Cherenkov Telescope Array

Unveiling the violent universe

I. de la Calle, J.L. Contreras and M. Martinez on behalf of CTA-Spain

The International CTA Consortium

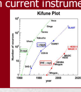
Astronomy and particle astrophysics with very high energy (VHE) gamma rays

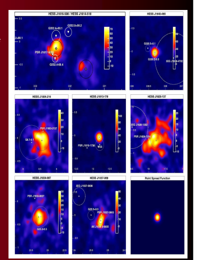
The universe is a unique laboratory to study fundamental physical processes at extreme energies, well beyond any energy scale that can ever be reached with accelerators on Earth. Gamma-ray astronomy at high energies (VHE) probes the non-thermal universe at Tera-electronvolt energies by tracing populations of high-energy particles in distant regions of our own and other galaxies, allowing to address key issues in areas of astronomy, astrophysics and fundamental physics.

The Physics case for CTA

- **Investigation of the most energetic processes in the Universe**
- **Understanding the cosmic particle accelerators**
- **Mapping the energy density of cosmic rays in the Galaxy**
- **Probing the environment of black holes and neutron stars**
- **Cosmology and the history of galaxy formation**
- **Probing the validity of fundamental physics laws at extreme energies**
- **What is the origin of Dark Matter ?**

VHE gamma-ray astronomy has grown to a genuine branch of astronomy, allowing imaging, photometry and spectroscopy of sources of high-energy radiation. Source types include supernova, pulsar wind nebulae, binary systems, stellar winds, various types of Active Galaxies as well as sources without an obvious counterpart. It is expected that CTA will discover more than 1000 TeV-gamma-ray sources - galactic and extra-galactic - a factor of >10 more than those detectable with current instruments.

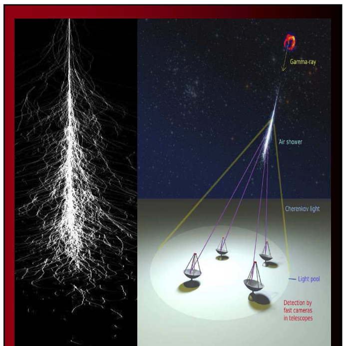




VHE sources from the H.E.S.S. survey of the central part of our galaxy

Detecting VHE gamma-rays

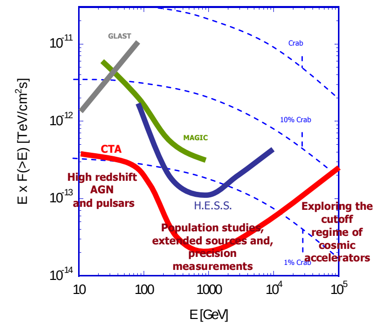
The Imaging Atmospheric Cherenkov Technique



When highly energetic cosmic particles hit the atmosphere, cascades of relativistic particles are generated *(left)*. These cascades emit faint flashes of Cherenkov light with nanosecond duration. Large telescopes focus the Cherenkov light onto fast photo-sensor arrays where the signal is read out. With stereoscopic observations using several telescopes *(right)* the properties and direction of the primary particle can be reconstructed with high accuracy, and gamma rays coming from sources can be identified.

Sensitivity of CTA

Modern telescopes, using the IACT pioneered by the Whipple Collaboration (US), can detect fluxes down to 1% that of the Crab Nebula.



The Cherenkov Telescope Array (CTA)

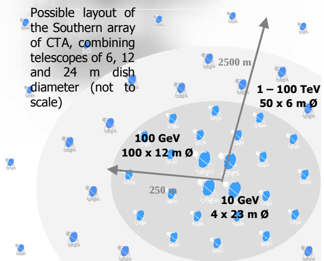
The great success of current generation instruments (H.E.S.S., MAGIC and VERITAS) has demonstrated the great potential of the young field of TeV gamma-ray astrophysics. In order to fully exploit this potential and serve a wider community of users, the next generation instrument CTA aims at providing a significant performance improvement in spectral coverage, angular and timing resolution and operability.

