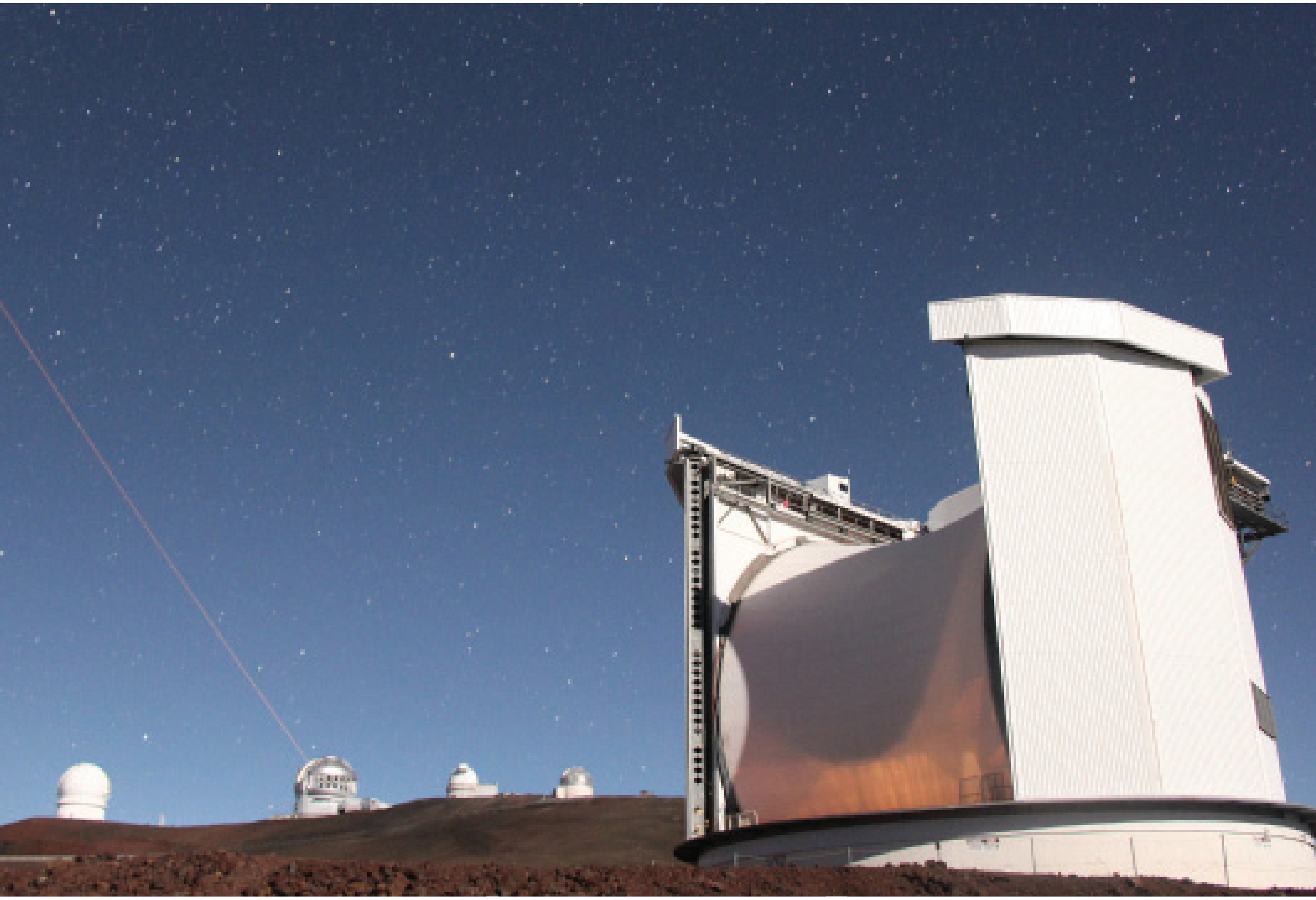
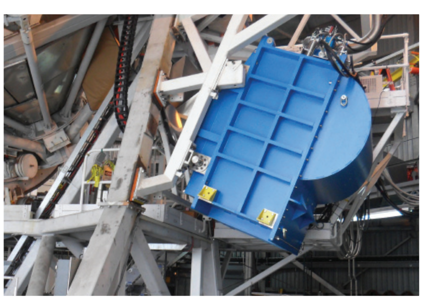
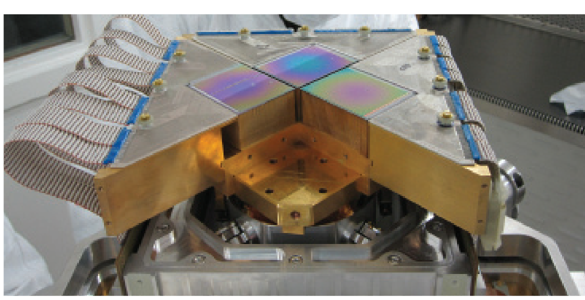
East Asian Observatory News







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East Asian Observatory News

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In this Issue:

