The Dwingeloo Radio Telescope and the Spirit of Amateur Science

by Michelle Thompson W5NYV

In a quiet corner of the northeastern Netherlands, near the edge of the Dwingelderveld National Park, stands a monument to an extraordinary moment in scientific history, and to an even more extraordinary amateur renaissance. The Dwingeloo Radio Observatory, completed in 1956 with a 25-meter dish, was briefly the largest radio telescope in the world. This silver spiderweb helped map the spiral arms of the Milky Way and discover previously hidden galaxies. But this is not simply a story about a telescope. It's a story about what happens when professional science ends and amateur passion begins.

The 1950s saw an explosion of radio astronomy. This was a time when we started seeing the true face of the universe. The Dwingeloo telescope began construction in 1954. When Queen Juliana inaugurated it on April 17, 1956, it represented one of the most advanced efforts to listen to space. Using the 21-cm hydrogen line, astronomers mapped the spiral structure of the Milky Way with increasing detail and discovered high-velocity clouds. These are rivers of gas streaming through space. The hydrogen line is an electromagnetic spectral line at 1420.4 MHz, and is used to map the most abundant element in the universe, hydrogen. The radiation comes from the electron in a hydrogen atom flipping to align with the spin of the proton, which releases a photon. In the 1990s, during a survey of galaxies hidden behind the dust of our own Milky Way, the telescope discovered a rather large galaxy, confirmed by infrared observations and named Dwingeloo I. And, it had a companion, Dwingeloo II.

By 2000, the telescope was no longer in operation. Professional radio astronomy had moved on to interferometers and arrays. The Dwingeloo dish, once the world's largest, stood silent. At over 100 tons and gathering nothing but rust, the future was very uncertain.

This is where many stories of obsolete infrastructure would end. But not ours.
In January 2007, a group of enthusiasts established the C.A. Muller Radio Astronomy Station foundation, known as CAMRAS. The C. A. stands for Cornelis Alexander Muller, one of the Dutch pioneers of radio astronomy. In June 2012, they physically removed the telescope dish for restoration. But CAMRAS didn't restore Dwingeloo to create a museum piece. They brought it back to active life. And, not just life for an insular few, but a place where people could learn and participate in science and technical education.

What makes the Dwingeloo revival remarkable isn't just technical. It's also cultural and philosophical. As we radio amateurs know, the word "amateur" comes from the Latin amator, meaning "lover". To be an amateur in a pursuit is to have a passion for it. The CAMRAS volunteers are radio amateurs, amateur astronomers, engineers, students, and experimenters who have transformed what was once the world's premier professional instrument into what might be called the world's premier amateur instrument.

Here are some recent achievements.

They've detected signals from Voyager 1, nearly 25 billion kilometers away in interstellar space, making Dwingeloo one of only a few telescopes in the world capable of receiving these incredibly faint signals. This achievement had previously been done in the amateur community at Bochum Observatory in Germany, a 20-meter amateur radio telescope with a deep bench of active volunteers. The Deep Space Exploration Society (DSES) in Colorado, USA, with their 18-meter dish, hopes to join this group in the near future.
In October 2021, a team including Thomas Telkamp, Jan van Muijlwijk, and Tammo Jan Dijkema bounced a LoRa IoT message off the Moon. This was the first time that this had been done with a small RF chip, setting a distance record of 730,360 kilometers (https://eandt.theiet.org/2021/11/24/european-scientists-bounce-first-lora-message-moon).

Dwingeloo detected their first Fast Radio Burst (FRB) in March 2024, joining the hunt to understand these mysterious cosmic flashes. What makes this particularly remarkable is that the receivers, built by radio amateurs, were not specifically optimized for receiving broadband signals like those from FRBs.

Dwingeloo achieved their first Venus bounce in March 2025. This involved transmitting radio signals that traveled 42 million kilometers to Venus and back. This was first done by amateurs at Bochum Observatory in 2008. DSES has Earth-Venus-Earth (EVE) plans here too. CAMRAS volunteer Cees Bassa directly supported and documented this work, confirming that the expected Doppler effects matched what was observed and recorded at Dwingeloo and at the collaborating site Astropeiler Stockert. Stockert is another significant amateur radio astronomy site and was involved in planning and executing the EVE 2025 event. Stockert is located in Germany and more information about them can be found at https://www.astropeiler.de/en/.

