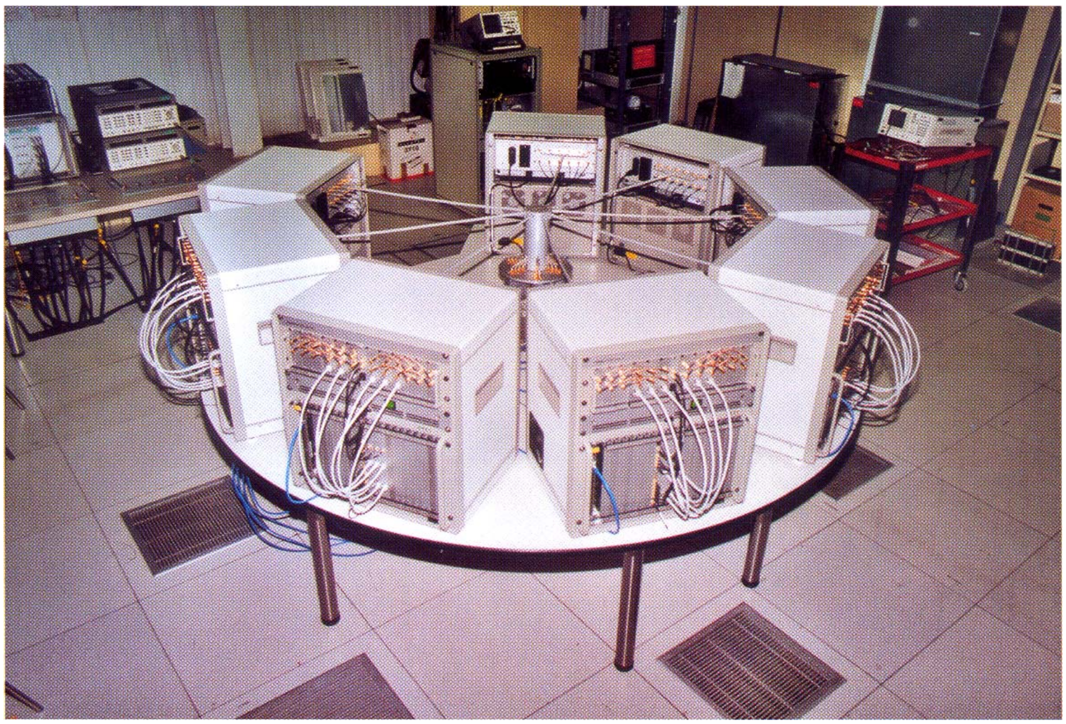
IRAM 2000



ANNUAL **REPORT**

Front Cover : The new, third generation correlator for the Plateau de Bure interferometer with 6 antennas. It has been designed and built by the IRAM Backend Group and completed in May 2000. After extensive testing in Grenoble, the system has been installed on the Plateau de Bure in September 2000. Already with the currently available 5 antennas, it has improved the data quality. Its design characteristics which can today not yet be exploited allow for a total bandwidth of 2.56 GHz (as compared to 0.96 GHz of the old system), higher flexibility provided by its 8 units (instead of 6), channel spacings in powers of 2 (instead of 4), and a global digital performance characterized by 9.8 Teramultiplications per second (instead of 1.3). With the new correlator the 6 telescope array can be operated in the phased mode which will provide excellent sensitivity for VLBI experiments.

ANNUAL **REPORT**

2000

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1. INTRODUCTION

The very special situation which has arisen from the two accidents that struck the Plateau de Bure Observatory in July and December 1999, has determined many of the activities in the year 2000. One example is the fact that the IRAM Executive Council held three meetings in Grenoble, in January, June and October 2000, giving support and encouragement to the IRAM staff, and following together with the institute the various developments.

The helicopter accident on December 15th, 1999 has forced us to look very carefully at the question of how to transport people up to and down from the Plateau de Bure as long as there is no new permanently available means of transport that replaces the previous cable car system. As long as there is no fully satisfactory solution, there will be an impact on the activities on the Plateau de Bure that can be executed. As an immediate measure following the second accident, the station was put into a restricted mode where safeguarding the installation was the main purpose. This allowed us to reduce the size of the team on the mountain to a minimum of four, compatible with a single helicopter rotation to exchange teams. This reduced staffing as well as general safety considerations implied that observations had to be stopped and the receivers in the telescopes to be warmed up to avoid to fly in and handle helium bottles during winter period.

With the aim to create a more complete understanding and awareness of where special risks lie and which activities require specific precautions, a team from the CERN Safety Division was asked to make a safety audit of the station. In addition, a safety engineer has been hired on a fulltime basis who has in the meantime worked out a large number of individual safety procedures as well as a general safety plan that defines procedures and interfaces both within IRAM and with several external support organizations in cases of emergency.

With these and other measures, some of which are described in Chapter 4 of this report, it has been possible to slowly increase the level of activities on the Plateau de Bure again. As a first step, during the summer months, maintenance was carried out on the telescopes in order to prepare them for the next winter season. Then, in the fall of 2000, the new correlator system for 6 antennas was brought up to the plateau and successfully commissioned with the current 5 antennas. Work on the completion of the mount for Antenna 6 was eventually resumed in November, and in December we restarted observing on a "best effort basis". The receivers had already been cooled down again in the summer because test observations were needed to check the status of each antenna and of the full array before and after maintenance interventions, and to also check out the performance of the new correlator system.

In parallel to what happened at the PdB Observatory, considerable progress was made in studying and identifying future means of transport for people and for materials. One of the decisions taken was to separate the two in the future, and to repair and transform the old cable car system into a lift that will exclusively be used to transport supplies and equipment to the plateau. All transport of people would be made by a different, new transport system for which different options were identified in a detailed study by engineering companies that has been initiated by the CNRS/INSU. The hope is that a decision will be taken and actual work will start on the future means of transport to the Plateau de Bure in the course of 2001.

As evidenced by the scientific highlights described in Chapter 2 of this report, IRAM and its community have been able to continue research and to produce excellent scientific results despite the special circumstances mentioned above. Especially at the 30m telescope, the results obtained with a bolometric camera built by the MPIfR, Bonn and with the new generation of heterodyne receivers that have been installed at the 30m telescope since the fall of 1999, have made a major impact, especially on extragalactic research.

With the aim to attract young astronomers, also from institutes which do not yet have a tradition in millimeter-wavelength radioastronomy, IRAM has organized a second Interferometer School which was attended by some 70 young researchers.

This training program is one of several activities with which IRAM tries to contribute in a significant way to the ALMA project. Aside from support of science and system studies, support of the European prototype antenna development, work on signal transport and backends, and work on software developments, the two main areas where IRAM seeks a long-term involvement are receiver development and integration, and a European Data Center for the ALMA project.

The challenges that come from the further development of the existing installations and from the ALMA project together with the strong support from the IRAM funding organizations have motivated and enabled the research and development that is reported here.

2. HIGHLIGHTS OF RESEARCH WITH THE IRAM TELESCOPES IN THE YEAR 2000

2.3 SUMMARY

Among the projects at the IRAM telescopes that were done or published in 2000, a few highlights were :

- New detections of dust emission from high-redshift quasars and starburst galaxies.
- A new millimeter-VLBI study of 3C273.
- Kinematics of the circumnuclear molecular gas in the Seyfert 1 galaxy NGC 3227.
- Observations of the counterrotating molecular disk in the spiral galaxy NGC 3593.
- Distribution and Properties of Molecular Clouds in M31.
- Maps of molecular gas in the dwarf galaxies NGC 205, Haro 2 and UM 465.
- Maps of disks and outflows around intermediate-mass stars and protostars.
- Structure of the protostellar collapse candidate B335 in CS(5-4) emission.
- Maps of pre-Orion-type cores in the Trifid nebula.
- Detection of the free radical SiCN in the circumstellar envelope of IRC+10216.
- Size of the Centaur Chariklo deduced from its millimeter continuum flux.

2.2 EXTRAGALACTIC RESEARCH

New detections of dust emission from high-redshift quasars and starburst galaxies.

The 37-beam Max-Planck millimeter bolometer array (MAMBO) was used at the 30 m telescope to detect at 1.2 mm two high-redshift quasars from the Sloan Digital Survey sample, namely SDSSp 015048.83+004126.2 at z=3.7, and J033829.31+002156.3 at z = 5.0. The latter is the third highest redshift QSO known and the highest redshift millimeter-emitting source yet identified. The combination of the millimeter data and centimeter data from the VLA indicate the mm emission is most likely thermal dust emission, with implied *dust* masses of 10^8 M_Θ, possibly heated by the quasar.

The bolometer array also detected several other faint dust sources that are probably high-redshifted starburst galaxies. Two of the new sources, toward the cluster of galaxies Abell 2125 (**Fig.** 2.1), have fluxes of 4 mJy at 1.2 mm, and have VLA radio counterparts with flux densities of 75 µJy at 1.4 GHz. If the centimeter radio and millimeter emission are both due to starbursts, then the radio-to-mm flux ratios imply redshifts. z > 2. Another source, previously discovered with the SCUBA array at 850 µm in the Canada-UK Deep Submm Survey, CUDSS14A, was also observed at 1.3 mm with the IRAM interferometer. The improved source position from the interferometer is within 1.5" of the SCUBA 850 μm centroid and also within 1.5" of a 44 μJy cm-radio source and a faint extremely red galaxy that had been previously identified as the submm source. A model of the spectral energy distribution suggests the source lies within the redshift range 2 to 4.5, with a luminosity of 4 x 10^{12} L_{Θ}, that is, in the range of the ultraluminous galaxies. The present data, however, cannot distinguish between a starburst or AGN origin of this luminosity. (Carilli et al, 2000, ApJ, 533, L13 ; Bertoldi et al. 2000, A&A, 360, 92 ; Gear et al., 2000, MNRAS, 316, L51).

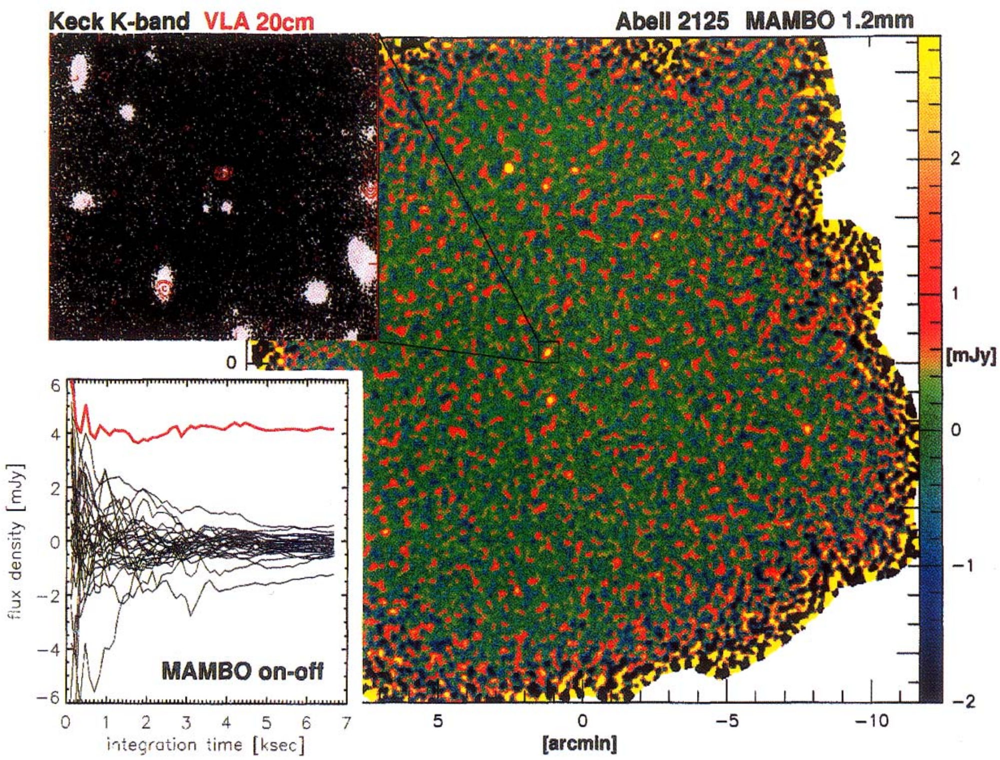

Fig. 2.1 Multibeam bolometer map toward the cluster Abell 2125. The color map *(right)* shows the region mapped with the Max-Planck Millimeter Bolometer array (MAMBO), and the inset *(lower left)* shows the decrease in the noise *(black traces)* in the 36 off-source bolometer elements as a function of time, while the on-source detector *(red trace)* shows the signal from the dust source in the center of the field. This source was also detected with the VLA at 20 cm, and with the Keck I telescope in the *K* band at 2.2 μm *(upper left).* The dust source is probably a high-redshift object, well beyond the Abell 2125 cluster at z = 0.24, some of whose galaxies are visible on the AT-band image (Bertoldi et al. 2000, A&A, 360, 92).

Millimeter VLSI study of 3C273

At sub-milliarcsecond resolution, the core of the nearby quasar 3C273 shows a one-sided core-jet structure several milliarseconds long. Because of relativistic beaming, the jet breaks up into multiple components that appear to separate at superluminal speeds from the brightest component, which is assumed to be a stationary core near the supermassive black hole. Data from mm-VLBI observations involving the 30m telescope in 1994, 1995, and 1997 have now been analysed and show that the apparent speeds of the millimeter components in the jet are 4 to 8 times the speed of light, and that the components appear to accelerate as they move out. The maps **(Fig. 2.2)** are suggestive of a helical jet. Comparison with centimeter data shows that the apparent ejection angle varies by 30 to 40 degrees, with a time scale of 16 years. Corrections for variations in the apparent speed suggest that the true period of precession is greater than 150 years, and that the 16 year variation is superimposed on this. It is not clear whether the faster time scale is that of a Kelvin-Helmholtz instability in the outflow, or a geometric effect due to nutation of the accretion disk around the black hole. The interpretation is complicated by opacity effects near the core, which cause the apparent bending angle of the jet to vary with observing frequency by the order of 15 degrees between 15 and 86 GHz. The data are not yet sufficient to show whether the apparent speed of the jet also varies with frequency (Krichbaum et al. 2001, in preparation).

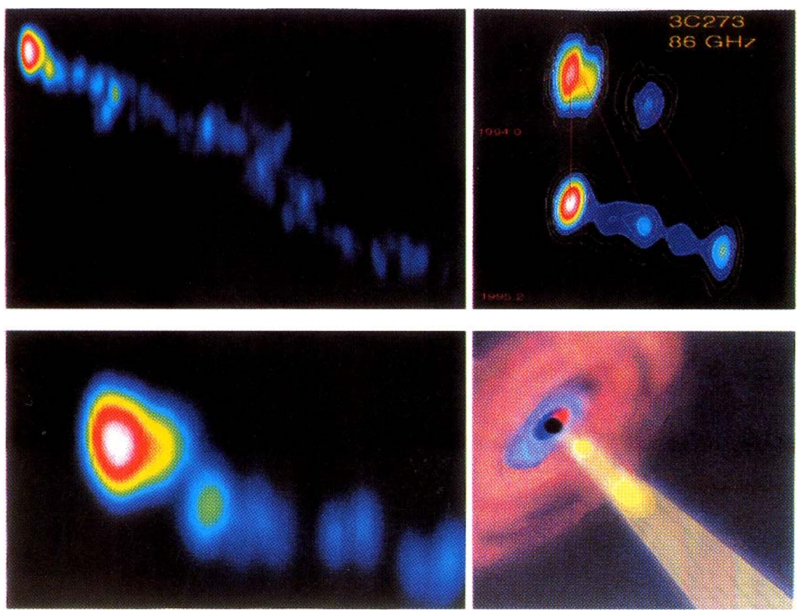

Fig. 2.2 **VLBI Maps of the core region of** 3C273 at 86 GHz. *(JUpper right:)* Comparison of 3mm maps in 1994 and 1995, showing apparent superluminal motion of hot spots in the jet. *(Upper left:)* VLBI map of 3C273 in 1997.3, with a beam of 0.5 x 0.1 milliarcsec, showing 3mm emission in the jet out to 10 milliarcsec from the bright core. *(Lower left:)* Zoom on the core region, from the same data from 1997.3, but analysed with a resolution of 50 micro-arcsec, which corresponds to a spatial scale of 1000 Schwarzschild radii for a black hole with a mass of 10^9 M_Θ. *(Lower right:)* Artist's impression of the jet.

***Kinematics of the circumnuclear molecular gas in the Seyfert 1 galaxy NGC** 3227*

Seyfert galaxies have optically bright nuclei, which are the hot accretion disks around black holes. In most "unified" pictures of Seyfert galaxies, the apparent difference between broad-line Seyfert 1 galaxies and narrow-line Seyfert 2 galaxies is supposed to be due to a circumnuclear "torus" close (10 pc) to the accretion disk, which, depending on its inclination to our line of sight, may obscure the broad line region. Some Seyfert galaxies are hard to classify. NGC 3227, a Seyfert galaxy at a distance of 17 Mpc, has been variously classed as type 2 (high-excitation, narrow emission lines predominate) and as type 1 (broad emission lines visible, from a region much closer to the black hole accretion disk). Observations of NGC 3227 with the IRAM interferometer have now been interpreted in terms of a warped, circumnuclear nuclear ring of diameter 100 pc. These data suggest that the generally low and varying emission line strength may be due to obscuring gas in this warped molecular ring, rather than in the postulated small nuclear torus.

The interferometer data were taken in the CO(l-O), CO(2-1), and HCN(l-0) lines. The observations in the CO(2-1) line have a resolution of 0.6″ (80 pc). The interferometer maps show that 30% of the total CO emission is in the central 8" of the galaxy, with the dominant structure being a circumnuclear ring of radius 1.5" **(Fig. 2.3).** About 80% of the gas in the circumnuclear region is in purely circular rotation, but there is some evidence for gas streaming along a bar, onto the nuclear ring. Quite remarkably, the gas in the central arcsecond shows apparent counter-rotation. Rather than gas motion in a "nuclear bar" potential, this behaviour can be best explained by a warping of the inner molecular gas disk. Modelling of the longest-spacing, highest-resolution data indicates that there is gas at a distance of only 13 pc from the nucleus, and that the rotation curve within the central arcsecond starts rising again, toward the nucleus. This is the first time that mm CO-line emission has been detected interferometrically at such small radii from the nucleus of a Seyfert galaxy. These data imply a lower limit on the enclosed mass of about 2 x 10^7 M_Θ in the inner 25 pc, which roughly agrees with estimates, from Hp-line reverberation mapping, for the mass of the central black hole (Schinnerer, Eckart, & Tacconi, 2000, ApJ, 536, 393).

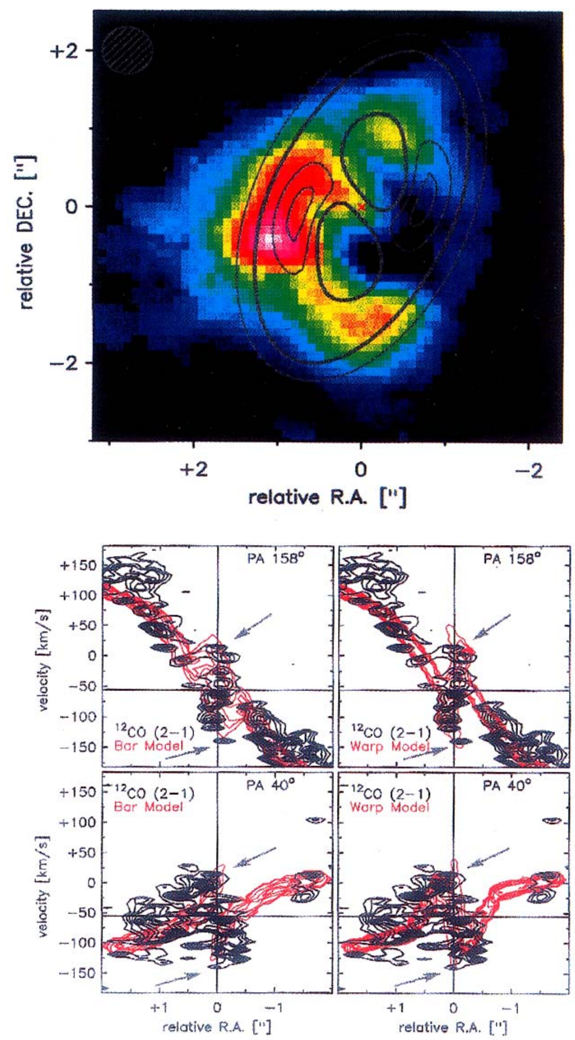

Fig. 2.3 Circumnuclear ring in the Seyfert 1 galaxy NGC 3227. *(Upper:)* Intensity map of CO(2-1) line emission in NGC 3227 (in colour), mapped with the IRAM interferometer. The contours show the intensity map of the best warp model, at 40, 65 (thick), 80 and 90% of the peak intensity. The red cross marks the position of the fitted dynamical center. *(Lower):* Position-velocity diagrams in NGC 3227. *Upper panels:* The data (black contours) along the line of nodes (p.a. 158°). The red contours show the predictions of a bar model (left) and a warped-disk model (right). *Lower panels:* Similar diagrams along position angle 40°. Near the nucleus, the data indicate a rising rotation curve towards smaller radii, between the extremes indicated by the arrows, which implies an enclosed mass of > 2 x 10^7 M_Θ (Schinnerer et al. 2000, ApJ, 533, 826; and ApJ 524, L5).

