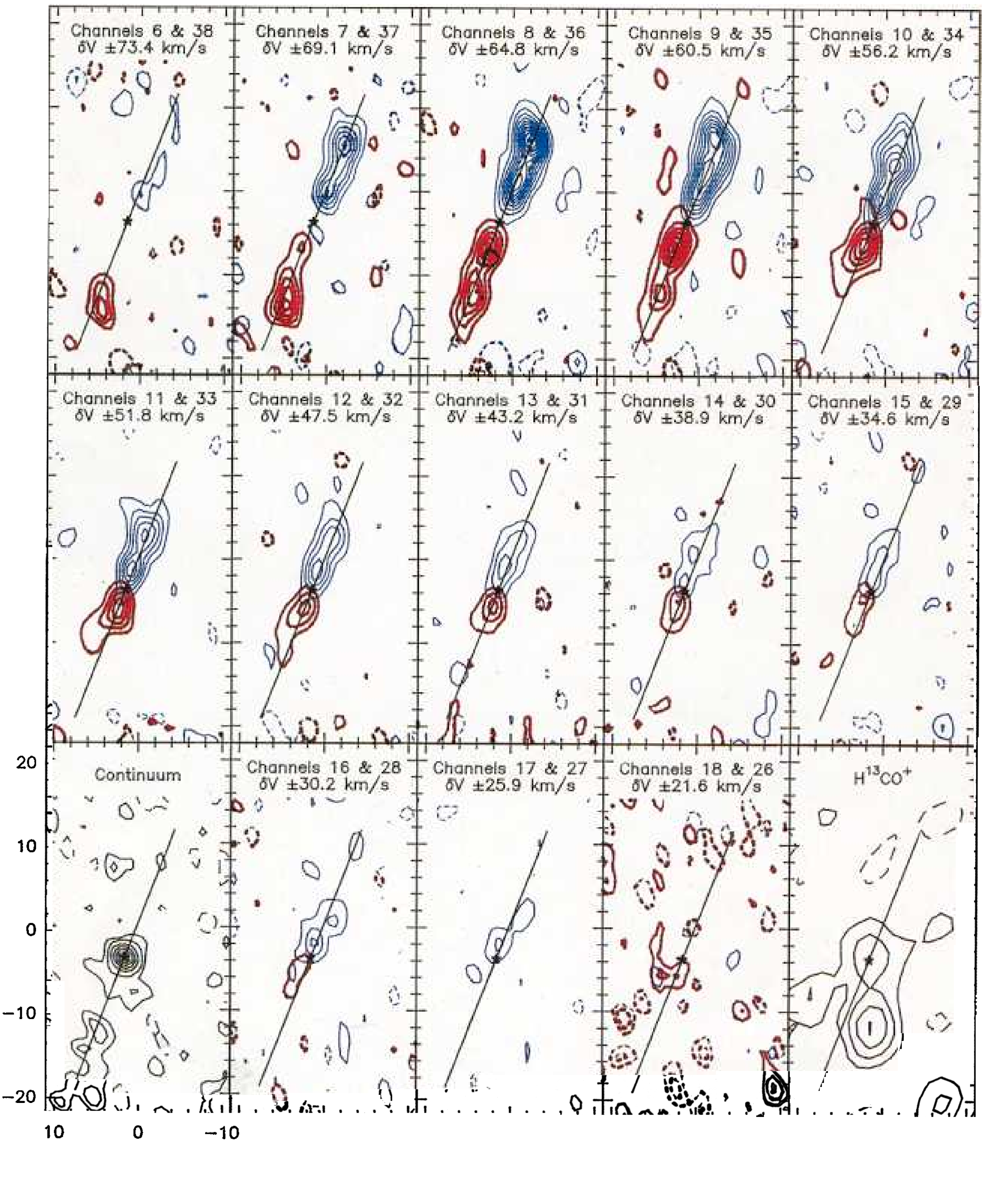
IRAM 1990



ANNUAL REPORT

SiOJ = 2 → and $H^{13}CO^+J = 1$ → maps of the high velocity molecular outflow in L1448 with the IRAM Plateau de Bure interferometer. Spatial resolution is 2.8" by 2.3" for SiO. 2.4" by 2.0" for the continuum emission, and 6.2" by 4.4" for $H^{13}CO^+$. The continuum peak is only 14 mJy, and the lowest contour is 1 mJy per beam (S. Guilloteau et al.).

ANNUAL REPORT
1990

Edited bv

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SUMMARY

From 1979 to 1989 IRAM has been in a build-up phase under the leadership of M. Peter de Jonge as the IRAM Project Director. The very successful development work during this period has been recalled in the last Annual Report and shall not be repeated here. With the 30m telescope on the Loma de Dilar in operation since 1985 and officially inaugurated in 1987, and with the official inauguration of the 3-element interferometer on Plateau de Bure in September 1989, this phase had come to a natural end.

Following a decision by IRAM's Council in 1989, the new Scientific Director and Deputy Director took their offices on January 1st, 1990. While Peter de Jonge has left IRAM in the middle of 1990, Dennis Downes, the former Deputy Director, continues in IRAM as Head of the Astronomy Division.

Basically, all of the original goals, set out in the JIMA report during the 70's, have successfully been accomplished by the previous Direction. The tools are there now, to be exploited by the astronomers from the IRAM member states and beyond.

The only major change compared to the JIMA planning has been the decision to increase the size of the unit telescope for the interferometer from 10-m to 15-m diameter at the expense of loosing one antenna for the time being. However, antenna 4 had never been forgotten, and will now quickly be realized in the coming three years, as IRAM's current biggest investment project. This quick realization is possible only because work on subsystems for this telescope had actually begun already.

The quick realization of the fourth antenna for Plateau de Bure has been made financially possible by Spain's decision to join IRAM as a new member state. Spain will be represented by the Instituto Geográfico Nacional (IGN) while France is represented by the Centre National de la Recherche Scientifique (CNRS), and Germany by the Max-Planck-Gesellschaft (MPG). Spain's contribution will be 6%, applicable also to the past investment.

Scientifically the year 1990 has been a very rich one with both the 30-m telescope and the interferometer being in operation for most of the time, the interferometer since October 1990 for the first time as a guest observer facility. Highlights are summarized in Section 2 of the report.

The demand on the IRAM telescopes has continued to increase through 1990, now making the burden on the Program Committee almost unbearable. The increase is not only caused by more requests from within the IRAM member states, but also from other countries, in particular the US and Japan. This illustrates the worldwide appreciation for the performance of the IRAM facilities.

At the end of 1989 bad storms had hit the telescopes on both sites, and during 1990 we tried to understand the technical and the operational consequences of these events. For the interferometer this unfortunately meant that some major repair/exchange work on the backside cladding had to be done which brought us back into the 2-element mode for several weeks, thereby affecting the final phases of the commissioning. Further interruptions of the 3-element-mode in the future can not be excluded because repair/exchange work on the frontside panels may become necessary.

Technically the year 1990 has brought a lot of progress in the junction fabrication and receiver areas, including a wider and very successful implementation of Niobium SIS junctions. It has been possible (and necessary) to quickly turn over the laboratory development into systems working at the telescopes. This success has eased the receiver situation, and should continue to do so in view of the higher reliability of refractory junctions. In the backend area, it has been possible to finish and successfully test the prototype of the new generation autocorrelator which is expected to go to the telescopes in 1992.

Technical progress has also been made in the manufacturing area by creating an in-house capability for electro-forming, and by putting into operation a microprocessor-controlled milling machine which increases the production accuracy and reproducibility.

To allow the field stations to fully benefit from the development and production capabilities at the Grenoble Headquarter, a special attempt was made to closely coordinate the technical activities at all IRAM sites.

IRAM could not fulfil its role as a service institution without the skill and dedication of all of its staff members. It has been a privilege and a pleasure to Bernard Lazareff and to myself to experience and benefit from the talents of all our colleagues.

2. HIGHLIGHTS OF RESEARCH WITH IRAM TELESCOPES IN 1990

2.1 SUMMARY

The following pages describe a few of the many scientific programs executed at the IRAM observatories, published or carried out in 1990. The main areas of research during the past year have been Galaxies, Young Stellar Objects, Circumstellar Envelopes, Molecules and Solar System studies. Some highlights are:

- Further detections of CO in distant, ultraluminous infrared galaxies, to a distance of ~ 1 Gpc;

- Detection of HCN in Markarian 231, the most distant detection of this molecule so far (~ 200 Mpc);

- Further accumulation of evidence that the far infrared continuum radiation from quasars is thermal emission from dust, and not synchrotron emission;

- Further detections of CO in elliptical galaxies;

- Completion of CO maps of the central region of the galaxy M51;

- A very high ratio of molecular to atomic gas mass in the galaxy NGC 4314;

- Further new detections of molecules in galaxies: SiO, H13CO+, H13CN, HN13C and HNCO;

- IRAM interferometer maps of HCN in the centers of the galaxies Arp 220 and IC 342;

- Studies of the outflow in Orion B and two new outflow sources near Orion KL;

- Discovery of continuum emission from the source of the spectacular outflow in L1448 ; IRAM interferometer maps of the molecular emission in this compact, highly collimated bipolar flow;

- New molecular maps with the 30 m telescope of the DR 21 region;

- Interferometer maps of relative positions of SiO maser components to an accuracy of 0.01 arc sec;

- Interferometer maps of CCH and NaCl in IRC+10216;

- Interferometer map of the outflow from CRL 618;

- Detection of three new radicals: H2CCC, H2CCCC and HCCN;

First radio detections of HDO on Mars and Venus;

Detection of hydrogen cyanide, formaldehyde, hydrogen sulfide and methanol in Comet Austin and in Comet Levy;

Dectection of radio continuum from Comet Austin at a distance of .47 A.U. the farthest radio continuum detection of a comet to date.

GALAXIES

Distant Galaxies (> 70 Mpc)

Deep CO

CO lines have now been detected with the 30 m telescope in about 30 galaxies at distances > 70 Mpc. The CO(2-1)/(1-0) ratio in most of these galaxies is 0.6, as in most nearby galaxies. The most distant detections are at redshifts z = 0.26 and 0.22, which are the farthest CO detections with any telescope to date, and the largest emission-line redshifts yet measured in radio astronomy.

Distant Dense Gas Tracers

The 30 m telescope has also made the most distant detections of HCN in Markarian 231, and of ^{13}CO, CS and HCO+ in Arp 220. These detections indicate prodigious quantities of molecular gas in these distant galaxies, propitious for star formation.

The IRAM interferometer has mapped the HCN concentration in the center of the ultraluminous infrared galaxy Arp 220. The nucleus contains 1010 solar masses of molecular gas at densities of 10^4 to 10^5 H_2 molecules per cm^3. As this gas is concentrated in a central source of diameter 3 arc sec, the inner few hundred parsecs of this galaxy can be considered as a giant, dense molecular cloud.

CO in Markarian Galaxies

CO(1-0) and (2-1) emission has been detected towards the centers of fifty Markarian galaxies and compared with measurements of the dust continuum emission at 1.3 mm. Gas masses derived from CO and from dust are in reasonable agreement, indicating general validity of the H_2 mass to CO luminosity ratio derived in our Galaxy.

Dust Emission from Quasars

Measurements of the continuum emission at 1.3 mm with the MPIfR bolometer on the 30 m telescope now provide impressive evidence that the submillimeter / far infrared radiation from many quasars and radio galaxies is thermal emission from dust, and not a continuation of the non-thermal spectrum present in the radio range. The steep turnover between the mm data from the 30 m telescope and the far infrared data from IRAS is readily explained by dust emission on kpc scales, for nearly all of the radio-quiet quasars. Of radio-loud quasars, all of the steep spectrum and half of the flat spectrum quasars show a spectral dip in the submillimeter range, between the nonthermal radio emission, and the (thermal) far infrared emission. The difference between radio-loud and radio-quiet quasars thus seems to be due to the orientation of the thermal disk, jets and extended radio lobes relative to the observer, as well as to the isotropic luminosities of the quasars (Fig. 2.1).

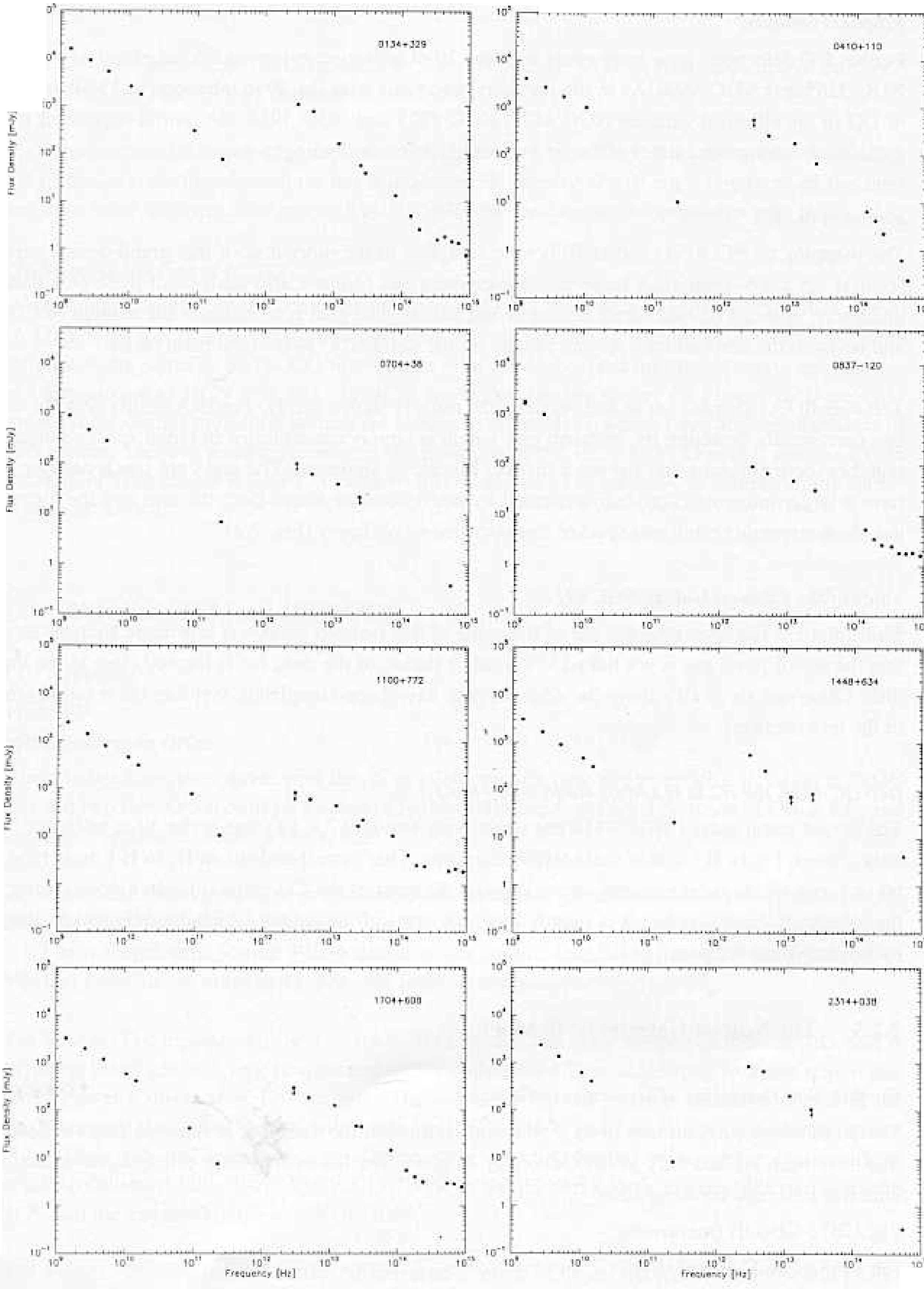


Fig 2-1: Continuum spectra of lobe-dominant radio sources. The data taken with the MPIfR bolometer on the 30m telescope (near 10^{11} Hz in the diagram) show that the far infrared emission cannot be a smooth continuation of the non-thermal radio spectrum, but must be a separate physical component, probably thermal emission from dust.

