Chajnantor Observatory Report

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This is a summary of the activities at the Chajnantor Observatory over the first year of the SAINT agreement (1 August 2005 – 31 July 2006).

The primary activities are listed and discussed below.

1) Switch-off of generators and mothballing of CBI

In order to conserve funds, we wanted to switch off the generators as soon as we stopped CBI observing on July 31 2005. However, Detroit Diesel was concerned about the effects of leaving the generators off during cold weather, and said that it would void our guarantees and maintenance contract. So we operated from August-December in a low power mode, and then in January Detroit agreed that it was warm enough at the site to switch off the generators completely, which we did from mid-January to mid-May. The power plant was brought back into operation without difficulty in May. The CBI itself was mothballed from 1 August 2005 to 15 May 2006.

2) Design, construction and installation of a new cooling system

An essential part of the long-term operations plan is an upgrade to the cooling system, to reduce the power consumption, hopefully by about a factor two, by replacing the original active cooling system with a passive air cooling system which cools the circulating coolant liquid. This upgrade was carried out by Manchester, under Colin Baines, who is now in charge of cooling at the CO. The costs were covered primarily by Manchester. Chajnantor Observatory engineers assisted with the installation and testing.

3) Replacement of all 26 helium lines on the tri-axial mount

The old helium lines were leaking badly and it was essential to replace these. The purchase and shipping costs were covered by Oxford (50%), with the remainder split equally between Manchester, Stanford and Caltech. Chajnantor Observatory engineers carried out the replacement of the lines. The new lines and fittings are compatible with QUIET needs.

4) Bringing QUIET mount back into operation after mothballing for 10 months

There were some problems with bringing the mount back into operation, as is always the case when a telescope has been mothballed for some time. Most of these problems were easily resolved. One problem, which appears to have resolved itself, was with the elevation drive. The drive was having difficulty maintaining the pointing accuracy (to better than 6 arc seconds). We have experienced this problem twice before when the CBI was out of operation for a period of weeks-months, and on both occasions it disappeared

as we continued to use the telescope. Although we have carried out extensive tests of the elevation drive when this problem has appeared after each period of disuse, we have not been able to pinpoint the cause.

5) Tests of the mount + new bearings

These have focused primarily on the elevation drive, as described above. We also carried out tests of the azimuth and deck drives, and they are working well. The new deck bearings are on hand in Chile. We plan to swap over the bearings in December or January. Chajnantor Observatory engineers carried out these tests.

6) Replacement of Site and San Pedro Computers

It was essential to replace the old Sun computers, which were ten year old machines, for the following reasons:

(1) in view of their age it would have been difficult to upgrade any of the development software on the Suns, or to install free commercial software, like MATLAB, etc. without first upgrading to a new version of Solaris, which would have required bigger pressurized disks in custom-made containers, more memory, etc.;

(2) with the Suns it was very difficult for anyone but Martin Shepherd to switch a spare Sun to act as a control computer, whereas this is trivial with the new setup --- in fact we have already verified that the San Pedro computer can act as a backup for the telescope control computer;

(3) there was no easy way to recover from a computer failure with the ten year old system;

(4) for security when we connect to the Internet; and

(5) to enable us to install frame-grabbers for automatic optical pointing.

Martin Shepherd carried out the development and assembly of the systems, using raid arrays for data storage. This turns out to have been an excellent choice on Martin's part.

The QUIET Project "signed off" on the site computer plan that Martin presented, and gave us the go-ahead, so we hope that the new computers will be adequate for QUIET needs, but we still have to make this assessment; i.e., there may be further expenditures involved in preparing for QUIET.

The San Pedro computer is identical to the two computers on site, and can serve as a backup to these in an emergency.

This task turned out to be a very time-consuming and costly business, but the new system is working extremely well. SAINT committed $20K in funds to this task, which were

funds that had been saved on diesel by not operating for much of this year. This covered 25% of the costs of this task, the remainder was covered by Manchester (70%), and QUIET (5%).

