Survey of interdisciplinary collaborations between ApP experiments and other fields

Proceedings of the interdisciplinary workshop with presentations, summary of discussions and guidelines for improving interdisciplinary collaborations

Proposal/Contract no.: 235489

Project coordinator name: Thomas Berghöfer

Project coordinator organisation name: PT-DESY (Projektträger DESY)

Work Package 3

Deliverables D3.1 and D3.3

February 13, 2011

Bernard Revaz

Maurice Bourquin

Bijan Saghai

Preliminary Note

This document contains the deliverables D3.1 “Survey of interdisciplinary collaborations between ApP experiments and other fields” due for June 2010 and D3.3 “Proceedings of the interdisciplinary workshop with presentations, summary of discussions and guidelines for improving interdisciplinary collaborations” due for June 2011.

The deliverable D3.1 had to be postponed due to late replies to the survey. As the workshop took place in December 2010 and as the corresponding deliverable D3.3 is now ready, we decided to combine both deliverables in one document. The content of the deliverable D3.1 in included in the chapter 3 of the present document, while the chapters 2, 4, 5 and 6 constitute the deliverable D3.3.

1. Introduction

Astroparticle physics (ApP) covers a wide spectrum of activities. These activities have risen during the last 20 years from largely speculative statements to a high level and well recognized field of research where Europe is definitely a leader. This new field of research has developed interfaces with a remarkable number of environmental sciences: atmospheric physics and chemistry, climatology, geology, seismology, planetary sciences, volcanology, marine biology, oceanography, glaciology, space weather, and biology in extreme conditions. The high quality of the research, the number of disciplines involved, and the impact of the research for questions of social concern motivate a proactive attitude by ASPERA to foster and accompany these research activities. The goal of this document is to report on the activities conducted in the frame of the WP3 of ASPERA-2 in view of building active synergies between ApP researchers and environmental sciences.

The dialogue between particle physics and environmental sciences has a long and rich history. The most illustrative figure of this dialogue is probably the scientist C.T.R. Wilson: C.T.R. Wilson started his investigations on the electrical conductivity of the atmosphere, a very important topic at the end of the 19th century in the foggy highlands of Scotland. Wilson was struck by the beauty of coronas and "glories" (coloured rings surrounding shadows cast on mist and cloud), and he decided to reproduce these natural phenomena in the laboratory. This research, based on the imitation of meteorological phenomena in the laboratory, resulted in one of the most important tool of particle physics, namely the cloud chamber. The experiment CLOUD, whose goal is to reproduce and quantify the effect of the cosmic rays on the climate changes in the confined environment of the CERN laboratory, uses a similar approach with the technologies of our time and in the present context of a strong demand for more extensive information on climate changes.

While C.T.R. Wilson was confining the atmosphere in his chambers and bringing them to the laboratory, ApP is going the other way around: it is taking the tools of particle physics from the confined environment of the laboratory into the natural environment to study the particles of the cosmos. What is of particular interest in this move from the lab to nature, is the extensive use of the material of which the environment is made, which is turned into an ally, a tool, or a proxy to perform scientific experiments. Few examples, the atmosphere, the ice cap or the sea are used as a Cerenkov radiation media in the astroparticle telescopes (MAGIC, HESS, CTA, IceCube, Antares, Nemo, Nestor or Baikal). Similarly, the atmosphere becomes a fluorescence medium in the Pierre Auger Observatory. Mountains are turned into shields to protect experiments devoted to the detection of rare events in the underground labs, etc. It should be noted that this attitude towards the environment contrasts with that of optical astronomy, where the atmosphere is exclusively an obstacle to the observation of cosmic objects.

Using the environment as a particle detector implies that its properties are known with accuracy, and monitored so that its state can be taken into account in the determination of the particle interactions. Extensive research for that purpose are performed within the Pierre Auger Observatory, IceCube, Antares, and NEMO collaborations. There is something very deep, and fascinating in this relation, which is restoring a continuity between the study of the cosmos and the study of our environment, and it is this that we wanted to capture in the title of the workshop that ASPERA has organized on this subject “From the Geosphere to the Cosmos”.

