PI9CAM, History and Restoration

Jan Van Muijlwijk, PA3FXB

In 2004 I became aware of the possibility that the 25m Dwingeloo radio telescope could become available for radio amateurs and EME. Back in 1956, it was the first radio telescope of this size in the world and it marked the start of professional radio astronomy. It was a thrill to imagine that we radio amateurs were going to use this magnificent historical instrument for EME! Looking back through the things that happened since then, I must say this was a life changing event…

The story of our first years reviving the telescope was told in 2008 at the EME conference in Florence and I showed many pictures of the great instrument. Now four years later I am very happy to tell you that it's 100% sure the dish will be saved.

At this very moment the big restoration is on its way. The Dwingeloo dish has now been designated as a national monument and that opened the way to all kinds of funding. The restoration will cost more than 1,000,000 Euros and is being done by professionals.

Update, 2004-2012

A short recapitulation of what happened between 2004 and the start of the full restoration in 2012…

In 2004 the dish was in bad shape and it was very clear that a big restoration was needed to save it for the future. ASTRON (the owner of the dish) had no money even for maintenance, let alone restoration. An investigation by a steel construction company concluded that although the dish needed major restoration it was not at the verge of collapse and that is was safe to revive it for a few years. But after those few years it would be absolutely necessary either to restore the dish completely, or to lose it.

ASTRON has a great communications and PR department and they generated a lot of nation-wide interest in the situation of the dish. To make a long story short, many volunteers, most of them radio amateurs, joined forces and started the CAMRAS foundation.

CAMRAS stands for ‘C A Muller Radio Astronomy Station’. C A Muller was a radio astronomer and radio amateur (PA0CAM) who worked at the Dwingeloo dish for many years. He was the first to use the dish for ham radio on 2m many years ago, and in our present callsign PI9CAM we honour him.

The ever growing CAMRAS foundation has attracted volunteers with all kinds of skills and together they were able to get the dish back in action and get it QRV on EME. The first activation on EME took place in May 2008. Tracking was not 100% but it worked and this was a great moment for us all! All together we have now activated PI9CAM on EME 39 times from May 2008 to April 2012 covering 144 MHz, 432 MHz, 1296 MHz, 2320 MHz, 3400 MHz and 5760 MHz. We even did some RX-only experiments on 217 MHz listening to NAVSPASUR echoes from the Moon and Venus.

In the meantime ASTRON worked very hard to get the dish restored completely. In 2007 it was nominated to become a national monument but it took until February 2011 before we were sure to receive money from the government to do the restoration. And again it took until April 2012 before we were sure that some other important sponsors would add enough money to cover the complete restoration. Some patience is needed when big money is involved…

But the good news is that the restoration is on its way now and that in 2013 the dish will be as good as new again.

