Project Number 1	212343	Project Acronym 2	LAGUNA

SEVENTH FRAMEWORK PROGRAMME

THEME RESEARCH INFRASTRUCTURES

FP7-INFRASTRUCTURES-2007-1

Grant agreement for: Collaborative Project

Annex I – "Description of Work"

Project acronym: LAGUNA
Project full title: **Design of a pan-European Infrastructure for Large Apparatus studying Grand Unification and Neutrino Astrophysics**
Grant agreement no.:

Date of preparation of Annex I (latest version):
Date of approval of Annex I by Commission:

List of Beneficiaries

Beneficiary no.	Beneficiary name	Beneficiary short name	Country	Date enter project	Date exit project
1. (coordinator)	Swiss Federal Institute of Technology Zurich	**ETH Zurich**	Switzerland	1	24
2.	University of Bern	**U-Bern**	Switzerland	1	24
3.	University of Jyväskylä	**U-Jyväskylä**	Finland	1	24
4.	University of Oulu	**UOULU**	Finland	1	24
5.	Kalliosuunnittelu Oy Rockplan Ltd	**Rockplan**	Finland	1	24
6.	Commissariat à l'Energie Atomique / Direction des Sciences de la Matière	**CEA**	France	1	24
7.	Institut National de Physique Nucléaire et de Physique des Particules (CNRS/IN2P3)	**IN2P3**	France	1	24
8.	Max-Planck-Gesellschaft zur Förderung der Wissenschaften e.V.	**MPG**	Germany	1	24
9.	Technische Universität München	**TUM**	Germany	1	24
11.	H.Niewodniczanski Institute of Nuclear Physics of the Polish	**IFJ PAN**	Poland	1	24

	Academy of Sciences, Krakow				
15.	KGHM CUPRUM Ltd Research and Development Centre	**KGHM CUPRUM**	Poland	1	24
16.	Mineral and Energy Economy Research Institute of the Polish Academy of Sciences	**IGSMiE PAN**	Poland	1	24
17.	Laboratorio Subterraneo de Canfranc	**LSC**	Spain	1	24
27.	Universidad Autonoma, Madrid	**UAM**	Spain	1	24
19.	University of Durham	**UDUR**	United Kingdom	1	24
20.	The University of Sheffield	**USFD**	United Kingdom	1	24
21.	Technodyne International Ltd	**Technodyne**	United Kingdom	1	24
23.	University of Aarhus	**U-Aarhus**	Denmark	1	24
24.	AGT Ingegneria Srl, Perugia	**AGT**	Italy	1	24
25.	Institute of Physics and Nuclear Engineering, Bucharest	**IFIN-HH**	Romania	1	24
26.	Lombardi Engineering Limited	**Lombardi**	Switzerland	1	24

PART B

B1. Concept and objectives, progress beyond the state-of-the-art, S/T methodology and work plan

B.1.1. Concept and project objectives

Neutrinos are messengers from astrophysical objects as well as the Early Universe and can give us information on processes happening in the Universe, which cannot be studied otherwise. The first successful detection of neutrinos from the supernova SN-1987A by the Kamiokande underground experiment (Japan), recognized with the Nobel Prize in 2002, has opened the field of low energy neutrino astronomy, to date a 20-year long tradition of incredibly rich physics with large underground detectors, the largest one being the 22.5 kton Super-Kamiokande experiment.

These underground instruments, thanks to technical breakthroughs, have achieved new fundamental results like the solution of the solar neutrino puzzle and the evidence for physics beyond the Standard Model of elementary interactions (SM) in the neutrino sector with non-vanishing neutrino masses and lepton flavor violation. In parallel, stringent limits on the flux of supernovae relic neutrinos have been set, testing star formation models. With the largest scintillator detector ever built, KamLAND has announced first evidence of neutrinos emitted by radioactive elements within the Earth (geoneutrinos), opening the way to new methods of investigation of the Earth's interior. Soon neutrinos will be further studied with an intense accelerator neutrino beam from the newly built J-PARC accelerator complex in Japan (T2K experiment) directed towards Super-Kamiokande. More fundamentally, large underground detectors have pushed the proton lifetime towards limits in the range of a few 10^{33} years.

These results and discoveries have revolutionised our understanding of particle physics and have opened a new window on phenomena beyond the SM. As a result, new physics, involving new particles and new forces, must indisputably exist at very high-energy scales, possibly in the range of 10^{16} GeV or higher. It is necessary to unveil its characteristics and to answer the fundamental questions concerning the unification of all known forces, the origin of neutrino masses and the problem of flavour.

While the Large Hadron Collider at CERN with a proton-proton center-of-mass energy of 14 TeV will provide information on the physics at the electroweak energy scale (or TeV scale), crucial tests of the new physics at 10^{16} GeV, much higher than those accessible at the LHC, can only be obtained via searches of proton decay and by a precise determination of the parameters that describe neutrino masses and mixing.

The next-generation very large volume underground observatories searching for rare events as proton decay and studying various terrestrial and extra-terrestrial sources of neutrinos will therefore answer fundamental questions of particle and astroparticle physics and will shed light on the fundamental laws of Nature which would otherwise remain unresolved.

It is reasonable to assume that this physics programme will span over 30 years and more, with the involvement of several generations of worldwide researchers. Investigating the proton lifetime up to 10^{35} years will provide a very stringent, perhaps ultimate test of the Grand Unification hypothesis. After the optical observation of supernovae (SN) by mankind during the last centuries and the SN1987A neutrino detection, the next observable event with neutrinos will occur with high probability in the next decade and with near certainty in the next 30 years. Meanwhile the background flux of neutrinos from relic supernovae will be observed. The study of neutrino properties has shown the first indication of physics beyond the SM. New discoveries, like CP-violation in the leptonic sector, are expected in this field.

B.1.2. Progress beyond the state-of-the-art

The need to plan even larger and better instruments

As discussed above, further advances in low energy neutrino astronomy and astroparticle physics, as well direct investigation of Grand Unification of fundamental interactions require the construction of next-generation very large volume underground observatories. With complementary techniques, facilities on the mass scale of 50 kton to 500 kton could dramatically increase the potential of past and present underground detectors. However as expected, these developments represent rather large extrapolations compared to current worldwide state-of-the-art, requiring advances in several fields, such as underground civil engineering, mechanical engineering, large scale detector instrumentation and integration, and last-but-not-least safety and environmental issues.

There is currently no underground infrastructure in the world able to host instruments of this size, although many European national underground laboratories with high-level technical expertise are currently operated with forefront smaller-scale underground experiments (see Figure 1). Very large underground laboratories are being considered in Japan in the context of the Hyper-Kamiokande[1] project and in the USA as part of the DUSEL process[2]. A pan-European research infrastructure able to host new generation underground instruments with total volumes in the range of 100'000 m^3 up to 1'000'000 m^3 will provide new and unique scientific opportunities and very likely lead to fundamental discoveries in the field of particle and astroparticle physics, attracting interest from scientists worldwide.

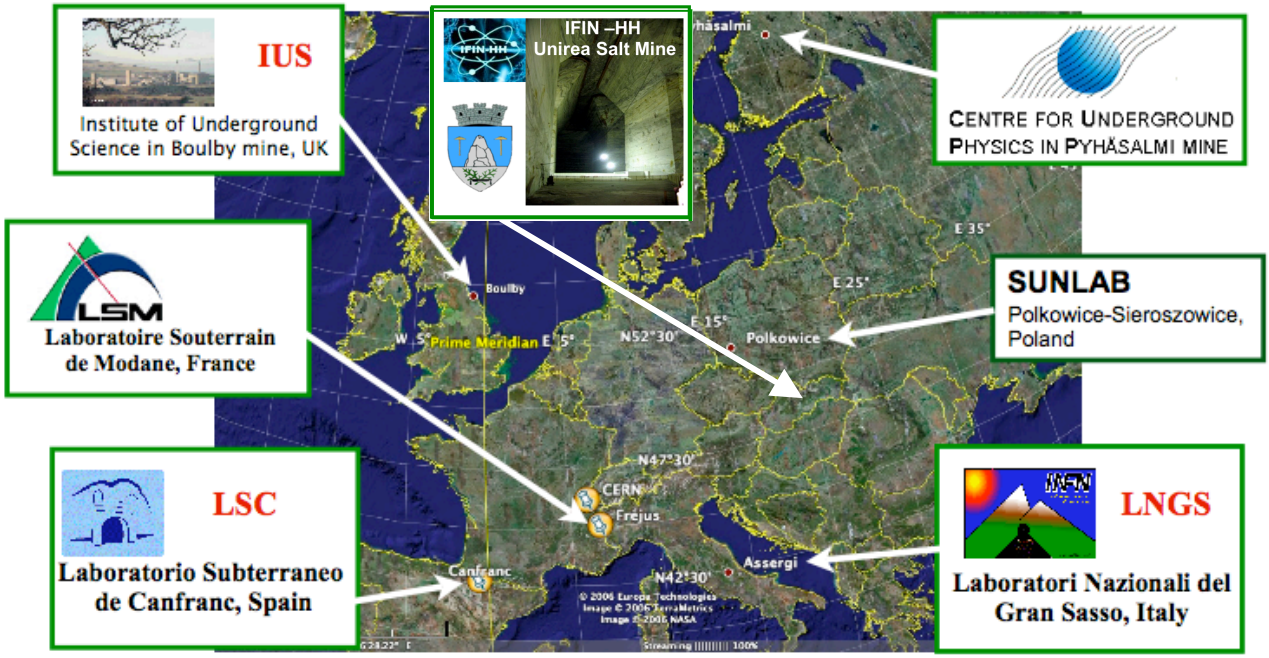


Figure 1 The existing or emerging six national underground science laboratories.

Several conceptual ideas for next-generation very-massive, multi-purpose underground detectors have emerged in Europe over the last few years. All the designs consist of large volumes of liquid observed by detectors, which are arranged on the inner surfaces of the vessels. The liquid simultaneously acts as the target and as the detecting medium. The first one relies on the concept of Super-Kamiokande and uses water (MEMPHYS R&D project), the second builds on the initial experience with the ICARUS programme and uses Liquid Argon (GLACIER R&D project), the third extrapolates experience gained in reactor experiments and BOREXINO and uses liquid scintillator (LENA R&D project). See Figure 2.

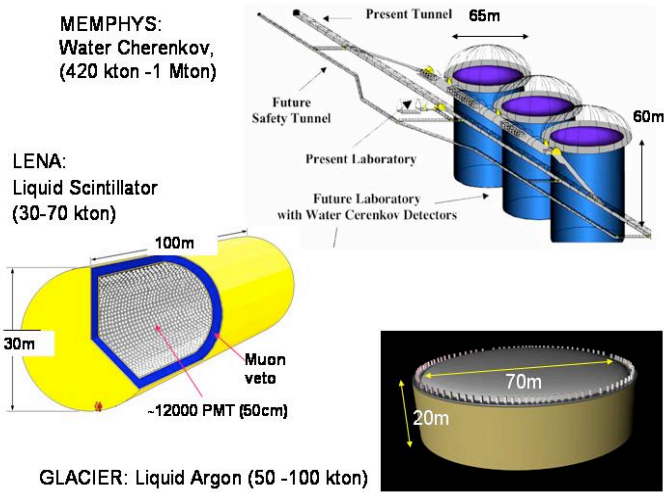


Figure 2 R&D projects being discussed in Europe as possible next generation very large volume underground detectors: MEMPHYS, LENA and GLACIER.

The present Design Study (DS) will focus on the study of feasibility and design of such a new infrastructure in Europe. It will consider the three different detector technologies presently being investigated by European research institutes, and several potential underground sites in order to identify the scientifically

[1] K. Nakamura, "HYPER-KAMIOKANDE: A next generation water Cherenkov detector for a nucleon decay experiment," Front. Phys. 35, 359 (2000).
[2] See http://www.dusel.org

and technically most appropriate and cost-effective strategy for future large-scale underground detectors in Europe. The main deliverable will be a report, which should contain relevant information for a forward decision.

More specifically, we will evaluate these three technologies:

MEMPHYS R&D: As the cheapest available (active) target material, water is the only liquid that is realistic for extremely large detectors, up to several hundreds or thousands of ktons. Water Cerenkov detectors have sufficiently good resolution in energy, position and angle. The technology is well proven, as previously used for the IMB, Kamiokande and Super-Kamiokande experiments.

LENA R&D: Experiments using liquid scintillator as the active target provide high-energy resolution and offer low-energy threshold. They are particularly attractive for very low energy particle detection, as for example solar neutrinos and geo-neutrinos. Also liquid scintillator detectors feature a well-established technology, already successfully applied at relatively large scale in the Borexino and KamLAND experiments.

GLACIER R&D: The liquid Argon Time Projection Chamber (LAr TPC) detection technology has among the three the best performance in the identification of the topology of interactions and decays of particles, thanks to the bubble-chamber like imaging performance. LAr TPCs are very versatile and work well with a wide particle energy range. Experience with such detectors has been gained within the ICARUS project. Novel R&D is necessary to understand the extrapolation of this technique to very large masses.

The three mentioned detector types represent a variety of complementary aspects: They have similar (high) discovery potential and exhibit some interesting elements of complementarity (see Table 1). MEMPHYS would collect the largest statistics, GLACIER would have the best pattern recognition, LENA would have the lowest energy threshold. MEMPHYS and LENA are superior in anti-neutrino detection while GLACIER is best in neutrino detection. Neutrinos and anti-neutrinos together provide the full information to study supernovae. MEMPHYS has complementary sensitivity to LENA and GLACIER on proton decay flavour signatures.

From a technical point of view, the three technologies have in common similar requirements for their design, installation and operation in the future underground facilities. The DS will create the opportunity for a concerted effort towards a global optimization of the projects, increasing the probability of success with the elaboration of shared strategies.

Table 1 Overview of the physics potential of the three types of instruments considered

Topics	**GLACIER** (100 kt)	**LENA** (50 kt)	**MEMPHYS** (400 kt)
proton decay, sensitivity (years) decay mode $e^+\pi^0$ decay mode anti-ν K^+	 $0.5 \cdot 10^{35}$ $1.1 \cdot 10^{35}$	 TBD $0.4 \cdot 10^{35}$	 $1.0 \cdot 10^{35}$ $0.2 \cdot 10^{35}$
SN at 10 kpc, # events CC NC ES	 $2.5 \cdot 10^4$ (ν_e) $3.0 \cdot 10^4$ $1.0 \cdot 10^3$ (e)	 $9.0 \cdot 10^3$ (anti-ν_e) $3.0 \cdot 10^3$ $5.0 \cdot 10^3$ (p) $6.0 \cdot 10^2$ (p)	 $2.0 \cdot 10^5$ (anti-ν_e) - $1.0 \cdot 10^3$ (e)
Diffuse SN # Signal/Background events (after 5 years)	60/30	(10-115)/4	(40-110)/50 (with Gadolinium)
Solar neutrinos # events, 1 year	^{8}B ES : $4.5 \cdot 10^4$ Abs: $1.6 \cdot 10^5$	^{7}Be: $2.0 \cdot 10^6$ pep: $7.7 \cdot 10^4$ CNO: $7.6 \cdot 10^4$ ^{8}B(CC): $3.6 \cdot 10^2$ ^{8}B(NC): $5 \cdot 10^3$	^{8}B ES: $1.1 \cdot 10^5$
Atmospheric ν # events, 1 year	$1.1 \cdot 10^4$	TBD	$4.0 \cdot 10^4$
Geo-neutrinos # events, 1 year	Below threshold	$1.5 \cdot 10^3$	Below threshold

B.1.3. S/T methodology and associated work plan

B.1.3.1. Overall strategy and general description

Towards a proposal around 2010

Without any doubt, a very large underground detector facility has an extremely rich physics programme. The construction and operation clearly represents a difficult technological challenge and a significant investment on the scale of several hundred millions of Euros. It is intimately connected to the question of large underground infrastructures. To set the scale, the Hall B at the Gran Sasso underground laboratory near Rome (Italy) is one of the largest volumes available today for underground experiments. It has an instrumentable volume of about 15'000 m^3. In comparison, this DS foresees total instrumentable volumes ranging from 100'000 to 1'000'000 m^3.

The choice of the most appropriate technology, of the site and of the designs of such super-massive detectors will be carefully optimized taking into account the technical feasibility and predicted costs, the multiple physics goals, and also the possible existence of accelerator neutrino beams.

