Cherenkov Telescope Array (CTA)

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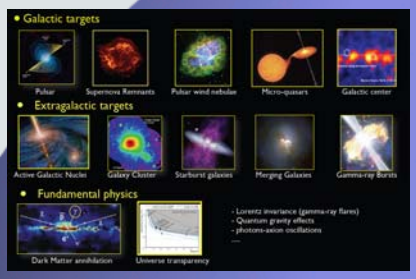
for the CTA consortium

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 Cherenkov Telescope Array - CTA - is a proposed new project for ground based gamma-ray astronomy. CTA is an example of astroparticle physics application in Grid which conjugate 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. In the context of the CTA design study some activities are in progress (e.g. Monte Carlo simulations, data format definition and archiving) in EGEE and some perspectives of implications of ICT-based infrastructures such as the future EGI for the needs of a project like CTA are under investigation.

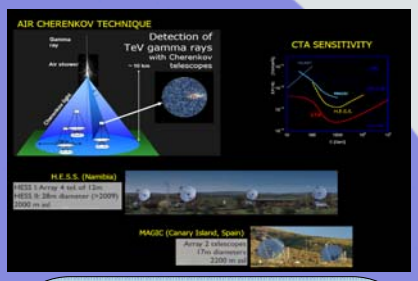


CTA

The Cherenkov Telescope Array (CTA) [1] is a proposed new project for ground based gamma-ray astronomy planned to consist of several tens of large Imaging Atmospheric Cherenkov Telescopes (IACTs). The outstanding results obtained by current European ground-based very high energy (VHE) gamma-ray experiments, like H.E.S.S. (High Energy Stereoscopic System) [2] and MAGIC (Major Atmospheric Gamma-ray Imaging Cherenkov) [3], have generated considerable interest in both the astrophysics and particle physics communities and have spawned the urgent wish for a next-generation, more sensitive and more flexible facility.

CTA stands for an initiative to build the next generation ground-based gamma-ray instrument, which is supposed to serve as an open observatory to a wide astrophysics community.

The observatory will consist of two arrays: a southern hemisphere array to allow, in particular, for a deep investigation of galactic sources, and a northern hemisphere array dedicated mainly to northern extragalactic objects.
The final layout of the arrays such as the exact number of telescopes, their sizes, their configuration and the overall performance are still under investigation using detailed Monte Carlo simulations as well as technical feasibility studies for individual components. To reach the required sensitivity several tens of 3 different sized telescopes might be needed to cover the intended range in gamma-ray energies. The CTA consortium is performing a Design Study (DS) for the optimization of the performance of the planned observatory and to study its possible implementation. The CTA consortium is meeting the challenge of an intense activity dedicated to the design study which started in 2008 and which aims to result in 2010-2011 in the commissioning of prototype telescope(s) that meet the requirements.
Implementation of the array could start after first verifications with these prototypes, from 2013 to 2018, with the observatory start running in 2014.

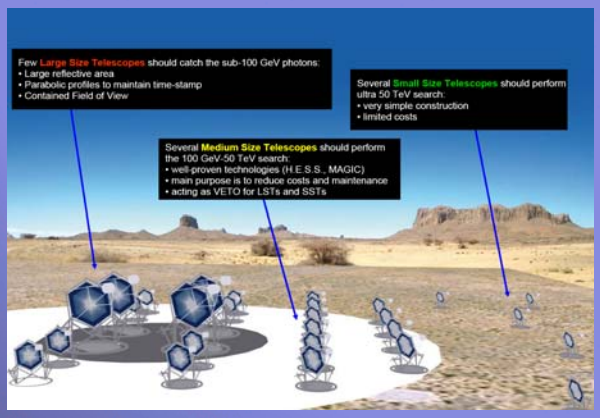


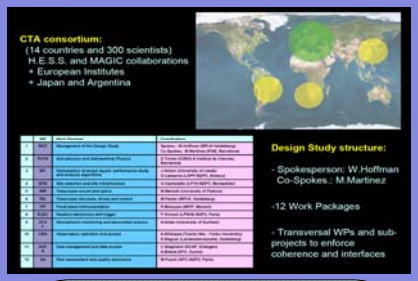
Gamma-ray astronomy

Gamma-ray astronomy probes the non-thermal phenomena in the universe, where cosmic ray (CR) particles are accelerated to extremely high energies. Gamma rays are neutral, thus they travel undisturbed by inter-stellar or inter-galactic magnetic fields and therefore trace back their origin, while they interact with local radiation/dust fields thus providing useful information on the morphology of the emission region. A clear physics potential of this field has been demonstrated, which is not only restricted to pure astrophysical observations, but also allows significant contributions to the field of particle physics and cosmology.

VHE IACTs

VHE γ-rays interacting with atmospheric nuclei, generate an electromagnetic shower. The showers extend over several kilometres in length and few tens to hundreds of meters in width, and their maximum is located at 8−12 km altitude. For energy < 100 TeV, a sizeable fraction of the charged secondary shower particles move with ultra-relativistic speed and emit Cherenkov light. Imaging Atmospheric Cherenkov Telescopes (IACTs) reflect the Cherenkov light at the focal plane where a multi-pixel camera records the shower image. CTA foresees a factor of 10 improvement in sensitivity compared to the current European IACT systems (H.E.S.S. and MAGIC) in the energy domain of about 100 GeV to some 10 TeV and an extension of the accessible energy range well below 100 GeV and to above 100 TeV.



