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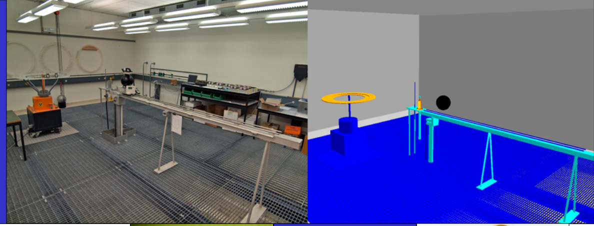

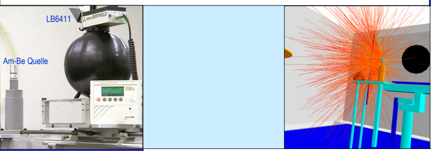

Stability of a Berthold LB6411 neutron probe

H. Hoedlmoser, Ch. Schuler, G. Butterweck and S. Mayer
Paul Scherrer Institut, CH-5232 Villigen PSI, Switzerland

At the accredited PSI calibration laboratory neutron reference fields traceable to the standards of the Physikalisch-Technische Bundesanstalt (PTB) in Germany are characterized by means of a Berthold LB6411 neutron probe which is used as a secondary standard. It is known that this detector suffers from an unstable, increasing dose rate reading in the order of up to 5%. In this work the behaviour was investigated by means of long term measurements up to 10 h under irradiation with ambient dose equivalent rates up to 24 mSv/h. The reading of the instrument was found to reach a plateau after 90 min in an irradiation with 10 mSv/h ^{252}Cf. The plateau is reached faster for higher dose rates. This supports the correlation of the effect with a charging effect in the proportional counter, as suggested by the manufacturer. The effect could also be duplicated in an irradiation with photons from a ^{137}Cs source. The decay time of the accumulated charge was found to be very long, i.e. the instrument showed a stable reproducible reading for up to six hours after the plateau was reached. From these observations a conditioning procedure was derived which ensures a stable operation after an irradiation of the instrument preceding its use in reference measurements.

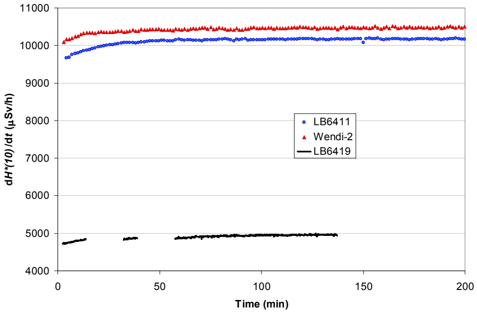

Figure 1: Signal drift and stabilization of three neutron detectors.

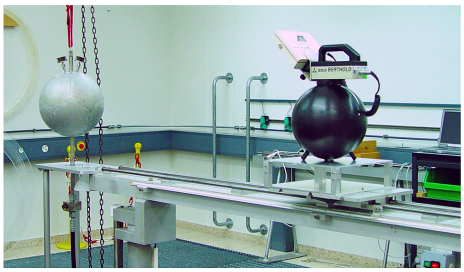

Figure 2: LB6411 on neutron irradiation bench.

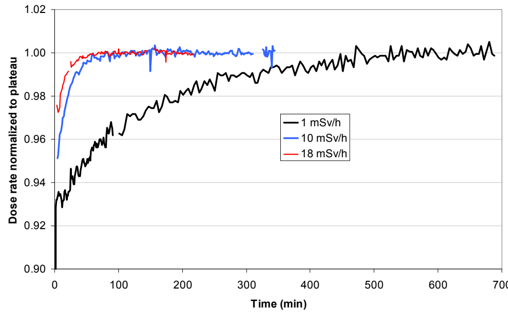

Figure 3: Duration of stabilization correlates with dose rate.