The technical and economical feasibility of an underground observatory of this magnitude, perhaps ultimate in size, requires a strong coordinate and coherent European strategy and is heavily reliant on the possibility to contain costs compared to today's state-of-the-art by a careful optimization of all elements involved in the project: (1) the excavation and preparation of the underground space, (2) the design and construction of the tank, (3) the instrumentation and (4) the safety aspects. This implies that cost is optimized at all level of the project, and must heavily rely on careful design and engineering.

The study will involve a coherent and well-coordinated EU-wide design effort towards a large infrastructure, solving common problems together, taking into account the unique technological expertise in rare event detection technologies, underground excavation and construction, such that mature designs and credible scenarios can be proposed around 2010.

An important point is the possibility to eventually couple the research instruments that will be studied in this DS with existing or future neutrinos produced by accelerators. In Europe, the CERN Council at its December 1999 meeting has approved the CNGS project. Construction started in September 2000, and the first beam was obtained in the Fall 2006. This beam will serve the OPERA experiment at LNGS for the next five years. Improved knowledge of neutrinos oscillation parameters requires precise measurements of parameters governing neutrino oscillations, which will require new high intensity neutrino oscillation facilities in which neutrino beams are generated using new and highly challenging concepts. Whatever the kind of beam that will be technically realisable, it will require a massive underground detector as a far detector. Therefore, we will address a fundamental point in the feasibility of future long baseline neutrinos programme, since it will assess where in Europe, very large underground detectors could be conceivable and at what cost.

Subdivision in workpackages

The main goal of the DS is to bring together on one hand the scientific community interested in this kind of research infrastructure and on the other the industrial and technical experts able to help assess its feasibility. The DS is subdivided into 4 workpackages (WP), interconnected with each other. The list of WP is the following:

WP1 = Management, coordination and assessment
WP2 = Underground infrastructures and engineering
WP3 = Safety, environmental and socio-economic issues
WP4 = Science impact and outreach

WP1 – Management, coordination and assessment

This WP will be led by the ETHZ beneficiary and will be coordinated by André Rubbia (ETHZ) with the help of a 0.5 FTE recruited administrative staff. The Executive Board and the Governing Board will also be involved in these activities (see section B.1.4).

The management WP will coordinate the contractual, financial and administrative aspects of the Design Study and will oversee the technical and scientific work of the other WPs. It will be responsible for ensuring the project milestones are achieved and the deliverables produced on time. Furthermore, this WP will be responsible for knowledge management for the Design Study, coordinating the protection, use and dissemination of the knowledge generated during the project.

The first task is to outline a management structure to allow efficient coordination of all contractual, financial and administrative aspects of the Design Study. This will be completed within the first 4 months of the project, although the management network created will continue, through the various WP leaders, to monitor milestones, ensuring that deliverables are produced on time.

To be completed in the 12th month, the first year report document (**Deliverable 1.1**) will summarize the work done in all WP, and will compare progress against milestones and deliverables, and outlining any conclusions that can be drawn.

To be completed in the 24th month of the project, the final year report (**Deliverable 1.2**) will describe the achievements of the Design Study and will include a detailed comparison of all sites and experiments considered. It will contain the scientific and technical information related to excavation of large caverns in those sites, addressing the technical and legal feasibility, the total associated cost (±30%) of the infrastructure and total time of technical realization (±1 year). Based on the findings, a recommendation will be made for the feasibility of the project with respect to scientific performance, underground construction, engineering infrastructure, and cost.

WP2 – Underground infrastructures and engineering

This WP will be led by the TUM beneficiary and will be coordinated by Franz von Feilitzsch (TUM) with the help of Lothar Oberaurer (TUM). The studies specific to each site will be coordinated by specific participants of the consortium as listed in Table 2.

For all sites, there will be two partners: a scientific institute and a technical (engineering) partner. The role of the technical partner is to prepare the technical part of the design and to study the feasibility of the rock construction. The role of the scientific partner is to provide scientific expertise for the design, particularly outlining the requirements and preferences of the experiments and acting as a link between the technical partner and the scientific community.

Table 2 Sites to be explored during the DS.

Name	*Region*	*Site type*	*Study coordinated by*	*Technical partner*
1) Boulby mine (United Kingdom)	Boulby	Mine/salt (potash) or rock	Neil Spooner (USFD)	CPL (via USFD)
2) Fréjus (France)	Fréjus	Road tunnel / hard rock	Luigi Mosca (CEA)	Lombardi
3) New Italian site	300 and 850 km away from CERN	Not yet known	Antonio Ereditato (U-Bern)	AGT
4) LSC (Spain)	Pyrenees	Soft rock	Luis Labarga (UAM)	*Subcontract (see section B.1.6)*
5) Pyhäsalmi (Finland)	Pyhäjärvi	Mine / hard rock	Juha Peltohiemi (UOULU)	Rockplan
6) SUNLAB (Poland)	Polkowice – Sieroszowice	Mine / salt & rock	Agniezska Zalewska (IFJ PAN)	KGHM CUPRUM
7) IFIN-HH (Romania)	Prahova	Salt / shallow depth	Romul Mircea Margineanu (IFIN-HH)	SALROM SA

The site studies will focus on the technical issues of underground large-scale civil engineering needed to host large volume instruments. The purpose is to assess the feasibility of large underground caverns in the potential European sites to host the large volume detectors.

The feasibility studies will include geological studies of the sites, analysis of available rock samples and simulations of rock mechanics. As a guideline, the topics to be addressed for each seven sites are summarized in Table 3:

Table 3 Guidelines that will be given to the various sites during their feasibility study.

Basic topic	**Foreseen study**
Basic rock studies	Rock structural studies including bore holes and analysis Rock water content and issues of removal and disposal of water (pumps and pipes) Rock activity analysis Rock environmental issues including dust or other

	hazards
Main excavation design issues	Optimum size for vertical cylindrical tanks Requirements for rock bolting or other extra structures within caverns Design of ancillary caverns, rooms and access roadways Stability for at least 30 years (in connection with WP3) Optimal access methods for cavern excavation and tank construction Requirements and costs of interaction with tunnel companies or mine Limitations to rate of rock removal from site Environmental restrictions to rock excavation and disposal Provision of power and services required during excavation Special requirements during excavations such as dust control Procedures and timescale for excavation, type of excavation (horizontal, vertical)
Excavation outfitting	Treatment and securing of cavern walls (rock bolting etc) Provision of general support structures, internal buildings and walls
Services to underground facility	Power provision Ventilation Radon control costs Other services: humidity, temperature and air conditioning, communications (internet), water.
Special services	Provision of secondary containments (dump) for water, liquid noble gases or scintillator (in connection with WP3) Provision of pumps, special ventilation and structures for cryogenic liquid handling Provision of water treatment facilities Assessment for use of magnetic fields Investigation of underground assembly of the tanks, by assessing construction strategies as a function of underground access methods
Surface buildings and support	Outline requirements for surface facilities, restrictions and costs New build or extension/mods to existing facilities
Safety during and after excavation	(in connection with WP3)
Suitability for other applications	Any restrictions of use for science – suitability for microbiology, environmental science, engineering etc
Level of impact	What added value – from education and school links, exchanges with local industry and mine/tunnel companies (e.g. CPL, Cuprum, KGHM, etc.) Economical and social impact
Political issues	What level of local and regional support and contributions (financial and in kind)
Legal and land ownership issues	Legal issues of environment

	Local and national political issues or restrictions Planning permissions and lease agreements
Operating costs	Operating and power costs Access costs, including cost of separate access roadways and/or shafts or tunnels to allow independence from operators Mine operating costs after closure (if relevant)
Decommissioning	Implications and costs for decommissioning the sites if any
Risk analysis	

Reports, subject to commercial confidentiality where appropriate, with conceptual designs of the underground cavities will be delivered, recommending the sites that are technically suitable for large excavations and if relevant which target liquids can be envisaged in a particle location. Estimates for costs of cavern and access excavations will be included. A critical comparison of these costs, pointing out potential relative and absolute cost differences, will be included in the report**. See Table B.1.3.4 Deliverables 2.1-2.8 for the complete list of reports**.

The final deliverable (**Deliverable 1.2**) is a feasibility document containing the scientific and technical information related to excavation of large caverns in those sites, addressing the technical and legal feasibility, the total associated cost (±30%) of the infrastructure and total time of technical realization (±1 year).

Task 1 Feasibility study for CUPP/Pyhäsalmi

This task will be coordinated by Timo Enqvist (UOULU) and will involve UOULU, U-Jyväskykä, U-Aarhus, ETHZ, TUM (scientific partners) and Rockplan (technical partner). A CUPP pre-feasibility study for a deep laboratory was done in 2002, with two drill holes. The rock was found to be very good, though the rock pressure was high. That study did not consider as large cavities, still did not show any evident obstacle for such cavities. The feasibility of large underground constructions in a new underground laboratory located by the Pyhäsalmi mine will be further studied in this task. The integration into the infrastructures and operation of an active mine will be specifically studied.

Task 2 Feasibility study for Fréjus

This task will be coordinated by Luigi Mosca (CEA) and will involve CEA, IN2P3 (scientific partners) and Lombardi (technical partner). In Fréjus a pre-feasibility study for excavation of very large cavities in the context of the MEMPHYS project was done 2005[3]. It included rock mechanical analysis using the existing data of the rock in the road tunnel. No technical obstacles for caverns of the kind needed by the MEMPHYS project were discovered so far. Using the general rock properties the optimal shape of the cavity for MEMPHYS was found to be individual cylinders (3 to 5) of ca 250 000 m^3 each. The cavity for GLACIER in its preferred form was found to be infeasible, but another form was suggested (e.g. 2 modules of 50 ktons each). This task will consist of a more advanced and precise study including the basic equipments of the laboratory, as needed by each target liquid. Fine-tuning of the shape of the cavities will be an important point of the study. In addition, a study of compatibility between the excavation operations for a megaton-scale laboratory at the Fréjus site and the running conditions of the future safety tunnel at the Fréjus (with a diameter = 8 m) will be assessed: need of ventilation, of excavated rock evacuation, etc.

Task 3 Feasibility study for Boulby mine

This task will be coordinated by Neil Spooner (USFD) and will involve USFD (scientific partners) and CPL (technical partner). The Boulby mine, a working salt and potash mine in north east England, at 1100m deep, is the deepest mine in Britain with over 1000km of tunnels excavated over the last 40 years. The potential for expansion is a priori excellent and there is already interest from the mine operators Cleveland Potash Ltd (CPL) in excavating deeper to exploit polyhalite ore. Whereas excavations in the salt seam are limited to 8m wide by 5m high, polyhalite is thought to be a far more competent rock, which is expected to be self-supporting over large areas. Based on a core sample taken from the polyhalite seam 200m below the salt and potash layers, CPL predicts that labs as large as those seen in existing hard rock locations are possible, and that cavities 30m wide and high are potentially feasible. In its current form LENA appears to be viable, and based on the cavity geometry permitted by the surrounding rock, GLACIER and potentially MEMPHYS could also be adapted to fit. The concept of a new underground science facility in this seam is

[3] "Cavernes de 1 Million de metres cubes : Étude préliminaire de faisabilité" STONE (Juin 2005) http://www.apc.univ-paris7.fr/APC_CS/Experiences/MEMPHYS/ and "Étude préliminaire de faisabilité de puits de grande dimension (au Fréjus) : Méthodes de réalisation Coûts et Délais SETEC-TPI (12 octobre 2005)"

strongly supported by CPL. The study in this DS would involve strategic exploration to identify the economic viability of mining the deeper polyhalite resources, and a full appraisal of the feasibility of establishing a full laboratory with all associated services required for underground science including specific reports for each proposed experiment and their requirements both above and below ground. CPL would act as a professional engineering consultant and would liaise with Sheffield University, the scientific institute. The main aim for CPL would be to undertake a detailed scientific environmental study of the polyhalite deposit to assess suitability for a deep laboratory for the science intended, and hence to inform critical areas of the facility design. Boulby mine is a fully functioning salt and potash mine, and as such it is only correct that the mine operators CPL have the final decision on the making public of any and all facts concerning Boulby mine and CPL deemed to be of a private, proprietary, or sensitive nature for whatever reason by way of a confidentiality agreement. This will provide written assurance from the Principle Investigators, before any feasibility study is carried out, and is seen as an essential first step of the design study.

Task 4 Feasibility study of a shallow site in Italy

This task will be coordinated by Antonio Ereditato (U-Bern) and will involve ETHZ, U-Bern (scientific partners) and AGT (technical partner). The CERN CNGS project, approved by the CERN Council in 1999, has been commissioned in the Fall 2006. This high-energy beam, using the CERN accelerator complex, is directed towards the Gran Sasso Underground Laboratory and will serve the underground OPERA experiment located in Hall C of LNGS for a period of about five years. The current optimization of the CNGS beam is tuned to the particular physics programme of the OPERA project and exhibits limited interest for the physics addressed in the present DS. The physics potential of an intensity upgraded and energy re-optimized CNGS neutrino beam coupled to an "off-axis detector" of very large mass could offer interesting physics opportunities. Within this WP, possible shallow depths sites at 300 and 850 km from the neutrino source will be investigated taking into account possible upgrades its intensity of the CERN accelerator complex and/or new beam lines, in agreement with CERN long term plans.

Task 5 Feasibility study for SUNLAB

This task will be coordinated by Agniezska Zalewska (IFJ PAN) and will involve IFJ PAN, IGSMiE PAN, ETHZ (scientific partners) and KGHM CUPRUM (technical partner). The Sieroszowice Underground LABoratory (SUNLAB) is planned to be located in the Sieroszowice mine, which belongs to the KGHM holding of the copper mines in the west-southern Poland. The site is placed 70 km from the airport in Wroclaw and 40 km from the motorway A4 crossing the southern Poland in the west-east direction. At a depth of 900-1000 meters below the surface there is a layer of salt about 70 meters thick. Over and under the salt deposit, layers of high stiffness and strength parameters (anhydrite, limestone and dolomite) are observed, often water saturated. So far, the cavities executed at such depths in the Polish rock salt formations were of a smaller scale. One of existing caverns, 100 m long, 15 m wide and 15 m high, is located in Sieroszowice at 950 m below the surface. It serves now for measurement purposes. The movements of the salt walls have been monitored since 1997 in order to better understand a viscous creep of salt at big depths. A very large underground infrastructure for the LAGUNA project would be an innovating enterprise. In Sieroszowice an initial study was done in 2004/2005, showing prospects to host a large detector for GLACIER Liquid Argon detector. The preliminary conclusion of finite elements analyses showed that very large caverns in the salt layers could be potentially considered. The full pre-feasibility study for SUNLAB will be performed by KGHM Cuprum in close collaboration with IGSMiE PAN and the Sieroszowice mine's personnel. It will embrace all mining and geological aspects of large salt cavern design, from its location selection to water and energy supply. 3d stability analysis performed using the finite differences numerical tool (Flac3d) will permit determining the optimum cavern's shape constituting the main objective of the overall study. This feasibility study will focus particularly on salt-rock creep behaviour as well as the appropriate strength hypothesis assessment based on mechanical tests performed in KGHM Cuprum laboratory site, validated later on by field measurements in the existing underground salt chambers. During the computation procedure, salt-rock and surrounding hard rock mass will be scanned out whether the values of stability measures expressed by so called safety margins are maintained within a given safe bounds. This kind of numerical modelling will include the multi-phase and time-dependent excavation process and salt-rock creep behaviour in long-term horizon as well.

Task 6 Feasibility study for LSC

This task will be coordinated by Luis Labarga (UAM) and will involve LSC, UAM (scientific partners) and will subcontract technical work (technical partner). The Canfranc laboratory is located at 1080 m over the sea level and has a natural rock shielding amounting up to 2450 meters water equivalent. Of the original laboratory a 100 m^2 hall is still operational with access from a dismissed railway tunnel, now used as safety tunnel for the parallel road tunnel. A new laboratory was recently constructed, with access both from the road and the safety tunnels. It consists in two halls and service areas for a total surface of about 1500 m^2. Presently a modest extension with a new hall of about 250 m^2 is being considered. Within this WP, possible further extensions of the laboratory either near the current site, which offers a dedicated entrance via the

abandoned train tunnel, or in the neighbouring sites, will be investigated. The LSC does not have its own Geotechnic Department and therefore the Characterization-Feasibility Study will be subcontracted to one outside company. This will be chosen between at least three candidates after the mandatory tendering procedure within the Spanish Law. We have identified and contacted three geotechnical companies in Spain that apparently are able to do the job and have explicitly shown their interest on it. They are a) "STMR S.L." which has participated in some crucial phases of the construction of the current LSC, b) "GEOCONSULT-España, Ingenieros Consultores S.A." which accredits the design and construction-supervision of caverns with volumes of the same order of magnitude as required in LAGUNA (mainly for mining purposes), and c) "GEOCONTROL S.A." which accredits the design of large caverns for several hydraulic power plants both in Portugal and Spain.

