EXPERIMENT-MONTE CARLO COMPARISON

SASY Tech Note 10, M. Blecher, VA TECH, 9/24/97

In this note experimental (EXP) data from april'97 (target was liquid H) is compared with Monte Carlo (MC) data. The target center was 3 xtals downstream of the XTAL BOX center along the beam during these runs. The EXP data were prepared by M. Lucas and A. Cichocki as described in other LEGS Tech notes.

DATA PREPARATION

Briefly, the experimental data were prepared as follows. Pulse heights and times in the endcap (EC) bars (B) and vetos (V) were aligned on a run by run basis. Similarly for the pulse heights in the xtals (X). A subset of events in which charged particles struck B 10-13 and neutrals deposited the most energy in one of the nine central X of the bottom face were chosen. In my notation the X columns run from 1-10 with 1 being most upstream and the rows run from 1-9 in the direction transverse to the beam. The correct X are in rows 4-6 and columns 5-7.

Once ADC and TDC channels were aligned overall normalizations to energy (E) and time (t) were obtained by lining up the peaks with those from MC generated γp$\rightarrow$ π^0p data. In this case initial photon energies, k$\approx$290-310 MeV were used. Then events with k=248.5-252.5 were passed to me for analysis and comparison with MC.

Both γp$\rightarrow$ π^0p and γp$\rightarrow$ γp data were generated using photons of the same central tagger energies, k_c as found in the EXP data. These weren't smeared with the tagger resolution (FWHM=5.5 MeV). This is a small effect which was checked later in the analysis. Figure 1 shows the k_c spectra for the EXP data (top) and the MC data (bottom). The solid angle for the final state π^0 and γ was 0.25882 > cosθ > -0.70701, 0 < ϕ < 360 deg. Thus most MC events didn't satisfy the criteria of striking the correct B or X and were thrown out. However, there is no bias in this case because the same occurs for EXP data.

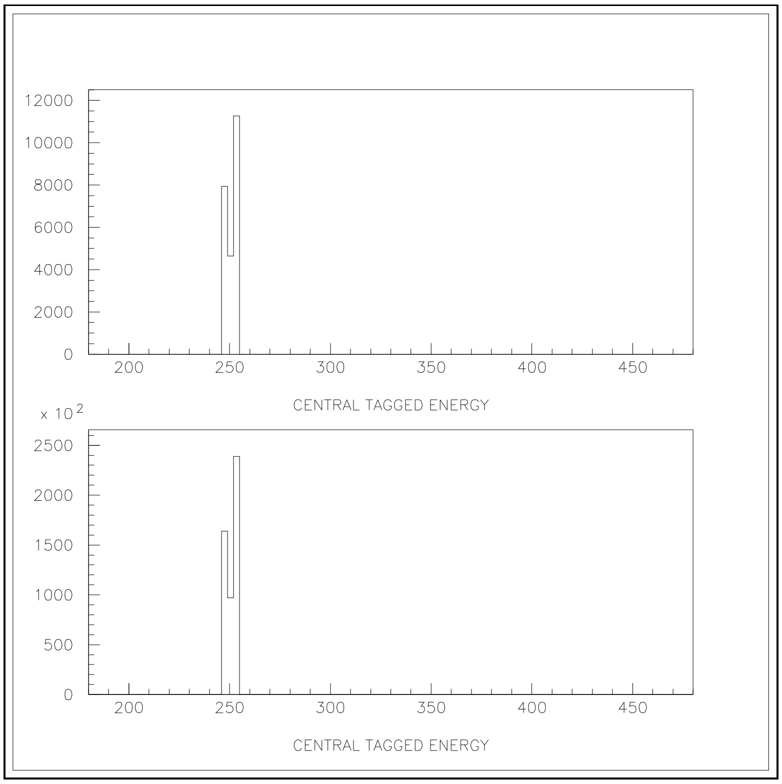

FIG. 1. Central tagged energy spectra: EXP (top), MC (bottom).

The MC events were passed to the smearing part of my code. There the E deposited in the V and B were smeared with a gaussian of σ=0.15E. The t were smeared with a gaussian of sigma = 0.3ns on each end, zero time (t_{tag}) was smeared with a gaussian of 0.6 ns, and then t relative to t_{tag} was digitized into 0.5 ns bins. A walk correction for varying E had little effect over a fairly wide range. To treat the MC events like EXP events I required a similar energy cut on the X (total E > 100 MeV), as required by M. Lucas.

