British Astronomical Association

Radio Astronomy Group

Baseline 2006 April
Volume 1 Number 3
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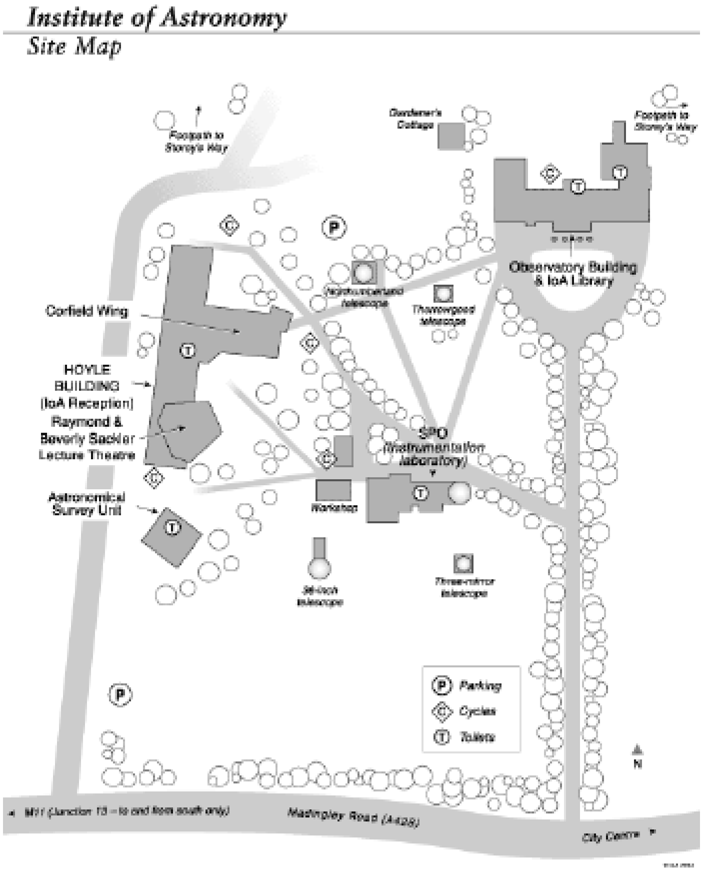
VLF Receiver Launched

www.britastro.org/radio

GROUP NEWS

Group Meeting Institute of Astronomy 2006 September 23 10:30



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Lat: 52:12:52N (52.2145)   Lon: 0:05:43E (0.0954)

Dr Jim Cohen, Jodrell Bank
The Methanol Multibeam Project

The Methanol Multibeam (MMB) Project is a joint UK and Australian project to survey the Milky Way for methanol masers, which signal the birth of massive new stars. A purpose-built 7-beam receiver was jointly constructed by Jodrell Bank Observatory and the Australia Telescope National Facility. It was commissioned in January 2006 and in its first science run on the Parkes Telescope it detected 94 new methanol masers. Jim will describe the scientific rationale for the project, the multibeam receiver, and present some of the latest results.

Dr Laurence Newell
The *Starbase* Project

David Farn
The BAA RAG Hydrogen Line Receiver

John Cook
Preliminary Results with the VLF Receiver

Members' Presentations

Transient Radio Bursts

The discovery has been announced of a previously unknown type of rotating neutron star radio source, varying on timescales of minutes to hours. Eleven objects characterized by single, dispersed bursts having durations between 2 and 30 ms. The average time intervals between bursts range from 4 min to 3h with radio emission typically detectable for less than 1s per day.

Maura.McLaughlin@manchester.ac.uk
Nature 439, pp817-820 (2006 February 16)
taco.nature.com/nature/journal/v439/n7078/full/nature04440.html#abs

Anomalous X-ray Pulsar

Another fairly new object is the Anomalous X-ray Pulsar (AXP). They are now widely believed to be *magnetars* – young, isolated, highly magnetized neutron stars. These energetic X-ray pulsars are characterized by slow rotation periods of ~5-12 seconds and large magnetic fields. Less than ten are currently known.

en.wikipedia.org/wiki/Anomalous_X-ray_pulsar

Flight Refuelling Amateur Radio Society

RAG members in the Poole and surrounding area are invited to discuss possible collaboration using the facilities and expertise within the *Flight Refuelling Amateur Radio Society*. They have members who are actively operating and constructing at 1GHz-10GHz and have exclusive use of a 3.7m parabolic antenna. They would also be interested if any local members would be willing to give a talk at one of their regular club meetings. Contact Julian Smith on jules@g0nzo.co.uk.

Radio Fireball Event Database Launched

A new database has been launched to correlate the FFT spectra from radio fireball events. Many interesting observations can be found at:

www.flickr.com/photos/radiofireballs
www.tvcomm.co.uk/radio

For more information, contact Andy Smith
g7izu@television.f9.co.uk

Many thanks to Jeff Lichtman for some of the news items!

Baseline

2006 April Vol. 1 No. 3

The Circular of the Radio Astronomy Group

Editor Dr Laurence Newell

Secretary Mrs Karen Holland

The *Circular* is published four times per year. The BAA is not responsible for individual opinions expressed in articles, letters, reviews or reports of any kind. Material published in the *Circular* does not necessarily express the views of the BAA Council or of the RAG Officers.

Contributions

Please send all contributions to Karen Holland, either in paper form, or electronically.

karen.holland@xcam.co.uk

It is our policy to use Système Internationale (SI) units wherever possible.

www.simetric.co.uk

Advertisements

Advertisements are invited from both commercial vendors and from individual members. Please make sure that any images are supplied with at least 100dpi resolution, preferably not compressed (by JPEG etc.). There is no charge for this service.

Deadline

All material submitted for publication in the *Circular* must be received by the Editor no later than one month before the next publication date.

Membership of the RAG

There is currently no subscription for membership of the Radio Astronomy Group or for the PDF form of the Circular. If you wish to make use of the *Starbase* Plug and Play Observatory, please contact Karen Holland for a client configuration form.

radiogroup@britastro.com

www.britastro.org/radio

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Radio Astronomy Group Meeting
University of Cambridge
Institute of Astronomy
2006 September 23

From the Coordinator

Laurence Newell
Radiogroup@btinternet.com

Group News

Officers

For personal reasons Terry Ashton has had to step down as Assistant Coordinator and 2.695GHz team leader for the time being. I would like to thank Terry for his support and advice as the Group has been growing, and hope that he will soon be able to rejoin us full time, and to continue to contribute to our success. The post of Assistant Coordinator is therefore currently vacant. Terry will, however, be assisting Peter King in the renovation of the MRAO 151MHZ interferometer, and we are grateful that he is able to take on this role.

Paul Edwards has kindly agreed to take over the leadership of the 2.695GHz project, with much appreciated assistance from Martyn Kinder (and we are not letting Terry go from the team that easily!).

Stuart Withnall has also decided to withdraw from the development team, and we thank him for his contributions.

Membership

We now have 140 members on our email and postal mailing lists. This is 30 more people since the last Circular, representing a recruitment rate of one every three days! The full list of members is again given at the end of the *Circular.* If your information is incorrect, please don't hesitate to contact us with any corrections. There is currently no charge for membership, and you do not have to be a member of the BAA, although we would like you to join! We have recently correlated our membership list with that of the BAA, and find that about 40% of the RAG are members of the BAA.

Group Events and Publicity

The continued rise in membership stems largely from our attendance at several events in the past few months. Sales of Circulars remain good - we are now in our third print run. If you know of an event at which the Group could have a presentation or a display stand, please let us know. We have been to the following events since the last *Circular*.

- Orwell Astronomical Society, Ipswich
- BAA Observer's Workshop, Milton Keynes
- BAA Winchester Weekend
- ARRMS Microwave Conference

We will also have a stand at the forthcoming BAA Exhibition Meeting at the Cavendish Laboratory, Cambridge, on Saturday June 24th. This is an important event on the BAA calendar; please try to be there!

Cambridge Meeting 2006 September 23

The date of our next public meeting has been set. We have booked the lecture theatre at the University of Cambridge Institute of Astronomy, for Saturday September 23rd, starting at 10:30. It may be possible to arrange for a tour of the MRAO on the Sunday, if there is sufficient interest from people willing to stay overnight. Please let myself or Karen Holland know as soon as possible. The preliminary meeting details are given on the inside of the front cover. The Institute of Astronomy is easy to get to, and there is ample car parking.

Technical Team Meetings

The planned development team meeting took place in Northampton on January 14th, and a report is given later in this *Circular*. Another meeting is scheduled for May 13th, where we hope to examine the prototypes of the 2.695GHz and Hydrogen Line receivers, and to finalise the design goals of the controller module. By that time we should have some feedback from the VLF Receiver beta testers, so we can decide on when (or if!) to make the next batch. We also hope to approve the production of a dual-axis magnetometer module, designed by John Cook.

Northampton Meeting 2005 CD ROM

The first Group Meeting in Northampton in 2005 October was so successful that we decided to produce a CD ROM containing all of the presentations (and other miscellaneous materials). The CD is at last available, and has proved to be very popular: we have already sold nearly 50. They are available from Karen, as described in RAG MART. (The presentations are in Microsoft Powerpoint format; some material is in PDF or MPEG.)

Circular Contributions

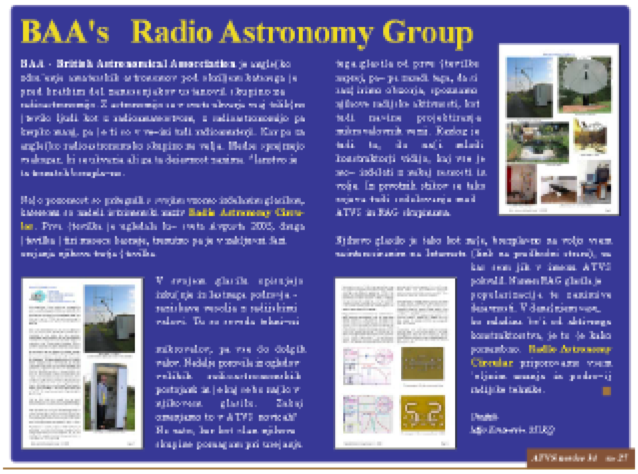
I am very aware that there is still no printed discussion of the design of the *Starbase* software or database, or of the Controller Module. Please bear with us, we want to get it right before plunging into print! We have had extensive discussions about the architectural approach, and the development options. The technical team would like to hear your views on these any any other matters.

There is a short article later in the *Circular* giving guidance for potential authors. If you intend to submit an article, please take the time to read the advice - we are still getting material which requires reworking in order to maintain the quality of reproduction. The usual culprits are diagrams which do not scale well, or the use of JPG or similarly compressed images. Microsoft Word is a mixed blessing – it is best to *avoid* it, please! Microsoft Visio is an excellent choice for the preparation of diagrams. Please help me to print as many articles as possible by making my 'assembly job' easier!

VLF Reports

John has produced a paper summarising the past year's results of our first active Observing Programme. He continues to issue VLF monthly reports to those on his mailing list. If you would like to receive the reports, please contact John. They will (eventually) be available as PDF downloads from our website.

ATVS – Slovene ATV association


BAA's Radio Astronomy Group

We have kindly been given advertising space in the newsletter of the Slovene ATV Association, which was filled by the latest version of our flyer. A page from the newsletter shows material from our Circular in Slovenian!

Mijo Kovacevic, S51KQ. Slovenian ATV & Repeater Manager, ATVS Slovene ATV association, P.O.Box 11, SI-3212 VOJNIK lea.hamradio.si/~s51kq

Aims and Objectives

Here once again are our Aims and Objectives. You are encouraged to distribute the *Circular* to anyone you feel may be interested in our activities.

Aims and Objectives

- To give assistance to new amateur radio astronomers
- Set up a panel of Technical Advisors
- Co-ordinate Group Observing Programmes
- Encourage information exchange
- Provide design information, hardware and software

Development Project

- To produce a modular *Plug and Play Observatory*
- No radio or electronics expertise required by users
- Multiple receivers with programmable controllers
- Integrated software and database of observations

Group Officers

The Group administrative officers are:

Group Coordinator	Laurence Newell
Assistant Coordinator	*vacant*
Group Secretary	Karen Holland

Technical Teams

The members of the development teams and Observing Programmes are listed below. Email addresses are available in the List of Members at the end of the Circular.

2.695GHz Receiver

Paul Edwards
Martyn Kinder
Terry Ashton

1.420GHZ Receiver

David Farn
Alan Morgan

VLF Receiver (and Magnetometer)

John Cook
Karen Holland (production and testing)

Controller Module

Mark Byrne
Laurence Newell
Trevor Sutton

Starbase Java Software

Laurence Newell
Trevor Sutton

Database, FTP and Website

Database	James Wilhelm
FTP server	Martyn Kinder
Website	*vacant*

MRAO 151Mhz Liaison

Peter King
Terry Ashton

Laurence Newell

Group Coordinator
2006 April

Secretary's Report

Karen Holland
karen.holland@xcam.co.uk

Summary of the MK meeting with BAA Officers

A small sub-group of the Technical team (Laurence, Karen, Martyn Kinder and Trevor Sutton) were able to get to the Milton Keynes BAA meeting to talk to some BAA officers (President Richard Miles, Vice President Tom Boles and Treasurer David Boyd) about the proposed module production. In particular we wanted to know if we would be permitted to make and sell the units with the BAA's name and logo on them, or if this might prove difficult.

The outcome of this brief meeting was that, for the time being we will sell the units as a *closed-group*, to BAA members only, but without the BAA logo and name on. The discussion has clarified the issue of how we handle our finances, and from now on, all money that has been generated specifically from BAA activities, such as the sale of Circulars, CDs, any profits from meetings etc, will be paid directly to the BAA, who provide us with a budget to help us to run the group. Any financial transactions that relate to the manufacture or sale of our Plug and Play Observatory (PnP) modules, will now go through a separate bank account, that is not linked to the BAA in any way.

In practice this means that if you are paying the group for Circulars, CDs, meeting attendance etc., or anything that has the BAA's name or logo associated with it, then any cheques should be made out to the *British Astronomical Association*. If you are paying us for a VLF module, or in the future, other PnP modules, or if you wish to donate money to the group's PnP project, then cheques should be made out to *Radio Astronomy Group*.

Laurence will manage and run the BAA budget and finances relating to income and expenses associated with our BAA 'account'. If anyone thinks that they might incur expenses relating to the work of the group, which they might want to claim, then they must contact Laurence before they spend, to ensure that he is happy to sign the claim form that you will need to submit to him (available from me or Laurence).

I will manage and operate the Radio Astronomy Group bank account, that is associated with the project funds, although Laurence has access to this account also, via the Internet In order to maintain openness, with respect to this account, I will present a summary of the accounts in each Circular. If anyone would like a full-copy of the accounts that I maintain, please contact me, and I will supply a copy. The PnP project is intended to be non-profit-making, and any change in this state would be notified.

Financial Report 2005-09-27 to 2006-03-31

This report of the accounts, when read after the note above, will appear to contradict what I have said about where the money should go! This is because, until we had the meeting at Milton Keynes, it was not entirely clear how we should operate the account. Future reports of this account will show transactions relating to non-BAA group activities only.

Income

Harold Ridley Grant	£250
Cash from Meeting 2005	£115.50
Cash from meeting for pcbs, raffle etc.	£52.27
Cash for Circulars	£99.50
Interest	£0.17
Meeting Donations by Technical Team	£72.50
VLF Rx modules	£222.90
Total	£812.84

Expenditure

Speakers 2005 expenses	£110
Transfer of Cash to BAA	£209.87
VLF Rx Boxes	£201.52
Total	£521.39

Current Balance	£291.45

Membership Enquiries

Membership of the section is currently free, and simply involves giving us your details to store in our database, so that we can add you to our email (or postal, if necessary) distribution list to keep you informed of activities and news about the group.

If you would like to join, please send me your details; the minimum I require is your name and email address (for email only contact), but I would be very happy to receive additional information such as your address, telephone numbers, and information regarding your level of experience, or specific interests in radio astronomy, especially if you feel able to help us with one of our projects.

Circular Subscriptions

Although the circulars are downloadable from the website in PDF format, some people prefer a paper copy of the Circular. If you would like to take out a subscription, you can send me a cheque, made out to the British Astronomical Association, for £3.50 per issue. Please do not send money for more than 4 issues at a time. The circulars will be posted out each time, and a subscription reminder will be sent out when you receive your last issue.

Speaker List

I have been producing a speakers list that will be made available on our web pages. The aim of this list is to provide a useful resource for schools and local societies, that will also help to promote radio astronomy. The list will include anyone who is willing to give talks on any area of radio astronomy. The list is not intended to be a list of speakers who will promote the BAA radio astronomy group, although we would, of course, be happy to provide publicity material to anyone who is happy to distribute it.

If you feel that you would like to be included on the list, please let me have your name, contact details and any other information that is relevant such as the specific talk title or area that you are happy to talk about, together with any geographical restrictions that you might apply. If in doubt, leave information out, as you can always opt to reject an offer to speak if you feel that an invitation is not suitable, and you might be in a position to recommend one of the other speakers.

Current speakers on the list are:

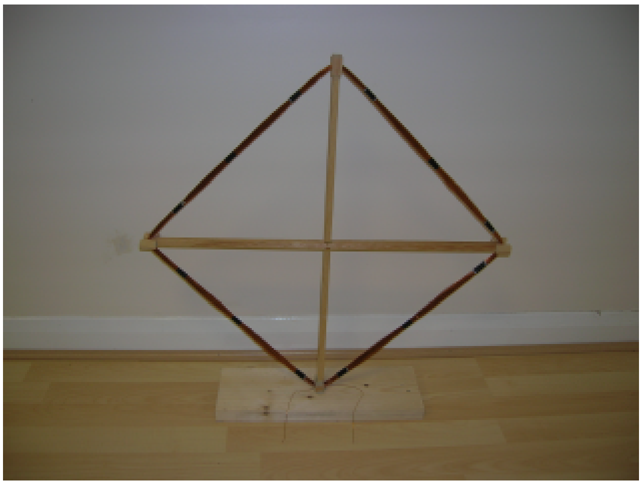
Brian Coleman: *Radio Astronomy – a beginners view*
Bob Marriott: *The History of Radio Astronomy in the BAA*
Laurence Newell: *Introduction to Radio Astronomy in the BAA*
James Wilhelm: *TBA*

VLF Receiver Production

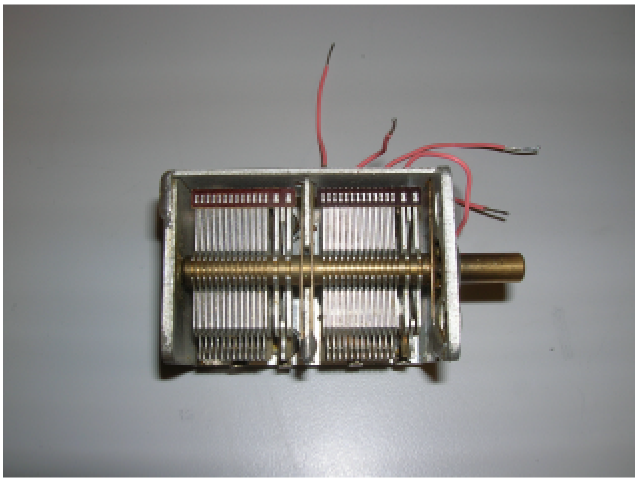
Since my last report, things have progressed considerably with respect to VLF receiver production.

After the 10 bare PCBs were supplied to me some time ago, I sent one off to John Cook, who kindly assembled one and fully tested it, before returning it to me. This meant that I had a known good, and tuned-in receiver, ready to work with.

I built an aerial, according to John's instructions (see the photograph below), and used a number of polystyrene capacitors as padding capacitors in parallel with an air-spaced variable capacitor, to tune it into 19.5 KHz.



The Holland Loop



Tuning Capacitor

19.5kHz is the frequency that the receiver had been tuned to, in order to receive the signal from the Anthorn military transmitter in Cumbria, which John felt was a fairly reliable transmitter to use. For the combined A2D and datalogging software, I bought a Maplin Electronics, intelligent autoranging digital multimeter with PC interface (N38BZ now £29.99); this has an RS232 PC interface using a serial cable, and comes with software, test leads and manual.

This meant that I had my system working reasonably well, and this was shown working at the Winchester meeting, although I think that I still need to set the gain a little higher; it is clear that it takes some time and fiddling around to get the systems working correctly!

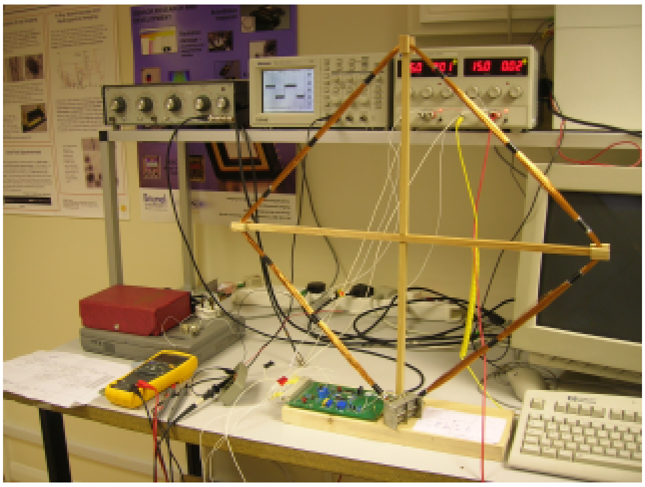
I ordered all the parts for assembly of the remaining 9 systems, and my son Mike assembled this first batch as shown in the following photographs:

Prototype VLF Assembly by Mike Holland

Of these remaining 9 systems, I sent 3 out immediately to people who were willing to take them untested (Laurence, Martyn Kinder and Trevor Sutton), and they provided me with my first set of feedback regarding the construction of the boards, so that I could take account of this for the remaining 6 boards. Martyn had his receiver up and running extremely quickly, and took it as a demonstration system to the Milton Keynes meeting.

I started to try to test out the boards using an old pulse-generator that I have at work, to inject a signal in place of the antenna, for test purposes only, but unfortunately the signal levels that this provided were rather too large to be suitable. John Cook kindly provided me with an 18.4KHz oscillator that is far more suitable, and I have started to use this to set up the receivers.

I am currently in the process of working through each transmitter, checking firstly that the current levels drawn are consistent with normal operation, and then setting the potentiometers (for frequency tuning, Q and RF gain) to a level at which correct operation can be confirmed (by checking pin 14 of IC1 of the circuit.



The VLF Test Rig

This photograph shows the test set-up, during which I was checking out my receiver settings prior to checking the rest of the prototypes. For each receiver I am producing a test sheet, which includes the oscilloscope trace of the output of IC1 pin 14, together with the oscillator input signal, when the receiver is operating correctly, and noting the current drawn and any other test details noted. At the current time, I am not clear how much effort I should put into setting the receivers up, as this is a task that could expand to fill much time! For the moment, I am simply setting the receivers up so that they are tuned into the 18.4KHz test signal, and have a reasonable gain without oscillation. The receiver recipients will need to tune the receivers into whatever frequency they intend to use, and set the gain to a suitable level; my quick test only serves the purpose of ensuring that there have been no manufacturing errors, and that the receiver is functioning. I am hoping that the beta-testers will provide me with feedback to help me to improve the testing of the next batch, if this is thought necessary.

The VLF Production Line

I have also just received the boxes that the receivers will be housed in, and have started to install the tested boards in the boxes. I expect to have these remaining 6 boxes completed this week, and will be sending a mail to the beta-testers to ask them to send the balance of payment, ready for receipt of their boxes.

