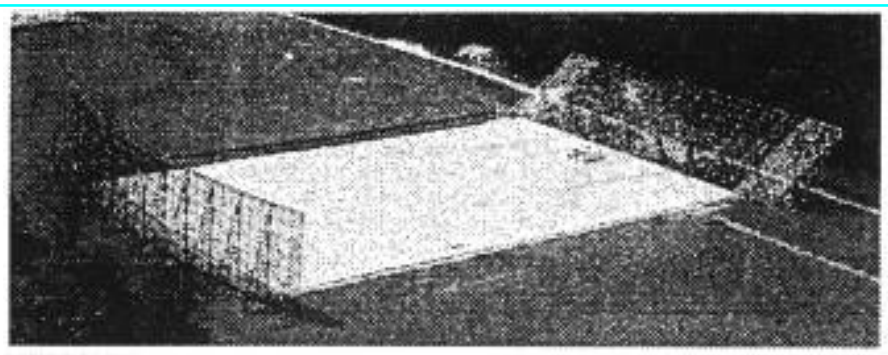
North American AstroPhysical Observatory

NAAPO (North American AstroPhysical Observatory)

"Signals"
Volume 15 Number 02
The NAAPO Newsletter
(August/September 1999)

SIGNALS

Visit us on the web! http://www.bigear.org.



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COORDINATOR'S CORNER
Phil Barnhart

After the trauma of editorial change and shifting deadlines last month, I realized that the Volume and Issue numbers had been left off the last newsletter. Get out your most recent newsletter (it is probably on the floor of the bird cage by now) and mark it "Volume 15, Number 2." If that is all that goes awry, we really have very little to worry about. The real shock came to me that we are, in fact, nearing the completion of 15 years of active existence of the formal organization (NAAPO) of volunteers that has operated the "Ohio State University Radio Observatory." There is some degree of satisfaction to be taken from our having managed to preserve a part of the great legacy of performance of an institution that significantly contributed to the pioneering years of radio astronomy.

Note from Webpage Editor:

Phil Barnhart and I now believe that the issue referred to above by Phil (i.e., the Spring 1999 issue) should **NOT** have been changed to "Volume 15, Number 2", because it was really "Volume 15, Number 1" (and that is the designation I gave it on this website).

Related to that, the printed version of this current issue was labelled "Volume 15 Number 3 (August/September 1999)", but that is incorrect. I have changed its designation on this website to: "Volume 15, Number 2 (August/September 1999)".

Though BIG EAR has fallen to the wrecking ball, we have managed to salvage the original data files along with much of the paraphernalia, and to capture a measure of

the spirit of the old times to be applied to the development of new technologies and routines for the exploration of the universe by radio.

Within the next few months we will see the construction and placement of a historical marker recognizing BIG EAR and the contributions to radio astronomy of this instrument and the many people associated with its operation. This monument will be placed alongside U.S. Highway 23, not far from the entrance to Perkins Observatory. We will send out an announcement of the dedication ceremony as soon as we know when it will occur.

-P.B.-

UPCOMING EVENTS....

Regularly scheduled meetings: 1st & 3rd Saturdays at 10 a.m., at the OSU SatComm facility.

Directions to the Facility may be obtained by calling the Volunteer Coordinator at (614) 882-6711.

RECOGNIZING BIG EAR

The Ohio Bicentennial Commission and the Ohio Historical Society have accepted our proposal for a historical marker for BIG EAR to be placed alongside U.S. Highway 23 near the entrance to Perkins Observatory. This two-sided metal monument will describe the telescope, record the significance of its operation, and recognize those who ran it for the nearly forty years of its existence.

After a review of the narrative, and the metal-etching of the two photographs that are to appear on the marker, the whole thing will be cast in metal, and preparation for its erection, placement, and dedication will begin.

The preparation of our proposal has been going on for several months. Special thanks are offered to Tom Hanson for getting the ball rolling with the Historical Society and the Bicentennial Commission and to Jerry Ehman for a masterful job of annotating the narrative with references to the literature (historians being notably careful in the documentation of "historical" statements).

