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Statistics of a σ/q ~ 2 Data Stream from Planck/LFI

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1. Introduction

The present document resumes the statistical features of the expected data streams for the Planck/LFI radiometers, after the baseline acquisition and onboard processing chain, including the s/q ~ 2 II quantization.

1.1 Scope of the Document

The document has been motivated by the need to document synthetically the specialized information needed to tune and test the onboard data compression algorithm and its performances.

In addition this document resumes the generation and he features of the quantized data streams, generated to test the compression algorithm.

1.3 List of Acronyms

BCE	Bad Compression Event
CAM	Compression Algorithm Module
CAMAL	Compression Algorithm Module Alarm
CFE	Compression Failure Event
CRC	Compressed Data Chunk
DCC	Data Coding and Compression
DCK	Data Chunk
DFH	Data Field Header
DPC	Data Processing Centre
ECM	Error Control Module
h/k	House Keeping
PDF	Packet Data Field
PDF_GM	PDF Generation Module
PDFA	PDF Assembler
PEC	Packet Error Control
PPN	Pointing Period Number
RAC	Radiometer Acquisition Chain
RIC	Radiometer Identification Code
s/c	Space Craft
sci	Science
SD	Source Data
SDAEM	Scientific Data Acquisition and Elaboration Module

SEV	Statistical Evaluation
SPDF	Scientific PDF
SPDF_GM	Scientific PDF Generation Module
SPDFH_GM	Scientific PDF Header Generation Module
SPH	Source Packet Header
STSP	Scientific Telemetry Source Packet
STSP_GM	STSP Generation Module
SuT	Summary TSP Tag
SuTSP	Summary Telemetry Source Packet
TBC	To Be Confirmed
TBD	To Be Defined
TOD	Time Ordered Data
TSMP	Time Stamp
TSP	Telemetry Source Packets
ZBPA	Zero Bits Padding Area

1.4 Applicable and Reference Documents

[1] *On-Board Data Processing, Compression and Telemetry Rate* - ISSUE # 3.0 - 21 April 2000

[2] SCI-PT-ICD-07527 *Packet Structure – Interface Control Document* – Issue: 1 September 2000

[3] PL-COM-OAT-SP-001 *Planck IDIS Data Model Specification Document* – Issue: 2.1, 21 July 2000

[4] *Data streams from the Low Frequency Instrument On-Board the Planck Satellite* – A&A, Vol. 147 No. 1 November II 2000, p.51

[5] ECSS-E-70/41 *Telemetry and Telecommand Packet Utilization Standard*

[6] PL-LFI-OAT-TN-011 *Quantization Errors on Simulated LFI Signals* – ISSUE # 0.1 – 10 July 2000

[7] PL-LFI-OAT-TN-015 *Requirements on the OnBoard LFI Compressor*

2. Signal Description

Details about the signal composition are better explained in the applicable documents. Here we give some general remark only.

2.1. Simulation Parameters

The simulation is performed assuming an angle between the spin axis and the telescope of 85 degrees, a resolution of 33 and 10 arcmins for the 30 and 100 GHz channels respectively. The number of samples for each circle is 1980 at 30 GHz and 6480 at 100 GHz.

2.2. Main Signal Components

The signal is composed by noise (white noise plus 1/f noise) plus astrophysical components.

Main astrophysical components which should be considered are:

1) The CDM - CMB
2) The Galaxy
3) Point Sources
4) The Cosmological Dipole
5) Glitches induced by Cosmic Rays (not included in this simulation).

As shown in [4] the white noise, the cosmological dipole, and to some extent, the sorption cooler are the main components in the signal affecting the compression efficiency. It has been shown that 1/f noise does not change significantly the compressibility of the signal [4], while the other components are not so relevant, since either they are embedded in the noise, or they represents a large variations over a small percentage of the samples.

Indeed the signal is nearly gaussian, so about 99.7% of the unquantized samples should be contained into a +/-3-sigma interval about the mean (i.e. 12 levels) [1].

