

Monte Carlo Performance Studies of Candidate Sites for the Cherenkov Telescope Array

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ABSTRACT

The Cherenkov Telescope Array (CTA) is the next-generation gamma-ray observatory with sensitivity in the energy range from 30 GeV to beyond 300 TeV. CTA is proposed to consist of two arrays, with one in each hemisphere. The evaluation process for the candidate sites for CTA is supported by detailed Monte Carlo simulations, which, as presented here, take different attributes like site altitude and geomagnetic field configuration into account. All site candidates fulfil the CTA science requirements.



Introduction

Detailed Monte Carlo (MC) simulations using CORSIKA and sim_telarray are used to evaluate the performance for the following CTA site candidates:

Candidate site name	Latitude, Longitude	Altitude [m]	B _{hor} [μT]	B _{z ↓} [μT]
Aar (Namibia)	26.69° S 6.44° E	1640	10.9	-24.9
Armazones (Chile)	24.58° S 70.24° W	2100	21.4	-8.9
Leoncito (Argentina)	31.72° S 69.27° W	2640	19.9	-12.6
Leoncito++ (Argentina)	31.41° S 69.49° W	1650	19.9	-12.6
San Antonio de los Cobres (SAC; Argentina)	24.05° S 66.24° W	3600	20.9	-8.9
Meteor Crater (USA)	35.04° N 111.03° W	1680	23.6	42.7
San Pedro Martir (SPM; Mexico)	31.01° N 115.48° W	2400	25.3	38.4
Teide, Tenerife (Spain)	28.28° N 16.54° W	2290	30.8	23.2
Aar@500 m (hypothetical site)	26.69° S 6.44° E	500	10.9	-24.9

A typical MC set for one site comprises about a billion simulated gamma-ray and electron, and about 100 billion proton events. All simulations are at 20° zenith angle and two different azimuth directions (north & south). Two different candidate array layouts have been used (Fig 1).

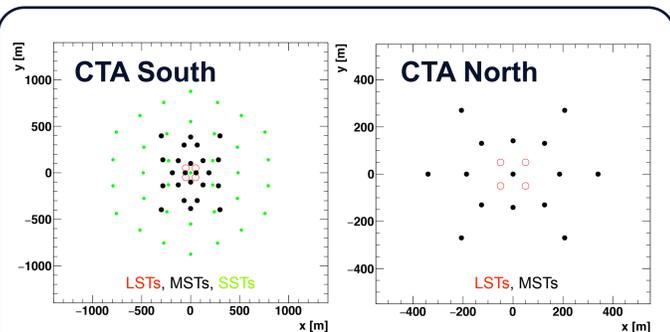


Fig. 1:

Considered array layouts for CTA South (left figure); consisting of 4 large-sized telescopes (LSTs), 24 mid-sized telescopes (MSTs), and 35 7m-class small-sized telescopes (SSTs) and CTA North (consisting of 4 LSTs and 15 MSTs).

ACKNOWLEDGEMENTS

We gratefully acknowledge support from the agencies and organizations under *Funding Agencies* at www.cta-observatory.org
 GM acknowledges the support through the Young Investigator Program of the Helmholtz Association.

The authors acknowledge the European Grid Infrastructure for providing computing resources.

Differential sensitivity

The primary performance criteria for the site evaluation are differential sensitivities over the entire energy range of CTA from 30 GeV to 300 TeV. The differential sensitivity is defined as the lowest flux, for which an independent detection (>5 sigma significance, ≥10 excess events, and >5% of the remaining background) in each energy bin (five logarithmic bins per decade of energy) could be made.

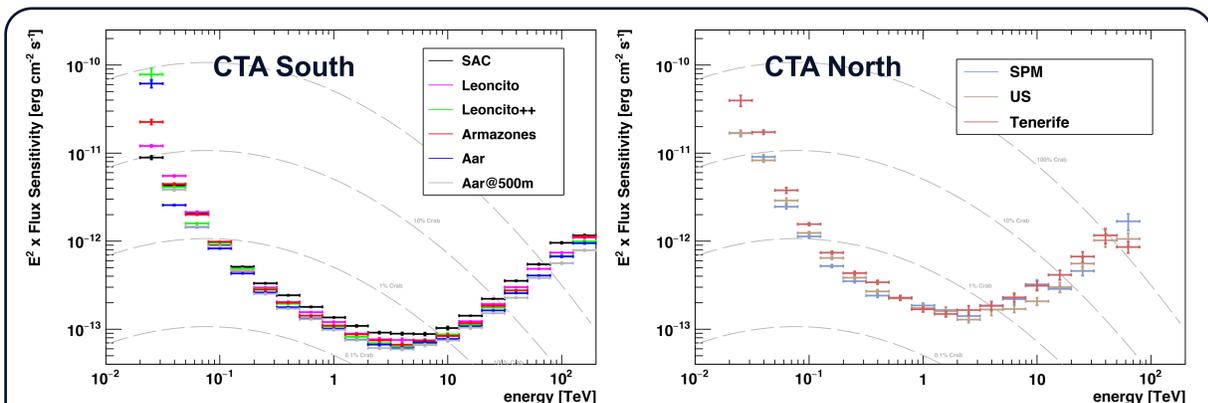


Fig. 2:

On-axis differential sensitivities for 50h of observations for the considered site candidates. Averaged sensitivities calculated from telescopes pointing north and south are shown.

Impact of altitude, geomagnetic field strength and night-sky background

The figure of merit for comparison of the performance at the different site candidates is the performance per unit time (PPUT; $F_{sens, ref}$ is a reference sensitivity), calculated over all energy bins:

$$PPUT = \left(\prod_{N_{bins}} \frac{F_{sens, ref}}{F_{sens}} \right)^{1/N}$$

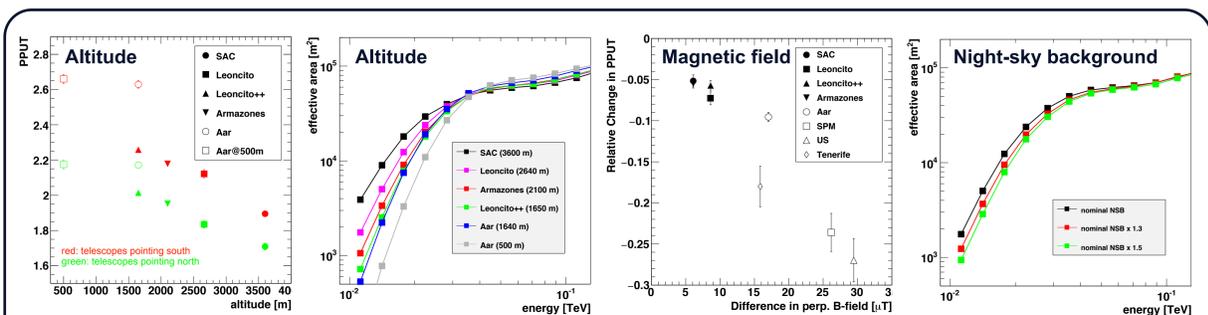


Fig. 3: Performance per unit time and effective area as function of altitude, geomagnetic field and night-sky background level (NSB). Lower altitude sites perform generally better, although with a higher energy threshold. The geomagnetic field strength and angle to the shower direction affect significantly the development of the air shower. Sites with lower geomagnetic field strengths provide higher sensitivity. The NSB affects the sensitivity almost only at threshold energies, higher NSB rates result in higher energy thresholds.

Please see proceedings for a complete bibliography.