

Innovative improvement of radioactivity flow detection

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The accuracy of a measurement of a radioactivity is mainly determined by the number of events obtained.

In case the obtained number of registered events is small, the potential variation is high.

$$\text{Sigma} = \text{sqr } N$$

N is the number of obtained events.

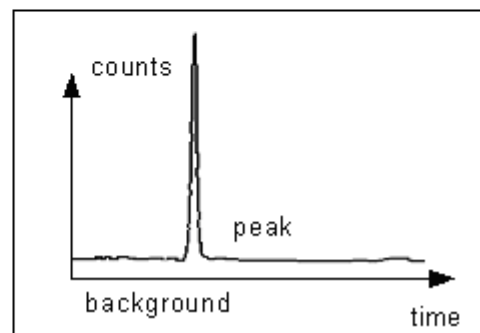
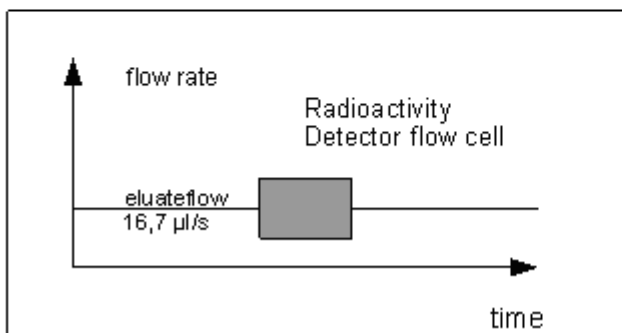
So far, that is quite well known and trivial.

In the practice of radioactivity detection, it is often not so simple, to enlarge the number of registered events in order to obtain a more „precise measurement value“. Other parameters of the same measurement may be deteriorated so strongly, that the total recording is not acceptable anymore.

$$C = A_1 \times E_2 \times V/F$$

1. Injektion of 10A, often not available
2. efficiency encrease: not available

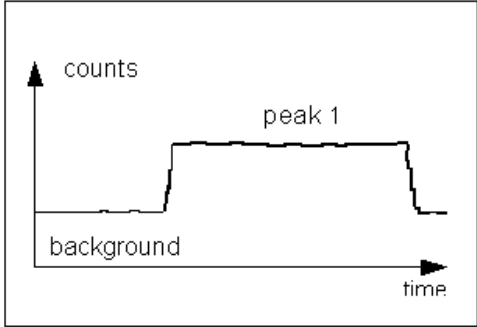
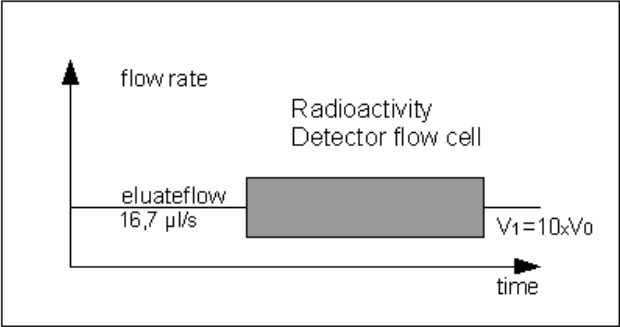
C=counts
A=activity (Bq)
E=efficiency (%)
V=Volumen (µl)



A radioactive eluate is flowing through a detection flow cell at a given flow rate.

Quite often the injected activity can not be – easily – extended by factors. Obviously it is impossible to improve the efficiency of the detection by factors.

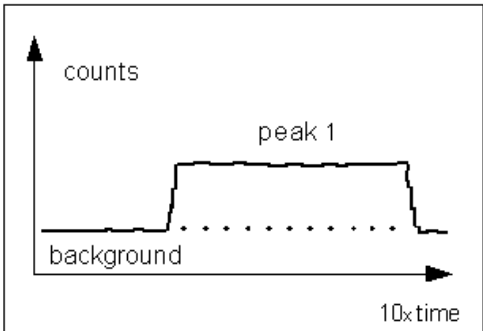
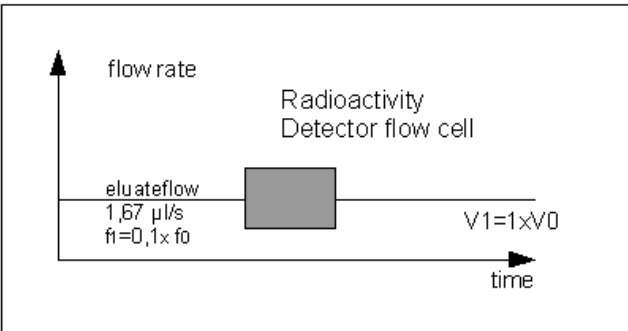
$$10C = A \times E \times 10V/F$$



In case the the flow cell is 10 times larger than the original, the number of obtained counts can be 10 times higher.