Nearby Galaxies (10 <D < 70 Mpc)

Elliptical Galaxies

Further CO detections have been made with the 30 m telescope in two additional elliptical galaxies, NGC 3265 and NGC 5666. As in the previous detections with the 30 m telescope in 1988 and 1989 of CO in the elliptical galaxies NGC 4472, NGC 1275 and NGC 3928, the central regions of these galaxies contain several times 10^8 solar masses of molecular hydrogen gas.

Emission in M51

The mapping of $^{12}CO(2\text{-}1)$ and (1-0) is now complete in the inner disk of this grand-design galaxy (central 3.5'x 3.5' region). A large-velocity-gradient and Monte-Carlo analysis of these new data is underway, in terms of cold cores, hot cores and haloes. The goal is to estimate the amount of CO in and between the arms without relying blindly on the standard CO-Av conversion factor.

The overall CO distribution in and between the arms is shown nicely. The IRAM survey is the only one consistently detecting the interarm gas, which is largely concentrated in radial spurs connecting together the main arms and having a distinct kinematic signature. The arms are much broader and have a larger integrated flux than indicated by interferometer maps. Both the arm and the interarm gas show streaming motions expected from density wave theory (Fig. 2.2).

Study of the Edge-on Galaxy NGC 891

Molecular gas has been detected out of the plane of this isolated galaxy. A kinematic analysis shows that the out-of plane gas is not linked to a bend or flaring of the disk, but is located close to the inner disk. Observations of CO along the edge-on disk have been completed, yielding the rotation curve of the inner regions.

In NGC 4314, the H2 to H I Mass Ratio is 60 - to - 1 !

The barred spiral galaxy NGC 4314 has a relatively strong 0.2 K CO line at the 30 m telescope, but only a weak 1 mJy H I line at the Arecibo telescope. This corresponds to an H_2 to H I mass ratio of 60 to 1, one of the most extreme values known. As most of the CO emission is in a nuclear ring, in the middle of the stellar bar, it is mainly the outer arms of the galaxy which are deficient in atomic hydrogen. What happened to it ?

The Nearest Galaxies (< 10 Mpc)

Further New Detections of Molecules in Galaxies

The 30 m telescope continues to be a powerful instrument for detecting in other galaxies molecules that have been studied only in our Galaxy up to now. The list of first-time extragalactic detections with this telescope now includes:

- in 1987: CH_3OH (methanol);
- in 1988: CN, C_2H and HNC;
- in 1989: HC_3N (cyanoacetylene), N_2H+ and CH_3CCH (methyl acetylene);
- in 1990: SiO, $H^{13}CO$+, $H^{13}CN$, $HN^{13}C$ and HNCO (isocyanic acid).

Thermal SiO(2-1) emission was detected in the ground vibrational level towards the nucleus of NGC 253, where its intensity relative to that of other high density molecular tracers is similar to that in hot, dense cloud cores like Orion KL in our Galaxy.

HNCO has been detected in NGC 253, Maffei 2 and IC342, $H^{13}CO+$ in NGC 253, IC342 and M82, while $H^{13}CN$ and $HN^{13}C$ were detected in NGC 253.

Six millimeter transitions of cyanoacetylene (HC_3N) have been studied in the galaxy NGC 253. Most of the gas emitting these lines has a moderate H_2 density of 10^4 cm^{-3}, but some of the lines come from more highly excited gas with $n(H^2) > 10^5$ cm^{-3} and kinetic temperatures > 60 K.

HCN Near the Nucleus of IC 342

The molecular clouds near the center of the galaxy IC 342 have been mapped in the HCN line at 88.6 GHz with the IRAM interferometer, with a synthesized beamwidth of 2.4 arc sec. This resolution is the same as on the CO maps made with the Nobeyama millimeter array, and allow a direct comparison of HCN with CO. In HCN, the higher density tracer, the Plateau de Bure maps show the three central molecular complexes closest to the nucleus, which have angular diameters of 3 to 5 arc sec. There is good agreement in the positions of the HCN and CO peaks, and the CO to HCN ratio in these clouds is 7-to-1, a value typical of the nuclei of galaxies, in contrast to the spiral-arm ratio of 20-to-1.

2.3 YOUNG STELLAR OBJECTS

2.3.1 Outflows

Outflow Sources in Orion

Further studies have been made with the 30 m telescope of a new outflow source in Orion B (NGC 2024) and two new Orion outflow sources, a highly collimated outflow 1.5' south of Orion KL, and another new outflow 2' north of Orion KL.

NGC 2024: The Orion B outflow is very compact and bipolar, in contrast to the powerful, extended unipolar outflow previously known in Orion B. The newly-discovered outflow is associated with the 1.3 mm continuum source FIR-6 and a water maser, indicating that FIR-6 cannot be an isothermal protostar, as suggested previously from 30 m bolometer observations.

Orion South: The bipolar outflow 1.5' south of Orion KL has been mapped in thermal SiO, and is likely to be the origin of a very straight and highly collimated CO jet emanating from the region and extending over a distance of 120 arc sec. The source of the outflow, the second strongest in the Orion A region after IRc2, is the millimeter peak CS3/FIR4, and has also been observed in the CO(7-6) line, with the Kuiper Airborne Observatory, which is further evidence for a hot outflow. The jet's collimation (length to width) is 15:1, one of the highest known, comparable to that in rho Oph A, and the extended outflow in NGC 2024.

Orion North: The new bipolar outflow discovered 2' north of Orion KL has been mapped in CO(2-1), and also detected in thermal SiO and $C^{34}S$. The energy in this new flow is about 0.01 per cent of that in the well-known flow from Orion IRc2.

Extremely High-Velocity Molecular Jets in NGC 1333 (HH 7-11)

The extremely high velocity CO wings found by Lizano et al. (1988) have been mapped with the 30 m telescope, and shown to be bipolar, with high collimation. The wings arise in a flow from the star SVS13, with a terminal velocity of 170 km/s.

Exciting Source of the Spectacular Outflow in L1448

A compact continuum source has been found at the center of symmetry of the L1448 molecular outflow, thanks to bolometer observations at 1.3 mm with the 30 m telescope and to interferometer observations at 3.5 mm with the IRAM interferometer. The source spectrum is consistent with optically thin dust emission, and may come from a disk around the young stellar object which is the source of this outflow. The very unusual fact about this outflow is its high abundance of SiO, which is enhanced ten thousand times over that in the ambient cloud, suggesting that shocks are removing silicon from dust grains.

This continuum source, called RNO 14, has now been mapped in SiO with the IRAM interferometer. The interferometer maps show two highly collimated jets at apparent radial velocities of 70 km/s, centered on the compact continuum object.

A Bipolar Flow in the rho Ophiuchi Cloud Core

The first clear-cut evidence for outflowing molecular gas in the main core of the nearby *rho* Ophiuchi dark cloud has been found with CO(2-1) observations with the 30 m telescope. The new outflow is not driven by any of the embedded near infrared sources in the area, but by a sub-mJy 6 cm source, VLA 1623, which turns out to be one of the strongest millimeter continuum sources in the rho Oph cloud, as shown by bolometric observations at 1.3 mm at the 30 m telescope.

2.3.2 Compact H II Regions

Molecular Maps of the DR 21 Region

DR 21 was one of the first sources to be recognized as a compact H II region, twenty-five years ago. New maps have been made with the 30 m telescope of the molecular cloud structure in the vicinity of this source. The C^{18}(2-1) data at 219.56 GHz show line wings indicating the presence of several outflow sources. Towards DR 21 the $C^{18}O$ emission follows the direction of the outflow seen in the vibrationally excited infrared lines of molecular hydrogen. From the millimeter data, the mass in the western lobe of the DR 21 outflow is 1800 solar masses, and the energy is 7 10^{46} ergs (Fig. 2.3).

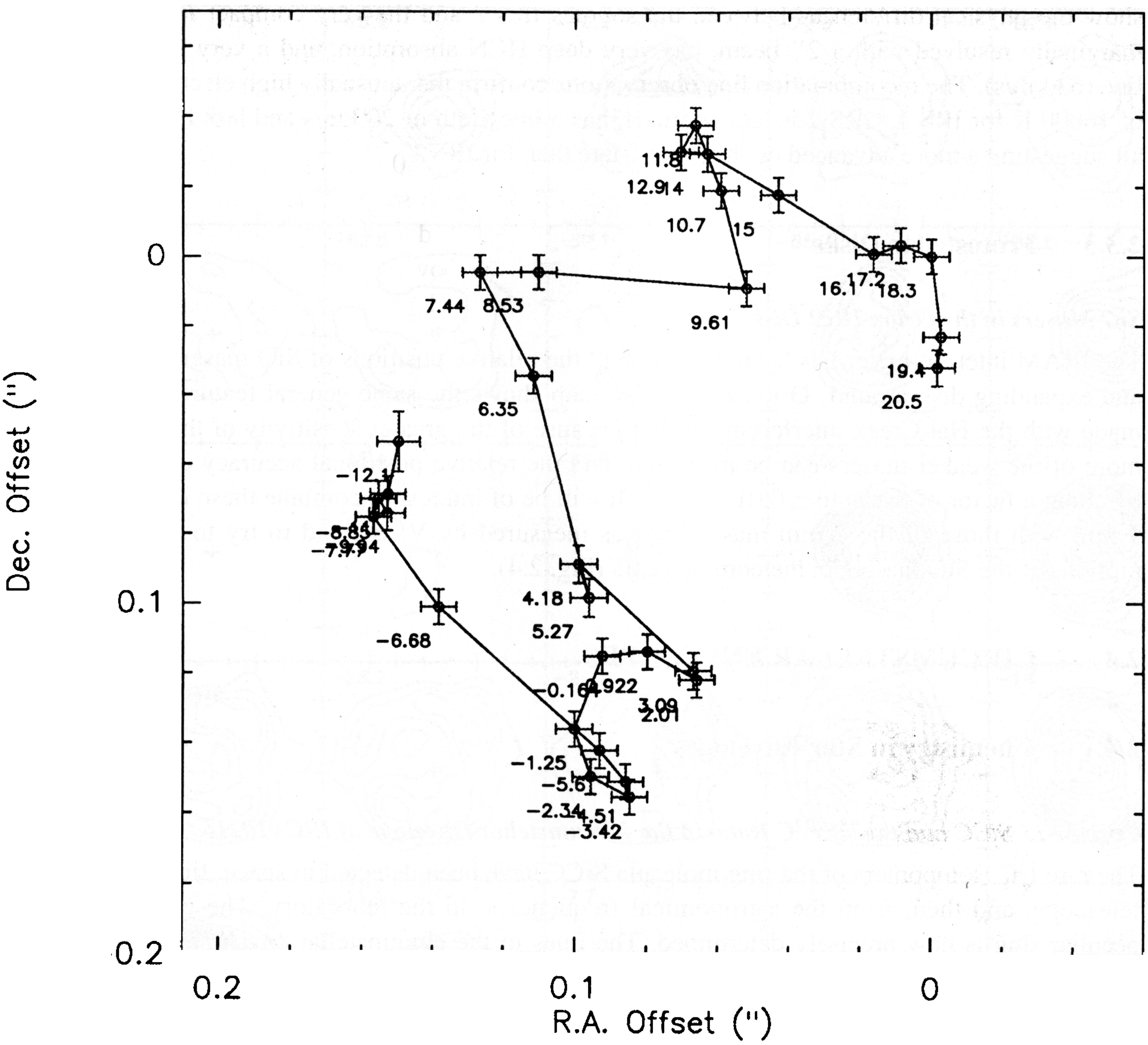


Fig 2-4: Relative positions of SiO masers in Orion-IRC2. Labels are radial velocities, in km/s. The size of crosses shows the error bars of 5 to 10 milli arc sec. The solid line connecting the points traces the direction of the spectrum in velocity space from red-shifted velocities (top right) to blue-shifted velocities (left side).

Continuum, HCN and H42alpha Line Maps of NGC 7538

The compact H II regions in NGC 7538 have been mapped with the IRAM interferometer in the continuum and in the HCN and the hydrogen 42alpha lines. The maps from Plateau de Bure nicely show the physical differences between the sources IRS 2 and the very compact IRS 1: IRS 1 is marginally resolved with a 2" beam, has very deep HCN absorption, and a very broad H42alpha line (63 km/s). The recombination line observations confirm the unusually high electron temperature of 16000 K for IRS 1. IRS 2 is less compact, has a linewidth of 20 km/s and less HCN absorption, all suggesting a more advanced evolutionary state than for IRS 1.

Protostellar Disks

SiO Masers in the Orion IRc2 Disk

The IRAM interferometer has been used to map the relative positions of SiO masers in the rotating and expanding disk around Orion IRc2. The map shows the same general features as in the map made with the Hat Creek interferometer, but because of the greater sensitivity of the IRAM dishes, more of the weaker masers can be measured, and the relative positional accuracy can be improved by about a factor of three, to ± 0.01 arc sec. It will be of interest to combine these measurements at 3 mm with those of the 7 mm maser lines as measured by VLBI, and to try to measure proper motions of the SiO masers in the coming years (Fig. 2.4).

2.4 CIRCUMSTELLAR ENVELOPES

Chemistry in Star Envelopes

Carbon-13 SiCC and the $^{13}C/^{12}C$ Ratio in the Circumstellar Envelope of IRC+10216

The rare ^{13}C isotopomers of the ring molecule SiCC have been detected in space, first with the 30 m telescope, and then, from the astronomical frequencies, in the laboratory. The geometry of this peculiar ring is now precisely determined. The lines in the circumstellar envelope IRC+10216 are strong enough in the rare species (and thin enough in the main species) for accurate measurements of the $^{12}C/^{13}C$ abundance ratio.

Interferometer Maps of CCH and NaCl in IRC+10216

The IRAM interferometer has been used to map CCH at 87.3 GHz in the envelope of IRC+10216. The interferometer maps have been combined with single-dish maps from the 30 m telescope in order to have all of the flux. The maps show limb brightening in a ring of 30 arc sec diameter, over a velocity range -10 to -80 km/s (Fig. 2.5).

The interferometer has also mapped the distribution of salt, NaCl, in IRC+10216. The source of this refractory molecule, found in space for the first time with the 30 m telescope three years ago, has been resolved with the interferometer.

The maps in these two relatively low intensity molecular lines are a good demonstration of the sensitivity of the IRAM interferometer.