The dedication will be announced as soon as plans are finalized.

[For a detailed accounting of the work which went on behind the scenes to bring this project to fruition, please see "Historical Marker," below, under "EDUCATION, PUBLICATIONS, AND PUBLIC RELATIONS"]

Welcome, New Volunteers!

(in alphabetical order)

Bret Boggs
Scott DeJane
Scott Horn
Cheryl Mason-Middleton
Michael Myers
Jay Rhoads
Hans Schantz
James Windbigler
Jim Withrow

These folks bring a variety of skills to the group, from antenna design to computer skills to design expertise! **We're glad you've joined us!**

CHIEF OBSERVER'S REPORT
Russ Childers

We are still looking for a way to access data on the 15 CD-ROMs containing LOBES narrow-band and continuum data, in order to do further analysis of both types of data.

Russ Childers and Paul Oakes will be working together on this, beginning by attempting to transfer the necessary programs and data from a Macintosh platform to an IBM-compatible platform.

ARGUS ANTENNA DESIGN, CONSTRUCTION, AND TESTING

REPORTS:

May 1st, 1999:
Phil Barnhart passed around photos he took of the WHIPS cone #4. Jerry Ehman noted that the set of photos showing construction of the first three WHIPS cones (which he had shown at the previous meeting) were being donated to the group for archiving.

Steve Ellingson has assigned Ken Ayotte the task of testing the bi-filar helix wound on WHIPS cone #4. The first task will be to measure the standing wave ratio (SWR) at the frequencies of 400, 800, 1200 and 1600 MHz. Testing at the two higher frequencies can be done indoors, but testing at the two lower frequencies must be done outdoors.

May 15th, 1999:
Jerry showed plots from Ken of results from testing the real antenna (a bi-filar conical helix). After receiving a .tar file that neither Bob Dixon nor Jerry could read, Bob obtained a bit map file and a related text file. The bit map file showed two graphs: (1) reflection coefficient vs. frequency; and (2) voltage standing wave ratio (VSWR) vs. frequency. The frequency range for both graphs was about 400 - 2000 MHz. The text file presented a database of frequency vs. reflection coefficient. The graph of reflection coefficient (measured in dB) and the graph of VSWR both showed a very cyclical pattern (about 3 cycles every 200 MHz). Jerry noted that his MiniNec results of the comparable model for impedance vs. frequency also showed cycles but at about half the rate (i.e., about 3 cycles every 400 MHz). Jerry commented that he hopes that Ken will be able to perform both impedance vs. frequency and antenna pattern vs. frequency measurements for the test antenna, in order to allow a better comparison of real vs. model antennas.

June 5th, 1999:
Jerry reported that he now has in his possession the data generated by Ken's antenna testing procedure. He reported that it is hard to compare the graphs of the actual measurements with the graphs he had generated with the antenna design program, due to differences in what was being measured on each graph. Bob stated that Steve and Ken had indicated that the performance of the antenna was so bad that some things just weren't worth measuring. They felt that perhaps there is something

seriously wrong with the antenna construction (perhaps an electrical short?), since they were getting unusually high reflections. After some consultation around the table, it was decided that the theoretical SWR was 9 to 1.

June 19th, 1999:
Bob reported that Brian Baertlein has already been doing a lot of testing on the antenna that the volunteer group built. He has suggested a design change: the feed line should come up through the axis; the transformer needs to go right at the apex. He said that the antenna has too much impedance. Bob sent him an e-mail stating that we were ready to proceed with the building of another antenna with the new design.

July 3rd, 1999:
Jerry presented reports in two areas: (1) a comparison of MiniNec (theoretical) results and Ken's (actual) results for the test bi-filar logarithmic spiral conical helix antenna; and (2) use of a spreadsheet to graph data from the three-microphone Audio ARGUS.