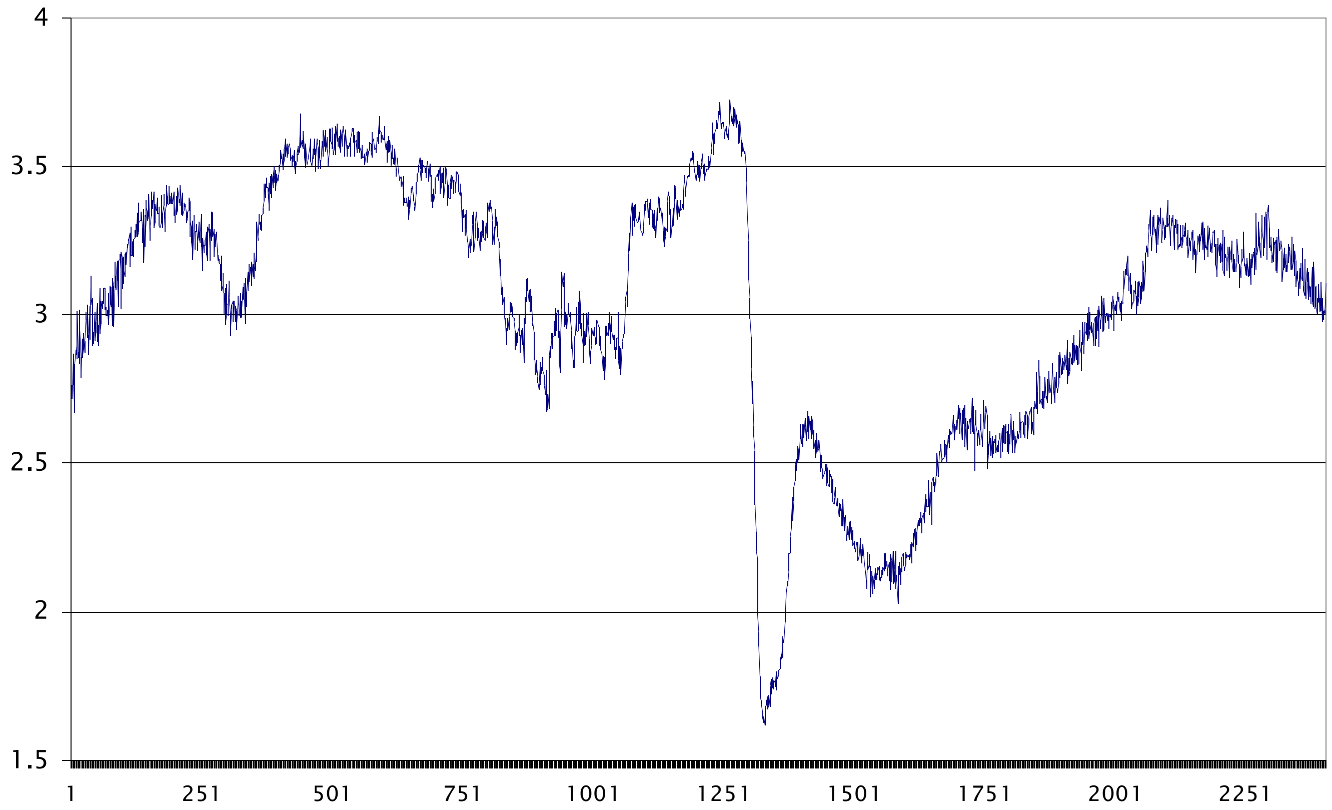
The Next Build of VLF receivers, and Beyond

Although the current batch of receivers is only just at the stage of being shipped to the beta-testers, and I would like to allow them some time to evaluate the modules before embarking on the next build, I am currently maintaining two waiting lists for VLF modules. One list is for people who would like to receive a VLF module in advance of the controller being ready, and the other list is for people who would like a VLF receiver once they are able to buy the controller also. Recipients of the early VLF receiver (without the controller) will need to feel happy that they can deal with the A2D conversion and provide the data logging software that is required.

I currently have eight names on the list for the next build, and one person awaiting the final version of the receiver with controller. If you would like to be added to either waiting list, please let me know. Once I am ready to start the next build, I will contact list-members asking for a £25 deposit if they are still interested, and the balance of payment will be requested when the unit is ready to be shipped.

The current cost of the VLF receiver is approximately £90, and, in addition to this you need to supply the materials necessary to construct the aerial (approximately £10), the variable capacitor (£13 from Jackson Brothers, although we are looking for cheaper alternatives), and the A2D converter (£29.99 if using the Maplin multimeter, or less if you build one yourself and use with freely available data logging software).

Providing all goes well, I anticipate starting the next batch of receivers at the end of June, to give the beta-testers two months to set-up and use their receivers and provide me with feedback that might influence the next build. I estimate that it will normally take me approximately 8 weeks to get a build out (doing this in my spare time), but in the case of the next build, August summer holidays may add a few weeks to that time.



First Light from the Holland Loop!

A recording made on 2006 April 22, showing the effect of sunrise near the centre.
The vertical scale is in Volts (a direct output from the receiver),
and the horizontal scale shows the number of samples taken.

A Total Flux HF Radiometer

Colin Clements

clem@c-clements.go-plus.net

This article is aimed primarily at three specific groups:

- the rank beginner
- those with limited 'real estate'
- school physics groups as a possible first R.A. Project

Summary

It has long been known that Solar, Jovian, and Cosmic radio noise storms can be detected at High Frequencies (3 to 30 MHz, HF) with modest equipment. The stronger examples of both Solar and Jupiter noise storms are detectable with only a half-wave or folded dipole connected to a Short Wave receiver of reasonable sensitivity. As the attenuation of HF signals through brick and slate is minimal, the author wanted to investigate the viability of a simple Radiometer employing a loft-mounted dipole for the detection of the Sun, Jupiter, the plane of the Galaxy, and perhaps one or two of the strongest discrete sources. The Radio Astronomy service has a frequency allocation (with *shared primary status*) from 25.55 MHz to 25.67 MHz; while this is fine for continuum sources such as the Sun and the Galactic plane, Jovian radio emission has a defined spectral peak at around 10MHz and its flux density decreases sharply above this frequency (up to a cut-off at around 40 MHz). Amateurs have traditionally monitored Jupiter from 18MHz to 21MHz as a compromise between ionospheric transparency (10 MHz signals are effectively blocked) and the flux density of the received emission. It will be clear that any receiving system intended to detect Solar, Galactic, *and* Jovian HF radio emission will need to be frequency-agile (given the crowded nature of the Short-Wave spectrum) and the critical component will therefore be the aerial. Conventional dipoles are narrow-band devices, but there is a little known dipole with wide-band characteristics that allows us to get round this problem.

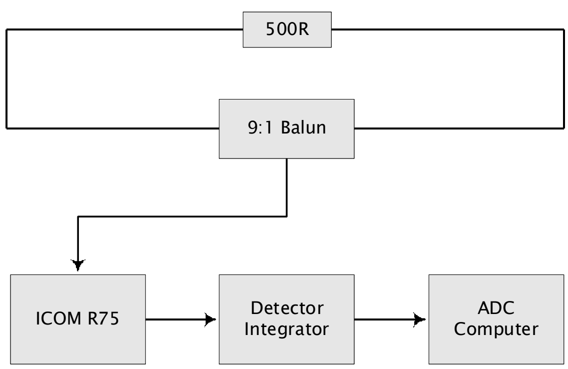


Fig 1 The Radiometer

Figure 1 illustrates the basic Radiometer layout; a single dipole feeds into an HF receiver, the audio output of which is rectified and averaged. A single-channel ADC and computer act as the data logger.

The Receiving System

The Radiometer comprises only four components:

- a specialized wide-band dipole known as the 'T2fD'
- an ICOM R-75 HF receiver
- a detector / integrator
- a data-logger (computer and ADC)

The Aerial

First developed in the U.S.A. during the late 1940s, the 'Terminated Tilted Folded Dipole' (T2fD) is a rarely encountered dipole terminated internally with its characteristic impedance (Fig. 2).

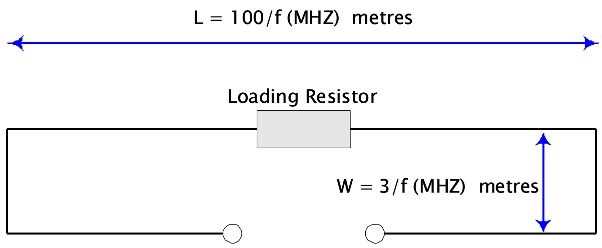


Fig 2 The Terminated Tilted Folded Dipole

This renders the device much less sensitive to sources of man-made radio interference such as fluorescent lighting, domestic electric wiring, television sets etc., and unlike more conventional dipoles its performance is little affected by structures in close proximity such as walls and metal pipes. The T2fD is a 'Travelling Wave' antenna and by ensuring a constant impedance throughout its entire length, signals are less prone to distortion. It has a deserved reputation as a 'quiet' antenna but its most surprising feature is a 5:1 frequency coverage i.e. it will receive efficiently from the lowest design frequency up to five times that frequency *without 'dead zones'*. It was this wide-band characteristic that first attracted the author's attention. Claims are also made for some signal gain although exact figures are disputed.

Most published designs employ a 390R resistor with a 4:1 balun, but L.B.Cebik [1] has shown that the standing wave ratio varies greatly across the frequency coverage with this combination. Higher values of resistor yield an improvement in standing wave ratio (SWR) and Wellbrook Communications [2] market a purpose built T2fD magnetic balun with an integral 500R resistor and a 9:1 impedance ratio; this is the balun the author has employed. Incidentally, the only purpose 'tilting' the dipole serves is to improve the geographical reception pattern; it has no effect on the operational performance and when mounted horizontally will exhibit a beam pattern similar to conventional dipole configurations. The design equations for the T2fD are simple: the overall length is 100 divided by the lowest required frequency in megahertz, with the result in metres. The dipole width is 3 divided by the lowest required frequency (MHz) with the result again in metres.

The Receiver

Following recommendations by R.S.Flagg [3], the author purchased an ICOM R-75 HF Communications receiver. This unit has certain features that make it particularly suitable for Radio Astronomical purposes:

- two-stage internal RF pre-amplifier
- frequency coverage to 60 MHz
- an AGC disabling function
- multi-mode reception capability

This last feature is relevant as the R-75 has a wider dynamic range in the *Single Sideband (SSB)* mode than in conventional AM, and for this reason Mr. Flagg recommends that the receiver be operated in SSB for both Jovian and Solar monitoring. ICOM has ceased production of the R-75, but examples of the type are now appearing on the second-hand market and the author purchased a unit for £360 in 2005. New receivers may still be available from specialist suppliers and should cost around £650.

The Detector / Integrator

Output is taken from the external loudspeaker socket (a 3.5mm miniature jack) on the rear of the R-75 and fed into a simple voltage-doubler and integration circuit with a time constant variable from 1 second to 23 seconds.(Fig. 3). The receiver volume determines the 'drive' level to the detector unit.

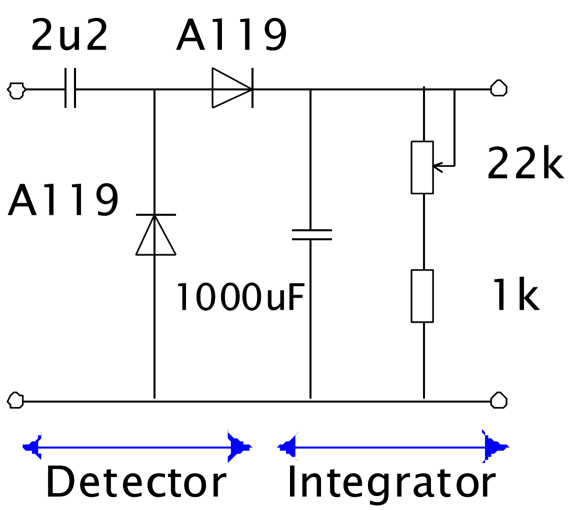


Fig 3 The Detector and Integrator

The Data-Logger

The final component is the data recording device and an ADC / PC combination provides a convenient solution. The *Analogue to Digital Converter* is built around the single-channel MAXIM MAX187 integrated circuit [4] and constructional details are available on the RadioSky website [5]. The author built the ADC onto a back-plane slot-blocking metal cover such that it could be mounted in an unused computer expansion port and draw its power from the PC's internal supply. As an added precaution, the unit was fitted with an on-board 5 Volt regulator fed from a spare 12 Volt line rather than directly from the 5 Volt supply itself. Radio SkyPipe is the software package used here, and can be down-loaded free of charge from RadioSky [5]. SkyPipe software also supports 16-bit sound card inputs, and this approach may be favoured by those who want to avoid any electronic construction.

Dipole construction

In the author's case, the lowest anticipated frequency was 20 MHz (a wavelength of 15 metres); this resulted in a dipole length of exactly 5 metres and a width of 15 centimetres. The dipole itself was constructed of 25mm angle aluminium with individual sections bolted together, and four wooden dowels were used to separate and support the horizontal dipole elements. The 500R terminating resistor (2 x 1K in parallel, the integrated resistor in the balun was not used) was supported by a standard dipole centre-section insulator and *must be* NON-INDUCTIVE.. The angled wooden roof supports served as a convenient mounting surface for the dipole, which was held in place by plastic insulators. UR67 (RG213) was used to connect the dipole to the receiver; the author does not recommend the use of RG58 or similar cables.

System Settings

The receiving system was tested at four frequencies with the receiver's AGC switched off:

- 20.4 MHz
- 25.6 MHz
- 29.5 MHz
- 38.0 MHz

This was necessary to ensure that any recorded flux increases were common to all frequencies thus eliminating the possibility of a terrestrial cause. Although the balun has a quoted upper frequency limit of 30 MHz, the author was curious as to the slope of the fall-off in coverage; drift scans were therefore conducted at 38 MHz (there is an official Radio Astronomy frequency allocation from 37.5 to 38.25 MHz) and the balun was found to be serviceable at this frequency.

Early trials revealed the need for a long time constant, and all recordings were made with the maximum integration time of 23 seconds. The majority of recordings were obtained with the R-75 operated in SSB (USB) mode, a few being made at AM for comparison. However, these AM results were disappointing and confirmed the superior dynamic range of the R-75 in the SSB mode. Use of the receiver's internal RF preamplifier was unnecessary; at upper HF the sky noise temperature is some 50,000K, and a good receiver will have a noise temperature of 40,000K or less rendering additional pre-amplification essentially pointless.

Observational Results

The system was run round the clock for several days at a time, with each frequency being allocated a 24 hour slot.

The Sun
We are currently at solar minimum, and during March 2006 there were no obvious flux increases that could be attributed to Solar activity.

Jupiter
The planet was not well placed for observation during the system evaluation period, and no results are offered.

The Galactic Plane
All results are shown on the next page for clarity.

Cosmic noise from the Plane of the Galaxy was recorded at 20.4, 25.6 and 29.5 MHz (Fig. 4). As can be seen, the three drift profiles are not identical and the author believes that ionospheric transparency differed over the three days in question (the 3rd, 8th, and 11th March). The drift-scans in Fig. 5 were obtained at all four test frequencies and show good correlation; the plane of the Galaxy was perpendicular to the dipole (south) at approximately 10:00 UT, but Cygnus 'A' was also in the antenna beam at this time. Of particular interest is the very sharp flux increase at the left-hand side of Fig. 5; peak flux occurred at around 03:50 UT at all four test frequencies, occupying a time scale of approximately 35 minutes. Fig. 6 shows two drift-scans obtained on successive days during October 2005 at 25.6 MHz. Both Cass ‘A’ and the Galactic Plane were directly north of the dipole at the time of recording.

Please Note: the ionosphere still plays a significant role at upper HF and drift-scans conducted on any two consecutive days may not be identical, particularly at 20.4 MHz and 25.6 Mhz.

Recommendations for Further Development

While the Radiometer has the advantage of relative ease of assembly, the detector/integrator lacks refinement and improvements are possible. A high impedance buffer between the integrator and the ADC would be beneficial, coupled with a longer time constant to further reduce baseline noise. The basic integrator was designed with a continuously variable time constant, but the author now believes that fixed integration of 30 to 50 seconds would be adequate.

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Glossary

ADC	Analogue to Digital Converter
AGC	Automatic Gain Control
AM	Amplitude Modulation
HF	High Frequency (3 - 30MHz)
RF	Radio Frequency
SSB	Single Side Band
SWR	Standing Wave Ratio
T2fD	Terminated Tilted Folded Dipole
USB	Upper Side Band

Fig. 4

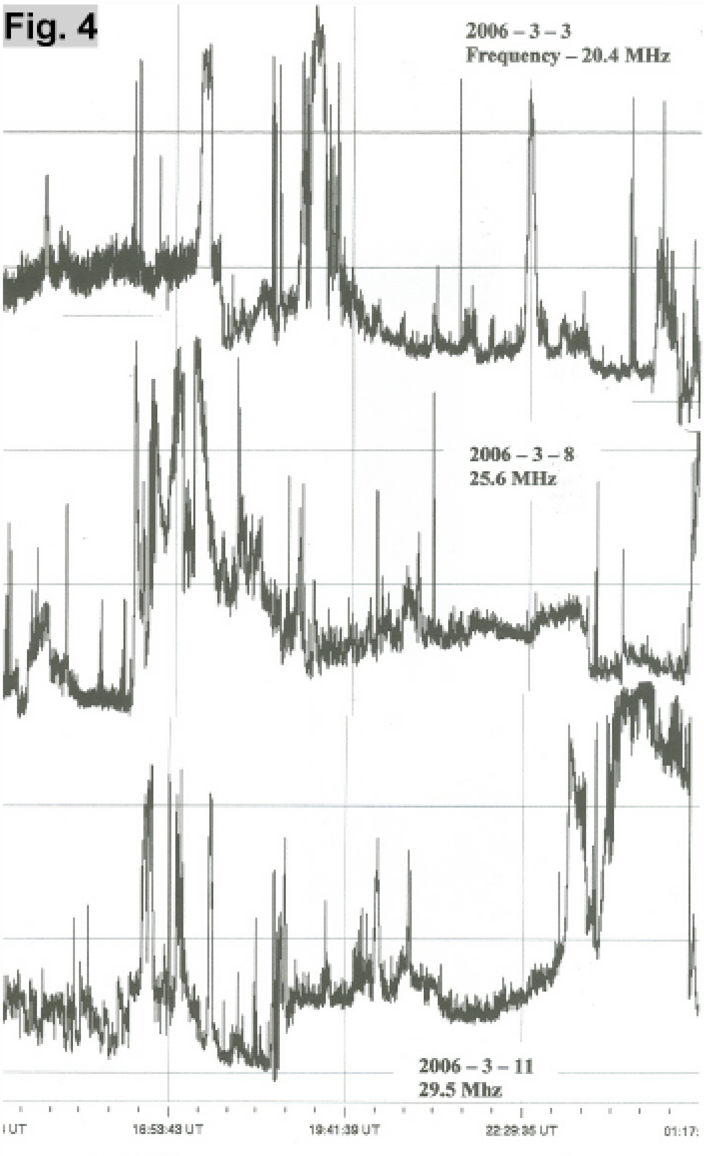


Fig. 5

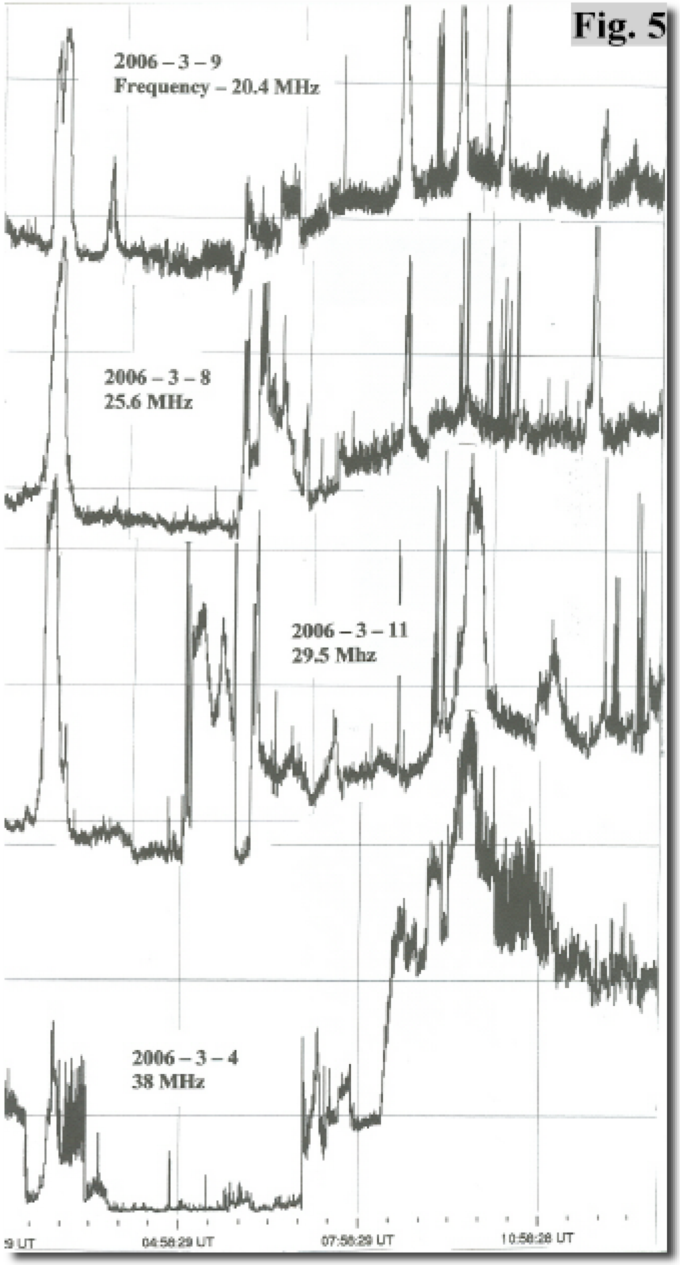
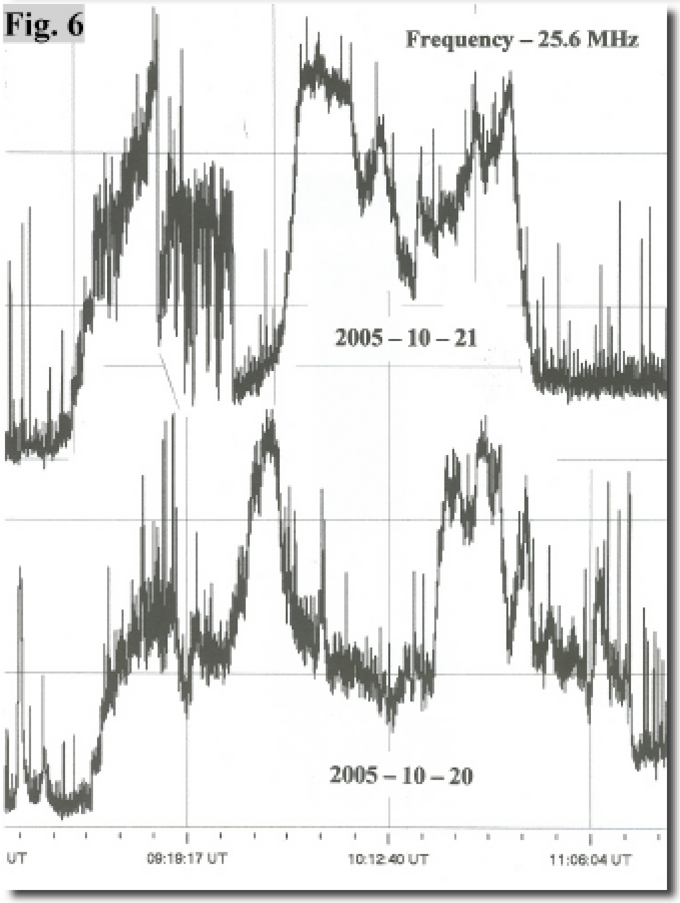
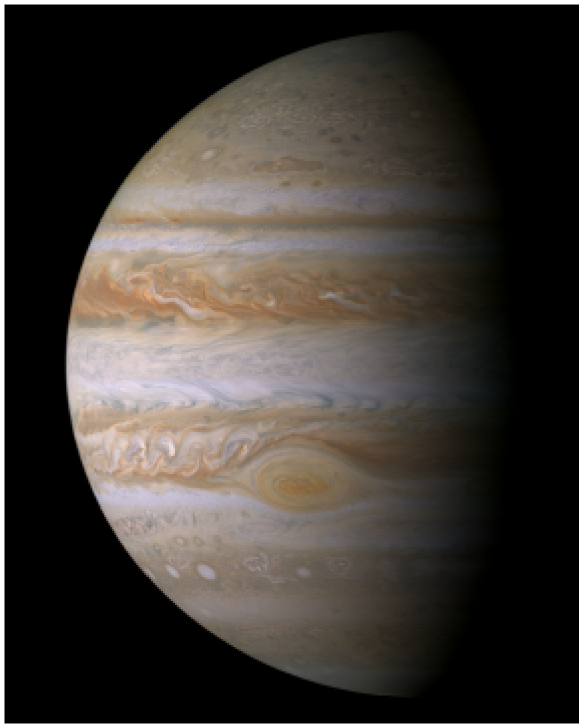


Fig. 6





Photograph courtesy of NASA

The Bandwidth-Aperture Tradeoff in Backyard Radio Astronomy

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In stark contrast to our optical astronomical colleagues, variety is not the spice of an amateur radio astronomer's life. With the exception of the Sun, even the few radio sources that are considered "strong" by the professionals are distressingly weak by the standards of normal radio reception. I have been a member of several RA groups over the years, and have built several systems at different frequencies (e.g. see my BAA Journal article [1]), but the overall return for the effort invested always seems a bit thin. I have detected the four "strong" sources, Cass A, Cygnus A, Taurus A and Virgo, and was quite pleased about it at the time. But one quickly discovers that the limits of your modest system have been reached, and it's back to the drawing board.

