Summary of the Pion Production Sessions

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Abstract. This is a short summary of the 10 talks given in the Pion Production Sessions at NUINT12. There were 2 very interesting themes that spanned talks - problems with data for single nucleons and pion absorption in the nuclear medium. In addition, a number of interesting new efforts were described.

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INTRODUCTION

Although pion production experiments are interesting on their own to many of us, their primary purpose in the field is to provide information about backgrounds and systematic errors in many neutrino oscillation and cross section experiments.

SINGLE NUCLEON CROSS SECTIONS

Low statistics bubble chamber experiments from many years ago provide the only data we have for pion production from single nucleons. There are 3 reactions for ν_μ and for $\overline{\nu}_\mu$; all were measured with deuterium bubble chambers. The primary experiments are ANL [1] and BNL [2] for neutrino energies less than 2 GeV, the region of interest for many theorists. Unfortunately, they are systematically different and differentiating between them is not simple.

Theory speakers in this session Hernandez [3] and Lalakulich [4] stress how they must account for this. The Valencia group [3] finds an average of the data and determines an estimated error which is then propagated into any results for a nuclear target. The GiBUU group defines an error band in a similar way.

This is one of the barriers to future progress in this field. At the moment, no new experiments to measure these basic cross sections are anticipated.

PION ATTENUATION IN THE NUCLEAR MEDIUM

Interpreting the MiniBooNE pion production data, charged [5] and neutral [6], was the topic of 3 speakers (Hernandez, Lalakulich, and Rodriguez). The pion energy spectrum integrated over beam energy and pion angle spans the region 50-400 MeV, decreasing approximately linearly between 100 and 250 MeV. This is very interesting because it covers the region where pion attenuation due to absorption through the Δ resonance should be important. Calculations of the theoretical groups differ from the data in both shape and magnitude. Each shows a dip at the energy where the Δ peaks, about 160 MeV. All pion attenuation functions come from pion beam data. All models then make the assumption that pions produced in the nuclear medium interact same as pions in a beam interacting with nuclei. Rodriguez gathered results from theory and from the generators for π^+ and π^0 production. He finds the most significant differences are in shape, highlighting the pion attenuation issue. The generators do a little better than the theoretical calculations.

Here, there is a need for new data and reports on new experiments show that new views of the situation are not far away. Eberly and Higuera (MINERvA) showed preliminary data for charged and neutral pions; expectations are for publications within the next year. Murdoch and Vacheret (T2K) showed significant progress toward results within the next year or two for charged and neutral pions. Results for the pion attenuation problem highlighted above and for a variety of other issues (axial form factor, resonances at higher energies) an be anticipated. MINERvA will provide the first new $\overline{\nu}_\mu$ pion production data in a long time.

NEW THEORY

The new directions for calculations were encouraging. Athar presented updates on previous results for kaon production and first results for eta production. Nakayama talked about a new group formed in Japan to work on neutrino-nucleus theory; their work will be an outgrowth of previous work for electron-nucleus theory. Alvarez-Ruso told the group about a recent result for production of single photons in neutrino-nucleus calculations. This new calculation improves the nuclear physics input from a previous result [7].

SUMMARY

The session was a lively presentation of experimental and theoretical results, many of them unpublished. The reader is directed to the contributions of the speakers in these same proceedings for more details. The best existing calculations are unable to fit the pion energy spectrum coming from MiniBooNE. Fortunately, new experiments will both check and add to the existing results. New calculations are encouraging and important for future success.

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