Pion Identification Methods in Pion Photoproduction Measurements at MAX-lab

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Introduction

One of the unsolved problems in nuclear physics is describing the properties of nucleons in terms of the framework provided by quantum chromodynanimcs (QCD). Pion photoproduction is one of the processes where both experimental and theoretical measurements can be performed accurately. In particular pion photoproduction near threshold can be compared with results from approaches such as Chiral Perturbation Theory and model independent Partial Wave Analysis.

Figure 1: 2011 IRES participants on one of Copenhagen's many bridges

Pions@MAX-lab

The recently upgraded tagging facility at MAX-lab is particularly well suited to perform these experimental measurements. The new facility is capable of tagging photons up to 200 MeV with an energy resolution of less than 1 MeV.

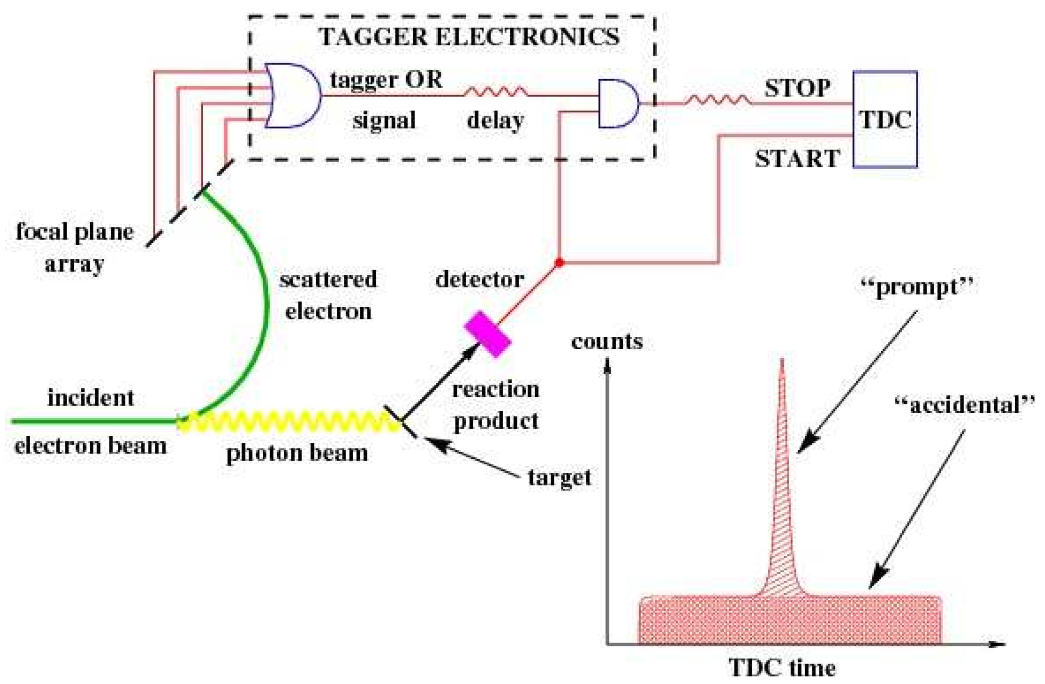


Figure 2: Schematic of the MAX-lab tagger electronics.

