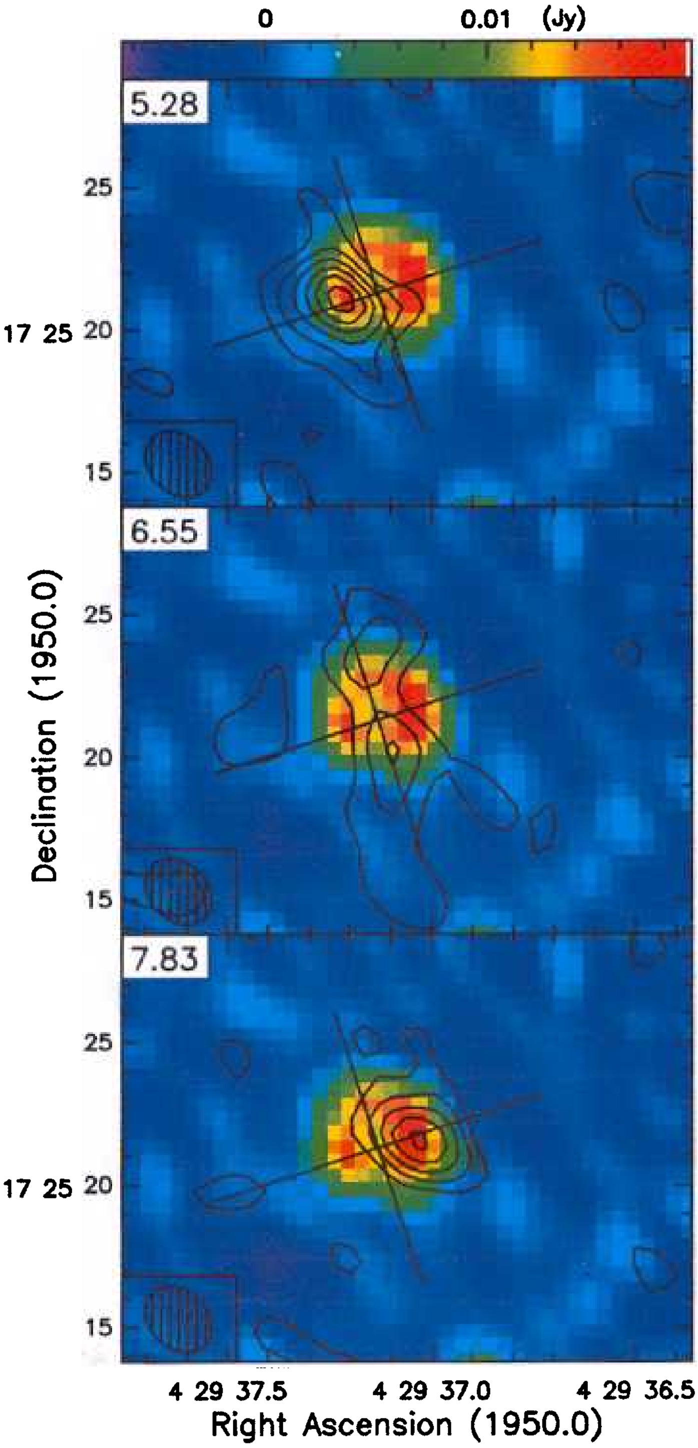
IRAM 1993



ANNUAL REPORT

Front Cover :

Observations with the Plateau de Bure Interferometer of the circumbinary disk around the young double star GG Tau. The figure shows the superposition of the high resolution continuum map (in color) with three velocity channels (black contours) of the ^{13}CO J=1-0 emission. These observations reveal unambigously that the material is located in a rotating ring (cf. Dutrey, Guilloteau and Simon, 1994).

ANNUAL REPORT
1993

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TABLE OF CONTENTS

1. INTRODUCTION

In 1993 again a wealth of scientific results has been produced with both the 30m telescope and the Plateau de Bure interferometer by a still growing user community. A flavor of the results obtained should be provided by the summary of highlights in Chapter 2 of this report.

At the 30m telescope the users benefitted from further improvements of some of the SIS-receivers, including a very performing 345 GHz system on loan from the MPE, and from the availability, for the first time, of a 7-channel bolometer which was provided for this observing run by the MPIfR.

At the interferometer the commissioning of Antenna 4 was successfully completed and throughout much of the year the interferometer operated as a 4-element array. The doubling of instantaneous baselines has significantly increased the mapping efficiency of the instrument as witnessed e.g. by the successful studies of circumstellar rings and outflows associated with young stellar objects, and circumstellar envelopes around evolved stars.

On the personnel side, two major changes occured in 1993 concerning the IRAM-Granada station management which went from Albert Greve to Wolfgang Wild who joined IRAM in the fall of the year, and the Grenoble receiver group which is now headed by James Lamb who ioined IRAM in October of 1993.

New projects which have started include the preparation of dual-channel receivers for the interferometer, a multibeam heterodyne system for the 30m telescope, and the acquisition of a 37-channel bolometer array in a cooperation with the MPIfR. IRAM will in particular be responsible for providing the necessary data reduction software as part of the Grenoble software package.

Concerning future developments, the most important event was the discussion at the June 1993 Council Meeting of a funding scheme for Antenna 5. Hopefully a solution will eventually also be found for Antenna 6. Given current economical conditions, funding of one more antenna puts a major extra burden on the IRAM partners, and it is clear that the funding has to be spread out over several years. Nevertheless, one of the options presented by IRAM has been adopted and is now being implemented. It allows first contracts for subsystems of Antenna 5 to be signed in 1994. Connected to the enhancement of the interferometer capabilities was a geological study for the extension of the baselines towards the west and in the northern direction on the Plateau de Bure.

In preparing for Antenna 5 and in view of the pinhole problems in the surface layers which cover the carbon-fibre panels now in use on the Plateau de Bure telescopes (see Annual Report 1992), IRAM began the study of an alternative design based on panels made from aluminium alloy. Two full-size prototype panels have actually been built and are now undergoing detailed testing. They have to comply with the same specifications, including dimensions and weight, as the carbon-fibre panels. A call for tender has verified the feasibility of the series production of the new panels in industry and its economical attractiveness.

2. HIGHLIGHTS OF RESEARCH WITH THE IRAM TELESCOPES IN 1993

2.1 SUMMARY

Of the many projects done at IRAM's observatories or published in 1993, some highlights were:

- Detections with the 30m telescope of continuum emission from quasars at redshifts of 3.2 and 4.7, which may be thermal emission from dust.

- A CO study at the 30m telescope of 35 distant ultraluminous galaxies which indicates that these galaxies are opaque to all wavelengths shorter than 100 microns, with a constant ratio of CO flux to 100-micron flux of about 4 km/s.

- A new catalog of the millimeter flux variations of 118 quasars and radio galaxies at 90, 150 and 230 GHz, from observations with the 30 m telescope.

- Maps with the 30 m telescope of the peculiar elliptical galaxy NGC 1275 (= 3C 84), that show the 6 10^9 solar masses of molecular gas is apparently in a rotating disk of radius 3 kpc.

- Interferometer maps of HCN in the central few hundred parsecs around the nucleus of the Seyfert galaxy NGC 1068 . The distribution of the molecular gas may account for the anisotropy of the nuclear radiation observed in the visible and ultraviolet.

- Maps with the interferometer of the southwest part of the galaxy M82, in the HCN line. The maps resolve the central molecular ring into numerous giant molecular clouds similar to those in the center of our Galaxy.

- A map made with the 30 m telescope and the MPIfR 7-channel bolometer array, of the continuum emission from cold dust in the edge-on spiral galaxy NGC 891. The dust emission is closely correlated with the CO emission and poorly correlated with the distribution of atomic gas.

- Interferometer observations of molecular absorption lines from gas in our Galaxy toward the extragalactic sources 0212+735, NRAO 150, BL Lac, 2013+370, and 0727-115.

- A search for molecular oxygen in cold dark clouds, with negative results. The result suggests the carbon to oxygen ratio in dark clouds may be higher than its "standard" cosmic abundance ratio.

- A new survey at 250 GHz of radio continuum emission from 270 stars. With the current bolometer sensitivity, nearly all types of stars in the Hertzsprung-Russell diagram can be detected at the 30 m telescope.

- Interferometer maps in ^{13}CO of a thin disk in Keplerian rotation around the close binary GG Tauri. The line and continuum data suggest that in the disk, CO is depleted by a factor of 20 relative to its abundance in the general interstellar medium.

- Detection with the 30 m telescope of a submillimeter hydrogen recombination line maser in the young, massive star MWC 349. The data suggest the masers come from the inner edge of a rotating and contracting disk around the star.

- Interferometer maps of $C^{18}O$, HCO^+, CH_3CN, H41α, and H59γ lines and the mm continuum near the ultracompact H II region W3(OH). The methyl cyanide (CH_3CN) images show two compact sources, one toward the water masers east of the H II region and another at the position of the OH masers seen against the H II region.

- Interferometer maps of the 95 and 98 GHz molecular lines of the MgNC, C_4H, and C_3H radicals in the carbon rich stellar envelope IRC+10216. The emission arises in a shell of radius 15 arcsec, unlike the centrally peaked emission of NaCl, SiO, SiS, CS and CO.

- Interferometric detection of CO in the troposphere of Neptune.

- Detection with the 30 m telescope, of acetonitrile (methyl cyanide) in the atmosphere of Titan.

EXTRAGALACTIC RESEARCH

Distant Sources (> 70 Mpc)

Dust in a Quasar at a Redshift of 4.7 ?

Continuum emission at 1.25 mm has been detected at the 30 m telescope from two quasars at high redshifts: the quasar 1202-0725 at a redshift of 4.7, and the quasar 2132+0216 at a redshift of 3.2. Fluxes are about 10 mJy, and if the emission is coming from the quasars and not from other sources in the beam, then the rest-frame wavelengths would be 220 and 300 microns, respectively. If the emission is thermal radiation from dust, the signal level implies an enormous amount of interstellar matter, and it should be possible to detect CO. Searches for CO at the 30 m telescope in these objects, however, have been negative, possibly because of the limited redshift range covered in the spectral line searches so far.

Ultraluminous Galaxies

Measurements at the 30 m telescope of 35 ultraluminous galaxies show that the CO line flux, in units of Jy km/s, is remarkably proportional to the far infrared flux at 100 microns, in Jy, with a ratio of CO to far IR flux equal to 4 km/s. This proportionality supports a model in which the dust radiation from ultraluminous galaxies is opaque for all wavelengths shorter than 100 microns. This provides additional evidence that the dust mass in the center of these galaxies is high and that the central gas mass is a large fraction of the dynamical mass. These considerations yield a relation between the distances to the galaxies and the ratio of the gas mass to CO luminosity.

New Millimeter Flux Catalog
A third IRAM catalog has been published of flux densities of 118 extragalactic radio sources observed at 90, 150, and 230 GHz at the 30 m telescope. The sources are mostly flat-spectrum quasars and a few radio galaxies with high flux densities at millimeter wavelengths. This third instalment presents previously unpublished measurements from November 1990 through the end of 1992. The publication also provides figures showing the millimeter flux variations from 1984 through 1992 of 83 sources from all three IRAM catalogs.

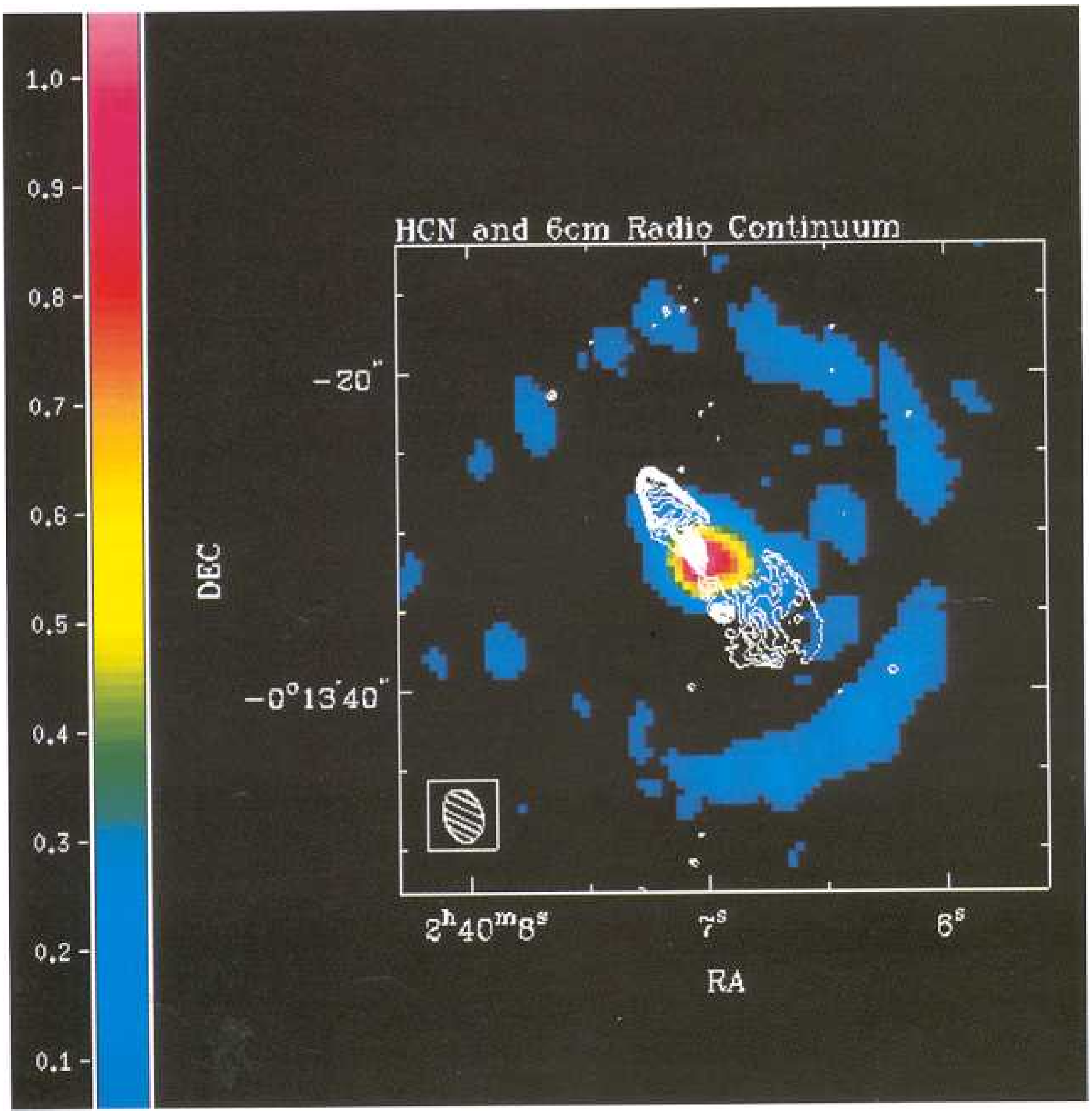


Fig. 2.1 HCN and radio continuum emission in the nucleus of the galaxy NGC 1068. The HCN emission mapped with the IRAM interferometer is shown in color (blue = weakest features, in the ring around the center, typically 3 K km/s; red = molecular cloud at the nucleus, 21 K km/s). The synthesized beam of 3" x 2" is shown at lower left. The white contours show synchrotron emission from the nuclear jets at a wavelength of 6 cm, as mapped with the VLA in 1986.

2.2.2 Nearby Galaxies (10 < D < 70 Mpc)

The Dense Obscuring Material in the Nucleus of NGC 1068

The interferometer has been used to map the HCN emission at 88.6 GHz around the nucleus of the Seyfert 2 galaxy NGC 1068. This galaxy is known to have an active central source ejecting relativistic electrons into jets which extend into two opposite directions. In recent years, evidence has accumulated that the nucleus is surrounded by a large amount of hot, dense molecular gas extending over a 350 parsec region. This evidence came from infrared spectroscopy and broad-band imaging, from optical and ultraviolet images showing a conical beaming of this radiation, and from millimeter interferometry in the CO line. The new results from the IRAM interferometer (Fig. 2.1) show that in contrast to the CO maps, in which the dominant feature is an outer ring 15" from the nucleus, the HCN is weak in the ring, but strongly peaked near the nucleus, in a 7" region extending northeast-southwest where a stellar bar is seen in the infrared. At the nucleus, the HCN/CO brightness ratio has a very unusual ratio of about 2:1 . In other galaxies, the ratio is typically in the range 1:100 to 1:10. This indicates that the HCN is in dense, opaque clumps without the usual rarefied envelopes. These diffuse envelopes may have been stripped away by the intense radiation and wind from the active nucleus. The interaction between the directed wind and radiation from the nucleus with the central bar and disk of molecular clouds may explain the strong NE/SW asymmetry in the brightness of the continuum radio emission and the narrow line optical emission.

CO Mapping of NGC 1275

The peculiar giant elliptical galaxy NGC 1275, in the Perseus cluster of galaxies is one of the strongest extragalactic radio sources, having a Seyfert nucleus emitting hard X-rays. NGC 1275 is thought to be accreting an X-ray cooling flow of 200 solar masses per year, and is probably interacting with another galaxy. CO emission from NGC 1275 was discovered with the 30 m telescope in 1988, indicating 6 x 10^9 solar masses of molecular gas. The galaxy has now been mapped in CO(1-0) and (2-1) at the 30 m telescope. The maps show that most of the molecular gas is within a radius of 3 kpc from the center of NGC 1275, and appears to be rotating in a disk at position angle of 120°. The total velocity spread of the rotating structure is about 450 km/s, which, depending on the inclination of the rotating disk to the line of sight, may be consistent with a stellar mass of about 10^{11} solar masses interior to a radius of 3 kpc.

2.2.3 The Nearest Galaxies (< 10 Mpc)

Dust Distribution in the Edge-on Spiral Galaxy NGC 891

The 30 m telescope has been used with the MPIfR 7-channel bolometer array to map the 1.3 mm continuum emission from the edge-on spiral galaxy NGC 891. This continuum emission arises mostly in cold (< 20 K) dust associated with molecular clouds. It correlates remarkably well with the CO emission and poorly with H I emission, up to a radius of 7 kpc from the center of the galaxy. The H_2 mass derived from the cold dust emission is about 3 times lower than that derived from CO, and about 20 times higher than the mass of gas associated with the warm dust observed by the IRAS satellite.

