Calibration of a neutron source for the XENON experiment

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The XENON Dark Matter Project is an experiment which is geared to searching for WIMPs (Weakly Interacting Massive Particles), a variant of Dark Matter. It has been set up in the Gran Sasso underground laboratory and uses liquid xenon as a target material to detect super-symmetrical particles. Numerous universities and laboratories worldwide are involved in this experiment.

In the detector, events are sought in which WIMPs generate a recoil nucleus and which can be detected by means of a certain signature in the measurement signals. Calibration measurements with a neutron source – which is also used to generate recoil nuclei in the xenon – determine whether an event fulfils the required criteria. Furthermore, the analysis of the events recorded in the XENON detector has to take into account the contribution originating from the neutrons present in the underground laboratory.

These properties of the detector are investigated by means of particle transport calculations. A measurement with a weak neutron source of known source strength is necessary to validate the calculations. Within the scope of the XENON100 collaboration, a ^{241}Am-Be neutron source was purchased, and a neutron emission rate of (220 ± 30) s^{-1} was determined from the ^{241}Am activity of (3.7 ± 0.5) MBq specified by the manufacturer. Measurements carried out with this source at the XENON detector showed a clear discrepancy with the results obtained by means of the particle transport calculations.

For more clarity, the emission rate of this source was measured accurately by PTB. For this purpose, a ^{3}He detector of the Bonner sphere spectrometer NEMUS was used in a moderator arrangement (Fig. 1). The emission rate was determined by comparing the XENON100 neutron source with a PTB calibration source of the same type whose emission rate is traceable to national standards. Thereby, the influence of the orientation of the source inside the irradiation facility as well as its contribution to the measurement uncertainty were investigated (Fig. 2).

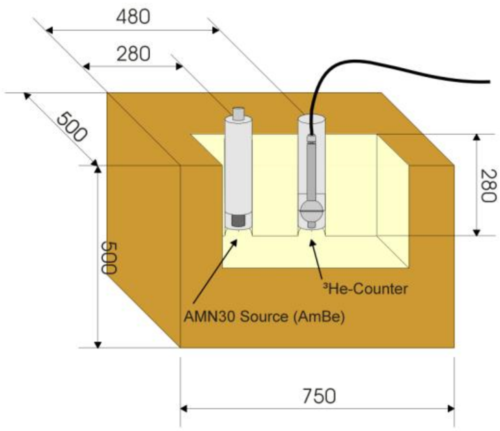

Fig. 1: Set-up for the measurement of the neutron emission rate. The ^{3}He detector and the neutron source under test are accommodated in a moderator made of paraffin wax.

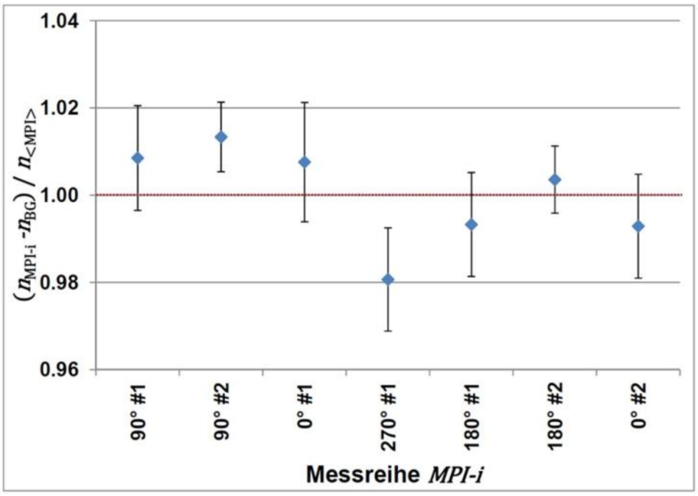

Fig. 2: Count rate normalized to the mean value for different emission directions of the neutron source.

These measurements yielded a value of (159.6 ± 3.9) s^{-1} for the emission rate. This result, which deviates by approx. 30 % from the nominal value, yields a very good agreement between the particle transport calculations and the measurements.

Literature

E. Aprile et al.: Response of the XENON100 dark matter detector to nuclear recoils. Phys. Rev. D 88, 012006 (2013)

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