# Validation of the commissioning of NIKA2, for an opening to the community

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### Introduction

The goal of this document is to gather in a short form the essential parameters characterizing the instrument performance and viability, and the criteria necessary for an opening to the community.

The validation of the criteria doesn’t mean the end of the instrumental work. In particular for all parameters identified as not optimal and possible to improve the work will continue in the view of possible future upgrades. That’s why we call the current commissioning “phase 1”.

The commissioning for the future upgrades will be called “phase 2”; it will consist of test runs which will alternate with science runs.

### Tables of criteria for the commissioning

As a framework of the NIKA2 collaboration, the MoU contains a list of expectations for the instrument characteristics and performance; this list is obviously the base for the commissioning criteria.

**It is mandatory that each measure reported in the tables is accompanied by a reference document describing the test scans used for the determination of the value and enough details on the processing allowing an independent verification using the same data.**

In red the measured parameters which values have to meet or be better than the specifications to validate the commissioning, in blue the parameters which values may be lower than specifications if accompanied by an argumentation agreed between the NIKA2 consortium and IRAM, **and in bold green between brackets the related pages in the reference document nika2\_commissioining\_v01.pdf (version of June 27, 2017)**.

## Main table

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Wavelength (central) [mm]** | **2.0** | **1.2** | **1.2 (A1)** | **1.2 (A3)** |
| **Frequency (central) [GHz]** | **150** | **250** |  |  |
| Measured central frequency [GHz] **{p. 4, 75}** | 152 | 257 | 256 | 258 |
| NEFD(1) [mJys1/2/beam] goal on 90 % of the pixels | 10 | 15 |  |  |
| NEFD(1) [mJys1/2/beam] specification on 50 % of the pixels | 20 | 30 |  |  |
| Measured NEFD(1) [mJys1/2 /beam] {p. 29, 76} | 6 | 22 |  |  |
| Fraction of usable pixels (KID) **{p. 6}** | 78 % | 73 % | 70 % | 76 % |
| Number of KID total / valid pixels  **{p.6 official, p.9 2bm & 5bm, p.10}** | 616 / 481, **553**, 508, 543 |  | 1140 / 793, **952**, 840, 925 | 1140 / 872, **961**, 868, 944 |
| FWHM [arcsec] goal | 16 | 10 |  |  |
| FWHM [arcsec] specification | 18 | 12 |  |  |
| Measured FWHM [arcsec] **{p. 28}** | 17.5 | 10.9 | 10.9 | 10.9 |
| FOV diameter [arcmin] goal | 6.5 | |  |  |
| FOV diameter [arcmin] specification | 5 | |  |  |
| Effective FOV [arcmin] **{p. 9 & 75** but miss gridstep value**}** | 4.9 (or 5.9) | 5.6 | 5.4 (or 5.7) | 5.6 (or 5.8) |
| Pixel size in beam sampling unit [F] goal | 0.6 | |  |  |
| Pixel size in beam sampling unit [F] specification | 0.9 | |  |  |
| Effective pixel size in beam unit [F] **(2)** | 0.93 | 1.09 |  |  |

(1) Practical value for a good sky: 2mm pwv, 60° elevation.

(2)Calculated from real array pixel size [2.75mm / 2.0 mm] and unvignetted pupil diameter [27m].

## Secondary table

The following table is constructed from the instrument characteristics description of the MoU

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Effective bandwidth (∫­­·d) indicative values(2) [GHz] | 50 | 100 |  |  |
| Measured effective bandwidth(2) (∫­­·d) [GHz] **{p. 4}** | 42.1 | 46.7 | 47.8 | 45.7 |
| Noise scaling down with integration time power law expectation for one hour, out of confusion limit | √t | |  |  |
| Effective power law of noise reduction with integration time (power must be > 0.4) **{p. 46}** | 0.51 | 0.53 | 0.54 | 0.54 |
| Dynamic range criteria: NEFD increase between 0.1 and 0.5 atmospheric opacity must be slower than the theoretical increase of pure photon noise NEFD, which values (0.1 🡪 0.5 opacity) are given for reference | 3 🡪 7 | 4 🡪 12 |  |  |
| Dynamic range criteria: values of NEFD between 0.1 and 0.5 opacity; slope must be slower than the pure photon noise **{p. 45 & 71}**(4) | 7 🡪 10 | 26 🡪 35 |  |  |
| Maximum expected dispersion of the angular resolution (FWHM) on the FOV surface: goal (specification) | 5% (10%) | |  |  |
| Measured dispersion of the angular resolution (FWHM) on the FOV **{p. 28}** | 0.2” (1.8%) | 0.2” (1.1%) |  |  |
| Absolute photometry of a point source goal (and specification); part that comes in addition to the calibrator model uncertainty | 5% (10%) | |  |  |
| Absolute photometry of a point source measured, in addition to the calibrator model uncertainty **{p. 36-41 tbc}** | <10% (tbc) | <10% (tbc) |  |  |
| Relative photometry of a point source goal (and specification) ; part that comes in addition to the calibrator model uncertainty | 3% (5%) | |  |  |
| Relative photometry of a point source measured in addition to the calibrator model uncertainty **{p. 36-41 tbc}** | ~5% (tbc) | ~5% (tbc) |  |  |
| Polarization(3) sensitivity for the Q and U Stokes parameters, goal (specification) | 2× (3×) NEFDI | |  |  |
| Polarization(3) sensitivity for the Q and U Stokes parameters measured | Not necessary for phase 1 review | | | |

(2) The bandwidth is not part of the MoU requirement per say, though NIKA2 is presented as a continuum instrument filling the atmospheric windows available at Pico Veleta; the indicative values translate into quantified values this notion of filling window, and the measured effective bandwidth, which can be 10-30% smaller, are not acceptance criteria but an indication that the instrument spectra must be characterized.

