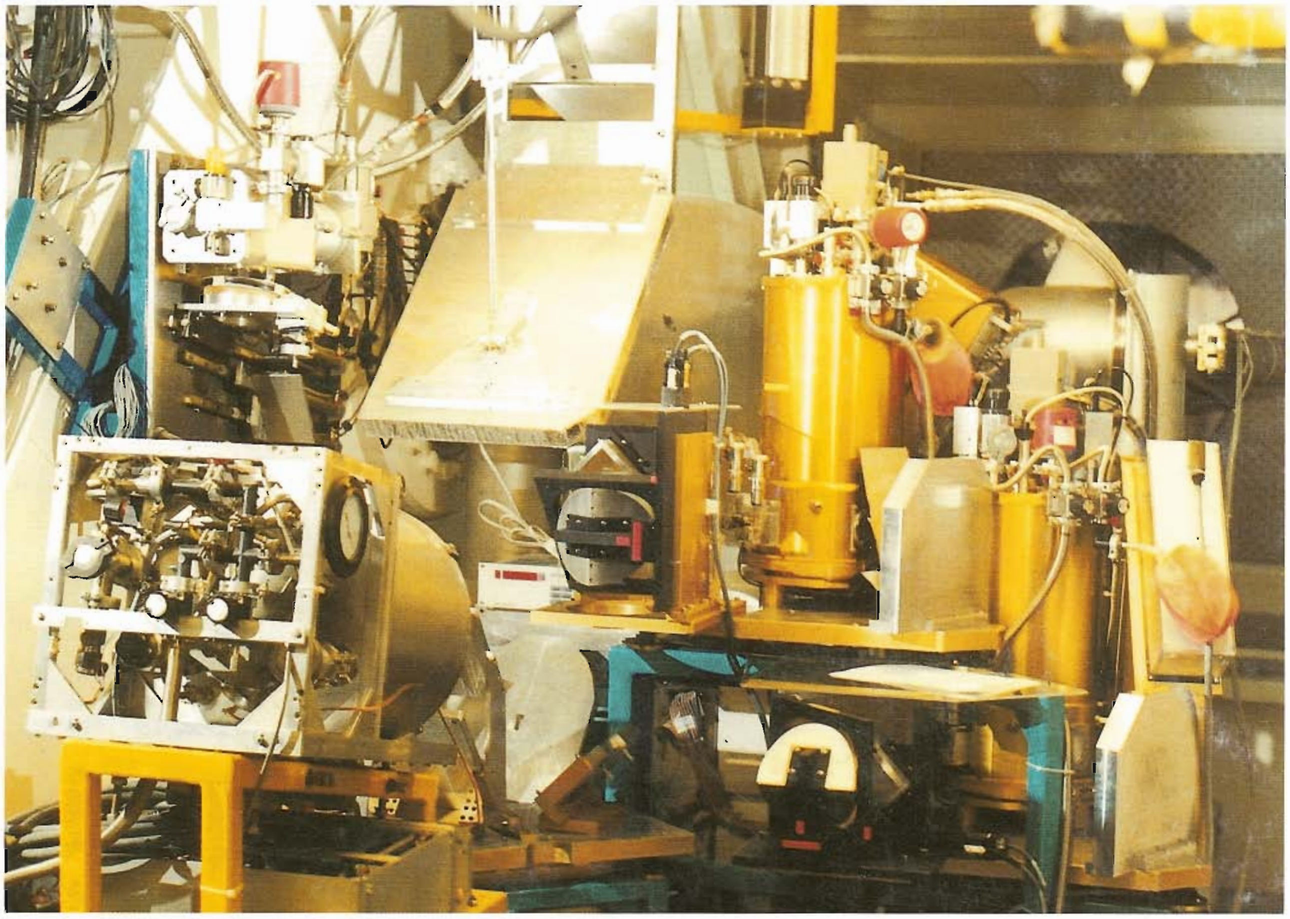
IRAM 1998



ANNUAL REPORT

Front Cover : The receiver cabin of the 30m telescope on the Pico Veleta, Spain after its complete refurbishment in September, October 1998. The picture shows the new dual channel receivers together with the old 2mm receiver which is still to be replaced (fall of 1999). Several of the mirrors that direct the beam to the various receiver locations are seen. Also shown is the new calibration system (attached to the wall on the left). For details see Sections 3 and 5.

ANNUAL REPORT
1998

Edited by

Michael Grewing

with contributions from:

Walter Brunswig
Gilles Butin
Thierry Crouzet
Dennis Downes
Albert Greve
Bernard Lazareff
Javier Lobato
Christelle Mesureur
Santiago Navarro
Robert Neri
Juan Peñalver
Alain Perrigouard
Jean-Louis Pollet
Karl Schuster
Marc Torres
Wolfgang Wild

INSTITUT DE RADIO ASTRONOMIE MILLIMETRIQUE
INSTITUT FÜR RADIOASTRONOMIE IM MILLIMETERBEREICH
INSTITUTO DE RADIOASTRONOMIA MILIMETRICA
300 Rue de la Piscine
Domaine Universitaire de Grenoble
38406 SAINT MARTIN D'HERES
France

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1. INTRODUCTION

1998 marked the 10th anniversary of the detection of the first fringes with the Plateau de Bure Interferometer, then comprising two telescopes. It is not a mere coincidence that 10 years later construction work has started on antenna number 6 ! The PdB interferometer has over the years greatly improved its capabilities, and the quality and nature of the scientific results obtained, together with the results obtained with other instruments, have been a great stimulus to develop millimetre-wave interferometry further. At IRAM, the partner organisations have agreed to go from the originally approved three telescopes to six and to invest in baseline extensions that today allow sub-arcsecond resolution. At a global scale, the scientific communities in the United States, in Europe, and in Japan have all put a large (sub-) millimetre array on the top of their priority lists for future projects in ground-based astronomy. An instrument 5 to 10 times as powerful as the Plateau de Bure Interferometer will indeed open up (sub-) millimetre interferometry to all fields of astrophysics: to solar system studies, studies of the interstellar medium and stellar physics, the study of galaxies and their nuclei, and to studies of the early universe, and 1998 will also go down as the year in which enormous progress has been made towards a large southern hemisphere millimetre array, now called the ALMA project (Atacama Large Millimetre Array), which will be a truly international project with countries around the world participating.

This mounting interest in interferometry is, however, no reason to ignore the role that single dish millimetre-wave telescopes are playing and will continue to play, and 1998 has for several reasons been a particularly good year for the IRAM 30m telescope. Most importantly, the receiver cabin of this telescope has been completely overhauled with the aim to prepare it for a new generation of dual channel and multi-channel receivers with excellent performances, and a potential for further enhancements in the future. To fully exploit the performance of the best receivers, particular attention was given to the optics, and to an improved calibration system. Also, the long-term efforts to increase the beam efficiency of the telescope at the high frequency limit were continued and led not only to a significant reduction of the surface errors but also to a much better understanding on what are the limiting factors. Details are given in Chapter 3. Also, the remote observing facility has now been brought to a level which makes it attractive to use it. Guest observers are invited to do so either from Granada or from Grenoble, but the system can also be exported to other institutes. As a longer term activity, preparations have started to replace one day the current telescope control software by a more modern and easier to maintain version. As in previous years, this Annual Report begins in Chapter 2 with the scientific highlights some of which could not have been obtained without the instrumental progress made in recent years. While only 3 of the 10 highlights mentioned this time refer to extragalactic studies, the actual situation is much more balanced. Extragalactic projects are competing more and more with Galactic ones and take an increasing share of the telescope time at both observatories.

Chapters 3 and 4 summarise the major technical activities at the two IRAM observatories. On the Plateau de Bure, the surfaces of antennas 1, 2, and 4 were improved by exchanging all panels with large numbers of pinholes against less severely damaged ones from antenna 3, which had been equipped with aluminium panels in the year before. One set of carbon fibre panels will soon receive a conductive paint cover and will be used on antenna 6. One of the carbon fibre subreflectors has also been exchanged against a new subreflector machined from a solid block of aluminium, applying the same technique as for the aluminium panels. Given its good performance, more aluminium subreflectors will be built for use on antenna 6 and as replacement units, should more of the original ones deteriorate.

Chapter 5 describes in some detail the activities at the IRAM headquarter in Grenoble. It was decided to completely re-build the clean room used by the SIS group to develop junctions, micro-bolometers etc. The new facility offers stable, controlled conditions that should allow a much better process control and therefore much higher reproducibility of the results. This is indeed a key issue for the future given the fact that much larger numbers of junctions will be needed for multi-channel receivers and for large array projects like the ALMA project.- The production of a new generation of receivers for the 30m telescope has already been mentioned above. Another major development that is ongoing concerns the completely new correlator that is needed for the Plateau de Bure for 6 antennas. During 1998 much progress has been made with the IRAM-designed correlator chip, which has successfully been tested and showed performance characteristics well in excess of the original specifications.

Chapter 6 summarises IRAM's financial situation. With little changes on the income side, the share of personnel costs has slightly gone up. As a consequence, new hirings have been delayed, amplifying the manpower limitations in some areas, a fact which requires careful attention in view of the new challenges that are ahead of us, e.g. an active support of the ALMA project.

2. HIGHLIGHTS OF RESEARCH WITH THE IRAM TELESCOPES IN 1998

2.1 SUMMARY

Among the many remarkable results obtained with the IRAM telescopes in 1998, or published in this year, we mention in particular the following :

- The detection of CO(4-3), CO(9-8) and dust emission in APM 08279+5255, a recently-discovered, bright, gravitationally-lensed quasar at a redshift of 3.9.

- A fully-sampled map of the molecular gas in the barred galaxy NGC 1530, made by combining data from the 30m telescope and the interferometer.

- An on-the-fly CO map of the southwest half of the Andromeda Galaxy, M31, showing the thin molecular spiral arms, well correlated with the dust lanes and the peaks in the atomic gas.

- Results from the IRAM key project on small-scale structure of pre-star-forming regions, with a wealth of spatial and velocity information on molecular clouds in five different CO lines.

- New ^{13}CO images of the GG Tau circumbinary ring with a resolution of 0.6 arcsec, showing that 80% of the disk mass is concentrated in a narrow ring of width 80 A.U.

- CO maps of the HH 211 molecular outflow, showing the low-velocity outflow cavity, the high-velocity, strongly collimated jet, and the dusty disk around the protostar.

- Maps of hot gas and dust in a protostellar cluster near the high-mass star-forming region W3(OH), showing 3 peaks in the hot core region 6″ east of the compact HII region

- A complete map of the remarkably thin shell around the carbon star TT Cygni, ejected from the star about 6000 years ago.

- Maps of the proto-planetary nebula M1-92, showing a central disk and a bipolar, double-shell, with outflow velocity along the disk's axis increasing with the distance from the central star.

- CO maps of the expanding molecular disk around the jets in the planetary nebula KjPn 8, showing that the disk is aligned with the youngest and fastest (300 km/s) of the bipolar jets.

2.2 EXTRAGALACTIC RESEARCH

2.2.1 Distant Sources

Detection of CO(4-3), CO(9-8) and Dust Emission in a Quasar at a Redshift of 3.9

The IRAM interferometer has been used to detect the lines of CO(4-3) and CO(9-8) in the recently-discovered broad absorption line quasar APM 08279+5255. The molecular lines have a redshift of 3.911, which appears to be the true cosmological redshift of the quasar's host galaxy. This implies the quasar's optical emission lines at z = 3.87 are blueshifted by a kinematic component of -2500 km/s, and along with the broad absorption lines, probably arise in the quasar's wind or jet, moving toward us. The CO line ratios suggest the molecular gas is at a temperature of 200 K, at an H_2 density of 4000 cm^{-3}. The interferometer also detected the dust emission at 94 and 214 GHz (emitted wavelengths 650 and 290 microns ; see **Fig. 2.1**). The extremely high CO and dust luminosities suggest magnification by gravitational lensing. From the size measurements so far, the magnification is estimated to be a factor of 7 to 30 for the CO lines and the far-IR continuum, and 14 to 60 for the optical/ultraviolet light. In this interpretation, the molecular gas and dust are in a circumnuclear disk of radius 90 to 270 pc around the quasar.

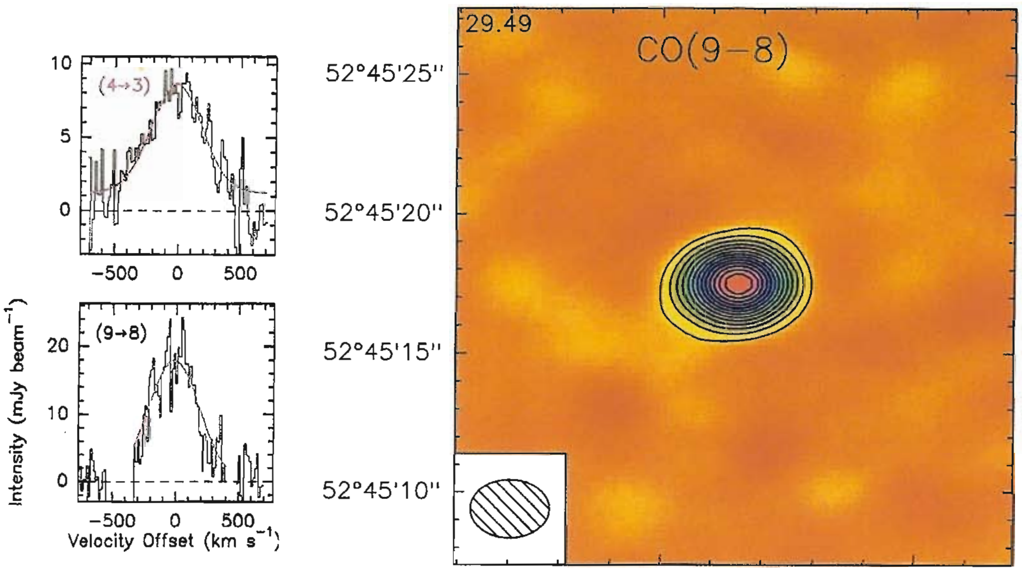

Fig. 2.1 CO and Dust in the Quasar APM 08279+5255 at a Redshift of 3.9 . *Upper left :* CO(4-3) spectrum, taken with a resolution of 16 km/s. *Lower left :* CO(9-8) spectrum with the same resolution. *Right :* CO(9-8) map, with a beam of 3″ x 2″ (insert). All data are from the IRAM interferometer.

NGC 1530 : Combined Data from the 30m Telescope and the Interferometer

The barred galaxy NGC 1530 has been mapped with the IRAM 30m telescope with a factor of 3 oversampling, in order to generate short-spacing visibilities to complement longer-spacing data from the IRAM interferometer. The new, combined map gives a large improvement in sensitivity and shows nicely the extended CO lanes along the bar of the galaxy. These molecular gas lanes, which are density waves or shocks created by the bar, show a remarkable kinematic pattern. Upstream of the dust lanes, the molecular gas is moving at 50 to 100 km/s away from the galaxy's center, while in the lanes and downstream of the lanes, the molecular gas moves at 70 to 150 km/s toward the galactic center. The intensity of the shocks is greatest near the central CO concentration, and decreases to zero at the ends of the bar. Star formation, as indicated by H-alpha emission, is intense around the nucleus of the galaxy and at the ends of the bar. The H II regions are generally downstream of the CO lanes. The star formation may be inhibited in the lanes where the shocks are too strong. From these data, the cutoff velocity appears to be in the range 80 to 170 km/s for the relative velocity of any cloud entering the density wave, above which the cloud cannot form stars.

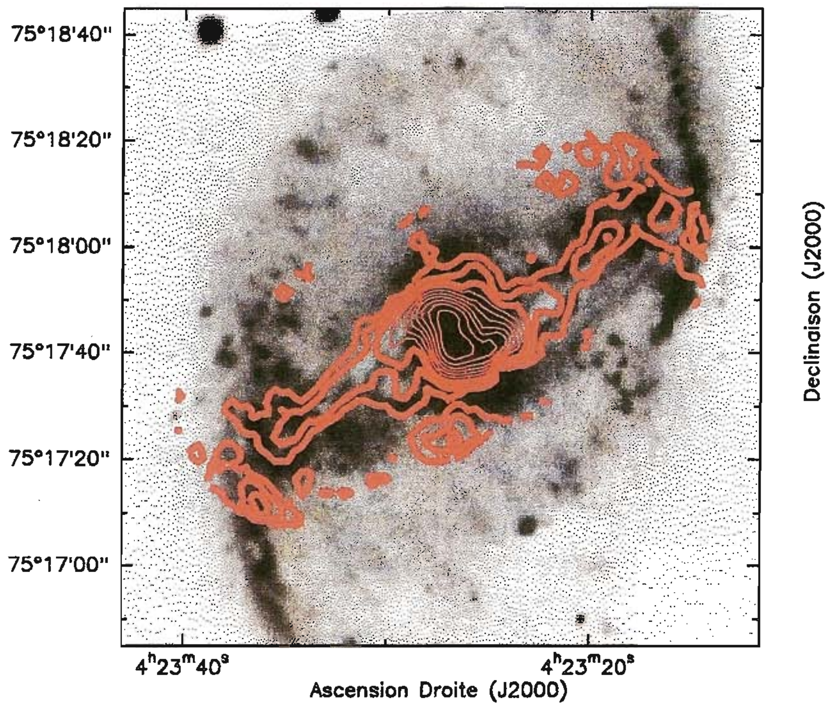

Fig. 2.2 Combined 30m and Interferometer CO Map of the Barred Galaxy NGC 1530. The integrated CO(1-0) contours are shown in steps of 4 Jy km/s, with a beam of 5.3 arcsec, superimposed on an optical image of the galaxy.

On-the-Fly CO Map of M31

The CO(1-0) line emission in the southwest half of the Andromeda galaxy, M31, has been mapped with the on-the-fly technique with the IRAM 30m telescope, with a resolution of 23 arcsec. A few selected fields have also been mapped with the IRAM interferometer with a resolution of 2 arcsec (9 parsecs). There is an excellent correlation between the CO and the dust lanes on optical images (**Fig. 2.3**). All dark lanes with galactocentric radii < 15 kpc are detected in CO. The molecular spiral arms are quite thin, and coincide with the crests in the H I spiral arms. The CO emission is always brighter where the extinction by dust is larger, while the H I emission can be bright in regions with only moderate visible extinction. CO is never observed where H I is faint, or the extinction is low. The CO velocities indicate large streaming motions in the immediate vicinity of bright H II regions.

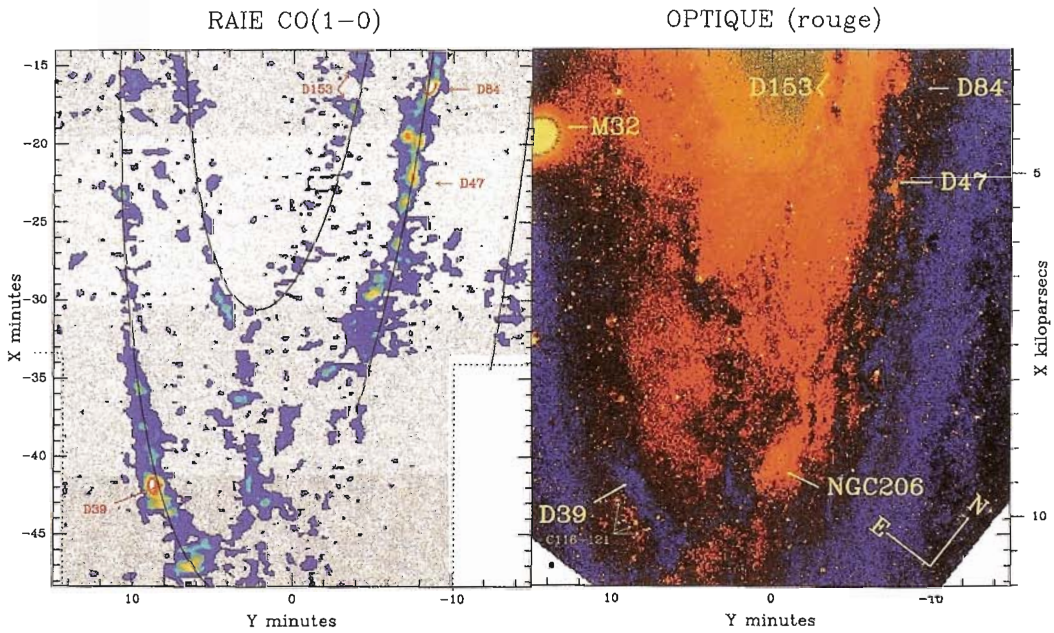

Fig. 2.3 CO in the Southwest Half of M31 . *(Left):* The integrated CO(1-0) emission mapped at the 30m telescope. The *X* and *Y* coordinates are along the major and minor axes of the galaxy. The peak intensity in the map is 20 K km/s, and the r.m.s. noise is 0.5 K km/s. The solid lines are fits to the arms of the galaxy, and the labels indicate prominent dust clouds in the Hodge catalogue. *(Right) :* Optical (red) image, from the Palomar Sky Survey, with the dust clouds labeled as in the CO image. Note the good correspondence of the CO and the optical dust lanes.

2.3 STAR FORMATION

2.3.1 The IRAM Key Project on Small-Scale Structure of Pre-Star-Forming Regions

The recent IRAM key project at the 30m telescope was a study of the environment of low-mass dense cores in molecular clouds. Dense cores are observed to have little turbulent support, and it is this lack of turbulent support that makes the cloud cores gravitationally unstable and allows subsequent star formation. The physical processes which dissipate the turbulent support of molecular clouds are expected to be active in the environments of the dense cores, and it was an aim of the key project to obtain more information on these processes. The selected fields all contained a starless dense core of low internal velocity dispersion. Maps were made in 5 lines, $^{12}CO(1\text{-}0)$ and (2-1), $^{13}CO(1\text{-}0)$ and (2-1), and $C^{18}O(1\text{-}0)$, with 22" and 11" beams, a sampling of 7.5", and a velocity resolution of 0.05 km s^{-1}. The spatial resolution of the higher frequency maps is ~1700 AU. Thanks to the amount of data (>30 000 spectra), the good signal-to-noise ratios, and the number of lines observed, several new results were obtained:

(1) Unresolved structure is still present in the channel maps of all the fields and all the lines. The velocity gradients reach values as large as 10 km s^{-1} pc^{-1}, implying large accelerations never observed before at small scale in non-star-forming clouds.

(2) The texture and velocity dispersion of the gas bright in ^{12}CO and barely detected in ^{13}CO are both significantly different from those of gas that is bright in all three isotopes -- i.e., the gas of the dense cores (see **Fig. 2.4**). There is a rich and complex structure in the gas that is bright in ^{12}CO only. Its velocity dispersion is much larger than that of the dense cores.

(3) The dense cores are not isolated structures but are connected, in both space and velocity, to other structures that are often elongated.

(4) The temperature ratio of the two lowest CO rotational transitions is remarkably uniform, with the line ratio R(2-1/1-0)=0.65±0.15 for 80% of the data points in the three fields.

(5) The ^{13}CO lines reach intensities as large as those of the ^{12}CO lines, although the line profiles are in general neither flat-topped nor self-reversed, as might be expected for high optical depth.

These spectral properties indicate the lines arise in small (<200 AU), dense cells, weakly radiatively coupled to each other. There is also an anti-correlation between the intensities of the ^{13}CO lines and their linewidths, which may indicate that as the turbulent support is lost, the radiative coupling of the cells increases, yielding higher line intensities.

The key project data are available in fits format at ftp://lra.ens.fr/pub/users/panis/kp_release.

Further observations are underway at the 30m telescope and the IRAM interferometer to characterize the nature of the small scale structure traced by the ^{12}CO lines in the environment of these same dense cores and to examine the possible link with the dissipative turbulence.