Jerry noted that Bob had sent him two files containing Ken's results of measurements of the bi-filar logarithmic spiral conical helix; one file was a text file of the data values, and the other file was a bitmap containing two graphs of the data. The quality of the graphs was poor, so Jerry decided to import the data into a spreadsheet in order to generate better graphs. After putting "hard returns" in after each record, the data was input to a spreadsheet and parsed to create one cell per data value. Each record contained for each measurement the frequency, power reflection coefficient, power reflection coefficient in dB, and VSWR. Jerry noted that the VSWR values in the data could not be reproduced from the power reflection coefficient, so he generated the correct values. He then plotted the following three plots: (1) power reflection coefficient vs. frequency; (2) power reflection coefficient (in dB) vs. frequency; and (3) VSWR vs. frequency.

Jerry showed these plots to the group. He noted that the only parameter common to both Ken's measurements and the MiniNec results was VSWR. Next he presented two plots of VSWR vs. frequency: (1) MiniNec results; and (2) Ken's revised data. Jerry realized that these two plots could not be superimposed because the MiniNec analysis used a different set of frquencies than Ken's set of data. Thus, Jerry did a new analysis with MiniNec using exactly the same set of frequencies as in Ken's data. Two additional plots were shown: (1) a plot of VSWR vs. frequency showing superimposed both the new MiniNec results and Ken's revised data; and (2) a plot of

the ratio VSWR(Actual Data)/VSWR(MiniNec) vs. frequency.

These two plots were the definitive plots. They showed that: (1) the VSWR for MiniNec tended to rise with frequency while Ken's revised VSWRs tended to fall with frequency; (2) MiniNec VSWRs ranged from about 7 to 12 while Ken's revised VSWRs ranged from about 4 to 10; (3) the oscillation of VSWR with frequency was twice as fast for Ken's revised data than for the MiniNec results.

The fact that the revised actual VSWRs were not even close to being the same as the theoretical VSWRs shows that we have a real problem. Jerry noted again that he wished to have antenna pattern measurements of the test antenna at a few frequencies so that he could compare them to the MiniNec data.

DATA ANALYSIS AND REDUCTION

REPORTS:

May 1st, 1999:
Danielle Douglas has been looking at the Campanella strip-chart digital continuum data looking for "Whoa!"-type responses, in which the positive horn and negative horn amplitudes are significantly different. She said that she has not yet found any such responses.

May 15th, 1999:
Danielle announced that she would be making a presentation at her high school about radio astronomy, particularly the "Big Ear" and ARGUS projects, and about her work looking for "Whoa!"-type signals on the strip-chart recordings made at the time of the LOBES survey. She invited Phil (who is her mentor for her work with NAAPO) to attend her high school presentation.

Danielle has not found any recordings of the desired type yet. Those present at the NAAPO meeting talked about the importance of work like that which she is doing and how often discoveries can be made from looking at such charts.

June 5th, 1999:
Phil reported that Danielle was unable to attend today's meeting due to her graduation from Westerville South High School. Congratulations, Danielle!

June 19th, 1999:

Phil reported that Danielle will be working with Russ Childers' programs to analyze the data for transient events.

July 17th, 1999:
New volunteer Jim Withrow offered to work on the LOBES continuum data; he and Ang Campanella worked on this after the meeting.

FACILITIES UPGRADES AND MAINTENANCE

REPORTS:

May 1st, 1999:
Four lockable enclosed storage cabinets were moved out into the hall after a previous meeting, but were not locked at that time. Since the contents are valuable, there was a discussion about which locks and keys would be used. Bob will bring three Radio Observatory keys from home for use on these cabinets.

Phil noted that storage trailer #2, which leaks, needs to be fixed, and that some material in that trailer needs to be sorted.

May 15th, 1999:
Phil noted that the sliding end door to the storage trailer in front of the SatComm building was open when he arrived. He presumed that it must have been left open at the end of the last meeting. [*See next paragraph.*] Nothing got wet although the wind blew some computer printouts off shelves onto the floor. No damage was done; nothing was missing. In light of finding the door to the storage trailer open, Phil reminded us that the last person out has the responsibility to check that everything is locked up properly.

