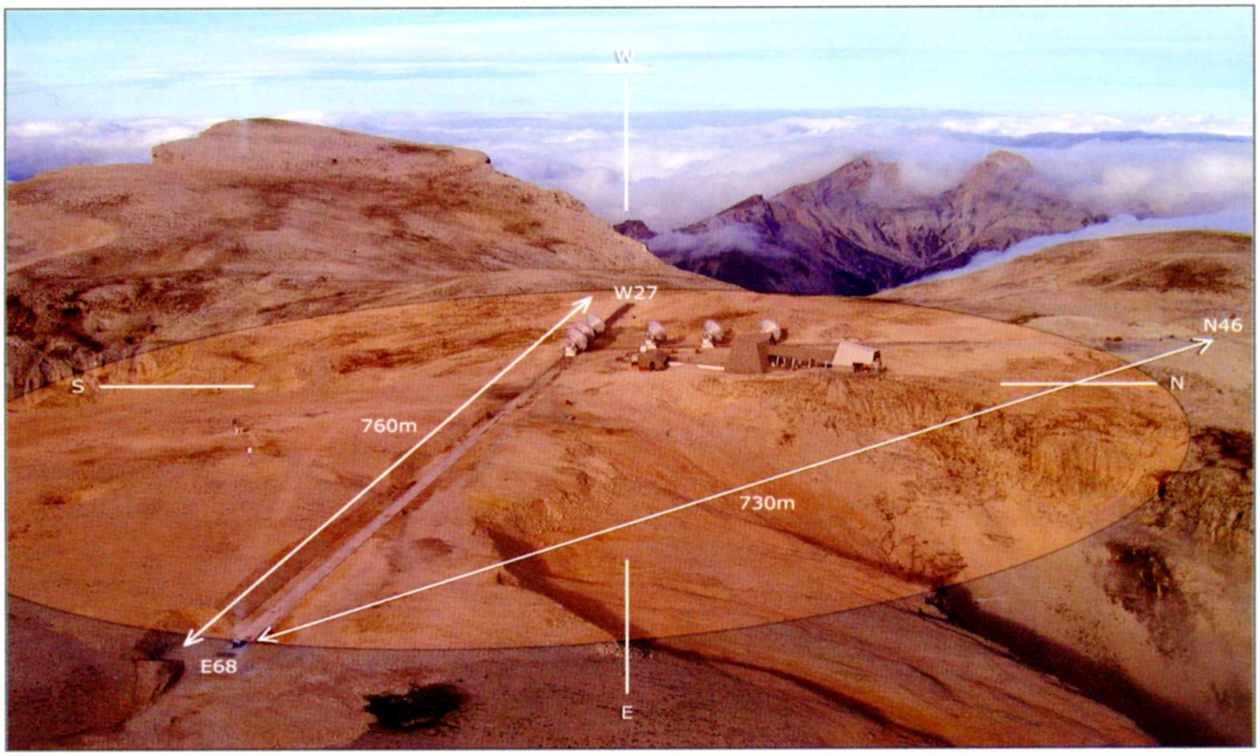
IRAM 2005



ANNUAL REPORT

Front Cover: Aerial view of the Plateau de Bure Observatory in the fall of 2005. With the new stations at the far ends of the northern (N46) and eastern (E68) track extensions, the Plateau de Bure Interferometer provides baselines of up to 760m.

ANNUAL REPORT

2005

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1. INTRODUCTION

In 2005, IRAM has successfully completed a major development project, and has reached an important milestone on a second one. Both projects started more than 5 years ago: the extensions of the northern and southern tracks of the interferometer on the Plateau de Bure, figuring on the cover page of this report, and a new control system at the 30m-telescope and its periphery. The track extensions allow to almost double the maximum angular resolution of the IRAM Interferometer.

Despite this emphasis on technical work, a wealth of scientific results has been obtained in 2005. Some highlights are described in Section 2 of this report. Observations of distant extragalactic objects have not only produced more detailed results on molecules that allow to characterize the physical and chemical conditions in the young universe, but it has also been possible to detect the 158-micron fine-structure line of C^+ in a quasar at redhsift 6.4! This is its first detection at high redshift, and it complements the successful detections of neutral carbon made in 2003 and 2004 with the IRAM telescopes. Important results have also come from observations of solar system objects, like the measurements of the wind speeds in the atmosphere of Saturn's moon Titan, and measurements of the size and density of Kuiper belt objects. On these objects, evidence is accumulating that they are made of pristine material from the time when the solar system was formed.

The decision to extend the tracks on the Plateau de Bure had already been decided in 1998 and work started in 1999. But due to the accidents in 1999, it had to be stopped. The work restarted in 2004, and it was successfully completed in 2005. This would not have been possible without a major planning effort by the PdB management team, the efficient work by outside companies, and by all of the PdB staff. Also, the refurbished cable car, now operating as a "blondin", played a key role: more than 1700 rotations were necessary to transport all the equipment and materials that were needed for the track extensions to the Plateau de Bure. In the meantime, first scientific results have been obtained with the new baselines, and they are extremely rewarding.

Another important technical milestone for the PdB Interferometer was the installation of the first unit of the new generation of receivers on antenna 6 of the PdB array. This receiver underwent extensive testing that still continues during the 2005/06 winter season, and the lessons learnt will benefit the final production of the full series that is due for delivery in the fall of 2006.

Concerning the development of a new control system for the 30m telescope, we recall that the original system was delivered to IRAM together with the telescope by the MPIfR in Bonn.

The software was running on computers that are no longer technically supported, and it used electronic control boards which no longer meet modern standards. After years of preparation, starting with conceptual design work, with progressive changes from CAMAC to VME standards, and with changes of computers and operating systems, a new software package for the control of the 30m telescope and its periphery was finally ready for commissioning. The switchover was made in November 2005, and much of its functionality has now been tested. As the debugging proceeds, more functions will soon become available. The new system offers possibilities for further developments as the telescope and its periphery evolve.

In 2005, IRAM has continued the technical development work for the ALMA and the EU-funded AMSTAR project. This work is mostly carried out by staff hired on special project funds. In both cases, very good results have been obtained as described in some detail in Section 5. For ALMA in particular, the design and development activities have successfully been completed, and the first (pre)production units of actual ALMA hardware have been fabricated and delivered. Due to delays at ALMA project level, the planning and the contractual arrangements for the full series production are still pending and awaiting finalisation and signature. IRAM has prepared itself for the next phase by creating additional lab and office space for the receiver group inside the existing building, and a new floor will be added to the already existing extension building.

Despite a number of study activities and a series of discussions between the CNRS/INSU, IRAM and the local authorities in the villages around the Plateau de Bure, and in the Prefeture and the "Conseil General" in Gap, a final decision on a new reliable access to the Plateau de Bure observatory was still pending by the end of 2005. After the previous baseline solution, a tunnel plus an elevator project, had to be given up in 2004, the CNRS/INSU and IRAM had proposed the construction small, private road on the side of La Joue du Loup. Its technical and financial feasibility had been demonstrated, but it met with strong opposition from the local authorities. As a result, the discussion returned to one of the options discussed early on but rejected at that time, a new cable car system at the location of the old cable car. Given the amount of time that has passed, and given the fact that the legal procedure in connection with the accident in 1999 has come to an end with the final judgement by the Court of Appeal in October 2005, this solution looks very promising at the time of writing this report and is actively being pursued.

A solution to the access problem, as well as new scientific and technical developments will be the first big challenges for the new IRAM management that has taken over on January 1st, 2006, with Pierre Cox as the new Director, and Karl Schuster as his Deputy.

2. HIGHLIGHTS OF RESEARCH WITH THE IRAM TELESCOPES IN 2005

2.1 SUMMARY

Among projects at the IRAM telescopes done or published in 2005, a few highlights were :

- **Detection of the redshifted C^+ 158-micron line in the quasar SDSS J1148+52 at z = 6.4**: After the detections in the past two years by the IRAM telescopes of spectral lines of *neutral* carbon in high-redshift sources, the redshifted 158-micron line of *ionized* carbon has now been detected in the z = 6.4 quasar SDSS J1148+52.
- **A strong HCN(5-4) line from the extraordinary gravitationally-lensed quasar APM 08279+52 at z = 3.9.** This is the first clear detection of high-J HCN emission redshifted into the 3-millimeter atmospheric window. The line strength implies a large mass of warm, high-density (5×10^5 cm^{-3}) molecular gas in this high-redshift quasar.
- **Multiple CO lines from the three images of the galaxy SMM J16359+6612 at z = 2.5** have been measured with the 30m telescope. The fluxes in the CO line ladder indicate moderate excitation, possibly in a merger of two galaxies.
- **Molecular gas in the nuclei of galaxies:** Analyses of the gas flows in several galaxies with low-luminosity active galactic nuclei suggest that, for radii within 200 pc of the center, gravitational torques from the stellar bulge prevent gas inflows to the AGN.
- **Study of a warped molecular gas disk in the elliptical galaxy NGC 3718.** This gas disk strongly resembles that in Centaurus A / NGC 5128, but the nuclear activity is quite different.
- **Detection of deuterated ammonia in interstellar dark clouds:** varying fractionation ratios on the way from NH_3 to ND_3 imply gas-phase chemistry, not grain-surface chemistry.
- **Galactic molecular clouds:** The velocity field in the Horsehead nebula, mapped in $C^{18}O$ at the 30m telescope, shows the "neck" structure is not self-gravitating. The Horse's "head" is a photon-dominated region illuminated by UV radiation from the star σ Orionis.
- **Protostellar outflows:** A shock-induced, photon-dominated region (PDR) in the Herbig-Haro object HH 2 is revealed by comparison of 30m line maps with infrared images.
- **Disks around young stars:** Sub-arcsecond imaging of molecular gas and dust in the envelope around the star AB Aurigae shows non-Keplerian motion in a warm (68 K) disk at about 100 AU from the star.
- **Solar system:** New interferometer measurements yield wind speeds in the upper atmosphere of Saturn's moon Titan. Size estimates of the Kuiper Belt Object UB313 based on millimeter data indicate it is larger than the planet Pluto. Densities of Kuiper Belt objects, based on such measurements, suggest these objects are like the nuclei of comets, not planets.

2.2 HIGH-REDSHIFT DETECTIONS

Z=6.4189: First detection of the 158-micron line of ionized carbon in a high-redshift quasar.

After the redshifted 370 and 610μm lines of *neutral* carbon were detected with the IRAM telescopes in 2003 and 2004 in four high-*z* sources (Cloverleaf, F10214, PSS2322, SMM J14011), the redshifted C^+ 158-micron fine-structure line of *ionized* carbon has now been detected with the 30m telescope in SDSS J1148+52, the most distant known quasar. This is the first detection of this line in a high redshift source. At the quasar's redshift of $z = 6.42$, the C^+158μm line is redshifted to 256 GHz. The center of this line agrees well with the center of the quasar's CO(6-5) line at 93 GHz, which was previously detected with the IRAM Interferometer (**Fig. 2.1,** from Maiolino et al. 2005, A&A, 440, L51).

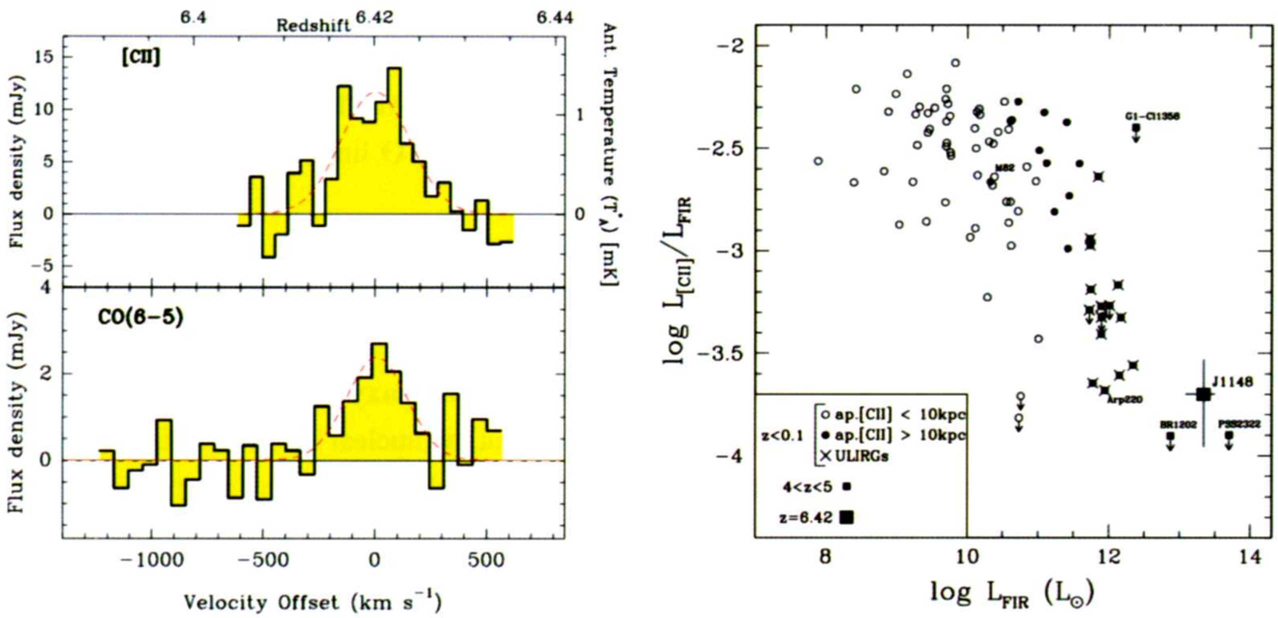


Fig. 2.1: Detection of the ionized carbon line at 158 microns in a high-redshift quasar.

Left diagram: Spectra of the quasar SDSS J1148+52, showing the ionized carbon line at 158 microns, redshifted to 1.2mm, detected in 2005 at the IRAM 30m telescope (*upper spectrum*), and, for comparison, the CO(6-5) line, redshifted to 3mm, previously detected with the IRAM Interferometer (*lower spectrum,* from Bertoldi et al. 2003).

Right diagram: Ratio of the C^+ line luminosity to the far-infrared luminosity of the dust continuum, in a sample of galaxies, plotted as a function of the far-IR luminosity. For low-redshift galaxies, this ratio uses data from the ISO Long Wavelength Spectrometer. The location of the quasar J1148 in the lower right corner of this diagram shows that its ratio, like that of Arp220, is about 10 times lower than in local, lower-luminosity starburst galaxies (Maiolino et al. 2005, A&A, 440, L51).

The ratio of the C^+ -to-far-infrared luminosity is only 2×10^{-4}, which is about ten times lower than that observed in local, normal galaxies. This low value of the C^+-to-far-IR ratio, also seen in ultraluminous infrared galaxies in the low-redshift universe, may be due to the high gas density in these objects, which results in a quenching of the ionised carbon line. In these dense-gas conditions, the CO molecule takes over from atomic carbon as a principle gas coolant of the interstellar medium. The other factor that contributes to the low C^+-to-far-IR luminosity ratio is the tremendous strength of the dust continuum emission in these ultra-luminous far-infrared objects. The warm dust, heated by starbursts and the quasar, radiates about 10,000 times more power than that due to the lines in the CO ladder. This ultra-strong dust continuum makes a "normal" flux of the C^+ line appear relatively weak in comparison.

Z=3.9113: Strong HCN(5-4) line from the extraordinary lensed quasar APM 08279+5255.
The IRAM Interferometer has been used to detect HCN J=5-4 emission from the ultraluminous quasar APM 08279+5255 at a redshift z=3.911. This is the first clear detection of high-J HCN emission redshifted into the 3-millimeter atmospheric window (**Fig. 2.2**).

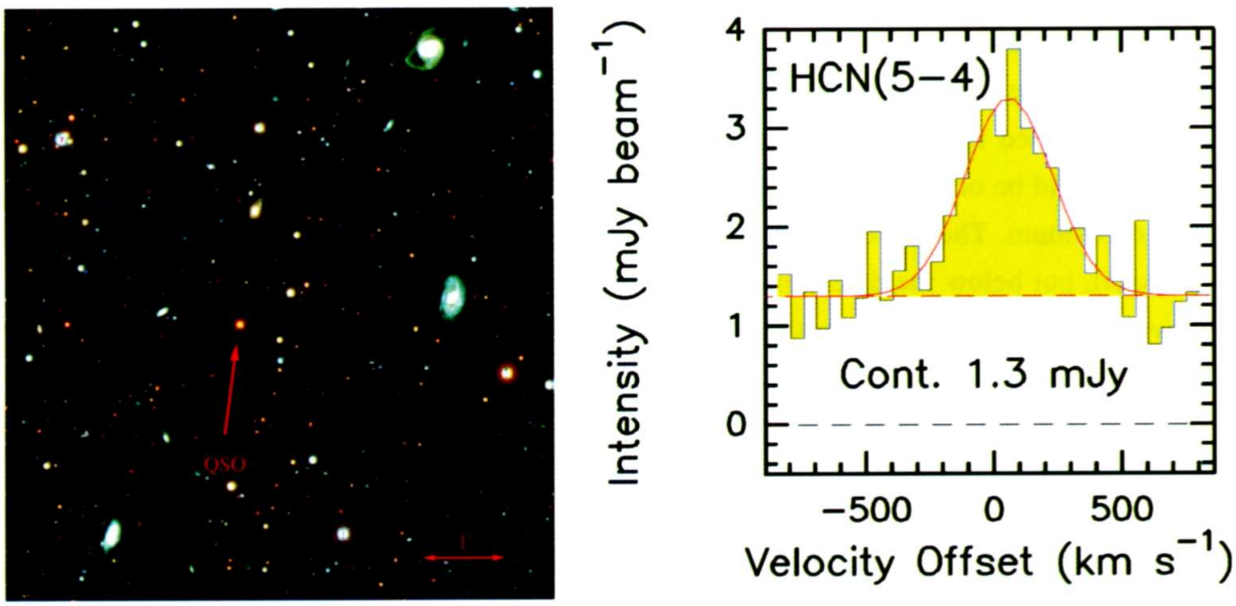


Fig. 2.2: Strong HCN(5-4) line from the quasar APM 08279+5255 at z = 3.9.
Left side: Due to its redshift, the quasar APM 08279 appears as a red star near the center of this optical image of an 8 x 8 arcmin field around the quasar, taken with the NOAO 4-m telescope. This field also contains 7 Lyman-Break galaxies near a redshift of z = 2.97, indicating a moderate clustering (factor of 5 overdensity) along the line of sight to the quasar (from N. Bouché & J. Lowenthal, image NOAO-AURA-NSF).
Right side: HCN (5-4) line detected with the IRAM Interferometer. The line profile appears above the dust continuum of 1.3 mJy. The zero of the velocity scale is at 90.229 GHz, the channel width is 15 MHz (50 km/s), and the r.m.s. noise is 0.47 mJy. (Wagg et al. 2005, ApJ, 634, L13, plus new data from Weiss et al. 2006, in preparation).

The APM 08279 quasar is strongly gravitationally lensed, but even after correcting downward for the lensing amplification, it is still one of the most intrinsically luminous objects in the universe. The new data imply an apparent HCN(5-4) line luminosity of 4 x 10^{10} K km/s pc^2 (about 100 times the CO(1-0) luminosity of the Milky Way!). The 440 km/s linewidth of the HCN(5-4) line matches that of the previously observed high-J CO lines in this object, so the emission from both species probably comes from the same place: a warm, dense, circumnuclear disk. The ratio of HCN to far-infrared luminosity is 1/2000, near the end of the range observed in nearby star-forming galaxies, and comparable to that observed in the very few high-redshift objects so far detected in the lower-level HCN(1-0) line (Wagg et al. 2005. ApJ, 634, L13).

Z=2.5174: Multiple CO lines from the three images of the galaxy SMM J16359+6612.

In last year's annual report, we described the detection of CO(3-2) in all three images of the gravitationally-lensed submillimeter galaxy SMM J16359+6612, at a redshift of 2.5 (with the IRAM Interferometer by Kneib et al. 2005, A&A, 434, 819, and at OVRO by Sheth et al. 2004, ApJ, 714, L5). This object lies behind the massive galaxy cluster Abell 2218 at z = 0.175, that strongly amplifies the emission from the otherwise faint background galaxy into three widely separated images. The three images are magnified by factors of 22, 14, and 9, and the maximum image separation is 41 arcsec, much larger than any other gravitational lens system detected at radio wavelengths. Without the lens amplification, the true flux of this galaxy would be only 0.1 mJy at the peak of the CO(3-2) line and only 0.2 mJy in the 1.2mm dust continuum. These are fluxes expected from typical high-redshift galaxies (Lyman break galaxies), but below the detection limits of most current surveys. The gravitational lens thus provides a rare opportunity to study a typical, faint, high-redshift galaxy. The initial IRAM observations showed that the CO(3-2) has two velocity components, each 220 km/s wide, separated by 280 km/s in velocity and by 1 arcsec on the sky, The molecular gas mass is about $3x10^9$ Msun.

The IRAM observers concluded that the source may be a compact merger of two Lyman-break galaxies, with the two nuclei at a projected separation of 3 kpc (corrected for lensing). In this year's annual report, we can now add new information from the 30m telescope, which has detected the CO(3-2), CO(4-3), CO(5-4), and CO(6-5) lines in this object (**Fig. 2.3**). These CO lines have a double peak in all transitions. The CO line ratios, and thus the physical conditions of the gas, are the same in the blue and redshifted components. The CO line fluxes reach a maximum in the CO(5-4) line, and then decrease. This behavior shows that the molecular gas is less excited than in high-redshift quasars or even in nearby starburst galaxies like M82. This difference in excitation is mainly due to a lower average H_2 density, suggesting that the gas is less centrally concentrated than in nuclear starburst regions in local galaxies. One possibility is that the molecular gas may reflect an intermediate evolutionary stage of the merger, in between that of the Antennae galaxies (low rate of star formation) and that of the more evolved ultraluminous infrared galaxies (high rates of star formation). The new IRAM 30m study has been published by Weiss et al., 2005, A&A, 440, L45.

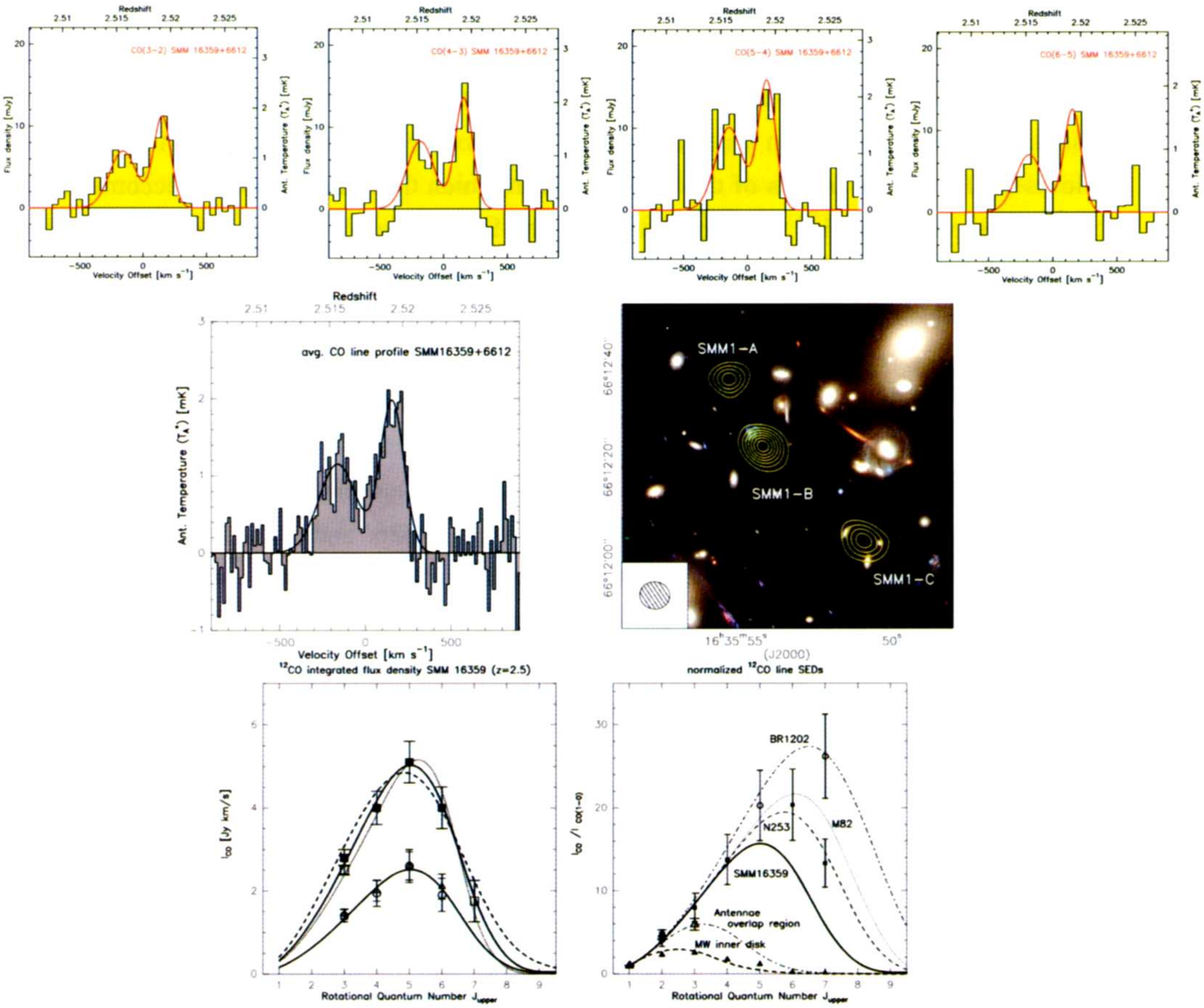


Fig. 2.3: Multiple CO lines from the triply-imaged z=2.5 galaxy SMM J16359+6612.
Top panels: CO(3-2), CO(4-3), CO(5-4), and CO(6-5) lines observed with the 30m telescope toward SMM16359. *Middle left:* Average spectrum of these four CO lines, with velocity scale relative to z= 2.5174. *Middle right:* IRAM Interferometer CO(3-2) contours from the three images of the same galaxy, superposed on a Hubble Space Telescope 1 x 1 arcmin optical image. Overexposed white spots are galaxies in the foreground Abell 2218 cluster. Long colored arcs are lensed images of galaxies behind the cluster (from Kneib et al. 2005, A&A, 434, 819).
Lower left: CO fluxes vs. rotational quantum number; upper data points are for the sum of the blue and red-shifted components, lower points are for the blue and red components separately.
Lower right: Comparison of fluxes in the CO ladder, normalized to CO(1-0), for different galaxies. The IRAM 30m data and analysis are from Weiss et al., 2005, A&A, 440, L45.

2.3 NEARBY GALAXIES.

Molecular gas in the nuclei of galaxies: Gravitational torques repel the gas .

How does gas fall into the supermassive black holes at the centers of most large galaxies? It has long been thought that this gas somehow comes from the circumnuclear regions, at radii within a few hundred parsecs of the black hole. This gas has to fall, or be driven, into the black hole's range of influence, where the gas will "feel" the black hole's gravity, rather than the gravity of all the stars in the nuclear bulge. For a 10^7 Msun black hole, this capture radius is about 1 pc, about a million times larger than the "size" (Schwarzschild radius) of the black hole itself. The active phases of the black holes, in which the galaxies' nuclei become bright (Seyfert galaxies), require accretion rates into the black hole of 0.1 to 1 Msun/year. The percentages of galaxies in this bright-nucleus phase imply that the activity lasts ~50 million years, so the black hole has to be supplied with 5 to 50 million solar masses of gas during this active period. New observations with the IRAM Interferometer show however, that the fueling of the black hole is not so easy. In fact, most of the time, the asymmetric gravitational potential of the stars in the nuclear region *prevents* the gas from falling into the nucleus. New CO observations with the Interferometer provide high-resolution data for modelling the gas flows in the circumnuclear disks of NGC 4321, 4579, 4826, and 6951 **(Fig. 2.4).** These objects have low-luminosity active galactic nuclei (LINER or Seyfert 2 nuclei). The IRAM CO data were used to calculate the timescales for gas flows, and near-infrared images that show the stellar disk and bulge were used to derive the gravitational potentials of the stars. The asymmetric (bar) potentials of the stars produce torques that change the angular momentum of the gas, and the mean torques on the gas can be estimated from the Interferometer maps of the CO. The results of these analyses suggest that the stellar torques are positive (repulsive) within 200 pc of the nuclei, that is, they act to *prevent* fueling of the nuclei on these scales. The authors also suggest that the often-cited mechanism of dynamical friction of giant molecular clouds is ineffective in overcoming the outward-pushing gravity torques. Instead, a more likely mechanism may be viscous torques in high-density circumnuclear rings, at radii of 100 to 500 pc. Within each cycle of formation and destruction of a stellar bar potential, lasting about 10^9 years, viscous torques in the dense circumnuclear rings may build up and eventually become effective in bringing gas into the central black holes. The nucleus could then have a bright accretion disk only in "brief" episodes of 10^7 to 10^8 years, until the bar rebuilds itself and its torque then drives outward all the gas inside the nuclear ring, thereby turning off the fuel supply to the nucleus (Garcia-Burillo et al. 2005, A&A, 441, 1011).

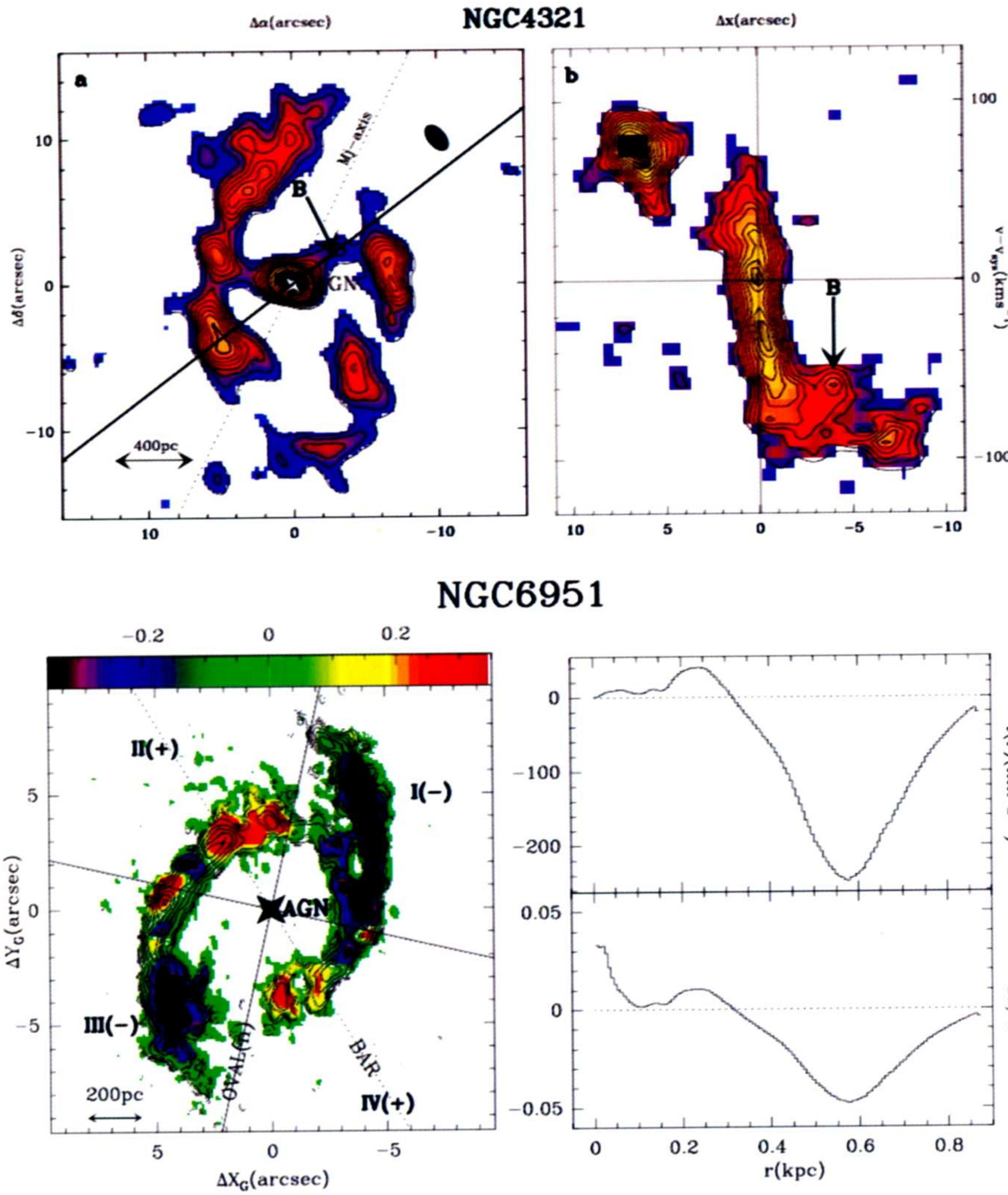


Fig. 2.4. Molecular gas flows near the nuclei of galaxies. *Upper left:* Interferometer map of CO(1-0) in NGC4321. The two nuclear spiral arms at r = 1 kpc are connected by a gas bridge (***B***) to a barely-resolved, inner gas disk at r = 150 pc, centered on the AGN.

