TAOSON

SIGNAL

Issue No. 3 November, 2008

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TAOSON Director-- David Fields N4HBO

Newsletter Editor --Bill Seymour KM4YL

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I. Welcome

Welcome to the **Tamke-Allan Observatory Solar Observation Network. TAOSON** was conceived in 2007 and operated for its first year as a student group at TAO with members Tyler Moore, Heather Fries and David Fields. In 2008 we opened up the group to the larger local amateur radio astronomy community.

The primary purpose of TAOSON is to keep local radio astronomers in touch and help coordinate their activities as they maintain their radio astronomy research sites. To this end we maintain a server for storing and sharing data, schedule at least one meeting per month, and assist each other when needed. Most members support the Society of Amateur Radio Astronomers (see www.radio-astronomy.org).

TAOSON participates in the TAO Academic Associates of colleges and universities where members share research and scientific goals. This is both science and a humanistic endeavor that encourages cultural exchange. TAOSON also helps advise the TAO Space Explorer Groups with a common goal of developing capable and motivated human beings that will serve the community and become future scientists and contributors to a better world.

Membership is free if you're actively doing radio astronomy. Otherwise, membership is still free and you are invited to help with our projects.

II. Meetings

TAOSON

Regular monthly meetings are held at 2 P.M. on the 2rd Sunday afternoon of the month. The location alternates between TAO and Skynet. **Special meetings will be called as the need arises.**

Meeting format will usually include a brief tutorial on a radio astronomy topic of interest, a work session on some chosen task or topic, a meal or refreshments, and a brainstorming session about projects.

Area Optical Astronomy Groups Which Support TAOSON

Oak Ridge Isochronous Observation Network (Orion) meets at 7:00 P.M. on the first day of each month The Club Room, Oak Ridge Civic Center. See www.roanestate.edu/obs and www.orioninc.org

Barnard Astronomical Society (BAS) meets at 7:00 P.M. on the second Thursday of each month at the UT Chattanooga Clarence Jones Observatory. See BAS@chattanooga.net.

III. The TAOSON Signal

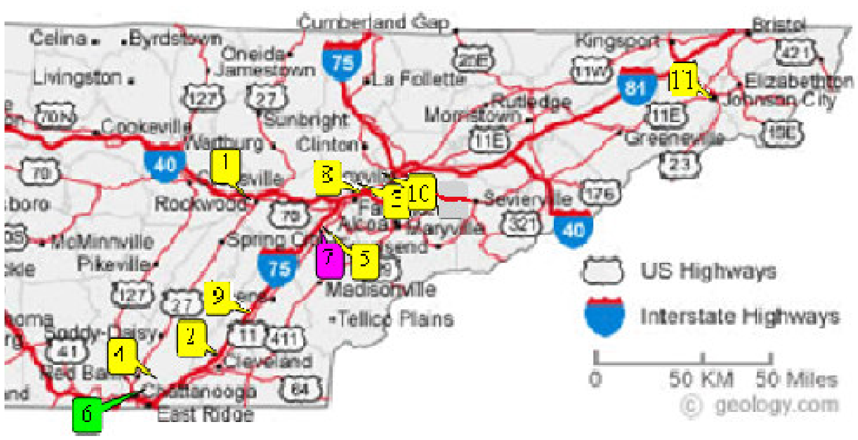
Our newsletter, the TAOSON Signal, will be published on or near the the first day of each month. Every effort will be made to protect the e-mail addresses on the distribution list and the privacy of their owners. Feel free to circulate and share copies of the Signal.

Items for the newsletter will be submitted by email to Editor Bill Seymour at swafseymo@bellsouth.net and to David Fields at fieldsde@aol.com, not later than ten days prior to the next publication date. We encourage each active member to submit a paragraph that summarizes site activities, goals and ideas. Members are also invited to submit questions to the Editor to be considered in the newsletter and at meetings.

IV. Research Site Locations and Capabilities

TAOSON sites include those shown on the following map and identified in the following table.

Site locations and primary capabilities are as follows:



TAOSON FACILITIES DIRECTORY

Site Location	Site Name	Code	Control Operator	Lat./Long.	Telephone	Operations
Rockwood (1)	TAO	TAO	David Fields	35.8322/ 84.6175	865-376-1362	21cm, 15m, optical, Ku, Spectrocyber, Interferometer
Cleveland (2)	Skynet	SN	Bill and Melinda		423-478-9043	21cm, 15m, optical, Ku, Spectrocyber, VLF
Solway (3)	Solway	SOL	David Fields	35.9641/ 84.2021	865-927-5155	15m, Ku, optical H-alpha VLF
Chattanooga (4)	Riverbend	RB	Dick Castle		423-870-4398	15m
Knoxville (8)	Blue Meadow	BLM	Linda Fippin		865-539-6826	VLF
Niota (9)	Niota	CL	John Mannone		423-337-2197	Ku, optical, VLF
Hixson (6)	Big Ridge	BR	Bill Seymour		423-870-8552	15m, Ku, optical VLF
Lenoir City (5) (7)	Lenoir City	LC	Aaron Haun		865-986-7153	Server

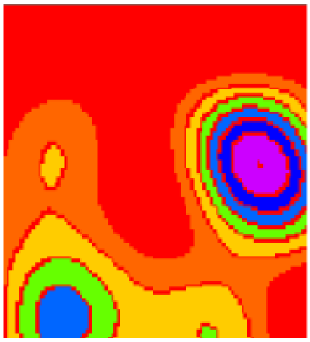
Karns 10	KA	Carl Lyster	SpectraCyber, VLF
Johnson City 11	JC	Heather Fries	Quantitative Optical, SID planned
Puerto Rico	PR	Wanda Diaz	Spectrocyber, 15m
UNAM, MX	UN	Stan Kurtz	SRT, Homebrew IBT, SpectraCyber, 15m

V. Basic Research Activities at Tamke-Allan Observatory

See www.roanestate.edu/obs . Free Public Skygazes are conducted on the 1st and 3rd Saturday evenings of each months and TAOSON members are invited. TAOSON meeting is held on the second Sunday of the month.

