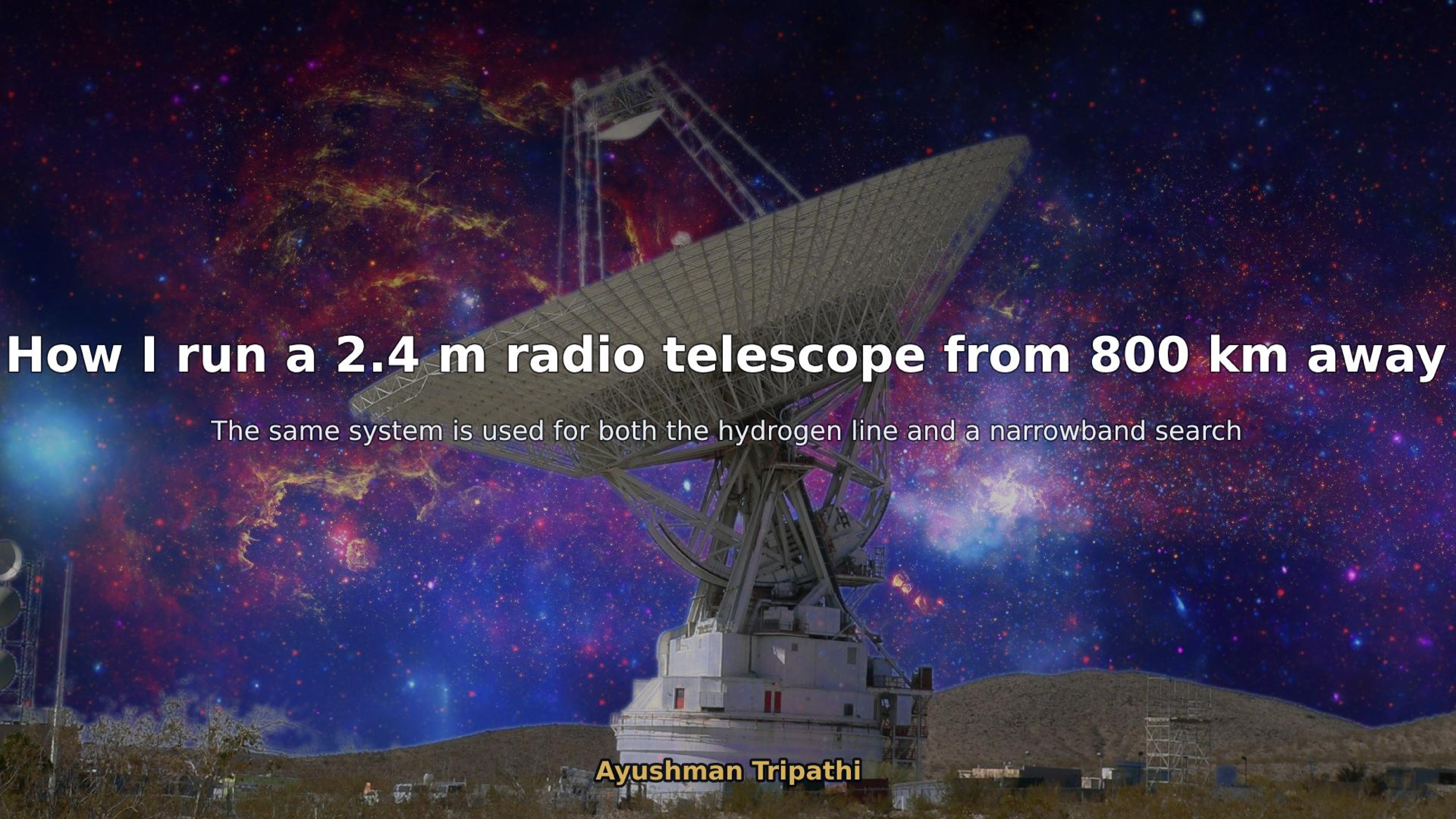


How I run a 2.4 m radio telescope from 800 km away

The same system is used for both the hydrogen line and a narrowband search

Ayushman Tripathi


The radio telescope observes continuously, 24 hours a day.
It has no motor. It is aimed at a fixed direction, and the rotation of the Earth sweeps the sky through its beam, a full circle each day. Astronomers call this a drift scan.
AQUILA

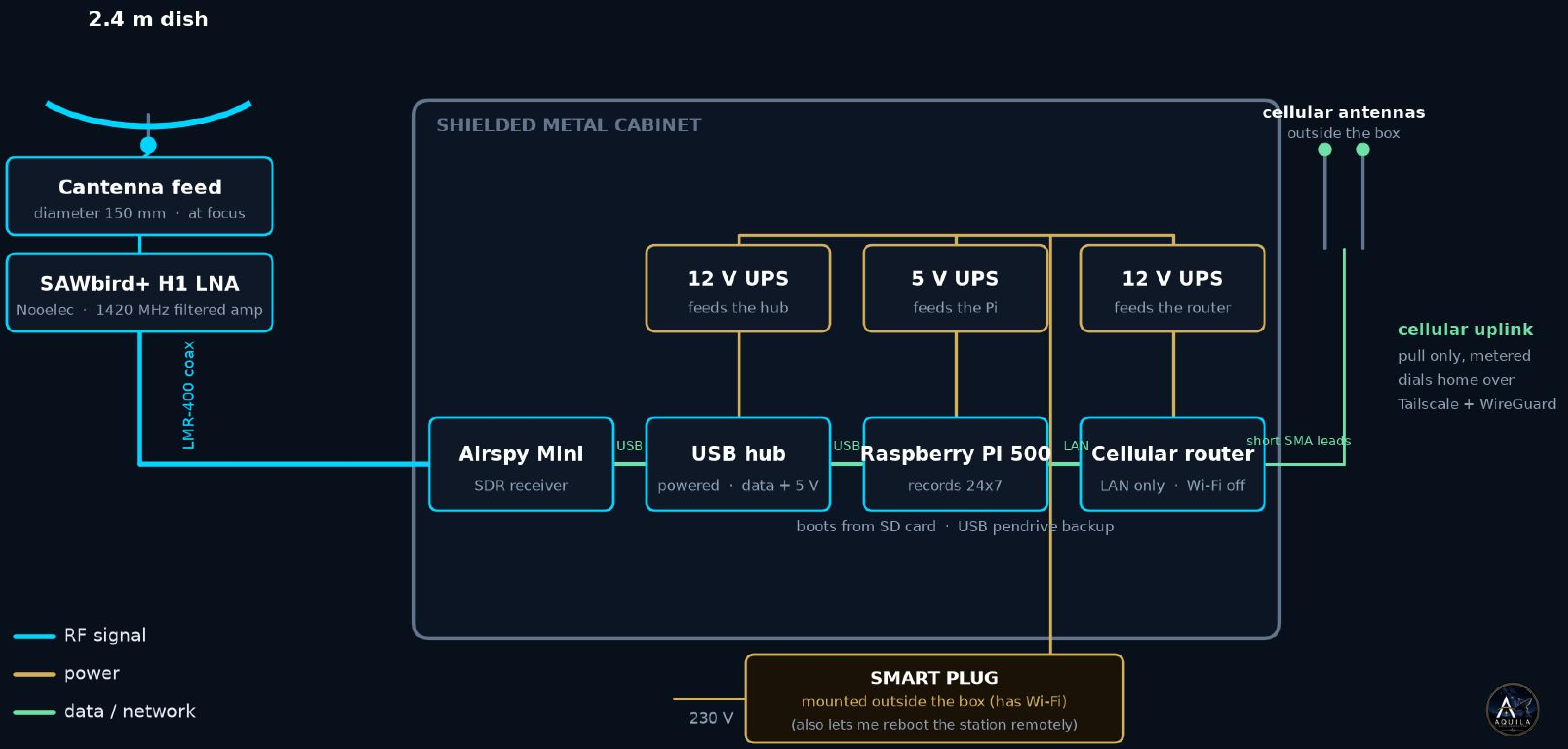
The feed is an aluminium can.