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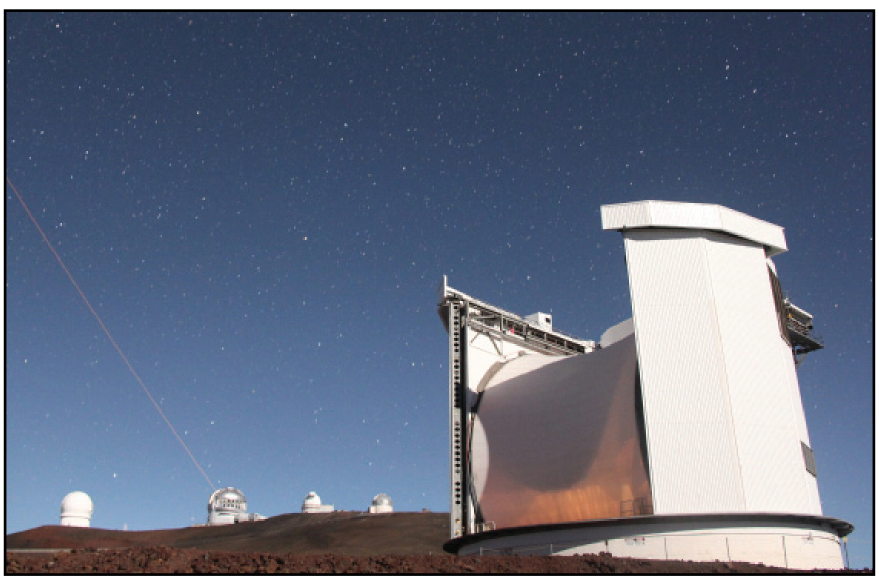

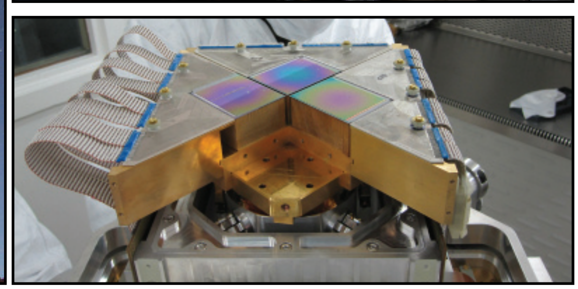

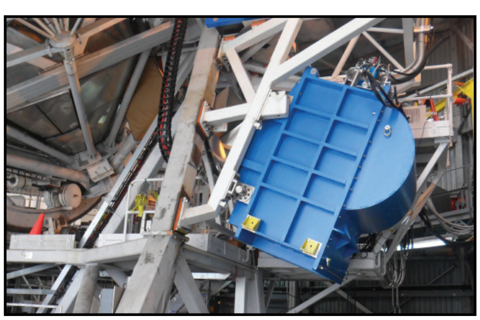

Front cover

From top-left clockwise: The JCMT against a backdrop of the optical and infrared telescopes of the Maunakea summit. JCMT workshop, Japan, January 2015. The SCUBA-2 450 micron focal plane array - during assembly. SCUBA-2 hanging at its Nasmyth focal station.

JCMT Operates As The East Asian Observatory

Paul Ho, Director General of EAO

On March 1, 2015, the East Asian Observatory officially took over the operations of JCMT. Thirty three members of our original JCMT staff have become the first staff members of the EAO. As in a relay race, the original JCMT consortium of UK, Canada, and Netherlands, have run a terrific first leg. The EAO has received the baton and we will endeavor to run a terrific second leg. It is our conviction that JCMT has a very bright future and we will continue to ensure its long term success. It is important for the EAO to state from the beginning that we also acknowledge that it is a privilege for astronomers to be working on Maunakea. We thank our Hawaiian hosts for allowing us to work at the greatest observatory in the Northern Hemisphere, and we promise to always be a good steward for as long as we are here and to respect our environment.

March was a difficult month on Maunakea, and we had very significant snow accumulations which prevented operations to proceed. Our staff worked relentlessly to bring all the instruments back on line, and also to carry out a significant amount of maintenance work. SCUBA-2 was warmed up for maintenance and cooled down again successfully. HARP and Receiver A were both cooled down successfully. At the end of March, JCMT conducted a successful VLBI experiment imaging the Galactic Center supermassive black hole, SgrA*. At the same time, an initial period of Pilot Science began. The proposal pressure was at the level of about 3 to 1 in terms of telescope time, thanks to the hard work by the JCMT staff who had visited the East Asian regions ahead of time to stimulate interest and to help prepare proposals. A Call for Proposals for the 2015B semester has now successfully concluded, with a very healthy oversubscription for observing time of about 5 to 1. A new Call for Survey Proposals has just been released.

Figure 1. The JCMT handover signing: Back row left to right: Jun Yan, Director General, National Astronomical Observatories of China; Dr Guenther Hasinger, Director, Institute for Astronomy, University of Hawaii; Professor Gary Davis, former Director of the Joint Astronomy Centre. Front row left to right: Dr Paul Ho, Director General, East Asian Observatory; Professor Matt Platz , Assistant Chancellor for Academic Affairs, University of Hawaii; Professor John Womersley, Chief Executive STFC. (Credit: Hollyn Johnson/Professor Gary Davis/STFC)

The JCMT Board and the EAO Board have endorsed our intention to develop a new generation of instruments to enhance the capability and sensitivity of our telescope. While we are commissioning both FTS-2 and POL-2, we also intend to increase significantly the number of pixels for heterodyne spectroscopy and for continuum imaging. We are also working with Caltech on the development of the Time-Pilot instrument which will measure the intensity of the redshifted [CII] line at 157μm from galaxies with z~5-9: the Epoch of Reionization. We will report on our progress on these developments in upcoming Newsletters.

Figure 2. Workshop participants at the January 2015 JCMT workshops held at NAOJ, Tokyo (top), ASIAA, Taipei (middle), and NAOC, Beijing (bottom).

