HEXAGON
MANUFACTURING INTELLIGENCE

CASE STUDY

REACHING FOR THE STARS WITH HEXAGON

CENTRE DE RECHERCHE ASTROPHYSIQUE DE LYON, FRANCE

Advanced measurement equipment is the key to unlocking the mysteries of the universe

Created in 1995, the Centre de Recherche Astrophysique de Lyon (CRAL) is a fundamental research laboratory for major observatories that focuses on astrophysics and instrument development. Teams of opticians, mechanics, project managers, scientific computational scientists and electronic engineers at CRAL are building spectrographs to equip large research telescopes around the world. The centre operates under three supervisory bodies: the University of Lyon; the National Centre for Scientific Research (CNRS); and the Ecole Normale Supérieure (ENS) de Lyon.

When an astrophysics researcher wants to explore a distant galaxy, discover the chemical composition of galaxies or find exoplanets, a simple telescope is typically no longer enough: we must add a “smart eye” to it. To detect, for example, light from young galaxies, the characteristic lines of the hydrogen atom need to be isolated, which requires a spectrograph that can disperse light into its component wavelengths for further analysis.

Innovative Technological Combinations

Such a task also demands advanced knowledge of the position of the object. That's why the CRAL has developed the concept of the integral field spectrograph or 3D spectrograph, at once both an imager and a spectrograph. When a call for tenders for such an instrument is accepted by international research organisations, CRALs instrumentation department will oversee building a part of it, in close collaboration with the team of researchers who define their needs.

Florence Laurent, optical design engineer and head of the CRAL instrumentation team, explains further. "In astronomy, the light collected by the telescope passes through the layers of the atmosphere and the photons recovered are disturbed. A few years ago, the images received were naturally degraded and the instruments didn't need to be very precise. Since the 2000s, adaptive optics systems have been correcting atmospheric disturbances in real time and allow for much finer images to be obtained at a better resolution. So the engineers had to create ever more aligned instruments. And this alignment requires suitable and efficient metrology instruments.

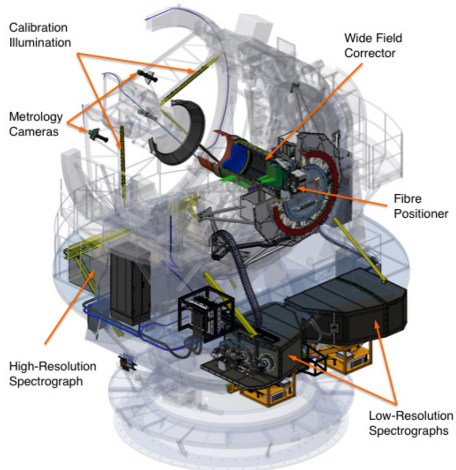
"Our first measuring instrument was a ROMER Sigma measuring arm, followed by a 3D TESA sensor in 2008 during the MUSE[1] project. The arm was used to align objects with each other and to measure small systems. The TESA sensor was dedicated to the verification of mechanical supports, machined to an accuracy of 10 microns. But the volume constraints of the complete assembled instrument (the largest instrument ever installed on a telescope) required a larger scale measuring machine."0

Larger Scale with a Laser Tracker

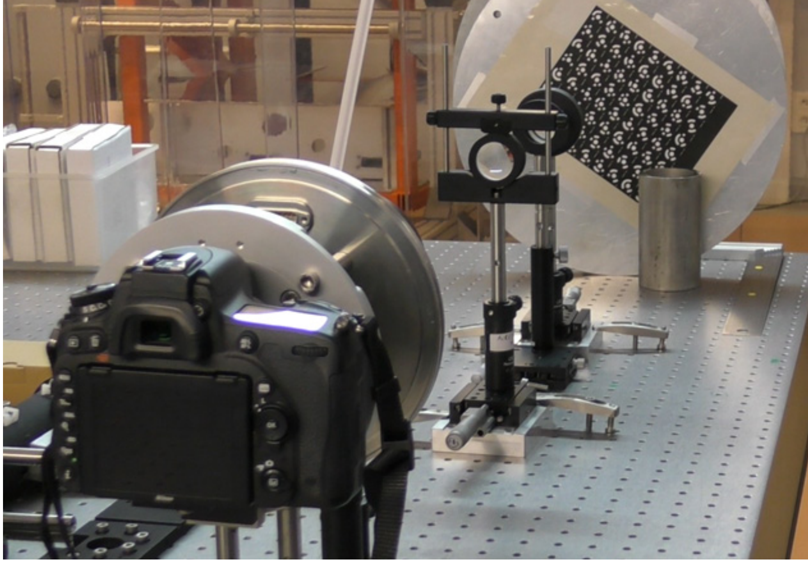
"Our colleagues at the Institute of Astrophysics in Göttingen had a Hexagon laser tracker that they lent us. This allowed us to use a Leica Absolute Tracker, both at the CRAL and on-site in Chile, on the telescope's own platform, to ensure the position of the instrument in relation to the telescope," recalls Mrs Laurent.

CRAL is currently working on the 4MOST project as part of a consortium of 13 European institutes led by the Leibniz-Institute for Astrophysics in Potsdam, Germany. The 4MOST instrument is a multifibre wide-field spectrograph for the VISTA telescope of the European Southern Observatory (ESO) in the Atacama Desert in Chile.