As Ang Campanella, Tom Hanson, and Jerry Ehman were leaving the meeting, they noticed that the door to the storage trailer was down, with its lock in place, but that the lock's shackle (u-shaped piece) was bent and therefore the trailer was unlocked. With some hammering and bending of the shackle, the lock was made usable again and the trailer re-locked. It appeared that the lock had been vandalized and the trailer had been entered, although it also appeared that no items had been damaged or taken. It was concluded that the trailer had in fact been locked properly at the end of the previous meeting, and that vandalism was the reason for its being open.

June 19th, 1999:

We still need to make storage trailer #2 waterproof, Phil reported. He said that he has a waterproof roofing compound which might serve the purpose.

There was additional discussion about how to prevent further break-ins to the trailer in front of the SatComm building. Sue Oakes stated that she thought that the remnants of an old sign ("Tools") painted on the rear of the trailer may have attracted thieves' attention (although this has been painted over, it is still faintly visible). Cindy Brooman agreed, stating that the police reports in her local paper frequently mention tool thefts. It was decided that we should cover the sign in an attempt to deter further vandalism.

Sue Oakes brought in 32 MB in RAM chips — a gift to NAAPO from her husband Paul. She turned these over to Tom Hanson. We can always use more memory in our computers....

July 3rd, 1999:
Marilyn McConnell-Goelz brought in the desktop computer which she is donating to the group. It is a 486 with 16 MB of memory. Tom stated that this equipment will be useful for Audio ARGUS and C-language programming.

COMPUTER EQUIPMENT NEEDED

Cindy Brooman has placed an advertisement on the BIG EAR website for a used laser or inkjet printer. The equipment currently in the meeting room does not include a printer capable of supporting the graphics-rich multimedia environment prevalent today. It is hoped that someone will know of new or gently used equipment that could be donated, and will respond to this message and our need.

VOLUNTEERS NEEDED

Bob Dixon told us that Steve Ellingson has a project for the volunteer group. He needs someone to take on the task of building a database of all of the known artificial satellites. The database would contain orbital information to make it possible to do a real-time lookup of what is in the telescope's beam at any given time.

Hans Schantz said that he believes that there are utilities on the Web to do this. Bob Dixon replied that the system will need to function in stand-alone mode, and therefore it will probably be necessary to build our own database.

Additional information on satellite databases was later presented on the Radio Observatory "listserv" (online discussion group). Bob reported on the Satellite RFI Database that the SETI Institute is supporting at Georgia Tech, and Bret Boggs noted the Visual Satellite Observer's Home Page with a variety of links to related sites.

ARGUS HARDWARE DEVELOPMENT

REPORTS:

May 1st, 1999:
Phil Barnhart reported on the barn sale that he and Dick Smith held, which netted funds for NAAPO and (attempted to) empty Dick's barn of items (which he has been kind enough to store there) from the former BIG EAR Administration Building. Among the items sold were the water softener, storage tank, and shower, along with rolls of BIG EAR wire mesh. Two wall sinks, a five-gallon toilet, more pieces of flat screen, and a large number of sash weights remain to be sold.

Phil stated that any materials which do not have O.S.U. tags on them can be sold; Bob Dixon noted that O.S.U. has officially written off all items formerly at the BIG EAR site. (What is not sold will eventually be moved to the SatComm site.) Phil gave the "windfall cash" which was generated by the barn sale to Bob for use at the upcoming Dayton Hamvention in order to purchase items needed by the Radio Observatory, and the ARGUS project in particular.

June 5th, 1999:
Bob Dixon reported on the Dayton Hamfest which he, Steve Ellingson, Ken Ayotte, Paul Oakes and others attended. A large number of small items needed for the RF ARGUS project were located, including adapters, cables, rolls of copper, filters, etc. Bob also reported that the RF ARGUS project is moving along nicely, with the construction of more antennas by Steve Ellingson and others.

July 17th, 1999:
Ang Campanella gave an overview of our Audio ARGUS hardware (computer, three sound boards, and three amplified microphones). This overview included a comparison between radio and audio frequencies and wavelengths. This engendered much discussion of what should be done to improve our hardware, including: (1) multichannel analog-to-digital (A/D) boards with precision clock/timer built in; (2) the need for/desirability of uniform timing and sampling; and (3) flaws (nonuniformity and coarseness) in the clock in PCs. Bob Tournoux said that he

would try to work on a multichannel A/D with timer to be put into a PC. Several others expressed interest in helping to advance this project.