HCN in the inner region of M 82

The IRAM interferometer has mapped the south-west part of the central starburst region of the galaxy M82 in the HCN(1-0) line, with a 3"x 2" beam. The central molecular ring is resolved into individual giant molecular cloud complexes with sizes and masses similar to those in the

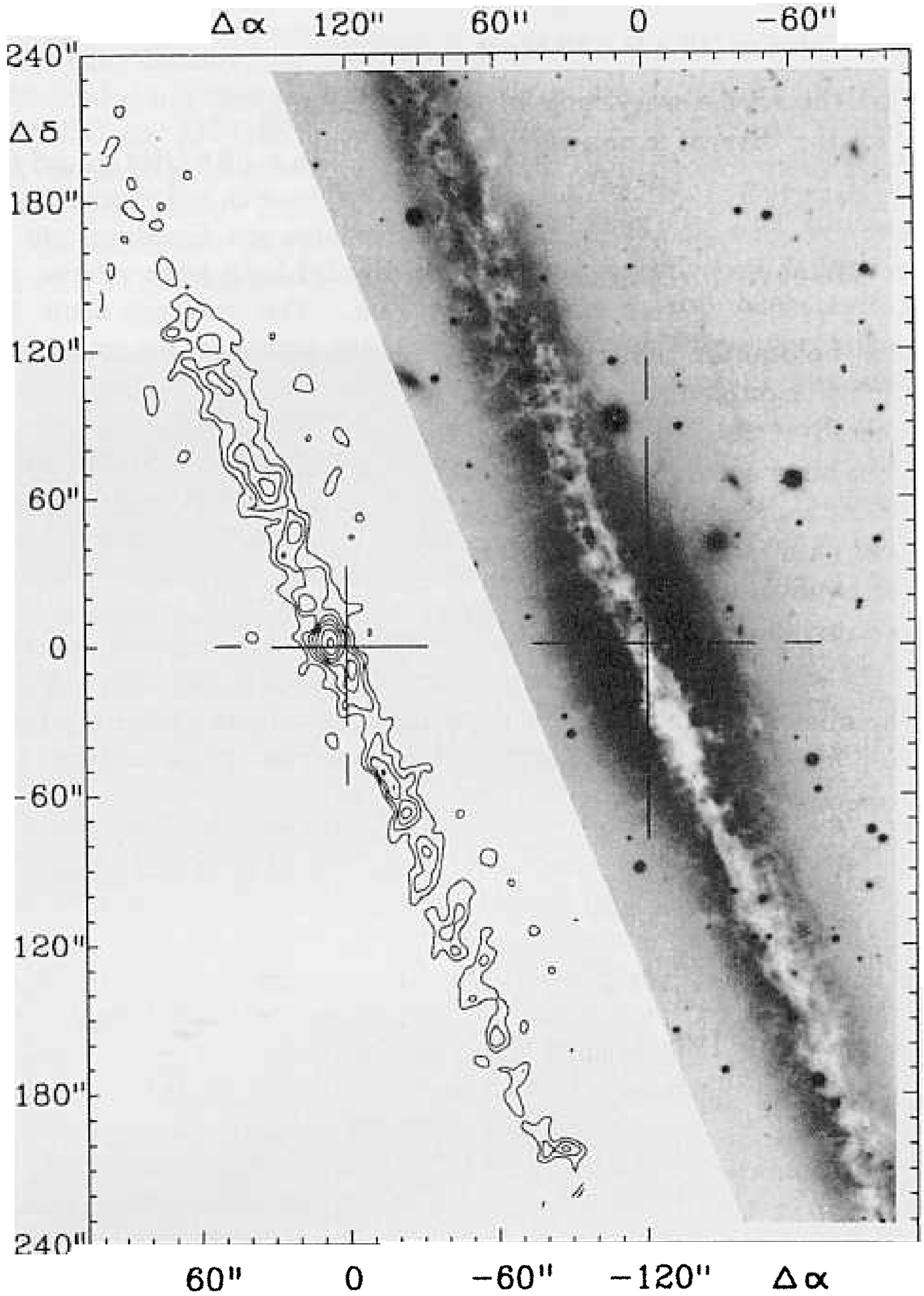


Fig. 2.2 : *left:* Map made with the 30 m telescope of the 1.3 mm continuum emission from cold dust in the edge-on spiral galaxy NGC 891. *right:* Optical photograph of NGC 891.

central parts of our Galaxy. The dense molecular cores do not coincide with supernova remnants in the center of M82, but do seem to be embedded in a huge photodissociation / photoionization region. An intense and compact (4") molecular complex of 1.2 x 10^7 solar masses is displaced by about 5" from the M82 nucleus. This peculiar complex coincides with the 12.4 micron peak and with the radio recombination line centroid, and hence is a very active site of star formation. The global HCN(1-0)/HNC(1-0) line ratio in M82 is 2-to-1, about the same as in hot, dense star formation regions in our Galaxy. The mass of gas derived from the molecular line observations is a very large fraction (about 40%) of the dynamical mass within the same region, as derived from the rotation curve. This unusual situation may help explain why M82 is undergoing a powerful nuclear starburst at the present epoch.

2.3 YOUNG STELLAR OBJECTS

A Submillimeter Recombination Line Maser in MWC 349

The first detection of a radio recombination line maser at *submillimeter* wavelengths has been made with the IRAM 30 m telescope and confirmed with the JCMT. The line is the hydrogen 26α-line at 353 GHz. The recombination-line masers in the young, massive star MWC 349 are thought to originate on the inner edge of a circumstellar disk, where the disk's gas is ionized by the ultraviolet radiation from the star. The star also produces a strong, opaque, stellar wind. At frequencies lower than 100 GHz, the opaque region is larger than the disk, preventing the masers on the disk's inner edge from being seen at centimeter radio wavelengths. The differences between the blue- and red-shifted maser spikes in velocity, line width, intensity and degree of maser saturation can be explained if the disk containing the masers is rotating and also contracting toward the star at a velocity of 5 km/s or less.

Images of the Rotating Ring around GG Tauri

Interferometer observations of the 2.6 mm line emission from ^{13}CO show a fully resolved, rotating thin disk around the young close binary star GG Tau. The rotation curve and geometry agree well with a model of a Keplerian disk inclined 43^o to the line of sight and orbiting a binary system with a total mass of 1.2 solar masses, consistent with the stellar luminosities (Fig. 2.3). Interferometer images of the dust continuum emission show that the disk extends to an outer radius of at least 800 AU, but has a large inner hole of radius 180 AU, probably due to tidal forces induced by the binary star, in an eccentric orbit. The dust ring may be located at the position where the orbital period of the disk is in resonance with the period of the binary star. Angular momentum transfer from the binary to the disk will increase the orbital eccentricity and stop further accretion onto the stars, increasing the lifetime of the circumbinary disk. The dust continuum flux and the ^{13}CO and $C^{18}O$ line fluxes imply the CO abundance in the disk is about 20 times lower, relative to the total mass of gas and dust, than it is in the general interstellar medium.

The Molecular Surroundings of W3(OH)

IRAM interferometer maps have been made of the compact H II region W3(OH) in the mm continuum and in the molecular lines of $C^{18}O$, CH_3CN, and HCO^+ (Fig. 2.4), and the hydrogen recombination lines H41α and H59γ. The ionized gas in the compact H II region is detected in the recombination lines and in its free-free continuum emission. The methyl cyanide (CH_3CN) images show two compact sources, one at the cluster of water masers to the east of the H II region and the other at the high-density molecular clump that contains the OH masers seen toward the H II region. Both molecular sources have temperatures of order 100 K. At 111 GHz, there is also a compact, 112 mJy continuum source at the water maser cluster. If this emission is from dust, then the gas mass associated with the source at the water maser cluster is 30 solar masses, and the mass loss rate is about 5×10^{-3} solar masses per year, presumably from a young OB star still surrounded by a very thick cocoon of dust, with a column density of 3×10^{25} cm^{-2}.

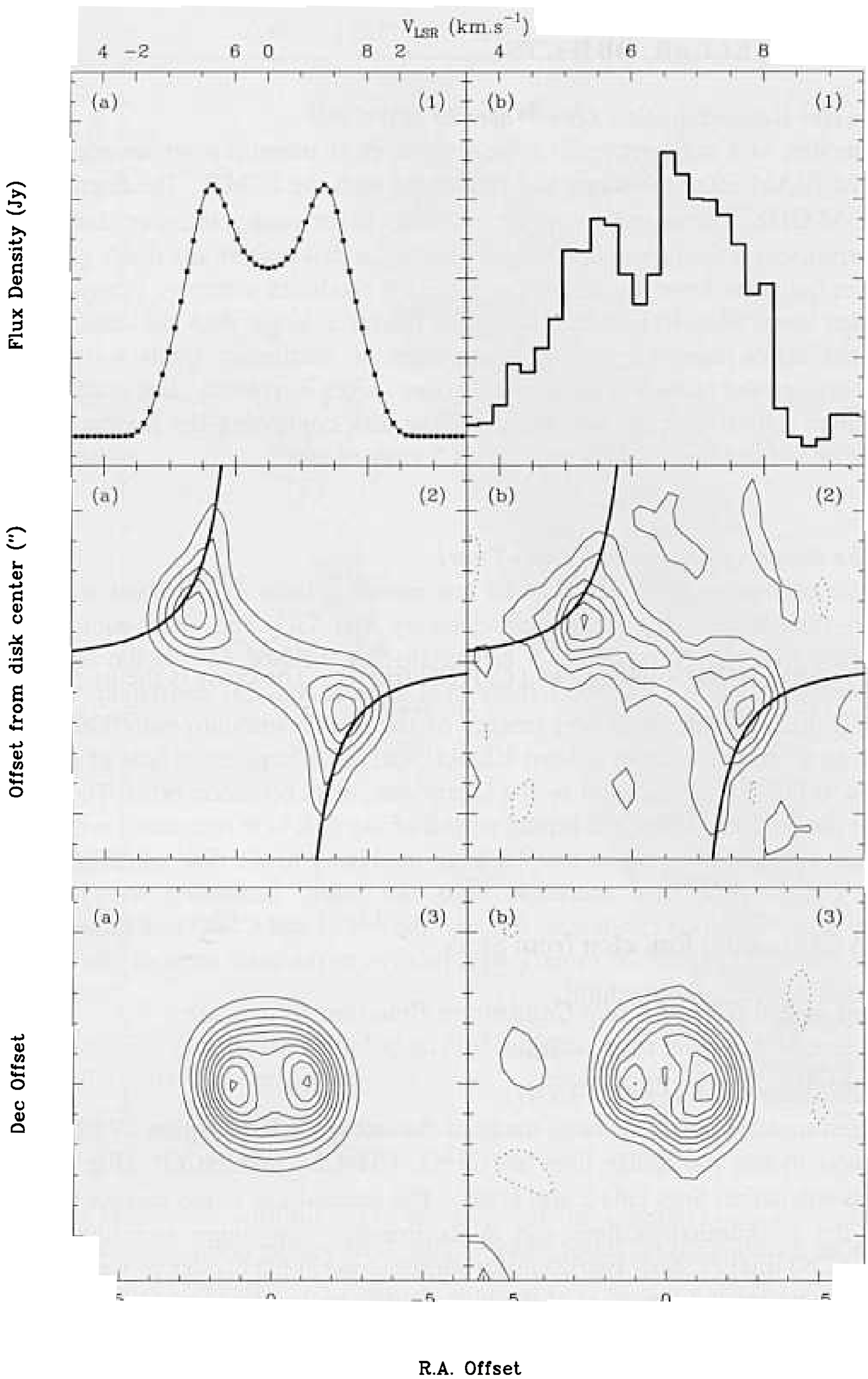


Fig. 2.3: Rotating ring around GG Tauri: comparison of model (left column) and interferometer observations (right column). *Part 1, upper panels:* Spatially integrated ^{13}CO intensity vs. velocity (topmost scale). *Part 2, middle panels:* Position-velocity diagrams in the plane of the disk. The solid curves show the expected loci for Keplerian rotation for 1.2 solar masses and a disk inclination of 43° , contour step 1 K ; the model has been convolved with the interferometer beam of 2.6" x 2.0" . *Part 3, bottom panels:* Continuum emission from dust in the disk, contour step 2 mJy/beam; continuum beam 2.1" x 1.4" .

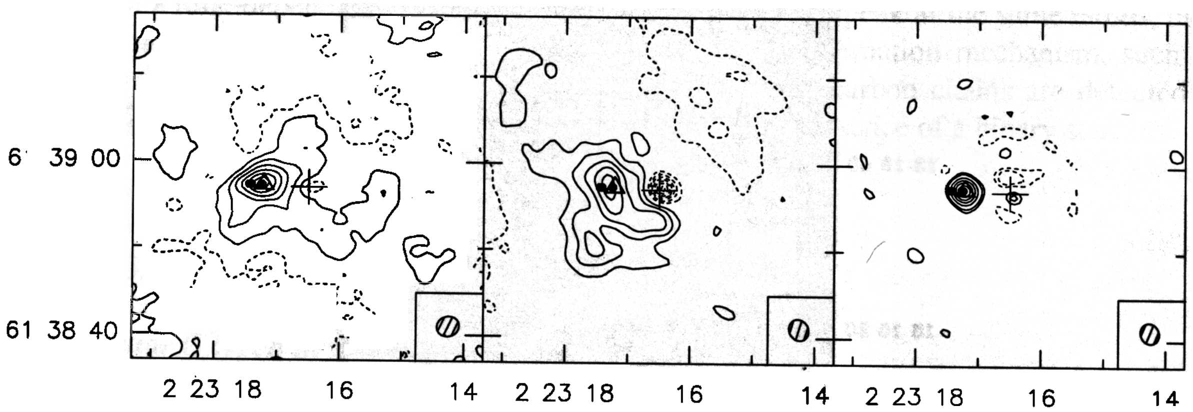


Fig. 2.4 : Interferometer maps of gas near the compact H II region W3(OH) in the molecular lines of $C^{18}O$ (left), HCO^+ (middle), and CH_3CN (right). The cross is the map phase center, near the main H II region, the filled circles are the positions of water masers and the open triangle is the HCN peak. Note that the molecules are all peaked near the location of the water masers.

CIRCUMSTELLAR ENVELOPES

2.4.1 Radio Continuum Emission from Stars

A New Survey at 250 GHz of Radio Continuum Emission from Stars

The 30 m telescope has been used with the MPIfR bolometer to survey 270 stars of different types for 250 GHz continuum emission. The results show early type stars often have fluxes that deviate from that expected from a uniformly expanding wind, probably because of temperature and density fluctuations in their lower atmospheres. For Wolf-Rayet stars, this deviation seems to depend on effective temperature. A substantial fraction of the 250 GHz flux of pre-main sequence stars seems to come from shells of warm dust. Nearby giants and supergiants show ample 250 GHz emission from a transition layer between their photosphere and chromosphere. Optically variable stars are not very strong emitters at 250 GHz, except for a few β Lyrae type stars and symbiotic stars.

Chemistry and Dynamics of Stellar Envelopes

MgNC and the Carbon-Chain Radicals in IRC+10216

The infrared source IRC+10216 is a famous evolved star whose circumstellar envelope has an extremely rich spectrum of molecular lines. About 50 molecules, including highly refractory compounds and highly reactive species have been identified in this dusty envelope.The IRAM interferometer has mapped IRC+10216 with resolution 4" x 3" in the 95 and 98 GHz lines of the MgNC, C_4H, and C_3H radicals (cf. Fig. 2.5.).

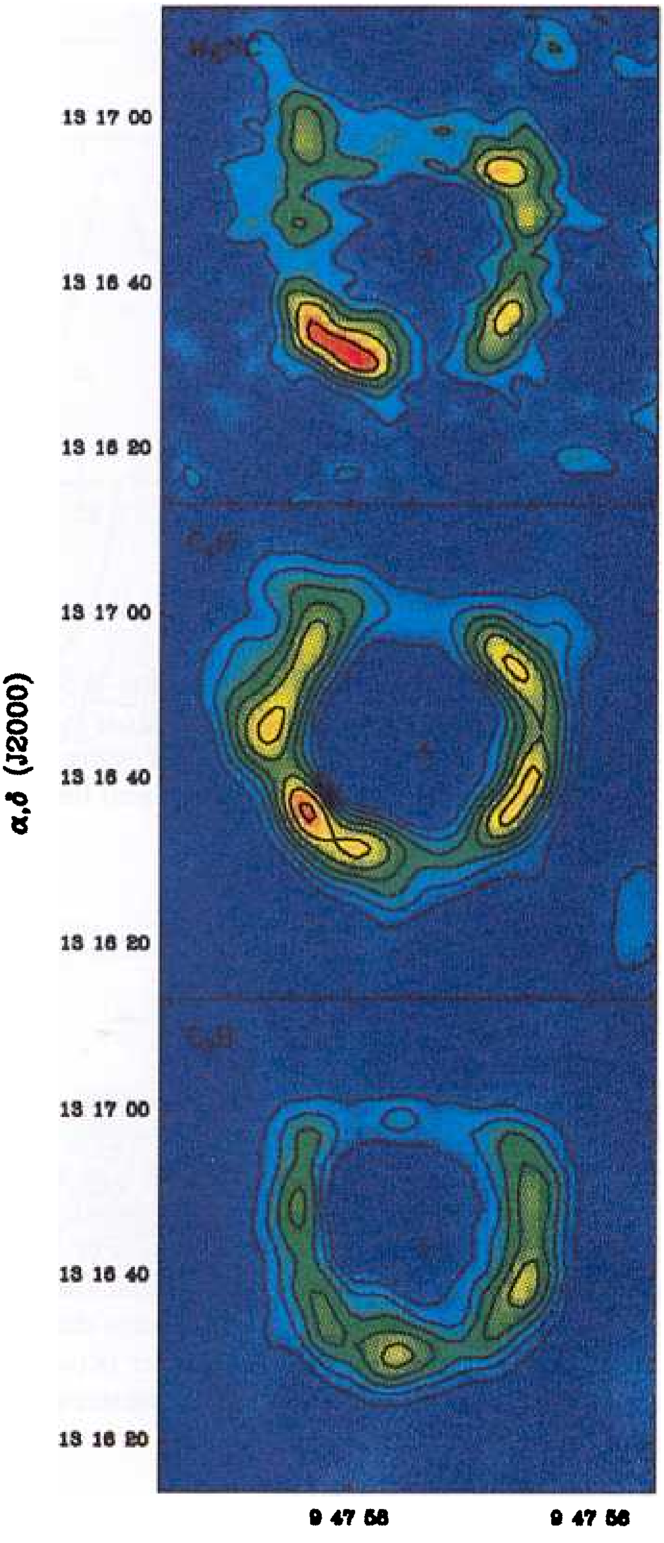


Fig. 2.5: Maps from the IRAM interferometer, with a 5" beam, of the circumstellar envelope of IRC+10216, in MgNC (top), C_4H (middle), and C_3H (bottom). A point-like mm continuum source coinciding with the IR source (cross) has been removed from the maps. Each box shows the emission in a velocity range of -21 to -34 km/s. The C_4H and C_3H maps lack some short spacing information, as the interferometer data for these two molecules have been combined with only a single spectrum from the 30 m telescope.

