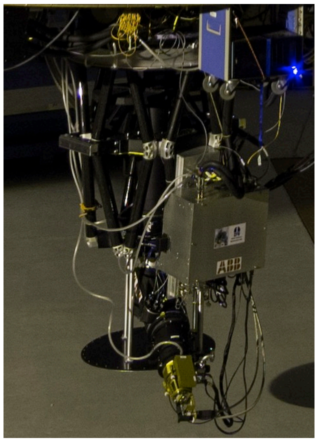
Upgrade on **SITELLE**



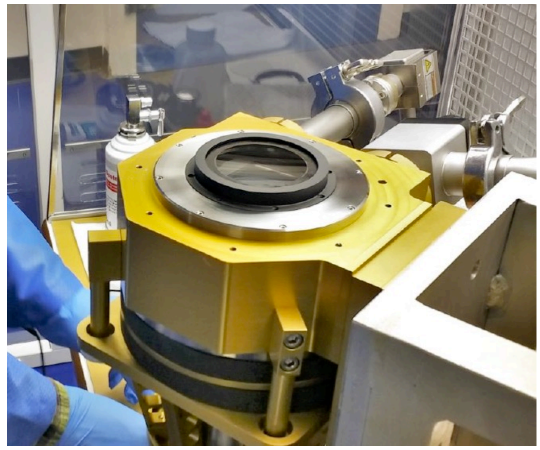
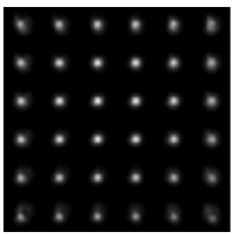


Figure 1: Installation of the SITELLE corrector lenses on the cryostats.

BEFORE



AFTER

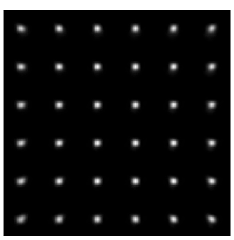


Image Quality and Focus Upgrade

The field curvature inherent to SITELLE's design led to unexpected observational and analysis issues. The field curvature led to a global image quality (IQ) that was lower than expected, especially near the edges of the field, which caused a poor, and target dependent convergence of best focus. Following thorough review and testing of the optical system, an upgrade to the optics was suggested and implemented through 2019. The upgrade consisted in the installation of a field-flattening lens to replace the CCD cryostat windows of both camera ports.

The SITELLE focal plane corrector lenses were received in the spring of 2019 and installed on the cryostats in June (Figure 1). The on-sky engineering test performed on September 12 showed that the corrector lenses were operating as expected. Figure 2 shows the best focus as a function of the radial position before and after the installation of the corrector lens for both detectors. In addition to testing the impact of the lenses on the system, the two detector optical axes were realigned prior observing, and the tilt of the CCDs was optimized using on sky engineering time. A notable effect of the new corrector lens is that SITELLE's field of view has been reduced by 2.6%, bringing SITELLE's plate scale to 0.3114"/pixel. However, the improvement gained by the alignment of the field of view of the two ports, resulted in an actual net lost of only 0.3%.

