DeGeN – Measurement Vehicle for Radioactive and Nuclear Material

T. Köble, W. Berky, S. Chmel, H. Friedrich, M. Risse, W. Rosenstock, O. Schumann

Fraunhofer INT, Euskirchen, Germany

Naturally occurring radioactivity can be affected by various factors. Among others it strongly depends on the materials embedded in constructions or geological structures. For detection and documentation of radiation as well as recognition of anomalies when passing by a conventional station wagon was equipped with a measuring system which comprises gamma scintillation detectors and large-volume neutron detectors. The car's position is monitored by GPS and synchronized with the measured data. The analysis of the measured data can be performed on the spot or later on. These data may be visualized as a diagram or implemented in a chart as a color-coded track.

A thorough understanding of the natural background radiation is especially important in order to precisely detect the contribution of radioactivity by the radioactive or nuclear material in the wake of any event of radioactive release, e.g. an accident. The distribution and potential danger of said radioactivity may be assessed more quickly then.

Measurements of the variations of environmental radioactivity were performed with the Fraunhofer INT's measurement car DeGeN. We examined the effects of different built-in materials or road surfacing as well as the effect inside an underground passage-way.

Neutron measurements are performed with ^{3}He filled detectors on both sides of the measurement vehicle. For gamma detection the vehicle operates two NBR probes using the NBR (Natural Background Rejection) method. This method enables the user to discriminate between artificial and natural radiation and therefore to eliminate the option of the presence of sources emitting artificial radiation at an increase of the measured values. Furthermore, an electrically cooled Germanium detector for high resolution gamma spectroscopy is also implemented in the vehicle's measurement system. It may be operated on board or outside the vehicle for identification. Figure 1 illustrates the setup of the measurement system. The display of the measured gamma dose rate and neutron count rate values is shown in figure 2.

Figure 1: Setup of Fraunhofer INT’s measurement vehicle with two rows of neutron detectors on either side, two scintillation gamma detectors (NBR probes) on the far side of the neutron detectors close to the rear side doors, the Germanium detector for isotope identification at the car’s rear, and the monitor showing the current measurement results at the car’s front.

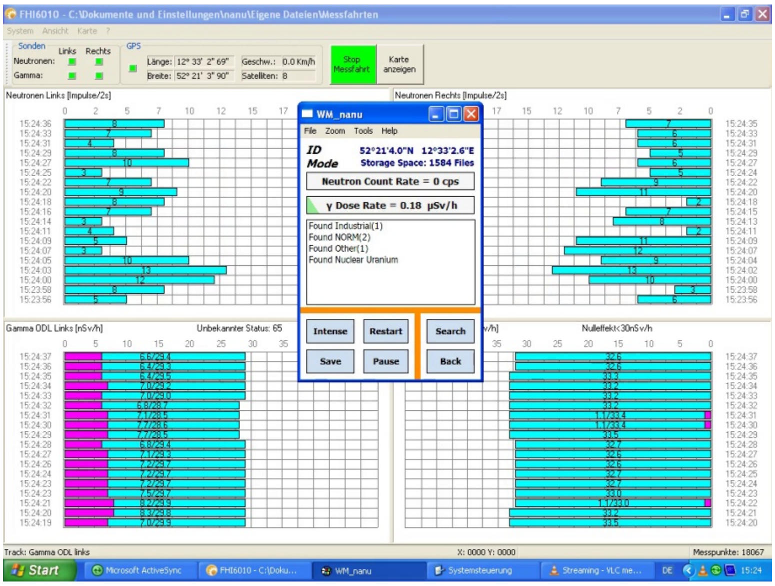

Figure 2: Display of the measurement results on the car’s monitor; top: neutron count rates measured on both sides of the car, bars move downwards when updated values are shown; bottom: gamma dose rate values measured on both sides, bars move downwards as well; center: transferred display of the Germanium detector showing ID results.

The natural background radiation is caused by two components: terrestrial and cosmic radiation. Terrestrial radiation is generated by nuclides (e.g. Uranium, Thorium, and Potassium nuclides) which are present within the Earth’s crust and upper mantle with a higher density close to the Earth’s surface. Different materials such as concrete, asphalt, soil, and gravel contain different concentrations of these nuclides and therefore emit different levels of background radiation. Moreover, Radon nuclides created in the Uranium decay chain tend to fumigate from the solid materials, adding to the natural background especially in basement rooms and tunnels which the Radon gas cannot leak from. In contrast, neutron background radiation is caused by cosmic radiation predominantly and is therefore usually lower in basement rooms and tunnels because of their shielding effect.

These effects of an increased concentration of Radon nuclides could be verified with the measurement vehicle when passing an underground tunnel. Such a measurement is illustrated in figures 3 and 4. Figure 3 shows the measured data at the exit of the city tunnel in Berlin with a considerable decrease of the gamma dose rate because of the reduction of the Radon concentration outside the tunnel. A slight increase of the neutron count rate can also be seen. Figure 4 shows the corresponding position of the vehicle at the tunnel exit in a chart where this position is marked with a red dot. The colored track near the car’s position indicates that the gamma dose rate has returned to a typical background value, hence the green color.

