Okanagan Observatory
Radio Astronomy
RAdius

May 2013

2013 Beckons with great promise

and REPEATABLE RESULTS!

Okanagan College Joins the Project *by Hugh Pett*

The radio telescope project started when Okanagan College's Richard Christie made an offhand remark about a basic one he had seen in 2010. Now, a number of people at the College are getting involved.

Last summer Roland Oliynyk offered to do any excavation work needed for the telescope mounts, as well as make a model of a design I had sketched. When I asked him several months later how the model was going, he said he had been talking to a friend, who was keen to design the mount and draft engineering drawings for its construction.

To the mix of OC people, add Vlad Neykov, from the Mechanical Engineering Technology program. After joining Roland in a visit to my garage to measure the dish I had (in pieces) there, he told me that he had talked to two more OC profs, Randy Brown (Electronic Engineering Technology) and Ken Langedyk (Civil Engineering Technology), who thought their students might like to get in on the action. Then Randy brought Kevin Bradshaw to the first meeting I had with Randy's students.

There are certainly lots of things to do, for each of these groups. Unfortunately, most of the students that came to the initial meetings were in their final year, and heading off in a couple of months to jobs. But it was clear from those early meetings that even first year students would be able to do most of the available tasks. I expect that come September, there will be a number of working groups of students, counselled by their profs, taking on some of these opportunities:

survey the location for the first two antennas; the mounts have to be aligned as nearly East/West as possible, ideally within less than a centimeter, and they should be as nearly level as possible. Our Observatory site slopes down from East to West, by about 3 feet, I think, but it could be a lot less. Good practice for a Civil Engineering crew. Then if the Civil students want more to do, there is lots of additional surveying eventually needed for the Observatory in general.

prepare the engineering drawings for the mount design; Vlad has a couple of Mechanical Engineering students working on this now.

design and build electronic circuits for the mount control circuitry, and for several components of the communications between the mounts and the central control computer. This requires use of surface-mount technology, in which typical resistors, capacitors etc. are only 2mm long! A couple of Electronic Engineering students have expressed strong interest, so we will have to wait and see if they can spare the time to work on things.

As you can see, the Mechanical Engineering work is furthest along, and Vlad is keen to get a mount built this year. Roland may be digging up there soon! But a lot of design work lies ahead before any actual construction and digging can begin.

It amuses me repeatedly that so much could flow from a few throw-away sentences at the June 2011 Kelowna monthly meeting. Thank you again, Richard Christie!

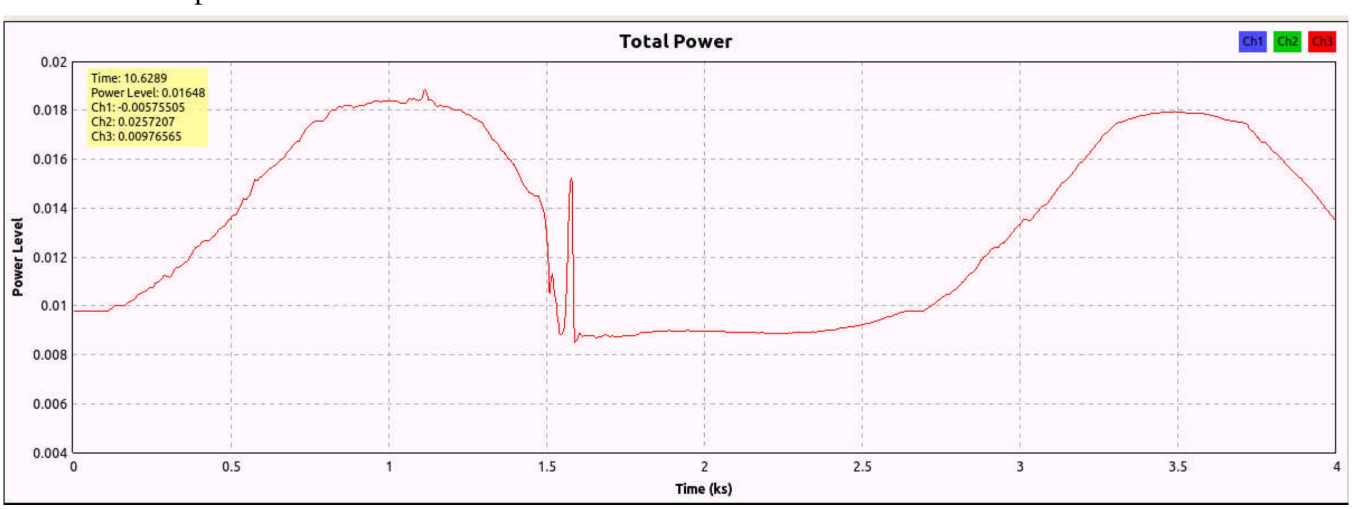
REAL results - REPEATEDLY!