Observations of the counterrotating molecular disk in the spiral galaxy NGC 3593.

The interferometer has been used to map the CO(l-0) line in the inner disk of the galaxy NGC 3593, an Sa spiral at a distance of 12 Mpc. This galaxy has two counterrotating, exponential stellar disks, an outer, massive one, with a radial scale of 40" and a mass of 1.2 x 10^{10} M_Θ, and an inner one with a radial scale of 10" and a mass of 3 x 10^9 M_Θ. Most of the atomic hydrogen is in an outer ring well beyond the optical radius of the galaxy, and at a different orientation than the rest of the galaxy. This suggests the original galactic disk was perturbed by the accretion of a smaller galaxy, possibly a satellite galaxy. In contrast to the atomic gas, most of the ionised gas is in H II regions in a circumnuclear ring of radius 10" that rotates in the same sense as the inner stellar disk. About half of the CO emission, corresponding to an H_2 gas mass of 1.5 x 10^8 M_Θ, is in the starbursting, circumnuclear disk with a radius of 10". The rest of the molecular gas is in a one-arm spiral feature that stretches from the circumnuclear H II ring to the outer radius of 35". This one-armed spiral mode is as expected for a two-stream instability generated by the two counter-rotating components. The CO data **(Fig. 2.4)** show that at all radii, the molecular gas is counterrotating with respect to the outermost, massive stellar disk. A plausible origin of the counterrotating disks is a merger, about 10^9 years ago, of the original NGC 3593 with a gas-rich dwarf galaxy moving in the retrograde sense to the rotation of NGC 3593. This strongly braked the accreted gas, which then fell inward toward the center, forming a ring. Many of the stars in the innermost, counterrotating stellar disk may have thus formed relatively recently, during this accretion and infall. (Garcia-Burillo et al. 2000, A&A, 363, 869).

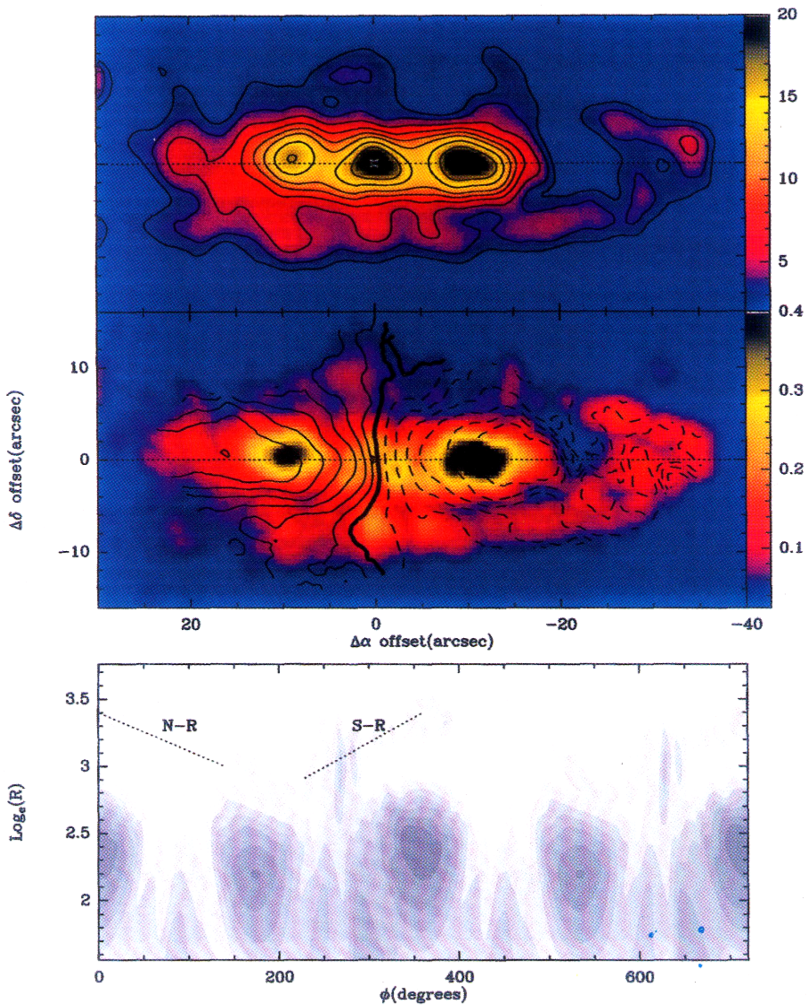

Fig. 2.4 CO in the counter-rotating molecular disk in the spiral galaxy NGC 3593.

(Upper:) CO(1-0) integrated intensity in the center of NGC 3593. Position offsets are relative to the dynamical center of the galaxy; a contour step corresponds to 3 Jy km/s / beam area. *(Middle:)* CO isovelocity contours in steps of 15 km/s relative to the systemic velocity of 630 km/s (thick contour), superposed on a map of peak brightness (grey scale); dashed contours indicate negative velocities.

(Lower:) Peak brightness, deprojected onto the galaxy plane, in polar coordinates. The dashed lines N-R and S-R indicate the location of the one-armed spiral, which appears in this plot as two straight ridges. (Garcia-Burillo et al., 2000, A&A, 363, 869).

Distribution and properties of molecular clouds in M31.

At a distance of only 800 kpc, the Andromeda Galaxy, M31, is the nearest large spiral galaxy in the sky. Unlike the Milky Way, M31 is rather quiescent, with a low star-forming rate and the absence of a central molecular ring. The *atomic* hydrogen in this galaxy has been mapped many times, but because the H I is spread out in thick arms, and because the galaxy is highly inclined to our line of sight, it has not been easy to identify a single, global spiral pattern. In contrast to the atomic hydrogen, the molecular gas is in thin spiral arms, and is an ideal tracer of the dense interstellar medium. To study the distribution and properties of molecular clouds, the 30m telescope has been used in the on-the-fly mode to map the CO(1-0) line over the entire disk of M31. Somewhat surprisingly, over galactocentric radii from 2 to 15 kpc, the observed CO is in a simple, two-armed, trailing logarithmic spiral pattern with a constant pitch angle of about 7°, observed on the sky at inclination 78° and position angle 37.7° **(Fig.** 2.5). This pattern may be stabilized by M31's central bulge, which is more prominent than that of the Milky Way, and by the lack of warping of M31's central disk by the satellite elliptical galaxies, NGC 205 and M32.

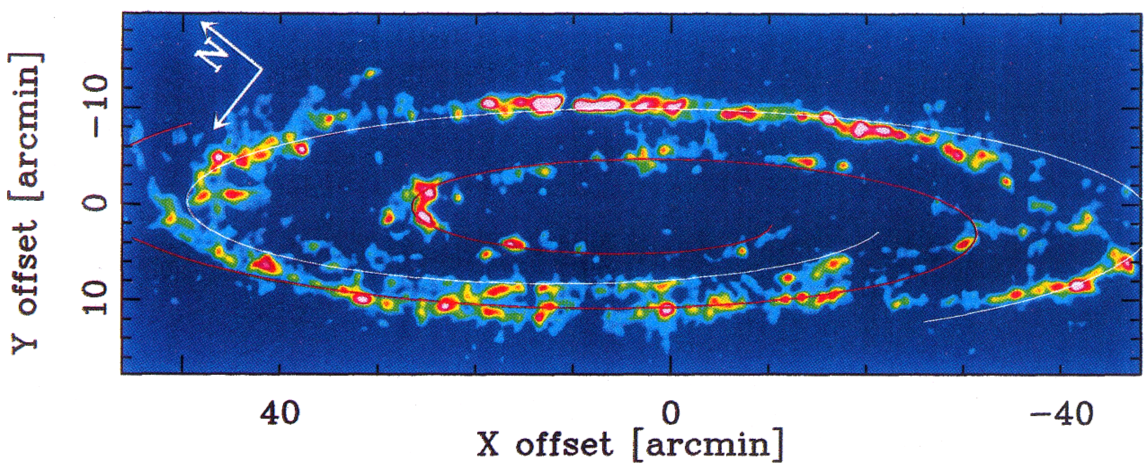

Fig. 2.5 **Molecular Clouds in M31.** The map shows the CO(1-0) integrated intensity, as mapped with the 30m telescope, smoothed to a resolution of 45″. The solid and dashed lines indicate a model of two trailing logarithmic spiral arms, with pitch angles of 6° and 8° (Nieten et al. in preparation).

A comparison with maps of the optical extinction yields for the ratio of CO intensity to the dust opacity of $I_{CO}/E(B-V)$ = 10 K km/s per magnitude, and for the ratio of the gas column density to the extinction of 2 x 10^{21} cm^{-2} /mag^{-1} , both ratios being close to those measured in molecular clouds in our Galaxy. The many CO concentrations on the 30m map have sizes of 100 to 200 pc, so they are associations of giant molecular clouds (GMCs), rather than the clouds themselves. The observed CO(2-1)/(1-0) line ratios of 0.4 to 0.9 suggest *true* cloud brightness temperatures of 10 to 30 K, as in warm GMCs in our Galaxy. The *observed* brightness temperatures, however, are only about 1 K, so the filling factor in the telescope beam is 10 to 30, and the GMC associations are thus made up of several individual clouds, the brightest of which have true sizes of 6 to 10 pc and masses of 10^4 M_Θ- The total mass of a GMC association would then be about 10^5 M_Θ, similar to that of the Orion molecular cloud. The net result is that in extinction, temperatures, sizes, and masses, the molecular clouds in M31 look just like those in the Milky Way. The big difference is the complete absence in M31 of a strong central molecular ring, the lack of a large concentration of molecular gas near the galaxy's center, and the lack of large galactic center GMC associations like Sgr B2. M31 also has no big starburst regions like W49 and W51 out in its spiral arms. All this may be the result of M31 having less total gas than our Galaxy, and a larger, more symmetric nuclear bulge, with no galactic center bar. (Guélin et al., 2000, in *The Interstellar Medium in M31 and M33).*

Dwarf galaxies: A study of molecular gas in NGC 205

Dwarf galaxies are the most common type of galaxy in the sky, and although many of them contain large quantities of *atomic* hydrogen gas, most of the local-universe dwarf galaxies are gas-poor. They are often called dwarf ellipticals, because they are more or less spheroidal, with surface brightness declining smoothly and exponentially with radius. Because they are gas-poor, small, and mostly far away, it is hard to detect *molecular* gas in dwarf galaxies. An exception is the Andromeda galaxy's dwarf elliptical companion, NGC 205, in which CO was first observed by Sage and Wrobel in 1989. A new study has been made with the 30 m telescope at 17 positions in this galaxy in the 1-0 and 2-1 lines of ^{12}CO and ^{13}CO. A search was also made for the 1-0 lines of HCN and HCO^+. The distance of this galaxy is only 0.8 Mpc, so at 3 mm, the 30 m telescope beam corresponds to 87 pc. The 30 m survey indicates that NGC 205 has 10^5 solar masses of molecular gas, about 10,000 times less than contained in the Milky Way. The main result of this study is that the molecular clouds in NGC 205 closely resemble the giant molecular clouds in the disk of the Milky Way. They have the same ^{12}CO(2-1)/(1-0) ratio of 0.5, indicating subthermal excitation, the same $^{12}CO/^{13}CO$ ratio of about 8, indicating moderate opacity, and the same ratios of CO to HCN and HCO^+ of >10, typical of clouds in our Galaxy's disk. Estimates from CO and from optical extinction of gas-to-dust mass ratios are also consistent with the canonical value of 100 that is typical of clouds in our Galaxy. There is a striking difference, however, in the relation of the molecular gas to the atomic gas: the molecular cloud envelopes have H I column densities at least ten times lower than for the molecular clouds in our Galaxy. An explanation may be that the star populations in NGC 205 produce an UV field that is a hundred times weaker than the standard UV field in the solar neighbourhood. This weak UV field may make it easier to form and preserve molecular gas in low-luminosity ellipticals like NGC 205 than in spiral galaxies like the Milky Way, where molecular gas in the outer envelopes of molecular clouds can be dissociated by the strong stellar UV radiation. In all other respects, however, the molecular clouds are the same, so dwarf elliptical galaxies may be forming stars just as the spiral galaxies do (L.M. Young, 2000, AJ, 120, 2460).

Dwarf galaxies: Molecular gas in blue compact dwarf galaxies

About 5% of all dwarf galaxies belong to a particular class called the blue compact dwarf galaxies. These objects are among the smallest star-forming galaxies known, and are thought to form stars in a burst lasting 10^8 years, with quiescent periods of 10^9 years between bursts. Although their blue colour indicates extreme *current* star formation, only a few of these galaxies have been detected in CO. A new search for CO(1-0) and (2-1) lines in 8 blue compact dwarf galaxies has been made with the 30m telescope, and CO was mapped in two of them, Haro 2 and UM 465. In these galaxies, the molecular gas mass appears to be similar to the H I mass, while in the non-detected galaxies, the upper limits on the molecular mass are about 10 times lower than the H I mass. (Barone, Heithausen, Huttemeister, Fritz, & Klein, 2000, MNRAS, 317, 649)

2.3 STAR FORMATION

Disks and outflows around intermediate-mass stars andprotostars

Herbig Ae/Be stars are intermediate-mass (1 to 20 $M_{\odot}$) counterparts of T Tauri stars. Like T Tauri stars, they disperse their protostellar dust cocoons and become visible before they settle down to normal life on the Main Sequence. To gather basic data on this process, the 30m telescope and the interferometer were used at 1.3 and 2.6 mm to measure the continuum and CO lines from the protostar NGC 7129-FIRS 2 and the Herbig Be stars Lick Ha234 and HD 200775. These objects are in different stages of pre-Main Sequence evolution, with ages of several thousand years (the protostars) to 8 million years (the Herbig Be stars). The interesting result of this new study is that circumstellar disks and bipolar outflows are not detected around the Herbig Be stars. These massive stars (> 5 $M_{\odot}$) have evidently dispersed their outer disks, and ended their energetic bipolar outflows early in their evolution, possibly before they appeared as visible stars. It is now clear from the millimeter continuum map **(Fig. 2.6)** that the pre-main sequence star LkHoc 234 is actually a member of a cluster of young objects, mostly hidden by dust. In contrast to the mm-quiet Herbig Be stars, there is strong mm emission from several protostars in the Far-Infrared Sources (FIRS) in NGC 7129. They are called FIRS 1-MM 1 (a new discovery), FIRS2-MM1, and IRS6. There is also an outflow of molecular gas from a new infrared star, FIRS2-IR. In FIRS2, there are two mm sources, one of which produces a blue-shifted CO outflow. Surprisingly, the red-shifted lobe of the CO outflow comes not from FIRS2-MM1, but from a new infrared source, which is not seen on the millimeter maps. No mm continuum emission is detected toward LkHoc 234 itself, which sets an upper limit of 0.1 $M_\odot$ on the mass of any circumstellar dust disk around this star. Toward the star HD 200775, in the reflection nebula NGC 7023, the mass of any circumstellar dust disk is less than 0.002 $M_\odot$, the lowest upper limit obtained so far for a Herbig Be star. For the protostars that were detected in the mm range, the luminosities are consistent with intermediate mass objects (3.5 to 4.5 $M_\odot$), suggesting that once they disperse their dust envelopes, they too will emerge as Herbig Be stars. (Fuente et al, 2001, A&A, 366, 873).

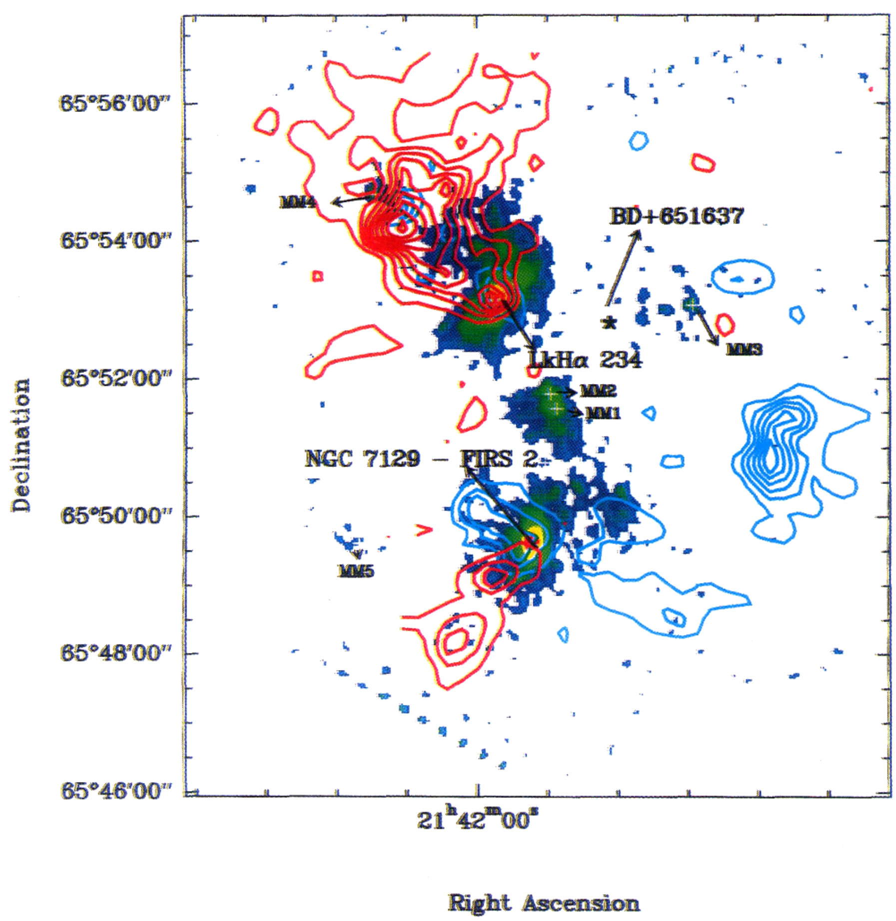

Fig. 2.6 CO and mm continuum emission toward NGC 7129. *Red contours :* Integrated CO(2-1) line emission in the redshifted outflow lobe; contours run from 10 to 100 K km/s in steps of 15 K km/s, over the range (-7, + 11) km/s ; *Blue contours :* blueshifted CO(2-1) outflow, over the range (-30, -13) km/s, contours run from 10 to 60 K km/s in steps of 10 K km/s. *False color scale :* The 1.3mm continuum emission from dust. The labels indicate the locations of the millimeter sources, infrared sources and visible stars. (Fuente et al., 2001, A&A, 366, 873).

Small-scale structure of the protostellar collapse candidate B335 in CS(5-4) emission.

The infall motions toward a forming protostar are hard to find because 1) only a small fraction of the pre-stellar nebula is accelerated to velocities comparable to intrinsic spectral line widths, 2) fast outflows from the poles of the pre-stellar disk entrain a lot of mass and mask the slow inflow in the plane of the disk, 3) the ordered flows, both in and out, are confused with the surrounding turbulence in the > 10" beams of single-dish millimeter telescopes. One of the best candidates for inflow motions so far has been the dust globule Barnard 335, at a distance of 250 pc, which contains a low-luminosity object, possibly a protostar, detected only at wavelengths longer than 60 microns by the *IRAS* satellite. Previous single-dish studies in a variety of molecules had shown spectral line profiles that could be interpreted in terms of contraction toward the putative protostar. The innermost regions of the cloud core should have the highest density and the highest inflow velocities.