JCMT Regional Workshops

Jessica Dempsey, Head of Operations

In the last two weeks of January, 2015, a series of workshops were held in Tokyo, Taipei and Beijing that introduced astronomers from the Asian regions that support the EAO Institutes (NAOC, NAOJ, KASI, and ASIAA) to the science, instrumentation, operations and capabilities of the JCMT. The prime objective for these workshops was to bring together these scientists and those from the continuing partner regions (UK and Canada) having previous JCMT experience, in the hope of initiating new and exciting collaborations.

Given how little time there was before the start of EAO/JCMT operations in March 2015, the workshops also aimed to jump-start understanding of JCMT usage with introductory workshops on everything a new JCMT user needs to convert proposals into publications.

More than two hundred scientists participated. In all the workshops, introductory talks were provided by JCMT staff members Per Friberg, Harriet Parsons and Jessica Dempsey, covering a range of topics including JCMT instrumentation, operations, proposal creation and submission, and introductory discussions on data reduction techniques. These talks can be accessed at www.eaobservatory.org/jcmt/help/workshops/. For the three of us, the hospitality that we received in all locations was beyond expectation and made us feel extremely welcome.

In each region, local and visiting scientists presented a wide-range of talks to initiate discussion and collaboration on new science projects that could be embarked upon at JCMT under the new EAO operation. The particular focus in Tokyo was on large, survey-type programs which were of interest to scientists in all participating regions. At all of the workshops, however, it was clear from the presentations by astronomers from the Asian communities that a great deal of serious discussion and thought had already been given to how best to use JCMT to do powerful science. This impression was confirmed when the responses to both the Pilot Science Call for Proposals, and then the 15B Semester Call were measured (see article 'JCMT's new community is inspired'), and showed that the interest in JCMT sparked at the workshops has continued to develop in EAO's Asian regions.

It was also extremely encouraging to meet the new generation of young, enthusiastic and extremely gifted students and post-docs who attended and contributed to the workshops. We were overwhelmed by the keen interactions during our tutorials and workshops. This experience over all others gave us high confidence that, with this new and growing community, the JCMT has a vibrant future.

Figure 3. Workshop participants in Japan talk science in a break off session lead by Doug Johnstone (top left). Workshop participants are taken through the proposal submission process in a hands on session led by Harriet Parsons in Japan (above left). Jessica Dempsey leads a tutorial on the Heterodyne reduction pipeline in China (above right).

JCMT's New Community Is Inspired

Iain Coulson, Senior Support Scientist & Jessica Dempsey, Head of Operations

The newly minted EAO, and its stalwart staff at the JCMT, faced a challenging set of issues in early 2015. Firstly, the transition of operations necessitated full closure of JCMT in February. At the start of March, the JCMT engineering and technical staff performed the remarkable feat of restoring the entire facility, systems and instrumentation to full working order in less than three weeks, despite serious delays from a late-season ice storm. Nevertheless, the first observing under EAO operations began well, with a spectacularly successful ten-day VLBI run in participation with our neighbors at SMA.

At the same time, the JCMT science staff faced a separate dilemma: Would there be any science to do, especially given the short time period before JCMT was to go back on-sky? The new (and old) EAO and JCMT partner regions needed to be roused to action. The question to be answered was: would JCMT be in demand by our new user base? In the era of ALMA, and the prevalence of remote operation of telescopes, does a single-dish submillimetre telescope still command interest and attract astronomers?

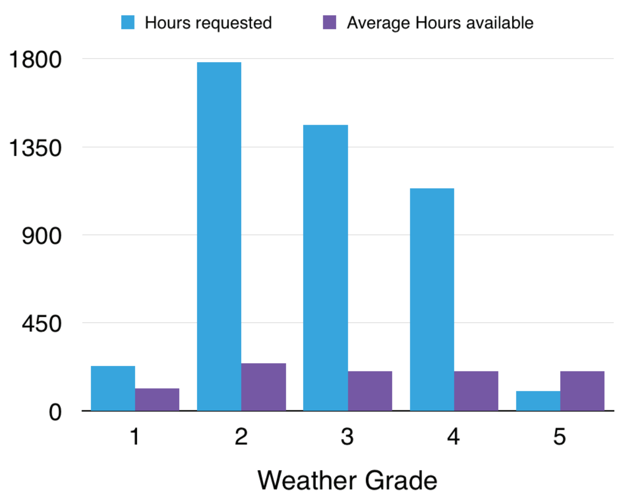

Figure 4. Observing time requested in each weather grade for semester 15B in comparison to that expected in the months of August through January.

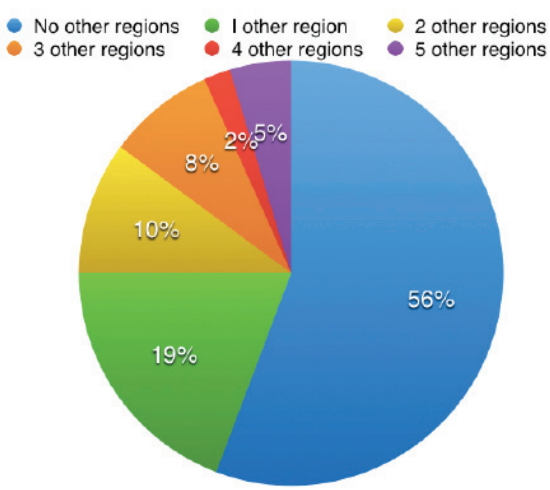

Figure 5. The distribution of 15B proposals by number of regional collaborators.

