ASTRI SST-2M prototype and mini-array simulation chain, data reduction software, and archive in the framework of the Cherenkov Telescope Array


ABSTRACT

The Cherenkov Telescope Array (CTA) is a worldwide project aimed at building the next generation ground-based gamma-ray observatory. Within the CTA project, the Italian National Institute for Astrophysics (INAF) is developing an end-to-end prototype of the CTA Small-Size Telescopes and leads a collaborative effort for a mini-array of (at least) nine ASTRI telescopes, proposed to be deployed at the southern CTA site. The CTA/ASTRI team is developing an end-to-end software package for the reduction of the raw data acquired with both ASTRI SST-2M prototype and mini-array. The group is also undertaking a massive Monte Carlo simulation data production aimed at simulating the CTA SST-2M and mini-array performance. A data archiving system, for both ASTRI SST-2M prototype and mini-array, has also been developed by the CTA/ASTRI team as a testbed for the scientific archive of CTA.

INTRODUCTION

The Cherenkov Telescope Array (CTA) represents the next generation of IACT facilities and will have dramatically better performance than current generation of IACTs and broaden the science accessible at very-high-energy (VHE, E ≥ 50 GeV) [2]. ASTRI (Astrofisica con Specchi a Tecnologia Replica Italiana) [3] is a sub-project within CTA led by the Italian National Institute for Astrophysics (INAF). The primary goal of the ASTRI project is the realization of an end-to-end prototype of the CTA small-size telescope in dual-mirror (SST-2M) Schwarzschild-Couder configuration. The prototype, named ASTRI SST-2M and located in Serra La Nave (Mt. Etna, Sicily), is currently undergoing the scientific validation phase. When this phase is complete, the project aims at deploying, for the CTA southern site pre-production phase, a set of (at least) nine ASTRI telescopes, named the ASTRI mini-array. ASTRI includes (besides all hardware and control software systems) [3] the full data processing and archiving chain, from raw data up to final scientific products [4,5].

ASTRI DATA REDUCTION AND SCIENTIFIC ANALYSIS SOFTWARE

The ASTRI data reconstruction and scientific analysis software (A-SciSoft) is the official package of the ASTRI project being developed for the ASTRI SST-2M prototype and mini-array data processing. The software is composed by a set of independent modules (see Fig. 1) organized in efficient pipelines that implement the algorithms to produce a complete set of results shown, from raw data to the final scientific products. The code has been conceived to be easily ported to parallel computing architectures, such as multi-core CPUs and graphic accelerators (GPUs), and new hardware architectures based on low-power consumption processors (e.g. ARM) [5].

ASTRI SIMULATION CHAIN

Monte Carlo (MC) simulations are an essential component during all phases of the development and operation of an IACT, from its design to the acquisition of data. Large samples of atmospheric showers and their detection by ASTRI telescopes have been simulated using the same simulation chain adopted by CTA [7,8]. These MC productions are being used to validate the ASTRI simulation chain and to test the data reduction software.

ASTRI SCIENTIFIC ARCHIVE

The ASTRI prototype project has been used as testbed for many technological archive solutions involved in long term storage, data mining and user access to a large amount of astronomical data. A first demonstrator for a distributed archive concept model as required by the CTA consortium was developed and will be tested in the pre-production phase of the CTA observatory within the mini-array ASTRI telescopes [6].

ASTRI DATA CHALLENGE

In order to test the whole data reconstruction and scientific analysis chain in the case of single telescope data reduction, a data challenge was conceived. The bulk of the scientific events was extracted from a dedicated ASTRI MC production. Using the whole available MC statistics, two samples were created: a Crab Nebula [9] observation (ON sample, ~5.8 hours equivalent) and an observation of an empty sky region (OFF sample, ~5.5 hours equivalent). Both ON and OFF data were formatted at raw-data level in compliance with the ASTRI prototype (FITS) format. The ON and OFF data samples were successfully reduced from DLO up to the generation of scientific products with the A-SciSoft software package. The instrument response functions (IRFs) were generated from MC gamma-ray events and from the OFF sample. The ctools [10] were successfully used to derive the scientific products shown in Fig. 2. The results are basically in line with the performance expected for a single ASTRI telescope in the case of Crab Nebula observations and demonstrate the proper behavior of the whole data reduction chain.

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REFERENCES