B1.1.4 Aims and objectives

The *Discover the COSMOS* initiative aims to face the problem of the falling interest of students towards science and following scientific careers by introducing innovative practices for *eScience* by using existing e-Infrastructures, framed in a pedagogical approach that promotes inquiry based teaching. The demonstration of the effective integration of science education with e-infrastructures will be realised through a monitored-for-impact use of *eScience* activities, the ***Discover the COSMOS* Demonstrators**, which will provide feedback for the take-up of such interventions at large scale in Europe**,** by presenting the main ways that e-Infrastructures can leverage educational activities by a) *Creating virtual classrooms* by interconnecting the schools and the research centers, b) *making scientific and educational resources available worldwide* through advanced repositories and effective search mechanisms and c) *supporting effective community building between researchers, teachers and students*. More analytically the main objectives of this project are the following:

- **Select a series of *eScience* initiatives that successfully introduce the scientific methodology in school science education, by utilizing existing research infrastructures of frontier research institutions enriched with online tools (data analysis tools, simulators & games) and web-interactive educational material.** The *Discover the COSMOS* initiative aims to create a pool of *eScience* applications that provide access to CERN infrastructures (LHC, ATLAS, CMS), to the "Las Cumbres Observatory Global Telescope Network" in Hawaii and Australia, and to the Liverpool robotic telescope on the island La Palma in the Canaries (and potentially to the ESA Gaia Mission). The project partners are developing and testing for many years such innovative applications (supported by relevant materials and resources) that promote creative problem solving, discovery, learning by doing, experiential learning, critical thinking and creativity, simulating the real scientific work (e.g. making real time observations using robotic telescopes, analysing read data from CERN detectors, implementing experiments in space). These applications, apart from data analysis tools, provide 2D and 3D animations and simulations of physical processes and experiments, virtual visits to advanced experimental devices and detectors, educational games and projects presenting the basic concepts of science, videos and live web casting events, introductory and training sessions. The selection of these initiatives will be carried out in the framework of WP2 following the development of a series of parameters that will be provided by the *Discover the COSMOS* Pedagogical Framework.
- **Integrate these initiatives under a common educational approach and develop the *Discover the COSMOS* Demonstrators that could be exploited and widely used from the educational communities in Europe and beyond**. The aim of the project is to envision a more effective collaboration between schools and research, by constructing a framework for improving current educational practices and learning processes in science and mathematics through the effective implementation of advanced technological tools and applications that simulate how science works. The aim of the project is to analytically map the process for the effective implementation of these applications in school environments as part of curriculum (integrating them in the everyday school practice) or extra-curriculum activities (e.g. masterclasses, summer schools, contests). The selection and integration of the *eScience* initiatives will aim to support the best possible practices of learning, teaching, and assessment. The proposed integrations, called the ***Discover the COSMOS* Demonstrators,** will be realized through the effective utilization of a wide range of ICT applications for educational purposes based on a participatory methodology in which users will play a very active role in creating additional components, through the creative use of constructionist principles and related ICT technologies. Furthermore the design of the proposed activities will include interactive career cancelling approaches in order to increase awareness of the value of studying science and mathematics among students by demonstrating potential career opportunities. This work will be realized in WP2.
- **Implement the *Discover the COSMOS* Demonstrators at large scale in Europe, and organize a series of raising awareness activities that will introduce students and teachers to *eScience***

through the use of real scientific instruments (robotic telescopes, accelerators and particle detectors). During the project implementation educational communities will have access to a unique collection of open educational resources (linked with the science curricula) that have proven their efficiency and efficacy in promoting inquiry based education and that are expanding the limitations of classroom instruction (see section 1.2). The *Discover the COSMOS* project is bringing together a network of educational communities and research centres in Germany, Austria, Spain, Portugal, United Kingdom, France, Greece and Switzerland in order to act as the pilot group for the project activities (see sections 2.4.1 and 2.4.2). Additionally the project activities will be integrated in a series of existing national and international initiatives (e.g. masterclasses, Galileo Teachers Training Programme, CERN summer schools) to increase the impact of the proposed approach. The necessary guidance and support will be provided to teachers and students in the pilot sites. The effective coordination of the work that will be performed in WP2, WP3 and WP5 will safeguard the successful large scale implementation of the project activities in the target communities.