One of the foundations of science is that when you observe something, you can observe the same thing over and over again. One-time events, such as the famous WOW! moment many years ago in the SETI activity, do not actually prove anything.

Statistics is often maligned, by both those who do not understand it, and by those who do but distort its meanings. One requirement, that must always be present before something can even be called statistics (in the mathematical sense), is having more than one measurement of something. Mathematical statistics has numerous formulas, and some of the most basic have denominators with (n-1) in them, the n being the number of measurements. As many of us know, trying to divide by zero is a thankless, and endless, task. (Unless you do it on an ancient mechanical calculator, in which case it is fun to watch the repair technician put the pieces back together!)

Last year I got a set of results from my helix antenna that looked as though they could be observations of the Sun. But I could never get the same result again: the first result was non-repeatable.

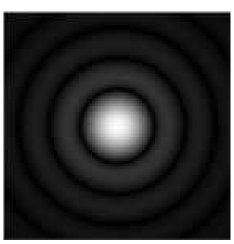
I am now using the first 10-foot dish, sitting beside my house, to collect the signals from the heavens. Fortunately I have very friendly and accommodating neighbours. This dish collects 7 times the radio energy of my helix antenna, and YES! I have recorded clear repeatable graphs of the total energy being received when the dish is pointed at the Sun.



Notice that the shape of the two peaks is the same, and the height is the same above the flat base line. The spikes at 1.6ks (kiloseconds) result from my shifting the dish to point just ahead of the Sun. The flat line centred on 1.7ks shows the base for the peak at 3.5ks, and also the very slight rise of the side lobe at 2ks.

As you see in the picture, my "mount" is an ancient plastic patio chair, which I manoeuvre underneath the ribs of the dish, until the shadow of the white focus box falls almost at the centre of the dish and the brown circular feed reflector.

Racing inside to the radio telescope computer, I watch as the trace on the screen first rises, then falls off in a classic peaked curve. On one of these tests, I let the trace continue for a couple of hours after the main peak at 3.5ks, and noticed an obvious second "peak" at about 1.7ks, although much smaller than the main one. (I think there is even a third peak at 0.7ks.) All radio antennas receive signals from directions away from the main one of interest; these are the side-lobes that can often confuse the radio operator into thinking the signal is coming from somewhere else.



This is seen in well-built optical telescopes, the Airy Disk. The same effect causes side lobes for radio telescopes, or in the case of a dish, concentric rings of reduced intensity.

The real measure of the signal is how much stronger it is than the radio noise that is always present. In the case of these traces, the noise is 5dB less, a good rule of thumb is that 3dB means half as strong, 6dB means 1 quarter as strong - it is a logarithmic scale. A good result in my radio astronomy has the signal more than a couple of dB greater than the noise; not superb, but good. As I get better at this, and do more with the computer processing of the results, the numbers will improve.

Using the above image, and the handy yellow box that gives precise numbers for the trace levels, I computed the lowest flat level to be 5.1dB less than the peak at the right, which was right at the maximum for that transit.