TAO is our primary meeting and workshop site. Capabilities include SpectraCyber, Jove system, IBT, Ku interferometer, and meteor bounce, plus some optical stuff that includes an 8" refractor, 12" reflector scopes, Sky Scout and spectrometers. SpectraCyber was built by Carl Lyster and used by Heather Fries last year for mapping.

The Ku band interferometer has also been used recently for mapping – this plot shows (left) the Ku emission from the sun and a near Clarke Belt satellite. Meteors are enjoyed by trying to detect the reflection of FM radio signals from their ionized tails. The photo on the (right) shows the pretty night sky during the Perseid shower at 4 AM on August 12.



VI. TAOSON Projects

Radio Jove **Dick Castle, Jove Coordinator, K2IMH**

Welcome to the Radio Jove portion of the newsletter. Radio Jove is a NASA sponsored project to monitor the Sun and Jupiter at 20.1 MHz. It is teaching tool for radio astronomy for middle

/high school, college students, amateurs and research groups. You build your own receiver and dual dipole antenna. Radio Jove web site is: **radiojove.gsfc.nasa.gov.**

The TAOSON group presently has 3 systems on-line with another being built. Sites are:

1. Harriman, TN - Tamke Allen Observatory- David Fields
2. Cleveland, TN - Skynet -Bill and Melinda Lord
3. Chattanooga, TN- Riverbend- Dick Castle
4. Hixson, TN –Big Ridge; Being built-not operational yet- Bill Seymour

Our objective is to monitor the Sun/Jupiter and see how the ionosphere affects the signals in different locations in close proximity. Data will be collected via Skypipe and sent to a server to be stored for analyses. TAO and Riverbend sites have been on-line since 2004. The Skynet Jove receiver has been recently built at Bill and Melinda Lord's with very high professional standards. Starting back in the Fall last year they built a separate radio astronomy building next to their roll-off roof optical building. A dual dipole antenna was constructed and installed permanently. After that the Jove receiver was built and Skypipe software was installed on the computer. At this point we were ready to start collecting data. Early this spring we built Ten Tec 1056 receiver and then modified it for 20.1 MHz. We calibrated all three site receivers to Kelvin units on Skypipe using the Jove calibrator. A calibration procedure was also written. We have participated in four Radio Jove tele-conferences. These phone teleconferences bring together people from all over the world to discuss Sun/Jupiter events in real time. Presently we are in the process of building a portable dual dipole antenna system using fiberglass poles. The antenna system can be set up in less than 15 minutes and then be stored in a military bag for ease of carrying to outdoor events. As you can see we have been very busy and accomplished quite a lot in short span of time. We still have a lot to do and have only hit the tip of the iceberg. Next month I'll publish a list of outstanding projects we plan to accomplish in the next few months.

Meteor Bounce using Naval Space Surveillance Radar

Have a look at this month's site reports from TAO, Solway, and Karns.

Itty Bitty Telescope (IBT) **Tom Crowley**

[Several TAOSON members are members of the Society of Amateur Radio Astronomers (SARA) and take part in the SARA Navigator Project. Through this project, we have borrowed SARA IBTs, Ku band radio telescopes. Tom Crowley, SARA President and Navigator Coordinator, has agreed to be TAOSON project coordinator for our IBTs.]

SARA is developing a **new** Itty Bitty Radio Telescope (IBT) for the International Year of Astronomy (IYA) 2009. Initial tests have shown the new instrument is capable of a 90% meter deflection when looking at the Moon with an 18-inch dish. Now that's radio astronomy! We are planning on developing two versions, one will be able to do a level of real science and the other will cost much less and make a great intro or demo telescope.

So just what is an IBT you ask? It consists of a direct TV satellite dish and LNB, with the advent of High definition satellite broadcast many of these small dishes are being discarded. You or your neighbor may have a dish that's ready to be tossed, and may well do the "green" thing and recycle it to an IBT. You simply add a satellite detector from Ebay or Radio Shack or order a Channel Master 1040IFD tuning meter for under $80 on the web, build a base and you are ready to go.

If you are interested in building your own IBT check out:
http://www.aoc.nrao.edu/epo/teachers/ittybitty/procedure.html

Many SARA members have built IBT's and have had good success with them. SARA editor John Mannone has used an IBT to determine speed and Doppler shift of an automobile. All right -- not quite radio astronomy, but a unique experiment nonetheless.

For more information on the International Year of Astronomy check out:
http://astronomy2009.us

VII. Reports from The Sites

Niota

There are many good websites for helping the beginner, as well as the experienced, amateur radio astronomer. Join the radio astronomy webring to find some of these, http://a.webring.com/t/Radio-Astronomy?sid=20. And while you are at it, visit my website, Adventures in Astronomy, one of the currently 29 registered. It has a useful section on radio astronomy, http://home.earthlink.net/~jcmannone/. For example, the navigation bar will direct you to *Radio Astronomy Web Tools*, *Sun/Ionosphere Connection: Physics with the 20 MHz Antenna*, *Plasma Bubbles* and other headings.

