of narrowband maser emission from interstellar molecules. At present, 4-MHz filters installed at the antennas provide a maximum resolution of 2 kHz; 1-MHz and 2-MHz filters would improve the resolution to 250 Hz.

Extra stations for antennas

The quality of the images produced from Compact Array data depends on the number and distribution of the spacings between pairs of antennas. At the moment the available spacings include many multiples of the basic 15-m spacing. This creates a problem when extended objects (i.e. those that cover a lot of sky) are being observed; artefacts appear in the radio images. Adding extra antenna 'stations', to create a different pattern of spacings, would make the problem less severe. Extra stations could also provide more sets of 'small' antenna configurations: such sets are useful for certain low-frequency spectral line studies, and essential for high-frequency work.

'Tying' of the Array

It is likely that the six antennas of the Compact Array will be 'tied' together occasionally, to be used as the equivalent of a single 54-m diameter telescope. This would be useful in, for instance, VLBI projects (see page 16).

A high-frequency capability

Institutions around the world are becoming more interested in building radio telescope arrays that can operate at millimetre wavelengths. Several arrays are planned, or already operating, in the Northern Hemisphere. As yet there are no such arrays in the Southern Hemisphere - although sooner or later they will be built here, by Northern Hemisphere institutions. Equipping the Compact Array for high-frequency operation in the near future would exploit a 'window of opportunity', and place Australian astronomy at the leading edge in this area. The band of frequencies between 85 and 115 GHz is extremely rich in important molecular lines, and the Compact Array antennas were designed to operate in this range.

The Array could be upgraded for high-frequency work by:

- designing and building receiving systems for frequencies of 84-116 GHz;
- building a 1-km north-south track linked to the existing 3-km east-west track, and a new, low-precision rail-track to link the 6-km antenna to the existing track; and
- developing a high-frequency focal-plane feed array.

ASTEC (the Australian Science and Technology Council), in its 1992 report on 'Major National Research Facilities', identified this project as one of seven 'most likely proposals for development over the next decade'.

Observations near 116 GHz can be hampered by water vapour in the Earth's atmosphere. At the moment, the quality of the sky at Narrabri is uncertain, and so tests are being done with a water-vapour radiometer. Before the Array is fully upgraded to higher frequencies, a pair of antennas will be set up to operate as a millimetre-wave interferometer, as a trial. As well, much will be learnt from the outfitting of the Coonabarabran antenna for higher frequencies, which is already under way (see page 26).

Parkes radio telescope

12-25 GHz receiving system

Many important molecular lines have frequencies between 12 and 25 GHz. At the moment, however, the receiving systems on the Parkes telescope can cover only a band of frequencies near 12 GHz (for a spectral line produced by the methanol molecule) and a region between 21 and 24 GHz (water vapour and ammonia lines). There is considerable interest in outfitting the antenna with a system that can cover the whole band; this will be developed as a prototype for receivers for the the Compact Array and Coonabarabran.

A multi-beam system for hydrogen-line observations

Astronomers are interested in surveying the southern sky for the neutral hydrogen gas in interstellar space. But doing such a survey with the Parkes radio telescope would be impractically slow, if a conventional single-feed receiver were used. To make this work feasible the ATNF will construct a nine-beam feed array for Parkes. Overseas partners are being sought, to share costs.

Space VLBI

As mentioned on page 16, space VLBI will soon be a reality, with the launch of the Russian satellite, RadioAstron, and the similar VSOP satellite of Japan. (Australia's participation in RadioAstron is discussed on page 16.) With its large radio telescopes and southern location, Australia is in a unique position to contribute to the scientific success of both space missions. The extent to which ATNF antennas can be dedicated to space VLBI has to be decided upon in light of the potential scientific returns and competing demands for Telescope time. At present it seems likely that up to ten per cent of observing time could be made available on the Parkes antenna or the tied Compact Array for Space VLBI work.

The ATNF is represented on the RadioAstron International Science Council (RISC); the VSOP Science Steering Council (VSSC); and working groups of the Inter Agency Consultative Group (IACG), whose members are drawn from the world's major space agencies.

Appendix A

Program of Observations, 1992

1. Observations made with the Australia Telescope Compact Array, December 1991-November 1992 inclusive

Observers	*Affiliations*	*Program*
Amy, Dopita, Turtle, Milne	USyd, MSSSO, USyd, ATNF	The young oxygen-rich SNR 1E0102-72.3 in the SMC
Amy, Turtle	USyd, USyd	HI observations of a strong compact source in the LMC
Anderson, Ekers, White, Danziger	UWS, ATNF, UWS, ESO	AT Compact Array observations of the ROSAT deep Pavo field
Anderson, White, Danziger	UWS, UWS, ESO	Radio survey of a large sample of ROSAT X-ray selected extragalactic sources
Beasley, Ball, Stewart, Slee, Cram	NRAO, USyd, ATNF, ATNF, USyd	Radio observations of HD 15555
Beck, Harnett, Haynes, Wielebinski, Klein, Krause	MPIfR, USyd, ATNF, MPIfR, MPIfR, MPIfR	AT observations of NGC 2442 and the Circinus galaxy
Bignami, Caraveo, Mereghetti, Manchester, D'Amico	IFM, IFM, IFM, ATNF, UBol	Search for a synchrotron nebula in G296.5+10.0
Bookbinder, Guedel, Saar, Brown	UMar, JILA, UMar, JILA	Coordinated AT-ROSAT observations of M-Dwarfs
Brown, Bromage, Jeffries	JILA, RAL, UBir	AT continuum observations of 'Speedy MIC' (HD 197890)
Brown, Skinner, Stewart, Zealey	JILA, JILA, ATNF, UWol	Extended radio continuum emission around IRS7
Budding, Slee, Stewart, Beasley, Ball	CO, ATNF, ATNF, USyd, USyd	Radio observations of seven southern contact binaries
Budding, Slee, Stewart, Innis, Nelson	CO, ATNF, ATNF, UBir, ATNF	Observations of 'Speedy MIC'
Burgess, Hunstead	USyd, USyd	The Southern 3C Survey
Carignan, Demers, Côté, Beaulieu	UMon, UMon, MSSSO, MSSSO	The HI distribution and kinematics of dwarf spheroidals
Carignan, Meurer	MSSSO, UMon	Dark matter and the extended HI disk of NGC 2915
Chapman, te Lintel Hekkert	ATNF, MSSSO	A search for 3-cm and 6-cm continuum emission from proto-planetary nebulae
Chapman, te Lintel Hekkert	ATNF, MSSSO	OH-line observations of five proto-planetary nebulae
Côté, Carignan, Freeman	MSSSO, UMon, MSSSO	HI kinematics of dwarf galaxies in the Sculptor and Centaurus groups
Dopita, Milne	MSSSO, ATNF	The young oxygen-rich SNR 1E0102-72.3 in the SMC
Drake, Stewart, Brown, Linsky	NASA, ATNF, U Col, U Col	A radio survey of southern helium-strong magnetic stars
Duncan	ATNF	Studies of strong southern sources
Duncan, Wark	ATNF, ATNF	AT calibrators
English, Freeman	MSSSO, MSSSO	The kinematics of HI in merging galaxies
Faulkner, Wood, Wright	MSSSO, MSSSO, ATNF	21-cm mapping of the globular cluster Omega Centauri

