CTA Instrument Response Functions - README

(release version prod3b-v2)

This README files provides background information for the CTA Instrument Response Functions as released on the CTA webpage (https://www.cta-observatory.org/science/cta-performance/).

Monte Carlo Simulations:

The performance values are derived from detailed Monte Carlo (MC) simulations of the CTA instrument based on the CORSIKA air shower code (v6.9+, with the hadronic interaction models QGSjet-II-04 and URQMD, [1]) and telescope simulation tool sim_telarray [2]. A power-law gamma-ray spectrum with photon index 2.62 was assumed in the calculations, although none of the instrument response functions (e.g. differential flux sensitivities, effective areas, angular or energy resolutions) depends on the assumed spectral shape of the gamma-ray source. Background cosmic-ray spectra of proton and electron/positron particle types are modelled according to recent measurements from cosmic-ray instruments.

Nominal telescope pointing is assumed, with all telescopes pointing directions parallel to each other (performance estimation for other pointing modes, e.g. divergent pointing will be provided in the future). Performance estimations are available for two zenith angles (20 deg and 40 deg), and for each zenith angle for two different azimuth angles (corresponding to pointing towards the magnetic North and South). There are significant performance differences found between the two azimuthal pointing directions (especially for the Northern site) as the impact of the geomagnetic field is large enough to influence notably the air shower development. For general studies, the use of the azimuth-averaged instrument response functions is recommended.

Instrument Response Functions (IRFs):

The analysis has been tuned to maximize the performance in terms of flux sensitivity. The optimal analysis cuts depend on the duration of the observation, therefore the IRFs are provided for 3 different observation times, from 0.5 to 50 h. IRFs are provided as binned histogram or FITS tables. It should be stressed, that the full potential of CTA in terms of angular and energy resolution is not revealed by these IRFS, due to the focus on the optimisation for best flux sensitivity.

In general all histograms are binned with a 0.2-binning on the logarithmic energy axis (5 bins per decade); some selected histograms (e.g. effective areas or energy migration matrices) are provided with a finer binning. Effective area and energy migration matrix are available in a double version: one for the case in which there is no a priori knowledge of the true direction of incoming gamma rays (e.g. for the observation of diffuse sources), and another for observations of point-like objects (including among the analysis cuts one on the angle between the true and the reconstructed gamma-ray direction).

IRFs are provided in ROOT format, as FITS tables, and for some on-axis IRFs also as simple ASCII files. The FITS tables can be used directly as input to science analysis tools like ctools (see http://cta.irap.omp.eu/ctools/, and especially http://cta.irap.omp.eu/ctools/users/user_manual/response.html) or gammapy (see http://docs.gammapy.org/en/latest/index.html). The values of the IRFs are identical for the different file format, with one exception: the angular point-spread function is approximated by a Gaussian function for the FITS tables, while the ROOT files contain the full distribution.

Acknowledgement:

In cases for which the CTA instrument response functions are used in a research project, we ask to add the following acknowledgement in any resulting publication:
“This research has made use of the CTA instrument response functions provided by the CTA Consortium and Observatory, see https://www.cta-observatory.org/science/cta-performance/ (version prod3b-v2) for more details.”

File Naming (examples):
CTA-Performance-prod3b-v2-North-20deg-average-50h.root: IRF for CTA Northern site on La Palma, 20 deg zenith angle, azimuth-averaged pointing, optimised for 50 hours of observation time
CTA-Performance-prod3b-v2-South-20deg-average-50h.root: IRF for CTA Southern site in Paranal, 20 deg zenith angle, azimuth-averaged pointing, optimised for 50 hours of observation time
CTA-Performance-prod3b-v2-South-40deg-S-30m.root: RF for CTA Southern site, 40 deg zenith angle, South pointing, optimised for 30 minutes of observation time

List of files:
README.txt - this README file
CTA-Performance-prod3b-v2-FITS.tar.gz - IRFs in FITS format (making use of the HEASARC’s caldb indexing) - includes IRFs for 20 deg, 40 deg, and 60 deg zenith angle, average, north and south pointing
CTA-Performance-prod3b-v2-20deg-ROOT.tar.gz - IRFs in ROOT format for 20 deg zenith angle, azimuth-averaged, north and south pointing
CTA-Performance-prod3b-v2-40deg-ROOT.tar.gz - IRFs in ROOT format for 40 deg zenith angle, azimuth-averaged, north and south pointing
CTA-Performance-prod3b-v2-60deg-ROOT.tar.gz - IRFs in ROOT format for 60 deg zenith angle, azimuth-averaged, north and south pointing
CTA-Performance-prod3b-v2-20deg-ASCII.tar.gz - (selected) IRFs in ASCII format for 20 deg zenith angle, azimuth-averaged, north and south pointing
CTA-Performance-prod3b-v2-40deg-ASCII.tar.gz - (selected) IRFs in ASCII format for 40 deg zenith angle, azimuth-averaged, north and south pointing

CTA-Performance-prod3b-v2-60deg-ASCII.tar.gz - (selected) IRFs in ASCII format for 60 deg zenith angle, azimuth-averaged, north and south pointing

[1] https://www.ikp.kit.edu/corsika/
[2] Bernloehr, K. 2008, Astroparticle Physics, 30, 149