

GIANO cookbook for observers

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January 2015

About this document

This document is intended as a first, reference guide for the GIANO observers, as provided by the GIANO team, in collaboration with F. Ghinassi from the TNG.

It contains a brief introduction (Section 1) and a description of the GIANO science (Section 1.1), an overview of the instrument characteristics (Sections 2; 2.1) and of the echellogram format (Section 2.2), first estimates of performances and recommended integration times (Section 2.3) as inferred during the Commissioning and Science Verification runs performed in 2013 and 2014, the overall observational strategy for the acquisition of science and calibration spectra (Sections 3; 3.1), a list of suitable telluric and radial velocity standards (Section 3.2), and a description of the main panels and functions of the Graphical User Interface (Section 4).

A summary of the main actions that the observer needs to undertake to run GIANO is reported in Section 5.

1.0 Introduction

GIANO is a near IR high resolution spectrograph mounted at the Nasmyth A focus of the TNG. The instrument provides cross-dispersed echelle spectroscopy at a resolution of 50,000 over the 0.95 – 2.45 micron spectral range in a single exposure. It is fiber-fed with two fibers of 1 arcsec angular diameter at a fixed angular distance of 3 arcsec on sky.

GIANO can acquire spectra either of astrophysical objects and sky simultaneously, or of calibration lamps (halogen for flat-field and U-Ne for wavelength calibration) and dark frames.

The project has been entirely funded by INAF within the second generation instrument plan of the Telescopio Nazionale Galileo (TNG) in La Palma. This instrument has been commissioned at the TNG in the course of 2012 and 2013 and it is now offered to the Community.

1.1 GIANO science

High resolution near IR spectroscopy has a huge scientific potential in our understanding of several hot topics of modern planet, stellar and extragalactic astrophysics, in particular to probe *Origins* at various scales.

Indeed, the near IR spectral range has an enhanced sensitivity to intrinsically red (i.e. cool) and/or reddened (by dust extinction) objects and it is the region where at high redshift most of the emission and absorption features, commonly exploited when studying local galaxies, are shifted. Hence it is the ideal spectral range to perform detailed studies of the physics, chemistry and kinematics of exo-planets and proto-planetary disks, star forming regions and evolved stellar populations in the Local Universe and of high redshift galaxies and intergalactic medium.

A high resolution IR spectrograph, with full spectral coverage in a single exposure like GIANO at a 4m-class telescope like the TNG, represents a formidable observing facility in the following astrophysical fields.

1) monitoring of late type M-dwarfs to search for planets around them and to characterize their properties (spot and magnetic activity, asteroseismology, rotation, etc.). M-type stars are indeed the most abundant stars in our Galaxy, hence obtaining statistics of planet occurrence and

architecture around them is of great importance for understanding the physics of planet formation and evolution and its dependence on the stellar host properties.

2) to characterize the atmosphere of transiting hot giant planets, by means of both transmission (nightside) and emission (dayside) spectroscopy. Several molecular features (water, carbon monoxide and dioxide, methane etc.) can be resolved and accurately measured.

3) to measure velocities, chemical abundances, magnetic fields etc. of a large variety of cool stars and stellar populations along the entire HR diagram and in different environments.

Indeed, the near IR spectra of K and later spectral type stars are rich in molecular (e.g., CO, OH, CN) lines, ideal to obtain accurate chemical abundances and abundance patterns of the CNO-group elements, and of neutral atomic lines to measure the other key metals. Other molecular lines like e.g., HF (to obtain fluorine abundances in cool giants) and FeH in very cool dwarfs can also be properly measured.

GIANO can take high quality spectra of *i)* Pre-Main Sequence T-Tauri stars and other less evolved class I objects in nearby star forming regions, *ii)* M-dwarfs in the solar neighborhood, old giants in the inner disk, bulge and *iii)* more massive and brighter Asymptotic Giant Branch (AGB) and red supergiant (RSG) stars in the Local Group. These measurements are crucial for our quantitative understanding of star formation, stellar evolution, stellar mass loss, winds and magnetic fields, nucleosynthesis and chemical enrichment processes.

4) to characterize the physical, chemical and kinematic properties of cool giant and supergiant stars in Galactic and extra-galactic star clusters. GIANO at the TNG can measure individual giants in Galactic open and old globular clusters and in their surrounding fields, especially in the inner disk and bulge where extinction is prohibitive for optical spectroscopy.

Integrated light measurements in extra-galactic star clusters out to distances of a few Mpc can also be attempted, with the two-fold goal of deriving their chemical composition and dynamical mass and constrain the star formation history, chemical enrichment and Initial Mass Function of their host galaxy.

A comprehensive list of possible science cases and observing programs can be found in the GIANO White Book posted on the GIANO webpage (<http://www.bo.astro.it/giano/documents/GIANOWhiteBook.pdf>). A few other examples of the scientific potential of GIANO, based on spectra acquired during night sky tests, have been also recently published in a few papers (see Oliva et al. 2013, A&A, 555, 78; Origlia et al. 2013, A&A, 560, 46; Origlia et al. 2014, Proc. SPIE 9147-E9).

2.0 The GIANO instrument



Figure 1. *The GIANO spectrograph in the TNG Nasmyth A platform (left) and the telescope interface (right).*

The GIANO instrument has two main modules, the cryogenically cooled spectrograph and the warm preslit and interface system. The preslit system also includes a fiber mechanical agitator and a rackmount with the electronics and the calibration lamps. An additional rackmount contains the detector warm electronics and controls.

The GIANO spectrometer is mounted on a rigid aluminum bench thermally connected to a LN2 tank. Following the ray-path from the entrance window, the spectrometer includes a flat window, a cold stop, a filters wheel, a slit, the spectrometer optics (7 mirrors, 3 prisms, 1 grating) and a 2k2 HgCdTe detector array.

All these elements are included inside a vacuum chamber that is permanently connected to all the sub-systems (pipelines, valves, pumps, sensors, PLC) necessary to create, maintain, monitor and control the vacuum and the cryogenic status of the spectrometer. All the operations are performed and supervised by the PLC. The PLC is controlled through a dedicated panel. The LN2 supply for cooling down the system is 800 liters in three days, while for normal operations is 30 liters/day.

The spectrometer optical design is based on a three mirrors anastigmat (TMA) combination used in double-pass, which acts both as collimator and camera. The collimated beam is 100mm and the system focal length is 420mm. The dispersing element is a commercial 23.2 l/mm R2 echelle grating working at a fixed position in a quasi-Littrow configuration, with an off-axis angle of ~ 5 degrees. A system of prisms from high dispersing IR optical materials acts as cross-disperser. The optical performances of the system are excellent, with $>80\%$ en-squared energy within one pixel over most of the array area. A more detailed description of the spectrometer, its cryogenic system and controls can be found in a dedicated document posted on the GIANO webpage (http://www.bo.astro.it/giano/documents/manual_GIANO_cryo_PLC_v01p4_19oct2013.pdf).