HIT ANALYSIS

After the above smearing and selection both EXP and MC events are histogrammed. In the following figures the solid histogram is for EXP data and the dashed histogram is for MC data. The total number of EXP and MC events are made equal. Figure 2 shows several distributions. The number of X clumps above threshold (E > 5 MeV) is either 1 or 2 as expected, although MC sees more 2 clump events. The multiplicity of the points (E > 2.5

MeV) in such clumps is similar. MC indicates fewer events with only one point. The number V and B points above threshold (0.5 MeV) is typically 1 as expected. A few experimental events show more than 1 hit B, but since experiment looks at everything possible that is to be expected.

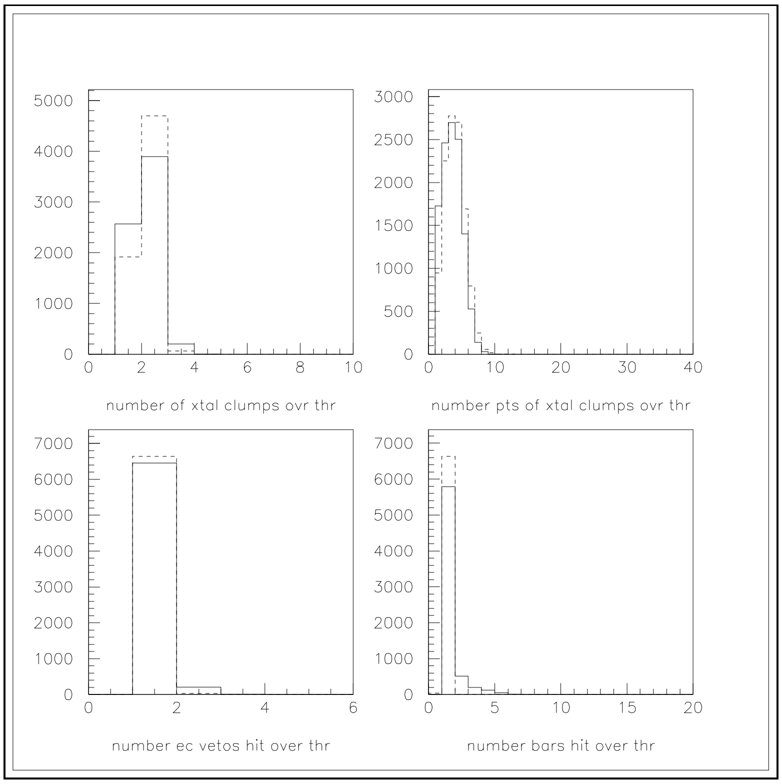

FIG. 2. Various distributions in X and EC, solid(EXP), dashed(MC).

In figures 3-6 the B E and t, the highest E X clump, and the V E are shown. The four sections of the plot are for cases when B 10,11,12, or 13 has E above threshold. It is clear from figure 3 that the experimental energy spectra have much worse resolution and an undesirable high energy tail. The latter is partly but not totally responsible for the fact that the EXP means are much larger than the MC means. Only for B 11 are the means nearly equal. In this case the MC rms=8.7 MeV while the EXP rms=12.5 MeV. This includes the 15% MC energy smearing on the B and is an effect that must be improved. In figure 4 the B t are shown. B 10 and 11 have overlapping means and somewhat greater EXP rms values. There must be an error in the EXP B 12 t. There is no change in the mean from that of B 11, however, protons scattered at larger angles into B 12 are moving slower. The EXP B 13 spectrum would be okay if not for very small time events. As you will see these are cut in the Compton analysis.

The highest X E clump shown in figure 5 have larger MC means: 3,4, and 2 % larger when B 10,11, and 12 are hit, respectively. The rms values are similar and if anything the EXP resolution is slightly better and indicates no need to smear the MC X E. The EXP data shows [sharper,broader] [low,high] energy sides which may indicate some EXP nonlinearity. In figure 6 the V E spectra indicate that the shapes are in agreement but the EXP means are too low (by 1.3, 0.9, 2.5 MeV for B 10, 11, 12).