Task 7 Feasibility study for IFIN-HH

This task will be coordinated by Romul Mircea Margineanu (IFIN-HH) and will involve IFIN-HH (scientific partners) and SALROM SA (technical partner). The Unirea salt mine in the slanic mine of the Prahova region (Romania) is an interesting potential site for the design study. The mine is administrated by SALROM SA, (Romanian National Salt Society). The salt exploitation ended in 1971. For the time being the mine is used for tourism and medical purposes. The access into the mine is assured by an elevator able to carry up to 65 tons. The network of galleries of Unirea salt mine are very large. The current area is 70000 m^2 and 2.9 million m^3 have already been excavated. The salt lens is about 5km x 3 km x 0.5 km. A gallery of about 1,000,000 m3 could be dug at a depth of 450 m. The costs are about 30€/ton, 1 m3 ~ 2.2 tons. The price of 1 ton of salt on the market is about 40€.

Task 8 Site specific impact of assembly of large underground tanks

This task will be coordinated by André Rubbia (ETHZ). The ETHZ beneficiary (scientific partner) and Technodyne (technical partner) will concentrate on this task: an assessment will be made of the feasibility of underground construction and assembly of large tanks, and the strategies required based on the underground access route and local infrastructure. In an above-ground scenario the large storage tanks are usually constructed using common civil construction techniques. As there is no restriction on headroom the use of large cranes is normal. In the underground scenario it is less likely that there will be enough headroom to allow the use of large cranes. The domed roof is normally constructed on the bottom of the tank and then raised and welded in place using air pumped into the vessel. This technique is commonly used when manufacturing these types of tank and does not present a problem underground. The only requirement being a supply of electricity to power the air fans needed to raise the roof. An alternative technique could then to be employed where the roof is built first together with the top ring of the shell. The assembly would then be jacked up about 3m and the next lower ring installed. Successive ring welding / jacking operations would be performed until the shell is completed without the use of a large crane. This is a common technique for large diameter oil storage tanks. The order of construction of the tank would be as follows: (a) base (b) roof and deck (c) outer shell (d) base insulation (e) inner shell base (f) inner shell (g) insulation. This task will generally investigate the impact on the site of the assembly and operation of the large tanks.

WP3 – Safety, environmental and socio-economic issues

This WP will be led by the USFD beneficiary and will be coordinated by Neil Spooner (USFD) with the help of Phil Lightfoot (USFD). It will identify both general and specific hazards for the underground sites and will establish associated safety protocols and additional infrastructure to mitigate the risks.

Task 9 Assessment of hazards events and risk analysis

The beneficiary USFD will be responsible for this task. The implications of a serious incident in a LAGUNA site are profound and depending on the severity could result in the closure of all facilities. In many countries it is a legal requirement that all accidents resulting in injury or having the potential to cause harm be reported. In addition to the publication of a document detailing the safety policies and protocols required to ensure safety of LAGUNA staff, general underground personnel, and visitors, health and safety awareness of employees would be improved through continuous laboratory safety appraisals, equipment inspections, training, and courses. The minimum standards would be determined by the individual codes and rules set out by the specific site owners, the local law, and the governmental site inspectorate, and would include appropriate training, safety equipment, emergency procedures, and protocols. Mine sites have different issues compared to tunnel sites with regard to emergency egress, ventilation systems, fires, large volume liquid gas emergencies, production of liquid cryogens and air quality monitoring. Appraisal of each site will reflect this. A risk management consultant or in some cases mining and safety experts employed on site by the facility owners, will identify potential failures or unexpected incidents and their effect on the project. In addition to leaks, fire, engineering delays and scientific underperformance, these

should include discovery of unacceptable rock properties during cavern excavation, major underground rock collapse in either the cavern or the access routes, and closure of the host site should it become economically unviable. Although catastrophic rupture of a liquid or liquid noble gas tank in an underground site is by far the worst-case scenario, the technologies involved in large tank production coupled with many decades of incident free operation belie concern. Throughout the world cryogenic tanks of similar design are operated without problem and have been designed to withstand earthquakes and subsidence. Leaks are far more likely to occur due to thermal expansion of liquid scintillator or during transfer from the storage facility to the main experimental tanks. In this case total liquid containment is essential and the report will detail ancillary equipment, procedures, control systems, and environmental monitors required to achieve this. The report will also investigate commercial solutions for tank monitoring and environmental control such as pumps to circulate noble liquids to avoid stratification – liquid fractionation producing thermoclines within the volume possibly due to pockets of impurities – potentially leading to rapid evolution of gas on turnover. In the event of a total power failure, emergency power would be provided to vital scientific support systems such as liquid scintillator cooling, purification of both liquid scintillator and liquid noble gas, and noble gas boil off compression via diesel generators. These generators would also supply power to life support systems such as emergency lighting, ventilation of toxic gases or smoke and the underground communication network. The report will identify in detail the total power demands for each system and the requirements imposed by the site hosts due to integration of an additional power generating system within the overall local grid. The problem of power and of heat dissipation in underground locations will be considered. Fibre optic cabling will enable communication and small-scale data transfer, although the report will also include potential upgrades for an improved transfer network, and will detail proposed environmental monitoring and control devices. Finally, each LAGUNA experiment represents a significant investment and, in today's global climate, must be viewed as a potential terrorist target. The report will identify security measures both to limit site access to those approved and qualified and to safeguard the underground systems from attack. More generally, a list of actions needed to guarantee the safety of the population at large, in particular of those that live or work nearby, will be developed.

Task 10 Safety and monitoring of large-scale underground tanks

The beneficiary ETHZ will be responsible for this task and will accomplish this task in collaboration with Technodyne and other industrial partners to be defined during the course of the DS. Safety of large systems can benefit greatly if existing and proven solutions are identified and utilized whenever possible. We mention as an example the case for LNG tanks: for over 40 years, WHESSOE S.A.[4] has developed instrumentation and safety shut-off valve systems for LNG / LPG storages, ensuring that all hazardous aspects are known and controllable. In close cooperation with leading gas companies, new technologies have been extensively tested for endurance, accuracy and reliability in harsh environments. WHESSOE'S Total LNG Storage tank Instrumentation Solution® consists of one single, totally integrated tank instrumentation package and integrated SCADA platforms. All instrumentation such as process level gauges, LTD gauge, in-tank temperature sensing and transmission devices as well as leak detection and cool-down monitoring system are designed and built at their manufacturing facilities. All system components are to be interconnected in a fully redundant communications loop. Information obtained from all tank instrumentation is displayed, using clear and concise displays, at the control system. WHESSOE is the only company worldwide, supplying a single source, total LNG storage tank instrumentation complete with LNG MASTER® Stratification and roll-over predictive software[5].

Task 11 Site specific impact of liquid procurement and tank filling

The beneficiary ETHZ will be responsible for this task and will accomplish this task in collaboration with Technodyne and USFD. This task will evaluate the methods of procurement in large quantities of each target liquid and the consequence for each specific site. This is not without causing significant technical and safety issues and potentially creates interference with local activities of the site. Strategies to bring very large quantities of liquids into the underground tanks will be discussed and an optimization of the liquid procurement methods will be attempted. Availability nearby the sites will be investigated and costs for transport will be estimated taking into account purity at delivery. Methods of local production and their impact on the site will be assessed. The filling techniques of deep underground tanks avoiding recontamination will be defined. In addition, methods to further purify and maintain high purity levels of the liquids will be designed by extrapolation to large scale of existing methods employed in currently operating projects. In the case of liquid Argon this will include both the cryogenic cooling requirements within the detector tank, and the boil off rate induced by auto-refrigeration. Although unlikely to occur more than once in the lifetime of the experiment, the emptying of the tanks will be addressed.

[4] Whessoe S.A. - 135, Rue de Bitche - 62100 Calais Tél.: +33 (0)3 21 96 49 93 - Fax : +33 (0)3 21 34 36 12 - contact@whessoe.fr

[5] LNG MASTER® is developed and owned by Gaz de France.

Task 12 Final report on safety and environmental issues

The beneficiary USFD will be responsible for this task. The report, subject to commercial confidentiality where appropriate, will include an assessment of site specific power requirements such as the installation of additional transformers for air conditioning, ventilation, atmospheric purification, pumping and chiller systems, underground workshops, surface buildings, experimental areas, cranes and associated heavy duty equipment required during construction. It will identify alternative ventilation and cooling schemes for tailored cooling of sensitive components such as the heat exchange on compressors. The report will identify safety considerations specific to each proposed site in addition to emergency response equipment, air monitoring, and egress procedures, such as hazardous material handling, dedicated ventilation piping for the removal of boil off noble gas, cryogenic coolants, and toxic scintillator vapour, and containment systems for scintillator and liquid noble gas spillages. It will detail an emergency management plan, fire containment procedures and evacuation route. It will identify training required for the underground rescue and emergency response teams relevant to the specific experimental target material, and will detail the steps required to contain and dispose of hazardous laboratory materials, and subsequent decontamination in accordance with local law. It will consider the possible failure modes for each experiment, making an assessment of the severity of each, the potential costs involved, and ways in which each can be mitigated.

Task 13 Socio-economic impact of the research infrastructure on the sites

This task will be coordinated by Phil Lightfoot (USFD). It will involve the beneficiaries responsible for the each site feasibility study, namely USFD for Boulby, U-Bern for the Italian site, UAM for Canfranc, CEA for the Fréjus, IFJ PAN for the SUNLAB site, UOULU, U-Aarhus, U-Jyväskykä for CUPP and IFIN-HH for the Romanian site. In contact with the local governments at each site, a report on the potential socio-economic impact of the construction and operation of the research infrastructure will be produced. It is a priori expected that local communities will generally directly or indirectly benefit from the presence of this unique research infrastructure yet could also be affected by the construction and operation of the laboratory. This task will attempt to quantify this impact and propose solutions to mitigate any possible negative aspects.

WP4 – Science Impact and Outreach

This WP will be led by the IFJ PAN beneficiary and will be coordinated by Agniezska Zalewska (IFJ PAN) in a tight collaboration with Manfred Lindner (MPG) and Silvia Pascoli (U-DUR). This WP will explore the physics of different detector technologies at different underground laboratory sites in order to identify the best strategy for future large-scale detectors.

Task 14 Theoretical activities supporting experimental programme

Silvia Pascoli (U-DUR) will be responsible for this task. The task will particularly involve the MPG, U-DUR, U-Aarhus, U-Jyväskykä, UOULU, UAM (with UGR) as well as IN2P3 beneficiaries. The main focus of the WP is to investigate the best strategy for a large underground detector, aiming at measuring proton decay and a rich neutrino physics program. The most promising channel for proton decay depends on expectations from a larger theoretical picture. These expectations evolve due to new theoretical insights as well as due to experiments, which will be carried out in future years. Theoretical expertise is needed to study the most promising decay channels, lifetimes and the corresponding search strategies. Examples how theory may play an important role in this project is given by new results from lepton flavour violation (LFV) experiments and from LHC. New LFV experiments should see a signal in the years to come and the type of signal has profound consequences for the flavour structure of physics beyond the Standard Model. In the same way, LHC-experiments may or may not find supersymmetry, which has immediate consequences for the expected lifetimes, decay channels and search strategies for proton decay.

Task 15 Education and Outreach

Agniezska Zalewska (IFJ PAN) will be responsible for this task. The task will particularly involve the IFJ PAN, USFD as well as IN2P3 beneficiaries. The interdisciplinary character and non-standard problems of this research create unique opportunities for teaching and outreach. Students of physics, astrophysics, geology, civil engineering, geo-mechanics and hydrology can mix, make first class research in their field and learn much about the other fields. An important aspect is attracting good students to scientific careers. The goals for outreach are:

- A document for the general public explaining all the aspects of underground science and its achievements and prospects in Europe (**Deliverable 4.1**)
- A scienfitic paper for the particle and astrophysics and general physics communities (**Deliverable 4.2)**
- A public web site popularising the research done in the framework of LAGUNA.
- Hands-on displays related to underground science.
- Advertising the LAGUNA project during the "open doors" days of the participating institutions.
- Popularising LAGUNA via the European newspapers, radio and TV.

- Contacts with local communities and, in the case of mines, with the mine personnel.

In addition, specific actions at particular sites will be considered: for example, at Boulby the idea to build on this foundation by carrying out a viability and funding study for a dedicated surface building featuring a visitors centre illustrating underground science and mining, a video conferencing studio, scientific workshops and conference rooms suitable for public lectures was proposed. One would investigate potential sources of funding from the local education authority, through local and national government grants, the tourist board, and CPL. In addition one would evaluate the use of internet education technologies such as interactive online study courses, and the value of recruiting summer students. Finally, meeting with senior scientists from earth sciences, engineering, and geological disciplines would be organized. The developments of links with, and the formulation of letters of intent from potential collaborators in the fields of bio-science, geo-physics, environmental sciences, geo-chemistry, and microbiology to study for example microbial evolution, population, and diversity could be considered. In addition one would foster links with geological and engineering groups to identify potential research topics such as the interaction of mechanical, thermal, chemical, and hydrological processes on the nature of underground rock, and would investigate the potential for long-term studies using novel geophysical imaging technologies to measure pressure and stress changes, and hence the long-term stability of large cavern excavations.

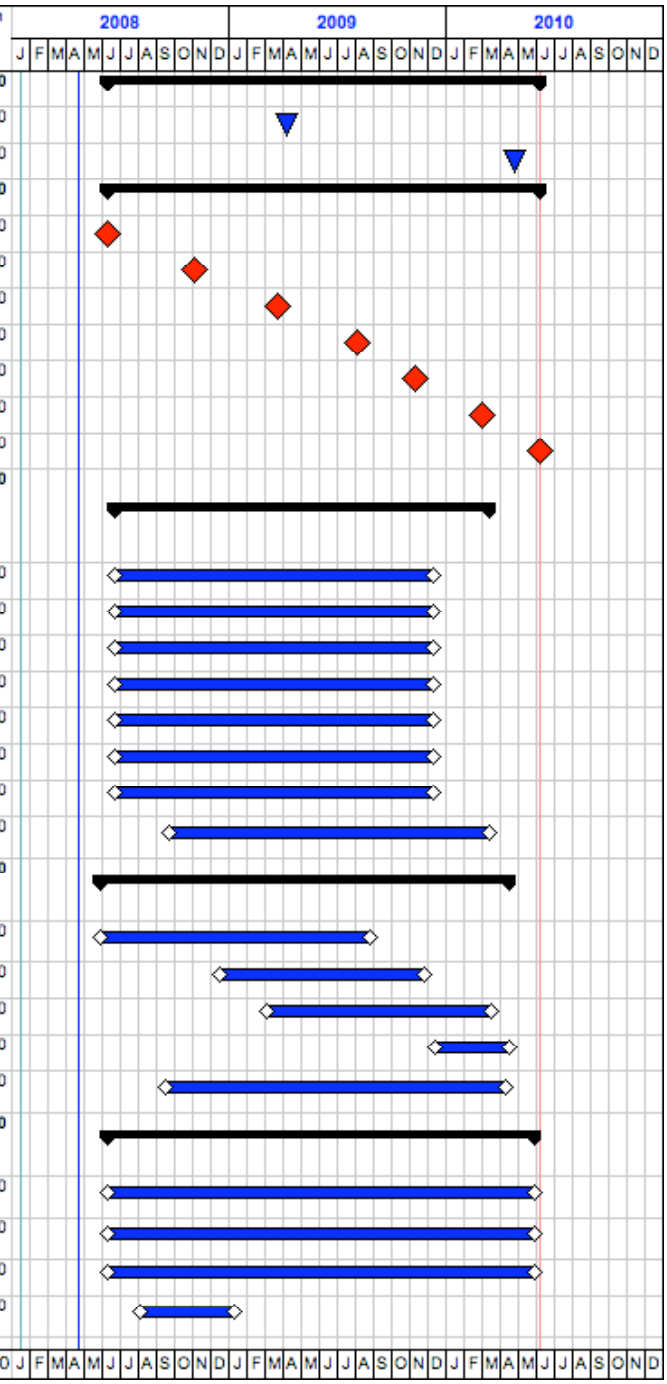
Task 16 Investigation of synergies with the European Strategy for Particle Physics and the CERN laboratory

The beneficiary ETHZ will be responsible for this task. As was pointed out in the ESR, the LAGUNA DS must proceed in symbiosis and synergy with the recommendations and roadmaps developed within the realm of the European Strategy for Particle Physics and CERN. This task will initiate and conduct technical and strategy discussions with CERN, in particular for what concerns the feasibility of future neutrino facilities from CERN and directed towards the sites investigated in this DS.