Upper right: Position-velocity diagram along position angle 127° (diagonal line in map at left). Gas kinematics across the gas bridge (***B***) depart from circular rotation. The analysis of the gravitational torques suggests that most of the gas flow is outward, not inward.

Lower left: CO contours of NGC 6951, superposed on a map of the variation of angular momentum density (torque multiplied by gas column density). Positive torques (red/green) accelerate the gas, negative torques (blue/violet) decelerate the gas.

Lower right: Calculated torque/unit mass and fraction of angular momentum transferred to the gas in a single rotation, both vs. radius from the nucleus. The torques are due to the nuclear oval rather than the outer bar of NGC6951. Torques are negative over the nuclear spiral arms, but become positive near the AGN, and do not currently favour any further fueling of the AGN. (Garcia-Burillo et al. 2005, A&A, 441, 1011).

Study of a warped molecular gas disk in the elliptical galaxy NGC 3718.

While the previous report was on gas flows in *spiral* galaxies with active nuclei, another study has been made of an unusual *elliptical* galaxy with a molecular gas disk, NGC 3718. This northern-sky object resembles the southern-sky elliptical NGC 5128 that hosts the famous radio source, Centaurus A. Both galaxies have a large, warped dust lane running across the stellar bulge. In the central 4 kpc of both galaxies, the dust lanes' neutral hydrogen is depleted, and molecular hydrogen dominates the neutral gas. Both galaxies have an active nucleus; Cen A is a strong radio galaxy, and the nucleus of NGC 3718 has a weak radio source, broad (2350 km/s) nuclear Hα emission, and strong [O I] emission with a width of 570 km/s, all suggesting a hidden AGN. The IRAM Interferometer has been used to map CO(1-0) and (2-1) in a 7-field mosaic along the dust lane of NGC 3718 (Krips et al., 2005, A&A, 442, 479). In CO(1-0), the new interferometer data were combined with an earlier map made at the 30m telescope by Pott et al. (2004, A&A, 415, 27).

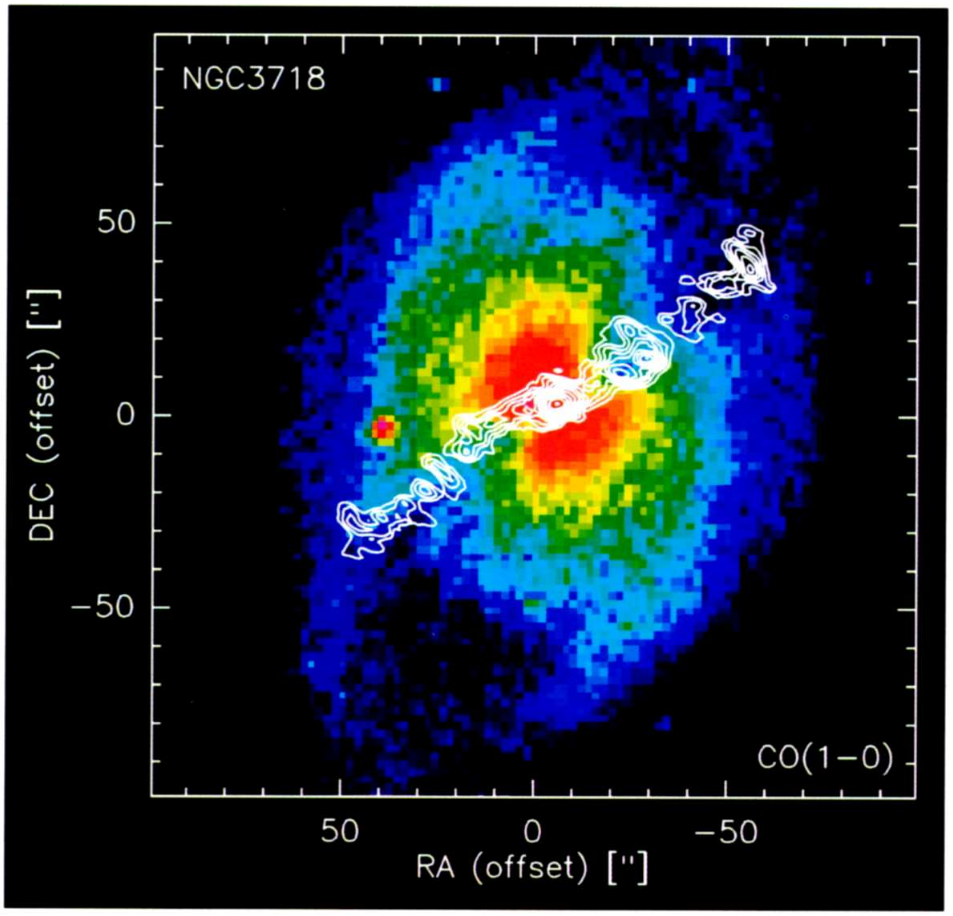


Fig. 2.5: Study of a warped molecular gas disk in the elliptical galaxy NGC 3718.
Contours of CO(1-0), mapped with the IRAM Interferometer, and supplemented with short-spacing data from the IRAM 30m telescope, superimposed on a Palomar Sky Survey optical image of the galaxy. CO contours are 1.0 to 6.0 in steps of 0.5 Jy km/s, and the combined PdBI+30m data set has a beamwidth of 7.8 x 4.5 arcsec, and recovers all of the single-dish CO flux (Krips et al. 2005, A&A, 442, 479).

The map in **Fig. 2.5** shows CO peaks at the nucleus and at ±1.3 and ±4.0 kpc from the center. Kinematic modelling shows that all these peaks, including the central one, are due to orbital crowding effects on the lines of sight; they are not real "sources" in the sense of self-gravitating molecular clouds.

The best kinematic model that explains all the features is a series of warped and tilted concentric rings. Rapidly rotating gas at 700 pc from the center is in an inner, warped ring. Contrary to the look of the CO map, the modelling does not need a stellar bar to explain the observed gas motions down to a radius of 250 pc. The CO warp and east-west asymmetry are probably both due to an interaction with NGC 3729, a companion galaxy ~10′ east, at the same redshift. The striking similarity of NGC 3718 to NGC 5128 --- same total mass, molecular mass, dust mass, size scale, CO luminosity, and same kinematics --- is in stark contrast to the spectacular difference in their nuclear activity. Cen A is not only an order of magnitude stronger in both the radio and the far-IR, but also has the well-known radio jets and lobes, of which there is not the slightest trace in NGC 3718. All this suggests that galaxy interactions and mergers that create strongly warped disks probably do not have much influence on the radio continuum properties that are ultimately due to the activity of the central black hole. Similarly, NGC 3718's lower star formation rate (lower far-IR luminosity) relative to Cen A is also probably not correlated with strongly warped molecular rings or their creation history.

2.4 MOLECULAR CLOUDS IN OUR GALAXY.

Deuterated ammonia: In cold dark clouds, varying fractionation ratios on the way from NH_3 to ND_3 imply gas-phase chemistry, not grain-surface chemistry.

In the past eight years, the discovery of multiply-deuterated molecules has revitalized the study of dense cores of interstellar dark clouds. There have been two main ideas to explain the large deuterium fractionation in cold, dense cores. The first invokes low-temperature (<20 K), ion-molecule reactions that exchange deuterium atoms for hydrogen, *in the gas phase* (Watson, 1974, ApJ, 188, 35). The second hypothesis invokes chemistry *on dust grains* that trap deuterium, as well as hydrogen, out of the gas. In the gas-phase, a given molecule should have different deuterium fractionation ratios at each step in deuteration, because each step involves different chemical reactions; these ratios should also vary from source to source. In contrast to these predictions, grain chemistry models predict that deuterated species should all have similar ratios, because each ratio is proportional to the original D/H abundance in the gas around the grains. A good test to see which idea is right comes from the ammonia molecule, because in cloud cores, it has four forms: with hydrogen only, and in singly-, doubly-, and triply-deuterated versions. The 30m telescope has been used to observe 13 interstellar clouds in singly-deuterated ammonia, NH_2D (at 86 and 110 GHz), and in doubly-deuterated ammonia, ND_2H (111 GHz, and 207 and 216 GHz). In the dark cloud Barnard 1, the IRAM data showed the first detection of the hyperfine structure in the lines of ND_2H (**Fig. 2.6**).

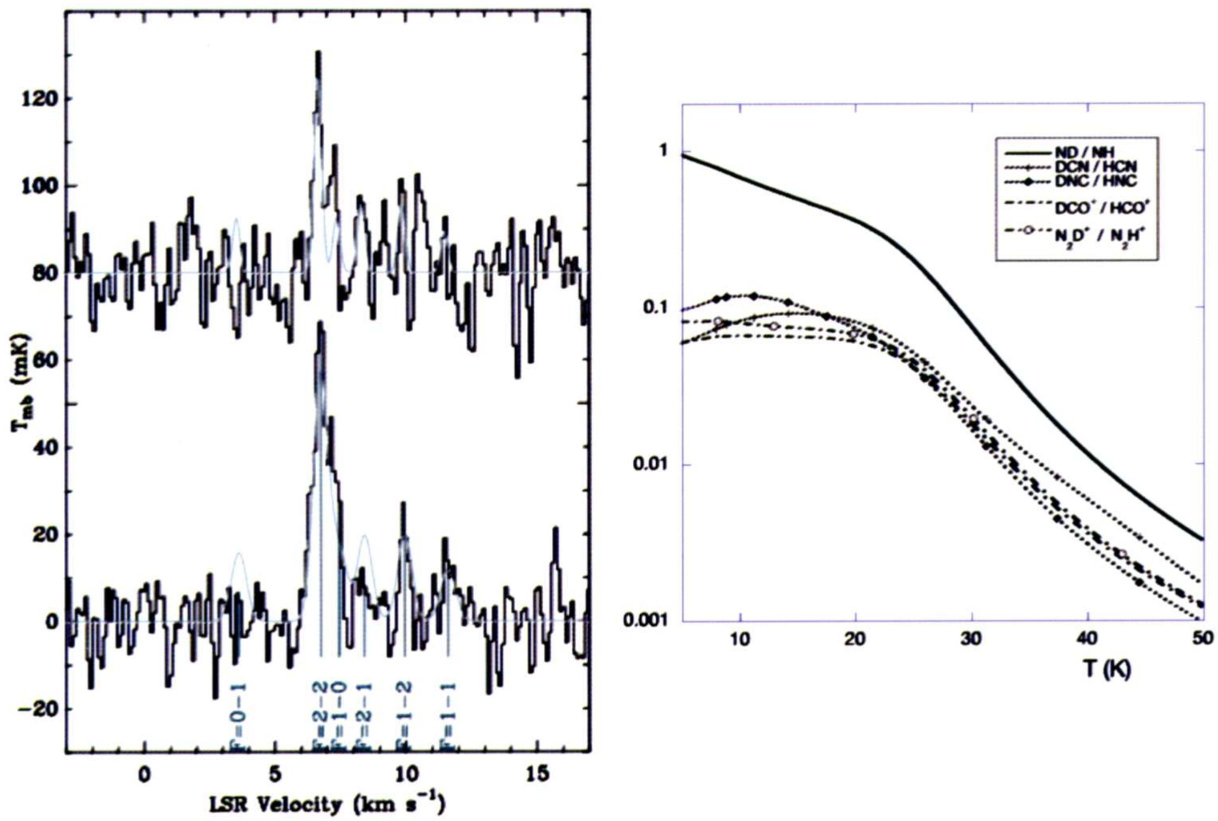


Fig. 2.6: ND_2H lines in the dark cloud Barnard 1, and model calculations for other deuterated molecules. *Left side :* Spectra of doubly-deuterated ammonia, ND_2H, in the 1_{10}—1_{01} lines of the ortho (bottom) and para (top) lines near 110.8 GHz, observed at the 30m telescope, with locations of hyperfine components indicated along the velocity scale at the bottom.

Right side : Gas-phase model predictions of ratios of deuterated species of other, mostly nitrogen-containing molecules as a function of temperature. The uppermost curve is for ND/NH, which is about ten times higher than for the other ratios shown here. The exothermic reactions that yield the strong deuterium fractionation operate in cold gas, at temperatures less than 20 K (Roueff et al. 2005, A&A, 438, 585).

Subsequently, ND_2H hyperfine structure was also found in the 335 and 389 GHz lines at the Caltech Submillimeter Observatory (Lis et al. 2006, ApJ, 636, 916). The 30m-telescope maps of NH_2D and ND_2H , and Caltech maps of ND_3, all show that the lines do not peak at the young stellar objects embedded in the cloud, but are instead offset from these protostars, possibly in their outflows. This suggests that gas heating by the protostars may decrease the deuteration that built up during the earlier, low-temperature, pre-stellar phase. The observed relative abundances agree well with gas-phase chemical models, which predict abundances relative to undeuterated NH_3 of 10% for singly-deuterated, 0.7% for doubly-deuterated, and 0.06% for triply-deuterated ammonia. The observed triply-deuterated ND_3 – to- NH_3 ratios of 10^{-4} to 10^{-3} imply a tremendous enhancement, by 11 to 12 orders of magnitude over the cosmic deuterium-to-hydrogen ratio. These enhancements of deuterium species happen thanks to gas-phase exothermic reactions with molecular ions like H_3^+ and its deuterated variants. If these ions were to react with CO or other abundant species, the build-up of deuterated molecules would be quenched. The discoveries of deuterated species in recent years have mostly been in clouds with large depletions of CO, so dust grains obviously play a crucial passive role, by condensing abundant molecules like CO out of the gas, to form CO-rich ices on the grains, thereby allowing ions like H_3^+ to remain in the gas. This is an important ingredient in the success of gas-phase chemical models in explaining the observed deuterium fractionation ratios (Roueff et al. 2005, A&A, 438, 585).

Deuterated Thioformaldehyde in the Barnard-1 dark cloud

An unexpected result of a line survey of dark clouds at the IRAM 30m telescope has been the discovery of singly and doubly deuterated thioformaldehyde (HDCS and D_2CS) in the dark cloud Barnard 1. While HDCS had previously been seen at lower frequencies in the TMC-1 cloud, this is the first detection of D_2CS in space. These data have been combined with observations of undeuterated thioformaldehyde, H_2CS and $H_2C^{34}S$, as well as with the different isotopic species of formaldehyde (H_2CO) to obtain a precise value of 6.70±0.05 km/s for the systemic velocity of the dense gas in the Barnard-1 cloud, and to obtain precise line frequencies of deuterated thioformaldehyde that significantly improve previous frequencies from laboratory spectroscopy (**Fig. 2.7**). For thioformaldehyde, the observations yield abundance ratios of H_2CS-to-HDCS = 3, and H_2CS-to-D_2CS = 9. The analogous ratios for H_2CO observations are 7 and 13. These ratios are in reasonable agreement with the predictions of the gas-phase chemical models described above (Marcellino et al., 2005, ApJ, 620, 308).

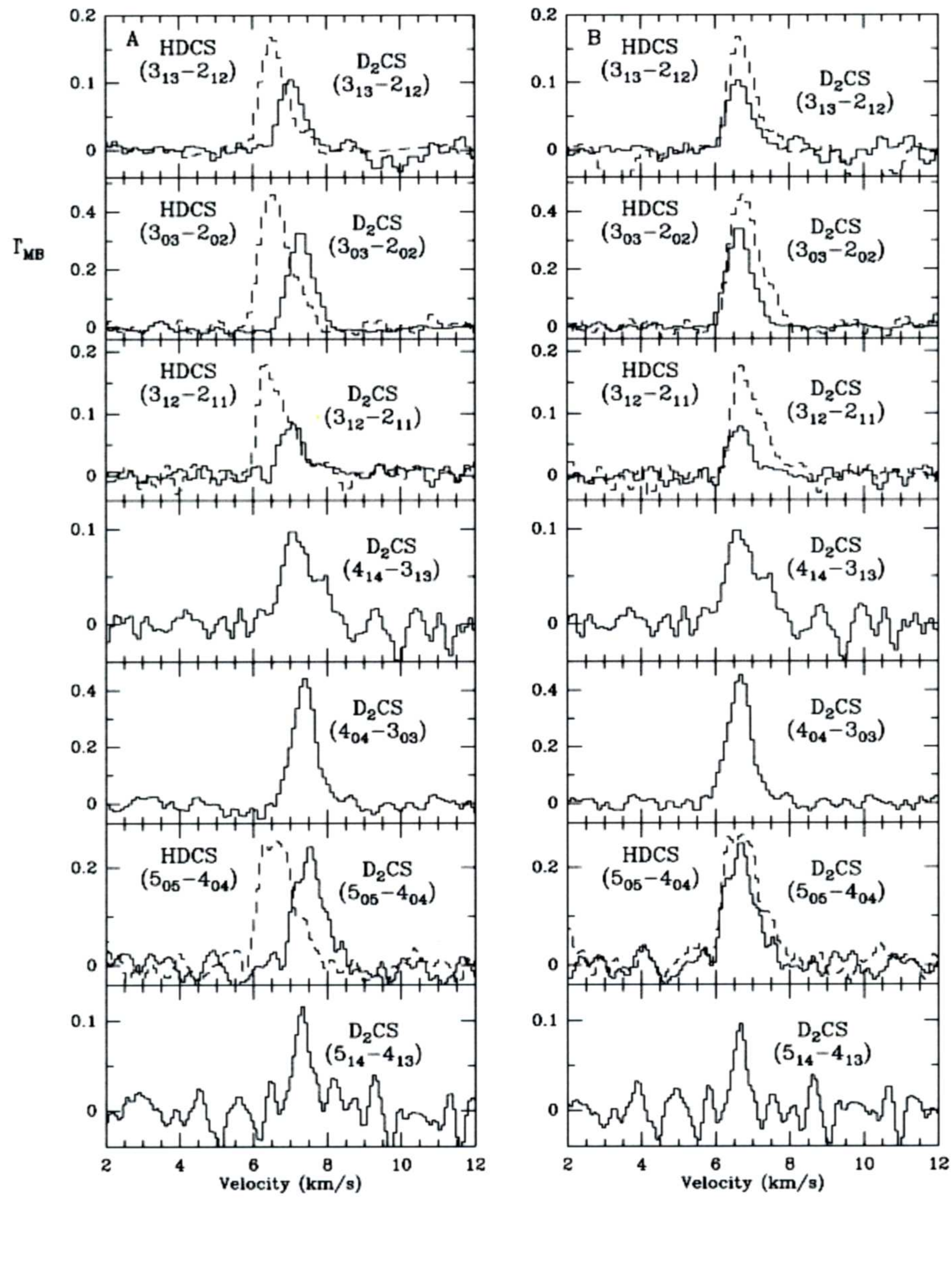


Fig. 2.7: Deuterated Thioformaldehyde in the Barnard-1 dark cloud.
Observed transitions of HDCS (*dashed lines*) and D_2CS (*solid lines*), with line frequencies adopted from previous laboratory spectroscopy (*left panel*), and with the best-fit corrections from the actual frequencies observed in space (*right panel*). (Marcellino et al., 2005, ApJ, 620, 308)

2.5 YOUNG STARS

Galactic molecular clouds: Velocity field and star formation in the Horsehead nebula.

The IRAM 30m telescope has been used to map a 7x8 arcmin region containing the well-known Horsehead nebula in Orion with both the Heterodyne Receiver Array (HERA) in the $C^{18}O$(2-1) line at 1.4mm, and with the MAMBO 117-pixel bolometer array in the 1.2mm dust continuum (**Fig. 2.8**)

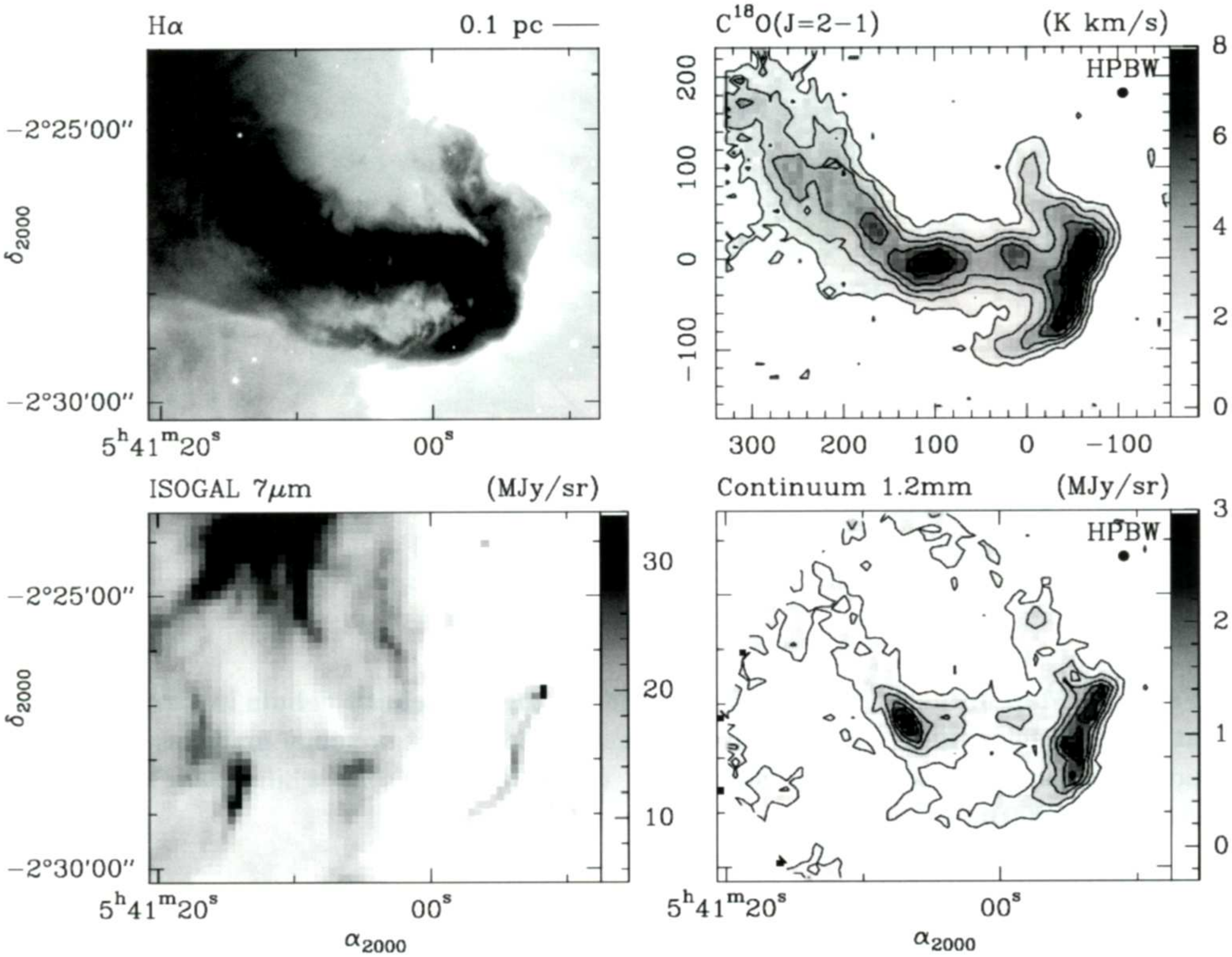


Fig. 2.8: Hα line, $C^{18}O$ line, aromatic hydrocarbon, and 1.2mm dust emission from the Horsehead nebula in Orion. *Upper left:* Optical Hα line image (Reipurth & Bally); *Upper right:* $C^{18}O$(2-1) line map made with the HERA multibeam array at the IRAM 30m telescope; *Bottom left:* 7μm emission from aromatic hydrocarbons, imaged with the ISO satellite; *Bottom right:* 1.2mm dust emission, mapped with the MAMBO 117-beam bolometer at the 30m telescope.

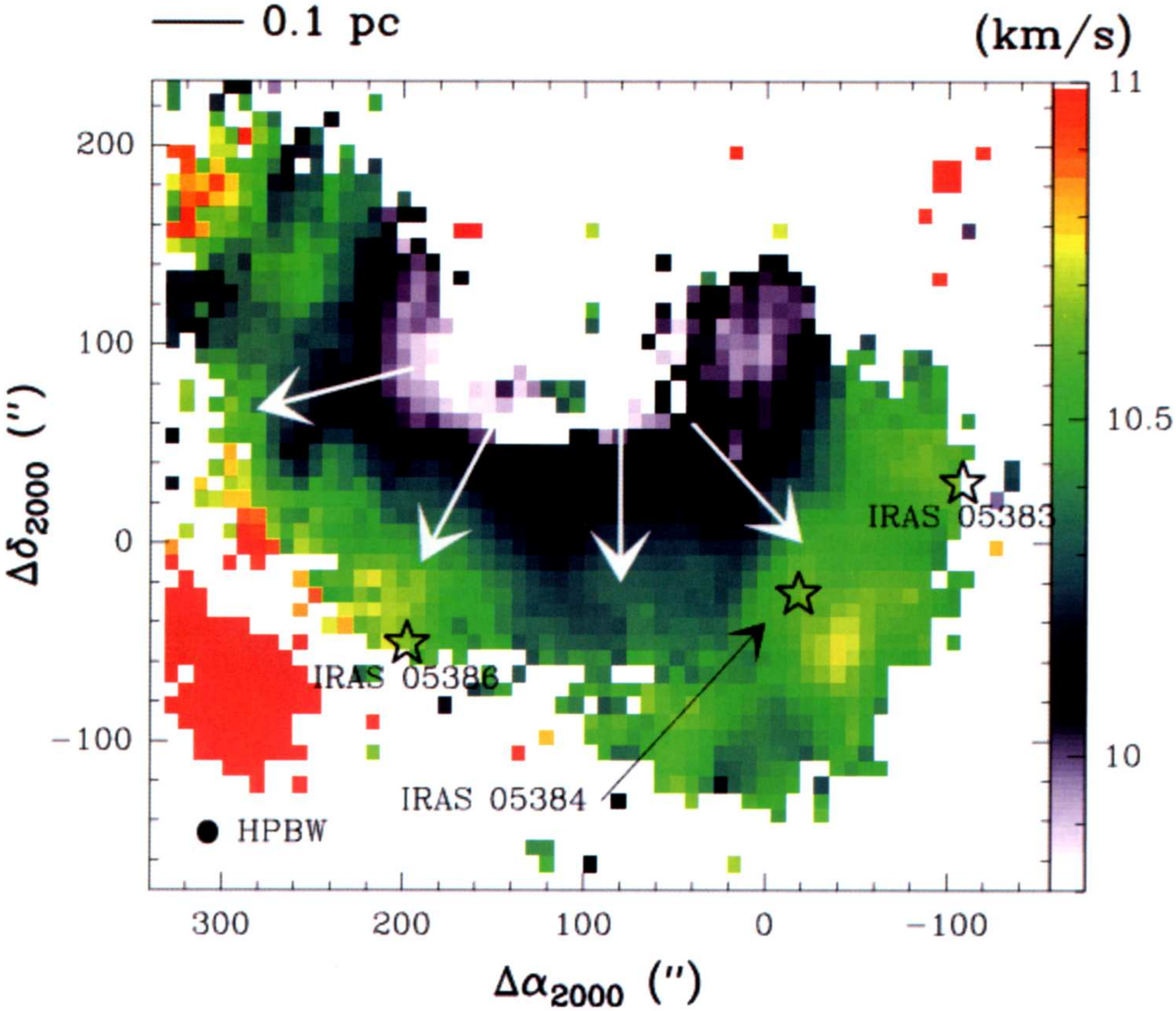


Fig. 2.9: Map of the $C^{18}O$ velocity centroids in the Horsehead nebula in Orion mapped at the 30m telescope. White arrows indicate directions of velocity gradients at different positions across the neck of the Horsehead (Hily-Blant, Teyssier, Philipp, & Güsten 2005, A&A, 440, 909).

The new data are compatible with the following scenario: the Horse's "head", outlined by a bright halo in optical images, is a curved-ridge, Photon-Dominated Region (PDR), illuminated by the O9.5 star σ Ori, located 0.5° to the west. This PDR region is connected to the main molecular cloud L1630 to the east, by the "neck" of the Horsehead, which is a filament of dust and gas that is not massive enough to be self-gravitating, but appears to be confined by the external pressure of the surrounding ionised gas. The CO and 1.2mm dust maps show several dense cores, with H_2 densites of (2 to 4) x 10^4 /cm^3, and kinetic temperatures of 20 to 30 K. Transverse velocity gradients of a few km/s/pc are seen all across the pillar that makes up the "neck" (Fig. 2.9), with a systematic variation that suggests the current shape of the Horsehead might be due to centrifugal effects in the original PDR pillar (Hily-Blant et al. 2005, A&A, 440, 909).

Protostellar outflows: The shock-induced, photon-dominated region (PDR) in the Herbig-Haro object HH 2.

Spectral-line data from the IRAM 30m telescope have been combined with mid-infrared data from the ISO satellite to study the spectacular shock emission regions Herbig-Haro 1 and 2 in Orion (**Fig. 2.10**). IRAM data in ^{12}CO, ^{13}CO, and SO show that the outflowing gas from the radio source VLA-1, the driving source of the high-velocity flow, extends well beyond the shock front at HH 2, suggesting that the downstream gas was accelerated in previous outflow ejections. This far-out gas looks like it has been pushed loose from its parental molecular cloud, because it is now spread around a cavity, probably excavated by the protostellar outflow. The SO line emission is mainly detected in gas that has been shock-heated by the outflow. The strongest of these regions, HH 2H-A, emits UV radiation that has created a Photon-Dominated Region at the cavity boundary, as seen in the mid-infrared aromatic hydrocarbon bands and in the continuum between 5 and 17μm. This continuum arises from very small grains, probably shock-evaporated from larger grain mantles and then transiently heated to high temperatures by UV photons (Lefloch et al. 2005, A&A, 433, 217).

Disks around young stars: Sub-arcsecond imaging of molecular gas and dust in the non-Keplerian disk and envelope around the star AB Aurigae.

The IRAM Interferometer has been used to map the star AB Aurigae in ^{12}CO, ^{13}CO, $C^{18}O$, and in the dust continuum at 3 and 1.3mm. These observations show the structure of the circumstellar material around AB Aur in close-in regions where Hubble Space Telescope optical and IR imagery is blocked by light from the star itself (**Fig. 2.11**). The IRAM maps show that the environment of AB Aur is quite different from the protoplanetary disks around T Tauri stars like DM Tau. Instead of being centrally peaked, the mm dust continuum has a bright, asymmetric, arc-like feature at about 140 AU from the star. The molecular-line emission comes from a very extended flattened disk that is rotating around the star. Model fits to the position-velocity data indicate non-Keplerian motion, with a rotation velocity decreasing as $1/R^{0.4}$. The disk has an inner hole with a radius of 70 AU. The disk is warm, with a CO(2-1) temperature of 68 K at 100 AU, and there is no evidence for depletion of CO molecules onto dust grains. The departure from Keplerian motion may be due to the early evolutionary state of the disk, to a disturbance of unknown origin, or to a possible low-mass companion at about 40 AU from AB Aurigae (Piétu et al. 2005, A&A, 443, 945).