John C. Mannone
October 9, 2008
Niota, TN Site

UNAM, MEXICO

Our 2.4 GHz radio telescope project has morphed into a dual C+K band radio telescope project. (C band is about 5 GHz, K band is about 11 GHz.) The original plan had been to use several Down East Microwave Low Noise Amplifiers (LNAs) followed by their receive-only downconverter to convert the 2.4 GHz signal to 144 MHz prior to detection. However, we were getting lots of harmonics and/or intermodulation products out of the downconverter, and also we needed at least one (if not two) additional LNAs to get to a reasonable level for doing the down conversion. The student doing the project needs to finish up and get on with her life, so we decided that a more easily realized project would be to substitute a commercial Low Noise Block Converter (LNB) for the Down East Modules. We have a C-Band LNB on hand and will be buying a dual (C+K) band LNB in the next month or two. We will also have to change antennas (the clamshell we were going to use at 2.4 GHz would be quite lossy at C-band and totally transparent at K band) but fortunately we have several extra paraboloids that can be brought into service. We hope to mount the LNB and the antenna in November, and have first light in December.

Stan Kurtz
October, 2008

SOLWAY

DESIGN A METEOR DETECTOR.

Suppose that you want to design the ultimate meteor detector. Here are some characteristics that you might wish include in your design:

- Identifies meteor ionization trails by radio reflection;
- Located in a portion of the sky accessible to TAOSON sites (not in direction of Nashville, Knoxville, or Atlanta, to minimize radio background – perhaps to the Southwest);
- Features continuous transmission of carrier;
- Carrier is in an unused portion of the radio spectrum – all ours to listen to;
- Government would relax controls so we could use frequency without bothering to interact with the FCC;
- Beam (no reason to limit antenna cost – we wouldn't have to pay) would be directional (upward) to minimize forward scatter to our receivers;
- Stabilized frequency, so we could use Doppler shift to extract information;
- Upward beam also presents same zero-Doppler in all directions;
- Very high power (over 1 Megawatt, continuous, to permit detection of small objects -- crazy to consider but this is all theoretical – right?);
- Frequent upgrades to ensure no degradation of signal;
- Maintenance of transmitters would be done and paid for by someone else, so we could concentrate on detection and analysis;
- Power for transmitters would be paid for by someone else (I know – too ambitious).

This is the end of the wish list. Because….. **we have it!**

Characteristics of our system are

- Identifies meteor ionization trails by radio reflection; **YES, we just must listen**
- Located in a portion of the sky accessible to TAOSON sites (not in direction of Nashville, Knoxville, or Atlanta, to minimize radio background – perhaps to the Southwest); **YES, look above Kickapoo, TX, for maximum sign**al
- Features continuous transmission of carrier; **YES, continuous for 50 years, with the beam front about 2/3 the path to Regulus.**
- Carrier is in an unused portion of the radio spectrum – all ours to listen to; **YES, 216.98 MHz**
- Government would relax controls so we could use frequency without bothering to interact with the FCC; **YES, the frequency is ours to listen to**

- Beam (no reason to limit antenna cost – we wouldn't have to pay) would be directional (upward) to minimize forward scatter to our receivers; **YES, we have it, with transmitter beam arrays 2 miles long**
- Stabilized frequency, so we could use Doppler shift to extract information; **YES, highest quality stabilization**
- Upward beam also presents same zero-Doppler in all directions; **YES, we have it**
- Very high power (over 1 Megawatt, continuous, to permit detection of small objects -- crazy to consider but this is all theoretical – right?); **YES on the high power but NO, not theoretical. Actually 1 MegaWatt is piddling. Our system has an effective beam power of 6.3 billion watts.**
- Frequent upgrades to ensure no degradation of signal; **YES, upgrade cost of just under $1,000,000,000 has already been paid;**
- Maintenance of transmitters would be done and paid for by someone else, so we could concentrate on detection and analysis; **Yes, taxpayers paid again.**
- Power for transmitters would be paid for by someone else (I know – too ambitious) **NO, not too ambitious, taxpayers are paying for 1,000,000 KW hours of power per month.**

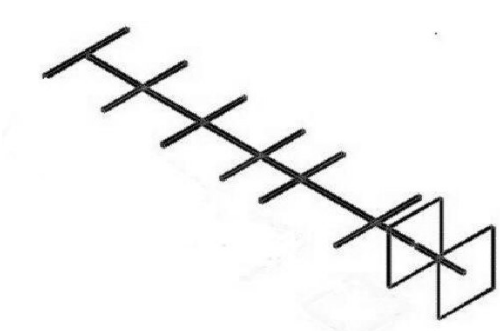
So we can listen to the Naval Space Surveillance Radar. The site consumes about 1,000,000 KWH per month to generate one of the highest power ERP signals on earth, 6.3 billion watts ! When the moon passes through the antenna's beam, the return echo can be heard on earth with only a dipole antenna attached to a receiver. The Kickapoo signal has now travelled over 37 light years into space since being switched on in 1958.

Here are parameters for an antenna that we can use that I designed using the ARRL Amateur

Tamke-Allan Observatory Antenna Design Sheet						216.98	Megahertz			
Element	Length (in) at 408 Mhz	Spacing (in) at 408 Mhz		New Freq (Mhz)	Element Length (in)	Element Length (cm)	Side Length (in)	Side Length (cm)	Spacing (in)	Spacing (cm)
Loop Reflector	32	0		216.98	60.17	152.84	15.04	38.21	0.00	0.00
Loop Radiator	30.8	7.5			57.92	147.10	14.48	36.78	14.10	35.82
Director 1	12.56	13			23.62	59.99			24.44	62.09
2	12.2	24			22.94	58.27			45.13	114.63
3	12.2	29.8			22.94	58.27			56.03	142.33
4	12.2	38.5			22.94	58.27			72.39	183.88
5	12.2	47.2			22.94	58.27			88.75	225.43
6	12.2	55.9			22.94	58.27			105.11	266.98
7	12.2	64.6			22.94	58.27			121.47	308.54
8	12.2	73.3			22.94	58.27			137.83	350.09
9	12.2	82			22.94	58.27			154.19	391.64
10	12.2	90.7			22.94	58.27			170.55	433.19
11	12.2	108.1			22.94	58.27			203.27	516.30
12	12.2	116.8			22.94	58.27			219.63	557.85

