IRAM 1996

ANNUAL REPORT

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Edited by

Michael Grewing

with contributions from:

Walter Brunswig
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TABLE OF CONTENTS

INTRODUCTION

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2. SCIENTIFIC HIGHLIGHTS OF RESEARCH WITH THE IRAM TELESCOPES IN 1996

2.1 SUMMARY

Of the many projects done at the IRAM observatories or published in 1996, some highlights were:

- Observations of molecular gas and dust around a radio-quiet quasar at a redshift of 4.7
- Map of gravitationally-lensed CO emission in the Cloverleaf quasar with 0.5" resolution.
- Detection of CO in a giant arc produced by gravitational lensing through the Abell 370 cluster of galaxies.
- CO observations and a new interpretation of the anomalous spiral arms of the galaxy NGC 4258.
- High resolution line and continuum studies of protostellar condensations in NGC 2024.
- Mapping in CO of the molecular outflow in the jet complex of Herbig-Haro object HH111.
- A mosaic map at 230 GHz of CO in the molecular jet of HH 21
- Studies of the chemistry of the disks around the young stars DM Tau and GG Tau
- CO maps of the circumbinary disk around UY Aurigae.
- Bolometer-array mapping of small scale structure in the dust continuum emission from the Rho Ophiuchi cloud cores.
- Discovery of the C_7H and C_8H radicals in the circumstellar envelope of IRC+10216.
- Detection of huge outgassing of molecules from comet Hale-Bopp at large heliocentric distances.
- Interferometer maps of CO and HCN in comet Hyakutake.

EXTRAGALACTIC RESEARCH

Distant Sources

Molecular gas and dust around a radio-quiet quasar at a redshift of 4.7

Galaxies make a significant fraction of their stars in giant starbursts at the beginning of their existence. In the objects with the largest known redshifts, quasars and radiogalaxies at $z \geq 4$, the presence of dust and molecular gas traces the synthesis of heavy elements. The giant starbursts that form these heavy elements are similar to the starbursts in other luminous galaxies in the local universe. An example of this phenomenon is the radio quiet quasar BR1202-0725 at $z = 4.69$, which has been mapped with the IRAM interferometer in 1.35 mm continuum emission and in CO emission (Fig. 2.1). The map shows a double image, indicating either gravitational lensing or a companion galaxy of the quasar, or both. The detection of CO indicates a large mass of warm molecular gas in one of the most distant galaxies known. At the time of reception of the photons, the metric distance of this galaxy is about 20 percent greater than that of the other two high-redshift CO detections --- IRAS 10214+47 and the Cloverleaf quasar (see below). The CO and dust detections show that conditions conducive to huge starbursts in a molecular interstellar medium enriched in carbon, oxygen, and metals, existed very early in cosmological history, when the universe had only 10 percent of its present age.

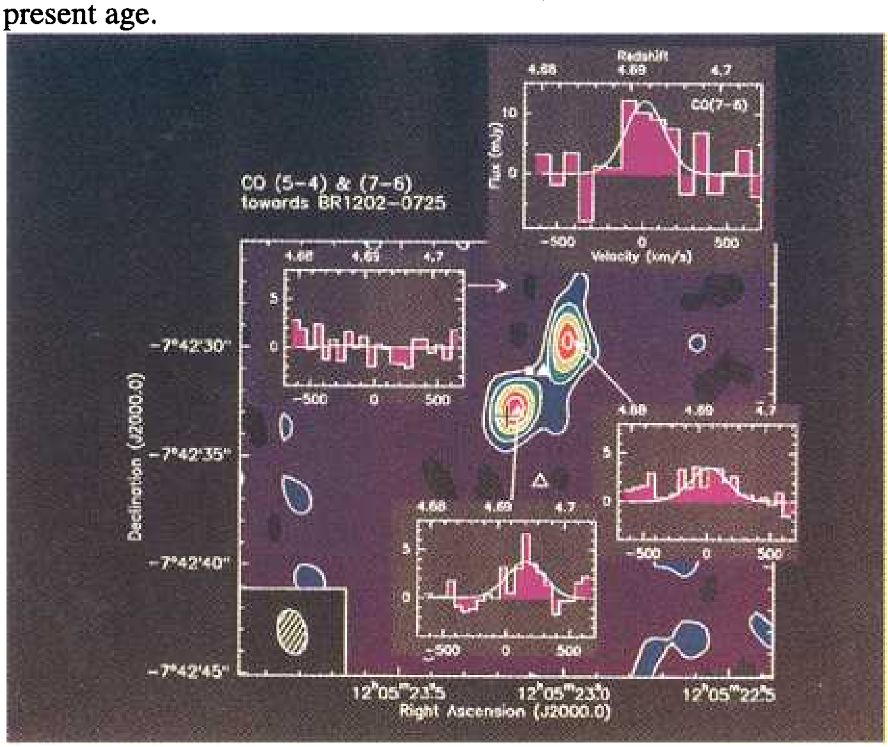


Fig. 2.1 ***CO line and dust continuum emission from the quasar BR1202-0725 at a redshift of 4.7.*** IRAM interferometer spectra of the CO(5-4) line emission are shown in the two lower insets, next to the 1.3 mm continuum image. The inset at the top shows the spectrum of the CO(7-6) line observed with the IRAM 30 m telescope. The small triangles show the location of the optical quasar and its visible companions.

Map of gravitationally lensed CO emission in the Cloverleaf quasar with 0.5" resolution.

CO emission from the Cloverleaf quasar, H1413+117, was first detected with the IRAM interferometer in 1994. Since then, the interferometer baselines have been extended, and new receivers made it possible to observe the higher-frequency CO(7-6) line in the quasar, with a resolution of 0.5 arcsec. The new map resolves the CO emission into three spots, without any evidence for a velocity gradient. The four optical images of the quasar are pointlike, even with the high resolution provided by the Hubble Space Telescope, but the CO spots are extended into the form of an arc. The CO spots are displaced inward relative to the optical spots, meaning that the Einstein ring and the magnification for the CO are both smaller than they are for the optical quasar. This suggests that the true (unlensed) radius of the CO source is about 600 pc.

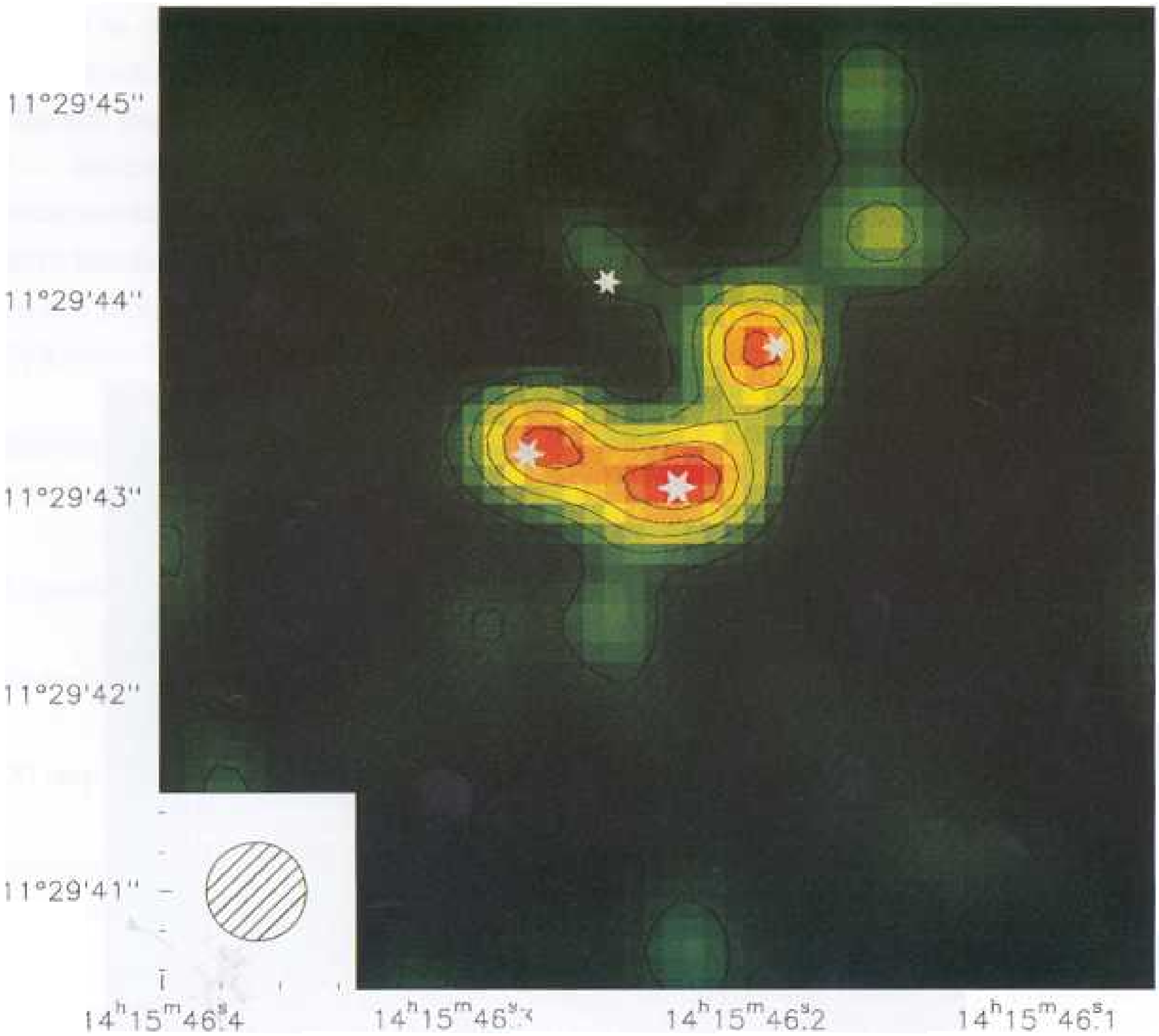
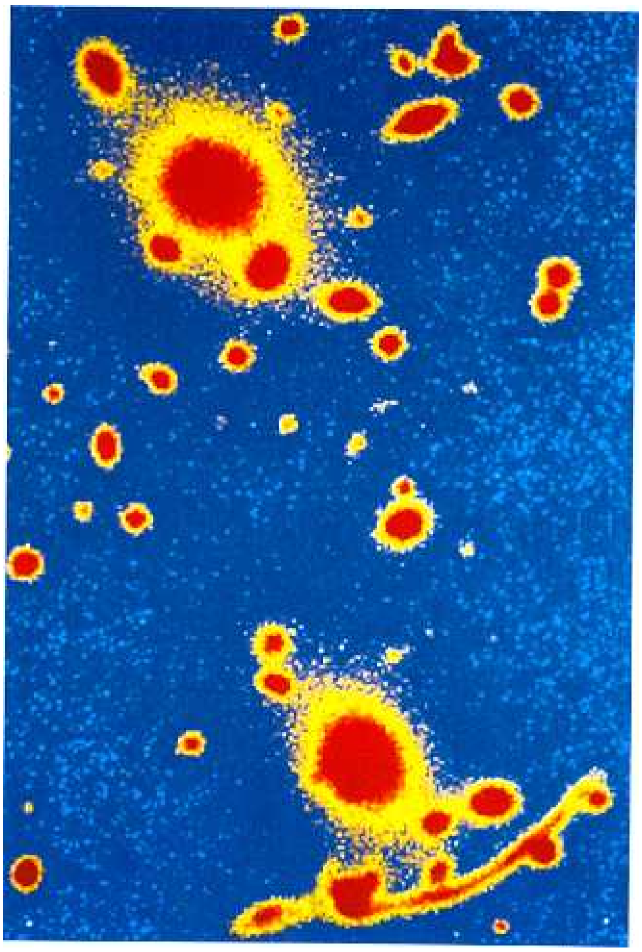


Fig. 2.2 ***Map of the CO(7-6) from the Cloverleaf quasar, H1413+117, made with the IRAM interferometer at 226.7 GHz.*** The 0.5" beam is shown at lower left. The stars indicate the positions of the four optical images of the quasar; the size of the stars is proportional to the brightness of the four spots in the optical V band.

CO lines from a giant arc produced by gravitational lensing

CO(2-1) emission has been detected with the 30m telescope from a bright arc in the Abell 370 cluster of galaxies (Fig. 2.3). The foreground cluster has a redshift of 0.37, and the CO in the arc has a redshift of 0.725. This redshift moves the CO(2-1) line, which is normally at 1.3 mm, into the 2 mm band. The CO arises in a distant galaxy well behind the cluster, and like the optical starlight from the galaxy, the CO is gravitationally deflected by the cluster into the form of an arc. If the lens magnification factor is about 14, as estimated from the optical image, then the molecular mass of the background galaxy would be 1.4 x 10^9 solar masses, about the same as the Milky Way. The detection is at about the 4 sigma level, and it would be useful to have confirming observations.



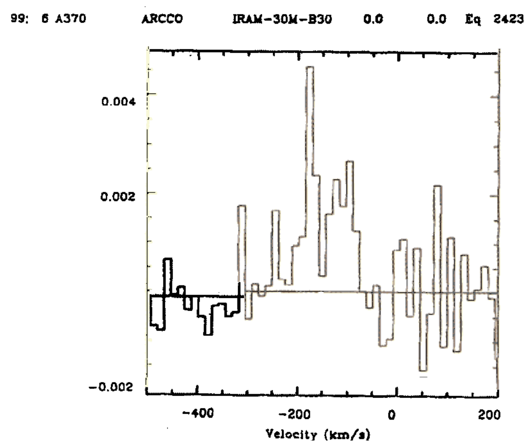


Fig. 2.3 ***Galaxy cluster Abell 370*** (*left:*) False-color optical image from the Canada-France-Hawaii telescope of the center of the galaxy cluster Abell 370. North is up, east is left. The galaxies in the cluster have redshifts of 0.37. The bright arc has a redshift of 0.73.
(*right:*) CO(2-1) spectrum of the arc in A 370. The line, normally at 230 GHz, is redshifted to 133.6 GHz. The vertical axis is line temperature ($T_A{}^*$) in K. The integration time is 8.5 hours and the r.m.s. noise in 13 km/s channels is 0.8 milli-K.

2.2.2 Nearby Galaxies

CO observations and a new interpretation of the anomalous arms of NGC 4258

New maps have been made with the 30m telescope of CO(2-1) in the anomalous arms of the galaxy NGC 4258. The molecular gas is well correlated with the arms and extends 2 kpc from the center. Along these arms, the molecular gas is relatively dense (10^3 cm^{-3}) and warm (50 to 100 K) with a total H_2 mass of 10^9 solar masses. The CO has a characteristic *S*-shaped morphology along which the molecular gas moves *toward* the nucleus, not away from it.

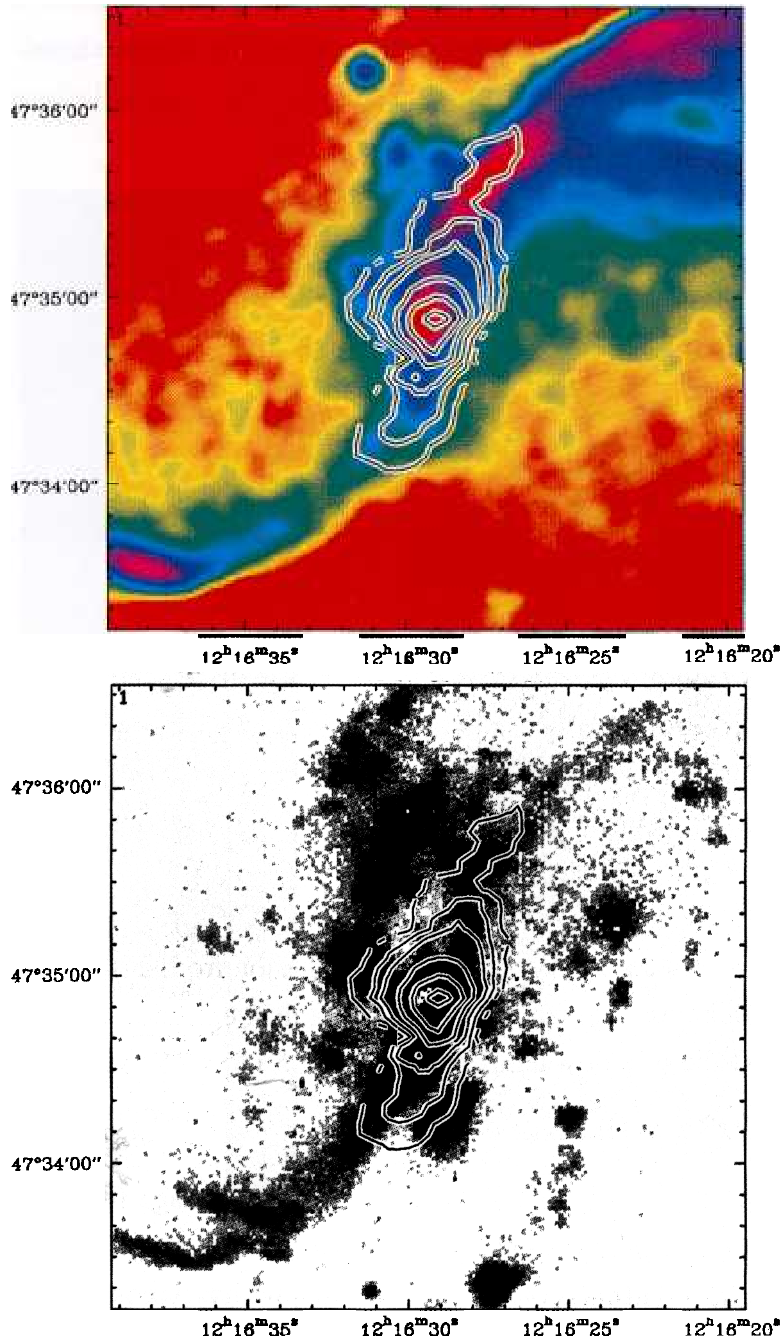


Fig. 2.4 ***CO in the anomalous arms of NGC 4258*** CO(2-1) integrated intensity (white contours), measured at the 30m telescope, over a 600 km s^{-1} wide band, superposed on a 6 cm VLA radio continuum map (upper) and an Hα image (lower).

Contrary to previous interpretations, the new data suggest that the anomalous arms in NGC 4258 trace the gas flow due to a bar rather than the outflow of a jet. Both the *S*-shaped morphology and the velocity dispersion in the CO are characteristic of barred galaxies. In the bar of NGC 4258 most of the gas is molecular, not atomic. The molecular gas is bounded by the sharp leading edge in the radio continuum. In this new interpretation, the nonthermal radio continuum arises in the compressed magnetic field of the bar shock. The Hα emission along the anomalous arms also arises in the bar shock. That is, the radio continuum, the optical line emission and the soft X-rays are produced via the bar shock, and are unrelated to the black hole at the center of the galaxy. The Hα and radio emission extend to a distance of ~7 kpc from the central region and may trace the hot (10^6 K) gas that leaks out of the bar structure and escapes from the disk in the vertical direction. With sufficient sensitivity and angular resolution, similar radio and soft X-ray emission will also be found in the shock fronts of other, more distant, barred galaxies.

2.3 YOUNG STELLAR OBJECTS

High resolution studies of protostellar condensations in NGC 2024.
IRAM interferometer observations toward the HII region NGC 2024 provide new information on the prominent, far-IR dust cores FIR 5 and FIR 6, discovered in the 1980's by bolometer observations at the 30m telescope. Observations of the (2-1) line of $C^{34}S$ with a resolution of 2" x 4" reveal several clumps of gas with line temperatures 20 to 30 K, which shows that even the $C^{34}S$ isotope is optically thick. The velocity dispersion of the gas clumps around FIR 5 yields a dynamical mass of 12 solar masses within a radius of 10 arcsec. Near FIR 5, the $C^{32}S$ line brightness temperature is 40 K, so the line excitation temperature and the gas kinetic temperature are at least this high.

