BrilLanCe (B380) detectors

A new generation of room-temperature gamma-ray detectors has recently been introduced by Quartz&Silice (Nemours, France) which has several advantages over the well-known NaI(Tl) crystals. The main advantages for the average user are its superior energy resolution of ≤3% for the 662 keV line of ^{137}Cs, the enhanced full-energy peak efficiency as compared to NaI(Tl) and its stability of light yield with varying temperature. Another important advantage is the very short scintillation flash which allows more precise timing and better coincidence resolving times. In summary:

- **resolution ≤3%**
- **efficiency twice that of NaI(Tl)**
- **little temperature sensitivity**
- **very fast signals**

A drawback of B380 material is the fact that it contains very long-lived natural radioactivity (^{138}La) which decays by β^- and electron capture, thus creating a fairly complex background in every spectrum. However, due to the highly constant nature of the background radiation, the necessary correction is simple.
The internal background amounts to approx. 140 cps in a 3”x3” BrilLanCe detector. Whereas most of the counts constitute some continuum, a doublet peak around 1460 keV can be taken for internal energy calibration. However, it requires special treatment when the contents of ^{40}K in a sample shall be determined. Several characteristics of the new BrilLanCe detectors will be demonstrated in the following.

Scientists in our company have conducted extensive research on the new B380 detectors and we are proud to announce that we are now able to provide you with software that can quantitatively analyse B380 spectra and that deconvolutes even complex multiplets. The main results of our research are:

- **we know the B380 peakshape**
- **we know the shapes of B380 baselines**
- **we know the resolution function (FWHM)**
- **we know the efficiency function**

We can now provide you with complete portable B380 γ-ray spectrometers with quantitative high-precision spectrum analysis and nuclide identification.

We now promote this product to our customers !

An instructive comparison between NaI(Tl) and B380 detectors is presented in Figure 1. Two spectra are shown that were measured under completely identical conditions from a Thorium sample.
A 1.5"x1.5" NaI(Tl) detector and a 1.5"x1.5" B380 detector measured the same Thorium source from the same distance and for the same livetime.