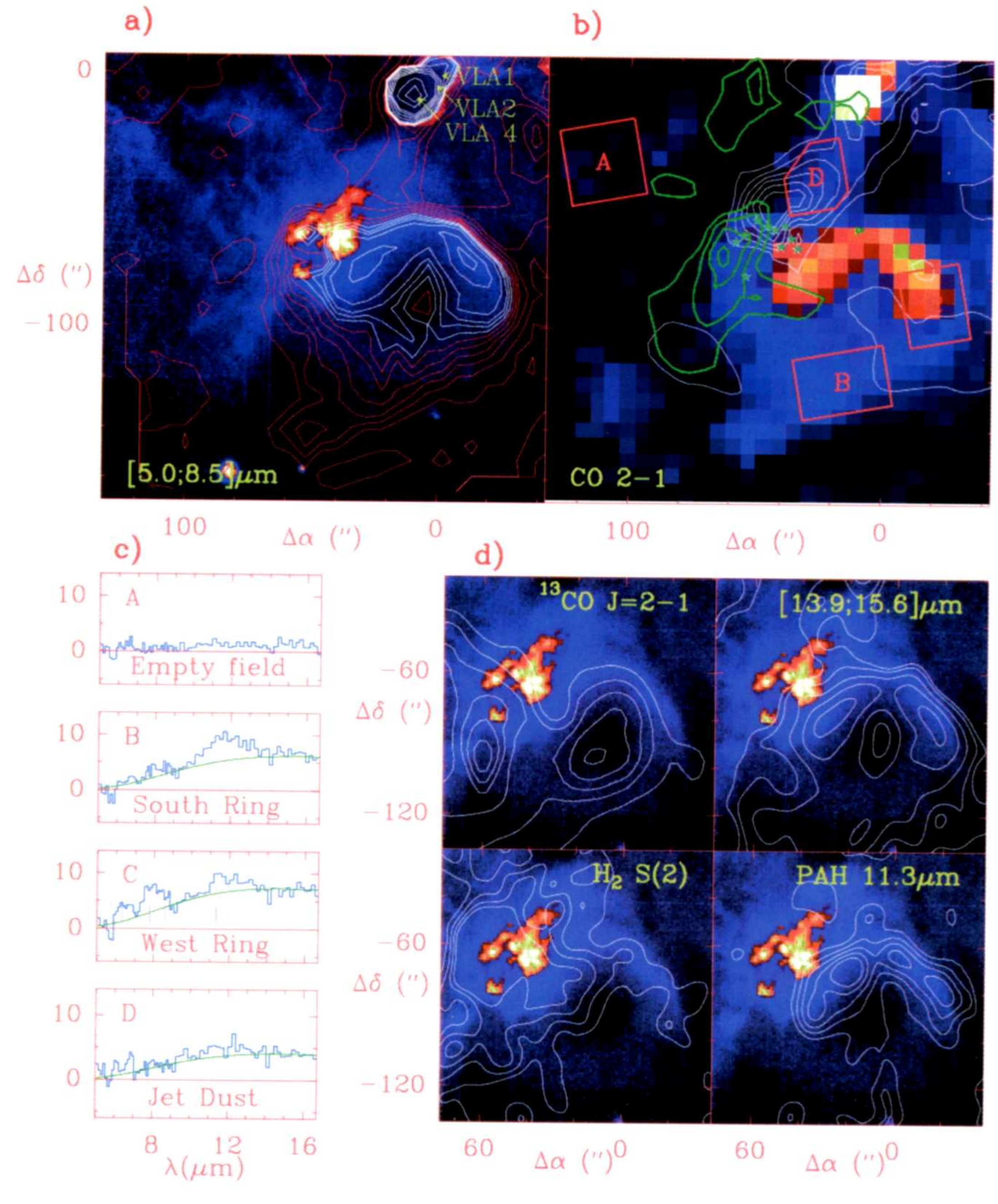


Fig. 2.10. Shock-induced PDR near the Herbig-Haro object HH 2. a): Mid-IR contours superimposed on an optical [S2] image (Reipurth 1993; the shock at HH 2 is red-yellow, fainter emission is blue). **b):** IRAM 30m map of $^{12}CO(2\text{-}1)$ in the flow moving toward us (green contours), and away from us (thin white contours), both superimposed on the mid-IR (red pixels). **c):** mid-IR PAH spectra, taken at the boxes in panel b). **d):** IRAM ^{13}CO map of molecular gas, compared with mid-IR continuum from hot dust, the H_2 line at 12μm from shocked gas, and the 11.3μm feature from aromatic hydrocarbons, all superimposed on the

optical [S2] image, in blue-red. The outflow comes from the upper right. The main CO peak is downstream from the shock at HH 2 (Lefloch et al. 2005, A&A, 433, 217).

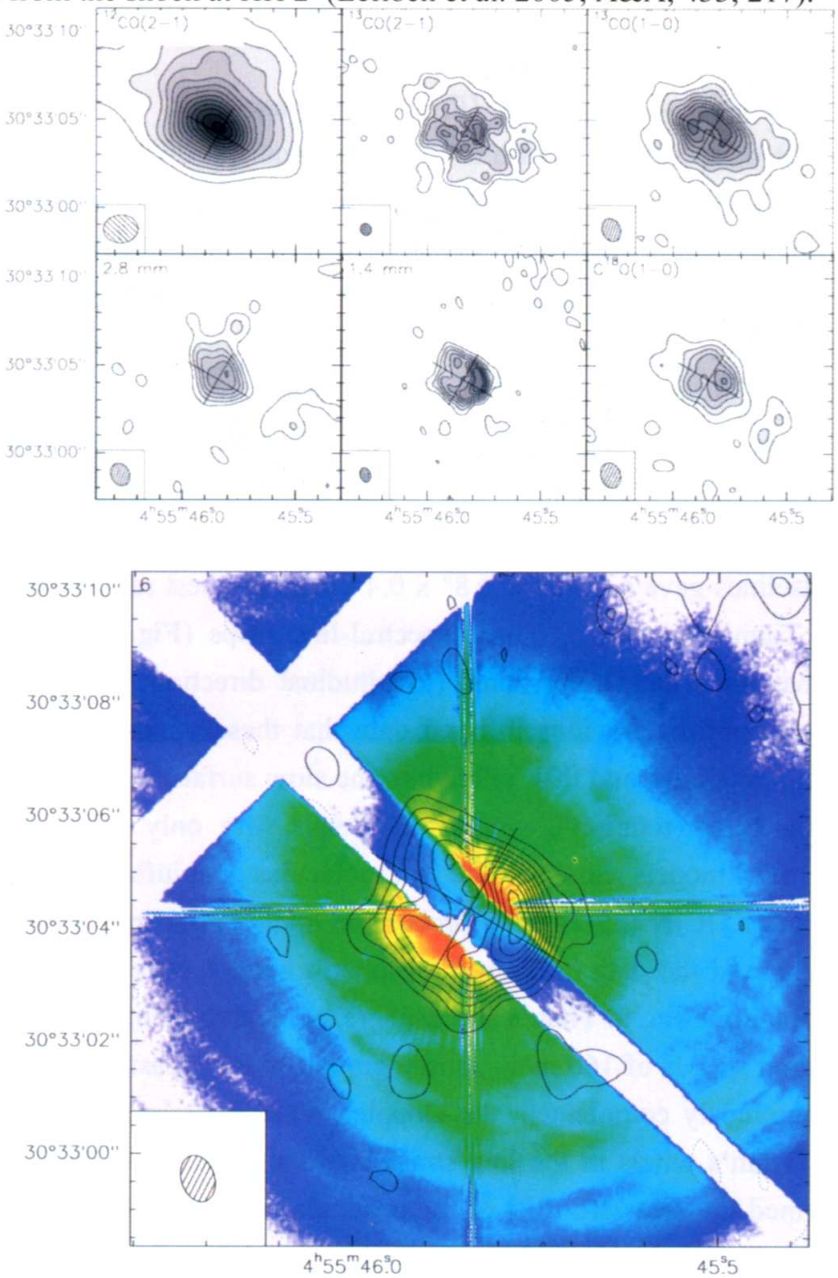


Fig. 2.11: IRAM Interferometer maps of AB Aurigae.

Upper: Integrated line and continuum emission around AB Aurigae. The upper panels show ^{12}CO and ^{13}CO, and the lower panels show the 2.8 and 1.4mm dust continuum, and the C^{18}O map. The synthesized beams are indicated in the boxes at the lower left of each map. The ^{13}CO map has the best resolution, 0.72"x 0.63", and the cross in each map indicates the directions of the major and minor axes of the AB Aur disk, as derived from the CO-line data.

Lower: IRAM 1.4mm continuum contours, superposed on the HST image from Grady et al. (1999; in false colors). The IRAM map, with a resolution of 0.85"x 0.59", can sample circumstellar material closer to the star than the HST, because the millimetre radiation comes only from the surrounding dust, while the optical imagery has to block out the bright light from the central star, and has no information within the stripes across the image that are due to the optical mask (Piétu et al. 2005, A&A, 443, 945).

SOLAR SYSTEM

Zonal winds on Titan measured with the IRAM Interferometer.

Titan is the largest of the planet Saturn's 47 moons, and the organic chemistry of Titan's atmosphere may resemble that of the primitive Earth about 4 billion years ago, and may give clues on how life arose on Earth. On January 14, 2005, the European Space Agency's Huygens probe reached the upper layers of Titan's atmosphere, and landed on the surface two and one-half hours later. What it found during its parachute descent basically confirmed wind measurements made during 2003 and 2004 with the IRAM Interferometer, that are described by Moreno et al. in 2005 A&A, 319, 437. In these ground-based measurements, the Interferometer observed the J=25-24 line of cyanoacetylene (HC_3N) at 227 GHz, and the four line components of the J=12-11 transition of methyl cyanide (CH_3CN) at 221 GHz. The interferometer baselines gave a beam of 0.8" x 0.4", with the best resolution in the east-west direction, along Titan's equator. These spectral-line maps (**Fig. 2.12**) show systematic Doppler shifts that trace the strong zonal (longitudinal direction) winds in Titan's upper atmosphere. They confirm previous infrared data that these winds are "prograde" (in the direction of Titan's rotation), and that, relative to the slow surface rotation of 12 m/s, Titan's atmosphere is in "super-rotation", similar to Venus, the only other known example. Atmospheric chemical models show that the two molecules give information on two different altitude regions. The HC_3N (25-24) line probes the middle atmosphere (mesosphere) at an altitude of 450 km, and the data indicate mesospheric wind speeds of 60 m/s. The CH_3CN (12-11) line probes farther in, to Titan's stratosphere, at an altitude of 300 km. Here, the data indicate higher wind speeds of 160 m/s. These ground-based measurements with the IRAM Interferometer thus nicely complement the Doppler Wind Experiment (DWE) on Huygens, which measured Titan's winds in the low stratosphere and the troposphere. These "on-the-spot" data confirmed the eastward drift of the prograde winds above an altitude of 120 km, but also found that the winds dropped to zero and reversed direction (to the west) below an altitude of 7 km, near the top of the tropospheric boundary layer.

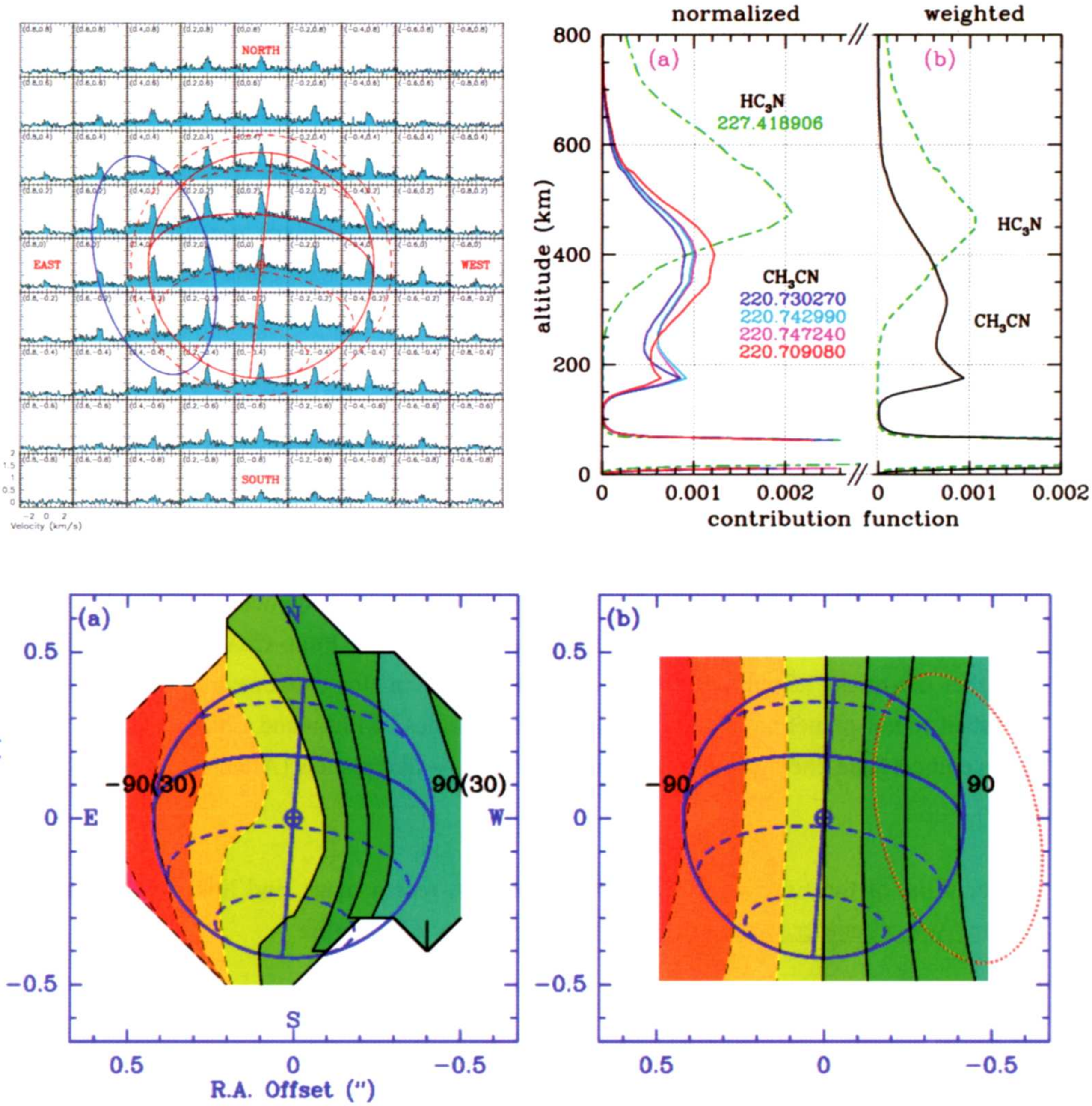


Fig. 2.12: IRAM Interferometer measurements of zonal winds on Titan. *Upper left:* Map of HC_3N spectra across Titan (red circle, diameter 5150 km, about 1 arcsec). The dashed circle indicates the atmosphere at an altitude of 400 km. The blue ellipse shows the 0.8 x 0.4 arcsec beam at 1.3mm. A similar map has been made in CH_3CN.

Upper right: Atmospheric model of Titan, showing the altitudes probed by the IRAM data.

Lower –left panel: Doppler velocity map from the CH_3CN data; dashed contours are negative velocities, solid contours are positive velocities, contour steps are 30 m/s.

Lower --right panel: Simulated Doppler velocity map, for a rotating sphere with an equatorial wind velocity of 170 m/s, convolved with the IRAM beam. The maximum predicted lineshift of 90 m/s agrees well with the observed map on the left. (Moreno et al. 2005, A&A, 437, 319).

Density estimates of Edgeworth- Kuiper Objects.

By early 2006, astronomers have catalogued about 1000 recently-discovered distant minor planets orbiting the Sun, mostly beyond the planet Neptune in a region known as the Edgeworth-Kuiper Belt. These distant objects have different reflection spectra from those of the well-known asteroids between Mars and Jupiter, and their composition may be unchanged since the formation of the solar system. For the brightest of these objects, with known orbits, one may use the blackbody formula and measured millimetre fluxes to estimate sizes. A new study has used the IRAM 30-m detection and size estimate with observations of the orbit of the binary Kuiper Belt object 1999 TC36 to determine its density, which turns out to be only 0.12 g/cm^3.

Applying this method to other known Kuiper Belt binaries, results in a mean density of 0.25 g/cm^3 for the statistical ensemble of binaries. Remarkably, these low densities are the same as the density of the nucleus of comet Halley, 0.26 gm/cm^3, derived from the molecular production rates and the resulting orbit changes. These low densities strengthen the idea that the distant minor planets ("Kuiper Belt objects") and the cometary nuclei are pristine, undifferentiated planetesimals. It also suggests that the Pluto-Charon binary, which has higher densities (1.9 gm/cm^3 for Pluto, and 1.6 gm/cm^3 for Charon) is not a member of the distant minor planet population. The higher densities of Pluto and Charon suggest that they have undergone chemical and thermal processing --- like planets (Altenhoff et al. 2005 A&A, 441, L5).

For a list of the Edgeworth-Kuiper Belt Objects, recent news, and links to other sites, see http://www.boulder.swri.edu/ekonews/ compiled by J.W. Parker.

The trans-neptunian object UB313 is larger than Pluto.

In 2005, new observations at 1.2mm with the IRAM 30m telescope were made of UB313, the most distant object known in the solar system (**Fig.s 2.13 and 2.14**). These new data yielded a flux density, S(250 GHz) of 1.27±0.26 mJy. This flux of the object at geocentric distance Δ is given by $S = (\pi d^2 / 4\Delta^2)\, B(T)$, where d is the diameter, $B(T)$ is the Planck formula, and T is the equilibrium surface temperature, which at millimetre wavelengths is only weakly dependent on the surface reflectivity. From this formula and the measured 30m telescope flux, the observers have determined a diameter of 3000 ± 300 km, which makes UB313 the largest known trans-neptunian object, even larger than Pluto (2300 km). Combining the millimetre data with optical data, yields an albedo of 0.6, strikingly similar to that of Pluto, suggesting that the methane seen in the optical spectrum causes a highly reflective icy surface (Bertoldi et al., 2006, Nature, 439, 563).

Fig. 2.13: Size comparison of the distant minor planet UB313. Indicated are the sizes of the asteroid Ceres, the planet Pluto, Neptune's moon Triton, the "tenth planet" **2003 UB313**, the Earth's Moon, Saturn's moon Titan, and Jupiter's moon Ganymede.

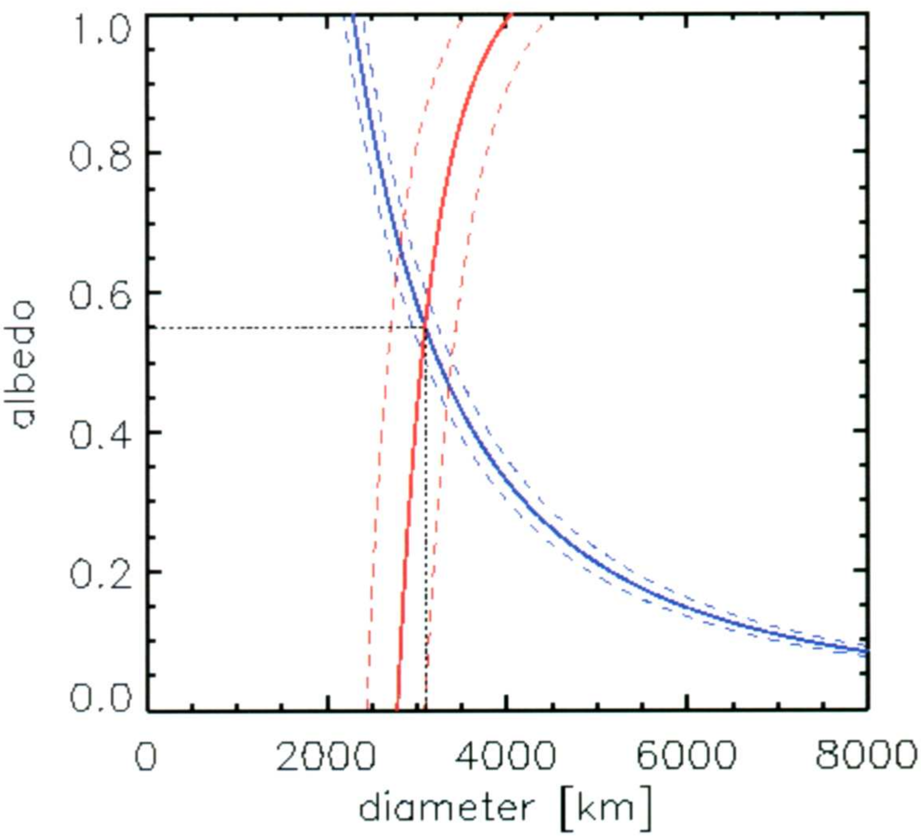


Fig. 2.14: The IRAM 30m telescope flux measurement yields an estimate of the size of the distant minor planet UB313. The optical brightness of UB313 gives a constraint on the diameter and albedo (blue curve). The 1.2mm flux measured at the 30m telescope gives the diameter directly (red curve). The intersection of the red and blue curves gives the best current estimate of both diameter and reflectivity (albedo) (Bertoldi et al. 2006, Nature, 439, 563).

3. PICO VELETA OBSERVATORY

3.1 STAFF CHANGES

In March, *Felipe Lara* from the logistics group retired. In June, *Axel Weiß*, the astronomer responsible for the bolometer pool observing, left IRAM to take up a position at the MPIfR in Bonn. In October, *Stéphane Léon* was hired in the Astronomy group. His main duty will be to manage the pooled bolometer observations. By the end of 2005, our telescope operators *Fernando Anel* and *David Martínez* left IRAM for a longer-term leave of absence. *Víctor Espigares*, formerly in the informatics group, became member of the operators' group. In December, *María Moreno* joined the logistics group as a cook/cleaning lady.

3.2 TELESCOPE OPERATION

Despite of the larger amount of technical time scheduled to test and install the New Control System (NCS) of the 30-m telescope, nearly 70% of the total time could be used for observations. This is mainly due to the extremely good weather conditions during the first half of 2005.

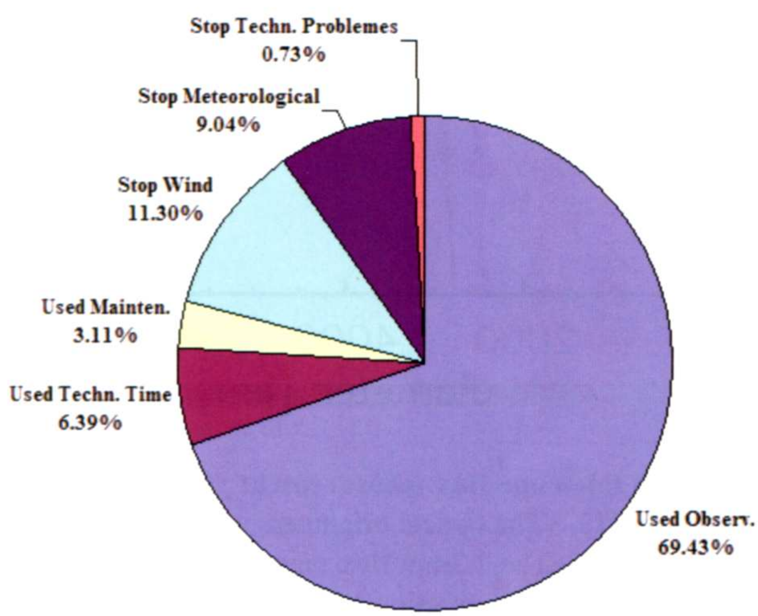


Fig. 3.1: Time distribution at the IRAM 30m telescope in 2005

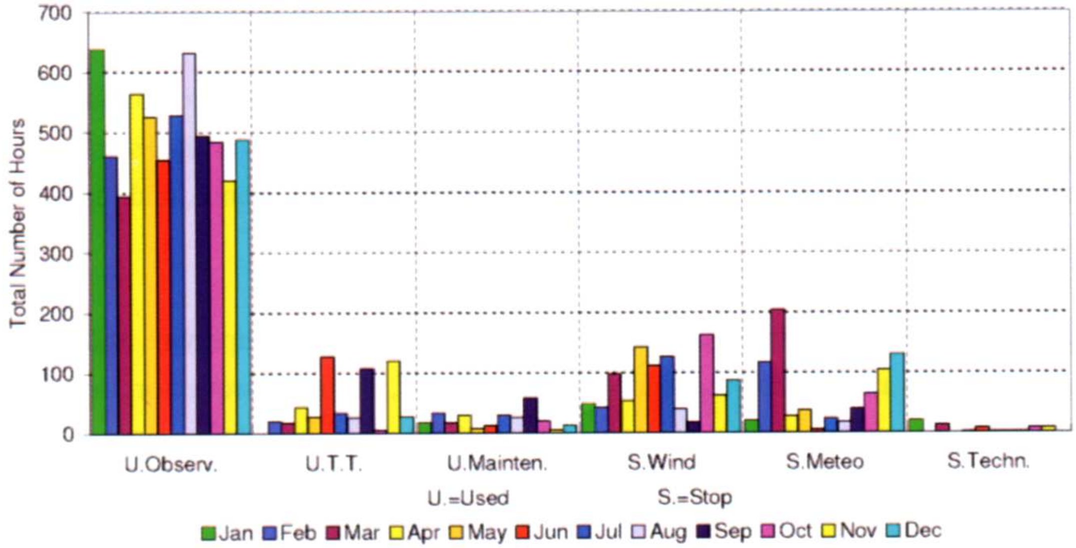


Fig. 3.2: Monthly time distribution at the IRAM-30m telescope (U.Observ.=used for observations, UTT=used for technical tests, U.Mainten.=maintenance time).

In 2005, about 110 projects were scheduled in the pool observing mode during the winter 2004/05, the summer 2005, and the winter 2005/06 periods. A substantial amount of the work went into the adaptation of the pool software system to the NCS. The completely new way of observing, and the new data format necessitated a complete revision of the data acquisition software into the MySql database, and of the interface with the data reduction package MOPSIC. It was decided to make these changes first for the bolometer observations because they represent the largest fraction of pool observations. By the end of the year, the pool system was nearly completely adapted to the NCS for the bolometer observations.

In a collaboration with scientists from the Instituto de Astrofísica de Andalucía (IAA), IRAM has started to develop new tools for an archive of radio data. The present focus is on the pool database. This activity is funded for three years by the Spanish Ministry of Science and Education, and is linked to the European initiatives towards an international "Virtual Observatory" (IVO).

3.3 ANTENNA AND ELECTRONICS

The main task of the antenna group has been to support the daily operation of the observatory. i.e. to intervene in case of problems with the equipment, and/or the setting up of the observations, to carry out the necessary, mostly preventive maintenance, and to repair/replace broken equipment

During 2005, long periods of time were dedicated to monitor, supervise and improve the integration of the antenna and the associated subsystems, i.e. the subreflector, the wobbler, the encoders, the inclinometers, the weather station, the backends, and the backend synchronization into the NCS.

In addition, the following activities were performed in the course of the year:

- Although new equipment usually consumes less power than old one, the increasing number of backends, computers and receivers made it necessary to acquire a new more powerful Uninterrupted Power Supply (UPS). This has successfully been installed at the observatory. The previous UPS, in operation since 1991, had a maximum output power of 100 KVA. The new UPS can deliver up to 250 KVA.

- The initial Sulzer design for the temperature control of the antenna heating system has been replaced by a digital control and a computerized monitoring program. In this way, the 1 K temperature oscillation of the antenna backstructure can be suppressed. In addition, the antenna heating is powered in a random way instead of the predefined sequence applied before. This should help to further improve the pointing stability and the efficiency of the antenna, but the effects still need to be quantified.

- The cooling liquid of the antenna temperature control system has been replaced by a new substance (R408A) that fulfills the recommendations of the Montreal Protocol. A qualified company has removed the old cooling agent for its ecological decomposition.

- All the antenna temperature control modules have now been replaced. Following the replacement of the module for the control the backstructure temperature in 2004, in 2005 the modules for the control of the quadrupod temperature and the glycol temperature of the primary circuit have been replaced.

- Antenna efficiency measurements have been performed (IRAM Newsletter 63). Table 3.1. shows the aperture efficiency at the measured frequencies. While prior to 1992 the aperture efficiency at 350 GHz was just 0.1, actual conditions predict a value of 0.23. We conclude that, technically, the 30m telescope seems now suitable for observations at frequencies above 300 GHz, which might be an option e.g. for zero spacing observations for the Plateau de Bure interferometer.

- A new electrical switching box, replacing the old one, has been installed in the observatory building at the level of the control room.

- Three high voltage cabinets, two for protection of both transformers and a third one for the measuring equipment, have been ordered and will be installed when the road is open again in the spring of 2006.

- A mobile phone detector has been installed in the control room of the observatory to prevent interferences.

Table 3.1: Measurements of the 30-m telescope characteristics in March 2005

Freq.(GHz)	F_{eff}	HPBW(")	η_A	B_{eff}
86	0.950 $\pm$0.015	28.3 $\pm$0.4	0.60 $\pm$0.02	0.76 $\pm$0.04
145	0.945 $\pm$0.021	17.0 $\pm$0.2	0.51 $\pm$0.02	0.65 $\pm$0.02
210	0.915 $\pm$0.019	11.8 $\pm$0.4	0.45 $\pm$0.06	0.57 $\pm$0.04
260	0.877 $\pm$0.020	9.5 $\pm$0.4	0.37 $\pm$0.04	0.46 $\pm$0.04

The 1 MHz and 100 KHz filterbanks were completely adapted to the new VME latch scalers and the CAMAC counters were substituted at the time of the NCS switchover. The 18 continuum V/F units of HERA 1 and 2 were also moved from CAMAC to VME latch scalers, and the control of the Distribution Box and 1MHz processor were implemented in VME as well.

In March 2005, all spare sampler boards for the VESPA autocorrelator had been used up. The failing component was unfortunately the most critical one: the fast comparator which was obsolete and without direct replacement. Given the critical importance of VESPA for most heterodyne observations and its unique capabilities (polarimetry, ultra-high resolution, etc.), a solution in the form of a small module that performs the same function using more modern components has been selected. The main difficulty was to fit the prototype module inside the board area of the single chip that it replaces: the module has 15 components and occupies 16.5x16.5 mm^2. These comparators actually have slightly better electrical characteristics (smaller offsets and faster metastability resolution. The prototype of the replacement module for VESPA sampler chips is shown in Fig. 3.3, on top of a 2 Euro coin. A few modules were hand assembled for prototyping and testing. The fabrication of a larger series, which should be sufficient for the rest of the life of VESPA, has been subcontracted to a Spanish company.

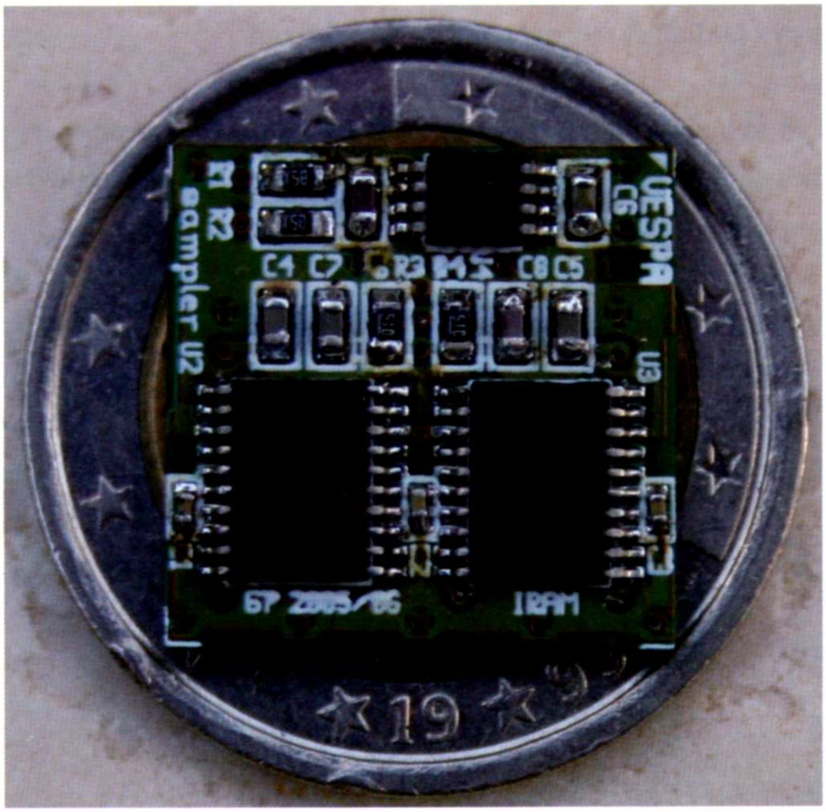


Fig. 3.3. Prototype of a new sampler for VESPA. A 2 Euro coin indicates its size.

Another problem, the occasional occurrence of spurious lines in VESPA spectra, was traced back to oscillations of the voltage regulators on the sampler boards. This was in turn caused by the failure of aging electrolytic capacitors, of which over 300 were replaced.