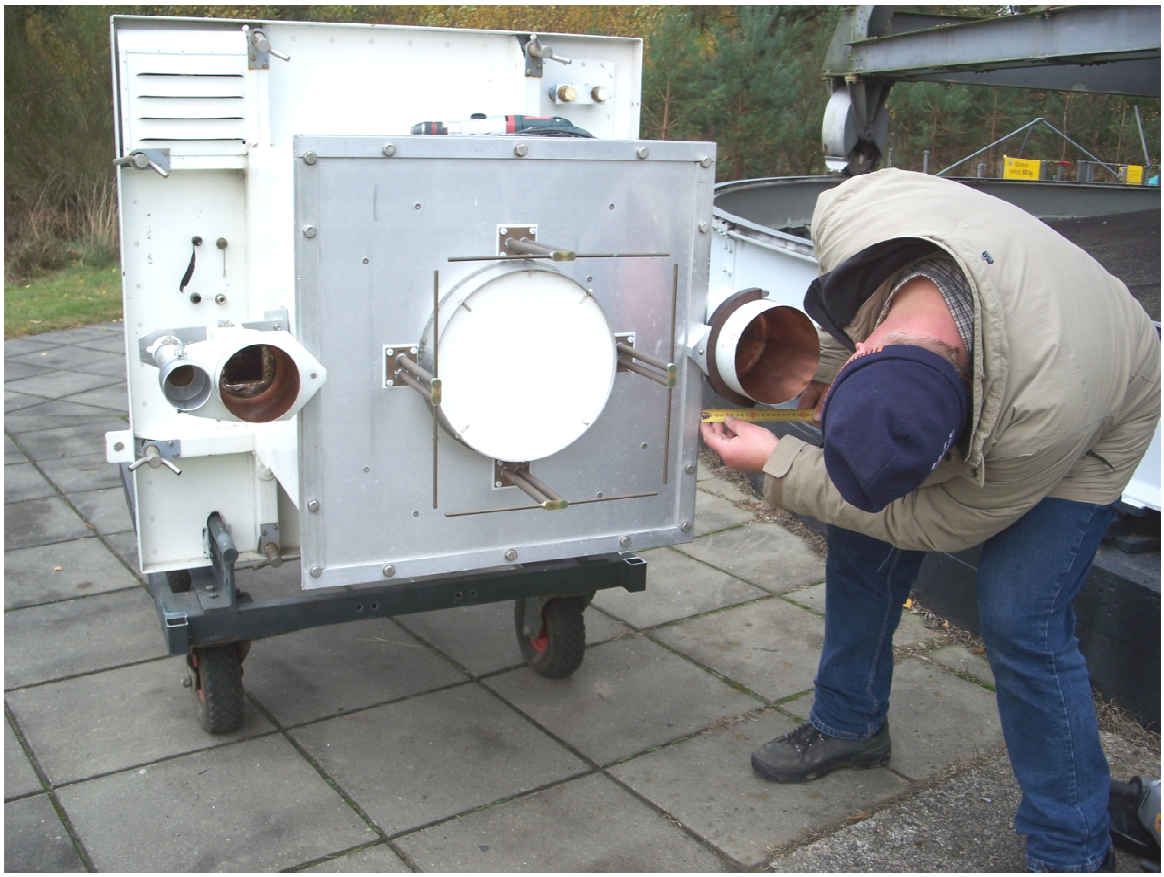
Feeds and Equipment

The dish now has a very robust ‘focus box’ construction. That is because in the seventies the radio astronomers used helium cooled (and therefore heavy) preamps, so the feed mounting construction was changed from a lightweight 3 pole construction to a heavy 4 pole construction. To balance the dish it was then necessary to add some extra counterweights. The focus box can only be reached by a 15 m high elevator, with the dish set at zero degrees elevation and at a fixed azimuth.

The focus box is in fact a box-in-box construction. The inner box can be remotely moved to bring the feeds exactly into focus – an EMEer’s dream – and to work more comfortably on the feeds the inner box can be taken out and brought down to ground level (see photo below). When all feeds are mounted the inner box is elevated again and replaced in the outer box. As you can imagine, this is a rather time-consuming process so we chose to simultaneously mount as many feeds as possible, although this

also results in having to offset the dish a bit when changing to certain bands. We use the following feeds:

144 MHz:	Dual 3-el yagis only horizontal
432 MHz:	Two dual dipoles horizontal and vertical
1296 MHz:	OM6AA septum feed
2320 MHz:	W2IMU plus septum (tnx ON7UN / ON4BCB)
3400 MHz:	square septum feed
5760 MHz:	round septum feed



The 1296 MHz feed horn is exactly in the centre and the 144 MHz and 432 MHz dipoles are mounted around this feed. Feeds for 2320 MHz, 3400 MHz and 5760 MHz are mounted at either side, so on these bands we need to offset the dish.

The radio gear is not owned by CAMRAS but is brought to the site by several operators who take part in the activation. The heart of the station is a TS2000X. On 2 m we have used different PAs from several operators. On 70 cm we have a Henry PA. On 23 cm we use a SSPA made by PE1RKI. We only once activated the dish on 13, 9 and 6 cm, and the equipment for those bands was on loan from many different radio amateurs.