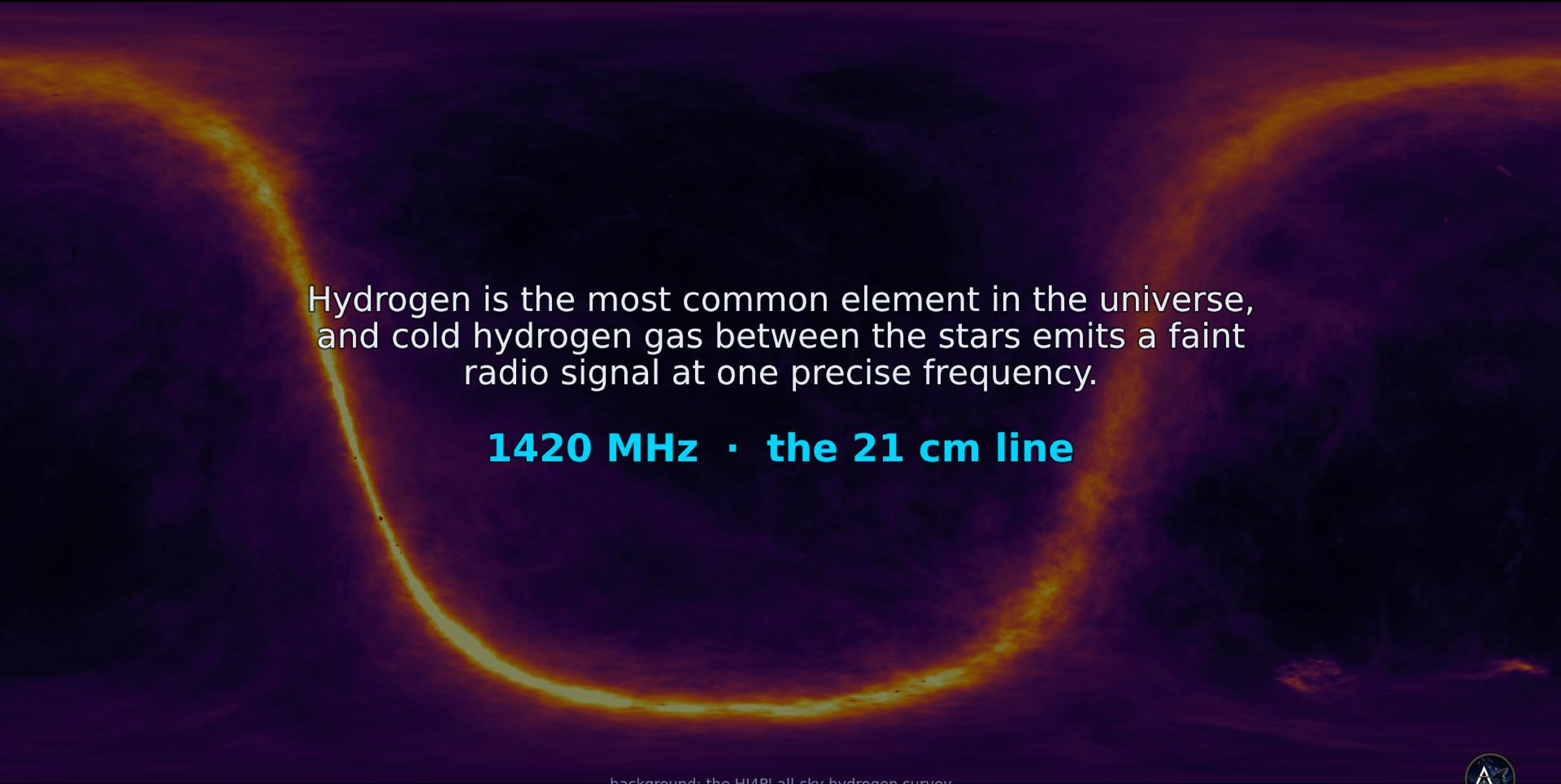
A homemade 150 mm cantenna, tuned on a NanoVNA.

quality inspector: Tom the cat

THE REAL SETUP

how every piece actually connects at a remote, unattended site

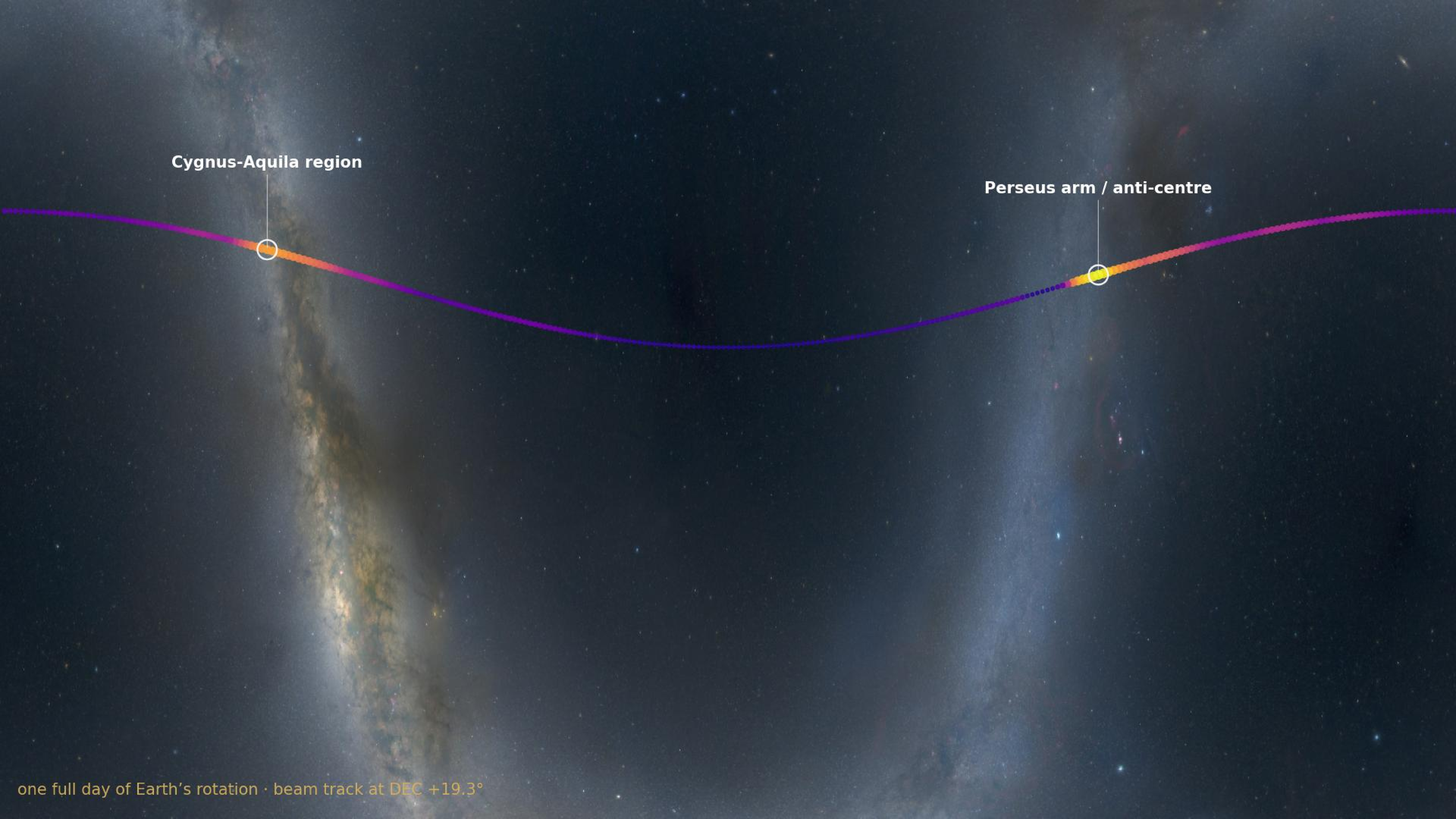




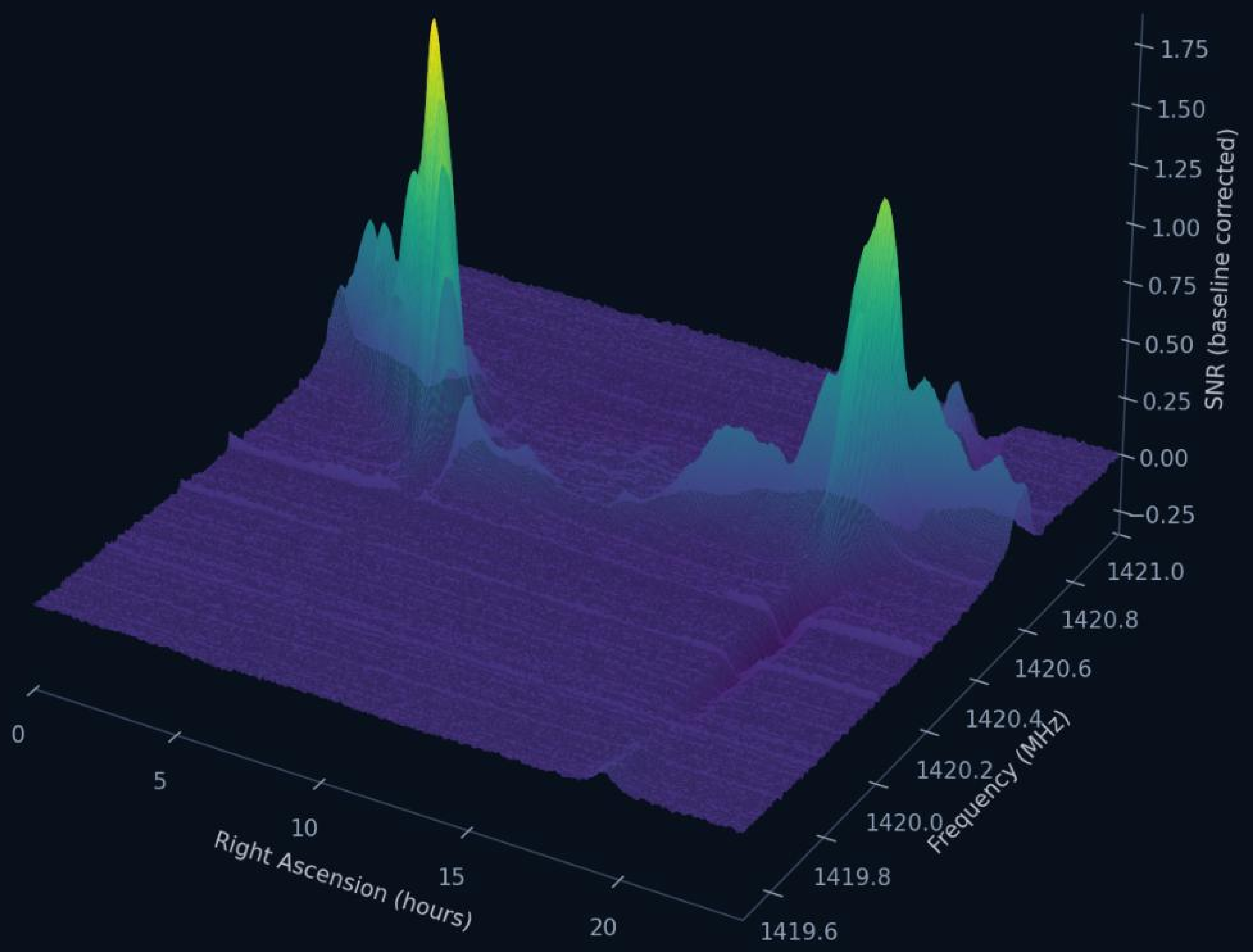
Hydrogen is the most common element in the universe, and cold hydrogen gas between the stars emits a faint radio signal at one precise frequency.