We now want to be more specific on what is of interest for environmental sciences, particularly on the key characteristics of ApP infrastructure that are of interest for environmental sciences. We identified four such features:

1) Access to remote or hostile environment in which the ApP infrastructures are operated. It is obvious that we live in a word where sensors are more and more present and interconnected, but deploying sensors in remote or hostile environment (ice cap, abysses, deserts, caves, space) will always be, by definition, a difficult and costly task. So, sharing these infrastructures, as is already done in Antares, Nemo, Nestor or IceCube, is a bonus in the use of public resources.

2) Competence in complex sensing systems, such as particle detectors, developed for these infrastructures that may be used for environmental research.

3) Technologies allowing the process of large quantities of extremely pure and/or exotic materials, such as those developed for the detection of rare events (dark mater, neutrinoless double beta decay …).

4) Systems for data acquisition, processing, and dissemination that are developed for these projects.

As a consequence of the importance of these existing and foreseen activities at the interface between ApP and environmental sciences, ASPERA has included in the Road Map for the development of ApP in Europe, the strengthening of the relations with the environmental sciences. In ASPERA-2, a specific task T3.1 is devoted to the implementation of an active interface between the ApP researchers and the other scientific fields. This report details the actions performed in that frame.

2. Survey

Purpose of the survey

A questionnaire has been sent to the spokespersons of the European ApP experiments and to the directors of the European laboratories hosting ApP experiments with the aim of mapping the running projects involving ApP and environmental sciences. The present chapter summarizes and analyses the replies to this questionnaire.

Questionnaire

The questionnaire has been prepared by the participants of WP3 and approved by the ASPERA JS. It was sent to 50 experiments and infrastructures. It can be concluded that all known European ApP activities are covered by this survey, with the exception of the ApP theory activities. The questionnaire is available in an appendix.

Replies

The replies to the questionnaire allow identifying 30 different interdisciplinary projects. These projects are listed in Table 1. The ApP infrastructures in relation with these projects are the Pierre Auger Observatory, ANTARESCube, KM3Net, and NEMO, and the underground laboratories LNGS and LSM.

Conclusions drawn from the survey

- **The environmental sciences involved in the 30 projects from which replies have been received are oceanography, seismology, climatology, volcanism, glaciology, atmospheric physics and chemistry, meteorology, geodynamics, tectonophysics, environmental radioactivity, toxicology, and biology.**

This confirms the great diversity of the environmental fields involved in collaborative research with ApP projects and infrastructures. Note that the space experiments are not completely covered by the questionnaire. As a consequence, research fields such as biology in space conditions or space weather are not described here. These topics have been presented in the workshop by the ARGO-YBJ collaboration.

- **The interdisciplinary projects that are visible in this survey are related to large ApP infrastructures (Pierre Auger Observatory, ANTARES, IceCube, KM3Net, and NEMO, and the underground laboratories LNGS and LSM).**

It is likely that smaller projects have to be more focused and therefore are less inclined to include interdisciplinary research. Because of their scale, large infrastructures have more flexibility to integrate interdisciplinary activities. Some large infrastructures have opened their facilities to interdisciplinary research through formal contracts with organizations, such as LNGS. There are incentives by the agencies or by the EC to do so.

