Experiences with CP on 10GHz

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EME2016

With thanks for contributions from : OK1KIR, LX1DB, HB9Q and SM6FHZ

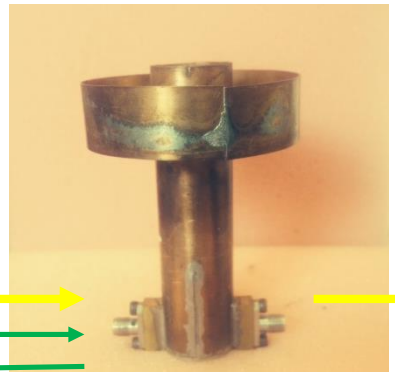
Topics

- Expectations for CP
- Testing a feedhorn
- Checking circularity (with OK1KIR)
- Development test software for measuring S/N ratio
- Checking CP sense (with HB9Q and LX1DB)
- Comparison of LP-LP and CP-CP on own echoes
- Comparison of CP-CP and LP-CP (with LX1DB)
- Conclusions

My initial expectations for CP

- CP to CP signal levels would be same as for LP to LP
- CP to LP would have 3dB loss
- CP might have narrower signals
- Since CP has been in use now by many stations for some time, everyone would be using the same CP sense
- CP Feeds are not that easy to build compared to LP

Lab testing of the SM6FHZ 0.692 wl feed

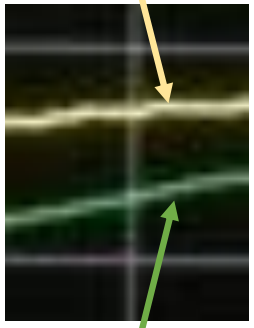


Return loss

isolation

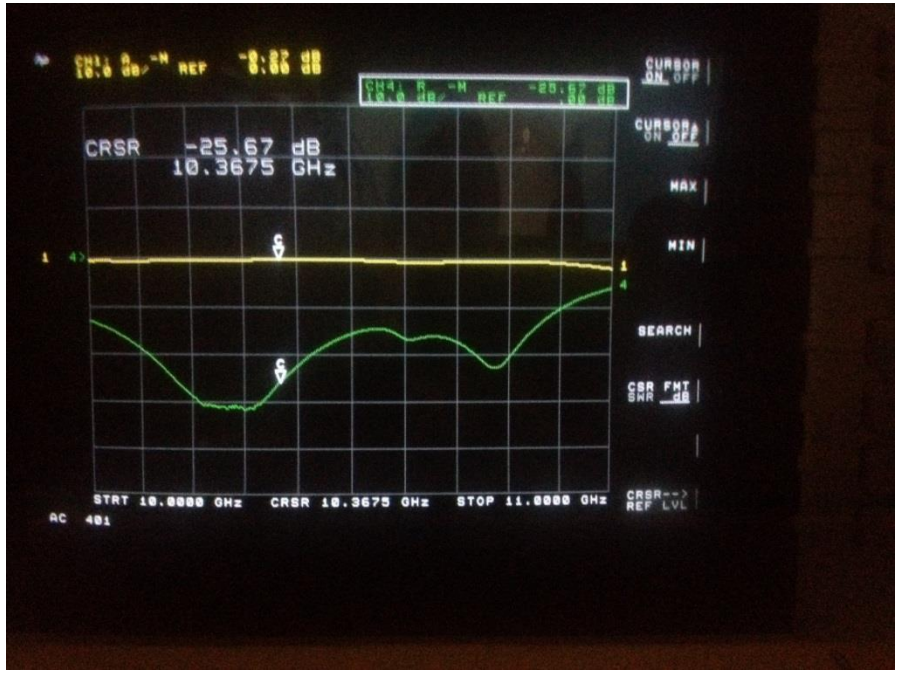
Copper shorting plate

Isolation



Return loss

10-11GHz
10dB/div



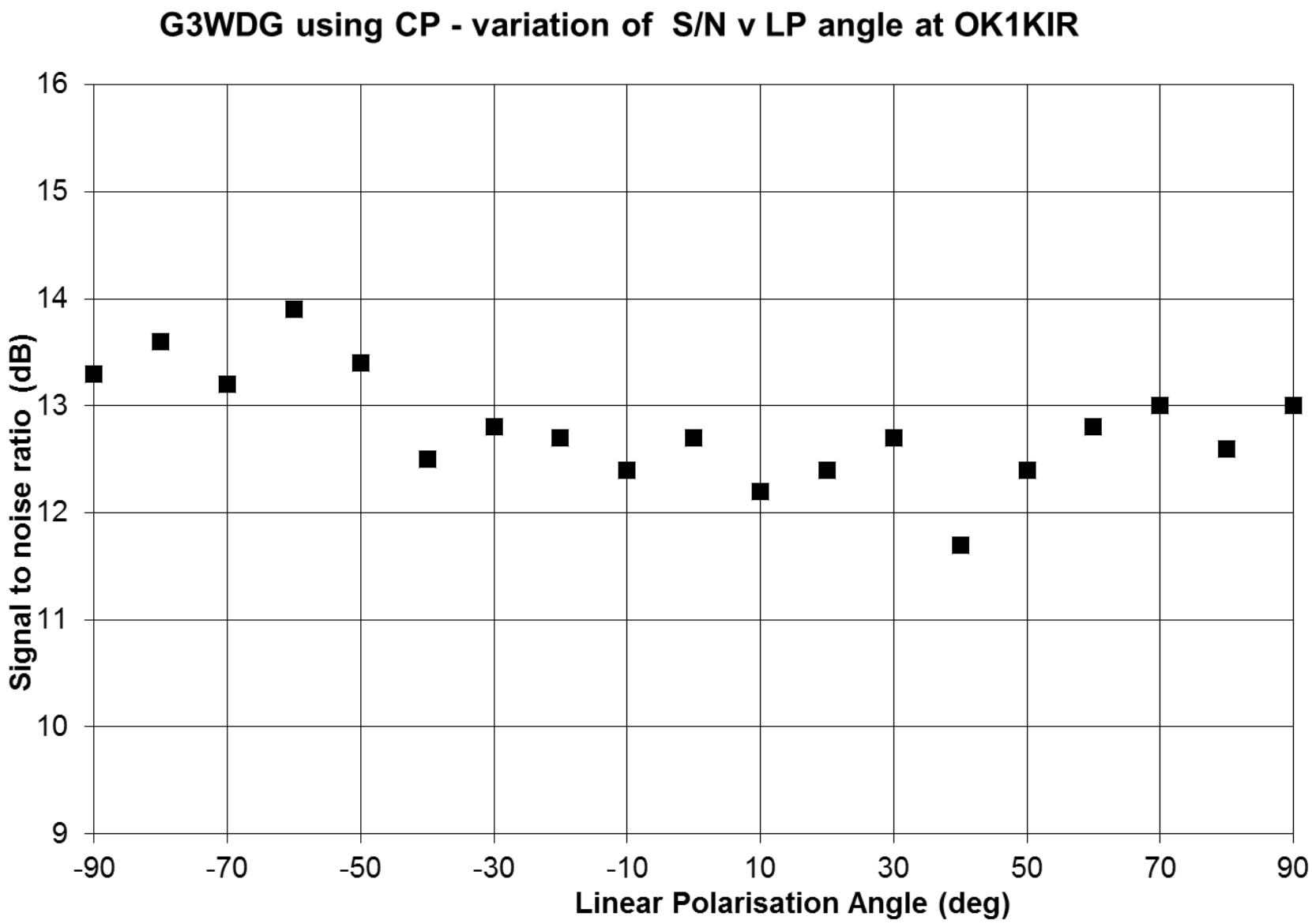
Feed open, with choke at -3.5mm

RL = -28.5dB,
Isol = 23.4dB

Feed mouth shorted with plate

RL = -25.7dB
Isol = 0.3dB

Testing the feed off the moon - CP to rotatable LP



Each point is average of **48 sec** carrier

Duration of test **38min**

OK1KIR auto tracked

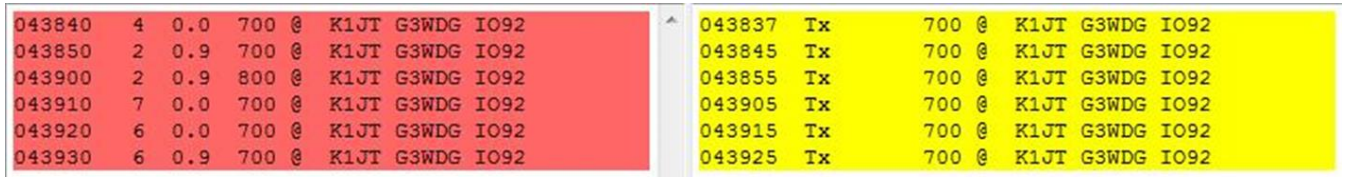
G3WDG optimised on moon noise with dead reckoning tracking

Signal to noise obtained from FFT routine (“Echoplot1”) written in Matlab

S/N not corrected for the small increase in libration spreading over the test

Comparison of LP and CP Signals

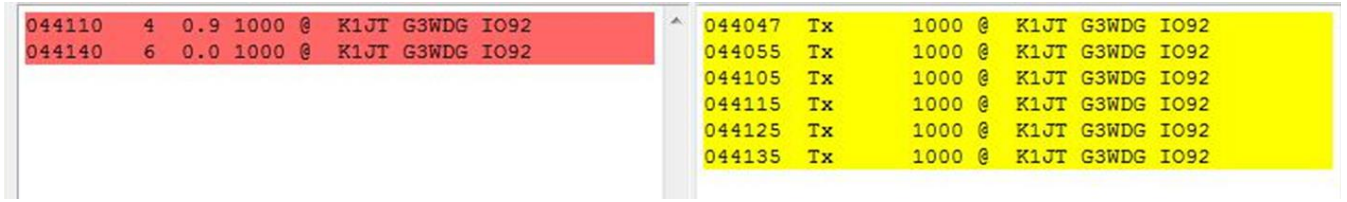
Attempted to use own echoes with WSJT fast modes and look at decoding success



