Cryogenic Detectors for the Solar Neutrino Experiment GNO

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The Gallium neutrino experiment GNO (= Gallium Neutrino Observatory, formerly GALLEX) located at the Laboratori Nazionali del Gran Sasso (Italy) detects solar neutrinos via the reaction ^{71}Ga(ν,e)^{71}Ge. Due to the low energy threshold of 233 keV the experiment is mainly sensitive to pp-neutrinos, which represent about 53% of the total signal predicted by theory; further contributions to the signal are produced by ^{7}Be-neutrinos (27%), ^{8}B-neutrinos (12%) and CNO- neutrinos (8%). The target consists of 101 tons of $GaCl_3$ dissolved in water and HCl containig 30.3 tons of natural Gallium, thus corresponding to an amount of $\sim 10^{29}$ ^{71}Ga target nuclei. The ^{71}Ge atoms produced by solar neutrinos are extracted from the gallium tank approximately every 4 weeks and introduced into low-background proportional counters as Germane gas (GeH_4).

With a view to reducing both statistical and systematic errors in the experiment the miniaturized proportional counters still in use could be replaced by high resolution cryogenic detectors to measure the decay of ^{71}Ge to ^{71}Ga. The chemical extraction method which provides, in a monthly cycle, about ten ^{71}Ge-atoms out of 100 tons of Galliumtrichloride solution, represents a highly efficient ($\sim$95%) and well established procedure that must not be altered. Evidence that proportional counters (detection efficiency: 65% to 75%) should be replaced by the more efficient cryogenic detectors is supplied by the example of a 4π-detector (detection efficiency:$\sim$98%) that has been developed and tested successfully at the Technische Universität München (TUM).

However some modifications still have to be carried out to meet the goals set by the experimental procedure of GNO. The time window between extraction and measurement being very small due to the short half-time of ^{71}Ge ($T_{1/2}$ = 11,43d) first steps have been taken to develop a detector concept comprising the possibility of independently performing the chemical deposition of germanium via CVD (= chemical vapour deposition) onto a piece of superconducting foil, for instance Niobium and, in a second step, of integrating it via glueing in the detection apparatus itself. First measurements showed promising results nd are to be continued intensively in the next few months.

Another crucial point for the implementation of a cryogenic detection concept in GNO is the deposition efficiency of the Germane gas (GeH_4) onto the cryogenic detector. Great efforts have been made to increase the efficiency of this CVD process: By means of very localized heating, using a miniaturized deposition chamber, reducing the volumes during the process and by increasing gas transfer efficiencies, the overall efficiency of the Ge deposition onto the surface of a cryogenic detector was significantly improved from first $\sim$1% to 70% and in a second step to $\sim$91%. The efficiency was determined using several independent methods of which the NAA (= Neutron Activation Analysis) proved to be the most accurate one. The present efficiency of this CVD process being in the range of GNO's chemical extraction efficiency, further steps can now be taken towards a prototype run at the Gran Sasso Laboratory.

In order to show the feasibility of "Cryo-GNO" and to prepare the prototype phase at the Gran Sasso Underground Laboratory (3600 m.w.e), a new dilution refrigerator has been set up in the Underground Laboratory (15 m.w.e) of the "Beschleunigerlaboratorium/Maier-Leibnitz-Laboratorium" in Garching. The cryostat will soon be shielded by a myon-veto consisting of plates of plastic scintillator and a low-activity lead shielding thus allowing first longterm measurements.

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