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GIOVE, a new low-background Ge-spectrometer at MPI-K

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A new germanium gamma spectrometer (GIOVE) has been added to the screening facility of the MPI for Nuclear Physics to meet the needs for material selection for the double beta and dark matter projects Gerda Phase II [1] and XENON 1T [2]. It bridges the gap in sensitivity between the GeMPI spectrometers at LNGS [3, 4] and the older generation low background spectrometers at the Heidelberg low level laboratory [5]. The background rate at Heidelberg, originally two orders higher compared to the Gran Sasso based spectrometers is mainly due to events induced by incompletely vetoed muons and by higher neutron flow as well as by a higher cosmogenic activation rate. Progress in radio-purity of the detector materials is a further reason.

GIOVE (Germanium spectrometer with Inner and Outer VEto) has two independent veto systems consisting of plastic scintillator plates and a neutron moderator interlayer of borated polyethylene (PE) in its Pb/Cu shield. Further neutron moderation is obtained through the plastic scintillator layers.
All materials used in the construction of the cryostat and the shield were selected by extensive radio purity measurements with the existing spectrometers. Not all demands in radio-purity could be met and thus compromises had to be made. One example is the residual about 80 mBq/kg 40K contamination of the purest boron compound we were able to find at reasonable cost. It prohibited to place the borated PE at the most favourable position, namely between the innermost Pb layer and the Cu gladding around the detector chamber.
Especially challenging was the light readout of the inner plastic scintillators. Here, low activity 1"x1"PMTs have been used, similar to the ones originally selected for the XENON100 dark matter detector [6].
The addition of neutron moderation layers made the shield too bulky for the sample chamber to be accessed from the outside. Therefore, samples are placed into Cu containers which are lowered into the sample chamber hanging under the before raised shielding plug. Rn suppression is achieved by a nitrogen purged air lock/glove box system and gas tight sample containers.

The double veto system reduces the total background rate (40-2700 keV) from 2.8x104 to 293 counts (d kg)-1 and thus only one decade apart from the GeMPI spectrometers.
Further performance and constructional details of GIOVE will be discussed. The Monte Carlo simulation of the full setup including the characterisation of the germanium diode will be described.

[1] Gerda proposal to LNGS, September 2004
[2] XENON 1t proposal to LNGS, April 2010
[3] Heusser G., M. Laubenstein, H. Neder, radionuclides in the environment, edited by P. P. Povinec and J. A. Sanchez-Cabeza, Elsevier, Amsterdam (2006) 495-510
[4] Rugel G. et al., Nuclear Physics B (Proc. Suppl.) 143 (2005) 564
[5] Aberle C. et al., MPI-K Progress Report (2010) 258-259
[6] Aprile E. et al. (XENON100), Astropart.Phys.35 (2011) 43-49

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