Pion Identification in Photonuclear Measurements at MAX-lab

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for the

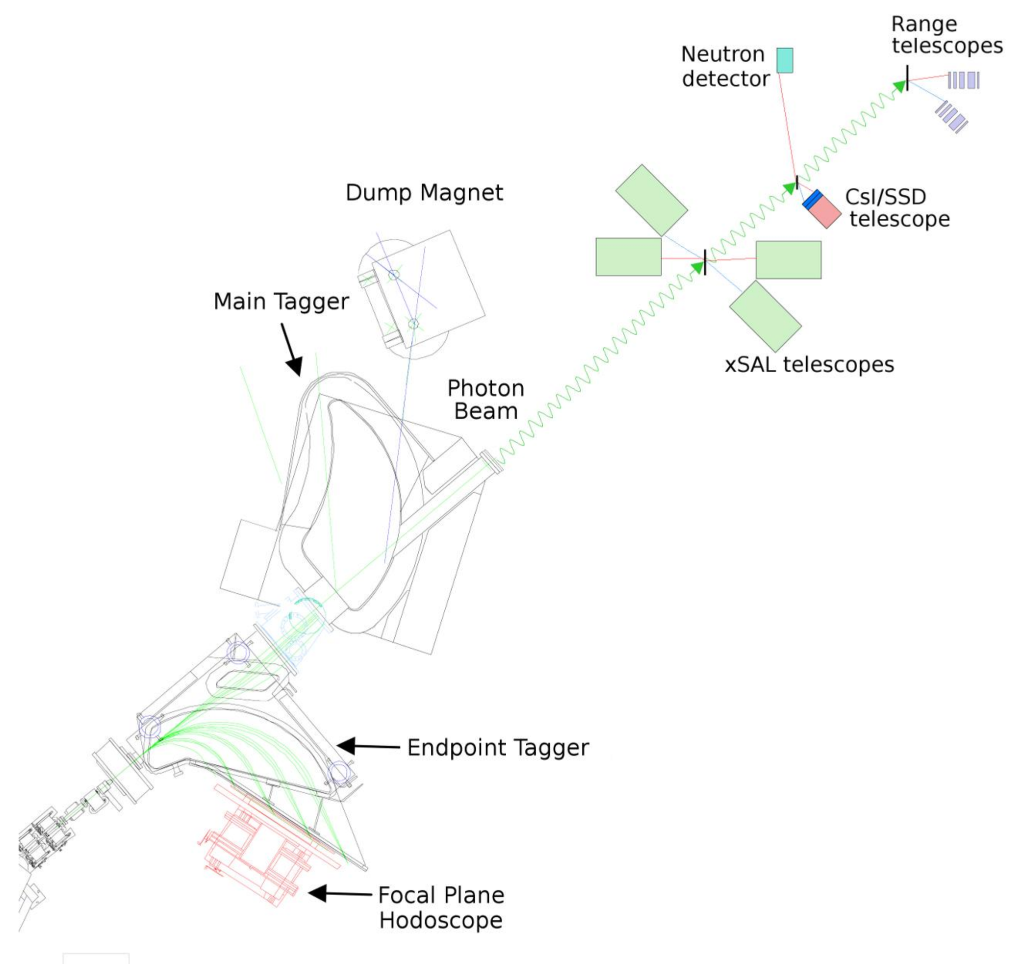
PIONS@MAXLAB Collaboration

Introduction

Pion photoproduction near threshold is one of the few low-energy processes where it is possible to formulate QCD-based effective theories. One of the important questions in nuclear science today is to describe the properties of the the nucleon in this framework. Pion photoproduction involves a direct rearrangement of the quarks in the nucleon and the results from these measurements can be compared with the predictions from various quark-based models.

