History of optical and radio alignments of NIKA2

Samuel Leclercq. Last update 23/02/2021.

Summary

- run 1 (2/10/15) : Global optical alignment using lasers, mounts and mirrors M3, M4, M5, M6.

- run 5 (4/10/16) : Optical axis alignment using lasers on external mirrors to NIKA2 window, moving M5 3 points system.

- [run 7 (8/12/16) : Check only of radio axis using eccosorb on window (+ simulation of a cold optics misalignment in NIKA2 and the way to recover from it with the external optics).]

- run 8 (10-24/01/17) : Radio axis alignment moving internal M7-M8 block, and 1st check.

- [run 10 (18/04/17) : Check only of both optical and radio alignments.]

- run 12 (22/10/17) : Check of both optical and radio alignments; put both at same point on NIKA2 window, moving M6 3 points system.

- {run 20 (1-10/09/18) : Changes of dichroics => opening of the cryostat and dismounting M7-M8 block. Theoretically mechanically put back exactly in the same place, but not check done on alignment. Nevertheless, no oddities found with the subsequent pointing session, which was the last one done until end 2019.}

- {run 37 (7/11/19) : Robert notices progressive change of pointing correction from run 22 to 37, a hint of a possible gradual misalignment.}

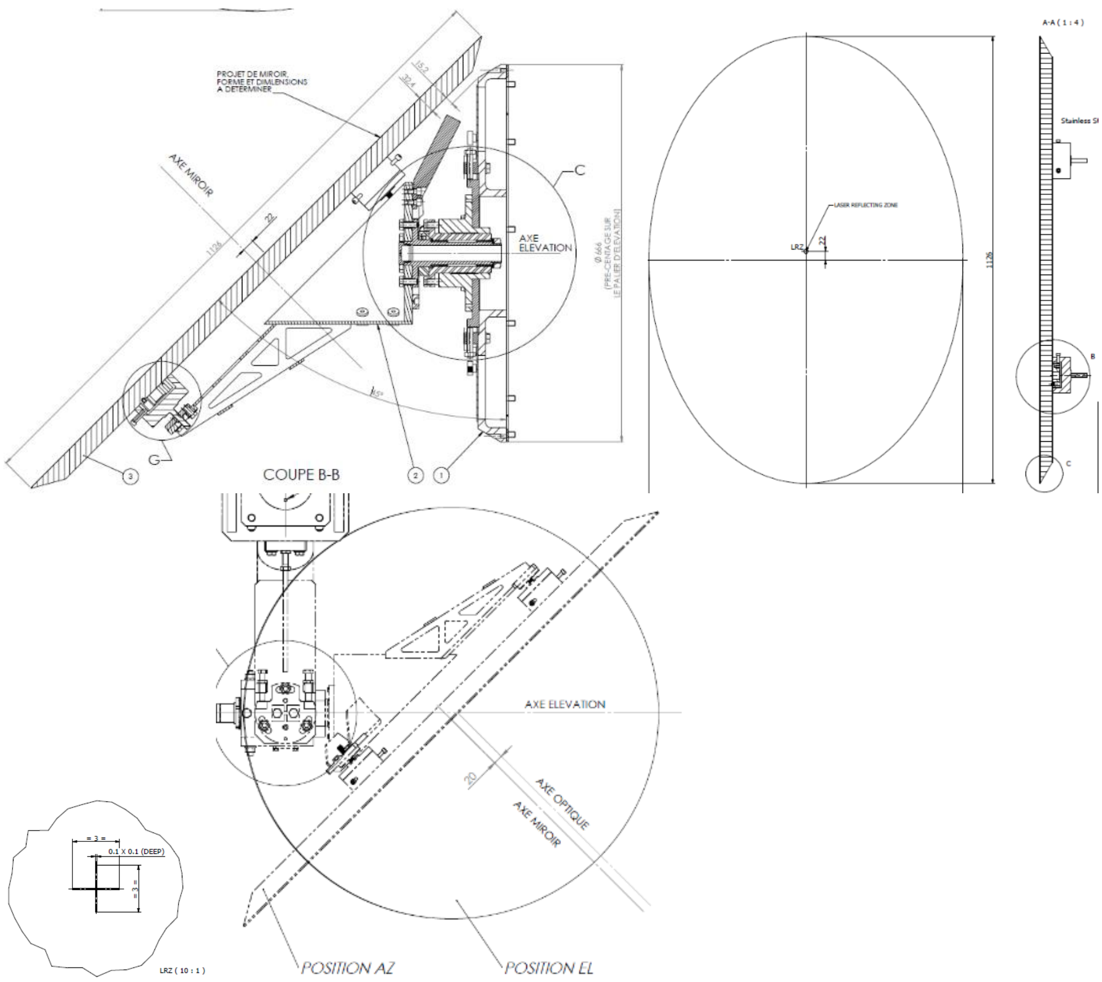
- run 38 (3/12/19) : Before the run Santiago and Miguel did a new optical alignment, moving M6 3 points system to put back the laser at the same position on the Window as run 12.