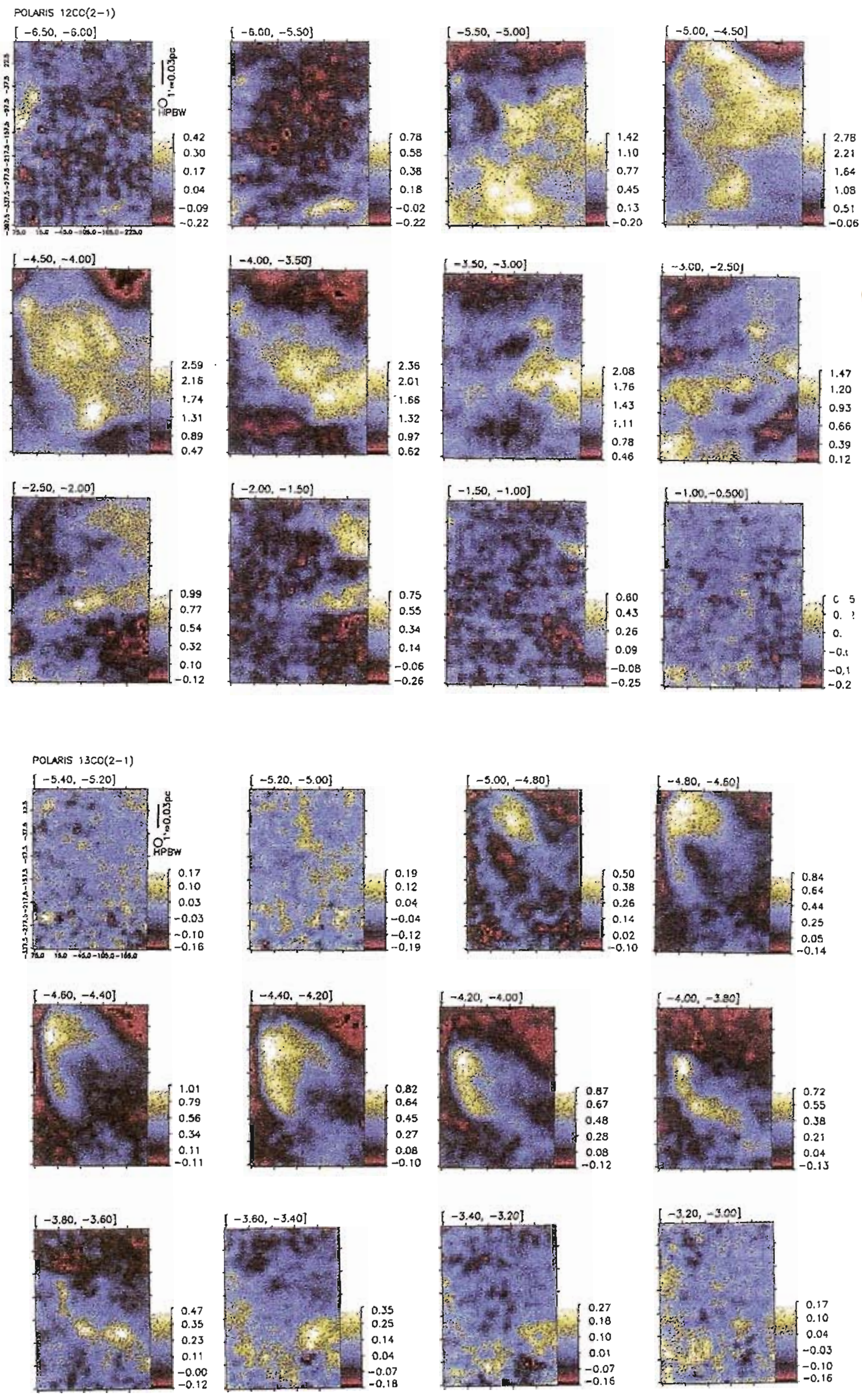

Fig. 2.4 Velocity maps of the Polaris field. *(top) :* ^{12}CO(2-1), *(bottom) :* ^{13}CO(2-1). Velocity intervals (km s^{-1}) are given at the top of each panel. The linear size scale and the offsets (arcsec) are shown in the top left panel. Intensity scales (K km s^{-1}) are at the right of each panel.

Another objective of this IRAM key project on the small-scale structure of pre-star forming regions was to extend the mass spectra for molecular cloud fragments and other scaling laws ---known on large scales from previous investigations with smaller telescopes --- down to the smallest scales accessible with the 30m telescope. **Figure 2.5** shows a combination of the small-scale data from the 30m telescope with large-scale data obtained with the Center for Astrophysics 1.2m telescope and the University of Cologne (KOSMA) 3m telescope for the Polaris Flare region, analyzed with a Gaussian clump decomposition. For the data in the $^{12}CO(1\text{-}0)$ and (2-1) lines, there is no deviation from the power law slope of the mass spectra $dN/M \sim M^{-1.84}$, over a range in masses of more than five orders of magnitude, from masses of several tens of solar masses down to Jupiter masses. The size spectrum is in agreement with a power law of the form $dN/R \sim R^{-3.0}$. The mass-size relation is a power law of the form $M \sim R^{2.31}$ over a range of more than two orders of magnitude in size.

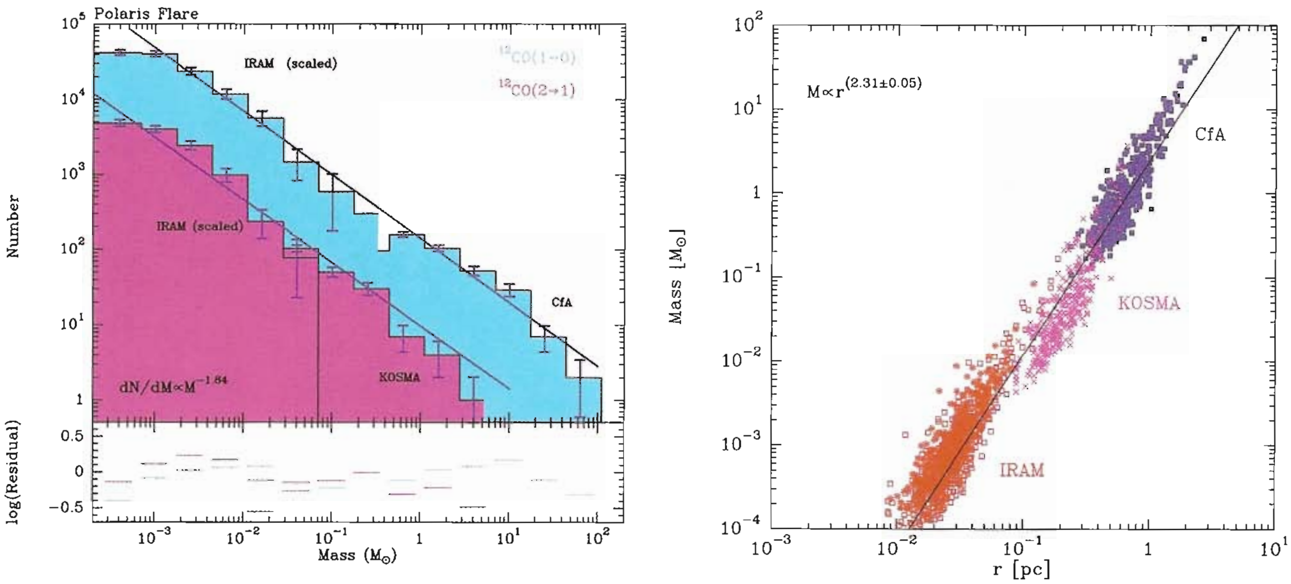

Fig. 2.5 Mass spectra and mass-size relation for pre-star-forming molecular clouds. *Left :* Molecular cloud mass spectra from IRAM 30m telescope data and larger-scale studies with the 1.2m telescope of the Center for Astrophysics (CfA) and the 3m telescope of the University of Cologne (KOSMA). *Right :* Molecular cloud mass-size relation for the same combination of data.

2.3.2 Young Stellar Objects

New Images of the GG Tau Circumbinary Ring

The IRAM interferometer has been used to make sub-arcsecond images of the millimeter dust emission and the ^{13}CO(2-1) line emission in the young quadruple star system GG Tauri (**Fig. 2.6**). The observations resolve the circumbinary disk of the close (0.3″) binary into two distinct components : an extremely dense, sharp-edged ring, surrounded by an extended disk. Continuum emission from dust is also detected at the center of this structure, probably from the smaller circumstellar disk or disks around the two stars. The CO velocities show the ring+disk system is in Keplerian rotation, and yields an estimate of 1.3 solar masses for the mass of the two stars inside. The temperature in the ring+disk system is consistent with heating by starlight. Subsequent near-IR adaptive optics imaging at the CHFT confirmed the existence of the central hole in the ring and the inclination angle determined at mm wavelengths. Comparison of the mm maps with the optical and near-IR images indicates a disk thickness compatible with hydrostatic equilibrium.

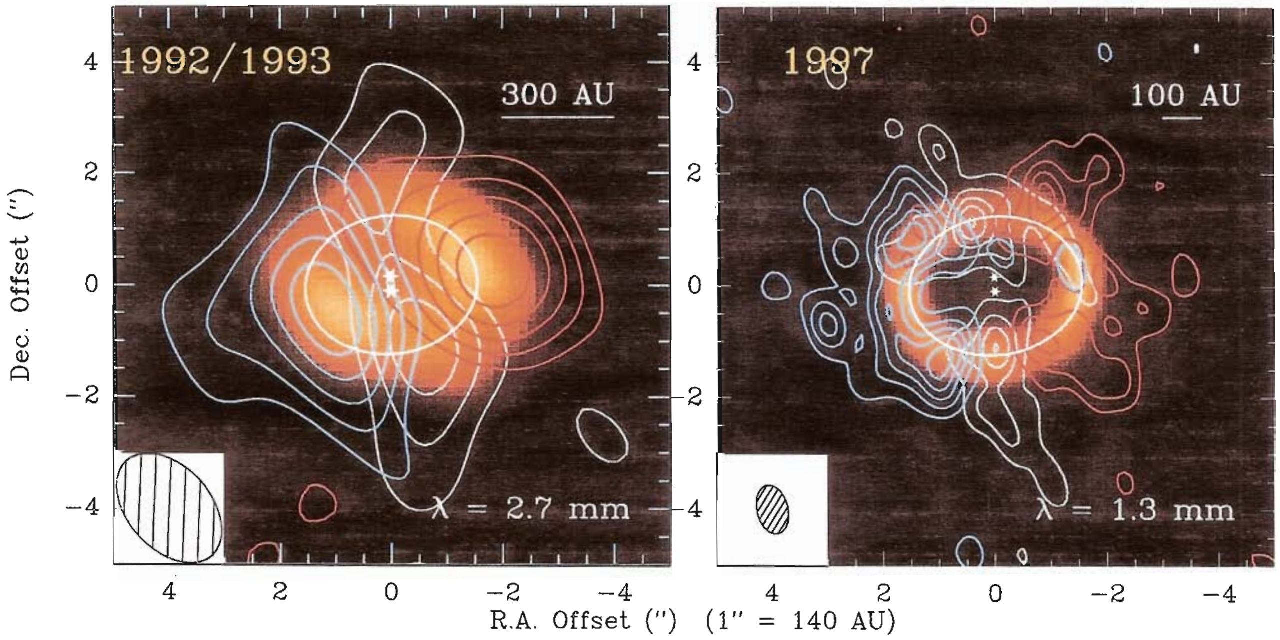

Fig. 2.6 The GG Tau Circumbinary Ring. The two images, at 3mm (*left*) and 1.3mm (*right*) show how the IRAM interferometer improved in resolution and sensitivity between 1992 (left) and 1997 (right). The blue, grey, and red contours show intensities at velocities of 5.5, 6.5, and 7.5 km/s in ^{13}CO(1-0) (*left*) and (2-1) (*right*). The background is a false-colour image of the thermal dust emission at 2.7mm (*left*) and 1.3mm (*right*). The beams are shown at lower left, and the star symbols at the center show the location of the binary.

The Jet-Driven Molecular Outflow of HH 211

The interferometer has been used to map the CO(1-0) and (2-1) lines in the molecular outflow associated with the extremely young HH 211 jet. At low velocities, the CO emission traces the outflow cavities, while at high velocities, the CO shows an extremely well collimated, continuous jet (**Fig. 2.7**). The observations also show the thermal continuum emission from dust, in a disk around the central protostar, and elongated perpendicular to the jet. The shape of the cavities traced by the low-velocity CO emission agree well with simple analytical models of a jet-driven flow, with entrainment of interstellar gas at the head of a traveling bow shock. The age of the jet is estimated to be about 1000 years.

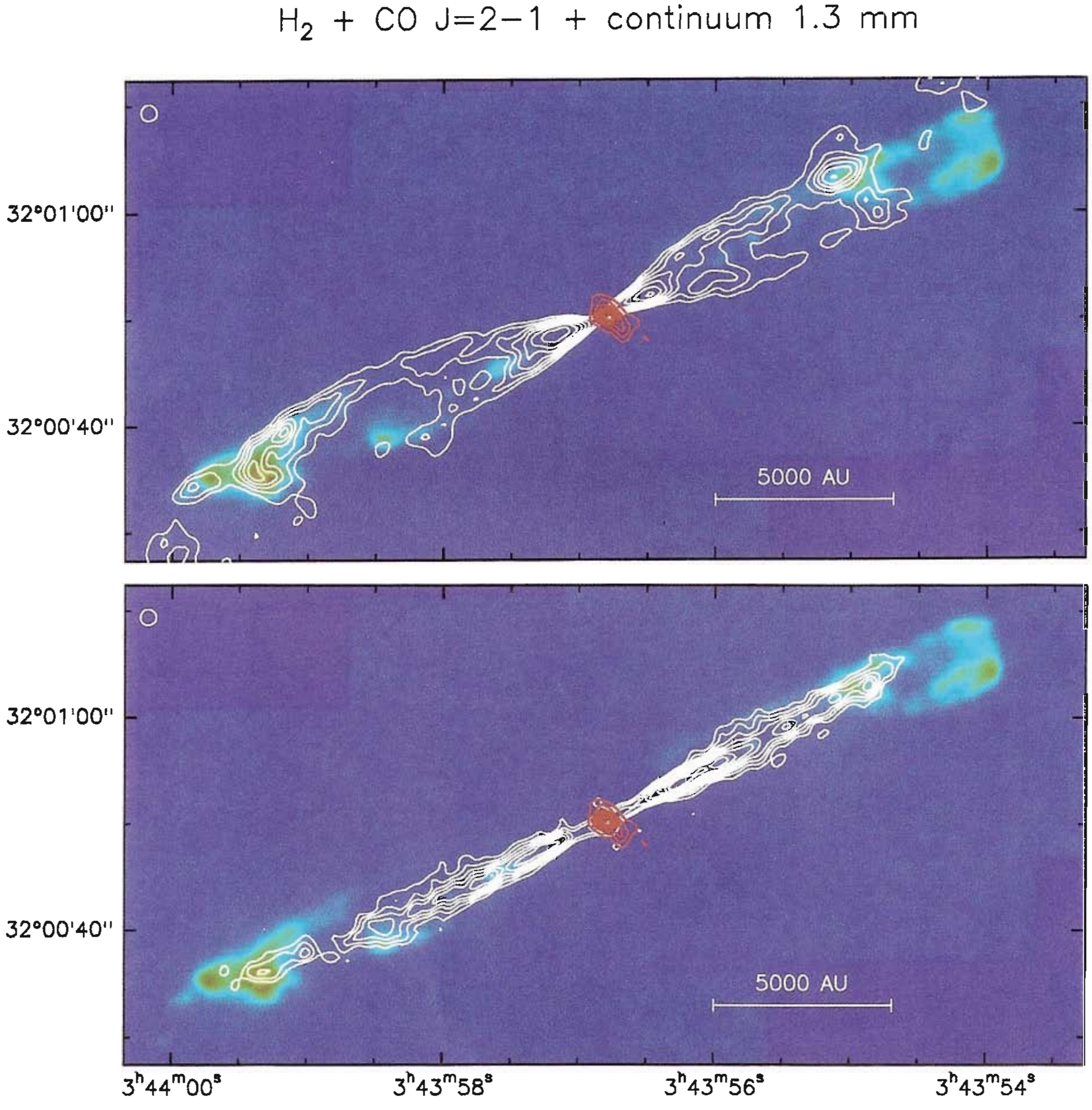

Fig. 2.7 CO(2-1) emission (white contours) in the HH 211 outflow, from the low-velocity cavity *(upper diagram)* and the high-velocity jet *(lower diagram)*, superposed on the molecular hydrogen emission mapped in the infrared by McCaughrean et al. (in green), and the 1.3mm continuum emission from dust (red contours).

Hot Gas and Dust in a Protostellar Cluster near W3(OH)

New interferometer maps have been made at 1.3mm with 0.5″ resolution of the high-mass star-forming region W3(OH). The maps show the compact H II region at W3(OH) itself and the hot core region 6″ east, the site of the bipolar outflow observed in water masers (**Fig. 2.8**). The new map shows the thermal emission from dust in the hot core region, and resolves it into three peaks, each of which is coincident with centimeter-wave radio continuum sources, one of which is non-thermal. The new map of the dust emission indicates that the hot core has a mass of 15 solar masses. Many molecular lines were detected in these new observations, which show that two of the peaks are caused by dust emission at a temperature of about 200 K, indicating that the dust is heated by new stars.

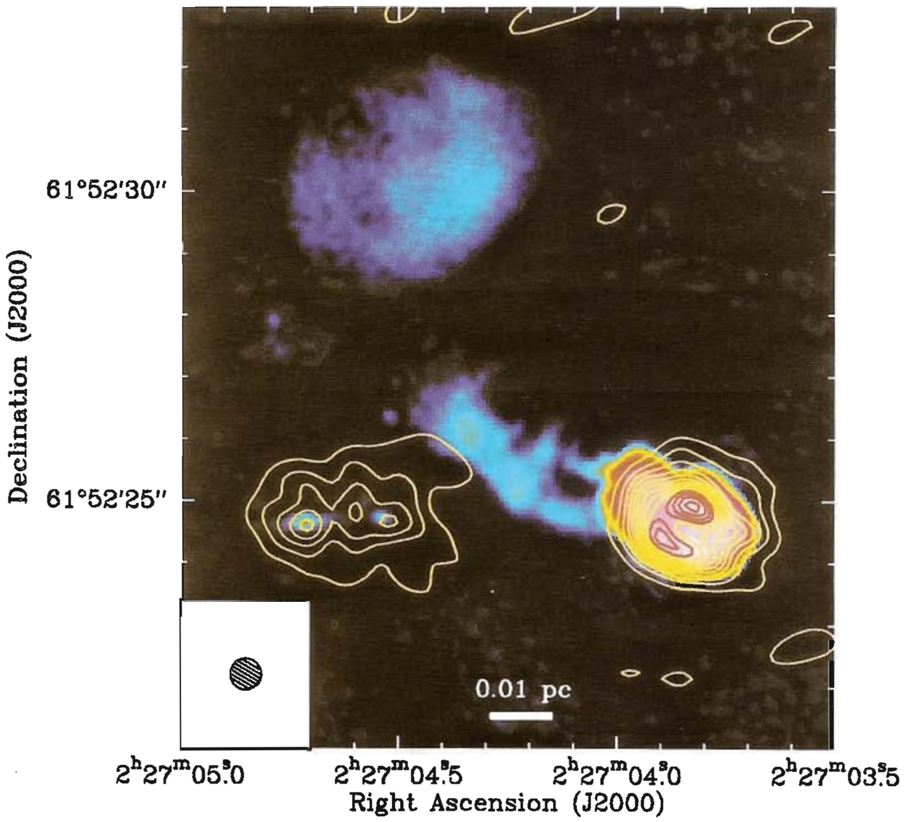

Fig. 2.8 Continuum map at 220 GHz of the star forming region W3(OH) from the IRAM interferometer (contours), superposed on the 8.4 GHz VLA image (blue-red color scale). The 220 GHz emission is free-free emission from the H II region (the source to the right), and thermal emission from dust in the heavily obscured, hot-core region (the source to the left). The 0.5″ beam at 220 GHz is shown at lower left.

2.4 CIRCUMSTELLAR ENVELOPES

2.4.1 Red Giant Envelopes

Two envelopes around the Carbon Star TT Cygni

The star TT Cygni belongs to the class of carbon stars , so named because of the apparent abundance of carbon-containing molecules in their envelopes. The carbon is the dredged-up product of nuclear burning in the interior of the star. Carbon stars blow off a large fraction of their mass in a stellar wind that enriches the interstellar gas with heavy elements. Maps of CO in TT Cygni with the IRAM interferometer show a compact, central envelope that has been blown off the red giant star during the past few hundred years, indicating that mass loss is currently occurring at a rate of 10^{-8} solar masses per year. Much more striking than this current mass loss however, is a remarkably thin (1.3″) outer ring at a radius of 0.25 light years (34″) from the star. The thin outer ring is a nearly spherical shell of molecular gas that was ejected in some type of flare, and that has been expanding outward for the past 6000 years. Its present expansion speed is 13 km/s, and it contains 0.02 solar masses of molecular gas (**Fig. 2.9**).

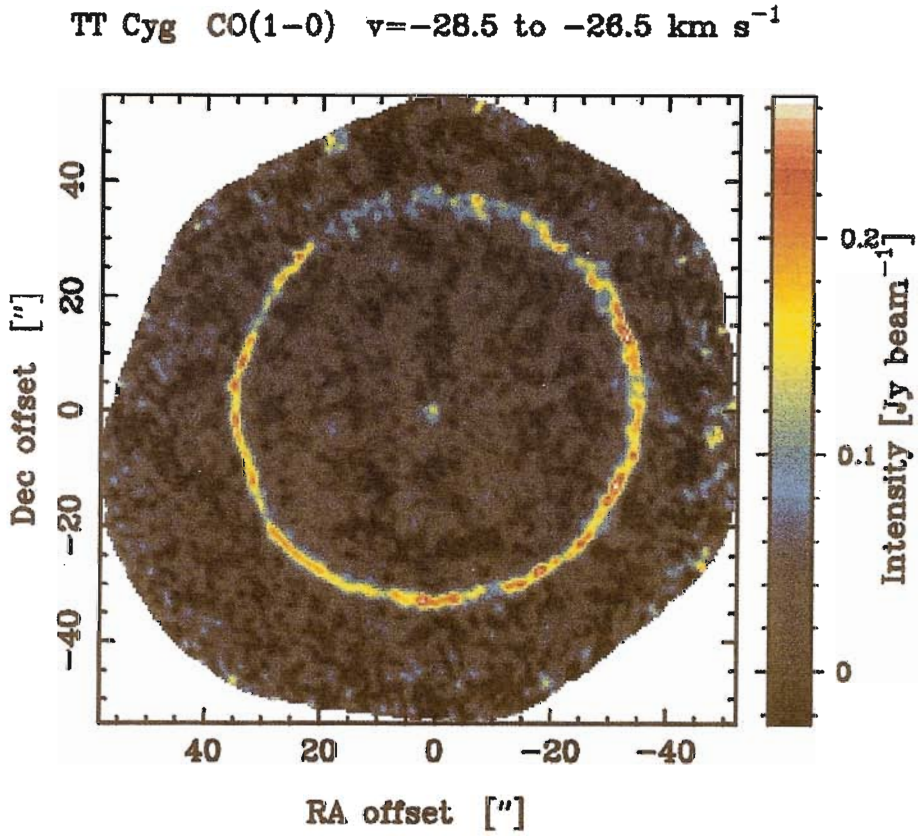

Fig. 2.9 Two envelopes around the Carbon Star TT Cygni. Interferometer map of CO(1-0) in the star TT Cygni, showing the central, compact molecular envelope, and the outer thin shell. The diameter of the outer shell is 68 arcsec, and the synthesized beam is 2 arcsec.