But the chromatographic resolution may be unacceptable.

$$10C = A_1 \times E_2 \times V/0,1F$$



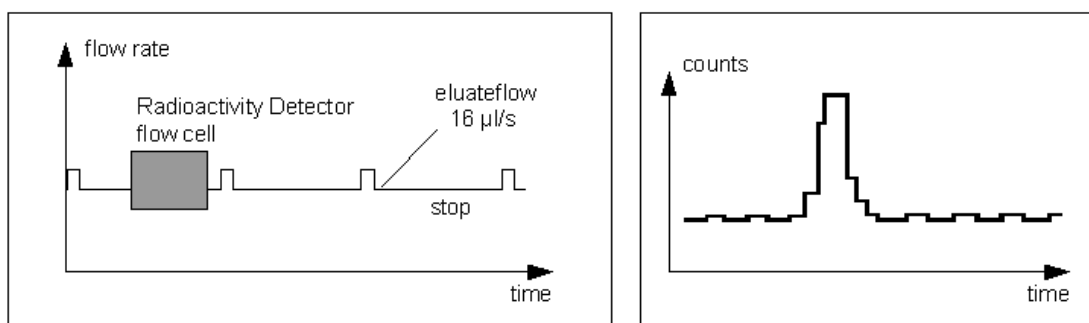
In case the flow rate will be reduced by a factor of 10, 10 times more radioactive events can be counted in the original cell volume.

But the run time of the chromatogram would be extended by a factor 10 as well.

There is a flow system solution available which:
 stores the complete, separated eluate in a capillary loop forward flowing
 there after the complete eluate is pumped backwards flowing in steps
 means the pump moves one fraction in to the flow cell and stops flow in order
 to count this fraction for a longer (preselected) time in static mode.
 The result is a „histogram type“ of record, which presents extended statistical
 accuracy for every fraction.
 The total run time of a chromatogram requires a multiple time of the original.

One could imagine theoretically to apply „preset count“ in place of „preset
 time“ and generate an histo-chromatogram with equal statistical error for
 every fraction, but the run time will be much longer than the original.

$$10C = A_1 \times E_2 \times V/0,1F \quad (\text{stop flow 1:10})$$



at stopflow ratio 1:10
10 times more counts
bad histogram resolution

Quite often the radiochromatographic system has an automatic sample injector.

One could image to repeat the measurement of a complete chromatogram run by a special program, which automatically repeats the run in case the detected number of events is too small.

Usually the run time of a radio-HPLC may be 30 minutes. Repeating the total run would mean, to extend the run time per sample considerably to multiple times 30 minutes.

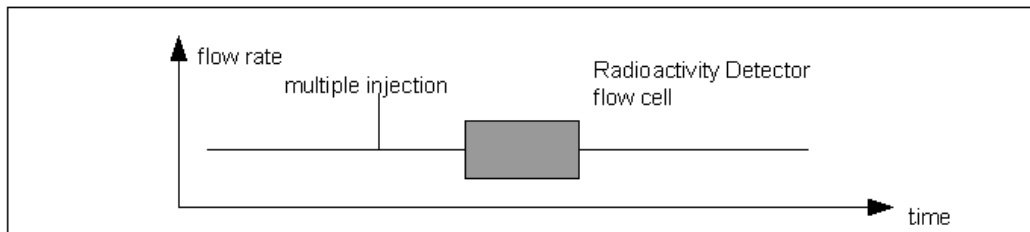
In order to accumulate several „single“ runs to one „accumulated“ run the

chromatographic conditions have to be absolutely stable, otherwise the „sum-chromatogram may deteriorate unacceptably.

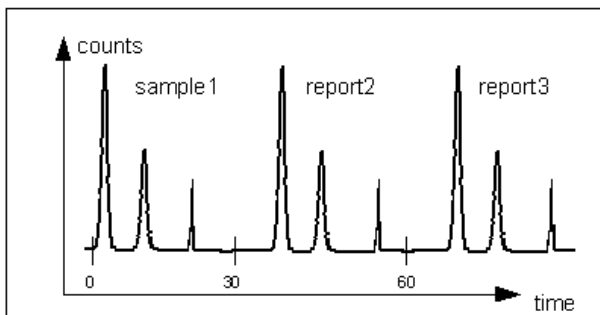
In case the chromatographic conditions can be guaranteed stable, the sum-chromatogram would contain the extended number of obtained radioactive events per fraction.