To probe this inner, dense region, a new study has been made of B335 with the IRAM interferometer in the CS(5-4) line at 245 GHz, with a velocity resolution of 0.13 km/s, and a beam of 2.5" (0.003 pc), which is 20 times smaller in area than beams previously used on this line in B335. The interferometer easily detects a 1.2 mm continuum flux of 40 mJy from dust in the barely resolved protostar, which is presumably the dynamical center of the gravitational contraction inside of B335. The interferometer results show quite convincingly that the infall interpretation of the single-dish line profiles is wrong. Instead of inflow centered on the protostar, the emission shows an east-west pattern of clumps aligned with ridges in the bipolar outflow cavity. In other molecules that are strong emitters at low densities, this cavity can be traced over arc minute scales.

The blue-shifted wing of the high-density tracer CS(5-4) seen in earlier, single-dish profiles, and previously thought to be the infalling gas, is not centered on the protostar at all, but is instead offset by 5", and appears to be a dense clump in the protostar's bipolar outflow, which is viewed nearly face-on (**Fig. 2.7**). These high-resolution CS(5-4) observations of B335 are a major obstacle for all contraction models in which gravity accelerates infalling gas to free-fall speeds. The observations show that the unresolved spatial kinematics cannot be inferred from subtle radiative transfer signatures in broad-beam spectral-line profiles. (Wilner et al. 2000, ApJ, 544, L69).

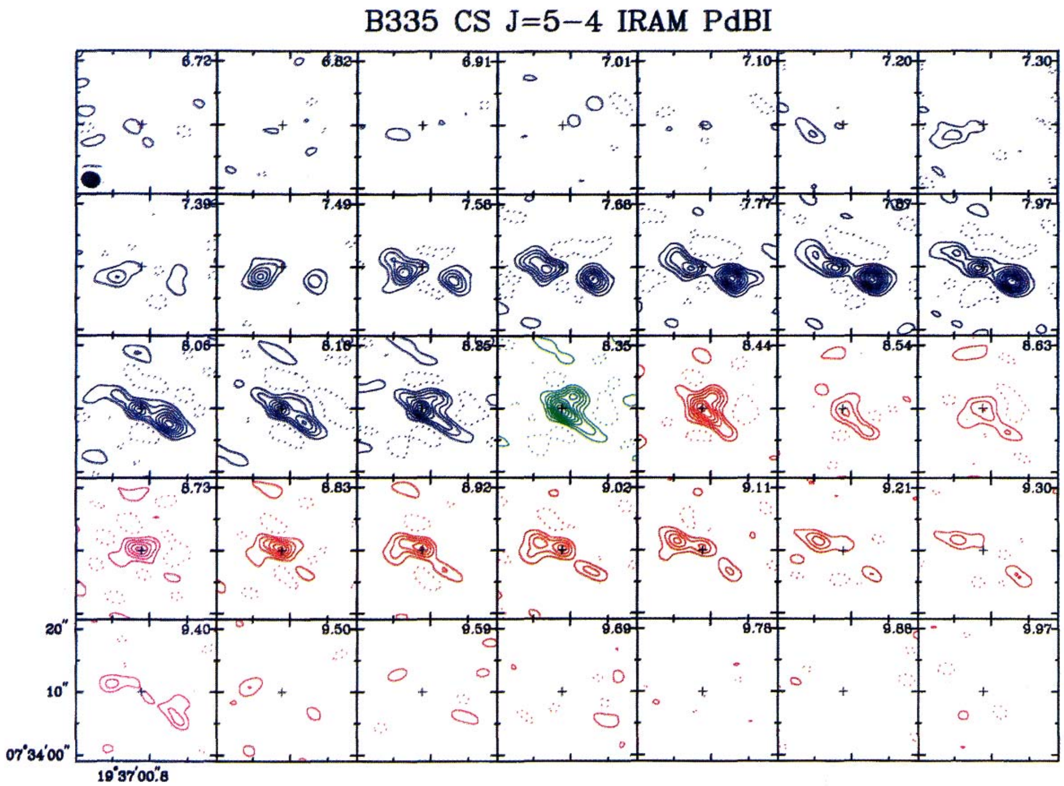

Fig. 2.7. Interferometer maps of CS(5-4) emission in B335. Labels in the upper right corner of each map indicate the LSR velocity, in km/s. Individual panels span *22"* (5500 AU at 250 pc distance). The cross at the center of each map marks the position of the 1.2 mm continuum source. The beam is 2.9"x 2.3" (ellipse in top left panel). Contour intervals are 0.9 K (300 mJy/beam). The profiles toward the continuum source lack the broad wings expected from an inside-out collapse model. The observed wing emission is significantly displaced from the protostar, and appears to be part of an outflow, rather than an infall as was previously thought.

Pre-Orion-Type Cores in the Trifid Nebula.

The Trifid Nebula is a young H II region at a distance of 1.7 kpc, that has been created in a localized burst of star formation. Like many other H II regions, it has bright-rimmed globlules that may contain protostars, either inside the ionized zone, or at its outer border. To study these objects, the 30 m telescope has been used to map the CS(3-2), ^{12}CO, ^{13}CO, $C^{18}O$, and thermal SiO(2-1) lines, and, with the MPIfR 19-beam bolometer, the dust continuum emission at 1.2 mm. The map of the thermal dust emission **(Fig. 2.8)** reveals several massive condensations with masses ranging from 8 to 90 M_{Θ}. Data from the molecular lines mapped with the 30 m telescope and from far-infrared emission at 45-200 μm observed with the

Infrared Space Observatory (ISO) LWS instrument show that these condensations are made of very dense (10^6 to 10^7 H_2 cm^{-3}) and cold gas and dust (temperature 20 K). Two of the condensations, TC3 and TC4, are associated with outflows, and resemble closely some of the massive protostellar cores observed in Orion. The dust cores are embedded in a dense layer of molecular gas that appears to be material compressed by the precursor shock of the ionisation front driven by the main exciting star of the Trifid Nebula. Analytical models suggest that dense cores of the size and mass of TC3 and TC4 can form from fragmentation of the dense compressed layer. Hence rather than being pre-existing protostellar globules that are now being hit by the shock, the formation and contraction of TC3 and TC4 may actually have been triggered as a result of the expansion of the nebula, about 10^5 years ago. (Lefloch & Cernicharo, 2000, ApJ, 545, 340).

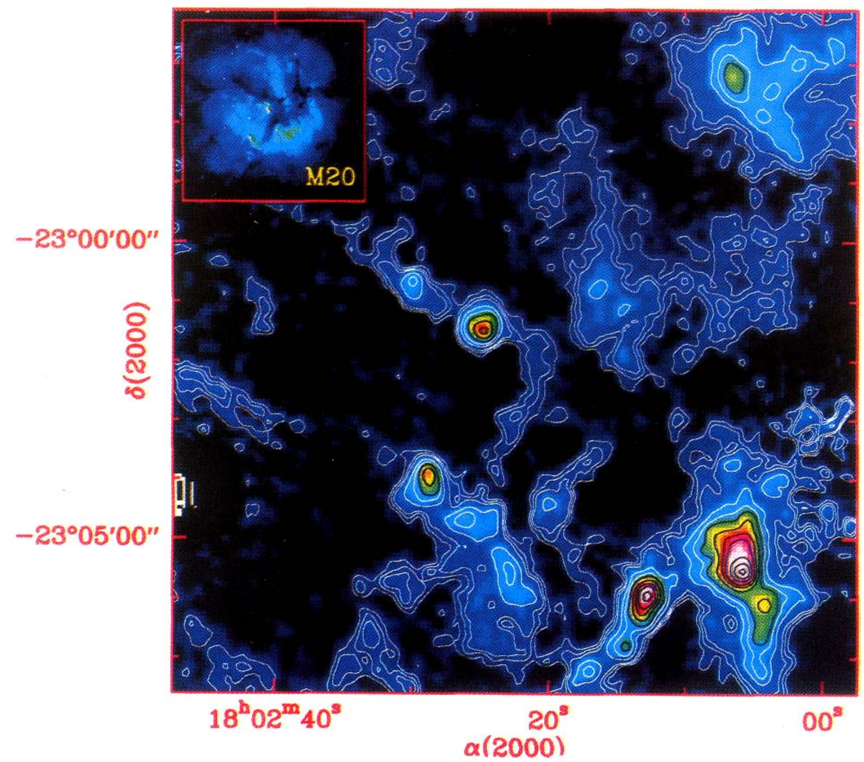

Fig. 2.8 Dust emission at 1.3 mm, in the Trifid Nebula (M20). The contours show a map of the mm continuum made with the MPIfR 19-channel bolometer at the 30 m telescope, with scans at a speed of 4"/sec and the secondary mirror chopping at a rate of 2 Hz. The resolution was smoothed to 15". The Trifid condensations TC3 and TC4 are the two strongest sources at the lower right . The most intense source, TC3, has a peak flux of 390 mJy. The extended lanes in the 1.3mm emission coincide with the dust lanes seen in optical images of the nebula. The inset in the upper left shows an Hα image of the Trifid Nebula, on a different scale (Lefloch and Cernicharo, 2000, ApJ, 545, 340).

2.4 CIRCUMSTELLAR ENVELOPES

Detection of the free radical SiCN in the circumstellar envelope ofIRC+10216.

The 30 m telescope has been used to detect the free radical SiCN in the envelope of molecular gas around IRC+10216 (known in the optical as CW Leo), a carbon-rich star at a distance of about 140 pc. The envelope expelled by this star is rich in both refractory compounds and reactive species. The *refractory* compounds are stable, metal-bearing molecules like SiS, that are formed in the hot stellar atmosphere and then expelled into the envelope. Interferometer maps show that these refractory, stable compounds are in a compact region within a second of arc of the central star. Unlike the refractory compounds, the *reactive* species — which include free radicals and linear carbon-chain radicals like C4H — must form in the cold, tenuous circumstellar medium. Interferometer maps show that these reactive species are in a thin shell, about 4" wide, in the outer envelope, at a radius of 15" from the star. The four metal-containing free radicals detected up to now, SiC, SiN, MgNC, and MgCN, are in this outer shell.

Recently, the team of Apponi et al. (2000 ApJ, 341, L25) measured the microwave spectrum of SiCN in a laboratory discharge tube. In its electronic and vibrational ground states, this linear molecule has rotational spectra consisting of a series of spectral lines that are regularly spaced every 11 GHz. In the 3mm band, lines appear at 83, 94, and 105 GHz **(Fig. 2.9).** Each line of this rotational series is split into A doublets separated by 25 MHz. In IRC+10216, each component of a A doublet appears as a line with two cusps separated by 29 km/s (10 MHz at 3mm), which correspond to the front and back of the expanding envelope around the star. Such lines are characteristic of optically thin line radiation from a spherical shell that is hollow inside, expanding with constant velocity, and is larger than the telescope beam. The line profile of SiCN resembles that of C_4H, which has been shown by IRAM interferometer maps to be located in the thin outer shell around the star, so SiCN is very likely to be in this shell as well. If the rotational temperature of SiCN is 20 to 30 K, then its abundance relative to H2 is 4 x 10^{-9} in the shell. This is 20 times lower than the abundance of SiC and MgNC, but about equal to that of MgCN. The low abundance of SiCN does not give a clear indication on how it is formed. Some possibilities are ion-molecule reactions (the ion Si^+ with HCN) or radical-radical reactions involving C2H and CN, or reactions on the surfaces of silicate grains. (Guélin et al. 2000, A&A, 363, L9).

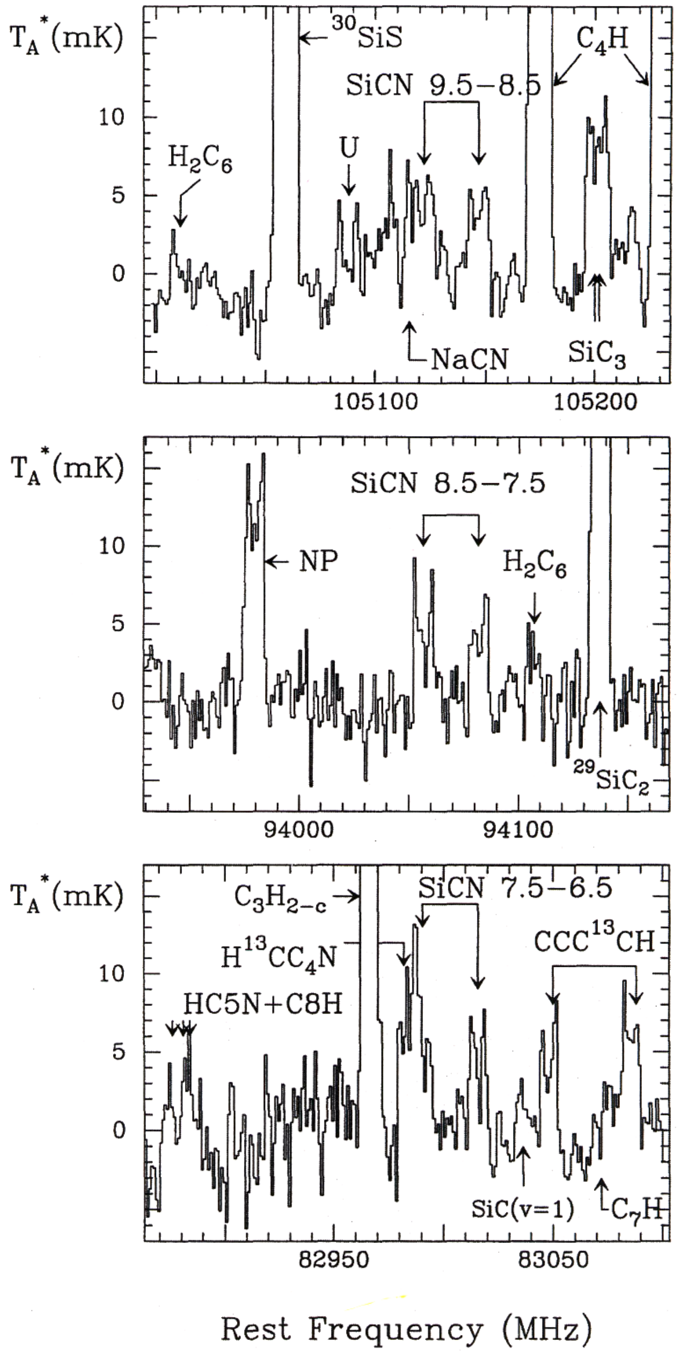

Fig. 2.9 Detection of SiCN in IRC+10216. The figure shows spectra from the 30m telescope of three successive rotational transitions of SiCN near 105 GHz (upper), 94 GHz (middle), and 83 GHz (lower). Each line is split into A doublets (indicated in each panel by two connected arrows under the SiCN label). Each A doublet component has two cusps due to the expansion of the circumstellar envelope. Other identified lines are also indicated.

2.5 **SOLAR SYSTEM**

Size of the Centaur Chariklo deduced from its millimeter continuum flux.

Our solar system is surrounded by the Kuiper Belt, a 100-AU diameter ring of icy planetesimals that condensed from the original pre-solar disk. As of this year, about 330 Kuiper Belt Objects are known, out of an estimated population of 70,000 objects with diameters > 100 km. The largest one is the "planet" Pluto, with its moon Charon. Most of the Kuiper Belt Objects are at radii of 30 to 50 AU from the Sun. Because they are made of ice and dust, Kuiper Belt Objects that wander into the inner solar system heat up and partially vaporize, thereby becoming (short-period) comets. There are two subsets of these objects: (1) the Scattered Disk Objects, with elliptical orbits with semimajor axes of 85 AU and perihelia near 35 AU, which were probably ejected from the Kuiper Belt by interaction with Neptune, and (2) the Centaurs, which have perihelia between the orbits of Jupiter and Neptune, a dynamically unstable region that limits their lifetimes to about a million years. Because of their large number (55 Centaurs now known, out of an estimated population of 2600 Centaurs with diameters > 70 km), the Centaur population must be continuously replenished from the Kuiper Belt.

At a distance of 40 AU, even the largest, 600-km diameter., Kuiper Belt Objects would have a 1.2mm flux density of only 0.5 mJy, which requires too much observing time with current millimeter telescopes. The Centaurs, however, are closer than most of the Kuiper Belt Objects, and their fluxes are higher. The first millimeter detection was that of Chiron, the prototype Centaur. This object was observed with the 30m telescope in 1994 by Altenhoff & Stumpff, who derived a diameter of 168 ± 20 km, a value later confirmed by lunar occultation data. A second centaur, Chariklo, which was discovered with the optical Spacewatch telescope in 1997, has now been detected with the MPIfR 37-channel bolometer array on the 30 m telescope **(Fig. 2.10).**

The diameter of the object can be calculated from its mm flux, with the formula:

$$d = \left[\frac{4 \cdot \Delta \cdot S}{\pi \cdot B(T_b) \cdot e} \right]^{1/2}$$

where A is the mean *geocentric* distance (12.62 AU during the Chariklo observations), S is the measured flux density (2.03 ± 0.30 mJy), and $B(T_b)$ is the Planck function at the brightness temperature, T_b , calculated for the mean **heliocentric** distance (13.35 AU). The great advantage of millimeter observations over infrared or visible observations is that numerous studies of asteroids have shown that **the mm emissivity, *e* , *is always 1.*** Hence there is no need to estimate an albedo, and in principle, diameter estimates from mm fluxes can be as accurate as lunar occultation measurements. The mm flux measured at the 30m telescope implies that Chariklo has a diameter of 273 ±19 km. (Altenhoff, Menten, & Bertoldi, 2001, A&A, in press; For further information on Kuiper Belt Objects, see http://www.ifa.hawaii.edu/faculty/jewitt/kb.html).

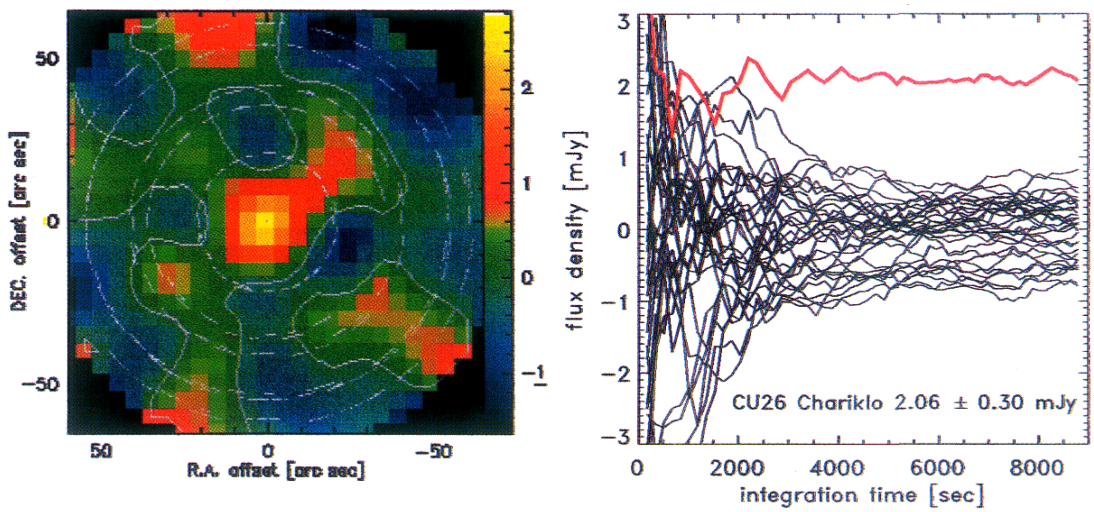

Fig. 2.10 Detection of the Centaur Chariklo with the 30 m telescope. *(Left:)* Map made with the 37-beam bolometer array, showing the detection of Chariklo in the center of the field. *(Right:)* Plots of the integrated signals of all bolometer channels as a function of integration time. The central, on-source channel (red line) shows a signal of 2 mJy. The noise in the off-source channels decreases with the square root of time, and reaches an r.m.s. value of 0.45 mJy after 2.4 hours.

3. Pico Veleta Observatory

3.1 Staff Changes

Gilles Niccolini, cooperant in the astronomy group left IRAM Granada in January 2000, Christophe Risacher, cooperant in the receiver group left IRAM in April 2000. In the fall two new cooperants joined IRAM: Alexandre Duflos (computers), and Frederic Damour (Astronomy). As in the preceding year, Hauke Hein (receivers) was delegated to the SMTO in Arizona during the winter months. Albrecht Sievers has moved from an astronomer's position to a position attached to the computer group.