043840	4	0.0	700	@	K1JT	G3WDG	IO92
043850	2	0.9	700	@	K1JT	G3WDG	IO92
043900	2	0.9	800	@	K1JT	G3WDG	IO92
043910	7	0.0	700	@	K1JT	G3WDG	IO92
043920	6	0.0	700	@	K1JT	G3WDG	IO92
043930	6	0.9	700	@	K1JT	G3WDG	IO92

043837	Tx	700	@	K1JT	G3WDG	IO92
043845	Tx	700	@	K1JT	G3WDG	IO92
043855	Tx	700	@	K1JT	G3WDG	IO92
043905	Tx	700	@	K1JT	G3WDG	IO92
043915	Tx	700	@	K1JT	G3WDG	IO92
043925	Tx	700	@	K1JT	G3WDG	IO92

Full power



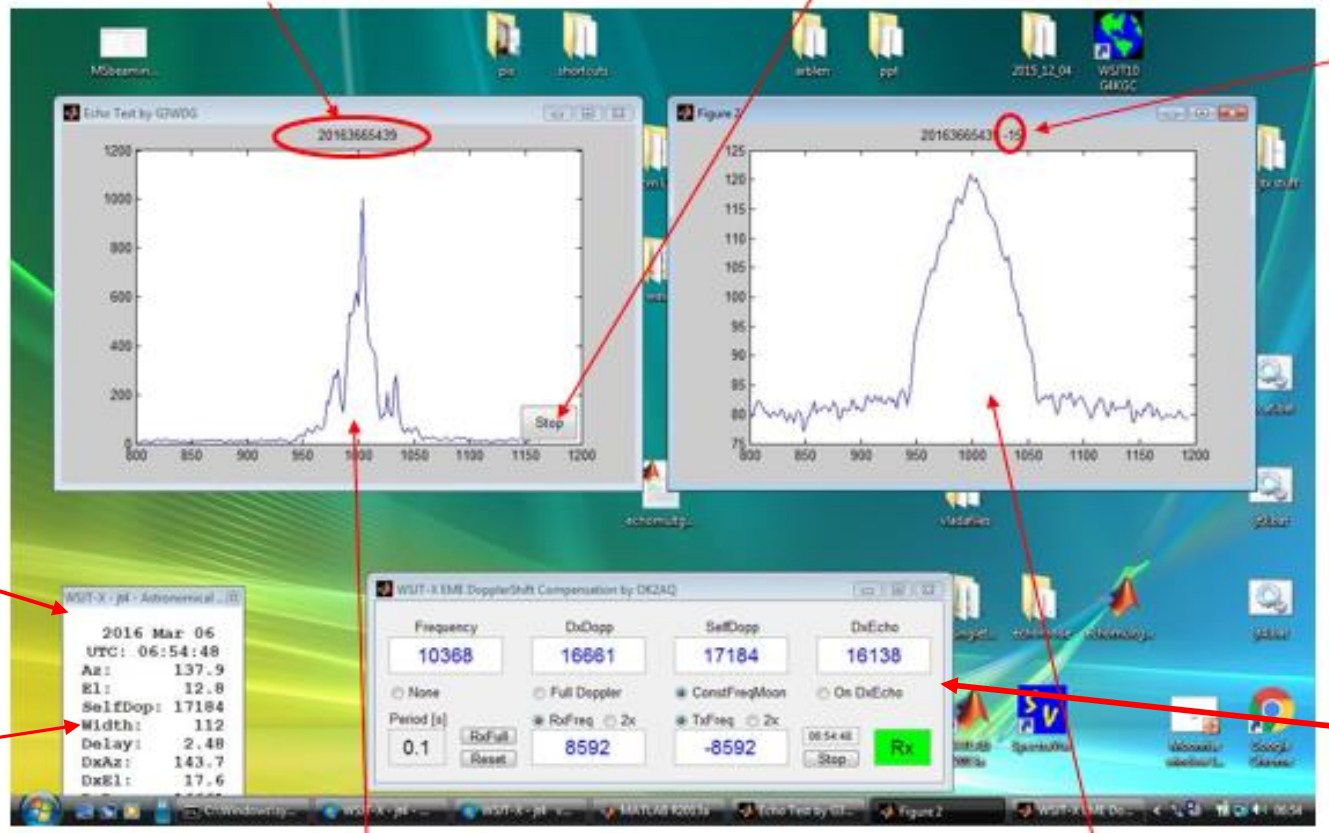
044110	4	0.9	1000	@	K1JT	G3WDG	IO92
044140	6	0.0	1000	@	K1JT	G3WDG	IO92

044047	Tx	1000	@	K1JT	G3WDG	IO92
044055	Tx	1000	@	K1JT	G3WDG	IO92
044105	Tx	1000	@	K1JT	G3WDG	IO92
044115	Tx	1000	@	K1JT	G3WDG	IO92
044125	Tx	1000	@	K1JT	G3WDG	IO92
044135	Tx	1000	@	K1JT	G3WDG	IO92

Reduced power

Results were rather variable and difficult to interpret. JTMSK showed some clear advantage for LP. Led to development of “Echo” program (in Matlab) to measure S/N of own echoes.

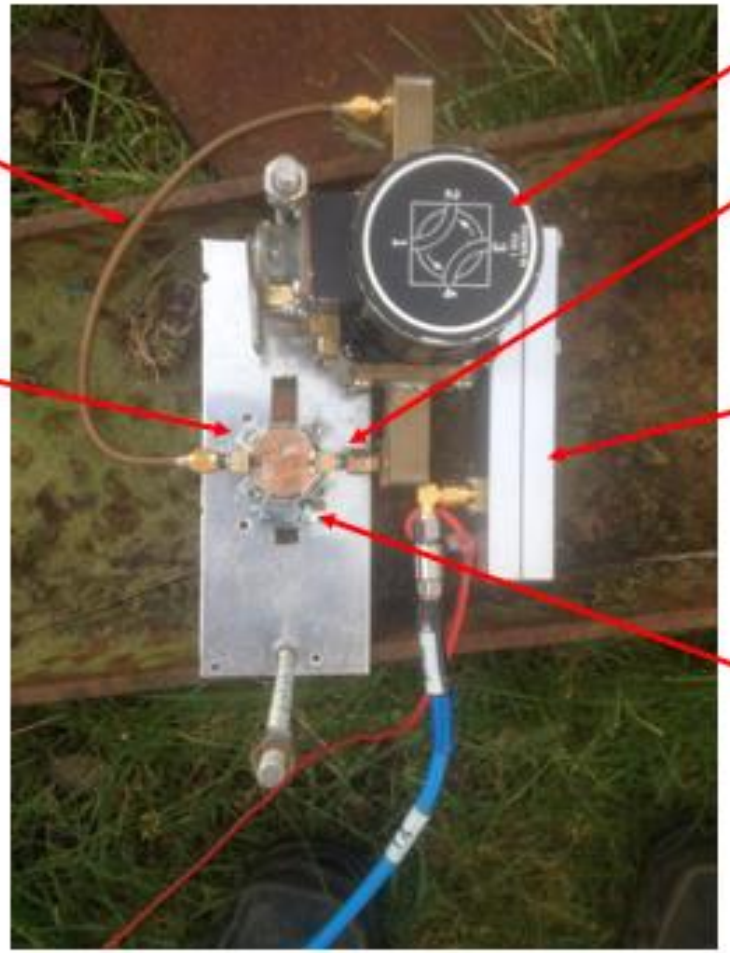
Echo (and Dopp) in operation



Measurement accuracy verified using echo tests at different TX power: 16 echo average accurate to **0.2dB** over **3dB** dynamic range, **0.3dB** to **17dB** and **0.5dB** to **23dB**

OK2AQ's Dopp Window set to Constant Frequency on Moon for Doppler correction

Testing sense of received CP signals



WG switch (operated from shack)

141 semirigid link (approx 0.5dB loss)

RX port

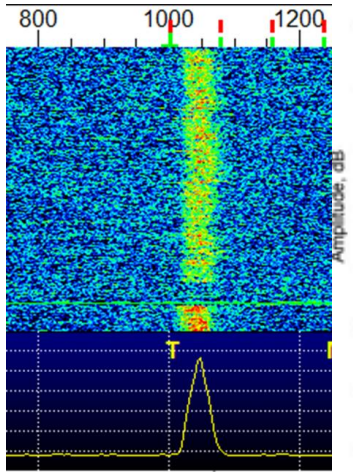
TX port
Used as second RX port for opposite sense CP