- **Create virtual learning communities of educators, students and researchers and involve them in extended episodes of playful learning.** The project will involve teachers, students and researchers in collaborative learning activities. Being part of a professional network will encourage interaction and will provide them with opportunities to enrich their practices and professional context through cooperation within and between schools, universities, and frontier research institutions, collaborative reflection, development and evaluation of instruction, exchange of ideas, materials and experiences, quality development, cooperation between teachers, students and researchers and support and stimulation from research. Furthermore by bringing together researchers from two different fields of Science, particle physics and astronomy this project will promote the cooperation between operators of different infrastructures to achieve trans-national collaboration and the designing of effective and interdisciplinary educational activities. In this way it is expected that it will extend the "dialogue" between scientists and the educational community, will enforce the collaboration between schools and research organisations, will promote scientific culture in society and will help young people to acquire a better understanding of the role of science and technology in society. The development of the virtual learning community (see section 2.4.2) will be enhanced by the *Discover the COSMOS* Community Support Environment that will provide tools for community building and support, and will encourage cooperation between teachers, students and researchers. It will be a comprehensive open learning network where teachers can access their colleagues' course materials, share their own, and collaborate on affecting their everyday practice. This work will be realized in the framework of WP3.
- **Systematic validate the proposed approaches and activities in order to identify their impact in terms of the effectiveness and efficiency.** We are used to ask for a participatory system design in the sense that users or other selected stakeholders participate in the design process, but we are not very much used to the perspective, that the evaluation process itself is subject to an intensive participation process influenced by designers and users. The *Discover the COSMOS* validation methodology offers a framework for validating the introduction of innovation in schools so that piloting and field testing results can be collated and analyzed systematically and then disseminated widely, thus ensuring rapid impact and widespread uptake. The key areas of interest of the proposed validation methodology will be Science Pedagogy, Organisation issues (e.g. impact on the curriculum), Technology – tools, services and infrastructure, Economic – value for money, added value, Cultural and linguistic issues. The project will be implemented in schools, science teacher training centers, and research centers in different countries; this will allow the evaluation of different attitudes against the use of inquiry based techniques in different cultures providing thus ways for intercultural dialogue to improve these attitudes. This work will be realized in the framework of WP5.
- **Design and implement a systematic raising awareness strategy that will contribute to the effective communication of the project's results and outcomes.** In this framework the aim of the consortium is to formulate a common set of guidelines and recommendations on how scientific work can be used to provide an engaging educational experience through the exploration of "real science". In this way the *Discover the COSMOS* aims to contribute to a better understanding of

science and the role that it plays in society. To this end the project consortium will deliver a set of guidelines for the research and the educational policy communities to further explore and exploit the unique benefits of introducing *eScience* in schools. The *Discover the COSMOS* approach asks for knowledge areas integration, effective and close cross-institutional collaboration, and organisational change in the field of science education. This effort will be documented analytically and systematically in the **"Effective Ways of Introducing *eScience* in Schools"** document. The main objective of the work is to generate a structured set of recommendations that will form the reference for a pan European roadmap for the introduction of *eScience* activities in schools. This document will be the first step in a journey of educational reform that might take many years. It will be the map. The achievement of the high quality science teaching requires the combined and continued support of all involved actors, researchers, policy makers and curriculum developers, science teacher educators, teachers, students and parents. This work will be realized in the framework of WP5.

B1.2 Contribution to the coordination of high quality research

Research infrastructures play an increasing role in the advancement of knowledge and technology and their exploitation. Because of their ability to assemble a 'critical mass' of people and investment, they contribute to national, regional and European economic development. They are therefore at the core of the knowledge triangle of research, education and innovation. The *eResearch2020 - The Role of e-Infrastructures in the Creation of Global Virtual Research Communities* study[17] carried out on behalf of the European Commission, Directorate General Information Society and Media, in order to understand better the organizational, collaborative and technological developments in e-Infrastructures which are effective in supporting virtual research organizations in different fields, has concluded in four scenarios for the future, promoting as the ideal one the *Research Revolution,* in which change takes place at all levels including schools. In this framework the ***Discover the COSMOS* coordination action** aims to add its contribution to the efforts for the realization of the Europe 2020 strategy which announces re-focusing of research and innovation policy for building Europe's innovative advantage by a) demonstrating the key role of e-Infrastructures in the development of highly motivating and flexible learning environments, b) demonstrating *how science works*, c) implementing a series of innovative *eScience* scenarios (the *Discover the COSMOS* Demonstrators) for school practice that offering access to unique scientific resources to teachers and students organised under a systematic pedagogical framework and d) providing a model for the coordination of educational and outreach activities of major research infrastructures.

