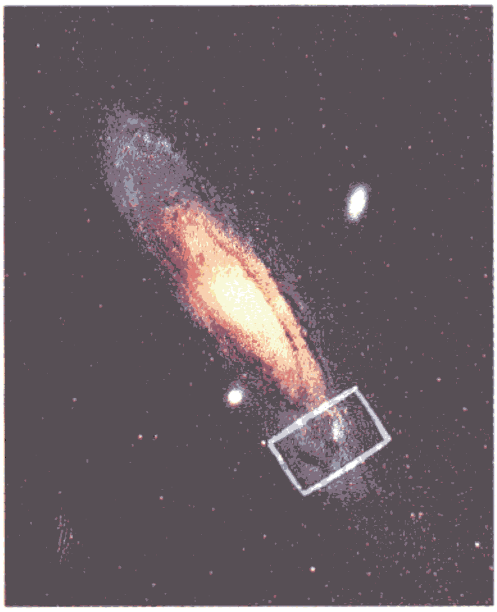
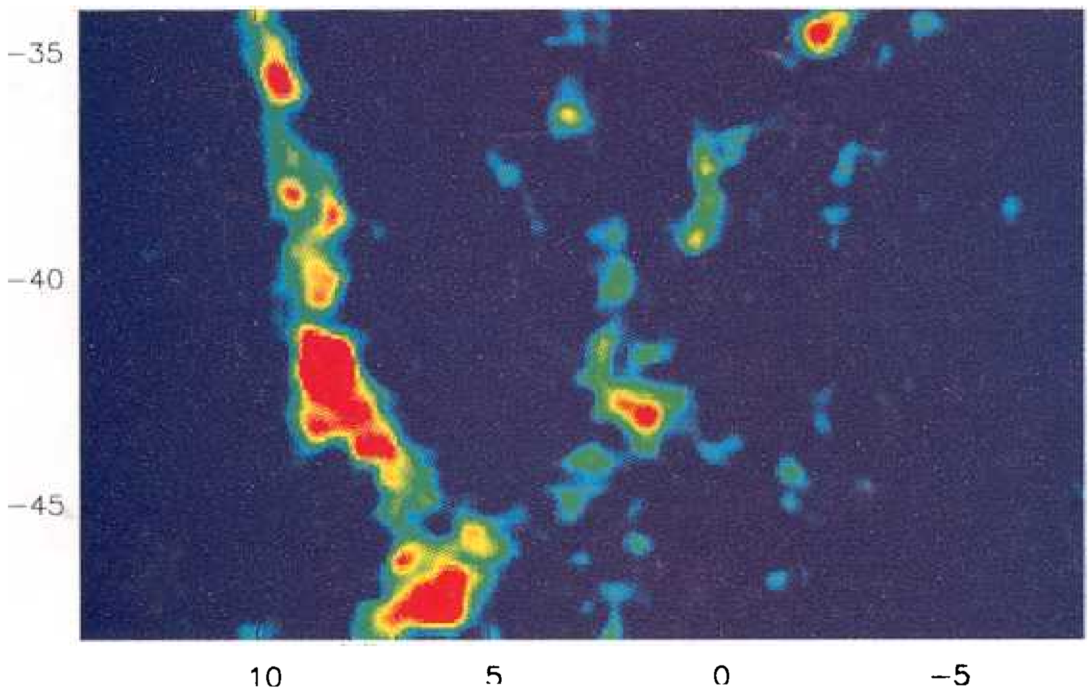
IRAM 1995



CO(1-0) IRAM 30-m telescope



ANNUAL REPORT

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ANNUAL REPORT
1995

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1. INTRODUCTION

The opening of a second "window" for the Plateau de Bure Interferometer with the arrival of the dual-channel 3 mm and 1.3 mm SIS receivers in the summer of 1995, was certainly one of the major steps in the development of this instrument. This step was further amplified by the completion of the track extension which has given us three more stations (W20, W23, W27) on the E-W track, now 408 m long, and one more station (N29) on the N-S track which has now a length of 232 m. With these improvements sub-arcsecond imaging has become possible, and this will undoubtedly play a key role in many of the future scientific projects. The new receivers perform indeed so well that we can use the 230 GHz total power measurements for active phase corrections, a mode which will significantly enhance the amount of useful observing time. A further, very substantial enhancement will come with the completion of Antenna 5. Its mount was finished well before the end of 1995, and work on the reflector will start at the beginning of 1996. This reflector will be fully equipped with a new type of aluminium panels (instead of the carbon-fibre panels used on antennas 1-4). By the end of the year, the manufacturer had almost completed the entire batch of 176 panels (plus spares) according to specifications. The commissioning of the telescope is foreseen for the second quarter of 1996.

Many improvements have also come to the Pico Veleta Observatory, the most visible one being the arrival of a new, second 3 mm receiver which was integrated by the receiver group in Granada with many components coming from the receiver group in Grenoble. Its excellent performance allowed to carry out some very ambitious observing projects and created a strong pressure to advance the next generation of receivers for the 30 m telescope as much as possible. The development, test and full implementation of the 'On-the-Fly' observing mode at the 30 m telescope has equally been a breakthrough. The users can now execute mapping programs in relatively large areas of sky, something for which there has always been a demand but which could never be done because of the prohibitively large amounts of observing time needed.

As one can expect, these (and other) new capabilities of the IRAM instruments have led to many new discoveries, and Chapter 2 of this report gives a compilation which must, however, remain incomplete and cannot really do justice to hundreds of scientific projects that have been executed in the course of the year. The results are meant to highlight *vis-a-vis* the wide astronomical community what scientific impact single dish and interferometric observations at millimeter wavelengths are now capable to make. It may be a good time to fully realise this as we have started to dream about, and to work for, a new generation of still more powerful instruments in a wider international context.

2. HIGHLIGHTS OF RESEARCH WITH THE RAM TELESCOPES IN 1995

SUMMARY

Of the many projects done at IRAM's observatories or published in 1995, some highlights were:

New observations and a new interpretation of CO(3-2) in the hyperluminous galaxy IRAS F10214+4724.

Search for molecular oxygen in a $z = 0.69$ molecular cloud.

A study of the kinematics of molecular gas in the barred galaxy NGC 1530.

A map of the cold dust and molecular line emission in NGC 4565.

Observations and analysis of the molecular ion CO^+ in the star-forming clouds in Orion and M17.

Interferometric 2.7 mm continuum and ^{13}CO -0) observations of the dust and gas distribution around T Tauri stars in Taurus-Auriga.

A study of the filamentary structure of the interface between the atomic and the molecular phases in NGC 7023.

Interferometric molecular line observations of the circumstellar envelope(s) around Camelopardalis.

Detection of a new metal-bearing free radical, MgCN, in IRC+10216.

First observations of Comet Hale Bopp at the IRAM 30m telescope.

An analysis of the radio line observations of comet 109P/Swift-tuttle.

2.2 EXTRAGALACTIC RESEARCH

2.2.1 Distant Sources (> 70 Mpc)

New Observations and a new Interpretation of CO(3-2) in IRAS F10214+4724

New observations with the IRAM interferometer of CO(3-2) from the highly luminous galaxy IRAS F 10214+4724 show that the source size is 1.5" x ≤ 0.9" ; they display no evidence of any velocity gradient. The measured CO size, and optical and IR data that show the galaxy is probably gravitationally lensed, lead to a new model for the CO distribution (Fig. 2.1).

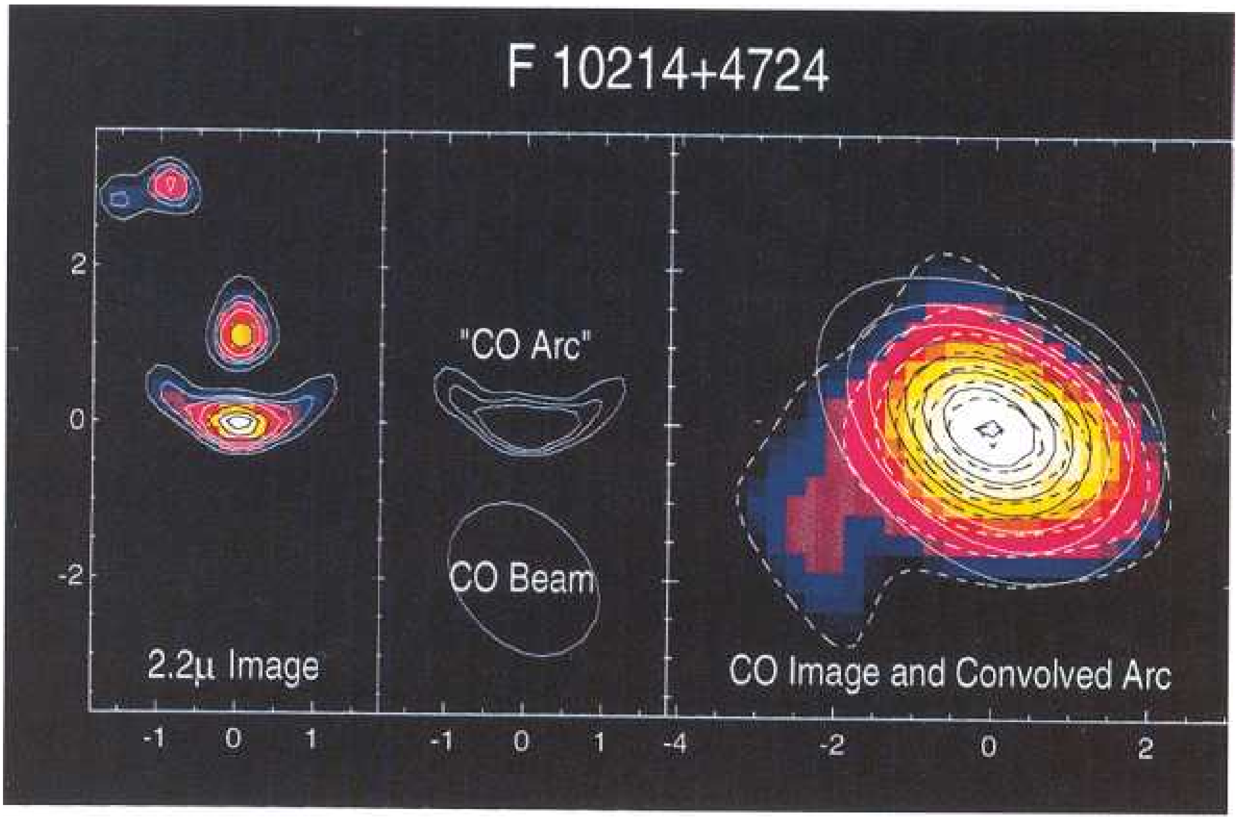

Fig. 2.1 CO(3-2) from the galaxy IRAS F10214+4724 at z = 2.3 .
The infrared image of the galaxy shows a bright compact source superimposed on an extended arc. The CO image is also extended, and comparison of the CO map with the infrared image of the galaxy indicates that the molecular gas is in the extended arc rather than in the compact source. The *left panel* shows a Keck telescope 2.2 μm image with 2, 4, 6, 12, 25, 50, and 75% contours. The lensing galaxy is north of the arc. The *middle panel* shows the IRAM beam and the truncated 2.2 μm image used to model the CO arc. The *right panel* shows the IRAM CO map in color and dashed contours. Solid contours are the model image obtained by convolving the beam with the arc. The model provides a good fit to the observed CO map.

In contrast to many lensed objects, the millimeter data yield a good estimate of the intrinsic CO and sub-mm surface brightnesses, thereby allowing a derivation of the CO and far IR/sub-mm magnifications. The CO is magnified 10 times and has a true radius of 400 pc and the far IR is magnified 13 times and has a radius of 250 pc. The true far IR luminosity is 4 - 7 x 10^{12} solar luminosities and the molecular gas mass is 2 x 10^{10} solar masses. This is nearly an order of magnitude less than previously estimated. Because the far IR magnification is lower than the mid and near IR magnification, the intrinsic spectral energy distribution peaks in the far infrared. That is, nearly all of the energy of this object is absorbed and re-emitted in the far infrared. In CO luminosity, molecular gas content, CO linewidth, and corrected far IR luminosity, 10214+4724 is a typical, warm, IR ultraluminous galaxy.

Search for molecular oxygen in a $z = 0.69$ molecular cloud

The 30 m telescope has been used to make a new, sensitive but still negative search for molecular oxygen in a dark molecular cloud at a redshift z=0.685 in a search for the redshifted 368 and 424 GHz oxygen lines. The absorbing cloud is seen in several molecular lines in projection on a small-diameter background continuum source. Although an optically thick $C^{18}O$ line is detected in absorption in this dark cloud, there was no detection of the 424 GHz O_2 line in absorption. This confirms that the O_2 abundance in the gas phase must be lower than 0.014 times that of CO, a result that has previously been obtained only as an average over an entire galaxy. The best 1-sigma limit towards a single galactic dark cloud up to now had been $O_2/CO \leq 0.07$, and this result has now been improved by a factor of five.

2.2.2 Nearby Galaxies (10<D<70 Mpc)

CO in the barred galaxy NGC 1530

IRAM observations have been made of the barred spiral galaxy NGC1530 in CO(1-0) with the interferometer and in CO(1-0) and (2-1) with the 30m telescope. Along the galaxy's bar, there is abundant molecular gas associated with the dust lanes seen on optical images (Fig. 2.2). Near the nucleus, the interferometer maps show strong shock fronts and a nuclear ring. There appears to be very little or no gas at the nucleus itself. Perpendicular to the bar, the shock fronts are barely resolved and extend <3". Most of the molecular gas in the galaxy is in a central ellipse with a major axis of 3.5 kpc. This major axis and the strongest velocity gradients are perpendicular to the bar. Position-velocity diagrams are consistent with the molecular gas following elliptical orbits along the bar, but show important deviations at the strong shocks fronts and close to the nucleus, where the gas follows orbits perpendicular to the bar. Giant molecular cloud complexes are detected near the ends of the bar and much fainter CO is detected in molecular clouds in the southeast spiral arm. In spite of its high CO luminosity and great central concentration of molecular gas, the galaxy has only a modest far-infrared to CO ratio, which suggests a relatively low rate of star formation. Although the molecular gas has a latent capacity to fuel a large starburst, further infall to the center is probably hindered by the closed orbits 1.5 kpc from the nucleus. Hence most of the gas cannot attain the critical density needed for a large starburst.

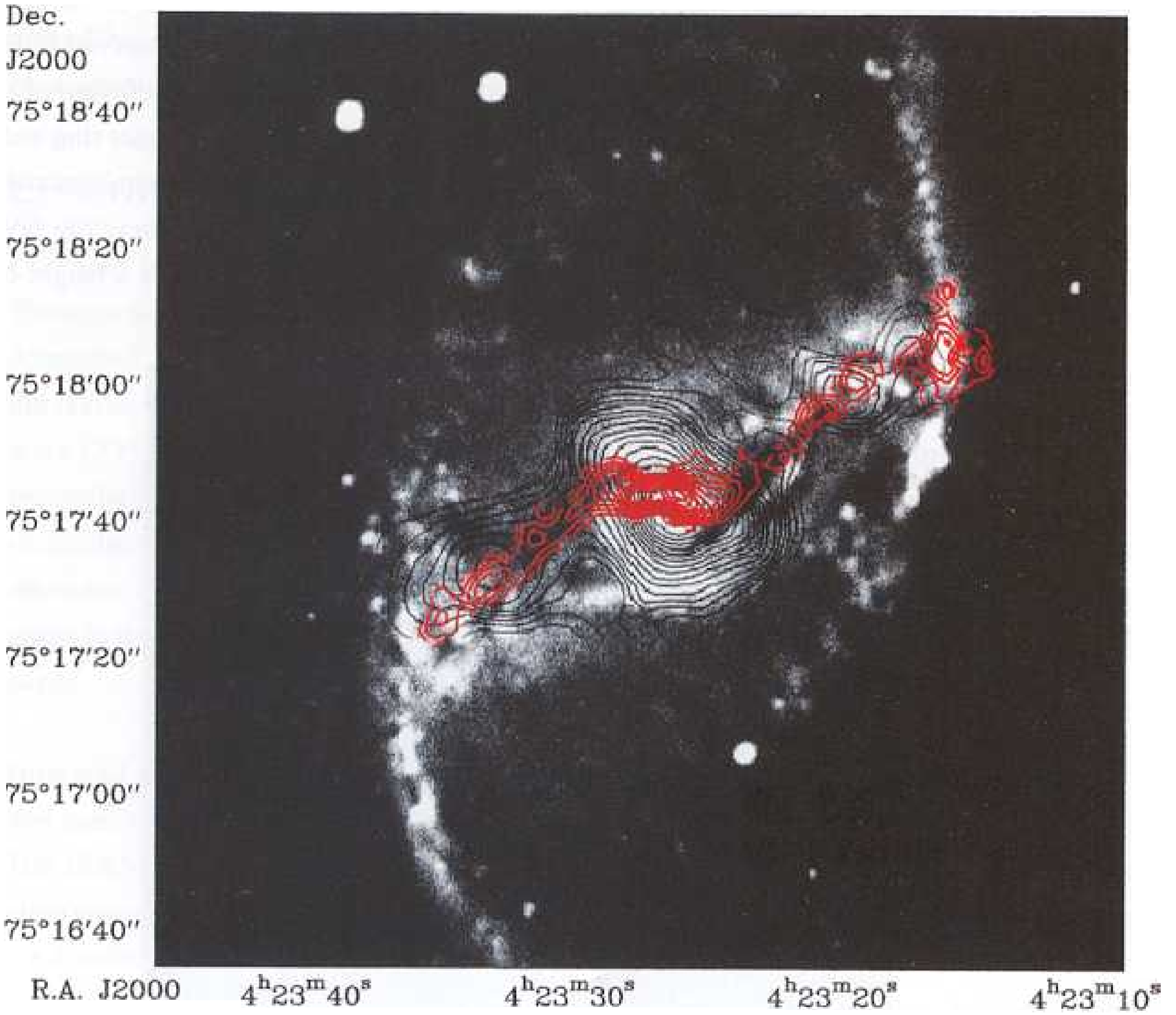

Fig. 2.2 CO in the barred galaxy NGC 1530, superposed on an optical image. The red contours show the CO (1-0) emission, mapped over a range of 60 km/s and a resolution of 3" with the IRAM interferometer, from the gas in the dust lanes along the galaxy's bar. The central black contours show the CO(2-1) emission mapped with the 30m telescope over a range of 200 km/s and a resolution of 13", from the galaxy's nuclear ring.

2.2.3 The Nearest Galaxies (<10 Mpc)

Cold dust and molecular line emission in NGC 4565

The 30-m telescope has been used to map the 1.2 mm continuum emission and the ^{12}CO (1-0) and (2-1) line emissions in the edge-on spiral galaxy NGC 4565. NGC 4565 is strong in the HI line, but weak in CO, contrary to the galaxies mapped so far at 1.2 mm. The CO emission in NGC 4565 resembles that in the Milky Way. It shows a compact central source surrounded by a "molecular ring". The molecular ring peaks between 1' and 1.5' from the center (3 - 5 kpc) and has an outer radius of roughly 3'. It is half the size of the broad "plateau" observed in HI and shows narrow structures which could be spiral arms. The 1.2 mm continuum follows CO near the center and HI at the periphery. Like CO, it shows a central peak and an inner ring and, like HI, a weaker, extended plateau. This is the first time that dust emission is unambiguously detected in extragalactic HI clouds. Like HI, the 1.2 mm contours are warped near the NW edge of the galaxy. The warp, already apparent at half the optical radius, reaches a height of 50" (2.4 kpc) at the edge of the optical disk (Fig. 2.3.).

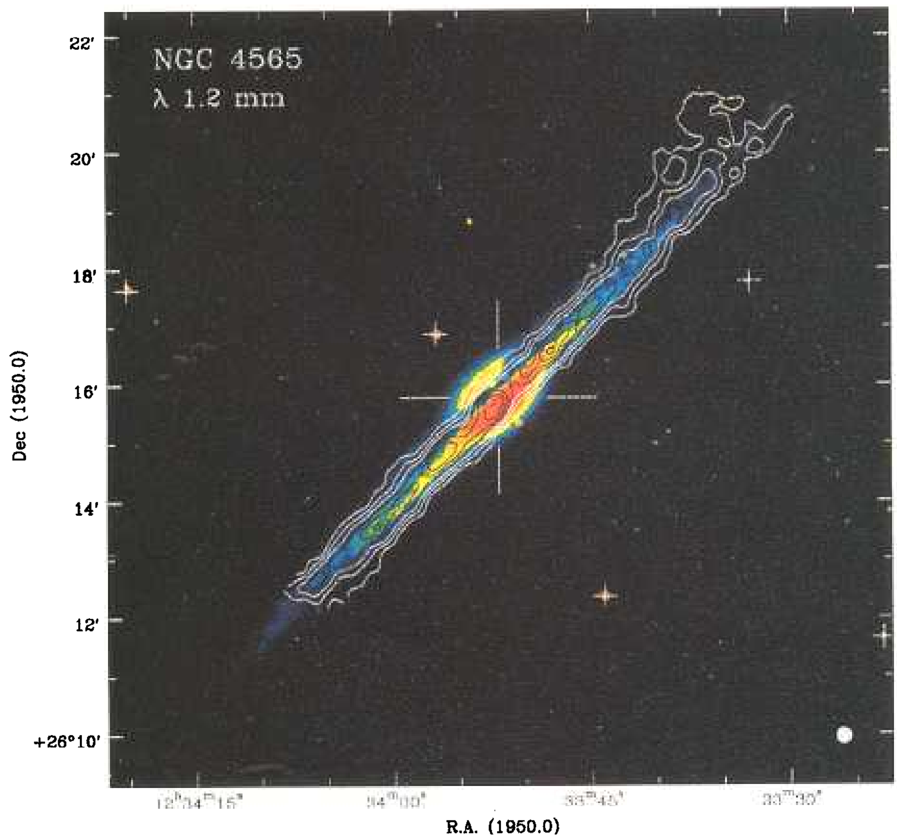

Fig. 2.3 Continuum emission from dust at a wavelength of 1.3 mm, in the edge-on galaxy NGC 4565, mapped with the 30m telescope. The contours of the mm emission are superposed on a false-color image of the optical emission of the galaxy.

The average dust temperature is 18 K near the center and 15 K in the HI plateau. From the 1.2 mm continuum intensity and the HI line integrated intensity, the dust absorption cross section per H atom is derived to be $\sigma^{H}_{1.2mm} = \tau/N_H = 5 \times 10^{-27}$ cm^2 in the plateau. This value is very close to theoretical predictions for local diffuse clouds. The velocity field derived from CO can be described by rotation (solid body rotation between 0 and 4 kpc, constant velocity further out) plus non-circular motions. The non-circular motions are observed mostly near the "arms" and near the nucleus. They are probably the signature of a spiral density wave and/or of a central bar. The presence of a bar could explain the box shape of the central bulge on optical photographs.