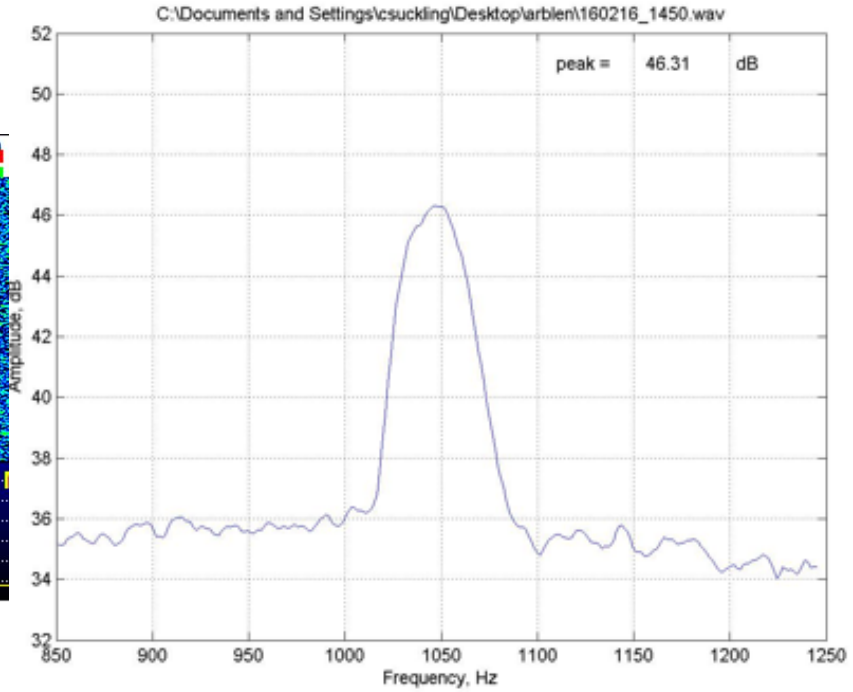
DU3BC preamp

Feed is SM6FHZ 0.692 wl septum design

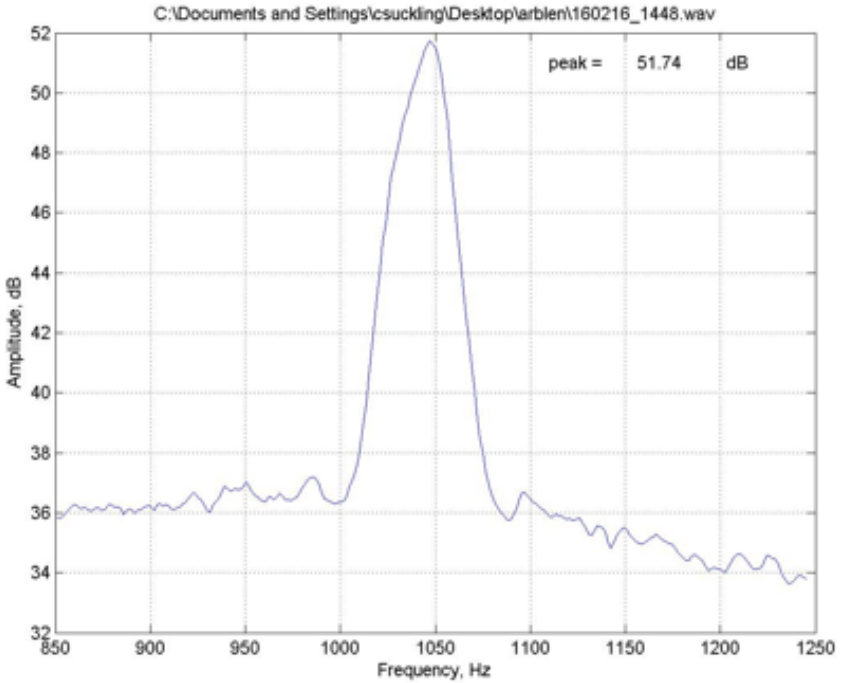
EME Calc estimates ~1dB lower sensitivity for TX port due to 0.5dB cable loss

First CP to CP sense test (G3WDG - HB9Q)

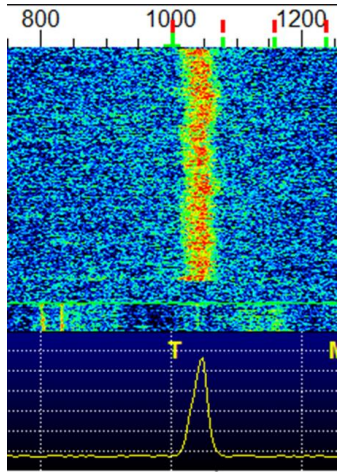




RX port



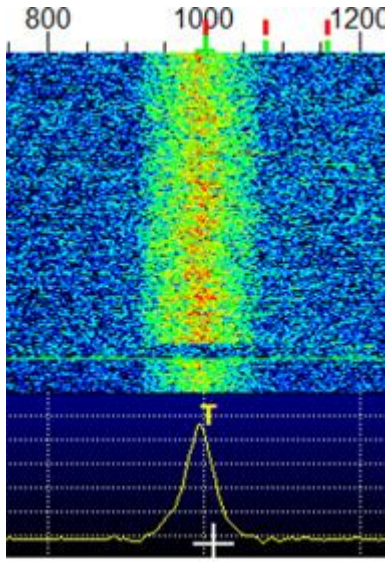
TX port

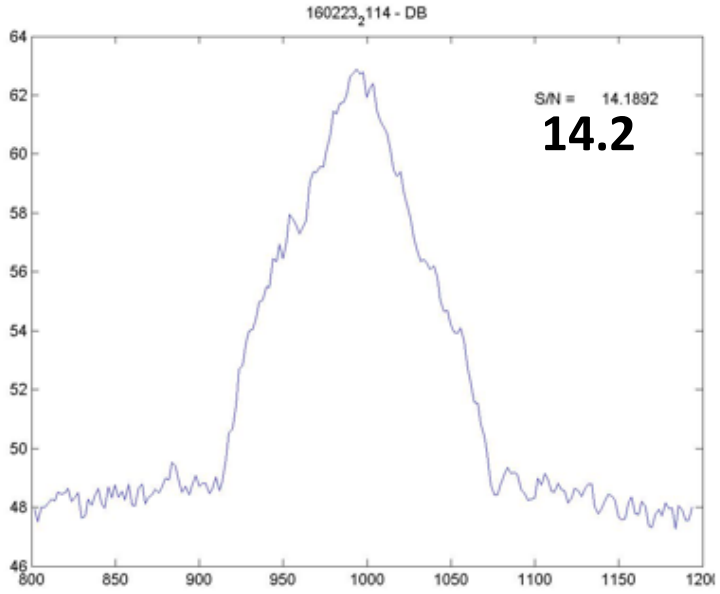


XPD = (51.7+1) – 46.3 = 6.4dB

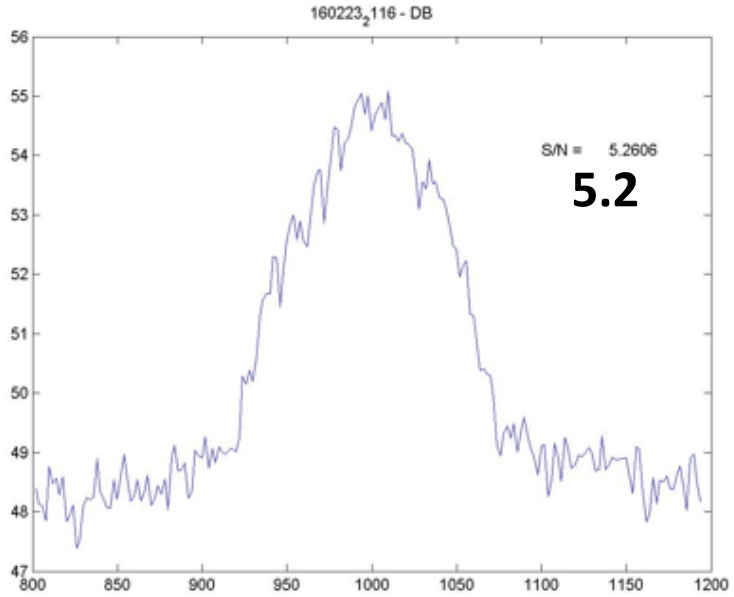
Stronger signal on my TX port meant that one of us had the ports the wrong way round!

Second CP-CP sense test (with LX1DB)

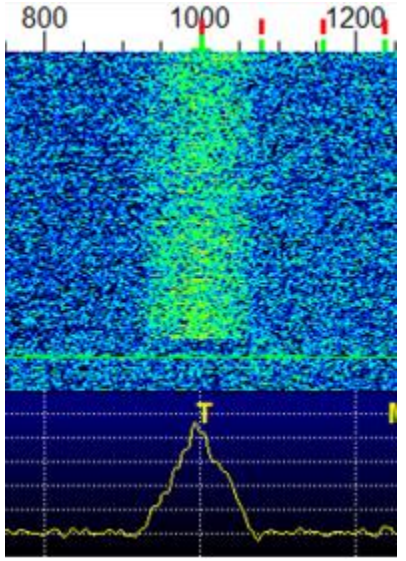




RX port



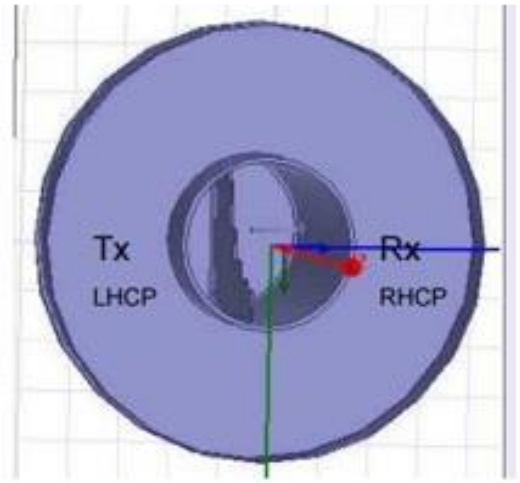
TX Port



XPD = 14.2 – (5.2+1) = 8dB

1dB added to TX port signal to account for cable loss

Feedhorn port definitions



2 *Circular Polarization*

This discussion was about the extension of EME circular polarization standards to the higher microwave bands. Circular polarization is already standard on 23cm and 13cm – for reference, the standard is:

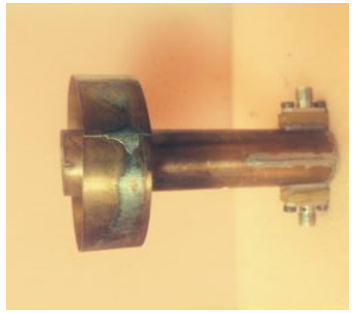
Transmit RHCP, receive LHCP [1]

Reflection from dish reverses sense of CP, so this is why TX is connected to ***LHCP*** port of feed to get ***RHCP*** out of the dish.

