Review of WTMicrowave* WT-A9940-Q08 *Chinese Hydrogen Cavity Filter covering hydrogen band.

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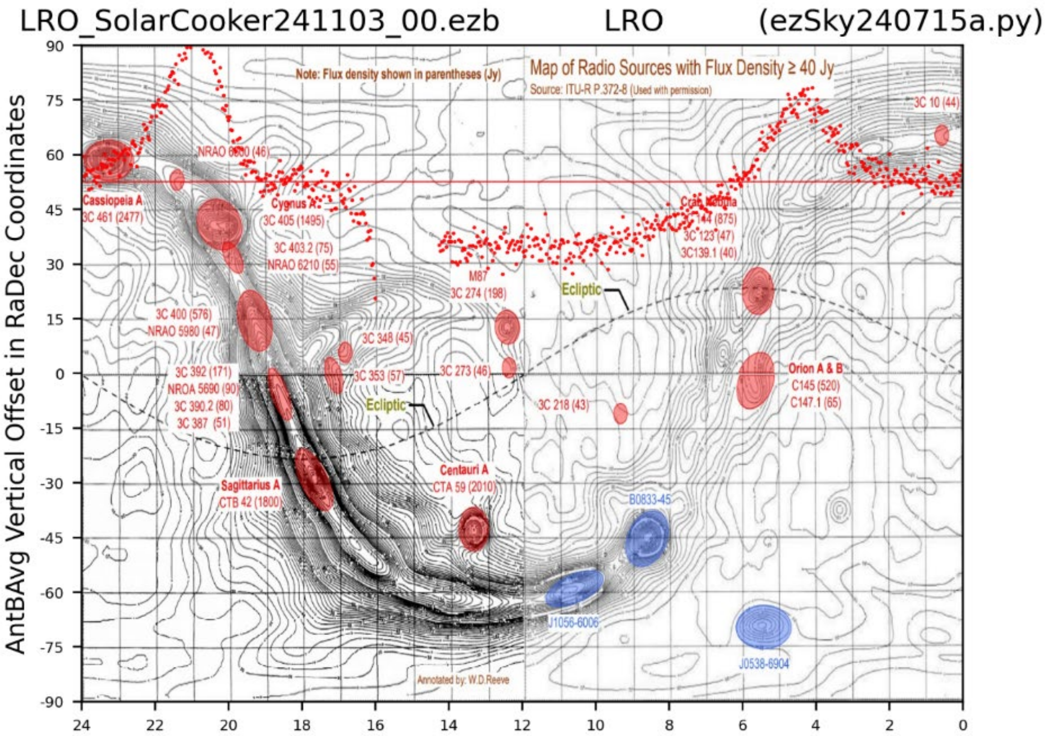
Filtering hydrogen signal.

The availability of cheap and effective antennae/dishes and software defined radios (SDRs) has made it much more practical to create and run an effective (and oftentimes quite large) Milky Way mapping radio experiment in any station with a moderate backyard and access to an external power socket. SARA has created a well put together and described project called "Scope in the Box" to encourage first year undergraduates and other people with an interest in astronomy and physics but not necessarily a higher-level qualification in the area to conduct such mapping for themselves, demonstrate the arms of the Milky Way, measure its mass, and explore the role of dark matter in affecting velocity in different regions of the galaxy. The Milky Way is composed mostly of hydrogen and, therefore, the mapping is best done using the frequency for hydrogen (1420.405MHz). Unfortunately, this area of the electromagnetic spectrum is subject to quite a lot of radio interference in many of the areas in which we live, a situation made worse as more houses are built and more people living in built up areas become interested in taking up radio astronomy as a hobby. It is therefore important to explore methods that effectively filter the signal to isolate this frequency and a small range around it to incorporate Doppler shifted signal.

Many amateur radio astronomers use the Nooelec SAWBird H1 low noise amplifier (LNA) to achieve this filtering (https://www.nooelec.com/store/sdr/sdr-addons/sawbird.html), available for $44.95 at the time of writing of this article on amazon.com (https://www.amazon.com/Nooelec-SAWbird-H1-Applications-Frequency/dp/B07XPV9RX2). The SAW filter in this device provides significant attenuation at +/- 30 MHz either side of 1420 MHz This current paper looks at an alternative filter using a different design that provides an attenuation over a narrower frequency range, promising to improve signal to noise ratio and give clearer hydrogen signals and improved detail in the maps produced in systems using it.

