

**NATIONAL RADIO ASTRONOMY OBSERVATORY**  
**Tucson, Arizona**

**INTEROFFICE MEMO**

**TO:** All Tucson Engineers  
**FROM:** John Payne  
**DATE:** December 7, 1998  
**SUBJECT:** MMA Receiver Development

This is an initial attempt at defining the program of work that needs to be undertaken for the receivers to be used on the first two antennas for the MMA. This is a slight expansion of what is available in the MMA project book, and here I assign tasks and we can use this as a basis for discussion. G. Moorey will be arriving in January, and he will be in charge of the building of these first two receivers, known as evaluation receivers and their integration into the antenna. However, it seems wise to start on the longer lead time items now and at least have a baseline plan to alter and criticize.

**General Description of Evaluation Receivers**

As described in the Project Book the receivers will cover the following bands:

30-40 GHz-HFET Amplifier

86-115 GHz-SIS or HFET-possibly both

210-270 GHz-SIS

*within comparison  
- oil unit - not sure of 4-6 GHz performance - may be microphonic*

All bands are dual linear polarization.

*Is this agreed?*

There is one important consideration and that is that the receivers will be used for continuum measurements with a nutating subreflector, so it is important that in the continuum mode, the noise is close to theoretical at the low switching frequency, less than 10Hz, of the nutator.

Following are some notes on the various components of the Evaluation Receivers together with some tests that need to be done in the future. Some of these tests will help in improving the performance of the 12m telescope. The phase stability tests will lead to improved spectral purity and should benefit VLBI observations. The experiments regarding the excess continuum noise will hopefully point the way to improvements on the receivers at the 12m.

## Optics

The final f number of the Cassegrain optical system now stands at 6.78. We should take this number as the baseline number and assume that it will not change with antenna diameter. James Lamb is figuring out the optics at present. He is working on two designs. One is a conventional system in the focal plane, the other a system that uses an external mirror to shape the illumination so as to increase the gain. He will deliver a report to us in the next month with details of both design and performance of both systems. A crucial detail will be the extra noise added by the external reflector, and this may well be frequency dependant. We need a plan to settle this question, and it could be that we will want to evaluate both systems on the prototype antenna. There are many other issues to be decided here. I list them as well as I can together with options: who should make the various decisions and by when, if appropriate.

? 1) James designs the optics. The feeds and lenses. *specify w/ly types & f12/22*

2) Where are the feeds made? I would suggest that the Green Bank shop fabricate the 30-50 GHz and the 86-115 GHz feeds. They have done a great job on the existing 86-115 GHz feeds. Other options are: The Owens Valley shop or the U of A shop. We need to look at the electroforming process and if it is needed. Several organizations have demonstrated the manufacture of corrugated feed horns up to 600 GHz by direct machining, and we may decide that this is the route to go. *who?*

3) We need a fully instrumented antenna range. The options as I see it are as follows.

- a) We resurrect the range in Tucson that James built several years ago.
- b) We build a new one either in Tucson or OVRO.
- c) We instrument the new antenna range in Green Bank for mm wavelengths. *Yes*

In view of the increased interest in operating the Green Bank Telescope at high frequencies this might be a good option. We need a decision on this in the next couple of months. In order to make the decision we need to know the cost of the commercial equipment along with how high in frequency it is possible to go together with an estimate of how much it would cost to extend the frequency range.

A major question that needs to be decided is the need to measure phase on the receiver feeds. This will certainly be needed on the holography receiver and may be important for the MMA in the mosaicing mode of measurement. To get the maximum range of spatial frequencies from the MMA we will need to use data which in effect uses the extreme left of one antenna with the extreme right of another. Uncalibrated phase patterns at the edge of each antenna could give rise to problems.

I'd suggest that Darrel, myself, Phil Jewell, James and Peter meet soon to make a decision on the antenna range. We should aim for a decision by the end of January. Another point to be made is that we are proposing to operate all frequency bands off axis. Although the calculations indicate distortions that are so small as to be neglected these should be confirmed by moving the beam of each receiver on axis with a simple mirror system and comparing on and off axis performance.

### **Polarization Diplexer**

Ed Wollack and Jeff Kingsley have produced a prototype that operates over 75-110 GHz but it needs some refinement. Ed has left NRAO but has indicated his willingness to continue working on it. We need to establish a timetable for the completion and test of this first waveguide OMT and an extension of its range to 210 - 270 GHz. We will need mechanical engineering help from Jeff's group for this. I will work with Ed and Jeff to get a schedule worked out.

