



THE CTA site search

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Abstract: CTA will be the next generation of Imaging Atmospheric Cherenkov telescopes. With an increase of about a factor of 10 in sensitivity, it is predicted that CTA will discover over 1000 sources emitting very high energy gamma rays. The task of selecting the optimal sites (one in the Northern Hemisphere and one in the Southern one) for CTA is not a trivial one since the performance of CTA will strongly depend on this decision. It would be desirable to choose the best skies in the World. However there are many other factors that play a major role in the final decision of the sites. In this paper we present the CTA site requirements (as they appear in the already released Call for Proposals) as well as the different factors to be considered in the final decision of the sites. We also present the work in progress carried out by the CTA SITE Work Package as well as the sites that are already under consideration in both Southern and Northern Hemisphere.

Keywords: gamma rays, observatories

1 CTA site

1.1 CTA

Imaging Atmospheric Cerenkov Telescopes (IACTs) are ground based telescopes that observe the Universe in very high energy (VHE, 30 GeV - 30 TeV) gamma rays. They use the atmosphere as part of the detector. When a VHE gamma enters the atmosphere it interacts with its molecules generating a particle shower that travels faster than light in this media, emitting thus Cerenkov light. The telescopes capture this very faint and brief Cerenkov light making an image of the particle shower. From the amount of light and shape of this cascade Cherenkov image detected the energy of the primary gamma as well as its arrival direction are derived. Due to the spectacular success of the current IACTs (with HESS, MAGIC and VERITAS leading the field) that have already detected over a hundred VHE gamma sources, there is a desire in the scientific community to build the next generation of this kind of telescopes. Over eight hundred scientists and engineers from 25 countries have joined their effort to fulfill such a desire designing CTA, the Cerenkov Telescope Array. CTA aims to provide continuous energy coverage from tens of GeV to over 100 TeV increasing the sensitivity by an order of magnitude around 1 TeV. It also aims to improve the angular and temporal resolution and to provide whole sky coverage by building one observatory in each Hemisphere. CTA will be

the first IACT operated as a proposal-driven open observatory.

1.2 SITE

The scientific output of CTA will strongly depend on the sites in which it is located as the weather conditions and quality of the atmosphere (part of the detector) greatly vary from site to site. Apart from the atmospheric conditions that determine the quality of the observations directly affecting daily CTA performance, there are also other criteria very relevant for the site selection such as geographical location, existing infrastructure or availability of the land.

The most important issues related to weather conditions are:

- The fraction of clear nights of CTA sites must be high. Good sites have well above 60% clear nights and the best sites up to 80% clear nights. For the IACTs it is desirable that it rains sometimes because this cleans the mirrors that are completely exposed. Hail on the other hand represents a danger as it can damage the unprotected mirror surface. Snow and ice on the telescopes hinder the observations and would require a heating system in the mirror structure increasing the overall cost of CTA. There is also a maximum snow load for survival of the telescopes.