$$10C = (A \times E \times V/F) + (A \times E \times V/F) + (A \times E \times V/F) + \dots$$

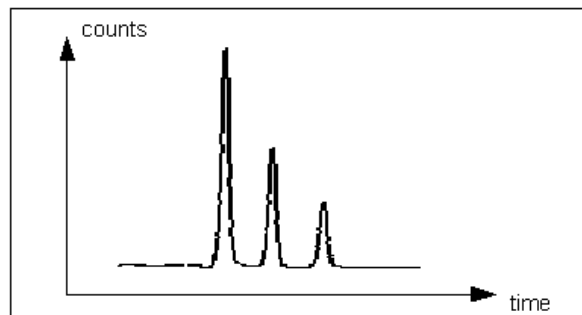
repeated sample injection



chromatogram addition n-times counts



total run time | 1 run x n-in-samples



In case the eluate of a chromatogram runs through a first flow detector which is immediately followed by a second , third , fourth etc. the total run time of one sample would be extended by the very small time of the eluate required to flow through the immediately following second, third, fourth etc detector.

The total run time per sample would be same as one run plus the flow time of a few seconds through the second, third and fourth etc detector.

As many immediately following separate detectors are used, the system needs to record every one separately.

The delay of the eluate flowing from the first to the second, third and fourth detector is determined individually by the flow system.

The individual runs are projected back to the start of the same run time of the first chromatogram and every data point of each single chromatogram is

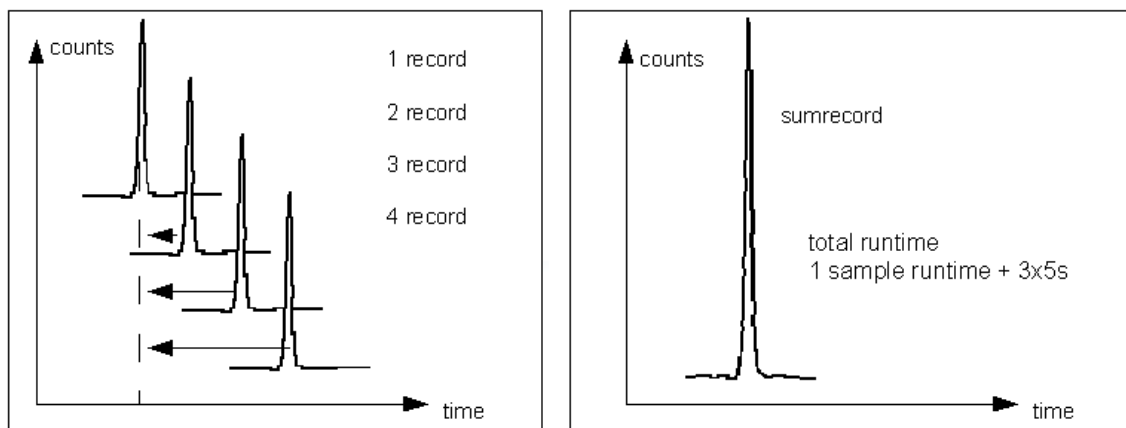
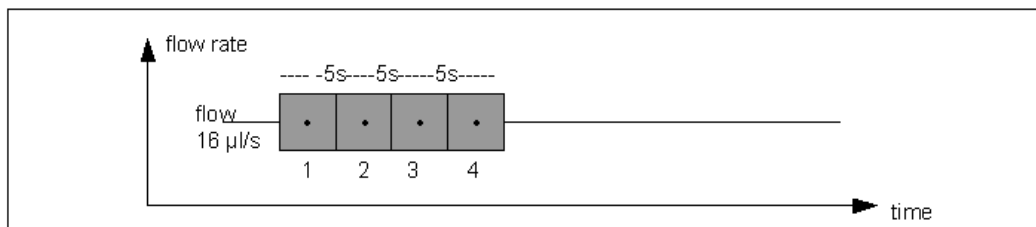
added up to one sum-chromatogram.

The sum-chromatogram contains as many times more „obtained radioactive events“ as detectors are in sequence.

The variation of the chromatographic conditions are small (neglectable) because the extra „delaytime“ of the total run is seconds (very small).

Mira/Ramona quattro flow detector array

$$10C = A \times (E_1 + E_2 + E_3 + E_4) \times V/F$$



sumpeak = 4 times single peak

The evident drawback of this „array-type“ detection system may be speculated to be quite expensive, because it requires the extension to many separate detectors. That is obviously not the case.