However there are rare samples which departs from this range (Spikes). Spikes have different characteristics according to their origin. Three kinds of Spikes may be considered: rare gaussian fluctuations in the noise (RGF), Fast Transient Events (FTE) likely due to cosmic rays, very Bright Sources (BS).

RGF are gaussian (for a not quantized signal) but are very rare (theoretically only 0.3% of the samples).

The brighter of the BS is Jupiter, which may generate a signal as large as 500 mK i.e. at the present quantization step: about 420 levels. Jupiter, and the outer planets, will be framed at most about 10 times during the mission. They will influence about 3 pixels per turn, and three pointing periods, so we expect that the overall number of samples affected by them will be less than 0.4% per circle in less than 0.4% of the circles.

The Galaxy peaks at maximum at about 8 – 9 levels, but affects less than ten samples per circle, i.e. less than 0.05% of the total.

[1] But see further for the full statistical analysis of the quantized signal. See also [4] and [6].

Other BS which are out of the 3 sigma level are rare. A conservative estimate will put their number to less than 1%.

A statistical model for Fast Transient Events (FTE) is not ready yet, so we can not simulate them. However it is likely that they are quite rare in the LFI radiometers. In principle each FTE will cause a saturation of the signal in the data stream. So we should expect isolated samples whose values are near 0 or 65535. However only a small fraction of the samples will be affected by FTE. If their frequency is equivalent to once every some minutes they will affect less than 0.1% of samples.

Taking all of this in account, we may very conservatively state that no more than some percent of the samples will depart from the averaged signal by more than 3 sigma. As demonstrate by test described in [4] these samples does not influence the compressibility of the signal. *However their presence shall be accounted for when the dynamical range for the signal to be compressed has to be estimated.* This is important when the number of 16 bits symbols which has to be codified by the compressor has to be evaluated. *A compression algorithm unable to manage Spikes, shall be considered unsatisfactory and so rejected*.

The cosmological dipole introduces a peak to peak ~6 mk (~5 levels) sinusoidal modulation of the zero point with the period of 1 circle. Its amplitude changes with the pointing period. If not subtracted before compression its main effect is to enlarge the signal rms (which should be about 2 levels) of about a 2 or 3 levels. So that the full signal rms will be equivalent to about 5 levels.

However tests conduced with a smaller quantization step (equivalent to the a.d.c. quantization step) shows that for the baseline compressor, the introduction of the dipole reduces the compression efficiency of at most some per cent (using the self-adaptive compressor) [4].

Sorption Cooler (SC) [8] introduces two main sources of fluctuation with two main periods: 4000 sec and 600 sec, while the main sub-minute harmonic is the 17 sec period. Some simulations show a peak-to-peak variation equivalent to 2 mK i.e. less than two quantization steps (at the nominal σ/q ~ 2). The weight of such components and the amplitude in the not averaged signal, depends on the details of the mechanical assembly spacecraft, the sampling frequency, and the tolerance to SC failures. Consequently a detailed model will evolve in the near future. It is likely that the 4000 sec and 600 sec components will introduce nearly sinusoidal signals with about or less the same amplitude of the cosmological dipole. On the contrary, the 17 sec component amplitude is equivalent to about 1% of the main components amplitude, i.e. some hundredth of mK and its effect will be completely negligible for the sake of compression efficiency. If so, the SC will act as a time varying baseline which will not affect the signal compressibility more than the cosmological dipole, and likely will affect it less.

3. Quantization Process

Two quantization steps are expected in the signal: the first quantization is performed by the ADC, while the second quantization, i.e. quantization before compression, is perfomed by the on board computer. Here only the second quantization is considered, since it is the main on board process affecting the signal compressibility.

3.1. Role of the II Quantization

The task of the second quantization is to shrink the entropy to a level, which is manageable by the compression algorithm.