3.2 30-m Telescope Operation

The operation of the 30-m telescope was generally smooth in 2000. As shown in Fig. 3.1 almost 2/3 of the total time could be used for astronomical observations. As every year the 30-m telescope participated in about 14 days of VLBI observations. About 24% of the time was lost due to meteorological conditions (clouds, precipitations, wind). Because of the long hold time of receivers, maintenance time could be further reduced from 4.1% in 1999 to 3.5% in 2000. The maintenance time includes receiver filling and maintenance, and time for interventions at the telescope and at the computer. 6.4% of the time were used for technical activities such as the replacement of a defective cryostate, a new telescope controller etc.

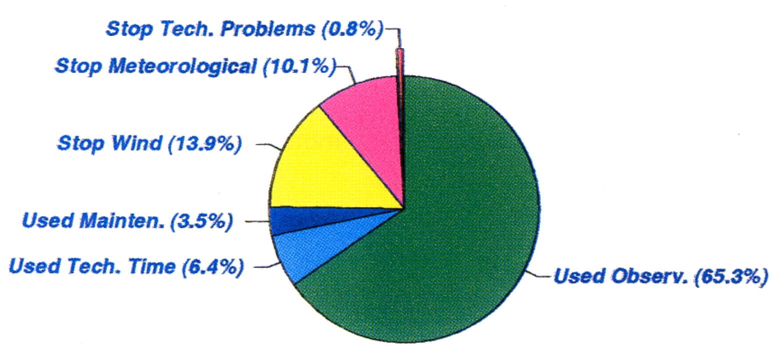

Fig. 3.1: Distribution of the total telescope time for the year 2000.

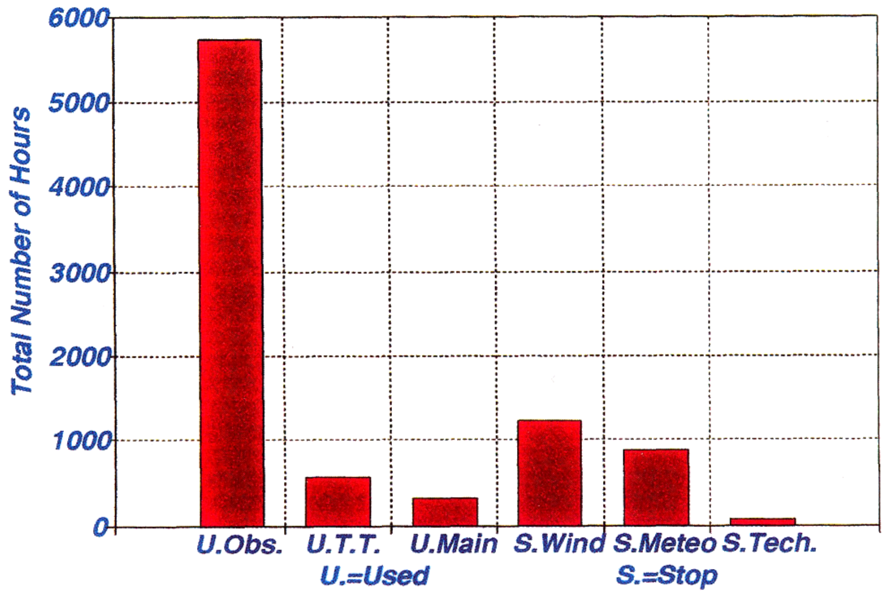

Fig. 3.2: Distribution of the total telescope time for 2000 in hours.

0.8% of the time were lost due to technical problems. This statistics includes only failures of more than 2 hours duration. Most losses of observing time were due to computer (40%) or antenna (45%) failures.

In order to calibrate bolometer observations one needs to compare them to the measurement of a source with a well known flux. Since the best calibrators, Mars and Uranus, are not always visible, secondary continuum calibrators have been observed. The measurements included mapping of the objects in order to determine their shape and extent and On/Off measurements yielding their flux density per beam. The summary of these observations, including tables of flux densities per beam for the secondary calibrators, have been made available on the IRAM Granada WWW site (www.iram.es).

Weather dependent scheduling has now become an integral part of winter observing at the 30-m telescope. When the weather is not good enough for the most demanding bolometer projects, either less demanding bolometer projects have been observed or heterodyne projects. The latter has become possible after the switching time between SIS receivers and bolometers has greatly been reduced.

3.3 Antenna

A new programmable controller (PLC) for the antenna servo control and interlock system has been successfully installed. For the replacement, the antenna had to be completely stopped for four days. Among others, enhanced features of the new system are the remote control and diagnostic possibilities by means of an Internet connection.

Inclinometer measurements are now introduced frequently in the pointing models. This permits to determine two of the pointing constants without the need of astronomical measurements. A sporadic problem of elevation pointing jumps was identified with the malfunction of one of the six subreflector spindle encoders. The encoder was exchanged. In 2001 all the single spindle encoders will be replaced by double spindle encoders to get redundant information (as with the antenna axes encoders).

The PT100 temperature sensors, as well as inclinometers, are now read under VME LINUX. Eight new temperature sensors have been installed to monitor temperatures of the four prime focus support legs. Two VME modules model IK320 from Heidenhain have been installed to read the position of the antenna axes encoders with a precision approximately 10 times better than with the old CAM AC modules. They permit to read the encoders simultaneously with the CAMAC and VME systems. With these modules, all the necessary hardware in the antenna to replace CAMAC by VME is available.

3.4 Reflector Surface

A small surface adjustment (80 screws) of the outer two panel rings was made in August 2000. In September the surface rms was measured by holography at 39 GHz. No significant change in surface quality was detected (rms 53 microns), probably because the time variable astigmatism was higher (100 microns) during the holography measurements than in previous years (50 microns). Without this aberration the surface rms was 45 microns, amplitude weighted and axially resolved.

The beam efficiency has been measured regularly. The values can be well fitted (see **Fig. 3.3**) by the theoretically predicted Ruze function. The recommended values are now automatically set in the OBS antenna control program.

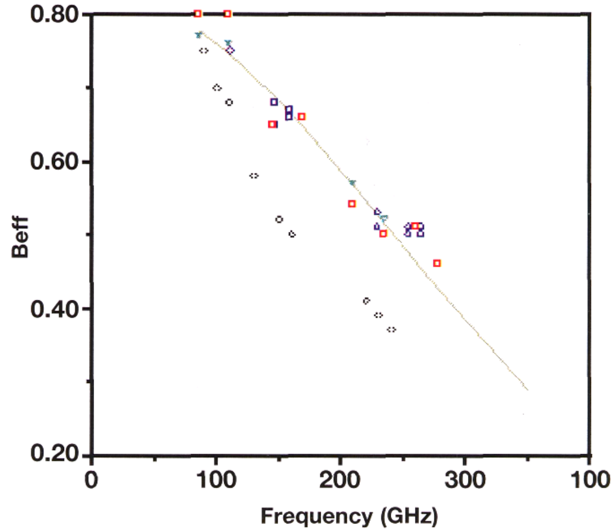

Fig. 3.3: The beam efficiencies measured during the last year together with the best-fit Ruze function. The circles denote measurements carried out in November 2000, triangles and squares measurement done in October 1999 and January 2000 and the diamonds efficiencies valid before July 1997.

In figure 3.3 the efficiencies valid before July 1997 are also included to demonstrate the considerable progress made after the last surface adjustments, which becomes most obvious at high frequencies.

3.5 Receivers

Shortly after the installation, on September 1999, channel C270 was found to have developed some extra noise, presumably due to a mechanical or electrical degradation of the junction during the transport to Spain. The whole C cryostate was therefore replaced in August 2000. Complete installation, including system check and alignment, was done in three periods of 10 hours (day time only) proving the feasibility of the pre-aligned base plate concept: almost a "Plug and Play" device.

The improved reliability of the new set of cryostats has lead to a change on the operation of the receiver group staff. Since October, all bolometer recycling tasks are handled by the operators' group. Consequently, the planning of the receiver group staff has been revised: the presence of the receiver engineer at the telescope was first limited to the period Monday-Friday each week, and later to maintenance days and days where special tasks were foreseen. There is, however, a continuous standby service for emergencies. The modification of the planning has permitted the receiver staff to participate in the ALMA project. Since October and in collaboration with the H.I.A. (Canada), IRAM Granada has been assigned the work package on Infrared filters and vacuum windows. IRAM staff is investigating the mechanical stability, leak rates and the transmission properties of various materials.

Fig. 3.4. Burst chamber constructed at IRAM Granada for mechanical and leak rate tests of vacuum window materials for the ALMA project

An uncooled Schottky tipping radiometer receiver operating at 225 GHz to measure the atmospheric opacity is being built. The new calibration loads have been measured in Grenoble showing very good performance. The receiver noise temperature is of order 1200 K. The system is expected to be finished during the spring of 2001.

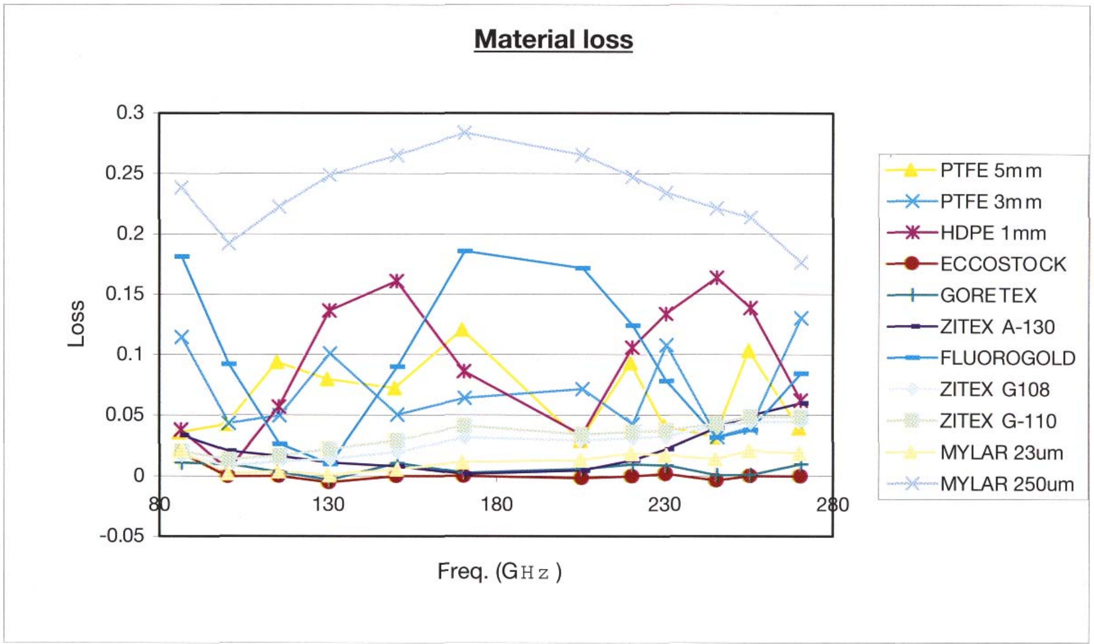

Fig. 3.5. RF transmission measurements for ALMA project.

The 37 channel 1.2 mm bolometer was used with great success at the 30-m telescope during the winter months of 2000. One of the problems in switching from bolometers to heterodyne receivers had been the necessity to replace a ring mirror behind the sub-reflector by an absorber ring. In December 2000 this ring was replaced by a tilted mirror that should reduce the standing waves for heterodyne observations without increasing the background noise seen by the bolometer.

The observer can now determine the rejection of the image sideband (G_i) for any of our heterodyne receivers from the the OBS antenna control program. The value of G_i is determined using a Martin-Puplett-Interferometer

In preparation for the installation of the coming multibeam heterodyne receiver (HERA), a series of elements have been installed or modified: (1) An electrical power line with a transformer for the required supply of the helium compressor. (2) The water chiller machine has been repaired and tested with a heater of 5 kW to simulate the Daikin compressor load. (3) New cooling lines connecting the water chiller machine to the helium compressor have been installed and tested.

Fig. 3.6. The new reflecting ring behind the secondary fixation.

3.6 Backends

In 2000 two prototypes of 256x4 MHz filterbanks were interfaced with a VME system; they were tested in the Granada labs and installed at the telescope. The software to integrate the new filterbank was developed in cooperation between the computer group and the backend group. The filterbank software differs from the backend software used until now: data is transferred directly to a data reduction system. This allows a faster sampling (expected 10 samples/s) and sampling outside of subscans. In order to be compatible with the current telescope control system and data reduction software, the data files are merged with tracking information on the data reduction system producing standard raw data files again. **Fig. 3.7** shows a spectrum of the CO (J=2-1 line) toward the galaxy Arp 220 showing broad emission.

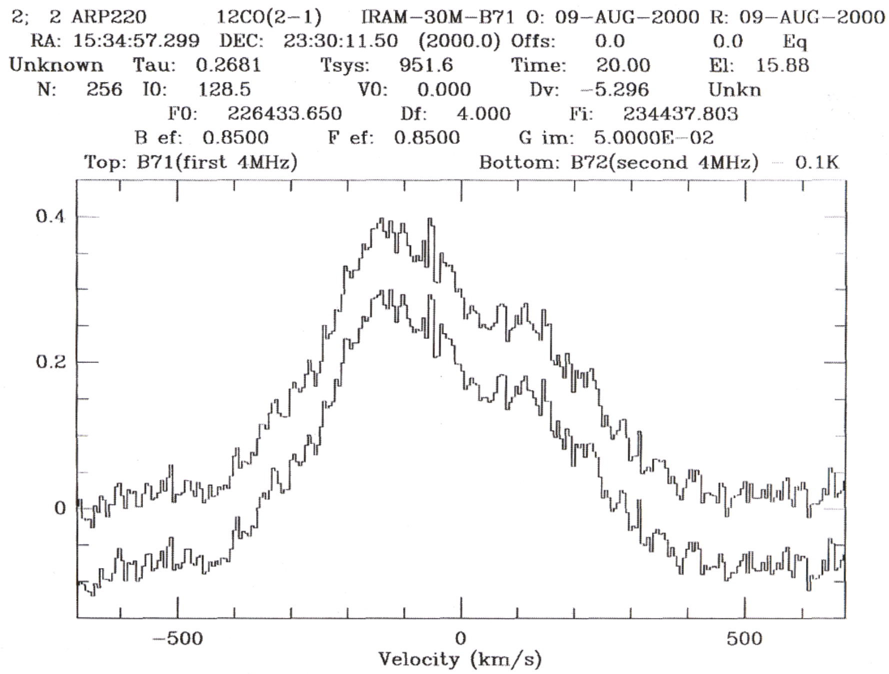

Fig. 3.7 The profile of the CO (2-1) line toward Arp 220 taken simultaneously with either of the two 256 x 4MHz filterbanks. The spectra are, within the receiver noise, identical. It is now possible to simultaneously observe with three receivers of 1 GHz bandwith each (namely using the new 4 MHz systems and the old 1 MHz filterbank).

The backend group has started to create a prototype of VME-interfaced filterbank, having in mind the progressive migration of all the old filterbanks to VME interface.

A concept was elaborated to reuse the old Plateau de Bure Autocorrelator for the IRAM 30m telescope with just few hardware modifications in view of the demands of the future 9-pixel multibeam receiver.

3.7 **Computers and Software**

The MPIfR bolometer has been connected to two backends that were also provided by the MPIfR: (1) BOGLE (installed in 1999): a VME/VxWorks based system with buffering under LINUX that uses pulse counters. (2) ABBA: a MS-Windows/Lab View based system that uses high resolution DACs. The BOGLE software and its integration have been improved. ABBA was installed this year and will be able to run the new 117 channel MPIfR bolometer. The MPIfR bolometer team also intends to improve data quality by new observing modes that have been implemented together with IRAM staff (e.g. sampling at 125 Hz).

The remote observing station at the MPIfR in Bonn is operational now and has been used for observations and monitoring. Another remote observing station has been installed at the ENS in Paris and a first observation was done in December 2000. Both remote stations have been operated via the Internet, which is cheaper and has a much higher bandwidth than ISDN lines. In case of high net traffic, a connection via ISDN lines is optional. In total, there are now four remote stations for the 30-m telescope: in Granada, Grenoble, Bonn and Paris. Their operation is generally smooth. To offer remote observers an online view of the telescope, a web camera has been installed (accessible from the www.iram.es site).

Observers can now also do data reduction under LINUX. All project accounts are now available under LINUX and HP/UX and a powerful two processor LINUX system has been installed at the observatory. Most of the GILDAS software is now running under LINUX, in particular the bolometer data reduction can be done on several fast LINUX PCs using NIC and/or MOPSI (data reduction system by R. Zylka, MPIfR Bonn) software. In addition, several commercial packages like Mathematica, IDL, the NAG FORTRAN 95 compiler and numerical library, WordPerfect and StarOffice are available.

Most UNIX workstations at the 30-m now use Network Time Protocol (NTP) to synchronize their clocks. As reference clock we use a VME clock module that receives a time signal from a GPS receiver. This clock module is read out by a VME computer running PPC LINUX, which serves as the local stratus 1 time server. Some systems requiring high accuracy, like backends, synchronize via direct ethernet connection to this server. Most other systems synchronize via broadcast messages.

Work on our plans for a New Control System (NCS) for the 30m telescope continues, and in many areas we have reached decisions about priorities, features, and solutions. Details and regular updates can be found on the WWW pages for this project at http://www.iram.es/FutureControl30M. Among the high priority user features for the NCS are: observations with focal-plane arrays, continuous data taking, e.g., fast on-the-fly observations, remote observing, service observing, and flexibility of observing and scheduling. This means one has to foresee very large data rates, optimize the standard observing modes and make them easy to use, automate where possible.

3.8 Infrastructure

The main electrical supply is now supervised by a dedicated PC. Every minute all the electricity important parameters as the three phases voltages, currents and power consumption are recorded and saved on disk. The goal is to supervise the stability of the power supply and to characterize the profile of the power consumption. At the observatory, there are seven high current switches for the electricity supply, which were revised by the manufacturer.

Diesel generators at the observatory are able to deliver up to 200 kW of electricity power when working in a balance mode. Unfortunately, up to now, the balance was adjusted manually, after which it degraded rapidly when the electrical load changed. A new control system has been developed to automate the balance of the electrical loads between both diesel generators.

Eight new lightning rods have been installed to improve the lightning protection of the observatory. These lightning rods replace the old ones, which had several points broken, and they are placed a bit higher. One of the new lightning rods is a special design with faster performance to open an electricity channel to discharge atmospheric static electricity.

A concrete platform was built at the observatory for the construction of a geodetical vertex to determine the precise astronomical coordinates of the observatory and the local deviation of the vertical. **Fig. 3.8** shows the new platform with a team and equipment from the Spanish Instituto Geografico Nacional (IGN).

Negotiations have continued with the Spanish "Ministerio de Ciencia y Tecnología" to declare a radio protected area around the observatory. The goal is to obtain a protection equivalent to the law currently in force for the optical observatories on the Canary Islands ("Ley del Cielo", i.e. "Law of the Sky").

