Isaac Newton Group of Telescopes

La Palma, the most northwesterly of the Canary Islands, harbours one of the largest arrays of telescopes in the world, the Roque de Los Muchachos Observatory (ORM). It stands over 2400 m above sea level, on the rim of the Caldera de Taburiente National Park. The site was chosen due to its clear and dark skies, which are exceptional conditions for astronomical research. The remoteness of the island and the remarkably stable atmosphere, together with the continuous effort to protect the night sky from light pollution, ensures a spectacular quality for astronomical observations making it one of the best locations in the world to gaze and study the universe.

A wide variety of telescopes are hosted at the observatory, which is operated by the Instituto de Astrofísica de Canarias (IAC). Among the facilities at the ORM, there is the Isaac Newton Group of Telescopes (ING), a result of a collaboration between the United Kingdom, the Netherlands, and Spain. 95% of the observing time is shared among institutions from these countries, and the remaining 5% is reserved for large scientific projects to promote international collaborations.

The ING operates two telescopes: the 2.5 m Isaac Newton Telescope (INT) and the 4.2 m William Herschel Telescope (WHT), operational since 1984 and 1987, respectively. Thanks to a strong instrument development programme which guarantees the use of the latest trends in technology, the ING remains at the forefront of astronomical research.

The first unequivocal evidence for the existence of a black hole of stellar dimensions in our galaxy was provided by the INT. Other astrophysical studies with this telescope include the first detection of a dark galaxy, the discovery of new galaxies in the Local Group, the detection of the breakup of the nucleus of comet C/1999 S4, and the discovery of a gigantic stream of stars in the halo of the Andromeda galaxy.

The WHT has also played an important role in producing several scientific results. Examples of this are the detection of the accelerated expansion of the Universe (awarded the 2011 Nobel Prize), and the contribution from various observations related to the fields of observational cosmology, gamma-ray bursts, galaxy dynamics, star evolution, and solar-system bodies. WEAVE, aims at keeping the WHT in the frontline of space exploration, taking thousands of spectra every night.

Further information in: https:/www.ing.iac.es/weave/

WEAVE

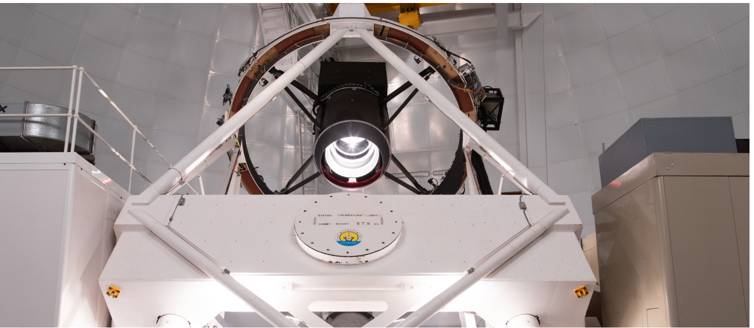
WEAVE (WHT Enhanced Area Velocity Explorer) is a powerful, next-generation multi-fibre spectrograph mounted at the prime focus of the WHT. It was designed and built by an international consortium led by ING partner countries. The project has been the result of the collaboration and effort of several institutions worldwide.

WEAVE uses optical fibres to gather light from up to 1000 celestial individual sources in a single exposure. The data is collected by robotically-positioned optical fibres in the focal plane and is fed into a two-arm spectrograph, located on a platform lower down the telescope. The spectrograph then separates the light into its different wavelengths or colours, and records them on large-format CCD detectors. The resulting spectra contains the fingerprint of the physical and chemical properties of the targets, which astronomers use to test their theories and unravel the history and evolution of the Universe, and also to measure velocities along the line of sight through the Doppler effect.

One of WEAVE's unique features among multi-object spectrographs is its superb sharpness when splitting the incoming light into its component wavelengths, also known as spectral resolving power, which in high-resolution mode is five to ten times greater than that of other multi-object facilities in the northern hemisphere. It can operate in three different modes, using different sets of fibres according to the science: the MOS (Multi-Object Spectroscopy), the mIFU (mini Integral-Field Units) and the LIFU (Large fixed Integral-Field Unit) modes.

Spectroscopic resolutions:

- Low Resolution (LR) mode: 5000 (MOS, mIFU), 2500 (LIFU) from 366 to 959 nm.
- High Resolution (HR) mode: 20,000 (MOS, mIFU), 10,000 (LIFU) over ranges 404 - 465 nm, 473 - 545 nm and 595 - 685 nm.



Components

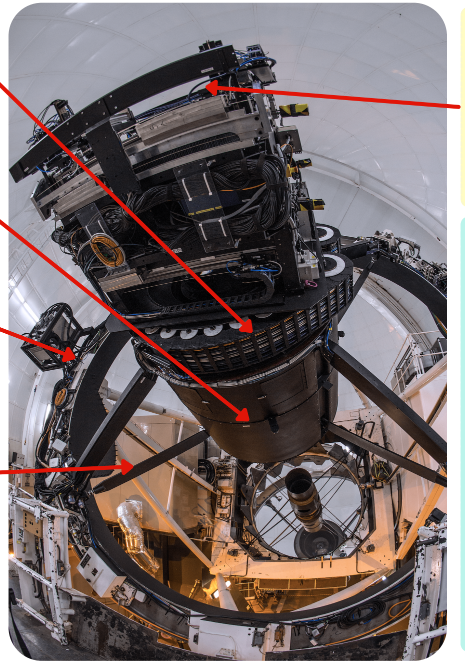
Cable wrap & prime focus rotator: a high-level control system delivers a fixed position angle on sky while tracking. The cable wrap routes the optical fibres through the telescope structure to the spectrograph.