On 2 m, 70 cm and 23 cm the PAs are located in the radio room under the dish which is 60m coax cable away from the feeds. This results in 350 W at the feed on 2 m and 70 cm and 65 W at the feed on 23 cm.

Some EME Results and Statistics

During the 39 EME activations of the dish we have made 1543 QSOs.

Breakdown by bands		**Breakdown by modes**	
144 MHz:	290	CW:	653
432 MHz:	403	JT:	735
1296 MHz:	783	SSB:	145
2320 MHz:	43	SSTV:	7
3400 MHz:	8	FM:	1
5760 MHz:	7	Olivia:	2

We were also able to make 18 firsts:

70 cm: BX1AD, KG6DX, V5/KT6Q, 5Z4EME, TK5JJ, 8Q7QQ, 3B8EME, TI2AEB, C56EME, PJ4X, PJ2/PE1L, 8P9HP and EY8ZF

23 cm: LZ1DX, LY2BAW, 4Z5LV and 4U1ITU

6 cm: SV3AAF.

High bands ARRL weekend

After doing EME on 2 m, 70 cm and 23 cm with the dish for more than a year we thought it would be nice to try on the higher bands. So we decided to give it a go in November 2009 during the ARRL Microwave EME contest.

We gathered all kind of equipment from all over the country and even Belgium to become QRV on 13, 9 and 6 cm. Everybody who tried to assemble a radio station of several modules built by different people knows how big a challenge this can be. It was a lot of work but in the end we succeeded in having all three bands QRV.

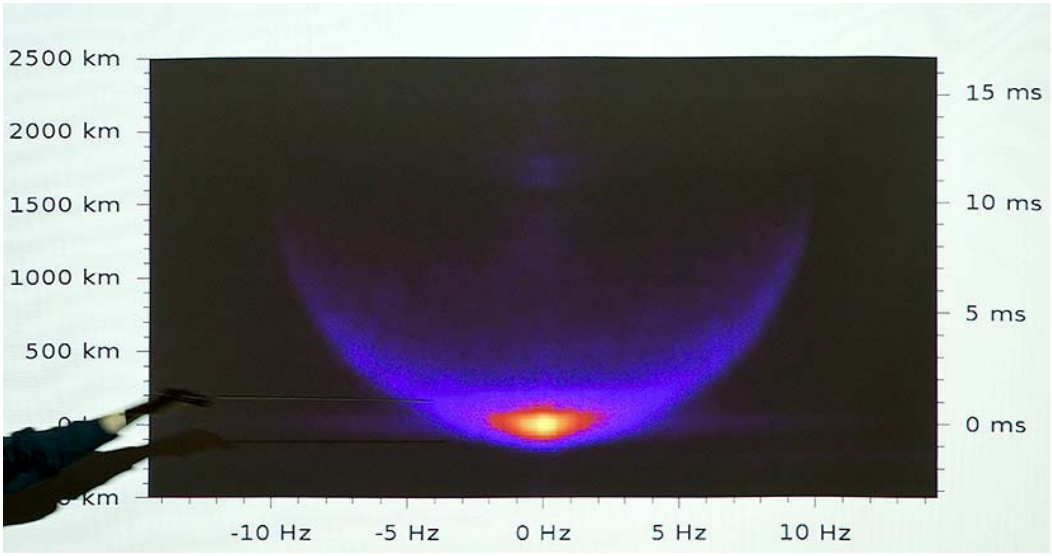
On 13 cm it worked excellent! The dish should have a gain of about 55 dB on this band, so it was no surprise that we experienced huge echoes. On 9 and 6 cm it was different; we had less power there and because the 9 and 6 cm feeds were displaced sideways from the focus we also needed to offset the dish to get good echoes. Much to our surprise we noticed that the amount of offset for maximum echo changed. Beamwidths on 9 and 6 cm are less than the Moon itself so pointing accuracy of the dish is critical. On 2 m, 70 cm and 23 cm this was never a problem but on 9 and 6 cm it was. Since then our radio astronomy friends who share the dish have done much work on getting an ever-better pointing accuracy. The big advantage in our modern times is that all kinds of little systematic pointing errors can be corrected in the software. For example, after the November 2009 weekend we learned that the rail on which the dish is riding is not 100% flat, and also that the virtual elevation axis is not completely horizontal. The tracking software is now corrected for those errors.

