Okanagan Observatory
Radio Astronomy

RAdius

August 2013

May 13, 2013 - the big crash! and HUGE results!

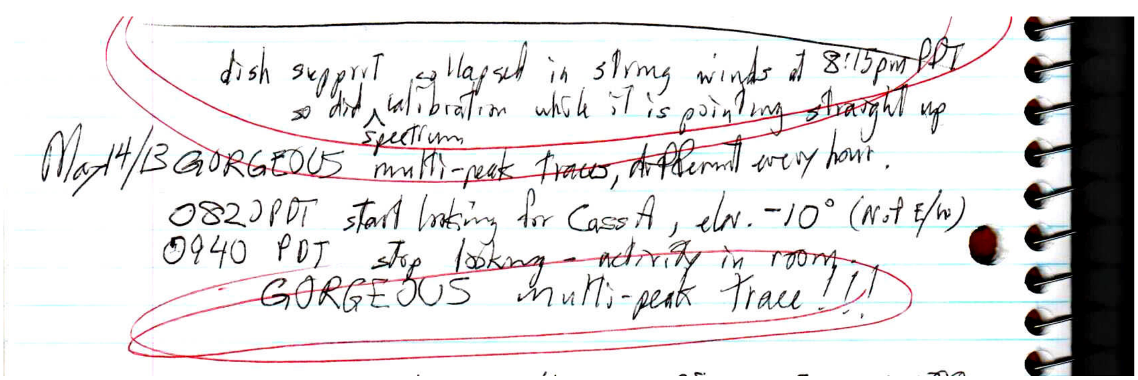
or: how I learned to love the capriciousness of the winds around our house!

For more than a week in early May, I was getting nice, consistent results showing the Sun transiting the 10-foot dish beside the house. I figured that was as good as I was going to get until maybe next year, when a dish could be working at the Okanagan Observatory.

The wind picked up the evening of May 13; I tethered the dish with a rope, so that the dish would not crash into the garden of my tolerant neighbours.

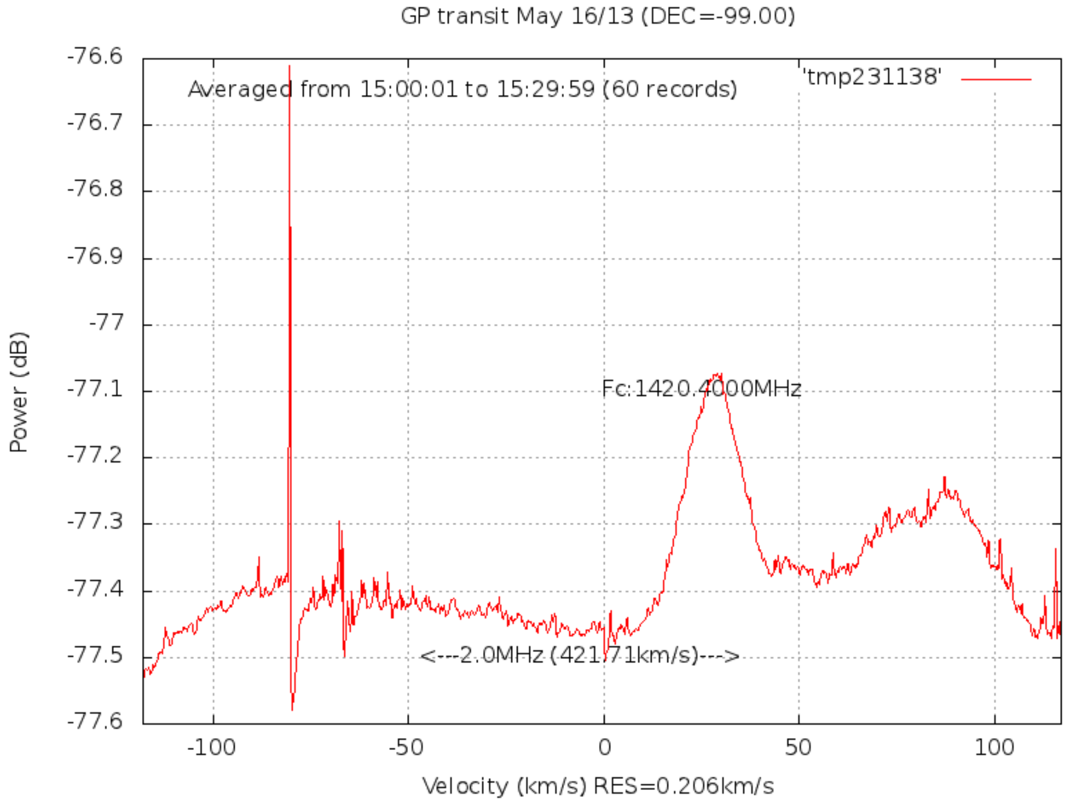
At nearly 50km/hr, the overnight winds were howling. A glance out the window showed the dish flat on its back - pointed almost straight up! The wind had swung the dish around on its tether and flipped the chair out of the way.

