THE WORLD BELOW 400 GHz

The Periodical Newsletter of the
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General Meeting November 2018

A General Meeting of the Waikato VHF Group
will be held on

Sunday, 4th November, 2018 at 1:30pm

at the Silver Fern Farms Event Centre, (aka Te Aroha Events Centre), 44 Stanley Ave., Te Aroha.

Click HERE for a location map of the Te Aroha Events Centre.

The speaker for the meeting will be Vern Talbot, ZL1TKG.
Vern will about Broadcasting Spectrum Design, and how radio spectrum must acknowledge receiver capabilities.

Non members and visitors most welcome.

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FOX DELTA kitsets

In the world of Amateur Radio kitsets, some kits are easy to build, and some are complicated. Some use SMD/SMT devices, while others use through-hole technology. At Fox Delta the emphasis is on easy to assemble kits with any SMD devices being presoldered.

The team at Fox Delta, VU2FD, I2TZK and K7SFN provide full information on kits including schematics, any software needed, and FAQ's.

Please see http://www.foxdelta.com/products/ for the list of HF and VHF/UHF kits.

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Repeaters/Beacons

The Waikato VHF Group owns and maintains a number of repeaters and beacons in the greater Waikato and Bay of Plenty area. These are available for sponsorship for a period of 1 year. Please see http://zl1is.info/sites.html for a list of repeaters, beacons & links that are currently available for sponsorship. If you are interested in sponsoring one of them, please contact our Secretary (ZL1GWP) or Treasurer (ZL1TAT).

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AUT Radio Astronomy Presentation

Tim Natusch, Deputy Director, AUT Institute for Radio Astronomy & Space Resarch at Warkworth 15 August 2018

The last amateur visit to this site was part of the Easter Convention 2013. This presentation was organised by the Hibiscus Coast Radio Club. It took place in a room at the site of the 30 m dish. This dish is owned by Spark and managed by the AUT Radio Astronomy Department.

Radio Astronomy

The main areas of interest of AUT studies are:
Pulsars Rotating star with a narrow beam from its axis, up to 1000 revolutions per second.
Magnetars Neutron stars thought to have magnetic fields that emit gamma rays on collapse.
Radio Galaxies
AGN Active Galaxy Nucleus
Blazars An AGN with a jet of radiation and ionised nuclei at near the speed of light.
Black Holes These emit radiation as they attract matter into their nucleus.
Satellite tracking
Geodesy and Astrometry
Radio recombination lines
Fast radio bursts

Radio Astronomers are interested in objects 15 – 20° or more above the horizon. Objects below that angle have too much atmosphere in the path for good reception and resolution of the data that can be extracted. There is absorption of certain frequencies by the atmosphere which are avoided for observation and the pressure to make radio spectrum available for human activities causes interference with reception over much of the spectrum. There are some gaps specifically reserved for astronomy. Examples are 6.65 – 6.675 GHz and the Hydrogen Line at 1.40 – 1.427 GHz. VBLI observations are made at 1.66 – 1.668 GHz, 4.99 – 5.03 GHz.

The telescopes

The 12 m dish can receive on 1.1 – 1.7 GHz, 2.1 – 2.4 GHz, 8.9 GHz.

The 30 m dish was optimised for "C" Band operation at 3.7 – 4.2 GHz RX and 6.0 – 6.6 GHz TX. It is currently used at 6.1 – 6.8 GHz and 4.5 GHz. A feed has been built locally for 4.8 GHz. The -3 dB half beam width of a 30 m dish at 6.5 GHz (Methanol Maser) is 0.05°. This requires very accurate pointing to gain the full benefit of such a large antenna. The 30 m dish has an RMS variation of 1 mm deviation of surface accuracy. It would be usable up to 22 GHz with some reduction of gain. Both dishes have switchable left / right hand circular polarisation.

The design of the dish is a Parabola with Cassegrain (hyperboloid) reflector back to the centre of the dish. This reflected signal at the dish is focused at infinity so that periscope

reflectors can be used to direct the received energy to the feed. The path is enclosed in a large metal pipe. The feed itself (common in the 80s) is a very solid series of pipe sections of 1 m diameter at the top and 4 m long down to the driven element. It is heavy enough that the current structure of the dish could not support its weight without considerable strengthening to reduce the distortion of the dish surface that would result if the feed moved with the dish.
The current low noise amplifiers provide a Noise Figure (NF) of 0.6 dB at 6.5 GHz at room temperature corresponding to 60°K Noise Temperature. Looking at the ground would be about 300°K as a heat radiator. There is a planned project to use cryogenic cooling of the amplifiers to operate them at a noise temperature of around 20°K. The wanted signals are generally below the noise floor and require averaging in order to detect them. The Janksy[1] is the astronomical unit of energy. The space noise floor is about 500 Jansky = 10^{-26} W / sq m. The wanted signals may be 1 Jansky. If the telescope was pointed at the sun the electronics would quickly be fried. Pointing must be at least 5° away from the sun to protect the equipment.

