ApPEC, ASPERA etc

ASPERA- 1st Workshop for the Astroparticle Roadmap

7-8 November 2006 Valencia, Spain

ApPEC: Astroparticle Physics European Coordination

- Following the model of NuPECC, in 2001, several European scientific agencies signed an agreement, endorsed by the European Science Foundation, aiming essentially at :
  - Promoting and facilitating co-operation within the growing European astroparticle physics community;
  - Developing long term strategies and offering advice to national funding agencies or other institutions as appropriate;
  - Expressing the views of the astroparticle physics community in international forums;
  - Establishing a system of peer-review assessment applicable to projects where ApPEC members are involved.
- ApPEC comprises two bodies, a Steering Committee (SC) and a Peer Review Panel (PRP):
- 12 national funding agencies

Astroparticle Physics or Particle Astrophysics

1. What is Astroparticle Physics?

Astroparticle physics is a new field of research emerging from the convergence of physics at the smallest and the largest scales of the Universe. In particle physics we investigate the intimate structure of matter and the laws that govern it. In astronomy and astrophysics, we study the structure of the Universe and its evolution from the initial hot Big Bang. It is cosmology that links the theory of particle physics with that of the very early Universe. Any discovery in particle physics has an immediate consequence on the understanding of the Universe and, inversely, discoveries in cosmology have fundamental impact on theories of the infinitely small.

ASPERA

2. What Is ASPERA?

ASPERA arises from the existence of ApPEC (Astroparticle Physics European Coordination). This is a consortium of national funding agencies which came into being **in** 2001 when six European scientific agencies (later growing to thirteen) took the initiative to coordinate and encourage Astroparticle Physics in Europe. ApPEC's aims are

a) To develop long term strategies

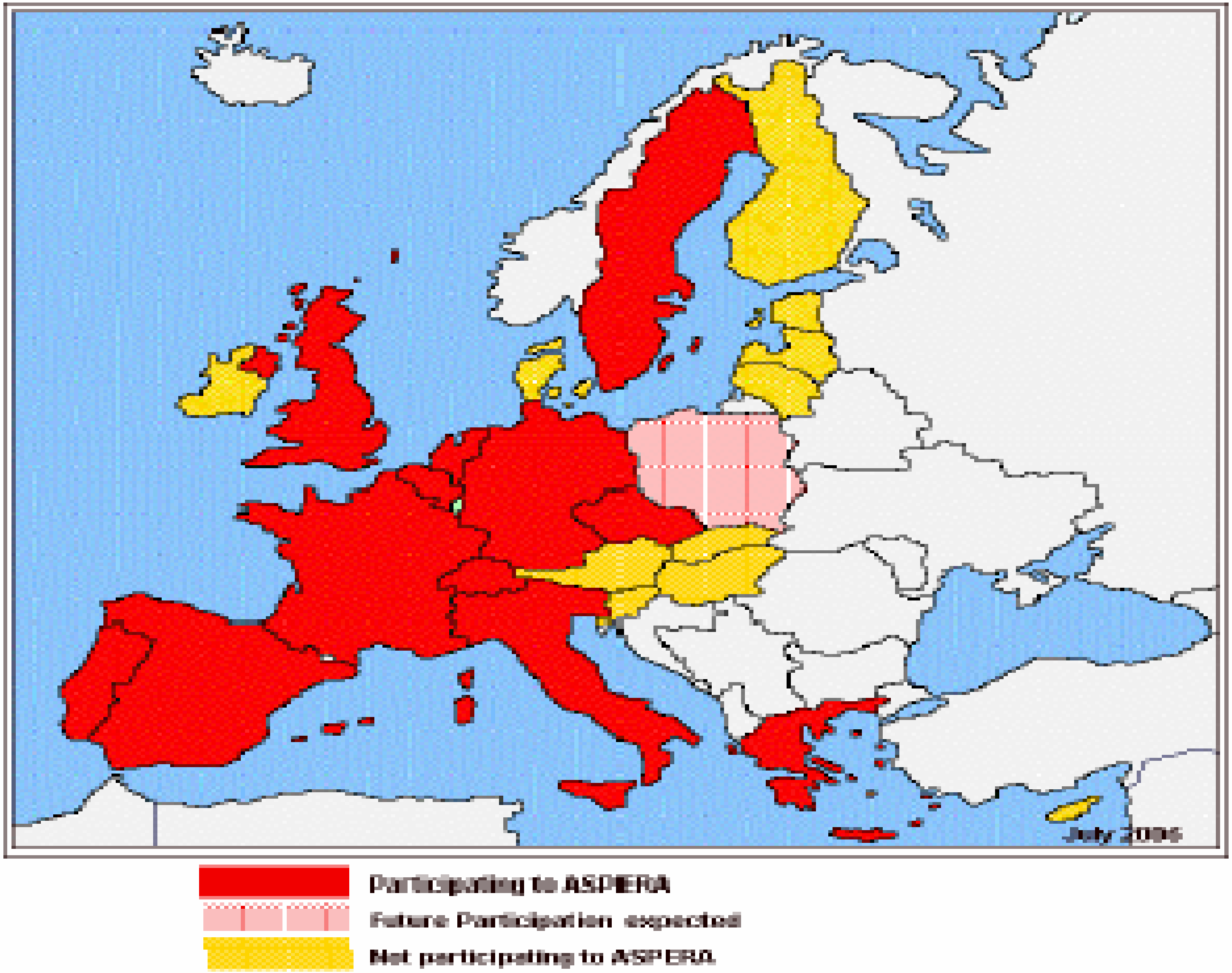
b) To express the views of European Astroparticle Physics in international forums, and