2.3 YOUNG STELLAR OBJECTS

CO^+ ions in star-forming clouds in Orion and M17

Theoretical chemical models predict large abundances of CO^+ ions at the edges of photon-dominated regions (PDRs), where molecular clouds are exposed to intense stellar far-ultraviolet radiation. An observational study has been made with the 30-m telescope of mm-wave CO^+ N=2 -1, J=5/2-3/2 and J=3/2-1/2 rotational lines at 236 GHz from the star-forming molecular clouds in Orion, M17 and S140. Intense CO^+ line emission is produced in the molecular cloud/HII region interfaces in the Orion Bar and M17 SW with peak integrated intensities of 1.3 to 1.9 K km s^{-1} in the J=5/2-3/2 line. The observed CO^+ emission probably arises in the photon-dominated regions on the surfaces of dense molecular clumps at the cloud edges.

Dust and gas distribution around T Tauri stars in Taurus-Auriga. I. Interferometric 2.7 mm continuum and ^{13}CO (1-0) observations

The IRAM interferometer has been used to make new ^{13}CO (1-0) and 2.7 mm continuum observations of 33 young star systems in Taurus-Auriga (Fig. 2.4). The goal was to compare the distribution, and hence the evolution, of the circumstellar material around young star single stars and binaries. The sample included 2 triples, 16 binaries, 14 singles, and one object of unknown multiplicity. Continuum emission was detected in 12 systems at S/N > 5, and probable detections were made in another 5 stars. A weak emission line binary system, V 773 Tau, is remarkable in that its 2.7 mm continuum decreased from ~ 30 mJy to ~ 0 mJy in less than six months. The single stars are, on average, stronger 2.7 mm continuum sources than the multiple star systems. Significant estimates of the sizes have been obtained for 8 single stars. they imply large (R > 150 AU) disks, with relatively flat density distributions (emissivity flatter than r$^{-1.5}$). The spectral energy distributions in the millimeter range can be fit with a dust

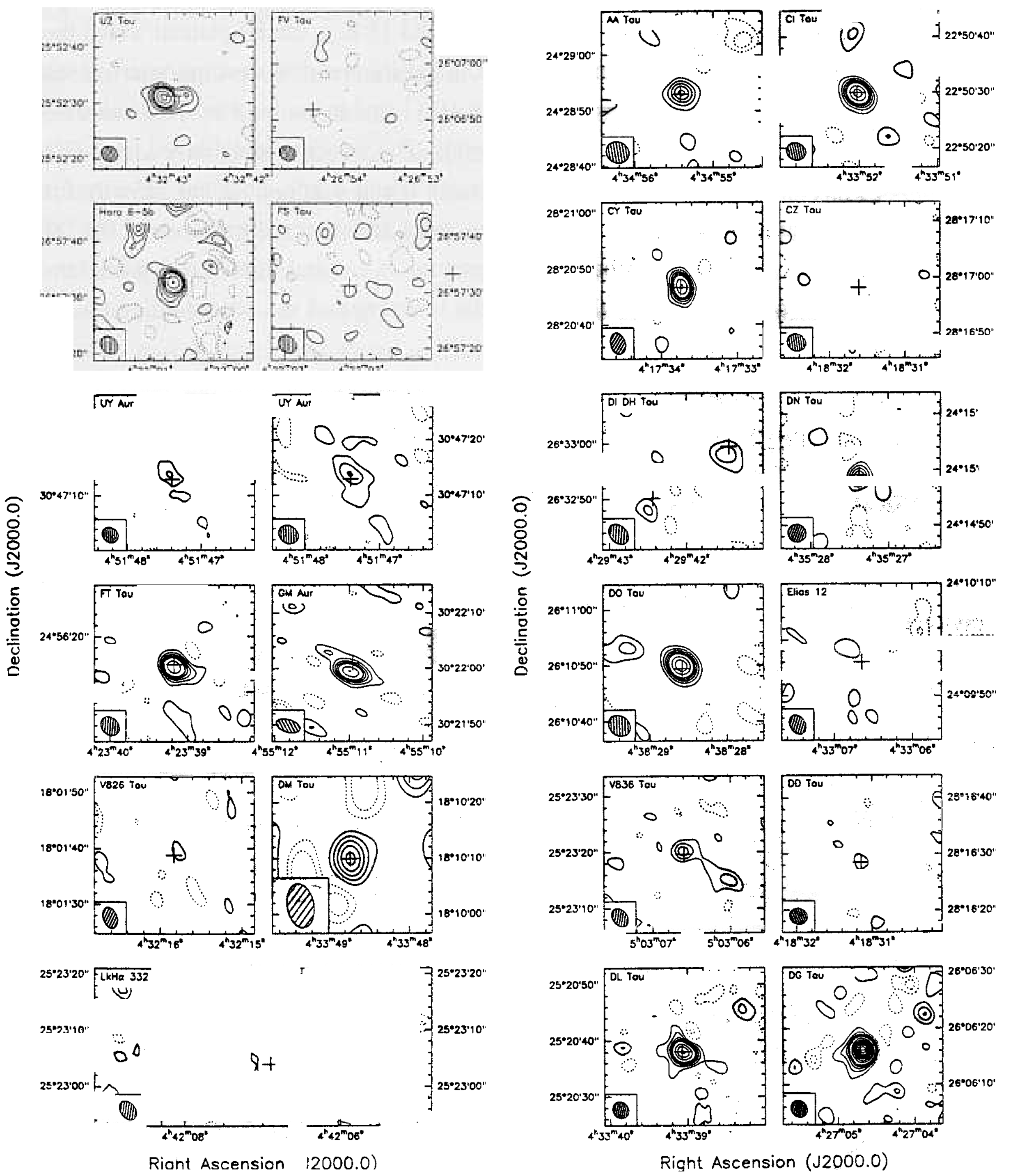

Fig. 2.4 Continuum images of T Tauri stars, as observed at a wavelength of 2.7 mm with the IRAM interferometer. The crosses indicate the nominal positions of the stars, corrected for proper motion. Coordinates are J2000.

emissivity law K_ν ν^β with β in the range 0.5 to 1. Only DG Tau, Haro 6-5b and UY Aur have detectable ^{13}CO (1-0) emission. ^{13}CO emission, but no 2.7 mm continuum, is also found in the LkHα 332 region and near FS Tau; however, it does not appear to be associated with the known stars. If the emission comes from circumstellar disks, then disk masses derived from the dust emission at 2.7 mm are about 20 times larger than the masses derived from the ^{13}CO (1-0) upper limit.

New images of GM Aurigae

New images have been obtained in late 1995 with the new dual-frequency receivers at the interferometer of GM Aur, a pre-main-sequence star located at a distance of 150 parsecs. The longest baseline was 160 m, yielding a 1.8" x 1.6" beam at 230 GHz .The image in Fig. 2.5 shows the thermal emission of dust in the circumstellar disk of GM Aur.

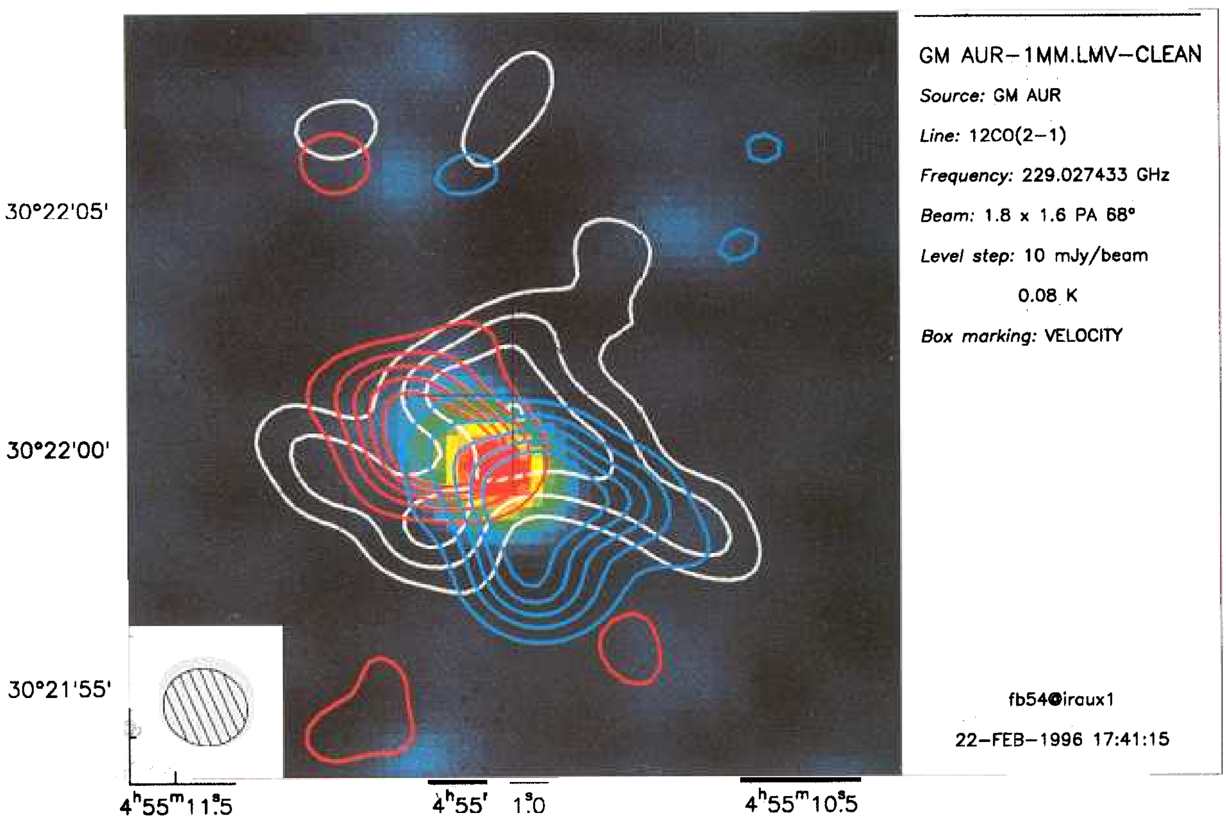

Fig. 2.5 The proto-planetary disk around the T Tauri star GM Aur, observed with the IRAM interferometer. The white contours show the CO(2-1) emission at a velocity channel near the systemic velocity (about 5.9 km/s), the blue contours show the CO emission at 4.9 km/s and the red contours show the CO emission at 6.9 km/s. The velocity gradient is along the major axis of the disk and is consistent with Keplerian rotation.

The filamentary structure of the interface between the atomic and the molecular phases in NGC 7023

IRAM interferometric and single-dish data have been used to determine the structure of the photodissociation region associated with the reflection nebula NGC 7023 (Fig. 2.6). The HCO^+ (1-0) line has been mapped with the IRAM interferometer and the 30-m telescope, and the 21cm HI line with the VLA. The interferometric HCO^+ data show the existence of four high density molecular filaments with different velocities located at the interface between the atomic and the molecular gas.

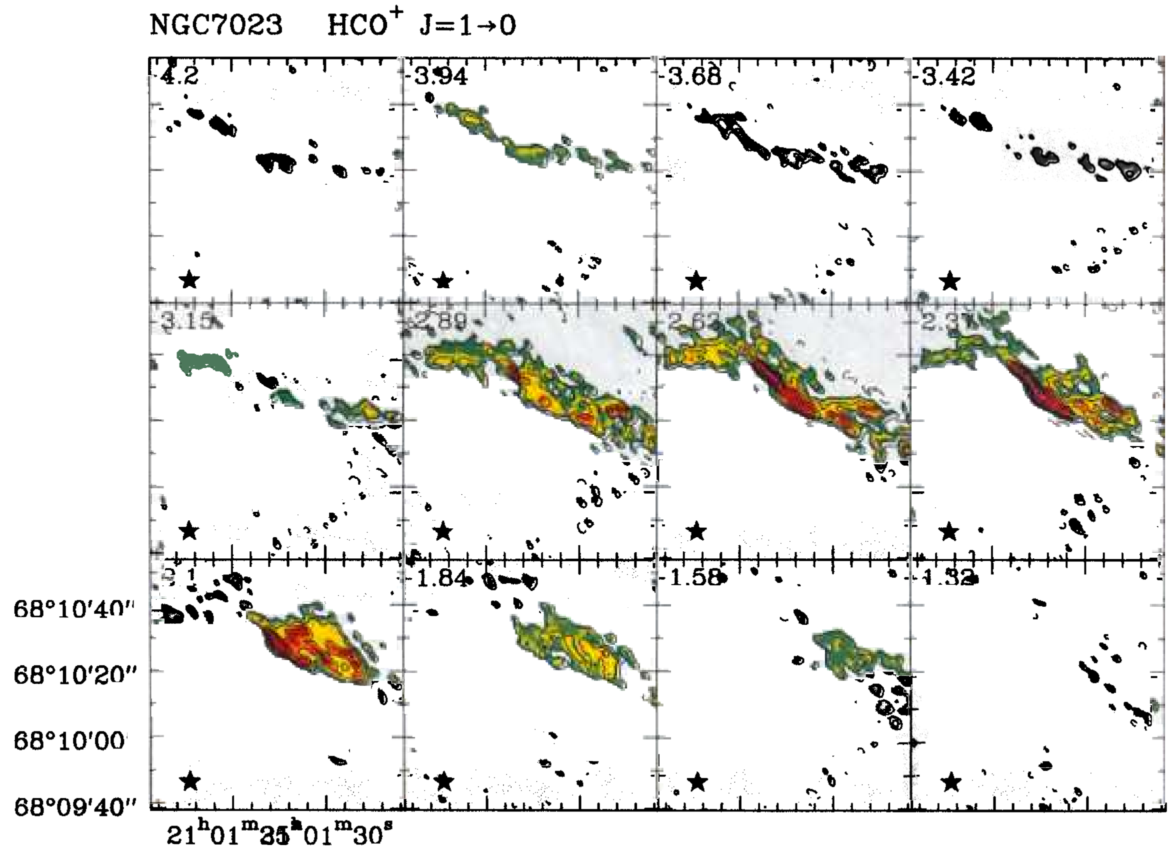

Fig 2.6 An HCO^+(1-0) mosaic map of the line emission towards the reflection nebula NGC 7023. The filamentary structures are regions of enhanced hydrogen density located in a narrow ridge (50" x 15") ~ 46" northwest of the star HD 200775 at the interface between the molecular and the atomic regions. Contours are from 100 mJy to 700 mJy in steps of 100 mJy. The velocity is marked on the top-left corner of the panels.

From the comparison of the single-dish and the interferometric HCO^+ data with HI emission, it appears that two filaments are located on the inner walls of the HI clump, immersed in an atomic medium, while two other filaments are immersed in the molecular cloud. The thickness of the filaments are ~ 6", and the densities are 10^5 to 10^6 cm^{-3}. The molecular filaments match perfectly the infrared filaments found at 2.1 μm, suggesting that the infrared and millimeter data are both probing high-density regions.

2.4 CIRCUMSTELLAR ENVELOPES

Interferometric molecular line observations of the circumstellar envelope(s) around U Camelopardalis

The circumstellar envelope of the carbon star U Cam has been mapped in the HCN(1-0) and CN (N=1-0) lines with the IRAM Interferometer (Fig. 2.7.1 and Fig. 2.7.2). There is evidence of a two-envelope structure : an outer extended envelope, possibly a shell, with a radius of ~ 7 x 10^{16} cm, that expands with a velocity of ~ 25km s^{-1}, surrounding an inner envelope with a radius of ~ 6 x 10^{15} cm and an expansion velocity of only ~ 13 km s^{-1}. These data suggest that the mass loss rate during the formation of the outer envelope was higher than during the present mass loss epoch. Thus, there is evidence for a significant variation in the mass loss characteristics of U Cam within the past thousand years.

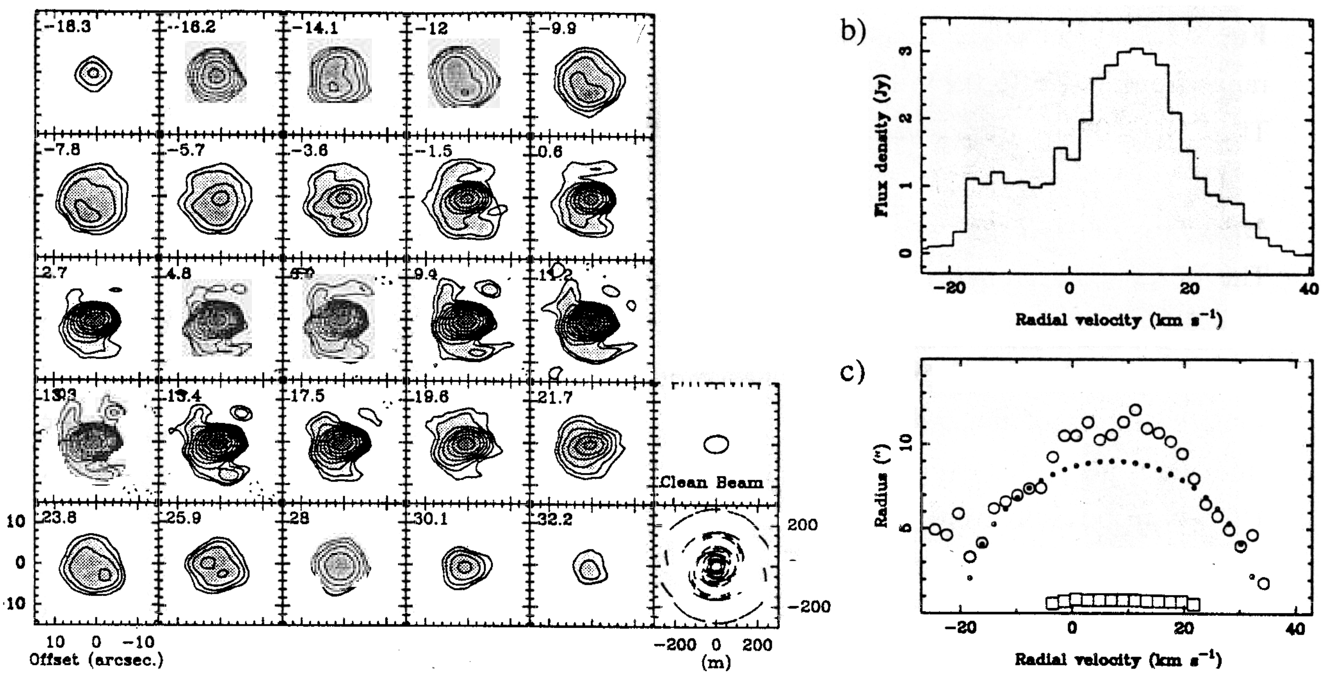

Fig. 2.7.1 a) Velocity-channel maps of the HCN(1-0) emission towards U Cam. Contour spacing is logarithmic. The beam is 5".9x4".2. The last panel shows the uv plane coverage. b) The HCN(1-0) spectrum obtained from the map data. c) Size estimates for the inner (squares) and outer (circles) envelopes. The small dots give the relation $\theta(v_z) = \theta(0)\,(1 - (v_z / v_e)^2)^{1/2}$ with v_e = 26 km s^{-1} and $\theta(0)$ = 9".

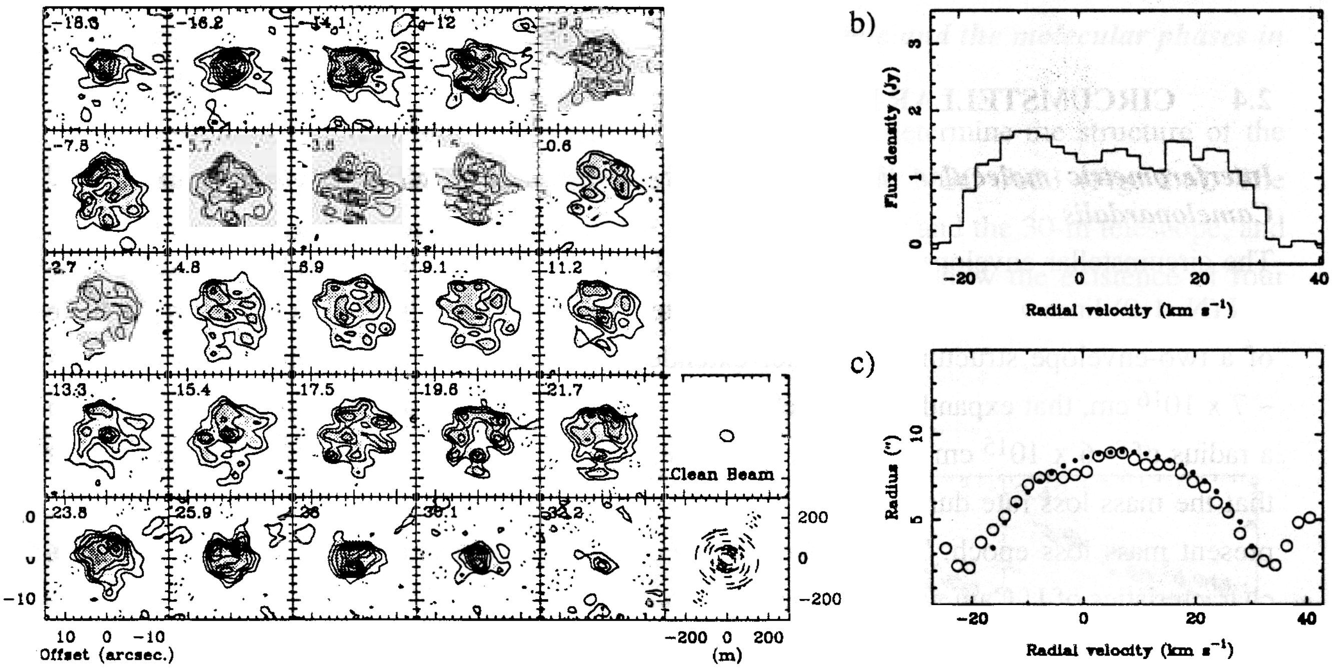

Fig. 2.7.2 a) Velocity-channel maps of the CN(N = 1 - 0) emission towards U Cam. Contours range from -0.075 to 0.175 by 0.025 Jy beam^{-1} (zero is omitted). The beam is 3".4 x 2".6. b) The CN(1 - 0) spectrum obtained from the map data. c) Size estimates for CN.