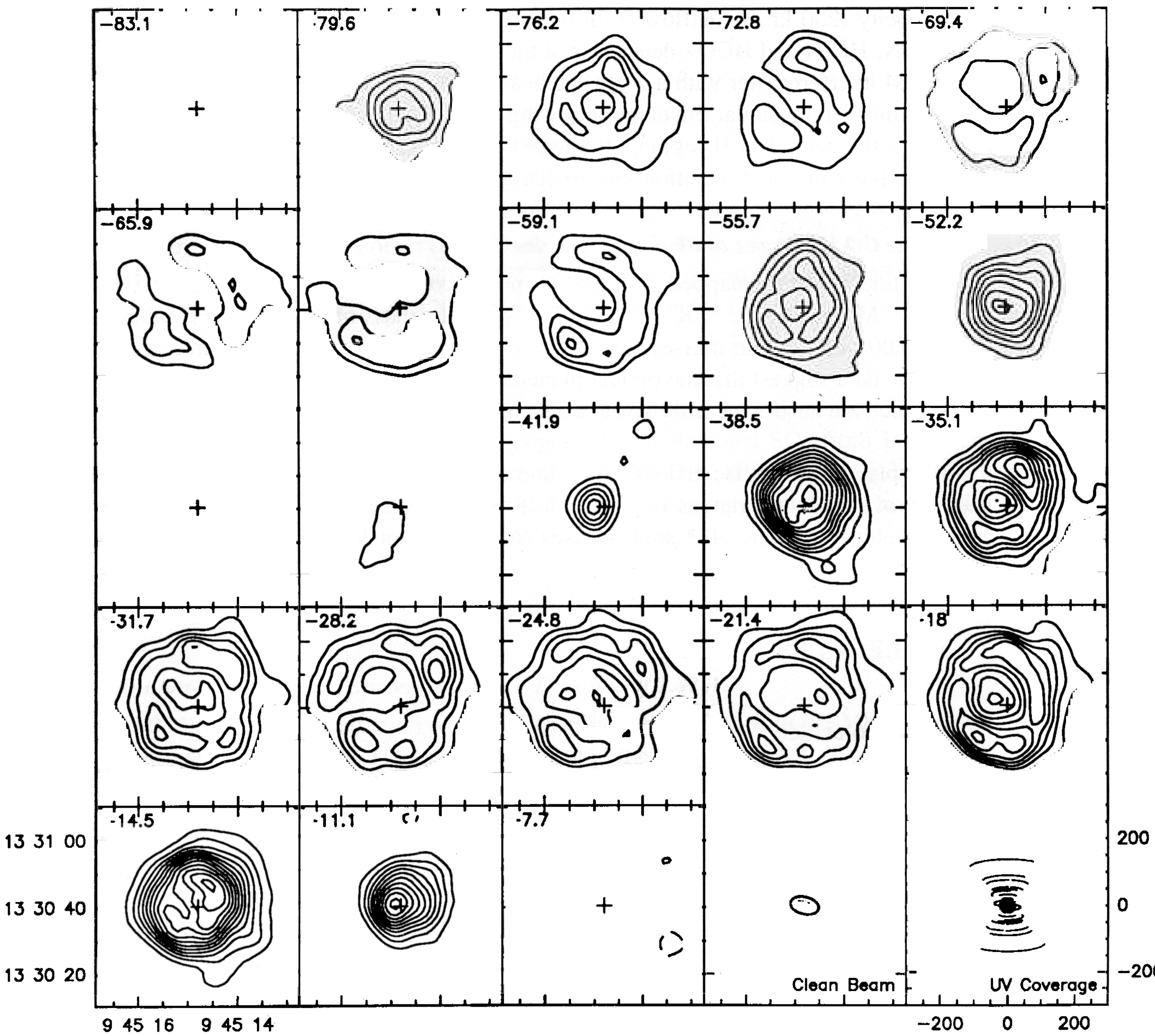


Fig 2-5: Map of the CCH molecular line at 87.3 GHz in the envelope of IRC+10216. The map has been made by combining data from the IRAM interferometer and the 30m telescope.

2.4.2 Post Red-Giant Stages

HCN Flow from CRL 618

The high-velocity (200 km/s) outflow from the protoplanetary nebula CRL 618, reported in 1989 from CO, HCN, HC_3N and HCO+ detections at the 30 m telescope, has now been mapped in HCN with the IRAM interferometer with a 3 arc sec beam. The map resolves the outflow as well as the slowly expanding circumstellar envelope, allowing a precise positioning of these two components with respect to the central H II region. It suggests that CRL 618 has just reached the short-lived stage where stellar winds and radiation start to disrupt the massive envelope.

Structure of the CO Envelopes of Planetary Nebulae

The CO(2-1) line has been mapped with the 30 m telescope with 12" resolution in five planetary nebulae: M1-7, M4-9, M2-51, NGC 7293 and VV 47. The mass of molecular gas in the envelopes ranges from 0.001 to 0.1 solar masses, and the ratio of molecular to ionized gas masses ranges from 0.005 to 5. The data suggest that the optical planetary nebulae are the ionized parts of the molecular envelopes, which are destroyed as the nebulae expand.

In the young planetary nebulae BD+30°3639 and M1-17, the CO(1-0) and (2-1) lines show high speed winds, over velocity ranges of 132 and 78 km/s, respectively. In this compact stage, the molecular envelope contains >0.3 solar masses (in M1-17), at least ten times that of the ionized nebula.

2.5 MOLECULES

New Molecules

Detection of Three New Radicals: H_2CCC, H_2CCCC and HCCN

These radicals, whose spectra have been recently studied in the laboratory, have now been detected in space, with the 30 m telescope. The first of these radicals has been observed in TMC1, M17, W51, and IRC+10216, and the other two in IRC+10216. All three radicals have allenic (double-bonded) linear structures, contrary to the long carbon chain molecules which have been detected so far (e.g. the cyanopolyynes). Their detection opens new perspectives for theories of the formation of interstellar carbon chain molecules, and suggests that they may be the first detected members of two new carbon chain families.

Astrochemistry

Hydrogen Sulfide

A study of the H_2S and SO_2 abundance distributions in half a dozen interstellar clouds is underway, based on 30 m telescope observations of these species with 16" angular resolution.

Phosphorus-Bearing Molecules

A systematic study of phosphorus-bearing molecules (PN, HPO, HCP, PH_3, CP) has been carried out in well-known molecular sources, with the NRAO 12 m and the IRAM 30 m telescopes. New detections were made of PN in six warm star-forming regions, but not in cold clouds or circumstellar envelopes. The molecule CP had been previously detected with the 30 m telescope in the envelope of IRC+10216. This survey yields constraints on the depletion onto dust grains of phosphorus in interstellar clouds: it may be depleted by a factor of 10^3 in warm, dense gas, 10^5 in cold gas, or else the abundance of atomic phosphorus is much higher than predicted by steady state models.

2.6 SOLAR SYSTEM STUDIES

2.6.1 Planetary Atmospheres

First Radio Detections of HDO on Mars and Venus

Deuterated water, HDO, has been observed with the 30 m telescope in emission on Mars at 143.7 and 225.9 GHz, and in absorption on Venus at 225.9 GHz. The D/H ratio is estimated to be about 10 times the terrestrial value on Mars, and 120 times the terrestrial value on Venus.

Sulphur Dioxide Lines From Io

Gaseous sulphur dioxide, SO_2 was observed on Jupiter's moon Io by *Voyager*, and SO_2 frost had been identified on its surface. The 30 m telescope has now detected SO_2 from Io at 222 GHz. These observations imply an SO_2 surface pressure of 4-35 nanobars, which means a column density of 4 10^{16} molecules per cm^2, averaged over the surface. The non-detection of hydrogen sulfide at 169 GHz rules out H_2S as a major constituent of Io's atmosphere.

2.6.2 Comets

Radio Continuum Detected from Comet Austin at a Distance of 1.47 A.U.

In March 1990, the continuum radiation of Comet Austin was detected with the MPIfR bolometer at the 30 m telescope, with a flux of 11±3 mJy. At the time the comet was at a geocentric distance of 1.47 A.U., probably the largest distance at which a radio signal of a comet has been detected. From the radio flux, the grain halo of comet Austin was similar in diameter, grain size, and mass to that of comet Halley in 1986.

Detection of Hydrogen Sulfide and Methanol in Comet Austin

In addition to the continuum detection, line radiation from Comet Austin was also observed with the 30 m telescope; in May 1990 lines of hydrogen cyanide, formaldehyde, hydrogen sulfide and methanol were detected. The first two molecules, HCN and H_2CO, had been previously found with the 30 m telescope in comets Halley and Brorsen-Metcalf. The latter two molecules, H_2S and CH_3OH, had not been seen in comets until now. As H_2S condenses at very low temperatures (< 57 K), its presence may severely constrain theories of the formation of cometary nuclei. As CH_3OH is destroyed by ultraviolet radiation and high temperatures, its presence may mean that comets still contain some of the original matter from the pre- solar nebula.

Further Detections of Molecules in Comet Levy

Comet Levy was observed in August 1990 at the 30 m telescope. As in Comet Austin, molecular lines of HCN, H_2CO, CH_3OH and H_2S were detected at intensities corresponding to production rates of 10^{26} to 10^{27} of these molecules per second. A dozen transitions of methanol were detected, with relative intensities suggesting a rotational temperature of 30 K. All the lines were blueshifted by 0.1 to 0.3 km/s relative to the systemic velocity of the comet, suggesting anisotropic outgassing towards the Sun.

Analysis of HCN in the Stratosphere of Titan

Hydrogen cyanide, HCN, was originally discovered in the atmosphere of Titan by the infrared spectrometer on Voyager 1. The first detection of a radio line from Titan, the HCN(1-0) line at 88 GHz, was made with the 30 m telescope in 1986, and further 30 m observations were continued in later observing sessions. An analysis of these data has now been published. A number of models can fit the data, but they all suggest an increase of the HCN concentration with altitude, consistent with analyses of Voyager infrared data, but with a smaller abundance in the lower stratosphere, and a steeper vertical concentration gradient than predicted by current photochemical models.

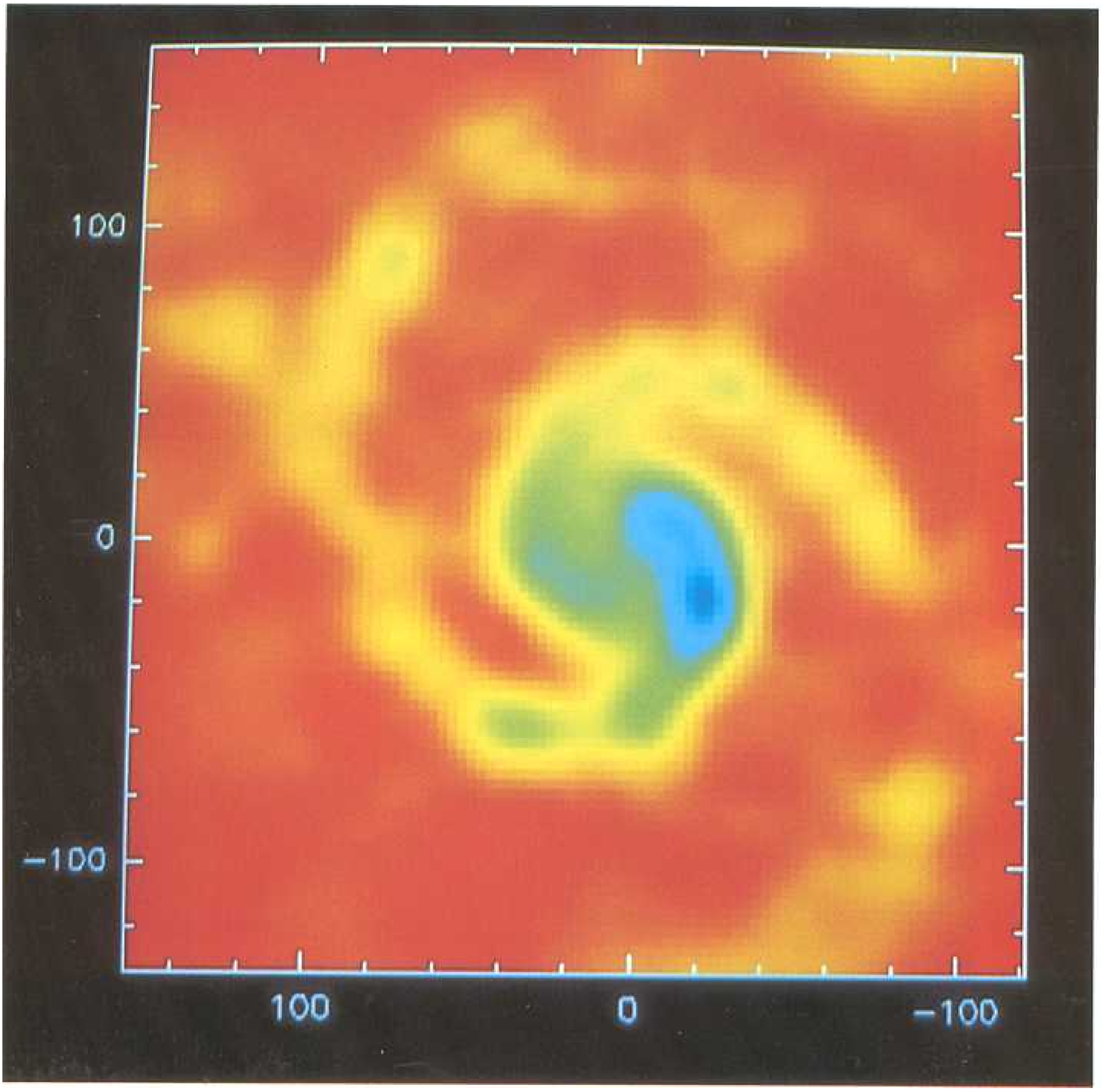


Fig. 2.2: CO(2-1) line brightness distribution in the galaxy M51 observed with a resolution of 12" with the IRAM 30 m telescope (scale in arc seconds). The CO molecule is a good tracer of the beautiful grand-design spiral arms. Note the high arm-interarm contrast.

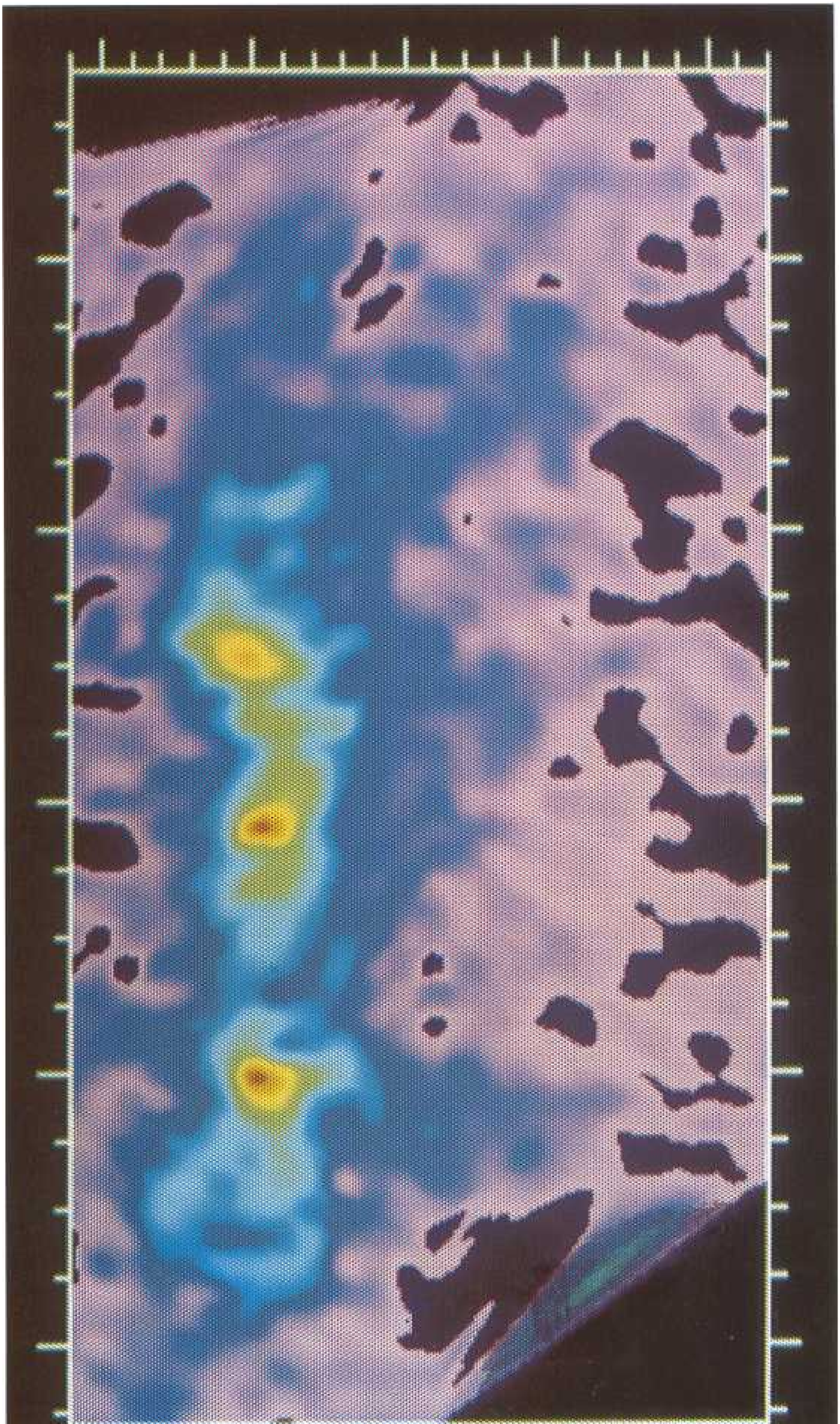


Fig. 2.3: Map made with the IRAM 30 m telescope, of the intensity of the $C^{18}O$ (2-1) line in the DR21 region, integrated from V_{LSR} = -8 to 5 km/s. Resolution = 12 arc seconds = 0.2 pc.