- **The majority of existing or future large ApP infrastructures have integrated synergies with environmental sciences in their strategy, activities and/or in their agenda.**

The following list gives examples of actions taken by agencies or ApP collaborations in view of supporting the scientific activities at the interface between ApP and the environmental sciences:

1. The LNGS and the National Institute of Geophysics and Vulcanology have signed an agreement for the utilization of the Gran Sasso infrastructure for geophysics research. The agreement is available at the following link: server11.infn.it/ctt/Documenti/ingv.pdf. In addition, LNGS has been recognized by the European Union (EU) a Major Research Infrastructure. In the frame of the TARI (Transnational Access to major Research Infrastructures), the laboratory hosts environmental sciences research (For instance the Groundwater Radon Monitoring project).
2. Antares is organizing its marine research activities within the MEUST network.
3. The NEMO SN1, within the NEMO infrastructure, is a multidisciplinary platform for deep sea research.
4. The projected large ApP infrastructures KM3Net (deep sea research), CTA (atmospheric physics) and LAGUNA (geoneutrinos) have integrated interdisciplinarity as a part of their future activities. These projects have specific WP devoted to the organization and planning of interdisciplinary research within the future research infrastructure.
5. THE PIERRE AUGER OBSERVATORY is organizing a workshop on the use of the Observatory as a site for interdisciplinary Science (April 2011)
6. With respect to the UG labs involvements in environmental sciences research, information has been collected through the ASPERA task T2.3 on the linking of the infrastructures.

- **Half of the projects are already financed as interdisciplinary projects**

Half of the projects (15) identified in the survey are supported by interdisciplinary programmes. Therefore, there already exists experience in the support to the synergies between ApP infrastructures and environmental sciences among the ASPERA members (esp. INFN, CEA, and CNRS).

- **Models of interaction between ApP projects and environmental sciences**

Part 9 of the questionnaire was aimed at better defining how the ApP activities and the environmental sciences are connected in the interdisciplinary projects. The results are reported in Table 2. These data show that the interaction can be described by various models. We describe below two extreme cases.

A first model, that we call the “multidisciplinary platform”, has two main characteristics: Firstly there is a transfer of technologies and methodologies from the ApP domain towards the environmental sciences, and, secondly, the project is fully motivated by a scientific problem defined within the environmental sciences. The key features of this model are: the application of specific sensors for environmental science research on existing ApP infrastructure (0 in column 1, 1 in column 2) and the use of ApP data for environmental sciences research (1 in column 4). In this model, ApP scientists collaborate with the environmental scientists (1 in column 5) but the results of the environmental science are not of direct interest for ApP research (0 in column 6). Typical examples of this model are the marine science projects at Antares.

In a second model, that we call the “integrated project”, the environmental science project is intimately linked to the ApP project (1 in column 6). In that case, the ApP physicists develop or apply procedures and technologies for the environmental research, appropriate them, and integrate them in their own infrastructure. A typical example is the atmospheric science at The Pierre Auger Observatory, where the project is using high end equipment developed for atmospheric physics. It is interesting to note that in The Pierre Auger Observatory, the competence in atmospheric physics has been developed within the collaboration. The scientists in charge of these activities are now integrating the community of atmospheric physics and chemistry. These “integrated projects” are double sided: firstly they are aimed at supporting the ApP collaboration by providing the required understanding of the media used for the ApP physics and secondly they target scientific issues within the environmental science domain.

Table 1

Infrastructure	Project	Contact person	Field
Antares 1	Deep sea bioluminescence	Ivan Dekeyser	Oceanography, Marine biology
Antares 2	Pressure effects on marine prokaryotes, ANR Potes	Christian Tamburini	Oceanography, marine microbial ecology
Antares 3	Euro SITES Integrated European network of deep sear observatories	Christian Tamburini	Oceanography
Antares 4	AAMIS	Christian Tamburini	Oceanography, bioluminescence
Antares 5	Seasonal survey of O dynamics in deep sea OPERA Dark Vador	Dominique Lefèvre	Oceanography
Antares 6	Deep sea acoustic transmission line ALBATROSS	Dominique Lefèvre	Oceanography
Antares 7	Deep sea broadband seismometer	Anne Deschamps	Seismology
Antares 8	Deep sea bioacoustical signals observation	Michel André	Marine biology
NEMO 1	NEMO-SN1	Paolo Favali	multidisciplinary (Geology, geophysics, vulcanology, seismology)
NEMO 2	NEMO-OnDE	G. Pavan, E. Migneco	Bioacoustics, marine mammals detection
NEMO 3	ESONET/LIDO-DemoMission	Michel André	
IceCUBE Atmo	Boreholes optical logging of dust and volcanic dust	Budford Price	Climatology, volcanism, glaciology
IceCube Glaciology	Shear rate of ice	Ryan Bay	Glaciology
IceCube Glaciology	Windborne microbes in ice	Budford Price	Microbiology, origin and evolution of life