Radio Handbook:

The antenna design is for a Quagi, which should look like the image on the right, if 8 elements



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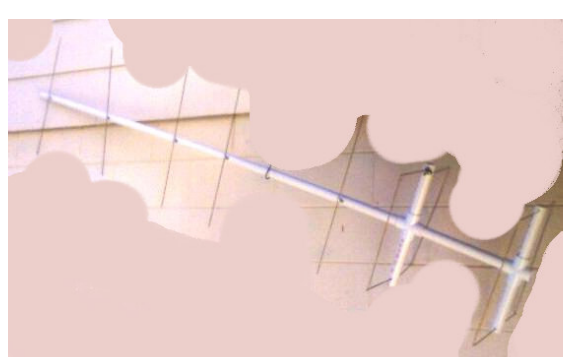


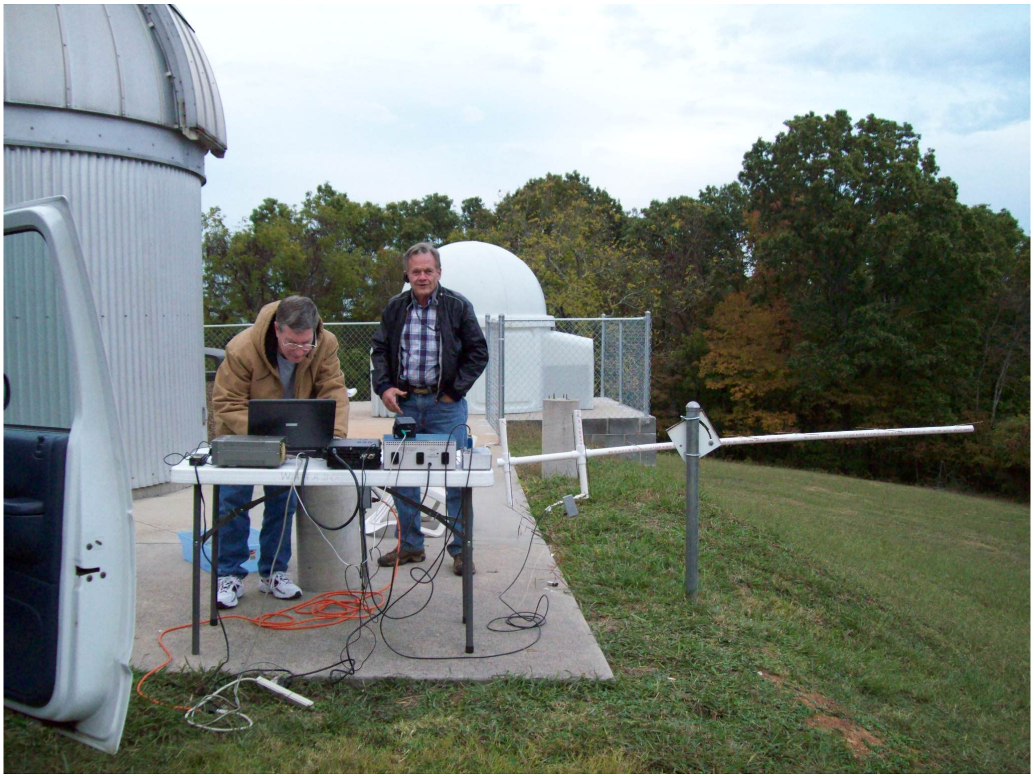
are used. Here's how it looked (on the left) in final 7-element form (last week, just in time for the Orionid meteor shower!