The interferometer also detects compact continuum emission from dust at FIR 5 and FIR 6.
At FIR 5, the peak brightness temperature of the 3mm dust emission is 4.5 K, unusually high at this wavelength. If the true dust temperature in FIR 5 is >40 K, as in the CS clumps, then the continuum source (presumably the protostar's envelope) has a mass of <1.5 solar masses; if the dust temperature is > 100 K, then the mass of the FIR 5 continuum source is < 0.4 solar masses. The mechanical power in the outflow from FIR 5 is 2 solar luminosities, and outflow sources can have a radiant luminosity a few hundred times the mechanical power. A high luminosity would mean high-temperature, and a dust temperature of 100 K at FIR 5 would yield the observed anti-correspondence between the dust continuum and the molecular-line emission

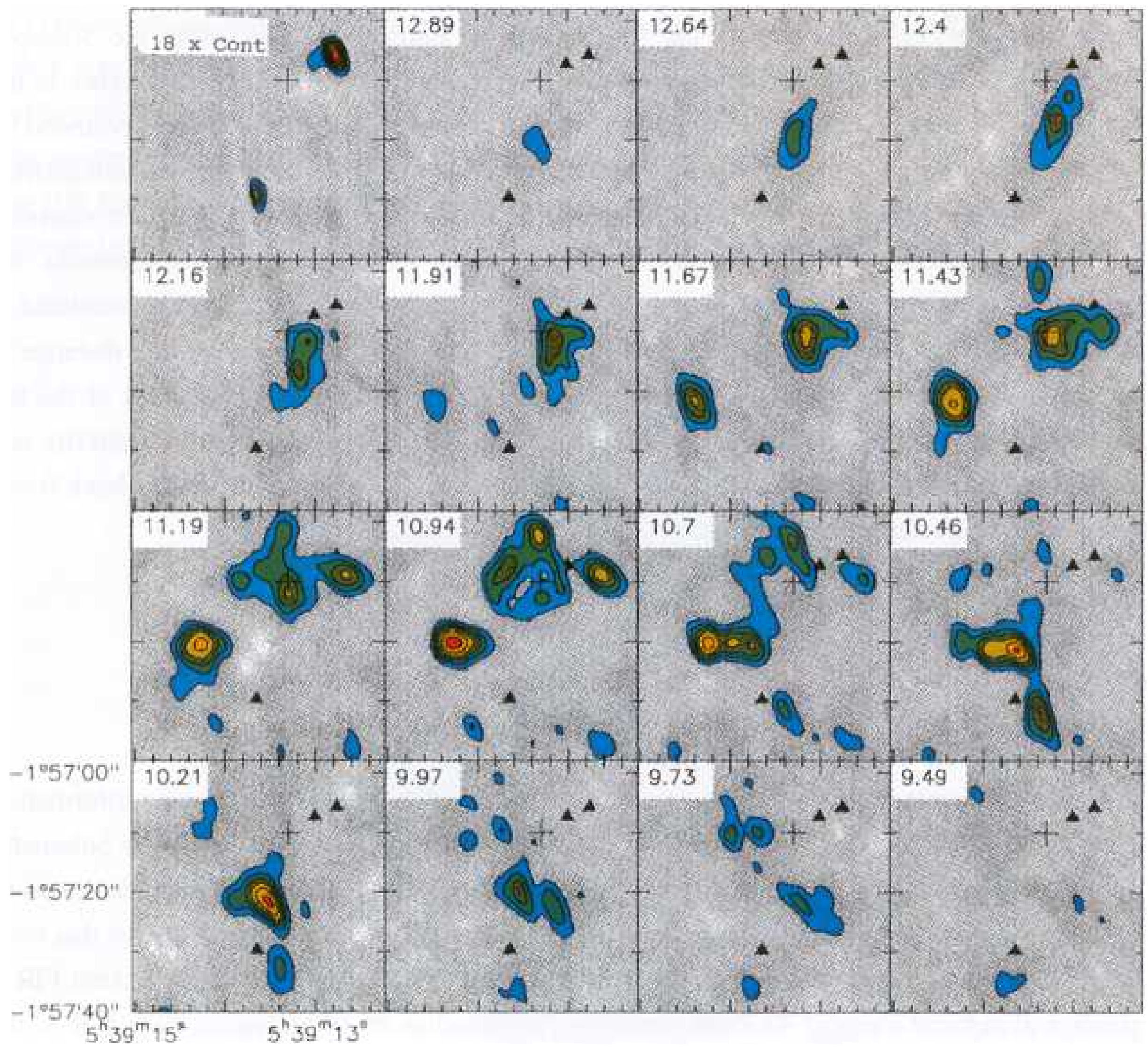


Fig. 2.5 ***Interferometer maps of continuum and $C^{34}S$ line emission at 3 mm near the sources FIR 5 and 6 in NGC 2024.*** The top left panel shows the continuum emission mapped with a beam of 3.8" x 1.6", and a contour spacing of 10 mJy/beam, or 0.2 K. The other panels show maps of $C^{34}S$(2-1) line emission in channels 0.24 km/s wide. Labels are velocities in km/s.The contour interval is 150 mJy/beam or 1.9 K. The beam for the line observations is 4.4" x 2.4".

CO maps of the molecular outflow in the jets of Herbig-Haro 111.

CO(1-0) maps have been made with the IRAM Interferometer of the molecular outflow in the jets of Herbig-Haro 111 (Fig. 2.6). The Herbig-Haro jet is found to coincide with a highly collimated CO flow, with two distinct velocities, possibly providing kinematic evidence that the CO flow surrounds the HH jet. A second well defined bipolar molecular flow, at large angles to the principal flow axis, coincides with the HH 111 infrared flow that emanates from the (presumably binary) driving source detected with the VLA ; the region thus harbors one of the rare quadrupolar molecular flows. Extremely high-velocity CO is found towards the principal HH working surface at the same velocity as the optically emitting gas, whereas this emission is weak towards the Herbig-Haro jet. Since the inclination of the HH jet is known from optical observations to be 10° to the plane of the sky, there must be CO in the flow with space velocities of up to 500 kms^{-1} ! Further out, and precisely along the flow axis, there are three equidistant CO « bullets » with space velocities of about 240 kms^{-1}, and which are not detected in the optical. These bullets may be the result of earlier eruptions which are now moving through a very tenuous ambient medium without any observable shocks. It appears that the Herbig-Haro jets and CO bullets are different manifestations of the same physical phenomena, and appear to be driving the low-velocity molecular outflow.

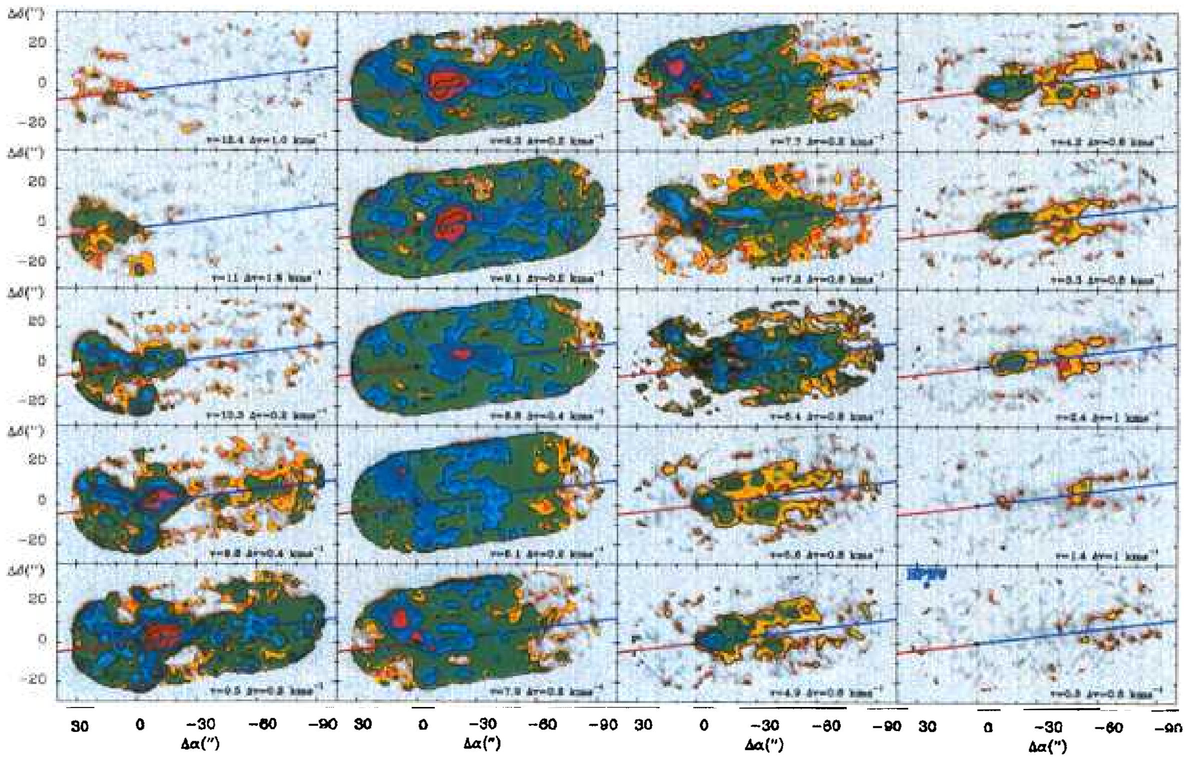


Fig. 2.6. ***CO in the jets of HH 111.*** ^{12}CO (1-0) observations of the Herbig-Haro region, one of the most striking optical jets in the Orion B complex. The maps (3" resolution) show blue-shifted emission in several knots and bow shocks emerging from intermediate positions in a 2 arcmin long east-west cavity. These bright features are probably remnants of various eruptive events of the past. The cavity (remarkable for its gun barrel appearance in the channel maps at 4.9, 5.6, and 6.4 km/s) reflects the clean-cut negative imprint of the optical jet which now apparently drives undisturbed through the huge molecular cloud around the core of HH 111.

New images of molecular outflows from protostars.

The interferometer has been used to make new images of the molecular outflows from L1157 and HH 211. HH 211 is a recently discovered, extremely young and symmetric outflow that can be seen in the 2 micron infrared emission of shocked molecular hydrogen. The very first mosaic map made with the IRAM interferometer at 230 GHz - a mosaic of nine fields - has revealed the internal structure of the cool molecular outflow that is associated with the shocked gas. The low-velocity CO(2-1) emission shows the limb-brightened cavities, while the high-velocity CO gas traces a collimated jet inside the cavities. The protostellar condensation, seen in the 1.3mm dust continuum emission, is at the center of the two lobes of the outflow, and is elongated perpendicular to the jet axis. These observations support scenarios in which a protostar, surrounded by a compact dusty disk, emits a jet with a large bow shock that creates the molecular outflow lobes.

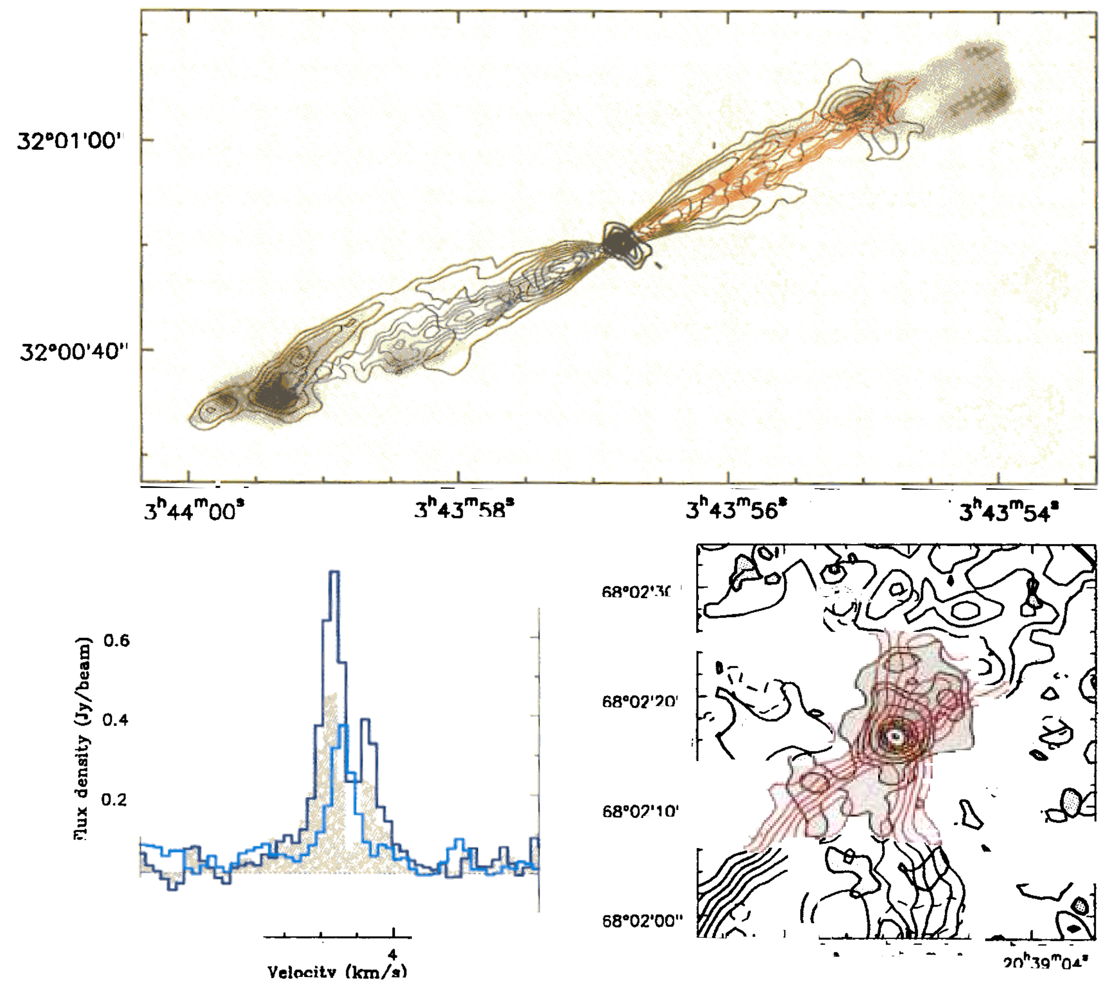


Fig. 2.7 (*Upper figure*) : Emission of molecules and dust in the bipolar outflow from HH 211. False colors: Molecular hydrogen emission at 2 microns. Thin black contours: integrated low-velocity CO(2-1) emission. Red and blue contours: red- and blue-shifted high-velocity CO(2-1) emission. Thick black contours : continuum emission at 1.3 mm

(*Lower figure*) : Observations of the protostar L1157-mm at 2.5" resolution: Spectra of $C^{18}O$(1-0) (in grey), ^{13}CO(1-0) (filled), and ^{12}CO(1-0) (blue) observed toward the central source (left panel), and continuum emission at 3mm (grey) superposed on the integrated CO emission (right panel).

L1157-mm is an extremely young protostar, driving a powerful, highly collimated molecular outflow. IRAM interferometer observations of the central source reveal an extended component in the 3mm continuum emission that is clearly associated with the flow. It probably traces the strong interaction between the high-velocity outflow and the molecular envelope surrounding the protostar. In addition, the ^{13}CO spectra show red-shifted self-absorption, suggesting that material is still falling into this object. Infall and outflow thus appear to be occurring simultaneously in the very early stages of star formation.

Small scale structure in the dust continuum emission from the rho Ophiuchi cloud cores.

The 30 m telescope has been used with the MPIfR 19-beam bolometer array to map the dust continuum emission at 1.3 mm from the rho Ophiuchi cloud cores. The map is a mosaic of 12 different fields observed with the 19 beams taking data continuously, « on the fly » , as the telescope scanned the region. The bolometer maps show several compact circumstellar emission regions around young stellar objects and pre-stellar condensations and also the more extended emission from dust in the molecular cloud itself (Fig 2.8).

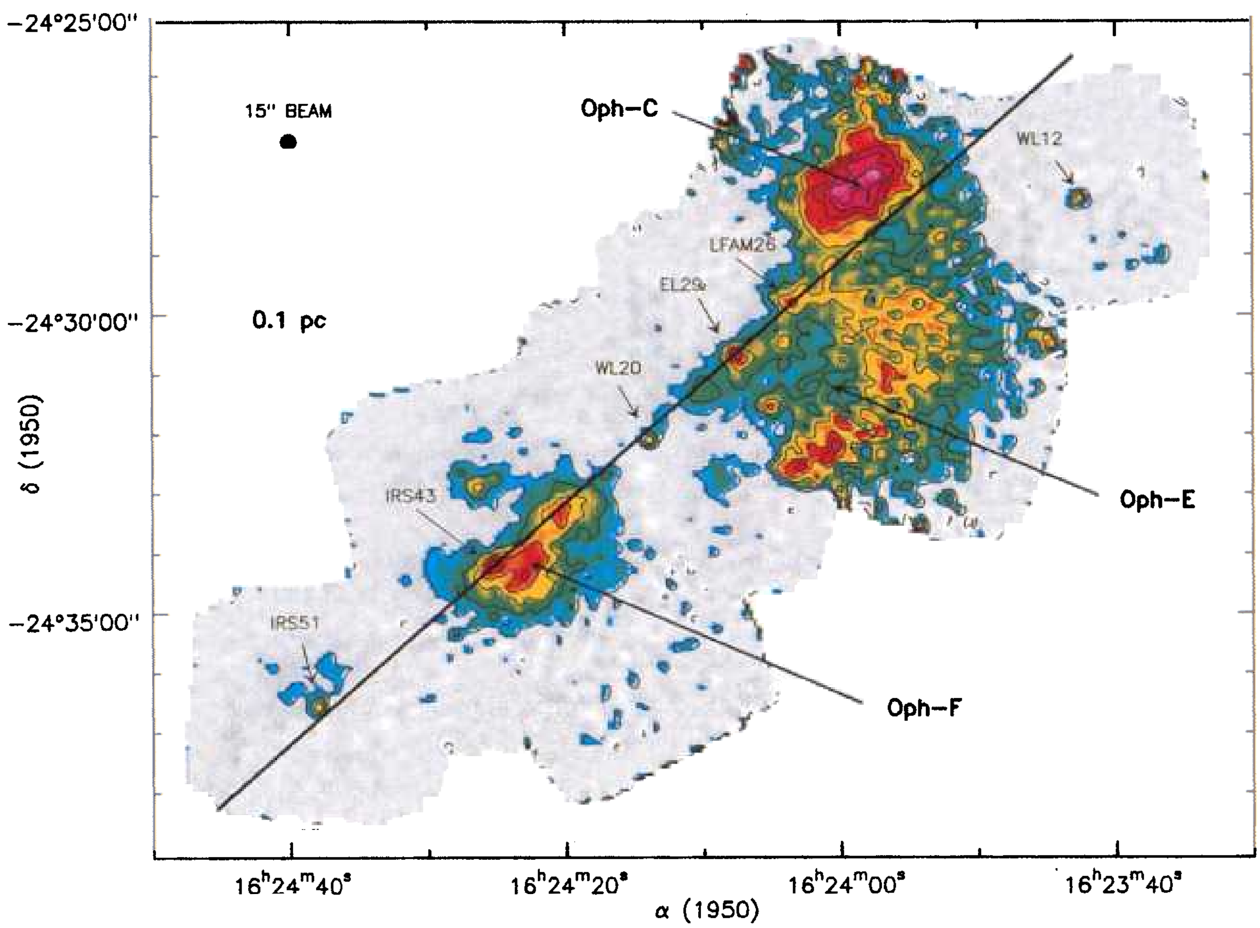


Fig. 2.8 ***Cold dust near rho Ophiuchi.*** Mosaic of 12 fields near rho Ophiuchi mapped with the MPIfR 19-beam bolometer array. The map shows the continuum emission from dust at a wavelength of 1.3 mm. The data have been smoothed to a resolution of 15 arcsec.

CO maps of the binary star UY Aurigae

The IRAM interferometer has been used to map the velocity structure of the disk around the young binary star UY Aurigae. The maps made in the ^{13}CO lines at 1 and 3 mm show clear evidence for a resolved Keplerian disk (Fig. 2.9). This is only the second circumbinary disk ever discovered.

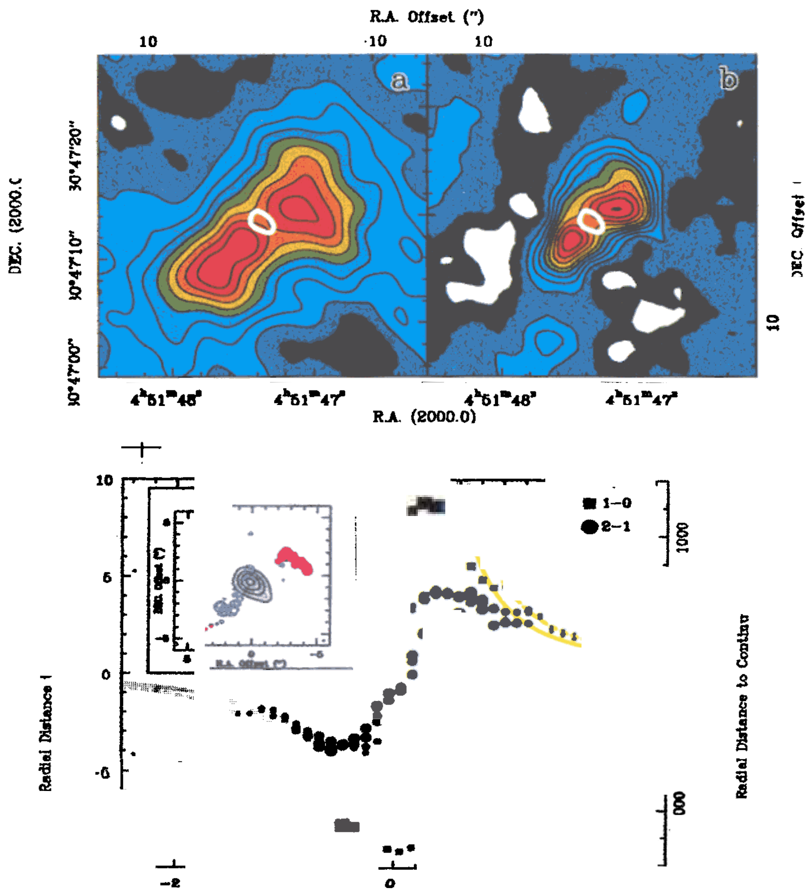


Fig. 2.9 ***Velocity structure of CO emission around the binary star UY Aur.***

Upper : The integrated intensity maps of $^{13}CO(1\text{-}0)$ (a) left and $^{13}CO(2\text{-}1)$ (b) right observed towards UY Aur. The beams were 6" x 4" in CO(1-0) and 3" x 2" in CO(2-1). The continuum source is indicated by the 8mJy contour in white and is centered on the stars.

