HPSDR – Griffin

or

A Whisper & a Chirp

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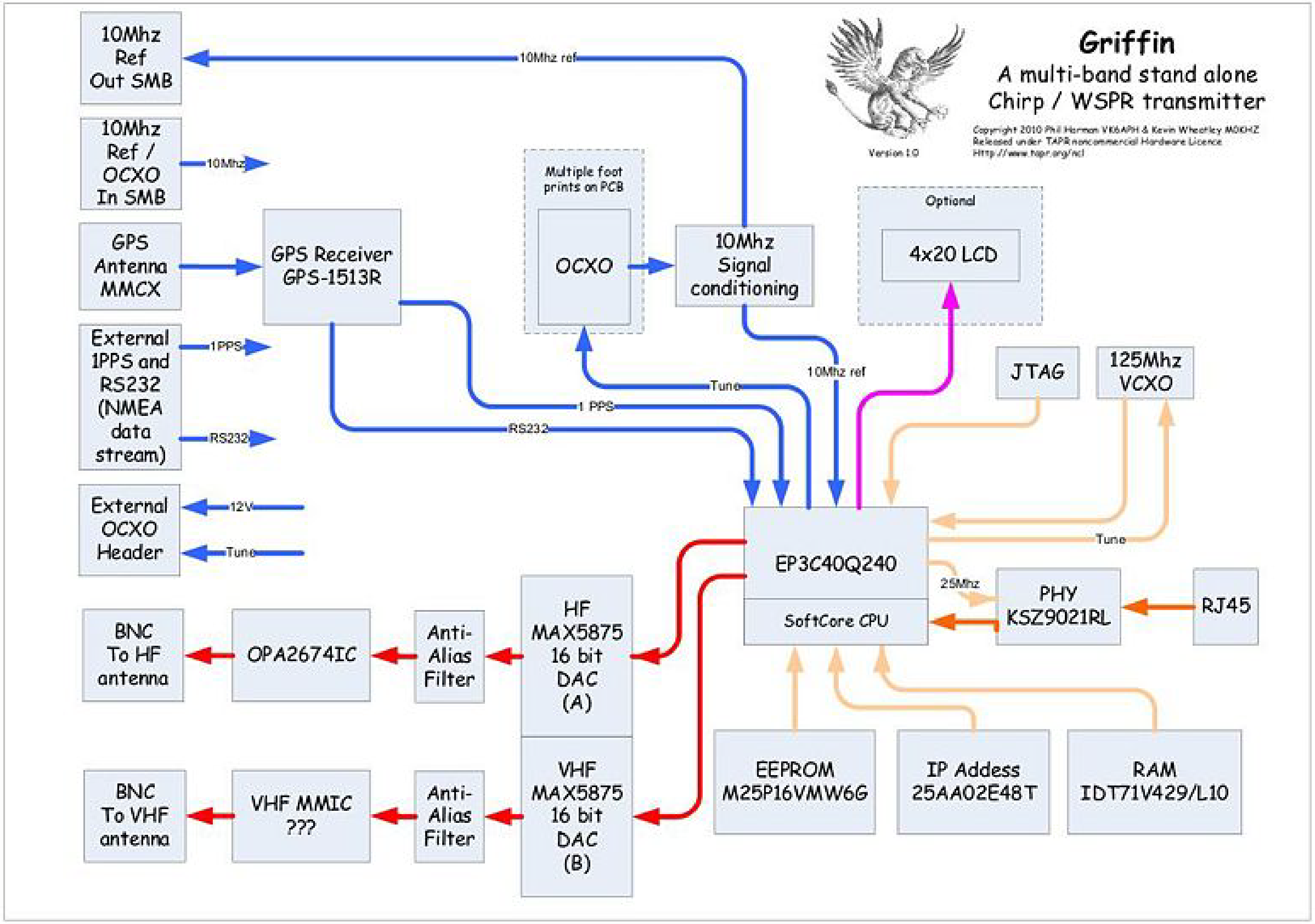
Dayton Hamvention – 20th May 2011

Overview

- Griffin is a High Performance Software Defined Radio (HPSDR) project supported by T.A.P.R.
- Griffin provides the driver stage for an HF/VHF beacon
- The bock diagram is as follows:



Griffin
A multi-band stand alone
Chirp / WSPR transmitter
Copyright 2010 Phil Harman VK6APH & Kevin Wheatley M0KHZ
Released under TAPR noncommercial Hardware Licence
Http://www.tapr.org/ncl
Version 1.0
10Mhz Ref Out SMB
10Mhz ref
10Mhz Ref / OCXO In SMB
10Mhz
GPS Antenna MMCX
GPS Receiver GPS-1513R
External 1PPS and RS232 (NMEA data stream)
1PPS
RS232
External OCXO Header
12V
Tune
Multiple foot prints on PCB
OCXO
10Mhz Signal conditioning
Optional
4x20 LCD
Tune
1 PPS
RS232
10Mhz ref
JTAG
125Mhz VCXO
EP3C40Q240
SoftCore CPU
Tune
25Mhz
PHY KSZ9021RL
RJ45
BNC To HF antenna
OPA2674IC
Anti-Alias Filter
HF MAX5875 16 bit DAC (A)
BNC To VHF antenna
VHF MMIC ???
Anti-Alias Filter
VHF MAX5875 16 bit DAC (B)
EEPROM M25P16VMW6G
IP Addess 25AA02E48T
RAM IDT71V429/L10

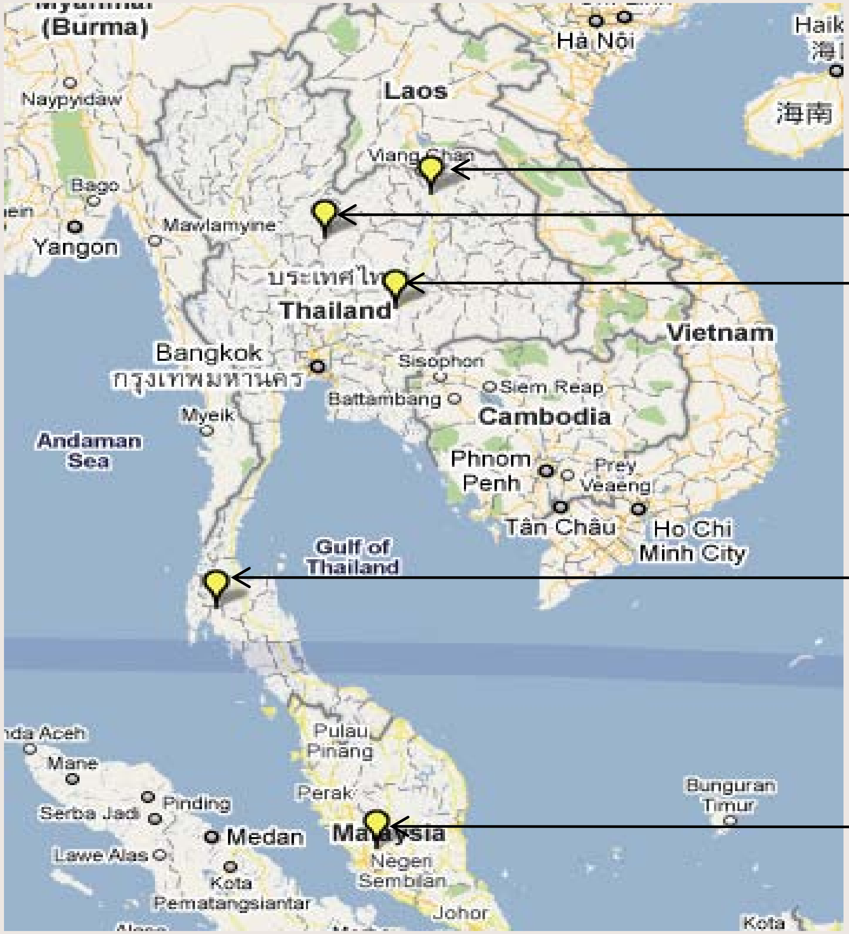
Griffin - Features

- Supports all types of Beacon modulation (CW, WSPR, RTTY etc) plus any future mode
- Simultaneous beacons, each with different modulation, on same or multiple bands
- GPS locked so high frequency and time accuracy
- Internet access for remote control and configuration
- New code can be uploaded via Ethernet/Internet
- Uses high gate count FPGA so room for future upgrades

Griffin – new features

- 6m Band operators facing loss of early warning propagation indicators
- Low Band VHF TV transmitters being removed due to introduction of Digital TV
- Features of TV transmitters:
  - Well located
  - High power (500kW ERP)
  - 24 hour operation
  - Stable and know frequencies

Griffin – new features



TV9 – 37kW – 48.26MHz

TV7 – 50kW - 48.26MHz

M3 - 37kW - 48.24MHz

TH1 – 40kW - 48.25MHz

RTM1-100kW – 48.23MHz

Griffin – new features

- How can we provide alternatives as these TV transmitters are removed from service?
- Three things under our control:
  - Beacon Power
  - Beacon Bandwidth
  - Beacon Time