David Fields
N4HBO

TAO

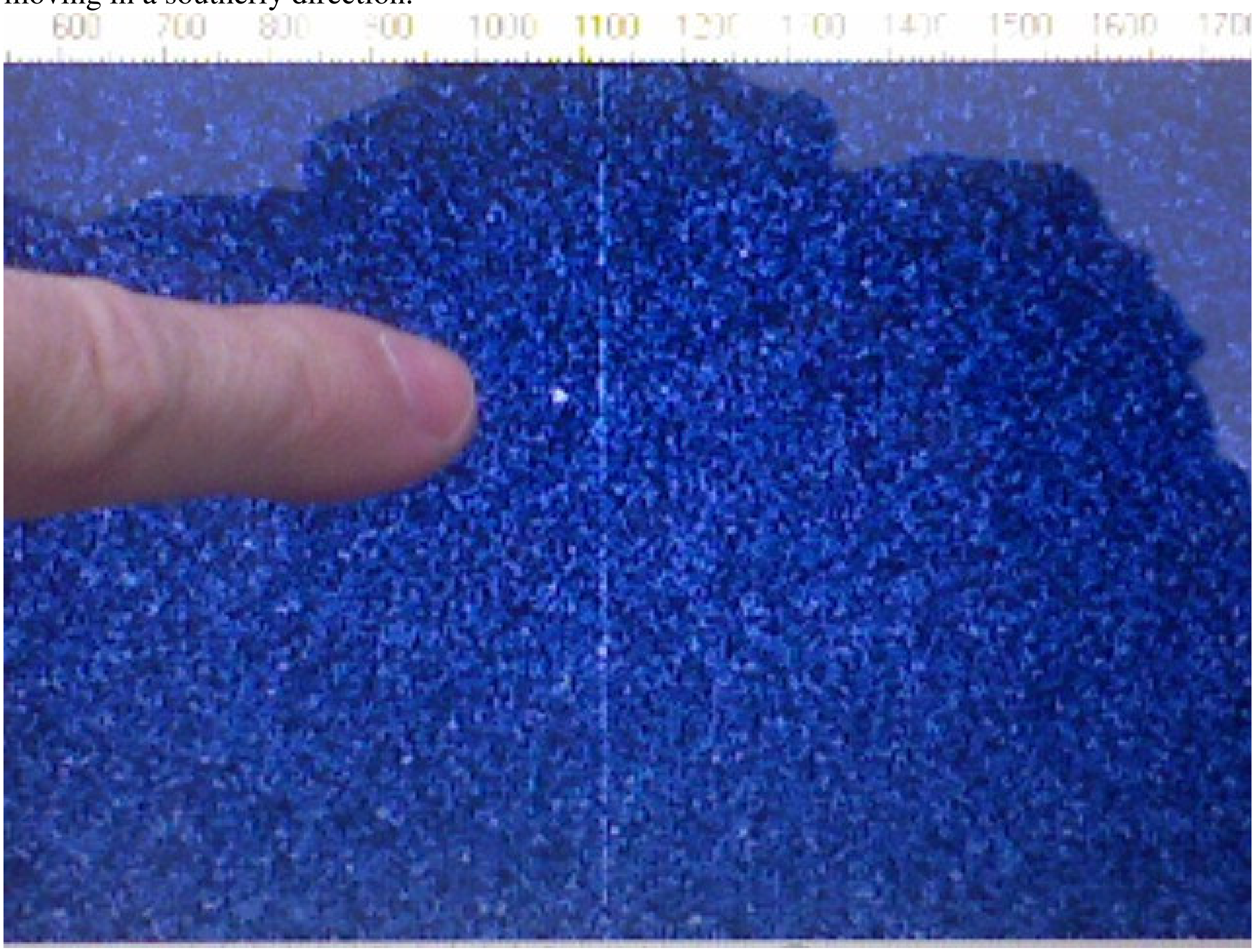
Initial data have been taken from TAO, tracking objects passing through the Naval Space Surveillance beam. Using the antenna described in the Solway Site Report by David and the convertor described in the Karns Site Report by Carl.

This photo, taken before astronomy class where it was used, shows Carl adjusting the spectral display parameters. David is reaching for the laser pointer. To his left is the NAVSPASUR antenna.



The following figure shows the equipment setup. From the left is the receiving down convertor (216.98 MHz to about 50 MHz), the power supply, the communications receiver tuned to about 50 MHz, and the laptop computer running a spectrum analyzer with a water fall display.

This photo of the computer display, taken at TAO, shows a fast object with large Doppler shift, moving in a southerly direction.

