



NIRSpec Technical Note
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Description of the NIRSpec optical ground support equipment (OGSE)

Abstract:

In this document we describe the NIRSpec OGSE available during the instrument level calibration campaigns.

1 INTRODUCTION

During the instrument level on-ground calibration campaigns, NIRSpec is tested inside a cryogenic chamber at IABG, Ottobrunn, Germany. Inside the chamber, there are several optical stimuli available, providing flat field and point source illumination over the 0.6-5.0 μm wavelength range of NIRSpec.

2 SCOPE

The scope of this document is to provide information on the optical ground support equipment available during the NIRSpec instrument level calibration campaigns. In Section 3 we describe the test setup at IABG. Sections 4 and 5 deal with the calibration light source (CLS) and the radiometric calibration spectral source (RCSS), respectively. Most of the description given is condensed from Ferruit (2009) and references therein.

3 OVERVIEW OF THE OGSE AND TEST CHAMBER

The NIRSpec cryogenic test facility consists of three parts (see Figure 1):

1. The main chamber where the NIRSpec instrument is mounted
2. The cross-piece
3. The CLS (see below for more details)

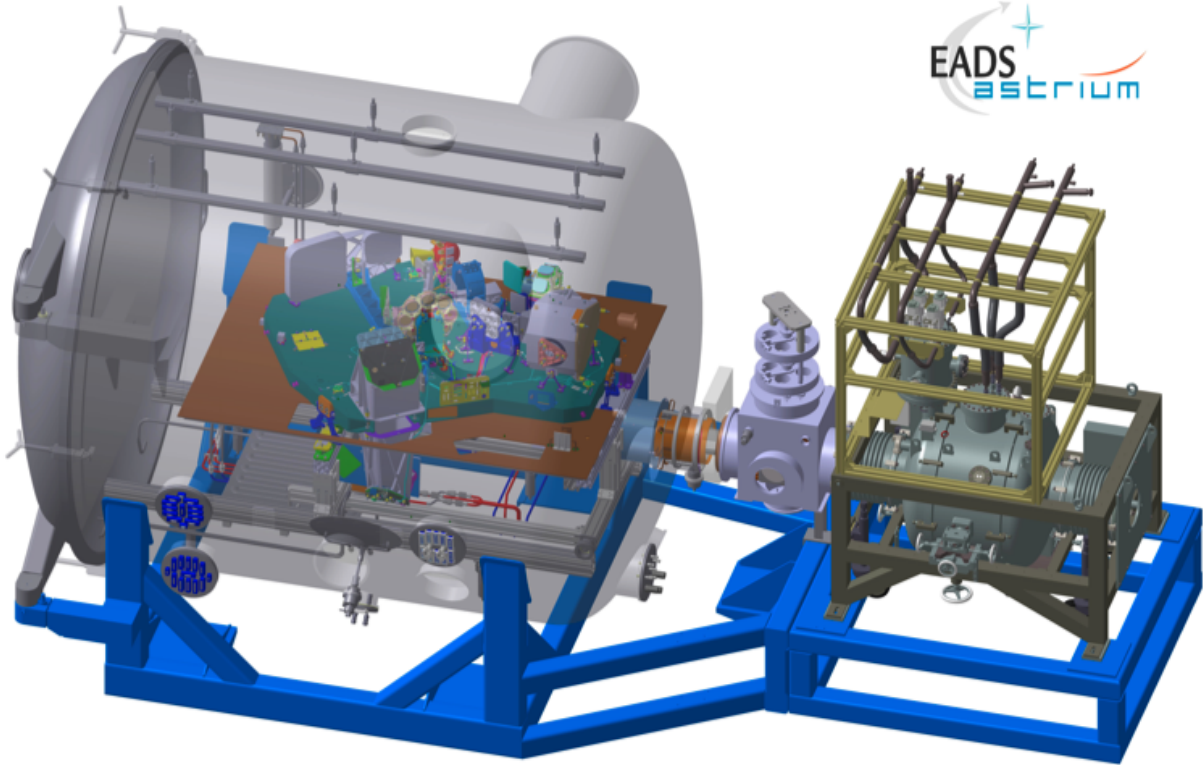


Figure 1: Sketch of the thermal vacuum test setup. NIRSpec is located in the cryo chamber on the left, the calibration light source (CLS) is located on the right. The middle part is the cross piece that is used as a view port to align NIRSpec and the CLS with respect to each other.