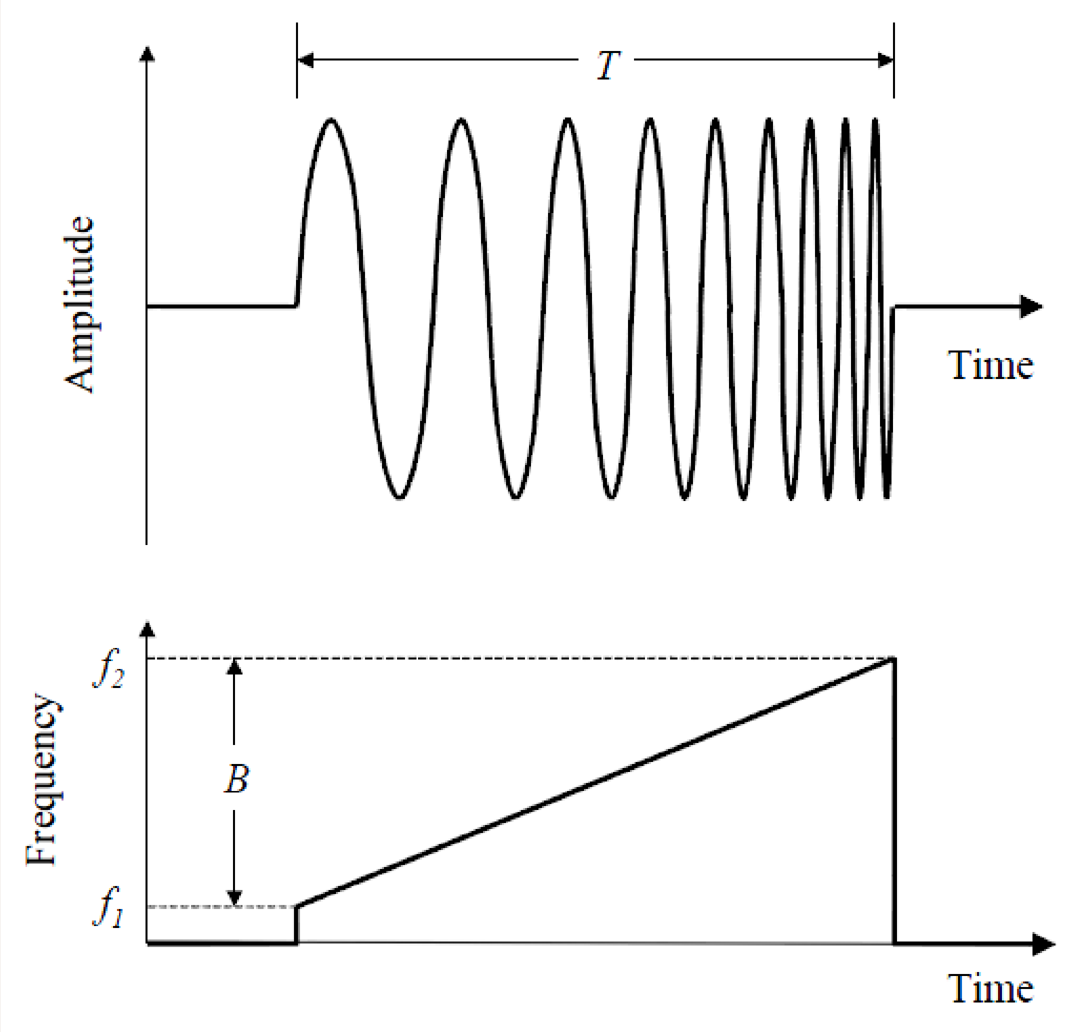
Griffin – new features

- Power – 10 to 50W is typical, cost and FCC regs
- Bandwidth – in VK beacons are 2kHz spacing
- Time – Most beacons run 24 hours
- What other systems have power restrictions?
  - RADAR
  - 1MW ERP for a land based system
  - 10kW ERP for plane and boat systems
  - So how do RADAR systems solve the power problem?

RADAR - Chirp

- RADAR systems use a technique called ‘Chirp’ to increase the ‘Effective’ Radiated Power.
- Rather than transmit a steady carrier they sweep it over a frequency range in a specific time

RADAR - Chirp

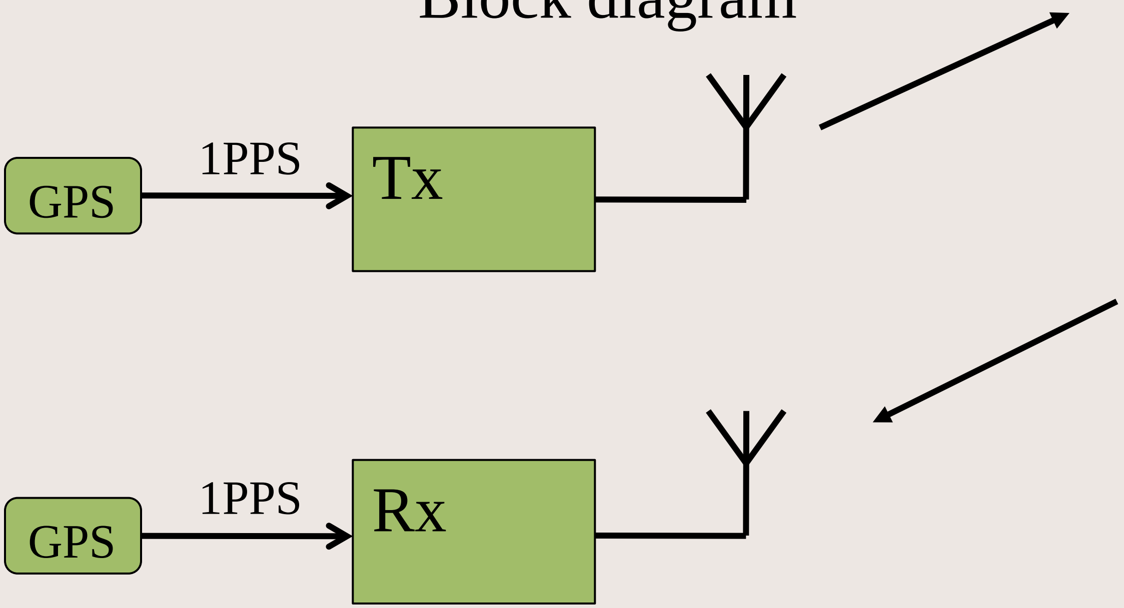


RADAR - Chirp

- Effective increase in Radiated Power is
  ERP ∞ Bandwidth (Hz) x Time (seconds)
- So, sweep over 1kHz in one second = 1000 or 30dB
- Easy to do with an Analog beacon and trivial using Digital Signal Processing e.g. Griffin!
- Receiver can be a conventional SSB receiver + sound card or DDC e.g. HPSDR – Mercury receiver.
- Receiver uses a 'Matched Filter', implement using a PC
- Receiver needs to know *exactly* when the Beacon Chirp started.
- Use 1PPS from GPS receiver to synchronize Beacon and receiver

