

CIDA/STARDUST Example of Data Calibration

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Abstract

We present a step by step tutorial of how to calibrate CIDA/STARDUST data using laboratory spectrum. We convert the numerical units of the instrument readout into meaningful physical values. A guide for the interpretation of this time-of-flight signal as a mass spectrum is outlined.

1. The Calibration Principle

The data as provided by the instrument consists of housekeeping information and science data in one or several redundant hardware channels. The housekeeping data serves as technical support information and is not normally needed for data analysis. The data to be analysed therefore consists of four vectors 8192 long,, representing two redundant high and two redundant low sensitivity channels. The fourth channel is used for two purposes. The first half (samples 1 to 4096) carries the output of the charge sensitive amplifier connected to the target, the second half is a redundant to channel 3. A sample laboratory spectrum is shown in Figure 1.

At the end of each data vector, a calibration sequence of four distinct current pulses is injected. The sequence usually starts with an unwanted transient. The calibration pulses are the response to the four injected currents with the values shown in Table 1.

Name	Injected Signal [μA]	Start Position
Cal-1	53.2	7351
Cal-2	167	7501
Cal-3	532	7651
Cal-4	1670	7776
Background	0	8101

Table 1. Values of injected calibration signal into a TOF-spectrum.

The relation between the current and the numerical reading is described by a theoretical relation:

$$N = C_1 + C_2 I + C_3 \log(1 + I/C_4)$$

Using the four calibration injection levels and this knowledge, it is possible to compute the coefficients given the data in Table 1 and the values in the signal.

Applying the described transformations, transforms the recorded raw signal into a time of flight spectrum. The spectrum amplitude is given in μA sampled at 40 MHz (sample points 25 ns apart).

Knowing two mass peaks, it is possible to use the relation

$$t = a \sqrt{m} + b$$

to find the constants a and b defining the relation between mass and sample time.

2. Application to Laboratory Spectrum

The example presented is chosen to hilite the method. The steps involved are:

1. Compute the mean background of the spectrum. This is conveniently done by taking the very last samples in the spectrum, positions starting at eg. 8101. The result is slightly different for the different channels. Make sure that the region used for the background estimation does not contain any real signal.
2. Compute the mean of say 50 samples from each of the channels present starting from the positions given in Table 1. The difference indicates directly the difference in gain. Make sure that there is no contamination by real signal.
3. Knowing the injected currents (Table 1) and the levels (step 2), the constants C_i can be calculated.
4. Having the constants C_i , one can build a lookup table for $I = I(C_i, N)$. Knowing this completes the amplitude calibration.
5. Looking at the TOF-spectrum and knowing (or guessing) that the first major peak seen is Hydrogen and that the large double peak at end of the spectrum is Silver, it is possible

to compute an estimate for a and b connecting the mass and the time of flight. Note that there is a small $\sim 10^{-3}$ variation of a depending on whether the impact is central or peripheral due to a small different in the distance between the target surface and the acceleration grid.

6. It is important to note that the relative yields of ions are strongly dependent on the detailed chemical properties of the incident dustgrain and of the local target composition and structure. Therefore it is incorrect to infer relative abundances from the above procedure directly.

3. Numerical Values for the Example Spectrum

This section provides values for the example spectrum.

3.1 Background and Calibration Injection Levels

The background and the calibration levels estimated from 50 samples starting at the positions indicated in Table 1 are:

	Background	Cal-1	Cal-2	Cal-3	Cal-4
Ch1	18.58	35.84	62.32	90.46	100.08
Ch2	17.16	33.78	59.92	88.76	97.50
Ch3	16.64	41.12	68.24	101.58	110.16
Ch4	15.24	38.78	64.34	96.84	103.38

Table 2. Background and calibration injection levels computed for the example spectrum.

Error estimates!!!!

3.2 Computation of Constants

The computation of the numerical constants has to be made numerically iteratively using some standard technique. The result is:

	C_1	C_2	C_3	C_4
Ch1	18.58	-0.313	311	462
Ch2	17.16	-0.365	401	566
Ch3	16.64	-0.027	46.5	71.4
Ch4	15.24	-0.016	40.2	64.0

Table 3. Coefficients for the equation connecting the numerical raw value and the physical current as calculated from the example spectrum using the values in Table 1.

3.3 Lookup Table Connecting Current and Numeric Value

Table 4. Contains the data values of the lookup table obtained by using the constants in Table 3.

Result of inverting equation (1) using the coefficients in Table 3.

Table 4. Lookup table connecting numeri values and currents.

3.4 Transforming Time-of-Flight Spectrum int Mass-Spectrum

Identifying the Hydrogen peak at $t = 2944$ and ^{107}Ag at $t = 4614$ gives the two equations:

$$2944 = a + b$$

$$4614 = a\sqrt{107} + b$$

The solution is $a = 178.7$ and $b = 2765$.

Example Event

Lab.event: 192750_0045996F