2.4.2 Planetary Nebulae

Structure and Dynamics of the Proto-Planetary Nebula M1-92

IRAM interferometer maps of $^{13}CO(2\text{-}1)$ in the proto-planetary Nebula M1-92 show a central disk and a bipolar, double-shell structure, with the outflow velocity along the disk's axis increasing with distance from the central star, up to a maxium speed of 70 km/s (**Fig. 2.10**). The disk has a diameter of 10^{17} cm (2.5″), while the thin walls of the double shell have a width of only 2 x 10^{16} cm (0.6″). The double shell is probably a relic of an old shell ejected when the star was on the asymptotic giant branch (AGB star). In the post-AGB phase, the star started to emit two energetic bipolar jets that have shocked the old shell and formed the double-shell structure. The mass of the molecular envelope is 0.9 solar masses and its age is 900 years. The jets must have interacted with the envelope in a shorter time than this. The jets cannot be driven by radiation pressure from the star, because it is not luminous enough to account for their kinetic energy. The observed molecular disk is also too large to collimate the jets, so where do these jets come from ? One possibility is that they arise near the star, which in its post-AGB phase has shrunk to a size of 10^{12} cm. If the star has re-accreted about 0.05 solar masses of the material that it previously ejected, then this new, compact, (and unobserved) accretion disk might be the origin of the fast, bipolar jets.

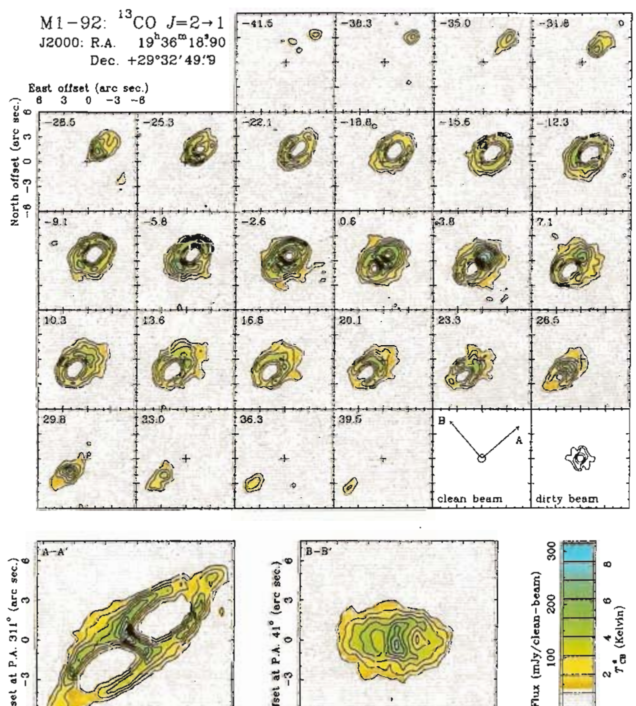

Fig. 2.10 Maps of $^{13}CO(2\text{-}1)$ in the proto-planetary nebula M1-92. *Upper panels :* Maps at different velocities (in upper left of each box, in km/s). *Lower panels :* Position-velocity diagrams along the symmetry axis of the nebula (*left*) and perpendicular to it (*right*).

CO Imaging of the Molecular Disk around the Jets in the Planetary Nebula KjPn 8

The IRAM interferometer has been used to make CO(1-0) maps with a 2.5″ beam of the planetary nebula KjPn 8. The maps confirm the presence of a molecular disk around the point of origin of the spectacular, 13' x 4' episodic jets in this object (**Fig. 2.11**). The disk is 30" in diameter, with an expansion velocity of 7 km s^{-1}. The axis is aligned with the youngest and fastest (300 km s^{-1}) of the bipolar jets, and there is evidence for interaction between the jets and the disk. The inner 4" of the disk is photoionized by the central star. The disk-jet system dominates the environment of this young nebula and should govern the morphology of KjPn 8 as it evolves to become fully ionized.

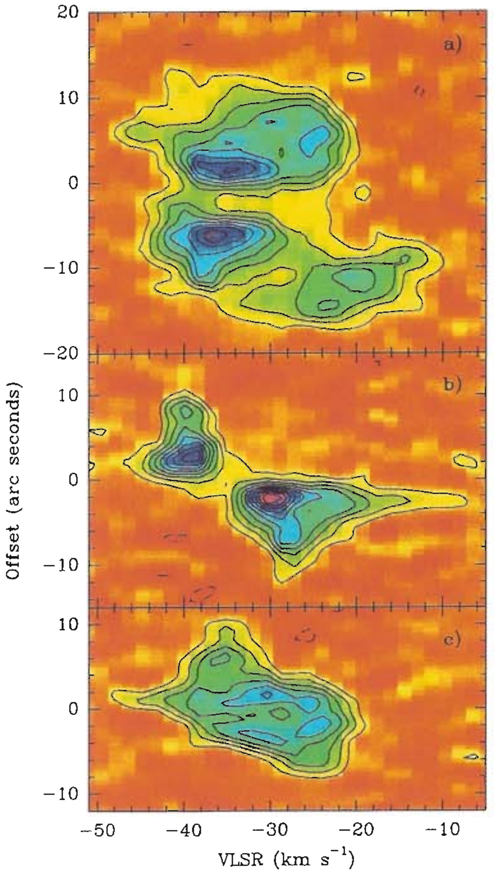

Fig. 2.11 Molecular Disk in the Planetary Nebula KjPn 8. CO(1-0) position-velocity cuts perpendicular to the disk (*upper*), along the disk (*middle*), and parallel to the disk at a 3.5″ offset (*lower*). The contour step is 0.4 K. The 4″-diameter ionized nebula lies in the central gap in the top and middle diagrams. The two peaks in the middle diagram show that most of the gas expands at 7 km/s (corrected for inclination). The long tail in the middle diagram is a jet, with an outflow velocity of 28 km/s.

3. PICO VELETA OBSERVATORY

3.1 30m Telescope Operation

The operation of the telescope was generally smooth throughout 1998. During September/October, the receiver cabin was completely refurbished. This represents the most extensive technical activity at the telescope since its construction. Details about the refurbishment are given in the section on receivers.

As in all previous years, the telescope was regularly maintained for about 13 hours per week, including receiver filling, receiver maintenance, test tunings, telescope, computer and backend maintenance. In addition, a number of periods of technical time were used for improving the telescope and observing modes, replacing and repairing equipment, surface measurements (holography) and adjustments, and working on changes in the telescope system.

As shown in Figure 3.1, also in 1998 the major fraction of the telescope time could be used for astronomical observations, namely about 60 % of the total telescope time. About 19 % were used for technical activities. The fraction of technical time relative to observing time was higher in 1998 because of the receiver cabin refurbishment which necessitated a shutdown of the telescope for all astronomical observations for a period of 5 weeks. About 15 % of the total time was lost due to bad weather ("stop meteorological") and wind ("stop wind").

Figure 3.2 shows the use of telescope time in 1998 in hours. The statistics are based on entries made by the telescope operators. The loss of telescope time due to technical failures (of more than two hours duration) was 1.1 %. Most problems could be solved quickly, also because experienced personnel was at the site.

The Granada astronomers provided throughout the year assistance and help to the visiting astronomers, taking care also of pointing and calibration measurements, as well as doing service observing for short projects.

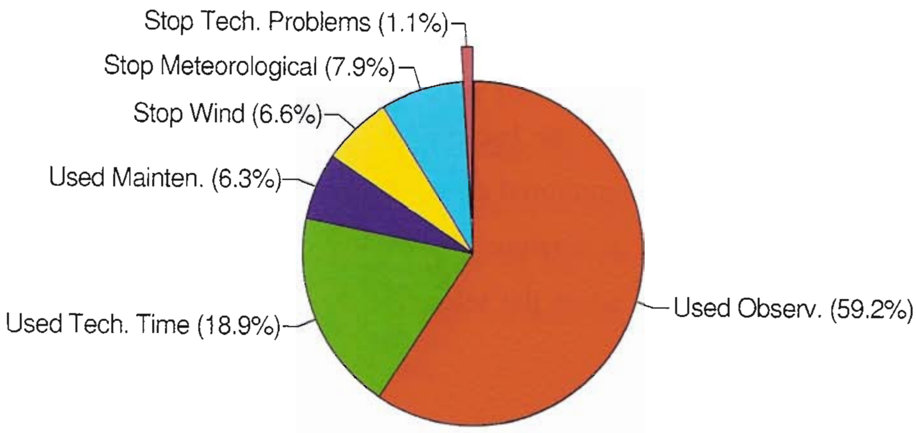

Fig. 3.1: Distribution of telescope time for the year 1998. About 60 % of the total time were used for observations, and almost 20% for technical activities.

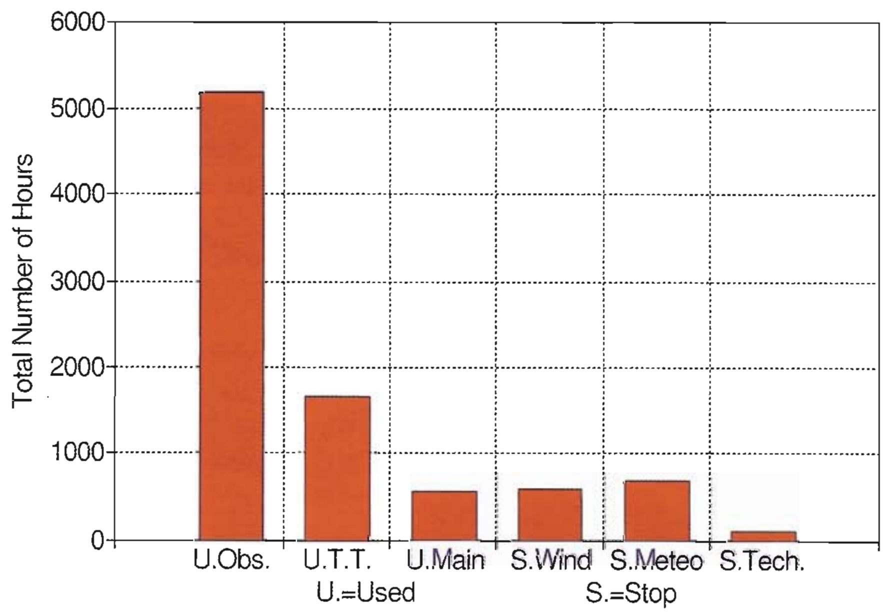

Fig. 3.2: Telescope use during the year 1998 in number of hours.

3.2 Antenna

Temperature Measurements

The installation of new temperature sensors has been completed: there are now 45 new sensors in the yoke, 105 sensors in the backstructure, and 1 sensor in each feedleg. The thermal state of the telescope is monitored every 5 minutes with an accuracy of better than 0.05°C. Figure 3.3 shows the temperature distribution of the backstructure (4 top and 4 bottom layers) on 23 July 1998 when the telescope was in a homogeneous thermal state (rms(T) approx. 0.5°C).

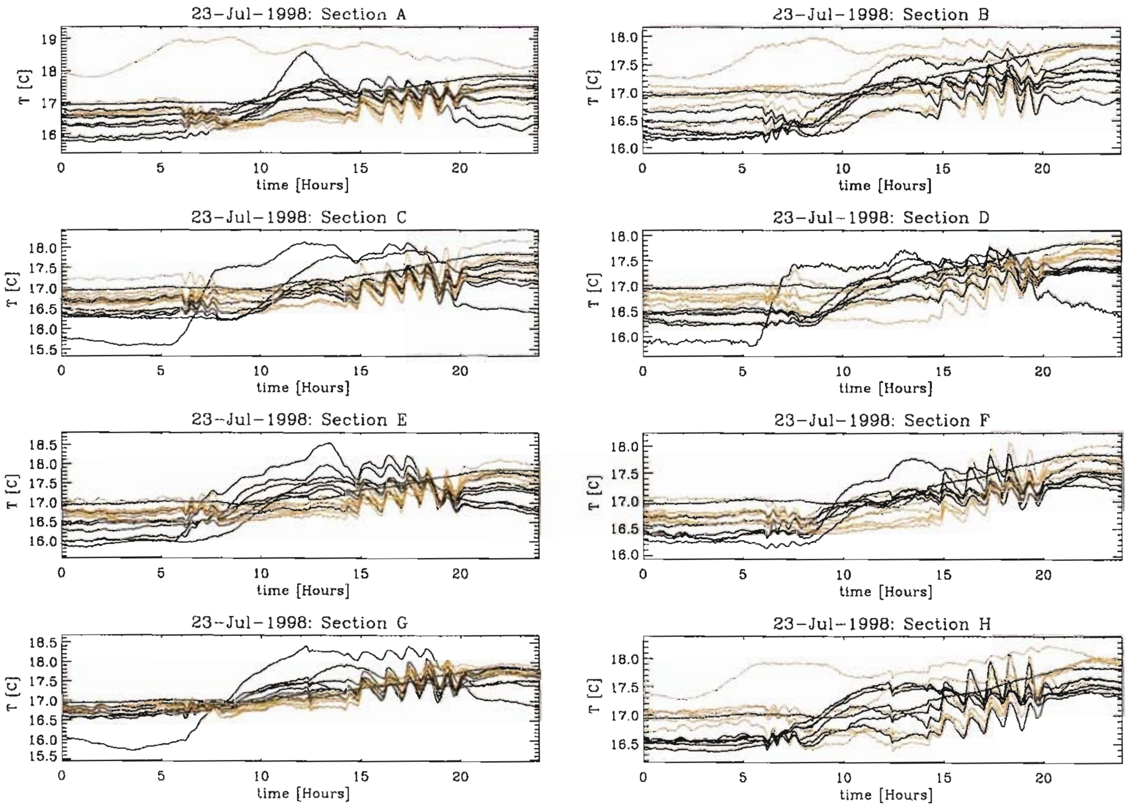

Fig. 3.3 : Temperature distribution inside the backstructure of the 30m telescope as measured on 23 July 1998. The surface is divided into 8 sectors which are equipped with 12-14 sensors each. The master temperature is shown as reference in all sub-panels.

Computer simulations with the structural finite element model (FEM) of the 30-m telescope (including the yoke, backstructure, feedlegs) have confirmed that the readings of the temperature at roughly 150 FEM nodes and the extrapolation to the non-measured nodes (roughly 2200) give a detailed and realistic picture of the thermal state of the telescope. The comparison of measurements on the telescope of focus and surface changes confirm that the predictions of the thermal structural deformations from the FEM are correct. The temperature recordings will be used to localise, if possible, the source of the residual thermal deformations.

The predictions from the finite element calculations (FEM) have also been used in a diffraction program to predict the resulting beam patterns. This program gives parameters which characterise the quality of the beam of the telescope. Having obtained more experience with these predictions, the parameters and the synthesised beam pattern for the actual state of the telescope may eventually be made available to the observer for particularly critical observations. A first analysis shows that at 1.3mm wavelength (230 GHz) the main beam may degrade by about 10% during 5-10% of the time.

Inclination measuring system

A new inclination measuring system (LEICA Nivel 20) has been installed on top of the antenna azimuth axis to measure the tilting of the antenna pedestal. Numerous measurements have been performed which have permitted to evaluate the good status of the antenna azimuth bearing and to determine the continuous changes in time of the antenna pedestal tilting. Currently the system is operative and programmed to record data whenever the antenna moves in azimuth more than 90°, thereby allowing to determine the most recent tilt parameters. The goal is to implement in real time the tilt parameters into the antenna pointing model.

Subreflector Alignment

Spacers have been installed to correct the misalignment between the hyperbolic subreflector and its fixation to the support ring. The inclination angle in the sky has improved from 25" to 10".

Backstructure Cladding

A broken plate (it had disappeared, perhaps due to a lightning strike) on the top of the antenna backstructure has been replaced by a new one.

3.3 Holography of the telescope surface

Time was available for holography during the refurbishment of the receiver cabin in September 1998. The remaining problems were solved and good measurements without « ripple » artifacts are now possible out to the telescope rim (cf. Figure 3.4).

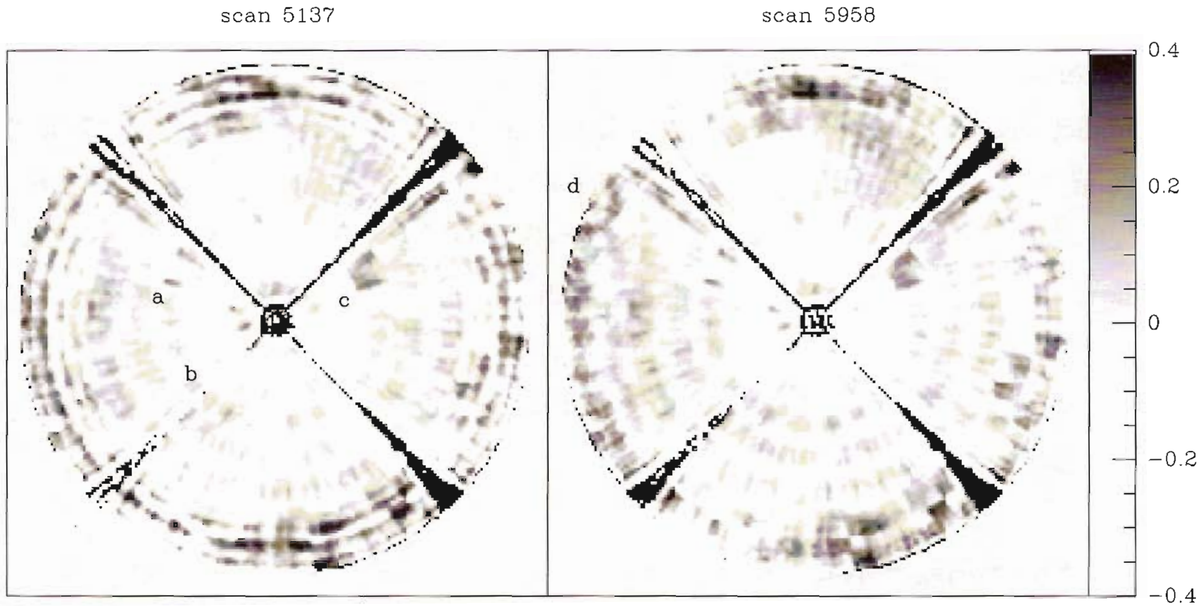

Fig. 3.4: Two (out of many) aperture phase maps obtained during the Sep 1998 holography session. The wedge scale is in radians at the measurement frequency (39.5GHz); 0.1rd corresponds to 60μm surface error. During the session, the cause for the ripple pattern seen in the outer part of the map on the left-hand side was found and eliminated. In the inner parts, that are not affected by this artefact, note the good consistency of individual details. The radial spokelike structures arise at the edges of individual panels (generally two panels/frame). Individual features of interest are identified: (a) a frame in ring 3, that has 5 adjustment screws instead of the usual 4, and whose outer rim is bent; (b) a frame that has one badly adjusted corner, partly corrected in the second map; (c) the test frame, intentionally raised by 100μm; (d) diffraction ring caused by a metallic structure near the prime focus.

The accuracy of the measurement and adjustment process was checked by making known screw movements and comparing with the holography results (cf. Figure 3.5). The reproducibility of the holographic measurements was also assessed. Screw settings were derived for the outer two rings of panels and improved values were derived for the innermost panels. The adjustment of the telescope surface has been completed, but the performance of the antenna has not been assessed yet.

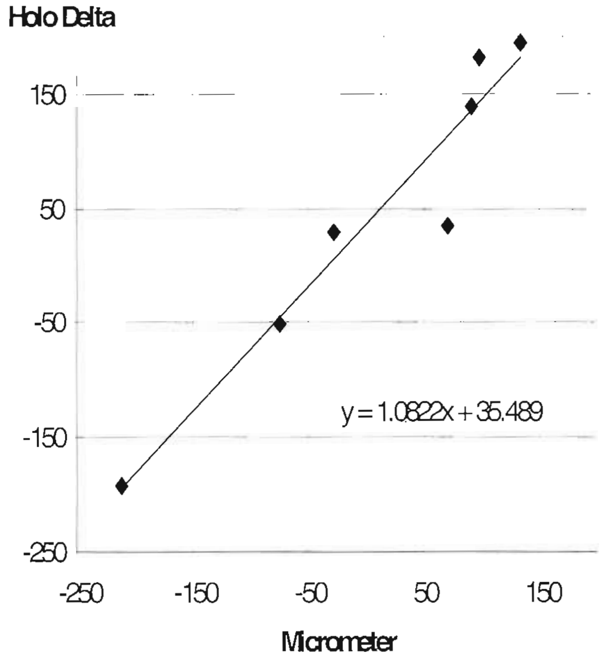

Fig. 3.5: Agreement between mechanical and radio measurements of panel displacements. In the middle of the holography run, seven screws were adjusted. The abscissa is the screw displacement, measured with a micrometer. The ordinate is the difference between holography solutions for each screw, before and after the adjustment; each solution is based on the average of several maps.

Holographic measurements of the telescope surface were also obtained when the temperature distribution within the backup structure was perturbed. This data was taken with the aim of verifying the predictions of the finite element program which uses measured temperatures to predict deformations. As mentioned already above, present indications are that defocus and astigmatic changes can be reliably predicted and higher order aberrations are under study.

As an alternative to the satellite ITALSAT which was used until now as a signal source for holography, a 39 GHz transmitter has been constructed by the receiver group in Grenoble. It was installed on the peak of Pico Veleta, at a distance of 2.7 km from the telescope, and the initial tests show that data comparable in quality to the satellite results can be obtained.

3.4 VLBI

The 30-m telescope participated in 1998 in all CMVA-coordinated global 3 mm VLBI observations for a total of approximately 15 days. Part of the observations were lost because of poor weather conditions. The preparation of the observations at Pico Veleta was supported by the MPIfR (Bonn), while the IRAM - Granada staff runs most of the observing sessions alone.

The VLBA terminal was upgraded by the MPIfR-staff for the use of thin tapes. IRAM provided 10 thin tapes for the global tape pool.

For the future upgrade of the Pico Veleta terminal to MK 4, and for future VLBI experiments on the Plateau de Bure, IRAM has ordered two MK 4 formatter units at Allied Signals, to be delivered in the autumn of 1999. Inquiries are going on for the purchase of a tape recorder unit for the Plateau de Bure.

The future terminal on the Plateau de Bure will use a recently refurbished maser, on permanent loan to IRAM from the CNRS.

3.5 Receivers

During the past year the long awaited new receiver cabin project for the 30m telescope was finally started. The cabin itself underwent major refurbishment, and most of the receivers, the optical layout, the calibration systems and control accessories were modified if not completely redesigned. On September 1st, the telescope operation was stopped and the work on the cabin and on the installation of new receivers began. Two months had been foreseen to modify and improve the cabin and its infrastructure, and to install the optics and new receivers etc. . A great number of people, both from Granada and from Grenoble, were involved in this work.

The refurbishment of the cabin

In the cabin itself, the following activities were carried out :

- The floating floor has been completely changed and the cabin has been painted after some 16 years of use.

- A bridge crane, able to reach all existing receiver locations has been installed.
- The electrical distribution has been completely remade. Twelve outputs with independent safety mechanisms and remote alarm status sensors are now available. Provision has also been made for the future multibeam compressor.
- Some protection against the never ending water leak problem has been developed and installed.
- Nine IF cables for the coming multibeam receiver have been added to the existing set of cables.

Fig. 3.6: Work in the receiver cabin. The floor is prepared for the new receiver support structure.

New optical layout, a new generation of receivers, and other new components

The optical layout in the cabin has undergone a series of improvements, taking into account also future needs like the accommodation of future cryostats, multibeam receivers etc. The heart of the new design is the dual channel hybrid cryostat designed by the receiver group in Grenoble. The cryostat, similar in design to the PdB receivers, was first brought to Granada in late 1997 but due to technical reasons it was not until May 1998 that the prototype was tested at the telescope. Experience with the new receiver demonstrated good performance in terms of noise temperature, stability and ease of operation and, at the same time, helped to identify some minor problems.