The effect of different road surfacing could also be verified as shown in figures 5 and 6. Figure 5 visualizes a change of the track surface on a German motorway, namely a transition from asphalt to concrete. The corresponding variation in the measured gamma dose rate is shown in figure 6. The measurement refers to a transition from concrete to asphalt and back which is only partly visualized in figure 5. The change of the gamma dose rate during this transition is obvious whereas the neutron background did not change with respect to the typical deviations of the neutron count rate.

The measurement system DeGeN comprises gamma and neutron detectors with high sensitivity suitable for detecting radioactive and nuclear (RN) material. Because of the high sensitivity, even minor changes of the natural background radiation can be registered which is tremendously important for the discrimination between the presence of actual RN material and mere modifications of the natural background. Questionable measurement results which could lead to wrong response measures are more likely to be prevented then.

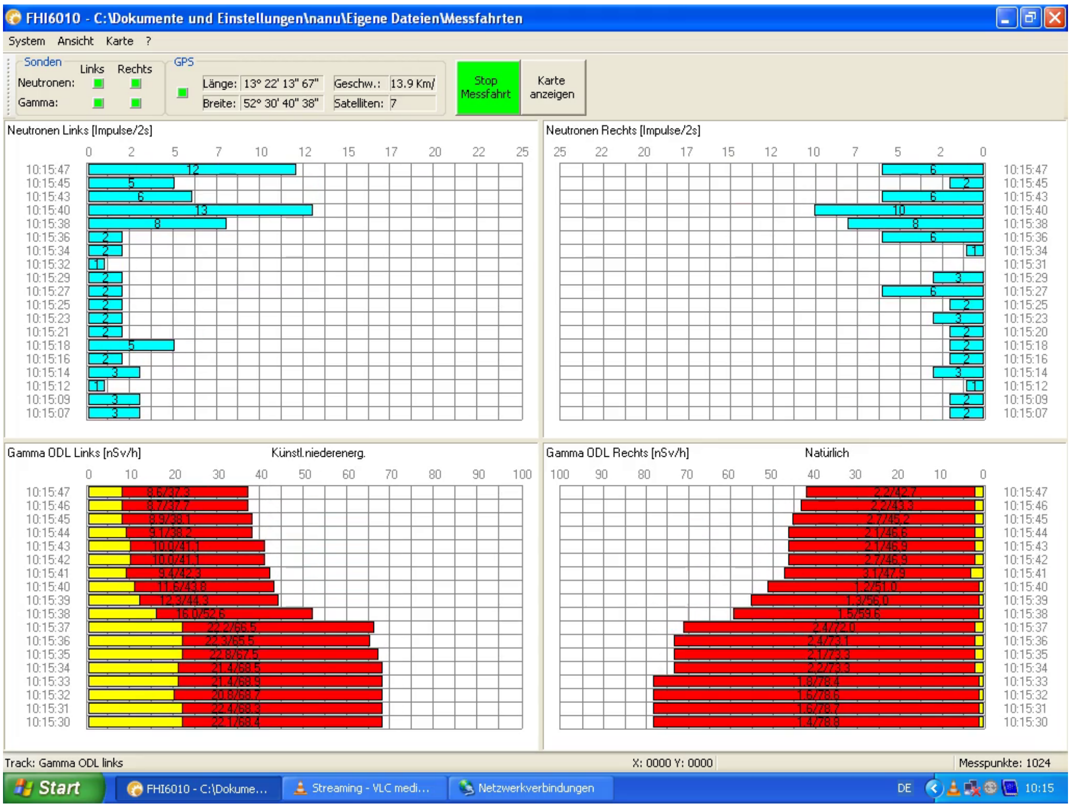

Figure 3: Display of gamma dose rate reduction and increase of neutron count rate when exiting a tunnel (bars move downwards).