1420 MHz · the 21 cm line

background: the HI4PI all-sky hydrogen survey

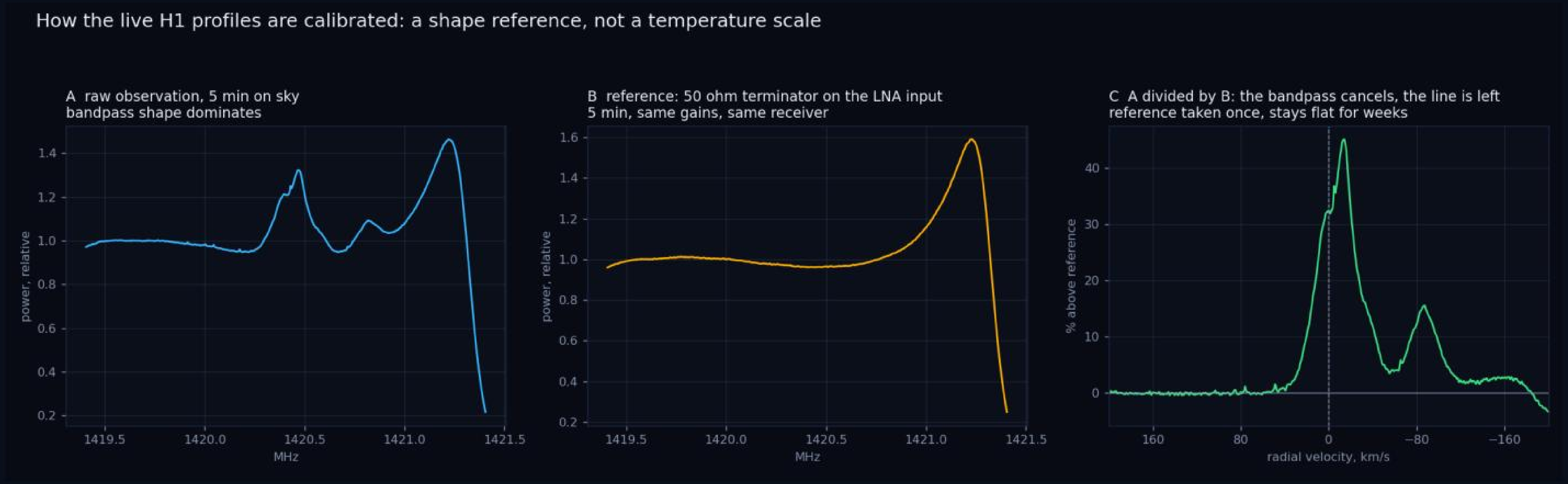

Cygnus-Aquila region
Perseus arm / anti-centre
one full day of Earth’s rotation · beam track at DEC +19.3°

Aquila Radio Observatory - 2.4m Dish - 2026-07-02
DEC: 19.3°



CALIBRATION WITHOUT A THERMOMETER

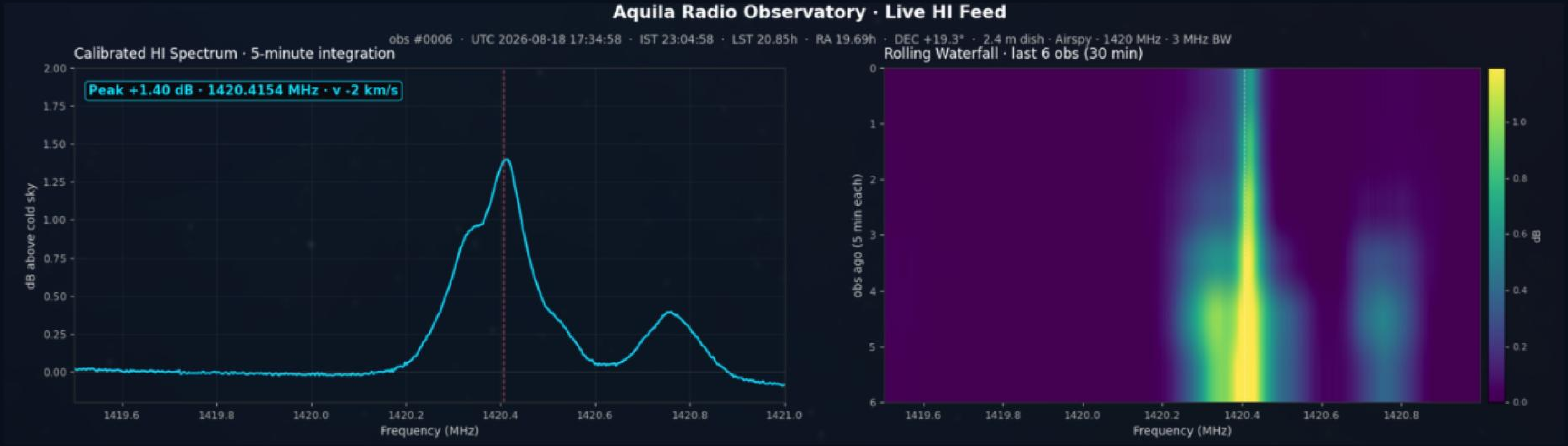
a 50 ohm resistor tells the receiver what flat looks like



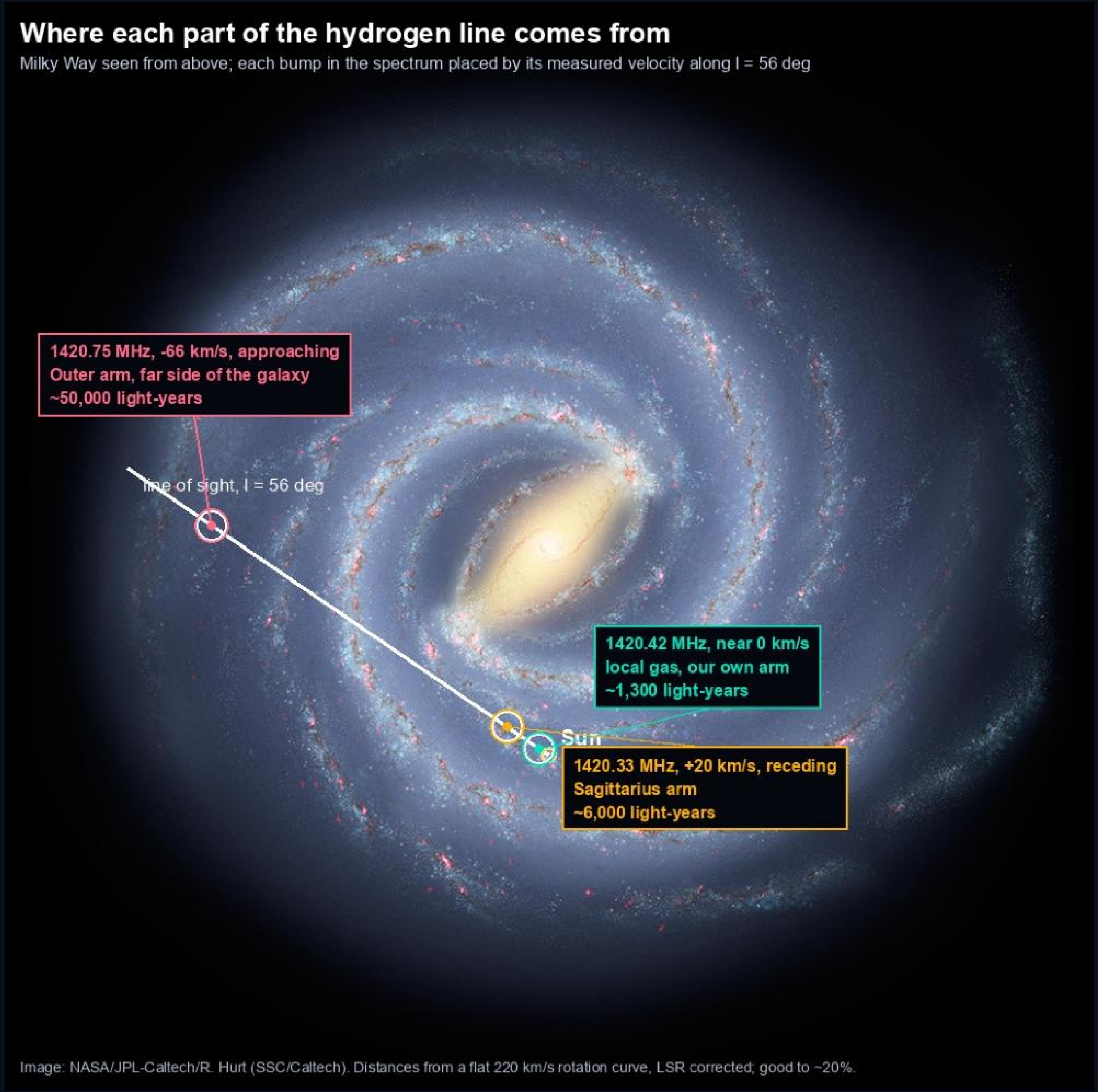
Divide the sky by the resistor and the receiver cancels out. Whatever bump is left came from the sky.