B1.2.1 Developing more conductive, highly motivating and flexible learning environments

There are many educational and outreach initiatives that aim to introduce the work of the scientist in the school classroom. **Hands on Particle Physics Masterclasses** (http://www.physicsmasterclasses.org), initially implemented at a European scale in 2005 in the framework of the *World Year of Physics* is demonstrating to the students *how science works* and **Galileo Teachers Training Programme** (http://www.site.galileoteachers.org/), initially proposed in 2009 in the framework of the *International Year of Astronomy* offers training to science teachers on how to use the scientific methodology in their classrooms. Both these initiatives are considered as extremely successful in the field worldwide. The *Discover the COSMOS* action aims to build on these successful initiatives and to go a step further, by proposing ways that (through the effective use of existing e-infrastructures) **could scale them up to include more students and teachers worldwide**. By utilizing the use of existing e-Infrastructures, the project will bring into the classroom activities that are based on real-world problems and will involve students in finding their own answers and solutions, testing their ideas, receiving feedback, and working collaboratively with other students and researchers beyond the school classroom. For example following the model of Hands on Particle Physics Masterclasses, **a series of virtual collaboration activities,** called **e-Masterclasses** will be designed and implemented, **promoting inquiry based and problem solving processes in virtual and**

blended learning environments. In this case students could perform the assigned tasks from their schools, allowing for more schools to be involved in the process. Collaboration in the framework of e-Masterclasses will demonstrate the potential of e-Infrastructures to meet the large computational demands of the proposed on-line collaborative learning processes. For example the extended computational capabilities of GEANT could enable the exploitation by teachers and students with limited ICT resources (e.g. school communities in remote or disadvantaged areas) to the advanced *Discover the COSMOS eScience* applications that enable innovative ways for teaching and learning. To this end, the *Discover the COSMOS* Communities Support Environment will offer innovative, interactive, collaborative and context-aware functionalities, which will be student-centred, focusing on contextualized and adaptable learning experiences.

Hands on Particle Physics Masterclasses (http://www.physicsmasterclasses.org/)

Each year about 6000 high school students in 23 countries come to one of about 110 nearby universities or research centres for one day in order to unravel the mysteries of particle physics. Lectures from active scientists give insight in topics and methods of basic research at the fundaments of matter and forces, enabling the students to perform measurements on real data from particle physics experiments themselves. At the end of each day, like in international research collaboration, the participants join in a video conference for discussion and combination of their results. The Hands on Particle Physics Masterclasses is a powerful illustration of how an *eScience* experience can provide rich and meaningful opportunities for people to participate in and learn about science. With the appropriate guidance from the research teams, students can use tools of science as they learned the practices, goals, and habits of mind of the culture of science. Similarly, in the framework of this initiative the scientific community responded to participants, modifying their project design as a result of feedback and continued interest in the project (Johansson et. al.)[18]. Through this fruitful collaboration, the relationship between scientists and students evolved, resulting in all members contributing and gaining valuable scientific knowledge.

B1.2.2 Demonstrating How Science Works

The proposed activities will simulate the work of real scientists who have access to facilities and resources regardless their location. In this way our approach will focus on the presentation of new working methods and models, based on the shared use of resources across different disciplines between researchers in virtual research communities in all *eScience* fields. The *Discover the COSMOS* approach aims to demonstrate a series of educational activities in which **students will be engaged in "border crossings" from their own everyday world culture into the subculture of science**. The subculture of science (collective set of norms, practices, language, and tools) is in part distinct from other cultural activities and in part a reflection of the cultural backgrounds of scientists themselves. By developing and supporting experiences that engage learners in a broad range of science practices, we can increase the ways in which students identify with and make meaning from their science learning experiences. For this purpose the educational context of the *Discover the COSMOS* is not transmitted in a theoretical way but rather in a biomatic way in the form of a real life experience. The project team will provide ICT tools and scaffolds that enhance learning, support thinking and problem solving, model activities and guide practice, and that allow for representation of data in different ways. In the framework of the proposed activities students will be able to personalize a set of resources for reference and problem solving. A great variety of learning activities could be supported from the *Discover the COSMOS eScience* applications: browsing and querying Internet resources from different research centres and laboratories; virtual visits to advanced research infrastructures where the experimental settings will be presented to students as 3-D visual objects and representations (e.g. walking in a visualised magnetic field); realization of remotely controlled experiments using advanced experimental instruments (e.g. telescopes and particle detectors); communication with fellow students, teachers and experts; experimentation with everyday phenomena; visualization of complex physical phenomena or mathematical problems (e.g. performing geometrical calculations in 3D environments). A rich collection of technical tools, appropriately orchestrated in the *Discover the COSMOS* learning environment will be available to teachers and their students. During the proposed activities students' initial predictions can be compared with data from the different experiments that they will have the chance to realise. The consortium believes that the proposed approach will improve everyday teaching for several reasons:

- **Increasing motivation:** Students are more likely to feel a sense of personal investment in a scientific investigation as they will actively participate in the research procedure and will add their own aesthetic touches to the different tools they are using for experimentation. Such an approach could help to make science “fashionable” among students. It has to be noted also that inquiry based pedagogy (supported by the use of ICT tools) address a variety of learning styles and strengthen higher order thinking skills essential for success in mathematics, science, engineering, and technology related courses.