SAWBird H1 LNA Dongle (below).

Data collection on a hydrogen-line radio telescope (1420MHz – Easy Radio Astronomy) (below).



A Chinese Cavity Filter for Hydrogen.

A Cavity Filter is a type of radio frequency (RF) filter used in communication systems to filter out noise and select signals at specific frequencies. They are typically composed of one or more hollow metal cavities containing conductor structures (www.temwell.com/en/pages/what-is-cavity-filter).

Cavity Filters operate using resonance. They contain a resonator with a tuning screw (to fine-tune the frequency) inside a conducting box. An RF or microwave resonator is a closed metallic structure (i.e., waveguides with both ends terminated in a short circuit). The resonator oscillates with higher amplitude at a specific set of frequencies, called resonant frequencies. When an RF signal passes through the cavity filter, a resonator acts as a band-pass filter and passes RF signals at specific resonant frequencies while blocking other nearby non-resonant frequencies. The resonant frequency of the cavity resonator depends on its dimension (length, width, height), mode number, dielectric constant (εr), and magnetic permeability (μr) of the material of construction. In a cavity filter, the resonator is fitted with a screw to tune the frequency range which allows to modify the physical length (inner space length) of the resonator as well as its capacitance to the ground, hence tuning the resonant frequency. Cavity filters are used in the MHz/GHz frequency range. They provide high Q-factor (i.e., high-selectivity/sharply attenuates the unwanted signals), low insertion loss, and robust temperature stability when compared to other forms of filters commonly used in amateur radio astronomy. These advantages make cavity filters ideal for use in microwave and millimetre-wave systems, particularly in professional systems, which need filters with high-Q factor, lower insertion loss, and temperature stability. Advantages of cavity filters: (1) High Q-factor (up to the order of 106), low insertion loss, and robust temperature stability. (2) Superior selectivity and good frequency stability. (3) Reduces the transmitter sideband noise and protects receivers against desensitization. (4) Better performance in microwave range (including 1420MHz that we use for hydrogen detection) when compared to other common forms of filter (https://www.everythingrf.com/community/what-are-cavity-filters).

Traditionally, amateur radio astronomers have had to make their own cavity filters if they wished to use one, a labour-intensive exercise requiring some skill and a lot of fiddling and ideally additional expensive equipment to tune the filter accurately. Commercial versions have been very expensive, limiting their use to professional observatories. However, like most areas of technology, new ranges of these devices have become available from China at much more competitive prices, and these new models provide an opportunity to consider these filters for amateur applications.

I obtained an example of the WT-A9940-Q08 cavity filter from WTMicrowave (www.wtmicrowave.com), which is designed to cover 1400-1427 MHz, and gives up to 69 dB attenuation either side of this. This gives a range of -20 MHz to +7 MHz from 1420 MHz, an improvement over the +/-30 MHz of the Nooelec SAWBird H1 LNA.

WTMicrowave WT-A9940-Q08 cavity filter 1400-1427 MHz (below).

This cavity filter has N-type connectors at either end, so adapters are required to use with cables terminated with SMA connectors commonly used in amateur radio astronomy stations where software-defined radios are usually used, or the connector needs to be changed on the cable. Those users who control their systems with an amateur radio transceiver should be able to directly connect to the filter.

Specifications of the WT-A9940-Q08 cavity filter (below):

S/N	Item	Parameters	
1	Center Frequency(F0)	1413.5MHz	
2	Pass Band Frequency	1400 ~ 1427MHz **	
3	Pass Band Insertion Loss	≤1.5dB	
4	Pass Band Ripple	≤0.6dB	
5	Pass Band Return Loss	≥23dB	
6	Stop Band Rejection	≥50dB @ DC ~ 1375MHz	≥50dB @ 1452 ~ 3500MHz
7	Impedance	50 Ohms	
8	Power Handling	200W Max.	
9	Connectors	N-Female	
10	Surface Finish	Painted Black	
11	Temperature Range	-30℃ ~ +70℃	
12	Material	Housing: 6061 Aluminum alloy Cover: LY12 Aluminum alloy Tuning screw: H62 Copper alloy	Resonant column: H59 Copper alloy Connectors: H59 Copper, Plated ternary alloy Other screw: Stainless Steel
13	Dimensions	180*46*25mm	
14	Net weight	0.374 KG	