3. PICO VELETA OBSERVATORY

3.1 30-m Telescope Operation

Operation of the IRAM 30-m telescope has been rather smooth throughout 1990, and several significant upgrades of the receiver frontend and backend systems have been made. As in previous years, the telescope was stopped for regular preventive maintenance during 8 hours per week. All heavy maintenance work was concentrated in a 2-week period during October. Only one major break-down occured (simultaneous failure of the 2 azimuth servos on December 5), stopping the telescope for 50 hours. Total down-time for technical problems was 82 h. More than 50 percent of this time would, however, have been lost due to bad weather anyhow.

The wobbler, although occasionally still showing unexplained problems, has been working quite reliably. The system is used heavily (see figure 3.1) and must be regarded as an essential component of the total system.

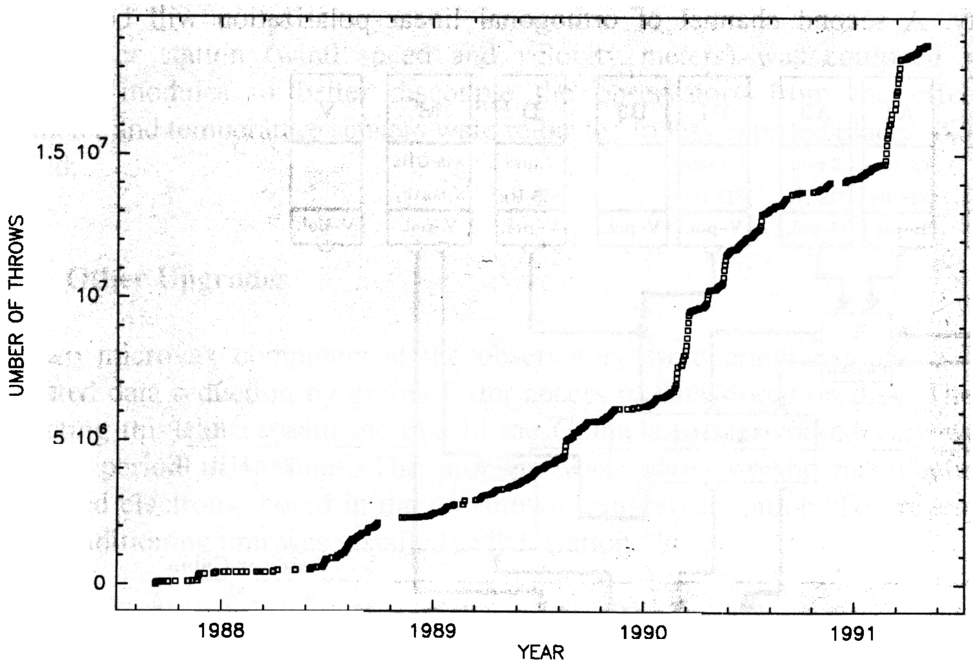


Fig. 3.1: Development of the use of the 30m telescope wobbler system as function of time

3.2 Major Changes of the Observing Environment

The most important improvement occured in June, when after 2 years of development and construction in Granada the new backend distribution box was installed. This box permits to connect under full computer control up to four 1 GHz wide IF signals to any combination of up to nine backends. Figure 3.2 shows the present organisation of the 30-m IF signal chain with the new distribution box. It uses exclusively solid-state components and provides four novel high-quality broad-band detectors for IF monitoring and continuum work. Performance in terms of noise, dynamic range and cross talk is very satisfactory. No problems occured since its first installation.

The control programs OBSINP and OBS were modified for use with the new box, so that the observer has its full versatility available without any manual interaction. For better display of the complex information, OBS was split into 2 screen pages. More complex observing modes, like using 3 or (in the future) 4 receivers simultaneously, are thus greatly simplified.

The installation of a new acousto-optical spectrometer (designed and constructed by the Observatoire de Meudon in collaboration with IRAM-Granada) provided much needed backend power. This AOS covers 510 MHz with 1 MHz wide channels. Its very good frequency and gain stability permits its use in normal total power observing modes with integration times of up to 1 minute. Its carefully matched components produce a spectroscopic baseline of the same quality as the filter banks, and a flexible data acquisition program permits the use of the instrument in switched power. The AOS was opened to general use in June. It is working since then without any serious problem.

A new 3mm Schottky receiver, designed and constructed in Granada with support by the MPIfR, was successfully commissioned in October. The receiver is optimized for continuum observations near 90 GHz. Its first channel has a DSB noise temperature of 140 - 180 K and excellent stability. A second channel of orthogonal linear polarization will be available

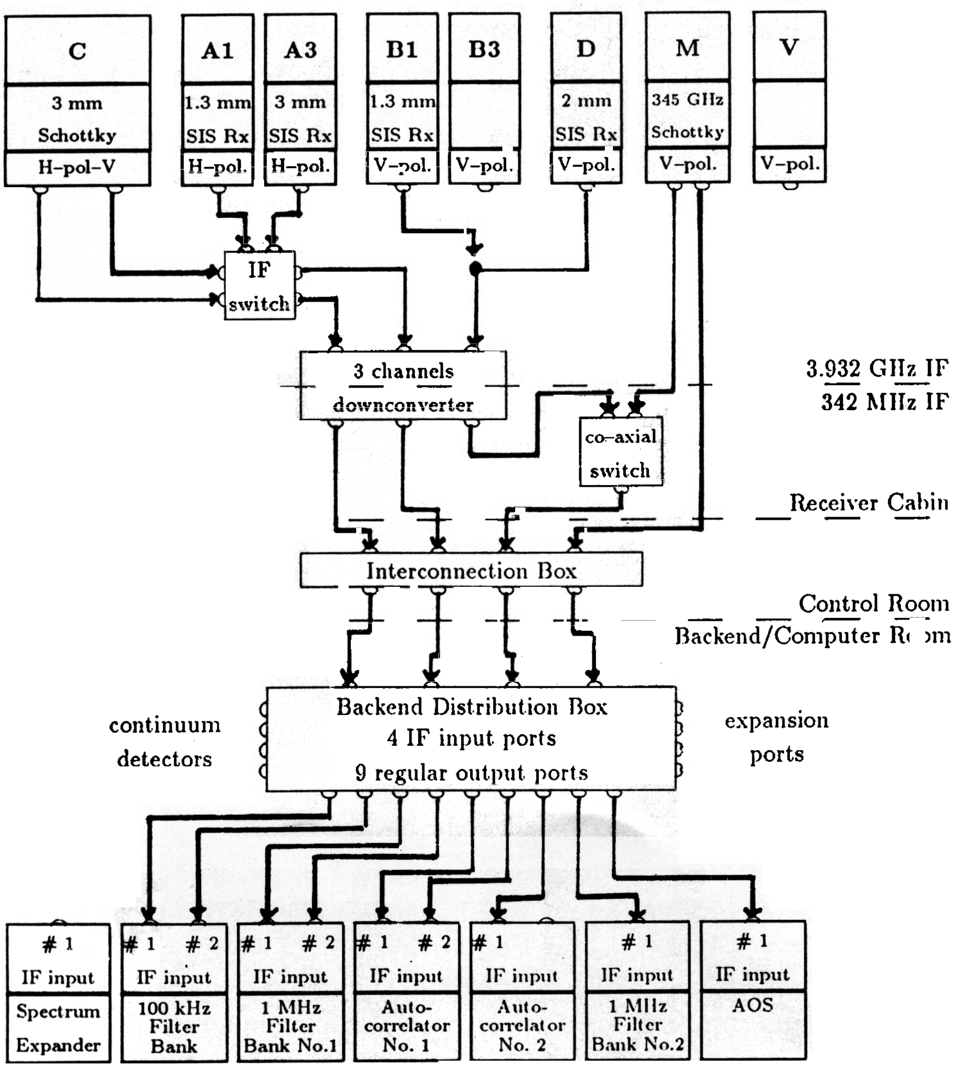


Fig. 3.2: Layout of the new 30m IF signal chain based on the new distribution box

at a later date. The receiver is fully incorporated into the telescope's control program. Switching of IF and quasi-optics components is made in an automatic way, transparent to the observer. The receiver is installed in the Nasmyth cabin to provide the most stable reference position for pointing.

3.3 Observatory Infrastructure

With the installation of a second independant pump and other measures, the operation of the old water line was made more reliable. The supply of water to the observatory worked without any problem throughout the winter.

All remaining components for the second water line are available. Some electrical work remains to be done, before this line will be fully operational.

The new high voltage switches have arrived at the observatory. When installed they will permit rapid switching between the two HV supply lines which the observatory is connected to.

The weather station (wind speed and velocity meters) was equipped with overvoltage protection modules to better discouple the observatory from the effects of lightning. Barometer and temperature sensors were relocated to less exposed places. No further damages occured.

3.4 Other Upgrades

The two microvax computers at the observatory were integrated into a VaxCluster. This facilitated data reduction by giving faster access to data stored on disk. The microwave link connecting this cluster with the one in the Granada office worked very well except for an extended period in summer. The problem was solved by the manufacturer replacing an overheated electronic board in the downtown transceiver station. To prevent further damage an air conditioning unit was installed in that station.

New couplers have been installed in all encoders. Due to their more symmetrical construction they are expected to cause smaller drifts of the encoder reading with changing temperatures. First measurements of 2 of the 4 new couplers indicate that the temperature coefficient is indeed 2 to 3 times smaller than with the old couplers. The long term pointing stability is compatible with such an improvement.

A new procedure was developed to measure the small scale encoder errors. Now these errors can be determined for all encoders within a few hours, i.e. about 20 times faster than it was possible before. A systematic measurement revealed a problem in one encoder (aging?), but with the help of correction values installed in the encoder electronics all errors were reduced again to well below 1".

For holography a special transmitter working at 96 GHz was constructed. The instrument was installed outside of a cabin on the peak of Pico de Veleta during the January holography session. Very satisfacory gain and frequency stability were obtained. Several maps of the telescope aperture were obtained. Their analysis showed the surface rms to be of 65 ± 14 µ.

In the context of preparing the observatory for VLBI observations a Rubidium clock has been installed, improving the stability of the observatory's time base by 2 orders of magnitude. Also, a GPS receiver systen has successfully been installed. The modifications of the drive program which are necessary for VLBI are under way.

3.5 Development Work

Work of the Granada laboratory concentrated on the development of a system for computer control of receiver tuning. The design of all electronics boards and their interface to a PC and possibly the antenna control computer is finished. A first stage of a prototype including the PC control of many of the basic servo functions (Gunn oscillator, phase lock etc.) is operational. The control software will allow to set parameters from a look-up table and fine-tune them interactivelv.

In the backend area, a design was studied for a new IF processor for the 1 MHz filter banks. It will replace the old units with modern ones based on a modular design and solid-state components. Its new oscillators will permit to synthesize a 1024 MHz contiguous bandwidth apart from the more standard configurations.

For the next generation spectral correlator being constructed by the Grenoble backend group a prototype phase-locked oscillator (L04 at 820 MHz) was built.

3.6 Other Activities

The remote observing station in the Granda office was used regularly with good success by both the Granada staff and other experienced 30-m observers. Observations in the simpler observing modes can be carried out as efficiently as from the telescope itself. Remote observing has also been tried from Grenoble but so far only on an experimental basis.

For the first time since the introduction of the value added tax in Spain, the Granada office was successfull in obtaining a (partial) refund of the its VAT expenditures during 1988 in Spain.

A new car was bought to replace the aging Renault 4.

4. PLATEAU DE BURE INTERFEROMETER

4.1 Operation of the 3 Antennas

This was the first full year where all 3 antennas have been available in the array, resulting in maps, spectra, and structural studies, some of which have briefly been described in chapter 3. For the first time, it has been possible to execute a number of guest observer programs that had been recommended by the Program Committee.

The interferometer is now regularly run by two operators and one astronomer on the site. Various "quick-look" facilities are available to assess the quality of the data before changing to a new configuration. With the growing experience it has been possible to increase the level of automation of the observing procedures. This has led to an increase in the overall system efficiency.

Pointing Studies

We have understood and corrected the inclinometer's data, and a better fit to astronomical measurements has been achieved. However, diurnal variations in the inclination of the azimuth axis were shown to reach 6" peak to peak, which are very probably caused by thermal effects (Sun, wind). New LEICA inclinometers with improved sensitivity and stability will be purchased to study these effects in detail. The pointing even at 3mm can still run into slight difficulties, and it is clear that observations at 1mm will require further improvements of the pointing model, the fitting procedure, the controls etc.. To help in this direction, the mechanics of the optical telescopes has been improved, and a third TV camera has been purchased to avoid any change-overs between antennas in the future. Interferences (from switched DC power supplies for the Az and El motors) are still perturbing the 2 less sensitive cameras; inexpensive as compared to the one with an image intensifier, they now need filters and stabilizers at the level of their own DC supply.

Other Upgrades

New terminals to replace old equipment in the control room have been ordered. The computer configuration with one microVAX 3400 for real time control and a second one for data reduction, both sharing the same disks, has been very stable . It is possible to keep data for one week before transfering them to Grenoble via high density cassettes.

While the rear claddings of antennas 1 and 3 have been improved, in particular by exchanging the silent-blocks, antenna 2 has not yet been refurbished. As a consequence, its operation is still restricted to low wind speeds, a time-consuming precaution (enter into the hangar every time when the weather forecast predicts winds in excess of 60 km/h; then return to station, re-do pointing and baseline routines). The front surface panels (A1 and A2 mainly) show a steadily increasing number of small defects which are found during inspections and sealed off by stickers to avoid their growth. Discussions are under way with the manufacturer, to find a long-term solution to this problem.

4.4 Cable Car

On the cable car, due to wear created near the counterweight rollers in the lower station (after more than 10 years of service), we followed APAVE advice to slide down 18m of both support cables, taken from the reserve on drums at the upper station. This work was completed in September by TREFILUNION, who supplied the cables, and successfully verified by APAVE again. To avoid a repetition, discussions are going on with POMAGALSKI, the main cable car builder, to modify the construction.