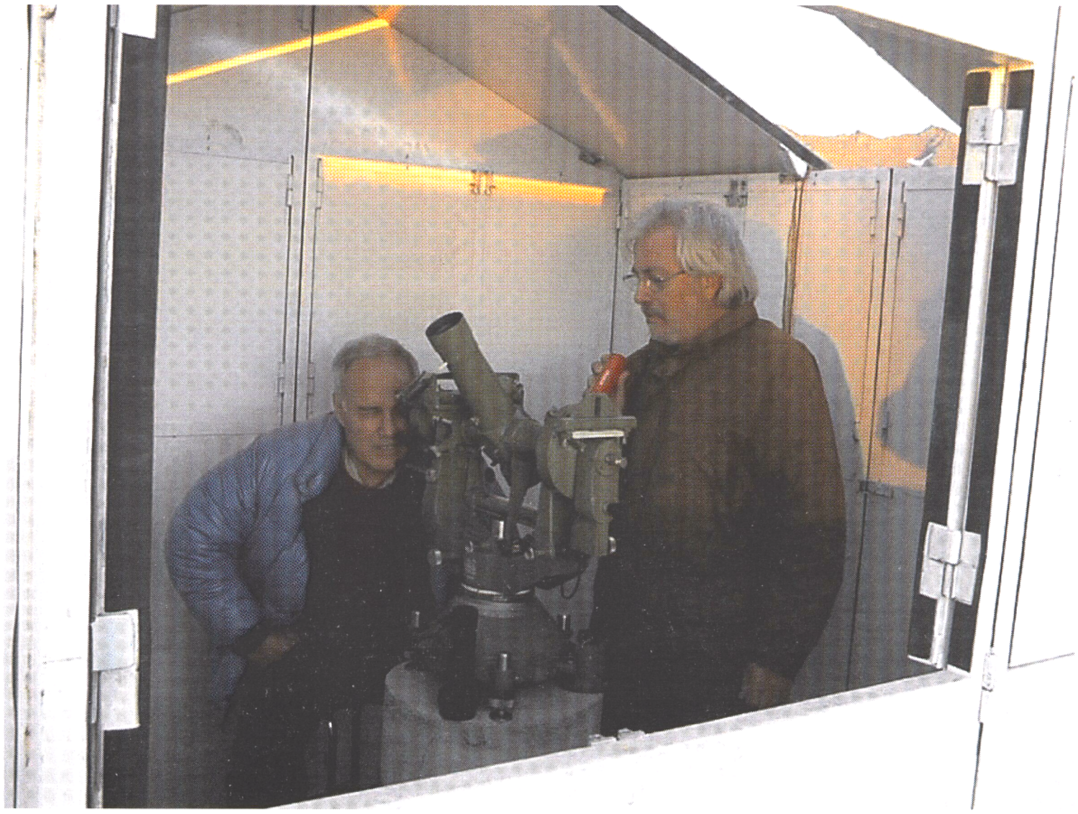

Fig. 3.8. The Spanish Geographical Institute determined the deviation from the vertical and exact astronomical and geographical coordinates using astronomical measurements with a Wild T4 theodolite.

3.9 Safety

A company was hired to provide services in prevention of working risks, following a recommendation of the Spanish law for safety aspects. As a consequence of this contract the safety aspects of different activities has been analyzed by the company experts and several documents have been produced with recommendations to continue improving the safety.

A new station for fire detection has been installed at the observatory replacing the old one. The new station includes the fire sensors used before. With the new station it is now possible to identify the individual fire sensors. There are now a total of 83 sensors at the observatory; 37 of them, installed in the most fire hazardous zones, have been already changed to the new model.

Floor plans and signs for emergency exits have been improved at the observatory and the Granada office. IRAM staff was trained by the Granada fire brigade in fire extinguishing techniques **(Fig. 3.9.).**

Fig. 3.9: IRAM staff training fire extinguishing

The snow car has been equipped with a GPS receiver to improve the safety of the winter transports. 80% of the calculated positions (at the rate of one per second) have a position error less than 6 meters. The receiver has a graphical display of the route to the telescope.

3.10 Logistic Support

As in previous years, the observatory provided meals, lodging, transport and assistance for approximately 200 visiting scientists. In addition, IRAM Granada organized the Young European Radioastronomers' Conference (YERAC) together with the Institute de Astrofisica de Andalucia (IAA) and the University of Granada with 60 participants from all over Europe. IRAM Granada hosted a meeting of the committee for the allocation of radio frequencies (CRAF) with 20 participants.

4. PLATEAU DE BURE OBSERVATORY

4.1 Interferometer Status

As a consequence of the two accidents that had happened in the year before, the activities at the Plateau de Bure observatory were kept at minimum level during most of the year 2000. Given the problems to bring people safely up and down from the observatory as long as no fully reliable, new transport system is available, the staffing of the observatory remained limited to four people whenever possible, in order to reduce the number of helicopter flights. In addition, the teams were asked to stay a full week, and longer if weather conditions did not allow helicopter transport. Three different teams were formed, consisting of an operator, two technicians for electrical and mechanical assistance, and a cook. IRAM agreed with the company responsible for the helicopter transport special, much tighter conditions than those stipulated by aviation rules. In addition, anybody using the helicopter or going up by foot must be properly equipped. As a consequence of these restrictive measures, priority had to be given to safeguarding the installations, and to execute the necessary maintenance work whereas observations were stopped between December 15th, 1999 and December 2000.

As a second mode of access ground transport has been authorized since February 2000: accompanied by a mountain guide, staff members are taken up to the Sommarel area with a four-wheel drive vehicle in summer and with a ratrack in winter. Then they have to overcome the last slope near the so called "Window" on foot before arriving at the level of the plateau, about 800 meters from the observatory.

At the beginning of May members from the safety division of CERN (Geneva) visited the observatory for a safety audit of the station. They summarized their findings in a detailed report which contains a number of recommendations some of which could be implemented immediately, others still being awaiting implementation.

In order to follow-up on the safety actions recommended by the CERN team, and to work out special safety procedures for all tasks to be executed on the Plateau de Bure, a safety engineer has been hired. He has in the meantime worked out a general safety plan, including the

Fig. 4.1 The ratrack that has been bought to transport IRAM staff between Superdevoluy and the Sommarel area in winter time. The cabin can accommodate 6-8 passengers. It is operated by staff from the ski station, under contract with IRAM.

aspects of transport and eventually the evacuation of the personnel. The procedures for the transport of personnel by helicopter and on the ground have been detailed and an internal emergency plan for the evacuation of the Plateau de Bure personnel has been elaborated and iterated with the external organizations that would be involved in the case it is needed. Amongst the additional safety equipment that has been bought it is worth mentioning the purchase of a heart defibrillator, and the installation of a direct video-link to the hospital in Gap for medical advice when needed.

It was decided to restart the cooling of receivers by the end of June in order to carry out astronomical tests of the antennas and various subsystems of the interferometer before starting the necessary maintenance work. The receivers were started again on June 20th and 21st. Fortunately, all systems performed well. Throughout the maintenance period, test observations with the interferometer were continued for a few hours every day. This limitation was imposed to avoid the presence of more than a minimum number of people on the Plateau in order to control the risks, at the same time it allowed to monitor the status of the status, and in particular the effect that the maintenance work had on each antenna.

As a consequence of this very restrictive observing mode, none of the observing programs which the Program Committee had recommended for execution during the summer period could be done. Instead, and still under test conditions, priority was given to tasks linked to the installation of the new correlator system and the replacement of the secondary mirror on antenna 3.

In preparation for an eventual restart of regular observations in the winter period, we moved the interferometer into the C2 configuration at the end of October, as it turned out just a few days before the first important snowfall started.

Regular scheduling of observations started again on December 1st, but still on a 'best effort' basis, i.e. if the working conditions and high priority technical activities require it, the observations would be interrupted as needed. Unfortunately, the weather conditions in December 2000 put additional constraints, causing e.g. a poor phase stability, leading to an overall observing efficiency of about 15%. A total of 7 projects had been started and at least partially completed by the end of the year (see also Chapter 7, Annex I).

4.2 New Equipment, Hardware Changes

Mid June, a four-wheel drive has been purchased and transported by helicopter to the Plateau de Bure to be used for out-door interventions.

Following a recommendation from the CERN safety group, a 250 L helium bottle with a hold time of a few weeks has also been purchased to facilitate the regular helium-filling interventions on the antennas.

As one of the results from the maintenance period which had started on July 20th and ended on September 20th, we have now replaced the three actuators which control the on-axis motion of the subreflectors. The vertical actuators had already been exchanged during the previous maintenance period. During the last few years most of the old actuators had shown signs of increasing fatigue and it was only a question of time when to replace them. The new actuators provide a higher positional precision and have shown to perform reliably.

Shortly after the end of the maintenance period, the aluminum subreflector of antenna 3 had to be replaced. A close inspection had revealed a deformation on the bottom surface which, as evidenced by a series of holographic measurements, was significant enough to justify its replacement. We used the subreflector foreseen for the sixth antenna. The replacement was completed on November 22nd and extensively tested in the days thereafter.

One of the long-standing problems has been the sealing between the panels of the backstructure of the antennas. The adhesive tape which was used in the beginning did not withstand more than one or two winter seasons. During the maintenance of antenna 5, its replacement by rubber sealings, which had already been started in the year before, was completed. All 5 antennas now benefit from this new solution.

As in previous years, the antennas which still have Hostaflon covered carbon fiber panels have carefully been inspected to check for (new) pinholes. More than 9000 stickers had to be glued on to avoid a substantial degradation of the surface. Finally, the surface quality of all antennas has been measured. Surface adjustments were verified by holographic measurements and the surface accuracy is now better than 60 microns (rms) or better on all the antennas.

A very important step has been the installation of the new 6-antenna correlator which was made in September 2000. After very few initial problems, the new correlator rapidly has lived up to expectations. It supports a much wider bandwidth (100-1100 MHz), provides by default seven different modes of configuration and is able to handle signals from six antennas. This has led to a substantial improvement of the data taken even with the current 5-antenna array. Its full capabilities will, of course, only be exploited when antenna 6 is finished. The new correlator is operated via Ethernet Hub directly by the central control and data acquisition computer.

As has been reported elsewhere before, one of the special features of the new correlator is the possibility to operate the interferometer as a phased-array for VLBI experiments. In preparation for such experiments a MKIV formatter, a tape recorder unit, and the FS-9 computer control system have been bought. The components of the VLBI terminal will be pre-assembled and verified in the Grenoble backend laboratory in the course of 2001, for a first VLBI test hopefully in the fall of 2001.

Fig. 4.2 Arrival of the new correlator for 6 antennas on the Plateau de Bure in September 2000.

4.3 Summer School

During June 12-16, 2000 IRAM organized the second Millimeter Interferometry Summer School (IMISS-2). The school attracted over 70 participants from all over Europe and a couple from overseas. Students had the opportunity to actively participate in the school and to present posters on their own research work. The school focussed on both theoretical and observational aspects with special emphasis on the Plateau de Bure Interferometer. A few lectures were, however, also devoted to techniques and observations with optical interferometers. The informal style allowed for considerable interaction and discussion between the participants. The lecture notes will be made available in electronic and in printed form in the spring of 2001.

5. GRENOBLE HEADQUARTERS

5.1 SIS GROUP ACTIVITIES

Fabrication of SIS junctions and related process development

100 GHz junctions have been produced and the processing was used to track down different critical points in the current fabrication process such as the reliability of the lift-off steps and step edge coverage. New resist technologies have been explored to overcome the different shortcomings.

A new multi-layer resist technique has been applied to improve lift-off steps (see **Fig. 5.1).**

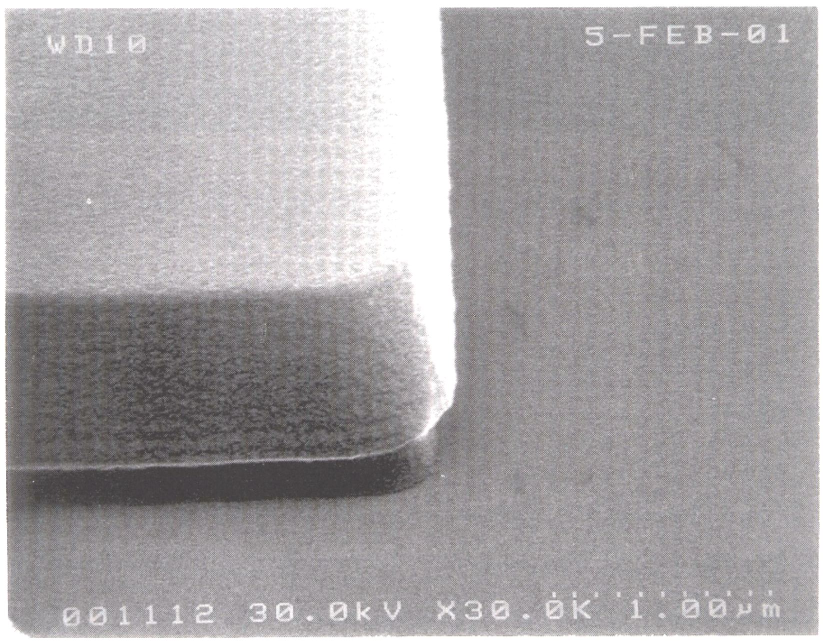

Fig. 5.1 Lift off resist profile obtained with multi-layer resist technique.

Focused Ion-Beam (FIB) etching has been used to analyse critical points in the standard process, (see **Fig. 5.2**).

230 GHz junctions have been produced for the IRAM multi-beam receiver (HERA). All mixers could be equipped with junctions from one single wafer with good and homogeneous performance. This result has important implications for the preparation of junction production for the ALMA project.

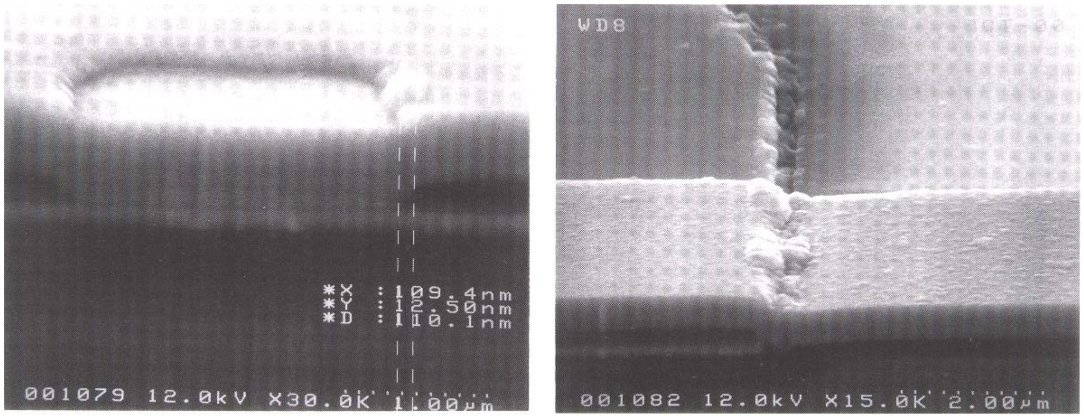

Fig. 5.2 a) Cross section e-beam micrograph of a SIS junction obtained after FIB etching, b) Inspection of a short circuit between different Niobium layers due to incomplete dielectric step edge coverage.

The definition of 1 μm^2 junctions by e-beam lithography has been further refined for the production of junctions for 480-640 GHz (HIFI Channel 1, HERSCHEL=formerly FIRST). This development is part of a collaboration with DEMIRM and financially supported by CNES. The current densities of devices could be successively increased up to 15 kA/cm^2 with quality parameters above 20. Such high-current-density/high-quality combinations were thought to be impossible in the past **(Fig. 5.3**). For rapid verification of the integrated matching circuit an open structure set-up was used for FTS characterisation of devices before final dicing **(Fig. 5.4**).

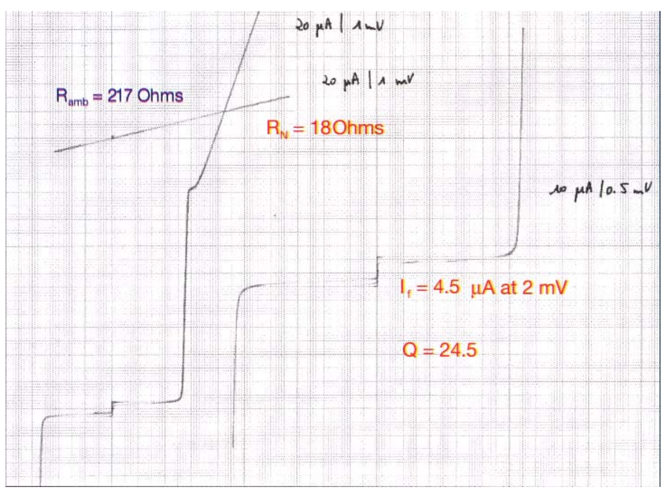

Fig. 5.3 I-V-characteristic of a 1 μm^2 , 15 kA/cm^2 SIS junction for HIFI Channel 1.

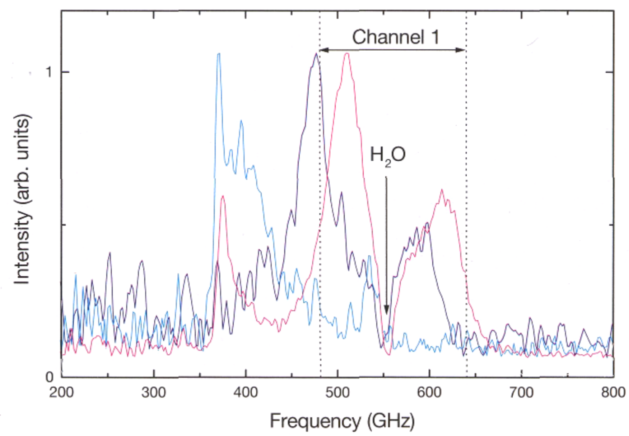

Fig. 5.4 Direct detection frequency response of three different versions of junctions produced for HIFI Channel 1. The strong H_2O absorption feature at 554 GHz is due to residual water vapour in the Fourier-Transform-Spectrometer.

With the e-beam process, developed for HIFI, also new types of junctions for 350 GHz were fabricated for the IRAM PdB/ALMA mixer development **(Fig. 5.5)**.

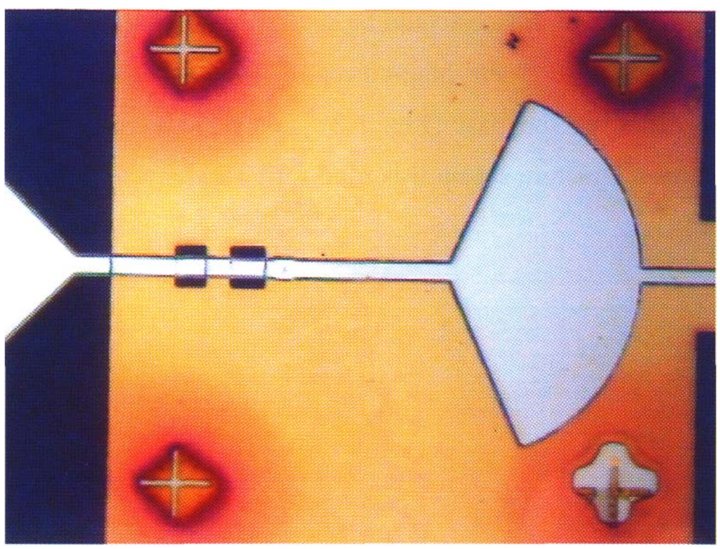

Fig. 5.5 Micro-graph of junctions for a new type of 350 GHz wave guide mixer.

The current junction fabrication process is limited to junction sizes around 1µm due to the self-aligned lift-off step after junction etching and SiO_2 deposition. Planarisation is an effective way to overcome these limitations. After earlier planarisation studies using non-selective back etching a comparative study using CMP technology has been carried out in collaboration with LETI. Although parameters still have to be adjusted the results were encouraging and the development will be pursued.

To improve the speed of DC characterisation and the quality of documentation, an automatic DC control system has been implemented. This set-up is just a starting point for a rapid and precise characterisation of a large number of devices that will be needed for the ALMA project.

Study on physics of ultra-thin Nb and NbN films andHEB mixer development

The development of Hot-Electron-Bolometer Mixers for THz applications (e.g. SOFIA) has been continued. Very thin superconducting films play a key role in such devices. The physical properties of sputtered ultra-thin Nb and NbN films have been thoroughly investigated. Crystallographic properties have been determined with a wide range of analytic methods and the electrical characteristics have been measured as a function of film thickness and deposition parameters. The results allowed to establish a simple physical model to represent the most important parameters such as the critical temperature and the sheet resistance as a function of film thickness.

To improve the quality of ultra-thin (3nm) NbN films a MgO buffer-layer on a single crystal quartz substrate was introduced (see **Fig. 5.6**). Devices made from such films allowed to achieve receiver noise temperatures below 700 K (DSB) at 800 GHz.

