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NATIONAL RADIO ASTRONOMY OBSERVATORY
Charlottesville, Virginia

March 6, 1997

MEMORANDUM

To: R. Brown

From: J. Payne J.P.

Subject: Laser LO System for the MMA

INTRODUCTION

On 12 June 1996, I wrote a memo outlining a possible LO system for the MMA using optical fiber to distribute the LO to the 40 antennas from a central location. The main advantages of such a system are cost savings and a more easily accessible and maintainable system. There are, of course, many potential pitfalls to such a new system. A few months ago we decided to address the first of these, namely the feasibility of phase locking the beat note between two external cavity lasers to a high spectral purity microwave standard. In order to do this, we rented two external cavity lasers from the company New Focus and successfully demonstrated this crucial phase locking performance. We have reviewed the literature, attended a "Microwave Photonics" conference, and now feel ready to proceed to the next stage of the feasibility study for the project. At this point a rather substantial financial investment will be required. The purpose of this memo is to give a brief summary of the problems that have been considered and likely solutions to these problems. It is not the purpose of the memo to go into detailed implementations of the proposed system on the MMA; there are intense ongoing discussions and a variety of methods of implementation. It is considered to be more important at this time to focus on a demonstration of a system that will answer all reasonable doubts on a system of this type.

CONSIDERATIONS

What follows is a brief summary of the various points that have been considered and a course of action for the next year.

Wavelength of Operation:

We have chosen the popular 1550 micron window for the operating wavelength for the following reasons:

1) Commercial fiber has the least loss and is least dispersive at this wavelength.

2) As mentioned in the previous memo, this has led to an impressive array of easily available commercial products driven by a booming market. Prices are falling and the range of components is expanding.

Type of Laser:

Given the choice of wavelength above, we have considered two types of laser:

1) An external cavity tuneable diode laser.

2) An Erbium doped fiber laser.

Various considerations have led to the choice of the external cavity laser. Although the Erbium doped fiber laser has a higher power output and greater spectral purity, it is more expensive and, we believe, may be more difficult to phase lock. Given our good experience with the phase locking of the external cavity laser, we have decided to stay with this type — at least during the initial stages of the project.

Polarization Considerations:

This is a complex subject that we have debated for some time. In the laboratory it is simple to generate two linear polarizations from the two lasers, combine them using polarization maintaining fiber, and then inject them, at an easily defined and controlled polarization angle into the photo-detector to obtain the desired microwave signal. In the proposed application, however, the two signals will be transmitted over several Km of fiber — preferably inexpensive single mode fiber — and the control of the state of polarization at the receiving end with the inevitable bends is a matter of some debate. Without going into all the details, we believe that this is a fairly easily solved problem but a demonstration over a length of fiber comparable to the lengths that will be used in practice is considered important at this stage.

Noise Considerations:

At the start of the project, this was a major concern as the proposed system, when used with our existing mixers, will add additional noise that may be significant. However, the proposed devices for the MMA will be balanced mixers that will give noise rejection of at least 10 dB. Moreover, the mixers will likely use two junctions rather than the four or six used at present, thus reducing the LO power requirement with a consequent reduction in noise originating on the LO.

The Photo-Detector:

Obviously, this is one of the key items in the whole system. We are working on a collaborative venture with several organizations and are optimistic that suitable devices can be built. We have yet to write a formal agreement with any organization and are working on achieving this. We have established a good relationship with a group at UCLA and this group seems the most likely candidate at present.

Work Plan:

We plan to go ahead, assuming that the idea is going to work. The work for the next year is going to be focused on removing any doubts that we may have and demonstrating a prototype system, including propagation through several Km of fiber.

In Charlottesville Tony will work with one or more external groups on the design of a waveguide mounted photo-detector. At present we have three potential collaborators: New Focus, UC/Santa Barbara, and UCLA. Of these three, the most likely is UCLA and we are in the process of very detailed discussions with them. The first photo-detector will cover the 70-115 GHz range and the second the 200-300 GHz range. We hope to let a contract with them within the next month.

In Tucson we intend to build up a prototype transmission system. This will involve the purchase of two tuneable lasers from New Focus, two 60-GHz photo-detectors, several Km of fiber, and all the components needed to demonstrate the transmission of a 60-GHz phase-locked local oscillator signal in a manner as close as possible to the final system. This will require an investment of about $70k. I will work on this with Bill Shillue and Darrel, and a demonstration should be possible in about six months from the time we place the first orders. At the end of this development, we will be in a position to take a 70-115 GHz and a 200-300 GHz photo-detector and demonstrate the millimeter-wave capabilities in a real receiver situation. If, by this time, the development of the image-separating, balanced mixer system has progressed well, it may well be possible to incorporate the laser LO system into the prototype MMA receiver.

c: D. Emerson
A. R. Kerr
B. Shillue
J. Webber