The level of II quantization should be used as a partially free parameter to slightly adjust the signal statistics in order to fit the required compression performances. As shown in [7] the amount of noise introduced in the data will change linearly with the quantization step, and for a Ist quantization step equivalent to $\sigma/q{\sim}10$ the quantization noise is dominated by the II quantization.

An optimized II quantization step should be tuned looking to the performances of the true compressor. With the baseline $\sigma/q = 2$ we expect to obtain a compression performance which is equivalent to about 95% of the theoretical one (computed for the distribution of unquantized data) [4]. This compression rate may be reduced by the dipole and sorption cooler effects. The extent of the reduction depends on the ability of the compressor to follow the variation in the signal statistics induced by them. The expected reduction is however small, being at most some percent. At last the compression rate may depends on the way in which the compressor will manage the packet.

4. Random Error Propagation

Analytical approximation of the noise (or error) propagation is detailed in this section.

The first step is the high frequency signal acquisition plus the first quantization at each channel performed by the ADC. The quantization step is q_{I} and white noise rms $\sigma_{\mathrm{wn,hf}}$ given by the sampling time $t_{\mathrm{hf}} \sim 1/8000$ sec. The intrinsic ADC Read Out Noise (RON) will introduce a further noise whose variance is $\sigma_{\mathrm{ron}} \sim 0.5$ adu, where 1 adu = q_{I}.

Taking in account the quantization error [4] the noise r.m.s. of the single sample is about:

$$\sigma_{\mathrm{a,hf}} = \sqrt{(\sigma_{\mathrm{ron}}^2 + \sigma_{\mathrm{wn,hf}}^2 + q_{\mathrm{I}}^2 / 12)} \qquad (1)$$

note that the distribution of this noise is not gaussian since quantization introduces a strong kurtosis.

The averaging over N_{hf} samples to obtain one low frequency sample will reduce the variance per low frequency sample to:

$$\sigma_{\mathrm{a,lf}} = \sqrt{(\sigma_{\mathrm{ron}}^2 + \sigma_{\mathrm{wn,hf}}^2 + q_{\mathrm{I}}^2 / 12)} \, / \sqrt{N_{\mathrm{hf}}} \qquad (2)$$

at the opposite of (1) this error is nearly gaussian [4]. If both the reference load and sky are subject to the same noise and are readed by the same adc, (2) is representative of the noise on both the signals.

The next step is two take the reference load and sky samples for the same phase of the beam switch and subtract them, after the reference load is weighted by the r gain factor.

The variance of the signal induced by noise for each phase switch channel will be:

$$\sigma_{\Delta T,\mathrm{lf}} = \sqrt{(1+r^2)}\, \sigma_{\mathrm{a,lf}} = \sqrt{(1+r^2)} \sqrt{(\sigma_{\mathrm{ron}}^2 + \sigma_{\mathrm{wn,hf}}^2 + q_{\mathrm{I}}^2 / 12)} \, / \sqrt{N_{\mathrm{hf}}} \, . \qquad (3)$$

The opposite phase switch signals are subtracted subtracted and divided by 2, this will left the noise r.m.s. unchanged.

The II quantization will introduce a further noise. The best will be to perform the second quantization after the subtraction of the two switch samples. If q_{II} is the second quantization step the r.m.s. will be:

$$\sigma_{\Delta T} = \sqrt{[\sigma_{\Delta t,\mathrm{lf}}^2 + q_{\mathrm{II}}^2 / 12\,]} = \sqrt{[(1+r^2)\,(\sigma_{\mathrm{ron}}^2 + \sigma_{\mathrm{wn,hf}}^2 + q_{\mathrm{I}}^2 / 12) / N_{\mathrm{hf}} + \alpha_1 \, q_{\mathrm{II}}^2 / 12]}. \qquad (4)$$