The EAO region JCMT workshops were intended to initiate connections with our new community, and were held in January 2015 (see the article 'JCMT Regional Workshops' on the previous page); the first call for proposals was opened on March 1st.

Pilot Science

The Pilot Science semester (April – July 2015) was designed (by necessity and intent) to provide open access to as many new community astronomers as possible. Given the compressed timetable in 15A, it was not possible to convene a Time Allocation Committee (TAC) to assess proposals; JCMT staff liaised with all PIs to ensure technical feasibility only. Project requests were limited to a maximum of 30 hours. The primary intent was to allow as many projects as possible to obtain some data, thus informing future 15B and survey proposals and familiarizing our new regional scientists with the details of JCMT operations.

The results were reassuring, to say the least, with 144 proposals received and total requested hours more than 3 times that available. Flexible scheduling rules were initiated to distribute observing over the greatest number of projects. As of June 29th, data have been obtained for 107 Pilot Science projects.

15B Semester

Hot on the heels of the deadline for Pilot Science proposals, the 15B Call for Proposals was issued. It became clear that the new JCMT community is deeply invested in the science opportunities at the telescope, with 140 PI proposals received, and a total oversubscription of an unprecedented factor of 5. HARP and SCUBA-2 were each requested for about 40% of the time; with Receiver A in demand for the remaining 20%. As in previous observing semesters, weather bands 2,3,4 were most frequently desired, with lesser demand for Grade 1 and Grade 5 (see Figure 4). Demand in every region was high: each regional community asked for total time that exceed their allocations by factors from 4 to 14. There is no doubt that JCMT remains in demand. A TAC is at work right now to assess and rank these proposals by scientific merit; we should have a very healthy PI program in semester 15B.

Observing with our new community

The JCMT continues to operate 'flexibly' - i.e. with programs observed according to the prevailing weather conditions (opacity). We have also maintained the 'visiting observer' model. Observers in the Pilot Science semester have been invited on the basis of their demands for time: those requesting large amounts of good weather have been invited preferentially. However, since we operate a flexible observing queue this does not disadvantage those whose programs can tolerate poorer weather. In 15B, observers will be invited based primarily on their TAC ranking. JCMT staff have been excited to welcome new faces to the telescope, and look forward to meeting many more in the coming months. This mode will continue in semesters 15B and 16A.

Pleasingly, and considering how short a time the EAO and partner regions have been joined in operations at JCMT, collaborations between the community represented by the EAO Institutes (NAOC, NAOJ, KASI, and ASIAA), and the UK and Canadian universities are already burgeoning. Nearly half of all 15B proposals involve collaborations between scientists from at least two regions (Figure 5). Collaborations are strongly encouraged, especially with the advent of the Survey proposal Call, which is open now and closes on July 31st, 2015.

SCUBA-2 : An Astronomer's Mapping Machine

Dan Bintley, SCUBA-2 Instrument specialist

As visitors to JCMT walk up the steps to the antenna floor, they cannot fail to notice SCUBA-2, the enormous blue box that hangs overhead. But what goes on inside that box? We describe here some of the unique features of SCUBA-2 (Holland et al. 2013) that make it the world's most advanced submillimetre camera and explain how it is used to map the submillimetre sky.

Let's get the name out of the way first: SCUBA, the 'Submillimetre Common User Bolometer Array' was a groundbreaking instrument for JCMT, which led a revolution in submillimetre astronomy in the 1990s. SCUBA was in operation on JCMT for 9 years from 1996 and was an unprecedented success, revealing a much colder Universe, containing prestellar and starless cores, molecular clouds, faint high-redshift galaxies and cold dust in nearby galaxies. Before SCUBA, continuum submillimetre astronomy was done with single detector instruments; and mapping extended regions with a single 'pixel' is excrutiatingly slow.

SCUBA (together with SHARC at the Caltech Submillimeter Observatory) introduced background limited, large-scale detector arrays to the submillimetre astronomy community. The SCUBA shortwave (450μm) array had 91 feedhorn-coupled bolometers, closely packed to form a hexagon, while the longwave (850μm) array had 37. A bolometer is a detector whose electrical resistance changes as a function of irradiance and can be thought of as a thermal detector. By cooling to low temperatures, bolometers are exceptionally sensitive. The sensitivity of the SCUBA arrays was limited by the photon noise of the sky and telescope background, rather than the detectors themselves.

