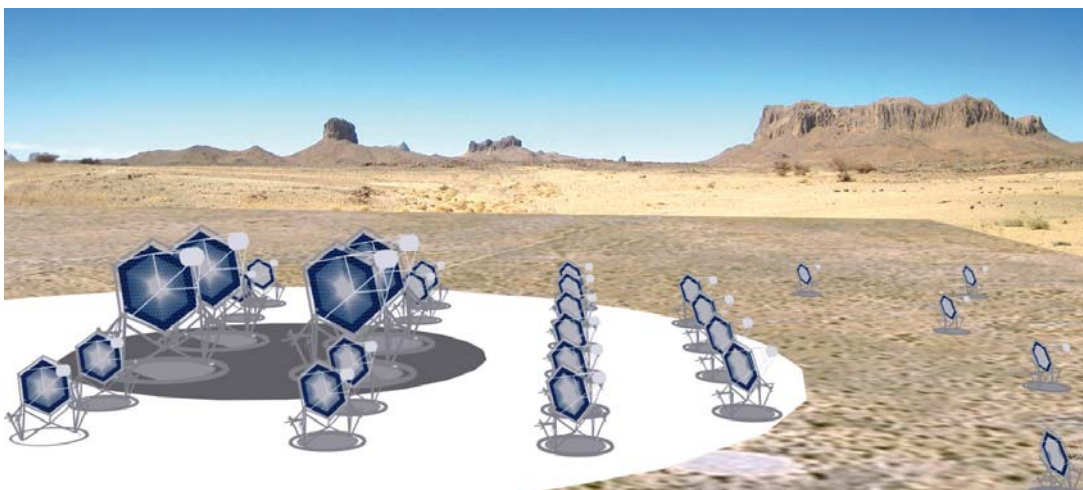


CORE – CTA Observatory Research E-Infrastructure

Funding scheme: Combination of collaborative project and coordination and support action – Integrated infrastructure initiative project (I3)

Call topic: INFRA-2010-1.2.3: Virtual Research Communities

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Glossary

A&A	Astronomy & Astrophysics
AOC	Array Operation Centre
ASPERA	AStroParticle ERAnet
ASTRONET	ASTRONomy NETwork
CANGAROO	Collaboration of Australia and Nippon for a GAMMA Ray Observatory in the Outback
CCIN2P3	Centre de Calcul de l'IN2P3
CE	Computing Element
CTA	Cherenkov Telescope Array
CTACG	CTA Computing Grid
COMETA	COnsorzio Multi Ente per le Tecnologie di calcolo Avanzato
EC	European Commission
EGEE	Enabling Grids for E-science
EGI	European Grid Initiative
ESFRI	European Strategy Forum on Research Infrastructures
e-VLBI	e- Very Long Baseline Interferometry
FITS	Flexible Image Transport System
GEANT	Gigabit European Academic Network
gLite	EGEE Grid middleware
H.E.S.S.	High Energy Stereoscopic System
ICT	Information and Communication Technology
IVOA	International Virtual Observatory Alliance
LB	Logging and Bookkeeping service
LCG	LHC Computing Grid
LFC	LHC File Catalogue
MAGIC	Major Atmospheric Gamma-ray Imaging Cherenkov
MC	Monte Carlo
NGI	National Grid Initiative
RESPECT	Recommended External Software for EGEE Communities
SDC	Science Data Centre
SE	Storage Element
SOC	Science Operation Centre
SSC	Specialized Support Centre
PM	Person Month
PY	Person Year
UI	User Interface
VERITAS	Very Energetic Radiation Imaging Telescope Array System
VHE	Very High Energy
VO	Virtual Organization
VObs	Virtual Observatory
VOMS	Virtual Organization Membership Service
VSG	VHE gamma-ray Science Gateway
WMS	Workload Management Service
WN	Work Node

ABSTRACT

CTA (in the ESFRI-roadmap) is proposed as a next-generation open observatory for very high energy gamma rays. The three main logical units of the CTA observatory are: the Science Operation Centre (SOC), in charge of the organization of observations; the Array Operation Centre (AOC) in charge of operating and monitoring the telescope arrays; the Science Data Centre (SDC) for data dissemination to the scientific users through the IVOA. Existing ICT-based infrastructures, such as EGEE and GEANT, are recommended solutions for all data management tasks of these three logical units.

The high data rate of CTA together with the large computing power requirements for data analysis demand dedicated resources, thus EGEE-Grid infrastructures and EGEE-Grid middleware for distributed data storage, data analysis and data access are considered the most efficient solution for the CTA e-infrastructure.

Possible sites to host the CTA observatory with optimal observing conditions are in southern Africa, Latin America, Central America and the Canary Islands. Thus pan-European and extra-European end-to-end networking is a critical issue for CTA. Networking will make the gamma-ray astronomy data worldwide accessible through the CTA EGEE-Virtual Organization following the example of other projects in astronomy. The global integrated approach of Grid access conditions together with a GÉANT high bandwidth research network is an important issue.

The CORE project aims to propose the development of an integrated application of e-infrastructures like EGEE-Grid, GÉANT and IVOA for the architecture of the CTA observatory and aims to deploy end-to-end services in support of a wide scientific community for open data access for CTA. All levels of data will be archived in a standardized way in order to allow access and re-processing by the scientific community. Access to all levels of data and Grid infrastructures will be provided by a single access point, the "VHE gamma-ray Science Gateway".

I. Scientific and/or technical quality

I.1. Concept and objectives

In March 2007, the High Energy Stereoscopic System (H.E.S.S.) project was awarded the Descartes Research Prize of the European Commission for offering “A new glimpse at the highest-energy Universe”. Together with the instruments MAGIC and VERITAS (in the northern hemisphere) and CANGAROO (sharing the southern hemisphere with H.E.S.S.), a new wavelength domain was opened for astronomy, the domain of very high energy (VHE) gamma rays with energies between about 100 Giga electronvolts (GeV, 10^9 eV) to about 100 Tera electronvolts (TeV, 10^{12} eV), energies which are one hundred billion to one hundred trillion times higher than the energy of visible light. High energy gamma rays probe the “non-thermal” Universe, where mechanisms other than thermal emission by hot bodies allow the concentration of large amounts of energy into a single quantum of radiation. A key result of recent years was that sources of very high energy particles are ubiquitous in our Galaxy and beyond. The total number of detected objects approaching 100, including more than two dozen extragalactic objects, confirms the conjecture that such high-energy phenomena play a significant role in the cosmic matter cycle.



Figure 1: The H.E.S.S. telescope system in Namibia.

Cherenkov telescopes detect the optical Cherenkov radiation generated by charged particles in the cascades which high energy gamma rays initiate in the Earth's atmosphere. Using the atmosphere as a detection medium, ground-based gamma-ray detectors achieve large detection areas. Current telescope systems such as H.E.S.S. and MAGIC are capable of detecting sources with strength of 1/100 of the flux of the Crab Nebula – the strongest persistent source of very high energy gamma rays – and of resolving structures on a scale of about 5 arc-minutes. In the field of VHE gamma-ray astronomy, Europe, with the H.E.S.S. and MAGIC instruments and their H.E.S.S. II and MAGIC II expansions, holds a leading position. Performance of these current instruments is still far from fundamental limits imposed by the physics of air showers; the energy threshold of the instruments is governed by the dish size, their coverage beyond about 10 TeV is limited by the area covered by the telescope array, and performance at mid-energies could be improved by viewing showers with more than the current 2-4 telescopes, and over a larger area.

The spectacular astrophysics results from current Cherenkov instruments have generated considerable interest, both in the astrophysics and astroparticle physics communities. In response, both communities have rallied behind the urgent call for a more sensitive and more flexible next-generation facility. The improved performance is expected to lead to the discovery of a broad range of new phenomena in astroparticle physics and high energy astrophysics. The proposed CTA facility – an array of Cherenkov telescopes built on proven technology deployed on an unprecedented scale – will allow the European scientific community to remain at the forefront of research; CTA is listed on the ESFRI roadmap. For the first time, the CTA project

unifies the research groups working in this field in Europe in a common strategy, resulting in a unique convergence of efforts, human resources, and know-how.

With CTA VHE gamma-ray astronomy will evolve from scientific collaboration-led experiments to public observatory where astronomers will submit proposals and receive data, software or analysis services, and support. Making data understandable and usable by the scientific community at large has been the driving force of the development of astrophysics during the 20th century and it is expected that open access to CTA will significantly increase the scientific harvest of the instrument.



Figure 2: The two MAGIC telescopes on the Canary Island of La Palma (Spain).

One of the challenges to design the CTA observatory is to handle the large amounts of data generated by the instrument and to provide simple and efficient user access at any level and according to astrophysical standards. The CORE (CTA Observatory Research E-infrastructure) proposal is aiming at developing and implementing the CTA observatory research e-infrastructure for efficient and high performance data handling based on a modern and innovative computing environment with a high acceptance in the astronomical community in order to integrate and increase the research capacities of the international gamma-ray astronomy research community. The main objectives of the CORE proposal are:

- Implementation of European e-infrastructures adapted to the needs and requirements of the future gamma-ray observatory CTA;
- Evolution, deployment, and coordination of structured information systems related to data management, including ICT-based infrastructures (Information and Communication Technologies) such as Grid computing, software and middleware;
- Development of a virtual research facility including user-configured tools for data access, data processing and archiving, and data analysis in close collaboration with existing European VHE gamma-ray facilities (e.g. H.E.S.S. and MAGIC).

The activities described in this proposal will result in an integrated set of services to the scientific community (WP NA3, NA4, SA1, JRA5, JRA2), extend the application of e-infrastructures (WP SA1, JRA1, JRA4) to CTA and pave the way to federate the data from the existing experiments (WP SA2, SA3, SA4, JRA3) through the application of common standards and tools.

These services will enable a large number of users from particle physics and astrophysics to access and effectively use e-infrastructures in order to increase their capacities to analyze gamma-ray data and therefore participate in the relevant research. It will also guarantee integrated access to astrophysics and gamma-ray data collected by very different instruments,

experiments and scientific communities in order to be able to correlate them and improve their scientific usability.

1.1.1. The CTA Observatory

The CORE project is a central part of CTA proposed as a next-generation open observatory for very high energy gamma rays. CTA will consist of arrays of Cherenkov telescopes, aiming to (a) increase sensitivity by another order of magnitude, (b) extend the energy range by an order of magnitude and thus provide wide and uniform energy coverage from a couple of tens of GeV to beyond 100 TeV in photon energy, (c) increase the angular resolution and hence the ability to resolve the morphology of sources, (d) significantly boost the detection area and hence the detection rates, of particular importance for transient phenomena and at the highest energies, and (e) enhance the all sky survey capability, the monitoring capability and the flexibility of operation. Low-energy coverage is crucial both for the study of Galactic sources such as pulsars, and of sources at cosmological distances, where high-energy gamma rays are attenuated in interactions with background light. The high energy coverage allows probing the cut-off regions of Galactic particle accelerators, crucial for the understanding of acceleration mechanisms.

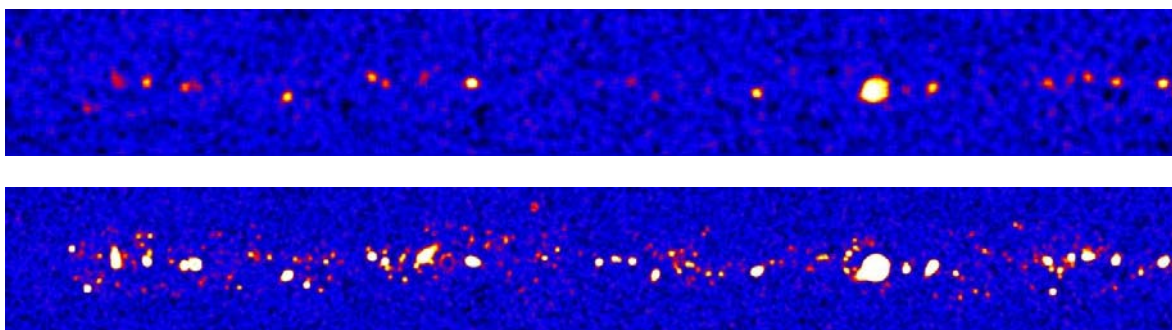


Figure 3 Top view: The Milky Way seen with the H.E.S.S. instrument after 500 hours of observation. Bottom view: Simulation of the Galactic plane as seen with CTA after 500 hours of observations. The increase in the number of VHE sources is clearly visible.

CTA will achieve its performance by combining different telescope sub-arrays: a few very large telescopes optimised for detection of low-energy showers will be surrounded by a core array of some tens of 10-12 m class telescopes, covering about 1 km² and providing optimal sensitivity in the 100 GeV to 10 TeV domain. A halo array of sparsely distributed 10 m class telescopes or of a larger number of smaller telescopes allows for the even larger detection areas required for the rate-limited regime beyond 10 TeV.

CTA prototype telescopes will be commissioned in 2011-2012 and the installation of the array will start in 2013. It is expected that data taking with the partial array will start in 2014 and that the full array will be operational in 2017. A critical issue of the CTA observatory is the timely establishment of structured information systems related to data management through the application of European e-infrastructures for easy access and analysis of the data at a world-wide scale.

A simplified logic work flow diagram of the CTA observatory is shown in Fig. 4. The three main logical units of the CTA observatory are: the Science Operation Centre (SOC), taking over all management tasks related to the organization of observations (e.g. evaluating, selecting and technically preparing the observation proposals submitted by the scientific community); the Array Operation Centre (AOC) in charge of operating (through scheduling and execution of the approved observations) and monitoring the telescope arrays; the Science Data Centre (SDC) for data reduction, data archiving and data dissemination to the scientific users through the International Virtual Observatory Alliance (IVOA). Existing ICT-based infrastructures, such as EGEE and GÉANT, are potential solutions for an efficient and high performance e-infrastructure for CTA for all data management tasks of these three logical units. The main issues inherent to the observatory work flow, which benefit from the above mentioned ICT-based infrastructures

applications are: 1) data flow, data transfer and archive; 2) data reduction, data analysis and open access; 3) Monte Carlo simulations.

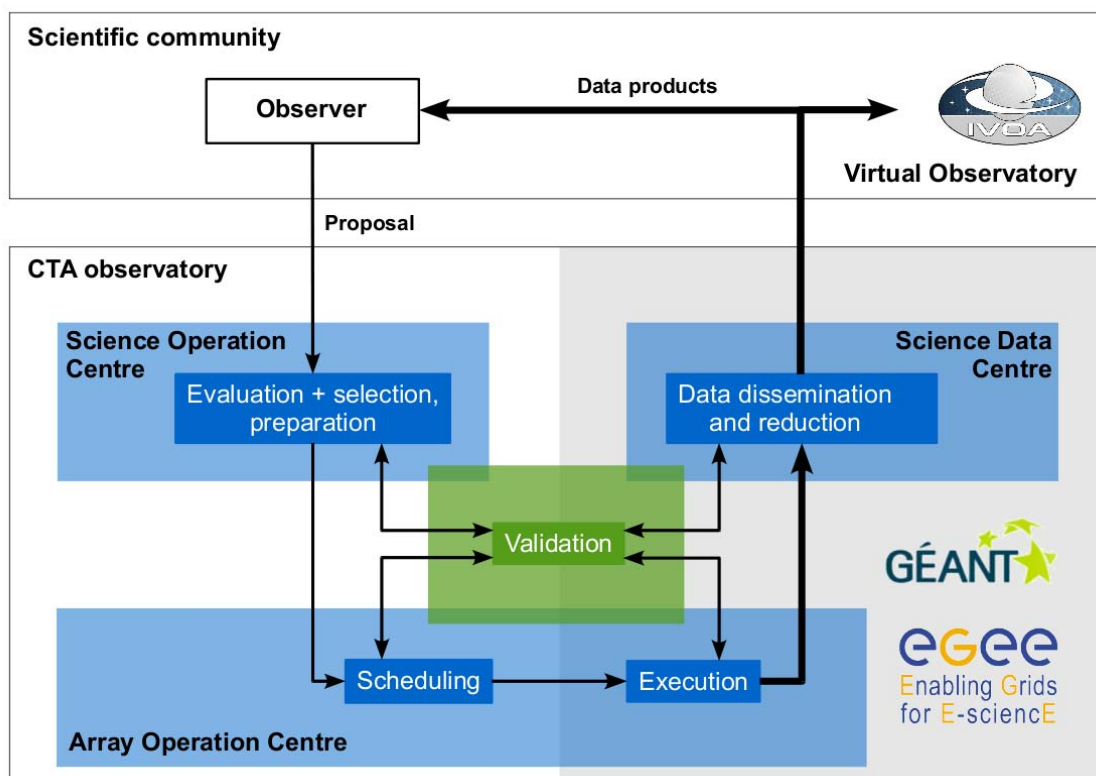


Figure 4: Logic work flow diagram of the CTA observatory. The three main logical systems which guarantee the observatory functionalities are the Science Operation Centre, the Array Operation Centre and the Data Centre. Data handling and dissemination build upon existing ICT-based infrastructures, such as EGEE and GÉANT.

1.1.2. Grid computing, data pipeline, archive and standardization

Grid computing

CTA will consist of many tens of telescopes of different type. The telescopes will be autonomous units with various subsystems (Cherenkov camera, calibration and sky monitoring devices, telescope and mirror steering units) each of which acts as an independent data source. The Cherenkov cameras will be equipped with roughly 2000 pixels and will produce triggers at a rate of 10 kHz. Telescope-level and array-level triggers will select events at a rate of about 3 kHz. The event size per camera will be larger than 10 kB. The resulting main data stream for permanent storage is of the order of 1 GB/s and dominates all other monitoring and control data streams. Besides the telescopes, CTA comprises devices for monitoring of weather and atmosphere and other smaller scientific instruments. The total data volume implied will be in the range 1 to 3 PB per year.

Massive Monte Carlo simulations are an essential tool in order to optimize the best configuration and performance of the CTA installation and for the analysis of the data. Performance depends on a large number of parameters including the general layout of the installation, telescope sizes and locations, and many more technical aspects like telescope optics, camera field-of-views and pixel size, signal shapes and trigger logic. A full simulation of the detector response to gamma and background events is generally needed. Since the discrimination between gamma and hadron showers is going to surpass even that of the best current instruments by a significant amount, huge numbers of background showers have to be simulated before conclusions on the performance of a particular configuration can be drawn.

Additionally Monte Carlo simulations play a central role in the data analysis from Cherenkov telescopes in order to calibrate the scientific data. Processing, access and analysis of Monte Carlo data thus are common practice of scientists involved in Cherenkov experiments. In CTA Monte Carlo simulations will demand massive computing, storage resources as well as an efficient worldwide access of the scientific community.

The high data rate of CTA together with the large computing power requirements for Monte Carlo simulations demand dedicated computer resources which can be well handled through the Grid approach. Thus EGEE-Grid infrastructures and EGEE-Grid middleware for distributed data storage and data access are considered the most efficient solution for the CTA e-infrastructure. The size of the Grid facilities can easily be adapted to the CTA data-flow requirements (e.g. through a “light-Grid” solution). The Grid approach results in a homogeneous organization of software for Monte Carlo production, data reduction, data analysis and end-user analysis tools application in interface with the VObS by using the same EGEE middleware and by exploiting the same resources of the distributed computing centres supporting the CTA EGEE-Virtual Organization.

Data pipeline

Possible sites to host the CTA observatory with optimal observing conditions are in southern Africa, Latin America, Central America and the Canary Islands. Thus pan-European and extra-European end-to-end networking is a critical issue for CTA. The global integrated approach of Grid access conditions together with a high bandwidth research network is an important topic to be studied. The traditional approach of current VHE gamma-ray experiments (e.g. H.E.S.S. and MAGIC) for data transport, i.e. making use of high capacity magnetic tapes, is not applicable to CTA. The tape-based technology is becoming less well supported and comparatively more expensive. The international connectivity provided to Europe's research and education community and focused on international research networking projects funded by the European Commission (GÉANT) will open perspectives of Gb/s connectivity not only among European institutes but also for instance with Latin America and Africa, where local projects of improving research telecommunications capacity are in progress (e.g. respectively ALICE and EUMEDCONNECT). This will offer high-rate data-flow in real time between the CTA sites and the Data Centre. Furthermore networking will make the gamma-ray astronomy data worldwide accessible through the CTA EGEE-Virtual Organization following the example of other projects in astronomy (e.g. e-VLBI) which have been able to calibrate, analyze and correlate in real time data together with datasets from others observatories from around the world.

Data archive and standardization

In the processing of VHE air shower gamma-ray data, including that from CTA, there is a natural progression from the very large volume of raw trigger data coming directly from the cameras, to the much smaller high-level science-ready products such as sky images, spectra, etc. Because of the increasing level of calibration information input and summarising assumptions, together with the loss of re-analysis flexibility as the data are processed to higher levels, we believe that there is value in providing to the user data from a variety of processing levels. This will enable the expert user to extract the maximum scientific value from their observations, while also allowing the wider community easy access to reliable results from the telescopes. Based on our previous observatory experience, we can anticipate that the quality of the products at the various levels will evolve in such a way that initially the lower level products will be the most trusted, while as the analysis matures the higher level products will become the norm.

We have formalised the concept of product levels as follows. All of these levels will exist in the data processing, although which of these will be released for community use is to be established during the CORE project.

Data level	Description
Level 0	The raw photomultiplier tube and ancillary telescope data. There will be a file for each camera observation, containing one record per camera read.
Level 1a	The PMT calibrated version of Level 0.
Level 1b	Contains the image shape parameters, at the same frequency as Level 1a.
Level 2a	Has the reconstructed shower parameter in a single file for all cameras with a record for each shower. A variety of parameterization schemes may be offered.
Level 2b	The cleaned and calibrated gamma-ray photon list, having one record per photon. The amount of data is much reduced compared to the equivalent Level 2a data.
Level 3	Files are the binned high-level products: sky images, spectra and time series.
Level 4	Files are observatory-level files, such as the CTA survey sky maps, the CTA catalogue, etc.

The processing of data from Level 0 to Level 2b is a major computational challenge that has to reduce a typical volume of 10 TBytes data per observation into a few tens of MBytes of high-level data within a couple of hours. This low-level data processing will make heavily use of Grid technology by spanning hundreds of processes within a global pipeline. The data processing includes as well the MC simulations which are a key tool for the calibration of Cherenkov data. The integrated services and infrastructures dedicated to the MC production, analysis and disseminations have also to be taken into account in the CTA data pipeline.

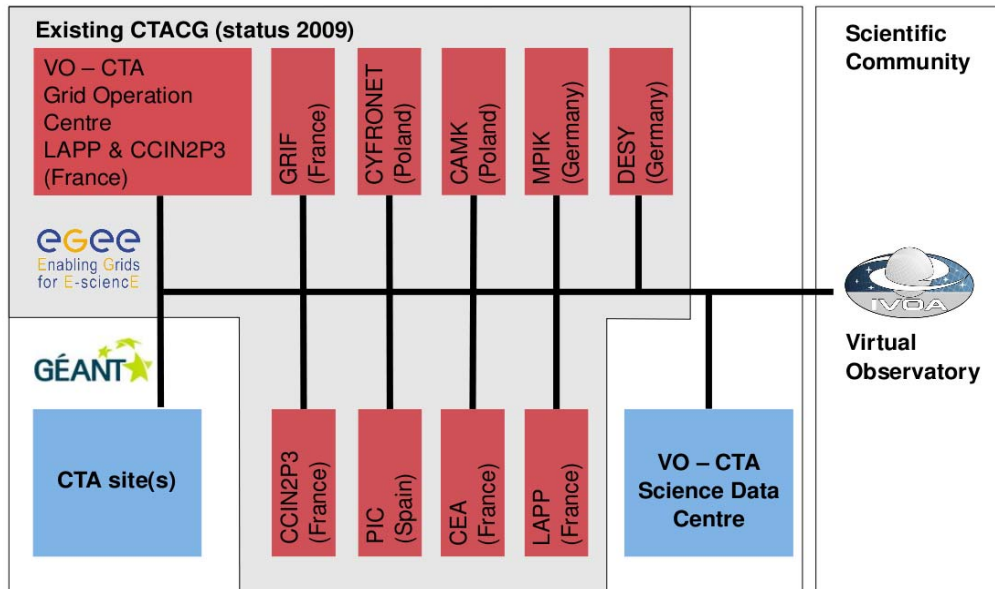


Figure 5: Logic view of the integrated application of e-infrastructures like EGEE-GRID, GÉANT and IVOA for the architecture of the CTA observatory together with the 2009 status of the CTACG projects as will be explained in Section I.2.3. The VO-CTA Grid Operation Centre houses the Workload Management Service (WMS), LCG File Catalogue (LFC), and the Virtual Organization Membership Service (VOMS) and other EGEE services.