- **Extending the experimentation possibilities:** The use of advanced experimental infrastructures (like telescopes) and the access to data from frontier experiments (like ATLAS and CMS) can serve as spurs to the imagination, promoting the interest of the students to be involved in scientific investigation. They will personally experience the procedures involved in an authentic research project and thereby gain a far better understanding of science and engineering. The proposed procedure will be freed from the pressing time limitation of the teaching hour. In this way their classroom is transformed into a scientific laboratory. The partnership believes that students can come to view the astronomical observations or the data analysis procedures as a craft that rewards dedication and precision but simultaneously encourages a spirit of creativity, exuberance, humour, stylishness and personal expression.

- **Developing critical capacity:** Too often students accept the readings of scientific instruments without question. When students will get involved in the proposed activities for example by performing their own experiments and observations, they should as a result develop a healthy scepticism about the readings and a more subtle understanding of the nature of the scientific information and knowledge.

- **Making connections to underlying concepts:** Our working hypothesis is that amending the traditional scientific methodology for experimentation with visualization applications and model building tools will help students and learners in general to articulate their mental models, make better predictions, and reflect more effectively. Additionally, working to reconcile the gaps and inconsistencies within their mental models, system models, predictions and results, will provide the learners with a powerful, explicit representation of their misconceptions and a means to repair them.

- **Understanding the relationship between science and technology:** Students will gain firsthand experience in the ways that technological design (and mainly e-Infrastructures) can both serve and inspire scientific investigation. The *Discover the COSMOS* learning environment will offer the option of teaching students as individuals, in small groups and in large groups while it will provide links to other schools and research facilities in their country and abroad. The versatility of the tools that will be integrated is one of the most compelling factors of the project.

A sustained school-research experience like Hands on Particle Physics Masterclasses provides an ideal opportunity for students to become familiar with the process and culture of science and even to become engaged participants in the scientific enterprise. In the framework of the project short-term or one-time such informal science education experiences will be more challenged to acquaint learners with the culture of science in the fullest sense. Through participation in such *eScience* activities, students can develop a greater appreciation of how scientists work together and the specialized language and tools they have developed. In turn, students also can refine their own mastery of the language and tools of science. For example, students participating in the “hunt of Higgs Boson” mission come together as a community to solve a particular problem (see Figure 1.2). Using the tools of science to analyse data and to select the best candidates, students become more familiar with the means by which scientists work on their research problems (e.g. selection of a small number of candidate events out of an extremely large amounts of data through the development of effective filtering mechanisms). The repertoire of the proposed *eScience* applications (see section B1.2.3) will facilitate various patterns of group working. Flexibility is the key, because whatever visions of education we design our systems around, we can be sure that they will need to perform in a very different way in a few years’ time. The *Discover the COSMOS* learning environment will allow students to work through material at their own pace, with different levels of support according to their own preferences. Inevitably, different students will embrace technology to greater or lesser extents and in different ways through the complementary interfaces the system offers. By engaging in scientific activities, students also develop greater facility with the language of scientists; terms like *hypothesis*, *experiment*, and *control* begin to appear naturally in their discussion of what they are learning. In these ways, students begin to gain entry into the culture of the scientific community and start to change the way they think about themselves and their relationship to science. They think about themselves as science learners and develop an identity as someone who knows about, uses, and sometimes contributes to science. When a transformation such as this one takes place, young people may begin to think seriously about a career in a research laboratory.

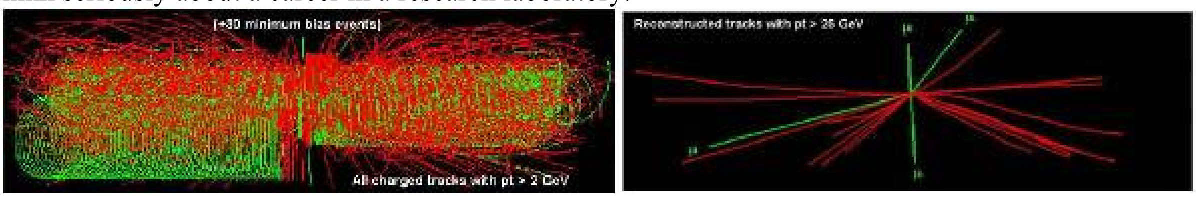


Figure 1.2: *In the framework of the project students will be involved in activities like "The LHC Data Challenge": Starting from the event on the right we are looking for the "signature" on the left (images from CERN). By Involving students in such activities and problems in eScience we can demonstrate the need for significant computing power and the importance of e-Infrastructures in such scientific process.*