Does not matter whether launches are probe or WG – it is which side of the septum that the launch is that determines LHCP or RHCP

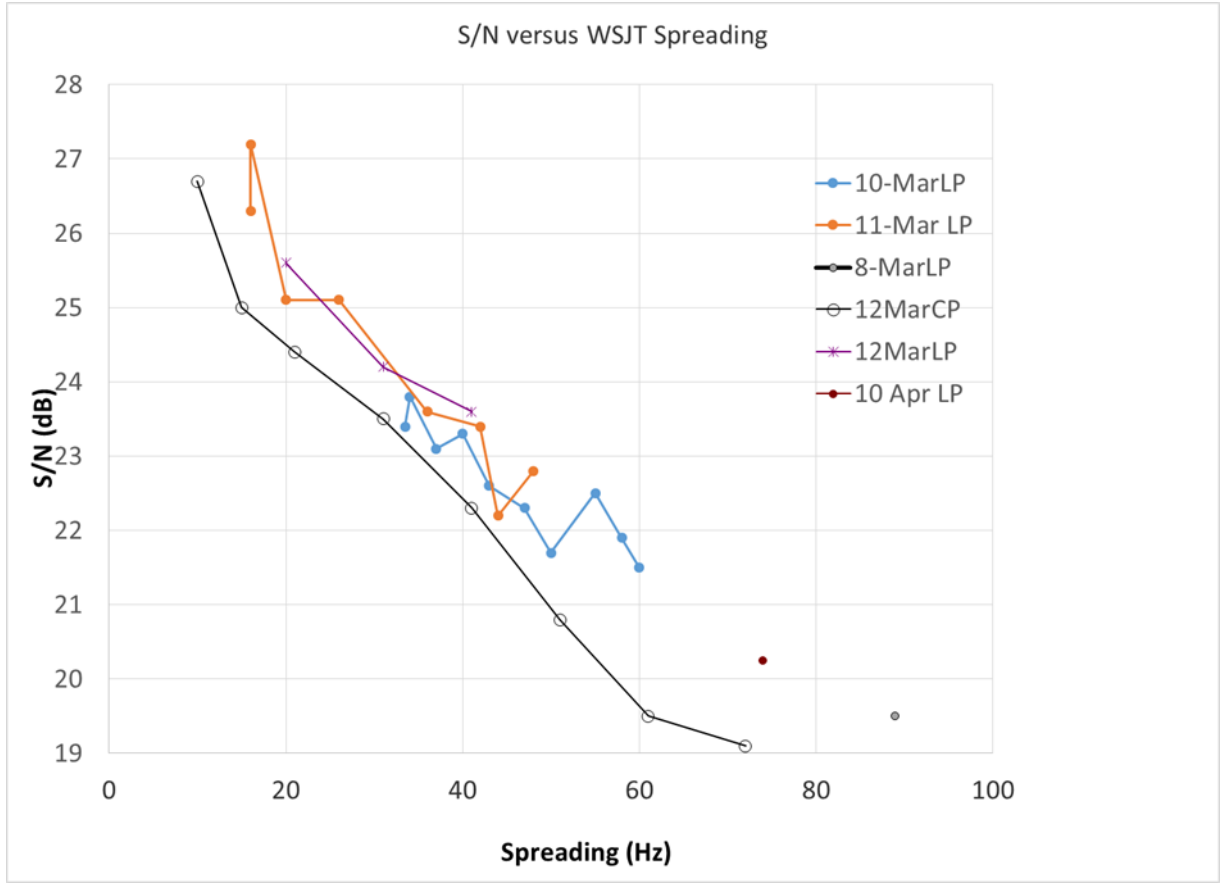
Self Echo tests to compare LP to LP and CP to CP

- Tests done over several days around March 2016 perigee
- Echoes taken at elevations from 15-35 deg
- TX power ~80W at the feed. Feeds had identical dimensions.



- Series of echoes taken for 1-2 hours with one feed up to minimum libration point, then feeds swapped and more data taken
- The first feed used was alternated every day (LP and CP)
- Weather was reasonably constant for each day's test
- For these tests, CP system had 0.3dB advantage

Results of own echo tests



S/N reported by Echo reduces as signal width increases, showing need for correction for amount of spreading

- Comparing echo levels over 8 separate tests over several days, showed an average signal level **1.3dB** higher for LP to LP than for CP to CP, at the same levels of libration spreading.

- CP system should be 0.3dB better, making the actual difference more like **1.6**dB.

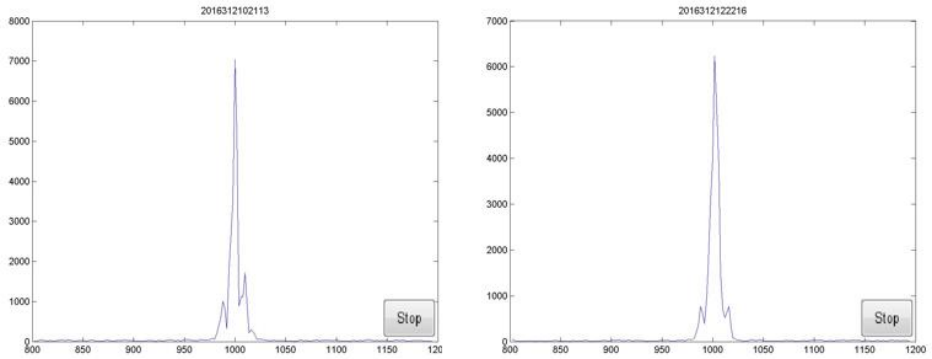
Comparing signal shapes with CP and LP

- Some references noted that with CP signals were narrower than LP

- If so, this would give CP an advantage over LP under marginal conditions, for both CW and digital modes

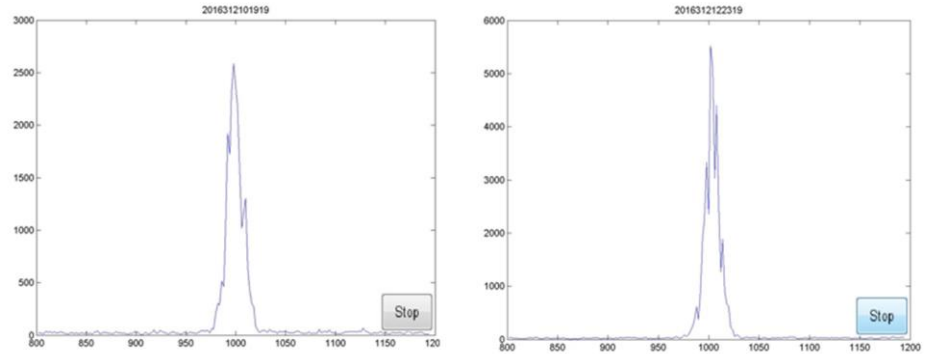
Comparison of echo shapes from one set of 16