THE SPECTRUM

one evening crossing of the galactic plane



The tall peak is local gas in our own arm. The shoulder on its left is the Sagittarius arm.
The separate bump on the right is the outer arm on the far side of the galaxy.
The next slide shows where each one lives.



ONE SPECTRUM, THREE DISTANCES

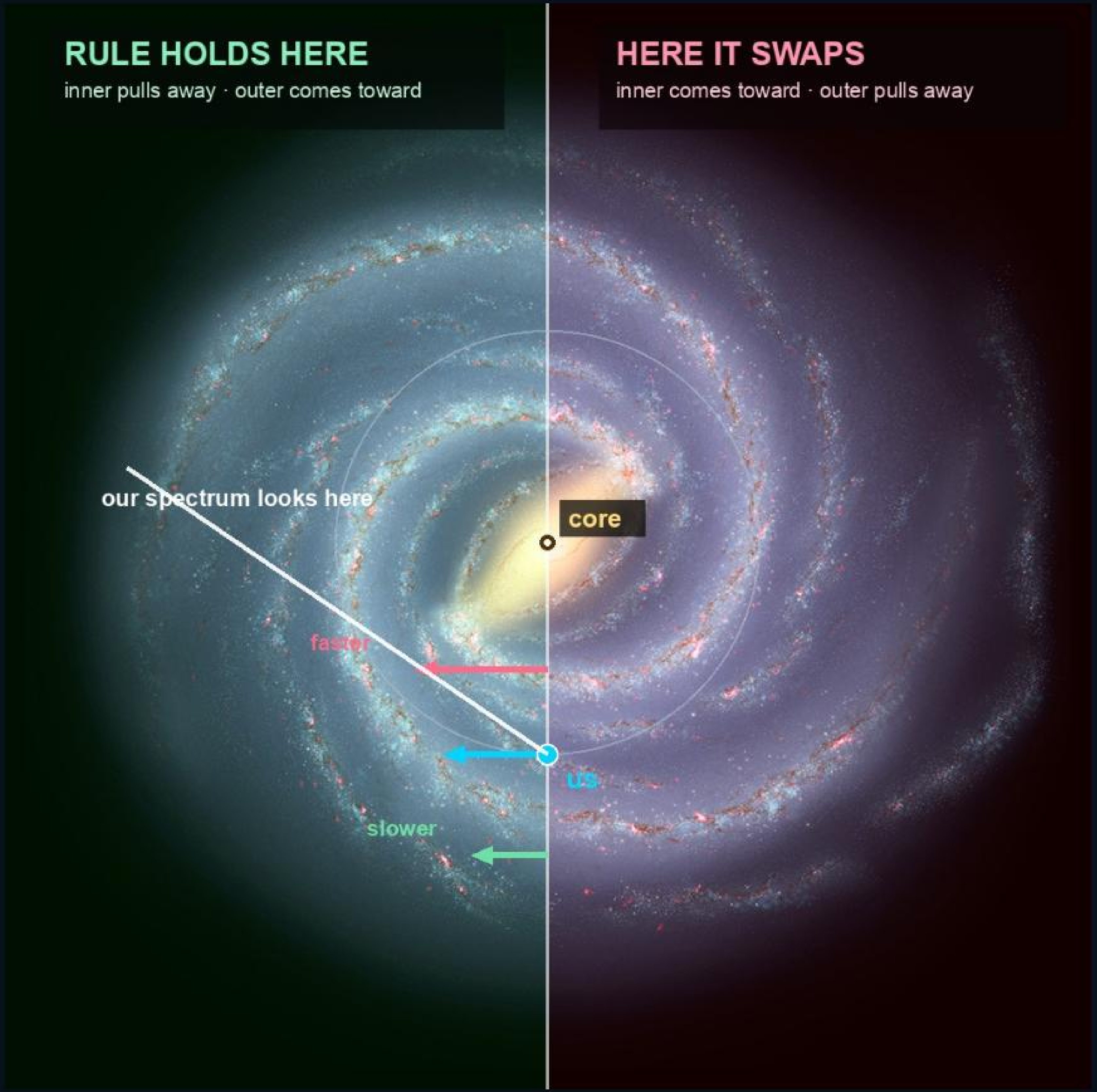
The galaxy spins, so each arm moves at its own speed toward or away from us.

That speed shifts the line, up to a few hundred kHz. Measure it and each bump becomes a place.

The farthest gas here is 50,000 light years away, seen with a TV dish.

A RULE TO REMEMBER

inner is always faster; what you see depends on where you look



Closer to the core means a faster orbit.

Gas inside our circle moves faster than us.
It runs away from us. Its line shifts to lower
frequency, like the bump at 1420.33.

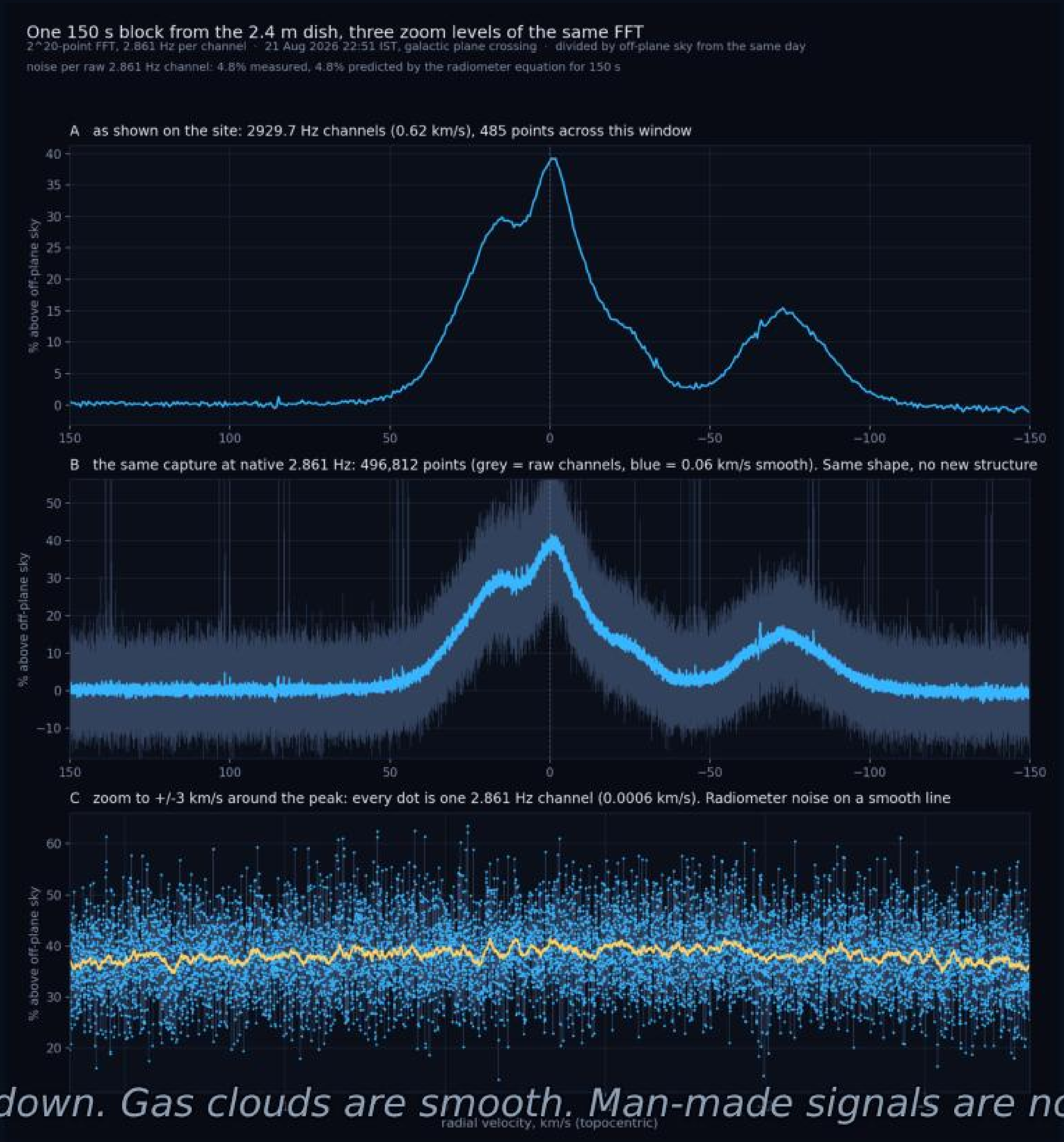
Gas outside our circle moves slower.
We catch up to it. It comes toward us. Its line
shifts to higher frequency, like 1420.75.

