Protocol of

"Herouni Mirror Telescope's Advisory Group" meeting

Participants: as mentioned (list below)

Date: **10 May 2021**

Meeting place: Zoom, online

Discussion format: Q&A

Discussed questions:

1. **Presentation by Arevik Sargsyan of last experiment and its developments**
2. **Harro Verkouter presented the results of the discussion regarding the last experiment**
3. **Leonid Gurvits: what is the best guess about the a priori knowledge of the pointing of the telescope, its current position?**
4. **Arevik Sargsyan: If I understand well, Michael suggests another measurement, something like using the sub-reflector as a correlator. Is it the idea to have something on the upper side of the sub-reflector?**
5. **Leonid Gurvits: Arevik, what is the prospect of fixing the electrical and mechanical problem of the motion? I think that's now the most critical thing.**
6. **Arevik Sargsyan: number one problem of our project**

Participants

	Name	**Institute**	**Expertise**
1.	Uwe Bach	MPIFR, DE	Effelsberg VLBI friend and EVN TOG chair
2.	Leonid Gurvits	JIVE, NL	JIVE representative, space science and radio astronomy
3.	Kees van't Klooster	ESA/ESTEC- retired	Radio telescopes and antennas
4.	Harro Verkouter	JIVE, NL	VLBI digital instrumentation and data engineering
5.	John Sarkissian	CASS (Parkes Observatory), AU	Radio telescope operation and development
6.	Jacob W.M. Bars	ESO, MPIFR, DE-retired	Antenna engineering, Professor
7.	Michael Lindqvist	Onsala observatory, SE	VLBI and radio astronomical

			observations
8.	Arevik Sargsyan	HUSC, AM	Antenna engineering
9.	Ashot Aslanyan	JAF	CEO
10.	Karine Darbinyan	JAF, HUSC, AM	Responsible for the project, operational management

1. Presentation by Arevik Sargsyan of last experiment and its developments

As agreed last time, we made the third sky-track measurements on the radio telescope using the last three objects from that list prepared together with John Sarkissian in 2020. We have chosen the sources most appropriate to be observed, taking into account the unmovable situation of the telescope, looking somewhere to the Zenith, and the fit that patch antenna for 4.5GHz. And we had the possibility to use some spectrum analyzers from National Instruments (which is, of course, not a great radio-meter).

We had observations last Nov-Dec, and thanks to the rotation of the Earth, it was possible now (on 23rd of April) to see the other three sources from that list in the daytime. All three sources, coming one after another, are point sources – one is Perseus and two quasars in a Taurus constellation. Honestly speaking that work was like trying to find a black cat in a dark room – seeking for something well knowing that there is nothing. The frequency was too narrow, 8.3 minutes of ark. Therefore, there were no results.

Current observation was made together with Suren Eyramjyan (RF specialist). Then, on April 29th we had a short discussion of the results with Harro Verkouter and Kees Van't Klooster.

2. Harro Verkouter presented the results of the discussion regarding the last experiment

Kees Van't Klooster, Arevik Sargsyan, Suren Eyramjyan and myself, we discussed the experiment. Our point sources looking from the side loops of the antenna definitely look like that, and Kees Van't Klooster and myself, we have advised that we need to try those measurements a few times more to be sure that this is it the case – to repeat the same measurement every day and to see if the same pattern appears. There are different options for how to proceed. The decision of which one - say a 48-hour-long track or daily by 2-3 hours - that is at your discretion, because from my end, I have absolutely no idea what will be the best or the easiest arrangement at your end.

There is something more that we can do for the future, there are other options to explore, for example, using another digital receiver, but I think that only makes sense as the next step.

3. Leonid Gurvits: what is the best guess about the a priori knowledge of the pointing of the telescope, its current position?

Arevik Sargsyan: So, we know that according to measurements from the age of the spherical reflector, using till the lights, it is not so precise data, but we know that it is 1.5 degrees

to the North and 0.3 degrees to the West - 2 coordinates position, the Zenith angle. On East/West - 0.3 degrees to the West, Azimuth degree and declination. **Leonid Gurvits:** This is mechanical pointing of all the focal structures. **Arevik Sargsyan**: And we can change the position of West and East, and can't change the position of North and South.