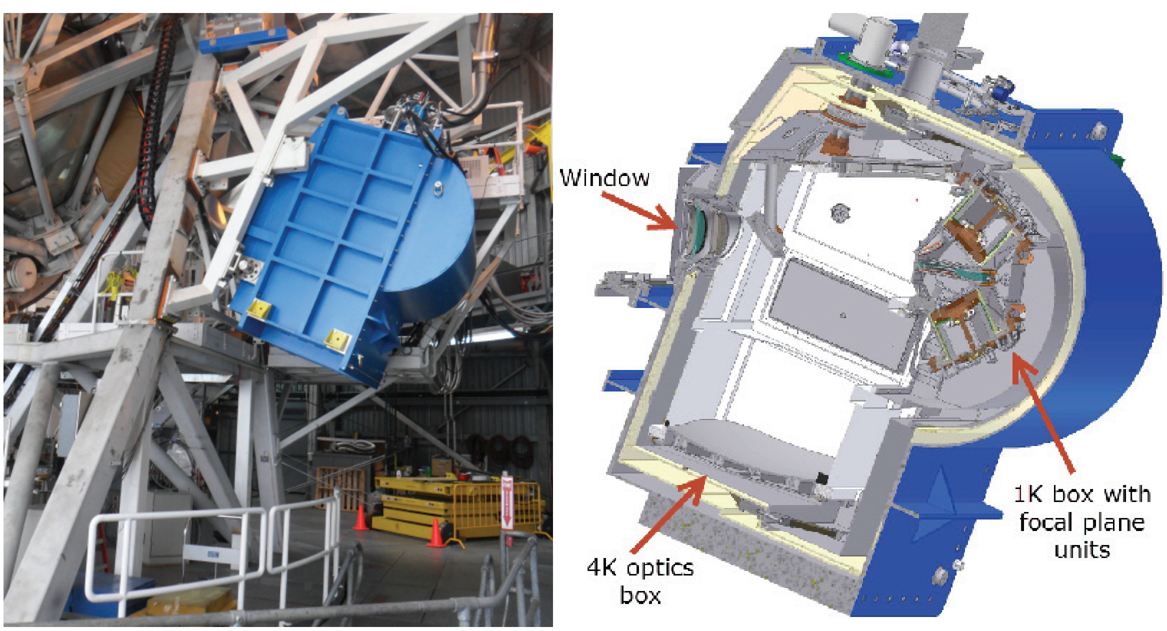

Figure 6. SCUBA-2 on JCMT (left). A cross section view of the SCUBA-2 cryostat, showing the location of the cooled mirrors and the focal planes units (right).

Being a 'common user' instrument

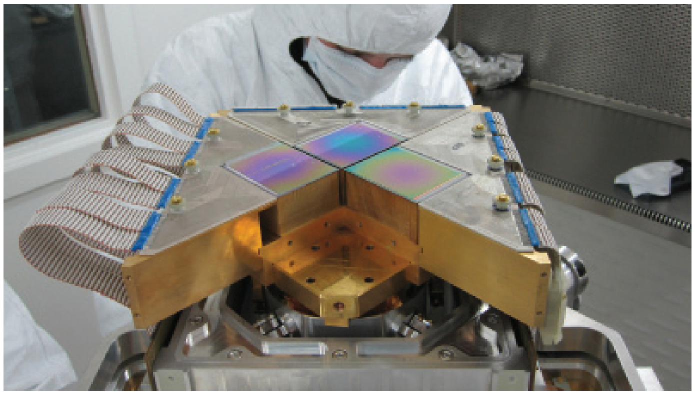

Figure 7. Assembling the 450μm focal plane at JCMT. The array is made from four sub-arrays, each with 1280 TES.

means that the observing strategy, data reduction software and techniques were developed in conjunction with the instrument, enabling all observers to get the best out of their allocated time. The common user model for instrumentation has been continued and further developed for SCUBA-2.

SCUBA-2 was envisioned as a successor instrument to SCUBA. One of the key scientific motivations was to survey large areas of the submillimetre sky, with a target of a hundred fold increase in mapping speed over SCUBA. This goal has been achieved. At 850μm and in good weather, SCUBA-2 can map a field of diameter 3 arcmin to a RMS noise level (in the map) of 1mJy in 3 hours. For a field of diameter 1 degree, the RMS noise is 30mJy in 15 minutes, and below 6mJy in 7 hours.

In its lifetime, SCUBA mapped 41 square degrees of sky. In its first three years, SCUBA-2 has already surveyed 1778 square degrees to a significant depth. This includes completing six major JCMT legacy surveys (albeit scaled down due to time constraints), and many PI led projects. However, this is only a fraction of the entire visible sky (23000 square degrees from JCMT), so there is much more to do. The combination of JCMT, with its 15m dish, and SCUBA-2, with its 45 arcmin field of view, is the state of the art for submillimetre mapping and will remain so for many years to come.

SCUBA-2 instrument design

At the heart of SCUBA-2 are two sets of 5120 superconducting Transition Edge Sensors (TES), working at each of two wavelengths (5120 at 450 and 5120 at 850μm), and assembled in four subarrays (Figure 7). Transition Edge Sensors were chosen as the best emerging technology, with the potential to make the leap to kilo-pixel detector arrays. TES can be fabricated on silicon wafers using the same lithographic, deposition and etching techniques used in semiconductor integrated circuit manufacture, they can be made to be more sensitive than the NTD bolometers used in SCUBA, and, importantly for a practical low temperature detector array, they can be readily multiplexed using a SQUID based readout.

In the JCMT Newsletter #33, Wayne Holland described some of many steps, the successful pioneering work and many tribulations in the fabrication of the detector arrays. The SCUBA-2 TES is a molybdenum/copper bilayer, tuned to have a superconducting transition temperature (Tc) of ~ 140mK for the 850μm array.

The doped silicon brick has a thickness equal to $\lambda/4$ at 850μm to make it an efficient absorber of incoming radiation. The 450μm detector is identical, except that the brick thickness is $3\lambda/4$ and the Mo/Cu TES is tuned to make Tc~200mK, to handle the higher total power at 450μm.