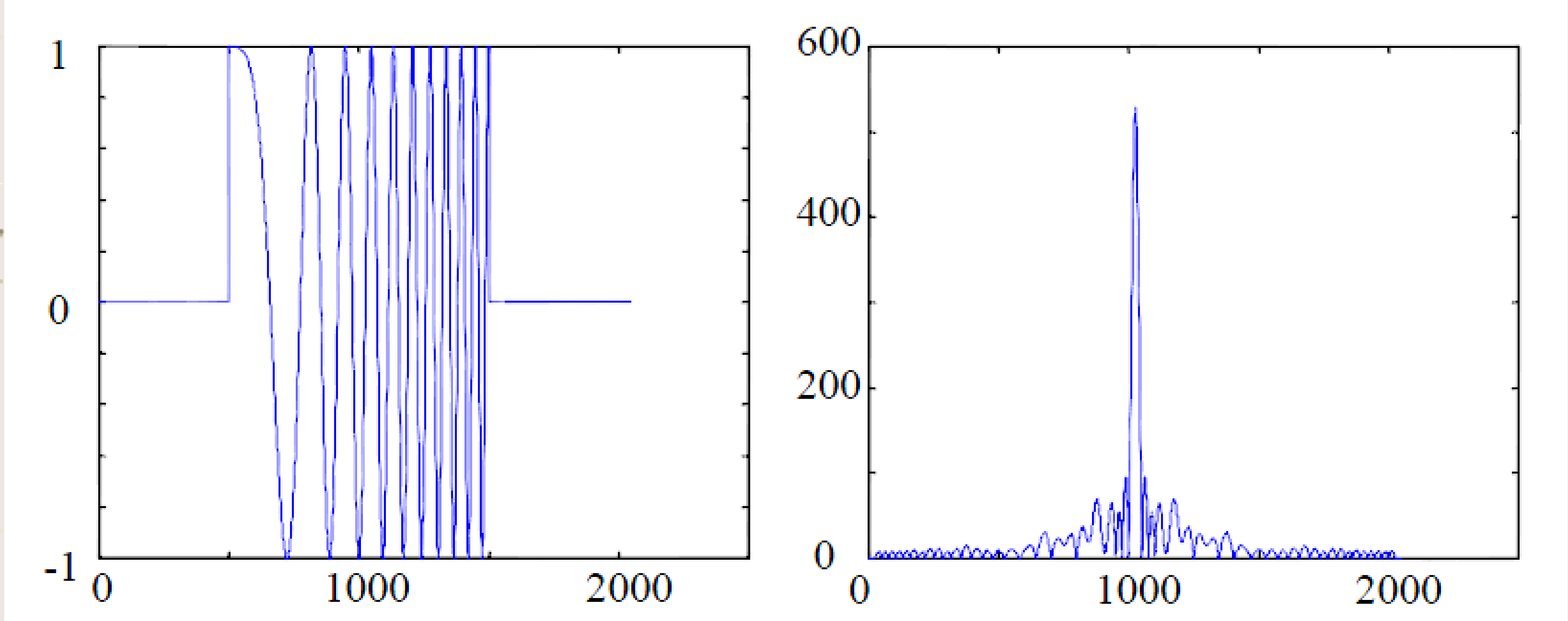
VK3OE – Chirp RADAR

Block diagram



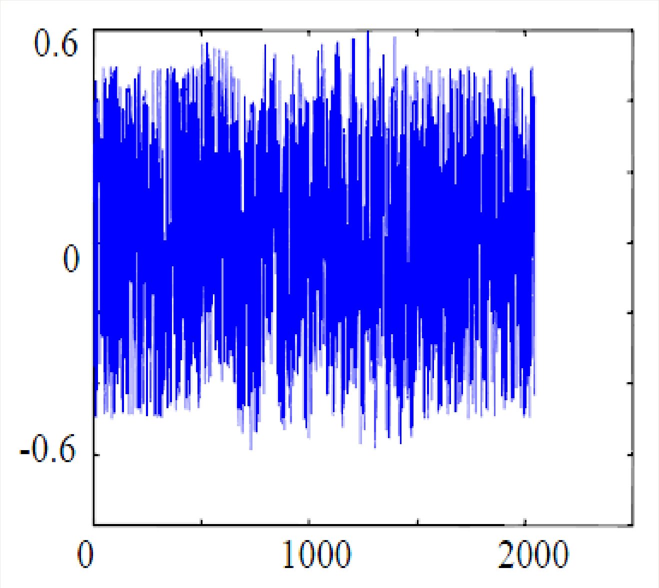
RADAR - Chirp

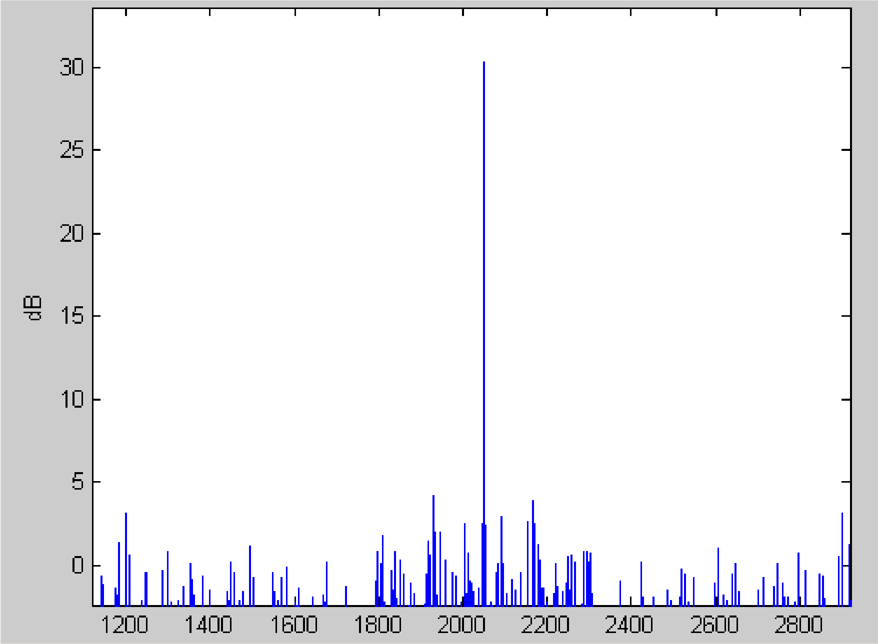
- Matlab simulation



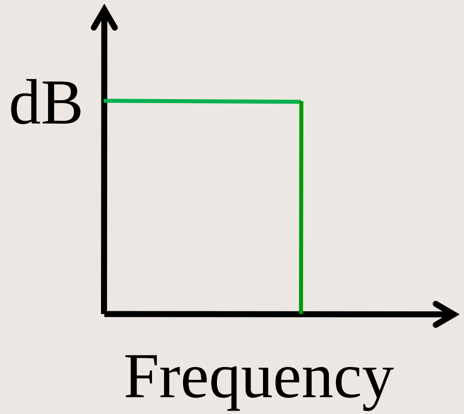
RADAR - Chirp

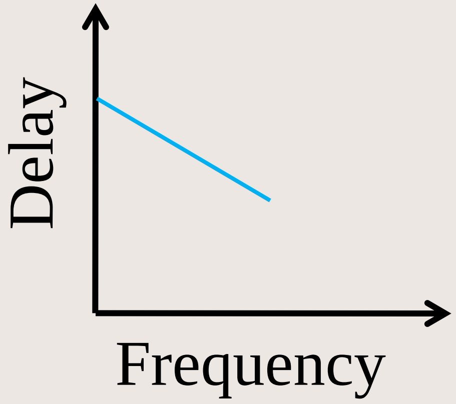
- Matlab simulation



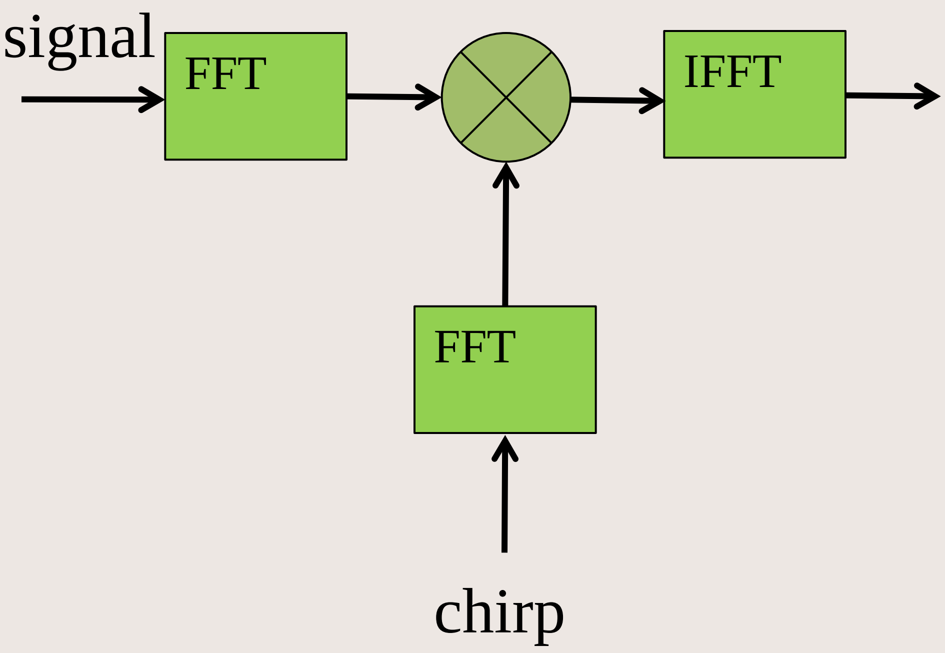


RADAR - Chirp





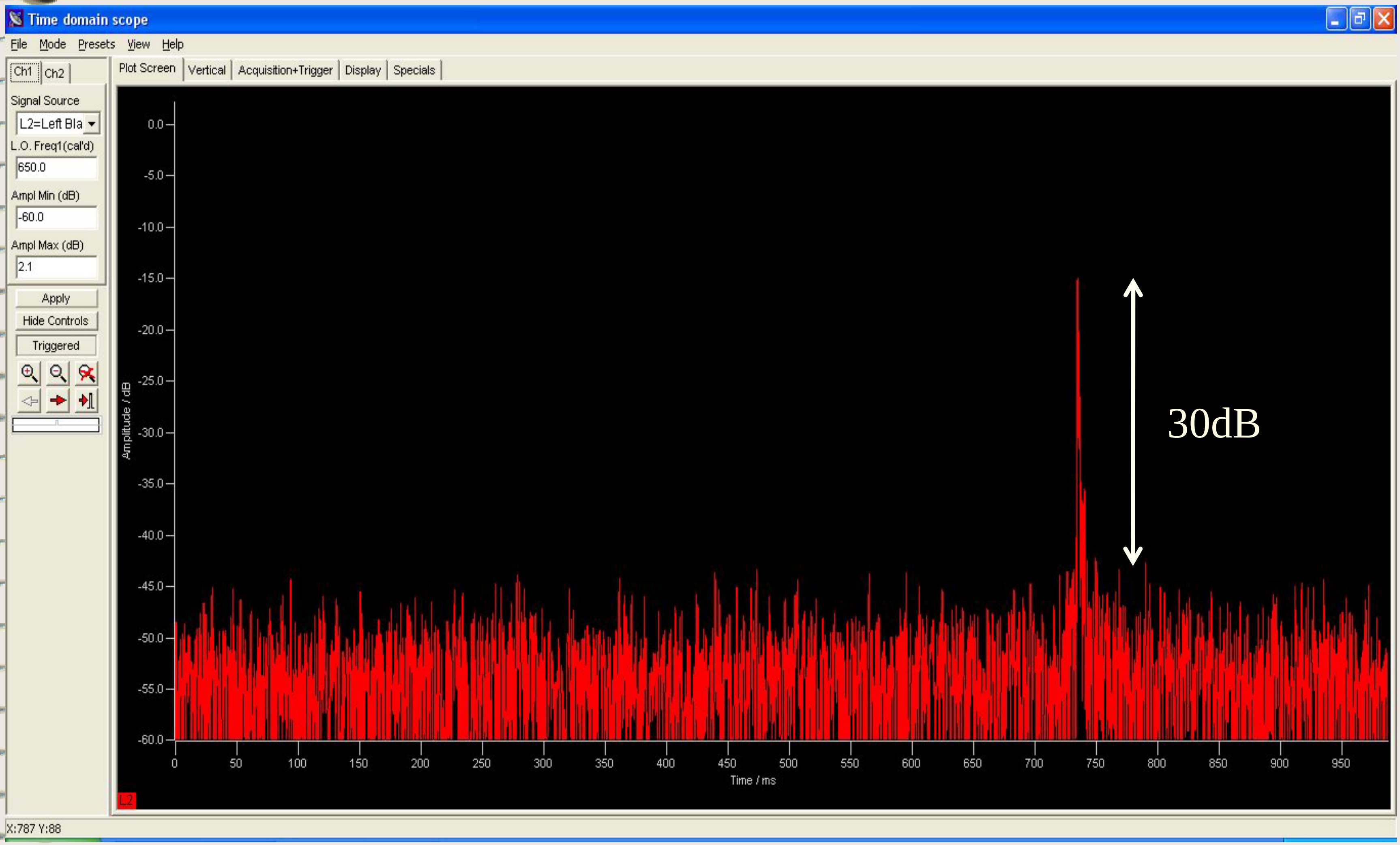
Matched Filter



RADAR-Chirp

- Test – VK6HK to VK3OE on 20m. 2,750km path between Perth and Melbourne.
- Signal at VK3OE not audible in 2.4kHz bandwidth.
- Decoded using PC Software ‘Spectrum Lab’ by DL4YHF.

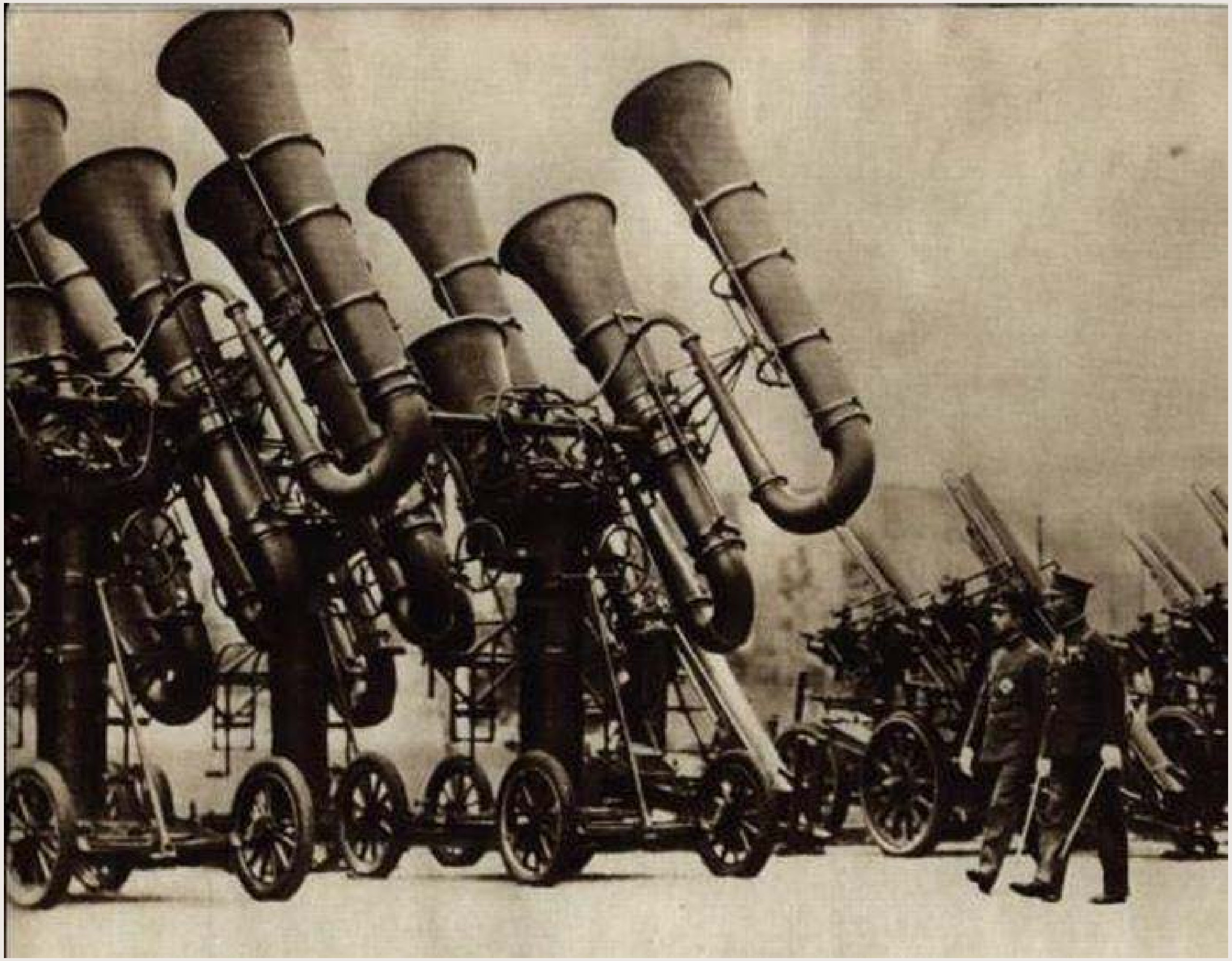
RADAR - Chirp


Time domain scope
File Mode Presets View Help
Ch1 Ch2