- [run 42 (24/02/20) : Check of optical alignment using laser, no change with respect previous alignment end 19.]

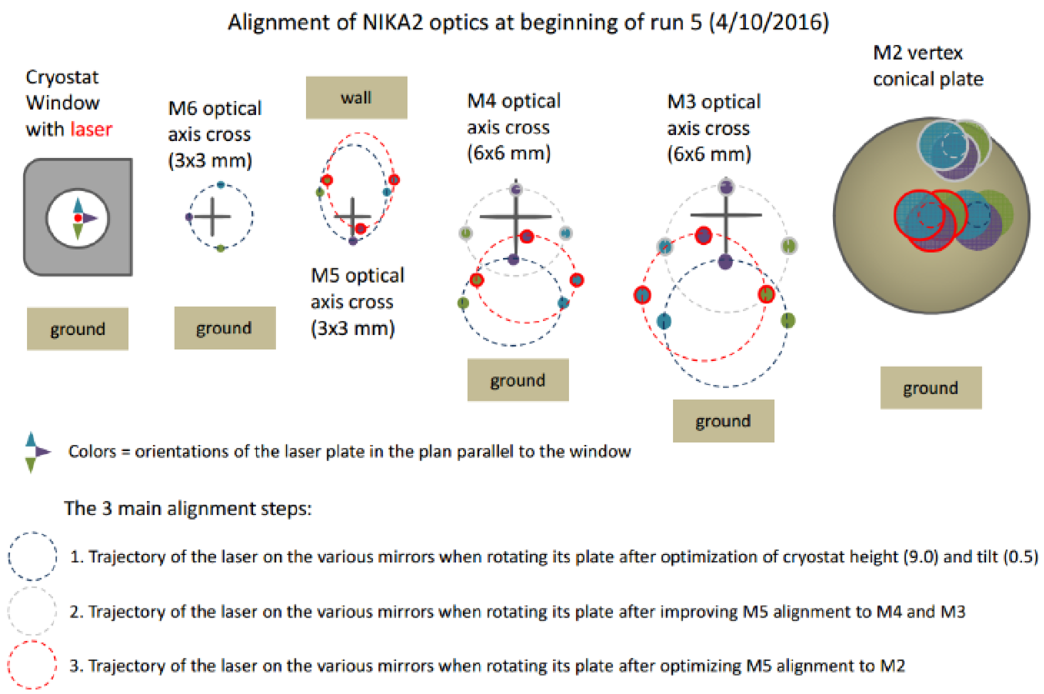
Details

The details given below come from an email I wrote after Robert's mention of change of pointing corrections in November 2019, to inform IRAM colleagues who were not there few years ago about the history of the NIKA2 alignment.

- Take care that the laser spot from M3 must not be at the center of M4! Because of the converging shape of the beam, the fact that M4 is at 45° of the optical axis and the spacing constraints that require to intersect the 2w contour of the 6.5' FOV, then the optical axis must be offset from the center of the mirror. There's a cross engraved on the surface of the mirror to mark where the spot should be: it's 22 mm toward the wall edge, as shown on the screenshot below (M4 in EMIR position). Note that on M3 the offset is 20 mm toward the edge closer to the cabin center.