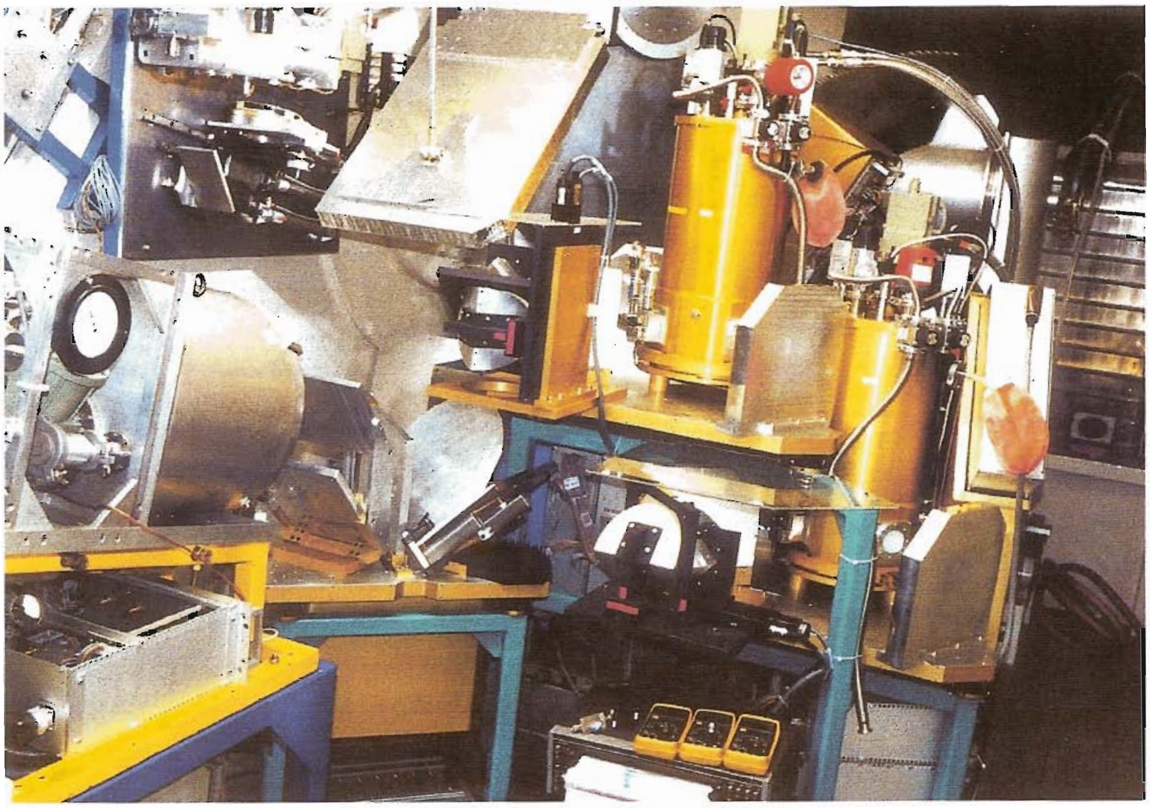

Fig. 3.7: The new receiver cabin after the refurbishment. One of the new dual channel receivers (golden dewar) can be seen.

The Granada staff has been especially involved in the development of:

- A new cold load reference which uses a closed cycle cryostat. It replaces the old nitrogen bath. The equivalent radiometric temperatures measured at the reference plane (the divider position) are close to 80 K for all the bands, short term stability seems to be good and shows no symptoms of vacuum degradation after four months of continuous operation. Some modulation of the spectrum caused by reflections on the dewar window or cold absorbers still need to be improved though it does not seriously affect the observations.
- A new calibration system with a new optical layout that includes a polarisation grid for reducing the dynamic and for polarisation measurements. The grid can be remotely switched in front of the cold load and will shortly have the possibility of changing the polarisation angle. Figure 3.8 shows the new calibration system.
- A switchable flat mirror (M5) for selection between normal receivers and the future multibeam receiver.
- A new optical table with anti-vibration absorbers to accommodate e.g. the bolometers (MPIfR bolometer-arrays, Diabolo etc.).

- A new optical arrangement and mirror support to bring the beam to the focal plane of the bolometer. It uses better and bigger mirrors for reducing the losses on the 37 channel bolometer array.
- A laser diode for alignment purposes. The laser is permanently installed on the elevation axis, behind the M3 mirror. It is now the main reference for optical alignment of all the mirrors inside the receiver cabin.

Fig. 3.8: The new calibration system in the refurbished receiver cabin.

One of the first consequences of the installation of the new receiver cabin is the clear improvement in the relative alignment problem that the old system was suffering. Due to the compactness of the design and the very rigid mechanical supports designed by the Grenoble team, the relative alignment is now very good and stable for months. The successful installation of the new receiver cabin layout, including the first set of dual channel (3mm + 1.3 mm) receivers, is a major step towards the modernisation and improvement of the frontend part of the telescope. The arrival of two more dual channel (2mm + 1.1 mm) receivers in 1999, and of the 230 GHz multibeam receiver will further enhance the capabilities of the 30m telescope.

3.6 Backends

During 1998, apart from routine activities, the main task was the design of a new wide-band filterbank: The work focussed on the following components :

- The filterboard was prototyped, tested and works satisfactorily. Nevertheless, modifications are needed to facilitate the series production, and to replace the detector diode which is no longer available.
- A test set-up was built to ease the adjustments of the board. It needs upgrading and should eventually run under computer control.
- The prototype of a quint local oscillator plug-in module was designed, tested and works satisfactorily. The construction of the three needed definitive modules has started.
- Voltage-to-frequency converters and Latch Scalers: the detailed electrical diagram was established in collaboration with Grenoble. The FPGA to be soldered upon has successfully been programmed. The realisation of a complete prototype board has started.
- For the RF pre-processor ("gamelles") so far only an electrical diagram was made.
- The manufacturer for the C.E.M. housing was chosen. The mechanical design has started.
- A more accurate estimate of the necessary power supply was made. Although tight, it appears that all the modules which are needed will fit in the initially allocated volume.
- No progress has been made so far on the timing and computer connections.

Apart from the work on the filterbank, the VLBI recorder was upgraded to operate with thinner tapes.

The backend synchronisation system has been changed from CAMAC to VME. This system produces the necessary interrupts to synchronise the data acquisition according to the phase generated by the different calibration devices such as the wobbler, beam switching, polarimeter, and others. This system produces also the interrupts when observing in total power mode and in the frequency switching mode, and it commands the frequency for the 2nd reference of the receivers. The new system, developed under VME, gives also enhanced performance as compared to the CAMAC system used before.

3.7 Computers and Software

The highlight activities in 1998 are described below. They include :

(1) A new HP workstation at the 30m telescope

(2) Wider use of Linux at IRAM Spain

(3) Remote Observing from IRAM Grenoble

(4) Work on the receiver cabin refurbishment

(5) Development of new monitoring and control software

New HP workstation at the 30m telescope

We have installed a new HP workstation at the Pico Veleta observatory. Like the other Unix systems installed it is a multi-user system and can be accessed via the network from other desktop systems. The main features of the new workstation give an improvement by a factor of four over the old systems (main memory, CPU performance) and the system configuration is state-of-the-art (fast ETHERNET, graphics subsystem, fast-wide SCSI).

The new system runs with version 10.20 of the HP/UX operating system. The second HP workstation at the MRT also has been updated to version 10.20. The HP workstation in Granada will be updated to the new HP/UX version in early 1999. One of the older workstations is now reserved for system tests.

Linux at IRAM Spain

During 1998 we have installed several more Linux systems. They are now used for desktop systems, VLBI control, in the receiver cabin, as web and e-mail server, and for remote observing from Granada.

We have one system configured as a "power" system with a fast CPU, large memory, fast-ethernet, fast-wide SCSI and a removable disk (Iomega Jaz). Several data reduction packages are available on this system.

Linux has also been ported to a VME board with a PowerPC processor. It is planned to use this system for autocorrelator control. This would allow to use the autocorrelator in the future with integration times below 1 sec (in the On-the-Fly mode).

Remote Observing from IRAM Grenoble

Remote observing from Grenoble is now offered also to non-IRAM observers. We use a dial-up ISDN line as the Internet line does not guarantee sufficient communication capacity at any moment.

In Grenoble, we use an HP/UX workstation and a MS-Windows PC. We have installed a videoconference hardware and software in Grenoble, Granada and at the telescope, and use the MS-Windows system to offer a videoconference during remote observing. The software for remote observing has been modified and now (even) the users consider it to be easy to use.

The remote observing software could also be installed at other institutions if they fulfil certain requirements (ISDN, Linux or HP/UX workstation).

Receiver Cabin

During the fall of 1998 the receiver cabin was completely rebuilt. Some parts of receiver control now use different hardware. A second VME crate was installed to control the new receivers and the beam splitter. Computer control of the equipment is done now completely via VME and a Linux system in the receiver cabin. The operator and receiver engineer can control the splitter and calibration equipment with a graphical interface (cf. Figure 3.9).

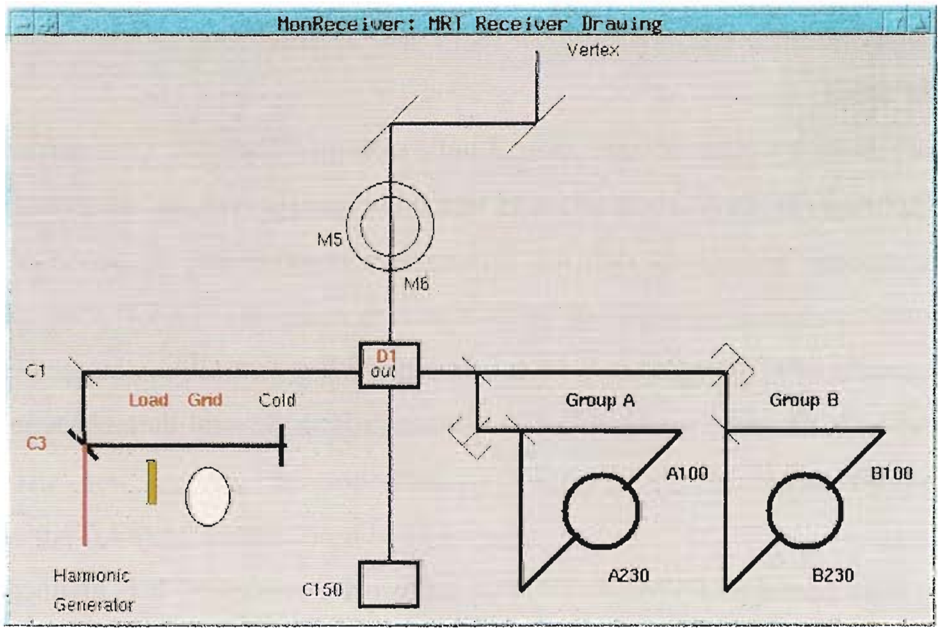

Fig. 3.9: Display of the receiver and optics monitoring software.

New Monitoring and Control Software

Status monitoring and operator control of the 30m telescope was originally using CAMAC equipment (Monitor, Touch Panel, ...) and serial terminals. To overcome limitations of this approach (i.e. to allow monitoring from the Granada office or the receiver cabin) we had developed several utilities over the last years. Some of these utilities form part of the current version of the remote observing software. However, these utilities put more load on the antenna control computer and the network and do not necessarily arrange items in a logical way.

Therefore, in 1998 new software for monitoring and control was written that uses X-Window for graphical interfaces (in tcl/tk). Status messages are transmitted over the network via so-called broadcast messages. By that, monitoring is possible now on several desktop stations at the same time without increasing the network load. Nevertheless, control of equipment is restricted to the operator and, in the case of the receivers, to the receiver engineer on duty.

In 1999, it is planned to incorporate the new monitoring software into the remote observing software.

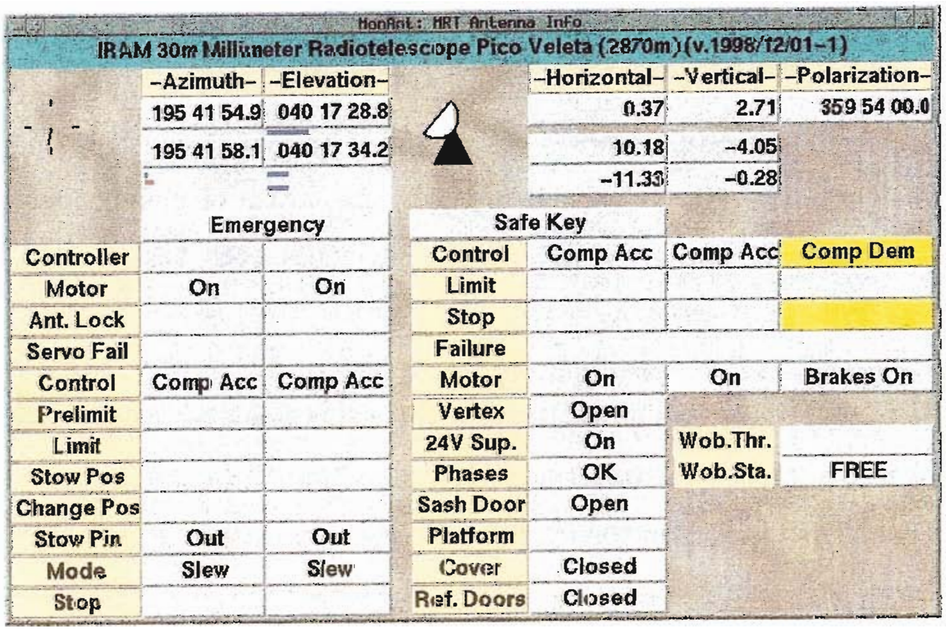

Fig. 3.10: New antenna status display.

Other Items

The "Project Management Software (PAM)" has been improved to handle visitor accounts and backups for over 200 projects per year

The electricity distribution for the computer equipment has been changed. Several general power failures and problems with the current No-Break system affected the computer network. A new No-Break system has been ordered and installation is foreseen for March 1999.

3.8 Infrastructure Improvements

The receiver cabin has been equipped with a new electrical installation, with new bigger cross-section cables laid out and a new distribution box.

The two diesel generators have been equipped with new regulators to facilitate the balance of the electrical load between both.

The computer area in Granada has been equipped with a new electrical distribution system to solve power failure problems due to the old installation and to prepare it for the future UPS unit. Two new ultrasonic humidifiers have been installed, in addition to the one that was in service already. The three ultrasonic humidifiers are controlled by an automatic system to guarantee a constant humidity in the observatory building. With the arrival of this modern system, which consumes only 1.5 KW, the old conventional system has been disconnected. It consumed 20 KW !

A second GPS receiver has been installed. This second GPS has three main applications: (1) as a backup system to supervise the maser and synchronise the VLBI terminal, (2) to control the observatory rubidium clock, maintaining the observing time accurate to better than 2 µsec, and (3) to deliver the IRIG B time signal to synchronise other systems as e.g. VME crates. Also, the MPIfR new bolometer backend BOGLE is synchronised in this way.

3.9 Safety Precautions

A 30 hours first aid training course has been given in Granada by the Red Cross instructors. Twelve IRAM workers, who usually work at the observatory, have followed the course (Figure 3.11).

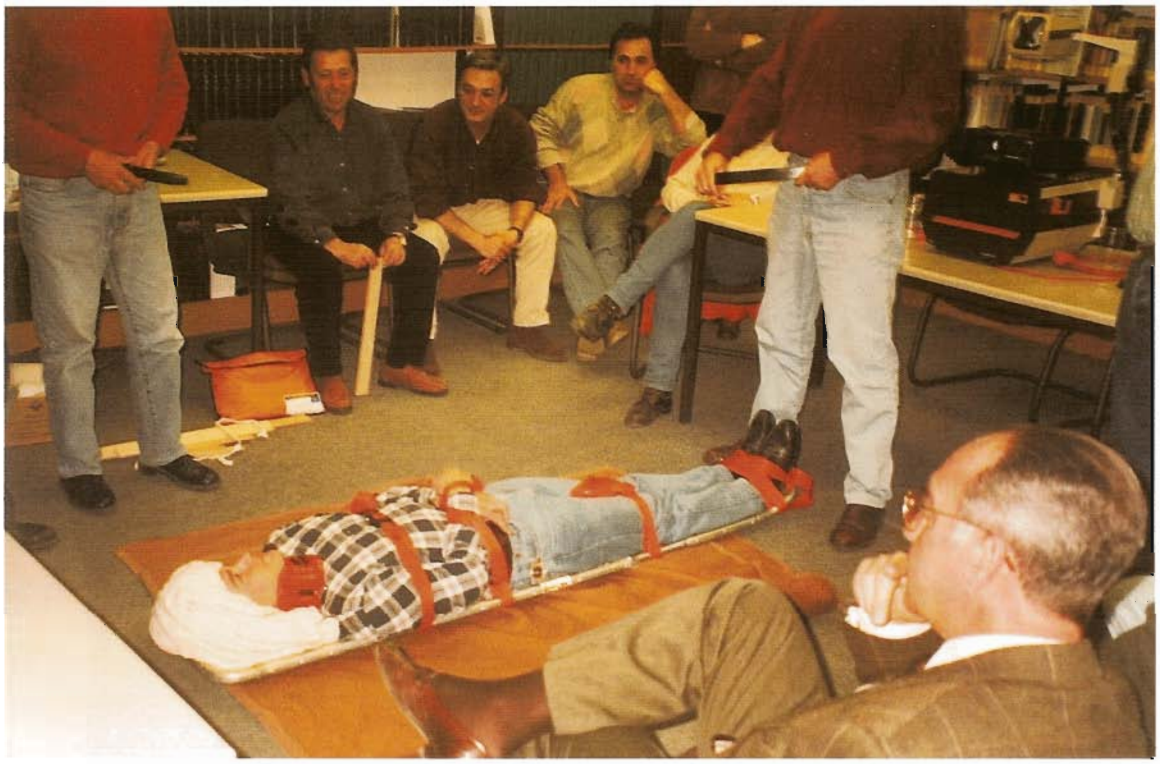

Fig. 3.11: IRAM staff members receiving a First Aid training course at the Pico Veleta Observatory.

A 4-hours training course for extinguishing fires has been given at the observatory by the Granada fire brigade. A new independent water pressure group has been installed to feed the five fire hoses at the observatory. The installation is now compatible with the CEPREVEN recommendations for fire protection.

All the water pump systems at the observatory are now able to work with mains or generators. For that purpose a second power supply line has been installed to feed all the water pressure systems directly from the diesel generators in the case of a fire emergency. Fire resistant cables were used for this second power line.

A maintenance contract has been signed for the fire alarm system in Granada.

3.10 Administration - Accommodation - Transport

A new (second hand) ratrack was bought and put into operation. The new machine is a Kassbohrer PB 42.240 D with a new cabin for the passengers which offers more comfort and safety.

As in all the years before, the Granada office handled the transport and the accommodation (and many special wishes) of approximately 200 visitors.

4. PLATEAU DE BURE OBSERVATORY

4.1 Interferometer Status

Operation

The Plateau de Bure interferometer was operated with more than 40% efficiency throughout the year: the weather conditions on the site were very good towards the end of the winter period, conditions were relatively good from spring to fall, and exceptionally good weather occurred during the months of November and December.

The remaining 60% of the time went into tests, adjustments, maintenance, and were lost due to bad weather conditions. On average the weather conditions were about the same as in 1997.

The output of scientific data was the highest ever achieved: about one hundred projects have successfully been completed with the Plateau de Bure interferometer in the course of the year. Compared to previous years, significantly more extragalactic projects were carried out. In Section 7.2 a detailed list is given of all the projects scheduled and brought to completion in 1998.

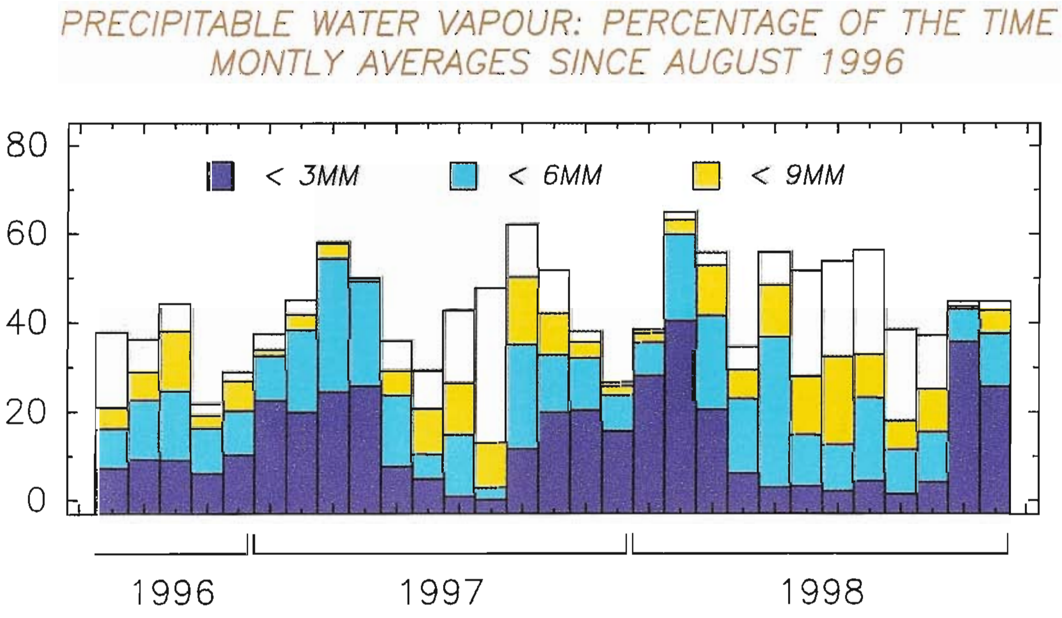

Fig. 4.1: The atmospheric water vapour content recorded on the Plateau de Bure since August 1996. In February 1998, the interferometer was operated for more than 40% of the time (12 days) with less than 3mm precipitable water vapour in the atmosphere. Observations in the high frequency window (205 to 240 GHz) and observations on extended baselines (A and B configurations) are for the most part carried out in the winter months.

Maintenance

As in previous years, a number of modifications were made in addition to the normal maintenance work, resulting in a somewhat longer period with only 4 antennas in operation (cf. Fig.4.2).

A substantial amount of work in 1998 went into the replacement of many of the carbon fibre panels on antennas 1, 2 and 4. All panels that had suffered large numbers of pin-holes in the thin plastic foil that covers these panels (87 in total) were replaced by carbon fibre panels that had been dismounted in the year before from antenna 3 when that antenna was completely re-equipped with a new set of aluminium panels.

The idea is to take the aluminised plastic foil off from the more severely damaged panels and to refurbish them, e.g. by applying a layer of conductive paint.

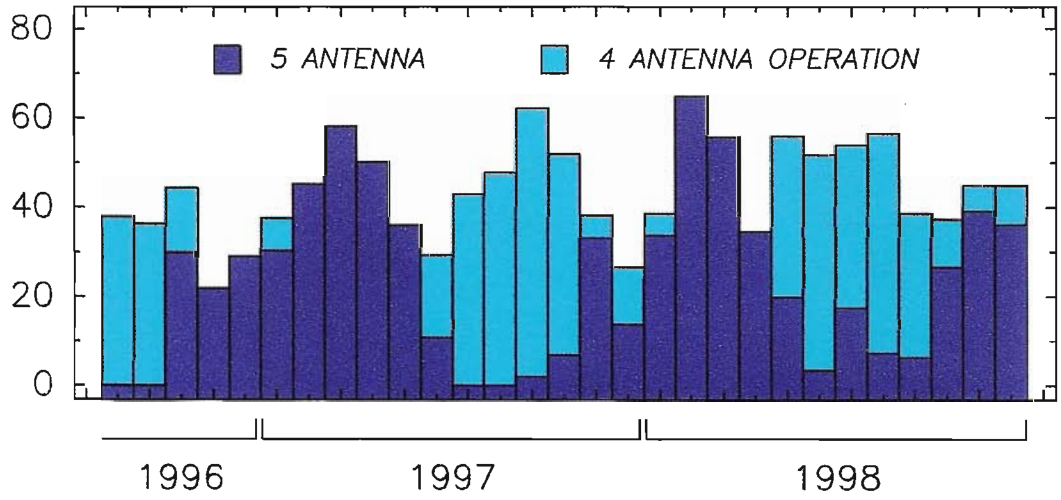

Fig. 4.2: The percentage of time for astronomical observations since August 1996. At that time the Plateau de Bure interferometer started operating with 5 antennas. During the summer months, observations are in general made with 4 antennas. The June to October period coincides with the annual maintenance period of the interferometer.