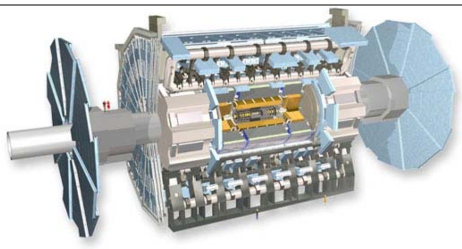
B1.2.3 The Discover the COSMOS Repertoire of eScience Resources - Developing authentic educational experiences

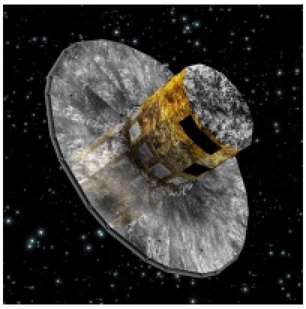
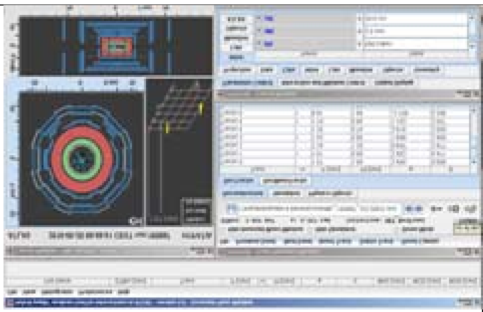
The *Discover the COSMOS* pedagogical framework will highlight and promote exemplary educational and outreach activities for schools. Such a process will help to chart the course into the future. By building on the best of current practice, the *Discover the COSMOS* approach aims to take us beyond the constraints of present structures of schooling (pedagogical, organisational and technical barriers) toward a shared vision of excellence. The consortium will present a series of exemplary practices, resources and applications (analysis tools, data repositories, simulations and advanced visualizations) that provide students with experiences that enable them to achieve scientific literacy, criteria for assessing and analysing students’ attainments in science and learning opportunities that school programmes afford. The outcome of this work, **the *Discover the COSMOS* Demonstrators,** will be the window onto live scientific experiments and phenomena, ongoing research, and the personalities and stories of working scientists across Europe. The *Discover the COSMOS* consortium brings together key players in the field of Particle Physics (CERN, IASA, UoB, TUD, LBL) and Astronomy (IAP, NUCLIO, UoC, UCM, CAM, LJMU, LBL) outreach that have invested major efforts to introduce frontier research issues into the schools classrooms in Europe and beyond.

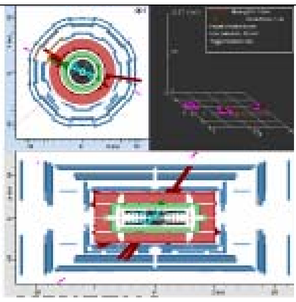
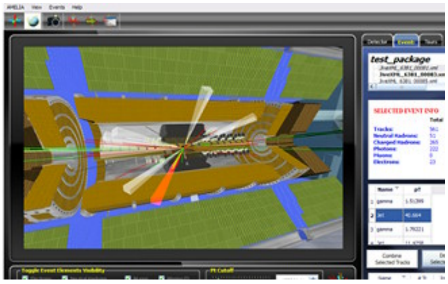
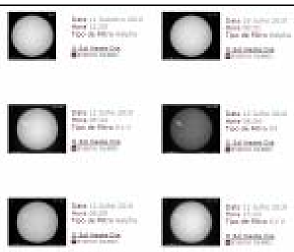
Figure 1.3: *The Discovery Space (D-Space) service contributes to the access to and sharing of advanced tools, services and learning resources for schools. The service aims at the deployment of a virtual science thematic park that connects schools, universities and science museums with a network of robotic telescopes around the world. The system is based on the use of Grid technology to facilitate fast and reliable access to the network of the telescopes and the databases of the participating observatories. The aim is to bring to students, teachers, researchers and individuals (amateur astronomers, visitors of science parks) all around the world the opportunity to use remotely controlled robotic telescopes in real time giving accessibility to unique resources as the sky is a vast and unique laboratory of science, always in operation, accessible at all times from everybody from everywhere, where all sorts of interesting physical phenomena take place most of which is impossible to reproduce in any scientific laboratory. Finally it supports the provision of key skills to the future citizens and scientists (collaborative work, creativity, adaptability, intercultural communication).*