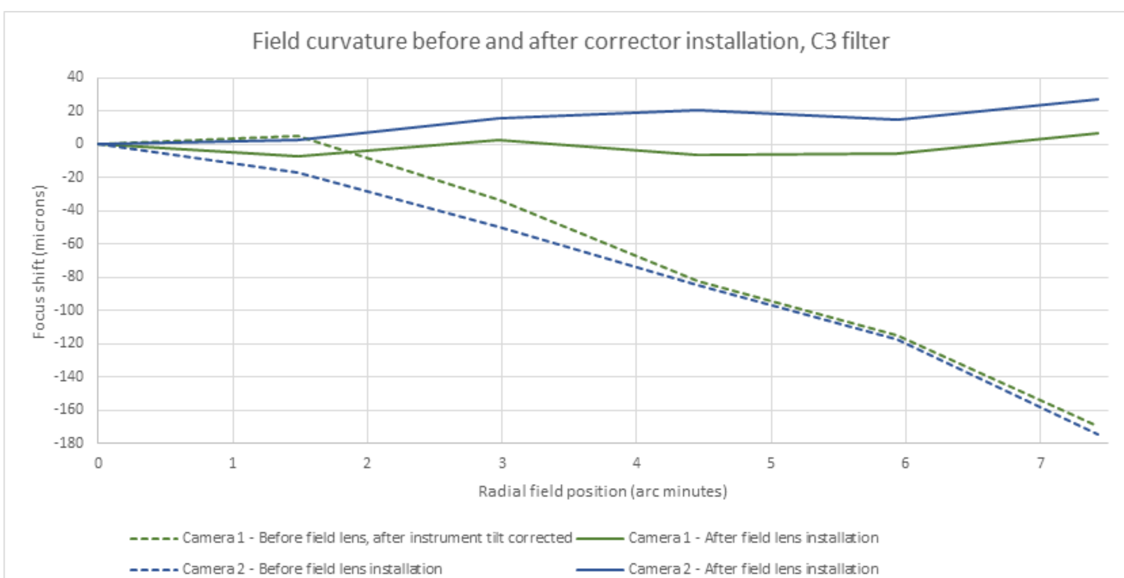


Figure 2: Best focus as a function of radial field position for SITELLE's cameras (Green and blue for camera 1 and 2 respectively). The dashed and solid curves respectively correspond to before and after the installation of the corrector lens for both detectors.

With a more consistently flat focal plane, our ability to automatically adjust the telescope focus

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is improved and is less affected by the position of the stars in the target field. Consequently, we observed the best mean IQ so far with SITELLE; 0.55" during the October 2019 run, with similar IQ values seen in the 2020A semester. A rough indicator of this global IQ improvement is obtained by comparing the best IQ obtained over long periods before and after the change: This translates roughly into a ∼0.15" global enhancement of the mean IQ of SITELLE.

Furthermore, the encircled energy diameter across the field was significantly reduced. This facilitates the reconstruction of mosaic fields by preserving the effective spatial resolution in the corners of the field. Figure 3 shows the 90% encircled energy diameter (EED) before and after the installation of the corrector lens for both detectors. Before the upgrade, a 90% EED exceeding 1.7" was common in areas of the field further than half the field diameter from the center, after the upgrade, the same metric is below 1.3" over most of the field.

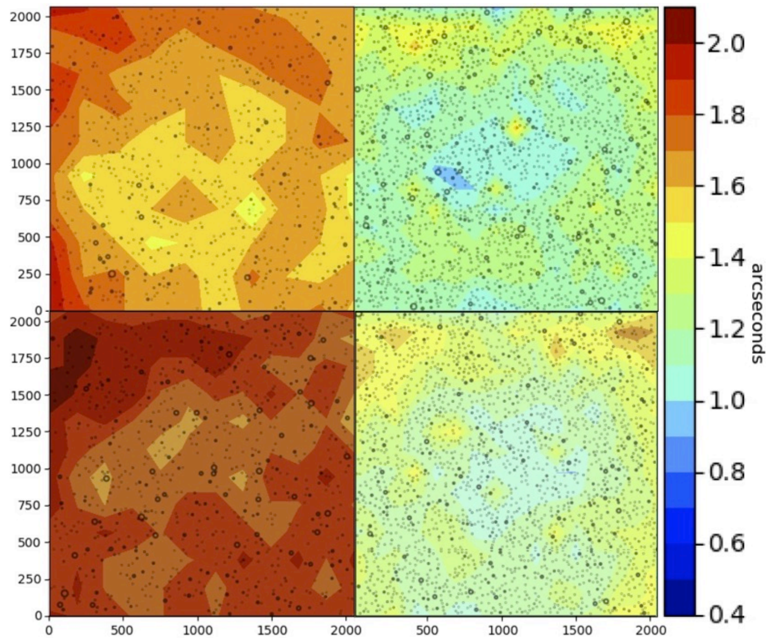

Figure 3: Comparison of the 90% encircled energy diameter (EED) before (left) and after (right) the installation of the focal plane correctors. Black circles represent stars used in the EED analysis.