PIONS@MAX-lab

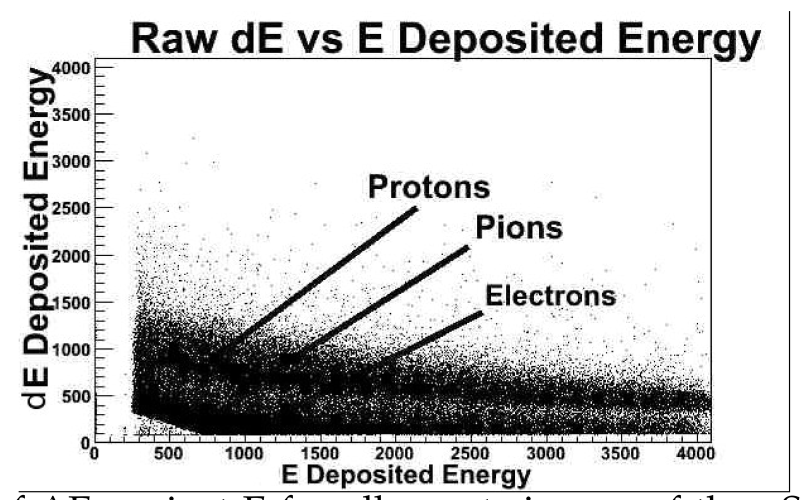
The newly upgraded accelerator and photon tagging facility at MAX-lab is capable of tagging photons up to 200 MeV, at high rates and with excellent energy resolution and is ideally suited to perform these measurements.



As a part of the PIONS@MAX-lab program, experiment NP014 ran in June of 2009 to collect data on $\gamma + p \to \pi^+ + n$. C and CH2 targets were used and the outgoing particles were detected in plastic scintillator ΔE-E telescopes.

Identification of Pions

Due to different energy losses for different particle types, plotting ΔE vs E will show separate bands for the different particles. However, due to the low event rate for pions, the standard ΔE-E particle identification methods are not sufficient to separate the pions from the large electron and proton background.



A plot of ΔE against E for all events in one of the xSAL telescopes. The pion event will lie between the electron and proton bands. They are swamped by these background events here, and cannot be isolated.

To isolate the pion events, the acquisition electronics was set-up to record information from the $\pi \to \mu$ decay and using this it becomes possible to separate the pion events from the background.

The E-counter energy signal was sent to both a long (160ns) and short (60ns) gated QDC. All events will deposit the same energy in the short gate and in the long gate but a later occurring $\pi \to \mu$ decay deposits extra energy in the long gate.

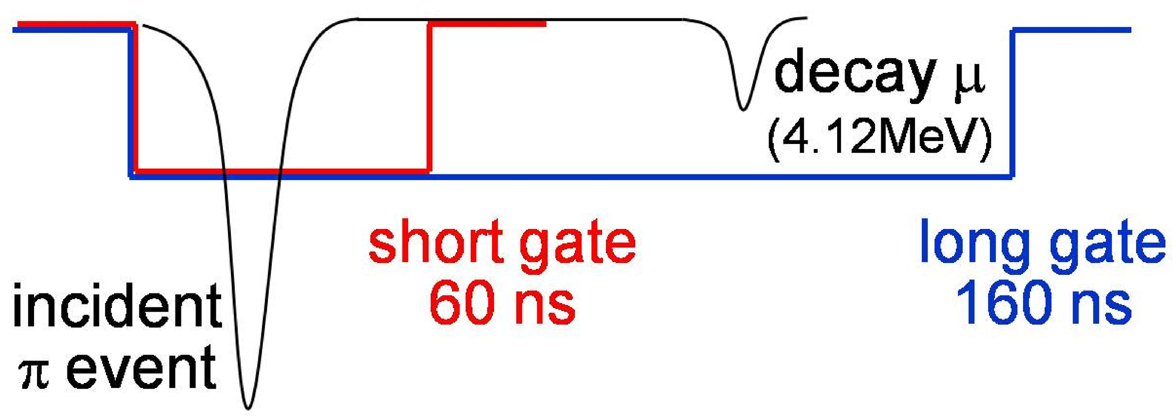
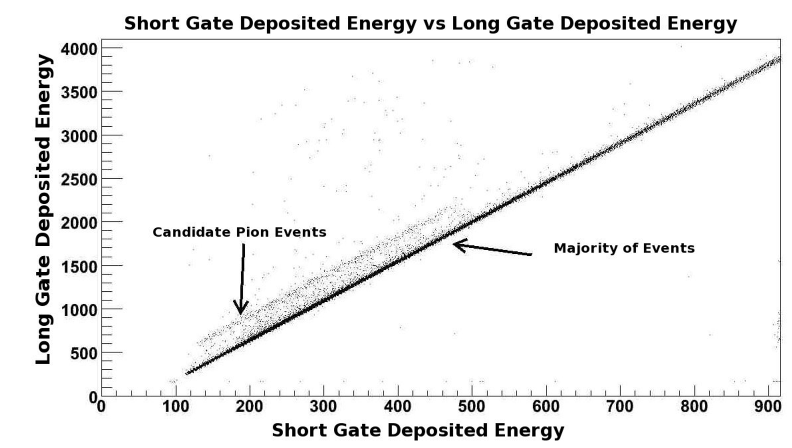