CP LP



CP LP

Narrow individual echoes

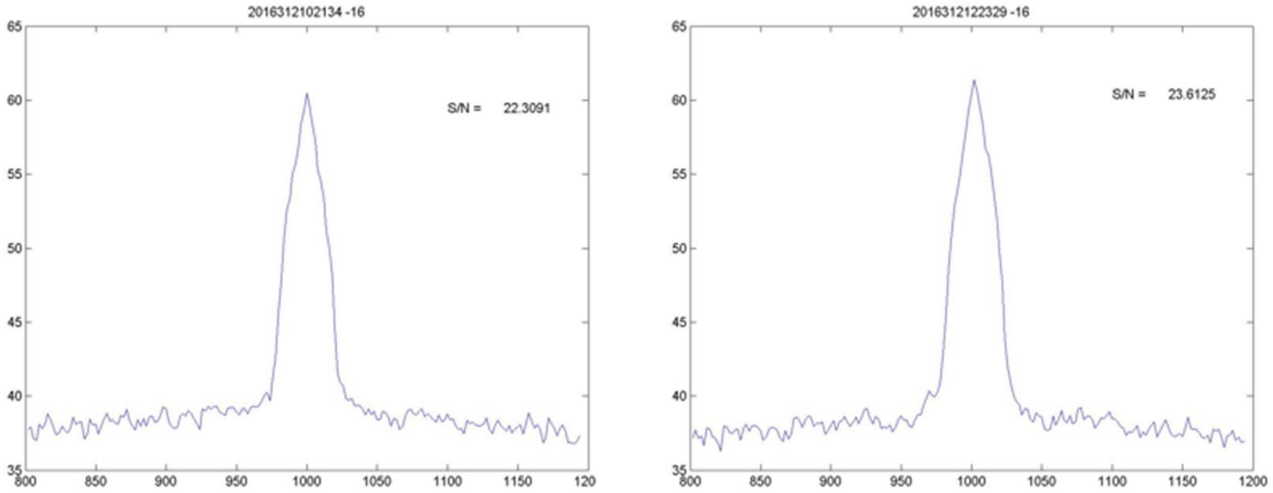


CP LP

Wider individual echoes

Width: 43

CP LP

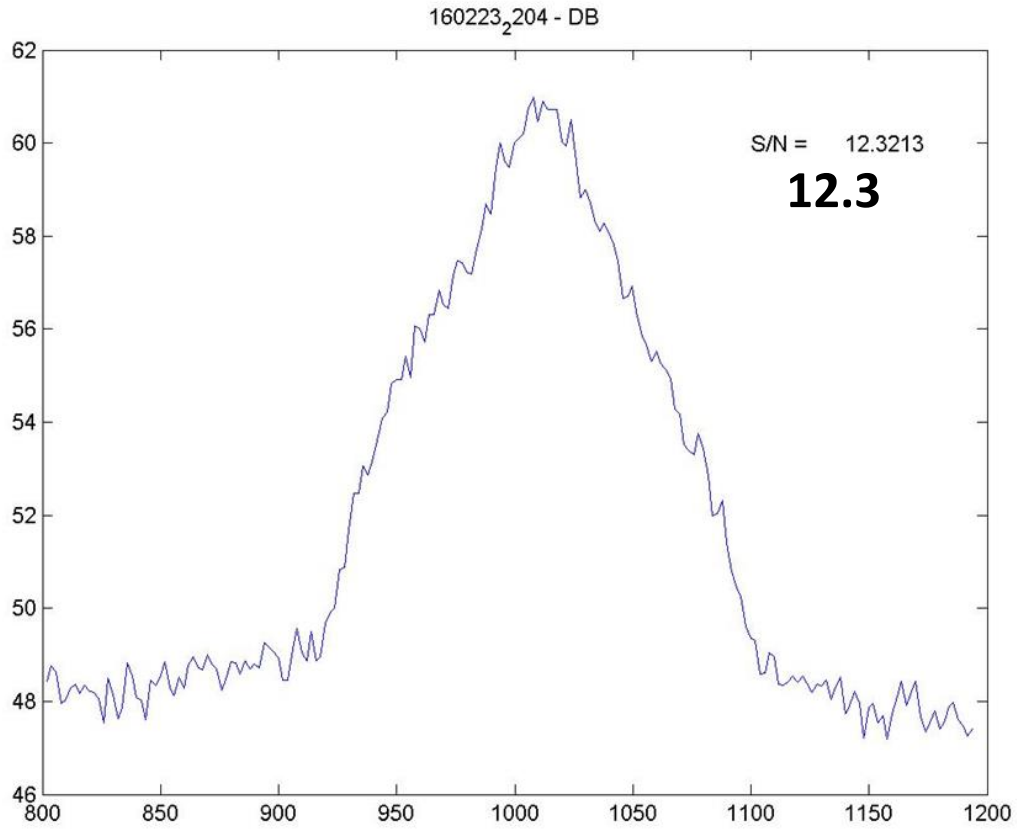


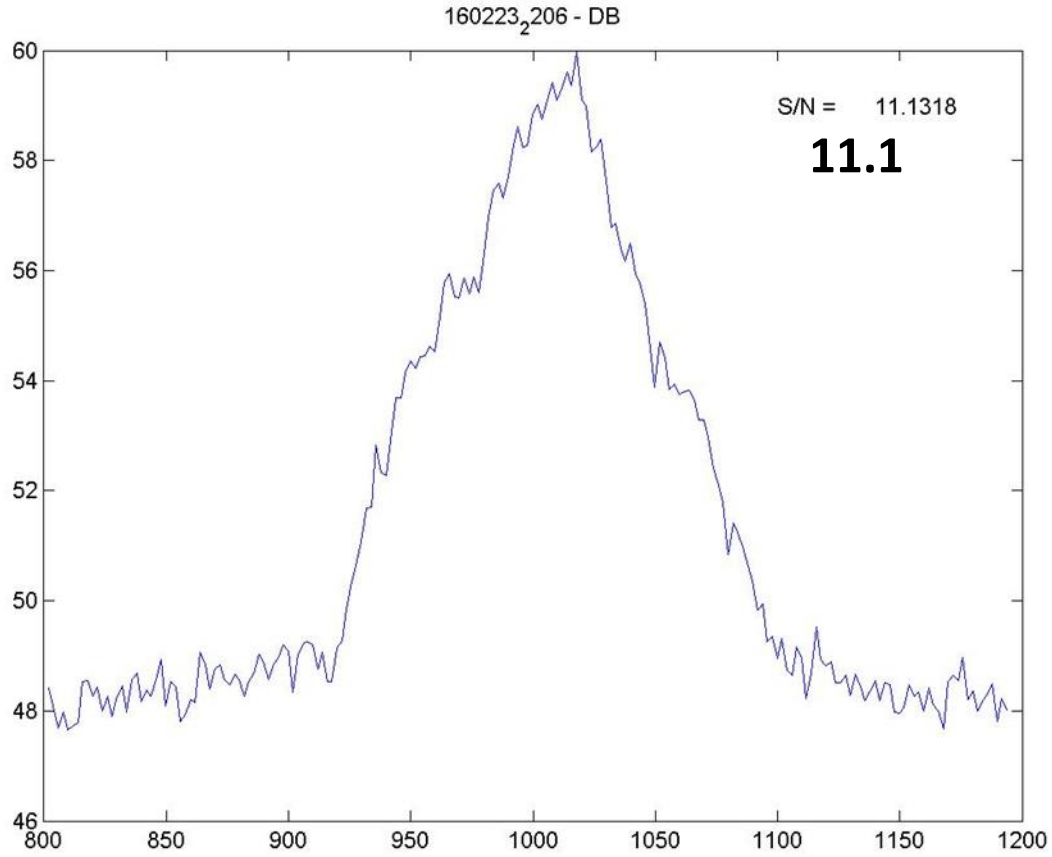
CP LP

16 echo sum (log plot)

Archive of many signals with different spreading available!

LX1DB-G3WDG tests – LP to CP (both senses)





Signal on RX port (12.3) ~ signal on TX port (11.1+1)

1dB added to TX port to account for cable loss

CP to CP and CP to LP comparison (with LX1DB)

- CP to CP measures **14.2dB** S/N (slide 10)
- CP to LP measures **12.2dB** S/N

- I expected this to be 3dB, in practice it was 2dB.
- LX1DB confirmed similar results from tests he has done in the past

Note: LX1DB's LP and CP feedhorns also have same aperture and choke arrangements

Depolarisation prediction (from OM6AA, ref 4)

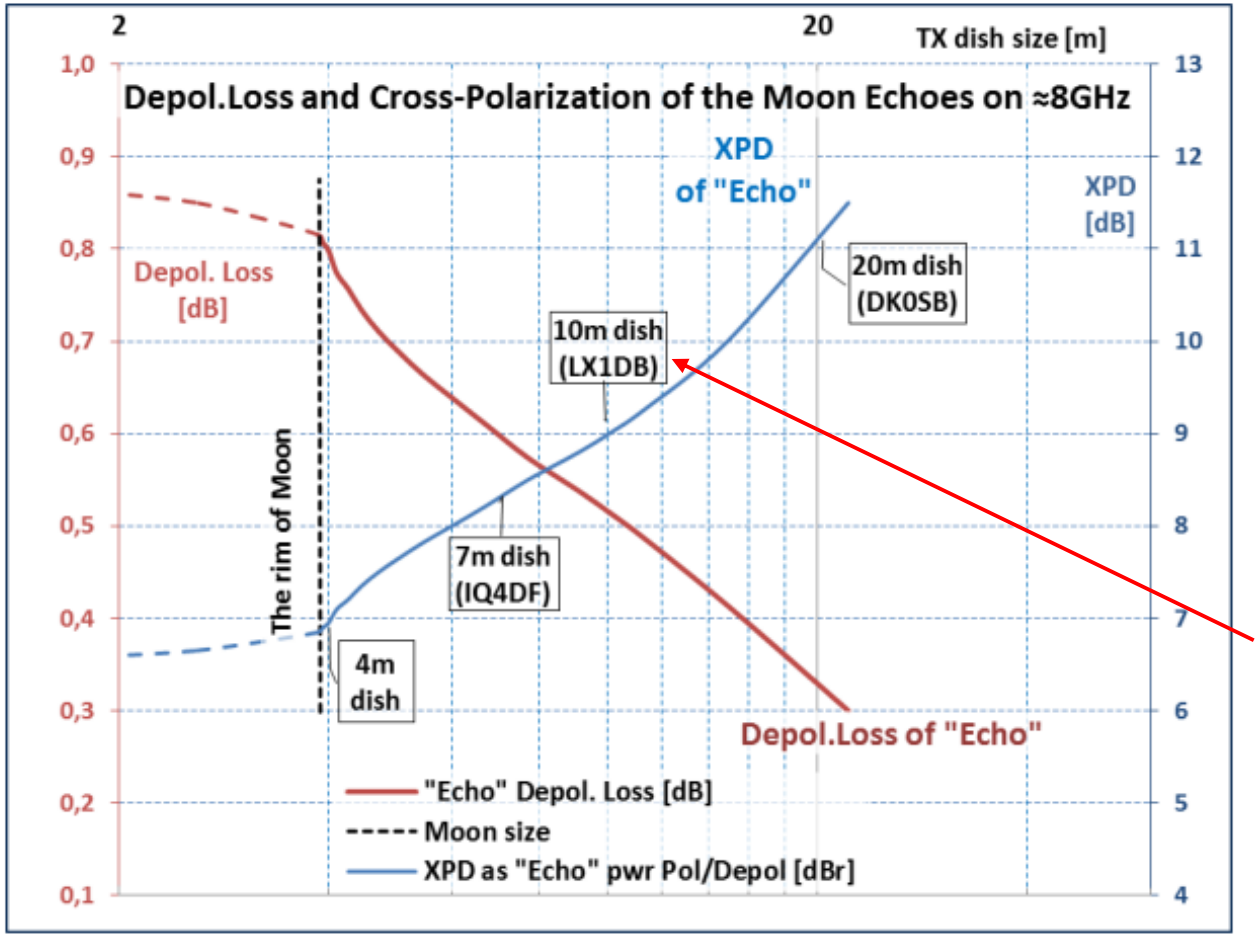


Fig.8 – Estimate of Cross-Polarization Discrimination (*XPD*) and polarization loss of the lunar echoes on the 3.8 cm band as a function of the transmitting antenna dish diameter. The beam shape was approximated by a Gaussian distribution function.