B.1.3.2. Timing of work packages and their components

Assumed starting date : June 2008; Anticipated duration: 24 months

Activity Name	Start Date	Finish Date	Duration (Work Days)
WP1 – Management	**6/9/08**	**6/7/10**	**520.00**
First year report	4/6/09	4/6/09	0.00
Final report	4/26/10	4/26/10	0.00
LAGUNA general meetings	**6/9/08**	**6/7/10**	**520.00**
Kickoff meeting	6/9/08	6/9/08	0.00
General meeting 1	11/3/08	11/3/08	0.00
General meeting 2	3/23/09	3/23/09	0.00
General meeting 3	8/3/09	8/3/09	0.00
General meeting 4	11/9/09	11/9/09	0.00
General meeting 5	3/1/10	3/1/10	0.00
Final meeting	6/7/10	6/7/10	0.00
WP2 – Underground infrastructures and engineering	**6/23/08**	**3/12/10**	**450.00**
Feasibility study for CUPP/Pyhäsalmi	6/23/08	12/11/09	385.00
Feasibility study for Fréjus	6/23/08	12/11/09	385.00
Feasibility study for Boulby	6/23/08	12/11/09	385.00
Feasibility study for CNGS off-axis	6/23/08	12/11/09	385.00
Feasibility study for SUNLAB	6/23/08	12/11/09	385.00
Feasibility study for IFIN-HH site	6/23/08	12/11/09	385.00
Feasibility study for LSC	6/23/08	12/11/09	385.00
Site impact of underground assembly of large undeground tanks	9/22/08	3/12/10	385.00
WP3 – Safety, environmental and socio-economic issues	**5/28/08**	**4/14/10**	**491.00**
Assessment of hazards events and risk analysis	5/28/08	8/26/09	326.00
Safety and monitoring of large-scale tanks	12/15/08	11/24/09	247.00
Site impact of liquid procurement and tank filling	3/5/09	3/17/10	270.00
Final study on safety and environmental issues	12/14/09	4/14/10	88.00
Socio-economic impact of the research infrastructure on the sites	9/15/08	4/9/10	410.00
WP4 – Science impact and Outreach	**6/9/08**	**5/28/10**	**515.00**
Theoretical activities supporting experimental investigations	6/9/08	5/28/10	515.00
Optimization of the physics potential of the research infrastructure	6/9/08	5/28/10	515.00
Education and Outreach	6/9/08	5/28/10	515.00
Synergy with European Strategy for Particle physics and with CERN	8/4/08	1/9/09	115.00
			6,081.00



B.1.3.3. Work package list / overview

LIST OF WORK PACKAGES (WP)

WP Number 53	WP Title	Type of activity 54	Lead beneficiary number 55	Person-months 56	Start month 57	End month 58
WP1	Management, coordination and assessment	MGT	1 (ETHZ)	27	1	24
WP2	Underground Infrastructures and Engineering	RTD	9 (TUM)	165	1	24
WP3	Safety, environmental and socio-economic issues	RTD	20 (USFD)	44.5	1	24
WP4	Science Impact and Outreach	RTD	11 (IFJ-PAN)	62.4	1	24
	TOTAL			**298.4**		

B.1.3.4. Deliverables list

LIST OF DELIVERABLES TO BE SUBMITTED FOR REVIEW TO EC

Delive-rable Number 61	Deliverable Title	WP number 53	Lead beneficiary number	Estimated indicative person-months	Nature 62	Dissemi-nation level 63	Delivery date 64
1.1	First year report	1	ETHZ	5	Report	Public	12
1.2	Final report on European underground research infrastructure and its science	1	ETHZ	10	Report	Public	24
2.1	Interim report for CUPP/Pyhäsalmi	2	UOULU	18	Report	Public	16
2.2	Interim report for Fréjus	2	CNRS	18	Report	Public	16
2.3	Interim report for Boulby	2	USFD	18	Report	Public	16
2.4	Interim report for CNGS off-axis	2	U-Bern	10	Report	Public	16
2.5	Interim report for SUNLAB	2	IFJ PAN	18	Report	Public	16
2.6	Interim report for LSC	2	LSC	18	Report	Public	16
2.7	Interim report for IFIN-HH	2	IFIN-HH	10	Report	Public	16
2.8	Final joint report on potential European sites	2	UOULU	20	Report	Public	24
3.1	Site specific safety overview report	3	USFD	20	Report	CO	12
3.2	Final report on safety	3	USFD	20	Report	CO	24
3.3	Report on liquid procurement	3	USFD	10	Report	RE	20
3.4	Report on socio-economic impact	3	USFD	10	Report	RE	20
4.1	Deep science paper for general audience	4	IFJ PAN	20	Report	Public	24
4.2	Scientific paper for the physics community	4	IFJ PAN	20	Report	Public	24
			Total	245			

PU = Public
PP = Restricted to other programme participants (including the Commission Services)
RE = Restricted to a group specified by the consortium (including the Commission Services)
CO = Confidential, only for members of the consortium (including the Commission Services)
Restreint UE = Classified with the classification level "Restreint UE" according to Commission Decision 2001/844 and amendments
Confidentiel UE = Classified with the mention of the classification level "Confidentiel UE" according to Commission Decision 2001/844 and amendments
Secret UE = Classified with the mention of the classification level "Secret UE" according to Commission Decision 2001/844 and amendments

B.1.3.5. Work packages description

Description of Work package:

Work package number	1	**Starting date or starting event:**	Contract start date
Work package title:	Management, coordination and assessment		
Activity type:	MGT		
Participants number:	1-27	All participants in the Governing Board will devote approx. 1 person x month, while all other participants will devote 0.5 person x month	
Person months per participant:	0.5-1		

Objectives: Coordinate the contractual, financial and administrative aspects of the Design Study and oversee the technical and scientific work of the other work packages. Ensure that the project milestones are achieved and the deliverables produced on time. Take care of the knowledge management for the Design Study, coordinating the protection, use and dissemination of the knowledge generated during the project.

Description of work (possibly broken down in tasks), and role of participants:

- Coordination task: coordination of the contractual, financial and administrative aspects of the Design Study, including delivery of annual reports and control of the funds.
- Oversight task: oversight of the technical and scientific aspects of the Design Study, including the monitoring of milestones and ensuring that deliverables are produced on time.
- Knowledge task: management of the knowledge generated by the Design Study, including its protection, use and dissemination.
- Promote international contacts with Europe, North America and Asia. Develop outreach activities in Europe.

Deliverables (brief description and month of delivery):

- Report of 1st year activities in month 12, summarizing the work done by all the WPs and comparing progress against milestones and deliverables.
- Final report, submitted in month 24, describing the achievements of the Design Study, including the design of the facility, checking that all deliverables have been delivered. The report includes: (a) comparison chart of all sites (b) recommendation of the feasibility of the sites for a particular set of experiments (c) cost predictions (d) preliminary plans for the cavities and supporting underground infrastructures (e) drawings.

Project Number 1	212343	Project Acronym 2	LAGUNA

Description of Work package:

Work package number	2	**Starting date or starting event:**	1
Work package title:	Underground infrastructures and engineering		
Activity type:	RTD		

Participant number:	1	2	3	4	5	6	7	9	11	15	16	17	27	20	21	23	24	25	26
Person months per participant:	8	2	2	3	22	2	2.5	2	2	17	12	16	3	20	14	2	10	8	18

Objectives:

- To assess the feasibility of large underground caverns in seven potential European sites to host large volume detectors of each kind.
- To provide the technical information, including cost estimates, needed for potential construction decision and site selection.
- To assess the site impact of the construction of underground tanks on the facility and estimate time of underground realization

Description of work:

The technical issues of the construction of large-scale underground cavities are studied. The studies include general geological studies of the sites, preliminary designs for the cavities, simulations of rock mechanics, analyses of local rocks, planning of the cavity construction and cost optimisation.

This WP consists of the following tasks:

- Start up by defining the common basis so that all studies are comparable.
- Feasibility studies made separately and competitively but coherently for each site, sharing experiences.

For each site there is a scientific partner and a technical partner. The technical partner (an engineering company) will do the technical studies and designs, while the scientific partner sets the goals and acts as a link between the technical partner and the scientific collaborators. All sites need their own partners that know well the local conditions.

- Generic designs of underground tanks will be developed using as a starting point the specifications for large volume above-ground tank EUROCODES 3 (Part 4-2, BS EN 1993-4-2 Silos, tanks and pipelines – Tanks) to allow the understanding of the site impact of their construction and safe operation.
- The investigation of an underground assembly will be performed via partnership and/or subcontracting to specialized industries and with contact and/or partnership with companies exploiting mines or road tunnels
- Regular meetings among senior physicists, industry and specialized engineers will be held in order to address the implications of the design choices to the science, and to balance the benefits to engineering aspects against the impact they may have on the physics

Deliverables (brief description and month of delivery):

- Interim reports for each site will be delivered within the first 16 months.
- The main deliverable is a final report in month 24 on the feasibility of constructing large-scale underground research infrastructures. The report includes: (a) comparison chart of all sites and experiments considered (b) recommendation of the feasibility of each experiment on the sites (c) cost predictions (at ±30% accuracy) for underground construction (d) preliminary plans for the cavities and supporting underground infrastructures (e) visual outline drawings.

Project Number 1	212343	Project Acronym 2	LAGUNA

Description of Work package:

Work package number	3	**Starting date or starting event:**				1								
Work package title:	Safety, environmental and socio-economic issues													
Activity type:	RTD													
Participant number:	1	2	3	4	5	6	7	9	11	15	17	27	20	25	26
Person months per participant:	8	1	1	4	4	1	1.5	1	1	4	3	1	6	1	1

Objectives:

- Identify potential safety and environmental risks for each target liquid
- Assess legal authorization requirements for each target liquid
- Define interface and the sharing of responsibilities in terms of safety between the research infrastructure and the host (road tunnel or mine)
- Evaluate the methods of the procurement of large quantities of each target liquid and the local safety impact and cost associated to the in-situ procurement of a given quantity of each target liquid
- Define tank filling techniques maintaining the specifications during the process and their impact on the site
- Assess the socio-economic impact of the research infrastructure in the different sites

Description of work (possibly broken down in tasks), and role of participants:

- Investigate commercial solution for monitoring of large scale tanks and assess their applicability to each target liquid
- Define needed services (ventilation system, electrical power requirements, liquid spill containment infrastructure, radon filter, etc…)
- Subcontract studies of risk analysis with safety experts
- Perform a seismic analysis of the tanks in the underground site
- Assess the procurement of the cryogenic liquids via contacts with leading European companies in the market. The study will involve estimation of costs and transport methods.
- In contact with local governments, develop a the socio-economic impact report for the local communities and other interested parties

Deliverables (brief description and month of delivery):

- In month 12, a confidential report will be produced from each underground site in which the pertinent safety considerations are addressed. In addition to generic factors such as an appraisal of the underground safety protocols and the safety and support infrastructure, the document will detail regional environmental issues, transportation infrastructure and relevant local laws. Finally the report will identify key safety considerations specific to the type of experiment, which might be located at each site.
- The final confidential report in month 24 will define all safety and environmental issues of selected sites, and will include the additional infrastructure required for safe operation, in conjunction with the overall safety strategy of the host (road tunnel or mine). This will include the possible failure modes of each experiment, methods by which this risk can be mitigated, and a risk analysis for each site.
- In month 20, a restricted report on the liquid procurement will be completed.
- In month 20, a restricted report on the socio-economic impact of the research infrastructure at each site will be completed.

Project Number 1	212343	Project Acronym 2	LAGUNA

Description of Work package:

Work package number	4			**Starting date or starting event:**									1
Work package title:	Science Impact and Outreach												
Activity type:	RTD												
Participant number	1	2	3	4	6	7	8	9	11	27	18	19	20	23
Person months per participant:	8	2	2	0.5	3	10.5	5	3	7	1	5	7.4	5	3

Objectives:

- Optimization of the physics potential of the research infrastructure
- Multi-disciplinary and assessment of "other" sciences (biophysics, geophysics, geo-engineering)
- General public education and outreach concerning potential large underground research infrastructure in the Europe and in the world

Description of work (possibly broken down in tasks), and role of participants:

- Theoretical activities supporting the definition and optimizing the experimental programme
- Prepare document for general public, a website and hands-on displays, outreach activities
- Synergy with European Strategy for Particle Physics and CERN laboratory

Deliverables (brief description and month of delivery):

- Deep science paper for general audience in month 24
- Technical paper for the particle, astroparticle and astrophysics or other physics community, in month 24
- Website, in month 12

B.1.3.6. Efforts for the full duration of the project

Indicative efforts (man-months) per Beneficiary per Work Package

Beneficiary number	WP1	WP2	WP3	WP4	Total per Beneficiary
1. ETHZ	15	8	8	8	39
2. U-Bern	0.5	2	1	2	5.5
3. U-Jyväskylä	0.5	2	1	2	5.5
4. UOULU	1	3	4	0.5	8.5
5. Rockplan	0.5	22	4	0	26.5
6. CEA	0.5	2	1	3	6.5
7. IN2P3	0.5	2.5	1.5	8.5	13
8. MPG	0.5	0	0	5	5.5
9. TUM	0.5	2	1	3	6.5
11. IFJ PAN	1	2	1	7	11
15. KGHM CUPRUM	0.5	17	4	0	21.5
16. IGSMiE PAN	0.5	12	0	0	12.5
17. LSC	0.5	16	3	0	19.5
27. UAM	0.5	3	1	6	10.5
19. UDUR	0.5	0	0	7.4	7.9
20. USFD	1	20	6	5	32
21. Technodyne	0.5	14	6	0	20.5
23. U-Aarhus	0.5	2	0	3	5.5
24. AGT	0.5	10	0	0	10.5
25. IFIN-HH	0.5	8	1	0	9.5
26. Lombardi	0.5	18	1	0	19.5
Total	26.5	165.5	44.5	60.4	296.9

B.1.3.7. List of milestones and planning of reviews

LIST AND SCHEDULE OF MILESTONES

Milestone number 59	Milestone name	WP number 53	Lead beneficiary number	Delivery date from Annex I 60	Comments
1.1	Establish management and final consortium agreement	1	ETHZ	1	Kickoff meeting
1.2	First year report	1	ETHZ	12	First year report released
1.3	Final report	1	ETHZ	24	Final report is submitted
2.1	Feasibility study for all sites	2,3	UOULU	16	An interim report on the feasibility of all sites
3.1 (a-f)	Site specific safety protocols	2,3	USFD	12	An interim restricted report on the underground safety and support infrastructure
3.2 (a-f)	Site specific environmental and legal factors	3	USFD	12	An interim restricted report on the legal and regional considerations
3.3	Liquid procurement and handling for each target	3	USFD	20	A report on the procurement and filling of each liquid
3.4	Report on socio-economic impact	3	USFD	20	Restricted report
4.1	Deep science general audience paper	4	IFJ-PAN	24	
4.2	Scientific paper for the physics community	4	IFJ-PAN	24	

TENTATIVE SCHEDULE OF PROJECT REVIEWS

Review number 65	Tentative timing, i.e. after month X = end of a reporting period 66	Planned venue of review	Comments, if any
1	After project month: 10		General meeting #2
2	After project month: 19		General meeting #4
3	After project month: 24		Final meeting

Implementation

B.1.4. Management structure and procedures

The structure of the DS foresees in addition to the coordinator and the deputy coordinator, the existence of the governing board (GB) and a joint secretariat (JS). Their tasks are defined below:

The **coordinator** is responsible for the overall legal, contractual, ethical, financial and administrative management of the consortium, the co-ordination of knowledge management and other innovation-related activities, overseeing the promotion of gender equality in the project and overseeing science and society issues related to the research activities conducted within the project. He will ensure general liaison between the contractors and the Commission. He will submit financial statements, will receive in trust for the consortium all payments from the Commission and will distribute them among the contractors according to their decisions. He will represent the Design Study to the public and especially to partner councils inside and outside the EU not yet participating in the network. He will be accountable for keeping all contract commitments, for submitting all reports and financial records required from the Commission, for overlooking the joint secretariat, for supervising the implementation of the decisions of the Governing Board. The deputy coordinator whose main task is the scientific secretariat of the GB assists him.

The coordinator is Prof. André Rubbia. The deputy will be nominated during the first month of the DS.