Radio astronomers, both amateur and professional, use the telescope for Earth-Moon-Earth (EME) experiments and communications. Dwingeloo also conducts pulsar observations, participates in Very Long Baseline Interferometry experiments, tracks spacecraft, and contributes to citizen science projects. The line between amateur and professional has become beautifully blurred.

CAMRAS regularly opens the telescope to visitors, youth, education, amateur astronomers, radio amateurs and other interested parties. What was once a temple of elite science has become a commons. This is a place where anyone with passion and curiosity can reach out and touch the universe. Recently, visitors from Open Research Institute (ORI) were fortunate enough to be able to spend the day at Dwingeloo. This is the story of what we were able to observe. Find out more about ORI at https://openresearch.institute.

Thomas Telkamp bridges the worlds of large-scale networking, amateur radio experimentation, and cutting-edge space technology. He's a pragmatic engineer and a dedicated and confident experimenter, with a career that spans internet backbone work to satellites and deep space. Not only highly competent technically, Thomas was a delightful and generous host for our day at Dwingeloo.

The day's adventure began in Utrecht, in a hotel overlooking the Utrecht Conservatory and a short walk from the Dom Tower. Built in the 1300s, the Dom tower is the symbol of the city of Utrecht, and sets both a historical and cultural tone for the region. Travel to Dwingeloo from downtown Utrecht was accomplished by a combination of bus and then car, but could also have been done by train. The rich structured greens, browns, and grays of the tree-lined urban streets quickly gave way to smoothly variegated greens of farmland and forests.

Arriving at the radio telescope feels a bit sudden. The gradually narrowing country lane bends around one last gentle curve and then ends in a small and tidy parking lot. At the top of the lot is a small house that was occupied in the past by an on-site caretaker. The building is still used at the site to provide a restroom and meeting place for visitors and operators. Much like many modern fire observation and ranger stations in the United States, the modern Dwingeloo site no longer needs a live-in caretaker. However, the infrastructure is still there. At the bottom of the lot, a short pathway leads directly to the telescope.

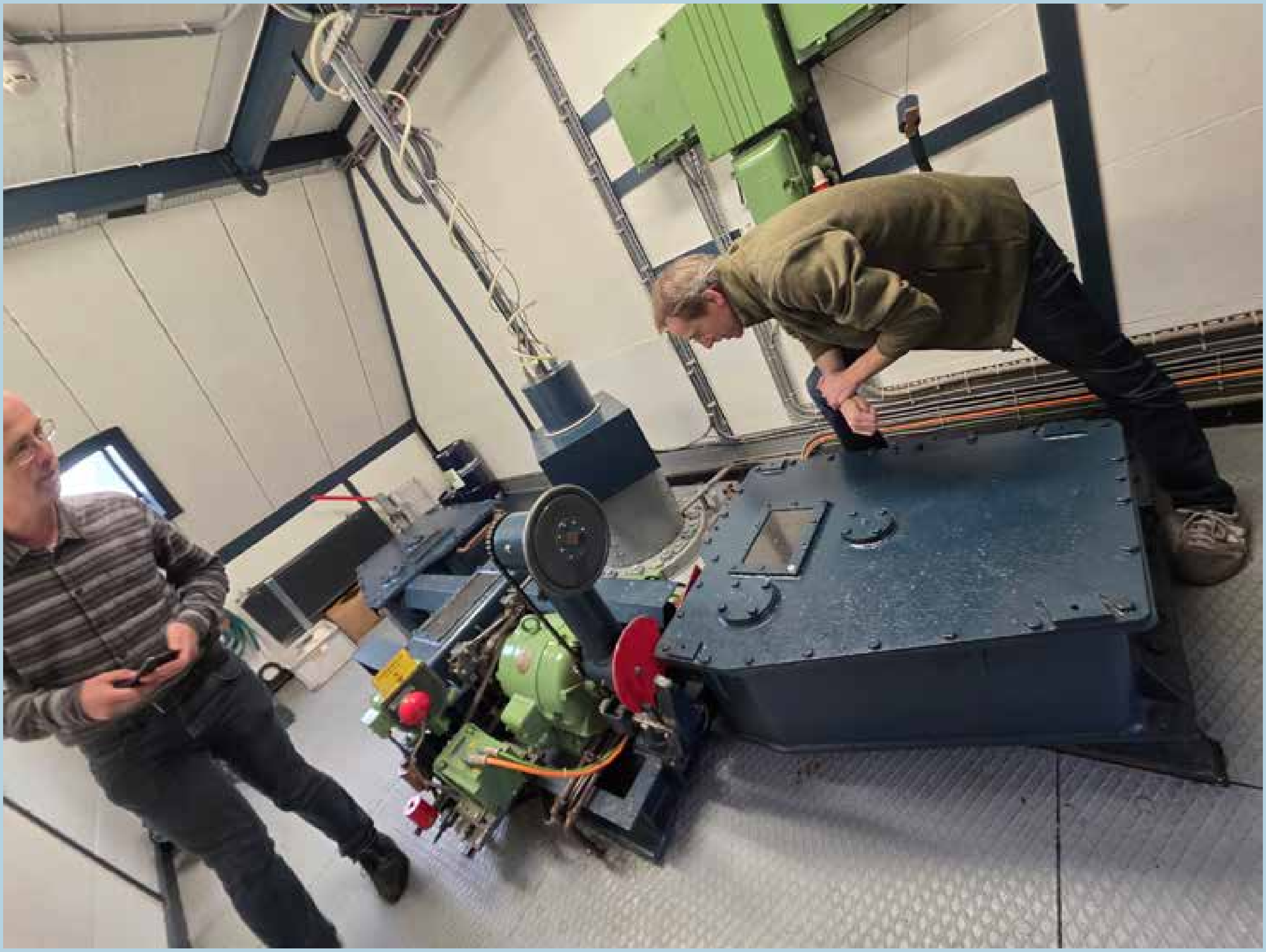
The 25-meter diameter dish support structure rests on a set of large metal wheels that run on a circular track. The telescope building, immediately below the dish, sits up above the track and rotates with the telescope. The motor room is inside this building, off the hallway that connects the front door to the control room.
With the wheels fully exposed at the outside perimeter of the structure, every startup requires a careful inspection and clearing of the track. At 90,000 kg (~200,000 lbs), the scope would easily crush anything on the track. For comparison, this is approximately equal to the weight of a diesel locomotive. In the photo below, note the brushes on either side of the wheel, to sweep away blockage or debris.

