

Proposal: Conceptual Design for a common-user facility near-IR Intermediate Resolution Spectrometer for the GTC

Preparado por
Prepared by

NIRINTS Team

Revisado por
Revised by

Eduardo Martín
Roser Urqui
Victor Sánchez Béjar

Aceptado por
Accepted by

GRANTECAN

CENTRO DE ASTROBIOLOGIA (CSIC-INTA)

Carretera de Ajalvir Km. 4

28850 Torrejón de Ardoz

Madrid

SPAIN



4 SCIENCE CASES

4.1 Introduction

The highly-competitive science cases of NIRINTS have carefully been developed by a large team of international scientists. These studies have taken place in the framework of the initial instrument requirements provided by GRANTECAN in the Announcement of Opportunity. There are six key research topics that drive the conceptual design of the instrument, and seven additional science cases that demonstrate the breath of topics that can be studied with the proposed concept. Those science cases can be addressed by the three observing modes proposed for NIRINTS; namely, a multi-object mid-low resolution mode (M-LR), an integral field mode with mid-high resolving power (M-HR mode), and a high-resolution single object mode (HRM).

4.1.1 Key science topics and their observing modes

The highlights of the six key science cases and the observing modes that enable them are the following:

- 1) Giant planets around young stars (M-HR and HRM)
- 2) The Initial Mass Function of galactic young open clusters (M-LR and M-HR)
- 3) Physics and evolution of high-*z* galaxies (M-LR)
- 4) Detection of habitable rocky planets around the nearest stars (HRM)
- 5) Characterization of transiting hot jupiters (HRM)
- 6) Atmospheric characterization of transiting rocky planets (HRM)

4.1.2 Complementary science topics and their observing modes

Additional science cases have been provided by our team to demonstrate the breath of topics that can be addressed by the proposed observing modes of NIRINTS. These complementary science cases are the following:

- 7) Protostellar disks (M-HR and HRM)
- 8) Stellar activity and chemical abundances (M-HR and HRM)
- 9) Gamma-ray bursts (M-LR)
- 10) Local ULIRGs (M-LR)
- 11) Follow-up observations for high red-shift galaxies lensed by clusters (M-LR and M-HR)
- 12) Protoplanetary nebulae (M-HR)
- 13) CNO isotopic abundances in massive HBB AGBs in Local Group Galaxies (M-HR)

4.1.3 Top level science requirements

Science cases listed above with numbers 1, 2, 3, 7, 8, 9, 10, 11, 12 and 13 require intermediate



resolution spectroscopy ($R=7000-25000$) in the near-infrared (YJHK) and multi-object capabilities (20-40 objects). The desired radial velocity precision is in the range 0.1-1 km/s. High-throughput is necessary for observing objects with faint magnitudes. A total efficiency of 10% or larger is required to make NIRINTS a highly competitive instrument with respect to other near-infrared spectrographs in 8 or 10-meter class telescopes.

Science cases listed above with numbers 1,4,5,6 and 7 require high spectral resolution to resolve the spectral lines ($R=70,000$) and broad spectral coverage to maximize the amount of Doppler information in each spectrum.

Science cases listed above with numbers 4,5 and 6 require hyper-stabilization in pressure and temperature, and no moving parts inside the spectrograph. Other requirements imposed by those science cases include the following:

- 1) High quality detector with cosmetics, read-out noise and dark current comparable with CCDs.
- 2) Accurate and simultaneous wavelength calibration. Probably more than one method should be used in the near-infrared. In the optical regime, two different wavelength reference systems are used: ThAr and an absorption cell. More recently the laser-comb method has been investigated in the laboratory but it has not been fully implemented yet for RV surveys.
- 3) Homogeneous illumination of the spectrograph entrance (HARPS uses image scrambling).

4.1.4 Summary of proposed instrument concept

To meet all the requirements specified by the key science cases, we propose a versatile instrument that has the following capabilities: multi-object fiber-fed spectroscopy at mid-low resolving power (M-LR) over a field of view of 5 square arcminutes, an integral field mode at mid-high resolving power (M-HR), and a high-resolution single object mode (HRM). The M-LR and M-HR observing modes operate over the whole near-infrared wavelength range (0.9 – 2.5 microns). The number of objects, the resolving power and the wavelength range covered by those two observing modes are selected by the observer using the instrument control software. The HRM has a hyper-stable echelle design and provides a resolving power of $R \sim 70,000$ covering the spectral region from 0.9 to 1.8 microns. The observing configuration of the HRM is fixed and cannot be changed by the observer.

High throughput of the M-LR and M-HR modes is ensured with a compact design that allows us to attach this module to the ring provided by GTC at one of the folded Cassegrain focal stations. The estimated size and weight of this part of NIRINTS is such that it is compatible with the restrictions provided by GRANTECAN for an instrument located in this focal station. This module will be coupled to the facility derotator and autoguider units provided by GTC. The HRM module will be fiber-fed to a hyper-stable room located at the Coudé room in the GTC basement level. The HRM mode corresponds to the project formerly known as NAHUAL, which was proposed as a visiting instrument at GTC, and now it has become a part of NIRINTS.

All of the observing modes use the same telescope interface and fiber robot. The two arms mentioned will also share part of control electronics, and will be seen as a single more powerful entity.