Since the baseline is $\sigma_{\Delta T,\mathrm{lf}} / q_{\mathrm{II}} = K$, where K is a constant and having $\alpha_1 = 1.18$ (see appendix):

$$\sigma_{\Delta T} = \sqrt{\,[(1+r^2)\,(\sigma_{\rm ron}{}^2 + \sigma_{\rm wn,hf}{}^2 + q_{\rm I}{}^2/12)\,/\,N_{\rm hf}\,]}\ \sqrt{(1+1.18^2/(12\,K^2))}\ . \qquad (5)$$

Introducing representative baseline values for the 30 GHz: $r = 1$, $q_{\rm I} = 0.3$ mK, $\sigma_{\rm wn,hf}{}^2 = 20$ mK, $N_{\rm hf} = 10^2$, $K = 2$, $\sigma_{\rm ron} \sim q_{\rm I}/2 = 0.15$ mK, the r.m.s. for the signal expected after the II quantization will be:

$$\sigma_{\Delta T,30\rm GHz} \sim 2.87 \text{ mK}.$$

The reason for the α_1 coefficient resides in the fact that the quantization error distribution, for a single sample, is not normally distributed (see Figure 1). As a consequence 1σ will contain less than 68% of the samples. Indeed, in itself it would have no meaning to add in square noises with different statistical distributions as the statistical meaning of the variance changes [2]. However since the wanted result is the range of values containing a percentile p of the all samples (usually p = 68.7%, i.e. for a normal distribution 1σ) a corrective factor $\alpha(p)$ is introduced, in this case: $\alpha_1 = \alpha(p\!=\!68.7\%) = 1.18$. Note that this corrective factor is not introduced into the first quantization term, since as more samples are added to generate a low frequency samples, as smaller is the size of the non-normality. I.e. in the limit $N_{\rm hf} \to +\infty$: $\alpha(p) \to 1$ for any p.

5. TOD Examples

A set of TOD(s) for the 30GHz and 100GHz channels, have been generated as follow:

i) All the components, as described in [4] are added in order to generate a map which is convolved with the beam pattern for the 30GHz, and 100 GHz.

ii) The map is scanned using the Flight Simulator at four relevant locations corresponding to: the Galactic center, where the signal from the Galaxy is maximal; the cosmological dipole vertex, where the signal from the dipole is maximal; the direction ortogonal to the Galactic center, where the signal from the Galaxy is minimal; and the direction ortogonal to the dipole; where the signal from the dipole is minimal. Plus two intermediate locations where the Galaxy and the Dipole has an intermediate value.

iii) Each location is scanned for 24 hours, i.e.: 12 hours before the crossing of the selected direction, and 12 hours after.

iv) Each TOD is generated by the F90 code as a list of 4 bytes integers [3], saved with the most significant byte first. The samples are contained in the two least significant bytes (third and fourth byte) of each group of 4. The program `int42int2.c` recovers these bytes and saves them in the final file. The F90 file is divided in records whose length is given by the number of samples for circle. Each record is marked by a 4 bytes sequence at the begin and at the end of record, the program `int42int2.c` removes these symbols during the extraction of the information.

v) The data in the final file is composed of 16 bits, unsigned integers, stored according to the Big Endian scheme. Each file is 5.44 MBytes long for the 30GHz and 17.80 Mbytes long for the 100 GHz.

[2] This may be demonstrated starting from the computation of likelihood.

[3] Standard F90 does not allow writing directly 2 bytes integers.

vi) Only the II quantization is performed, this is not the exact treatment yet, but since the first quantization is expected to be at a σ/q_{I} ~ 10 or larger and a large number of high frequency samples are added to obtain the final sample, the II quantization dominates the statistics.

vii) The quantization step q_{II} = 1.2 mK is near the baseline σ/q_{II} ~ 2 for 100 GHz, while the baseline for the 30 GHz is q_{II} = 0.5 mK. Other quantization steps are added to allow a comparison.

Appendix: Naming of Generated TODS

Simulated TODs are composed of a stream of 16 bits integers, with the MSB stored as the first byte.

Simulated TODs are listed in Table 2.

