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NATIONAL RADIO ASTRONOMY OBSERVATORY
Charlottesville, Virginia

January 30, 1989

MEMORANDUM:

TO: AD's, Engineers, Scientists (Staff)

FROM: M. Balister MB

SUBJECT: Central Development Lab Report

I have put this report together to familiarize NRAO staff with the work currently going on within the Central Development Lab. I have not gone into too much detail regarding individual projects since the intention is to give a more general indication of the work which is covered in more detail elsewhere in quarterly reports, users' meetings, etc.

If you have any comments or suggestions as to how the CDL can better attend to the needs of the sites in areas where we have the expertise, let me know.

Attachment

CENTRAL DEVELOPMENT LAB REPORT
(Post Weinreb)

Michael Balister
January 30, 1989

1. Summary

2. Introduction

3. Millimeter-Wave Development

4. Millimeter Array Proposal Support

5. Spectral Line Receiver Development

6. HEMT Amplifier Development and Production

7. Voyager/VLBA Receiver Development

8. Proposals for Externally-Funded Projects

9. Sale of Amplifiers for Scientific Research

10. CDL Budget for 1989

1. Summary

This report covers the current status of NRAO's Central Development Lab (CDL) at Ivy Road in Charlottesville. Current projects and staff activities are described, including collaboration with outside organizations, proposals for funding from other agencies, and sales of components. The 1989 budget is also discussed.

2. Introduction

Historically, the development work being done in the CDL has been in three major areas: (1) millimeter-wave receiver components, (2) low-noise GASFET and HEMT amplifiers, and (3) digital systems, interfaces and also computer maintenance for the Charlottesville computer group.

The third area is no longer covered from within the CDL. Most of the people are still around; Escoffier, Brown, Wireman, and Runion were transferred to the VLBA project, and Dowd went to Tucson. Two positions were transferred to the Computer Division, but one was later lost during a personnel reduction.

The following is the current list of personnel grouped by responsibilities. Three persons on the list are charged to the VLBA project to cover VLBA amplifier and receiver construction within the CDL.

Millimeter-Wave Group

Bailey
Boyd
Horner
Johnson
Kerr
Pan

HEMT Amplifier and VLBA Receiver Construction

Crady (VLBA)
Harris
Lakatosh (VLBA)
Pospieszalski

Machine Shop

Dillon (VLBA)
Taylor

General

D'Addario (AOS, space radio astronomy)
Granlund (half time; general, theoretical studies)
Srikanth (antennas, feed design, etc.)

Electroplating

Summers

In the general area, these persons work on a variety of projects and have less specific responsibilities than the rest of the group. They are available to work on problems as they come up anywhere within the observatory. For example, Granlund is currently working on the VLBA correlator project, and D'Addario and Srikanth are involved in a proposal for a Green Bank antenna replacement for the 300-foot telescope.

3. Millimeter-Wave Development

The major responsibility of this group is the development of state-of-the-art detectors for the frequency range 70-360 GHz. In order to support these devices on telescopes, there has been some development in the past on frequency multipliers. The work of this group is currently divided between development of SIS mixers (including device fabrication) and support of Schottky mixers, frequency multipliers and SIS mixers that are currently in use at Tucson.

This group works closely with R. Mattauch at the University of Virginia in producing SIS devices. Although NRAO is highly dependent on this group, we have not been able to maintain our financial support at a satisfactory level. Support of the UVA effort by other organizations is minimal due in part to a proliferation of university groups involved in this sort of work competing for the same limited funds. Fortunately for NRAO, we have had loose collaborative arrangements with IBM and Hypres which have provided additional sources of SIS devices for NRAO.

In the past the integration of these components into cryogenic receiver packages has been done sometimes in Tucson and sometimes in the CDL. The pros and cons of this have been discussed repeatedly and since the millimeter development work is done in Charlottesville and the receiver support is in Tucson, there seems to be no easy solution. Payne (Tucson) has spent a considerable portion of the last six months in the CDL building a 4 K closed-cycle refrigerator/dewar system including optics for a series of SIS receivers in the frequency range 1-3 mm.

4. Millimeter Array Proposal Support

From within the CDL several persons have been involved in providing support to the NRAO millimeter array design concept. This is expected to result in a proposal for a millimeter array by the end of 1989. Kerr and D'Addario have been responsible for the receiver and correlator inputs to this work. Most of the current development work within the millimeter-wave group of the CDL is directly applicable to the millimeter array project.

The CDL was also responsible for the construction of four 225 GHz radiometers (tippers) for making atmospheric measurements at potential sites for the millimeter array.

5. Spectral Line Receiver Development

Many spectrometers have been built in the CDL for use at sites. Three spectrometers (autocorrelators Models II, III and IV) were built by

Shalloway for the 300-foot and 140-foot telescopes. A hybrid correlator has been recently built by Weinreb, Escoffier and Dowd and is currently being completed in Tucson by Dowd, prior to moving it to the telescope.

Although the hybrid correlator can analyze up to eight IF channels simultaneously, the maximum IF bandwidth per channel in the eight-channel mode is limited to 300 MHz. This is insufficient for some 230 GHz programs using the eight-beam, 230 GHz, Schottky mixer receiver that has been built in Tucson. Expansion of this spectrometer would be possible but not attractive because of the dependence on a limited number of outdated VLA chips and also high cost in parts and labor.

It has been decided that the most promising technology for the next generation of spectrometers for multi-beam receivers (up to 32 beams) is the acousto-optical spectrometer (AOS). The reason for this is that reasonable cost and wide bandwidth are the major requirements of the individual spectrometer. Flexibility which is a prime advantage of the hybrid correlator spectrometer is not necessary for this application.