7) Pointing tests

Pointing tests were carried out by Clive Dickinson and Tim Pearson, with much assistance for the Chajnantor Observatory engineers, who were bringing the electronics and cryogenics systems back into operation. The results of these tests showed a total rms error of 11.7 arcsec and a maximum error of 17.3 arcsec. We think that this is well within the 9 arcsec pointing spec on QUIET, since this spec is for the rms error in positioning pixels on the map (an average of many scans), not on the instantaneous pointing. But we still need to determine the accuracy of pointing reconstruction during rapid scanning

8) Work on telescope control software for observation in rapid scanning mode

A number of changes to the basic PMAC code were required to accommodate this new observing mode. Shepherd has successfully completed these changes. QUIET paid for this task by Shepherd.

9) Tests of mount in rapid scanning mode

These tests are continuing, with the result thus far being that the maximum rate in fast scanning mode is 2.5 degrees per second in azimuth , and the maximum acceleration is 12 arc minutes/sec/sec. These are lower than required for some scanning modes that have been suggested for QUIET. We are looking into whether it might be possible to increase these rates, but for the present these are the numbers that should be used. A full report on these tests has been submitted to QUIET by Martin Shepherd, who carried out this work with Erik Leitch, and the Chajnantor Observatory engineers, with the costs being covered by SAINT and QUIET.

10) Development of the Don Esteban Facility in San Pedro

This has chewed up a LOT of time, but it is a good development for SAINT and QUIET, since it will significantly reduce the accommodations costs in San Pedro, while providing more services (e.g. broadband internet link, cheaper meals, better workspace, etc.). Chajnantor Observatory engineers have carried out the work. The costs were borne by SAINT, ACT and ASTE, who will share this new facility. Caltech has loaned SAINT $30,000 to cover its share of the upfront costs. $22,000 of this amount is recoverable, and will be paid back to SAINT (and then to Caltech) by the owner of the facility over a two-year period. The remaining $8,000 will be budgeted in the SAINT 2006-2007 budget. The cost of a bedroom with bathroom en suite will now be $40 per night, including breakfast, which the guests prepare for themselves. Other astronomy groups will be able to rent rooms at the facility at a cost of $60 per night. The CCAT, KOSMA and APEX groups have said that they will rent from the facility in preference to renting

from local hotels. There is a broadband Internet link (included in the $40 per day costs), and a laundry service and meal service at extra cost ($8 per meal). As from February 1 2007, SAINT will have 4.5 bedrooms, ASTE will have 4.5 bedrooms, and ACT will have 3 bedrooms. At present SAINT has 3 bedrooms, ASTE has 3 bedrooms, and ACT has no bedrooms. SAINT and ASTE moved into the new facility in late September, ACT will take up occupancy in early February. The facility is a ~20 minute walk from the town center.

11) Upgrade of oxygenation systems

Due to lack of funds, the oxygenation systems were running inefficiently. These have been upgraded using SAINT and Manchester funds. Chajnantor Observatory engineers carried out this task.

12) Upgrade of power plant

This task has consumed and wasted a lot of my time, of the manager's time, and of the Chajnantor Observatory engineers' time: In January Shell Chile informed us that we had to upgrade the fuel spill catchment within three months, or they would stop delivering diesel. We contracted with Shell to do the work, and they sent two successive sets of incompetent subcontractors to do the job. Each time this wasted both manager's and engineers' time, since they spent days working with the subcontractors before they could convince Shell that they were incompetent. Meanwhile Shell's prices were escalating. This is not the first time that Shell Chile has demonstrated total incompetence, but there is only one alternative choice (Copec), and we are not convinced that they would be better. Eventually Shell conceded that they could not do this job, and they withdrew from the bidding. We contracted with ECIM for this work, and it has recently been completed (see photos on Chajnantor Observatory web pages). The cost of the upgrade was $35K in the ECIM contract, which was covered by Manchester, and the labor of Chajnantor Observatory engineers, which SAINT covered.

13) Development and design of microwave link between site and San Pedro

Martin Shepherd, Tim Pearson and Chajnantor Observatory engineers have spent a lot of time on this, and we are about to increase its priority substantially. We would like to have a new system in place within about four months. Manchester has paid all the costs associated with the Chajnantor Observatory engineers' work.