Mass Loss in AGB stars

The IRAM interferometer, which is more sensitive than the other mm arrays to small scale structures, is particularly well suited to study IRC+10216's dense core. A program of mapping the chemically most significant molecules is under way with this instrument. Fig. 2.8 shows some examples of maps observed at Plateau de Bure with a ~ 3" synthesized beam. The emission is integrated over a 5 km s^{-1} wide interval, centered on the source systemic velocity. The CN map results from a mosaic of 7 interferometer fields spaced by 20" steps ; the others are derived from single field observations and are not corrected for the 50" primary beam. Some maps (CN, C_3H, C_4H, CS, SiC_2 and MgNC) include short spacing data, obtained with data from the 30m telescope. The continuum emission, a point like source of flux 60 mJy, has been removed. The maps of Fig. 2.8 confirm that the radicals and the cyanopolynes have hollow-shell distributions and that the small stable molecules are centrally peaked, as predicted by the gas-phase models. The rings and the central sources show a rich azimuthal structure, in the form of thin arcs and clumps, with a crude axis of symmetry (see e.g. the C_2H and SiS maps). The rings also show a radial structure suggesting the presence of double or even triple shells (e.g. the CN and C_2H maps).

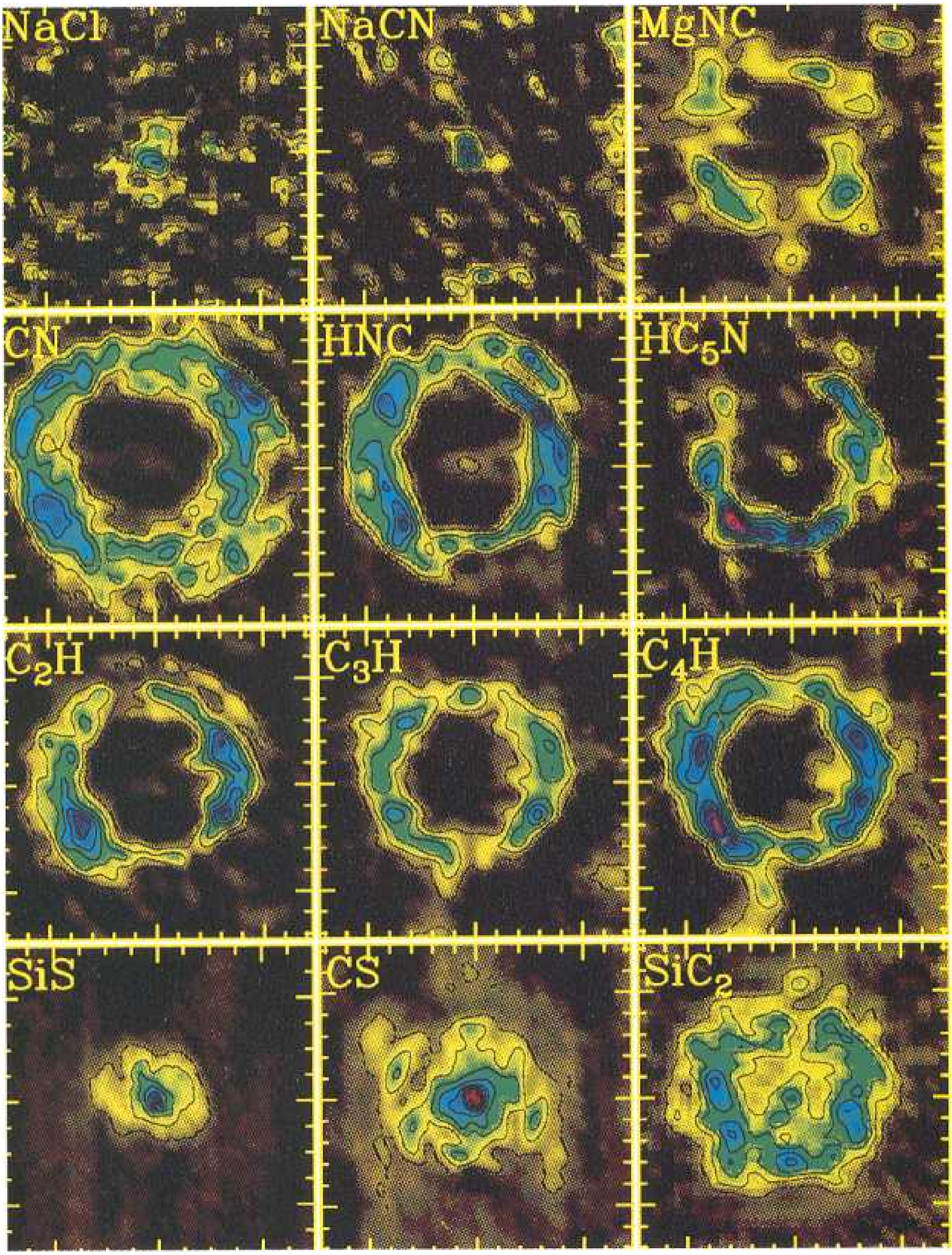

Fig. 2.8 The IRC+10216 envelope, observed with the IRAM interferometer, with an angular resolution of ~ 3" in the 3 mm lines of different molecules. The line intensities are integrated over the central 5 km s^{-1} interval.

Some of the maps show both a central source and a ring (CS and SiC_2). Note that the rings are off-centered by ~ 2" to the east of the central star. Most of the bright clumps are visible on several maps. Since the lines have different excitation conditions and opacities, the clumps are not just due to the excitation, but must trace an increase in column density. Similarly the decrease in intensity toward the N-NE and S-SW (see C_2H) probably indicates a hole in the envelope.

Detection of MgCN in IRC+10216 : A new metal-bearing free radical

A new metal-containing molecule, MgCN, has been detected toward the late-type star IRC +10216, using the NRAO 12m and IRAM 30m telescopes. The N = 11-10, 10-9, and 9-8 transitions of this species, which has a $^2\Sigma^+$ ground state, have been observed in the outer envelope of this object at 3 mm. For the N = 11-10 transitions, the two spin-rotation components are clearly resolved and conclusively identify this new radical. These measurements imply a column density for MgCN of $N_{tot} \sim 10^{12}$ cm^{-2} in the outer shell, which corresponds to a fractional abundance of ~ 7 x 10^{-10} relative to hydrogen. This molecule, the metastable isomer of MgNC, is the third metal-bearing species thus far identified in the outer shell of IRC +10216, and its detection implies a ratio of MgNC/MgCN ~ 22. MgCN may be formed through a reaction scheme involving magnesium and HNC or CN, both prominent outer shell molecules, or through synthesis on grains.

2.5 SOLAR SYSTEM

Radio line observations of comet 109P/Swift-Tuttle

Observations of comet 109P/Swift-Tuttle, made with the IRAM 30 m telescope both before (Nov. 1992) and after perihelion (Jan. 1993) have now been analysed in terms of their physical and chemical information, and they are therefore included here. The molecules HCN, H_2S, H_2CO and CH_3OH were detected with strongly asymmetric line profiles (Fig. 2.9), probably due to the jets seen at visual wavelengths. From methanol rotation diagrams the average rotational temperatures were 70 K in November 21 1992 and 45 K in January 1993. The relative production rates were $Q/Q(H_2O)$ = 0.1%, 0.4%, 0.5% and 4-7% in November 1992 for HCN, H_2S, H_2CO and CH_3OH, respectively, and 0.05%, 0.2%, and 2% in January 1993, for HCN, H_2CO and CH_3OH, respectively. The decrease of non-water parent molecules from November to January, raises questions about the homogeneity of the nucleus and the sublimation process. This analysis is being refined using a non-spherically symmetric model taking into account the jet structure.

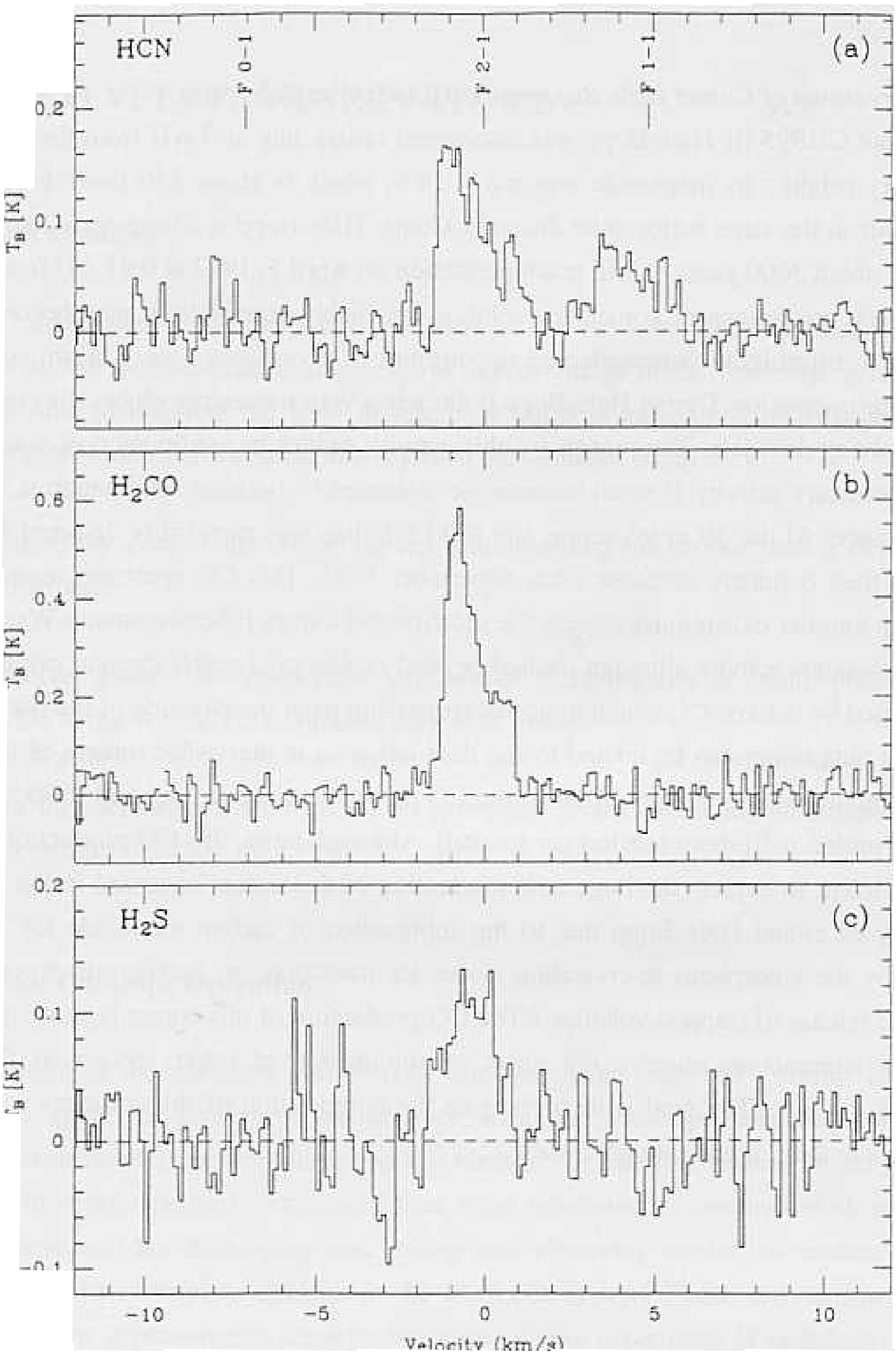

Fig. 2.9 Molecular spectra of 109P/Swift-Tuttle taken on Nov. 21, 1992 at the 30 m telescope: a) the HCN (1-0) line at 88.6 GHz ; b) the H_2CO 3_{12}-2_{11} line at 225 GHz ; c) the H_2S 1_{10}-1_{01} line at 168 GHz. The spectral resolution is 39 kHz; 100 kHz, and 78 kHz, respectively. The velocity scale is with respect to the comet rest velocity. The line intensity is main beam brightness temperature in K. Note the asymmetric profiles, especially in the formaldehyde (H_2CO) line.

First observations of Comet Hale Bopp at the IRAM 30 m Telescope

When Comet C/1995 01 Hale-Bopp was discovered in late July at 7 AU from the Sun, it was already very bright : its magnitude was m_V = 10.5, which is about *250 times brighter* than comet Halley at the same heliocentric distance. Comet Hale-Bopp is a long-period comet, with a period of about 3000 years. It will reach perihelion on April 1, 1997 at 0.91 AU from the Sun and, although predictions of cometary evolution are highly unreliable, it may become a very bright object, offering an unprecedented opportunity to investigate a very bright comet with modern instrumentation. Comet Hale-Bopp is already a very interesting object. Its coma shows rapidly evolving dust jets. The reason for this activity cannot be sublimation of water - - the driver of cometary activity at small heliocentric distances - - because sublimation is inefficient at this distance. At the 30 m telescope, the CO (2-1) line was marginally detected in August 1995, and then definitely detected since September 1995. This CO spectrum resembles that observed in another exceptional object, the short-period comet P/Schwassmann-Wachmann 1, which has gaseous activity although located beyond Jupiter on a nearly circular orbit. The line is blue-shifted by 0.4 km s^{-1}, which indicates outgassing from the day-side of the nucleus. This anisotropic outgassing can be related to the dust jets seen in the visible images of the comet. For a CO rotational temperature of 10 K, the CO production rate in Aug-Oct 1995 was 1.3 to 4.2 x 10^{28} molec. s^{-1} (about one ton per second). Although large, this CO production rate may not be sufficient to explain the huge dust production of this comet observed in the visible. Is the activity of comet Hale-Bopp due to the sublimation of carbon monoxide ice ? Or is it triggered by the amorphous-to-crystalline water ice transition, an exothermic process which induces the release of trapped volatiles ? The CO production of this comet is being monitored, as well as attempts to observe the onset of sublimation of other species as the comet approaches the Sun. The goal is to investigate the composition of the cometary ices and to obtain clues to their outgassing processes.

3. PICO VELETA OBSERVATORY

3.1 Staff Changes

In 1995, there were fewer staff changes than in the years before. This made it easier to complete all the technical tasks, changes and improvements of the telescope system while at the same time maintaining the level of telescope support for visiting astronomers. In total, 3 staff members left, and 3 new members joined the Granada group.

In the astronomy group, one cooperant left after finishing his service, and a new cooperant joined the group.

In the receiver group, two cooperants left (one of them because of health problems before finishing his term). A receiver technician joined the group.

In view of the increasing work load for the computer group, an additional computer scientist joined the group.

3.2 30m Telescope Operation

The operation of the telescope was smooth throughout the year 1995. About 13 hours per week were spent for preventive maintenance, including telescope, receiver, computer and backend maintenance, receiver filling, and test tunings. In addition, several longer periods and a number of shorter periods of technical time were scheduled to continue work on telescope improvements and for developing and testing new observing modes, to replace and repair equipment, and to complete changes in the telescope system. These activities which led to some significant improvements are reflected in the higher percentage of technical time (about 7 %, Fig. 1) as compared to the previous year (4.9 %), although many technical tasks were done in parallel during the regular maintenance time. Almost no additional extra time was needed for *ad-hoc* repairs.

The activities referred to above included - among many others - the installation of a second 3 mm SIS receiver (making four receiver operation possible for the first time), installation and tests of other receivers during dedicated periods (345 GHz receiver, MPIfR 7-channel and 19-channel bolometers), commissioning of receiver remote control for most of the receivers, installation of new 1 GHz wide down-converters (allowing a 1 GHz instantaneous bandwidth

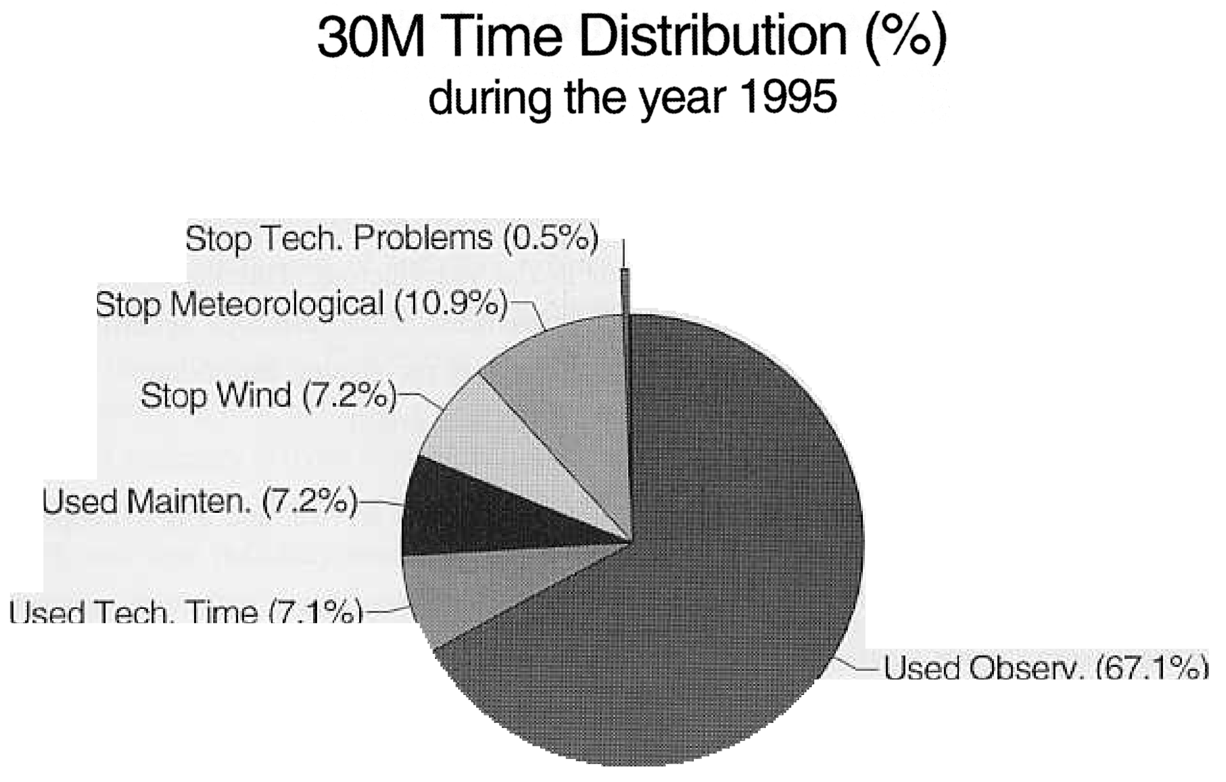

Fig. 3.1: The use of telescope time during the year 1995.

with one of the 1 mm receivers), spectral line on-the-fly mapping development and tests, change of the 1 MHz filterbank processor in order to have a 1 GHz wide filterbank and more flexibility, change of a 1 mm SIS mixer, new reference synthesizers, the preparation of 3 mm VLBI runs, tests of VLBI at 1.3 mm, introduction of UNIX workstations at the telescope and in Granada, rebuilding the telescope computer network, holography measurements, reflector surface adjustment, and implementation of frequency switching with three receivers simultaneously.

Figure 3.1 shows the percentage of the telescope use during the year 1995. In Figure 3.2 the same information is given as number of hours spent or lost, respectively. The increased number of hours lost due to bad weather ("stop meteorological") was caused by persistent bad weather in the month of December. The amount of lost time due to technical problems was fairly small during 1995. Note that a total of almost 6000 hours was used for observations. The statistics is based on entries made by the telescope operators.

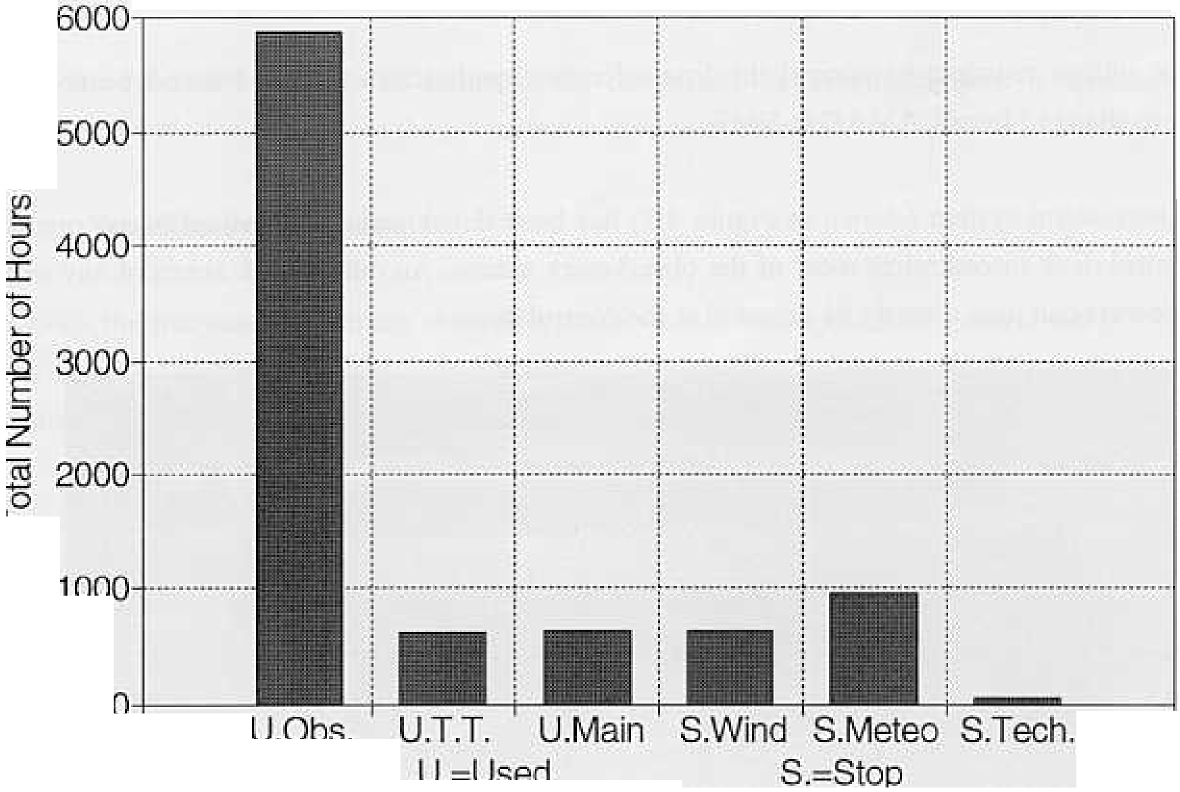

Fig. 3.2: Telescope use during the year 1995 in number of hours. Note that almost 6000 hours were used for observations.

For the majority of the astronomical projects, we were able to make receiver tunings well in advance of the actual observations. 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 of service observing for short projects.