The 13 cm operation was a big success, but on 9 and 6 the QSO rate was lower than hoped for. This was mainly because every time we switched bands we had to find a new position for our maximum echo again and with a big dish it takes a lot of time. Anyway, we had a lot of fun, we learned a lot and it was a great experience.

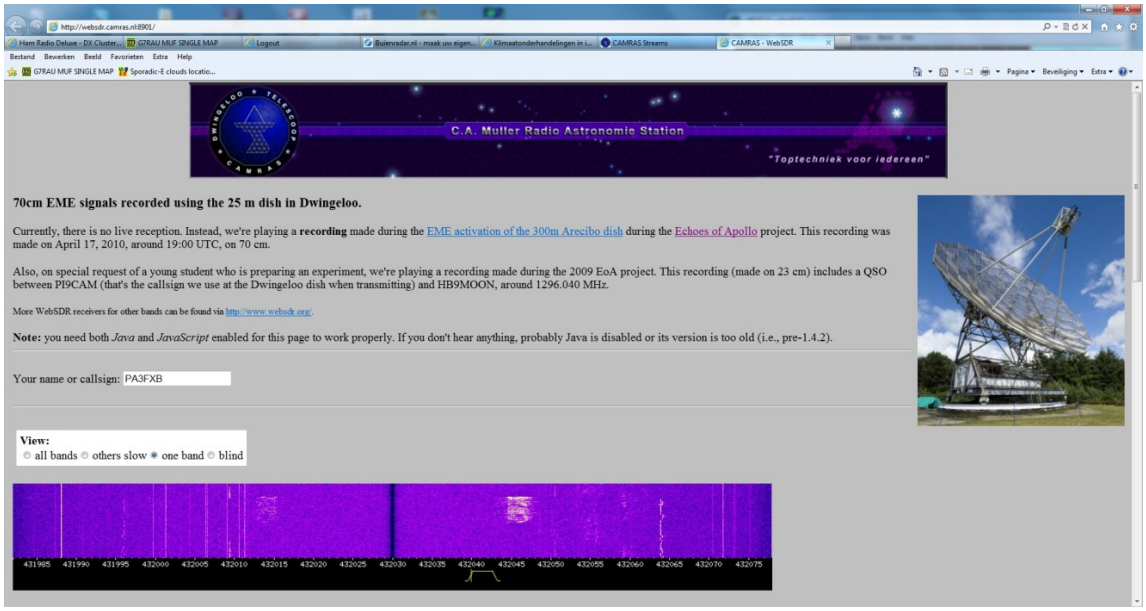
Our Belgian ‘sponsors’ ON7UN and ON4BCB visited us one night and made a lot of QSOs. For me it was the longest period of time with very little sleep. At the end of the event I realized that I hade been there for 62 hours with only 4 hours of sleep… it must have been the adrenalin that kept me going!

Radar echo picture of the Moon

Pieter-Tjerk PA3FWM developed a way to make a radar picture of the Moon using only our 65 W 23 cm signal. Sending what we called ‘strange sound’ to the Moon, he recorded the echoes with his SDR. After much computer processing of the result he could produce this picture! We see that the best reflection is from the centre of the Moon and we also see the effect of libration.



WebSDR and JOTA



The same Pieter-Tjerk also is the developer of the WebSDR. This is a SDR system which can be visited on the Internet (http://www.websdr.camras.nl:8901/) and every visitor can pick his own frequency to listen to.