ARGUS SOFTWARE DEVELOPMENT

REPORTS:

May 1st, 1999:
Harry Kitchen, Tom Hanson, and Jerry Ehman have all been working on Audio ARGUS software development. Jerry and Tom have installed C compilers on their home computers in order to assist Harry in software development. The program SB_ADC_F.C, which polls the three sound cards, still needs a modification to allow for the calibration of the three sound cards/amplifiers.

May 15th, 1999:
Harry tried compiling his Audio ARGUS demonstration program (written in C) with two different C compilers on the SatComm computers, but was not successful.

June 5th, 1999:
Harry stated that he has written two programs for the Audio ARGUS project. One program generates random data to form an ARGUS display. The second program takes data (however many samples you request) from three sound cards and writes the data out to a file. The latter program is called SB_ADC (for Sound Blaster Analog to Digital Converter). Jerry is in the process of installing software on his home computer to aid in this project.

June 19th, 1999:
Jerry stated that he compiled and ran the demo program which provides a false set of data to generate a signal display. He said that the other program, which does the actual polling of the sound cards, still needs to be modified to allow adjusting of the amplifiers for each individual card. We need to be able to adjust the three cards so that the input is equal.

July 3rd, 1999:
Jerry created some artificial data for Audio ARGUS and generated spreadsheet plots in preparation for receiving real data. Tom noted that certain measurements of the three microphone amplifiers and three sound boards need to be made (i.e., calibration), and suggested that Jerry create simulations of the Audio ARGUS data in developing his analysis. Jerry agreed to do this.

One of our new volunteers, Bret Boggs, has had experience in using software to compensate for differences in the sensitivity of hardware. He may be able to add his expertise to the solving of the Audio ARGUS calibration problem.

July 17th, 1999:
Bret has examined Harry's data acquisition software and has made a few modifications. There was discussion about adjusting the gains of the three microphones (each microphone is actually a sound-level meter in which only the microphone and internal attenuator and amplifier are being used).

Ang noted that because of the 10 dB step attenuator on each microphone and inherent differences in gains among the internal amplifiers in the three microphones, it would probably be possible to get no better than 3 dB differences between any two of the microphone outputs.

Steve Brown noted that he learned from his dissertation analysis that differences in gain among receiving elements after amplification are not nearly as important as differences in timing (arrival of signals), if the main goal is to determine the direction of a signal. This would apply to both RF ARGUS and Audio ARGUS.

EDUCATION, PUBLICATIONS, AND PUBLIC RELATIONS

(Organized by topic and by date within topics)

HISTORICAL MARKER

REPORTS:

May 1st, 1999:
Phil Barnhart handed out the latest version of the text for the BIG EAR historical marker. Some language changes were suggested. Phil noted that the Ohio Historical Society will need documentation to validate all of the claims that are made in the text. Because Jerry Ehman has a set of the Radio Observatory reprints (although with several missing), Phil asked him to go through them, and through John Kraus's book *Big Ear Two,* photocopying text that would validate our claims. Jerry agreed to do so. Phil commented that, in addition to the text, the marker will have an etching of an aerial photograph of BIG EAR on Side 1 of the marker and an etching of the "Wow!" signal printout on Side 2.

May 15th, 1999:
Jerry talked about the proposed historical marker text. At the last meeting he had agreed to go through Kraus's book and the OSURO reprints that he had on hand, in order to locate references validating the statements made in our marker text. After receiving the corrected text, and answers to some questions via e-mail from Phil, Jerry generated a color-coded WordPerfect document which he circulated and then gave to Phil.

Tom Hanson handed Phil an official notice from the Ohio Historical Society that 12 copies of our documentation were needed by the OHS by the end of June. Phil and Jerry agreed that Jerry would generate a new color-coded printout of the marker text with references, making multiple copies of it, and also making various numbers of copies of the references (he will mail these to Phil at his home because too much time will elapse before our next meeting).