3.4 RECEIVERS

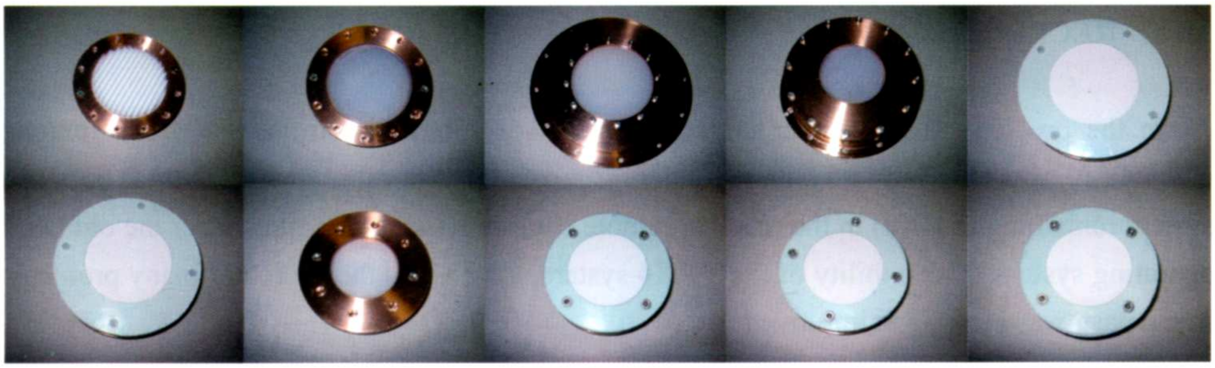
As in the previous year, another unit of the receiver control electronics (VRX1), running under OS/9, was changed into a more modern Linux crate. After this change, there is only one system remaining (VRX2) in the receiver remote control network that runs under the old OS/9 operating system. The stability of the VRX4 system, which was the source of many problems in the past, was also much improved.

The winter season was especially cold with temperatures reaching –24 C. Because of this, numerous problems occurred due to ice formation in the compressed air distribution and the water-cooling system for the HERA receiver. As a consequence, the heat exchanger for HERA had to be replaced and the freezing point of the cooling liquid had to be decreased to –30 degrees.

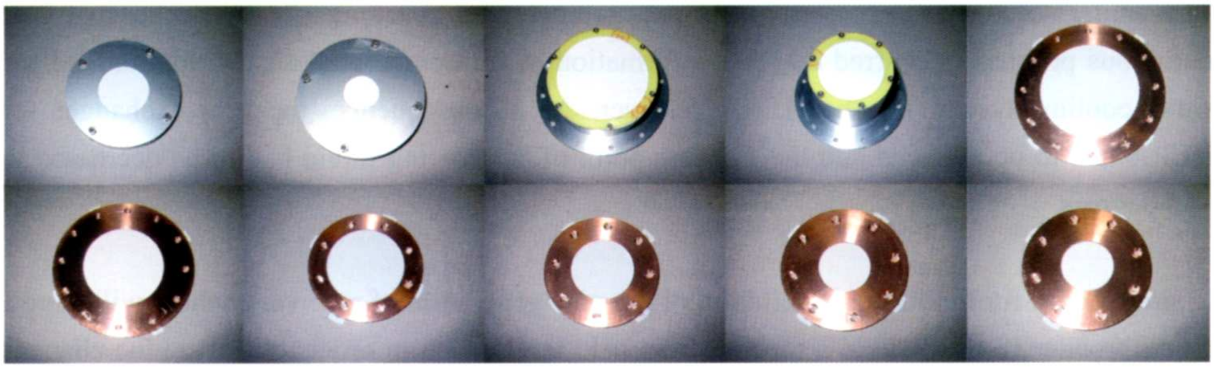
In preparation for the future installation of the new generation of receivers, which will have a much broader IF bandwidth, a meeting was held in Granada in order to analyze the changes that will be needed to adapt the present backend system to the new receivers. The results have been written up in a document. As a first step, a second set of ten high quality coaxial cables was installed at the telescope.

The remote control and diagnostic capabilities for the current receivers was further improved by the addition of phaselock IF monitoring and remote readout of the pressure in the vacuum circuit of all cryostats. The data are accessible on the IRAM local web page.

Work on infrared filters, and on the testing of windows for the ALMA project continued during most of the year. Latest measurements indicate that the problem of fractures and cracks, found on the windows and linked to the molded fabrication process, was finally solved. Figure 3.5 shows the measured results of two sample materials subjected to an over pressure of three Bars. Sample F is the latest material under test with a more refined processing procedure- note the reduced deformation and extended time. The last four sets of infrared filters, including a new design for the band 1 and 2 - 15K stage, were finished and delivered to Rutherford Appleton Laboratory (R.A.L.) With this delivery all the infrared filters for the first eight cryostats are completed.



110K set



15K set

Fig. 3.4: Infrared filters for the ALMA receivers

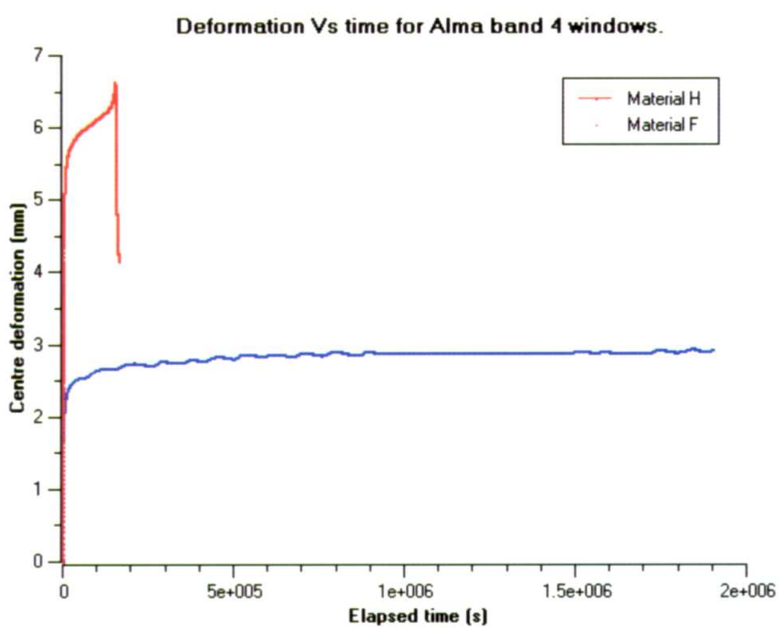


Fig. 3.5: Window deformation (in mm) at 3 bar over-pressure as a function of time. Material H shows a well-defined rupture point whereas material F is still rupture free at the time of writing this report.

A group at the Goddard Space Flight Center (G.S.F.C.) is currently developing a transition-edge superconducting (T.E.S.) bolometer array of 8 by 8 pixels (possibly 8 by 16 pixels). It has been agreed that this instrument will be tested at the 30m telescope. Two members of the instrument design team visited the telescope in order to discuss the mechanical, optical and data interfaces to the telescope. The instrument is expected to be ready for installation by the end of 2006.

3.5. VLBI

In April and October, two global 3mm VLBI sessions of five days were successfully carried out. In addition, two successful tests (2 nights) were done within IRAM (PV and PdB) in order to investigate the cause of phase jumps observed in the PdB VLBI data, and to qualify the New Control System behavior in the VLBI observing mode at PV.

The Mark5 recorder was equipped with a new power supply due to the increasing capacity of disks (actually 400GByte) and the resulting higher power demand.

A Base Band Converter (BBC) of the Data Acquisition Rack was broken and the necessary repair was carried out locally with the support from other institutes. Jodrell Bank supplied a replacement for the no-longer produced and otherwise difficult to find integrated circuit. The VLBI community greatly benefits from this kind of cooperation between different institutes.

3.6. COMPUTERS AND SOFTWARE

During 2005, much of the activity in the IRAM Granada computer group was dedicated to the New Control System (NCS). A new server system was installed with the new computer that will run as the central system of the NCS. The new system has two processors and ten 200GByte Sata disks that are configured to form a fault tolerant RAID system. A new tape drive can store up to 400GByte with a transfer rate of 80MBits/s. We also have a backup system that can replace the fileserver and normally is used for data analysis.

The software to handle projects and to create CDs/DVDs with user data had to be adapted to the NCS. As requested in particular for pool observations, the observer now can use two computers with a total of four 19inch monitors. Monitoring software to supervise the computers and the processes running had to be adapted to the new control system. We continued to move old data from tapes and DATs to CD-Rom disks. This task is not yet finished.

As the NCS requires major modifications at the remote observing stations, remote observing will be not available during the first few months under NCS operation. It will be put back into operation in 2006.

Internet telephony has successfully been used between Granada and the Pico Veleta Observatory for NCS tests, remote observing from Granada, and telephone conferences. It has also been used between Granada and Madrid, and it is expected that more sites will use this option in the future.

The radiolink between Granada and the Pico Veleta observatory started to fail again. A new system had to be ordered that will raise the communication capacity to 11MBits/s full duplex. It has recently become operational, after a period where IRAM was using leased equipment.

A very important milestone was reached in November 2005, when the 30m-telescope operations were switched from the old system to the new hardware and software, built on VME and Linux standards. This step had taken several years of design and development work. It was carried out by an NCS core team with eight IRAM staff members, located in Granada and in Grenoble. In addition, other staff members carried out related work on data processing software.

For early observations, only a limited set of features was supported. More have been added in the meantime or will be added in the near future. Since December 2005, observations have been possible with the single-pixel heterodyne receivers and the bolometer. The 4 MHz and 1 MHz filterbanks and VESPA (autocorrelator) are supported as well as the continuum backends, including ABBA for the bolometer.

All four standard "switching modes" can be used, i. e., total power-, beam-, and frequency-switching, as well as the wobbler mode. Supported observing modes include calibration for heterodyne receivers, pointing, focus, tip (for bolometer), track (single position with frequency switching), ON-OFF, and On-The-Fly (OTF) maps.

Only observations of planets and sources in the Equatorial J2000 system are well tested up to now, with offsets in the radio projection, in true-angle horizontal coordinates, and in the Nasmyth system, i. e., for receiver pixels that are offset from the main axis.

The observer interacts with the NCS through a new command-line interface nicknamed "paKo" using the usual SIC interpreter. Most paKo commands are similar to those in the old control system, but already prepared for additional flexibility. The full paKo program can run detached from the rest of the NCS, e. g. for preparing and testing source and line catalogs and scripts for the setup of hardware and of observing modes.

Most data are acquired continuously in independent data streams, which are then automatically combined into raw data files in FITS format. For heterodyne and spectroscopy data, new software (MIRA) can read data from these FITS files and analyze and plot calibration, pointing, and focus measurements. MIRA also applies calibration results to the data to plot calibrated spectra and write them to files in CLASS format for further processing. Up to now, MIRA has been used manually, but for standard observations it will be automatic in the near future. The MOPSIC software plays a similar role for bolometer data.

Up-to-date news and notes about the NCS are available to visitors on a set of dedicated Wiki pages at the observatory. This Wiki system includes pages where observers can write down requests and suggestions. This feedback has already helped significantly to make the NCS more reliable and easier to use.

In early 2006, observations with HERA and WILMA will become possible with the NCS, as well as additional observing modes, and the switch to other coordinate systems. Also, completely new options and observing modes are in preparation.

Information about the NCS, including the user manual, is available at the IRAM Granada website.

3.7 INFRASTRUCTURE

The road from Borreguiles to the telescope had to be repaired in the summer of 2005, and a new concrete gutter was installed to better cope with the water from melting snow in spring.

After 22 years, new floor coverings were installed in most of the dormitories at the observatory, and several new shelves have been installed in the observatory library.

3.8 SAFETY

Two heavy trap-doors in the antenna tower which have to be open while equipment is carried up to the receiver cabin (helium, nitrogen, receivers etc.), have been equipped with motors (Fig. 3.6) to facilitate their operation and to improve the safety.

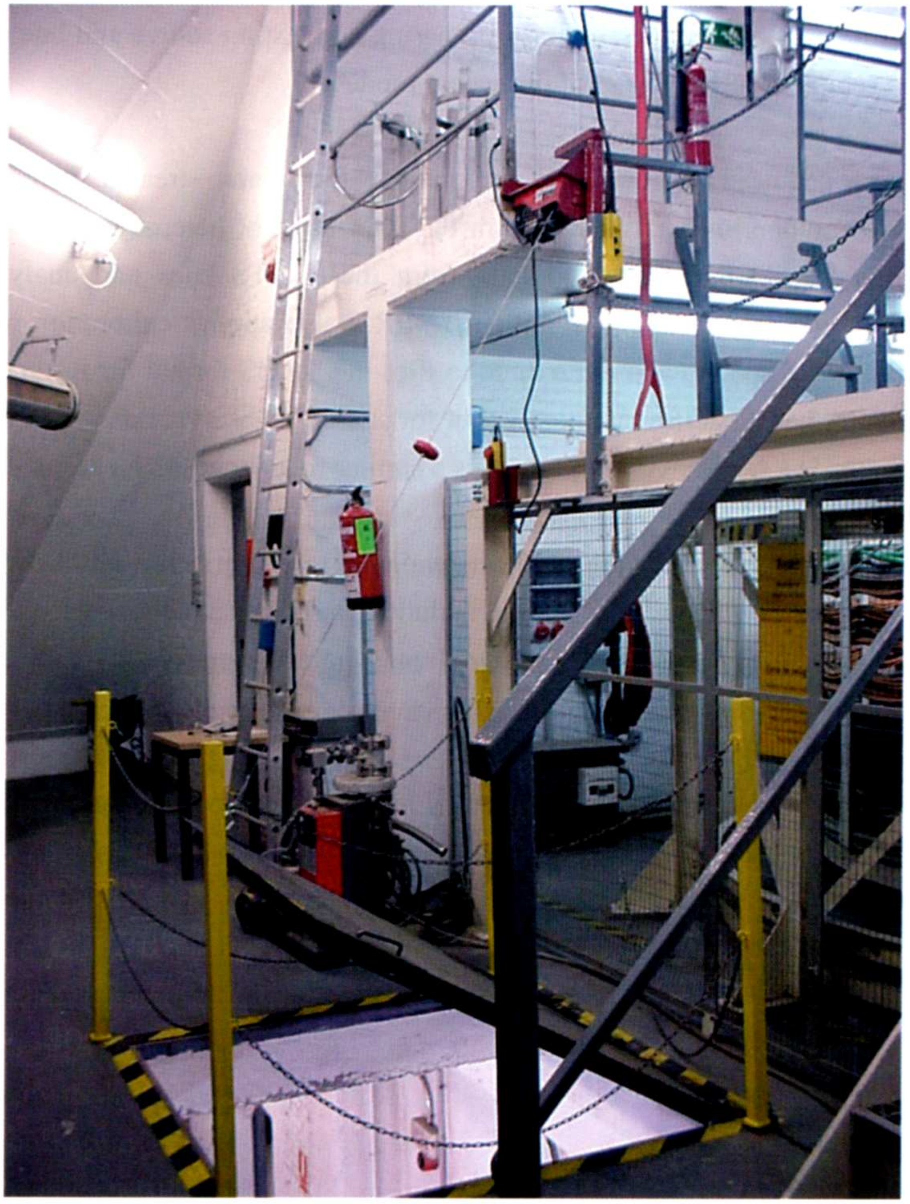


Fig. 3.6: The trap-doors in the telescope tower are now operated by motors.

The IRAM staff received a training course on general safety issues in January, and a training course on the basics of first aid in October. Both training courses had been subcontracted to the "Outside Prevention Service". An automatic external defibrillator (AED) was purchased for the observatory (Fig 3.7), and 8 staff members who usually work at the observatory received a special training for its operation.

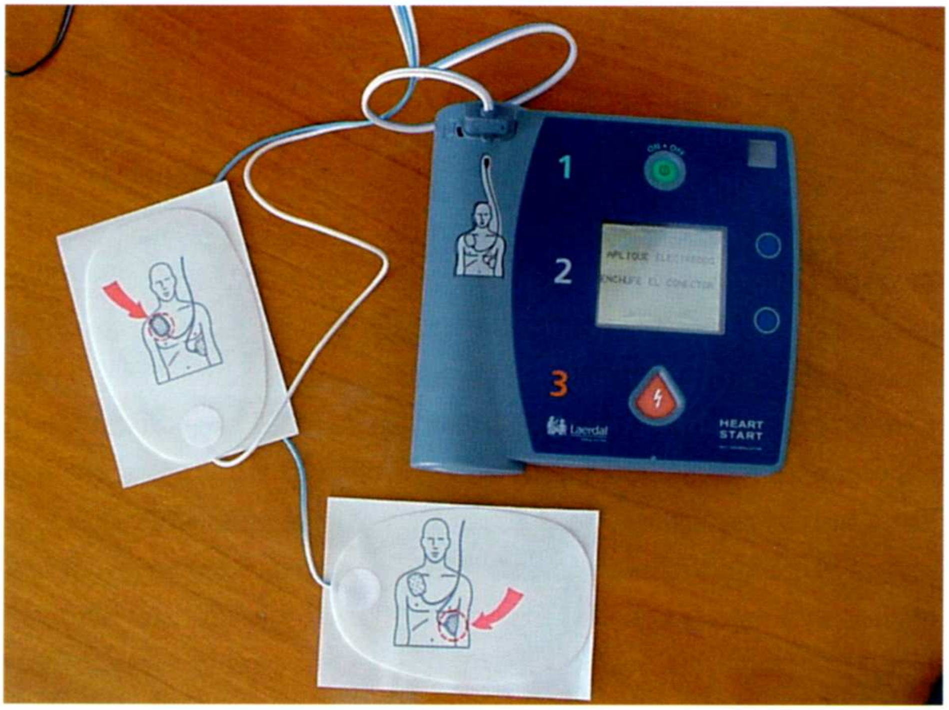


Fig. 3.7: An automatic External Defibrillator is available at Pico Veleta Observatory for emergencies. The staff has been trained in how to use it.

3.9 MISCELLANEOUS

IRAM has anxiously been following plans of CETURSA, the company operating the Sierra Nevada ski resort, to construct a tunnel for skiers, which would pass very close to the telescope (only about 50m away). The Station Management and the IRAM Direction have expressed their concern to CETURSA that the construction work could harm the telescope and the observations.

A meeting of the EU funded RadioNet Synergy Group was hosted by IRAM Granada in the spring. During one week in October, the third IRAM Observing School was organized in Pradollano. In total, 45 students (53% of them female) from 20 different countries attended the school. Ten lecturers and teaching assistants participated in the teaching which included lectures, tutorials and observations with the 30-m telescope (Fig. 3.8). The aim is to attract new users for existing and future mm-telescopes.

Fig. 3.8 Participants of the IRAM Observing school are performing their first observations with the 30m telescope under the guidance of one of the teaching assistants (photo courtesy of Th. Cavalie).

4. PLATEAU DE BURE OBSERVATORY

4.1 OBSERVATIONS

The Plateau de Bure Interferometer performed according to expectations with almost no downtime due to equipment failure during scheduled observations. The winter weather conditions have been particularly favorable at the Plateau de Bure, with almost no snow (contrary to other regions in Europe) and with long periods of excellent phase stability and low atmospheric opacity. More specifically, the weather conditions on the site were excellent in February, March, November and December, relatively good from spring to fall, and rather poor in January. The percentage of telescope time scheduled for observing programs was on average 50% of the total time (up to 60% from January to April). Additional 10 to 15 percent were spent on receiver tuning, testing equipment, surface adjustments, VLBI testing and antenna maintenance as in previous years. The remaining 35 to 40% were lost to poor weather conditions.

The strong pressure on the observing time at Plateau de Bure means that only the best rated programs can be executed. In total, more than 114 different projects, including 2 proposals for Director's Discretionary Time, were scheduled at the PdBI in 2005. These projects correspond to 88 accepted programs, with almost equal weight on galactic and extragalactic science. The full list of proposal titles, authors, lines observed etc. is given in Chapter 7.2. This list demonstrates the broad scientific potential of the Plateau de Bure Interferometer. The periods April 14 to 18, and October 14 to 18 were reserved to coordinated 3mm VLBI continuum observations together with several other radio observatories in Europe and the United States.

Despite the limited ability to carry out configuration changes in winter conditions, it has been possible to successfully schedule all four (ABCD) configurations of the interferometer in 2005. To optimize the observability of A-rated projects with respect to Sun avoidance limitations and weather constraints, the scheduling of the A and B configurations was readjusted shortly after the beginning of the winter 2004/2005 period. As in previous years, between spring and fall a large amount of observing time in the D configuration was invested into the detection of line-emission from carbon-monoxide in high-redshift galaxies.

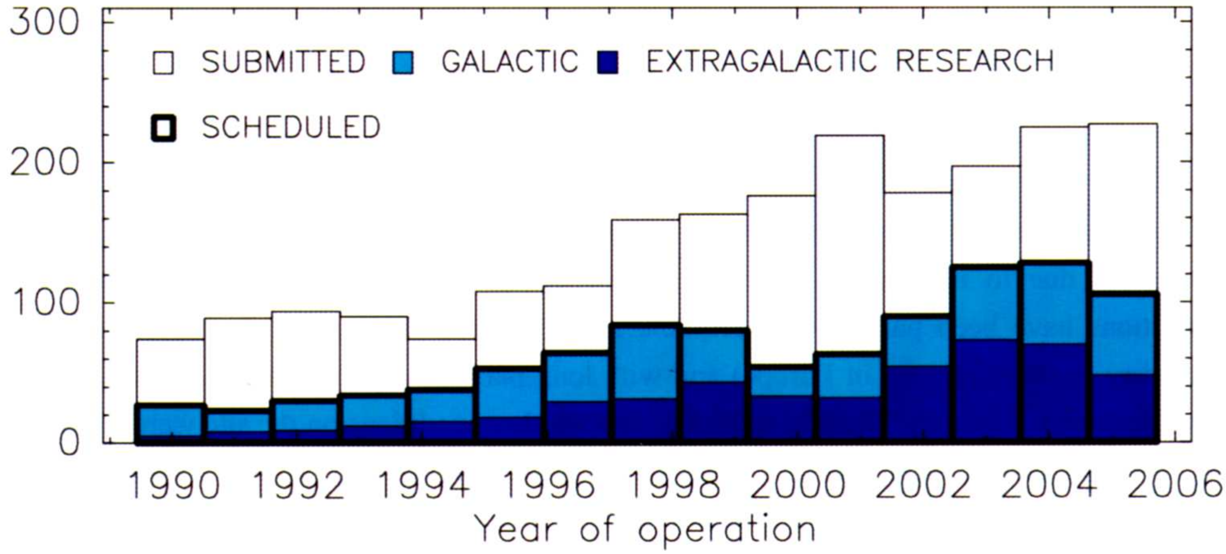


Fig. 4.1: The number of scientific proposals scheduled on the Plateau de Bure Interferometer from May 1990 to May 2005. The average pressure factor was 2.3 in 2005. The LST range covered by the Orion and Taurus regions is one of the most oversubscribed in the winter period.

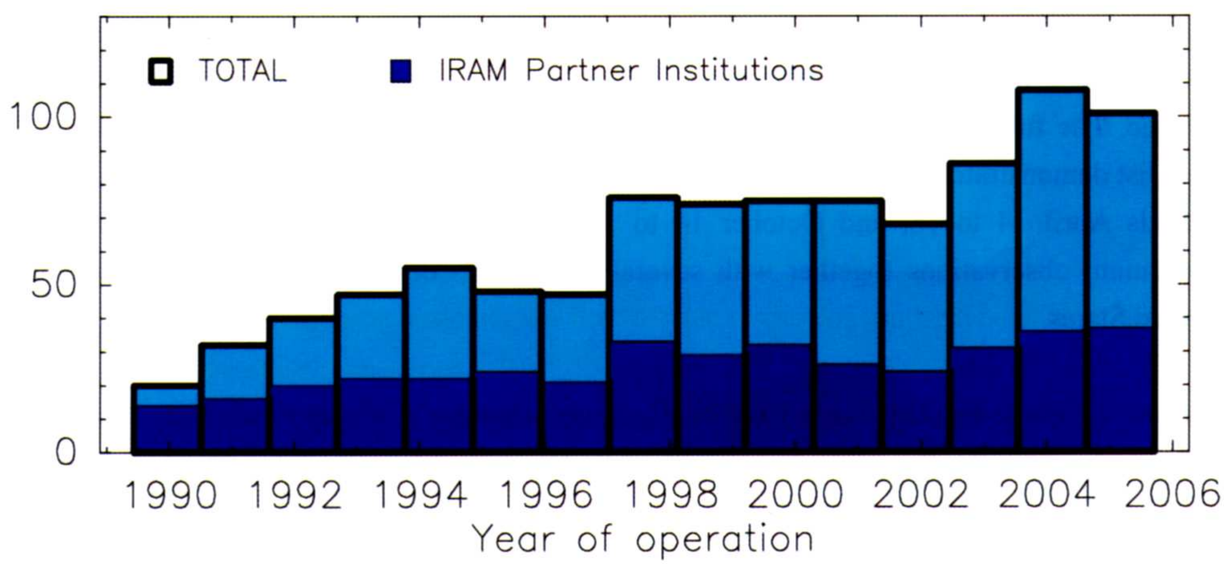


Fig. 4.2: The number of institutions represented annually by users having submitted a proposal for observations with the Plateau de Bure Interferometer.

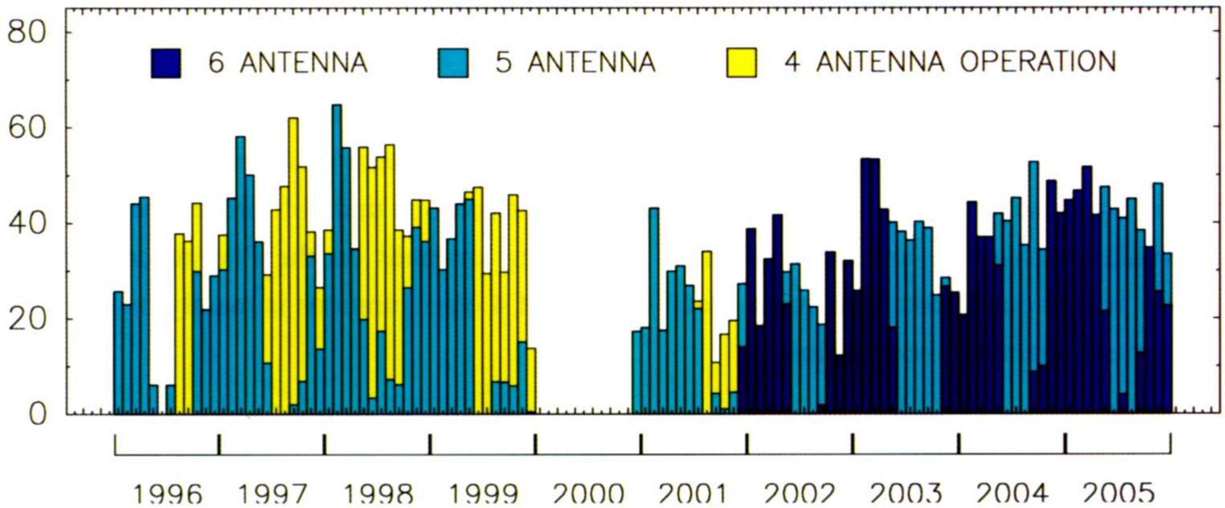


Fig. 4.3: Percentage of net-integration-time used for astronomical observations in the last ten years. In the May to October period, which coincides with the annual maintenance period, observations are in general made with a subset of the six-element array. Antenna 5 became operational in the summer 1996, Antenna 6 at the end of 2001. As a consequence of the accidents, observations had been stopped from December 15, 1999 to December 1, 2000.

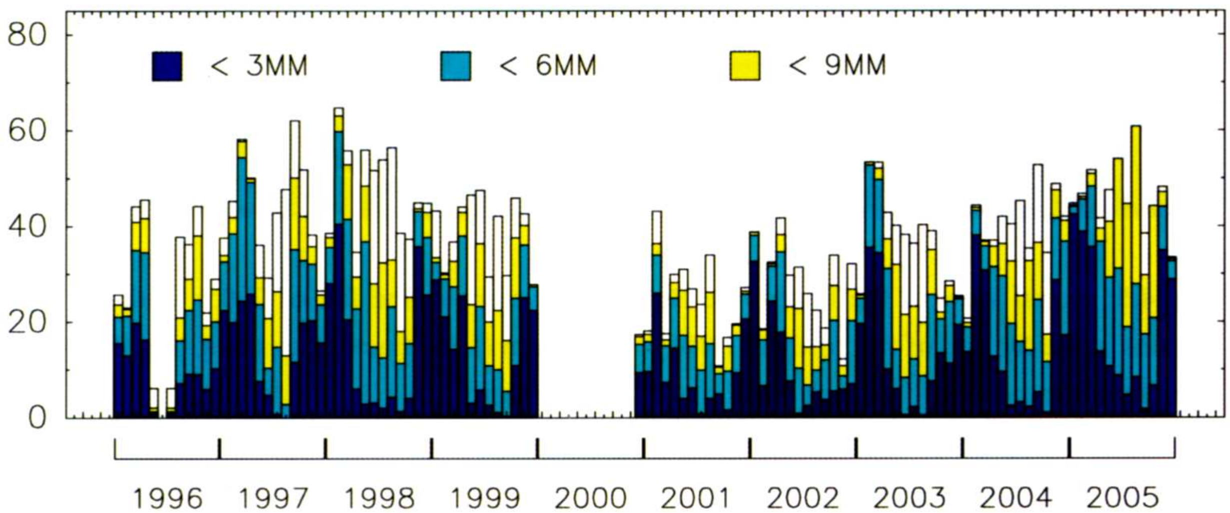


Fig. 4.4: The atmospheric water vapour content recorded on the Plateau de Bure since January 1996. Observations in the high frequency window (202 to 245 GHz) and observations in extended configurations are for the most part carried out in the winter months.

4.2 NEW CONFIGURATIONS OF THE PdB ARRAY

Work on the northern and southern track extensions was finally completed at the beginning of November. With two new stations at the far ends of the eastern (E68) and northern track (N46), a new set of configurations was defined as the result of a trade-off process between the optimum uv-coverage and the difficulties of moving antennas on the Plateau de Bure in snowy winter conditions. The current total number of 4 configurations is mainly imposed by the current operational constraints.

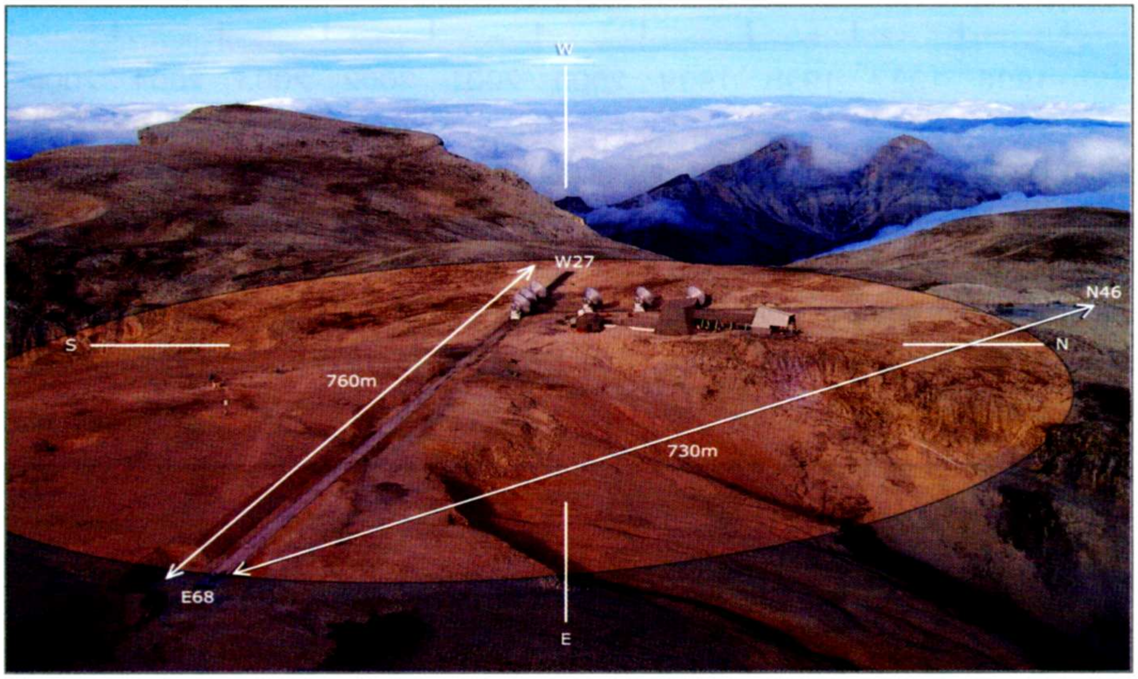


Fig. 4.5: Aerial view of the Plateau de Bure Observatory in the fall of 2005. With the new stations at the far end of the northern (N46) and eastern (E68) track extensions, the Plateau de Bure Interferometer will provide baselines of up to 760m.

With the new stations E68 and N46, the six-element array will observe on baselines of up to 760m east-west (+86%) and 368m north-south (+59%) with only 4 primary configurations. Despite this small number, the new configurations and their combinations result in synthesized beams with low sidelobe levels and a wide range of spatial resolutions, and provide a major improvement (a factor of 2.5) in the surface resolving power of the six-element array.

The four entirely new configurations range from the most compact (D) to the most extended (A). The design of the configurations has been a product of careful considerations, which are outlined together with the properties of the new beams in a publication (Karastergiou et al.

