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THE VLA WIDEBAND (70 MHz) SYSTEM

VLA Test Memo No. 230

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SUMMARY

We recommend that further attempts to use the 70 MHz wideband modification to the VLA be abandoned. We note that although the modifications to the hardware did not lead to a reliable improvement in the performance of the VLA, the associated modifications to the online software did increase the SNR by about 8% and reduced the level of closure errors.

INTRODUCTION

In 1996 D. Bagri, building on an earlier suggestion by B. Clark (VLA Electronics Memo #148, 1975) proposed a system to (almost) double the VLA continuum bandwidth (VLA Electronics Memo #227). The essence of the proposal was to replace the current 50 MHz quadrature networks in the samplers by networks at 100 MHz, and combining the four multiplier products in such a way as to produce full complex correlation while sampling at the 100 MHz rate. Bagri identified the hardware and software changes which would be required.

In 1997 Bagri (VLA Test Memo #206) urged that implementation of the online software to support full complex correlation should be undertaken, since to do so would offer an immediate gain in SNR. Subsequently Bagri (1998:VLA Test Memo #210) reported that in tests the anticipated improvement of 8% was achieved, and that in addition the average closure errors are considerably smaller than what was previously achieved. Bagri then implemented the hardware on three antennas and the test results were sufficiently encouraging (VLA Test Memo #211) that the decision was made to outfit all VLA systems with the modification. The installation of the hardware on the last antenna was completed late in 2000.

TEST OF THE WIDEBAND SYSTEM

During the period August 2000 - September 2001 a number of tests were made of the system, using observations with the VLA of both blank fields and continuum sources. The results from the principal observing runs have been summarized in a number of reports which are included here as appendices.

The observations in August 2000 and September 2000 had respectively 13 and 21 antennas with the hardware modifications in place. The 70 MHz data were characterized by large closure errors. The heavy editing done in response to the closure errors resulted in maps at 70 MHz which actually had a higher rms than did the comparable 50 MHz maps (Appendix A). The presence of higher closure errors has persisted throughout the entire year of tests.

The observations of January 30, 2001 were made with the entire array. They showed some encouraging progress in that the rms of the integrations on a single correlator were improved at 70 MHz as compared to those at 50 MHz by about the anticipated amount (Appendix B). However, the observations at the wider band required much more extensive flagging,

and the rms in the map of a blank field was much higher than it should have been. In addition there were significant systematic affects in the map of the strong calibrator 3C84, even after some self calibration.

A series of observations were made in March, and it was in the course of these experiments that a serious modulation in the amplitudes on strong sources in IF A was found (Appendix C). The effect is also there in phase. The magnitude of the effect -- up to 20% -- was sufficient to explain the difficulty which K. Sowinski had in determining delays for that IF, and severely limited the dynamic range in maps with strong sources present. However, editing IF A out in its entirety removes any advantage in sensitivity that the wideband system might have offered.

The March data were analyzed in more detail, and the results were summarized in a report on May 4,2001 (Appendix D). It was found that in general the data do integrate down both with time and with number of antennas, and that with heavy editing the remaining data approach the theoretical sensitivity. However three problems were identified which prevent the wideband system being used in a routine fashion. They are the modulation in IF A, the increased noise in IF A, and the general lack of reliability as evidenced by high numbers of closure errors and the need to edit out certain IF's because they contaminate the maps (IF C on antenna 8 is the worst example).

An observation was made in June which showed that the problems with IF A had been considerably reduced, though not eliminated (Appendix E). Unfortunately it is not clear what modifications to the system, if any, led to this improvement. A test of an intermediate bandwidth (60 MHz) proved inconclusive.

During all of this time there was vigorous discussion of why IF A performed poorly, and what could be the cause of the amplitude modulation. A number of tests of past data bases were performed and there are numerous brief e-mails. As an example, one such test explored two suggestions by B. Clark, and involved using a couple of antennas for which the delays had been set to approximately the "delay half-power". Unhappily, because by now the modulation had been much reduced the results were inconclusive (Appendix F).

The most recent test continued the trends found previously (Appendix G). Data taken in the 70 MHz configuration needed more editing. The maps of a blank field reached a lower rms at 70 MHz than at 50 MHz, but the improvement was only about one-half of the expected amount. Maps of fields containing sources of various strengths showed mixed results, but the 70 MHz data produced no clear advantage.

CONCLUSION

After some initial success in which the wideband system was improved, we have reached the point where there is little progress. The system is more fragile that the standard 50 MHz configuration, in that more extensive editing is needed, there is a clear problem in IF C, antenna 8, and there may be intermittent problems with that IF on other antennas. IF A on all antennas has an rms for an individual correlator integration that is 3-5% higher than for other correlators, and there is a coherent amplitude modulation on strong sources and certain antennas of about the same amount. Technical reviews of IF A and IF C, antenna 8 have not been able to isolate the problems. Although the use of the 70 MHz system on blank fields appears to provide some improvement in sensitivity over the 50 MHz system, the factor is not as great as is expected from the ratio of the bandwidths. The performance of the 70 MHz system for fields containing point sources of a range of flux is no better than that of the 50 MHz system.

We conclude that it will be difficult to solve the remaining system problems without using a lot of effort that could otherwise be spent in support of EVLA activities. Without solving these problems, the system is not sufficiently reliable to attract usage by observers, nor is the improvement great enough to offset the risks inherent in using it.

APPENDICES

APPENDIX A : Test of the Wide Bandwidth System on the VLA --
Analysis of Data from August 5 and September 7
December 13,2000

APPENDIX B : Wideband Tests on the VLA January 30,2001
February 14,2001

APPENDIX C : E-mail note of April 3 describing results of
March 22 and March 27, with figures appended
September 18.

APPENDIX D : Summary of Tests on Integration of VLA Data
May 4,2001

APPENDIX E : E-mail notes of June 4 describing results of
observations of June 1. The two original e-mails
have been combined into one report for the purpose
of this appendix.

APPENDIX F : VLA Wideband Tests of June 7,2001
July 3,2001
(VLA Test Memo #225)

APPENDIX G : Test Observations of August 12,2001
September 10,2001