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STATUS AND PRELIMINARY PERFORMANCE WITH COSMIC DATA OF THE WARM IRON CALORIMETER IN SLD[*]

SLD–WIC Collaboration

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1. Introduction

The SLD is an e^+e^- detector optimized for Z^0 physics, and is approaching completion at the Stanford Linear Accelerator Center (SLAC). The Warm Iron Calorimeter (WIC) is a device built using limited streamer tubes to instrument the magnet yoke, and has a double purpose: it will measure the energy of tails of hadronic showers escaping from the Liquid Argon Calorimeter (the main instrument of SLD calorimetry) and the coil, and it will also be used as a muon identifier and tracker.

The design choices, construction details, and expected performance have already been described elsewhere.[1] In this note, we report on the present status of the WIC, and show some preliminary results obtained from cosmic ray data.

2. Overall system integrity

The WIC tubes are operated at a voltage of 4.75 kV (the nonflammable gas mixture 88%CO_2–9.5%iC_4H_{10}–2.5%Ar is being used[2]).

After about 1000 hours of continuous operation, there are 165 disconnected tubes in the WIC, compared with a total of $\sim$ 8600 streamer tubes. This figure includes modules disconnected because of gas leaks, as well as modules which have been strained during installation, due to different mechanical mounting, and are known not to work properly. Most of the tubes which failed to hold HV did so during the first few hours after turn-on.

The WIC electronics[3] is designed to acquire data from $\sim$ 90000 strip channels and $\sim$ 9000 calorimetric towers. The readout is actuated for the strips via 3000 32-channel boards,[4] supervised by 42 controllers/multiplexers[5] and 6 FASTBUS custom modules.[6]

For the pad readout,[7] the signals from towers are sent via shielded cable to 64 VME cards, housing the preamplifier hybrids and sample-and-hold devices, and are read out serially under the control of 16 VME cards containing ADCs and timing functions. The number of problem channels in the detector is below the 1% level;

most of these are due to hardware shorts to ground, or towers shorted together, and can easily be recovered.

3. Trigger and data taking

The WIC is a self-triggering device: the outputs of the onboard common threshold discriminators are added to give a fast OR of the 32 channels of each board, and this OR can be daisy-chained to other boards in a physical layer of chambers. The individual digital ORs from separate layers are then added in the controller cards, and compared to a (programmable) minimum number of triggered layers, to build a "modular" intelligent trigger, which also has the capability of requesting specific layers, and ignoring noisy ones. These modular triggers are finally combined into the Cosmic Logic Unit (CLU)[8]: a FASTBUS module which generates an SLD-wide trigger, by requesting, under software control, any combination of digital ORs from the detector. A typical trigger is the request of two tracks in opposite octants.[◇]

Up until now, several hundred thousand cosmic muons have been recorded in the WIC, usually requiring the coincidence of diametrically opposed octants of the barrel as a trigger. Different combinations of octants have been used, in such a way as to illuminate the detector as uniformly as possible. A characteristic event is shown in Fig. 1.

WIC triggers are routinely used by other SLD subsystems to collect cosmic rays, for calibration and diagnostic purposes. A special ("pointing") trigger was also developed, using four special layers in each octant, equipped with strips transverse to the beam direction, in order to trigger on cosmic muons passing through the center of the detector: this type of trigger was used to obtain tracks useful for calibration of the Central Drift Chamber.

◇ The CLU was not yet implemented at the time this report was given, and in its place a normal fast coincidence, gated with the beam crossing signal, was used. The CLU has been installed since then, and found to perform according to specifications.

4. Preliminary performance of the detector

The behavior of the WIC as a calorimeter, as well as preliminary results of its performance, are extensively reported in Ref. 7. One typical event is shown in Fig. 2: the two lego-plots refer to the twofold segmentation in depth of the WIC towers, and the two axes of each plot (ϕ and θ channel number) cover the entire solid angle. The two peaks correspond to the entrance and exit points. In Fig. 3, a distribution of pulse heights is given, with pedestals subtracted. In both Figs. 2 and 3, the data were not corrected for geometric effects.

