OPERA and the dance of neutrinos

On 23 September 2011, the OPERA experiment announced an unexpected measurement of the speed of neutrinos between CERN and Gran Sasso. This led to an impressive media coverage.

CERN

23 September 2011: during the seminar of the OPERA collaboration in CERN's main auditorium.

It is a long time since we know that neutrinos have a strange behaviour. But it is the first time that they show an ability to hit the headlines of most newspapers around the world. And it is not every day that physics is on the front page. Who could have predicted that « neutrino » would be the name of a particle known to everyone? Of course, it is far too early to talk about a discovery. No doubts, many physicists are skeptical with the result of these «speeding neutrinos». This is of course a very healthy attitude, since the results of the OPERA experiment were very unexpected. But it's already amazing to see the vast mobilization of the community to address this issue, both from the experimental and the theoretical points of view. The whole community is srutinizing this result, and there has not been a day without new papers published that attempt to find a possible explanation for the OPERA results. It is now really important that other experiments are able to get the same measurement in order to either contradict or confirm the OPERA result, since this is the only way to solve the issue. This, however, will take months to happen. >>

This month:

Next meetings:

> ASPERA Roadmap update event
21, 22 November 2011 - Paris

> Technology forum | Cryogenics, vacuum
March 2012 - Darmstadt

> Computing workshop forum
April 2012 - Hanover

But there is another question about these neutrinos. Were the OPERA collaboration and institutions supporting it right to communicate it? Some people complained about the huge impact of the OPERA result in the media. However, the vast majority of the media welcomed the transparency and honesty of how this result was presented to them. It was even possible in several countries to read editorials in high level daily newspapers, explaining the way science works, which is something that is rarely seen.

Actually, institutions involved adopted a low profile plan for communications on the subject, contrary to what is thought by many. And the objective was certainly not to present the OPERA result as a discovery. In addition, the result would be huge if it is confirmed, so there was no real need «to oversell» it. On the other hand, there was a real need for explaining what this result was and why it was discussed in the community, so it was just to set up some communications. It is also important to note that at no time the result was presented as a «discovery» by its authors, either any institution involved. Some big titles obviously used such words, but this was unavoidable. Moreover, it would have happened anyway, and probably

« I was very surprised by this result, especially since the neutrinos of the supernova 1987A have been detected roughly within an hour of the optical signal. If the derived speed at the CERN/Gran Sasso experiment was correct, the supernova neutrinos would have arrived four years earlier. However, I was really ecstatic about this publication with all data and measurement details. It is a great example for scientific transparency. On top of that, I really appreciate that the authors explicitly hesitated to give a physical interpretation of their measurements. Sometimes I just think that there might be a very small, simple effect that was accidentally ignored. »

Guenther Hasinger, director of the Institute for Astronomy, University of Hawaii (former director of the Max Planck Institute for Extraterrestrial Physics, Garching)

« The measurement of the neutrino velocity performed by the OPERA detector is a great example of synergy among different fields of research: neutrino physics, accelerator physics, geodesy and metrology. This collaboration allowed to measure the distance between the origin of the neutrino beam and an uncertainty of 20 cm over the 730 km travel path and establish a time-link between CERN and the Gran Sasso Laboratory with an accuracy of about 1 ns. The outcome has been a time of flight measurement with small systematic uncertainties: the relative difference of the muon neutrino velocity with respect to the speed of light was measured to be: $(v-c)/c=(2.48\pm 0.28(stat.) \pm 0.30(sys.))\times 10^{-5}$, with an overall significance of 6 σ.

However, despite the large significance of the measurement and the many checks conducted to look for instrumental effects and systematic errors, its potentially great impact on physics justifies great care and prudence. Therefore, OPERA will continue to investigate possible possible but yet still unknown systematic effects that could explain the observed anomaly. This will be conducted in parallel to the running in the CNGS beam to improve the measurement by increasing the statistics.

One can ask about the possible interpretations of the result. Nowadays the main interest of the Collaboration is to pin-down possible sources of unknown systematics and define a short/medium term experimental programme to further assess the result. The potential impact on science is too large to draw immediate conclusions or attempt interpretations. »

Pasquale Migliozzi, OPERA collaboration (INFN)

even more if OPERA had not communicated in such a way. Who can believe that the OPERA result would have remained shared only amongst physicists while nowdays any information is spreading like >>

wildfire through social networks? Even a few days before the CERN seminar, which took place in order to invite the community to srutinize the work of the OPERA collaboration, rumors started to emerge on some blogs.

