The JCMT Newsletter

Kūlia I Ka Nu'U

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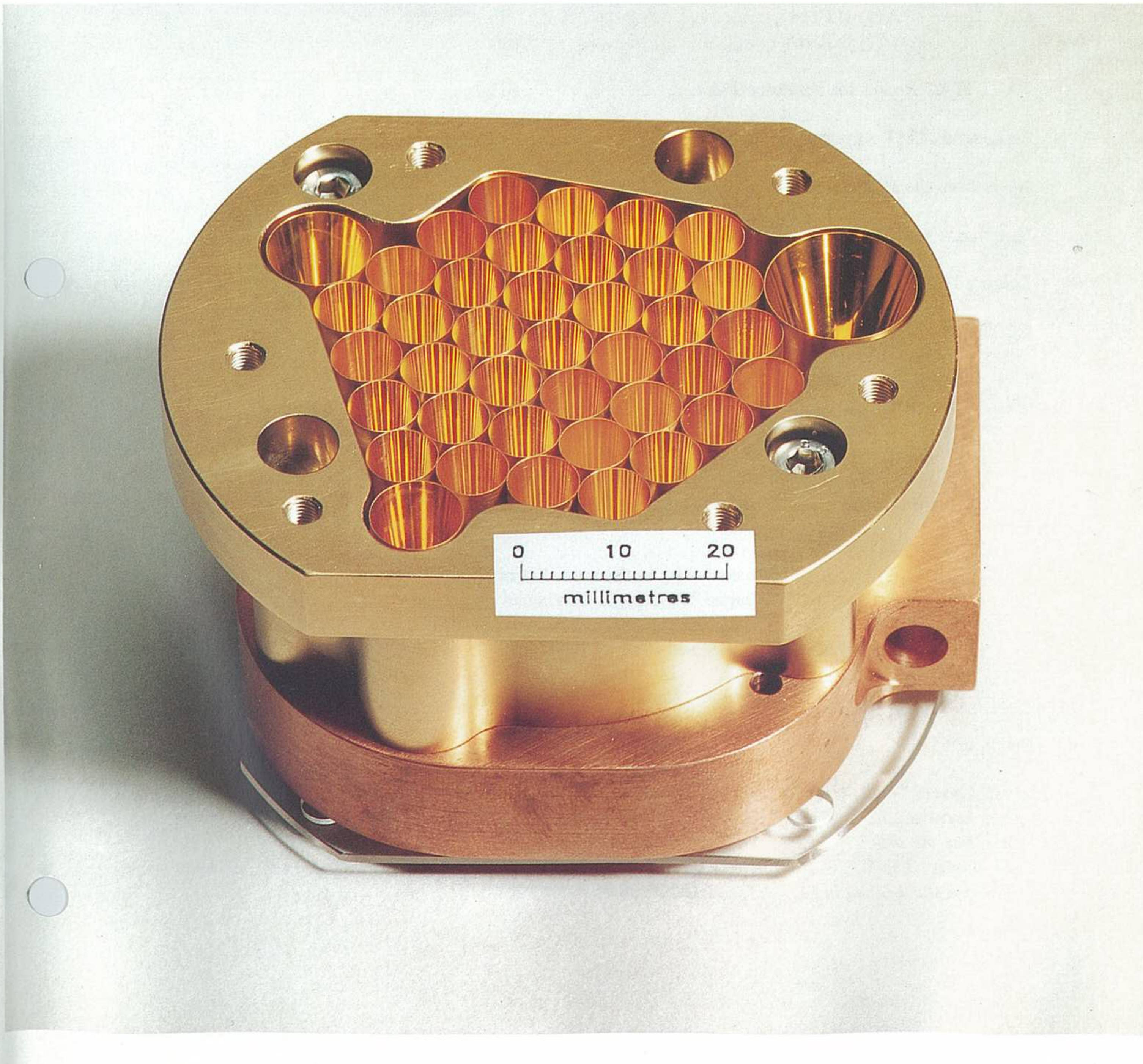


Contents

Front Cover: *The SCUBA 850 μm feedhorn array, consisting of 37 hexagonally-packed conical horns. The 3 larger horns outside the array are the feedhorns for the 1100 μm, 1400 μm and 2000 μm "photometric" pixels. See the article in the Technical News for further details.*
Back Cover: *The SCUBA cryostat. The array shown on the front cover is maintained at 0.1 K in the heart of the cryostat behind stages cooled to 100 K, 30 K and 4.2 K..*

People, Events & Things

Personnel Changes

Malcolm Smith resigned as Director, JAC to take up the position of Director at the Cerro Tollolo Inter-American Observatory in Chile. Malcolm had been in charge of the JAC since 1985. We wish Malcolm and Anamaria a successful and happy time in La Serena.

Denis Urbain has joined the JCMT team as a Radio Astronomical Instrument Specialist. Denis was recently working for IRAM stationed at the 30 m telescope in Spain.

Derek McCall has been appointed the new Head of Administration at the JAC. Derek comes from the SERC, Swindon office where he has held several administrative roles during the past 15 years.

Rob Millenaar has been posted to the JCMT for a one year period to provide support for the DAS and to take over several of Rob de Haan's duties. Rob was one of the key members at NFRA involved in the construction of the DAS.

James Scobbie has joined the JCMT Software Group. Jamie was recently a part of the La Palma software group working on the Isaac Newton Group of telescopes.

Events

Congratulations also to **John White** and **Kirsten Mollegaard** on the birth of their son **John** on 3rd September 1993.

Congratulations to **Dayna Oda-Kell** and **David Kell** on the birth of their son **Dillon** on 5th October 1993.

Accommodation in Hilo for Extended Visits

The JCMT Advisory Panel and JCMT Board have stressed how important they rate having accommodation available in Hilo for those making extended (say more than a week) stays in Hilo (as opposed to at Hale Pohaku). Therefore, I have organised an apartment in the Hilo Lagoon Centre. This has maid service and general amenities. JCMT visitors will be able to stay in this apartment rent free, but will need to pay for food, telephone and other incidentals. We are hoping that an apartment will become available by the time this Newsletter is published. Those wishing to make use of this should contact me. It will be available on a first-come-first-served basis, so book early. Let me stress that this facility is not available for those observers staying a couple of extra days to reduce data - it is specifically for extended stays.

When this apartment is not in use, it will be available for UKIRT visitors at the economic rate.

Director JCMT

High Altitude Medicals

There have been considerable mutterings about the high altitude medical examination for visiting observers over the past few months. At this time I shall say that discussions have taken place between SERC and JCMT representatives and medical personnel highly qualified in high altitude matters.

Whilst awaiting the results of these discussions visiting observers should continue to follow the instructons written in section 2 of the 'Visiting Observer Information for Planning an Observing Run at the JCMT' notes which have been circulated to all successful applicants. Any queries should be referred to the JAC.

Graeme Watt, ROE

Changed Acknowledgement for JCMT Papers

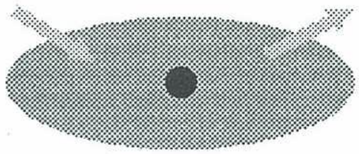
Those of you clever enough to have managed to reduce your JCMT data and publish it must be aware of the standard phrase of acknowledgement that ought to be inserted somewhere in the text of your publication. Due to (a) changes within the management structure of the Observatories (ROE, JAC, RGO and La Palma), and (b) forthcoming changes to the research councils (in our case from Science and Engineering Research Council to Particle Physics and Astrophysics Research Council) this acknowledgement on all papers using data from the JCMT should now mention:

The James Clerk Maxwell Telescope is operated by the Observatories on behalf of the Science and Engineering Research Council of the United Kingdom, the Netherlands Organisation for Scientific Research, and the National Research Council of Canada.

With effect from April 1st 1994 'Science and Engineering' should be replaced by 'Particle Physics and Astrophysics'.

CIRCUMSTELLAR MATTER 1994

29 August - 2 September, 1994 **EDINBURGH, SCOTLAND**



The Conference is to be held at the Edinburgh Conference Centre on the Heriot-Watt University campus to the south-west of the city of Edinburgh. The talk sessions will run from Monday morning through Friday mid -afternoon. A concurrent or recent overview of all features of circumstellar matter will be presented. The presentations and posters should lead participants to a better understanding of the processes of star formation, early stellar evolution and the later stages of evolution. The proceedings of this Conference will be published. This work will form the basis for a major review of circumstellar processes.

Titles for sessions include: Pre-Main Sequence Shells and Discs; Proto-Stellar Evolution; Pre-Main Sequence Outflows; High Mass Stars; Ultra-Compact H II Regions; Dust Grain Composition; Interstellar Chemistry; Vega-Type Discs; proto-Planetary Nebulae; AGB and Post-AGB Objects; Shocks in Circumstellar Winds.

Invited Review Speakers: P.André, P.W.Brand, E.B.Churchwell, R.J.Cohen, W.C.Danchi, W.W.Duley, L.W.Hartmann, P.J.Huggins, G.R Knapp, C.R.Masson, I.R.Stevens, E.F.van Dishoeck, A.Zijlstra, R.Zylka.

For further information: contact Graeme Watt (ROE): tel: +44 31 668 8310; fax: +44 31 662 1668; e-mail: REVAD::GDW (Starlink) or GDW@STAR.ROE.AC.UK (InterNet) or 19889::GDW (SPAN).

The next PATT deadline for JCMT applications is:

21st March 1994

To ensure prompt processing, please ensure that your applications are sent to the correct establishment. Applications for JCMT time should be submitted to the national TAG of the Principal Investigator (PI) or, if the PI is not from one of the 3 partners, to the national TAG of the first named co-investigator on the application who is from one of the partners. International applications (those with no applicants from one of the partners) should be submitted to the UK national TAG. Members of the JCMT staff in Hawaii count as International (not members of the 3 partner countries) unless they are the PI on an application when it should be forwarded to the appropriate national TAG.

Country paying salary of Principal Investigator		
Canada	**Netherlands**	**UK or Other**
JCMT Time Allocation Group, Herzberg Institute of Astrophysics, 100 Sussex Drive, Ottawa, Ontario K1A 0R6 CANADA	JCMT Program Committee, Leiden Observatory, P O Box 9513, 2300 R A Leiden, NETHERLANDS	PATT Secretariat, SERC, Polaris House, Swindon, SN2 1ET, UNITED KINGDOM

Message from the Director

The JCMT continues to perform well and the statistics for time lost due to faults during semester X were very encouraging. During semester Y we have been concentrating on the performance of the heterodyne instrumentation, as observers have experienced a number of niggling faults. I am not yet satisfied with the performance of any of the three receivers in terms of reliability or their ability to retain their published absolute sensitivity values. This and a number of other niggling problems associated with such things as 'out of lock' faults have led me to ask Per Friberg to produce a detailed report of the status of heterodyne instrumentation, our maintenance procedures and recommendations for the future.

We are now preparing for the onslaught of new instrumentation. Both SCUBA and RxB3 are scheduled to arrive in the autumn and I will be working closely with both groups of receiver builders with the hope of commissioning both receivers at the earliest possible time. However, all parties are aware that SCUBA has top priority and currently there is a direct clash between the two instruments in terms of delivery dates. A small delay by SCUBA however would enable B3 to slide into the slot. We await the outcome with bated breath. I am also directing the attention of both the SCUBA team and local staff to the operation of SCUBA, in terms of observer/TO input/control. This and a number of other factors will lead to the control room undergoing a major upgrade in terms of equipment and ergonomics during the next semester. Users should also start to see a big improvement in the aesthetics of the telescope entrance lobby and the downstairs area.

The telescope had its first focal length change last year and at the time of writing the second (and last for the immediate future) movement of about 8 mm has just been completed. This should improve dramatically the high frequency sensitivity and beam shapes. The new archiving/system information software package (Sybase) has arrived and we will be working hard in the next few months implementing the new archiving system. Archiving SCUBA data has immense data storage requirements which are causing some concern and resultant expenditure. The software group are looking toward a better level of user support, both in terms of data analysis packages and facility utilities.

This last six months has seen the completion of the changes in JCMT (and JAC) management structure. With the departure of Malcolm Smith to the CTIO in La Serena, I have taken over as Head of JAC. However this task is nothing like as daunting as it might seem as the JAC has a new Senior Executive Officer who has taken over much of the work previously undertaken by Malcolm. In terms of progressing changes to the overall workings of the JAC, these fall in line with progressing my personal mission statement for the staff of the JCMT. To this end, an intensive two-week training period was arranged, including general training for all staff, along with the first small step in terms of management training for the current line managers. We have much further to go.

The new JCMT Management structure has been approved by the JCMT Board and comprises a second level of senior management. The key post in this aspect is that of Telescope Manager, who has responsibility for day-to-day operation of the telescope and for upgrade projects. Richard Prestage is the current occupant of this post, who along with the Chief Engineer, bear the responsibility for the basic welfare and overseeing improvements to the facility. Chris Purton continues as Telescope Scheduler and TO Supervisor, Henry Matthews as Information Coordinator in a joint group with Graeme Watt in Edinburgh. Göran Sandell takes over as Head of the Telescope Group from Richard Prestage, who continues to Head the Software Group.

In addition to the management changes, construction of the JCMT Mission Statement, team definitions and introduction of the training sessions outlined above, I have concentrated on producing the first stage of the long term plan for the Facility. This has taken on-board the work of Adrian Russell and includes the latest discussions about the JCMT instrumentation. Along with the Upgrades Package, the B-Band array remains the highest priority but the funding availability and complexity of this project means that the next six months will be devoted to a thorough design review (including costing and timescales) before we are certain exactly what can be produced. This will be presented to the Board at the November meeting. The B-Band array is a major project, which will not come to fruition for a number of years, and so in order to retain a degree of flexibility I took the opportunity to introduce a wedge in the funding to allow small, innovative new instruments to be provided. This is discussed elsewhere in the Newsletter.

The long term plan for the Facility is intimately linked to the level and stability of the funding. It is expected that more progress on this will be made at the November Board. In the meantime, a number of potential operational/financial scenarios are being worked through. Budget expenditures are being subjected to a major review. Flexible scheduling remains one of my major goals, however this is also tied up with levels of funding and operational models. The Advisory Panel and PATT will be requested to provide further input at their next meetings. It is anticipated that the final paper will go to the November Board.

The next months promise to be hectic, exciting and I trust, tremendously rewarding. The coming six months will have a major impact in determining the long term future of the JCMT as we look towards operations into the next Century.

Ian Robson

Completed Statistics from the Confidential Observer Reports

An article discussing preliminary findings, based on 31 reports, appeared in the previous issue of this Newsletter. The following is just an updated transcript of that text with modifications where necessary.

The confidential observer reports were introduced at the behest of the JCMT Advisory Panel and the JCMT Board to monitor the quality of service provided to the users. The period of the experiment covered the entire 6 months of Semester X and the first month of Semester Y. At the end of the experiment the dataset contained 52 Confidential Observer Reports, which represented a return rate of only 60% since there were some 87 different observer programmes during the period. These data supply a baseline against which future performance can be measured.

From their home base, 94% of potential observers had access to a copy of 'A Guide for the Prospective User', and 71% were contacted by their Support Scientist, who generally extended a both a welcome and a status report (85%). Some 23% of observers requested further documentation be sent to them and in all reported cases it was delivered promptly. As a result of this, the majority of prospective observers left their home base adequately informed/briefed (44%), with 42% feeling well prepared. Only 1 individual felt poorly informed and 2 felt poorly briefed.

On arrival in Hilo, 58% were met by their Support Scientist. During their period in Hilo most observers felt they were getting instructive assistance from their Support Scientist on the status of the telescope, administrative details, and tactics to improve their observing programme. Only 70% answered the question but 90% of these stated 'instructive'. A significant few (<7) were not impressed with their assistance.

At HP the data reduction facilities received ratings of 8/18/15/6 for poor/adequate/good/excellent.

Once observing, the Telescope Operators gained highest credit with their knowledge of the telescope, their willingness to give information about the operations and their efficiency at controlling the observations. 71% of observers were very impressed with their knowledge of the telescope; 54% with their operational infomation; the remainder were adequately satisfied with both aspects. 81% thought the TOs were very efficient at commanding (the telescope!). The Support Scientists did almost as well. 74% of observers were very impressed, 22% were adequately satisfied, but 2 people thought they were getting poor service.

The Support Scientists accompanied the observers on their first night 89% of the time with 49% remaining for subsequent nights. For those shifts where the Support Scientists did not remain, 73% of observers felt well able to carry out their observations. Again 2 observers felt they were poorly equipped to continue alone. Everybody that answered the question (50/52) mentioned that the TO gave adequate support. All but twice did the Support Scientists mentioned that they would be 'on call' if needed and over an average of about 4 callouts per observer the response was excellent.

All but 5 observers managed to perform some, if not all, data reduction on-line. Most people took their data away on exabyte but seemed reluctant to define their preferred method of data transfer. The scores in this section of the form were:

	transferred	preferred
networked:	9	5
9-track tape:	6	4
other (ie: exabyte):	32	4

Not many observers wanted to stay in Hilo after their run with 71% leaving within 1 day of coming down the mountain. 81% of those answering the question did not believe they could complete their data reduction in JAC although 89% thought JAC facilities adequate and 52% essential.

Most people (67%) failed to find any documentation in Hilo (!). Those that did generally gave it a 'good' grade. The documentation at the telescope received a 53% good, 27% adequate, 20% excellent. HP fared less well with only 54% good, 40% adequate, 6% excellent, and 26% poor. The grades for accessibility of these documents follow closely these values.

And finally... Most people (71%) managed to complete the form in less than 10 minutes (27% in less than 5 minutes). One poor soul took 30 minutes, and 4 could not manage to answer the question!

Graeme Watt, ROE

Expected Availability of Instruments during Semester 94B

Introduction

Semester 94B (1 August 1994 - 31 January 1995) instrument availability and sensitivities are summarized below. Additional details can be found in 'The James Clerk Maxwell Telescope: A Guide for the Prospective User', which is available through the JCMT Section of the Royal Observatory Edinburgh, by contacting the JCMT Group at the Herzberg Institute of Astrophysics in Canada or the NFRA at Dwingeloo, The Netherlands, or from the Joint Astronomy Centre in Hawaii. The current version is dated December 1st, 1993. An e-mail fileserver system now exists to provide instrumental data, both archival and current, and other information. To get acquainted send the one-line message "help" to the Internet address JCMT_INFO@JACH.HAWAII.EDU. The User Guide also may be browsed on the Internet hypertext-based World-Wide Web.

Spectral Line Observations

Three SIS mixer receivers form the core of the heterodyne program, A2, B3i and C2. One other receiver (G2) is available via collaboration with the MPE, Garching group. A summary of the properties of this instrumentation is given in Table 1 below.

Receiver temperature values (T_{rx}) are typical (average) numbers for each receiver; there are significant changes as a function of frequency. The efficiencies (where measured) are accurate to at least 10%. The beam can be slightly elliptical and may depend somewhat on frequency. A new version of Receiver G2 is expected to be installed in March 1994, and as yet only best estimates are available.

Users should note that because both Receivers A2 and C2 use an EIP counter to phaselock the Gunn local oscillator, the resolution achievable is limited by the Gunn's intrinsic phase stability. According to recent measurements on A2, this results in a line width of about 380 kHz. This has the consequence that lines observed with A2 are broadened instrumentally by an additional 0.45 kms^{-1}, and thus A2 is **NOT** suitable for the observation of sources requiring velocity resolution better than a few tenths of a kms^{-1}. We expect that lines observed with C2 will be broadened by a similar amount. Note that the line frequency itself is not affected by the phase 'jitter'.

In the case of B3i (and B3) a much more agile phaselock system is used that can suppress the Gunn oscillator's inherent phase noise. Thus for B3i the resolution is limited only by the spectrometer.

Late in 1994, a dual-mixer dual-waveband SIS system (Receiver W; 'W' for 'wide-band optics') for 450 → 490 GHz and 650 → 690 GHz windows may be commissioned. It is likely that any pair of the four mixers will be useable in combination. Receiver W will likely replace both C2 and G2. At present no further details are available.