The main chamber holds the NIRSpec instrument, a cryo-mechanism (CMO) with different masks that also holds the RCSS, and a folding mirror. NIRSpec is enclosed in an inner shroud cooled by Helium to temperatures ~ 40 K, simulating the ISIM environment. Only the lower part of the coupling optics is sticking out of this shroud so that it can be illuminated by the CLS. The chamber also has an outer shroud cooled to ≤ 100 K by LN_2 (liquid Nitrogen), enclosing the inner shroud, the CMO, and the fold mirror. This outer shroud extends through the cross-piece and up to the exit port of the CLS, so that no part of NIRSpec should ever see directly any surface with $T > 100$ K.

The cross-piece has a pair of 45° mirrors that can be lowered into the beam in order to align the CLS with NIRSpec via two side windows. When these mirrors are retracted, cold shutters are put in place.

4 THE CALIBRATION LIGHT SOURCE AND CMO

The CLS is housed in its own vacuum vessel and can be isolated from the main chamber by means of a vacuum valve that goes through a retractable part of the outer shroud at the cross

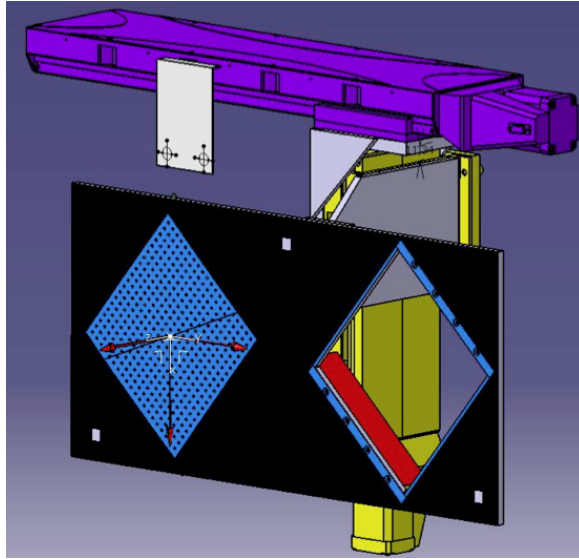


Figure 2: Sketch of the OGSE cryo-mechanism with its two masks, PHM (left) and FSM (right).

piece.

The light source consists of a gold-coated integrating sphere of 60 cm diameter and a light box mounted on top. The light box carries four filter- and aperture-wheels and holds the primary light source, a tungsten filament inside a hermetically sealed package with a Sapphire window from Helioworks. The integrating sphere and the light box are cooled to a temperature ≤ 100 K in order to suppress thermal background radiation in the wavelength regime of NIRSpec. The output of the sphere holds a mask that mimics the JWST pupil. Light coming from the sphere is going through the cross-piece and is then re-directed to the NIRSpec pick-off mirror by a fold mirror in the cryo chamber.

The filters and apertures in the light box are used to provide suitable illumination levels for all modes of the NIRSpec instrument, including flat fields (for both imaging and spectroscopy) and spectral references using Fabry-Perot filters and a rare earth standard (Erbium absorption lines). An Argon emission line lamp is directly mounted on the sphere and its light coupled in via a small hole and a short-pass filter (actually a slab of BK7 glass with the same temperature as the sphere itself). This lamp is used as the primary wavelength standard for NIRSpec during the on-ground calibration, because the wavelengths of the Argon emission lines are very accurately known (Kerber et al. 2008). Furthermore, the CLS features a fiber coupled $2.8 \mu\text{m}$ laser to measure the slit function (line spread function) at this wavelength.

The CMO holds two masks that are located in the focal plane in front of NIRSpec that are illuminated by the CLS. The field stop mask (FSM) is used to provide a flat illumination to NIRSpec, whereas the pinhole mask (PHM) provides a grid of point sources for distortion and focus measurements in imaging mode (see Figure 2). The state of the CMO and its position are available via the CMO_SYSI and CMO_SSS[X,Y,Z] keywords found in the fits header of NIRSpec instrument level exposures, where "SSS" can be "GLO" (global coordinates), "PHM" (for pinhole mask), "RCS" (for the RCSS), and "FSM" (for the field stop mask).

Table 1: Available modes of the CLS.

