

NATIONAL RADIO ASTRONOMY OBSERVATORY
Charlottesville, Virginia

January 23, 1997

MEMORANDUM

To: R. Brown

From: J. Payne

Subject: MMA Receivers

INTRODUCTION

Darrel and I met in Tucson with the idea of drafting a very basic plan for the MMA receiver development. In this plan, we make the following assumptions:

- 1) By the year 2000, we wish to have a prototype antenna with a 230 GHz receiver with a LO system suitable for evaluation of two antennas connected as an interferometer. The second antenna could be identical to the prototype or, as an alternative, the 12-m antenna on Kitt Peak.
- 2) At the same time, we may need a holography receiver for measuring the prototype antenna. This receiver would probably be at 38 GHz aimed at LES 9, but we may employ other frequencies or methods, perhaps a maser line at 86 GHz. The point to be made here is that if we take delivery of two antennas simultaneously, then, together with the correlator, we would be able to use the pair to perform holography using astronomical objects. Darrel and I both feel that a stand-alone measurement using a satellite, followed by a measurement using radio sources, would be the way to go.
- 3) We will also need at that time a 30 GHz receiver, along with its optical switch for the testing and evaluation of the phase calibration technique using the fast switching concept.
- 4) Note that, although not in the receiver development plan, we assume that a correlator suitable for the initial tests will be available.
- 5) This plan addresses the design, development and construction of the 40 receiver systems needed for the final array and assumes that we start almost immediately on the buildup of the workforce needed to accomplish this.
- 6) An intermediate step that we believe is necessary to meet the schedule of a test array of four antennas by 2003 is to equip these four antennas with 67-350 GHz receivers that will almost certainly not be the final MMA receivers and may even be simple double-sideband receivers although we would obviously attempt to make the packaging such that an upgrade to the final design would be possible.

TASKS

We believe that in order to have a chance of meeting the very ambitious schedule that we have to immediately start on the following tasks:

- 1) A 230 GHz Receiver: This receiver would be a simple dual-channel receiver using similar technology to that used at the 12-m telescope now. It is conceivable that similar inserts to the existing system would be used. If the system is made single sideband, it would use the optical system that is in use at present on the 12-m. One or two of these systems would be built according to the decision as to use the 12-m as one of the initial pair or a second antenna.
- 2) Optics Design: It is obvious that this step is urgently needed before any receiver design work can be attempted. We are very weak in the area of feed design, and this problem needs to be addressed.
- 3) Holography Receiver: This will be needed in the year 2000 for the measuring and setting of the first antenna with the caveats mentioned above. We need to be at least planning the best strategy for these measurements now.
- 4) 30 GHz Receiver: This receiver will be needed on the prototype array to prove and refine the phase calibration principle. Along with the receiver will be needed the switching mirror to connect the 30 GHz receiver to the optical chain.
- 5) Final Receiver: We identify this receiver as being the final receiver being equipped initially with the necessary components to cover the 67-350 GHz bands but, if possible, with space for the later addition of the sub-millimeter bands. Thought on the packaging and optical arrangement of this receiver should begin now.
- 6) LO Development: We anticipate that the initial interferometric testing at 230 GHz will take place with a conventional LO system similar to that used at present on the 12-m. From our VLBI experience at 230 GHz, we know that the present system is just good enough and with some modest effort could probably be improved. In spite of this, it is clear that serious effort must start immediately on the final LO system. The proposed laser system holds such promise for savings in cost and ease of maintenance that we believe that a major effort should be mounted now on this approach and, at the same time, an effort on an improved conventional system should proceed.
- 7) Cryogenics: The decision made on the nature of the 4 K system for the array will have a tremendous impact for years to come. We believe that the initial two antennas will need to be equipped with J-T systems that will very likely be identical to the systems in use at the 12-m today. It is a top priority that a highly competent person be assigned to evaluating the various options open to us and, if needed, purchase and evaluate any possibly suitable commercial systems. This should take place immediately.
- 8) Subreflector: Although not a part of the receiver systems, the design and construction of a nutating subreflector would likely fall on the Tucson people and the decision as to whether such a device is needed should be made as soon as possible.

ESTIMATES

The attached table shows very preliminary estimates of manpower needed to support the receiver development until the year 2001. The estimate does not include the CDL staff, of course, and the machine shop effort has not been included. All that is estimated is the engineering effort needed. With a bit of smoothing out, the following figures seem to be about right.

| | |
|------------------------|--|
| EE - | 1.5 in 1997, building up to 4 in 2000 |
| Programmer - | 0 in 1997, building up to 1.5 in 2000 |
| Technicians - | 0 in 1997, building up to 4 in 2000. |
| Mechanical engineers - | 0.5 building up to 2 in 1999-uncertain after that. |

These figures are very soft. So many things could change them. For instance, a build/buy decision on the cryogenics could greatly influence the final numbers.

| PROJECT | | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|----|------|------|------|------|------|
| 230 GHz dual-channel evaluation receiver | EE | 6 | 24 | 24 | 12 | 12 |
| | T | 0 | 24 | 24 | 12 | 12 |
| | P | 0 | 2 | 10 | 3 | 3 |
| | ME | 6 | 6 | 3 | - | - |
| holography receiver | EE | 0 | 6 | 6 | 6 | 2 |
| | T | 0 | 0 | 4 | 6 | 2 |
| | P | 0 | 0 | 6 | 6 | 2 |
| | ME | 0 | 3 | 3 | - | - |
| optics design | EE | 6 | 6 | 6 | 6 | 3 |
| | T | - | - | - | - | - |
| | P | - | - | - | - | - |
| | ME | - | 6 | 3 | 3 | - |
| 30 GHz receiver | EE | - | 3 | 3 | 3 | - |
| | T | - | - | 3 | 2 | - |
| | P | - | - | - | - | - |
| | ME | - | 3 | 3 | - | - |
| laser LO | EE | 6 | 12 | 12 | 12 | 12 |
| | T | 2 | 6 | 6 | 6 | 6 |
| | P | - | - | - | - | - |
| | ME | - | 3 | 3 | - | - |
| cryogenics | EE | - | 12 | 12 | 12 | 12 |
| | T | - | 6 | 6 | 12 | 12 |
| | P | - | - | - | - | - |
| | ME | - | - | - | - | - |
| final 65-350 GHz | EE | - | 24 | 24 | 24 | 24 |
| | T | - | - | - | 24 | 36 |
| | P | - | - | - | 12 | 12 |
| | ME | - | 3 | 12 | 3 | 3 |
| EE Man-Months | | 18 | 87 | 87 | 73 | 70 |
| Programmer Man-Months | | 0 | 2 | 16 | 18 | 6 |
| Technician Man-Months | | 2 | 36 | 43 | 62 | 72 |
| ME Man-Months | | 6 | 24 | 27 | 6 | 3 |

c: D. Emerson
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