



Rapporti Tecnici INAF INAF Technical Reports

Number	310
Publication Year	2024
Acceptance in OA@INAF	2024-05-09T11:39:34Z
Title	Characterization of wedge windows for the absorption cells of GIANO-B
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Handle	http://hdl.handle.net/20.500.12386/35114 ; https://doi.org/10.20371/INAF/TechRep/310

**Characterization of wedge windows for the
absorption cells of GIANO-B**

Mar 2024

Document Number: LOCNES_TRE_001

Document Version: 1.0

Document Type: Test Report

Document Status: Released

Releasing Organisation: LOCNES Consortium

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LOCNES Applicable Documents

The following documents, of the exact version shown, form part of this document to the extent specified herein. In the event of a conflict between the documents referenced herein and the content of this document, the content of this document shall be considered as superseding.

AD1 Infrasil wedged optics drawing OP-IS302-64

AD2 GIANO chamber Cell drawing v0.5

AD3 GIANO gas-absorption cells IAG-288418 v1.5

Purpose and scope

This document aims to explain the characterization work of two wedge windows, which currently serve as spares for the absorption cells of GIANO-B spectrograph. This work became necessary due to discrepancies found within the technical documentation and testing provided by the window manufacturer.

GIANO-B Overview

GIANO-B is the high resolution near-infrared (NIR) spectrograph of the Telescopio Nazionale Galileo (TNG), which provides cross-dispersed echelle spectroscopy at a resolution of ~ 50000 in the 0.9-2.45 μm spectral range in a single exposure. GIANO-B started its regular operations in October 2017.

Wedge windows Overview

The windows are circular, measuring 68.2 mm in diameter. The window faces are wedge-shaped with a non-coplanar configuration, featuring an angle of 0.5° . For additional information, please refer to the documents located in the "LOCNES Applicable Documents" section of this report.

Activity report

The windows undergoing the characterization process reported in this document are identified with the ID: SN11 and SN12. These windows are provided to the TNG staff for laboratory tests to characterize and calibrate the optical setup to be inserted into the GIANO-B pre-slit. Additionally,

these windows serve as spare parts in case replacement is needed for any of the three GIANO-B absorption cells.

Windows SN11 and SN12 were specifically brought to Italy to perform the tests listed below.

For completeness of information: the other 8 fused silica windows are currently installed on their respective four absorption cells. Meanwhile, the cells SN1 and SN2 feature parallel-faced windows made of BK7.

Measure the transmissivity of each window.

- UV-VIS-NIR at Merate laboratories.

For the measurement of the transmissivity of individual windows, a Jasco V-770 was used.

Both the calibration baseline and transmittance measurements were obtained by automatically averaging three different scans in the 200-2700 nm range.

Jasco returns transmittance measurements already calibrated for the baseline. As the last measurement, a transmittance measurement was acquired without inserting any sample (in the plot identified as no_sample) to verify the baseline's validity for the entire measurement campaign.

For further details regarding the instrumentation, please refer to the document 'V-770 UV-Vis/NIR Double Beam Spectrophotometer', available on the website "www.jascoinc.com/products/spectroscopy".

- IR at INAF-IAPS laboratories

Some measures of the transmittance of the SN-12 window have been acquired in the IR band making use of the Bruker Vertex 80 FT-IR spectrometer available at the laboratories of IAPS Rome. Below is reported a measurement of transmissivity in the range 2300-5200 nm.

For further details regarding the instrumentation, please refer to the document "Flyer VERTEX 80: FT-IR Spectrometer", available on the website:

"www.bruker.com/en/products-and-solutions/infrared-and-raman".