Plot Screen Vertical Acquisition+Trigger Display Specials
Signal Source
L2=Left Bla
L.O. Freq1(cal'd)
650.0
Ampl Min (dB)
-60.0
Ampl Max (dB)
2.1
Apply
Hide Controls
Triggered
0.0
-5.0
-10.0
-15.0
-20.0
-25.0
-30.0
-35.0
-40.0
-45.0
-50.0
-55.0
-60.0
Amplitude / dB
0 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800 850 900 950
Time / ms
L2
30dB
X:787 Y:88

Griffin - Chirp

- So we have a beacon with better than WSPR performance (but we trade bandwidth for time).
- We can juggle Bandwidth and Time for higher gain e.g. 2kHz over 10 seconds gives 43dB (10w = 200kW ERP).
- If we chirp for 1 second but integrate over a minute we gain 17dB, total of 50dB.
- What else can we use the Chirp signal for?
- Perhaps a RADAR

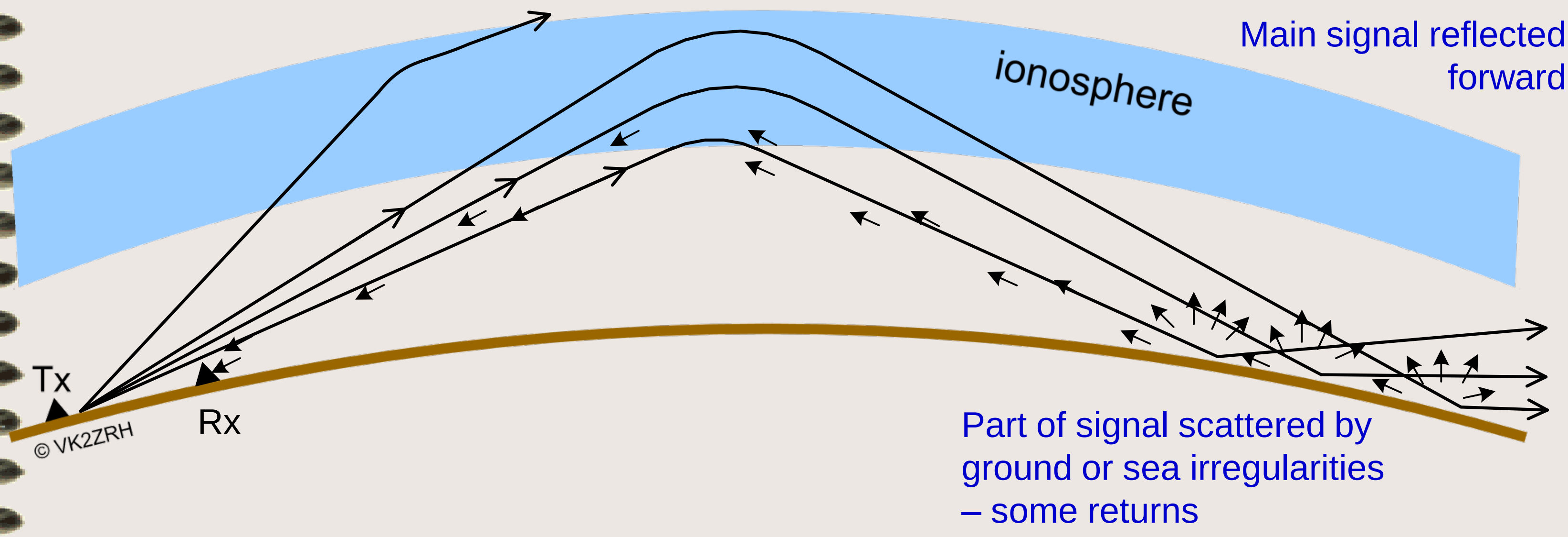
Early RADAR



Home Brew?