We walked around and inspected the track, and then climbed the rain-slick metal stairs to the front door of the telescope building. It felt like boarding a ship or a large airplane. There are enough windows in the control room to see that you are at least a story up off the ground. A skylight in the ceiling gives you a clear view of the mesh dish and feed above.

After setting down our backpacks and the radio gear Thomas brought for the day, the first task was to take off the brake and start up the motors. The engine room is small, with enough space for at most six or seven people to crowd around the motors and gears. There have been changes over the years to the configuration of the motors and gears, with the old infrastructure still bolted into place beside the new. Since the entire building moves with the scope, the power cables can slowly wrap around the stationary main support shaft. Worst case, too many rotations in the same direction could cause the cables to wind up tightly and break. The control room software keeps track of how far around the cables have wrapped and won't let the telescope keep rotating past the point of damage, but it's good to unwind in advance of any long maneuvers or rotations that might be planned for the day. Otherwise, you might be prevented from doing what you want by the software, and have to spend time to unwind the power and communications cables.

We were soon joined by another CAMRAS volunteer, Tammo Jan Dijkema, an engineer and mathematician with a keen interest in radio astronomy.

Below, Tammo at left and Thomas at right inspect the motor after startup. In the upper middle of the image is a vertical shaft that connects the ground to the building and telescope. Cables that are brought in to the building can wrap around this shaft. A monitoring system makes sure that the telescope does not rotate too far in either direction.



With all the setup completed, we moved to the main room of the building. Tammo took one of the operating positions in front of the equipment racks and immediately below a large overhead monitor. Thomas started setting up the radio telescope.

Tammo explained that when demonstrations are done for school field trips and other public open houses over the course of the year, the observations are recorded. These collections and stores of sampled data from the demonstrations allow Dwingeloo to plot Doppler differences of deep space targets. Over the course of a year, objects appear to move away or towards the Earth. These long-term longitudinal studies provided yet another valuable resource for amateur radio astronomy enthusiasts and experimenters.

When the scope slews, or moves quickly between observation settings, one can clearly feel and see the building move and the dish rise or fall. When it settles down to observe at the same rate of rotation as Earth, or at sidereal rate, the movement is much more subtle. One might only notice after a while that the view out the window has changed.