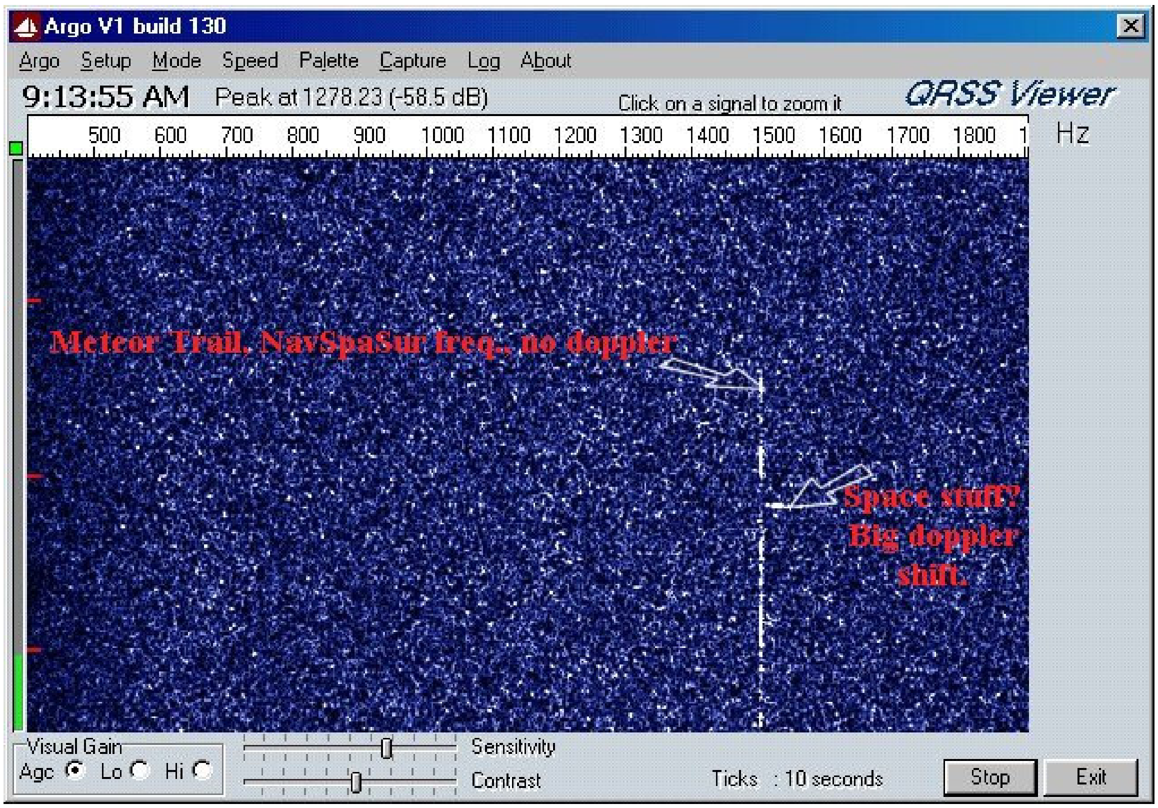


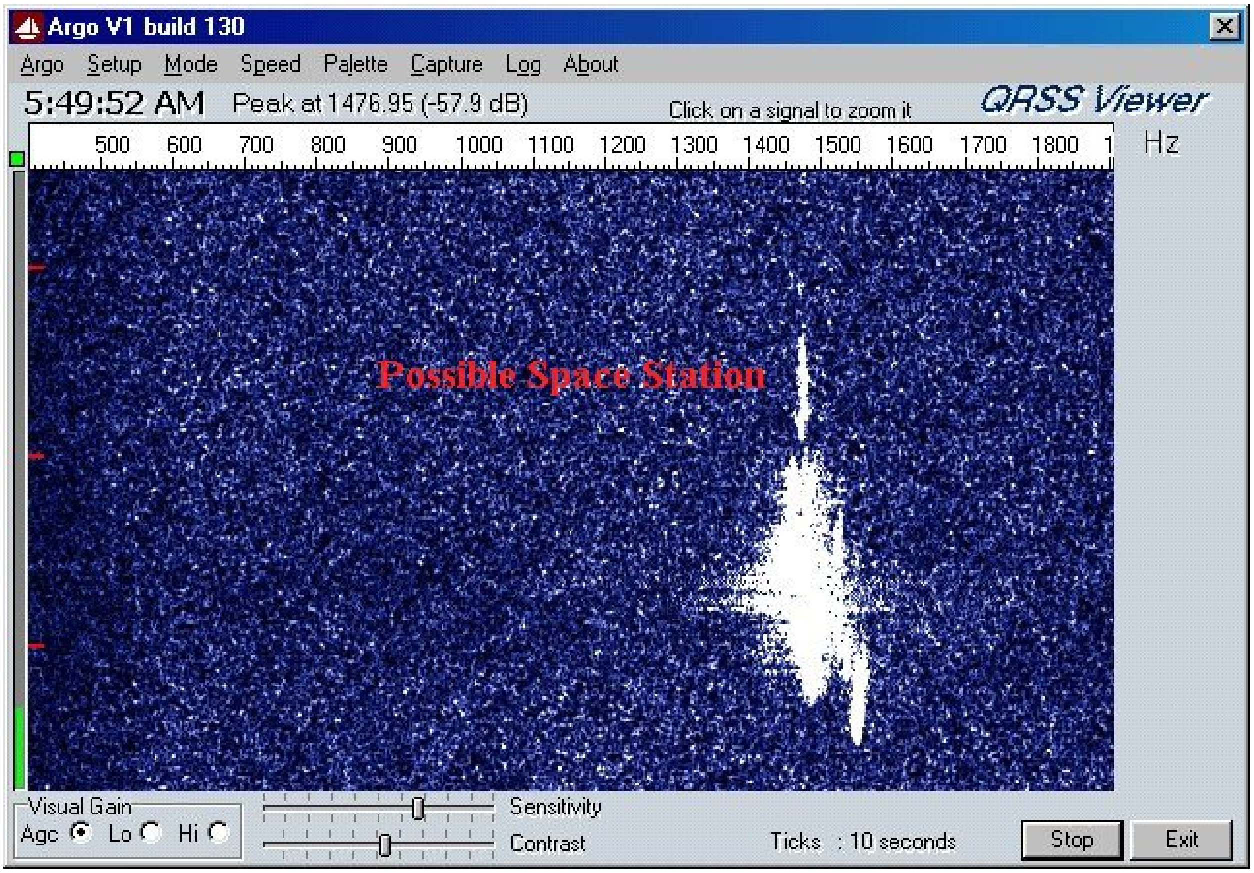
KARNS

Initial data have been taken from the Karns TAOSON site, operated by Carl Lyster, WA4ADG, demonstrating reception of Naval Space Surveillance signals. .

A down convertor was used to shift the reflected radar signal from 216.98 MHz to around 50 MHz. Receiver output was input to the sound card for analysis. Initial scans showed a few apparent meteors, plus a large reflection, perhaps from the space station.

Several spectral analysis programs are available, each with its own strengths and weaknesses. This display, using the Argus program shows the scattered beam signal, plus a possible meteor.





This is a possible detection of the ISS:

VIII. The History of Radio Astronomy

Part One: Origins
Significant Steps and Investigators on The Pathway from 1933 to 1954

by Bill Seymour

I. 1933; Karl Jansky in America.

At the Holmdel Station of The Bell Laboratories while using his creative antenna to determine the levels of radio interference for commercial communications to be expected at a wavelength of 14.6 m, **Jansky** identified a steady hiss component in the radio background and concluded that this hiss coincided with the sidereal day and had to be associated with sources beyond the earth.

II. **1937; Grote** Reber **in America**

This young engineer working in his spare time constructed a 30 foot paraboloid reflector in his back yard in Wheaton, Illinois. After much unsuccessful experimentation, he finally achieved good results at 160 MHz in 1940. The editorial board of The Astrophysical Journal had difficulty deciding whether or not to publish **Weber's** first paper in 1940, which seemed to be so baffling with unfamiliar language and subject matter. Later, In an important 1944 paper, he published a detailed map of the radio sky, showing important features of the galactic radiation from the Milky Way

III. 1944; Jan Oort in Holland

Reber's published papers had very little immediate influence on American Astronomy, but they had an interesting consequence abroad. The Dutch astronomers at Leiden Observatory, under the influence of **Jan Oort**, received the issues of The Astrophysical Journal at the end of World War II. **Reber's** articles were discussed intensively. **Oort** concluded that the crucial need was to discover a spectral line in the radio spectrum. Galactic structure was **Oort's** main interest, but interstellar dust obscures most of our galaxy from view. If radial velocity could be measured by observing a Doppler shift in the line frequency, a powerful new tool would be available to galactic astronomers. An associate, **Hendrick van de Hulst,** showed that atomic hydrogen (the most abundant constituent of interstellar gas) should have a measurable spectral line at 21 cm wavelength. Under **Oort's** direction, the Leiden Observatory was among the first to pursue the new science of radio astronomy and was a major presence for many decades.