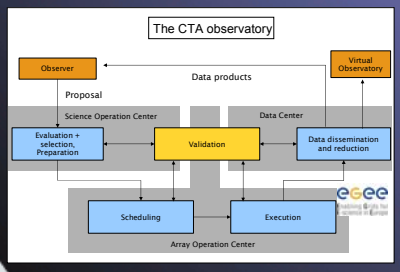


Design Study

The CTA consortium is performing a Design Study (DS) for the optimization of the performance of the planned observatory. The DS is focused on currently available technology, explores and compares different solutions already adopted by current IACT systems and keeps open the option for future upgrades with new technology. The primary targets are:
- to narrow down the multidimensional space of design options, optimizing the relation between performance and cost of the facility;
- to lay out a clear path for how such a facility can be constructed and operated;
- to build and test prototype telescope(s) that are suitable for mass production for a large array of telescopes.

The CTA Consortium

The CTA consortium is a partnership between the H.E.S.S. and MAGIC collaborations plus several European institutes and recent interest from world-wide institutions. Activities are coordinated and discussed with the USA AGIS (Advanced Gamma-ray Imaging System) scientists, who work on a similar project. The consortium hosts already around 50 institutes, 14 countries and 300 scientists.
The CTA Design Study is performed within a set of 12 work packages, which are defined to allow for a well-focused work on the specific sub-tasks. The coordination of the work in each package and the supervision of their work plans, as well as the interfacing to the other work packages is done by a management team of experts



The CTA Computing Grid project

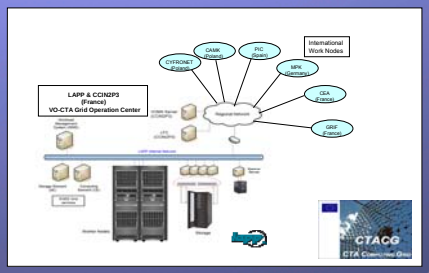
CTA is an astroparticle physics research infrastructure aimed to work as an observatory, which provides observatory services and tools thus making gamma-ray astronomy accessible to the entire international community. The CTA consortium has started exploring the ICT-based infrastructures to be implemented for the CTA observatory purposes and in particular the corresponding applications in the context of: intercontinental data transfer, data reduction and data storage; distributed resources for data calibration, analysis and reprocessing; storing/retrieving approaches for data in open access format (e.g. FITS, Flexible Image Transport System); setup and execution of complex work-flows.

CTA Computing Grid (CTACG) [4] is sub-project of the CTA Design Study dedicated to these specific topics and aiming at optimizing the application of Grid technology for the CTA simulation, data processing and storage, offline analysis and the Virtual Observatory interface through a dedicated global CTA EGEE Virtual Organization.

Positive experiences have already been achieved through applications of Grid technologies in the context of services for distributed computing resources exploitation for Monte Carlo studies.

The main issues inherent to the observatory work flow, which could benefit of Grid applications and which concern the CTACG project are:

1) Monte Carlo simulations;
2) Data flow, data transfer and storage;
3) Data reduction, data analysis and open access.



The Observatory

The three main sub-systems of the CTA observatory are: the *Science Operation Center*, taking over all management tasks related to organization of observations (e.g. evaluating, selecting and technically preparing the observation proposals); the *Array Operation Center* which is the on-site service in charge of operating (through scheduling and execution of the approved observations) and monitoring the telescope array; the *Data Center*, is the place for software development and data analysis and its tasks are data reduction, data archiving and data dissemination to observers.

Existing ICT-based infrastructures, such as EGEE, are potential solutions to provide the CTA observatory with best use of e-infrastructures for the specific data management purposes of these three sub-systems.

[1] CTA, http://www.cta-observatory.org/
[2] H.E.S.S., http://www.mpi-hd.mpg.de/hfm/HESS/
[3] MAGIC, http://wwwmagic.mppmu.mpg.de/
[4] CTACG, http://lappwiki01.in2p3.fr/CTA-FR/doku.php?id=cta-computing-grid-public
[5] LAPP, http://www.lapp.in2p3.fr/
[6] CCIN2P3, http://cc.in2p3.fr/

GRID applications: MC simulations and analysis

The final layout of the CTA array such as the exact number of telescopes, their sizes, their configuration and the overall performance are investigated using detailed Monte Carlo simulations requiring important computing resources and easy distributed data access for the analysis. The need to fulfill such requirements has motivated the Grid-approach. The CTA EGEE Virtual Organization was created in 2008 by the LAPP-CTA [5] group which, in cooperation with the IN2P3 Computing Center (CCIN2P3) [6], has the role of CTA-VO Grid Operations Center (CTA-GOC) taking over the management tasks, responsible for the Grid-operations coordination and the workload management.
The CTA VO is now supported by 12 sites from 4 countries and currently exploited by more than 30 users from more than 15 institutes and more than 7 countries.

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