# NAAPO (North American AstroPhysical Observatory)

"Signals"
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The NAAPO Newsletter
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## 11/21/92 MEETING NOTES

***Earl Phillips***

The meeting began at roughly 10:11 am. Those in attendance were Phillips, Stephens, Ayotte & son, Hanson, Barnhart, Dixon, Brown, and Campanella.

Barnhart reports that he has been in telephone contact with Steve Willard, and we may obtain some Sun workstations as a result of Steve's efforts for the cost of shipping them to us. Thanks Steve! Also, the Cuyahoga County Astronomical Club is scheduled for a tour of the site and Perkins Optical today.

Stephens reports that he has just returned from Canada. He brought back a truck of his equipment. He hasn't been able to get siding quotes for the garage yet, but that situation has been resolved by the carpenter that renovated the office building.

Brown reports that he has been spending a lot of time writing his thesis, the subject of which is the Argus Project. Also, he and Russ have written a program that converts the binary continuum data to ascii format, readable by any computer.

Janis has been busy buttoning up Dreese 805 in preparation for its closing in December for the asbestos removal.

Hanson has delivered a PDP-11/750 to Dreese, but will not plug it in until after Dreese reopens. His card project is also in a state of flux due to the fact that the cards must be moved, again due to the asbestos removal at Dreese.

Dixon reports that the tractor he donated has been delivered. Thanks Bob! He also offers a powerful magnet to anyone who'll pick it up. Our Development Fund suffers from a 25k deficit that will require attention soon. He also brought pictures and posters from the facility in Boston that controls the HST; gotten while he was in Boston attending a computer conference.

Ken Ayotte brings pictures of the radio telescope he is building. It operates at 400 MHz, and he feels he has detected a quasar already.

John Ayotte continues to work on the real-time display project.

The meeting broke at roughly 11:56 am, with most going off to their respective tasks.

## 12/5/92 MEETING NOTES

***Earl Phillips***

The meeting began at roughly 10:02 am. Those in attendance were Childers, Campanella, Bob Pearsol, Phillips, Don James, Barnhart, Brown, Dixon, John & Ken Ayotte, Janis, Hanson, and Huck.

Barnhart reports that he & Dixon dined with Steve Willard recently. Many subjects were discussed, and Steve has offered us machine/electronics shop services as needed. He has also expressed interest in the flat moving project, as his specialty is measurement & control. Steve has built his own radio observatory, complete with 2 12' antennas operating interferometrically. He is interested in building a low noise digital narrow band switch for us. Barnhart also reports that Dick Smith, the carpenter that renovated the RO office building, will apply the siding to the garage. We received a check from Jill Tarter (thanks Jill!) to continue Signals production.

Dixon reports that he will bring his Arecibo slides to the next Saturday meeting. He brought a box of hand tools today to donate to the cause. He will begin working on an article for "The Planetary Report" on the Argus Project.

Stephens reports that he has been busy cleaning up the site, and is attempting to get the dumpster removed. He has ordered materials for the electrical upgrade of the garage, and will proceed with that project when they have been obtained.

Brown reports that he is still working on his thesis, and is understandably busy with that.

Childers reports that he has written a report on his pattern matching algorithm (see below).

Janis reports that Dreese 805 will not be closed as thought, until at least the summer break, for the asbestos removal.

Hanson reports that much card moving has been done, and there is much more to do.

Ayotte reports that he is still working on the real-time display project.

The meeting ended at roughly 12:20 PM, with most going off to their respective tasks.

## 12/19/92 MEETING NOTES
***Earl Phillips***

The meeting began at roughly 10:01 am. Those in attendance were Brown, Barnhart, Phillips, Childers, Dixon, Stephens, Ayottes, Hanson, and Campanella.