c) Establish a system of peer review assessment applicable to Astroparticle physics projects.

The FP6 ERANET program ASPERA, starting on the 1st of July 2006, comprises **16 national funding agencies in Europe** responsible for funding Astroparticle physics research. It also comprises two transnational agencies: (CERN) as full participant and (ESA) as associated partner. Among its goals is the inclusion, before the end of the program, of all European national agencies having programs in Astroparticle Physics.

Role*	No.	Participant name	Short name	Country
CO	1	Centre National de la Recherche Scientifique	CNRS	France
CR	2	Bundesministerium für Bildung und Forschung	BMBF	Germany
CR	3	Commissariat à l'Energie Atomique	CEA	France
CR	4	Centre Européen de Recherche Nucléaire	CERN	International
CR	5	Fundação para a Ciência e a Tecnologia	FCT	Portugal
CR	6	Fonds National de Recherche Scientifique	FNRS	Belgium
CR	7	Stichting voor Fundamenteel Onderzoek der Materie	FOM	Netherlands
CR	8	Fonds voor Wetenschappelijk Onderzoek-Vlaanderen	FWO	Belgium
CR	9	Istituto Nationale di Fisica Nucleare	INFN	Italy
CR	10	Ministerio de Education y Ciencia	MEC	Spain
CR	11	Ministry of Education Youth and Sports	MEYS	Czech Republic
CR	12	Swiss National Science Foundation	SNF	Switzerland
CR	13	National Center for Scientific Research"Demokritos"	DEMOKRITOS	Greece
CR	14	Particle Physics and Astronomy Research Council	PPARC	United Kingdom
CR	15	Projektträger DESY	PT DESY	Germany
CR	16	Fundacion Espanola de Ciencia y Tecnologia	FECYT	Spain
CR	17	Swedish Research Council (Vetenskapsradet)	VR	Sweden

ASPERA in Europe



ASPERA TASKS

WP1 Objectives: Determination of present status of European research funding relating to ASTROPARTICLE (WP leader: FOM)

WP2 Objectives: Definiton of astroparticle physics roadmap and common actions necessary for the astroparticle ERA (WP leader: Partner PPARC)

WP3 Objectives: Implementation of new European-wide procedures for large infrastructures (Work package leader: Partner INFN)

WP4 Objectives: Consortium common electronic infrastructures, communication and extension (WP leader: Partner BMBF/PTDESY)

WP5 Objectives: Consortium Management (WP leader: Partner CNRS)