2006, ApJS). The primary aim has been to find configurations that result in close to circular beams with low sidelobes, and can be combined in pairs to better sample the uv-plane and achieve a variety of spatial resolutions. The most extreme (A and D) configurations were optimized first, the slightly less extended configuration (B) was adapted to match the uv-coverage of the A configuration and the last configuration (C) was designed to complement both B and D. The new configurations will be applied for the first time during winter 2005/2006 scheduling period.

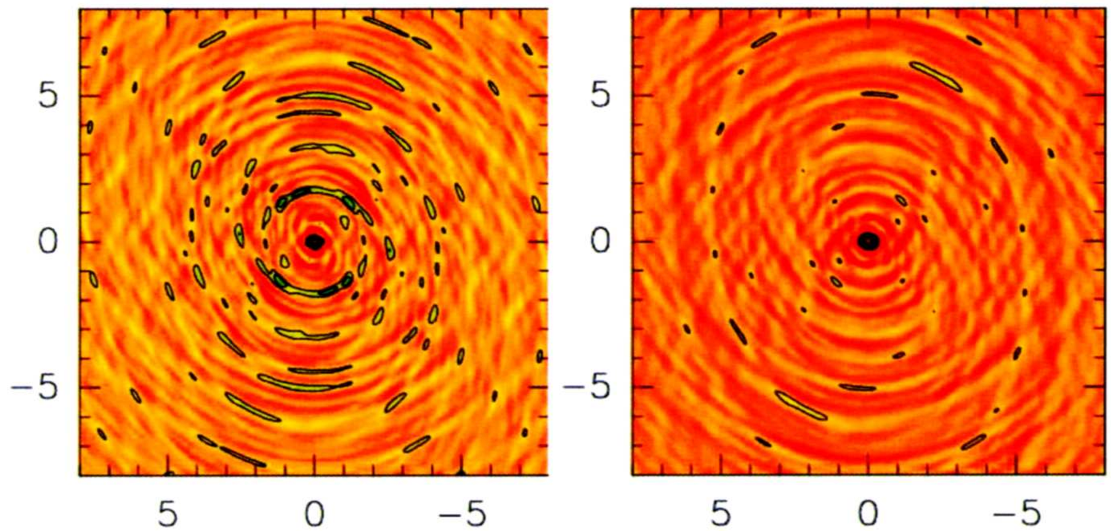


Fig. 4.6: Synthesized beams of the new A configuration (left – angular resolution is 0.30" x 0.24" at a frequency of 300 GHz in the primary beam of the Plateau de Bure antennas), and of the AB configuration (right - 0.35"x0.30"). Note the excellent sidelobe level (5%) of the AB configuration. The New Generation Receivers will permit observations up to an observing frequency of 370 GHz.

4.3 VLBI OBSERVATIONS

The Plateau de Bure phased array increased its sensitivity with the identification and removal of a parasitic phase noise. A 12 hour test observation on February 8th between the Plateau de Bure and Pico Veleta showed that the responsible element was a frequency generator. The phase noise disappeared when it was exchanged against a spare. Numerous other tests on the phasing, fringe tracking and sub-array definition in VLBI mode were performed at the same time, which the Bure system all passed successfully. In parallel, Pico Veleta tested the new functionalities of the new telescope control software (NCS) for VLBI.

For the test and during the April 2005 Global VLBI session, the PdBI operated with the EFOS-1 frequency standard on loan from the geodetic VLBI station Wettzell, Germany. The EFOS-1 maser was then returned to Wettzell, and the repaired CNRS maser, in use before, took its place again. With the removal of the parasitic phase noise, the potential of the Plateau de Bure for future high frequency VLBI observations has been confirmed, and IRAM (with a substantial financial contribution from the MPIfR Bonn) proceeded to order a new maser from the Observatoire de Neuchâtel, Switzerland, which will be delivered in the summer of 2006 to replace the aging CNRS maser.

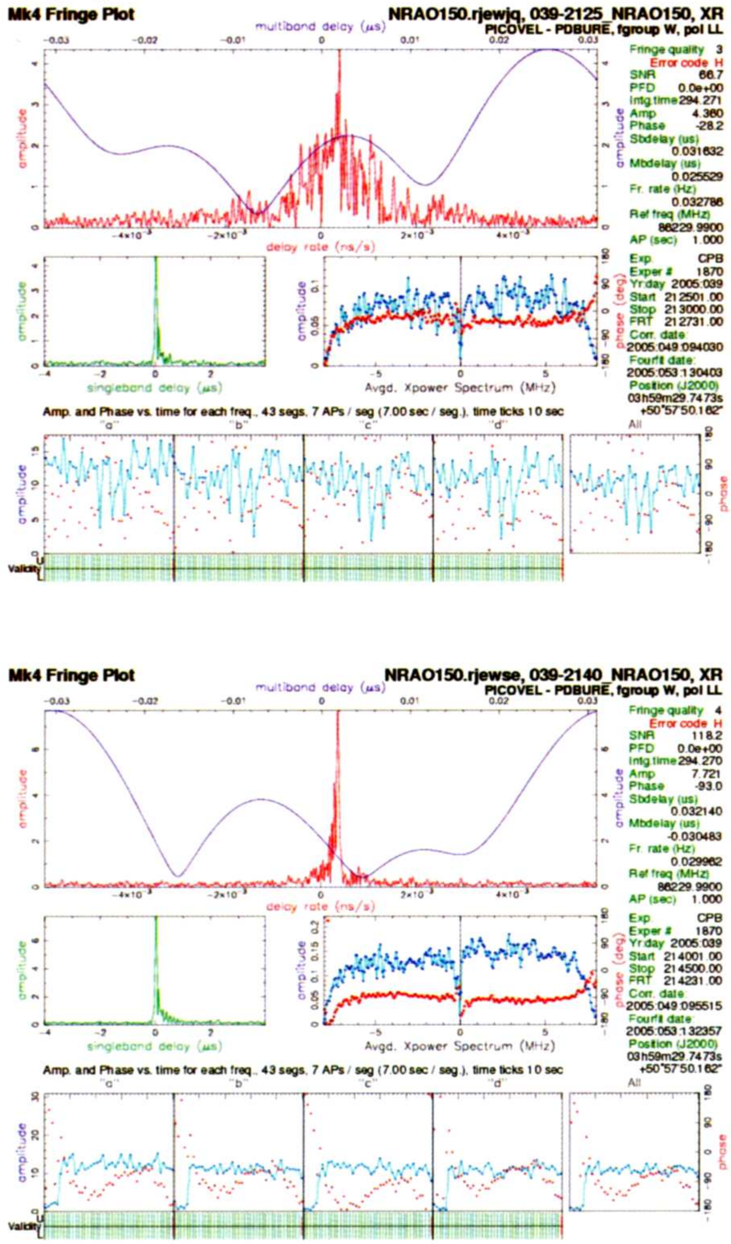


Fig. 4.9: Identification of the spurious phase noise in the PdB VLBI data. The upper plot shows observations with the unstable frequency generator, the lower plot with the stable one (the first seconds of the lower plot are perturbed by the switching).

In the Global VLBI session in April 2005, four regular projects were scheduled, plus one Director's time proposal on SGRA*, and a polarization test observation. Pico Veleta participated to 87.8%, PdB only to 16.5% due to bad weather. The polarization test showed that additional software needs to be developed before the PdB can join in regular dual-polarization VLBI observations. The fact that Bure suffered from bad weather for a number of VLBI April sessions motivated a detailed study of the PdB weather statistics, which indicates that the weather patterns in April have changed over the last eight years. For 2006, the Global VLBI session has therefore been shifted to May to improve the probability of good 3mm weather.

In the Global session in October 2005, eight regular projects were scheduled. This time PdB observed for 90.3% of the time, and Pico Veleta during 41.3% (due to bad weather).

4.4 MAINTENANCE

As in previous years, the maintenance of the interferometer was carried out during the summer. The logistics support group, located at the Grenoble headquarters, coordinated the activities. The group also organized the training and working schedule of personnel recruited on fixed-term contracts (as in previous years, 3 mechanics were hired during this period to ensure that the maintenance work on each antenna did not exceed 3 weeks), scheduled transports by helicopter or transports on ground, provided assistance to the Observatory staff when needed, and coordinated all other technical activities.

4.5 ANTENNA AND EQUIPMENT IMPROVEMENTS

Antenna surface improvements

The loss of surface reflectivity detected on antennas 1, 2 and 4 in the fall of 2004 has been a problem of rising concern. The Hostaflon film that covered the surface panels of these antennas was removed in the summer of 2004 from a large number of panels in all cases where reflectivity losses were considered too important, or where the risk of delamination of the underlying carbon fibre support seemed too high. It had been decided to refurbish these panels with a reflective layer of silver, and to protect them with white cover paint. Owing to a problem in the application of the conductive silver paint, large reflectivity losses were unfortunately found on a number of the refurbished panels. This effect was understood in the spring of 2005 when laboratory tests showed that the losses were a caused by the drying process of the metallic silver paint at room temperature. Losses of less than 2% were achieved by drying the silver paint at temperatures of 80^{o} C before putting the protection layer of white paint.

The long-term behaviour of painted panels seems encouraging. No significant signs of degradation or loss of reflectivity were detected in the silver painted panels of antenna 6; these were painted in the summer of 2001.

On the basis of this learning process, a few hundred panels were removed from the surfaces of antennas 1, 2 and 4, refurbished using the improved painting procedure and placed back. The Science Operations Group (SOG) of the Plateau de Bure interferometer provided technical support to readjust the surfaces of these antennas, using a dedicated surface readjustment technique. Holographic measurements were first made for each antenna to measure deviations from the ideal parabolic surface. The phase pattern obtained on surface rings 5 and 6 was then compared to measurements obtained with high-precision level gauges (see Fig. 4.7) to provide corrections accurate to a few microns. This method proved to be very particularly interesting for the outer surface rings which are more difficult to measure accurately by holographic techniques because of the illumination pattern of the antennas. Furthermore, this method for adjusting the surface can be applied in the hangar, thereby reducing the demand for excellent weather conditions that are needed for holography. While surface panels of ring 5 and 6 were readjusted with this new method, panels from the inner rings were corrected iteratively using holographic measurements on astronomical targets.

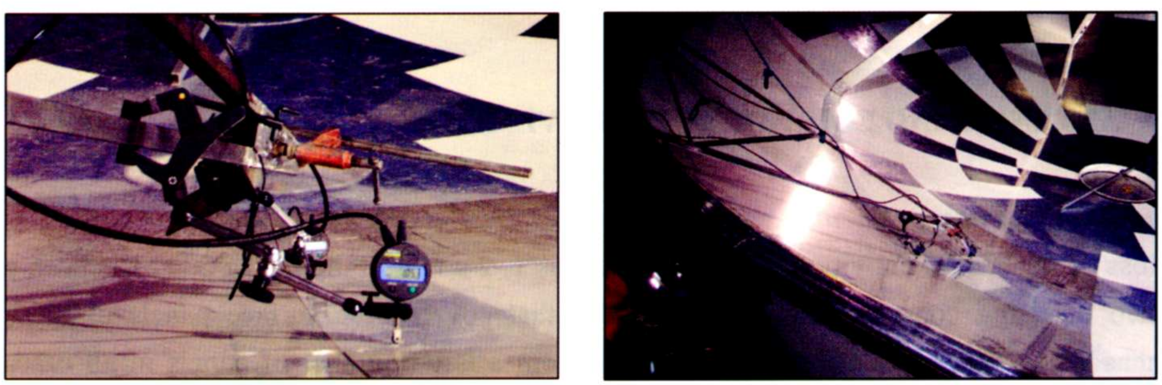


Fig. 4.7: High-precision gauges on the top and bottom of a ring 5 panel on antenna 4. *Left side:* the measurement device; *right side:* Global view of the mounting with gauges and support arm. Because of the quadrupod legs, this surface measurement technique works only for ring 5 and 6 panels.

In parallel, a study is ongoing to assess the long-term performance of electroformed Nickel panels (developed by the Italian company MediaLario) as a replacement for the carbon fibre/Hostaflon panels. The monitoring of two MediaLario panels, mounted on a rigid and unsheltered platform, tilted at an angle of 30° facing the south and the north, and exposed to sunlight and changing weather conditions, is under way since March 2005. At the end of the maintenance period, it was decided to equip antenna 4 with 18 MediaLario panels (4 panels on ring 4, and 6 panels on rings 5 and 6, respectively), and to arrange these in a uniform way to minimize asymmetries in the back structure because of their higher weight. A thorough inspection of the panels and a detailed report on their behaviour will be established in the summer of 2006.

Fig. 4.8: Two ring 4 MediaLario panels oriented North and South mounted on their unsheltered test platforms.

The subreflector of antenna 3 was replaced in the fall of 2005, shortly after signs of epoxy delamination and damages of the Hostaflon surface were detected. Subsequent holographic measurements were made to adjust the alignment of the newly installed subreflector. These measurements revealed that previous surface adjustments of a few tens of microns had influenced the shape of the main dish as a compensation of the surface errors of the previous subreflector.

The surface of all antennas was readjusted in the fall and verified with holographic measurements. According to the final analysis, the surface accuracy of antennas 1, 2, 3, 4 and 6 was found to be in the 40 to 50 micron range on the inner four rings, and 10 to 20 microns higher on the external two rings.

In connection with the plans to improve the Ruze efficiency of the interferometer for operation at frequencies above 300 GHz, holographic measurements were made to evaluate the long-term stability of the surface adjustments made in 2004 on antenna 5. No significant changes in the surface precision of this antenna were detected by the end of 2005. The antenna was found to be adjusted to an overall precision of 35 microns, i.e. 20-40 microns in the inner four rings, and 10 to 30 microns higher on the external two rings. These results seem to indicate that the surface quality remains stable over time, and that antenna efficiencies of, or even better than, 30 Jy/K can be achieved at 300 GHz.

New Generation Receivers

In connection with the plans to upgrade the Plateau de Bure antennas by a new receiver generation, a prototype unit of the next generation receivers was installed on the Plateau de Bure and is in operation since the beginning of the 2005/06 winter period. It was installed in the receiver cabin of antenna 6 at the end of November, followed by a period of initial testing in December. It turned out, that the receiver efficiency at certain tuning frequencies is lower than expected from previous tests carried out in the receiver lab in Grenoble. Also, the image band rejection is only a factor ~4-5, again less than what was initially expected. These issues were still under investigation at the time of writing this report. It is expected that they can be solved before the summer-2006 scheduling period begins.

The optics of the prototype receiver were modified to achieve compatibility with the present receivers which operate simultaneously in dual frequency mode at 2.6mm and 1.3mm. Shortly after installing the prototype receiver, it became apparent that the beams of the two receivers were not properly aligned. At the time of writing, adjustments had significantly corrected the focal plane alignment of the 2.6mm and 1.3mm receivers. The prototype unit is operated in dual frequency mode at 2.6mm and 1.3mm with a slightly modified frequency scheme in order to match the 580MHz IF of the present receivers. As a consequence, observations in the image sideband at 2.6mm and 1.3mm yield useful data only on baselines which include antennas still equipped with the present receivers.

Computers

In connection with the plans to equip all six antennas with New Generation Receivers, work has started to replace the existing VME racks running OS/9 in the pedestal of antenna 5 and in the receiver cabin of antenna 6 with boards running the Real Time Application Interface (RTAI) Linux operating system. The new boards appear to work very satisfactorily.

4.6 PHASE CALIBRATION, DATA REDUCTION, AND ARCHIVING

The 22GHz radiometric phase-correction system

Throughout 2005, the atmospheric phase calibration scheme implemented in 2004 has been routinely used. The implemented scheme is based on measurements of the fluctuation of the 22 GHz water vapor line and the application of an atmospheric model to relate the fluctuations to the astronomical phase. During the first full year of operation, several monitoring tools have been put in place to follow the correct behavior of the radiometers and the software. This gives the possibility to solve potential hardware and software problems very soon after they develop.

The daily monitoring indicated the presence of an interference signal in the first of the three radiometer channels, around the frequency of 19 GHz. This is most likely due to a geostationary satellite, with Ka band transponders. Although the satellite is only detected at a specific position in altitude and elevation, there are plans for more geostationary satellites at different positions emitting at similar frequencies. Care must be taken with such sources during data calibration.

The installation of the first unit of the next generation receivers on Antenna 6 was accompanied by a new radiometer for this antenna. This device is a modified version of the prototype 22 GHz receiver, with the horn orientated differently to match the optics of the astronomical receivers.

At the end of 2005, work began by a Marie Curie fellow to transform the current scheme of phase corrections, based on the 22 GHz radiometer data, into an even more powerful absolute atmospheric phase correction scheme.

Data Reduction

The year 2005 saw 34 investigators from Europe and overseas visiting Grenoble and spending a total of 153 days at IRAM to reduce data from the Plateau de Bure Interferometer, and 4 astronomers reducing data remotely from their home institutes.

Since January 2004, limited travel funds have been available to eligible astronomers from non IRAM partner countries for expenses incurred during their stay at IRAM for reducing data from the Plateau de Bure Interferometer. These funds are made available by the European Commission under the FP6 programme. For the year 2005, access time was allocated to 12 eligible proposals corresponding to a total of 239 hours of observing time.

Data archive

As a collaborative effort with the Centre des Données astronomiques de Strasbourg (CDS), data headers of observations carried out with the Plateau de Bure Interferometer are conjointly archived at the CDS since June 2004, and are available for viewing via the CDS search tools. For now, the archive contains coordinates, on-source integration time, frequencies, observing modes, array configurations, project identification codes, etc. for observations carried out in the period from December 1990 to September 2004.

Associated raw data files were not available for distribution as of December 2005, but discussions with the IRAM advisory committees and the IRAM Council on the archiving policy and release of raw data have started.

4.7 SITE ACCESS AND INFRASTRUCTURE IMPROVEMENTS

Site Access

2005 was marked by the rejection, by the local communities, of the project of connecting the observatory to the ski resort of La Joue du Loup by a small private road, which was presented to the communities by IRAM and INSU. In view of this refusal, and considering a study carried out by Scetauroute at the request of INSU during 2005, a proposal was made at the end of the year to the Mayor of Saint-Etienne en Dévoluy, to build a new cable car at the site of the old one. The studies for this project are currently under way.

Blondin

Having obtained the last authorizations for the operation of the blondin, it could be operated again by the subcontractor team from C2EI as of April 1st, 2005. It was decided to start immediately with an operation around the clock, i.e. three 8-hour shifts per day, from Monday till Saturday morning. A maximum number of transports was needed in order to prepare the construction site for work on the track extensions, and to ensure its adequate supply with materials.

For this intensive mode of operation, a team of 9 persons was created and trained by C2EI for the operation of the machine, which proved itself reliable throughout the works. A total of more than 1700 rotations of the Blondin were necessary to furnish the construction site with the necessary equipment and materials.

It is significant to note that the start-up of the Blondin made it possible to finally clean the site of all the waste that had accumulated during several years.

Track extensions

The work on the extension of the Eastern track (E68), and the Northern track (N46) started at the beginning of April with the ascent of the various pieces of necessary equipment (machines, aggregates, installation of the water supplies, etc.)

The companies "Charles Queyras TP" and "GARDIOL" worked together on the construction site, in order to meet the deadlines. The necessary machines (a dozen in total) were transported to the Plateau de Bure after being disassembled into sub-units that were compatible with the load capacity of the Blondin. They were then reassembled on the site by specialized companies. Considering the volume of the construction work and other activities on the site, and the number of persons on the plateau (up to 34 persons in total, including 23 for the construction work), a temporary building (with bedrooms, showers, etc.) had to be erected to accommodate up to 12 persons for the duration of the work. For the same reason, the team EUREST that is responsible for the food and the housing at the Observatory, had to be doubled during the construction period. To minimize the interface problems between the various activities that went on in parallel, IRAM installed a special Coordinator on the site during the entire construction and maintenance period.

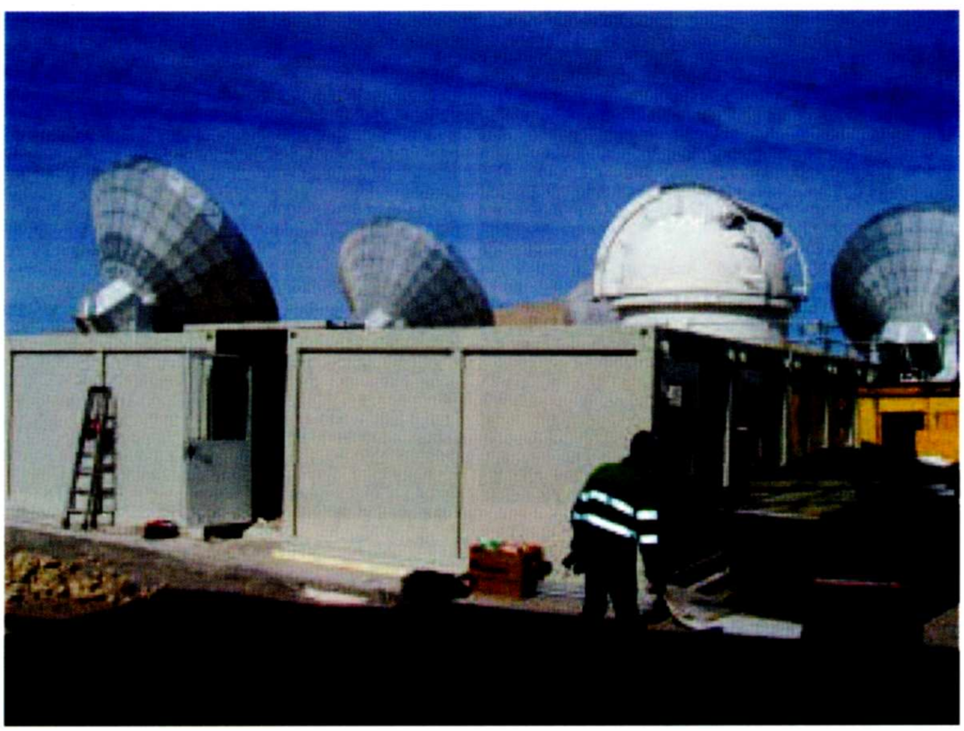


Fig. 4.13: Construction of the temporary building near the building of POM2, which can also accommodate up to 8 people.

The extensions of the northern and eastern tracks were carried out in parallel in order to benefit to the maximum extent from the equipment and personnel that had to be brought up to the Plateau de Bure for the season.

For both track extensions, the following operations were realized:
- Digging and cleaning of the trenches for the concrete supports for a total of approximately 1000 linear metres or 2000 m^3 of rock;.
- Casting of the 2 stations N46 and E68, then positioning of the centring rings;
- Formwork and casting of the track supports on a length of 1000 metres (a volume of about 1200 m^3 of concrete.);
- Installation and precision setting of the track rails.
- Casting of the concrete paving of the stations and of the concrete paving between the tracks after having set up the heaters of the stations and the copper cables that ensure the equipotentiality of the tracks in case of thunderstorms.
- Installation of all electric components (energy, HiQ, LoQ, PLM, heaters, etc.) in the stations and their connection to the existing system.

The work greatly benefited from a relatively lenient meteorology, which allowed us to finish the whole construction in the middle of October 2005, and to use the new extended configuration during the winter 2005/2006.

Fig. 4.14: O*n the left*: Form working and casting of a portion of the southern track support of the Eastern track extension. *On the right*: implementation and control of the location of the centring ring of the station N46.

4.8 SAFETY ISSUES

Concerning the management of safety issues on the Plateau de Bure, the most important items for 2005 were the risk analyses in connection with the track extension work. A number of preventive measures and detailed safety plans had to be worked out for the transport of a large number of people, for the transport of special equipment and materials, and for the use of explosive materials.

Especially for the transport of large and heavy pieces of equipment with the blondin, C2EI made more than 10 risk analyses, and developed the necessary procedures. Many additional risk analyses for other activities have been carried out by IRAM, resulting in more than 25 safety plans ("plans de prevention").

To make sure that all 35-37 people who were working on the Plateau de Bure at certain times fully respected the safety rules, IRAM had assigned a special Coordinator who was permanently on the site while the work was going on. Except for 2 emergency evacuations for personal health reasons, there was fortunately no accident despite the heavy work that has been carried out.

As part of the preventive measures program, and in compliance with the French regulations in force, an extensive check of the electrical wiring system, the fire detection system, the automatic extraction system in the correlator room, as well as of all lifting and individual protection devices has been carried out.

Concerning the access to the Plateau de Bure with the rattrack, a preventive maintenance has been made and crucial components have been exchanged.

The entire Plateau de Bure staff participated in a training of first aid and fire fighting, which are organized in regular intervals.

4.9 INTERNAL WORKSHOP

In May 2005, the Plateau de Bure Science Operations Group (SOG) organized a half-day workshop for the operators. The aim of the workshop was to share theoretical, practical and technical insights among the participants by means of presentations by IRAM experts on the 22 GHz radiometers and the design of the Plateau de Bure antennas.

5. GRENOBLE HEADQUARTERS

5.1 SIS GROUP ACTIVITIES

The IRAM superconducting device group has pursued several important development projects during the year 2005. This includes the development and fabrication of SIS junctions for all IRAM projects, and for ALMA. Considerable progress has been made on novel devices, and new key equipment has been acquired and commissioned.

The SIS junction production for the new generation PdB receivers as well as for ALMA Band 7 prototype cartridges has given excellent results in terms of record noise temperatures, a fact that will have a mayor impact on the competitiveness of the future instruments. The results further show IRAM's readiness for the production of large numbers of SIS junctions as required for the ALMA production phase or for future large focal plane arrays.

The oxidation technique to achieve Aluminium-Oxide barriers has been extended to low current densities (thicker barriers) with the installation of a high-pressure system in the load lock of the current sputter system.

The thermal evaporation system has been upgraded with a current stabilisation and a new thickness monitor.

Low damage plasma etching of SiO_2 layers has been developed for our ICP equipment. The process is compatible with the standard etching of Niobium. This technique will considerably enhance the parameter space for the design of cryogenic superconducting circuits.

The set-up for Tc measurements has been revised and improved.

A new mask aligner has been purchased from EVG (EVG620) which will backup and complete the existing MJB3 system from SUESS. The system allows for convenient wavelength change, proximity exposure and backside alignment.

The NbN HEB development for THz mixers has been continued and fundamental work has been done on the deposition technique of ultra-thin NbN layers as well as their characterisation with a broad range of new techniques. A high temperature deposition system has been set up with substrate temperatures of up to 800 C°. Synchrotron X-ray scattering has been used at the ESRF in Grenoble in order to investigate the substrate-film interface, and the film grain structure. In collaboration with the University of Tuebingen a cryogenic electron beam scanning technique was employed to test current models of the thermodynamics within HEB detectors.

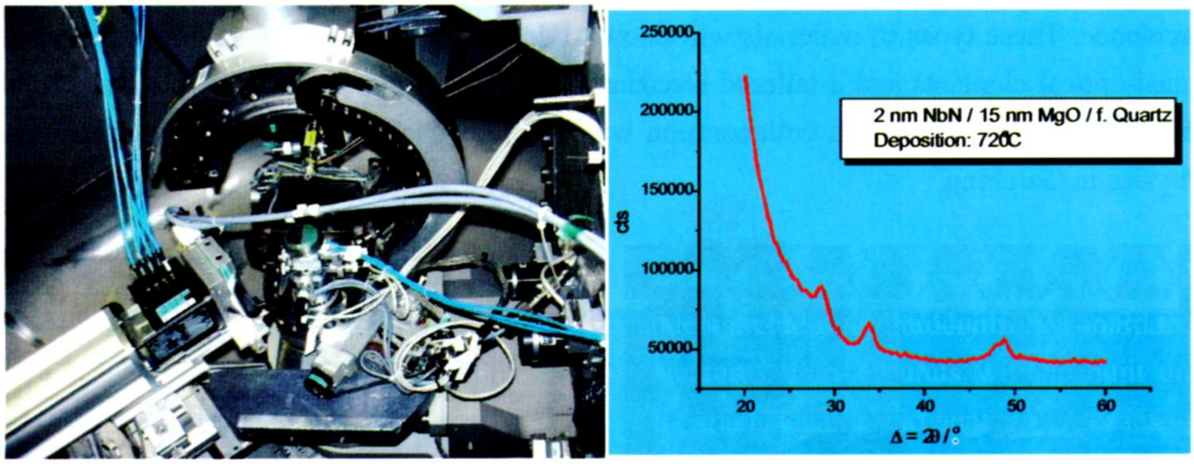


Fig. 5.1: Small angle X-Ray scattering set up at the ESRF (left), and diffraction spectrum of ultra-thin NbN films using 10keV synchrotron radiation (right).

During 2005 a new approach for low voltage actuation of cryogenic MEMS was developed. The technique employs meander type suspensions with thick superconducting actuator electrodes. By this, intrinsic film stress can be mastered and well-controlled device parameters are achieved. First prototypes of tunable filters for 22 GHz have been fabricated.

Fig. 5.2: Surface mounted cryogenic MEMS using meander type suspensions. The structures are made by metal film deposition on a polymer layer and subsequent structuring, using highly directive plasma etching. Typical bridge heights are 3 μm and voltages of ~20V are applied for electrostatic actuation.

Deep Silicon micro-machining has been used to fabricate effective dielectric materials for the mm range. Extensive calculations have been done to model effective dielectric constants of various structures. Hexagonal structures have been found to be adequate for micro-machining while offering polarisation independent effective dielectric constants for perpendicular incidence. These types of materials will allow to design completely new solutions for planar quasi-optical elements and a tailored electrical environment for detectors in this wavelength range. This work is done in collaboration with the Max-Planck-Institute for extraterrestrial Physics in Garching.

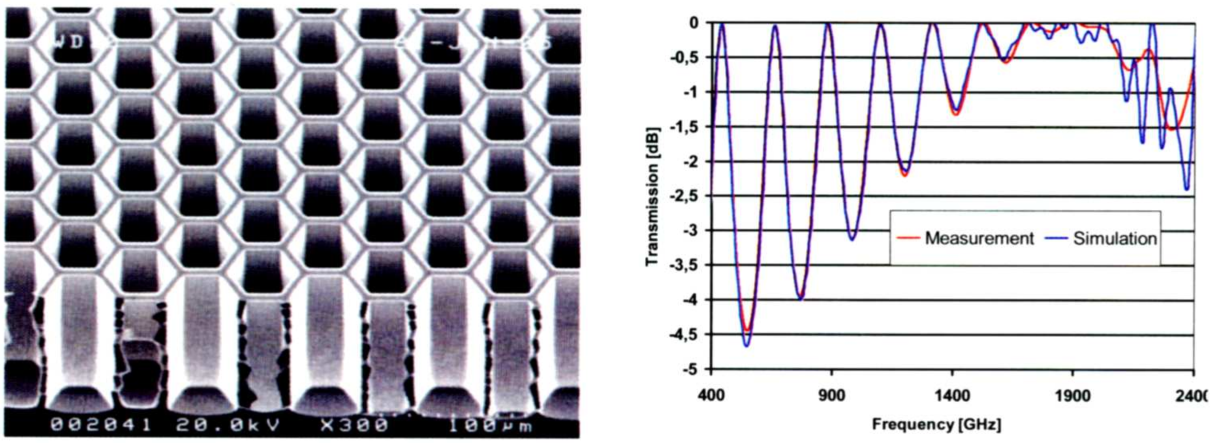


Fig. 5.3: *Left side*: E-beam micrograph of an effective dielectric medium fabricated by deep reactive Silicon plasma etching; *Right side*: Comparison of measured and simulated transmission curves of a silicon window using such structures as antireflection layers (right) for a frequency of 2 THz.

5.2 RECEIVER GROUP ACTIVITIES

5.2.1 IRAM Receivers

PdBI new generation receivers.

These receivers are designed to allow observing in any of four frequency bands, with one band, dual-polarization, being used at any time, and a second band being pre-tuned and phase-locked, available e.g. for phase calibration. The mixers are single-sideband, backshort-tuned; they can be tuned USB or LSB, both choices being available in the central part of the RF band. The IF bandwidth is 4GHz (4-8 GHz).

The #1 receiver was completed in a reduced configuration (frequency bands 100GHz and 230GHz), compatible with the existing receivers. It was installed on Antenna 6 in November, to be used in regular array operation and extensively tested during the 2005/2006 winter period. Making this #1 receiver compatible with the previous generation front-ends required two temporary modifications. The first one concerns the optics. A polarization-diplexing grid combines the 100GHz and 230GHz beams (nominally separated in the focal plane) to allow simultaneous observing in these two bands (one polarization each band). The second one concerns the frequency plan. A so-called ad hoc downconverter translates a 500MHz portion of the first (4-8GHz) IF to the 1.2-1.7GHz band of the "old" front-ends, while preserving phase/frequency coherence with the rest of the array.

Following the installation, it appeared that the interferometric efficiency of Antenna 6 was sometimes degraded with respect to that of the other antennas. This symptom was diagnosed to arise from several causes that were progressively identified. At the time of writing, these problems are largely resolved.