The single-layer efficiency and average cluster size have been studied, using muon tracks, as a function of the threshold on the strip discriminators. Figure 4 shows that the efficiency is stable over the whole range of thresholds from 2 to 8 mV. The average value of 85% is in good agreement with expectations from earlier measurements, taking into account the dead zones between chambers in the same layer. The average cluster size decreases smoothly with increasing threshold, and the optimal setting point is at 2–3 mV. In fact, while efficiency does not decrease appreciably raising the thresholds beyond this level, the rate of clusters with two consecutive strips to the "normal" 3-strips clusters becomes higher, affecting adversely the resolution.

The efficiency can also be plotted as a function of the angle of impact of the muon on the chamber. In Fig. 5, the horizontal axis represents this angle (in absolute value), projected in a plane orthogonal to the wires. It can be seen, according to expectations, that the effect of dead regions between chambers is more relevant for orthogonal crossing.

A preliminary measurement of the spatial resolution obtainable from WIC strips is given in Fig. 6, in which we plot the difference between the measured point in one layer, and its expected position (from a fit of all other layers to a straight line). The central part has been fitted to a Gaussian having $\sigma = 4.4$ mm, and the tails are due to low-momentum muons, the trajectories of which are more affected by multiple scattering, and more bent by the magnetic field in the iron. No cut has been made on the χ^2 from the track fit. Work on software alignment of chambers is still in progress, and data taking with field both on and off will help to reach the design resolution in the near future.

5. Conclusions

Some preliminary results from analysis of cosmic ray data taken using the Warm Iron Calorimeter built for SLD have been shown. These results already demonstrate the capabilities of the WIC to operate as expected, both as a calorimeter and as a muon identification and tracking device.

References

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4. See Ref. 3, and references therein.
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6. G. M. Bilei et al., IEEE Trans. on Nucl. Sci. NS–35 (1988) 282.
7. P. N. Burrows et al., SLAC–PUB–5305, August 1990.
8. See contribution by M. Carpinelli, in these proceedings.

Figure Captions

1. A representative cosmic-ray event as seen by the WIC strips.
2. A typical cosmic muon in the WIC calorimetry towers.
3. Distribution of pedestal-subtracted pulse height for WIC towers.
4. Variation with discriminator threshold of efficiency and average cluster size for WIC strips.
5. Efficiency of WIC chambers as a function of crossing angle.
6. Distribution of fit residuals for cosmic muons.

