Jeopardy Review Update of Experiment 93-043

Measurement of the $\Delta\Delta$ Component of the Deuteron by Exclusive Quasi-elastic Electron Scattering

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I. INTRODUCTION

This is an update of the attached proposal 93-043. The discussion presented there remains valid and constitutes the bulk of the proposal for jeopardy review.

The goal of the measurement is observation of the small component of the deuteron wavefunction in which the composition of the deuteron is two Δ resonances rather than the usual proton and neutron. Although this small component of the deuteron wavefunction has never been directly observed, it has long been assumed in models which fit the electromagnetic form factors of the deuteron. Furthermore, microscopic models of the deuteron's structure consistently predict a significant $\Delta\Delta$ component. Upper limits on $P_{\Delta\Delta}$ (the squared-amplitude of the $\Delta\Delta$ component) from previous attempts at direct observation do not exclude the strengths indicated by interaction models and by the electromagnetic form factors. The deuteron provides a unique laboratory for the study of such virtual excitations because isospin conservation requires that Δ excitations occur in pairs, providing a "spectator Δ" as a signature of interaction on a pre-existing Δ.

II. HISTORY

The proposal originally requested 25 days of running. Because some of the e1 running could be used for background studies, that request was modified in the PAC presentation to 16 days of dedicated beam contingent upon the N^* running on deuterium being approved. The experiment was approved for the full 16 days of running requested and the N^* program was approved. Because of the overlap in target and running conditions both the N^* program and the present experiment were later grouped by the CLAS Collaboration into the e1 run period for CLAS.

In the three years since CLAS began running, most of the time has been used to provide data to groups of experiments which could run together. Although the present experiment is part of the e1 run period, its simultaneous requirements of reversed field and deuterium

target make it incompatible with running of other experiments. This made it less favorable to perform the measurement in the first few years of CLAS operation. Further, it was seen to be a clear advantage to examine the parasitically acquired results of the other planned deuterium running before pressing ahead with the dedicated running. The first of that data was taken last year (in the e1d and e5 run periods) and has been undergoing calibration in preparation for "cooking". CMU graduate student Jeff Lachniet is making a significant contribution to that effort.

III. STATUS

The theoretical motivation for this experiment remains strong. A recent QCD-inspired calculation of the deuteron structure [1] predicts a value of $P_{\Delta\Delta}$=0.3% very similar to the earlier predictions of meson-exchange calculations cited in the proposal. Recent studies [2] confirm the importance of the $\Delta\Delta$ component in understanding the electromagnetic structure of the deuteron, and emphasize the importance of understanding it in order to correctly extract G_E^n from deuteron measurements.

Two relevant measurements on deuterium were made last year in CLAS experiments. Because of the distribution of charged particles, full-field running has a low acceptance for the reaction of interest, so low-field or reversed-field deuterium running is of greater relevance. The e1d run period included several days (about 640 μC accumulated beam) of deuterium running with a torus current of 1500A (about 4/9 of full field) at 2.475 GeV. Also, the e5 run period included a few days (270 μC accumulated beam) of running on a dual-cell deuterium/hydrogen target with the toroid field reversed at -2250A (-2/3 of full field) at 2.558 GeV. These measurements are expected to provide very useful information, at least about background rates from re-scattering processes which have so far only been estimated. If they indicate that backgrounds are under control, then we will advocate scheduling of the dedicated beam time for this experiment.

Unfortunately, these parasitic data are not yet ready for analysis. Preliminary calibration

has just been completed for the e1d data set, which is now undergoing "pass-zero cooking". Calibration is in progress for the e5 data set.

Figures A and B of this update show very preliminary angular distributions for back-angle Δ^{++} from each of these parasitic data sets. These distributions were made from a pre-calibration cooking of a small fraction of the data, and so are subject to possible large errors in momentum assignments and even in particle identification. Only qualitative information can then be extracted from the figures. The figures show, for reconstructed Δ^{++} momentum more than 45 degrees away from the momentum transfer direction, the distributions of:

i) All reconstructed Δ^{++} (discarding only those for which a negative value would be assigned to the square of the missing mass)

ii) Those events in which no unexpected track is seen, other than the electron and possibly decay products of a Δ^-

iii) Those events in which a track consistent with Δ^- decay is seen

iv) Those events with evidence of both a π^- and a neutron from the Δ^- decay. (No such events are seen in the e5 data examined so far.)

Because of very low statistics and poor calibration, no cuts have yet been applied on the missing mass of the Δ^- nor on the unobserved Δ^--decay product in case iii. Even with these very loose cuts, it is seen that the Δ^{++} angular distribution is strongly forward-peaked, as expected for the background re-scattering terms. Only the large-angle events constitute a potential background to the present measurement. At present very little can be concluded, except that the large-angle events are not overwhelming, even in the absence of background rejection cuts.

