Liquid Nitrogen/Argon Bubble Chamber Design Project

Final Report of Work Under

Grant AFOSR-61-86

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This research was supported by the
General Physics Division, AFOSR,
SRPP
under [redacted]/Grant AFOSR 61-86

I. Introduction

This project was undertaken with the purpose of designing some equipment for research in high-energy physics, and of planning experiments to be done at the ZGS accelerator at the Argonne National Laboratory. Three lines of investigation were followed: the design of a bubble chamber suitable for use with liquid nitrogen or liquid argon; the design of a spark chamber for some specific experiments; and the detailed investigation of several experiments.

II. Bubble Chamber

A 3" diameter bubble chamber was built to test the operating characteristics of a number of liquids. Since the initial measurements were to be made on liquid nitrogen and liquid argon, a very simple gas expansion system was used. The expansion was accomplished by simply releasing the gas above the liquid to the atmosphere. This type of expansion has the advantage of extreme simplicity. The disadvantages--rather slow expansion (10 ms), increased load on the cooling system, and high gas consumption--are more than compensated for by the increased reliability and ease of operation. For testing gases which cannot be released to the atmosphere (because of expense, fire hazard, etc.) a piston expansion system has been built.

The bubble chamber was tested by photographing the tracks formed by Compton-scattered electrons from a Na^{22} γ-ray source.

In liquid nitrogen tracks were observed when the initial pressure was in the neighborhood of 18 atmospheres absolute. Liquid argon is sensitive at a pressure of 26 atmospheres. The temperature of the gas is the boiling point of the liquid at the indicated pressure.

A 12" diameter chamber built along the lines of the 3" prototype is entirely feasible. Larger diameters become questionable due to the rather high pressure required for the liquids used.

A more complete description of the bubble chamber and of the measurements is contained in the master's thesis, "The Characteristics of a Bubble Chamber using Liquid Nitrogen and Argon" by David E. Pellett, University of Kansas, 1962. A brief statement of results has been submitted to the journal, <u>Nuclear Instruments and Methods</u>.

III. Spark Chamber

Two spark chambers were built with active volumes of 4" x 6" x 2" and 9" x 12" x 13" respectively. Since we were primarily interested in using the spark chambers to identify particles either by range or by the interactions in the plates, we considered primarily the design of chambers using thick metal plates.

The spark chambers were built by stacking plates inside a gas-tight box connecting alternate plates to ground, and to a pulsed voltage source. The small chamber contained three high voltage plates and four ground plates, i.e., six gaps;

the larger chamber contained nine high voltage plates and ten grounded plates. The plates were only slightly rounded on the edges and corners. Plates were stacked with lucite spacers 1/2" diameter 1/4" thick. It was found necessary to hold the tolerance on the thickness of the spacer to about 0.01 mm, to insure uniform sensitivity within the chamber. Sparking over the insulators was eliminated by the simple procedure of placing 3/4" squares of Scotch Electrical Tape on the corners of the plates so that the lucite insulators rested on tape rather than directly on the metal.

The small chamber was used in a series of tests of various filling mixtures. The simplest mixture we found was one using pure helium with a quenching gas - ethyl acetate. With no quenching gas, the chamber was insensitive due to a corona-like discharge over the insulators and the edges of the plates. With too much quench, the chamber again becomes insensitive. Over a wide range of concentrations, centered near 0.4 ml of ethyl acetate (liquid) per cubic foot of helium (atmospheric pressure) a uniform sensitivity near 100% is obtained.

In the tests with the small chamber, a single scintillation counter was used to trigger the voltage pulse. Many of the particles which passed through the counter did not pass through the spark chamber, so that the voltage pulse was applied to the chamber when no ionized track existed in the chamber. With a long voltage pulse, sparks always develop somewhere in the chamber. However by shortening the pulse, the chamber could be made quite stable in the absence of an ionized track.

