NAL PROPOSAL No. 32

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# TEST AND CALIBRATE A LARGE NaI(Tl) TANC DETECTOR AND TO MEASURE NEUTRAL HADRON TOTAL CROSS SECTIONS

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Preliminary Proposal

to the

NATIONAL ACCELERATOR LABORATORY

to

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## 1. Introduction

A research program is presently under way at the High Energy Physics Laboratory (HEPL) to develop total absorption nuclear cascade (TANC) detectors for hadrons, both charged and uncharged, at super-high energies. Similar work, also at HEPL, has already demonstrated the very attractive characteristics possessed by total absorption shower counters (TASC) for electrons and $\gamma$-rays at high energies (see references 1 and 2 attached). These properties include 100% detection efficiency, large acceptance aperture, wide dynamic range, stability and simplicity of operation, fast time response and, not least, an excellent energy resolution. Monte Carlo calculations[3] lead us to expect that the properties of the TANC detector will parallel quite closely those of the TASC. At 100 GeV, for example, a TANC detector 7 nuclear absorption units in length and 3 absorption units in diameter should be able to define the energy of an incident hadron to 5% (FWHM). We propose to test at the National Accelerator Laboratory (NAL) a TANC detector which is already under construction at HEPL, and to apply this detector to physics experiments at NAL. This detector will be particularly suited to experiments demanding the detection and measurement of neutral hadrons.

To our knowledge no other laboratory is presently pursuing a TANC detector development program, and we know of no other instrument which has comparable potential at NAL energies. The most obvious alternative is the ionization calorimeter. This is basically a sampling device and is inevitably subject to the statistics of the sampling process. A reliable quantitative comparison between the TANC detector and the ionization calorimeter at NAL energies has not yet been made and will probably have to await the availability of the high energy test beams at NAL.

2. TANC Detector Development Program at HEPL

The aims of the current research program at HEPL include the following:

(a) The construction of a NaI(Tl) TANC detector 7 nuclear absorption units (~ 100 inches) in length and 2 absorption units (30 inches) in diameter. This detector will probably be available late in 1971 and will be initially tested at SLAC.

(b) A systematic study of the nuclear cascade process, both experimental and theoretical, in order to learn how best to construct a TANC detector.

(c) An investigation of the information to be gained from image intensifier photographs of the nuclear cascade in NaI(Tl). This should provide information on the incident hadron direction and possibly help to distinguish between different hadrons.

In addition, one of the participants in this proposed research program is currently engaged in a search for new scintillation materials which may be preferable to NaI(Tl) for TANC detectors. One possibility (see reference 4 attached) is thallium chloride, which is 1.9 times more dense than NaI(Tl) and should make possible TANC and TASC detectors correspondingly reduced in size. A small thallium chloride crystal, 3 inches in length and 3 inches in diameter, will soon be tested at HEPL.

3. Proposed Experimental Program at NAL

We propose, as Phase I of our experiment, to calibrate a large NaI(Tl) TANC detector at NAL up to the maximum energy possible using a momentum-analyzed proton beam. It will also be interesting and desirable to calibrate the detector in a pion beam.

The most obvious experimental applicationsof a calibrated TANC detector at NAL are the following:

(a) To survey the yields of $\gamma$-rays and neutral hadrons in secondary beams. Measurements of this type are presently being made at HEPL using TASC detectors, and preliminary studies have been made at SLAC.

(b) To measure neutron and $K_L^o$ total cross sections as a function of hadron energy. We have already made such measurements at SLAC (see reference 5 attached), using time of flight (and not a TANC detector) to identify and to define the energy of the hadron. The time of flight technique will not be possible at NAL and the use of a fully developed TANC detector will be essential.

We propose, as Phase II of our experiment, to measure neutron and $K_L^o$ total cross sections on hydrogen and deuterium as a function of hadron energy. These measurements will require substantially pure neutron and $K_L^o$ beams, or the development of a technique for distinguishing between those two beam components. We would be interested in discussions with the NAL staff aimed at developing the best experimental approach,as we become more familiar both with the properties of the TANC detector itself and the characteristics of the neutral beams at NAL. It is also very likely during this process that we will identify other applications of both TANC and TASC detectors at NAL. Such applications might also emerge from our current research program in neutral beams at SLAC.

4. Experimental Arrangements

Phase I of the experiment can be conducted in check-out of test beams. It is difficult to estimate the total amount of beam time required but we would expect a need for several days, not necessarily in one continuous run.

We anticipate that the experimental arrangement and procedures for Phase II of the experiment will be quite similar to those described in reference 5 (with the substitution, of course, of a TANC detector as the primary hadron detector). Liquid hydrogen and deuterium targets approximately one meter in length will be required. The measurements will be made by the good geometry technique and the targets will be rotated in and out of the beam at frequent intervals. The total beam time employed will be quite short. Assuming a neutral hadron flux of $10^4$/sec/10 GeV/c , measurements of an adequate statistical precision can be obtained in a matter of hours. In practice several days will probably be required for testing and several more for the systematic accumulation of satisfactory data. With the exception of sweeping magnets and beam collimators, all of the experimental apparatus can be supplied by HEPL.

## REFERENCES

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