IV. OUTLOOK

The most important information which has been learned since the proposal is that the CLAS has been performing very well over three years of operation. Because of the large

angular coverage and multiple-track reconstruction required for this measurement, it is important to have very good acceptance and efficiency. The CLAS has lived up to expectations so no reduction in scope of the measurements is foreseen relative to the proposal.

Much more information will become available over the next year as cooking is completed on the e1d and e5 data sets and the Δ^{++} distributions are extracted (with meaningful cuts on the Δ^{-}) for the subset of interest. Assuming no indications of problems are uncovered in these low-energy data sets, the proposers of this experiment would hope to schedule the measurement to run within the next two years. This is, of course, subject to internal negotiations within the CLAS collaboration to optimize use of the CLAS.

We request the re-approval of 16 days of running at 4.0 GeV with a deuterium target and reversed toroid field.

REFERENCES

[1] A.N. Ivanov, H. Oberhummer, and M. Faber, Euro. Phys. Jour. A **8**, 125 (2000).

[2] A. Amghar, N. Aissat, B. Desplanques, Euro. Phys. Jour. A **1**, 85 (1998).

FIGURES

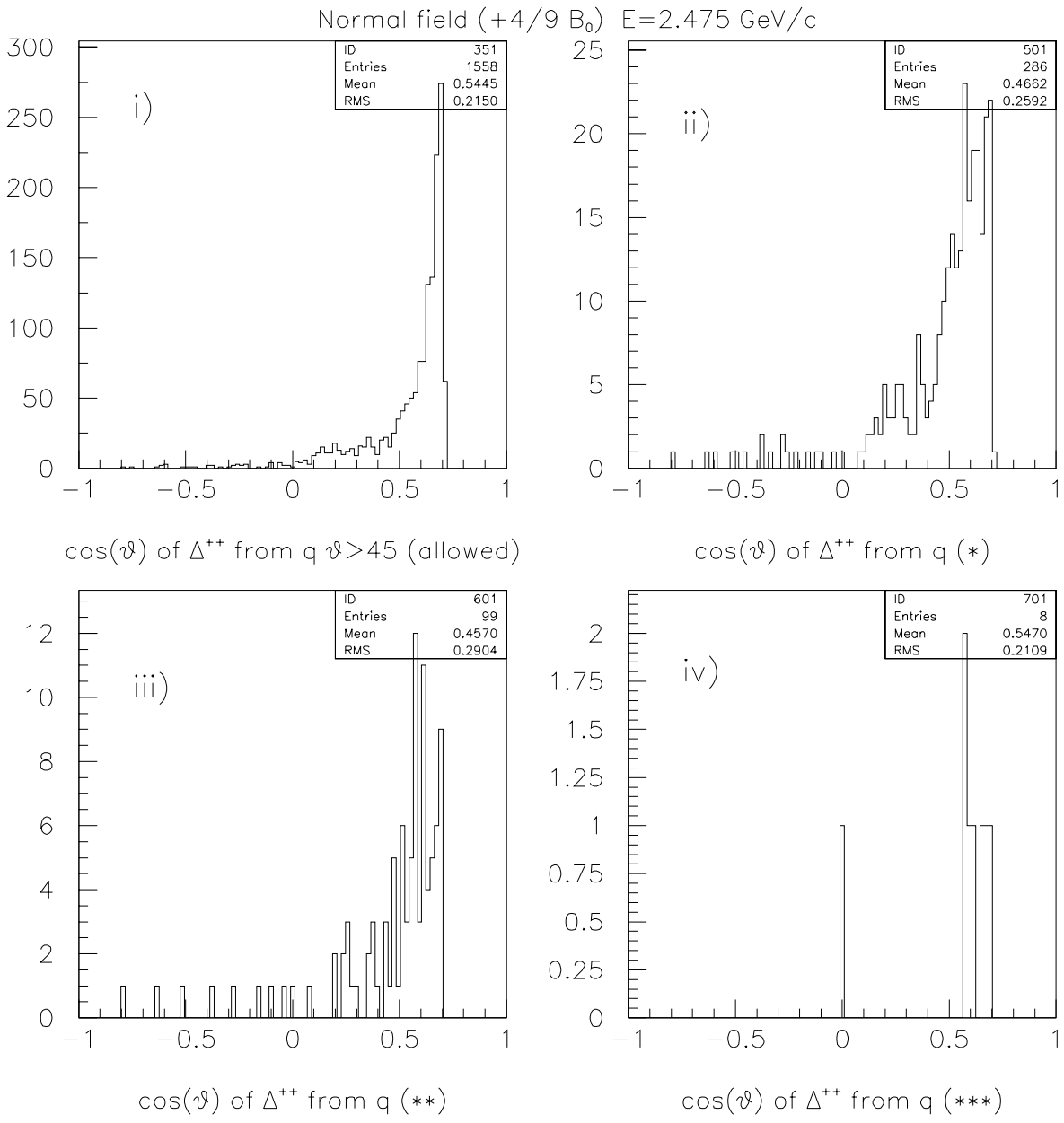

Fig. A) Distribution of reconstructed Δ^{++} angle relative to momentum transfer direction for low-field running in e1d run period. Figures represent i) All events, ii) rejecting events with extra track, iii) with one track of type expected from Δ^{-} decay, iv) with two such tracks.