John Sarkissian: How much you can move it on Azimuth exactly? **Arevik Sargsyan**: How much we want. But there is no need for that, because the Earth is rotating. **Leonid Gurvits**: Exactly. So, Azimuth is not that important. I mean you need to adjust the Azimuth angle to the specific declination. For East/West - the natural forces will take care of it, the only question is the timing of the process, which actually doesn't matter. You say that it is 1 degree North/South Zenith angle and something on Azimuth. Now, this is the first statistical momentum, the expectation, what is the precision of this value? **Arevik Sargsyan**: Plus-minus half degree, 30 arc minutes. **Leonid Gurvits**: Is it 1 sigma, 3 sigma, or what? Because if we talk about the source which is indeed compact, almost point light, then with this sort of uncertainty it will be difficult to catch it. **Arevik Sargsyan**: Yes, and that is why the test No3 was unsuccessful, but we remember about test No2 which was the base for the report of the AG last year. It was done for the Cygnus X loop and we have some certainty there, and as you remember we repeated the measurement after 13 days and got the same results with the shift of 54 minutes. The test No1 was partly successful: it was a 24-hour-long track with electricity supply problems. As Harro said, it is necessary to make another long-term observation with appropriate work with cables. During these tests we used the radio-receiver placed on the leg inside of the dish, close to the sub-reflector. During the next observation we should place it in the building, so we need some time for preparation, and it will be interesting maybe to see the repetition of the track.

4. **Arevik Sargsyan: If I understand well, Michael suggests another measurement, something like using the sub-reflector as a correlator. Is it the idea to have something on the upper side of the sub-reflector?**

Michael Lindqvist: I don't know where to place it, I just mean to avoid problems if those exist with pointing the telescope. You can have your own cosmic source which means that you can at least see what is coming through the system to the back-end and by that see the power of your back-end.

John Sarkissian: I'm not sure that the optics of the antenna is exactly, but we can object signal-in to check the entire signal path. It's good to have optics of your particular antenna.

Leonid Gurvits: The suggestion by Michael to use an artificial noise source can be done by a radio-engineer, it is very simple. Ultimately we will not be able to move until and unless the telescope can be pointed electromechanically in a normal way. Then will be the question of the calibration of the primary beam.

5. **Leonid Gurvits: Arevik, what is the prospect of fixing the electrical and mechanical problem of the motion? I think that's now the most critical thing.**

Arevik Sargsyan: We have all the necessary information about what is there, what happened and how to repair, and we have a plan of how to do that. We need our mechanical engineers to fix the mechanical problems with the axis, which could take one month, as it's not so difficult to do. Motors are in a good condition, it is necessary to solve the task with the supply of the electricity, maybe it'll be necessary to repair some cables coming to the motors, as we have motors on the axis. We need an additional few months for that.

6. Arevik Sargsyan: number one problem of our project

As you know, we need to have the governmental decision about the body who will own the facilities. Our activities in this direction continue almost 3 years, starting from Leonid Gurvits's visit [2018]. At this moment, thanks to our GR activities we are trying to do something new with two new players, as the Ministry of Economy can't be a locomotive before the Government. We met with the newly appointed Minister of HighTechIndustry [Hayk Chobanyan] and met with the newly appointed rector of the National Polytechnic University - both are interested in making a joint locomotive. We try to do our best PR/GR and try to join any possible forces for that. I know that it is not so easy to understand from your position how we are struggling against our Government.

We have also good results: we are organizing an International Working Group mainly for stressing, pressing and pushing our state bodies. We have AG's report, two supporting letters from the Board of Directors of the EVN JIVE. Now we try to make it wider: probably we will organize a big International Working Group on different issues (scientific, engineering, business development, legal, human resources issues, etc). Literally yesterday we had a Zoom meeting with three radio-astrophysicists from the US and Germany, who are Armenians from the Diaspora - Levon Pogosian, Vahe Petrossian from Stanford and Armen Sedrakian from Frankfurt. They looked through the papers I preliminary sent to them, they know about the AG. They ask to be a part of the Scientific Working Group together with you. They might be helpful, useful and try to organize and hold an explanatory conference and to start to write a White Paper for further funding opportunities etc.

John Sarkissian: How long before the ownership is resolved and you own the facility? And how much will it cost to refurbish the telescope? **Arevik Sargsyan**: We have no answer to the question of the ownership, we now want to get the right to start the legal aspect works that we plan to do. We have a lot of basic information and now need to start the administrative stuff. Because of new elections and the political situation in RA, we can't give an exact time estimation.

John Sarkissian: If not you, but the other body, who owns the facilities, what that body plans to do? **Arevik Sargsyan**: It'll be a separate state entity, mostly scientific oriented. It's impossible to say now which ministry will oversee that entity, but we go to an intergovernmental model, with a council with chairs for all stakeholders. Regarding the funding for HUSC, we estimate that around 20% will be received from the Government, 80% - by fundraising from the different sources, crowdfunding, sponsorships, etc. We already developed the project, we have the business concept. As a force from abroad, currently the strongest weapon is AG, but we aim to increase that force. This is a desirable development which we try to facilitate. We are asking for one year after the transition of facilities, for discussing with all stakeholders in our country and abroad and for forming the most effective managerial structure of the Herouni Center. **Karine Darbinyan**: If the question is "if not we, as a Jurisdiction Armenia Foundation, who will govern and handle the telescope", in that case the answer is that the telescope will remain at the disposition of the Ministry of Economy and the underline state CJSC, but in any cases I think it will be destroyed - the antenna, the telescope in a few years will be destroyed. At first, they currently have no project concerning the development and the maintenance of the telescope. The second question is that during our debates at the Parliament they publicly said that they see the future of the telescope by destroying it. So, there is no other player, only we are on the scene, as a body who wants to develop and to do something with this telescope, as in other cases it will just disappear. **John Sarkissian**: In order to save it and not to make it destroyed, you need to have an idea how much it will cost to refurbish it and put it into a position that we could use, at least at the point where we could move the axis and point it. **Arevik Sargsyan**: We have even more. You can see