A more visual way to see the impact of the upgrade is shown on Figure 4, where the star's normalized point spread function (PSF) has been averaged in the sections of a 6x6 grid of the field of view. A further benefit, not anticipated before the upgrade, is that the astrometric solutions derived from crowded stellar fields are now more accurate due to the tighter PSF.

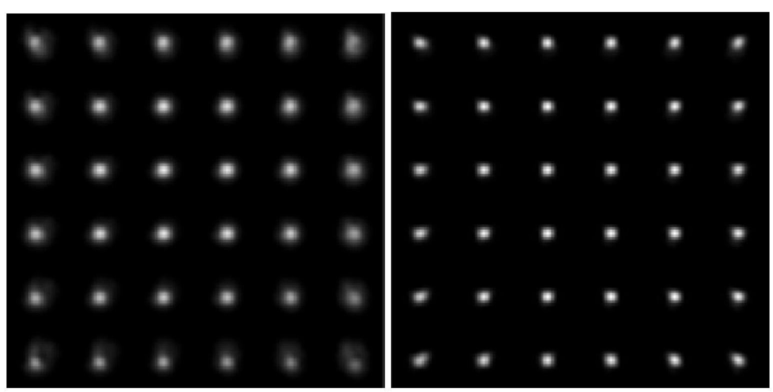

Figure 4: PSF of the stars in the SITELLE field of view before (left) and after (right) the upgrades. A linear grayscale intensity scaling has been applied.

Impact on Science

SITELLE is used on a wide range of targets to answer a variety of science questions. Although, the impact of this upgrade on the science programs must generally be assessed on a case-by-case basis, typically the impact on a given program will depend on whether targets consist of diffuse or point like sources.

Large program: The SITELLE Large Program SIGNALS (www.signal-survey.org) aims to observe a large number of HII regions in nearby galaxies. This upgrade will help to acheive more uniform spatial sampling of the HII regions and facilitate mosaic reconstructions. In addition, a better IQ helps to disentangle clustering of HII regions, and will enable the detection of fainter unresolved objects in the dataset: small and faint HII regions, planetary nebulae and supernova remnants.

PI programs: In addition to programs that might be affected in the same way as SIGNALS, some PI programs are targeting point like sources such as stellar clusters and galaxy clusters (z>0.1), as well as extended and diffuse milky way objects covering the whole SITELLE field. For these programs, a lower detection threshold is achieved for faint point like sources 0.15 [mag] dimmer, or with 15% less exposure time. The upgrade also globally improves the photometric accuracy, especially in crowded fields.

To summarize, the principal effects of the upgrade on science programs are:

- A field of view reduced by 0.3%, for a plate plate scale of 0.3114”/pixel.
- More reliable convergence of the automated focus routine.
- An improved mean IQ of $\sim$0.15”, as a global rough estimate.
- Less ”flaring” of the PSF, especially in the field corners, that was leading to large encircled energy diameters above 80% encircled energy.
- Better astrometric solutions.
- A lower detection threshold for point like sources (i.e. 0.15 [mag] dimmer, or a reduction of 15% of the exposure time for a given threshold).
- Improved mosaic reconstruction efficiency.
- Increased spatial resolution, especially at the edges of the field.
- Reduced impact of clustering of objects and structures in the target.
- Less cross-contamination of sources in a crowded field.
- etc.

We are confident that this will help the community to get a better return from the SITELLE data! If you have any questions, do not hesitate to contact us.

Mahalo, the SITELLE support team.