The **governing board** (GB) comprises 1 representative from each LAGUNA participant. It is responsible for all management decisions of the network and for the approval of all documents results and approaches related to the LAGUNA activities. It has overall responsibility for monitoring the work performed, reviewing the objectives and progress achieved towards sustained co-operation and the specific objectives set and discussing corrective actions where necessary. The GB also has a general responsibility for the dissemination of information. Decisions are taken when more than 2/3 of the members are present or have proposed a proxy, by simple majority. It will meet at least once per year.

- The members of the Governing Board are: A. Rubbia (ETHZ), A. Ereditato (U-Bern), J. Maalampi (U-Jyväskylä), T. Enqvist (UOULU), J. Salmelainen (Rockplan), L. Mosca (CEA), T. Patzak (IN2P3), M. Lindner (MPG), F. von Feilitzsch (TUM), A. Zalewska (IFJ PAN), W. Pytel (KHGM CUPRUM), K. Slizowski (IGSMiE), A. Bettini (LSC), L. Labarga (UAM), S. Pascoli (U-Durham), N. Spooner (USFD), J. Thompson (Technodyne), H. Fynbo (U-Aarhus), R. Margineanu (IFIN-HH), M. Temussi (AGT Ingegneria) and M. Russo (Lombardi).

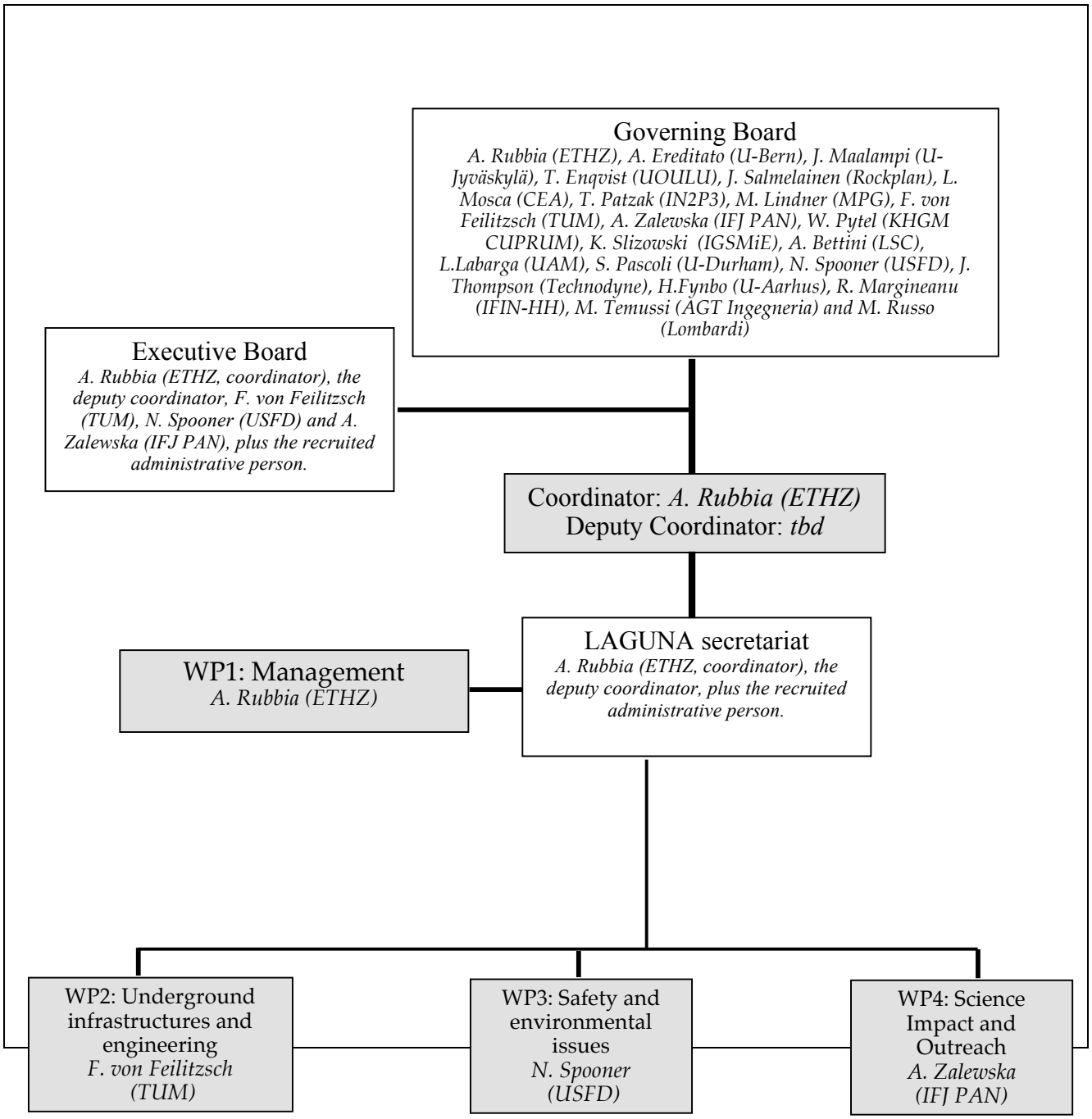
The **executive board** (EB) assures the day-to-day follow-up of the program and it is formed by the coordinators, the 4 workpackage leaders F. von Feilitzsch (TUM), N. Spooner (USFD) and A. Zalewska (IFJ PAN) plus the administration responsible members. It will be responsible for the co-ordination and harmonization of all LAGUNA actions and particularly for the administrative and co-operative support of all transnational research activities. It will follow up all important horizontal issues and will prepare the GB meetings of the LAGUNA consortium. It will also be responsible for public relation issues and for the contents of the LAGUNA website. It will meet every two months, and decisions will be taken on a unanimity basis. On exceptional cases differences may be resolved by qualified majority rule (2/3 of the members) or can be directed to an exceptional GB meeting.

- The members of the Executive Board are: A. Rubbia (ETHZ, coordinator), the deputy coordinator, F. von Feilitzsch (TUM), N. Spooner (USFD) and A. Zalewska (IFJ PAN), plus the recruited administrative person.

The **LAGUNA Secretariat** assures the day-to-day follow-up of the programme and it is formed by the coordinator and its deputy, the administration plus invited members of the LAGUNA consortium, like for example the leaders of the workpackage, depending on the session. The close interaction of the consortium partners in the joint secretariat belonging to different national institutes will improve coordination and internal quality control, but will most notably increase the acceptance and transparency within the LAGUNA consortium. All relevant quality control information within the six work packages will be collected within the project management. The division of labour between the partners is explained in the Workpackage description. The joint secretariat will be responsible for the coordination and harmonisation of all LAGUNA actions (electronic communication tools, …), and particularly for the administrative and cooperative support of all transnational research activities. The joint secretariat will keep contact with all participants of the consortium. It will follow all important horizontal issues and will prepare the meetings of the LAGUNA consortium: the Governing Board, and the LAGUNA general meetings. It will also be responsible for public relation issues and for the contents of the LAGUNA website. The GB and LAGUNA meetings of the joint secretariat will be held at the different capitals of the countries participating in the

network. Each major meeting will be accompanied by a joint secretariat meeting, while independent meetings will also be organized.

- The members of the LAGUNA Secretariat are: A. Rubbia (ETHZ, coordinator), the deputy coordinator, plus the recruited administrative person. When necessary, WP coordinators will be asked to joint for particular meetings.



B.1.5. Beneficiaries

ETH Zürich – Swiss Federal Institute of Technology Zurich, Physics Department
The ETH Zurich, often called Swiss Federal Institute of Technology, is a science and technology university in the city of Zurich, Switzerland. Its full name is Eidgenössische Technische Hochschule Zürich, with ETHZ also being a common unofficial abbreviation. The ETH is an internationally oriented university. It is a member of the IDEA League and the International Alliance of Research Universities IARU.
The Institute for Particle Physics (IPP) belongs to the Physics Department. The Institute's main research projects address fundamental questions in the following three research fields:
(1) experiments at the frontier of high-energy interactions between fundamental particles, (2) experiments in neutrino physics and 3) experiments in Astroparticle Physics.
Profile of staff members who will be undertaking the work:

- Prof. Dr. A. Rubbia, head of the institute of particle physics, group leader, leading the ArDM and GLACIER R&D efforts. Chairman of CHIPP (Swiss Institute for Particle Physics. Elected member of the T2K executive board. Attended CERN course of management. Experimental high-energy particle and astro-particle physics, Search for neutrino flavor oscillations, Search for proton/neutron decay, Physics with positron/positronium, Detector R&D, Direct search for dark matter in the Universe, Phenomenology, Physics computing. Present and past international research projects: NA61, T2K, OPERA, ArDM, ICARUS, NOMAD, L3.
- Dr. A. Badertscher, senior researcher, detector construction, liquid Argon TPC detectors
- Dr. M. Laffranchi, PostDoc researcher, detector design and assembly, liquid Argon TPC detectors
- Dr. A. Marchionni, PostDoc researcher, neutrino beams and neutrino physics, expertise in detectors and accelerators, detector development, liquid Argon TPC detectors, electronic and readout systems

[U-Bern] University of Bern, Laboratory for High Energy Physics (LHEP)
The University of Bern is one of the most important Swiss Universities. Already in 1528 it was structures as a " Hohe Schule". Today there are about 20000 students subdivided in 8 faculties: Theology, Law, Economics and Social Sciences, Medicine, Veterinary Medicine, Human Sciences and Science. The faculty of Science provides teaching and researches in the fields of Mathematics, Physics astronomy and philosophy, Chemistry and Biochemistry, Biology, Geology and Geography. Physics is subdivided into three institutes (Physics, Applied Physics and Theoretical Physics). The laboratory for High Energy Physics (LHEP) is one of the three departments of the
Physics Institute. More information can be found in: http://www.unibe.ch/and
http://www.philnat.unibe.ch/
LHEP has also a long tradition in research and teaching. Elementary particle physics is one of the key specializations of the Institute of Physics at the University of Bern. K. Pretzl who succeeded B. Hahn in 1988 started a series of new projects in the field of particle physics. In particular he contributed to the search of strange-quark matter with the NA52 experiment in the heavy ion beam at the CERN Super Proton Synchrotron (SPS). Under his leadership the LHEP participated in the conceptual design of the ATLAS experiment for LHC. He also started a line of research on neutrino physics, joining the OPERA experiment for the search for neutrino oscillations. After retirement of K. Pretzl in 2006, A. Ereditato was appointed as his successor and is presently leading LHEP. The current activities of LHEP include the ATLAS, OPERA and T2K experiments in addition to an R&D study on novel particle detectors (as in particular LAr TPCs). As far as the latter subject is concerned we are realizing at LHEP,in collaboration with ETHZ and the University of Granada, a 5 m long LAr TPC detector (ARGONTUBE), in the framework of the GLACIER R&D program.
Profile of the staff members who will be undertaking the work:

- Prof. Dr. A. Ereditato, group leader, LAr detectors, management, physics. Experience in neutrino and astroparticle physics. Experience with large neutrino physics experiments at CERN and LNGS (CHARM II, CHORUS, OPERA, ICARUS) Experience with particle detectors: calorimeters, LAr TPC, emulsion detectors, imaging.
- Tit. Prof. Dr. U. Moser, Particle detectors, infrastructure, underground sites Experience with particle detectors and HEP experiments, also in neutrino physics (OPERA).Experience with organization of scientific activities.
- Dr. M. Messina, PostDoc senior researcher, Physics, LAr detectors, underground sites, outreach. Experience in particle physics and neutrino physics. Experience in LAr TPC detectors.
- Dr. I Kreslo, PostDoc researcher, Particle detectors, DAQ, experience with liquid scintillators, imaging. Experience in high space-resolution detectors (emulsions, capillaries, scintillator trackers,

liquid scintillators, imaging).

[Jyväskylä] University of Jyväskylä

The University of Jyväskylä is one of the best and most popular Universities in Finland. It mainly attracts the students from the central part of the country. Natural sciences and mathematics, human-centred sciences, sport and health sciences as well as teacher education form the core fields of the research and education. The University has the third highest number of Centres of Excellence in Finland and has been named a University of Excellence in Adult Education by the Finnish Ministry of Education.

The Department of Physics performs research and offers education at highest international level on nuclear and accelerator-based physics, materials physics and high energy physics. In addition, it hosts a teacher education program. The accelerator laboratory is a Centre of Excellence under the national centre of excellence program. Part of the research is done at CERN. There is also a very strong theory group.

The main task of Jyväskylä is to work in close cooperation with CUPP on the design of the underground infrastructure for the new underground laboratory (WP2), address safety and environmental issues (WP3) and contribute to science impact and outreach (WP4).

Profile of the staff members who will be undertaking the work:

- Dr. Wladyslaw H. Trzaska. Scientific background in experimental nuclear and high energy physics, Project Leader of ALICE T0 detector, coordinator of the Nuclear Reaction Research at Jyväskylä, spokesman of the underground experiment EMMA.
- Prof. Jukka Maalampi, Head of the Department. Scientific background in theoretical physics, strong interest in sterile neutrinos.
- Prof. Jouni Suhonen. Scientific background in theoretical physics, strong interest in beta decay and matrix element calculations; author of a textbook for advanced students on nuclear concepts and microscopic theory.

[UOULU] University of Oulu

The University of Oulu is an active scientific learning and research community of 17 000 students and 3000 staff members. Its task is to promote well-being and education in Northern Finland by implementing high-quality international research. The University's six faculties and their departments form a multidisciplinary academic institution that enables diversified studies and multifaceted research.

The University aims to develop itself further as an internationally high-level scientific community by paying particular attention to the needs of science and society. The University's goal is to clarify and strengthen its competitiveness and know-how. Ability for renewal and multifaceted know-how form the recipe for success, and active participation in the international scientific community is the basis for such renewal and development. Strategic goals include the promotion of the University of Oulu as an attractive work place for international top-scientists, which means that teaching and research has to be of high quality. The University creates high-level research environments for international research groups.

The University of Oulu runs an underground laboratory in Pyhäsalmi mine, referred to as Centre for Underground Physics in Pyhäsalmi (CUPP). Oulu Southern Institute administers it, which is a regional organisation of the University of Oulu.

CUPP has been planning or running an underground laboratory since 1997. CUPP has hosted or realised some small-scale experiments in the lab, including neutron measurements. The current experimental activity focuses on a cosmic ray experiment EMMA (Experiment with MultiMuon Array) shallow underground, and the future plans concentrate on LAGUNA.

A prefeasibility study and preliminary plan for a new underground laboratory was made in 2002 with Rockplan. The University of Oulu has experience on participation on planning and developing of several major construction projects for its recent new premises.

The main task of Oulu in this Design Study is to work on WP2, the design of the underground infrastructure for the new underground laboratory that is the subject of this project. In more detail, Oulu is responsible for the scientific aspects for the Finnish candidate site and links with the participant Rockplan, which is the respective technical partner. Oulu also contributes to WP3 (safety and environmental issues), particularly studying the site specific aspects and WP4 (Science impact and outreach).

Profile of the staff members who will be undertaking the work:

- Dr. Timo Enqvist, senior researcher, manager of the Pyhäsalmi laboratory. Scientific background: experimental nuclear physics and astroparticle physics.
- Dr. Pasi Kuusiniemi, PostDoc: experimental nuclear physics and astroparticle physics.
- Prof. Kari Rummukainen, Department of Physical Sciences, University of Oulu: professor of theoretical

particle physics, with the responsibility for the research program and teaching of particle physics at the University of Oulu. Scientific background in Cosmology and Finite temperature field theory.

CNRS – IN2P3 – Université Paris Diderot Paris 7

The IN2P3 (CNRS) is the national French institutes concerned with particle, nuclear physics. The institute also funds major programs in astroparticle physics in collaboration with the Institute of the Sciences of the Universe INSU/CNRS, other departments of CNRS and other national organisms (CNES for space, IFREMER for the sea, etc.) .

IN2P3 has been created in 1971 as an institute of CNRS devoted to particle and nuclear physics, and more recently to astroparticle physics. It is tied by decree ties with the University research and has also strong connections with DAPNIA (CEA)(Dapnia) and CNES (Spatial program). IN2P3 is composed of 23 Laboratories most of which are contracting with universities and CNRS (so called UMR). One of these laboratories, the CCIN2P3, is a Computing Center supported and used by both DAPNIA (20%) and IN2P3 (80%).). In 2005 the total IN2P3 permanent staff was 2488 persons (491 CNRS researchers, 304 University professors, 1460 CNRS staff, 233 University staff). The IN2P3 & CEA run the Fréjus-Modane Underground Laboratory (LSM) since 25 years and are involved in a wide spectrum of neutrino and astroparticle experiments.