Dixon put on a very good slide show from his trip to Arecibo in October. He attended the Opening ceremony of the NASA-HRMS project. He discovered that the Flag Of Earth flies there! He has also been corresponding with Steve Willard on several topics. Steve has volunteered to construct a proto-type bay controller, part of his larger plan to fully automate the entire flat. Barnhart reports that he will begin attending the Tuesday meeting at Dreese 805 in 1993, due to the fact that his first-wife's work schedule has been altered dramatically. Otterbein is donating another mainframe.

Stephens reports that he needs help with raking the leaves on the grounds. Barnhart has offered to send an electronic message to Sue Snyder, in an attempt to get her students to help in this project.

Brown reports that he is still bogged down in his thesis writing.

Childers brings a list of detections his pattern matching algorithm has received. The Dicke switch driver is malfunctioning. This causes about 1/2 of the survey channels to be "deaf", so we are currently receiving on about 1500 channels.

Hanson will be delivering a box of cards to Dr. Dixon, so that he can determine their format and document that information.

The meeting broke at roughly 12:15 PM, with most going off to their respective tasks.

## From: Russell K Childers

<rchilder@magnus.acs.ohio-state.edu>
Subject: Continuum pattern match algorithm
Organization: The Ohio State University
Date: Tue, 1 Dec 1992 21:42:26 GMT

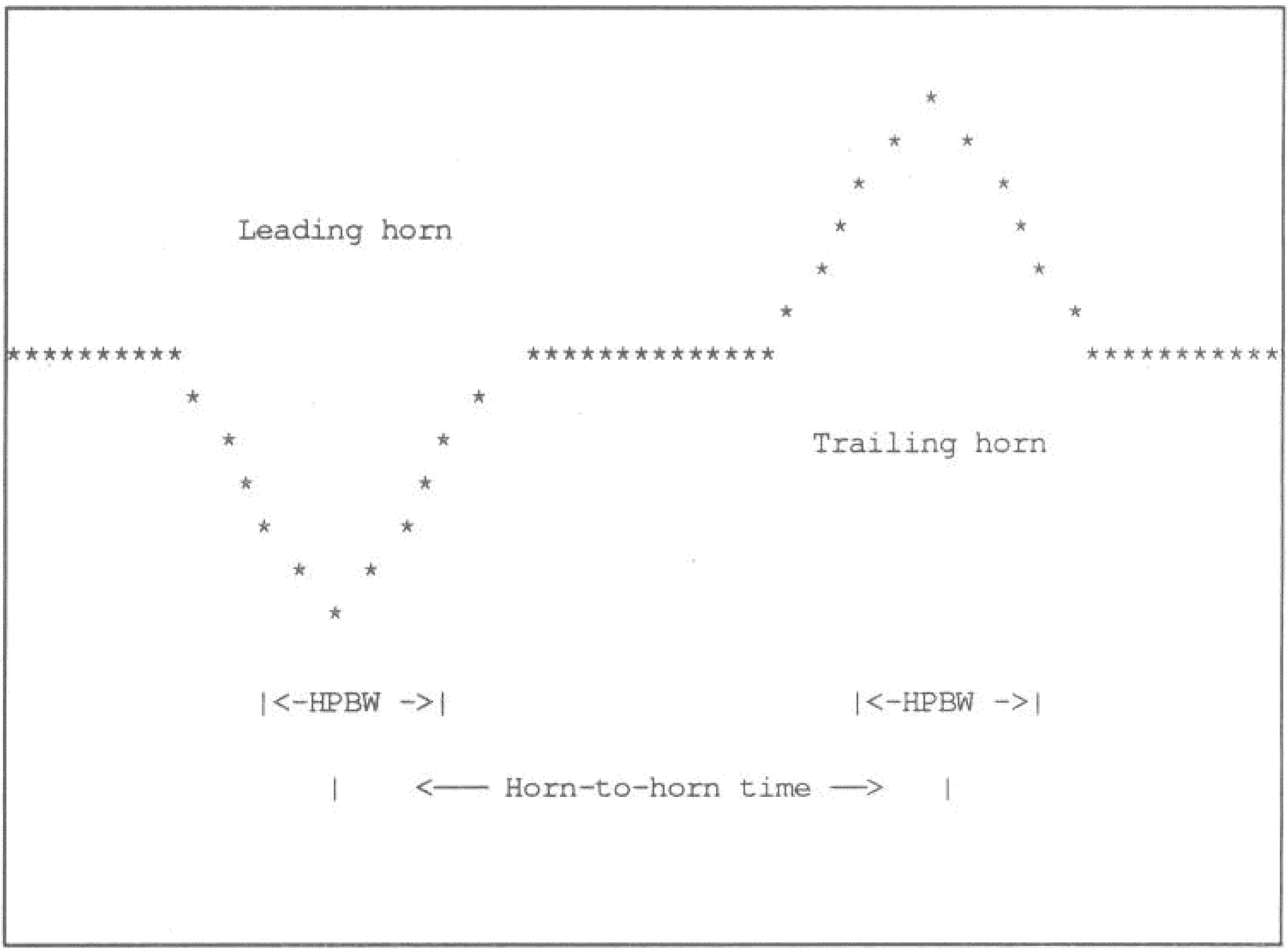
The following report is rather lengthy. It also gets technical. It will be best understood by those who regularly attend the Tuesday or Saturday meetings and by those familiar with radio astronomy and some signal processing. Note: my terminology's are at times colloquial if not accurate. Please bear with me...