Forbes, Norris, McCulloch, English	CfA, ATNF, ATNF, MSSSO	High resolution of starburst galaxies
Fosbury, Ekers, Wilson	ESA, ATNF, ATNF	PKS 2152-69 image
Freudling, Lagrange, Vidal-Madjar, Beust, Ferlet, Forveille	AO, OGR, IAP, IAP, IAP, OGR	Gas around Beta Pictoris
Glass, te Lintel Hekkert	SAAO, MSSSO	Deep search for OH stars in the Galactic Centre clear fields: Sgr I and NGC 6522
Gregg, te Lintel Hekkert, van Gorkom	MSSSO, MSSSO, UCol	An HI Image of the Fornax cluster of galaxies
Guedel, Benz, Nelson, Lim, Schmitt	JILA, ETH, ATNF, UMar, MPE	Observations of UV Ceti simultaneously with ROSAT
Harnett, Haynes, Beck, Lesch, Klein, Wielebinski	USyd, ATNF, MPIfR, MPIfR, MPIfR, MPIfR	20-cm continuum observations of NGC 4945
Harnett, Haynes, Beck, Wielebinski, Klein	USyd, ATNF, MPIfR, MPIfR, MPIfR	ATCA observations of NGC 1672 and NGC 1566 at 120 cm and 6 cm
Haynes, Beck, Wielebinski, Harnett, Klein, Ehle	ATNF, MPIfR, MPIfR, USyd, UBonn, MPIfR	Spurs or jets of radio emission from the core of NGC 4945
Haynes, Klein, Wielebinski, Harnett	ATNF, RAIUB, MPIfR, USyd	Fine-scale structure of the magnetic field in the LMC
Higdon, Wallin, Staveley-Smith	UTex, NRL, ATNF	Neutral hydrogen mapping of three southern ring galaxies
Hunstead, Wieringa, Miley, Liang	USyd, ATNF, UL, MSSSO	High resolution images of ultra-steep-spectrum sources
Jaffe, Fabian, McNamara, Edge	LO, CfA, KI, CfA	Neutral hydrogen in cooling flow clusters of galaxies
Jones, McAdam	USyd, USyd	Radio galaxies of large angular size
Jones, Nelson, Stewart	UQld, ATNF, ATNF	Coronal models of RS CVn and other stars deduced from flux and polarization spectra.
Kaspi, Johnston, Manchester	UPr, ATNF, ATNF	The G308.8-0.1–PSR 1338-62 association
Koekemoer, Bicknell, Ekers	MSSSO, MSSSO, ATNF	The extended emission line FR I/FR II radio galaxy PKS 2014-55
Koekemoer, Bicknell, Ekers, Schilizzi	MSSSO, MSSSO, ATNF, NFRA	The extended emission line radio galaxy PKS 2356-61
Koorneef, Richter	STScI, STScI	High spatial resolution 21-cm observations at positions of several early-type supergiant stars in the LMC and SMC
Levasseur, Carignan, Byun	UMon, UMon, IAHI	Opacity and thickness of edge-on spiral disks
Liang	MSSSO	The HST cluster 0050-21
Liang, Ekers, Subrahmanyan, Silk, Couch	MSSSO, ATNF, ATNF, UCal, UNSW	Observation of the Sunyaev-Zel'dovich effect
Liang, van Gorkom, Ekers, Wilson	MSSSO, UCol, ATNF, ATNF	Pencil-beam survey of HI objects towards the South Galactic Pole
Lim, Nelson, Benz, Guedel, Schmitt	UMar, ATNF, ETH, UCol, MPE	A simultaneous X-Ray observation of Rossiter 137A and B
Lim, Nelson, Guedel	UMAR, ATNF, JILA	Thermal and non-thermal emission of the FK Comae star HD 32918

Lim, Nelson, Kilkenny, Dempsey, Carter	UMar, ATNF, SAAO, NASA, UNSW	Rotational modulation of AB DOR: # IV. Stellar parameters and relationship between radio emission, starspots and large regions of unipolar magnetic fields
Lim, Nelson, Vaughan, White, Kundu	UMar, ATNF, MU, UMar, UMar	Radio imaging of the pre-Main-Sequence triple stellar system LDS 587
Lim, Stencel, Wark, Mikolajewska	UMar, UCol, ATNF, NCAC	Radio imaging of symbiotic stars: #I. A quick survey for resolvable objects
Lindblad, Jögsäter, Sandqvist	StO, StO, StO	High resolution radio continuum observations of the fast rotating active nuclei of NGC 1672
Manchester, Staveley-Smith, Kesteven	ATNF, ATNF, ATNF	Imaging and polarization of SNR 0540-693
McCall, Rucinski, Killeen, Buta	YU, YU, ATNF, UAI	Search for neutral hydrogen in A2311.8-4353
McConnell, Ables, Hall, Jacka, Hamilton, McCulloch	ATNF, RP, ATNF, RP, UTas, UTas	Detection of point sources in the direction of 47 Tucanae
McConnell, Ables, Hall, Jacka, Hamilton, McCulloch	ATNF, RP, ATNF, ATNF, UTas, UTas	Detection of point sources in selected southern globular clusters
Mebold, Dickey, Greisen, Herbstmeier, Wilson, Haynes	UBonn, UMinn, NRAO, UBonn, ATNF, ATNF	21-cm absorption in the Magellanic System: # II. A deep survey of the LMC
Milne, Barlow, Walton, Clegg	ATNF, UCL, UCL, RGO	6-cm flux densities and diameters for fourteen Galactic-bulge planetary nebulae
Milne, Danziger, Turatto, Cappellaro	ATNF, ESO, AOA, AOA	Radio detection of historical supernovae
Milne, Dickel	ATNF, UIl	The SNR N103B in the LMC
Milne, Dickel	ATNF, UIl	The SNR 0519-690 in the LMC
Milne, Dickel, Junkes	ATNF, UIl, UKiel	Observations of the SNRs N49 and N49B in the LMC
Milne, Dickel, Junkes, Klein	ATNF, UIl, MPIfR, MPIfR	Imaging of the SNR N63A in the LMC
Milne, Kesteven, Haynes	ATNF, ATNF, ATNF	The Galactic SNR RCW 103
Milne, Kwok	ATNF, UCalg	Radio imaging of IRAS planetary nebulae
Morganti, Killeen, Fosbury, Tadhunter, Seregoaliguieri	UBol, ATNF, ESO, RGO, AOAR	The radio structure of 2-Jy sources
Nelson, Lim, White, Guedel, Vaughan	ATNF, UMAR, UMAR, JILA, MU	Search for rotational modulation of radio emission from 'Speedy MIC'
Norris, Booth, Aalto, English, Greisen	ATNF, OSO, OSO, MSSSO, NRAO	HI imaging of NGC 3256
Norris, Roy, Blank, Kesteven, Troup, Reynolds	ATNF, ATNF, USyd, ATNF, ATNF, ATNF	Observations of Seyfert galaxies and radio-quiet quasars
Norris, Whiteoak, Wieringa, Caswell	ATNF, ATNF, ATNF, ATNF	6-GHz methanol masers
Pohl, Harnett	MPIfR, USyd	The connection between tidal interaction and galactic wind phenomena in the close pair NGC 1531/32
Pottasch, Van de Steene	KI, KI	Observations of young planetary nebulae candidates
Price, Norris, Haynes	UNM, ATNF, ATNF	Middle lobe of Centaurus A
Puche, Holdaway	NRAO, NRAO	An HI mosaic of the 30 Doradus region
Rhee, te Lintel Hekkert	UNAM, MSSSO	NATs in rich clusters: the shape of galaxy orbits
Robertson, Marson	USyd, USyd	Nature of the strong source PKS 0511-48