Lower : position of the molecular line peak vs velocity offset (relative to the velocity of the molecular cloud). Filled circles : ^{13}CO J=2-1 ; filled squares : ^{13}CO J=1-0. The size of the markers is proportional to the line intensity. The data indicate *a resolved Keplerian disk.* The yellow lines are Keplerian rotation curves for a disk orbiting a 0.7 M⊙ star for inclinations of 0° and 30° to the line of sight. The inset shows the position of the emission centroids and the continuum source (filled contours). Filled red circles mean redshifted emission, open blue circles mean blueshifted emission. The rotational pattern indicates an axis at an angle of 47°.

Studies of the chemistry of the disks around the young stars DM Tau and GG Tau.
The 30m telescope has been used to detect the molecules CN, HCN, HNC, CS, HCO^+, C_2H, and H_2CO in the protoplanetary disks of DM Tau and GG Tau. This is the first time that organic molecules have been observed in objects that may be representative of the disk surrounding the sun at the epoch of the formation of our solar system. These molecules are underabundant with respect to dense interstellar clouds. The molecules at radii of 100 to 900 AU from DM Tau are depleted by factors of 5 (for carbon monoxide) to 100 (for formaldehyde). The molecules C_2H and CN have relatively large abundances, typical of a photon-dominated chemistry.

2.4 CIRCUMSTELLAR ENVELOPES

Discovery of the C_7H and C_8H radicals in IRC+10216
A surprising result of mm astronomical surveys has been the detection of many molecules unfamiliar on Earth. The most remarkable of these species are the linear acetylenic chain radicals C_nH, where n runs from 2 to 6, which were identified in space before they were studied in the laboratory. The C_nH radicals are abundant in the dark cloud TMC1 and in the circumstellar envelope of IRC+10216. The latter source is particularly interesting because it offers an unique opportunity to study molecule formation and destruction processes as a function of time. It is believed that these long chain radicals and the cyanopolyne chains $H(CC)_nCN$ are formed directly in the circumstellar shell.

The radical C_8H has now been found in the carbon star envelope IRC+10216. Ten lines have been identified with harmonically related frequencies and with regularly increasing intensities (3 lines in the IRAM 3 mm spectral survey and 7 lines in the 7 mm Nobeyama survey of Kawaguchi et al., 1995). The rest frequencies can be closely fitted with the standard formula for the energies of a linear molecule with a rotational constant B = 586.676 MHz, a distortion constant D = 6.3 Hz, and half-integer quantum numbers J. The value of B is within 0.1% of that predicted by Pauzat et al. (1991) for the $^2\Pi$ ground state of C_8H and the value of D typical of a linear acetylenic chain with the weight of C_8H. The half-integer J numbers are also consistent with a $^2\Pi$ state, confirming that the identification is correct. Furthermore, thirty lines of the new radical have now been detected in the laboratory and confirm that the newly found lines in IRC+10216 arise from C_8H.

Following the discovery of C_8H in IRC+10216, a second discovery was made in this same star, this time of the linear carbon chain radical C_7H. This radical has also been recently observed in the laboratory, and its rotational line frequencies are precisely known. With this new detection, the family of acetylenic chain radicals C_nH, is now complete up to $n = 8$. The members with even numbers of carbon atoms are more abundant than the odd number members: C_8H is four times more abundant than C_7H.

2.5 SOLAR SYSTEM

Cometary nuclei are kilometer-sized bodies that were probably formed by the accretion of grains in the solar nebula. The agglomeration of objects like cometary nuclei - the planetismals - led to the formation of the planets. The comets we observe nowadays are the leftover remnants of this process. Cometary nuclei have large amounts of volatile ices, like water ice and carbon dioxide ice. This means the comets must have formed in the outer parts of the solar nebula. New comets like Hyakutake may have formed in the Uranus-Neptune zone and then may have been ejected out to very distant orbits by the growing proto-planets. Because of their small size and their long stays in the outer parts of the solar system, cometary nuclei have not had many thermal or chemical changes since their formation. Their composition gives us clues about the condensation and accretion processes which formed cometary nuclei 4.5 billion years ago. Comets develop an atmosphere rich in gas and dust as they approach the Sun. At distances of about 1 AU from the Sun, the cometary activity is driven mainly by the evaporation of water ice.

The years 1995-96 provided a rich harvest of new results, with the apparitions of two remarkable comets, Hale-Bopp and Hyakutake. Both of these comets were extensively studied with the IRAM telescopes.

Detection of huge outgassing of molecules from comet Hale-Bopp at large heliocentric distance.

Soon after its discovery at 7 AU from the Sun, the exceptionally bright comet Hale-Bopp was observed with radio telescopes to investigate the outflowing gas. Observations at the IRAM 30m telescope revealed a production of carbon monoxide with a rate as large as $2\ 10^{28}\ s^{-1}$ in September 1995. Since then, the comet has been regularly observed with the IRAM 30m telescope. The comet has been monitored in its approach from 7 AU towards the Sun. The observations with the 30m telescope and other radio telescopes have shown the successive turning on of the CO, CH_3OH, HCN, OH, H_2S, CS, H_2CO, and CH_3CN lines, revealing the progressive release of these volatiles from the cometary ices. The line shapes indicated a preferred outgassing towards the Sun. The temperature in the cometary coma has been derived from simultaneous measurements of several transitions of the same species, showing a progressive increase of rotational temperature from 15 K to 30 K with decreasing heliocentric distance. These gas temperatures are lower than the dust temperatures.

In October 1996, the CO 230 GHz and HCN 89 GHz lines were mapped at the IRAM interferometer (Fig 2.10), and HCN and CO were detected close to the nucleus. The emission sources are compact, but spatially resolved. The angular distribution is not isotropic. A rough map at the 30m telescope also shows anisotropic outgassing with more emission toward northwest. The intensity distribution corresponds to a decrease in density with the square of the distance from the cometary nucleus.

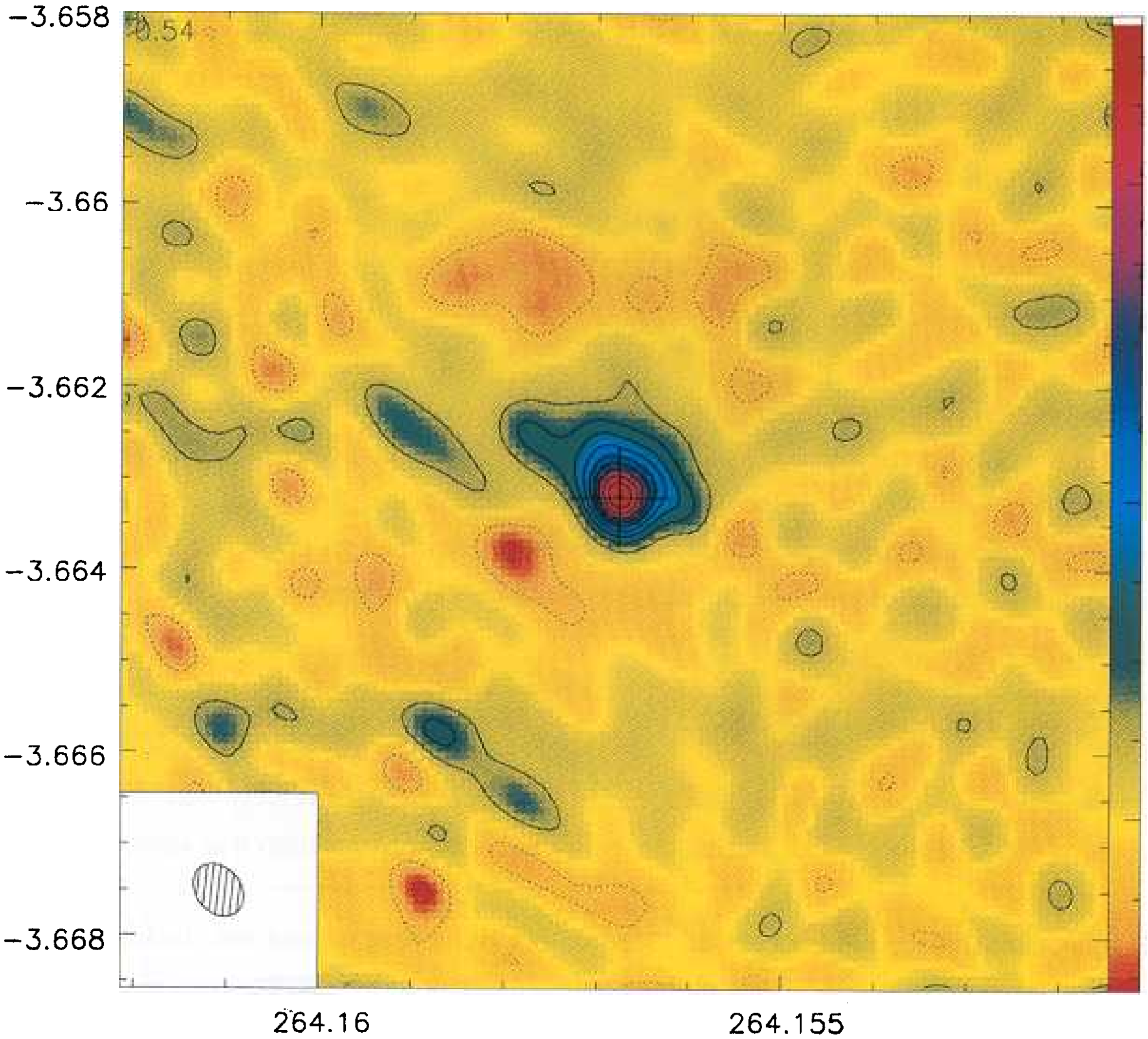


Fig 2.10 ***IRAM Interferometer map of CO(2-1) emission from Comet Hale-Bopp on October 26, 1996.*** The beam is 2.3″ x 1.7″. Coordinates are R.A. and Dec expressed in degrees. The interferometer has also mapped the HCN(1-0) line emission from the comet.

Observations of Comet Hyakutake

Comet Hyakutake made a spectacular close approach of only 0.1 AU from the Earth in March 1996, and extensive spectroscopic studies resulted in the detection of new cometary molecules. The CO(1-0) and (2-1) lines in comet Hyakutake were mapped with the IRAM interferometer, and found to be extended. The interferometer also detected the lines of methyl cyanide, CH_3CN, at 92 GHz in the comet. The abundance of this molecule is 0.01% relative to water vapour, which accounts for 80% of the total number of molecules in the cometary gas.

3. PICO VELETA OBSERVATORY

STAFF CHANGES

In the year 1996 there were only few staff changes which helped to maintain the support for visiting astronomers at a high level.

The astronomy group was joined by a new cooperant. In the receiver group, Hauke Hein who had been delegated for 2 years to the SMTO to support the commissioning work on the HHT returned to Granada. Jose Antonio Lopez, a receiver engineer from the Centro Astronomico de Yebes who had replaced him during this period returned to his home institute. A new cooperant joined the group. A technician was hired for the backend group.

30m TELESCOPE OPERATION

The operation of the telescope was affected in part by the extremely bad weather in the winters 1995/96 and 1996/97. During the rest of the year, the operation was smooth.

Regular maintenance work of about 13 hours per week was carried out, including receiver filling, receiver maintenance, test tunings, telescope, computer and backend maintenance. In addition, a number of periods of technical time were used for tasks of improving the telescope and observing possibilities, replacing and repairing equipment, holography, and working on changes in the telescope system.

As in the previous years, a large fraction of the telescope time could be used for astronomical observations (Fig.3.1), although in 1996 this fraction was somewhat smaller (about 59 % compared to 67 % in 1995). The reason was the persistent bad weather during the first quarter of 1996 and also in the month of December. Fig. 3.3 gives an impression of the amount of snow that has fallen. In 1996, 27 % of the total time was lost due to bad weather ("stop meteorological") and wind ("stop wind"), whereas in the years 1994 and 1995 this loss was around 18 %. A large part of the scheduled bolometer observations could not be carried out, and the pressure for bolometer observing time on the 30m telescope increased for the winter 1996/97.

Fig. 3.2 shows the use of telescope time in 1996 in hours. The loss of observing time because of bad weather occurred mainly in winter. The statistics is based on entries made by the telescope operators.

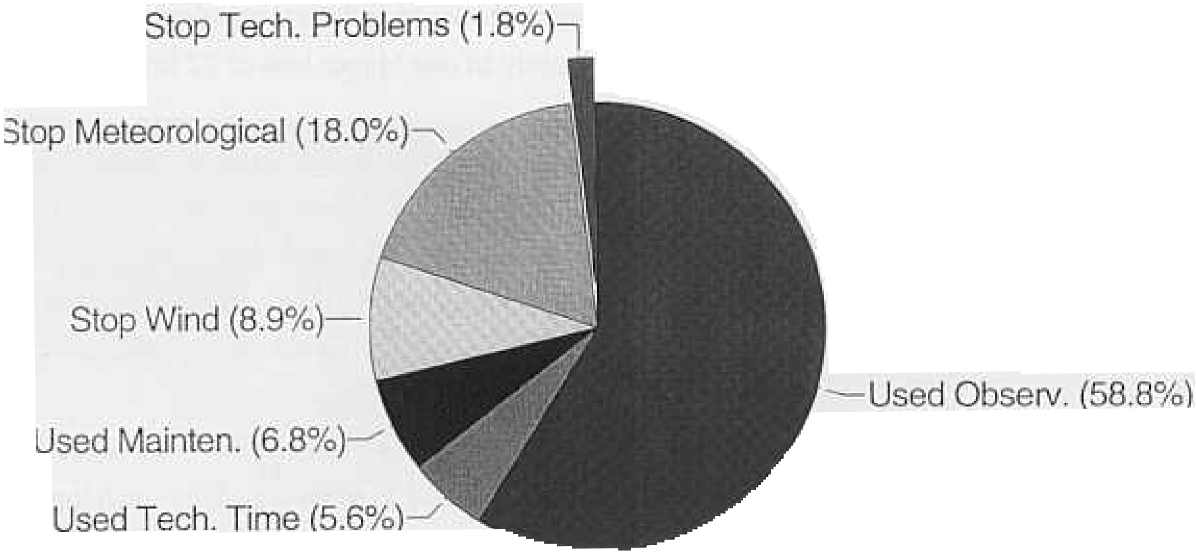


Fig. 3.1: Distribution of telescope time for the year 1996. The percentage lost because of bad weather ("stop meteorological") and wind ("stop wind") is significantly higher than in previous years. This decreased the time used for observations.

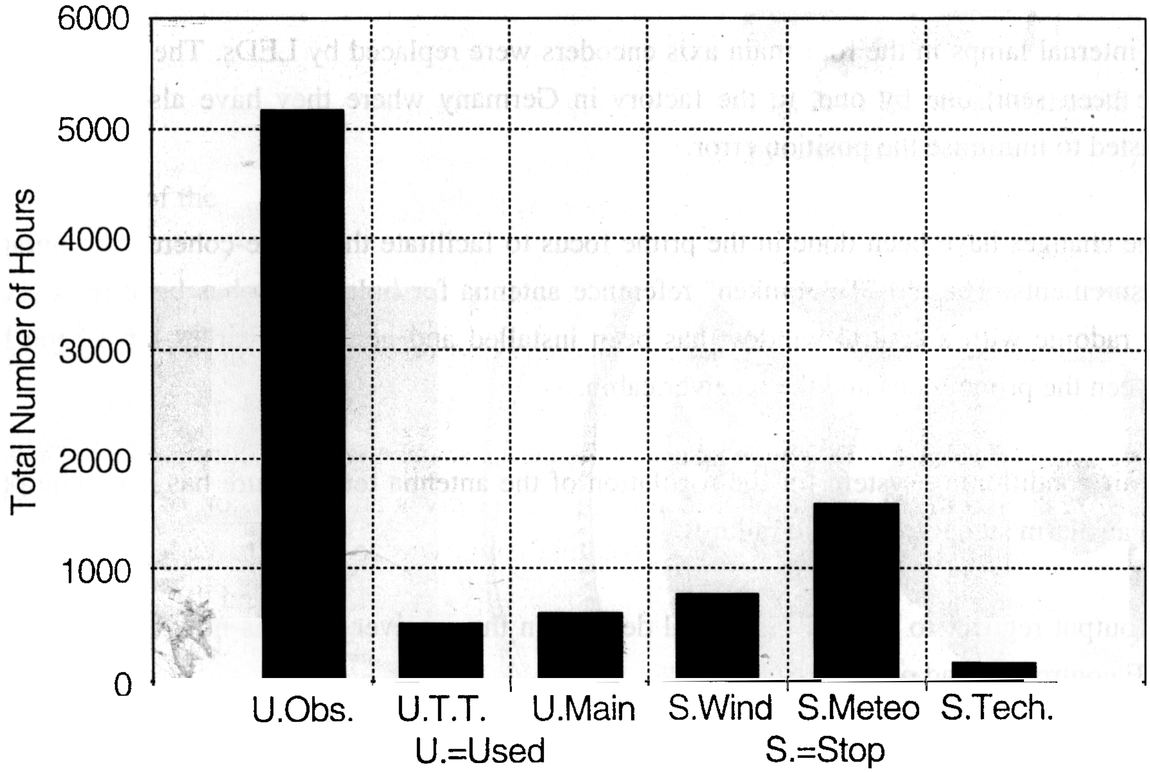


Fig. 3.2: Telescope use during the year 1996 in number of hours.

Although still small (1.8 %), the loss of observing time due to technical problems is somewhat larger than in the previous year. The cause lies mainly in one bigger loss of 72 hours.

For the majority of the astronomical projects, we were able to make receiver tunings well in advance of the actual observation. The constant presence of a receiver engineer at the site helped a lot towards the smooth receiver operation. 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 service observing for short projects.

In the area of telescope power supplies, a new unit with four voltages has been installed to power the antenna and motor encoders plus the associated electronics. This exchange was done in order to have a more reliable system and in preparation for the future VME antenna control.

Spanish (and European) legislation made it necessary to replace the pyralene transformer by a new oil transformer. The new transformer is equipped with fault indicators. The old transformer has been sent for incineration following the established regulations. Fig. 3.4 shows the loading of the old transformer for transport.

The internal lamps in the four main axis encoders were replaced by LEDs. The four encoders have been sent, one by one, to the factory in Germany where they have also been newly adjusted to minimise the position error.

Some changes have been done in the prime focus to facilitate the phase-coherent holography measurements. The old "Telefunken" reference antenna for holography has been removed, a new radome with a central window has been installed and new coax cables have been laid between the prime focus and the receiver cabin.

The air conditioning system for the regulation of the antenna temperature has been equipped with an alarm signal to indicate failures.

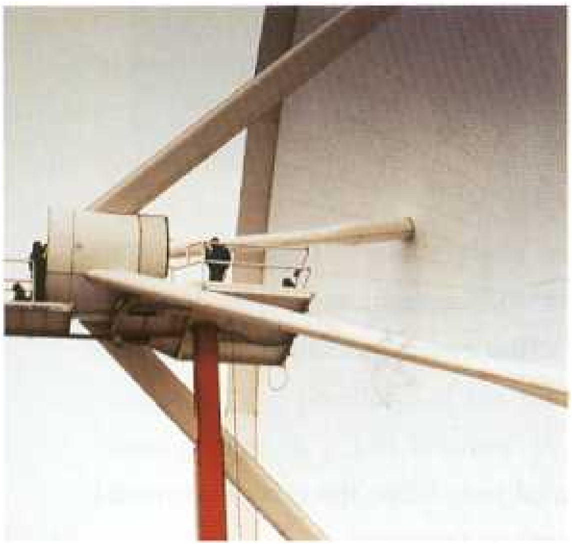
The output register to control individual devices in the receiver room is now operated under VME control instead of CAMAC.