Furthermore as will be explained in 1.2.3 the bulk of computing resources for MC and data analysis purposes have already been allocated and their upgrading (for the purposes of the CORE project) is part of the CTA consortium investments-plan and e-infrastructures strategy for the next years (see Fig. 5).

All levels of data will be archived in a standardized way in order to allow access and re-processing by the scientific community. Access to all levels of data will be provided by a single access point, the “VHE gamma-ray Science Gateway”. Figure 5 shows an overview of the integrated application e-infrastructures like EGEE-Grid, GÉANT and IVOA for the architecture of the CTA observatory and aimed to deploying end-to-end services and tools in support of a wide scientific community.

1.1.3. Scientific and Technological objectives vs. topics addressed by the call

Current gamma-ray Cherenkov instruments are operated as experiments. The CORE proposal is aimed at defining and implementing an integrated strategy for e-infrastructures application for open data access for CTA. The main objectives of the project divided into service, joint research, and networking activities are:

Service activities:

- Support, operate and manage the CTA EGEE-Virtual Organization Grid infrastructure and design it for the future CTA data processing. Software and services deployment, integration, test and certification for the following activities: Monte Carlo simulation and analysis, scientific data reduction and production, data analysis, data storage.
- Organize archives of all levels of astronomical data (metadata and data), provide web-based access and analysis tools and implement policies and tools for repositories compliant with CTA archives.
- Design and implement software to analyze archived data compatible with other existing large high energies experiments (data format, tools, and user's point of view). Provide gamma-ray Cherenkov data and on-line physics modelling software tools to astronomical users through the VObs framework (e.g. light curves, images, final spectra).
- The resulting tools and services developed and delivered by the services and network activities, and addressed to all level-data user access and analysis, will be integrated into the “VHE gamma-ray Science Gateway”. The gateway will be the official gamma-ray virtual community gateway and will also make available open access tools for the data analysis of sub-sets of H.E.S.S. and MAGIC data for validation purpose and to increase awareness and scientific interest to VHE gamma-ray physics.

The above listed objectives aim to respond to the topics of the INFRA-2010-1.2.3 call:

- *Deployment of end-to-end e-infrastructure services and tools, including associated interfaces and software components, in support of virtual organizations in order to integrate and increase their research capacities;*
- *Building user-configured virtual research facilities/test-beds by coalition of existing resources (e.g. sensors, instruments, networks, and computers) from diverse facilities, in order to augment the capacities of research communities for real world observation and experimentation; as reported in the document “n_wp_20101_en.pdf” – “WP – Capacities-European Commission C(2009)5905 of 29 July 2009”*

Joint research activities:

- Define a hierarchical data model fulfilling the CTA observatory requirements. Develop strategy and policies for integrated European e-infrastructures (GÉANT and EGEE) for data transfer, data reduction and data pipelines management purposes, by linking and integrating the Array Operation Centre and the Data Centre.
- Develop interfaces between CTA infrastructures (and services) and the applications available (or user-developed), directly accessible to the end user (integrated into the

VSG). Upgrade of characterizing formats of archived data into IVOA by adding specific Cherenkov gamma-ray data requirements e.g. VObs capacity to deal with time flagged data.

- The H.E.S.S. and MAGIC experiments will provide subsets of their data in order to test the infrastructure developed in this project. This allows to fully test the functionality and performance of the infrastructure ranging from Level 0 to Level 4 data including systematic effects not included in simulated CTA data. We will pave the way for an open data access of the VHE gamma-ray data taken with existing experiments in order to archive this data for later usage.
- Develop interfaces between the CTA archive and data at different wavelengths and from different experiments. This will be a Multi-Wave-Length on-line archive (integrated into the VSG).

The above listed objectives aim to respond to the topics of the INFRA-2010-1.2.3:

- *Deployment of e-Infrastructures in research communities in order to enable multidisciplinary collaborations and address their specific needs.*
- *Integrating regional e-Infrastructures and linking them to provide access to resources on a European or global scale.*

Networking activities:

- Management of the CORE project: assuring access provision and pooling of distributed resources; coordination with similar initiatives in international astrophysics and astroparticle physics for a global and sustainable approach in the field; liaison and coordination with ASPERA, ESFRI, EGEE/EGI, GÉANT and IVOA.
- Study commonalities between the operations, data formats and archiving of existing experiments in order to be able to create a system which efficiently meet the community's needs.
- Develop a common “vocabulary” to be used in the implementation of tools to analyze the data, leading to an extended and comprehensive data-model to be adopted in the largest possible astrophysics community.
- Provide briefings and support to the community for IACT data analysis (and related developed software) as well as tutorials and training courses to new users increasing trans-national and sustainable access to EGEE-Grid and IVOA e-infrastructures.

The above listed objectives aim to respond to the topics of the INFRA-2010-1.2.3:

- *Addressing human, social and economic factors influencing the creation of sustainable virtual research communities as well as the take up/maintenance of e-Infrastructure services by communities.*

I.2. Progress beyond the state-of-the-art

I.2.1. State-of-the-art in VHE gamma-ray astronomy

With the results of the latest generation of ground-based gamma-ray instruments such as H.E.S.S., MAGIC and VERITAS, very high energy gamma-ray astronomy has grown to a genuine branch of astronomy, allowing imaging, photometry and spectroscopy of sources of high-energy radiation. The number of known sources of very high energy gamma rays is now close to 100, and source types include supernovae, pulsar wind nebulae, stellar winds and active galaxies as well as unidentified sources without obvious counterpart. H.E.S.S. has conducted a highly successful survey of the Milky Way covering about 600 square degrees which resulted in the detection of two dozen new sources; however, a survey of the full visible sky would require an unfeasible decade of observations.

Due to the small flux, instruments for detection of very high energy gamma rays (above 10 GeV) require a very large effective detection area ($\sim 10^5 \text{ m}^2$), thus eliminating space-based instruments

which directly detect the incident gamma rays. Ground-based instruments allow much larger detection areas. They detect the particle cascade induced when a gamma ray is absorbed in the atmosphere, either by using Cherenkov telescopes to image the Cherenkov light emitted by secondary electrons and positrons in the cascade, or by detecting the air shower particles which reach the ground (or mountain heights) with arrays of particle detectors (air shower arrays).

Compared to Cherenkov telescopes, ground-based air shower arrays have the advantages of a large duty cycle (they can observe during daytime), and of large solid angle coverage. However, their sensitivity is at the level of the flux of the Crab Nebula, the strongest known steady source of VHE gamma rays. Results from current air shower arrays demonstrate that there are very few sources emitting at this level. The recent rapid evolution of VHE gamma-ray astronomy was primarily driven by Cherenkov instruments, which reach sensitivities of 1% of the Crab flux for typical observing times of 25 h, and which provide significantly better angular resolution. Properties of the major current Cherenkov instruments are listed in the following table.

	CANGAROO	H.E.S.S.	MAGIC	VERITAS
Location	Australia	Namibia	Canary Islands	US
Latitude	-31°	-23°	+29°	+32°
Current telescopes	4 x 50 m ²	4 x 107 m ²	1 x 240 m ²	4 x 110 m ²
Operational since	2004	2004	2004	2007
Upgrades in progress	-	1 x 600 m ²	1x 240 m ²	-

All these instruments are operated by the groups who built them, with very limited access for external observers and no provision for open data access. Such a mode is appropriate for current instruments which detect a relatively limited number of sources, the analysis and interpretation which can be handled by the manpower and experience accumulated in these consortia. However, a different approach is called for CTA, with its expected ten-fold increase in the number of detectable objects.

1.2.2. State-of-the-art of e-infrastructure in astronomy and astroparticle physics

Astronomy faces an avalanche of data. Larger telescopes and faster detectors produce terabytes of raw data, images, spectra and catalogues which are processed by powerful computerized tools. These data sets cover the sky in different wavebands, from gamma- and X-rays to optical, infrared and radio. New specific tools supporting newly acquired data are regularly added to the palette of tools already available to best characterize and understand the Universe. In the near future, new survey telescopes imaging the entire sky every few days and Cherenkov telescopes imaging atmospheric particle showers on time scales of nanoseconds will yield data volumes measured in petabytes.

Astronomers begun very early to define the standards for data exchange: FITS was defined in 1979 for the exchange of radio and optical images on electronic media, and is currently the standard used in astronomy not only for data exchange, but also as the format of observatory archives. Along those lines, since the 1980's, high energy astronomy has developed standards and conventions to store data products for X-ray and soft gamma-ray space missions. If part of that effort started within the European Space Agency in the frame of the EXOSAT mission, it was then largely pushed by the High-Energy Astronomy Science and Archive Research Centre (HEASARC) at NASA Goddard Space Flight Centre. A number of conventions and software tools were developed to ensure proper archiving and interoperability of the data produced by all space-based high-energy observatories worldwide.

A scientific challenge is thus the integration and efficient extraction of knowledge from such increasingly large, heterogeneous and complex data sets. The solutions to many of these problems, applied to the astronomical domain, have been developed and mastered by the projects and initiatives (at the national, European and international levels), which fall under the generic label of Virtual Observatory (VOs).

The European Virtual Observatory (Euro-VO) initiative is an integrated and coordinated program designed to provide the European astronomical community with the tools, systems, research support and data interoperability standards and practices necessary to explore the digital, multi-wavelength universe picture stored in distributed astronomical and astrophysical data archives worldwide. The VOs initiative is coordinated by the International Virtual Observatory Alliance (IVOA), which promotes the definition and maintenance of the VOs standards. The incarnation of the standards into operational systems, and thus the practical implementation of the interoperability among the different data ranges, is left to the continental and national VOs projects and the data providers (e.g. the observatories). The Euro-VO is a very remarkable example of an operational, interoperable data and service grid, relying on generic infrastructure elements that depend upon (whenever needed) discipline-specific interoperability standards, with a discipline-wide, worldwide provider and user community. The crucial role played by the VOs concept in the exploitation of the scientific potentialities of the new generation of ground based and space borne experiments has been stressed by the main coordinating bodies of European research and has been indicated in the European roadmaps for the development of both astrophysics and astroparticles.

Data archive and standardization are typical issues in the management of astronomical data which may be efficiently addressed through a coherent and integrated application of existing European ICT-based infrastructures. CTA is in line with the European Space Agency strategy aiming to make effective the natural link among Science Archives, EGEE-Grid and VOs by proposing the common EGEE-middleware for the data management; the Grid porting users' software for data analysis and providing open access to important computing resources for the on-the-fly reprocessing from the Archives. The classical Science Data Centres devoted to high-level data archive and analysis is thus empowered by being a Work Node of the CTA EGEE-Virtual Organization and supported by the Virtual Grid data processing architecture guaranteed by the CTA-VO-Grid-Operation Centre (see Fig.2).

1.2.3. State-of-the-art of e-infrastructure applications in CTA

CTA is a future European research infrastructure exploiting the long-term presence and experience in EGEE of the particle physics community and the more recent and growing activities of the astronomical community to promote the definition and maintenance of the VOs data standards (IVOA).

A feasibility study of applications of Grid solutions for CTA is in progress within a dedicated CTA Computing Grid (CTACG) project. CTACG is aimed to optimize the application of Grid technology for CTA simulations, data processing and storage, offline analysis and the Virtual Observatory interface through a dedicated global CTA EGEE Virtual Organization. Positive experiences have already been collected through applications of Grid technologies for massive Monte Carlo simulations on distributed computing resources. The need to fulfil the requirements for the simulation studies of CTA has motivated the EGEE-Grid-approach and defined the mission of the CTACG project: to build and maintain a data storage and analysis infrastructure for the entire CTA consortium during the phases of the design study and then to the worldwide scientific community interested in the analysis of future CTA data.

The CTA EGEE-Virtual Organization (VO) was created in 2008 by the French LAPP-CTA group in cooperation with CNRS-IN2P3 French Computing Centre (CCIN2P3). Today the CTA VO is supported by 10 Work Nodes (computing centres), e.g. LAPP, CCIN2P3, CYFRONET, CAMK, PIC, MPG, CEA, CIEMAT, GRIF, and DESY from 4 countries (France, Germany, Poland and Spain); it is used by more than 30 members from more than 15 institutes and more than 7 countries. The CTA VO resources (currently more than 400 TB of storage and hundreds of CPU cores equivalent) are currently exploited intensively for massive Monte Carlo production and

simulated data analysis purposes. In the following table we summarize the active Work Nodes in 2008-2009 which have participated to the Monte Carlo mass production and analysis challenge.

The overall computing resources permanently provided by national institutes (and not exclusively in the GRID) for the CTA Design Study purposes in the years 2008-2009 correspond to an equivalent investment of the order of ~1MEur/year.

More recently some institutes are committing to investments dedicated to build up new computing centres to be included in EGEE, equivalent in size to a Tier-2 LCG centre and dedicated to astrophysics and which in future would support the CTA VO (e.g. CNRS-APC (France)) and even principally dedicated to build up a CTA Data Centre (e.g. ISDC (Switzerland)). The Liverpool University's newly commissioned North West Grid cluster and the Irish e-INIS computer centre are both going to support the CTA VO very soon. The Italian support is going to be provided through the INAF-OAT and INAF-OAC computing clusters and in particular by the COMETA consortium.

The CNRS-LAPP laboratory hosts a computing centre supporting Grid applications and services (e.g. it is an LCG-Tier 2 centre) that has, together with the professional capacity offered by the local IT division, enabled the rapid organization, management and support of the CTA VO. At LAPP it was possible to benefit from Grid middleware and software applications already at work for LCG and now extended to CTACG. For example, LAPP, through a constantly up-to-date version of the gLite middleware, provides and maintains central resources exploited by the CTA VO as Workload Management Service (WMS), Logging and Bookkeeping service (LB), User Interfaces (UI), Storage Element (SE), Computing Element (CE). Two more critical services for the CTA-VO administrations, namely the LCG File Catalogue (LFC) and the registration portal Virtual Organization Membership Service (VOMS) server are provided and supported by the CCIN2P3, the CNRS-Tier1 computing centre.

WORK NODE	INSTITUTE	COUNTRY	STORAGE ELEMENTS (TB)	COMPUTING ELEMENTS (CPU hrs/month)
CCIN2P3	CNRS	FRANCE	230	70000
LAPP	CNRS	FRANCE	15	30000
CYFRONET	AGH	POLAND	80	25000
CAMK	Polish Academy of Sciences	POLAND	10	5000
PIC	DEiU/CIEMAT / IFAE/UAB	SPAIN	8	12000
RZG	MPG & IPP	GERMANY	10	10000

Data standard in astronomy is one more issue that started to be considered and studied within the CTA consortium. The VOTable format is under investigation in CTA since it has the hierarchy and flexibility of XML and offers an efficient bridge to "Flexible Image Transport System" (FITS) files for users retrieving datasets from a dedicated Web interface. The VOTable approach allows the transmission of metadata only with links embedded to large data, and might allow connection to a CTACG-LFC catalogue data base when the user requires access to lower level of data for deeper analysis purposes. Preliminary tests of data base implementation of H.E.S.S. published data and applications of VOTables are in progress.

1.2.4. Advances beyond the state-of-the-art

The CTA facility will advance the state of the art in astronomy at the highest energies of the electromagnetic spectrum in a number of decisive areas, all of which are unprecedented in this field. In particular through the proposal of the CORE project the major areas where the gamma-ray world-wide community will achieve significant advances are

European and international integration

For the first time, CTA will combine the experience of all European groups working with atmospheric Cherenkov telescopes. Scientific partners from the United States and Japan claim interest to join the project, thus forming a basis for a world-wide collaboration.

Operation as an open observatory

CTA will – for the first time in this field – be operated as a true observatory, open to the entire astrophysics (and particle physics) community, and providing support for easy access and analysis of data. Data will be made publicly available and will be accessible through Virtual Observatory tools. Service to professional astronomers will be supplemented by outreach activities and laymen interfaces to the data.

Implementation of a Grid based e-infrastructure

A major advance will be the implementation of Grid based e-infrastructures for the purpose of CTA data handling and dissemination with

- Scalable and dynamic architecture which can be extended with additional services as required.
- Global secure access to computing resources, data, software and results.
- Facilitate creation of distributed data repositories, data mining, indexing and search.
- Data management capabilities.
- Metadata, annotation and replication.

Last but not least the Grid infrastructures offer a valuable “framework for collaboration” because all organizations can participate and contribute, with low cost access to resources and almost negligible extra costs for the national funding agencies, with the key added value of getting a powerful lever-arm for strengthening the world-wide gamma-ray community.

Implementation of a high performance network

Open data access to a world-wide community and an efficient data transmission among CTA institutes and different regional subsystems (namely the Northern and Southern CTA sites, the pan-European data processing centres and extra-Europe partners) will require high-speed network facilities. This is one major advance compared to current Cherenkov telescopes.

Combining Virtual Observatory and EGEE-Grid technology

Finally the combination of the VObs and of the EGEE-Grid technology, offering a complete and integrated working environment, is the path followed by CTA to foster the VHE gamma-ray astronomy research community. Such an approach is in line with the today common view on ICT-based infrastructure applications of the Astronomy and Astrophysics community.

1.3. Methodology to achieve the objectives of the project

The objectives of the CORE project will be achieved by fostering cooperation and understanding between the participants originating from the particle physics and astronomical communities. The project will contribute to the structuring and integration of the European Research Area and communities in particular at the frontier between particle physics and astronomy.

The vision supporting the activities is the one where the “CTA observatory research infrastructure” is based on three pillars: the Grid infrastructure layer (for the data management purposes), the Network infrastructure layer (for the data communication and dissemination), the VObs infrastructure (for the organization of open access and provision of high-level data and services to the world-wide astrophysics community). For the strengthening of these foundations

the CTA consortium will apply three major European e-infrastructures respectively EGEE, GÉANT and IVOA.

The project will provide an integrated set of services made of public data in common interoperable format and access methods, a scientific analysis software package for these data, a simulation framework necessary to calibrate the data, a data archive for high energy astronomy and support for the users.

1.3.1. Work Packages and provision of integrated services

The structuring effect in a scientific community of projects like CORE aimed to open data access and to provide computing resources for the scientific users has been demonstrated in a variety of cases in the past. It is thus expected that CORE will have a strong structuring impact on the extended community of astrophysics and astroparticle physics. To achieve this goal the CORE project is structured in Networking, Service and Joint Research activities to:

- guarantee a smooth cooperation of the CORE project and sub-projects with EU e-infrastructure projects, i.e. EGEE, GÉANT, and IVOA and with CTA;
- commit the broad expertise of the CORE consortium in the relevant fields in dedicated well focused work packages to offer services to the community.

Work packages have been defined in order to efficiently implement the CTA observatory research e-infrastructure. To clarify this strategy, it is useful to give here a brief overview of the logical relationships between the different WPs. These relationships will be reflected in the dependencies between individual deliverables.

The Networking Activity work packages:

- coordinate the project itself and the synergies with Institutions and International corresponding projects(WP NA1): e.g. EC, ESFRI, ASPERA, ASTRONET, EGEE (EGI and NGIs), GÉANT and IVOA;
- coordinate with the CTA consortium (WP NA2) to ensure a seamless incorporation of the CORE project deliverables into the CTA project;
- ensure of adopting common data format vocabulary homogeneous and coherent with similar standards applied by the astronomical community (WP NA3);
- ensure that the integrated services will become known in the community (WP NA4).

The Networking Activity work packages are the foundations of the project and provide a high level of steering for all integrated activities within the project itself.

The Service Activity work packages are in charge of the deployment and development of the integrated services infrastructures:

- Deployment and maintenance of Grid infrastructure (WP SA1) devoted to data processing and storage which provides the services and framework for integrating the activities of the other service work packages;
- Provide services devoted to all levels of data archiving (WP SA2);
- Develop and implement main software tools for data analysis to be then provided to open access (WP SA3);
- Combining the integrated services in a community gateway to provide access to resources, services and science on global scale (WP SA4).

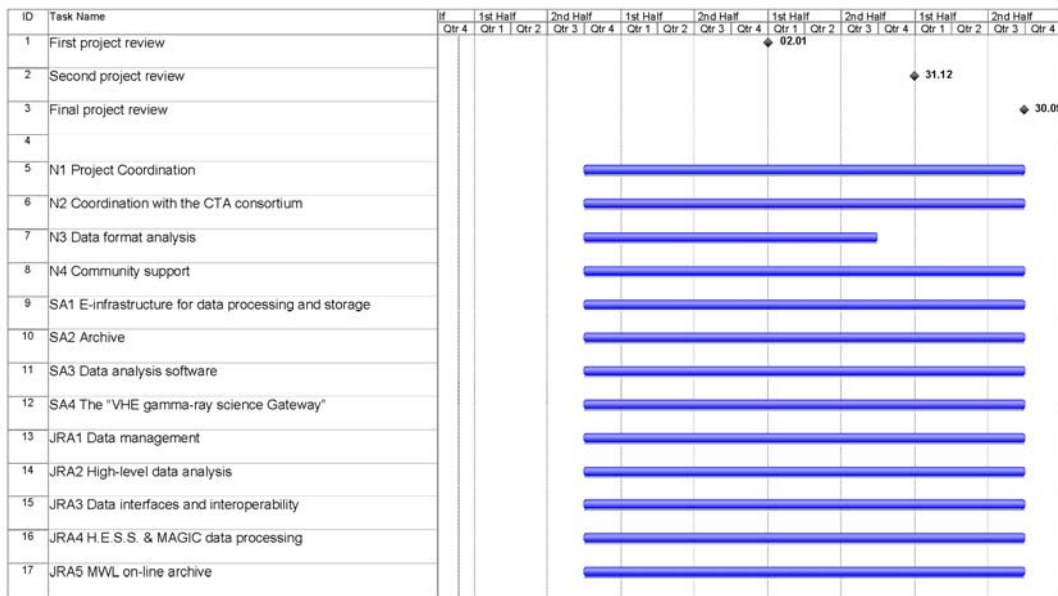
Finally some Joint Research activities are necessary to implement the integrated services and to make the best use of the data which will become available with CTA. The Joint Research work-packages are all oriented to enable multidisciplinary collaborations within the CORE project and address the community specific needs:

- WP JRA1 will focus on a study of the feasibility of e-infrastructures applications for the future CTA observatory;

- Development of a high-level CTA data analysis in the framework of the VObs will be performed in WP JRA2;
- Assessment of the required evolution of existing standards from data access and data archive will be performed in WP JRA3;
- WP JRA4 will validate the CTA e-infrastructure through its application to H.E.S.S. and MAGIC data;
- The bridge from the CORE services offered by the VHE gamma-ray community gateway to the multi-wavelength paradigm and the largest scientific community will be established in WP JRA5.

