Cryogenic Detector Development for GNO ◊

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GNO measures the solar neutrino flux using the inverse β decay reaction ^{71}Ga+$\nu_e \rightarrow ^{71}$Ge, which has a threshold of 233keV. It has succeeded the GALLEX experiment in April '98. Due to the low energy threshold the detection of the low energy pp neutrinos is also possible. They suffer least from uncertainties in the theoretical prediction and constitute about 90% of the integral solar neutrino flux. Currently they can be observed only by the experiments using gallium as target. For GNO the latter consists of 30.3t of gallium in the form of a 101t aqueous solution of $GaCl_3$. The ^{71}Ge atoms produced during a 3-4 week exposure are extracted from the target solution and detected via their backward decay, ^{71}Ge+$e^- \rightarrow ^{71} Ga^*$, with low background proportional counters. This decay is an electron capture process with a half life of 11.4d. Its signature is the emission of Auger electrons and X-rays.

To make use of the full potential of this experiment in respect to solar physics and non standard neutrino properties, a reduction of the total experimental uncertainty consisting of statistical and systematic contribution is necessary. The statistical uncertainty can be decreased by increasing the physical target mass, as it is planned for GNO, or by increasing the counting efficiency . A higher counting efficiency can be realized e.g. by a new detector concept.

The increase of counting efficiency can also be correlated with a reduction of the systematic error: The major contribution to the systematic uncertainty (>70%) is associated with the detection of the decay ^{71}Ge+$e^- \rightarrow ^{71} Ga^*$: Escape processes, a non homogeneous detector response in the counter volume and the prediction and setting of the energy acceptance windows for genuine ^{71}Ge events restrict the overall counting efficiencies to (65 - 75)% depending on the individual proportional counter. The probability of these processes is known with an uncertainty, which enters the overall uncertainty.

If these processes were excluded, the associated uncertainty would obviously not contribute to the systematics. Hence the improvement of counting efficiency simultaneously evokes a reduction of the systematic uncertainty.
We have designed and experimentally tested a new detector concept for a highly efficient detection of the ^{71}Ge decay without changing the chemical procedures in GNO. The latter were already optimized during the development of the GALLEX experiment and exhibit efficiencies over 95%.

The new detector concept is based on low temperature thermal calorimeters, which can offer a low threshold and a good energy resolution.

The low temperature calorimeters we are using consist of a dielectric absorber crystal and a thin superconducting metal film. The metal layer is stabilized in the transition region between its normal and superconducting state. There it is very sensitive to temperature variations, caused e.g. by an energy deposit in the absorber.

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