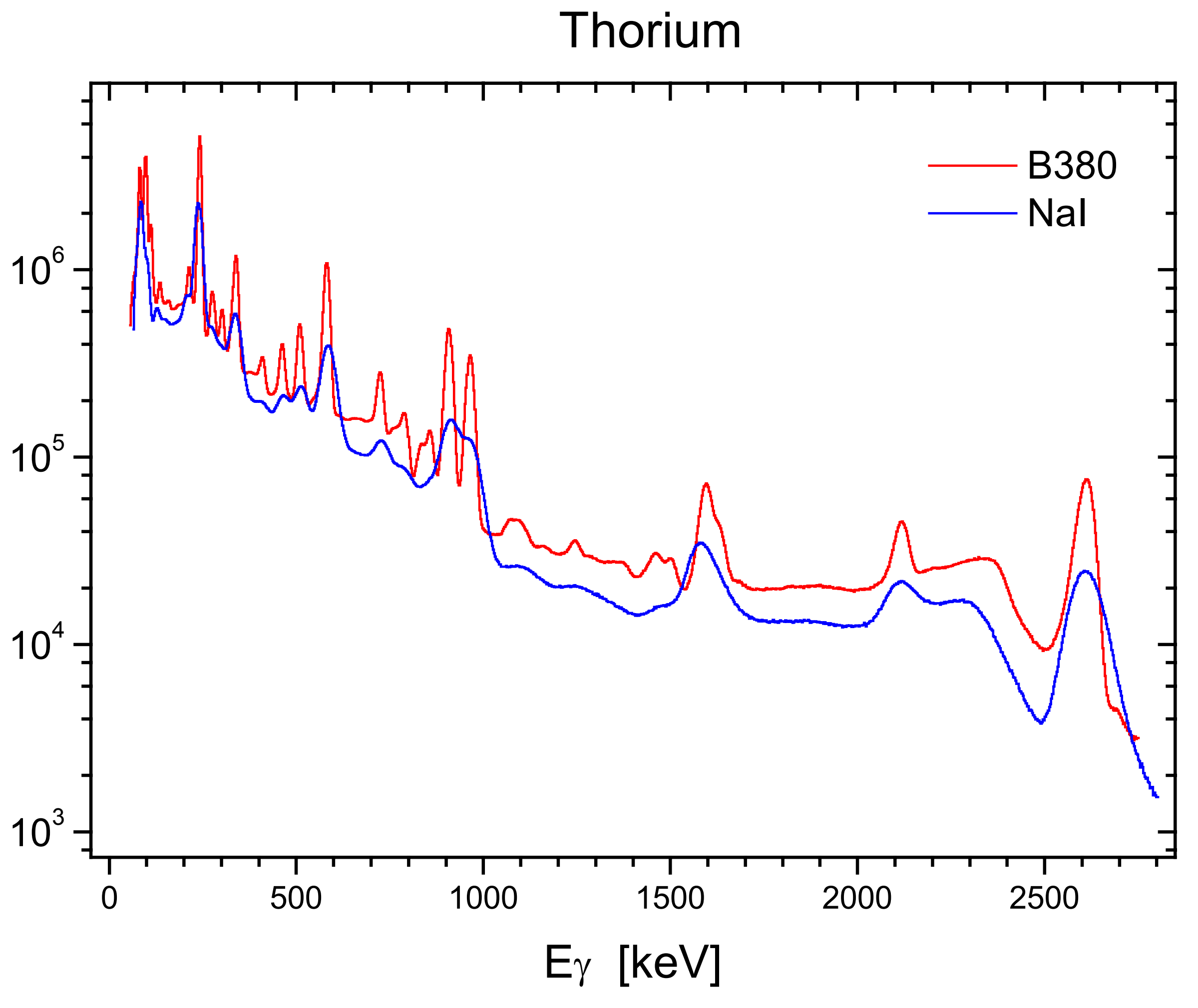

Figure 1: *Spectra measured under identical conditions with a NaI(Tl) and a BrilLanCe detector from a Thorium source.*

The BrilLanCe (red) spectrum is about twice as high as the NaI(Tl) spectrum (blue), indicating superior overall efficiency. One can see that the efficiency advantage increases with increasing γ-ray energy, thus making B380 particularly useful for measurement of high-energy gamma-rays. Moreover, many peaks that are sometimes not even visible with NaI(Tl) are clearly visible and easily analyzed in the B380 spectrum. Good examples are the doublet around 850 keV, which is the narrow doublet before the two large peaks around 911 keV and 969 keV, or the doublet at 1460 keV and 1496 keV.

Even more instructive for potential applications is the section around 600 keV from two spectra of ambient background radiation that were taken with 1.5"x1.5" NaI(Tl) and 1.5"x1.5" B380 detectors. A very small contamination of ^{137}Cs is present in the spectra as shown in Figure 2.