14) Installation of new (1.4 m) antennas on CBI mount (CBI2)

The Oxford Group has designed and constructed a set of 1.4m antennas to replace the original 90-cm CBI antennas, in order to increase the CBI's sensitivity to the "excess" signal and to SZ measurements. It is an elegant design. Work was carried out at Oxford and in Chile by the Oxford Group and by the Chajnantor Observatory engineers. While there are some teething problems, we think these have been resolved, and hope to start observing with CBI2 by mid-November.

At the Chajnantor Observatory over the last year, the CBI2 program has been given lower priority than the computer work and scanning tests being carried out for QUIET and the development of the Don Esteban Facility. The CBI2 project has been invaluable as a test case for how we should operate with QUIET.

15) Repair of receivers and other electronics to make CBI2 operational

This has been a time-consuming task for the Chajnantor Observatory engineers over the last few months. It is, of course, of primary interest and use for CBI2, but is was also necessary in order to carry out some of the pointing tests.

16) Education and Public Outreach (EPO)

It is required of each new astronomical project coming to Chile that it have a well-developed EPO program that takes into account the needs of the local community. The CBI and CIB2 are grandfathered in, and are not subject to this requirement. However, our colleagues at the Universidad de Chile informed me last March that all new projects coming to the CO will be subject to this requirement, and they specifically requested me to take charge of this part of the QUIET requirement, which I agreed to do. Since then I have had extensive discussions with our colleagues at the Universidad de Chile, the Universidad de Concepcion, the local community in Concepcion, the local high-school science teacher in San Pedro, the principle of the local high school, and the Mayoress of San Pedro, concerning this requirement for QUIET, and I have suggested to them a program that both the Chilean Universities and the local communities are delighted with. This involves bringing schoolteachers from San Pedro and Concepcion to California for training at Caltech/JPL and the Lewis Center for Educational Research (LCER), and giving them instruction in a highly innovative program that we are developing at the Owens Valley Radio Observatory (OVRO) with JPL and the LCER. Under this program high-school students will be able to control the OVRO 40m Telescope from their classrooms in San Pedro and Concepcion and they will work directly with scientists at Caltech and JPL. The Chajnantor Observatory engineers were enormously helpful in all of these negotiations, and they will play a significant role in this program in the future. The additional costs of this project, i.e. those outside of the Chajnantor Observatory engineers' time, are being born by Caltech and JPL.

17) The 10% Requirement for Chilean Astronomers

Another requirement for all astronomical projects in Chile is that 10% of the time on the instruments be given to the Chilean astronomy community. With cmb instruments, it is not possible to do this in the usual way, by allocating observing time to Chilean astronomers on a competitive basis. This is/was also a CBI requirement. We have met this on the CBI in the following three ways:

(i) Our colleagues at the Universidad de Chile and the Universidad de Concepcion are full scientific collaborators on the CBI

(ii) We have explored scientific projects of joint interest and made CBI observing time available to Chilean astronomer with scientific programs that could use the CBI effectively

(iii) I have strongly encouraged the Chajnantor Observatory engineers, who all have degrees in electrical engineering (6 years at a Chilean university), to do PhD theses. This has enabled us to retain these engineers for much longer than would otherwise have been possible, and it also provides very strong motivation for them. This approach has also been very well received by the Chilean astronomy community, who point to Caltech as the example they would like other foreign universities with astronomical projects in Chile to follow. Two of our engineers, Bustos and Reeves, are in their third year of graduate school and will graduate in the next year. With QUIET coming to the Chajnantor Observatory, and, being mindful of the importance that our Chilean University colleagues attach to the training of PhD students at the CO, I have for some time been encouraging our third engineer at the Chajnantor Observatory, Oyarce, to undertake a PhD, and I am happy to say that he decided last June to do so. I visited the Universidad de Concepcion specifically to discuss this with the faculty there, and this is proceeding well. Clearly, the Chajnantor Observatory engineers are heavily involved in this activity, since these are their theses. This activity also takes up a considerable amount of my own time, but I view it as essential for a good relationship between the projects at the CO and our Chilean hosts. It also enables us to tap into a pool of talent that it would otherwise be difficult to access. These Chilean engineers have spent terms at Caltech as special students, and come out at the top of the astronomy graduate students in standard coursework.