Another important change concerned the replacement of the carbon fibre subreflector on antenna 3 by the first of a series of new subreflectors, made from solid blocks of aluminium by a technique similar to that used to make the aluminium panels. This subreflector arrived just before the end of the maintenance period, and it was extensively tested in early October. Its surface accuracy equals that of the carbon fibre units. Due to its different mechanical construction it did initially have an important lateral offset which was detected during a series of holographic measurements and corrected shortly thereafter. In these tests, small horizontal misalignments were also found for the subreflectors on antennas 1, 4 and 5, and subsequently corrected to optimise the positioning of these subreflectors.

The surface accuracy of all antennas was newly assessed. Surface re-adjustments were verified by holographic measurements and the accuracy found to be better than 50 microns on antennas 1 and 4 and better than 60 microns on antennas 2, 3 and 5.

Among the minor improvements that were made, we mention the complete replacement of the de-icing racks on antennas 1, 2 and 3. The equipment showed first signs of fatigue. Another effort was made to improve the pointing of antenna 1. The balljoint supporting the actuator for the vertical translation of the subreflector was replaced with a new model to remove some of the sporadic pointing jumps in elevation. Monitoring is underway to evaluate its long-term performance.

4.2 Projects under Development

In connection with the long-term plan to extend the capabilities of the Plateau de Bure interferometer, two new development projects were started in the course of the year: the construction of the sixth antenna, and the extension of the N-S track from now 232m to 368m.

Construction of Antenna 6

All major components for the construction of a 6^{th} antenna for the Plateau de Bure interferometer have been contracted in the course of 1998, and towards the end of the year the components of the mount arrived at the station. The assembly work on the Plateau de Bure will officially start in the first week of January 1999. Antenna 6 should be ready for commissioning work by the beginning of the year 2000.

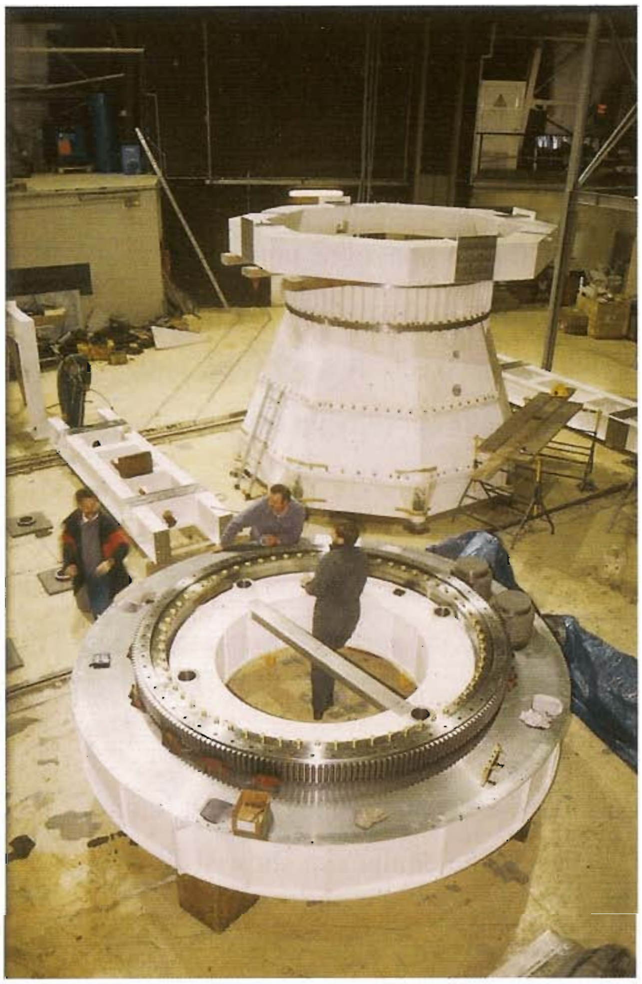

Fig. 4.3: The beginning of the assembly work for Antenna 6 on the Plateau de Bure.

Extension of the N-S track towards station N46

In preparation for an extension of the N-S track detailed studies of the properties of the structure of the rock were performed, and in the summer of 1998 the levelling work began by blasting the rock that blocked the path north of station N29. A total of approximately 16000 m^3 of stones had to be removed from this location. Altogether more than 40000 tons of excavation material were moved to create a flat area of 1500 m² on which the 136 m long track extension will be built during the summer of 1999.

Fig. 4.4: A drilling rig close to N29 during the preparation of the ground levelling work for the new track extension. Far in the background three antennas of the interferometers kept at a safe distance from the blasting areas.

4.3 Improvements of the Infrastructure

Signal Distribution

In preparing for the arrival of the 6th antenna and the necessary changes of the cabling, a 55m long underground duct was constructed between the basement of the living quarters, from where the cables run towards the individual stations, and the correlator room in the hangar. The duct allows to put both HiQ and LoQ cables for six antennas together with a set of spares.

Cable-car

To facilitate maintenance and repair work on the cable-car system, and to increase the safety of the persons executing the work, a special platform has been purchased that can replace the normal cabin.

A special system has been developed to monitor the accumulation of ice on the cables under certain meteorological conditions. The system triggers an alarm which prompts the operators to run the cable at certain intervals, thereby preventing the ice from building up to critical levels.

Infrastructure

The increased use of compressed air in the hangar area and in the associated workshops and laboratories led to the decision to install a new circuit which is by now fully operational.

Safety Issues

The radio link system in place on the Plateau de Bure as part of the safety precautions has been extended to the lower cable-car station. It automatically transmits data from several sensors to the control room and also connects to outside telephone lines.

4.4 Data Analysis and Local Contacts

While the data analysis software has become very stable and can now be ported to several software environments, an error was discovered in the February 1998 release of the CLIC program which could have an effect on the visibility tables in the case of spectral line observations . The error has, of course, been corrected as soon as possible, and the principal investigators of the projects that could have been affected have immediately been warned.

With the start of the summer period, an IRAM astronomer was assigned as a "local contact" to each of the A and B rated projects. The "local contact" is responsible for helping in the detailed planning of the observations, their quality control, and throughout the data reduction phase. This procedure allows the users' community to be more directly involved in all phases of the execution of projects, thereby helping to optimise the scientific output.

5. GRENOBLE HEADQUARTERS

5.1 SIS GROUP ACTIVITIES

The SIS group develops and fabricates superconducting radiation detector elements such as SIS junctions and micro-bolometers for the receivers on the IRAM telescopes and for other ground and space borne observatories.

The SIS junctions are made from Nb-Al-Alox-Nb or NbN-MgO-NbN tri-layers and are structured on a μm^2 scale by means of photo- or electron-beam lithography. SIS elements are used as mixer elements up to frequencies of about 1 THz. Microbolometers are fabricated as small superconducting bridges from very thin NbN or Nb films and structured with the aid of electron beam lithography on the scale of 100 nm. Such devices can serve as efficient mixer elements for frequencies of several THz .

A recurrent problem in the existing IRAM SIS device facility was its cramped environment and its insufficient air conditioning and air purity. In the beginning of 1998, a new clean room facility was therefore installed which allows processing under stable and well-defined conditions (humidity, temperature). The design of the new clean room (class 100/1000) follows modern concepts with a separation between the clean area (processing) and grey area (pumping, ventilation, fluid and gas distribution). The new clean room also improved working conditions in general as the various devices were arranged in a more ergonomic way.

After completion of the new clean room installations, all machines have been restarted and re-calibrated after a thorough maintenance. Regular work in the clean room was started again during the summer of 1998. In general it was found that the numerous small details which were necessary for junction production were more difficult to re-establish than to restart the deposition machines. In the following months the photo resist system had to be changed, because the trend in microelectronics to very large fabrication facilities led our former supplier to restrict his photo resist deliveries to unreasonably large packing quantities.

After an intensive phase of process optimisation, junctions of good quality for 100 GHz could be produced towards the end of 1998 and junctions for the new 300 GHz channels are under production. Improvements in yield and process control remain, however, still to be achieved.

To this end, a series of activities has been started to improve the control over thin film parameters before, during and after processing.

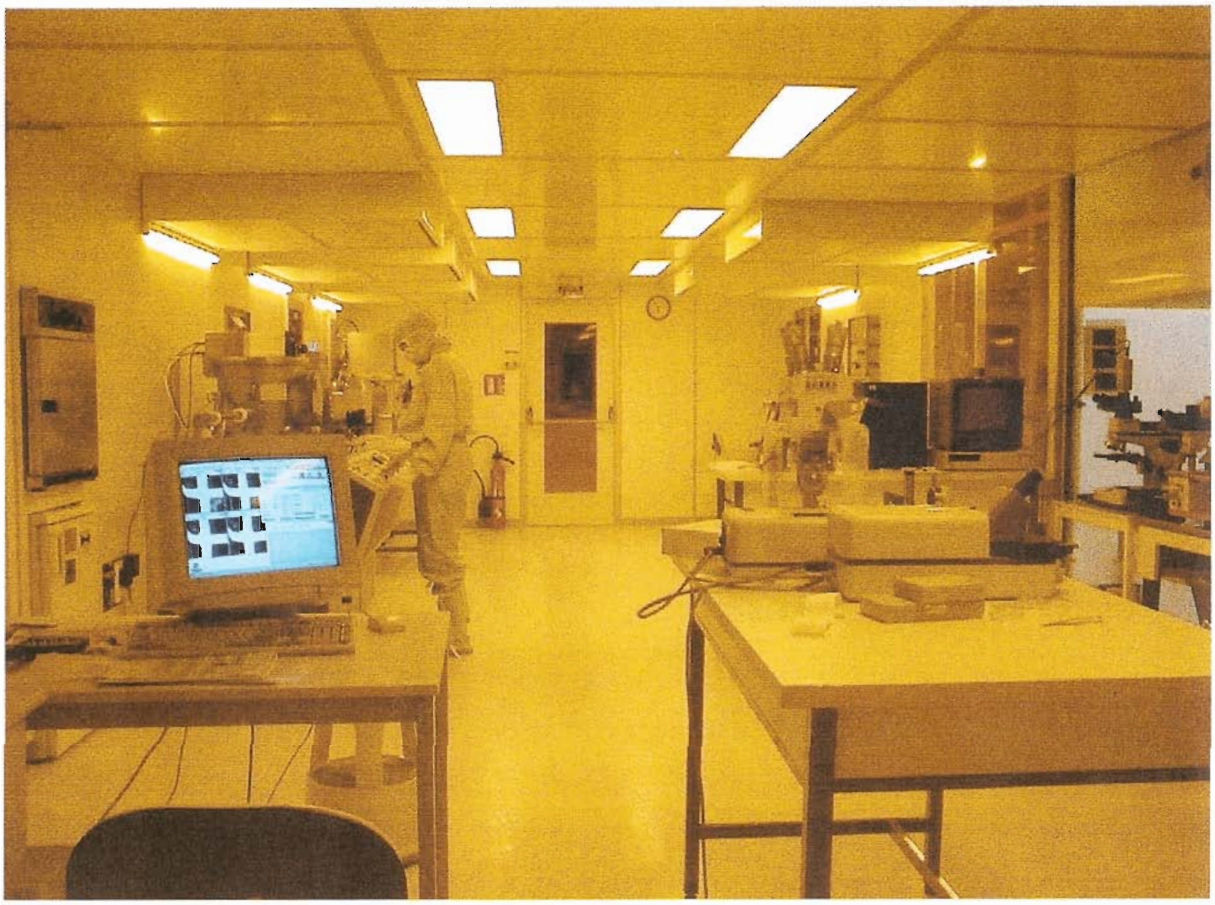

Fig. 5.1 : The new IRAM clean room for processing of superconducting devices.

Work has been started on the definition of submicron Nb junctions by means of automatic electron beam lithography. This method should allow for a much better accuracy in surface area for junctions below $1 \mu m^2$. However new ways of deposition and lift-off of the following SiO_2 layer have to be found for such small junctions.

Development work on hot electron microbolometers (HEB's) has continued during the year 1998. Since three years the SIS group has been able to produce very good HEB's on the basis of very thin NbN film technology. During the last year, most work was spent on developing a better and more efficient characterisation of these elements. A method for the characterisation of the HEB's IF bandwidth by a cryogenic impedance measurement was successfully established. These measurements show that the current devices have an IF bandwidth of about 2 GHz, still considerably smaller than theoretical calculations suggest.

In order to control and to improve RF coupling structures, a Fourier transform spectrometer has been built. The spectrometer is based on a Martin-Puplett interferometer and is fully under remote control. A convenient data reduction and graphical display program was included in the control software. Measurements of the NbN HEB's with dipole-antennas show a very broad matching around the desired frequency of about 800 GHz.

The spectrometer will also serve to characterise matching structures for SIS junctions and will soon be equipped with a N_2 chamber to avoid atmospheric absorption lines. Work on diffusion cooled HEB's made from Nb films has been started during 1998. In contrast to the phonon-cooled NbN elements such devices possibly offer a higher IF bandwidth with similar noise performance due to rapid cooling by diffusion of hot electrons.

The activity in the SIS group has been focussed on the developments which are required for the IRAM telescopes. Traditionally the laboratory has always been open to collaborations, a fact which is also reflected in the various ongoing projects with other groups. While the HEB development is a collaborative effort between IRAM and the MPIfR Bonn to prepare SOFIA instrumentation, the electron beam definition of high quality Nb junctions is developed within the FIRST collaboration between IRAM and DEMIRM, Paris, with the financial support of the French space research organisation CNES.

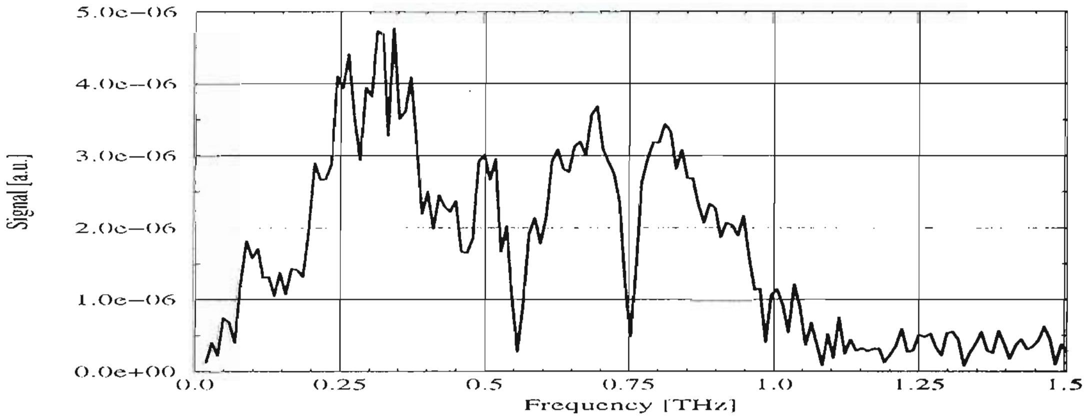

Fig. 5.2 : Spectral sensitivity of a dipole-coupled NbN Hot Electron Bolometer as measured with the Fourier Transform Spectrometer. The sharp absorption features at 560 and 750 GHz are due to water vapour in the spectrometer.

5.2 RECEIVER GROUP ACTIVITIES

5.2.1 Receivers on the telescopes

30-m telescope, prototype dual-channel.

In May, the prototype dual-channel receiver —covering the 100GHz and 230GHz bands— was successfully installed at the 30-m telescope, replacing the 3MM1 and 230G1 receivers. That replacement resulted in the following benefits to the users : substantial gains in receiver noise (standard reference plane), especially for the 100GHz channel; very good total power stability; speed and repeatability of the automated tuning; predictable performance in multi-frequency observations due to the lower losses of the Martin-Puplett diplexer compared with the dichroic plate that was previously used. A few problems were encountered in the following areas : relative focus; He hold time; MP diplexer motor control; either they had a minimal impact on the observing efficiency or were resolved in a few days. A rather extensive account of the prototype installation was given in the IRAM Newsletter #36; for that reason, and because the prototype was superseded by the receiver cabin refurbishment, we do not give more details here.

30-m telescope, new cabin, general

The receiver group contributed to the 30-m cabin refurbishment in Sep-Oct 1998, in cooperation with several other groups of IRAM in Grenoble and Spain.

Two dual-channel cryostats, named A and B, were built and characterised. Tuning tables for all local oscillator, multiplier, and mixer parameters, were prepared with a sampling of 1GHz in Gunn oscillator frequency, for both DSB and SSB modes. Each cryostat was integrated with the optical subsystem, comprising a baseplate, two elliptical refocussing mirrors, and the Martin-Puplett interferometer (MPI) that is used for diplexing. It was then aligned, using the antenna range, such that the radio beams from both channels would agree in position and angle with an optically defined master axis. These two cryostats were installed in the new cabin in October 1998.

It is normally foreseen that a full subsytem (cryostat+optics plate) should be available at the telescope for replacement in case of a failure (at present the third unit —the above mentioned prototype— has been brought back to Grenoble for improvements). Besides, the mechanical design allows to perform the following without loss of alignment: replace the MPI; dismount a cryostat and replace an RF component (mixer or IF amplifier). One spare LO system for each band is also available on the site.

New cabin optics

The layout of the new receiver cabin optics is shown in schematic form in Figure 5.3. The letters *H, V* indicate the polarization of radiation along certain parts of the beam distribution. Some parts of the optical path that are actually perpendicular to the paper have been folded flat: this explains why they are labelled both *H* and *V*. The beam coming from the sky meets the divider D1, which can be one of the following: a mirror, one of two grids with horizontal or vertical wires, or just empty (a second mirror may be used for calibration); this is implemented by a "juke-box" mechanism under computer control. Therefore, each of the two groups AB, CD receives, out of the two available linear polarisations, none, either, or both. Then, in each group, grid G1 steers the *V* pol (if available) to A (resp. C) and the *H* pol (if available) to B (resp. D). The MPI associated with each cryostat performs a frequency-dependent change of the polarisation state, so that (ideally) the polarisation for the 230 GHz (resp. 270 GHz) channel remains *H*, while the polarisation for the 100 GHz (resp. 150 GHz) channel is flipped by 90°; actually, these conditions are not met exactly, but the losses are in general small (<2.5% in 90% of all cases). The two orthogonal polarisations are steered by grid G3 towards each of the two windows located on opposite sides of each cryostat.

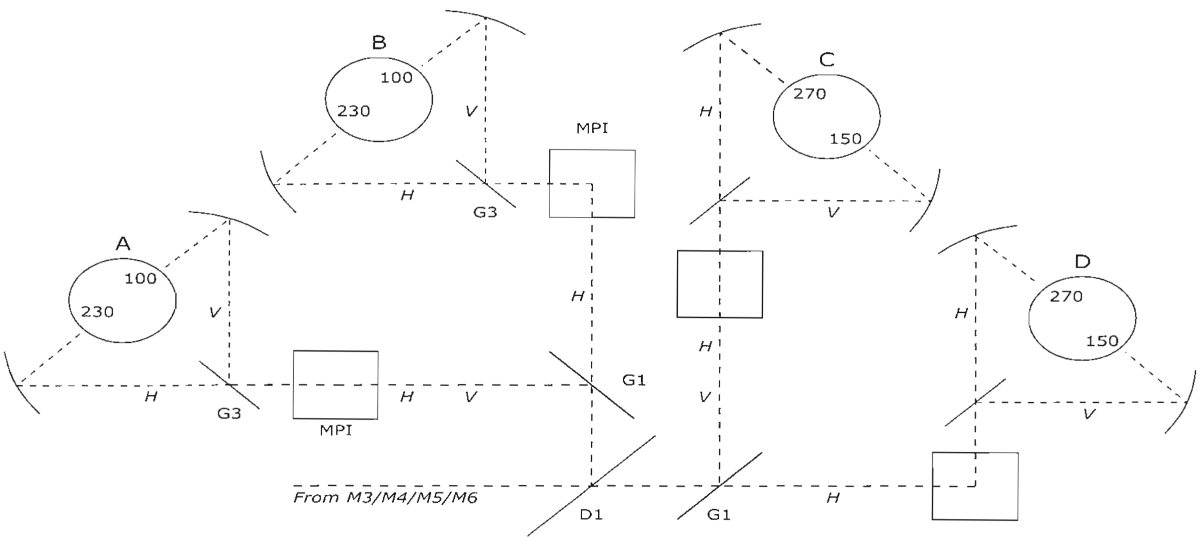

Fig.5.3: Schematic layout of the receiver cabin optics as finally adopted. The three-dimensional structure has been spread on a plane; so, the representation is not fully accurate. As of March 1999, only the dewars A and B are installed, together with the "old" 2MM receiver. See text for further explanations.

A new calibration system has been designed and built by the 30-m receiver engineers. It uses a standard CTI cryocooler, making available a cold load with an effective temperature close to 75K, an ambient load, and an adjustable cold load (not in use so far) to reduce the dynamic range in calibrations.

Available modes in the present, interim situation are: A+B, 2MM+B. Available modes in final configuration will be: A+B, C+D, A+D, B+C.

30-m, new receivers, performance

The nominal tuning ranges for the new receivers, for which they were designed, are:

A100/B100	83.5–115.5 GHz
A230/B230	200–255 GHz

In practice, these ranges can be exceeded slightly (see Fig. 5.4). The extended tuning range is supported on a best-effort basis. There is still room for improvement for the 230GHz channels: a) the optical losses between the dewar window and the calibration plane are 10%, versus 5% for the 100GHz channel: a new design for the cold optics has been made, it will soon be tested and implemented on the prototype dewar; b) the 230GHz mixers use 2μm^2 junctions, we expect to obtain a flatter noise curve using 1μm^2 junctions, of which two wafers have been produced by the SIS group.

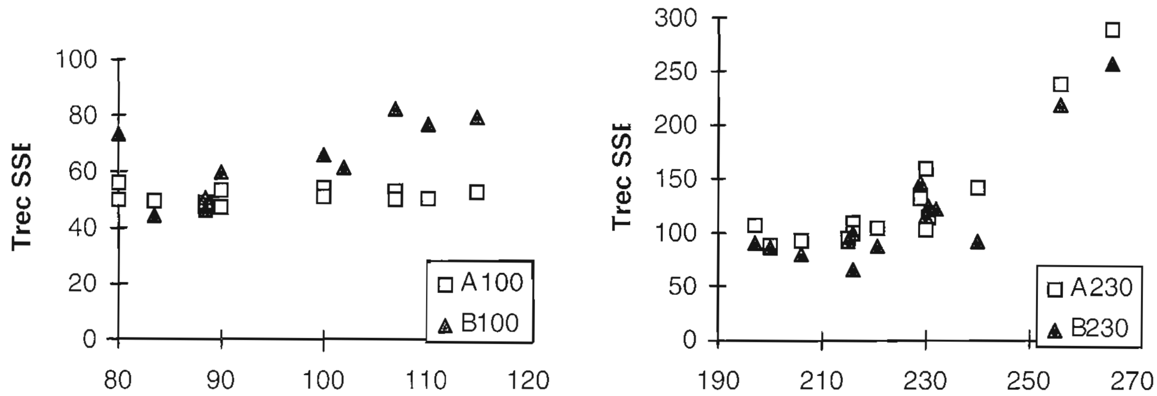

Fig. 5.4 : Receiver temperatures measured after installation, in the standard reference plane, versus signal frequency. The receivers are tuned SSB, with rejections ≥20dB for A100, B100, and ≥13dB for A230, B230.

The image band rejection of these receivers is typically 20–25dB for the 100GHz channels and 13–17dB for the 230GHz channels.

The stability of the new receivers has been tested by recording the total power output, sampling every 50ms for 900s. The results are shown in Figure 5.5. On timescales of 3–30s, typical of pointing scans, the peak-to-peak scatter is $1–2\times10^{-3}$ corresponding to $2–4\times10^{-4}$ rms. These receivers have been found to be stable enough that total power observations using A100 (rather than the focal plane chopper) is now the preferred mode for pointing scans.