Unlike the centrally peaked emission of NaCl, SiO, SiS, CS and CO, the MgNC emission arises in an expanding shell of radius 15" (4.5 x 10^{16} cm). The patchy appearance of the MgNC, C_4H, and C_3H maps reflects a clumpy gas distribution. The shell-like distribution is the result of a time-dependent chemistry. Since the three radicals peak at the same radius, they must form almost simultaneously. This suggests a common formation mechanism, such as desorption from dust grains. The shell where MgNC and the carbon chains are detected is shifted by 2" from the infrared source, possibly suggesting the presence of a binary star.

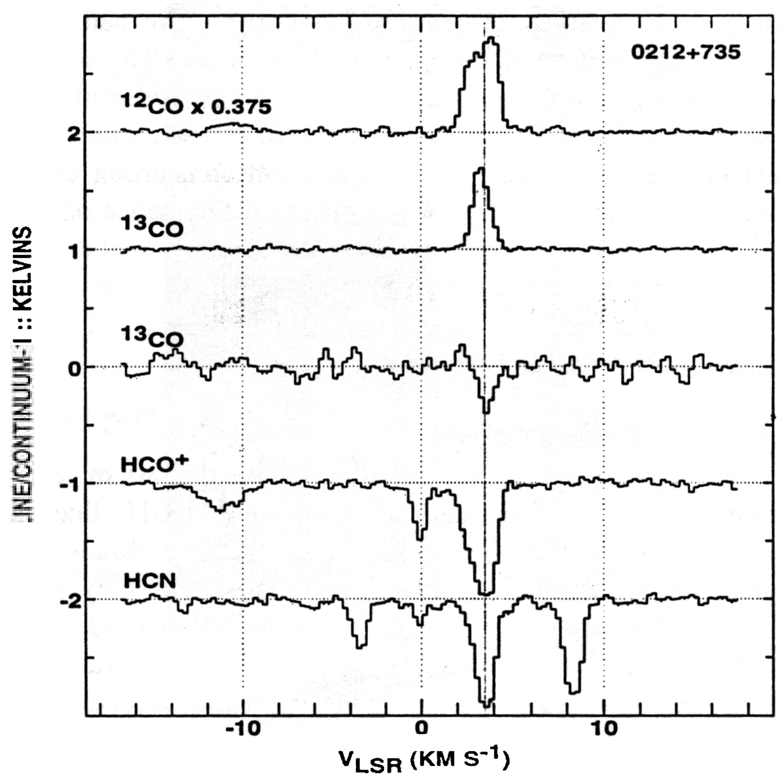
2.5 MOLECULES, ASTROCHEMISTRY

No Molecular Oxygen in Cold Dark Clouds

A search for molecular oxygen has been carried out with the 30 m telescope toward the prototypical dark clouds TMC2, L134N, and B335, in the 234 GHz line of $^{16}O^{18}O$. Upper limits to the O_2 / CO abundance ratio are about 0.2 in all three clouds. These are the first limits to the O_2 abundance obtained toward dark clouds, and they are similar to those previously obtained toward warm clouds. Chemical equilibrium models predict a value of [O_2 / CO] = 0.5, if the abundance ratio [C / O] = 0.4 , the cosmic value. The models could be brought into agreement with the negative results from the observations if the carbon to oxygen ratio in dark clouds is actually 0.7, instead of its textbook value.

Interferometer Observations of Molecular Line Absorption in Interstellar Clouds

The IRAM interferometer has been used to detect absorption line profiles of ^{13}CO, HCO^+, C_2H, CN, HCN, and HNC in a nearby molecular cloud in our Galaxy, on the line of sight to the extragalactic source BL Lac. A total of 12 lines were detected, corresponding to relatively low optical depths of 0.3 to 1.5 . Because the excitation is quite weak, the column densities are extremely reliable. The relative abundances of ^{13}CO, HCO^+, C_2H, CN, and HCN are similar to those in TMC-1, the well-known dust cloud in Taurus, but N_2H^+ (not detected) and HNC are deficient toward BL Lac by factors of three to six. It appears that there is less than one magnitude of optical extinction associated with the molecular cloud. The absorbing gas is probably only 330 parsecs from the earth, with a mass of only a tenth of the mass of the sun. Additional detections of Galactic molecular line absorption have been made on the lines of sight to the extragalactic continuum sources 0212+735, 0355+508 (NRAO 150), 2013+370 and 0727-115. In the directions toward 0215+735 and 0355+508 (Fig. 2.6), the HCO^+ absorption profiles have more and wider lines than are seen in ^{13}CO. Some very strong HCO^+ components are absent in the ^{13}CO emission profiles and are either quite weak or absent even in ^{12}CO emission. The absorption lines probably come from gas in the outer envelopes of molecular clouds, where the visual extinction is 1 magnitude or less. At such low densities, models of dark cloud chemistry do indeed predict unusual variations of the HCO^+/CO ratio.



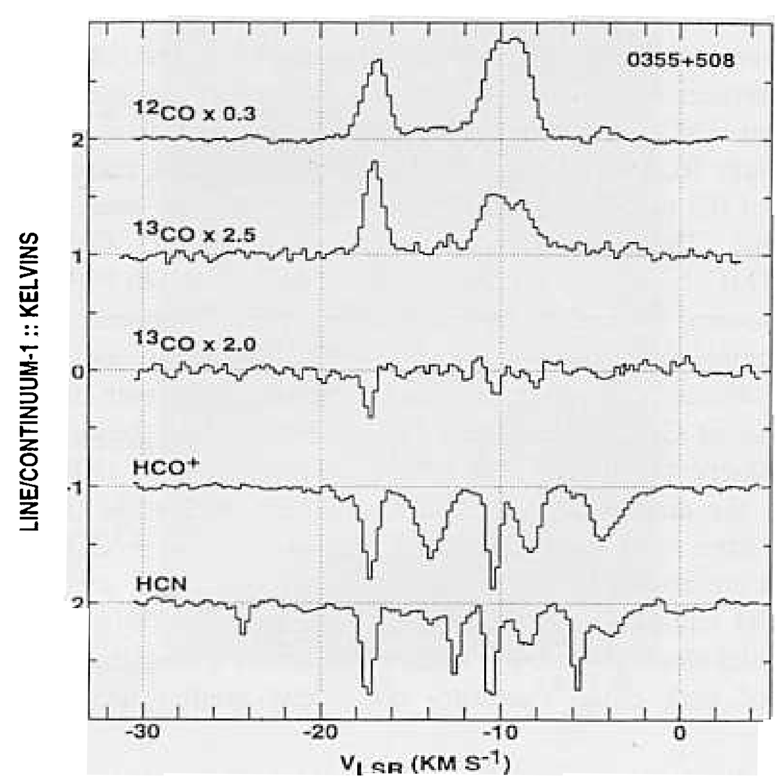


Fig. 2.6: Emission and absorption profiles from gas in our Galaxy, seen in the direction of the extragalactic continuum sources 0212+735 and 0355+508 (NRAO 150). The emission line spectra are from the NRAO 12 m telescope, and the absorption lines were detected with the IRAM interferometer.

2.6 SOLAR SYSTEM

CO in the Troposphere of Neptune

The CO J=1-0 line has been detected with the IRAM interferometer in the atmosphere of Neptune. The line has been detected in absorption, with a linewidth greater than 5 GHz and a line to continuum ratio of 5.3 ± 1.5 percent. Such a detection is probably only possible with an interferometer, and also requires an accurate calibration of the receiver's sideband gain ratio to a precision of better than 2 percent. This result means that CO, which had been detected previously in Neptune's stratosphere, is also present in the planet's troposphere, with a mixing ratio of 0.8 to 1.5 parts per million. Hence the CO abundance is about the same in the troposphere as it is in the stratosphere. This means the CO probably does not originate from infalling debris, as had been suggested previously, but from the interior of the planet (Fig. 2.7)

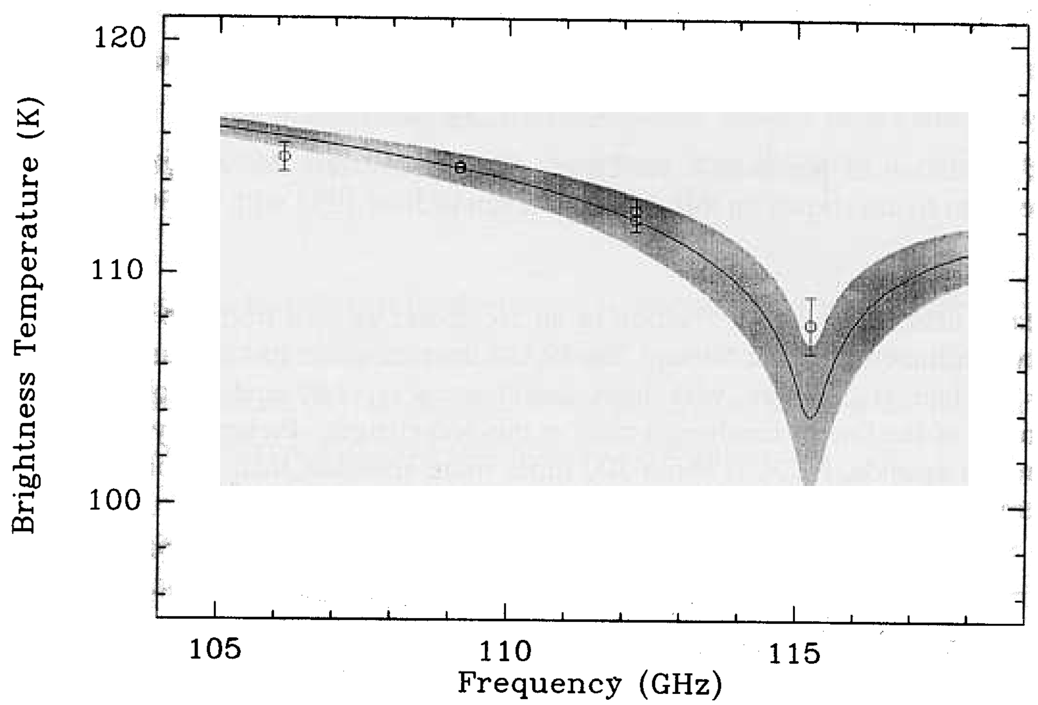


Fig. 2.7 : Detection of the CO J=1-0 line in absorption in the troposphere of Neptune. The solid line corresponds to a model with a CO mole fraction of 1.2 parts per million, and the shaded area represents ± 30 percent abundance variations around this value.

Acetonitrile in the Atmosphere of Titan

Titan is the only satellite of the solar system known to have a substantial atmosphere, mostly molecular nitrogen. The gas methane, CH_4 , was discovered by G. Kuiper with near-infrared spectroscopy of Titan's atmosphere in 1944. In 1980 the *Voyager* spacecraft detected in Titan's atmosphere many more simple hydrocarbons, probably made in methane photochemistry, as well as the gases carbon dioxide CO_2 , hydrogen cyanide HCN, cyanogen C_2N_2 , and cyanoacetylene HC_3N . Subsequently, the 30 m telescope was used in 1985 to observe the millimeter lines of HCN in the atmosphere of Titan. This was the first ground-based detection of a molecule in a satellite of the solar system at millimeter wavelengths. The 30 m telescope has now been used again to find in the atmosphere of Titan the molecule acetonitrile (or methyl cyanide, CH_3CN). This is the first new organic molecule to be detected on Titan since the *Voyager* results 13 years ago. The detection at Pico Veleta shows seven individual line components of this compound at a wavelength of 1.3mm (Fig. 2.8).

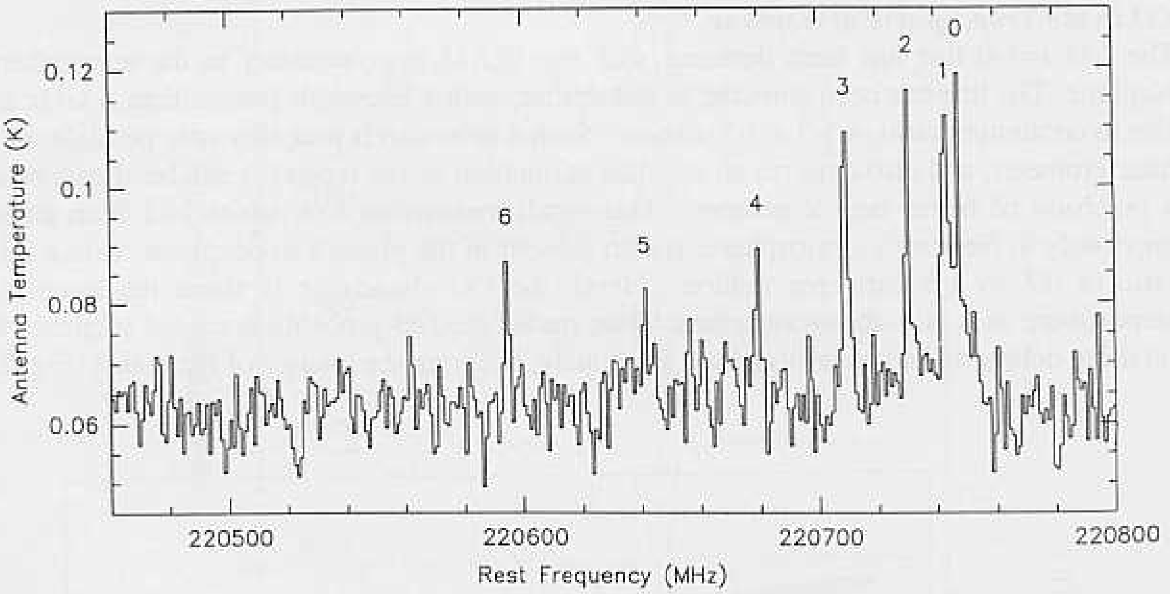


Fig. 2.8: Detection of acetonitrile on Titan. Seven individual line components of CH_3CN (numbered 0 to 6) are shown on this spectrum taken in June 1993 with the 30m telescope.

Since Titan's diameter is only a fraction of an arcsecond as seen from the earth, it is a point source for a millimeter interferometer. The IRAM interferometer has been used to measure the HCN J=1-0 line at 3.4 mm with high sensitivity (Fig. 2.9) and to obtain an accurate measurement of the line to continuum ratio at this wavelength. Preliminary estimates indicate that hydrogen cyanide, HCN, is about 300 times more abundant than acetonitrile, CH_3CN, in Titan's atmosphere.

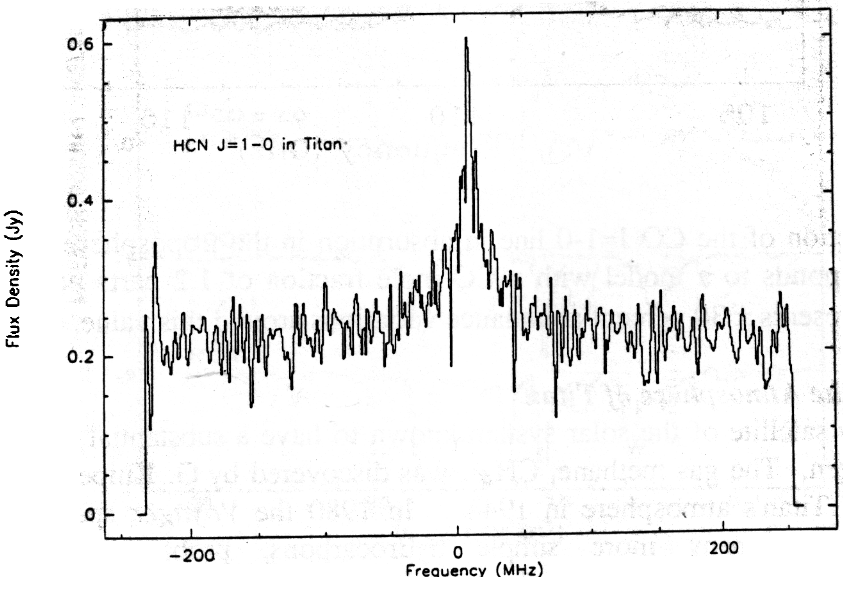


Fig. 2.9: Observation of the HCN J=1-0 line at 88.6 GHz in the atmosphere of Titan. The line was detected in the IRAM interferometer's lower side band, while Titan's continuum radiation was detected with high sensitivity in the upper side band.

3. PICO VELETA OBSERVATORY

3.1 STAFF CHANGES

In June 1993 we lost one of our senior colleagues and friend, Dr.Hans Steppe, who was one of the first scientists to join the IRAM staff. He lost his life in a tragic mountain accident in Austria.

In the fall of the year Albert Greve who had served as Station Manager in Granada since the beginning of 1991 returned to Grenoble. He was succeeded by Wolfgang Wild who took office in October 1993.

With Spain now being a full member, the IRAM Council approved a new procedure for the appointment of the Deputy Station Manager for the Granada station. Juan Penalver agreed to serve in this capacity while continuing at the same time with his tasks as chief telescope engineer.

In order to compensate at least in part for the loss of astronomical expertise in the astronomers' group in Granada, caused by the return of the former Spanish Co-Director of the station to Yebes and the untimely death of Hans Steppe, it was decided to increase the number of post-doc positions and to recruit an additional astronomer-cooperant.

Further staff changes occurred in the operators' and in the receiver group. Since one engineer had left and as Hauke Hein was supporting the work at the H.H.T. (Arizona) during a six months period, it was decided to delegate one receiver engineer from Grenoble to Granada.

3.2 30m TELESCOPE OPERATION

The operation of the telescope was productive and smooth during most of the time, also because of relatively mild climatic conditions. The telescope was regularly maintained for approximately 12 hours per week, including receiver fillings, receiver maintenance, test tunings, and computer and backend maintenance. A longer maintenance period of roughly 7 days was used for a general revision of the subreflector and improvement of the electrical distribution system. There were no major mechanical or electrical failures during 1993.