IceCube Glaciology	Monitoring of the stratosphere with muons	P. Desiati/S.Tilav	Atmospheric physics, climatology, meteorology
LNGS 1	ERMES Environmental Radioactivity monitoring for Earth Sciences	W. Plastino	Earth Physics, seismology, volcanology, geodynamics, tectonophysics, atm. Physics, meteorology, oceanography, climatology, env. Radioactivity, radiodating
LNGS 2	GIGS Geodetic extensometers	L. Crescentini	Seismology, geodesy, geophysics
LNGS 3	Natural radioactivity in soils	D. Magaldi	geology
LNGS 4	Environmental radioactivity	E. Fiorini	Env. Radioactivity, radioactivity protection
LNGS 5	UNERSEIS Seismic array	R. Scarpa	Geophysics, seismology
LNGS 6	Measurement of traces using IC plasma mass spectroscopy	E. Previtali	Geology, biology, environmental and material sciences, archaeometry
LNGS 7	Measurement of As traces in biological samples	E. Fiorini	Toxicology, biology
KM3Net	Deep sea observatories for earth and sea sciences	E. Migneco	Geology, geophysics, seismology, biology, oceanography, climatology
AUGER 1	State variables of the atmosphere	B. Keilhauer	Atmospheric physics
AUGER 2	Optical transmittance of the atmosphere	L. Wiencke	Atmospheric physics
AUGER 3	Optical extinction of the atmosphere	M. Prouza	Atmospheric physics
CTA	(no reply)		Atmospheric physics (cloud camera, Raman lidar)
LAGUNA	(no reply)		Geoneutrino physics, geophysics

Table 2: Results of part 9 of the questionnaire (0: No, 1: Yes, 2: Partly)

	env.scientists participated in the conception of the ApP infrastructure from the beginning	sensing systems for env. science are added on to existing ApP infrastructure	specific modules have been added on particle physics detectors for env. science	raw ApP dat used for env. science purpose	Particle physicists contribute to data processing for env. science research	Env. science results have been used for the ApP data analysis
Auger 1	2	1	0	0	2	1
Auger 2	1	1	0	2	2	1
Auger 3	0	1	0	0	1	1
Antares 1	2	1	1	1	1	2
Antares 2	0	1	1	1	1	0
Antares 3	0	1	1	1	1	0
Antares 4	0	1	1	1	1	2
Antares 5	0	1	1	1	1	0
Antares 6	0	1	1	0	1	0
Antares 7	0	1	1	0	1	0
Antares 8	0	1	1	1	1	0
Nemo 1	2	1	1	1	1	2
Nemo 2	1	1	1	1	1	1
Nemo 3	2	1	1	1	1	1
LNGS 1	1	1	1	1	2	2
LNGS 2	1	1	1	0	2	2
LNGS 3	0	0	0	0	1	0
LNGS 4	1	1	1	0	2	1
LNGS 5	1	2	1	1	1	0
LNGS 6	1	2	2	0	1	0
LNGS 7	1	2	0	2	1	2
IceCubeAtmo	0	0	0	1	2	1
IceCube Glacio	0	1	1	0	0	2
IceCube Glacio	0	1	1	0	1	1
IceCube Glacio	0	0	0	0	2	0

3. Workshop

Introduction

A workshop has been organized by ASPERA in Paris, in Le Palais de la Découverte on December 1-2, 2010. The goal of the workshop was to invite the scientific communities and the funding agencies to discuss how these synergies can be promoted and encouraged for the development of science and to the benefit of society.

