INSTITUTE OF PHYSICS PUBLISHING PHYSICA SCRIPTA

Phys. Scr. **T127** (2006) 52–53 doi:10.1088/0031-8949/2006/T127/019

Lessons after 3 years of running GENIUS-TF in Gran Sasso

I V Krivosheina and H V Klapdor-Kleingrothaus[1]

Max-Planck-Institut für Kernphysik, PO 10 39 80, D-69029 Heidelberg, Germany

E-mail: Irina.Krivosheina@mpi-hd.mpg.de and H.Klapdor@mpi-hd.mpg.de

Received 26 May 2006
Accepted for publication 11 June 2006
Published 1 September 2006
Online at stacks.iop.org/PhysScr/T127/52

Abstract

After operation of GENIUS-TF over 3 years with finally six naked Ge detectors (15 kg) in liquid nitrogen in Gran Sasso, we realize serious problems for realization of a full-size GENIUS-like experiment: (i) background from ^{222}Rn diffusing into the setup, on a level far beyond the expectation. (ii) Limited long-term stability of naked detectors in liquid nitrogen. None of the six detectors is running after 3 years with the nominal high voltage. Three of the six detectors do not work at all any more. The HDMS (Heidelberg Dark Matter Search) setup at LNGS, operates the first enriched ^{73}Ge detector worldwide, and looks for spin-dependent WIMP-nucleon coupling at the Gran Sasso Underground Laboratory. The results (85.48 kg d) improve the best present existing limits on the WIMP–neutron spin-dependent cross-section (obtained from ^{129}Xe) for low WIMP masses (Klapdor-Kleingrothaus *et al* 2005 *Phys. Lett.* B **609** 226–31).

PACS numbers: 95.55.Vj, 14.60.Pq, 23.40.−s, 29.40.−n

1. Introduction

Up to now the only existing test facility for a project operating naked Ge detectors in liquid nitrogen such as GENIUS [1] and its copies (Cameo, Gerda) is the GENIUS-Test Facility (GENIUS-TF) which has been operating now for over 3 years in Gran Sasso.

The first four naked Ge detectors (in total 10 kg) were installed on 5 May 2003 (GENIUS-TF-I). This has been reported in [2].

2. The GENIUS-TF-II and III setups

In October 2004, we have installed a new setup GENIUS-TF-II (see figures 1 and 2), containing now six naked Ge detectors (in total 15 kg), and, as technical improvement, a second copper vessel for further shielding of radon. That ^{222}Ra diffusing into the setup has been a problem for GENIUS-TF-I has been described in detail in [3]. The inner shielding by bricks of (5–10 cm) polycrystalline germanium (∼300 kg) was used also in this setup forming the inner highly efficient shield of the Ge detectors (see figure 2).

The thin wall (1 mm) inner copper box containing the liquid nitrogen is made of high-purity electrolytic copper and is thermally shielded by 20 cm of special low-level styropor, the outer copper box (also made of electrolytic copper) is followed by a shield of 10 cm of electrolytic copper (15 tons) and 20 cm of low-level (Boliden) lead (>35 tons).

The high-purity liquid nitrogen used is produced by the BOREXINO nitrogen plant, which has been extended to increase production capacity to be able to provide enough nitrogen also for GENIUS-TF (see [2, 3]).

GENIUS-TF-III started operation at the beginning of March 2005 after the inner shield of polycrystalline Ge bricks had to be removed according to the contract with the Kurchatov institute.

3. ‘Progress’ of operational parameters

3.1. *Background from ^{222}Rn*

The unexpected (according to our Monte Carlo simulations [4]) high background from ^{222}Rn in GENIUS-TF-I (see [3]) has been reduced in GENIUS-TF-II by about a factor 5 (see [10]). This ^{222}Rn background is compatible with the goal of GENIUS-TF to search for dark matter [5], but will be a *serious problem* for any full GENIUS-like experiments,

---

[1] Spokesman for HEIDELBERG-MOSCOW, GENIUS-TF and HDMS Collaborations.

0031-8949/06/127052+02$30.00

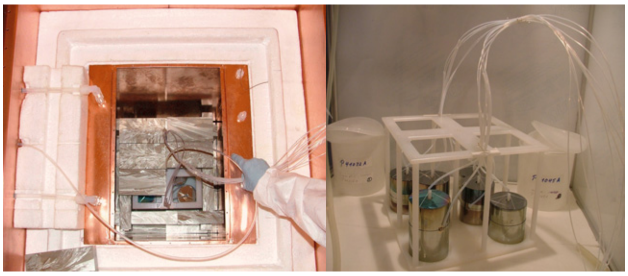

Figure 1. Left: view from the top on the GENIUS-TF-II setup during installation in October 2004. Right: the six contacted naked Ge detectors.

