TAIGA-IACT poining control and monitoring software status

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Executive summary for ICRC2021

The TAIGA-IACTs are part of the hybrid TAIGA experimental complex, located near lake Baikal in Tunka valley, Siberia, Russia. The telescopes have segmented mirrors in Davis-Cotton design with the reflector diameter of 4.3 m and an imaging camera with PMTs in its focus to detect nanosecond flashes of Cherenkov light from EAS. Since 2020 two IACT telescopes are installed and operate on the TAIGA site. The third telescope is in deployment and will be commissioned and put in operation in 2021. The TAIGA-IACT telescope has an alt-azimuth mount and a camera in the focus of a segmented Davis-Cotton design reflector. The camera of the telescope has 9.6^{o} field of view and 0.36^{o} pixel resolution. The telescope operates in wobble mode switching the direction every 20 minutes. For the pointing calibration and measurements, a CCD camera is installed on the dish near the mirrors. The CCD camera captures the sky region with the field of view of the telescope and the telescope camera with positioning LEDs installed along the perimeter. As the telescope camera does not allow to perform astrometry by stars directly, a special white calibration screen is installed inside the camera. The calibration can be rolled and unrolled remotely.

The telescope control software developed using the EPICS framework. The FITS file format is used for CCD-camera image storage. Astrometry.net software is used for processing of the telescope field of view region on CCD-camera images. The telescope trajectory is calculated using the SOFA software and applying the telescope pointing model. The operator GUI is developed using the EPICS Qt framework and provides hardware control and monitoring of the telescope status and parameters.

The telescope pointing a transformation chain is presented. The telescope direction can be estimated by the telescope shaft encoders and by the CCD camera installed on the dish. The telescope pointing calibration measurements with the unrolled screen are regularly performed between the observation periods in the small moon in order not to waste the observation time. The pointing model estimation of the telescope direction has smooth not static systematic. An experiment with unrolled calibration screen showed that the direction estimation using the CCD camera does not have such systematic. The telescope trajectory is reconstructed with the CCD camera corrections to take it into account. The corrections are performed online during the tracking and offline for future data analysis

By the data with unrolled screen difference between the prediction of the source position by the telescope camera model using direction estimated using the CCD camera and measured spot position has about 0.01 degrees standard deviation by both axes. The mean offset of measured positions from predicted positions of a bright star image does not exceed 0.01 degrees by both axes for calibration data during the 2020-2021 season. The calibration gives good accuracy for the entire season and it has good time stability.

As an additional independent test of the CCD-camera transformation accuracy, special runs based on the measurements of anode current on the PMTs are performed. The results of such measurements for different altitude, different distances and directions from the camera center is presented. The data show that the estimation of the source position on the telescope focal plane is not worse than 1 CCD camera pixel (0.02 degrees).

Conclusion. The telescope direction estimation using the pointing model is corrected by the CCD camera to achieve better accuracy. The CCD camera transformation calibration is time stable and the accuracy for the 2020-2021 season is better than 1 CCD pixel (0.023 degrees). The position of a source on the telescope focal plane is calculated using the telescope camera model. The telescope pointing and a source position calculation accuracy were checked by the anode current, the result accuracy is not worse than 1 CCD camera pixel (0.023 degrees).

Reference. You can find other contributions related to the TAIGA project by the following link: https://icrc2021-venue.desy.de/search/title/TAIGA. See also about new approach for the IACTs pointing modeling: https://icrc2021-venue.desy.de/search/title/CTBend