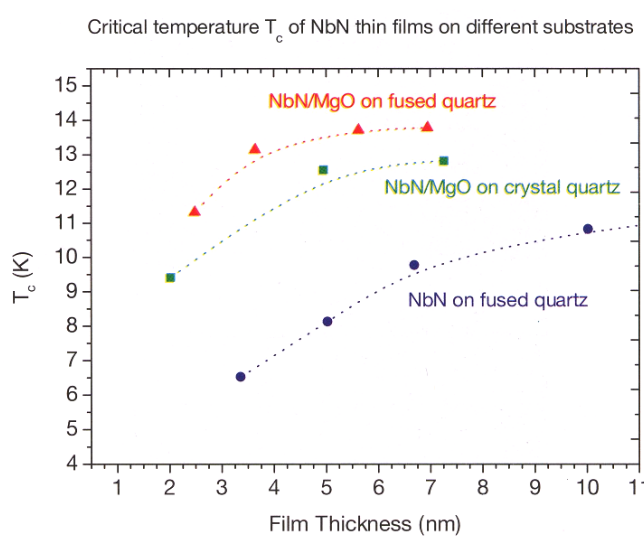

Fig. 5.6 Onset of superconduction for thin NbN films on various substrates.

Air-bridge technology

The SIS group started a development on air-bridge technology. Air-bridges allow low capacity line crossings, an important element for the fabrication of concentrated inductors or high impedance planar transmission lines. Air-bridges may also allow to create a new class of integrated tuning circuits.

5.2 RECEIVER GROUP ACTIVITIES

5.2.1 Receiver Construction and Maintenance

230 GHz Multibeam receiver

The receiver group provided support and manpower for the multibeam receiver project. Nine elementary mixers were characterized, each one a first time, then a second time when better junctions became available. The RF module, comprising the nine mixers with LO injection, cold optics, and cold IF amplifiers, was assembled and wired. It was then integrated into the dewar. Cryogenic tests were performed, and RF characterization partly completed before the end of the year.

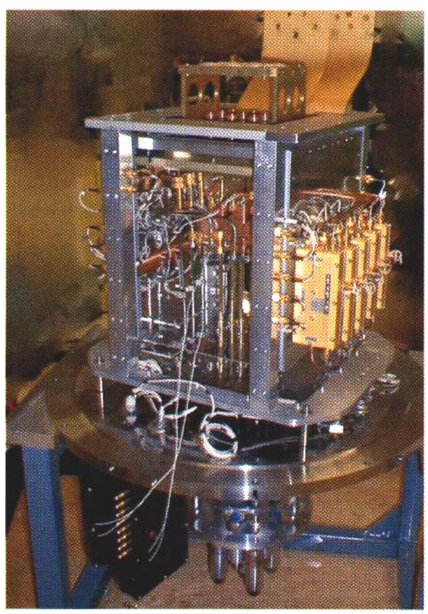

Fig. 5.7 The 1.3mm HERA receiver (Heterodyne Receiver Array).

30-m Telescope

The dual-channel "C"-receiver was replaced with the available spare following a degradation of its 270GHz channel. Back in the lab — now being the spare receiver — it was overhauled; in particular, the two mixers were replaced with units that have wire-bonded connections to the junction: this should improve the reliability; tuning tables have been established, and that unit is now ready as a spare.

Two spare local oscillator boxes — one for LO band "B" (66.5-91 GHz) and one for LO band "C" (82-101 GHz) — were built and characterized.

The receiver group participated in the holography session. The improvement of the surface accuracy was confirmed using the ITALSAT beacon, but the measurements using a transmitter on the Pico Veleta summit were plagued by artifacts (probably ground reflections).

Plateau de Bure Interferometer

Because of the temporary stop of all observing activities on the Plateau de Bure, the five dual-channel receivers had been put out of operation for a number of months. The receiver group supported their successful re-commissioning, and their subsequent maintenance.

22-GHz Water vapor radiometers for the PdBI

The purpose of these radiometers is to obtain a real-time estimate of the precipitable water vapor projected density on the line of sight of each antenna, allowing the correction of the atmospheric phase. This is achieved by a differential power measurement between three channels, in the center and on either side of the 22-GHz water line, respectively. A very high stability is required. The goal is 50µm rms path length accuracy per antenna (14° rms phase at 230GHz).

A second unit has been built, which is identical to the first one (see the report for 1999). Its stability is at least as good as that of the first receiver. An automated test bench has been built for characterization of the components in the series production of the remaining five units. Tests on the sky are foreseen in the first quarter of 2001.

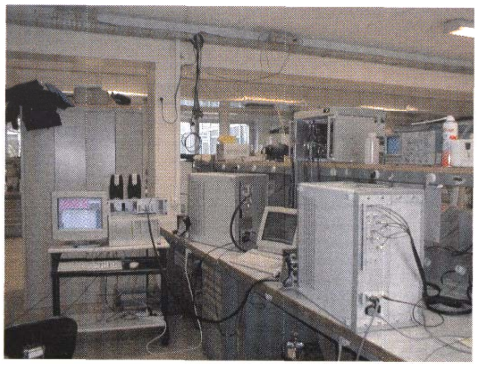

Fig. 5.8 Two WVR units being tested in the lab

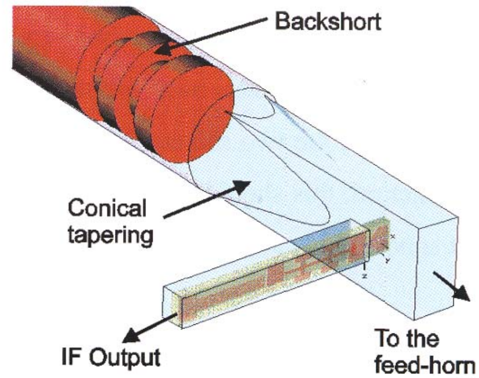

Fig. 5.9 A sketch of the full-height waveguide SSB mixer under development.

New receivers for the PdB-Interferometer

These receivers will have four frequency channels: 100, 150, 230, and 270 GHz, each dual-polarization.

An evaluation prototype dewar has been built, based on a Daikin GM/JT cryocooler. Cryogenic and vibration tests were successful. Prototype dual-polarization modules for the 100 GHz and 230 GHz bands have been designed, built, and characterized.

5.2.2 Development

New mixer type

A new mixer type was designed for the band 260-370 GHz. It uses a single SIS junction, probe-coupled to a full-height waveguide. Two versions were actually designed: one, single-sideband tunable with a moving circular backshort, foreseen for the Plateau de Bure interferometer, and the other, fixed-tuned, double sideband, designed for ALMA band 7. Junctions have been successfully fabricated by the SIS group (see **Fig. 5.5**); first measurements are due early 2001.

New LO couplers

New types of LO injection couplers have been designed and characterized, using thin metal foils: a broadwall multihole coupler, and a cross-guide coupler. They are easier to fabricate, and give more flexibility in system design.

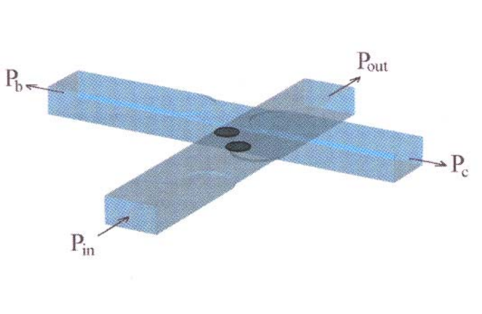

Fig.5.10 Sketch of a new design for a cross-guide coupler

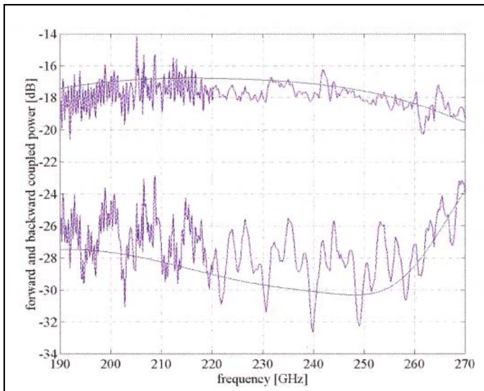

Fig.5.11 Model predictions (FDTD method) and measurements for the forward and reverse coupling of a new cross-guide coupler

5.2.3 Design Work for the ALMA Project

IRAM took responsibility for the following work packages in Phase 1 (design):

Optics configuration. With participation from several other institutes, an optical configuration has been designed for the 10 ALMA bands, that satisfies a number of constraints, including the following: high coupling efficiency, low thermal loading, and compactness.

Band 7 cartridge design. Work has started for the design of a cartridge prototype for ALMA band 7 (275-370GHz). The baseline design is dual-polarization, with double sideband mixers (see above new mixer type). The status of the design work as of end 2000 is reported in: http://www.nrao.edu/almamirror/projectbk/construction/chap5/chap5.pdf

Windows and infrared filters. Work has started to characterize the RF and IR transmission properties of various types of vacuum windows and infrared filters. That work is based in the Granada receiver group, in collaboration with the Herzberg Institute (Canada).

5.35.3 **BACKEND DEVELOPMENTS**

5.3.1 New 6-antenna Correlator

The correlator construction was completed by May, 2000. It underwent a 3-month test period during which special attention was paid to the phased array mode for VLBI. A report on this particular mode has been written. No infant mortality on the 1920 correlator chips was found. The correlator has been shipped to the PdB observatory on the 22nd of September and installed by a reduced team. First fringes were obtained two weeks later. After a few problems of amplitude level, the correlator was fully operational.

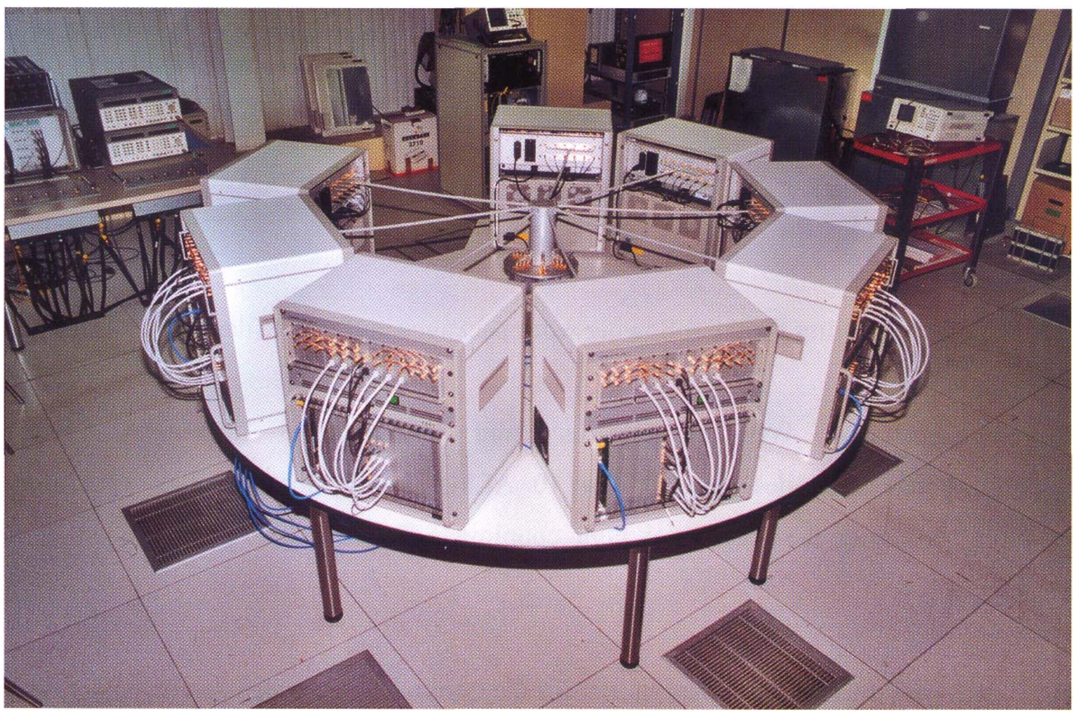

Fig. 5.12 The new 6-antenna correlator during testing in the laboratory in Grenoble.

5.3.2 Multibeam autocorrelator

A design for a lowcost, easily reproducible, 512 channel, IGHz wide digital backend has started. This is particularly interesting in the prospect of a very large number of simultaneous receivers. The key elements are a full 2-bit, 1 Gs/s sampler module, a 450 MHz wide SSB mixer and a fast digital demultiplexer. Those elements are being developed. A prototype sampler has shown promising results.

5.3.3 Retrofit of the PdB correlator

After 8 years of service, the 6 correlator units have been flown down to Grenoble to be refurbished and reconfigured as a new backends system for the Pico Veleta, after a suggestion from G. Paubert. This system will cover the need for high-resolution spectrometry for the new 9-channelbeam receiver, allow polarimetry measurements by cross-correlation, and dramatically increase the channel count for the standard receivers.

5.3.4 ALMA

In order to evaluate the prototype samplers that are developed for ALMA in Bordeaux, a simplified 4GHhz autocorrelator is being built. It will be able to work on 3 or 4-bit devices. Its resolution and efficiency are very poor but are just sufficient to assess the quality of the fresh sampler design, in terms of linearity, amplitude stability and frequency roll-off.

More detailed reports on the above topics are available on the WWW at http://iram.fr/TA/backend.

5.4 COMPUTER GROUP

5.4.1 Hardware Changes

In order to benefit from our new fast network, twisted pair cables, switches and hubs at lOOMbits/s, we have studied the purchase of a new file server available from both the PC's and Workstations (under CIFS and NFS).

A server NAS from NetworkAppliance with a capacity of 512 MBytes has been selected and installed in the summer. Its high performance and availability is based on a RAID4 disk system and backup snapshots.

All personal accounts have been moved to the server in the fall, and the project accounts will follow in 2001 with the increase of the server capacity.

A backup system based on a library MammothTape has been added by the end of the year. This solution increases our protection against loss of data.

5.4.2 Software Changes and New Developments

All recently bought PC's as well as older ones which have been updated, are now running under Windows 2000. This system has proven more stable and is easier to maintain by the system administrator. It allows to restrict *ad hoc* modifications by the users.

Specific software has been developed for the following purposes:
Control and acquisition software for the new Plateau de Bure correlator;
Control and monitoring software for the multibeam receiver to be installed in 2001 at Pico Veleta.

Both developments are based on Linux implemented diskless VME controllers and they use a VME driver written at IRAM/Granada.

For the testing of the 22GHz receivers, VME interfaces have been produced and a data acquisition system has been prototyped.

5.4.3 Support for the ALMA project

Considerable effort went into the support of software development for the ALMA project. The group has participated in a test with the Kitt Peak antenna in order to check the feasibility of a common software package. Also, in order to get ready, Labview in conjunction with a CAN controller has been tested on Windows in connection with another CAN controller mounted on Linux and checked with its proper driver.

5.5 TECHNICAL GROUP

5.5.1 Mechanical workshop

A large amount of time has been spent on:

- the recruitment of a new micro-mechanics technician for the production of mixers
- the workshop extension project
- the choice of a 4 axis lathe

Throughout the year, the workshop has produced micro-wave components such as:

- 210-270 GHz mixers, horns, couplers, lenses etc. for both the ALMA project and the new generation Plateau de Bure receivers
- 500 GHz horns (with 0.1 mm wide corrugations) and junction carriers for the FIRST project.
- new models of crossed guides 320 GHz couplers with a calibrated 0.01 mm thick brass foil.
- components for the preparation for the second polarisation of multiple-beam receiver (mixers, horns, lenses etc.)

5.5.2 Drawing office

In collaboration with the micro-wave engineers, the drawing office has:

- studied the integration of the 22 GHz receiver assembly in the cabin of the Plateau de Bure telescopes

- designed all the components, microwave and other, manufactured both internally and externally.
- Followed all design studies or manufacturing carried out with industrial help.

5.5.3 Electro-forming

The laboratory for electro-forming has been completely renovated in compliance with the current legislation.

5.5.4 Antenna 6

- The assembly of the thermal isolation started again in November 2000 and will finish in June 2001.
- the group has worked on an assembly report for the whole reflector. It describes in detail all steps of the assembly and the verifications to be carried out.

5.5.5 Bure observatory

In collaboration with the team at Bure, the group has studied all the operating modes for the handling and transportation of goods with the blondin, which should be put into operation in May 2001.

A number of projects have been supported by the technical group in connection with the maintenance of the antennas 1-5 on the Plateau de Bure.

6. PERSONNEL AND FINANCES

6.1 Personnel

The personnel plan for the year 2000 allowed for 102.5 positions. *De facto* only 94.13 positions were filled with staff on longer-term or unlimited contracts while 7.5 positions were used for shorter-term contracts (see below). Of the staff positions, 67.03 are based in France and 27.10 in Spain. The MPIfR (Bonn) and the MPI fur Extraterrestrische Physik (Garching) jointly financed half a position in the SIS laboratory for the production of diodes.

Furthermore, 5 post-docs (4 FR, 1 ES), 4 thesis students (3 FR, 1 ES) and 4 « cooperants » (ES), plus 1 person delegated by DEMIRM/Paris in the framework of the FIRST project, worked at IRAM. 1 PhD student in the astronomy group was partly funded by the German Science Foundation (DFG) through a contract with the Astronomical Institute at Potsdam.

Extra workloads during certain periods of the year made it necessary to issue a large number of limited-term contracts. This corresponded to:

- 2.14 man-years on Bure, to complete the 3 teams for maintenance and logistic support,
- 5.34 man-years in Grenoble, for replacements and additional work in the Administration and in the technical groups.

6.2 Finances

IRAM's financial situation in 2000, as well as the budget provisions for 2001, are summarised in the attached tables.

2000 - Operating budget

a) Expenditures were lower than anticipated .

- Savings were made in the personnel budget, since not all positions were occupied throughout the year. In particular, some persons retired at the beginning of the year and were not immediately replaced. Some hirings in the framework of the 35-hour week agreement occurred late in the year.

- Due to the situation at the Plateau de Bure (no scientific observations from 19.12.99 to 1.12.00; access problems), many activities had to be postponed or slowed down.
- savings were made in the budget for heating and electricity (this budget is by definition uncertain)

b) Income was much higher than expected, due to

- higher banking interest rates
- a new contract with CNES, which was signed in the course of the year,
- reimbursement of services rendered by IRAM personnel

This led to an operation budget in excess of 3.4 MF, taking into account a carry-forward of 26.000 FRF from the 1999 operation budget.

2000 - Investment budget

a) Expenditure concerned mainly :

- scientific equipment (for the FIRST project, for the Bure "new generation" receivers, a spectrum analyser, UNIX and HP stations, etc.)
- safety equipment for the Plateau de Bure (medical equipment, videoconference systems, etc.) and vehicles to ensure the safety of the transport to Bure (ratrack + 4-wheel drive)

b) Income

Additional income resulted from a contract signed with the CNES for the FIRST project.

Taking into account the carry-forward from the 1999 budget, the 2000 investment budget was in excess by about 12.6 MF. Of this sum 6.1 MF correspond to outstanding commitments where orders have been placed but not yet paid.

BUDGET 2000
(in FRF)

2000 - EXPENDITURE

Budget heading	Approved	Actual
Operation / Personnel	42,843,000	41,234,142
Operation / other items	16,109,000	16,652,133
TOTAL OPERATION	**58,952,000**	**57,886,275**
Investment (general + 6th antenna)	18,125,544	6,102,965
TOTAL EXPENDITURE excl. VAT	**77,077,544**	**63,989,240**
VAT	5,326,211	5,326,211
TOTAL EXPENDITURE incl. VAT	**82,403,755**	**69,315,451**

2000 - INCOME

Budget heading	Approved	Actual
CNRS contributions	31,654,500	31,654,500
MPG contributions	31,654,500	31,654,500
IGN contributions	4,041,000	4,041,000
TOTAL CONTRIBUTIONS	**67,350,000**	**67,350,000**
Carry forward from 99 (Op+Inv.)	7,891,544	7,891,526
IRAM's own income	1,836,000	4,772,069
TOTAL INCOME excl. VAT	**77,077,544**	**80,073,595**
CNRS contribution for VAT (20,6%/19,6%) *	5,326,211	5,326,211
TOTAL INCOME incl. VAT	**82,403,755**	**85,339,806**

* = 20,6% /19,6% on CNRS contribution to operation budget

BUDGET PROVISIONS 2001

(in FRF)

2001 - EXPENDITURE

Budget heading	Approved
Operation / Personnel	44,988,000
Operation / other items	16,012,000
TOTAL OPERATION	**61,000,000**
Investment - general	18,525,544
TOTAL INVESTMENT	**18,525,544**
TOTAL EXPENDITURE	**79,525,544**
VAT (19,6%)	5,415,931
TOTAL EXPENDITURE incl. VAT	**84,947,475**

2001 - INCOME

Budget heading	Approved
CNRS contributions	32,454,501
MPG contributions	32,454,501
IGN contributions	4,143,128
TOTAL CONTRIBUTIONS	**69,052,130**
IRAM's own income	2,207,870 *
Carryforward from 1999/2000	8,265,544
TOTAL INCOME excl. VAT	**79,525,544**
CNRS contribution for VAT (19,6)	5,415,931
TOTAL INCOME incl. VAT	**84,947,475**

* 1.600.000,00 FRF as the basis agreed. If 61.000.000,00 FRF were effectively needed for operation, IRAM will have to increase the own income to the level mentioned, If this is not possible, IRAM is authorised to transfer up to 607.870,00 FRF from the investment budget to the operating budget.