Ryder, Staveley-Smith, Malin, Walsh	MSSSO, ATNF, AAO, UNSW	The unusual radio source in NGC 1313
Saripalli, Subrahmanyan, Hunstead	ATNF, ATNF, USyd	Giant radio galaxy 0319-453
Schachter, Elvis, Wright, Stocke, Perlman	HSS, HSS, ATNF, UCol, UCol	Bright far southern BL Lacs in the Einstein Slew Survey
Slee, Budding, Stewart	ATNF, CO, ATNF	Early star observations
Staveley-Smith, Killeen, Wilson, Norris, Chapman, Sault	ATNF, ATNF, ATNF, ATNF, ATNF, ATNF	Magnetic fields in active galactic nuclei
Staveley-Smith, Manchester, Kesteven, Reynolds, Tzioumis, Killeen	ATNF, ATNF, ATNF, ATNF, ATNF, ATNF	SNR 1987A
Staveley-Smith, Ryder, Malin, Walsh	ATNF, MSSSO, AAO, USyd	Kinematics and star-formation in the asymmetric barred spiral NGC 1313
Staveley-Smith, Sault, Kesteven, McConnell, Hatzidimitriou, Côté, Freeman, te Lintel Hekkert	ATNF, ATNF, ATNF, ATNF, AAO, MSSSO, MSSSO, MSSSO	A study of the Small Magellanic Cloud
Stewart, Caswell, Haynes, Nelson	ATNF, ATNF, ATNF, ATNF	High resolution image of the Circinus X-1 nebula at 4.8 GHz
Stewart, Haynes, Gray	ATNF, ATNF, USyd	Magnetic field structure in the 'Tornado' source G357.7-0.1
Subrahmanyan, Ekers	ATNF, ATNF	The peculiar radio source G25.5+0.2
Subrahmanyan, Hunstead, Saripalli, Burgess	ATNF, USyd, UBonn, USyd	The unusual radio source 0319-456
Subrahmanyan, Saripalli	ATNF, UBonn	Radio galaxies as a probe of the intergalactic medium
Subrahmanyan, Silk, Sinclair	ATNF, UCal, ATNF	A search for arcminute-scale CMBR fluctuations
Taylor, Dougherty, Waters	UCal, UCal, KI	Radio emission from IRAS bright Be stars
te Lintel Hekkert, Chapman	MSSSO, ATNF	3-cm and 6-cm imaging of two proto-planetary nebulae
te Lintel Hekkert, Chapman, Caswell, Killeen, Dejonghe, Habing, Kalnajs	MSSSO, ATNF, ATNF, ATNF, RUG, RUL, MSSSO	1612-MHz OH survey to complete the IRAS/OH surveys
te Lintel Hekkert, Côté, Maloney	MSSSO, MSSSO, NASA	HI observations of two face-on galaxies
Tzioumis, Jauncey, Reynolds, McAdam, King, Preston, Costa	ATNF, ATNF, ATNF, USyd, UTas, JPL/NASA, UWA	A complete sample of extragalactic radio sources
van der Klis, Nelson, Stewart	UAm, ATNF, ATNF	Joint AT/Hard X-Ray observations of black-hole candidates
van Langevelde, van Dishoeck, Israel	LO, LO, LO	OH absorption towards Centaurus A
Viallefond, Boulanger, Lequeux, Okumura, de Graauw, Rubio, Whiteoak	MO, MO, MO, MO, KI, UChi, ATNF	21-cm line aperture synthesis of selected regions of the Magellanic Clouds
Walsh, Staveley-Smith, Ekers, Freeman	ATNF, ATNF, ATNF, MSSSO	Dark matter in galaxies
White, Lim, Duncan, Drake	UMar, UMar, ATNF, NASA	η Carinae, the Homunculus and the Keyhole Nebula
White, Lim, Duncan, Nelson, Drake	UMar, UMar, ATNF, ATNF, NASA	A high spatial resolution observation of η Carinae: the radio structure of the Homunculus
White, Lim, Nelson, Vaughan, Kundu	UMar, UMar, ATNF, MU, UMar	The radio characteristics of single active cool giant stars
Whiteoak	ATNF	A 6-GHz study of the CH_3OH clouds of SGR B2
Whiteoak, Large, Cram	USyd, USyd, USyd	High-resolution imaging of a MOST peculiar source
Whiteoak, Ott	ATNF, MPIfR	The distribution of HI clouds in the southern spiral galaxy NGC 4945
Whiteoak, Peng	ATNF, UNSW	The distribution of HI, OH and H_2CO clouds in the radio galaxy NGC 5128
Wieringa, Haynes	ATNF, ATNF	A new gamma-ray source at 0209-513
Wieringa, Kesteven	ATNF, ATNF	Dark matter in microlens interference
Wieringa, Sault, Marson	ATNF, ATNF, RP	Multifrequency synthesis mapping of a powerful FR II radio galaxy
Wright, McConnell, Kesteven, Tasker, Vaughan, Savage, Griffith	ATNF, ATNF, ATNF, MU, MU, AAO, MIT	Positions, structure and identifications for strong sources from the PMN survey
Zealey, Coleman	UWol, UWol	Neutral hydrogen in highly disturbed galaxies

2. *Observations made with the Parkes radio telescope, December 1991-November 1992 inclusive.*