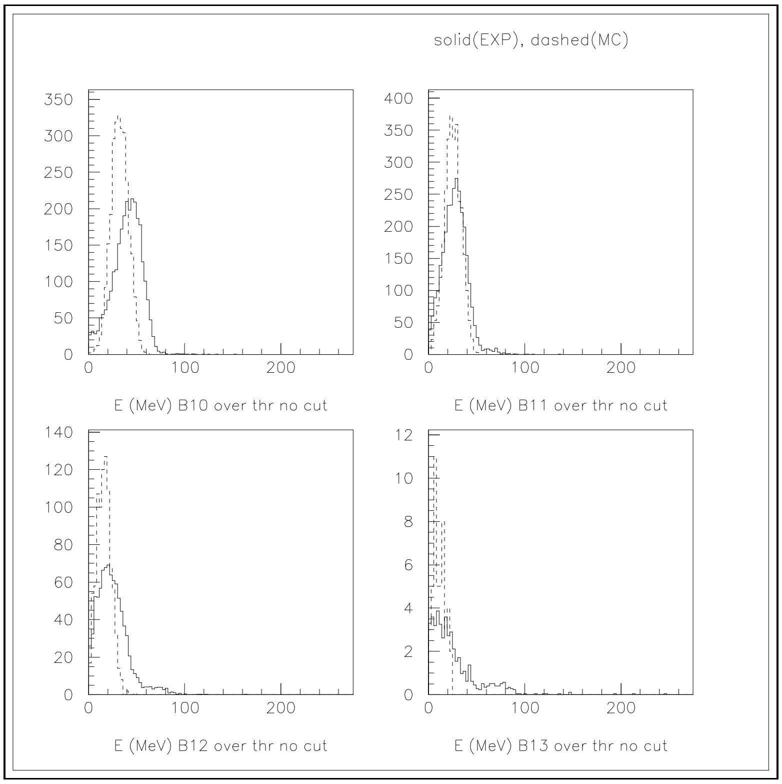

FIG. 3. Energy spectra (MeV) B 10-13, solid(EXP), dashed(MC).

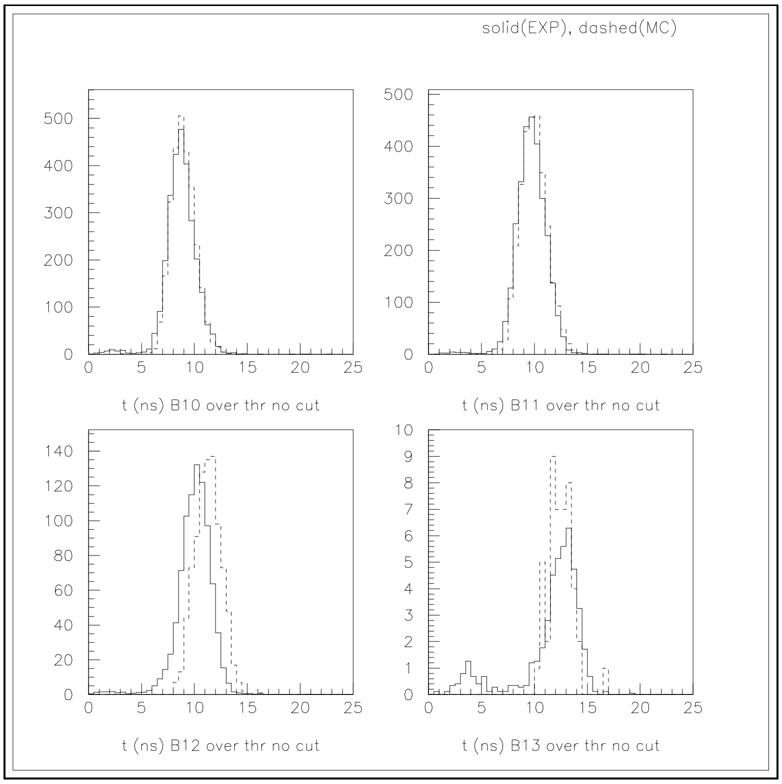

FIG. 4. Time spectra (ns) B 10-13, solid(EXP), dashed(MC).