Each file represents 1 day of data, i.e 24 pointing periods of 60 minutes.

The scale is chosen to have the zero signal equivalent to 2^{15}.

TODs are named according to the following code:

`tod_`*frequency*`ghz_`*q*`mk_`*cooler-status*`_`*direction*`.bin`

frequency = 30 – 100 (GHz)

q = is the quantization step (in 0.1mK).

Values for the 30 GHz are: 0.5 mK (*q* = 05), 1.0 mK (*q* =10), 2.0 mK (*q* =20), corresponding to s/q = 2, 1, 0.5 (the last has been added just for a test).

Values for the 100 GHz are: 1.2 mK (*q* = 12) and 2.4 mK (*q* =2.4), corresponding to s/q = 2 and 1.

cooler-status = is the number of secondary units in the sorption cooler broken.

Values are: `6_equal` -> all ok, `1_bad` -> 1 unit is broken, `3_bad` 3 units are broken.

direction = has 6 value (0 to 5) and indicates the pointing direction, as explained by the next table.

direction	ecliptical longitude	Note:
0	171°.833	Minimum dipole
1	126°.833	Intermediate dipole
2	81°.833	Maximum dipole
3	266°.083	Maximum Galaxy Signal
4	308°.083	Intermediate Galaxy Signal
5	350°.083	Minimum Galaxy Signal

Table 2 Entropies measured on the first hour of each simulated TOD.

Tod Name	Freq. (GHz)	Q Step (mK)	Cooler Status	Eclp. Long. (deg)	Entropy
tod_30ghz_05mk_6_equal_0.bin	30	0.5	6_equal	171.333	3.27954
tod_30ghz_05mk_6_equal_1.bin	30	0.5	6_equal	126.333	4.00462
tod_30ghz_05mk_6_equal_2.bin	30	0.5	6_equal	81.333	4.30886
tod_30ghz_05mk_6_equal_3.bin	30	0.5	6_equal	265.5833	4.30058
tod_30ghz_05mk_6_equal_4.bin	30	0.5	6_equal	307.5833	3.97891
tod_30ghz_05mk_6_equal_5.bin	30	0.5	6_equal	349.5833	3.28390
tod_30ghz_10mk_6_equal_0.bin	30	1	6_equal	171.333	2.31268
tod_30ghz_10mk_6_equal_1.bin	30	1	6_equal	126.333	3.01922
tod_30ghz_10mk_6_equal_2.bin	30	1	6_equal	81.333	3.32046
tod_30ghz_10mk_6_equal_3.bin	30	1	6_equal	265.5833	3.31350
tod_30ghz_10mk_6_equal_4.bin	30	1	6_equal	307.5833	2.99434
tod_30ghz_10mk_6_equal_5.bin	30	1	6_equal	349.5833	2.31458
tod_30ghz_20mk_6_equal_0.bin	30	2	6_equal	171.333	1.43530
tod_30ghz_20mk_6_equal_1.bin	30	2	6_equal	126.333	2.07366
tod_30ghz_20mk_6_equal_2.bin	30	2	6_equal	81.333	2.36186
tod_30ghz_20mk_6_equal_3.bin	30	2	6_equal	265.5833	2.35537
tod_30ghz_20mk_6_equal_4.bin	30	2	6_equal	307.5833	2.05200
tod_30ghz_20mk_6_equal_5.bin	30	2	6_equal	349.5833	1.43610
tod_30ghz_05mk_1_bad_0.bin	30	0.5	1_bad	171.333	3.27952
tod_30ghz_05mk_1_bad_1.bin	30	0.5	1_bad	126.333	4.00463
tod_30ghz_05mk_1_bad_2.bin	30	0.5	1_bad	81.333	4.30884
tod_30ghz_05mk_1_bad_3.bin	30	0.5	1_bad	265.5833	4.30058
tod_30ghz_05mk_1_bad_4.bin	30	0.5	1_bad	307.5833	3.97889
tod_30ghz_05mk_1_bad_5.bin	30	0.5	1_bad	349.5833	3.28391
tod_30ghz_10mk_1_bad_0.bin	30	1	1_bad	171.333	2.31264
tod_30ghz_10mk_1_bad_1.bin	30	1	1_bad	126.333	3.01925
tod_30ghz_10mk_1_bad_2.bin	30	1	1_bad	81.333	3.32041
tod_30ghz_10mk_1_bad_3.bin	30	1	1_bad	265.5833	3.31347
tod_30ghz_10mk_1_bad_4.bin	30	1	1_bad	307.5833	2.99441
tod_30ghz_10mk_1_bad_5.bin	30	1	1_bad	349.5833	2.31460
tod_30ghz_20mk_1_bad_0.bin	30	2	1_bad	171.333	1.43526
tod_30ghz_20mk_1_bad_1.bin	30	2	1_bad	126.333	2.07373
tod_30ghz_20mk_1_bad_2.bin	30	2	1_bad	81.333	2.36185
tod_30ghz_20mk_1_bad_3.bin	30	2	1_bad	265.5833	2.35522
tod_30ghz_20mk_1_bad_4.bin	30	2	1_bad	307.5833	2.05205
tod_30ghz_20mk_1_bad_5.bin	30	2	1_bad	349.5833	1.43611
tod_30ghz_05mk_3_bad_0.bin	30	0.5	3_bad	171.333	3.27933
tod_30ghz_05mk_3_bad_1.bin	30	0.5	3_bad	126.333	4.00444