Ever since I started working at the Radio Observatory (RO), I have wanted the computer to tell me that the receiver was working well. I wanted it to tell me something like "I saw the sun at noon" or "I saw the galactic plane at the proper right ascension". The **LOBES (LOw Budget ETI Search system)** SETI program which I wrote and which was the subject of my thesis could do such things, but only with extremely strong sources. What we needed was an algorithm which could recognize weaker, celestial point sources.

The continuum (broadband) receiver at the RO site has been receiving data for many years. Natural point sources make a distinctive antenna pattern which is easy to recognize visually. Until now, one has had to run a strip chart recorder or read data saved on computer to observe natural sources. Recently, I implemented an on-line (real time) pattern recognition algorithm on the PDP-11 at the RO site which compares the continuum receiver output to the known antenna pattern created by continuum point sources: This algorithm has been very successful at recognizing such point sources.

The current receiver setup at the RO is a variation of the classic Dicke receiver. A Dicke receiver continuously switches between a feed horn and a known noise source. A device called a "phase detector" compares the switched output of the receiver to the switching signal. The output of the phase detector essentially provides a voltage proportional to the difference in power between the noise source and radio power as seen by the feed horn. This setup provides great stability and accuracy in calculating the power of sources as seen by the feed horn. This type of receiver was used to conduct the Ohio Survey during the 1960's and early 1970's. Currently, instead of switching between a calibrated noise source and a feed horn, the receiver switches back and forth between two identical feed horns. Thus, one feed horn is the "reference" and the other is the "signal". Actually, one can envision this setup better by imagining the power of one feed horn being positive, the power of the other as being negative, and the output of the phase detector as the sum of both. If a source is in front of one feed horn, the output is positive, and if a source is in front of the other feed horn, the output is negative. The feed horns are situated in the focal plane of the RO such that sources will drift past first one then the other feed horn. The spacing between the feed horns ensures that a point source will not be in front of both horns simultaneously.

The "dual feed horn pattern" looks like this:




This is the ideal antenna pattern for point sources. Since most of the natural radio sources are point sources, knowledge of this pattern is most useful. The "HPBW" is the half-power beam width of the parabolic reflector at 1415 megahertz. The "Horn-to-horn time" is the time a source takes to go **From the center of the leading feed horn to the trailing feed horn**.