Work package No	Work package title	Type of activity	Lead partic no.	Lead partic. short name	Person - months	Start month	End month
NA1	Project Coordination	MGT	1	CNRS (LAPP)	44	1	36
NA2	Coordination with the CTA consortium	COORD	2	Erlangen	12	1	36
NA3	Data format analysis	COORD	1	CNRS (LUTH)	81	1	24
NA4	Community support	SVC	2	Erlangen	38	1	36
SA1	E-infrastructure for data processing and storage	SVC	1	CNRS (LAPP)	140	1	36
SA2	Archive	SVC	5	UNIGE	113	1	36
SA3	Data processing software	SVC	9	MPG	144	1	36
SA4	The “VHE gamma-ray science Gateway”	SVC	1	CNRS (LAPP)	44	1	36
JRA1	Data management	RTD	1	CNRS (LAPP)	59	1	36
JRA2	High-level data analysis	RTD	1	CNRS (CESR)	141	1	36
JRA3	Data interfaces and interoperability	RTD	8	INAF	86	1	36
JRA4	H.E.S.S. & MAGIC data processing	RTD	4	IFAE	161	1	36
JRA5	MWL on-line archive	RTD	8	INAF	56	1	36
	TOTAL				1109		

1.3.2. Gantt-Chart



1.3.3. Risk management

The activities within the scope of the CORE proposal generally represent low risk. A list of 'standard risks' common to software projects in a distributed scientific environment and thus to all work packages and activities in this proposal is given. In sections 1.4 to 1.6 we only highlight specific risks that go beyond the risks described below.

Title: Getting the right people to do the job.

Description: It is important to have the required experience and knowledge to undertake a project like CORE. Without them, project goals and schedules might be unrealistic from the onset. Over a project period of 3 years, it is possible to acquire a certain level of knowledge and experience.

But the bulk needs to be brought into from knowledge and experience gained in former projects.

Severity: Major

Likelihood: Low

Mitigation: Be in contact and collaborate with the people leading their respective field of expertise. Where not yet available, build up project internal knowledge and foster exchange of knowledge between project partners.

Title: Communication effort between project partners is underestimated.

Description: In a widely distributed project like CORE it is important to establish effective and efficient communication channels. Otherwise, project goals, milestones or individual deliverables may be compromised.

Severity: Significant

Likelihood: Low

Mitigation: Use teleconferences and other electronic media, to facilitate the exchange of information and ideas between the geographically distributed project participants. In addition, a solid travel budget allows the personal contact and exchange of ideas in dedicated project meetings.

Title: Deliveries (services) are late

Description: In projects like CORE, experience shows that it is almost inevitable that some deliveries will be delayed with respect to the initial plan.

Severity: Significant

Likelihood: High

Mitigation: As described in section 2.1 a management structure will be implemented that includes regular progress meetings and reports. In this way early detection of possible delays is possible.

Corrective actions can be triggered early enough in the process.

Title: Computing resources failures

Description: The minimal required availability of computing resources (SE and CE) is an essential factor for the achievement of the objectives of a project like CORE. Otherwise, work progress will be slowed down and some objectives would need to be revisited and delayed.

Severity: Significant

Likelihood: Low

Mitigation: The resources already provided by the national agencies (within the CTACG project) and those already scheduled to be provided in the next three years to the CTA projects are more commensurate to the activities, objectives and deliverables of the CORE project. Furthermore major Work Nodes (Tier-1) are able to provide with the extra-resources eventually missing.

Title: Project partner lose interest or focus

Description: Over a period of several years, the focus and priorities of research groups involved in the project may change. The project goals, the schedule or individual deliverables might be impacted by this

Severity: Significant

Likelihood: Minimum

Mitigation: Have project partners with solid interest in the advancement of the science related to CORE. Additionally, the consortium agreement will establish the procedures and the obligations of the partners. The document will identify the actions to be taken in case the most important milestones are not met and the influence this has on the cost to completion

I.4. Networking Activities and associated work plan

The networking activities of the CORE work plan ensure a coordinated design of the CTA observatory research e-infrastructure for an efficient and high performance data handling of CTA data based on a modern and innovative computing environment with a high acceptance in the astronomical community as a whole. These activities are essentials to guarantee a successful running of the different CORE sub-projects as part of the CTA computing and software activities and to develop a CTA data standard in terms of formats and description aiming for a wide acceptance within the astronomical community.

The CORE project comprises the handling of CTA data ranging from the various data sources, i.e. hardware components of the CTA instruments or auxiliary software components, via transport, storage and archiving of data to the final data access and analysis of scientific users based on standards widely used in the astronomical community. The CORE project will foster the cooperation and coordination with astrophysics and astroparticle physics for a global and sustainable approach for data handling in the field. The CORE project is embedded in the CTA computing and software project with a number of interfaces to other software development activities of the CTA computing and software group and to the software environment of the astronomical community.

There are four work packages which are Networking Activities. The task of the first work package, NA1, is to coordinate the CORE project to guarantee a smooth running of the different sub-projects organized in the different networking, service and joint research activities. NA1 will interface the CORE project with ASPERA, ESFRI, EGEE/EGI, GÉANT and IVOA.

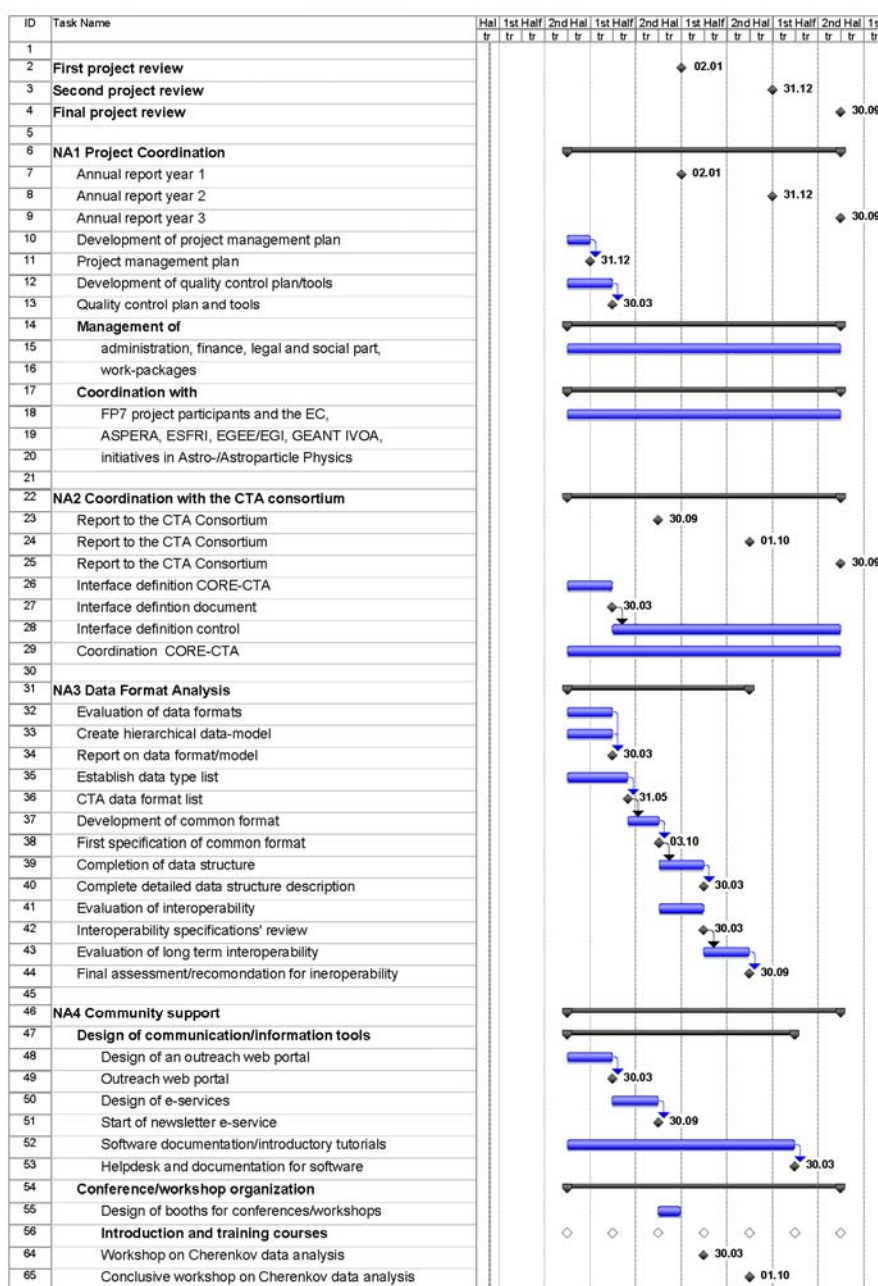
The second work package, NA2, is in charge of coordinating the activities of the CORE project with the other activities of the CTA computing and software group. An interface definition document together with regular common meetings of the people from the CORE project and other people from the CTA computing and software group guarantee a seamless incorporation

of the software and computing products of the CORE project into the overall CTA software and computing infrastructure.

The work package NA3 is aimed at defining the specifications of a common data format needed for the interoperable usage of CTA data together with other data from high energy astronomy data centres. The differences and commonalities of the data formats in different Cherenkov experiments together with standards in high energy astronomy will be investigated to result in an extended hierarchical data format.

The fourth work package, NA4, provides the necessary means to open the CTA data to the community of science users. Documentation, tutorials and introductory courses will be developed and workshops will be organized which will result in an educated access of scientific users to high-energy gamma-rays data, analysis and use of modern e-infrastructures developed and applied in the CORE project.

1.4.1. Gantt-Chart



1.4.2. Work Package List

Work package No	Work package title	Type of activity	Lead partic no.	Lead partic. short name	Person-months	Start month	End month
NA1	Project Coordination	MGT	1	CNRS	44	1	36
NA2	Coordination with the CTA consortium	COORD	2	Erlangen	12	1	36
NA3	Data format analysis	COORD	1	CNRS	81	1	24
NA4	Community support	SVC		Erlangen	38	1	36
	TOTAL				175		

1.4.3. List of Deliverables

Del. no.	Deliverable name	WP no.	Nature	Dissemination level	Delivery date (proj. month)
NA1.1	Project management plan	NA1	R	PP	3
NA1.2	Quality control plan and tools	NA1	R	PP	6
NA1.3	Annual report	NA1	R	PP	12,24,36
NA2.1	Interface definition document	NA2	R	PP	6
NA2.2	Report to the CTA Consortium	NA2	R	PP	12,24,36
NA3.1	Preliminary study of data format/model	NA3	R	PP	6
NA3.2	Comprehensive list of CTA data types	NA3	R	PP	8
NA3.3	First set of specifications for the common format	NA3	R	PP	12
NA3.4	Interoperability specifications' review; first complete detailed data structure description	NA3	R	PP	18
NA3.5	Final assessment and possible recommendations for long term interoperability	NA3	R	PP	24
NA4.1	Outreach web portal (to be included into the VSG)	NA4	O	PP	6
NA4.2	Semester e-infrastructure (Grid and VObs) introduction and training courses	NA4	O	PP	6
NA4.3	First communications at international conferences and/or workshop	NA4	O	PU	10
NA4.4	Newsletters e-service	NA4	O	PU	12
NA4.5	Booths to be used at conferences and workshop	NA4	O	PU	15
NA4.6	First workshop on Cherenkov data analysis	NA4	O	PU	18
NA4.7	Helpdesk and documentation for software distribution (accessible from the VSG)	NA4	O	PU	30
NA4.8	Conclusive workshop on Cherenkov data analysis	NA4	O	PU	32

1.4.4. Detailed work package description

Work package number	NA1	Start date or starting event:	1
Work package title	Project Coordination		
Activity type	MGT		
Participant number	1		
Participant short name	CNRS		
Person-months per participant	44		

Objectives

- Act as contact point
 - between the FP7 project participants and the European Commission;
 - for ASPERA, ESFRI, EGEE/EGI, GÉANT and IVOA;
 - for partners.
- Guarantee liaison and coordination with
 - ASPERA, ESFRI, EGEE/EGI, GÉANT and IVOA;
 - similar initiatives in international Astrophysics and Astroparticle Physics for a global and sustainable approach in the field;
 - Policy-making level institutions.
- Assuring access provision and pooling of distributed resources.
- Management of
 - the administrative, financial, legal and social part of the project;
 - the work-packages .
- Audit and steering of the work-packages
- Ensure fulfillment of all obligations, i.e.
 - progress monitoring and reporting;
 - providing configuration management, control quality assurance and procedures for documents and delivered e-products.

Description of work

A management structure is needed to guarantee a smooth inter-play between the different sub-projects of the different networking, service and joint research activities. This will be ensured by this work-package, which is responsible for

- general management of the project, according to the management structure defined in Section 2, monitoring and steering the project in close contact with the executive board, organizing meetings of the boards, reporting to the EC, accepting deliverables.
- providing project wide support for configuration management, quality standards and electronic services for accepting deliverables. This will be performed applying management and quality standards already in place at CNRS.
- providing information and feedback about e-infrastructures application in the project (and the development of associated services) to the corresponding reference projects and/or institutions, e.g. EGI, GÉANT, IVOA, in form of participation to dedicated forums.
- providing progress reports of the project and feedback on common experienced ICT and e-infrastructures issues within dedicated ESFRI forum (e.g. the one recently proposed jointly by EGEE and GÉANT)

and will be lead by CNRS-LAPP.

Deliverables

NA1.1 - (Month 3) Project Management Plan

NA1.2 - (Month 6) Quality control plan and tools

NA1.3 - (Every year) Annual report

Work package number	NA2	Start date or starting event:	1				
Work package title	Coordination with the CTA consortium						
Activity type	COORD						
Participant number	2	9					
Participant short name	Erlangen	MPG					
Person-months per participant	6	6					

Objectives

- Coordination of the computing and software developments of the CORE project with the developments of the CTA project not covered in this project, i.e.
 - documentation of the interfaces of the CORE projects and other CTA software and computing projects
 - control of the interface definitions during the development phase of the CORE project
 - establishing a regular exchange between the developers of the CORE and the CTA projects
- Establishing an expert interface for requests from and to the CORE project from and to CTA

Description of work

The CTA computing and software project is aimed at designing, developing and implementing the full computing infrastructure and software system to run CTA as an open observatory. The CORE project is an essential and well defined part of the software and computing efforts of CTA comprising the necessary e-infrastructure for data handling and open data access. The task of this work package is to coordinate the manifold interfaces of the CORE and CTA projects and is performed and led by Erlangen which coordinates all software developments of CTA.

In a first step the interfaces related to the data handling but also related to technical conventions for software developments for CTA will be documented to guarantee a seamless incorporation of the CORE developments into the CTA computing and software developments at a later stage.

Regular meetings of the people involved in the CORE project with people involved in the software developments of CTA will be organized.

Erlangen and MPG Munich will perform these tasks with 6 PM each distributed over 3 years.

Deliverables

- NA2.1 - (Month 6) Interface definition document
 NA2.2 - (Every year) Report to the CTA Consortium

Work package number	NA3	Start date or starting event:				1		
Work package title	Data Format Analysis							
Activity type	COORD							
Participant number	1	2	4	5	6	9	10	12
Participant short name	CNRS	Erlangen	IFAE	UNIGE	EKUT	MPG	CEA	ULEIC
Person-months per participant	31	6	15	6	6	3	4	10

Objectives

- Investigate common points and peculiarities of data formats adopted by different Cherenkov experiments and high-energy communities in order to create an extended hierarchical data-model.
- Establish an exhaustive list of data types needed for the processing of CTA data (event data, auxiliary data, calibration data).
- Document all data structures using the appropriate data definition language.
- Promote the implementation of interfaces (cross-references) between the archived VHE data and other high energy data centres.

Description of work

The processing of CTA data requires a large variety of information coming from different sources. The CTA telescopes will produce event, shower and housekeeping data, the environmental monitoring (and in particular the atmosphere monitoring) will provide auxiliary data, and calibration campaigns will provide calibration data that allow conversion of the measurements into physical units. Data formats need to be defined for all the various data types. This activity will lead to an extended and comprehensive data-model, which will include all the features needed for the subsequent developments.

We will compare the data structure used in different experiments, for all level of data, and develop a common "vocabulary" to be used in the implementation of the tools and interfaces for CTA, also with other HE experiments in mind:

- Define names and meaning of features for data description
- Standardization of such metadata format for interoperability.

This work requires an in-depth knowledge of the different experimental and observational techniques and of the capabilities of the instruments currently in use, therefore CNRS-LUTH with 3 PMs, Erlangen with 2 PMs and IFAE with 2 PMs.

A number of conventions are already used by astronomers (from radio to soft gamma-rays) to describe data, thus the starting point will be the development already made by the astrophysics community to build the Virtual Observatory. This set of assumptions will have to be reviewed and extended to include the concepts adopted in the astroparticle physics. This will be done by CNRS-LUTH, CNRS-CESR, IFAE, UNIGE and EKUT with 6 PMs, 3 PMs, 5 PMs, 6 PMs and 6 PMs respectively.

This activity will lead to an extended and comprehensive data-model, which will include all the features needed for the subsequent developments.

NA3 will work in close collaboration with SA3 and at interface with JRA3, which

assesses the required evolutions of interoperability standards and perform the technical work necessary for their adaptation.

After the first test round, the work will have to be reviewed and fine tuned. The evaluation of the data model and adjustments will be performed by CNRS-LUTH (19 PMs), Erlangen (4 PMs), IFAE (8 PMs), MPG (3 PMs), CEA (4 PMs) and ULEIC (10PMs).

Deliverables

NA3.1 - (Month 6): Preliminary study of data format/model

NA3.2 - (Month 8): Provide comprehensive list of CTA data types

NA3.3 - (Month 12): First set of specifications for the common format

NA3.4 - (Month 18): Interoperability specifications' review; first complete detailed data structure description

NA3.5 - (Month 24): Final assessment and possible recommendations for long term interoperability

Work package number	NA4	Start date or starting event:	1			
Work package title	Community support					
Activity type	SVC					
Participant number	1	2	6			
Participant short name	CNRS	Erlangen	EKUT			
Person-months per participant	11	24	3			

Objectives

- Coordinate outreach actions for the support of project and the community involved.
- Organize e-tools (web portal and newsletters) to provide communication and information services to the project partners and the corresponding scientific community.
- Organize software documentation and introductory tutorials.
- Coordinate participation and communication of the achievements of the projects at international conferences and workshop.

Description of work

An outreach dedicated web portal (integrated in the VSG) shall be created and maintained to give up-to-date information on the project, its progress and the achieved milestones. The site update and technical maintenance will need continuous availability of the developer at a relatively low level of activity throughout the project. The passive information provided on the VSG will be complemented by newsletters e-services. Erlangen (6 PMs) will led this task.

Periodical introductory training sessions to the EGEE-Grid framework and the VObs tools and analysis approach will be organized. Such training is oriented to the projects partners less familiar with the applied e-infrastructures and then to the larger community of users getting access to the products and services delivered by the project itself during its evolution. User-training and introductory courses will be organized by the CTA-VO Grid Operation Center (in collaboration with other operators from the main CTA Work Nodes). More general training and support are also envisaged to be achieved through EGEE, IVOA and the dedicated EGEE-SSC-A&A. This task will be performed by CNRS-LAPP (5 PMs) and CNRS-LUTH (3 PMs).

Service and support will be provided by a help desk system to answer questions concerning the installation and the usage of the CTA software. A list of answers to frequently asked questions (FAQs) shall complement the user support activities. The design of the helpdesk will be done by EKUT (3 PMs) together with Erlangen (3 PMs).

The organization of workshops with courses on the specificity and usage of single Cherenkov telescopes and of telescope arrays will offer an opportunity for young scientists to enter this relatively new field of research. The data analysis workshops by experienced scientists in the field will be followed by hands-on practical sessions with real data. (CNRS-CESR 3 PMs and Erlangen 6 PMs).

The progress and achievements of the project shall be presented in specific conferences and reported in their proceedings. We think in particular of the big conference held every year on Astronomical Data Analysis Software and Systems, where the progresses on data handling and analysis software are presented by the main data centers worldwide. It is also foreseen to approach the scientific community

by presenting CTA services at various conferences on high-energy astronomy. In addition to presenting posters, we will have interactive booths with a demonstration running on a computer and an equipped end-user analysis station, allowing more exchange of information between the presenter and the scientific community. The organization will be done by Erlangen (9 PMs).

Deliverables

NA4.1 - (Month 6) Outreach web portal (to be included into the VSG)

NA4.2 - (Every 6th month) Semester e-infrastructure (Grid and VObs) introduction and training courses

NA4.3 - (Month 10) First communications at international conferences and/or workshop

NA4.4 - (Month 12) Newsletters e-service

NA4.5 - (Month 15) Booths to be used at conferences and workshop

NA4.6 - (Month 18) First workshop on Cherenkov data analysis

NA4.6 - (Month 30) Helpdesk and documentation for software distribution (accessible from the VSG)

NA4.7 - (Month 32) Conclusive workshop on Cherenkov data analysis

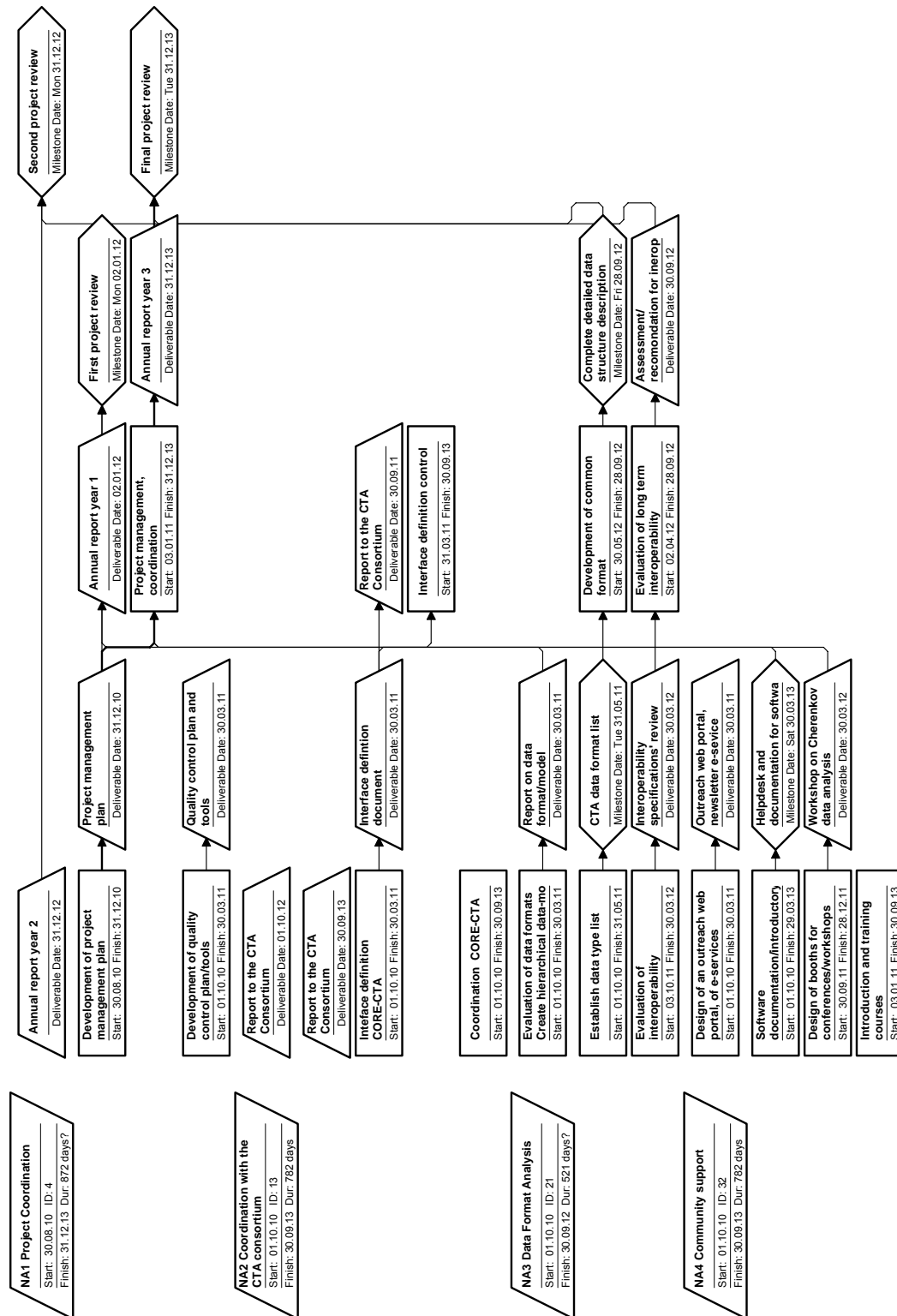
I.4.5. Summary of effort

Partic. no.	Partic. short name	WP NA1	WP NA2	WP NA3	WP NA4	Total person months
1	CNRS	44		31	11	68
2	Erlangen		6	6	24	36
4	IFAE			15		15
5	UNIGE			6		6
6	EKUT			6	3	9
9	MPG		6	3		9
10	CEA			4		4
12	ULEIC			10		10
Total		44	12	81	38	175

I.4.6. Milestones

Milestone number	Milestone name	Work package(s) involved	Expected date	Means of verification
1	List of CTA data types	NA1	8	Annual report 1
2	First project review	NA1, NA2, NA3, NA4	12	Annual report 1
3	Data structure definition	NA1	18	Annual report 2
4	Second project review	NA1, NA2, NA3, NA4	24	Annual report 2
5	Helpdesk	NA4	30	Annual report 3
3	Final project review	NA1, NA2, NA3, NA4	36	Annual report 3

I.4.7. PERT DIAGRAM



1.4.8. Risk and contingency

Title: Scientific Community awareness and outreach.