Being by nature a lazy soul, I decided to plot the observations anyway - my log notations say it all:



2013, not 2014 or even later!

Suddenly, I was getting clear multiple-peak spectra from neutral hydrogen with many different orientations of the dish. The two brightest hydrogen sources in the sky, Cassiopeia A and Cygnus A, require a tilt from vertical of only 9 degrees, a very stable (thank goodness - one toppling event is enough to last me a LONG while!) shift using a low patio table.



This plot shows the power level on the left, with the main peak at about 30km/s about 0.4dB above the noise floor.

The very-narrow spike at -80km/s is an artefact of the receiver, the so-called "local-oscillator" peak. I eventually learned how to move that spike out of the way.

Recall that my first "real" results (as reported in the May 2013 issue of RAdius), results that I could reliably repeat, showed the power of the radio emissions from the Sun. Appropriately, this is called a "Total Power" observation, or TP for short. That way of observing collects ALL the power being emitted by the Sun (over quite a wide band of frequencies), and adds it up into one number. This happens every few seconds, and gets its own point on the plot.

The plot on this page shows the power of the radio emissions at many different frequencies, in this case 2048 separate values - a "spectrum" or SP. This requires a larger antenna, and also more processing of the raw data, since there is a lot going on every few seconds.

The power at each frequency is quite small, hence the need for a larger antenna to get meaningful observations. I had not realized while making the Sun observations, that the 3-meter dish was more than big enough to give me really good observations of the spectrum of the hydrogen gas spread throughout the Galaxy. That happened with the Big Wind Event!

Total Power vs. Spectrum: which kind of observation to do?

My Ottawa radio astronomy colleague Marcus has been using a small, 1.0meter dish to make careful TP observations of the neutral hydrogen gas spread throughout the Milky Way Galaxy. He has encountered a number of problems, trying to keep one set of observations consistent with the next; and the next, and so on. Lots of separate factors conspire to make the measurements more- or less-sensitive, and thus change the observed TP values. The antenna can be more sensitive when wet (or dry), the temperature of the low-noise amplifier at the focus of the dish can change how strongly it amplifies the signals, and the operating voltage used to power the amplifier can shift in various ways, including by temperature.

All these things change what gets recorded in the computer as "data".

As soon as my equipment started recording good spectra from Galactic hydrogen, I switched to that and temporarily abandoned the Total Power observations. More results flowed from many different parts of the sky - anywhere I pointed the dish gave nice clear spectra. (a note: Ken Tapping had mentioned that was what should happen.)

The pursuit of spectra fitted in exactly with the long-term goal of my efforts, to study turbulence in the gas clouds emitting the hydrogen spectra I was observing. This was a possibility mentioned by Eric Rosolowsky when he talked at our RASC Okanagan Centre Annual General Meeting in November, 2011. He said that the turbulence in the gas clouds was not currently being studied by professional radio astronomers, and he expected that a small-dish radio telescope (such as I have now) might be able to do real, original science on the turbulence.

My efforts then focused on improving the collection of spectral data, and its display in a meaningful manner.

I was puzzled as to why my two main radio astronomy practitioners, Ken Tapping and Marcus Leech, kept on about the difficulties they were having with their own TP measurements. I spent some time thinking about ways to control the absolute values of the power data that make up the spectra streaming from my radio telescope. This included things like baking the amplifier in a temperature-controlled oven!

Finally, I twigged that Marcus and Ken had a very different sort of requirement, and mine was MUCH simpler in that one way: for spectral observations, the important measurement is the frequency of the radio waves coming from each peak in the plots. The exact "height" of a peak above the "base" is not all that important at the moment; it is a good idea to try to make the height repeatable, the same from one day to the next, but it does not affect the goal of searching for evidence of turbulence in the hydrogen gas clouds.