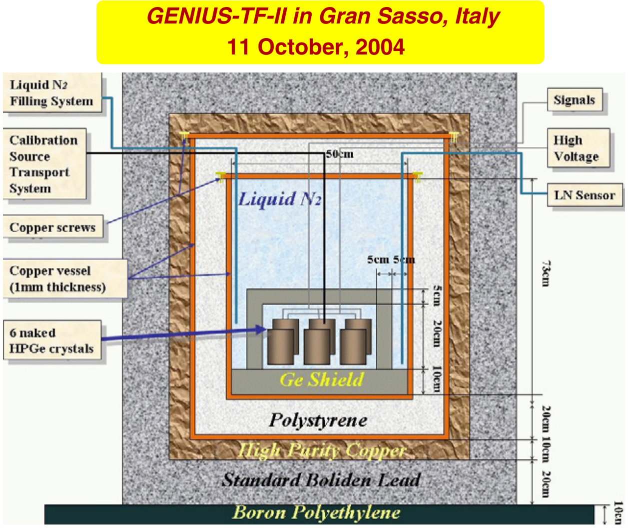

Figure 2. Schematic view of the TF-II setup.

because the ^{222}Rn leads to the 'famous' background lines from ^{214}Bi near the Q-value for double beta decay of ^{76}Ge [6, 7].

3.2. *Long-term stability*

The most dramatic result is obtained for the long-term stability of the detector operation in liquid nitrogen [10]. It is shown in table 1. As a result of increasing leakage currents, finally from the initial six detectors at present only three are still working and *not one of them* with the nominal high voltage (see table 1). The reasons for the deterioration of the surface purity with time which could lead to the increasing leakage currents need further investigation. The long term energy resolution also decreases systematically [8].

4. Conclusions

GENIUS-TF is the *only setup with naked Ge detectors worldwide running underground and over a longer time period*. It has lead to important insight into the conditions of technical operation of naked Ge detectors in liquid nitrogen. The relatively large background from ^{222}Ra diffusion is a problem unsolved up to now. The main problem realized is, however, the increase of leakage current after long running of the detectors, which could be caused by increasing surface impurity of the crystals. This led to serious restrictions of the high voltages applicable and finally to destruction of the detectors. *The information GENIUS-TF delivered after almost 3 years of operation on the possibility of long-term operation of such experiments, may cast some doubts on the possibility of such experiments on larger scale in general.*

Table 1. The high voltages applied to the detectors after installation in GENIUS-TF I, II and III as function of time, and the nominal voltages.

Det-s	D1	D2	D3	D4	D5	D6
GENIUS-TF-I, from 10.12.2003 to 25.09.2004						
10.12.03	2404	2603	2879	2301	n. inst.	n. inst.
06.04.04	2600	2220	2879	2301	–	–
04.05.04	2600	2220	3200	2500		
GENIUS-TF-II, from 18.11.2004 to 28.02.2005						
08.10.04	250	1296	261	954	1253	502
18.11.04	364	2200	347	2298	3501	1015
20.01.05	,,	,,	,,	,,	,,	1000
GENIUS-TF-III, from 15.03.2005						
15.03.05	80	1802	20	2153	3501	980
03.05.05	0	1700	0	1500	3501	980
09.03.06	–	1700	–	–	3500	911
19.05.06	–	1600	–	–	2100	850
Nom.	3000	2600	3200	2500	3500	2000

References

[1] Klapdor-Kleingrothaus H V, Hellmig J and Hirsch M 1997 *GENIUS-Proposal* 20 Nov. 1997
Klapdor-Kleingrothaus H V, Hellmig J and Hirsch M 1997 *Z. Phys.* A **359** 351 and 361–72
Klapdor-Kleingrothaus H V, Hellmig J and Hirsch M 1998 *J. Phys. G: Nucl. Part. Phys.* **24** 483
Klapdor-Kleingrothaus H V, Hellmig J and Hirsch M 1997 *CERN Courier* (November) 16

[2] Klapdor-Kleingrothaus H V *et al* 2003 *Nucl. Instrum. Methods* A **511** 341
Klapdor-Kleingrothaus H V *et al* 2003 *CERN Courier* **43** (no. 6) 9

[3] Klapdor-Kleingrothaus H V *et al* 2004 *Nucl. Instrum. Methods* A **530** 410

[4] Klapdor-Kleingrothaus H V *et al* 2002 *Nucl. Instrum. Methods* A **481** 149–59

[5] Tomei C, Dietz A, Krivosheina I and Klapdor-Kleingrothaus H V 2003 *Nucl. Instrum. Methods* A **508** 343–52

[6] Klapdor-Kleingrothaus H V *et al* 2004 *Phys. Lett.* B **586** 198
Klapdor-Kleingrothaus H V *et al* 2004 *Nucl. Instrum. Methods* A **522** 371

[7] Gromov K Ya *et al* 2006 *J. Part. Nucl. Lett.* **3** 30

[8] Klapdor-Kleingrothaus H V *et al* 2005 *Gran Sasso Annual Report 2005* p 63–71

[9] Klapdor-Kleingrothaus H V, Krivosheina I V and Tomei C 2005 *Phys. Lett.* B **609** 226–31

[10] Klapdor-Kleingrothaus H V 2006 *Nucl. Instrum. Methods* A at press