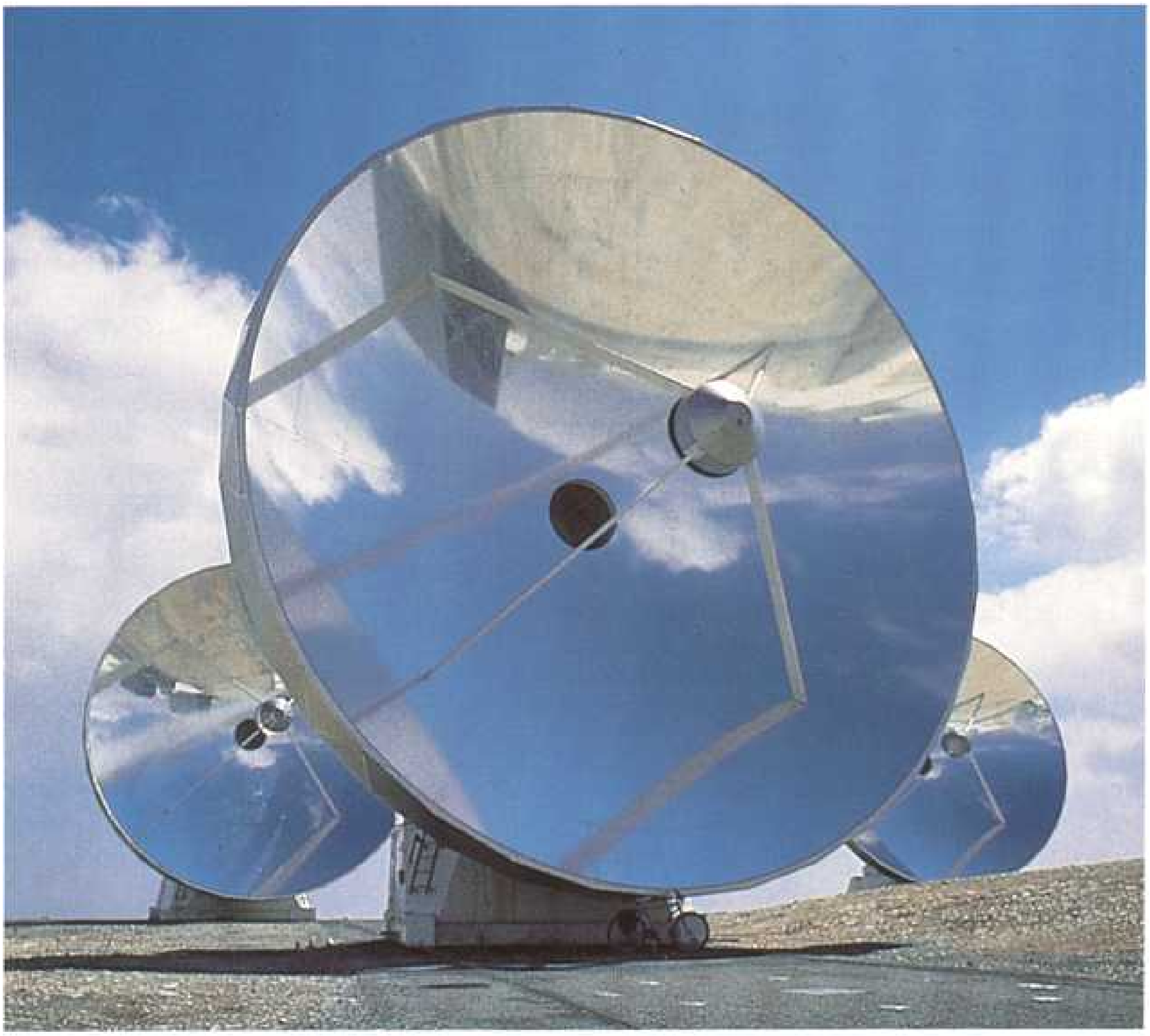


Fig. 4.1: The first three 15-m dishes of the IRAM interferometer on Plateau de Bure

5. GRENOBLE HEADQUARTERS

5.1 SIS Group and Receiver Group Activities

5.1.1 General

The outstanding development in the receiver area for 1990 was the successful implementation of Nb junctions in 80-115 GHz receivers on the 30-m telescope and the PdB interferometer. While the performance of these receivers is equal or better than that of their Pb-based counterparts, their reliability is significantly improved. Junctions and complete receivers can now be stored and transported at ambient temperature, and a cryogenics fault is of no consequence for the survival of the junction. The changeover to Nb junctions is actively pursued at other frequencies.

5.1.2 Junction Fabrication

Nb/AlOx/Nb junctions are more stable than our traditional Pb/Bi junctions. The SIS group has therefore taken up the fabrication of this type of junction, and has reported last year the production of large area (approx 50 sq. micron) devices. At present the minimum area that can be fabricated is 1.5 sq. micron. The anodization spectroscopy process has been implemented and is a valuable diagnostic tool. Junctions have been made for various frequencies as described below:

100 GHz. Two receivers with Nb junctions are now in routine use, one on Plateau de Bure, the other on the 30-m telescope in Spain. Junctions of this type have also been delivered for mixer and direct detection experiments to the MPI für Radioastronomie in Bonn.

230GHz. The success at 100 GHz has motivated us to start the development of junctions for 230 GHz. Such junctions are shown on Fig.5.1. They will be tested early in 1991.

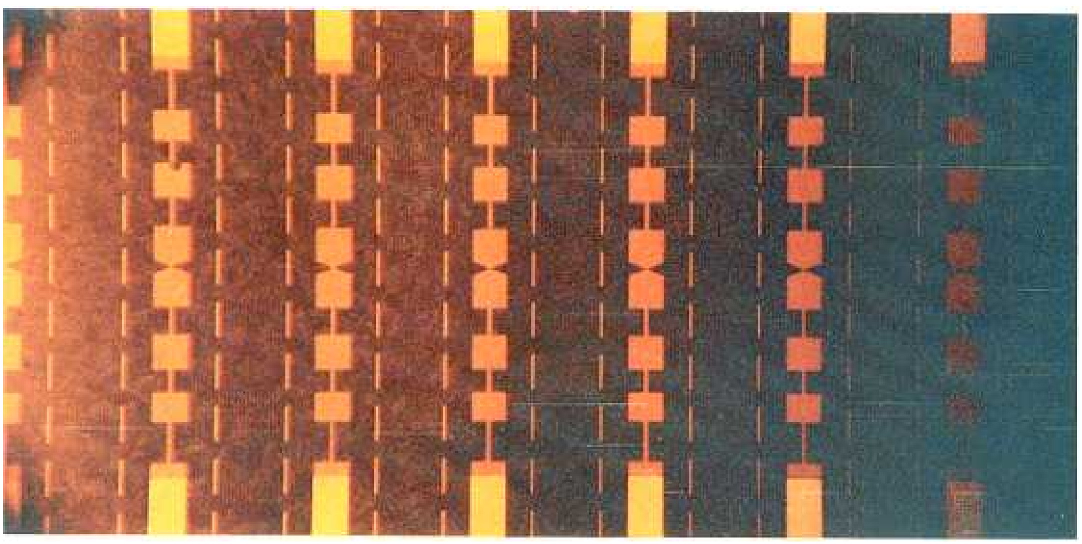


Fig. 5.1 The first 230 GHz Niobium SIS junctions designed and produced in IRAM

345 GHz. Junctions for waveguide mixers have been fabricated for IRAM and for the MPI für Extraterrestrische Physik in Garching. Junctions with log-periodic antennas have been fabricated for IRAM and for the MPI für Radioastronomie. Only a few of these junctions have been tested so far, and the process is not optimized yet.

690 GHz. These junctions with integrated V-antennas have been made in our laboratory by a member of the MPI für Extraterrestrische Physik.

SIN junctions. In these junctions one superconductor is replaced by a normal metal (N). SIN junctions have no Josephson effect which can interfere at high frequencies with quasi-particle mixing. We have developed two types of Nb-based SIN junctions.

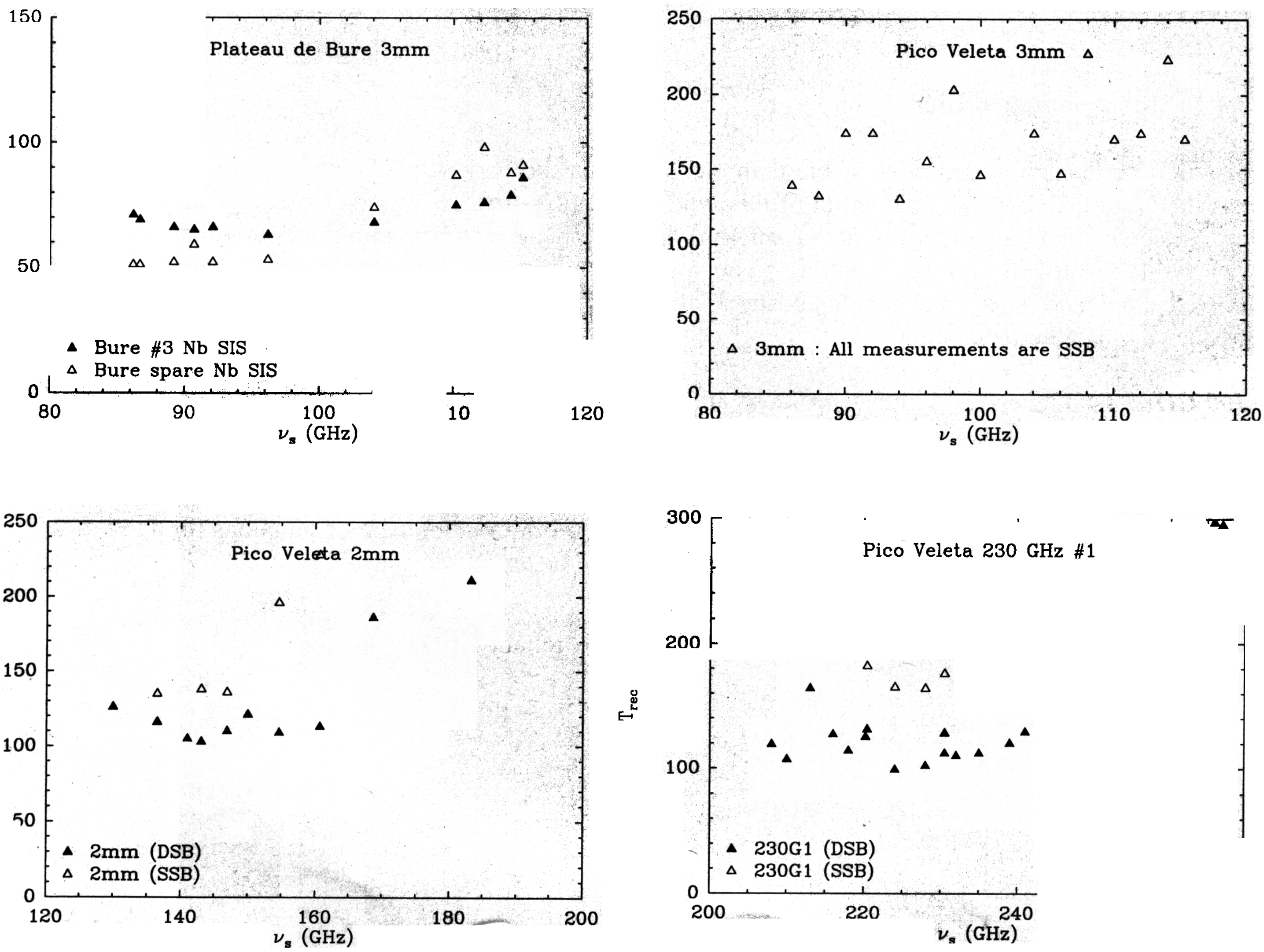


Fig. 5.2: Performance of SIS receivers on the Plateau de Bure and Pico Veleta receivers
Top: Niobium SIS receivers for the 3mm band
Bottom: Lead/Bismuth SIS receivers for the 2mm and 1.3 mm band

Receivers for 30-m Telescope

The cryostat for the 3-mm receiver was replaced in July, with replated screens to improve the hold time. A 3-mm mixer with improved block design and Nb SIS junction was installed in October. Its performance is the best ever achieved at the 30-m (see Fig. 5.2).

Following a failure of the cryogenic system, the 1.3-mm receiver #1 was entirely replaced in October. The hold time is now close to 7 days, and the receiver temperature is equal to the best ever obtained at the 30-m (see Fig. 5.2).

Following also a cryogenic failure, the junction of the 2-mm mixer was replaced in December. The performance of the present system is also quite good (see Fig. 5.2).

Receivers for the PdB Interferometer

The LO systems have been replaced in all three antennas with new systems using 85-115 Gunn oscillators, thereby eliminating the triplers and simplifying the tunings. One of these oscillators was built in IRAM.

A 3-mm mixer using a Nb junction was installed in Antenna #1 Its performance is shown in Fig. 5.2).

A complete 3-mm receiver using a Nb junction is ready for replacement of the Pb-based receiver of antenna #3.

Laboratory Work

Besides the full receiver replacements mentioned above, two more MkIII cryostats have been fully reconditioned and will be used for replacement of the 30-m 2-mm and 1.3-mm #2 receivers.

The prototype closed-cycle cryostat (MkIV) works quite reliably. The situation is not as satisfactory for the pre-series unit: the acceptance tests, started in July, have met with numerous problems.

Many 3-mm Nb junctions have been tested (some of them provided by the Ecole Normale Supérieure). Very good performance is obtained, around 50K DSB T_{Rec}.

Several Gunn oscillators (70-90, 85-115 GHz) and frequency triplers (210-270 GHz) were built and tested.

The design of the cryostat, its layout, and the optics for the 4-channel systems to be installed in the MkIV cryostats is completed. Waveguide injection of the L.O. has been adopted for reduced cross-talk and minimum signal loss.

The ESTEC contract for the study of 230/345 GHz SIN mixers was concluded. Although the junction characteristics were as good as could be expected, the mixer performance -in agreement with model calculations was significantly worse than with SIS. The contract was not renewed for phase 2, because no agreement was reached on a work package that would justify IRAM's involvement.

A Hewlett-Packard 8510 20 GHz network analyzer has been installed. By using IRAM-built harmonic mixers and other equipment, this analyzer has been extended to the millimeter range. First tests in the 3-mm band show an impressive 50-dB dynamic range. Extension to higher mm-bands is planned for 1991.

Intensive modelling studies of the waveguide mixers have been pursued. Good agreement between theory, scale measurements with the network analyzer, and actual measurements have greatly enhanced the understanding of waveguide mixer structures. Innovative designs will be tested in 1991.

5.2 Backend Developments for Year 1990

The development of the new generation of digital correlation spectrometers has entered the phase of system assembly. One unit and the relevant modules have been assembled and are under test. The final production will consist of 6 such units for the Plateau de Bure interferometer, and 2 for the 30m telescope (the number of units for the Plateau de Bure interferometer has been raised this year from 4 to 6).

The design and production of all components belonging to one unit has been finalised and all the boards and modules are waiting for system acceptance before being mass-produced. The aim of the test is to discover system effects (interference, overload, etc.) which can be reduced by minor module design modifications, before the module itself is reproduced. The system behaviour will then be largely predictable at delivery time, so the 8 units will probably require minimal interactions during their life on the sites.

All the hardware (modules, racks, wiring...) will be assembled by subcontractors. The first set of modules has been dispatched to several of them to select the best quality/price service.

The components which will be used, have been listed, and the most critical ones were ordered in quantity to prevent shortage, which often occurs on silicon products.

Module test facilities have been developed simultaneously in view of a fast commissioning of the equipment next year.

5.3 Computer Group

In 1990, two communication lines to the outside world were installed: one to the French packet switched network (TRANSPAC), and then to any network of this type. DECNET protocol is supported to remote connection, file transfer and mailing.

The other line is linked to SPAN (Space Physics Analysis Network), a restricted DECNET network. The synchronous communication performs at 9600 bauds.