Thomas rewrote some of the software that handles connecting to the telescope and summarizes status and

results. This software is a modern and SDR-friendly update of professional software from the 1990s. There is a user interface of the dish health and safety information that runs on one of the resident computers. The concern on this particular day was high winds throughout the region. The evidence of the inclement weather had been all over the Utrecht city center, with leaves and limbs covering the sidewalks and at least one large branch coming down at daybreak in the middle of a cafe. The size of the Dwingeloo dish means it presents a large wind load, and above a certain wind speed, we would be limited in how we could operate and would have to settle for a much more conservative set of objectives. Any winds higher than the limit would cancel the session entirely. The dish health screen was mostly green indicators, but yellow flashed intermittently. We would have to keep a close eye on that. Fortunately, the software made monitoring dish health as easy as it could be.

Thomas explained how "back in the day" the foundational 21-cm hydrogen line survey was made in this very room. This survey revealed previously unknown Milky Way structures. Against the backdrop of the survey results on a large poster on the wall, we connected the Ettus B210 to the telescope. The B210 is an Ettus Research (National Instruments) software defined radio, and has excellent receiver performance. UHF and 13cm operations are done with a manual patch in the equipment rack. With a laptop, the radio data metadata format SigMF, and a modest amount of cabling, the entire universe can come to life with the B210 and a Python script.

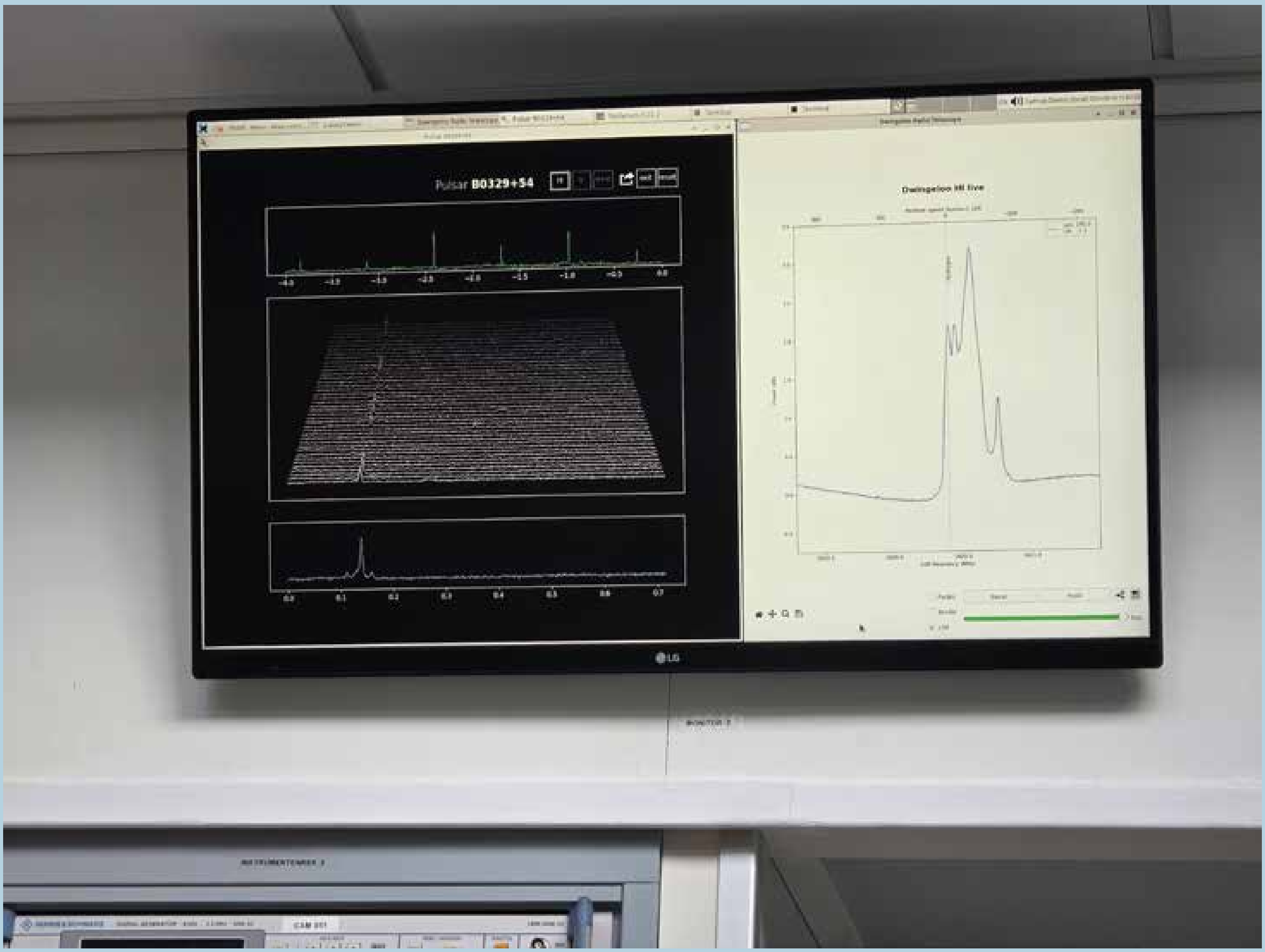
Thomas described efforts earlier in the year to find and receive the carrier signal from the Voyager spacecraft. This was a highlight for CAMRAS, as it's a challenging signal to receive. Another challenge? RFI. Sources of radio-frequency interference range from electric fences, which have been around for decades, to the relatively new "intruder" of electric bicycles, or e-bikes.