IV. 1942-45; G. C. Southworth and J.S. Hey in America

Solar radio astronomy had its start during WW II. Although **Reber** had included a solar radio measurement in his 1944 paper, **Southworth** at The Bell Laboratories in 1942 detected thermal radiation from the sun at wavelengths of 10 cm and 3 cm. Publication was delayed because of the war until 1945. During the same time period, **J.S. Hey** doing research at the Army Operations Research Group showed that intense radar interference in England during 1942 had not come from German jamming activities but rather from the Sun, which had a large group of sunspots at that time. This also marked the beginning of the study of non-thermal solar radiation when **Hey** recognized that the interference was far too intense to be of thermal origin. It is ironic that the celestial radio sources discovered by **Hey,** as well as by **Jansky** much earlier, came as a result of the study of the origins of radio communication interference on earth.

V. 1946; Joseph Pawsey in Australia and Martin Ryle in England

After the war, radio astronomy research intensified. However, the radio bursts previously discovered by **Hey** had small angular sizes, and the filled aperture arrays in general use at that time had beamwidths of several degrees. This created an unacceptable angular resolution. Thus, both the Australian and English groups developed interferometric techniques, **Pawsey** obtaining 8 arcmin resolution at 3 cm wavelength and **Ryle** using a two-element interferometer with which 20 arcmin of resolution could be obtained. During the next ten years, both groups gradually shifted a significant part of their research efforts away from the Solar System to an examination of radio sources in the more distant universe.

VI. 1948; John Bolton and Gordon Stanley in Australia

This new direction was spawned by the previous work of **Hey** and his group who published a 64 MHz map of the sky that confirmed the details of **Reber's** map. Shortly it was noticed that the maximum in Cygnus (approx. 20h plus 40 degrees) showed fluctuations on a time scale of approximately 10 seconds. This suggested that the dimensions of the source must be a few light seconds, comparable to the size of a star, and not many light years (which would occur from an origin in dilute interstellar gas). Thus, the Solar Radiometer at Sydney was pressed into service to find the new radio source. **Bolton and Stanley** saw for the first time Cygnus A.

VII. 1948; Martin Ryle and Graham Smith in England

The radio interferometer in Cambridge was used to observe the Northern sky. In addition to confirming Cygnus A, they found that the maximum emission in the constellation Cassiopeia (near 24h plus 60 degrees in **Reber's** 1944 map) was the most intense radio source in the sky and called it Cassiopeia A.

VIII. 1949; Josef Shklovsky in The Soviet Union

He independently predicted the 21 cm hydrogen line and also suggested that there were molecular lines that might be detected. The hydroxyl radical was seen as a promising possibility, but it was not until 1964 that the work of **Barret et.al.** confirmed the hydroxyl line.

IX. 1950-1954: The Science of Radio Astronomy Develops Rapidly On Three Continents

During this period, the literature reveals a heated controversy concerning whether general galactic radiation was a combination of emissions from multiple radio stars, or just noise from the general interstellar medium. Various proposals going back to the 1937 theoretical proposal of **Whipple and Greenstein** (cosmic dust could not be the source of radio noise) and the 1940 theoretical study by **Henyey and Keenan** (thermal bremsstrahlung from electron-ion collisions in a hot interstellar gas) were not entirely satisfactory. The definitive answer seemed to have been previously given in 1947 by **Charles Townes** who showed that thermal bremsstrahlung from electron-ion collisions could not be the source of the radio noise because a gas temperature of 150,000 degrees Kelvin was required—higher than any investigator at the time would be willing to accept. From **Jansky's** time, it was generally postulated that stars such as the Earth's Sun could not be responsible for the observed radio wave intensity in the sky. Clearly, the discovery of a new type of emitter was needed, and the matter took several years to resolve.
By 1950, both British and Australian radio astronomers showed that fluctuations in intensity of discrete radio sources were caused by scintillation of the earth's ionosphere and were not a property of the radio sources.
Concurrently, optical identification of radio sources began to be published, the first in 1949 by **Bolton, Stanley, and Slee.** They showed that the radio source Taurus A was probably in the Crab Nebula, the supernova remnant of 1054 A.D. Further, **Bolton, et. al.** also showed that the

positions of the radio sources Virgo A and Centaurus A agreed with the sky locations of the bright galaxies M87 and NGC 4528.

In the following years, theory moved rapidly. In 1950, **Alfven and Herlofsen** had tentatively postulated that "radio stars" generated their radio emissions by a synchrotron process--the harmonic radiation generated by electrons of relativistic energy circulating in magnetic fields. Evidence of the existence of interstellar magnetic fields had been shown by **Hiltner and Hall** who determined the previous year that starlight is polarized. The most reasonable deduction was that interstellar dust grains are elongated and aligned by the action of a large scale magnetic field imbedded in the interstellar gas.

Enrico Fermi had supported this foundation in 1949 with the idea that cosmic ray particles are accelerated by collisions with interstellar gas clouds in which the magnetic field is embedded.

Keipenheuer advanced the idea of galactic background radio sources in 1950 by suggesting that the source is synchrotron radiation from cosmic ray electrons gyrating in the galactic magnetic field. As opposed to thermal bremsstrahlung, this mechanism was definitely non-thermal. It was becoming clear that the discrete radio sources also had too high a surface brightness to be characterized by an equilibrium thermal mechanism.