To better quantify the problem, the Cross-Polarization Discrimination Term, *XPD*, is introduced and defined as:

$$XPD = 20 \log \left| \frac{E_{cross}}{E_{co}} \right| \qquad [1]$$

Where: *Ecross* is the Electric Field Cross-Polarization Component Phasor
Eco is the Electric Field Co-Polarization Component Phasor
XPD is expressed in positive decibels

This is incorrect – LX1DB uses a 3m dish

Note that *XPD* for dishes with diameter below 4 meters can be expected to be about 6.5dB.

Discussion

- CP depolarization (ref OM6AA paper with Vlada's comments about XPD of about 6.5dB) , and how this could cost 0.8-0.9dB. With LP, depolarization is about 10-11dB.

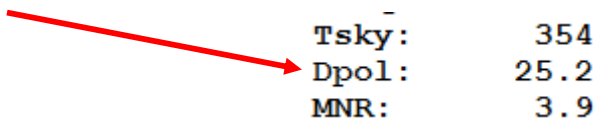
- Maybe CP also depolarizes to linear components as well to explain 2dB loss not 3dB LP to CP, and ~0.5dB poorer performance on CP to CP compared to LP to LP than might be expected from the 6.5dB XPD on CP
- Some depolarization possible also from the dishes?

Conclusions

- CP to CP performs worse than LP to LP by approx. 1.6dB
- CP to LP has 2dB loss
- No observed difference in spectral width between CP and LP
- CP is of course useful to overcome spatial loss in some cases
- For ultimate performance LP to LP with allowance for spatial offset is best

It is expected that stations interested in working small-dish “tropo sized” stations will continue to use LP, preferably rotatable.

For contests and activity days CP has an advantage.

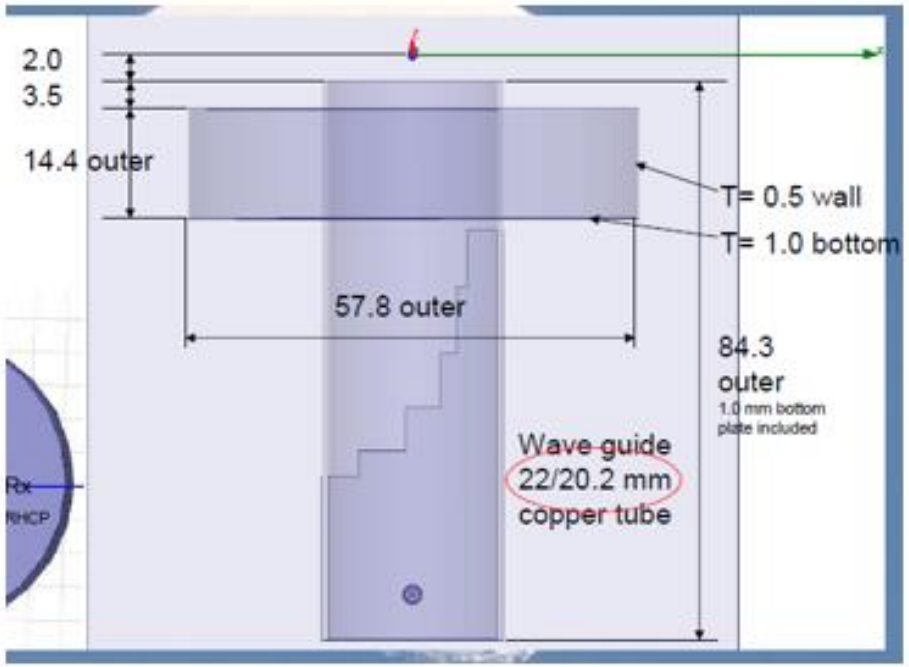


Thank you for your attention!

Backup material

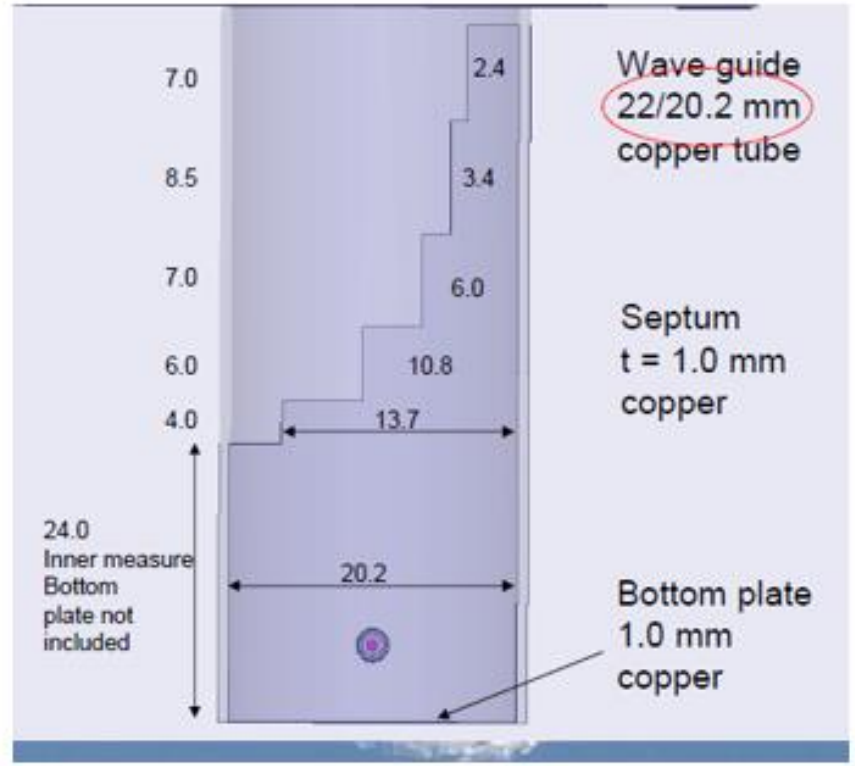
- Feedhorn design
- Building feedhorn
- ‘Echo’ features
- Determining S/N
- Adding echoes improves accuracy
- Validating Echo accuracy
- Origin of 0.3dB

