**Telescope & Instruments**

**GIANO-B – the Near-Infrared High Resolution Spectrograph of the TNG**

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**Introduction**

GIANO-B is a near infrared high resolution spectrograph mounted at the TNG. GIANO-B is the upgrade of GIANO, which operated at the TNG in the March 2015 - August 2016 period. GIANO-B commissioning was carried out in September 2016 through March 2017, and the instrument is offered to the community for regular use starting October 2017. GIANO-B provides cross-dispersed echelle slit spectroscopy at a resolution of $\sim 50000$ in the near infrared 0.9-2.45µm spectral range in a single exposure. Both the original spectrograph and its upgrade projects were entirely funded by the Istituto Nazionale di Astrofisica (INAF). More information on GIANO-B can be found in the following paragraphs, in the GIANO-B Observer Manual and in the reference papers below.

**Spectrograph slit**

Unlike GIANO, which was fiber-fed, GIANO-B pre-slit now feeds the telescope light directly on the spectrograph slit. The cold slit, located inside the spectrograph’s cryogenic dewar, has on-sky dimensions of 6”×0.5”. Point sources can be observed on one of the three predefined “A”, “B” and “C” positions, located roughly at the 1/4, 3/4 and
½ of the slit length along spatial axis, respectively ("C" loosely stands for "center"). GIANO-B auto-guider is designed to guide on these slit positions. Extended sources or sky can be observed through the entire slit and without auto-guiding. See the “Observing strategies (modes)” paragraph below.

Detector

The GIANO-B spectrograph detector is a HAWAII-2 2048×2048 array. During an exposure, a number of non-destructive detector readouts are performed every 10 seconds. These exposure ramp segments are processed after the end of the exposure into a single image containing the data of the entire ramp. The minimum integration time is 10 seconds, the possible integration times on target are 10, 30, 60, 100, 200, 300 and 600 seconds. Some detector parameters are reported in Table 1.

<table>
<thead>
<tr>
<th>Detector</th>
<th>HAWAII-2 2048×2048</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pixel size / scale</td>
<td>18µm, 0.25&quot; on sky</td>
</tr>
<tr>
<td>Read-out noise</td>
<td>5e⁻²/pix</td>
</tr>
<tr>
<td>Gain</td>
<td>2.2e⁻²/ADU</td>
</tr>
<tr>
<td>Dark current</td>
<td>0.05e⁻²/s/pix</td>
</tr>
<tr>
<td>Resolution element</td>
<td>2 pix for 0.5&quot; slit</td>
</tr>
</tbody>
</table>

Auto-guider (AG)

GIANO-B AG is designed to guide on the predefined “A”, “B” and “C” positions on the spectrograph slit. The AG is mechanically coupled with the spectrograph dewar. It receives the reflected light of the target source from the dewar entrance dichroic window. The reflected light has a limited spectral range: GIANO-B AG operates in the 850-950 nm range. The closest photometric band is SDSS z. The AG field of view is ∼18"×18". In moonless transparent sky and 0.8" seeing conditions the AG reliably guides on targets of up to z≈13mag. Any worse sky conditions degrade this performance. These AG characteristics have to be taken into account for observations preparations.

Observing strategies (modes)

The two types of the observing strategies with GIANO-B are “nodding” and “stare”. In the nodding strategy, one or more pairs of spectra are taken with the object positioned alternatively in predefined “A” and “B” positions within the slit. An optimal removal of the detector noise and sky background is thus obtained through a subtraction of the spectra obtained on A and B positions. In the stare observing strategy, object and dedicated sky spectra are obtained on different positions on the sky (usually with considerable separation in between) and the removal of the sky background and detector noise is done through subtraction of object and sky spectra.
• **Nodding A-B.** As described above, in this mode the object is placed and switched between predefined A and B positions in the slit. For each A-B pair of a nodding observation, the object is first positioned and observed in A and then in B position. These actions are carried out repeatedly as many times as needed to obtain the desired number of A-B pairs and consequently the desired total exposure time. The two positions are at about \( \frac{1}{4} \), and \( \frac{3}{4} \) of slit length in the spatial direction. The switching between the positions is done by the tip-tilt mirror of the instrument pre-slit unit. During the exposures, the object is kept on the selected position by the AG which, sends the correction offsets to the telescope. A-B nodding is the preferred observing mode for stars (compact objects).