In the area of the telescope servo motors, new modules to control the spindle brakes have been installed. This new batch of modules has solved the problem of the older series which failed relatively often and stopped the observations. A second spare frigorific dryer to dry the air in the pipe to cool the wobbler shakers has been bought and installed as a second operational unit.

The broken deicing elements in the reflector and feedlegs have been repaired during the summer in collaboration with the company ZARGES.

In the receiver cabin a new electrical distribution box with differential protection of 30 mA and an alarm in the case of failure has been installed. The lights and outlets in the antenna tower have also been protected with 30 mA differentials.

The output registers to control the first reference synthesizers for the heterodyne receivers were changed from CAMAC to VME.

A new alarm system (shown in Figure 3.3) has been developed and installed in the operator control desk to centralize most of the observatory alarms. An out-of-lock alarm of any of the receivers can now directly be detected at the control desk.

Fig. 3.3: Alarm control panel at the operators' desk.

The MPIfR bolometer has been interfaced to the IRAM observing system in the receiver cabin instead of the computer room. For the new 19-channel MPIfR bolometer we have developed the interface box to accommodate the output signals from the bolometer to the counters in the scaler modules. Thus the bolometer is integrated in our observing system in a similar way as the heterodyne receivers.

Three low voltage network analyzers have been installed in parallel to monitor the power supply parameters. This is an improvement with respect to the situation before when only information about the three phase current was available in the control room.

The motor of one of the diesel generators has been overhauled. Now the delivered electrical power is the same as after the initial installation.

With the Spanish Ministerio de Industria the conditions and responsibilities to operate and maintain the platform to access the prime focus have been clarified.

3.3 New Observing Modes

In 1995, the frequency switching observing mode - which was opened for general use in 1994 - was extended to three receivers simultaneously. The baseline quality depends strongly on the frequencies used. Preliminary tests were done with four receivers.

An On-The-Fly observing mode (OTF) has been implemented and tested for heterodyne observations. In this mode, the telescope beam drifts across the source, while data is taken continuously and recorded every 1 or 2 sec (depending on the number of spectrometer channels). Any scanning direction can be chosen and successive scans can be concatenated to make a map (as in the bolometer `mapping' mode). Up to 4 receivers can be used simultaneously. OTF observations were carried out successfully in December 1995 on two test programs (M 31 and Cep B). The large data acquisition rate (up to 1 Mbyte/min) has, however, caused data storage and handling problems. Although a new version of CLASS has been developed, the software is not yet user-friendly and at the end of 1995 was still in an experimental state.

Very fast data sampling has been tested and used for a pulsar detection program. This technique required hard- and software modifications.

3.4 VLBI

Following up on the first combined 3 mm and 1.3 mm experiments between the 30 m telescope and one antenna of the Plateau de Bure Interferometer that were successfully carried out in November and December 1994, a further combined experiment was scheduled for March 1995. Improvements on the technical side allowed to further increase the S/N ratio, and to extend the observations to new sources. The correlation and fringe fitting of these data is in progress at the MPIfR in Bonn.

3.5 Reflector Surface

Based on previous holography measurements, an adjustment of just one quadrant of the telescope surface was made in August. This was a test in which an undercorrection by a factor of 0.7 was applied. Subsequent holography in November indicated a clear reduction in the surface error of the quadrant in question.

In order to better understand the influence of residual thermal perturbations on the surface accuracy, a new finite element model of the backstructure and yoke was computed, using a new, commercial software package. The work was executed by Ph. Raffin. The model will allow to calculate reflector surface deformations for actual thermal load cases. The temperature measurements will be provided by some 150 sensors, homogeneously distributed in the backstructure and yoke. The installation of these sensors will be finished mid 1996.

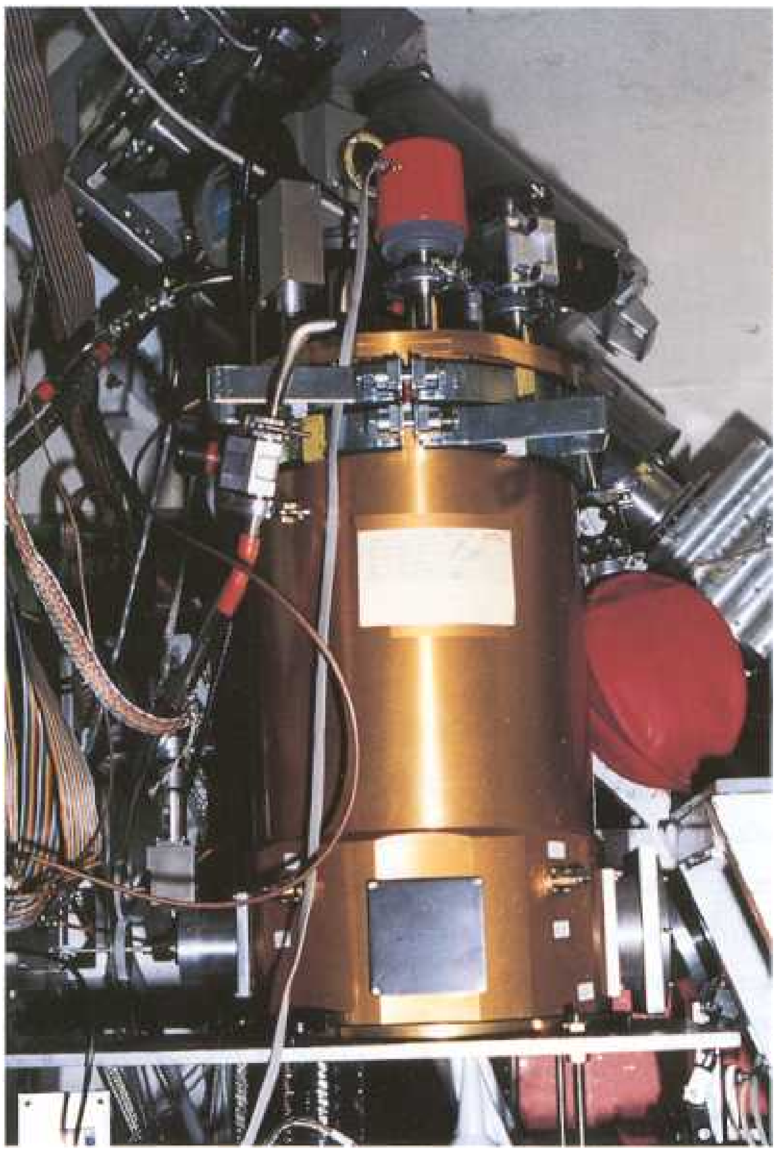

Fig. 3.4: View of the new second 3 mm SIS receiver installed in the receiver cabin of the 30m telescope.

Receivers

As in the years before, several changes and improvements were completed apart from routine work (tuning, receiver filling and general maintenance, small repairs etc.) and special installations of other frontends. The most visible improvements to the observers were the installation of a second 3 mm SIS receiver, and the availability of 1 GHz bandwidth with one of the 1 mm receivers.

The new 3 mm SIS receiver (Fig. 3.4) has been built in a collaboration between the receiver groups in Granada and Grenoble. The receiver design is similar to the one used on the Plateau de Bure. The receiver has been installed in October 1995 and is available for observations since then. Its general performance at the telescope is very good, giving SSB noise temperatures between 55 K and 85 K (including optical losses and spillover) with a 30 dB image sideband rejection (Fig. 3.5). The receiver stability seems to be good and the helium hold time is excellent: about 40 days, giving us the possibility of filling it only once per month instead of twice per week as for the rest of receivers. This is the first time that four receivers can be used simultaneously at the 30m telescope.

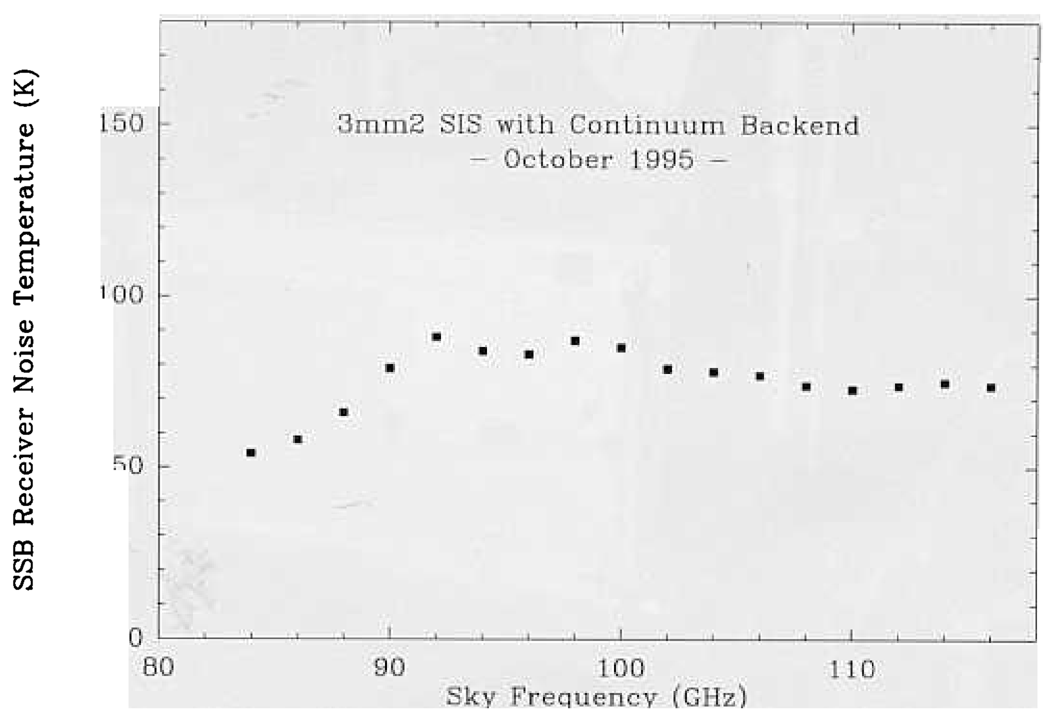

Fig. 3.5: SSB receiver noise temperature of the newly installed second 3 mm SIS receiver at the 30m telescope. Noise temperatures were measured with the telescope calibration system and include optical losses and spillover. Image sideband rejection ranged from 25 dB to 40 dB.

A VME remote control system has been installed and is now routinely operated for the two 3 mm SIS receivers. It is also controlling the local oscillator chain of the 2 mm and 230-G2 while the G1 receiver will be connected at the beginning of 1996. Most of the times the automatic tuning procedure gives acceptable receiver performance with a gain in tuning time and ease of operation.

With the modification of the remotely controlled local oscillator for the 2mm SIS receiver, the tuning range was initially reduced, leaving some important molecular transitions at the band edges unaccessible. The problem has been solved with the installation of a new Gunn oscillator with a wider tuning range. Sky frequency coverage is now from 129 GHz to 183 GHz.

The synthesizers of the first LO reference have been completely renewed (Fig. 3.6). This was necessary because of an increasing failure rate of the old synthesizers. The new synthesizers also provide a much higher frequency resolution. Thus no Doppler correction is needed on the second reference anymore. The new synthesizer unit includes a frequency control system that provides a check of the actual frequency settings.

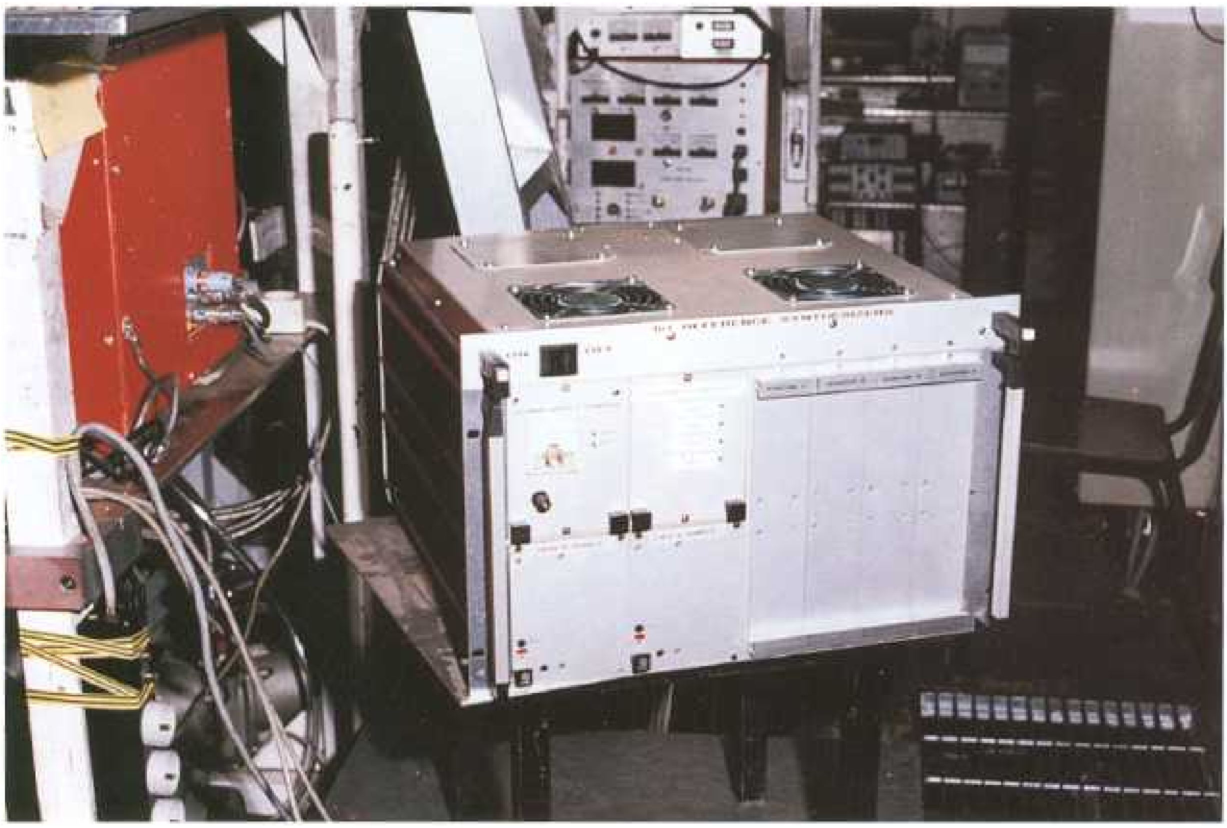

Fig. 3.6: The new unit containing four first reference synthesizers and a frequency control system.

In order to profit from the 1 GHz bandwidth capability of the 230-G2 receiver, a new 1 GHz wide second down-converter unit and IF amplifier board were designed and built by the Granada staff. The wide band observing mode has been tested and is offered to visiting astronomers

Frequency switching with three receivers has been tested and is now available. The four receiver frequency switching mode has passed preliminary tests and will be available after final tests.

The baseline of the 230 G2 receiver degraded during the year. After some tests, the 1 GHz bandwidth cold HEMT amplifier was identified as a possible cause of the problem and was then replaced. Firsts tests indicate that the baseline problem has been cured.

Aging of the 3 mm 1 cold head led to strong noise and mechanical vibrations in the receiver. The cold head could not be replaced immediately due to operational reasons. Later, the replacement was carried out in collaboration with Grenoble staff.

The frequency multiplier in the 2mm receiver was found to have degraded. It was no longer able to cover the very wide tuning range. A very good replacement was made available and was installed in the system.

Again during 1995, a number of additional instruments have been installed during dedicated periods or for special projects. These include the IRAM 345 GHz receiver, the MPIfR 7- and 19-channel bolometers, the DIABOLO bolometer from the IAS, and a polarimeter.

3.7 Backends

The most important task during 1995 was the implementation and testing of the 1 GHz bandwidth observing mode. In addition, support was given to "routine" activities like holography, VLBI, maintenance.etc..

The new hardware of the 1 GHz filterbank processors (c.f. Fig. 3.7) was installed at the telescope at the end of December 1994 tested under real observing conditions. In cooperation with other groups, the possibility of observations with 1 GHz bandwidth with one 1 mm receiver was offered to astronomers. The necessary software modifications were made by the computer group. Long term stability tests were carried out, looking for some eventual "platforming" when concatenating spectra from different banks. No effect could be observed at a level visible in normal astronomical use.

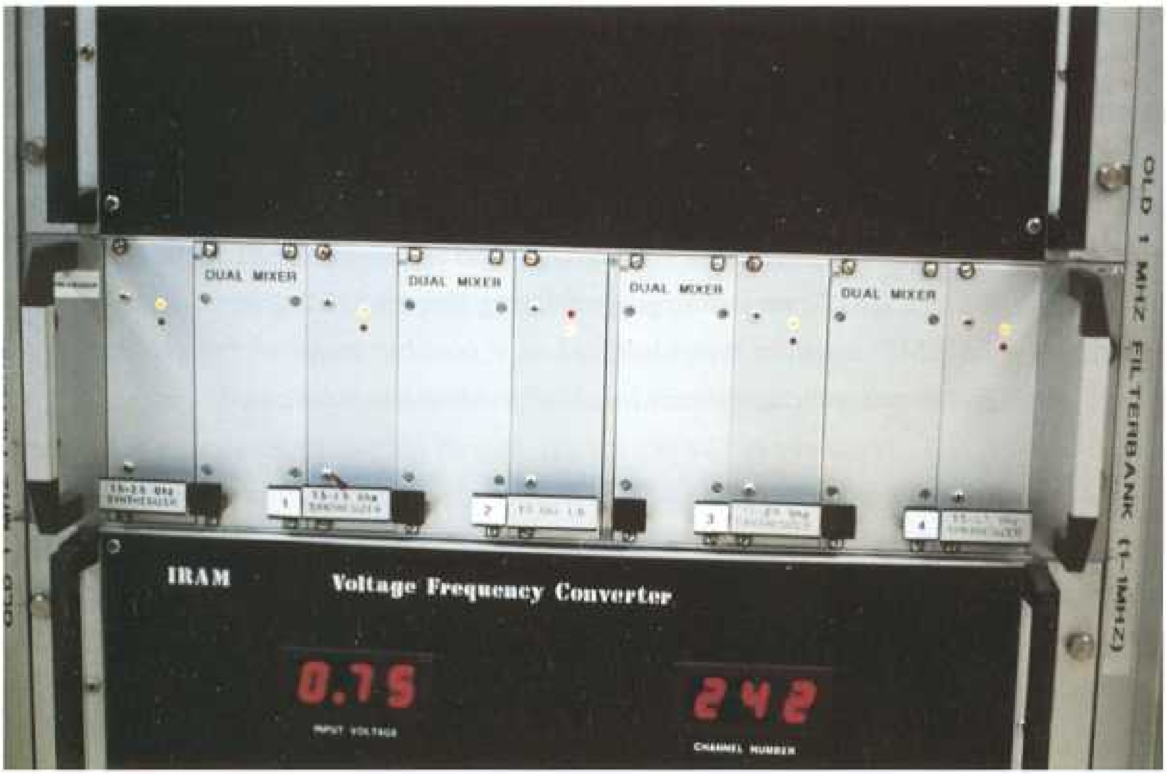

Fig. 3.7: IF processor for the 1 MHz filterbanks. It allows to couple the four units of 256 x MHz each in various ways.

The construction of a new cable processor (to be installed in the backend room between IF cables and the distribution box) was started. The purpose of this device is to equalize IF cable losses, to allow the measurement of the IF continuum power and to provide an input for test signals.

The modular continuum detectors have been built and tested. First tests indicate that the specifications are met. Completing this project is foreseen for the first quarter of 1996.

In January, a test with a 1 GHz wide acousto-optical spectrometer (AOS) from the University of Cologne was performed.

In September, a commercial analogue optical fiber link was tested in view of a possible replacement of the IF cables between the receiver cabin and the control building. Further tests are necessary to investigate in detail the performance.

3.8 Computer and Software

In 1995, apart from the daily operation, changes and significant improvements were done in the area of computers and software.

The most visible improvement was the introduction of the operating system UNIX, both at the telescope and the Granada office through the purchase of three HP Unix workstations. Two are installed at the 30m telescope and integrated into the local area network. Access to files on a remote system is possible via NFS. Software developed by the computer group allows the observer to reduce the observations online on the new workstations, thus benefiting from their much higher performance. One HP workstation is installed and integrated into the local area network in the Granada office. The HP workstations are mostly used for spectral line and bolometer data reduction using the software packages GAG and NIC. They are also indispensable for the recently implemented spectral line on-the-fly mapping mode.

The network at the telescope has been rebuilt completely in order to provide a higher reliability and more flexibility. Fig. 3.8 gives an overview of the current network situation.

IRAM SPAIN - COMPUTER NETWORK (DECEMBER 1995)

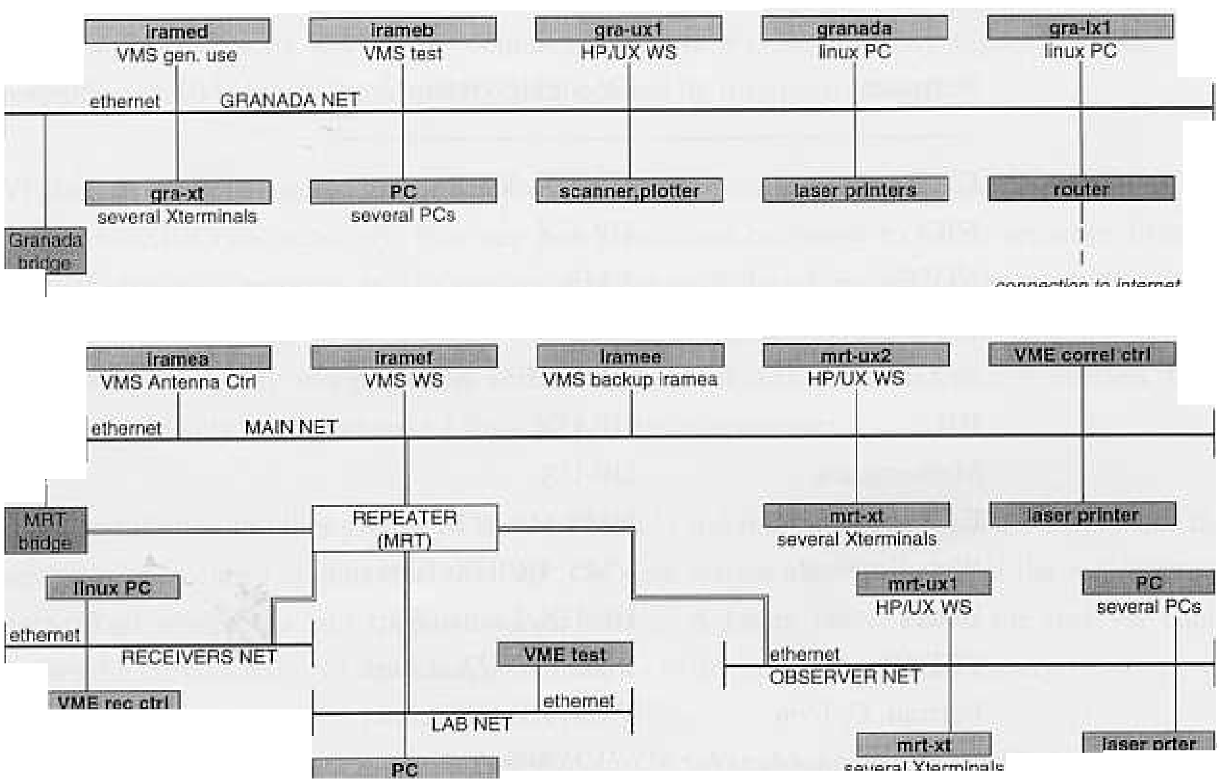

Fig. 3.8: Schematic view of the computer networks in Granada and at the 30m telescope. The telescope network is divided into several branches to increase the error tolerance.

two networks are currently connected via a modem (which will be replaced by a fast radio link in the near future). An Ethernet repeater splits the telescope network into several branches (main net, receivers net, lab net, observer net), preventing that errors in one branch affect the other branches. This solution improved the Ethernet reliability and error tolerance significantly. The cabling has been renewed using cable trays and special connectors which allow to disconnect a device without affecting the Ethernet.