We started with 23 cm only, but when the dish is QRV we can do 23 cm and 70 cm at the same time. We have often seen many visitors to this system. When there are no

contests the system works in real time, but during contests we introduce a delay of five minutes for obvious reasons. There is much to be heard via this system, and there is only one 'problem' because when we transmit the WebSDR goes more or less into overload as a result of our own strong signals.

During the Arecibo 70 cm activation we ran several days as a RX-only WebSDR station. This was a huge success – hundreds of listeners used the system to receive the Arecibo signals, and we needed to run an extra server to keep up with the demand! In the last few months of operations we had a problem with a new WebSDR server as it appeared to be not stable enough, but after the big restoration we hope to be back with a more robust system.

The last very nice operation involving the WebSDR was the Jamboree On The Air (JOTA) in 2011. Several Dutch Scouting groups have built their own 70 cm Yagi to try to bounce their signal off the Moon to be received by PI9CAM. After some initial tests earlier that year we found out it was possible to receive very QRP JT65b signals on 70 cm. The WebSDR showed the reflections and after some trying it appeared possible to decode these JT65b signals. Imagine the looks on the faces of the Scouts when they realized that they had successfully bounced a signal off the Moon! There were also a few Scout groups that succeeded in having a QSO with us.

A very successful and highly motivating event!

Radio Astronomy

This subject is not really Moon or EME related. The dish was built in 1956 to be used for radio astronomy so it's only fair to mention some results our radio astronomy friends had with the revived dish. Normally radio astronomers listen on different frequencies from us radio amateurs, which could mean that every time we wanted to switch from EME to radio astronomy we might have to switch antennas. Not a very nice prospect as I already mentioned, because working on the focus box is a time-consuming process.

We were very happy when we found out that our 23 cm OM6AA feed had a very good second SWR 'dip' at 1420 MHz – a fantastic coincidence as 1420 MHz is the hydrogen frequency! On 23 cm we measure about 3 dB of Moon noise so our total system Moon-bounce sensitivity is more affected by this Moon noise than by a very low noise preamplifier. This allowed us to tune our G4DDK VLNA for best performance on 1420 MHz and made the radio astronomy guys happy without suffering on 23 cm. A nice detail is that with this G4DDK VLNA the Dwingeloo dish is now more sensitive than it ever was during its professional life!

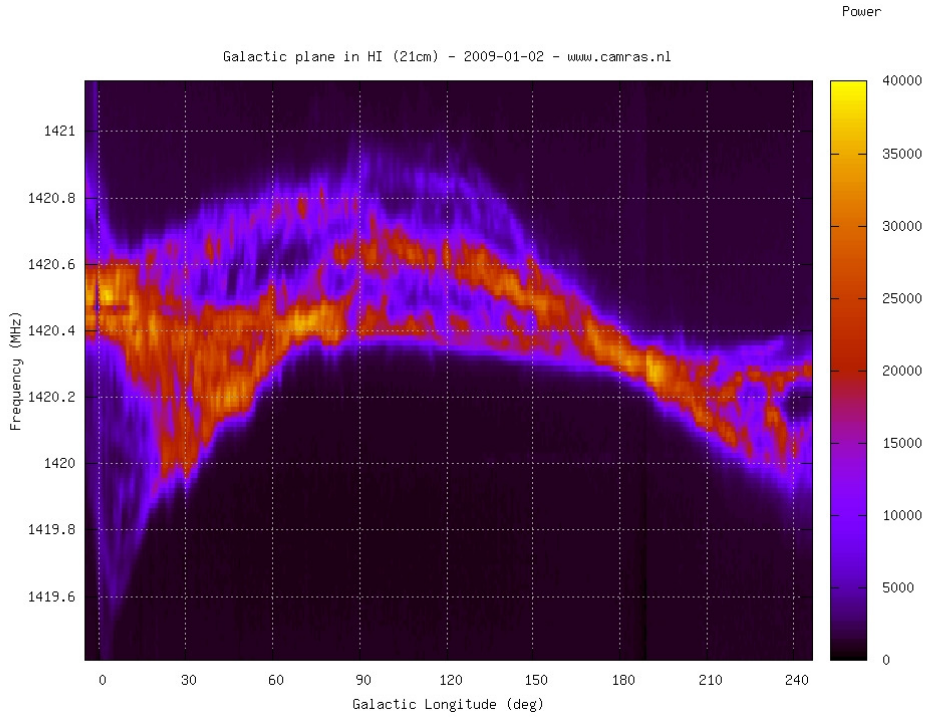
Pulsars, Hydrogen-line mapping and the Andromeda galaxy