Based on the experience obtained during the assembly and the initial operation of the #1 receiver, several modifications were made, to be implemented in the remaining 6 units, and to be retrofitted into the #1 unit once it will be back in the lab as a spare. Besides relatively minor modifications of the cryostat, it was decided to change the design of the first LO reference, for improved cross talk behaviour. A new design for the 100GHz mixer chip is also under way, to improve the stability.

With all the design issues resolved and the demonstrated operation of the #1 unit, a planning has been established to build in parallel the remaining 6 units until autumn 2006.

Mixers for PdBI new generation receivers.

Four mixers (two polarizations, two bands) were mounted into the #1 receiver (only two are actually used in the compatibility mode of joint operation with the "old" receivers). Four other mixers for the 230GHz band were characterized in preparation for the construction of the remaining receivers. No more mixers were characterized for the 100GHz band, since it has been decided to modify the mixer chip design, and that modification had already started.

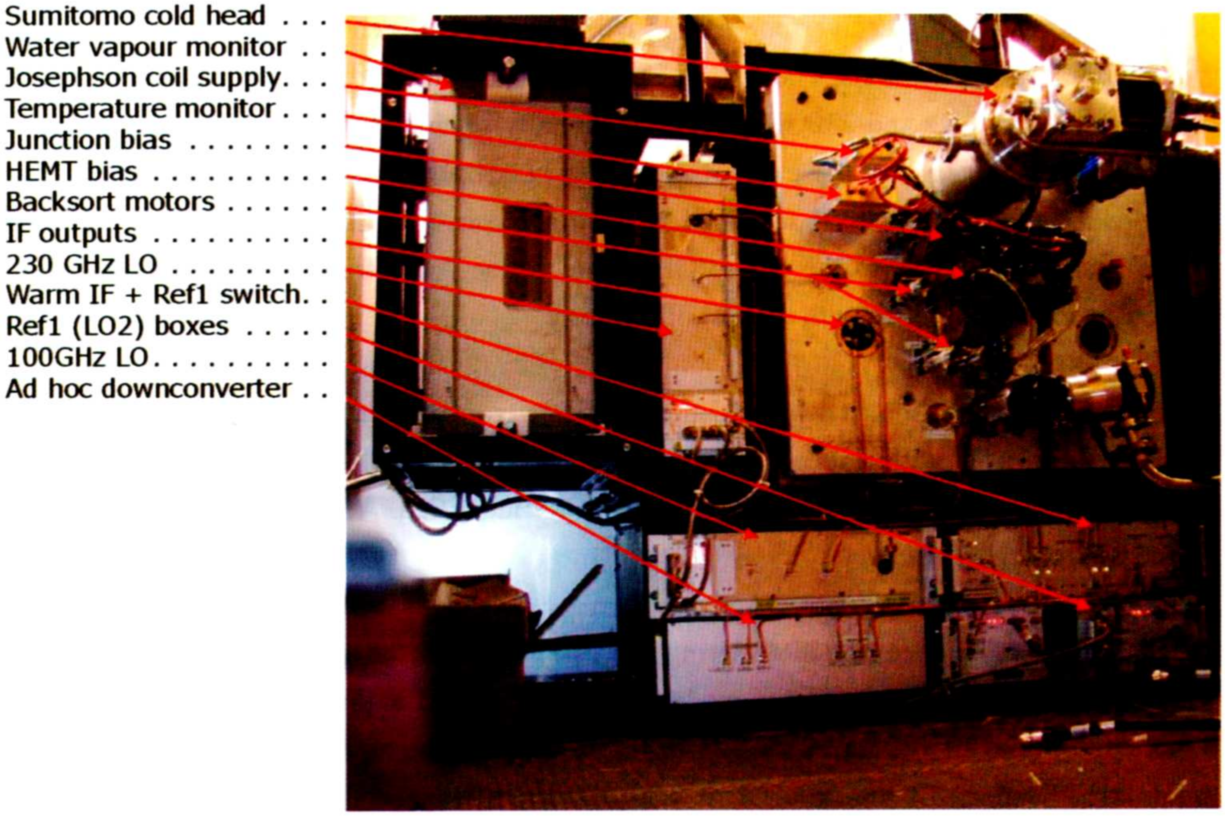


Fig. 5.4:. A view of the #1 receiver in the cabin of Antenna #6.

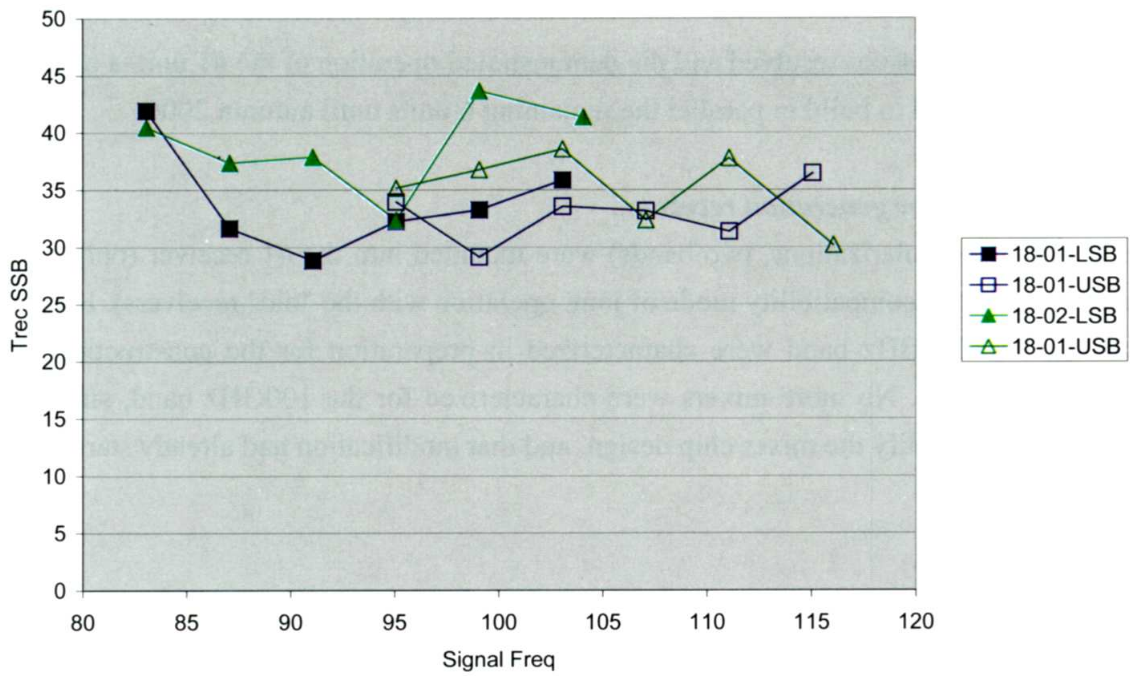


Fig. 5.5: Laboratory performance of the two 100GHz band mixers installed in the #1 PdBNG receiver. While the noise performance is rather good, stable operation can be problematic at some frequency points. A new mixer chip, based on a design improved in that respect, is under way as of end 2005.

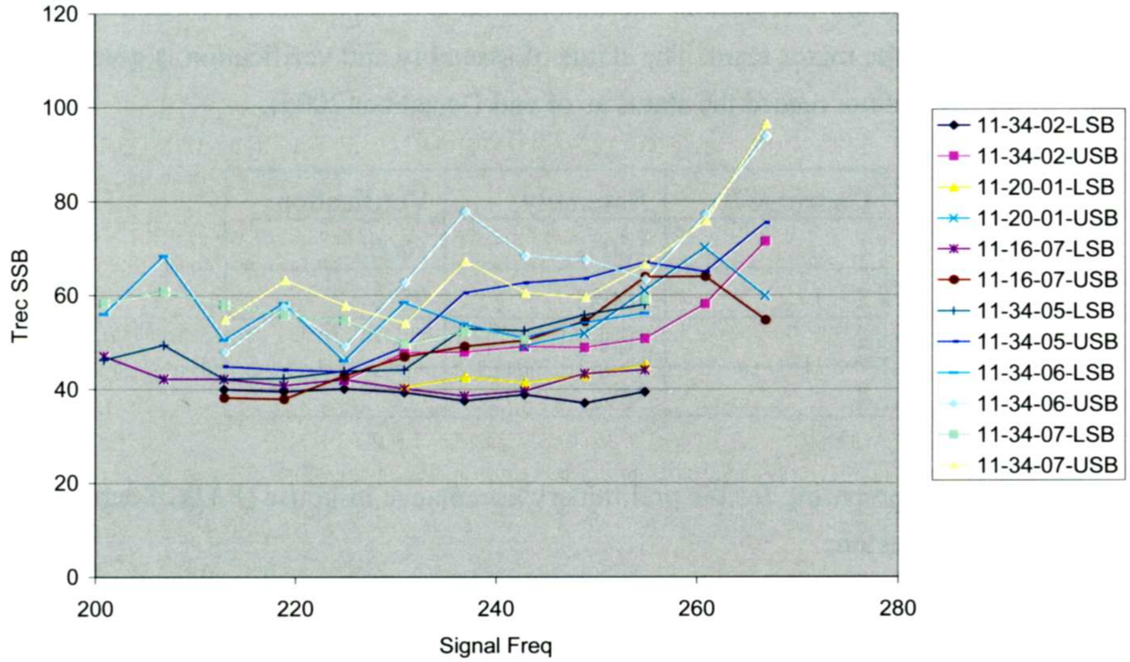


Fig. 5.6: Noise performance of the 6 mixers characterized for the 230GHz band in 2005, including the two installed in the #1 receiver.

Pico Veleta receivers

No significant intervention was needed in 2005.

5.2.2 ALMA work

Band 7 cartridge development and construction.

On the mixer construction side, significant progress has come from the full automation of the DSB and 2SB test sets. A DSB mixer can now be characterized over the LO tuning range in ~30min, while the measurement of the image rejection of a 2SB mixer (22 LO frequencies, times 41 IF band frequencies, times 2 sideband outputs, total 1804 measurements) takes 4 hours without human intervention, except for refilling the liquid nitrogen cold load. The automation of mixer measurements was made possible by the combination of in-house hardware and software developments with the availability of full electronic LO's supplied by the ALMA project.

A number of DSB and 2SB mixers have been built and characterized, meeting the contractual specifications. See the 2004 Annual Report for typical results.

Concerning the cartridge integration, the automation developments have been carried over (partly so far) from the mixer team. The status of assembly and verification is given as of end January 2006 (we did not record the status as of end December 2005):

Cartridge #	Assembly	Verification
1	100%	100%
2	100%	95%
3	100%	
4	75%	

The Band 7 team is preparing for the preliminary acceptance in-house (PAI) of cartridge #1, a project payment milestone.

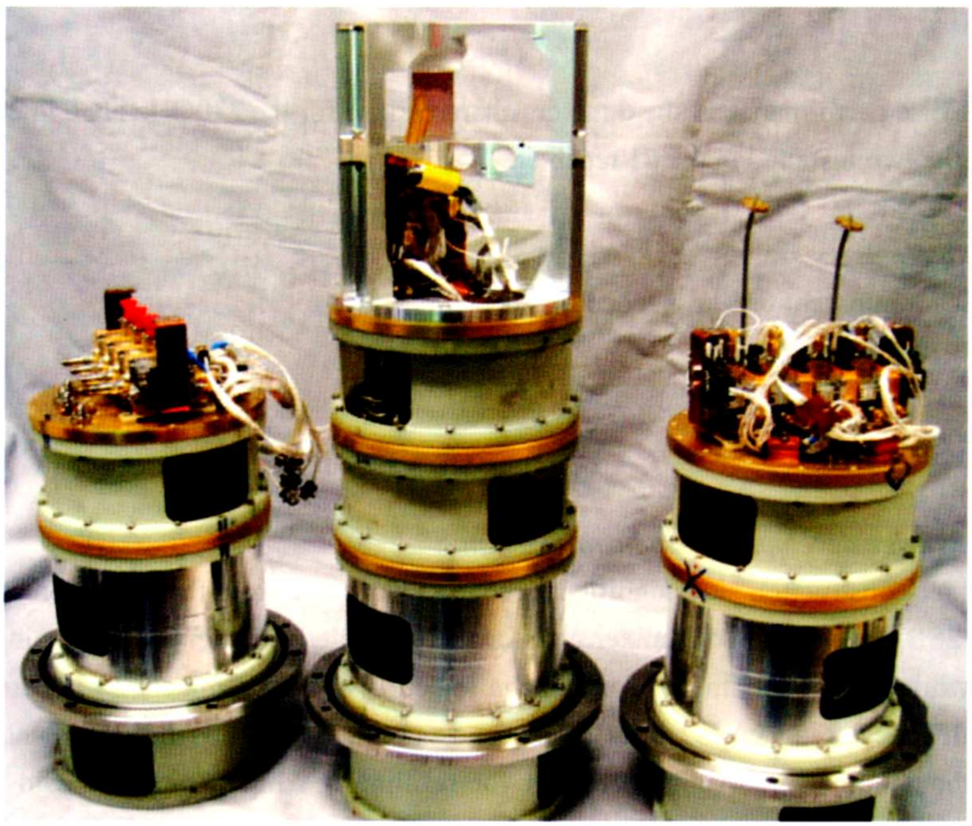


Fig. 5.7: A snapshot of the ALMA Band 7 cartridge construction, as of August 2005.

Optics and Calibration contracts

The work on the Optics work package, involving design studies and qualification measurements, was brought to completion with the submission of a design report. The same can be stated regarding the Calibration work package.

5.2.3 Other contract work

AMSTAR

The IRAM involvement in EU-FP6 RadioNet "AMSTAR" project was already mentioned in the Annual Report 2004. It comprises:

- WP 2.1.1: *Development of wide IF band SIS mixers for 80-116 GHz*, with the goal to achieve a 8 GHz IF bandwidth for a 3mm SIS mixer;
- WP 2.4.1: *Focal plane heterodyne array* (in collaboration with Rutherford Appleton Laboratories), with the goal to design and build a demonstrator array receiver for the 2mm band, using SIS mixers with photonic local oscillators.

The work on WP 2.1.1 did not progress beyond modelling, due to a statutory leave of the PI. The work on WP 2.4.1 reached a significant milestone, demonstrating operation of a 150GHz-band SIS mixer with a room-temperature photonic local oscillator, with a noise performance equivalent to a classical Gunn-multiplier LO.

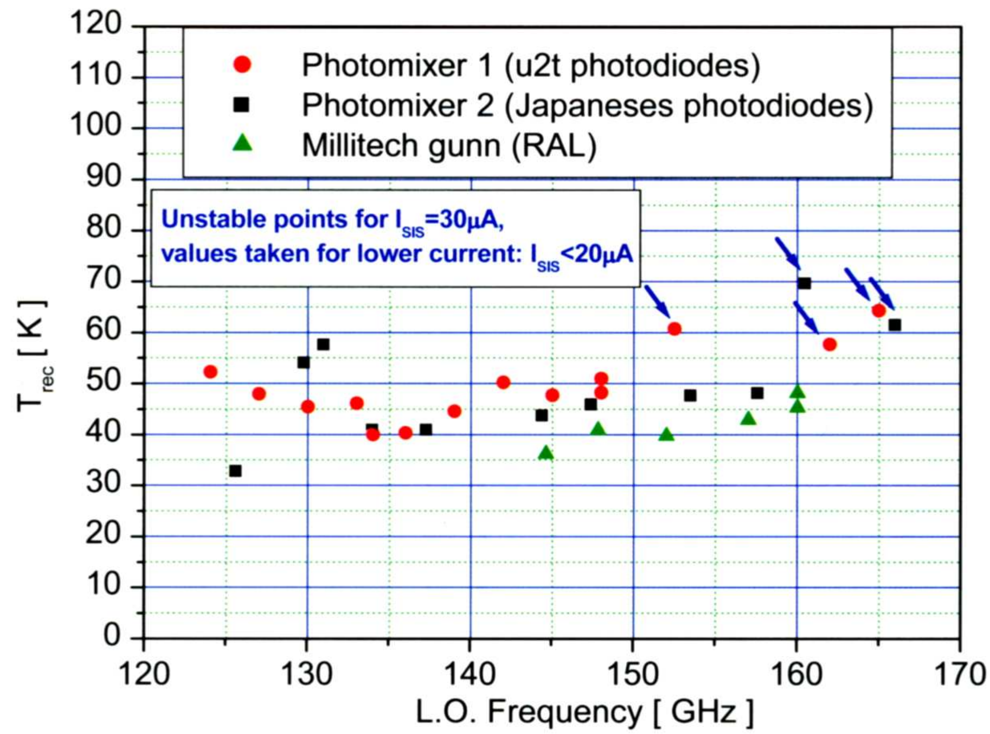


Fig. 5.8: Noise performance of the IRAM 150-GHz band SIS mixer with RAL photonic local oscillators, for comparison the results obtained with a Gunn-multiplier LO are also shown.

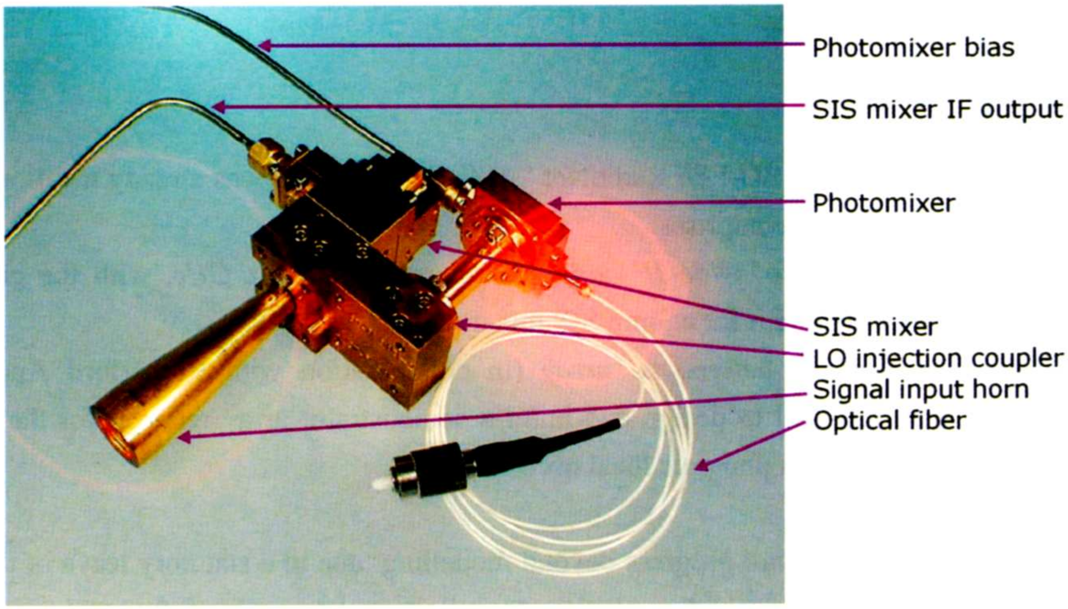


Fig. 5.9: Integration of the photonic LO with the SIS mixer. In the tests performed so far, the photonic LO was at room temperature. The "laser glow" is simulated.

5.2.4 Instrumentation and development activities

Solid-state local oscillator with full electronic tuning

This development, mentioned in the previous Annual Report, was brought to completion, up to the demonstration of low-noise operation of a 300-GHz band SIS mixer

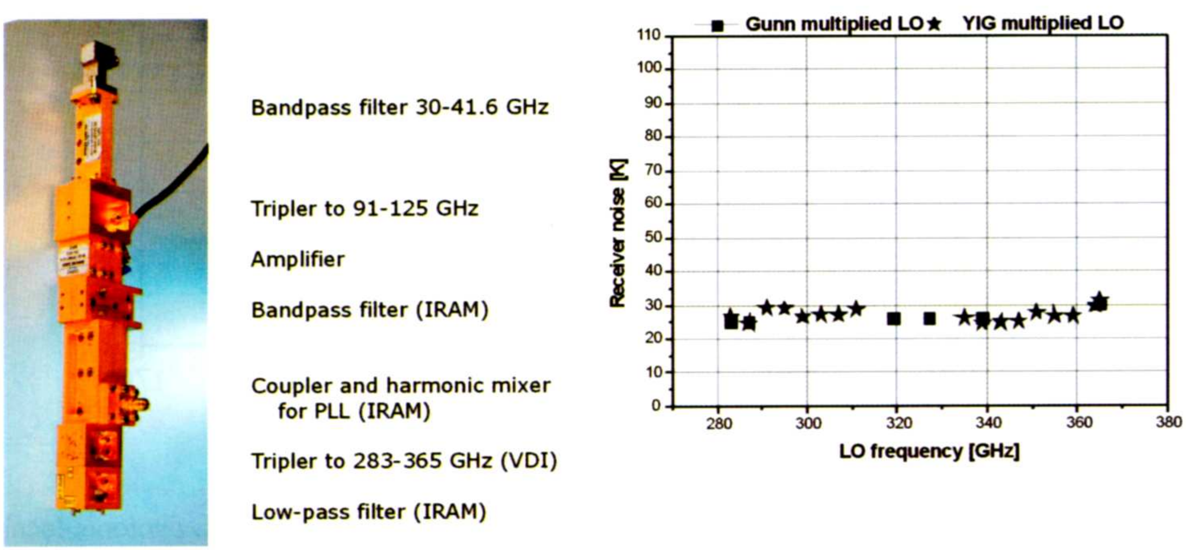


Fig. 5.10: *Left Side*: Full-electronic local oscillator for the 283-365 GHz band. Only the waveguide elements are shown; not shown are the lower frequency, coaxial elements: YIG oscillator 15.7-20.3GHz, and doubler. *Right Side*: Comparison of the noise performance of the same 300GHz band SIS mixer, pumped either by a traditional Gunn-tripler, or by the full-electronic local oscillator. The millimeter-wave bandpass filters developed for this project are a key element of the noise performance of the LO. (Int.J.I.R.MM.Waves, in press).

5.3 BACKEND DEVELOPMENTS

5.3.1 Completion of the ALMA contract for digitizer clocks

A batch of 8 (+one spare) pre-production units has been built, tested, and packed for delivery. This completes the ongoing contract for the first 8 ALMA antennas. Another contract will be issued later for further antennas.

5.3.2 Design of the laser transmitters for the Plateau de Bure Interferometer

The IF transmission rack #1 has been built and tested. It includes a microcontroller board that provides various laser protection and monitoring features. Further units will be built and incorporated in the PdBNG receivers. All the critical parts have already been purchased.

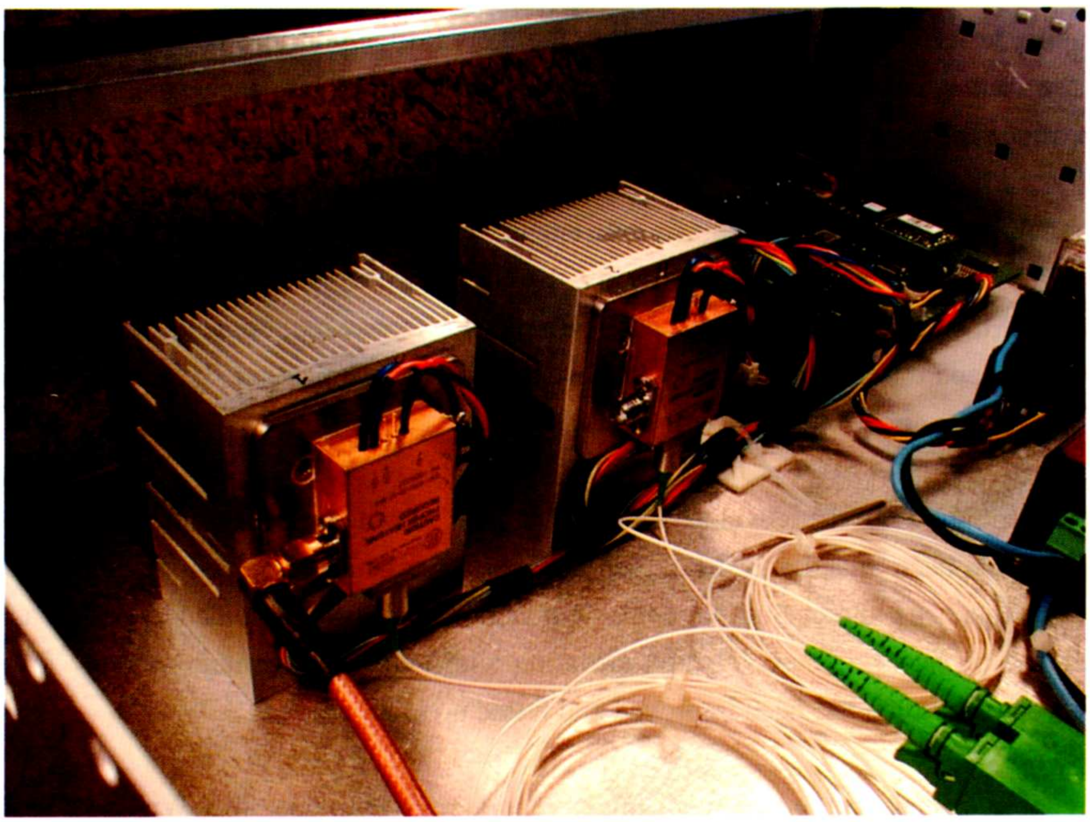


Fig. 5.11: The laser modules, together with their cooling and monitoring hardware.

5.3.3 Prospects on future IF transport and processing for Pico Veleta

Widening the receiver bandwidth to 4 or 8 GHz at the 30m-telescope, will require not only new backends but also new IF processing and transport systems. This task is quite demanding, and a meeting with the engineers has been held in Granada to define its envelope both in budget and manpower. A report is available upon request.

5.4 COMPUTER GROUP

In 2005, the major software and hardware development in the computer group was driven by the installation of the first new generation receiver in one antenna at Plateau de Bure. The new receiver, with polarization capability, which replaced the previous-generation receiver, had to stay compatible with the existing control system.The new receiver control is based on Linux, Python applicatons and CAN interfaces. The applications include the data acquisition and control layers, the graphical user interface and some tune-up utilities. The CAN links include master controllers and series of slave controllers for the motors, the bridges for the I2C field bus, and the analog and digital input/outputs interfaces. These controllers were mainly designed in 2005, but their production continues into 2006 for the first receiver. Physically, this new control system is located in the receiver cabin of antenna 6, and as it has still to control and monitor the subreflector unit and the 22GHz receiver already interfaced through VME boards. A VME PC-like SBC (Single Board Computer) has been selected for all computing tasks. The communications with the mount drive unit located in the pedestal and with the central computer in the central control building remain unchanged to permit the progressive replacement of the receivers and the upgrade of the computing facilities.

In parallel, the mount drive system for one antenna (#5) has been upgraded. Here also all the VME interfaces were unchanged but only the SBC was replaced. A real-time version of Linux, RTAI, was the solution to the demanding fast response requirements. The same Linux distribution, apart from the kernel, will be used for all antennas, in the pedestals and the cabins, when the current upgrade will be completed.

As a contribution to the development of the new 30m-telescope control system, some facilities have been added and debugging sessions have been carried out at Pico Veleta. A protection against a direct Sun hit with the generation of a Sun avoidance circle has been added. The preset to a source at high elevation with maximum azimuth velocity for Earth rotation compensation has been improved and tested up to 88.5degree.

In Grenoble, a new method of managing the numerous PC under MS Windows has been tested. The installation is in progress. It is based on Microsoft tools. Two Windows server have been set up, and with Active Directory software packages may be deployed now and configured from the servers. The new centralized purchase package Busi4 has already been installed with this new method. The deployment methods with their specific installation scripts are now easily tested on pseudo or dummy PCs which can be simulated with different Windows versions or setups on virtual PCs with the help of VMware, the virtualization solution for Linux or Windows.

In order to prepare the next steps, a method of synchronization of the passwords for UNIX/Linux and MS Windows has been developed and installed. Also a Microsoft solution for serving printers is being tested. Upgrades and evaluations have been carried out throughout the year. These include:

- Installation of postfix as a replacement for sendmail for the mails. Its configuration is easier.
- Update of Spamassassin to improve the filtering of the spams.
- Upgrade of IMMSS to fight viruses in the mails.
- Evaluation of Linux distributions Fedora Core 3 and 4.
- Upgrade to RedHat 9 of all Linux desktops.
- Debugging and improvement of user tools buidDVD, getproj, savedata, etc.

For the scientific software development a new 64 bit PC-based server with ECC memory has been installed and configured with Fedora Core 3 64 bits.

As part of the recurrent duties, a large fraction of time has been devoted to the maintenance of the numerous PCs at Grenoble and Bure, the installation of security patches, the protection and maintenance of the archives, and the customization of new machines

5.5 SCIENTIFIC SOFTWARE DEVELOPMENT GROUP

The main achievement in 2005 was the development of a new version of the CLASS software that was specially designed for handling large data sets. 30m-telescope users started to use it successfully in the fall of 2005.

CLASS is the GILDAS (http://www.iram.fr/IRAMFR/GILDAS) software that has been used for years at the 30m-telescope to reduce and analyse the spectroscopic data. CLASS is also used in many other facilities (e.g. CSO, Effelsberg, APEX), and it is considered for use by Herschel/HIFI.
The development of CLASS started in the 1980s, and it was therefore written in FORTRAN77 and tailored to reduce pointed observations. On-The-Fly (OTF) support was added later on, but it showed limitations as the quantity of OTF data increased quickly over the years. Indeed, the advent of multibeam spectral-line receivers (HERA at the 30-m) has increased the number of spectra by several orders of magnitude. For instance, a fully sampled (4" sampling) map of 1°x1° is done with the HERA receiver in only 30 hours (4"/s scanning velocity), resulting in 8×10^5 spectra. This represents 1.6GB of data (assuming 500 spectral

channels per spectra). It was thus decided to develop a new version of CLASS, written in FORTRAN90, that would allow an easy reduction of large OTF data sets without loosing, of course, all existing tools that work satisfactorily.

To ease the reduction of large data sets, it is necessary to enable complex operations on a large quantity of spectra, while keeping an easy access to every single spectrum. Both types of operations were optimized in order to work with a minimum of input commands. To do this, the same command names may be used on a single spectrum or on a collection of spectra gathered in an index list. Among the operations already optimized towards large data sets are listing, visualization and baseline subtraction. Listing capabilities were expanded to quickly display in a compact form the whole file content in a way similar to a table of content. Two-dimensional displays (intensities of all spectra as a function of the spectra number and of the velocity/frequency, see Fig. 5.12) enable the quick inspection of the data (e.g. platforming,

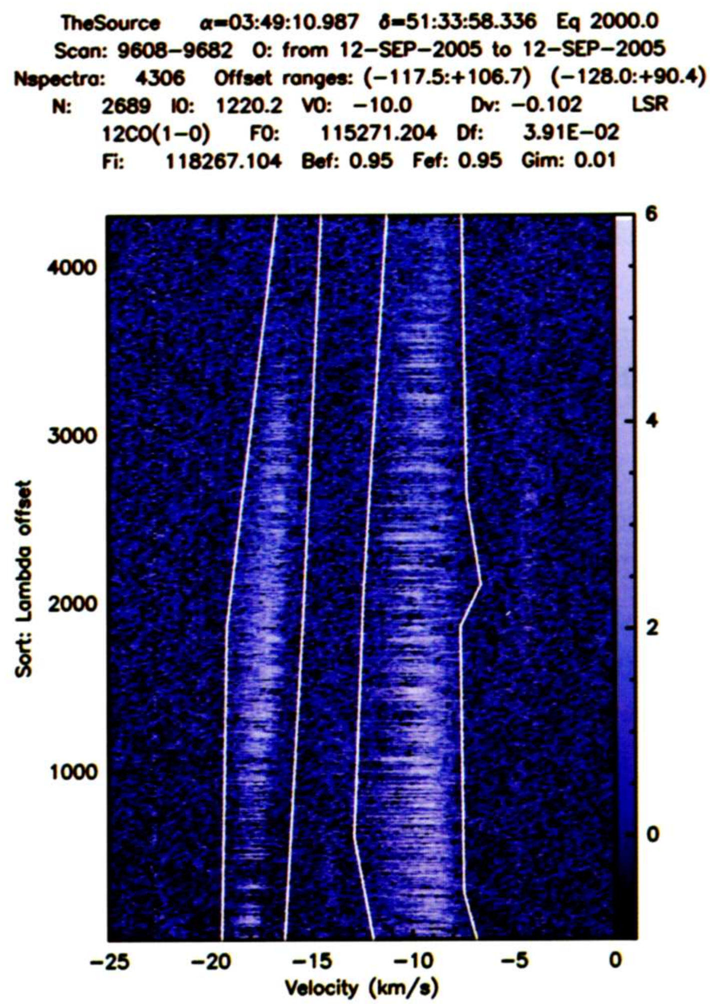


Fig. 5.12: 2D visualization of about 4300 spectra, sorted by increasing lambda offset. The two polygons displayed in white allow to define the area that contains signal and should therefore not be used for baseline fitting.

ripples, line strength, kinematics). This feature is further improved by the possibility to sort the spectra in different orders (by time, by coordinates, by backend name, etc.). Using those basic capabilities, more sophisticated interactive utilities as the one shown in Fig. 5.13 have been developed to ease the exploration of the large data sets. Baseline subtraction being a crucial operation in spectral line data reduction, the capabilities of CLASS were extended to enable the definition of baseline windows on an arbitrary number of spectra through the drawing of an arbitrary number of polygons on the two-dimensional displays (see Fig. 5.12).