(3) The polarization characteristics of the instrument are not part of the phase 1 of commissioning. But they will have to be part of the phase 2.

(4) See Figure 42 of ref document (NEFD astro vs tau/sin(el)) as a better reference characteristic than the 2 values given in the secondary table.

## Tertiary table

The following table is constructed from the characterization plan and various outcomes of data processing after one year of test runs. The following characteristics don’t need to meet a special requirement; however they need to have been characterized with documented values. Some can be seen as landmarks toward possible future upgrades.

|  |  |  |
| --- | --- | --- |
| **Characteristic description** | **Indicative values(8)** | **Actual value** |
| Synchronization between instrument and scan information (delays of Elvin messages) | < 100 ms | <10 ms >99% of the time, but few 100s ms occasionally |
| Synchronization between instrument and telescope coordinates  *(for information with acquisition rate = 23 Hz, sample duration = 43 ms)* | < 100 s | 26 s(I) |
| Extra overheads per subscan introduced by NIKA2 | < 2 s | 6 s (tune subscan) |
| FOV maximal grid distortion | < 3% | 16(II) % |
| **Instrument stability: Allan Variance of the NEFD (or the RMS per sample)(4)** |  | **?** |
| **Instrument stability: mean fraction of valid pixel’s TOIs discarded due to jumps or other effects per day.** |  | **?** |
| Flat field dispersion for the near field (forward efficiency) | < 10% | Feff FF gradient >>10% on array 1 lower on array 2 & 3 |
| Flat field dispersion for the far field (main beam) | < 10% | MB FF gradient >10% on array 1 lower on array 2 & 3 |
| Gain elevation efficiency maximum deviation from heterodyne reference(5) (EMIR) | <15% | **?** |
| **Atmospheric opacity in the line of sight accuracy (total power capacity): standard deviation of the population of 2mm/­1mm as a function of ­2mm in the range [0.1;0.6] over a run w.r.t expected curve** | **<10%** | **?** |
| List of possible scan types, including calibration, with validated quick look procedure | Pointing, Focus, OTF | |
| Best average focus over an array in terms of M2 Z shift with respect to the best central focus **{p. 20?}** | -0.2 mm | -0.25 mm ? |
| Maximal focus difference in terms of M2 Z shift between the most extreme pixels on the focal surface, for most extreme of the 3 arrays **{ p. 20}** | -0.4 mm | -0.60 mm |
| Focus difference between arrays in terms of M2 Z shift between the reference pixel and the centre of the most distant array **{ p. 20?}** | < |0.2 mm| | +0.10 mm ? |
| XYZ focus optimization: deviation from the optimum in terms of fraction of power in residuals of beam fit **{p. ?}** | 5% | Lateral focus = 0 +/- 0.05 mm(9) ? |
| **Instrument internal NEFD and stability demonstrated through dark tests** | If not available for phase 1 review please give an explanation | |
| Diffuse emission recovery(6), comparison of a known source maps with literature | Not necessary for phase 1 review | |
| Software or list of software that will allow processing of science scans for Guaranteed Time observation and Open Time observations(7) | Not necessary for phase 1 review | |

(4) For meaningful values, the considered period must contain at least 10 independent scans during which the atmosphere opacity must have changed by less than +/-0.1.

(5) The gain elevation efficiency is mainly a telescope property, but its precise value depends on the illumination of the primary mirror by the instrument. An accurate determination is necessary for high photometry performances.

(6) The diffuse emission recovery characterisation is not part of the phase 1 of the commissioning; it will be addressed during the phase 2.

(7) The reference document for this relatively broad entry will have to identify 2 possible stumbling blocks: [1] Software to process data online: reduce scans of pointing, focus, skydip, beam maps to provide information to observers on data quality and on how to continue observing. This software also provides a quick view of maps on science targets. [2] Software to reduce all data offline and provide a preliminary version of \*calibrated\* maps (corrected for flat fields, atmospheric transmission, etc.). The production of final data products is not the aim for phase 1.

(8) These values are not requirements, but just indications of what we would typically expect, what matters most is not the value itself but that these parameters have been investigated during the commissioning.

(9) Require extremely high instrument & sky stability for reliable determination: such conditions have never been met over the 10 test runs.

1. <http://www.iram.fr/wiki/nika2/index.php/File:PPS_Synchronization.pdf>
2. <http://www.iram.fr/wiki/nika2/index.php/June_15,_2016,_FXD,_KID_position_mapping_and_Field_distortion>