• **Stare Object-Sky.** In stare observing strategy the object is placed on a predefined (usually central, C) position of the slit and one or more object spectra are obtained. After the object exposures, the telescope points to a different portion of the sky and one or more spectra (the same quantity as for the object) of sky are taken. During the object observation, the target is kept on the selected position by the AG which sends the correction offsets to the telescope. This observing strategy is used for extended objects, which cannot be observed in A-B nodding mode, as their images (spectra) in the slit will overlap. In this mode, the auto-guiding is switched off when the sky spectra are taken. Also, if necessary the auto-guiding can be switched off for target observations too, for instance, when extended sources are observed.

• **Stare.** In this strategy, the object exposures are not coupled with any subsequent sky observations, i.e. only the object is observed at one of the three possible positions (A, B or C). Single or multiple repetitive exposures can be done. This mode is used when an acquisition of spectra pairs is not required and a single exposure is sufficient. As in Stare Object-Sky mode, in Stare mode the auto-guiding can be switched off if necessary.

**Exposure time calculator (ETC)**

GIANO-B ETC is developed as an aid for observation preparation. It can be accessed through the following link:

• [GIANO-B Exposure Time Calculator](#).

The ETC signal-to-noise ratio (S/N) estimates are based on the instrument performances in actual target observations. Up to 15\% error should be allowed for the ETC S/N estimates.

**Observing overheads**

Additionally to the general telescope pointing (\( \approx 5 \) min on average) and target acquisition-identification (\( \approx 5 \) min on average) overheads, instrument related overheads including those of detector resets and readouts, telescope or AG nodding and sky acquisition have to be taken into account. For AB Nodding observations, an average of 1-1.5 min (depending on the target magnitude) overheads per exposure are accumulated due to detector and AG operations. For Stare Object-Sky observations, single exposure overheads on average are of 1 min for detector and AG operations and include also relatively small telescope offsets, within 1-1.5\" for sky acquisition. In case of bigger telescope throws additional 15-20 sec have to be summed.
New Short Time Scheduler (NSTS)

GIANO-B NSTS is used to prepare, modify and schedule the Observing Blocks (OB). These blocks are predefined groups of available instrument and telescope commands and procedures that can be executed by the Sequencer to carry out both on-sky night time science observations and calibrations. The OBs can be prepared and modified using NSTS in the TNG Control Room immediately before or during the observations (online mode), they can also be prepared well in advance of the observations (offline mode) without a need to be at the Telescope. For your convenience, here the NSTS binary and Java Web Start file are provided.

- NSTS Java Web Start file
- NSTS Java binary

NSTS can be downloaded and used on any user machine at home (institution), as far as it is used in the offline mode. This is a convenient way to prepare the OBs even before coming to the Telescope. More information on NSTS and how to operate it is available in the GIANO-B Observer’s Manual below.

NSTS catalog file

The NSTS catalog is a text file with a predefined format which can be parsed by NSTS. The catalog is a convenient way of loading single or multiple OBs into NSTS. Any text editor can be used to create a catalog, as far as its formatting requirements are met. Here an example catalog file is provided, containing entries for three GIANO-B observing strategies.

- GIANO-B NSTS catalog example.

This example catalog can be downloaded and modified as required. For more information on the NSTS catalog and its preparation please refer to the GIANO-B Observer’s Manual below.

Observer’s Manual

The Observer’s Manual is a guide for GIANO-B observers. Its contents will be continuously updated with most recent and best practices of the instrument use.


GIARPS mode

GIANO-B can be operated simultaneously with HARPS-N in GIARPS mode, to obtain optical to near-infrared high resolution spectroscopy spanning the 0.383 - 2.45 micrometer wavelength range.

Currently these GIARPS mode operations cannot be guaranteed and are offered on best effort basis. A unified instrument control software is foreseen, however at present the GIANO-B and HARPS-N standalone instrument control software/GUIs have to be used independently (though simultaneously) in order to carry out GIARPS mode
observations. A short Observer’s Guide describing the use of the control software of both instruments for simultaneous observations is provided below.

- **GIARPS Mode Short Observer’s Guide.**

**References**


Claudi, R. et al., “GIARPS: the unique VIS-NIR high precision radial velocity facility in this world”, Proc. SPIE 9908, 99081A.

**Contact information**

The users of GIANO-B are encouraged to send a feedback on the content of this web page and the manuals. Also, any kind of instrument related problem or error reporting is welcome.

Please email to Avet Harutyunyan (avet at tng.iac.es).