Jasco V-770 measurement parameters

The measurements of the transmissivity of individual windows were carried out with the following settings:

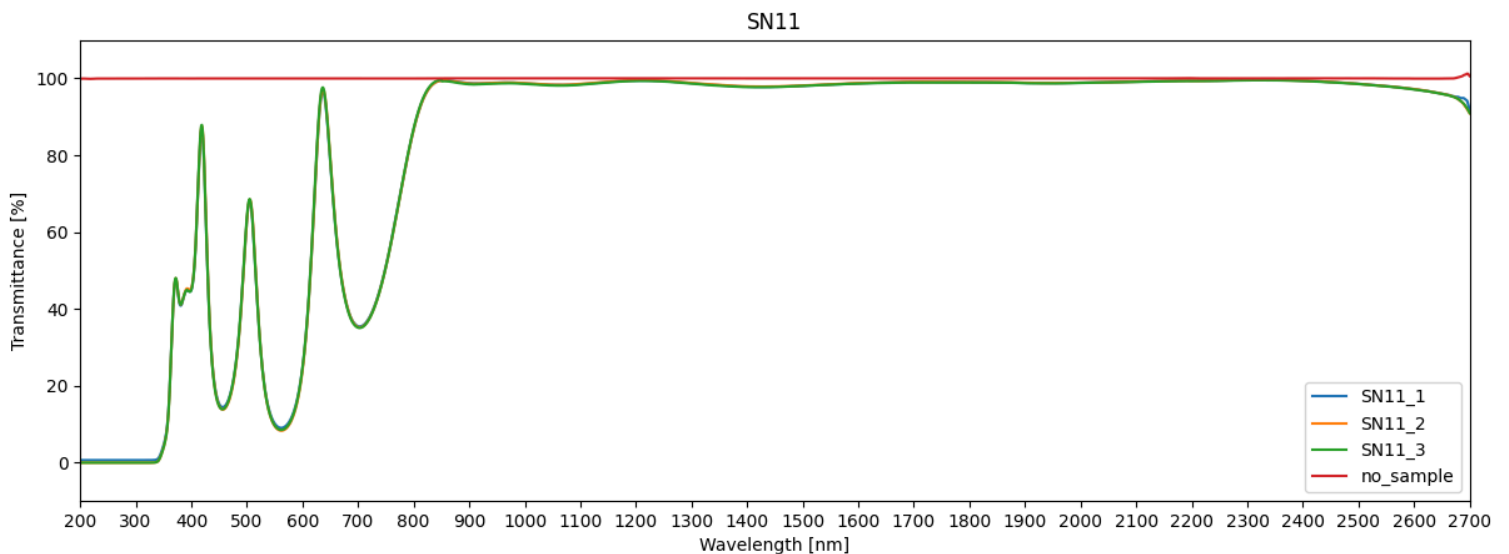
Photometric mode %T
Measurement range 2700 - 200 nm
Data interval 1 nm
UV/Vis bandwidth 12.0 nm
NIR bandwidth 4.0 nm
UV/Vis response 3.84 sec
NIR response 3.84 sec
Scan mode Continuous
Scan speed 200 nm/min
Change source at 340 nm
Change grating at 850 nm
Light source D2/WI
Filter exchange Step
Correction Baseline
No. of accumulations 3

Bruker Vertex 80 measurement parameters

Detector: InSb/InGaAs
Lamp: MIR/NIR
BeamSplitter: KBr/Caf 2
Resolution: 2 cm⁻¹
No. scans: 256