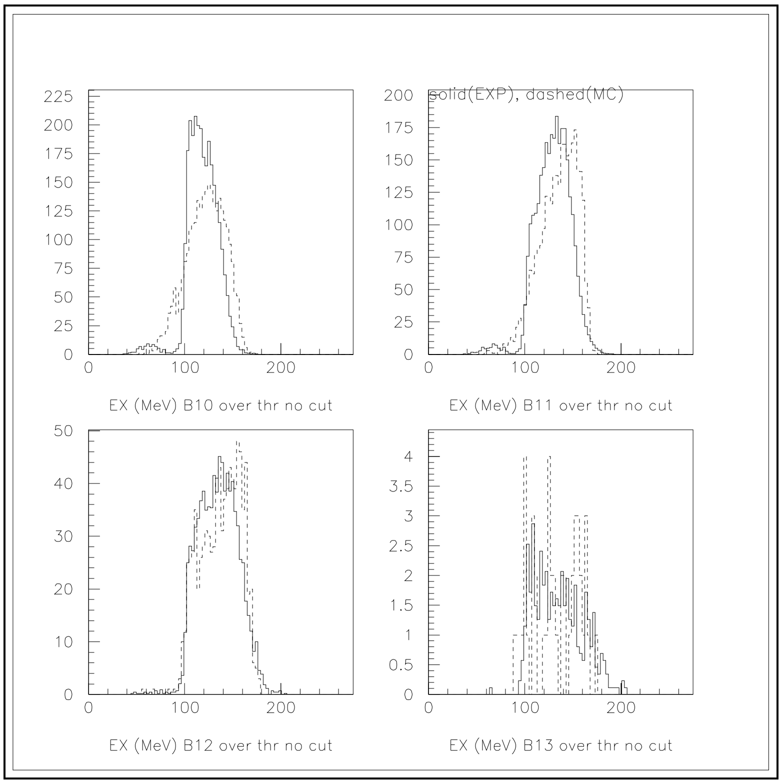

FIG. 5. Highest E X clump spectra when B 10-13 hit, solid(EXP), dashed(MC).

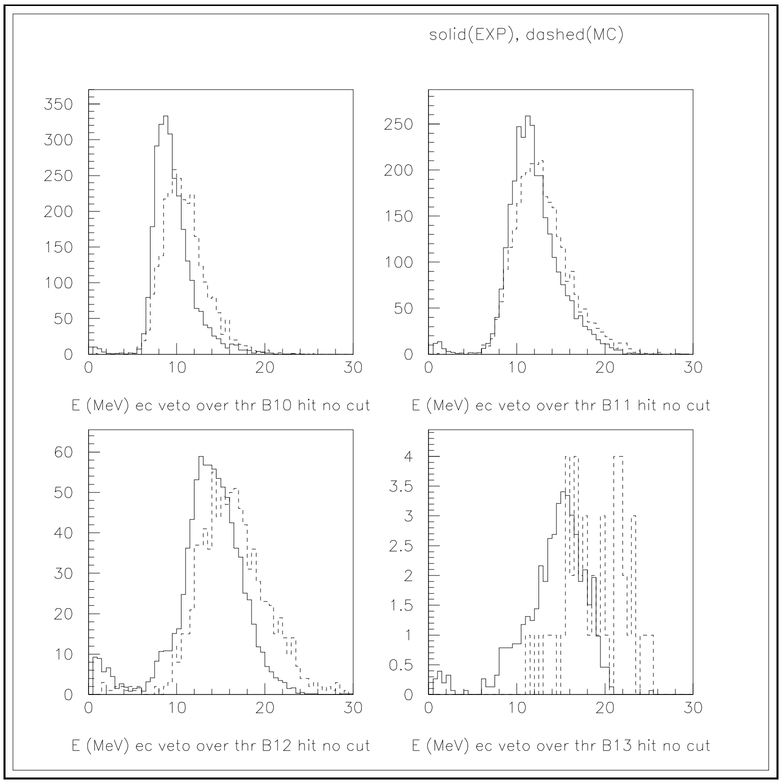

FIG. 6. V E spectra when B 10-13 hit, solid(EXP), dashed(MC).