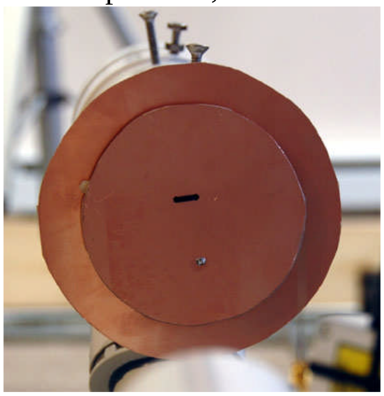
It is supposed to be fairly easy to get signals from the gas along the plane of the Milky Way Galaxy. Marcus in Ottawa is doing this regularly with a dish only a meter wide, so I will eventually get good observations of the gas emission spectrum, the so-called H1 line at 1420.4MHz. Another day!

Feeding a Dish

Actually, the "feed" in a radio telescope is the thing being "fed", scooping up the radio signal reflected from the metal dish to the focus of the parabola, just as happens with an optical telescope mirror. The feed is the equivalent of your camera, at the focus of the mirror.

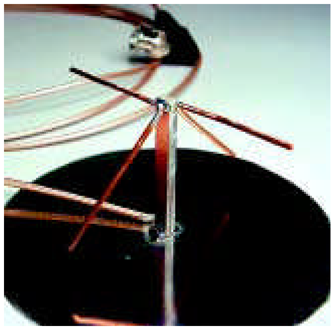
The feed is the real antenna, receiving the signals from all parts of the dish. This means it must try to "see" every part of the dish, and hopefully almost equally. It takes some special effort to design such an antenna, and it is one of the areas in which experimentation is still a good thing, and an ongoing challenge to the radio astronomer.

Not only must the feed "see" every part of the dish equally, it must NOT see what lies beyond the dish, the ground. This is because the ground acts like a radio source, as a "black ball" radiator at its current ambient temperature, for example 300Kelvins in the summer. Many objects of interest radiate at less than this temperature, and so would be lost in the "noise" from the ground.



No feed is perfect, they are all a compromise between the two competing requirements, and so a feed has a quality, an "illumination efficiency", that shows the overall effectiveness at receiving the signals the dish collects. A typical feed has an efficiency of about 50-70%; my first effort, called a "patch feed" (left), is probably less than 50%, so the signals I have been getting from the Sun are not as good as if I used a different feed.

My next feed will be a "modified turnstile" antenna, of a type that can be used to receive GPS signals. Since GPS satellites can be anywhere in the sky, an antenna for GPS work needs to be able to see every part of the "dish" that is the sky. The trick is in making the two simple antennas (called "dipoles") that comprise the antenna work together amicably to cover all parts of the sky, or in my case the dish. The one thing I am not sure of is how much of the ground will be visible as well - I'll find out soon!



There are lots of ways to make a feed, and they can start looking kind of strange. Here is the one used by Marcus to listen to the galactic gas clouds. And yes, it really is a 6-inch-wide coffee can plus other short metal tubes. If I don't make any of mine work well, I may adopt Marcus' design - he is getting really good results.

First Antenna Location

As in retail sales, location is vitally important. And so it will be at the Okanagan Observatory when it comes time to put the antennas on their mounts.