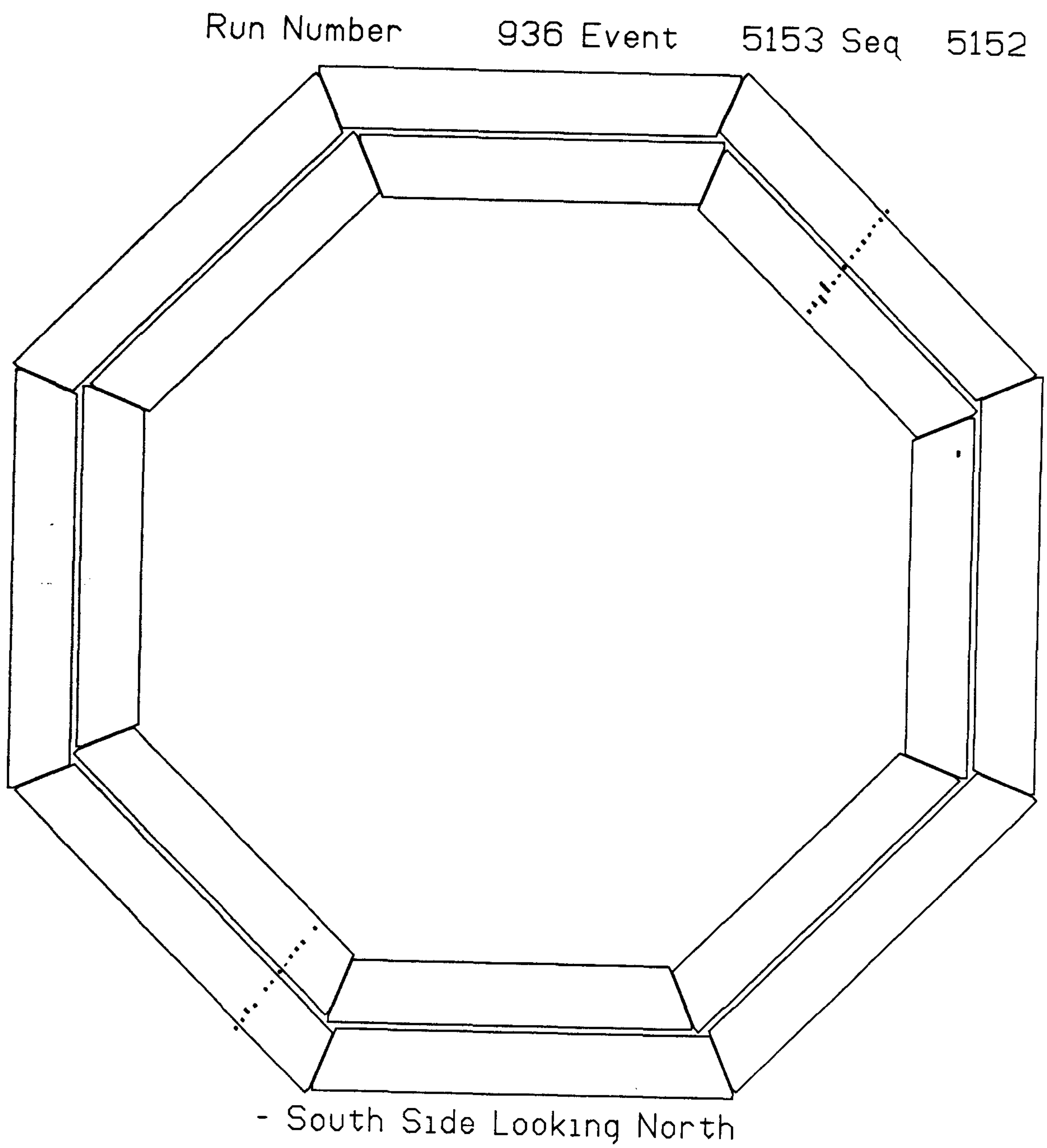


Fig. 1

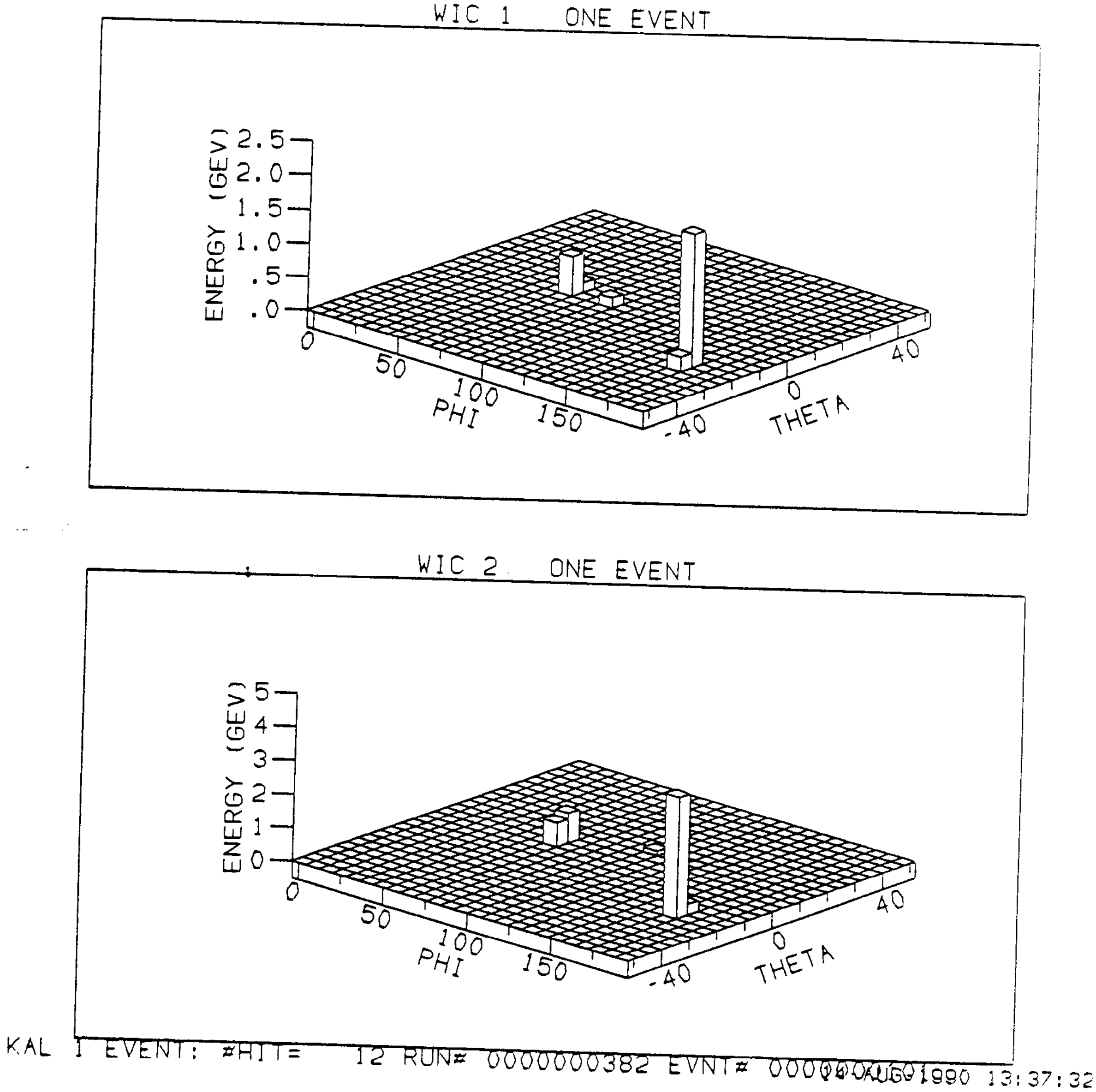

WIC 1 ONE EVENT
ENERGY (GEV)
2.5
2.0
1.5
1.0
.5
.0
0
50
100
150
PHI
-40
0
40
THETA
WIC 2 ONE EVENT
ENERGY (GEV)
5
4
3
2
1
0
0
50
100
150
PHI
-40
0
40
THETA
KAL 1 EVENT: #HIT= 12 RUN# 0000000382 EVNT#
1990 13:37:32

