

The dual-band NIKA: Technical Note 1 v2.2,
IRAM run 2011

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Miscellaneous frequency and fits file information for the IRAM2011 run.

Chapter 1

Frequencies

Data acquisition rate is $f_{acq} = \frac{1.9 \times 10^3}{80} = 23.75$ Hz, hence one integration is 42.1053 ms.

To get the absolute frequency, $\text{Hz_per_bin} = \frac{498.074 \times 10^6}{2^{18}} = 1900.0015$ Hz .

If one uses the IDL routine `read_camera_data`, then the tone frequency of each kid is available in kHz as `kidpar.kid_freq`. Both 1 and 2 mm channels span a range of frequencies from 1.311 to 1.524 GHz.

The so-called *RfdIdQ* (the first vector in the data for each kid) is the resonance central frequency in units of Hz starting at zero at the beginning of each scan (by construction). Thus, it is not the absolute frequency. One can work out how the tone frequency is different from the central resonance frequency by propagating from scan to scan the offsets obtained from the last frequency sweep scan. In more detail: I is the integration of 40 elementary measurements

$$I = \sum_{j=0}^{39} i_j ,$$

with one elementary measurement acquired at 0.950 kHz. The modulation of the carrier frequency occurs with a step of 2 kHz at this rate of 0.950 kHz (the modulation period is thus 2.10526 ms). The measured dI is the difference between the integration of 20 measurements in the high frequency steps and the integration of the 20 measurements in the low frequency steps:

$$dI = \sum_{k=0}^{19} (i_{2k+1} - i_{2k})$$

So the derivative of I should be written as

$$\frac{\partial I}{\partial f} = 2 \frac{dI}{2 \text{ kHz}} ,$$

and similarly for Q (beware with *YAFOT*, yet another factor of two). The *RfdIdQ* is obtained by integrating the following formula:

$$\Delta RfdIdQ = \Delta f \frac{\Delta I. \langle dI \rangle + \Delta Q. \langle dQ \rangle}{\langle dI \rangle^2 + \langle dQ \rangle^2} ,$$

where Δ represents the difference of measurements between one sample and the previous sample and $\langle \rangle$ means that an average of the 100 values centered on the sample has been computed and $\Delta f = 1$ kHz.

Chapter 2

File Exchange format

TOI

Time ordered information (TOI) files containing the raw NIKA data or clean data should be exchanged between the parties (IRAM, IN, Cardiff, ...). We propose to stick to the format agreed with IRAM during the NIKA#3 October 2011 run. We can extend it if needed with flags and calibrations. Files are split by wavelength, so we generate 2 files per scan.

Primary header (extension 0) should contain a line stating the origin of the data:

TELESCOP= 'IRAM 30m' / Telescope Name

ORIGIN = 'IRAM ' / Organization or institution

DATE = '2012-01-21T09:31:01' / file creation date (YYYY-MM-DDThh:mm:ss UT)

INSRUME = 'NIKA2011_IRAMOct_2mm'

Other comment or keyword lines can indicate the processing used. For the present conversion I use the keyword N2I (NIKA to IRAM)

N2I = 'v8 ' / 'NIKA to IRAM conversion program version '

DATE = '2012-01-21T09:31:01' / file creation date (YYYY-MM-DDThh:mm:ss UT)

INTTIME = '0.0421053' / 'seconds per integration'

COMMENT raw data

Secondary header (extension 1) should contain one line stating the name of the extension and what is in the binary table in extension 1 *e.g.*:

'EXTNAME', 'RawData', 'MJD, Sample, Raw R, I, Q, dI, dQ'

The data themselves are written as the R column, then the I column, and so on. In one fits column, we have 150 detectors per line (150 columns) and the time samples increasing with the line number. Thus a 2D array is embedded in one fits column. MJD is a double. Sample in long integer. Data are single or double precision float. Flag column can be added as byte.

FPG

The focal plane geometry should be described in fits binary table files with the following format:

One line per detector. As many columns as needed. For example,

PixelNumber, Pixel_xindex, Pixel_yindex, x_arcsec, y_arcsec, FWHMmajor_arcsec, FWHMminor_arcsec, BeamAngle_degree

PixelNumber goes from 0 to 149 (one FPG file per channel). Pixel_[x, y]index is an integer giving the association of a given sky beam to a grid node. [x,y]_arcsec are the sky beam position in Nasmyth coordinates (i.e. after derotation from elevation). FWHM[major,minor]_arcsec is the beam FWHM of the elliptical Gaussian fit along with the beam orientation in degrees (anticlockwise from the x axis, TBC).

The header should contain the date and scan number from which the FPG has been deduced.