Finally, there was probably no other choice for the OPERA colaboration. For any other result of less impact, the organisation of a seminar between scientists is quite natural and common. But in this case, the organisation of such a seminar, without explaining to people outside the field the principle of such an approach would most likely have been far much worse in the media.

At least the OPERA result has had the merit of showing how science works with its doubts, errors and successes. And it highlights as never before that astroparticle physics is a lively and very promising field, for future major discoveries. Thank you Mister Einstein. ■

Submitted by Arnaud Marsollier (CERN / IN2P3)

« A test of the effect with the same method and similar accuracy (by MINOS) cannot be expected before 2013; also T2K could add information. Also in IceCube we will look for superlunimal effects with different approaches. Actually, I do not believe that any of these experiments will provide a confirmation of superluminal neutrino velocities; but if yes, this would boost neutrinos to the top position of particle and astroparticle physics. LAGUNA, already now one of the «Magnificient Seven», would become the undisputed number One.

Thinking only about projects running or being planned at present would however be too shortsighted. Several theories may be able to account for the effect, from extra dimensions to quantum gravity. There would be ways to test predictions of these theories which are not necessarily related to neutrinos. I cannot speculate what these could be. But I am sure, that not only the present ASPERA roadmap, but many other roadmaps would have to be totally rewritten. »

Christian Spiering, Chairman of the ASPERA Scientific Advisory Committee

Grand unified forces: Helmholtz Alliance for astroparticle physics

An interview with Johannes Blümer, scientific spokesperson of the Karlsruhe Institute of Technology Center Elementary Particle and Astroparticle Physics (KCETA), Germany.

What's the goal of the new Helmholtz Alliance for astroparticle physics?

The goal is to unite the many efforts in astroparticle physics all across Germany and even beyond. We are 22 partners: The Helmholtz Centers KIT and DESY, 15 German universities, three Max Planck Institutes as well as the Institut AstroParticule et Cosmologie (APC) in Paris and the Kavli Institute for Cosmological Physics (KICP) of the University of Chicago.

How important is something like a relatively national alliance in the era of European or even global collaboration?

Helmholtz Alliances set the focus on the partnership between Helmholtz Centers and German universities. They are part of the Pact for Research and Innovation, a measure to improve science funding in Germany. But for sure, the scientific content is never national. I think with an alliance like this Germany can interact on the international stage as a very strong and visible partner.

You have almost two dozen partners in the alliance. How do you get a system like this running?

We organise the work in tasks. We have tasks for the main scientific topics, like the hot universe, the dark universe, astroparticle theory and technology. Then we have officers for the contact to LHC and to astronomy, for equal oppor- >>

tunities, for graduate student issues and administration. The day to day work of the alliance will be run by an Executive Board of relatively few people. For globally important issues there is an Alliance Member Board with one member per institution and with some elected representatives from the entire alliance. Of course, there is an international Advisory Board. So, this light and well proven structure is quite similar to the one of many international collaborations.

Was it a bureaucratic nightmare to set up this alliance?

No, it wasn't complicated because the driver is the common scientific goal to push forward the field of astroparticle physics. We have some discussions with the many legal departments. But I don't think that it is a real obstacle.

Where would you like to see the biggest progress within the next years: in the theoretical understanding, in better data or in new technologies?

That's a difficult question! [laughs] I have no preference. I would like to see any substantial progress.

Where would expect to see it?

That's extremely hard to say. For instance, dark matter is a discovery sector – and so are the others. But the key point is that the current observatories or big detectors are all somewhat at the lower limit of sensitivity and/or statistical power when compared to our wishes. A new discovery will not come in like a loud bang. It will sneak in with few events per year.

What's your personal driver to be in this field?

I just find it fascinating how the smallest particles and their properties determine the universe at large. And by observing one or the other you provide inputs to the other.

Will this alliance have an impact on the recruitment and education of young researchers?

I think it will have a significant impact. We have seen this already with the Virtual Institutes that have been active some years ago. The spirit of these institutes was still alive when we formed the new Helmholtz Alliance. If we have open positions we can always say it is part of the Helmholtz Alliance for astroparticle physics etc. Helmholtz benefits as well, because the Association gets even more visible as a brand in astroparticle physics. We will make considerable efforts to lift the support of young scientists and research training of our about one hundred doctoral researchers to the highest possible level, all across the alliance.