That is the green half, where our spectrum
looks. In the pink half it is reversed. Why?

Think of a faster car in the inner lane.
Ahead of you it pulls away. Behind you the
same car is catching up, coming toward you.
Same car, same speed, different side.
That is all the pink half is.

ZOOMING IN: 2.9 Hz PER CHANNEL

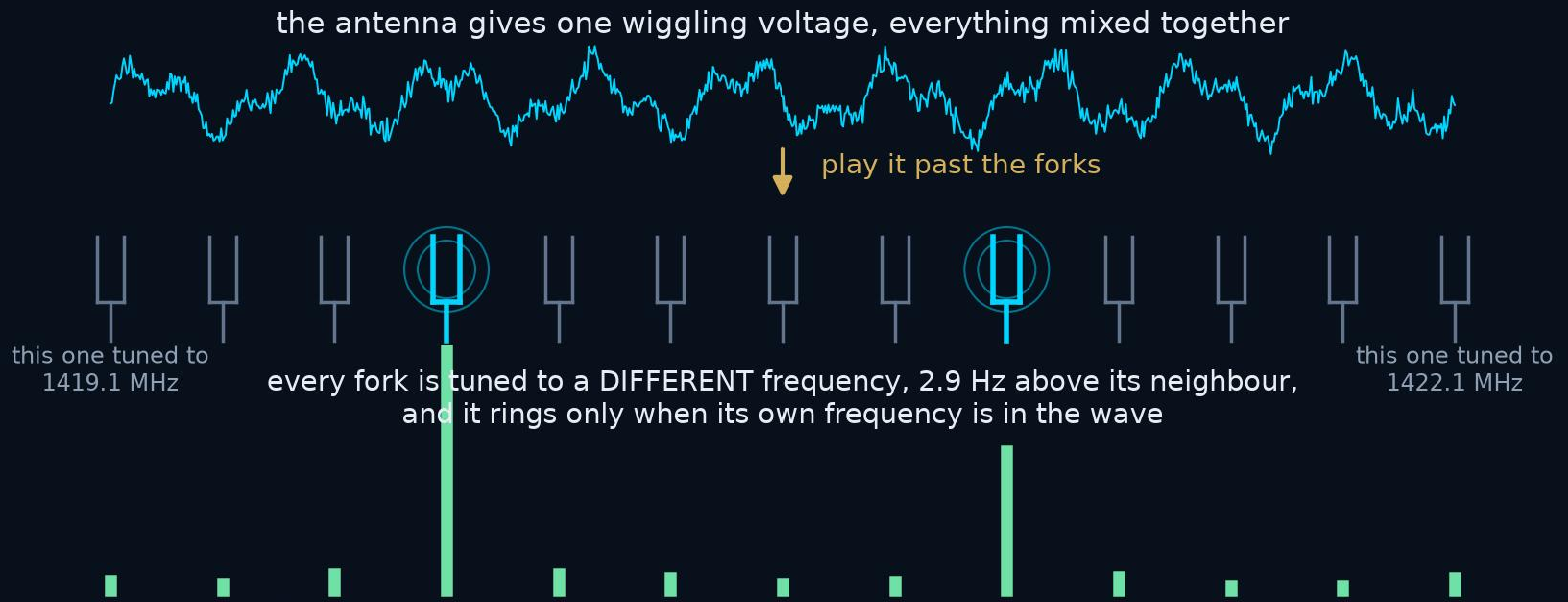
the same line through a million channels



The line stays smooth all the way down. Gas clouds are smooth. Man-made signals are not. That difference is the whole SETI idea.

WHAT THE FFT REALLY IS

a row of a million tuning forks



how hard each fork rings, written side by side, IS the spectrum. One fork = one channel.

A tone is just a frequency. A fork only asks: is my frequency in this wave, and how strongly?
Your ear does the same with sound, that is how one orchestra reaches you as separate notes.
The FFT size in SDR software, 512 or 1024 or 4096, is simply how many forks you use.
Double the forks and each one gets twice as picky, but it must listen twice as long.
My setting is FFT 1048576: a million forks, each 2.9 Hz picky, a third of a second of listening.

AQUILA RADIO OBSERVATORY

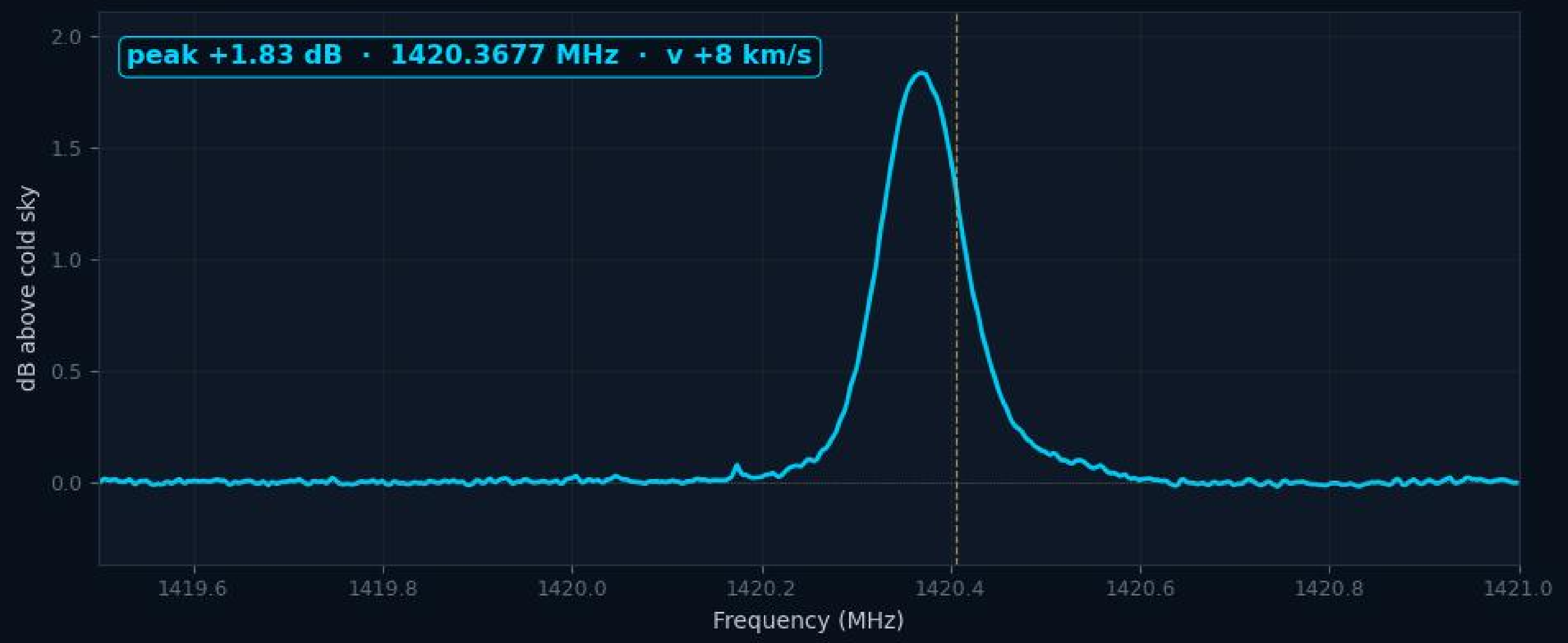
Daily HI Drift Scan · 2.4 m dish · Airspy · 21 cm

