the recent testing success. Figure 3 hints at some of GHOST's capabilities.

The Cassegrain Acquisition Unit, also designed and built by the AAO, was previously shipped to Chile from Australia and tested in advance of the upcoming arrival of the spectrograph. After the spectrograph, slit viewer, and optical cable arrive in Chile, we expect to have all sub-assemblies of the GHOST instrument fully integrated and functioning in the second quarter of 2020 in preparation for commissioning.

First Light with NGS2

The Canopus adaptive optics (AO) bench of the Gemini Multi-conjugate adaptive optics System at Gemini South recently received a significant upgrade: its new Natural Guide Star Wavefront Sensor, also known as the Natural Guide Star Next Generation Sensor (NGS2). The original system consisted of three moving probes to pick up guide stars in the field, channel the light into fibers, and project it onto a quad-cell for tip-tilt detection. This system worked but in practice was cumbersome to use, mainly due to each probe's tiny field of view and the large light losses in the system. This implied large acquisition times and a brightness limit for the stars that significantly restricted sky coverage.

For the above reasons, a team from the Australian National University spearheaded an alternative approach, making use of novel electron-multiplying CCD technology that allows imaging the whole field of view. Up to three guide stars can be selected on that image. For tip-tilt wavefront sensing on each of the stars, small windows centered on each star are then read out at high speed, making use of the extreme low noise characteristics of the electron-multiplying CCD.

The new NGS2 was incorporated into the Canopus optical bench last September (Figure 4). This was no trivial exercise, because it required removing the AO's three large optical components and dismantling the original NGS system. But it all worked out, thanks to the careful preparations made by the NGS2 team.

Commissioning took place last October. Apart from Gemini personnel, the team had the great pleasure to work with François Rigaut (Australian National University) and Benoit Neichel (Laboratory of Astrophysics of Marseille) during the commissioning nights (Figure 5, next page). Collaboration from the weather was a weak point, seriously hampering progress. However, the team tested the full system, and put it through its paces.

The first results have been very positive. AO performance under reasonable weather conditions achieved an image quality of 83 milliarcseconds, indicating that the fully integrated system worked well (Figure 6). Acquisition of the three natural guide stars was

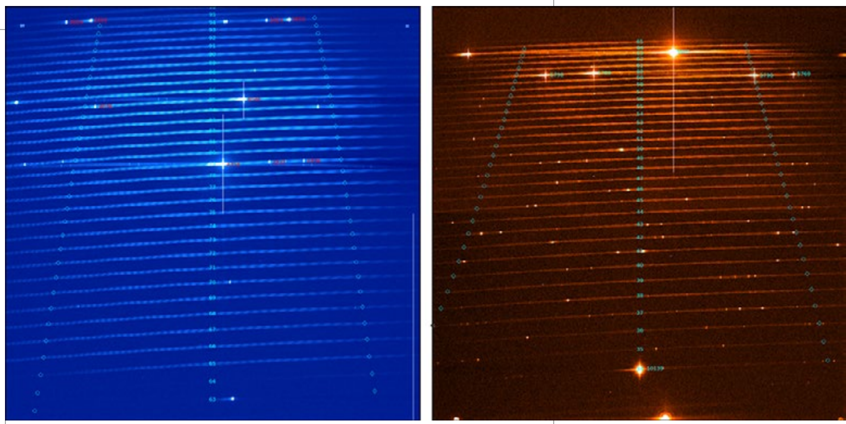

Figure 3.
Blue and red GHOST images of a mercury lamp, with the spectral orders labeled and 1.1 x free spectral range in each order highlighted. Continuous wavelength coverage from 359 nm to well beyond 1 micron (Requirement: 363 - 950 nm). Significant wavelength overlap between orders (with overlapping orders between arms).

Credit: Greg Burley

Figure 4.
The new NGS2 unit after installation into the Canopus optical bench.

Figure 5.

A tense moment in the control room when all the AO loops were closed with NGS2 for the first time. Official first light on NGS2!

Credit: René Rutten

very quick, achieving a gain of several minutes over the original NGS system for every acquisition (Figure 7).

A key driver for the NGS2 project was to work with fainter guide stars. Whereas the original NGS system could guide down to about R = 15.5 magnitude under good conditions, the new system has been proven to work even beyond R = 18 magnitude; a remarkable improvement that significantly increases sky coverage, bringing many more objects into reach of the GeMS/GSAOI instrument.

During the upcoming observing runs with GeMS/GSAOI, we will gain more experience on NGS2's performance. We will update the web pages with the latest information for users. Meanwhile, we invite interested users to exploit the system with new and previously inaccessible targets.

The NGS2 project has been made possible thanks to the tight collaboration between many people. The initiative, a large part of the funding, and the design and build of NGS2 was primarily done by a team at the Australian National University in collaboration with Gemini engineers and astronomers. Without such a strong collaboration the project would not have prospered.

SCORPIO Making Steady Progress

With the exciting build phase of the Spectrograph and Camera for Observations of Rapid Phenomena in the Optical and Infrared (SCORPIO) — a powerful next generation instrument for Gemini South — underway, the SCORPIO team has been busy in the last quarter of 2019. On November 22nd, Gemini staff and subcontractor FRACTAL attended the project's Quarterly Review at the Southwest Research Institute (SwRI) facilities in San Antonio, Texas. Gemini staff noted that significant progress has been made on sev-

Figure 6 (bottom left).

During the brief moments of good weather on the commissioning nights, the full MCAO system with NGS2 could be tested on the central condensation of stars in the Tarantula Nebula (RMC 136).

Figure 7 (bottom right).

NGS2 control panel, showing the field of view on the NGS2 EMCCD camera, and the identified three natural guide stars. Individual guide star window images are shown in real time on the bottom left. This system has proven to be much easier, faster, and better to operate.