It is not really serious at all how high the base is, as long as the extra height of a peak is the same from day to day. In fact, in another serendipitous moment, I had temporarily stored the dish with the top resting on the eaves of my house. The receiver continued to operate, and wonder of wonders - there were spectra, just as before. This was surprising, because at least half of the dish was looking right at my neighbours' house! Both Marcus and Ken had been warning me that anything on the ground emits lots of radio power, much more than the signals I was seeking from the Galaxy.

The puzzle resolved itself when I realized that yes, the "base" of the signal (the flatish part of the plot) is higher, but there are still the peaks in the same places, and the same relative heights.

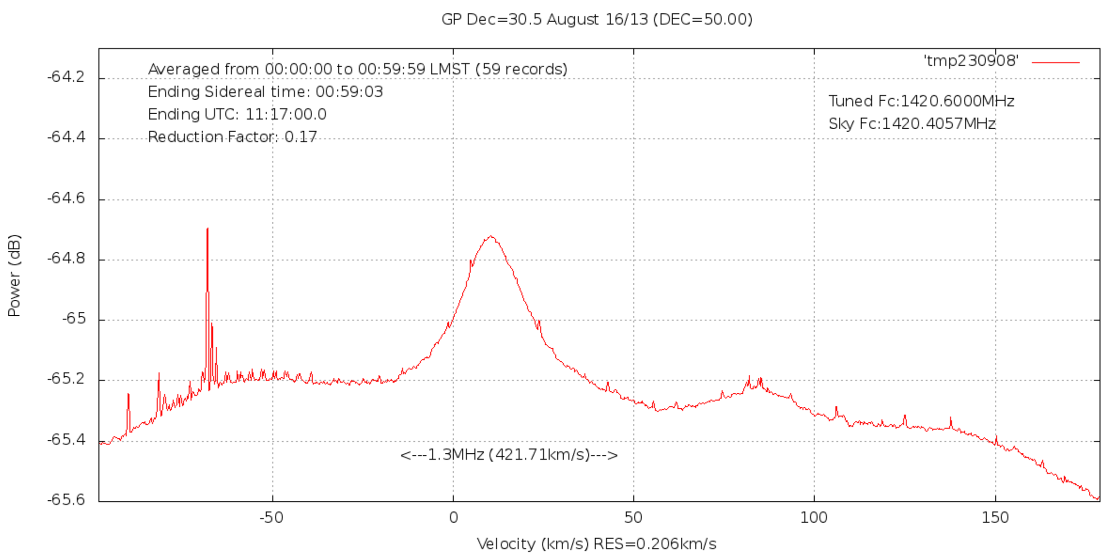
Since my goal is frequencies of the peaks, and irregularities in the peaks (the evidence of turbulence), I can get meaningful results when the direction of the dish skims the roof of Ron and Shirley's house.

Repeated Observations: a cornerstone of all science

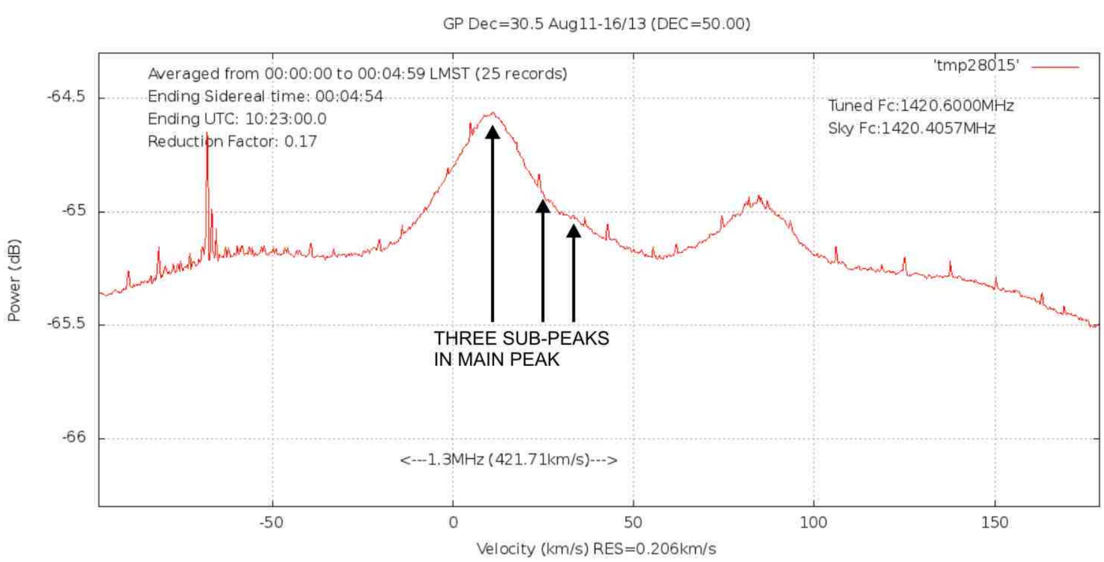
Recently I completed a little over 5 days of continuous observing in one direction (Declination=34), as the Earth swept the dish beam through the circle.