Observers	*Affiliations*	*Program*
Ables, Jacka, McConnell, Deshpande, Hamilton, McCulloch	RP, RP, ATNF, UTas, UTas, UTas	Observations of millisecond pulsars
Broadhurst, Côté	ROE, MSSSO	Low surface brightness objects: redshift survey
Caganoff	UMel	HI absorption toward PKS 0456-301
Carignan, Demers	UMon, UMon	The HI contents of nearby dwarf galaxies
Caswell, Vaile, Ellingsen, Whiteoak, Norris	ATNF, UWS, UTas, ATNF, ATNF	Galactic and Magellanic Cloud methanol masers at 6.6 and 12 GHz
Chapman, Killeen, Caswell, te Lintel Hekkert, Harnett	ATNF, ATNF, ATNF, MSSSO, USyd	OH/IR stars and the Galactic Centre distance
Chapman, te Lintel Hekkert	ATNF, MSSSO	A search for OH maser emission from supergiant stars with far infrared excesses
Deshpande, McCulloch, McConnell, Wilson, Davis	UTas, UTas, ATNF, ATNF, ATNF	21-cm observations of southern pulsars
Digel, de Geus, Snowden, Kerr	CfA, UMar, MPE, UMar	HI observations of Ophiucus
Faulkner, Wood, Wright	MSSSO, MSSSO, ATNF	21-cm search in massive globular clusters
Gregg	MSSSO	HI content of a dwarf elliptical with young stars
Hall, Nyman, Olofsson, Wark	ATNF, ESO, OSO, ATNF	When do SIO masers finally die?
Haynes, Harnett, Klein, Wielibinski, Spencer	ATNF, USyd, UBonn, MPIfR, USyd	12-GHz observations of southern galaxies
Haynes, Junkes, Harnett	ATNF, UKiel, USyd	Deep polarization mapping of Centaurus A
Haynes, Klein, Wielebinski, Harnett	ATNF, MPIfR, MPIfR, USyd	A search for polarization in the LMC and SMC at 21 cm
Haynes, Stewart, Reich, Reich, Gray	ATNF, ATNF, MPIfR, MPIfR, USyd	Polarization mapping at 6 cm of the Galactic Centre

Hyland, Robinson, Bourke, James	ADFA, ADFA, ADFA, ADFA	Ammonia observations of Bok globules
Kaspi, Manchester, Johnston, Lyne, D'Amico	UPr, ATNF, ATNF, JB, UBol	Pulsars in SNRs
Keenan, Conlon, te Lintel Hekkert	Q's, Q's, MSSSO	Mapping of HI in the sightlines to early-type halo stars
Manchester, Johnston, Glowacki, Lyne, Bailes, Harrison, Robinson, Lorimer, D'Amico, Nicastro, Kaspi	ATNF, ATNF, ATNF, JB, JB, JB, JB, JB, UBol, UBol, UPr	70-cm pulsar survey and timing
Milne	ATNF	3-cm polarization: Vela SNR
Milne, Caswell, Haynes, Kesteven, Stewart	ATNF, ATNF, ATNF, ATNF, ATNF	Polarization mapping of SNRs with high Faraday rotation
Milne, Haynes, Stewart	ATNF, ATNF, ATNF	Puppis A polarization
Norris, Kandalian, Staveley-Smith, Whiteoak, Roy	ATNF, BAO, ATNF, ATNF, USyd	A search for ultra-luminous OH megamasers
Norris, Wellington, Peng	ATNF, ATNF, UNSW	A search for methanol megamasers
Richter, Kraun-Korteweg, Henning	STScI, KI, NFRA	Spiral galaxies in the Zone of Avoidance
Richter, Sackett, Sparke	STScI, UPitt, UWis	An HI survey of polar ring galaxies
Richter, Schröder, Tammann	STScI, UB, UB	HI observations of Fornax cluster galaxies
Slysh, Kalenskii, Val'tts, Norris	ASP, ASP, ASP, ATNF	Search for 44-GHz methanol masers
Tarter, Webster	SETI, NASA	High-resolution interference measurements from 1 to 3 GHz
te Lintel Hekkert, Chokshi, Likkel	MSSSO, JPL, UII	A search for OH emission from QSOs
te Lintel Hekkert, Côté, Maloney	MSSSO, MSSSO, NASA	HI observations of face-on galaxies
te Lintel Hekkert, Gregg, Quinn, Freeman, Lavery	MSSSO, MSSSO, MSSSO, MSSSO, MSSSO	HI absorption observations of cooling flows
Viallefond, Boulanger, Lequeux, Okumura, de Graauw, Rubio, Whiteoak	MO, IAS, MO, MO, KI, UChi, ATNF	21-cm line observations of selected regions of the Magellanic Clouds
Visvanathan	MSSSO	High-luminosity spirals in the direction of the Great Attractor
Whiteoak	ATNF	Observations of 23-GHz ammonia transitions in galaxies
Whiteoak, Norris, Peng	ATNF, ATNF, UNSW	Search for 6- and 12-GHz methanol transitions associated with other galaxies