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

0.1 Dec 28 - Jan 04

Ident.	Title	Preq. (GHz)	Authors
152.99	A deep CO survey of the most powerful radio galaxies in the local universe	111, 113, 223, 225	Lim, Combes, Van Trung Dinh, Leon
188.99	Probing dense molecular gas in merging galaxies : a reevaluation of galaxy evolution scenarios		Rigopoulou, Tacconi, Genzel, Lutz, Looney, Lehnert, Tacconi-Garman
84.99	OTF mapping of regions of enhanced dissipation of turbulence	110, 115, 220, 230	Falgarone, Hily-Blant, Pineau des Forets, Boulanger, Teyssier, Pety, Miville
112.99	The nuclear bar of NGC5728 : fueling the AGN ?	114, 228	Combes, Leon

0.2 Jan 04 - Jan 18

Ident.	Title	Freq. (GHz)	Authors
188.99	Probing dense molecular gas in merging galaxies : a reevaluation of galaxy evolution scenarios		Rigopoulou, Tacconi, Genzel, Lutz, Looney, Lehnert, Tacconi-Garman
87.99	The effects of the evolution in the confining material of the HII regions	113, 145, 226	Rodriguez-Franco, Martin-Pintado, Fuente, Gaume
112.99	The nuclear bar of NGC5728 : fueling the AGN ?	114, 228	Combes, Leon
186.99	The evolution of starbursts : Measuring the gas content of K+A and A+em galaxies	115	Barden, Tacconi, Lehnert, Rigopoulou
139.99	The hot gas in distant clusters with Diabolo observations of the SZ effect	Bolometer	Desert, Giard, Pointecouteau, Benoit
145.99	Reactive molecular ions in PDRs(II)	81, 85, 98, 155, 236	Fuente, Black, Martin-Pintado, Rodriguez-Franco, Garcia-Burillo

0.3 Jan 18 - Feb.01

Ident.	Title	Freq. (GHz)	Authors
145.99	Reactive molecular ions in PDRs(II)	81, 85, 98, 155, 236	Fuente, Black, Martin-Pintado, Rodriguez-Franco, Garcia-Burillo
95.99	Mm detection of lensed extremely red objects at large redshifts	Bolometer	Fort, Omont, Mellier, Co x, Bertoldi, Casoli, Maoli
166.99	Search for molecular gas in 3C273	99	Casoli, Loinard
191.99	A wide field blind survey at 240 GHz	Bolometer	Bertoldi, Kreysa, Menten, Zylka, Genzel, Lutz, Tacconi, Carilli, Owen

0.4 Feb. 01 - Feb. 15

Ident.	Title	Freq. (GHz)	Authors
162.99	An unbiased mm continuum survey for protostellar outflow sources in Orion A	Bolometer	Stanke, McCaughrean, Menten, Zinnecker, Zylka
191.99	A wide field blind survey at 240GHz	Bolometer	Bertoldi, Kreysa, Menten, Zylka, Genzel, Lutz, Tacconi, Carilli, Owen
178.99	Imaging at 230GHz of plerionic components of galactic SNRs	Bolometer	Bandiera, Cesaroni, Neri

0.5 Feb 15 - F eb29

Ident.	Title	Freq. (GHz)	Authors
158.99	A search for thermal dust emission from high redshift QSOs from the sloan digital sky survey	Bolometer	Carilli, Strauss, Fan, Knapp, Schneider, Bertoldi, Menten, Rupen, Yun
178.99	Imaging at 230GHz of plerionic components of galactic SNRs	Bolometer	Bandiera, Cesaroni, Neri
90.99	Mm detection of ELAIS and FIRBACK ISO deep surveys sources	Bolometer	Omont, Cox, Dole, Lagache, Puget, Bertoldi...
159.99	Search for variations in Pluto's 1 mm continuum emission	Bolometer	Lellouch, Paubert, Moreno

0.6 Feb 29 - Mar 14

Ident.	Title	Freq. (GHz)	Authors
191.99	A wide field blind survey at 240GHz	Bolometer	Bertoldi, Kreysa, Menten, Zylka, Genzel, Lutz, Tacconi, Carilli, Owen
Δ 03.00	1mm monitoring of the gamma ray flaring Mrk421		Henri
133.99	1.3mm photometry of SCUBA sources to be proposed for PdB identification	Bolometer	Lutz, Hughes, Dunlop, Rowan-Robinson, Oliver, Mann, Ivison, Tacconi, Genzel
179.99	Gaz and dust in spiral galaxies	Bolometer	Gear, Amure, Stevens
δ 01.00	Confirmation of the detection of CO+ in Cyg A		Fuente
136.99	Unbiased large scale mapping of the galactic center	Bolometer	Wolszczan, Wielebinski, Lisenfeld
158.99	A search for thermal dust emission from high red-shift QSOs from the sloan digital sky survey	Bolometer	Carilli, Strauss, Fan, Knapp, Schneider, Bertoldi, Menten, Rupen, Yun
159.99	Search for variations in Pluto's 1mm continuum emission	Bolometer	Lellouch, P aubert, Moreno
169.99	A systematic search for high mass protostars	Bolometer	Beuther, Menten, Schilke, Sridharan
δ 011.00	CO(l-0) in NGC 4666		Baudry, Lisenfeld

0.7 Mar 14 - Mar 28

Ident.	Title	Freq. (GHz)	Authors
158.99	A search for thermal dust emission from high redshift QSOs from the sloan digital sky survey	Bolometer	Carilli, Strauss, Fan, Knapp, Schneider, Bertoldi, Menten, Rupen, Yun
δ 03.00	1mm monitoring of the gamma ray flaring Mrk421		Henri
δ 04.00	Deep spectrum radio source 0305+35		Roettgering
δ 05.00	1.2mm survey of luminous Z>4 QSOs		Omont, Cox, Bertoldi, McMahon
159.99	Search for variations in Pluto's 1mm continuum emission	Bolometer	Lellouch, Paubert, Moreno
δ 07.00	Baseline correction in NGC 1569 bolometer maps		Lisenfeld
191.99	A wide field blind survey at 240GHz	Bolometer	Bertoldi, Kreysa, Menten, Zylka, Genzel, Lutz, Tacconi, Carilli, Owen
δ 08.00	1mm flux of an ISO-bright z=2 QSO		Mack
90.99	Mm detection of ELAIS and FIRBACK ISO deep surv eys sources	Bolometer	Omont, Cox, Dole, Lagache, Puget, Bertoldi...
82.99	Molecular gas in tidal dwarf galaxies : Beyond detection	112, 114, 224, 225, 229	Braine, Luc, Lisenfeld, Leon, Brinks, Charmandaris
168.99	The structure of the D_2CO emission in IRAS16293-2422	Bolometer	Loinard, Castets, Ceccarelli, Caux, Tielens

0.8 Mar 28 - Apr 11

Ident.	Title	Freq. (GHz)	Authors
196.99	A search for small hydro-carbons in CRL618 and IRC+10216	85, 95, 110, 136, 239	Cernicharo, Guélin, Pardo, Neri
168.99	The structure of the D_2CO emission in IRAS16293-2422	Bolometer	Loinard, Castets, Ceccarelli, Caux, Tielens
169.99	A systematic search for high mass protostars	Bolometer	Beuther, Menten, Schilke, Sridharan
114.99	The chemical structure of B68 from 0 to 30 mags of extinction : molecular abundances and depletion	93, 109, 112, 230	Lada, Bergin, Alves
δ02.00	Comet Linear		Altenhoff, Kreysa, Menten, Thum
191.99	A wide field blind survey at 240GHz	Bolometer	Bertoldi, Kreysa, Menten, Zylka, Genzel, Lutz, Tacconi, Carilli, Owen
δ 04.00	Deep spectrum radio source 0305+35		Roettgering
δ 03.00	1mm monitoring of the gamma ray flaring Mrk421		Henri
104.99	NGC3077-Phoenix : Birth of a dwarf galaxy ?	110, 115, 220, 230	Heithausen, Walter
185.99	OTF mapping of M31, the closest spiral galaxy	115, 230	Neininger, Nieten, Guélin, Lucas, Wielebinski, Berkhuijsen, Beck, Ungerechts

0.9 Apr 11 - Apr 25

Ident.	Title	Freq. (GHz)	Authors
114.99	The chemical structure of B68 from 0 to 30 mags of extinction : molecular abundances and depletion	93, 109, 112, 230	Lada, Bergin, Alves
δ 04.00	Deep spectrum radio source 0305+35		Roettgering
VLBI			Greve
185.99	OTF mapping of M31, the closest spiral galaxy	115, 230	Neininger, Nieten, Guélin, Lucas, Wielebinski, Berkhuijsen, Beck, Ungerechts
δ 09.00	Cold dust in M104		Wielebinski, Krause, Dumke
δ 03.00	1mm monitoring of the gamma ray flaring Mrk421		Henri
76.99	Search for CO in Pluto's atmosphere	115, 230	Bockelee-Morvan, Lellouch, Paubert, Colom
171.99	A survey of CO in extreme cooling flow clusters	89, 92, 103, 155, 160, 200	Edge, Fabian, Alien, Cravford, Johnstone

0.10 Apr 25 - May 9

Ident.	Title	Freq. (GHz)	Authors
81.99	Determination of the CO production rate of comet 1999J2 (C/Skiff)	88, 230, 266	Festou, Paubert, Parker, Stern
155.99	Molecular D/H ratios in low mass cores	167, 168, 216, 244, 257	Hatchell, Millar, Fuller, Roberts
108.99	Circumstellar ^{36}S : a probe of the s-process in C-stars	95, 142, 237	Mauersberger, Henkel, Langer, Chin
77.99	OTF spectroscopy to study the kinematics of the central galaxy	98, 219, 220, 230	Guesten, Zylka, Philipp, Ungerechts
118.99	A search for outflows towards ultracompact HII regions with CH_3OH and H_20 maser emission	110, 220	Moscadelli, Cesaroni, Codella
160.00	The degree of ionization in starless cores	86, 144, 216, 260	Caselli, Guélin, Hirota, Myers, Ohishi, Saito, Tafalla, Walmsley, Zucconi

Ident.	Title	Freq. (GHz)	Authors
193.99	Recombination lines in the starburst galaxy ARP220	84, 97, 206, 132, 251	Viallefond, Anantharamaiah, Goss, Zhao
69.00	The young detached CO shell around the carbon star U Camelopardalis	115, 230	Lindqvist, Olofsson, Lucas, Schoeier, Neri, Bujarrabal, Kahane
δ 03.00	1mm monitoring of the gamma ray flaring Mrk421		Henri
173.99	Deuterium enhancement : a clue to the physico-chemistry of protoplanetary disks	87, 89, 143, 203, 225	Wiesemeyer, Dutrey, Guélin, Guilloteau, Moreno
115.99	Star formation history : Search for CO sources at 0.3 > z > 1	83, 116, 107, 174, 208	Melchior, Combes, Viallefond
δ 15.00			Cesaroni, Neri

0.11 May 9 - May 23

Ident.	Title	Freq. (GHz)	Authors
149.99	First uniform CO map of the antennae	109, 114, 219, 229	Henkel, Walsh, Schulz, Mauers-berger, Vallenari
88.99	Bipolar flow L1157 and comets : similar ices, but to which extent ?	131, 133, 142, 203, 220, 227	Despois, Bockelee-Morvan, Bachiller, Crodsier, Biver, Lis
110.99	Shock induced chemistry in the HH288 molecular outflow	85, 87, 90, 113, 205, 218	Gueth, Schilke
170.99	A search for CO emission in HDF850.1 : a new redshift	82, 207, 205, 203, 83	Solomon, Downes, Evans, Lanzetta, Yahata
202.99	CO in the barred galaxy NGC4535	114, 229	Reynaud, Bosnia, Roussel, Sauvage, Vigroux
109.99	Interferometric mosaics of young molecular outflows short spacings observations	115, 203	Gueth, Beuther, Schilke

0.12 May 23 - Jun 6

Ident.	Title	Freq. (GHz)	Authors
93.00	$C^{18}O$ zero-spacing measurements in M82	109	Weiss, Neininger, Henkel, Klein
33.00	Chemistry in the X-irradiated gas surrounding the A GN in Cygius A	84, 147, 253, 83, 140	Fuente, Black, Martin-Pintado, Rodriguez-Franco, Garcia-Burillo
48.00	The origin of the X-ray Fe 6.4Kev line in the galactic center	85, 128, 214	Martin-Pintado, de Vicente, Rodriguez-Fernandez, Rizzo
69.00	The young detached CO shell around the carbon star U Camelopardalis	115, 230	Lindqvist, Olofsson, Lucas, Schoeier, Neri, Bujarrabal, Kahane
32.00	Search for CO in Cygnis A	109, 218	Fuente, Black, Martin-Pintado, Rodriguez-Franco, Garcia-Burillo, Planesas
96.00	Understanding the chemistry of SiO in external galaxies	86, 130, 129, 217, 216	Garcia-Burillo, Martin-Pintado, Greve, Fuerte, Rodriguez-Fernandez

0.13 Jun 6 - Jun 20

Ident.	Title	Freq. (GHz)	Authors
96.00	Understanding the chemistry of SiO in external galaxies	86, 130, 129, 217, 216	Garcia-Burillo, Martin-Pintado, Greve, Fuerte, Rodriguez-Fernandez
46.00	Molecules in the envelopes around yellow hypergiants	89, 113, 96, 147, 247	Bujarrabal, Castro-Carrizo, Neri, Sanchez-Contreras, Alcolea
19.00	The evolution of starbursts : measuring the gas content of K+A and A+em galaxies	115	Barden, T acconi, Lehnert, Rigopoulou
94.00	The evolution of protostars and their bipolar outflows	86, 130, 217, 145, 225	Bachiller, T afalla

0.14 Jun 20 - Jul 4

Ident.	Title	Freq. (GHz)	Authors
71.00	A search for interstellar cyanogen N-oxide, NCCNO	87, 92, 106, 152	Thorwirth, Lichau, Schilke, Winnewisser, Bensch
89.00	First search for CO in red low surface brightness galaxies	113, 230	O'Neil, Hofner, Schinnerer
81.00	Molecular gas properties of M31, the closest spiral galaxy	115, 110, 220, 230	Neininger, Nieten, Guélin, Lucas, Wielebinski, Beck, Ungerechts
30.00	Searc h for three basic silicon compounds SiCCH, SiCN and SiNC	94, 105, 108	Guélin, Muller, Apponi, McCarthy, Thaddeus, Cernicharo

0.15 Jul 4 - Jul 18

Ident.	Title	Freq. (GHz)	Authors
30.00	Searc h for three basic silicon compounds SiCCH, SiCN and SiNC	94, 105, 108	Guélin, Muller, Apponi, McCarthy, Thaddeus, Cernicharo
81.00	Molecular gas properties of M31, the closest spiral galaxy	115, 110, 220, 230	Neininger, Nieten, Guélin, Lucas, Wielebinski, Beck, Ungerechts
57.00	A cold core in the NGC 2023 PDR	93, 98, 109, 219, 244	Walmsley, Zucconi, Wyrowski
34.00	The high density peak in L1544	109, 136, 216, 260	Caselli, Comito, Walmsley, Tafalla, Mjers
51.00	Ionization and infall properties of bolometer-discovered protocluster condensations	85, 93, 104, 136, 216	Andre, Belloche, Motte, Despois
79.00	Hot or cold molecular gas in the bulge of M31 ?	115, 230	Melchior, Boone, Guélin, Neininger, Viallefond
27.00	A direct measurement of the density structure around high mass YSOs through C33S multiline obs.	96, 145, 242	Walmsley, Cesaroni, Olmi, Testi, Zucconi
64.00	A multi-wavelength approach to ULIRGs : molecular mass estimates from CO obs.	98, 100, 201, 203	Lara, Alberdi, Colina, Planesas
87.00	Gas content and star formation efficiency of dwarf galaxies	113, 230	Albrecht, Chini, Lemke

0.16 Jul 18 - Aug 1

Ident.	Title	Freq. (GHz)	Authors
84.00	Continuum observations of Comet C/1999 S4 II. 250GHz obs. on Pico Veleta	Bolometer	Altenhoff, Kreysa, Menten, Thum
85.00	Molecular outflows from massive stars	110, 115, 214, 230	Gallego, Lisenfeld
62.00	OTF mapping of regions of enhanced dissipation of turbulence	110, 115, 220, 230	Falgarone, Hily-Blant, Pineau des Forets, Teyssier, Pety, Miville
02.00	Mercury's thermal surface	86, 230	Greve, Thum, Moreno
90.00	Investigating the composition of the ices in Comet C/1999 S4 (LINEAR)	88, 145, 147, 168, 219, 230	Bockelee-Morvan, Biver, Colom, Crovisier, Henry, Despois, Moreno
22.00	Correlation between the 7.7/6.2 µm UIR band gradient and the physical conditions	83, 89, 188, 145, 211, 244	Joblin, Dartois
171.99	A survey of CO in extreme cooling flow clusters	92, 93, 103, 155, 200	Edge, Fabian, Alien, Crawford, Johnstone
35.00	Deuterated molecules in dense cores and star forming regions	85, 88, 93, 141, 177	Roueff, Gerin, Tine

0.17 Aug 1 - Aug 15

Ident.	Title	Freq. (GHz)	Authors
168.99	The structure of the D_2CO emission in IRAS16293-2422	110, 140, 137, 211, 236	Loinard, Castets, Ceccarelli, Caux, Tielens
06.00	Dissipating protoplanetary disks : the case of BP Tau and CO Tau	115, 220	Dutrey, Guilloteau
54.00	Mass, column densities and extent of H_2 toward UC HII regions	110, 220	Gallego, Mauersberger, Wilson, Ruiz
44.00	Search for glycine in sun-like protostars	111, 107, 136, 144, 217	Cecarelli, Castets, Lefloch, Loinard, Faure
42.00	The influence of turbulence on the structure of prestellar cores	110	Bacmann, Andre, Pety

0.18 Aug 15 - Aug 29

Ident.	Title	Freq. (GHz)	Authors
69.00	The young detached CO shell around the carbon star U Camelopardalis	115, 230	Lindqvist, Olofsson, Lucas, Schoeier, Neri, Bujarrabal, Kahane
75.00	Pre-stellar and protostellar cores in the Trifid nebula	86, 89, 144, 216, 260	P erez-Martinez, Lefloch, Cernicharo
02.00	Mercury's thermal surface	86, 230	Greve, Thum, Moreno
92.00	Probing dense molecular gas in merging galaxies		Looney, Rigopoulou, Tacconi, Genzel, Lutz, Lehnert, Tacconi
42.00	The influence of turbulence on the structure of prestellar cores	110	Bacmann, AndreJ Pety
31.00	Star formation in a cirrus cloud ?	96, 146, 244	Heithausen, Bensch
114.99	The chemical structure of B68 from 0 to 30mags of extinction : molecular abundances and depletion	93, 109, 112, 230	Lada, Bergin, Alves
19.00	The evolution of starbursts : measuring the gas content of K+A and A+em galaxies	115	Barden, Tacconi, Lehnert, Rigopoulou

0.19 Aug 29 - Sep 12

Ident.	Title	Freq. (GHz)	Authors
04.00	Measuring the DCO+/HCO+ ratio in protoplanetary disks	86, 140, 144, 211, 216	Dutrey, Guilloteau, Guélin, Gueth, Wiesemeyer
31.00	Star formation in a cirrus cloud ?	96, 146, 244	Heithausen, Bensch
02.00	Mercury's thermal surface	86, 230	Greve, Thum, Moreno