MAP

Maps can be written in the usual primary extension (0) as cubes (NAXIS1 and NAXIS2 should be the x and y map coordinates, NAXIS3 being the number of maps). The header should describe the meaning of NAXIS3 and how the maps are ordered (by scans, by detector, by [average, noise, weight] triplet, and so on.). They share the same projection system which is described in the primary header.

Chapter 3

New polynomial fit

There are limitations to the on-line computation of the Response in frequency as shown in Chap.~1. The averaging by 100 points can produce hysteresis effect whereas we would like to go back to the same resonance frequency when the Kid is back to the same I , Q . We have a new formulation that involves 2D polynomial fitting of

$$F = P(I, Q)$$

where P is a polynomial of the two measured quantity and F is the resonance frequency to be found. The first derivative of that function yields the inverse of the dI , dQ measurements. We minimize the quantity

$$A = \sum_i \left[\left(\frac{\partial F}{\partial I} - \frac{dI \Delta f}{dI^2 + dQ^2} \right)^2 + \left(\frac{\partial F}{\partial I} - \frac{dI \Delta f}{dI^2 + dQ^2} \right)^2 \right] (dI^2 + dQ^2)$$

for a given Kid and a given scan which yields the polynomial coefficients and thus the resonance frequency up to a constant.

The figures show that the obtained new frequency (in blue in the upper left panel) called Pf as a function of sample number is different in amplitude but usually closely follows the initial frequency measurement (black in the upper left panel) Rf (upper middle panel). The white noise is barely affected (upper right panel). Lower panels show the quality of the fit with a third-order polynomial (black dots are the measurements, blue diamonds are the results of the fit, contours represent constant value of the resonance frequency).