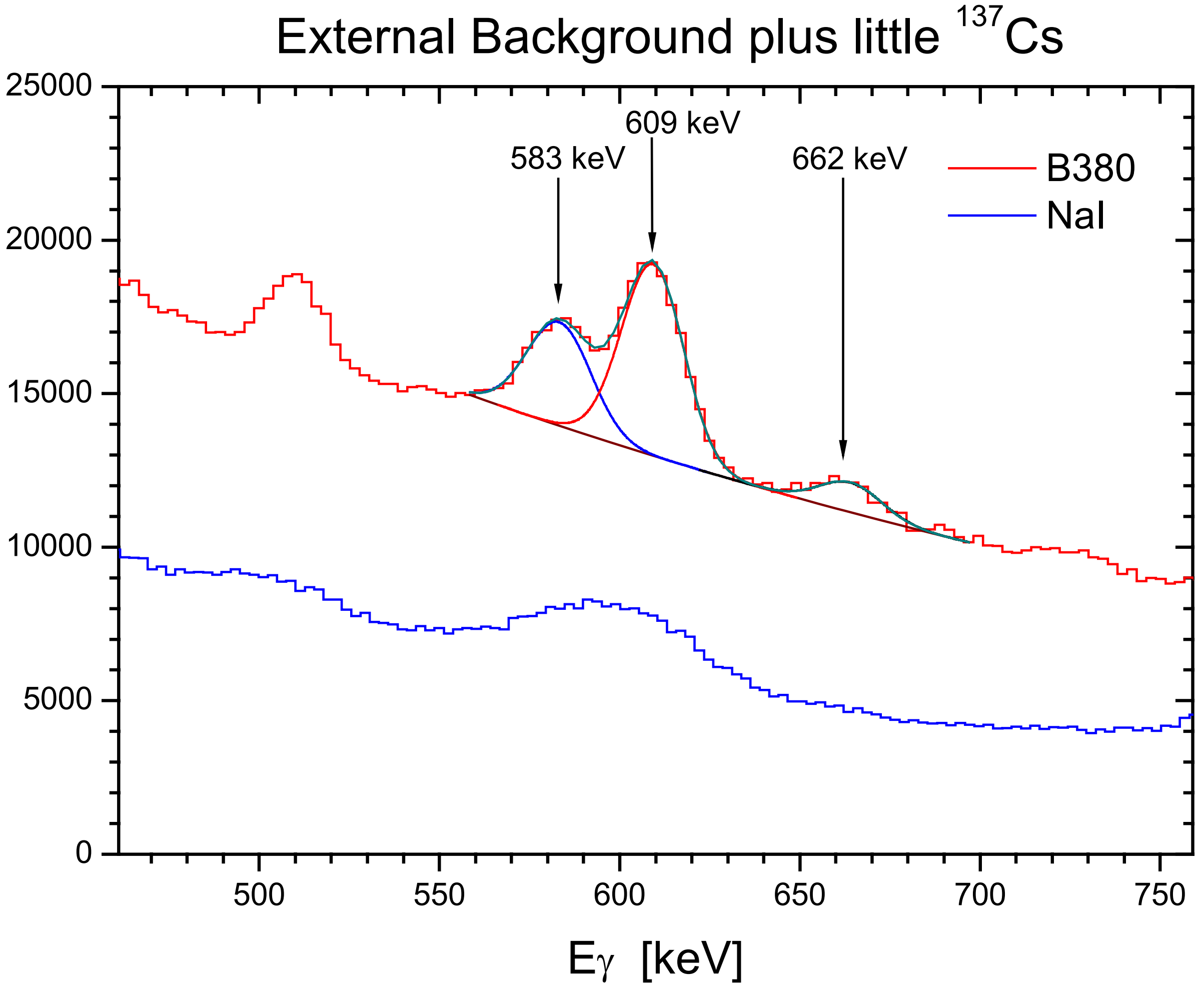

Figure 2: *Section of ambient background spectra measured with BrilLanCe and NaI(Tl) detectors under identical conditions. Full lines in the red spectrum are the baseline, fitted peaks and the sum function.*

The 662 keV peak from ^{137}Cs is easily detected and quantified in the red B380 spectrum whereas it is hardly detected and not analyzed in the blue NaI(Tl) spectrum.

Please note the good, quantitative separation of peaks at 583 keV (from ^{232}Th progeny) and 609 keV (from ^{238}U progeny) in the B380 spectrum. It means that one can use a portable B380 spectrometer for **in-situ** prospecting measurements and on-the-spot analysis of the spectra. This will immediately yield the absolute U/Th ratio and, when measured in a calibrated geometry, it gives the absolute ^{238}U and ^{232}Th activities. The same in-situ versatility applies for any other spectrometric application.

Uncertainties of the activities are not significantly higher than in measurements using cooled HPGe detectors. For such measurements, the very high efficiency of B380 detector is particularly advantageous. The full-energy peak efficiency of a 3"x3" B380 detector is about the same as the efficiency of a 200% (rel.) HPGe detector. A 2"x2" B380 is comparable to a 90% (rel.) HPGe!