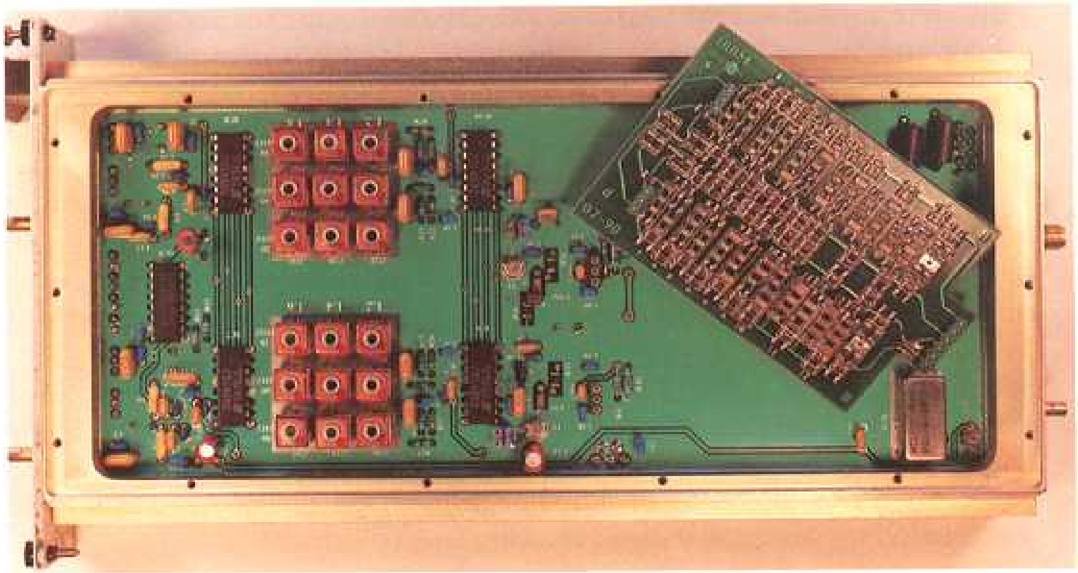


Fig. 5.3: Backend module for the next-generation IRAM digital correlator

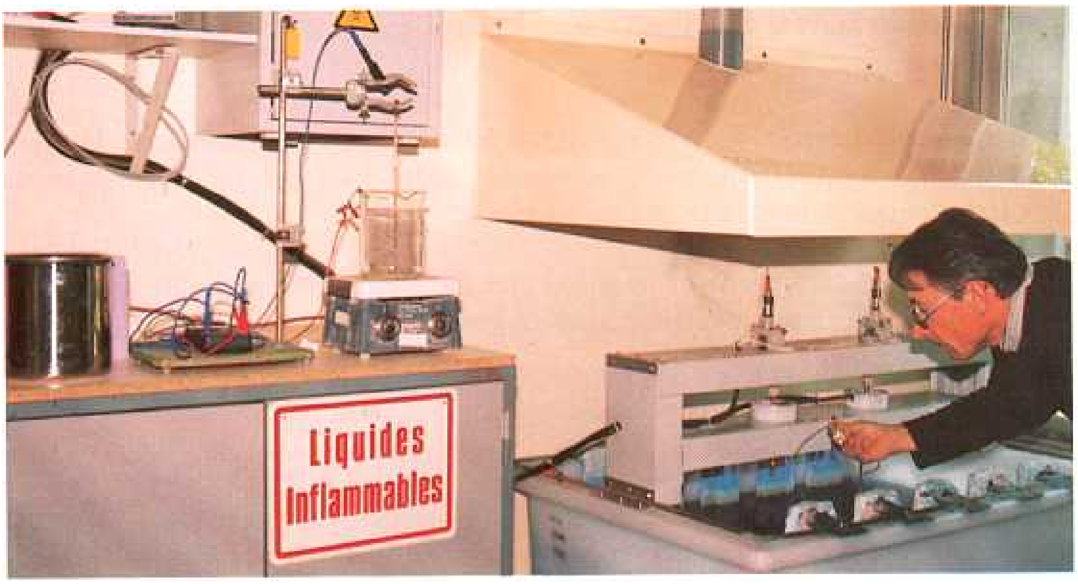


Fig. 5.4: Electroforming bath for receiver components

Fig. 5.5: Metrology bench in the IRAM mechanical workshop

Tests were carried out to select new PC 386 for technicians and astronomers. The specific requirement was to be compatible with DEC PC LAN communication, and to support X windowing. By the end of the year, five PCs were ordered, two for astronomy data reduction, and three for general purpose (development and management).

The TCP/IP protocol was installed on the development VAX VMS system. With the acquisition of the corresponding product for the VME system, this protocol becomes a standard means of communication between all machines including the new to come UNIX computers. For the future correlator, it will replace the CERN product tested last year.

A laser printer was installed on Bure, and the microVAX station cluster was upgraded with more memory (16MB for machine IRAM02) and new Winchester disks (2 times 766MB).

The Computer Group contributed to the selection, the purchase and the installation of the PC work station for computer-assisted drawing.

The Computer Group furthermore searched for a solution to the limited user licence problem of the VAX work station cluster and proposed a new microVAX 4000 as a server both for the VAX cluster and for the PC network. The new machine was ordered by the end of the year to be installed in early 91.

With this new server, the VMS cluster should be stable for some time. The next purchase will concern a RISC/UNIX work station in order to meet the special needs of extensive interferometer data reduction.

Data acquisition (correlator product) and the receiver control software for Plateau de Bure have further been improved during the course of the year.

5.4 Technical Group

This group was founded in IRAM only 1 ½years ago. One of its tasks has been to improve the interface between design activities for and the manufacturing of micro-wave components, receivers and antennas by providing advice on the choice of materials and their manufacturing aspects to the groups concerned.

A second very important task, which will continue into the future, has been the development of new manufacturing techniques. This was helped by several major investments like the purchase of a numerically controlled milling machine, the improvement of the equipment in the control room, the creation of a new laboratory for electro-forming, and the purchase of a CAD work station.

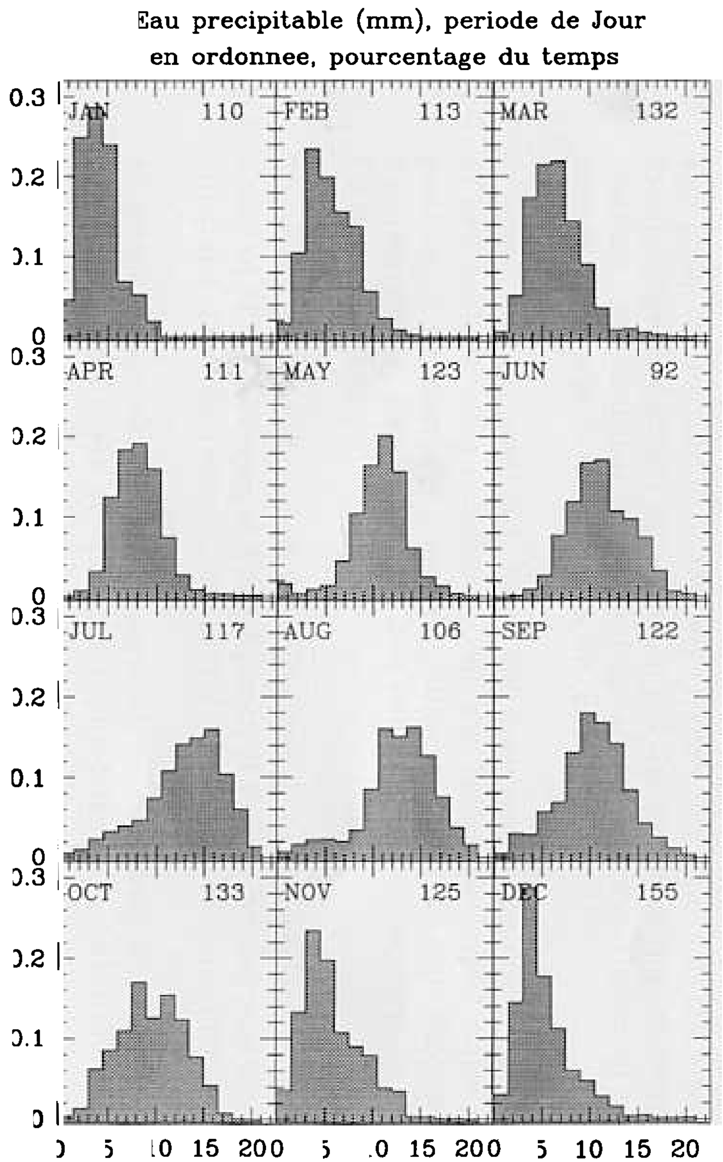
The overall number of requests for manufacturing has clearly increased during 1990, reaching a total of 213. This comes as a consequence of various development activities in the receiver group and at the observatories, and is likely to continue for some time.

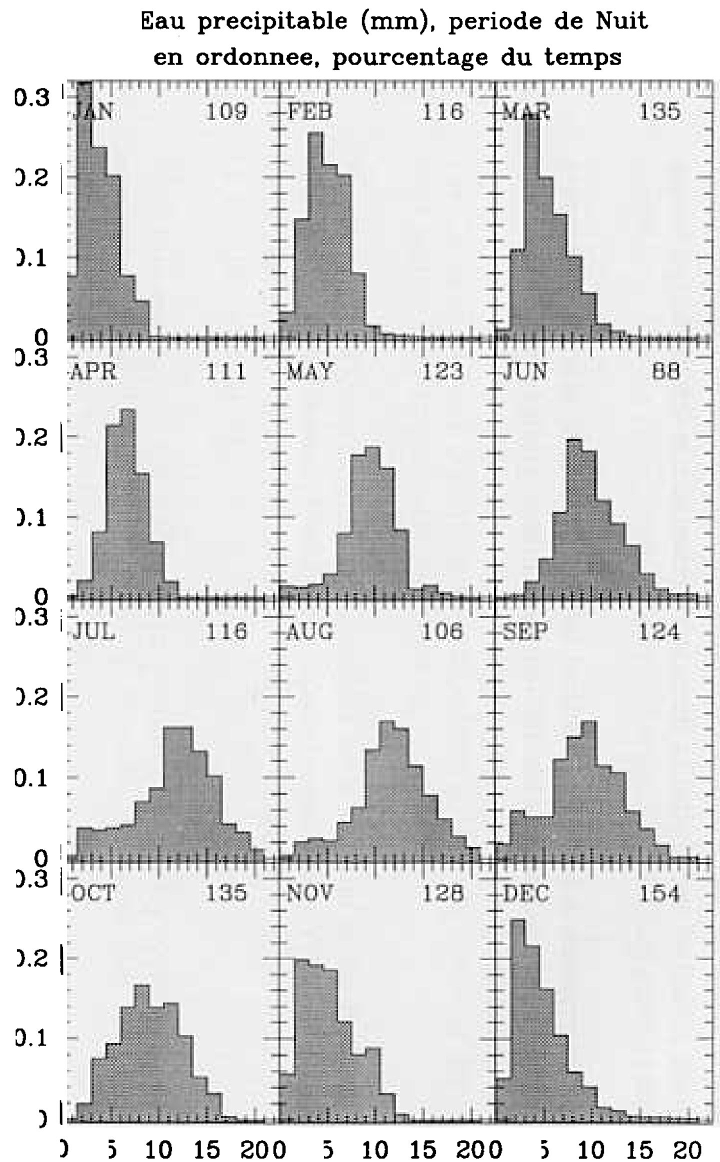
In order to cope with this heavy work load, manufacturing was executed to a large extent by contractors. This mode of operation required that the work had to be well documented, including a clear set of specifications and acceptance criteria, as well as closely monitored during the fabrication phase.

The technical group also assured the technical follow-up of the 3 telescope mounts on Plateau de Bure, and was responsible for the administration of the related documentation and drawings, inluding their updating in the case of modifications or improvements.

Recently, the group took under its responsibility the construction of the 4th telescope mount (to be finished in autumn 1992).

Furthermore, to exchange experience in the mechanical field and in view of a possible future collaboration, the group got into touch with the corresponding groups at the MPI für Radioastronomie/Bonn and at the University of Cologne.





Statistics of the precipitable water column above Plateau de Bure based on data collected between September 1985 and January 1991 during a total of 34632 hours, (i.e. the data are not completely contiguous and not evenly distributed). The calculations based on temperature and humidity measurements have been performed by G. Duvert, Laboratoire d'Astrophysique, who kindly has made these figures available to IRAM.

6. PERSONNEL AND FINANCES

During 1990, the total number of persons employed by IRAM was 102, including the Spanish Co-director of the Granada station. Of these 101 persons, 91 are IRAM staff members and 10 are PhD students or post-docs, 6 in Grenoble, and 4 in Granada.

One of the staff positions in the SIS laboratory is jointly financed by the MPIfR and the MPI für Extraterrestrische Physik. The MPIfR furthermore finances one post-doc position in Spain. One of the students has a French/Spanish scholarship, and the Spanish Co-director is paid by IGN.

IRAM's financial situation in 1990 and the budget provisions for 1991 are summarised in the following tables.

The total costs in 1990 were higher than originally planned, mainly due to the change of the IRAM Direction.

During the year, 1.6 MF were invested in new equipment for laboratories, and 1.5 MF were paid to MAN for reflector panels for the 4th Interferometer antenna. Further investments were made in receiver and backend construction (1.5 MF), computer purchases (1 MF), administration and transport (0.6 MF) and infrastructure improvements for Pico Veleta (0.6 MF).

Income other than contributions was lower than foreseen due to delays in income from outside contracts.

During the year, the problem of the reimbursement of Spanish Value Added Taxes was partially resolved. The tax office reimbursed the V.A.T. for 1988, but the taxes for 1986 and 1987 have not yet been paid back to IRAM.

The Instituto Geografico Nacional (IGN), Madrid, joined IRAM as an official partner on 28 September 1990. IGN now participates with 6% of the annual operations and investment budgets, as well as with a one-time contribution for the earlier IRAM investments.

Budget 1990

Expenditure

Budget Heading	Budget K FF	Actual K FF
Personnel	32 277	32 309
Operations	13 754	12 522
Investments	17 471	8 225
Value-added taxes	3 770	4 147
	67 272	**57 203**

Income

Budget Heading	Budget K FF	Actual K FF
Contribution CNRS	26 578	26 637
Contribution MPG	26 578	26 637
Contribution IGN	8 811	8 811
Other Income	1 535	974
Contribution CNRS for Value-added taxes	3 770	4 147
	67 272	**67 206**

Budget Previsions 1991
(K FF)

Expenditure

Budget Heading	Approved Budget
Personnel	32 648
Operations	13 252
Investments	8 659
Value-added taxes	3 978
	58 537

Income

Budget Heading	Approved Budget
Contribution CNRS	25 455
Contribution MPG	25 455
Contribution IGN	3 249
Other Income	400
Contribution CNRS for Value-added taxes	3 978
	58 537