Description: The awareness in the scientific community will depend on the quality of outreach services offered and amount of information activities provided by CORE.

Severity: Significant

Likelihood: Minimal

Mitigation: Provide a newsletter to a wider scientific audience. Implement the web-outreach portal into the VSG will allow getting both the awareness and the involvement of the scientific community in the use of services and tools provided by the CORE project.

Title: E-infrastructures community awareness and acceptance is not appropriate.

Description: The awareness in the e-infrastructure community (e.g. EGEE) will depend on the amount of information activities provided by CORE.

Severity: Significant

Likelihood: Minimal

Mitigation: Provide a solid budget for travelling to participate to conferences, workshops etc. This will greatly contribute to disseminate the information about CORE. Furthermore the EGEE/EGI & GÉANT initiatives to involve the ESFRI projects in a public as well as dedicated forum to guarantee the awareness and the follow up of initiatives like CORE are already in place (e.g. CTA invited communication to the last EGEE09 conference held in Barcelona).

Title: Tutorial and introductory courses.

Description: The efficiency in integrating the complementary competences of CORE partners as well as of new partners and users willing to join the project strongly depend on the quality of tutorial tool and training actions.

Severity: Significant

Likelihood: Minimal

Mitigation: Modules and content of general training sessions to the introduction to use the e-infrastructures in place (EGEE, VObs), and already at work, in the CTA consortium are the same as those already organized and applied since several years by the corresponding European projects, e.g. EGEE and IVOA. Within CTACG, tutorial communications and documentations are prepared, updated and provided to the consortium through a dedicated web portal. The efficiency of such actions is proved by the constant increase of certified users joining the CTA VO and scientists involved in data format development within the VObs framework.

I.5. Service Activities and associated work plan

The service activities of the CORE work plan are aimed at establishing the design of the CTA archive, its data transfer and access methods, proving the framework for the analysis of CTA data, and verifying the operation of the resulting system with limited datasets from the existing Cherenkov observatories: H.E.S.S. and MAGIC. These activities are an essential pre-cursor to the implementation of the full CTA archive system necessary to allow its full scientific exploitation by the widest possible community of scientists.

The CTA archive will be implemented on the EGEE Grid infrastructure. EGEE is Europe's leading grid computing project, providing a computing support infrastructure for over 10,000 researchers world-wide. It is an essential component of the CTA system due to the crucial role that massive Monte-Carlo simulations play in the correct interpretation of gamma-ray air shower data. In addition, the operational CTA system will be reliant upon the GÉANT network infrastructure to provide the high capacity data lines from the observatory sites to the CTA archive in Europe. With its unrivalled geographical coverage, high transmission speeds, innovative networking technology and a range of user-focused services, GÉANT remains the most advanced international network in the world.

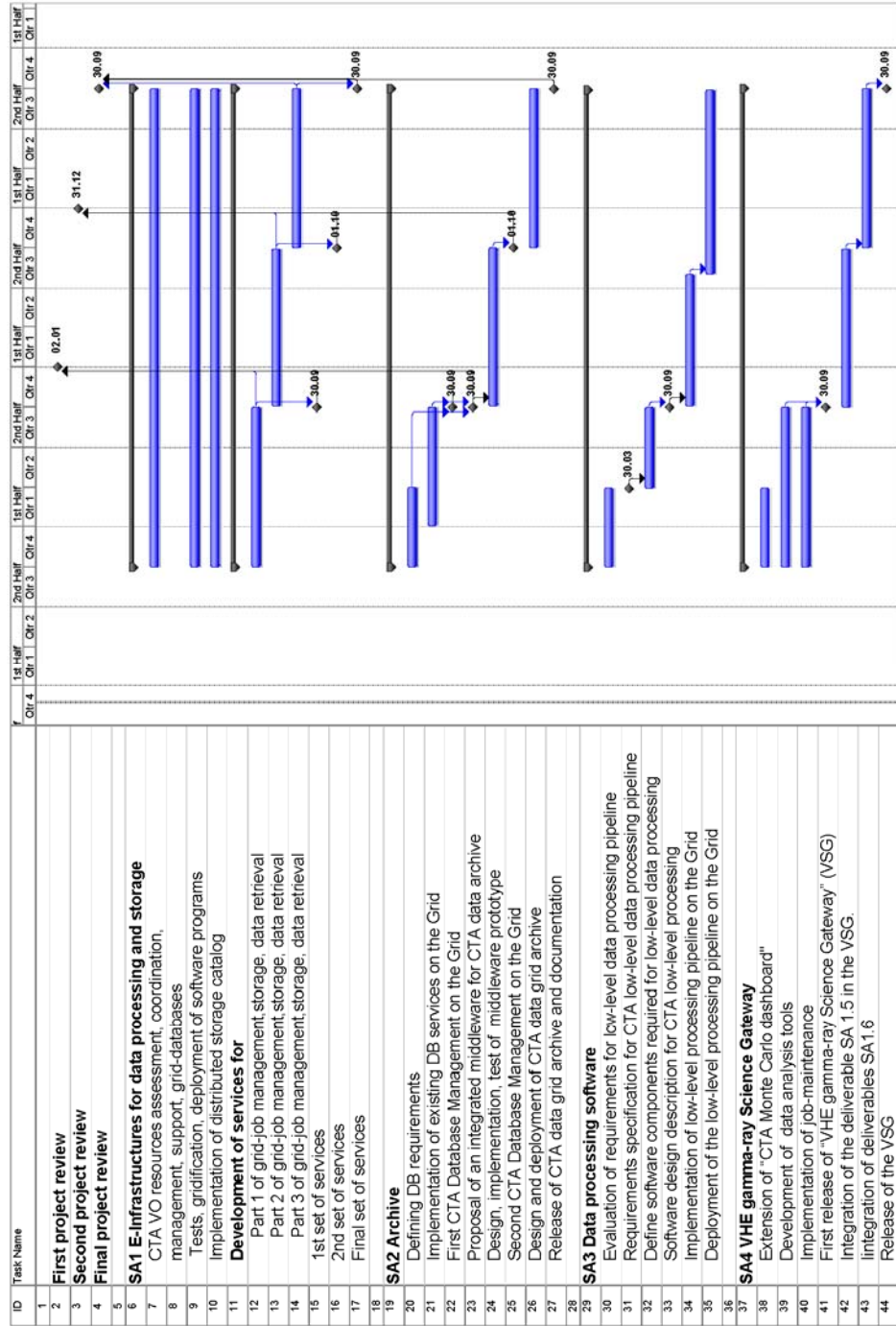
There are 4 work packages which are Service Activities. The first of these, SA1, will ensure that the EGEE Grid Infrastructure meets the requirements for the archiving and analysis of existing VHE gamma ray data and the future CTA data. The establishment, maintenance and support of an EGEE Virtual Organization for CTA and the deployment of grid resources are key elements of this activity.

The second work package, SA2, provides the design of the archives of all metadata and data required for H.E.S.S., MAGIC and CTA. Data from all observatories will be provided to the community at multiple levels of scientific processing from relatively raw data for expert users to science-ready products for the wider community. The archive database tables and their links have to provide for efficient operation of the archive system.

SA3 is the work package which develops the analysis software framework, both to run in the grid environment, and also downloadable to run on a users' machine. Also to be produced within SA3 are the tools required to process the H.E.S.S. and MAGIC data through to the science-ready level; these tools will serve as prototypes also for the processing of simulated CTA data.

The Service Activities are completed by SA4, The Very High Energy Gateway. This will be the single access point for all science users of CTA, and will allow not only access to the standard data products at all levels of processing, but also a command interface to enable new processing to be performed under user control. Naturally, user support documents produced in NA4 (Community Support) will be available via the VHE gamma ray gateway.

1.5.1. Gantt-Chart



1.5.2. Work Package List

Work package No	Work package title	Type of activity	Lead partic no.	Lead partic. short name	Person-months	Start month	End month
SA1	E-infrastructure for data processing and storage	SVC	1	CNRS	140	1	36
SA2	Archive	SVC	5	UNIGE	113	1	36
SA3	Data processing software	SVC	9	MPG	134	1	36
SA4	The “VHE gamma-ray science Gateway”	SVC	1	CNRS	44	1	36
	TOTAL				431		

1.5.3. List of Deliverables

Del. no.	Deliverable name	WP no.	Nature	Dissemination level	Delivery date (proj. month)
SA1.1	Release first set of services	SA1	O	PU	12
SA1.2	Release first mid-term set of services	SA1	O	PU	24
SA1.3	Release final and complete set of services	SA1	O	PU	36
SA2.1	First “CTA Database Management on the GRID” report	SA2	R	PP	12
SA2.2	Second “CTA Database Management on the GRID” report	SA2	R	PP	24
SA2.3	Release System “CTA Data Grid Archive”	SA2	P	PU	36
SA2.4	Final report on “CTA Data Grid Archive”	SA2	R	PU	36
SA3.1	Requirements Specification for the CTA low-level data processing pipeline	SA3	R	PP	6
SA3.2	Software Design Description for CTA low-level processing	SA3	R	PP	12
SA3.3	Deployment of low-level processing pipeline on the Grid	SA3	O	PP	24
SA3.4	Final deployment of low-level processing pipeline on the Grid	SA3	O	PU	36
SA4.1	Extension of CTA Monte Carlo dashboard	SA4	O	PP	6
SA4.2	First release of the VSG	SA4	O	PP	12
SA4.3	Integration of SA1.5 in VSG	SA4	O	PP	24
SA4.4	Release VSG	SA4	O	PU	36

1.5.4. Detailed work package description

Work package number	SA1	Start date or starting event:			1	
Work package title	E-Infrastructures for data processing and storage					
Activity type	SVC					
Participant number	1	3	4	7	8	13
Participant short name	CNRS	DESY	IFAE	CAMK	INAF	DIAS
Person-months per participant	30	24	6	26	30	24

Objectives

- Support, operation and management of the CTA EGEE-Virtual Organization (vo.cta.in2p3.fr) Grid infrastructure and associated services for Monte Carlo simulation and data analysis purposes.
- Design, implementation and tests of the configuration of the CTA-VO computing infrastructures and services for the needs of the data processing and storage of the future CTA observatory.

Description of work

The archiving, access and management of the future CTA data through existing European ICT-based infrastructures has to be done in a coherent way. Therefore the CTA archive will be implemented on the EGEE Grid infrastructure, providing open access to important computing resources for the on-the-fly reprocessing from the archives.

- This main task will be guaranteed by the CNRS-LAPP (6 PM) laboratory where the CTA-VO Grid Operation centre is based; the software development and implementations for the data processing purpose as well as the gridification of major components of the CTA software will be a task shared among different partners. (DESY 6 PM, CAMK 5 PM, INAF 6 PM and DIAS 5 PM).
- A second major task is to re-organize the overall structure of the CTA Virtual Organization for the different functionalities, i.e. data processing and archiving purposes, software development and tests, user data analysis and the coexistence of MC data and MC processing options for scientific calibration purposes and the re-organization of the work nodes (and the corresponding resources in support of the VO) (CNRS 4 PM, DESY 5 PM, IFAE 3 PM, CAMK 6 PM, INAF 6 PM and DIAS 6 PM).
- Investigation, tests and (in certain cases) development and/or fine tuning of EGEE-oriented services for data archiving, secure (encrypted) data management, metadata management. (CNRS 4 PM, INAF 5 PM, DESY 4 PM, CAMK 5 PM and DIAS 4 PM).

Other important set of services to be provided are:

- The simplification of the user interface, e.g. simplify authorization/authentication (e.g. obtain X509 certificates, etc.); easy access to common codes; relevant tutorials and documentation; expertise in grid-enabling applications; online helpdesk; (CNRS 6 PM, IFAE 3 PM and INAF 3 PM).
- Data analysis services: availability of computing resources for data processing and

storage; open source software for data analysis; easy access to data and metadata archived in the catalogue; access to all data levels from raw data to level-4 data; (CNRS 5 PM, INAF 4 PM, DESY 9 PM, CAMK 10 PM, DIAS 9 PM).

- Maximum coherence with EGEE (EGI): Interface with the “RESPECT program” (Recommended External Software for EGEE CommuniTies) concerning, in particular, job definition and management and management of grid-databases interacting with heterogeneous RDBMS; grid enabled access interface to wide spread data sources; synergies with the SSC for mutual exchanges and a cross-fertilization of knowledge and tools between user communities. (CNRS 5 PM, INAF 6 PM).

Deliverables

SA1.1 - (from Month 0 to 36) CTA VO resources assessment, coordination, management, and support via the LAPP CTA VO Grid Operation Centre: including tests, gridification and deployment of software programs, implementation of distributed storage catalogue and grid-databases.

SA 1.2 - (Month 12) Release of *first* set of services for data-analysis, grid-job management, storage and data retrieving open to the user community.

SA 1.5 - (Month 24) Release of *mid-term* set of services for data-analysis, grid-job management, storage and data retrieving open to the user community.

SA 1.6 - (Month 36) Release of *final and complete* set of services for data-analysis, grid-job management, storage and data retrieving open to the user community.

Work package number	SA2	Start date or starting event:				1	
Work package title	Archive						
Activity type	SVC						
Participant number	1	4	5	8	9	12	13
Participant short name	CNRS	IFAE	UNIGE	INAF	MPG	ULEIC	DIAS
Person-months per participant	44	6	14	8	3	14	24

Objectives

Design and implementation of the Grid-CTA archive system for all levels data.

Description of work

One major task consists in designing a CTA Grid relational catalog integrating heterogeneous data and all levels of scientific data. Such a task will be conducted in interface with the EGEE community, the Earth-Science and Astrophysics SSC as well as in particular those communities already involved in projects concerning the development of database management in Grid (e.g. the GRelC middleware included in RESPECT). The CTA EGEE-VO has already established a series of contacts with such communities and a first survey on Data-Base solutions for CTA is already in progress. The major steps to be envisaged are :

- Defining the database requirements for the CTA (all-level and all kind) data.
- Defining the user (all-level) requirements.
- Upgrading the simple Grid LCG-based data-base already applied in the CTA MC dashboard through the implementation of existing "Databases management services on the Grid" into the CTA VO.
- Designing the CTA intermediate (Level 2a and Level 2b) and high-level (Level 3 and Level 4) data archive (including coherence with the high-level VObs CTA data format and VObs astronomical conventions).
- Continuous fine-tuning of the implementations of the archive model and Grid services adopted by series of periodical tests and through users' direct experience feedback.

The work will be shared among partners based on their experiences: UNIGE bring its expertise in astronomical data management and community services. CNRS, IF AE, INAF and DIAS already have experience in deploying grid services and archive. INAF with CNRS will bring their experience and contact to the VObs. MPG and ULEIC will bring their expertise in respectively low-level and high-level archive issues

Deliverables

SA2.1 - (Month 12) Release of the first "CTA Database Management on the GRID" report on database requirements and existing services for database management on the grid; proposal on a possible integrated middleware for CTA-data archive.

SA2.2 - (Month 24) Release of the second "CTA Database Management on the GRID" report based on the first middleware prototype of integrated CTA archive in Grid; operation, maintenance, access and tests results of its implementation in the CTA VO Grid Operation Center.

SA2.3 - (Month 36) Release of the system CTA DATA GRID ARCHIVE.

SA2.4 - (Month 36) Release of the final "CTA DATA GRID ARCHIVE" documentation and final corresponding report.

Work package number	SA3		Start date or starting event:				1	
Work package title	Data processing software							
Activity type	SVC							
Participant number	1	2	5	6	7	9	10	11
Participant short name	CNRS	Erlangen	UNIGE	EKUT	CAMK	MPG	CEA	UCM
Person-months per participant	27	18	13	3	20	9	20	24

Objectives

The main objective of this work package consists in the development of a gridified low-level data processing pipeline for CTA that is fully integrated in the CTA-VO infrastructure and that allows near real time processing of CTA raw data (Level 0) to calibrated high-level data ready for science analysis (Level 2b).

Description of work

The processing of data from Level 0 (telescope raw data) to Level 2b (photon lists ready for science analysis) is a major computational challenge that has to reduce a typical volume of 10 TBytes per observation into a few MBytes of high-level data within a couple of hours. This low-level data processing will make heavily use of Grid technology by spanning hundreds of processes within a global processing pipeline of which the output has to be gathered and combined in a coherent way into the final high-level data products. Low-level data processing will be split into per-telescope processing tasks (Level 0 to Level 1) and into multi-telescope shower reconstruction tasks (Level 1 to Level 2b) that take into account the observatory configuration, instrument transfer functions, and the observatory environment (in particular the atmospheric conditions).

The purpose of this work package is to design the low-level processing pipeline and to demonstrate its deployment within the Grid infrastructure. A gridified low-level processing pipeline will be developed that makes use of dummy processing tasks to emulate CTA data processing. The processing pipeline will be benchmarked and optimized to fit the project requirements. Pipeline development will be done in close interaction with SA1, making use of the CTA-VO computing infrastructures and services.

The corresponding work package contains the following tasks:

- Evaluate the requirements of the low-level processing pipeline in the framework of the Grid infrastructure.
- Define the software components required for low-level data processing and their relationships in view of a Grid deployment.
- Design gridified low-level processing pipeline and dummy processing components.
- Implement the low-level processing pipeline and dummy components.
- Test and optimize the low-level processing pipeline.

The work will be shared among partners based on their experiences: MPG coordinates the input of the various groups and is responsible for ensuring the quality of the tests and optimization of the pipeline. CNRS, UCM, CEA, EKUT and Erlangen bring their

expertise in the systematic analysis of VHE data (H.E.S.S. and MAGIC). CNRS, UCM and CAMK will add experience on Grid computing development. UNIGE adds the experience in astronomical data management

Deliverables

SA3.1 – (Month 6) Release of the “Requirements Specification for the CTA low-level data processing pipeline” report

SA3.2 – (Month 12) Release of the “Software Design Description for CTA low-level processing” report

SA3.3 – (Month 24) Implementation and initial deployment of the low-level processing pipeline on the Grid

SA3.4 – (Month 36) Final deployment of the low-level processing pipeline on the Grid

Work package number	SA4	Start date or starting event:				1	
Work package title	VHE gamma-ray Science Gateway						
Activity type	SVC						
Participant number	1	5	6	8	9		
Participant short name	CNRS	UNIGE	EKUT	INAF	MPG		
Person-months per participant	12	20	3	6	3		

Objectives

- Design and implementation of the web-based open access to Grid infrastructures and data repository through an integrated user oriented “VHE gamma-ray Science Gateway” - VSG.
- Development of tools for high-level data access and processing including: high-level analysis software, VObs interfaces, etc..

Description of work

Development and deployment of user-configured web services and tools clearly conceived for the users' expectations fostering the awareness of the Grid computing framework. A CTA Monte Carlo “dashboard” is already under development within the CTACG sub-project. It implements applications oriented to all different levels of user requirements, e.g. interactive scripts for multi-job submissions and monitoring; browser of files within the CTA LFC catalog and in the corresponding data-base for generated atmospheric showers and the simulated telescope arrays' performance. The upgrading of the CTA dashboard towards the conception of a community gateway will bring to the design and implementation of the “VHE gamma-ray Science Gateway” (VSG).

The VSG will integrate the following main services and for each of them the corresponding interfaces will be tuned on both expert and non-expert users to foster the wider scientific community as possible:

- Services to access Grid infrastructures for Monte Carlo and data analysis.
- Services to access data storage in the Grid and archive.
- Services to access high-level archive data in the VObs...
- Services to access and download portable CTA software

The work will be shared among partners based on their experiences: CNRS will continue to coordinate the Gateway development and together with INAF will bring the strong expertise in Grid services and related developments. UNIGE will coordinate the development and implementation of all hi-level astronomical tools based on their experience in managing Space Data Centers. EKUT and MPG will bring their contributions on the design of the VSG for the data analysis requirements.

Deliverables

SA4.1 - (Month 6) Extension of the existing “CTA Monte Carlo dashboard” to the “VHE gamma-ray Science Gateway” functionalities: simulation on demand with generic proxy, CTA consortium open-access to archived simulations files and to simulated scientific data for physics case studies.

SA4.2 – (Month 12) First release of “VHE gamma-ray Science Gateway” (VSG) including tools for data analysis within the Grid, job-submission, job monitoring and outputs retrieving.

SA4.3 - (Month 24) Integration of the deliverable SA 1.5 in the VSG.

SA4.4 – (Month 36) Release of the VSG with the full integration of deliverables SA1.6

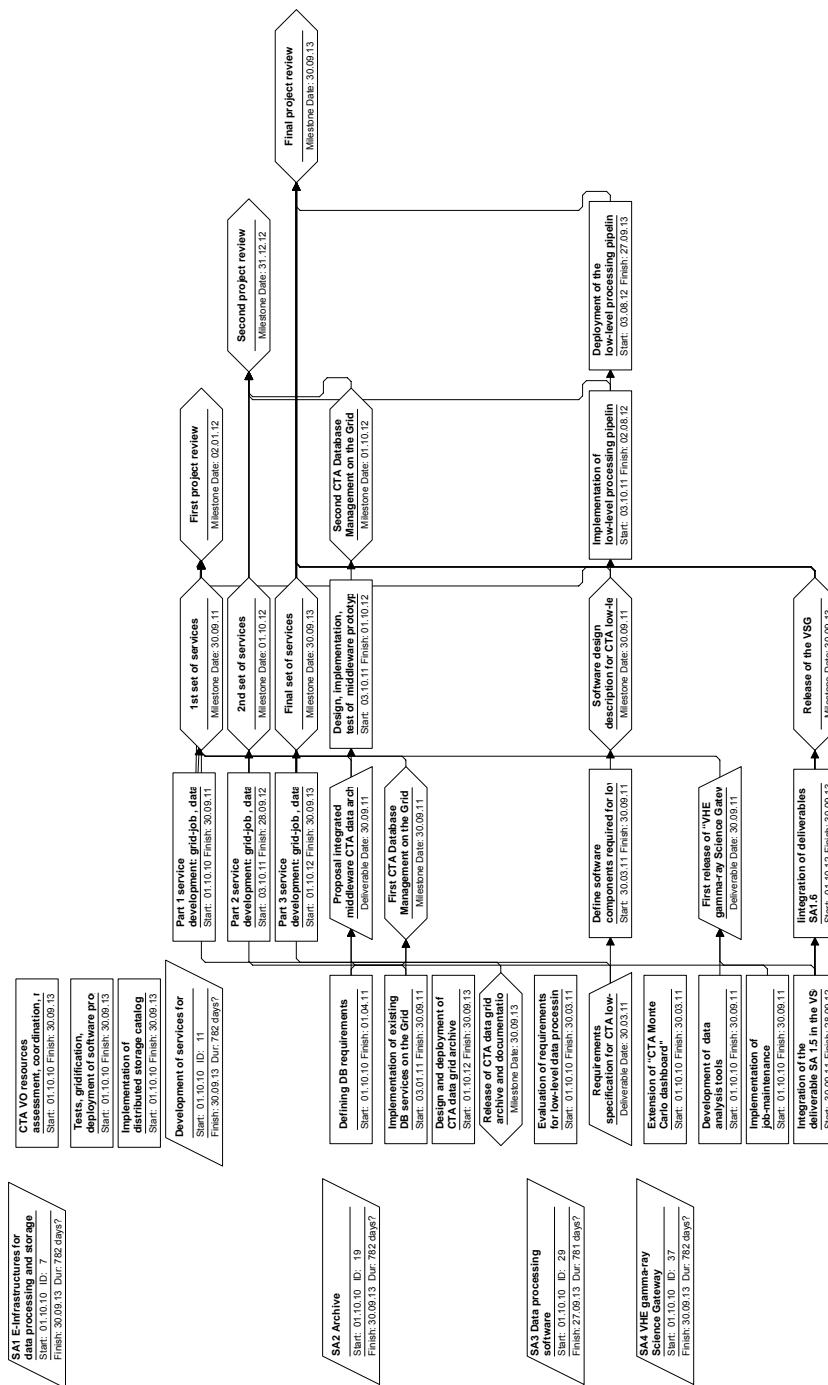
I.5.5. Summary of effort

Partic. no.	Partic. short name	SA1	SA2	SA3	SA4	Total person months
1	CNRS	30	44	27	12	113
2	Erlangen			18		18
3	DESY	24				24
4	IFAE	6	6			12
5	UNIGE		14	13	20	47
6	EKUT			3	3	6
7	CAMK	26		20		46
8	INAF	30	8		6	44
9	MPG		3	9	3	15
10	CEA			20		20
11	UCM			24		24
12	ULEIC		14			14
13	DIAS	24	24			48
Total		140	113	134	44	431

I.5.6. Milestones

Milestone number	Milestone name	Work package(s) involved	Expected date	Means of verification
1	Release first set of services	SA1	12	
2	Release mid-term set of services	SA1	24	R
3	Release final set of services	SA1	36	R
4	1st report on CTA Database Managment on the Grid	SA2	12	R
5	2 nd report on CTA Database Managment on the Grid	SA2	24	R
6	Release of CTA Data grid archive	SA3	36	R
7	Design Description for CTA low-level processing	SA3	12	R
8	Release of the VSG	SA4	36	R

1.5.7. Pert diagram



1.5.8. Risk and Contingency

Title: Low-level software development not finalised.