One of the misfortunes of life in the northern hemisphere is the absence of sources in the 100-1000 Jansky range, at the VHF and UHF frequencies that are favoured for amateur observers. At 150MHz, the four cited sources have flux densities of 12,000, 9,000, 1500 and 1000 respectively. These can, and have, been detected by many amateurs over the years using equipment similar to, or one and the same as, a typical amateur radio VHF setup. But scanning the Cambridge catalogues, there is not much else to observe above 100 Jansky in strength. In effect, this means that it is necessary to increase the sensitivity of a typical amateur setup by more than an order of magnitude in order to open the door to the dozens of sources which are in the 10-100 Jy range.

The most obvious, and widely assumed as the only, approach to doing this is to increase the antenna aperture. A 3 metre diameter dish, for example, would represent nearly an order of magnitude increase in aperture over a 1 metre dish, and with a well-designed receiver the four strong sources are just about detectable with a 1m^2 aperture, at frequencies around 1GHz. But this is not really quite enough, and may do no more than extend your system sensitivity down into the "dead zone" between 100Jy and 1000Jy. It also poses logistical and technical problems. Planning regulations notwithstanding, the higher focal ratio dishes that are easier to build are very difficult to feed effectively without "overspill" ruining the receiver noise performance. I have convinced myself, over the years, that although dishes are the most obvious path to higher antenna aperture, the need to place the LNA out in the elements is an additional, but much-ignored, limitation on receiver sensitivity.

It turns out there is another option for increasing the sensitivity, and this has formed the focus of my own developments for the last few years. The option is to greatly increase the pre-detection bandwidth of the receiver. The radiometer equation tells us that the system sensitivity is proportional to the antenna aperture (we knew that!) but also proportional to the square root of the pre-detection bandwidth. A typical amateur setup tends to use readily available components, and this usually includes some kind of a communications receiver with a low IF. Such receivers are designed to detect modulated signals that have bandwidths in the range of 1 to 100kHz, and for AM reception may have a selectable IF bandwidth which is in the range of 2-20kHz. It is normal practice to select the lowest possible IF bandwidth which passes the modulated signal; this will give the highest signal-to-noise ratio. But a radio astronomy receiver is different, for a number of reasons. The signal in question is now very weak in comparison to the receiver background noise, possibly as much as 40dB, or 10,000 times weaker. But the actual signal itself is also a broadband noise source, which fills any selected receiver bandwidth. Increasing the IF (or pre-detection) bandwidth has much the same effect as having a number of separate receivers, all reaching their own independent averaged reading of the signal strength. The detector in a broadband receiver is able to average the results from all of these imaginary separate receivers, thus getting a much more accurate answer. The mathematics (which I won't go into here) tells us that the benefit is proportional to the square root of the pre-detection bandwidth.

For example, if instead of using our 10kHz receiver, we redesign the receiver to give us 100MHz of bandwidth, the sensitivity for the same antenna aperture will increase by a factor of 100 (100 is the square root of 100MHz divided by 10kHz). This is a spectacular opportunity; we can now in principle extend our sensitivity down into the 10-100Jy zone, using a small antenna!

Needless to say, there are a number of problems associated with making a receiver with such a large bandwidth. Firstly, it drives our frequency of operation up into the GHz bands, since below 1GHz there will be too much interference over any 100MHz band (even 1MHz is optimistic!). Unfortunately, the signal strengths of most radio astronomy sources drop significantly as one progresses upwards in GHz. Recent experiments I have performed show that it is remarkably difficult to find a "quiet" 100MHz patch anywhere at all in the spectrum, although I have managed to identify a region around 1400MHz which may suffice in my (rural) location. (My original system was designed for 5-6GHz operation, but was blasted out of existence by the radio altimeter signals from passing aircraft!). The design of both the LNA and antenna feed also become more challenging as the operating bandwidth increases. Here I have something of an advantage, having been professionally involved in microwave amplifier design for 30 years, and having access to the necessary design tools, equipment, and semiconductor devices that are necessary to do an adequate job. I am hopeful, however, that the final designs will be repeatable at reasonably low cost.

So my present development goals are to design a suitable antenna and LNA combination that will give me a receiver with a 20K noise temperature. I say combination, because all too often (and very much so in commercial satellite TV dish assemblies), the very low noise figure now readily obtainable using GaAs PHEMTs ends up being compromised by overspill from the small dish antenna. I have concluded that the approach taken by Penzias and Wilson at Bell Labs in the late 50s has much merit. After all, they did build a receiver that was sensitive enough to detect the cosmic background radiation. The key element in their system was the use of a horn antenna. These are rather monstrous things to construct, in comparison to dishes having similar aperture, but they have two enormous advantages over dishes: negligible sidelobes, enabling the receiver noise performance to be fully realized, and a waveguide feed which can be conveniently piped inside the observation shack. Thus the LNA and all the associated receiver components can be kept dry and free from the elements. If the latter benefit seems a little "wimpy", read Wilson's own account of the discovery; he cites this as one of the main benefits of the horn-reflector antenna he used in this classical experiment. Needless to say, my own horn antenna will start off as a scaled-down version. Horns have another advantage over dishes in that although they consume more material the dimensions are relatively uncritical. But there's no free lunch; at 1.4GHz, a 1 metre square aperture horn really needs to be at least 2 metres long.

With a noise-free horn antenna of 1m^2 aperture, a 20K LNA, 100MHz bandwidth, and a realistic 10 second integration time, the radiometer equation says I would have a system sensitivity of 1 Jansky! I will believe that if and when I see it, but it would certainly seem that such a system truly does have the potential to detect sources below 100Jy. I will keep you posted.

In conclusion, I should say that this concept was originally proposed in an article by Ken Tapping, and I myself have had the good fortune to be personally acquainted with another professional radio astronomer, Darrel Emerson, who has helped me along with the development of this approach.

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A Computer Model for Detection of Gamma Ray Bursts

and X-ray transients at Very Low Frequency Radio Telescopes

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Abstract

The VLF computer model proposed in this paper examines whether gamma ray bursts (GRB) or X-ray transient flux from distant supernova can be detected by the current generation of amateur VLF radios. Arguments presented in this paper compare how GRBs created from supernova events might cause detectable signatures similar to magnetar or other local X-ray transient Sudden Ionospheric Disturbances (SID). High-energy GRB and short hard X-ray transients of supernova (SN) origin affect the upper ionosphere through Compton free electron interaction and not through magnetic field reconnection in the way that local solar plasma might affect the Earth's magnetosphere and ionosphere. Gamma ray and X-ray ionisation of the upper F2 layer should be a measure of ionising radiation as small as 10^{-13} J, yet this may not be detectable with current amateur VLF radios. High-energy solar plasma and X-ray flare interactions causing ionisation have larger energy regimes, which affect the lower ionosphere layers and are easily detectable with VLF receivers. Local atmospherics such as lightning and sprites also confound detection of SN GRB. Only events of very long duration, such as the night-time ionosphere disturbance from SRG1900+14, or a recent 'super flare' from SGR1806-20 located toward the centre of our galaxy (estimates of between 6.4kpc and 9.8kpc away from Earth), (Cameron 2005) and GRB030329 have been detected at Very Low Frequencies, (Peterson, Price 2003), and (Price 2003).

Introduction

VLF detection of short-hard GRB or X-ray bursts depends on line of sight geometry of the impact with ionosphere layers and the orientation of VLF receiver and transmitter. Intense flux density from coronal mass ejections and other solar plasma phenomena often interact with the Earth's magnetosphere and upper thermosphere, rather than the ionosphere. GRB and X-ray transient interactions may be negatively influenced by the existing ionisation proportion of the incoming heated solar plasma, or solar wind, as well as their own photon flux density's inability to penetrate into the cooler ionised particles at lower layers (Lyon 2000). Shock waves from X-ray transients result in high-energy electrons crossing into previously ionised cooler layers. For detection of distant GRB and X-ray transient bursts the shock waves depend on the geometry, or line of sight, between the shock wave, receiver and VLF transmitting stations on the ground. Neither solar X-rays nor high energy transient X-rays from GRB or magnetars penetrate the cooler F, E and D layers (Figure 1) through the magnetic field, and do not affect direct free electron interaction at the Earth's poles (Hill 1991).

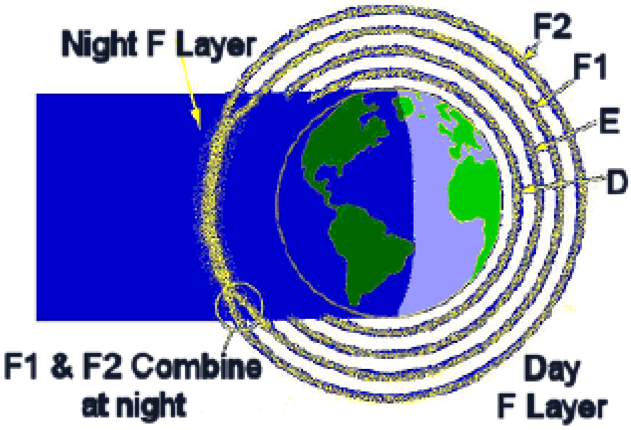


Figure 1: shows the splitting up of the ionosphere during the day into various layers, and reconnection of these layers during the night, courtesy of Joseph DiVerdi.

Solar plasma interaction is different from interaction of extra-galactic short-hard Gamma Ray Bursts or X-ray transients (XRB) from objects like magnetars. A GRB will interact with the Earth's upper thermosphere directly with much less flux density and are not influenced by the outer magnetosphere like solar plasma from solar coronal mass ejections or proton-electron plasma flares. On the other hand, GRB photons may cause a detectable Compton Effect (CE), which is measurable as electron-volt-flux in square centimetres per steradian per second in the ionosphere. As GRB and short hard X-ray photons interact with free electrons in the upper ionosphere the free electrons re-emit lower frequency ultraviolet-light and perhaps synchrotron radio waves as the result of the Compton Effect. Signatures from the GRB-CE may not create the sudden rise and gentle fall-off often seen in VLF recorded voltages of solar plasma interactions. However, Solar X-ray flares that have the energy to cross into lower F, E and D layers of the ionosphere have been detected as SIDs with VLF radios. It is possible GRB or hard X-ray transient signatures show a slight drop in VLF signal during local nighttime hours, although, to-date most VLF detection of GRB and X-ray transients have been recorded during the day as a SID type signature. However, any VLF detection of GRB or X-ray transients and magnetars such as SGR1806-20 and SGR1900+14, rely on the geometry of the incoming flux density and the line of sight arrangement of the receivers and transmitters on the ground (Figure 2).

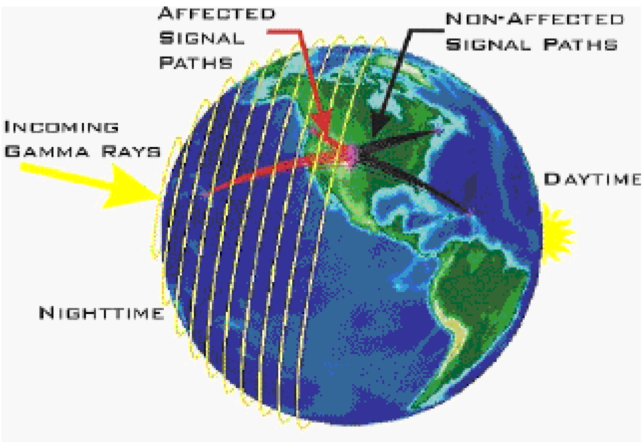


Figure 2: shows the propagation of waves coming in from a gamma ray burst and being in the correct geometry for VLF detection from signals from Hawaii to Colorado (Inan 1999).

Current thinking about the origin of extra-galactic high-energy events such as a GRB or within galaxy magnetar X-Ray transients, appears to be focused on progenitors of either neutron stars, perhaps in a binary system, or the collapse of massive young star, which creates a supernovae (Shilling 2002). Supernova GRB or X-ray transients are the result of massive O and B type star collapse, with subsequent rapid spin-up of the resulting remnant neutron star. These stellar 'collapsars' create a distant supernova remnant, which in turn create an incredible amount of energy (Ward-Thompson 2002). The magnetar type event is caused by a massive rotating neutron star, which emits high energy X-rays because of a reduction in angular momentum, causing a 'star quake' (Kouveliotou 2005) (Figure 3).

After three to four years of active monitoring GCN alerts, there have been only two likely events recorded in the Northern Hemisphere with VLF receivers. It becomes evident, that for VLF detection with the current receivers, these events have to be of long duration and not too distant; greater than 20 seconds for GRB030329 with a z

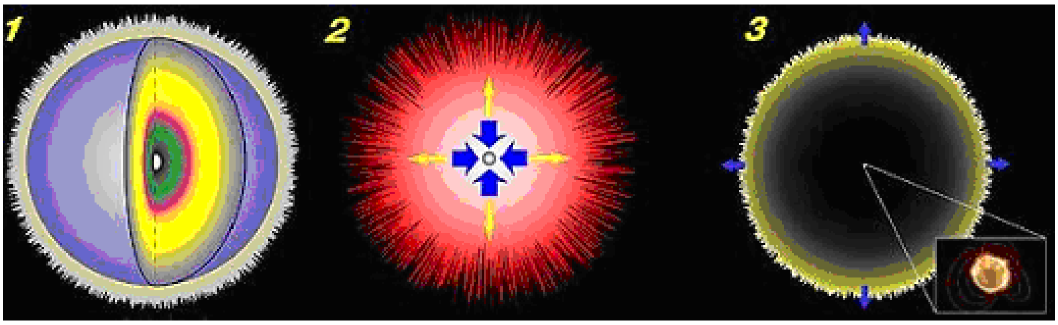


Figure 3 making a neutron star – and a magnetar – starts (1) with a massive star that has burned up all of its fuel, then (2) collapses and causes a massive explosion, the supernova, which blows off the outer layers and (3) compresses the core. http://science.nasa.gov/newhome/headlines/ast19jul99_1.htm

<= 0.168 as noted by Uemura, M., et al, (2003), and perhaps up to 400 seconds for SGR1806-20 at approximately 6.4kpc within our galaxy.

Methods

Detectable GRB and X-ray transient flux density energy intensities ranging from perhaps 10^{-14} to ~ 10^{-10} Joule per square centimetre per steradian per second, which may be energetic enough to cause re-emission of free electrons in the ionosphere, can be modelled as producing ultraviolet light and then re-ionisation with energy values given by equation (1) (Hwang 1997). Estimates for VLF detection of the gamma ray, X-ray flux density ε as the high-energy photons interact with free electrons in the upper ionosphere can be derived from the following basic assumption; that the voltage received at the VLF radio telescope is a measure of:

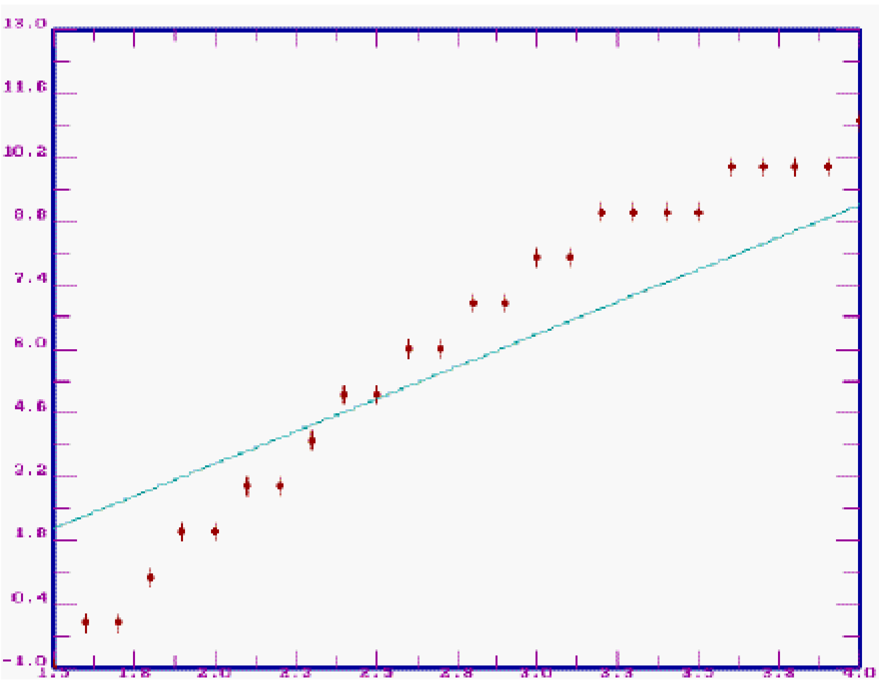
$$f = \varepsilon m c^2 \quad \text{(Eq. 1)}$$

f is the X-ray flux density and varies from 10^{-10} to 10^{-14} Joule, averaged over a 1 second interval (Figure 4). The one second interval is chosen as the best the Gyrator II VLF radio can resolve with confidence (Hossfield 2002).

The VLF computer model converts f into voltage measurements for the Gyrator II radio telescope. For voltage values less than 1.5 volts, measured as an offset above the 'background' where the value of f ~ 0, there would be no Compton Effect (CE) of an ionosphere disturbance detection. The model calculates voltage drops below the 1.5 'background' as a large drop in f. This means that any value within the range of 1.5 volts to 2.8 volts as recorded by the VLF radio would potentially represent enough energy to be considered a GRB or X-ray transient event. However, this is below a calibrated maximum level of 4+ volts for average night-time ionosphere measures of VLF radios.

Figure 4: this graph is a model and assumes an incoming burst temperature equivalent to 1,200 K per steradian per cm per second, this would be a large event at 10^{-11} J, and quiescent thermosphere temperature at 220 K. Compton Effect photon density at the thermosphere is considered a specific heat in the current model and is measured as kT. As the difference between the CE photon burst and ionosphere temperature increases from UV emissions, there is an increase in the amount of re-ionization. This is measured as flux density per volt recorded at the VLF telescope (dots).

The y-axis on this graph estimates the equivalent GRB or X-ray flux density converted to electron volts (eV) in square centimetres per steradian per second. Units on the y-axis are powers of 10 exponents (eV). VLF voltages are on the x-axis.



For example: 2 Volts on the x-axis would be approximately 10^2 eV on the y-axis. A GRB or X-ray flux density detected at 2.3 Volts on the x-axis would be approximately $10^{4.6}$ eV on the y-axis. Any GRB or x-ray event at or above 1.5 volts on the x-axis, $10^{.02}$ eV, should be detectable.

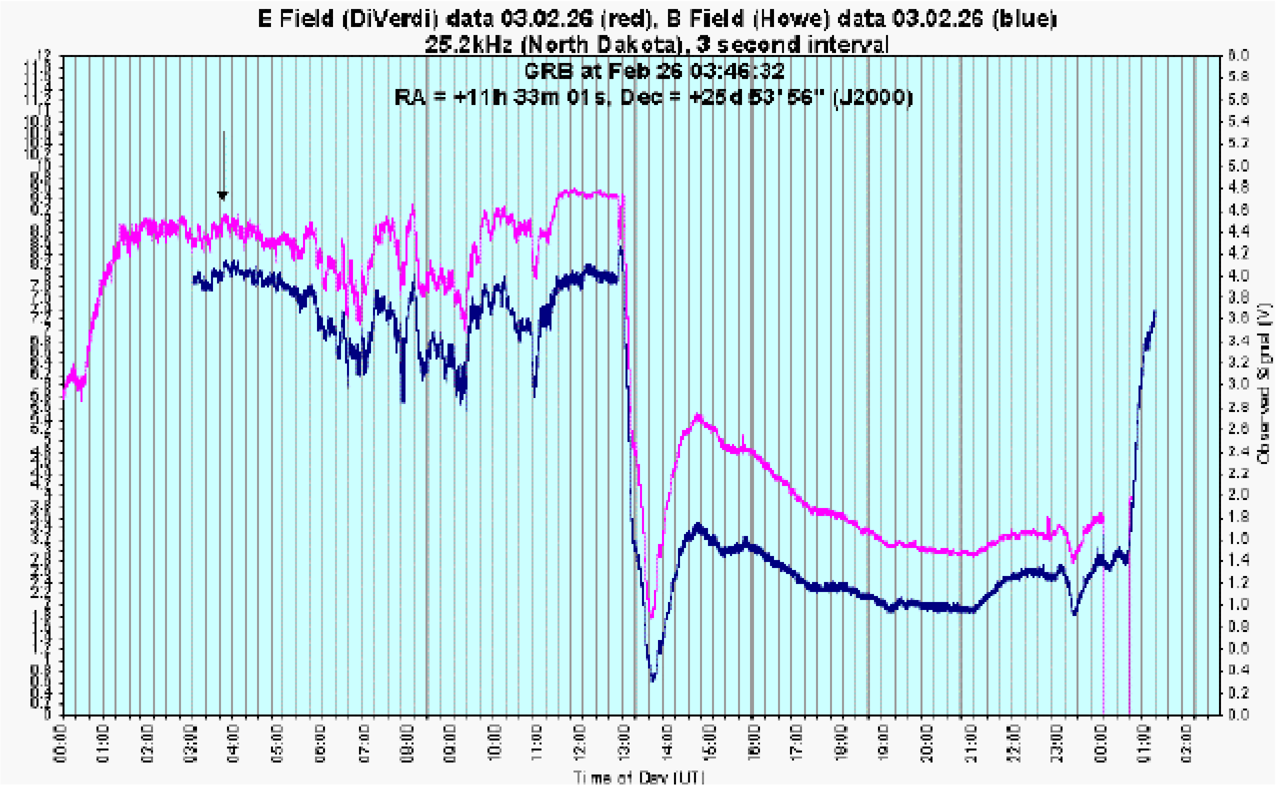


Figure 5, shows two different radio configurations, the Gyrator II with a 1.5 metre B-field loop antenna (Hossfield 2002), and Joseph DiVerdi's VLF radio with an E-field 2 metre whip antenna. These data show a daily trace where there was a weak GRB at 03:46:31.99 UT. There was no increase in voltage close to a recorded GRB event at 3:46UT, 2003 February 26. And with all the night-time atmospherics it is very difficult to declare detection. (GRB Detection Date: 2006-02-26 03:46:31.99 UT GRB Notice Date: 2006-02-26 05:47:21 UT)

At voltage ranges greater than 1.5 to 2.3 the GRB or X-ray transient flux density could represent a major SID affecting the ionosphere such as SRG1900+14, or more recently, SGR1806-20.