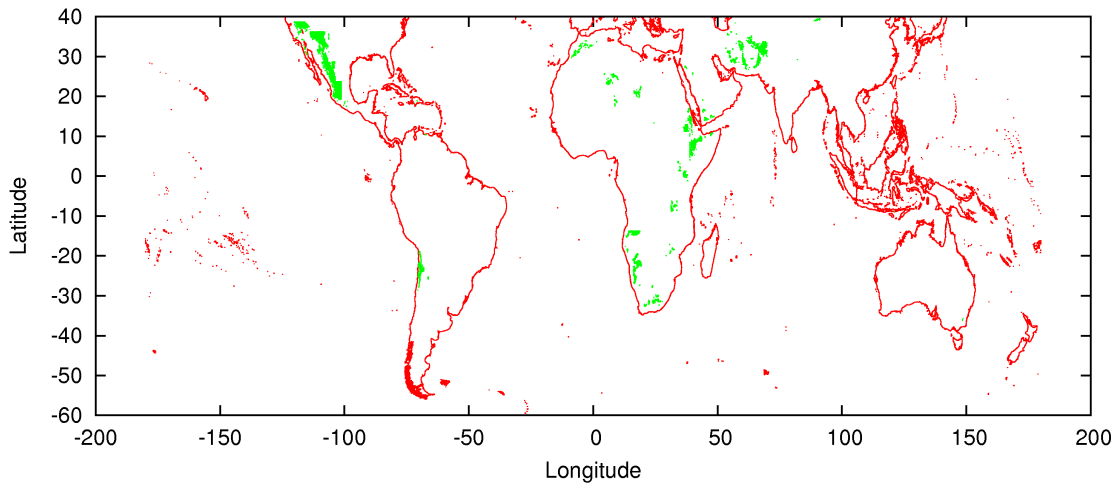


Figure 1: World map showing the possible areas that satisfy the basic criteria for building CTA: flat area of 10km^2 at the altitude between 1500 and 3500m a.s.l, low night sky background, and sufficiently low cloudiness.

- Very high humidity is a reason to stop observations, so the sites should not have a large fraction of nights with high humidity, particularly if not correlated with clouds that render the observations impossible anyways.
- Wind speed also affects operation efficiency as well as survival conditions of the telescopes. Wind speeds above 30 km/h may impact the quality of the observations and above 50 km/h no observations will be performed. For CTA sites, the wind speed should be as low as possible and in any case lower than 50 km/h for 80% of the observable time. Peak wind speeds can go beyond 200 km/h in some sites which would directly affect cost of the structure.

The Cerenkov light in its way down (from about 10km to about 2km, where the observatory is located) interacts with the molecules and aerosols in the atmosphere before it reaches the telescopes. The amount of light and shape of the particle shower image will therefore strongly depend on the vertical structure of the atmosphere. As the amount of energy and arrival direction of the gamma are derived from these quantities, the quality of the atmosphere will be crucial for a good performance of CTA.

- The transparency of the atmosphere should be high without much aerosols and dust.
- The night sky background (NSB) introduces noise in the data, thus it should be low for the energy range for which CTA sensors are active (the specific numbers are given in the Call for proposals). It should be noted that apart from streetlights and man made lights in general there is also a natural component of NSB that is time dependent.

VHE gamma astronomy from the ground has systematic errors associated of around 30%. A great part of it is due to the ignorance of the exact structure of the atmosphere that not only changes from place to place but also with time. A good monitoring and subsequent modeling of the atmosphere in the experimental analysis would certainly improve the quality of the data. The CTA work package ATAC (atmospheric monitoring, associated science and instrument calibration) is working to develop state of the art instrumentation for atmospheric monitoring.

The geographical factors to be considered are:

- The latitude of the two sites should be around 30 North and South respectively for whole sky coverage.
- For optimum overall performance the altitude of the sites should be between 1500 and 4000m. These numbers come from simulations performed by the CTA Monte Carlo work package (MC WP).
- The available flat area for the construction of the CTA array of telescopes should be of 1km^2 for the Northern array and about 10km^2 for the Southern array.
- The component of the geomagnetic field parallel to the ground should be as low as possible, as it changes the transversal momentum of the shower of particles affecting thus the shape of its image viewed by the telescope and therefore affecting CTA performance.
- The seismic activity should be very low, otherwise it would increase the overall cost of the telescope structure and could also cause damage if very high.

Already existing infrastructure (power, internet, workshops, bedrooms, restaurant, toilets) and good accessibility

(distance and type of road to the airport, nearest city, harbor, hospital) would lower CTA overall cost allowing the construction of more telescopes for a given budget which would impact CTA scientific output. For a detailed list of infrastructure and accessibility factors that will be taken into consideration in the site selection look at the Call for Proposals for CTA SITES, see section 3.

