Neutron Measurements at NWA

A question which arises in considering scintillator as a fast trigger element for muons at the SSC or at high luminosity colliders is the flux and energy spectrum of soft (1 MeV neutrons) which are produced in hadronic showers in calorimeters or beamline elements. There is concern that in high rate environments a neutron sea will exist giving rise to an unacceptable number of accidentals in a level 1 scintillator trigger designed to make a crude but fast muon momentum measurement. The question of neutrons is also important for designers of the inner tracker elements at the SSC which need be concerned with radiation damage from neutrons in silicon detectors and electronics as well as the effect of neutrons on gas filled straws containing hydrogen. Finally, hard data on the flux and energy spectrum of neutrons arising from hadronic showers could serve as a benchmark to test hadronic shower and neutron transport Monte-Carlos such as Geisha/Anisn and Hetc/Morse.

We propose to make a series of measurements in the NWA beamline at Fermilab where D0 (E-740) is presently calibrating different sections of its calorimeter. Using Bonner spheres, three liquid scintillator counters, and plastic scintillator counters (see Figure 1) we will measure the neutron flux and energy spectrum at several different locations around the D0 calorimeter test load at several incident momenta from 10 - 150 GeV. If time permits we will also move the calorimeter off the beamline axis and measure the neutron rate behind the NWA iron beamstop. We will also investigate various thicknesses and types of shielding to reduce the counting rate from low energy neutrons.

We believe there to be no electrical or mechanical safety hazards associated with the scintillation counters or Bonner spheres. Each detector has one signal and one high voltage cable running from it to an electronics rack containing a Camac crate and several Nim bins. We employ no high current DC power supplies or flammable gas. To date we have run completely parasitically with the NWA test beam experiment (i.e. we have had no control over beam type and momentum or controlled accesses) however we are in the process of negotiating for a small amount of dedicated beam time for the iron beam stop measurement before the end of the present fixed target period.

The status of these measurements is that the detectors and PC based data acquisition system were installed in early July. Several weeks were spent calibrating the detectors using an Am-Be source and data taking commenced soon thereafter. The biggest problem we presently face is a large background of low energy neutrons coming from either the NE or NT beamlines (sections NE8 or NE9) or from the primary target dump for the NWA line (section NW4). Figure 2 shows a plot of the number of neutrons as a function of pulse height ratio for a liquid scintillator detector when the NWA line was off. (We use a poor man's pulse shape discrimination to tag neutrons from gammas and muons by splitting the phototube anode signal and sending the two signals to ADC's with a short and long gate length. The pulse height ratio is the ADC counts taken with a short gate divided by that using the long gate.) Figure 2 shows a large background of neutrons and presumably muons and noise not associated with the NWA secondary beam. By gating the neutrons with a 750 ns beam gate defined by beam particles in the NWA line we are able to eliminate most if not all of this background. The resulting number of neutrons from a pion beam incident on the D0 calorimeter is shown in Figure 3. We are in the process of sending the neutron triggers to a TDC in addition as a further check that what we are seeing is associated with hadronic showers in the calorimeter.

The project manager for this activity is Kenneth Johns of the University of Arizona. Contributing graduate students are Eric James, David Fein, and Kam Kwong from Arizona. The Radiation Safety Department at Fermilab expressed interest in our neutron measurements also and Marcia Torres, a graduate student at the University of Michigan, is collecting data with the Department's Bonner Spheres as part of her PhD thesis.