GIANO was designed, optimized and built for receiving the light directly from the telescope, via a simple re-imaging system (two lens doublets). However, due to constraints imposed on the telescope interfacing during the pre-commissioning phase, it had to be provisionally positioned on the rotating building, far from the telescope focus and a new interface, based on IR-transmitting ZBLAN fibers, was designed.

The current preslit system includes two different optical benches, one mounted on a quasi-gravity-invariant structure, consisting of a horizontal bench fixed to a vertical bearing attached to the telescope flange, and the other mounted directly on one side of the GIANO cryostat. The two preslit boxes are optically connected by a couple of fibers optics, assembled in the same SMA connector and used to simultaneously measure the target and the sky.

The core diameter of each fiber is 85 micron (1 arcsec on sky), the distance between the two fiber centers is 250 micron (3 arcsec on sky). A third fiber is used for calibration, and can be illuminated either by a halogen lamp for flat-field or by an U-Ne lamp for wavelength calibration.

A more detailed description of the preslit system and telescope interface can be found in a dedicated document posted on the GIANO webpage, namely http://www.bo.astro.it/giano/documents/GIANO_Preslit_manual_description_and_performances_14-11-2013_v2.pdf (see also Tozzi et al., GIANO Preslit, Proc. SPIE 9147-360).

2.1 The GIANO detector

The GIANO spectrograph is equipped with a 2048 x 2048 HAWAII-2 detector, whose main parameters are summarized in Table 1.

The minimum integration time is 10 sec and allowed on-source exposure times are 10, 20, 60, 120, 200, 300, 600 sec. There are two read-out modes: double-correlated (for 10 sec short exposures) and multiple non-destructive (for all the other allowed exposure times, multiple of 10 sec).

In the multiple non-destructive readout mode, n -frames of 10 sec are acquired, where n is equal to the on-source exposure time in sec divided by 10 sec. The saturation limit of 18000 ADU/pixel applies to each individual 10 sec readout, only. Normally, only extremely bright stars with negative JHK magnitudes saturate.

Table 1: *Parameters of the GIANO detector.*

Detector	HAWAII-2 2048x2048
Pixel size	18 microns, 0.25 arcsec on sky
Gain	2.2 e-/ADU
Readout Noise	5 e-/pixel
Dark Current	0.05 e-/s/pixel
Saturation	~18000 ADU/pixel in 10sec
Spectral Coverage	0.95 - 2.45 microns (complete coverage up to 1.72 microns, see Sect. 2.2)
Spectral Sampling	2 pixels at R~50,000
Spatial Sampling	4 pixels for 1 arcsec fiber

The acquisition system of GIANO saves all the multiple non-destructive read-outs as well as the final, ramped frames in the data archive.

The ramp analysis is performed off-line, after the integration is terminated. Alike other sensors of the same type, the GIANO detector is affected by reset anomaly. This phenomenon produces extra-noise and patterns in the first frame(s) taken after the pixels reset. The strength of the reset anomaly depends on the previous status of the array and on the clock time used to reset the pixel. We found that the best strategy to cancel all the effects of reset-anomaly is starting the integration with 2 reset-read sequences, followed by a series of non-destructive reads. The first frame is always ignored, while the second is only used to compute the flux of pixels exposed to strong signals, which approach the saturation in < 30 sec. For all other pixels, only the non-destructive reads are used to compute the flux via Fowler sampling.

2.2 The GIANO echellograms

The GIANO echellogram (see Figures 2-4) has a fixed format and includes the orders from 32 to 80, covering the 0.95-2.45 micron wavelength range.

It has a full spectral coverage up order 45, while at lower orders the spectral coverage is progressively reduced down to 75% at order 32 (see Table 2). Due to a 2x image slicer, each 2D frame contains four tracks per order (two per fiber).

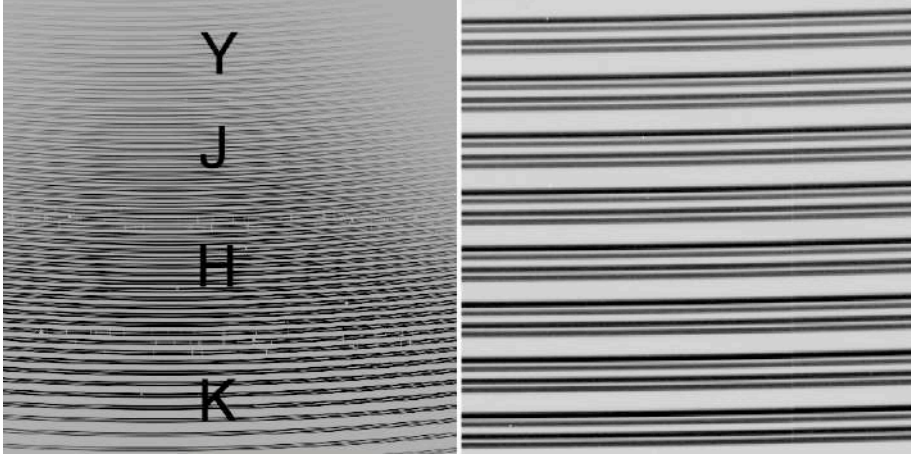


Figure 2.

GIANO 2D-spectrum of the halogen lamp used as flat-field. Left panel: the whole echellogram. Right panel: a zoomed view of the echellogram, where for each order the four tracks corresponding to the two sliced fibers are better visible.

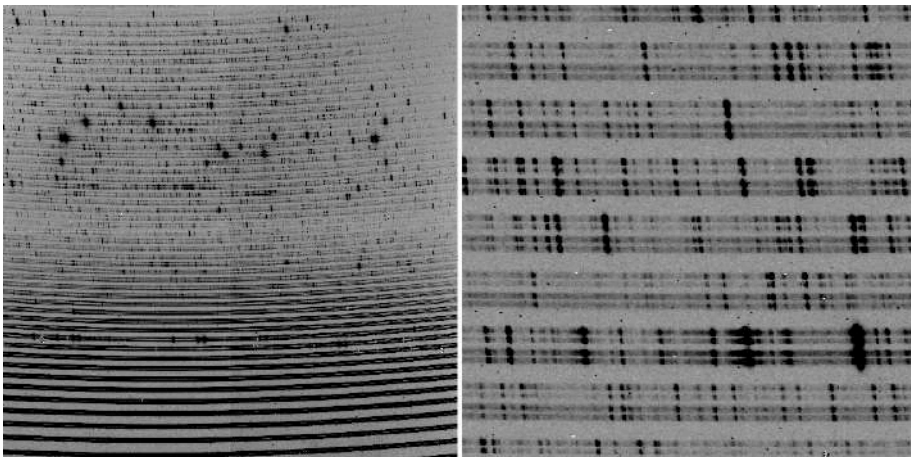


Figure 3.