Table 2 Entropies measured on the first hour of each simulated TOD (contd.).

Tod Name	Freq. (GHz)	Q Step (mK)	Cooler Status	Eclp. Long. (deg)	Entropy
tod_30ghz_05mk_3_bad_2.bin	30	0.5	3_bad	81.333	4.30871
tod_30ghz_05mk_3_bad_3.bin	30	0.5	3_bad	265.5833	4.30057
tod_30ghz_05mk_3_bad_4.bin	30	0.5	3_bad	307.5833	3.97893
tod_30ghz_05mk_3_bad_5.bin	30	0.5	3_bad	349.5833	3.28385
tod_30ghz_10mk_3_bad_0.bin	30	1	3_bad	171.333	2.31266
tod_30ghz_10mk_3_bad_1.bin	30	1	3_bad	126.333	3.01899
tod_30ghz_10mk_3_bad_2.bin	30	1	3_bad	81.333	3.32026
tod_30ghz_10mk_3_bad_3.bin	30	1	3_bad	265.5833	3.31341
tod_30ghz_10mk_3_bad_4.bin	30	1	3_bad	307.5833	2.99445
tod_30ghz_10mk_3_bad_5.bin	30	1	3_bad	349.5833	2.31444
tod_30ghz_20mk_3_bad_0.bin	30	2	3_bad	171.333	1.43543
tod_30ghz_20mk_3_bad_1.bin	30	2	3_bad	126.333	2.07346
tod_30ghz_20mk_3_bad_2.bin	30	2	3_bad	81.333	2.36150
tod_30ghz_20mk_3_bad_3.bin	30	2	3_bad	265.5833	2.35510
tod_30ghz_20mk_3_bad_4.bin	30	2	3_bad	307.5833	2.05204
tod_30ghz_20mk_3_bad_5.bin	30	2	3_bad	349.5833	1.43573