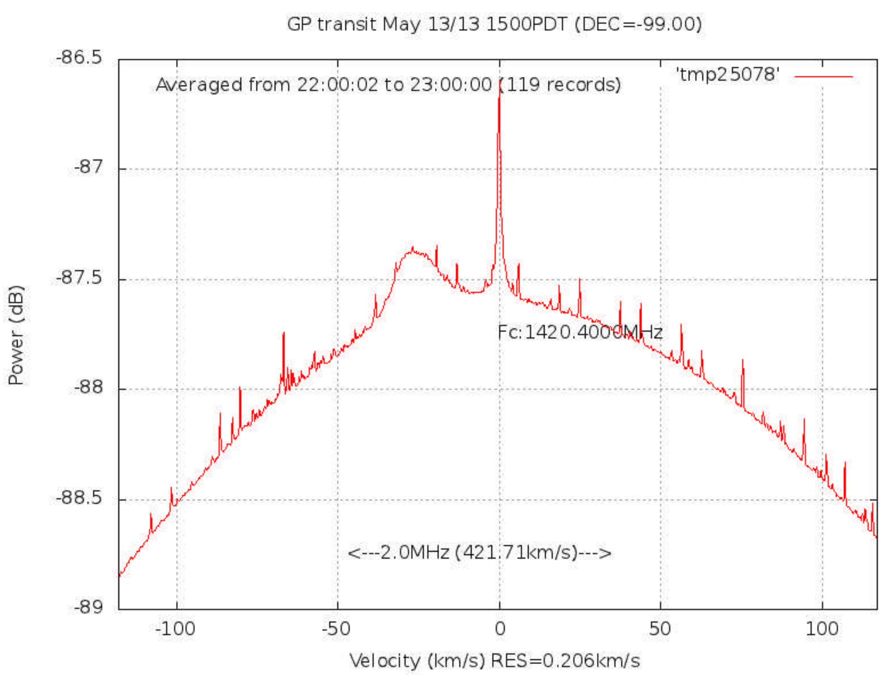
To make simpler the processing mathematics for many types of observations, it is desirable to have the antennas aligned East/West. Also, to make tracking in the sky easier, it is a good idea to have the antennas the same distance from the centre of the Earth (in other words, "level" with each other). The Observatory site provides good opportunities to do all of this, without interfering with other activities there.

My first choice for an antenna is in behind the SkyTheatre, just the other side of the drainage ditch, on a fairly flat bit before the steep rise up the hill to the North.

Roland will have a chance to practice levelling it further. This antenna will have to be built a little higher than the next one, to the East.

This is why having the Civil Engineering students survey the locations will be important. These locations have another advantage, since they are readily viewed by the various cameras at the Observatory.

This will provide a measure of security and safety, and also a good "reality check" for antenna operation - is it REALLY pointing where the computer says it is?



NEWS FLASH!

GALACTIC HYDROGEN GAS CLOUD CONFIRMED HEADING AWAY FROM EARTH AT 26 KILOMETERS PER SECOND!!

Over the Winter at the Okanagan Observatory

A goal of the radio telescope project is to be able to observe around the clock, in all seasons. This means the equipment must work in the scorching heat of Summer (up to 50C in the full Sun), and the chilly times of Winter (down to -30C). The motors and other components at the mounts are quite rugged, and can readily work through this temperature range; some of the electronics, such as the home computers needed, require a less extreme range.

During the winter of 2012/13, I monitored the temperature of the electronics inside the cabinet at the South-East corner of the Support Building (SuB). A standard 6 feet tall office supplies cabinet, plus good insulation on all sides, together with a 60Watt long-life incandescent light bulb on a thermostat, carried the cabinet through the winter just fine. The lowest recorded temperature was -5C, on one of the circuit boards, when the air outside was near -30C. This was only one day, all other times the temperature remained positive. The cabinet was thrown together rather quickly last Fall, and needs some re-working to close some gaps in the insulation.

I fully expect that when all the electronics is installed in the cabinet, the light bulb will not be needed. I may even have to air-condition it! Or at least draw cooler air from under the SuB up through the box around the cabinet.

The steps ahead - the three-year roadmap

Some things still to come

Surveying antenna sites

Verifying design concepts for mount, communications

Construction projects:

- -second helical antenna, to record interference patterns and learn how to interpret them (on hold, pending work on the dish antennas)
- -single dish, fixed azimuth, local control of elevation (Spring 2013: **ACHIEVED**)
- -single dish observations of galactic gas cloud turbulence (as achieved by Marcus) (Summer 2013)
- -single dish, Az-El mount with .2deg pointing accuracy (Summer 2014)
- -dual dish, Az-El mount with .2deg pointing accuracy (Summer 2015)
- -dual dish, Az-El mount with .2deg pointing accuracy operating as an interferometer (Summer 2016)

THIS ISSUE OF RAdius: published May 13, 2013, by Hugh Pett, hipett@uniserve.com

If you are seeing RAdius for the first time, and would like to receive future issues, please email me and let me know where to send them.