DATA RECORDING AND PROCESSING COMPUTER
FOR THE NRAO 36-FOOT TELESCOPE

Dave Buhl

July 15, 1970

A number of problems have been encountered in using the present data recording system, which can be alleviated by a new processing computer with appropriate inputs and outputs to provide instantaneous display of spectral line observations (see S. Weinreb's memo of June 8, 1970). A major problem is that at present, data cannot be evaluated until it is stacked on the CDC 6400 in downtown Tucson, making it difficult to optimize receiver and telescope operation in less than 2-4 days. This means that considerable observing time is wasted, since most of the spectral line receivers used in Tucson are experimental laboratory mixers and paramps which tend to be very temperamental.

A second problem concerns the compatibility of the tape drive at the 36-foot with the CDC computer downtown and also difficulties in reading tapes on the IBM 360 which have been written by the CDC 6400. A single 7-track drive which is compatible with the Charlottesville IBM 360 tape drives would solve this problem. Some capatibility with the CDC 6400 tape drives would be desirable, however the main consideration should be tapes which can be read in Charlottesville. Preliminary processing of the data could be done at the 36-foot telescope in Tucson and final processing on the IBM 360. A disc storage facility at the 36-foot is necessary to provide a program library, initial data recording, and memory space for initial editing and stacking. This would allow the observer to write data from several different telescope tapes on the disc. The data can be edited and stacked on the disc, and then recorded on tape to provide a permanent record of the reduced data which can be used on any computer. At present some observers have resorted to punching many boxes of cards directly from the unreduced telescope tapes just so they will be able to read the data into their own computers.

A third problem is one that exists at all NRAO telescopes, and that is the absence of any program for computing radial velocities of the earth with respect to the local standard of rest (LSR). As a result most observers run DOPCAL (Written by John Ball) or DOPSET (a modified version written by Mark Gordon and Dick Manchester) on the IBM 360 before an observing run. This means that hundreds of pages of printout listing line frequencies and sources for each half hour during the observing period must be run. A much more efficient system would be to have the computer at the telescope compute the radial velocity and apply the corrections to the laboratory frequency to come up with a synthesizer setting. This could be done either from a position inputed from the keyboard or from the telescope position. The observer would input his molecule rest frequency, multiplier and offset. The computer would then calculate the correct synthesizer frequency.

The same program could also be used to calculate the center velocity of the line profile when the preliminary data reduction is done. This requires the Right Ascension, Declination, Sidereal Time, and Synthesizer Frequency to be recorded on the magnetic tape at the time of observation.

Once the center velocity has been calculated for each scan, they can be stacked with the appropriate shift to line up the radial velocities. Plots and Magnetic Tape Output can then be obtained for the final stack once the observer has determined that he has optimized the choice of scans to be stacked.

The Input and Output requirements are given in Table I. The hardware needed consists of a keyboard input, digital memory scope and plotter, magnetic tape drive and magnetic disc storage. In addition, a line from the DDP 116 is necessary to provide RA, DEC and LST; as well as a line from the synthesizer giving the frequency to be used in the velocity calculation. Other inputs can be entered through sense switches or the keyboard.

In Table II are listed the functions the software programming is expected to perform. Data processing is to be done while the observations are being made so that data recording and data processing are simultaneous functions. Radial velocity calculations will have to be made before observations and during data processing.

This system should be ready as soon as possible as spectral line observations are scheduled for this fall. The hardware interface between the DDP 116 and the Data Computer will be a single line providing LST, RA and DEC serially. The DDP presently outputs the telescope position (RA and DEC) to Nixie indicators on the console. The Synthesizer Frequency interface is presently available in Tucson, but may require some modification for the new computer. The software development can be done in two stages with the Synchronous Detection, Data Recording and Data Processing functions being written first, and then the LSR calculation left until the system is debugged and operating.

Table I. Hardware

Output	Plotter Scope Mag Tape Mag Disc
Input	Keyboard Sense Switches Mag Tape Mag Disc
Data In	100 Channels of Data Scan No. LST RA DEC Line Rest Frequency Synthesizer Frequency Integration Time Source Receiver Cal Temp

Table II. Software

Data Recording

1. Display current scan.
2. Display On - previous OFF.
3. Display Stack of previous On's and Off's.
4. Find EOF and start recording.
5. EOF tape.
6. Calculate synthesize setting and LSR velocity for source using telescope RA and DEC.

Data Processing

1. Dump scans from input tape onto disc starting at scan A and ending at scan B.
2. Display individual scans and specified On-Off's.
3. Stack specified scans from disc and display.
4. Delete specified scans in stack and display.
5. Add specified scans to stack and display.
6. Shift scans in stack to line up radial velocities.
7. Edit stack to maximize S/N.
8. Remove Baseline slope and curvature.
9. Plot out results.
10. Write data stacks from disc onto output tape.

Frequency and LSR Velocity Calculation

1. Input lab rest frequency.
2. Input RA, DEC, VEL from tape and keyboard.
3. Calculate velocity for scans on tape.
4. Stack scans and shift to correct for center velocity differences.
5. Print out center velocity and shifts.