COMPTON ANALYSIS

Both EXP and MC events are now passed to the analysis part of the package. This part obtains directions, total EC energy (corrected for E_{loss} if any), decides on the particle id of charged particles in the EC, and calls neutrals in the X a γ if the X clump has >1 hit. The events are analysed to select proton-Compton scattering. In order to calculate kinematic variables or cuts one can use $k=k_c$ (this may not be the correct k due to the incident photon energy resolution, but is the best one can do) and the detected proton angle. The latter comes from the time difference of the two ends of the struck B. These two variables are sufficient to calculate the rest of the kinematics in Compton scattering.

The main cuts are: one photon in X, a proton in the EC, and no π, γ, or e in the EC. To veto γ and e in the EC, timing in all elements and E in the Pb glass are used. Pions are identified via timing, dE, and E in the second and third B layers. Figure 7 shows similar MC and EXP spectra for θ_γ(calculated-detected) indicating correct direction determination.

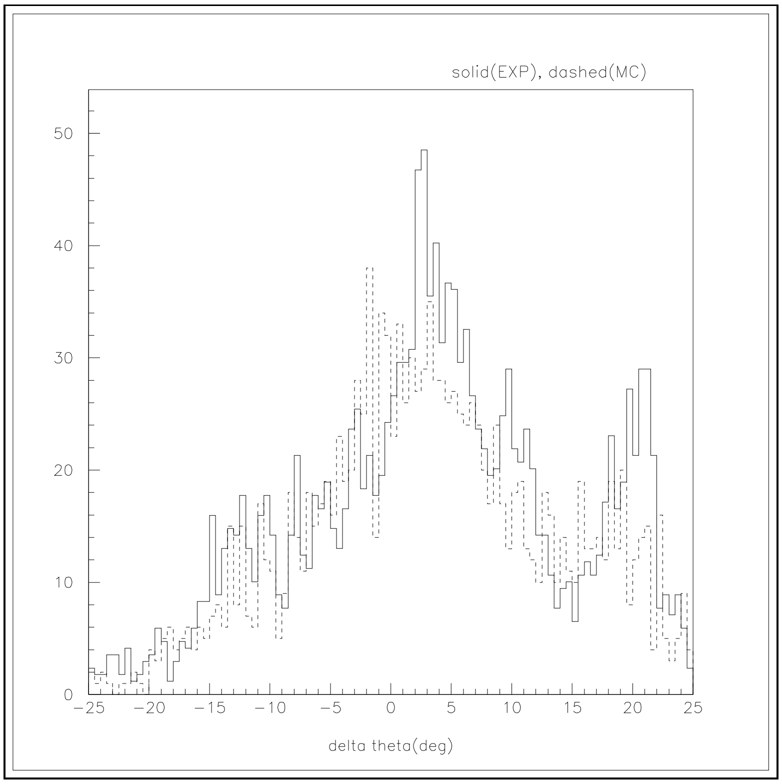

FIG. 7. θ_γ(calculated-detected) deg, solid(EXP), dashed(MC).

In Compton scattering the γ and the proton are coplanar so that ϕ_γ-ϕ_p $\equiv$ $\Delta\phi$=180°. A kinematic cut of (180 $\pm$ 20)° is also used in the following spectra. Figures 8-11 repeat figures 3-6 except that the Compton cuts are on. Aside from a reduction in events and the fact that the B 13 time spectra are now in agreement the same comments as above hold.

Now to the nitty gritty. The MC generated 500K π^0 and 50K Compton events. The π^0/Compton ratio is 100-200 so I normalized the Compton events by 0.1 and added the spectra. The result is shown in figure 12. There the calculated-detected photon E (horizontal axis) is plotted versus the calculated-detected proton KE (vertical axis). There is a nice separation between the two types of events. In the figure there are, after normalization, about 100 Compton and 1000 π^0 events. This ratio occurs because π^0 events are severely cut. However, the same plot for the EXP data (figure 12) shows no evidence for Compton/π^0 separation. Note that the horizontal axis centroid of the π^0 events has shifted from MC = 30 MeV to EXP = 50 MeV.