This let me average 5 times as many observations as in the plots made up to that point. By using sidereal time for selecting the records to be plotted, I could ensure the dish was pointing at the same spot in the sky. Each of my plots covered 24 or 25 spectrum records, every 5 minutes. That meant computing 288 plots for a full sidereal day.

In effect, I was simulating approximately what would happen with a tracking antenna, pointing for 25 minutes at one spot in the sky. The results are gratifying: very little change in the base level, and quite smooth peaks in many of the plots. A tracking antenna would be better yet, since it can keep the dish pointed within 0.2 degree of one spot, as against my 5-minute averaging technique which translates to 1.25 degree. And of course a fully-tracking antenna can stay on one point for up to 11 hours, anywhere in the sky, and forever in certain directions close to the North celestial pole.



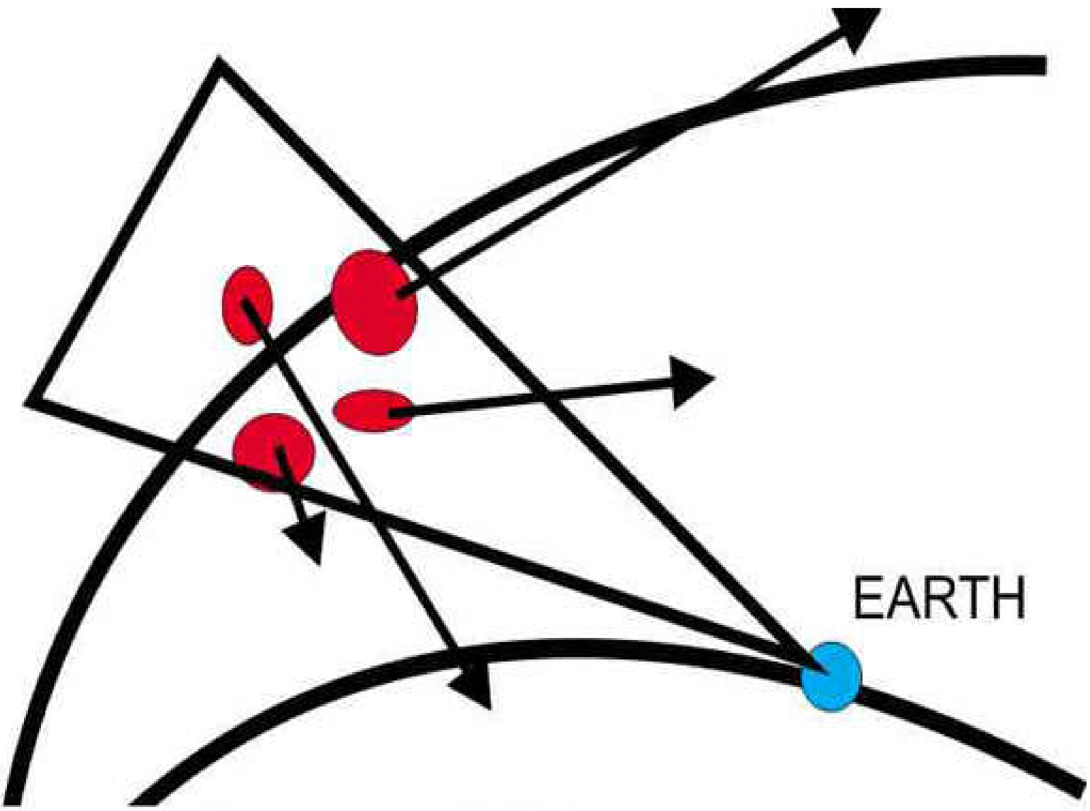
Here is a normal plot I routinely do, which averages an hour's worth of data.



And here is a plot of the main features in the above plot, from my 5-minute sequence. The second-highest peak is much better defined; the noise "roughness" is very similar.