Underneath the detector wafer and indium bump bonded to it, is an even more complicated device; the 2D-SQUID MUX wafer, designed and fabricated by NIST, the National Institute of SCience and Technology at Boulder, Colorado. The MUX uses niobium SQUIDs to read out each TES and to multiplex the array, enabling signals from 40 TES to be put onto a single pair of wires. This is necessary to keep the thermal load on the focal planes manageable.

The SCUBA-2 cryostat is so large because it was designed to accommodate not only the two focal planes but also the final three reimaging mirrors. The mirrors are cooled to 4K to reduce the power loading on the arrays.

SCUBA-2 is constructed as a series of nested subsystems and enclosures that operate at different temperatures. The 1K box incorporates a cold stop aperture that defines the field of view of the detectors and a movable cold shutter (Figure 8) that effectively seals the 1K box to light and allows for consistent setup of the TES arrays. The twin focal planes share the same 45arcmin^2 view on the sky

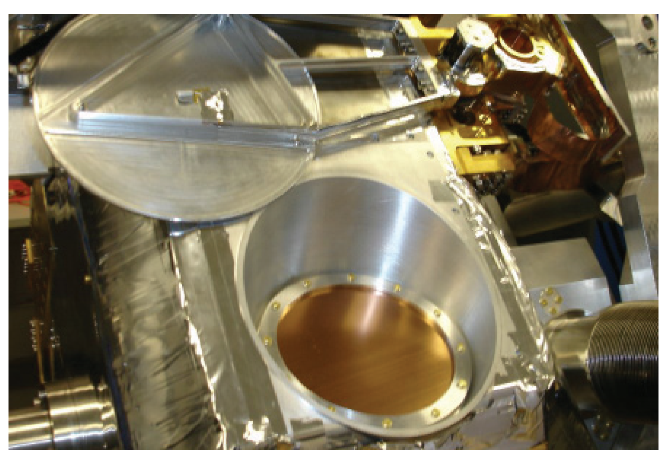

Figure 8. The cold stop aperture and movable shutter on the 1K box.

and observe simultaneously by using a dichroic beam-splitter. Metal-mesh filters and thermal blockers in the optical path from the cryostat window to the TES arrays are used to limit the thermal and radiation loads on the various subsystems. Full details of the filter properties and the measured profiles can be found on the JCMT website.

Array setup and calibration

A unique feature of the SCUBA-2 detectors, is the inclusion of a resistive heater for each TES. The heaters are used in conjunction with the TES bias voltage to put the TES into the superconducting transition; later they are used to compensate for the changes in the optical power loading on the arrays, as the cold shutter opens and as the sky background changes. The heaters are also used for detector calibration at the start of each observation.

An array setup is an automated routine that is run when required, to optimise the SQUID MUX parameters and put the detectors into the optimal performance state i.e. where the effective NEP (noise equivalent power) of each subarray is minimized. An array setup is done 'in the dark' with the cold shutter closed. When the shutter is opened, a servo loop reduces the heater power on each subarray to keep the total power on the detectors constant. The same servo loop is run between sequences in an observation (but not during data taking) to compensate for changes in sky power; this keeps the TES close to their optimum performance and increases the dynamic range.

At the start of every observation (saved into the first subscan, or data file), each TES is calibrated by means of small ramps of the TES heaters (a few pW peak to peak), to measure the responsivity of each individual TES. This is used to calibrate the detector signal in terms of the equivalent power change on the TES.

A Flux Conversion Factor (FCF) determined from an observation of an astronomical standard source, converts the responsivity-corrected TES power signal into a calibrated flux in janskys in the final reduced data map. A wavelength dependent extinction correction relating the level of precipitable water vapor (PWV) measured along the line of sight during SCUBA-2 observing to the attenuation of the astronomical signal is also applied.

Calibration observations of standard sources are done regularly during the night, usually bracketing science observations. A full description of the SCUBA-2 calibration is found in the calibration paper, (Dempsey et al. 2013) and online at; http://www.eaobservatory.org/jcmt/instrumentation/continuum/scuba2/calibration/

Observing modes

To map the sky effectively and recover large-scale structure against a slowly varying sky background and with detector 1/f noise, we require a scan pattern that has both spatial and time modulation. The same region on the sky needs to be scanned in different directions and with different time periods to be most effective. To achieve this, two scanning modes have been commissioned that move the antenna in distinctive patterns across the sky (see Figure 9). Constant Velocity (CV) 'daisy' scans are particularly useful for imaging point sources or compact sources less than 3 arcmin across, while the rotating 'curvy pong' pattern was designed for mapping larger areas (15-60 arcmins). The reduced SCUBA-2 maps from either pattern can be mosaicked together to make larger maps.

Data reduction

The final piece of the SCUBA-2 mapping jigsaw is data reduction. The creation of maps from the raw timeseries data is handled by the SMURF package within the Starlink software collection. Maps are made using an iterative