### **IF Amplifiers**

The IF will be 4-6 GHz and the cooled amplifiers will be supplied by the CDL. I will work on a schedule for the delivery of those amplifiers with John Webber.

### **Mixers and 30-40 GHz Amplifiers**

The 86-115 GHz mixers will be the same as we use now- adjustable back short devices. The 30-40 GHz amplifiers will be HFET provided by the CDL. The 210-270 GHz mixers will be fixed tuned similar to those we now use.

### **Isolators**

Pamteck makes suitable cooled isolators. Antonio should get quotes on these immediately.

### **Bias tees**

These will be supplied by the CDL.

✓  
4-wire? 6-wire? something else?

### **Windows**

These will be supplied by the CDL.

OK 3mm & shorter - somebody else 30-40 GHz  
OK? BMA?

### **IR Filters**

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Work on suitable filters will be done in Tucson by Larry.

### Dewar

The dewar needs some discussion. It should be planned to accommodate all the final bands for the MMA and should be available for heat load tests with all the apertures for the final bands open. My inclination is to make it a round SS dewar similar to that used on the 12m but there are many other options that need looking at. This is a crucial issue that needs a separate detailed program of work. I will organize this in the near future.

**The 4k refrigerator** — *call it 3.5K (2.5K if possible)*

This is another crucial issue that should involve Larry, John, Graham and Harry. It would be nice if the refrigerator used on the evaluation receivers is the same as that used on the final receivers but this unlikely as the final refrigerator selection process will extend well into the construction of the first receivers. Harry has been looking into this and we need a decision within the next couple of months. The decision boils down to two options: use the existing NRAO design or buy a commercial system. I will try to organize things so that a decision gets made.

### Circuitry

Our present receivers on the 12m suffer from excess low frequency noise on the detected IF output. Things seem worse than several years ago in this respect. We need to set up a test dewar and make careful measurements on this effect. Hopefully what is learned may be applied to the 12m system. Andrea is an ideal person to investigate this and come up with a solution as the problem is almost certainly in the bias for the SIS junctions. He should work with Graham and Harry on this.

### LO System

It would be ideal if the evaluation receivers could use the same LO system as the final MMA receivers. This is too big a risk to take so we must assume that we use a similar system to that used on the 12m today. Antonio has done a great job at figuring out the power levels etc and we need to order parts now as delivery is long, particularly on the triplers from Millitech. For the 30-40 GHz band we can use commercial parts and this can wait until Graham gets here. For the 86-115 GHz band we will use a Gunn. For the 210-270 GHz band we will use one 70-90 GHz InP Gunn: divide the power (100mW) and feed two fixed tuned Millitech triplers.

We can proceed with the necessary orders immediately. Antonio should order the Millitech triplers and the waveguide components. I will get in touch with John Carlstrom ( I

could not catch him in Chicago) and find out about the Gunns.

### **Spectral Purity**

This is a vital issue that needs work and is applicable to the 12m VLBI work. Bob Freund is the local expert on this and will need to be heavily involved. Also we will need clean mm sources to demonstrate the photonic calibration scheme. I would suggest the following course of action:

- 1) I get together with Bob and lay out a plan that satisfies the testing of the photonic calibration scheme, the testing of the spectral purity of the LO system for the evaluation receivers and also make sure that we have the components needed for a systems test for the first interferometer. In fact there is likely to be considerable overlap in terms of equipment between testing and the interferometer system. *duplication?*
- 2) Bob places orders for the necessary test equipment. We should do this as soon as possible and not stint on equipment.

### **Things to do immediately**

- 1) Antonio orders LO components.
- 2) Antonio orders general lab equipment needed. He should consult with the various engineers but get the orders placed as quickly as possible.
- 3) Antonio consults with Graham and Harry about receiver test equipment and orders it.
- 4) John gets together with Bob and generates a plan so Bob can order the necessary test equipment.
- 5) John gets in touch with John Carlstrom and sees about Gunn oscillators. If he won't sell them will he give us the design?
- 6) John gets the interested parties together and makes a decision on refrigerators.
- 7) John checks with John Webber on the CDL components.
- 8) John coordinates the OMT work.
- 9) John coordinates the dewar decision.

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10) John makes sure that the antenna range decision gets made soon.

I have probably missed a lot out of this first attempt but its a start.

JP/jm

cc: Robert Brown  
Darrel Emerson  
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Peter Napier