7.1 ANNEX Ia : TELESCOPE SCHEDULE FOR THE IRAM 30m TELESCOPE

IRAM 30-M TELESCOPE — JANUARY 1990—FEBRUARY 1990 — Update: 2 January 1990

Week	Date	Ident.	Title	Freq.(GHz)	Authors
01	Jan 2–8	252–89	Isotopic Ratios in Envelopes of Evolved Stars	139,147, 220,230	Kahane, Cernicharo, Guélin, Gomez-Gonzales
		255–89	Chemical Evolution of Carbon-Rich Circumstellar Envelopes	89,113,130,145, 227,245	Loup, Omont, Forveille, de Jong, Groenewegen
		250–89	$^{12}C/^{13}C$ Ratio in Carbon Stars	220,230	Kahane, de Jong
		65–89	HCN Observation of Circumstellar Envelopes	89,230,130	Omont, Forveille, Loup, te Lintel, Hekkert et al.
		251–89	$^{12}C/^{13}C$ Circumstellar ^{13}C-rich Envelopes	139–147, 227–245	Jura, Kahane, Omont, Audouze
		244–89	Molecules in Photodissociation Regions	115,110,220,230 98,147	Fuente, Martin-Pintado, Cernicharo, Bachiller
02	Jan 9–16	78–89	CO Observations of Proto-Planetary Nebula Candidates from IRAS Survey	115, 230	Pottasch, Manchado, Henkel, Sahu, Zijlstra, te Lintel, Ratag
		189–89	CO Emission from Lobe-Dominant Quasars	115, 230	Steppe,Krishna
		126–89	Two OVRO Fields in the Centre of M33	115, 230	Wilson, Scoville, Guélin
		133–89	CO and SiO Maps of NGC 7538-IRS1	217, 230	Wilson, Johnston, Walmsley, Henkel, Schilke
		264–89	CO in Early-Type Galaxies	115, 230	Wiklind, Henkel
		80–89	$^{26}Al/^{27}Al$ Isotopic Ratio in IRC+10216	216, 218, 328	Guélin, Cernicharo, Slysh
03	Jan 16–22	166–89	CO Absorption in Front of QSO 0248+43	115, 230	Boissé, Kazès, Casoli, Combes
		164–89	Oxygen in NGC6240, Arp220, 3C84	115	Casoli, Gérin, Combes, Encrenaz, Pagani
		165–89	The Molecular Ring of NGC 7479	115, 230	Combes, Gérin, Casoli, Kenney
		168–89	Molecular Clouds in Andromeda	110,115,220,230, 98, 147	Braine, Casoli, Combes, Sofue, Nakai, Handa
		161–89	Double Rings in NGC 4631	230, 110	Sofue, Handa, Krause, Wielebinski
		175–89	Search for SO_2 in Io's Atmosphere	222	Lellouch, Belton, de Pater, Encrenaz, Gulkis
		226–89	IRAM Line Calibrator Catalog Continued	several	Mauersberger, Kömpe, Steppe, IRAM staff
04	Jan 23–30		Holography		
		226–89	IRAM Line Calibrator Catalog Continued	several	Mauersberger, Kömpe, Steppe, IRAM staff
		36–89	Frequency Survey 328–348 GHz	328–348	Schulz, Güsten
		30–89	Probing the Birthsites of Massive Stars	88–145,245–266,343	Güsten, Serabyn, Schulz, Downes
05	Jan 30–Feb 6	187–89	Molecular Spiral Structure in M51	115, 230	Guélin, Garcia-Burillo, Brunswig, Cernicharo et al.
		16–89	SiO, CO and $C^{34}S$ Maps of W3	98–147, 217–237	Gaume, Claussen, Johnston, Wilson
		254–89	The Abundance of Interstellar Water	203, 225	Walmsley, Baudry, Jacq, Henkel, Mauersberger
06	Feb 6–13	131–89	Rare CO Isotopes in M82's Nucleus	220, 331	Harris, Wild, Eckart, Jackson, Genzel
		129–89	Isotopic CO, CS and HCN Observations	230–270, 330–355	Stutzki, Wild, Harris
		234–89	^{13}C Isotopes in M82's Nucleus	86, 330	Harris, Wild, Eckart, Genzel, Jackson
		76–89	Galactic Center Circumnuclear Ring	268	Jackson, Genzel, Harris
07	Feb 13–20	234–89	^{13}C Isotopes in M82's Nucleus	86, 330	Harris, Wild, Eckart, Genzel, Jackson
		76–89	Galactic Center Circumnuclear Ring	268	Jackson, Genzel, Harris
		178–89	Extragalactic HCO^+ and HCN	89, 141, 267	Rieu, Jackson
		144–89	MWC349 Recombination Line Maser	92, 160, 231	Thum, Martin-Pintado, Bachiller
07	Feb 20–27		Bolometer Tests	250	

LSTs are on the bi-weekly observatory schedule. Tuesdays 8 a.m. to 4 p.m. are reserved for maintenance.

IRAM 30-M TELESCOPE			MARCH 1990		Update: 2 January 1990
Week	Date	Ident.	Title	Freq.(GHz)	People
09	Feb 27–Mar 5	128–88	Bolometer Projects		Mezger, Haslam, Kreysa, Chini, Zylka et al.
10	Mar 6–12	227–89	Pre-Main Sequence Objects		Beckwith, Chini, Sargent
		247–89	Late Type Stars		Walmsley, Omont, Forveille, André, Chini
		269–89	Dust Emission in Star Burst Galaxies		Wielebinski, Chini, Klein, Krügel
		221–89	Disks around Orion Trapezium Cluster		Zinnecker, Chini, McCaughrean
		209–89	Continuum Obs. of Nearby Comets		Altenhoff, Kreysa, Schmidt, Thum
		232–89	Physical Properties of Asteroids		Altenhoff, Johnston
		208–89	Emission Temperature of Pluto/Charon		Altenhoff, Johnston
		228–89	ρ Oph Cloud Core A		André, Martin-Pintado, Despois, Montmerle
11	Mar 13–19	228–89	ρ Oph Cloud Core A		André, Martin-Pintado, Despois, Montmerle
		212–89	Survey for Young Galaxies		Schultz, Kreysa, Steppe
		229–89	Are Massive Disks Powering Outflows?		Cabrit, André, Steppe
		242–89	ρ Ophiuchi Cloud Core		Montmerle, André, Steppe
		171–89	Continuum Emission of Normal Galaxies		Roland, Franceschini, Andreani
		72–89	Molecular Clouds in Bright QSO		Roland, Jaffe
12	Mar 20–26	174–89	Molecular Gas in Elliptical Galaxies	230	Gordon
		196/197–89	MM-Recombination Lines and Widths	35,145,230	Gordon, Walmsley
		182–89	Optically Opaque Extragalactic Nuclei		Henkel, Mauersberger, Wilson
		233–89	H_2 Densities in ρ Ophiuchus B.	137	Wilson, Mauersberger, Henkel, Kõmpe
		207–89	H_2CO in OH Megamaser Sources		Henkel, Baan, Mauersberger
		214–89	Isotope Ratios in Low-Mass Galaxies		Becker, Henkel, Wilson
		200–89	H_2 Densities in the Orion Clumps	137	Wilson, Henkel, Mauersberger, Kõmpe
13	Mar 27–Apr 2	204–89	HDO and 0_3 in Venus and Mars	241	Th. Encrenaz, Gulkis, Lellouch, Paubert
		248–89	Star-Forming Regions in Galaxies	230	Paubert, Lazareff
		226–89	IRAM Line Calibrator Catalog	ral	Mauersberger, Kõmpe, Steppe, IRAM staff
		249–89	Interaction of Flow in HL Tau	47,220	Lazareff, Monin, Pudritz

LSTs are on the bi-weekly observatory schedule. Tuesdays 8 a.m. to 4 p.m. are reserved for maintenance.

Week	Date	Ident.	Title	Freq.(GHz)	People
14	Apr 3–9	261–89	Map of CO(2–1) in NGC 3079	115, 230	Downes, Garcia-Barreto
		257–89	Ultraluminous IR Galaxies	104–109, 209–217	Downes, Solomon, Radford, Kazès
		258–89	Structure in Dense Cores	110, 220	Fuller, Myers, Falgarone, Puget
		142–89	Molecular Gas to Compression	110–115, 220, 230	Puget, Pérault, Falgarone
15	Apr 10–16	159–89	Molecular Gas in Planetary Nebulae	230, 115, 140	Huggins, Forveille, Omont, de Muizon, Cox et al.
		219–89	Search for CO in OH/IR Stars	115, 230	Winnberg, Olofsson, Lindqvist, Henkel
		220–89	Chemistry of TX Cam	86–150, 213–272	Olofsson, Lindqvist, Winnberg, Nyman, Rieu
		218–89	Carbon Star TT Cyg	115, 230	Olofsson, Carlström, Eriksson, Gustafsson, Wilson, Rieu
16	Apr 17–23	191–89	6 Protoplanetary Nebulae in CO	115, 230	Planesas, Bachiller, Bujarrabal, Martin-Pintado
		31–89	CO Observations of Cygnus A	109, 218	Mirabel, Planesas, Kazès, Sanders
		194–89	Molecular Jets and Bullets	89–115, 220–230	Bachiller, Gomez-Sanchez
		97–89	Wolf-Rayet Stars	115–147, 220–266	Bujarrabal, Alcolea, Bachiller
		192–89	Kinematics of a Cloud in the Orion Region	115, 230	Rodriguez, Gomez-Gonzales, Martin-Pintado, Bachiller
17	Apr 24–May 1	217–89	Density Structure of Sgr B2	206, 137	Martin-Pintado, de Vincente, Wilson
		243–89	Gas around Orion/IRc2	86–130, 230	Martin-Pintado, Rodriguez, Bachiller
		51–89	CO in N5447 and N5471	115, 230	Viallefond,Cox, Lequeux, Pérault
		240–89	CO in the Region NGC 604	115, 230	Viallefond, Boulanger, Pérault, Cox, Lequeux
18	May 1–8	240–89	CO in the Region NGC 604	115, 230	Viallefond, Boulanger, Pérault, Cox, Lequeux
		222–89	The Case of RLeo	86, 130, 217	Cernicharo, Brunswig, Paubert, Liechti, et al.
		116–89	CO Deficiency in the Coma Supercluster	115, 230	Casoli, Combes, Gérin, Buat
		97–89	Wolf-Rayet Stars	115–147, 220–266	Bujarrabal, Alcolea, Bachiller
		11–89	CO of Infrared Quasars	83–110	Wilson, Zylka, Scoville, Sanders, Zensus
19	May 8–22	45–90	CO in the Spirals of the Coma Cluster	115, 230	Casoli, Gérin, Combes, Buat
		46–90	CO in Ring Galaxies	115, 230	Casoli, Dupraz, Combes
		47–90	A complete CO(2–1) and (1–0) Map of the Inner Disk of NGC 6946	115, 230	Casoli, Clausset, Viallefond, Boulanger, Combes
		83–90	Search for $^{16}O^{18}O$ in Galactic Molecular Clouds	109, 234, 220, 104	Casoli, Combes, Encrenaz, Gérin, Laurent
		82–90	Molecular Survey of 100 Spiral Galaxies	115, 230	Braine, Casoli, Combes, Dupraz, Gérin, Klein, Wielebinski
		247–89	Bolometer Measurements of Late Type Stars	240	Walmsley, Omont, Forveille, André, Chini
		171–89	Millimetric Observations of the Continuum Emission of Normal Galaxies	250	Roland, Franceschini, Andreani
		73–90	Continuum Observations of Comets Austin and Schwassmann–Wachmann 3	250	Altenhoff, Kreysa, Schmidt, Thum
		63–89	Investigation of Anomalous Refraction	90, 226	Altenhoff, Downes
		12–90	Search for Molecular Lines in Comet Austin 1989cl	89, 226, 266	Crovisier, Colom, Bockelée–Morvan, Gérard, Despois, Paubert

Week	Date	Ident.	Title	Freq.(GHz)	People
19	May 8–22	20–90	High Resolutions CO Maps of Contrasting Galaxies	115, 230	Downes, Solomon, Radford, Viallefond
		21–90	CO in Further Distant Luminous Galaxies	115, 230	Downes, Solomon, Radford
		59–90	A Multiline Study of Dense Molecular Gas in Arp220	87, 88, 96, 108 144, 216, 241	Radford, Downes, Solomon
21/22	May 22–June 5	20–90	High Resolutions CO Maps	115, 230	Downes, Solomon, Radford
		21–90	CO in Further Distant Luminous Galaxies	115, 230	Downes, Solomon, Radford
		59–90	A Multiline Study of Dense Molecular Gas in Arp220	87, 88, 96, 108 144, 216, 241	Radford, Downes, Solomon
		12–90	Molecular Lines in Comet Austin 1989 cl	89, 226, 266	Crovisier, Colom, Bockelée– Morvan, Gérard, Despois, Paubert
		57–90	Determination of the Physical Conditions of the Regions where SiO and SiS Emission Arises	86, 130, 215, 85 128, 212, 91 127, 217	Martin–Pintado, Bachiller, Fuente, Gomez–Gonzales
		8–90	High Resolution Observations of Photodissociation Regions	110, 112, 115 149, 224	Fuente, Martin–Pintado, Cernicharo, Bachiller
23/24	June 5–19	67–90	Very Dense Gas in Star Forming Region: A Multi–Transition CS Study	98, 147, 245, 96	Jaffe, Martin–Pintado, Gomez–Gonzales, Evans, Plume
		18–90	Envelopes around Miras with Optical Counterparts	110, 115, 220, 230	Bujarrabal, Alcolea
		38–90	CO Emission from Nova Shells	115, 220, 230	Bujarrabal, Liechti, Alcolea
		194–89	Extremely High–Velocity Molecular Jets and Bullets		Bachiller, Gomez–Sanchez
		16–90	Discontinuous Mass–loss in Evolved Stars	110, 115, 1[illegible], 220	Alcolea, Bujarrabal
		17–90	Protoplanetary Nebulae with Strong FIR Excess	89, 90, 115, 130 220, 230	Bujarrabal, Alcolea, Planesas
		42–90	CO in two Evolved Planetary Nebulae		Bachiller, Huggins, Forveille, Lequeux, Cox
		41–90	CO in the Crab Nebula		Bachiller, Huggins
		40–90	High Velocity Outflow on the Dense Core in MonR2		Tafalla, Bachiller
25/26	June 19–July 3	55–90	CO Obs. of Radio–quiet Quasars	98, 115, 230	Alloin, Antonucci, Barvainis, Gordon
		144–89	Monitoring of the variable recombination line Maser Emission in NWC 349	92, 160, 230	Thum, Martin– Pintado, Bachiller
		74–90	SiC Maser Emission	156, 160	Guélin, Cernicharo, Paubert, Thaddeus
		126–89	Two Ovro Fields in the Center of M33	115, 230	Wilson, Scoville, Guélin

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Week	Date	Ident.	Title	Freq.(GHz)	People
27/28	July 3–17	22–90	Structure of dense Gas in Giant Molecular Clouds	147, 245	Solomon, Wilson, Walmsley, Rivolo
		58–90	Dense Molecular Gas in Starbursts	88, 98, 147, 245	Solomon, Radford, Downes, Sage
		59–90	A Multiline Study of Dense Molecular Gas in Arp220	87, 88, 96, 108 144, 216, 241	Radford, Downes, Solomon
		137–89	High Spatial Resolution Mapping of Molecular Emission from Circumstellar Envelopes		Sahai, Bujarrabal, Liechti
		69–90	Mass–Loss Envelopes in Northern S Stars	110, 115, 220, 230	Sahai, Liechti
		189–89	CO Emission from Lobe–Dominant Quasars		Steppe, Krishna
		85–90	Tidal Interactions in the Star Formation Acticity of the Stephan Quartet of Galaxies	115, 230	Moles, Cernicharo
		64–90	CO in Markarian Galaxies	110, 115, 220, 230	Chini, Krügel, Steppe
		49–90	Multifrequency CS Observations of Bipolar Outflows	98, 146, 244	Rudolph, Rieu, Bachiller
29/30	July 17–31	65–90	Internal Motions and Density in Dense Cores: High Resolution Obs. of C_3H_2	85, 145	Fuller, Myers, Falgarone, Puget
		53–90	Molecular Gas in Actively Starforming Galaxies	89, 115, 231, 266	Kastner, Zucherman, Forveille, Omont
		255–89	The Chemical Evolution of Carbon–Rich Circumstellar Envelopes	88, 113, 130, 145	Loup, Omont, Forveille, de Jong, Groenewegen
		55–89	HCN Observations of Very Cold Circumstellar Envelopes	88, 230, 130	Omont, Forveille, Loup, Te Lintel Hekkert, Heske, Habing Caswell, Sivagnanam
		24–90	$^{12}C/^{13}C$ Ratio in Carbon Stars	220, 230	Kahane, de Jong
		251–89	Measurements of $^{12}C/^{13}C$ in Circumstellar ^{13}C-Rich Envelopes		Jura, Kahane, Omont, Audouze
31/32	July 31–Aug 14	189–89	CO Emission from lobe–dominant quasars		Steppe, Salter, Saikia
			Matter around young stellar objects in the RHO OPHIUCHI Cloud Core	226	
		75–90	HCN and HCO^+ Mapping of NGC253 and IC 342	89, 267	Rieu, Jackson, Henkel, Mauersberger, Ho
		9–90	Molecular Clouds and Star Formation in Nearby Dwarf Galaxies	115, 230	Becker, Wilson, Henkel
		100–90	HCN and HCO^+ in the nuclei of starburst and Seyfert galaxies	90	Rieu, Jackson, Mauersberger, Henkel