RADAR

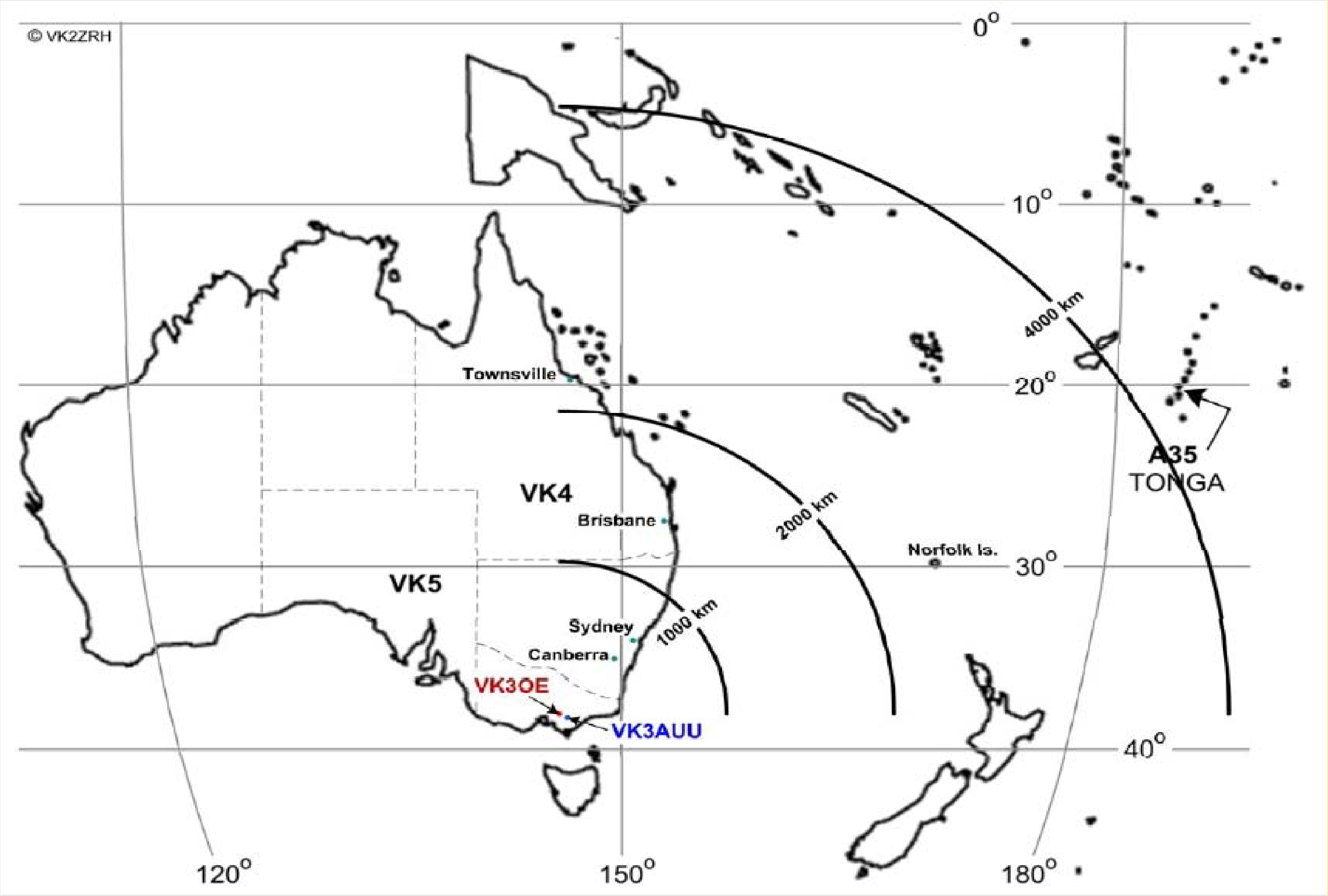
Backscatter – Principle of Operation



RADAR - Chirp

- For a RADAR we run full power into a high gain directional antenna
- We use one station as the transmitter and another as the receiver. Transmit was on 6m from VK3OE and Receive at VK3AUU some 65km apart.
- Receiver antenna 15 elements on a 24m boom, 14dBd gain.

RADAR

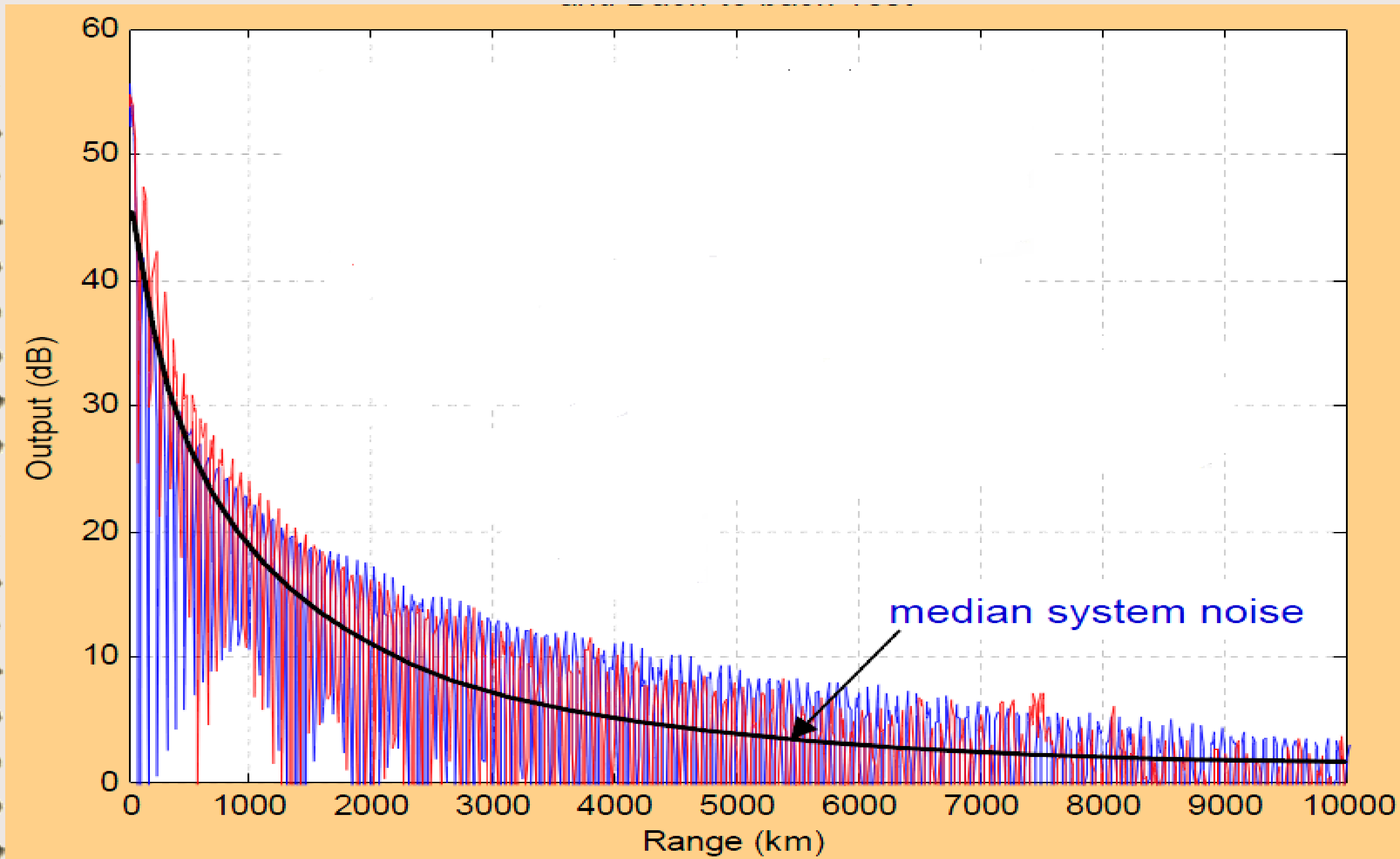


© VK2ZRH
0°
10°
20°
30°
40°
120°
150°
180°
Townsville
VK4
Brisbane
VK5
Sydney
Canberra
VK3OE
VK3AUU
1000 km
2000 km
4000 km
Norfolk Is.
A35
TONGA

