DESCRIPTION FOR THE GENERAL PUBLIC

Optical emission from astronomical objects can be relatively easily studied with ground based telescopes. This is however not the case for the observations of photons with shorter wavelengths, i.e. higher energy, observations. The x-rays and MeV-GeV (energies of millions to billions of electronvolts) gamma-rays are being observed using satellites due to the absorption of the photons in the atmosphere. However, at even higher energies the fluxes of photons from cosmic ray sources are too small to be detected by the small size instruments located in the satellites. To observe such very high energy (VHE, above 30 GeV) photons we exploit a trick of nature. A VHE gamma-ray entering the Earth's atmosphere interacts with the atmospheric nuclei producing in an electromagnetic cascade (the so-called air shower) thousands of secondary electrons and positrons. These particles move faster than light in the atmosphere and therefore produce faint and fast flashes of the so-called Cherenkov radiation. Ground based Imaging Atmospheric Cherenkov Telescopes (IACTs) register this light as images of individual gamma-ray air showers. This technique is relatively recent. The first VHE source, Crab Nebula, was detected in 1989 by the Whipple telescope followed by rather slow detection of ~10 more sources in the next 15 years. The breakthrough came around year 2004 when the current generation of arrays of a few telescopes with finely pixelized cameras started to operate. In the last 10 years, the number of the known VHE gamma-ray sources raised from ~10 to over 170. The 3 major IACT systems currently operating are: MAGIC in La Palma, Spain, H.E.S.S. in Namibia, and VERITAS in Arizona, USA. All those experiments are small arrays of 2-5 telescopes. The next generation of the IACTs is the large world-wide project called Cherenkov Telescope Array (CTA). CTA plans to build a big array of ~100 telescopes in 3 different sizes. It is expected that the CTA will not only greatly increase the number of known VHE sources but also enlarge the energy range available to the IACT technique to span between few tens of GeV up to hundreds of TeV.

The currently known VHE sources span a broad range of classes of objects, from binary systems, pulsars and their wind nebulas, through supernova remnants up to various kinds of active and starburst galaxies. By investigating the gamma-ray spectra and the light curves of those objects we can study the processes of acceleration of charged particles, and also look for plausible candidates for cosmic ray production sites, a riddle that puzzles scientists since 100 years. The results of observations with IACTs also gives scientists unique window for an investigation of the models of fundamental physics and cosmology. The detected rapid, only minute time scale, flares of distant sources which are as large as the distance from the Earth to the Sun are good candidates to study the Quantum Gravity effects, where the speed of light depends on its energy. The gamma-ray emission from distant active galactic gives us a unique opportunity to probe extragalactic background light (the diffuse light emitted by all the galaxies and space dust) and extremely weak magnetic fields in the extragalactic space, which in turn give us important information about cosmology. Searching for the signature of the Dark Matter annihilation or decay in vicinity of massive objects is another physics target of IACTs. Scientists also aim to detect a signal from direction of short, still not fully understood Gamma Ray Bursts to better understand those objects.

Studies of gamma-ray emission from all those types of objects are however marred by strong cosmic-ray related background (other than gamma-ray very energetic particles that reach Earth’s atmosphere). Even in the case of bright objects for each gamma-ray there is of the order of thousand of cosmic-ray events which obscure its view. Special analysis methods are used to identify and exclude in the IACT data the background events to extract such a weak signal. In this project we are planning to study in depth the structure of the background events to better understand and remove them from the data. This will allow us to improve the performance of the CTA. We will concentrate on the energy range below 100 GeV which so far was barely explored by IACTs, because the images of the showers are to small for an efficient separation between gamma and much more abundant cosmic rays. Using the large telescopes, which will be a part of the CTA, may change it. The large mirror dishes will allow catching much more light from individual events, providing more clear images.

The results of our project can be used not only for CTA. The analysis methods developed here, might be also applied for the existing IACTs. Reanalysis with improved methods of the 10 years of the data of the current generation of Cherenkov telescopes might reveal new discoveries that are hidden in the already taken data.