GIANO 2D-spectrum of the U-Ne lamp. Left panel: the whole echellogram. Right panel: a zoomed view of the echellogram, where some Ne (the brightest) and many (fainter) U lines are visible.

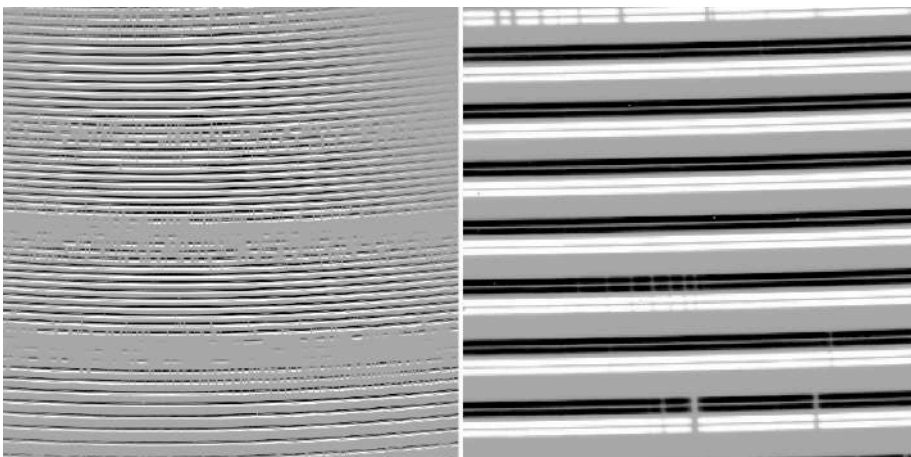


Figure 4. *GIANO noded (A-B) 2D-spectrum of a bright star. Left panel: the whole echellogram. Right panel: a zoomed view of the echellogram, where for each order the four tracks corresponding to the two sliced A (positive) and B (negative) fibers are better visible.*

Table 2: *GIANO echellogram parameters: wavelengths are in Angstroms and in vacuum.*

# order	λ_0	λ_{\min}	λ_{\max}	$\Delta\lambda$
32	23974	23699	24224	0.256
33	23247	22979	23490	0.249
34	22562	22302	22799	0.242
35	21917	21664	22146	0.235
36	21308	21062	21531	0.229
37	20731	20492	20948	0.222
38	20185	19952	20396	0.217
39	19667	19440	19872	0.211
40	19174	18953	19375	0.206
41	18706	18490	18902	0.201
42	18260	18049	18451	0.196
43	17835	17629	18021	0.191
44	17429	17228	17611	0.187
45	17041	16844	17219	0.183
46	16670	16478	16844	0.179
47	16315	16126	16486	0.175
48	15974	15790	16142	0.172
49	15648	15467	15812	0.168
50	15334	15157	15495	0.165
51	15033	14860	15191	0.161
52	14744	14573	14898	0.158
53	14465	14298	14616	0.155
54	14197	14033	14345	0.152
55	13938	13777	14084	0.150
56	13689	13531	13832	0.147
57	13448	13293	13589	0.144
58	13216	13063	13354	0.142
59	12991	12841	13127	0.140
60	12774	12627	12908	0.137
61	12564	12419	12696	0.135
62	12361	12219	12491	0.133
63	12165	12024	12292	0.131
64	11974	11836	12100	0.129
65	11790	11654	11913	0.127
66	11611	11477	11732	0.125
67	11437	11305	11557	0.123
68	11268	11138	11387	0.121
69	11105	10977	11221	0.119
70	10946	10819	11060	0.118
71	10791	10667	10904	0.116
72	10641	10518	10753	0.114
73	10495	10374	10605	0.113
74	10353	10233	10461	0.111
75	10214	10096	10321	0.110
76	10080	9963	10185	0.108
77	9948	9833	10053	0.107
78	9821	9707	9923	0.106
79	9696	9584	9797	0.104
80	9574	9464	9675	0.103

2.3 GIANO performances

First estimates of the overall GIANO performances (spectral accuracy and sensitivities), as measured during the Commissioning and Science Verification runs of 2013 and 2014, are summarized in Table 3.

The absolute efficiencies of GIANO have been measured using a commercial, certified blackbody source. The absolute efficiency of the GIANO spectrometer (without fiber) is $\approx 21\%$ at 2.2 micron, $\approx 16\%$ at 1.6 micron and $\approx 11\%$ at 1.2 micron. The end-to-end efficiency of the instrument (with the current TNG fiber feeding system) is $\approx 60\%$ lower.

Preliminary on sky estimates of the limiting magnitudes within the reaching of GIANO are consistent with AB \sim 12.

Table 3: *GIANO spectral accuracy and sensitivities.*

Wavelength calibration ¹ accuracy with U-Ne lamp	300 m/s (r.m.s)
Radial velocity ² accuracy with telluric lines	7 m/s (r.m.s)
Maximum S/N ³ on flatfield (about photon-noise limited)	~ 1000 (Y,J), ~ 300 (H,K)
Maximum S/N ³ on stars (limited by fiber modal noise)	~ 70 (Y,J), ~ 50 (H,K)
Zero point (J-band, Vega mag for 1 ADU/s)	10.1
Zero point (H-band, Vega mag for 1 ADU/s)	10.3
Zero point (K-band, Vega mag for 1 ADU/s)	10.2
Limiting magnitude (z-band, Vega mag) of the guiding camera ⁴	15

Notes:

¹ The optimal **wavelength solution** uses ~ 500 U-Ne lines distributed over all orders and provides a wavelength calibration accuracy of ~ 300 m/s equivalent to $\sim 1/10$ of a pixel (r.m.s). This solution has been also cross-checked over about 300 OH and O₂ atmospheric emission lines as well as some telluric features in the observed spectra, for which accurate laboratory and/or theoretical wavelengths are available.

² **Radial velocities** are obtained by cross correlating observed and reference lines on single orders and deriving corresponding CCFs; the latter are then weighted-summed. Internal errors amount to 3-5 m/s and are ultimately limited by the uncertainty in the stellar radial velocity and by the radial velocity signal of the CCF, while the r.m.s scatter from different exposures of the same star amounts to 7 m/s. These errors do not depend on the spectral type of the star.