it in detail in the business concept placed in Wiki. Currently it is estimated at 2.6mln US dollars (around 2mln euros) over a period of 5 years; starting from the second year after the start of the project we will be ready to join the EVN JIVE network. This amount is capital cost plus operational cost. Roughly speaking it makes 400 thousand euros per year or maybe more at the beginning. We ask from the Government for 0.2mln per year. **Leonid Gurvits**: There is a real danger that if this project is not going well, by the alternative ownership of the facility the interest there will be just to remove, destroy it and that's it. Now, in order to prevent this from happening, is there a need only for a governmental decision or is there a need for some other actions too? For example, if the facility is declared as a national historical monument, as happened with many telescopes actually, it is protected already and can't be destroyed. **Arevik Sargsyan**: Herouni did it in the 00s. It is a nationally protected monument. **Leonid Gurvits**: That's good news.

Leonid Gurvits: The second thing is that the new government will be installed only after the election, and the election is at the end of June [23rd of June]. What if anything can be done now in addition to the couple of letters which are already sent from us? We as an Advisory Group do not represent a Government which can talk to Government at the same level. We are experts who can advise somebody to do or not to do something else. In this situation we have no tools or leverage, but sending a letter supporting the initiative. We did so from the side of EVN. So, what else do you think could be done realistically to first preserve the facility and second to make possible at least the minimal refurbishment as was discussed? First things first, the pointing must be fixed mechanically, but it looks like it can't be done without the permission. Could this permission be achieved only when a new government is in place, sometime in the middle of summer/close to autumn? **Arevik Sargsyan**: We are now stressing our GR and forming an International Working Group with many sub-groups. And we are going to meet today's government during next weeks, before the election, represent the IWG and state permission for the IWG to make its activities including maybe mechanical repair, for being able to make the first sky tracks. Again with the aim to have an expert conclusion on the topic that this project is very important both for Armenia and for the world. Probably it will work, and probably during this season we will start to make the first maintenance works on the axis, simultaneously the preparation of the new control system which actually needs no big money, because we have some institutions which should help us in that work. Elections mean delay, again. **Leonid Gurvits**: Is there a chance to do this mechanical repair under an undefined ownership situation? The reason for this question is that more real, successful cases might be shown. **Arevik Sargsyan**: We will try to do that, this is our tactics and main idea with IWG.

Leonid Gurvits: From a technical perspective, what prevents us from presentively, clear, positive detection of the results is the fact that we can't point the telescope properly because there is mechanical malfunction. If this mechanical malfunction can be fixed, hopefully tests can be successful and this will significantly strengthen any voice in support of the initiative. Results will show that the telescope in principle provides detection and it works. It looks like it is in the interest of everybody involved in the project to put every effort to fix the mechanical problem, especially if it is not terribly complicated from an engineering perspective, then to repeat tests as quickly as possible. **John Sarkissian**: I agree. The strongest case you can make is to show good results with the telescope. And the imperative thing is to fix the mechanical side. That's the most we can do - to demonstrate the case of keeping it operating, then being closed down. **Harro Verkouter**: Maybe if you keep on taking measurements a whole week, even by the end of the week you might have something to show. At least it builds experience with the system, with taking measurements and analyzing them. And then, if by the time you get the mechanical thing fixed, you might be even allowed to do better. **Uwe Bach**: If you have again a 48-minutes track, you might see some correlation, the 4-minutes late arrival of the sources on next day also. **Arevik Sargsyan**: Agree with you, will try to make it in parallel. **Leonid Gurvits**: What is missing is the ability to move the telescope. That's the point.

7. **Uwe Bach: next steps and next meetings?**
Arevik Sargsyan: During May we plan to visit the site with the Minister of HighTechIndustry, who is interested in being the leader of the project and to present it to the Government. Currently different people from the Government help us to get permissions to visit the site and to organize different works there, but this does not cover the mechanical repair, of course. **Arevik Sargsyan**: We have a need not only in mechanical repair works, but also to manage works on the control system. **Arevik Sargsyan**: I have a speech at the EVN CBD meeting on Wednesday, at 12:00, I will present the case in that sense. **Uwe Bach**: Agree to meet at the middle of June, but depends on the meetings with the Ministry of HighTechIndustry and the rector of NPI.