Paul Boven (PE1NUT) is a professional radio astronomer who works at JIVE which is located in the ASTRON building in Dwingeloo. This gives excellent circumstances for Paul to do amateur radio astronomy at a high level using the dish. Paul is very interested in pulsars and one of his goals was to hear a pulsar with the Dwingeloo dish. He built his own FPGA based wideband receiver and the result was great – we are able to receive the strongest pulsar every day! This makes another great show for visitors.

Back in 1956, the first big project for the dish had been to map the structure of our own Milky Way galaxy on the hydrogen frequency in a very accurate way. At the time, it was a major breakthrough in the world of astronomy as there were no computers, so everything had to be processed and calculated by hand. Imagine the work! It took them six months to get some results. We were thrilled by the idea of repeating these historic measurements with assistance from modern software, so Paul wrote special software

and guess what… in about *half a day* he created this map of the Milky Way in hydrogen radiation.

The Andromeda galaxy is our neighbour in the universe and is visible to the naked eye on dark nights with clear sky. At radio frequencies the Andromeda galaxy is much bigger so it's a nice object to study. It appeared possible to determine the rotation of this galaxy by measuring the Doppler shift of the moving hydrogen, and the results matched very nicely with the known professional results.



NAVSPASUR and Venus

In the USA we find the strongest radio transmitter on the planet, the NAVSPASUR radio 'fence' to detect satellites orbiting the earth. NAVSPASUR consists of three systems and uses frequencies near 217 MHz.

More background info on: http://www.itr-datanet.com/~pe1itr/navspasur.html

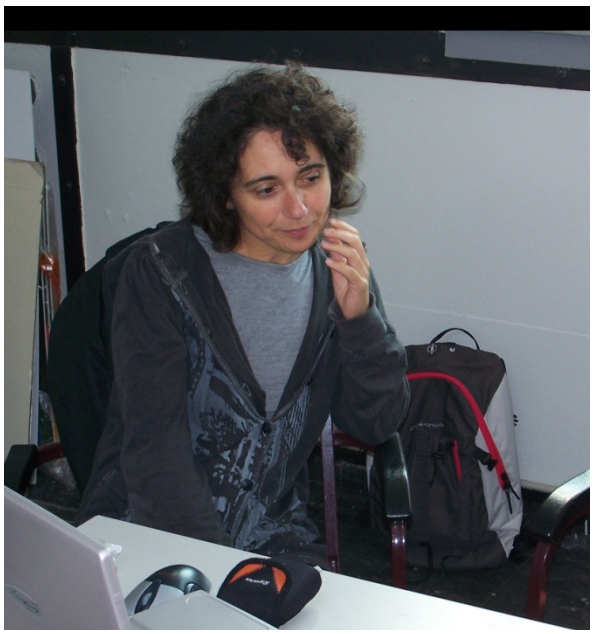
With a small Yagi it is possible to receive Moon echoes from the NAVSPASUR system when the Moon passes through its beam. For this, you do not need a 25 m dish… but PE1ITR suggested the possibility that we might also be able to see the reflection from Venus.