June 5th, 1999:
Phil discussed the status of the historical marker application. He had completed nearly all of the application, with the exception of the section titled "Significance and Relevance." He brought along a rough draft of the paragraphs for this section. The group looked over this draft and made some suggestions for revised wording. Bob feels that the OHS selection committee will likely look at this section first, in order to determine whether the rest of the application is worth reviewing; therefore, this section is probably critically important.

Phil has looked over the area along U.S. Highway 23 and selected a site near the entrance to Perkins Observatory which he feels would be a good place to locate the marker: it is just after the end of the guard rail and has a paved pull-off area.

June 19th, 1999:
Phil brought a copy of the final version of the historical marker proposal to the meeting. It looked very professional (but did we ever think it wouldn't?)! Phil included photos of the proposed location for the marker, as well as a black and white photo of the BIG EAR Radio Telescope which is to be etched on the marker.

July 3, 1999:
Phil said that he returned from a short vacation to find some frantic messages had been left for him. Apparently, there was a small problem with our historical marker application: we were supposed to indicate our "abject poverty" in the cover letter

since we were applying for matching funds.

Phil revised the cover letter, including three paragraphs stating our financial need, before resubmitting the marker application materials. He indicated that our having to pay for the marker would have a serious impact on our ability to purchase ARGUS project components.

Phil also stated that the Ohio Historical Society committee has a policy of not mentioning any living person in historical marker texts. Therefore, technically, we were not supposed to mention John Kraus! This was completely unacceptable, since without him the BIG EAR radio telescope would never have been built. Phil thought it possible that the committee would make an appropriate exception in this case. The OHS committee is to meet again in the middle of July.

BIG EAR WEBSITE

June 5th, 1999:
Cindy Brooman brought in the website reports from April and May for ***www.bigear.org*** . There were 18,936 document requests in April, and 29,954 in May! The number seems to be growing, possibly from people adding us to their list of preferred sites.

Phil is being inundated by volunteer applications through e-mail from the website, and has requested assistance in corresponding with the various individuals who have written. Tom Hanson volunteered his assistance in corresponding with those who indicate proficiency with C programming.

Cindy Brooman wondered why so many people from remote locations are completing the volunteer form, despite the up-front mention of the fact that volunteers should be local (due to the hands-on nature of the current projects.) She will think about further changes to the script to cut down on the number of applications from folks far afield.

June 19th, 1999:
Cindy Brooman stated that her modifications to the volunteer form at the website have been successful. When someone from outside of Ohio tries to submit a volunteer application (after a number of notices that volunteers should be local), the script returns a polite message saying "Thank you for your interest, but..." and does not forward e-mail to Phil. This has significantly cut the number of applications we

have been receiving. With fewer applications, Phil has more time to respond to volunteers who are local. Prior to this, many people from remote locations — including foreign countries — had been filling out the volunteer form.

Jerry Ehman stated that he has been getting correspondence from the website concerning the "Wow!" signal. One man said that he had previously worked for the military in radar. He relayed his doubt that the "Wow!" signal could have been caused by military radar, since it was never at frequencies as low as 1420 MHz.

Jerry also received e-mail from Tobias Wobble, suggesting that Jerry rewrite the 20th Anniversary "'Wow!' Report" for a popular publication.

July 3rd, 1999:
Cindy Brooman brought in the website report for the month of June to give to Phil. During that time, ***www.bigear.org*** received 22,166 document requests.

July 17th, 1999:
Jerry noted that Cindy has reorganized the portion of the BIG EAR website dealing with ARGUS. The homepage menu item on Argus is a link to another page of links to various articles on ARGUS. Included are articles written by Bob Dixon (previously on the website under the old organization) plus three new articles (two by Steve Ellingson and one by Brian Baertlein, both of ESL). These new articles had been given to Bob Dixon, who asked Cindy to put them on our website; Jerry encouraged everyone to read these articles.

OTHER VOLUNTEER ACTIVITIES

June 19th, 1999:
Phil stated that he thought it would be a good idea to have a working session for new volunteers at some point.