The expected outputs of the workshop were twofold:

- Firstly, to prepare a working document for the funding agencies and the ApP projects on the collaborative research within these infrastructures;
- Secondly, to publicize the potential of the ApP infrastructures for collaborative research within the scientific community.

Programme

The programme covered a largely significant number of the most important topics that had been identified in the survey. The titles and the speakers of the talks of the workshop are given in the Table 3. The speakers came from Europe, USA, China, and Russia. The abstract of the talks are available in the appendix while the slides can be downloaded on the website of the conference http://indico.cern.ch/conferenceDisplay.py?confId=109104.

Table 3

Subject	**Speaker**
Atmospheric physics at Auger	B.Keilhauer (Germany, KIT)
Cosmic rays and climatology	U.Baltensperger (Switzerland, PSI)
Correlation of ultra-high energy cosmic rays with lightning	P. Krehbiel (USA, New Mexico Tech)
Marine sciences at Antares	P.Coyle (France, CNRS-CPPM)
Geoneutrino physics and nuclear activities monitoring	D.Lhuillier (France, CEA - Saclay)
Bioacoustics and geophysics at NEMO	G.Riccobene (Italy, LNS-INFN Catania)
Muon radiography applied to volcanology	J.Marteau (France, IPN-Lyon)
Cosmic ray-produced radionuclides in Earth sciences	T. Dunai (Germany, Univ. of Cologne)
ARGO-YBJ: a straightforward approach for space weather forecasting	Z.Cao (China, IHEP)
Environmental sciences in glacial ice	B. Price (USA, UC Berkeley)
Gravitational wave antennas and seismology	P.Lognonné (France, IPG Paris)
ApP and associated sciences at LNGS	L.Votano (Italy, LNGS)
ApP and associated sciences at LSM	F.Piquemal (France, LSM)
Laguna, a design study for a Large Apparatus for the	F. von Feilitzsch (Germany, TUM)

search for Grand Unification and Neutrino Astronomy	
CTA, associated sciences and energy considerations	S.Nolan (UK, Univ. of Durham)
AGILE: terrestrial gamma-ray flashes as powerful particle accelerators	M.Tavani (Italy, INAF and Univ. of Rome)
BAIKAL: an underwater laboratory for ApP and environmental studies -	Prof. N.Budnev (Russia, Irkutsk State Univ.)

Impact of the workshop

The success of the workshop is testified by the large number of registered participants (98) coming from many European countries..

A press conference has been organized by Arnaud Marsollier, the Press Officer of ASPERA. The press conference focused on the three following topics:

•LIDO - for listening to the deep sea environment from home over the internet,

•The CLOUD experiment at CERN, which studies the impact of cosmic rays on clouds and climate,

•3D-radiography projects for volcanoes, using particle detectors.

Following this event, articles on the workshop have been published in journals and newspapers, including Le Monde, Le Figaro, The Economist, Der Spiegel, Le Temps (…)

Roundtable of the workshop

(To be completed)

Discussion

The discussion was aimed at exchanging the experience and the opinions of the member of the community on the interdisciplinary activities. The following topics have been discussed by the participants and some of their comments on these topics are presented below.

1) Is there something common across these activities?

The majority of the participants agree that participating to this Workshop and exchanging point of views and experience on their activities was useful. One participant notes that the topics are very diverse, which makes the exchange difficult.