This spectrograph breaks down the light that arrives from a star or galaxy into component wavelengths and will be able to detect the chemical and kinematic substructures in the stellar halo, bulge and thin and thick discs of the Milky Way, allowing for the disentanglement of the origins of the galaxy. The 4MOST project is currently in its manufacturing phase with the start of scientific operations planned for 2022.



After receiving the scientific specifications, CRAL, who are in charge of carrying out construction of the two low-resolution spectrographs of the 4MOST instrument, will first devote two years to preliminary studies of the instrument – optical drawings, mechanical drawings, electronic drawings – to evaluate the concept. Two more years will then be needed to complete the final plans. And once the green light is received, the team will have the optics and mechanics manufactured. All ordered parts will be centralised at the site in Lyon



for assembly and alignment – crucial tasks such as the positioning of a mirror in relation to the interfaces. This alignment must, for some elements, be extremely precise, namely in the 10-micron range.

High Accuracy Made Easy

“A complete metrology solution combining a measuring arm with a laser tracker was ideal and offered the necessary flexibility that we needed and will need. The acquisition of this collection was made possible thanks to the financing of the LABEX Lyon Institute of Origins[2] (LIO) . We exchanged our old and by now obsolete measuring arm for a new Absolute Arm and also acquired a Leica Absolute Tracker AT403.

“Our measuring devices were immediately operational and allowed us to start our operations very quickly. The desired tolerances were part of the specifications and the 11.5-micron accuracy of the Absolute Arm 85 Series was just what we were looking for. The ergonomics of the new arm make it very pleasant to use: it’s very well balanced and offers excellent accessibility to our targets. Its USB and WiFi connections are also very convenient.

“The highly visual import of CAD data using SpatialAnalyzer is a big advantage and offers clear, fast and simple reports. The many options possible during the set-up of the new arm were also very useful. Five employees were trained in two sessions, allowing us to use the arm in between and obtain concrete and dedicated answers to our requests.”

Modern Problems Require Modern Solutions

The CRAL technical team is also working on the study of the HARMONI instrument within the Extremely Large Telescope (ELT)[3] project. This instrument has the capacity to see in the infrared where “everything radiates”. To avoid seeing only the reflection of the instrument’s mechanics and optics when exploring galaxies, the instrument temperature must be lowered to 130 Kelvin – minus 143 degrees Celsius. This temperature drop must be made in several steps, the first of which is to create a vacuum (to avoid frost). The instrument must therefore be placed in a cryostat, which makes metrological measurements technically very complex with traditional measuring instruments (perpendicularity of the laser, coefficient parameter to compensate for deformation due to window, etc.).

> Hexagon’s instruments and solutions offer us a complete range that is essential in our research.”
>
> Florence Laurent
> Optical design engineer and team leader of the CRAL instrumentation division

To avoid these issues with traditional metrology tools, CRAL opted for photogrammetry by developing a special periscope. This development is carried out using an AICON DPA Series system that has been customised by the technical team.

“Each project allows us to improve our measurement processes and operate our machines more efficiently. The portability of the laser tracker allows us, for example, to check directly with our suppliers. The combination of the Absolute Arm with the laser tracker will be operational very soon and will offer us a real time saving in the installation of, for example, the arm references,” says Mrs Laurent.

[1] The MUSE (Multi-Unit Spectroscopic Explorer) is a second-generation wide-field 3D spectrograph operating in the visible wavelength range developed for the Very Large Telescope (VLT) of the European Southern Observatory. MUSE was designed to explore space in three dimensions (location and distance) and detect the youngest galaxies. It was first used on the VLT on 31 January 2014.

LABEX LIO UNIVERSITÉ DE LYON

[2] The authors are grateful to the LABEX Lyon Institute of Origins (ANR-10-LABX-0066) of the Université de Lyon for its financial support within the "Investissements d'Avenir" (ANR-11-IDEX-0007) programme of the French government, which is operated by the National Research Agency (ANR).

[3] The European Giant Telescope (Extremely Large Telescope), is a terrestrial telescope that is part of a series of three giant telescopes under construction and scheduled to open in 2025. Built by the European Southern Observatory, it should allow major advances in the field of astronomy thanks to a primary mirror that boasts a diameter of 39 metres.

Hexagon Manufacturing Intelligence helps industrial manufacturers develop the disruptive technologies of today and the life-changing products of tomorrow. As a leading metrology and manufacturing solution specialist, our expertise in sensing, thinking and acting – the collection, analysis and active use of measurement data – gives our customers the confidence to increase production speed and accelerate productivity while enhancing product quality.

Through a network of local service centres, production facilities and commercial operations across five continents, we are shaping smart change in manufacturing to build a world where quality drives productivity. For more information, visit **HexagonMI.com**.

Hexagon Manufacturing Intelligence is part of Hexagon (Nasdaq Stockholm: HEXA B; **hexagon.com**), a leading global provider of information technologies that drive quality and productivity across geospatial and industrial enterprise applications.

- COORDINATE MEASURING MACHINES
- 3D LASER SCANNING
- SENSORS
- PORTABLE MEASURING ARMS
- SERVICES
- LASER TRACKERS & STATIONS
- MULTISENSOR & OPTICAL SYSTEMS
- WHITE LIGHT SCANNERS
- METROLOGY SOFTWARE SOLUTIONS
- CAD / CAM
- STATISTICAL PROCESS CONTROL
- AUTOMATED APPLICATIONS
- MICROMETERS, CALIPERS AND GAUGES
- DESIGN AND COSTING SOFTWARE