(1) Receiver A2

A2 is a single-channel receiver. Its excellent low-noise performance results in a total system temperature (T_{sys}) of better than 400 K at the zenith across most of the band under normal conditions.

(2) Receiver B3i

B3i (also a single-channel device) is one of the best receivers available in this band in the world. The DSB receiver temperature response is not constant with frequency, and ranges from a best value of near 160 K at 355 GHz (even better values have been recorded below 310 GHz), up to about 265 K at 330 GHz. On the sky, SSB system temperatures below 600 K have been obtained under good conditions. The local oscillator system of B3i permits frequency-switched observations with a recommended maximum switch of 150 MHz.

The dual channel version of B3i, B3, is scheduled to be commissioned in autumn 1994, and may be available to users at the end of Semester 94B, depending on the exact timing of its arrival and that of SCUBA. The performance characteristics of B3 are unknown at present, but in terms of receiver temperature there should be a considerable improvement over B3i.

(3) Receiver C2

C2 is a single-channel receiver which covers frequencies from about 450 to 504 GHz. In May 1993 it successfully completed commissioning and has been used for PATT observations since that time, when atmospheric conditions have permitted. Generally this is when the opacity of the atmosphere measured at 225 GHz is less than 0.1 at 461 GHz, and less than 0.06 at 492 GHz.

Two Gunn oscillators (overlapping at 475 GHz) are used to cover the complete frequency band; changing Gunns during an observing night is not encouraged. The performance of C2 has considerably exceeded expectations: DSB receiver temperatures of 190 and 220 K are typical near 460 and 490 GHz respectively. Under the excellent conditions encountered during commissioning, total SSB system temperatures were sometimes less than 1000 and 2000 K respectively. Typical system temperatures are usually 3000 and 4000 K, or better, under decent observing conditions.

(4) Receiver 'G2'

Early in Semester 94A, the first use of a new SIS receiver for the 650 → 692 GHz band is expected. A Gunn oscillator gives continuous coverage across this band, which includes both the CO(6-5) and ^{13}CO(6-5) transitions. This receiver will replace the single-channel Schottky device which has been in use for a few years. For the time being, a receiver for the 800 GHz band will not be offered.

The new receiver will provide a considerable improvement in performance over the old Schottky system. Although the receiver has yet to be installed on the JCMT it is estimated that the typical DSB receiver temperatures should be around 1000 K. The resulting single-sideband system temperatures are extremely sensitive to atmospheric conditions, but are likely to be of the order of 25000 K under practical conditions. Receiver 'G2' is on loan from the MPE group in Garching and observers interested in using it must contact either Dr. A. Harris or Dr. L. Tacconi (e-mail HARRIS or LINDA at MPE-GARCHING.MPG.EDU for further information).

(5) Spectrometer Backends

The Digital Autocorrelation Spectrometer (DAS) has 2048 delay channels having a total maximum bandwidth of 920 MHz in each of two inputs. It is capable of a wide range of configurations, with spectral resolutions of between 0.14 and 1.5 MHz. The widest bandwidth modes are useful only for receivers (such as C2) with sufficient IF bandwidth. A 750 MHz configuration is available to make use of the full IF bandwidth of receivers A2 and B3i. In narrow-band modes it is possible to observe several lines from either sideband with high resolution. Installation of the AGC circuits and a number of software modifications in July 1993 overcame the earlier problem with baseline matching between 'sub-bands', so that the wider-band modes are now fully useable.

The AOSC is an acousto-optical spectrometer which offers a resolution of about 330 kHz and a total bandwidth of 500 MHz for a single IF channel. The AOSC serves as a backup for the DAS. Receiver G2 has its own dedicated AOS.

(6) Approximate rms sensitivities after 30 minutes' integration

Table 2 displays the calculated rms noise in Kelvin after a total observation time of 30 minutes (this assumes 15 minutes on source, 15 minutes on a reference position), at selected line frequencies, for three different atmospheric transmissions. In the first case, a 'typical good' value is used for the system temperature, based on the observed distribution of values over the last six months. In parentheses, the expected values of the rms noise are given for 'exceptional' (corresponding to a water vapour pressure of 0.5 mm in all cases) and 'marginal' weather conditions. In the latter case the highest value of water vapour pressure (given in terms of zenith optical depth at 225 GHz; 'τ(max)' below) at which we recommend observations for the given frequency is used. The behaviour of atmospheric transmission with water vapour pressure impacts strongly on the system temperatures of receivers B3i, C2 and G2, and conditions worse than 'marginal' render observations unrewarding.

The values in Table 2 reflect calculations made assuming an observing elevation of 60 degrees, and (except for receiver G2) use of the DAS in its 500 MHz standard configuration. The transmission in the 'exceptional' and 'marginal' cases has been derived from IRAM's ATM routine (authored by Stephane Guilloteau). Estimates only are available for G2 at this time.

For relatively narrow line sources frequency switching is an attractive option. The chief advantage of this technique over either position- or beam-switching is that the telescope never leaves the source position. Thus its use reduces the rms noise by a factor of 1.4 over those values given in Table 2 for the same total integration time. Frequency switching is implemented in hardware for B3i (and presumable also B3), and via software ('slow frequency switching') for A2 and C2.

Continuum Observations

(1) UKT14

Contingent on progress with SCUBA (see below), the UKT14 bolometer system (which of course includes the polarimeter) will not be available for part of Semester 94B. **Proposals requesting its use only during the first 3 months of Semester 94B will be accepted.**

(2) SCUBA

The Submillimetre Common-User Bolometer Array is expected to arrive in Hilo in autumn 1994. After undergoing tests in Hilo it will displace UKT14 on the left-hand Nasmyth platform, in order to undergo mechanical, electrical and cryogenic fitting. It will not be available for astronomical observations until some time later during the lengthy commissioning period in Semester 94B. **Regular proposals for** the use of SCUBA will not be accepted for Semester 94B. However, as the capabilities of SCUBA are proven they are expected to be released piecemeal to the user community and announcements will be made for opportunities for the use of SCUBA in a service mode as part of the commissioning sequence.

If progress on SCUBA remains on track, simple, photometric observations will be the first to be released in this mode. The situation is quite fluid and will continue to be updated in the e-mail fileserver system as information becomes available.

Henry Matthews, JAC

Table 1. Summary of spectral line observational data.

	Freq. (GHz)	IF (GHz)	T_{rx} (K)	Efficiency Ap.	Beam	fss	Tel. losses	HPBW (")
A2	218-280	1.50	95	0.54	0.72	0.80	0.92	20.8
B3i	298-380	1.50	180	0.42	0.53	0.70	0.89	14.3
C2	450-504	3.94	200	(0.30)	0.43	0.66	0.80	10.5
G2	660-692	1.50	1000	0.23	0.30	0.60	0.65	7.0

Table 2. Approx. rms sensitivities after 30 mins' integration.

Freq (GHz)	Receiver	T_{rx} (K)	T_{sys} (K)	Δv (MHz)	τ (max)	Rms noise (K)	
230	A2	95	400	0.38	0.20	0.035	(0.026,0.059)
266		140	600	0.38	0.20	0.052	(0.036,0.093)
331	B3i	265	1500	0.38	0.10	0.130	(0.087,0.250)
345		180	800	0.38	0.15	0.070	(0.057,0.220)
461	C2	190	3000	0.38	0.08	0.26	(0.15, 0.86)
492		220	3800	0.38	0.06	0.33	(0.24, 1.02)
661	G2	1000	16200	1.00	0.08	0.76	(0.40, 1.40)
692		1000	21000	1.00	0.08	0.99	(0.47, 2.10)

European & National Astronomy Meeting 1994

5 - 8 April 1994

ENAM94 incorporating the 3rd Royal Astronomical Society National Astronomy Meeting & 3rd Annual European Astronomical Society Meeting will be held at the Edinburgh Conference Centre at Heriot-Watt University from Tuesday 5th April to Friday 8th April co-hosted by the Royal Observatory Edinburgh and the University of Edinburgh.

PROGRAMME

Solar Physics - Solar System - Stars & Stellar Systems - Degenerate Stars - Star Formation - Galactic Structure - Normal Galaxies - High-z Galaxies - Galaxy Evolution - Jets from Stars to Quasars - Active Galaxies & Unified Models - Clusters of Galaxies - Gravitational lensing - Cosmology & Large-Scale Structure - Astroparticle Physics & Inflation - High-Resolution Imaging - Infrared/Submillimetre Astronomy

The Royal Astronomical Society recently established annual National Astronomy Meetings, covering any topics at the forefront of astronomical research, in both observational and theoretical fields. The European Astronomical Society organises similar meetings, but concentrating more on a specific theme. Every third year, the EAS meeting coincides with a national meeting of one of the member countries. There will be morning plenary sessions with invited review. Afternoons will comprise three parallel sessions, with symposia organised by session chairmen, at which contributed papers may be presented.

To register your interest in attending, and for more information contact:

Mrs Anne Bryans, Royal Observatory, Blackford Hill, Edinburgh EH9 3HJ

Tel: +44 31 668 8100 Fax: +44 31 668 8264 E-mail: ABB@STAR.ROE.AC.UK (Internet)

PATT ITAC Report for Semester 94A

Allocations

The individual partner TAGs hold meetings in their respective countries prior to the PATT session to assess applications from their own country. At these meetings informal numbers of shifts are nominated for each application in a priority order. The Chairmen of each TAG bring their respective lists to the PATT where the ITAC combined the awards, include discussion of the engineering and commissioning requirements and assess the international applications. The final allocations of shifts are made by the ITAC.

Applications to be considered	
Appls from University of Hawaii	13
Appls with International status	15
Appls with UK status	42
Appls with Canadian status	34
Appls with Netherlands status	13
TOTAL :	**117**

The PATT meeting for semester 94A was held at the Queen's Moat House Hotel in Nottingham, UK on 7th & 8th December 1993.

Awards (in 16-hour nights)	
No of nights in semester 94A	181.00
Engineering/commissioning	34.00
University of Hawaii (10%)	14.50
Director's discretionary use	4.00
Available for PATT science	**128.50**

Only 8 of the 13 University of Hawaii applications were awarded time by the UH TAG.

International status is given to any application where the only named individual from any partner country is a member of JCMT staff based in Hilo. If that individual is the PI then the application is assessed by the appropriate national TAG. International applications are assessed by the Chairmen of the national TAGs at the ITAC meeting.

16-hr nights requested to PATT: 284
Nights available for PATT science: 129

Oversubscription = 2.2

The oversubscription for the previous three semesters were 2.15, 2.36 and 1.89.

Awards by country paying salary of PI	16-hr nights
Nights to International	3.0
Nights to UK	67.5
Nights to Canada	33.0
Nights to Netherlands	25.0

The award given to Canada includes a 3 shift payback from the UK quota for past under-allocation. This payback is now complete.

The number of successful applications for the forth-coming semester was 79. The average length of time awarded per application was 3.7 shifts.

For those not familiar with the JCMT formula, the total time requested is divided amongst the PI and collaborators. 50% of the time is awarded to the country paying the salary of the PI. The remaining 50% is divided equally over **ALL** investigators (including the PI).

Since the quotas are now balanced on a semester by semester basis there is little requirement to complete the calculations using the JCMT formula.

For completeness the 16-hr nights awarded for semester 94A using the formula are 63.2:31.5:25.1 for UK:CDN:NL - very similar to the figures in the table above.

However the International nights come out as 13.9, much higher than the 3.0 above. This indicates that a significant fraction of time is being awarded to International collaborations with a member of the partner consortium being PI on the applications.

Instrument distribution	
UKT14	43%
RxA	19%
RxB	16%
RxC	22%
RxG	1%

Note the extremely strong interest in use of C-band instrumentation with a corresponding drop in requests for B-band. The reduction in allocation of time for UKT14 from the around 50% level, normal for previous semesters, is entirely due to reduced request. Observers are anxiously awaiting the arrival of SCUBA to continue their programmes.

Long Term Status

Application L/M/94A/U19 was approved for long term status for three semesters. Since the continuum instrument would be changed during this period an observing report and re-estimate of the integration times will be required at each subsequent UK-TAG meeting.

Engineering & Commissioning

The engineering & commissioning time for 94A is dominated by instrument commissioning. Significant commissioning slots have been placed in June (for RxB3) and July (for SCUBA).

The ITAC detailed several 'backup' programmes to be placed in the schedule should RxB3 and/or SCUBA fail to meet their delivery date. Now that both instruments have been delayed, further details will be made available as soon as possible from the national TAGs through the e-mail, exploder, JCMTINFORM and JCMT_INFO systems.

Service time

Some discussion was held about service applications not being completed in any given semester. This was usually due to lack of suitable observing slot to observe a given RA range.

Some effort will be put into the schedule for 94A to ensure some of the backlog of uncompleted programmes is removed.

It is imperative that all UKT14 applications are completed by the middle of next semester.

Allocations for this semester are:

CDN	=	8 shifts allocated
NL	=	4 shifts allocated
UK	=	8 shifts allocated

In addition several applications did not have their backup programmes approved. In this case the time becomes service time.

Redesign of the JCMT Application form

It has been decided to design a more appropriate observing application form for the JCMT. It is likely that each of the partner countries will devise their own layout although it is hoped that some commonality will be evident. The process is well under way with a new form (PATT3 for the UK community) available for use in semester 95A.

Reminder of Changes to Semester Numbering

By the new convention, semesters that run from February through July are designated as 'A' and those running from August through January as 'B'. These are to be preceded by the last two digits from the year (which is likely to cause an additional problem in 2000, if we ever get there!). Therefore the current semester from Feb'94 to Jul'94 is known as 94A. Your applications for the forthcoming semester should refer to 94B.

Changes in Assessments Procedures

A report from the Chairman of the ITAC was given to the November meeting of the JCMT Board detailing the comments from the ITAC on the changes in the assessment and allocation procedures that have been in effect for the past few semesters. The current system of assessment (by national TAG) and allocation (through ITAC) will continue. Potential applicants for observing time in Semester 94B should check to ensure their applications are mailed to the correct establishment. See boxed item in the Newsletter for the deadline and mailing addresses.

Graeme Watt, ROE
ITAC Technical Secretary

Successful JCMT Applications for Semester 94A

PATT No.	Principal Investigator	Shifts Given	Title of Investigation
C01	Ivison R J	2	Are there masers in symbiotic Miras?
C02	Rucinski S M	2	Rho Oph B1 at high transitions of formaldehyde
C03	Naylor D A	4	Search for tropospheric CO in Neptune
C05	Matthews H E	1	A high frequency hydrogen recombination line maser
C07	Welch G A	3	Distribution and kinematics of molecular gas in the dwarf elliptical galaxy NGC 205
C08	Joncas G	3	G104.7+2.8S, a supernova remnant-molecular cloud interaction site?
C10	Daines	2	Sub-millimetre continuum spectra of ultra-compact H II regions
C11	Harris A I	2	A short-submm line survey of the Orion-KL region
C12	Kwok S	2	CO emission from planetary nebulae with large IR excesses
C13	Mitchell G F	5	Optical jets, molecular outflows and neutral winds
C15	Papadopoulos P P	2	CO J = 3-2, 2-1 in Seyfert galaxies
C16	Lee S -W	2	CO observations of NGC 3044
C19	MacLeod J M	2	Observations of dense, warm gas associated with the young stellar object IRAS 04368+2557
C20	Avery L W	3	A targeted search for shock enhanced interstellar chemicals
C23	Davis G A	2	Search for tropospheric HCN in Jupiter
C24	Scott D	3	Search for C II emission from high redshift absorption systems
C26	Wilson C D	3	The temperature of molecular clouds in M33
C27	Thornley	3	Temperature variations of molecular gas in nearby flocculent galaxies
C28	Wilson C D	4	The origin of the large scale distribution of C I in M17
C30	McCutcheon W H	3	A 335 - 365 GHz line search in NGC 6334 I and I(North)
C31	Vallée J P	2	Submm survey of magnetic field directions in molecular disks
C32	Bastien P	1	Submm polarisation survey of molecular clouds
C34	Matthews H E	2	A search for vibrationally excited NH_3 in galactic sources
I05	Patel N A	2	Neutral carbon and CO observations of bright rims in IC 1396
I10	Walker C E	2	A study of [C II] towards optically selected damped Lyman-α systems
I14	Womack M P	2	A sensitive search for CO emission from Pluto's atmosphere
H01	Jewitt D	3	Submillimetre continuum studies of comets
H02	Ladd E F	3	Submillimetre continuum observations of stellar density enhancements
H04	Ladd E F	4	Observations of star forming dense cores with rare isotopes of CO
H07	Evans A S	6	Submillimetre spectroscopy of high redshift radio galaxies
H08	Senay M C	5	CO emission from comets
H09	Owen T	2	CO and HCN on Neptune
H11	Owen T	3	Comet Shoemaker-Levy strikes Jupiter
H12	Sanders D B	3	CO (3-2) and CO (2-1) survey of the galactic plane
N01	Henning Th	7	CS in disks around very young stars
N02	Miley G K	6	Radio galaxies at z > 2
N03	Helmich F P	8	W3 chemistry
N04	Israel F P	7	C I in galaxy centres
N05	van Dishoeck E F	4	Ionisation in molecular clouds
N06	de Jong Th	4	C I in IRC+10216
N07	Tauber J	2	Photodissociation in NGC 7023
N09	Miley G K	4	CO in z = 2.9 galaxy

Successful JCMT Applications for Semester 94A

PATT No.	Principal Investigator	Shifts Given	Title of Investigation
N11	Coleman P H	2	Blazars in nearby radio galaxies
N12	Jaffe W	2	Nuclear disks in Virgo ellipticals
U01	Dent W R F	2	The dust:gas ratio around Vega
U02	Dent W R F	2	Temperature structure in massive disks and the usefulness of molecular thermometers
U03	Dent W R F	3	Relationship between the optical and molecular jets in HH111
U04	Lasenby A N	2	High negative velocity emission in the Galactic Centre
U06	Macdonald G H	2	The circumstellar structure of IRAS 18265-1517
U07	Minchin N R	6	C I observations of edge-illuminated molecular clouds S140 & M17SW
U09	Marscher A P	9	Multifrequency monitoring of γ-ray bright blazars
U10	Gear W K	4	Millimetre polarimetry of blazars: are jets in BL Lacs & quasars the same?
U11	Griffin M J	4	Does high-velocity outflow begin in the earliest stages of star formation?
U12	Griffin M J	4	Luminosity:circumstellar mass relationship for YSOs: a submm survey of L1641
U13	Orton G S	6	Observations of the collision between comet Shoemaker-Levy and Jupiter
U16	Evans A	3	Mm continuum observations of carbon stars
U17	Ward-Thompson D	4	Compact prestellar clumps in L1689S
U18	Ward-Thompson D	4	A bolometer survey of newly-discovered candidate protostars
U19	Zylka R	3	The variability of Sgr A* - a black hole in the Galactic Centre?
U20	Watt G D	6	Search for NH_2 in dark cloud regions
U21	Puxley P J	4	A study of the dust content of H II regions
U24	Tacconi L J	6	Mid-J, CO observations of galaxies: subthermally excited gas?
U26	Holland W S	3	Investigating the magnetic field structure around candidate protostar objects
U27	Dent W R F	4	The $^{12}C/^{13}C$ ratio in dark clouds
U28	Röttgering H	3	CO emission in powerful compact radio sources
U30	White G J	8	Observations of the centre of the Galaxy in C I and CO J=4-3
U33	Little L T	4	C I/CO ratio in molecular cloud cores associated with low mass young stellar objects
U34	Little L T	3	C I/CO observations of massive molecular clouds
U35	Longair M S	3	A study of dust in high redshift radio galaxies
U36	Hills R E	2	Continued search for C^+ emission from high redshift quasars
U37	Scott P F	4	Studies of embedded FIR sources in the vicinity of H_2O masers
U40	Emerson J P	3	Millimetre polarisation and dust grain alignment in disks of young stellar objects
U41	Mathieu R D	5	The evolution of disks around young binary stars
U42	Rawlings J M C	2	High resolution observations of HCO^+ and H_2CO in dense cores
U45	Hills R E	9	CO excitation and gas masses of infrared luminous galaxies

News from the JCMT Board

The JCMT Board held its fourteenth meeting on 1/2 November 1993 at the Royal Observatory, Edinburgh. It considered management, Operations, the instrumentation programme, and financial and staffing matters; discussed the development of a long-term plan and a mission statement for the JCMT; received presentations from ROE staff and external speakers; and visited the laboratories at ROE to see instrumentation work in progress, particularly on SCUBA.