For better evaluation of the telescope operation, we introduced, in the middle of 1993, a more detailed log-book with entries made by the telescope operators. Based on these data, the telescope operational statistics for the period June to December 1993 is shown in Fig. 3.1.

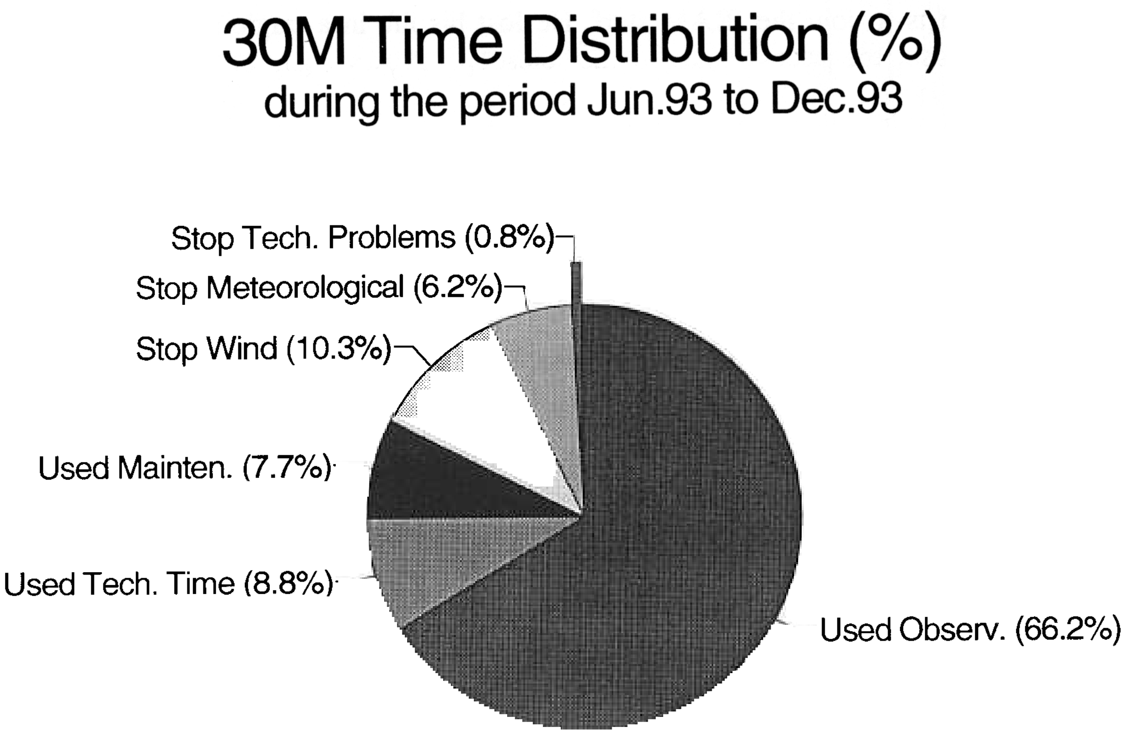


Fig.3.1: Distribution of telescope time for the period June to December 1993

For the majority of astronomical projects, we were able to make receiver tunings well in advance of the actual observations. The constant availability of a receiver engineer or technician at the site helped a lot towards the smooth receiver operation. The Granada astronomers provided throughout the year assistance in the observations, taking also care of the pointing and calibration. An extension of the spectral line calibration catalog to higher frequencies is nearing completion. The pointing model of the telescope has been investigated in detail; further measurements of the anomalous refraction have been made.

High quality observational data are, to a large extent, obtained through observations with the wobbler. In the past, frequent failures of the wobbler occurred in wintertime because of icing caused by the residual humidity of the compressor air. The installation of an air-dehumidifier has solved this problem. The status of the wobbler is now thoroughly checked by a dedicated PC.

As a follow-up on earlier concerns about wind forces on the telescope, IRAM asked advice from an expert for wind effects on buildings/structures from the Technical University Aachen.

INFRASTRUCTURE

After 12 years of use, the access road to the telescope shows signs of deterioration. In a longer-term plan, we have started repairs: the construction of a wall in the upper bend to avoid further ground erosion, part of the road has been reconstructed in the lower bend, the drainage system has been cleaned and improved.

The leaky water distribution tank, located close to the Laguna, has been replaced by a bigger steel tank. A better water filter has been installed at the telescope.

A heat-humidity-interchanger has been installed at the telescope, to provide better climatized air. The climatization-ventilation system of the Granada offices has been completely renewed. At the telescope, the carpet of the dining room has been replaced, the windows have been repaired, the rooms have been painted.

REFLECTOR SURFACE

39 GHz phase retrieval holography measurements using the geostationary satellite ITALSAT were made in June, July and September. The coordinates provided by the Italian Telespazio have now sufficient accuracy for us to track the satellite without preliminary determination of the orbit at Yebes.

After correcting the phase retrieval maps for defocus, coma and astigmatism, very good correspondence was found between the transmitter holography map (made at 86 GHz, 11 degree elevation) and two subsequent ITALSAT maps (43 degree elevation). On the basis of this agreement it was decided to adjust the reflector surface; this was done in December 1993.

Considerable time and thought were spent to understand the misalignment of the subreflector and also the astigmatism of the telescope. The astigmatism is found to be variable in amplitude during daytime due to solar heating. The surface adjustment was directed to reduce the nighttime astigmatism to low values, but a variable daytime astigmatism will remain. However, the measured systematic wavefront errors are now below the precision specification of the telescope.

3.5 RECEIVERS

The junction of the 230 G1 receiver was changed for a niobium junction.

The LO coupler of the 3 mm Schottky pointing receiver was repaired, and the receiver can be tuned again. At the same time, an attempt to install the second mixer was not successful since only one mixer survived the cooldown. Unfortunately, the working mixer also suffered a serious degradation during cooldown, resulting in a much higher receiver temperature.

The IF of the 3 mm SIS receiver has been changed to 1.5 GHz, the IF of the other receivers is 4 GHz. The down-converter of the 3 mm SIS receiver has been changed accordingly.

The Granada receiver staff has started the construction of a second 3 mm SIS receiver, expected to be ready in approximately one year.

Special receiver installation and related astronomical tests and observations involved:
- the MPE 350 GHz receiver built by H.Rothermel (11 days),
- the MPIfR 7-channel 230 GHz bolometer array (37 days),
- the IRAM single-channel 230 GHz bolometer IBOL-B (10 days).

Test were made with the IRAM 350 GHz SIS receiver in preparation for future use (1994) by guest observers

A Martin-Puplett interferometer for the measurement of the receiver sideband rejection has successfully been completed, and the instrument is installed in the focus cabin. The final application requires further studies of its characteristics and automation for remote use.

The Granada receiver engineers participate in the design of the optics for the 37-channel bolometer array.

3.6 BACKENDS

The IF distribution box was completed and installed at the telescope. It is now possible to select via OBS all the backends as well as to fully configurate (receiver, bandwidth, resolution) both correlators (automatic attribution of subbands without intervention of the observer). The incorporation of the correlators and the upgrading of the backend control thereby is [illegible]iated to full satisfaction.

A special backend for holography has been built and calibrated. The quality of the holography measurements is now determined only by atmospheric instabilities and the signal level of the satellite/source.

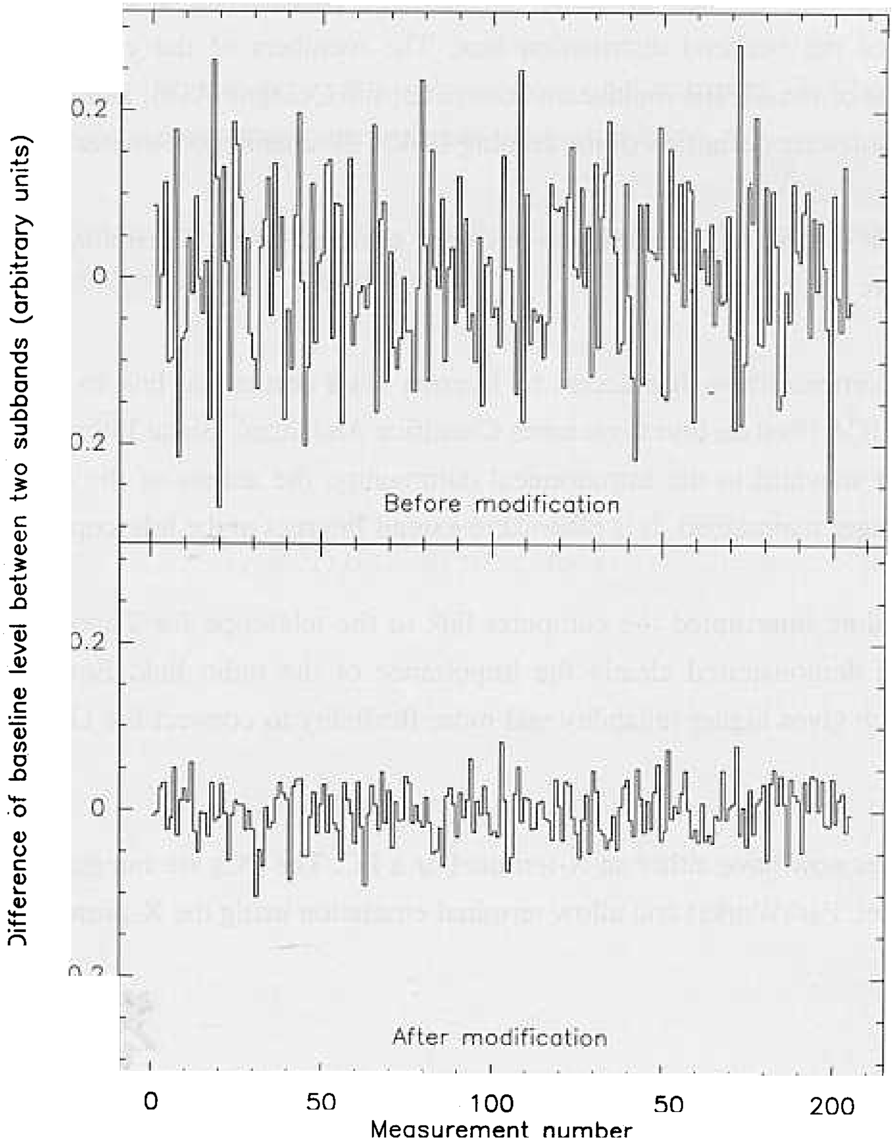


Fig. 3.2: Improvement in correlator subband platforming. Displayed is the difference in platform between two adjacent subbands as determined in 200 measurements.

Work on the 1 GHz processor for the filterbanks was continued.

Preliminary investigations were made about the "platforming" effect of the correlators, and several causes of this effect were found. A first modification was made to cure the dominant effect which reduced the "platform height" by a factor of 3 or 4. Correction of other causes of this effect is pending, the ultimate goal is to reduce this effect below the observable level.

3.7 COMPUTERS

The computer group, assisted by some astronomers, participated in the incorporation and programming of the backend distribution box. The members of the computer group were involved in tests of the MPIfR multibeam bolometer, the Cologne AOS, and participated in the computer and software definition of the coming IRAM 37-channel bolometer array.

The 'quick-look' display at the telescope has been changed to an X-terminal providing faster display and more flexibility.

The Granada computer now has access to Internet via a permanent link to the University of Granada and RICA (Red de Investigaciones Cientifica Andaluza). Since Internet is the *de facto* communication standard in the astronomical community, the access of the local network via SPAN is no longer maintained. It is planned to extend Internet to the telescope.

A hardware failure interrupted the computer link to the telescope for 2 months. The lack of communication demonstrated clearly the importance of the radio link. Equipment has been purchased which gives higher reliability and more flexibility to connect the Granada office and the telescope.

Nearly all offices now have either an X-terminal or a PC. The PCs are integrated into the local network (Decnet, PathWorks) and allow terminal emulation using the X-protocol.

3.8 VLBI

A 3 mm/1 mm VLBI campaign was successfully executed in April, a 7 mm campaign was made in July. 7 mm and 3 mm VLBI observations may now be considered as routine observations (with support from the MPIfR).

3.9 SAFETY

The computer-backend room at the telescope was equipped with a new fire extinguishing system.

A training in fire-extinguishing was provided by the Granada fire brigade, and the telescope personnel also participated in a First Aid course. Four more fire hoses have been installed (2 in the building, 2 in the telescope), 20 extra fire extinguishers have been bought.

3.10 ADMINISTRATION - ACCOMODATION - TRANSPORT

The Ratrac has been made more comfortable for personnel transport. The bottles with liquid helium and nitrogen are now transported outside the person cabin.

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

4.1 INTERFEROMETER STATUS

Although in operation now since three years, the interferometer has been significantly upgraded in 1993.

The most significant progress has come with antenna 4. However, many difficulties were encountered during the commissioning of this antenna:

The deicing system of the subreflector legs was not reliable, and almost caused the destruction of one leg.

The antenna suffered from pointing problems in elevation

Switching from three to four antennas has revealed a number of subtle problems with the correlator system: timing problems, problems with the Walsh functions for cross-talk reduction and sideband separation, bandpass calibration accuracy, etc. These problems have been corrected now. Since the general software policy adopted for Plateau de Bure data was to store all parameters used to control the interferometer, data acquired while these problems existed can usually be corrected *a posteriori.*

Progress has continued on the pointing. The pointing jumps in elevation which affected antenna 1 and 4 have been clearly identified as resulting from hysteresis effects in the subreflector actuators. The replacement of the actuators in antenna 1 cured the problem, but for antenna 4, the spare actuators ordered from the manufacturer turned out to be incompatible with the models we had (despite the fact that they have the same reference numbers).

Another important step in improving the array sensitivity has been the understanding of the origin of losses due to phase noise in the local oscillators of some antennas. This was due to poor harmonic mixer performances, and to high frequency noise coming from aging power supplies in antenna 2.

Along the same line, the receiver alignment (and hence the illumination of the antennas) has been improved on two antennas. Repeated holography measurements have help to systematically improve the surface quality (now about 70 µm on all antennas).

Fig. 1: The now fully completed four elements of the Plateau de Bure Interferometer (photo: A.Rambaud/IRAM).

4.2 OBSERVING PROJECTS

The Plateau de Bure Interferometer has fully completed 75 projects. For the second consecutive year, an exceptionally bad weather period during the fall delayed quite significantly a number of projects, so that late in 1993, 16 projects were still awaiting completion.

The repartition of the 91 projects per country is the following:

Country	By First Authors
IRAM	24.0
Germany	22.0
France	28.0
Spain	7.0
USA.	9.0
Others	1.0

These numbers are a very poor representation of the effective use of the interferometer, since projects range from small detection experiments carried out by one or two astronomers, to large, multi-national collaborations equivalent to several complete syntheses. The original PI is not necessarily the first author on the publication. For example, US projects are generally carried out in collaboration, and often turn out to be published with a first author from IRAM.

Per category of projects, the repartition is

Star Formation, PMS	22
Circumstellar Envelopes	22 [1)]
Galaxies	24
Molecular Clouds	10
Solar Systems	2
Others	12

[1)] including one project equivalent to several syntheses

The range of topics covered by the interferometer continues to increase. Unfortunately, the visibility of results obtained with the Plateau de Bure Interferometer is still very low due to the slow rate of publication. While this is somehow understandable because of the complexity of the instrument, it is important that this be changed.

4.3 DATA ANALYSIS

The advent of the new correlator required a significant upgrade of the CLIC package. As usual, the upgrade has been made in an upward compatible way. The new CLIC version completely handles the six units of the correlator, with four antennas, and is also able to process data coming from the old correlator system. Special care has been taken to handle phase closure relations and broad-band signals ("pseudo-continuum" channels) in order to leave open the possibility of self-calibration and hybrid mapping when the four antennas are used.

While developing this new CLIC version, a number of subtle errors in the previous CLIC program were discovered. The most significant one is the 98 kHz shift of the LO3 system which had not been accounted for. Other errors were only relevant for very special cases, and normally did not occur in standard data reduction, provided the guidelines described in the documentation were strictly followed.

Some problems were also encountered in the new CLIC program which have only recently been solved. It is important to note that most problems were only discovered during full scale data reduction of projects in Grenoble. Many subtle problems were related to compiler bugs or undiagnosed compiler misuse; the expertise in this field has increased significantly and we hope to reduce such effects to a negligible amount in the future.

Less visible but also very important progress has been made for the mapping stage, with the development of a more flexible, interactive, CLEAN-based deconvolution program, and, in collaboration with the Observatoire de Grenoble, a completely redesigned version of the GreG plotting package. The new versions incorporate a comprehensive handling of color displays (bitmap) and completely supersede the previous GreG/GRAPHIC programs. The new facilities forced some incompatible changes in some command names, although most users may not even notice.

These facilities are now released as standard part of the GILDAS package, and support for the older versions has been terminated. A new version of CLIC allowing antenna-based calibration of all parameters is under test, but not yet fully debugged.

A software exportation system has been built. The software is available from anonymous ftp (on iraux2.iram.fr). The source code and an installation procedure are available for Unix computers. Successful installations have been performed on several platforms: HP 700, IBM RS/6000, SUNs.

Support for VMS could no longer be provided during the last years. Some work is going on with the Observatoire de Grenoble to try to bring the VMS version up-to-date. However, because of manpower limitations, it is likely that further development will no longer occur under VMS.

OTHER DEVELOPMENTS

4.4.1 LO System

The second generation LO system is now working in the lab. A gain of 15 dB in phase noise is obtained as compared to the current generation. A high precision frequency synthesizer will allow better Doppler tracking, specially at 230 GHz. Final integration, including software development to control the systems, has started.

4.4.2 Baseline Extension

A geodetic survey has been carried out to control the ground quality and find out the possible positions of new stations for the extension of the baselines. An increase of the baseline length by 50 % is possible, and studies are under way to optimize the choice of the station positions.

Phase monitoring

We are beginning to study possibilities for compensating the atmospheric phase fluctuations by monitoring sky emissivity variations. Such a system, if feasible, should allow the recovery of a significant amount of observing time.

5. GRENOBLE HEADQUARTERS

5.1 SIS GROUP AND RECEIVER GROUP ACTIVITIES

5.1.1 General

A second SIS User Meeting was held at IRAM on November 4 and 5. Representatives from the following institutions attended the meeting:
University of Groningen/SRON, University of Cambridge, Rutherford-Appleton-Laboratory, Laboratoire de Spectrométrie Physique - Grenoble, Laboratoire d'Astrophysique - Grenoble, Observatoire de Bordeaux, CNET-Paris, University of Bremen, CNES-Toulouse, Max-Planck-Institut for Radioastronomy at Bonn, KOSMA-Cologne, DEMIRM/ENS-Paris, Max-Planck-Institut für Extraterrestrische Physik-Garching, LETI-Grenoble.