Also, you can see that the main peak is composed of at least 3 peaks, close to each other in frequency.

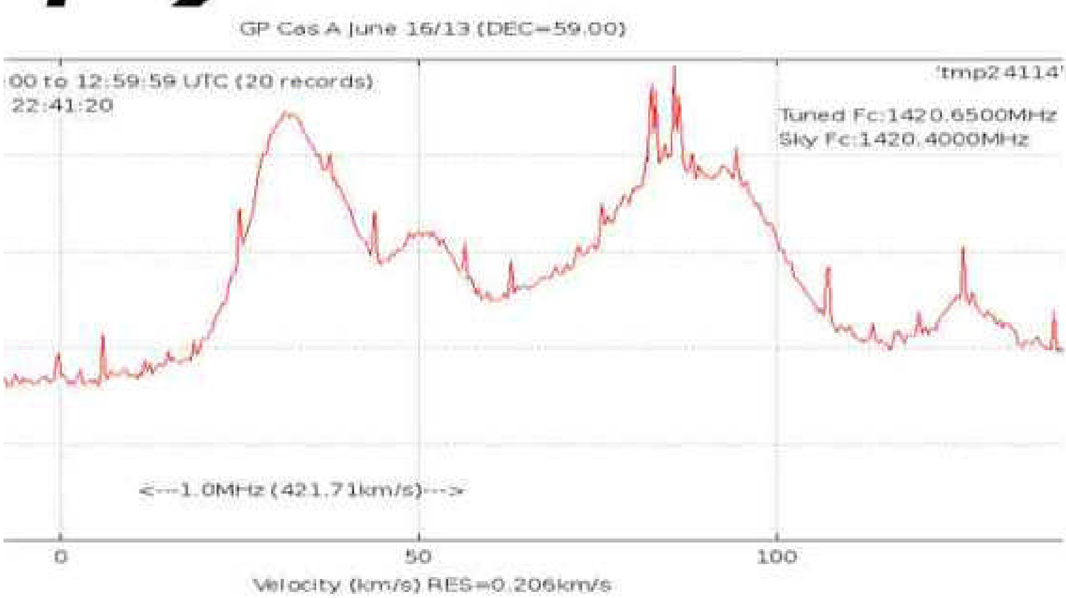
Galactic Hydrogen Gas Clouds: they are everywhere



Galaxy Spiral Arm

4 gas clouds, at different distances, speeds and directions of motion

our radio telescope, with the beam encompassing all 4 clouds



at least 4 main peaks, in the direction of Cassiopeia A, the strongest non-Solar-system radio source around

The Pan-Canada Collaboration: Ken Tapping, Hugh Pett, Marcus Leech

Science does not exist as isolated individuals. By its very nature, it requires a variety of collaborations. As many of you know, the Okanagan Valley is blessed with Canada's premiere radio astronomy observatory, D.R.A.O. near White Lake, 15 minutes south of Penticton. Several of the people in the Okanagan Observatory radio telescope project work or have worked at DRAO: Ken Tapping, Chris Purton, and Rod Stuart.

Ken right at the beginning recommended I contact Marcus Leech, who was doing fascinating things near Ottawa. After exchanging reams of data, thousands of emails, and numerous physical bits and pieces, I think it is safe to say we three are in a serious amateur radio astronomy collaboration. As the neophyte in the group, my contributions have mostly been the asking of naive questions, and the testing of Marcus' software as he makes it ever more useful (as in: "Marcus, why does the display freeze after I do this?") As you see in this issue's report on my observing efforts to date, my contributions are becoming much more substantive.

In mid-September, Marcus will fly into the Okanagan for a week's visit, during which we three hope to further develop this collaboration.

Among other things for consideration, we will look at the possibility of extending the mandate of the radio telescope project of the Okanagan Observatory, to make it easy for other interested parties to establish radio telescopes there. The Observatory extends up the hill to the north for 10 hectares (25 acres), making it possible to site antennas away from the structures, and screened by the wooded slope from the Observatory's optical astronomers. The trick is operating such telescopes at some distance from the main structures, with their power and communications.

By experimenting next summer with a second dish in the main "bowl" at the Observatory, and trying to link it to the processing computers and communications using amateur radio frequencies, I may find out how to dot the hillside with antennas.

The steps ahead - the three-year roadmap

Some things still to come

Surveying antenna sites

Verifying design concepts for an Az-El mount, and for communications to remote locations around the Observatory grounds

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 (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)

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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.