French laboratories have strong activities at CERN and all the other major particle physics facilities around the world (Fermilab, Stanford, Desy, Tsukuba, Jefferson laboratory, RHIC etc.).

The University of Paris Diderot – Paris 7 is partner of the IN2P3 via the APC Laboratory, UMR 7164.

Profile of staff members who will be undertaking the work:

• Pr. Thomas Patzak, project director at APC/IN2P3/University Paris Diderot-Paris7 (UMR 7164): leads the IN2P3 group of this project. Scientific activity in neutrino physics and particle physics detector development.

• Dr Jean-Eric Campagne, researcher at LAL/IN2P3. Scientific interest in neutrino physics and nucleon decay search, co-coordinator of the MEMPHYS project, chairman of the Modane Underground Laboratory Scientific Committee.

• Dr. Alessandra Tonazzo, researcher and lecturer at APC/IN2P3, has contributed to different high-energy collider experiments, both with detector development and with data analysis

• Dr . Dario Autiero (IPNL/IN2P3), responsible of the neutrino group at IPN Lyon. Scientific background in neutrino physics with the NOMAD and OPERA experiments. Leads the local group of the LAGUNA project.

• Dr. Sacha Davidson (IPNL/IN2P3) theorist at IPNL laboratory

[CEA] Centre Energie Atomique (France)

In 2005 DAPNIA employed a total of 820 persons (420 engineers (including 200 researchers), 246 technicians and administrative staff, 19 CNRS or University staff and 135 non permanent staff (PHD, postdocs).

DAPNIA is composed of 7 services. For both DAPNIA and IN2P3 there are about 180 graduate students.

The IN2P3 & CEA run the Fréjus-Modane Underground Laboratory (LSM) since 25 years and are involved in a wide spectrum of neutrino and astroparticle experiments.

French laboratories have strong activities at CERN and all the other major particle physics facilities around the world (Fermilab, Stanford, Desy, Tsukuba, Jefferson laboratory, RHIC etc.). IN2P3 and DAPNIA have developed high competences in all technical fields related to particle physics.

Profile of staff members who will be undertaking the work:

• Dr. Luigi Mosca, former Director of LSM and at present Scientific Adviser for future projects at Fréjus site

• Dr. Marco Zito, PostDoc researcher at CEA/DAPNIA. Leader of the T2K team in Saclay.

[MPG] Max-Planck-Gesellschaft zur Förderung der Wissenschaften e.V.

The Max-Planck-Institut für Kernphysik (MPIK) in Heidelberg and the May-Planck-Institut für Physik (MPP) in Munich are two well known institutions in particle and astroparticle physics. Both institutes are included via their head organisation, the Max-Planck-Gesellschaft (MPG). Coordination is done via the Max-Planck-Institute für Kernphysik in Heidelberg. The experimental activities at MPIK are based on a strong research record in experimental neutrino physics and low-background techniques. The involved theoretical expertise at MPIK and MPP involves well known experts working on a broad set of topics which are directly and indirectly relevant for the LAGUNA proposal. The expertise includes on the formal side theoretical studies of neutrino mass models, extensions of the Standard Model which can accommodate neutrino properties and proton decay. The theoretical activities include various activities concerning the modelling of neutrino sources, including supernovae neutrinos, geo-neutrinos, neutrino beams, and reactor neutrinos. Another topics is the propagation of neutrinos in matter in the Earth and in supernovae and detection channels. Development and application of the GloBES software, a powerful simulation tool for long baseline

and reactor neutrinos with three flavour oscillations in matter. There exists also a lot of expertise in the phenomenology of Dark Matter and axions and in theories beyond the Standard Model providing Dark Matter or axion candidates.

Profile of the staff members who will be undertaking the work:

- Prof. Dr. Manfred Lindner, director at MPI für Kernphysik, expertise in theoretical particle and astroparticle physics, phenomenological studies in neutrino physics.
- Dr. Stefan Schönert, MPI für Kernphysik, project leader, expertise in neutrino physics at low energies, underground and low background physics, detector technology.
- Prof. Dr. Georg Raffelt, MPI für Physik, senior research scientist at MPI für Physik, expertise in theoretical particle and astroparticle physics.
- Prof. Dr. Wolfgang Hampel, senior research scientist at MPIK, expertise in neutrino physics at low energies, underground and low background physics, detector technology.
- Prof. Evgeny Akhmedov, senior researcher at MPIK, expertise in theoretical particle physics
- Dr. Christian Buck, senior researcher at MPIK, expertise in neutrino physics and scintillator development.
- Dr. Hardy Simgen, senior researcher at MPIK, expertise in neutrino physics and low background techniques.
- Dr. Josefa Oehm, senior research scientists at MPIK, expertise in low background physics.
- Dr. Jochen Schreiner, senior research scientists at MPIK, expertise in low background physics.
- Dr. W. Rodejohann, senior researcher at MPIK, expertise in theoretical neutrino physics

[TUM] Technische Universität München, Physikdepartment E15

The institute E15 of the faculty of Physics at the Technische Universität München, Germany, is playing a leading role in Astroparticle Physics. Expertise has been achieved in the fields of solar neutrino measurements (GALLEX, GNO, and BOREXINO experiments), Dark Matter search (CRESST experiment), and experiments for investigating intrinsic neutrino properties (GÖSGEN, BUGEY, DOUBLE-CHOOZ). Technical expertise has been obtained in the development of scintillating detectors with extremely low levels in radioactivity. In addition large experience has been gained in cryogenic detector developments and in methods to characterise background levels with neutron activation and high sensitivity gamma spectroscopy. For this purpose a shallow site underground laboratory in Garching has been built. Experience in working in deep underground laboratories was obtained in the Italian Gran Sasso facility. Knowledge on electronics, data acquisition, single photon counting, data analysis, and Monte-Carlo calculations has been acquired. Connections to the High-Tech companies Fa. Vericold, Ketek, Infineon (Germany), Aquiris (CH) and ETL (UK) are fostered. The institute enforces public outreach with open doors days, information days for pupils, public seminars, by supporting the science-Lab of the Technical Museum in Munich. The group consists of 2 professors, 3 senior researchers and 7 PhD-students. A mechanical workshop including 2 engineers belongs to the institute. The group under Prof. F. von Feilitzsch is active in this field since 27 years.

Profile of the staff members who will be undertaking the work:

- Prof. Dr. Franz von Feilitzsch, chairman of the institute. Expertise in dark matter, neutrino and underground physics, and detector technology.
- Prof. Dr. Lothar Oberauer, Extraordinarius. Expertise in neutrino physics at low energies, rare event physics, detector technology and underground low background physics.
- Dr. Marianne Göger-Neff, senior researcher. Expertise in neutrino physics and scintillator development.
- Dr. Jean C. Lanfranchi, senior researcher. Expertise in low temperature detector developments, neutrino physics, and Dark Matter search.
- Dr. Walter Potzel, senior researcher. Expertise in Moessbauer-effect, low temperature detectors, neutrino physics, and Dark Matter.

IFJ PAN and its Polish partners

The H. Niewodniczanski Institute of Nuclear Physics of the Polish Academy of Sciences (IFJ PAN) in Cracow is one of the leading and of the largest Polish research institutes. The Institute carries out basic and applied research in physics. At present the Institute is involved, as a constructer, in 18 projects of the Sixth Framework Programme.

The basic research, both theoretical and experimental, concerns particle physics and astrophysics, nuclear and strong interactions physics and condensed matter physics. The experimental teams from IFJ PAN participate in the large international collaborations: ATLAS, LHCb and ALICE at LHC (CERN), ZEUS and H1 at HERA (DESY), Belle at KEKB (KEK), PHOBOS at RHIC (BNL), Auger in Argentina, ICARUS at Gran

Sasso, T2K at J-PARC and ILC. Physicists in these teams are supplemented by an excellent technical staff whose mandate comprises the design and construction of detector mechanical structures, cooling systems, readout electronics, DAQ and trigger systems for experiments. This staff has also provided a significant contribution to the LHC Computing Grid and to the construction of the LHC accelerator.
The Institute, originally established as a nuclear physics research laboratory over 50 years ago, has by now expanded its research over a broad range of interdisciplinary applications of physics. It has for several years served as a leading regional centre in radiation and environmental biology, environmental physics, medical physics, dosimetry, nuclear geophysics, radiochemistry and material engineering.
In the LAGUNA project the group from IFJ PAN will closely collaborate with three other groups of Polish physicists from the A.Soltan Institute for Nuclear Studies (IPJ) in Warsaw, University of Silesia (US) in Katowice and University of Wroclaw (Uwr). In a ranking of the Ministry of Science and Higher Education in Poland all four institutions are classified as belonging to the (top) first category in physics research. IPJ, similarly to IFJ, carries a variety of research in physics and in particular has very strong experimental groups in particle and nuclear physics participating in many international projects. US and UWr have strong theory groups specialising in different aspects of neutrino physics. The Laboratory of Low Activities, in the Institute of Physics of US, carries environmental studies with use of α, β and γ spectrometry systems. At present, the group, within the ILIAS/TARI project in the 6th FP, is involved in measurements of natural radioactivity in several European Underground Physics Laboratories.
The wide range of the basic and applied research carried out by the highly qualified staff of IFJ PAN and of its scientific partners in Poland will be fully exploited in WP4, coordinated by IFJ PAN. The list of the Polish higher level personnel involved in the LAGUNA project includes:

- Prof. Agnieszka Zalewska (F), IFJ PAN – Head of Department of Studies of Neutrinos and Dark Matter
- Prof. E. Rondio (F), IPJ – senior researcher
- Prof. J.Kisiel (M), US – senior researcher
- Assoc. Prof. J. Sobczyk (M), Uwr – senior researcher
- Assoc. Prof. J.W. Mietelski (M), IFJ PAN – Head of Department of Nuclear Physical Chemistry

[[LSC] Laboratorio Subterráneo de Canfranc
The LSC is a new facility for Underground Science. It is located under the Pyrenees mountain "El Tobazo" in Canfranc (Huesca, Spain). The over burden at the site provides 2500 meters water equivalent of shielding. Administratively, it is conceived as a Consortium of the Spanish Ministry of Education and Science, the Aragon Regional Government and the University of Saragossa.

Profile of the staff members who will be undertaking the work:

- Prof. Alessandro Bettini. LSC Director. He has a vast experience in experimental particle physics covering fixed target, collider and underground experiments with pivotal contributions to the LEBC-EHS, UA1, ICARUS and GERDA experiments. He is one of the world leaders responsible of last decade's boost of neutrino physics to its actual top place in scientific research. He has been Director of the "Laboratori Nazionali del Gran Sasso", the largest underground scientific facility in Europe, during the years 1998 to 2004.

[UAM] University Autonoma Madrid and its Spanish partners
The University Autonoma Madrid is one of the most important Spanish universities in scientific research. Its Department of Theoretical Physics has among its members very relevant Scientists in the field of Particle Physics in both, theory and experiment.
The University of Granada is one of the largest universities in Spain from the point of view of the number of students assigned to it and from the amount of scientific production in international peer-reviewed journals. At European level, it has played a significant role both in innovation for education and research. In 1990, a theoretical group on Particle Physics was created. It is now a well-established research group that plays a relevant international role in the study of the phenomenology of the Standard Model and the Physics beyond it. Recently, in 2002, this group was complemented by the creation of an experimental group on High Energy Physics. This is one of the youngest and more emergent groups for this field in Spain. In particular, it is the only one of these characteristics in the autonomous region of Andalucia (FEDER region type I). The group activities have been fully funded and supported since their onset by the Spanish Agency for Particle Physics. Nowadays the group is composed of three doctors, five Ph.D. students, an electronic engineer plus two technicians. It also operates a laboratory mainly devoted to R&D with cryogenic detectors.

Profile of the staff members who will be undertaking the work:

- Prof. Luis Labarga (UAM). He has a large experience in experimental particle physics. He has

contributed substantially to the following experiments: TASSO at PETRA (DESY), MARK II at the SLC (SLAC), ZEUS at HERA (DESY) and to the design and construction of ATLAS at the LHC (CERN).

- Prof. Antonio Bueno (Granada). Leads the Granada group of this project.
- Dr Julio Lozano (Granada), senior PostDoc researcher.

[USFD] University of Sheffield and Boulby

The University of Sheffield is a premier research University in the UK, participating here through the Department of Physics and Astronomy. Members of the department (led by Spooner) play a leading role in UK and European Astroparticle Physics through development of underground detector technology (for dark matter and neutrino physics) in Boulby Underground Laboratory at Boulby Mine, North Yorkshire. Our role at Boulby gives us unique experience to be a major contributor to LAGUNA - Boulby is the largest and longest running deep mine-based laboratory in Europe. Established in 1988 and expanded in 1999 with new facilities, is has been host to successful dark matter (NAIAD, ZEPLIN, DRIFT) and other experiments and has a strong record of R&D in connection with the ILIAS FP6 programme. The group (currently three academics and 10 students, technicians and PDRAs) has extensive experience gained over 15 years directly relevant to the workpackages in LAGUNA including: excavation and mine operations; development of large underground infrastructures and laboratories in mine environments; underground background and environment research; scintillator, liquid Argon, photon detection, electronics and data acquisition technology for underground detectors; engineering of unusual pressure vessels for underground use; interaction with non-physics applications, industrial cooperation and public outreach.

Profile of the staff members who will be undertaking the work:

- Prof. Neil Spooner, Director Boulby Laboratory, group leader. Expertise in dark matter, neutrino and underground physics, and detector technology
- Dr. Vitaly Kudryavtsev, senior academic researcher. Expertise in dark matter and rare event physics, detector technology and underground background simulations
- Dr. Sean Paling, senior researcher. Expertise in underground operations and engineering, rare event physics, analysis and detector development
- Dr. Phil Lightfoot, senior researcher. Expertise in cryogenic liquid, scintillator and gas technology underground, mine operations and engineering, rare event physics, novel readout techniques.
- Dr Matt Robinson, senior researcher. Expertise in data reduction, data analysis, simulations and data acquisition systems.

[UDUR] Durham University

Durham University is a world-class university in the city of Durham and at the Queen's Campus in Stockton, in the United Kingdom. It is engaged in high-quality teaching and learning and advanced research and partnership with business. Its academic teaching and research programmes are delivered through departments contained within three faculties: Arts and Humanities, Science, and Social Sciences and Health. The Department of Physics is part of the Science Faculty.

The Institute for Particle Physics Phenomenology (IPPP) was founded in 2000 as a joint venture of Durham University and the UK Particle Physics and Astronomy Research Council (PPARC). The IPPP is part of the Centre for Particle Theory (CPT) in Durham, based jointly in the Departments of Mathematical Sciences and Physics, with a number of academic staff having joint appointments in the two Departments. Its aim is to foster world-class research in particle physics phenomenology, and to provide a forum for interaction between experimentalists and theorists, coordinating common interests and future research through a series of discussion meetings, workshops and conferences. Within a short space of time, the IPPP has achieved international recognition and the recent Second International Review of UK Research in Physics and Astronomy stated ``The IPPP has had major successes: creating a critical mass of particle theorists in Durham. There have been very healthy interactions reviving particle phenomenology throughout the UK."

An extensive visitor programme brings world-class researchers to the IPPP for periods ranging from a few days to a year. Training for the next generation of particle physicists is provided through guidance in research, and dedicated graduate lecture programmes and summer schools.

Research activities cover all aspects of particle phenomenology and, in particular, topics directly related to the LAGUNA proposal, namely physics Beyond the Standard Model of Particle Physics, and neutrino physics. Known experts work on i) neutrino phenomenology, concerning the study of neutrino properties in present and future experiments, ii) theoretical aspects of neutrino physics with particular focus on the origin of neutrino masses, iii) the role of neutrinos in the Early Universe and in the evolution of astrophysical objects as supernovae. Expertise on extensions of the Standard Model, which predict proton decay, and on dark matter is also present.

The main task of Durham concerns the science impact and outreach (WP4), providing theoretical support to the experimental investigations and contributing to the detector simulations, in order to fully explore and

optimise the physics potential of the LAGUNA research infrastructures.

Profile of the members who will be undertaking the work:

- Dr. S. Pascoli, faculty member. Research in neutrino physics, extensions of the Standard Model and cosmology.
- N.N., postdoctoral researcher. Expertise in neutrino phenomenology, …

[U-Aarhus] University of Aarhus

A high level of quality in both research and education is the aim of the University of Aarhus. Since its early beginnings in 1928, the university has provided both the Danish and international communities with more than 42,000 graduates, and has left its own special mark on the city of Aarhus, the Danish society and the international research community. The University of Aarhus has a reputation for education and training – a brand that extends well beyond Denmark's borders. It is a lively, modern university, which collaborates with the business community, cultural centers and other universities throughout the world.

