# Astrophysics on the edge: New Instrumental Developments at the ING

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## Abstract

Present and future key instruments at the ING are introduced, and their corresponding latest scientific highlights are presented.

•GLAS (Ground-layer Laser Adaptive optics System): The recently installed 515-nm laser, mounted on the WHT (William Herschel Telescope), produces a bright artificial star at a height of 15 km. This enables almost full-sky access to Adaptive Optics observations. Recent commissioning observations with the NAOMI+GLAS system showed that very significant improvement in image quality can be obtained, e.g. to 0.16 arcsec in the H band.

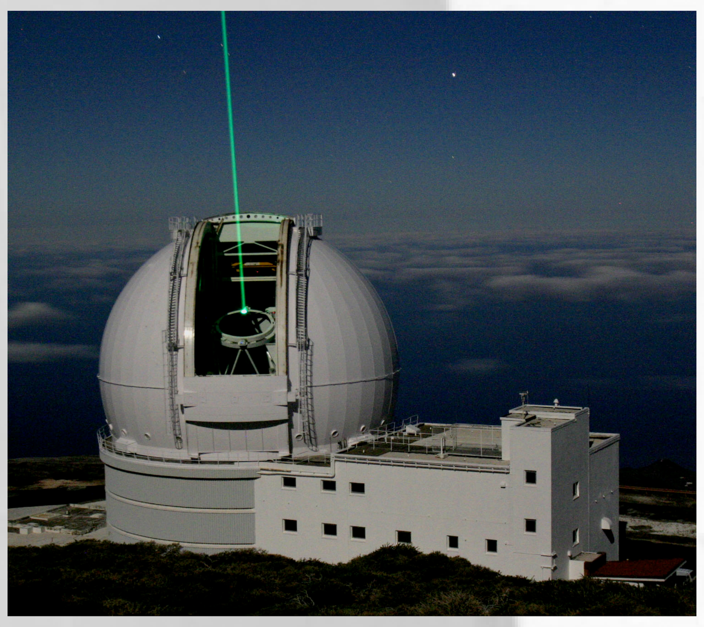
•QUCAM2: A Low Light Level (L3) CCD camera for fast spectroscopy with the ISIS spectrograph at the WHT, which is designed for exploring the high time-frequency domain. It is a powerful instrument for research on compact objects such as white dwarfs, neutron stars or black holes, stellar pulsations, and compact binaries.

•HARPS-NEF (High-Accuracy Radial-velocity Planet Searcher of the New Earths Facility): An extremely stable high-resolution (R=120000) spectrograph for the WHT which is being constructed for commissioning in 2009-2010. Its radial velocity stability of <1 m/s may in the future be even further improved by using a Fabry-Perot "laser-comb", a wavelength calibration unit capable of achieving an accuracy of 1 cm/s. This instrument will effectively allow to search for earth-like exoplanets.