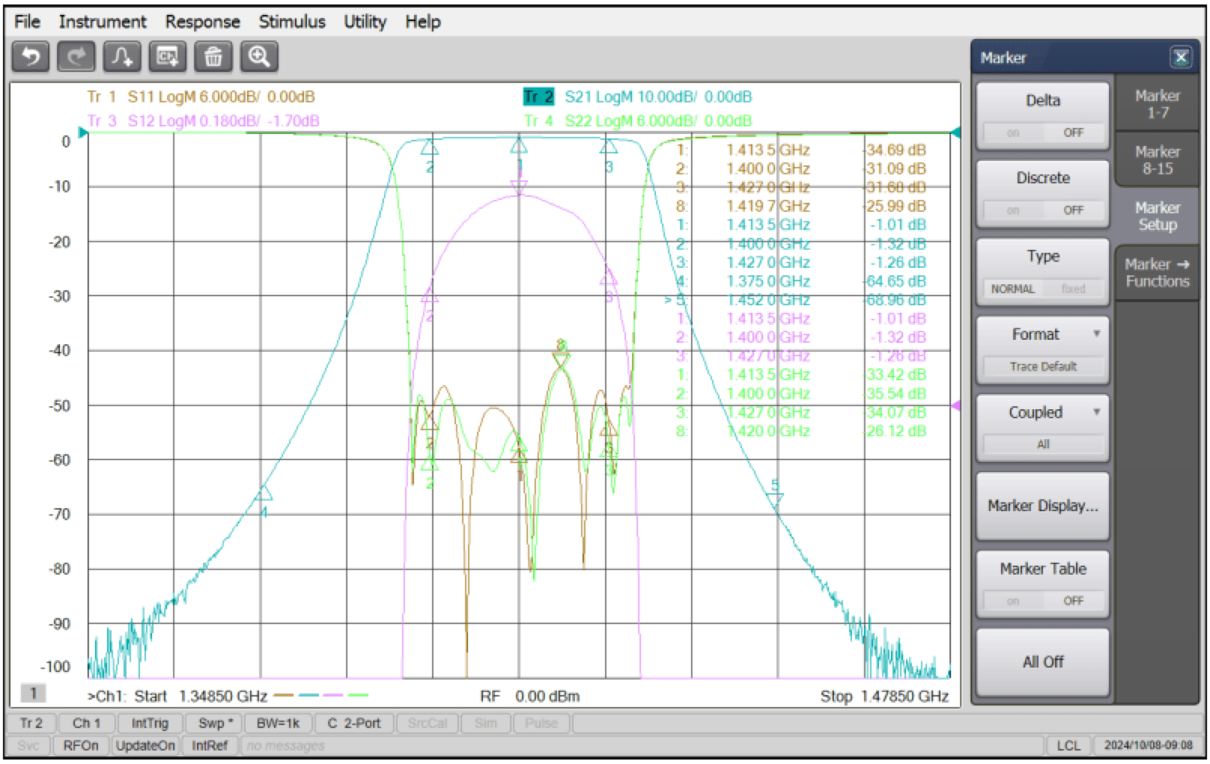
Outline Drawing of the WT-A9940-Q08 Cavity Filter (below, dimensions units: mm, dimension tolerance +/-0.5mm):