Other fundamental criteria are the political and economic conditions: availability of the land and conditions to access it, political stability and political support, financial or in-kind contribution by the hosting region, scientific support at regional and national levels, distance to closest scientific facility and site synergy with other scientific projects, technical and industrial support at regional and national levels, cost of manpower and living conditions of permanent staff. Last but not least: safety. The presence of dangerous animals, wild fires, criminality and risk of diseases has to be evaluated as well as the international and national labor regulations.

An impact study must be performed whatever the sites selected for CTA are. The requirements for this study may change from place to place. Some of the environmental factors to be studied are: waste management, energy (renewable energy as a possible source) and clearing of the telescopes from the site after the end of CTA lifetime and reforestation.

2 Areas of interest

Our preliminary search yielded several areas of interest. These are the areas that satisfy the basic conditions for the flat area, clear and dark sky, and the appropriate altitude. The resulting map of the world with possible locations is shown in Figure 1.

2.1 North

The Northern Hemisphere presents several excellent sites for CTA. While this is not clearly seen in Figure 1, there is a very good site in Tenerife, close to the Izaa observatory at an altitude of 2200m. There is quite a lot of places in North America, especially in the south western United States, and north western corner of Mexico. Of particular interest here is the area near the San Pedro Martir Observatory in Baja California at an altitude of 2400m. There are also several very good sites in Arizona that are being considered now. Additionally there are interesting sites in the northern region of India, in the proximity of the Hanle observatory.

There seems to be quite a number of excellent areas in Iran and Afghanistan yet they are not considered for CTA due to political reasons.

2.2 South

The Southern Hemisphere presents two geographical regions that satisfy the basic requirements. These are the South African region and South America.

Within the South African region we consider the well documented site used for HESS telescope at the elevation of 1800 m above sea level, but also a site near the Sutherland Observatory. Currently we are also investigating two other possible sites in Southern Namibia.

In the South America region we are now concentrating on two sites in Argentina. One lies near the CASLEO observatory at the elevation of approx 2600 m. The second site, is located near the city of San Antonio de los Cobres in the province of Salta and is located at the elevation of approximately 3600 m.

The list of the Southern sites is a result of a two fold process; on one hand it is a result of thorough site search by the group, and on the hand it is a result of the recent internal call for site proposals described below.

3 Call for proposals

Within the preparation phase we have decided to launch a call for proposals for CTA sites. The call has been structured in two stages: the call for Southern sites that were due on Jun 30, 2011, and the call for Northern sites due at the end of 2011. The call is available at the internal CTA pages, for more information please contact the authors. The Southern site proposals are under internal scrutiny now, and they will be reviewed by an panel of experts at the end of the year. The Northern site proposals will follow the same procedure: first an internal analysis followed by a review. The entire procedure is expected to last less than 12 months from the proposal deadline for each region: north and south.

4 Current work

The current work of the group concentrates on two analysis method. The first is the satellite data analysis. For this task we were using the databases available from the MODIS, METEOSAT, and GOES satellites.

Since most of the candidate sites do already host astronomical observatories, the second line of investigation consists on gathering the archival weather data from those observatories and comparing it. In order to be able to compare these measurements done with very different equipment (e.g. in order to do a cross-calibration) we have built a series of four weather stations (ATMOSCOPES) in order to deploy them to the different CTA candidate sites. Each ATMOSCOPE is equipped with: the weather station measuring wind, temperature and humidity, as well as an IR meter for cloudiness, and a night sky background meter.

The first ATMOSCOPE has been deployed to the HESS site in the beginning of July and the remaining ones will be sent to Argentina, Tenerife, and Mexico or the United states in the nearby future. By the time this report is published all of the units will be at their locations.

5 Conclusions

We are planning to narrow down the choice of sites to not more than two sites for Northern and for the Southern Hemispheres within 12 months of the proposal deadline. Then we expect that the final choice will be done before the end of the CTA preparatory phase, i.e. before September 2013.

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