0.20 Sep 12 - Sep 26

Ident.	Title	Freq. (GHz)	Authors
31.00	Star formation in a cirrus cloud ?	96, 146, 244	Heithausen, Bensch
70.00	Chemistry in disks around Herbig Ae stars	98, 219, 230, 150, 93	Henning, Ilgner, Schreyer, Klein, Bacmann
56.00	A molecular survey of CRL618 : from mm waves to the near IR	133, 141, 153	Cernicharo, Guélin, Pardo, Neri
49.00	A search for small hydro-carbons in CRL618 and IRC+10216		Cernicharo, Guélin, Pardo, Herpin
06.00	Dissipating protoplanetary disks : the case of BP Tau and CQ Tau	115, 220	Dutrey, Guilloteau
01.00	Molecular gas in tidal dwarfgalaxies : beyond detection	113, 114, 224, 226	Braine, Due, Lisenfeld, Leon, Brinks, Charmandaris
44.00	Search for glycine in sun-like protostars	111, 107, 136, 144, 217, 223	Cecarelli, Castets, Lefloch, Loinard, Faure

0.21 Sep 26 - Oct 10

Ident.	Title	Freq. (GHz)	Authors
02.00	Mercury s thermal surface	86, 230	Greve, Thum, Moreno
72.00	The circumstellar environment of HD 45677	99, 147, 231, 256	Thum, Morris
11.00	Ion chemistry in photon- dominated regions : Examining the HCO+/HOC+/CO+ chemical nebulae	235, 236	Savage, Ziurys, Highberger
09.00	A searc h for in terstellar and circumstellar KH	202	Ziurys, Savage, Highberger
10.00	A search for interstellar and circumstellar MgNH2	130, 156	Ziurys, Savage, Highberger, Guélin, Cernicharo
12.00	Confirmation of A1NC in IRC+10216	155, 251	Ziurys, Savage, Highberger, Guélin, Cernicharo

0.22 Oct 10 - Oct 24

Ident.	Title	Freq. (GHz)	Authors
95.00	High latitude CO observations of NGC 5775	114, 229	Lee, Leon, Garcia-Burillo, Irwin
02.00	Mercury s thermal surface	86, 230	Greve, Thum, Moreno
26.00	A deep search for infall wings in contracting cores	93, 154, 230, 267	Bourke, Myers, Tafalla, Won, Lee, Wilner
03.00	A search for CO emission in HDF850.1 : a new redshift	82, 201, 203, 205	Do wnes, Solomon, Evans, Lanzetta, Yahata
98.00	Probing the existence of X-ray dominated regions around low-mass protostars	115, 208	Lefloch, Ceccarelli, Loinard, Castets, Tielens
25.00	The role of H2S in the evolution of molecular outflows	104, 168, 216, 99, 138	Codella, Bachiller, Saraceno
80.00	The origin of protostellar pairs	93, 86, 115, 130, 140, 225	Tafalla, Badiiller
59.00	H2S and CH3OH in protostellar outflows : probing outflow interactions	168	Buckle, Fuller, Hatchell

0.23 Oct 24 - Nov 07

Ident.	Title	Freq. (GHz)	Authors
59.00	H2S and CH3OH in protostellar outflows : probing outflow interactions	168	Buckle, Fuller, Hatchell
02.00	Mercury s thermal surface	86, 230	Greve, Thum, Moreno
65.00	A deep CO surv ey of the most powerful radio galaxies in the local universe	111, 114, 223, 229	Lim, Combes, Leon, van Trung Dinh
03.00	A search for CO emission in HDF850.1 : a new redshift	82, 201, 203, 205	Downes, Solomon, Evans, Lanzetta, Yahata
73.00	Densities of massive protostellar objects	97, 144, 146, 244	Beuther, Menten, Schilke, Sridharan
87.00	Gas content and star formation efficiency of dwarf galaxies	113, 230	Albrecht, Chini, Lemke

0.24 Nov 07 - Nov 21

Ident.	Title	Freq. (GHz)	Authors
72.00	The circumstellar environment of HD 45677	99, 147, 231, 256	Thum, Morris
82.00	Search for new high redshift molecular absorption line systems		Combes, Wiklind
132.00	CO in the barred galaxy NGC 4535	114, 229	Reynaud, Bosnia, Roussel, Sauvage, Vigroux
61.00	Search for molecular gas in HVC through QSO absorption	89, 230	Combes, Charmandaris
52.00	Molecular gas in merger remnants, traced by shells	114, 229, 228	Charmandaris, Combes, van der Hulst, van Gorkom
53.00	The nuclear bar of NGC 5728 : fueling the AGN ?	114, 228	Combes, Leon
166.00	Identifying the specific phase of protostellar evolution traced by HCN	86, 88, 265	Yun, Andre, Belloche, Santos
179.00	A search in redshift space for molecular absorption lines towards 3C446 at z = 1.404	84, 223	Wiklind, Combes, Baker

0.25 Nov 21 - Dec 5

Ident.	Title	Freq. (GHz)	Authors
171.00	Chemical evolution ahead of Herbig-Haro objects	86, 89, 168, 244, 267	Hatchell, Viti, Williams, Girart
168.00	A 3mm line survey of the simplest star forming regions (feasibility study)		Mauersberger, Martin-Pintado, Thum, Tafalla, Paubert
204.00	A wide shallow search for the most luminous high-redshift galaxies	Bolometer	Bertoldi, Menten, Kreysa, Bertarini, Reichertz, Carilli, Owen, Genzel, Lutz
205.00	Caught in the act : Triggered star formation in Orion cometary clouds ?	Bolometer	Stanke, McCaughrean, Menten, Smith, Zinnecker
185.00	ULIRGs at 1.2mm : constraining the cold dust emission of starburst galaxies	Bolometer	Menten, Bertoldi, Lutz
134.00	Far IR emission from Lyman break galaxies	Bolometer	Baker, Adelberger, Dickinson, Lutz, Sanders, Steidel, Bertoldi
64.00	A multi-wavelength approach to ULIRGs : molecular mass estimates from CO observations	96, 98, 101, 201, 203	Lara, Alberdi, Colina, Planesas
198.00	Recombination lines in the starburst galaxy Arp 220	84, 97, 206, 132, 251, 279	Viallefond, Anantharamaiah, Goss, Zhao
123.00	Cold dust associated with molecular and atomic gas in M31	Bolometer	Zylk a, Guélin, Neininger

0.26 Dec 5 - Dec 19

Ident.	Title	Freq. (GHz)	Authors
203.00	Comparing the structure of turbulent and thermal dense cores	Bolometer	Tafalla
117.00	Search of the earliest stages of massive star formation	Bolometer	Motte, Schilke, Menten
134.00	Far IR emission from Lyman break galaxies	Bolometer	Baker, Adelberger, Dickinson, Lutz, Sanders, Steidel, Bertoldi
173.00	Determining the orientation of radio-loud active galaxies	Bolometer	Van Bemmel, Barthel
184.00	Dust in dense cirrus cores	Bolometer	Heithausen
216.00	Selecting CSOs for molecular absorption studies : 250GHz flux measurements	Bolometer	Peck, Menten
205.00	Caught in the act : Triggered star formation in Orion cometary clouds ?	Bolometer	Stanke, McCaughrean, Menten, Smith, Zinnecker
204.00	A wide shallow searc h for the most luminous high-redshift galaxies	Bolometer	Bertoldi, Menten, Kreysa, Bertarini, Reichertz, Carilli, Owen, Genzel, Lutz
119.00	Cloud fragmentation and the origin of the IMF : Wide field bolometer imaging of NGC 2264	Bolometer	Andre, Motte, Belloche, Ward-Thompson
127.00	Observations at 250GHz of SCUBA submm back-ground sources	Bolometer	Carilli, Bertoldi, Menten, Ivison, Smail, Chapman
200.00	Comparison of dust emission of bright QSOs at z = 2 with z > 4	Bolometer	Omont, Bertoldi, Cox, Isaac, McMahon, Pridey
212.00	1.2mm continuum survey of high redshift PSS quasars	Bolometer	Cox, Omont, Bertoldi, Djorgovski, Isaak, McMahon
140.00	1mm continuum observations of 6 lensed quasars	Bolometer	Barvainis, Ivison, Alloin, Antonucci

0.27 Dec 19 - Jan 2

Ident.	Title	Freq. (GHz)	Authors
119.00	Cloud fragmentation and the origin of the IMF : Wide field bolometer imaging of NGC 2264	Bolometer	Andre, Motte, Belloc he, Ward-Thompson
155.00	Is molecular deuteration in dark cloud cores caused by CO depletion ?	110, 140, 218, 231	Bacmann, Ceccarelli, Castets, Loinard, Lefloch
218.00	Investigating the connection betw een molecular ices and gas phase chemistry	86, 109, 144, 154, 219, 231	Gerin, Dartois, D Hendecourt, Roueff, Pineau des Forets
117.00	Search of the earliest stages of massive star formation	Bolometer	Motte, Schilk e, Merten
41.00	A 2218 : deeper into the extragalactic background than the HDF		Ivison, Blain, Kneib, Peacock, Dunlop, Smail, Holland, Jenness
208.00	Dynamical signatures of a MHD instability along a dense filament	89, 110, 115, 220, 230	Falgarone, Hily-Blant, Phillips, Pety
147.00	High latitude CO observations of NGC 5775	114, 229	Lee, Leon, Garcia-Burillo, Irwin

7. ANNEX I: TELESCOPE SCHEDULES

7.2 PdB Interferometer

Ident.	Title	Line	Authors
K029	Measuring the high- velocity molecular emission in PPNe	$^{12}CO(1-0)$ $^{12}CO(2-1)$	J.Alcolea A.Castro-Carrizo V.Buiarrabal R.Neri
K02F	A systematic search for high-mass protostars — zooming in on IRAS 19217+1651 and IRAS 20293+3952	SiO(2-l) $^{12}CO(2-1)$	H.Beuther F.Gueth K.Menten P.Schilke T.Sridharan
K031	Search for HOC^+ and $C0^+$ in diffuse clouds	HOC+(1-0) $^{12}CO+$	H.Liszt R.Lucas J.Black
K034	Probing infall in Class 0 young stellar objects with inverse P-Cygni profiles	$N_2H+(1-0)$ $H_2CO(3-2)$	J.Di Prancesco P.Myers D.Wilner
K038	Interferometric observations of CO and CO^+ in Cygnus A	$^{12}CO(1-0)$ $^{12}CO+$ $^{12}CO+(2-l)$	A.Fuente J.Black J.Martin-Pintado A.Rodriguez-Pranco S.Garcia-Burillo P.Planesas
K044	Nuclei of galaxies: gas dynamics and AGN fueling	$^{12}CO(1-0)$ $^{12}CO(2-1)$	S.Garcia-Burillo F.Combes A.Eckart L.Tacconi L.Hunt S.Leon A.Baker P.Englmaier F.Boone E.Schinnerer R.Neri
K057	The circumstellar disk of the embedded source HH30	$^{13}CO(1-0)$ $^{13}CO(2-1)$	F.Gueth A.Dutrey S.Guilloteau

List of projects started after December 1st in the C2 configuration of the Plateau de Bure Interferometer.

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

815. NEW MOLECULES IN COMET C/1995 01 (HALE-BOPP) Investigating the link between cometary and interstellar material D. Bockelee-Morvan, D.C. Lis, J.E. Wink, D. Despois, J. Crovisier, R. Bachiller, DJ. Benford, N. Biver, P. Colom, J.K. Davies, E. Gerard, B. Germain, M. Houde, D. Mehringer, R. Moreno, T.G. Paubert, H. Rauer 2000, A&A 353, 1101

816. MULTIPLE MOLECULAR OUTFLOWS IN AFGL 2688
P. Cox, R. Lucas, PJ. Huggins, T. Forveille, R. Bachiller, S. Guilloteau, J.P. Maillard, A. Omont 2000, A&A 353, L25

817. CO DETECTION OF THE EXTREMELY RED GALAXY HR10 P. Andreani, A. Cimatti, L. Loinard, H. Rottgering 2000, A&A 354, LI

818. A HIGH-RESOLUTION STUDY OF EPISODIC MASS LOSS FROM THE CARBON STAR TT CYGNI H. Olofsson, P. Bergman, R. Lucas, K. Eriksson, B. Gustafsson, J.H. Bieging 2000, A&A 353, 583

819. ON THE RADIO SPECTRAL INDEX OF GALAXIES U. Lisenfeld, H.J. Volk 2000, A&A 354, 423

820. A SEARCH FOR EXTENDED DISKS AROUND WEAK-LINED T TAURI STARS
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821. SiO IN DIFFUSE TRANSLUCENT AND "SPIRAL-ARM" CLOUDS R. Lucas, H.S. Liszt 2QOO, A&A 355, 327

822. THE STRUCTURE AND STABILITY OF INTERSTELLAR MOLECULAR ABSORPTION LINE PROFILES AT RADIO FREQUENCIES H. Liszt, R. Lucas 2000, A&A 355, 333

823. LARGE-SCALE SHOCKS IN THE STARBURST GALAXY NGC 253 Interferometer Mapping of a ~600 pc $SiO/H^{13}CO^+$ CIRCUMNUCLEAR DISK S. Garcia-Burillo, J. Martin-Pintado, A. Fuente, R. Neri 2000, A&A 355, 499

824. THE INTERSTELLAR MEDIUM IN THE EDGE-ON GALAXY NGC 5907
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M. Dumke, M. Krause, R. Wielebinski 2000, A&A 355, 512

825. HIGH RESOLUTION OBSERVATIONS AT λ= 3 mm OF THE OH 231.8+4.2 MOLECULAR OUTFLOW C. Sanchez Contreras, V. Bujarrabal, R. Neri, J. Alcolea 2000, A&A 357, 651

826. THE HOT CORE OF THE SOLAR-TYPE PROTOSTAR IRAS 16293-2422: H_2CO EMISSION
C. Ceccarelli, L. Loinard, A. Castets, A.G.G.M. Tielens, E. Caux 2000, A&A 357, L9

827. RADIO SUPERNOVAE, SUPERNOVA REMNANTS AND HII REGIONS IN NGC 2146 OBSERVED WITH MERLIN AND THE VLA
A. Tarchi, N. Neininger, A. Greve, U. Klein, S.T. Garrington, T.W.B. Muxlow, A. Pedlar, B.E. Glendenning 2000, A&A 358, 95

828. DENSE GAS IN NEARBY GALAXIES XIII. CO SUBMILLIMETER LINE EMISSION FROM THE STARBURST GALAXY M82 R.Q. Mao, C. Henkel, A. Schulz, M. Zielinsky, R. Mauersberger, H. Storzer, T.L. Wilson, P. Gensheimer 2000, A&A 358, 433

829. COMPARATIVE CHEMISTRY OF DIFFUSE CLOUDS I. C_2H and C_3H_2 R. Lucas, H.S. Liszt 2000, A&A 358, 1069

830. THE ENORMOUS ABUNDANCE OF D_2CO IN IRAS 16293-2422 L. Loinard, A. Castets, C. Ceccarelli, A.G.G.M. Tielens, A. Faure, E. Caux, G. Duvert 2000, A&A 359, 1169

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833. MULTI-WAVELENGTH OBSERVATIONS OF THE MASSIVE YSO RAFGL7009S E. Dartois, M. Gerin, L. d'Hendecourt 2000, A&A 361, 1095

834. CO BAND EMISSION FROM MWC349
I. First overtone bands from a disk or from a wind?
M. Kraus, E. Kriigel, C. Thum, T.R. Geballe 2000, A&A 362, 158

835. THE ORIGIN OF THE HH7-11 OUTFLOW R. Bachiller, F. Gueth, S. Guilloteau, M. Tafalla, A. Dutrey 2000, A&A 362, L33

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837. ASTRONOMICAL DETECTION OF THE FREE RADICAL SiCN M. Guélin, S. Muller, J. Cernicharo, A.J. Apponi, M.C. McCarthy, C.A. Gottlieb, P. Thaddeus 2000, A&A 363, L9

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839. STRUCTURE AND CHEMICAL COMPOSITION OF THE SILICATE DUST AROUND OH/IR STARS K. Demyk, E. Dartois, H. Wiesemeyer, A.P. Jones, L. d'Hendecourt 2000, A & A 364, 170

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841. THE MINOR AXIS OUTFLOW OF NGC 2146 A. Greve, N. Neininger, A. Tarchi, A. Sievers 2000, A&A 364, 409

842. A $\lambda=2$ MM MOLECULAR LINE SURVEY OF THE C-STAR ENVELOPE IRC+ 10216
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844. CO (4-3) AND DUST EMISSION IN TWO POWERFUL HIGH-z RADIO GALAXIES, AND CO LINES AT HIGH REDSHIFTS P.P. Papadopoulos, HJ.A. Rottgering, P.P. van der Werf, S. Guilloteau, A. Omont, W.J.M. van Breugel, R.P.J. Tilanus 2000, ApJ 528, 626

845. NEW CO AND MILLIMETER CONTINUUM OBSERVATIONS OF THE z=2.394 RADIO GALAXY 53W002 D.Alloin, R. Barvainis, S. Guilloteau 2000, ApJ 528, LSI

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847. A CO SURVEY OF GIANT MOLECULAR CLOUDS NEAR CASSIOPEIA A AND NGC 7538
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849. EXCITATION ANALYSIS OF SO AND SO_2 IN THE PROTO-PLANETARY NEBULA OH 231.8+4.2 S.M.X. Claude, L.W. Avery, H.E. Matthews 2000, ApJ 545, 379

850. DYNAMICAL MASSES OF T TAURI STARS AND CALIBRATION OF PRE-MAIN-SEQUENCE EVOLUTION M. Simon, A. Dutrey, S. Guilloteau 2000, ApJ 545, 1034

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852. FORMATION OF MOLECULAR GAS IN THE TIDAL DEBRIS OF VIOLENT GALAXY-GALAXY INTERACTIONS J. Braine, U. Lisenfeld, P.-A. Due, S. Leon 2000, Nature 403, 867

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863. IRAM 30M CONTINUUM SURVEYS OF STAR-FORMING REGIONS P. Andre, F. Motte, R. Neri 2000, in *Imaging at Radio through Submillimeter Wavelengths* eds. J.G. Mangum, S.J.E. Radford ASP Conf. Series 217, 152

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865. MULTI-FIELD IMAGING WITH THE IRAM PLATEAU DE BURE INTERFEROMETER F. Guetlf, S. Guilloteau 2000, in *Imaging at Radio through Submillimeter Wavelengths* eds. J.G. Mangum, S.J.E. Radford ASP Conf. Series 217, 291

866. IMAGING AT THE IRAM PLATEAU DE BURE INTERFEROMETER S. Guilloteau, R. Lucas 2000, in *Imaging at Radio through Submillimeter Wavelengths* eds. J.G. Mangum, S.J.E. Radford ASP Conf. Series 217, 299

867. DISTRIBUTION AND PROPERTIES OF THE MOLECULAR CLOUDS IN M31 M. Guélin, C. Nieten, N. Neininger, S. Miiller, R. Lucas, H. Ungerechts, R. Wielebinski 2000, in *The Interstellar Medium in M31 and M33* eds. E.M. Berkhuijsen, R. Beck, R.A.M. Walterbos Shaker Verlag, R.F.A., 15

868. CO, HI AND DUST IN M31
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H.R. Dickel, J.A. Williams, D.E. Upham, W.J. Welch, M.C.H. Wright, T.L. Wilson, R. Mauersberger, L.H. Auer 2000, 33rd ESLAB Symp. *Star formation from the small to the large scale* eds. F. Favata, A.A. Kaas, A. Wilson ESA SP-445, 359

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J. Penalver, U. Lisenfeld, R. Mauersberger in *Radio Telescopes,* ed. H.R. Butcher Proc. of SPIE, Vol. 4015, 632

872. 250 GHz OBSERVATIONS OF Be STARS
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873. ALMA: L'UNION FERA LA FORCE S. Guilloteau 2000, Ciel et Espace N° 364, 30

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780. DEUTERIUM FRACTIONATION IN DENSE AMMONIA CORES S. Tine, E. Roueff, E. Falgarone, M. Gerin, G. Pineau des Forets 2000, A&A 356, 1039

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785. COLD DUST IN THE STARBURST GALAXY M82
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787. L483: A PROTOSTAR IN TRANSITION FROM CLASS 0 TO CLASS I M. Tafalla, P.C. Myers, D. Mardones, R. Bachiller 2000, A&A 359, 967

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9. ANNEX III - IRAM Executive Council and Committee Members, January 2000

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