The shape of a B380 efficiency function is shown in Figure 3 where full-energy peak efficiency functions of a 1.5"x1.5" B380 and a 25% (rel.) p-type HPGe detector are compared.

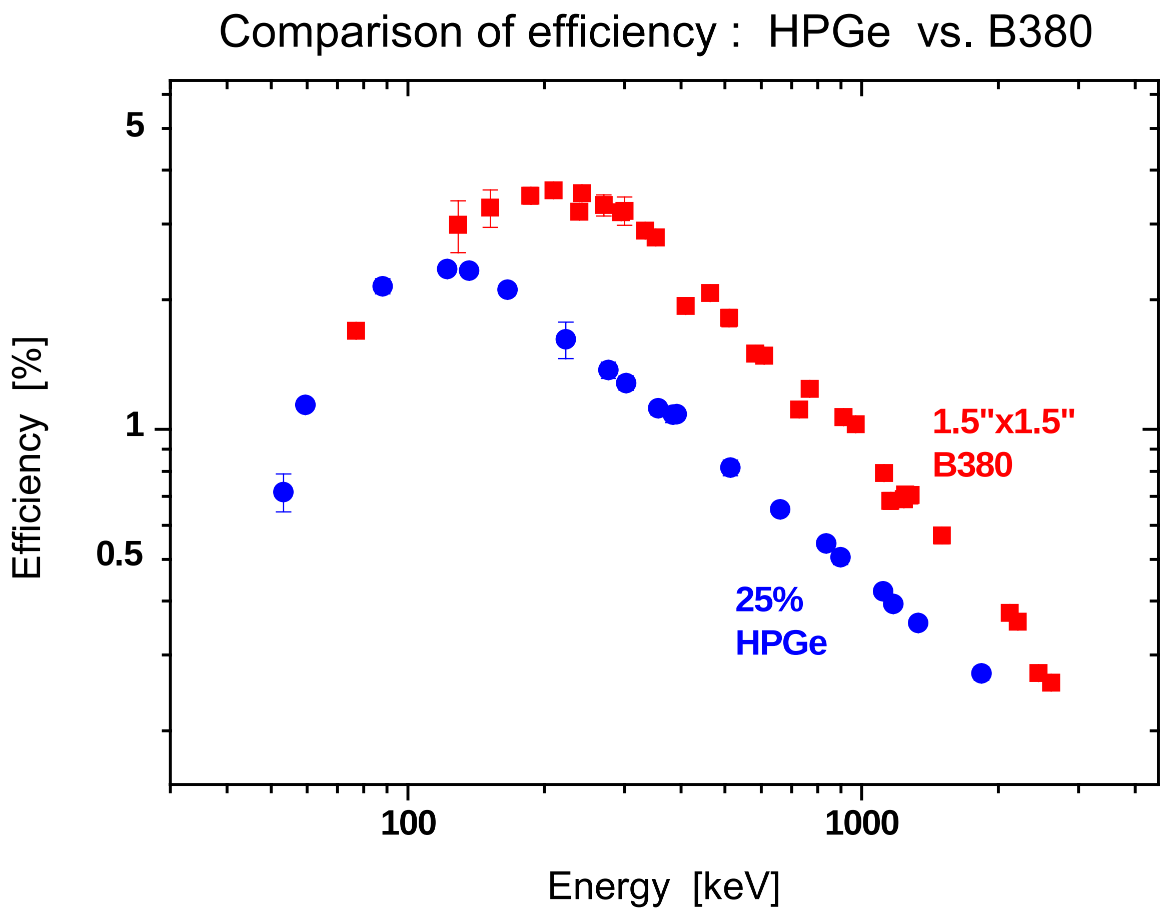

Figure 3: *Full energy peak efficiency functions for a 25% (rel.) p-type HPGe and a 1.5"x1.5" B380 detector.*

It is clear that the efficiency in the relevant energy range between 100 keV and 2 MeV is significantly higher for the B380 detector than for HPGe. This property yields very precise measurements with good statistics over the energy range that is most populated by and relevant for decay gammas, but without any disturbance by γ/X-ray concidences.

