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GBT Scientific Working Group Meeting of September 20, 1994

4 PM EDT

We are trying a new phone conferencing system:

DIAL 804-984-0622 anytime after 3:55 PM EDT and it should work.

AGENDA

I. Update on the Project

II. Spectrometer News -- use of spectrometer for pulsar observations. (see attached report)

III. Receiver update (see attached information).

IV. GBT hardware and software on the 140 foot -- progress report.

IV. Scientific agenda items for 1994-95.

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K-BAND RECEIVER STATUS

The GBT K Band receiver has been mounted on the 140 foot telescope since July. While rotten weather has kept us from getting a definitive test of its performance so far, there are extensive lab measurements which can be used to estimate its properties on the GBT. The expected Tsys contribution from each component of the two K band receivers ON THE GBT is as follows:

Freq	Tamp +	Tpol,feed,etc +	Tspill +	Tsky	=	Tsys
18-22	17	3	2	16	=	38 K
22-26	18	6	2	16	=	42 K

These numbers are band averages for both channels and use Tspill as calculated in GBT memo #87 and Tsky (which includes the CMBR) from the VLBA project book. Work is under way to obtain new amplifiers with a lower Tamp. It is likely that the K band receiver will have a lower Tsys than given here by the time it is installed on the GBT.

The current status of GBT receivers is accessable through the World Wide Web under the GBT entry in the NRAO home page.

F.J. Lockman

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The GBT Spectrometer Integration System

I) Introduction

The following text describes a proposed long term accumulator (LTA) for the GBT spectrometer. This design for the LTA is determined largely by the requirements for pulsar observations and hence is contrary to early decisions in the project that were aimed at preventing pulsar requirements from driving the spectrometer design. Study of this LTA design, its performance and its cost, is required to see if justification exists for its adoption.

II) Overview

First, a brief description of the GBT spectrometer and how this LTA fits in with the current design.

The GBT spectrometer has an inherent property of performing many short integrations due to the strategy employed for matching bit rates between 2-GHz samplers and 125-MHz clock rate correlator chips. This strategy consists of using a fast RAM memory to input samples from a high speed sampler and then to output short bursts of contiguous samples at low clock rates to 16 parallel correlator chips.

Each correlator chip is driven by bursts of 131,072 contiguous samples at the chip clock rate of 125 Mbits per second. Each burst is thus approximately 1.0485 msec in duration and the entire spectrometer timing structure is built around this memory cycle period.

Earlier concepts of the LTA assumed that the 32-bit accumulators in each correlator chip would integrate lag results for several (16) memory cycles. Result dump from the correlator chips would have been every 16-msec which implied relative simple and slow LTA requirements.

To take full advantage of the native spectrometer architecture to better support pulsar observational requirements however, consideration is now being given to dumping lag results into the LTA every memory cycle. By doing this, the dump from each correlator chip can be tagged as belonging to a specific pulsar phase and integrated into a corresponding time bin within the LTA memory structure. A given sampler output can be processed by several correlator chips and by use of the individual chip blanking terms, high time precision within a pulsar period can be obtained.

This proposed change has very little effect on the GBT spectrometer design except for the LTA and the back end. The back end is affected only because the resulting high speed requirements of the LTA necessitate doing accumulation in 32-bit fixed point arithmetic rather that the earlier intended single precision IEEE floating point format. Hence, the LTA must be read and cleared about once a minute by the back end to prevent overflow and longer term integrations must be done in the back end.

A 1-Mbit by 32 by 2-bank memory must be supplied for each of the 16 correlator cards in the spectrometer. This memory size is about 4 times the size originally considered and requires access times about 4 times as fast. Overall, the spectrometer will require 32 1-Mbit X 32 static RAM modules at about $1,000 each. This cost is by far the major cost increase to be incurred by implementing the new design.

III) Performance

Since the size of the LTA memory is dictated by pulsar requirements, non-pulsar performance should not be of concern. Memory space for all lags will be provided with as much space for various bins for signal, reference, cal, etc., as is needed. Hence, no trade-offs need be made for non-pulsar observations.

For pulsar observations (where a pulsar of known period is observed), 1,048,576 memory locations will be provided for each correlator card in the system. This allows a lag-time bin product of;

$$T \times L = 1{,}048{,}576 \;/\; (S \times P)$$

where,

- T = number of time bins across the pulsar period
- L = number of lags for each spectrum.
- S = number of active samplers
- P = 2 if polarization cross products are required
- P = 1 if no polarization cross products are required

If signal/reference memory bins are required, the T x L figure is reduced by a factor of 2.

The trade-off between lags and time bins will require some modification of the non-pulsar spectrometer design (other that the LTA). The trade-off will be accomplished by utilizing only fractional parts of the memory cards that drive the correlator. By using only part of the memory, the memory cycle duration discussed above can be cut to 1.0485/N msec for some integer N. The shorter memory cycle time will mean that there will be insufficient time in each memory cycle to shift out all of the 1024 results in a given correlator chip. Thus, if only 512 of the 1024 results are shifted out each memory cycle, a factor of 2 more time bins are made available in the LTA memory. The maximum size of N will probably be 4 implying a limitation to the equation above.

The time resolution obtained is calculated by dividing the memory cycle duration by the number of parallel correlator chips available to process a given sampler output. In the limit of performance (one active sampler), each

1.0485 msec memory cycle would be sub-divided 256 times (by the 256 correlator chips in the system) yielding a time resolution of 4.096 usec. Blanking signals to each correlator chip will limit the correlations in a given memory cycle to the 4.096 usec interval per chip.

Time bins in the LTA that result would have some time smear because an entire 4.096 usec integration would be accumulated into the same time bin of the 1024 available even though it may span two bins. As a result, the pulsar period will have time bins mapped across it that have the response shape seen below;

```
                         |  |
                      -->|  |<-- R (see below)
                         |  |_____________________
time bin x                  /                      \
                           /                        \
                     _____/                          \_____________________________
                           |                        |                             |
                           |<--   period/1024    -->|<--   period/1024     -->|
                           |                        |  ______________________  |
time bin x+1                                         /                        \
                                                    /                          \
                     ______________________________/                            \_____

                     ---------------------------time---------------------------->
```

Below is a table of performance. The figured shown in this table are independent of sample rate.

S	L	P	T	R
1	1024	1	1024	4.096 usec
1	512	1	2048	2.048 usec
1	256	1	4096	1.024 usec
2	1024	1	512	8.192 usec
2	512	1	1024	4.096 usec
2	256	1	2048	2.048 usec
2	1024	2	256	16.384 usec
2	512	2	512	8.192 usec
2	256	2	1024	4.096 usec

Where,

S = number of active samplers
L = number of lags per product
P = 1 for no polarization cross products, 2 for cross products
T = number of time bins across pulsar period
R = time resolution

For very fast pulsars, where T x S is greater than the pulsar period, the time smear discussed above becomes extreme, resulting in fewer effective time bins across the period than indicated by the table. It looks as if, in such cases (or for any observation for that matter), the LTA time bins can be limited to a portion of the pulsar period. More thought is required to make sure that this approach is possible.

Finally, an interface will be provided from the GBT spectrometer so that the raw results from the correlator chips can be captured by external equipment as they are being dumped into the LTA. The individual correlator chip blanking signals can be used, as above, so that each result would be from a sub-multiple of the memory cycle time.

Ray Escoffier
September 18, 1994