These two values change as the declination of the antenna changes. Nominal values are 30 seconds for the HPBW, and

150 seconds for the Horn-to-horn time at zero degrees declination. (The RO can observe between -40 degrees and + 64 degrees declination.) For other declinations one need simply divide the 30 and 150-second values by the cosine of the declination. Thus, at +60 degrees declination, for example, the HPBW is 60 seconds and the Horn-to-horn time is 300 seconds. Armed with this information, I wrote an algorithm which constructs the above beam pattern in digital memory. The computer samples the output of the continuum phase detector once every ten seconds, so the pattern is calculated for ten-second increments for the particular declination being observed. After every sample is taken (once every ten seconds), a "window" of data is compared to the ideal pattern. If the data matches the ideal pattern well, a message is printed out on a printer at the RO. An example of the message looks like:

```
2.15  4   1.56   04:31:23 RA 43.32 dec  1950
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where

2.15 is a measure of fit of the data to the ideal pattern. The smaller the number, the better the fit.

4 is where in the 10-second window the data fit the pattern the best. This number varies from 1 to 10.

1.56 is the number of flux units of the source. This value is calibrated off of the Ohio Survey for known sources. It is essentially a scaled value of the peak-to-peak value of the input data.

04:31:23 RA is the Right Ascension of the source precessed to 1950 coordinates.

43.32 dec is the declination of the telescope precessed to 1950 coordinates.

It is necessary to precess the Right Ascension and declination to 1950 coordinates because that was the reference frame used for the Ohio Survey.

The "2.15" value is the "mean squared error" between the data in the "window" and the ideal dual feed antenna pattern. What I do is first normalize the data to have zero average value. Typically, the average value of the data is around 2048. This is the "zero volts" value of the output of the phase detector translated to computer digital value by the Analog-to-Digital converter. Once the data is converted to zero-mean by subtracting out the average value, it is again normalized so that its maximum value is equal to or less than +1, and its minimum value is equal to or greater than -1. This is done by dividing all data values by the maximum value (or minimum value, which ever has the largest absolute value). I do this because the ideal antenna pattern I created has all values falling between +1 and -1. At this point, the data is on the same scale as the ideal antenna pattern, and both have zero average value. Then — this is the critical part — I subtract the normalized data values point-by-point from the ideal antenna pattern, square each difference, add all the squared differences, then divide by the total number of points in the data "window". This provides the "average squared difference" or "mean squared error". To make this value easier to read, I multiply the result by 10. Thus, the "2.15" means that "ten times the average squared error of each data point **From the ideal pattern** is 2.15". Whew!

At this point, it may not be obvious, but if the input data EXACTLY matches the ideal pattern, the mean squared error is equal to zero. This is because when the algorithm subtracts the data point by point from the ideal pattern, all differences are zero. Hence the square of all differences are zero, and the average of all these zero values is – zero. Thus, a perfect fit produces a zero mean squared error.

If the input data is random noise, then there will be relatively large differences between each data point and the corresponding point on the ideal pattern. When these differences are squared, the values we come up with are all non-negative and (mostly) non-zero. When the average of all these positive values are taken over the entire "window", a (relatively) large positive number results. This indicates a poor fit.

The receiver system can currently resolve sources of 0.5 flux units or greater, and my algorithm detects these. The Ohio Survey could resolve sources of around 0.2 flux units, so some sources are not seen which theoretically could be. This is OK, since there are many sources at each declination of 1.0 flux units or greater. Right now, around 20 or so sources are detected every day which can be confirmed by looking at the Ohio Survey. This is fantastic, I believe.

In the works is a method for the computer to identify the names of the sources when it detects them. Wataru Ebihara has contributed a great deal toward this end. John Ayotte is also working on a similar system.