The feed 22/20.2

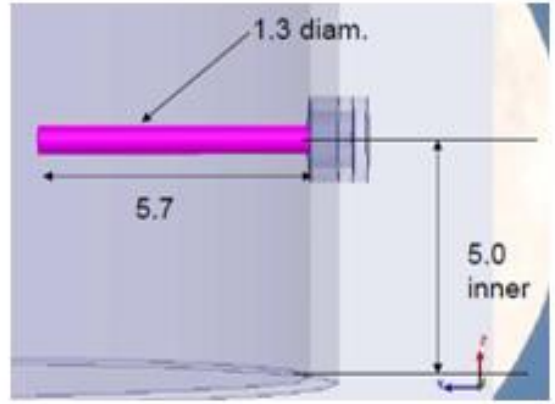


Rim 14.4 x sot

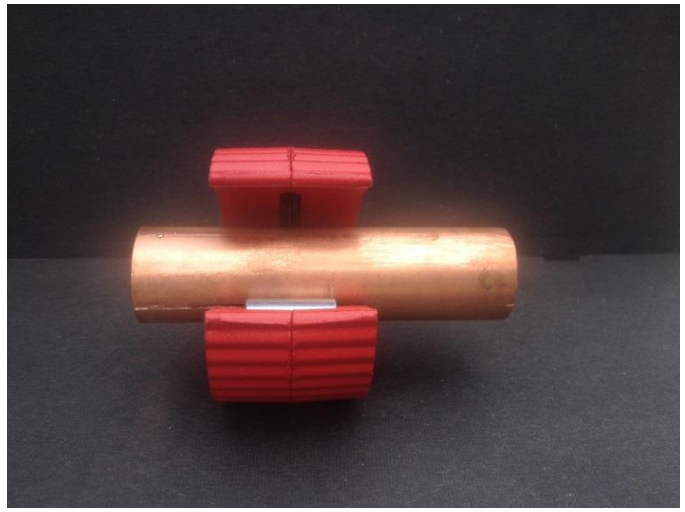
0
7
15.5
22.5
28.5
32.5
56.5

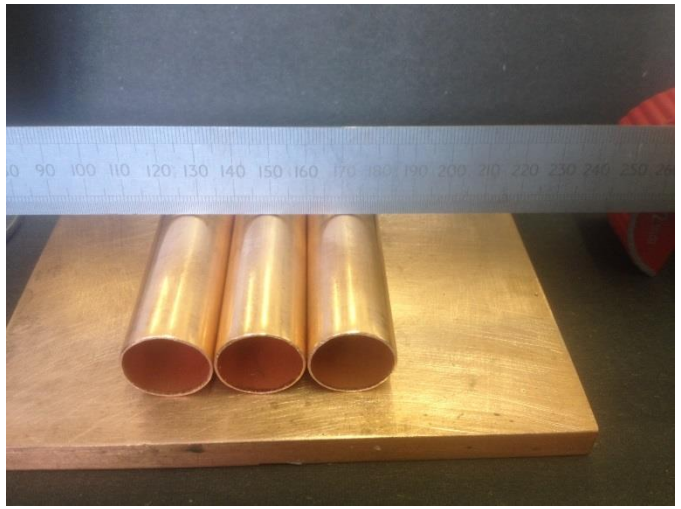


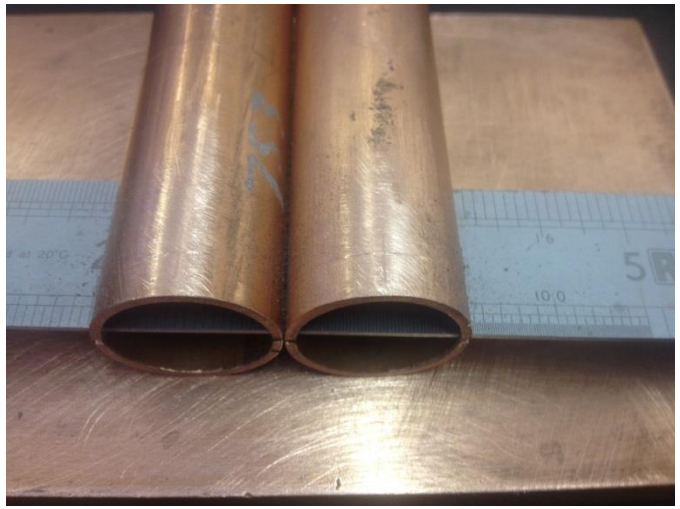
3.0
4.0
6.6
11.4
14.3
21.4

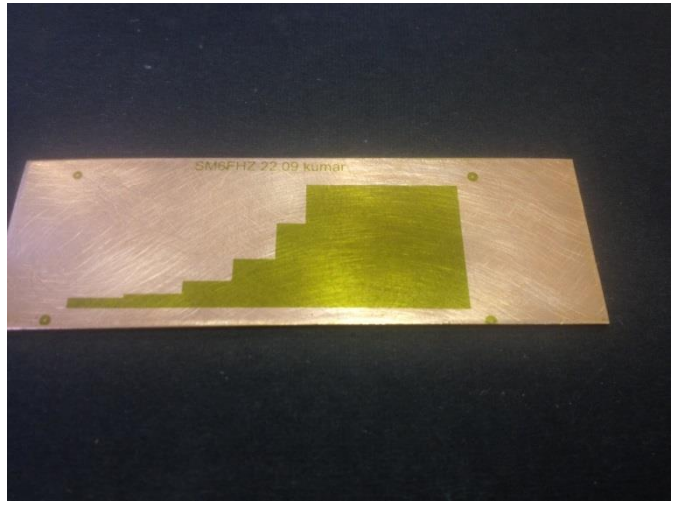


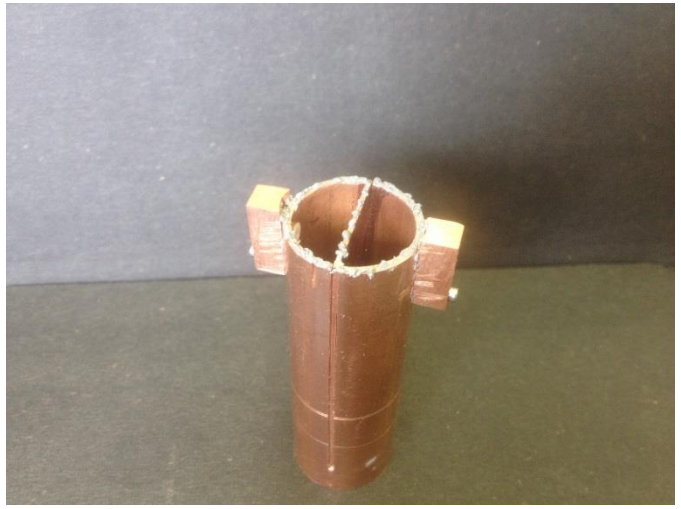
Building the feedhorn (Refs 2 and 6)







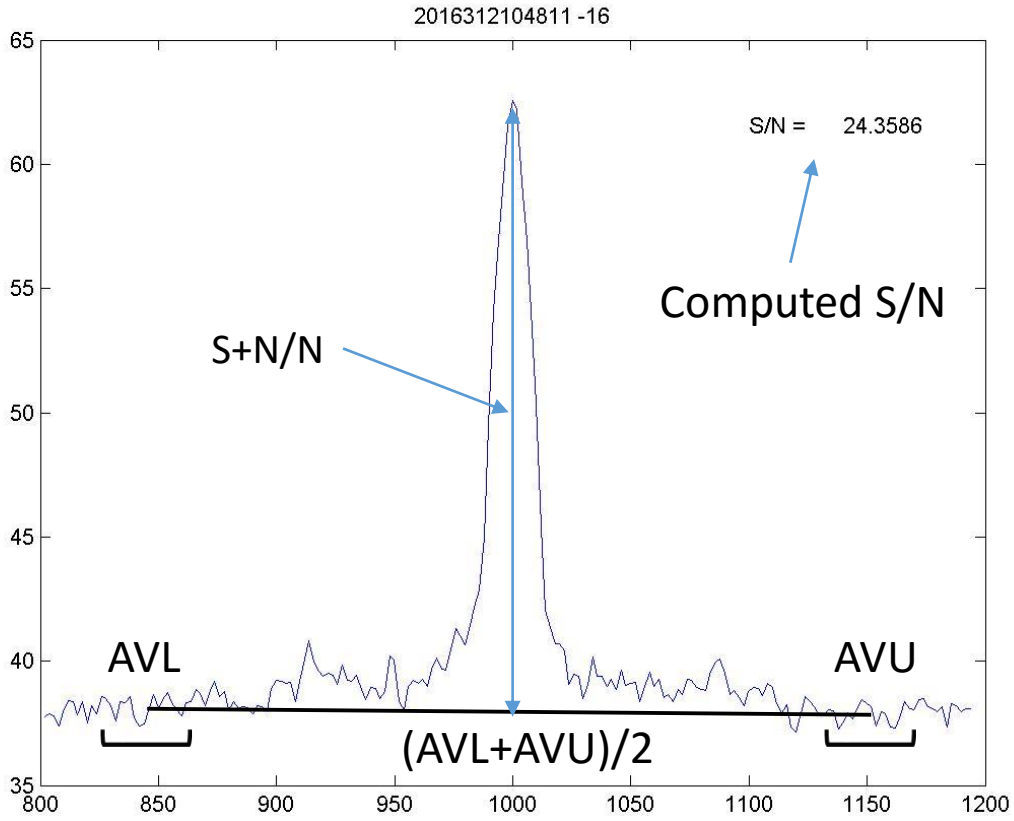




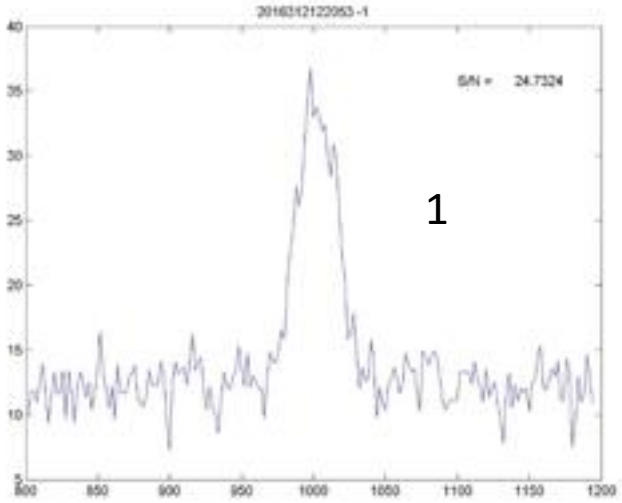
‘Echo’ features

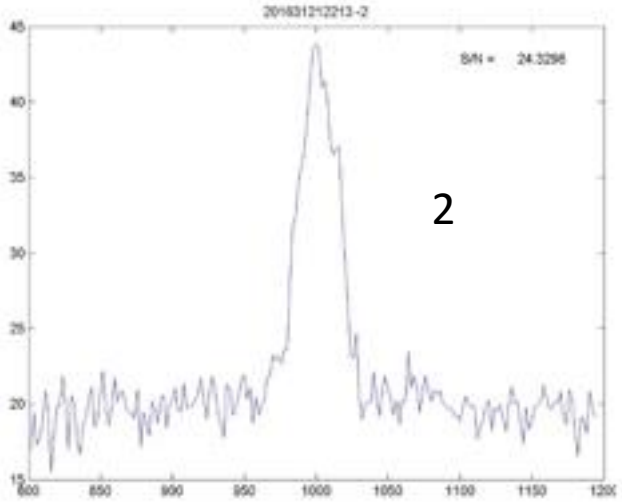
- PTT T/R switching using COM Port RTS line
- Sinewave generator as audio source to rig
- Takes audio from RX, records for 3s, truncates to 2.5s and then performs FFT (sliding method with 50% overlap)
- Plots linear spectrum of every echo and cumulative log “average” on screen
- User entry settings window for sample rate, smoothing, tone freq, COM port and audio output level (units 0 to 1), and number of FFT points
- Automatic saving of jpegs for every echo, and cumulative average
- Automatic saving of wave files for every echo (length=2.5 sec, SR=12000Hz)
- File dialogue box to select output folder
- Stop button
- Selection of linear or log average plot (Echo2)
- S/N corrected calculation displayed on cum log plot