Observational activities at Dwingeloo come in categories. Natural objects and phenomena in the universe, human objects in the universe, radio amateur communications (EME, EVE), and educational outreach. Dwingeloo is a SATNOGS station, and regularly contributes observations of satellites to the database under the amateur radio call sign PI9CAM (PI9RD since November 2024).

Due to a happy travel coincidence, Paul Hearn and his wife Pam were able to join us. Paul and Pam were deeply involved with putting on the 2025 EU Conference on Amateur Radio Astronomy (EUCARA25), held just a few weeks prior. They described some behind-the-scenes work and the inspirational keynote from Professor Jocelyn Bell Burnell. She discovered pulsars in 1967, and pulsars were on the list of the day's targets.

We were then joined by Ed Dusschoten, the chair of CAMRAS. He dropped by to check in with Thomas and Tammo and meet Paul and Pam. His enthusiasm for both the site and the role were clear. He made sure the volunteers had everything they needed and shared key historical details with those of us visiting.

Our first observational target was the pulsar in Cassiopeia A. It is in the plane of the Milky Way. We are looking at it through two arms of our galaxy, which presents a complicated and interesting spectral response. Thomas explained the transmission and absorption lines on the spectral display, and how to identify the different arms of the galaxy.



Pulsars are believed to be rapidly rotating neutron stars, which are what stars become when they run out of fuel and collapse. Instead of being a fiery ball of gas, they are believed to be composed of neutrons. Pulsars have very strong magnetic fields which funnel jets of particles out along their two magnetic poles. When these poles happen to point towards Earth, then we can detect the energy as it sweeps by us like the light from a distant lighthouse. The period of pulsars ranges from 2 milliseconds up to many seconds, with the longest discovered so far rotating once every 6 hours.

The science of pulsars is more than enough justification for amateur and professional study. However, the influence of pulsars doesn't stop with science. "Le noir de l'Etoile" by Gérard Grisey, is a modern percussion music piece. It is inspired by the pulsar PSR 1919+21. Dwingeloo is one of the few sites where audio recordings of pulsars can be made and is actively involved with the art as well as the science of space.

Our next goal was to capture the so-called "Giant Pulses" from the Crab Nebula. Since RFI can also come through in these observations, it takes skill, patience, and quality computer programming to weed out the RFI and leave only the true pulses from PSR B0531+21, otherwise known as the Crab Nebula Pulsar. After some hand-editing of the Python script to better capture the 33ms period pulses, Thomas then explained an additional innovative feature of the way Dwingeloo is set up for amateur radio astronomy. Often, a digital radio signal stream of IQ data (in phase and quadrature complex baseband samples) are available to one instrument at a time. The consumer of the radio samples is usually a software program or another piece of hardware. At Dwingeloo, Thomas has modified the software infrastructure to allow multiple consumers of the IQ data stream. This was a big resource improvement over the way it was done before. This allows multiple people to use the data stream at the same time.

