AN ANNEALING STATION FOR THE SEGMENTED GERMANIUM DETECTOR ARRAY

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Detectors incorporating crystals of segmented high-purity germanium mark a notable advance in gamma ray detection technology. An array of such detectors would allow significant improvements in gamma ray measurements. In 1997, a proposal was written [1] and in 1998 the NSCL received funding from the National Science Foundation (NSF) to begin construction of an array of 32-fold segmented germanium detectors.

Eurisys Mesures of France was chosen to manufacture the detectors. Contained in the germanium proposal were funds for the ancillary equipment required for the proper functioning of the detectors. This equipment includes a system to automatically fill with liquid nitrogen all 18 detectors simultaneously, a test stand to determine the exact position of the crystal within the cryostat and an annealing station to repair radiation damage in the detector crystals.

The annealing of germanium crystals which have been radiation damaged is but one of the many challenges in carrying out gamma ray detection. Germanium crystals used in gamma ray detection are often exposed to fluxes of neutrons. This can also occur at the NSCL where extraneous neutrons are produced via fragmentation reactions. Neutron radiation can cause serious resolution loss in germanium and other semi-conductor detectors. Neutrons entering a detector crystal collide with the germanium nuclei in their highly ordered crystal lattice. Such defects formed in the crystal reduce the detector's ability to efficiently detect gamma rays. Annealing is a process in which glass, metals and other materials are treated to render them less brittle and more workable. Material is heated and then cooled slowly and uniformly. Annealing lessens the possibility of failure by relieving internal strains. In the case of germanium crystals, annealing allows the crystal lattice to reform, thus restoring the detector's resolution. This presented a challenge. The NSCL needed a method to anneal detectors efficiently and safely so they can be made readily available for experiments.

The annealing process will require the detectors to be unavailable for approximately five days. After warming to room temperature for one day, the detector will be attached to one of the two annealing systems where it will be under vacuum and the crystal will be heated to 100 °C. Following three days of annealing, the detector can then be removed from the annealing station and cooled to liquid nitrogen temperature over the course of one more day.

The annealing station consists of two identical systems, such that two detectors can be annealed simultaneously. Each system is comprised largely of two components: a vacuum system and a controller box.

The vacuum is provided by a Varian Minuteman Turbo-V250 Dry Pumping System. It consists of a 250 l/s, water-cooled turbo pump and a Vacuubrand MZ 2V diaphragm roughing pump (0.7 l/s). The pumping systems have achieved vacuums as low as 4×10^{-7} torr. Gauges for the system include two Varian "ConvecTorr" thermocouples and one Bayard-Alpert Ion gauge. All three gauges are controlled by a Varian "senTorr" Gauge Controller.

The control box was designed and assembled at Argonne National Laboratory, building on the experience gained there in designing similar control boxes for the Gammasphere detectors. The controller remotely controls the Varian pumping system and monitors the valve and vacuum status. The controller interlock must not allow annealing until the valve is open, the vacuum is good and the turbo pump is at full speed. If the valve closes, vacuum is bad, or the turbo pump goes off, the controller will stop the annealing process. The controller features a telephone dialer capable of paging a member of the experimental group if problems arise during the multi-day annealing process. The intelligence in the controller is a Programmable Logic Controller (PLC), model number CPU 31101, manufactured by Modicon.

Fig. 1: The Gamma Annealing Station showing the vacuum systems (below) and the controller boxes (above).

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References

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