Fig. 2

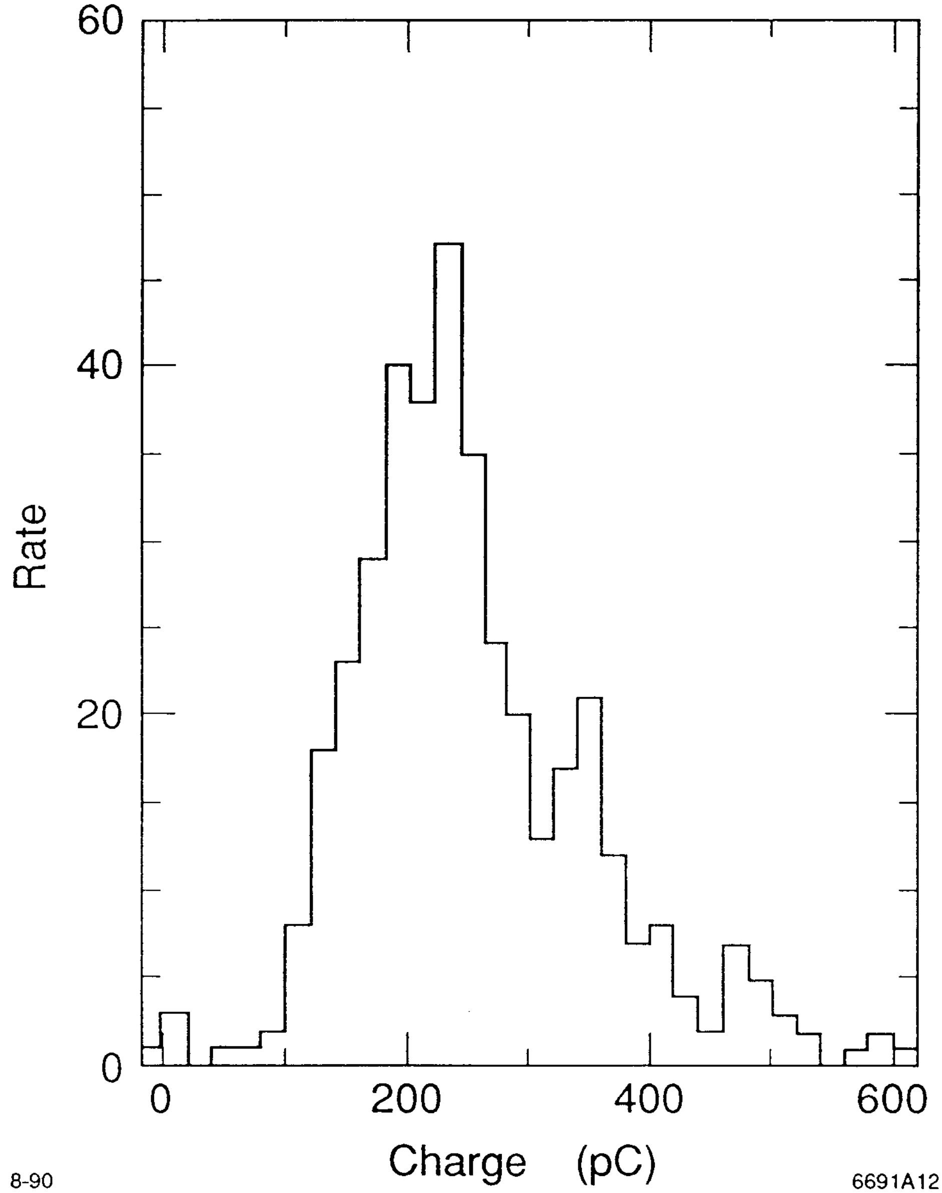
