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Concluding remarks

– A personal view –

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Abstract. The eighth edition of the VLVnT conference series has been organised in October 2018 in Dubna, Russia. We witnessed a very well organised workshop, with a multitude of presentations, sparkling with new results and ideas. This short document is meant to summarise a few observations and considerations relating to neutrino telescopes, rather than to highlight individual results or presentations.

1 Introduction

Those who are long enough in the field to remember the first VLVnT, 2003 in Amsterdam[1], may have used one of the rare calm moments during VLVnT 2018 to contemplate the development in these past 15 years. Where have we been then, and where are we now? In 2003, the AMANDA and the Baikal NT telescopes had demonstrated that neutrino detection in deep ice or water is possible. The next-generation instruments, however, were still far away. ANTARES in the Mediterranean Sea was in its first, difficult construction phase, IceCube was a plan, KM3NeT a vision and GVD not even that. Neutrino astronomy was the aspiration driving us.

Now we have a decade worth of data from ANTARES and IceCube, GVD and KM3NeT are under construction, and future plans for IceCube-Gen2 are becoming more and more concrete. IceCube has discovered a diffuse flux of cosmic neutrinos and the first astrophysical neutrino source. Neutrino astronomy has become real. In addition, neutrino telescopes have been found to be versatile instruments for investigating fundamental properties of neutrinos by assessing oscillations of atmospheric neutrinos – a new aspiration has materialised.

The three major key words that characterise my sentiments on these developments are: Pride, ambition, and cooperation.

2 Pride, or: what we have achieved

The IceCube discoveries mentioned above have changed the paradigm of neutrino astronomy: formerly, it was all about searches – now it is on observations. This development came just in the right time to secure the future of the field. In addition, the contemporary discovery of gravitational waves has highlighted the capabilities and importance of multi-messenger

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[1]http://www.vlvnt.nl/vlvnt2003.html

astronomy, which is gaining huge momentum and in turn gives a big push to neutrino astronomy. Reaching these successes required a long period of technical development, patience, and perseverance. The neutrino telescope community can and should be proud on these achievements, and on its determinedness to reach them. This is also true for the preparation of the next-generation neutrino telescopes: We needed and we need stamina and we had to and have to overcome problems, but indications are that we will succeed – another reason to be proud, particularly for the GVD team who presented first results and re-established Lake Baikal on the neutrino telescope world map.

The idea to use densely instrumented installations for precision neutrino physics with atmospheric neutrinos is much younger than that of neutrino astronomy, and when it first came up it was not taken serious by many established neutrino groups. This approach, however, has matured, also due to open, fruitful and successful cooperation between the "ice and water hemispheres". Let's take this as a guiding example for the future.

3 Ambition, or: what we want to achieve

Neutrino astronomy has become real, but we are at the very beginning of it. For most of the cosmic neutrinos, we don't know where they come from. From most hypothesised neutrino sources, we have not yet found a signal. There are no signs of neutrinos from GRBs, Galactic sources or dark matter annihilation. We will definitely need a lot of time and most probably larger telescopes to bring neutrino astronomy to fruition, maybe also new detection methods. We will need to intensify and further develop our use of computational methods such as machine and deep learning to get the most out of our data.

Most importantly: We do not want neutrino astronomy to come to an end with the current and currently planned instruments. We should therefore start considering a long-term program beyond GVD, KM3NeT and IceCube-Gen2, and we should do so soon. We should also foster the development of neutrino physics capabilities of neutrino telescopes as a program of its own right, not merely as a parasitic opportunity.

4 Cooperation, or: how we can achieve it

We have gone a long way from being competitors to becoming partners. In the future, big and expensive projects in fundamental science will compete with each other across disciplines, nations and communities – in other words, it will not be IceCube vs. KM3NeT, but maybe astronomy vs. gene technology. The report of the Science Council of Japan on the International Linear Collider (ILC)[2] is a prime example reflecting this development.

If we want to succeed, we need to get organised, to further enhance our level of cooperation, and to speak with one common voice. A successful example for such a process was the formation of the Gravitational Wave International Committee (GWIC)[3], which was instrumental in steering and synchronising gravitational wave research on a global scale, and with a time horizon of decades. A coherent effort including neutrino astronomy as well as neutrino physics may have good prospects in the "global science league". With the Global Neutrino Network (GNN)[4] we already have a very good starting point for this coordination process. If used with care and courage, GNN can be the right instrument for building our future strategy.

[2] http://www.scj.go.jp/ja/info/kohyo/pdf/koyjo-24-k273-en.pdf
[3] https://gwic.ligo.org
[4] http://www.globalneutrinonetwork.org