Tod Name	Freq. (GHz)	Q Step (mK)	Cooler Status	Eclp. Long. (deg)	Entropy
tod_100ghz_12mk_6_equal_0.bin	100	1.2	6_equal	171.333	3.39323
tod_100ghz_12mk_6_equal_1.bin	100	1.2	6_equal	126.333	3.62540
tod_100ghz_12mk_6_equal_2.bin	100	1.2	6_equal	81.333	3.76664
tod_100ghz_12mk_6_equal_3.bin	100	1.2	6_equal	265.5833	3.76312
tod_100ghz_12mk_6_equal_4.bin	100	1.2	6_equal	307.5833	3.60858
tod_100ghz_12mk_6_equal_5.bin	100	1.2	6_equal	349.5833	3.39506
tod_100ghz_24mk_6_equal_0.bin	100	2.4	6_equal	171.333	2.43610
tod_100ghz_24mk_6_equal_1.bin	100	2.4	6_equal	126.333	2.65013
tod_100ghz_24mk_6_equal_2.bin	100	2.4	6_equal	81.333	2.78638
tod_100ghz_24mk_6_equal_3.bin	100	2.4	6_equal	265.5833	2.78296
tod_100ghz_24mk_6_equal_4.bin	100	2.4	6_equal	307.5833	2.63362
tod_100ghz_24mk_6_equal_5.bin	100	2.4	6_equal	349.5833	2.43778
tod_100ghz_12mk_1_bad_0.bin	100	1.2	1_bad	171.333	3.39327
tod_100ghz_12mk_1_bad_1.bin	100	1.2	1_bad	126.333	3.62538
tod_100ghz_12mk_1_bad_2.bin	100	1.2	1_bad	81.333	3.76666
tod_100ghz_12mk_1_bad_3.bin	100	1.2	1_bad	265.5833	3.76313
tod_100ghz_12mk_1_bad_4.bin	100	1.2	1_bad	307.5833	3.60860
tod_100ghz_12mk_1_bad_5.bin	100	1.2	1_bad	349.5833	3.39505

Table 2 Entropies measured on the first hour of each simulated TOD (contd.).

Tod Name	Freq. (GHz)	Q Step (mK)	Cooler Status	Eclp. Long. (deg)	Entropy
tod_100ghz_24mk_1_bad_0.bin	100	2.4	1_bad	171.333	2.43615
tod_100ghz_24mk_1_bad_1.bin	100	2.4	1_bad	126.333	2.65014
tod_100ghz_24mk_1_bad_2.bin	100	2.4	1_bad	81.333	2.78639
tod_100ghz_24mk_1_bad_3.bin	100	2.4	1_bad	265.5833	2.78296
tod_100ghz_24mk_1_bad_4.bin	100	2.4	1_bad	307.5833	2.63364
tod_100ghz_24mk_1_bad_5.bin	100	2.4	1_bad	349.5833	2.43776
tod_100ghz_12mk_3_bad_0.bin	100	1.2	3_bad	171.333	3.39325
tod_100ghz_12mk_3_bad_1.bin	100	1.2	3_bad	126.333	3.62537
tod_100ghz_12mk_3_bad_2.bin	100	1.2	3_bad	81.333	3.76664
tod_100ghz_12mk_3_bad_3.bin	100	1.2	3_bad	265.5833	3.76313
tod_100ghz_12mk_3_bad_4.bin	100	1.2	3_bad	307.5833	3.60854
tod_100ghz_12mk_3_bad_5.bin	100	1.2	3_bad	349.5833	3.39501
tod_100ghz_24mk_3_bad_0.bin	100	2.4	3_bad	171.333	2.43610
tod_100ghz_24mk_3_bad_1.bin	100	2.4	3_bad	126.333	2.65014
tod_100ghz_24mk_3_bad_2.bin	100	2.4	3_bad	81.333	2.78639
tod_100ghz_24mk_3_bad_3.bin	100	2.4	3_bad	265.5833	2.78293
tod_100ghz_24mk_3_bad_4.bin	100	2.4	3_bad	307.5833	2.63359
tod_100ghz_24mk_3_bad_5.bin	100	2.4	3_bad	349.5833	2.43772

Figure 1 Normal Probability Plot for 100.000 samples, at 100 GHz, no dipole. The II quantization step is performed at 1.2 mK. Note how, the quantization noise shrinks most of the data in the central levels, leading to a marked deviation from the normal distribution.