3. Very Long Baseline Interferometry Observations, December 1991-November 1992 inclusive.

Observers	*Affiliations*	*Programs*
Chapman, te Lintel Hekkert, Norris	ATNF, MSSSO, ATNF	OH 1667-MHz line observations of IRAS 15405-4945
Ellingsen, Norris, Amy, Diamond, Ferris, Gough, McCulloch, Reynolds, Troup	UTas, ATNF, ATNF, NRAO, ATNF, ATNF, UTas, ATNF, ATNF	VLBI observations of 6-GHz methanol masers
Gurvits, Kardashev, Popov, Schilizzi, Jauncey, Tzioumis, Reynolds, Barthel, Kellerman, Pauliny-Toth, Costa, Nicolson, Preston, King, McCulloch, Ferris, Gough, Wark	PNL, PNL, PNL, NFRA, ATNF, ATNF, ATNF, KI, NRAO, MPIfR, UWA, HartRAO, JPL, UTas, UTas, ATNF, ATNF, ATNF	The radio structure of quasars at red shift >3
Gwinn, Desai, Reynolds, Tzioumis, Jauncey, King, McCulloch, Nicolson, Flanagan, Jones	UCSB, UCSB, ATNF, ATNF, ATNF, UTas, UTas, HartRAO, HartRAO, JPL	Speckle VLBI observations of the Vela pulsar
Jauncey, Tzioumis, Meier, Preston, Gough, Wark, King, McCulloch, Nicolson, McCleod, Ferris, Reynolds	ATNF, ATNF, JPL, JPL, ATNF, ATNF, UTas, UTas, HartRAO, HartRAO, ATNF, ATNF	VLBI monitoring of the nucleus of Centaurus A
Norris, Wellington, McCulloch, Reynolds, Diamond, Peng, Kesteven, Ferris, Gough	ATNF, RP, UTas, ATNF, NRAO, USyd, ATNF, ATNF, ATNF	VLBI observations of methanol masers
Reynolds, Jauncey, Manchester, Ferris, Staveley-Smith, Tzioumis, Wark, Norris, Campbell-Wilson, Johnston, Russell	ATNF, ATNF, ATNF, ATNF, ATNF, ATNF, ATNF, ATNF, USyd, NRL, NRL	Radio structure of SN1987A
Reynolds, Jauncey, Tzioumis, Johnston, Russell, King, McCulloch	ATNF, ATNF, ATNF, NRL, NRL, UTas, UTas	VLBI positions of southern radio stars
Ryder, Staveley-Smith, Reynolds	MSSSO, ATNF, ATNF	The unusual radio source in NGC 1313
Tzioumis, Jauncey, Reynolds, Gough, Ferris, Wark, Meier, Preston, Murphy, Jones, King, McCulloch, White, Nicolson, Costa	ATNF, ATNF, ATNF, ATNF, ATNF, ATNF, JPL, JPL, JPL, JPL, UTas, UTas, UWS, HartRAO, UWA	Observations of the curious curved jet source 1549-790
Tzioumis, King, McCulloch, Reynolds, Jauncey, Wark, Ferris, Gough, Nicolson, Costa, Preston, Meier, White	ATNF, UTas, UTas, ATNF, ATNF, ATNF, ATNF, ATNF, HartRAO, UWA, JPL, JPL, UWS	VLBI observations of compact doubles
Tzioumis, Reynolds, Jauncey, Schilizzi, Hunstead, Dobbie, Costa, King, McCulloch, Preston, Meier, Gough	ATNF, ATNF, ATNF, NFRA, USyd, USyd, UWA, UTas, UTas, JPL, JPL, ATNF	Compact Steep Spectrum (CSS) sources
Tzioumis, Slee, Reynolds, Pedlar, Axon, Collison, Saikia	ATNF, ATNF, ATNF, JB, JB, JB, GMRT	PTI observations of NGC 1808

Affiliations

AAO	Anglo-Australian Observatory
ADFA	Australian Defence Force Academy
AIR	Astronomy Institute Ruhr Germany
AMES	AMES Research Centre USA
AO	Arecibo Observatory USA
AOA	Astronomical Observatory Asiago Italy
AOAR	Astronomical Observatory Arleti Italy
ASP	Astro Space Centre Russia
ATNF	CSIRO Australia Telescope National Facility Australia
BAO	Byurakan Astrophysical Observatory Armenia
Bol	University of Bologna Italy
CEN	Centre d'Études Nucléaires Saclay France
CfA	Centre for Astronomy Cambridge USA
CNR	Consiglio Nazionale delle Ricerche Sicily
CO	Carter Observatory New Zealand
CU	Curtin University Australia
DRAO	Dominion Radio Astronomy Observatory Canada
ESA	European Space Agency Netherlands
ESO	European Southern Observatory Germany

ETH	Eidgenössiche Technische Hochschule Zurich Switzerland
Ferm	Enrico Fermi Institute University of Chicago USA
GMRT	Giant Metrewave Radio Telescope India
GMU	George Mason University USA
HartRAO	Hartebeesthoek Radio Astronomy Observatory South Africa
HSS	Harvard Smithsonian Institute USA
IAHI	Institute of Astronomy Hawaii
IAP	Institute of Astronomy Paris France
IAR	Instituto Argentino de Radioastronomia Argentina
IFM	Istituto per Ricerche in Fisica Cosmica Milan Italy
IPAC	Infrared Processing and Analysis Centre USA
JB	Jodrell Bank UK
JHU	Johns Hopkins University USA
JPL	Jet Propulsion Laboratory USA
KI	Kapteyn Institute Netherlands
LO	Sterrewacht Leiden Netherlands
MIT	Massachusetts Institute of Technology USA
MO	Observatoire de Meudon France
MPE	Max-Planck-Institut für extraterrestrische Physik Germany
MPI	Max-Planck-Institut für Radioastronomie Germany
MSSSO	Mount Stromlo & Siding Spring Observatories Australia
MU	Macquarie University Australia
NAOJ	National Astronomical Observatory of Japan
NASA	National Aeronautics and Space Administration USA
NCAC	Nicholas Copernicus Astronomical Centre Poland
NFRA	Netherlands Foundation for Research in Astronomy
NRAO	National Radio Astronomy Observatory USA
NRL	Naval Research Laboratories USA
OAA	Osservatorio Astrofisico di Arcetri Italy
OAB	Osservatorio Astronomico di Brera Italy
OAC	Osservatorio Astrofisico di Catania Italy
OGR	Observatoire de Grenoble France
OHP	Observatoire de Haute Provence France
OMs	Observatoire de Marseille France
OSO	Onsala Space Observatory Sweden
PMO	Purple Mountain Observatory China
Q's	Queens University Belfast Ireland
RAIUB	Radioastronomy Institute, University of Bonn Germany
RGO	Royal Greenwich Observatory UK
ROE	Royal Observatory Edinburgh Scotland
RP	Radiophysics Laboratory Australia
RRI	Raman Research Institute India
RU	Rutgers University USA
RUG	Rijks Universiteit Gent Belgium
SAAO	South African Astronomical Observatory South Africa
StO	Stockholm Observatory Sweden
STScI	Space Telescope Science Institute USA
SU	University of Sydney Australia

TGU	Tokyo Gakugei University Japan
UAm	University of Amsterdam Netherlands
UB	University of Basel Switzerland
UBir	University of Birmingham UK
UBonn	University of Bonn Germany
UBr	University of Bristol UK
UC	University of Colorado USA
UCal	University of California USA
UCalg	University of Calgary Canada
UChi	University of Chile South America
UCol	Columbia University USA
UCor	Cornell University USA
UDur	University of Durham UK
UHam	Hamburger Sternwarte Germany
UHel	University of Helsinki Finland
UIl	University of Illinois USA
UL	University of Leiden Netherlands
ULA	University of Louisiana USA
UMan	University of Manchester UK
UMar	University of Maryland USA
UMel	University of Melbourne Australia
UMich	University of Michigan USA
UMinn	University of Minnesota USA
UMon	University of Montreal Canada
UNag	University of Nagoya Japan
UNAM	University of New Mexico USA
UNev	Univeraity of Nevada USA
UNSW	University of New South Wales Australia
UPitt	University of Pittsburgh USA
UPr	Princeton University USA
UQld	University of Queensland Australia
UTas	University of Tasmania Australia
UTor	University of Toronto Canada
UToy	University of Toyama Japan
UW	University of Wales UK
UWA	University of Western Australia
UWash	University of Washington USA
UWis	University of Wisconsin USA
UWol	University of Wollongong Australia
UWS	University of Western Sydney Australia
YO	Yunnan Observatory China
YU	York University Toronto Canada