VLBI

IRAM participated in two 3 mm global VLBI observing sessions (of approximately 15 days in total) in January and October. Unfortunately, a substantial part of the time was lost because of

Fig. 3.4 : Removal of the old pyralene transformer

Fig. 3.5: Installation of the modified radome



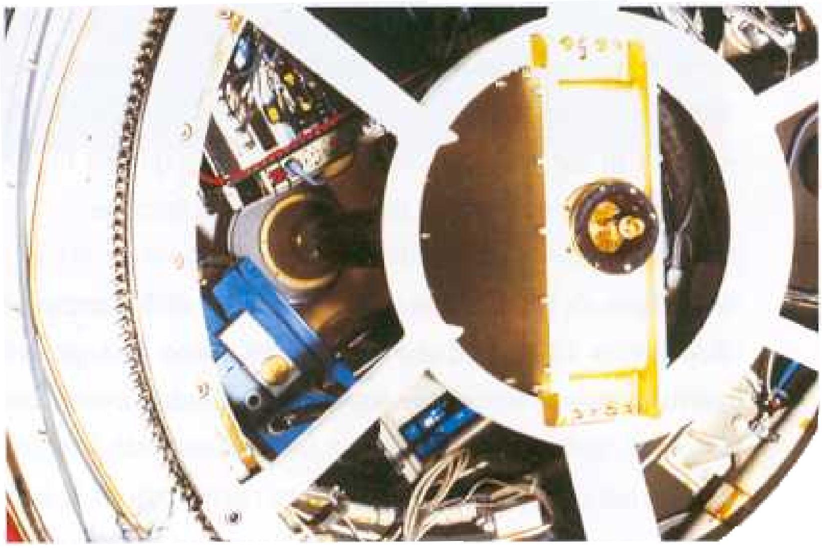


Fig.3.6 : The holography receiver installed in the prime focus.

extremely bad weather (even in October), and because of technical problems (with the maser among others).

The VLBI terminal has been improved by installation of the FS 9 PC control system.

As before, the VLBI observations were made with support from the MPIfR in Bonn and the Centro Astronomico de Yebes.

3.4. REFLECTOR SURFACE

A new coherent holographic measurement system was successfully tested on the 30m telescope in June and September 1996. Its purpose is to give faster and more detailed images of the surface errors of the telescope main mirror with the ultimate aim of improving its high frequency performance. The new system uses a 30cm diameter phase reference antenna and is designed to receive signals at 39 GHz from the ITALSAT satellite. The initial tests showed that a 128x128 pixel map of the aperture could be scanned in about 3 hours. This gives about 10,000 measurement points over the telescope surface, each with a precision of about 40 microns. This accuracy is determined by the atmospheric effects such as seeing and scintillation. The increased resolution makes it easier to diagnose tilted panels and even defects in individual panels. The increased measurement speed over that of the previously used phase retrieval technique will make it possible to study thermally induced deformations of the backup structure and reflecting surface.

To monitor the actual temperature variations of the 30m main reflector, 108 temperature sensors (PT100) have been installed in the antenna backup structure. These sensors allow to follow the evolution of the mean temperature and gradients. The installation of some 50 more sensors in the yoke structure had to be postponed to 1997 because of winter conditions which did not allow to work in this part of the telescope.

Temperature measurements (at intervals of 5 minutes) of the backup structure have started in September 1996, and the analysis of these data gives as a first result a detailed view of the performance of the active temperature control system.

By introducing known temperature perturbations it is planned to validate the computer model of the telescope and to design measures for improving its surface accuracy.

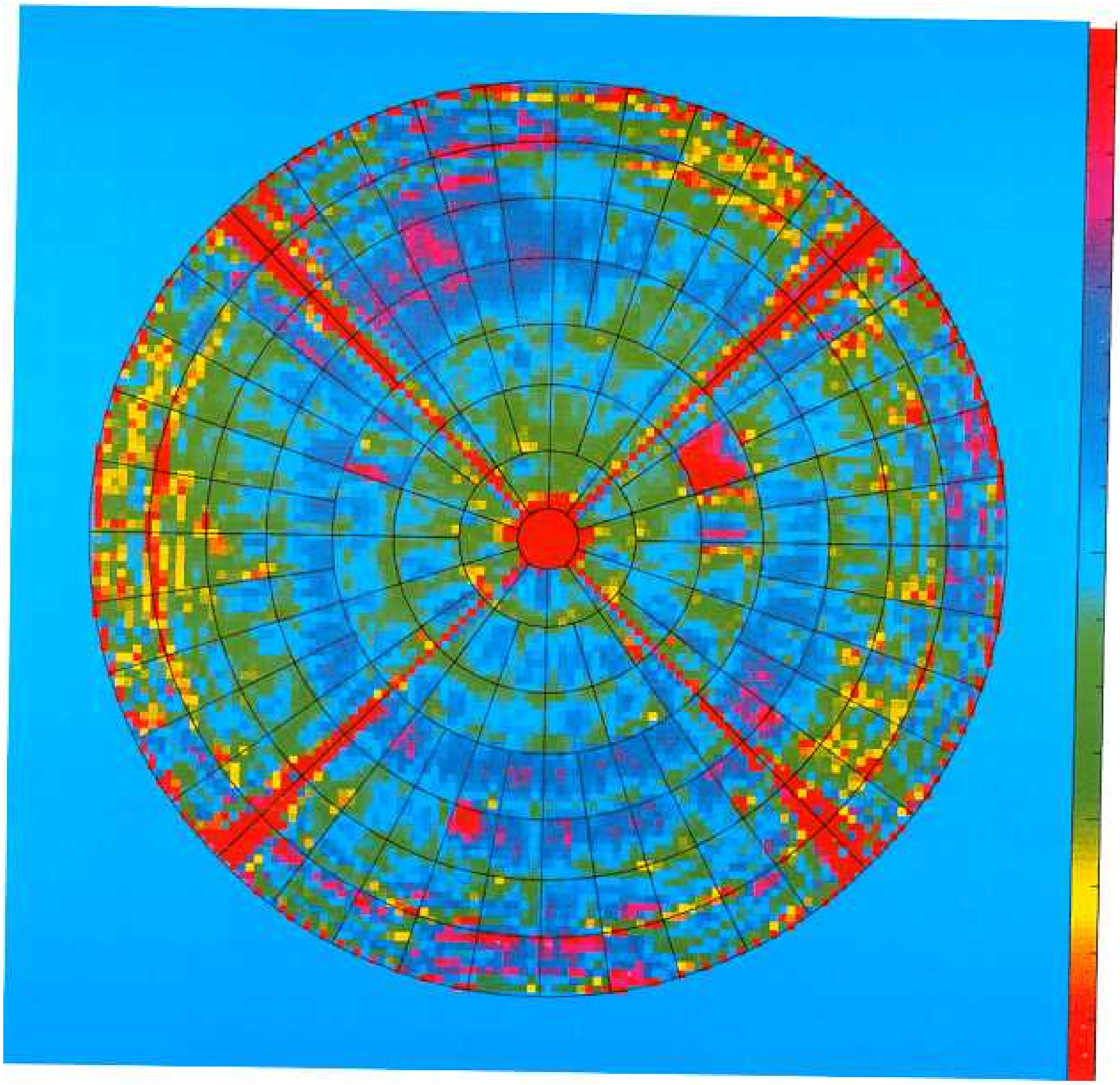


Fig. 3.7: Aperture plane phase map of the 30m telescope showing the deviations from a perfect paraboloid shape. It is a back view and represents the average of 5 night-time measurements. It indicates that the telescope has a root mean square surface error of about 80 microns. The precision of the measurements is about 16 microns. The colour range plotted here covers +/– 240 microns. A displaced test panel (red) can be seen together with two incomplete rings of tilted panels.

3.5. RECEIVERS

As in previous years, apart from routine work (tuning, receiver filling, small repairs, general maintenance etc.), several modifications and improvements have been carried out in the 30 m receiver cabin, new equipment has been installed and tested, some problems have been identified and corrected, some other problems still remain and are under investigation.

After the HEMT amplifier in the 230G2 (1.3 mm) receiver was causing instabilities in the IF output power for a second time, a new 1 GHz HEMT amplifier has been installed, and the problem seems to have disappeared.

The first 3 mm receiver slightly degraded its noise temperature during the year. At the same time the backshort drive was causing problems due to the very strong mechanical coupling, leading to some breakdowns of the motors and gear boxes and the consequent loss of the tuning parameters. A new mixer has been installed. A new LO coupler made of a dielectric mylar foil at 45 degrees has been installed for some time at the first 3 mm receiver. In spite of the improvement found for the system noise temperature (up to 30 K at some frequencies), it was finally dismounted because of severe mechanical vibrations which caused large instabilities.

The old ADRET synthesizers, now only used as a second reference for the PLL circuits, show fewer breakdowns after the installation of an improved ventilation system. However, they should be replaced some time in the future.

Despite several efforts of completely sealing the receiver cabin from incoming water, some problems remain with the optics and the electrical distribution. The most critical optical components (grids) received a special protection. A better and safer power distribution scheme for the electrical circuits in the receiver cabin is now also available.

A long standing problem with the receiver control VME crate has finally been identified and corrected. Since then no further VME crashes have been reported. The transfer of some receiver functions to the new VME system, previously controlled by CAMAC, still continues and now includes the first reference synthesizers and all the calibration equipment.

The mount of the fixed Nasmyth mirror has been improved. It is now mounted on a high precision bearing which allows to turn the mirror accurately between the bolometer position and the heterodyne receivers. This will make it possible to switch faster between continuum and spectral line observations. After this installation, the optical alignment of the two Nasmyth mirrors has been checked, and a partial realignment proved to be necessary.

The polarization rotator/splitter for the 3mm-G1 optical path has been replaced by an improved design: the parallelism of the mirror and grid assembly can now be adjusted precisely, the micrometer screw also allows a better reproducibility with almost no play or backlash.

Apart from routine observations using the 30m facility SIS receivers, a number of special observations and projects, partly involving guest observer equipment, were carried out. These special projects included :
- VLBI at 3 mm and 2 mm wavelength (the 2 mm VLBI being a test observation),
- the search for a pulsar signal at millimetre wavelength,
- 7 and 19 channel bolometers,
- a new polarimeter for Zeeman effect measurements,
- a guest observer bolometer called DIABOLO, and
- the new prime focus dual-channel receiver for holography.

3.6. BACKENDS

In addition to routine activities, a new generation of continuum detectors was installed at the 30-m, and mass production was started to interface the future 1.3 mm multibeam SIS receiver.

Work on a new cable processor which had been started in 1995 was completed. The system was assembled, tested and installed early in 1996 to give better performance (flat 1 GHz bandwidth) and increased reliability (thanks to its modular plug-in design).

New power supply units were built for the filterbanks, since the old ones were clearly showing aging effects. Again, a plug-in technique was chosen to permit a quick repair by the simple exchange of a module in case of breakdown. All the filterbanks are now powered by this technique.

Work has started in preparation of the arrival of the multibeam receiver. After discarding the optical fiber solution for the transmission of the IF signals from the receiver cabin to the control building, a coax copper cable was installed in the tower for test purposes (check of length, losses, and other parameters). The manufacturing of "cable processor" units for the initial 9-channel multibeam receiver has started. The concept can easily be extended to 18 channels in the future. The power unit mainframes were assembled directly for an 18-channel machine: when needed, we just have to insert modules to power 9 more channels. All these tasks will be finished, and the equipment installed at the telescope in 1997.

For pulsar detection experiments at millimetre wavelengths, a second fast sampling unit was built and has successfully been used during the observations.

3.7. COMPUTERS AND SOFTWARE

Apart from the daily operation and routine maintenance and upgrades, the computer and software installation have further been improved.

The most visible change to visiting astronomers, and awaited by many, was the installation of a fast and reliable computer link between the Granada office and the 30m telescope. The modem solution proved to be more and more inadequate for today's needs of access to remote computers and fast data transfer. In 1996, a 2 Mbit/sec point-to-point microwave link was installed, merging the two networks at the telescope and the Granada office into virtually one network.

The memory of the HP/UX workstations has been increased to 128 MB. All workstations have a DAT drive (DDS-2 format) and disks. The DAT drives are mounted in StorageWorks Boxes which allow easy reconfiguration in case of problems and promise also to be more reliable than the previous solution.

The available disk space for users and visitors has been increased notably. A new laser printer has been installed at the observatory. It allows duplex printing and up to 600x600 pixels/inch. It is connected to the network and can be used from any UNIX systems.
The backup policy has been revised to incorporate the new systems. A detailed report is available on our WWW pages.

New network monitoring software has been installed. The software has been developed at the Universities of Braunschweig (D) and Twente (NL). It allows the telescope operator to monitor the state of the network and the systems needed for observation, and the technical staff to monitor the performance, network load, analyse problems, etc. The computer network in Granada has been changed to use now mostly twisted pair connections and HUBs.

Although the changes in the network configuration introduced in past years had improved the reliability significantly, there was still room for further improvements. A new Ethernet switch now separates better the different Ethernet segments of the observatory network thus isolating problems in one branch from the other branches. Fig. 3.8 shows a schematic of the network at the 30m telescope, with the devices that are essential to continue observations indicated in colour.

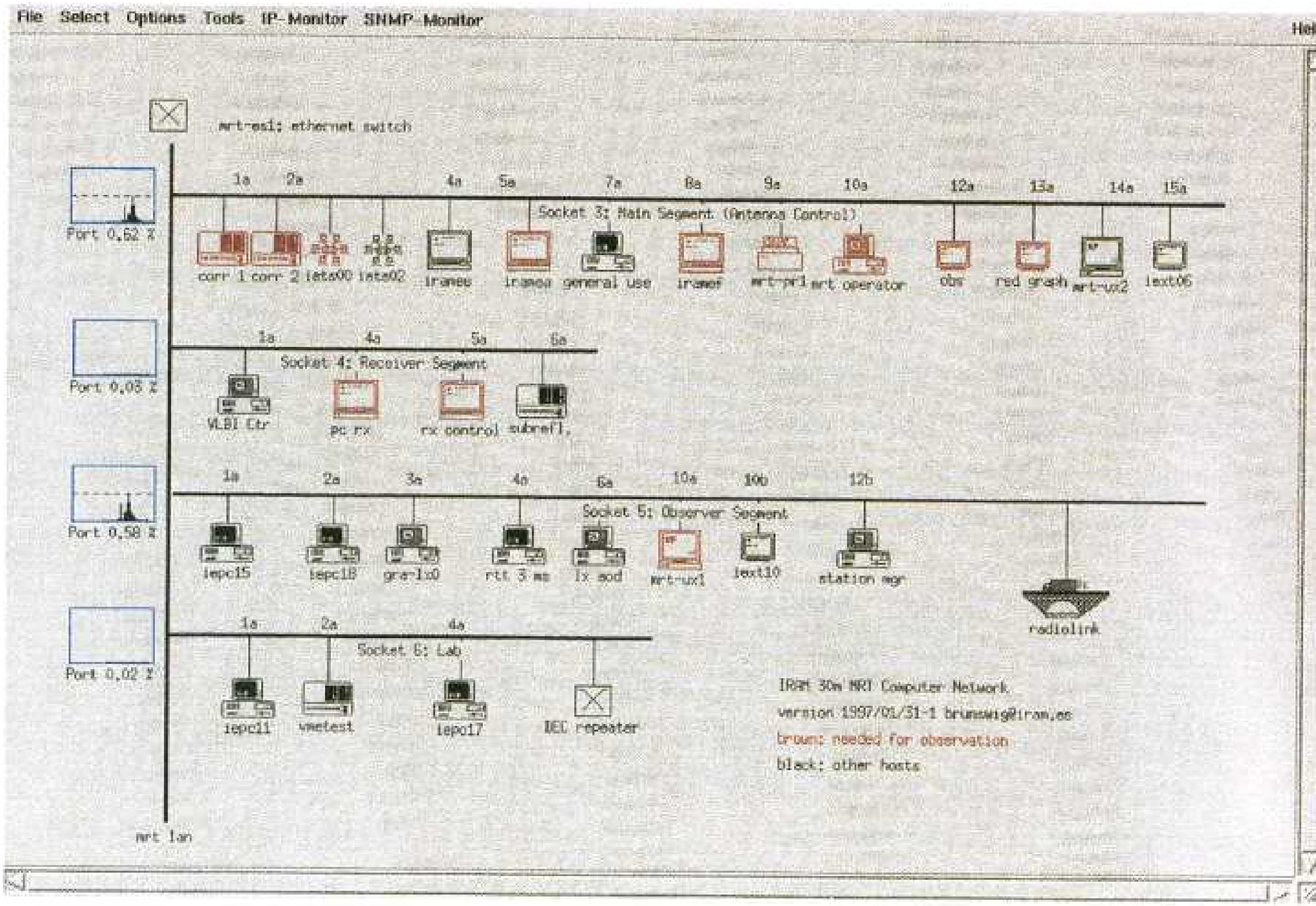


Fig. 3.8: Schematic of the computer network at the 30m telescope. It is connected to the Granada network via a 2 Mbit/sec radiolink. The devices necessary to carry out observations are marked in colour.

The CLASS, CAL, and RED software has been upgraded. In particular, the OTF observing mode required major modifications. Part of this work has been done in collaboration with IRAM Grenoble.

The bolometer data reduction software NIC, developed at IRAM in collaboration with the MPIfR, Bonn and the IAS, Saclay, was installed on the HP/UX workstations. In collaboration with the Grenoble headquarters, the software was debugged and modified, using the experience gained through the daily use at the telescope. The data acquisition has been modified. Bolometer data can now be read directly in the receiver cabin via a CAMAC processor that has been installed there.

The backend control software was modified to allow continuum sampling every millisecond. This mode has successfully been used for pulsar observations.

During 1996, the spectral line On-The-Fly (OTF) observing mode, which was first implemented in 1995, has been further developed and improved. In collaboration with the Grenoble headquarters, the data reduction software has been made more flexible, and new commands were introduced. As this observing mode requires large amounts of disk space for data reduction, we have reserved 4 GB disks on two HP workstations for this mode. First tests with sampling times below one second have been carried out.

A new concept for the chart recorder control has been developed. It allows to display any number of channels on a X-Window and choose which channel to put on the chart recorder. Another PC based system that has been developed by the receiver group allows to record total power data of the receivers for off-line analysis.

A LINUX system has been installed for the telescope operators that allows to control the receivers in the same way as in the receiver cabin.

The migration from CAMAC to VME has continued throughout 1996. More CAMAC receiver interfaces have been replaced by VME boards. The PT100 temperature sensors in the main reflector backup structure (see Section 3.5) are read via a VME interface. Work has started to replace the autocorrelator processors with faster systems which will be necessary for using the autocorrelators with the frequency switching and fast OTF observing modes in the future. A general server software has been developed to allow access to VME from VMS and UNIX systems.

The IRAM Granada WWW pages have undergone a general "face lifting", and hopefully now provide more information and better and easier access to it. We also use the WWW to improve the internal communication (operator, receiver, and astronomer-on-duty reports, computer maintenance infos).

Due to a change of the electronic mail format, we were forced to phase out the old electronic mail system in spring, and to put into operation new software. The new software uses a LINUX system for mail exchange. Under UNIX we mostly use 'pine' as e-mail viewer software.

INFRASTRUCTURE

The exchange of the pyralene transformer with a new oil transformer has been mentioned already. New electrical outlets have been installed in the control room and adjacent offices in order to clean the area, as much as possible, of electrical cables. A new electrical earth has been dug outside the observatory to improve the protective ground for the electrical installation.

Further improvements have been made on the waste-water system at the observatory

A battery of capacitors has been connected to the electrical installation in the Granada office to reduce the maximum instantaneous power consumption, and to minimise the reactive currents

3.9. SAFETY

Both cranes at the tower of the observatory have been revised and improved by an authorised company (recognised by the Spanish Ministry of Industry) to comply with the existing regulations. The emergency light installation in the control building has been modified in order to be connected to the UPS instead of individual batteries.

3.10. ADMINISTRATION - ACCOMODATION - TRANSPORT

The transport to the observatory in the first quarter of 1996 and during December of the same year was often affected by the persistent bad weather. More than once the transport had to be cancelled because of a snow storm, high wind, poor visibility, excessive amounts of snow and the danger of snow slides. This included the transport foreseen on December 31st with the result that the same team which had already celebrated Christmas at the telescope also spent New Year's Eve on the mountain.

The usual small repairs and maintenance work on the buildings have been carried out. The observatory living area has been desinfected by a specialised company. Following advice from outside experts, the contracts with the electricity company SEVILLANA for both the observatory and Granada office have been modified in order to lower the consumption-independent part of the electricity bill.

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

4. PLATEAU DE BURE OBSERVATORY

4.1. Interferometer Status

1996 has been full of events for the Plateau de Bure Interferometer. On the technical side the major event has certainly been the arrival of antenna 5. On the scientific side the first sub-arcsecond images have been a real highlight.

4.1.1 High Angular Resolution

In January-February 1996, the interferometer used for the first time the recently completed 408m-baseline. Analysis of the data indicates that sub-arcsec angular resolution was indeed achieved, with good phase stability even at 230 GHz on several projects. Phase noise as low as 20 degrees r.m.s. on the 408-m baseline was actually measured.

The phase accuracy of the interferometer was significantly improved when we implemented the correction for a slight offset in the intersection of the azimuth and elevation axes of the antennas. 1.5" resolution at 230 GHz (CD array) was routinely achieved even on relatively "low" declination sources. The "active" phase correction system based on the total power monitoring reached an accuracy of about 20 degrees r.m.s. at 230 GHz on time scales of 20-min. It has, however, rarely been used during the winter season because the weather was generally so good that there was no need for phase corrections. This changed in the spring when the phase correction system became very useful.