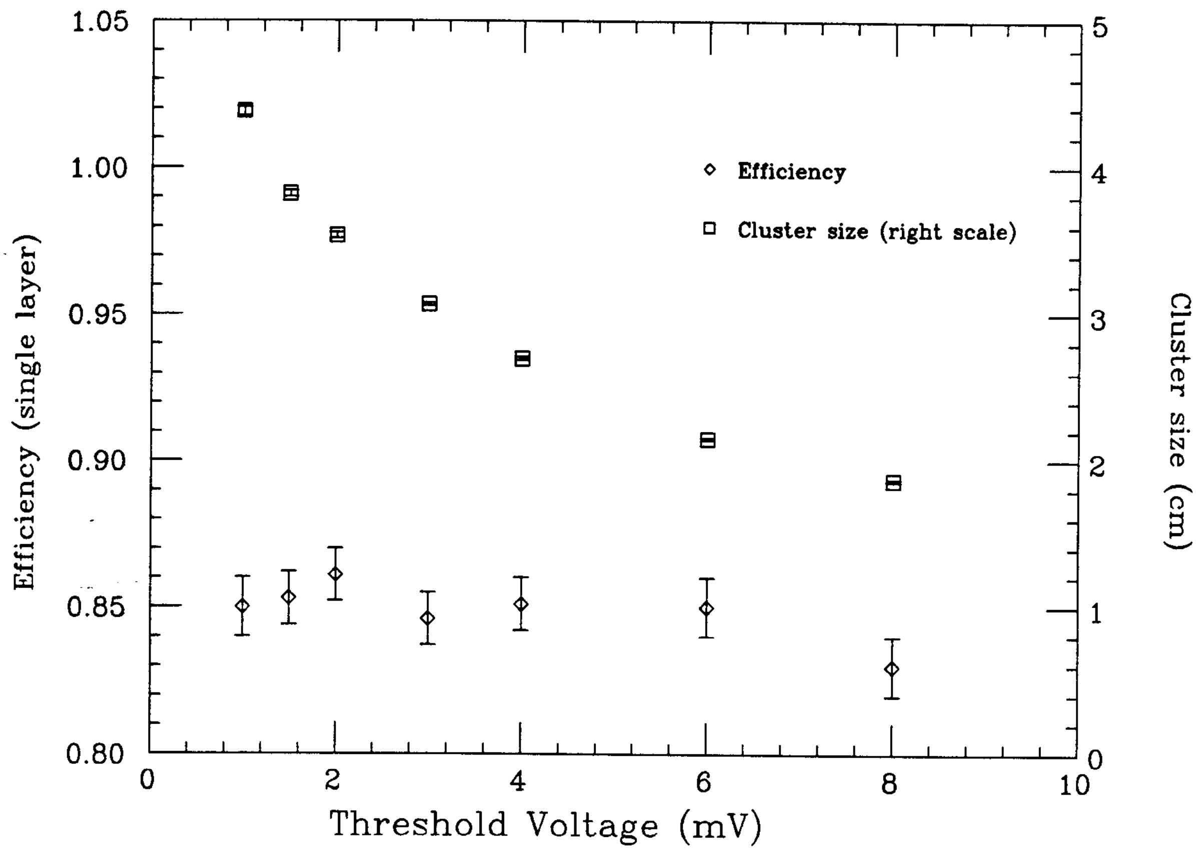
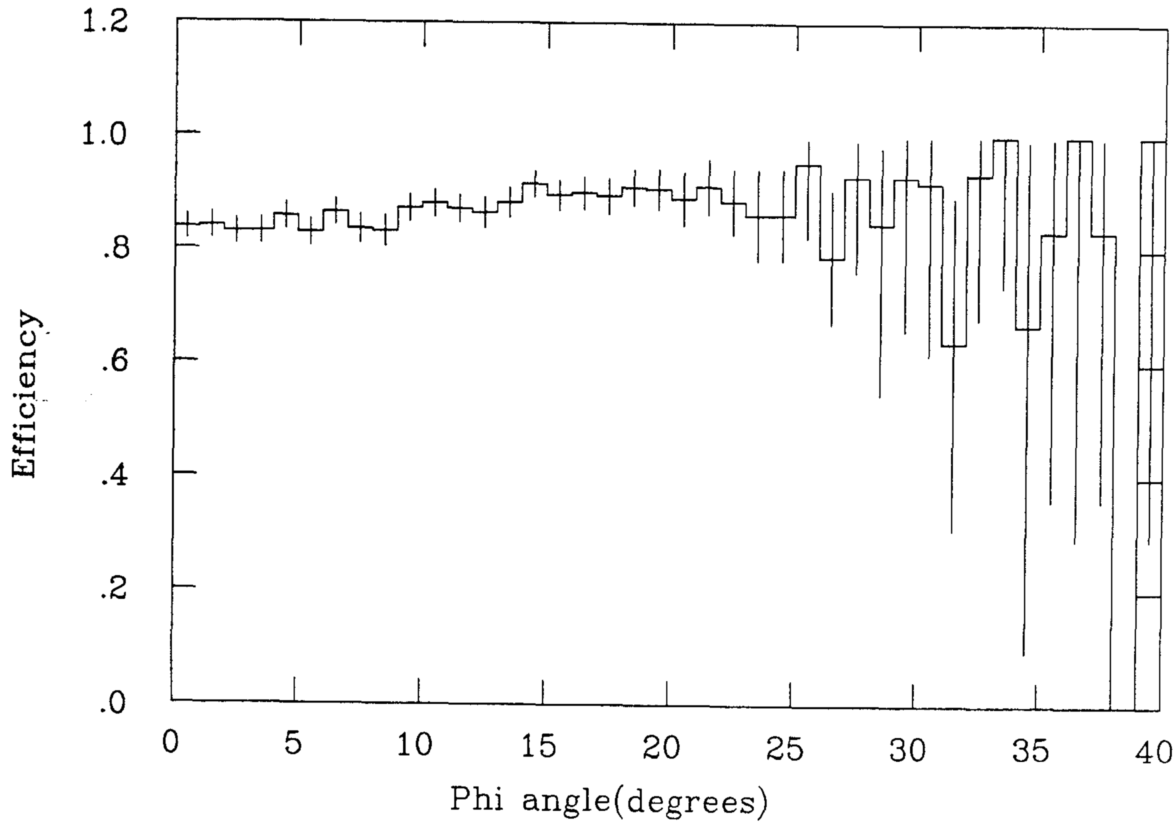