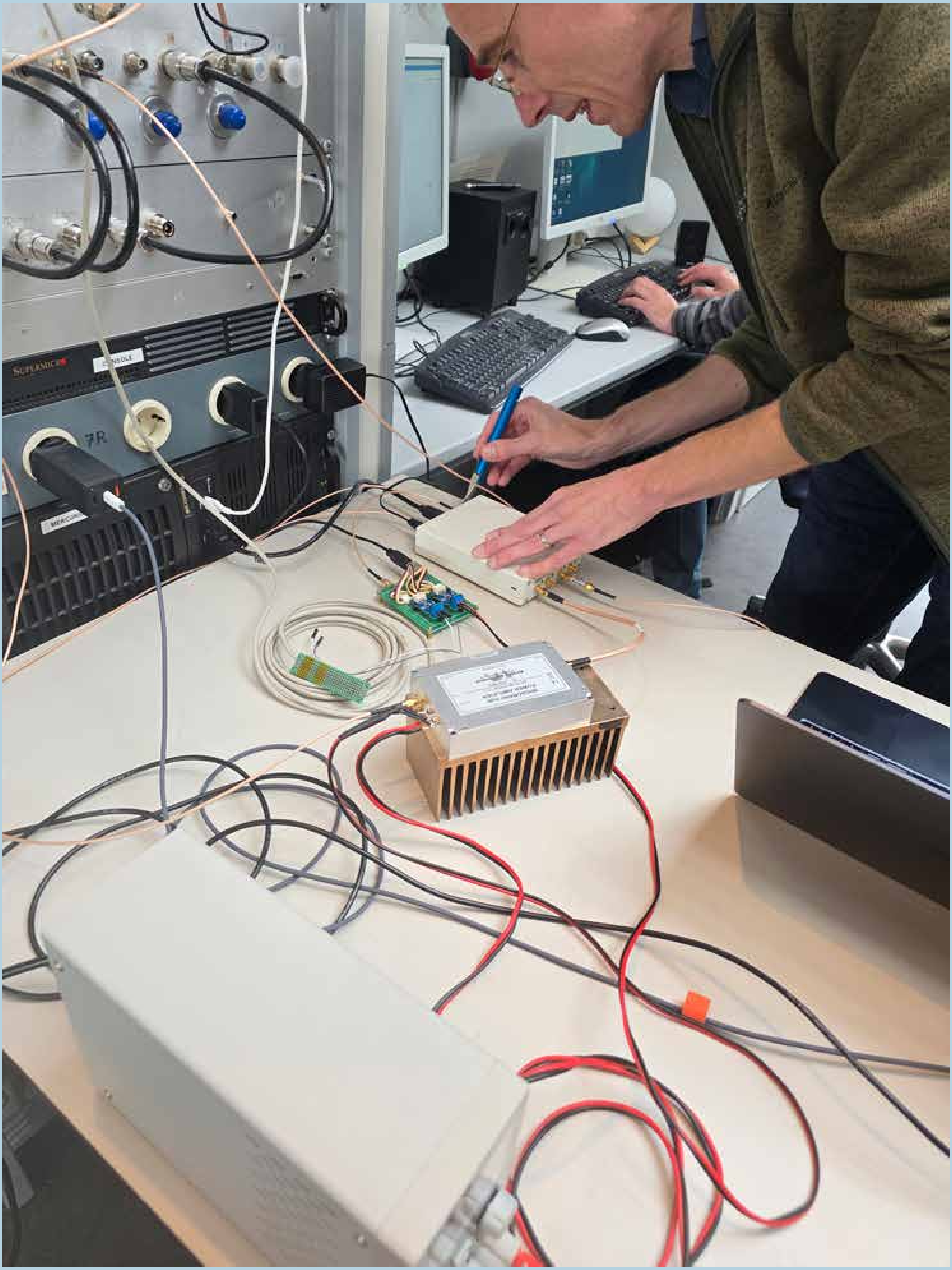
After everything was set up and confirmed to be working as expected, we watched the user interface on the big overhead monitor and waited. The "giant" pulses that we were looking for come every few minutes. We needed to capture and analyze them. If they were a clean spike, then they were probably local noise. If they had the expected and predicted amount of dispersion, then we considered them to be coming from the pulsar. After a while, a small collection of bursts at the right frequency and with the right dispersion showed up. Optimism grew and then became confidence. We'd successfully observed giant pulses from the Crab Nebula. These are radio signals from 6,500 years in the past. Signals produced today won't reach earth until the year 8525.