The raytest-method of the determination of the smallest detectable peak (G.Dietzel,R.Grugel, thecolumn.eu.com.March2007) is well known and accepted.

The full-width-half-maximum of every peak is determined and the foot width is calculated at 2,5 x FWHM.

For that foot-width the background counts are „counted“ for every potential peak.

From this individual background count, sigma, the square root of the number of

background counts is calculated.

At background mean + 3 times sigma of background mean, the Gauss distribution curve defines, that 99,5% of all possible background counts are lower than this limit.

Every peak, which is higher than background mean + 3 sigma of background mean is with a probability of 99,5% a radioactive fraction and not any background variation.

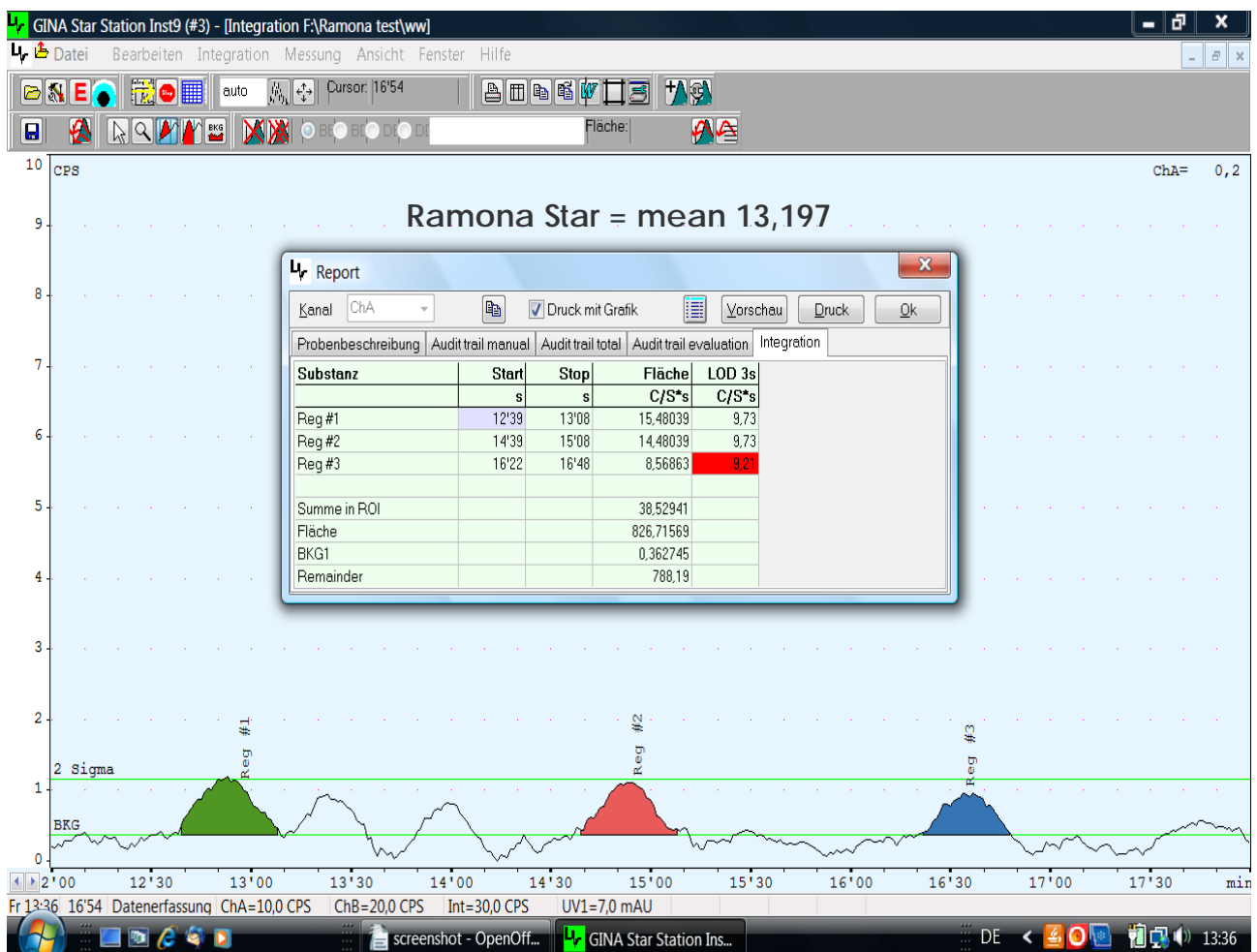
For easy orientation the line of background mean + 3 sigma can be drawn along the chromatogram.