RADAR

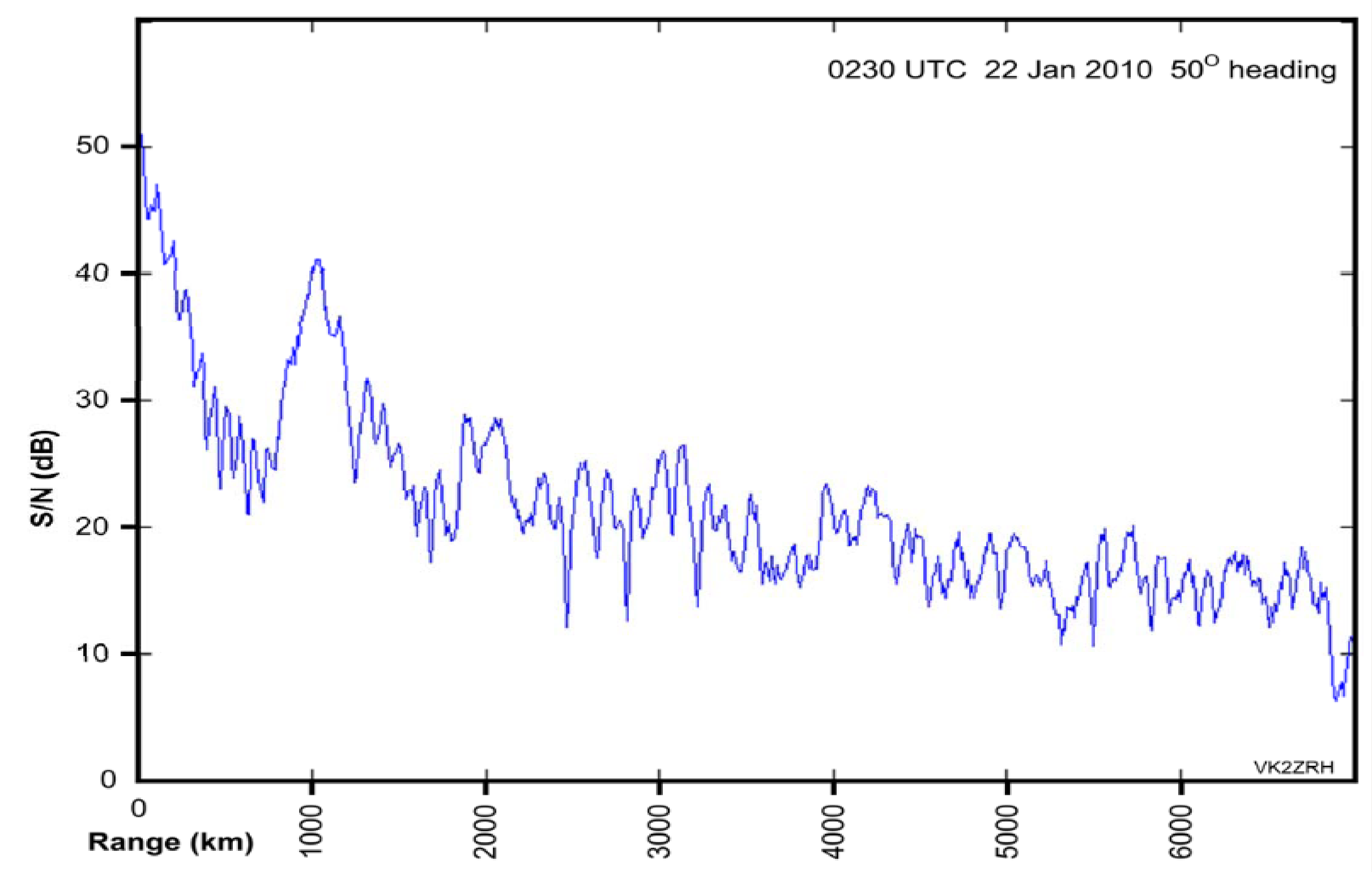
- Analysis of all the RADAR images done by Roger Harrison, VK2ZRH.
- Internationally acknowledged expert in propagation research and ionosonde development
- Ex Australian Ionospheric Prediction Service (IPS) www.ips.gov.au

RADAR

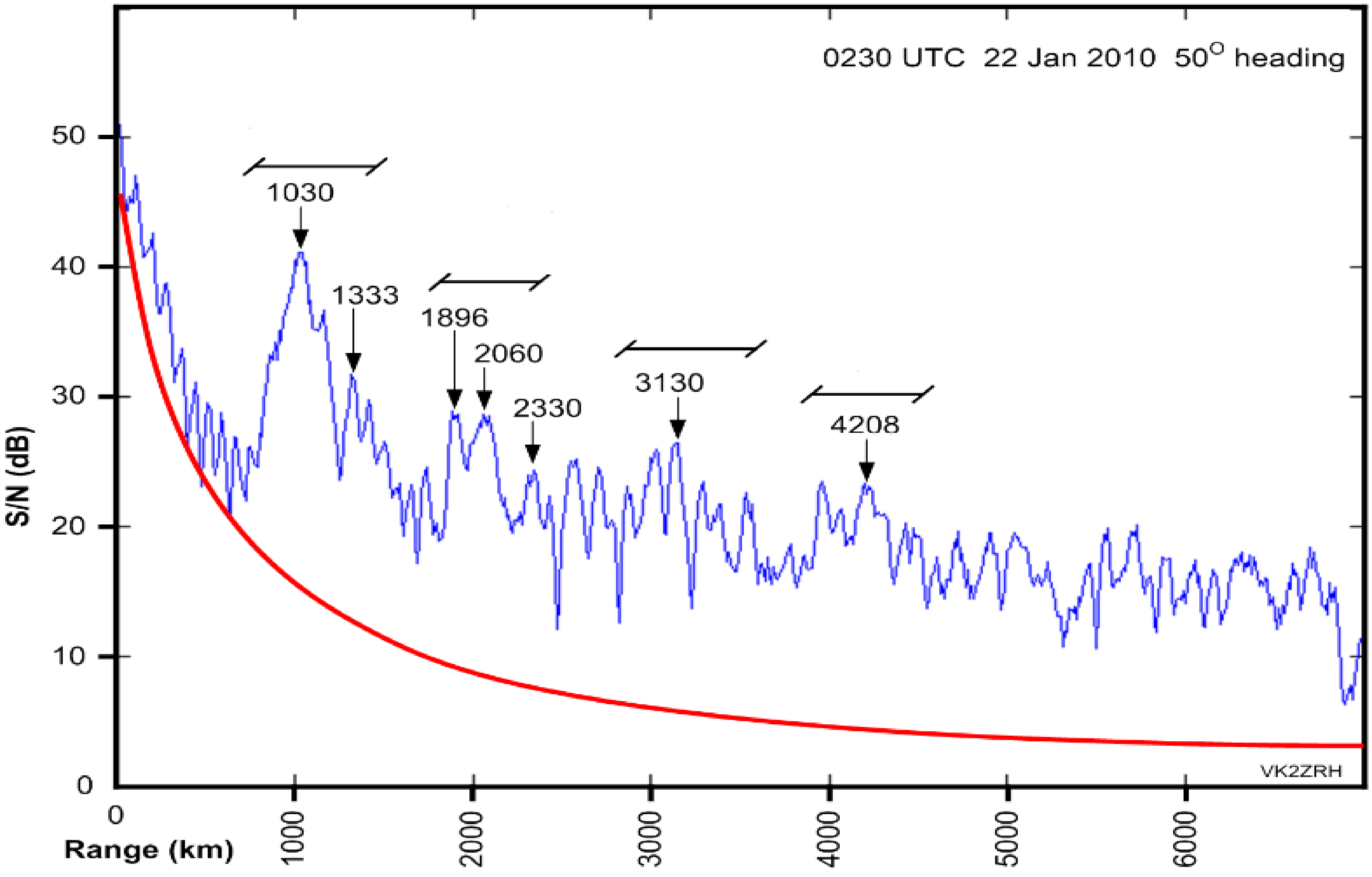


60
50
40
30
20
10
0
Output (dB)
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
Range (km)
median system noise