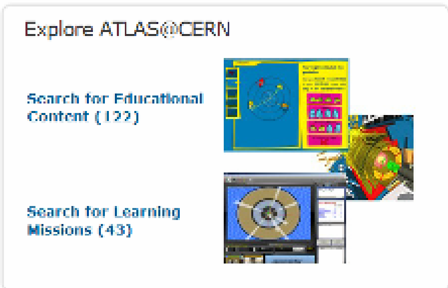
The CERN High School Teachers Training Programme (http://teachers.web.cern.ch/teachers/), the Hands On Particle Physics Masterclasses (http://www.physicsmasterclasses.org/), the Galileo Teachers Training Programme (http://www.site.galileoteachers.org/), the Hands On Universe initiative (http://www.euhou.net/), the National Schools Observatory (http://www.schoolsobservatory.org.uk/), the SkyWatch European Contest (http://www.discoveryspace.net/skywatch2007/) are some indicative examples of successful initiatives that make use of large scale research infrastructures (detectors, accelerators and telescopes) and advanced *eScience* applications. Table 1.2.1 presents the *Discover the COSMOS* backbone infrastructure that will facilitate the deployment of the proposed inquiry based activities in the European science classrooms. The *Discover the COSMOS* infrastructure consist of user-friendly interfaces which abstract service provision from the underlying research infrastructure complexities while they provide environments for virtual access to (remote) instruments as well as user-driven "composition" of virtual facilities and test beds. The necessary link to the school science curriculum will be implemented using a multilingual *Science Education Vocabulary* that has been developed already by the consortium members (Sampson et al, 2008[19], COSMOS, 2008[20]). The goal of the *Science Education Vocabulary* is to associate the users, the educational activities and pedagogical models. Such an approach addresses also the multilingual and multicultural issues arising in this project. The *Discover the COSMOS* applications and the proposed scenarios of use offer a “feel and interact” user experience, allowing for learning “anytime, anywhere” by employing advanced and highly interactive visualization technologies and also personalised ubiquitous learning paradigms in order to enhance the effectiveness and quality of the teaching and learning process. These materials have been tested in different educational settings (schools, teacher training centres, outreach programmes, workshops, and summer schools) in Europe and beyond and they have proven their efficiency and efficacy as inquiry based resources. In the framework of the project the consortium proposes value-added services to increase the utility of these resources through coordination, systematic dissemination and effective teachers’ community building.

Table 1.2.1: *Advanced Research Infrastructures and eScience applications that will be used in the framework of the Discover the COSMOS educational activities.*

Research Infrastructures	
	**ATLAS** (www.atlas.ch) is a particle physics experiment at the Large Hadron Collider at CERN. The ATLAS detector is searching for new discoveries in the head-on collisions of protons of extraordinarily high energy. ATLAS will learn about the basic forces that have shaped our Universe since the beginning of time and that will determine its fate. Among the possible unknowns are the origin of mass, extra dimensions of space, unification of fundamental forces, and evidence for dark matter candidates in the Universe.
	**CMS** (http://cms.web.cern.ch/cms/) is a high-energy physics experiment in Cessy, France, part of the Large Hadron Collider (LHC) at CERN. CMS is designed to see a wide range of particles and phenomena produced in high-energy collisions in the LHC. Like a cylindrical onion, different layers of detector stop and measure the different particles, and use this key data to build up a picture of events at the heart of the collision. Scientists then use this data to search for new phenomena that will help to answer questions such as: What is the Universe really made of and what forces act within it? And what gives everything substance? CMS will also measure the properties of previously discovered particles with unprecedented precision, and be on the lookout for completely new, unpredicted phenomena.