New IRAM, commercial and public domain software packages have been installed. These include NIC for bolometer data reduction, a new (experimental) CLASS version for on-the-fly data reduction, IDL for scientific data analysis and visualization, Mathematica for advanced interactive mathematical computation, and WWW browsers.

The user at the telescope and in the Granada office can now choose between different operating systems according to the application. Vax/VMS, HP Unix HP-UX, MS-DOS/Windows and Linux (Unix on PCs) are available. Some software packages are installed only under specific operating systems, others are available on several computers.

The main software packages are:

Software	Operating system
GAG software	HP-UX, VMS
NIC	HP-UX
NOD2	VMS
TOOLBOX	VMS
TeX/Latex	VMS, HP-UX, Linux
IDL	HP-UX
Mathematica	HP-UX
EAN (e-mail)	VMS
Web-Browser	VMS, HP-UX, Linux
Emacs	HP-UX, Linux
TCP/IP tools	VMS, HP-UX, Linux
Fortran, C, Icon	VMS, HP-UX, Linux

and many packages for MS-DOS/Windows:
PathWorks, eXcursion, MathCad, Wordperfect, QuattroPro, Designer, OrCad, and others.

During 1995 several modifications of the control software were implemented. These included the software support of the new 1 GHz filterbank processor, a narrow band continuum pointing mode, and the data acquisition of the multibeam bolometer channels in the receiver cabin. The narrow band continuum pointing software allows to choose the bandwidth in the range from 2 to 32 MHz.

The calculation of local oscillator frequencies, done by the drive software of the telescope, was carefully revisited at the beginning of the year, leading to minor improvements, which are transparent to the observer. In October the software was modified to acccount for new first LO reference synthesizers, which work at frequencies of about 5 GHz compared to the old ones which worked at about 100 MHz. The optical convention is used for all Doppler corrections by the drive program and by the observing software. The Doppler corrections for raster maps and position switching observations are now done in a consistent way. This solved the longstanding problem of the first scan sometimes showing residuals of the atmospheric CO line.

The observer is now free to choose to give source velocities in the helio-baryo-centric system instead of the default helio-centric system. It has been confirmed that the accuracy of the frequency calculations and of the connected hardware is significantly higher than the best resolution of 10 kHz (= 13 m/s at 230 GHz) offered by the spectrometers.

Visitors at the 30m telescope now have their own specific project account (instead of the former OBSERVER account). This step was considered necessary to better separate different parallel observing projects and to protect observational data from unintentional deletes. New (and larger) disks had to be installed because of the increased amount of data (19-channel bolometer, on-the-fly mapping) and associated need of disk space for data reduction. OTF mapping typically creates about 1 Mbyte of raw data per minute.

In cooperation with other groups of IRAM Granada and our colleagues at IRAM Grenoble the new receiver control system was installed. The new system allows to control the receivers via networked processors and speeds up their tuning. A Linux based PC in the receiver cabin shows the current status of the antenna and allows to do the receiver setup locally.

Another field of activity was the implementation of networking software (FTP, NFS, ...). We started to offer a WWW-server (address: http://www.iram.es/irame_home.html) and an ftp anonymous account. So-called WWW-browsers were installed on the different platforms.

At present this software is mainly used for internal documentation and visitor information. Much of the 30m documentation as well as general information for visitors is now available under Mosaic.

At the end of 1995 we finally managed to get an ISDN link to the Internet (through the University of Granada). This link now runs at 64 KBaud which means an increase in speed of a factor of six. However, during office hours the communication with systems abroad is usually much slower.

The computer group also participated in the tests of the DIABOLO bolometer and in test measurements of a pulsar. A Unix course was given by the computer group for the telescope operators and interested staff.

3.9 Infrastructure

A new water tank with a capacity of 30 cubic meters has been built close to the observatory. The reason is twofold: firstly, there is a longer autonomy in the daily water consumption (about 2 weeks), and secondly a big water reserve is available in the case of a fire. Figure 9 shows the water tank during the construction.

Fig. 9: Construction of a water tank next to the Pico Veleta Observatory.

A new and more solid fence has been installed around the observatory for safety reasons.

Two information boards about IRAM and the 30m telescope have been installed outside and inside the observatory.

About 700 m^2 of the access road to the observatory have been covered with an elastic layer to avoid the degradation caused by the ratrack chains during winter periods with little snow.

3.10 Safety

In case of health problems at the telescope, a general practicioner can be consulted by telephone (Monday to Friday, daytime). He is informed about the medicine available at the telescope and can give professional advice.

New fire sensors have been installed in the maser room at the observatory and neighbouring areas.

The electrical transformer rooms in the observatory have been equipped with big bottles of CO_2 for fire extinguishing.

Five big transportable fire extinguishers (25 kg of powder each) have been installed (two in the Granada office and three in the observatory) in different floors for the case of big fires.

In the Granada office, the fire alarm central has been enlarged from 25 to 42 sensors to cover all the areas including the rooms of the residencia. Two horns outside the building will notify the guardian in case of a fire (important when nobody is in the office).

The electrical installation in the Granada office has been modified changing the electrical differential protection from 300 mA to 30 mA. The water pipes of all the water heaters in the observatory, as well as in the Granada office and residencia, have been electrically isolated to prevent risks due to a possible hazardous electrical leak.

3.11 Administration - Accomodation - Transport

After 13 years, a number of general repairs in the control building were necessary. The kitchen was renovated, and smaller repair and maintenance work was carried out in the bedrooms and in the dining room.

The transport to the telescope during the winter was generally difficult due to the snow conditions. Although there was little snow, it was too much to allow accessing the telescope by car, and it was too little to use the ratrack comfortably and without risk of damage for the chains and the road. Some transports came close to a "space qualification vibration test".

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

4. PLATEAU DE BURE OBSERVATORY

Interferometer Status

Five years after its official opening to the IRAM community, the Plateau de Bure Interferometer has seen its first light in the 210-250 GHz window.

This has undoubtedly been the major event in 1995. There are, however, many more almost equally important events which occured in the course of the year:

The complete replacement of the local oscillator distribution system
The installation of dual-frequency receivers on all antennas
The extension of the baselines up to 408 m E-W and 232 N-S
The demonstration of active phase correction techniques based on total power monitoring
The construction of the mount for Antenna 5

The installation of the dual frequency system started on April 3. First fringes at 230 GHz were obtained on April 12, 12:35 on 3C84 on a 160 m baseline (i.e. with higher angular resolution than any previous observation at Bure). The array was back into operation on April 26. The last receiver was installed on Antenna 3 on May 22-23, and 4 antenna fringes obtained in the evening of May 23.

A first image at 230 GHz was obtained in June, despite the unfavorable period of the year. Some 230 GHz data were obtained in September and October. Early November, the 3mm and 1.3mm receivers were co-aligned to within 2-3" on all antennas, subreflector positions were optimized, antenna surfaces re-aligned by holography, and regular observations at 1.3mm began.

Data obtained in November showed a significant dependence of the phase as a function of elevation, resulting in artefacts in the image. This effect is proportional to the frequency and was not significant at 3mm. It is caused by small offsets in the intersection of the azimuth and elevation axes. A complete analysis of 22 sessions of baseline measurements carried on in 1995 allowed us to determine the most accurate values for this parameter: -1.0 ± 0.1, 0.35 ± 0.1, 1.40 ± 0.1 mm on Antennas 2, 3, 4 respectively, Antenna 1 being taken as the reference.

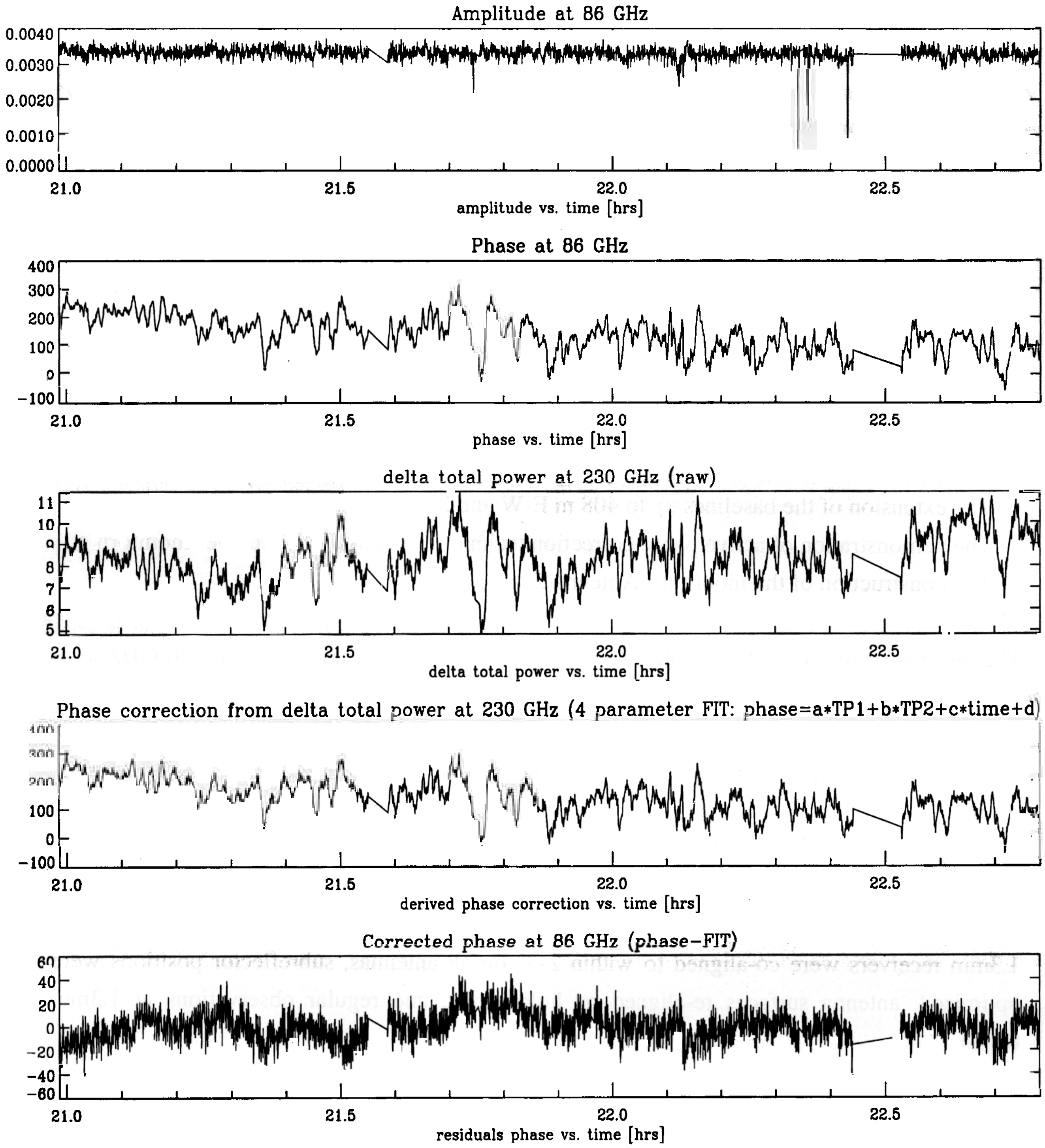

Fig. 4.1: Observations of 3C279 with antennas 1 and 4 on a baseline of 160.5 m. **Sub-panel 2** (from the top) shows the measured phase fluctuations. The *sub-panel at the bottom* shows the remaining phase fluctuations, after the phase correction algorithm has been applied. This is based on the 230 GHz total power measurements (cf. *sub-panel 3*). The fit parameters used (cf. sub-panel 4) were a = 47.6, b = -56.2, c = -100.6, and d = 3238.

Preliminary analysis of the data taken in Nov-Dec 1995 confirms the ability of Plateau de Bure Interferometer to produce routinely images with 1-1.5" resolution at 230 GHz in winter time. In fact, the phase stability was found to be so good that the phase compensation system was unnecessary in practically all cases during this time of the year.

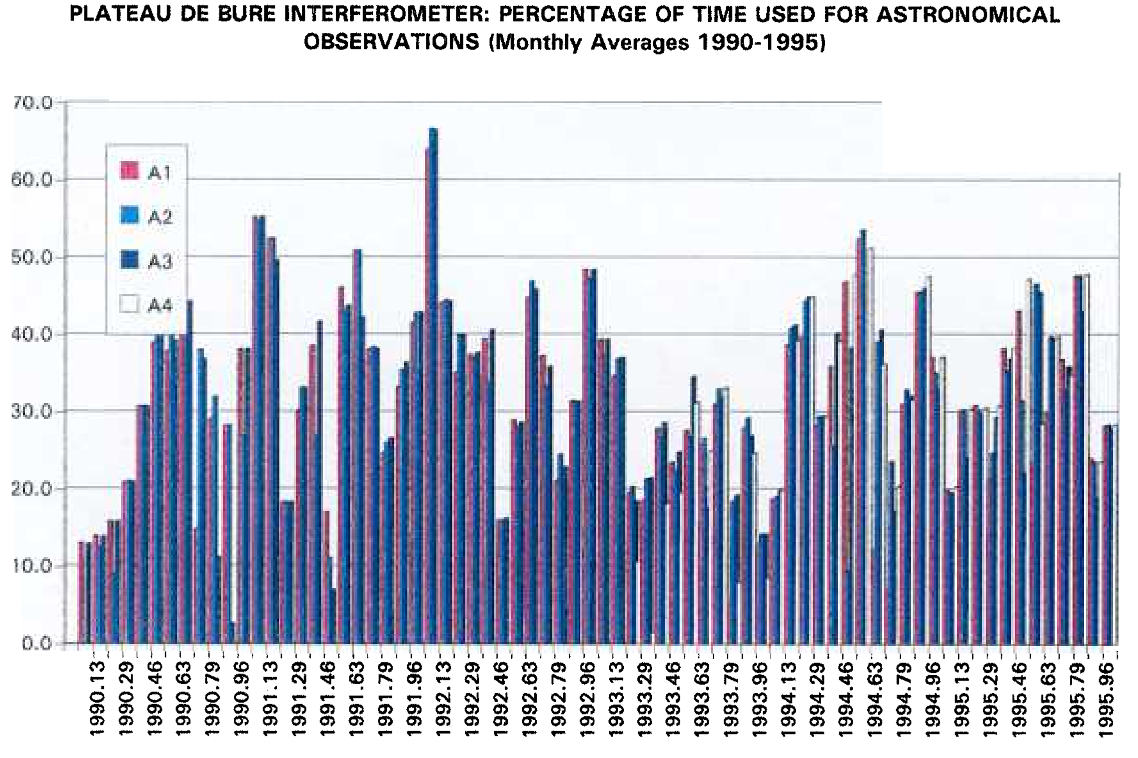

Fig. 4.2 : The percentage of time used for astronomical observations since the beginning of 1990. At the beginning of this period, only three telescopes were available, later four, and soon the Plateau de Bure Interferometer will comprise five telescopes.

Some spectacular 230 GHz results obtained in 1995 included the spatial resolution of the dust emission in a quasar at z=4.7, and the observation of a proto-planetary disk in Keplerian rotation in GM Aur (see Chapter 2).

4.2 Technical Work

As mentioned already, the work on the extension of the E-W and N-S tracks has practically been completed. The only task remaining concerns the final layer of asphalt between the tracks which will be put in the summer of 1996, after the ground had time to settle. The new stations, W20, W23, and W27 and N29 are fully operational and have successfully been tested.

Fig. 4.3 : Aerial view of the Plateau de Bure in the summer of 1994 (picture taken by J.P.Wallez). The track extension work on the E-W arm is already well advanced, the extension to the North has been prepared. The new stations are fully operational since the fall of 1995.

In April 1995 the assembly work for Antenna 5 began on the Plateau de Bure. Contrary to the procedure adopted for Antenna 4, it was decided to advance the work on the telescope mount as much as possible before the beginning of assembly work on the reflector. This allowed us to install and test most of the electrical equipment and control mechanisms in an early phase, thereby saving time during the final assembly and commissioning phases. Antenna 5 was the first to receive the new telescope control system that will be implemented on all the telescopes in 1996, and testing was therefore of particular issue.

The new telescope control system will put the displacement, the anchoring, and the lifting operation as well as the de-icing system of all antennas under the control of a programmable computer.

On September 18th, 1995 a helicopter approached Antenna 3 within very close distance, throwing material up from the ground into the reflector. This caused 1382 impacts, 434 of which have perforated the Hostaflon/aluminium layer. A total of 78 pannels is affected by this event. So far only preliminary repair work was done. The cost of the final repair work is covered by the insurance company.

A station safety review early in 1995 had revealed the fact that in the case of fire, water could not easily be pumped between the living area, where the big tanks are located, and the hangar. Work has begun to create an intermediate pump station to overcome this situation.

5. GRENOBLE HEADQUARTERS

5.1 SIS GROUP ACTIVITIES

General

With the arrival of more and more equipment in the SIS-laboratory, maintenance and repair have become major issues. Efforts have therefore been made to improve the performance and reliability of some of the equipment. This includes the automatization of the SiO_2 sputter process and a computerized junction test circuit.

The SIS group has been asked to participate in an ESA/ESTEC contract for the development of supra-terahertz receivers using NbN technology. The task of the IRAM laboratory is to develop and deliver NbN mixer elements which can be operated at 1.5 terahertz and above. The development of SIS detectors for optical photons has been started in collaboration with the Laboratoire d'Astrophysique Grenoble (LAG). IRAM's task is to develop appropriate SIS junctions. This work is supported by a contract with ULTIMATECH.

Junction Fabrication

100 GHz

A further set of standard junctions was fabricated.

230 GHz

To achieve better uniformity over the wafer for the multibeam receiver, quartz substrates with higher surface quality have successfully been used. Other 230 GHz devices were made using crossed resist lines to improve the reproducibility of 1 μm^2 junctions.

Junction Fabrication by Visitors

In April and August a member of the MPIfR, Bonn fabricated mixer elements for 460 and 690 GHz.

5.1.3. Junction Development and Related Activities

Nb Junctions Embedded in Al Tuning Circuits

The fabrication process has been optimized to obtain lower junction leakage currents and higher electric conductivity of the Al films. Devices were delivered to the MPE. The DSB receiver noise temperature at 800 GHz is at present 1500 K.

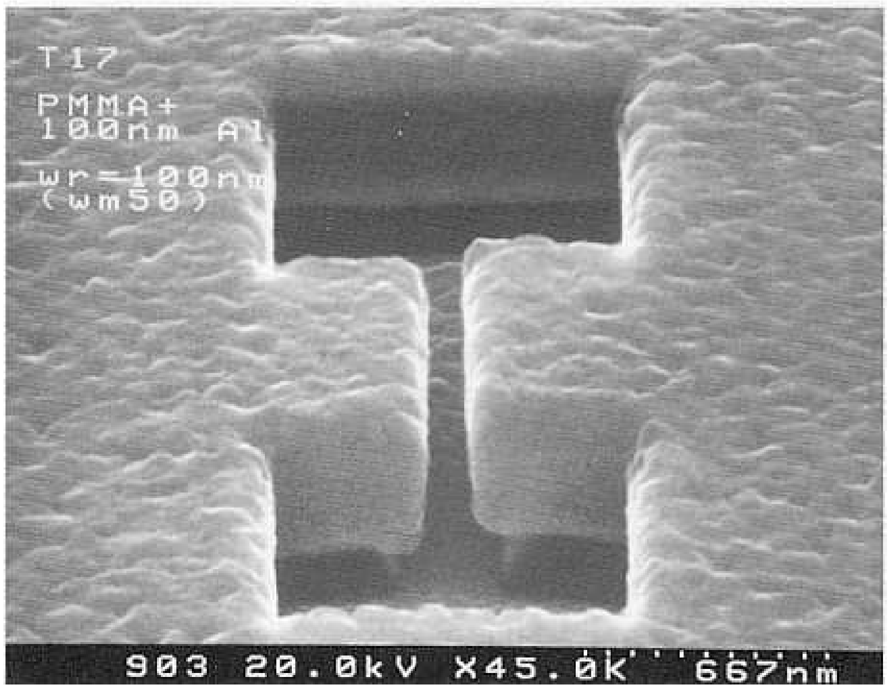

Fig. 5.1 : Lift-off stencil defined in a 600 nm thick e-beam resist PMMA double layer. The PMMA channel width is 100 nm. An aluminium film was sputter-deposited for subsequent lift-off.