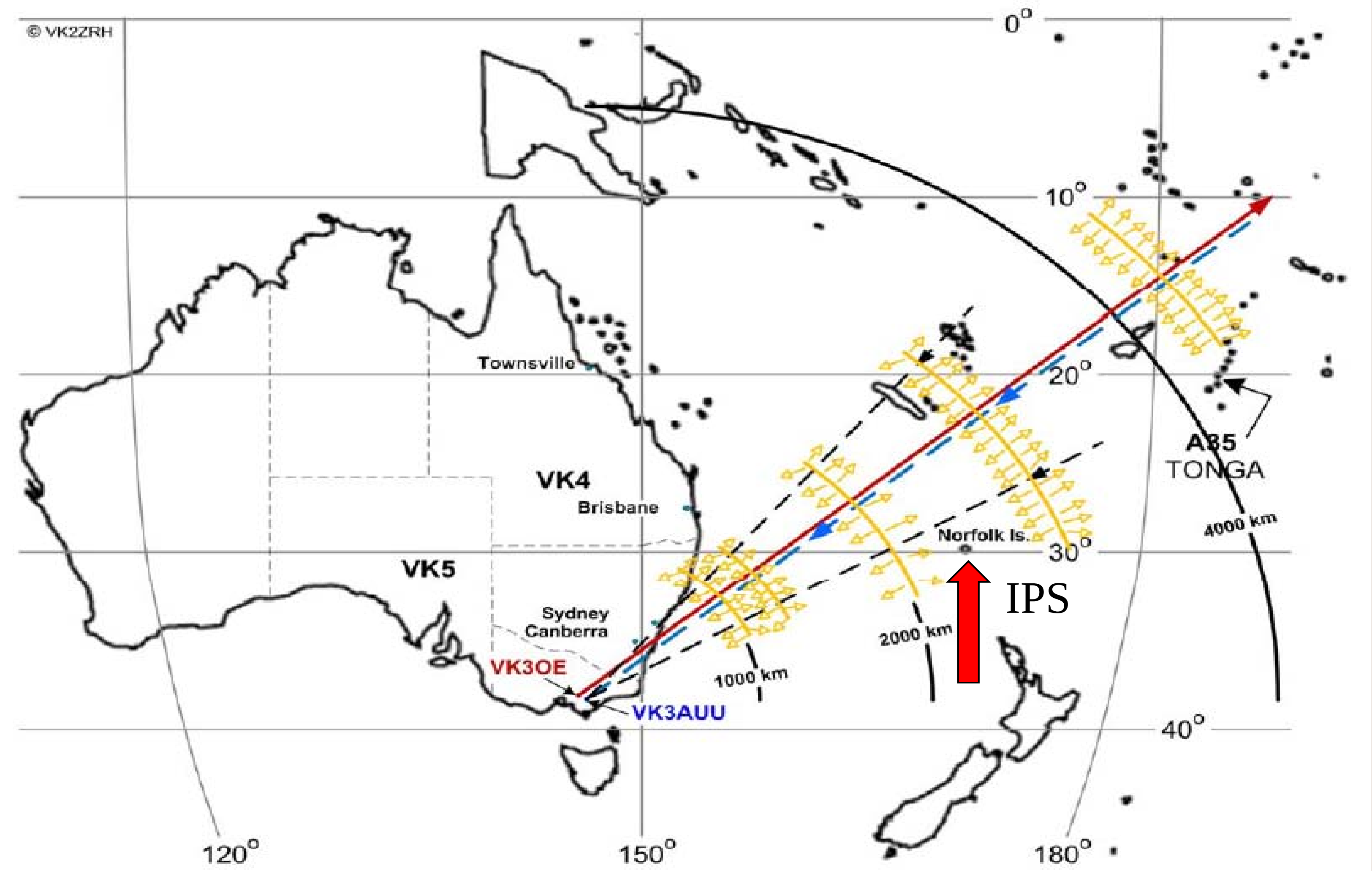
Multi-hop Sporadic E



Multi-hop Sporadic E



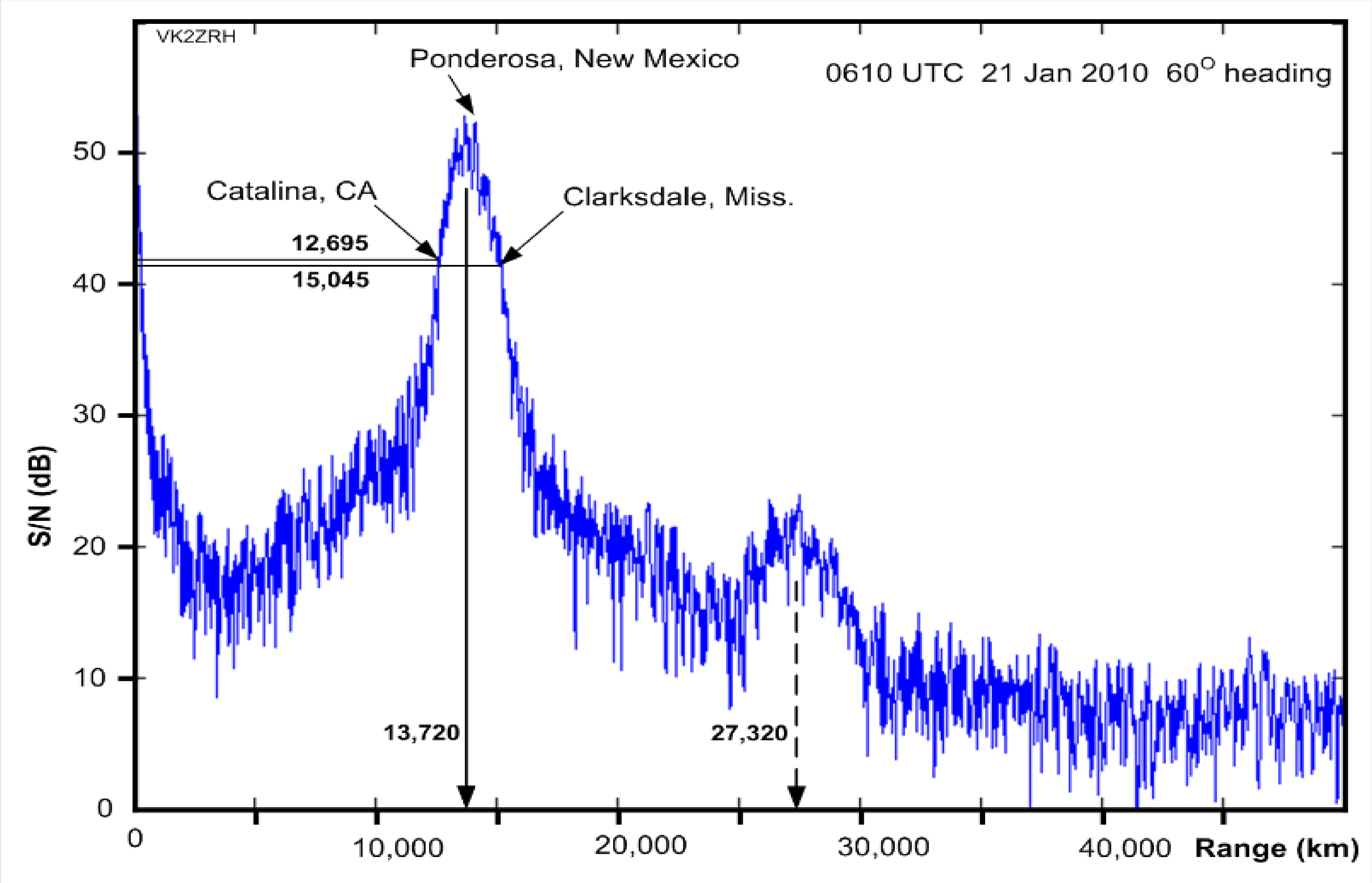
Multi-hop Sporadic E



Multi-hop Sporadic E

- Multi-hop Sporadic E confirmed via Norfolk Island Ionogram
- VK3 worked T35A

Es and TEP



VK2ZRH
Ponderosa, New Mexico
0610 UTC 21 Jan 2010 60° heading
Catalina, CA
Clarksdale, Miss.
12,695
15,045
13,720
27,320
S/N (dB)
50
40
30
20
10
0
10,000
20,000
30,000
40,000
Range (km)

Results

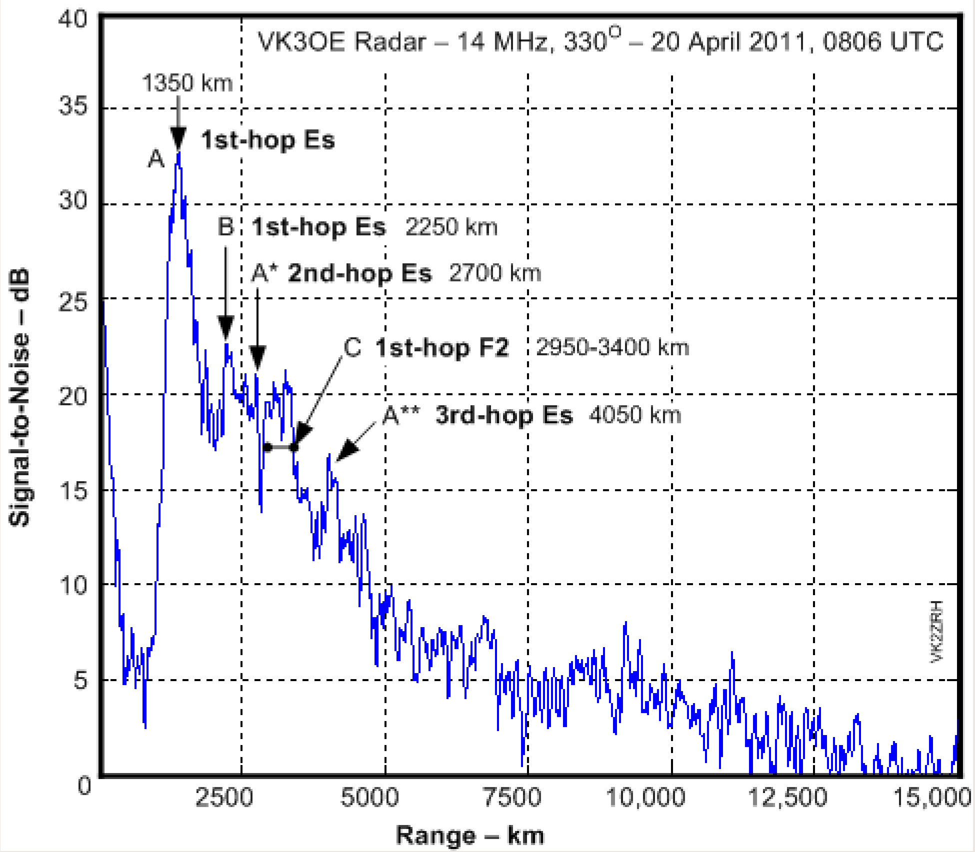
- Hundreds of tests over 12 months indicate that the VK3OE system is 100% reliable & repeatable.
- Initial tests over 12 months ago.
- Current status.

