**Program QUENCH**

The program QUENCH can be used to establish a quench curve from experimental measurements of a set of quenched sources in liquid scintillation (LS) counting. This curve can then be used to determine the detection efficiency of a source from the quenching index given by the LS counter.

Each experimental point of the measured set of quenching sources is described by their quenching index, their detection efficiency and the standard uncertainty on these two quantities. The uncertainty on the standard solution used to prepare the set of quenched sources is obviously important in this problem but induces a correlated effect on the experimental points. For example, if the activity of this standard is overestimated, the detection efficiency of all the quenched sources will be underestimated. This induces a correlation between the experimental points which must be accounted for.

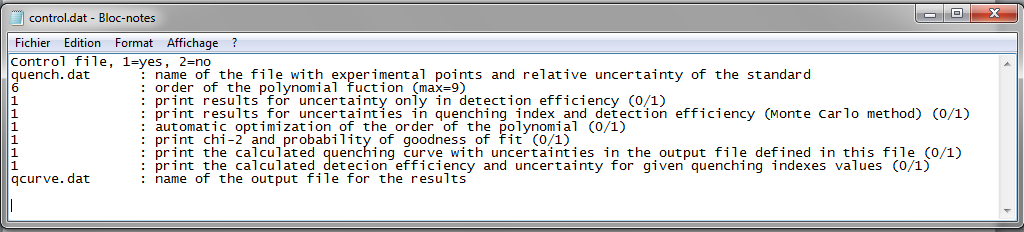
The program is based on a Monte Carlo method. Many Gaussian fluctuations of the experimental points are calculated and a polynomial is fitted to each of these fluctuations. The mean and experimental covariance matrix of the parameters of this fitting function are calculated and the uncertainty of the fitted function can be estimated using the law of propagation of variances (GUM) or from the Monte Carlo calculation (GUM supplement 1). The program can also give the calculation results which would be obtained when the uncertainty on the quenching index is not considered.

The program can work with quenching indexes measured on various LS detector. It was tested on the following counters: TriCarb and Quantulus (Perkin Elmer), Guardian 1414 (Wallac) and various locally made TDCR counters.

The program uses two input files described hereafter. Two output files are generated.

This program is freeware and the author is not responsible of its use or misuse. Please report any comment or problem to [philippe.cassette@cea.fr](mailto:philippe.cassette@cea.fr).

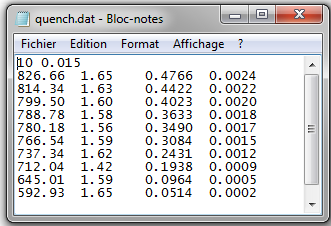
**Input file : control.dat**



This text file can be edited (e.g. using notepad) to modify the options of the 1st column described hereafter.

1. Line: do not modify
2. Line: name of the file with experimental quenching curve points and relative standard uncertainty on the activity of the standard sources used. This file must be in the same directory than the program QUENCH.
3. Line: order of the polynomial function. It must be lower than the number of experimental points but there is no advantage to use high-order value. A value from 2 to 4 is probably OK.
4. Line: if 1 the results of the fit by only considering uncertainties on the detection efficiency are printed.
5. Line: if 1 the results considering both uncertainties on detection efficiency and on quenching indexes are printed.
6. Line: if 1, the fitting process starts with the polynomial order defined at line 3 but this order is reduced if some parameters of the fit have negligible values and if this does not increase the chi-2 value.
7. Line: if 1 the chi-2 value and probability of the goodness of fit are printed.
8. Line: if 1 the quench file with Monte Carlo uncertainties are printed in the file defined at line 10. This curve is an interpolation of the experimental points over 100 values.
9. Line: if 1 the program asks for quenching index values and gives the detection efficiency calculated using three methods: 1-without considering uncertainties on the quenching index value, 2-with considering uncertainties on both quenching index and detection efficiency, the uncertainty being calculated with the covariance matrix and the law of propagation of variances, 3-same than 2 but uncertainties are calculated by a Monte Carlo method (GUM supplement 1) without the use of the covariance matrix.
10. Name of the output file for the results. This file is in the same directory than the program QUENCH.

**Input file:** file with the name defined in ‘control.dat’, e.g. ‘**quench.dat**’, containing the experimental quenching points and the relative standard uncertainty of the activity of the standard solution used to prepare the quenched sources for the experimental quenching points.



1st Line: number of experimental points, *n*, and relative standard uncertainty on the activity of the solution used to prepare the set of quenched sources. Here there are 10 points and the uncertainty on the activity of the standard is 1.5 %.

Lines 2 to (n+1), experimental points: quenching index, absolute standard uncertainty on the quenching index, detection efficiency and absolute standard uncertainty on the detection efficiency respectively. It must be pointed out that the uncertainty on the detection efficiency must not include the uncertainty on the standard solution used to prepare the set of quenched sources, as the effect of such uncertainty is correlated for all points and is specifically addressed in the QUENCH code. Any suspected systematic bias on the detection efficiency must not be included here.

**Output files:**

**qcurve.dat**: file detailing the results and giving the parameters of the fitting function and their covariance matrix. Results are printed according to the options specified in the file ‘control.dat’.

**courbe.dat**: file with the results of the interpolation of the experimental points. 100 values are printed between the minimum and maximum values of the experimental quenching indexes. The reported uncertainties are the absolute standard uncertainties on the detection efficiencies calculated with the full Monte Carlo method, i.e. without using the law of propagation of variances. The method used is described in the supplement 1 of the GUM.