MANAGEMENT

The Board accepted the designation of Professor Robson as Head JAC, and proposed changes within the JCMT staffing structure. In particular, the Board welcomed the creation of the post of Telescope Manager, responsible to Director JCMT.

OPERATIONS

Director JCMT reported on Operations, drawing particular attention to the continuing work on the telescope to match the focal length to the panel shape, the decrease in time lost to faults and the positive response to the introduction of Confidential Observer Reports. A highlight of the semester was the JCMT-CSO interferometry run.

JCMT TIME ALLOCATION

The Board formally approved the adoption on a permanent basis of the trial time allocation scheme which has been operated for the past two semesters.

FLEXIBLE SCHEDULING

The Board endorsed in principle the desirability of a move to some form of flexible scheduling, and encouraged Director JCMT to pursue the possibility of a trial scheme to confirm feasibility and identify issues which may need to be addressed.

OBSERVATORY BACKUP PROGRAMME

The Board supported in principle the creation of an Observatory Backup Programme which could carried out whenever a visiting observer's main programme could not be done and their own backup programme had not been approved by ITAC/PATT.

Director JCMT explained that the Observatory Backup Programme had been designed and automated so that it could be carried out by the TOs with the visiting astronomers merely present for safety reasons, and at very little cost to anyone. It was intended to represent the minimum acceptable level of programme that should be done on the JCMT. It would produce very good science and good benefits for the JCMT, but was not dramatically challenging. The decision on when to switch to a backup programme - whether the observer's own, if it had been approved by ITAC, or another if the observer's own is not approved - would continue to be planned between the visiting astronomer and the support astronomer in advance, and any disputes resolved with Director JCMT in advance of observations.

The Board did not assess the proposal; it had been submitted through the PATT application route to be assessed in normal competition. The Board fully supported this procedure, and stressed that it would be open to any user to submit a backup programme which could be done by the TO without any additional staff resource (this would, for example, necessitate it being automated).

GUIDELINES FOR COMMON USER OPERATION OF INTERFEROMETRY

The Board agreed guidelines for common user operation of interferometry whereby proposals for interferometry will first be sent to an interferometry assessment panel for technical assessment and scientific ranking and will then be sent to the appropriate body (the national TAG or ITAC) which will decide whether it agrees with the interferometry sub-group. ITAC will be responsible for making the final decision on the basis of the priority list submitted by the national TAG. A member of ITAC (the individual to be agreed by ITAC) will be a member of the interferometry assessment panel.

INSTRUMENTATION

The Head, JCMT Receiver Programme reported on progress with instruments under construction. SCUBA and RxB3 are expected to be delivered in Semester 94A; however, both instruments have suffered some delays. RxW is expected to be delivered to Hawaii the following semester. The Board agreed in principle the future instrumentation programme comprising Upgrades, the B-band array and a flexibility wedge for innovative new instrumentation, and asked for a detailed plan to be presented at the May 1994 Board meeting.

OTHER BUSINESS

The Board noted Dr Malcolm Smith's move from JAC to become Director, CTIO, and formally expressed its appreciation of his contribution to the JAC and JCMT.

The Board also noted that this had been Dr McCutcheon's last meeting, and the Chairman thanked Dr McCutcheon on behalf of the Board for his contribution during his membership.

The next meeting of the Board will take place on 9-11 May 1994 in Hawaii.

Rowena L Sirey
Secretary, JCMT Board

Instrument Management Advisory Group

Meeting on December 13th 1993

Request for proposals to provide new instruments for the JCMT

At the recent meeting in Ottawa on Oct. 19th, the JCMT Advisory Panel were presented with a number of possible options for the future instrumentation programme for the JCMT. They prioritised the options as follows:
* **IF switch box** - to accommodate RxB3 & RxW.
* **Upgrades Programme** - to remain state of the art at A, B, C & D-bands.
* **B-band array phase I** - a 16 pixel 345 GHz array using the DAS and capable of being upgraded to more pixels and other frequencies.
* **B-band array phase II** - provision of 16x 1 GHz IF and Spectrometer (MIDAS).
* **B-band array phase III** - upgrade to 32 pixels/IF/Spectrometer channels.

Plus a wedge of funds of approximately 10% of the spend on instrumentation in the Development Fund to provide opportunities for innovative new instruments for the JCMT.

The JCMT Board endorsed these recommendations at its meeting on November 1st & 2nd.

I am now issuing invitations for members of the community to bid for support to provide a new instrument from the wedge identified above. As a guide the instruments are expected to cost up to ~£80k each and around two years to construct and commission. A number of instruments have already been identified and are listed below along with their 'champions' or contact persons.

* SCUBA Polarimeter	- Jacques Vallée
* VLBI	-
* 200 micron Photometer	- Matt Griffin
* FTS	- David Naylor
* RxE1	- Bill Dent

Those interested in proposing a new instrument, or wishing to make inputs to those listed above should note the requirements and time scales listed below.

Proposals must contain:
1. Principal and Co-Investigators.
2. A full scientific case (up to six pages including diagrams).
3. A technical case and a detailed plan for construction, with a preferred time scale, detailing where items will be constructed and where acceptance tests will be undertaken prior to shipping.
4. Full costing (to include commissioning, essential spares and contingency).
5. Any other aspects which the proposers deem appropriate.

Proposals must be received by the Head, JCMT Instrumentation Programme on or before Friday March 11th 1994. The proposals will be refereed. Recommendations will be made by the JCMT Advisory Panel (meeting on April 26th 1994) for submission to the JCMT Board (meeting during the week beginning May 9th 1994).

If you have any questions regarding the above please contact Dr Adrian Russell (APGR@STAR.ROE.AC.UK).

Professor Ian Robson, Director JCMT

Editor's Bit

Welcome to Number 2 of the JCMT Newsletter. Judging by the cheers and kind words you did appreciate the first issue and I hope you will find the contents of the current one just as entertaining.

My deepest sympathy to the demise of the UKIRT Newsletter which has finally been swallowed up by the Observatories structure. The ING and UKIRT will be publishing a new Newsletter named SPECTRUM with Captain Scarlet (I mean Keith Tritton) at the helm.

Not much in the way of response for a new title for this Newsletter. Top of the list comes **SMOG** (Sub-Millimetre Observatory Gazette) but I think I'll hold off a bit on that (thanks Derek!).

The highlight of the forthcoming semester has got to be the advent of SCUBA. Several articles are dedicated to it with emphasis on the **'do not submit PATT applications for SCUBA requesting time in semester 94B'**.

A point of interest is the Interferometry Working Party headed by Adrian Webster. The last time Adrian threw a party was the last time the Hilo Lagoon allowed anybody to hold a pool party! I can't quite remember what all the fuss was about...

You like the new plastic see-through wrapper I hope. It saves Dorothy and I ages packing envelopes and carting them down to the Lodge for posting. Watch out for further improvements in future issues. If you have not yet returned the questionnaire (somewhere near the back page) please do so as this is an essential method for keeping our mailing lists accurate and complete.

Happy reading...

TECHNICAL NEWS

SPECX Notes

The good news (for those for whom that sort of news is good) is that, thanks largely to the efforts of Horst Meyerdierks at The University of Edinburgh, and following an intensive burst of work over Christmas on my part, SPECX should shortly be available on Starlink UNIX platforms. Large parts of the port are complete but it is not quite clear when there will be enough of a system to be worth releasing it to Starlink. At the date of writing (4th January) neither GSD nor FITS i/o has been implemented, so there is still no way to import data other than by direct conversion of VAX files in SPECX internal format. Horst has written a standard SPECX command to do this - for the present anyway it produces .SDF files, which use Starlink NDF and HDS libraries. Remo Tilanus has been working on a GSD reader, and converting the FITS stuff should not be too difficult (although tape i/o will probably not be supported under UNIX), so with any luck it will not be too difficult to finish off V6.4.

Unfortunately a number of the nicest features of the VAX version - such as ^C handling and proper support for dual-screen alpha graphics terminals - are unlikely to be available in the first UNIX version (6.4), and users may notice some "debug" type statements which are unfortunately necessary to circumvent bugs in the f77 compiler, but for most purposes SPECX V6.4 should satisfy the need. With any luck it will be released to Starlink during February, and if not, then soon after. Whether the documentation will be available by then is another matter.

Horst is aware of the need to be able to export SPECX to non-Starlink sites without them needing to take on the whole of the Starlink environment, and I am assured that this will be possible. However in the first instance it is probable that UNIX software will be available only through ROE, or later through the Starlink Librarian - in any case, probably not from me directly.

Meanwhile, for those who do have access to a VAX still, and while you are at the telescope, the improvements in V6.3 should make life easier. In fact the release of this version has been prompted mainly by the successful commissioning of the DAS, which in turn has required major changes in the internals of SPECX to accommodate extra header information required to define the frequency scales accurately. Several new commands have been added for dealing with DAS data, while others have been modified slightly.

Most importantly, the SPECX internal datafile and map format has changed. As always, SPECX 6.3 is able to read any existing files and maps you may have, but it is no longer able to write to them. Map files (with the .MAP extension) are converted to V3 the first time they are opened by the new program - if you intend also to use earlier versions of SPECX then make a copy of the map before you use V6.3 for the first time. This is not true of ordinary datafiles; you just can't write spectra to them any more, but it is a simple matter to open a new file and then copy the spectra across one by one or in a DO loop.

The reason these file formats have had to change is to accommodate the LO and IF frequencies in the header, along with the velocity of the source in various frames. These were not previously available in the GSD file, but were derived within SPECX from the specified source-frame centre frequency of each sub-band. This is not however a natural way to do things, and proved prone to error with increasingly complex data such as those produced by the DAS. Hence the change. Since things were changing I have taken the opportunity to tidy up some other relics of bygone computer systems - RA and Dec are now stored internally as REAL*8 degrees, and the map offsets are stored as reals. This has meant changes to some of the macros supplied with SPECX, and if you use these variables in your own macros then you will need to modify them accordingly.

1. New and modified commands:

CLIP-SPECTRUM --- Sets all values in a spectrum outside of the specified range to a specified value.

CONCATENATE-SPECTRA --- Combines all sub-bands of the spectra in X & Y stack positions into a new spectrum (the individual sub-bands are retained).

WRITE --- A version of PRINT modified to write into an SCL character variable which can then be used in response to a request of character input (a filename say).

READ-FITS-SPECTRUM --- Reads a SPECX or CLASS FITS spectrum from a disk-FITS file into the X stack position.

OPEN-FITS-FILE --- Replaces OPEN-FITS-OUTPUT-FILE, and has new questions.

CLOSE-FITS-FILE --- Replaces CLOSE-FITS-OUTPUT-FILE.
SET-PLOT-SCALE --- Now lets you specify auto-scaling for the X and Y plot axes separately.
SET-MAP-PARAMETERS --- Now lets you specify that the map axes are to be scaled in sexagesimal form - i.e., RA and Dec in HMS.
SHOW-VARIABLES --- Accepts VMS-type wildcards, so that, for example, the command ">> show-var f*" will return all SCL variables that begin with the letter f.
PLOT-LINE-PARAMETERS --- As well as the existing set of parameters (Tmax, Vmax, Integrated intensity and Delta(v)), now also offers you the 1st and 2nd moments of the line profile. The 1st moment is the Centroid; the 2nd moment approximates the line width for lines of good Signal/Noise ratio.

2. Bad channel/Magic value handling

Bad-channel handling has been available for some time in the various mapping functions, although it tends to go unseen (except when you forget to do an INTERPOLATE for sparsely sampled data). A version of this has now been introduced for single-spectrum data. Channels in spectra set to this value are not displayed on plots, or used in computing quantities such as maximum intensity or line width. Channels which end up being unspecified, as the result of a SHIFT operation say, are now set to the bad channel value, rather than zero as before. Bad channels can be interpolated over with smoothing commands such as HANN, SMOOTH, CONVOLVE, BIN etc.

You can determine the current setting of the bad channel value by doing:

```
>> print badpix_value
```

and if you don't like it, you can change it by doing:

```
>> badpix_value = -100
```

for example. The one place where bad channels in spectra are not handled well is in spectra in a map cube - fewest problems will result if you smooth over such bad channels before ADDing to the map, or choose a value of badpix_value close to zero (I tend to use 10^{-5} by default). Although we did have some teething problems with this feature, it seems to be working pretty well now - It is particularly useful for dealing with DAS data, where the end channels of each sub-band tend to be set to 10^4 or some such similar value, and totally destroy the auto-scaling of plots.

Note that if you change the value of badpix_value as shown above, then previously "hidden" channels in your data will now be displayed, and/or used in reduction operations.

3. Map display

A few mostly cosmetic changes have been introduced here. Displays involving greyscales will mostly now have a scale-bar displayed wherever there seems to be most room. This is not foolproof however, and for some unfortunately sized maps the scale-bar may vanish off the edge of the plot area - just do SET-MAP-SIZE if this is the case. Note that the scale bar will **not** appear in the case of PLOT-LINE-PARAMETERS when more than one map is made - the various maps in this case have different scales, and it did not seem sensible to try to generate scale-bars for each independent panel.

Also, you can now display RA and Dec coordinates (only) in all forms of map display (GRID, CHANNEL-MAP, GREY, CONTOUR and PLOT-LINE-PAR) in standard sexagesimal notation. That is, absolute positions are displayed, in HMS and DMS respectively. You can however still display things in the old way if you want - the map centre RA and DEC are now indicated in the axis labels. Use SET-MAP-PARAMETERS to change the default axis scaling.

4. FITS i/o

There have been ongoing problems with exchanging single spectra in FITS format between SPECX and CLASS. We (Remo Tilanus and I) believe that this has now been cured, following minor changes to both programs (with the cooperation of the CLASS authors at IRAM). Certainly SPECX now seems to produce valid CLASS spectra. I have also resurrected John Richer's FITS reader, and with a great deal of hacking turned it into a standard command that reads disk-FITS spectra (SIMPLE=.TRUE. only) into the X position of the stack. This command is READ-FITS-SPECTRUM - open the FITS file with OPEN-FITS-FILE and close it afterwards with CLOSE-FITS-FILE as before (note that the names of these commands are changed from OPEN-FITS-OUTPUT-FILE and CLOSE-FITS-OUTPUT-FILE respectively).

FITS maps are more of a problem. Claire Chandler has recently modified WRITE-FITS-MAP to make it compatible with AIPS (it always used to be, so I assume that AIPS has changed too...), but this is probably **not** compatible with CLASS. We may eventually need separate commands to write FITS maps for different targets.

5. Frequency and Velocity scaling of Plots

It is now possible to produce plots which have the image sideband frequency along the top axis. To get this, all you have to do is to choose the absolute frequency options in SET-X-SCALE. Note however that it is unlikely to be correct unless the display frame is the one in which the source is at rest. Since you may have observed with (say) the LSR velocity not equal to that of the source itself, I can't protect you from this. But in most cases it will be sufficient to do

>> SET-VELOCITY-FRAME yes lsr radio vlsr

That is, choose a velocity reference frame which is defined as having velocity offset with respect to the standard of rest the same as that of the source itself (modify as appropriate for heliocentric, geocentric or telluric frames, and for different velocities or velocity definitions).

HOWEVER... You must realize that most plotting packages, PGPLOT amongst them, accept REAL*4 numbers only. So if you display things in absolute frequency, it is not possible to get velocities accurate to better than a couple of MHz in three hundred odd GHz, no matter how accurately they are calculated internally in SPECX. For more accurate displays, choose a convenient reference frequency in the absolute frequency option in SET-X. For example, if you have a set of lines in the range 338 → 339 GHz, then choose a reference frequency of 338 GHz, and remember to add this back on to any frequency you determine with FIT-GAUSSIAN, or using the cursor.

My thanks to Remo Tilanus in particular for his help, provision of DAS data, and rapid turn around of queries while we were solving the problems associated with the DAS. My apologies to anyone who may have been inconvenienced by problems in the Beta-test version - I hope you appreciate that it was the only way to make DAS data available at all.

Rachael Padman, MRAO

Source Positions

Following discussions at the JCMT Advisory Panel and Board, observers will be requested to give precise coordinates of their positions in the new edition of the PATT (or whatever) telescope application form. This is to ensure that we can monitor the sources approved by PATT and attempt to ensure that, for instance, SERVICE observations do not unintentionally scoop approved programmes. This will become even more important in the SCUBA era. Source name is of little help as many sources go by a number of names.

We intend to input approved sources onto the new archiving/database system to help us in this matter. If observers wish to retain confidentiality of their source positions, then they are free to do so, but at their own risk.

Director, JCMT

Interferometry

Introduction

At the November 1993 meeting, the JCMT Board endorsed the plan outlined below for opening up Short Baseline Interferometry (SBI) for users commencing with applications for semester 94B. The plan is also acceptable to the CSO.

The plan is similar to that in operation for Receiver G, however SBI is a strictly bilateral project requiring complete collaboration between the JCMT and the CSO. The staff of both facilities must work closely together to ensure that the technical details required for an interferometry run are satisfied, and the scheduling is co-ordinated. The CSO are equal partners in the joint venture. It is essential that data release from all SBI runs is carefully monitored so that potentially spurious results arising from, for example, phase variations can be avoided. Therefore it is sensible that an entire SBI allocation be viewed as a single experiment with a number of sub-investigations. The consortium members would support all the observations and would have the responsibility of validating the data quality from each SBI run.

Use of SBI

The over-riding criterion for collaboration by users in Short Baseline Interferometry is the potential of the individual(s) to enhance the scientific productivity of both telescopes. This should include one or more of: the provision of scientific input; technical expertise in interferometric techniques; technical expertise in data analysis.

The possibility of offering short baseline interferometry runs will need to be agreed by the Directors of both telescopes well in advance of the semester concerned. The approximate time for SBI runs within the semester will also be agreed. Either Director will have the right to decline to participate in any one semester due to other pressures.

In the future, an announcement of the intention to support SBI in the forthcoming semester and an invitation for potential users to apply for time will be made in the JCMT Newsletter, JCMT_INFO, and national e-mail exploders well in advance of the closing date for receipt of telescope time applications. The current JCMT (TAG/ITAC) time allocation process will be used for applications and subsequently to allocate time for SBI. Applicants will apply to use the common facility, not to a particular telescope. The CSO user community will be invited to apply through their usual application procedure.

The applications will be reviewed by a special interferometry sub-group comprising members from the CSO, JCMT, SBI consortium and ITAC. This group will meet by e-mail and assess applications for technical feasibility and will provide a ranking for scientific importance. The ranked list of proposals will then be forwarded to the respective TAGs and ITAC (including CSO TAC) for subsequent review and time allocation. The Director JCMT will be responsible for ensuring that communications between the respective time allocation groups is coordinated.

Following this stage, the consortium members will have the right to decline to support an SBI run (if, for example, the time awarded was less than the minimum required to justify the level of support required - this is the same arrangement as for RxG). For the purposes of time allocation and time attribution, there will be PI's and Co-Is for each component of the science programme. Time will be attributed according to the currently agreed formula.

Information on the performance of SBI is given in the July 1993 and February 1994 JCMT Newsletters. The key parameters are that the baseline is 164 metres long (with a 44 metre North-South component) and that in cross-correlation mode the DAS provides 800 (complex) channels covering 125, 250, 500 or 920 MHz of bandwidth. Only one sideband is correlated at a time. Observations are strongly affected by atmospheric phase fluctuations and the amount of these is very variable. Even under good conditions, coherent integration times are generally limited to about 100 seconds. Those interested in applying to make use of SBI should contact the Director JCMT in the first instance (EIR@JACH.HAWAII.EDU). Applications are now solicited for semester 94B.