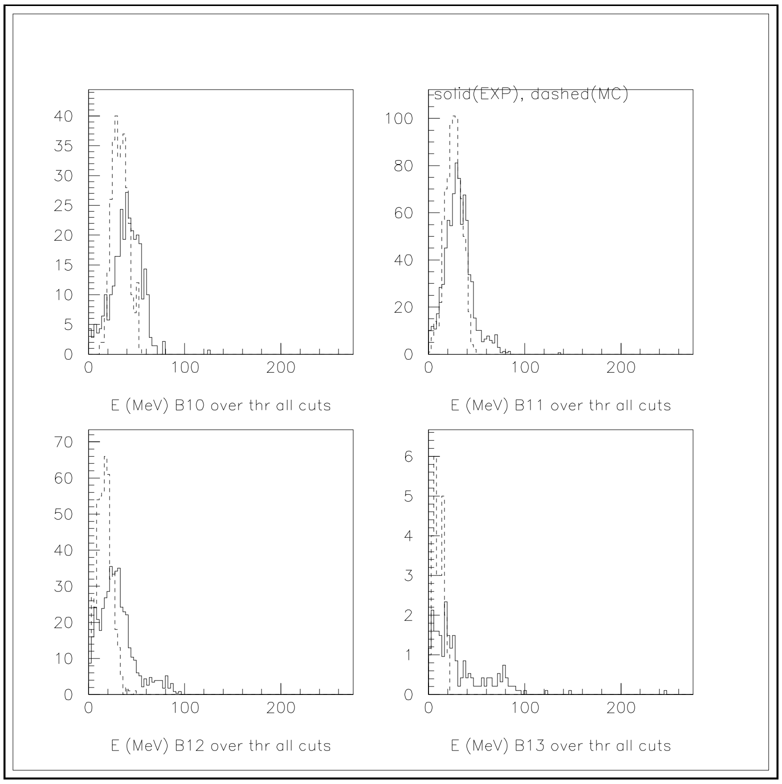

FIG. 8. Cut E spectra (MeV) B 10-13, solid(EXP), dashed(MC).

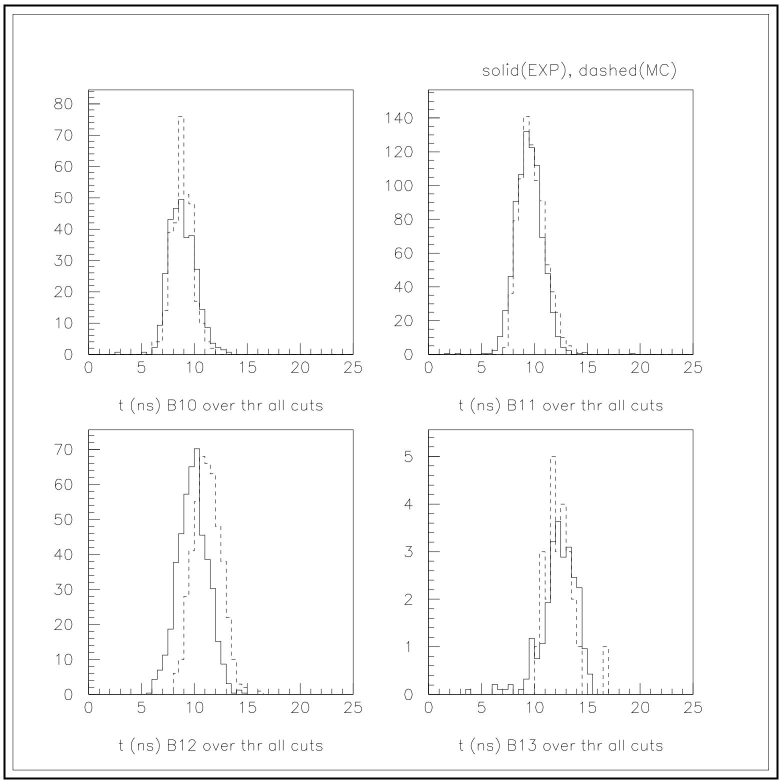

FIG. 9. Cut t spectra (ns) B 10-13, solid(EXP), dashed(MC).