1) Measured signal drift

Stability measurements were carried out with a ^{252}Cf source. The observed signal drift (Fig. 1) is an increase of the reading of the instrument in the order of about 5% and depends on the previous irradiation history. The effect has also been observed with a Thermo Wendi-2 and a Berthold LB6419 probe, which use similar ^{3}He proportional counters. The effect is not related to any warm up phase of the instruments. In Fig. 1 the reading of the instrument increases until it reaches a plateau. The time it takes to arrive at the plateau depends on the dose rate during irradiation – see Fig. 3. For higher dose rates the plateau is achieved sooner, which supports the assumption of a charging effect due to the free charges produced in the irradiation.

2) Stability of plateau reading

After the plateau is reached the LB6411 operates stable, i.e. the instrument is "conditioned". Short interruptions of the irradiation and changes in the applied dose rate do not cause the instrument to lose this conditioning – compare Fig. 4. The initial reading of an unconditioned LB6411 depends on the previous irradiation history. E.g. in several conditioning experiments (Fig. 3) it was observed that the initial level depends on how much time has passed since the last use of the instrument, whereas the final level of the plateau remains unchanged. The conditioning experiments combined with test source measurements in Fig. 5 confirm this behaviour.

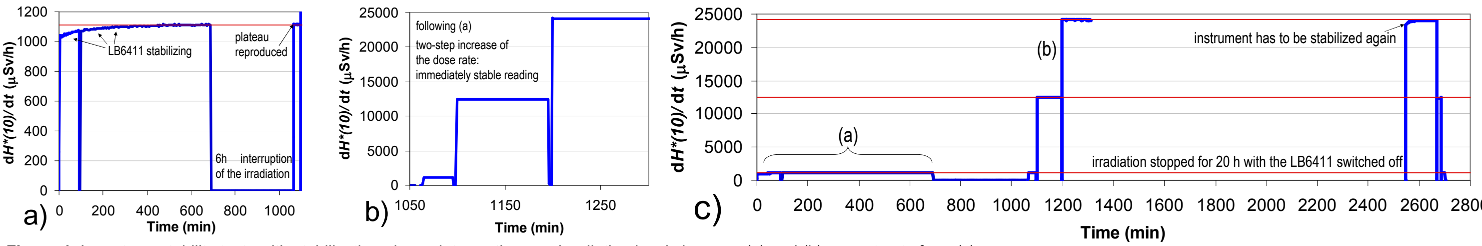

Figure 4: Long term stability tests with stabilization phase, interruptions and radiation level changes. (a) and (b) are extracts from (c).

3) Conditioning procedure

As a **standard conditioning procedure** an irradiation with **10 mSv/h (^{252}Cf) during 90 min** was used. The conditioning can also be achieved by irradiation with high doses of photons.

4) PTB calibration and stability correction

As the signal drift of the LB6411 is a known issue, PTB specifies a calibration factor that has to be normalized to the reading with a test source obtained during calibration at PTB, i.e. a stability correction factor c_s is required. For the conditioned LB6411 the reading with this test source was confirmed to be reproducible within ~2% in a series of experiments (Fig. 5). From these results a stability correction c_s was derived, which can be used for a conditioned instrument instead of repeatedly performing test source measurements and normalization.

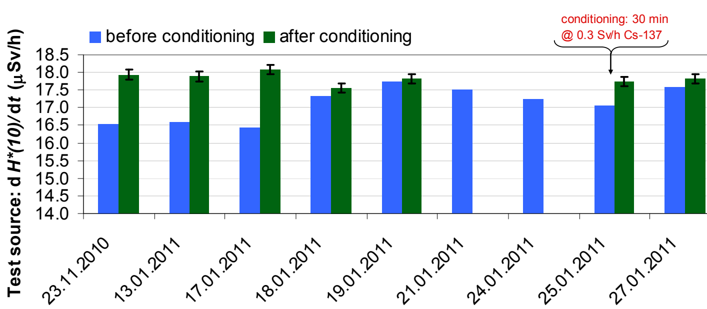

Figure 5: Test source reading before and after conditioning (= irradiation with 10 mSv/h during 90 min).