³ Fibers suffers of **modal noise**, whose amplitude increases with increasing wavelength. GIANO uses a mechanical agitator to decrease the effect of fiber modal noise on the spectra. This mechanism works quite well for diffuse sources like the calibration lamps: the residual noise in the K-band drops from $\sim 2\%$ (without agitator) to $\sim 0.3\%$ (with agitator). However, when observing scientific targets (e.g. stars), the modal noise is amplified by effects related to the non-uniform illumination of the fiber, which also depends on the seeing conditions and on the tracking/guiding performances of the telescope. The maximum signal-to-noise achievable in the K-band is about 20 (without fiber-agitator) and 50 (with fiber-agitator). The maximum signal-to-noise is slightly higher at shorter wavelengths. Modal noise mostly affects those science cases that needs measurements of broad (a few tens pixels) features or the continuum.

⁴The **guiding is performed on the object itself** by using a CCD camera mounted inside the GIANO interface box, which receives red light (850-950 nm, about the z band) from a dichroic filter. Hence, **for a proper guiding, targets must be brighter than z \sim 15 mag.**

3.0 Observing with GIANO

GIANO has one observing mode at $R \sim 50,000$ and can acquire spectra either of astrophysical objects and sky simultaneously, or of calibration lamps (halogen for flat-field and U-Ne for wavelength calibration) and dark frames.

Observations of science targets are normally performed by nodding-on-fiber (see Figure 4), i.e. target and sky are taken in pairs and alternatively acquired on fiber A and B (AB cycles), respectively, for an optimal subtraction of the detector noise and background. From each pair of exposure an (A-B) 2D-spectrum will be computed (see Figure 4). The positive (A) and negative (B) spectra of the target star will be then extracted and summed together to get a final, 1D wavelength-calibrated spectrum with the best possible signal-to-noise ratio.

In order to observe with nodding-on-fiber it is important to verify that there are no bright sources (comparable with the target) within a radial distance of a few arcsec, in order to always have one of the two fibers observing an empty sky field.

In case of contaminating bright sources nearby the target or of an extended (a few arcsec) target object observations can be performed in stare mode, and background exposures can be taken before and/or after the target ones, by offsetting the telescope to an empty sky field.

Recommended on-source integration times to reach $S/N \sim 50$ per spectral pixel on the continuum (about modal-noise limited) for stars of different magnitudes are listed in Table 4, and overheads in Table 5. In case of extremely bright stars (typically with negative JHK magnitudes, like e.g. Arcturus) a gray filter should be used to avoid saturation.

Calibration lamp (flat and U-Ne) spectra are acquired in stare mode, since lamps are diffuse sources and illuminate both fibers, simultaneously. Calibrations can be taken in day-time, e.g. in the afternoon before the observations, and/or in the morning after the observations.

A recommended sequence of exposures for calibrations is as follows: 5-10 darks, 5-10 flat-fields of 60 sec and 1 U-Ne of 300 sec.

Table 4: *Recommended on-source integration times.*

Target Vega magnitudes	On source integration times (seeing < 1 arcsec)
JHK < 3	200 sec = 1AB cycle with 100sec on A and 100sec on B
$3 \leq JHK < 6$	600 sec = 1AB cycle with 300sec on A and 300sec on B
$6 \leq JHK < 7$	1200 sec = 2AB cycles with 300sec on A and 300sec on B
$7 \leq JHK < 8$	1800 sec = 3AB cycles with 300sec on A and 300sec on B
$8 \leq JHK < 9$	2400 sec = 4AB cycles with 300sec on A and 300sec on B
$9 \leq JHK < 10$	3600 sec = 6AB cycles with 300sec on A and 300sec on B

Notes:

- 1) Allowed detector integration times (DIT) on individual fibers are as follows: 10, 30, 60, 100, 200, 300 sec. Recommended DITs for most applications are 100s (JHK <3) and 300s (JHK >3).
- 2) For sources with JHK >10 Vega mag, the achievable S/N strongly depends on the seeing and sky transparency. Recommended exposure times are >1.5 hr, i.e. >9 AB cycles with 300 sec on A and 300 sec on B.
- 3) In case of bad seeing (>1.0 arcsec) spectra of stars with JHK < 9 can still be acquired by increasing the number of AB cycles.
- 4) When sources have significantly different J, H and K magnitudes, one can use as reference the faintest or the most scientifically interesting one.

Table 5: *Overheads.*

Overheads	Time
Telescope pointing and centering	5-10 min
Detector readout and reset correction	1min per AB cycle
Telescope nodding and other settings	1 min per AB cycle

3.1 Guiding and finding charts

As mentioned in the Note 4 of Table 3, the guiding is performed on the object itself by using a CCD camera receiving red light (850-950 nm, about the z band) from a dichroic filter. The field of view of the guiding camera is about 40 arcsec x 40 arcsec.

For a proper target identification, centering in the fiber and guiding, finding charts with a field of view of 1.5 arcmin x 1.5 arcmin in red bands (e.g. I to J) are recommended, especially in case of highly reddened objects and/or crowded fields.

3.2 Telluric and radial velocity standards

The most suited telluric standards are the hottest O-type stars, since they are the most featureless in the near IR spectral range. A list of useful telluric standards in the Northern Hemisphere is provided in Table 6.

Table 6: *Telluric standards.*

Star	Sp.T.	V	I	RA 2000	Dec 2000
Hip029147	O7	8.45	8.04	06:08:55.82	+15:42:18.30
Hip029216	O6	7.55	7.52	06:09:39.57	+20:29:15.50
Hip031348	O7	7.96	7.62	06:34:23.57	+02:32:02.90
Hip032067	O6	6.36	6.42	06:41:59.23	+06:20:43.50
Hip034536	O6	6.23	6.23	07:09:20.25	-10:20:47.70
Hip088469	O6	5.89	5.69	18:03:52.44	-24:21:38.60
Hip089584	O6	8.13	7.91	18:16:49.65	-16:31: 4.30
Hip089729	O5	8.51	7.86	18:18:40.87	-12: 6:23.30

The most suited radial velocity standards for GIANO are K or later type stars, since their near IR spectra contain a sufficient number of neutral atomic lines to perform an accurate calibration of the zero-velocity point. However, the latter can be also (and likely better) calibrated using the telluric lines. A list of useful radial velocity standards in the Northern Hemisphere from the ELODIE catalog is provided in Table 7.