5.1.2 Junction Fabrication

100 GHz
Junctions with an integrated tuning circuit were fabricated for the first time.

230 GHz
A second iteration with modified tuning circuit was made.

345 GHz
IRAM junctions with integrated tuning structure were delivered to the MPIfR for the SMT.

460 and 690 GHz
For these frequencies, devices for quasioptical receivers with biconical antenna (460 and 690 GHz) were made for the MPE. A waveguide version for 690 GHz was delivered to the MPIfR.

5.1.3 Junction Development Related Activities

Current Density
For junctions operating at sub-millimeter wavelengths, a fabrication process was developed to obtain current densities up to 10 000 A/cm^2.

Energy Gap

The gap frequency $f_g = 2\ \Delta/h$ of good niobium is about 730 GHz at 3 K. For practical niobium junctions f_g is often below 691 GHz, an important astronomical frequency. A fabrication process has therefore been developed which could help to increase the energy gap Δ. For junctions with current densities up to 5000 A/cm^2, a gap frequency of 710 GHz at 3 K has been reached in this way.

Double-Barrier Junctions

Various tests were carried out with double-barrier junctions. Irradiation up to 350 GHz showed coherent response of the two superimposed junctions. First mixer experiments in the frequency range from 180 to 250 GHz gave DSB receiver noise temperatures around 100 K. Compared to single-barrier devices, drawbacks were noted. The J-V curves indicate heating and/or non-equilibrium effects in the middle electrode, the junction pair becomes non-uniform after moderate thermal annealing and needs a larger magnetic field to suppress Josephson effects.

Resonances with the Integrated Tuning Circuit

The interaction between the Josephson oscillation and the integrated microstrip resonator of the mixer can create self-induced current steps in the Junction I-V curve. This effect has been studied in some detail for mixer circuits designed for frequencies up to 690 GHz. For certain tuning structures, the location of the current step is closely related to the design frequency. Thus a simple dc measurement of the current step can show if the circuit resonates at the desired frequency.

NbN Junctions

First NbN devices have been fabricated. The MgO tunnel-barrier was made by sputter deposition of MgO or by oxidizing a sputtered Mg film. The quality of the I-V curves is not good enough for SIS mixers so far.

NbN films were delivered to the university of Cologne for measurements of the surface roughness, the transition temperature, and of radio frequency properties.

For the investigation of various process steps, NbN mixers were fabricated from trilayers made by the Electrotechnical Laboratory in Japan. Such a mixer was tested in the MPE. The DSB noise temperature at 220 GHz was 320 K.

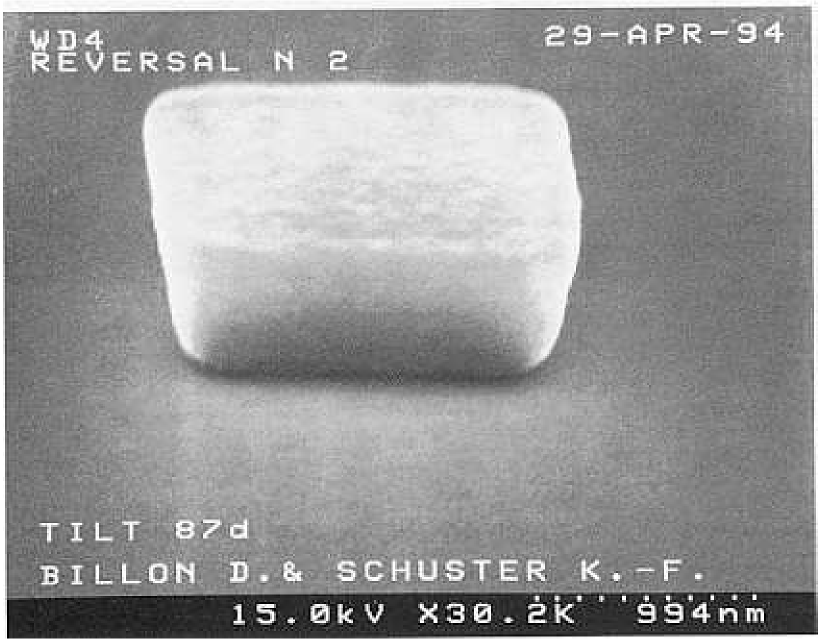


Fig. 5.1: Application of the electron-beam microscope to study the quality of photoresist stencils. To define the area of an SIS junction, a wafer is first covered by a photoresist, then exposed to light through a chrommask, thermally annealed, again exposed to light (without mask), and finally developed. In the present case these process steps left a small resist stencil which defines the later junction area. The aim which was successfully achieved was to obtain a stencil with re-entrant walls.

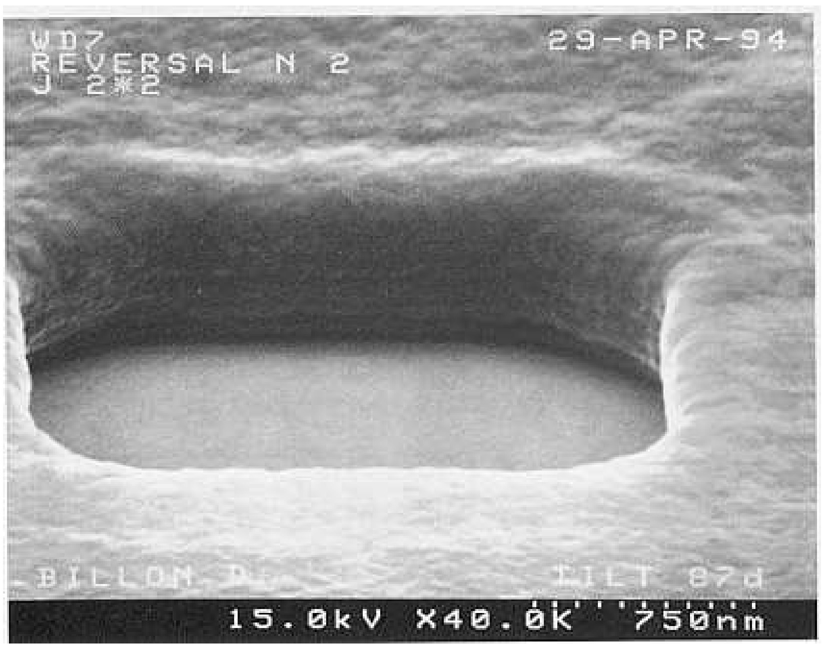


Fig. 5.2: The same as above except that this time the mask was the "negative" of the one used before.

New Equipment

A field emission scanning electron beam microscope was installed and is used for process improvements.

5.1.4 - New Receivers and Upgrades at the Telescopes

Dual-Channel Receiver for Plateau de Bure

At the end of 1992, it was decided that too much time had been wasted with the the Air Liquide cryocoolers, and that they were unlikely to ever provide a reliable cryogenic platform for future receivers. Even before the contract with Air Liquide was formally terminated, it was decided to start the development of an interim dual-channel receiver based on a commercial hybrid cryostat from Infrared Laboratories. This cryostat comprises a CTI350 GM cryocooler, that cools the two heat shields and the IF amplifiers, and a 5-liter He bath.

The receiver features two mixers in the 3mm and 1.3mm bands, that can operate simultaneously in orthogonal polarizations. The two local oscillators are fed into the dewar by stainless steel waveguides and reach each mixer through a sidewall multihole coupler, fabricated in IRAM. This is made possible by the modest LO power requirements of SIS mixers. The suppression of the quasi-optical diplexer eliminates one adjustment and one potential source of instability. The signal beams are refocussed by two elliptical mirrors and recombined in a polarization grid. Such refocussing, together with polarization flipping by roof-top mirrors and internal polarization diplexing, allows a cold load calibration of each receiver. The design ensures a wavelength-independent illumination.

At of end 1993, the cryogenic tests were completed, and a hold time of 21 days was achieved in the working configuration. The two receivers were operated simultaneously; only a weak interference was noted when the signal frequencies are harmonically related.

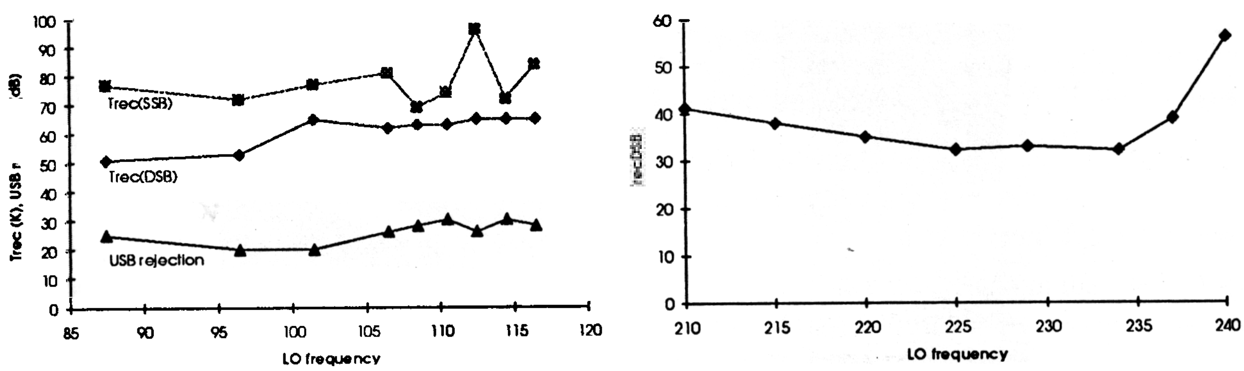


Fig. 5.3: Receiver temperature measurements for the first 3mm and 1.3mm dual channel which is being readied for Plateau de Bure.

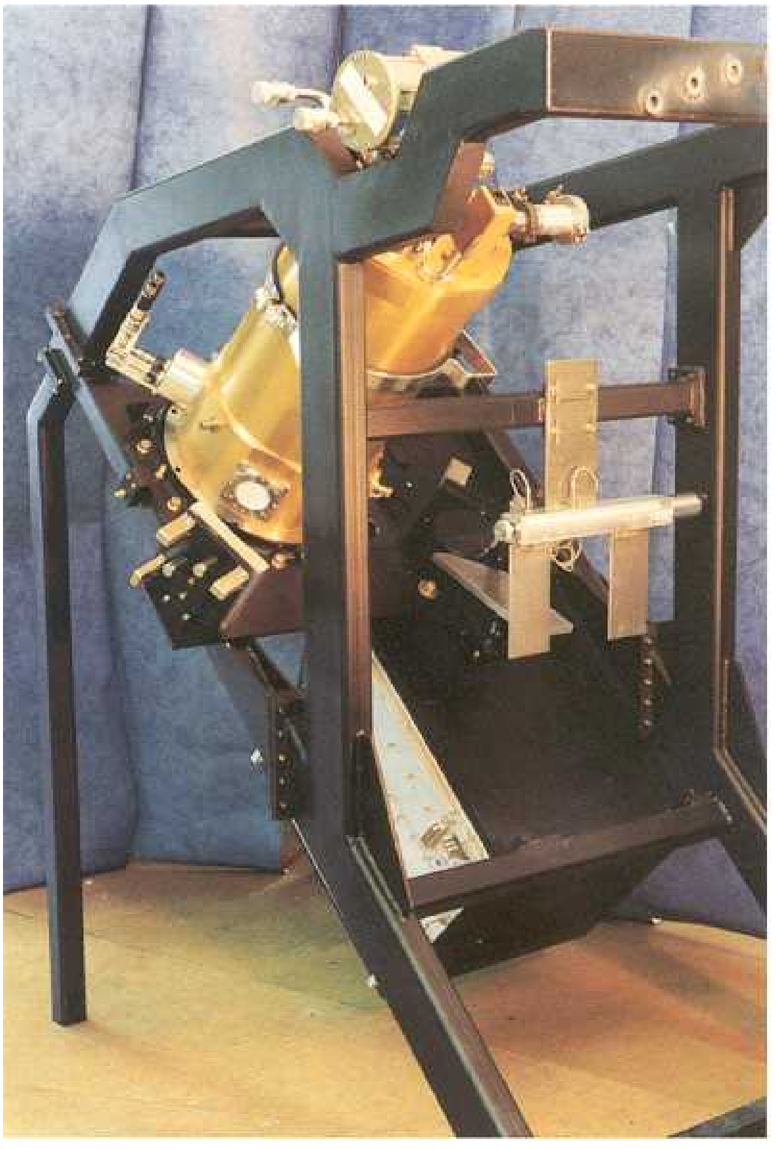


Fig. 5.4 : The first PdB dual channel receiver (hybrid cryostat) mounted in its support structure. One dewar window and elliptical mirror can be seen on the front side.

MK III Receiver for PdB Antenna 4

The 3mm receiver built in 1992 for antenna 4, in a traditional MK III cryostat, was installed sucessfully early in 1993, and has worked properly since then.

230 GHz Receiver at Pico Veleta

A new mixer was installed in the 230 GHz receiver at the end of 1992, and was mentioned in the previous annual report as having stability problems. These problems were diagnosed and solved early in 1993. The actual performance recorded during operation at the telescope is shown in Figure 5.5.

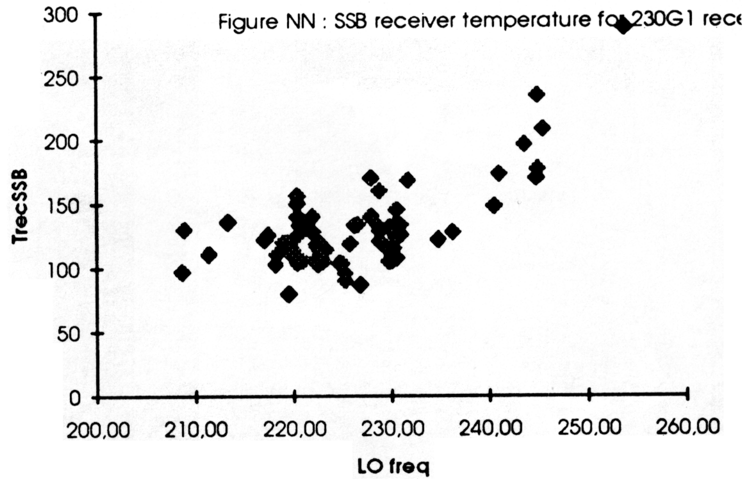


Fig. 5.5: SSB receiver temperature measured at the telescope of the 230 GHz receiver after the replacement of the mixer.

345 GHz Receiver for Pico Veleta

The 345 GHz SIS waveguide receiver developed at IRAM in 1992 was installed at the 30-M telescope and offered for two weeks in March for scheduled observing. The forward coupling efficiency was measured as 0.8, but the aperture and main beam efficiencies still reflect the imperfections of the dish. The DSB receiver noise measured at the telescope is shown in Figure 5.6. Later in 1993, this receiver was modified to include LO injection by a waveguide coupler. Since the backshort is operated at a fixed position, only the local oscillator needs to be adjusted during operation.

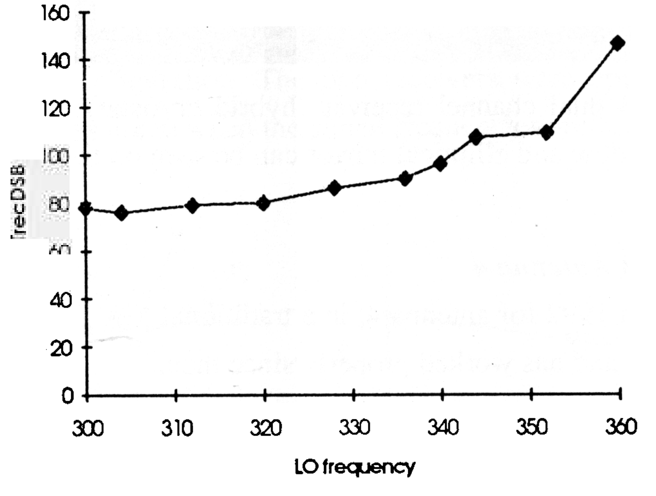


Fig. 5.6: The 345 GHz DSB receiver noise measured at the telescope.

Identical junctions have been provided to the MPIfR and have been installed in a receiver which will go to the H.H.T. (Arizona). Differences in performance are probably caused by substantial differences between the MPIfR and IRAM mixer block designs.

Fig. 5.7: Dual-channel receiver being characterized under computer control. From left to right: receiver engineer, phase lock monitor, receiver dewar, X-window display, local oscillator modules.

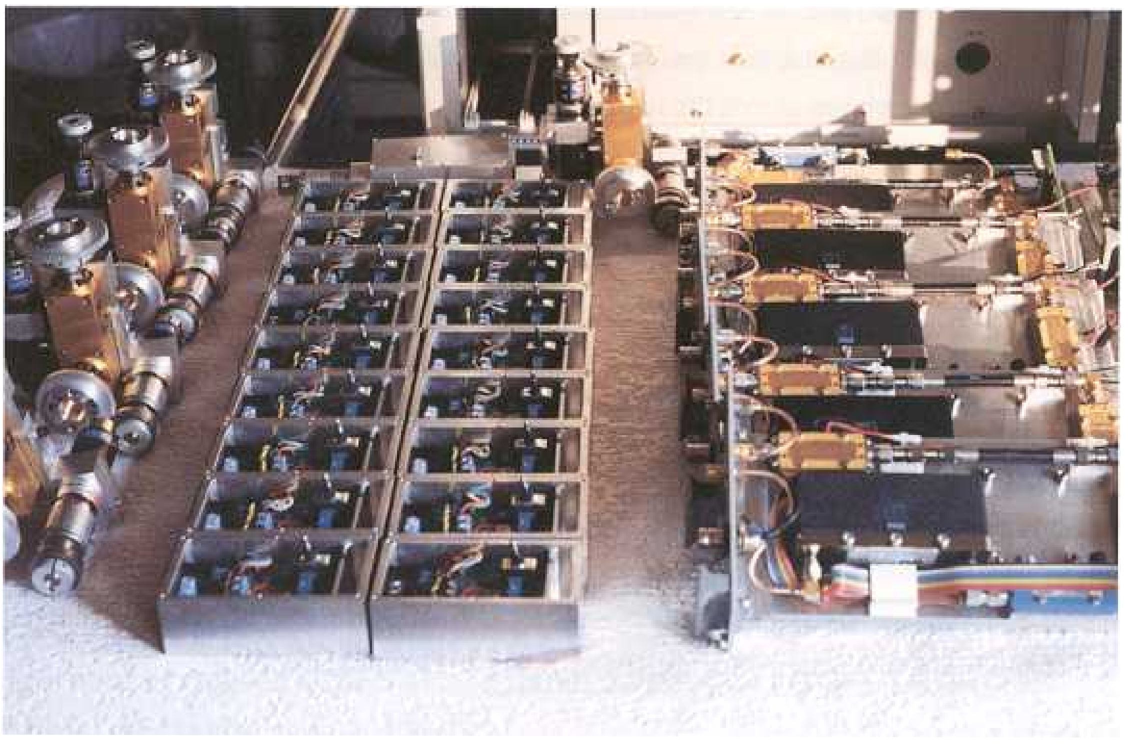


Fig. 5.8: Series production of the new remote control system units.