Prime focus corrector: a new atmospheric dispersion and field corrector, comprising a collection of six new lenses, with one of the largest astronomical lenses ever built, provides a good image quality over a 2 degree field of view.

Fixed top-end: robots and the central can sit on the new ring. The telescope can be focused by moving the whole structure.

Spectrograph: the fibres feed a dual-arm (blue+red) spectrograph housed in one GHRIL (Ground-based High-Resolution Imaging Laboratory) Nasmyth enclosure. Each arm has a two CCD detectors of 12,000x12,000 pixels. A dichroic splits the light between both arms. Dispersion is affected by a VPH (Volume-Phase Holographic) grating in each arm, giving five spectroscopic modes: LR-R, LR-B, HR-B, HR-G, HR-R.

Resolution	BLUE	GREEN	RED
LOW	366-606 nm	-	579-959 nm
HIGH	404-465 nm	473-545 nm	595-685 nm

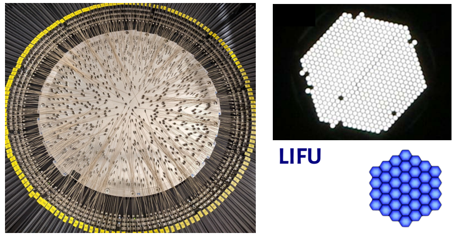


Fibre positioner: The fibres are arranged in three rows to avoid collision and to maximise the flexibility of the sky configurations, which are carried out. The two robots, Nona & Morta, pick and place the fibres with high accuracy using magnets. Then, a tumbler is rotated by 180 degrees so that plates A and B swap positions. The system also entails part of the acquisition and guidance subsystems.

Focal plane modes

In the **MOS** mode individual fibres can be positioned anywhere within the field of view, with each fibre intercepting a circular area of sky of 1.3 arcsec diameter. There are two sets of MOS fibres, for each of the plates: A (960 fibres) and B (940 fibres).

To carry out integral-field spectroscopy, WEAVE can use the **mIFU** mode, in which the fibres are organised into 20 fibre bundles (each consisting of 37 fibres covering 11x12 arcsec on the sky) that can be positioned anywhere within the field of view on plate B, or the **LIFU** mode, in which a single IFU is positioned at the centre of a hexagonal field of view (78x90 arcsec^2) with the tumbler at 90 degrees. The array of 547 closely-packed fibres have a circular cross-section with a 2.6 arcsec diameter on the sky.



LIFU

MOS

mIFU

Observations

WEAVE observations are prepared by applicants and are specified as observing blocks (OBs) containing all the information required. Observations are executed in service mode by ING staff, with the aid of an OB scheduler. This optimises the observing time by matching OBs with the required conditions, and taking into account the science priority. The results of the observations can be checked at the telescope using a quick-look software. Data reduction, extraction, and calibration of the spectra are carried out automatically by the WEAVE pipelines, and are eventually provided on the WEAVE archive.

Science

Observing time at the WHT

WEAVE aims to observe thousands of targets every night over at least 5 years, generating more than 30 million spectra.

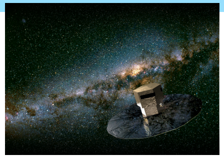
Around 2/3 of the observing time is used for 8 dedicated surveys, the WEAVE Survey, while the remaining time is for open-time observations, which includes the international time or ITP proposals.

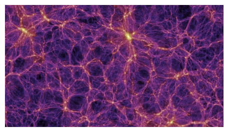
The WEAVE Survey science goals are to complement the major space- and ground-based programmes in the current and coming decade, including Gaia, LOFAR and Apertif. Its wide-ranging science purposes cover various fields of galactic and extragalactic astronomy.

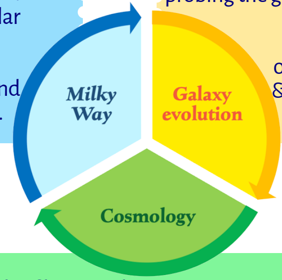
Milky Way archaeology: measuring radial velocities and stellar abundances for millions of stars.

Star, circumstellar and interstellar physics: characterising young and massive stellar populations and the interstellar medium.

White Dwarfs: studying the death of stars and the local star-formation history of the Galaxy.







Stellar populations at intermediate redshift: determining stellar properties of galaxies at z=0.3-0.7.

Galaxy clusters: probing the galaxy evolution as a function of environs.

Apertif: observing stellar and gaseous kinematics & physical properties of gas-rich galaxies, complementing Apertif's surveys.

Quasars: a study of large-scale structure using quasar absorption lines.

LOFAR: a follow-up of more than a million selected low-frequency radio sources from LOFAR survey to probe galaxy evolution over cosmic time.