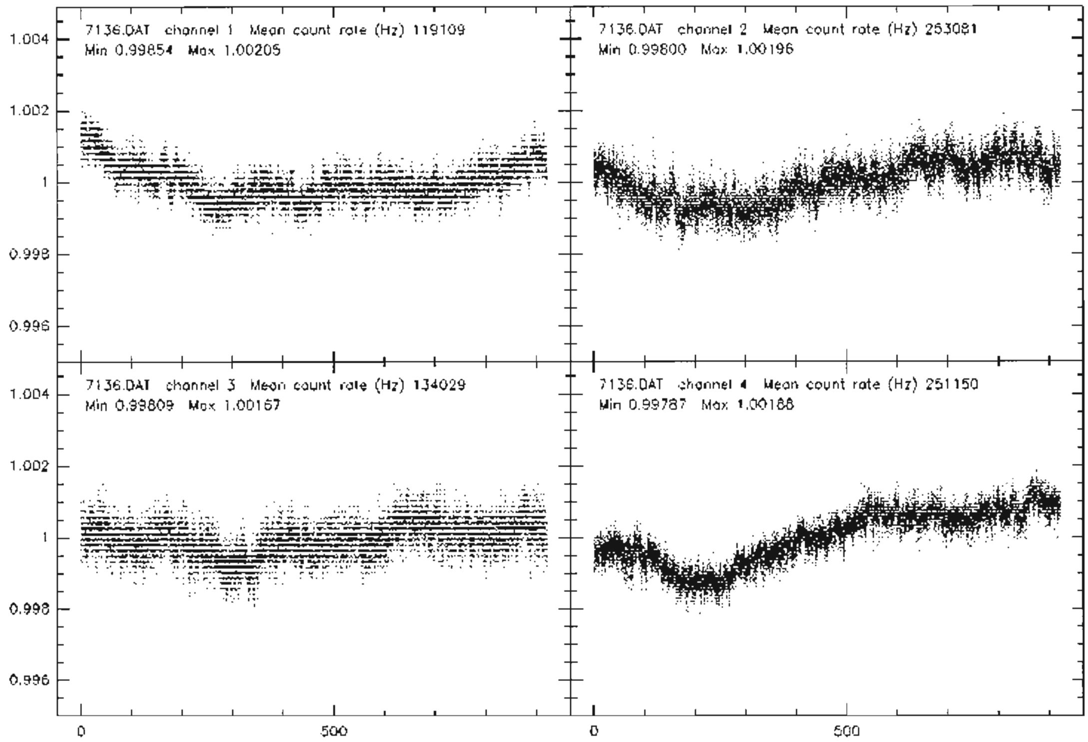

Fig. 5.5 : Continuum stability of the four new receivers; sampling interval 50ms, recorded for 900s. Channel codes are 1:A100, 2:A230, 3:B100, 4:B230. The data have been normalised to the mean value. The stripes are due to quantisation in the acquisition system.

Extensive measurements of pointing, focus, efficiencies were performed by the astronomical commissioning team. A report can be found at: http://www.iram.es/rxcabin/news.html. We summarise here the main results. The four beams are within a circle of 2" diameter. Some beam sizes and efficiencies are given in the table below, and compared with values measured in 1994/95 (30m Manual, Appendix A).

Freq / Epoch	HPBW(")	F_{eff}	B_{eff}
100 / 1998	24	0.90	0.75
100 / 1995	*24*	*0.92*	*0.70*
225 / 1998	10.6	0.84	0.48
230 / 1995	*10.4*	*0.86*	*0.39*

The agreement in beamwidths shows that the illumination taper has not changed. The differences in the values of F_{eff} are probably not significant. The improvement in B_{eff} values is more likely to be due to an improvement of the antenna surface and/or alignment than to an improvement of the receiver illumination pattern.

Together with the good values for the receiver temperatures in the reference plane, the consistent values of F_{eff} (between 1995 and 1998) show that, despite its relative complexity, the new cabin optics does not carry an excessive penalty in terms of optical losses. The 100GHz receivers have a focus offset of -0.3mm relative to the 230GHz receivers; if the focus is optimised for the latter. This causes a loss of on-axis efficiency of 3.1% at 100GHz, which can be decreased if a compromise focus is adopted.

345 receiver at the 30-m telescope.

In 1998, the 345GHz SIS receiver was again scheduled at the telescope, providing excellent SSB receiver noise temperature : 50K (6dB rejection), equivalent to { INCORPORER Equation.2 } (note that the MMA specification for that frequency range is { INCORPORER Equation.2 }). Under good weather conditions, the system noise was about 400K on the { INCORPORER Equation.2 } scale.

Figure 5.6 shows the substantial gain that is provided by SSB operation —rejecting atmospheric radiation in the image band— over DSB operation.

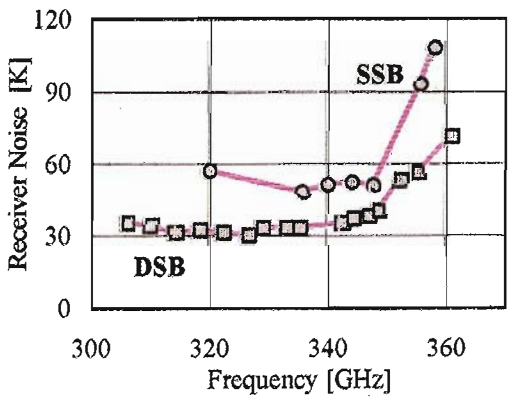

Fig. 5.6 : Double and single sideband receiver noise temperature, measured in front of the cryostat window.

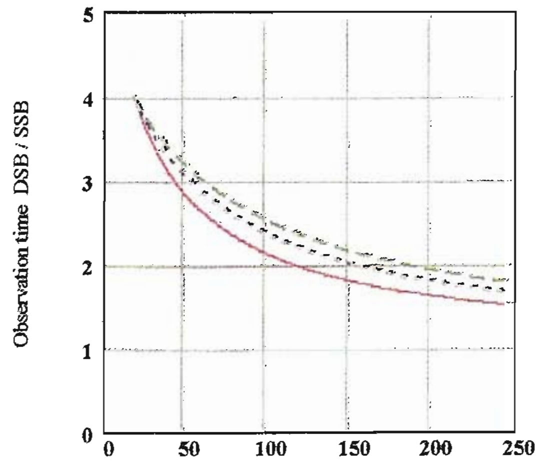

Fig.5.7 : Speedup factor of SSB versus DSB operation at 345GHz at the 30-m telescope for precipitable water 0.5mm (solid line), 2mm (short dash), and 4mm (long dash).

Holography transmitter

A 40GHz transmitter has been built. It was installed on the summit of Pico Veleta and tested during the September holography session. The maps obtained with this near-field source appear to be of a quality similar to the quality of maps obtained with ITALSAT. The thermal frequency drift will be improved until the next holography session.

5.2.2 Development work

Receiver for Plateau de Bure antenna 6

The construction of the dual-channel receiver for PdB antenna 6 has been started: the cryogenic part is characterised and waiting for the delivery of cold RF parts.

Next generation Plateau de Bure receivers

In cooperation with the astronomical staff, the specifications have been defined: 4 frequency bands, dual polarisation. No dual-frequency observations, since the same goal can be achieved by time-sharing. The four dual-polarisation units will be side by side in the focal plane, and switching between bands will be achieved by pointing offsets. Several preliminary layouts have been discussed, and a final choice should be made in the first quarter of 1999.

Water vapour radiometer

After defining specifications with the scientific staff, an evaluation receiver has been designed and built. Specific instrumentation for the 22GHz band had to be procured and/or developed. Tests for stability and for possible man-made interference are scheduled for the first quarter of 1999. The prototype, featuring three channels in the core and wings of the 22GHz water line, will be built in 1999.

Wideband continuum frontend

A wideband continuum frontend has been demonstrated, that, using a comb generator on the LO input, effectively downconverts into a single IF band a large ($\approx$30) number of sidebands from the RF band, while having a good multi-band (the equivalent of the usual double-sideband) noise temperature: 55K.

5.2.3 Laboratory equipment

Confocal resonator

A mm-wave confocal resonator has been designed, built, and characterised in the framework of a summer student project. It will be used to measure accurately the refractive index and losses of the dielectrics employed in receiver construction.

Antenna range

The hardware and data acquisition software of the antenna range have been modified. The quality of the data and the dynamic range have substantially been improved.

5.3 BACKEND DEVELOPMENTS

5.3.1 Wideband spectrometer experiment

The prototype wideband autocorrelator, built by CESR/Toulouse, in cooperation with the University of Bordeaux and IRAM-Grenoble has successfully been tested during several days on the 30m telescope. Although this machine is of the hybrid type (4 sub-bands), no platforming effect has been found. This encouraging result can be attributed to :

a) the design of the fixed-frequency type IF processor

b) the linearity of the sampler

c) good luck or a testing period which was not long enough,

or any combination of a,b,c. Whatever the actual coefficients of this combination have been during the experiment, the design of reduced distortion electronics appears to be extremely rewarding. This machine has now been returned to Toulouse where a space-qualified version will be developed for the ESA mission FIRST. The acquired knowledge will be applied on future designs.

5.3.2 Correlator for 6 antennas

- Correlator Chip

The IRAM-designed correlator chip has been delivered on schedule and 16 units were immediately installed on the 16-chip correlator board. The tests have been totally successful, with measured clock speeds (board + chip) largely exceeding the design goals. This chip does not integrate plenty of channels but lends itself to economic, automated mass-production. A batch of 2300 units has recently been ordered.

- Correlator System.

The chip is generally seen as the key element of a system, but a large number of less visible electronic modules or PC boards have been developed concomitantly. For 85% of them, the development phase has been terminated and the design is ready for production. A few items are already produced in final quantity.

A WEB page has been created where detailed and updated information on the evolution of this project can be found . Please look at: http://iram.fr/TA/backend/backend.html

5.4 COMPUTER GROUP

In 1998, the computing facilities has been improved by the following actions:

- Installation of 2 RAID disk systems connected to the stations/servers dedicated to data analysis. They help to greatly increase the on-line data storage capacity, and their high reliability allows to extend the intervals between data backups.
- Reorganisation of the computer room with better access to the hardware for maintenance, better accessibility of the peripherals available to the users and growth potential for future system enhancements.
- Installation and setup of a new bi-processor server which is the most powerful computer available at IRAM, and reserved with priority to data reduction and available in particular to our visitors.
- Setup of a ppp server to accept IP connections from remote PCs via a telephone line.
- Installation of a new tool which gives to all users the possibility to backup any UNIX files on CD-ROM.

The computer group has participated in the successful refurbishment of the 30m receiver cabin by contributing to the development of several new hardware components, in particular the Martin Puplett Interferometer control, and the installation of the software for receiver control, setup and monitoring.

Work has also been done on the development of a bus which will be used to connect small devices in an updated version of the receiver control with simplified wiring. The I2C bus is controlled by a VME board which has been designed, developed and tested.

The multibeam bolometer software named NIC has been further improved by adding new features which will be offered to the users for the next winter period.

A WEB server has been installed in the library at Grenoble. Navigation in the list of books and a search by author names or titles is now possible.

The computer group has actively participated in developing further the system for remote observing together with the computer group in Granada. Members from the group have supported astronomers during observations with the 30m telescope from IRAM-Grenoble. To facilitate the contact between the remote observer and the operator on the site, a video conferencing system can now be used, in parallel to all necessary data links between the computers on both sides.

5.5 TECHNICAL GROUP

5.5.1 Mechanical Workshop

Much of the activity of the staff of the mechanical workshop in 1998 was focussed on the refurbishment of the receiver cabin of the 30m telescope. The mechanical components were not only fabricated in Grenoble but also a test-assembly was made to minimise the time for final assembly at the telescope.

The staff of the mechanical workshop has furthermore produced a large number of microwave components like mixers, horns, lenses and others for the 150/270 GHz receivers. It also participated in the assembly of the components of the multibeam receiver which passed a first cryogenic test.

In order to further improve the fabrication of waveguides, a systematic study was performed to better understand the influence of the tool, the speed and orientation with which the tool is applied etc. Figures 5.8 a,b show examples of the results obtained.

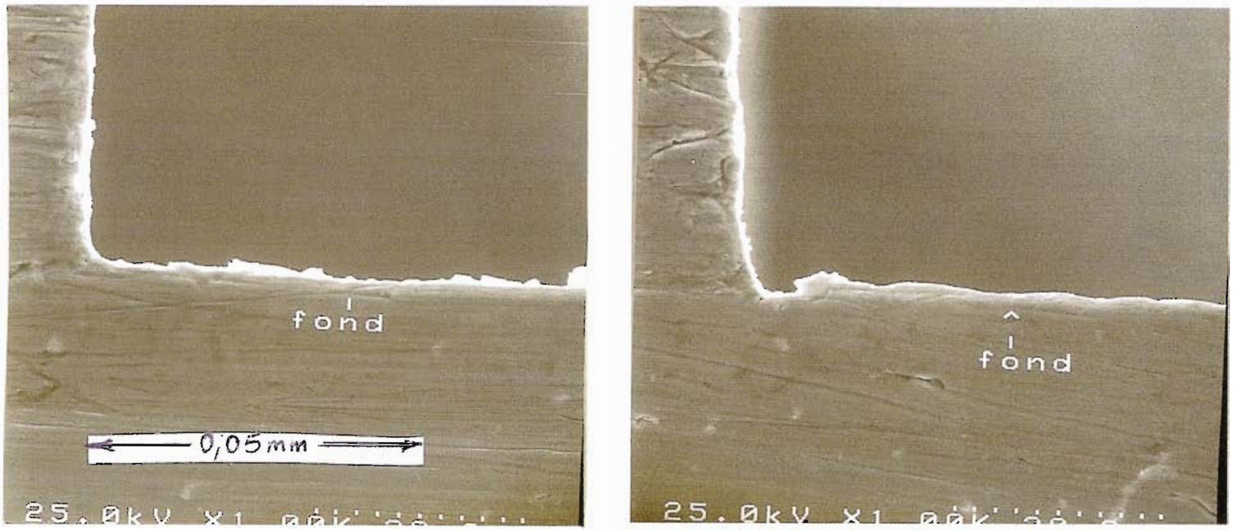

Fig. 5.8 : Electron-beam microscope images (magnification 1000) of two test pieces fabricated during a systematic study to improve the fabrication of waveguides. (a) piece machined by milling with the tool advancing in opposite direction w.r.t. the sense of rotation of the tool, (b) piece machined by milling and subsequent chiselling.

5.5.2 Drawing Office

The drawing office worked on numerous mechanical designs, in close collaboration with the IRAM staff in France and in Spain. The subjects were :

- The arrangement and the support structure for the 100/230-150/270 GHz receivers for the receiver cabin of the 30m telescope, taking into account the overall arrangement of the optics, the existing interfaces, and the boundary conditions set by the new cabin layout.

- The details of the new layout of the cabin and of all of the mechanical components of the new receiver cabin (about 100 plans)

- The detailed design and construction of the beam splitter (cf. Figure 5.10).

- The monitoring of a number of external contracts for the fabrication of mechanical components and their assembly.

- The documentation of all microwave components used at the Pico Veleta Observatory and at the Plateau de Bure Interferometer.

5.5.3 Antenna 6

The technical group is responsible for following the fabrication of the mount of Antenna 6 and for the overall planning and monitoring of the construction work of the telescope.

In 1998 the components of the mount have all been delivered to the Plateau de Bure, i.e. all mechanical and electrical parts, and all parts of the thermal protection system. One of the major pieces is shown in Figure 5.10 during the production phase at Ferry-Capitain, France. Another important piece is shown in Figure 5.11, the azimuth ring.

The current planning for the completion of Antenna 6 assumes the following schedule :

Mechanical assembly	01/99 – 03/99
Electrical installations	04/99 – 05/99
Thermal protection	06/99 – 08/99
Assembly of the reflector	09/99 – 12/99
Astronomical commissioning	January 2000

Fig. 5.9 : The new beam divider in the receiver cabin at the 30m telescope.

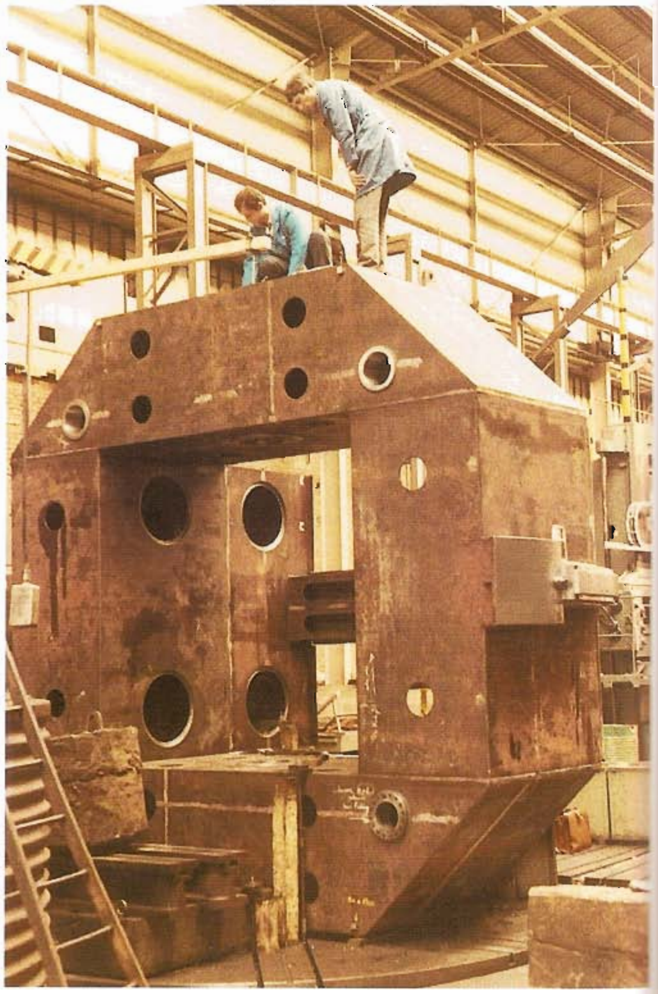

Fig. 5.10 : The central hub of Antenna 6 during fabrication at Ferry-Capitain.

Fig. 5.11 : The azimuth ring during inspection at the manufacturer FAG, Germany. The external diameter is 2800 mm. The diameter of the bearing is 2550 mm. Its axial precision is 20 μm and its radial accuracy is 25 μm .

5.5.4 Technical Support for the Plateau de Bure

As in previous years, the technical group has closely collaborated with the technical staff on the Plateau de Bure during all maintenance work on Antennas 1-5.

6. PERSONNEL AND FINANCES

6.1 Personnel

In 1998, IRAM had a total of 94.15 positions occupied. Of these, 67.02 were allocated in France, and 27.13 in Spain. In addition, the MPI für Radioastronomie (Bonn) and the MPI für Extraterrestrische Physik (Garching) jointly financed one half of a position, allocated to the SIS laboratory for the production of junctions.

Furthermore, 6 post-docs (5 FR, 1 ES), 5 thesis students (FR) and 3 « coopérants » (ES), plus 1 person delegated by DEMIRM/Paris in the framework of the FIRST project, worked at IRAM.

1 PhD student in the SIS laboratory was partly funded by the German Ministry for Education, Research and Technology (BMBF-Verbundforschung), another PhD student was funded by the German Science Foundation (DFG) through the university of Würzburg, and a third one by the CNRS.

During certain periods of the year, additional personnel was hired on short term contracts to cope with special tasks. These contracts correspond to 2.48 FTEs on Bure (for maintenance work and logistic support mainly), and 2.34 FTEs in Grenoble (for replacements in the Administration and technical groups).

6.2 Financial Matters

IRAM's financial situation in 1998 as well as the budget provisions for 1999 are summarised in the attached tables.

1998 - Operation Budget

Expenditures were lower than anticipated, mainly due to

- savings in heating and electricity costs (this budget is by definition uncertain)
- savings in personnel costs by keeping several staff positions open
- lower exchange rates losses in connection with the introduction of the EURO

Income was higher than anticipated due to the

- successful completion of projects executed under contract for other agencies (e.g. ESO)
- an exceptional transfer from the investment to the operating budget

As a result, the operating budget shows an excess of 2.6 MF at the end of the year.

1998 - Investment Budget

The main expenditure items were concerned with :

- the 6th antenna on the Plateau de Bure
- the completion of the SIS clean room
- receiver (incl. the multi-beam receiver) and back-end instrumentation
- the purchase of VLBI instrumentation
- preparatory work for the extension of the N-S track on the Plateau de Bure
- the purchase of a new ratrack for the Pico Veleta Observatory

For some projects the financial provisions had to be corrected downwards for 1998 because of delays in the development or in the delivery of items. The corresponding funds will, however, be needed in 1999.

Taking into account the carry-forward from the 1997 budget, more than 19 MF were spent on the 1998 investment budget, and additional orders were placed for an amount of 8.5 MF.

BUDGET 1998
(in KFF)

1998- EXPENDITURE

Budget heading	Approved	Actual
Operation / Personnel	42.1250	40.1902
Operation / other items	13.7550	14.1426
TOTAL OPERATION	**55.8800**	**54.3328**
Investment (general + 6th antenna)	33.3410	19.9312
TOTAL EXPENDITURE excl. VAT	***89.2210***	***74.2640***
VAT	5.2650	5.2650
TOTAL EXPENDITURE incl. VAT	***94.4860***	***79.5290***

1998 - INCOME

Budget heading	Approved	Actual
CNRS contributions	30.3808	30.3810
MPG contributions	30.3808	30.3810
IGN contributions	3.8784	3.8784
Contributions 6th antenna	6.6000	6.6000
TOTAL CONTRIBUTIONS	***71.2400***	***71.2404***
Carry froward from 97	16.4810	16.4810
IRAM's own income	1.5000	2.6390
TOTAL INCOME excl. VAT	***89.2210***	***90.3604***
CNRS contribution for VAT (20,6%) *	5.2650	5.2650
TOTAL INCOME incl. VAT	***94.4860***	***95.6254***

* = 20,6% on CNRS contribution to operation budget

BUDGET PROVISIONS 1999

(in KFF)

1999- EXPENDITURE

Budget heading	Approved
Operation / Personnel	42.1250
Operation / other items	14.8450
TOTAL OPERATION	**56.9700**
Investment - general	10.2600
Investment - 6th antenna	6.9000
TOTAL INVESTMENT	**17.1600**
TOTAL EXPENDITURE	***74.1300***
VAT	5.4190
TOTAL EXPENDITURE incl. VAT	***79.5490***

1999 - INCOME

Budget heading	Approved
CNRS contributions	33.4281
MPG contributions	33.4281
IGN contributions	6.2738
TOTAL CONTRIBUTIONS	**73.1300**
IRAM's own income	1.0000
TOTAL INCOME excl. VAT	***74.1300***
CNRS contribution for VAT (20,6%)	5.4190
TOTAL INCOME incl. VAT	***79.5490***

7. ANNEX I : TELESCOPE SCHEDULES

7.1 IRAM 30m Telescope

0.1 Dec 30 - Jan 13

Ident.	Title	Freq. (GHz)	Authors
147.97	Dense core form: small scale density structure of the env. of low mass cores	96,98,109,144	Falgarone,Gerin,Panis et al.
178.97	Time scale for gas dissipation around older PMS low mass stars	89, 230	Sterzik,Dutrey,Schuster, et al.
136.97	GRS 1915+105 : A runaway black hole ?	89, 230	Mirabel,Chaty,Rodriguez

0.2 Jan 13 - Jan 27

Ident.	Title	Freq. (GHz)	Authors
162.97	Flux density measurements of a sample of flat-spectrum radio sources	bolometer	Patnaik,Menten,Kreysa
172.97	Young gal. their starbursts and central activity in Hubble deep...	bolometer	Kreysa, Biermann, Menten et al.
159.97	A systematic search for high-mass protostars	86,110,230,241	Menten, Sridharan, Schilke
208.97	Dust in high z QSOs	bolometer	Omont,McMahon,Maoli,Cox et al.