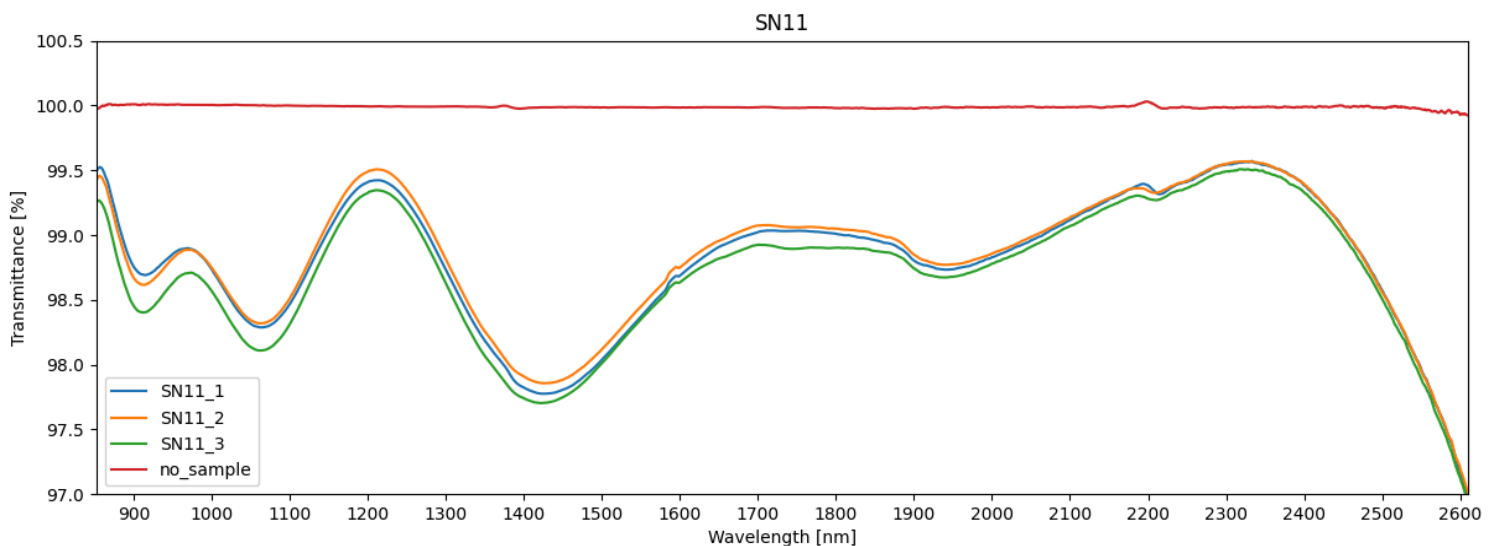
Measurements

SN11 wavelength range 200-2700 nm (acquired with the Jasco)



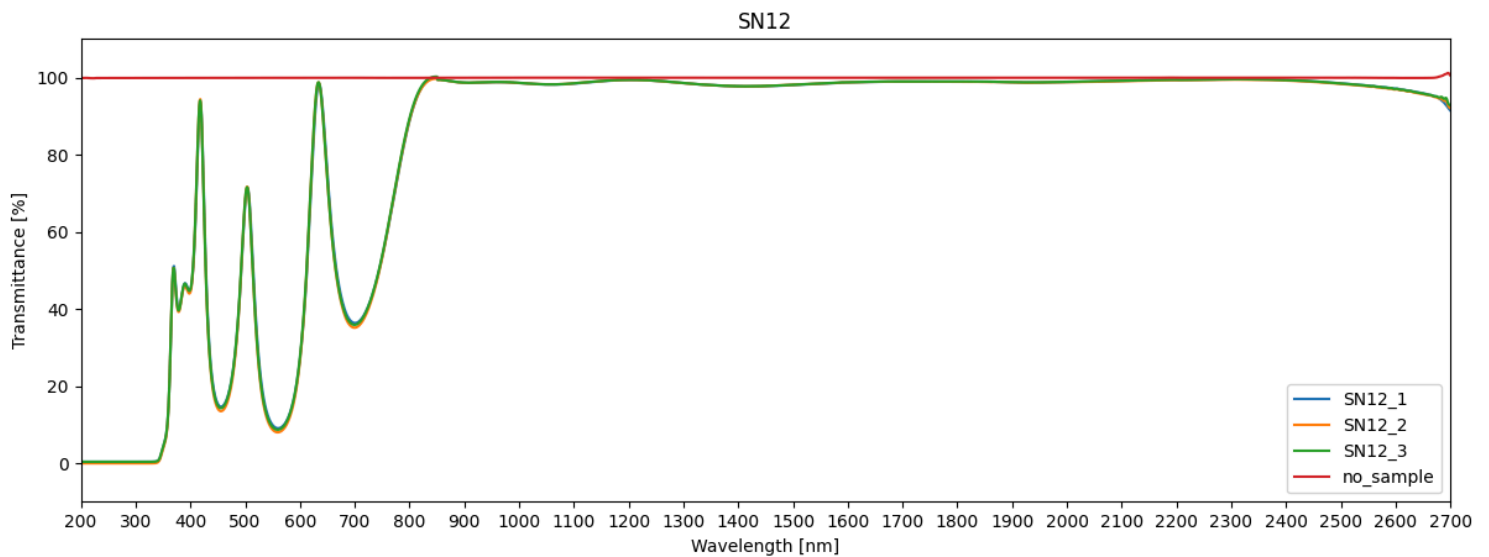
In the figure above, the transmissivity spectra of wedge window number SN11 are shown, within the spectral range between 200 and 2700 nm. The blue, orange, and green curves represent three different measurements analyzing different regions of the window, using the same Jasco settings. The red curve represents a control spectrum obtained without inserting any sample into the Jasco.