2) Impact on environmental sciencies:

Riccobene and Coyle say that the associated fields are not structured the same way as astroparticle physics, they are more fragmented. Actually the interaction with ApP helped these fields to become more structured through the requirements set by large experiments. Another example is the proposal for using the Grid for the data dissemination in submarine acoustics. Concerning the acoustic measurement, the possibility to use real time and permanently deployed sensors has changed the mode of operation of the biologists involved in these projects: beforehand, the measurements were performed on a one shot basis, usually with an R.O.V. sent to the sea with a data logger, which was analyzed afterwards. The atmospheric monitoring at the Pierre Auger Observatory offers interesting data for atmospheric physics. What is needed in terms of time resolution is different (short times for Auger vs longer averaging for atmospheric physics). Tibor Dunai says that his field (isotope geochronology) requires more precise data in the geographical distribution of low energy cosmic particles. This is not of strong interest for cosmic rays physics but very relevant for his field.

3) Data dissemination and Standards of the associated fields

Lognonne says that the question of the data format and rapid dissemination is an issue across what he saw during the meeting, for instance the seismic data of Baikal, he would like these data be integrated in seismic networks. Similarly, Watson says that he was not aware when he did the atmospheric monitoring equipment for Auger that the integration in meteorological network requires an English standard (albedo, etc) to be considered (see talk by B. Keilerhaus) : the equipment used for this measurements are standard meteo instruments but the environment has to be designed according to standards, which is not the case. P. Krehbiel says that the lightening monitoring is still at the research level, there are yet no standard (meteorological, aeronautics) but it is likely that it will be. Space weather alert systems using cosmic rays are even more long term. Xx says that there are examples of implementation of open data in the ApP infrastructures (for example the SN monitoring).

4) Continuation of the workshops/conferences “From the Geosphere to the Cosmos”

A majority of participants agree that it is worth doing a continuation of this workshop. In ten years, this field has raised from a very speculative lists of possible subjects of research to high quality scientific achievements. Therefore, an event fully devoted to this field is desirable (not a subsection of another conference). M. Bourquin asks who would fund these conferences, as ASPERA is not supposed to support scientific conferences.

5) Relations with the ” 7 Magnificents”

Thomas Berghöfer insists that the role of ASPERA is to fund the 7 Magnificent. He wants the participants to go back to their agencies and see how the associated sciences can help to support these.

6) How can we assess the relevance of these topics for the associated sciences?

Few participants ask about the relevance of the topics presented in the workshop for the associated field and how this can be assessed. M. Bourquin says that the organizing committee was fully aware of this question and has invited experts of the associated fields to participate. (Lognonne, Dunai, biologists collaborating with Nemo and Antares). Riccobene says that he came to the workshop with biologists collaborating with him.

7) Integration of the ApP scientists in the associated sciences

B. Keilhauer describes how the Auger scientists have been slowly integrating in the small atmospheric fluorescence community. The process is slow. It took about 8 years to be integrated; typical things to assimilate are very specialized computational skills for the calculation for fluorescence. In this case, the “ApP scientists” are making use of the methodologies and the equipment developed by atmospheric physicists or chemists.

8) Interdisciplinarity

F. van Freilitzsch says that when working between disciplines we have to accept that we cannot be excellent in all the relevant fields, he gives the example of particle physics and geology in the field of geoneutrinos.

4. Actions

The scientific activities at the interface between ApP and environmental sciences have been shown to be a rich field with many scientific achievements of high quality. Promoting these activities and inviting scientists to propose new projects is therefore desirable. As a first step in this direction, ASPERA will edit a glossy paper describing 1) the main scientific achievements at the interface between ApP and the interdisciplinary sciences and 2) the facilities and the infrastructures (existing and future) where these activities can be conducted. The required documentation can be selected from the documents collected during the activities of Task 3.1. The glossy paper will be distributed in the agencies and ministries of ASPERA and in the communities.

5. Overall conclusions

The general impression is that of a very exciting meeting. Several scientists from environmental sciences claim that many topics benefit largely from expertise, technologies and infrastructures built for Astroparticle physics. Another such workshop should be organized, although a supporting institution has not been identified.