	**The Large Hadron Collider (LHC)** is a particle accelerator used by physicists to study the smallest known particles – the fundamental building blocks of all things. It will revolutionise our understanding, from the minuscule world deep within atoms to the vastness of the Universe. Two beams of subatomic particles called 'hadrons' – either protons or lead ions – will travel in opposite directions inside the circular accelerator, gaining energy with every lap. Physicists will use the LHC to recreate the conditions just after the Big Bang, by colliding the two beams head-on at very high energy. Teams of physicists from around the world will analyse the particles created in the collisions using special detectors in a number of experiments dedicated to the LHC.
	**Gaia** (http://www.esa.int/science/gaia) is an ambitious ESA mission to chart a three-dimensional map of our Galaxy, the Milky Way, in the process revealing the composition, formation and evolution of the Galaxy. Gaia will provide unprecedented positional and radial velocity measurements with the accuracies needed to produce a stereoscopic and kinematic census of about one billion stars in our Galaxy and throughout the Local Group. This amounts to about 1 per cent of the Galactic stellar population. Combined with astrophysical information for each star, provided by on-board multi-colour photometry, these data will have the precision necessary to quantify the early formation, and subsequent dynamical, chemical and star formation evolution of the Milky Way Galaxy.
	**The Faulkes Telescope Project** (http://www.faulkes-telescope.com/) is the education arm of Las Cumbres Observatory Global Telescope Network (LCOGTN). LCOGTN operates a network of research class robotic telescopes. Currently there are two telescopes, one in Hawaii and the other in Australia. These telescopes are available to teachers for them to use as part of their curricular or extra-curricular activities and are fully supported by a range of educational materials and a team of educators and professional astronomers.
	**The Liverpool Telescope**, http://telescope.livjm.ac.uk, is a fully robotic astronomical telescope (located on the Canary Island of La Palma) owned and operated by the Astrophysics Research Institute of Liverpool John Moores University in north west England. It was designed and built by Telescope Technologies Limited, a spin-off company of the University, as the prototype of their production-line range of two-metre class telescopes. The LT was therefore the "first off the line". The telescope itself is a two-metre Cassegrain reflector, with Ritchey-Cretien hyperbolic optics, on an altazimuth mount. Up to nine different instruments can be mounted at the Cassegrain focus, one in the "straight through" position and eight more on side ports accessible by a rotating "science fold" tertiary mirror.
***eScience* Applications** (2D and 3D interfaces and analysis tools, Scientific data repositories and archives, educational repositories)	
	**HYPATIA** http://hypatia.phys.uoa.gr/ (Hybrid Pupil's Analysis Tool for Interactions in Atlas) is part of the ATLAS Student Event Challenge (ASEC), a contemporary educational project regarding Particle Physics. HYPATIA is focusing in high-school education and engages students to work with the most advanced techniques used by modern particle physics. It enables students obtain a better understanding of the interactions between fundamental particles of matter by studying "events" detected by the ATLAS experiment. The deployment of such tools simplifies the teaching of physical principles and eliminates the idea that physics and Science in general is too complicated to understand.

	**MINERVA** http://atlas-minerva.web.cern.ch/atlas-minerva/ is an interactive analysis tool for students to learn more about the ATLAS experiment. It is based on a simplified setup of the ATLAS event display, Atlantis, which allows users to visualise what is happening in the detector by using 2D animations. Minerva has currently developed two main scenarios of use which are both based on identifying particles produced from collisions. Students have the chance to get a glimpse of how scientific experiments are performed in particle physics and how new discoveries are made.
	**AMELIA** http://amelia.sourceforge.net/index.html is a 3D application with focus on particle physics processes in ATLAS. It allows students and other users to get acquainted with collision events that are produced within ATLAS, analyse their data and study the tracks of particles. AMELIA is the only tool that provides 3D representations of the collision events enabling students to see how particles are detected as they pass through. It allows the user to rotate, zoom and select virtual pieces of the ATLAS detector and events. Videos, animation, sound, interactive visualization and data analysis are integrated in a single framework, making AMELIA a very useful and effective tool in the hands of students.
	**SalsaJ** http://www.euhou.net/ is a student-friendly astronomical images analysis tool. It works with FITS image format thus making it suitable for analyzing images from most professional telescopes. SalsaJ is designed to be easy to install and use. It allows students to display, analyse, and explore real astronomical images and other data in the same way that professional astronomers do, making the same kind of discoveries that lead to true excitement about science. SalsaJ is available in 25 European languages and it is widely used from teachers in many European countries.
	**LTImage** http://www.schoolsobservatory.org.uk/astro/tels/ltimage is a simplified image processing tool designed especially for students. It is developed by the National Schools' Observatory and it aims to facilitate educational activities that require analysis of image data from astronomical telescopes. LTImage works with FITS image format thus making it suitable for analyzing images from most professional telescopes.
	**The "Sun for all" scientific archive** http://www.mat.uc.pt/sun4all/ includes over 30.000 Sun images captured the last 80 years. It aims to promote Science in general and astronomy in particular, among students. "Sun for all" focuses on the exploration of the Sun's properties by the students when using real scientific data and tools and thus implements the teaching of mathematics, sciences and elementary informatics.

	**The Discovery Space Portal (**www.discoveryspace.net): The portal offers access to 6 robotic telescopes seamlessly into one virtual observatory and provides the services required to operate this facility, including a scheduling service, tools for data manipulation and access to related educational materials. The portal gives students the opportunity to use remotely controlled telescopes in a real-time. In this way it enables students to increase their knowledge on astronomy, astrophysics, mathematics and other science subjects and improve their computer literacy while strengthening their critical thinking skills. Students are able to graphically view all quantities under study and the data correlations. The service has 1,100 registered users (teachers and students).
	**COSMOS Portal** (www.cosmosportal.eu): The COSMOS portal is an experimental laboratory for students and teachers, aiming to improve science instruction by expanding the resources for teaching and learning in schools, providing more challenging and authentic learning experiences. The COSMOS Portal offers tools and templates that support teachers to design their own inquiry based activities using numerous resources (photos, videos, animations, exercises, graphs, links). Additional it offers tools for community building and collaboration. The COSMOS portal currently contains more that 100,000 Educational materials and Learning Activities, while it is frequently used from the 3,000 active registered teachers.
	**The Learning with ATLAS@CERN Portal** (www.learningwithATLAS-portal.eu): The portal contains educational resources, such as access to near real-time data and interactive analysis tools (e.g. AMELIA, HYPATIA tools allow users to explore that ATLAS experiment in an intuitive way, which is much friendlier to students, http://atlas.ch/students.html), 3D and 2D animations of physical processes in a game like approach, teacher resources (e.g. professional development materials, lesson plans, projects and activities, http://teachers.web.cern.ch/teachers/), student-centred materials (e.g. data library, communication area, student's magazines), applications for educational projects and collaborative activities.