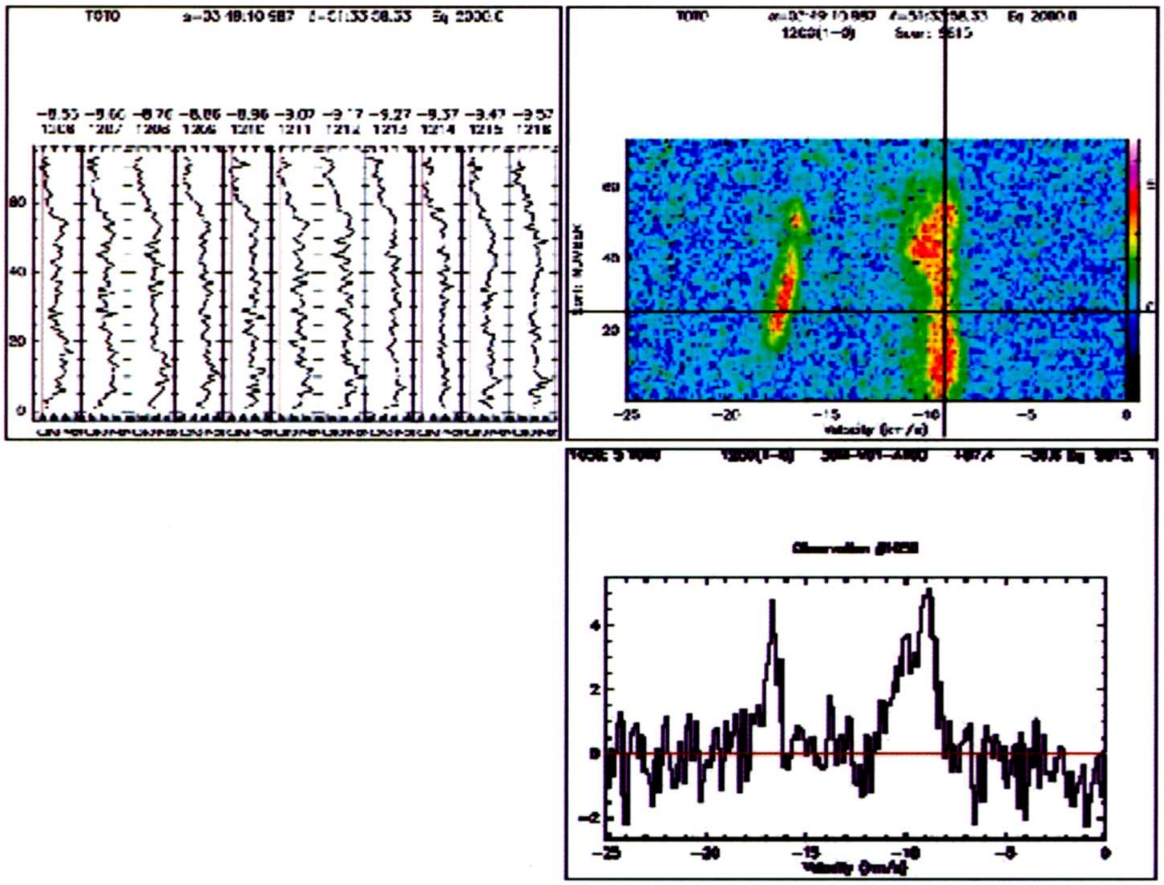


Fig. 5.13: Data exploration utility using position/velocity plots with interactive cuts at constant position or velocity.

Others improvements were also implemented. For instance, the building of images from non-gridded spectra was fully rewritten to enable a better control of the parameters (resolution, grid definition, etc.) by the users. The fitting tools that were available in CLASS have been grouped in a new FIT\ language. All GREG utilities, including the tools to visualize gridded spectra cubes (e.g. displaying channel maps or position-velocity diagrams, with interactive possibilities) are now available from CLASS. Finally, the documentation has been fully updated. For the coming year, it is planned to anticipate the increase in the bandwidths of the instruments by removing CLASS limitations in the definition of the frequency/velocity axis of the spectra (i.e. definition of non-linear axis) while continuing to improve the capabilities of CLASS for reduction and analysis of large datasets from either single or multibeam receivers.

A public release of the new CLASS is foreseen for 2006. A technical memo ("CLASS Evolution: I. Improved OTF support" by Hily-Blant, Pety and Guilloteau) describing in detail all the new features is available at http://www.iram.fr/GENERAL/reports/class-evol1.pdf.

5.6 TECHNICAL GROUP

The staff in the workshop has dealt with a total of **199 requests** for mechanical components, 118 of which were handled internally, and 81 were subcontracted to outside companies but still required the preparation and the follow-up of the work.

5.6.1 Mechanical workshop

The workshop has produced a large number of microwave components, mixers , couplers, horns for PdB-NG2, PICO-NG2, ALMA band 7, and AMSTAR for the frequency bands at 100/150/230 GHz and 320 GHz.

A new 3-axes CNC machine has been bought from MIKRON in order to further improve the accuracy and the reproducibility of the machining.

Fig. 5.14: View of the IRAM mechanical workshop

Fig. 5.15: Different backshorts used in mixers and other microwave devices

5.6.2 Drawing Office

The drawing office worked on numerous mechanical designs, in close collaboration with the other groups. This work included:

- the design of all new microwave components for the PdB-NG2, ALMA, and AMSTAR receivers
- the support structure for the PdB-NG2 receivers in the cabin of the PdB antennas
- various design work for other the technical groups

5.6.3 Electro-forming

The laboratory has electro-formed many horns. An example is shown in Figure 5.16.

Fig. 5.16: Cross section of a twisted horn (cornet "twisté") for 230 GHz

5.6.4 Technical support for antennas

As in previous years, the technical group has closely collaborated with the technical staff on the Plateau de Bure during the antenna maintenance period, and whenever other interventions were needed.

6. PERSONNEL AND FINANCES

6.1 PERSONNEL

In 2005, 104.5 positions were foreseen in the Personnel Plan. IRAM had a total of 103.24 positions filled with staff on longer-term or unlimited contracts, of which 76.99 positions were based in France, and 26.25 in Spain.

Furthermore, 4.3 post-doc positions were filled in France, of which 2 were financed by the EU Marie-Curie Fellowship Program, and 2 PhD students were supported by IRAM in Spain.

In addition, the equivalent of 5.38 positions (FTEs) was used for shorter-term contracts to cope with extra workload during certain periods of the year. This additional workforce was distributed as follows:

- 0.08 FTE on Plateau de Bure to complete the 3 teams for maintenance;
- 4.3 FTEs in Grenoble, for replacements and additional work that had to be carried out by the Administration and in the technical groups;
- 1.0 FTE in Spain, for replacements and urgent technical work.

6.2 FINANCE

IRAM's financial situation in 2005, as well as budget provisions for 2006, are summarised in the attached tables.

2005- Operating budget

a) The overall expenditure was lower than anticipated despite the fact that some exceptional charges were much higher than foreseen. This was more than off-set by charges for particular projects being lower than expected, and in particular by lower than forecasted personnel costs because not all positions were occupied. Also, part of the salary costs are now charged to a special project budget, i.e. they no longer appear in the IRAM budget;

b) Income was higher than expected, due to
- Additional income from European Union projects;

- Exceptional income linked to the integration into the IRAM budget of the benefit on some production contracts coming to an end in the course of 2005;
- Exceptional products linked to the cancellation or reimbursement of charges and provisions.

This led to an operation budget in excess by 1,028,561.62 €, taking into account a carry-forward of 778,062.37 € from the 2004 to the 2005 operation budget.

2005 - Investment budget

a) Despite the over expenditure to be noted for the North and East-track extensions on Plateau de Bure, the total expenditure was lower than foreseen. It went mainly into scientific equipment and instrumentation (Bure "new generation" receivers, spectrum analysers, computers, etc.).

b) Income
The income was much lower than estimated, as one income from a specific contract could not be reintegrated into IRAM's budget.

Taking into account the carry-forward of 1,494,992.51 € from the 2004 budget, the 2005 investment budget shows a deficit of 98,696.73 €. Commitments amount to 495,562.37 €.

BUDGET 2005

(in €)

2005 - EXPENDITURE

Budget heading	Approved	Actual
Operation / Personnel	7,200,000	6,805,810
Operation / other items	3,500,500	3,630,776
TOTAL OPERATION	**10,700,500**	**10,436,585**
Investment	3,443,661	3,247,816
TOTAL EXPENDITURE excl. VAT	***14,144,161***	***13,684,401***
VAT	862,592	862,592
TOTAL EXPENDITURE incl. VAT	***15,006,753***	***14,546,993***

2005 - INCOME

Budget heading	Approved	Actual
CNRS contributions	5,136,120	5,136,120
MPG contributions	5,136,120	5,136,120
IGN contributions	655,675	655,675
TOTAL CONTRIBUTIONS	***10,927,914***	***10,927,914***
Carry forward from 04	2,273,055	2,273,055
IRAM's own income	943,192	1,413,297
TOTAL INCOME excl. VAT	***14,144,161***	***14,614,266***
CNRS contribution for VAT (19,6%) *	862,592	862,592
TOTAL INCOME incl. VAT	***15,006,753***	***15,476,858***

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

BUDGET PROVISIONS 2006

(in €)

2006 - EXPENDITURE

Budget heading	Approved
Operation / Personnel	7,362,500
Operation / other items	3,406,000
TOTAL OPERATION	**10,768,500**
Investment - general	2,313,409
TOTAL INVESTMENT	**2,313,409**
TOTAL EXPENDITURE	***13,081,909***
VAT (19,6%)	879,746
TOTAL EXPENDITURE incl. VAT	***13,961,655***

2006 - INCOME

Budget heading	Approved
CNRS contributions	5,238,342
MPG contributions	5,238,342
IGN contributions	668,725
TOTAL CONTRIBUTIONS	**11,145,409**
IRAM's own income	1,636,702
Carry forward from 2004	299,798
TOTAL INCOME excl. VAT	***13,081,909***
CNRS contribution for VAT *	879,746
TOTAL INCOME incl. VAT	***13,961,655***

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

7. ANNEX I : TELESCOPE SCHEDULES

7.1. IRAM 30m TELESCOPE

DECEMBER 28 – JANUARY 11

Ident.	Title	Freq. (GHz)	Authors
233.04	Galaxy evolution and star formation efficiency in the last half of the Universe	115, 230	Combes, Garcia-Burillo, Gerin, Schinnerer, Braine, Walter, Colina
142-04	CO (2-1) Imaging of the powerful FR I Radio galaxic NGC 3801	227	Lim, Leon, Combes, Dinh-V-Trung
243-04	Search for CCH in L134N	83, 166	Momose, Morisawa, Miyamoto, Watanabe, Kawaguchi, Kasai
155-04	Mapping CO (2-1) around NGC1275 with HERA	870, 876, 113, 226	Edge, Wilman, Crawford, Hatch, Fabian, Johnstone
204-04	A study of the excitation conditions of NNH+ in molecular clouds	93, 186, 279	Cernicharo, Daniel, Dubernet, Thum
500-04	OBSERVING POOL	MAMBO	

JANUARY 11 – JANUARY 25

Ident.	Title	Freq. (GHz)	Authors
500-04	OBSERVING POOL	MAMBO	

JANUARY 25 – FEBRUARY 8

Ident.	Title	Freq. (GHz)	Authors
500-04	OBSERVING POOL	MAMBO	
127-04	Wet galaxies in the early Universe	108,146,214,…	Maiolino, Walmsley, Caselli
216-04	N2D+/N2H+ ratios as tracers of gas-phase deuteration in star forming regions	231,279	Roberts, Millar
201-04	Small scale dynamics of tenuous filamentary structures	230	Hily-Blant, Falgarone, Teyssier

FEBRUARY 8 – FEBRUARY 22

Ident.	Title	Freq. (GHz)	Authors
129-04	Density and temperature maps of massive protostars	241	Leurini, Beuther, Menten, Schilke
208-04	Probing the dynamics of massive protoclusters	93,244,260,267	Peretto, Minier, André, Motte, Burton, Purcell, Hill
226-04	^{12}CO(2-1) and ^{13}CO(2-1) mapping of M51 with HERA	230,220	Mookerjea, Schuster, Kramer, Wiesemeyer, Garcia-Burillo, Stutzki
184-04	The first Infrared dark clouds in the outer galaxy : deep mapping with HERA	219	Teyssier, Frieswijk, Shipman, Spaans
215-04	A fragmentation arm between IRAS 06056+2131 and IRAS 06058+2138 ?	220	Posselt, Schreyer, Forbrich, Henning, Klein
158-04	Gas and dust properties in molecular clouds : HERA imaging of L977	219	Richer, Bell, Kramer, Buckle
500-04	OBSERVING POOL	MAMBO	
220-04	D3O+ and the oxygen budget of molecular cloud cores	221,220	Caselli, van der Tak, Ceccarelli, Dore

FEBRUARY 22 – MARCH 08

Ident.	Title	Freq. (GHz)	Authors
500-04	OBSERVING POOL	MAMBO	

MARCH 08 – MARCH 22

Ident.	Title	Freq. (GHz)	Authors
127-04	Wet galaxies in the early universe	108,146,214, 103,139,227…	Maiolino, Walmsley, Caselli
010-04	A 3mm line survey of the simplest star forming regions	86-100	Marcelino, Mauersberger, Martin-Pintado, Thum, Tafalla, Paubert, Cernicharo, Fonfria, Roueff, Gerin
124-04	High-resolution spectroscopy of triatomic radicals and ions	72,77,87	Van der Tak, Müller, Muders, Schmid-Burgk
500-04	OBSERVING POOL	MAMBO	
193-04	The deuteration and excitation of rm N2H+ in massive cold cores	77,93,154,279	Wyrowski, Thompson, Gibb, Hatchell, Pillai, Belloche, Caselli, Walmsley
118-04	Hot water in evolved stars	96-268	Cernicharo, Daniel, Pardo,, Dubernet, Valiron

MARCH 22 – APRIL 06

Ident.	Title	Freq. (GHz)	Authors
500-04	OBSERVING POOL	MAMBO	
196-04	Star formation on intermediate size scales : the VY CMa molecular complex	220,219	Schuller,Menten,Raid
222-04	Tracing the Dense Molecular Gas in M 82 With H_2CO Transition Lines	218	Mühle,Seaquist
112-04	Searching for an outflow from a very low luminosity protostar	230	Crapsi,Bourke,Myers
156-04	Observation of HCO^+ in the Red Rectangle	89,178,267	Roueff,Geppert
201-04	Small scale dynamics of tenuous filamentary structures	230	Hily-Blant,Falgarone,Teyssier
136-04	$^{18}O/^{17}O$ ratios across the Galaxy	219	Henkel,Wouterloot,Brand,Mauesberger

APRIL 05– APRIL 19

Ident.	Title	Freq. (GHz)	Authors
210-04	A Sensitive 1mm –high frequency- and 2mm line surveys of Orion IRc2	130-170,240-280	Cernicharo,Tercero,Pardo,Senet,Masso
251-04			
121-04	HDO abundance in the envelope of solar-mass Protostars	80,151,225,241	Castest,Caux,Ceccarelli,Parise Tielens
234-04	A Search for Deuterated Formaldehyde (HDCO) Towards IRC+10216 :A Definitive Indicator of a Cometary System	128,134	Schilke,Saavik Ford,Neufeld,Melnick
120-04	Unbiased Spectral Survey of the Low-Mass Protostar IRAS16293-2422	81-115,130-177,197-241,241-281	Caux,Schilke,Castets,Ceccarelli,Tielens,Van Dishoeck,Cazaux,Comito,Helmich,Kahane,Parise,Wakelam,Walters
218-04	Revealing the Kinematics of a pair of new gigantic bipolar dust jet candidates	110,115,220,230	Weinberger,Aryal,Castro-Carrizo

APRIL 19 – MAY 03

Ident.	Title	Freq. (GHz)	Authors
237-04	$H^{17}{}_2O$ and H18/2O in Galactic Hot Cores	194,203	Mauesberger,Wilson,Cernicharo
204-04	A Study of the excitation conditions of NNH^+ in molecular clouds	93,186,279	Cernicharo,Daniel,Dubernet,Pagani,Thum
171-04	3mm HCN vibrationally excited masers in C-rich AGB stars	89087	Alcolea,Desmurs,Soria-Ruiz,Bujarrabal,Colomer
191-04	M 82 – a large scale CO survey	230	Weiss,Greve,Walter,Ott
111-04	Deep study of the circumstellar envelopes of AGB & early post-AGB stars	115, 230	Castro-Carrizo, Alcolea, Bujarrabal, Grewing, Lindqvist, Lucas, Neri, Olofsson, Schoïer, Winters
119-04	Measuring line polarization using the Goldreich-Kylafis effect	109,97	Forbrich,Menten,Belloche,Thum, Wiesemeyer
177-04	Detection of Flares from Sgr A*	231	Wiesemeyer,Schuster,Downes,Thum,Eckart
166-04	Tracing pre-starburst dense gas and cold dust in the Antennae galaxies	88,267,220	Haas,Aalto,Olsson

MAY 03– MAY 17

Ident.	Title	Freq. (GHz)	Authors
137-04	Magnetic Fields in Dense Clouds – CN Zeeman Observations	113	Falgarone,Crutcher,Troland
225-04	The First unbiased volume-limited survey of CO in elliptical galaxies	115,114	Sage,Welch,Young
241-04	2mm line survey of selected position in the central region of the Milky Way. Last step.	159-173	Martin Ruiz,Mauesberger,Martin-Pintado,Requena
151-04	Pre-impact chemical investigation of comet 9P/Tempel 1	88,147,157,168, 225,230,241,24 4,265	Biver,Bockelée-Morvan,Boissier,Crovisier,Colom, Lecacheux,Moreno,Paubert,A'Hearn,Meech
238-04	Velocity Structure of CB246, Seismic Oscillations in a Starless Globule ?	88,109,265,89,9 8,96,86,93,219	Lada,Teixeira,Bergin
215-04	A 'fragmentation arm'between IRAS 06056+2131 and IRAS 06058+2138	220	Posselt,Schreyer,Forbrich,Henning,Klein

MAY 17 – MAY 31

Ident.	Title	Freq. (GHz)	Authors
054-05	A search for S_3 (Thiozone), S_4 and C_6H_5 (Phenyl) in selected astronomical sources	85-110,130-150, 220-250	Guélin, Cernicharo, McCarthy, Thaddeus
300-05	OBSERVING POOL	MAMBO	
024-05	Searching for interaction evidences of a possible large-scale jet in Cygnus X-3 and the ISM	115-216, 230-292	Pérez-Ramirez, Leon, Marti, Garrido, Luque, Paredes

MAY 31 – JUNE 14

Ident.	Title	Freq. (GHz)	Authors
098-05	Unbiased spectral survey of the low-mass protostars IRAS16293-2422	81-115, 130-177, 197-241, 241-281	Caux, Schilke, Castets, Ceccarelli, Tielens, van Dishoeck, Cazaux, Comito, Helmich, Kahane, Parise, Wakelam, Walters
020-05	Characterizing the physical conditions and the grain chemistry associated with the shock-precursors	86-115, 130-138, 217-267	Jimenez-Serra, Martin-Pintado, Rodriguez-Franco, Requena-Torres, Martin
111-04	Linking local and high-z ULIRGs : MAMBO photometry of the Stanford sample	MAMBO	Greve, Min Yang, Ivison
085-05	Dust mapping in edge clouds 1 and 2 (EC1 and EC2)	MAMBO	Henkel, Millar, Ruffle, Roberts, Lubowich
093-05	The local IR-HCN correlation in nearby normal spiral galaxies	88, 244	Gao, Solomon

JUNE 14 – JUNE 28

Ident.	Title	Freq. (GHz)	Authors
080-05	Kinematics of bolometer prestellar condensations	86-109, 144-147, 216-267	André, Belloche, Onishi, Tachihara, Peretto
021-05	The impact of galaxy interactions on molecular clouds	112-114, 225-237	Krmpotic, Klaas, Lemke
005-05	$H_2{}^{17}O$ and $H_2{}^{18}O$ in galactic hot cores	194, 203	Mauersberger, Wilson, Cernicharo
028-05	Molecular clouds in the outer milky way	203	Braine, Schuster, Combes, Brouillet, Gardan, Soubiran
049-05	Deep HERA mapping of very nearby low metallicity spiral galaxies	203	Braine, Schuster, Sievers, Brouillet, Gardan

JUNE 28 – JULY 12

Ident.	Title	Freq. (GHz)	Authors
055-05	A 3mm polarization survey of AGNs	86	Thum, Wiesemeyer, Ungerechts, Krichbaum
006-05	The fate of comet 9P/Tempel 1 after DEEP IMPACT	88-168, 220-271	Biver, Bockelée-Morvan, Boissier, Crovisier, Colom, Lecacheux, Moreno, Paubert, A'Hearn, Meech
049-05	Deep HERA mapping of very nearby low metallicity spiral galaxies	203	Braine, Schuster, Sievers, Brouillet, Gardan
238-04	Velocity Structure of CB246, Seismic Oscillation in a Starless Globule ?	88,109,86,265,89,98,96,86,93,219	Lada,Teixeira,Bergin

JULY 12 – JULY 26

Ident.	Title	Freq. (GHz)	Authors
064-05	Finding chemical complexity ?	98, 239	Cazaux, Caselli, Walmsley
003-05	The precessing jet in the high-mass protostar IRAS20126+4104	86, 130, 217, 260	Cesaroni, Bacciotti
002-05	Does NO follow the dust ?	93? 150	Walmsley, Caselli, Pineau des Forêts, Flower, Akyilmaz
079-05	The chemically unevolved starless dense core L1521B-2	93, 109, 112, 219, 224	Kauffmann, Bertoldi, Tafalla, Pillai
098-05	Unbiased spectral survey of the low-mass protostar IRAS16293-2422	81-115, 130-177, 197-241, 241-281	Caux, Schilke, Castets, Ceccarelli, Tielens, van Dishoeck, Cazaux, Comito, Helmich, Kahane, Parise, Wakelam, Walters
103-05	A 3mm line survey of the simplest star forming regions	86-100	Marcelino, Mauersberger, Martin-Pintado, Thum, Tafalla, Paubert, Cernicharo, Fonfria, Roueff, Gerin
038-05	A massive prestellar core in the IRAS 19388+2357 region	112, 224, 93,242, 98, 244, 230	Beltran, Cesaroni, Brand
047-05	A search for CO emission in low-luminosity radio galaxies	111-114, 224-229	Laing, Parma, de Ruiter, Wilson
088-05	Probing the molecular evolution of pre- and protostellar cores	89, 97, 109,90, 93, 96	Buckle, Richer, Roberts
095-05	The potentially composite core B18-1	77, 93, 144, 219	Kauffmann
090-05	A search for the CF+ molecular ion	102, 205	Schilke, Neufeld, Wolfire
071-05	The nature of the enigmatic IRAS object 19312+1950	87-97, 104-115, 140-157	Menten, Alcolea, Schilke, Schuller

JULY 26 – AUGUST 09

Ident.	Title	Freq. (GHz)	Authors
071-05	The nature of the enigmatic IRAS object 19312+1950	87-97, 104-115, 140-157	Menten, Alcolea, Schilke, Schuller
098-05	Unbiased spectral survey of the low-mass protostar IRAS16293-2422	81-115, 130-177, 197-241, 241-281	Caux, Schilke, Castets, Ceccarelli, Tielens, van Dishoeck, Cazaux, Comito, Helmich, Kahane, Parise, Wakelam, Walters
023-05	Chemical inventory of the mini-hot core NGC 7129-FIRS 2	97-113, 130-198, 202-220	Fuente, Ceccarelli, Caselli, Rizzo, Planesas, Johnstone
010-05	The star-formation law in the newly-discovered extended disk of NGC4625	115	Gil de Paz, Boissier, Madore, Kennicutt, Swaters, Sheth, Simon, Bolatto
037-05	Wet galaxies in the early universe	75, 150, 225, 256, 97, 132, 215, 235,265…	Maiolino, Caselli, Walmsley, Nagao
105-05	A search for infall motion in high mass star formation regions	144, 147, 241, 244	Wu, Henkel, Wei, Zhu, Wang
090-05	A search for the CF+ molecular ion	102, 205	Schilke, Neufeld, Wolfire
074-05	Dense cores as tracer particles : testing turbulent cloud models	93, 219	Tafalla, Kirk, Santiago, Johnstone, Friesen

AUGUST 09 – AUGUST 23

Ident.	Title	Freq. (GHz)	Authors
098-05	Unbiased spectral survey of the low-mass protostar IRAS16293-2422	81-115, 130-177, 197-241, 241-281	Caux, Schilke, Castets, Ceccarelli, Tielens, van Dishoeck, Cazaux, Comito, Helmich, Kahane, Parise, Wakelam, Walters
081-05	Chemistry and physics of an archetype bowshock	86-110, 130-245	Lefloch, Chapillon, Schuster, Cabrit, Ceccarelli
078-05	18151-1208 : Three stages of high-mass star formation	96, 97, 144, 146, 218, 225, 244	Herpin, Bontemps, Wyrowski, van der Tak, Helmich, Baudry
019-05	Cold gas along cooling flow galaxies radio lobes	114, 94, 229	Salomé, Combes
073-05	The chemistry of orbiting disks around post-AGB stars	115, 110, 108, 88, 86, 90, 130, 146, 203, 220, 244	Bujarrabal, Quintana-Lacaci, Alcolea, Castro-Carrizo
094-05	Probing dense gas tracers in LIGs and ULIGs : HCO+ vs. HCN	82, 83, 84, 85, 87	Gracia, Garcia-Burillo, Planesas, Colina

AUGUST 23 – SEPTEMBER 06

Ident.	Title	Freq. (GHz)	Authors
099-05	Outflows from Infrared dark clouds (IrdCs)/High-mass starless cores (HMSCs) ?	86, 110, 230, 241	Beuther, Sridharan
002-05	Does NO follow the dust ?	93, 150	Walmsley, Caselli, Pineau des Forêts, Flower, Akyilmaz
062-05	^{12}CO(1-0) mapping of UGC10214 – the "Tadpole" galaxy	111, 223	Jarrett, Lisenfeld, Xu
041-05	CO line SEDs at high redshift – submm galaxies	131, 141, 164, 167	Weiss, Downes, Walter, Henkel
021-05	The impact of galaxy interactions on molecular clouds	112, 113, 114, 225, 226, 227, 228, 229	Krmpotic, Klaas, Lemke
025-05	Search for molecular gas in a high velocity cloud detected with Spitzer	HERA	Boulanger, Deschênes, Nehmé
085-05	Dust mapping in edge clouds 1 and 2 (EC1 and EC2)	Bolometer	Henkel, Millar, Ruffle, Roberts, Lubowich
044-05	3 mm HCN vibrationally excited masers in C-rich AGB stars	89	Ruiz, Alcolea, Bujarrabal, Colomer, Desmurs
091-05	Searching for molecular gas in the "VirgoHI21 dark halo"	114, 229	Henkel, Mauersberger, Weiss

SEPTEMBER 06 – SEPTEMBER 20

Ident.	Title	Freq. (GHz)	Authors
084-05	S-bearing molecules in high mass protostellar objects	94, 97, 133-168, 216-267	Herpin, Wakelam, Minier, Bontemps
055-05	A 3mm polarization survey of AGNs	86	Thum, Wiesemeyer, Ungerechts, Krichbaum
076-05	HNCO and CH_3OH in external galaxies. New tracers of the nuclear activity	131, 145, 259, 265	Martin-Pintado, Requena-Torres, Martin, Mauersberger
081-05	Chemistry and physics of an archetype bowshock	86, 88, 89, 96, 110, 130, 145,217, 220, 245	Lefloch, Chapillon, Schuster, Cabrit, Ceccarelli
041-05	CO line SEDs at high redshift – submm galaxies	131, 141, 164, 167	Weiss, Downes, Walter, Henkel
009-05	CO in the most distant radio galaxy at z=5.2	92, 111	Klamer, Weiss, De Breuck, Ekers
005-05	$H_2{}^{17}O$ and $H^{18}{}_2O$ in galactic hot cores	194, 203	Mauersberger, Wilson, Cernicharo
040-05	Confirming the new molecular extragalactic detections	81-99, 100-106, 211-225	Martin-Ruiz, Mauersberger, Martin-Pintado, Henkel
241-04	2mm line survey of selected position in the central region of the Milky Way. Last step.	159-173	Martin Ruiz,Mauesberger,Martin-Pintado,Requena

SEPTEMBER 20 – OCTOBER 04

Ident.	Title	Freq. (GHz)	Authors
059-05	Carbon photo-chemistry and dust in photo-dissociation regions	85, 87, 219, 220, 230	Goicoechea, Abergel, Bernard, Boulanger, Cernicharo, Gerin, Habart, Joblin, Le Bourlot, Maillard, Smith, Teyssier, Verstraete, Reach
086-05	CO content in the hosts of nearby ($z<0.06$) QSOs	109-113, 219-227	Bertram, Eckart, Fischer, Krips, Straubmeier
092-05	Multi-line survey of the Sgr A* environment – Preliminary measurements	218-226, 230-267	Stankovic, Seaquist, Muehle, Menten, Leurini
032-05	Properties of the molecular gas in the metal-poor starburst galaxy NGC1569	110, 220	Muehle, Huettemeister, Seaquist, Klein
062-05	$^{12}CO(1-0)$ mapping of UGC10214 – The "Tadpole" galaxy	111, 223	Jarrett, Lisenfeld, Xu
053-05	Shock-induced chemistry in the HH211 molecular jet	85-90, 113-140, 205-265	Gueth, Guilloteau

OCTOBER 04 – OCTOBER 18

Ident.	Title	Freq. (GHz)	Authors
110-05	Deep study of the circumstellar envelopes of AGB & early post-AGB stars	115, 230	Castro-Carrizo, Alcolea, Bujarrabal, Grewing, Lucas, Neri, Quintana-Lacaci, Oier, Winters
047-05	A search for CO emission in low-luminosity radio galaxies	111, 114, 224, 229	Laing, Parma, de Ruiter, Wilson
015-05	Truncated stellar disks vs. molecular gas density	115, 230	Galletta, Bettoni, Casasola, Combes, Pohlen
017-05	The dynamics of high-mass star forming regions	86, 89, 110, 173, 220, 230, 260, 267	Gonzalez-Alfonso, Melnick, Li, Blanco Avalos
055-05	A 3mm polarization survey of AGNs	86	Thum, Wiesemeyer, Ungerechts, Krichbaum

OCTOBER 18 – NOVEMBER 01

Ident.	Title	Freq. (GHz)	Authors
005-05	$H_2{}^{17}O$ and $H^{18}{}_2O$ in galactic hot cores	194, 203	Mauersberger, Wilson, Cernicharo
103-05	A 3mm line survey of the simplest star forming regions	86-100	Marcelino, Mauersberger, Martin-Pintado, Thum, Tafalla, Paubert, Cernicharo, Fonfria, Roueff, Gerin
300-05	OBSERVING POOL	MAMBO	
018-05	Large molecules in the galactic center. A uniform grain mantle composition ?	81, 82, 90, 94, 95, 111, 197,201, 215, 220	Requena-Torres, Martin-Pintado, Rodriguez-Franco, Martin, Morris
039-05	2 mm line survey of selected position in the central region of the Milky Way. Last step	166-175	Martin-Ruiz, Mauersberger, Martin-Pintado, Requena
102-05	Atmospheric sounding of Mars in support of Mars express observations	110, 220, 115, 230, 226, 216, 143, 242, 251, 168, 218	Encrenaz, Paubert, Billebaud, Lellouch