Appendix B

Membership of the AT Users Committee, as of October 1992

Chairman

Dr J. G. Robertson	*University of Sydney*

Members

Dr G. V. Bicknell	*Mount Stromlo and Siding Spring Observatories, Australian National University*
Dr D. G. Blair	*University of Western Australia*
Dr R. W. Clay	*University of Adelaide*
Dr R. Coleman	*University of Sydney*
Dr W. J. Couch	*University of New South Wales*
Dr M. J. Drinkwater	*Anglo-Australian Observatory*
Dr P. D. Godfrey	*Monash University*
Dr P. J. Hall	*CSIRO Australia Telescope National Facility*
Dr R. W. Hunstead	*University of Sydney*
Prof. A. R. Hyland	*University of New South Wales*
Dr D. L. Jauncey	*CSIRO Australia Telescope National Facility*
Dr K. Jones	*University of Queensland*
Dr P. M. McCulloch	*University of Tasmania*
Dr L. Staveley-Smith	*CSIRO Australia Telescope National Facility*
Dr P. te Lintel Hekkert	*Mount Stromlo and Siding Spring Observatories, Australian National University*
Dr A. E. Vaughan	*Macquarie University*
Dr G. L. White	*University of Western Sydney*
Dr W. J. Zealey	*University of Wollongong*

Appendix C

AT Future Development Plan, as of November 1992

Item	**Priority**	**Totals**		1992-93		1993-94		1994-95		1995-96		1996-97	
		$ (1000s)	labour (mn-yr)	$ (1000s)	labour (mn-yr)	$ (1000s)	labqur (mn-yr)	$ (1000s)	labour (mn-yr)	$ (1000s)	labour (mn-yr)	$ (1000s)	labour (mn-yr)
Compact Array													
Test equipment	-	-	-	35	-	50	-	50	-	50	-	50	-
3-mm band	3	900	12	-	-	120	4	-	-	120	4	130	4
12-25 GHz receivers	1	700	18	-	1	200	5	250	6	200	5	-	-
3/6 cm upgrade	1	20	2	20	2	-	-	-	-	-	-	-	-
Computer upgrade	2	220	5	-	-	100	3	-	-	-	-	-	-
Narrow-band backend	3	50	3	-	-	-	-	-	-	50	3	-	-
Three extra stations	1	200	0	-	-	200	0	-	-	-	-	-	-
Misc. improvments	2	-	-	40	-	35	-	35	-	35	-	35	-
Parkes													
Test equipment	-	-	-	35	-	50	-	50	-	50	-	50	-
12-25 GHz receivers	1	120	4	50	1	70	3	-	-	-	-	-	-
Improved 20-cm system	0	30	1.5	0	0.5	-	-	-	-	-	-	-	-
Autocorrelator	2	10	1.5	-	-	-	-	10	1	-	-	-	-
21-cm multibeam system	2	250	9	-	-	150	4	50	5	-	-	-	-
Single-dish software	-	-	3	-	1	-	1	-	-	-	-	-	-
Misc. improvements	-	-	-	40	-	20	-	20	-	20	-	20	-
Coonabarabran													
SIS receivers	1	150	3	100	3	-	-	-	-	-	-	-	-
12-25 GHz receivers	1	120	4	-	-	120	2	-	-	-	-	-	-
AO spectrograph	-	10	1	10	1	-	-	-	-	-	-	-	-
256 MHz IF system	1	10	1	10	1	-	-	-	-	-	-	-	-
Simultaneous 13/3 cm operation	-	50	2	-	-	-	-	50	2	-	-	-	-
Work station	-	20	-	-	-	20	-	-	-	-	-	-	-
Long Baseline Array													
Extra satellite links	-	80	1	-	-	-	-	-	-	-	-	-	-
External antennas	1	15	0.2	15	0.2	-	-	-	-	-	-	-	-
Epping Computing													
Work stations	1	250	1	0	-	50	-	50	-	50	-	50	-
Epping engineering													
Test equipment	-	-	-	35	-	50	-	50	-	50	-	50	-
Millimetre-wave test equipment	-	315	-	150	-	-	-	-	-	-	-	-	-
Operational support	-	-	-	35	4	-	4	-	5	-	5	-	5
Total	-	3435	86	575	15	1235	26	615	19	625	17	385	9
AT Construction													
LBA correlator	1	50	12	10	5	40	5	-	2	-	-	-	-
LBA recorder/playback	1	550	2	550	2	-	-	-	-	-	-	-	-

The 1992/93 budget is fixed. Figures for the following years are a combination of projected expenditures and new developments, and will be revised to match available resources.

Appendix D

Students' projects and affiliations, 1992

University (PhD, MSc and BSc(Hons)) students co-supervised by ATNF staff

Name	*University*	*Project Titles*
David Abbott	Sydney	Millimetre-wave imaging strategies for the AT Compact Array
Martin Anderson	Western Sydney	Radio survey of a large sample of ROSAT X-ray selected extragalactic sources
Jon Bell	Australian National University	Timing millisecond pulsars
David Blank	Sydney	Radio continuum emission and the unification of active galaxies
Simon Ellingson	Tasmania	Methanol masers
Miroslav Filipovic	Western Sydney	Extended objects in the LMC
Richard Gooch	Macquarie	Advanced visualisation techniques to handle astronomical data cubes and images
Andrew Gray	Sydney	Structures near the Galactic Centre
Sally Houghton	NSW	AT Compact Array observations of 6.7-GHz methanol in Sagittarius B2
Vicky Kaspi	Princeton (USA)	A search for pulsars in supernova remants
Lucyna Kedziora-Chudczer	Sydney	A statistical study of a possible association between quasars and galaxies
Edward King	Tasmania	VLBI observations of peaked spectrum sources
Anton Koekemoer	Australian National University	Excitation and dynamics of extended emission-line regions in powerful radio galaxies
Haida Liang	Australian National University	Studies of galaxy clusters
Duncan Lorimer	Manchester (UK)	A 430-MHz survey for pulsars in the southern sky
James Lovell	Tasmania	VLBI observations of southern active galactic nuclei
Simone Magri	Western Sydney	The design and construction of a 16-interrupt O-bus interface circuit
Alan McPhail	Macquarie	Non-linear iterative image reconstruction techniques for images with known point-spread function
Martin Ott	MPIfR (Germany)	CO and HI observations of NGC 4945
Clive Robinson	Manchester (UK)	A search for pulsars in globular clusters
Alan Roy	Sydney	Active galactic nuclei
Niven Tasker	Macquarie	Positions and optical identifications of sources in the Parkes PMN survey
Wilfred Walsh	NSW	Studies of dwarf galaxies

Appendix E

ATNF Operational Plan, 1992-93

Objective

The ATNF's main objective is to operate and develop the Australia Telescope National Facility as a prestigious and world-class radio astronomical observatory dedicated to the advancement of knowledge.