Description: Low-level software developed on a dummy model is not conform to the actual computing infrastructures and/or real complexity of the CTA research infrastructures. Such a risk could imply that the objective of the task is achieved but the deliverables is not fully applicable by the end of the CORE project.

Severity: Marginal

Likelihood: Low

Mitigation: This risk is definitely mitigate by a series of concurrent actions and considerations as follow: the development and delivery of a detailed computing model (delivered in JRA1) by the end of the CORE project to which the software is adapted; the construction of telescope prototypes for the fine tuning of the operation mode of CTA during the life cycle of the CORE project as well as the possibility to use H.E.S.S. and MAGIC as test benches, will allow to test and validate the dummy model of the developed software.

I.6. Joint Research Activities and associated work plan

The joint research activities of the CORE work plan comprise the development of the CTA computing model, the achievement of a CTA-GÉANT network cooperation agreement, the processing of data from existing VHE gamma ray instruments and simulated data from CTA, the definition of a set of standards for VHE gamma ray data consistent with astronomical practice and the implementation of software to convert current VHE gamma ray data to the standards-compliant form. Finally, a multi-wavelength archive will be established which will facilitate the scientific joint analysis of VHE gamma ray data and relevant data from lower photon energies.

These activities are essential to achieve the innovative solutions necessary to enable efficient and highly functional data collection, management and data curing. The new end-to-end services provided by our joint research activities, in combination with the service and network activities, will provide a major new facility for the large community of European astronomers, astroparticle physicists, and particle physicists, paving the way for the fullest possible scientific exploitation of the CTA, as well as perhaps providing a mechanism by which the data from the current VHE gamma-ray instruments might be eventually be made available to the community. This expansion of the potential user community for VHE gamma ray data, by the new combination of the EGEE Grid, the GÉANT network, and the Virtual Observatory, will place European scientists in a world-leading position in this field.

JRA1, Data Management, will ensure that data from the CTA will flow efficiently and without delay to the archive by the creation of an agreement with the GÉANT network organisation; CTA will likely be placed in remote locations (to achieve the necessary altitude and low levels of light pollution) with currently poor network infrastructure, GÉANT are the ideal organisation to provide the network infrastructure. Additionally this work package will develop the CTA computing model, this enables the processing software to run on the grid infrastructure, either as routine processing or in response to user requests.

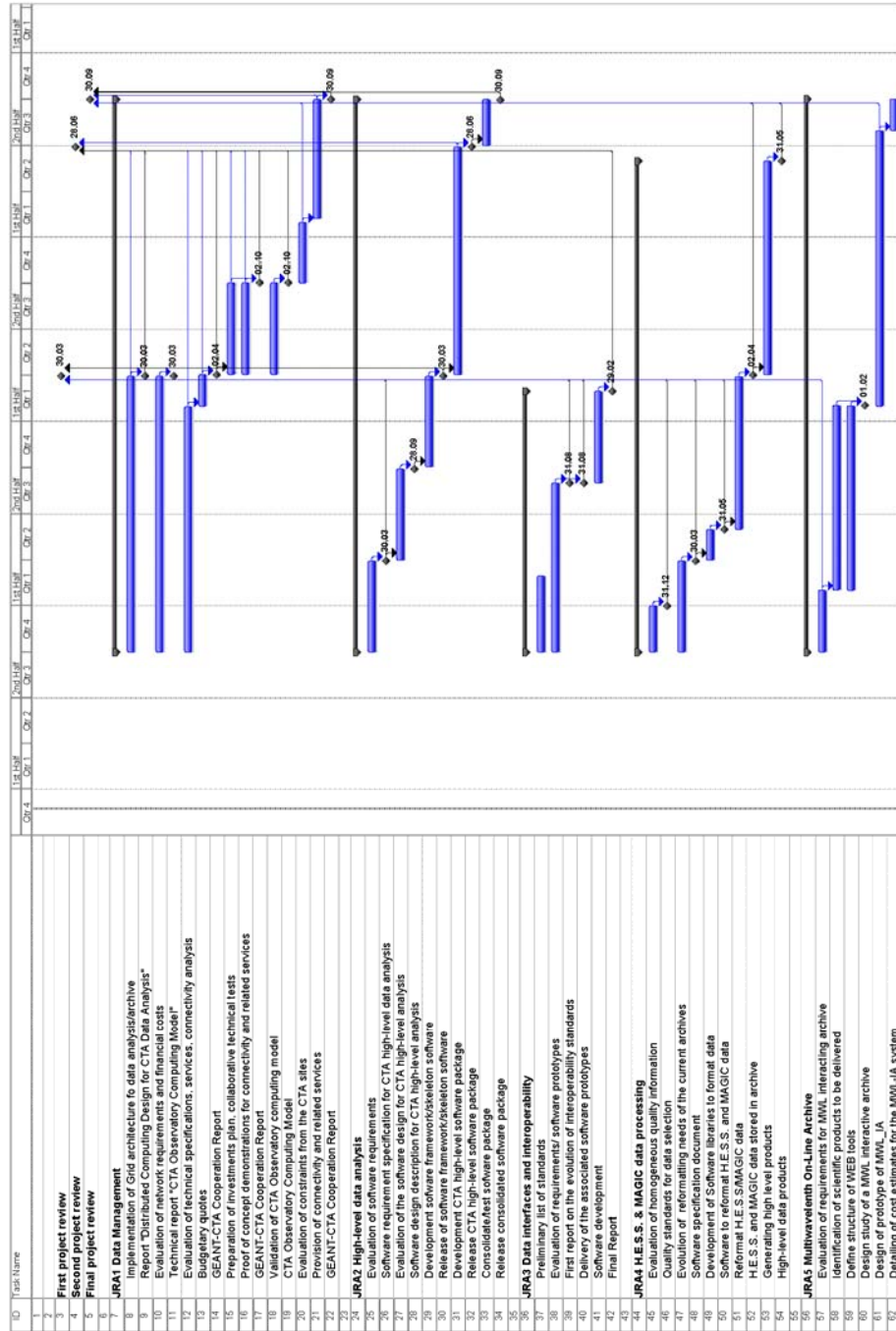
The second work package, JRA2, provides the tools for the high level data analysis for CTA in a framework that will enable both the astroparticle community and the astronomical one to fully exploit the data products provided by the CTA-VO infrastructure. This will allow science analysis in the framework of the VObs.

Data interfaces and interoperability (JRA3), will ensure the integration of CTA data within the Virtual Observatory infrastructure, developing on the work performed by NA3. This is needed because there has never before been any such data publically available. Study of current astronomical metadata standards and VHE gamma ray data conventions is enquired for this purpose; this will be achieved by a close working relationship with both VHE gamma ray and IVOA scientists.

The processing of H.E.S.S. and MAGIC data, under the responsibility of JRA4, is the test of the system which validates the concepts, design and implementation of the combination of other elements provided by CORE. Specific low level data from these operational VHE gamma ray instruments will be passed through the analysis packages executing on the grid, leading to science-level products stored in the archive. This end to-end test is the proof of the CTA telescope to user concept.

The Multi-Wavelength Archive provided by JRA5 will facilitate the full scientific exploitation of the VHE gamma ray data by providing a web-based system which will provide a highly functional, easy to use inter-comparison and combination capability with other relevant celestial datasets. There is work to define the requirements, design the software tools to manage the MWL archive in the context of the VHE gamma ray gateway (SA4), develop the web interface, and populate the archive with existing datasets.

I.6.1. Gantt-Chart



1.6.2. Work Package List

Work package No	Work package title	Type of activity	Lead partic no.	Lead partic. short name	Person-months	Start month	End month
JRA1	Data management	RTD	1	CNRS	59	1	36
JRA2	High-level data analysis	RTD	1	CNRS	141	1	36
JRA3	Data interfaces and interoperability	RTD	8	INAF	86	1	36
JRA4	H.E.S.S. & MAGIC data processing	RTD	4	IFAE	161	1	36
JRA5	MWL on-line archive	RTD	4	INAF	56	1	36
	TOTAL				503		

1.6.3. List of Deliverables

Del. no.	Deliverable name	WP no.	Nature	Dissemination level	Delivery date (proj. month)
JRA1.1	Distributed Computing Design for CTA Data Analysis	JRA1	R	PP	18
JRA1.2	CTA Observatory Computing Model	JRA1	R	PP	18
JRA1.3	First "GÉANT-CTA Cooperation Report"	JRA1	R	PP	18
JRA1.4	Second "GÉANT-CTA Cooperation Report"	JRA1	R	PP	24
JRA1.5	Implementation of CTA Observatory Computing Model	JRA1	O	PP	24
JRA1.6	GÉANT-CTA Cooperation Report	JRA1	R	PU	36
JRA2.1	Software Requirement Specification for CTA high-level data analysis	JRA2	R	PP	6
JRA2.2	Software Design Description for CTA high-level analysis	JRA2	R	PP	12
JRA2.3	Finalise implementation of CTA specific components	JRA2	O	PP	24

1.6.4. Detailed work package description

Work package number	JRA1	Start date or starting event:			1		
Work package title	Data Management						
Activity type	RTD						
Participant number	1	3	4	9			
Participant short name	CNRS	DESY	IFAE	MPG			
Person-months per participant	14	24	18	3			

Objectives

Strategy and policies for integrated European e-infrastructures as GÉANT and EGEE for data transfer, data reduction and data pipelines management purposes, by linking and integrating regional CTA sub-systems (namely the Array Operation Center and the Data Center).

Description of work (possibly broken down into tasks) and role of partners

A preliminary view of the computing model for the CTA observatory, based on the actual CTA computing architecture at work for Monte Carlo and data analysis purpose, is proposed in Fig.2. In order to validate such a model and/or introduced a few modifications (e.g. to make it more regional or fully distributed either almost-centric oriented) a computing model simulation analysis will be performed. Such a task will require the definition of the requirements and constraints and the investigation of the corresponding solutions in terms of: probable required bandwidths between the collaborating institutes, limits on the types and number of computing tasks that could be carried out at the collaborating institutes, and order-of-magnitude estimates of the financial cost of the required computing infrastructure. (CNRS 5 PM, DESY 4 PM, IFAE 6 PM, MPG 3 PM).

- One more joint research activity consists in studying the interoperability aspects between the Grid and the scientific instrumentation (the CTA telescopes) making possible the monitoring and the remote control of telescopes and related astronomical instrumentation. Such an issue is already explored and developed within RESPECT. The aim of this task is to implement available EGEE services develop and/or adapt them to the CTA specifications and then contribute to the definition of the global computing model for the CTA observatory. (DESY 12 PM and IFAE 6 PM).

Among the services offered by GÉANT the “Network Provisioning” and related security protocol for the transmission of CTA data are critical for this project.

- Computing and network infrastructures requirements for the CTA Array Operation Center(s) and the Data Center(s) according to their corresponding computing tasks as assigned according to the outcome of the CTA computing model analysis will be investigated. (CNRS 5 PM, DESY 8 PM, IFAE 6 PM).
- Open data access to a world-wide community and an efficient data transmission among CTA Institutes and different regional subsystems are issues to be tackled through a constant collaboration with GÉANT which will consult the availability of research network capacities and data transmission protocols. Particularly critical is the GÉANT help on performance issues and performing technical tests on the intercontinental connection between the CTA sites and Europe. (CNRS 4 PM).

Deliverables

JRA1.1 - (Month 18) Release of the “Distributed Computing Design for CTA Data Analysis” report for the implementation of the Grid architecture finalized to data analysis and archive.

JRA1.2 – (Month 18) “CTA Observatory Computing Model” technical report including network requirements and financial costs estimates.

JRA1.3 – (Month 18) First “GÉANT-CTA Cooperation Report” about technical specifications, services, connectivity analysis and budgetary quotes.

JRA1.4 – (Month 24) Second “GÉANT-CTA Cooperation Report” targeted to investments plan, collaborative technical tests and proof of concept demonstrations for connectivity and related services.

JRA1.5 – (Month 24) Implementation of the “CTA Observatory Computing Model” finally adopted by the CTA collaboration and its validation through series of tests of virtual CTA data workflow and pipelines.

JRA1.6 – (Month 36) Final “GÉANT-CTA Cooperation Report” on provision of connectivity and related services responding to the CTA computing model requirements and the constraints from the final choice of the host sites for the two CTA telescopes arrays.

Work package number	JRA2	Start date or starting event:					1
Work package title	High-level data analysis						
Activity type	RTD						
Participant number	1	5	6	7	8	9	10
Participant short name	CNRS	UNIGE	EKUT	CAMK	INAF	MPG	CEA
Person-months per participant	41	14	27	12	12	15	20

Objectives

The objective of this work package consists in the development of a high-level CTA data analysis framework that enables the astronomical and astroparticle communities to fully exploit the data products provided by the CTA-VO infrastructure and to allow science analysis in the framework of the VObs. The software technologies will be based on open source and portable software technologies will be public domain and will not depend on any centralized service to ensure long term maintenance by the community.

Description of work

The CTA science analysis software is a set of tools intended for distribution to the science community that allows the analysis of CTA high-level (Level 2b) data with the purpose of generating astronomical images, spectra and lightcurves. The software will also be embedded in the CTA-VO infrastructure to provide high-level data products (Level 3) through VObs to the user community.

Standards developed by the high-energy community will be followed where applicable and eventually adapted to the needs of the CTA observatory. Particular emphasis will be put to ensure long term maintenance of the software by the community, recognizing that preservation and access to digital data and software are central to any scientific observatory.

The software will be designed as user-friendly multi-platform analysis package and will be distributed as binary and source code to the community. Particular emphasis will be put on the implementation of analysis standards that are widely used in the high-energy community and on the full embedding of the software in the VObs by implementing the data format standards developed in NA3.

The software will be based on open source and portable software technologies that will be adapted to CTA needs. A requirements analysis of the CTA needs is thus a critical part of this work package. Possible software libraries relevant for this purpose are the Gammalib vesatile toolbox for high-level analysis of astronomical gamma-ray data developed by CNRS-CESR, the conversion of existing Cherenkov telescope software developed by CEA, or the DAL, PIL and RIL, developed by UNIGE.

The work package contains the following tasks:

- 1) Develop the requirements for the high-level CTA data analysis software.
- 2) Decide on the basic software infrastructure to be used, including standard libraries maintained in the community.
- 3) Produce an architectural design, including interface specification.
- 4) Split the responsibilities for the development among the participating institutes.
- 5) Release the software framework and libraries.

- 6) Release of a first prototype of the CTA high-level software.
- 7) Test the software, iterate the documentation and the software as needed.
- 8) Release the consolidated software including analysis scripts.
- 9) Test the software with the data provided by JRA4. Quality standards and procedures will be enforced during the development cycle.

The work will be shared among partners based on their experiences: Based on its strong involvement in VHE data analysis software development, CNRS will lead and coordinate the research. Other participating institutes have a lot of experience in developing software for ground-based or space experiment, which should ensure a refined requirements analysis.

Deliverables

JRA2.1 – (Month 6) Release of “Software Requirement Specification for CTA high-level data analysis”.

JRA2.2 – (Month 12) Release of “Software Design Description for CTA high-level analysis”.

JRA2.3 – (Month 18) Release of the software framework and skeleton software.

JRA2.3 – (Month 30) Release of the first CTA high-level software package.

JRA2.4 – (Month 36) Release of a consolidated software package, including analysis script and test report.

Work package number	JRA3	Start date or starting event:				1	
Work package title	Data interfaces and interoperability						
Activity type	RTD						
Participant number	1	5	8	12	11		
Participant short name	CNRS	UNIGE	INAF	ULEIC	UCM		
Person-months per participant	30	6	14	12	24		

Objectives

- Assessment and development of agreed standards for all aspects of the interoperability layer common to astrophysics and astroparticles, using the work performed by NA3 on in-depth analysis of Cherenkov data structures and of Vobs standards.
- Coordination with IVOA activities for the definition of the IVOA standards and protocols for data access, data description and query language also for the astroparticle data.

Description of work

CTA data require the integration within the VObs infrastructure of tools (such as, for instance, MC simulation codes) which already exist within the astroparticle community.

Assessment of the required evolution of existing standards, will involves two main strands.

- Formulation of requirements and the technical plan by technical debate, exchange of best practice, and code sharing with VObs. partners.
- Development of software prototypes implementing and testing the draft standards, and recommendation to transform astroparticle data in order to be compliant with VObs. standards.

This can be done by performing R&D studies for Data Access, Data Model adopting VObs Query Language protocols and standards in the context of astroparticle data.

In particular this will include:

- Studying the VObs standards and assessing possible technologies to implement these standard to astroparticle data.
- Production of draft documents describing the standards.
- Writing prototype implementation the VObs standards onto real astroparticle data holdings from MAGIC and HESS.
- Assessment of feedback from implementation of conversion tools and provision of data and services from SAs, and from the other JRAs.
- Input to and discussion in the IVOA working groups and attendance at IVOA meetings.
- Interaction with the other WPs: technical debate, exchange of best practice.

If applicable, publish these implementations into the Euro-VO Registry of VObs resources.

The work will be shared among partners based on their experiences: INAF, with its strong involvement in both the VObs and astroparticle data archiving and analysis, will coordinate the work and ensure relations with IVOA. All other institutes are already participating in publishing data into the VObs.

Deliverables

JRA3.1 (Month 5): Preliminary list of standards

JRA3.2 (Month 11): First report on the evolution of interoperability standards, and delivery of the associated software prototypes

The report summarises the achievements on this point, analyse the state of the VObs. scene, and make recommendation for implement the VObs standards in the astroparticle data

JRA3.3 – (Month 18): Final Report

Work package number	JRA4	Start date or starting event:	1				
Work package title	H.E.S.S. & MAGIC data processing						
Activity type	SVC						
Participant number	1	2	4	6	8	9	12
Participant short name	CNRS	Erlangen	IFAE	EKUT	INAF	MPG	ULEIC
Person-months per participant	22	18	27	36	26	20	12

Objectives

- Retrieve public observational data sets auxiliary information and logs in electronic format.
- Transform key information not available in electronic format to become machine readable.
- Cure data sets. Only complete and self-contained observational data sets will be considered for archival.
- Provide the infrastructure for the data storage of reformatted data.
- Provide conversion tools between the individual and the common formats.
- Reformat data to the common data format.
- Derive homogeneous quality information.
- Generate high level data products using the software developed through WP SA3
- Preserve tracking information (processing and software version, parameters, calibration and simulation tracking).

Archive the data with proper meta-data to allow their exploitation by the science community at large and by software tools.

Description of work

The H.E.S.S. and MAGIC experiments will provide subsets of their data in order to test the infrastructure developed in this project. This allows to fully test the functionality and performance of the infrastructure ranging from Level0 to Level4 data including systematic effects not included in simulated CTA data.

The work package contains the following tasks:

- Preserving and curing the data: The data of the different experiments are not homogeneous. In each project different problems are faced, e.g. atmospheric absorption due to the Saharan Air Layer in case of MAGIC or changing number of available telescopes in the case of H.E.S.S. Various data structures have to be incorporated. In cases where part of the necessary data quality or environmental information is not available in computer readable format, this will need to be converted from human readable format. Data affected by problems have to be corrected or rejected.
- Providing of the software and reformatting of the current archives: The data available in the archives of the experiments have to be converted to the standard VHE data format. Software libraries to read/write reprocessed Cherenkov data (Level2b to Level4) according to the CTA data model and conventions used in high energy astronomy have to be developed. In addition, software libraries will be provided for common parameter interface handling, error and alert handling, logging and traceability of the data processing.

- Archiving the reformatted data: The reformatted data (Level 0 to Level 4) will be organized in a similar way for the various experiments and stored in a data repository developed in SA1 and SA2.
- Generating high level products: From the event lists and auxiliary data, standardized high level data products (e.g. sky images, source spectra and source light curves) will be generated using the software developed in WP SA3.

The work will be shared among partners based on their experiences: The participating Institutes have a lot of experience in developing software. Basically, they have designed the software framework as well as the analysis software for either H.E.S.S. or MAGIC, as well as organized the corresponding archiving.

Deliverables

JA4.1 - (Month 3) Quality standards for data selection

JA4.2 - (Month 6) Software specification document

JA4.3 - (Month 20) Software to reformat H.E.S.S. and MAGIC data

JA4.4 - (Month 30) H.E.S.S. and MAGIC data stored in archive

JA4.5 - (Month 32) High-level data products

Work package number	JRA5	Start date or starting event:			1	
Work package title	Multiwavelength On-Line Archive					
Activity type						
Participant number	6	8	9			
Participant short name	EKUT	INAF	MPG			
Person-months per participant	12	38	6			

Objectives

- Definition of the requirements of an e-system to interface CTA data and data at different wavelengths and from different experiments, including protocols for MWL data access in the VObs context.
- Design of the soft tools to manage the CTA archive in a MWL context (integrated into the VSG).
- Design of a web interfaces to the final user.
- Development of a prototype system with the MAGIC and H.E.S.S. data available.
- Cost estimation of the multiwavelength interactive archive system for the CTA

Description of work

CTA will provide a set of data complementary to those obtained with other astronomical facilities. As a consequence, the community of users of the CTA data will be not limited to those most familiar with the instrumentation, but will span scientists of different fields. In advance, key questions in many fields of modern astrophysics need multiwavelength and multi-messenger approaches (e.g., for AGN, GRBs, Dark Matter, cosmology, Cosmic Ray sources, etc.). The archival CTA data and the results of the standard data processing will have to be easily readable and accessible to a larger community. As a part of this project this WP will:

- Design a multiwavelength interactive archive (MWL_IA) system that will be able to compare a FITS-based high-level event list format, as well as scientific products (e.g., catalogues, sky maps, spectra and light curves), coming from CTA with data and products coming from other experiments and at other wavelengths. INAF, EKUT and MPG have a large experience in managing astrophysical databases as well as data analysis from different experiments. This design study will include:
 - Scientific and technical requirement;
 - Data and information exchange protocols definition;
 - Detailed flow charts for software tools to compare CTA data with other data;
 - Project of the WEB interfaces between the MWL_IA and the final users;
- Realisation of a prototype of this archive using available MAGIC and H.E.S.S. data. INAF, EKUT and MPG will take care of this part.