Fig. 3



1.05
1.00
0.95
0.90
0.85
0.80
0
2
4
6
8
10
5
4
3
2
1
0
Efficiency
Cluster size (right scale)
Efficiency (single layer)
Cluster size (cm)
Threshold Voltage (mV)

Fig. 4



1.2
1.0
.8
.6
.4
.2
.0
Efficiency
0
5
10
15
20
25
30
35
40
Phi angle(degrees)

Fig. 5

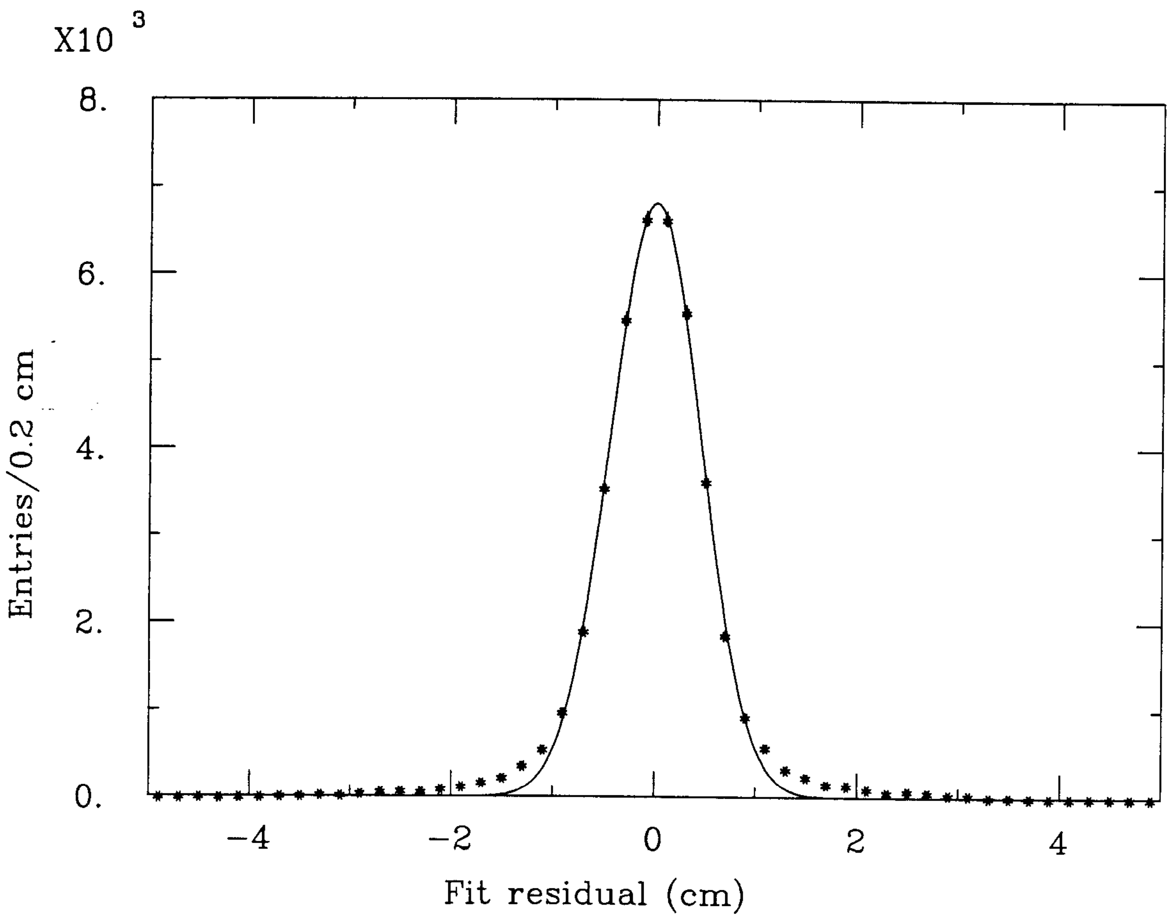


Fig. 6