Our strategy is to:

- *Exploit the unique southern location and technological advantages of the Australia Telescope to maintain its position as a world-class facility supporting both Australian and international researchers*
- *Use the strong scientific research program to direct the instrumental development and ensure a high profile for radio astronomical research in Australia.*

The ATNF's broad system engineering design capability and sophisticated end-users, in combination with key technologies provided by the CSIRO Division of Radiophysics, result in an extraordinary degree of vertical integration. This generates great opportunities for future developments and technology transfer and provides a showpiece for Australian technology.

Specific Objectives (and percentage of total resources)	***We plan to:***
To pursue a program of research in astronomy and astrophysics, using primarily radio techniques, that will complement the National Research Facility role. (9%)	Investigate the properties of radio stars, atmospheres of stars and HII regions. Image selected southern supernova remnants in the Galaxy and the Magellanic Clouds. Complete 80% of a new survey for millisecond and other short-period pulsars, and continue of studies of newly discovered and previously discovered pulsars. Observe radio emission from normal galaxies, active galaxies, radio galaxies and quasars. Study 21-cm HI radio emission to determine the dynamics of galaxies and large-scale structures of the Universe. Investigate the properties of methanol maser sources and their implications for star formation, using single-dish surveys, AT Compact Array imaging and VLBI imaging. Make high-resolution, long baseline interferometry observations using ATNF telescopes in conjunction with other telescopes in Australia and overseas. Set up collaborative agreements for ATNF antennas to participate in the global VLBI network, the Russian RadioAstron Space VLBI program, and the Japanese VSOP Space VLBI program. Establish an astrometric reference frame for southern hemisphere radio sources.
To operate the Parkes radio telescope, the Narrabri Compact Array, and the Coonabarabran antenna as a National Facility. (60%)	Provide a level of access to ATNF facilities that satisfies the community of scientific users. Complete full documentation for the Compact Array. Host annual meetings of the ATNF Steering Committee to develop policy for the operation of the ATNF. Through workshops, newsletters and documentation, keep the AT user community informed of the capability of ATNF facilities and recent scientific highlights. Hold meetings of the Time Assignment Committee to review and rank requests for observing time. Hold meetings (at least once a year) with representatives of the AT user community, to obtain feedback on current operations, to set priorities for instrumental development, and to disseminate information on the capability and operational status of the facility. Develop a proposal for NASA's use of the Parkes and Coonabarabran antennas in the SETI targeted search program.
To operate and develop the joint ATNF-RP computing facility. (6% [ATNF component])	Continue to operate and develop hardware and software for the network of computers at the CSIRO Radiophysics Laboratory and the ATNF observatories. Maintain electronic networks connecting with other institutions (both within and outside Australia). Continue to collaborate on the design and development of the new image processing system for synthesis radio telescopes (AIPS ++).

To develop the next generation of instrumentation.
(20%)

Develop a system to enable astrophysicists to better visualise their data, particularly large data cubes and complex data sets.

Develop a 80-115 GHz observational capability for the Coonabarabran 22-m antenna.

Evaluate the potential use of the MPI (Bonn) acousto-optical spectrograph on the Coonabarabran antenna.

Design and build a prototype receiver system for the band 12-25 GHz using HEMT devices fabricated by the CSIRO Division of Radiophysics.

Explore the potential for international collaboration to build a multi-beam receiver for 21-cm hydrogen line surveys, using the Parkes radio telescope.

Install hardware and software to achieve phase-stable links for the AT Compact Array.

Develop millimetre-wave systems, in collaboration with the CSIRO Division of Radiophysics.

Collaborate with university groups on instrumentation for VLBI.

To promote the activities of the ATNF and to provide information and educational resources.
(5%)

Operate the Parkes and Narrabri Visitor Centres.

Inform educational institutions and the general public about Australia's research in astronomy, through publications, the media, talks and special events.

Provide training for 'sandwich course' and part-time engineering students.

Give 'work experience' to school students.

Run a 'summer student program', to motivate young scientists considering a research career.

Provide collaborative supervision with universities for PhD students in the fields of engineering and astronomy.

Provide engineering advice and facilities to industry.

Appendix F

Membership of the ATNF Steering Committee, as of October 1992

Chairman

Prof. P. A. Hamilton	Pro-Vice Chancellor (Research), *University of Tasmania*

Members

Ex-officio

Prof. R. D. Ekers	Director, *CSIRO Australia Telescope National Facility*
Dr R. D. Cannon	Director, *Anglo-Australian Observatory*
Dr D. N. Cooper	Chief, *CSIRO Division of Radiophysics*
Dr R. H. Frater	Director, *CSIRO Institute of Information Science and Engineering*

Astronomers

Prof. L. E. Cram	Head, *School of Physics, University of Sydney*
Prof. K. C. Freeman	*Mount Stromlo and Siding Spring Observatories, Australian National University*
Prof. D. B. Melrose	Director, *Research Centre for Theoretical Astrophysics, University of Sydney*
Dr R. N. Manchester	*CSIRO Australia Telescope National Facility*

International Advisers

Dr W. M. Goss*	Director, *Very Large Array, National Radio Astronomy Observatory, USA*
Prof. M. Morimoto	Former Director, *Nobeyama Radio Observatory, Japan*
Prof. V. Radhakrishnan	Director, *Raman Research Institute, India*
Dr P. A. Vanden Bout*	Director, *National Radio Astronomy Observatory, USA*
Prof. L. Woltjer	Former Director-General, *European Southern Observatory*

(*alternating)

Industry

Mr J. N. Almgren	Chairman, *J. N. Almgren Pty. Ltd.*
Mr W. G. Gosewinckel, A. O.	Former Managing Director, *Aussat Pty. Ltd.*

Appendix G

AT Time Assignment Committee

Chairman

Ex-officio

Prof. R. D. Ekers, Director, *CSIRO Australia Telescope National Facility*

Members	***Expiry of term***
Dr J. L. Caswell, *CSIRO Australia Telescope National Facility*	December 1992
Dr R. W. Hunstead, *School of Physics, University of Sydney*	December 1992
Prof. D. S. Mathewson, *MSSSO, Australian National University*	December 1993
Dr E.M. Sadler, *Anglo-Australian Observatory*	December 1993

Operations of the Time Assignment Committee

As is usual for astronomical facilities, the AT telescopes are 'oversubscribed': that is, there are more applications for observing time than can be accommodated. Therefore it is necessary to cull observing proposals. This is done by the Time Assignment Committee. The Committee meets three times a year. It has four members (who normally serve for a period of two years); when necessary, it can also co-opt extra participants from other institutions.