Up to now, many pioneering experiments in Astroparticle Physics have been on a scale whereby they could be implemented by small teams funded nationally. This has now changed such that, except for some specific topics the most promising new projects need large multidisciplinary teams on a European scale or even world level. The rapid development of the field has led to the design and the construction of infrastructures whose size, complexity and cost reach often levels requiring the cooperation of several scientific teams from different countries. These infrastructures are of three kinds:

- Underground laboratories (shielding the experiments from the cosmic muon background), where room and services are provided to receive experimental devices.
- "Observatories" or "telescopes" or "antennas" on earth whose optimal size is generally large due to the weakness (for gravitational waves) or the scarcity (for very high energy gamma rays, neutrinos or very high energy cosmic rays) of the signals which are to be detected.
- Satellite observatories of high energy gamma rays, cosmic rays or gravitational waves.

ASPERA

Europe is already a leading player in the field of Astroparticle Physics and European teams have already made significant contributions in many key areas. There are about 2000 European scientists involved in the field in some fifty laboratories. The consolidated cost of the current European program is close to 400 million Euros. The investment cost of current experiments range from ten to a hundred million euros per experiment. Future projects will increase the scale of investment by at least a factor 5. The consolidation of the existing coordination of the different projects at the European level has become a necessity.

The aims of ASPERA for European research in Astroparticle Physics will be translated into the following 10 goals (dispatched into 5 Workpackages described further below):

- Propose **common or compatible methods of benchmarking and managing** large European Astroparticle Physics infrastructures
- Compile a **common information system**, which lists and compares the various review and funding mechanisms for Astroparticle Physics research in Europe.
- Establish **joint transnational electronic infrastructure facilities**, comprising tools for communication, coordination and internet based information systems.
- Create a **scientific roadmap** for Astroparticle Physics, and linking with the more general European scientific infrastructure roadmap, as planned by EU structures (for instance ESFRI).
- **Assess and identify which innovative Research and Development fields** are inherently convergent and are most suitable for joint research projects with high European added value.
- Propose **uniform processing and evaluation schemes** for all types of joint transnational proposals, which can be agreed by the national agencies.
- Identifying **possible links amongst existing infrastructures** (e.g. gravitational antennas, neutrino telescopes, gamma ray telescopes, space and ground in cosmic ray physics).
- Enable **pan-European collaborations** of the next generation of large scale infrastructures.
- Coordinating an examination of selected translational R&D domains with a view to **developing a model call for R&D proposals**.
- Provide guidance and **possible frameworks for national agencies to align some of their resources** in order to fund large Astroparticle Physics transnational research programmes.

Six basic questions

1. What is the Universe made of?
2. Do protons have a finite life-time?
3. What are the properties of neutrinos? What is their role in cosmic evolution?
4. What do neutrinos tell us about the interior of Sun and Earth, and about Supernova explosions?
5. What is the origin of cosmic rays? What is the view of the sky at extreme energies?
6. What is the nature of gravity? Can we detect gravitational waves? What will they tell us about violent cosmic processes?

Neutrinos and neutrino astronomy

4.1.Neutrinos and neutrino astronomy

A series of violent phenomena in the Universe emit high-energy (multi-GeV) neutrinos. The detection of high energy neutrinos would give important clues for the origin of cosmic rays, a centennial puzzle still unsolved, or could reveal the presence of dark matter. An ambitious program of sub-marine or sub-ice neutrino telescopes for their detection is in progress. Different sub-marine neutrino telescope projects are in advanced prototyping stage in the Mediterranean (ANTARES near Toulon, NEMO in Sicily and NESTOR in the Peloponnese).

I. A km^3 scale detector would be needed to effectively start neutrino astronomy. A km^3 submarine detector in the Mediterranean is complementary (coverage of the full sky) and has advantages (looking towards the very active galactic centre) with respect to an equivalent detector in the Antarctic (ICE-CUBE).

Other experiments, seeking to understand neutrinos, further involve the study of natural radioactivity, specifically the process known as beta-decay. The most sensitive limit comes from the Heidelberg-Moscow Germanium experiment in Gran Sasso. Improvements are expected from the currently running NEMO at Fréjus and CUORICINO-CUORE in Gran Sasso.