An analysis of complex multiplet in a gamma-ray spectrum taken for 5 minutes from a ^{166m}Ho source with a 2"x2" BrilLanCe detector is shown in Figure 4. The baseline under peaks is indicated and various fitted peaks are shown in different colours. The white line is the sum function of all peaks plus baseline which goes well through the spectrum histogram.

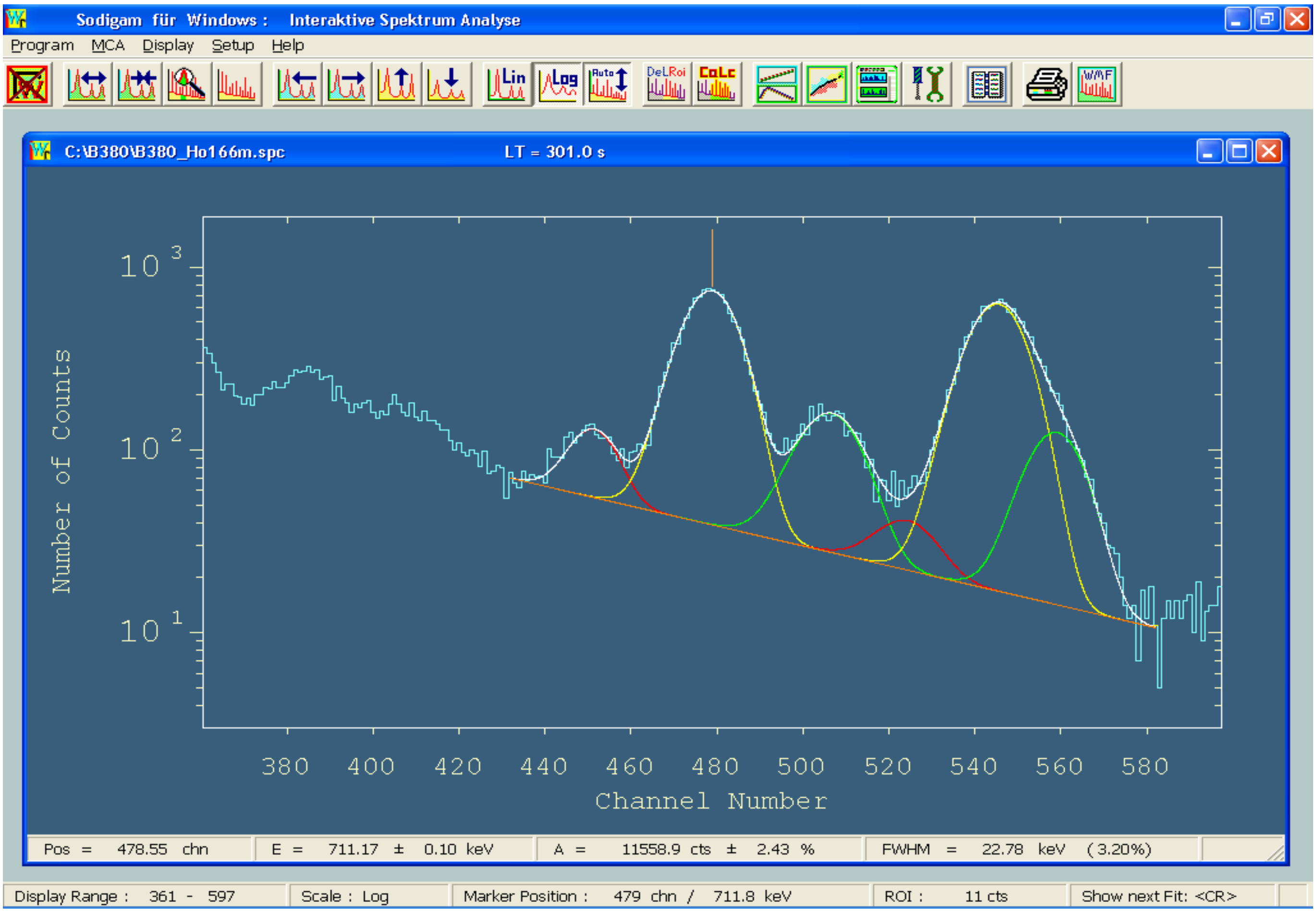

Figure 4: *Fraction of a ^{166m}Ho spectrum together with multiplet fit display.*

The quantitative nuclide activity calculation from this multiplet is shown in Figure 5 where activities calculated from each individual peak are shown relative to the weighted average activity which was determined from all peaks of ^{166m}Ho. There is remarkable agreement to within one standard deviation (1σ) of all fitted peakareas with the sample activity, the only one exception being the peak around 779 keV, which is the red peak around channel 525. This small peak with 3.33% intensity is strongly masked by close-lying neighbours at 752 keV (13.2%) and at 810 keV (63.3%). In order to improve the accuracy