Table 7: *Radial velocity standards.*

HD	Sp.T.	V	B-V	RV km/s	RA 2000	Dec 2000	p.m. ra arcsec/yr	p.m. dec arcsec/yr
3765	K2V	7.36	0.94	-63.30	00:40:49.2696	+40:11:13.824	0.35569	-0.66891
38230	K0V	7.36	0.83	-29.25	05:46:01.8857	+37:17:04.735	0.487	-0.5097
73667	K2V	7.64	0.83	-12.10	08:39:50.7917	+11:31:21.621	-0.10935	-0.49989
79210	M0V	7.62	1.41	10.65	09:14:22.7935	+52:41:11.849	-1.53358	-0.5628
82106	K3V	7.20	1.00	29.75	09:29:54.8245	+05:39:18.484	-0.5041	0.11
128165	K3V	7.23	1.00	11.25	14:33:28.8671	+52:54:31.644	-0.19219	0.24753
131977	K4V	5.75	1.02	26.85	14:57:27.9996	-21:24:55.710	1.03418	-1.7256
139323	K3V	7.60	0.95	-67.20	15:35:56.5661	+39:49:52.023	-0.44891	0.05029
145742	K0	7.57	1.06	-21.85	16:00:36.6741	+80:37:40.074	-0.01531	0.02481
190007	K4V	7.46	1.13	-30.40	20:02:47.0447	+03:19:34.278	-0.09228	0.12076
221354	K0V	6.74	0.84	-25.20	23:31:22.2088	+59:09:55.861	1.1061	0.11297

3.3 Data Handling

The acquisition system of GIANO records three types of spectra, namely

1) 1 reset and (N+1) 10 sec multiple non-destructive read-out frames, needed to obtain one ramped-reduced frame with total exposure time of (Nx10) sec. These frames are codified with the name **GIANORAW.yyy-mm-ddThh-mm-ss.000.fts**.

2) the ramp-reduced frame generated by combining the (N+1) multiple non-destructive read-outs frames a few minutes after the integration is terminated.

This frame is codified with the name **GIANO.yyyy-mm-ddThh-mm-ss.000.fts**.

3) the quickly ramp-reduced frame created in real time by the GIANO GUI, by simply computing the difference between the first and last non-destructive read-outssh livia@.

This frame is created to only for quick look purposes by the GIANO GUI and it is codified with the name **GIANOQL.yyy-mm-ddThh-mm-ss.000.fts**.

All these frames are saved in the gianoPC directory /home/giano/data/giano/yyymmdd (the ramped frames are saved in the directory *ramp_reduced* and the quicklook frames in the directory *tatanka*). They are also sent to the Italian Astronomical Archive of Trieste (if the SAVE button in the GIANO GUI is selected) from where the user can retrieve them.

4.0 The GIANO Graphical User Interface

A complete description of the GIANO Graphical User Interface (GUI) is provided in a dedicated document posted on the GIANO webpage (http://www.bo.astro.it/giano/documents/GIANO_GUI_V1.pdf). Here we summarize the main features and we describe in some more detail the panels that manage the exposure setting and execution.



To start an observing session with GIANO, one has to click on the GIANO IDL GUI icon (shown here on the left) on the desktop of the WSASTRO workstation and the user interface main window will appear as shown in Figure 5.

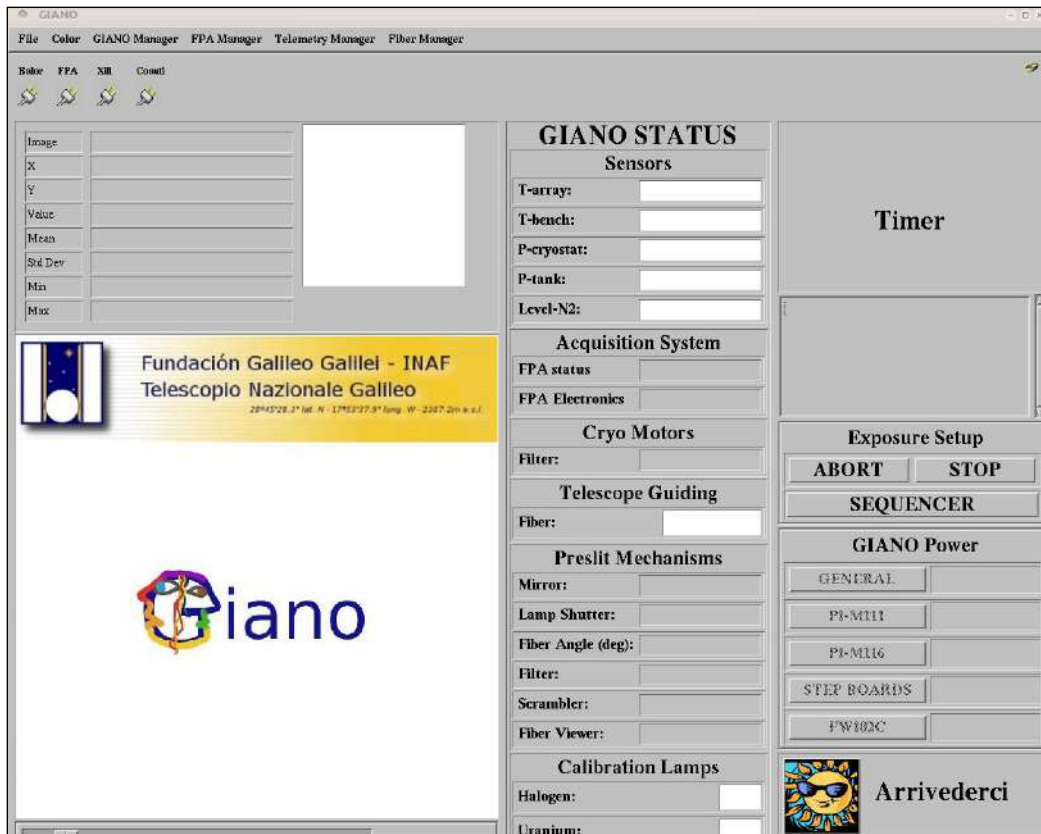


Figure 5. The GIANO GUI main panel as it appears when starting an observing session.

The top part of the GUI main window contains 6 scroll down menus (Figure 6), namely: File menu, Color menu, GIANO manager menu, the Focal Plane Array (FPA) manager menu, the Telemetry manager menu and the Fiber manager menu.