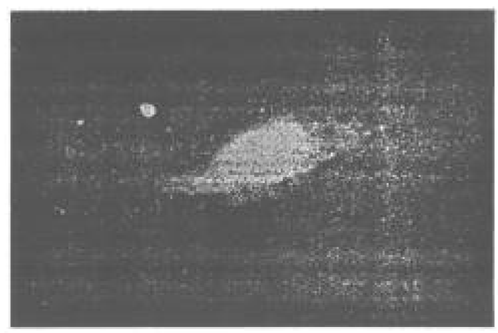
Now one can go into the Focus Room and look at a printer and can confirm that the receiver is properly working without looking at reams of strip chart paper. Hooray!

## COORDINATOR'S CORNER

***Phil Barnhart***

Many things happen without our intervention or even our knowledge. This is especially the case in an organization with many minds in many parts of the world directed toward a common goal — like NAAPO. I have had the pleasure of watching things come to fruition over the past month or two which have simmered on several fronts for many years. To mention a few -

The moving horn cart now operates smoothly along rails under control of the observing program on the main data acquisition computer. This is due in large measure to efforts on the part of Bob Stephens — both while he was still in Canada and after joining us here at Big Ear, and the cleverness and growing talent of Russ Childers who made great strides in modifying the old cable drive into the chain drive that works so effectively. We still monitor the position with the worlds longest slide wire potentiometer, a simple, effective device that serves us well.



At long last we have a convenient way to check the over-all system against the Ohio Survey (and ultimately other source lists of radio objects in the sky). Russ Childers has implemented a pattern recognition algorithm in the continuum channel to identify sources as they are detected. He demonstrated at our last Dreese Lab meeting that the computer digs out of the noise sources in the range of 1 or 2 flux units. This means in the present ambient temperature survey mode we are capable of picking up about two-thirds of the Ohio Survey objects ON EACH SCAN OF THE SKY. The Ohio Survey actually used multiple scans to pull objects out of the noise, so we are now approaching the signal sensitivity of the original survey.

Steve Brown has stirred renewed interest in the ARGUS project begun by Jim Bolinger. It has become evident that we have to get on with the spreading of the word about this. Someone will certainly get a similar idea and this has been an on-going part of the Observatory program for many years. It is looking good.

Promise of a HEMT input low noise amplifier for the front end will buy us some lower system noise as well. We have potential along this line from more than one source.

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I have to take this opportunity to again thank those who have stuck by us through all sorts of trials and tribulations and have willingly supported the NAAPO operation with their financial donations. We have received generous contributions from Jill Tarter, Paul Horowitz, John Kraus, Amy Bouska and Skip Lewis. For Jill and Paul to make a financial commitment to our endeavor is particularly noteworthy because they each operate independent SETI programs. Amy and Skip simply recognize a good thing when they see it. We recognize good people when we see them. John, of course, IS and will always be Big Ear.

MANY THANKS!!!!!!

## Phil Barnhart's Observation

I noticed a very interesting phenomenon during the Dixon Slide presentation at the December 19 working session at the RO. Bob had flown to Puerto Rico to attend the kick-off of the NASA High Resolution Microwave Survey at Arecibo. Along with all the photos of relay racks, antennae, reflector sections, exotic flowers and beautiful hotels, there was a sizeable selection of pictures of festive dancing and rejoicing. Of particular interest was the fact that Jill Tarter was the only person appearing in all the pictures. She apparently danced all partners, including her husband, into the floor. She was obviously one happy kid.

Keep dancing, Jill.
*Phil Barnhart*

## OBSERVATORY WISH LIST

There are a number of items that we would really be able to use around the observatory. We will publish a more complete listing for possible donation next issue, but for the present time we invite our friends to keep their eyes and ears open for potential items to consider for donation to NAAPO. Companies are always on the move and any items that are to be discarded or donated are fair game as far as we are concerned.

We do request that available documentation accompany the hardware where possible. Items we desire are:

1. Apple MacIntosh computer — hard drive desired. This would be convenient for our 'real time' sky display being developed by John Ayotte on a Mac.

2. A small copy machine for the site office.

3. Dot matrix printers for the focus room.

4. Paper supplies — note pads, graph paper, envelopes, etc.

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