## On the edge of spatial resolution

# GLAS

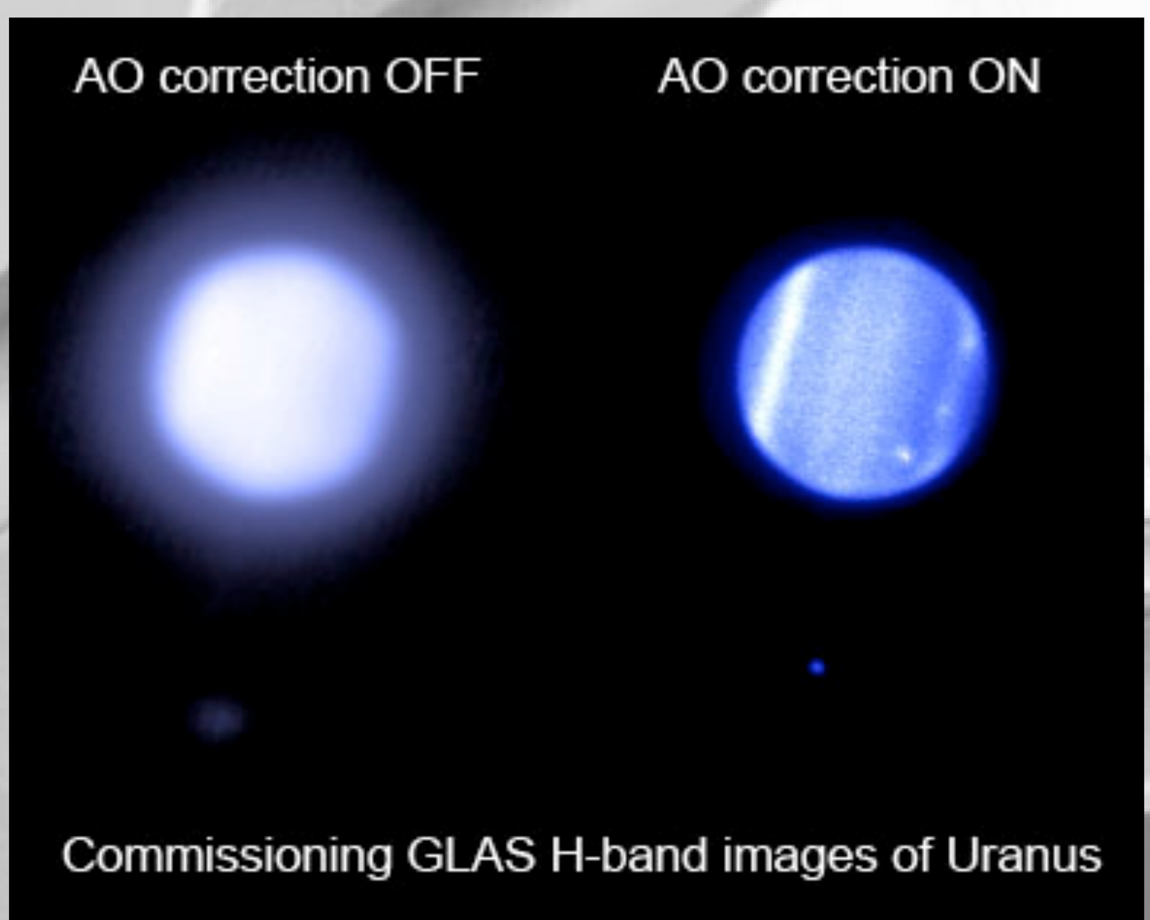
Forget about the atmosphere...



The 20W-power GLAS (Ground-layer Laser Adaptive optics System) 515 nm LASER, mounted on the WHT, produces a star-like point at a height of 15 km.

The Rayleigh back-scattered light from this bright artificial star is captured by a dedicated wavefront sensor where the signal is analyzed in order to correct for atmospheric turbulence at a rate of 300 Hz. This enables almost full-sky access to Adaptive Optics (AO) observations with the INGRID near-infrared imager or the OASIS optical integral-field spectrograph.

Recent Commissioning observations with GLAS showed that correction up to the diffraction limit of the telescope (0.16 arcsec in the H band) is achievable.

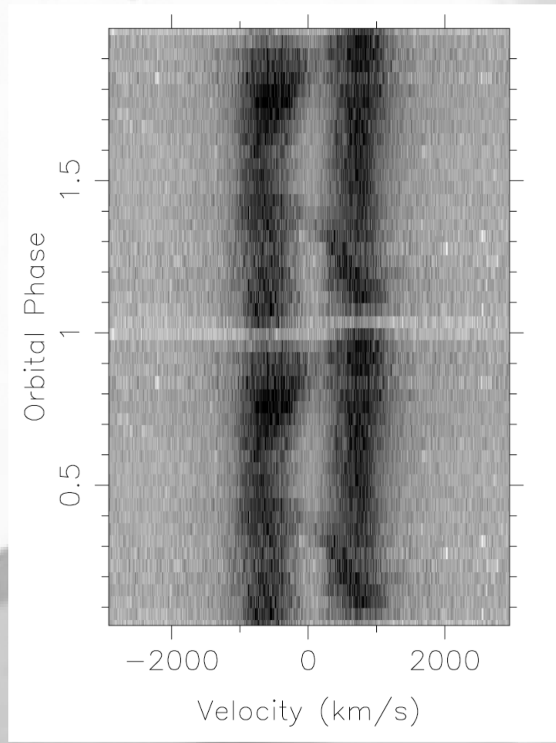



*Comparison of H-band images of Uranus with GLAS and adaptive optics correction off (left) and on (right). The faint point at the bottom is the moon Miranda, which has moved aproximately 0.7 arcseconds between the times both images were taken. Credit: René Rutten, Javier Méndez and the GLAS commissioning team.*