II. The next generation of "double-beta decay" experiments will need to use detectors of one ton mass scale of natural radioactivity material, reduce the backgrounds and increase the sensitivity by at least an order of magnitude.

Neutrinos and neutrino astronomy

A neutrino accelerator program to test the neutrino properties is in progress both in the US and Europe (CERN to Gran Sasso). A solar neutrino program is also in progress with BOREXINO in Gran Sasso. Historically the experiments that searched for proton decay played a leading role in the discovery of neutrino mass and also in the birth of the domain of astroparticle physics through the discovery of the Supenova 1987a neutrino signals. In the future:

III. A new generation of neutrino supernova and proton decay observatories, from one hundred thousand tons to a megaton, needs European coordination.

Gravitational waves

4.2.Gravitational waves

Einstein predicted the existence of gravitational waves in his theory of general relativity, but they have not yet been detected. The search for them has been conducted up to now mainly by resonant bar detectors operated at cryogenic temperatures. While the bars are continuously improving their sensitivity the interferometer detectors have recently entered in operation. In Europe the Franco-Italian VIRGO detector, operated by the consortium EGO near Pisa, is in the commissioning phase and the German-UK detector GEO 600, near Hanover has already started to collect scientific data. A completely new antenna in Europe on the horizon of 2010-2015 is under discussion. A tenfold increase in sensitivity increases the possibility of detection by a factor 1000, since this last goes as the volume of the sensitivity reach. Finally, ESA and NASA are planning to fly around 2013 in a shared effort, LISA a 5 million km arm length interferometer to detect gravitational waves at very low frequencies and study in detail gravitational wave signals.

IV. ASPERA will define the European roadmap of upgrades needed by present antennas for the detection of gravitational waves; a detection that could be among the most impressive discoveries of this century. The integration of this program in a world context will be also studied. The complementarity of the ground base program with the ambitious ESA/NASA space program of LISA will be evaluated and accompanied by the proper measures.

4.3. Dark matter and dark energy

Astronomical and cosmological observations indicate that standard ("baryonic") matter forms only 5% of the matter-energy density of the Universe. There are strong experimental indications that the remaining density consists of some form of non-baryonic non- luminous matter, called "dark matter", which contributes to 25% of the total, while the so-called "dark energy" that accelerates the expansion of the Universe contributes the other 70%.

Searches for the direct detection of dark matter are taking place in a variety of sophisticated experiments using cryogenic detectors or noble gases as targets and detectors, sheltered from cosmic radiation in underground laboratories across Europe. Examples of these are liquid xenon scintillation and ionisation targets (ZEPLIN, XENON, WARP), Germanium or Sodium Iodide detectors (CRESST, EDELWEISS, HDMS, NAIAD, DAMA/LIBRA, IGEX,ROSEBUD, ANAIS, HMDS) in the Gran Sasso (Italy), Fréjus (France) and Camfranc (Spain) tunnel laboratories or the Boulby Mine (UK). Furthermore, another dark matter candidate: "the axion" is actively searched by the CAST experiment at CERN. Indirect searches for dark matter decay products will be performed on ground (neutrino and gamma ray telescopes) and in space (GLAST, Agile, Pamela, AMS-02).

Dark Matter and Energy

V. The ultimate goal for direct detection dark matter experiments is a ton of bolometric material, exhibiting hopefully a double signature of the interesting events, operating at background levels of the order of 1 background event per ton and per year.

The "dark energy component" will be addressed by systematic searches using both earth based and satellite-borne telescopes, aiming at a high statistics determination of the high redshift Type Ia supernovae distribution, gravitational lensing effects, "baryon oscillation wiggles" and other cosmological effects. These studies are at the border between astroparticle physics and more cosmologically oriented studies. In the context of this ERANET an inter-prioritisation of the studies will be done in collaboration with the astrophysics ERANET (ASTRONET) .

VI. An inter-prioritisation, between the "dark energy" studies and other astroparticle projects will be addressed in view of a coherent European view on the subject.