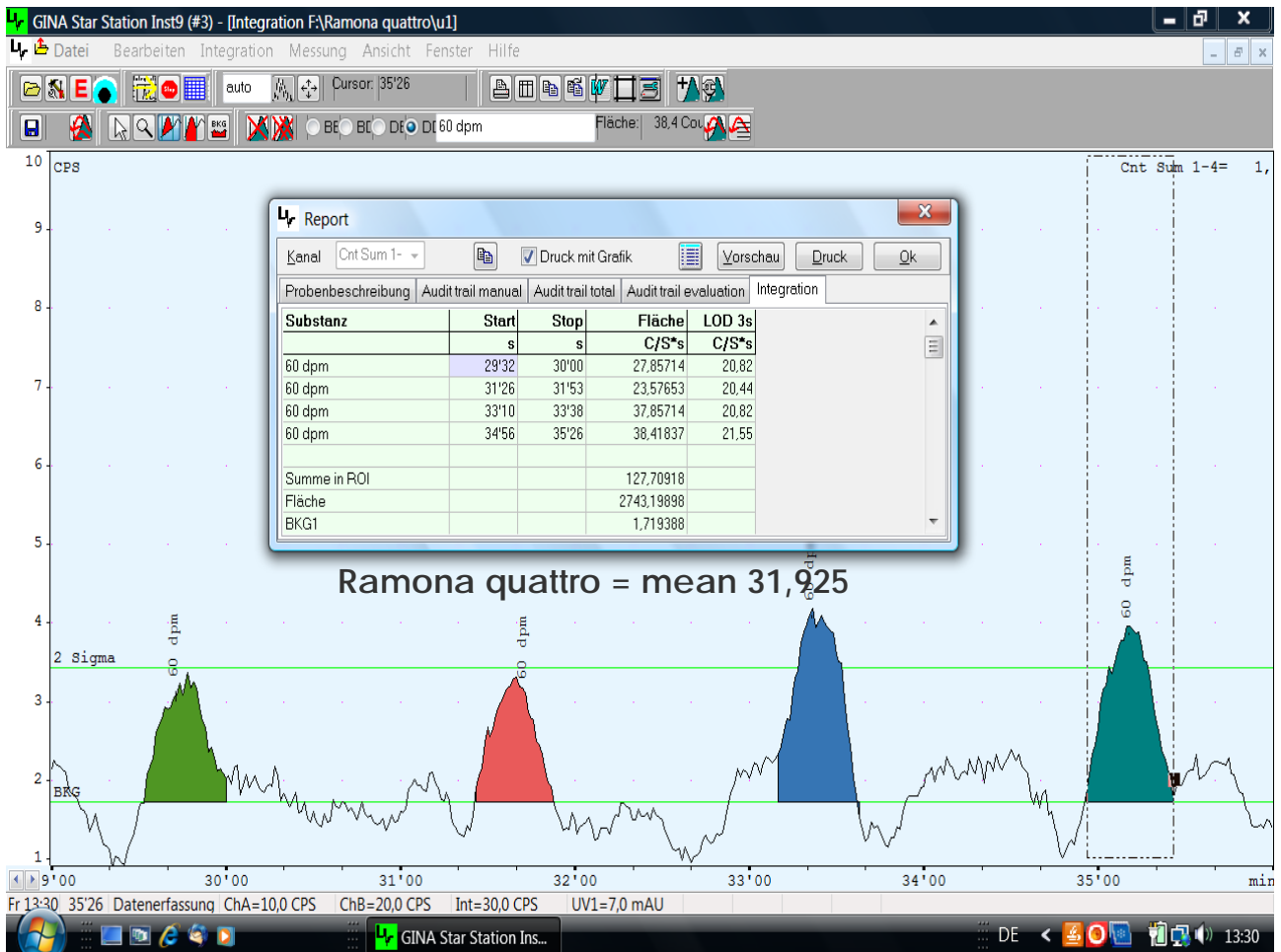
raytest performed a test of sensitivity between the best beta-radioactivity-flow-detector Ramona 2" photomultiplier with digital output and Ramona quattro 1 1/8" photomultiplier with same digital output for LOD-determination.

We used ¹⁴C-labelled solution and injected repeatedly an activity of about 1 Bq/peak.

The flow rate was 1 ml/min. The energy-channel was the same. We obtained the number of counts in Ramona star as well as in Ramona quattro.

The results can be compared in the following diagrams:





As the result we obtained a mean of 2,42 times more counts per peak in Ramona quattro compared to Ramona star 2“.

The combination of the „array type“ radioactivity flow detector Ramona quattro with this „limit-of detection“-calculation is the ultimate state of the art in sensitivity of radioactive flow detection.