5.1.5 - Future Receivers and Laboratory Developments

Remote Control for Receivers

The new receiver remote control system has been through an intense development phase during 1993. The hardware comprises four main parts :

1)a VME rack containing the processor, Ethernet interface, digital, A/D and D/A interfaces;

2) an intermediate rack containing analog modules;

3) a shielded interface to sensitive electronics, directly attached to the cryostat;

4) a local oscillator module, including also the room-temperature IF amplifiers.

The choice of VME gives access to numerous industry-standard hardware, software, and communication components.

By the end of 1993, all modules had been tested with base-level software. Modules for 8 remote control systems (each capable of controlling up to 4 receivers) have been fabricated by subcontractors and are being tested and integrated. The same control system, with minor variations in software and IF frequency, will be used for future receivers and upgrades at both sites.

SIS Mixer Progress

Improved laboratory results have been obtained in the 1.3mm band, with a receiver using LO injection via a waveguide coupler and cold optics. The frequency coverage is still not adequate for telescope use. A 3mm-band waveguide mixer featuring a fixed waveguide stub tuner is under test. It gives very promising results: a 20-dB rejection of the USB can be achieved at all frequencies across the tuning band.

Laboratory Instrumentation

The mm-wave vector network analyzer built by IRAM around an HP8510 has been extended to the 1.3mm frequency band, delivering a 40-dB dynamic range. It is extremely valuable to check numerous components such as couplers, horns, etc... before integration into systems.

A Martin-Puplett interferometer has been built. Associated with a chopped load and a PC-based interactive software, it allows automated and accurate measurement and optimization of the noise and sideband ratio of receivers, eliminating the need for extra signal sources and calibrated power meters. It has also been used as a Fourier transform spectrometer to measure the frequency response of the IBOL-B single-channel bolometer.

Closed-Cycle Cryocoolers

Following detailed investigations involving visits to the manufacturers and users in Japan, Daikin closed-cycle cryocoolers were selected for future PdB receivers and for the 30-M multibeam heterodyne receiver. Both Daikin and Sumitomo cryocoolers showed an excellent reliability record in field use; Daikin was selected because of available technical support in Europe by APD (UK). The Daikin cryocooler provides 3 watts of cooling power at 4.2K, to be compared with 100 mW nominal for the Air Liquide machine, and typically 20 mW for a hybrid cryostat. The contract for five units was signed on 29-Oct-93, and deliveries are due in April and May 1994.

5.2 BACKEND DEVELOPMENTS

5.2.1 Next Generation Backends

Several technologies for a next generation ultra-wideband backend have been carefully considered, for some of these experimental results are available, but none of these technologies was found mature enough to be chosen as a baseline for a new big development project.

The technical activities of the BE Group have instead been concentrated on the development of an enhanced LO distribution system for the interferometer in order to replace the aging Camac-based one which is actually limited to 4 antennas

5.2.2 Progressive Withdrawal of Camac

The digital phase rotators and phase meter modules have been re-designed in VME standard and make use of the most recent DDS (Direct Digital Synthesis) technology. The whole system is modular and allows the extension to 5 or 6 antennas. It offers an upward compatibility with the existing one. A unique phase meter has been built which has shown an absolute accuracy of 16 bits per turn (15 seconds of arc). This will help in reducing to 0.5 degree @ 1mm the phase drift due to the coaxial cable.

5.2.3 A New Low-Noise 2nd LO

The phase noise of the present 2nd LO reduces the sensitivity of the interferometer by ~ 5% at 100 GHz, and would cause a ~ 20% loss at 220 GHz. A new DRO-based motorized oscillator block, associated with high-speed electronics has been designed, and demonstrated a 15 dB yield in phase noise, thus reducing the associated sensitivity loss to the 1% level. A new master synthesizer and high quality diplexers have been purchased. The IF transportation system design has been modified to remove several small effects found during the past years. Its bandwidth has been raised from 600 to 900 MHz to allow for future improvements.

5.3 COMPUTER GROUP

In 1993, the first HP workstations have been updated to model 735 which reaches a CPU performance of 147 SPECmarks. Later we received 2 new workstations HP9000/735 with the aim of enhancing the data analysis capabilities. These stations were funded by the Volkswagen foundation in connection with the VLBI project. All HP stations are by now equipped with 80MB of RAM.

Two color printers have been purchased. The first printer from Canon is connected to a PC, itself on the network. PostScript files produced either on VMS or UNIX can be processed and printed from the PC. This printer has also scanning and photo-copying possibilities. The Tektronix printer purchased later in 1993 interpretes Adobe 2 PostScript files. It is directly connected to a UNIX station which behaves as a printer server for all the workstations.

Communication between the PCs and the workstations has been improved. Some PC's (those used by the astronomers) use the TCP/IP protocol layer from FP Software on which an X emulation software has been installed. For the other PCs a new version of PathWorks is being installed. This version is compatible with LAN-Manager which gives now full connectivity possibilities to VMS and UNIX since a LAN-Manager server runs on iraux1, an HP UNIX workstation.

In order to match the address scheme of RENATER (the French Research network), we have recently changed our Internet network address. Our network which corresponds to a Class C Internet address format (193.48.252.*) has been split into 3 subnetworks, one for the Plateau de Bure and two for Grenoble. In such an operation, host addresses, which would have corresponded to the fourth subnet, cannot be used.

Subnets at Bure and at Grenoble are linked via routers, modems and a permanent line with a bandwidth of 19 kbps. The router at Grenoble also connects our subnets to the World Internet via the next node on grenet.fr. The next operation has been to install a name server and to obtain an internationally recognized domain name. The domain name of our network is iram.fr with a primary name server on iraux2.iram.fr. Any machine on our network can be called (e.g. with ftp, telnet ...) by either its Internet address number or its domain name (for instance 193.48.252.22 or iraux2.iram.fr).

Mail routing facilities have been installed on all UNIX workstations. Messages can be sent or received from any station. However we suggest to use the common mail address iram.fr to contact a person at Grenoble (the received mail message will be seen from any station at Grenoble). For the Plateau de Bure the address is iraux3.iram.fr.

With these new possibilities of connectivity we made available the Astrophysics Data System. Catalogue services and the abstract database are of a great use for the scientists.

Mosaic, a user-friendly software distributed by the US National Center for Supercomputer Applications is now available. It is a distributed hypermedia system designed for information discovery and retrieval via Internet and in particular to the World-Wide Web (WWW), an information system based on hypertext. We have installed a WWW server on iraux2.iram.fr in order to test the potential possibilities of this new concept and to make available IRAM information, data and scientific results. For WWW experts the URL (Uniform Resource Locator) of this server is http:/iram.fr/www/iram.html.

5.4 TECHNICAL GROUP

5.4.1 General Developments

In 1993 we were able to purchase of a numerically controlled lathe. This equipment allows the manufacturing of corrugated aluminium mandrels for the electro-forming of horns, as well as for the production of corrugated focusing lenses. At the same time a more efficient software for the numerically controlled milling machine was purchased (cf. Fig. 5.9). It allowed us to manufacture the first elliptical mirrors in our workshop.

New forming techniques have been developed, together with local manufacturers. An electro-erosion technique is now used for cutting out 115 to 350 GHz mixer backshorts, and for the realization of rectangular holes in the waveguides for the fixation between couplers and mixers.

Several mixers, couplers, transitions, etc. were manufactured in the mechanical workshop, especially -for the first time- the 350 GHz coupler and the polarization lens for Pico Veleta whereby it was necessary to manufacture special tools for the numerically controlled milling machine (see Fig. 5.10).

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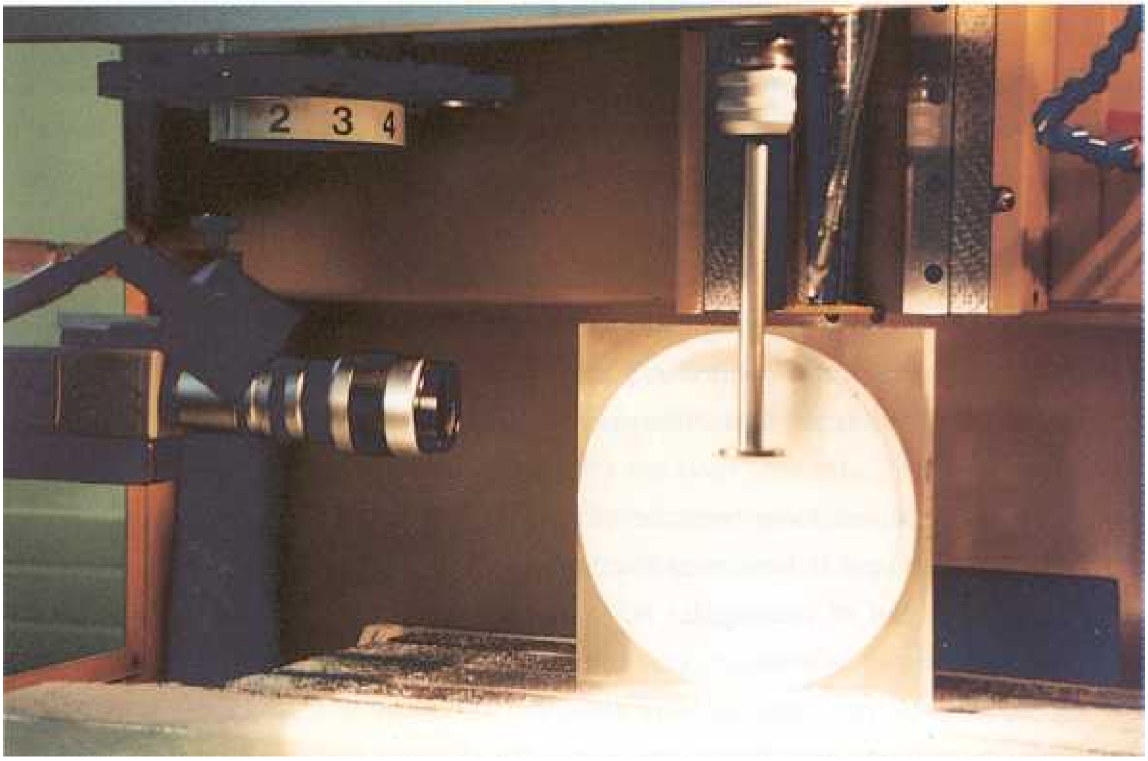

Fig. 0: Th ab cati ectri cally olled

The sed car oni th rod

The overall number of internal requests for manufacturing reached a total of 268, of which 52 were executed by external subcontractors. Fig. 5.11 below shows the evolution of the workload over the last five years.

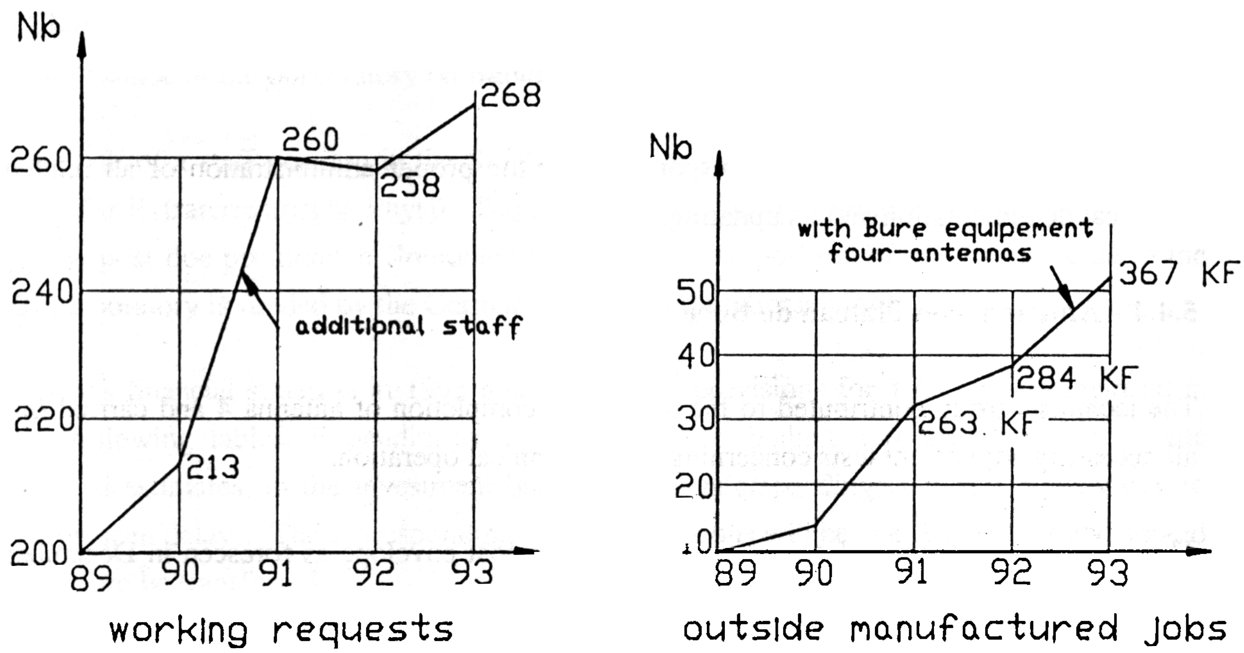

Fig. 5.11: The evolution of the workload in the IRAM mechanical workshop over the last five years.

5.4.2 Drawing Office

A large number of design studies have been carried out. These include :

for the new receiver for Plateau de Bure which uses an Infrared Laboratory cryostat, the support structure which accomodates its 115- 230 GHz elliptical mirrors, as well as its calibration loads and the integration of polarizers needed for VLBI experiments (cf. Fig.5.3);

the new supports for the 3mm, G1, 2mm receivers on Pico Veleta, and the mechanics for the polarization lens.

the modification of the sputter chamber in the SIS laboratory, the pivoting mirrors, and the boxes for polarization separators, etc.

Technical Support for Plateau de Bure

The technical group has been responsible for all mechanical aspects concerning the four antennas on Plateau de Bure. It is working in close collaboration with the local maintenance group in order to improve the operational performance of the interferometer and to reduce the downtime due to technical problems to a minimum.

The drawing office has also been responsible for the proper administration of all related technical documentation and its updating.

Antenna 4 on Plateau de Bure

The technical group contributed to the successful completion of antenna 4 and carried out all necessary adjustment tests concerning the mechanical operation.

The project was completed on schedule within the cost envelope as foreseen in December 1990. The first astronomical tests could be made in April 1993.

6. PERSONNEL AND FINANCES

In 1993, IRAM had a total of 108 employees. Of these, 94 were IRAM staff members, and 14 were PhD students, post-docs or cooperants. Of these, 8 worked in Grenoble and 6 in Granada. Five persons with temporary contracts had to be hired in addition for the maintenance of the observatory on Bure as well as for tasks in Grenoble.

One half of a staff position in the SIS laboratory is jointly financed by the MPIfR and the MPI für Extraterrestrische Physik. The MPG and CNRS contribute to the funding of some of the post-doc positions in Grenoble and Granada. The position of one PhD student in the SIS laboratory is funded by the German BMFT (Verbundforschung).

IRAM's financial situation in 1993 and the budget provisions for 1994 are summarised in the following tables. Expenditures in the operations budget correspond closely to the original estimates. In the investment budget some underspending occurred, mostly due to unforeseen delays. The corresponding budget provisions will be needed in 1994 and should therefore be transferred.

The major items in the investment budget were: 3.4 MF for receivers and backends, 1.7 MF for new laboratory equipment, 0.9 MF for cryogenic components, 0.8 MF for computer equipment, 0.4 MF for improvements in the existing IRAM antennas in Spain and France, with an additional 0.4 MF for VLBI. In the area of administration and transport 0.7 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 income related to special projects (e.g. NbN sputter system, VLBI), or as a result of interest and exchange rate gains.

The long-standing problem of the reimbursement of the Spanish Value Added Tax (V.A.T.) payments which IRAM had claimed, has now mostly been resolved. The tax office has reimbursed the V.A.T. since 1988, but the reimbursement for 1986 is still pending. According to a court decision in Madrid, IRAM can not be reimbursed any more for the V.A.T. of 1987.

The planned extension for the Grenoble headquarters could only be started at the end of 1993 (0.2 MF) due to delays in getting approval from the local authorities. Because of urgent needs, temporary solutions had to be found within the existing headquarters building to accomodate some the activities of the receiver group and to find office space for new students.