It should be appreciated that it will only be possible to accommodate a very small number of projects on this occasion. Although the system can operate in the 230 - 270 GHz band, the unique capability is at frequencies above 300 GHz. Applicants should therefore concentrate on the band covered by the RxB3 receiver. Applicants should use the standard PATT form but no backup programme is required.

Interferometry Working Party

Dr Adrian Webster has agreed to Chair a working party to revisit and update the previous (1990) reports to the JCMT Board concerning the potential future involvement of the JCMT in interferometry - both arrays and VLBI. The study will revisit the scientific case and address the potential of the JCMT and the scientific opportunities in terms of projected projects and timescales. Funding requirements will also be updated. Those interested in making an input to the working party should, in the first instance, contact Dr Adrian Webster (ASW@STAR.ROE.AC.UK). Other members of the working party are Prof. G. Wynn-Williams (UH), Dr. R. Le Poole (Netherlands) and Dr. E. Seaquist (Canada). The working party is expected to report to the April meeting of the JCMT Advisory Panel.

Director JCMT

JCMT Newsletter Deadline

The copy deadline for articles and contribution for the issue number 3 of this Newsletter is:

30th June 1994

This is the date by which ALL contributions MUST be on my desk and/or pc. It is set hard so that layout, printing and distribution can be achieved in advance of the following PATT deadline. Canadian and Netherlands authors should check with their Associate Editors who may set earlier copy deadlines.

Graeme

Weather and Fault Statistics for Semesters X and Y

Introduction

This article is an experiment to present the weather and fault details in a form useful for indicating improvements in reliability and efficiency of the JCMT systems and the data collected with them. The authors would appreciate any comments from the readers on methods of presentation and/or the content of the article.

Weather Statistics

In order to track-down better the amount of allocated time lost through weather and other faults, semester X saw the introduction of primary and backup time lost. These statistics for both semester X and semester Y are shown in Table 1.

The extended hours used showed a decrease in semester X over the previous semester but increased in semester Y due to imminent arrival of SCUBA and RxB3 in semester 94A. The importance of having satisfactory backup programmes available is clearly demonstrated from the table, with 24% of primary time lost but only 1% of the backup time being lost to weather. The data from Table 1 are shown graphically in Figure 1 (a) and (b).

Statistical use of the CSO Tau values

Figure 2 shows a summary of all the CSO tau data collected by the JCMT computer during the period from 15th April 1993 through the end of September. The lack of completeness, evident from Table 2, is indicative of the unreliability of the network link between JCMT and CSO as well as an indication of those periods when the tau meter was unavailable due to maintenance or saturated due to storm conditions. Work is progressing to improve

Semester X

Month (1993)	Hours available	extended hours used	primary programme lost to weather (hours)	%	backup programme lost to weather (hours)	%
February	440.0	0.0	29.0	6.0	0.0	0.0
March	464.0	0.0	48.0	10.0	0.0	0.0
April	464.0	47.0	1.0	0.0	0.0	0.0
May	496.0	39.0	18.8	3.8	0.0	0.0
June	480.0	31.8	48.0	10.0	0.0	0.0
July	488.0	16.7	196.5	40.3	7.5	1.6
Total	2832.0	134.5	341.3	12.1	7.5	0.3

Semester Y

Month (1993)	Hours available	extended hours used	primary programme lost to weather (hours)	%	backup programme lost to weather (hours)	%
August	486.0	38.3	194.9	40.1	5.2	1.1
September	480.0	20.3	88.8	18.5	0.0	0.0
October	484.5	19.4	219.5	45.3	13.3	2.7
November	475.5	21.8	26.0	5.5	1.0	0.2
December	472.0	33.0	108.0	22.9	2.5	0.5
January	430.5	22.9	47.0	10.9	7.0	1.6
Total	2828.5	155.7	684.2	24.2	29.0	1.0

Table 1: *JCMT weather statistics for semester X and semester Y.*

the robustness of the link and the completeness of the data collected has now significantly improved.

Month	% data collected
February	<10
March	<10
April	50
May	70
June	30
July	50
August	70
September	92

Table 2: *completeness of CSO data during period discussed in the text.*

Access to the CSO tau data has been made available to the JCMT by the staff at the CSO for which we are extremely grateful.

Fault Statistics

As shown in Table 3, the faults during both semesters were comfortably below the current quality target of 5% of clear time lost to faults. Much progress has been made in producing new maintenance and inspection systems to identify faults before they cause telescope down-time.

Graeme Watt, ROE

Iain Coulson, JAC

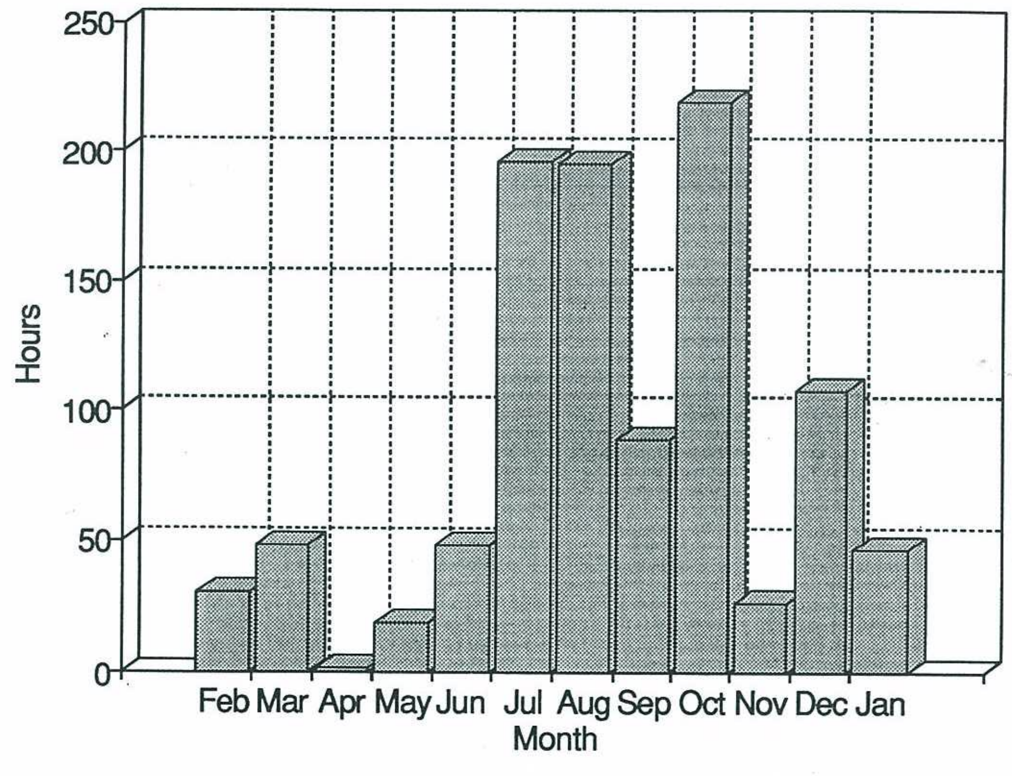


Figure 1: *the weather loss (in hours) per month throughout semester X and Y.*

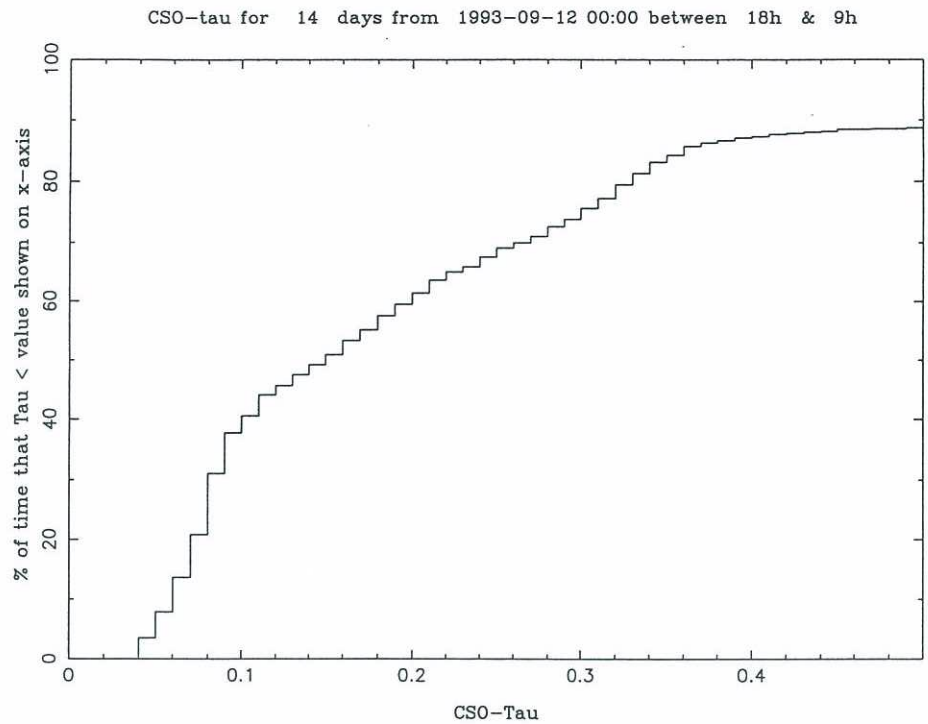


Figure 2 (a): *shows the type of CSO tau plot now obtainable with the SKY software program at the JCMT. The display is the cumulative frequency distribution of CSO tau values over a 14 day time interval beginning on 12th September. The data is monitored each day for the entire period from 6pm through till 9am the following morning. The abscissa is the tau value (at 225 GHz) with a cutoff set at 0.5 Nepers and the ordinate is the percentage of the time interval when tau is less than that value. Data courtesy of CSO.*

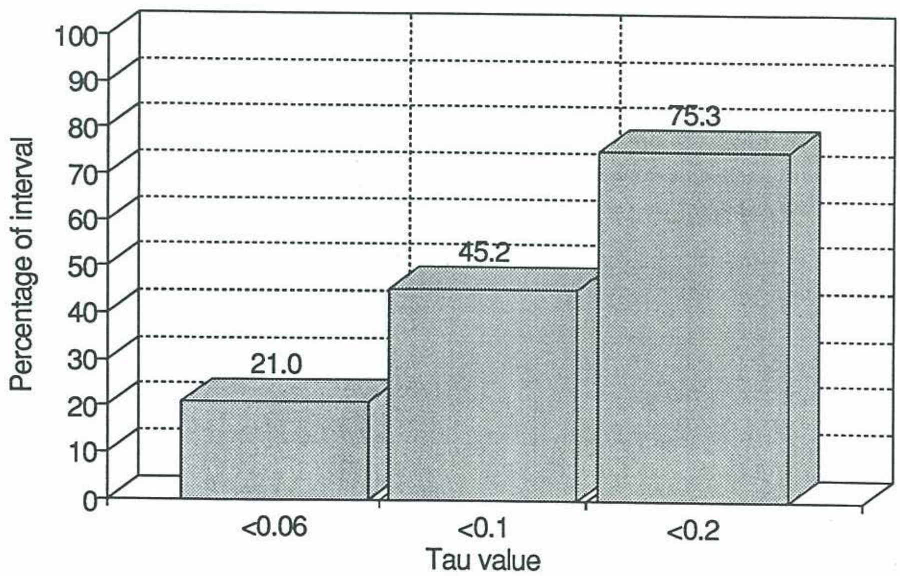


Figure 2 (b): *summary of CSO data for a period of 76 days from 15th April to 26th September 1993. The CSO value for tau is given in Nepers. A Neper is the natural logarithm equivalent of the decibel for units of attenuation. Thus it is the exponent power index for the ratio of two intensities: for I_1 attenuated to I_2 then $I_1/I_2 = e^{-N}$ with N the attenuation in Nepers. Data courtesy of CSO.*

Semester X

Month (1993)	Available hours	Total	ANT	INS	COMP	SOFT	CAR	OTH
Feb	440.0	18.0	0.0	8.0	0.0	2.0	4.0	3.0
March	464.0	22.0	0.0	18.0	0.0	0.0	1.0	2.0
April	464.0	20.0	4.0	8.0	1.0	4.0	0.0	1.0
May	496.0	6.3	0.0	0.2	2.2	1.6	1.5	0.9
June	480.0	11.8	0.7	8.0	0.0	2.4	0.0	0.7
July	480.0	4.7	1.0	2.7	0.0	0.0	0.0	1.0
Total	**Available**	**Total**	**ANT**	**INS**	**COMP**	**SOFT**	**CAR**	**OTH**
P(hrs)	2824.0	82.8	5.7	44.9	3.2	10.0	6.5	8.6
	P(%)	**2.9**	0.2	1.6	0.1	0.4	0.2	0.3
	B(hrs)	6.3	0.0	4.0	0.8	0.0	0.0	1.6

Semester Y

Month (1993)	Available hours	Total	ANT	INS	COMP	SOFT	CAR	OTH
August	486.0	11.1	0.0	8.5	0.10	0.0	0.0	2.5
Sept	480.0	5.4	4.0	1.0	0.0	0.0	0.0	0.4
Oct	484.5	17.1	13.0	3.3	0.6	0.0	0.0	0.3
Nov	475.5	7.1	0.5	3.0	0.0	1.3	0.0	2.3
Dec	472.0	17.3	6.2	6.7	0.0	0.0	0.0	4.4
Jan	430.5	18.2	0.6	9.9	3.1	1.5	0.0	3.2
Total	**Available**	**Total**	**ANT**	**INS**	**COMP**	**SOFT**	**CAR**	**OTH**
P(hrs)	2828.5	76.2	24.3	32.4	3.8	2.8	0.0	13.1
	P(%)	**2.7**	0.9	1.1	0.1	0.1	0.0	0.5
	B(hrs)	10.0	0.0	5.6	0.0	0.3	0.0	4.1

Figure 3: *JCMT fault statistics for semester X and semester Y. Wherever possible the faults are categorised into ANT = antenna; INS = instruments; COMP = computer hardware; SOFT = software; CAR = carousel; with the remainder going to OTH = other. The figures in the table may appear not to add up correctly due to rounding in the original program. P defines the time lost from Primary projects. The category B(hrs) is the time lost to Backup projects. Including the backup loss into the total for P(%) results in the* **TOTAL CLEAR TIME LOSS = 3.3% for both semesters.**

SUBMILLIMETRE COMMON USER BOLOMETER ARRAY

SCUBA

SCUBA: The Submillimetre Common-User Bolometer Array

Many of you will know all about SCUBA and what it will do, and are waiting with bated breath for the chance to use it on JCMT (don't worry, your chance is coming!). Some readers however may not be aware of SCUBA, or else have heard the name and wondered what on earth it is (other than being a self-contained underwater breathing apparatus). The purpose of this article is to clarify for any current or potential users what exactly SCUBA is and explain some of the things it will do (only some because I'm sure you clever people out there can think of lots more!).

So what is SCUBA ? Well, it is a submillimetre camera and photometer. It has 2 arrays of detectors, one of 37 pixels optimised for 850 µm and one of 91 pixels optimised for 450 µm. These 2 arrays look out simultaneously at the same area of sky with a field-of-view of approximately 2.3 arcminutes. Each pixel is diffraction limited, which corresponds to a resolution of 6 arcseconds at 450 µm and 12 arcseconds at 850 µm. There is a filter mechanism which means that the 850 array can also be used at 750 or 600 µm and the 450 array can be used at 350 µm, with slightly less than optimised sensitivity and resolution. In addition to the arrays there are 3 separate pixels individually optimised for 1100, 1400 and 2000 µm. These pixels look out simultaneously but are offset from each other on the sky. All the detectors in SCUBA will be able to achieve background photon-noise limited sensitivity (it achieves this by cooling the detectors to 0.1K, pretty cool eh ?). To enable accurate calibration of data, SCUBA also has a sky transmission calibration system and an internal calibrator to remove variations in detector sensitivity.

What will it look like ? The heart of the matter is of course the detector arrays, and there is a very pretty picture of one of these on the newsletter cover. Once SCUBA is in use you will never see these again, as they will be hidden deep in the heart of the instrument, which is a rather large beast and will be mounted on the left-hand Nasmyth platform, where UKT14 is now. SCUBA and its associated plumbing and electronics will take up most of the platform and look something like Figure 1.

Most of this bulk is taken up with refrigeration and its associated plumbing and control system. A sketch from a different angle of the SCUBA cryostat and external optics without all the electronics and plumbing is shown in Figure 2.

To give you a better idea of the optical layout, a sketch of the optics minus the surrounding metalwork is shown in Figure 3. Note that the size of the internal optical components has been considerably exaggerated with respect to the external mirrors for clarity.

Basically the telescope gets re-imaged at the cryostat window and again onto the dichroic inside. This splits the long and short wavelengths before they get relayed through the appropriate filters in the filter drum onto the arrays (or the 3 long wavelength pixels which are mounted on the edge of 850 µm array. You'll notice that the optics are all reflecting and the beam gets folded around through quite large angles. There are lots of subtleties involved in designing the mirror surfaces to do this and then having to machine them which I don't have the space to go into here but will be discussed in a future paper (Murphy et al in prep) along with other complications in the optical design of SCUBA.

The arrays themselves are hexagonally close-packed (see cover picture), which is the most efficient way to collect photons, however the detector feed-horns do undersample the focal plane. This may seem unwise, however it is not possible to fully-sample and still make the horns efficient at coupling to the Airy pattern in the focal plane. As a result it is necessary to 'jiggle' or 'scan' the detector positions on the sky to make a fully sampled image, which I'll explain shortly.

How do you observe with SCUBA ? It depends on what you're trying to achieve, but there are 3 main observing modes. First and simplest, point-source photometry. You can do this with both arrays simultaneously or with one of the long-wavelength 'photometric' pixels, and you observe just as you would with UKT14, chopping and nodding to remove sky and telescope, and integrating until you have the detection or upper limit you require. The difference will be that SCUBA will be many times more sensitive than UKT14 and because you'll be doing fast and frequent calibrations the data will also be of much higher quality.

For looking at extended sources there are 2 mapping modes. For sources smaller than the field of view, there is what we call 'stare' mode or sometime 'jiggle-stare'. Basically you chop and nod as for photometry, but because of the undersampling mentioned above, you also need to move the detector positions on the sky to get a fully-sampled image. This is achieved by means of making slight tilts to the secondary mirror. It is necessary for each detector to move to 16 different positions before a fully-sampled image is created. This is illustrated in Figure 4.

Notice that although the detectors are in a regular hexagon, their positions on the sky are somewhat distorted, this is a consequence of the off-axis mirrors in the SCUBA optics.

The second mapping mode is for objects larger than the field of view of SCUBA, and is called 'chop-scan'. It is analogous to the technique known as 'on-the-fly' mapping with UKT14 and uses the same basic principle of the Emerson, Klein and Haslam algorithm for restoring a differential map. You chop as usual with the secondary mirror and also scan the telescope along the direction of chop, as long as you start and finish on blank sky you can then restore the source structure. You might think you need to go back and take another scan to fill in the gaps between detectors in SCUBA, however in fact if you chop and scan along a direction as shown in Figure 5 then a fully sampled image is obtained in a single scan, and you simply have to drop down far enough to allow the next scan to overlap with the bottom of the previous one, and build up a large image in this fashion.

What about data reduction ? There will be a dedicated colour workstation delivered with SCUBA, on which flat-fielded and sky-extinction corrected data will be displayed in real-time as it is acquired. This data will also be written to disk and for many, if not most, observers this will be able to do as much reduction as they will want or need. However, for those who want to look again at the data afterwards, simple demodulated data will also be written to disk, and a data-reduction package will be available for post-observing reduction. For those who prefer to handle their data within some other package they are more familiar with SCUBA data can be exported on magnetic tape.