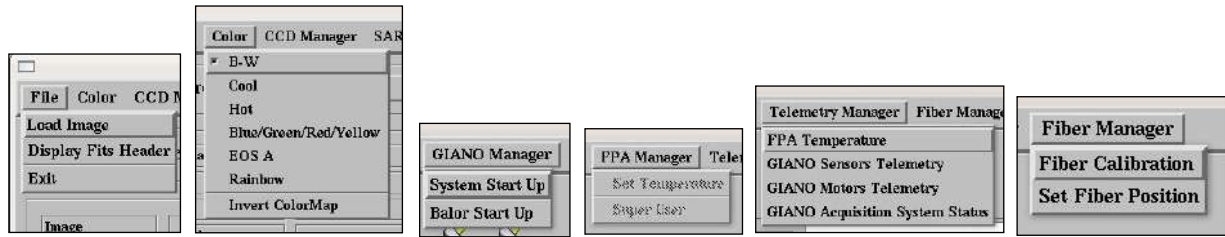


Figure 6. The scroll down menus of the GIANO GUI.

- The **File menu** allows the user to open a file (see e.g. Section 3.3), to display the FITS header of the image currently displayed and finally to exit from the GUI.
- The **Color menu** allows the user to change the color table used to display the image.
- The **GIANO Manager menu** allows the user to perform the start up of the instrument. There are two entries in the menu: The System Start Up button and the Balor Start Up button.
- The **FPA Manager menu** is disabled in this version of the GUI.
- The **Telemetry Manager scroll down menu** allows the user to check the status of the GIANO instrument. It has 4 entries: FPA temperature, GIANO sensors telemetry, GIANO motors telemetry and GIANO Acquisition System Status
- The **Fiber Manager Menu scroll down menu** allows to move the fiber at the entrance of the spectrograph in order to find the position that maximizes the input signal in the slit. This operation should be performed by the TNG_staff before each calibration and observing night.

Below the scroll menus there is a panel (Utilities Panel, see Figure 7) containing few informative icons of the status of the GIANO servers and daemons.



Figure 7. GIANO Utilities Panel.

The GUI main window can be divided into three main sub-windows, namely the **Quick Look Area** (left), the **Status Area** (middle) and the **Exposure Control Area** (right),

The Quick Look Area allows the user to get information on the last image acquired by the instrument or on the one loaded through the file menu. Several tools are available to analyse the image.

The Status Area contains all the information regarding the status of the instrument.

The Exposure control area contains buttons to start the sequencer panel, to stop an exposure (or group of exposures) and a series of widgets that give information on the action being performed by the GUI and/or the instrument.

QUICK LOOK PANEL AREA

The Quick Look Panel Area (Figure 8) is used to display the echellogram images obtained through the FPA and to give the user the possibility to perform a quick look analysis. It can be divided in four different sub-areas, namely 1) image statistics area, 2) zoomed image area, 3) main display area, and 4) a scrollbar to change intensity and contrast of the images displayed.

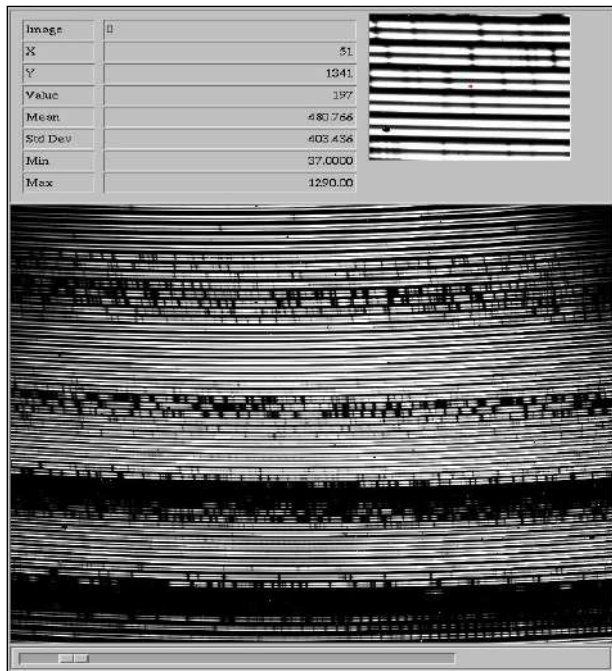


Figure 8. *The Quick Look Panel Area of the GIANO GUI.*

In the *Image Statistics Area* the following information are provided.

- The name of the image
- The X coordinate of the cursor
- The Y coordinate of the cursor
- The image value below the cursor
- The average value in a 20x20 box centred on the cursor
- The standard deviation in a 20x20 box centred on the cursor
- The minimum value in a 20x20 box centred on the cursor
- The maximum value in a 20x20 box centred on the cursor

This information is updated by moving the cursor inside the *Main Display Area*.

In the *Main Display Area* the last acquired detector image or the one loaded through the file menu is displayed. The full image is rescaled to a size of 800x800 pixels.

In the *Zoomed Image Area* an area of 100x100 pixels around the cursor position, magnified by a factor of two, is displayed.

Limited data analysis is available on line (quick look). A list of the implemented functions is given below. To start the analysis place the cursor on the *Main Display Area* click the left mouse button and then press one of the following keys.

- c – Plots the image column corresponding to the cursor position.
- l – Plots the image line corresponding to the cursor position.
- e – Draw a contour plot of an 20x20 pixels subarea centred on the current cursor position.
- s – Draws a surface plot of the 20x20 pixels subarea centred on the current cursor position.
- h – Draws an histogram plot of the 20x20 pixels subarea centred around the current cursor position.
- k – Performs a Gaussian fit along the detector columns around the current cursor position.
- j – Performs a Gaussian fit along the detector rows around the current cursor position.
- x – Extracts an order of the echelle spectrum.
- q – Deletes the graphic window.

After pressing the key a graphic window is drawn displaying the results of the analysis.

All the keys work when the mouse is positioned in the Main Display Area.

The keys are always disabled during the detector readout and during the GIANO setup.

STATUS AREA

The Status Area includes six panels, providing various information on the status of the GIANO hardware.

The Sensors Status Panel gives information on the temperature, the pressure and the amount of LN2 present inside the GIANO cryostat. In particular the listed parameters are: the temperature of the FPA, the temperature of the cryogenic optical bench, the pressure inside the cryostat, the pressure inside the liquid Nitrogen tank, and the weight of the whole cryostat that, of course, depends on the amount of LN2 inside GIANO. A green background indicates that the values are within the nominal working range, yellow background is a warning implying that some action has to be taken, a red background tells that a potentially dangerous situation compromising the observations if not the instrument is present.

The Acquisition System Status Panel gives information on the status of the FPA acquisition system. The FPA status that can be IDLE (when waiting for a command) or BUSY (when exposing) and the FPA electronics can be OK or NOTOK.