There was mention of reports being written for the SETI Institute by Steve Ellingson describing our progress in the last year. Phil pointed out that one of the services which NAAPO could provide would be assistance with report writing, should that be needed. Sue Oakes volunteered her assistance in editing for grammar, mechanics, and the like.

July 3rd, 1999:

Marilyn McConnell-Goelz reported that she is fairly sure that NAAPO must file a tax return in May of 2000 for the tax year 1999. Marilyn also suggested that we advertise on the website for a volunteer with an accounting background. Michael Myers then mentioned that he had been in accounting for ten years, and that he has a brother who is a certified public accountant.

July 17th, 1999:
The desirability of raising funds for NAAPO was discussed. It was recalled that, in the past, pictures had been taken during each BIG EAR Open House when people stood in front of the feed horns; these pictures were later made available in exchange for a donation to the project. The question was raised whether and where some ARGUS equipment could be set up to allow a similar thing to be done. No decisions were made at this time.

Cheryl Mason-Middleton asked if it is possible and appropriate to ask OEMs and other companies for donations of equipment, either new or used. It was noted that the Radio Observatory has in the past received such donations, some usable and some not.

Ang Campanella asked those who were present if they thought it would be a good idea to have working groups come in early, perhaps an hour before the regular meetings, in order to get some work done (which could then be reported on at the meeting), or whether it was better to come back to work after the meeting (and lunch). Most felt that coming back after lunch was preferable.

IN THE NEWS...

BIG EAR

May 1st, 1999:
Jerry Ehman handed out copies of an article from the June issue of *Astronomy* magazine. The article (pp. 56-61), entitled "Meet the Radio Man," describes John Kraus and the building of BIG EAR. (It is subtitled "Maybe you can't make a silk purse out of a sow's ear, but John Kraus could make Big Ear out of an empty purse.") Phil noted that some photographs that he took, and that Bob sent to the magazine, were mistakenly credited to John Kraus. Another picture in the article — the one of Jerry simulating the writing of the "Wow!" notation on the computer printout — was taken by Dan Fleisch.

SKAI

June 5th, 1999:
Bob reported that Brian Baertlein, another staff member at ESLab, has become interested in Square Kilometer Array project after attending a conference with Steve Ellingson. According to Bob, there had been no "official" entity in the U.S. involved in the Square Kilometer Array project, unlike in the other countries which are participating.

The SETI Institute is forming a consortium of universities (at $3,000 each) in the U. S. to participate in the research and development. Now, thanks to Brian Baertlein's interest, the ElectroScience Lab has paid the $3,000 necessary for OSU's membership in the consortium. Good going, Brian! And thank you, Steve, for involving Brian in the project!

1HT

June 5th, 1999:
Jerry Ehman brought a handout for everyone — a copy of the article titled "Giant SETI Radio Telescope Planned" — from *Sky & Telescope*. The article discusses the planned One Hectare Telescope which is to be constructed at Berkeley's Hat Creek Radio Observatory in Northern California. The end of the article mentions work in progress at OSU's ElectroScience Laboratory by Bob Dixon and Steve Ellingson (although his last name was misspelled Ellington!).

June 19th, 1999:
Bob told us that the SETI Institute has called Steve, and is very interested in having him work on the front end for the One Hectare Telescope. They would like to get this online by September. Bob thinks it has something to do with wanting to show the rest of the world that the United States has the technology to build the SKAI telescope. Bob was concerned that we not derail the current ARGUS RF project, so additional personnel might be required.

SETI

May 1st, 1999:
Jerry Ehman handed out copies of an article from the June issue of *Astronomy* magazine. The article (pp. 30-32), entitled "SETI Shifts from Radio to Lasers," talks

about three new SETI programs that will look for laser pulses with optical telescopes. Jerry noted that Stuart Kingsley's COSETI project is not mentioned. It was also noted that the title inaccurately states that there is a shift in SETI studies from the radio band to the optical band. In fact, both are occurring.

June 5th, 1999:
Jerry brought a copy of the *Planetary Report* which included an article titled "Thoughts on SETI".