When can I use it ? SCUBA is currently undergoing laboratory testing and commissioning at ROE, and is scheduled for delivery to JAC in the autumn of 1994. There will be a lengthy period of installation and initial tests before any astronomical measurements will even be attempted, and ***no applications for use of SCUBA will be accepted in the next PATT round.*** However it is intended that a large block of time will be reserved for SCUBA use and that as soon as possible, time will be made available to the user community in a service programme. Observing modes will be made available in the order in which they are commissioned, starting with photometry, then jiggle-stare mode and finally chop-scan mode. Applications forms will be released and accepted only via e-mail, further details are given elsewhere in this newsletter.

Walter Gear, ROE

Application for SCUBA Observing

We anticipate that SCUBA will commence astronomical commissioning at the beginning of semester 94B. Commissioning SCUBA is going to be a lengthy and time-consuming task. In order that users can participate at the earliest time, I intend to begin some level of general SCUBA observations during the commissioning phase. These observations will comprise small scale programmes or even single observations, (as for example exploratory work or samples for future programmes) such as those typically suitable for current SERVICE programmes and will be undertaken by the commissioning team on behalf of the users. **THEREFORE CONTINUUM OBSERVATIONS REQUESTING UKT14 WILL BE ACCEPTED FOR TIME IN THE FIRST 3 MONTHS OF SEMESTER 94B. NO SCUBA PROPOSALS WILL BE ACCEPTED BY PATT FOR THE ENTIRE 94B SEMESTER.**

Users will be informed nearer the time, by national e-mail exploders or by reading the JCMT_INFO system in Hawaii (see the July 1993 Newsletter) how they should apply for SCUBA observations; for what months and for what blocks of time. Details will be provided as soon as possible to enable users to understand the sensitivity levels of SCUBA and the observational parameters. It has been agreed with PATT that submission for these serviced observations will be by e-mail and that the first types of programmes to be solicited will be for point source photometry.

Extensive programmes are not allowed for this call for observations, the object of the exercise is to allow the widest community involvement in SCUBA at the earliest times. Photometry will be followed by small scale mapping, then larger scale mapping and finally photometry of extremely deep 'blank fields'. It is expected that the national TAGs will set aside blocks of time for these SCUBA serviced observations and it is also anticipated that the national TAGs will allocate the precise observations to be undertaken. Members of the SCUBA commissioning team will provide technical input regarding the suitability of proposals.

Director JCMT

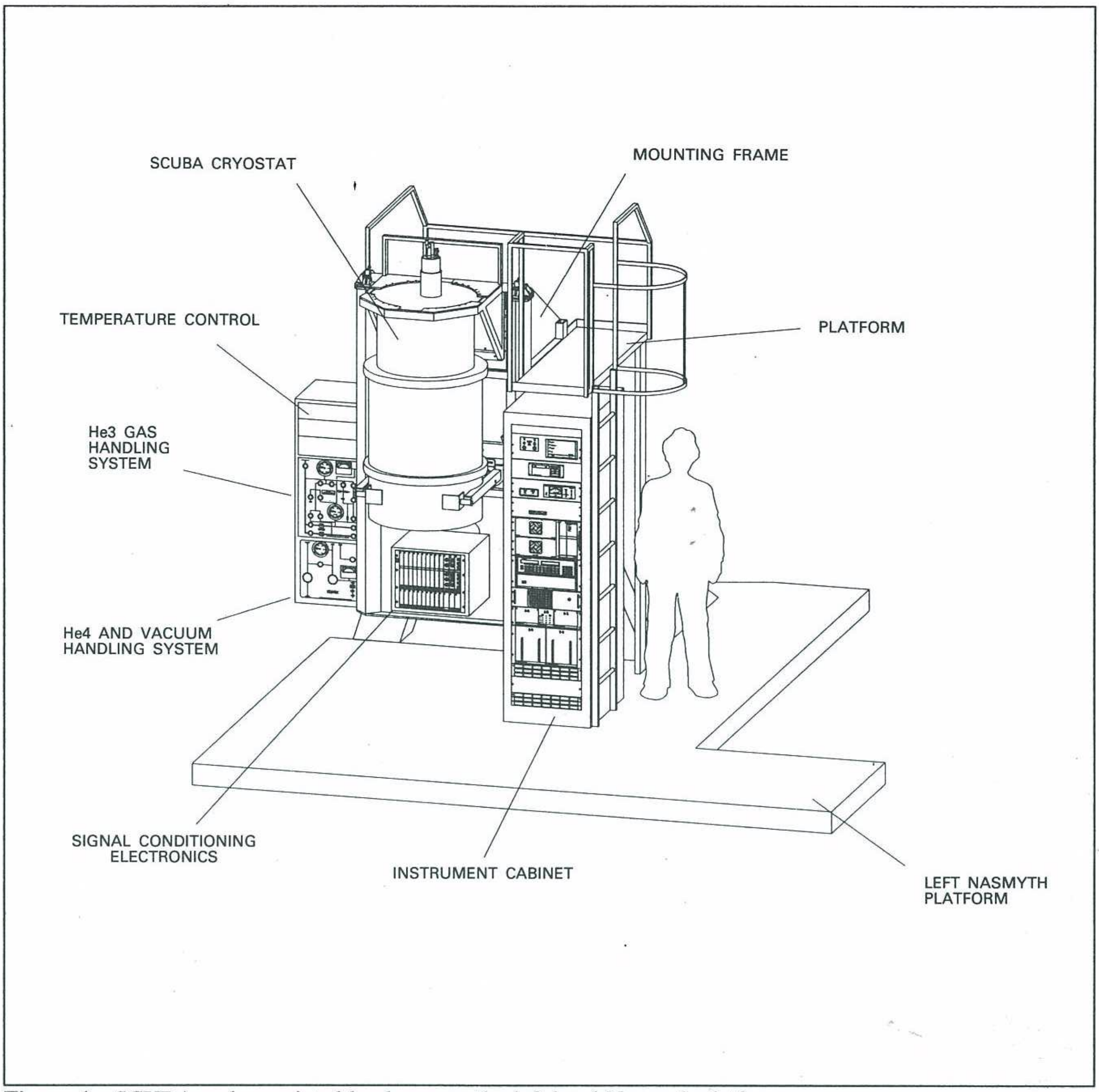


Figure 1: SCUBA and associated hardware on the left-hand Nasmyth platform.

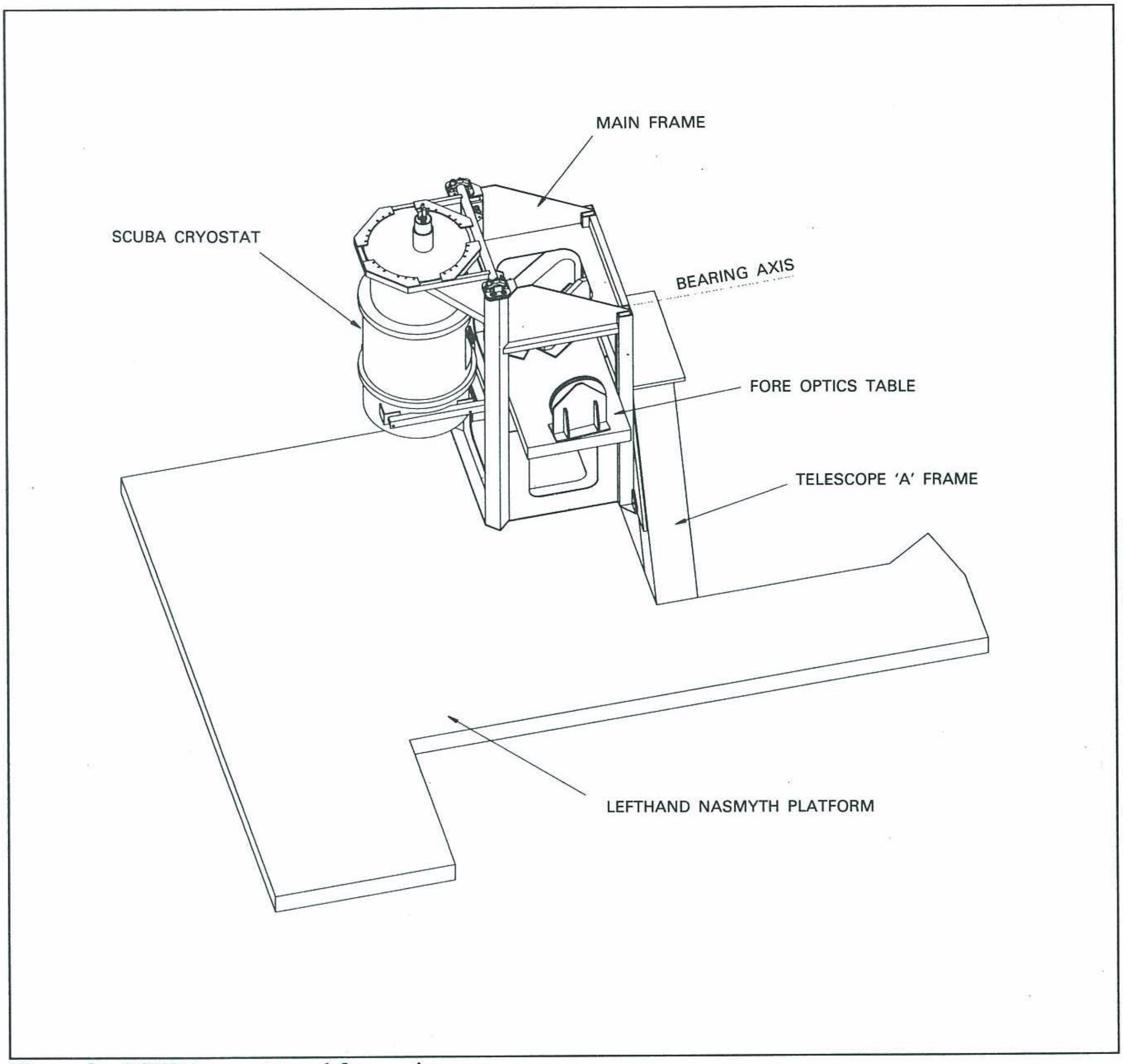


Figure 2: SCUBA cryostat and fore-optics

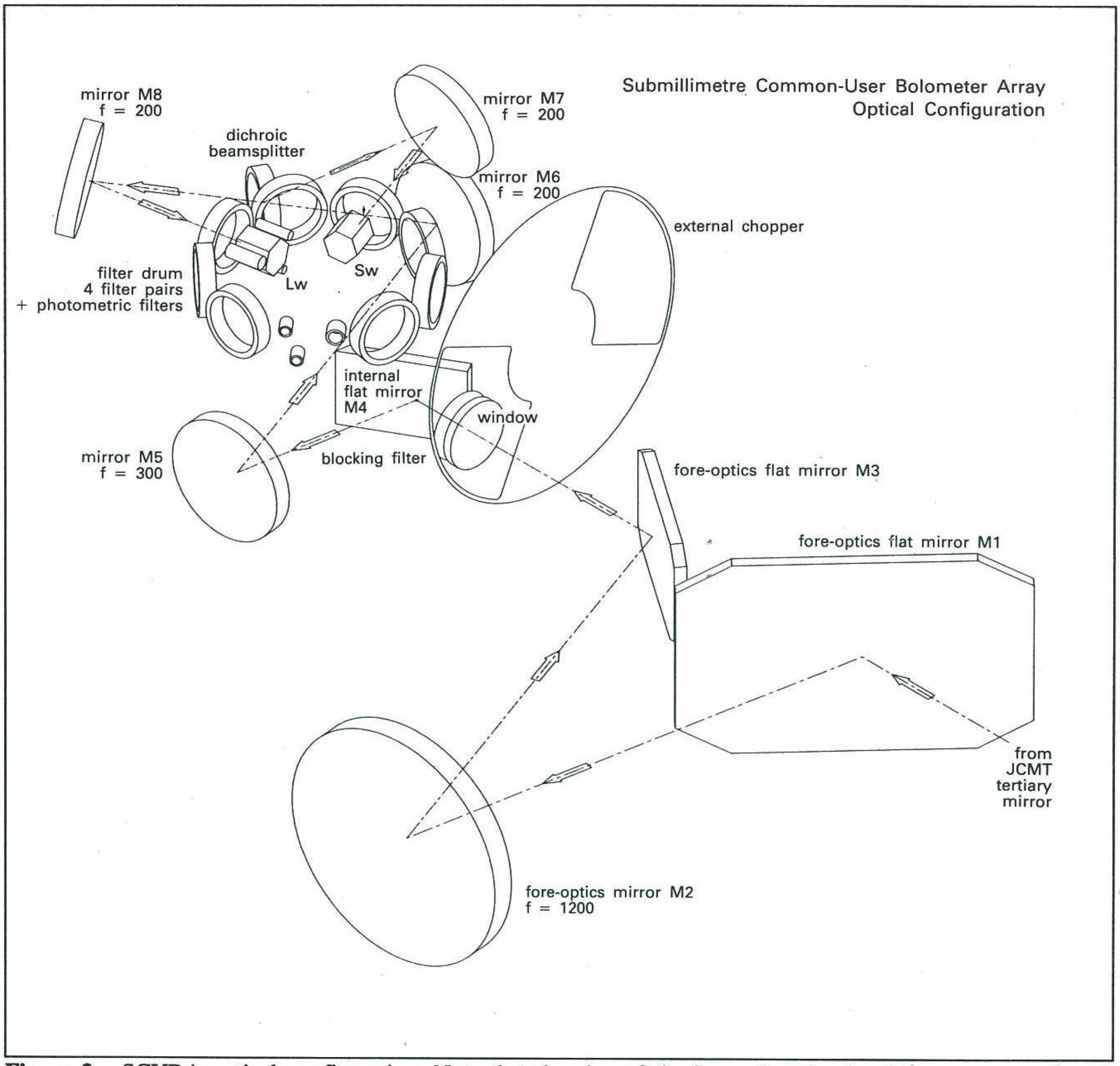


Figure 3: SCUBA optical configuration. Note that the size of the internal optics has been exaggerated with respect to the external mirrors for clarity.

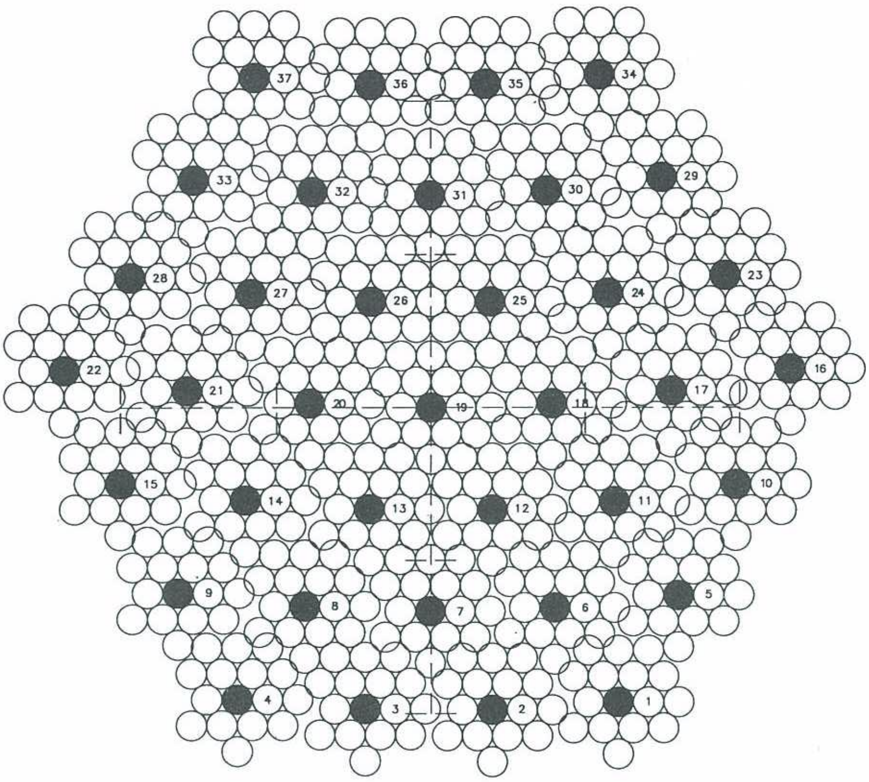


Figure 4: Pixel positions on the sky for a fully-sampled 'jiggle-stare' map taken with the SCUBA LW array.

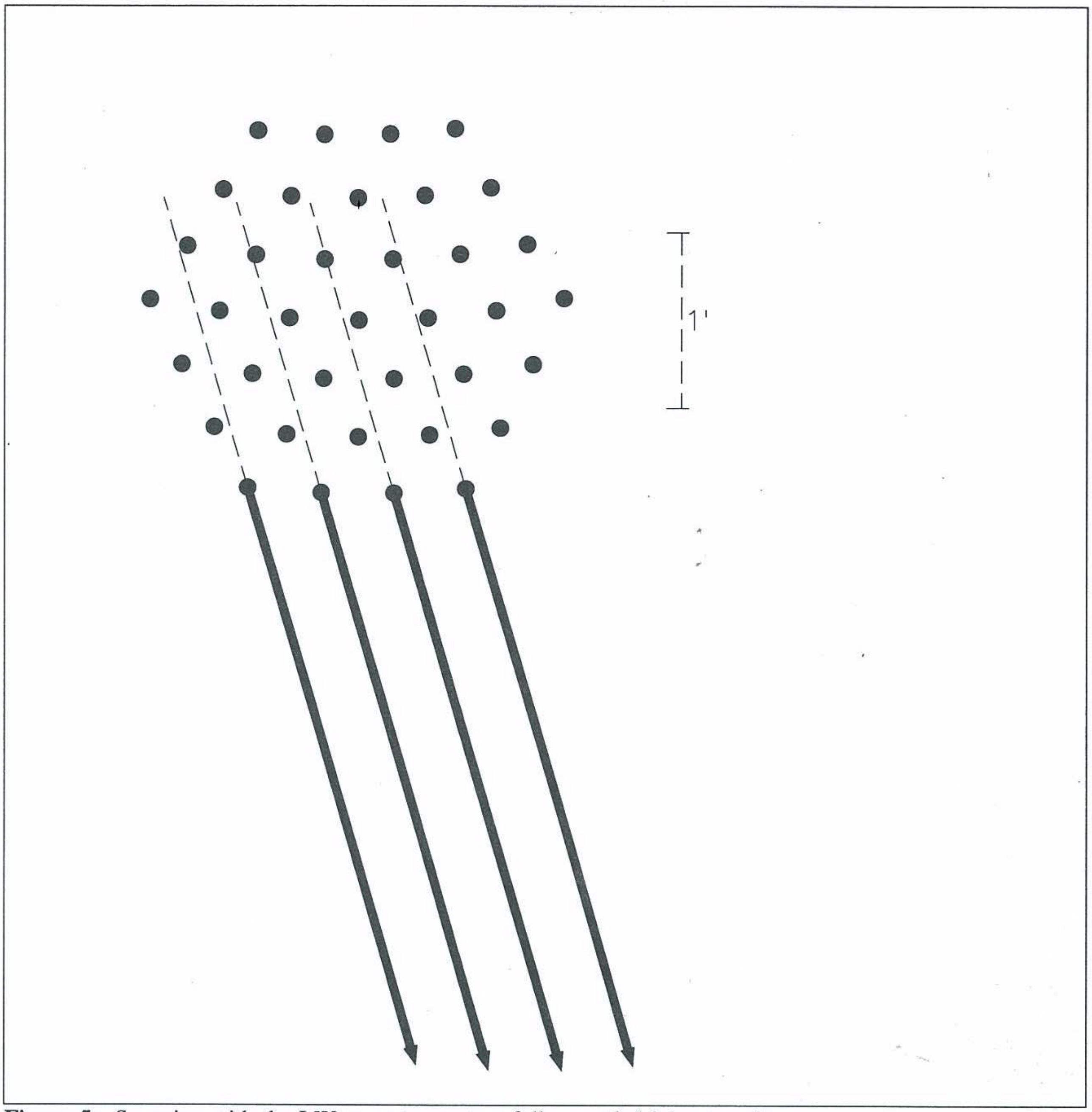


Figure 5: Scanning with the LW array to create a fully-sampled 'chop-scan' map.