SN11 wavelength range 850-2600 nm (acquired with the Jasco)



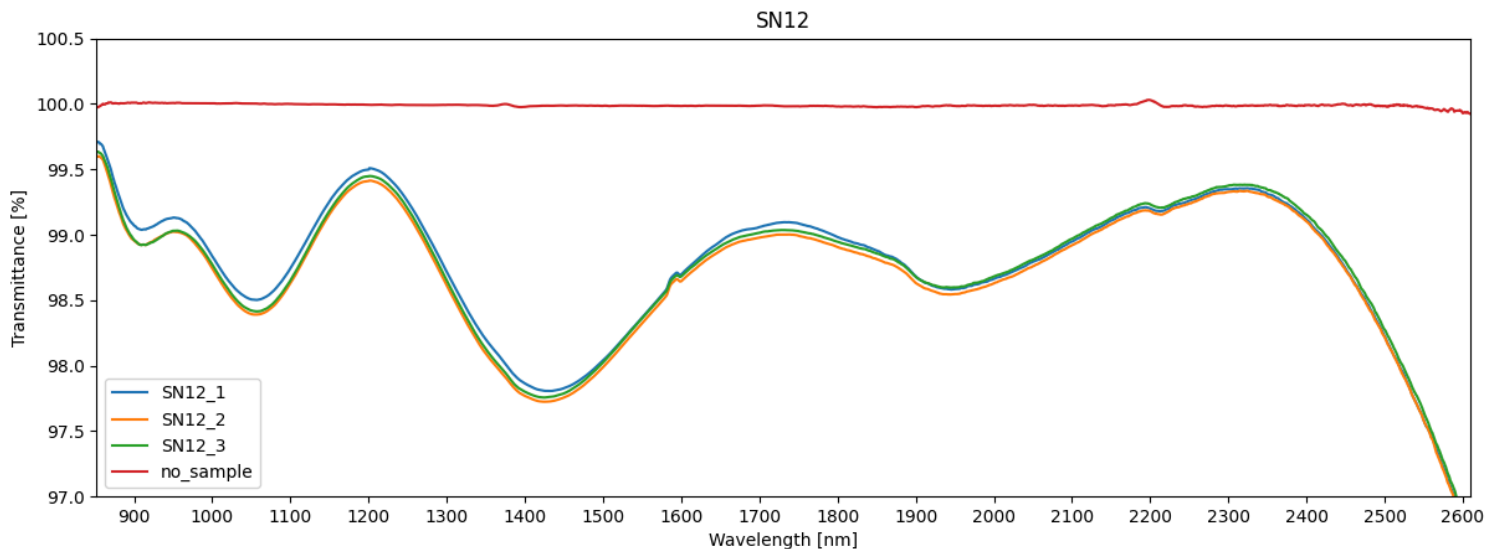
In the figure above, the transmissivity spectra of wedge window number SN11 are shown, within the spectral range between 850 and 2600 nm. The blue, orange, and green curves represent three different measurements analyzing different regions of the window, using the same Jasco settings. The red curve represents a control spectrum obtained without inserting any sample into the Jasco.