The Time Assignment Committee observes the following guidelines:

- All observing proposals are assessed on their scientific merit.
- If a proposal is deferred and not considered, it will be reconsidered for the relevant period as if it were a new proposal (i.e., not receiving special status).
- Proposals that have received an allocation of time, but which cannot be carried out due to technical failures, will have have their time reallocated.
- If a proposal requests collaboration the TAC will suggest suitable Australian collaborators (not necessarily ATNF staff).
- It is sometimes necessary to test new equipment and techniques, or make other alterations to telescope operation. An observing proposal that can be combined with such testing may be allocated 'test time', which exists separately from normal allocations of observing time.
- Observers are requested to inform the ATNF of any publications arising from their observations.
- VLBI requests will be approved by the TAC in competition with other proposals.
- PhD students will be given special consideration regarding time-lines, and perhaps protection in their thesis areas.

Appendix H

Completed Milestones of the ATNF's 1991-92 Operational Plan

Completion of the Australia Telescope's construction

- The 6-km array has been brought to full design specifications. Phase stabilisation was achieved in September 1992.
- The first VLBI observations with the Coonabarabran antenna were made in November 1991.
- The basic software for the control and monitoring of the Compact Array, and for editing and calibrating data, has been completed.
- The Australia Telescope was the subject of a special issue of the *Journal of Electrical and Electronics Engineering, Australia,* in June 1992.

Research in astronomy and astrophysics to complement the National Facility role

- Recent observations are discussed on pages 5 to 11 of this report.
- ATNF antennas are frequently used for national and international VLBI observations. (See page 16.)
- ATNF antennas will be used in the space projects RadioAstron and VSOP (see page 16). Planning for the use of the antennas in these projects is on schedule.

Operation of ATNF antennas as a National Facility

- The ATNF Steering Committee met in November 1991 to continue the development of policy for the operation of the ATNF.
- The AT User Support Group produces the AT Newsletter every three months, to inform the user community of developments pertaining to the AT.
- The User Support Group has also produced user guides for all the AT sites.
- The Time Assignment Committee has met every four months to review and rank requests for observing time.
- The AT Users Committee has met twice a year, giving the ATNF feedback on current operations, setting priorities for instrumental development, and disseminating information on the ATNF's capability and operational status.
- NASA's use of ATNF facilities for SETI research in 1994 is being negotiated.

Operation and development of the joint ATNF-RP computing facility

- New hardware and software has been put in place for the network of computers used at the Radiophysics Laboratory and the ATNF observatories at Parkes and Narrabri. AIPS is being provided on an increasing number of Sun workstations.
- The ATNF is contributing to the design and development of the new image processing system for synthesis radio telescopes, AIPS ++. (See page 17.)
- The ATNF is developing a system that will help astrophysicists to better visualise their data.

Future development of instrumentation

- The Coonabarabran antenna will be outfitted with an auto-correlation spectrometer.
- A 6-GHz/12-GHz receiver system is operating at Parkes. (See page 26.)
- The ATNF is collaboration with the Universities of Tasmania and Western Australia to develop 5-GHz VLBI systems. (See page 16.)

Appendix I

ATNF Operations Budget, 1991-92

Item	*Expenditure (thousands of dollars)*
Office of the Director	775.0
National Facility support	265.0
Astrophysics	1007.0
Computing (ATNF funded)	628.0
AT Marsfield site overheads	1433.0
Parkes operation	1296.0
Narrabri operation	2596.0
Parkes visitors centre	175.0
Engineering	1395.0
Future development	585.0
Maintenance	243.0
Total	***10398.0***

Appendix J

AT Construction Budget, as at 30 June 1992

Item	*Expenditure to 30/6/92*	*Provision*	*Liabilities*	*Uncommitted Funds*
Antennas	25155.7	0	0	0
Connell Wagner	2594.5	0	0	0
Electronics	12680.0	516.9	21.7	495.2
Salaries*	5445.7	0	0	0
Other works and services	4457.9	0	0	0
Total	***50333.8***	***516.9***	***21.7***	***495.2***

* Includes employer's contribution to superannuation.

Appendix K

Publications, December 1991-November 1992

1. Papers based on Australia Telescope observations

BLAIR, D.G., NORRIS, R.P., TROUP, E.R., TWARDY, R., WELLINGTON, K.J., WILLIAMS, A.J., WRIGHT, A.E. & ZADNIK, M.G. "A narrow-band search for extra-terrestrial intelligence (SETI) using the interstellar contact channel hypothesis". *Mon. Not. R. Astron. Soc.*, **257**, 105-109 (1992).

BUDDING, E., BANKS, T. & KILMARTIN, P.M. "Recent optical photometry of AB Dor and its interpretation". *Astrophys. Space Sci.*, **188**, 390 (1992).

BUDDING, E., BURGESS, A., CHAN, S. & SLEE, O.B. "Observations of AB Dor at 8.4 GHz and interpretation". In *Surface Inhomogeneities on Late-Type Stars 1992*, ed. P.R. Byrne & D.R. Mullan, Springer-Verlag, p. 253.

CAMPBELL-WILSON, D. & JAUNCEY, D.L. "Rising from the cosmic ashes." *South. Astron.*, **5** (3),15-17 (1992).

CASWELL, J.L. & STEWART, R.T. "The Galactic Plane radio source G321.48+1.02: is it extragalactic?" *Proc. Astron. Soc. Aust.*, **10**, 21-23 (1992).

CASWELL, J.L., KESTEVEN, M.J., STEWART, R.T., MILNE, D.K. & HAYNES, R.F. "G308.8-0.1: an unusual supernova remnant containing a short-period pulsar, PSR J1341-6220". *Astrophys. J.*, 399, L151-L153 (1992).

CHAPMAN, J.M., STAVELEY-SMITH, L., AXON, D.J., UNGER, S.W., COHEN, R.J., PEDLAR, A. & DAVIES, R.D. "The megamaser galaxy III ZW 35". *Proc. Astron. Soc. Aust.* (Proc. 5th Asian-Pacific Regional Astron. Meeting), **9**, 241-242 (1992).

DESAI, K.M., GWINN, C.R., REYNOLDS, J.E., KING, E.A., JAUNCEY, D.L., FLANAGAN, C., NICOLSON, G.D., PRESTON, R.A. & JONES, D.L. "A speckle hologram of the interstellar plasma". *Astrophys. J.*, **393**, L75-L78 (1992).

DUNCAN, R.A. & SPROATS, L.N. "Synthesis 6-cm images of 22 strong southern radio sources". *Proc. Astron. Soc. Aust.*, **10**, 16-20 (1992).

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