SCIENCE HIGHLIGHTS

Detection of a very large dust mass in the most distant known galaxy

How and when the first galaxies formed remains one of the most important unanswered questions in modern astronomy. Despite numerous and varied observational programmes designed to detect primeval galaxies [1], the long-anticipated first generation of galaxies has yet to be discovered. In recent years it has been suggested that the failure of emission-line searches to detect such objects might, at least in part, be due to the fact that they are extremely dusty. While the possibility that primeval galaxies might be glorified versions of the dusty starburst galaxies seen at low redshift may be bad news for optical emission-line searches, it is good news for the JCMT; at redshifts $z > 2$ the peak of the thermal dust emission which occurs at rest-frame wavelengths ~100 µm is redshifted into the sub-millimetre. In fact at 800 µm the effects of cosmological dimming are offset at $z > 1$ (almost exactly for $\Omega_0 = 1$, $H_0 = 50$ kms^{-1} Mpc^{-1}) by the strongly negative k-correction which arises as the filter climbs the Rayleigh-Jeans tail of the thermal dust emission [2,3]. For this reason interest in sub-millimetre cosmology has mushroomed in recent years, and with the impending arrival of SCUBA the era of sub-millimetre searches for primeval galaxies is almost upon us.

As we await the dawn of sub-millimetre imaging, an alternative and complementary approach is to study known high-redshift galaxies in an attempt to determine whether any of them can be justly awarded the title primeval. Unfortunately, of course, virtually all the known galaxies with $z > 2$ are powerful radio galaxies, and it has become increasingly clear [4] that many of their UV → near-infrared properties are seriously distorted by the secondary effects of the nuclear activity. Consequently, the determination of radio galaxy ages using spectrophotometric models of galaxy evolution [5,6] has become somewhat dubious. We have therefore embarked on a programme to measure, or at least constrain, the level of dust emission in radio galaxies at $z > 2$, in order to obtain independent estimates of both the ongoing star-formation rate, and the dust+gas masses in these potentially young galaxies. While the pursuit of this programme in the last days of UKT14 is undoubtedly difficult, we have persevered in the belief it is nevertheless worthwhile, simply because any high-redshift galaxy which is detectable by UKT14 must automatically contain an interestingly large mass of dust (~10^9 $M_\odot$). Our belief (based in part on recent CGS4 near-infrared spectroscopy [7]) that at least some high-redshift radio galaxies may indeed be extremely dusty, has now been proved justified with the sub-millimetre detection of the $z = 3.8$ radio galaxy 4C41.17, the most distant known stellar system [8].

We observed 4C41.17 at 800 µm using UKT14 in September 1993. During a period of very dry and stable conditions, a total of 3 hours of contiguous integration was obtained as the radio galaxy was followed through transit. The observation was made using a beam size of 16.5 arcsec (=110 kpc for $\Omega_0 = 1$, $H_0 = 50$ kms^{-1} Mpc^{-1}), chopping at 7.81 Hz with an east-west throw of 60 arcsec. The result was a measurement of $S_{800\mu m} = 17.2 \pm 3.1$ mJy. Detailed statistical testing of the internal consistency of the integration [9] indicates that the quoted error is a genuinely realistic estimate of the uncertainty in the flux density. Perhaps significantly, 4C41.17 yielded the only such clear detection at this flux level in our sample of six $z > 2$ radio galaxies [3].

Detailed modelling of the far-infrared spectrum of 4C41.17 is clearly neither merited nor feasible on the basis of a single data-point. However, physically interesting numbers can still be derived from this result. On the basis of its optical-infrared SED, and its complex ultraviolet morphology it has been suggested that 4C41.17 may be a genuine example of a giant elliptical galaxy in the process of formation [8,10]. We can use our sub-millimetre photometry to test the plausibility of this idea via two essentially independent routes. First we can estimate the dust mass, and hence the gas mass within the ≈100 kpc beam to determine whether a significant fraction of the ≈10^{12} $M_\odot$ of stars found in present-day radio galaxies has still to be converted into stars in 4C41.17. Second, if we assume the far-infrared luminosity of 4C41.17 is produced by dust warmed by young stars, we can estimate the ongoing star-formation rate.

Determination of the dust mass in 4C41.17 is complicated by uncertainties in both dust temperature and adopted cosmology. Assuming T = 50 K, $\Omega_0 = 1$ and $H_0 = 50$ kms^{-1} Mpc^{-1} leads to a value of $M_{dust} = 1.1 \times 10^9$ $M_\odot$. When combined with the fairly high gas:dust ratios inferred at high redshift [11], this results in an estimated gas mass $M_{gas} \approx 10^{12}$ $M_\odot$, comparable to the stellar mass in a low-redshift giant elliptical radio galaxy. The uncertainty in this number is rather large, but the true value is virtually certain to lie between the extreme values of $M_{gas} = 5 \times 10^{10}$ $M_\odot$ (adopting T = 70 K, gas:dust = 100, and $\Omega_0 = 1$) and $M_{gas} = 1.7 \times 10^{13}$ $M_\odot$ (adopting T = 30 K, gas:dust = 1000, and $\Omega_0 = 0$). Thus, although the exact result depends on one's favoured choice of rather controversial parameters, it seems likely that a significant fraction of the mass of 4C41.17 has yet to be converted into stars at $z = 3.8$. However, the lower limit to M_{gas} is not high enough to exclude the possibility that the mass of 4C41.17 is dominated by a population of stars formed at much higher redshifts.

Estimation of the ongoing star-formation rate can be achieved via comparison with nearby starburst galaxies such as M82, provided one assumes that the dominant source of dust heating is young stars rather than a buried quasar. Such an assumption may appear unreasonable in such an active object, but nevertheless, whereas in high-redshift quasars such as 1202-07 one can be sure that a quasar is present [12], as yet there is no clear evidence for a significant quasar contribution in 4C41.17. 4C41.17 is essentially 1000 times more luminous than M82 at far-infrared wavelengths [13], and so simple scaling yields an estimated star-formation rate in the range 2000 $\rightarrow$ 10000 $M_\odot$ yr^{-1} (for $\Omega_0 = 1 \rightarrow 0$). Given the reasonable possibility of quasar heating, these values are perhaps best regarded as upper limits, but nevertheless, taken at face value they certainly do not exclude the possibility that 4C41.17 is indeed essentially primeval. First, the very young ($\approx 10^8$ yr), dusty model, successfully fitted to the UV-optical SED of 4C41.17 by Chambers *et al.* [8] (their model D), predicts a star-formation rate of $\approx$4300 $M_\odot$ yr^{-1}. Second, star-formation rates of this order are obviously consistent with a 10^{12} $M_\odot$ elliptical galaxy being observed during a canonical 1-Gyr formation starburst.

However, even if our high inferred star-formation rates are correct, a consistent picture can also be provided by a much older galaxy undergoing a violent starburst. In fact (if one attempts to adopt an extremely 'anti-primeval' stance) the UV-optical SED of 4C41.17, the lowest estimates of M_{gas}, and star-formation rates $\approx$1000 $M_\odot$ yr^{-1} can all be reconciled with a 10^8 Gyr starburst involving only $\approx$1/50th of the mass of an underlying galaxy in which 98% of the stars formed at redshifts $z > 10$ [14].

We intend to make further JCMT observations of 4C41.17 at both shorter and longer wavelengths. Observations with SCUBA should allow us to obtain significantly improved constraints on the dust temperature and hence several of the derived values given above. We also hope to use SCUBA to either measure or set rather stringent limits on the dust masses of other high-redshift radio galaxies which at present remain undetectable with UKT14. We can then begin a detailed investigation of the cosmological evolution of dust in radio galaxies.

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Millimetre and Sub-millimetre Wavelength Continuum Observations of Protostellar Candidates

The evolutionary stages of a protostar from molecular cloud to its arrival on the main sequence are not known in detail. We are attempting to increase this knowledge by studying sources from the IRAS catalogue, selected to be in an early pre-main sequence stage. Previous observations of $J = 1 \rightarrow 0$ CO (3 isotopes), and 6 cm continuum for 39 sources were analyzed with the IRAS data, and we deduced that 11 objects were in the pre-main sequence stage (Ref. 1). We are continuing with a multi-wavelength line and continuum study of a subset of these sources using the JCMT.

This note reports on continuum observations of nine sources from reference 1. These observations were made to define better the IR spectrum and permit a more accurate determination of luminosity, to determine the distribution of dust emission, and to estimate the dust temperature. Comparison of dust and gas temperatures will offer some insight into the values of densities. All nine sources were mapped at 1100 and 800 microns, and 5 of the 9 were mapped at 450 microns.

Figure 2 shows fits of modified blackbody spectra to the continuum fluxes. The four parameters which determine the fit are opacity at 450 microns; emissivity, which determines how the opacity varies with frequency; source solid angle; and temperature. We are able to construct a simple model for these dust clouds by fitting only two curves to each set of data points. In all cases, good fits are obtained by fitting one curve to the two fluxes at 12 and 25 microns, and one curve to the fluxes at wavelengths 60 microns, and longer. The curve fitted to the fluxes at wavelengths 60 microns and longer represents a least squares fit. The curve is fitted to 4 or 5 points and the source size is known. The other curve, having only two points, and with the source size not known, does not represent a least squares fit. While the parameters derived from this curve are most likely not unique, some of them are, at any rate, representative. These curves distinguish two components, a larger, cool component, and a smaller hot component. Parameters are given in Table 1, for both components.

IRAS name	Emissivity	Opacity (450 microns)	Diameter (pc)	Temp (dust) (K)
18151-1208	1.8 (1.5)	0.04 (0.05)	0.15 (0.006)	35 (120)
18162-2048	1.5 (1.5)	0.07 (0.05)	0.10 (0.004)	41 (127)
18316-0602	1.5 (1.5)	0.09 (0.05)	0.17 (0.008)	35 (140)
18517+0437	1.5 (1.5)	0.05 (0.02)	0.15 (0.001)	34 (156)
20188+3928	0.9 (1.5)	0.04 (0.05)	0.25 (0.005)	39 (130)
20216+4107	20. (1.5)	0.02 (0.02)	0.25 (0.004)	28 (123)
21334+5039	1.5 (1.5)	0.01 (0.02)	0.29 (0.006)	36 (126)
00338+6312	1.0 (2.0)	0.03 (0.02)	0.08 (0,0006)	36 (133)

TABLE 1. *The four parameters determining the fit (values in brackets refer to the smaller, hotter component. These values, while not unique, are representative, certainly for diameter, and temperature).*

Figure 1 shows maps of three representative sources. Most of the sources show simple structure, only somewhat larger than the beam at 800 microns. One source (not shown) is clearly double, but since we could not separate the IRAS fluxes for the two components, we were unable to determine parameters for the individual components, and it has been excluded from the analysis below.

Using the thin opacities, and assuming a gas to dust ratio of 100, dust masses, and molecular hydrogen column densities have been determined, and are shown in Table 2. Also shown in Table 2 are the gas temperatures, determined from $J = 2 \rightarrow 1$ CO which was assumed to be optically thick, and the total IR luminosity.

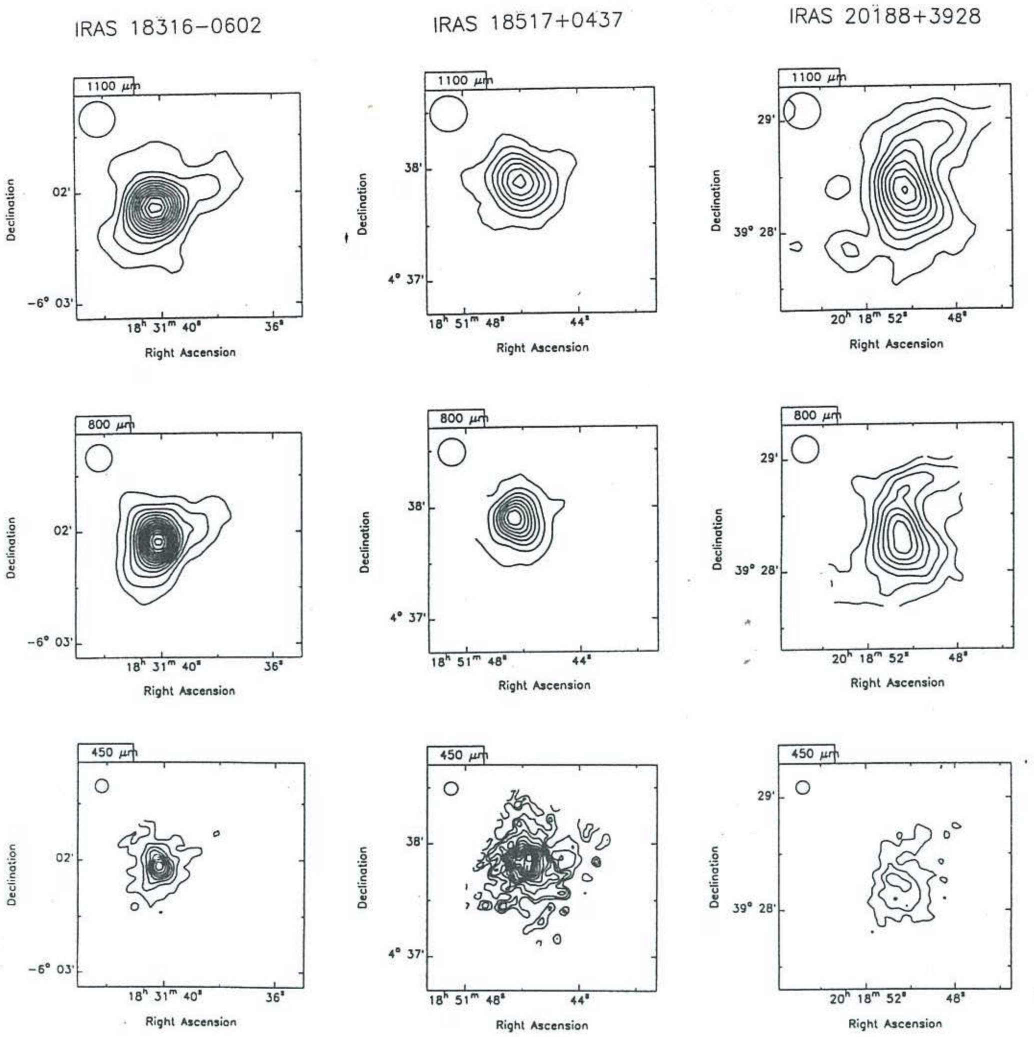

Figure 1. *Maps of continuum emission at three wavelengths for each of the three sources.*

In summary, we have been able to fit the observed fluxes with two modified blackbody temperature curves. One of these applies to a compact core with a temperature in the range 120 K to 156 K, and the other to a larger, cooler component with a temperature in the range 28 K to 41 K. The sizes of the larger components range from about 0.1 pc to 0.3 pc, approximately the size of a collapsing core where the density is predicted to vary as the -3/2 power of radius (ref. 2).

The dust masses are typically a few solar masses, and an independent estimate of the gas masses would allow us to determine the gas to dust mass ratio. The gas temperatures are approximately equal to the dust temperatures, which we expect for these densities. Some values are lower, but these temperatures may be a lower limit for gas which is not optically thick.

We are grateful to Dr. C. Rogers for the use of his software which enabled us to do the curve fitting.

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IRAS name	Dust mass ($M_\odot$)	$N(H_2)$ (x 10^{23} cm^{-2})	T(gas) (K)	L(IR) ($L_\odot$)
18151-1208	5.7 (0.006)	6.4	38	19700
18162-2048	3.2 (0.004)	7.7	35	19500
18316-0602	11.6 (0.003)	5.5	28	28500
18517+0437	5.0 (0.0001)	5.4	31	10900
20188+3928	4.9 (0.006)	2.0	--	27900
20216+4107	10.2 (0.001)	8.3	--	11700
21334+5039	5.0 (0.003)	1.5	--	22100
00338+6312	0.34 (0.00006)	1.5	--	1100

TABLE 2. *Derived parameters (The values in brackets are the dust masses for the smaller, hotter component. The luminosity is the total for the two components).*

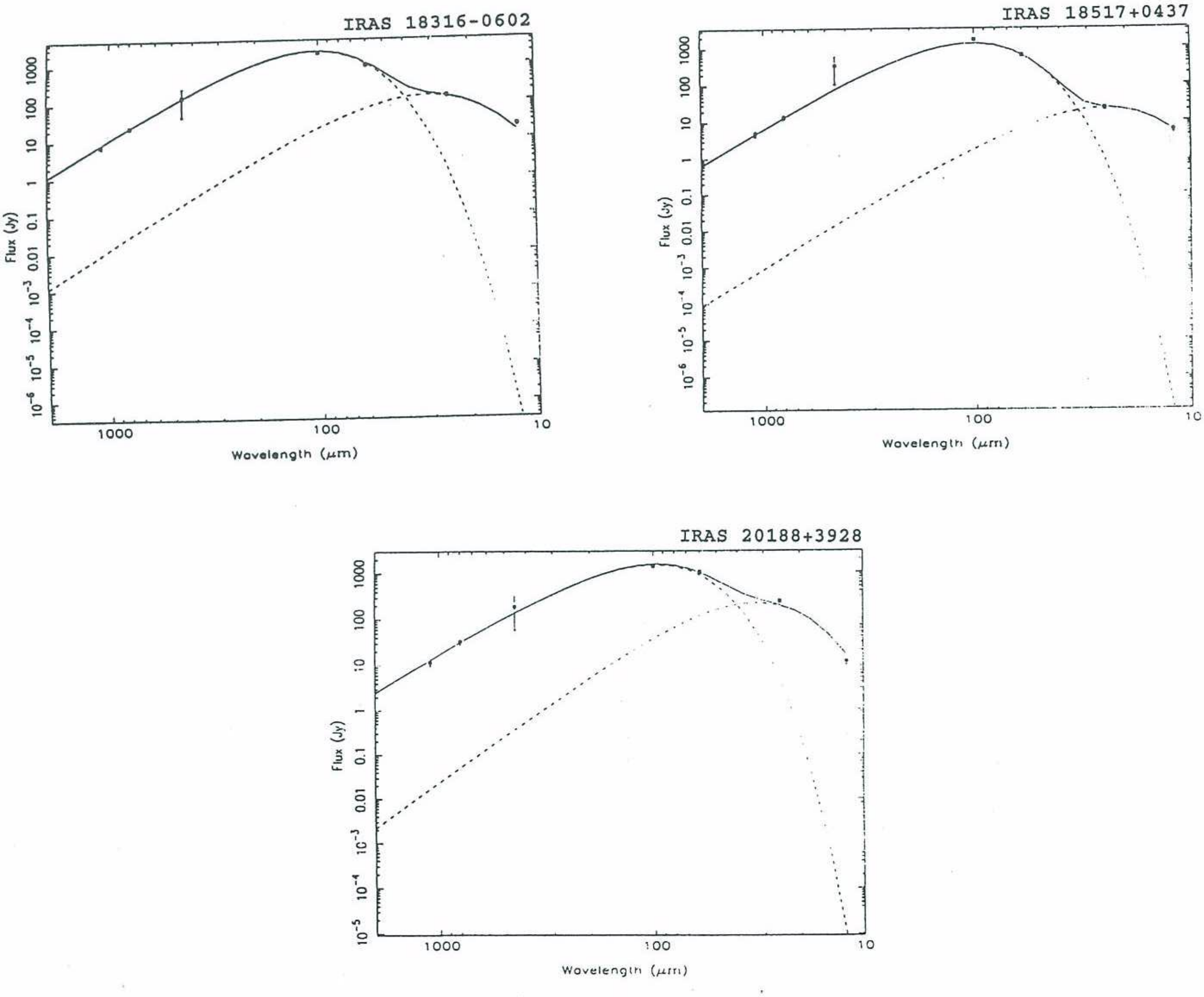

Figure 2. *Fits of modified blackbody spectra to the continuum fluxes. Each source can be represented by two components. The dashed curves are the fits to the fluxes of each component, and the solid curve is the sum. Error bars are generally not visible except for the 450 μm data point..*

C I emission from the outflow and PDR in S140

The L1204 molecular cloud lies to the northeast of the S140 H II region, produced by the nearby B0 star HD 211880. This molecular cloud has one of the best examples of an edge-illuminated PDR (e.g. Blair *et al.* 1978). Only 70-80 arcsec northeast of the PDR is an embedded cluster of three infrared sources (e.g. Beichman *et al.* 1979) which lie at the centre of a high-velocity molecular outflow (e.g. Snell *et al.* 1984). The outflow axis is along the southeast-northwest direction, parallel to the PDR. Minchin, White & Padman (1993 - hereafter MWP93) have recently compared single velocity

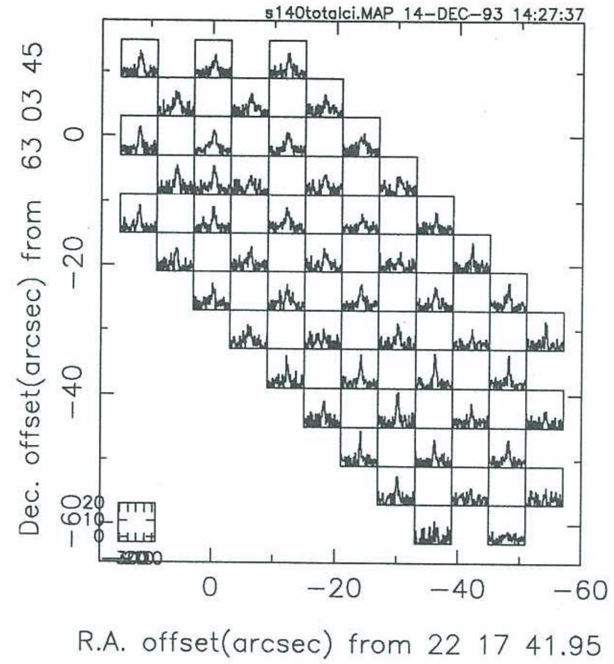

Figure 1. *A grid of the 51 C I $^3P_1 \rightarrow {}^3P_0$ line spectra. For each spectrum shown the velocity range is from -32 to 14 km s^{-1} and the T_{mb} range is from -3 to 20K.*

channel atomic carbon (C I) $^3P_1 \rightarrow {}^3P_0$ (492.1607 GHz) observations of White & Padman (1991) to various ^{12}CO and ^{13}CO emission line maps. The CI emission is mainly confined to a clumpy, elongated ridge-like feature adjacent to the edge of the molecular cloud and coincident with a similar feature seen in ^{12}CO emission. There is a second region of intense C I emission, located inside a ring of CS emission that surrounds the embedded infrared sources. They conclude that this C I emission may be produced by the outflow or embedded sources.