Work on a prototype AOS has been started in the CDL by D'Addario. This project is to determine the performance and cost of a 1024-channel spectrometer for analysis of an 1000 MHz bandwidth IF channel. The objective of this development program is to produce a complete spectrometer for the 12-m telescope to be used with eight (or more)-beam receivers.

6. HEMT Amplifier Development and Production

There are two major areas of current development. The first is wideband amplifiers (up to 100% bandwidth) to 35 GHz. These will be used to replace the upconverters in the GB upconverter maser receiver in GB and also to extend the 140-foot frequency coverage to 35 GHz. They will also be used in future 12-m receivers as IF amplifiers where the wide bandwidths will improve continuum observation sensitivity.

The second area of interest is in building higher frequency amplifiers starting at 43 GHz for the VLBA receivers. Here the availability of suitable HEMT's is a problem and a considerable amount of time is spent evaluating HEMT's from various manufacturers. Unfortunately, only a few of these sources are in a position to supply devices commercially.

As well as new development, there is some considerable effort in building amplifiers that were designed some time ago and are being used in VLBA and VLA receivers and as IF amplifiers on the 12-m telescope. These include 327 and 600 MHz, and 1.5, 8.4, 15 and 22 GHz amplifiers. For example, a total of sixty-one 22-25 GHz amplifiers had been built for the VLA and VLBA receivers by the end of 1988.

7. Voyager/VLBA Receiver Development

The construction of thirty X-band receivers for installation on the VLA for the Voyager/Neptune project has been recently completed. By 1991, 55 dual polarization receivers for the VLBA project will be built within

the CDL. These receivers will be for 8.4, 15, 22, and 43 GHz; also included will be the ambient temperature 300/600 MHz receivers. The receivers for 1.2-1.8, 2.2, and 5 GHz are being built in Green Bank.

8. Proposals for Externally-Funded Projects

In recent years support for development of new radio astronomy instrumentation has suffered due to the tight NRAO operations budget. In 1988 there was a spate of proposal writing that was driven to some extent by the desire to get a wider funding base for research and development at NRAO. Several of the proposals were for space projects, an area that we should be looking at for the future.

A summary of the proposals in which CDL personnel were involved follows:

a. "Center for Ultra-Low-Noise Electronics" Proposal to NSF, January 1988 - This UVA proposal was for a "science and technology research center." A major part of this proposal was a subcontract with NRAO to cover salaries of three senior persons and services provided by NRAO.

b. "Low-Noise Amplifiers for Space VLBI" Proposal to NASA Astrophysics Division, August 1988.

c. "The Orbiting Submillimeter Telescope" Proposal to NASA, Office of Space Science and Applications, September 1988.

d. "Ground Support of the RADIOASTRON Space VLBI Mission" Proposal to NASA Astrophysics Division, September 1988.

e. "High Resolution Imaging Spectroscopy at Terahertz Frequencies" Proposal to NASA, Office of Space Science and Applications, November 1988.

Proposals a, c, and e were in response to announcements of opportunity while proposals b and d were NRAO initiatives in response to a perceived interest by NASA.

9. Sale of Amplifiers for Scientific Research

There has been significant outside interest in many of our amplifiers. Other organizations have copied our lower frequency designs but although some have attempted to duplicate our 22-25 GHz (K-band) amplifiers, no group has succeeded. This is due in part to the lack of specialized equipment and personnel with experience in techniques necessary for the successful construction and testing of the amplifiers.

Since we received some indication of interest in purchasing 22-25 GHz amplifiers from NRAO by other organizations involved in building instrumentation for radio astronomy and earth science applications, we obtained permission in 1988 from the NSF to fill orders for small numbers

of amplifiers for the above applications. This only applies as long as there is no commercial organization willing to market amplifiers with similar specifications. So far we have sold three amplifiers (1989 cost $17,766 each). This price includes materials, manpower and overhead; a proportion of development and depreciation costs is also included. Two units went to NRL and one unit went to Toronto Iron Works (TIW) (supplied to Radio Research Station, Kashima, Japan). We have an order to ship one unit to NRO (Japan) and are attempting to get an export license. We have provided quotes for additional amplifiers to NRO, Jodrell Bank, University of Pennsylvania, and TIW.

We also have potential buyers for our broadband 8-18 GHz, 33 GHz and 43 GHz amplifiers when the design work is completed.

Our policy regarding this sort of work is only to consider components that are essentially identical to ones that are already being built in significant numbers for NRAO projects. For example, the sale of three amplifiers out of a total of 100 has an insignificant impact on work for NRAO projects. At the moment the paperwork associated with obtaining export licenses is a problem; hopefully, this will become routine after the first unit is shipped to Japan from NRAO.

The proceeds from the 1988 sale of three amplifiers at $14,677 each were distributed as follows:

$31,890	- credited to the CDL operating budget
12,141	- credited to the CDL research equipment budget
$44,031	

10. CDL Budget for 1989

The CDL operations budget for 1989 is as follows:

Salaries	523
Materials & Supplies	41
Travel	17
Building Rent	120
Communications/Utilities	5
Device Revenue	<26>
TOTAL	$680k

The tentative CDL Research Equipment (RE) budget for 1989 is $120k assuming a total NRAO RE budget of $690k. The probable breakdown is as follows:

Miscellaneous Projects and Test Equipment	$10k
Millimeter-Wave Development	30
Contract with UVA for SIS Devices	80
HEMT Amplifier Development	supported by amplifier sales

Additional support comes from all NRAO site budgets for work being conducted within the CDL which results in new instrumentation at sites. For example, during 1989 -

1) VLA support for 22 GHz amplifiers - $10k

2) Tucson support for AOS development - $15k

3) VLBA receiver support from VLBA budget covers the salaries of three persons within the CDL and materials as needed.