The main task of U-Aarhus in this Design Study is to work on WP2, the design of the underground infrastructure for the new underground laboratory in collaboration with the CUPP center at Oulu, and to WP4 (Science impact and outreach).

Profile of the staff members who will be undertaking the work:

- Dr. Steen Hannestad, scientific background: Theoretical astroparticle and neutrino physics. Current or past board member of several European networks in these fields. Member of the governing council for ILIAS.
- Dr. Hans Fynbo, scientific background: experimental nuclear physics and nuclear-astrophysics. Spokes-person and project leader for numerous experiments at CERN-ISOLDE and other radioactive beam facilities in Europe.

[Rockplan] KALLIOSUUNNITTELU OY ROCKPLAN LTD

is a consulting company founded in 1986 and has over 20 years experience in every kind of underground facilities. For the most part acting as main designer, the company has gained experience through various projects in the field of rock engineering. The staff is mainly made up of architects, civil and rock engineers and geologists. The staff of 30 persons is mainly made up of architects, civil and rock engineers and geologists. The company is SME. The company has specialized in managing the design, general design, rock engineering design and structural design. Additional plans and designs are produced in co-operation with experienced subcontractors.

- Kalliosuunnittelu Oy Rockplan Ltd, (Rockplan), is able to act as Design Manager, coordinating and controlling the work or as a main designer.
- General design by Rockplan embraces both layout design and architectural design. In carrying out general design the company aims to create a suitable, safe, technically high quality underground facility meeting the client's requirements.
- The aim of Rockplan in rock engineering design is to use properties of the rock to the best advantage, and to prepare high quality plans excavation, reinforcing the rock surface, sealing and waterproofing. A fundamental consideration of the design is safety during construction.
- Rockplan aims to produce structural designs that take account of the special requirements of underground construction in cost effective manner. Structural design is required for among other things: entrance ramps and shafts, internal floors and structures and blast-resistant barriers.

Additional plans and designs are produced in co-operation with experienced subcontractors.

The main task of Rockplan in this Design Study is to make the preliminary design and technical feasibility study of the underground construction in the Finnish site.

Rockplan has been actively taken part in innovate new technology underground projects. One of the first steps was Hirvihaara deep storage of natural gas in Southern Finland. Rock lined cavers of total volume of 1.6 M m^3 were located in 850 meters depth. The detailed design of hoisting and service systems was carried out in years 1990-92 for Neste Oy Natural Gas. To the same client Rockplan designed also a concept of steel lined natural gas storage. The client discontinued these projects.

Rockplan has completed design of a 150.000 m^3 steel lined petroleum storage in Finland. The storage consists of 5 tanks with diameter of 35 meters. This storage has been operated for 16 years. Client and details are confidential information.

Kamppi Centre (Kampin keskus), the largest single construction project that has been carried out in Finland, was the best construction site of the year 2003. The jury grounded the election on Kamppi's visionary rock engineering in difficult circumstances and innovative technical solutions. The blasting work has been remote sensored in realtime and the effects has been analysed for security purpose before the next coming blast.

Salmisaari, underground coal storage. The overall project involves 3,5 km of tunnel with 40 different cross sections. Total excavation of 550.000 m^3 of granite/gneiss has being undertaken, all of which was crushed and screened for reuse by the local construction industry. The underground silos are each 65 m-high x 40 m-diameter with circular plan cross-section. The volumetric capacity of each silo is 81.000 m^3. The Salmisaari coal transport tunnel will be re-equipped to charge the silos and a newly mined conveyor retrieval tunnel will be used to discharge the coal.

The staff members undertaking the work will include:

- Jarmo Roinisto, Chairman of the Board, Managing Director, M.Sc. (Civ.Eng.): Project management, design and supervision of rock engineering, tunnelling and underground spaces
- Juha Salmelainen, Development Director, M.Sc. (Eng.Geol.): management of rock engineering projects, site investigations and rock mechanical modelling
- Raimo Matikainen, emeritus professor of rock engineering, former Director General of the Finnish Geological Survey, Board member and vice chairman of The Finnish Academy of Technology: wide experience of engineering in mining industry and geological research
- Matti Hakala, Special Designer: rock modelling in 2D and 3D using the most advanced calculation programs

KGHM CUPRUM

The KGHM CUPRUM Ltd. Research and Development Centre (KGHM CUPRUM), which is a part of the KGHM Polska Miedź SA capital group, has existed for over 35 years. During the first few years of its activity the company developed the research and design studies for the Polish copper basin and then for many other home and foreign mine projects, which gave it a stable position in the non-ferrous metals, salt mining and mine construction industries. At present it widens its activity range participating in geological and mining projects of the European Union.

Being aware of the XXI-st century challenges the company widens its activity undertaking problems of environmental protection and companies restructuring. It is at the same time consultant, expert and authority in geology, extractive industry, minerals processing and environmental protection.

KGHM CUPRUM has a highly qualified and experienced team of specialists (over 140) who create the most modern technical solutions and guarantee services on a high quality level. It also has the ISO 9001 and 14001 certificates.

The company has its own, fully accredited laboratory of rock mechanics with excellent equipment for investigating rock behaviour under any kind of load. It has a special purpose software and unique test instruments like chromatographs for gas mixtures and volatile liquids analyses, an X-ray diffractometer, a spectrometer of infrared radiation, a modern noise level gauge, a portable system for gas emission measurements, a kit for measuring and analysing vibrations, thermovision equipment, instruments for non-destructive laboratory and field tests, and a set for water analyses.

The research activity of KGHM CUPRUM Ltd. RDC is presently focused on: geology, hydrogeology and mining projects feasibility studies, mining, including rock mechanics, mines electrification, automation, mechanisation and ventilation, minerals processing, environmental protection with its monitoring and wastes management, companies restructuring, economical studies, technical expertise and engineering concepts evaluation used mainly for copper mines (among them also the Sieroszowice mine) exploited by KGHM Polska Miedź S.A.

KGHM CUPRUM participated in geological and hydro geological, mining and environmental projects of the European Union within 5th and 6th FP including:

- Life Cycle Assessment of Mining Projects for Waste Minimization and Long Term Control of Rehabilitated Sites (LICYMIN) - G1RD - CT - 2000 – 00162
- Chemically Stabilized Layers (CLOTADAM) – G1RD-CT-2001-00480
- Lifetime Engineering of Buildings and Civil Infrastructures - (LIFETIME) - GTC1-2001-43046
- Network on European Extractive Mining Industries (NESMI) - G1RT-CT-2002-05078
- Search for a sustainable way of exploiting black ores using biotechnologies (BIOSHALE) – NMP2-CT-2004-50571

For many years CUPRUM has been organising domestic and international scientific conferences and seminars on roof bolting, minerals processing, metallurgy, environmental protection and mining in difficult rock-mass conditions. The company has an authorisation granted by the Minister of Environmental Protection, Natural Resources and Forestry to deal with: atmosphere protection, land surface protection, environmental impact assessments of investments and building structures.

The KGHM Cuprum contribution to the Laguna project will cover feasibility studies for large caverns, problems concerning the site accessibility, evaluating the geomechanical limitations excavation technology, ventilation requirements, costs evaluation (WP2), local geomechanical hazards assessment due to mine activity and environment protection analyses (WP3).

The staff members undertaking the work will include:

- Dr. hab. Witold Pytel – project leader, M.Sc. (Civ. Eng.), MBA: background in soil and rock mechanics, numerical modeling and rock mass stability analyses, risk assessment and management,
- Dr. Andrzej Grotowski, : expertise in environmental protection and mineral processing,
- Dr. Andrzej Markiewicz, Geologist: expertise in geological survey and tectonic structure research,
- Miroslaw Raczynski, M.Sc. (Electr. Eng.): expertise in electric power supply and automation in mines,
- Zbigniew Sadecki, M.Sc. (Min. Eng.): expertise in mine planning and equipment selection,
- Dr. Slawomir Gajosinski, M.Sc. (Min. Eng.): expertise in mine ventilation and air-conditioning

IGSMiE PAN

The Mineral and Energy Economy Research Institute is part of the Polish Academy of Sciences (IGSMiE PAN), which has been leading research work on mining, geology, engineering geology, geotechnics, raw materials management and environment protection.

One of the main activities of the Institute is research on the physical and chemical properties, especially geological, geothermal, mineralogical, and hydrogeological of salt massifs. The results created a base for mathematical and physical models of rock salt formation which have been used for designing natural gas and liquid hydrocarbons storage caverns in rock salt deposits.

The Institute has been coordinating research work on the site selection and formation for the Polish deep radioactive waste storage project. The Institute is also participating in two European Union research framework FP6 projects related to geothermal energy and to carbon dioxide sequestration.

Staff members of the Institute have broad experience in design and in assessment of large-scale excavation long-term stability, including natural hazards (water, gas outburst) in Polish rock salt deposits. They have been participating in most of research projects, related with Polish salt mining in the last years.

In the case of the underground infrastructure for the SUNLAB project, the Institute is competent in the following tasks:

- Determining the optimum localization criteria for the laboratory,
- Study of the physical and chemical (including geological) properties of rock salt from the site of the potential localization,
- Formulating the constitutive law and effort criteria for rock salt formation,
- Cavern stability evaluation.

The staff members undertaking the work will include:

- Kazimierz Ślizowski – Head of the Underground Storage Department.
- Wiesław Bujakowski – Head of the Renewable Energy Department
- Zenon Pilecki – Head of the Department of Geodynamics and Environmental Engineering
- Kazimierz Urbańczyk – Specialist in the mathematical modelling of physical processes
- Jarosław Ślizowski – Specialist in the geomechanics of rheological media

[IFIN-HH] "Horia Hulubei" National Institute of R&D for Physics and Nuclear Engineering

The origins of the National Institute of R&D for Physics and Nuclear Engineering - Horia Hulubei, IFIN-HH go back to as early as 1949 when a small Institute of Physics of the Romanian Academy was founded. It was reshaped in 1956 and renamed as the Institute of Atomic Physics (IFA), http://www.nipne.ro.

In 1977 the Central Institute of Physics (ICEFIZ) was set up to co-ordinate the entire physics research in Romania. The main institute of this system was the Institute of Physics and Nuclear Engineering (IFIN). In late 1996, IFIN was elevated to national institute and was named after Horia Hulubei, its original founder, becoming the Horia Hulubei National Institute of R&D for Physics and Nuclear Engineering (IFIN-HH).

IFIN-HH is a National Institute of Research & Development mainly funded by the Ministry of Education and Research

Facilities: U120 Cyclotron, 1959, MP Tandem Accelerator, 1974, Radioisotope Production Center, 1974, Nuclear Waste Processing and Storage Centres, 1974, Multipurpose High Dose Gamma-Ray Irradiator, 2000, cosmic ray muon detector WILLI (1995), Underground Laboratory – Slanic Prahova (2006)

The main research and development areas: theoretical physics and high energy, particle and astroparticle physics, atomic physics and nuclear structure, interdisciplinary researches with accelerated particle beams, nuclear technologies and radiation metrology, radiation biophysics and biochemistry, radioecology, instrumentation for nuclear research and technologies, information systems, data bases and computer networks

Profile of the staff members who will be undertaking the work:

•Romul Mircea Margineanu: senior scientist, founder and head of the Romanian Underground Laboratoy –

Slanic Prahova
•Bogdan Mitrica, scientist, works on cosmic ray muons, extensive air shower
•Ionel Lazanu, Prof. Faculty of Physics Bucharest, Nuclear Physics Department
•Iliana Brancus: senior scientist, head of the Romanian group of astroparticle physics, work on cosmic ray muons, Extensive Air Showers
•Corina Anca Simion: senior engineer, radio chemistry, Tritium, C14, Actinides
•Ana Apostu: research assistant, work on high resolution gamma ray spectrometry
•Alexandra Saftoiu: engineer, work on cosmic ray muons, Extensive Air Showers
•Sabin Stoica: senior scientist, work on theoretical physics: neutrinos, double beta decay
•Mirel Petcu: senior scientist, electronic specialist (DAQ)
•Octavian Duliu: Prof. Faculty of Physics Bucharest, Nuclear Physics Department
•Octavian Sima: Prof. Faculty of Physics Bucharest, Nuclear Physics Department
•Gheorghe Cata Danil: Prof. University POLITEHNICA Bucharest, head of physics cathedra
•Adrian Oprina: mine engineer, Slanic salt mine – director
•Florin Chipesiu: mine engineer, Slanic salt mine – technical director

Technodyne International Ltd
Technodyne International is a specialist Engineering Design consultancy, based in Eastleigh, on the UK South coast. Their main focus is on the design and engineering of Cryogenic Storage tanks but their broad scope of experience and flexible approach enables them to undertake a diverse range of projects, providing cost-effective and dependable solutions for their worldwide client base. Their in-house team of approximately 20 highly experienced and qualified engineers has accumulated over 300 man-years of valuable experience in the engineering industry, including Aviation, Automotive, Energy Supply, Marine, Nuclear, Oil & Gas, and Petrochemicals. During the last 10 years, they have worked on designs for over 40 large cryogenic storage tanks, including the current world's largest tanks for LNG storage, and they have been retained as engineering consultants on many others. No other company can combine this capability with their ability to harness the knowledge and experience gained from executing many very large and sophisticated projects for industrial applications, and defence projects: these are invariably "one-offs" (there are never any prototypes, or "trial runs", they must work first time). Their projects range from small consultancy roles, to involvement in those projects with a capital value in the hundreds of millions of Euros. As an ISO 9001 accredited company, their work is carried out to the highest quality standards, while their Health & Safety training complies with best industry practices.
The staff members undertaking the work will include:

- M. Haworth, director responsible for engineering, member of the institute of mechanical engineers, member of royal aeronautical society. Experience: 10 years as founder director, 4 years corporate management British Gas, 15 years in cryogenic tank and vessel engineering, and construction in the Petrochemical industry, 6 years experience in Defence and Aerospace special projects, total 35 years of experience in engieneering design, engineering, project management and construction of multi-discipline teams in small and large companies. Consultant of Owner's Team for tanks specs 3 new LNG tanks for Isle of Grain (UK), Owner Engineer Team member for new LNG terminal in Europe, consultant on refurbishment Design of LNG tank for Isle of Grain, fitness for purpose assessment of LNG tank, India, Review seismic capability of existing LNG tank (UK), assessment of ability to meet current codes, calculations, establish failure rates, meeting with HSE. LNG piping stress analysis. Design of 4 LPG tanks for Agip (Italy). Design of LNG tank (China). Design of Propane tank (Spain). Design of 80'000 m3 LPG tanks (full design package of calc, detail drawings, MTO). Modifications to LNG tank Dynevor.
- D. Gurney, engineering manager, team leader. Professional and competent computer systems engineer. Experienced in leading teams of software and hardware engineers and in the use of a variety of computers, operating systems and programming languages. Has an in-depth knowledge of software quality control systems, cost/time estimation and the use of structured methods to ensure successful project completion. Lead Engineer for the design of 7500m3 Liquid Ethylene Tank for Vijay Tanks, India. Lead Engineer for the concept design of a 75000m3 Liquid Argon Tank for basic element physics research. Lead Engineer for the design of a 10000m3 LNG Tank for Chemtex, China. Design and specification of insulation systems for various Cryogenic Tanks including LNG, Liquid Ethylene, Propane, Butane and Argon.
- J. Thompson, administration, finance, electrical and C&I engineering. Experience: 40 years in electrical and project engineering; 10 years as Director of Technodyne International Limited, a company specialising in cryogenic storage facilities for LNG, LPG etc, and in the design and supply of aerospace and industrial test facilities; Extensive project management experience of major electrical equipment installations worldwide; Bid preparation, equipment marketing and sales of

high value capital projects worldwide; Corporate Management of USA subsidiary company.

- R. Rogers, mechanical engineer. Engineering manager, over 35 years experience of mechanical engineering design and management on a wide range of capital plant and equipment. Work has included direct line management and direction of multi-disciplined engineering and design.
- B. Brockway, senior mechanical design-engineer. Design of Cryogenic Tank components, detail draughting. Responsible for design and supply contracts for 3x80'000 m3 LPG tanks, 15'000 m3 Ethylene tank (China), 25'000 m3 LPG tanks.
- Pool of three analysts and up to 8 drafters for engineering analysis

AGT Ingegneria Srl

AGT Ingegneria Srl (ISO 9001 accredited company), together with its partner (sub-contractor) Geoingegneria Srl, are both companies that work and collaborate in the field of road and geotechnical engineering.