02 Jul 2026

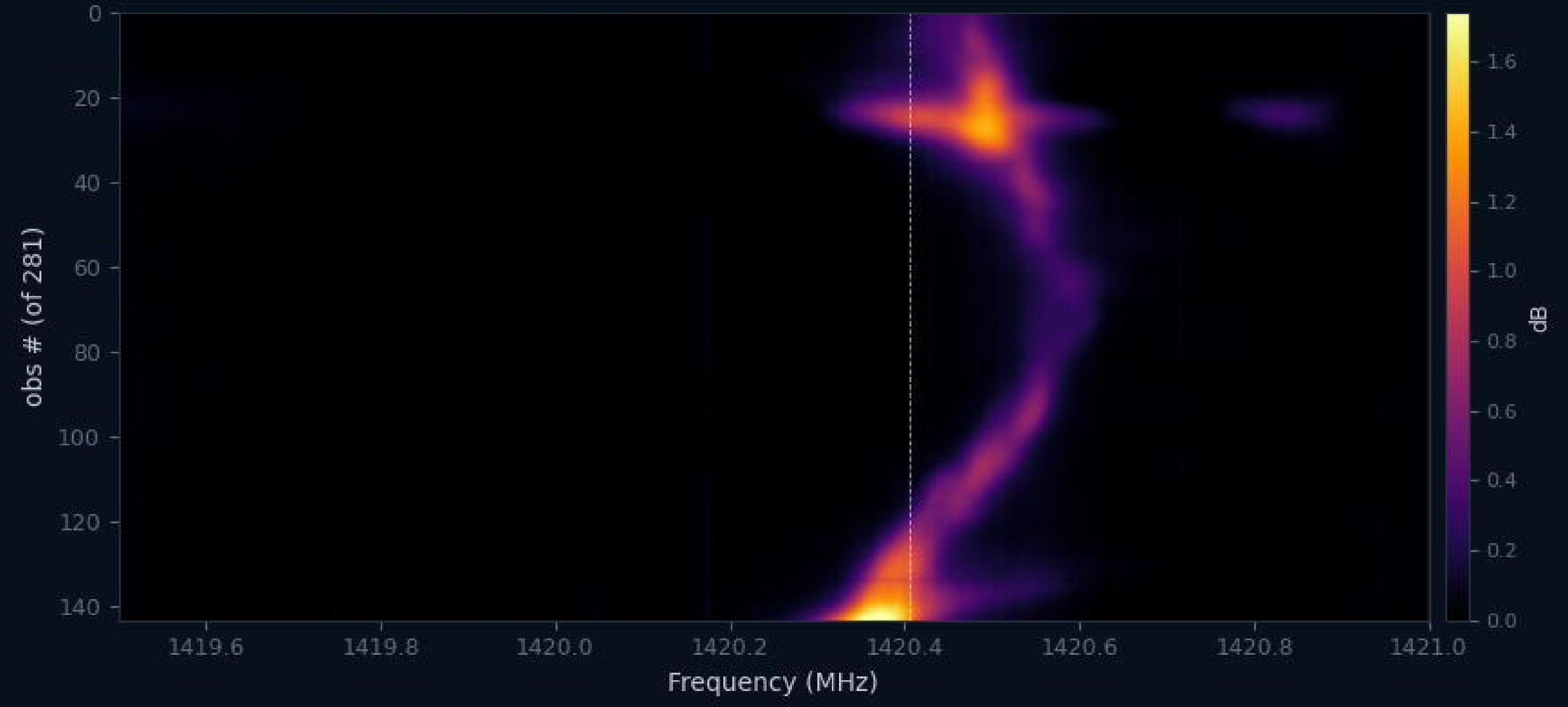
UT 06:41:05 · IST 12:11 · EST 01:41 · LST 6.83h

obs 143 / 281

Calibrated HI Spectrum



HI Drift · day so far (143 obs · 715 min)



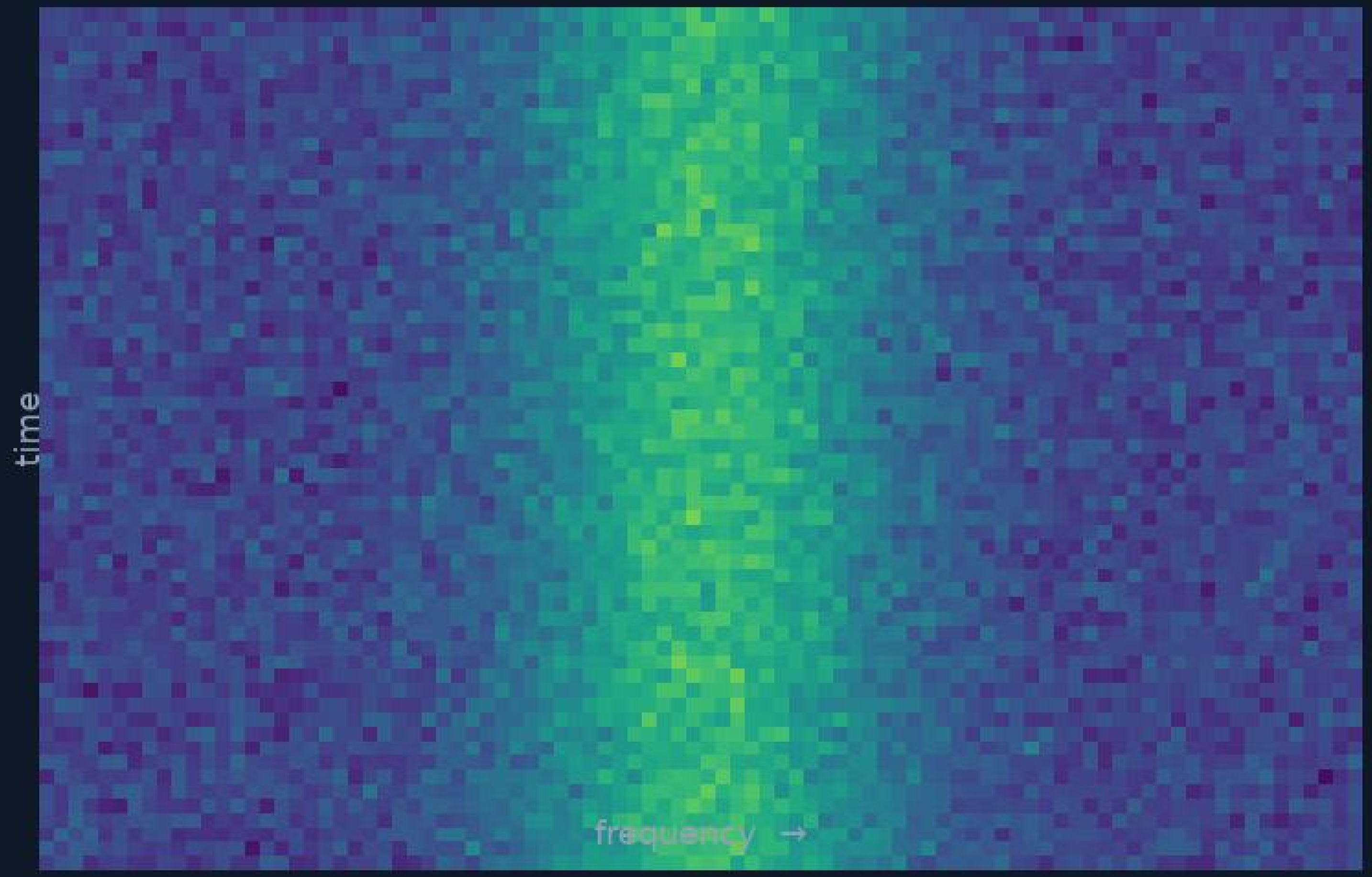
Sky Trace · DEC +19.3° · now at RA 5.64h · day peak +1.83 dB

SAME DATA, DIFFERENT QUESTION

what would a transmitter look like?