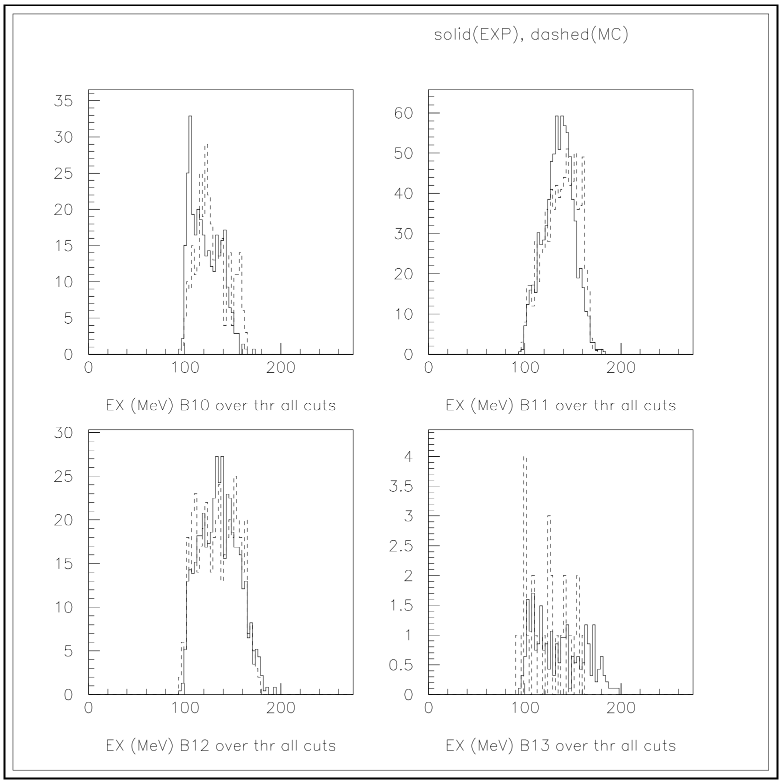

FIG. 10. Cut highest E X clump spectra when B 10-13 hit, solid(EXP), dashed(MC).

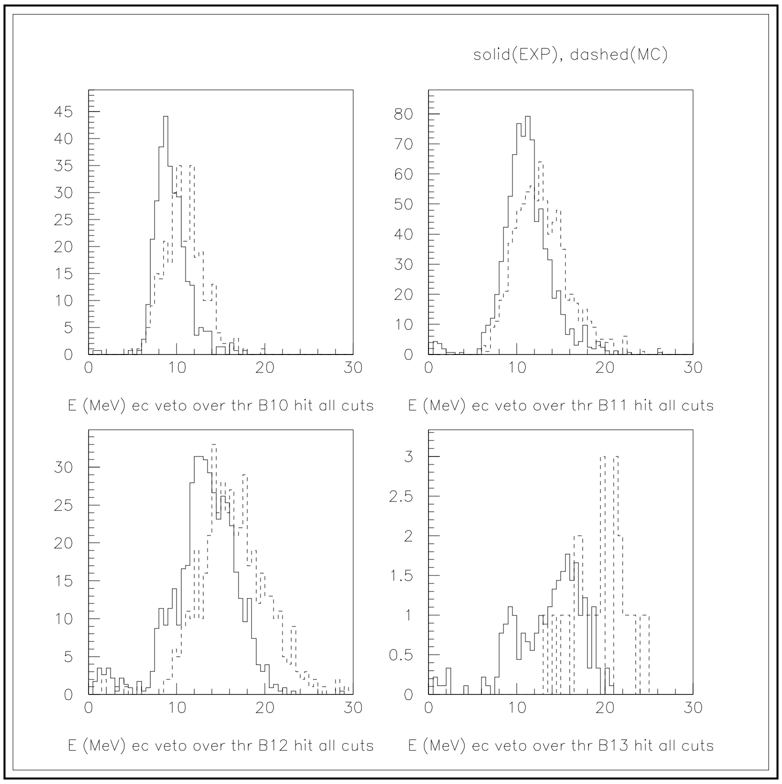

FIG. 11. Cut V E spectra when B 10-13 hit, solid(EXP), dashed(MC).