The VLF computer model expresses the increase of *k*T, as a Compton Effect temperature for the re-ionization of the ionosphere. As gamma ray and X-ray photons create UV emissions in free electrons in the higher layers of the ionosphere creating radiometer temperatures, which the VLF radio converts to DC voltages. The VLF computer model requires an estimate of the temperature of the incoming burst expressed in Kelvin, and an estimate of the ionosphere temperature also measured in Kelvin. (Burst estimates can be gathered from the GCN circular on the event.) These values are measured as a ratio for *k*T. Boltzmann's constant *k* is converted to decibels and used as the exponent of f. f is the X-ray flux energy of the ionosphere caused by the burst and is multiplied by mc^2 to estimate the energy of the high-energy X-ray emission as the Compton Effect re-ionises the ionosphere. Output from the model, at this time, displays an estimate of X-ray flux density on the y-axis of a graph (Figure 4) and the VLF voltage on the x-axis of the graph.

Results

Gamma Ray Bursts or short-hard X-ray transients of short duration such as GCN 1924 have little chance of being detected by amateur VLF receivers such as those being used today. However, longer, higher-energy bursts from magnetars like SRG1900+14 and SGR1806-20, or not-so distant supernova explosions such as SN2003dh (GRB030329) are detectable (Figure 5).

Figure 6 below is a detail of VLF data collected at the time of GRB030329. The VLF receivers recording the event were located in Fort Collins, Colorado USA, at approximately Longitude -105.08 and Latitude 40.54. This event happened before dawn during the night-time hours where the receiver signals were between 3.6 at 4.2 Volts (right y-axis on figure 4). Night-time is the worst time for detection due to all the atmospherics and lack of ionisation, but there is a noticeable drop in signal during the GRB event. As there were no other confirmations of this event from other AAVSO VLF receivers in North America it is difficult to say that this was a true detection.

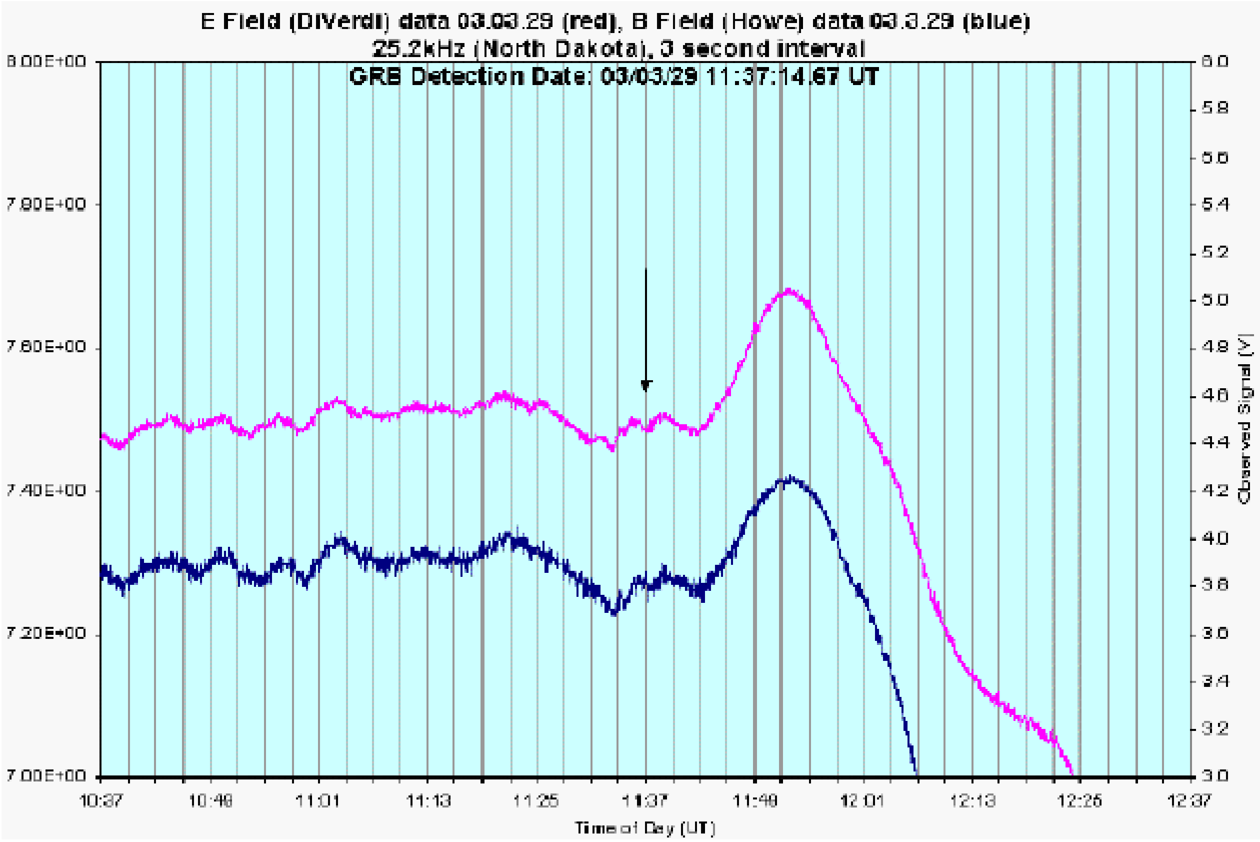


Figure 6: GRB030329 was detected by HETE-II satellite on 2003 March 29 at 11:37:14.67 UT. Optical spectroscopic observations determined its red shift to be z = 0.168 (Uemura 2003). These data represent two VLF radio receivers, one recording with a 2 metre whip antenna (red line) and one with a 1.5 metre loop (blue line). Both receivers show a slight drop at the onset of this event with a rise and fall off, but there are other possible explanations for these dips, especially during night-time hours. The large rise in the signals at 11:55 UT is a result of the Sun ionising the ionosphere as it rises over the horizon.

Magnetar Detection

These energetic outbursts begin with a brief (~ 200ms) spike of gamma rays with energies up to several MeV containing most of the flare energy. The spikes are followed by tails lasting minutes during which hard X-ray emissions gradually fade while oscillating at the rotation periods of the neutron star (Hurley 2005). Figure 7 shows this spike for SGR1806-20 as a 1.5 volt difference from the minimum to maximum, recorded by the VLF receiver, before the gradual re-ionising of the ionosphere. This would be a large event at 1.36 x 10^{-7} J cm^{-2} as measured from the RHESSI particle detector (Hurley 2005). This sets the incoming burst temperature equivalent to almost 1,000 K per steradian per cm per second given the line of site geometry of the incoming burst, the VLF receiver and VLF transmitter (Figure 2). If the quiescent ionosphere were at a temperature of 220 K the Compton Effect photon density would be the difference between burst temperature (1,000 K) and the quiescent ionisation temperature (220 K). The measured flux density per volt recorded at the VLF telescope would suggest $10^{.5}$ eV per steradian per cm per second (Figure 4) were recorded in the ionosphere in the line of sight.

Discussion

There are other dynamics involved in VLF detection, which would benefit from further study, such as; where is the optimum location of the VLF receiver when the burst wave hits the Earth's ionosphere. Gamma ray and short-hard X-ray transients from supernovae explosions should exhibit a response based on the measure of the Compton Effect from high-energy photons causing ultraviolet re-emission and possibly re-ionisation of Earth's upper ionosphere. Re-ionisation at ultraviolet radiation levels needs further study. However, the current computer model results predict photon flux levels, which translate to voltage level expectations for the current VLF receivers, provided the geometry of burst, receiver and transmitter are optimal and in line of sight.

Most GRB and X-ray transient events looked at so far have not been of high enough energy to be detected with current amateur VLF equipment, with the exception of GRB030329, and the most recent SGR1806-20 super flare (Price 2004).

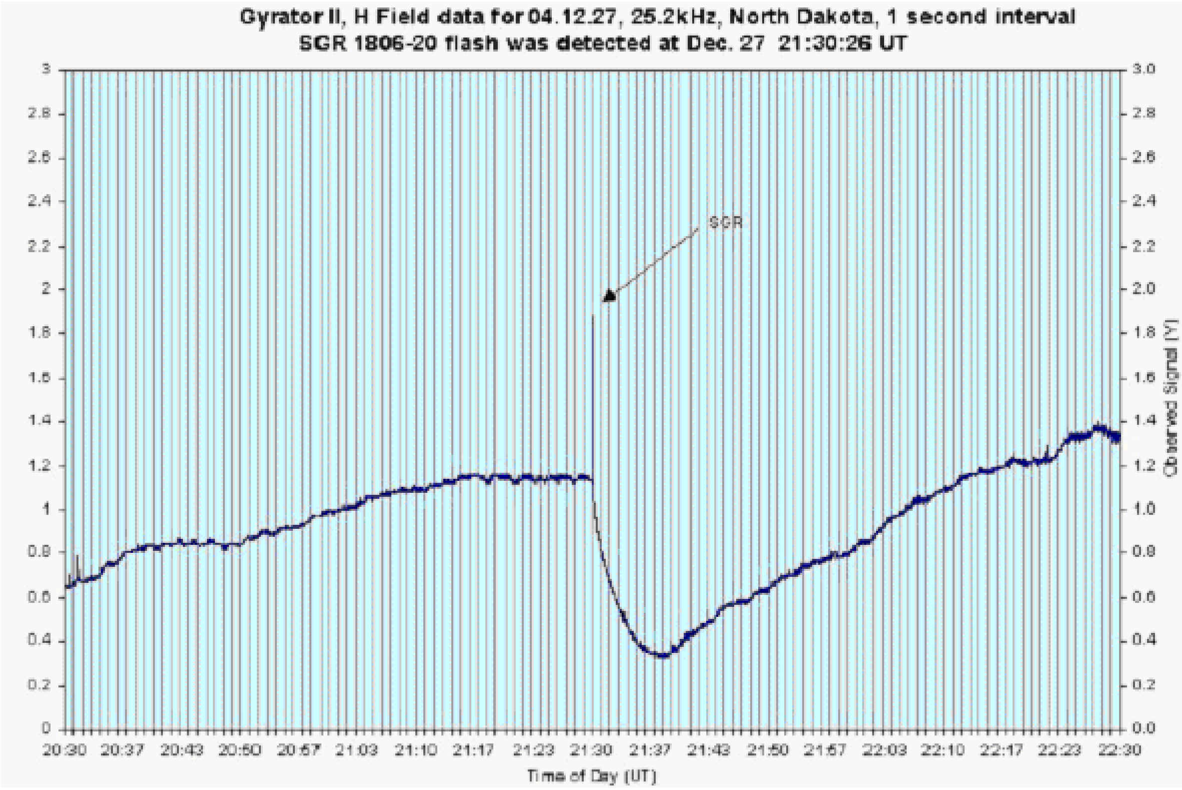


Figure 7: SGR1806-20 was detected by Swift satellite on December 27, 2004 at 21:30:26 UT. http://gcn.gsfc.nasa.gov/gcn3/2944.gcn3 AAVSO observers of this event were as follows:

Observer	Receiver Location	Transmitter and Location
Moos	Switzerland	FTA - St. Assie, France
Hill	Massachusetts, USA	NAA - Cutler, ME, USA
Winkler	Texas, USA	NAA - Cutler, ME, USA
Kielkopf	Kentucky, USA	NAA - Cutler, ME, USA
Campbell	Alberta, CA	NLK - Jim Creek, WA, USA
Howe	Colorado, USA	NML - LaMoure, ND, USA
Mc. Williams	Minnesota, USA	NML - LaMoure, ND, USA
Samouce	Montana, USA	NML - LaMoure, ND, USA
Kielkopf	Kentucky, USA	NPM - Lualualei, HI, USA (2nd receiver)
Mandaville	Arizona, USA	NPM - Lualualei, HI, USA
Lewis	California, USA	NPM - Lualualei, HI, USA
Winkler	Texas, USA	NPM - Lualualei, HI, USA (2nd receiver)

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Special acknowledgement goes to Dr. Joseph DiVerdi http://xtrsystems.com/vlf
and Peter Schnoor for their help and support.

Pulsars, History and Amateur Detection

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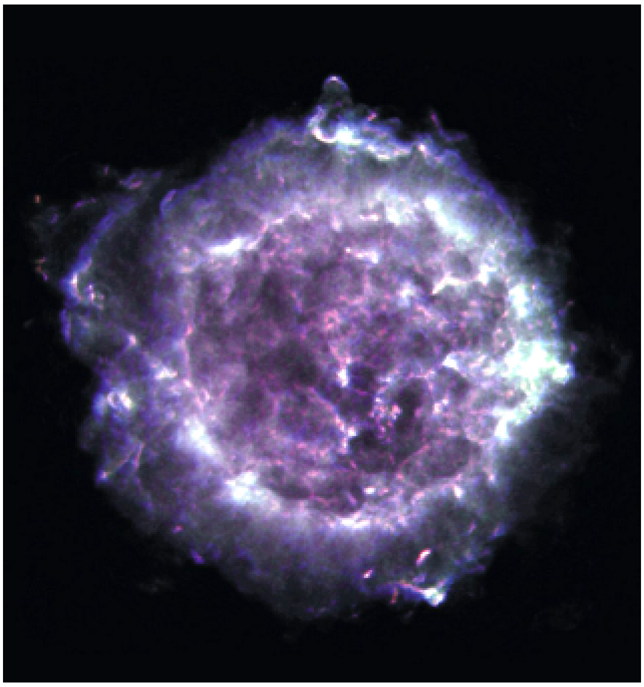
The Life of a Star – Pulsar Formation

Throughout a star's life in the main sequence, stars fight a dramatic battle against the forces of gravity – gravity tries to collapse the star by pulling its outer layers towards its centre. But the star fights back by releasing nuclear energy, which is fuelled by a rich supply of hydrogen. Eventually, usually after billions of years, stars deplete their fuel supply and must give up the fight. Some aging stars die quietly – others suffer violent deaths. The method depends on a star's mass. Stars about the same size as our Sun become white dwarfs, which shine for a very long time from leftover heat. Stars that have about 10 times the Sun's mass blow apart and often form neutron stars. Scientists believe that the Crab Nebula came from such a star.

The Crab Nebula, in the visible (Palomar Observatory)

A Star's Collapse

Once a large star exhausts its fuel supply, gravity takes over and the star is collapsed without opposition. Usually a star will find other sources of fuel like helium, carbon, oxygen and nitrogen, but these offer a short reprieve. Eventually the densities at the centre of the star get so high that the star cannot collapse much more at all. Instead all the pressure from the collapse is "stored," ready for release. Finally the conditions become so extreme at the centre of the star that all the "stored" pressure from the years of collapse is released in a single brilliant burst: a nova or a supernova, depending on the mass of the star. This explosion throws off the outer layers of the star and compresses its core even more. It was a supernova that created the Crab Nebula. During the explosion, the star gives off more energy than a galaxy of 100 billion stars. The outer layers being ejected create an expanding shell of dust and gas that become a supernova remnant. The Cassiopeia A remnant (below) is considered the strongest galactic radio object, other than the Sun.



Radio Image of Cassiopeia A Supernova
L. Rudnick, T. Delaney, J. Keohane, B. Koralesky and T. Rector
NRAO/AUI/NSF

The Birth of Neutron Stars

Besides the interstellar debris, supernova explosions often leave behind a cinder, the star's dense collapsed neutron core, which was created by the compression of electrons and protons. Called a neutron star, the object is about 10 km wide, has a mass greater than our Sun, and a density of about a billion tonnes per teaspoonful. Because of its small size and high density, the neutron star possesses a gravitational field 300,000 times stronger than the Earth's. Its rotation rate also increases dramatically during the collapse. Most celestial objects rotate, but neutron stars rotate very rapidly. The neutron star in the Crab Nebula rotates 30 times per second. It is the only kind of star that can rotate rapidly without breaking apart.

Pulsar Mechanics

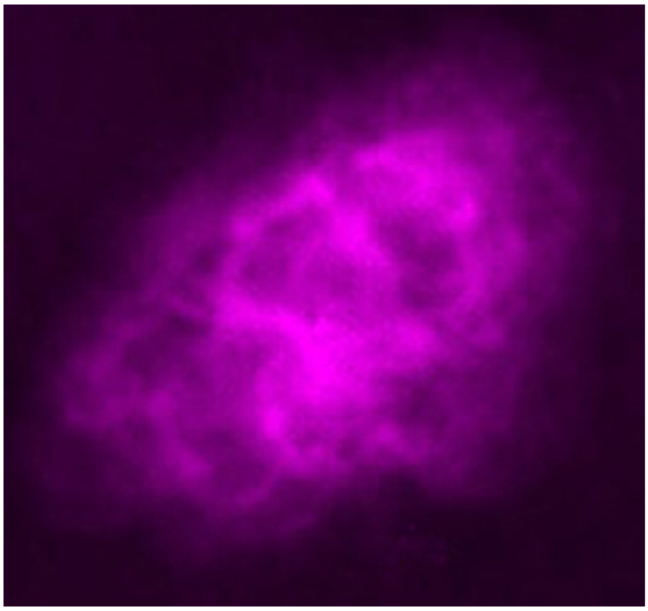
Some neutron stars – such as the Crab – emit radio waves, light, and other forms of radiation that appear to pulse on and off like a lighthouse beacon. Called pulsars, they don't really turn radio waves on and off – it just appears that way to observers on Earth because the star is spinning. Astronomers pick up the radio waves only when the pulsars beam sweeps across the Earth.

Pulsars possess a powerful magnetic field that traps and accelerates charged particles, and shoots them through space as radio waves. Their rapid rotation makes them powerful electric generators, capable of accelerating charged particles to energies of millions of electron Volts. The Crab, the youngest and most energetic pulsar, produces enough energy to power the nebula and make it expand. The real difference between a neutron star and a pulsar is that a pulsar has a magnetic field that is misaligned with the rotation axis - being tilted at an angle of about 30 degrees to the rotation poles.

A pulse's energy output lights up and expands the nebula around it. This action robs energy from the pulsar's rotation, so that it spins slower over time. This "spin-down" rate is a tiny percentage per year, so that it will take about 10,000 years for the pulsar to slow to half its current rotation speed. As time progresses, the Crab's pulses will become less intense, and its X-ray emissions eventually will end. The nebula itself will disappear after only a few thousands years. Eventually only the radio pulsar, beaming every few seconds, will remain.

First discovered in 1967, scientists jokingly dubbed pulsars LGM for "Little Green Men," because the radio signals were so regular it seemed to be a sign of intelligent life. Scientists can predict the arrival times of pulses a year ahead with an accuracy of better than a millisecond. They have catalogued more than 300 of them. But only two, the Crab and Vela, emit detectable visible pulses. The Crab emits radiation throughout the entire spectrum, including gamma and X-rays.

The Crab Nebula is one of the most famous radio objects. It is an optically viewable supernova remnant, and also a very strong radio source, The radio power of this object puzzled scientists, because it was recognized as being a supernova expansion discovered by Chinese astronomers as a 'guest star', in 1054 AD. By this time its heat would have radiated away into outer space, making it a very weak thermal radiator. Because it is a very strong radio source, astrophysicists had to find another mechanism for its radiated energy. In the supernova event, a pulsar was created in the Crab which sends out pulses at a rate greater than 33 per second, It is now believed that the pulsar continually pumps up' the energy of the leftover debris. The Crab pulsar is one of several that have been identified as central figures of supernovae debris, this particular pulsar has also been proven to pulse optically in synchronization with its radio bursts.

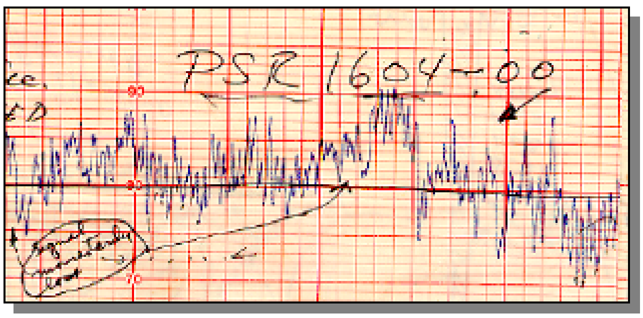


The Crab Nebula at radio wavelengths (VLA/NRAO)

It is important to note that although the Crab Nebula is a strong radio source that is easily detectable with amateur equipment, detection of the pulsar is much more difficult. Observation of pulsars requires very large antenna aperture which is associated with very small beam width. This separates the pulsar energy emission from surrounding sky noise. Additional signal processing equipment is also needed to fetch the pulses from the usual thermal noise produced by radio receivers.

Amateur Detection of Pulsars

Premier amateur radio astronomer, Robert M. Sickels was the first amateur to detect a pulsar, in the mid 1980s, at his home and lab in Fort Lauderdale, Florida. The operating frequency was 408 MHz and 612 MHz, using a 4m parabolic antenna.



Pulsar Observation (Robert M. Sickels)

The pulses emanating from the pulsar are usually embedded in the noise floor. In order to hear the pulses, one must have additional hardware or software to make the pulses audible. Bob Sickels used a number of different circuits to do this. Each one showed some degree of being able to extract the pulses - one of these was his 'Audio Pulse Enhancer'.

Pulsar Detection at 406 MHz

Modern detection methods rely on signal processing software to extract the very weak signals from the receiver noise. Over the past five years, my colleague Jim van Prooyen has developed a few different versions of software for the purpose of detecting Pulsars. In Jim's words - as a software engineer by trade and with my interest in Radio Astronomy, the two areas seemed to be perfect for this research.

In my research, I had read about the detection of Pulsars, the history of Jocelyn Bell and Dr. Anthony Hewish. In addition, I had read of the efforts of Robert M. Sickels (Fort Pierce, Florida, deceased 1993) and his work at 612 MHz. In further readings I found notes on the frequency range of 406 - 410 MHz as well as some microwave regions.

My first task was to find the best system for doing this type of research. As many of us are on one budget or another, this was my first concern. While attending a radio astronomy conference, at the National Radio Astronomy Observatory, Green Bank, West Virginia, I was introduced to the 406 MHz area by an engineer named Carl Lyster. After returning from the conference, I researched different off the shelf receivers/scanners being used for radio astronomy. Most of the receivers were quite highly priced and were not made primarily for doing radio astronomy. After careful consideration, I decided to adapt the existing Radio Astronomy Supplies 406.7 MHz Radio telescope (which was field proven and showed excellent system sensitivity). I started the process of adapting the current software and found that while the it was more than adequate for doing radio astronomy continuum observations, I would need to design a new software package for my special project, Pulsars.

Signal Processing

All versions of the pulsar detection program we developed continue to use the 406.7 MHz system and its associated software. Other Radio Telescope receivers and computers may be used with this software as long as the output file format is compatible with the input file format of the Pulsar Detector.

The pulsar detector works in the following manner. The signal is sampled using a time base that is some integral fraction of the (known) period of the pulsar. Each sample taken during the duration of a single pulse period is assigned to a bin. The sample can then be folded back over each period so that samples from corresponding bins are added together. Each time we add a new series of bin values for the ongoing totals, we "renormalize" by subtracting an amount from all of the bins so that the weakest bin value is brought back to zero. Random noise in each bin tends to average out, and bins which have a slightly higher average value, will gradually "grow" above the others. A picture then emerges which shows how the average strength of the pulsar signal varies over its period. A filter based on the pulsar period is then used for final processing of the data. data is sent to a file. Sample graphs are shown below.

System Hardware

406.7Mhz Radio Telescope Front End

3 Metre Antenna

Latest Hardware and Software Updates

- New 16 bit high speed A/D (Fall of 2005)
- Higher speed sampling, up to 1000 times per second.
- Survey of 45 pulsar done to test receiver and software
- New filing system to allow continuous operation

Future Developments

A 4 node *Beowulf* cluster of computers has been added to do processing in real time. The interface between the data collection system and the Beowulf cluster is almost complete with initial testing starting in March of this year. New features are planned to do searches for standard Pulsars and RRAT's.