You get additional funding of about ten million Euros for the next five years. How will you invest the money?

We have an elaborated plan that defines how we distribute the money. It is clear that a significant amount of it will go into salaries for people. A smaller part will be invested in buying hardware. There are also significant >>

resources for visiting scientists, for mobility, for equal opportunities. We manage all this jointly in the so-called Backbone.

Are you open for new partners?

Yes we are. A living network should never be a «closed shop» and so we will seek ourselves to identify more partners and we invite individuals, institutes and organisations to contact us. Together we achieve more! Limited funds are of course a concern, but we look into the future - a bright future, I believe. ■

Submitted by Dirk Lorenzen

Recently in the news...

The Nobel Prize in Physics 2011 | nobelprize.org
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Neutrini. Un nuovo laboratorio per studiarli | illuminotecnica.com
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España participará en el gran observatorio subterráneo de neutrinos | europapress.es
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«Estaremos a unos 70 grados bajo cero y con sol todo el día» | elperiodicodearagon.com
http://s.aspera-eu.org/rqz418

Deeper in underground physics

Deep underground laboratories are key infrastructures for astroparticle physics in areas such as dark matter search or neutrino physics which are truly “hot topics” with high competition, but also allow for interdisciplinary research like environmental sciences, geophysics… A meeting was organised in Saragossa and Canfranc in June 2011 to discuss views in this area, both at the European and global levels.

Deep underground laboratories are highly valuable shelters to search for very rare phenomena in nature, seeking to reveal some of the fundamental missing answers to our understanding of physical laws governing the construction and operation of the Universe. The first clear evidence for physics beyond the Standard Model came from discoveries made in underground laboratories charged with investigating cosmic rays and solar neutrinos. They established that neutrinos are massive particles and flavour lepton numbers are not conserved. It is thus not by chance that the European roadmap for astroparticle physics emphasises the need for strengthening the coordination of deep underground laboratories activities at the European or even international levels. It is particularly important considering the large infrastructures expected in Europe in the future such as, EURECA and DARWIN, the next generation dark matter projects, or LAGUNA, the large project for neutrino astrophysics and proton decay.

Europe has had a pioneering role in constructing underground laboratories since the early 1980’s, and at the present time the Italian National underground laboratory of Gran Sasso (INFN) is the largest such facility in the world. With the forthcoming projects, European scientists will continue to play a leading role in this field.

Fully dedicated to the deep underground laboratories projects, a workshop was organised in Saragossa >>

and Canfranc from 30 June to 2 July 2011. It was focused on neutrinos properties, dark matter search and stability of protons as well as on interdisciplinary research, with for objective to discuss about linking and coordinating more such activities, both at the European and the global levels.

The event brought together experts from 16 countries in Europe, America and Asia. The relevant ongoing and especially forthcoming projects in the largest worldwide underground laboratories on the above topics in the four continents were presented and discussed. All programs in the 11 deep underground laboratories in the world were reported upon: LNGS (Italy), LSM (France), LSC (Spain), Boulby (united Kingdom), DUSEL (United States), SNOLAB (Canada), ANDES (South America), Baksan (Caucasus), Kamioka (Japan), Jin Ping (China), Yangyang (Korea). The programme comprised a series of invited plenary talks, a round table session and a visit to the renovated Spanish underground laboratory of Canfranc.

This event offered an excellent opportunity in making progress towards the coordination of the European roadmap with relevant roadmaps worldwide. In particular, it opened very rich discussions in the way to develop strategic partnerships with strong international partners and synchronize the decision making process for major coming projects. ■

Submitted by Bijan Saghai (CEA - France)

Website & presentations: http://s.aspera-eu.org/DUGLs

Entry of Frejus' tunnel in France in the middle of which is located the underground laboratory of Modane (LSM) - Shielded by the Earth's crust, deep underground laboratories offer an environment where undesirable cosmic ray interactions are all reduced to operationally tolerable levels. Consequentially, the main reason for using deep underground laboratories to perform sensitive astroparticle experiments is that the cosmic rays muon flux decreases almost exponentially with increasing depth of rock overburden. Moreover, the neutron flux, due to Uranium and Thorium fissions in the rock, though dependent on local geology is in any case smaller underground than on the surface (Credit: LSM/IN2P3).