Pointing involves 2 drive motors for each axis acting in opposition to each other. The purpose is to reduce the effect of "lash" in the gear trains which manage the movement. Reporting of axis direction uses 26 bit encoders. This many bits is usually not linear and manufacturers appear to allow for up to 3 bits departure from perfect linearity. This is still 1 part in 8×10^6 or 0.00005°. A mathematical model is required to determine the difference between the requested pointing direction and the actual direction. It takes days of steering the dish around the directions where it may be required while recording data for analysis as to the location of known point sources in the sky. Fortunately the analysis of this data is straight forward. This process is redone quarterly to confirm accuracy. Following this calibration the tracking accuracy is about ±0.0001°. The 12 m dish is

done less often as its beam width is wider.

Many uses of the telescopes involve collaboration with other telescopes around the world. Where the radio energy is received at widely spaced locations and the time of reception is known accurately at all locations the resulting analysis will determine the location of the source with greater accuracy using Very Long Baseline Interferometry (VBLI). The clocks used for this purpose are usually Active Hydrogen Masers. These have very high short term stability over 24 hours and over a longer time period are predicted to have an accuracy of 1 second in 60 x 10^6 years. Caesium clocks don't have the same short term stability (but are cheaper). Because there are no perfect clocks for comparison, Allan Deviation, also known as two sample variance is used to quantify stability. A hydrogen maser can achieve 1 part in 10^{14} over a 1 second interval. An oven stabilised quartz crystal oscillator would achieve in part in 10^{11} over 1 second.

The telescope projects

Early astronomy used visible light only. As more of the radio spectrum is able to be observed the shape of celestial radio objects can change significantly. Measurement in the radio spectrum supplies data that drives physics to explain its origin and advance the understanding of the universe. For example it is though that when matter is captured by the gravitational field of a Black Hole about 40% of the matter is converted to radiated energy.
All telescopes use a standard control protocol to coordinate dish movements so that one computer can manage all of the telescopes involved in an observation. This work is currently done in collaboration with Australian and South African locations. 24 hours of data collection can generate 20 – 30 Terabytes of data. The site is connected to REANNZ with a 10 GB / sec link. The VBLI data can be sent online to the control telescope. In the past packs of disk drives were couriered to the control location.

Geodesy – The study of Earth orientation parameters and Plate Techtonics. 3 dishes aimed at the same radio source over 12 hours can lead to measurements down to 1 cm accuracy over a 10,000 km base line. It has been found that the North Island moves 5 cm NW per year (relative to ???). The South Island is going in a different direction along the alpine fault line. The North South axis of the Earth wobbles slightly relative to far stars. This wobble has an effect on the accuracy of GPS calculations. NASA uploads clock corrections to the satellites regularly to reduce the effect of the motion of the axis.

Astrometry – The collection of data using orbiting telescopes. Radioastron is a Russian space based telescope in a highly elliptical orbit that passes outside the moon's orbit which provides a very long baseline when an Earth based telescope is looking at the same object. 4.5 GHz is used to collaborate with Radioastron.

The Mars Express is a satellite that has been orbiting around Mars for the last 10 years. It passed near Phobos moon and was accelerated by its gravitational field. Observations of the resulting Doppler helped determine this moon's density. It was found to be a very low density, not sufficient to form the surface into a smooth shape.

Work for Spacex – The Dragon rocket is tracked using S Band 2.2 GHz with the 12 m dish. This helps to direct the rocket to dock with the space station during service missions.

Peter Loveridge 21 August 2018

This report has been expanded from notes taken during the presentation, using general knowledge and Google to fill in some gaps.

Tim Natusch is explaining what we see in the control room with the dish feed projecting down to the scaffolding above him. There is a row on cabinets behind him that processes the data and controls the steering of the dish.
Peter Loveridge 21 August 2018

[1] In honour of Karl Jansky, a forerunner in the study of Radio Astronomy

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