VLA SCIENTIFIC MEMORANDUM 121

Use of the Multichannel (Spectral Line) System for Continuum Observations with the VLA.

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Although most of the planning of the VLA multi-channel correlator system has thus far involved its use for spectral line work, it is quite likely that an equal amount of useful science will be generated by the system's application to continuum observations. For this reason it is important that the scientific requirements of the relevant continuum projects be carefully considered in the design of this system. In this memo I will try to outline these requirements and give examples of some of the types of experiments which would be done with the system.

The primary reason for using the multi-channel system for continuum work is to allow high sensitivity observations over a large field of view by reducing the effects of finite bandwidth (or delay beam). This subject has recently been discussed by D'Addario (1975). Examples of experiments with these requirements are as follows,

1. Determination log N - log S

2. Determination of the flux density, angular size relation for extragalactic sources.

Both of these experiments are classical radio astronomy problems which are relevant to cosmology especially at very low flux densities. Both experiments are also extremely important to the interpretation of other VLA experiments since they provide an estimate of the expected contribution of random background sources to any observation.

3. Determination of the radio galaxy luminosity function in clusters of galaxies.

4. High resolution observations of nearby galaxies.

Both of these experiments have wide spread importance to our general understanding of the radio properties of galaxies and rich clusters and certainly will be among the first experiments proposed for the VLA.

5. High resolution mapping of compact structures contained within low surface brightness radio galaxies, supernova remnants or HII regions.

High resolution mapping of radio galaxies such as Cygnus A and 3C 83.1 are of extreme importance to the physics of extragalactic sources. However many of the prime sources are too large for full mapping in the A configuration and thus could not be observed at full sensitivity and resolution without the multi-channel system. Similar work is also important for galactic sources.

6. Observations of radio star activity in nearby star clusters.

The high sensitivity of the VLA could be used most effectively if a large number of stars could be monitored simultaneously producing an n-fold increase in the efficiency of such searches.

7. Studies of transient sources (X-ray, etc.) with initially poorly known positions (± 2' - 15').

Often the most interesting phase of the radio history of transient X-ray outburst are lost because of initially poorly known positions. With a multi-channel system the VLA would be able to monitor the entire

error box of such events at almost full sensitivity. Otherwise, especially when outbursts occur when the VLA is in the A configuration, observations will have to wait days or weeks for refined positions.

The experiments listed above could all be performed with narrower bandwidths or by repointing the VLA to sufficiently many positions in the area of interest. However, since all of these experiments are sensitivity limited, these procedures effectively reduce the VLA sensitivity and make some of the projects impossible in reasonable periods of time.

The variety and significance of the experiments described should emphasize the necessity for the VLA continuum system to deal with the delay beam problems. Unfortunately as shown by D'Addario (1975) this would require channels with bandwidths no wider than 1.7 MHz for the A configuration at 1400 MHz. Even this specification does not completely eliminate the problem; however, it would require 240 such channels per baseline to correlate the full 100 MHz bandwidth and all four polarization channels. Clearly such a system is quite far beyond the possibilities presently being considered. The much modest system presently under consideration with four independent correlator banks each with 64 channels over a bandwidth of 3.125 MHz (4 I.F. channels, 11232 multipliers) is potentially quite useful, but would need to be somewhat flexible to make up for some of its limitations. A similar system with, say, half the total number of correlators proposed above would be of use for some experiments but is really inadequate for the full VLA.

The 4x (64 channel, 3.125 MHz) system must be flexible in the polarizations, bandwidths and number of telescopes which it can handle while using its switching rate and all of its correlators to full advantage. Several examples of common configurations which might be used are given in Table 1. Operation with all four polarization channels (RR, LL, RL, LR) or with only the parallel hands (RR, LL) is an important requirement. Also operation using a subset of the full array with a resulting narrower channel bandwidth should also be possible. Such a mode would be very useful either in bad weather or for special combinations of U, V coverage and field of view.

Table 1 summarizes examples of some configurations which should be possible.

Configuration	Number of Telescopes	Polarizations	MHz Channel Bandwidth	# of Channels per Polarization	Total Bandwidth
1	27	RR, LL	6.25	16	100
2	27	RR	6.25	32	200
3	27	RR, LL	1.56	32	50
4	27	RR, LL, RL, LR	3.125	16	50
5	27	RR, LL, RL, LR	12.5	8	100
6	27	RR, LL, RL, LR	0.781	32	25
7	19	RR, LL	1.56	32	100
8	13	RR, LL, RL, LR	1.56	32	100

Of these eight possibilities configuration 2 is the least useful.

In summary, the multi-channel spectral line system should be of considerable importance to continuum work. However, the 4x (64 channel, 3.125 MHz) system is of minimal capacity to handle the continuum problems

and must be designed with the continuum work in mind in order to be particularly useful.

D'Addario, L. R. 1975, VLA Scientific Memorandum 120