Deliverables

JRA5.1 - (Month 4): Report about the requirements for a MWL interacting archive to interface the data from Cherenkov Telescopes with data from other observatories and on the protocols to be used.

JRA5.2 – (Month 16): Design study for the realization of a MWL interactive archive to manage the CTA data access and comparison with data from other experiments and other instruments. We will identify the most important scientific products that will be delivered to the observer through the MWL_IA. This design study will include also the structure of WEB tools necessary to interface the MWL_IA to the final user defining

both the input and the output to the system.

JRA5.3 – (Month 34): Prototype of MWL_IA to manage data from MAGIC and H.E.S.S. and to compare them with data from space-based instruments (e.g., Fermi, AGILE, INTEGRAL, Swift, etc.) and ground-based instruments (e.g., optical and NIR Telescopes) . The prototype of this MWL_IA will also interface data with the most important astronomical catalogues. This prototype will be realized compliant to the VObs. requirements.

JRA5.4 – (Month 36): Detailed cost estimate for the realization and maintenance of the MWL-IA system.

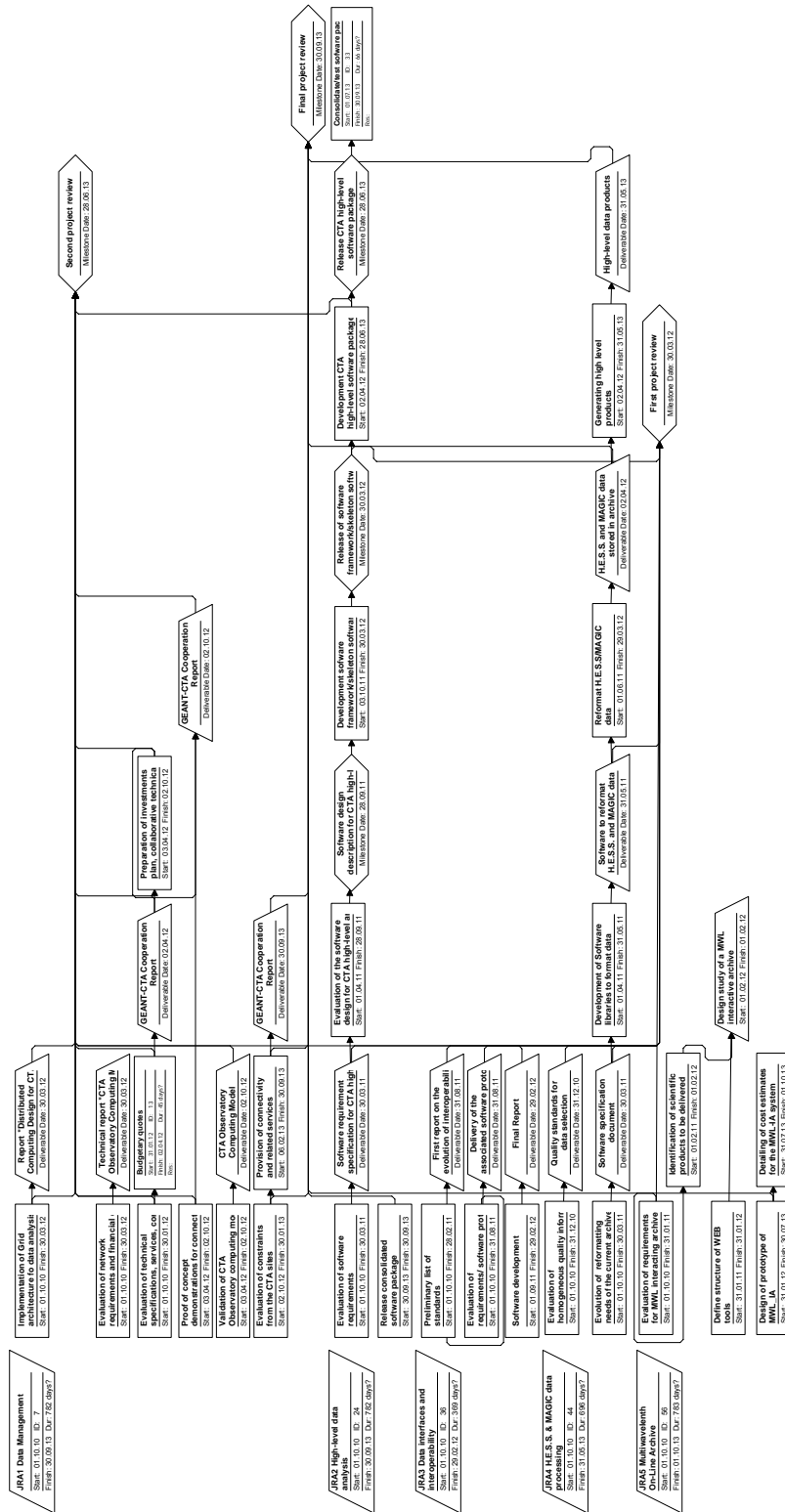
1.6.5. Summary of effort

Partic. no.	Partic. short name	JRA1	JRA2	JRA3	JRA4	JRA5	Total person months
1	CNRS	14	41	30	22		107
2	Erlangen				18		18
3	DESY	24					24
4	IFAE	18			27		45
5	UNIGE		14	6			20
6	EKUT		27		36	12	75
7	CAMK		12				12
8	INAF		12	14	26	38	90
9	MPG	3	15		20	6	44
10	CEA		20				20
11	UCM			24			24
12	ULEIC			12	12		24
Total		59	141	86	161	56	503

1.6.6. Milestones

Milestone number	Milestone name	Work package(s) involved	Expected date	Means of verification
1	First project review	JRA1, JRA2, JRA3, JRA4	12	R
2	Second project review	JRA1, JRA2, JRA3, JRA4	24	R
3	Final project review	JRA1, JRA2, JRA3, JRA4	36	R

1.6.7. *Pert diagram*



1.6.8. Risk and Contingency

Title: Final CTA sites not identified

Description: The computing data model and the GÉANT feasibility study for the CTA subsystems, links and management could be conclusively determinant in case of definition of the host countries for the CTA sites.

Severity: Marginal

Likelihood: Low

Mitigation: The CORE project will be conducted in the same time scale of the CTA Preparatory Phase and will be over for the starting time of the construction, therefore there are clear elements in support of the finalization of the choice of the CTA sites by the last year of life of the CORE project. However one has to consider that: a short list of a very few sites has been already provided; the negotiations with candidate host countries are in progress; last but not least the objectives of the CORE project are to provide a feasibility study applicable to almost all possible sites and further more to result in a series of requirements to optimize the choice of the site. Therefore critical for the CORE project will be simply the GÉANT support to our objectives but this corresponds to the natural scope of the GÉANT actions.

Title: IVOA standards keep evolving

Description: IVOA standards have been released, but are likely to keep evolving. Therefore CORE partners who have already implemented VObs-compliant services based on recommended IVOA standards may have to adapt them to the new standards.

Severity: Significant

Likelihood: Medium

Mitigation: CORE partners should make sure to participate in the discussion and agreement of IVOA standards, so that their evolution minimises the possible negative impact. CORE partners should develop their services in a flexible manner, taking into account possible slight evolution of the IVOA standards. Therefore, adapting the existing services to updated IVOA standards should not require too much work.

Include the issue into training activities.

II. Implementation

II.1. Management structure and procedures

Management Structure

The project requires a light but efficient management structure able to coordinate the activities of different participants and ultimately lead to the achievement of the common goals. To assure the results of the project being on schedule and within budget we propose a structure that has been proven to be effective in previous similar projects.

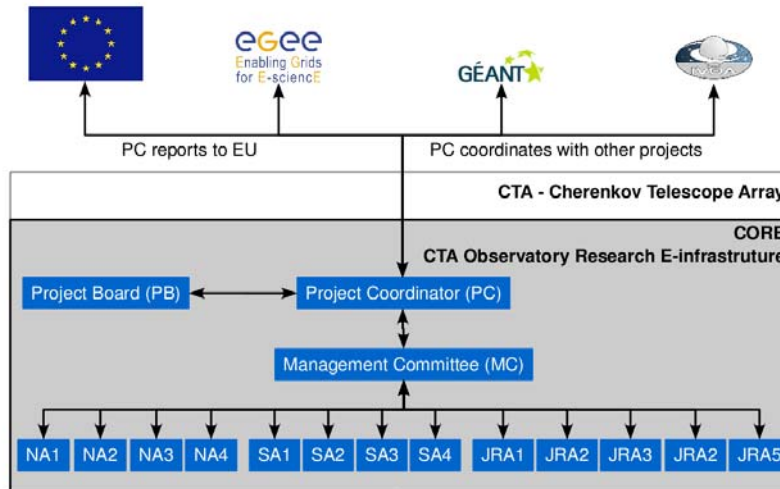


Figure 6: Organigramme of the CORE management.

The management structure comprises:

The Project Coordinator

The Project Coordination will be undertaken by G. Lamanna. He will be responsible of the overall management of the project and for the day-to-day operation, ensures administrative, financial and legal management and is the intermediary between the Consortium and the European Commission, monitoring progress and financial reporting. He will be assisted by a deputy and administrative staff. The Project Coordinator and his deputy guarantee as well liaison and coordination with EGEE/EGI, GÉANT and IVOA, and through such coordination they will involve representative experts from these three European projects to provide punctual advice and *steering* actions during the entire life of the project.

The Project Board

The Project Board composed of all partners' representatives, has mainly steering and supervision tasks. It takes decisions related to definition of project strategy, allocation of resources (manpower and funds), arbitration of any problems occurring (on partner's request) and decisions on possible expansion of the project to other participants. It also manages the exchange of information inside and outside the consortium. Partner representatives are responsible for the work within an activity of a Work Package being delivered on time and meeting the quality standards. The Board is chaired by the Project Coordinator, and will normally meet twice a year. We anticipate that most decisions of the Project Board will be reached by consensus, with votes representing an exception. Rules and voting procedures of the Project Board will be defined in the consortium agreement.

The Management Committee

The Project Coordinator and the Work Package Leaders will be members of the Management Committee. The Management Committee will be in charge of the implementation of the project strategies, progress control (Project Reports), resolution of any technical problems occurring, coordination of possible cooperation of participants with outside bodies. The Management Committee will also be able to designate advisors and experts to offer assistance to the

participants. The Management Committee will also be responsible for project coordination and will assure that all aspects of participants' activities can be monitored. It ensures the on-time completion and quality of the activities. The Management Committee will take its decisions by consensus. In the unlikely case that consensus cannot be reached, the Project Board will arbitrate the issue. The Management Committee will hold monthly teleconferences and will have face-to-face meetings as needed.

Work Package Leaders

The Work Package Leader coordinates the corresponding Work Package. He/She is responsible for the timely completion and the quality of the activities of his/her Work Package. All WP Leaders will work in close cooperation within the Management Committee to implement the project plan. The best candidate to the coordination of each Work Package of the CORE project is selected in agreement with all partners based on competences, recent and present commitments to the matter and tasks of the corresponding WP and coherently with previous experiences relevant to the tasks and the main objectives of the WP itself. Such criteria are critical to guarantee a safe and efficient start-up and consequent steering of the WP plan and as well as of the entire project.

Project Management

The Management Structure ensures the appropriate hierarchy of the decision-making levels. The Work Package Leaders are under a mandate from the Project Coordinator and take decisions on the Work Package procedures. Should any problems occur during the process, they will be resolved within the Management Committee. The Project Coordinator will present problems that could not be resolved at this level to the Project Board for arbitration.

The Management Committee develops a proposal for the Project Plan, which is approved by the Project Board. Work Package Leaders then further develop more detailed Work Package Plans according to the Project Plan.

Each Partner is responsible for organizing its in-house activities and fulfilling its in-house reports including the generation of financial reports and certificates.

The Work Package Leaders will develop the Work Package reports, which will be transmitted to the Project Coordinator. Project Coordinator's administrative staff will define report formats and the information gathered will be used to update the Project Plan. Progress, financial and technical reports will be assembled, studied and distributed. Use of information technologies and electronic data exchange will bring face-to-face meetings to a minimum.

The Project Coordinator is responsible for reporting progress and all relevant issues to the Board in the form of Progress Reports.

The Management Committee identifies any decisions of changes of direction in the project considered necessary by the European Commission or by the Management Committee itself. Major changes, involving modifications of resource investment, are discussed and approved by the Project Board. Regular progress reporting will highlight any potential problems and initiate corrective action. Any major issue which could affect the global CTA project will be submitted and discussed with the Management Board (Spokesperson, Co-Spokesperson and CTA WPs coordinators) of the CTA consortium. The Management Board of the CTA consortium will play the role of Advisory Board for the CORE project.

The Project Coordinator is responsible for assuring the compliance of the program with ethical and gender equality guidelines.

Communication within the project

A central web site will be set up to serve for information exchange within the project, and with the scientific community, making use of techniques such as Content Management Systems and Wikis or efficient downloading, uploading and updating of project information, minutes, reports etc. To minimize additional travel, we will try to combine project meetings with such other meetings, and use, to the extent possible, remote conferencing techniques.

II.2. Individual participants

Partner number: 1

Organisation name: Centre National de la Recherche Scientifique and participating laboratories

- I. APC, (IN2P3/CNRS et Université Paris 7, UMR 7164)
- II. Centre d'Etude Spatiale des Rayonnements (CESR INSU/CNRS et Université Paul Sabatier, UMR 5187)
- III. Laboratoire d'Annecy le Vieux de physique des particules (LAPP IN2P3/CNRS et Université de Savoie UMR 5814)
- IV. Laboratoire de l'Univers et de ses Théories (LUTH Observatoire de Paris et INSU/CNRS UMR 8102)

Short name: CNRS

Organisation description:

The Centre National de la Recherche Scientifique (National Centre for Scientific Research) is a government-funded research organisation, under the administrative authority of France's Ministry of Research.

CNRS's annual budget represents a quarter of French public spending on civilian research. As the largest fundamental research organization in Europe, CNRS carried out research in all fields of knowledge, through its seven research institutes : Mathematics (INSMI), Physics (INP), Chemistry (INC); Life Sciences (INSB); Humanities and Social Sciences (INSHS); Environmental Sciences and Sustainable Development (INEE); Information and Engineering Sciences and Technologies (INST2I); and its two national institutes: the National Institute of Earth Sciences and Astronomy (INSU); and the National Institute of Nuclear and Particle Physics (IN2P3).

Its own laboratories as well as those it maintains jointly with universities, other research organizations, or industry are located throughout France, but also overseas with international joint laboratories located in several countries. Measured by the amount of human and material resources it commits to scientific research or by the great range of disciplines in which its scientists carry on their work, the CNRS is clearly the hub of research activity in France. It is also an important breeding ground for scientific and technological innovation.

The two institutes of the CNRS concerned with the CTA project and working together are IN2P3 (National Institute of Nuclear and Particle Physics) and INSU (National Institute of Science of the Universe). The researchers and engineers are deployed in mixed research units, UMR (usually laboratories) where they work together with researcher lecturers employed by the University system. CNRS has set up the Interdisciplinary Programme "Particles and Universe: observation, data, information" which is relevant to the CORE Objectives.

The APC (AstroParticle and Cosmology) laboratory is a mixed-research-unit combining CNRS, University Paris 7 Denis-Diderot, Paris Observatory, and CEA. It unites researchers working on many of the current leading experiments in Astroparticle Physics and Cosmology, including H.E.S.S., Planck, Double-Chooze, Pierre Auger Observatory, Antares... The gamma-ray astrophysics teams at the APC have long experience in the domain, having worked on the pioneering experiments in the domain since the 1980's (Whipple, Thémistocle, CAT). They worked together on the development of analysis tools devoted to the imaging Cherenkov technique and are currently co-leaders in France of the HESS analysis framework HAP. They are working on the Monte-Carlo simulations and data analysis techniques in preparation for the advent of the HESS-II, in parallel with simulations for the definition of the characteristics of CTA. On the astrophysics side, they work on the understanding of Pulsar Wind Nebulae physics and the physics of Active Galactic Nuclei. Overall, the members of the team have a global vision of the issues involved in the analysis of all types of sources (galactic and extra-galactic, steady and variable, point-like and extended, soft or hard spectra...)

The Centre d'Etude Spatiale des Rayonnements (CESR) pursues research and education in astrophysics and astronomy in the field of solar system physics, infrared astronomy and high-energy astronomy by developing and exploiting space- and ground-based instrumentation. The CESR comprises a staff of 102 permanent employees (28 full-time national research employees,

26 professors and assistant professors, 48 engineering and administration positions) and about 60 contract positions (PhD, post-doc, engineers). The group of high-energy astrophysics includes 16 staff scientists who work in the fields of galactic compact objects, nucleosynthesis and positron annihilation, and high-energy astrophysics. The high-energy group of the CESR is involved in the space-based XMM-Newton, INTEGRAL and Fermi missions and in the ground-based H.E.S.S. project. The main future projects of the group comprise CTA and the French-Chinese SVOM mission for the study of gamma-ray bursts. Furthermore, CESR is leading the efforts in developing the GammaLib toolbox for high-level analysis of astronomical gamma-ray data.

The Laboratoire d'Annecy-le-vieux de Physique des Particules (LAPP) is one of the twenty laboratories forming the IN2P3 institute of CNRS. It is also a research unit of the Savoie University. Elementary particle physics and astrophysics as well as a rich R&D program are the three pillars of research for the 150 people, researchers, professors, engineers and technicians, administrative staff, working at the laboratory. Located 50 km south of CERN, the laboratory is very actively involved in several large international collaborations challenging the standard model of particle physics: BaBar, ATLAS, CMS, LHCb, OPERA. Messengers from space are studied in experiments like AMS, HESS, CTA or VIRGO which strives to detect gravitational waves. The experimental teams work in close contact with the phenomenologist teams from LAPTh, a theory laboratory hosted in the same building. The laboratory hosts a computing center serving as TIER2 for the LHC experiments and also used by laboratories of the Savoie University. Each year the laboratory welcomes about ten foreign visitors spending between few months and a year, fifteen PhD students, and many young master students.

Paris Observatory is the largest astronomy centre in France and one of the most important in the world. It represents alone one third of astronomy in France. It depends on the Ministry of Higher Education and Research, belongs to the category of 'Great Establishments', and has the status of an independent University. Paris Observatory is structured in 5 laboratories (GEPI, LESIA, LUTH, LERMA and SYRTE), one scientific unit (Nançay radio astronomy station), and one institute (IMCCE) covering all fields of astronomy and astrophysics. Each of these components is a Joint Research Unit of the CNRS and some are associated with other Universities. They are spread over three sites: Paris, Meudon and Nançay.

Paris Observatory benefits from sizable technical services, such as the largest library for astronomy in France, a very efficient computing department and an instrumental pool. Moreover, Paris Observatory develops training activities (pre-doc, doctoral, and post doc level) with the UFE "Teaching and Training Unit" and is responsible for the "Ecole Doctorale Astronomie et Astrophysique d'Ile de France".

LUTH is the 'Laboratory of the Universe and Theories', with more than 60 researchers active in observational and theoretical astrophysics, analytical and numerical simulations of astrophysical systems. LUTH is also strongly involved in the definition of standards and formats for the IVOA (International Virtual Observatory Alliance) mainly for molecular and atomic physics, for theory (VO-theory) and the characterisation of TeV data compatible with the Astronomical Virtual Observatory tools. The aim of this last point is to provide easy and transparent access to the high level data coming from H.E.S.S. (namely fluxes and light curves, spectra, maps) for immediate use by all astronomers.

Main tasks attributed:

The LAPP team will assure the coordination of the project (NA1) and in particular of those work packages (SA1, SA4 and JRA1) which cover the technical aspects of the Grid e-infrastructures implementation and development for CTA.

The CESR will bring its expertise in development of instrument related and astronomical community software systems.

The APC will participate to the development of analysis software of Cherenkov data and the corresponding archive.

The LUTH and the Paris Observatory will play a leading role of the WP NA3 and all activities related to the high-level astronomical data formats and related analysis.

Previous experience relevant to these tasks:

CNRS-IN2P3/INSU has been involved with the domain of Very-High-Energy Gamma-Ray Astronomy almost since its inception, through the Thémistocle, CAT, CELESTE, and HESS experiments. Our history regarding the development of simulations and analysis methods is extensive, with simulations of showers, and work on detector simulations code used in CAT and HESS, with extensive use of the facilities of the Lyon Computing Centre CC-IN2P3 as a HESS data centre. On the analysis side members of the group currently have developed many of the cutting-edge analysis methods used in the domain. CNRS-IN2P3 has been involved in several activities within the European Data Grid Project first and then in EGEE and CNRS-INSU is already strongly involved in the definition of standards and format for the IVOA (International Virtual Observatory Alliance) as well as designing software for medium high energy data (X-ray to soft gamma-ray).

Key persons:

Dr. Giovanni Lamanna, LAPP, CNRS tenured experienced research scientist; H.E.S.S. and CTA LAPP team leader; coordinator of the CTACG project and co-coordinator of the CTA Monte Carlo design study Work Package.

Prof. Catherine Boisson, LUTH, Coordinator of CTA AGN Physics Working group, member of the H.E.S.S. Collaboration. Coordinating the interface between the H.E.S.S. high level data and the Astronomical Virtual Observatory

Dr. Jürgen Knödlseder, CESR, Research Director at CNRS. He is CTA project leader at CESR.

Dr. Volker Beckmann, APC, Researcher experienced in high energy astrophysics data centers and committed to the construction of the computing centre at 'Space Campus' at University Paris 7.

Partner number: 2

Organisation name: Erlangen Centre for Astroparticle Physics, Friedrich-Alexander-Universität Erlangen-Nürnberg

Short name: Erlangen

Organisation description:

The ECAP is active in the field of gamma-ray, neutrino, and X-ray astronomy. It is involved in the H.E.S.S. and ANTARES experiments, is engaged in studies for the future large gamma ray observatory CTA, is coordinating the European design study KM3NeT for a future km³ scale neutrino project in the Mediterranean Sea and has established experience in acoustic detection of particle showers for the next generation of neutrino detectors. The staff currently encompasses five professors, 8 scientists, 26 PhD students and 15 diploma students.

Main tasks attributed:

Based on their major contribution of the H.E.S.S. software system and as coordinating institute of the CTA software and computing group the group will coordinate the interface to CTA, develop documentation, tutorials, and workshops to serve the community, and contribute to the design, implementation and test of the software system for the reformatting of the H.E.S.S. data, for open data access, and data analysis software.

Previous experience relevant to these tasks:

The group is responsible for the H.E.S.S. software system. The system and data formats were designed and implemented by members of the group. The group has an outstanding experience in the development of software for Cherenkov telescope systems for data storage, data access, and data analysis. The group is coordinating the computing and software group of CTA.

Key person:

Prof. Dr. Christian Stegmann, Chair for Physics, Full professor at the University of Erlangen, Convenor of the H.E.S.S. and CTA software and computing working group.

Dr. Ira Jung, Research Staff, H.E.S.S. run coordinator H.E.S.S., expert in Level 0 to Level 2b data processing and data analysis.

Partner number: 3

Organisation name: Deutsches Elektronen-Synchrotron

Short name: DESY

Organisation description:

DESY is one of the worldwide leading accelerator centres exploring the structure of matter. It is located on two sites, in Hamburg and Zeuthen. DESY is a research centre of the Helmholtz-Association and is financed to 90% by the federal ministry BMBF (Bundesministerium für Bildung und Forschung) and to 10% each by the Freie und Hansestadt Hamburg (DESY in Hamburg) and by Brandenburg (DESY in Zeuthen). The DESY base budget is ~170 MEuro (2007), its staff is ~1600 FTE. The facilities of DESY were used in 2007 by about 3000 scientists (1500 from abroad) from 45 nations, 920 in particle physics, 2100 in photon science. The computing division provides a central infrastructure and services for all departments on a very high level.