Beowulf is a design for high-performance parallel computing clusters on inexpensive personal computer hardware. Originally developed by Donald Becker at NASA, Beowulf systems are now deployed worldwide, chiefly in support of scientific computing.

en.wikipedia.org/wiki/Beowulf_ (computing)

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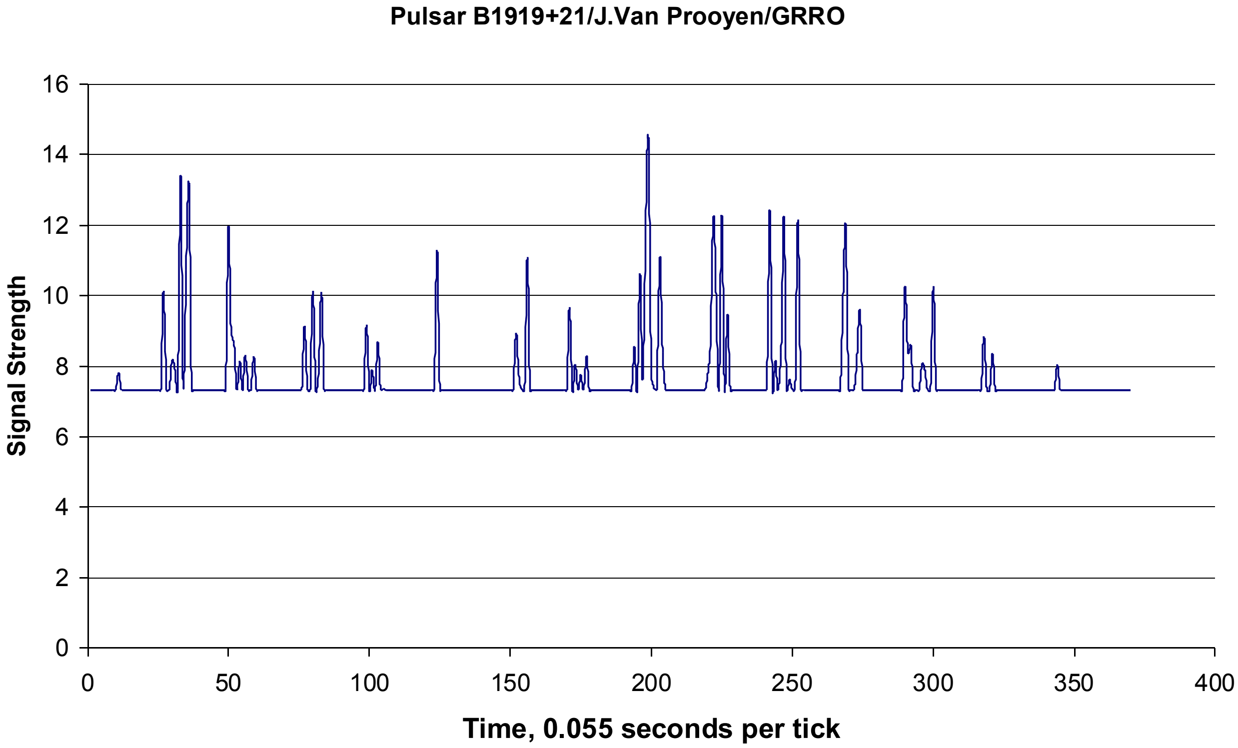

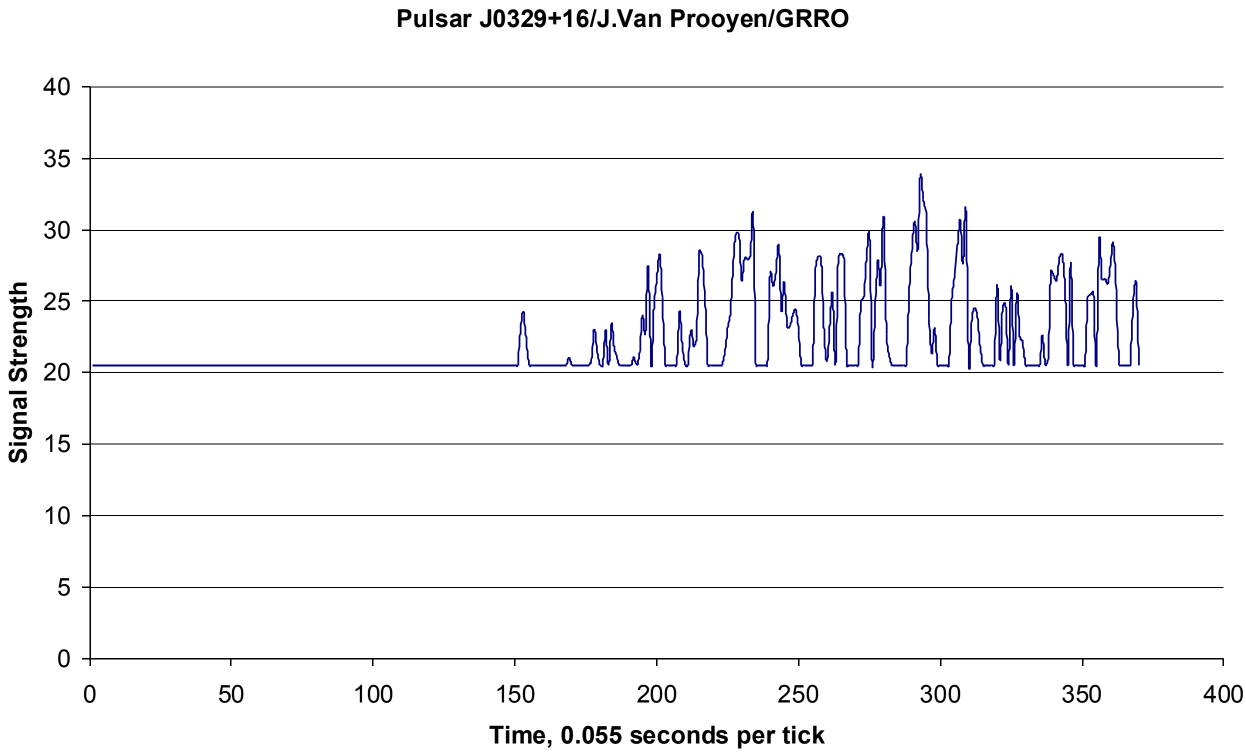

Sample Pulsar Observations

The charts above show results for pulsars B1919+21 and J0329+16. The signal pulses are clearly visible, fading in and out as the observation proceeds.

Acknowledgements

I would like to thank the following people for their help and expertise, and with supplying information for this publication.

Dr. Michael Kramer - Jodrell Bank, UK
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Bryan Gaensler - NRL

1.4GHz Hydrogen Line Spectrometer

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Alan Morgan
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Progress on the 21cm system has been steady rather than spectacular. Alan has concentrated on the LNA and I have focused on the downconverter to 151MHz.

Unless the downconverter electronics are mounted right on the feed point of the antenna, cable losses will require the LNA for 21cm to have relatively high gain. Alan is working on a two-stage design using a P-HEMT FET first stage. The result should be an LNA with about 35dB gain and a noise figure of about 0.4dB (noise temperature of 28K). Accurate measurements of low noise figures are not easy to do without modern professional instruments, but as a benchmark we have a working preamp with which to make comparisons.

The electrical design of downconverter was more or less completed by the technical meeting in January, but the mechanics were still developing. At the meeting, the choice of 151MHz as the 1st IF was questioned. The design was later reviewed and it was decided that the choice of IF would stand because of implications with filter design.

We are trying to make the telescope reasonably tolerant to adjacent channel interference, which requires the use of a conventional interdigital filter rather than a printed design. To maintain good stability, a machined aluminium box is required to house the filter. Drawings for a suitable housing were produced for the technical meeting, but it is a complicated design and to be practical, must be produced using an NC machine. Price was obviously going to be an issue, but the first quote received for manufacturing was so high that it put the feasibility of manufacturing this way in doubt.

Rather than get hung up on the problems of mechanical design, I set about building some circuits in an alternative type of box, using the facilities at hand. Tin boxes are too flimsy to house the filters directly, so brass frames were built inside the boxes into which copper resonators were soldered. This took a lot of drilling and tapping to complete and is not viable for the production version. The results are very compact and the filters have proved to be as good as predicted. See the response of the 1420MHz filter, flat to 0.1dB over about 20MHz bandwidth.

The 1571MHz local oscillator was the first unit to be built. The source uses a crystal controlled Butler overtone oscillator, built to a tried and tested design. This proved to be very touchy built in surface mount components and took some time to get right. There will need to be a further prototype incorporating some of the changes that have been made. However despite initial problems, the PCB has been installed into one of the boxes with a 4 pole filter and is currently producing power at 1571MHz. My own HP analyser is only good to 1.3GHz, but I hope to have access to a 3GHz analyser over Easter to get a better look at the output. See the photo of the local oscillator.

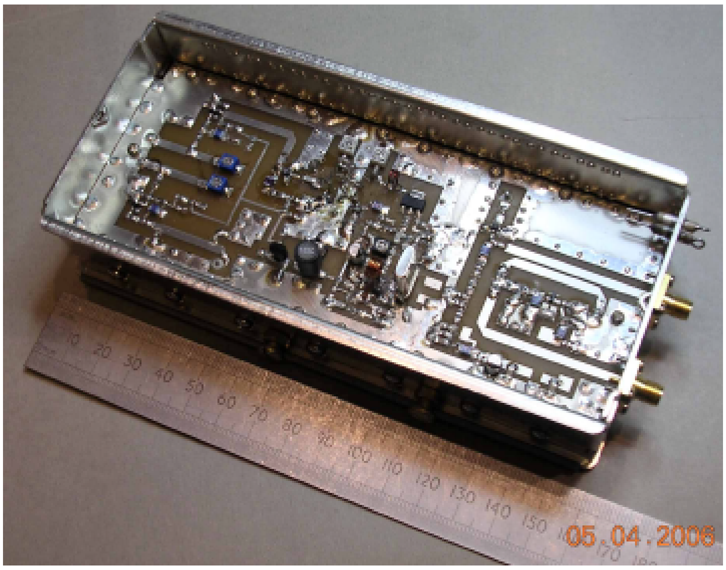
Meanwhile, I had handed some drawings for the machined box to Trevor Sutton at the technical meeting. Trevor eventually found a much more competitive quote for manufacture and I was keen to go ahead and order while completing the tin box prototypes. The prototypes have still not been ordered. Feedthrough capacitors were needed and the details were added to the drawing. There were then questions raised in an email exchange about the bandwidth of the receiver. These would have had implications on the filter design, which would in turn have required a modification to the drawings. I believe these issues are now put to bed, but because I am so close to testing the electrical prototypes, I have decided that I may as well hold fire, just in case an unforeseen problem is found that requires a change to the mechanical housing. See layout of machined box.

The circuit of the downconverter is quite conventional and it will be built using surface mount components. The signal path passes through a filter with 20MHz bandwidth before it reaches the frequency mixer. This mixer is a double balanced type supplied made by Mini Circuits. Ideally the filter would be terminated using isolators to present a good impedance match but the cost is prohibitive. Instead, monolithic amplifier ICs have been used before the filter and between it and the mixer. The Mini Circuit amplifiers provide a very good match to 50 Ohms over a wide frequency range but the disadvantage is that this produces excessive gain with the possibility of intermodulation problems. Careful choice of components and some attenuators should reduce these problems. The mixer must be terminated in an impedance of 50 Ohms to produce the best results, so again the attenuators help achieve this at the signal and local oscillator ports while the IF port feeds a broadband diplexer. The IF path includes a low pass filter to remove any residual local oscillator leakage and a further MMIC amplifier to maintain impedance matching. See the block diagram.

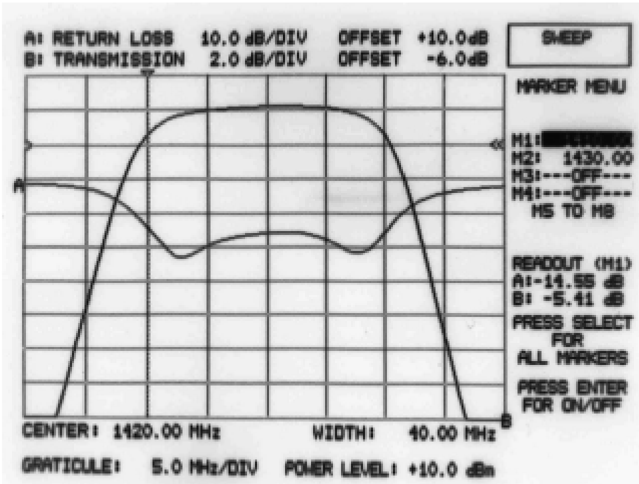
The following 151 to 38MHz stage has been designed and all the components collected. I want to build some prototype 151MHz filters before building a complete unit. Some form of gain control is required in the signal path to correct the levels reaching the detector. A programmable attenuator would be ideal situated before the main IF amplifier. This could be made using relays to switch in fixed attenuators but unless expensive relays are used, some form of DC wetting of the contacts will be needed to ensure reliability. If we implement a Dicke receiver at a later stage, this may require a fine adjustment of IF gain. I welcome comments about these issues.

Finally, a linear polarised feed horn suitable for a dish with f/d of about 0.5 has been tested at 1.42GHz. It has better than 20dB return loss and a reasonably symmetrical E/H pattern. The original design was by OE9PMJ and featured in Dubus 2/86, it is a 1.3 / 2.3GHz dual band feed. A VE4MA type feed will also be tested. This type of feed is better suited to dishes with f/d of about 0.35. A horn antenna using wire mesh is planned for the future.

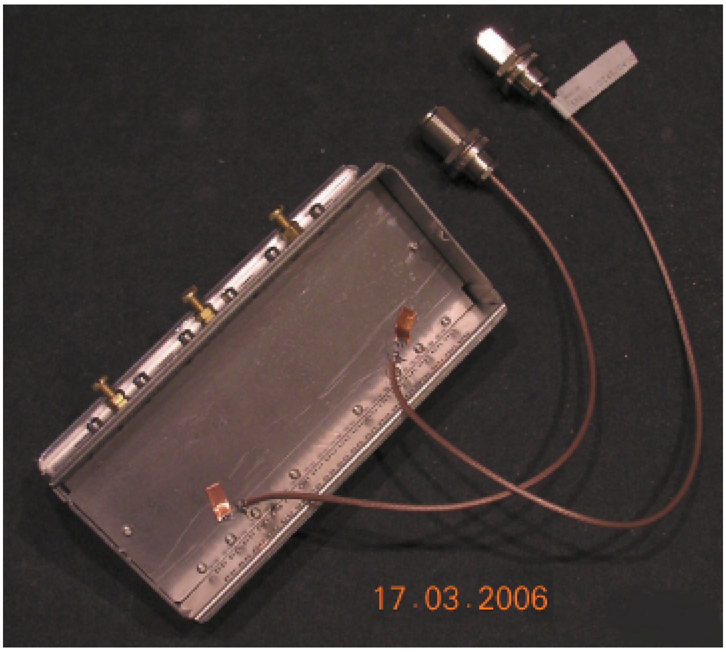
A Prototype Wideband Feedhorn



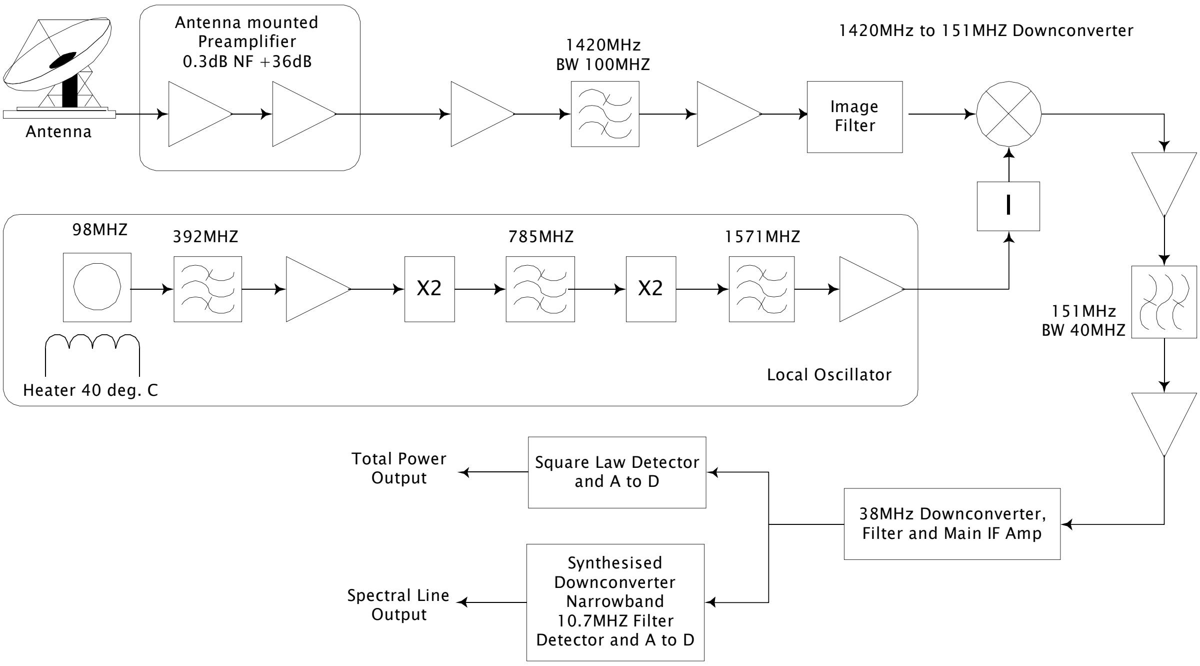
The Local Oscillator



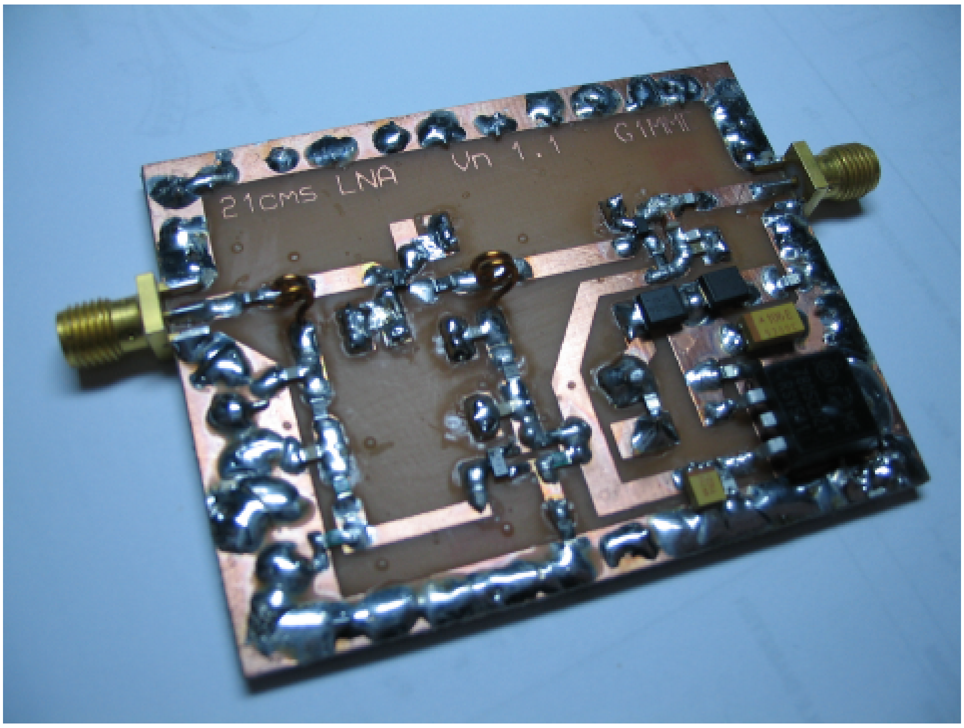
The Filter Response



A Tin Box!



The current design of the 1420MHz Receiver



The prototype 1420MHz Low Noise Amplifier

1420Mhz Low Noise Amplifier

Some progress has been made on the design and construction of the 21cms LNA which will be mounted close to the antenna. The first prototype has been built and can be seen above.

The aim of this part of the project is to have an amplifier will have approx 35dB of gain and 0.4dB noise figure. There are two active devices: an ATF-54143 P-HEMT which will give 20dB of gain, and a MGA 62563 which will provide 15dB of gain. The amp has an on-board 5v regulator so can be supplied with anything from 7v to 35v. It can be supplied with this voltage directly or via the output coax. The final version will have N type connectors on the input and output – the prototype is using SMA for convenience.

The prototype version has only just been constructed and although it does not appear to be oscillating madly it does not appear to be amplifying either. Initial inspection shows it is taking far less current than it should be so it's possible I've got some resistors mixed up. The investigation will continue!

VLF Observing Programme

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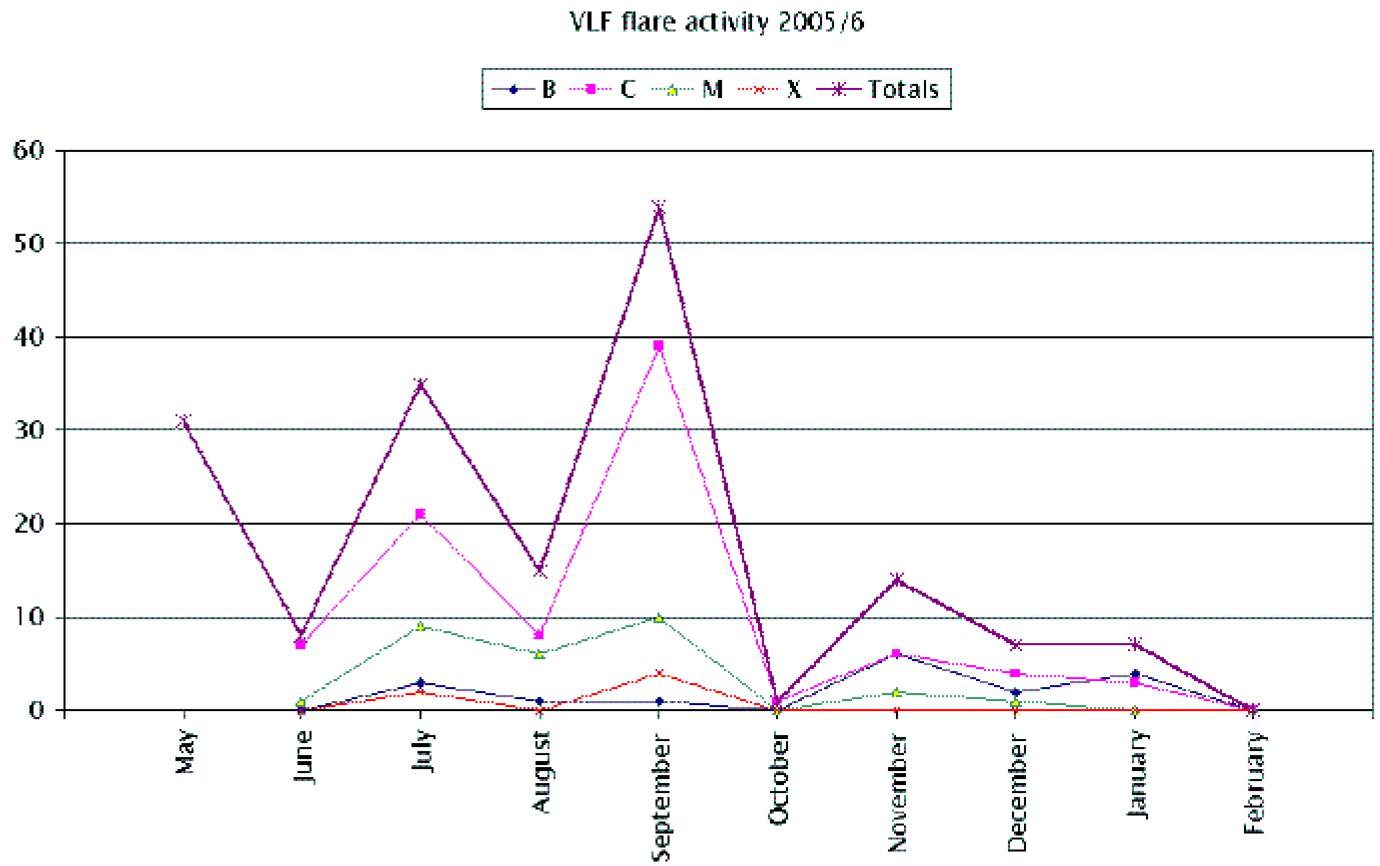
Solar Activity

As I took over this role in May last year, I still have less than 12 months worth of data collected; not a lot for analysis! I have 7 active contributors each month, and from their reports I generate a monthly summary chart that includes the X-ray class of each event recorded. I use the GOES data to match solar flares to our recordings and thus eliminate those events that are not of solar origin. I send copies of the summary to all contributors each month. As we monitor terrestrial transmissions that were never intended to be used as solar flare indicators, we are at the mercy of random changes in the received signal strength that often look very much like flare-induced SIDs. Having a second receiver monitoring at a different frequency helps in eliminating this interference, but is not always possible! With observers monitoring different frequencies, we should also cover breaks in transmission that often occur each day.