0.3 Jan 27 - Feb 10

Ident.	Title	Freq. (GHz)	Authors
208.97	Dust in high z QSOs	bolometer	Omont, McMahon, Maoli, Cox, Kreysa
168.97	HH energy sources,deeply embedded stars and protostellar condensations	bolometer	Chini, Reipurth, Sievers, Ward-Thompson
169.97	Emission mechanisms in quasars	bolometer	Chini, Kreysa, Meisenheimer, Klaas
170.97	Dust content and star formation efficiency of dwarf galaxies	bolometer	Albrecht, Lemke, Chini
128.97	Unbiased large scale mapping of the galactic center	bolometer	Zylka, Mezger, Duschl
145.97	The distribution of cold dust in the starburst galaxy NGC 3628	bolometer	Dumke, Neininger, Wielebinski, Krause, Guelin
186.97	Cold dust in two giant clouds associations of M 31	bolometer	Zylka, Guelin, Neininger, Dumke

0.4 Feb 10 - Feb 24

Ident.	Title	Freq. (GHz)	Authors
179.97	Compact steep spectrum radio sources : young or frustrated ?	bolometer	Klein, Fanti, Vigotti, Mack, Zoennchen
186.97	Cold dust in two giant clouds associations of M 31	bolometer	Zylka, Guelin, Neininger, Dumke
128.97	Unbiased large scale mapping of the galactic center	bolometer	Zylka, Mezger, Duschl
δ 24.97	Imaging and spectroscopy of the unusual IR source 1742-3005		Mezger
184.97	Search for the CII 158mm line in BR1335-0415	351	Guelin, Guilloteau, Omont
187.97	AINC in IRC+10216	143,155,215,227	Guelin, Ziurys, Apponi, Cernicharo
181.97	Tomography of the magnetic field in the disk of MWC 349	147,231,353	Thum,Morris
158.97	A search for C+ emission in the most distant radio galaxy	350	Roettgering, Isaak, Hills, van der Werf
105.97	Probing the different molecular gas components in the nucleus of IC342	241,244,259,265	Schulz, Guesten, Krause
196.97	CO+ emission from IRAS 1629	89,236,353,354	Ceccarelli, Castets, Caux
117.97	Mass determination for proto-planetary disks	bolometer	Natta, Grinin, Mannings, Ungerechts

0.5 Feb 24 - Mar 10

Ident.	Title	Freq. (GHz)	Authors
117.97	Mass determination for proto-planetary disks	bolometer	Natta, Grinin, Mannings, Ungerechts
167.97	Protoplanetary disks around solar type stars	bolometer	Kruegel, Chini, Kreysa, Siebenmorgen, Sievers
119.97	Continuing the watch for a mm-flare in the TeV-/Gamma source Mrk 501	bolometer	Krichbaum, Ungerechts, Lorens, Witzel, Kraus
146.97	The circumstellar environment of young brown dwarfs	bolometer	Bouvier, Forveille
212.97	Bolometer mapping of dark globules discovered by ISOCAM	Bolometer	Bacmann, Andre, Ward-Thompson, Abergel

0.6 Mar 10 - Mar 24

Ident.	Title	Freq. (GHz)	Authors
182.97	Dust, cometary globules and star formation in the Trifid nebula	bolometer	Lefloch, Cernicharo
134.97	Coordinated cm and mm observations of radio emitting X-ray binaries	bolometer	Paredes,Mirabel,Marti,Peracaula
131.97	Test for anomalous refraction with the multi-channel bolometer	bolometer	Altenhoff, Downes, Penalver
212.97	Bolometer mapping of dark globules discovered by ISOCAM	Bolometer	Bacmann, Andre, Ward-Thompson, Abergel
180.97	Cold dust and the total gas mass in NGC 4449	bolometer	Kohle, Klein, Neininger, Taylor
198.97	A 1.25mm continuum search for lensed AGNs	bolometer	Barvainis, Antonucci, Alloin
109.97	The nature of extremely red objects	bolometer	Cimatti, Andreani
119.97	Continuing the watch for a mm-flare in the TeV-/Gamma source Mrk501	Bolometer	Krichbaum, Ungerechts, Lorens, Witzel, Kraus
142.97	Mm wavelength dust emission of IC 10	bolometer	Wild, Greve, Sievers, Ungerechts, Jackson
160.97	Searching for triggered star formation in the Lagoon nebula	bolometer	McCaughrean, Tothill, White

0.7 Mar 24 - Apr 7

Ident.	Title	Freq. (GHz)	Authors
130.97	A crucial test of the photometric size determination method for asteroids	bolometer	Altenhoff, Johnston, Stumpff, Webster
139.97	The recent mass loss rate history of highly evolved stars	bolometer	Gronewegen, van der Veen, Habing, Omont
142.97	Mm wavelength dust emission of IC 10	bolometer	Wild, Greve, Sievers, Ungerechts, Jackson
148.97	A study of circumstellar disks in cluster environment	bolometer	Haisch, Lada
$\delta 4$	Unbiased large-scale mapping of the galactic center	bolometer	Mezger, Zylka
131.97	Test for anomalous refraction with the multichannel bolo	bolometer	Altenhoff, Johnston, Stumpff, Webster
119.97	Continuing the watch for a mm-flare in the TeV-gamma-source Mrk 501	bolometer	Krichbaum, Ungerechts, Lorens, Witzel, Kraus
$\delta 2$	First detected sources of the cosmic IR background: redshift constraints	bolometer	Guiderdoni, Omont, Neri, Clements, Elbaz, Puget

0.8 Apr 7 - Apr 21

Ident.	Title	Freq. (GHz)	Authors
199.97	Observation of ^{12}CO over the optical disk of the spiral M101	115,230	Viallefond, Boulanger, Caillat, van der Hulst, Lequeux
133.97	Molecular gas in distant, luminous, star forming regions	92,138,230	Ivison, Kneib, Smail, Blain
132.97	Extranuclear star-forming complexes in the merger Arp 299	108,228	Casoli, Willaime, Gerin, Viallefond
106.97	A search for new intergalactic molecular clouds	115,230	Brouillet, Baudry, Braine
159.97	A systematic search for high-mass protostars	86,110,230,241	Menten, Sridharan, Schilke
161.97	Probing the Dragon: SiO observations in HH288	86,140,241	Schilke, McCaughrean, Gueth, Dent

0.9 Apr 21 - May 5

Ident.	Title	Freq. (GHz)	Authors
106.97	A search for new intergalactic molecular clouds	115,230	Brouillet, Baudry, Braine
$\delta 7$	DCO+(3-2) 216GHz emission of the dark cloud L183		Stark
197.97	SiO emission in low velocity outflows from low-luminosity YSOs	86,130,217	Ceccarelli, Castets, Cox
187.97	AINC in IRC+10216	143,155,215,227	Guelin, Ziurys, Apponi, Cernicharo
141.97	The dynamic behaviour of IR carbon stars	88,130,230	Groenewegen, Omont, Habing, Sevenster
115.97	Heating of the galactic center GMCs	86,90,97,130,145	Martin-pintado, de Vicente, Wilson, Fuente, Huettemeister, Rodriguez
209.97	Search for a new sodium compound NaSH in IRC+10216	107,131	Kagi, Kawaguchi
$\delta 5$	is SiO emission in external galaxies associated to star formation ?	86,130,216	Martin-Pintado, Garcia-Burillo, de Vicente, Fuente
155.97	Molecular gas in the Peanut bulge spiral NGC 128	113,227	Garcia-Burillo, D Onofrio

0.10 May 5 - May 19

Ident.	Title	Freq. (GHz)	Authors
187.97	AlNC in IRC+10216	143,155,215,227	Guelin, Ziurys, Apponi, Cernicharo
143.97	Deep search for CO in the low surface brightness galaxy Malin 1	106,212	Braine, Brouillet, Radford
204.97	The abundance of water in the Milky Way	143,203,224,225	Mauersberger, Wilson, Gensheimer
129.97	A search for interstellar/circumstellar NaCH	113,135,158	Ziurys, Xin, Guelin
183.97	A study of the Trifid Nebula at optical, IR and radio wavelength	115,110,89,130,93	Cernicharo, Lefloch, Cox

0.11 May 19 - Jun 2

Ident.	Title	Freq. (GHz)	Authors
181.97	Tomography of the magnetic field in the disk of MWC 349	147,231,353	Thum, Morris
51.98	Oxygen burning and s-process nucleosynthesis	90,97,136,144,237	Chin, Henkel, Mauersberger, Langer
55.98	OTF mapping of M31, the closest spiral galaxy	115,230	Neininger, Nieten, Guelin, Lucas, Wielebinski, Beck, Ungerechts
45.98	CO observations of Sakurai's object	115,230	Groenewegen, Kerber, Bremer, Rauch
39.98	The continuing variability of BL Lac at 3.1m	86,230	Krichbaum, Ungerechts, Greve
53.98	The continuing study of the intergalactic molecular cloud near M81	110	Braine, Brouillet, Henkel, Mauersberger
30.98	Circumstellar 36S : probe of the s-process in C-stars	96,142,237	Mauersberger, Henkel, Langer, Chin
50.98	Missing spacing correction for interferometer maps of M82	110,115,220,230	Neininger, Weiss, Klein, Schilke

0.12 Jun 2 - Jun 16

Ident.	Title	Freq. (GHz)	Authors
45.98	CO observations of Sakurai's object	115,230	Groenewegen, Kerber, Bremer, Raush
55.98	OTF mapping of M31, the closest spiral galaxy	115,230	Neininger, Nieten, Guelin, Lucas, Wielebinski, Beck, Ungerechts
49.98	X-ray binaries: distance and extinction measurement	110,115	Corbel, Hannikainien, Chapuis, Dame, Vilbu, Durouchoux
41.98	A systematical study of the environment of Herbig Ae-Be stars (III)	110,146,230,97,244	Fuente, Martin-Pintado, Bachiller, Palla, Neri
56.98	Confirmation of our detection of the C_5N radical	87,89	Guelin, Neininger, Cernicharo

0.13 Jun 16 - Jun 30

Ident.	Title	Freq. (GHz)	Authors
66.98	Molecular gas in strongly interacting galaxies	111,113,222,225,227	Davoust, Zhu, Seaquist
02.98	Probing cloud evolution through observations of sulphuretted molecular species	99,138,219,104,222	Codella, Scappini, Bachiller
37.98	Velocity-dependent excitation in protostellar outflows	96,145,241,115	Bachiller, Walmsley, Codella, Colomer, Perez, Tafalla
188.97	Nature and kinematics of starless dense clumps in rho Ophiuchi	86,93,104,140,216	Motte, Andre, Bacmann, Despois, Neri, Bontemps
03.98	Completation of a deep investigation of SiO in HH7-11	86,130,217	Codella, Bachiller, Reipurth

0.14 Jun 30 - Jul 14

Ident.	Title	Freq. (GHz)	Authors
28.98	Towards measuring the magnetic field within protostellar outflows and pre-stellar dense cores	99,109,138,158,236,246	Thum, Andre, Morris, Fiebig, Ward-Thompson
34.98	Establishing the link between box-shaped bulges and bars in spirals:NGC1055	114,229	Garcia-Burillo, Bettoni
59.98	The darkest clouds in the galaxy:follow up of ISO discoveries	220,219,109,97	Perault, Omont, Teyssier, Hennebelle, Ungerechts
18.98	Testing models for the evolution of powerful extragalactic radio sources	108,94,93	O'Dea, Gallimore

0.15 Jul 14 - Jul 28

Ident.	Title	Freq. (GHz)	Authors
42.98	Vibrationally exited carbon chain molecules towards the protoplanetary nebula CRL618	85,103,136,259,267	Thorwith, Winnewisser, Wyrowski, Schilke
17.98	Are molecular envelopes around BM Gem O-rich or C-rich ?	86,88,130,147,220,230	Kahane, Jura
47.98	The effects of X-rays on molecular cloud cores	85,87,109,112,144	Caselli, Randich
52.98	Astronomical search for (CO)2	153,159	Winnewisser, Takano, Roth, Wyrowski, Stutzki, Hepp
δ12	Mm wavelength spectroscopy followup of the ISOPHOT serendipity survey		Toth, Lemke, Stickel, Herbstmeier, Lisenfeld
16.98	CO in long-lived circumstellar disks	115,230	Jura, Kahane
58.98	Molecular line study of high mass protostars	97,144,241,219	Nuernberger, Yorke, Grewing, Wiesemeyer

0.16 Jul 28 - Aug 11

Ident.	Title	Freq. (GHz)	Authors
01.98	SiO in PDR's	86,130,217	Walmsley, Schilke, Pineau des Forets, Martin-Pintado
43.98	Dense clumps in the Orion bar	86	Schilke, Wyrowski, Walmsley, Lis, Keene, Phillips
61.98	Variability of molecular absorption lines at z=0.25	92,142,143,213,214	Wiklind, Combes
07.98	Search for new high redshift molecular absorption line systems	87,94,203,207,217,219	Combes, Wiklind
14.98	Gas phase chemistry towards embedded stars	85,102,112,145,219,224	Caselli, Walmsley, Palumbo, Strazzulla, Leto
55.98	OTF mapping of M31, the closest spiral galaxy	115,230	Neininger, Nieten, Guelin, Lucas, Wielebinski, Beck, Ungerechts
10.98	Mapping of an active barred galax: NGC6951	114,229	Leon, Combes, Friedli

0.17 Aou 11 - Aou 25

Ident.	Title	Freq. (GHz)	Authors
δ13	Observation of the lensed radio galaxy PKS1830		Combes, Wiklind
33.98	Does $C^{18}O$ measure the total gas in the galactic center clouds ?	91,147	Martin-Pintado, Rodriguez, de Vicente, Fuente
26.98	Momentum excess in bipolar outflows of protoplanetary nebulae	110,220,230	Bujarrabal, Sanchez-Contreras, Alcolea, Carrizo
27.98	Chemical bistability in dark clouds : the diagnostic of deuterium fractionation	84,86,104,110,144,150	Gerin, Falgarone, Roueff, Pineau des Forets, Schilke
04.98	Monitoring of Jupiter stratosphere after the comet SL9 collision. Detection of $C^{34}S$	88,115,146,230,244,241	Marten, Moreno, Paubert

0.18 Aou 25 - Sep 8

Ident.	Title	Freq. (GHz)	Authors
63.98	Origin of the IMF and the star formation efficiency in 2 ISOCAM surveyed dense cores	104,110,112,144,209,220	Bontemps, Despois, Andre, Lefloch, Nordh, Olofsson, Kaas
δ09.98	SiO thermal emission lines towards young protostars in the NGC1333 star forming complex		Lefloch, Cernicharo
48.98	Using the sulfur chemistry as a chemical clock	98,104,165,216,251,258	Castets, Loinard, Ceccarelli

0.19 Sep 8 - Oct 20

Ident.	Title	Freq. (GHz)	Authors
	Holography and cabin works		IRAM staff

0.20 Oct 20 - Nov 10

Ident.	Title	Freq. (GHz)	Authors
24.98	Gas content and star formation efficiency of dwarf galaxies	113,114,115,227,228,230	Albrecht, Chini, Kruegel, Wild
55.98	OTF mapping of M31, the closest spiral galaxy	115, 230	Neininger, Nieten, Guelin, Lucas, Wielebinski, Beck, Ungerechts
67.98	How coherent are dense cores ?	93,112,144,216,224	Goodman, Caselli, Heyer, Arce, Williams, Wilner
22.98	Molecular hydrogen inventory in a low metallicity galaxy	110,115,220,230	Madden, Jones, Poglitsch, Smith, Sauvage
11.98	Extended molecular gas around lenticular galaxies	114,115,229,230	Sage, Welch, Mitchell, Henkel, Wiklind, Galletta
64.98	The interaction between giant Herbig-Haro flows and their surroundings	110,115,220,230	Arce, Goodman

0.21 Nov 10 - Nov 24

Ident.	Title	Freq. (GHz)	Authors
35.98	The composition of Jupiter family comet 21P/Giacobini-Zinner	88,145,147,168,225,230	Crovisier, Bockelee-Morvan, Colom, Germain, Lellouch, Despois
106.98	Detecting CO emission in the nearby LINER galaxy NGC 3718	114	Schinnerer, Eckart
73.98	^{12}CO(1-0) distribution around Aurigae	115,230	Bremer
135.98	Velocity-dependent excitation in protostellar outflows	110,220,230	Bachiller, Walmsley, Codella, Colomer, Perez, Tafalla
64.98	The interaction between giant Herbig-Haro flows and their surroundings	110,115,220,230	Arce, Goodman
67.98	How coherent are dense cores ?	93,112,144,216,224	Goodman, Caselli, Heyer, Arce, Williams, Wilner
197.98	DCO+ as a tracer of protostellar infall	110,144,216	Bachiller, Myers, Tafalla, Mardones, Caselli

0.22 Nov 24 - Dec 08

Ident.	Title	Freq. (GHz)	Authors
142.98	Fractional ionization in the collapsing starless core L1544	90,112,141,154,212,224	Caselli, Myers, Tafalla, Walmsley
94.98	Imaging at 230GHz of plerionic components of galactic SNRs	Bolometer	Bandiera, Cesaroni, Neri
78.98	A search for massive protostellar objects towards luminous IRAS sources	Bolometer	Schreyer, Henning, Launhardt
145.98	Momentum excess in bipolar outflows of protoplanetary nebulae II	11,116,220,230	Bujarrabal, Alcolea, Carrizo, Sanchez-Contreras
129.98	Density and turbulent structure of star forming cores	96,98,147,218,241,244	Tafalla, Caselli, Myers, Walmsley
151.98	Follow-up mm mapping of dark globules discoverd by ISOCAM	Bolometer	Bacmann, Andre
116.98	Dust in the low-metallicity dwarf galaxy NGC1569	Bolometer	Lisenfeld, Sievers, Wild
101.98	Cold dust and the total gas mass in NGC4449	Bolometer	Kohle, Walsh, Neininger, Henkel, Klein

0.23 Dec 08 - Dec 22

Ident.	Title	Freq. (GHz)	Authors
120.98	A study of circumstellar disks in young clusters	229	Haisch, Lada-C
72.98	Molecular gas near the Supergiant Shell in IC2574	115,230	Walter, Heithausen, Brinks
123.98	Monitoring of the gravitational lens PKS1830-211	94,141	Wiklind, Combes
93.98	Searching for dust in ultrared galaxies at high-z ?	Bolometer	Cimatti, Andreani, Roettgering, Tilanus, Eisenhardt, Stanford
137.98	Emission mechanisms in quasars	Bolometer	Muller, Chini, Haas, Kreysa, Meisenheimer
121.98	Extranuclear star-forming complexes in the merger Arp299	108,228	Casoli, Willaime, Gerin, Viallefond
75.98	Monitoring of Jupiter's stratosphere after comet SL9 collision	88,115,146,230,244,241	Marten, Moreno, Paubert
150.98	OTF mapping of M31, the closest spiral galaxy	115,230	Neininger, Nieten, Guelin, Lucas, Wielebinski, Berkhuijsen, Beck

0.24 Dec 22 - Jan 05

Ident.	Title	Freq. (GHz)	Authors
150.98	OTF mapping of M31, the closest spiral galaxy	115,230	Neininger, Nieten, Guelin, Lucas, Wielebinski, Berkhuijsen, Beck
123.98	Monitoring of the gravitational lens PKS1830-211	94,141	Wiklind, Combes
111.98	Molecular gas in merger remnants, traced by shells	114,228,229	Charmandaris, Combes
105.98	Molecular gas in the Elephant trunks of M16 extended OTMF maps	98,110,115,147,230	Ungerechts, Sievers, Wild, Kramer
144.98	H_2CO and CH_3OH in circumstellar disks around young stars		Wing-Fai-Thi, Van Dishoeck, Van Zadelhoff
125.98	Molecular line survey in PKS1830-211	83,90,135,141,151	Combes, Wiklind
177.98	Lunar occultations of IRC+10216	177	Cernicharo, Perez-Martinez, Brunswig, Paubert, Lucas

7. ANNEX I : TELESCOPE SCHEDULES

7.2 PdB Interferometer

Ident.	Title	Line	Authors
H071	Molecular gas and the CO - H_2 conversion factor in NGC1569	CO(1-0) CO(2-1)	S.Hüttemeister A.Greve U.Klein C.Taylor
H072	Molecular absorption lines at z=0.685 in B0218+357. Where does the absorption occur ?	CO(1-0) CO(2-1)	F.Combes T.Wiklind
H074	Molecular gas in elliptical galaxies	CO(1-0) CO(2-1)	T.Wiklind F.Combes C.Henkel
H076	Confirmation of CO detection in BRI0952-0115 and of CO spatial extension in BRI1335-0415, at $z = 4.4$	CO(5-4) Cont 1mm	A.Omont S.Guilloteau P.Cox P.Petijean R.G.McMahon
H077	Confirmation of CO detection in BRI0952-0115 and of CO spatial extension in BRI1335-0415, at $z = 4.4$	CO(5-4) Cont 1mm	A.Omont S.Guilloteau P.Cox P.Petijean R.G.McMahon
H078	High resolution ^{12}CO J =1-0/2.6mm mapping of the PPN PH231.8+4.2	CO(1-0) CO(2-1)	J.Alcolea V.Bujarrabal C.Sanchez-Contreras R.Neri
H079	CO emission of the ultraluminous galaxy F15307+3252 at $z = 0.9288$	CO(4-3)	M.Gerin R.Cutri F.Casoli M.C.Willaime H.Aussel
H080	Mapping molecules in the $z = 4.92$ lensed galaxy towards CL1358+62	CO(5-4) CO(11-10)	M.Franx F.Combes T.Wiklind P.van der Werf
H081	The IRAM deep fields	CO(5-4) Cont 1mm	F.Casoli B.Fort J.Lequeux Y.Mellier F.Bouchet A.Omont B.Guiderdoni S.Guilloteau J.-L.Puget
H083	Molecular gas in the merger remnant NGC3921: distribution and dynamics	CO(1-0) CO(2-1)	F.Casoli M.C.Willaime M.Gerin
H084	Extranuclear star-forming complexes in the merger Arp299	CO(1-0) CO(2-1)	F.Casoli M.C.Willaime M.Gerin F.Viallefond
H086	^{13}CO(3-2), CO(7-6) and 1.2mm continuum in IRAS F10214+4704	^{13}CO(3-2) ^{12}CO(7-6)	D.Downes P.Solomon
H088	The extremely-high-velocity outflow around HH7-11 and its origin	SiO(2-1) H^{13}CO(1-0) ^{12}CO(2-1)	R.Bachiller M.Tafalla M.Pérez-Gutiérrez A.Dutrey F.Gueth S.Guilloteau
H089	Mapping the circumnuclear ring of the nearby QSO IZw1	^{13}CO(1-0) ^{12}CO(1-0)	E.Schinnerer A.Eckart L.Tacconi
H091	A CO disk in the Red Rectangle ?	CO(1-0) CO(2-1)	C.Kahane V.Bujarrabal R.Bachiller J.Alcolea R.Lucas R.Neri M.Jura S.P.Balm
H093	High-resolution CO map of the $z = 4.7$ quasar BR1202-07: lens or two sources ?	CO(5-4) Cont 1mm	A.Omont D.Downes M.Guélin S.Guilloteau R.McMahon
H094	Gas fueling in Seyfert galaxies: the central bar in NGC4051	CO(1-0) CO(2-1)	L.Tacconi R.Genzel L.Tacconi-Garman E.Schinnerer J.Gallimore
H099	High resolution observations of the W3(OH) region	CH_3OH $C^{18}O$(2-1)	P.Wyrowski C.M.Walmsley P.Schilke K.M.Menten
H100	Observations of CO^+ in the planetary nebula NGC7027	HCO^+(1-0) CO^+(2-1)	P.Schilke K.M.Menten
H101	Proto-planetary disks in UXors	^{13}CO(1-0) Cont 1mm	A.Natta V.P.Grinin V.Mannings R.Neri