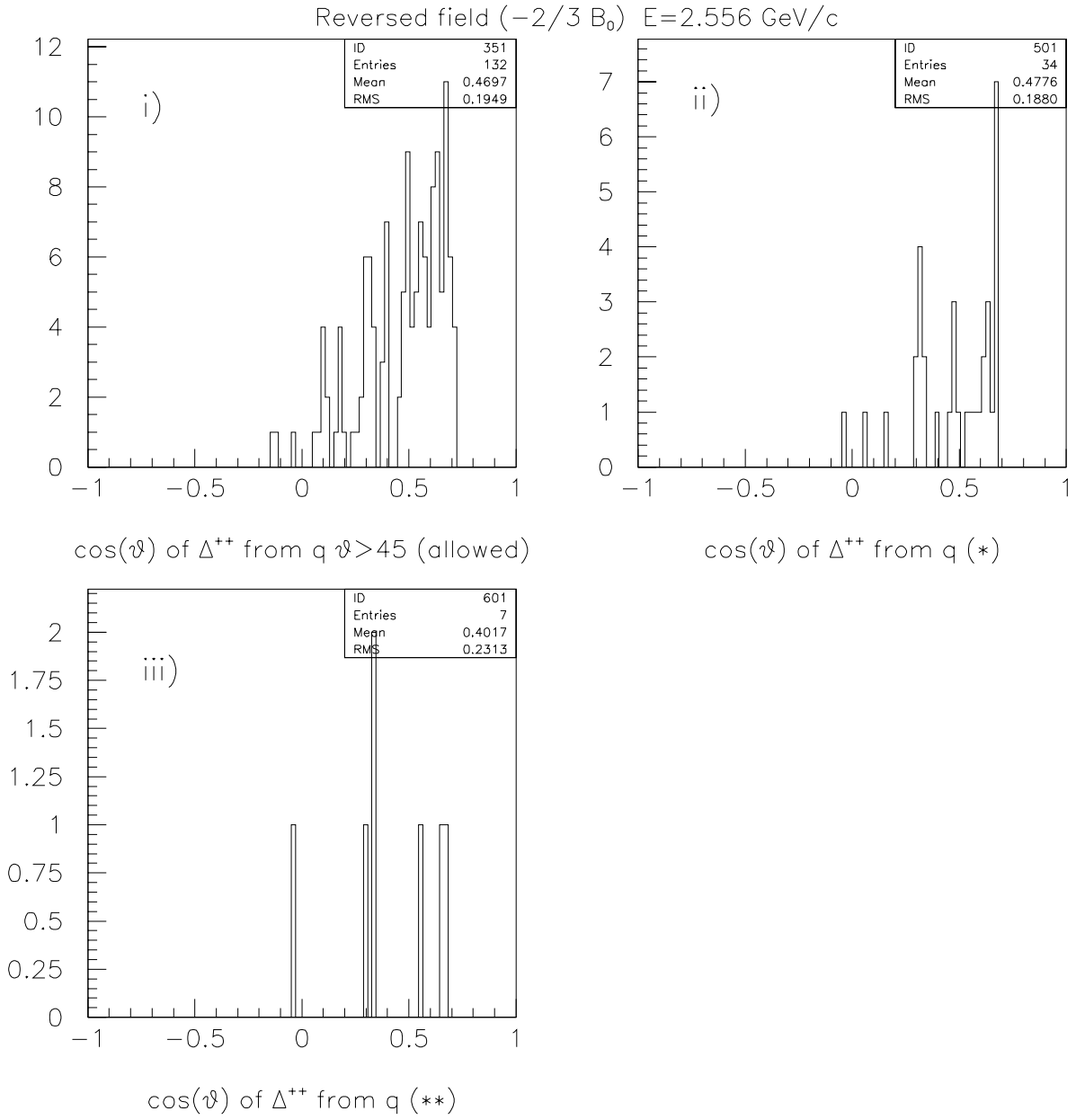

Fig. B) Distribution of reconstructed Δ^{++} angle relative to momentum transfer direction for reverse-field running in e5 run period. Figures represent i) All events, ii)rejecting events with extra track, iii) with one track of type expected from Δ^{-} decay.