HYDROGEN

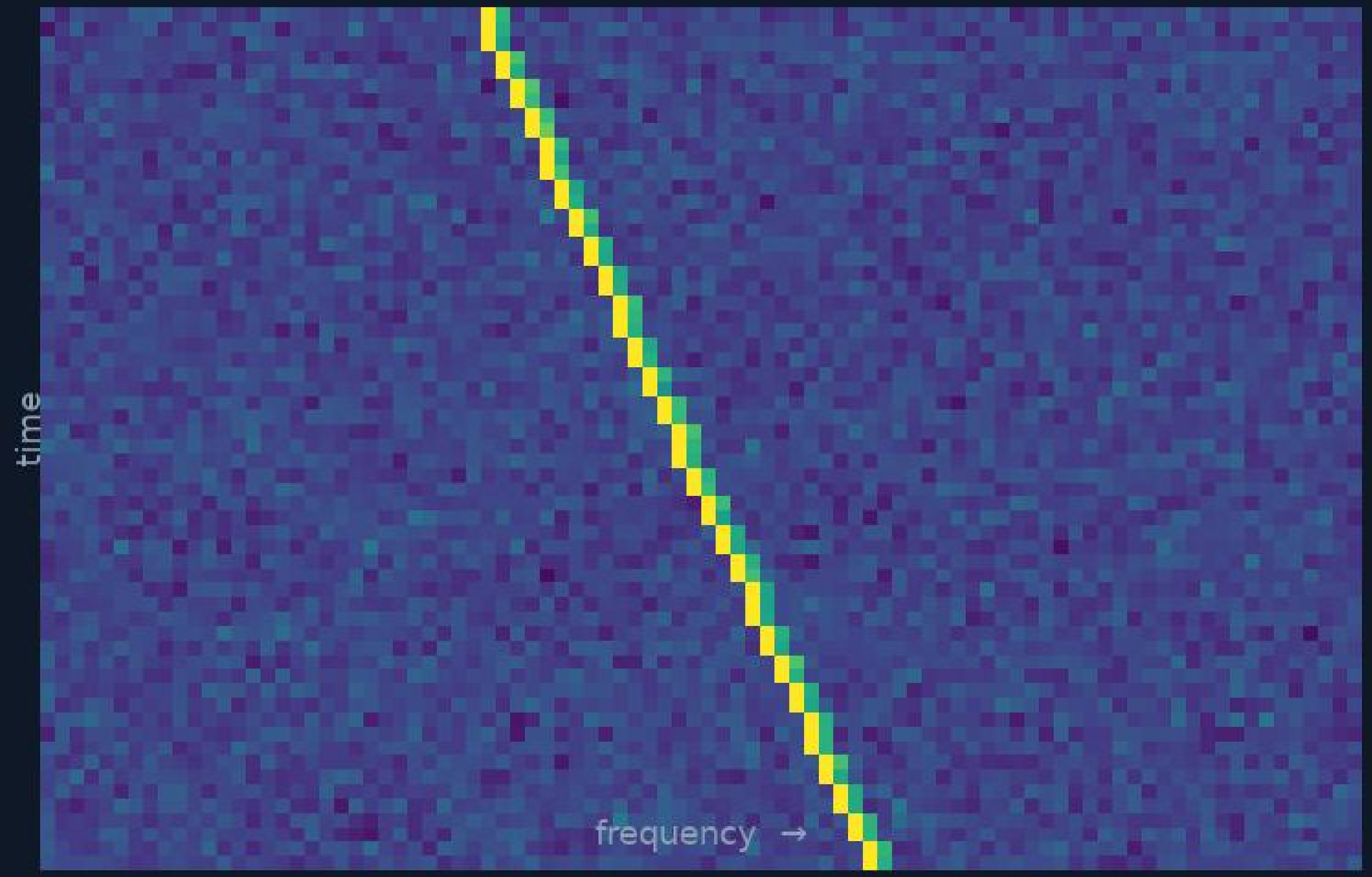
about 100 kHz wide



same place every day
smooth with no structure

A TRANSMITTER

a needle a few Hz wide



slowly drifts as planets spin
nothing natural is this narrow

THE SEARCH

both searches run on the same antenna and the same Pi

LISTEN

the SDR streams the band around 1420.4 MHz

→

SPLIT

one million channels of 2.9 Hz each

→

UN-SPIN THE EARTH

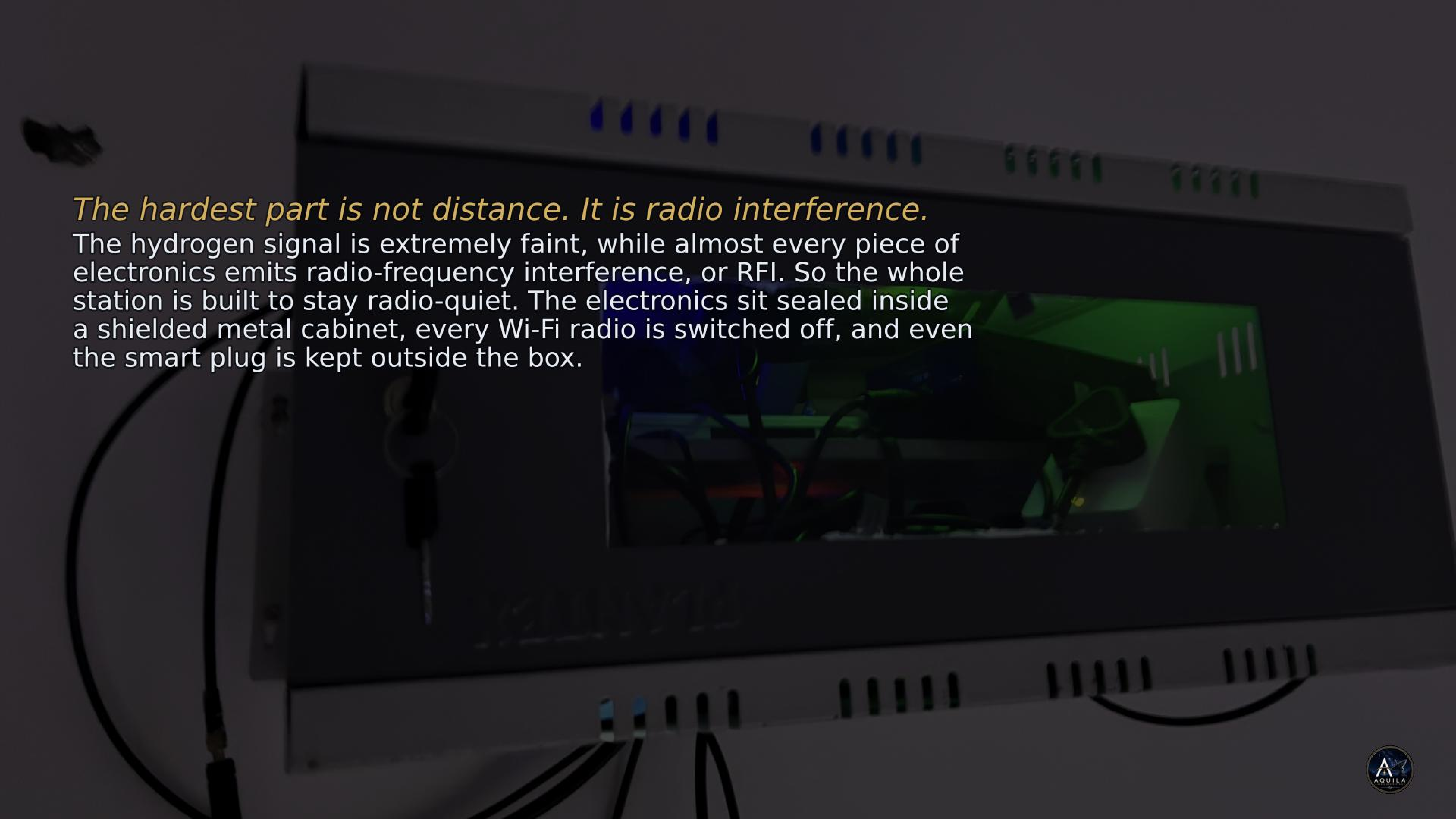
the Earth moves, so every sky signal slides slowly

→

KEEP THE NEEDLES

anything narrow that survives goes on a hit list

Un-spinning means this: the Earth spins and it orbits the Sun. That motion slides every real sky signal in frequency by an amount I can compute exactly. So I slide the data back.
Raw data is never stored. The Pi digests 3 million samples a second down to a short list.
The hydrogen line falls out of the same stream for free.



The hardest part is not distance. It is radio interference.

The hydrogen signal is extremely faint, while almost every piece of electronics emits radio-frequency interference, or RFI. So the whole station is built to stay radio-quiet. The electronics sit sealed inside a shielded metal cabinet, every Wi-Fi radio is switched off, and even the smart plug is kept outside the box.

THE TEXTBOOK FILTER DOES NOT WORK

the drift test, and why it fails

The classic rule says a real signal must drift in frequency and ground RFI must not.
I ran the rule on interference I had PROVEN was local. 97 percent of it passed.

Why does it fail? The rule assumes a ground transmitter holds a rock-steady frequency. Real electronics does not. Cheap oscillators wander as they warm and cool, so local noise drifts exactly like a real sky signal would.

What does work costs nothing:
a real sky signal must rise and fall exactly as the beam sweeps past it
and it must come back 3 minutes 56 seconds earlier every night by star time

No new hardware needed. The Earth does the work and I just wait.