Solar activity over this period has changed dramatically from a peak of 54 recorded events in 2005 September to nothing recorded in 2006 February. This is broadly in line with visual solar activity, and reflects our current position approaching solar minimum. I hope that these inevitable periods of very low activity do not discourage observers from sending in reports, as negative reports are just as valuable as positive ones. The simple chart shown here indicates the activity levels each month. Over time, this chart will build into a record of flare activity that can be directly compared with solar section prominence and relative sunspot numbers.



VLF Receiver Production

The VLF receiver is the first section of the Starbase project, and an initial quantity of 10 were made. These have been tested and are with group members to try out. Without the 'backbone' of the Starbase system to log data, users will have to make their own arrangements to record and analyse the signal. They also have to build an aerial, and find a suitable signal, all of which takes a bit of time. In due course I hope to start receiving a few more reports as these receivers are brought into use and produce some good data. So far, I am not aware of any problems with these units, but the experiences of their users will help in creating a good set of notes to go with the receiver in the future. I have personally built 4 copies of the circuit, and all produced good results.

Observations are welcome whatever type of receiver and aerial is in use, so please send in what you have recorded.

VLF Receiver Beta Testing

Martyn Kinder
asdasdasd

These notes describe my Beta testing of the BAA Radio Astronomy Group SID receiver designed by John Cook..

Background

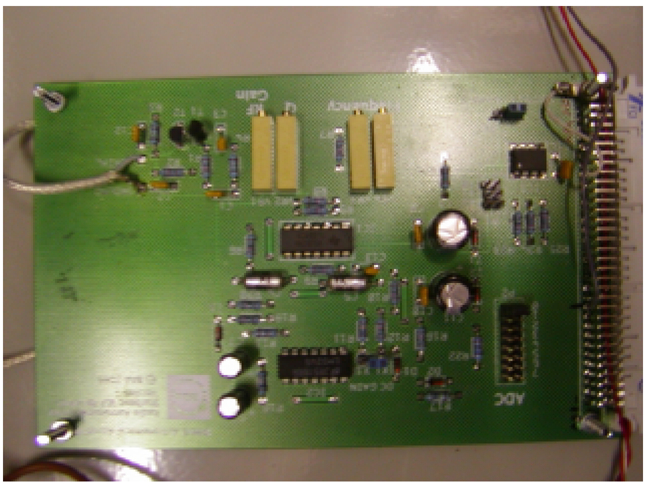
A SID (Sudden Ionospheric Disturbance) occurs when the atmospheric 'D' layer is degenerated following a solar flare. The receiver is tuned to a distant (approximately 1000km) Very Low Frequency (VLF) Radio Station. In my case, I have selected a station in Northern Germany transmitting on 23.4kHz.

The 'D' layer forms during daytime hours, and is normally fairly stable. When the 'D' layer degenerates, the received signal strength will decrease very quickly. It may be several hours before the 'D' layer reforms. By analysing the nature of the recorded pattern of the received signal, it is possible to deduce the strength and type of the flare as each flare type has a characteristic fingerprint.

The BAA RAG plan to offer a completed VLF Receiver module that will eventually plug into the Starbase system. The notes below document my observations integrating the unit into my own observatory

The Receiver Module

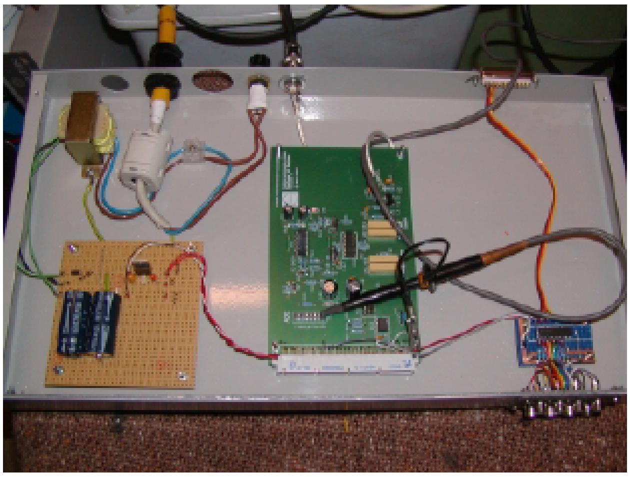
Typically, the receiver module will be supplied in its own RF shielded tinplate box. The interface to the outside world is via a 64 pin Eurocard connector and a BNC connector to the aerial. See the BAA RAG circular for a photo of the completed module. My early Beta was supplied without the tinplate box and has been inserted into my receiver system as supplied.



Martyn's VLF Receiver

Boxing it up

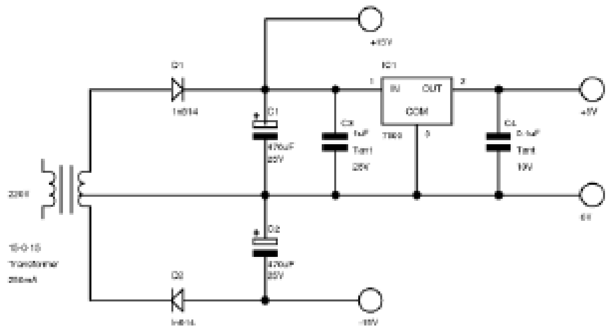
I managed to 'acquire' a 1U rack mount box from an IT installation that was being decommissioned. The box was originally used as Fibre Optic Patch Panel. I stripped out the connectors and filled in all the holes with Plastic Padding. A couple of coats of paint and it looks almost presentable. The three Printed Circuit boards were simply fastened inside the box using M3 screws and 12mm spacers. Special effort was made to ensure that everything running at 0V was earthed to the case of the box. The image below shows the general layout:



The VLF Receiver housed in a 1U 19inch Rack

Power Supplies

The unit requires +15, -15 and +5V DC supplies. Current consumption is fairly low, so a 250mA transformer was purchased from Maplin Electronics and a simple Power supply was assembled on Veroboard. The circuit diagram below provides a fairly smooth on-load unregulated supply of +/- 17V and a regulated supply of +5V.



The Power Supply

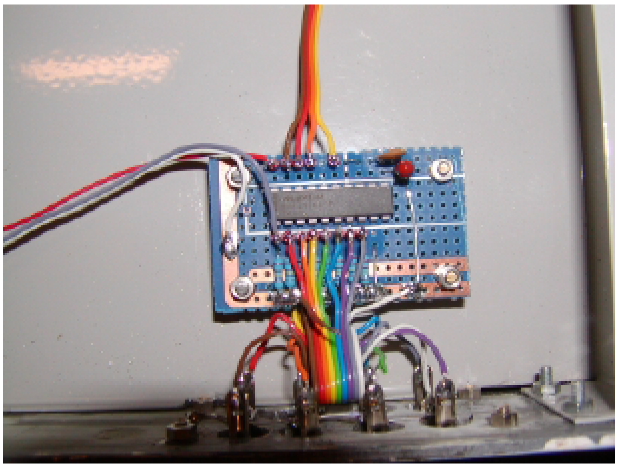
Mains input is fused inside the box with a 100mA fuse and the case is earthed. I have placed a ferrite block over the mains cable to try and suppress any mains bound interference.

Analogue to Digital Converter

The output from the receiver provides up to about 4V DC output. The reality is that this will be dependent on the efficiency and gain of the aerial. To interface to your computer, you will need to convert this DC output to a digital stream that the computer can understand. An Analogue to Digital Converter (ADC) performs this task for you. Radio Sky (http://www.radiosky.com/) supply a very nice piece of software called Radio-SkyPipe that is available as a download from their web site. It is available in two variants - a single channel restricted (free to use) variant or a fully featured 8 channel version available for a (relatively) low cost. Also available from their site is a circuit for an ADC based on the MAX186 ADC chip at:

http://www.radiosky.com/skypipehelp/skypipe8channelADC.html

I recreated the circuit onto some more stripboard. Connections to the outside world (Channels 2-8) will be via screened phono sockets. Channel 1 is connected to the Analogue output of the VLF Receiver. The ADC is located adjacent to the input to keep the unscreened leads as short as possible. The image below provides detail:

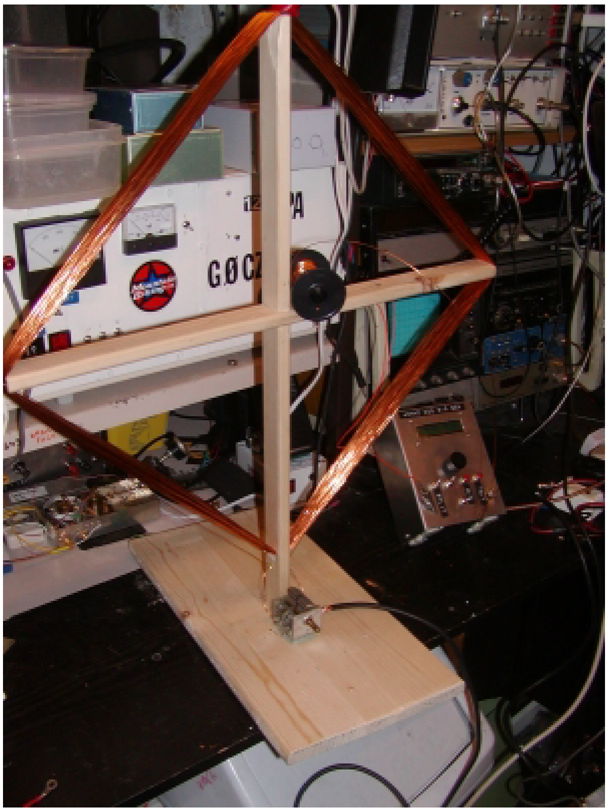


The MAX186 Analogue to Digital Converter

The Aerial

This is the fun bit! Getting the aerial tuned is a bit tricky and involves some maths. But use web resources where they are available.

The tuning of the aerial is dependent on three things. The frequency that you want to tune the aerial to, the inductance of the wire forming the aerial and the capacitance to bring onto resonance. Tuning is very sharp which means that the bandwidth is very narrow, so that you will need be quite sure of the variables.



The Kinder Loop

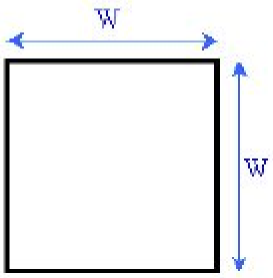
I used the inductance calculator at this web site

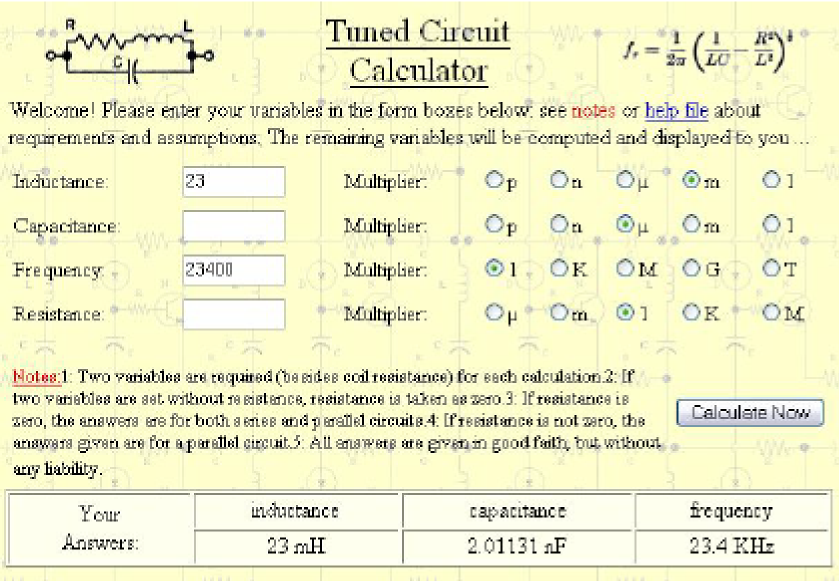
http://emcsun.ece.umr.edu/new-induct/

to calculate my loop inductance (see the screenshot on the next page). My loop comprised of 122 turns of .77mm diameter copper wire from Maplin Electronics on a 36cm square frame. Three rolls of wire are required. Smaller diameter wire can be used, but be careful that the resistive losses don't get too high as this will affect the performance of the aerial. The result from the calculator is an inductance of 23mH. Now we have to calculate the required capacitance to tune the aerial to 23,400Hz. Yet another online calculator exists at:

http://www.cvs1.uklinux.net/cgi-bin/calculators/tuned_circuit.cgi

To physically achieve this, we have to wire the capacitor in parallel with the coil we have painstakingly wound. It is very unlikely that the exact value capacitor will exist anyway so a variable capacitor will be required. Air spaced capacitors normally have a maximum value of about 400pF, so fixed value capacitors will be required to be wired in parallel to build up to the total capacitance required. See the diagram below. Use polystyrene capacitors for this job, they are much more efficient than ceramic capacitors. In an ideal world, you want as little capacitance as possible. They add nothing to the efficiency of the aerial and it is better to have a larger loop with more turns and use less capacitance. The capacitance is used only to bring the aerial onto resonance,





http://www.cvs1.uklinux.net/cgi-bin/calculators/tuned_circuit.cgi

- N: number of turns
- W: length of one side
- a: wire radius
- µr: relative permeability of the medium

$$L_{square} \approx N^2 \frac{2\mu_0 \mu_r w}{\pi}\left[\ln\left(\frac{w}{a}\right) - 0.774\right]$$

Choose units for a and W

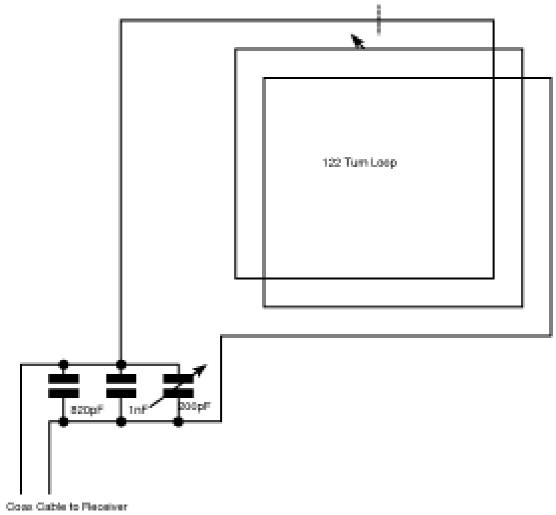
○ **meter** ⦿ **cm** ○ **inch**

Parameters	**Input**	
N	122	**turns**
W	36	
a	.077	
µr	1	
L	23030000	nH

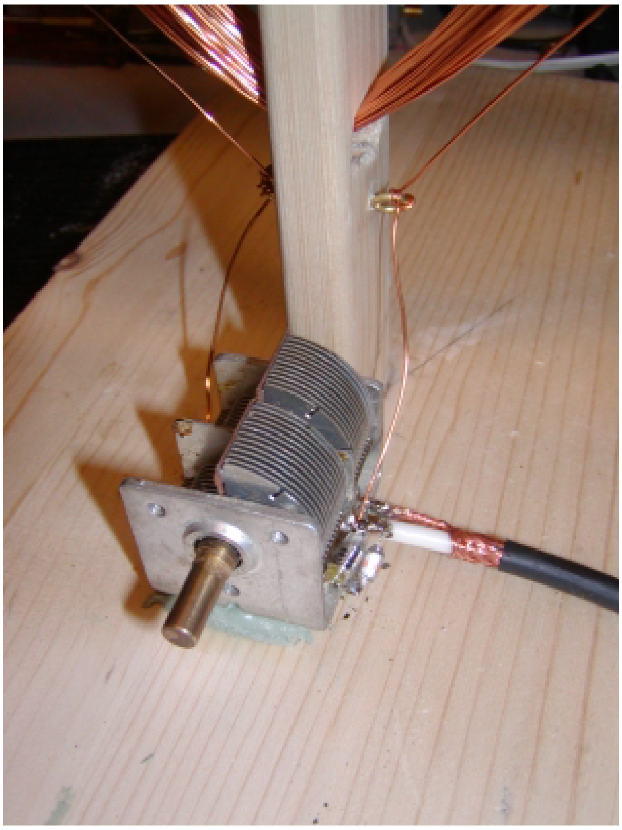
Try again Change Structure

http://emcsun.ece.umr.edu/new-induct/

Showing two of the useful calculators which may be found on the Internet



Loop Aerial Circuit Diagram



The photograph shows what this really looks like. Note the two small polystyrene capacitors across the capacitor. Both of the variable capacitor halves are in use. The capacitor is glued down to the baseboard using a dollop of Plastic Padding.

Getting it all working

Cable it all up, check all supplies are present and correct and you can start fine tuning. Install your data logging software (for instance, as described on the Radio Sky website). On the VLF board set the DC gain link to x10 gain - it will make life easier! Select ADC Channel 1 and check that the PC is recording. You will need to carry out this bit during daytime hours (not sunset or sunrise). Carefully tune the variable capacitor and watch the output. The receiver has a delayed response to changes in signal strength and it will lag tuning by a few seconds. Look for a peak. Once the peak has been identified, (adjusting the capacitor by about 5 degrees in either direction will see the signal fall rapidly) then you can start aligning the board. There are 4 trimmer potentiometers to adjust. Two optimise the Frequency, one sets the 'Q' or magnification and one sets the output gain. Overdriving these settings will cause the output of the receiver to take off. When this occurs, back the potentiometer by about 1/2 a turn and the level will drop again. Once all have been optimised, simply case it up and enjoy your instrument.

The coaxial feed cable

One other thing you will need to consider is the characteristic impedance of the coaxial cable feed from your loop aerial to your receiver. Use a good quality cable, not the rubbish that you get for TV aerial down-lead. I used RG58. This has a characteristic impedance of 50 Ohms. I am not particularly worried about matching - this is running at almost DC, but the cable does have a capacitance that needs to be considered. RG58 has a capacitance of 100pF per metre. For a short patch lead, this is fairly insignificant, but when you get bored with your object d'art or your partner demands that you put it out of sight or you want a cleaner signal and you put it in the loft, that 10 metres of cable forming a patch lead now has an additional capacitance of 1nF. If you don't allow for this, your receiver will suddenly stop working. Satellite TV coaxial cable may also be used. This has a characteristic impedance of 75 ohms and a capacitance of about 56-66 pF per metre depending on the type.

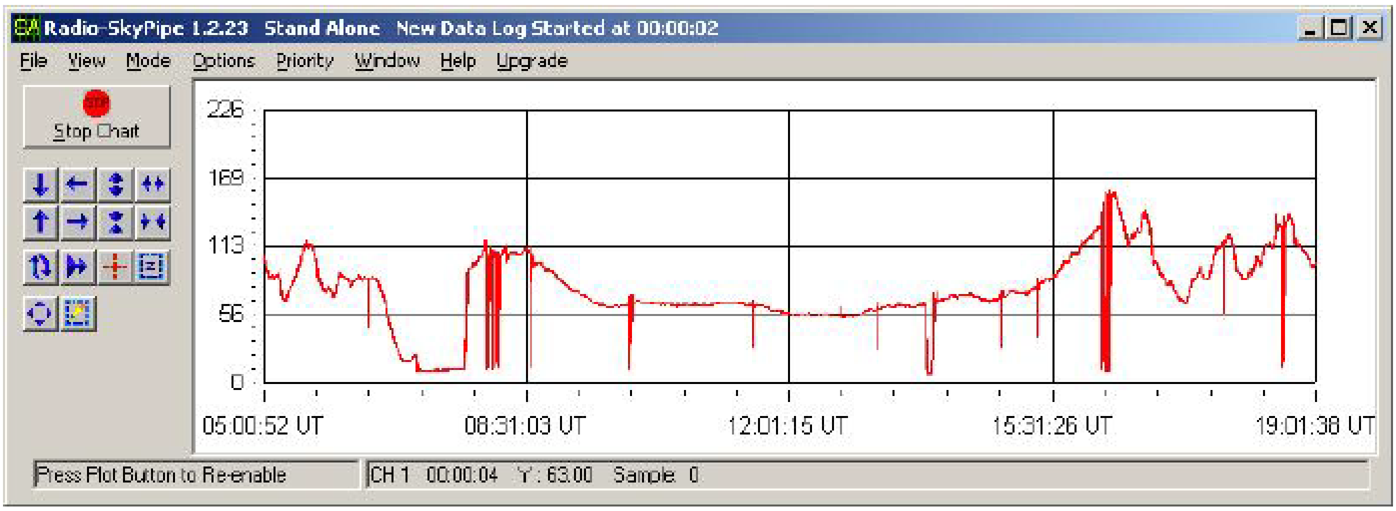
Orientation of the aerial

The maximum signal strength will be when the loop of the aerial is pointing in line (not broadside) to the signal transmitter. In this case, for my aerial located in Northwest England receiving a signal from the North German transmitter, the frame is aligned E-W.

Results

Early days yet, but at least it is working. The graphic below shows a 14 hour sample, clearly showing how the 'D' layer forms at dawn and disappears again at dusk. Note that dawn is UK time and dusk is German time.

It can also be seen where the transmitting station is turned off at dawn. I appear to have a few glitches as well that need to be resolved, but it is working. The aerial will be placed in the loft to try and keep it away from as much man made noise as possible. It is very susceptible to noise and would easily detect when the fluorescent lights were switched on and off. I may also build a larger aerial, perhaps 1m square. This will increase the capture area and by maintaining the same number of turns allow me to use a lower value load capacitance.



The VLF Receiver output, as shown by Radio-SkyPipe

An Introduction to Magnetometry

John Cook
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Simple amateur magnetometry is easy to do with the most basic of instruments. The "jamjar" magnetometer has been widely used by the Aurora section of the BAA for many years, and makes an excellent introduction. It consists of no more than a magnet suspended inside a jar, so that it is free to rotate and point to the magnetic north pole. To observe small changes in the Earth's magnetic field a mirror can be added to the magnet such that a light can be reflected on to a scale drawn on a convenient wall. Over a period of time the 'normal' daily behaviour of the magnet can be learnt, and abnormal behaviour can be identified.

The Earth appears as if it has a bar magnet buried deeply inside, near the centre, but offset such that the magnetic poles are some distance from the geographical poles. Surrounding the Earth is therefore a giant bar-magnet pattern of field lines which protect us from much of the ionised material thrown our way by the Sun. The constant stream of the solar wind pushes the field lines into a tear-drop shape, blunt towards the sun and drawn out into a long tail in the anti-solar direction. They all converge towards the magnetic poles, and dip down through the Earth's surface. Events on the Sun modulate the strength and speed of the solar wind, and so the Earth's magnetic field lines are similarly pushed around as the wind reaches us. With no other activity from the Sun, the Earth's rotation causes the field line pattern to shift from side to side between dawn and dusk. A magnetometer at the Earth's surface will detect this movement and show a small diurnal deflection in response.