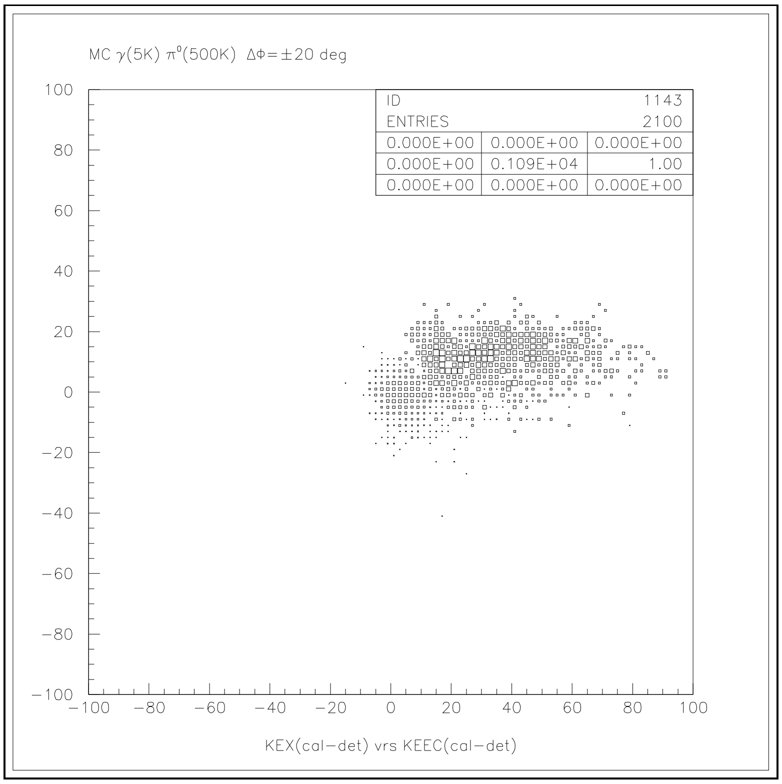

FIG. 12. MC data for Compton and π^0 events.

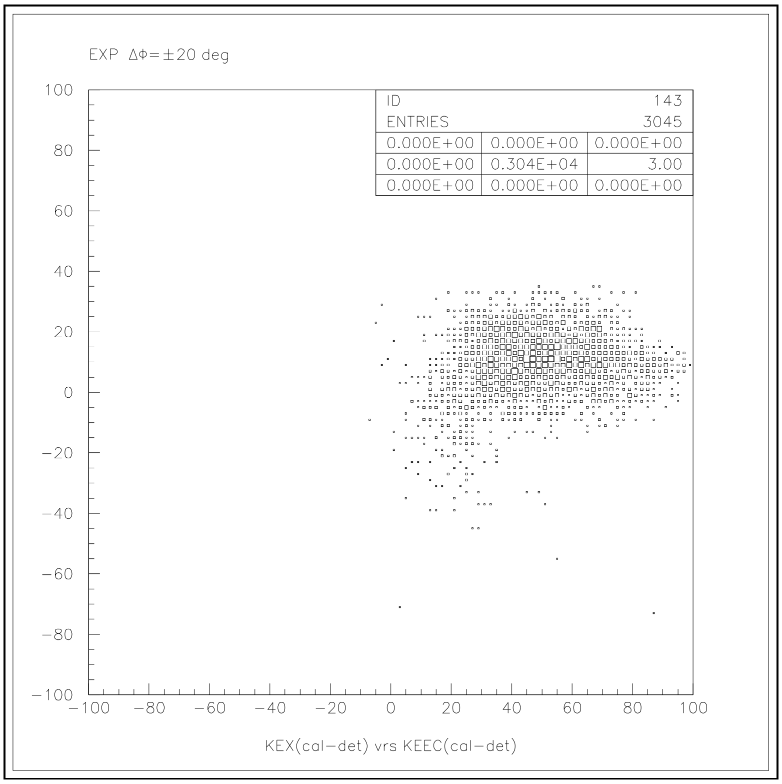

FIG. 13. EXP data for Compton and π^0 events..

Obviously the present situation must be improved for a successful experiment. In particular the ADC data must be reexamined. This is the only first go-around and hopefully iterations will lead to the desired improvement. Upgrades to the hardware should lead to additional improvements. A very fast Cerenkov counter will be installed in the tagger hutch reducing the t_{tag} resolution from 0.6 to 0.2 ns. The TDC time bin on the B has been reduced from 0.5 to 0.1 ns. Also the B have been pushed downstream 10 cm to reduce timing uncertainties. The ice target is 5 cm long compared to the 10 cm liquid target length. This should allow a better photon direction measurement and reduce the multiple scattering on the proton. However, the number of interactions for the same photon flux is reduced. Also it is uncertain whether or not the new laser will produce an increased photon flux at k$\approx$250 MeV.