VLTI: First Light for the Second Generation

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The Very Large Telescope Interferometer (VLTI) stopped operation on 4 March 2015 with the objective of upgrading its infrastructure in preparation for the second generation VLTI instruments GRAVITY and MATISSE. A brief account of the eight bustling months it took our interferometer to metamorphose into its second generation, under the supervision of the VLTI Facility Project, is presented.

Decommissioning of MIDI and PRIMA and move of PIONIER

The first operation was to decommission the Mid-infrared Interferometric Instrument (MIDI), in order to make room for its replacement, the Multi AperTure mid-Infrared SpectroScopic Experiment (MATISSE; Lopez et al., 2014). One after the other, warm optics, cryostat, cooling, cabling, and control electronics were removed from the VLTI Laboratory (Figure 1). Then, following the termination of the astrometric mode of the Phase Referenced Imaging and Microarcsecond Astrometry instrument (PRIMA; van Belle et al., 2008), its fringe sensor unit was partly dismantled, preserving just the metrology equipment for possible use in vibration metrology for the Unit Telescopes (UTs). Finally, the *H*-band instrument PIONIER (Zins et al., 2011) was moved to a new optical bench located on top of the FINITO fringe tracker (see Figure 2), this time to make room for GRAVITY (Eisenhauer et al., 2011) and its feeding optics (Figure 3). New dichroic mirrors mounted on movable periscopes were installed to pick up the *H*-band, while keeping transmission of the *K*-band to the IRIS tip-tilt sensor. With this move complete, the VLTI was verified to be operational one last time, before a more extensive and transformational shutdown.

Upgrade of the VLTI infrastructure

Over the past few years, as the next generation VLTI instruments GRAVITY and MATISSE were being developed, it became obvious that many aspects of the infrastructure of the VLTI needed to be upgraded.

Therefore in April 2015, the instruments in the VLTI Laboratory were covered with protective tarpaulins, just before beginning the major transformation. Very quickly, Paranal turned into a beehive, but not just in the VLTI Laboratory. Upgrade activities took place in many different locations: the four Coudé rooms of the UTs; the VLTI and the Combined Coudé Laboratories; and the VLTI computer room. In order to accommodate the new instruments, the

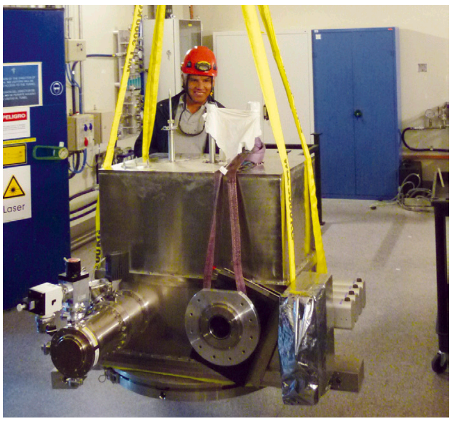

Figure 1. The MIDI cryostat is craned away from its base in the VLTI Laboratory after 12 years of productive work.

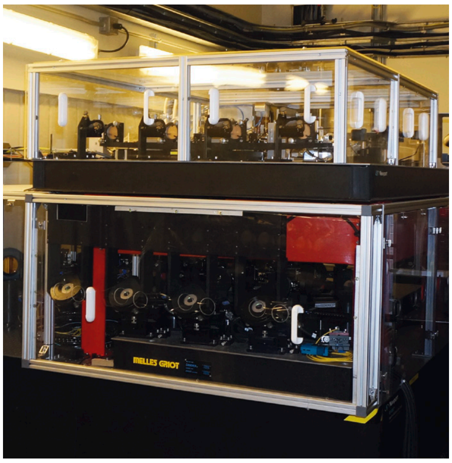

Figure 2. PIONIER, now located above FINITO in the VLTI Laboratory, is fed by four periscopes.

entire electrical, cooling, cryogenic, and network layout had to be modified. Drilling through the walls to open new cable ways, installing pipes for the new cooling system, changing the cooling pumps, feeding thick and heavy electrical cables, relocating and installing new service connection points and power distribution, all kept the teams extremely busy. See some examples in Figure 4.