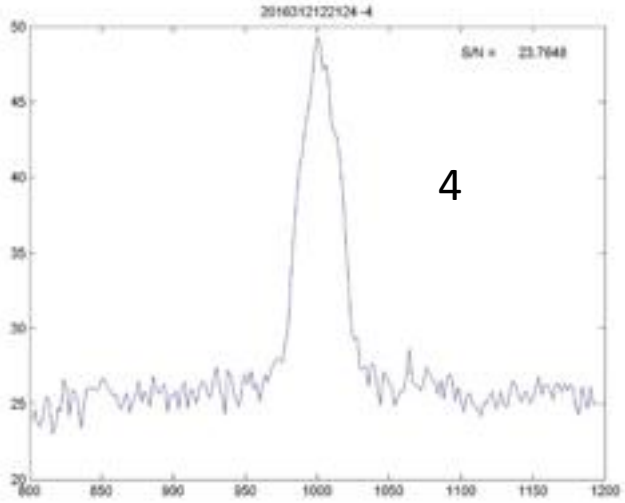
Determining S/N

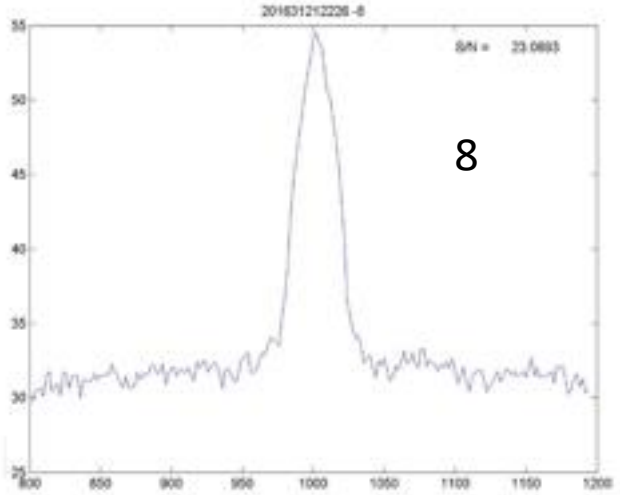


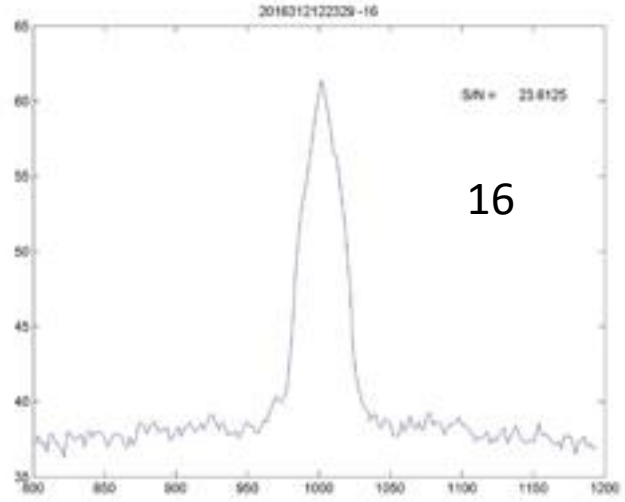
Summing echoes improves accuracy

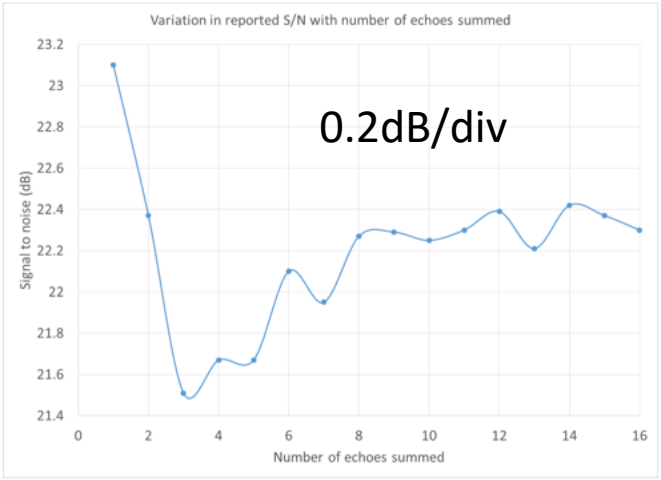




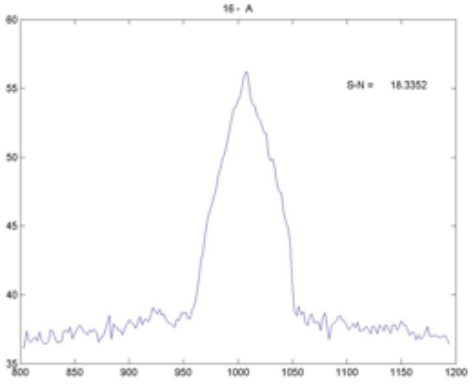


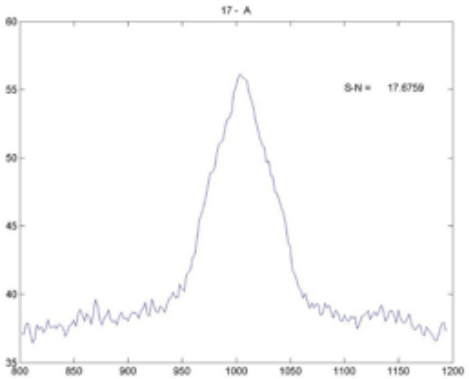


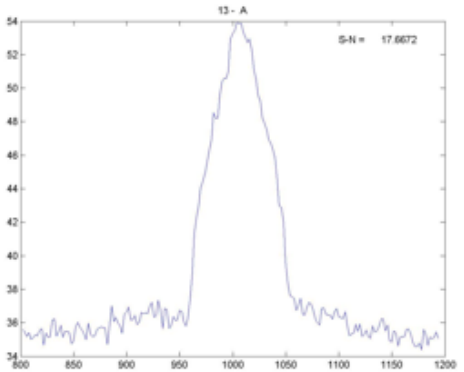




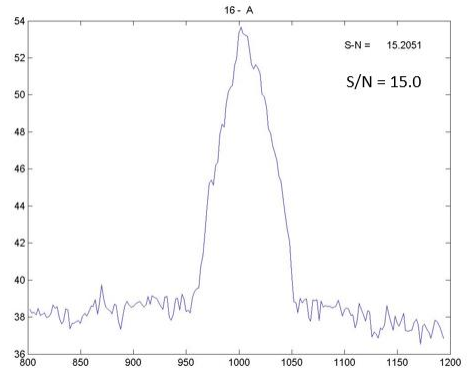
Validation of ‘Echo’ relative S/N measurements





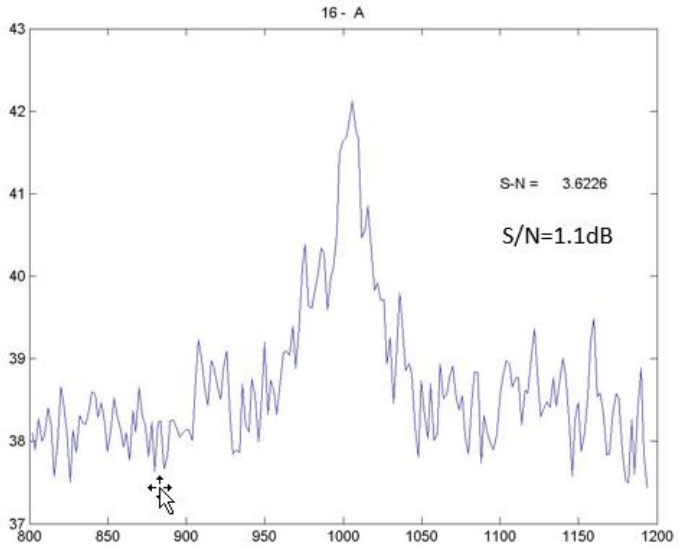


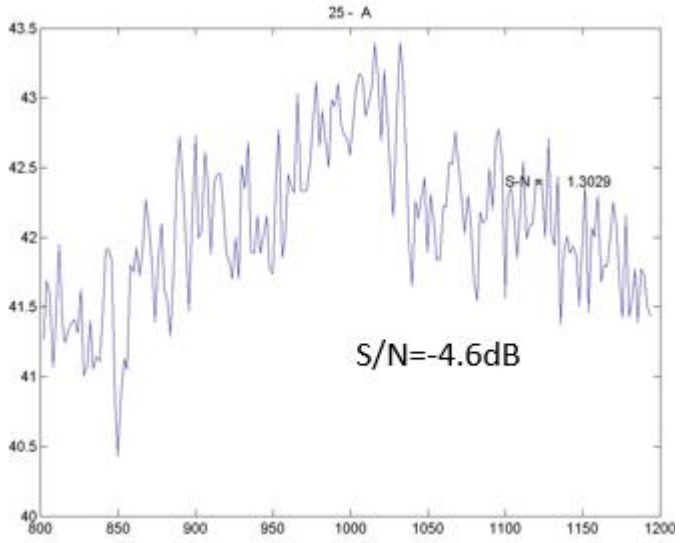
3 sets of 16 echoes at 100W: 0dB

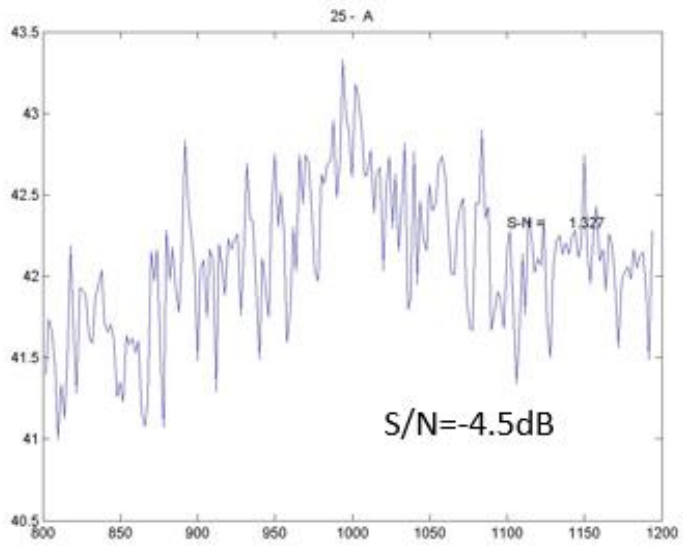


1 set of 16 at 50W : -2.8dB [-3dB]

Average = (18.3+17.7+17.7)/3 = 17.9dB [17.8dB S/N}







1 set of 16 at 2W : -16.7dB [-17dB]

2 sets of 25 at 0.5W: -22.3dB [-23dB]

Self Echo tests to compare LP to LP and CP to CP

LP version of SM6FHZ's 0.692 wl feed constructed to (hopefully) have same illumination pattern as the CP feed and hence same dish efficiency.

LP system has 0.7dB loss on TX compared to CP

CP system has 0.4dB lower RX sensitivity compared to LP

CP system should be 0.3dB better