Week	Date	Ident.	Title	Freq.(GHz)	People
31/32	July 31-Aug 14	144–89	Monitoring of the variable recombination Line Maser Emission in NWC349		Thum, Martin–Pintado
		159–90	Molecular Excitation in the dense core of ARP 220	87–96	Radford, Downes, Solomon
		97–90	Shocked extragalactic molecular gas: SiO as a chemical thermometer	86,130 217,268	Mauersberger, Henkel
		13–90	Molecular Gas in a Cluster Environment	115, 230	Sage, Henkel, Mauersberger
33/34	Aug 14–27	7–90	Oxygen Isotop Ratios in Extragalactic Nuclei	110, 220	Mauersberger, Sage, Henkel, Wilson
		54–90	D/H in the Galactic Center	216,144,88,264,90,234	Walmsley, Baudry, Jacq
		267–89	A Survey for CS Emission toward External Galaxies and CS Multilevel Studies toward NGC 6946 and Maffei 2		Mauersberger, Henkel
		29–90	Column Density of CO toward Cas A, from $C^{18}O$ Data	109, 218	Przewodnik, Wilson, Mauersberger, Kömpe
		14–90	Protonated Hydrogen Cyanide and the Formation of HCN and HNC	148, 222	Schilke, Walmsley, Henkel, Le Bourlot
		19–90	HCN and HNC Chemistry in Orion–KL	86, 144, 152, 173 173,217,228,260	Schilke, Harju, Mauersberger, Walmsley
		36–90	CS Surrounding Compact HII Regions		Cesaroni, Walmsley, Churchwell
		102–90	Detection of Interstellar CH_2DOH		Walmsley, Mauersberger, Jacq, Herbst
		222–89	Lunar Occultations of Molecular Sources: The Case of R Leo		Cernicharo, Brunswig, Paubert, Liechti, Garcia, Bachiller, Martin–Pintado
		48–90	Relation between Atomic and Molecular Gas Content in IRAS Galaxies	108, 115, 215, 230	Dennefeld, Bottinelli, Gouguenheim, Martin
		162–90	Search for molecular lines in Comet Levy (1990c)		Crovisier, Colom, Despois, Bockelé– Morvan, Paubert
35/36	Aug 28–Sep 11	162–90	Search for Molecular Lines in Comet Levy (1990c)		Crovisier, Colom, Despois, Bockelée–Morvan, Paubert
		31–90	HDO, O_3 and Sulfur Species in the Atmosphere of Mars	217, 218, 222, 237	Encrenaz, Gulkis, Lellouch, Paubert
		240–89	CO in the Star Forming Region NGC604	115, 230	Viallefond, Boulanger, Perault, Cox, Lequeux
		144–89	Monitoring of the variable recombination line Maser Emission in NWC 349	92, 160, 230	Thum, Martin– Pintado, Bachiller
		127–90	Measurements of the first protostar RHO OPH B	145, 218	Wilson, Kömpe, Mauersberger, Henkel

Week	Date	Ident.	Title	Freq.(GHz)	People
35/36	Aug 28–Sep 11	144–89	Monitoring of the Recombination line Maser emission in MWC 349	92,160,231	Thum, Martin–Pintado, Bachiller
		101–90	The Search for CO in Infra–red Quasars continued		Wilson, Mauersberger, Kõmpe, Sanders, Scoville, A Zensus
		129–90	Line Formation Physics in Infrared Quasars	220, 206, 140, 130	Wilson, Mauersberger, Scoville, Sanders, Zensus, Kõmpe
37/38	Sep 11–25	142–90	A Fresh Look at the Electron Density Problem: measurements of the DCO^+HCO^+ Abundance Ratio in 4 Cloud Cores		Guélin, Rowe, Marquette
		141–90	Request for Observing Time on the 30–m Telescope for searching for H_2CCC, a new radical of Astrophysical Interest		Guélin, Thaddeus, Gottlieb, Cernicharo
		119–90	A Search for remnant Gas associated with primordial solar Nebulae surrounding young solar–type Stars	230	Cabrit, André, Strom, Edwards, Skrutskie, Schloerb
		113–90	CO Observations of the Radio Quasar IIIZw2	105, 211	Steppe
		189–89	CO Emission from Lobe–dominant Quasars	115, 230	Steppe, Krishna
		145–89	Gaseous Content of Circumstellar Matter around Young Stellar Objects in the Rho Ophiuchi Cloud Core	110, 137, 141, 216	Montmerle, André, Despois, Martin–Pintado
		102–90	Detection of Interstellar CH_2DOH		Walmsley, Mauersberger, Jacq, Herbst
39/40	Sep 25–Oct 9	9–89	Is grain mantle evaporation confined	143, 230, 240	Jacq, Walmsley, Henkel
		56–90	CS surrounding compact HII regions		Cesaroni, Walmsley, Churchwell
		109–90	Outflows in the Serpens Cloud Core: the enigmatic source FIRS 1 and the PMS Cluster SVS 4	230, 220, 146, 145	Eiroa, Casoli, Gomez, Sakamoto
		144–89	Monitoring of the Recombination line Maser emission in MWC 349	92,160,231	Thum, Martin–Pintado, Bachiller
41/42			**TECHNICAL TIME**		
		143–90	Multiline CS observations of NGC 1068		Planesas, Martin–Pintado, Gonzalez, Bachiller
		92–90	A search for hot CO(V=1) towards shocked regions of the interstellar medium	114,220	Cernicharo, Gonzalez, Bachiller, G–Gonzalez, Martin–Pintado
		131–90	A search for vibrationally excited CO towards evolved stars and protoplanetary nebulae	114,228	Cernicharo, Gonzalez, Guélin
3/44	Oct 23–Nov 6	140–90	High Resolution Observations of CO Emission in the Envelopes of evolved Stars a Key to the Ultimate Evolution of the Stars with high Mass Loss ?		Lucas, Guilloteau, Guélin, Cernicharo, Forveille Loup, Omont, Bujarrabal, Martin–Pintado, Rieu

Week	Date	Ident.	Title	Freq.(GHz)	People
43/44	Oct 23–Nov 6	151–89	The Remarkable Young Star RE50N		Cernicharo, Reipurth
		152–89	A Study of the Interaction of the Conspicuous Optical Jet H111 with the Surrounding Molecular Gas		Cernicharo, Reipurth
		60–90	A Study of a CO Halo in NGC 4631	115, 230	Wielebinski, Krause, Golla
		80–90	CO(J=1-0/2-1) Observations of Halo Rotation in M82	115, 230	Krause, Sofue, Wielebinski, Reuter
		85–90	Tidal Interactions in the Star Formation Activity of the Stephan Quartet of Galaxies	115, 230	Moles, Cernicharo
		130–90	Monitoring of MWC 349	92, 160, 231	Thum, Martin–Pintado, Bachiller
		137–90	Completion of the CO maps of three remarkable bipolar outflows	230, 220, 115, 110	Bachiller, Cernicharo, Planesas
45/46	Nov 6–20	107–90	Molecular rings in NGC2841 and NGC7331		Combes, Gérin, Casoli
		108–90	Molecular Survey of 100 Spiral Galaxies	115, 230	Braine, Casoli, Combes, Dupraz, Gérin, Klein, Brouillet, Wielebinski
		51–90	CO Observations of the Anomalous $H\alpha$ and Radio Arms of the Spiral Galaxy NGC 4258	230, 115	Krause, Cox, Garcia–Barreto, Downes
		160–90	CO in further distant luminous galaxies		Downes, Solomon, Radford
		154–90	HCN($3 \rightarrow 2$) excitation and luminosity in ultraluminous IR galaxies	265, 245	Solomon, Radford, Downes, Sage, Barrett
		156–90	The molecular content of dwarf ellepticals	115, 230	Wiklind, Henkel, Rydbeck
		159–90	Molecular excitation in the dense core of ARP 220	87, 88, 96, 108 144, 216...	Radford, Downes, Solomon
47/48	Nov 20–Dec 4	103–90	An unbiased CO survey in early–type galaxies	115, 230	Wiklind, Henkel
		111–90	Protoplanetary sources: the role of the 21μm feature		Henkel, Omont, Mauersberger, Forveille
		98–90	The density spectrum of the molecular gas toward the nucleus of M82		Mauersberger, Henkel, Sage
		6–90	CO Emission from an SBO Galaxy	115, 230	Sage, Wiklind, Henkel
		159–90	Molecular excitation in the dense core of ARP 220	87, 88, 96, 108 144, 216...	Radford, Downes, Solomon
		134–90	The most massive bipolar outflow in the galaxy	239, 144	Wilson, Mauersberger, Kömpe

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Week	Date	Ident.	Title	Freq.(GHz)	People
47/48	Nov 20–Dec 4	130–90	Monitoring of MWC 349		Thum, Martin–Pintado, Bachiller
		148–90	High density small scale structure in the edges of molecular clouds		Falgarone, Phillips
		118–90	Comparison of the small scale structure in dense cores with and without stars		Fuller, Falgarone, Myers, Puget
49/50	Dec 04–Dec 18	87–90	HCO^+(J=3-2) Observations of Herbig–Haro Objects	267	Rudolph, Rieu Welch
		39–90	Observations of the $H^{13}CN$ and HC^{15}(3-2) lines on Titan	258,259,88	Bézard, Marten, Coustens, Paubert
		106–90	Mergers selected by their optical morphology		Combes, Casoli, Dupraz, Gérin
		122–90	HC_3N as a density tracer of circumprotostellar gas		Mezger, Mauersberger, Wilson
51–52	Dec 18–Jan 1	106–90	Mergers selected by their optical morphology		Combes, Casoli, Dupraz, Gérin
		120–90	A highly collimated bipolar outflow in the core of OMC–1	115,220,230,345	Schmid–Burgk, Güsten, Mauersberger, Wilson
		122–90	HC_3N as a density tracer of circumprotostellar gas		Mezger, Mauersberger, Wilson
		130–90	Monitoring of MWC349	92,160,231	Thum, Martin–Pintado, Bachiller
		145–90	Search for HC_7N around carbon rich planetary nebulae and dusty W–R stars	88,154,237	Jura, Kahane, Kroto
		149–90	Io'S atmosphere from microwave lines of SO_2	219–235	Lellouch, Belton, de Pater, Paubert
		4–90	Molecular clouds in the Tidal Arms and dwarf galaxies of the M81 group	115,230	Brouillet, Becker, Wilson, Henkel, Baudry

7.2 ANNEX Ib : TELESCOPE SCHEDULE FOR THE IRAM INTERFEROMETER

Contrary to the 30–m telescope where individually proposals are scheduled sequentially at fixed times, proposals accepted for the Plateau de Bure Interferometer are grouped together according to hour angles and executed as much as possible in parallel to avoid unnecessary changes of the interferometer configuration. This list includes projects which were carried on as part of the interferometer commissioning.

Ident.	Title	Authors (P.I.)
A001	HCN in CR1618	Neri, Guélin
A002	HCN and HCO^+ in Arp220	Radford
A003	HCN and continuum in Comet Austin	Wink
A004	H42α in NGC 7538 IRS 1/2	Wink
A005	C_2H and C_4H in IRC+10216	Lucas, Guélin
A006	HCN in O–rich CSEs	Guilloteau
A007	SiO J 2–1 in CSEs	Lucas
A008	HII regions as flux calibrators	Guilloteau
A009	SiO J 2–1 in YSOs	Wink
A010	Continuum in CSEs	Forveille
A011	HCN in IC342	Radford
A012	SiO and $H^{13}CO+$ in RNO–14	Guilloteau
A014	Gravitationally lensed quasars	Radford, Boissé
A015	Size of L1551	Guilloteau
A016	CO in Alloin's Quasar	Radford
A017	SiO Masers spot resolution	Lucas
A020	SiO maser in Orion	Guilloteau

ANNEX IIa - IRAM PUBLICATIONS

WARM GAS AND SPATIAL VARIATIONS OF MOLECULAR EXCITATION IN THE NUCLEAR REGION OF IC 342
A. Eckart, D. Downes, R. Genzel, A.I. Harris, D.T. Jaffe, W. Wild
1990, *Astrophys. J.*, **348**, 434.

DETECTION OF 183 GHz WATER VAPOR MASER EMISSION FROM INTERSTELLAR AND CIRCUMSTELLAR SOURCES
J. Cernicharo, C. Thum, H. Hein, D. John, P. Garcia, F. Mattiocco
1990, *AA* **231**, L15

223. MILLIMETRE INTERFEROMETRY
D. Downes
1990, in *Modern Technology and its Influence on Astronomy*
eds. J.V. Wall, A. Boksenberg, Cambridge Univ. Press, Cambridge, p. 57.

226. VIBRATIONALLY EXCITED AMMONIA IN THE GALAXY
P. Schilke, R. Mauersberger, C.M. Walmsley, T.L. Wilson
1990, *AA* **227**, 220.

229. DENSE MOLECULAR CLOUDS AND THE ARP 220 STARBURST
S.J. Radford, D. Downes, P.M. Solomon
1990, *Astrophys. J.*, **348**, L53.

230. DEUTERATED WATER AND AMMONIA IN HOT CORES
T. Jacq, C.M. Walmsley, A. Baudry, R. Mauersberger, P.R. Jewell
1990, *AA* 228, 447.

231. ANOMALOUS REFRACTION AT RADIO WAVELENGTHS
D. Downes, W.J. Altenhoff
1990, in *"Radio Astronomical Seeing"*, URSI/IAU Symposium,
eds. J.E. Baldwin and Wang Shouguan, International Academic Publishers, Beijing, p. 31.

232. λ 1.3 mm DUST EMISSION FROM THE STAR-FORMING CLOUD CORES OMC 1 AND 2
P.G. Mezger, J.E. Wink, R. Zylka
1990, *AA* 228, 95.

CO EXCITATION IN FOUR IR LUMINOUS GALAXIES
S.J.E. Radford, P.M. Solomon, D. Downes
1990 in *The Interstellar Medium in External Galaxies*
eds. D.J. Hollenbach, H.A. Thronson, NASA Conf. Pub. 3084, Washington, D.C., p. 378.

STRUCTURE OF THE DISK OF M82
M. Götz, C.D. McKeith, D. Downes, A. Greve
1990, *AA* **240**, 52.

235. SUPERNOVA 1987A at 1.3 mm
P.L. Biermann, R. Chini, A. Greybe-Götz, G. Haslam, E. Kreysa, P.G. Mezger
1990, *AA* **227**, L21

236. CO IN MARKARIAN GALAXIES
E. Krügel, H. Steppe, R. Chini
1990, *AA* 229, 17.

237. NGC 7027 AT MILLIMETER WAVELENGTHS: MICROTURBULENCE IN THE IONIZED SHELL
J.P. Vallée, S. Guilloteau, T. Forveille, A. Omont
1990, *AA* 230, 457.

238. EMISSION OF CO (J=1—0 and 2—1) in CRL 2688: PHOTOCHEMISTRY, KINETIC TEMPERATURE, AND MOLECULAR ABUNDANCE
Truong-Bach, D. Morris, Nguyen-Q-Rieu, S. Deguchi
1990, *AA* 230, 431.

239. FREE CP IN IRC+10216
M. Guélin, J. Cernicharo, G. Paubert, B.E. Turner
1990, *AA* 230, L9.

240. SPATIAL VARIATION OF THE PHYSICAL CONDITIONS OF MOLECULAR GAS IN GALAXIES
J.M. Jackson, A. Eckart, W. Wild, R. Genzel, A. I. Harris, D. Downes, D.T. Jaffe, P.T.P. Ho
1990 in *The Interstellar Medium in External Galaxies*
eds. D.J. Hollenbach, H.A. Thronson, NASA Conf. Pub. 3084,
Washington, D.C., p. 384.

241. CS IN NEARBY GALAXIES: DISTRIBUTION, KINEMATICS AND MULTI-LEVEL STUDIES
R. Mauersberger, C. Henkel
1990 in *The Interstellar Medium in External Galaxies*
eds. D.J. Hollenbach, H.A. Thronson, NASA Conf. Pub. 3084,
Washington, D.C., p. 381.

242. SULPHUR-BEARING MOLECULES IN DARK CLOUDS
A. Fuente, J. Cernicharo, A. Barcia, J. Gomez Gonzalez
1990, *AA* **231**, 151

243. HIGH-VELOCITY MOLECULAR BULLETS IN A FAST BIPOLAR OUTFLOW NEAR L1448/IRS 3
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9. ANNEXE III - IRAM Executive Council and Committee Members, January 1990

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