The *Discover the COSMOS* Demonstrators will be treated as case studies and will be disseminated in different environments (teachers' preparation and professional development institutions, schools) across Europe during the life cycle of the project. The process of observing and reflecting on teachers' actions, and on students' learning and thinking, can lead to changes in the knowledge, beliefs, attitudes, and ultimately the practice of teachers. Teachers can extend and apply knowledge presented in the case studies, formulate questions and ideas, learn from one another, become aware of alternative perspectives and strategies, reflect on real problems faced by practicing teachers, and increase their science knowledge, as many science topics are covered in the selected case studies.

B1.2.4 Coordination of Educational and Outreach Activities

By bringing together outreach groups from Particle Physics and Astronomy who have developed unique *eScience* applications and educational and training programmes for teachers and students the *Discover the COSMOS* action aims to propose a generic framework for the design, development, implementation and evaluation (both short and long term) of effective Educational and Outreach activities. The aim of the consortium is to formulate a common set of guidelines and recommendations on how scientific work can be used to provide an engaging educational experience through the exploration of "real science". Research on learning science makes clear that it involves development of a broad array of interests, attitudes, knowledge, and competencies. Clearly, learning "just the facts" or learning how to design simple experiments is not sufficient. In order to capture the multifaceted nature of science learning, the *Discover the COSMOS* approach proposes a roadmap that includes a series of "strands for the design of the Educational and Outreach Activities" and articulates the science-specific capabilities supported by the environment of a research infrastructure. This framework builds on a four-strand model developed to capture what it means to learn science in school settings[21] by adding two additional main strands incorporated for informal science learning, reflecting a special commitment to interest, personal growth, and sustained engagement that is the hallmark of informal settings.

The strands will provide a framework for thinking about elements of scientific knowledge and practice. The proposed framework will also describe a series of support functions that have to be deployed for the long-term impact of the proposed activities to be safeguarded. Such support actions could include support for: the integration and coordination of educational and outreach activities between groups across different research institutions; the science community and scientists interested in educational and outreach activities; the education communities interested in scientific content and applications; special events and activities that provide means and tools for web-based communication and collaboration. The proposed framework will provide a useful reference for helping educators and outreach groups in the informal science education community articulate learning outcomes as they develop programs, activities, and events, and further explore and exploit the unique benefits of introducing *eScience* in schools.

Table 1.2.2: *The main strands and the Educational Objectives for the design and implementation of Educational and Outreach activities for involving students in eScience.*

Strands	Educational Objectives
Sparking Interest and Excitement	*Experiencing excitement, interest, and motivation to learn about phenomena in the natural and physical world.*
Understanding Scientific Content and Knowledge	*Generating, understanding, remembering, and using concepts, explanations, arguments, models, and facts related to science.*
Engaging in Scientific Reasoning	*Manipulating, testing, exploring, predicting, questioning, observing, analysing, and making sense of the natural and physical world.*
Reflecting on Science	*Reflecting on science as a way of knowing, including the processes, concepts, and institutions of science. It also involves reflection on the learner's own process of understanding natural phenomena and the scientific explanations for them.*
Using the Tools and Language of Science	*Participation in scientific activities and learning practices with others, using scientific language and tools.*
Identifying with the Scientific Enterprise	*Coming to think of oneself as a science learner and developing an identity as someone who knows about, uses, and sometimes contributes to science.*

Furthermore, such an action asks for knowledge areas integration, effective and closes cross-institutional collaboration, and organisational change in the field of science education. The whole effort will be documented analytically and systematically in **"Effective Ways of Introducing *eScience* in Schools"** document that will be one of the main deliverables of the project. This document will be the first step in a journey of educational reform that might take many years. It will be the map. It has to be noted though that the achievement of the high quality science teaching requires the combined and continued support of all involved actors, researchers, policy makers and curriculum developers, science teachers' educators, teachers, students and parents.