BUDGET 1993

Expenditure

BUDGET HEADING	APPROVED BUDGET KFF	ACTUAL BUDGET KFF
Personnel	35.630	36.044
Operations	15.770	15.258
	51.400	51.302
Investment	20.000	8.863
Value Added Taxes	4.432	4.432
	75.832	64.597

Income

BUDGET HEADING	APPROVED BUDGET KFF	ACTUAL BUDGET KFF
Contribution CNRS	28.651	28.651
Contribution MPG	28.651	28.651
Contribution IGN	3.658	3.658
Other Income	10.440	13.426
Contribution CNRS for Value Added Taxes	4.432	4.432
	75.832	78.818

BUDGET PROVISIONS 1994

Expenditure

BUDGET HEADING	APPROVED BUDGET (KFF)
Personnel	36.785
Operations	16.415
	53.200
Investment	10.260
Value Added Taxes	4.650
	68.110

Income

BUDGET HEADING	APPROVED BUDGET (KFF)
Contribution CNRS	29.450
Contribution MPG	29.450
Contribution IGN	3.760
Other Income	0.800
Contribution CNRS for Value Added Taxes	4.650
	68.110

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

Date	Ident.	Title	Freq. (GHz)	People
Jan 5 - 19	141.92	Mapping of HDO on Mars and search for minor species (NO, SO, ClO)	115,143,250	Encrenaz, Lellouch, Gulkis, Paubert
	268.92	Search for molecular lines in comet Swift-Tuttle 1992t	88,145,225,265	Colom, Crovisier, Bockelée-Morvan, Jorda, Despois, Paubert
	274.92	Observations of 3C 273 at mm wavelengths as part of a multifrequency campaign	90, 210	Staubert, Steppe
	254.92	Mm continuum flux measurements of the 16 detected CGRO sources	90, 150	Steppe, Reuter
	148.92	Molecular oxygen in the z=2.3 galaxy ?	112,129,236	Casoli, Combes, Encrenaz, Gerin, Laurent, Pagani
	199.92	The chemistry of S-type stars	90, 147, 244	Bujarrabal, Omont, Fuente, Alcolea
	140.92	High angular resolution study of molecular chemistry towards photodissociation regions (PDRs)	86, 271	Fuente, Martin-Pintado, Rodriguez
	K003	Key Project : Small scale structure of pre-star forming clouds		Falgarone et al.
	271.92	Correlation between gas density and infrared colors	115, 230	Boulanger, Falgarone
Jan 19 - Feb 2	204.92	Flux densities of the planets at 350 GHz, telescope behaviour at 350 GHz		Greve, Rothermel, Steppe
	290.92	A study of the envelope-outflow interaction region in the proto planetary nebula CRL 618	345	Neri, Cernicharo, Garcia-Burillo, Grewing
	273.92	Search for recombination line masers at 350 GHz	353, 335	Thum, Martin-Pintado, Bachiller
	280.92	Search for the (CII) 158μm line at high redshifts		Guelin, Hills, Lequeux, Mac-Mahon, Omont
	270.92	Probing the different molecular gas components in the nucleus of IC 342	345,330,265,244	Krause, Schulz, Stutzki, Guesten
	275.92	Isotopic CO investigations of cloud dispersal around T-Tauri stars	110,220,330	Schuster, Anderson, Genzel, Harris, Rothermel, Tacconi
	224.92	A search for NaH in circumstellar and interstellar clouds	88, 289	Cernicharo, Guelin, Lazareff, Rothermel
	281.92	A 6 GHz-wide band survey of the 0.8mm spectrum of IRC+10216		Guelin, Cernicharo, Kahane, Lazareff, Rothermel
	128.92	A multiline study of SiO masers in evolved stars	86,129,215,258	Cernicharo, Bujarrabal, Santaren
	282.92	Search for LiH primordial lines	130, 233	De Bernardis, Dubrovich, Encrenaz, Masi, Melchiorri, Signore
	140.92	High angular resolution study of molecular chemistry towards photodissociation regions (PDRs)	86, 271	Fuente, Martin-Pintado, Rodriguez
Feb 2 - 16		*MPIfR guaranteed time*		
	208.92	Dust emission from NGC 3627	Bolometer	Sievers, Reuter
	263.92	Extension of dust disk in Vega-type stars	Bolometer Array	Kruegel, Lemke
Feb 16 - Mar 2	205.92	The 230 GHz continuum dust emission of NGC 2146	Bolometer	Greve, Sievers
	221.92	Small scale anisotropy of the cosmic microwave background at 230 GHz	Bolometer	Kreysa, Chini, Biermann
	216.92	Cold dust in M51 and NGC 891 : a key to the molecular gas content of spiral galaxies	Bolometer	Guelin, Garcia-Burillo, Mezger, Kreysa, Haslam, Lemke, Sievers

Date	Ident.	Title	Freq. (GHz)	People
	222.92	Mapping the extended, cold dust cloud around PsA : comet cloud or disk ?	Bolometer	Stern, Weintraub, Festou
	243.92	Search for continuum mm emission from QSO's with z>4	Bolometer	Omont, Mac-Mahon, Bergeron, Kreysa, Haslam
	201.92	Anatomy of a PIG II: Studying the dust properties	Bolometer Array	Guesten, Mundy, Serabyn, Wilking
	267.92	A black hole near a molecular cloud ?	Bolometer	Mirabel, Wink, Morris
	210.92	Millimeter continuum maps of Herbig-Haro energy sources	Bolometer	Reipurth, Sievers, Haslam
	266.92	Bolometer observations of the field near W30H at 230 GHz	Bolometer	Wink
	263.92	Extension of dust disk in Vega-type stars	Bolometer Array	Kruegel, Lemke
Mar 2 - 16	267.92	A black hole near a molecular cloud ?	Bolometer	Mirabel, Wink, Morris
	221.92	Small scale anisotropy of the cosmic microwave background at 230 GHz	Bolometer	Kreysa, Chini, Biermann
	209.92	Bolometer survey of Myers cores with no embedded sources	Bolometer	Andre, Ward-Thompson, Hills
	205.92	The 230 GHz continuum dust emission of NGC 2146	Bolometer	Greve, Sievers
	297.92	Circumstellar disk masses as a function of stellar mass and age	Bolometer	Zinnecker
	302.92	A 1.3mm search for extreme class I sources	Bolometer	Henning, Launhardt
	130.92	Mapping the circumstellar dust material around young luminous stars of low to intermediate mass	Bolometer	Andre, Cabrit, Montmerle, Menard
	131.92	Mapping of yound rotating cores in spiral arms	98, 147	Greaves, Williams
	261.92	Spatial distribution and mass of the circumstellar material around low-mass embedded YSOs	Bolometer	Andre, Cabrit, Bontemps
	262.92	Bolometer observations of Asteroids	Bolometer	Altenhoff, Johnston, Stumpff, Webster
	237.92	Oxygen isotope ratios and stellar initial mass functions in galaxies	109,220,115,230	Sage, Mauersberger, Brouillet
	223.92	Molecular gas in the central regions of M31	98,109,220,230	Lequeux, Allen
	194.92	The atmosphere of Io	221,146,224,219	Lellouch, Belton, de Pater, Gulkis, Paubert, Encrenaz
Mar 16 - 30	223.92	Molecular gas in the central regions of M31	98,109,220,230	Lequeux, Allen
	183.92	CO emission of the hypergiant HII complexes in M101	115, 230	Viallefond, Boulanger, Cox, Lequeux, Perault
	189.92	A search for the rotational Raman spectrum of SiO in O-rich evolved stars	152,172,173,260	Cernicharo, Gonzalez-Alfonso, Bujarrabal
	173.92	Calibration of the spectral survey made in IRC+10216 with the 30m telescope	89,114,174,265	Guelin, Cernicharo, Kahane
	186.92	High velocity ionized gas near young high-mass stars	92,99,210,231	Jaffe, Martin-Pintado
	154.92	Distribution of SO in the carbon-rich TMC-1 filament	99,138,236	Cox, Cernicharo, Walmsley, Lemme
	200.92	Molecular observations of symbiotic stars	115,130,230	Bujarrabal, Cernicharo, Alcolea
	235.92	Dense gas in absorption line systems towards quasars	151,226,113,161	Wiklind, Combes
	255.92	Molecular line observations of cold compact dust cores in the galactic center	96,110,220,244	Zylka, Lis, Morris
Mar 30-Apr 13	235.92	Dense gas in absorption line systems towards quasars	151, 226, 113	Wiklind, Combes
	256.92	HNCO as a tracer of gas shocked by the explosion of SgrA-East	87, 88, 153, 219	Zylka, Schilke, Roueff
	247.92	A search for CO in X-ray absorbed elliptical galaxies	113, 114, 226, 229	Helfer, Blitz

Date	Ident.	Title	Freq. (GHz)	People
	228.92	The "cloverleaf" : An excellent candidate for CO and CI emission from a quasar at z≃2.5	96, 98, 227, 229	Barvainis, Antonucci, Coleman
	288.92	^{13}CO J=1-0 emission toward 3 compact extragalactic continuum sources	110, 220	Liszt, Lucas
Apr 13 - 27	12.93	Molecular gas in NGC 3561	112, 224	Mirabel, Duc
	196.92	Chemical stratification in the helix nebula	115, 230, 90, 113	Forveille, Bachiller, Cox, Huggins
	194.92	The atmosphere of IO	221, 146, 143, 224	Lellouch, Belton, de Pater, Gulkis, Paubert, Encrenaz
	230.92	Search for circumstellar molecules around the red rectangle	86, 90, 174, 244	Jura, Kahane, Balm
	231.92	Circumstellar CO around bright oxygen-rich semi-regulars	230	Jura, Kahane
	232.92	CO mapping of the two component wind from the nearby semi-regular X Her	115, 230	Kahane, Jura
	60.93	High angular resolution molecular line observations of the clump-interclump structure in the Rosette molecular cloud	110, 147, 220, 244	Schneider, Stutzki
	259.92	A search for dense clumps in molecular outflows	97, 146, 220	Tafalla, Bachiller, Welch
	293.92	HNC and dense gas in a primeval starburst	105, 110, 140, 245	Solomon, Radford, Downes
	67.93	Multiline study of dense molecular gas in Arp 220	86, 89, 111, 134	Radford, Solomon, Downes
	68.93	The HNC and DCN luminosities of ultraluminous galaxies	89, 87, 142, 267	Radford, Solomon
Apr 27-May 11	103.93	Search for continuum mm dust emission from QSO's with z>4	Bolometer	Omont, McMahon, Bergeron, Kreysa, Greve, Cox
	253.92	CO abundances in the outer galaxy	104, 110, 220, 330	Wouterloot, Brand
	197.92	Molecular gas content in IRAS blue compact dwarf galaxies	113, 114, 227, 229	Petrosian, Comte, Turatto
	198.92	H_2S in absorption towards W49	168, 208, 99	Tieftrunk, Walmsley, Schilke
	214.92	A detailed study of an extremely quiescent core : L 1498	244, 147, 98	Lemme, Walmsley, Wilson, Muders
	20.93	Search for SO+ in the IO torus	116, 162, 208, 255	Rosenqvist, Crovisier, Lellouch, Paubert
	219.92	Distribution of HCO+ and CS in W49	267, 260, 241, 244	Dickel, Wilson, Mauersberger
	9.93	Search for CO 3-2 emission from luminous high redshift QSOs	92, 88, 110, 113	Van der Werf
	6.93	Venus' mesosphere global circulation and CO distribution	230, 115, 220	Lellouch, Rosenqvist, Billebaud, Paubert
May 11 - 25	21.93	Is the bar in NGC 5383 already depleted from gas ?	114, 228	Wielebinski, Von Linden, Reuter, Braine, Brouillet
	22.93	Kinematics and dynamics of the ringed spiral NGC 7331	114, 229	Wielebinski, Von Linden, Reuter, Braine
	108.92	Molecular condensations in the Dumbbell and the Helix	115, 230	Huggins, Bachiller, Cox, Forveille
	13.93	Hollow shell structure in the L1551 outflow ?	110, 220, 115, 230	Bachiller, Cernicharo, Tafalla
	56.93	Counter-rotating molecular disks in the spiral NGC 4826 ?	115, 230	Casoli, Gerin
	48.93	Search for ortho-water fundamental transition in IRAS 10214+47	116, 169, 229	Encrenaz, Combes, Casoli, Gerin
	54.93	A detailed study of MON R2	96, 144, 241, 88	Evans, Wang, Walmsley, Zhou, Rawlings
	79.93	New features in the recombination line maser in MWC349	120, 147, 231	Thum, Bachiller, Martin-Pintado
	278.92	CO maps of the detached envelope around the carbon star TT Cyg	115, 230	Olofsson, Bergman, Eriksson, Gustafsson, Rieu
	277.92	A search for circumstellar NO, NS and H_2CO	86, 150, 253	Olofsson, Lindqvist, Nyman, Winnberg, Rieu, Jura

Date	Ident.	Title	Freq. (GHz)	People
May 25-Jun 8	3.93	CO observations of the galaxy NGC 4501	114, 228	Bosma, Van Gorkom, Athanassoula
	89.93	CO observations of detached envelopes around M stars	115, 230	Loup, Waters, Zijlstra, de Jong, Nyman
	5.93	The chemistry of S-type stars	86, 90, 130, 244	Bujarrabal, Omont, Fuente, Alcolea
	71.93	Millimeter hydrogen recombination line emission from AGNs and stars	92, 91, 146, 231	Strelnitski, Smith, Martin-Pintado, Matthews, Thum
	19.93	Search for HCP on Saturn	239	Encrenaz, Lellouch, Paubert, Gulkis
	7.93	The carbon isotope ratio in extragalactic starburst nuclei	90, 108, 146, 226	Henkel, Mauersberger, Wilson
	44.93	Observations of CH_3CN and search for HC_5N on Titan	147, 220, 143, 218	Bezard, Marten, Paubert
Jun 8 - 22	223.92	Molecular gas in the central regions of M31	98, 109, 115, 230	Lequeux, Allen
	228.92	The cloverleaf: An excellent candidate for CO and CI emission from a quasar at $z\simeq2.5$	96, 98, 228, 229	Barvainis, Antonucci, Coleman
	45.93	CO observations of cooling flow galaxies with HI absorption	105, 211, 220, 222	Braine, Dupraz
	85.93	Weighting the molecular content in the Seyfert 2 NGC 5252	112, 225	Prieto, Freudling
	23.93	Dense cores and star formation in Bok globules	219, 147, 98, 244	Launhardt, Evans, Henning
	49.93	Mapping of IC342 in the HCO+ and HCN lines. Complementary data to the interferometer data to measure the emission at low spatial frequencies	88	Truong-Bach, Viallefond, Rieu, Combes, Lequeux, Radford
	50.93	Molecular gas and star formation within galaxies in the Bootes Void	110, 220, 109, 218	Sage, Weistrop
	88.93	The evolution of molecular outflows from low-mass YSOs	115, 147, 230	Andre, Bontemps, Cabrit, Despois, Terebey
	62.93	The evolution of the Rosette's tear drops	220, 110, 115, 230	Gonzalez-Alfonso, Cernicharo
Jun 22-Jul 6	62.93	The evolution of the Rosette's tear drops	220, 110, 115, 230	Gonzalez-Alfonso, Cernicharo
	67.93	Multiline study of dense molecular gas in Arp 220	86, 95, 111, 134	Radford, Solomon, Downes
	68.93	The HNC and DCN luminosities of ultraluminous galaxies	89, 138, 143, 267	Radford, Solomon
	37.93	Search for new silicon-containing molecules, H_2Si and C_2H_2Si	94, 148, 158, 221	Yamamoto, Saito, Izuha, Cernicharo
	38.93	Astronomical search for a new calcium-containing radical : CaNC	97	Saito, Steimle, Takano, Guélin
	64.93	Mm continuum flux measurements of the 16 detected CGRO sources	90, 150	Steppe, Reuter
Jul 6 - 20	96.93	Dense molecular matter associated with the FU Orionsis stars RN01B/1C in L1287. 30m observations to complement PdB data in uv plane	96, 115, 144, 220	Guilloteau, Lazareff, Le Floch
	95.93	The circumstellar disk and the outflow of the FU Ori star Par 21	109, 115, 220, 230	Le Floch, Lazareff
	97.93	Support mechanisms and protostellar collapse in cometary globules	97, 110, 220, 230	Le Floch, Lazareff, Gonzalez-Alfonso, Cernicharo
	67.93	Multiline study of dense molecular gas in Arp 220	86, 95, 111, 134	Radford, Solomon, Downes
	89.93	CO observations of detached envelopes around M stars	115, 230	Loup, Waters, Ziljstra, de Jong, Nyman
	8.93	High density gas in early-type galaxies	88, 89, 146, 230	Wiklind, Henkel

Date	Ident.	Title	Freq. (GHz)	People
Jul 20-Aug 3	80.93	L1221 : A dense clump laboratory	86, 99, 178, 219	Muders, Schmid-Burgk
	64.93	Mm continuum flux measurements of the 16 detected CGRO sources	90, 150	Steppe, Reuter
	92.93	Search for SO+ in molecular clouds	115, 162, 208, 255	Fuente, Cernicharo, Cox, Guélin
	35.93	What triggers the starburst in NGC2146 ?	115, 230	Greve, Reuter, Sievers
	87.93	Search for SO+IN circumstellar envelopes	115, 162, 208, 255	Cernicharo, Omont, Guélin, Lucas
	94.93	Search for SiC in shocked molecular clouds	81, 157, 236	Cernicharo, Martin-Pintado, Bachiller
	91.93	Investigation of the streaming motions in the SW part of M31	115, 230	Neininger, Guélin, Wielebinski
	256.92	HNCO as a tracer of gas shocked by the explosion of SgrA-East	87, 88, 153, 219	Zylka, Schilke, Roueff
	287.92	CO photodissociation at the edges of IRC+10216	110, 115, 220, 230	Guélin, Cernicharo, Omont
Aug 3 - 17	91.93	Investigation of the streaming motions in the SW part of M31	115, 230	Neininger, Guélin, Wielebinski
	14.93	Newly discovered proto-planetary nebulae	115, 230, 110, 88	Garcia-Lario, Bachiller
	39.93	A CN survey of galaxies	113, 110, 226, 88	Schilke, Brouillet
	78.93	Chemistry of a photon-dominated region : M17SW	113, 218, 99, 128	Lepine, Benayoun, Warin, Gruenwald
	47.93	Search for water maser emission in starburst galaxies	157, 101, 97, 94	Combes, Casoli, Gerin, Encrenaz, Rieu
	46.93	Molecular clouds in the outer parts of galaxies	115, 110, 220, 230	Combes, Casoli, Garcia-Burillo
	25.93	Search for galactic plane corrugations in warped galaxies	115, 230	Gomez de Castro, Garcia-Burillo, Florido, Battaner, Pudritz
Aug 17 - 31	81.93	Carbon isotopes in the molecular envelopes of evolved stars	92, 98, 138, 145	Kahane, Forestini, Forveille, Guélin, Cernicharo
	90.93	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	115, 230	Lucas, Neri, Guélin, Guilloteau, Kahane, Loup, Forveille, Omont
	82.93	Nitrogen and oxygen isotopes in the molecular envelopes of evolved stars	86, 219, 220, 224	Kahane, Forestini, Forveille, Guélin, Cernicharo
	K003	Small scale structure of pre-star forming clouds		Falgarone, et al.
Aug 31-Sep 14	K003	Small scale structure of pre-star forming clouds		Falgarone, et al.
	72.93	A search for Si_2C in IRC+10216	88, 103, 145, 96	Martin, Henning, Koempe
	187.93	CO distribution in the interacting active galaxy NGC 7674	111, 224	Moles, Marquez, Cernicharo
	124.93	High angular resolution study of molecular chemistry towards photodissociation regions (PDRs)	87,90, 97, 226	Fuente, Martin-Pintado, Rodriguez-Franco
	71.93	Millimeter hydrogen recombination line emission from AGNs and stars	92, 146, 221, 231	Strelnitski, Smith, Martin-Pintado, Matthews, Thum
	22.93	Kinematics and dynamics of the ringed spiral NGC 7331	114, 229	Wielebinski, Von Linden, Reuter, Braine, Brouillet
	79.93	New features in the recombination line maser in MWC349	120, 147, 231	Thum, Bachiller, Martin-Pintado
	74.93	H_2CO in the circumstellar disk of Sgr A	140	Wilson, Pauls, Johnston, Lemme
	26.93	Measuring the He/H gradient in our galaxy : a combined IR and radio technique	135, 106	Megeath, Herter, Stolovy, Wilson