- **Extended energy range, from some 10 GeV to some 100 TeV**
- **Factor 10 improved sensitivity at TeV energies**
- **Improved angular resolution down to 1-2 arcmin**
- **Factor 5 - 10 higher effective area; higher detection rates**
- **Temporal resolution in the sub-minute timescale**
- **Improved survey capability and full-sky coverage**
- **Optimized for reliability and robotic remote operation**

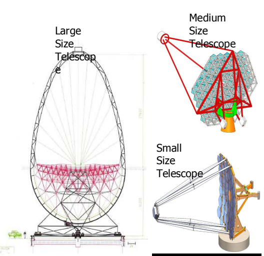
In order for CTA to achieve the envisaged performance, a large array of Cherenkov telescopes, between 50-100, of different sizes and distributed over an area of >1 km2 will be needed. The array will operate in a wide range of configurations depending on the nature of the scientific goals.

CTA will have full-sky coverage, by constructing two sites, one in the Northern and one in the Southern hemisphere and for the first time in this field, will work as an open observatory. The sites will be operated by one international consortium, and unlike current experiments, CTA will host its own Science Data Centre, where the data will be stored, made public and accessible through the Virtual Observatory.

Possible layout of the Southern array of CTA, combining telescopes of 6, 12 and 24 m dish diameter (not to scale)



CTA Telescope Technology: Facing the challenges

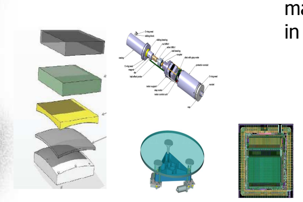


Design of telescope structures; concepts for safety and robotics

The development of cost effective, high-performance components for the *CTA* telescope array is a major technological challenge. Examples are:

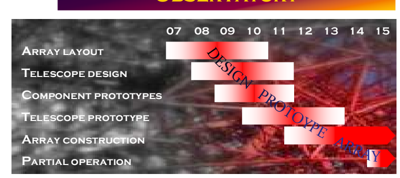
- **Construction of 50–100 optical telescopes with dish sizes of ~6, ~12 and ~24 m for robotic operation with maximum reliability**
- **Production of ~ 70 m² photo sensitive area with nanosecond response**
- **Development of high speed cameras with >100 000 electronics channels to be operated in a rough environment**
- **Development of production techniques for 10 000 m² focusing mirrors**
- **Data handling of up to 50 GByte/sec**

The CTA consortium meets these challenges in a *Design Study* that is jointly performed by all major European and international groups, and in cooperation with the industry.



Development of new production techniques for mirrors at large scale. Development of micro-electronics and photon detectors; custom designed ASICs

Timeline towards the CTA Observatory



A Joint International Approach

The CTA observatory as world-class research infrastructure will be open to the scientific community. The project directly involves more than 500 scientists from over 120 institutes across Europe, America, Asia and Africa. CTA is top ranked in the roadmaps of ASPERA and ASTRONET for future projects in particle astrophysics and astronomy. CTA is included in the 2008 update of the roadmap of the European Strategy Forum on Research Infrastructures (ESFRI). For further reading: arXiv:1008.3703

CTA–SPAIN is the Spanish branch of the CTA consortium. It is composed of groups working at ICE-ICCM, IFAE, UAB and UB (Barcelona), CIEMAT, UCM-ELEC and UCM-GAE (Madrid), IAC (Canary Islands) Around 50 persons currently actively contribute to this Effort and participate in the starting preparatory Phase work. A dedicated coordinating group is currently being formed in the RIA (Red de Infraestructuras de Astronomia) to study the implications for Spain of its participation in CTA.

The CTA-SPAIN Consortium explicitly invites interested members of the astrophysics communities to join this effort.

Contact:

http://www.observatorio-cta.es/, http://www.cta-observatory.org/