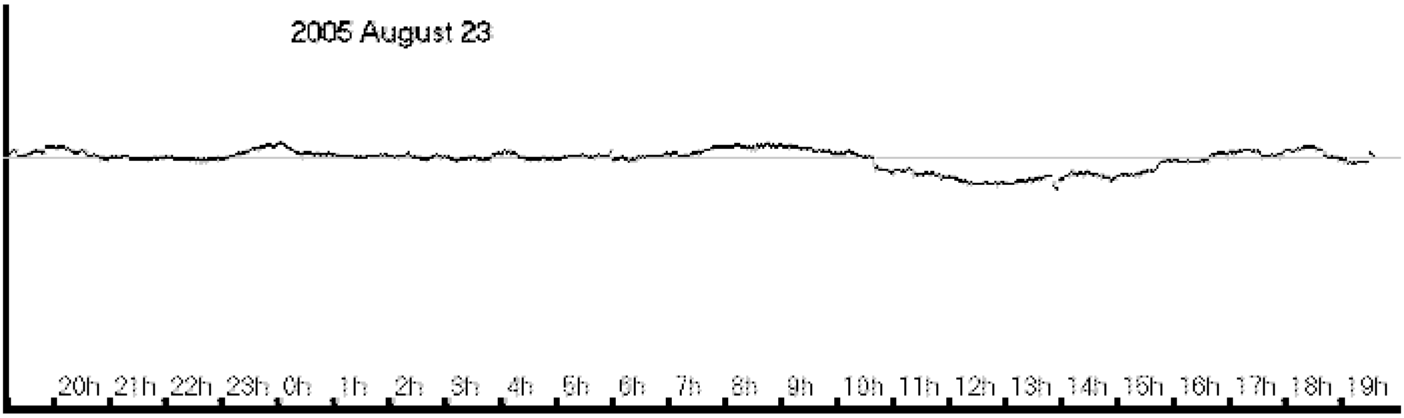
Of course, the Sun is far from quiet much of the time, and so is the solar wind. Flares and coronal mass ejections cause considerable turbulence in the solar wind and also to the Earth's magnetic field. Large flares can cause large interactions between the Sun's magnetic field and the Earth's, disrupting the normal diurnal pattern. The particles carried in the solar wind can work their way down into the ionosphere near the magnetic poles, as well as into the magnetotail on the night side of Earth. These are the root cause of aurora and magnetic storms, and can easily be observed with the jamjar magnetometer.

I built a recording version of the jamjar magnetometer many years ago, using a pair of Hall-effect sensors underneath the suspended magnet. See the photograph on the next page. The output was recorded on a data logger. The major drawbacks to this simple design are: 1, it also makes an excellent vibration detector and has recorded at least one Earth tremor and 2, all of its components become magnetised over time, and their field began to interfere with Earth's field. It also drifted badly with temperature and time. My answer was to build a solid-state version, not requiring an external magnet to follow the field. Magnetic sensors are now widely used in all sorts of direction sensing applications (compasses in cars, for instance). Examining the data sheets shows that they are quite sensitive enough for observing magnetic storms, and fairly easy to use. A magnetometer built this way should not drift with temperature, or become magnetised, is less sensitive to vibration, and could be calibrated if required.

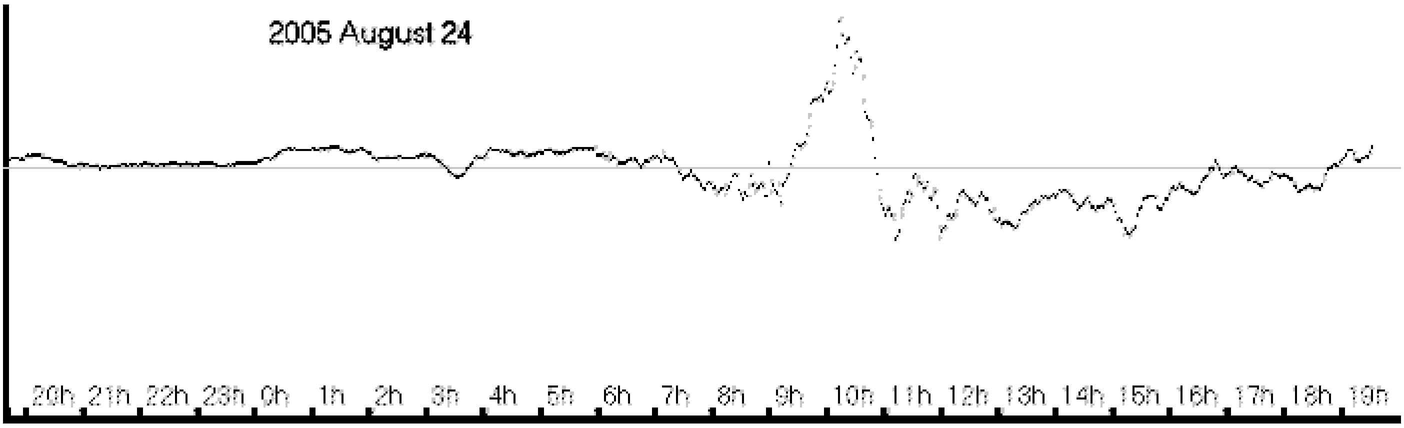
As the Earth's magnetic field exists in 3-dimensional space, a 2-axis device can be used to monitor horizontal and vertical components, or a single axis to monitor just the horizontal component. The design for the *Starbase* project will be a 2-axis magnetometer. I have been using a single axis version for a couple of years (see photograph), and find that it can be extremely sensitive to its magnetic environment, and so a gain (sensitivity) adjustment will be included. As I live on a modern housing estate, disturbances from vehicles can be a real problem; I know at what time the refuse collection occurs, as it clearly shows on my daily recordings! For users in a magnetically quiet environment, a higher sensitivity can be used, or even made adjustable according to prevailing conditions. Even with a lower sensitivity setting, the diurnal curve is well defined, and small disturbances (from the Sun) are obvious. Major magnetic storms will saturate the output in either direction, so that there is no doubt as to what is going on, even when the Sun is not visible.

Two recordings are shown here. That for 2005 August 23. shows the quiet diurnal curve quite well. There are minor disturbances visible, some of which are probably not of solar origin. The following day is quite different, with a major solar disturbance during the morning hours, followed by less dramatic activity during the afternoon and evening hours. An M2.7 flare at 14:21UT on the 23rd. may well have been the trigger for this burst of magnetic activity.

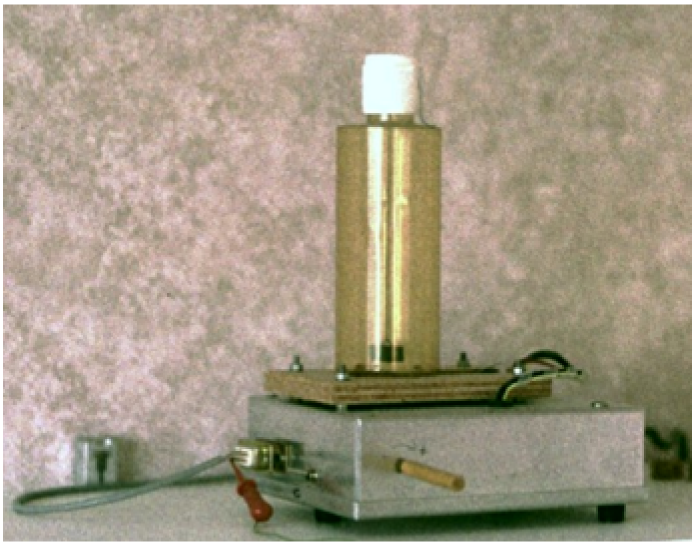
Combining magnetic observations with visual and other radio observations of the Sun will keep any observer up to date with current solar activity. Apart from the interest in making such observations, magnetic storms are often associated with aurorae. Keeping an eye on the magnetometer output will give advance warning that aurora might be occurring somewhere, and well worth looking out for. Local light pollution may well render a subtle green or red glow invisible, but that is another story.



John Cook Magnetometer - Quiet Diurnal Behaviour

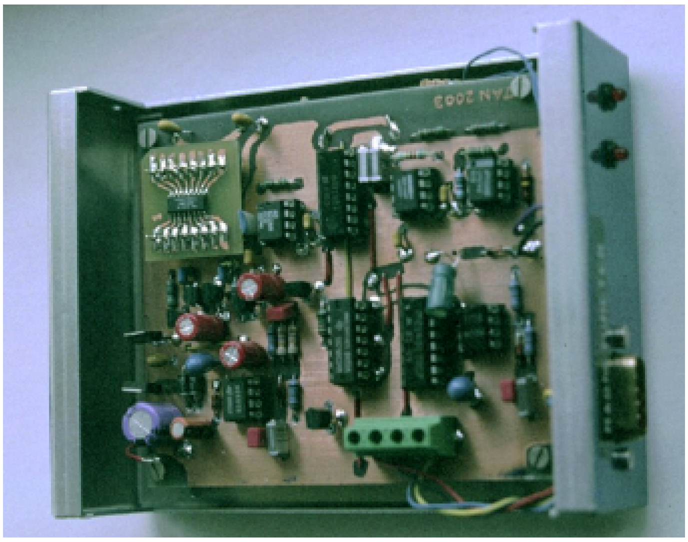


Magnetometer - Major Solar Event



The JamJar Magnetometer

This model of JamJar magnetometer was constructed by John Cook. The Hall-effect sensors are in the box underneath the jar assembly.
The original design is due to members of the BAA Aurora Section.



Magnetoresistive Magnetometer

This module is John Cook's own design for a single-axis magnetoresistive magnetometer. The sensor can be seen at the top left of the PCB.
This design forms the basis for the Starbase dual-axis magnetometer, currently in development.

Observatory News

Earth Moon Earth Polarisation test at Redenham

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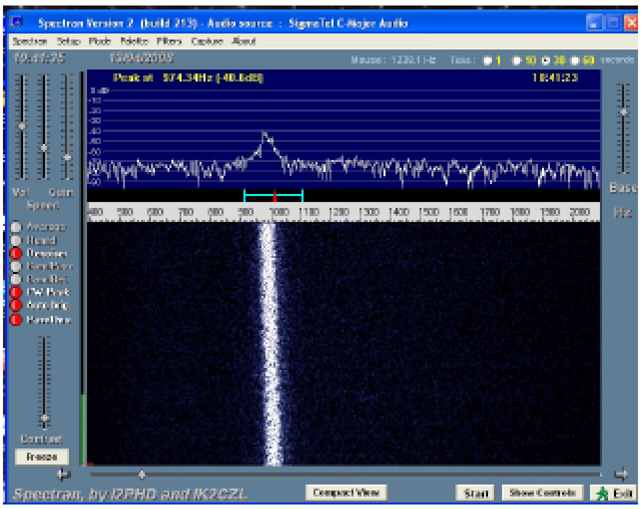
It has been established that the use of circular polarisation for Earth Moon Earth communications, particularly on the lower frequency microwave bands, has advantages over linear polarisation. In addition to overcoming the problems of spatial separation between stations at different longitudes, circular polarisation is claimed to offer some reduction in libration fading. Signals reflected from the moon suffer from loss of coherence due to the relative motion of the rough lunar surface which can be considered as a many-faceted reflector. For a demonstration of libration see www.qsl.net/kl6m/libration.htm. Libration fading is analogous to the speckle fading observed when coherent light from a laser is reflected from an optically rough surface. If you move the surface or the light source, the speckled areas move. At shorter (radio) wavelengths e.g. 3cm libration fading manifests itself more as spectral spreading. The echoes returning from the Moon are less coherent making them more difficult to resolve.

The image below, made using Spectran, shows amplitude *vs* frequency in the top part of the screen and Time *vs* frequency in the lower part . The scale across the display is frequency with the larger steps being hundreds of Hz. A spectrally pure signal would be displayed as narrow peak in the upper display an as a straight, narrow vertical line in the lower part. This trace shows that a signal reflected from the Moon has been spectrally spread to about 50Hz. The trace leans to the left because the Doppler shift from the Moon is always changing, falling as the Moon rises, dropping to zero near the zenith then continuing to fall ,i.e. becoming negative as the Moon sets.



A group of radio amateurs have been undertaking what I hope will be a series of tests to characterise the polarisation and spectral spreading of signals reflected from the Moon on 10368MHz (approximately 3cm). It is hoped that the data we collect will help develop improved Earth Moon Earth communications on the higher microwave bands.

The first of these tests was carried out between myself (G4NNS, 3.7m dish, Redenham, Southern England) using rotatable linear polarisation while LX1DB, (10m dish Luxembourg) transmitted with first linear and then circular polarisation. Recordings were made of both the linear and circularly polarised transmissions while the orientation of the linearly polarised receiving system was varied between vertical and horizontal in 10 degree steps. This test gave some useful indications that the scattering of polarisation by the rough lunar surface was not as great as had been anticipated but while the tests suffered from a number of shortcomings they provided a useful learning exercise and enabled us to propose a better protocol for future tests.

James G3RUH had seen news of these tests and kindly persuaded the AMSAT-DL team to arrange for the 20m antenna at Bochum in Germany to be available for the next tests which took place on 2006 April 2nd after their annual general meeting.

The Bochum radome in Germany

The AMSAT DL team transmitted a constant signal (after a five minute warm up) towards the centre of the Moon using 700W and vertical Polarisation on 10368.500MHz for two hours.

The principal receiving stations for this test were OK1KIR (Czech republic) (see the photo on the next page) with a team consisting of Tonda-OK1DAI, Vladimir-OK1DAK, Jan-OK1VAO and G4NNS (Southern England) assisted by Ronny SM7FWZ.

OK1KIR receiving station used in the tests

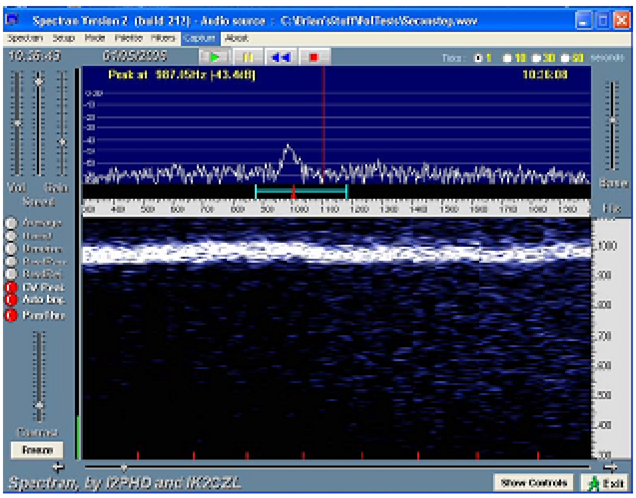
Both stations made extensive recordings of the Bochum signals with polarisation offsets ranging from zero to 90 degrees. An edited selection of these recordings can be found at:

myweb.tiscali.co.uk/g4nns/Poltests1.html

while complete data form OK1KIR can be found at: www.qsl.net/ok1vao/10GHz_pol_test/.

The recordings can be replayed on most audio software and can be replayed and viewed using Spectran which can be downloaded free from:

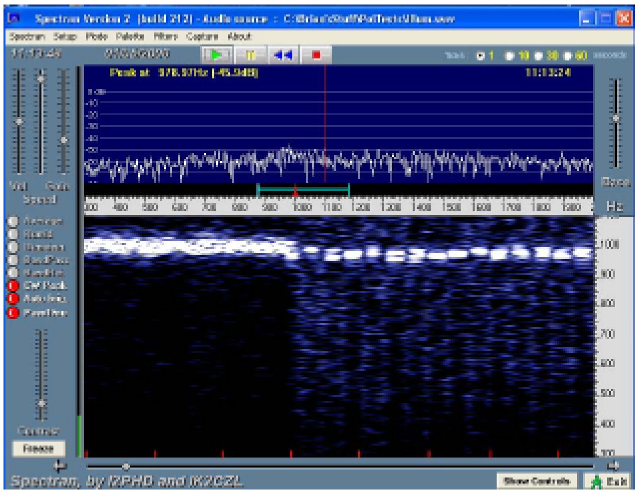
www.weaksignals.com.



The Spectran analysis of the received signal

In the spectrogram above, the density of the thick horizontal line represents signal strength. The red tick marks at the bottom represent increasing polarisation offset in 10 degree steps starting at 10 to the left and increasing to 90 degrees at the right. As expected, it shows the signal reducing as the offset increases. My subjective impression was that the loss was of the order of 10dB but we await DSP analysis for a more accurate estimate. A number of issues were raised in the light of these tests. Most obviously we lack data for Circular Polarisation (CP) to Linear and for CP to CP. It is hoped that these tests can be set up at a future date. Another issue is that the beam width of the Bochum antenna is such that it only illuminates a small proportion of the Moon at the centre of the disc. This might be expected to result in less spectral and polarisation spreading compared to a system which fully illuminated the whole disc of the Moon thus bringing into play surfaces with a greater range of relative distances velocities.

To explore these issues another test was set up on 2006 April 29th, this time with the signal provided by the IQ4DF team (Italy) using a smaller 7m dish and 200 watts. Again we have not yet been able to analyse the data but the spectrogram below shows the Bochum signal (left, continuous) and the IQ4DF signal (Right dashes). It is hard to conclude that the spectral spreading (vertical width on this trace) is greater for the IQ4DF (more fully illuminated) signal as might have been anticipated. On the contrary the under illuminating signal looks wider. But this may just be due to Its greater strength.



We will have to await more detailed analysis before we draw any conclusions. So if there is anyone out there who would like to help with the DSP analysis of signal strength relative to zero offset and of spectral spreading I would be very pleased to hear from them.

More on Bochum
www.amsat.org/amsat/articles/g3ruh/126.html
www.southgatearc.org/news/april2006/voyager1.htm

3peaks Radio Telescope

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John McKay's radiotelescope in the Yorkshire Dales National Park has recently been in the news as a result of John having to apply for retrospective planning permission! The news articles below and on the next page tell the story (published with the permission of the editor of the Craven Herald).

John contacted the Group for assistance when it began to look like permission would not be granted, and we responded with a letter to the planning committee, supporting John's application.

John would also like to thank Martin Morgan Taylor, of the Law School at DeMontfort University, a member of the BAA and of the RAG. Martin has professional interest in cases such as this, and in the problems of light pollution and the legal aspects of statutory nuisance. Martin also wrote to the planning committee, as did the Astronomer Royal of Scotland, and others as mentioned below. We are happy to report that John won his case, and can now concentrate on doing some radio astronomy!

Looking into space: astronomer John McKay and his radio telescope. 10/6/21.

Astronomer fights to keep telescope

AN astronomer's hopes of carrying out intensive research into outer space from his home in Horton-in-Ribblesdale could be dashed by the national park.

John McKay is seeking retrospective planning permission for a radio telescope, which resembles a large satellite dish, behind his house on Bransghyll Terrace.

But his plan has been recommended for refusal by the Yorkshire Dales National Park Authority when it meets on Tuesday.

Mr McKay has the backing of his neighbours and a petition in support has been signed by 50 residents in the village. He said he had not actively approached people but left a copy in the village's two pubs and post office.

Mr McKay wants the radio telescope in place for a partial solar eclipse later this month and is critical at the haste at which the planning application is being rushed through.

He said it was as though the aim was to stop the project as soon as possible without giving him the chance to fully present his case.

Mr McKay disputes that the telescope is a blot on the landscape, saying it cannot be seen from most public places.

"I have purposely built the dish close to the ground and it can be seen only from the west side of the lower car park in Horton-in-Ribblesdale and this view is obscured by telephone lines and electricity cables," said Mr McKay.

A radio telescope does not provide optical pictures of the universe but collects information on properties such as the rotational and radial velocities of stars and far-off galaxies. These can be presented as graphs.

Mr McKay, a retired radio operator in the Merchant Navy, has had a lifelong interest in astronomy and is studying for a degree in astral physics. He said the data collected would be open to educational establishments.

He has already had one approach from the head of physics department at St Mary's College, Blackburn, who asked if A-level students could visit when the telescope was completed.

"I'll be delighted to welcome them," said Mr McKay. "It shows there is a clear educational need."

Among those backing Mr McKay's work is the Astronomer Royal for Scotland, John Brown, Professor of Astronomy at Glasgow University.

He has written to the national park saying it would be a travesty to kill off the project and that its benefits firmly outweigh any minor detraction from the natural beauty of the area. "The Dales are a great part of our natural heritage but so also is the universe out there," said Prof Brown.

Horton-in-Ribblesdale Parish Council has expressed reservations but Mr McKay has criticised members for discussing the plan when it was not on the agenda.

He said that had denied him the opportunity to present his case.

National park officer Daniel Child has recommended refusal, saying the telescope is "alien to the character of the landscape".

Courtesy of the Editor of the Craven Herald

Some time later, the Craven Herald reports...

An astronomer has won the first round of his fight to keep a three-metre high radio telescope at his Horton-in-Ribblesdale home. John McKay erected the equipment, which resembles a large satellite dish, behind his house on Bransghyll Terrace. He was then forced to seek retrospective planning permission from the Yorkshire Dales National Park Authority. Initially it looked as though his hopes of carrying out intensive research into outer space were going to be dashed when officers recommended refusal. They said in a report to the meeting that the telescope was "alien to the character of the landscape". "The telescope is considered to harm the amenity of neighbours and not be in keeping with the locality," they added. However, members said they were minded to approve the plan after hearing that Mr McKay had the backing of neighbours and astronomy experts. Further reports will now be prepared and the application will go back to a future planning committee meeting for ratification.

In an e-mail to members, Michael Merrifield, professor of astronomy at Nottingham University, said: "Astronomy remains a uniquely attractive balance for an area like the Yorkshire Dales National Park. "It is a cutting-edge, high-technology science which shows that the area has a vibrant 21st century life, yet at the same time its requirements for peaceful undisturbed skies align it closely with the preservation goals of the national park. "Indeed, it was the sight of the glorious sky which greeted me when I emerged from Penyghent Pot late at night many years ago that really inspired me to become involved with the entire subject in the first place." Mr Merrifield added that the Three Peaks telescope was completely in character with the history and future of the national park. "Its scientific, educational and cultural benefits far outweigh its completely minimal impact on the landscape," he concluded.

Mr McKay also received backing from Professor John Brown, the Astronomer Royal for Scotland. His letter said: "My understanding is that the telescope is only visible over a limited area and I firmly believe its benefits outweigh any such minor detraction. It would be a travesty to kill it off just when it is reaching fruition."

A radio telescope does not provide optical pictures of the universe, but collects information on properties such as the rotational and radial velocities of stars and far-off galaxies. These can then be presented as graphs.

Mr McKay, a retired Merchant Navy radio operator, has had a lifelong interest in astronomy and is studying for a degree in astral *(sic)* physics. He said the data collected would be open to educational establishments. He has already had one approach from the head of physics department at St Mary's College, Blackburn, who asked if A-level students could visit when the telescope was completed. "I'll be delighted to welcome them," said Mr McKay. "It shows there is a clear educational need."

Technical Meeting 2006 January

Karen Holland

I present a summary of the technical team meeting here. This is necessarily a greatly reduced version of the minutes as it was a long day, and far too much was discussed to present here in its full form! If anyone would like a copy of the full minutes, let me know and I'll email a copy to you.

Present at the meeting were Antony Adcock, Terry Ashton, Mark Byrne, John Cook, Paul Edwards, David Farn, Karen Holland, Martyn Kinder, Alan Morgan, Laurence Newell, Trevor Sutton, and Stuart Withnall. Peter King sent apologies for his absence which was due to illness

Laurence gave an overview of the plans for the Plug and Play Observatory (PnP Observatory) which was to create a system that anyone would be able to plug together and use, even if they had no electronics expertise. There was some considerable discussion during the day regarding the architecture and specification of the system, and security procedures that would need to be implemented.

The VLF Receiver Project was well underway. John Cook had produced a prototype receiver which was tested and working well. He had produced some notes to go with the kit which comprised a circuit diagram, aerial construction instructions, notes on the receiver, an article on flare classification and monitoring, and an article that was currently being written listing the frequencies of the stations that were currently being monitored. Laurence said that we would provide a ready-assembled receiver box, and would not give out artwork. Some further work was required to see if it would be possible to find an alternative to the expensive air-spaced capacitors that were usually used. Analogue to Digital converters (A2D) would be required in order to make use of the receivers in advance of the controller becoming available.

Karen outlined the current costs, which amounted to around £80 per receiver. This cost was for the receiver box only, and excluded the costs associated with the aerial construction, the variable capacitor and the A2D converter and datalogging software. Karen noted that PC-interfaceable multimeters were available from Maplin for about £20, which would do the job of the A2D and the datalogging software.

