Minutes of the 12/07/2011 NIKA data meeting

S. Leclercq

Participants: RN, AM, RZ, SL, FXD, JP, AS, CK, HU.

Summary

Although sensitivities of ~30 (130) mJy*s^{1}/2 @ 2 (1) mm were achieved there was still many things wrong and perfectible in the last run, and with a careful processing Robert Zylka showed that all these things appear in the data, however many of them are known, understood and should disappear in the next run thanks to various improvements done on NIKA, and hopefully a better way of doing the observations (pointing, focus, tuning information...).

The aims of the meeting was to communicate about the status of the 2nd run data processing, about the collaboration between Xavier, Robert and Albrecht in that domain, and have a better view of its goals and work to do.
It turned out that this collaboration is not only important to lay the bases for an instrument well integrated to the IRAM system (in terms of data format and processing), but also the rigorous analysis by Robert gives a useful feedback underlining the things to improve in the prototype.

The main decision taken for the next run is that it would be good to have everything ready so that after each scan, IMBFITS that are readable and treatable by Robert can be automatically generated. This is a work for Albrecht Sievers, François-Xavier Désert, Robert Zylka, and maybe Hans Ungerechts and Alain Benoit. Next meeting we will have to evaluate this situation.
The need for an improved interfacing of NIKA with the telescope thanks to upgraded NCS data provided by Elvin was only briefly evocated because the persons concerned (Alain Benoit, Walter Burnswig and Juan Macias-Perez) were not present.
The need to define the future data format, including I, Q, dI, dQ and RF for thousands of pixels has also been evocated.

Minutes

SL: Introduction (see slides).

FXD: Status of the NIKA run 2 offline processing (see slides + reference document NIKA_KidCalibration_TechNote1_v2.pdf)

There's 3 main aspects of the data processing that have to be understood:
1) Calibration and photometry

2) Pointing, beams
3) Noise reduction (sky noise, electronic noise, jump noise,...)

FXD described the data characteristics and and problems from last year (excess gain dispersion for some pixels, magnetic shielding, etc.)
(TOI = Time Ordered Information).

Frequency sweep at 1kHz modulation giving not only I & Q but also dI & dQ will provide better measurements.

- Total power is proportional to the absolute KID phase change, not available in previous runs but should be ready for next run.
- Linearisation of response necessary to remove sky noise (non-linearity kill the removal efficiency)
=> These 2 points have to be addressed to be able to reach 5% photometry.

RZ: scans on Mars for pointing faster than MAMBO but could be much faster and efficient using the slow loop of NCS at 8Hz instead of the current 1Hz.
FXD showed 2" pointing accuracy from source to source, but RZ reminded that in beam maps there are offsets up to 10".

Photometry ~10% is not satisfactory. Improving on skydips reduction should help; 1st method shows a big dispersion, new method is better. The problems comes from the non-linearity of KIDs in skydips.
The dynamic range of sensitive KIDs is too small to handle >10K variation from the incoming photons without re-tuning. One solution could be to dedicate few KIDs on the array to skydips: they would have a poor sensitivity but big dynamic range.

Glitches & Jumps. There's more cosmic ray events expected than in bolometers (no membrane in KID), which could explain part of the high rate of glitches (dirac-like spikes). glitches are easy to identify and remove, jumps are much more problematic. We hope the new EM shielding will improve significantly the rates of glitches and jumps (already shown a x5 improvement in lab).

Electronic noise: RZ pointed that if it is correlated like sky noise, it makes no difference for the suppression procedure to know where it comes from.

NEFD for the next run expected to be 10x better @ 1mm (goal 35 mJy*s^1/2) and 2x better @ 2mm (goal 22 mJy*s^1/2)

RZ: presentation of all the problems he saw in the data provided by FXD (see plots and comments file).

Frequency sweeps before one scan: 3 sweeps were done, the structures of the pixels response changed.
=> Somebody changed the power on the KIDs to try a better tuning. This kind of information is currently missing from the data (IMBFITs). It should be included.

- Note: increasing the power increases the size of the IQ circle, which increases the response of the KID, until distortions appear, indicating we enter in the non-linearity regime killing the performance of the KID.

Scan on Mars: 11 jumps (~ 1 jump/minute), and the base line noise is not always correlated, some pixels jump higher than others then lower after a while !
=> Not sky noise, not signal, so what is it ?
I (SL) didn't hear a clear answer, except that the hope is that the new shielding will kill these effects.

Negative signal in some pixels on the Jupiter scans.
=> This is due to the position where the tone is with respect to the phase structure. For each new tuning the pixels with negative signal will change.
This should not be in the data, this should be corrected before.