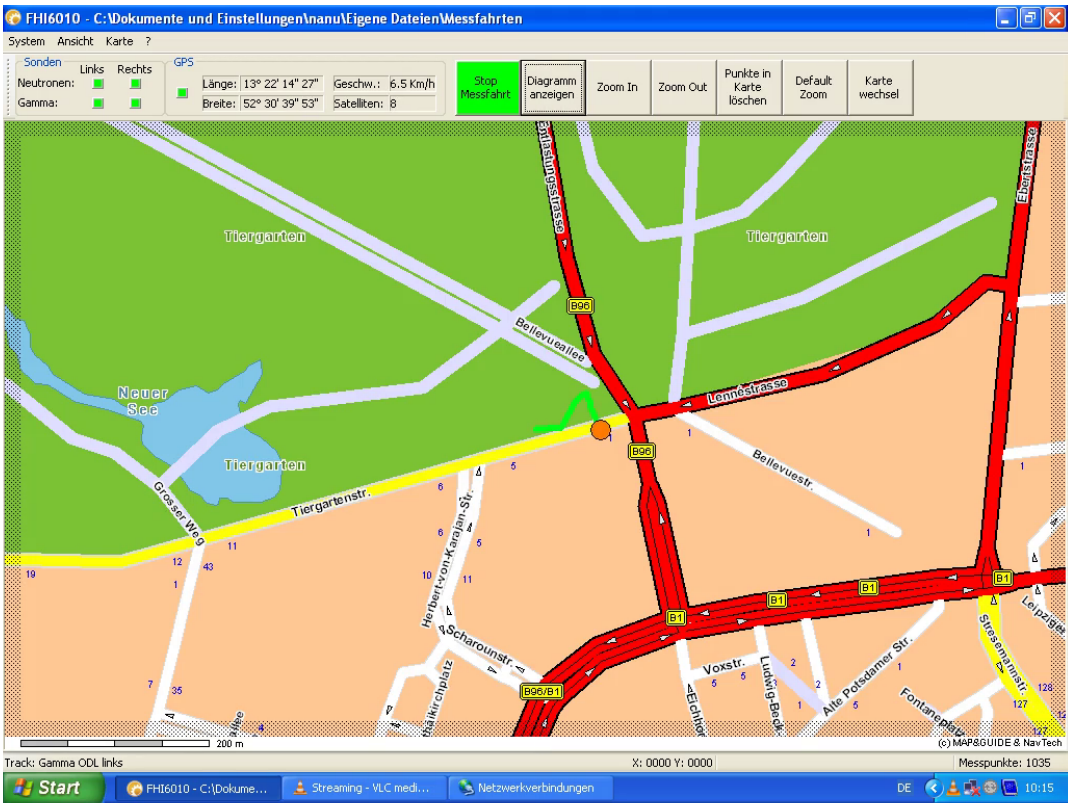

Figure 4: Chart of measurement area with car position at the tunnel exit (red dot).

Figure 5: Image of a change in road surfacing (asphalt to concrete).

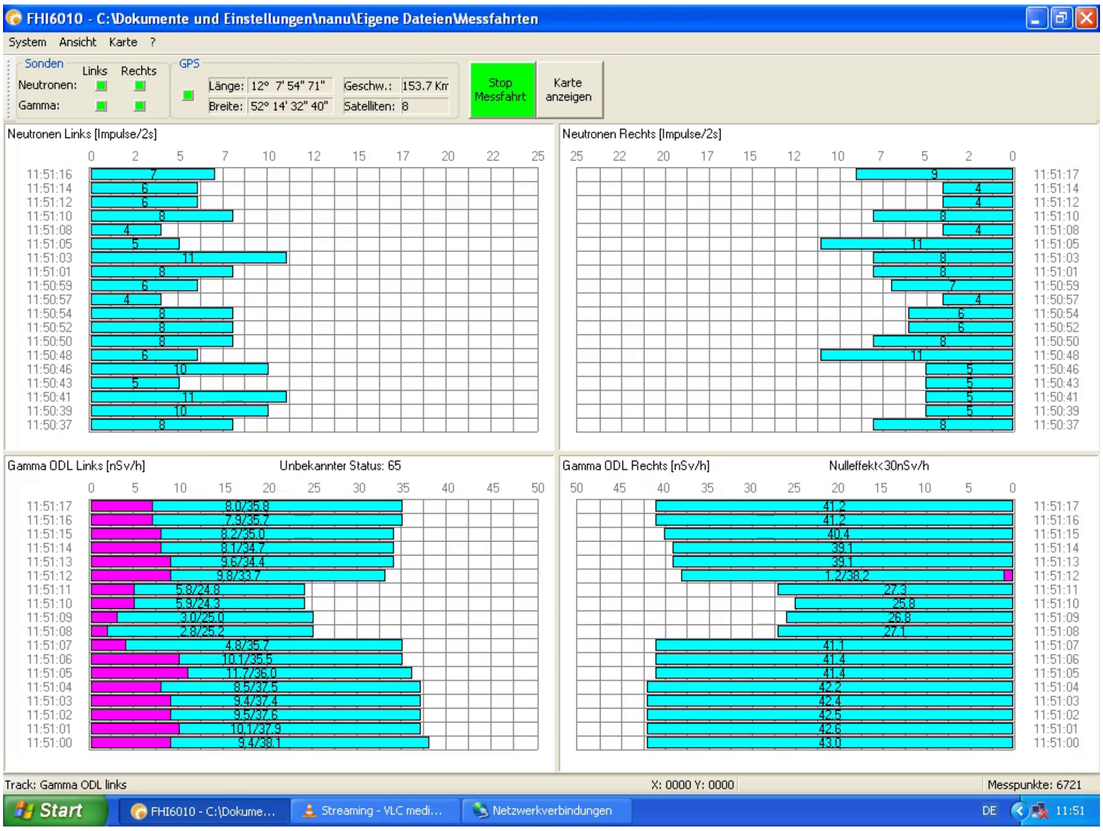

Figure 6: Display of gamma dose rate variations when passing different types of road surfacing (concrete to asphalt to concrete).