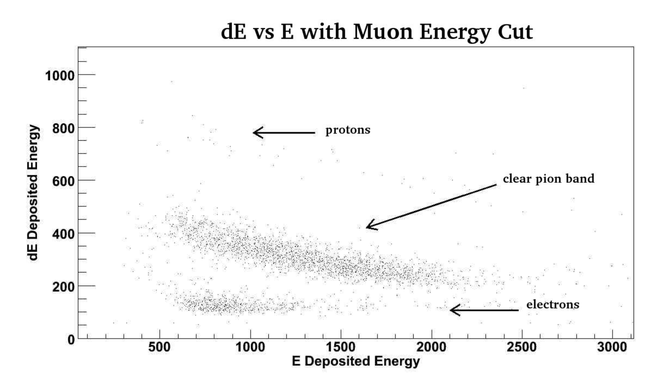
Illustration of the energy deposited into the long- and short-gated QDC for an E-counter signal from a $\pi \to \mu$ decay.

Analysis

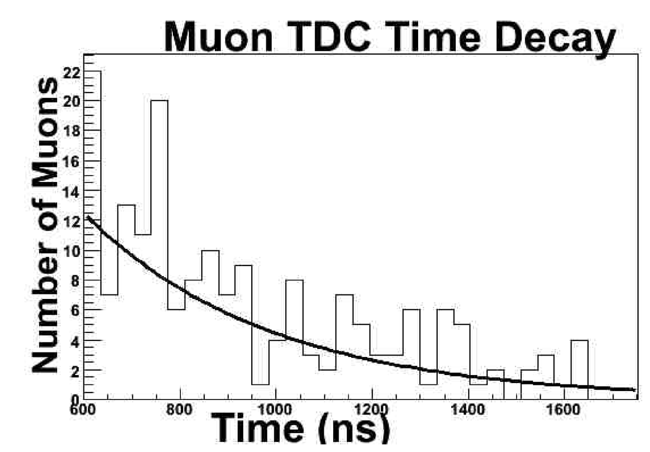
Plotting the value from the long-gate vs short-gate QDC shows most events deposited the same signal into both gates but some events show extra energy in the long gate, consistent with a 4.12 MeV muon.



Plotting ΔE-E for these "candidate pion" events, a clear pion band is seen, with some small remaining background events. In addition to the energy information from the QDC, the time of the second ("muon") signal from the E-counter was recorded in a TDC. A final cross check of these candidate pion events was made by fitting this time distribution and comparing with the known $\pi \to \mu$ decay time.



Plot of ΔE vs. E after selecting candidate pion events. The pion band is clearly evident.



Time distribution for the second E-counter signal for candidate pion events. The decay time is consistent with the known $\pi \to \mu$ lifetime.

The most recent analysis for two of the xSAL counters shows decay times of (27.2 $\pm$1.8) ns and (26.2 $\pm$2.6) ns, in excellent agreement with the 26 ns pion lifetime.The third counter was located at a forward angle, and additional work is needed to eliminate the high electron background present in this counter.

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