Gamma-rays

4.4.High energy gamma-rays

The study of high-energy gamma rays is currently the most promising approach in the search for the origin of cosmic rays. Europe is among the leaders of the field. Based on the experience of the pioneering experiments a new generation of high energy gamma ray telescopes entered or is entering in operation. Among them HESS in Namibia and MAGIC in the Canaries are European lead, and point to complementary parts of the sky. VERITAS and CANGAROO are US and Japan lead respectively. The ARGO Observatory in Tibet is the fruit of collaboration between INFN and several Chinese research centers for the study of cosmic gamma ray sources.

The ground telescopes are complemented by a series of satellite experiments such as the Italian led AGILE (2006) and the US lead, though with strong European participation, GLAST (2007) and AMS02 (2009). The complementarity between space and ground observatories will be exploited in the years to come. The new generation of ground telescopes striving to lower the detection threshold is under study.

VII. The complementarity of the north and south European telescopes, the modes of transnational access turning them to general observatories, their complementarity to space observations and the next generation telescopes will be studied and their implementation prepared.

4.5. Cosmic rays

Over the past three decades, enormously energetic but rare cosmic rays have been detected. The energies of these events are a billion times greater than the highest energies of particles that can be produced at accelerators on Earth. As these extremely energetic cosmic rays are very rare, our understanding of the sources producing them and the way they manage to reach detectors on Earth un-attenuated by the cosmological microwave background radiation is incomplete. The experiment AUGER in the Argentinian pampa is currently dominating the field and many European countries play a leading role in its deployment. In the immediately lower energies, a series of structures in the cosmic ray spectrum ("knee", ankle", etc) are suspected to indicate transitions from cosmic rays of galactic and extragalactic origin. The experiment KASKADE in Kalsruhe and EMMA in Pyhasalmi/Finland are studying this domain.Understanding the propagation of cosmic rays in the galaxy requires precise measurements of the fluxes and composition of many nuclei. This will be provided by the forthcoming space experiments Pamela, CREAM and AMS-02 (on the ISS).

VIII. The answer of AUGER, concerning the puzzle of the very high-energy cosmic rays is expected by mid-2007. Independently of the type of the answer (new physics or astronomy using very high energy particles) the after-AUGER, is in discussion. Complementing the south observatory with a northern one, or a satellite experiment looking down the earth atmosphere is an important infrastructure issue.

Antimatter search

4.6.Search for antimatter and other exotic states of matter

The absence of primordial antimatter in the cosmos is a puzzle in our current understanding of the structure of the Universe. It is very likely that the early Universe had matter-antimatter equality, so where is antimatter? Searching for nuclear antimatter in space is done either directly by studying the cosmic ray composition or indirectly by measuring the energy spectrum of the diffuse gamma rays flux. This search is better performed using space detectors, since antimatter cosmic rays quickly annihilate in the atmosphere. During the next five years, two space-borne magnetic spectrometers (Pamela launched in 2006 and AMS-02) will increase by three orders of magnitude the current sensitivity to nuclear antimatter.

The European led satellite INTEGRAL, by detecting nuclear gamma ray excitations is producing a mine of information on nuclear astrophysics processes, greatly increasing the topicality of the field. New very sensitive MeV gamma ray space-born detectors are in preparation. Here again coordination with the neighboring ASTRONET is needed.

IX. The search for antimatter and nuclear gamma ray excitations in space will be supported and coordinated in view of coherent presentations in the programs of ESA and NASA.

Gamma ray bursts

4.7.Gamma ray bursts, X-Rays etc.

The multi-wavelength study of gamma-ray bursts, energetic X-rays from tens to a hundred of KeV and other studies of the same sort are at the frontier between astroparticle physics and astrophysics studies proper. Sometimes the same instruments address both astrophysics and astroparticle problems. A coordination with astrophysicists organized in parallel structures (ASTRONET) will help the overall coordination of the field.

X. The contact with the neighboring discipline of astrophysics concerning stellar objects and messengers will be improved, and the equivalent priorities will be taken into account in the astroparticle physics roadmap.