The infrastructure of the inner and outer UT Coudé rooms had to be upgraded as well, to prepare the arrival of CIAO, the infrared wavefront sensors of GRAVITY. This was also the occasion to relocate the control equipment for the newly refurbished visible wavefront sensor of the Multiple Application Adaptive Optics instrument (MACAO; Arsenault et al., 2003), and the star separators, into new cabinets.

The challenging star separator upgrade of the Auxiliary Telescopes

The GRAVITY instrument needs the star separators on the Auxiliary Telescopes (ATs) to provide the field of view required by its dual field mode (Eisenhauer et al., 2011). As such, they are the only relay optics equipped with tip-tilt metrology feeding the GRAVITY beam combiner. As a consequence of the PRIMA astrometry demonstrator, AT3 and AT4 were already equipped with star separators. They however needed to be upgraded with variable curvature mirrors, in order to relay the pupil to the entrance of the delay lines, at a distance depending on the telescope station on the platform (Figure 5).

Providing better access to the relay optics under the Auxiliary Telescopes than the old maintenance station (G2), a new maintenance station (I2) became available (Figure 5). It was envisioned to support the AT upgrade as well as their long-term maintenance, without having to send the telescopes down to base camp.

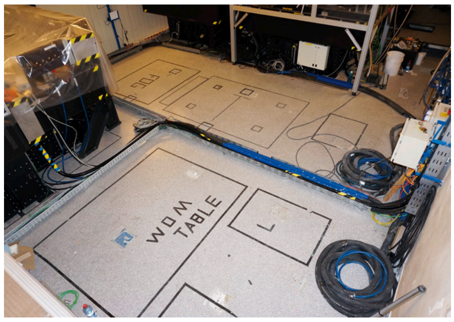

Figure 3. With MIDI removed and PIONIER relocated, the VLTI Laboratory was one step closer to receiving GRAVITY (location upper right) and MATISSE (location lower left).

Along with its control software, the variable curvature mirror upgrade on AT3 and AT4 was performed in April 2015. Then in May 2015, the upgrade of AT2 started, but very quickly appeared significantly more challenging than anticipated. Even though the opto-mechanical installation was progressing, work on the electrical front was not keeping pace, thus significantly delaying the testing of the control software and the system integration.

The need to schedule an unplanned emergency trip to Paranal to recover the electrical situation of the telescopes, combined with accumulating delays on the VLTI and the Combined Coudé Laboratories and UT Coudé rooms, forced the VLTI Facility Project to raise a red flag in June 2015. The recovery plan called for a significant increase in the number of staff involved, including the external contractors on site. Only then was it possible to complete the upgrades on AT2, and carry out the one on AT1 by the end of August 2015.

The upgrade of the Interferometer Supervisor and second light

The Interferometer Supervisory Software, the single gateway between the instru-

Figure 4. An album of work in progress for the VLTI upgrade: installation of the new false floor covering the cable trays running from the instruments (upper left); installation of a new cooling distribution system in the Combined Coudé Laboratory (upper right); integration of a more powerful pump to provide cooling for the second generation instruments (lower left); drilling of a new feedthrough between the Combined Coudé and the VLTI Laboratories (lower right).

Figure 5. Integration of a new star separator inside the relay optics structure of one of the Auxiliary Telescopes, as seen from the inside of the new maintenance station.