SN12 wavelength range 200-2700 nm (acquired with the Jasco)



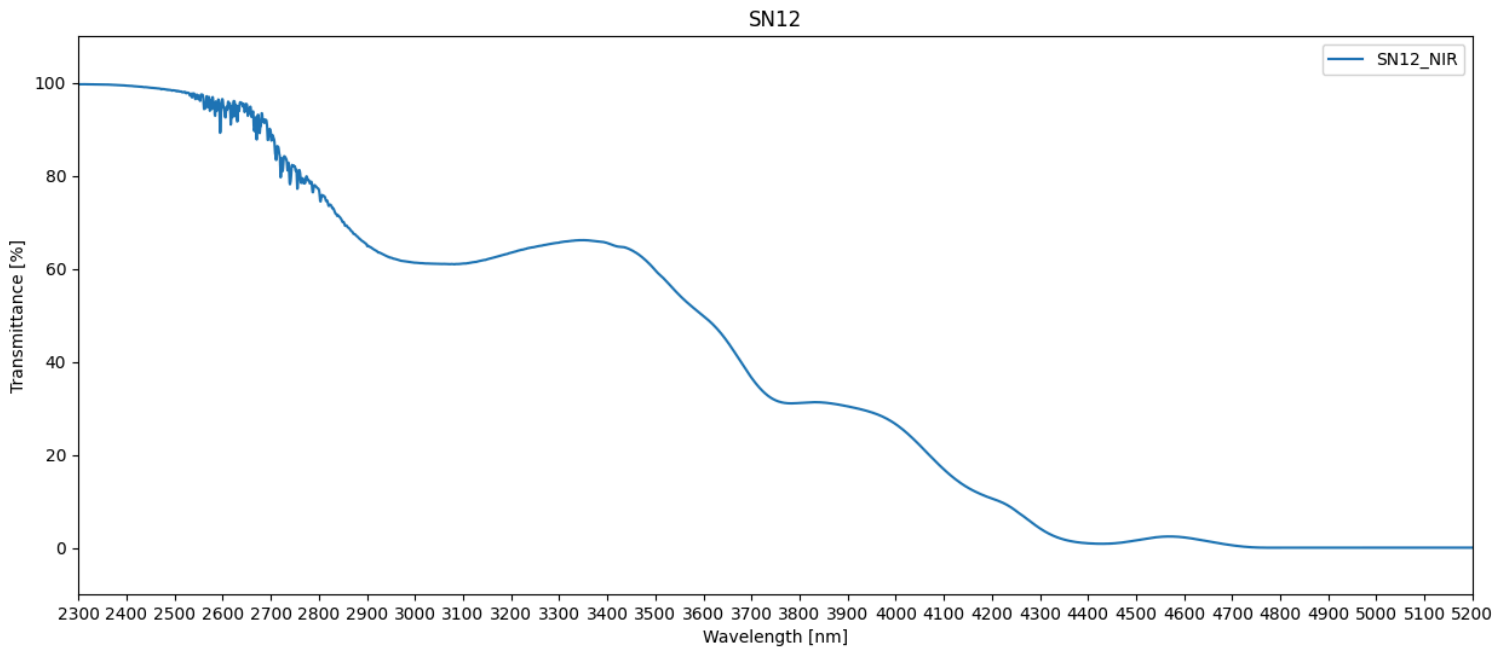
In the figure above, the transmissivity spectra of wedge window number SN12 are shown, within the spectral range between 200 and 2700 nm. The blue, orange, and green curves represent three different measurements analyzing different regions of the window, using the same Jasco settings. The red curve represents a control spectrum obtained without inserting any sample into the Jasco.

SN12 wavelength range 850-2600 nm (acquired with the Jasco)