Ident.	Title	Line	Authors
H105	Spectral survey of CRL618: from mm to near-infrared wavelengths	Line 3mm	J.Cernicharo M.Guélin R.Neri
H106	Resolving the molecular gas kinematics in the merger remnant NGC6240	HCN(1-0) CO(2-1)	R.Genzel J.Gallimore L.Tacconi M.Tecza D.Downes
H110	Structure and dynamics of the jet and outflow of the Class 0 object Cep E	SiO(2-1) CO(2-1)	B.Lefloch R.Neri J.Eislöffel
H111	GG Tau: a direct measurement of the disk mass	HCN(1-0) CO(2-1)	S.Guilloteau A.Dutrey M.Simon
H112	High mass star formation in S235A-B	HCO^+(1-0) $C^{34}S$(5-4)	M.Felli R.Cesaroni C.M.Walmsley R.Neri
H113	Weighting the stars	HCO^+(1-0) CO(2-1)	A.Dutrey S.Guilloteau K.Schuster F.Ménard G.Duvert M.Simon
H115	Estimating the density of the molecular filaments in the Photodissociation Region (PDR) associated with NGC7023	CS(2-1) CS(5-4)	A.Fuente J.Martin-Pintado R.Neri
H118	Circumstellar matter in the symbiotic binary system CH Cygni	SiO(2-1) CO(2-1)	J.Mikolajewska A.Omont R.Neri
H119	The jet-driven flow of HH211	CO(1-0) CO(2-1) SiO(5-4)	F.Gueth S.Guilloteau
H121	The CO envelope around the carbon star U Cam	CO(1-0) CO(2-1)	M.Lindqvist H.Olofsson V.Bujarrabal C.Kahane R.Lucas R.Neri A.Omont
H123	A remarkably thin molecular shell around the carbon star TT Cyg	CO(1-0) CO(2-1)	H.Olofsson R.Lucas P.Bergman J.Bieging K.Eriksson B.Gustafsson
H124	Looking for high-mass Class 0 objects: what powers H_2O masers ?	CO(1-0) CO(2-1)	C.Codella R.Bachiller M.Tafalla
H126	The clumpy structure of the IRC+10216: high angular resolution study of the inner circumstellar envelope	^{29}SiO	M.Guélin R.Lucas J.Cernicharo C.Kahane
H127	The accelerating flow in a carbon-rich envelope: CS $v = 1$ observations	CS(5-4)	R.Lucas M.Guélin J.Cernicharo
H132	Evolution of circumstellar disks - gas dissipation and planet formation	CO(1-0) CO(2-1)	R.Webb T.Forveille
H134	The shaping of planetary nebulae	CO(1-0) CO(2-1)	T.Forveille P.J.Huggins R.Bachiller P.Cox
H135	The shaping of planetary nebulae	CO(1-0) CO(2-1)	T.Forveille P.J.Huggins R.Bachiller P.Cox
H136	Molecular arms and streaming motions at a 10pc scale	CO(1-0) CO(2-1)	N.Neininger R.Lucas R.Wielebinski S.Garcia-Burillo H.Ungerechts
H137	Molecular arms and streaming motions at a 10pc scale	CO(1-0) CO(2-1)	N.Neininger R.Lucas R.Wielebinski S.Garcia-Burillo H.Ungerechts
H138	Circumstellar disks in the young cluster NGC2071	Cont 1mm	E.Lada K.E.Haisch
H139	Further CO observations of the radio galaxy 53W002	CO(3-2)	R.Barvainis D.Alloin S.Guilloteau R.Antonucci

Ident.	Title	Line	Authors
H140	Mapping the velocity field of a collapsing protostellar envelope: kinematics of GF9-2	CS(2-1)	H.Wiesemeyer F.Gueth R.Güsten
H142	Ultrasensitive CO observations of a gravitationally lensed quasar at $z = 3.6$ quasar	CO(4-3) Cont 1mm	R.McMahon P.Solomon D.Downes A.Omont
H–10	Monitoring the Gamma Ray Burster GRB980326	Cont 3mm	M.Bremer T.Galama A.Castro-Tirado
H–11	Monitoring the Gamma Ray Burster GRB980329	Cont 3mm	M.Bremer T.Galama A.Castro-Tirado
I001	The fueling of the massive nuclear starburst in the WR Galaxy NGC6764	CO(1-0) CO(2-1)	E.Schinnerer A.Eckart L.Tacconi T.Boller A.Sternberg
I002	Molecular gas in the on-going merger Arp295	CO(1-0)	F.Combes V.Charmandaris
I003	Molecular gas in the on-going merger Arp295	CO(1-0)	F.Combes V.Charmandaris
I004	The nuclear mini-spiral NGC4303	CO(1-0)	L.Colina F.Raluy P.Planesas
I009	Dynamics and star formation in the center of the starburst galaxy NGC2903	CO(1-0)	S.Leon S.Garcia-Burillo F.Combes P.Planesas
I011	Large-scale shocks in NGC253. The first interferometer map in SiO of an external galaxy	SiO(2-1)	S.Garcia-Burillo J.Martin-Pintado D.Bettoni
I015	SiO molecules in 'spiral arm' molecular clouds	SiO	R.Lucas H.Liszt
I016	What new chemistry is at work in diffuse clouds ?	HCO^+(1-0)	R.Lucas H.Liszt
I017	Molecular gas in a representative sample of nearby quasars	CO(1-0)	F.Casoli
I018	Millimetre continuum of quasars with far-infrared excess	Cont3mm	G.Henri M.Polletta T.Courvoisier
I019	The young stellar object NGC2264 IRS1	CS(2-1)	K.Schreyer Th.Henning R.Launhardt
I022	Search for 500 AU structures in the ^{12}CO emission of non-star forming clouds	CO(1-0)	E.Falgarone M.Perault J.Pety J-F.Panis
I024	The nature of a primeval protostellar object detected by ISOCAM: further constraints from its molecular environment	CS(2-1)	R.Güsten P.Cox H.Wiesemeyer
I027	A high resolution study of the outflow G173.58+2.45	CO(1-0)	F.Gueth K.Menten P.Schilke F.Wyrowski
I028	Taming the dragon - The CO molecular outflow of HH288	CO(1-0)	F.Gueth K.Menten P.Schilke F.Wyrowski M.McCaughrean
I029	Prenatal diagnostics of high mass stars: W3 IRS4/IRS5/IRS6	SiO(2-1)	P.Schilke F.Gueth K.Menten F.Wyrowski
I030	A new SiO maser in W3(H_2O) ?	SiO	F.Wyrowski F.Gueth K.Menten P.Schilke
I031	Completing the chemical study of the prototypical photodissocation region NGC7023	HCN(1-0)	A.Fuente J.Martin-Pintado R.Neri
I032	Completing the chemical study of the prototypical photodissocation region NGC7023	C_2H(1-0)	A.Fuente J.Martin-Pintado R.Neri
I034	A true massive protostar: RAFGL 7009S	^{13}CO(1-0) ^{13}CO(2-1)	E.Dartois F.Boulanger M.Gerin L.d'Hendecourt G.Pineau des Forets R.Neri
I035	A new look to the kinematics and the morphology of the gas surrounding the massive object SgrA*	SiO	J.Martin-Pintado P.de Vicente A.Fuente

Ident.	Title	Line	Authors
I038	A search for intra- to inter-day variability in a selected sample of highly active blazars	Cont3mm	T.Krichbaum A.Kraus A.Witzel J.Zensus M.Bremer
I042	CO(4-3) emission from the dusty $z = 3.53$ radio galaxy 1909+722	CO(4-3) Cont1mm	H.Röttgering A.Omont P.van der Werf W.van Breugel S.Guilloteau
I043	CO(4-3) emission from the dusty $z = 3.53$ radio galaxy 1909+722	CO(4-3) Cont1mm	H.Röttgering A.Omont P.van der Werf W.van Breugel S.Guilloteau
I047	Circumstellar disks in the HK Tau PMS binary	^{13}CO(1-0) ^{13}CO(2-1)	F.Menard A.Dutrey G.Duvert S.Guilloteau G.Duchene K.Stapelfeldt
I049	Further study of the dust continuum emission in BR1202-0725 at z= 4.7	Cont3mm	A.Omont P.Cox S.Guilloteau
I050	Search of CO emission in the dusty ultraluminous galaxy SMM02399-0136 at z=2.8	CO(3-2) Cont1mm	A.Omont R.McMahon R.Maoli S.Guilloteau P.Cox B.Fort
I051	Structure and kinematics of molecular clouds in M31 at radii of 6 and 18 kpc	CO(1-0) CO(2-1)	N.Neininger M.Guelin R.Lucas R.Wielebinski S.Garcia-Burillo H.Ungerechts
I052	Quiescent SiO emission in molecular clouds: the interaction of the NGC1333/IRAS4 jet with the ambient gas	SiO(2-1) SiO(5-4)	A.Castets B.Lefloch R.Neri J.Cernicharo
I057	Study of the nucleus of NGC4258	Cont3mm CO(2-1)	P.Cox D.Downes
I058	CO observations of a lensed galaxy at $z = 1$ detected by ISO	CO(2-1) CO(4-3)	R.Barvainis G.Helou R.Antonucci
I060	High resolution HCO^+ observations of the PPN OH231.8+4.2	SiO	C.Sanchez-Contreras J.Alcolea V.Bujarrabal R.Neri
I061	A search for molecular gas at $1< z <2$: the lensed quasar 0957+561	CO(3-2) CO(5-4)	F.Raluy P.Planesas L.Colina J.Martin-Pintado
I062	CO emission from the protoplanetary nebula M2-56	CO(1-0)	C.Sanchez-Contreras R.Neri J.Alcolea V.Bujarrabal
I069	CO(4-3) emission from the dusty $z = 3.79$ radio galaxy 4C60.07	CO(4-3)R Cont1mm	P.van der Werf A.Omont H.Röttgering J.Kurk
I071	IRAS23385+6053: a high-mass class 0 object	$C^{18}O$(1-0) $C^{17}O$(2-1)	R.Cesaroni J.Brand S.Molinari R.Neri F.Palla L.Testi Q.Zhang
I089	The formation of a cavity by a jet-driven outflow	CO(1-0) CS(5-4)	A.Fuente J.Martin-Pintado R.Bachiller R.Neri
I090	The dense gas and high-velocity outflow associated with an intermediate-mass protostar	CO(1-0) CS(5-4)	A.Fuente J.Martin-Pintado R.Bachiller R.Neri
I092	Imaging of an extremely red galaxy at $z = 1.44$	CO(2-1)R Cont1mm	P.Andreani A.Cimatti H.Röttgering R.Tilanus
I094	Observations of a probable proto-elliptical	Cont1mm	D.Clements S.Eales F.Hammer S.Lilly O.LeFevre
I096	The 4 arcs at z =4.04: a starburst galaxy behind Abell 2390 ?	CO(4-3)R CO(10-9)R	F.Combes T.Wiklind R.Neri
I126	Identification of a high redshift dusty galaxy detected in a deep submm survey of the HDF	CO(4-3)R CO(9-8)R	D.Lutz L.Tacconi R.Genzel D.Rigopoulou P.Andreani

Ident.	Title	Line	Authors
I127	Millimeter emission from starburst in the HDF	CO(3-2)R CO(9-8)R	D.Wilner D.Downes M.Wright
I128	The nature of the submillimeter sources in the Hubble and Canada-UK Deep Fields	CO(3-2)R CO(9-8)R	K.Menten F.Bertholdi F.Gueth P.Schilke S.White C.Carilli
I129	The nature of the submillimeter sources in the Hubble and Canada-UK Deep Fields	CO(3-2)R CO(9-8)R	K.Menten F.Bertholdi F.Gueth P.Schilke S.White C.Carilli
I130	Molecular gas and dust at z=3.87	CO(4-3)R CO(9-8)R	D.Downes R.Neri P.Shaver T.Wiklind D.Wilner
I134	Direct masses for the silhouette circumstellar disks in the Orion nebula	CO(1-0) CO(2-1)	M.McCaughrean K.Menten F.Gueth
I142	TMR1: tidal tail or outflow cavity	CO(1-0) CO(2-1)	R.Bachiller S.Guilloteau M.Tafalla A.Dutrey
I157	Millimetre detections of sources in the ISO deep surveys FIRBACK and ELAIS	Cont3mm Cont1mm	B.Guiderdoni D.Rigopoulou R.Genzel P.Ciliegi G.Lagache R.McMahon D.Clements H.Dole A.Omont P.Cox L.Tacconi R.Neri G.Miley R.Carballo M.Rowan-Robinson S.Oliver
I159	A CO survey of gravitationally lensed quasars	CO-R	R.Barvainis D.Alloin
I160	Molecular gas in a representative sample of nearby quasars	CO(1-0) Cont1mm	F.Casoli L.Loinard
I161	A search for CO absorption in the extreme outer disks of nearby spiral galaxies	CO(1-0) CO(2-1)	A.Ferguson F.Bertholdi
I--1	Monitoring the Gamma Ray Burster GRB980519	Cont 3mm	M.Bremer T.Galama A.Castro-Tirado
I--2	A blind search for molecular absorption lines at high redshifts	— —	M.Dumke M.Guélin R.Neri R.Lucas S.Guilloteau M.Grewing
I--3	Monitoring the Gamma Ray Burster GRB980703	Cont 3mm	M.Bremer T.Galama A.Castro-Tirado
I--5	CO and continuum observation of the BAL quasar APM08279	$^{12}CO(4-3)$ $^{12}CO(9-8)$	D.Downes R.Neri T.Wiklind D.Wilner P.Shaver
I--7	Observational constraints on SiO Maser	^{29}SiO	A.Baudry R.Lucas F.Herpin
I--8	^{13}CO and continuum observations towards the putative protoplanet next to TMR-1	$^{13}CO(1-0)$ $^{13}CO(2-1)$	P.Schilke K.Menten F.Wyrowski F.Gueth
I-10	A search for molecular gas at $1< z <2$: the lensed quasar 0957+561 (II)	CO(3-2) CO(5-4)	F.Raluy P.Planesas R.Neri L.Colina J.Martin-Pintado
I-11	Monitoring the Gamma Ray Burster GRB981220	Cont 3mm	M.Bremer T.Galama A.Castro-Tirado
I-12	Continuum observations of SCUBA source HDF850.1	Cont1mm	F.Casoli Y.Mellier
I-13	Continuum observations of SCUBA source HDF850.1	Cont1mm	D.Hughes J.Dunlop R.J.Ivison R.G.Mann S.Oliver J.Peacock M.Rowan-Robinson S.Serjeant

8. ANNEX II : PUBLICATIONS/ 8.1 PUBLICATIONS WITH IRAM STAFF MEMBERS AS (CO-)AUTHORS

694. THE MILLIMETER WAVELENGTH EMISSIVITY IN IC 5146
C. Kramer, J. Alves, C. Lada, A. Sievers, H. Ungerechts, M. Walmsley
1998, A&A 329, L33

695. CLUMP MASS SPECTRA OF MOLECULAR CLOUDS
C. Kramer, J. Stutzki, R. Röhrig, U. Corneliussen
1998, A&A 329, 249

696. MODELLING THE CLOVERLEAF: Contribution of a Galaxy Cluster at $z \sim 1.7$
J.-P. Kneib, D. Alloin, Y. Mellier, S. Guilloteau, R. Barvainis, R. Antonucci
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T.P. Krichbaum, W. Alef, A. Witzel, J.A. Zensus, R.S. Booth, A. Greve, A.E.E. Rogers
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698. A THIN MOLECULAR SHELL AROUND THE CARBON STAR TT CYG
H. Olofsson, P.Bergman, R. Lucas, K. Eriksson, B. Gustafsson, J.H. Bieging
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699. RESULTS OF THE SEST KEY PROGRAMME: CO IN THE MAGELLANIC CLOUDS
VII. 30 Doradus and its southern HII regions
L.E.B. Johansson, A. Greve et al.
1998, A&A 331, 857

700. MILLIMETRE DETECTION OF GRB 970508
M. Bremer, T.P. Krichbaum, T.J. Galama, A.J. Castro-Tirado, F. Frontera, J. Van Paradijs, I. F. Mirabel
1998, A&A 332, L13

701. DISKS IN THE UY AURIGAE BINARY
G. Duvert, A. Dutrey, S. Guilloteau, F. Ménard, K. Schuster, L. Prato, M. Simon
1998, A&A 332, 867

702. INFRARED LASERS IN THE CIRCUMSTELLAR DISK OF MWC 349
C. Thum, J. Martin-Pintado, A. Quirrenbach, H.E. Matthews
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703. MILLIMETER-WAVE THERMAL DUST EMISSION FROM LUMINOUS MERGERS
J. Braine, M. Dumke
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704. SiO SHOCKS IN THE L1157 MOLECULAR OUTFLOW
F. Gueth, S. Guilloteau, R. Bachiller
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705. MOLECULAR GAS IN THE BARRED SPIRAL M 100
II. $^{12}CO(1-0)$ Interferometer observations and numerical simulations
S. Garcia-Burillo, M.J. Sempere, F. Combes, R. Neri
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706. PROGRESSIVE DISPERSAL OF THE DENSE GAS IN THE ENVIRONMENT OF EARLY-TYPE AND LATE-TYPE HERBIG Ae-Be STARS
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707. ASTRONOMICAL DETECTION OF THE CYANOBUTADIYNYL RADICAL C_5N
M. Guélin, N. Neininger, J. Cernicharo
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708. ^{29}SiO ($v = 0$) AND ^{28}SiO ($v = 1$) J = 2 - 1 MASER EMISSION FROM ORION IRc2
A. Baudry, F. Herpin, R. Lucas
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709. VLBI OBSERVATIONS OF THE GALACTIC CENTER SOURCE SGR A* AT 86 GHZ AND 215 GHZ
T.P. Krichbaum, D.A. Graham, A. Witzel, A. Greve, J.E. Wink, M. Grewing, F. Colomer, P. de Vicente, J. Gomez-Gonzalez, A. Baudry, J.A. Zensus
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710. THE INITIAL CONDITIONS OF STAR FORMATION IN THE ρ OPHIUCHI MAIN CLOUD : WIDE-FIELD MILLIMETER CONTINUUM MAPPING
F. Motte, P. André, R. Neri
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711. EXTENDED COLD DUST EMISSION AT 1.3 MM FROM EVOLVED STARS
C. Sanchez Contreras, J. Alcolea, V. Bujarrabal, R. Neri
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712. INTERSTELLAR ISOTOPE RATIOS FROM MM-WAVE MOLECULAR ABSORPTION SPECTRA
R. Lucas, H. Liszt
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H. Widmann, K.S. de Boer, P. Richter et al.
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C. Ceccarelli, A. Castets, L. Loinard, E. Caux, A.G.G.M. Tielens
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717. CO STUDY OF THE GM AURIGAE KEPLERIAN DISK
A. Dutrey, S. Guilloteau, L. Prato, M. Simon, G. Duvert, K. Schuster, F. Ménard
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718. PHYSICAL PARAMETERS OF THE KEPLERIAN PROTOPLANETARY DISK OF DM TAURI
S. Guilloteau, A. Dutrey
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719. CO IN ABSORPTION AND EMISSION TOWARD COMPACT EXTRAGALACTIC RADIO CONTINUUM SOURCES
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R. Bachiller, S. Guilloteau, F. Gueth, S. Tafalla, A. Dutrey, C. Codella, A. Castets
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721. ^{13}CO AT THE CENTRE OF M82
N. Neininger, M. Guélin, U. Klein, S. Garcia-Burillo, R. Wielebinski
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722. A ^{12}CO ($J = 1 \rightarrow 0$) and ($J = 2 \rightarrow 1$) ATLAS OF CIRCUMSTELLAR ENVELOPES OF AGB AND POST-AGB STARS
R. Neri, C. Kahane, R. Lucas, V. Bujarrabal, C. Loup
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723. 50μas RESOLUTION VLBI IMAGES OF AGN'S AT λ3 MM
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724. THE GAIN-ELEVATION CORRECTION OF THE IRAM 30-M TELESCOPE
A. Greve, R. Neri, A. Sievers
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725. THE BEAM PATTERN OF THE IRAM 30-M TELESCOPE
A. Greve, C. Kramer, W. Wild
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R. Barvainis, D. Alloin, S. Guilloteau, R. Antonucci
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727. ADAPTIVE OPTICS IMAGING OF THE CIRCUMBINARY DISK AROUND THE T TAURI BINARY UY AURIGAE: ESTIMATES OF THE BINARY MASS AND CIRCUMBINARY DUST GRAIN SIZE DISTRIBUTION
L.M. Close, A. Dutrey, F. Roddier, S. Guilloteau, C. Roddier, G. Duvert, M. Northcott, F. Ménard, J.E. Graves, D. Potter
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728. MOLECULAR GAS IN MARKARIAN 109: CONSTRAINING THE O_2/CO RATIO IN CHEMICALLY YOUNG GALAXIES
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729. THE STRUCTURE AND DYNAMICS OF THE PROTO-PLANETARY NEBULA M1-92
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730. WIDESPREAD SiO EMISSION IN NGC 1333
B. Lefloch, A. Castets, J. Cernicharo,
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731. NEAR-INFRARED SPECTROSCOPY AND A SEARCH FOR CO EMISSION IN THREE EXTREMELY LUMINOUS IRAS SOURCES:
30m IRAS F09105+4108, IRAS 15307+3252, AND PG 1634+706
A.S. Evans, D.B. Sanders, R.M. Cutri, S.J.E. Radford, J.A. Surace, P.M. Solomon, D. Downes, C. Kramer
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PdB ULTRALUMINOUS GALAXIES
D. Downes, P.M. Solomon
1998, ApJ 507, 615

733. OBSERVATIONS OF THE SUNYAEV-ZEL'DOVICH EFFECT AT HIGH ANGULAR RESOLUTION TOWARDS THE GALAXY CLUSTERS A665,
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734. MILLIMETER AND SUBMILLIMETER HETERODYNE OBSERVATIONS OF TITAN: THE VERTICAL PROFILE OF
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735. CARBON MONOXIDE EMISSION AS A PRECISE TRACER OF MOLECULAR
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N. Neininger, M. Guélin, H. Ungerechts, R. Lucas, R. Wielebinski
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ed. I. Cherchneff and T.J. Millar
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737. MILLIMETER-WAVE OBSERVATIONS OF DIFFUSE CLOUDS
R. Lucas, H.S. Liszt
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738. OPTIMIZING RECEIVERS FOR GROUND BASED MM WAVE RADIO TELESCOPES
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739. A MULTIBEAM SIS MIXER MODULE FOR A FOCAL PLANE ARRAY RECEIVER
A. Karpov, J. Blondel, M. Carter, D. Billon-Pierron, K.H. Gundlach
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740. FIRST SPECTRA FROM A NEW, WIDE BAND, HYBRID DIGITAL CORRELATOR SPECTROMETER FOR THE FIRST-HIFI INSTRUMENT
Ph. Cais, L. Ravera, D. Lagrange, M. Giard, A. Baudry, J.Y. Mayvial
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741. LOW-NOISE HETERODYNE MIXING WITH NbN MICROBOLOMETERS AT 800 GHz
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F. Schäfer, P. van der Wal, E. Kreysa, K.H. Gundlach
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C. Kramer, J. Staguhn, H. Ungerechts, A. Sievers
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30m C. Henkel, Y.-N. Chin, R. Mauersberger, J.B. Whiteoak
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648. INFERRING ACETYLENE ABUNDANCES FROM C_2H: The C_2H_2/HCN ABUNDANCE RATIO
30m A. Fuente, J. Cernicharo, A. Omont
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Institut de Radio Astronomie Millimétrique
Domaine Universitaire, 38406 St Martin d'Hères, France -
Tél.: +33 [0]4 76 82 49 00 - Fax: +33 [0]4 76 51 59 38
E-mail address: username@iram.fr

Institut de Radio Astronomie Millimétrique
Observatoire du Plateau de Bure, 05250 St Etienne en Dévoluy, France
Tél.: +33 [0]4 92 52 53 60 - Fax: +33 [0]4 92 52 53 61

Instituto de Radioastronomía Milimétrica
Avenida Divina Pastora 7, Núcleo Central, 18012 Granada, España
Tél.: (34) 958 22 66 96 - Fax: (34) 958 22 23 63
E-mail address: username@iram.es

Instituto de Radioastronomia Milimétrica
Estación Radioastronomía IRAM-IGN del Pico Veleta, Sierra Nevada, Granada, España
Tél.: (34) 958 48 20 02 - Fax: (34) 958 48 11 48

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