The staff members who would be undertaking the work:

The two Technical Directors, Ing. Marco Temussi (AGT Ingegneria) and Ing. Giuseppe Ristaino (Geoingegneria) have more that 20 year experience in the above fields; their jobs in design have been committed by some of the most important italian purchasers, in the public and in the private sectors (both building firms and engineering companies)

The most significant achievements in the recent years are:

- the preliminary design of all the road and railway connections in the General Contractor tender for the bridge over the "Stretto di Messina" (coordinator: Ing. M. Temussi), which includes several tunnels longer than 1 km;
- advise, as consultants, about geotechnical, geo mechanics and computing matters in many executive designs committed for the renovation of several parts of the Salerno-Reggio Calabria motorway, including natural tunnels with double pipe, for a total length of 5,744 Km, and all the needed connections;
- advise, as consultants, about geotechnical, geo mechanical and computing matters in the executive design and the construction of the closest part to Terni of the new highway Civitavecchia-Orte-Terni-Rieti, which includes three natural tunnels (the "Valnerina" Tunnel – about 4 Km long - the "Svincolo Valnerina" Tunnel and the intermediate access, called "Discenderia" Tunnel) for about a total length of 5,060 Km, together will all the artificial excavations needed to connect them;

The feasibility study proposed by AGTingegneria, in co-operation with Geoingegneria and other experienced subcontractors, will include:

- The determination of the optimal location for the underground laboratory, based on the geological, the geomorphological and the hydro geological characteristics of the site, and taking into account the scientific requirements as well;
- The geological, geotechnical and geo mechanical characterization of the formations found in the area under investigation and in the selected site; the prediction of the mechanical behaviour of the rocks and the preliminary design of the underground pits, including the assessment and the check of the stabilization work for the excavation, achieved through the use of specific computing programs based either on custom code, developed within the companies, or on standard technical codes (f.e.m.), internationally used, such as: PHASES (Plastic Hybrid Analysis of Stresses for Estimation of Support), developed by E. Hoek, J.L. Corvalho e B.T. Corkum at the Toronto University; FLAC (Fast Lagrangian Analysis of Continua), developed by M.J. Coetzee, R.D. Hart, P.M. Varona e P.A. Cundall for the Itasca Consulting Group, Inc. Minneapolis, Minnesota, USA;
- The preliminary design of the infrastructure equipments (ventilation, power supply, etc.);
- The analysis and the study of the safety requirements and infrastructures;
- The preliminary design of the road links within the site, at all phases of the project (building, assembling and installation of the scientific equipment, normal working of the laboratory);
- The study and the evaluation of the environmental impact of the project;
- The estimation of the costs for civil works (excavation, structures, external roads) and of the time for the execution of the excavation and of the subsequent works.

Lombardi Engineering Ltd

Lombardi Engineering Ltd. was founded in 1989 as the successor to Giovanni Lombardi Ph. D. Consulting Engineers, active since 1955 in the civil engineering sector. With approximately 100 employees at the head office in Minusio (Switzerland) and its affiliated companies, Lombardi Ltd. offers a wide range of engineering services in various construction fields. The provided services cover the design, construction and operation stages of civil works, from preliminary studies to the continuous monitoring under normal and exceptional conditions. The continuing improvement of these services through an optimal combination of

experience and innovation has consolidated the company's position in the Swiss and international civil engineering markets. Visionary and innovative projects, brought to successful completion by a strong partnership with customers, are the best credentials for outstanding and high quality engineering services.
In the future, Lombardi Ltd. will continue to develop customer tailored and innovative solutions combining technological innovation with proven engineering practice. Significant resources are invested annually for research, development and optimisation of both traditional and specialised engineering services in order to offer best quality services resulting finally in optimised project costs.
The Lombardi SA Foundation is supporting young civil engineers promoting research and developments mainly in rock mechanics and hydraulic structures. A dynamic and experienced management team, and the independence from contractors or suppliers, are milestones of a proven company's organisation promoting customer partnership. Faithful to its commitment of quality and customer satisfaction, Lombardi Ltd. has the necessary potential to contribute actively in tomorrow's challenges in civil engineering sector.

Lombardi SA developed the design of the Fréjus safety tunnel. The information gained on geology, behaviour of the rock to excavation and tunnel operation will be made available within this research.

The staff members who would be undertaking the work:

- Ing. M. Russo, geotechnical and structural engineer, 12 years experience, in charge of structural and geotechnical aspects, he took charge of design of the safety tunnel to Frejus road tunnel, and of the access tunnel to underground Gran Sasso Laboratory (project 2002), he has been the project director of Modane access tunnel engineering on new Lyon-Turin railway line. He took part to the EU funded "Brite-Euram project" REEDS on anti-seismic devices in 1996-1998.
- Ing. U. Dröst, mechanical engineer, 14 years experience, in charge of ventilation and equipment aspects, he took charge of ventilation and cooling aspects in preliminary design of Lyon-Turin worksite, he took charge of ventilation design of road and railway underground structures. He was also, in 1998-2002, manager of the EU funded "Brite-Euram project " "Internal Colloing of Gas turbines" on heat transfer and cooling.
- Ing. A. Mordasini, civil engineer, 20 years experience, in charge of safety aspects and interfaces with road tunnel operation, designer of Frejus safety tunnel, he is in charge of safety aspects as a safety officer (by Tunnel Safety Directive 2004/54/EC) of major road tunnels among them the Mount Blanc tunnel, Fréjus tunnel, and the motorway tunnels on the stretch within Turin (F) and Chambery (F).
- Ing. U. Grässlin, 42 years experience, IT and supervision specialist, designed supervision systems and revisions of major underground structures as St. Gotthard road tunnel, Fréjus road tunnel, Mappo Morettina road tunnel.

B.1.6. Consortium as a whole

The consortium includes very different participants from academic and industrial sectors. These combine the best European expertise in their technical and scientific fields. Due to the many stages involved in the transferral of concepts into functional technical plans, dissemination of knowledge is guaranteed between the scientific community and industry throughout the process. This guarantees the best possible potential for the exploitation of the results of this study and of the subsequent steps.

There is a clear complementarity of expertise among the scientific partners of the consortium. They are united by common physics goals and form a community speaking the same language. The study gathers some of the top specialists in the field, working at some of the leading institutes in European particle and astroparticle physics. A long and well-structured preparation process has brought the members closer together and created a strong spirit of togetherness. A common scientific paper has already been published[6].

At the same time, a clear fraction of the consortium is composed of industries, selected uniquely because of their level of expertise. These companies represent the highest level of expertise that can be found in Europe to solve a particular problem. We are fortunate to have them as partners rather than subcontractors. In this way, they will be better integrated in the workflow and the exchange between scientists and engineers will be more efficient. In addition, the synergy between different companies in different countries working together, exchanging local expertise, to study multiple sites, with open access to information, will be an enriching experience. This is also one of the reasons why we proposed them as technical partners and not subcontractors.

Subcontracting: we intend to rely on subcontracting of part of the WP work in one specific case:

- Feasibility study in Canfranc (LSC): See Task 6.

Additional beneficiaries / competitive calls: we do not a priori intend to attract additional beneficiaries following competitive calls. However, it is worth underlining that the participation of the Italian National Institute for Nuclear Research (INFN) would have been welcome: the INFN has traditionally played an important role in particle physics and astrophysics in Europe and should have therefore been interested in participating in the present design study. It was not possible to convince the INFN management to sign the proposal or to enter negotiation once the proposal was accepted.

B.1.7. Resources to be committed

The "added-value" of the DS revolves around the need for an integrated and coherent European effort towards next generation large-scale underground science. The site and tank engineering corresponds to two regions of focus (explicitly WP2, and WP3), where the FP7 funding is expected to make the largest impact. In addition, the DS includes coherent activities in phenomenological and theoretical activities (WP4). In these latter, the involved institutes will commit their experienced manpower as shown in Table 1.3.6. This experienced staff will obviously bring along and make available their existing local infrastructure and available equipment to the DS project.

One can expect specific local or global sources of funding, to be synergistically employed with the EU funds. In addition, some of the underground sites included in this DS already have substantial infrastructures that can be exploited for this DS. The hosts (mine, tunnel) will also provide their infrastructures like access to existing and planned laboratory sites, typically at true-cost basis, and they will be involved in and informed on relevant steps of this DS. Most of the numerical computation involved in the civil and mechanical engineering will rely on the available infrastructure at the technical participants' home base.

It is also to be expected that several scientists from universities or institutes other than those listed as beneficiaries, will directly or indirectly complement the EC contribution by giving their time to work on the topics pertaining to this DS. In particular, we expect the physics work package (WP4) to foster an environment for general discussions within the scientific community, in dedicated seminar, workshops or international conferences.

[6] J. Aysto et al., JCAP 0711:011,2007, arXiv:0705.0116v1 [hep-ph].

B2. Impact

B.2.1. Strategic impact

Designing and constructing the next major underground laboratory and building the required large-scale instruments by far exceed the capacity of a single European nation and technically non-trivial. A common approach and a coordinated international effort are required to even conceive them. This DS is the most effective tool towards achieving this goal.

The LAGUNA consortium includes the highest-level expertise in Europe for the required tasks. All major European underground laboratories are partners or will be consulted, and emerging candidate sites are also represented. The countries proposing the site for the facility have assigned the best companies in underground engineering as partners. All universities and institutes participating in the collaborations of the suggested experiments are taking part in the project. Our human resources include more than 60 top-level scientists, representing also the scientific community taking advantage of the results of the experiments to be performed in the laboratories. The main deliverable will be a conceptual design report (CDR), which should provide the policy makers and the funding agencies all the information for a construction decision. The deliverables include "decision factors" such as technical feasibility (underground halls and their access, safety issues, procurement of large quantities of liquid material for the detectors, related infrastructure, ...), cost optimization (digging, safety, detector design...), physics performance (*e.g.* hall depth, baseline from accelerator facilities, ...), in addition to spin-off and outreach issues.

The infrastructure, if built in Europe, will certainly attract scientists from many parts of the globe and will ensure that Europe can continue to play a leading role in the field. Europe must act coherently and in a unified way in deep underground science. The very successful history of CERN, the largest particle physics laboratory in the world, shows that this is in principle possible.

B.2.1.1. Direct impact of the planned experiments on particle and astroparticle physics

Astroparticle physics has evolved as a new interdisciplinary field at the intersection of particle physics, astronomy and cosmology. It combines the experimental techniques and theoretical methods from both astronomy and particle physics. Particle physics is devoted to the intimate structure of matter and the laws that govern it. Cosmology addresses the large-scale structure of the Universe and its evolution since the Big Bang. Astrophysics studies the physical processes at work in celestial objects. Most discoveries in particle physics have immediate consequences on the understanding of the Universe and, vice versa, discoveries in cosmology have fundamental impact on theories of the infinitely small.

In 2005 the CERN Council initiated a Strategy Group to produce a Draft Strategy Document (DSD) addressing the main lines of Particle Physics in Europe, including R&D for novel accelerator and detector technologies. The DSD[7] was delivered to Council in July 2006 and unanimously approved. This document formed the basis of Particle Physics input to the European Roadmap on future, large-scale research infrastructures produced by European Strategy Forum on Research Infrastructures.

In this document, Council recognised that "A range of very important non-accelerator experiments take place at the overlap between particle and astroparticle physics exploring otherwise inaccessible phenomena; Council will seek to work with ApPEC to develop a coordinated strategy in these areas of mutual interest."

This DS will explore different detector technologies and different underground laboratory sites in order to identify the best strategy for future large-scale instruments in the domain of low energy neutrino astronomy as well as direct investigation of Grand Unification of the known elementary forces. Such detectors are needed for experiments where a small counting rate or weak interaction cross sections play a key role, notably the search for proton decay and for numerous applications in the area of neutrino physics and neutrino astronomy.

B.2.2. Plan for the use and dissemination of foreground

The final report resulting from this DS will be delivered to the appropriate funding agencies and policy makers (ApPEC, ASPERA, national agencies) for their evaluation. After appropriate reviews and consultancy, the respective organisations are expected to make decisions to define possible further steps to realise the considered infrastructure. In particular, we think that the report could be relevant to initiate its

[7] The CERN Council, in a special meeting held the 14th of July 2006 in Lisbon, agreed on the European strategy for particle physics. The strategy is defined by the 17 statements approved by Council, and contained in the Strategy Statement (available at http://council-strategygroup.web.cern.ch/council-strategygroup/).

consideration by the ESFRI committee. The report should contain enough necessary technical information required for the decisions, to be combined with the scientific priorities of the decision time.

This DS has a clear "user chain" flow for dissemination and exploitation, as illustrated in Figure 3. As was mentioned in the ApPEC/ASPERA roadmap, this DS emerges from a need of the scientific community. During the DS, the many reports to be compiled (see deliverables list) will serve as database of open documents. Many publications will be opened to the public and be disseminated in various ways:

- The intermediate results and the status of the project will be reported to the scientific community by regular presentations in conferences, workshops and seminars.
- The final report will be transmitted to ApPEC/ASPERA with the plan that the results of the feasibility of a large underground deep science research infrastructure in Europe (but global in nature) be included in the ESFRI roadmap.
- A web page showing the goals, results and status of the project will be set up and maintained by the LAGUNA executive board and secretariat.
- Technical reports resulting from this DS will be made available for all interested parties by electronic distribution.
- Scientific results will be published according to good scientific traditions in journals, reports and conferences.
- The final technical report will be announced on month 24 and distributed to the community, to the funding agencies, and where appropriate to the press.
- The "deep science" document will be printed and distributed to funding agencies, universities and schools worldwide.
- The LAGUNA web site will remain active even after month 24, although updates will be less likely to occur.

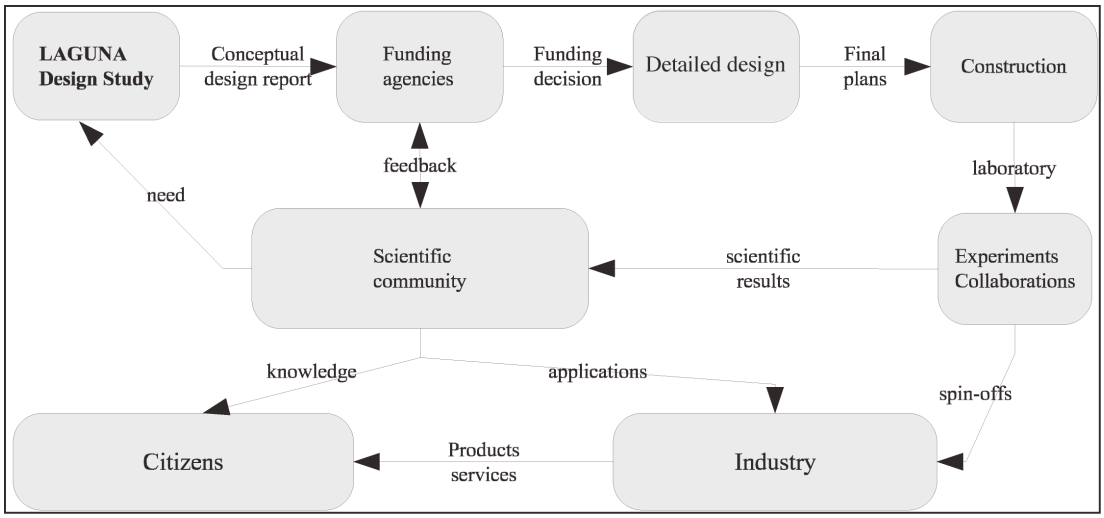


Figure 3 User chain flow.

The results of the studies will be published in a series a document, culminating with the final document. The final report will contain the objective and scientific information needed to reach the funding and construction phase. Assuming a positive feed-back from the funding agencies, the final report will be a starting point for a subsequent detailed design work. This would lead to final plans for construction and approval of the new research infrastructure. The experimental results to be obtained in the research infrastructure will provide top-class, forefront scientific results, which will feedback to the scientific community. Of course, citizens will be part of the process and will acquire knowledge from the scientific community. Similarly, direct spin-offs and applications will feed into the industrial component, which itself via products and services will provide improved quality of life to the citizens.

No serious issues related to intellectual properties management are expected, as the design study will produce information to the public, except otherwise governed by specific intellectual property rights or a confidentiality agreement, like e.g. in a few explicit internal items related to the exploitation of particular sites. In particular, some information about the mines will not be made public.