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Figure 2

length of run = 149s

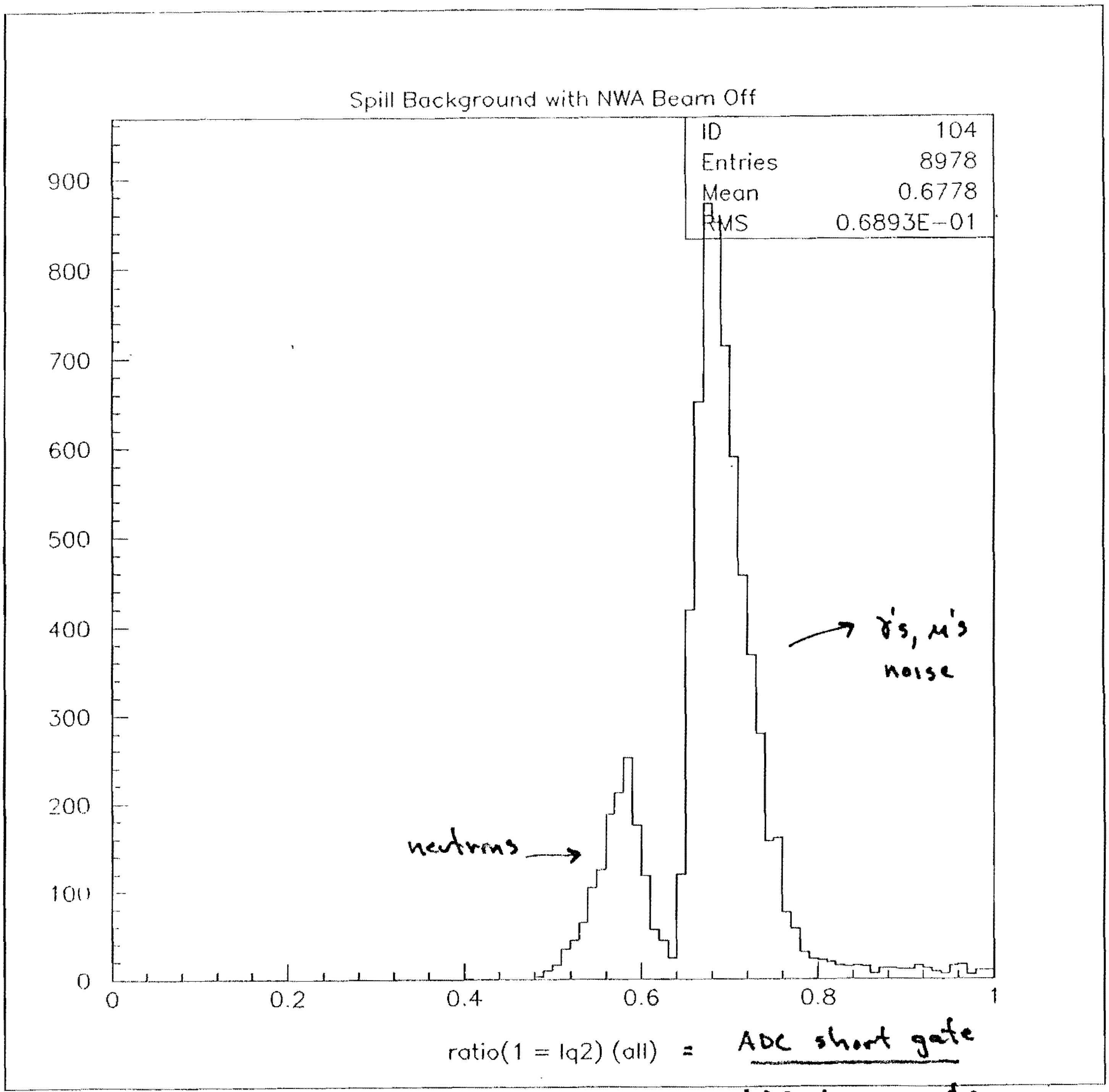
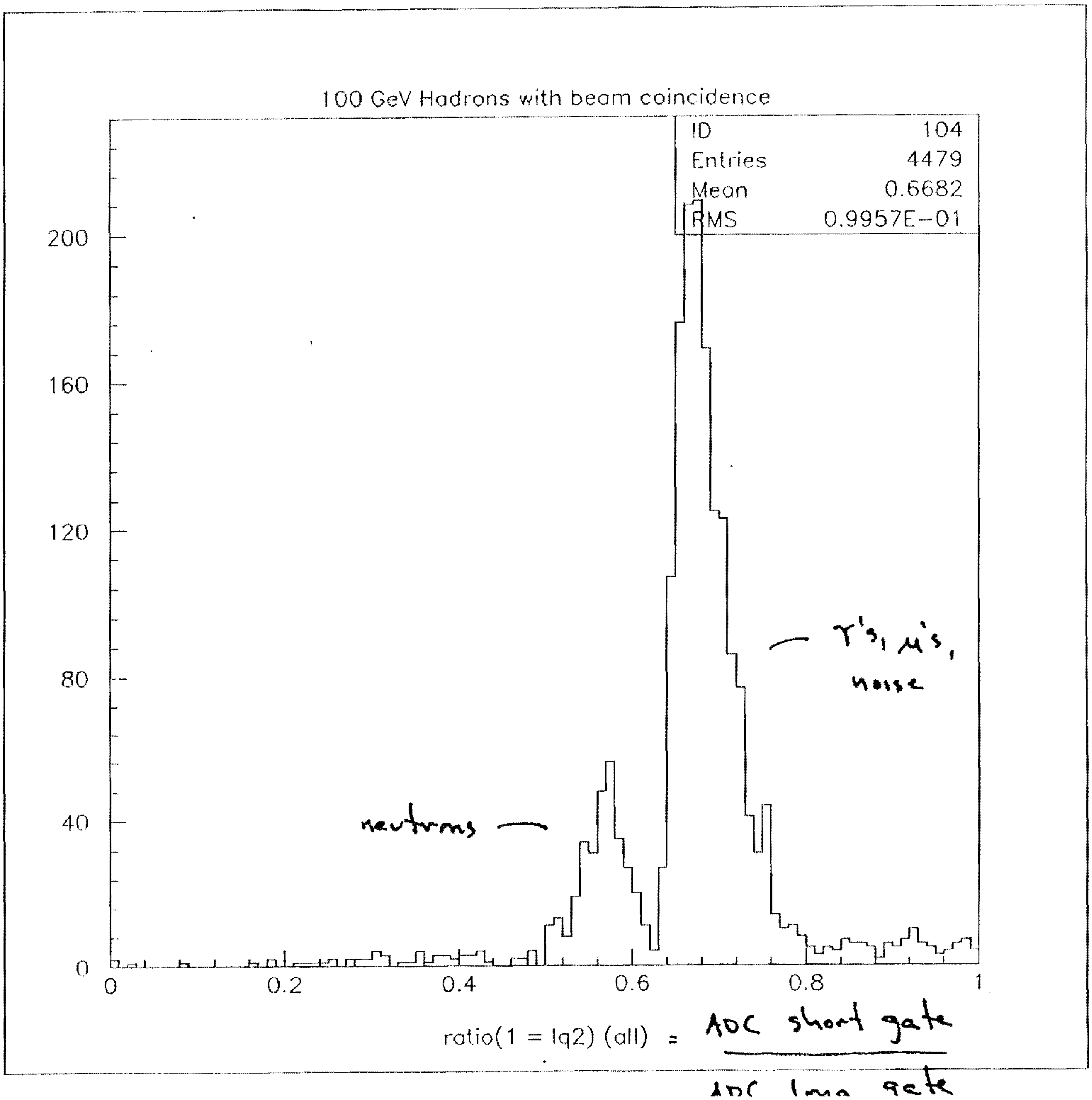