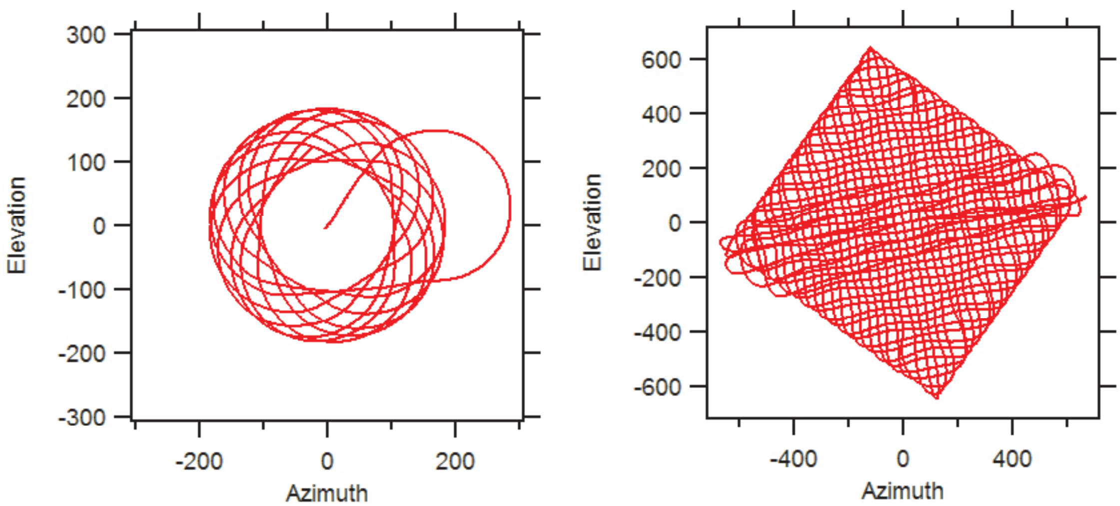

Figure 9. Telescope tracks for (left) CV daisy and (right) rotating curvy pong patterns Details of the SCUBA-2 scan patterns, including the limitations in antenna speed, acceleration and elevation and the uniformity of coverage in reduced maps are online: www.eaobservatory.org/jcmt/instrumentation/continuum/scuba-2/observing-modes

method (Chapin et el. 2013). Summit data reduction pipelines process SCUBA-2 data in real time, to provide control over data quality and feedback for the telescope operator and observers. The data is processed again with the full data reduction pipeline, using standard settings, before being archived. Users have access to both the raw and reduced data and a range of software tools to re-reduce data or to combine and process the reduced maps.

Future enhancements

SCUBA-2 is the state of the art for submillimetre mapping and our aim is to continue to improve it. We are investigating ways to increase the mapping speed by further optimizing the array performance. The data reduction techniques and software tools are continually being enhanced, as we gain more experience. The most exciting and anticipated additions are the two ancillary instruments for SCUBA-2; a polarimeter, POL-2, and a scanning Fourier Transform spectrometer, FTS-2. They are almost ready for science and when they are, this will open up many new avenues for the community.

Acknowledgements

SCUBA-2 was built by an international collaboration led by the UK Astronomy Technology Centre (UK ATC) at the Royal Observatory Edinburgh. The detectors and SQUID MUX were designed and fabricated by the USA National Institute of Standards and Technology (NIST) in Boulder. The wafers were prepared and 'deep'-etched by the Scottish Microelectronics Centre at the University of Edinburgh. The Raytheon Company did the bump bonding. The focal planes, sub-1K structures and filters were designed and manufactured by the Astronomy Instrumentation Group at Cardiff University. The readout electronics (MCE) and data reduction software are from the University of British Columbia, and the MUX wafer screening was done by the University of Waterloo. The dry dilution refrigerator was supplied by Leiden Cryogenics. The cold and warm mirrors were manufactured by TNO Science and Industry in collaboration with the National Aerospace Laboratory of the Netherlands. Funding for SCUBA-2 came from the JCMT Development Fund, the UK Office of Science and Technology and the Canada Foundation for Innovation.

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SCUBA-2 : 850 micron Legacy Release

Sarah Graves, Scientific Programmer

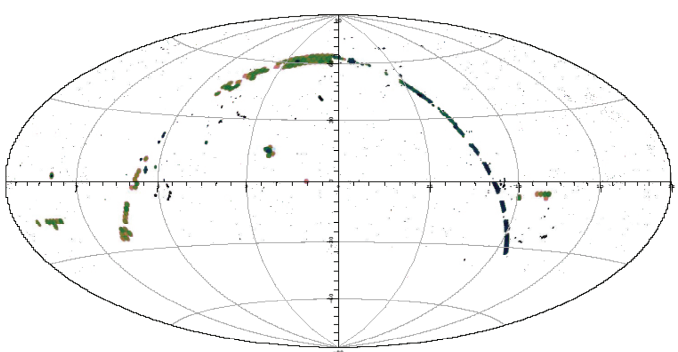


Figure 10. A full sky noise map from all the co-added tiles included in the JCMT SCUBA-2 850μm Legacy Release 1. Darker colors represent lower noise. Individual small Daisy mode observations can be seen scattered across the observable sky, barely visible on this scale as small points. Larger Pong-mode observations of various sizes can be more clearly seen, mostly concentrated along the plane of the galaxy and associated regions.

In Summer 2015, the JCMT is releasing standardised reductions, coadds and catalogues of detected emission for all public SCUBA-2 850μm observations taken between February 2011 and August 2013. This release aims to start making the legacy of SCUBA-2 observations available in an easier-to-use form for all astronomers.

The reduction method used for this release was chosen to maximise the confidence that could be placed on detected emission without requiring a detailed analysis of each observation, and to allow reduction of the full dataset in a reasonable time scale. This was achieved by using a more extreme filtering of large scale structure (no scales larger than a subarray, approximately 3 arcminutes), and a number of iterations that is low compared with many PI and Legacy Survey reductions. The observations were reduced onto a HEALPix grid using the HPX projection.