This is the theory, in practice we had to find compromise between the various systematic errors; On run 5 we found the following compromise, using the NIKA2 laser shutter, rotating it to get rid of its own misalignment (see run 5 daily report for more info):



One thing is missing on this sketch: checking the correct alignment of the telescope mirrors themselves; the above is correct only if this M2-M3-M4 alignment is correct. So it's good to use also the M3 elevation bearing laser to check that.

And because of the systematic errors, when you use the M3 laser, it's clear you have to rotate in elevation to find the correct orientation that fits the laser to the optical axis. I'm surprised you choose adjusting the laser to put it on the M4 center instead of adjusting it so that the spot rotates on itself instead of describing a circular trajectory. 2mm is not a very big offset though, just about the size of the laser itself. So, it's most probably fine; I trust your experience. Still I'm curious, why couldn't you do the elevation check?

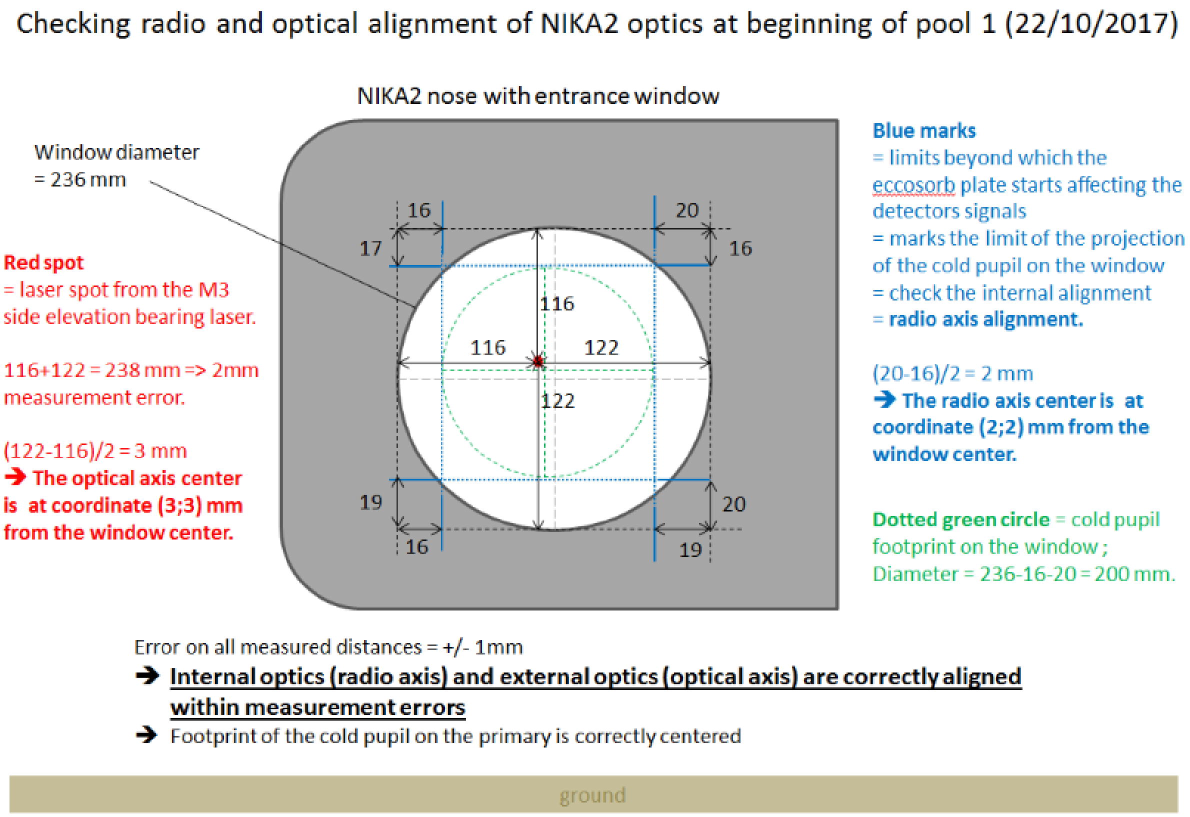
- All the above is about the "optical axis", i.e. the alignment of the optical elements outside the cryostat. Now there's the problem of the alignment inside the cryostat, and what we call the "radio axis" that corresponds to the alignment from the detectors to the sky. This is of course the most important one, and what is critical there is not much that the center of the array sees a source aligned with the M1-M2 optical axis, but rather that the illumination of the pupil is well centered, to minimize spillover M1; in other words the image of the edge the of M1 must be well centered on the cold pupil (see run 7 daily report for more explanation, or even better this link: http://www.iram.es/IRAMES/mainWiki/CompensateColdOpticTiltWithM6). If the optical elements are perfectly well aligned, then optical axis = radio axis, otherwise there's an offset.