DESY conducts basic research in natural sciences with special emphasis on the development, construction and operation of accelerator facilities in close collaboration with the respective user communities; Understanding the structure and dynamics of matter on entirely different scales of length and time, including the building blocks of matter and the fundamental forces as well as processes in the universe at the highest energies and the development of cosmic structures; Research on fundamental phenomena in condensed matter, plasmas, and in atoms, molecules and clusters, as well as on the structure and function of complex materials up to biomolecules.

With its location in Zeuthen, DESY is the pioneering European laboratory in high-energy neutrino astrophysics in the last 20 years. The big, future project of astroparticle physics at DESY is CTA, the Cherenkov Telescope Array. There are common professorships with the Humboldt University Berlin and with Potsdam University.

Main tasks attributed:

The DESY CTA team will bring their fundamental contributions in the activities oriented to the definition of the computing model and Grid technology application in the SA1 and JRA1 WPs.

Previous experience relevant to these tasks:

The DESY computing groups in Hamburg and Zeuthen have taken responsibility running a large Tier-2 centre in Germany based on WLCG (World Wide LHC Computing Grid), serving LHC experiments, the ILC group, and the HERA-experiments. In addition, DESY has set up and is operating in the framework of a Helmholtz Alliance the "National Analysis Facility", the computing infrastructure of a large analysis centre at DESY to support the German scientists with LHC data-analysis capabilities.

Based on the WLCG middleware a grid infrastructure for IceCube was installed. DESY Zeuthen provides the backbone for the IceCube European data centre and plays an outstanding role as Monte Carlo production site. The CTA group in Zeuthen set up, in accord with the CTA computing model, an LCG based grid-production production facility for Monte Carlo data.

Key persons:

Dr. Peter Kostka - on- and off-line software expert, with expertise in database access and massive computation

Dr. Stefan Schlenstedt - DESY project lead for the CTA Design Phase

Dr. Michael Winde - computing expert with experience operating small and large detectors

Partner number: 4

Organisation name: Institut de Física d'Altes Energies
(in collaboration with PIC - Port d'Informació Científica)

Short name: IFAE

Organisation description:

IFAE is a public research centre with its own legal entity created in 1990 as a Consortium between the Catalan Autonomous Government and a few Catalan universities to promote and support advanced research in High Energy Physics. It is located at the Campus of the UAB ("Universitat Autònoma de Barcelona") and is also a university research centre of UAB. It is structured in two divisions: theoretical physics with about 40 researchers and experimental physics, with about 60 researchers, engineers and technicians. It has its own electronics and mechanics workshops and its own administrative staff.

The experimental division has participated in several High Energy Physics experiments such as the ALEPH detector at CERN (Switzerland), the CDF detector at Fermilab (USA), the K2K detector at KEK (Japan) and is involved in major new particle physics experiments such as ATLAS at CERN or T2K at Japan. In addition it has an active group participating in medical application projects as Medipix and DEARMAMA. In recent years it started a new research line in observational cosmology joining projects such as the DES and EUCLIDE and leading the PAU collaboration, and in underground physics experiments co-leading the NeXT experiments.

In 1997 IFAE started also a strong activity in Astroparticle Physics by taking a very active role in the development and construction of the MAGIC gamma ray telescope. IFAE was responsible of the design and construction of the camera, all its auxiliary systems and control software, the telescope calibration system and calibration software, the central control system and the control house. It has also had a very active role in Monte Carlo and analysis software developments, and now in data analysis and publication. During the camera development, IFAE has been very involved in R&D for new photosensors and associated electronics.

The IFAE gamma-ray astronomy group has at present about 12 researchers. The leader of the CTA-IFAE group has been co-spokesperson and later spokesperson of MAGIC for over 7 years, and other group members have or have had top level responsibilities in different work packages within the MAGIC collaboration. IFAE has also been very deeply involved in the construction of MAGIC-II, where it has been co-responsible of the construction of the receiving, conditioning and digitizing electronics together with the INFN at Pisa, and also responsible of the MAGIC data centre running at the PIC ("Port d'Informació Científica"), a GRID LHC tier-1 computer centre associated to IFAE.

The PIC was founded in 2003 and maintained through a collaboration agreement among 4 institutions: Departament d'Educació i Universitats (DeiU), Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas (CIEMAT), Universitat Autònoma de Barcelona (UAB) and Institut de Física d'Altes Energies (IFAE). The PIC is a data center of excellence for scientific data processing supporting scientific groups working in projects which require strong computing resources for the analysis of massive sets of (distributed) data.

Main tasks attributed:

IFAE and PIC aim at bringing their experience in these fields into CTA through their participation in the SA1, SA2, SA3 and JA1 work-packages of CORE.

Previous experience relevant to these tasks:

IFAE and PIC have long experience in the analysis of Cherenkov telescope data, from their participation in the MAGIC experiment, which is relevant to the WPs NA3 and SA3. The two institutes operate the official MAGIC data centre hosted at PIC, which implies the data transfer from the MAGIC telescope, the data storage, analysis and post-processing. IFAE and PIC are

also already taking part in the CTA Monte Carlo working group, with experience in the analysis of the already existing simulated CTA data.

PIC brings into the project experience with the storage and processing of large amounts of data, acquired not just in the context of MAGIC: PIC is the Spanish Tier-1 for the WLCG project. With its computational infrastructure PIC provides an ideal environment for developing, deploying and operating scientific applications on grid infrastructures. Besides MAGIC, CTA and the WLCG, PIC participates in various scientific project such as astrophysical/cosmological and biomedical projects. Within the EGEE projects PIC also has the role of the Regional Operations Centre for South West Europe executing tasks operations, development, deployment and applications.

Key persons:

Dr. Javier Rico - ICREA/IFAE: coordinator of MAGIC official data centre, expert on analysis of MAGIC data

Dr. Abelardo Moralejo - IFAE researcher: software coordinator of the MAGIC collaboration, expert on analysis of MAGIC data. Participating in the CTA Monte Carlo working group.

Dr. Christian Neissner – PIC: coordinating Astronomy & Astrophysics activities at PIC

Roger Firpo - PIC - expert on data management, data processing and user support

Partner number: 5

Organisation name: INTEGRAL Science Data Centre, Geneva Observatory, University of Geneva

Short name: UNIGE

Organisation description:

The Geneva observatory pursues research and education in astrophysics and astronomy on various fields of research with 9 professors and their groups. The ISDC data centre for astrophysics with a staff of about 50 people is involved in the data processing of the INTEGRAL, Gaia, Planck and Astro-H missions. The group of high-energy astrophysics includes about 30 scientists with main fields of research in galactic and extragalactic high-energy sources, multi-wavelength observations, astroparticle physics, gamma-ray bursts and hardware development.

Main task attributed:

The ISDC will bring its expertise in astronomical data management, software and community services to the project to ensure that the VHE data will be used by the community at large and interoperable with X-ray and soft gamma-ray data.

Previous experience relevant to these tasks:

In 1995, the institute got the mandate from the European Space Agency to perform the INTEGRAL data acquisition, processing, archiving and distribution and to support the science community. The scientists have a broad experience of data analysis with all most major observatories, especially at high energies.

Key person:

Dr Roland Walter. ISDC/INTEGRAL Principal Investigator. Representative of UNIGE within CTA.

Partner number: 6

Organisation name: University of Tübingen, Institut für Astronomie und Astrophysik - Kepler Center for Astro and Particle Physics.

Short name: EKUT

Organisation description:

The *Institut für Astronomie und Astrophysik* of the Karls-Eberhard-University of Tübingen is part of the Kepler center for Astro and Particle Physics. The Kepler Center is involved in many large international enterprises and in several research programs. IAAT is organized in two Departments *Astronomie* and *Theoretische Astrophysik und Computational Physics*. The Astronomical Department constitutes of two Working Groups, Optical and UV Astronomy and High Energy Astrophysics. The latter, led by Prof. A. Santangelo, include 10 scientific collaborators (including post-docs), 15 students at Diploma and Ph.D. level, and about 12 collaborators in the technical and administrative infrastructure, with large and specialized mechanics and electronics shops and engineers. The research focus of the High Energy Astrophysics group is on Space Based X- and Gamma- Ray Astrophysics (current projects include XMM, INTEGRAL, eROSITA, and IXO), and VHE Gamma Rays Astrophysics (H.E.S.S. I and II, and CTA). The group is also participating to space based research for Ultra High Energy Studies (JEM-EUSO, and a UHE Space Observatory for the ESA "Cosmic Vision" program.)

Main tasks attributed:

NA3- Contribute to the settings of standards for VHE analysis; NA4- Availability of resources and the outreach capabilities of the University will be used to contribute to this task; SA3- contribution to low level data analysis; SA4- participation to the design and implementation of the VSG; JA2- Major involvement in the development of a data analysis framework for open VHE data access; JA4- Participate to the analysis, archiving and reformatting of HESS data; JA5 - Participation to the definition of strategies and tools for multi-wavelength analysis.

Previous experience relevant to these tasks:

Design and construction of for Space Based high-energy astrophysics instrumentation. Participation to 17 Balloon campaigns and to satellite developments (HEXE-MIR, ROSAT, ORPHEUS, XMM, INTEGRAL, BeppoSAX) from the early design phase to the final in-flight calibrations. Participation to the developments for H.E.S.S. II with main focus on the mirror control and alignment system, and mirror prototypes calibration and testing. Prototypal studies for the mirror control system and for a digital camera of CTA. Data Analysis and software developments: the scientific activity of the Astronomy Department has been characterized by extensive multi-wavelength data analysis, simulation and modelling on many classes of celestial objects emitting at high energies. These include Stellar Atmospheres, X-ray Binaries with Black Holes and Neutron Stars, AGN, Galaxies, VHE emitters. Such an activity has also required the development of specific filtering, reduction and analysis software from the instrument level to the general user level. The Institute has contributed as formal member to the scientific data centres of the following missions like ROSAT, INTEGRAL and BeppoSAX. It is also strongly involved in the preparation of a fits-based framework for near real-time analysis of high energy astrophysics data.

Key persons:

Prof. Andrea Santangelo, Director of IAAT, Head of the High Energy Astrophysics Section; Group leader of the HESS and CTA IAAT groups; Co-I of the INTEGRAL IBIS and ISDC Teams, of eROSITA, of the WFI and HTRS on-board IXO. European Coordinator of the JEM-EUSO mission.

Akad. Dir. Dr. Eckhard Kendziorra, expert of instrumental developments for High Energy Astrophysics, co-I of the XMM and eRosita missions;

Dr. Gerd Pühlhofer, Scientific Assistant, responsible for IAAT hardware and software contribution to H.E.S.S. II and CTA; strongly involved in TeV and multi-wavelength astrophysics.

Partner number: 7

Organisation name: Nicolaus Copernicus Astronomical Center

Short name: CAMK

Organisation description:

Nicolaus Copernicus Astronomical Centre of Polish Academy of Sciences is the largest astronomical institute in Poland. It employs over forty scientists with PhD degree and it educates more than twenty PhD students. Research is carried out into stellar evolution, the theory of accretion, high energy astrophysics, the dynamics of stellar systems, cosmology, relativity theory, the astrophysics of neutron stars, numerical simulations and other fields, comprising over 30 programmes funded by the governmental Ministry of Science and Higher Education and several international projects. CAMK can confer PhD and doctor habilitatus degrees.

Main tasks attributed:

CAMK and the affiliated CYFRONET computing centre have been among the first contributors supporting the CTA VO within the CTACG project. They will contribute to the tasks related to the development of the CTA low and high level software in GRID.

Previous experience relevant to these tasks:

Large expertise in technical operations of astronomical observatories together with large international projects coordination (CAMK is a current Polish coordinator of the INTEGRAL and HERSCHEL space projects, and SALT optical telescope). Experience in observations, data analysis, and theoretical interpretation of observations from optical (e.g. SALT, WET), X-ray (e.g. INTEGRAL), and gamma-ray observatories (e.g. H.E.S.S., GLAST). Experience in coordination of industry manufacture of parts for H.E.S.S. II. Expertise in large numerical simulations and coordination of numerical calculations with Polish supercomputer centres (Cyfronet, ICM). NCAC is also the European Enabling Grids for E-Science (EGEE) grid site.

Key person:

Dr. Rafal Moderski, associate professor at Nicolaus Copernicus Astronomical Center, Polish H.E.S.S. Coordinator; specialist in high energy astrophysics, relativistic jets, radiation mechanisms

Partner number: 8

Organization name: Istituto Nazionale di Astrofisica (INAF), with participating institutes

- I. INAF-Osservatorio Astronomico di Roma (OAR) with ASI-Science Data Center (ASDC);
- II. INAF-Osservatorio Astronomico di Brera (OABr);
- III. INAF-Osservatorio Astronomico di Cagliari (OAC);
- IV. INAF-Osservatorio Astronomico di Trieste (OATs);
- V. INAF-IASF Bologna (IASF-Bo);

Short name: INAF

Organization description:

INAF is the Italian National Institute for research in astronomy. It is organized as a network consisting of a total of 20 research structures geographically distributed all over the national territory and in Canary Island: the former Astronomical Observatories and Institutes. INAF coordinates and directly finances the astronomical research for the whole non-university based community, therefore more than 90 per cent of the researchers in the field are belonging to INAF (over 600 scientists with a permanent position); furthermore, the large majority of the university researchers working on astrophysics are associated to INAF. INAF has also built and is operating all the national ground-based astronomical facilities. The construction of space-born facilities (satellites and balloons and related instrumentation) is accomplished or coordinated by INAF, under contract with the Italian Space Agency (ASI), or other agencies providing the financing. INAF is involved in astroparticle experiments such as MAGIC, ARGO YBJ, AUGER, etc. INAF is also performing training and educational activities in collaboration with Universities at different levels (master, Ph.D., Post-Doc). The institute is involved in ESO and ESA activities as well as in other important international collaboration. INAF is also participating in many UE programmes in particular having leading roles in several Research Infrastructures. INAF has developed a large competence in the development of the Virtual Observatory (VObs) and on the use of the Grid infrastructure for the Astronomy and Astrophysics community. OATs is a node of the European GRID. Since 2004, INAF has participated in three VObs-related projects funded within the EU Framework Programmes: EuroVO-DCA, VO-Tech and EuroVO-AIDA. Since 2002, INAF is actively engaged in projects, both at national and international level, aimed at fostering the use of Grid technology for astronomical research, through the deployment of computing infrastructure and integration of domain-specific applications. INAF is part of the IGI (Italian GRID Infrastructures) and participated to the national GRID.IT multi-disciplinary project leading the DRACO project, specifically aimed to astrophysics. Since 2004 INAF is also participating in EGEE. INAF is also participating in some national computing resources that are already part of the GRID or will be part in the near future. In particular, INAF-OAC is part of the consortium CyberSar and INAF research structures in Sicily are part of the consortium COMETA. Both consortiums may provide to the INAF projects the access to GRID computing resources.

Main tasks attributed:

INAF will bring its expertise in MAGIC data analysis and in managing astronomical archives and the possibility to access a large amount of data from many different experiments (e.g. Fermi, AGILE, Swift, etc.). The INAF intend to lead the WP JRA5. We will also participate to the SA4 to test the software developed within this WP with data and to the JRA4 to prepare prototype of the MWA using data from MAGIC and H.E.S.S. experiments. INAF will also contribute in upgrading and developing VObs-compliant tools specific for Cherenkov telescopes (and aimed at CTA); in participating in the preparation of upgrades to IVOA standards needed to fit the needs for VObs-compliance of Cherenkov telescopes (SA1, SA2) and in porting of applications on the Grid (JRA2). INAF intends also to take the responsibility of the development of interfaces between CTA infrastructure and the final user (JRA3). INAF will also provide a support to the GRID activities providing access to the computing resources in OATs and OAC and within the CyberSar and COMETA consortia.

Previous experience relevant to these tasks:

In many INAF institutes there is a long lasting experience in multiband data handling from radio to gamma ray as well as in archives of astronomical data. Since a long time, INAF groups at OAR, OATs, OABr and, IASF-Bo are deeply involved in data processing, analysis from both space- and ground- based experiments. ASDC is a multi-mission science data centre cooperating with INAF, INFN, ESA and NASA. A specific agreement between ASI and INAF is on-going to manage the scientific activities and scientific personnel in ASDC. In ASDC there is a large expertise in the development of web based tools for the multi-wavelength data analysis and for the interactive on-line analysis of the data stored in the ASDC multi-mission archive. A good expertise in multi-wavelength analysis and astronomical archives management is also present in OAR and OABr, both institutes are also involved in the MAGIC experiment. The INAF group in OATs is also active in the fields of GRID technologies (deployment of infrastructure and integration of domain-specific applications) and is operating a computing cluster of 80 CPUs and more than 1 TByte of mass memory. OATs leads the VObs.it initiative, which has the purpose of coordinating the Italian publicly-available archives so as to make them compliant with the standards defined within the International Virtual Observatory Alliance (IVOA). VObs.it represents Italy within the IVOA, and the current IVOA Chair is an INAF staff member. IASF-Bologna group participated to the design and development of ground systems for several Space Missions (SAX, XMM, Integral, AGILE). In the Agile mission, this group has developed the system for the whole data archiving and for the quick look analysis which has been exploited along all the payload AIV and calibration campaigns. This group is responsible for the design and development of the Data Center within the Agile Team, and for the development of Pipeline and analysis software subsystems. OAC is mainly involved in the construction of the Sardinia Radio Telescope and within this project its scientist had acquired a large experience in managing huge quantities of astronomical data. OAC is also part, with 2 nodes, of the computing consortium CyberSar with 300+480 CPUs and several tens of TB mass memory.

Key Persons:

Dr. Lucio Angelo Antonelli, *INAF-OAR & ASDC*, expert in MAGIC data analysis and in multiwavelength astronomical archives.

Dr. Stefano Covino, *INAF-OABr*. Part of the MAGIC team, member of the Swift follow-up team.

Dr. Massimo Trifoglio, *INAF-IASF/Bologna*, expert in data format, data archiving and analysis.

Dr. Alberto Pellizzoni, *INAF-OAC*, expert in gamma ray data from satellite, member of the AGILE Team

Dr. Marco Molinaro, *INAF-OATs*, expert in the use and the development of the GRID and in the VObs.

Partner number: 9

Organisation name: Max Planck Gesellschaft

Short name: MPG

Organisation description:

The research institutes of the Max Planck Society perform basic research in the interest of the general public in the natural sciences, life sciences, social sciences, and the humanities. MPG includes 78 institutes, research centres, laboratories and project groups employing approx. 23,400 people. Included in this are approximately 4,300 scientists and 10,900 student assistants, fellows of the International Max Planck Research Schools, doctoral students, postdoctoral students, research fellows and visiting scientists.

The Max Planck Institute for Physics (MPP), in Munich, is structured with 4.5 divisions, each lead by a director of the MPG. The institute has 58 scientists including visitors and postdocs, 55 students at the diploma and Ph.D. level, and 106 persons in the technical and administrative infrastructure, with large and specialized mechanics and electronics shops and engineers. The Experimental Astroparticle Physics Division led by M. Teshima has activities on high-energy gamma-ray astronomy, dark matter search and high energy cosmic rays. The institute is leading the MAGIC project.

Main tasks attributed:

The MPG MAGIC team will lead the low-level data reduction and analysis software developments organised within the WP SA3. MPG will also contribute to the high-level software development and tools for user interface.

Previous experience relevant to these tasks:

MPG will contribute its knowledge and experience in the running of a large Cherenkov γ -ray telescope, specifically the MAGIC experiment at IAC – La Palma in the Canary Islands, Data management and Data analysis in Cherenkov telescopes.

Key persons:

Prof. Dr. Masahiro Teshima, Director at the MPP; Chair of the Collaboration Board

Dr. Robert Wagner, MPP: Coordinator of MAGIC AGN Physics Working group, MAGIC Operations and Safety Coordinator

Dr. Emiliano Carmona, MPP: Responsible for MC studies for MAGIC and CTA, MAGIC Software Coordinator

Partner number: 10

Organisation name: Commissariat à l'énergie Atomique

Short name: CEA

Organisation description:

CEA is a public body in France established to support research, development and innovation, not just in atomic physics, but in all aspects of physical science. The science research division (DSM) of CEA is composed of 3 physics department (Sap: astrophysics, SPP: particle physics and SphN: nuclear physics) and 4 associated technical departments. The physics department has roughly 300 staff physicists, students and post-docs. The technical staff is roughly 450 engineers and technicians.

SAp has a long tradition expertise in multi-wavelength astrophysics, employing a wide range of scientists and engineers whose interests span from theoretical modelling of astrophysical objects to instrumentation and observation in radio through very-high-energy gamma-ray wavelengths. The group is strongly involved in the development and operation of a wide variety of major astrophysical observatories, including: HESS, HESS II, the Fermi Space Telescope, XMM-Newton, HERSCHEL, Planck, INTEGRAL, JWST, as well as future projects such as SVOM, and of course CTA. Members participate in a number of large international collaborations.

Main tasks attributed:

Since SAp provides expertise in existing Cherenkov telescope arrays along with gamma-ray satellites, it is in a favourable position to contribute to develop data reduction and analysis software for CTA that can interface with the astronomy community at large (WPs SA3 and JA2).

Previous experience relevant to these tasks:

The high-energy astrophysics group in SAp brings strong expertise on data analysis and reduction for ground-based Gamma-ray telescopes, with strong experience in both software and hardware for three major Telescopes: the Whipple 10M, VERITAS, and H.E.S.S./H.E.S.S II. Members of SAp are additionally involved in the science analysis software for the Fermi (GeV Gamma-ray), XMM-Newton (X-ray), and INTEGRAL (hard -ray) satellites, bringing together a wide range of multi-wavelength experience. Members are experts in low-level "raw" data reduction, calibration, and high-level science products, covering the entire chain of software needed for a system like CTA.

Key person:

Dr. Karl Kosack - SAp - expert in the processing and analysis of data from atmospheric Cherenkov telescopes (a member of the H.E.S.S. and CTA collaborations), as well as their operation and construction in general, including the development of analysis packages and software coordination.

Partner number: 11

Organisation name: High Energy Physics group (GAE) of the Complutense University of Madrid

Short name: UCM

Organisation description:

The High Energy Physics group (GAE) of the Complutense University of Madrid (UCM), comprises around 15 persons. It is hosted in the Faculty of Physics of UCM, inside the department of Atomic and Nuclear Physics. It was the pioneer group in VHE Astrophysics in Spain, being active inside the HEGRA Collaboration since 1987. Presently, members of the group work inside the MAGIC, AUGER and CTA experiments.

UCM is the largest University in Spain and the Physics faculty also hosts strong groups in Astrophysics, Particle Physics and Computer Science.

The group collaborates with members of the enterprise INSA, which has experience in providing all kind of services to observatory sites, including software development and data diffusion.

The group has experience in the systematic analysis of VHE data, Grid computing and Virtual Observatory developments. Inside MAGIC the group is actually in charge of the onsite processing of acquired data. Data are processed directly at the Telescope site and made available to the collaboration in a few hours after their acquisition. Reduced data are transferred over the network to the MAGIC data center. Members of the group participate in the software development for satellite observatories, including Grid facilities and VObs access.

Main tasks attributed:

The above mentioned areas of expertise can find their application inside the JRA3 and SA3 packages.

Data processing software (SA3): Porting the whole MAGIC quick analysis chain onto Grid standards is one of the present objectives of the UCM group. Man power is already allocated for this project and its logical continuation in CTA resides in the activities planned in SA3.

Data interfaces and interoperability (JRA3): This WP can profit from the relation of members of the group with VObs activities. We can collaborate with other centres in the production of High Level products based on VObs standards. The group can help to port selected samples of MAGIC data to the VObs, act as an interface to software developed for it.

Previous experience relevant to these tasks:

As mentioned above the group has experience in the systematic analysis of VHE data, Grid computing and Virtual Observatory developments. Porting the whole MAGIC quick analysis chain onto Grid standards is one of the present objectives of the UCM group.

Key persons:

Dr. José Luis Contreras - UCM-GAE - Expert in data analysis for VHE experiments.