An interesting thought! Calculations made clear that it might be possible; but it would be difficult. PA3CEG constructed a dual dipole feed for 217 MHz and we mounted it in the dish. The Moon echo from NAVSPUR was incredibly strong and we also saw a clear reflection from a satellite, so the system was obviously working. Tension was rising when the moment came that we might see the reflection from Venus…

At the right time and on the right frequency (2497860 on the spectrum display) we saw a very faint line in the waterfall spectrum. Too weak to be 100% sure, as we also saw some very weak birdies now and then… so the pessimists concluded that we did not see a reflection and the optimists concluded that maybe we did. Sadly there was no opportunity to repeat the experiment, but when the dish is restored it would be nice to try it again.

Radio Astronomy and Art Projects

A dish so big at a site like Dwingeloo has a certain beauty – not only because of the technical possibilities but also because of the magnificent construction and the 'high tech' looks.



Because of that, all kinds of 'not mainly technical' people are attracted to it. This includes artists, who often have a very vivid imagination which sometimes results in great ideas!

The first artist who immediately saw the potential of the dish was Daniela de Paulis. She contacted CAMRAS and asked us if it was possible to do movies via Moon-bounce. What an interesting thought!

After some calculations it was clear that for doing movies via the Moon we needed a much bigger dish than the Dwingeloo dish, so I asked Daniela what she thought about non-moving SSTV images which probably could be exchanged via the Moon. That was a nice alternative, so the artistic part of that story I shall leave for Daniela to tell in the next presentation…

When we started to do those art projects I really had some explaining to do at CAMRAS. Many purely technical people do not have warm feelings towards art (to say the least…). But as soon as we started working on these projects – and as more and more people experienced the enthusiasm those performances created – they changed their minds about art. At least, about this type of art :-)

We did many EME SSTV sessions and are very happy with the cooperation of some fine stations that are able to produce a strong enough SSTV signal off the Moon:

- Howard G4CCH, who worked with us most of the times we did EME SSTV
- Bruce PY2BS, who also produces very strong images
- Dan HB9Q, who did the first SSTV QSOs with us on 23 cm and 70 cm
- And during the last event the group of SP6JLW did a great job.

Many thanks to all!

Another thing Daniela did was 'Poetry Night', reading poems to the Moon and using the echo of some phrases as an extra effect. During the presentation at the conference we will play some recordings. One of them will be Daniela reading the second chant of Dante's *Paradiso*, where the poet meets Beatrice who explains to him the nature of the Moon's dark spots.

Another recording will be the same text but as received by Howard G4CCH and John PA7JB. Fortunately John and Howard tuned their radios exactly the same so the pitch of Daniela's voice is exactly the same. I turned it into a full stereo audio recording by putting one recording on the left channel and the other on the right channel. A very interesting effect, especially on headphones. You hear the difference in QSB experienced at the different locations!

We hope to do more poetry nights in future, maybe even with poets live at the dish…

Music projects

Something completely different was the music project of the English band 'Zinta and the Zoots' for the Global Astronomy Month 2012. Simon Marchant, the leader of this band, contacted us and asked if it was possible to supply them with real-life strong noise from a radio source in the sky, to be mixed with a voice during a live performance. We set up a Skype link and relayed the live noise from Cassiopeia A (the strongest radio source in the sky, around +6 dB on 23 cm in Dwingeloo) to Canterbury in England where the show was performed. See: http://vimeo.com/39225378

Last event to mention here is the open air performance of the Solar Sound Ensemble. This happened at the dish in the presence of 200 visitors (luckily the weather was fine). Recordings of a pulsar and other celestial noise were used as an inspiration for the music that was composed by the Solar Sound Ensemble. During the sound show the dish was used as a 'screen' to project moving abstract images on. An awesome sight!

The BIG Restoration

This summer, 2012, the contractor has started work on the full restoration of the dish. The first big step has been to lift the dish from its mounting and transfer it onto the special cradle where most of the restoration work will take place.

As this paper had to be ready in June there was no possibility to include the most recent information in this printed version. My intention at the Conference is to show you many pictures of the most recent work on the dish, including some spectacular pictures of lifting the dish.

I hope to include as many new images on the Conference DVD as production deadlines allow. The DVD will also include the older presentation from Florence, with 158 pictures of the dish and details of how it was in 2008.