The Cryo Motors Status Panel gives information on the status of the cryogenics motors of GIANO. The panel is updated both pressing the GIANO motors telemetry button in the Telemetry Manager menu and every time an operation is performed on the instrument by the GUI (i.e., moving a mechanism or starting an exposure). There is only one cryogenic mechanism inside GIANO, namely the filter wheel. The wheel can have 4 positions: OPEN, CLOSED, GRAY5, GRAY10 (the latter two positions indicate that an attenuation filter of 5 and 10 mag, respectively, is inserted). Usually the filter wheel is in the OPEN position. CLOSED position is used for dark exposures.

The Telescope Guiding Status Panel tells the observer on which fiber the telescope is guiding. This field is managed by the autoguide program (the fiber selection cannot be done by the GIANO GUI) and is updated when exposing. There are three possible values: UNKWOWN, when no observation has yet been started, A or B when the telescope is guiding on the A or B fiber, respectively.

The Preslit Mechanisms Status Panel gives information on the status of the GIANO preslit. There are six mechanisms monitored, namely

- Exposure mode selection mirror. It can have three positions: Science (AB), Science+Calib (AC, not currently available), Calibration (CC).
- Lamp shutter. It can have two positions, Open or Closed.
- Wheel holding the fibers before the spectrograph's slit. The value shown is the position of the wheel in degrees.
- Lamp filter wheel. It can have six different positions (Open, ND-0.8, ND-1.4, ND-2.5, ND-4.1, Closed).
- Scrambler mechanism. It can be ON or OFF.
- Fiber viewer. This is the CCD camera used for guiding. It is managed by the autoguide system. It can be ON or OFF.

The Calibration Lamps Status Panel gives information on the status of the calibration lamps of GIANO. The three possible configurations, namely

- Halogen lamp Off (black) and U-Ne lamp On at 10% power (yellow)
- Halogen lamp Off (black) and U-Ne lamp On at full power (green)
- Halogen lamp On (green) and U-Ne lamp On at 10% power (yellow)

Note that once the system has been started up the U-Ne lamp is always on at 10% of its full power and is switched off only when exiting the GUI. When a wavelength calibration exposure starts the sequencer turns the U-Ne lamp at full power and when the integration ends the lamp turns at 10% of its full power automatically. Similarly, when a flat exposure starts, the sequencer turns on the halogen lamp and when integration ends the lamp turns off automatically.

On the bottom–right side of the status area there is the **GIANO Power Panel** that shows the status of the electronics and the **ARRIVEDERCI Panel** that contains a button to exit the GUI.

THE EXPOSURE CONTROL AREA

The Exposure Control Area includes four panels to manage an exposure.

The **Timer Panel** (see Figure 9) gives information on the status of the exposure (Exposing FPA, Reading Image or Done). When exposing, the panel will display “Exposing FPA”, the number of the exposure in the exposure sequence and, if there is more than one group of sequences, the group number. Also before, starting an exposure if the instrument configuration is changing then the panel will display: “GIANO Set Up Please Wait...”.

The **Console Panel** shows the messages related to the execution of a command by the GUI and other possible informative, warning, or error messages.

The **Exposure Setup Panel** contains three buttons: Abort, Stop and Sequencer.

The *ABORT* button immediately aborts the current exposure, the image is not read out. If the exposure was part of a sequence then the sequence is aborted.

The *STOP* button immediately stops the current exposure and the detector image is read out. If the exposure was part of a sequence then the sequence is aborted.

The *SEQUENCER* button is used to start the sequencer panel. When pressed it opens the window shown in Figure 9.

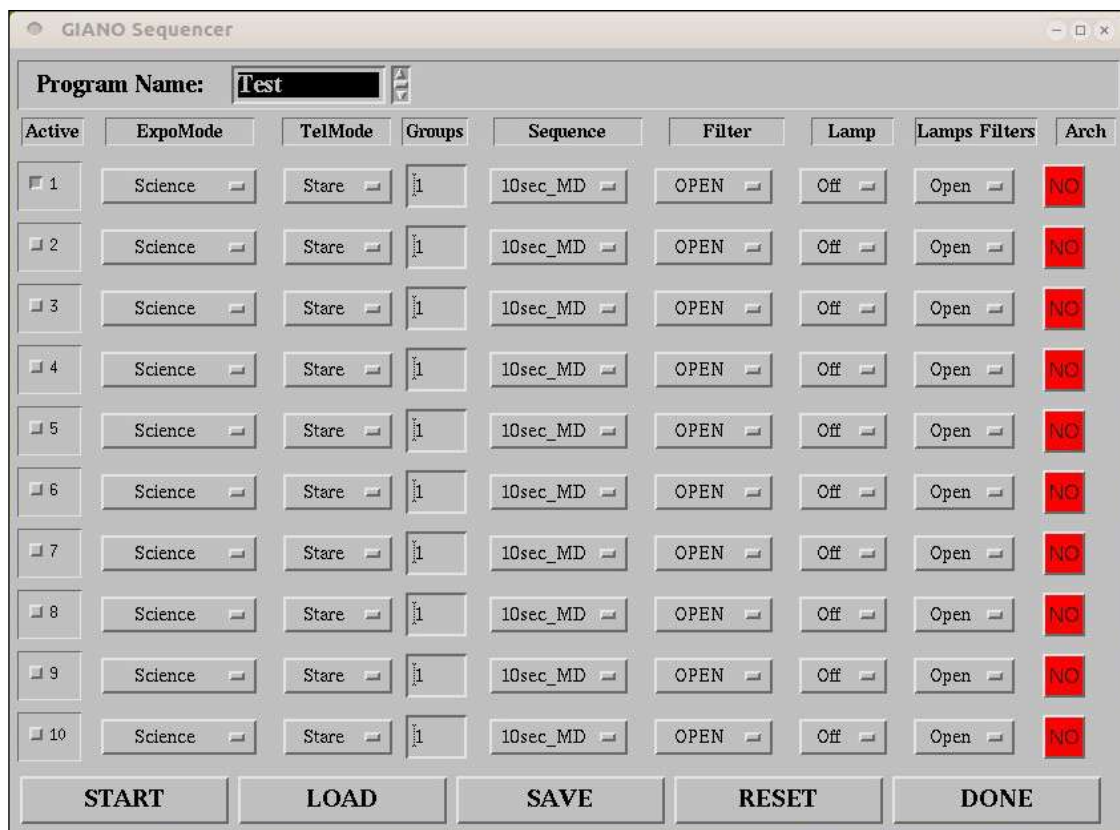


Figure 9. *The Sequencer panel.*

The function of the sequencer panel is to manage the exposures and instrument setup.

The panel includes a widget list on the top with the name of the observational programs currently active at the TNG. If none of them is selected then the default name is “Test”. However, it is very important to select the correct observational program, in order to have the spectra properly codified in the archive.