July 3rd, 1999:
Steve Ellingson and Brian Baertlein have written up the year's progress in digital signal processing and antenna design in their reports — available on the BIG EAR website — to the SETI Institute. The volunteer group is mentioned as contributing to their efforts.

REPORT FROM THE LAB....
By Cindy Brooman

Based on "A DSP Engine for a 64-Element Array," by Steven W. Ellingson, Ohio State University ElectroScience Laboratory

Supported by a grant from the SETI Institute, the ElectroScience Laboratory at The Ohio State University has been conducting research on a new, state-of-the-art digital processor which will analyze data from an array of antennas. The antenna array will be part of the proposed ARGUS system, the next-generation radio telescope which will be able to view the entire visible sky at once through the use of digital beam-forming.

In digital beam-forming, the signal output from each of the antennas in the array is converted from analog format (i.e., continuously varying electrical voltage) to digital format (computer ones and zeroes), and an extremely accurate digital time stamp is added. (The time stamp allows calculation of the direction of arrival, since radio waves from a particular signal arrive at some of the antennas just fractions of a second before they arrive at others.) The digital samples may then be added together in any number of combinations to form digital beams — the digital equivalent of where the telescope is "pointing."

With today's supercomputer-on-a-chip technology, it is possible to perform millions of these digital beam combinations very quickly, thus generating a radio picture of

the entire visible sky without having to physically move, or point, the antennas. Because traditional radio telescopes must be pointed in only one direction at a time, it is possible for a transient (short-lived) radio signal in another part of the sky to be overlooked. The ARGUS telescope, using software-defined signal processing, will greatly improve the odds of transient signal detection, and will cost less to build than traditional steel structures due to the falling cost of computer hardware. (Labor costs to build massive steel structures are also on the rise.)

Applications for the ARGUS system can be found in radio astronomy, the search for extraterrestrial intelligence (SETI), and parasitic bi-static radar (i.e., imaging objects passing overhead via a bounced radar signal). In SETI, for example, it is desirable to detect very weak, intermittent narrow-band (narrow frequency range) signals with no advance knowledge of either the frequency or the direction of arrival.

The digital signal processing experiment set up at The Ohio State University simulated the output from an 8 by 8 rectangular array of antennas (64 antennas in total). The simulated data was fed into an electronic circuit board containing two digital signal processing chips, called "SHARCs," manufactured by Analog Devices, Inc. The onboard digital signal processing (DSP) chips have what is called a "multi-processor memory space," a memory area which is accessible by both of the DSP chips on the board. The DSP chips also have a great deal of internal memory, which allows complete sets of data to be brought into the chip at one time for processing without the chip having to spend a lot of time waiting for parts of the data to arrive.

The researchers at OSU's ElectroScience Lab quickly realized that it took a lot of time for a chip to acquire a simulated data set, in fact so much time that there would be little time left over to process the data before the next data set arrived. Therefore, they came up with the idea of "rotating acquisition." In this method, one chip acquires the data, and another chip processes the data, and vice versa. One chip acquires the data and places it in the common memory area. The other chip then retrieves the data from the common memory area, processes it, and sends it out for storage. The chips take turns acquiring and processing the data.

The Ohio State researchers also figured out very rapidly that the DSP chips had a finite amount of processing ability within a given time due to the length of time required for performing the complex mathematical computations necessary for analyzing the data. They discovered that if the antennas were sending data at the rate of, for example, ten million samples per second, then the frequency range in the

analysis would have to be cut way back to perhaps only 20 kHz (kiloHertz) to allow time for the processing. This means that a transient radio signal at a frequency outside of the frequency range being analyzed would be overlooked. Conversely, if the antennas sent only thousands of samples per second, then a much larger frequency range, perhaps 10 MHz (megaHertz) could be used. However, this would mean that there was a wait time, or rest phase, for each antenna between samples. This would allow a short-lived signal to be overlooked during the wait time. Clearly, there was a tradeoff between how often the antenas were taking samples, which the researchers called "duty cycle," and frequency range. The only way to allow millions of samples per second over as wide a frequency range as possible would be to add many more DSP boards at increased cost. Assuming that a large amount of money for such a system might be obtained, this processing ability is theoretically feasible.

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