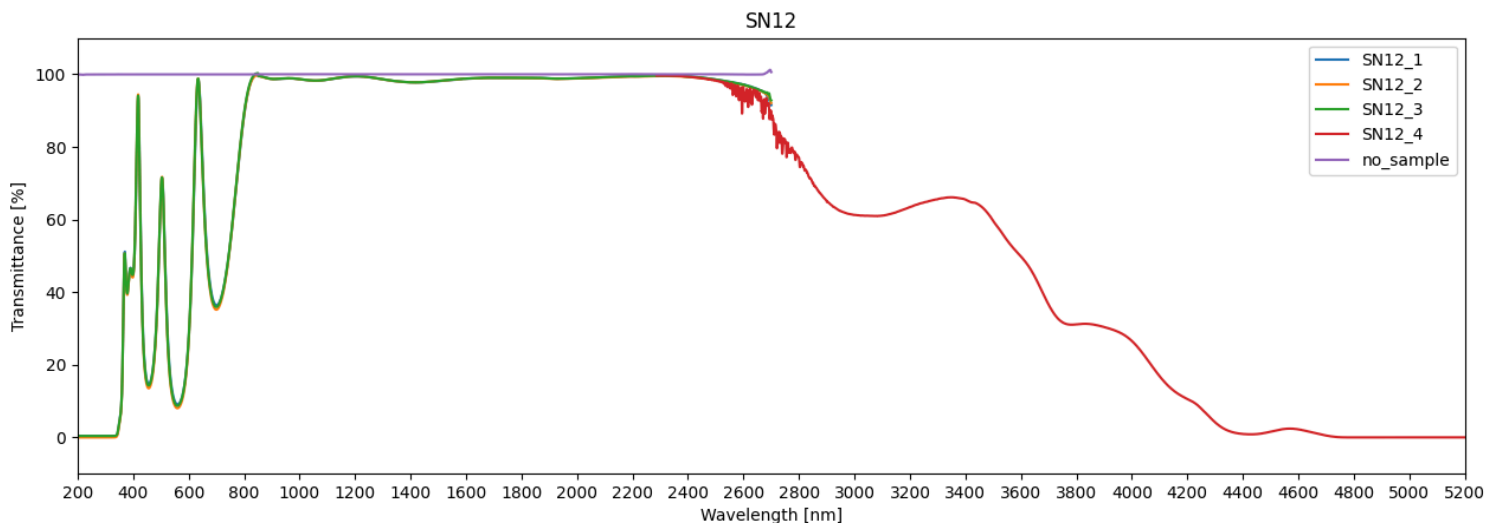
In the figure above, the transmissivity spectra of wedge window number SN12 are shown, within the spectral range between 850 and 2600 nm. The blue, orange, and green curves represent three different measurements analyzing different regions of the window, using the same Jasco settings. The red curve represents a control spectrum obtained without inserting any sample into the Jasco.

SN12 wavelength range 2300-5200 nm (acquired with the Bruker)



In the figure above, the transmissivity spectra of wedge window number SN12 are shown, within the spectral range between 2300 and 5200 nm. This measurement was obtained using the Bruker Vertex 80 FT-IR spectrometer.

SN12 overall transmissivity wavelength range 200-5200 nm



In the figure above, the overall transmissivity spectra of wedge window number SN12 are shown, within the spectral range between 200 and 5200 nm. The blue, orange, and green curves represent three different measurements analyzing different regions of the window, using the same Jasco settings. The red curve was obtained using the Bruker Vertex 80 FT-IR spectrometer. The purple curve represents a control spectrum obtained without inserting any sample into the Jasco.

Results

The examined windows meet the requirements. Following the conducted measurements, it is confirmed that the two windows are composed of Infrasil® 301/302 as required by design, and not Suprasil® 311/312, as inaccurately indicated in a transmission spectrum accompanying the products.

After the tests described here, at a later time, the window supplier notified us that Infrasil® 302 was utilized in the production of the windows. The manufacturer also clarifies that the absorption spectrum wrongly presented as a compliance test of the windows in reality was referring only to the anti-reflective coating, and for that a less expensive Suprasil® 311/312 substrate was employed. The manufacturer conducted this anti-reflective coating test internally to assess the quality and optical properties of the deposition process.

The tests carried out at the INAF laboratories in Merate and INAF-IAPS in Rome have therefore demonstrated that the wedge windows have been made with the correct Infrasil® 301/302 material. The windows exhibit optical and geometric properties fully compliant with the project specifications, and therefore have been accepted.

Data availability

All the measurements acquired with the Jasco and Bruker Vertex are available in numerical format upon request.