Remote Site

- VK3OE, Solar Powered, Internet access via 3G

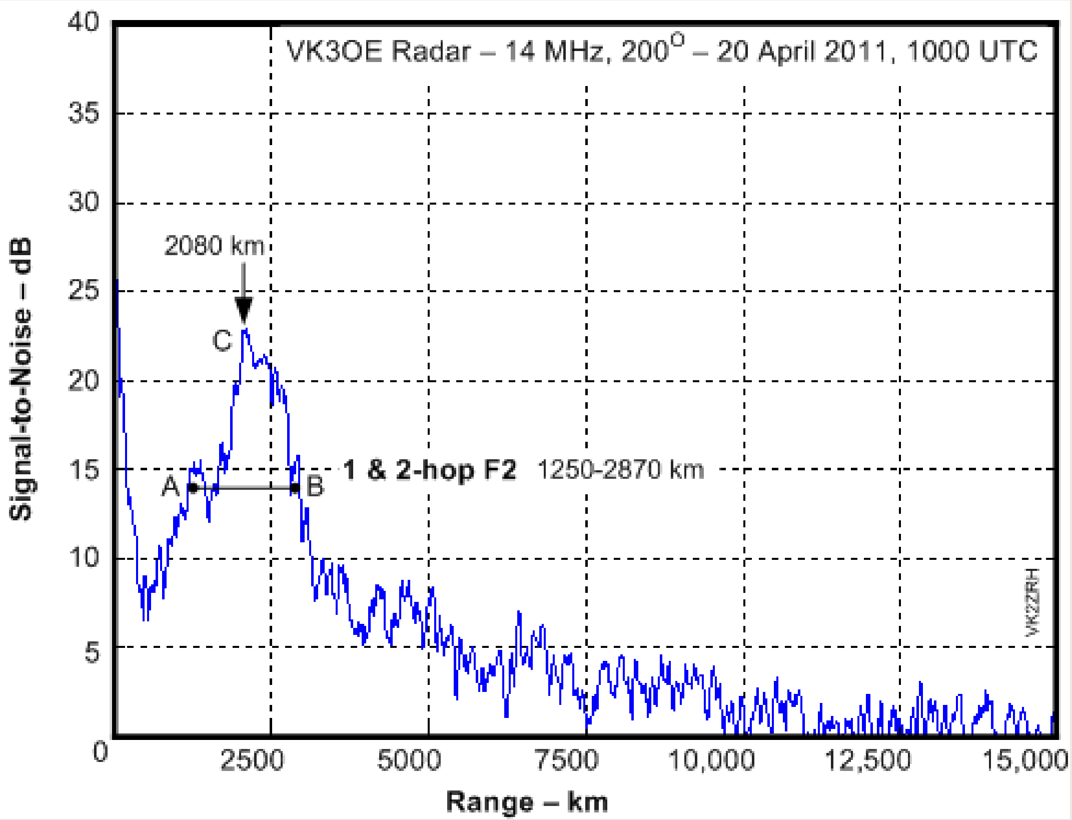
Chirp RADAR – 20m

- Transmit, 50 watts, vertical, Receive, 2 el Yagi, 142km from the transmit. 20 seconds averaged. 330 degrees.
- Image is is rather more complex than it first appears; it shows 3-hop Es and 1-hop F2 - the latter falling between the 2nd and 3rd Es hops. It must have been a busy evening in the ionosphere over Western-NSW and the NT!



Chirp RADAR – 20m

- As previous 200 degrees 10:00 UTC, 20 April 2011.
- Image shows mixed 1 & 2-hop F2. The Hobart ionogram shows the F2 layer at 200 km h'F2 and foF2 of 5.2 MHz, the MUF for the path would have been about 20 MHz

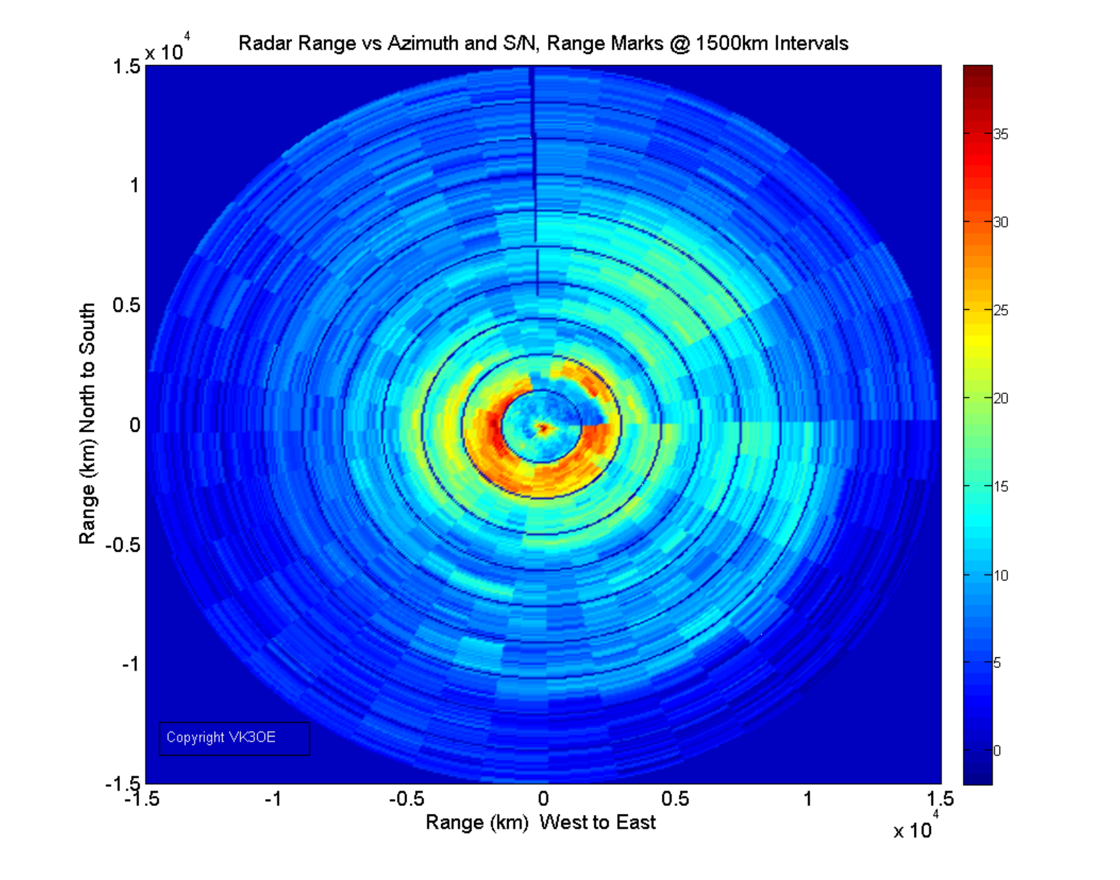


Chirp RADAR – 20m

- We can produce a PPI map over 360° by moving the receive antenna.
- The following plot was taken on 22nd & 23rd April 2011.
- A set of 10 chirps was sent in each of 36 directions and the results combined
- RADAR returns are evident at up to 10dB S/N out to 15,000km
- Range markings are at 1500km spacing

Chirp RADAR – 20m

- 22 April 2011, 10:30UTC (90 to 350 degrees) and 23 April 2011, 10:30UTC (350 to 90 degrees).



Summary

- A Chirp beacon will provide the equivalent system ERP of a TV Transmitter.
- Using Chirp RADAR we no longer need a signal at the other end in order to check if a path is open.
- Chirp RADAR can be used on *any* Amateur Band to check propagation in a specific direction.
- Open source software will be available. Hermann, DL3HVH, is developing a PC + CUDA application.
- Potential to build well sighted, Internet connected, remote Beacon and RADAR stations.
- High potential for discovering new propagation modes.

Acknowledgements

- Andrew, VK3OE, original idea
- David, VK3AUU, receiving station
- Roger, VK2ZRH, analysis & slides

Questions

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