In June 1993 we were allocated time on the JCMT to repeat the White & Padman (1991) observations, but this time using the new high-frequency multi-channel SIS receiver (RxC2), in conjunction with the AOSC. We also mapped the C^{17}O J = 3 $\rightarrow$ 2 (337.0611 GHz) line emission using RxB3i. The advantage of mapping C^{17}O emission is that, unlike ^{12}CO, ^{13}CO and C^{18}O, the line stays optically thin even in the densest core regions and is therefore the most accurate high-resolution tracer of CO morphology.

Figure 1 presents the C I spectra. There is a marked variation in line profiles across the mapped region. Towards the (0,0) position (the position of peak integrated CO emission) the lines are broad (FWHM ~5-6 km s^{-1}) with peak values of T_{mb} ~10-12K. Further to the southwest (the position of the PDR) the lines are distinctly narrower (~3-4 km s^{-1}) with several positions showing markedly higher values of peak T_{mb}, up to 18 K.
The greyscale integrated intensity map (Fig. 2a) shows considerable clumpy structure is present at this high resolution. The emission peak is close to the (0,0) position, as observed for CO and isotopes (see MWP93) but there is also an arm of emission extending along an arc southwards from the (0,0) position. There is a localised peak in emission on the PDR, at offset (-28, -42), which agrees closely with the position of the most intense localised peak on the single-channel C I $^3P_1 \rightarrow {}^3P_0$ map. For the rest of the paper we shall refer to this position as PDRc1 (PDR clump 1). There is a sharp decrease in emission at the south-western edge of the map, corresponding to the molecular cloud/H II region interface.

Figure 2(b)-(d) shows the integrated intensity observed in three velocity ranges, covering the blue wing (-20 to -10 km s^{-1}), core (-10 to -5 km s^{-1}) and red wing (-5 to 5 km s^{-1}) emission. Both the blue and red channel maps show a similar morphology. There is an integrated intensity peak near the (0,0) position, with the redshifted peak offset to the northwest, as observed for ^{12}CO lines in similar broad velocity channels (e.g. MWP93 Figs. 6 and 7). This emission is therefore likely to be associated with the atomic component of the bipolar outflow. The arc of emission seen in total integrated intensity is prominent in both the blue and red channels, in particular the blue. The core channel shows the emission from the ambient molecular cloud and the PDR. The most striking feature is PDRc1, which is more prominent than the integrated emission peak near the (0,0) position. The contrast between the blue/red and core channels is striking. There is no emission from the PDR observed in the blue/red channels. There is little evidence of the emission arc in the core channel, yet it is prominent in the both the blue and red channels. It must therefore be produced by the bipolar outflow. The direction of the emission arc implies it is associated with the southern, blueshifted outflow lobe.

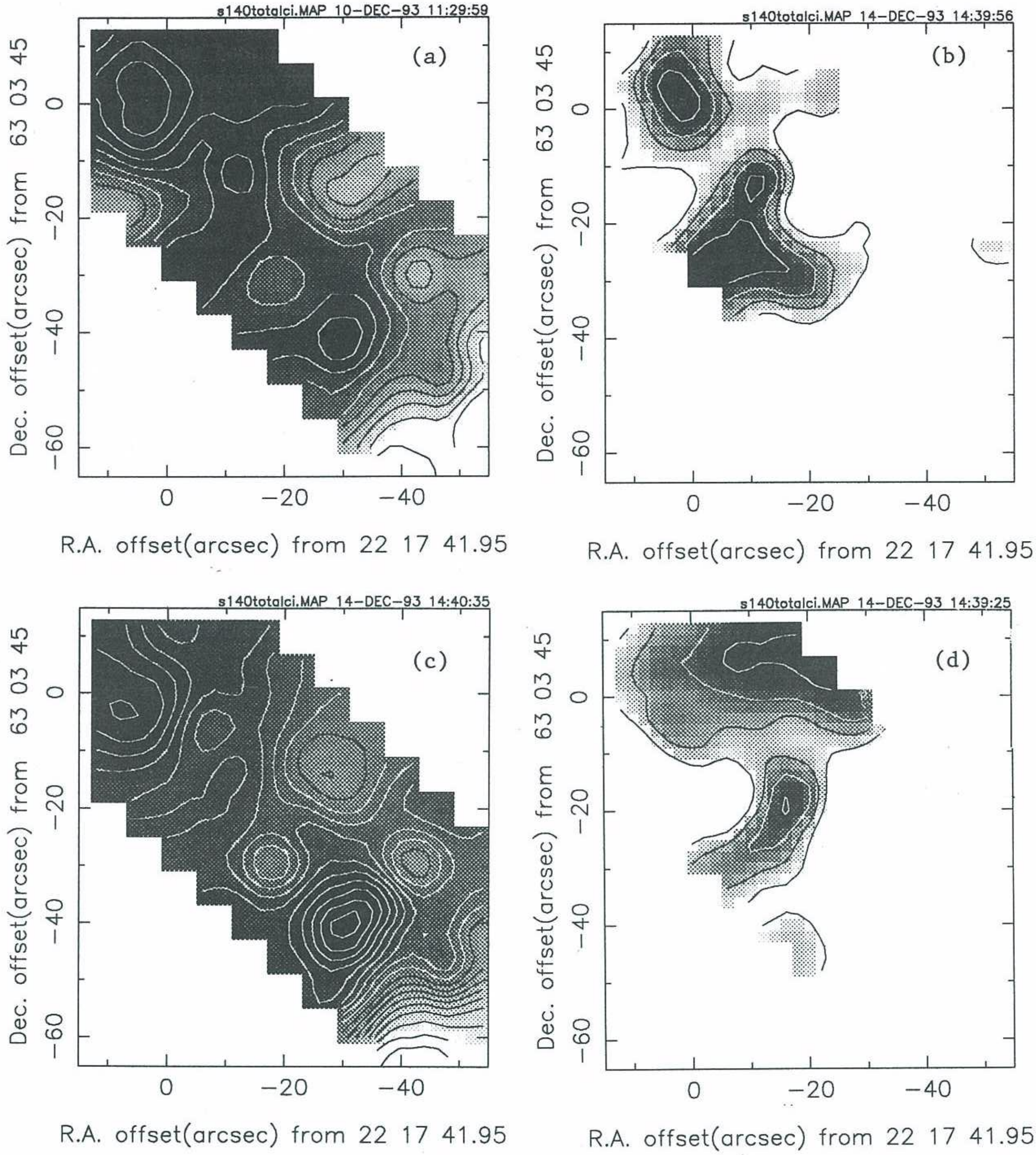

Figure 2. *Greyscale images, with isophotal contours overlayed, of the C I $^3P_1 \rightarrow {}^3P_0$ line. The integrated intensities between (a) -14 and 2 km s^{-1} -- the whole line (b) -20 and -10 km s^{-1} -- the blue-shifted wing (BW) (c) -10 and -5 km s^{-1} -- the core emission (CORE) (d) -5 and 5 km s^{-1} -- the red-shifted wing (RW).*

Figure 3 presents the $C^{17}O$ J = 3 → 2 data. The total integrated intensity map shows a similar morphology to the C I emission. The emission arc is again prominent, as is the main emission peak near the (0,0) position. It is immediately apparent that the C I and $C^{17}O$ arc features are not coincident, with the C I arc offset to the northeast by ~10 arcsec.

The column densities of CO and C I for spectra at the (0,0) position were derived over the same velocity ranges used for the greyscale plots shown in Figure 2. Standard equations were used. The CO column densities were derived from the ^{13}CO J = 3 → 2 spectrum shown in Fig. 1(a) of MWP93, assuming an isotopic abundance ratio of 65 and that the C I and ^{13}CO lines are optically thin. To test for enhancement or depletion of CI relative to CO in material associated with the outflow wings relative to the abundance ratio found in the ambient molecular cloud, we created the ratio

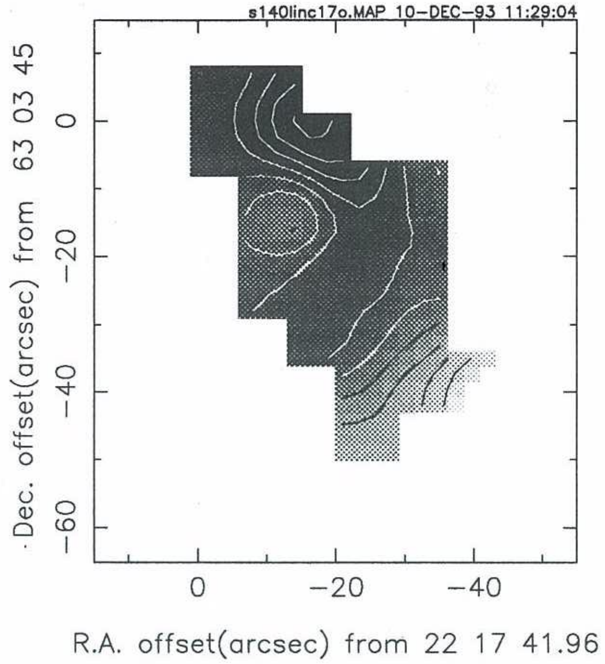

Figure 3. *Greyscale image, with isophotal contours overlayed, of the total integrated intensity between -14 and 2 km s^{-1} for the $J = 3 \rightarrow 2$ line of $C^{17}O$.*

$$\epsilon = \frac{N^{wing}{}_{C} \;/\; N^{core}{}_{C}}{N^{wing}{}_{CO} \;/\; N^{core}{}_{CO}}$$

A value of ε = 1 will therefore indicate no net enhancement or depletion of C I relative to CO for the outflow material. The abundance of C I is particularly high, N(C I)/N(CO) = 0.28 for the full velocity range of the line and 0.24 - 0.25 in the blue wing and core velocity intervals. The highest value of ε is 5.5, observed for the red wing. For the blue wing the value of ε = 1.0 shows that, although the abundance of C I relative to CO is high, it is not over-abundant relative to the ambient cloud material. For the red wing the value of ε = 5.5 confirms that not only is the abundance of C I to CO high, but it is also over-abundant relative to the ambient material.

The outflow region

As noted earlier, the C I and $C^{17}O$ arc features appear to be offset, with the $C^{17}O$ emission apparently tracing the dense, limb-brightened, blueshifted outflow cavity wall. This had not been seen in either CO or ^{13}CO emission line maps (e.g. MWP93), but is not surprising as the far higher optical depths of these lines will effectively 'mask' detailed structure. The CO and ^{13}CO maps show elongated arc-like blue and redshifted emission features extending from the (0,0) position to the north, with a high degree of overlap (MWP93), but no southern counterpart. However, a recent high-resolution map of the HCO^+ $J = 1 \rightarrow 0$ line (Wilner, private communication) shows both northern and southern arc-like features that extend from the (0,0) position, confirming the existence of the southern outflow component.

Both the high abundance of C I towards the molecular outflow source (N(C I)/N(CO) = 0.28) and the over-abundance of C I found at redshifted velocities (towards the outflow source and along the emission arc) require further examination. The morphology of this region implies that the C I emission along the arc feature originates from the inner edge of the molecular outflow wall (as delineated by $C^{17}O$ and HCO^+ emission). The high abundance of C I along the inner cavity wall must therefore be due to the dissociation of carbon-bearing molecules at the interface between the protostellar wind and the ambient medium. The effect of shocks on the chemical and physical processes at the interface between a stellar wind and the ambient cloud has been studied in a recent series of papers (McKee & Hollenbach 1987; Hollenbach & McKee 1989). Their model produces a 'two-shock' structure, with an inner shock where the wind decelerates as it impacts the cavity wall and an outer shock where the ambient gas is accelerated to the shell velocity. They find that although CO has nearly three times the binding energy of H_2, CO dissociation occurs quickly afterwards as it is chemically dissociated at similar gas temperatures (≥3000K) by the endothermic reaction $H + CO \rightarrow C + OH$.

Their model predicts the intensity of the C I $^3P_1 \rightarrow {}^3P_0$ line to be ~$5 \rightarrow 7 \times 10^{-6}$ erg cm^{-2} s^{-1} sr^{-1} for pre-shock densities of $10^3 \rightarrow 10^4$ cm^{-3} and velocities $30 \rightarrow 150$ kms^{-1}. This is in good agreement with the observed values of $7 \rightarrow 8 \times 10^{-6}$ erg cm^{-2} s^{-1} sr^{-1} along the arc of C I emission (within the error of ~$1 \rightarrow 1.5 \times 10^{-6}$ erg cm^{-2} s^{-1} sr^{-1}). Towards the outflow source itself (the 0,0 position) the intensity of C I emission is even higher ~$1 \pm 0.05 \times 10^{-5}$ erg cm^{-2} s^{-1} sr^{-1}. The enhancement here may be due to a high concentration of atomic carbon in the atomic wind close to the outflow source, as the wind expands into the outflow cavity it cools, leading to the formation of molecules (predominantly CO). It should also be noted that close to the young star the UV radiation field will be sufficiently intense to photodissociate CO, enhancing the observed C I abundance.

The fact that the C I arc feature is seen in both blue and redshifted emission cannot be a geometrical effect. The observation of both blue and redshifted emission along certain lines of sight towards molecular outflows has been previously noted. This is usually attributed to either a particularly wide opening angle for the outflow lobes or the outflow axis being directed close to the observers line-of-sight. This cannot be the case here as we do not observe redshifted $C^{17}O$ emission from the arc feature. If both the CO and C I emission trace the outflow cavity wall then they should both demonstrate similar velocity structure. The obvious implication is that both the observed blue and redshifted C I emission is produced at the same position, along the inner edge of the cavity wall for the **blueshifted** lobe of the molecular outflow.

We have already concluded that the C I emission is produced by the effect of shocks on the chemical and physical processes at the interface between the stellar wind and the cavity wall. This scenario may also explain the over-abundance of C I relative to CO at redshifted velocities. As Hollenbach & McKee (1989) point out, one of the signatures of shocks is the presence of broad emission lines arising from the large dispersion in velocity vectors. Where the wind interacts with the cavity wall the resultant ionized and dissociated material will be accelerated over a range of velocities about the original velocity of the ambient material. This will be observed as both blue and redshifted wings on emission lines emitted as the material cools. Hence both blue and redshifted C I emission may be present at positions on the outflow where only blue or redshifted CO emission is observed.

The PDR

The PDR is an elongated, narrow (~0.1-0.15pc) ridge-like feature that is adjacent to the south-western edge of the molecular cloud. C I emission from the PDR is only observed in a narrow velocity range, -10 to -6 kms^{-1}. Unfortunately our mapped area is smaller than the original single channel map, but it is still obvious that the PDR is extremely clumpy, with PDRc1 the dominant emission feature. There is a sharp decrease in emission at the south-western edge of the PDR, corresponding to the molecular cloud/H II region interface.

The close agreement between the new C I map and the original single-channel observations means that many of the conclusions by MWP93 are confirmed. The C I and ^{12}CO emission 'ridges' are coincident (see Fig. 14 of MWP93). This contradicts the original homogeneous cloud models for PDRs (e.g. Tielens & Hollenbach 1985; van Dishoeck & Black 1988) where C I and ^{12}CO are predicted to be in distinct, adjacent layers, with the CO deeper into the molecular cloud. The coincidence of the C I and ^{12}CO ridges and the observed clumpy structure of the C I ridge imply that a 'multi-component' model is appropriate. Such models predict that molecular cloud material is composed of distinct high density clumps, interspersed with a more tenuous interclump medium. UV radiation can penetrate deep into the cloud before heating and dissociating carbon-bearing molecules on molecular clump surfaces.

For PDRc1 we derived a C I column density of 9.7 $\pm 0.8 \times 10^{17}$ cm^{-2} and N(C I)/N(CO) = 0.29. These were derived using the $C^{17}O$ spectra obtained at the same position and assuming isotopic abundance ratios of $^{12}CO/C^{18}O$ = 300 and $C^{18}O/C^{17}O$ = 3.5. The emergent intensity at the position of PDRc1 is $8.7 \pm 0.7 \times 10^{-6}$ erg cm^{-2} s^{-1} sr^{-1}. These values are in close agreement with the conclusions of Hollenbach, Takahashi & Tielens (1991) that C I $^3P_1 \rightarrow {}^3P_0$ line emission from low-density PDRs ($10^2 \leq n_0 \leq 10^5$ cm^{-3}), such as S140, should have an emergent intensity of $\sim 10^{-5}$ erg cm^{-2} s^{-1} sr^{-1} and a column density of $\sim 10^{18}$ cm^{-2}, relatively independent of the incident FUV flux and the density of the cloud.

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Submillimetre Water Masers

In recent years water masers have once more become a major item of interest. The well known 22 GHz water maser is the brightest spectral line in the radio universe. The 22 GHz masers are natural beacons which highlight star-forming regions, dense circumstellar shells around evolved stars, and even some active galactic nuclei. These regions can then be imaged on milliarcsecond scales using interferometers such as MERLIN or VLBI.