Mode	Main usage description
FFV	Continuum source for spectrographic flat field in the 0.7-1.2 μm range (i.e. F070LP + G140M/H configurations)
FF1	Continuum source for spectrographic flat field in the 1.0-1.8 μm range (i.e. F100LP + G140M/H configurations)
FF2	Continuum source for spectrographic flat field in the 1.7-3.0 μm range (i.e. F170LP + G235M/H configurations)
FF3	Continuum source for spectrographic flat field in the 2.9-5.0 μm range (i.e. F290LP + G395M/H configurations)
FFB	Continuum source for spectrographic flat field in the 0.6-5.0 μm range (i.e. all PRSIM configurations)
FFM	Continuum source for imaging flat field illumination in the 0.6-5.0 μm range (i.e. all MIRROR configurations)
PSB	Continuum source (0.6-5.0 μm) for pinhole mask imaging
PS1	Continuum source (1.0-1.8 μm band-pass) for pinhole mask imaging
PS2	Continuum source (1.7-3.0 μm band-pass) for pinhole mask imaging
PS3	Continuum source (2.9-5.0 μm band-pass) for pinhole mask imaging
SR1	Continuum source with Erbium absorption line and band-pass filter (1.3-1.7 μm) for medium/high resolution spectroscopy (gratings)
SRB	Continuum source with Erbium absorption line and band-pass filter (1.3-1.7 μm) for low resolution spectroscopy (PRISM)
SL1	Spectral line source for the 1.0-1.8 μm range (i.e. F100LP + G140M/H configurations)
SL2	Spectral line source for the 1.7-3.0 μm range (i.e. F170LP + G235M/H configurations)
SL3	Spectral line source for the 2.9-5.0 μm range (i.e. F290LP + G395M/H configurations)
SL4	Spectral line source for the 1.0-5.0 μm range (i.e. the PRISM)
SR1-B	Like SR1, but without the band-pass filter
SRB-B	Like SRB, but without the band-pass filter
ARGON	Argon emission line source for spectrographic wavelength calibration
CLOSE	Lamp shutter closed and Argon lamp off (tungsten filament still on)

The CLS was radiometrically calibrated by the National Physics Laboratory, UK, with an absolute accuracy better than 10%. The CAA, NIRSpec's internal calibration source, will be calibrated during the ground campaign using the CLS as a secondary standard. The available modes of the CLS are given in Table 1, where "Mode" denotes the value of the CLS_CONF keyword. Please note that the 2.8 μm laser (aka unresolved line source, ULS) is not listed in the table, as it is operated manually and its status cannot be reflected in the fits header.

5 THE RADIOMETRIC CALIBRATION SPECTRAL SOURCE

The RCSS consists of a small integrating sphere with six redundant continuum light sources and a pinhole. This pinhole is imaged by a telescope of an Offner design that mimics the JWST telescope's f/20-beam and pupil, and supplies a point source to the instrument. The

Table 2: Available modes of the RCSS. The ”_N” denotes the nominal side of the RCSS electronics, there is an equivalent set of modes with ”_R” for the redundant lamps.

Mode	Main usage description
MOS1_N	Continuum source for Band I (0.7-1.2 μm , 1.0-1.8 μm) spectroscopy
MOS2_N	Continuum source for Band II (1.7-3.0 μm) spectroscopy
MOS3_N	Continuum source for Band III (2.9-5.0 μm) spectroscopy
MOSBB_N	Continuum source for broad band (0.6-5.0 μm) spectroscopy (PRISM)
IFS1_N	Continuum source for Band I (0.7-1.2 μm , 1.0-1.8 μm) high resolution spectroscopy
IFS2_N	Continuum source for Band II (1.7-3.0 μm) high resolution spectroscopy
IFS3_N	Continuum source for Band III (2.9-5.0 μm) high resolution spectroscopy

RCSS is mounted on the CMO that also holds the FSM and PHM for use with the CLS, limiting its patrol range to an area close to the S_1600_A fixed slit in NIRSpec. The main use of the RCSS is to measure the slit and diffraction losses of NIRSpec for its spectroscopic modes. The available RCSS modes are given in Table 2, where ”Mode” denotes the value of the RCS_CONF keyword found in the fits header of NIRSpec instrument level exposures.

6 REFERENCES

- Ferruit, P. 2009, On-ground calibration and characterization plan for the NIRSpec FM-level calibration campaign, Plan NIRS-CRAL-PL-0001, CRAL
- Kerber, F., Nave, G., & Sansonetti, C. J. 2008, ApJS, 178, 374