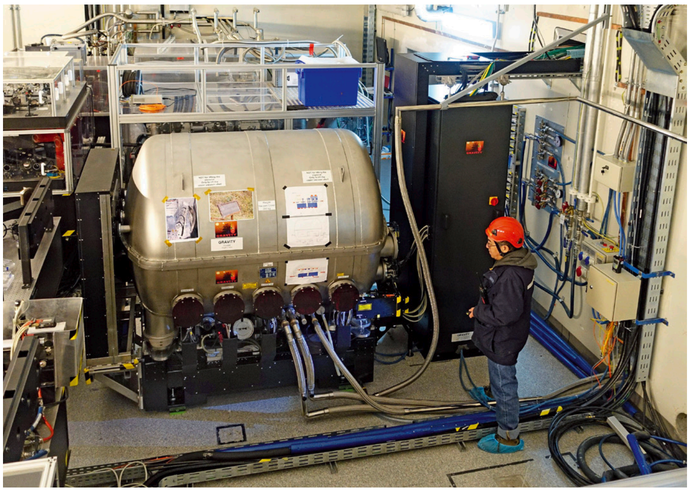

Figure 6. The GRAVITY beam combiner freshly installed in the VLTI Laboratory.

ments and the VLTI infrastructure, had to be adapted as well. Specifically, the objective was to make the VLTI behave like the single field interferometer it was before the upgrade, despite the installation of the star separators and its latent dual-field capability. This upgrade was successfully implemented in June and August 2015, leading to a straightforward and successful second light for the first generation instruments PIONIER and AMBER/FINITO on 23 August 2015. For observers, nothing has apparently changed. Yet, under the hood, the telescopes now point to a small offset position of the requested target, in order to avoid the edge of the star separator located at the Coudé focus. The same behaviour is planned for the UTs.

The readiness review and the re-commissioning of VLTI

On 26–28 August 2015, the upgrades of the ATs, the VLTI Laboratory, the Combined Coudé Laboratory and the UT Coudé room infrastructures were reviewed by an ESO internal board including observers from the GRAVITY, MATISSE, and ESPRESSO[1] instrument consortia. The objective was to assess the readiness for a re-opening of operations, and the integration of the GRAVITY beam combiner into the VLTI Laboratory. No show-stoppers were identified, although finalisation of the as-built documentation demands further attention. The month of September 2015 was used to re-commission the VLTI, verify the performance of the instruments, and open the three AT configurations (small: A0–B2–D0–C1; medium: D0–G2–J3–K0; large: A0–G1–J2–J3) planned for the operations in Period 96 (October 2015–March 2016).

The arrival of GRAVITY and the coming years

With only one month's delay on the schedule, the GRAVITY beam combiner was installed in the VLTI during October 2015 (Figure 6). The upgrade of the VLTI, especially at the level of the software interfaces, continued over this period, providing GRAVITY with the control it needs to achieve its mission. As a side effect of this installation and the presence of the consortium on the mountain, we have already received very valuable feedback on the performance of the upgraded VLTI, with a list of points to be addressed in the coming months.

Even though science operations started again in mid-November 2015, the pace of the VLTI Facility upgrades is not slowing down. The installation of star separators in the Coudé rooms of the Unit Telescopes 2 and 4 should be completed by February 2016, before the progressive arrival of the four CIAO infrared wavefront sensors in the March–September 2016 timeframe. In late 2016 – early 2017, the optics of the Coudé trains of the Auxiliary Telescopes will be replaced to improve the transmission of the VLTI imaging array. The adaptive optics instrument NAOMI (Dorn et al., 2014) will significantly improve the sensitivity, robustness, and fringe-tacking performance of the ATs by the end of 2018. All these activities will have to be carried out while GRAVITY expands its commissioning to astrometry and is made ready for observation of the S2 Galactic Centre event in 2017–2018. In the same timeframe, MATISSE will re-open the mid-infrared window of VLTI, and achieve its design sensitivity once the GRAVITY-for-MATISSE developments allow the two instruments to work together.

Without doubt, the VLTI will continue to be challenging and exciting for ESO and its community.

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Notes

[1] The Echelle SPectrograph for Rocky Exoplanet and Stable Spectroscopic Observations (ESPRESSO; Pepe et al., 2013) will be located in the Combined Coudé Laboratory and share its infrastructure with the VLTI instruments. As such, some of the infrastructure upgrades executed by the VLTI Facility Project will benefit this instrument.