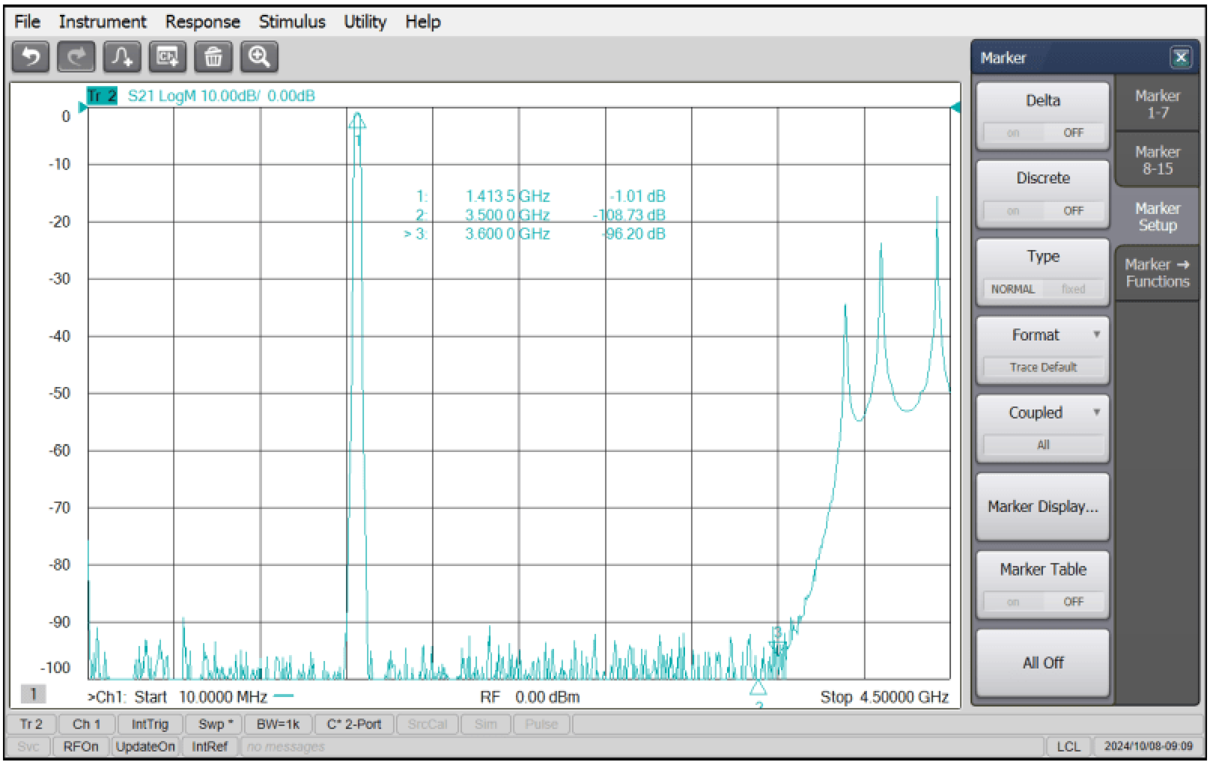
** The actual design bandwidth will be greater than the Pass Band Frequency, and there is no bandwidth limit.

The plots below show test report and curves for an example of these filters that I have been sent by the company (below).

Product Inspection Records

Model	WT-A9940-Q08		Item	Cavity Band Pass Filter		Quantity	3pcs
Test Data							
Appearance	Major Parameter					Other Parameter	
	Pass Band 1400 ~ 1427MHz F0=1413.5MHz			Stop Band		Connectors	Surface Finish
Reference value / S/N	Insertion Loss	Ripple	Return Loss	DC ~ 1375MHz	1452 ~ 3500MHz	N-Female	Painted Black
	<1.5dB	<0.6dB	>23dB	>50dB	>50dB		
1	1.32	0.31	25.9	64	69	N-Female	Painted Black
2	1.29	0.27	27.2	63	69		
3	1.33	0.31	27.1	66	71		
Verdict:	Inspection way：Full inspection				Data recording mode：Full record		
Test Equipment：N5227B	Date：2024-10-08		Tester：Liqiong Yong		Check：Xiaotao Yang		





Report on initial tests with the cavity filter.

I have installed the cavity filter in line before the SAWBird H1 on both of my hydrogen line radio telescopes (LRO-H1 and LRO-H2) at Lichfield Radio Observatory, UK (www.astronomy.me.uk). Effective detection of hydrogen is evident. As yet, I have not had an opportunity to test the systems with and without the filter, and will present this information in a future report.

Further information.

Further information about this project is available on the www.astronomy.me.uk website or by contacting me using the "contact us" page on that website.