4MOST: 4-metre Multi-Object Spectroscopic Telescope

The 4MOST consortium led by the AIP is conducting a Conceptual Design study for ESO for a very high-multiplex (2400–3000), wide-field (4–6 deg^2) fiber-fed spectrograph system for the 4m-class VISTA telescope to create a world-class survey facility that is unique in its combination of wide-field multiplex, spectral resolution and coverage, and sensitivity. The science is mostly driven by key all-sky, space-based observatories of prime European interest: Gaia, eROSITA and Euclid.

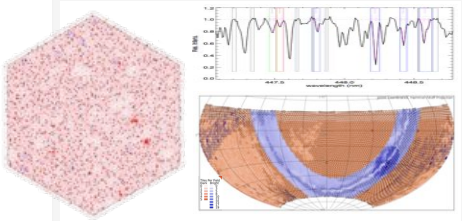
WWW.4MOST.EU

The Facility

The 4MOST facility is a spectroscopic survey facility running full time with many science cases observing simultaneously. This creates unique opportunities for both large surveys as well as for low target density surveys spread all over the sky. 4MOST is currently in a conceptual design selection phase together with MOONS (a smaller field IR MOS for the VLT), with a decision in Spring 2013.

Surveys and data products

4MOST will run several *Public Key Surveys* in parallel delivering ≥15 million (goal 30 million) spectra over 15,000–20,000 degree^2, an order of magnitude larger than SDSS at >2.5× the spectral resolution. The targets selected for these Public Surveys will be based on the science cases of the consortium and through open calls from ESO. The consortium surveys will ensure that the entire sky between +20˚<DEC <-70˚ and the Magelannic Clouds area will be covered by at least 120 minutes total exposure time build up from 20 minute sub-exposures. Areas with high target density will get more total visit time. All data, including high-level science products, will be made available to the general public in yearly increments similar to SDSS and RAVE.



To determine feasibility of the science goals the *4MOST Facility Simulator* (4FS) was created that simulates the full performance based on Design Reference Surveys (DRSs), key programs that define the instrument requirements the most. Each DRS has a full science input catalog that is simulated through a throughput and noise simulator (top right), a tile fibre assignment routine (left), an observation scheduling simulator (bottom right), and analyzed using a data quality software to produce survey figures-of-merit.

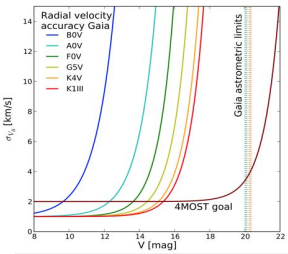
Consortium

Instrument Institutes
- Leibniz-Institut für Astrophysik Potsdam (AIP) (D)
- MPI für Extraterrestrische Physik, München (D)
- Ludwig-Maximilian Universität, München (D)
- Zentrum für Astronomie, Univ. of Heidelberg (D)
- Institute of Astronomy, Cambridge University (UK)
- Rutherford Appleton Laboratory, Oxford (UK)
- L'Observatoire de Paris, GEPI, Paris (F)
- NOVA, Dwingeloo (NL)
- ESO, Garching (EU)

Science Institutes
- University of Lund (S)
- University of Uppsala (S)
- University of Groningen (NL)

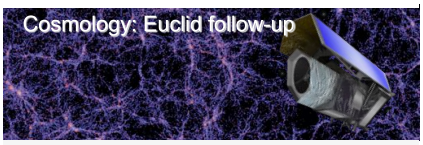
Science drivers

The 4MOST instrument complements Gaia in key areas where it lacks spectroscopic capabilities. Performing a large survey of faint Galactic stellar objects with 4MOST will determine the 3D Galactic potential and its substructure, measure the Galactic assembly history through chemo-dynamical substructure and abundance pattern tagging, determine the dynamical structure of the Milky Way and measure the influence of its bar and spiral arms, and find thousands of extremely metal-poor stars to constrain early galaxy formation and stellar evolution.



The 4MOST goal radial velocity accuracy compared to Gaia's accuracy. 4MOST's spectroscopic limits match Gaia's astrometric limits, thereby enabling 6D-phase space studies to Gaia's limits throughout the Milky Way.

A survey of galaxies in eROSITA X-ray clusters will measure the evolution of galaxy population in clusters, the cluster mass evolution, and provide competitive constraints on Dark Energy evolution. Using 4MOST to classify eROSITA point sources we will determine the nature of >1 million Galactic X-ray emitters and AGNs, constraining the evolutionary channels of stellar populations and the cosmic evolution of active galaxies to z=5.



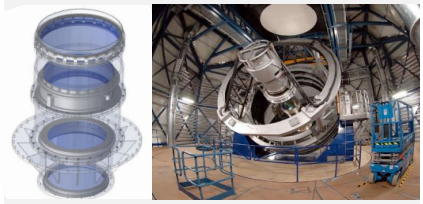
Constraints on Dark Energy properties and Galaxy Evolution will also be obtained through redshift surveys, especially for Euclid. 4MOST is also the ideal follow-up facility for other all-hemisphere optical/IR surveys like VISTA, VST, DES, SkyMapper, WISE, LSST, and radio surveys from ASKAP, MeerKAT, and SKA.

Requirements and specifications

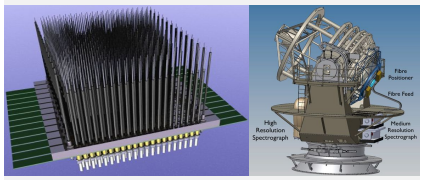
4MOST shall be able to obtain:
- *radial velocities* of ≤2 km/s accuracy of any star observed by Gaia: R~5000 spectra of 19 mag stars, S/N=10 per Ångström
- *abundances* of up to 15 chemical elements: R~20000 spectra of 16 V-mag stars with S/N=140 per Ångström
- *redshifts* of AGNs and galaxies (also in clusters): R~500 spectra of 22 r-mag targets with S/N=5 with >3 targets in ⌀=2'

Specification	Baseline	Goal
Field-of-View (hexagon)	3 degree^2 (⌀>2°)	>5 degree^2 (⌀>2.7°)
Multiplex fiber positioner	2400	>3000
Med-Res Spectrographs Passband	R~5000 400-900 nm	R~5000 390-1050 nm
High-Res Spectrographs Passband (~30% of all fibers)	R~20,000 395-456.5 nm & 587-673 nm	R~20,000 390-459 nm & 585-676 nm
# of fibers in ⌀=2' circle	>3	>7
Area (5 year survey)	1.5h x 15,000 deg^2	>2h x 20,000 deg^2
Objects (5 year survey)	15 x 10^6	>30 x 10^6
Start operations	Mid 2019	Early 2019

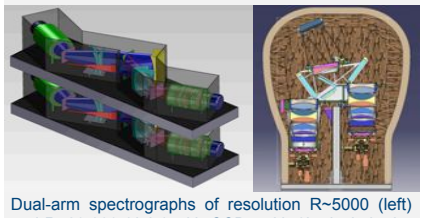
Instrument



Wide-field Corrector with 2.5s degree diameter field-of-view for the VISTA telescope.



Echidna-style positioner based on proven technology allows high fibre density and rapid reconfiguring. The spectrographs will be located on the telescope fork resulting in a short fibre routing and high efficiency.



Dual-arm spectrographs of resolution R~5000 (left) and R~20,000 (right) with CCDs with 8k pixels in the spectral direction in each arm.

October 2012