The best test we found to check the radio axis is the use of eccosorb (a 300K black body) on the sides of the entrance window, which is close to a pupil of the system (otherwise it wouldn't work). The KID must look at a very good sky (low opacity, and stable), we see when the KID signal is affected when we move the eccosorb toward the center of the window. The radio axis is at the center of the contour marked by the positions where the eccosorb starts to have an effect on the KID signals. That is how we found that the radio axis is not at the center of the window unfortunately.

On run 7 we saw the radio axis misalignment was important (> 1cm on the window). That explained some asymmetric strong distortion effects we had on the beams (in particular the "crowding"). On run 8 we opened NIKA2 and adjusted the position of the M7-M8 block to reduce as much as possible the radio axis misalignment with the optical axis (see daily report). After closing we found the radio axis was 5 mm left of the window center and 1.5 mm up. We tilted the M6 pointing to put the M3 laser on that position on the window. The end of run 8 showed improvements on the beams (see daily report).

On run 10 that we checked again the position of the new radio axis on the window (see April 18th, 2017 entry of the daily report). Laser was ~3.5 mm left (both at 0° and 85° elevation) and 4.5 mm up (bit more at 0° elev, bit less at 85°), so not quite like run 8, but change small enough to decide to not change anything since the since the sky was too noisy to check also the radio axis.

On run 12 (1st pool run, October 2017) we finally got a sky good enough to check correctly the radio and optical alignment together: here is the result (see daily report for details):



==> We are better than we thought, with a radio offset of only 2mm left and 2mm up. We compensate this misalignment with the M6 orientation to place the laser spot at the right position (+/- 1mm). Check these slides to see the effect of the radio misalignment and its compensation with M6:
http://www.iram.es/IRAMES/mainWiki/DailyReportsNika2Pool1?action=AttachFile&do=view&target=Alignments_check_NIKA2_optics_pool1_22-10-2017.pdf

Then up to run 19 (June 2018): no alignment checks... as there was no change on the instrument, and not obvious change on the data.

But then we changed the dichroic, in August, and reverse the change on September.... And apparently didn't checked again the alignment! Although we did the dichroic change without moving the cryostat, we dismounted the cold optics and mounted it back, which is not 100% bullet proof against a small misalignment...

=> So, despite the dichroic intervention on August 2018, the last alignment check before the one you did last week occurred on October 2017!!!

Nevertheless, I don't think the misalignment you found dates back to this change. The impact of the dichroic change must have been very small (by chance) since apparently the pointing session we did after the intervention resulted on a change of the pointing model that didn't triggered our attention, so probably not significantly bigger than the usual seasonal change.... And apparently this was the last pointing session we did, so unless I missed it or we didn't write it down in the daily reports since then, we had no pointing session for about 1.5 years!

Though I don't think that the misalignment dates from the wifi hunting, I suspect something more progressive, we should not discuss over hypotheses, impressions, feelings or thoughts;

we need facts, we need data, we have to check the pointing corrections of the 10 past runs at least to know the truth.

In conclusion: given the misalignment you found and given the elapsed time since the last alignment checks and the last pointing session. I warmly recommend that the next time we have a good sky we recheck the radio axis, make the laser alignment consequently and redo a complete pointing session. This will use up to a full day of good weather, but this is for the good of the quality of the science data that will follow. It completely worth it.