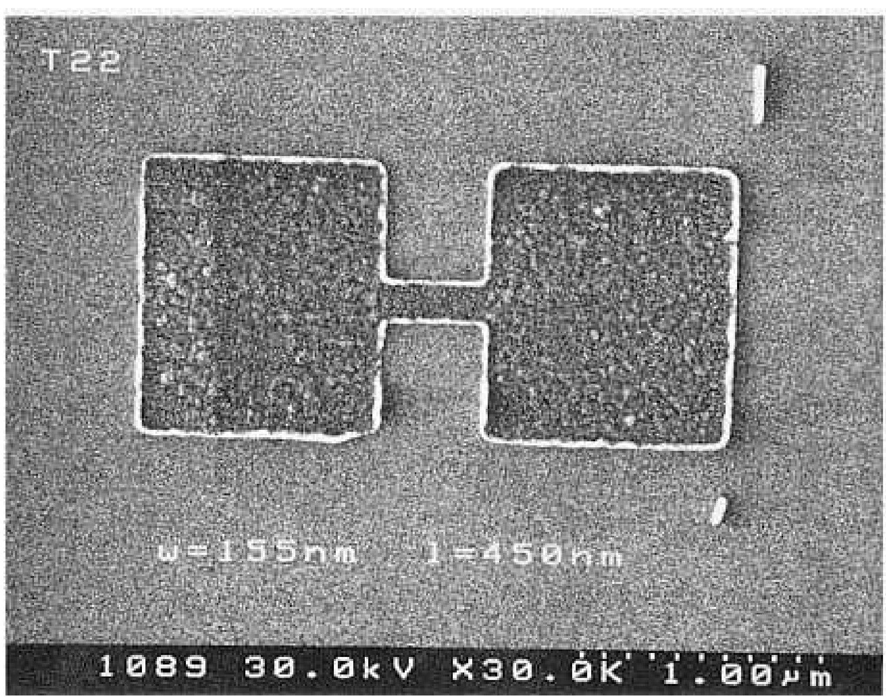

Fig.5.2 : Aluminium structure serving as mask for reactive ion etching of the underlying aluminium film. This pattern defines the hot-electron mixer. The width of the material bridge is 155 nm, the length is 450 nm, and the area of the square contact pads is 1+1 μm^2.

SIN Junctions
These devices gave good results at 300 GHz but still have a residual Josephson current due to the proximity effect between Nb and Al. Various arrangements of electrodes and intermediate layers are under investigation to further quench the proximity effect which can jeopardize an optimum mixer operation.

Photon Detectors
The preparation of SIS junctions for the detection of near-infrared and optical photons has been started and first devices are implemented in a prototype cryostat at the LAG for the development of the detector electronics.

NbN Junctions
Current densities up to about 20 kA/cm^2 could be achieved. Successful mixer tests at 150 GHz at IRAM and at 200 GHz at the MPE in Garching were made. In the coming years this technology will be developed further for applications up to the THz frequency range, in particular in the framework of the above mentioned ESA/ESTEC contract.

Bolometric Direct Detectors and Mixers
The development of hot-electron bolometers has been started. The key element of this new type of detector is a microbridge with critical dimensions between 100 and 300 nm. These microbolometers will be designed as mixers for the THz range and as direct detectors. For that purpose experience with electron-beam lithography must be built up (cf. Figure 5.1). First microbridges with a width of some 150 nm have been produced (cf. Figure 5.2). To test these devices at 300 mK, a cryostat with a He3 minifridge is now available.

5.2 RECEIVER GROUP ACTIVITIES

5.2.1 General

Equipping the Plateau de Bure Interferometer with coverage in the 1 mm band was the main activity of 1995. For Pico Veleta work continues on the 1 mm array receiver, and planning has started on upgrading the single-beam receiver system. A receiver for making full-phase holography maps has also been constructed to help with the improvement of the surface accuracy of the 30-m telescope.

5.2.2 Receiver Developments

Dual-Channel Receivers for the Plateau de Bure
The second, third and fourth dual-channel receivers for Plateau de Bure were completed and installed at the interferometer in the summer after extensive testing in the laboratory. During

the construction, several improvements have been made in the mixers and optics and the performance is better than that of the first one installed in 1994. Measurements of the relative collimation of the two channels were made by pointing, and the alignment on the secondary mirror by holography. Adjustments were then made to ensure that the relative pointing was within 2 arcsec.

Excellent performance has been obtained at the telescope. All the receivers are tuned automatically by the VME-based remote control system. Gain stability is extremely good and the total power fluctuations are of the order of a few parts in 10^4 over periods of several minutes. This has allowed the use of the receivers for measuring atmospheric brightness in the 1 mm band to estimate the pathlength in the atmosphere and correct the phases at 3 mm and 1 mm. Figure 5.3 shows the noise temperatures measured at the dewar window both in the laboratory and at the telescope. Construction of the receiver for the fifth antenna, and a sixth one as a spare were also started in 1995.

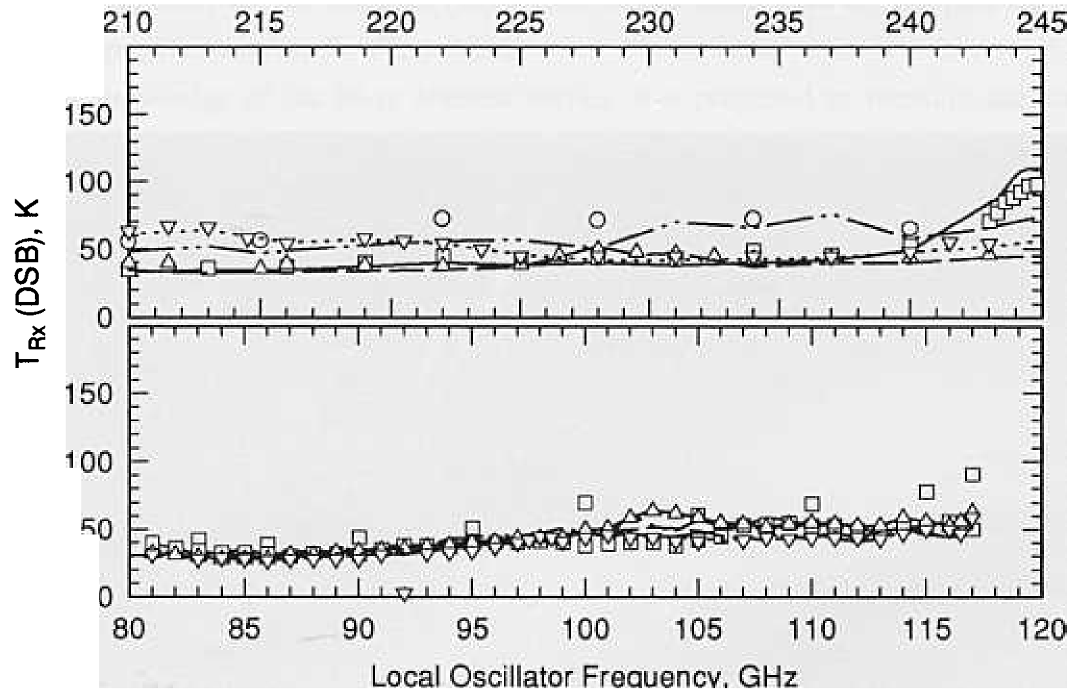

Fig. 5.3 : The noise temperatures of the four dual-channel receivers on the Plateau de Bure. Lines are automatic tuning, points are manual.

1 mm Array Receiver

Development continues on the 1 mm array receiver. Key areas of development for the project are the optical system, the local oscillator injection and the mixers.

The receiver will have two ellipsoidal mirrors that produce a reduced image of the focal plane. The images of separate points on the sky are then coupled into an array of corrugated horns by a matching array of dielectric lenses. The optical system also incorporates an optical rotator so that the array can have any orientation on the sky. After extensive numerical analysis and optimisation, the optical parameters of the system were finalised and feed horns, lenses, and mirrors made. Nine lenses packed together in a square 'fly's eye' configuration have been assembled and an optical system including the offset ellipsoids is ready for measurement on the antenna range.

Local oscillator (LO) power is coupled into the mixers by waveguide couplers. For each set of three mixers there will be a single LO line that has three coupling branches. This has the advantage of minimising LO power requirements. A prototype coupler has been developed and tested and is shown in Figure 5.4 A possible disadvantage of this method of LO distribution is that the power levels at the three mixers are not independent and the mixers need to be well matched across the band. Tests of mixers will be carried out to determine how well the matching is in practice. In case sufficiently good matching cannot be achieved a coupler in which the coupling for each mixer can be individually adjusted has been designed and tested.

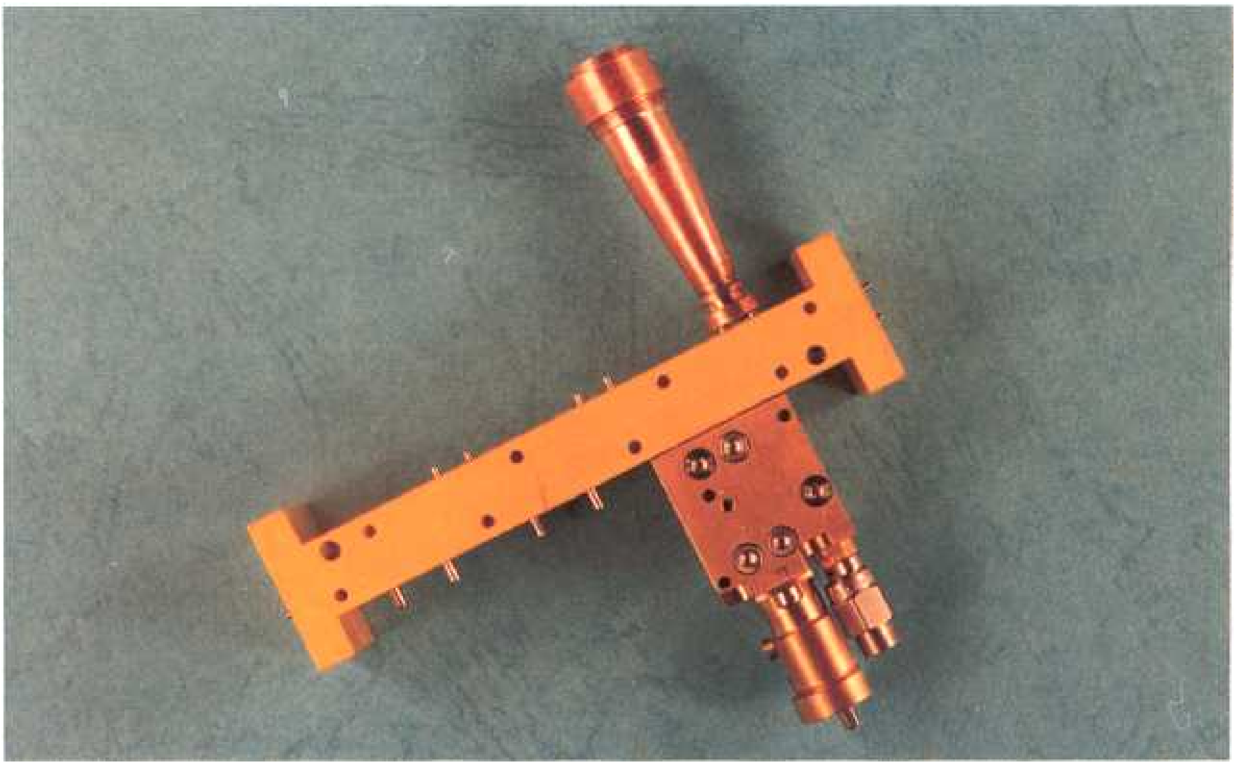

Fig. 5.4 : The 3-mixer coupler for the array receiver. It is shown with one of the new mixers and a corrugated feed horn. The local oscillator power is fed in from the right.

Mixers for the array will be based on those currently used in IRAM receivers. Close packing requirements dictate that the mixer is more compact and a new design of block has been manufactured to fit in a footprint of less than 24 mm × 24 mm. A test dewar is under construction to verify a row of 3 mixers with the fixed coupler.

New Receiver Cabin Proposal for Pico Veleta

A new layout has been proposed for the receiver cabin at the 30-m telescope. This will allow the introduction of the 1 mm array receiver, and new dual-channel single beam receivers. The optical layout, which permits a maximum of flexibility, uses Martin-Puplett Interferometers to diplex frequencies between different receivers. Various combinations of frequencies and polarisations (up to 4 channels at any time) can be accommodated.

The receivers will be based on the successful PdBI design. Some changes in the optics are needed to match the different f-ratio of the 30-m telescope. A system for polarimetry will be included. Five dewars have been ordered so that construction can begin in the first half of 1996.

39 GHz Holography Receiver for Pico Veleta

To improve knowledge of the 30-m antenna surface it is proposed to measure the complex radiation pattern of the antenna from which the aperture field and surface profile can be determined. A dual-channel receiver has been constructed to be installed at the antenna prime focus. One channel has a reference horn/lens which is pointed directly at a satellite source, while the other collects the signal at the antenna prime focus. The two signals are down converted with a common LO and sent down to an HP35607A Dynamic Signal Analyser. From the cross-correlation product measured in the analyser the relative phase of the two channels is determined. Fig.5.5 shows the receiver on the prime focus mounting ring.

The receiver is almost complete and initial tests indicate that the specified accuracy of 0.5° in phase can be achieved. Measurements will complement those made by phase-retrieval holography which also includes the subreflector in the measurement.

Dual-Channel Receiver for SEST

A contract was signed between IRAM and Chalmers/ESO to construct a dual-channel receiver for the SEST telescope in Chile. The design is essentially the same as for the Bure receivers. The IF frequency for the 1 mm band will be changed to 4 GHz with a 1 GHz bandwidth. Because of the different optics at the SEST, some small changes to the dewar internal optics are required. Jointly with Chalmers, an optical scheme using several ellipsoidal and

Fig. 5.5 : The 39 GHz holography receiver for the prime focus of the 30m-telescope. The reference horn is in the upper right corner.

hyperboloidal mirrors has been designed. This gives frequency-independent illumination of the secondary for both channels. Chalmers will construct the external optics, mount, and local oscillator, and the remote control will be made in Chile. IRAM has finished the dewar cabling and started mounting the internal components.

5.2.4 Instrumentation

Antenna Pattern Range

During the year the antenna measurement system was rebuilt mechanically and electronically. The mechanical improvements included the replacement of stepper motor drives with servo motors, resulting in a reduction in vibration and better control. Capabilities for making accurate phase measurements were added. The complete complex amplitude patterns of feed horns and quasioptical systems can now be measured rapidly with high dynamic range (~50 dB). Phase measurements were used on the dual-channel receivers to resolve some discrepancies in the focus between the 1 mm and 3 mm channels.

5.3 BACKEND DEVELOPMENTS

5.3.1 Installation of the new LO System on Plateau de Bure

The 10-year old building-to-antenna LO and IF transmission system, which was limited to 4 antennas, has been replaced by a completely new one. Both the antenna and building parts have been redesigned to allow for lower phase noise and simplified control. The equipment can already accept 6 antennas and 2 simultaneous receivers per antenna.

5.3.2 Extension of the Correlator for the 5th Antenna

The additional modules (both IF and digital) have been built and tested, including 48 new correlator cards. The relevant number of chips, plus a "life" spare stock has been delivered. A batch of 192 of them has been put immediately on permanent duty to check for eventual failures. None has been noticed after 6 months. The integration of these new cards to the existing correlator required them to be accomodated in remote units called satellites. The data coming from the present units will be sent to the satellites through serial links operating at 1 Gigabit/second. In the development phase of the Gigalinks some trouble was experienced with the clock recovery system, which was traced to on-board interference. A second layout achieved an error-free (at least better than 0.1 ppm) transmission. By December, a full-scale test had been performed for one of the new units and was fully sussessful.

5.3.3 Wideband Spectrometer for the 30-m Telescope

A high-quality sampler module has been designed and built to work together with the CESR digital correlator chip. Careful attention has been paid to get rid of several kinds of small distortions that generally occur at this point. The behaviour of the prototype is very good. A computer-controlled test bench has been found necessary to analyze the data in more detail.

5.4 COMPUTER GROUP

For the developments in 1995, the Computer Group has been occupied mostly with the new control system based on UNIX for the Plateau de Bure Interferometer.

That implies a completely new architecture around 2 HP workstations and VME chassis foreseen for realtime work. There are 2 VME chassis per antenna with one microprocessor per chassis. One, located in the pedestal, is in charge essentially of the antenna position, and the second in the cabin, to tune and monitor the receivers. The processors are linked via Ethernet. This development includes new hardware design for specific interfaces like the encoder signal processing board, the time synchronization board and the subreflector control module.

The software modifications take into account the experience gained with the previous version. It has been ported and adapted to the new task distribution and the new time constraints on the front-end microprocessors.

A test with only one antenna fully equipped with this system has been successfully completed during the summer.

In parallel, the receiver control software already operational on Plateau de Bure is continuously improved, and a new, very encouraging phase correction scheme for the spectral correlator at Bure has been implemented.

In Grenoble, the computing service improvements concern :

- back-up : more frequent user and system back-up with new purchased DAT autoloader with multiple cartridge set,
- printing with new network units and
- a preparation to update our top PCs to MS Window 95.

5.5 TECHNICAL GROUP

5.5.1 Mechanical Workshop

As ususal, the mechanical workshop manufactured all standard microwave components for the IRAM receivers, i.e. mixers, couplers, horns, lenses, 115, 230 and 345 GHz backshorts as well as the necessary tools for the assembly. The number of tasks carried out reached a total of 212, of which 64 were executed by local subcontractors.

A priority item in 1995 was the design and manufacturing of test components for the 230 GHz multi-beam heterodyne receiver, such as special mixers, couplers (cf. Figure 5.6), and lenses (cf.-Figure 5.7).

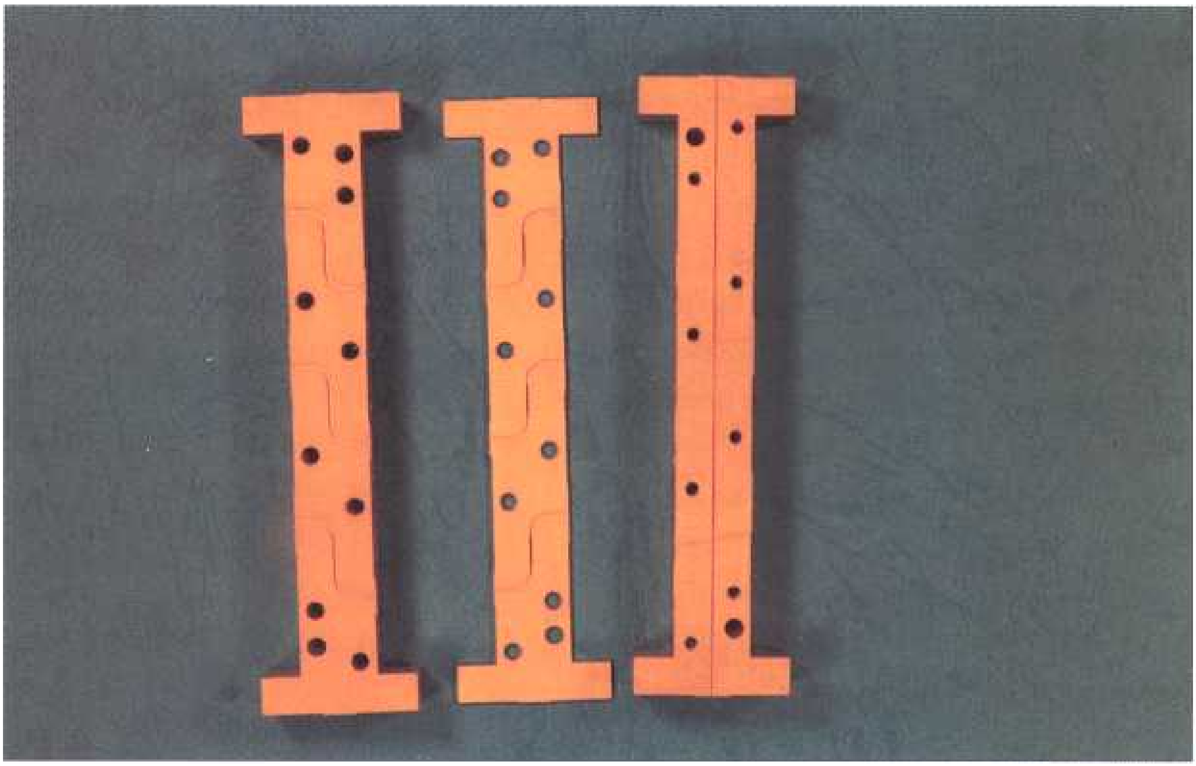

Fig. 5.6 : Test samples of the three waveguide coupler for the 230 GHz multi-beam receiver.

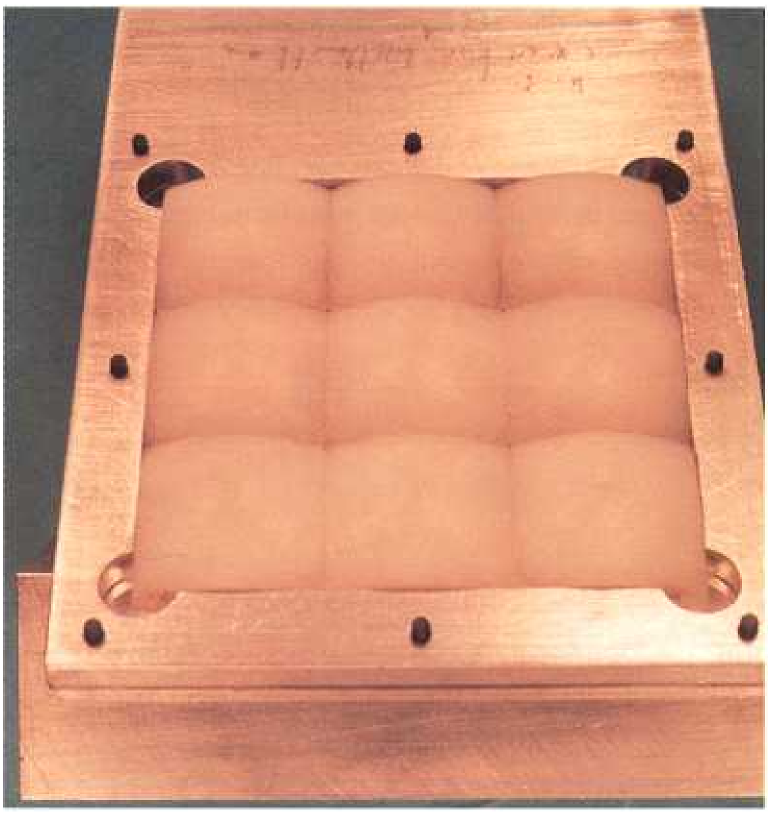

Fig. 5.7 : Lens system for the 230 GHz multi-beam receiver.

5.5.2 Drawing Office

In close cooperation with the micro-wave engineers, the office produced the drawings for the mechanical parts of the receivers and continues updating the files. It supported the design studies for a special test bench for the multi-beam receiver, a beam-derotator, the mechanical parts of the 39 GHz holography receiver, and mechanical parts for the multi-beam receiver to be mounted into a DAIKIN closed-cycle cryogenerator.

Technical Suport for the Plateau de Bure

Interferometer Maintenance Work

Together with the local group on the Plateau de Bure, the technical group in Grenoble supported the maintenance of the interferometer.

