Optimization of transient sources observation for the gamma-ray observatory CTA

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The Cherenkov Telescope Array (CTA) is the new ground-based very high energy (VHE; $E \gtrsim 100$ GeV) γ-ray observatory which should see its first light in 2016. Two large arrays of ∼50 Atmospheric Cherenkov Telescopes (IACTs) are to be deployed, one in each hemisphere. The goal is to reach an order of magnitude improvement in sensitivity, compared to current IACTs facilities.

Blazars, a particular class of active galactic nuclei (AGN), known to be VHE γ-rays emitter, are one of CTA's main science cases. Their extreme flux variability poses a challenge to the planing of their observation with IACTs, considering the small field of view and duty cycle (~ 1000 h/year) of these instruments. In this work, we develop a tool to optimize the observation of such variable sources with CTA. CTA observing strategies are modeled. CTA flexibility is taken into account and three different sub-arrays of telescopes are considered. Then, the strategies are defined by the observing windows' length and by their repartition in time which is taken to be periodic or random.

The fluxes of blazars and their variations in time are simulated and used to characterize the observing strategies' performances. Sets of reference light curves have been used, characterized by a Power Spectral Density (PSD) slope of 1.15, a 50% fractional variance, and a 50% non-linearity index have been used. The considered mean fluxes range from 1% to 30% of the Crab Nebula (a standard candle for γ-ray, whose flux above 100 GeV is equal to aqv).

We show that the detection probability depends not only on the total amount of observing time, but also on the length of the observing windows. Strategies that split the observing time into many small observations along the light curve yield higher detection probability compared to ones that concentrate the observations in few large windows. This is shown to be a consequence of positive fluctuations in the sources' emission, which are more likely to be observed when many observing windows are employed.

The observing strategies' optimization has been performed for two observing goals: fast detection and source monitoring. The best observing strategy balances the number of telescopes used and the amount of time needed to detect the source. The fastest detection of sources with a mean flux of 1% Crab is obtained using small sub-arrays and 10-minute, randomly taken observations. The best monitoring option is to simultaneously use five small sub-arrays, as it allows for the maximum number of sources to be observed and detected within one night. The length of the observing window needed for a successful monitoring depends on the mean source flux.

A preliminary study of the influence of light curves' properties on the choice of the best strategies is conducted. It appears that the light curve's variance and PSD index have a strong influence on the detectability of the sources and on the selection of the best strategy. This suggests that, upon preparing to observe a variable source, the properties of the source light curve its light curve must be taken into account to prepare the most efficient observing plan.