Below there are ten rows, each one corresponding to a sequence and including nine columns that can be buttons, scroll down menus and text widgets to set up an exposure (see Figure 10).

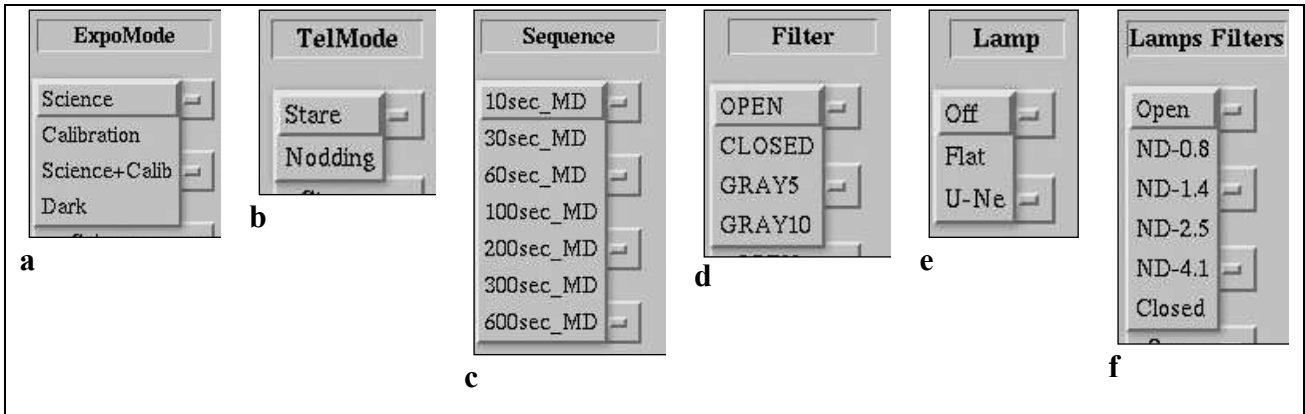


Figure 10. *The scroll down menus in the sequencer panel.*

In the 1st column there is a toggle button that activates the sequences. Only activated sequences will be executed. If no sequence is active a warning message will pop up. The GIANO acquisition system will run the active sequences following the order in the sequencer.

The 2nd column (Figure 10a) is a scroll down menu that allows to select the exposure mode, that is Science, Calibration, Science + Calibration (currently not available), Dark. In the science mode one of the fibers is pointed at the target object while the second at the sky. In the calibration mode both fibers are illuminated by one of the lamps. In the Science+Calibration mode one of the fibers is pointed at the target object while the second fiber is illuminated by one of the calibration lamps.

In the 3rd column (Figure 10b) there is a scroll down menu to select the telescope operation mode. There are two modes available: Stare and Nodding. In the stare mode the telescope keeps the target object on one fiber. In the nodding mode the telescope switches from one fiber to the other and back to the one it started from. In the nodding mode the active sequence is repeated twice.

In the 4th column (Figure 10c) the observer can write the number of times (groups) an active sequence in stare mode (only) is repeated.

In the 5th column (Figure 10d) the observer can select the desired exposure times. There are seven possible multiple non-destructive exposure times from 10 to 600 seconds.

In the 6th column there is a scroll down menu to select the desired cryogenic filter. Four choices are possible: OPEN (most of the cases), CLOSED (for dark exposures), GRAY5 (5 mag attenuation), GRAY10 (10 mag attenuation).

In the 7th column (Figure 10e) the observer can select the lamp (Flat of U-Ne) for calibration. It is Off for Science exposures.

The 8th column (Figure 10f) foresees the possibility of inserting a neutral density filter in front of one of the two lamps (currently not active).

The last column contains a button that allows (when green) to send the acquired spectra to the TNG archive. It is strongly recommended to set it “green” in order to have the data saved in the general archive.

At the bottom of the Sequencer panel there are 5 buttons.

The **START** button will execute sequentially all the activated sequences. In case any incongruence is found, either a warning is issued or automatically the interface corrects it. In case of a warning issue, a window displaying a message explaining the reason for the warning pops up. If the observer decides to ignore the warning, then the sequence is started, otherwise the procedure returns to allow the observer to remove the cause of the warning.

The **LOAD** button allows the observer to retrieve a given sequencer configuration. In this menu the observer can also find some typical calibration sequences.

The **SAVE** button allows the observer to save a given sequencer configuration. It is recommended to include in the sequence name their observing program keyword (e.g. A18_TAC23_comet).

The **RESET** button will reset the scroll down menus and editable text fields and the buttons to their default values.

The **DONE** button closes the sequencer panel.

5.0 Running GIANO in a nutshell

GETTING STARTED in the afternoon, before the observing night

- To start an observing session with GIANO, click on the **GIANO IDL GUI icon** on the desktop of the WSASTRO workstation and the user interface main window will appear.
- In the **GIANO Manager menu** select the System Start Up to perform the start up of the instrument. The **GianoMotors** window will appear; this window can be iconize or hide since it will not be used by the observer. The Start Up procedure ends when the sequencer button turns active.
- In the **Fiber Manager menu** select the Fiber Calibration. This procedure takes about 6 minutes and ends when the sequencer turns active.
- In the **GIANO Manager menu** press the **SEQUENCER button** to start the sequencer panel.
- In the sequencer panel select the proper **PROGRAM NAME** in the **drop down menu**.

CALIBRATION

In the sequencer panel press the **LOAD button** and select the **CAL_NIGHT_BEGIN sequence**.

It is recommended to use the following sequences:

- 10 Flats of 60 sec
- 10 Darks of 60 sec
- 10 Darks of 300 sec
- 1 U-Ne lamp of 300 sec
- 1 quick science acquisition in order to restore the motors setup for observations.

TARGET POINTING and CENTERING

This operation is done at the telescope workstation by the telescope operator.

The observer must have ready the target list and the finding charts, as detailed in Section 3.1.

Target names, coordinates and proper motions can be stored in a catalog to be sent to the telescope operator in the afternoon before starting the observing night.

INTEGRATING

- Set up desired observing mode and exposure parameters in the sequencer panel.
- Activate the sequence(s) and the archiving functions by pressing the first and last button in the sequence row(s).
- Press START to execute the active observing sequence(s).
- In the Main display Area the “growing” spectrum (refreshed every 10sec) will appear.
- Some quick-look analysis is allowed only at the end of an integration-ramp, but if more than one sequence is active, there is not enough time for an effective analysis. A more efficient quick-look analysis can be performed offline, by using the GIANOQL frames or the final ramped GIANO frames, as detailed in Section 3.3.

END of the NIGHT

When the observing night is finished the observer can press the **ARRIVEDERCI button** in the GUI main.