## On the edge of time resolution

# QUCAM2

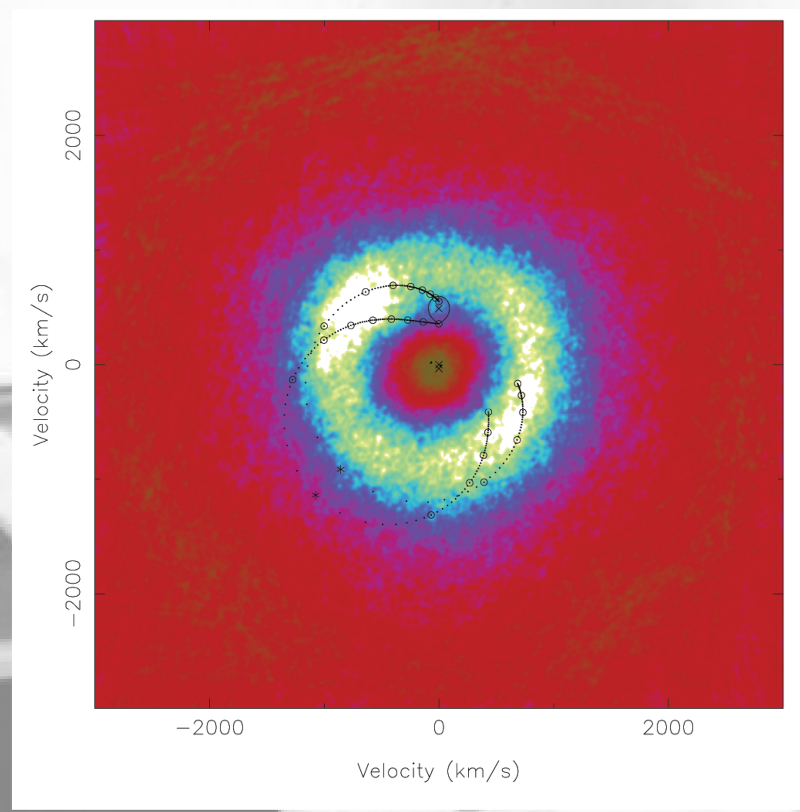
Faster and deeper than your own eye...




*Trailed spectra diagram of the Hα emission line of the eclipsing cataclysmic variable SDSS J1433+1011 with QUCAM2. The faintness of the system (V=18.6) and its short orbital period (78.1 m) would have prevented its study with ISIS in the standard spectroscopic mode. The emission S-wave produced by the bright spot in the system is clearly detected.*

An E2V electron-multiplying, low-light-level (L3) CCD camera is available for use on ISIS red or blue arm to perform fast spectroscopy. The L3 detector is a 1k x 1k pixel, 13 micron/pixel, full frame transfer device, which readout noise (RON) is nearly zero. Exposure times as short as 20 ms are possible as the system continuously exposes while reading the previous image. QUCAM3 will be available during semester 2008B so that simultaneous observations with both ISIS arms can be performed.

The QUCAMs are designed to explore the high time-frequency domain in spectroscopic mode. As examples, high time resolution, spectroscopic studies of compact binaries, neutron stars and black hole binaries, as well as stellar pulsations, are now possible at the WHT.