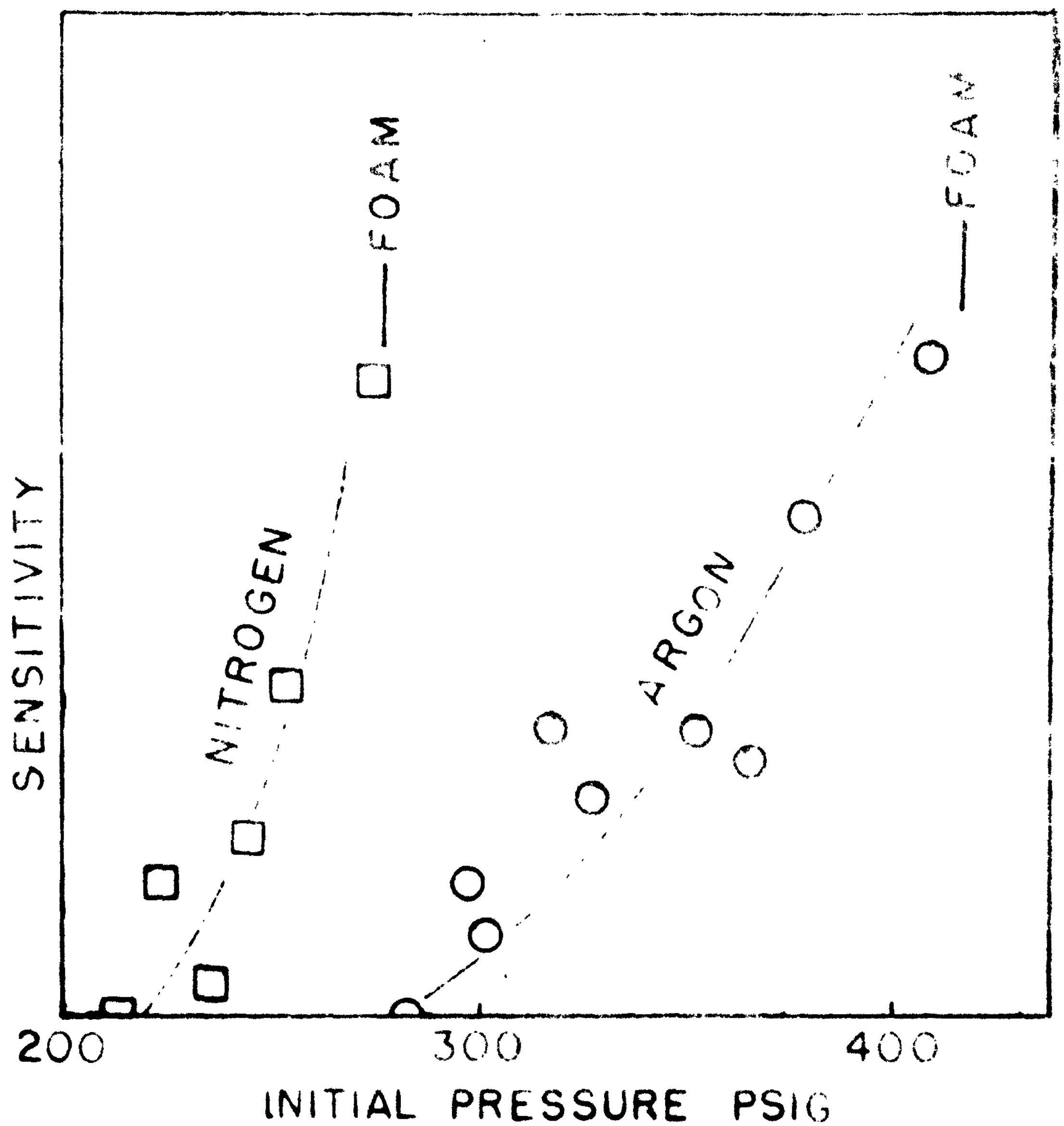
The power supply for the large chamber consists of a regulated high voltage supply which charges a capacitor bank of 30 500 $\mu\mu$f capacitors to about 15 kv. All capacitors are discharged by a single triggered spark gap. The pulse is transmitted to the chamber through 5 RG-8U cables connected in parallel. Each of the nine high voltage plates is connected to the cable assembly by a 56 ohm decoupling resistor.

The system has been tested for long periods and is quite satisfactory and reliable. It may be used as is - or scaled up or down to fit the needs of a specific experiment.

IV. Experiments

Some work has been done on possible schemes to detect the leptonic decay of the ω or η particles, (as suggested by Nambu and Sakurai, Phys. Rev. Lett. 8, 79 (1962). The most reasonable scheme appears to be by a system using two sets of spark chambers, one with thin plates near a liquid hydrogen target in which the particles are formed, and a second chamber with thick plates to distinguish between μ and π mesons, either by range or by nuclear interactions in the plates. The first chamber is required to give angular measurements of sufficient accuracy to establish the existance of the ω or η particles in the original interaction. A very short run in which the spark chambers would be triggered by the beam incident on the target would be sufficient to show the number of ω or η particles per incident pion. To determine the decay to μ mesons, the μ's would be used to trigger the spark chambers. From the observed tracks, one may eliminate the μ's formed by π decay or by contamination of the incident beam.

Some detailed calculations on the kinematics, multiple scattering to be expected, and the required accuracy of various measurements have been made. Work is being continued on this proposed experiment and will probably result in a proposal for time on the AGS accelerator at Argonne.


SENSITIVITY
INITIAL PRESSURE PSIG
200
300
400
NITROGEN
ARGON
FOAM
FOAM