With Crab Nebula Pulsar bursts successfully observed as a warmup, our next target was something completely different. Instead of passively receiving energy from a naturally occurring phenomenon incredibly far away, we were going to receive energy reflected from an artificial satellite relatively close to us. The target was the radar target sphere LCS-1. This satellite is a hollow sphere of metal 1.12 meters in diameter and has been in space since 1965, making it one of our oldest spacecraft. The orbit isn't expected to decay for another 30,000 years.

The radar cross section of the sphere is very well known. This allows stations on the ground to measure the performance of their radio systems by using it as a reflector. With no extra circuits or transponders or translators or repeaters in the way, using a passive metal sphere to test a reflected signal takes a lot of the guesswork out of characterizing a complicated radio system like Dwingeloo.

The relatively quick motion of a LEO satellite crossing the sky, compared to the essentially stationary location of a deep space object like a pulsar, requires the antenna to move faster in order to track. The higher the speed at which the antenna is moving, then the less margin it has with respect to wind speed. Another limiting factor for Dwingeloo is that the dish can track a LEO orbit only up to about 40 degrees of elevation above the horizon. Above 40 degrees elevation, there are complications and physical limitations. After careful review of the dish health screen, which was still showing green, and the projected orbit, which was below 40 degrees maximum elevation, Thomas decided we would try for LCS-1. And, the attempt was successful. The characteristic return appeared in the spectral display.

Thomas took another hard look at the weather. Windy conditions were happening at both Dwingeloo and Stockert, the other amateur radio site involved in today's EME attempt. Plans had been made to coordinate with Stockert on an EME bounce attempt with digital signal files. The wind was gusty but the forecast showed conditions improving. After some back and forth with Stockert, Thomas decided to move forward with the EME attempt. The B210 was now connected to a sequencer board, an amplifier, a power supply, and a massive