This release includes reductions of over ten thousand observations (including pointing observations). Over 5000 science observations, covering 789 square degrees and including over 2200 hours of observations, were then coadded together. This legacy release will be available and searchable through the JCMT Science Archive at CADC, using their standard Advanced Search portal.

In the future, we are planning both to continue our 850μm legacy release by updating our reductions and coadds with more publicly available SCUBA-2 data, and to expand this programme by releasing standardised reductions of the 450μm SCUBA-2 datasets and the heterodyne observations. We are also hoping to use the Virtual Observatory features of CADC's archive service to integrate queries to our legacy releases into other software such as GAIA.

A New Proposal Submission System For The JCMT

Graham Bell, Scientific Programmer

After the semester 15A call for proposals it was realized that our proposal system was in need of an overhaul. This is partly due to the sheer volume of proposals (a good problem to have) for the combined EAO queue, leading to a requirement for more efficient proposal assessment and transfer of data to the OMP (Observation Management Project). We also need a more flexible system which we can adapt to the shifting requirements of EAO operations.

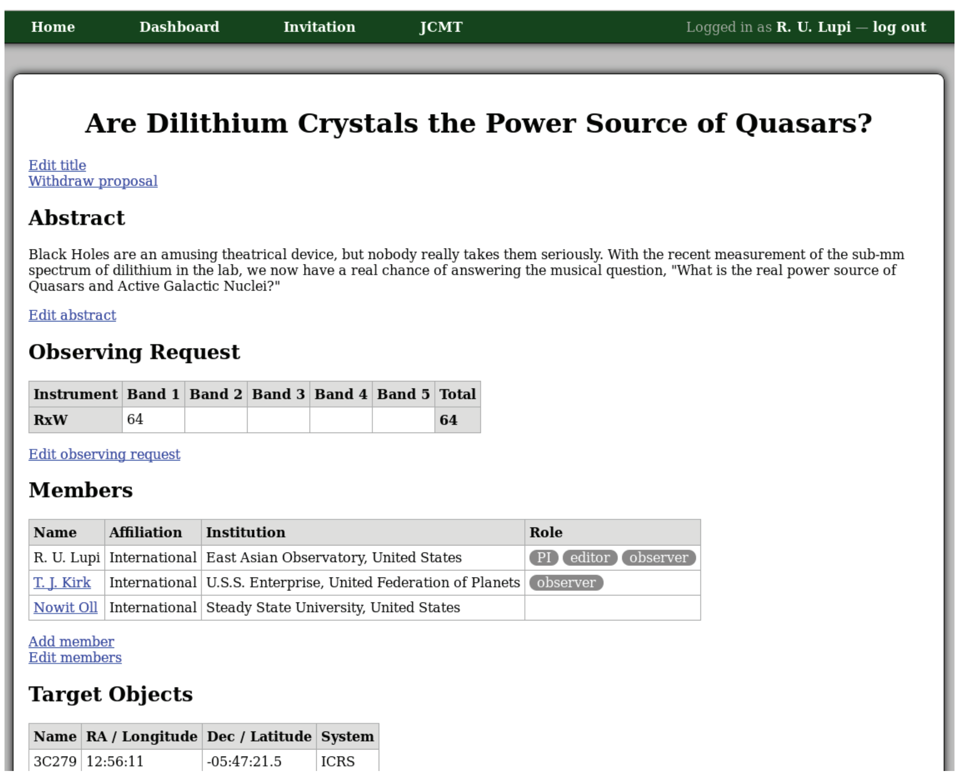
We have therefore begun a project to revamp our proposal handling system in three phases:

1. An automated import tool to bring accepted semester 15B projects into the OMP.
2. A new proposal submission system, which we aim to roll out for the semester 16A call later this year.
3. A new proposal review system for use by the Time Allocation Committee and proposal reviewers — this should record the time allocated for import into the OMP.

From a proposal author's point of view, we hope that a more modern and user-friendly interface will ease the burden of preparing a proposal. Planned enhancements in this regard include:

- Built-in integration time calculators which will allow you to attach results directly to your proposal.
- The option to have your name appear in a directory of users, allowing collaborators to easily invite you to participate in their proposals.
- On-line editing of the scientific and technical justification as a faster alternative to uploading PDF files.
- Target position tools to help identify possible clashes with survey projects or data already in the JCMT archive.
- The ability to continue editing a submitted proposal (before the deadline) without having to retract it first.

Finally we hope to improve the responsiveness of the system in the run-up to proposal deadlines by taking some of the PDF processing work off-line. However, please don't take this as encouragement to wait until the last minute to submit your proposal, especially in the first semester using the new system!


Home Dashboard Invitation JCMT Logged in as **R. U. Lupi** — **log out**

Are Dilithium Crystals the Power Source of Quasars?

Edit title
Withdraw proposal

Abstract

Black Holes are an amusing theatrical device, but nobody really takes them seriously. With the recent measurement of the sub-mm spectrum of dilithium in the lab, we now have a real chance of answering the musical question, "What is the real power source of Quasars and Active Galactic Nuclei?"

Edit abstract

Observing Request

Instrument	Band 1	Band 2	Band 3	Band 4	Band 5	Total
RxW	64					64

Edit observing request

Members

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Target Objects

Name	RA / Longitude	Dec / Latitude	System
3C279	12:56:11	-05:47:21.5	ICRS

Figure 11. Recreation of a vintage JCMT example proposal in the new system. This screen shot was taken from the development version at the time of writing — the system may well look different by the time it is released.

James Clerk Maxwell Telescope
East Asian Observatory