ASPERA Roadmap event - 21/22 November 2011 - Paris

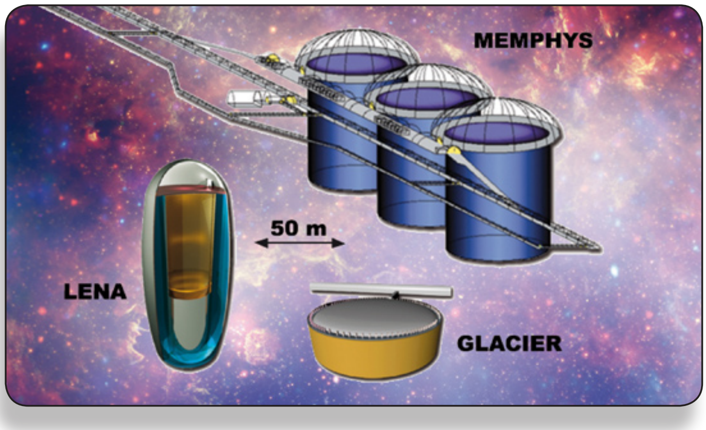
European Strategy for Astroparticle Physics

The Scientific Advisory Committee (SAC) prepared a complete draft of the update of the ASPERA road-map. The new roadmap, entitled "European Roadmap for Astroparticle Physics", will be presented on the 21st and 22nd of November 2011 at the Collège de France in Paris. This workshop will provide a unique opportunity to discuss how the priorities of European Astroparticle Physics are embedded in the European Large Infrastructure policy (ESFRI, CERN, ESO, ASTRONET), the synergies with more applied discipli-nes as e.g. the Geological or Environmental Sciences, as well as computing and industrial transfer actions.

> More information: http://s.aspera-eu.org/qK4fP9

A new step forward for LAGUNA

The second phase of the LAGUNA design study started officially on 18 October 2011 with a kick off meeting held at CERN. LAGUNA is the European project for a large volume underground neutrino detector.



Three liquid options are studied for LAGUNA: water (MEMPHYS), argon (GLACIER) or scintillator (LENA).

Underground neutrino detectors based on large liquid volumes have achieved fundamental results in particle and astroparticle physics, and were able to simultaneously collect events from several different cosmic sources. Neutrinos interact only very weakly with matter so they can travel very large distances in space and traverse dense zones of the Universe, thus providing unique information on their sources and an extremely rich physics programme.

In order to move forward, a next-generation very large multipurpose underground neutrino observatory of a total mass of around 100 000 to 500 000 tons is needed. This new facility will provide new and unique scientific opportunities, very likely leading to fundamental discoveries and attracting interest from scientists worldwide.

The principal goal of LAGUNA (Large Apparatus for Grand Unification and Neutrino Astrophysics) is to assess the feasibility of such a pan-European research infrastructure able to host the next generation, very large volume, deep underground neutrino observatory. The scientific goals of LAGUNA combine exciting neutrino astrophysics with research addressing several fundamental questions such as proton decay and the existence of a new source of matter-antimatter asymmetry in nature, in order to explain why our Universe contains only matter and not equal amounts of matter and antimatter.

This further step newly includes the study of long baseline neutrino beams from CERN accelerators. When coupled to such a neutrino beam, the neutrino observatory will measure with unprecedented sensitivity neutrino flavor oscillation phenomena and possibly unveil the existence of CP violation in the leptonic sector.

LAGUNA will detect neutrinos as messengers from further distant astrophysical objects as well as from the early universe. In particular, it will sense a large number of neutrinos emitted by exploding galactic and extragalactic type-II supernovae. It will also allow precision studies of other astrophysical or terrestrial sources of neutrinos, such as solar and atmospheric ones, and will search for new sources of astrophysical neutrinos like, for example, the diffuse neutrino background from relic supernovae, or those produced in hypothetic dark matter particle annihilation in the centre of the Sun or the Earth. Furthermore, it will allow unprecedented search for the proton lifetime with sensitivities up to 10^{35} years, pursuing the only possible path to directly test physics at the grand unified theory scale.

Called LAGUNA-LBNO, this design study is funded by the European Commission under the 7th Framework Programme and will last three years. LAGUNA is one of the Magnificent Seven , the large infrastructures included in the ASPERA Roadmap.

LAGUNA-LBNO brings together 300 scientists working at CERN and in 38 other institutions from Finland, France, Germany, Greece, Japan, Italy, Poland, Romania, Russia, Spain, United-Kingdom and Switzerland. It is coordinated by André Rubbia from ETH Zurich. ■

>> More about LAGUNA: http://www.laguna-science.eu/