NOVEMBER 01 – NOVEMBER 15

Ident.	Title	Freq. (GHz)	Authors
300-05	OBSERVING POOL	MAMBO	

NOVEMBER 15 – NOVEMBER 29

Ident.	Title	Freq. (GHz)	Authors
194-05	Characterizing the physical conditions and the grain chemistry associated with the shock-precursors (II).	86, 97, 115, 130, 244, 267	Jimenez-Serra, Martin-Pintado, Rodriguez-Franco, Requena-Torres, Martin
152-05	Chemical inventory of the hot core NGC 7129-FIRS 2 (II)	112, 147, 220, 112, 131, 202, 113, 130, 206	Fuente, Ceccarelli, Caselli, Rizzo, Planesas, Johstone
186-05	A deep survey of molecular and atomic gas in an optically selected sample of elliptical galaxies	114, 113, 229, 227, 226	Lisenfeld, Baes, Sabatini, Falony, Noordermeer, Lundgren
157-05	Study of the gas-grain chemistry in photon-dominated regions (PDRs)	109,243,168, 216, 99, 215, 116, 251, 109,241,128, 213	Fuente, Rizzo, Garcia-Burillo, Roueff, Usero

NOVEMBER 29 – DECEMBER 13

Ident.	Title	Freq. (GHz)	Authors
400-05	OBSERVING POOL	MAMBO	

DECEMBER 13 – DECEMBER 27

Ident.	Title	Freq. (GHz)	Authors
400-05	OBSERVING POOL	MAMBO	
076-05	HNCO and CH_3OH in external galaxies. New tracers of the nuclear activity	131, 145, 259, 265	Martin-Pintado, Requena-Torres, Martin, Mauersberger
221-05	Molecular gas chemistry in AGNs : NGC 1068	88-113, 244, 265, 267, 272, 279, 138, 150, 161, 262, 268	Usero, Garcia-Burillo, Fuente, Tacconi, Schinnerer, Rizzo
213-05	Probing dense molecular gas tracers in LIGs and ULIGs	87,89,88,86, 255,263,259, 261,256,262	Gracia, Garcia-Burillo, Planesas, Colina

7. ANNEX I: TELESCOPE SCHEDULES

7.2 INTERFEROMETER

Ident.	Title	Line	Authors
M042	A bright submm source possibly associated with a gravitationally lensed arc	Cont3mm Cont1mm	C.Borys D.Lutz L.Tacconi D.Scott P.Newbury G.Fahlman
M061	High-resolution observations of SMM J14011+0252	CO(3-2)R CO(7-6)R	D.Downes P.Solomon
N028	CO identification of submillimetre galaxies. II	^{12}CO(3-2)R ^{12}CO(4-3)R	R.Genzel R.Ivison F.Bertoldi R.Neri P.Cox A.Omont T.Greve S.Chapman I.Smail
N02C	Molecular gas in a large stellar complex in NGC 6946	^{13}CO(1-0) ^{13}CO(2-1)	U.Lisenfeld E.J.Alfaro Y.N.Efremov
N03D	The outflows of Orion KL revisited – SiO(5–4)	SiO(2-1)	H.Beuther L.Greenhill
N069	Studying the circumbinary and circumstellar	^{13}CO(1-0)	S.Guilloteau A.Dutrey
N072	Very dense gas in the Cloverleaf Quasar: search for HCN 4-3 emission	HCN(4-3) H_2O	P.Vanden Bout M.Guélin P.Solomon C.Carilli
O005	A high-mass starless core	N_2H^+(1-0) ^{12}CO(2-1)	H.Beuther T.K.Sridharan M.Saito
O013	Tracing the early time evolution of C-shocks in the L1448-mm outflow	SiO(2-1) CH_3OH	I.Jiménez-Serra J.Martín-Pintado A.Rodríguez-Franco
O016	Resolving the density gradient at the edge of the horsehead nebula	CS(2-1)	M.Gerin J.Pety A.Abergel J.Goicoechea C.Joblin E.Roueff D.Teyssier E.Habart
O018	Search for orbiting molecular disks around post-AGB stars	^{12}CO(1-0) ^{12}CO(2-1)	V.Bujarrabal H.V.Winckel R.Neri J.Alcolea A.Castro-Carrizo
O01C	Molecular gas chemistry in the circumnuclear disk of NGC 1068	SiO(2-1) CN(2-1)	S.García-Burillo F.Boone A.Usero S.Hüttemeister J.Martín-Pintado A.Fuente L.Tacconi E.Schinnerer A.Baker S.Aalto
O022	The correlation between radio continuum and CO emission: the case of NGC3627	^{12}CO(1-0) ^{12}CO(2-1)	R.Paladino M.Murgia A.Tarchi L.Moscadelli C.Comito
O02A	CO identification of (sub)millimeter galaxies IV.	CO(3-2)R CO(4-3)R Cont1mm	R.Genzel R.Ivison F.Bertoldi R.Neri A.Omont P.Cox T.Greve S.Chapman A.Blain I.Smail
O02C	Measuring the Gas Content of Massive UV Bright Galaxies at z=2	CO(3-2)R CO(7-6)R	A.Shapley L.Tacconi R.Genzel A.Baker D.Lutz M.Lehnert C.Steidel D.Erb M.Pettini
O02E*	Search for Glycine and Precursors	Gly3mm Gly1mm	F.Combes D.Despois G.Wlodarczak A.Wooten M.Guélin N.Brouillet
O02F	Tracing the maser emission in the infrared dark cloud G11.11−0.12	CH_3OH CH_3OH	T.Pillai F.Wyrowski S.Leurini K.M.Menten
O031	The small scale structure of Infrared Dark Cloud cores	^{13}CO(1-0)	R.Simon J.Rathborne J.Jackson R.Shah E.Chambers
O032	The hot corino of the solar type protostar NGC1333-IRAS4	CH_3CN Cont1mm	S.Bottinelli C.Ceccarelli J.Williams, R.Neri

Ident.	Title	Line	Authors
O034	A search for intermediate-mass (IM) hot cores using the PdB interferometer	CH_3OCHO CH_3CN Cont1mm	A.Fuente C.Ceccarelli P.Caselli D.Johnstone E.Van Dishoeck R.Neri R.Plume B.Lefloch M.Tafalla F.Wyrowski
O036	Fragmentation in massive precluster cores	NH_2D $C^{18}O(2\text{-}1)$	F.Wyrowski M.Thompson A.Gibb J.Hatchell
O038	The nature of extremely young massive protostars discovered by ISO	$HCO^+(2\text{-}1)$ $^{12}CO(2\text{-}1)$	S.Birkmann O.Krause D.Lemke
O039	Structure + kinematics of an embedded cluster of massive YSOs	CH_3CN CS(5-4)	V.Minier R.Cesaroni P.André M.Burton F.Herpin N.Peretto
O03A	Temperature and density map of a high mass star forming cluster	CH_3OH CH_3OH	S.Leurini H.Beuther K.Menten P.Schilke
O03B	The temperature structure of a high-mass protocluster and the origin of the IMF	$^{13}CO(1\text{-}0)$ H_2CO	H.Beuther P.Schilke
O03C	Exciting new vistas on the formation of high mass stars	CS(2-1) CS(5-4)	D.Nürnberger R.Chini V.Hoffmeister M.Nielbock M.Sterzik
O040	The First Extremely High Velocity Outflow in Taurus	SiO(2-1) $^{12}CO(2\text{-}1)$	J.Santiago M.Tafalla R.Bachiller D.Johnstone
O041	V380 Ori NE – zooming in on a molecular jet	$^{12}CO(1\text{-}0)$ $^{12}CO(2\text{-}1)$	K.Menten C.Davis G.Gueth M.Caughrean D.Nürnberger M.Smith T.Stanke J.Williams H.Zinnecker
O042	The kinematics of the photoevaporation disk around the massive star in MWC349	$H41\alpha$ $H30\alpha$	J.Martín-Pintado C.Thum P.Planesas
O043	Mass outflow and tidal interactions in FU Ori	$^{13}CO(1\text{-}0)$ $^{12}CO(2\text{-}1)$ $C^{18}O(1\text{-}0)$	S.Cabrit C.Dougados F.Malbet P.Garcia F.Ménard R.Lachaume
O044	Dust in embedded disks: when does grain growth occur?	Cont3mm Cont1mm	A.Natta L.Testi R.Neri
O045	Chemistry in Proto-Planetary Disks	$N_2H^+(1\text{-}0)$ $C_2H(1\text{-}0)$ $H_2CO(3\text{-}2)$ CS(5-4)	A.Dutrey T.Henning A.Bacmann E.Dartois F.Gueth S.Guilloteau P.Hily-Blant R.Launhardt G.Pineau des Forets V.Pietu D.Semenov J.Pety K.Schreyer
O046*	Properties and evolution of disks in high-mass YSO	CH_3CN CH_3CN	R.Cesaroni M.Beltrán R.Furuya R.Neri L.Olmi L.Testi C.Codella
O048	Mapping of two new protoplanetary edge-on disks	$^{13}CO(1\text{-}0)$ $^{12}CO(2\text{-}1)$	F.Ménard C.Pinte G.Duschêne G.Duvert K.Stapelfeldt C.McCabe A.Ghez D.Padgett
O049	PdBI Study of the Circumstellar Disk of V1647 Ori (McNeil's Nebula)	$HCO^+(2\text{-}1)$ $^{12}CO(2\text{-}1)$	N.Grosso B.Lefloch C.Ceccarelli C.Dougados T.Montmerle
O04D	Mass-loss variations in AGB stars II.	$^{12}CO(1\text{-}0)$ $^{12}CO(2\text{-}1)$	T.LeBertre J.M.Winters J.Pety R.Neri
O04E	Deep study of the circumstellar envelopes of AGB & early post-AGB stars	$^{12}CO(1\text{-}0)$ $^{12}CO(2\text{-}1)$	A.Castro-Carrizo J.Alcolea V.Bujarrabal M.Grewing R.Lucas R.Neri H.Oloffson F.Schöier J.M.Winters M.Lindqvist

Ident.	Title	Line	Authors
O04F	The Equatorial Disks of young Planetary Nebulae	$^{12}CO(1\text{-}0)$ $^{12}CO(2\text{-}1)$	R.Bachiller E.Josselin P.Huggins T.Forveille P.Cox
O053	Understanding the Emission Mechanisms in LLAGN –Coordinated Multi-Wavelength Observations of M81	$^{12}CO(1\text{-}0)$ $^{12}CO(2\text{-}1)$	R.Schödel A.Eckart M.Krips M.Jimenez-Garate S.Markoff
O055	Fueling IC342's Nuclear Star Cluster: Gas Kinematics and Properties (r< 15pc)	CN HCN $^{12}CO(2\text{-}1)$	E.Schinnerer D.Meier R.Böker
O056*	Molecular Gas in the latest-type Spirals: II. Mapping the nuclear CO distribution	$^{12}CO(1\text{-}0)$	T.Böker E.Schinnerer U.Lisenfeld
O057	Probing ongoing AGN feeding in NGC4321 (M100)	$^{12}CO(1\text{-}0)$ $^{12}CO(2\text{-}1)$	S.Garcia-Burillo F.Combes E.Schinnerer A.Usero R.Neri
O05A*	HCN in Ultraluminous Galaxies	HCN(1-0) CO(2-1)	D.Downes P.Solomon
O05E	Deep inside the Perseus cluster core – II - A dynamically perturbed cooling flow	$^{12}CO(1\text{-}0)$ $^{12}CO(2\text{-}1)$	P.Salome F.Combes
O060	Molecular Gas in the Local Analogs of LBGs	$^{12}CO(1\text{-}0)$ $^{12}CO(2\text{-}1)$	A.Baker L.Tacconi C.Martin R.Genzel D.Lutz M.Lehnert T.Heckman
O061	Molecular emission and absorption in the disk and jet-disk interface of the radiogalaxy 3C293	$HCO^{+}(1\text{-}0)$ $^{12}CO(2\text{-}1)$	S.Garcia-Burillo F.Combes A.Fuente S.Leon A.Usero R.Neri
O066	Neutral Carbon CI($^3P_2 \rightarrow ^3P_1$) and ^{13}CO in high$-z$ Quasars and Starbursts	$^{13}CO(3\text{-}2)$ CI(2-1)	A.Weiss D.Downes C.Henkel F.Walter
O067	A PdB Survey of CO in Submillimetre Galaxies V.	CO(3-2)R CO(4-3)R Cont1mm	R.Genzel R.Ivison F.Bertoldi R.Neri A.Omont P.Cox T.Greve S.Chapman A.Blain I.Smail
O068	High Resolution mm-Interferometry of Submm Galaxies: Testing High-z Mass Assembly	CO(4-3)R CO(7-6)R	R.Neri R.Genzel R.Ivison F.Bertoldi A.Blain S.Chapman P.Cox T.Greve A.Omont I.Smail L.Tacconi
O069	Sub-kpc CO mapping of a sub-mJy submm source at z=2.5 behind A2218	CO(3-2)R CO(7-6)R	J-P.Kneib R.Neri I.Smail
O06E	Millimeter observations of GRB and XRF afterglows in the SWIFT era (ToO)	Cont3mm Cont1mm	A.Castro-Tirado M.Bremer D.Battacharya S.Truskin J.Gorosabal S.Guziy
O06F	Io's atmosphere: study of the SO_2 and SO spatial distributions	SO SO_2-SO	E.Lellouch R.Moreno
O070	Mapping of Titan's wind at CASSINI/Huygens arrival	HC_3N HCN CN_3CN	R.Moreno A.Marten
O--5	Resolving a giant proplyd	$^{13}CO(1\text{-}0)$ $^{13}CO(2\text{-}1)$	P.Schilke D.C.Lis H.Beuther D.Wilner
P001	Mapping the D/H ratio in the Martian atmosphere	$^{12}CO(1\text{-}0)$ HDO $H_2^{18}O$	T.Fouchet R.Moreno F.Montmessin E.Lellouch T.Encrenaz
P003	How similar are IS and cometary ices: the ethylene glycol test	EG HDO	N.Brouillet T.Jacq A.Baudry T.Wilson J.Crovisier F.Bockelee-Morvan, D.Despois
P004	Physical Structure of Diffuse Molecular Gas Observed at the Plateau de Bure	$^{12}CO(1\text{-}0)$	J.Pety H.Liszt R.Lucas
P006	Searching for Initial Turbulent Support in the NGC 2264-C Protocluster Condensations	$N_2H^{+}(1\text{-}0)$ $C^{18}O(2\text{-}1)$	N.Peretto P.André A.Belloche P.Hennenbelle
P009	The nature of the Spitzer protostars	$^{12}CO(1\text{-}0)$ $^{12}CO(2\text{-}1)$	A.Crapsi M.Tafalla T.Bourke P.Myers P.Caselli M.Walmsley

Ident.	Title	Line	Authors
P00D	Chemistry in Proto-Planetary Disks (CID) – Part II	$^{12}CO(2\text{-}1)$ $HCO^{+}(1\text{-}0)$	A.Dutrey T.Henning A.Bacmann E.Dartois F.Gueth S.Guilloteau P.Hily-Blant R.Launhardt V.Pietu G.Pineau des Forets J.Pety K.Schreyer D.Semenov
P011	Rotation in T Tauri disks: a crucial test of jet launching models	$^{13}CO(1\text{-}0)$ $C^{18}O(1\text{-}0)$ $^{13}CO(2\text{-}1)$	C.Dougados S.Cabrit J.Pety D.Coffey L.Testi A.Natta F.Bacciotti
P016	The enigmatic IRAS object 19312+1950 – Evolved star, interstellar cloud, or both?	SiO(2-1) $^{13}CO(2\text{-}1)$	K.M.Menten J.Alcolea P.Schilke F.Schuller
P017*	Deep study of the circumstellar envelopes of AGB & early post-AGB stars	$^{12}CO(1\text{-}0)$ $^{12}CO(2\text{-}1)$	A.Castro-Carrizo J.Alcolea V.Bujarrabal M.Grewing M.Lindqvist R.Lucas R.Neri H.Olofsson G.Quintana-Lacaci F.L.Schöier J.M.Winters
P021	Probing the PDR chemistry in the nucleus of M82	$HOC^{+}(1\text{-}0)$ CN(1-0) CN(2-1)	A.Fuente S.García-Burillo A.Usero J.Ricardo-Rizzo M.Gerin
P023	Multiwavelength Observations of M81* The Molecular Environment of M81*	$^{12}CO(1\text{-}0)$ $^{12}CO(2\text{-}1)$	R.Schödel M.Krips A.Eckart E.Lindt
P028	Probing the Chemical Evolution at redshifts $z = 0.68 - 0.9$	H_2S–ISO HCN–ISO HCO^{+}–ISO	M.Guélin S.Muller R.Lucas
P029	IRAM observations of the most luminous starbursting galaxy	$^{12}CO(2\text{-}1)$ $^{12}CO(5\text{-}4)$	J.P.Kneib C.Borys T.Soifer D.Weedman
P02B	Very dense gas in the Cloverleaf Quasar: confirmation of HCN 4-3 emission	HCN(4-3)	P.VandenBout M.Guélin C.Carilli P.Solomon
P02E	CN emission in APM08279 at $z = 3.9$	HCN(4-3)R CO(9-8)R	A.Weiss F.Walter D.Downes C.Henkel
P02F	CO-dynamics of Lensed Submm Galaxies in A2218: Probing the Submm Background Light	CO(2-1)R CO(4-3)R	K.Knudsen J.P.Kneib R.Neri P.VanderWerf
P031	Confirming CO emission in 2 quasars at $z = 1 - 2$	CO(2-1)R	M.Krips R.Barvainis A.Eckart R.Neri
P032	A PdB Survey of CO in Submillimetre Galaxies VI.	CO(2-1)R CO(3-2)R Cont1mm	R.Genzel R.Ivison F.Bertoldi R.Neri A.Omont P.Cox T.Greve S.Chapman A.Blain I.Smail
P035	Search for CO in quasars at the end of the re-ionization epoch	CO(6-5)R Cont1mm	P.Cox F.Bertoldi A.Beelen R.Neri F.Walter C.Carilli X.Fan A.Omont M.Strauss
P036*	Millimetre observations of GRB afterglows in the SWIFT era (ToO)	Cont3mm	A.Castro-Tirado M.Bremer D.Bhattacharya S.Trushkin J.Gorosabel S.Guziy A.DeUgarte-Postigo M.Jelinek
P--2	Confirming the First Detection of Pure RotationalEmission from Vibrationally Excited CO with PdBI	SiO(2-1,v1) CO(2-1,v1)	K.Menten R.Guesten
P03F	Basic properties and evolutionary diagram for individual OB protostars	SiO(2-1) $^{12}CO(2\text{-}1)$	S.Bontemps F.Motte N.Schneider
P047	Benchmarking PDR models against the Horsehead edge: II.2 Fractional ionization	$H^{13}CO^{+}(1\text{-}0)$	J.Pety J.Goicochea M.Gerin E.Roueff D.Teyssier P.Hily-Blant A.Abergel E.Habart C.Joblin
P05C*	The First Extremely High Velocity Outflow in Taurus	SiO(2-1) $^{12}CO(2\text{-}1)$	J.Santiago M.Tafalla R.Bachiller D.Johnstone

Ident.	Title	Line	Authors
P05E⋆	The molecular disk orbiting the post-AGB star 89 Her	$^{12}CO(1-0)$ $^{12}CO(2-1)$	V.Bujarrabal H.Van Winckel R.Neri A.Castro-Carrizo J.Alcolea
P065⋆	Disk Formation in Early-Type Galaxies	$^{12}CO(1-0)$ $^{12}CO(2-1)$	F.Combes M.Bureau L.Young
P06F	The extended gas distribution in the advanced merger NGC4441	$^{12}CO(1-0)$ $^{12}CO(2-1)$	E.Manthey S.Hüttemeister S.Aalto
P074⋆	Radio recombination lines in Arp 220	H40α H30α	A.Baker M.Goss F.Viallefond
P07E⋆	Where is the absorption in the $z = 0.68$ intervening galaxy towards B0218?	$HCO^+(1-0)$ HCN(4-3)R	S.Muller M.Guélin F.Combes T.Wiklind R.Lucas
P081	CO Observations of Spitzer $z \sim 2$ ULIRGs with Strong PAH Emission	CO(3-2)R CO(7-6)R	L.Yan D.Lutz A.Omont D.Frayer P.Cox G.Helou L.Armus L.Tacconi
P088	Confirming $CH^+(1-0)$ detections in high-z objects	CI(2-1) $CH^+(1-0)$	E.Falgarone J.Cernicharo J.Black T.Phillips P.Cox P.Hily-Blant
P08B⋆	Revealing the Properties of SMGs without radio counterparts	Cont3mm Cont1mm	H.Dannerbauer F.Walter
P08C	A search for CO in the most distant QSOs	CO(6-5)R	R.Maiolino F.Bertoldi R.Neri C.Carilli P.Caselli P.Cox A.Beelen K.Menten A.Omont T.Nagao C.Walmsley F.Walter
P08D⋆	Millimetre observations of GRB afterglows in the SWIFT era (ToO)	Cont3mm	A.Castro-Tirado M.Bremer D.Bhattacharya S.Trushkin J.Gorosabel S.Guziy A.Ugarte-Postigo M.Jelinek

⋆ Projects close to completion on December 31, 2005.

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

1066. HCN AND HCO+ EMISSION IN THE DISK OF M31
N. Brouillet, S. Muller, F. Herpin, J. Braine, T. Jacq
2005, A&A 429, 153

1067. ATOMIC CARBON AT REDSHIFT ~2.5
A. Weiss, D. Downes, C. Henkel, F. Walter
2005, A&A 429, L25

1068. DETECTION OF TWO MASSIVE CO SYSTEMS IN 4C41.17 AT z=3.8
C. De Breuck, D. Downes, R. Neri, W. van Breugel, M. Reuland, A. Omont, R. Ivison
2005, A&A 430, L1

1069. A DUAL ORIGIN FOR NEPTUNE'S CARBON MONOXIDE?
E. Lellouch, R. Moreno, G. Paubert
2005, A&A 430, L37

1070. Q0957+561 REVISED: CO EMISSION FROM A DISK AT z=1.4
M. Krips, R. Neri, A. Eckart, D. Downes, J. Martín-Pintado, P. Planesas
2005, A&A 431, 879

1071. THE DISRUPTED MOLECULAR ENVELOPE OF FROSTY LEO
A. Castro-Carrizo, V. Bujarrabal, C. Sánchez Contreras, R. Sahai, J. Alcolea
2005, A&A 431, 979

1072. WARM GAS IN THE COLD DIFFUSE INTERSTELLAR MEDIUM: SPECTRAL SIGNATURES IN THE H_2 PURE ROTATIONAL LINES
E. Falgarone, L. Verstraete, G. Pineau des Forêts, P. Hily-Blant
2005, A&A 433, 997

1073. MOLECULAR GAS IN A z~2.5 TRIPLY-IMAGED, SUB-mJy SUBMILLIMETRE GALAXY TYPICAL OF THE COSMIC FAR-INFRARED BACKGROUND
J.-P. Kneib, R. Neri, I. Smail, A. Blain, K. Sheth, P. van der Werf, K.K. Knudsen
2005, A&A 434,819

1074. A STUDY OF THE KEPLERIAN ACCRETION DISK AND PRECESSING OUTFLOW IN THE MASSIVE PROTOSTAR IRAS 20126+4104
R. Cesaroni, R. Neri, L. Olmi, L. Testi, C.M. Walmsley, P. Hofner
2005, A&A 434, 1039

1075. ARE PAHs PRECURSORS OF SMALL HYDROCARBONS IN PHOTO-DISSOCIATION REGIONS? THE HORSEHEAD CASE
J. Pety, D. Teyssier, D. Fossé, M. Gerin, E. Roueff, A. Abergel, E. Habart, J. Cernicharo
2005, A&A 435, 885

1076. A DETAILED STUDY OF THE ROTATING TOROIDS IN G31.41+0.31 AND G24.78+0.08
M.T. Beltrán, R. Cesaroni, R. Neri, C. Codella, R.S. Furuya, L. Testi, L. Olmi
2005, A&A 435, 901

1077. DENSITY STRUCTURE OF THE HORSEHEAD NEBULA PHOTO-DISSOCIATION REGION
E. Habart, A. Abergel, C.M. Walmsley, D. Teyssier, J. Pety
2005, A&A 437, 177

1078. THE SPECTRAL ENERGY DISTRIBUTION OF CO LINES IN M82
A. Weiss, F. Walter, N.Z. Scoville
2005, A&A 438, 533

1079. RELATIVISTIC JET MOTION IN THE CORE OF THE RADIO-LOUD QUASAR J1101+7225
J.-U. Pott, A. Eckart, M. Krips, T.P. Krichbaum, S. Britzen, W. Alef, J.A. Zensus
2005, A&A 438, 785

1080. MOLECULAR GAS AND CONTINUUM EMISSION IN 3C48: EVIDENCE FOR TWO MERGER NUCLEI?
M. Krips, A. Eckart, R. Neri, J. Zuther, D. Downes, J. Schärwächter
2005, A&A 439, 75

1081. GRB 050509b: THE ELUSIVE OPTICAL/nIR/mm AFTERGLOW OF A SHORT-DURATION GRB
A.J. Castro-Tirado, M. Bremer et al.
2005, A&A 439, L15

1082. RADIO, MILLIMETER AND OPTICAL MONITORING OF GRB 030329 AFTERGLOW: CONSTRAINING THE DOUBLE JET MODEL
L. Resmi, M. Bremer et al.
2005, A&A 440, 477

1083. VELOCITY FIELD AND STAR FORMATION IN THE HORSEHEAD NEBULA
P. Hily-Blant, D. Teyssier, S. Philipp, R. Güsten
2005, A&A 440, 909

1084. MULTIPLE CO LINES IN SMM 16359+6612 – FURTHER EVIDENCE FOR A MERGER
A. Weiss, D. Downes, F. Walter, C. Henkel
2005, A&A 440, L45

1085. FIRST DETECTION OF [CII]158μm AT HIGH REDSHIFT: VIGOROUS STAR FORMATION IN THE EARLY UNIVERSE
R. Maiolino, P. Cox, P. Caselli, A. Beelen, F. Bertoldi, C.L. Carilli, M.J. Kaufman, K.M. Menten, T. Nagao, A. Omont, A. Weiss, C.M. Walmsley, F. Walter
2005, A&A 440, L51

1086. ON THE DENSITY OF EKOs AND RELATED OBJECTS
W.J. Altenhoff, F. Bertoldi, K.M. Menten, C. Thum
2005, A&A 441, L5

1087. THE ORBITING GAS DISK IN THE RED RECTANGLE
V. Bujarrabal, A. Castro-Carrizo, J. Alcolea, R. Neri
2005, A&A 441, 1031

1088. MOLECULAR GAS IN NUclei OF GAlaxies (NUGA)
III. THE WARPED LINER NGC 3718
M. Krips, A. Eckart, R. Neri et al.
2005, A&A 442, 479

1089. GRB 021004 MODELLED BY MULTIPLE ENERGY INJECTIONS
A. de Ugarte Postigo, M. Bremer et al.
2005, A&A 443, 841

1090. DETECTION OF A HOT CORE IN THE INTERMEDIATE-MASS CLASS 0 PROTOSTAR NGC 7129-FIRS2
A. Fuente, R. Neri, P. Caselli
2005, A&A 444, 481

1091. SULFUR CHEMISTRY AND ISOTOPIC RATIOS IN THE STARBURST GALAXY NGC 253
S. Martín, J. Martín-Pintado, R. Mauersberger, C. Henkel, S. García-Burillo
2005, ApJ 620, 210

1092. DEUTERATED THIOFORMALDEHYDE IN THE BARNARD 1 CLOUD
N. Marcelino, J. Cernicharo, E. Roueff, M. Gerin
2005, ApJ 620, 308

1093. CO (1-0) AND CO (5-4) OBSERVATIONS OF THE MOST DISTANT KNOWN RADIO GALAXY AT z=5.2
I.J. Klamer, R.D. Ekers, E.M. Sandler, A. Weiss, R.W. Hunstead, C. De Breuck
2005, ApJ 621, L1

1094. SIMBA OBSERVATIONS OF THE KEYHOLE NEBULA
K.J. Brooks, G. Garay, M. Nielbock, N. Smith, P. Cox
2005, ApJ 634, 436

1095. GRAIN EVOLUTION ACROSS THE SHOCKS IN THE L1448-MM OUTFLOW
I. Jiménez-Serra, J. Martín-Pintado, A. Rodríguez-Franco, S. Martín
2005, ApJ 627, L121

1096. A NEW INTERMEDIATE-MASS PROTOSTAR IN THE CEPHEUS A HW2 REGION
J. Martín-Pintado, I. Jiménez-Serra, A. Rodríguez-Franco, S. Martín, C. Thum
2005, ApJ 628, L61

1097. THE TEMPERATURE DISTRIBUTION OF DENSE MOLECULAR GAS IN THE CENTER OF NGC 253
J. Ott, A. Weiss, C. Henkel, F. Walter
2005, ApJ 629, 767

1098. HCN J = 5-4 EMISSION IN APM 08279+5255 AT z = 3.91
J. Wagg, D.J. Wilner, R. Neri, D. Downes, T. Wiklind
2005, ApJ 634, L13

1099. A MOLECULAR FILAMENT THREADED BY HELICAL MAGNETIC FIELDS?
P. Hily-Blant, E. Falgarone, G. Pineau des Forêts, T.G. Phillips
2005, Astrophys. & Space Sci., 292,285

1100. AN INTERFEROMETRIC CO SURVEY OF LUMINOUS SUBMILLIMETRE GALAXIES
T.R. Greve, F. Bertoldi, I. Smail, R. Neri, S.C. Chapman, A.W. Blain, R.J. Ivison, R. Genzel, A. Omont, P. Cox, L. Tacconi, J.-P. Kneib
2005, Mon. Not. R. Astron. Soc. 359, 1165

1101. FEEDING AGN: NEW RESULTS FROM THE NUGA SURVEY
S. García-Burillo, F. Combes, E. Schinnerer, F. Boone, L.K. Hunt, A. Eckart, L.J. Tacconi, S. Leon, A.J. Baker, P. Englmaier, R. Neri
2005, in *The Interplay among Black Holes, Stars and ISM in Galactic Nuclei*
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Cambridge Univ. Press, 427

1102. INTERMITTENCY OF INTERSTELLAR TURBULENCE: OBSERVATIONAL SIGNATURES IN DIFFUSE MOLECULAR GAS
E. Falgarone, P. Hily-Blant, J. Pety, G. Pineau des Forêts
2005, in *Magnetic Fields in the Universe: From Laboratory and Stars to Primordial Structures*
AIP Conf. Proc., 784, 299

1103. THE MULTIPHASE AND MULTISCALE DIFFUSE INTERSTELLAR MEDIUM
E. Falgarone, P. Hily-Blant, G. Pineau des Forêts
2005, in *The Dusty and Molecular Universe*
ed. A. Wilson
ESA SP-577, Noordwijk, Netherlands, 75

1104. CHEMICAL EVOLUTION IN THE ENVIRONMENT OF INTERMEDIATE MASS YOUNG STELLAR OBJECTS (IM YSOS): NGC 7129 – FIRS2 AND LKHα 234
A. Fuente, J.R. Rizzo, R. Neri, P. Caselli, R. Bachiller
2005, in *The Dusty and Molecular Universe*
ed. A. Wilson
ESA SP-577, Noordwijk, Netherlands, 87

1105. AGB MASS-LOSS AND RECYCLING
T. Le Bertre, E. Gérard, J.M. Winters
2005, in *The Dusty and Molecular Universe*
ed. A. Wilson
ESA SP-577, Noordwijk, Netherlands, 217

1106. THE 2 MM LINE SURVEY OF THE STARBURST GALAXY NGC253: SULFUR CHEMISTRY
S. . Martín, J. Martín-Pintado, R. Mauersberger, C. Henkel, S. García-Burillo
2005, in *The Dusty and Molecular Universe*
ed. A. Wilson
ESA SP-577, Noordwijk, Netherlands, 297

1107. COLD MOLECULAR GAS IN COOLING FLOW CLUSTERS OF GALAXIES
P. Salome, F. Combes
2005, in *The Dusty and Molecular Universe*
ed. A. Wilson
ESA SP-577, Noordwijk, Netherlands, 321

1108. VARIATION OF THE C_3H_2 CYCLIC/LINEAR ABUNDANCE RATIO ACROSS THE HORSEHEAD NEBULA PHOTO-DOMINATED REGION
D. Teyssier, P. Hily-Blant, M. Gerin, J. Cernicharo, E. Roueff, J. Pety
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ESA SP-577, Noordwijk, Netherlands, 423

1109. THE MILLIMETER AND SUBMILLIMETER SPECTRUM OF CRL618
J.R. Pardo, J.R. Cernicharo,
J.R. Goicoechea, M. Guélin, T.G. Phillips
2005, in *The Dusty and Molecular Universe*
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ESA SP-577, Noordwijk, Netherlands, 455

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A. Greve, M. Bremer, J. Peñalver,
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9. ANNEX III - IRAM Executive Council and Committee Members, January 2005

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