AM & FXD:
Re-sweep frequency necessary when background moves by ~10K.
With the 1kHz modulation we will have access to the derivative of I & Q => it will be possible to "auto-recenter" continuously the tone on the resonance; re-sweeping won't be necessary anymore.

<u>Main problem of the data: jumps.</u>

Crosstalk sometimes between adjacent KIDs.
=> We call them doubles. 3 reasons for crosstalks: electromagnetic, electronics, optical. Capacitor between neighbor pixels and electromagnetic perturbation cause shifts of resonance such that they some are close enough in the multiplexed line to influence each other.
Recent simulations (by MR, AM…) have shown this unwished effect of distortion of the resonance distribution on arrays with capacitors between neighbors. Work to improve this problem is in progress.

Some KIDs seem to loose the source.
=> They receive too much power and go off-resonance (this should disappear with the modulation).

Some KIDs are much noisier than the others.
=> Their resonance is unexpectedly small (simulations of arrays with inter-pixels capacitors show also the appearance of these small resonance)

- Beams particularly distorded on 1mm data (more elliptical than round). This feature is typical from a bad focus.
=> Focus was done only once at the beginning of the run. This is not sufficient at all, should be done several times a day.
- Largest pixel to pixel pointing offsets seen in beam maps: 10" ! Pointings with EMIR between NIKA observation slots show drifts of ~10-15" in Az & El along the day (typically 1" drift per hour).
=> Pointings were done only once a while during the NIKA run. This is not sufficient at all, should be done every few hours.

➔ These lack of rigor in the calibration procedures is responsible for a loss in S/N by a factor ~3 – 4 compared to correct calibrations !

Correlation plots (1 ref pixel vs other pixels) show not only double lines due to jumps but also very strange patterns that are identical in little groups of pixels => these patterns could be identified as a noise components but the fact that they are correlated only in small groups makes impossible to decorrelate the sky noise !

Oscillations in KIDs data at different frequencies.
=> Origin unknown, should show up as spikes in Fourier Transform domain.

The reconstruction of pixel map in an orthonormal reference frame shows a barrel distortion that looks compatible with the Zemax simulation of the optics. Pixel to pixel fluctuation along this barrel grip: crosstalk & pointing fluctuation.

Flat field. Several data show a clear gradient along the array.
=> Flat field necessary every ~1-2 hours. RZ: Attention ! Sky noise can't be used because it depends on forward efficiency, while sources depends on beam efficiency !
=> Another calibration scheme is necessary.

Variability of the pixel response by a factor ~7 @ 1mm and ~15 @ 2mm along the week (using several maps)
=> Due to tests of different tuning conditions in order to find the best sensitivity.

Big loss of mapping efficiency: the U-turn between 2 subscans takes ~5sec, which is way too long when the subscans are 6 sec long (case of the shortest ones). Increases the length of the subscan would be better (and helpful for sky noise). get coordinate data with higher rate (NCS slow loop @ 8Hz instead of 1Hz) would help a lot also.

Discussion:

NIKA team could produce IMBFITS from lab measurements for RZ so he could see better what effect is due to observation at the telescope and what is intrinsic to the instrument, and he would be able to anticipate better the future evolutions and test things before the runs.

For next run somebody from IRAM (RZ or AS or HU) should conduct NIKA team on things to do to get good observation (e.g. calibrations) and give real time feedback thanks to processing IMBFITS after each observation. AS: PaKo will have to "know" the instrument. So NIKA team would deliver FITS after each scan on a given location and AS will create IMBFITS in real time.

Q, I, RF are the 3 data stream currently provided by FXD in the FITS (Q & I are raw, RF is deduced from them and calibration). Next time dQ and dI will be also provided, and thanks to the 1kHz modulation RF will be directly given.

Skydips. We should use a cold load and warm load for each step of the sky dip to recalibrate the KID to a power adapted to the load. On each new array few pixels in

the corners could be designs to have a big dynamic range (and poor sensitivity) to be dedicated to the skydips.

To do:

Update of the telescope information broadcast by the Elvin server: Juan Macias-Perez, Alain Benoit and Walter Burnswig are in discussion to implement the new version in the summer.

Create automatic IMBFITS to be discussed (FXD, AS, HU).

For future run we should define new types of FITS to handle thousands of pixels.

After 3 hours meeting, not all the subjects listed at the beginning could be discussed. Another meeting will be organized in September. Subject pending:
- New update on the NIKA data formatting and processing by RZ and FXD.
- Work to do for the acquisition, interfacing with the telescope, automatic calibration procedures and information to include in the FITS.
- Future FITS format for possible big instrument.
- Global strategy for NIKA data processing.