WHAT A HIT MUST SURVIVE

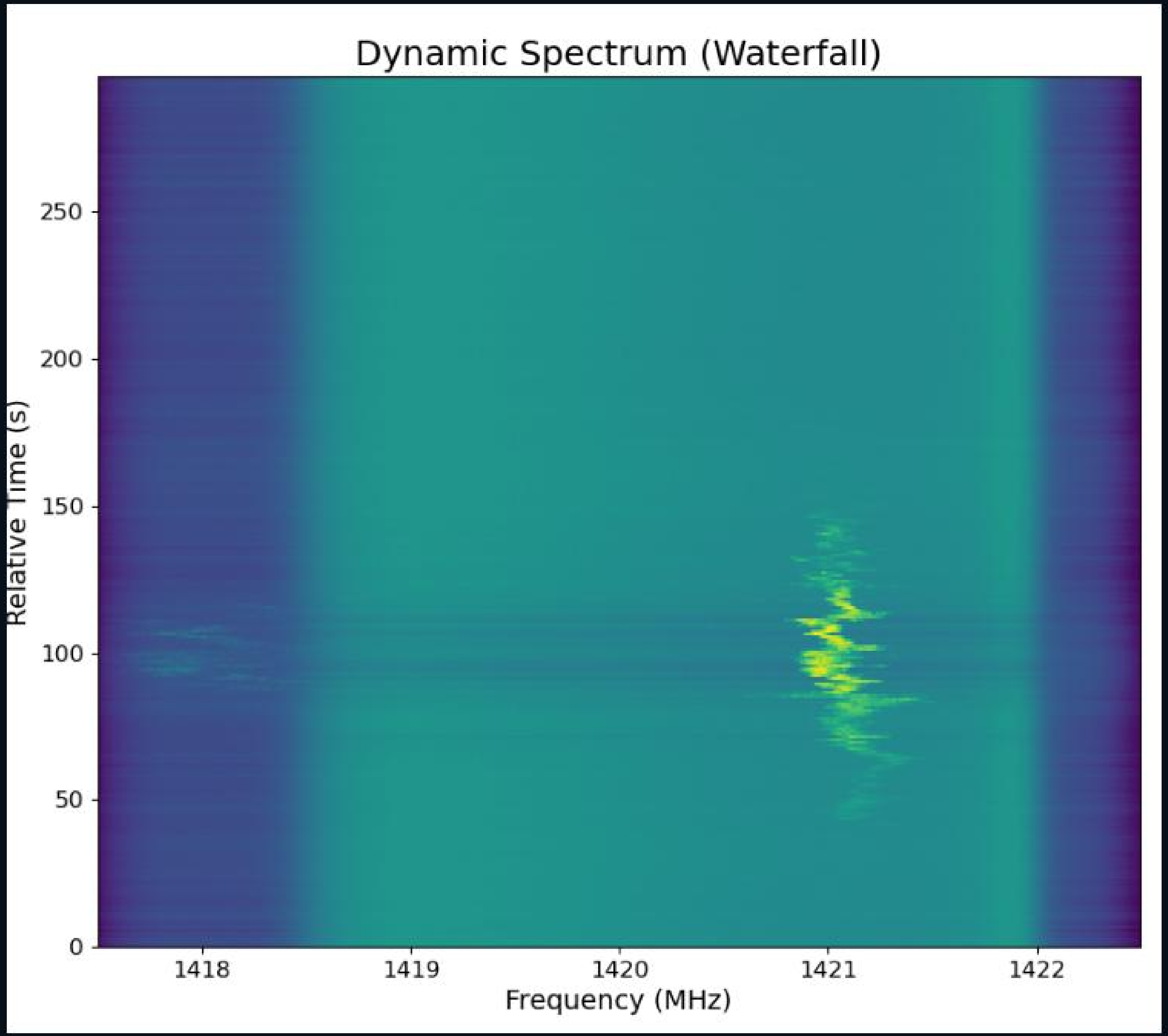
the checklist, cheapest test first

1	Is it at a frequency my own electronics is known to dirty?	**thrown out**
2	Does it repeat in evenly spaced copies across the band?	**thrown out**
3	Is it just always there, day and night? The sky moves. RFI stays.	**thrown out**
4	Does it rise and fall exactly like the beam sweeping a fixed point in the sky?	**kept, watched**
5	Does it come back 3 minutes 56 seconds earlier the next night?	**worth losing sleep**

Nothing has survived all five steps yet. For one small dish that is exactly how it should be.

AN OPEN CASE

this is why all that RFI discipline matters



9 August, 06:04 UTC.

A 46 second burst at 1421.1 MHz inside the protected band. It hit my small home dish. The scans before and after it are clean.

The time matches passes of a few satellites. Short suspect list: 2023-003E, Connecta IOT-2, Orbcomm FM19, S-Net B, Yaogan-35.

Now pointing the dish at predicted passes to catch one in the act.

The station is unattended, so it is built to run on its own.

It connects back to me on its own over a private network and serves its data out in small pulled pieces. The core system is kept read-only so a power cut cannot corrupt it, and a spare boot drive waits in case the memory card ever fails. After any outage, everything simply starts again.

WHAT ACTUALLY BREAKS

the site is unattended, so everything must fail safe

Power goes first.

A storm can take power out for 1 or 2 days. A 15 hour battery carries the Pi through.

Smart plugs reboot the Pi when it hangs.

4 of them died in one year and I still do not know why.

The cellular link is metered.

The site never pushes data out. Everything is pulled from outside and it stays under 100 MB a day.

I visit every 2 or 3 months.

Anything I did not automate is broken until then.

WHAT IS NEXT

making this easy enough for anyone

The whole pipeline goes open source on GitHub.

Every script that runs the dish and the search will be public.

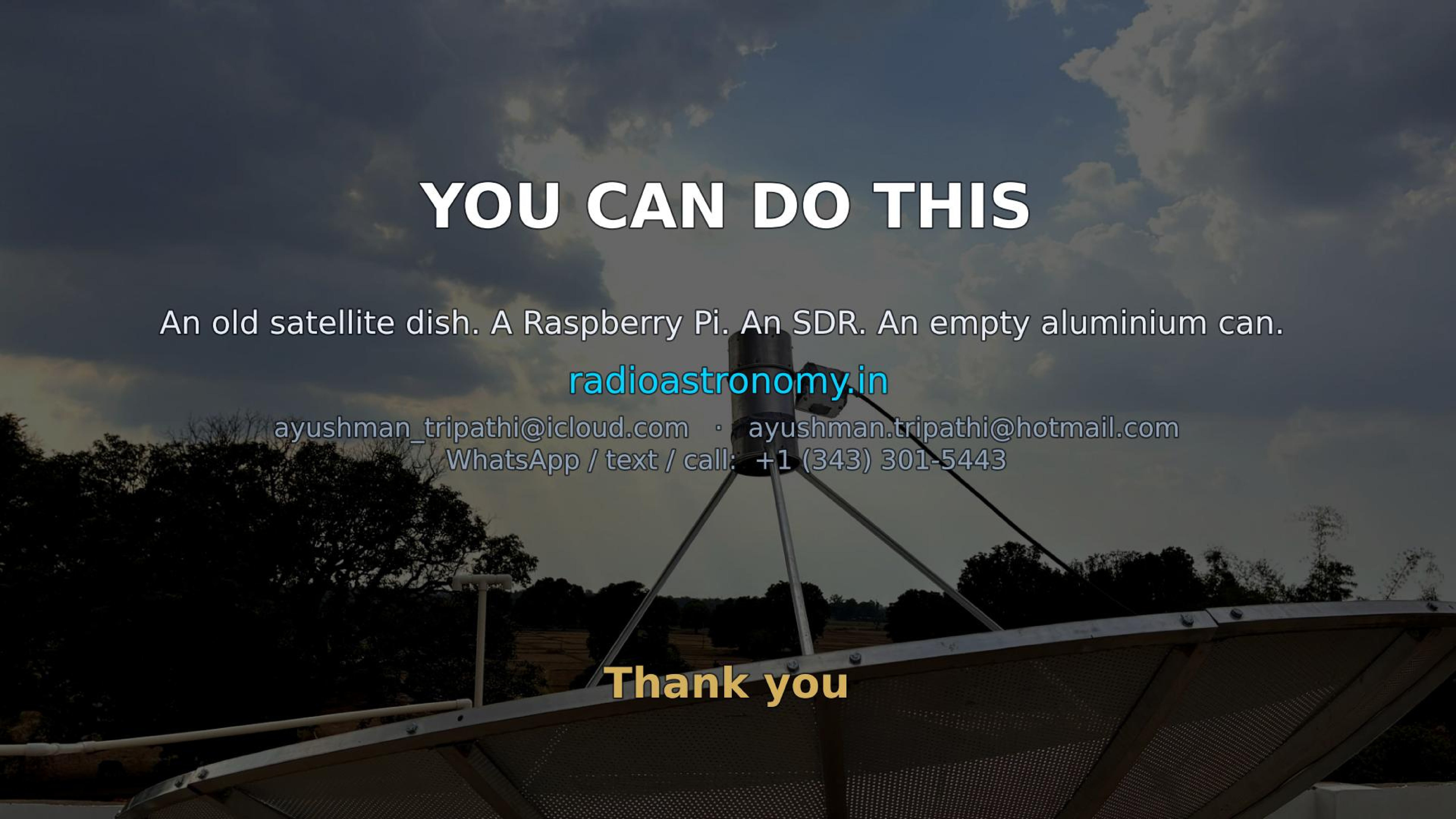
A control panel with a proper GUI.

Set it up once in the browser and it runs on its own. No scripts to touch.

Raspberry Pi first. Then Ubuntu. Then a free Windows app on the Microsoft Store.

The goal is a SETI station anyone can run at home with an old dish.

SETI@home let millions lend their computers. I want people to lend their skies.



YOU CAN DO THIS

An old satellite dish. A Raspberry Pi. An SDR. An empty aluminium can.

radioastronomy.in

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Thank you