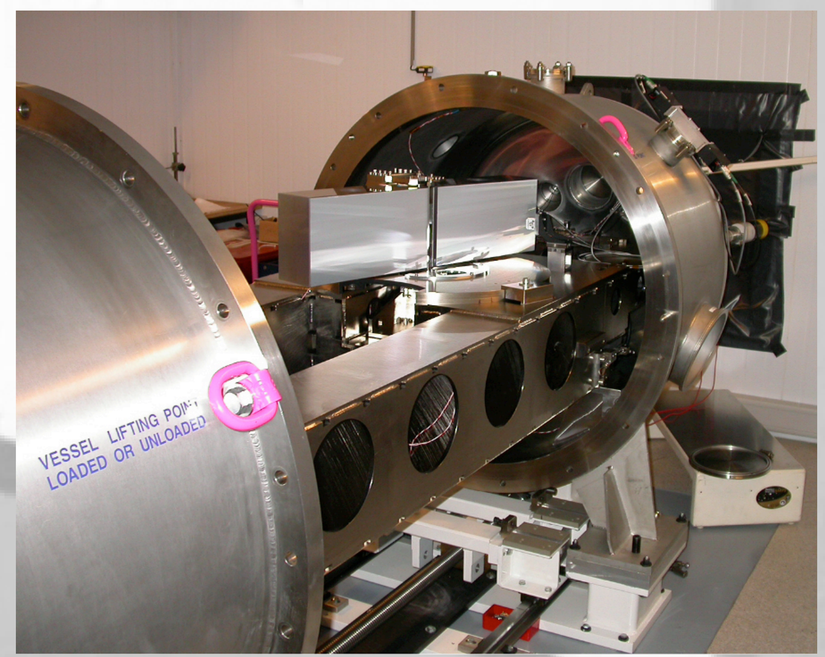



*Doppler tomogram of the Hα emission line of the same system. The ring-like emission from the accretion disc and the location of the bright spot are apparent.*

## On the edge of dispersion resolution

# HARPS-NEF

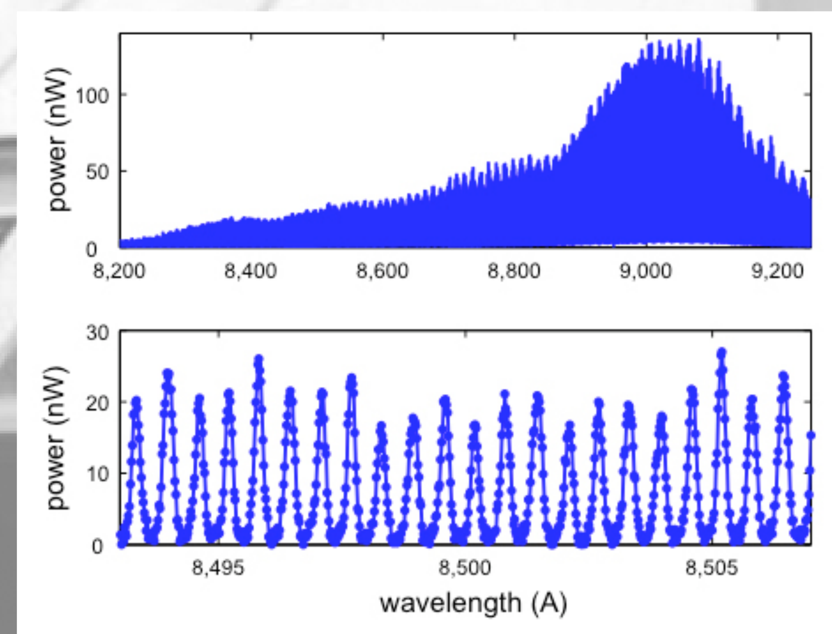
Measure the Doppler-shift of a racing snail...



*HARPS on the ESO-3.6m telescope.*

Fruit of the collaboration between the Harvard College Observatory, the Smithsonian Astrophysical Observatory and the Observatoire de Genève institutions, the HARPS-NEF (High Accuracy Radial-velocity Planet Searcher of the New Earths Facility) high-resolution (R~120000) spectrograph is intended to be mounted on the WHT and commissioned in 2009-2010.

Its extremely stable radial-velocity calibration accuracy of <1 m $s^{-1}$ will in the future be improved to <1 cm $s^{-1}$ with the installation of a Fabry-Perot laser "astro-comb" calibration unit, making HARPS-NEF ideal for finding earth-like exoplanets.




*Example astro-comb output spectrum with 37-GHz line spacing. Extracted from Li et al. 2008, Nature, 452, L610*

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