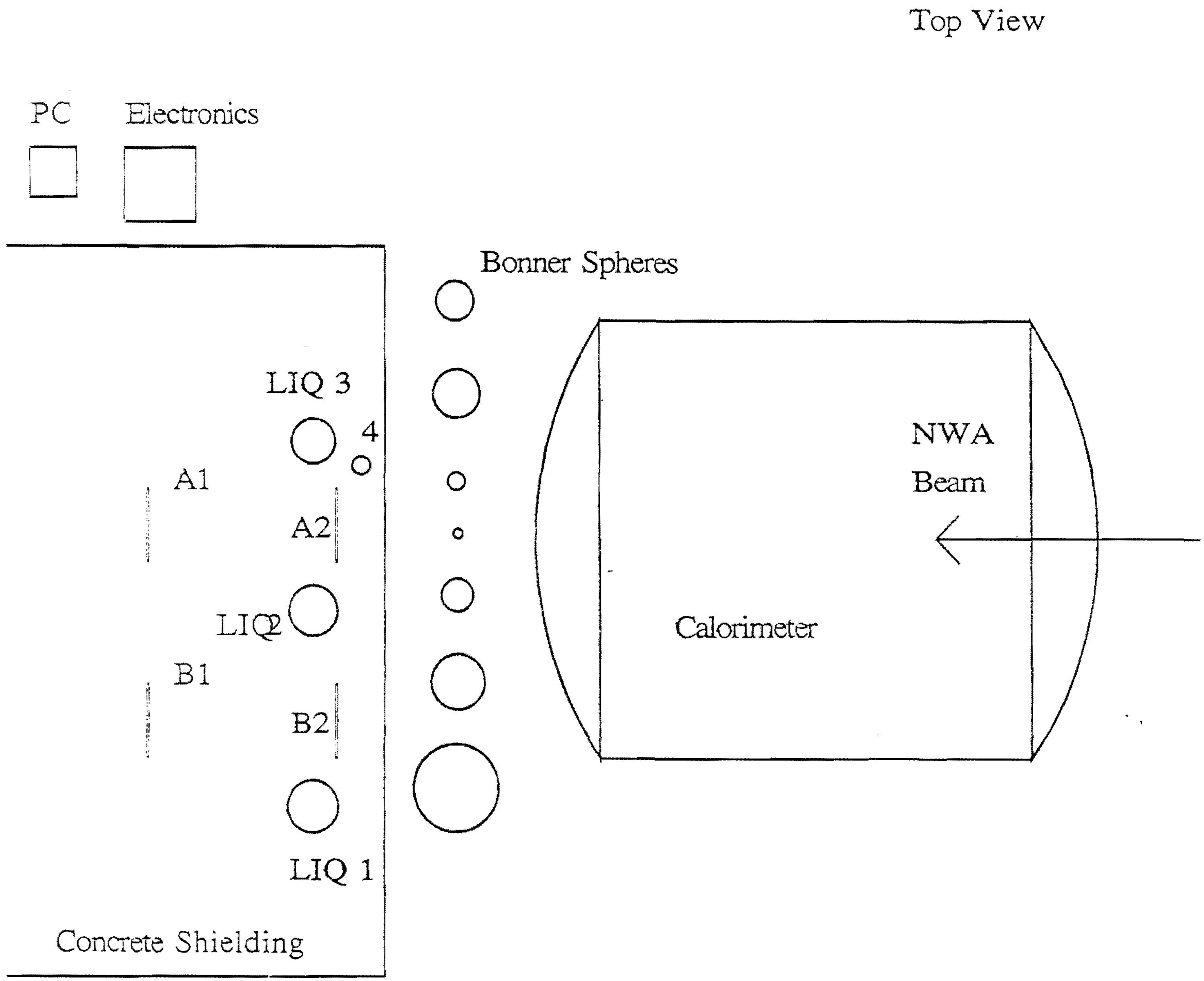


Figure 3

length of run = 874 s
beam counters = 3212007





LIQ 1,2,3 : Liquid Scintillators

4 : Sodium Iodide detector

A,B : Plastic Scintillator

Figure 1