4.1.2 Antenna 5

The interferometer has been stopped mid-May for major changes, all linked to the arrival of antenna 5.

- *New Power Generators*
  New Diesel generators have been installed to match the increase in power required by antenna 5. Re-cabling of the power distribution of the backend room was also required for the new correlator and computers.

- *New Central Computer System*
  All the CAMAC based instrumentation and the VAX computers have been decommissioned. Two Unix-based HP-J200 workstations (one for real-time control and acquisition, one for data reduction which could be used as a backup for the real-time computer) have replaced the VAX computers as central system.

- *New VME-based Pointing Control System*

  Antenna 5 is equipped with a VME-based interface for the Az and El pointing and tracking, as well as for the control of the transporter functions. Antennas 1, 2, 3, 4, which were originally equipped with CAMAC, have been retrofitted with a similar equipment for pointing and tracking, but the transporter functions have to be operated under manual supervision.

  VME microcomputers in each antenna interact with the HP-workstation through an Ethernet link. They receive time information and astronomical coordinates from the central computer, process them to Az/El and supervise the tracking of the antennas.

  New IF/LO Distribution System

  To handle one additional antenna, the IF/LO distribution system has been completely dismantled and rebuilt. The new system can already handle 6 antennas.

- *New 5-Antenna Correlator*

  The 4-antenna correlator has been totally upgraded to handle 5 antennas, with no loss of capabilities. The modification was a major one, since it represents a 60% increase in processing power. Yet, essentially all the original components of the 4-antenna correlator have been re-used. The new correlator is equipped with faster microcomputers, and allows atmospheric phase correction at all operating modes.

- *New Acquisition and Control Software*

  The large number of hardware changes made it necessary to completely re-write the control and acquisition software.

- *Antenna 5 Testing*

  Antenna 5 was brought out early June. First fringes with 5 antennas were obtained on June 16. Commissioning took somewhat longer than expected because of two subtle problems. First, the pointing behaved incorrectly. The elevation behaviour was first marginal, then became clearly incorrect. This was due to a defective coupling between the elevation encoder and the axis. Second, holography showed incorrect shapes for the panels of the inner ring. This problem was eventually identified in the fall as being due to a combination of a large initial error in the setting of the panels and a too stiff joint between the central hub and the inner ring which elastically deformed the panels. The joint was re-adjusted to allow the panels to relax to their correct shape.

Fig. 4.1 : Antenna 5 with its reflector made of 176 aluminium panels.

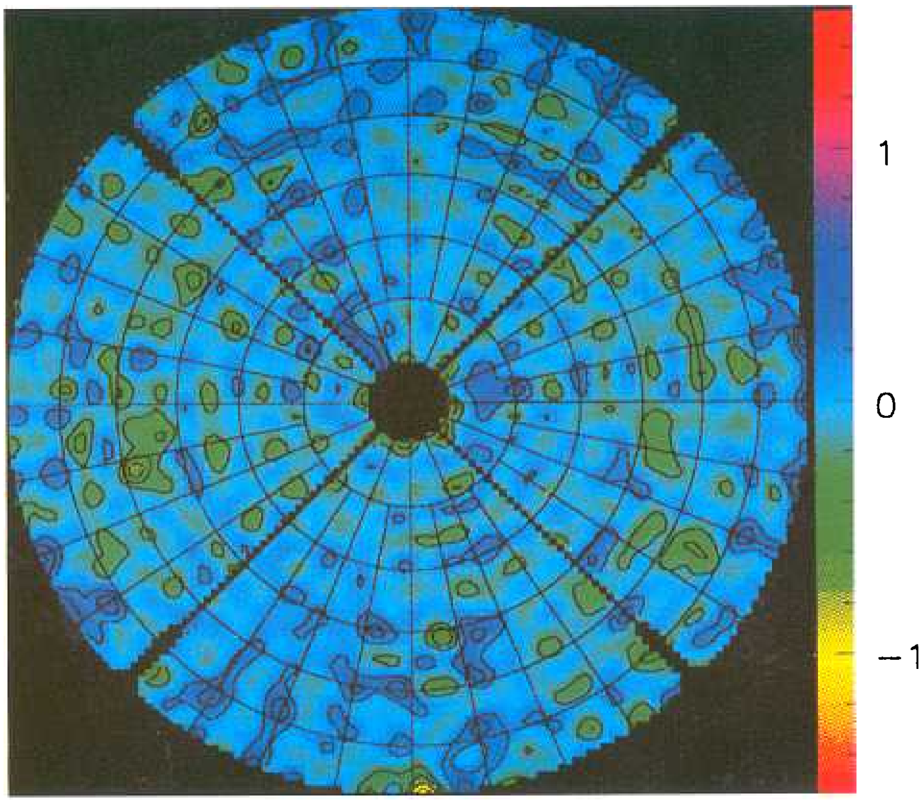


Fig. 4.2 : Holographic measurement of the surface quality of Antenna 5.

New Holography Technique

Using an improved holography technique, the surface of antenna 5 was adjusted to about 60 microns r.m.s., making it ready for 1.3 mm operation. The surface of antenna 4 was adjusted to better than 50 microns, and antenna 2 to better than 60 microns. All subreflector positions were optimized. In total, the efficiency of the antennas has been improved by 30% to 50% at 230 GHz as compared to the 1995 situation.

- *Better Receivers*

  All dual-frequency receivers have been co-aligned within 2". The receiver of antenna 4 (which was the first of the series and suffered from a focus offset between both channels) has been replaced by a new one. The co-alignment of the 2 channels was set up in the laboratory, and has been checked to be better than 2" on astronomical sources. The new receiver provides significantly better performance than the previous one: Trec is below 40 K DSB over most of the band (32 K DSB at 230 GHz).

  The old receiver is being refurbished in the laboratory. It will serve as a spare, or will be used to replace the receiver of Antenna 1 which has a high Trec near 245 GHz.

New Ratrack

To speed up the re-start of the observations after heavy snowfall, and in particular to ensure access to the outermost stations to allow the use of the longest baselines, a new "Ratrack" has been bought and delivered to the site. This should significantly accelerate the snow-cleaning and facilitate the access to the antennas under poor weather conditions.

With these major changes completed, the interferometer is now fully operational with 5 antennas. Initial results at 230 GHz have demonstrated a total sensitivity improvement of about a factor 2 as compared to the 4-element array. Unfortunately, the bad weather conditions in the fall of 1996 did not allow to fully exploit this gain factor astronomically.

GRENOBLE HEADQUARTERS

GROUP ACTIVITIES

General

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the photomask, and after the introduction of the new photo-resist, batches with good uniformity were obtained. Receiver noise temperatures between 80 and 100 K DSB in the frequency band 430 to 500 GHz have been obtained on the HHT.

For receivers approaching the THz frequency range, a fabrication process was developed which permits the integration of Nb junctions in Al tuning circuits. Based on this technology, another member of the MPIfR developed and realised mixer elements for 810 GHz. The receiver noise is 850 K at the laser frequency 803 GHz. This receiver is presently under test at the SMTO/HHT.

5.1.3 New Developments

Electron-beam lithography for junction fabrication

The first Nb mixer elements were successfully fabricated by combining photo- and e-beam lithography.

NbN THz mixing elements

In the framework of an ESA/ESTEC contract the possibility of using SIS mixers at 1.5 THz and beyond this frequency has been investigated. Only NbN can presently be used for the tunnel junctions at such high frequencies. A problem that remains to be solved are the large radio frequency losses in NbN tuning circuits. In a first step NbN junctions were therefore embedded in Nb tuning circuits whose properties are well known. A mixer experiment at 350 GHz gave 245 K DSB receiver noise temperature. Since Nb can not be used above 800 GHz, the NbN junctions are now integrated into Al tuning circuits. First mixer elements for frequencies up to 1.2 THz have been fabricated and delivered to Groningen (SRON) and Cologne (KOSMA) for further testing (Fourier-transform measurements and mixer experiments).

Bolometric Mixers

The development of hot-electron bolometric mixers has been pursued. There are two promising versions, the diffusion-cooled Nb and the phonon-cooled NbN bolometer. Appropriate e-beam lithography to obtain the required critical dimensions was developed. The

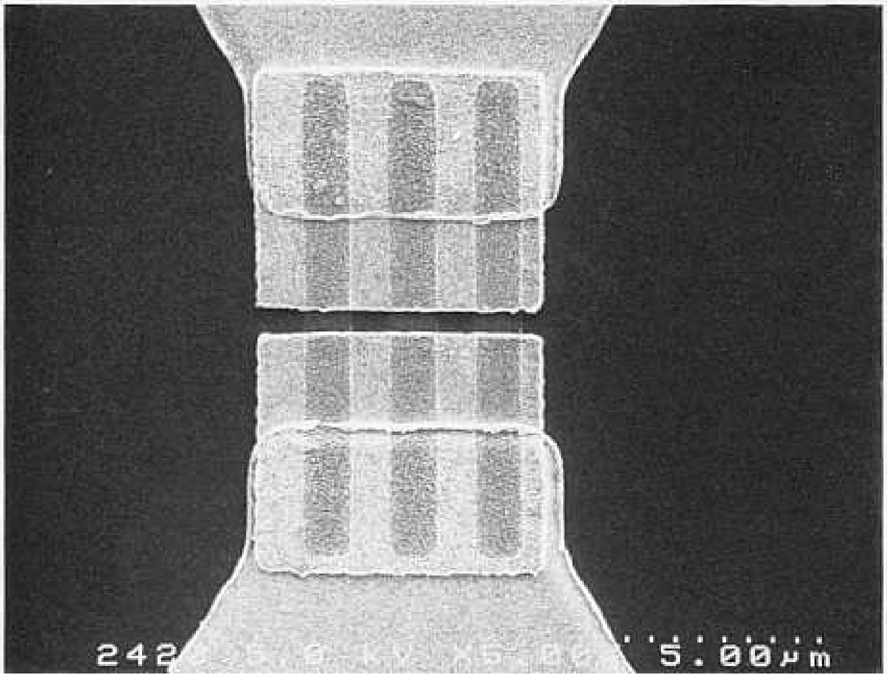

Fig. 5.1 : Photo of three parallel connected NbN microbridges for a bolometer mixer. Each bridge is about 0.4 µm long, 0.8 µm wide, and 5 nm thick.

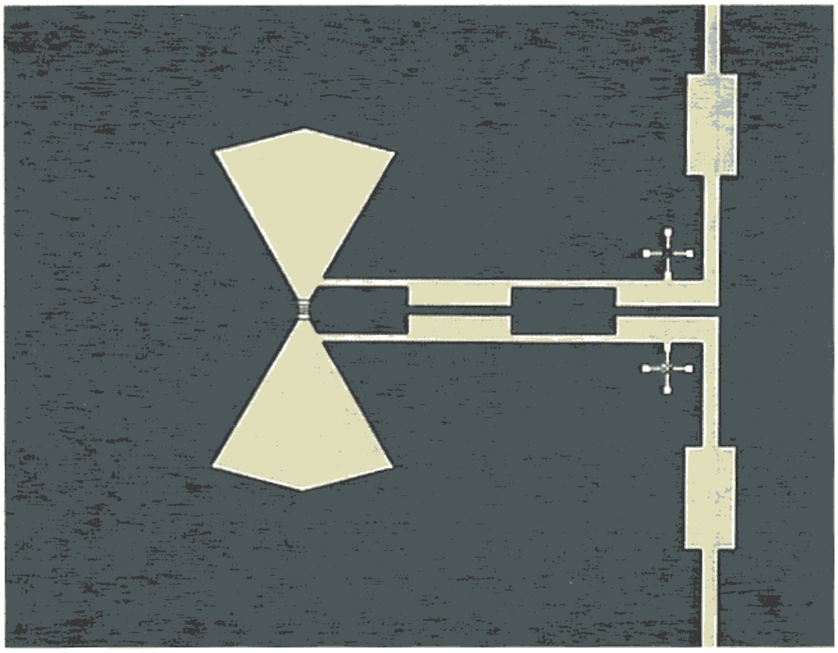

Fig. 5.2 : Integration of the three microbridges into a dipole-antenna. This bolometer mixer element gave a double-sideband receiver noise temperature of 960 K at 800 GHz. Such a result indicates that bolometer mixers may offer superior sensitivity to Schottky and SIS receivers at THz frequencies.

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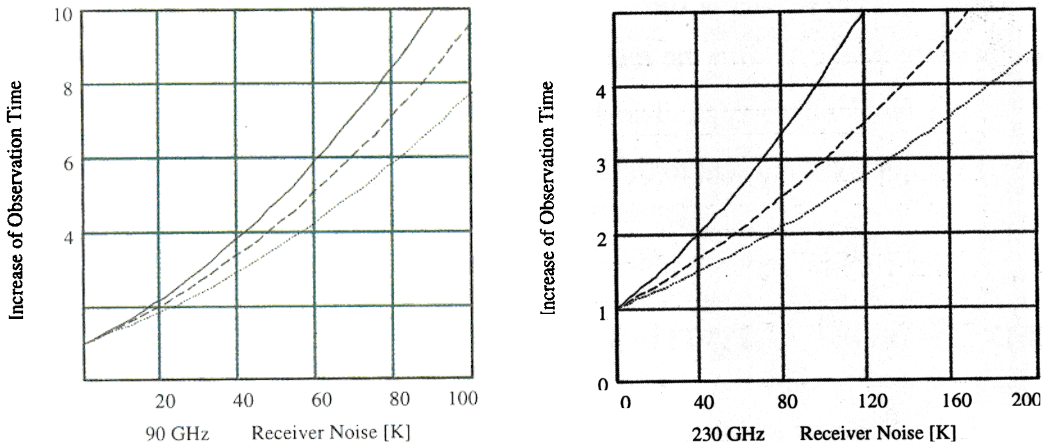

Fig. 5.3 : Relative integration time versus receiver noise for observations at 90 GHz (left) and at 230 GHz (right). The three curves correspond respectively to good winter conditions (2mm PW, solid line), average winter weather (4mm PW, dashed line), and good summer weather (7mmPW. dotted line). The calculations assume forward coupling efficiencies of 92% and 86% respectively at the two frequencies, and a 45 degree elevation.

In cooperation with the SIS group, junction quality criteria were defined to help ensure optimum and reproducible performance, and stable operation.

3mm mixers

Six 3mm mixers were produced for various receiver systems. The lowest noise achieved was 20K DSB at 90 GHz, while at 5 GHz, the minimum noise is 40 K and 45 K respectively for 6dB and 30dB image rejection

1.3mm mixers

The degree of reproducibility that can be achieved is illustrated in Figure 5.4. This results from a combination of careful design and high quality fabrication of junctions and mixer blocks. Note that the minimum noise is 20 K, or 1.8hv/k.

Seven mixers were prepared, also in the 3mm band, but with an IF range 3.5-4.5GHz and capable of SSB operation, for future 30m receivers, including the array receiver, and the SEST receiver (see below). Promising results were obtained with a new broad-band mixer chip, developed for coverage of the 200-270 GHz band.

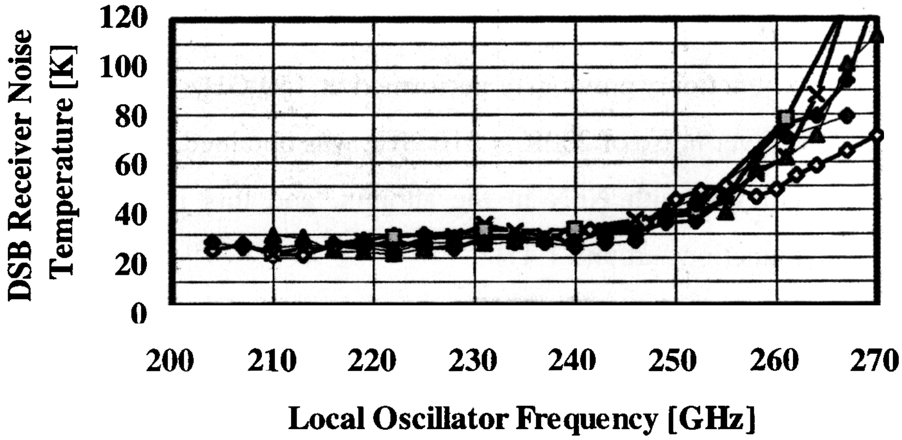

Fig. 5.4 : Noise performance of six 1.3mm mixers (1.5GHz IF, DSB operation) prepared for PdBI receivers and spares.

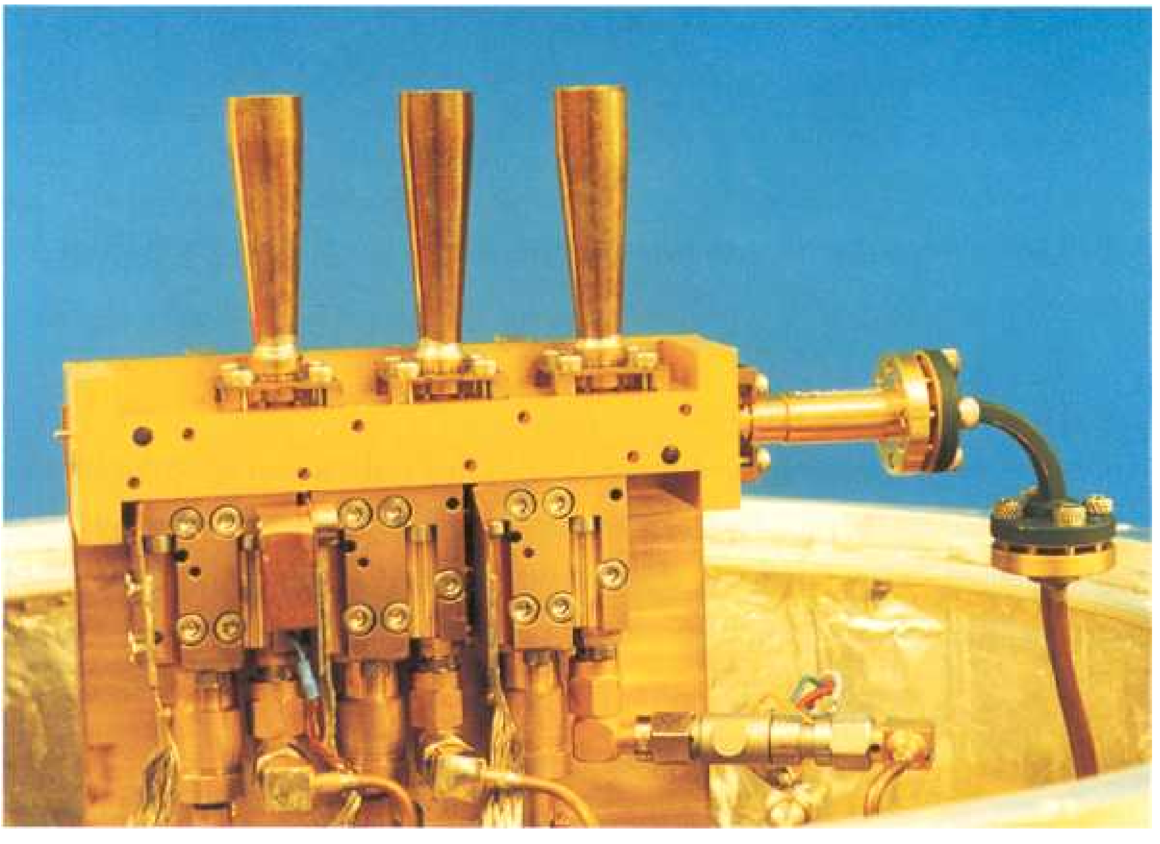

Fig. 5.5 : Three custom mixers developed for the 1.3mm array receiver, mounted on an integrated LO coupler. RF testing demonstrated that optimum mixer performance could be obtained with a single, common LO power adjustment.

SIS mixers with NbN junctions

Mixer experiments with NbN junctions, previously performed at 150 GHz, were extended to the submillimeter range. A receiver noise of 230K at 310 GHz was obtained; it is the first time that such a low noise is achieved with NbN in the submm, and this is an encouraging indication for the use of such junctions around THz.

5.2.3 Receiver Construction

Receivers for Plateau de Bure Interferometer

Three dual-channel receivers in hybrid dewars were completed in 1996. One was installed as part of the construction of antenna 5 of the PdBI. Another one, built as the 6th, spare receiver for the PdBI, was swapped with the receiver of antenna 4, which is being upgraded in the laboratory to benefit from the knowledge accumulated during the construction of successive receivers, notably improvements in the optics.

A third dual-channel receiver was delivered to the SEST group, who have installed it on their telescope.

Hybrid receivers for Pico Veleta

Five hybrid dewars were prepared (cabling, cryogenic and vacuum tests) for the new 30m receivers. A number of parts for these receivers have been fabricated, including a new block that integrates the LO injection couplers for both channels, and ensures accurate alignment of the two horns.