Alan Morgan had been working on the front-end of the 1420MHz receiver, and David Farn had been working on the rest of the receiver, and was currently working on the down-converter to 151 MHz.

David expected that interference would be one of the greatest problems that they would have to overcome, and so he was looking to limit the bandwidth as far as possible. He had bought a 1395 - 1450MHz 9 pole filter from Jeff Lichtman to use as a reference, and this had a wonderful performance, and he had started to look at the mechanical design of a similar filter. He had produced a sample, but he needed a good prototype making up on a CNC machine, as the original prototype detuned easily with squeezing! David was currently obtaining some quotations for producing a better prototype.

Terry Ashton said that he was about to update Paul Edwards who would be taking over leadership of the 2.7GHz receiver project for the current time. The design of the 38MHz IF strip had been completed, but it was not yet tested. Terry's part of the project had a spectrometer application in mind, so it was necessary be able to swing the local oscillators, and track changes, whereas Martyn's part of the project consisted of a full-power radiometer. Terry felt that there would be real opportunities to make possible discoveries at this frequency, due to the lack of spectroscopic work currently done in this region.

Martyn had been the group's whirlwind, achieving a staggering amount in a relatively short time. He outlined the items that he had been working on beginning with his 2.7GHz downconverter to 151 MHz; the 1.2 GHz 10mW local oscillator for the above; and also some test signal kit capable of generating 2.695 GHz. Martyn maintains an excellent set of web pages, and much of his radio astronomy group work is recorded in detail at http://www.czd.org.uk/astro/index.html.

It was agreed that we needed to give more thought to the plans for producing and pointing aerials for the kit, especially by either using or recommending off-the-shelf components as far as possible.

The controller module is a key part of the observatory system, and there was some considerable discussion about this. In particular, Mark Byrne, who is experienced in PIC programming, wanted to get some clear ideas about the specifications that were required, in order to be able to more clearly define the system requirements. The issue of whether Ethernet could be used was considered in great detail, and discussion continued for some considerable number of weeks after the meeting. Since that time, it seems that a slightly different approach to producing the controller may be considered, and this will be reported in the minutes of the next technical meeting (due to be held on May 13th); alternatively if you can't wait this long, or if you feel you are able to contribute, please contact Laurence for more details.

Laurence reported that the 151MHz project at MRAO project was progressing very well. Laurence had visited Guy Pooley, who was very supportive of our idea of having an Internet connection; Laurence was going to make a proposal suitable for submission to the computer department and Guy had agreed to support it. Peter was currently waiting for the preamps to be fitted (which university staff had to do for insurance reasons), then the telescope should be up and running.

Laurence explained that, for the Starbase Software Development project, he wanted to create a data-driven application, in which no assumptions would be made by the code, and everything would be configured from the database. He explained how the software would be designed and the hierarchy that it would be based around, together with the likely appearance of the final result. The user might end up with a screen display which had the appearance of a 19" rack (one of Laurence's favourite pieces of furniture!), in which all of the receiver units to which the user had access might be displayed as a unit in the rack. Clicking on the VLF unit in the rack image, for example, might display of logged data. If you had permission to access it, one of the racks might be the MRAO 151Mhz interferometer.

Datalogging would be done at a local level, controlled by the PIC. It was thought that it would be better from a security point of view for the central repository system to request data, and pull it back, rather than allowing users to pour their data into the repository.

Laurence gave a handout illustrating the draft Starbase Detector Module. It was thought that little dynamic range would be required at 1.4GHz, but that around 20dB would be required for solar flare detection.

John Cook had brought a circuit diagram for his magnetometer, and Laurence wondered if this could possibly be our next project. The whole group was unanimously in favour of going ahead with this, and it was agreed that this would be produced next.

There was a brief discussion as to whether a separate company might need to be formed in order to deal with the manufacturing, legislative and IP issues. It was agreed that it would be preferable to be able to produce the units as part of the BAA, and this way forward would be explored before considering other options. Since this technical meeting, a meeting has been held with officers of the BAA to discuss this, and this will be reported on separately in this Circular.

It was thought that the CE testing of the receivers would be relatively straightforward, and self-certification would be the route that we would adopt. WEEE and RoHS were legislative aspects that needed to be considered once we had had discussions with the BAA officers regarding the production of the units.

It was agreed that we might also need to consider our Third Party Liability if we started to use mains power for dish driving etc. However, it had been agreed that the rest of the PnP kit would be designed to run off a car battery, to avoid the mains issue.

Laurence reported that he already had material ready for the next Circular and he hoped to get 1 or 2 out before the September meeting. It was agreed that we would sell the next copies for £3.00 each (£3.50 with P+P), as the printing cost would be slightly higher due to the increased number of pages.

Upcoming meetings, at which we intended to have a presence were: the Milton Keynes Workshop on 25th February (see report in this circular); Winchester Weekend 7/8/9 April (help needed); Cambridge Exhibition Meeting 24th June (helpers needed for the stand): and don't forget our main meeting of the year the RAG Meeting on 23rd September at the Institute of Astronomy.

Karen presented the accounts, as they currently stood. It was clear that the VLF boards, for which we had paid, needed to be sold to enable us to ease our cashflow situation.

The BAA had said that we were not able to take cash into an account that linked itself with the BAA in any way, and the current account was therefore being closed, and a new one opened, with a non-linked name. Any money that belonged to the BAA must be paid directly to the BAA, and not into the new account. The new account mandate was signed at the meeting.

Laurence reported that we currently had approximately 140 members, and he was concerned that if we started to charge a subscription, the membership number would drop significantly. It was unanimously agreed that we should not charge for membership, but that we could possibly charge slightly more for attendance at meetings, and items we sold such as Circulars and PCBs, to enable the continued successful running of the group.

Laurence reported that there had so far been no activity on the website, due to the previous volunteer being unable to assist as expected. Callum Potter was redoing the BAA website such that HTML would no longer be required, and once conversion to the new format was complete, then it would be easier to write the site. We now had FTP access to the site. A website manager is urgently required; anyone who is interested please contact Laurence.

Terry Ashton had brought all the RAG archives along to be processed at BT (scan direct to PDF), and they would then be put on the website

Laurence wanted to know if we should proceed with a PPARC PUS application, given that if we were successful in an application, then the recipients would be legally liable for the money. Laurence also felt that he needed some assistance in making the application, and Martyn Kinder agreed to help.

The next technical meeting date was later set for 2006 May 13th, at Xcam in Northampton.

RAG Loan Items

Don't forget that the RAG has three industrial-quality PCs available for loan to BAA members! Each machine is fitted with a dual motherboard, with *twin* 500Mhz Pentium processor cards and SCSI RAID drivers. Each processor has one fixed and one hot-swappable 18Gb SCSI drive. The power supplies may be 24V DC or 240V AC.

Following further donations from BT, we now have various items of test equipment, including a 1GHz sampling oscilloscope, logic analysers, networking items and power supplies. If you have a particular development need, please let us know, we may be able to help.

MRAO 151MHz Liaison

Peter King
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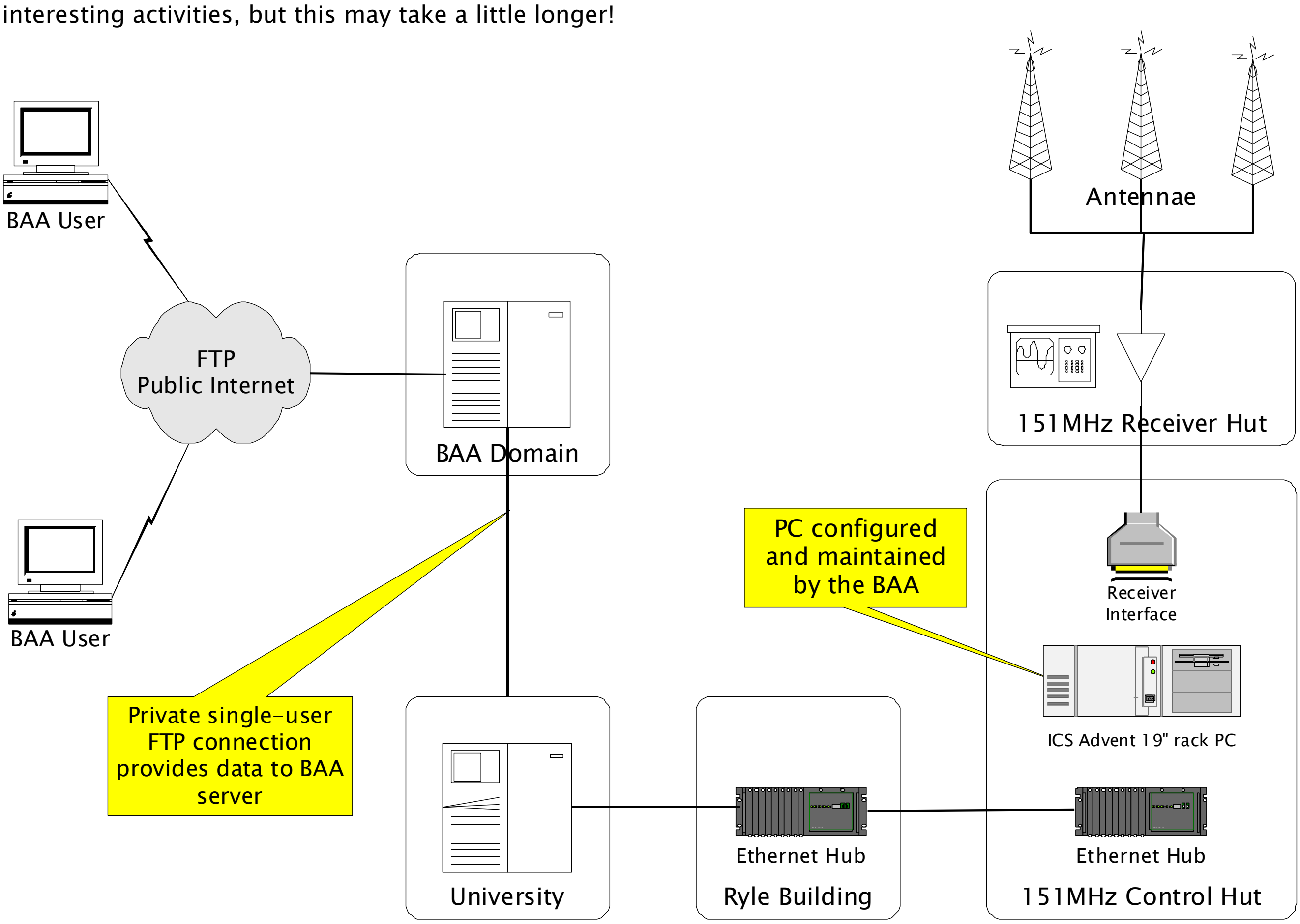
Terry Ashton
tjr@star.le.ac.uk

Three of the four Yagi arrays and the BAA Hut, at the MRAO

Good progress has been made with setting up the 151Mhz receiver at the Mullard Radio Astronomy Observatory (MRAO). The aerial amplifiers are in position, and all cabling checked. The RAG PC in the BAA hut is running a data logger. Laurence has been in negotiation with David Titterington, of the University's Computing Services, to arrange for a secure FTP link between the RAG PC and the outside world. This will operate via a 'gateway' machine, which will protect the University's network from unwanted intruders... (the diagram below shows the intended architecture). We hope to have a demonstration of a basic data transfer link at the BAA Exhibition Meeting in June, provided that we can get a connection arranged in the Cavendish.

Ultimately it should be possible for RAG members to download the telescope's current output directly from the observatory. We are trying to find a way of controlling the telescope's elevation via the FTP link, to allow more interesting activities, but this may take a little longer!



The proposed 151MHZ Interferometer MRAO network architecture

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140 people and counting! That’s very good in 18 months....

Guidance for Contributors

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This section is a list of guidelines which we ask you to follow if you are considering submitting an article for publication in the Circular. It will be much easier for us to import your article into the *PagePlus* publishing software if you follow these rules. This means a more accurate, more efficiently produced document, which means happier members! We are committed to delivering a quality publication, making the best use of your material.

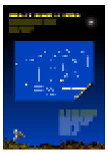
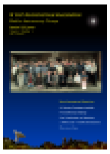
- Please supply ALL text in a plain, unformatted file, which preserves newline (carriage-return, line-feed) characters. For Windows users, Wordpad is ideal. Please DO NOT USE Microsoft Word! It requires a lot of effort to undo Word's 'features' and stylesheets. Also, Notepad treats newlines differently, and so requires a lot of manual intervention to put things right...
- Please use standard British English spellings, and avoid unnecessary abbreviations wherever possible (although we accept that common abbreviations such as JPG, USB, RF are inevitable).
- Please use the correctly punctuated forms of: etc. e.g. i.e. et al. ibid. and so on, to avoid our having to reformat.
- All images should be supplied individually, and NOT embedded within another document. Please use high colour-depth *uncompressed* formats wherever possible, such as PNG or TIFF. The images should be of the highest resolution available, at least 100dpi, and preferably 300dpi. Monochrome (black and white) images are acceptable, and of course JPGs if that is all you have.
- Please DO NOT USE Word for creating images - the resulting objects are awkward to import, and do not reproduce well. It is better to use a vector drawing tool like Visio, or create a 300dpi bitmap in PaintShop. The difference in quality is well worth the extra effort!
- It is useful if you can supply a separate document showing how the images relate to the text, either electronically or on paper.
- Please DO NOT combine several images in to one image file - they will have to be manually separated and/or cropped for inclusion on the page.
- Photographs of small objects should be taken with a plain white background if possible. This makes it much easier to cut out the image and blend it into the page. Similarly, please crop all images to remove unwanted areas; this helps to keep the file size down (the overall document for each Circular is about 80Mb before PDF conversion).
- Wherever possible, please supply any graphs or charts in their original numerical form either as Excel spreadsheets or as comma-delimited (x,y) files. This will ensure that all graphs have the same appearance, and can be produced to the same high quality output as the photographs. However, if (for example) your data logger can produce only JPGs, then please select the highest possible resolution output. It would be very useful to have a document showing how the graphs should appear, with legends etc. as required.
- Remember that the paper copy of the Circular is printed using a professional colour printer, capable of very high quality output. For instance, if an image chart has to fill the width of the page at 300dpi, then an image of at least 2000 pixels width is required.
- Please supply a caption or legend for each image, and for each chart or graph, again in a plain text form, in a separate file. The Circular style is to place the caption underneath each image, centred, and in italics. Remember to include the correct credits for any public domain images used.
- It is our policy to use Système Internationale (SI) units wherever possible. See www.simetric.co.uk if you are unfamiliar with the SI System. Please DO NOT USE feet, inches or Fahrenheit (or even Angstroms)!
- For simplicity, we will assume that copyright in all text and images shall remain with the original author, unless explicitly stated otherwise at the time of submission.
- We will assume that you are willing for us to publish your email address unless you let us know at the time of submission.
- All material should preferably be sent by email to Karen Holland at karen.holland@Xcam.co.uk.
- If all else fails, please send in your article typed double-spaced on plain paper!

RAG Mart

VLF Module

The BAA RAG *VLF Receiver*, our first real product, should soon be available for sale as a ready assembled and tested module. The receiver is intended to plug in to a *Starbase* controller (as yet unavailable), and requires +/- 15V DC power supplies. The receiver output is a voltage in the range 0 to 5V DC. Please contact John Cook for technical details, and Karen Holland for supplies.

Circular Back Issues

Circulars Volume 1 Numbers 1 and 2 are still available (we keep reprinting them). These cost £3.50 by post from Karen, or £3.00 from any exhibition stand near you!

Northampton Meeting CD ROM

All of the presentations given at the Northampton 2005 October meeting are available on this CD ROM, £3.00 by post from Karen, or £2.50 at an exhibition. A very useful introduction to the work of the Group.

RAG Greetings Card

Copies of the RAG Greetings Card (with envelope) may be purchased for 50p each, from Karen. Please note that these cards are blank inside, and may be used for any occasion.

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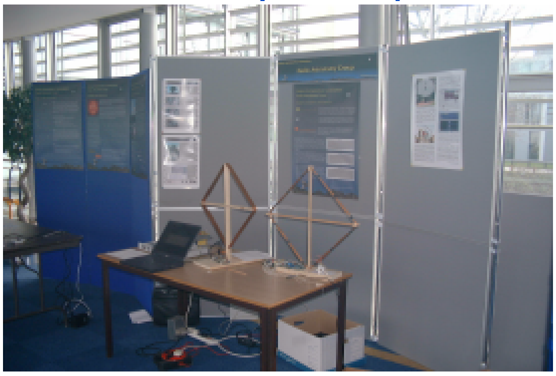
We hope that you have enjoyed reading the *Circular*. Please let us have your feedback; any comments, be they positive or negative, are most valued. All your suggestions will be carefully considered. Please send any articles and photographs to Karen Holland.

Baseline is set in 9pt. Lucida Sans Unicode, using Serif's PagePlus . It is intended for distribution in PDF format, or for printing at A4 size at 300dpi.

The Group blue is R000, G067, B191.
The Group yellow is R234, G225, B014.

Radio Astronomy Group Gallery

Laurence Newell presenting at the Orwell Astronomical Society, Ipswich in January (courtesy Peter Richards)



Three views of the RAG stand at the BAA Solar and Lunar Observer's Workshop at Milton Keynes in February.

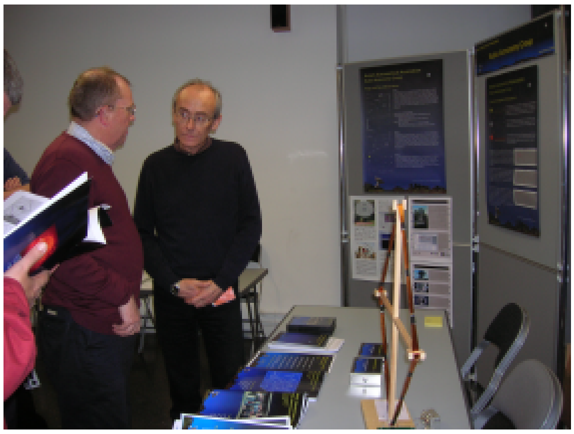
(Above) Martyn Kinder demonstrates his VLF Receiver to an enraptured audience. (courtesy Kevin Smith)

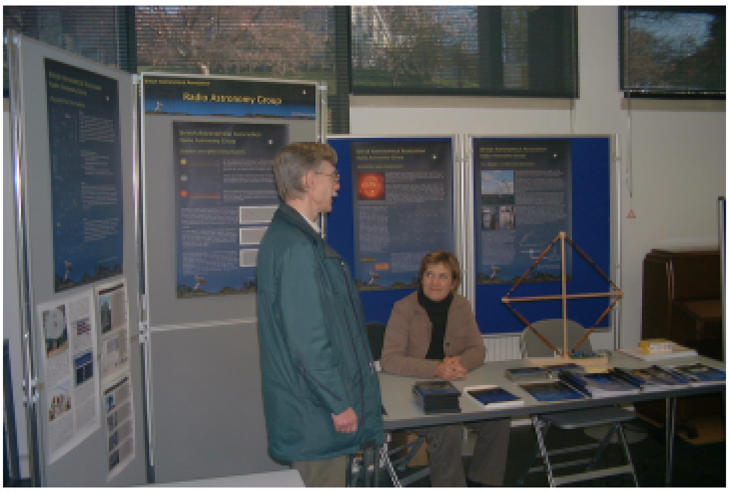
(Left) The Kinder Loop and the Holland Loop attract a lot of attention. (courtesy Nick Hewitt)

From left to right: Paul Edwards, Alan Morgan, Terry Ashton, David Farn, Karen Holland, Laurence Newell, John Cook, Martyn Kinder's leg, Trevor Sutton's head, Mark Bryne

Two views of the Technical Team Meeting in Northampton, in January. Stuart Withnall is to Laurence's left (below).

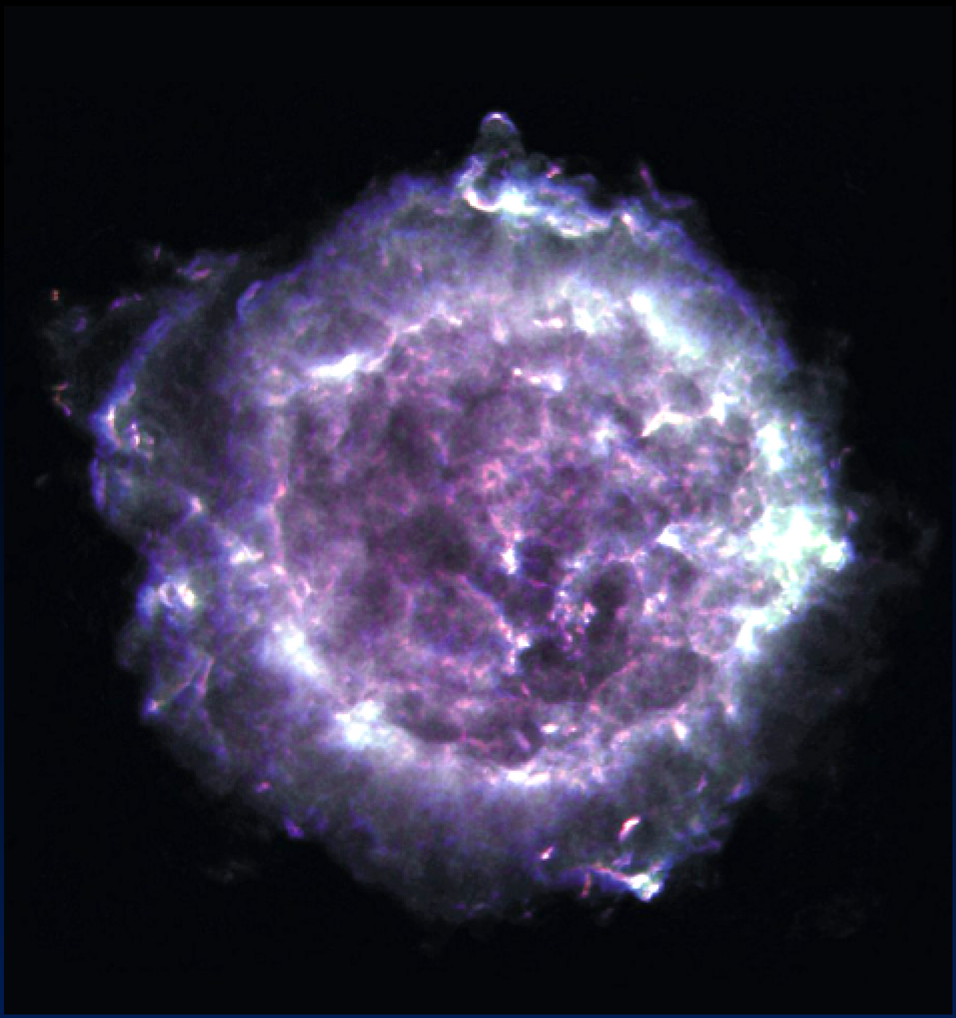
The star of every show!





John Cook and Karen Holland on the RAG stand at the BAA Winchester Weekend in April. Notice the 'Holland Loop'.

Two views of the Winchester Weekend, with stand visitors from Cardiff University (Below). We sold many Circulars and CD ROMs.



Cassiopeia A is the remnant of a supernova explosion that occurred over 300 years ago in our Galaxy, at a distance of about 11,000 light years from us. Its name is derived from the constellation in which it is seen: Cassiopeia, the Queen. A supernova is the explosion that occurs at the end of a massive star's life; and Cassiopeia A is the expanding shell of material that remains from such an explosion. This radio image of Cassiopeia A was created with the National Science Foundation's Very Large Array telescope in New Mexico. The image was made at three different frequencies: 1.4 GHz (L band), 5.0 GHz (C band) and 8.4 GHz (X band). Cassiopeia A is one of the brightest radio sources in the sky and has been a popular target of study for radio astronomers for decades. The material that was ejected from the supernova explosion can be seen in this image as bright filaments. Investigators involved in this research were L. Rudnick, T. Delaney, J. Keohane and B. Koralesky; image composite by T. Rector. (Date of Image: 1994). Courtesy: National Science Foundation

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