Design, development and calibration of the GRAVITY acquisition camera software to monitor four telescope beams

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Abstract

The GRAVITY acquisition camera is a four VLTI beams monitoring instrument, operating in the near-infrared. It has four imaging modes a) field imager: images the H-band science field and tracks the tip-tilt b) pupil tracker: images the pupil guiding laser beacons (1.2 μm) mounted on the secondary telescope using a 2×2 lenslet and tracks the telescope pupil motions c) aberration sensor: images the H-band science field using a 9×9 lenslet and evaluates the beam higher order aberrations d) pupil imager: re-images the telescope pupil with H-band science light. The science field tip-tilts are induced by the tunnel atmosphere. Their measurement is very critical to inject star light into the fiber-fed beam combiner with high coupling efficiency. The pupil tracker measures the lateral and longitudinal pupil motions. These measurements are used to guide the telescope beam in a closed loop. It minimizes the astrometric error by stabilizing the pupil plane with the sky plane. The higher order aberrations are used to characterize the beam quality of the telescope and also used for wavefront correction. The pupil and field images are used to verify the optical alignments and to monitor the pupil and field tracking strategy.

In this communication, a simulation of the acquisition camera system was carried out in the presence of VLTI aberrations. The VLTI aberrations consist of the adaptive optics residuals, slow tunnel seeing induced aberrations and also the optical vibrations, delay line carriages induced optical aberrations. The field imager has been simulated using a NACO Galactic Center image. The experimentally measured VLTI aberrations were introduced to the field imager and measured back with a precision better than 2 mas [**?**]. The atmospheric differential refraction effects were addressed.

The pupil tracker images were simulated by applying the experimentally measured optical aberrations resulting from the movement of delay line carriages. The true lateral pupil positions are measured with a precision of better than 3 mm for an 8 m beam (UT) and the longitudinal pupil position measured with a precision better than 20 mm at 80 mm compressed UT beam respectively. The pupil image is simulated by considering the telescope obstruction along with acquisition camera pupil lens diffraction effects. The aberration sensor consists of a Shack-Hartmann Lenslet array. A point source and Galactic Center aberration sensor artificial images were simulated. The experimentally measured VLT aberrations were applied to the artificial images and reconstructed back the VLT aberrations with an accuracy better than 100 nm for a 2s integration. In Fig. **??** the acquisition camera image for a single telescope is presented.

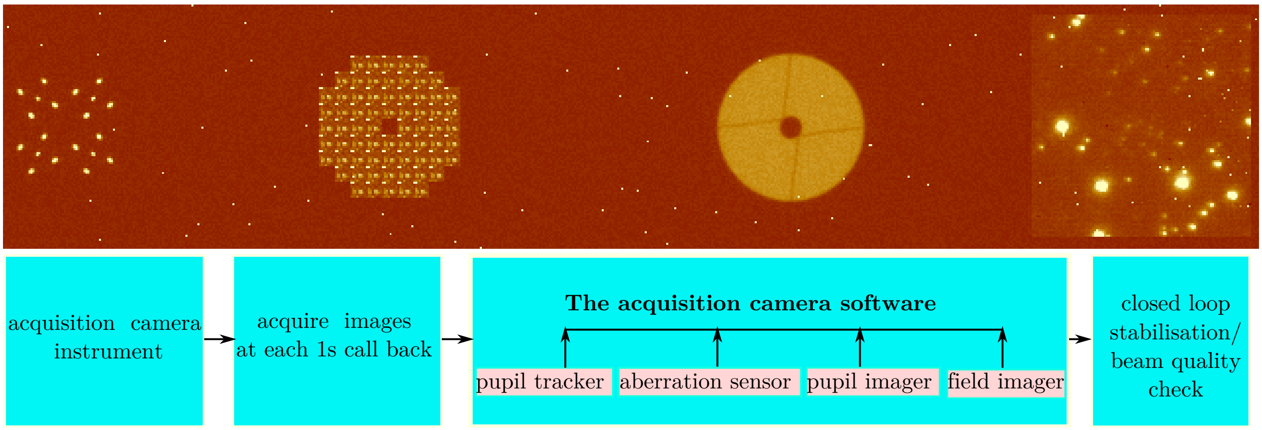

Figure 1: (Upper image) The acquisition camera detector image for a single telescope. The lower flowchart represents the acquisition camera software working flow.

The acquisition camera software is implemented using the ESO software standers and integrated within the GRAVITY software. During the observations, the software triggers automatic callbacks to new image events with a 1 Hz rate. For each call back, the Next Generation Detector acquires a new acquisition camera image and shares the image location with the acquisition camera software. As shown in Fig. **??**, the top level function of the software calls its four low level functions namely the field imager, the pupil tracker, the aberration sensor and the pupil imager. These functions take the respective image windows and extract the aberration parameters simultaneously for all the telescope beams. The estimated aberration parameters are then stored in the instrument database. Those parameters are used to apply the corrections for the pupil position shifts in a closed loop. They also make the light coupling scheme efficient because the parameters are used to apply the tip-tilts to the fiber positions in a closed loop. Furthermore to characterize the telescope beam quality. These software routines work simultaneously on the instrument work station in parallel with science observations. The software has special calibration functions, which is used to calibrate the reference positions automatically.

In the MPE lab, an experimental setup simulates the telescope with the artificial stars and the pupil guiding lasers [**?**]. The experimental image data has been acquired with simulating the pupil shifts, atmospheric effects. Also data has been acquired by varying the star and laser magnitudes. The experimental image data was analyzed. The extracted parameters are within the GRAVITY specifications. Currently the field imager, pupil tracker software are working in a closed loop with the instrument. The aberration sensor is now being adapted to the real instrument data.

References

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