The mixer for the 3mm number one receiver has been replaced.

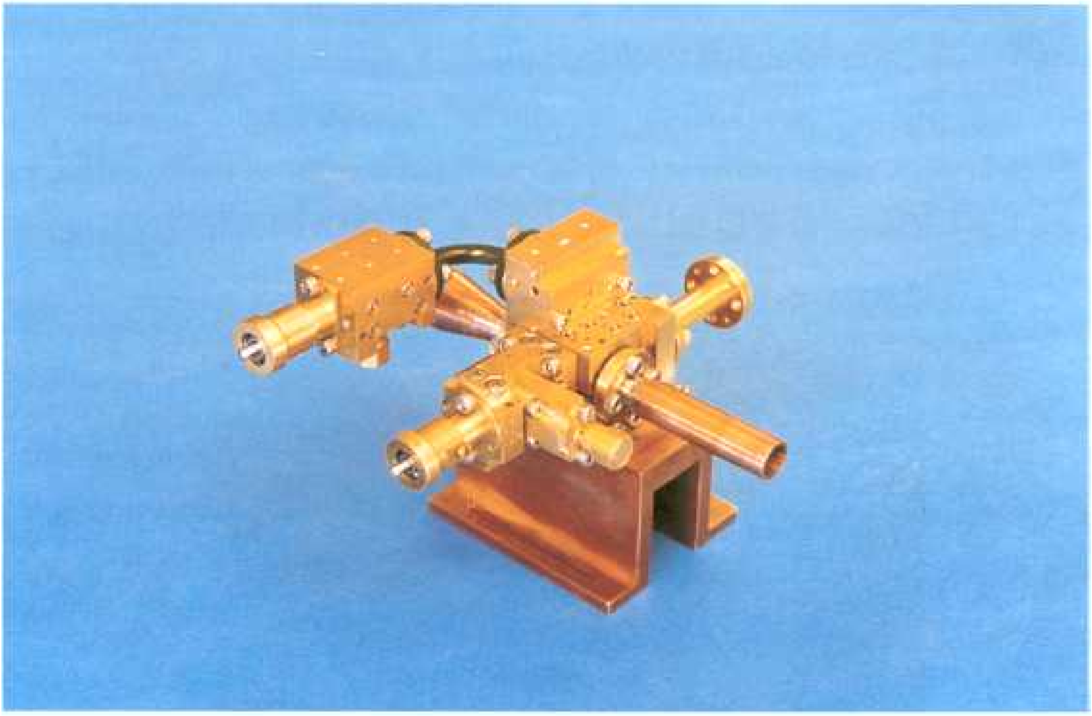

Fig. 5.6 : The cryogenic RF assembly for the new Pico Veleta receivers includes an integrated dual coupler unit, the horns and lenses, and the two mixer blocks. This design ensures the co-alignment of the two beams coming out of the cryostat.

345 GHz Receiver

The 345 GHz receiver has been modified : the input polarization was changed to H, allowing operation on a direct optical path, and the IF band changed to 3.5-4.5 GHz, which should allow SSB operation, and therefore to reach a lower system noise despite some increase in receiver noise.

1.3mm array receiver for Pico Veleta

All crucial technical concepts have been experimentally verified and the receiver is now in the construction phase. The complete optical system has been measured; the optical quality is excellent and in agreement with previous modelling; in particular, the 9cm diameter window foreseen for the cryostat appears to be fully adequate. Figure 5.7 shows the pattern of the nine beams measured in the telescope's focal plane. The concept of feeding the LO to mixer

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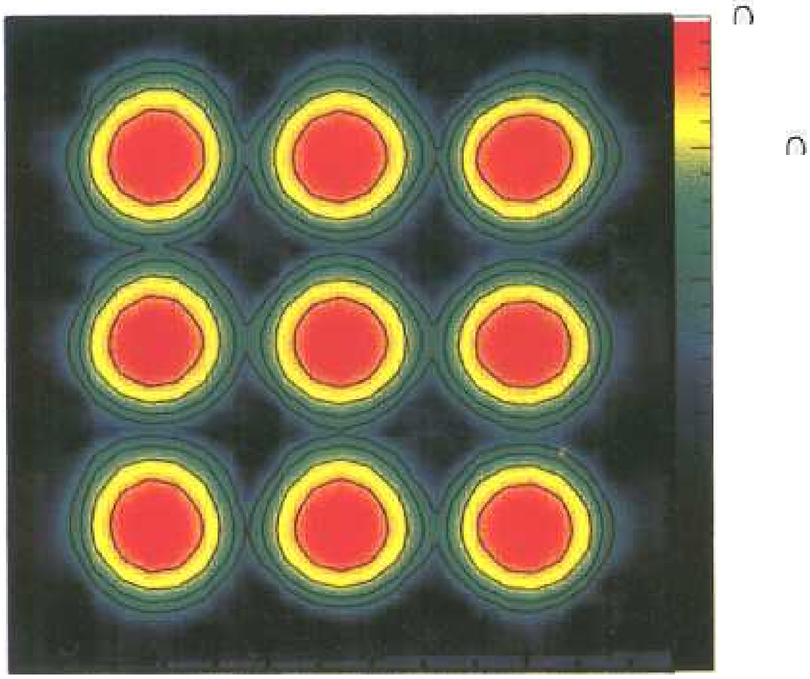

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The holography receiver operating at 40 GHz has been successfully employed to produce maps of the 30m reflector, for the first time with 128x128 pixels resolution. This led to a significantly improved understanding of the reflector's structure, including a previously unknown day/night curvature effect of the frame assemblies, and the diagnostic of uncontrolled motions of the subreflector spindles.

5.3 BACKEND DEVELOPMENTS

5.3.1 Upgrade of the Plateau de Bure Correlator Units

The arrival of the 5th antenna of the Plateau de Bure interferometer made it necessary to significantly increase the capacity of the correlator from 18,432 to 30,720 channels for the digital section, and from 3.840 GHz to 4.800 GHz for the analog section. To implement this without changing the technology, some surgery had to be done on the IF processors and distributors, and a block of six digital « satellite » chassis had to be added. These satellites are connected to the main units by twelve serial links at 1 Gigabit/second, using the Hewlett-Packard chipset. The six old units had been successively returned to Grenoble for refurbishment and re-installed on the PdB in less than 3 weeks. The new system has shown reliable performance ever since it was installed.

5.3.2 Component Development for High-Speed Correlator Board

A batch of 4 high quality sampler modules as well as a synthesized digital clock have been built and tested to join the CESR high-speed correlator board. Unfortunately, the chip has not been processed properly and was totally useless, thus causing a significant delay of this project.

5.3.3. Next Generation Plateau de Bure Correlator

A study of a next-generation correlator for the Pdb interferometer has been performed which would satisfy several ambitious requirements : more bandwidth and resolution, higher versatility, 15 simultaneous baselines (i.e. 6 antennas), and full-feature phased array mode for VLBI. A fairly detailed design for such a correlator is now available in documented form as IRAM internal Working Report N° 243.

Two critical items (wideband SSB mixer and FPGA-based delay line) for this system have been studied and prototypes built. The lab test results are very encouraging.

Fig. 5.8 : Block of 6 satellite correlator units receiving data from the master correlator (12 cables from the floor) at 1 Gigabit/second.

5.4 COMPUTER GROUP

5.4.1 Plateau de Bure Computer Control System

In 1996, the main task of the computer group has been to install the new control system for the Plateau de Bure Interferometer which has involved several aspects :

- Definition of two subnetworks, one dedicated to backend correlator data acquisition, and the second for general computing, user interfaces and even antenna and receiver micro connections ;

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UNIX Server

A new HP UNIX server has been purchased. It is an HP J200 computer with the possibility of an extension to a 2-processor machine. This machine will enhance the data reduction capabilities in Grenoble, especially for visitors.

TECHNICAL GROUP

Mechanical Workshop

Despite the temporarily reduced number of personnel, the workshop could satisfy the different orders with only slight delays.

Priority was given to the manufacturing of microwave components needed by the receiver group for the new dual-channel receiver HDV10-115/230 GHz that will be installed at the 30m telescope. The components that were built are: compact couplers 115/230 GHz (see Fig. 5.9), special 230 GHz mixers, 115 GHz mixers, horns, lenses, backshorts, windows, Martin Pupplet-interferometer, mirrors and all the related mechanical accessories. The total number of requests was 196, of which 53 were executed by local subcontractors.

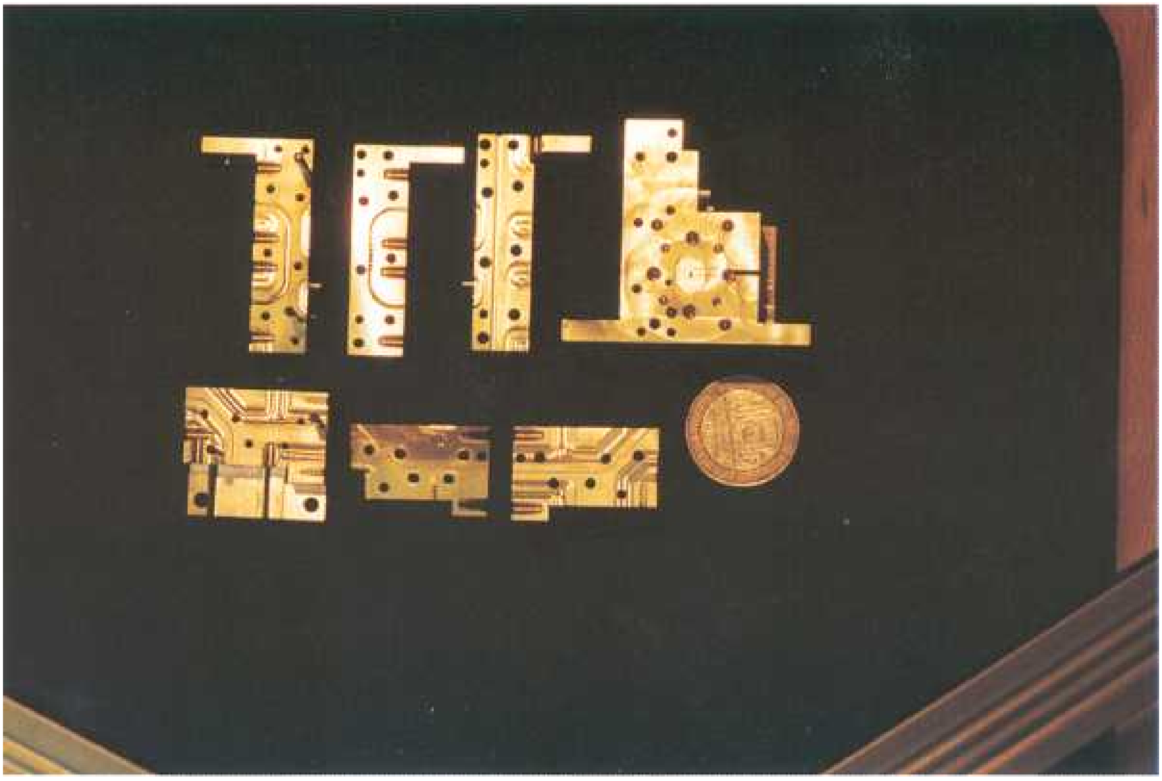
Drawing Office

In close cooperation with the microwave engineers, the office produced the drawings for the following projects

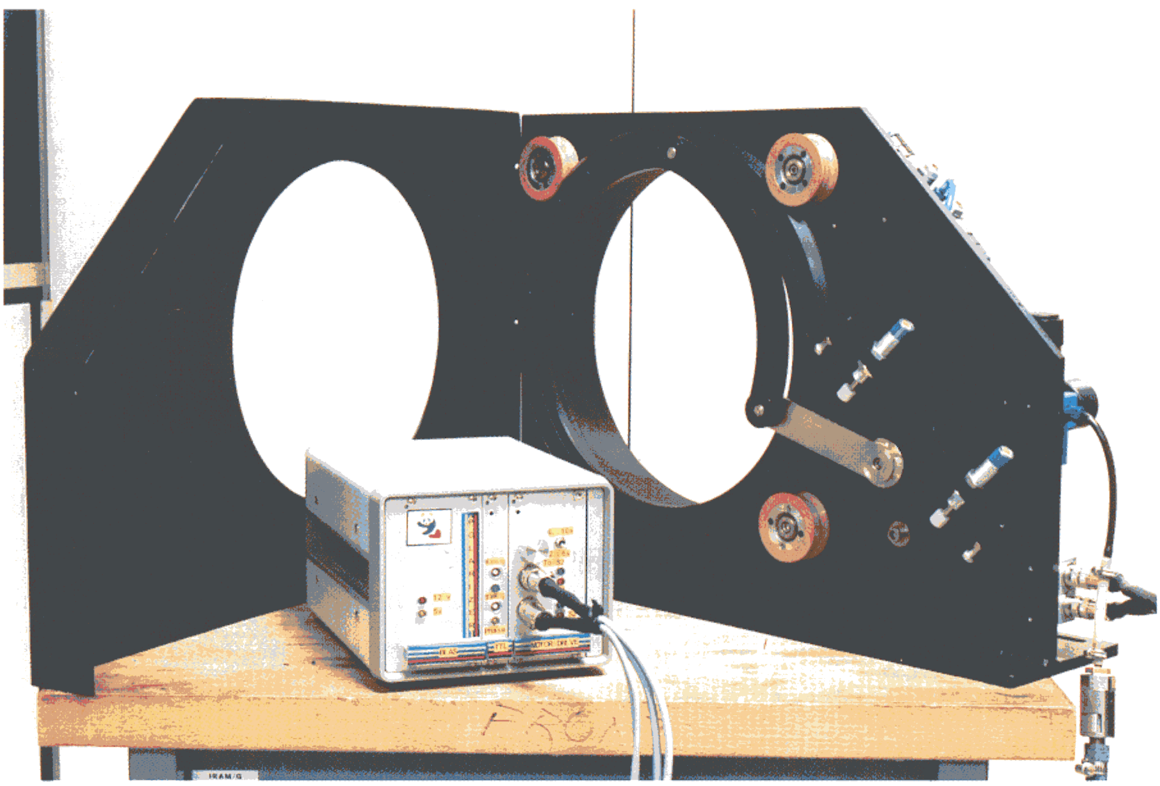
- design, verification, and fabrication of a circular polariser with a 300mm ∅ quarter wave plate at 113,4 GHz for Pico Veleta (see Fig. 5.10);
- realisation of a beam derotator for which first tests will take place in March 1997 ;
- detailed design study for the layout of the multibeam receiver to define the positioning of the various components (optical, microwave and cryogenic parts). The study will be completed by spring 1997.
- documentation of all microwave components used at the 30m telescope and on the Plateau de Bure interferometer.

Technical Support for the Plateau de Bure

As usual, the technical group worked in close collaboration with the groups on the Plateau de Bure for the maintenance of all 5 antennas.



5.9 : Components of the compact coupler for Pico Veleta for 115/230 GHz before assembly and assembled.



5.10 : 300 mm diameter polarizer for observations at 113.4 GHz at Pico Veleta (pneumatic-electric system).

6. PERSONNEL AND FINANCES

In 1996, IRAM had a total of 95,5 (out of 99) staff positions filled. Of these, 26,5 staff members worked in Spain, and 69 in France. In addition, 11 PhD students, post-docs and cooperants worked at IRAM, 3 in Spain and 8 in France. This brings the total number of employees to 106,5. As in earlier years, there was a need to sign short-term contracts to cope with the extra workload during certain periods of the year. This corresponds to 4 man-years in Grenoble, and 4,5 man-years on the Plateau de Bure. The extra work on the Plateau de Bure was caused by the construction of the 5^{th} antenna and by special maintenance work on antennas 1 - 4.

The MPIfR, Bonn and the MPI für Extraterrestrische Physik, Garching jointly financed one half of a staff position in the SIS laboratory.. The MPG and CNRS contributed to the funding of some of the post-doc positions in Grenoble and in Granada. The position of one PhD student in the SIS laboratory was funded by the German Ministry BMBF (Verbundforschung), and another position was partly funded by the MPIfR.

IRAM's financial situation in 1996 and the budget provisions for 1997 are summarised in the following tables. Expenditures in the operations budget 1996 are higher than the original estimates, especially due to hiring of personnel on short-term contracts. On the investment side of the budget some underspending occurred. One of the contributing factors was the total cost for the construction of Antenna 5 which could be kept below the original estimate. Another contributing factor was the delayed delivery of some laboratory equipment. Furthermore, some of the originally foreseen purchases were postponed from 1996 to 1997. The corresponding budget provisions must therefore also be transferred to 1997.

The major items in the investment budget were: 0.4 MF for the track extension, 5.2 MF for Antenna 5 on the Plateau de Bure, 2.9 MF for receivers and backends, 0.5 MF for cryogenic components, 0.6 MF for computer equipment, 0.9 MF for improvements in the existing IRAM antennas in Spain and France, 0.2 MF for equipment in the SIS laboratory, and 1.3 MF as a first payment for an additional set of aluminium panels. In the area of administration and transport 0.3 MF were spent, and 1.9 MF for improvements in the infrastructure and for technical equipment.

Income other than contributions from the IRAM partners was higher than foreseen due to interest gains, as well as the external funding of some projects.

BUDGET 1996

Expenditure

BUDGET HEADING	APPROVED BUDGET KFF	ACTUAL BUDGET KFF
Personnel	41.215	42.366
Operations	13.905	13.538
	55.120	55.904
Investment	28.580	15.692
Value Added Taxes	5.211	5.211
	88.911	**76.807**

Income

BUDGET HEADING	APPROVED BUDGET KFF	ACTUAL BUDGET KFF
Contribution CNRS	30.116	30.116
Contribution MPG	30.116	30.116
Contribution IGN	3.845	3.845
Contribution Antenna 5	6.800	6.800
Other Income	12.823	14.231
Contribution CNRS for Value Added Taxes	5.211	5.211
	88.911	**90.319**

BUDGET PROVISIONS 1997

Expenditure

BUDGET HEADING	APPROVED BUDGET (KFF)
Personnel	41.215
Operations	13.581
	54.796
Investment	10.260
Value Added Taxes	5.208
	70.264

Income

BUDGET HEADING	APPROVED BUDGET (KFF)
Contribution CNRS	30.106
Contribution MPG	30.106
Contribution IGN	3.844
Contribution Antenna 5	6.900
Other Income	1.000
Contribution CNRS for Value Added Taxes	5.208
	70.264

7. ANNEX I : TELESCOPE SCHEDULES / 7.1 30m Telescope

Jan 2 - 30

Ident.	Title	Freq. (GHz)	Authors
199.95	The spatial extent and abundance of water vapor in molecular clouds	183,86,230,241	Cernicharo, Gonzalez-Alfonso
226.94	The molecular content of prototypical molecular clouds	82,115,130,237	Cernicharo, Guélin, Kahane, Gonzalez-alfonso
201.95	Are optical jets associated to high velocity gas in molecular outflows ?	115, 230	Cernicharo, Neri, Reipurth
205.95	The dust to gas ratio in the darkest regions of cold clouds	109,219,96,144	Cernicharo, Cox, Zylka
194.95	The magnetic field in the MWC349 disk	231	Thum, Morris
181.95	Cold dust in NGC891, M51 and IC342: a key to the molecular gas content of spiral galaxies	bolometer	Zylka, Guélin, Mezger, Garcia-Burillo
180.95	Cold dust in four giant cloud associations of M33	bolometer	Guélin, Viallefond, Neininger, Zylka, Mezger
138.95	FIR/mm properties of extragalactic radio sources	bolometer	Fosbury, Andreani, Wehrle, Freudling, Cimatti
214.95	Systematic study of 1.25mm emission of APM radio quiet QSOs with $z > 4$	bolometer	Omont, McMahon, Cox, Kreysa, Bergeron
215.95	mm continuum studies of QSOs with z = 2 to 3	bolometer	McMahon, Omont, Cox
207.95	1mm search for primeval quasars or galaxies	bolometer	Barvainis, Antonucci, Hurt
96.95	A search for cold dust around pulsars	bolometer	Wolszczan, Reuter, Wielebinski
	VLBI OBSERVATIONS		IRAM staff + MPIfR

Jan 30 - Feb 27

Ident.	Title	Freq. (GHz)	Authors
	VLBI OBSERVATIONS		IRAM staff + MPIfR
210.95	Search for high z elliptical starbursts emitting the diffuse mm background	bolometer	Puget, Omont, Guiderdoni et al.
217.95	Search for small anisotropy of the cosmic microwave background	bolometer	Kreysa, Biermann, Chini, Zylka et al.
183.95	Continuum emission in young outflows	bolometer	Gueth, Neri, Guilloteau, Dutrey, Bachiller
181.95	Cold dust in NGC891, M51 and IC342: a key to the molecular gas content of spiral galaxies	bolometer	Zylka, Guélin, Mezger, Garcia-Burillo
182.95	Mapping the cold dust emission from HI warps	bolometer	Neininger, Guélin, Dumke, Zylka, Wielebinski
149.95	Dust emission from prestellar cores in Bok globules	bolometer	Launhardt, Henning, Osterloh, Zylka
166.95	Cold dust emission in Taurus dark clouds	bolometer	Cox, Cernicharo, Zylka, André, Ward-Thompson

