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Notes on Meeting of the MMA Systems WG, April 26, 1995

(1) Channelization and IF Transmission

About 2/3 of the meeting was devoted to discussion of points arising from the memo of April 18 on Channelization and IF Transmission that I circulated. One opinion was that we should be cautious with regard to expansion of bandwidth beyond the original specification for the array, and take care not to unduly raise expectations of astronomers. However, the general view seemed to be that at this point it is appropriate to look at how far the state of the art will let us go, and that sensitivity, and hence in certain cases bandwidth, is a parameter to maximize.

The greater transmission bandwidth required for digital transmission relative to analog (i.e. a factor of four) leads to a choice of analog transmission for continuum observation where the widest bandwidth is required. For observations of weak spectral lines the spectral fidelity (i.e. the ability to separate the line and continuum components) is important and is the main concern with respect to bandpass smoothness. Analog transmission will probably be satisfactory in this case, but until we have made some tests of the analog response we should not entirely rule out the possibility of using digital transmission for a narrow IF band (say, about 2 GHz) for the spectral line system. The ability to make simultaneous line and continuum observations is important, and essentially precludes the possibility discussed in section (5) of the April 18 memo in which two fibers with transmitters and receivers for about 10 GHz bandwidth could be used either for broadband analog transmission or narrower band digital transmission, but not both at the same time. Thus digital transmission for the spectral line observations would require separate transmission systems for the analog and digital signals. If analog transmission is satisfactory for spectral line observations only the two 10 GHz channels would be necessary and thus cost and development effort would be saved. Steve Padin offered to take a look at the the frequency response of the analog optical fiber system at Owens Valley, including intermodulation effects. These points are sufficiently important that they should also be addressed as part of the development phase of the MMA. The degree to which unwanted ripples in the response can be suppressed using isolators etc. should be investigated. Variations of gain with frequency that are too slow to be confused with line structure relatively unimportant. In the notes of the meeting of March 23 it was concluded that 40 dB was a desirable goal for spectral fidelity of the full array: for an individual fiber the requirement is reduced by something like a factor of root(40). It was also pointed out that the stability of any ripples, rather than minimization of the ripples, is the fundamental requirement. A backup plan for use of digital transmission for spectral line data should be kept in mind at this point. The additional cost of 8 Gb/s of transmission channel per antenna plus some complication in the LO system, etc. would, as a very rough estimate, increase the overall cost by something like $0.5M to $1M.

An interesting and effective method of removing an unwanted sideband at a frequency conversion is discussed by Barry Clark in his memo of April 21, in response to mine of April 18. This could reduce the filtering and frequency conversion required in Fig. 3 of my memo. It could also be used to eliminate one sideband of the SIS mixer response. Tony Kerr is looking into the possibility of making a sideband-separating mixer for the SIS front ends, using two SIS junctions on a single chip. This would provide 10 dB or more of isolation between the sidebands, enough to separate the noise, and greater isolation for the signal component could be obtained by quadrature phase switching or by using Barry's LO offset scheme. For maximum flexibility it was decided that it is very desirable to have independent fringe rotation for each of the four channels in my Fig. 3. In most implementations, fringe rotation requires a phase-locked oscillator which is offset in the loop by the required fringe frequency. This is most cheaply done on an oscillator that is otherwise fixed in frequency, such as the 6 GHz oscillator in the scheme of my memo. Note that one could easily incorporate an offset frequency for Barry's scheme at the same point as the fringe rotation.

The question of whether we need to be able to use both sidebands of the SIS mixer, separating the outputs after correlation, needs some further thought. Bob Brown concluded that access to both sidebands is essential in a memo dated Sept 24 1993, in which he summarized conclusions from the MMA Advisory meeting of that year. At that time the IF bandwidth of the SIS mixers being considered was 2 GHz. Since a banwidth of 4 GHz to 8 GHz now looks possible, the necessity for both sidebands is somewhat lessened. If both sidebands, with separation at the correlator output, are required, then fringe rotation must be applied at the first LO as well as at a later LO in each channel. This somewhat complicates the LO system, but is not a severe problem. The LO scheme needs some further thought which, I will try to give it.

(2) The Correlator

There was very little discussion of the correlator. Ray Escoffier has undertaken to provide a some more detailed thoughts on the correlator scheme outlined in section (3) of the March 20 meeting notes, and we will discuss them at our next meeting.

(3) Polarization

On the choice between circular and linear polarization, no-one in the group expressed a strong opinion. It seemed that the general preference was for the most straightforward system technically, thus minimizing the use of quasi-optical parts which add some degree of loss as well as requiring mechanical adjustment. It remains largely a choice for the front-end and antenna groups to work out with the astronomers.

(4) Calibration

A switched noise source is required to determine the gain of the receiving channels. Solid state noise sources are available up to over 100 GHz, but not as high as 300 GHz. A chopper wheel can be used in the optical path to the feed to introduce a periodic increases in the noise, but the amount introduced depends upon the difference between the noise temperatures of the lossy wheel material and the sky, and thus is not constant. An independent measurement of the sky temperature would be needed. It is also possible that noise from a source at a lower band could be frequency converted to a higher one, or that a frequency multiplier driven by a noise waveform could produce broadband, high-frequency noise. Some further development may be needed.

The question of whether or not an ALC loop should be included to hold constant the signal level at the sampler input also arose during this discussion. Unlike the VLA, the Hat Creek array does not use ALC, but the sampler levels can be set on demand by a control computer which monitors the power level at the sampler. Both schemes may have advantages under different conditions, so possibly both should be included. Further discussion is required.

Following the meeting, Durga pointed out that we should also consider the possible benefits of using a pulse calibration scheme of the type used in VLBI. At present such systems do not operate above about 40 GHz, but Rich Bradley at the NRAO CDL is looking into the possibility of extending the range to millimeter wavelengths using resonant tunnel diodes.

(5) Total Power Observations

Total power measurements are required to help fill in the low spacial frequencies, especially in mosaicing. The only satisfactory way to remove the component of atmospheric emission is by beam switching on the sky. There was some discussion on whether sufficient beam throw could be achieved with a tilting mirror and whether beam switching by pointing the whole antenna could be performed fast enough. Switching at no less than 1 Hz is desirable to take out atmospheric effects and it was mentioned that one gains considerably in effectiveness in going from 1 Hz to 5 Hz.

I checked the antenna situation with Peter Napier who told me that a goal for the antenna is to be able to move between a source and a calibrator 2 degrees away, and also allow time for the pointing to settle, in one second. This will enable a minimum cycle time of 6 sec for observation of a source and calibrator. This would not be fast enough for beam switching for total power. However, the antenna group are also looking into the provision of subreflector nutation with a throw of 2 to 3 beamwidths at 30 GHz and a nutation frequency of several Hertz. The antenna group are assuming that when moving to a calibrator the observing frequency may be required to switch to the 30 GHz band for maximum sensitivity, and then back to the band of interest when back on the source under investigation. Changing between frequency bands, including settling time for phase locked loops etc. must be less than one second.

The number of antennas that are required in the total power observations was also mentioned. Some thoughts on this can be found on MMA memo 107.

(6) Next Meeting

The next meeting will be Wednesday May 17, at 4 pm Eastern time. Note that this is one hour later than the last meeting. The call-in number is 804-984-0622, as before. The correlator will be the principal topic.