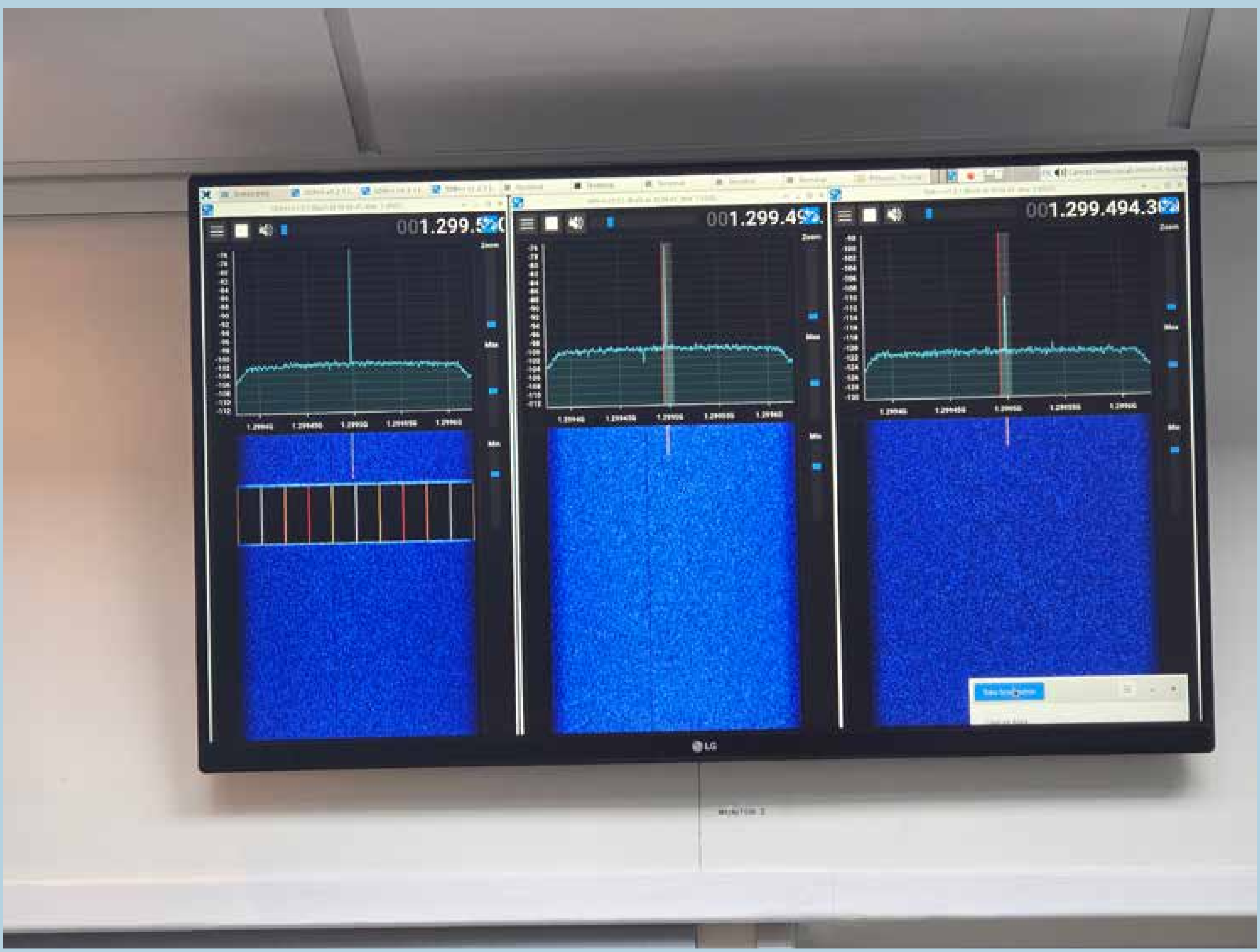


heat sink. The B210, like almost all SDRs, doesn't have enough transmit power on its own to drive radio instruments like the transmitter at Dwingeloo. It needs an amplifier to get into the 1-2 watt range to make things work.

In order to show the signals received from both sites at the same time at Dwingeloo, Thomas put the results up on the large overhead monitor. This showed a side-by-side display waterfall of the radio spectrum from both receivers. In order to get the receiver information from Stockert, Thomas logged in to Stockert over a virtual private network and then opened a secure shell tunnel back to Dwingeloo.

B210 transmit was tested and proven to work. The amplifier for the B210 was switched on. The Dwingeloo amplifier was then switched on. 10 sequences of 30 seconds were transmitted, and loud EME return signals were seen in the waterfall. The sequences sent to the Moon included Zadoff-Chu sequences. These coded transmissions are being constructed and studied as a possible signal type for EVE communication attempts coming up in October 2026. Using EME as a test bed for EVE lets experimenters like Thomas try out different digital signal processing techniques and signal structures without having to wait for Venus to approach close enough for an echo to be heard. Dwingeloo successfully received EVE carrier echoes in March 2025, during the most recent close approach of Venus. Stepping up from a carrier wave detection to communications reception will require advanced digital signal processing techniques and carefully coded signals. Experiments like today's EME bounce provide useful results and experience invaluable for an EVE attempt.

If coordinating two sites for live EME was impressive, then how about three?



Thomas expanded the EME experiment by logging into a citizen science accessible antenna at the Allen Telescope Array (https://www.seti.org/projects/ata/) located at Hat Creek Radio Observatory in Northern California. A third waterfall was configured in software and displayed on the overhead monitor. We now had Dwingeloo, Stockert, and ATA receivers simultaneously watching the Moon for a transmission of a digital amateur radio experiment from rural Netherlands. And, it worked. The return echo from all three sites was clearly seen and recorded at Dwingeloo. This proved that the communications and logistics links between three of the most significant amateur and citizen science radio astronomy sites in the world were working.

Closing down the telescope after so many successful observations was satisfying and a little bittersweet. The Dwingeloo story offers a template for how we might handle aging scientific infrastructure everywhere. Rather than abandoning instruments when professional science moves on, what if we recognized them as educational resources, as platforms for citizen science, as tools that can continue producing valuable data in capable amateur hands?

The volunteers at Dwingeloo have shown that with dedication, creativity, and collaborative spirit, amateurs can operate sophisticated instruments and make real contributions to our understanding of the universe. They've shown that the amateur spirit can be just as powerful a driver of discovery as professional funding and institutional support.

In the shadow of the Dutch pine forests, where a 25-meter dish still turns toward the cosmos, the future and the past of science meet. Professional expertise built Dwingeloo. Amateur passion brought it back to life. And somewhere between those two efforts lies a truth about human curiosity that no amount of rust can diminish.