Feb 27 - Mar 12

Ident.	Title	Freq. (GHz)	Authors
182.95	Mapping the cold dust emission from HI warps	bolometer	Neininger, Guélin, Dumke, Zylka, Wielebinski
225.95	Comparison of dust extinction and dust emission in IC 5146	bolometer	Kramer, Sievers, Lada, Walmsley
115.95	HH energy sources, deeply embedded stars and protostellar condensations	bolometer	Chini, Reipurth, Sievers, Ward-Thompson
108.95	Dust at high z	bolometer	Chini, Kruegel
215.95	mm continuum studies of QSOs with z = 2 to 3	bolometer	McMahon, Omont, Cox
177.95	Dust mm-wave emission from evolved stars : AGB envelopes	bolometer	Bujarrabal, Alcolea, Cernicharo, Neri, Cox
204.95	mm emission from dust envelopes around post-AGB stars	bolometer	Alcolea, Bujarrabal, Cernicharo, Cox, Neri
165.95	L 1544 : A collapsing starless core ?	bolometer	Tafalla, Myers, Bachiller, Mardones, Caselli, Benson

Mar 12 - Mar 26

Ident.	Title	Freq. (GHz)	Authors
230.95	Dust continuum structure of pre-protostellar cores	bolometer	André, Ward-Thompson, Motte
227.95	Density structure of protostellar envelopes in clusters: A bolometer mosaic of OphE/F and OphB2	bolometer	André, Motte, Neri, Bontemps
209.95	Survey for circumstellar disks in cluster environments	bolometer	Lada, Mundy, Beckwith
137.95	Confirmation of dust thermal emission in high red shift radio galaxies	bolometer	Freudling, Cimatti
131.95	Investigating the nature of true low-mass protostars	bolometer	Guesten, Wiesemeyer, Zylka
111.95	The recent mass loss rate history of highly evolved stars	bolometer	Groenewegen, Van der Veen, Loup, Habing, Omont
101.95	Submm cutoffs in distant quasars : checking some possible detections from JCMT	bolometer	Antonucci, Barvainis, Coleman
162.95	Dust emission observations of IR-quiet star formation regions	bolometer	Mooney, Mezger, Zylka
97.95	Multi-channel 250GHz bolo. observations of 2060 Chiron at Perihelion	bolometer	Altenhoff , Stern, Weintraub, Festou
112.95	Physical properties of asteroids,derived from light curves at 250GHz	bolometer	Altenhoff, Johnston, Stumpff, Webster
154.95	Attempt to detect Comet C/1995 01 (Hale-Bopp) at 250GHz	bolometer	Altenhoff

Mar 26 - Apr 9

Ident.	Title	Freq. (GHz)	Authors
δ03.96	Observations of Chiron and comet B2 (Hyakutake)	bolometer	Altenhoff
δ08.96	Study of 1.25mm emission of APM radio quiet QSOs with z	bolometer	Omont
δ15.96	Make up time for lost bolometric observations	bolometer	Fosbury
δ09.96	Cold dust emission in Taurus dark clouds	bolometer	Cernicharo
211.95	Dust emission in the DR21 outflow	bolometer	Liechti, Sievers
188.95	An independent estimate of the mass in merging galaxies	bolometer	Braine
δ11.96	Dust continuum structure of prestellar cores	bolometer	André
δ10.96	Make up time for bolometer programs affected by bad weather	bolometer	Osterloh
δ14.96	L1544 : A collapsing starless core ? : Make up time	bolometer	Tafalla, Myers, Bachiller, Mardones, Caselli, Benson
δ01.96	Bolo. observations of the $z = 1.93$ hyper-luminous IRAS galaxy TXFS0321+009	bolometer	Roettgering, Van Breugel, de Breuck, Dey
δ07.96	Confirming the detection of dust warps in NGC 4013 and NGC 5907	bolometer	Neininger, Guélin, Dumke, Zylka, Wielebinski
δ12.96	Additional bolometer observing time	bolometer	Wolszczan
δ16.96	Additional bolometer observing time	bolometer	Mooney, Mezger, Zylka
δ13.96	bolometer observing time for CepE object	bolometer	Lazareff
δ06.96	Search for primeval galaxies at ultrahigh red shifts	bolometer	Barvainis, Antonucci, Hurt

Apr 9 - Apr 23

Ident.	Title	Freq. (GHz)	Authors
197.95	Multifrequency monitoring of the gamma-bright blazar 0716+71	230,90,150	Wagner, Witzel, Krichbaum, Wild, Kramer, Quirrenbach
δ04.96	Observations of Comet C/1996B2 Hyakutake at the 30m telescope	bolometer	Bockelee-Morvan, Biver, Colom, Crovisier, Gerard, Rauer, Despois
203.95	mm wave recombination lines from external galaxies	99,135,231	Viallefond, Anantharamaiah, Goss, Zhao
236.95	A search for a new Fe-containing radical, FeCO	137,154,163	Kasai, Kawaguchi
122.95	NGC 2146 : Kinematic evidences of a merger-triggered starburst	110,220	Neininger, Greve, Klein, McKeith
235.95	Observation of the $H^{13}CN$ and $HC^{15}N$(3-2) lines on Titan	88,115,220,258,259	Marten, Hidayat, Paubert, Bezard
159.95	On the origin of high velocity SiO maser emission from late-type stars	86,129,230	Baudry, Alcolea, Cernicharo, Herpin

Apr 23 - May 7

Ident.	Title	Freq. (GHz)	Authors
159.95	On the origin of high velocity SiO maser emission from late-type stars	86,129,230	Baudry, Alcolea, Cernicharo, Herpin
106.95	Hot and cold interstellar gas in galaxies : The CO distribution in the Sa system NGC 2775	229	Hogg, Roberts, Bregman
231.95	Completing zero-spacing data for HL Tau in ^{13}CO(1-0)	110	Cabrit, Schuster, Guilloteau, André
197.95	Multifrequency monitoring of the gamma-bright blazar 0716+71	230,90,150	Wagner, Witzel, Krichbaum, Wild, Kramer, Quirrenbach
189.95	Isotopic CO observations towards X-ray scattering halos	110,115	Predehl, Schuster, Lucas
δ04.96	Observations of Comet C/1996B2 Hyakutake at the 30m telescope	bolometer	Bockelee-Morvan, Biver, Colom, Crovisier, Gerard, Rauer, Despois
147.95	Deriving an upper limit to T_{CMB} at $z = 0.886$	94,98,103,148	Wiklind, Combes
104.95	CO observations of radio quiet quasars	108,109,218,219	Colina, Planesas, Raluy
1.96	Time-delay measurements in the gravitational lens PDS1830-211	94	Combes, Wiklind, Kramer
148.95	A search for molecular absorption lines with unknown red shift	80,149	Wiklind, Combes
141.95	Search for the HCCNC isomer of HC_3N toward IRC+10216	89,139	Gensheimer
228.95	Follow up to 203 GHz observations of $H_2{}^{18}O$	203,80,225	Gensheimer, Wilson

May 7 - May 21

Ident.	Title	Freq. (GHz)	Authors
141.95	Search for the HCCNC isomer of HC_3N toward IRC+10216	89,139	Gensheimer
228.95	Follow up to 203 GHz observations of $H_2{}^{18}O$	203,80,225	Gensheimer, Wilson
158.95	Imaging the jet working surfaces in the RNO43 outflow: a multi-wavelength study	110,130,230	Richer, Cabrit, Bally, Bence, Padman
54.96	Search for the HCCNC isomer of HC_3N toward IRC+10216	84,102	Gensheimer, Wilson
92.96	A thorough radio spectroscopic investigation of comet Hale-Bopp	88,96,116,241	Crovisier, Biver, Bockelee-Morvan, Colom, Lellouch, Rauer, Despois
20.96	SgrA* : Is the -180 kms^{-1} gas close to the centre?	115,230	Wilson, Dahmen, Lemme, Pauls, Marr, Rudolph
23.96	Cold molecular gas toward Cassiopeia A	115,220,109,219	Wilson, Kalberla, Gensheimer
4.96	Neutral carbon in IRAS 10214+4724	107,149,245	Radford, Downes, Braine, Kramer, Solomon
128.95	Probing the H1/H2 transition layer in PDRs (II)	235,86	Fuente, Martin-Pintado
212.95	A new class of molecular clouds in the galactic center region	89,130,217	Martin-Pintado, Fuente, de Vicente
77.96	On-the-fly mapping of M31 in CO	115.230	Neininger, Guélin, Wielebinski, Hoernes, Berkhuijsen, Berk, Garcia-Burillo

Ident.	Title	Freq. (GHz)	Authors
179.95	Did we detect Aluminum 26 in IRC+10216 ?	167,234,267	Guélin, Ziurys, Apponi, Cernicharo
156.95	A search for interstellar/circumstellar FeF and FeCl	143,165,210,93,103	Ziurys, Allen, Guélin

May 21 - Jun 4

Ident.	Title	Freq. (GHz)	Authors
100.96	Post-perihelion observations of comet Hyakutake	88,145,168,230	Bockelee-Morvan, Biver, Colom, Crovisier, Gerard, Rauer, Despois, Moreno
128.95	Probing the H1/H2 transition layer in PDRs (II)	235,86	Fuente, Martin-Pintado
212.95	A new class of molecular clouds in the galactic center region	89,130,217	Martin-Pintado, Fuente, de Vicente
156.95	A search for interstellar/circumstellar FeF and FeCl	143,165,210,93,103	Ziurys, Allen, Guélin
179.95	Did we detect aluminum 26 in IRC+10216 ?	167,234,267	Guélin, Ziurys, Apponi, Cernicharo
85.96	30m observations of CO(7-6) and (5-4) in the QSO BR1202-07 at $z = 4.7$	101,141	Omont, Solomon, McMahon, Downes, Petitjean
26.96	^{13}CO in ultraluminous galaxies	110,115	Solomon, Downes
116.96	Compact flat-spectrum radio cores in nearby galaxies	86,138	Reuter, Lesch
35.96	A detailed study of selected infall candidates	93,140,225	Bachiller, Tafalla, Myers, Mardones

June 4 - June 18

Ident.	Title	Freq. (GHz)	Authors
1.96	Time-delay measurements in the gravitational lens PDS1830-211	94	Combes, Wiklind, Kramer
121.96	High density molecular clumps in the ionized cavity surrounding the galactic center	86, 130, 217, 244	Martin-Pintado, de Vicente, Fuente, Planesas
126.96	Is SiO emission in external galaxies associated to star formation ?	86, 130, 217	Martin-Pintado, Garcia-Burillo, de Vicente, Fuente
127.96	Does dense material confine HII regions ?	108, 113, 145, 226	Martin-Pintado, Gaume, Rodriguez, de Pree, Fey
46.96	On the Fly mapping of the Cepheus-B molecular cloud	109, 115, 219, 230	Ungerechts, Guélin, Kramer, Sievers, Wild, Cernicharo
44.96	IRAS 20468 : Confirming the collapse of a low-mass protostar	98, 147, 219, 241	Wiesemeyer, Guesten
57.96	A search for redshifted [NII] 205 micron emission from BR 1202-0725	256	Van der Werf. Yun
92.96	A thorough radio spectroscopic investigation of comet Hale-Bopp	88, 96, 115, 241	Crovisier, Bockelée-Morvan, Colom, Lellouch, Rauer, Despois, Moreno
14.96	CO(1-0) along the bar and CO(1-0) (2-1) isotopes in NGC 1530	114, 109, 108	Reynaud, Downes
10.96	Determination of the CO/H2 conversion in spiral galaxies	112, 114	Kruegel, Chini

June 18 - July 2

Ident.	Title	Freq. (GHz)	Authors
63.96	The magnetic field in the MWC349 disk (III)	86	Thum, Morris
94.96	A complete CO survey of the irregular galaxy IC 10	115,230	Wild, Kramer, Paubert, Sievers, Masset, Ungerechts, Greve
5.96	CO observations of 2 red carbon stars in the galactic halo	115, 230	Groenewegen, Oudmaijer
69.96	Does ethanol only form by evaporation from grains ?	91, 142, 234	de Vicente, Martin-Pintado
112.96	Molecular flows in the merging system of galaxies Arp299	114	Casoli, Angonin, Willaime, Gerin
113.96	CO mapping in isolated spiral galaxies	113, 115	Casoli, Sauty, Gerin

July 2 - July 7

Ident.	Title	Freq. (GHz)	Authors
122.96	The dust to gas ratio in the darkest regions of cold clouds	115, 230	Cernicharo, Cox, Zylka
123.96	Are optical jets associated to high velocity gas in molecular outflows ?	115, 230	Cernicharo, Neri, Reipurth
56.96	A conspicuous optical jet in the trifid nebula	97, 148, 230, 244	Cernicharo, Gonzalez, Cox, Lefloch, Garcia-Lopez
81.96	Probing the infrared field of the interior of hot cores	86, 87, 109, 110	Wyrowski, Schilke, Walmsley
δ20.96	Detection of C7H		Guelin, Cernicharo
114.96	Optical thickness of CO in Wolf-Rayet galaxies	113, 114, 226, 229	Davoust, Bridges, Wozniak, Contini, Considere
28.96	Search for S20 and OCS in IO s atmosphere	222, 219, 218	Lellouch, Belton, Strobel, Paubert
76.96	Chemical signatures of the dissipative structures of mol. clouds turbulence	89, 174, 262, 267	Falgarone, Joulain, Puget, Panis, Pineau des Forets

July 16 - July 30

Ident.	Title	Freq. (GHz)	Authors
59.96	A systematic study of the environment of Herbig Ae-Be stars	98, 110, 148, 220, 230	Fuente, Martin-Pintado, Bachiller, Palla
48.96	Molecular study of the energetic and young molecular outflow Cep E	86, 89, 96, 98, 115	Lefloch, Eisloeffel, Lazareff
82.96	Bars and rings in an active early-type galaxy : NGC 4457	115, 229	Garcia-Burillo, Sempere
1.96	Time-delay measurements in the gravitational lens PDS1830-211	94	Combes, Wiklind, Kramer
84.96	The HCS+ to CS dabundance ratio in cirrus clouds	85, 170, 213, 147, 244	Grossmann, Heithausen
28.96	Search for S_2O and OCS in IO s atmosphere	222, 219, 218	Lellouch, Belton, Strobel, Paubert
94.96	A complete CO survey of the irregular galaxy IC 10	115, 230	Wild, Kramer, Paubert, Sievers, Masset, Ungerechts, Greve
δ18.96	NGC 5907		Wielebinski, Dumke

July 30 - August 13

Ident.	Title	Freq. (GHz)	Authors
67.96	On the Fly observations of the Trifid nebula	109, 110, 115, 230	Cernicharo, Ungerechts, Lefloch, Cox, Bachiller
36.96	Search for molecular tori around AGN		Combes, Wiklind, Drinkwater
60.96	Search for high redshift molecular absorption line systems	89, 98, 104, 147, 157	Combes, Wiklind
29.96	Molecular clouds in the dwarf elliptical galaxy NGC 205	115, 110, 230, 220	Lo, Young, lequeux
43.96	CO survey for galaxies at 0.1 z 0.5	90, 102, 160, 247	Chen, Lo

August 13 - August 27

Ident.	Title	Freq. (GHz)	Authors
87.96	Stability of clumps in Lynds 1498	109, 219, 90, 235	Gensheimer, Wilson, Lemme
92.96	A thorough radio spectroscopic investigation of comet Hale-bopp	88, 96, 115, 241	Crovisier, Biver, Bockelee, Colom, Lellouch, Rauer, Despois, Moreno
8.96	Molecular gas in a distant, dust-rich radio galaxy	87, 131	Ivison, Dunlop, Archibald, Hughes
118.96	A detailed study of molecular outflows from FU Orionis stars	110, 230, 109, 220	Eisloeffel, Lefloch, Malbet
1.96	Time delay measurements in the gravitational lens PDS1830-211	94	Combes, Wiklind, Kramer
102.96	CO and ^{13}CO emission in the direction of extragalactic continuum sources	110, 115	Liszt, Lucas
11.96	A search for interstellar van der Waal complexes	86, 90, 91, 131	Havenith, Mauersberger, Wilson
7.96	CO mapping of the magellanic irregular galaxy NGC4449	115, 230	Klein, Henkel
22.96	A map of the source 3' North of Orion KL and selected positions in OMC1 in C170	112, 224, 109, 218	Wilson, Gensheimer, Dickel, Mehriger

August 27 - September 10

Ident.	Title	Freq. (GHz)	Authors
11.96	A search for interstellar van der Waal complexes	86, 90, 91, 131	Havenith, Mauersberger, Wilson
1.96	Time-delay measurements in the gravitational lens PDS1830-211	94	Combes, Wiklind, Kramer
128.96	Search for the CO-H_2 dime in the interstellar medium	91, 109	Allen, McKellar, Lequeux, Loinard
77.96	OTF mapping of M31 in CO	115, 230	Neininger, Guelin, Wielebinski, Hoernes, Berkhuijsen, Beck, Garcia-Burillo
22.96	A map of the sources 3' North of Orion KL and selected positions in OMC1 in C170	112, 224, 109, 218	Wilson, Gensheimer, Dickel, Mehriger

Ident.	Title	Freq. (GHz)	Authors
24.96	A new molecular core in Sgr B2	112, 224, 109, 218	Wilson, de vicente, Martin-Pintado, Gensheimer, Henkel
32.96	CN Zeeman observations : Magnetic fields in molecular clouds	113	Crutcher, Troland, Lazareff, Kazes
18.96	The ^{12}C ^{13}C ratio in the envi. of extreme ^{13}C rich carbon stars	230	Kahane, Forestini
135.95	Circumstellar dust without gas ?	115, 230	Jura, Kahane

September 10 - September 24

Ident.	Title	Freq. (GHz)	Authors
1.96	Time-delay measurements in the gravitational lens PDS1830-211	94	Combes, Wiklind, Kramer
78.96	The latest stages of the evolution of a bipolar outflow : NGC 7023	108, 110, 148, 220	Fuente, Martin-Pintado, Cernicharo, Rogers, Rodriguez-Franco
45.96	A CO map of the double-barred galaxy NGC 5850	114	Friedli, Combes, Leon
64.96	The giant molecular cloud W58	109, 110, 115	Thum, Ungerechts, Wink
107.96	Chemistry of the protoplanetary disks DM Tau and GG Tau	86, 144	Dutrey, Guilloteau
108.96	Chemistry of GM Aur protoplanetary disk	86, 96, 113, 226	Dutrey, Guilloteau

September 24 - October 8

Ident.	Title	Freq. (GHz)	Authors
1.96	Time-delay measurements in the gravitational lens PDS1830-211	94	Combes, Wiklind, Kramer
92.96	A thorough radio spectroscopic investigation of comet Hale-Bopp	88, 96, 115, 241	Crovisier, Biver, Bockelee et al.
77.96	On the Fly mapping of M31 in CO	115, 230	Neininger, Guélin, Wielebinski, Hoernes, Berkhuijsen, Berk, Garcia-Burillo
125.96	The eclipsed moon : Radiative and thermal behaviour of selected soils		Greve, Kramer, Pinet, Masson, Lellouch
107.96	Chemistry of the protoplanetary disks DM Tau and GG Tau	86, 144	Dutrey, Guilloteau
108.96	Chemistry of GM Aur protoplanetary disk	86, 96, 113, 226	Dutrey, Guilloteau
55.96	The origin of broad line wing emission in the Rosette molecular cloud	109, 115	Schneider, Stutzki, Williams
34.96	Multiline study of the extremely young protostellar core CB 17	86, 89, 145, 267	Launhardt, Henning, Schreyer, Ossenkopf
47.96	^{12}C ^{13}C isotopic ratio in PNe with 3He abundance determination	109, 110, 115, 230	Palla, Galli, Bachiller
58.96	Molecular gas in bipolar planetary nebulae	115, 230	Manchado, Guerrero, Bachiller
31.96	The CO-H_2 relation in planetary nebulae	115, 230	Huggins, Bachiller, Cox, Forveille
33.96	Prominent shock-chemistry variations in bipolar outflows : L1157	115, 230, 110, 220	Bachiller, Perez-Guiterez, Tafalla

October 8 - October 22

Ident.	Title	Freq. (GHz)	Authors
VLBI obs.			Greve
38.96	CS towards the star forming region at the S155-Cepheus B interface	97, 146, 244	Olmi. Felli
46.96	On the Fly mapping of the Cepheus-B molecular cloud	109, 115, 219, 230	Ungerechts, Guélin, Kramer, Sievers, Wild, Cernicharo
6.96	CO search in HII galaxies	114, 228, 229	Klein, Brinks, Mebold, Heithausen, Taylor