of the 779-keV peakarea to better than 2.9σ deviation from the average value, one must provide longer measurement times leading to larger area and improved statistical significance of the peak.

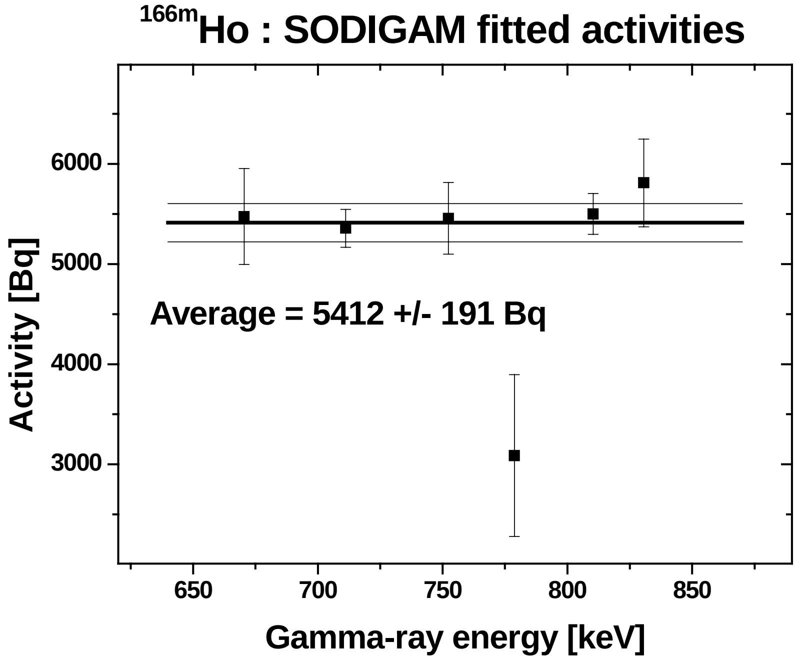

Figure 5:
^{166m}Ho activities calculated from individual peakareas of the multiplet shown in Figure 4. The average was calculated from all peaks of ^{166m}Ho.

Electronics used together with BrilLanCe detectors must be able to cope with signals that are about 10-times faster than those of NaI(Tl) detectors. In Figure 6 a specially adapted plug-on MCA (scintiSPEC-L) is shown which was developed for B380 material, yielding optimum performance and resolution for BrilLanCe detectors.
A 2"x2" B380 detector is attached to scintiSPEC-L in the Figure.

Figure 6:
2"x2" BrilLanCe B380 detector with scintiSPEC-L plug-on MCA

The scintiSPEC-L plug-on MCA is, however, available for all crystal sizes in which BrilLanCe detectors are provided on the market. Together with e.g. a Laptop PC and our proprietary software we can provide a portable γ-ray spectrometer.