Dr. Ignacio de la Calle - INSA - Experience in data analysis for VHE (MAGIC and VERITAS) and X-Rays. Organization of Multiwavelength campaigns

Software Engineer. Aitor Ibarra - INSA - Experience in software development for Astrophysics, Grid and VO.

Partner number: 12

Organisation name: University of Leicester

Short name: ULEIC

Organisation description:

The University of Leicester is a leading UK University committed to international excellence through world changing research and high quality, inspirational teaching. Leicester is ranked in the top 5% of universities in the world by two international studies: the Times Higher Education-QS World University Rankings 2008, and the Shanghai Jiao Tong Academic Ranking of World Universities 2008.

The Department of Physics and Astronomy at the University of Leicester in 2010 celebrates 50 years of success in Space Science. It has had instruments operational in space continuously for at least the last 40 years. The Department includes groups leading research in from condensed matter physics to theoretical and observational astrophysics. The X-ray and Observational Astrophysics group, participating in this proposal, has a distinguished record in high-energy astrophysics, having played a leading role in the provision of instruments for and the analysis of data from X-ray observatories such as Ariel-V, Exosat, Ginga, Rosat, Chandra, XMM-Newton and Swift. The XROA group programme now includes of the full range of ground-based and space-based facilities for multi-wavelength astronomy, ranging from the radio to the VHE gamma ray regime, and from exo-planets to the most distant objects in the Universe; it is supported by the Space projects group which is providing components of MIRI on JWST, Bepicolumbo (the ESA mission to Mercury), as well as playing a leading role in ESA's Aurora exploration programme.

The XROA group provides the UK Science Data Centre for the Swift gamma ray burst mission, having provided the X-ray camera. It also leads the XMM-Newton Survey Science Centre, which processes all data from XMM to make high-level science-ready products from individual exposure level up to the overall XMM source catalogue. This catalogue, containing around 250,000 distinct X-ray sources, will remain the largest X-ray catalogue for the foreseeable future. The group was also a leading member of the UK Virtual Observatory project, AstroGrid, which developed much of the infrastructure software and the standards in use today. The group is a research leader in extragalactic and galactic surveys, gamma-ray bursts, active galactic nuclei, normal and star forming galaxies, the Galactic Centre, X-ray binaries and cataclysmic variables, supernova remnants, white, red and brown dwarf stars, and searches for extra-solar planets.

Main tasks attributed:

Contribution of effort to: Data format analysis (NA3), Design and implementation of the grid archive (SA2), Data interfaces and interoperability (JRA3), and H.E.S.S and MAGIC data analysis (JRA4).

Previous experience relevant to these tasks:

The University of Leicester contributes its knowledge of the Virtual Observatory, high energy data conventions, on-line data archive provision, pipeline data processing for high energy astrophysics satellites, and scientific data centre provision in the work packages listed above.

Key persons:

Dr Julian Osborne - Long experience in the provision of on-line data archives for high energy astrophysics & scientific data centres for active international high energy astrophysics projects.

Dr Duncan Law-Green - Expert in the provision of high energy astrophysics data to the Virtual Observatory

Prof J Hinton (from Jan 2010) - Leader of Monte-Carlo simulations workpackage of the CTA design study

Partner number: 13

Organisation name: Dublin Institute for Advanced Studies

Short name: DIAS

Organisation description:

DIAS is an independent statutory body established under the Institute for Advanced Studies act of 1940. It has two primary duties; firstly, the advancement of specialist areas of knowledge and secondly, the training of students in methods of advanced research. It is the only body in Ireland devoted purely to fundamental and advanced research. It is organised in three quasi-autonomous schools of which the largest is the school of cosmic physics with two sections, Astronomy and Astrophysics and Geophysics. The Astronomy and Astrophysics section is the leading Irish research group in its area and specialises in two main areas, high-energy astrophysics and star formation.

In addition to theoretical and observational work, the importance of high-end computation has increasingly been recognised as fundamental to advanced research. The Astronomy and Astrophysics section has been to the fore in developing the national e-infrastructure and was a major player in setting up the Irish Centre for High-end Computing (ICHEC). More recently it is leading the e-INIS project to build an integrated e-infrastructure bringing together advanced optical networking, a federated national datastore, the national grid initiative Grid-Ireland and the computational resources of ICHEC.

Main tasks attributed:

DIAS will contribute to the development of Grid solutions for data management (SA1) and archiving (SA2).

Previous experience relevant to these tasks:

DIAS brings a strong theoretical and observational background in high-energy astrophysics, especially non-thermal gamma-ray and X-ray astronomy, particle acceleration theory and plasma astrophysics combined with experience of grid computing, federated data storage (based on iRODS) and virtual observatories.

Key persons:

Prof. Luke Drury: an expert in particle acceleration theory, a director of Grid-Ireland, member of the oversight board of ICHEC, Director of the e-INIS project.

Prof. Felix Aharonian: a leading world expert in gamma-ray astronomy, member of the Astro-H consortium for hard X-ray astronomy and a key participant in the precursor HEGRA and HESS experiments

Dr Keith Rochford: a computer scientist and coordinator of the e-INIS project. Expert in middleware technologies, data management and federated identity solutions.

II.3. Consortium as a whole

There is significant experience in the design, construction, commissioning and operation of Cherenkov telescopes in the European Community. The project participants represent the most significant experience in the construction and operation of Cherenkov telescopes arrays for current (H.E.S.S., MAGIC, VERITAS) and past (Whipple, CAT, HEGRA) experiments, and also of high energy astronomical observatories (XMM-Newton, INTEGRAL, AGILE, FERMI). The CTA project the first time unifies the research groups working in this field in Europe in a common strategy, resulting in a unique convergence of efforts, human resources, and know-how. An essential aspect is that CTA is viewed as part of an overall multi-wavelength, multi-messenger exploration of the Universe. An essential aspect is that CTA is viewed as part of an overall multi-wavelength, multi-messenger exploration of the Universe.

The consortium is composed of several groups dealing with data management in the current Cherenkov experiments, representatives of the user community and high energy astronomy data providers. In building CORE we are not starting from scratch. A feasibility study of applications of Grid solutions for CTA is in progress within a dedicated CTA Computing Grid (CTACG) project. CTACG is aimed to optimize the application of Grid technology for CTA simulations, data processing and storage, offline analysis and the Virtual Observatory interface through a dedicated global CTA EGEE Virtual Organization. Positive experiences have already been collected through applications of Grid technologies for massive Monte Carlo simulations on distributed computing resources. A fraction of the members of the CORE consortium are involved in the developing virtual observatory on the astronomical side and bring the experience gained to the present project.

CORE critical mass combines all expertise needed to tackle the complex problem of efficiently using the current e-infrastructures and developing user-configured tools and virtual research facilities in preparation to CTA. It gathers all the skills needed by this challenging project. The result is a Consortium that represents well the variety of the knowledge necessary for a successful completion of the challenge we want to face.

The consortium will promote collaboration at the technical and management level to ensure the broadest possible usage of the formats and conventions being developed in the frame of this project.

Many of the partners have an objective track record of successful collaborations among each other in the past. The technical and organizational skills are also well represented, and, as a whole, we believe this is the best-balanced Consortium in order to bring CORE to a success.

i) Sub-contracting: No subcontractors

ii) Other countries: No other countries

iii) Additional partners: No additional partners from outside the EC

II.4. Resources to be committed

The estimates for the required effort are based on the experienced gained by the project participants in similar previous projects. Contributions requested to the EC, according to the A forms, include:

Personnel costs:

The estimated total resources needed for all work packages is 1109 PM of which 50% are resources provided by the participating institutes. Proper coordination of the work packages is therefore essential also given that a fraction of the manpower quoted is engineers, where effective interfacing to the scientists is essential.

The CORE partners have estimated the total cost of this ambitious project above 10 MEUR. Though the EC rules would allow for a maximum EC Contribution of more than 7 MEUR, the consortium of institutes supporting CORE affirms its strong own commitment (especially via personnel staff) with a funding request limited to 4046940 Euros, to cover the necessary cost items described in this part. The EC contribution will be applied as follows:

- 14% (585 949 Euros) are used for Networking activities (with 7% especially devoted to Management, NA1);
- 29% (1 188 878 Euros) are used for Service Activities;
- 56% (2 272 113 Euros) are used for Joint Research Activities

Travel costs:

Travel costs to meetings vary between work packages and have been estimated as 5 k€ per PY. In addition 10 k€ per year is needed to support the presentation of the project at various conferences. We have also planned 25 k€ to encourage long exchanges of personnel between the participating institutes and 25 k€ to allow inviting experts from non participating institutes involved in the field to participate to specific meetings (especially concerning computing model, data archive model and operating centres architecture).

Other direct costs:

The computing power required for data preservation and reformatting will be provided by the participants. We also plan 10 k€ for outreach material and 4 k€ for the financial audits of the project.

The manpower requested to the EC will be imbedded in the collaborating institutes. We will encourage exchange of personnel between these institutes during the project to optimize cross fertilization and scientific collaboration. The manpower will partially consist of post docs. The project will therefore impact on the training of young scientists and participate to the development of the community.

In the following table we propose the equivalent consolidated investments of partners to support the CTA VO with Computing Elements (C.E.) and Storage Elements (S.E.) in the period 2008-2010 and the progression foreseen in 2011. Costs are computed based on reference grid of average values provided by IN2P3 and then applied to all Work Nodes.

YEAR	CONSOLIDATED EQUIVALENT INVESTEMENTS IN C.E. AND S.E. (personnel cost is not included)
2008	380 kEUR/Year
2009	650 kEUR/Year
2010	850 kEUR/Year
2011	> 1 MEUR/Year

This table demonstrates the important increasing efforts of national institutes to provide the computing resources required for the first part of the CTACG project and further more to fulfil the requirements of the CORE project.

III. Impact

III.1. Expected impacts listed in the work programme

The CORE project aim to implement an integrated strategy for e-infrastructures application in order to achieve the main goal of making Cherenkov array data and analysis methods available to all astronomers. The main objectives of the CORE project respond to the topics and contribute towards the expected impacts of the INFRA-2010-1.2.3 call as it was synthetically mentioned in I.1.3.

Increased effectiveness of European research through the broader use of e-Infrastructures by research communities

The application of GRID solutions, e-infrastructures and related services are proposed for an efficient and high performance data handling, based on a modern and innovative computing environment with a high acceptance in the astronomical community. GRID allows conjugating the observatory-wise CTA research infrastructure, the open access to European distributed computing infrastructures, and the open access approach to data and tools for scientific research.

The GRID framework, as already experienced in the first part of the CTA Design Study phase through the CTACG project, increases the effectiveness of the efforts and supports the federative participation to the research activities of scientists towards common scientific objectives. The CORE project will further strength the added value offered by a broad use of GRID e-infrastructures providing the way to make more effective the access to gamma-ray data of the CTA Observatory.

The CORE project proposes a new combination of the EGEE Grid, the GÉANT network, and the Virtual Observatory to provide a series of end-to-end services which will foster the effectiveness and the potential of the scientific return of the CTA infrastructure exploitation. Investigation of the application of European networking e-infrastructures (GÉANT) are considered in CORE as a critical aspect toward the preparation of the CTA Observatory Data Centres. It will guarantee the technical bridge to the effectiveness of an ESFRI project like CTA, which is foreseen to consist of two sites and be built on an extra-Europe host country. Furthermore the networking is the way to complement the GRID infrastructures making the sharing approach of computing resources and services more factual.

We recall that clear investments of participating countries, through the last ASPERA funding call, towards the first milestones of construction of CTA prototype components and subsystems, make even more important and coherent to fulfil the CORE objectives. The e-infrastructures

application strategy implemented through the CORE project will integrate the validation and prototyping phase of CTA and will increase, within the right time scale of the CTA project, the effectiveness of the corresponding research program.

The emergence of virtual research communities of European and international dimension that cannot be achieved by national initiatives alone

CTA is not only a future large European infrastructure within the ESFRI roadmap, CTA represents historically the convergence of a large community of physicists towards a European coordination and a consortium motivated by the common challenge to initiate a new scientific discipline (where Europe has been pioneer and today is world-leader): the high energy gamma ray astronomy.

Such an objective will be supported by a world-wide virtual research community which will exist largely in cyberspace, unconstrained by barriers of time and place, to provide to the global astronomical community with the CTA gamma-ray data and services for scientific analysis. This is the final aim of the CTA Observatory.

A virtual research community in the sense of a community of scientists working together linked by information and communications technologies and with the purpose of delivering the services and the products of the CORE project is the intrinsic motivation of the CORE proposal itself.

The first two years of prolific cooperation within the context of the CTA design study have triggered the emergence of a virtual community sharing the competences and the outstanding complementary results in the gamma-ray context achieved from all actual running Cherenkov telescope systems. With the CTA EGEE-VO all members of the CTA consortium have experienced how impossible was to fulfil the objectives of Monte Carlo simulation studies, the development of common data analysis software, tools and services at the limited level of a single institute or even a single country. The CORE proposal is aimed by the need of increasing the effectiveness of this virtual community to build up the right framework to improve cooperation and preparation of the CTA observatory

Easier development and adoption of standards, common tools, procedures and best practices

The CORE project will help to improve and accelerate the adoption of common astronomical research tools and practices by the VHE gamma-ray community. Providing the data and software in formats commonly used in astronomy, our project will create a highly competitive environment where young scientists should be able to train themselves by analyzing very high-energy data to be confronted to very demanding data analysis techniques and physical phenomena at the frontier of astronomy. The CORE project will provide a data repository, analysis software, archive interfaces and interoperation of the data repositories with other astronomical data centres through the GRID e-infrastructures and the VObs file and information transfer protocols. Our integrated services will be based on the use of the European GÉANT networking infrastructure. The integrated services, to be developed, aim to provide all scientists an easy-to-use controlled access to unique scientific facility. The project will also develop the relevant standards for data storage, archiving, access, and management activities.

The CORE virtual community will face the study of interoperability aspects between the GRID and the scientific instrumentation (the CTA telescopes) making possible the monitoring and the remote control of telescopes and related astronomical instrumentation of the Observatory. Furthermore the GRID enabled access interface to wide spread of data sources and computing infrastructures is a critical issue for the CORE project. These are just two examples of a series of tools, services and procedures which will be explored and developed in CORE but in total respect and coherence with already existent tools and common standards already in place within the EGEE “RESPECT program” and in synergy with the A&A EGI-SSC.

Use of e-Infrastructure services and tools by actors from new disciplines and scientific communities, increasing quality and attractiveness of e-Infrastructures

The astroparticle physics is the field of research at the intersection of particle physics, astrophysics and cosmology. Gamma-ray astronomy is one of the most active topics in astroparticle physics involving both the particle physics community and the astronomical community leading to the design of new types of research infrastructures.

The CORE proposal has been conceived by partners from these two communities and willing to make CTA the example of astroparticle physics application in GRID which conjugates the long-term presence and experience in EGEE of the particle physics community and the more recent and growing activities of the astronomical community mainly devoted to the GRID solutions for public distribution of observatory data. CORE is aimed by the action already taken to support the astronomical community to the right use of GRID e-infrastructures for the Observatory purposes and in the same time will support the particle physics community towards the application of the GRID paradigm with the final objective of providing the service of open access to data to a world-wide community and not simply a mutual applications of computing resources for the purposes of a restricted research community. The CORE project will be the platform of mutual exchange of complementary tools and know-how among different disciplines and scientific communities for a coherent project implying ICT-based infrastructures.

The purpose of the CTA virtual community as expressed in the objectives of the CORE project is to follow the path already at work in ESA, aiming to make effective the natural link among Science Archives, EGEE-Grid and VObs by proposing the common EGEE-middleware for the data management; the Grid porting users' software for data analysis and providing open access to important computing resources for the on-the-fly reprocessing from the archives. This is the paradigm which manifestly makes the synthesis of the experiences and best practices of e-infrastructure services from different communities and which was motivated by the attractiveness of the GRID technology for e-science.

The partners of the CORE project are convinced of the increasing attractiveness of the adopted e-infrastructures applications. Such a perception is shared already in the CTACG project, where such attractiveness has taken place; it has improved remarkably the quality of the cooperative work by an increasing sharing of resources in support of the CTA EGEE-VO; it has motivated the consequent conception of new ideas for services development and analysis software for the best use of the VO for the gamma-ray data analysis purposes. Now such attractiveness has been the main motivation of the CORE partners in preparing this proposal.

III.2. Dissemination and/or exploitation of project results, and management of intellectual property

All the results of the CORE activities will be made available, because intrinsically oriented to a world-wide community, at no cost to the community at large, in particular the data, the services and the analysis software built in the framework of this project.

The progress and results of the project will be made publicly available and will be presented at conferences and workshops. Integrated services and related technologies as presented in the proposal will also be made public. The integrated service will only make available public data. Results from the various CORE activities will be presented and documents will be made available for the CORE and for the world community. The CORE website will contain information on the CORE structure and activities, including work package meetings, board meetings etc. The results of the work packages (reports, publications etc.) will be posted on the website. Other information and links (workshops, conferences) related to the high-energy astronomy and astroparticle physics will be posted on the website and mailing lists will be used to disseminate the information.

Finally the VHE Gamma ray Science Gateway – one of the deliverable of the CORE project is the syntheses where through a web interface all levels of services, data and computing resources will be open to the world without any sever restriction but only one single fundamental requirement: the curiosity.

III.3. Contribution to socio-economic impacts

Thanks to the sharing of resources already in place as well in any EGEE project as in CTA, the consequent strategy adopted by the VHE gamma ray Virtual Community for data management will guarantee the easiest and cheapest involvement of institutes and countries with less immediate access to computing infrastructures in the activities of the CORE project. The virtual community behind the CORE project will produce a considerable impact to the capacity of even a single scientist to be socially determinant through the results of his research. In fact the CORE project will finally provide services and tools to develop the awareness of gamma-ray astronomy at global level and in the same time will provide tools and services which will remove obstacles and inequalities among institutes and countries on the mere basis of corresponding financial resources. The open data access and the free use of software and hardware for analysis at any level of expertise will impact on the capacity on any single scientist, thanks to the general support that the virtual community, behind the CORE project, will provide.

IV. Ethical issues

There are no specific ethical issues associated with this proposal. Concerning gender issues, the institutions involved are committed to gender equality and are prepared to support female scientists, who are at least in certain countries still underrepresented in this field of science.

The Consortium will promote best practice in employment and genders issues across the partners.

ETHICAL ISSUES TABLE

	YES	PAGE
Informed Consent		
• Does the proposal involve children?		
• Does the proposal involve patients or persons not able to give consent?		
• Does the proposal involve adult healthy volunteers?		
• Does the proposal involve Human Genetic Material?		
• Does the proposal involve Human biological samples?		
• Does the proposal involve Human data collection?		
Research on Human embryo/foetus		
• Does the proposal involve Human Embryos?		
• Does the proposal involve Human Foetal Tissue / Cells?		
• Does the proposal involve Human Embryonic Stem Cells?		
Privacy		
• Does the proposal involve processing of genetic information or personal data (e.g. health, sexual lifestyle, ethnicity, political opinion, religious or philosophical conviction)		
• Does the proposal involve tracking the location or observation of people?		
Research on Animals		
• Does the proposal involve research on animals?		
• Are those animals transgenic small laboratory		

animals?		
• Are those animals transgenic farm animals?		
• Are those animals cloned farm animals?		
• Are those animals non-human primates?		
Research Involving Developing Countries		
• Use of local resources (genetic, animal, plant etc)		
• Impact on local community		
Dual Use		
• Research having direct military application		
• Research having the potential for terrorist abuse		
ICT Implants		
• Does the proposal involve clinical trials of ICT implants?		
I CONFIRM THAT NONE OF THE ABOVE ISSUES APPLY TO MY PROPOSAL	YES	

V. Appendix

V.1. Letters of support

Letters of support from the following main European e-infrastructure projects/organizations are included in the next pages:

- Enabling Grids for E-scienceE (**EGEE**)
- International Virtual Observatory Alliance (**IVOA**)



Mail address:
Bob Jones
CERN, IT Department / EGE group
CH-1211 GENEVE 23
Switzerland

E-mail: bob.jones@cern.ch

Votre référence/Your reference:
Notre référence/Our reference: LoS CORE

Giovanni Lamanna
lamanna@lapp.in2p3.fr
**Laboratoire d'Annecy-le-vieux de
Physique des Particules**

Geneva, November 11, 2009

Dear Dr Lamanna,

On behalf of the EGEE-III project, I hereby state my support to the **CORE (CTA Observatory Research E-infrastructure)** project proposal. CORE foresees to establish an ICT infrastructure for the future Cherenkov Telescope Array (CTA) facility. The EGEE-III project deploys a production grid infrastructure across 300 sites in 45 countries which is used by more than 12 000 researchers in a wide variety of scientific disciplines. CTA has been using the EGEE infrastructure since 2008 for simulation studies.

The European Grid Initiative (EGI) will establish a sustainable grid service for the European scientific community, through the creation of a long-term, pan European grid infrastructure. The interaction between ESFRI projects like CTA and pan European e-Infrastructures, like EGI, are essential to build and instrument the European Research Area.

My colleagues and I wish CORE every success.

Yours sincerely,

Bob Jones
EGEE-III Project Director



International Virtual Observatory Alliance

Dr. Fabio Pasian, IVOA Chair

Address:

Osservatorio Astronomico di Trieste

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I 34143 – Trieste – Italy

pasian@oats.inaf.it

Trieste, 16 November 2009

Dr. Giovanni Lamanna

LAPP

Laboratoire d'Annecy-le-Vieux de Physique des Particules

Chemin de Bellevue

B.P. 110

F-74941 Annecy-le-Vieux Cedex

Subject: IVOA support to the CORE proposal

Dear Dr. Lamanna,

thank you for your document describing the CORE (Cta Observatory Research E-infrastructure) project, to be submitted to the Seventh Framework Programme of the European Union (EU/FP7), and its inter-relations with the international Virtual Observatory (VOs).

As you certainly know, the International Virtual Observatory Alliance (IVOA) is planning to expand its scope, both in terms of usability and involvement of different national and disciplinary communities. It is important for the development of astronomy that scientists become as much as possible aware of the advantages the VOs can bring to their everyday work, and are willing to share data and expertise with other members of the VOs world. The IVOA has organised a Liaison Committee which is expected to foster coordination and cross-fertilisation with neighbouring scientific domains. In particular, liaison with High-Energy Astrophysics and possible integration of activities is ranked high in the priorities of the IVOA.

The following activities CORE intends to implement are of particular interest to the Virtual Observatory:

- to make effective the natural link among CTA Science Archives, the Grid (EGEE, in your case) and the VOs;
- to design and implement software to analyse archived data compatible with other existing large high energies experiments (data format, tools, and user's point of view) and to provide gamma-ray Cherenkov data and on-line physics modelling software tools to astronomical users through the VOs framework;
- to develop interfaces between the CTA archive and data at different wavelengths and from different experiments (a Multi-WaveLength on-line archive);



- to upgrade the characterizing formats of archived data into the IVOA standards by adding specific Cherenkov gamma-ray data requirements (e.g. VObs capacity to deal with time flagged data);
- to develop a common “vocabulary” to be used in the implementation of tools to analyse the data, leading to an extended and comprehensive data-model to be adopted in different communities;
- to provide service and support to the community for IACT data analysis purpose as well as tutorials and training courses to new users increasing trans-national and sustainable access to EGEE-Grid and IVOA e-infrastructures.

These activities are very much in line with the IVOA aims and interests. In particular, they map well into a number of IVOA Working Groups defining standards: data formats are of interest to the Data Access Layer and the Data Model WGs, tools to the Applications WG, vocabularies to the Semantics WG, the link between Grid and VObs to the Grid and Web Services WG and to the Astro-RG group, which represents the IVOA in the Open Grid Forum (OGF).

It is therefore my pleasure, as Chair of the IVOA, to express my support to the CORE project, and to express the IVOA interest to liaise and collaborate with it.

Kindest regards,

A handwritten signature in blue ink, which appears to read "F. Pasian".

dr. Fabio Pasian, IVOA Chair