Track Extension

In addition, the technical group followed closely the track extension work on the Plateau, in particular the track alignment measurements and the installation of the station/antenna interface. The track extension work was completed on September 29th, 1995.

Antenna No.5

The technical group has been responsible for the planning of the construction of the antenna mount, for the monitoring and control of various manufacturing activities in outside companies as well as for the assembly of the mount on the Plateau de Bure. The delivery of all components followed closely the original plan, and assembly work could start in May 1995.

Fig. 5.8 : The transport of the central hub from the lower cable car station to the Plateau

The planning at the end of 1995 foresees the following remaining activities:

assembly of the backstructure and the aluminium panels	February - April, 1996
remaining electrical installations, installation of the receivers	April/May, 1996
total system tests, including first outdoors test	end May/begin.June 1996
first test of 5-element array	end of June. 1996.

6. PERSONNEL AND FINANCES

In 1995, IRAM had a total of 106,5 positions filled. Of these, 95,5 are occupied by IRAM staff members. 26,5 staff members worked in Spain, and 69 in France. A total of 11 PhD students, post-docs and cooperants worked at IRAM, 3 in Spain and 8 in France. In addition, short-term contracts were signed, corresponding to 2 man-years in Grenoble and 5 man-years on the Plateau de Bure. The employment on the Plateau de Bure was necessitated by the construction work for the 5th antenna.

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 contribute 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 is funded by the German BMBF (Verbundforschung), and another position is partly funded by the MPIfR.

IRAM's financial situation in 1995 and the budget provisions for 1996 are summarised in the following tables. Expenditures in the operations budget 1995 are lower than the original estimates due to the strike in France in early December 1995, which made it almost impossible to place orders and to receive materials. In the investment budget some underspending occurred, mostly due to slight delays in the manufacturing of certain components for Antenna 5 and during the track extension work on the Plateau de Bure. The corresponding budget provisions will be needed in 1996.

The major items in the investment budget were: 1.0 MF for the track extension, 19.0 MF for Antenna 5 on the Plateau de Bure, 3.8 MF for receivers and backends, 0.5 MF for cryogenic components, 0.8 MF for computer equipment, 1.1 MF for improvements in the existing IRAM antennas in Spain and France, and 0.3 MF for equipment in the SIS laboratory. In the area of administration and transport 0.9 MF were spent, and 0.3 MF for improvements in the infrastructure.

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

BUDGET 1995

Expenditure

BUDGET HEADING	APPROVED BUDGET KFF	ACTUAL BUDGET KFF
Personnel	40.120	40.634
Operations	14.780	13.942
	54.900	54.576
Investment	32.800	27.792
Value Added Taxes	4.712	4.811
	92.412	87.179

Income

BUDGET HEADING	APPROVED BUDGET KFF	ACTUAL BUDGET KFF
Contribution CNRS	29.603	29.603
Contribution MPG	29.603	29.603
Contribution IGN	3.778	3.778
Contribution Antenna 5	8.300	8.300
Other Income	16.416	18.683
Contribution CNRS for Value Added Taxes	4.712	4.811
	92.412	94.778

BUDGET PROVISIONS 1996

Expenditure

BUDGET HEADING	APPROVED BUDGET (KFF)
Personnel	40.470
Operations	14.326
	54.796
Investment	17.160
Value Added Taxes	5.247
	77.203

Income

BUDGET HEADING	APPROVED BUDGET (KFF)
Contribution CNRS	30.294
Contribution MPG	30.294
Contribution IGN	3.868
Contribution Antenna 5	6.900
Other Income	0.600
Contribution CNRS for Value Added Taxes	5.247
	77.203

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

0.1 Jan 3 - 17

Ident.	Title	Freq. (GHz)	Authors
219.94	Search for LiH rotational lines in collapsing primordial clouds at high redshifts	97, 145, 217	Maoli, de Bernardis, Melchiorri, Encrenaz, Signore
206.94	First chemical study of circumstellar disks	88, 113, 226, 260, 267	Dutrey, Guilloteau, Guélin
237.94	Outflow from the most symmetric protostellar jet : HH212	230, 132	McCaughrean, Zinnecker, Gueth, Dutrey, Guilloteau
105.94	Search for hydrogeneous compounds in the Martian atmosphere	115, 251, 236	Rosenqvist, Marten, Moreau, Moreno
107.94	Observation of Titan in the (3-2) line of HCN and detection of the $^{12}C/^{13}C$ ratio from ^{13}CO and $H^{13}CN$ lines	115, 220, 259	Marten, Hidayat, Bézard, Paubert
188.94	The spatial extent and abundance of water vapor in molecular clouds	183, 86, 230, 80, 204, 143	Cernicharo, Gonzalez, Bachiller
222.94	Pumping ^{29}SiO and ^{29}SiO maser emission through infrared line overlaps	85, 128, 171, 214, 257	Gonzalez, Cernicharo
173.94	Methanol abundance enhancement around young stellar objects	96, 109, 141, 219, 241	Bachiller, Colomer, Liechti, Walmsley

0.2 Jan 17 - 31

Ident.	Title	Freq. (GHz)	Authors
	CO excitation and H_2 masses of IR luminous galaxies : a proposal to observe the CO(3-2) line	339, 331, 316	Solomon, Downes, Greve
129.94	Probing the different molecular gas components in the nucleus of IC342	265, 259, 241, 354	Schulz, Guesten
147.94	High angular resolution of IRC+10216 : a key to the understanding of chemical processes in circumstellar envelopes	110, 113	Lucas, Guélin, Cernicharo, Kahane
138.94	2mm DCO+ absorption toward extragalactic continuum sources	144	Liszt, Lucas
145.94	Vibrationally excited CS in star forming cores	96, 241, 337, 340	Hauschildt, Guesten
197.94	CO+ in photon dominated regions	89, 235, 267, 354	Stoerzer, Sternberg, Stutzki
109.94	Mass-loss in carbon Miras with small pulsation periods	115, 230, 345	Groenewegen, Omont
134.94	A beta-line maser in MWC349 ?	335, 366, 353	Thum, Martin-Pintado, Strelnitski
176.94	HCN (3-2) and (4-3) in ultraluminous IR galaxies	85, 254, 339, 86, 261	Gao, Solomon, Downes, Radford

0.3 Jan 31 - Feb 14

	Title	Freq. (GHz)	Authors
233.94	The mm continuum emission from QSO's with z>4	Bolometer	Omont, McMahon, Bergeron, Cox, Kreysa
114.94	Search for cold dust envelopes around Herbig Ae/Be stars	Bolometer	Henning, Leinert, Fiebig
115.94	The youngest stellar cores in Bok globules - 1.3mm continuum mapping	Bolometer	Launhardt, Henning, Zylka
214.94	Mm continuum emission from radio weak quasars	Bolometer	MacMahon, Omont
209.94	Cold dust in NGC891, M51 and IC342 : a key to the molecular gas content of spiral galaxies	Bolometer	Zylka, Guélin, Mezger, Haslam, Kreysa, Sievers, Garcia-Burillo
122.94	An investigation of B3-VLA sources at λ1.3mm	Bolometer	Klein, Vigotti, Fanti, Gregorini, Reuter, Mack
142.94	Multichannel bolometer observations of 2060 Chiron near Perihelion	Bolometer	Altenhoff, Stern, Weintraub, Feston

0.4 Feb 14 - Feb 28

Ident.	Title	Freq. (GHz)	Authors
122.94	An investigation of B3-VLA sources at λ1.3mm	Bolometer	Klein, Vigotti, Fanti, Gregorini, Reuter, Mack
142.94	Multichannel bolometer observations of 2060 Chiron near Perihelion	Bolometer	Altenhoff, Stern, Weintraub, Festou
225.94	Simultaneous mm/gamma-ray observations of bright BL Lac objects	Bolometer	Wagner, Witzel, Krichbaum
162.94	Dust at high redshift : are QSOs and luminous IR galaxies related ?	Bolometer	Ivison, Chini, Seaquist, Papadopoulos
143.94	The first high-resolution maps of the Cas A and Crab SNRs at 1.3mm	Bolometer	Holland, Greaves
248.94	Cold dust around high-redshift quasars	Bolometer	Andreani, Casoli, Gerin, Cristiani, Lafranca
187.94	Cold circumstellar dust around newly ROSAT discovered T Tauri stars	230	Bouvier. André
163.94	Continuum observations of symbiotic stars : testing the standard model	Bolometer	Ivison, Seaquist
199.94	Structure of pre-protostellar cores	98, 147, 244, 342, 96, 144	André, Ward-Thompson, Motte
158.94	Deep 1.3mm observations of an X-ray selected complete sample of BL Lacertae objects	Bolometer	Gear

0.5 Feb 28 - Mar 14

Ident.	Title	Freq. (GHz)	Authors
	VLBI Observations and MPIfR Guaranteed Time		

0.6 Mar 14 - Mar 28

Ident.	Title	Freq. (GHz)	Authors
198.94	Size and density structure of low-mass protostellar envelopes	230	André, Motte, Neri
242.94	Completing the observations of the λ1.3mm emission in the edge- on galaxy NGC4565	Bolometer	Neininger, Zylka, Guélin, Dumke, Wielebinski
210.94	Cold dust in four giant cloud associations of M33	Bolometer	Guélin, Viallefond, Neininger, Zylka, Mezger
209.94	Cold dust in NGC891, M51 and IC342 : a key to the molecular gas content of spiral galaxies	Bolometer	Zylka, Guélin, Mezger, Haslam, Kreysa, Sievers, Garcia-Burillo
132.94	Dust properties in the isolated flocculent Sc galaxy NGC4414	Bolometer	Hoernes, Braine, Kruegel
119.94	Millimeter continuum emission in TMC-1	Bolometer	Cernicharo, Cox, André, Ward-Thompson, Zylka

0.7 Mar 28 - Apr 11

Ident.	Title	Freq. (GHz)	Authors
210.94	Cold dust in four giant cloud associations of M33	115, 230	Guélin, Viallefond, Neininger, Zylka, Mezger
165.94	The interstellar medium of nearby galaxies	Bolometer	Braine, Wielebinski, Guélin, Sievers
172.94	Extremely high-velocity CO emission in HH90/91	110, 115, 147, 230	Bachiller, Eisloeffel, Cernicharo
149.94	Detection of CO in galactic globular clusters	115, 230	Leon, Combes
128.94	Molecular clouds in the outer parts of galaxies : N891	115, 110, 230, 220	Combes, Garcia-Burillo, Casoli
229.94	Molecular absorption : a detailed study of the dense ISM at z=0.25 and z=0.68	87, 92, 115, 139, 145	Wiklind, Combes

0.8 Apr 11 - Apr 25

Ident.	Title	Freq. (GHz)	Authors
229.94	Molecular absorption : a detailed study of the dense ISM at z=0.25 and z=0.68	87, 92, 115, 139, 145	Wiklind, Combes
110.94	Molecular clouds in the prototype peanut galaxy NGC128	113, 227	Combes, Emsellem
191.94	Molecular line observations of high mass star forming GMC cores	96, 110, 144, 147	Mooney, Mauersberger, Mezger, Zylka
223.94	CO observations high redshift IRAS quasars	90, 96, 108, 144, 161	Roettgering, Van Breugel, Lehnert
224.94	Neutral carbon in IRAS 10214+4724	197, 149, 246	Radford, Downes
246.94	Searching and mapping the outflows around selected T Tauri stars	97, 110, 144, 220	Menard, Lefloch, Plazy, Monin

0.9 Apr 25 - May 9

Ident.	Title	Freq. (GHz)	Authors
226.94	The molecular content of prototypical molecular clouds	82, 115, 163, 204, 237	Cernicharo, Guélin, Kahane, Gonzalez
175.94	Disk temperature of the planets at 150 and 230GHz	150, 230	Greve, lefloch, Kramer, Moreno
146.94	CN and HCN in carbon rich circumstellar envelopes	88, 113, 226, 266	Lindqvist, Eriksson, Gustafsson, Lucas, Olofsson, Omont
160.94	A gravitational telescope to probe the gas content of distant normal galaxies	106, 108, 133, 142	Casoli, Fort, Boissé, Encrenaz, Mellier
221.94	CO observations of a sample of high redshift radio galaxies	103, 110, 138, 147, 153	Van Ojik, van der Werf, Miley, Roettgering
156.94	High density gas in megamaser galaxies	87, 84, 88	Baudry, Rieu, Baan, Henkel
172.94	Extremely heigh velocity CO emission in HH90/91	110, 115, 130, 220, 230	Bachiller, Eisloeffel, Cernicharo

0.10 May 9 - May 23

Ident.	Title	Freq. (GHz)	Authors
172.94	Extremely heigh velocity CO emission in HH90/91	110, 115, 130, 220, 230	Bachiller, Eisloeffel, Cernicharo
227.94	A systematic search for infall evidence in the youngest nearby stellar objects	98, 110, 145, 230	Bachiller, Tafalla, Myers, Mardones
170.94	Disruption of a dense core by an outflow in L1228 ?	115, 110, 147, 220	Tafalla, Myers, Bachiller, Chen, Wilner
120.94	CS towards the young stellar object NGC 2264-IRS1	97, 146, 219	Henning, Martin, van Dishoeck, Helmich
216.94	Circumstellar matter around Herbig Ae/Be stars	97, 183, 230	Fiebig, Papkalla, Launhardt
250.94	Molecular gas temperature, optical depth, and the N(H2)/ICO(1-0) factor. I : Isolated galaxies	109, 115, 219, 230	Braine, Brouillet, Baudry, Wielebinski
16.95	New molecular line observations of the cloverleaf quasar	92, 129, 161, 227	Barvainis, Alloin, Antonucci, Maloney
136.94	Search for CH_3OH on Titan	241	Bézard, Marten, Paubert
125.94	HCO^+1-0 emission toward a sample of young stellar objects in Taurus	89, 130, 219, 86	Van Dishoeck, Hogerheijde

0.11 May 23 - Jun 6

Ident.	Title	Freq. (GHz)	Authors
16.95	New molecular line observations of the cloverleaf quasar	92, 129, 161, 227	Barvainis, Alloin, Antonucci, Maloney
136.94	Search for CH_3OH on Titan	241	Bézard, Marten, Paubert
135.94	Pulsar detection at short mm wavelengths	80, 250	Morris, Thum, Booth
4.95	Confirming the detection of true low-mass protostars	96, 144, 115, 230	Guesten, Wiesemeyer, Fiebig
18.95	Anatomy of a dense core in the galactic cirrus	97, 99, 146, 219	Heithausen, Corneliussen, Grossmann
36.95	H_2S and N_2H^+ in the galactic cirrus	93, 168, 219	Grossmann, Corneliussen, Heithausen
31.95	SO_2, SO and OCS in the atmosphere of IO	221, 218, 143, 104	Lellouch, Strobel, Belton, Encrenaz, Gulkis, de Pater, Paubert
51.95	CO(2-1) observations along the anomalous Hα and radio arms of NGC 4258	230, 115, 88, 146	Cox, Downes

0.12 Jun 6 - Jun 20

Ident.	Title	Freq. (GHz)	Authors
4.95	Confirming the detection of true low-mass protostars	96, 98, 115, 230	Guesten, Wiesemeyer, Fiebig
10.95	Search for new molecular absorptions at high-z		Wiklind, Combes
15.95	Search for molecular absorption in the central tori of QSOs		Wiklind, Combes, Drinkwater, Webster
46.95	A detailed study of molecular outflows from FU Orionis stars	230, 110, 220;109	Eisloeffel, LeFloch, Malbet

0.13 Jun 20 - Jul 4

Ident.	Title	Freq. (GHz)	Authors
73.95	Time monitoring and origin of high velocity SiO maser emission	86	Baudry, Alcolea, Cernicharo, Herpin
31.95	SO_2, SO and OCS in the atmosphere of IO	221, 218, 143, 104	Lellouch, Strobel, Belton, Encrenaz, Gulkis, de Pater, Paubert
168.94	Molecular gas in the dwarf elliptical NGC 185	115, 230, 110, 229	Lo, Lequeux
79.95	A search for CO in Chiron	115, 230	Crovisier, Biver, Bockelee-Morvan, Colom, Lellouch, Despois, Paubert
26.95	Missing mass as cold molecular clouds		Wilson, Mangold, Solomon, Mauersberger, Henkel
24.95	The stability of clumps in L1498	219, 109, 146, 244, 96	Wilson, Gensheimer, Walmsley, Lemme

0.14 Jul 4 - Jul 18

Ident.	Title	Freq. (GHz)	Authors
19.95	*Do the PIGs in M42 contain molecular material ?*	113, 226, 110, 219, 146	Rodriguez, Martin-Pintado, Fuente
63.95	A new class of molecular clouds in the galactic center region	86, 91, 130, 214, 220	Martin-pintado, Fuente, de Vicente
75.95	Probing the H_1/H_2 transition layer in PDRS	*115, 162, 208, 235, 89*	Fuente, Martín-Pintado
35.95	The hot molecular ring around the Sgr B2 star forming cores	91, 147, 220, 102, 222	De Vicente, Martin-Pintado
20.95	Does dense material confine HII regions ?	108, 113, 145, 109, *218*	Martin-pintado, Gaume, Rodriguez, de Pree, Fey
14.95	CO observations of H_2O megamaser active galaxies	113, 226, 229	Planesas, Colina, Raluy
44.95	Observational *tests of chemical bistability* in dense interstellar clouds	*115*, 230	Gerin, Falgarone, Roueff, Pineau des Forets
43.95	Formation of CO along a dissipation region within a high galactic latitude HI cloud	115, 230	Boulanger, Falgarone, Zagury
74.95	L483 : The birth of a cometary nebula	96, 110, 130, 140, 230	Tafalla, Mardones, Myers, Bachiller, Fuller

0.15 Jul 18 - Aug 1

Ident.	Title	Freq. (GHz)	Authors
43.95	Formation of CO along a dissipation region within a high galactic latitude *HI cloud*	115, 230	Boulanger, Falgarone, Zagury
23.95	*The main molecular Bar of NGC 4321*	114, 229	Sempere, Garcia-Burillo, Combes
55.95	Chemical evolution in the outer galaxy	109, 115, 219, 224	Henkel, wouterloot, Mauersberger, Brand, Chin
85.95	H_2O emission from a circumnuclear disk	96, 232	Henkel

0.16 Aug 1 - Aug 15

Ident.	Title	Freq. (GHz)	Authors
12.95	$C^{17}O$ observations of hot cores	112, 219, 224	Hofner, Walmsley, Wyrowski, Churchwell
56.95	H CO+ and CO+ in photon dominated regions	86, 89, 146, 235	Stoerzer, Sternberg, Kramer
55.95	Chemical evolution in the outer galaxy	109, 112, 219, 224	Henkel, Wouterloot, Mauersberger, Brand, Chin
85.95	H_2O emission from a circumnuclear disk	96, 232	Henkel
71.95	*Dense molecular gas and the starburst indicator in galaxies*	88, 146, 229, 264	Gao, Solomon, Downes
78.95	Comparison of OH and CO emission in infrared evolved stars		Josselin, Loup, Omont
175.95	Multiline study of the young planetary nebulae NGC 7027	89, 88, 97, 226	Stoerzer, Sternberg, Stutzki, Kramer

0.17 Aug 15 - Aug 29

Ident.	Title	Freq. (GHz)	Authors
33.95	Narrow line emission from a molecular cloud with star formation	98, 109, 110, 147	Brand, Wouterloot
34.95	The $^{12}C/^{13}C$ ratio in the far outer galaxy	104, 109, 110, 209	Wouterloot, Brand
42.95	A search for circumstellar SiO maser in the extraordinary star, U Equ	86	Barnbaum, Omont
175.94	Disk temperature of the planets at 150 and 230GHz	150, 230	Greve, Lefloch, Kramer, Moreno
52.95	Molecular clouds and the age of starburst in Mrk barred galaxies		Davoust, Wozniak
37.95	A search for a new Fe-containing radical of FeCO		Kasai, Kamaguchi
22.95	The density structure of the NGC 1333 spherical shell		Castets, Monin, Langer, Warin

0.18 Aug 29 - Sep 12

Ident.	Title	Freq. (GHz)	Authors
72.95	Imaging the jet working surfaces in the RNO 43 outflow	110, 130, 230	Richer, Cabrit, Bally, Bence, Padman
9.95	600AU-scale clumping in the molecular cloud MBM 12	86, 88, 138, 146	Combes, Pfenniger
δ 07.95	CO in the giant arc of the cluster A370 ?		Casoli, Encrenaz, Fort, Boisse, Mellier
64.95	New millimeter methanol masers		Slysh, Kalenskii, Val'tts
84.95	LiCl and LiNC in the circum. clouds, planetary nebulae and protoplanetary nebulae...	84, 106	Lubowich, Turner, Sahai
15.95	Search for molecular absorption in the central tori of QSOs		Wiklind, Combes, Drinkwater, Webster
δ08.95	PKS 1830	244	Combes, Wiklind
48.95	The ^{12}CO line ratio in nearby starburst galaxies	115, 116	Greve

0.19 Sep 12 - Sep 26

Ident.	Title	Freq. (GHz)	Authors
175.94	Disk temperature of the planets at 150 and 230GHz	150, 230	Greve, lefloch, Kramer, Moreno
84.95	LiCl and LiNC in the circum. clouds, planetary nebulae and protoplanetary nebulae...	84, 106	Lubowich, Turner, Sahai
82.95	Gaseous counterparts of low-mass protostellar dust envelopes	86, 96, 109, 224	Andre, Despois, Blinder
58.95	Chemical study of GG Tau and DM Tau circumstellar disk	87, 85, 168, 236	Dutrey, Guilloteau, Guelin
74.95	L483 : The birth of a cometarv nebula	96, 110, 130, 230	Tafalla, Mardones, Myers, Bachiller, Fuller
δ 07.95	CO in the giant arc of the cluster A370 ?		Casoli, Encrenaz, Fort, Boisse, Mellier
70.95	^{13}CO emission from molecular complexes in M 33		Viallefond, Guelin, Cox
50.95	A search for circumstellar and interstellar MgCH3	88, 110	Ziurys, Apponi, Guelin
41.95	Probing the infall region of L 1527	100, 146, 244	Myers, Mardones, Wilner, Tafalla
7.95	Search for primordial molecules in Lyman-alpha damped absorbers	107, 116, 160, 143	Melchiorri, Signore, Encrenaz, Maoli et al
62.95	CN as tracer of circumstellar disk structure ?	113, 226	Dutrey, Guilloteau, Guelin, Schuster
80.95	Observation of CO in comet P/Schwassmann-Wachmann 1	115. 230	Crovisier, Biver, Bockelee-Morvan, Colom et al
δ09.95	Comet C/1995 01 (Hale-Bopp)	115, 230, 236, 168	Crovisier, Biver, Bockelee-Morva, Colom et al