Maser action requires a population inversion. The water molecule has a good mechanism to provide not just one but several population inversions. When the molecule is rotationally excited and able to decay radiatively, the decay proceeds preferentially down the constant J-ladders, leaving the lowest state in each ladder overpopulated. These so called backbone levels carry most of the population and are overpopulated with respect to other rotational states at a similar excitation level. Thus there are many possible maser transitions. The 22 GHz maser is the $6_{1,6}$-$5_{2,3}$ transition of ortho water, a sideways transition from the bottom of the J = 6 ladder to the J = 5 ladder. Both states are some 650 K above the ground state, but the transition comes out at the radio wavelength of 1.36 cm. (In ortho water the spins of the hydrogen nucleii are parallel, whereas in para water they are antiparallel).

It has long been expected that the water molecule would show many other masers due to similar population inversions across other J-ladders. These other masers are now being detected in the millimetre and submillimetre wavebands. They are doubly difficult to observe: not only do you need suitable receivers, but you also need a suitable site which is above most of the atmospheric water vapour. There is really only one suitable ground-based site and that is Mauna Kea. Neufeld & Melnick (1991, ApJ **368**, 215-230) calculated the expected maser strengths and the observability of the masers from a mountain top at 4.2 km, and from an aircraft at 13.7 km. In their model water is excited by collisions with hydrogen at typical densities of 10^9 cm^{-3} and temperatures of 400-1000 K. They also indicated how simultaneous observation of several maser transitions could be used to derive, or at least constrain, the physical conditions in the region.

Our interest in their work stems from interferometry. We have been mapping the 22 GHz masers in circumstellar envelopes with MERLIN, using the masers as a probe of the mass-loss from the evolved stars. If several masers could be mapped at once we would have a very powerful diagnostic of the physical conditions. We therefore proposed to use the JCMT to search for some of the new submm masers in circumstellar envelopes (the discoveries usually being in star-forming regions). We had the submm masers in mind as possible targets for the JCMT-CSO interferometer. We also wanted to see how much could be learned from simultaneous single-dish measurements of several maser lines. Thus the experiment we proposed was to observe a sample of 24 evolved stars simultaneously at 22 and 321 GHz, and to search them for the 325 GHz maser (which had been predicted in circumstellar envelopes but not detected). The sample of stars covered a range of types (Miras, semi-regular variables, supergiants and OH-IR sources), and a range of mass-loss rates, and all were catalogued 22 GHz sources.

The 325 GHz maser is particularly awkward to observe, because the atmosphere lets through only one photon in ten to the JCMT on a good night. Fortunately two of us were novices to submm observing, and we had our share of beginners' luck with the weather. We were also fortunate to be awarded service time. At the end of our final run in April 1993 we had collected 16 new 325 GHz masers, out of 19 sources observed. We also detected 16 sources out of 21 at 321 GHz, including 5 new detections.

Meanwhile back at the ranch the 22 GHz line was being observed using the 32-m MERLIN telescope at Cambridge U.K., relaying the signal over the MERLIN microwave link to the spectrometers at Jodrell Bank. The observations at the three frequencies were usually made within two days of each other. This was important because water masers are notoriously variable. Thus any attempt to measure meaningful line ratios needed near-simultaneous observations. Using Starlink and Internet we were able to log on to Jodrell Bank from the summit and keep in touch about the status of the cm and submm observations.

Calibrating the JCMT data was not easy. The strong atmospheric water lines gave very different transmissions in each sideband of the double-sideband receiver, and as a result the default calibration procedures which were applied to the data online were systematically in error. The data were recalibrated offline using measurements of the atmospheric opacity at 225 GHz and a standard model of the atmosphere. From these we derived the correct transmissions in each sideband, and hence the fudge factors necessary to rescale our spectra. Many of the new masers were found to be brighter than 100 Jy.

The first result we found is that the submm water masers are at least as widespread in circumstellar envelopes as the 22 GHz masers. The detected sources were those with the highest mass loss rates and the warmest envelopes. The lines tend to be detected all together (13 out of 19 sources were observed in all three lines), and the detected sources lie in the same region of the standard IRAS colour-colour diagram (12-25 vs 25-60 microns). The maser luminosity in all three lines is well correlated with the mass loss rate.

Looking at the actual spectra we see a strong family resemblance between the 22 and 325 GHz profiles, with features at the same velocities and with similar relative intensities. A typical example is shown in Figure 1. This is not too surprising a result, because the 325 GHz line is the $5_{1,5}$-$4_{2,2}$ transition of para water, and it is at a similar excitation level to the 22 GHz transition. The 321 GHz line on the other hand has an excitation temperature of almost 1900 K, and so we might expect it to be excited in hotter regions, for example nearer to the star. Our data give some support to this. Firstly the 321 GHz line often looks different from the other two, suggesting that it comes from a different location in the envelope. Secondly where the velocity extent is larger than 10 km/s we find the 321 GHz emission covers a smaller range than the other two lines, and/or it is nearer to the stellar velocity. This suggests that the 321 GHz line occurs nearer the star in an outwardly accelerating flow. On the other hand when the velocity extent is less than 10 km/s we see no systematic differences in the extent of the emission. Perhaps turbulence is masking the effect we see in stars with higher outflow velocities.

If the maser line ratios are to constrain the physical conditions it is important that the different lines really are excited in the same region. The shapes of the spectra suggest otherwise. Another type of evidence is provided by variability. Lines arising in the same gas and subject to the same fluctuating pump conditions should show correlated variations. We observed some of the sources at three epochs. In general we found that the 325 GHz line is less variable than the 22 and 321 GHz lines, suggesting that the 325 GHz maser is more nearly saturated. However the results challenge some of our simplistic assumptions. For example we find several cases of anticorrelated variations. Figure 2 shows the case of U Her, where the 22 and 321 GHz lines increase and develop new features, while the 325 GHz line decreases. On the other hand S CrB and RS Vir show the 22 GHz line increasing while the 321 and 325 GHz lines both decrease. R Crt shows a flare event at one velocity in 22 and 321 GHz only, while the 325 GHz feature at the same velocity does not change significantly. Clearly it will be difficult to find a unified explanation for these variations. The data suggest that different spectral features come from different regions and respond to local changes in the collisional pumping. Purely radiative excitation is definitely excluded. What we really would like now is simultaneous interferometry of the different lines. (PATT please note).

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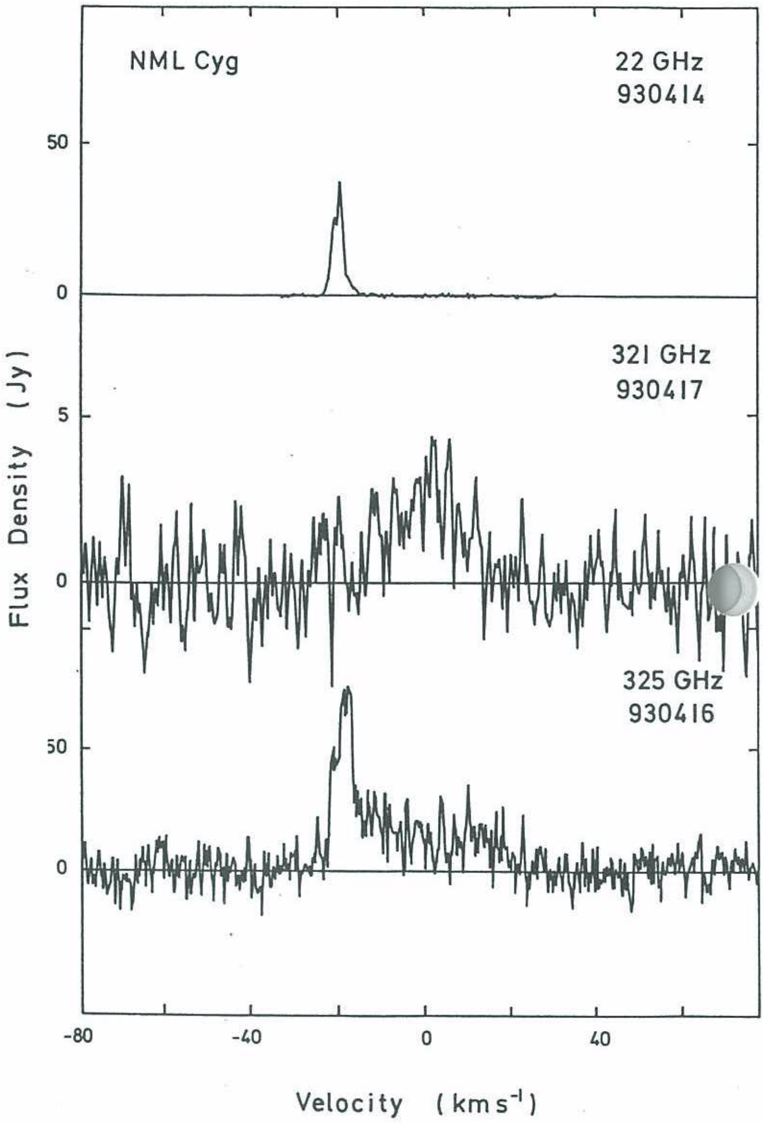

Figure 1. *Water maser spectra of the supergiant NML Cyg. The 321 and 325 GHz spectra were measured at the JCMT and have a velocity resolution of 0.33 km/s. The 22 GHz spectrum was measured at Jodrell Bank, and has a velocity resolution of 0.12 km/s. The 321 GHz line peaks near the stellar velocity of 0 km/s, whereas the 22 GHz and 325 GHz lines peak at a blue-shifted velocity of -10 km/s.*

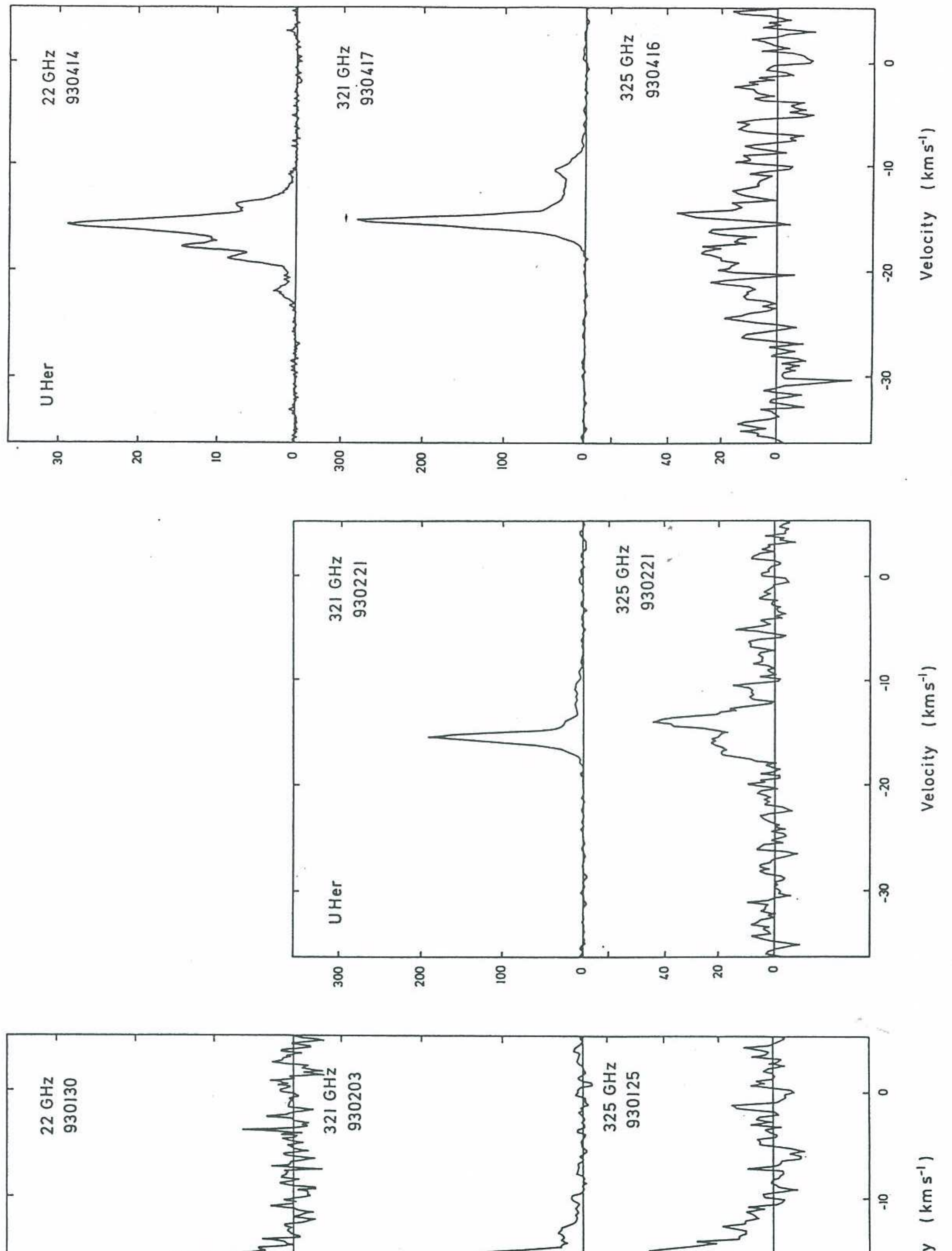

Figure 2. *Water maser spectra of the Mira variable U Her measured at three epochs at the JCMT and Jodrell Bank.*

Correlated X-ray and Millimetre Variability of the Quasar 3C273

The majority of the continuum emission from quasars like 3C273 is thought to arise in relativistic jets which are oriented close to our line of sight. The jet emission is therefore relativistically boosted so that it dominates the light from the quasar in the radio, millimetre and probably also the X-ray wavebands. The radio and millimetre emission is almost certainly synchrotron emission but the origin of the X-ray emission is unclear. One of the best ways of trying to understand the complex physical processes occurring in the relativistic outflow, and particularly the origin of the X-ray emission, is to observe the relative ways in which the X-ray and millimetre emissions vary with time.

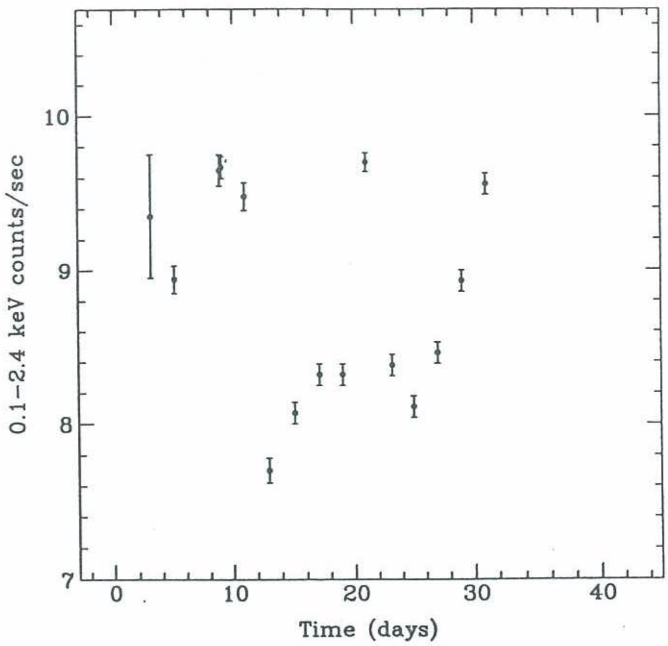

Figure 1: *0.1-2.4 keV X-ray lightcurve. Day 0 = 0 hrs UT on 10 December 1992.*

With this in mind we mounted a month-long coordinated campaign to observe 3C273 at the end of 1992 and beginning of 1993 with X-ray coverage by ROSAT, and millimetre-band observations by the JCMT, IRAM and the KPNO 12 m telescopes. 3C273 was observed 14 times by ROSAT with the PSPC, and once with the HRI, in the period 12 December 1992 - 10 January 1993. Observations were scheduled almost every day on the JCMT during this period but we lost many of these because of the dreadful weather on Mauna Kea last winter.

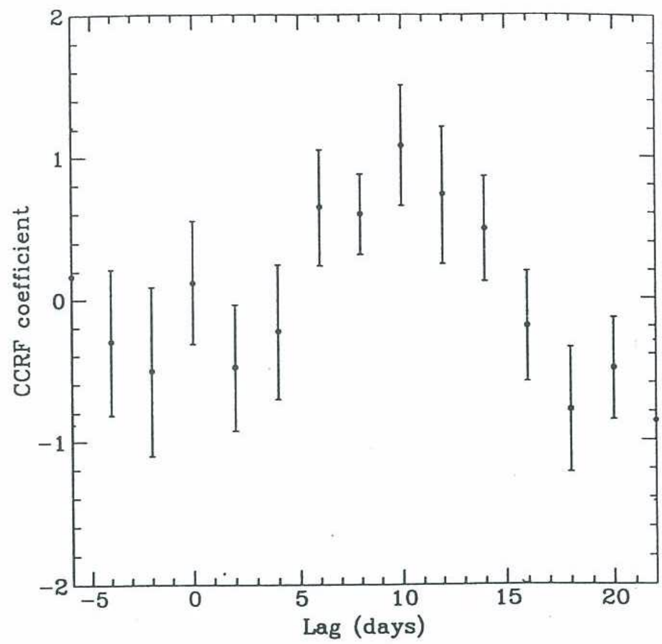

Figure 3: *Cross correlation of 1.5→2.4 keV X-ray and 1.1mm lightcurves.*

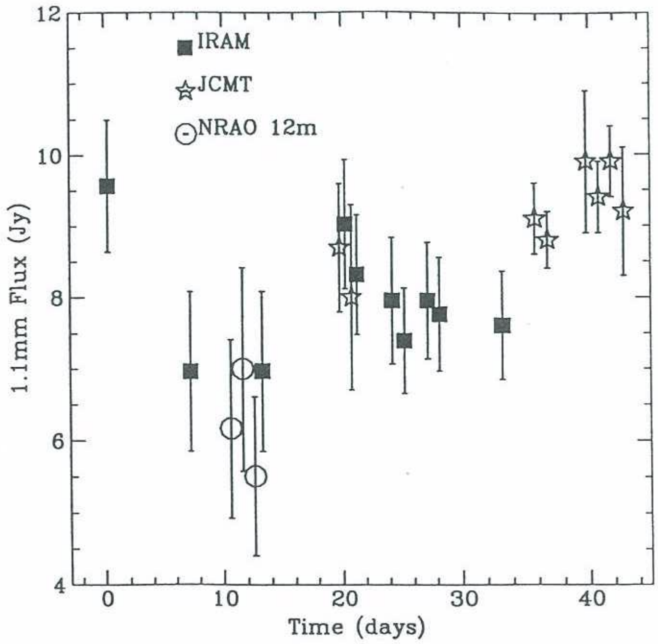

Figure 2: *1.1mm lightcurve of 3C273. Day 0 = 0hrs UT on 10 December 1992.*

However we were fortunate that observations with IRAM and with the NRAO 12 m were obtained during some of our worst gaps.

The resultant X-ray and millimetre light curves are shown in Figs. 1 & 2. The X--ray emission detected by ROSAT is variable, changing by up to 20% from day to day. The millimetre flux varies by a similar amount. The X-ray spectrum is best described by a combination of a steep and a flat power-law and although there is no correlation between the soft X-rays (0.1-0.5 keV) and the millimetre, we find a correlation at about the 3σ level with the hardest X-rays (1.5-2.4 keV). The X-rays lead the millimetre by about 10 days (see Fig.3). If confirmed, our detection of a link between the hard X-ray and millimetre fluxes would demonstrate that the hard X-rays are indeed produced in the jet, probably as a result of self-Compton scattering of the millimetre synchrotron photons by their parent electrons. The observation of a 10 day lag supports models in which the electrons are accelerated by shocks in the relativistic outflow (eg Marscher and Gear, 1985, ApJ **298**, 114) which then propagate down the jet. Models not involving shocks have greater difficulty explaining both the X-ray/millimetre lag and the hard X-ray spectral index.

Thanks are due to the large consortium of observers who made this campaign so successful. A full account of our observations and results will appear in Monthly Notices. A similar article has recently appeared in the UK ROSAT Newsletter.

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