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Program for Development of a Liquid Argon Calorimeter

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ABSTRACT

A specific program is outlined for the evaluation of liquid argon as a scintillator, and the development of large total absorption counters based on its use.

N O T I C E

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A companion CRISP note offers a review of the technique of total absorption counters, or calorimeters. There it is pointed out that one approach which is promising in principle, but which has not yet been realized in a full scale counter, is a continuous absorber of scintillating liquid argon (LA). In this note we suggest a program by which these counters could be developed.

We envision two stages of development: the building of a small counter and its use to investigate the fundamentals of scintillation of liquid argon in different states of purity, followed by construction of a device large enough to test performance as a hadron detector.

Stage 1

We need to know if the purity of the liquid argon is critical for production of the scintillation light and its transmission through the liquid. This is a study that requires some care, since the impurity atoms may fluoresce in the visible when they absorb the LA scintillation light, which is in the deep UV. A really thorough study would involve spectroscopy, but it is probably adequate to monitor simultaneously the UV light with a PMT with wave length shifter and the visible light with a plain PMT. The attenuation can be studied by varying the height in liquid in a vessel.

Since we want the attenuation length for the scintillation light to be several meters or more, the path length must be varied over about half a meter, to allow an adequate measurement.

Studies could also be made of the effectiveness of light collection. The light collection would be most uniform if the walls of the counter were covered with a diffusely reflecting substance. The approach which has been used in liquid helium counters of Siegal et al. is to coat the walls with white paint and then put a thin layer of wave length shifter on top. Measurements with and without the reflecting coatings would give the data necessary to evaluate the light collection in a large counter.

This device would also provide data on the time dependence of the light output, under different conditions. Present information indicates that LA is a "fast" scintillator but quantitative data are lacking.

At the same time, one would be able to study problems that might arise with photomultiplier tubes (PMT) at LA temperature. For example, one has heard that the counting rate in PMT with bi-alkali photocathodes may be limited by photocathode resistivity, though I have not observed this effect, even under rather extreme conditions. The resistivity will be even higher at low temperature though, and it may be a design consideration.

In general it seems that all the information needed for the design of a large detector, aside from the aspects dealing with nuclear-electromagnetic cascade development, can be obtained from the measurements with the small device.

Stage 2

The calculations and measurements reviewed in CRISP-72-45 "Calorimeters for ISABELLE", W. J. Willis, June 1972 are sufficient to give a rough estimate of the expected energy resolution in a large counter for high energy hadrons, but it is essential to test a detector at reasonably large scale to verify these estimates. Equally important is the experience which would be obtained and would indicate if much effort and expense is involved in the operation, relative to an ambient temperature device.

The smallest size that would reveal whether the gains expected by continuous sampling and good linearity are in fact realized, would be a cylinder about six feet in diameter and ten feet long. An optimum device for a test might add two feet in each of these dimensions.

A sketch shows a suggested design. The container is an adaptation of a standard LN_2 dewar. The phototubes are 2" diameter, costing about \$50 each, mounted along the walls, so that there are no windows involved. The dynodes are supplied from a common ribbon cable. Each anode is brought out and digitized separately. The temperature is maintained by a LN_2 cooling loop at the top.

The detector would be tested with electron beams, where the resolution might be determined by light collection uniformity, and with hadrons from 1/2 GeV to 30 GeV where there are competing mechanisms that limit the resolution. It might vary from 10% to 5% as the energy is increased.

The cost for the project would be largely in the scientific and technician manpower. The detector should prove useful in a number of AGS experiments; as an auxiliary device to the MPS, for example.

Figure 1. Full Scale Detector