October 22 - November 5

Ident.	Title	Freq. (GHz)	Authors
	Pulsar detection at short mm wavelength	90	Morris, Thum, Kramer Wielebinski
δ19.96	Campaign to determine the simultaneous radio-mm-submm spectrum of SgrA*		Zylka, Falcke
6.96	CO search in HII galaxies	14, 228, 229	Klein, Brinks, Mebold, Heithausen, Taylor
96.96	Oxygen-rich chemistry in NGC 7027: An ISO/LWS follow-up study	110	Cox, Barlow, Clegg, Baluteau, Gry, Caux
.96	Time-delay measurements in the gravitational lens PDS1830-211	94	Combes, Wiklind, Kramer
124.96	On the origin of high velocity SiO maser emission from late-type stars	86, 129, 230	Baudry, Alcolea, Cernicharo Herpin
116.96	Compact flat-spectrum radio cores in nearby galaxies	86, 138	Reuter, Lesch
65.96	CO observations of the $z = 1.93$ hyperluminous IRAS gal. TXFSO321+009	157. 236	Roettgering, van Breugel, de Breuck, Dey
17.96	Probing shocks and fast wind in the bipolar flow of V Hya.	88, 147, 244, 130	Kahane, M-Morris, Barnbaum
120.96	CN and HCO+ in the butterfly NGC2346	226, 89	Bremer, Neri
40.96	OTF CS survey of da gal. center cloud: interaction dense molecular gas/nonthermal filament	97, 146, 244	Kramer, Staguhn, Ungerechts, Lefloch, Sievers, Paubert
106.96	Search for the HC_4NC isomer of HC_5N in molecular and circumstellar clouds	84. 86	Guelin, Cernicharo, Thaddeus, Gottlieb
90.96	The zero spacing flux in the $^{12}CO(1-0)$ Bure observations towards the center of NGC 891	115	Garcia-Burillo, Guelin
47.96	^{12}C ^{13}C isotopic ratio in PNe with 3He abundance determination	109, 110, 115, 230	Palla, Galli, Bachiller

November 5 - November 19

Ident.	Title	Freq. (GHz)	Authors
47.96	^{12}C ^{13}C isotopic ratio in PNe with 3He abundance determination	109, 110, 115, 230	Palla, Galli, Bachiller
120.96	CN and HCO+ in the butterfly NGC2346	226, 89	Bremer, Neri
73.96	^{13}CO emission from molecular complexes in M33	110	Viallefond, Guelin, Cox
37.96	Towards the IMF : Protostellar condensations in cluster forming cores	109, 96	Blitz, Williams
1.96	Time-delay measurements in the gravitational lens PDS1830-211	94	Combes, Wiklind, Kramer
92.96	A thorough radio spectroscopic investigation of comet Hale-Bopp	88, 96, 116, 241	Crovisier, Biver, Bockelee-Morvan, Colom, Lellouch, Rauer, Despois
141.96	Time delay measurements in the gravitational lens PKS1830-211		Combes, Wiklind, Kramer
79.96	$C^{17}O$ observations of the molecular surroundings of W3(OH)	109, 112	Wyrowski, Hofner, Walmsley, Wink
194.96	$C^{34}S$ observations of the clumps in Lynds 1498	96, 144, 244	Gensheimer, Wilson, Lemme
196.96	H_2CO and SiO observations of NGC 2024	86	Wilson, Wink, Gensheimer, Mauersberger, Walmsley
204.96	Physics and chemistry of a newly discovered molecular core in the SgrB2 region	91, 147, 220, 112	Wilson, Gensheimer, Martin-Pintado, de Vicente
248.96	M81 : a standard galaxy ?	Bolometer	Brouillet, Baudry, Combes, Kaufman, Bash

November 19 - December3

Ident.	Title	Freq. (GHz)	Authors
216.96	CO(1-0) along the bar and CO(1-0 and (2-1)isotopes in the central concentration of NGC 1530	114, 109, 108	Reynaud, Downes
173.96	Further 30m telescope observations of OH231, 8+4.2	110, 115, 147, 230	Bujarrabal, Alcolea, Contreras
141.96	Time delay measurements in the gravitational lens PKS1830-211		Combes, Wiklind, Kramer
260.96	Excitation of a molecular cloud by the supernova remnant 3C391	98, 147, 244, 230	Reach, Rho, Wilner
158.96	Carbon, nitrogen and oxygen isotopes in the molecular envelopes of evolved stars	86, 92, 138, 224	kahane, Forestini, Guelin Cernicharo
190.96	Isotopic ratios of heavy elements in evolved stars	89, 145, 163, 176	Kahane, Forestini, Guelin Cernicharo
140.96	Probing shocks in the Wolf-Rayet nebula NGC 2359	110, 115, 147, 230	Kahane, St Louis, Doyon
238.96	^{13}CO and $C^{18}O$ in the nuclear region of IC 342	109, 110, 230	Viallefond, Van Trung, Rieu

December3 - December17

Ident.	Title	Freq. (GHz)	Authors
238.96	^{13}CO and C^{18}O in the nuclear region of IC 342	109, 110, 230	Viallefond, Van Trung, Rieu
190.96	Isotopic ratios of heavy elements in evolved stars	89, 145, 163, 176	Kahane, Forestini, Guelin, Cernicharo
141.96	Time delay measurements in the gravitational lens PKS1830-211		Combes, Wiklind, Kramer
144.96	Observations of the hot gas in clusters of galaxies with Diabolo through the Synyaev-Zel'Dovich effect	Bolometer	Desert, Bernard, Delabrouille et al.
145.96	Anisotropy measurements of the cosmic microwave background with Diabolo at the arcmn scale	Bolometer	Desert, Bernard, Delabrouille et al.
151.96	Dust properties of cold cores in molecular clouds : A diabolo study	Bolometer	Giard, Gaertner, Ristorcelli, Serra, Andre
162.96	Coordinated centimetric and millimetric observations of radio emitting X-ray binaries	Bolometer	Paredes, Mirabel, Marti, Peracaula
152.96	Emission mechanisms in quasars	Bolometer	Chini, Kreysa, Meisenheimer, Klaas
154.96	Dust at high z ?	Bolometer	Chini, Kruegel, Sievers
254.96	Systematic study of 1.25mm emission of radioquiet QSOs with z 4	Bolometer	Omont, McMahon, Cox, Bergeron, Kreysa

December 17 - December 31

Ident.	Title	Freq. (GHz)	Authors
162.96	Coordinated centimetric and millimetric observations of radio emitting X-ray binaries	Bolometer	Paredes, Mirabel, Marti, Peracaula
254.96	Systematic study of 1.25mm emission of radioquiet QSOs with z 4	Bolometer	Omont, McMahon, Cox, Bergeron, Kreysa
218.96	The physics of the NGC 1333/IRAS2 eastern and western shocks	86, 91, 109, 219	Castets, Lefloch, Langer
132.96	Monitoring of Jupiter after the comet SL9 collision	88, 115, 146	Marten, Moreno, Paubert
134.96	Molecular gas in the chemically young galaxy Mrk 109	111, 115	Frayer, Sauvage, Thuan, Seaquist
141.96	Time delay measurements in the gravitational lens PKS1830-211		Combes, Wiklind, Kramer
244.96	Chemical bistability in dark clouds : the diagnostic of deuterium fractionation	86, 90, 152, 262	Gerin, Falgarone, Roueff, Le Bourlot, Pineau des Forets
45.96	A CO map of the double-barred galaxy NGC 5850	114	Friedli, Combes, Leon
623.96	Search for the primordial molecule LiH in a dense molecular cloud		Combes, Wiklind
240.96	A thorough radio spectroscopic investigation of comet Hale Bopp	88, 96, 115, 241	Crovisier, Biver, Bockelee, Lellouch et al.
206.96	Molecular gas in faint blue galaxies at intermediate redshifts	153, 158, 138, 151	Wilson-C, Combes

Proj.	Conf.	Title	Authors	Molecules	Object	Type
E043	BC	The NGC 4321 nuclear bar	S.Garcia-Burillo M.Sempere	CO	NGC 4321	Gal
			F.Combes			
E045	BC	CH3CN towards G29.96-0.02	C.M.Walmsley R.Cesaroni	CH3CN	G29.96-0.02	YSO
		and G19.61-0.23	L.Olmi P.Hofner	13CO	G19.61-0.23	YSO
E057	BC	HCN mapping of the narrow line	L.E.Tacconi-Garman L.Tacconi	HCN	NGC3227	Gal
		region of NGC-3227	R.Genzel H.Kroker N.Forster			
F012	BC	CO in the center of NGC891	S.Garcia-Burillo M.Guelin	CO	NGC891	Gal
F030	CD	The bipolar outflow of Mira	P.Planesas N.Mauron	CO(2-1)	Mira	CSE
			R.Bachiller V.Bujarrabal	SiO(2-1)		
F032	CD	Dust emission from the Hot core	P.Hofner C.M.Walmsley	C17O(2-1)	W3(OH)	YSO
		at the W3(OH) water maser cluster	F.Wyrowski J.Wink D.Wilner	C17O(1-0)		
F035	A2	Dual frequency observations of L1551	C.Masson D.Wilner	Cont.	L1551-IRS5	YSO
F038	CD	Molecular clouds in the nucleus of	L.Tacconi D.Downes R.Genzel	CO(2-1)	NGC1068	Gal
		NGC1068: Properties of the bar inflow	A.Sternberg A.Quirrenbach	CO(1-0)		
		and the obscuring medium				
F042	CD	The nature of the hypercompact	A.R.Tieftrunk S.T.Megeath	C17O(2-1)	W3 IRS 5	YSO
		continuum sources in W3 IRS 5	R.A.Gaume T.L.Wilson	C17O(1-0)		
F043	CD	The nature of the hypercompact	A.R.Tieftrunk S.T.Megeath	C17O(2-1)	W3 IRS 4	YSO
		continuum sources in W3 IRS 4	R.A.Gaume T.L.Wilson	C17O(1-0)		
F044	AB	The starburst-AGN connection in	R.Genzel L.Tacconi	HCN(1-0)	NGC7469	Gal
		the Seyfert 1 nucleus of NGC7469	L.E.Tacconi-Garman	CO(2-1)		
F046	BC	Mapping the absorption in the	F.Combes	HCO+(2-1)	PKS1830-211	Mol, Othe
		gravitational lens PKS1830	T.Wilklind	CO(4-3)		
F047	BC	The high-mass protostellar core CB 3	R.Launhardt M.Osterloh	CS(2-1)	CB 3	YSO
			Th.Henning C.K.Walker			
F049	A1	Rotating nuclear rings in	D.Downes P.Solomon	CO	VII Zw 31, Mrk 273	Gal
		ultraluminous IR galaxies			Mrk 231, Arp 220	
F050	C2	CO excitation and opacity in	D.Downes P.Solomon	CO	Mrk 231	Gal
	D1	ultraluminous IR galaxies			Arp 220	
F054	A2	Size measurements of disks of YSO	A.Dutrey S.Guilloteau K.Schuster	Cont	T Tau, FT Tau	YSO
	C2		G.Duvert M.Simon L.Prato		DG Tau, L 1551	
	D1		F.M\'enard		UZ Tau, DL Tau	
					CI Tau, GM Aur	
F055	CD	The jet/flow interaction in the	F.Gueth	CO(2-1)	HH211	YSO
		HH211 molecular outflow	S.Guilloteau	CO(1-0)		
F056	CD	The arcsecond structure of the Class 0	S.Guilloteau A.Dutrey	C18O(2-1)	L1157	YSO
	+B	protostar L1157	R.Bachiller F.Gueth	HC3N (12-11)		
F058	CD	Studying circumstellar disks in Cluster	E.Lada L.Mundy M.McCaughrean	Cont.	Trapezium	YSO
		environments-I: Trapezium cluster	S.Guilloteau A.Dutrey			
F061	D	Detecting CO gas around GO Tau	T.Forveille R.Webb	CO(2-1)	GO Tau	YSO
F062	BC	High resolution mapping of Gas	T.Forveille R.Webb	CO(2-1)	HD 36112	YSO
		and dust orbiting HD36112		CO(1-0)		
F064	CD	The innermost filament of the PDR	A.Fuente J.Martin-Pintado	13CO(1-0)	NGC7023	Mol
		associated with NGC7023	R.Neri C.Rogers	CN(1-0)		
			G.Moriarty-Schieven			
F065	BC	The 200 km/s outflow in the proto-	R.Neri M.Bremer M.Grewing	CO(2-1)	CRL618	CSE
		planetary nebula CRL618 (III)	M.Guelin S.Guilloteau R.Lucas			
			J.Cernicharo S.Garcia-Burillo			
F068	AB	CO(3-2) and CO(6-5) in IRAS	D.Downes P.Solomon S.Radford	CO(6-5)	IRAS10214+4724	Gal
		F10124+4724		CO(3-2)		
F073	CD	13CO(1-0) and 12CO(2-1) in the	D.Reynaud D.Downes	13CO(1-0)	NGC 1530	Gal
		nucleus of the barred spiral NGC 1530		CO(2-1)		
F077	C	The molecular disk of MWC349	C.Thum E.Krugel R.Neri	CO(2-1)	MWC349	YSO
F078	D	The protostellar candidate HH 24 MMS	E.Krugel R.Chini C.Thum	CS(5-4)	HH24-MMS	YSO
F079	AB	Disks around massive stars	C.Thum J.Wink	H30α,H40α	G8168 G70293	YSO
F081	Any	CO absorption in molecular clouds	R.Lucas H.Liszt	CO(2-1)	3C454.3 0528+134	Mol
					1730-130 2200+420	
					0224+671 0212+735	
F082	DD	Spatial structure of the continuum	R.Lucas M.Guelin	Cont. CO(2-1)	IRC+10216	CSE
		emission of IRC+10216 at 1.3mm		AIF HCO+		
F083	A1	Astrometry of IRC+10216	R.Lucas S.Guilloteau	HCN V2, Cont.	IRC+10216	CSE
F084	D	PG 1634+706: An excellent	R.Barvainis D.Alloin	CO(2-1)	1634+706	Gal
		candidate for CO at Z>1	R.Antonucci			
F086	AB	High resolution 1mm observations of	R.Barvainis D.Alloin R.Antonucci	CO(7-6)	1413+117	Gal
		CO in the CloverLeaf	L.Tacconi S.Guilloteau	CO(3-2)		
F087	CD	1.3 mm Observations of M1-92	J.Alcolea V.Bujarrabal R.Neri	13CO(2-1)	M1-92	CSE
				HCN(1-0)		
F089	CD	Molecular gas in highly inclined	S.Garcia-Burillo F.Combes	CO(1-0)	NGC4013	Gal
		orbits at the center of NGC4013	M.Guelin			
F097	CD	The 12CO/13CO ratio in the merging	F.Casoli M.C.Angonin	13CO(1-0)	Arp299	Gal

		system of galaxies Arp 299	M.Gerin			
F098	CD	A high angular resolution study	J.Cernicharo R.Neri	CO(2-1)	HH111	YSO
		of high velocity bullets in HH111	B.Reipurth	CO(1-0)		
F103	DD	Continuum in UY Aur: a circumbinary	G.Duvert A.Dutrey	13CO(2-1)	UY Aur	YSO
		disk or mm emission from a jet ?	S.Guilloteau K.Schuster	13CO(1-0)		
			M.Simon L.Prato F.Menard			
G004	D	Confirmation of CO emission from a	R.Barvainis	CO(3-2)	53W002	Gal
		radio galaxy at $z = 2.39$	R.Antonucci D.Alloin			
G005	D	A new lensed, IRAS-detected CO	R.Barvainis	CO(3-2)	MG0414+0534	Gal
		candidate at high redshift	D.Alloin R.Antonucci			
G007	Any	A complete sample of	D.Downes P.Solomon	CO(1-0)	00262+4251, Mrk 1014	Gal
		ultraluminous IR galaxies			03158+4227, 07598+6508	
					08030+5243, 08572+3915	
					09320+6143, 10035+4852	
					10190+1322, 10495+4424	
					Arp 193, 13442+2321	
					14070+0525, 15030+4835	
					16334+4630, 19458+0944	
					23365+3604	
G008	B2, C2	CO excitation and opacity	D.Downes P.Solomon	CO	VII Zw 31, 10565+2448	Gal
	D1	in ultraluminous galaxies			Mrk 273	
G009	D	Search for extended millimeter	A.Omont S.Guilloteau	CO	BRI1335-04	Gal
		emission in 2 high z QSOs	R.Mc.Mahon P.Petijean P.Cox	Cont		
G010	D	Search for extended millimeter	A.Omont S.Guilloteau	CO	Q1230+16	Gal
		emission in 2 high z QSOs	R.Mc.Mahon P.Petijean P.Cox	Cont		
G012	BC	12CO kinematics in the ULIRG	L.E.Tacconi-Garman	CO(1-0)	UGC 05101	Gal
	(BB)	UGC 05101	R.Genzel L.J.Tacconi			
G013	D	The radio spectrum of β Lyrae	G.Umana F.Leone	Cont	β Lyrae	Oth
			C.Triglio			
G014	B1, C1	CO line emission from a gravitationally	M.N.Bremer W.Jaffe A.Omont	CO(2-1)	1608+656	Gal
	D1	lensed post starburst galaxy	N.Jackson J.Roland I.Snellen			
G016	D	Probing the inner circumstellar	F.Motte F.Gueth P.Andre	HC3N, C18O	L1448-IRS3, L1448-C	YSO
		environment of protostars	A.Dutrey S.Guilloteau R.Neri	Cont	IRAS3282, HH211	
					L1489, K4166, K4169	
					T4191-B, T4191-A	
					DG Tau, TMR-1, L1527	
G017	BC	The peculiar source HW2: a radio-jet ?	J.Wink C.Thum	H40α	Cep A HW2	YSO
				Cont		
G018	CD	Continuum and spectral snapshots of	D.Bockelee-Morvan N.Biver	HCN	C/1995 O1	Sol
		comet Hale-Bopp	P.Colom J.Crovisier E.Gerard	H2CO		
			H.Tauer D.Despois R.Moreno			
			G.Paubert J.K.Davies W.Dent			
G025	Any	Isotopic ratios in front of 3C111	R.Lucas H.Liszt	HC18O+	3C111	Mol
				N2H+, SiO,		
				C4H, CH3CN		
G026	D	Size measurements in disks of YSO	A.Dutrey S.Guilloteau	Cont	HL Tau, Haro6-10	YSO
		at 1.3mm	K.Schuster G.Duvert M.Simon		DD Tau, CY Tau	
			L.Prato L.Menard		DI/DH Tau	
G027	BB	The inner layers of the OH231.8+4.2	V.Bujarrabal J.Alcolea	SiO, HCO+	OH231.8+4.2	CSE
		nebula	C.Sanchez Contreras R.Neri	H13CN, SO		
G030	CD	A study of the high velocity winds	P.Cox R.Lucas S.Guilloteau	CS(2-1)	AFGL 2688	CSE
		in AFGL 2688	T.Forveille P.J.Huggings	CO(2-1)		
			R.Bachiller J-P.Maillard A.Omont			
G032	BC	Resolving the nucleus of the	E.Schinnerer A.Eckart	13CO(1-0)	I Zw 1	Gal
		nearby QSO I Zw 1	L.J.Tacconi L.E.Tacconi-Garman	12CO(2-1)		
			R.Genzel A.Quirrenbach			
G033	CD	Molecular gas in the nuclei of an	R.Wielebinski J.Braine	CO	NGC 660	Gal
		advanced merger	N.Brouillet A.Baudry			
G034	CD	A high-resolution CO mosaic of a	J.Braine N.Brouillet	CO	NGC 4414	Gal
		flocculent galaxy	A.Baudry			
G035	C2	The circumstellar environment	M.G.Hoare T.Henning	Cont 84+210	GGD27, S87IRS1	YSO
		of massive YSOs	H.Wiesemeyer		S106IRS3, CEP A2	
					GL490, NGC2024IRS2	
G036	C2	The circumstellar environment	M.G.Hoare T.Henning	Cont 110+240	GGD27, S87IRS1	YSO
		of massive YSOs	H.Wiesemeyer		S106IRS3, CEP A2	
					GL490, NGC2024IRS2	

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

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581. DUST AND GAS DISTRIBUTION AROUND T TAURI STARS IN TAURUS-AURIGA
I. Interferometric 2.7 mm continuum and ^{13}CO J=1-0 observations
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582. DISCOVERY OF THE C_8H RADICAL
J. Cernicharo, M.Guélin
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583. NO CO EMISSION FROM DAMPED LYMAN-α ABSORBERS
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A. Fuente, J. Martin-Pintado, R. Neri, C. Rogers, G. Moriarty-Schieven
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585. COLD DUST AND MOLECULAR LINE EMISSION IN NGC 4565
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M.A.T. Groenewegen, F. Baas, T. de Jonge, C. Loup
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F. Casoli, P. Encrenaz, B. Fort, P. Boissé, Y. Mellier
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505. FIRST MILLIMETER MAPPING OF THE JET AND NUCLEUS OF M87
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9. ANNEX III - IRAM Executive Council and Committee Members, January 1996

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