Date	Ident.	Title	Freq. (GHz)	People
	33.93	The column density of CO toward Zeta Ophiuchus	115, 230	Wilson, Mauersberger, Dahmen, Lemke
	189.93	Where have all the molecules gone ?	218, 144, 239	Wilson, Mauersberger
	174.93	CO observations of the X-ray absorbed elliptical galaxy NGC 4472	114, 229	Helfer, Blitz
	117.93	Abundance, excitation and isotopic variation studies of ^{12}CN, ^{13}CN, and C^{15}N in Orion A and B	108, 113, 220, 226	Simon, Stutzki
Sep 14 - 28	26.93	Measuring the He/H gradient in our galaxy : a combined IR and radio technique	135, 106	Megeath, Herter, Stolovy, Wilson
	32.93	The H_2 column density toward CAS A	110, 220, 109, 218	Wilson, Gaume, Johnston
	189.93	Where have all the molecules gone ?	218, 144, 239	Wilson, Mauersberger
	164.93	CO observations of the galaxy NGC 4501	114, 228	Bosma, Van Gorkom, Athanassoula
	165.93	The opacity of galactic disks	115, 230	Bosma, Athanassoula
	160.93	Physical properties of the major asteroids	90, 150	Altenhoff, Johnston, Stumpff, Webster
Sep 28-Oct 12	120.93	Studies of cold molecular gas	110,114,230	Lequeux, Allen
	134.93	CO abundances in the outer galaxy	109,110,115,230	Wouterloot, Brand
	153.93	CO in the Mice	112, 225	Casoli, Combes
	131.93	High velocity gas expelled out of the ring galaxy Karachentsev 29	109	Horellou, Combes, Casoli
Oct 12 - 26	113.93	Molecular gas in the central region of NGC253: A starburst environment with an active nucleus	115,146,230	Wielebinski, Von Linden, henkel, Mauersberger, Wiklind
	150.93	Calibrating the CO Tully-Fisher relation in Hercules		Kazes, Dickey, Sofue
	132.93	Investigation in the clump-interclump structure in the Rosette molecular cloud with high angular resolution CO observations	110,115,220,230	Schneider, Stutzki
	111.93	Soving the nitrogen isotope puzzle	86,88	Henkel, Chin, Mauersberger, Wilson, Dahmen, Langer
	122.93	Molecular clouds beyond the optical disk of the galaxy	110,115,230,98	Henkel, Digel, De Geus, Thaddesu, Huettemeister
	110.93	A high resolution study of the possible molecular counterpart to the galaxy center filament G359.54+0.18	230,220,97	Uchida, Guesten, Yusef-Zadeh
Oct 26 - Nov 9	122.93	Molecular clouds beyond the optical disk of the galaxy	110,115,230,98	Henkel, Digel, De Geus, Thaddesu, Huettemeister
	126.93	Sulfur nucleosynthesis : a critical check on oxygen burning in massive stars	98,144,145,230	Chin, Mauersberger,Langer,Henkel
	110.93	A high resolution study of the possible molecular counterpart to the galaxy center filament G359.54+0.18	230,220,97	Uchida, Guesten, Yusef-Zadeh
	KOO3	Small scale structure of pre-star forming clouds		Falgarone, et al
Nov 9 - 23	123.93	Search for redshifted CO emission from damped Lyman alpha absorbers	95,103,131,279	Van der Werf
	133.93	A search for dense clumps in molecular outflows	97,146,220	Tafalla, Bachiller, Welch
	144.93	A search for CO emission towards neutron stars interacting with the interstellar medium: the guitar nebula	115, 230	Cernicharo, Gonzalez-Alfonso, Gomez-Gonzalez
	107.93	A search for SO maser emission in O-rich evolved stars		Cernicharo, Alcolea, Bujarrabal
	177.93	CO observations of HD 98800 : molecular gas in a protoplanetary disk ?	110,115,230	Zuckerman, Kastner, Forveille, kahane

Date	Ident.	Title	Freq. (GHz)	People
Nov 23 - Dec 7	177.93	CO observations of HD 98800 : molecular gas in protoplanetary disk ?	110,115,230	Zuckerman, Kastner, Forveille, Kahane
	147.93	Study of the photodissociation region in NGC 7027: ^{13}CO and HCN single- dish maps	88,110,220	Cox, Guilloteau, Omont, Bachiller, Huggins, Forveille
	148.93	Further study of the carbon rich TMC-1 filament	97,135,237	Cox, Cernicharo
	159.93	Search for CO in high redshift, dusty, radio quiet QSOs	101,109,137,141	Omont, Solomon, Radford, Downes, McMahon
	103.93	Search for continuum mm dust emission from QSOs with $z>4$	Bolometer	Doyle, Griffin
	51.93	Bolometer service observations of the cloverleaf	Bolometer	Barvainis, Coleman, Antonucci
	176.93	The evolution of mass in circumstellar disks	Bolometer	Beckwith, Sargent, Osterloh
Dec 7 - 21	173.93	The spectral energy distribution of Vega-like stars	Bolometer	Butner, Walker, Beckwith, Lada
	169.93	Continuum observations of dust disks around main sequence stars	Bolometer	Bockelee-Morvan, Andre, Colas, Despois, Crovisier, Colom, Jorda
	161.93	Measurement of the extent of 9 red giant envelopes from ^{13}CO emission	110, 220	Kahane, Guélin, Neri, et al
	162.93	HC$_3$N (24-23) mapping of the circumstellar envelope IRC+10216	85,218,259	Audinos, Kahane, Lucas, Guélin
	183.93	Mg isotopes: a key to the synthesis of $25<A<27$ nuclei in AGB stars	95,97,131,143	Guélin, Forestini, Cernicharo
	178.93	Search for high velocity winds in proto-planetary nebulae	88,146,230	Neri, Bujarrabal, Bremer, Grewing, Guélin
	182.93	Investigation of the molecular component of the edge-on galaxy NGC 4565		Neininger, Dumke, Guélin, Wielebinski, Garcia-Burillo
	172.93	Dense molecular gas in rings and tails of luminous IR mergers	86,142	Gao, Solomon, Radford, Downes
Dec 21 Jan 4	182.93	Investigation of the molecular component of the edge-on galaxy NGC 4565		Neininger, Dumke, Guélin, Wielebinski, Garcia-Burillo
	KOO3	Small scale structure of pre-star forming clouds		Falgarone, et al
	128.93	CO measurements in a massive cold cloud very close to the Sun	115,230,110,220	Sempere, Trapero, Beckman, Davies, Combes
	149.93	Search for methylenimine in Titan's and Neptune atmospheres	226,146,89,109	Lellouch, Romani, Bezard, Marten, Rosenqvist, Paubert

Project	Conf.	Title	Authors	Molecules	Object	Type
A071	CD	CO observations of a sample of molecular clouds in the nearby spiral M 33 : A test of the W(CO)/N(H_2) conversion factor	F.Boulanger F.Casoli F.Combes P.Cox S.Garcia-Burillo M.Guélin J.Lequeux Nguyen-Q-Rieu N.Scoville F.Viallefond	CO	M 33	Gal
C018	B2	The distribution of SiO Maser spots around evolved stars	J.Cernicharo A.Baudry V.Bujarrabal	SiO	NML Tau, R Cas R Leo, R Aqr	CSE
C026	BC	The molecular counterpart of the dust disk in L1551: Origin of the outflow	A.Dutrey S.Guilloteau	CO $C^{17}O$	L1551-IRS5	YSO
C028	BC	The kinematics of shocks: SiO J=2-1 maps of the L1448 outflow termination	A.Dutrey R.Bachiller S.Guilloteau	SiO	L1448	YSO
C034	CD	Molecular gas in the elliptical NGC 759	T.Wilklind C.Henkel S.Radford	CO	NGC 759	Gal
C037	BC	M82 - The suicide of a starburst ?	N.Brouillet P.Schilke	HCO^+	M 82	Gal
C041	BC	Mapping of thermal methanol emission towards DR21-West and DR21(OH)	S.Liechti C.M.Walmsley K.M.Menten	CH_3OH	DR21-West DR21(OH)	Mol
C046	C2	Sunyaev-Zel'dovich effect in Abell 2163	M.Fischer S.Radford	Cont	A2163	Oth
C049	BC	Study of the photodissociation region in NGC 7027: HCN	P.Cox S.Guilloteau A.Omont R.Bachiller P.Huggins	HCN	NGC 7027	CSE
C050	CD	Study of the photodissociation region in NGC 7027: CN	P.Cox S.Guilloteau A.Omont R.Bachiller P.Huggins	CN ^{13}CO	NGC 7027	CSE
C053	C2 B3 B2	The HCN envelopes around red giant stars : Snapshots	M.Lindqvist H.Olofsson L.A.Nyman A.Winnberg K.Eriksson B.Gustafsson R.Lucas	HCN	U Cam RW LMi Y CVn	CSE
C054	BC	Shocked molecular gas from the superwind of NGC 3079	L.Tacconi R.Genzel A.Harris P.VanDerWerf	HCN	NGC 3079	Gal
C055	BC	Shocked molecular gas from the superwind of NGC 3079	L.Tacconi R.Genzel A.Harris P.VanDerWerf	CO	NGC 3079	Gal
C058	BC	Distribution of the molecular gas in the primeval galaxy IRAS 10214+4724	S.Radford D.Downes	CO(3-2)		Gal
C060	BC	The 200 km.s^{-1} outflow in the proto-planetary nebula CRL618: a follow up study	R.Neri J.Cernicharo M.Grewing S.Garcia-Burillo M.Guelin S.Guilloteau R.Lucas	CO	CRL618	CSE

Project	Conf.	Title	Authors	Molecules	Object	Type
C063	BD	CH_3CN towards G10.47+0.03 and G31.41+0.31	C.M.Walmsley R.Cesaroni L.Olmi	CH_3CN, ^{13}CO	G10.47+0.03, G31.41+0.31	YSO, YSO
	C2	Observations of Titan in HCN J=1-0 line	A.Marten A.Dutrey S.Guilloteau	HCN	Titan	Sol
D007	B2, C2,D	Extension of CN in C-rich circumstellar envelopes	A.Omont, H.Olofsson R.Lucas	CN, ^{13}CO	U Cam, RW LMi, Y CVn, LP And	CSE
D008	CD	Arp 118: a dynamically spectacular ring merger	S.Radford D.Downes Yu.Gao, P.Solomon	CO	Arp 118, NGC 1143	Gal
D011	BC	Star formation in W49N: triggered by clump-clump collisions ?	R.Guesten H.Wiesemeyer K.Uchida	$C^{34}S$, $^{34}SO_2$	W49 N	Mol
D018	C, D, B2	Do binaries have larger disks than single-stars	A.Dutrey G.Duvert S.Guilloteau M.Simon	^{13}CO, $C^{18}O$	UZ Tau, DD Tau, DG Tau, DL Tau, UY Aur, FV Tau	YSO
D026	BC	Dense Rotating Cores in OMC1 Streamers	R.Gusten J.Wiseman	$C^{34}S$	OMC1	YSO
D029	BC	The circumbinary disk of Haro 6-10	J.L.Monin F.Menard J.P.Berger A.Dutrey S.Guilloteau	^{13}CO, $C^{18}O$	Haro 6-10	YSO
D038	BC	Imaging Redshifted CO(3-2) from a damped Lyman α absorber	P.VanDerWerf S.Radford	CO	Q0836+113	Gal
D041	B	Search for CO absorption in interstellar clouds toward two bright quasars	R.Lucas H.Liszt	CO, ^{13}CO	0528+134, 3C454.3	Mol
D042	B	Survey of mm-absorption toward two quasars	R.Lucas H.Liszt	HCO^+, HCN, CN, HNC, C_2H	0212+735, NRAO150	Mol
D043	BC	The inner regions of preplanetary nebula	V.Bujarrabal R.Neri J.Alcolea M.Grewing	CO	M1-92	CSE
D048	BC	CO in the barred Galaxy NGC 1530	D.Downes S.Radford P.Solomon	CO	NGC 1530	Gal
D050	BC	CO observations of the FR II powerful radiogalaxy 3C368 at z=1.13	D.B.Sanders K.Chambers A.Evans S.Radford	CO	3C368	Gal

8. ANNEX II : PUBLICATIONS/ 8.1 IRAM PUBLICATIONS

372. DISTRIBUTION OF MOLECULAR GAS IN THE PRIMEVAL GALAXY IRAS 10214+4724
S.J.E. Radford, R.L. Brown, P.A. Vanden Bout
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373. S-BEARING MOLECULES IN O-RICH CIRCUMSTELLAR ENVELOPES
A. Omont, R. Lucas, M. Morris, S. Guilloteau
1993, A&A 267, 490

374. H_2O MASERS IN NEARBY IRREGULAR GALAXIES
R. Becker, C. Henkel, T.L. Wilson, J.G.A. Wouterloot
1993, A&A 268, 483

375. A SEARCH FOR PARENT MOLECULES AT MILLIMETRE WAVELENGTHS IN COMETS AUSTIN 1990V AND LEVY 1990XX : UPPER LIMITS FOR UNDETECTED SPECIES
J. Crovisier, D. Bockelée-Morvan, P. Colom, D. Despois, G. Paubert
1993, A&A 269, 527

376. HIGH DENSITY STRUCTURE OF THE L 1455 DARK CLOUD
J. Juan, R. Bachiller, C. Kömpe, J. Martin-Pintado
1993, A&A 270, 432

377. A MULTI-TRANSITION STUDY OF CARBON MONOXIDE IN THE ORION A MOLECULAR CLOUD II. $C^{18}O$
A. Dutrey, G. Duvert, A. Castets, W.D. Langer, J. Bally, R.W. Wilson
1993, A&A 270, 468

378. DETECTION OF INTERSTELLAR CH_2 DOH
T. Jacq, C.M. Walmsley, R. Mauersberger, T. Anderson, E. Herbst, F.C. De Lucia
1993, A&A 271, 276

379. DISTRIBUTION OF MOLECULAR GAS IN THE PRIMEVAL GALAXY IRAS 10214+4724
S.J.E. Radford, R.L. Brown, P.A. Vanden Bout
1993, A&A 271, L21

380. ROTATION OF STARS AND GAS IN M82
C.D. McKeith, J. Castles, A. Greve, D. Downes
1993, A&A 272, 98

381. DISCOVERY OF A COLD AND GRAVITATIONALLY UNSTABLE CLOUD FRAGMENT
R. Chini, E. Krügel, C.G.T. Haslam, E. Kreysa, R. Lemke, B. Reipurth, A. Sievers, D. Ward Thompson
1993, A&A 272, L5

382. THE RADIO STATE OF EXTRAGALACTIC γ- RAY SOURCES DETECTED BY CGRO
W. Reich, H. Steppe, R. Schlickeiser, P. Reich, M. Pohl, H.P. Reuter, G. Kanbach, V. Schönfelder
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383. CO IN MESSIER 51. I. Molecular spiral structure
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384. CO IN MESSIER 51 II. Molecular Cloud Dynamics
S. Garcia-Burillo, F. Combes, M. Gerin
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385. FIRST 43GHz VLBI DETECTION OF THE COMPACT SOURCE Sgr A* IN THE GALACTIC CENTER
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1993, A&A 274, L37

386. FIRST 43GHz VLBI OBSERVATIONS WITH THE 30m RADIO TELESCOPE AT PICO VELETA
T.P. Krichbaum et al.
1993, A&A 275, 375

387. PLATEAU DE BURE OBSERVATIONS OF MM-WAVE MOLECULAR ABSORPTION TOWARD BL LACERTAE
R. Lucas, H.S. Liszt
1993, A&A 276, L33

388. HIGH RESOLUTION CO OBSERVATIONS OF NGC 1275
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389. 1.3mm EMISSION IN THE DISK OF NGC 891: EVIDENCE OF COLD DUST
M. Guélin, R. Zylka, P.G. Mezger, C.G.T. Haslam, E. Kreysa, R. Lemke, A.W. Sievers
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390. CO IN THE TROPOSPHERE OF NEPTUNE: DETECTION OF THE J=1-0 LINE IN ABSORPTION
S. Guilloteau, A. Dutrey, A. Marten, D. Gautier
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391. MgNC AND THE CARBON-CHAIN RADICALS IN IRC+10216
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J. Lequeux, R.J. Allen, S. Guilloteau
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393. ANATOMY OF THE SAGITTARIUS COMPLEX III. Morphology and characteristics of the Sgr B2 giant molecular cloud
M.A. Gordon, U. Berkermann, P.G. Mezger, R. Zylka, C.G.T. Haslam, E. Kreysa, A. Sievers, R. Lemke
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394. GLOBAL PHOTOMETRIC STRUCTURE OF THE ORION NEBULA*
A. Greve, A.M. van Genderen, Th. Augusteijn
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395. MILLIMETER CONTINUUM MEASUREMENTS OF EXTRAGALACTIC RADIO SOURCES. III.
H. Steppe, G. Paubert, A. Sievers, H.P. Reuter, A. Greve, S. Liechti, B. Le Floch, W. Brunswig, C. Menendez, S. Sanchez
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398. HIGH EXCITATION SiO MASER EMISSION IN VY CMa: DETECTION OF THE v = 4, J=5-4 TRANSITION
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401. IRAS 2306+1450 : A COLD DUST COMPONENT IN THE NEARBY, HIGH-LATITUDE CLOUD MBM 55
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402. THE INFRARED MILLIMETRE-CENTIMETRE FLARING BEHAVIOUR OF THE QUASAR 3C 273
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414. SPHERICALLY SYMMETRIC KINEMATIC MODELLING OF PLANETARY NEBULAE
C. Diesch, M. Grewing
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9. ANNEX III - IRAM Executive Council and Committee Members, January 1993

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