National Radio Astronomy Observatory

Charlottesville, Virginia

Memo No. 15

Spectral Processor

Project 2.625

Specification Meeting

1 December 1982

Preliminaries

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Spectral Processor Meeting

1 December 1982

NRAO/Green Bank

Agenda* (Preliminary):

9:00 - 12:30 Scientific Specification

Overview..........................Dan Stinebring

Scintillation Observations.........Jim Cordes

Spectral Line Observations.........Bob Brown

Searching Techniques...............Marc Damashek

Polarization/Single Pulses.........Joanna Rankin

Timing Observations................Tim Hankins

Dedispersing I.....................Val Boriakoff

Dedispersing II....................Joe Taylor

Discussion

12:30 - 1:30 Lunch

1:30 - 2:30 Engineering Practicalities

Pulsar/Spectral Line Compatibility....Bill Brundage

RFI Excising.........................Rick Fisher

Discussion

2:30 - 5:00 Trade-offs and Bottlenecks in the Design

Discussion

*all presentations 15 minutes

Spectral Processor Meeting Preparatory Notes

The purpose of the meeting is to finalize the scientific specifications of the Spectral Processor (also known as the Pulsar Processor). We also hope to identify and head off any conceptual flaws that are lurking in the current design (cf. Memo 12). Since no hardware has been built and no detailed designs have been made, all of the current specifications and elements of the block-diagram are open for discussion. There has been a broad consensus, however, that the specifications and overall design are close to completion. We, therefore, ask that everyone come to the meeting with a detailed familiarity with Memo 12 and that revisions be suggested in as specific a manner as possible.

In the past month, the idea of using the heart of the Pulsar Processor, the FFT spectrometer, as the main part of a new spectral line backend has been revised and seriously reconsidered. There seem to be scientific and logistical advantages to combining the two projects, but no one has presented in detail the trade-offs involved in such a combination, and no decision on this question has been made. As a discussion starter, the spectral line observers probably want more spectral channels, N, per quadrant than the pulsar observers ($N = 1024$ rather than $N = 256$), which would mean coarser time resolution, $\Delta t = N/f_s$, for the same sampling frequency. Bob Brown will clarify the spectral line wish list at the meeting, and there will be time to discuss the important question of whether these projects should be joined.

Presentations at the meeting should center on how a given class of observations can best be accomplished with the current Processor design. What data flow bottlenecks exist and how might they be circumvented? How do the current specifications limit the sort of observations you would like to make, and can these constraints be lived with? What observational possibilities are we overlooking because we are not used to high-resolution spectra being produced at <100 microsecond intervals? How does the discovery of the millisecond period pulsar affect the current specifications and design?

Listed below are some of the topics that seem least settled and most in need of discussion. This list should only serve as a beginning for discussion. Hopefully, other important items will turn up during the meeting.

1. Dedisperser

How fast will the dedisperser run? Can it keep up with the sampling interval of 50 nanoseconds? Will it be practical to build a 256 channel dedisperser or will frequency merging be necessary before the dedisperser. Curvature of the dispersion sweep limits a linear channel vs. delay relationship to fractional bandwidths such that

$$\frac{f_B}{f_o} < \frac{1}{N}$$

With f_B = 20 MHz and f_o = 300 MHz this limits N to $\lesssim$ 15. How are we going to correct for this curvature?

Would it be useful to sweep the LO in order to slow down the effective dispersion sweep? Or top it altogether, thereby converting a time sequence into a spectrum as was done by McCulloch, Taylor, and Weisberg?

There has been some informal discussion of incorporating the dedispersing in the FFT itself. This does not seem workable to me because the time delays required are typically >> Δt, whereas the maximum delay information available in the computation of one spectrum is Δt. Does this miss the point?

2. Number of channels

N will probably be the most hard-wired of all the system parameters. Is 256 what pulsar observers want? What should N be for spectral line work? What if we have to trade-off time resolution and dynamic range in order to increase N?

3. Dynamic range

The dynamic range specification affects all parts of the design, from the analog anti-aliasing filter, through the choice of windowing function to apply to the time series, to the number of bits to carry at every stage of the FFT. Cordes suggested 40 dB in Memo 14 on the basis of pulsar fluctuations. That example had a $(\Delta f \Delta t)^{1/2} = 81$, however, whereas we will have $\Delta f \Delta t = 1$. This makes his estimate even safer. At the 300 foot with 1° K/Jy and $T_{sys} = 60°$ K, 40 dB of dynamic range would be exceeded by a spike of 6×10^5 Jy in an interval Δt (probably $\geqslant 12.5$ μsec). How far above the expected pulsar dynamic range do we need to go before every saturated spike is considered RFI? We clearly do not know in detail, but it seems that the engineers are more worried about this problem than the scientists.

4. Bandwidth adjustment

Specifications now calls for Δf variable in steps of 1, 3, 10, ... or 1, 2, 4, 8, ... Do we need all 10 binary steps between 78 kHz (f_B = 20 MHz, N = 256) and 0.1 kHz (Cordes, Memo 14)? More to the point, does this mean 10 separate anti-aliasing filters or will the narrower band filters be implemented digitally following initial 20 MHz analog filtering and sampling? Would it be possible to allow a continuously adjustable Δf over this range? It certainly is through control of the clock rate, but how would we do the filtering?

5. Portability

The feeling at Green Bank seems to be that the completed Processor will be too bulky and/or delicate to travel, except perhaps on site. Portability is, of course, further restricted if the device serves as the 300 foot spectral line backend. Does this change the specifications at all (were any made with an eye toward Arecibo)? Would NRAO be interested in building two machines if NAIC paid for one? Would NAIC be interested in such an arrangement?

6. Self-testing and Modularity

What sort of self-testing features are envisioned. Is the JPL design a good one to follow in this respect? How well does their self-testing scheme work. How modular will this system be? Which elements, if any, might be improvable in the future, say if a new spectrometer with twice the sampling rate become feasible?

7. Time-Frequency Merger or AP

The design now calls for a hard-wired merger that will allow the summation of time or frequency samples. There is also a desire to be able to write accumulated spectra to tape at a high data rate for special-purpose processing off-line. Should we consider substituting an Array Processor for the time-frequency merger? This would allow a variety of statistical processing to be done on the accumulated spectra, with only statistical averages being written to tape. A particularly fruitful application of AP processing power would be pulsar searching, especially for short-period, high-dispersion pulsars. How much, if anything, would the substitution of an AP for the merger add to the cost? Could we dedisperse in the AP?

8. Processor Control

Many features of the Processor control are left unspecified. External gating and external clock rates suggest themselves. What other control features need to be designed into this device from the beginning? How soon do we need to start developing the basic data-taking system of the control computer?