THEORY

4.8.Theory

Last but not least, it is common knowledge that the vitality of a field depends strongly on the vitality of the theoretical community concerned by its questions, or better still a field is often defined by the very questions that its theoretical community elaborates. This is even more true in astroparticle physics where its theorists need skills in more than one domain (cosmology, astrophysics, particle physics, nuclear physics, hydrodynamics and plasma physics) and very often special computing methods and means. The ERANET will examine the needs of the community and see that the institutional ways that it can be brought together, while of course the scientific convergence on common structuring themes is the task of ILIAS and other astroparticle physics networks that may emerge in the future.

Costs

The full spectrum of the proposed new infrastructures for the next ten years would cost of the order of 1 billion Euros. A strategic plan concerning these infrastructures is urgent. ASPERA will provide the vehicle to implement this European roadmap and common action plan in the area of Astroparticle Physics, working closely with the ESFRI roadmap committee, the Astrophysics ERANET ASTRONET (including ESO), the CERN strategic plan, the ESA Cosmic Vision and other structures preparing the 7th EU programme.

News

- SC ApPEC meeting in Warsaw 3.07.2006
- September 2006:

1- Sieć Neutronowa

2- Sieć Astrofizyczna

3- Porozumienie Cząstki-Astrofizyka-Kosmologia (teoria)

- November 2006 – zgoda MNiSW na przystąpienie Polski do ApPEC i ASPERA
- Meeting ToK 15-18/19 February 2007

Roadmap process

Phase I

Phase I of the Roadmap process is the final stage in the production of a Roadmap by the ApPEC Peer Review Committee. The PRC has developed its Roadmap draft in a series of meetings and consultations from 2003 onwards. Publication of the Phase 1 Roadmap is expected in January 2007.

1. The current draft of the PRC Roadmap (0ct19-2006 version) is available at http://indico.cern.ch/event/6788 and at,

http://www.ifh.de/~csspier/Roadmap-oct19.doc

http://www.ifh.de/~csspier/Roadmap-oct19.pdf

2. There will be a public presentation of the Roadmap by Christian Spiering (ApPEC PRC Chair) in a Workshop in Valencia on 7/8 November 2006. It is intended that the presentation of the Roadmap draft and first discussions in the presence of a wider community will be through 7 thematic groups:

- Dark matter: conveners: **N. Smith, G. Gerbier**
- Double beta: conveners**: F. Piquemal , A. Giuliani**
- High energy neutrino: conveners: **U. Katz, P. Lipari**
- High energy cosmic rays: convener: **R.Engel**
- Gamma rays : convener: **M. Martinez**
- Low energy neutrino and proton decay: convener: **A. Rubbia**
- Gravitational Waves: convener: **H. Lueck**

3. The Thematic groups will provide the first feedback on the draft Roadmap and continue to do so through to the end of 2006 prior to publication of the Phase 1 (PRC) Roadmap document in January 2007.

Phase II (the ASPERA Roadmap)

4. Phases II and (III) build on the PRC Roadmap to produce a more detailed ASPERA Roadmap. ASPERA is an ERANET activity initiated by ApPEC and funded by FP6.

5. It is intended that the Thematic groups should remain in existence throughout 2007 and enlarged to include as wide a consultation as possible. The groups will be asked to provide information on the resources (financial and human), timetabling, milestones and reviews and identify the necessary enabling R&D within the themes. The groups will be asked to prioritise topics within each of the thematic areas.

6. There will be a second Workshop in Amsterdam in September 2007 with further feedback culminating in a Phase II Roadmap document in January 2008.

Phase III

7. There will be a further phase (III) to the consideration of the Roadmap which is likely to involve some measure of prioritisation between broad thematic areas. The ApPEC Steering Committee could take the lead in this activity.

8. This will take place in the first part of 2008 and precise planning can only be in outline now but it should involve, for example, assessments between

- High energy cosmic rays (gamma, neutrino telescopes, charged cosmic rays)
- Gravitational waves
- Underground physics (neutrino mass and properties, proton decay, dark matter)

9. This might need some workshop activity with attendance to be defined in consultation with national funding agencies.

The Deliverables by July 2008 should be

- Roadmap with selected priorities (action plan)
- Definition of areas where common R&D calls could be launched
- Preparation of draft agreements for next phase large infrastructures