0.20 Sep 26 - Oct 10

Ident.	Title	Freq. (GHz)	Authors
70.95	^{13}CO emission from molecular complexes in M 33		Viallefond, Guelin, Cox
δ 10.95	Calibrated CO spectra of Mrk 273	111, 110	Downes
8.95	Molecular gas in galaxies of Hickson compact groups	115, 230	Menon, Combes, Leon
81.95	A search for volatile molecules in comet P/Schwassmann-Wachmann 1	89, 98, 109, 260	Bockelee-Morvan, Biver, Colom, Crovisier et al.
δ09.95	Comet C/1995 01 (Hale-Bopp)	115, 230, 236, 168	Crovisier, Biver, Bockelee-Morva, Colom et al
45.95	Investigation of molecular envelopes around T Tauri stars...	109, 110	Schuster, Cabrit, Harris
58.95	Chemical study of GG Tau and DM Tau circumstellar disk	87, 85, 168, 236	Dutrey, Guilloteau, Guelin
74.95	L483 : The birth of a cometary nebula	96, 110, 130, 140, 230	Tafalla, Mardones, Myers, Bachiller. Fuller

0.21 Oct 10 - Oct 24

Ident.	Title	Freq. (GHz)	Authors
175.94	Disk temperature of the planets at 150 and 230GHz	150, 230	Greve, lefloch, Kramer, Moreno
81.95	A search for volatile molecules in comet P/Schwassmann-Wachmann 1	89, 98, 109, 260	Bockelee-Morvan, Biver, Colom, Crovisier et al.
δ09.95	Comet C/1995 01 (Hale-Bopp)	115, 230, 236, 168	Crovisier, Biver, Bockelee-Morva, Colom et al
61.95	Kinematics and mass of a remarkable circumstellar disk and the flying ghost nebula	97, 109, 144, 230	Monin, Lefloch, Caux, Boulard
139.94	Observations of a protostellar candidate HH24-MMS	230, 219, 224, 244	Kruegel, Thum
83.95	^{13}CO(1-0) observations of IC 443 G	110	Keene, Phillips, Van Dishoeck
1.95	Molecular observations of OH 231.8+4.2	115, 230, 130, 217	Bujarrabal, Alcolea
2.95	Observations of SiO v=2 J=2-1 maser emission	85, 86, 130, 230	Bujarrabal, Alcolea, Colomer
11.95	Pre-protostellar structure in cloud cores TMC1 and L1498	93	Langer, Velusamy, Kuiper

0.22 Oct 24 - Nov 7

Ident.	Title	Freq. (GHz)	Authors
175.94	Disk temperature of the planets at 150 and 230GHz	150, 230	Greve, lefloch, Kramer, Moreno
222.94	Pumping ^{29}SiO and ^{30} SiO maser emission trough infrared line overlaps	85, 128, 214, 257	Gonzalez-Alfonso, Cernicharo
δ09.95	Comet C/1995 01 (Hale-Bopp)	115, 230, 236, 168	Crovisier, Biver, Bockelee-Morva, Colom et al
58.95	Chemical study of GG Tau and DM Tau circumstellar disk	87, 85, 168, 236	Dutrey, Guilloteau, Guelin
31.95	SO2, SO and OCS in the atmosphere of IO	221, 219, 216, 104	Lellouch, Stroebel, Belton, Encrenaz-T, Gulkis et al.
68.95	Mapping the Cepheus B molecular cloud	109, 110, 220, 230	Guelin, Kramer, Sievers, Ungerechts
δ12.95	Detection of CO(2-1) line in Cygnus A	109, 218	Mirabel
70.95	^{13}CO emission from molecular complexes in M 33		Viallefond, Guelin, Cox
δ13.95	Chemistry of protoplanetary disks around GG Tau and DM Tau	250, 270	Dutrey, Guilloteau, Guelin
6.95	CS towards the young stellar object NGC 2264-IRS1	97, 146, 219	Henning, Martin, Van Dishoeck, Helmich

0.23 Nov 7 - Nov 21

Ident.	Title	Freq. (GHz)	Authors
165.95	L 1544 : A collapsing starless core	bolometer	Tafalla, Myers, Bachiller, Mardones, Caselli, Benson
δ15.95	Separating infall and outflow motions in L484		Bachiller
218.95	A search for CO in Chiron	115, 230	Crovisier, Biver, Bockellee-Morvan, Colom et al.
221.95	Observations of CO and other volatiles in Comet 29P/Schwassmann-Wachmann 1	88, 115, 168, 236	Crovisier, Biver, Bockellee-Morvan, Colom et al.
208.95	A detailed study of selected infall candidates	93, 140, 225	Bachiller, Tafalla, Myers, Mardones
178.95	The dynamics of the outflows around selected T-Tauri stars	96, 109, 144, 146	Menard, Lefloch, Monin, Plazy

0.24 Nov 21 - Dec 5

Ident.	Title	Freq. (GHz)	Authors
69.95	OTF mapping of M31 A pilot study	115. 230	Wielebinski, Neininger, Guelin, Hoerners et al.
169.95	Observation of cold and very cold dust in galaxies with Diabolo	Bolometer	Desert, Bernard, Lamarre, de Luca, Pajot et al.
170.95	Anisotropy measure of the cosmic microwave background with Diabolo at the arcmn scale	Bolometer	Desert, Bernard, Lamarre, de Luca, Pajot et al.
171.95	Observations of the hot gas in clusters of galaxies with Diabolo through the Sunyaev-Zel'dovich effects	Bolometer	Desert, Bernard, Lamarre, de Luca, Pajot et al.
239.95	Dust properties of cold cores in molecular clouds : A diabolo study	Bolometer	Giard, Gaertner, Ristorcelli. Serra, et al.
153.95	Two molecular bars in NGC 4321 ?	229. 109	Sempere, Garcia-Burillo. Combes
237.95	Observations of Jupiter after the comet SL9 collision	88. 115. 230. 260	Marten, Moreno, Lellouch, Paubert
195.95	Sulphure chemistry in diffuse molecular clouds	168, 104	Lucas, Liszt

0.25 Dec 5 - Dec 19

Ident.	Title	Freq. (GHz)	Authors
127.95	A study of the kinematic structure of a low mass star forming region HD20075/NGC7023	[illegible]	Fuente, Martin-Pintado, Cernicharo, rogers
127.95	Probing the HI/H2 transition layer in PDRs (III)	235, 86	Fuente, Martin-Pintado
87.95	Circumnuclear disks and the H_2O megamaser phenomenon	178, 180, 115, 112	Henkel, Wilson-AS, Braatz. Koekemoer
50.95	A search for circumstellar and interstellar $MgCH_3$	88, 110	Ziurys, Apponi, Guelin
156.95	A search for interstellar/circumstellar FeF and FeCl	143, 165, 210, 93	Ziurys, Allen, Guelin
179.95	Did we detect aluminium 26 in IRC+10216 ?	167, 234, 267	Guelin, Ziurys, Apponi. Cernicharo
185.95	CN and HCO+ in the butterfly NGC 2346	226, 89	Bremer, Neri
516.95	Chemistry of protoplanetary disks around GG Tau and DM Tau	250. 270	Dutrey, Guilloteau, Guelin
157.95	Investigating the origin of high velocity wing emission in the Rosette molecular complex	88, 109, 115, 220	Schneider, Stutzki
68.95	Mapping the Cepheus B molecular cloud	109, 110, 220, 230	Guelin, Kramer, Sievers. Ungerechts
172.95	Fragmentation and protostellar collapse in globular filament GF9	98. 147. 219	Wiesemeyer, Guesten

0.26 Dec 19 - Jan 2

Ident.	Title	Freq. (GHz)	Authors
	A search for circumstellar and interstellar MgCH3	88, 110	Ziurys, Apponi, Guelin
	A search for interstellar/circumstellar FeF and FeCl	143, 165, 210, 93	Ziurys, Allen, Guelin
179.95	Did we detect aluminium 26 in IRC+10216 ?	167, 234, 267	Guelin, Ziurys, Apponi, Cernicharo
201.95	Are optical jets associated to high velocity gas in molecular outflows ?	115, 230	Cernicharo, Neri, Reipurth
219.95	Observations of volatile in Comet C/1995 01 (Hale-Bopp) at large heliocentric distances	88, 115, 168, 236	Crovisier, Biver, Bockelee-Morvan, Colom et al.
86.95	Molecular gas in faint blue galaxies at intermediate redshifts	153, 160, 230, 240	Wilson-C, Combes
201.95	Are optical jets associated to high velocity gas in molecular outflows ?	115, 230	Cernicharo, Neri, Reipurth
200.95	Neutral carbon in IRAS 10214+4724	107, 149, 245	Radford, Downes, Kramer. Solomon
164.95	CO(2-1) distribution in a dynamically spectacular ring merger : Arp 118 revisited	112, 224	Gao, Solomon, Downes. Radford
184.95	^{13}CO in ultraluminous galaxies	110, 115	Solomon, Downes
200.95	Neutral carbon in IRAS 10214+4724	107. 149. 245	Radford, Downes, Kramer. Solomon
226.95	^{12}CO J=2-1 observations of G359.93+0.04	230	Echevarria, M-Morris, Figer
163.95	HCN(3-2) observations of ultraluminous IR galaxies	83, 87, 249, 263	Gao, Solomon, Downes, Wild
164.95	CO(2-1) distribution in a dynamically spectacular ring merge: Arp 118 revisited	112, 224	Gao, Solomon, Downes, Radford
184.95	^{13}CO in ultraluminous galaxies	110, 115	Solomon, Downes
123.95	A detailed study of molecular outflow from FU-Orionis stars	230, 220, 109, 219	Eisloeffel, Lefloch, Malbet

7. ANNEX I: TELESCOPES SCHEDULES / 7.2 IRAM Plateau de Bure Interferometer

Project	Conf.	Title	Authors	Molecules	Object	Type
B032	BC	Mapping of CO in 3C48	T.L.Wilson J.Wink S.Guilloteau	CO	3C48	Gal
C061	BC	Morphology and kinematics of the molecular envelope of the planetary nebula M2-9	R.Neri R.Bachiller M.Grewing	CO	M2-9	CSE
D072	CD	The detached envelope of the carbon star TT Cyg	H.Olofsson P.Bergman K.Eriksson B.Gustafsson R.Lucas	CO	TT Cyg	CSE
E008	B2	AU scale structure in molecular clouds (?)	R.Lucas H.Liszt	CCH	NRAO150 3C111	Mol
E012	CD	Search for high density clumps in photodissociation regions NGC2023	A.Fuente R.Neri J.Martin-Pintado C.Rogers G.Moriarty-Schieven	NGC2023	CN	Mol
E014	CD	High angular resolution observations of IRC+10216: a key to the understanding of chemical processes in circumstellar envelopes	R.Lucas M.Guélin J.Cernicharo C.Kahane	C_4H SiS ^{30}SiS $HC^{13}CCN$ C_2H NaCN HNC HC_5N $HCC^{13}CN$ CCS C_6H	IRC+10216	CSE
E016	CD	The missing link: mapping the center of M82 in ^{13}CO	N.Neininger M.Guélin U.Klein R.Wielebinski S.Garcia-Burillo	^{13}CO	M82	Gal
E028	BC	Distribution and excitation of molecular gas in the nearby QSO I Zw 1	A.Eckart L.Tacconi L.E.Tacconi-Garman R.Genzel N.Nakai S.K.Okamura F.Schoniger	CO	IZw1	Gal
E031	CD	Chemistry in the narrow line region of NGC-1068: CS	A.Sternberg R.Genzel L.Tacconi	CS	NGC1068	Gal
E032	B	CO in the nucleus of NGC1530	D.Reynaud D.Downes	CO	NGC1530	Gal
E035	CD	Mapping the infall region of L1527	P.Myers D.Mardones D.Wilner H.Chen R.Forster	HC_3N	L1527	YSO
E037	BC	Molecular filaments in the merging system Arp299	M.Gérin F.Casoli	CO	Arp299	Gal
E039	BC	CO in one selected field in M51	S.Garcia-Burillo M.Guélin	CO	M51	Gal
E041	CD	The envelope of the carbon star RW LMi (CIT 6)	M.Lindqvist K.Eriksson A.Omont B.Gustafsson R.Lucas H.Olofsson	HNC HC_3N HC_5N SiS	CIT 6	CSE
E044	CD	A search for high mass protostars	R.Cesaroni E.B.Churchwell M.Felli C.M.Walmsley	CH_3CN HCO^+	20126+4104	YSO
E048	BC	High resolution CO(3-2) observations of The Cloverleaf quasar at z=2.5	R.Barvainis D.Alloin R.Antonucci L.Tacconi P.Coleman	CO(3-2)	H1413+117	Gal
E054	BC	H40α recombination line in M82	F.Viallefond K.R.Anantharamaiah A.Pedlar T.Muxlow	H40α	M82	Gal
E056	BC	The inner regions of preplanetary nebula II	J.Alcolea V.Bujarrabal R.Neri M.Grewing	^{13}CO	M1-92	CSE
E059	BC	Isotopic CO interferometry of the active binary system T Tau	K.Schuster A.Dutrey S.Guilloteau	^{13}CO $C^{18}O$	T Tau	YSO
E062	CD	High resolution CO observations of the envelopes of evolved stars: IRC+10420	R.Neri V.Bujarrabal J.Černicharo M.Bremer M.Grewing M.Guélin R.Lucas C.Kahane	CO	IRC+10420	CSE
E063	BCD	Are disks focussing young outflows ?	S.Guilloteau R.Bachiller A.Dutrey F.Gueth	^{13}CO $C^{18}O$	L1448 IC348, L1157	YSO
E064	BCD	The SiO jet in IC348 cooling of the shocked gas	F.Gueth H.Zinnecker S.Guilloteau A.Dutrey M.McCaughrean	SiO $H^{13}CO^+$	IC348	YSO
F004	BC	Mapping of CO in a barred galaxy with two young starburst	E.Davoust H.Wozniak T.Contini S.Considère	CO	NGC5430	Gal
F006	Any	$H^{13}CN$ absorption in 3C111	H.Liszt R.Lucas	$H^{13}CN$	3C111	Mol
F007	Any	CO absorption in molecular clouds	R.Lucas H.Liszt	CO	3C454,3 0528+134 1730-130 2200+420 0224+671 0212+735	Mol
F008	B2	Observational constraint on SiO Maser excitation	A.Baudry R.Lucas F.Herpin	^{29}SiO v0 ^{28}SiO v1	OriA IRC2	Oth
F009	CD	The inner anomalous arms of NGC 4258	M.Krause N.Neininger	CO	NGC4258	Gal
F010	CD	NGC 2146: a more distant M 82 ?	N.Neininger A.Greve U.Klein C.D.McKeith	CO	NGC 2146	Gal
F011	CD	Physical structure of the DM Tau protoplanetary disk	S.Guilloteau A.Dutrey M.Guélin	CO CN(2-1)	DM Tau	YSO
F012	BC	CO observations of the center of NGC891	S.Garcia-Burillo M.Guélin	CO	NGC891	Gal
F013	CD	Methanol emission from bowshocks in the NGC1333 IRAS-2 outflow	R.Bachiller F.Colomer S.Liechti C.M.Walmsley	CH_3OH CS(5-4)	NGC133-IRAS2	YSO
F014	BC	Disks around Massive Stars	C.Thum J.Wink	H41α	UCHII regions	YSO
F015	D	Dust emission from young outflows	F.Gueth R.Bachiller A.Dutrey S.Guilloteau	Cont. SiO 5-4	L1157 L1448	YSO
F019	CD	Rotation ? Infall ? Outflow ? Settling the controversy about HLTau	S.Cabrit S.Guilloteau K.Schuster P.André	^{13}CO $C^{18}O$	HL Tau	YSO
F023	CD	High resolution study of the environment of Herbig Ae/Be stars: LkHα 234	C.Dougados S.Cabrit P.André	^{13}CO $C^{18}O$	LkHα234	YSO
F024	CD	Are damped Lyα absorbers superluminous proto-galaxies ?	J.Braine D.Downes S.Radford	CO	PC1643+4631	Gal
F025	CD	The size of CO sources in Mrk273 and 4 other mergers	D.Downes P.Solomon	CO	Mkn273 00262+4251 15030+4835 16334+4630 23365+3604	Gal
F026	B	CO high resolution observations of 2 molecular clouds in the nearby spiral M33	F.Boulanger P.Cox M.Guélin	CO	M 33	Gal
F028	CD	CO observations of the Spiral Structure of NGC6946	F.Viallefond F.Boulanger S.Guilloteau	CO	NGC 6946	Gal

8. ANNEX II : PUBLICATIONS/ 8.1 IRAM PUBLICATIONS

508. CO(1-0) OBSERVATIONS OF THE COOLING FLOW GALAXY NGC 1275 WITH THE IRAM INTERFEROMETER
J. Braine, F. Wyrowski, S.J.E. Radford, C. Henkel, H. Lesch
1995, A&A 293, 315

509. MOLECULAR GAS IN COMETARY GLOBULES : CG4 AND CG6 IN THE GUM NEBULA
E. Gonzalez-Alfonso, J. Cernicharo, S.J.E. Radford
1995, A&A 293, 493

510. ACCURATE RADIO POSITIONS OF SiO MASERS
A. Baudry, R. Lucas, S. Guilloteau
1995, A&A 293, 594

511. VLBI DIFFERENTIAL ASTROMETRY OF THE RADIO SOURCES 1928+738 AND 2007+ 777 AT 5 GHz
J.C. Guirado, J.M. Marcaide, P. Elosegui, M.I. Ratner, I.I. Shapiro, A. Eckart, A. Quirrenbach, C.J. Schalinski, A. Witzel
1995, A&A 293, 613

512. THE OUTFLOW IN THE HALO OF M 82
C.D. McKeith, A. Greve, D. Downes, F. Prada
1995, A&A 293, 703

513. MILLIMETER-WAVE MOLECULAR EMISSION AND ABSORPTION PROFILES TOWARD CASSIOPEIA A
H. Liszt, R. Lucas
1995, A&A 294, 811

514. CO IN THE MAGELLANIC-TYPE IRREGULAR GALAXY NGC 4214
R. Becker, C. Henkel, D.J. Bomans, T.L. Wilson
1995, A&A 295, 302

515. 1.3 MM CONTINUUM EMISSION IN THE LATE-TYPE SPIRAL NGC 4631
Dust in NGC 4631
J. Braine, E. Krügel, A. Sievers, R. Wielebinski
1995, A&A 295, L55

516. NUCLEOSYNTHESIS IN AGB STARS: OBSERVATION OF ^{25}MG AND ^{26}MG IN IRC+10216 AND POSSIBLE DETECTION OF ^{26}Al
M. Guélin, M. Forestini, P. Valiron, L.M. Ziurys, M.A. Anderson, J. Cernicharo, C. Kahane
1995, A&A 297, 183

517. COLD DUST EMISSION FROM THE SPIRAL ARMS OF M51
M. Guélin, R. Zylka, P.G. Mezger, C.G.T. Haslam, E. Kreysa
1995, A&A 298, L29

518. SIMULTANEOUS AND QUASI-SIMULTANEOUS OBSERVATIONS OF THE CONTINUUM EMISSION OF THE QUASAR 3C273 FROM RADIO TO λ-RAY ENERGIES
G.G. Lichti, H. Steppe et al.
1995, A&A 298, 711

519. THE DISTORTED KINEMATICS OF MOLECULAR GAS IN THE CENTER OF NGC 891
S. Garcia-Burillo and M. Guélin
1995, A&A 299, 657

520. λ6cm AND λ2mm H_2CO ABSORPTION TOWARD COMPACT EXTRAGALACTIC MM-WAVE CONTINUUM SOURCES
H. Liszt and R. Lucas
1995, A&A 299, 847

521. THE JET-DRIVEN MOLECULAR OUTFLOW IN L1448
R. Bachiller, S. Guilloteau, A. Dutrey, P. Planesas, J. Martin-Pintado
1995, A&A 299, 857

522. 215 GHZ VLBI OBSERVATIONS: DETECTION OF FRINGES ON THE 1147 KM BASELINE PICO VELETA - PLATEAU DE BURE
A. Greve, M. Torres, J.E. Wink et al.
1995, A&A 299, L33

523. A METHOD OF SEARCHING FOR HIGH-REDSHIFT PROTO-GALAXIES
J.Braine
1995, A&A 300, 20

524. HYDROGEN RECOMBINATION β-LINES IN MWC349
C. Thum, V.S. Strelnitski, J. Martin-Pintado, H.E. Matthews, H.A. Smith
1995, A&A 300, 843

525. COMETARY GLOBULES
II. Observational Tests of Radiation-driven Implosion: The Case of CG7S
B. Lefloch and B. Lazareff
1995, A&A 301, 522

526. Fe I LINES IN LATE TYPE STELLAR UV SPECTRA
A. Greve, C.D. McKeith
1995. A&A 302, 165

527. RADIO OBSERVATIONS OF THE γ-RAY QUASAR 0528+134
Superluminal motion and an extreme scattering event
M. Pohl, H.P. Reuter et al.
1995. A&A 303, 383

528. THE W3 CORE: MASSES, DENSITIES, SIZES AND KINEMATICS
A.R. Tieftrunk, T.L. Wilson, H. Steppe, R.A. Gaume, K.J. Johnston, M.J. Claussen
1995. A&A 303, 901

529. RESULTS ON TYCHO PHOTOMETRY
V. Grossmann, M. Grewing, M.A.J. Snijders et al.
1995. A&A 304, 110

530. A 3D ITERATIVE DEPROJECTION TECHNIQUE. I. Development of the Algorithm and Tests
M. Bremer
1995, A&A. Suppl. 112, 551

531. MILLIMETER-WAVELENGTH OBSERVATIONS OF COMPACT STEEP-SPECTRUM SOURCES
H. Steppe, S. Jeyakumar, D.J. Saikia, C.J. Salter
1995, A&A Suppl. 113, 409

532. A RADIO CONTINUUM SURVEY OF SHAPLEY-AMES GALAXIES AT λ2.8 CM
I. Atlas of Radio Data
S. Niklas, U. Klein, J. Braine, R. Wielebinski
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R. Neri, C. Boucher

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S. Navarro, R. Neri

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A. Karpov, J. Blondel

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F. Mattiocco

CALCULATIONS TO REDUCE THE WEIGHT OF ALU PANELS
D. Plathner

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9. ANNEX III - IRAM Executive Council and Committee Members, January 1995

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