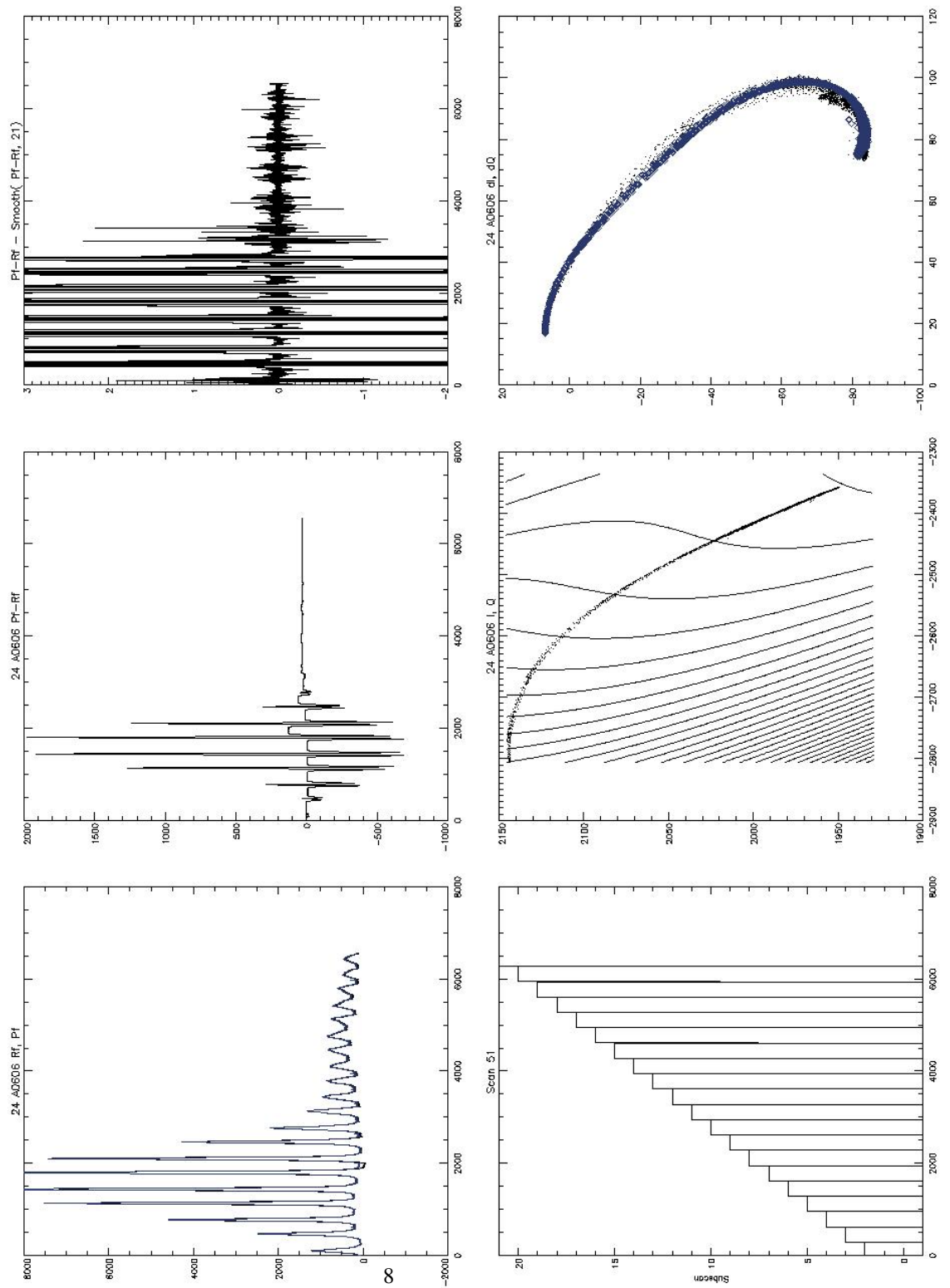


Figure 3.1: Polynomial fit to a scan on Mars for Kid 24

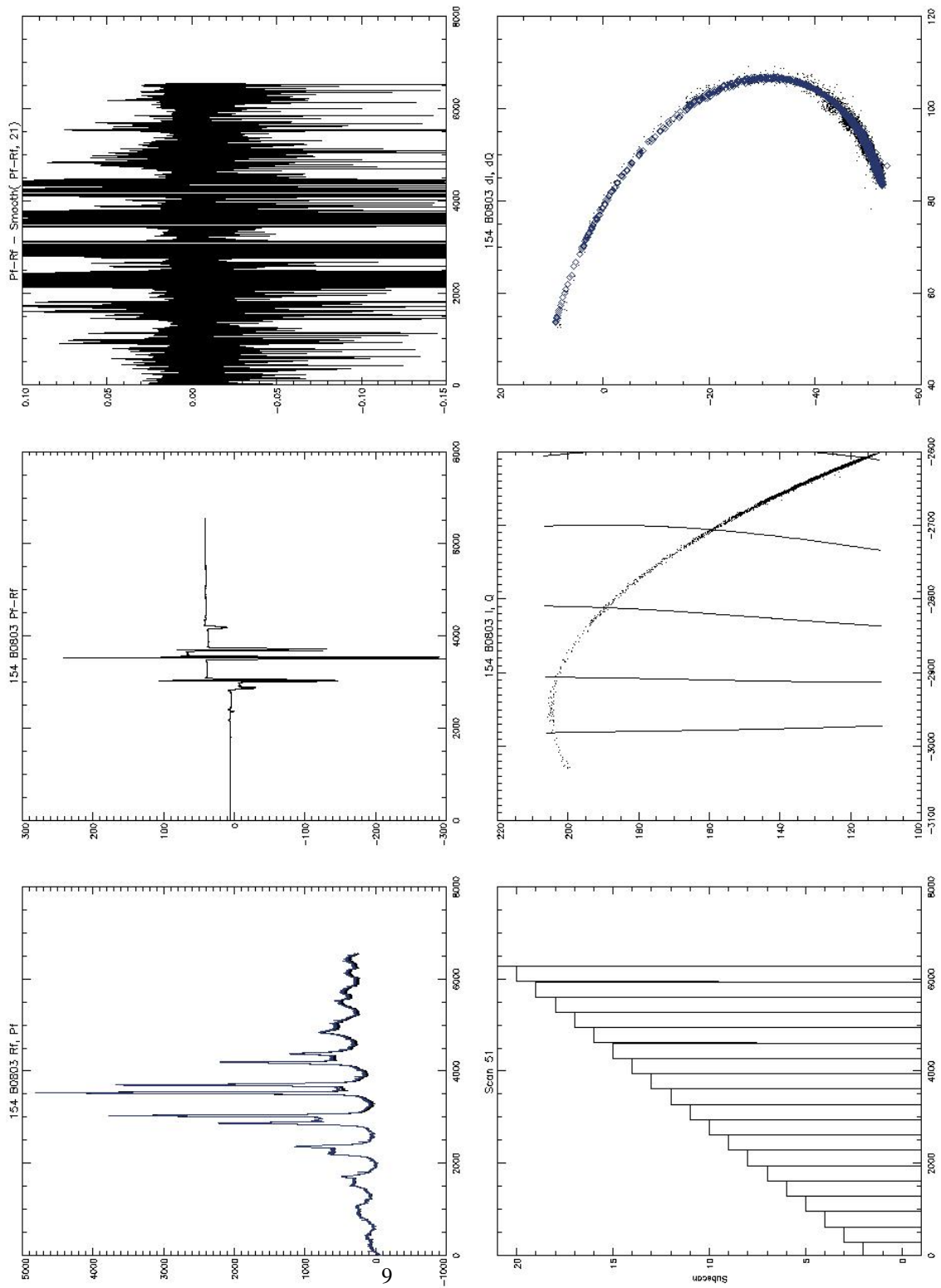


Figure 3.2: Polynomial fit to a scan on Mars for Kid 154