The Soviet theorists were quick to follow with the 1953 proposal of **Shklovsky** that the optical and radio emissions from the Crab Nebula are mainly synchrotron emission from energetic electrons in this supernova remnant.

In 1951, new initiatives in radio astronomy by **Oort** resulted in almost simultaneous observations in Holland (**Van de Hulst**), America (**Purcell and Ewen**), and Australia (**Christiansen**). These three teams reported their results in the same issue of <u>NATURE</u> that year. Also in 1951, efforts intensified among the British, Australians, and Americans to use precise radio sources to allow faint optical objects to be identified. **Smith** at the Cavendish Laboratory, **Mills** at Sydney, and **Baade and Mindowski** of The Mount Wilson Observatory produced some astonishing results. Cassiopeia A is apparently associated with a compact region of faint nebulosity, with wisps of varying radial velocities-- this is indeed a remnant of a supernova explosion.

The radio source Cygnus A turned out to be associated with a more surprising object-- a faint galaxy having a peculiar emission line spectrum and an enormous recession velocity of 16,000 km s-1. In spite of its great distance, Cygnus A has turned out to be the most intense extra-galactic object in the sky.

These results were reported at the 1952 International Astronomical Union (IAU) General Assembly in Rome and published by **Baade and Mindowski** in 1954. <u>The importance of the new science of radio astronomy was established and its future was secure.</u>

A vast range of new phenomena were now available for investigation: known supernova remnants like the Crab Nebula, supernova-related objects such as Cassiopeia A, nearby peculiar galaxies such as NGC5128 and M87, and very distant radio galaxies similar to Cygnus A. The study of galactic structure was being transformed by the availability of 21 cm neutral hydrogen radiation published by **Kwee, Muller, and Westerhout** in 1954.

Bernard Lovell founded a new branch of radio astronomy, the study of meteors by radar. A broad program including innovative radio interferometry studies of radio sources was also taking place in many countries.

X. 1954 and Beyond

New radio instruments of ambitious size were being planned and built at many observatories. New surprises in radio astronomy, such as quasars, pulsars, interstellar masers, and the cosmic background radiation lay in the future.

But the groundwork of radio astronomy had been firmly laid.

Source: Information compiled from An Introduction to Radio Astronomy, by Bernard F. Burke, Massachusetts Institute of Technology; and Francis Graham-Smith, Jodrell Bank, University of Manchester. Cambridge University Press, 1997.

Editor's Note: "The History of Radio Astronomy, Part Two—The Mature Science; 1954 to The Present Time" will be published in a later issue of The TAOSON Signal.

IX. Correction

(Editor's Note: The paragraphs below were inadvertently deleted from John Mannone's Anecdotal Biography in The September issue.)

The emphasis of space missions is rarely radio astronomy; nevertheless, its role is essential.

Though amateur radio astronomy doesn't require any special skills, understanding of basic electronics is helpful. However, the multidiscipline nature of astronomy in general and radio astronomy even more, draws many to the hobby. My academic background is particularly well suited for radio astronomy because it is a varied composite of the sciences and engineering: Electrical Engineering (Ph.D. candidate/University of Tennessee Knoxville, 2002), Plasma Physics (M.S./University of Tennessee Knoxville, 1988), Physical/Theoretical Chemistry (M.S./Georgetown University, Washington, DC, 1978), Chemistry (B.S./Loyola College, Baltimore, MD, 1970).

My academic interests are in astrophysical plasmas, particularly the solar wind and the ionosphere. I enjoy the study of electromagnetic theory, magnetohydrodynamics (MHD), wave-particle interaction and plasma bubbles. Radio astronomy plays an important role in their study. However, I am impassioned to advance astronomy education and astronomy outreach. I am especially interested in developing novel, as well as inexpensive, experimental techniques and analytical tools. Most notably is the application of fast Fourier transform (FFT) techniques to amateur radio astronomy.

Concerning visions or goals, I am driven toward improving recognition of amateur radio astronomy by the professional community. In addition, my efforts continue to ensure a more prominent position for SARA among the international amateur radio astronomers.

Many friendships have developed since I became an amateur radio astronomer, perhaps too numerous to list here; however, I feel compelled to draw attention to two individuals with whom I have collaborated: my friend and colleague, David Fields, who fosters an atmosphere conducive to critical thinking and most notably, the lovely Wanda Diaz, another fine physicist and dearest friend.

X. The Basics

Key concepts in radio astronomy are beamwidth, polarization, signal detection, and noise**.**

Beamwidth
The range of directions over which the effective receiving area of the antenna is large is the antenna beamwidth.

Polarization
Polarization is one of several physical phenomena (including interference and diffraction) that reveal the underlying wave characteristics of radiated energy. Polarized radiation is vibrating in one plane rather than in all directions. When photons are polarized, they are therefore given a directional coherence. Radio waves can be unpolarized or polarized. Types of polarization include simple linear, partial, circular, and elliptical.

Signal Detection and Noise
The accuracy of radio astronomy observations will be limited by the general background fluctuations that are known as noise. The detected signal is the sum of both the astronomical signal of interest and the interfering noise that is always present. The signal-to-noise ratio that is achieved in a detecting system depends on the duration of the observation and the bandwidth. A radiometer is defined as a device that distinguishes the astronomical signal from the interfering noise.

Sources: Information compiled from
An Introduction to Radio Astronomy; Bernard F. Burke and Francis Graham-Smith;
and
Physics; Eugene Hecht

XI. Notable Quote

> Of all human inventions, the most important has been the development of written language.
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> Carl Sagan, Cosmos