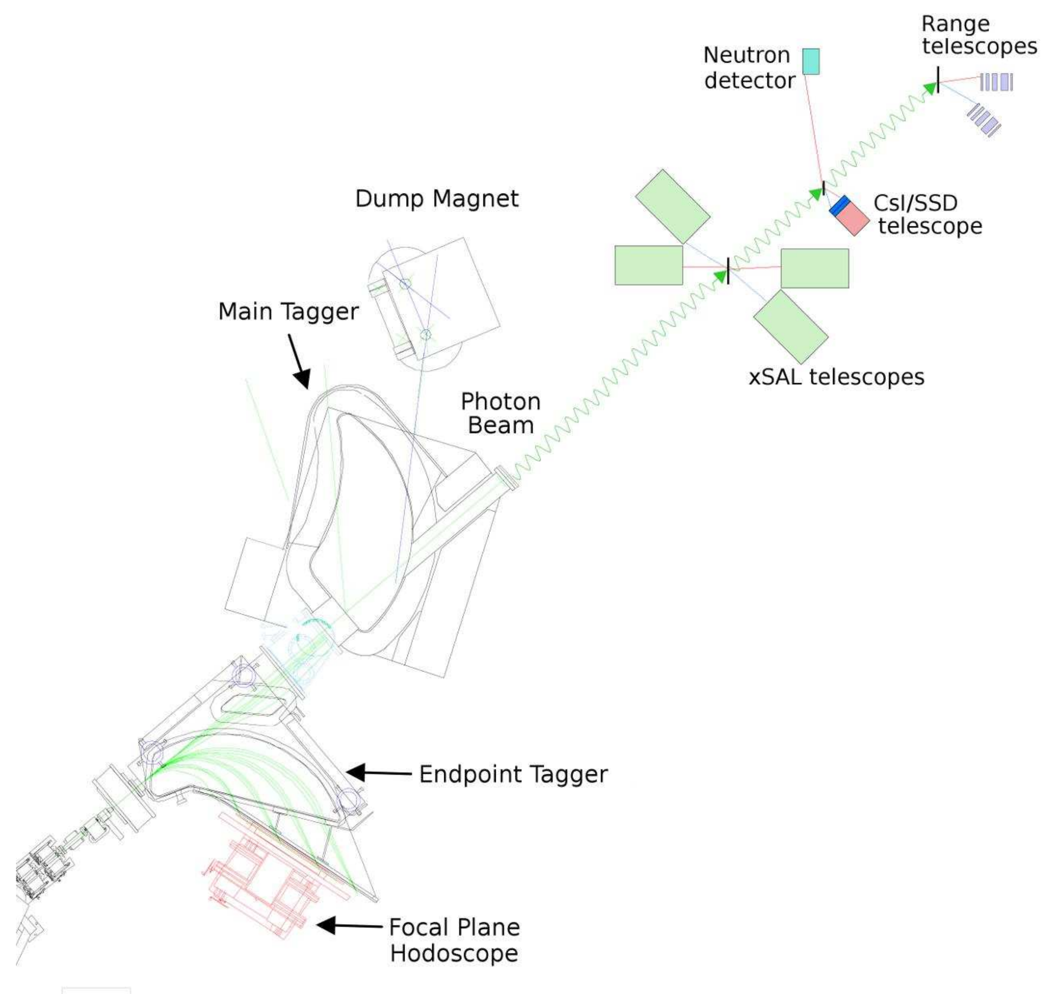
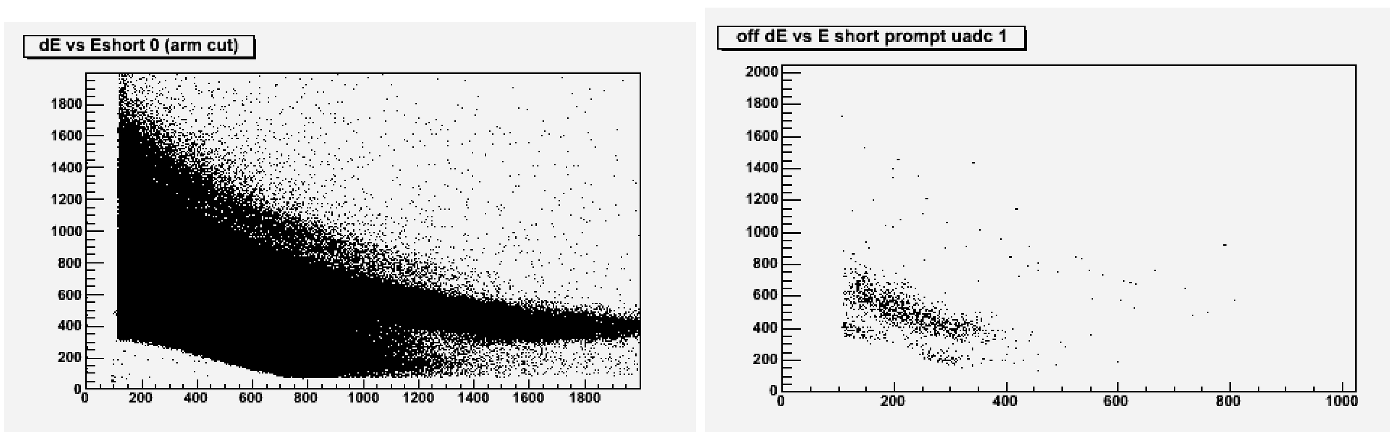


Figure 3: Schematic of the experimental setup showing the MAX-lab tagger as well as the three detector systems used for the pion photoproduction measurements: xSAL, CsI/SSD, and RANGE

The pion events from the $\gamma p \rightarrow \pi^+ n$ reaction were detected using several different detector systems. The xSAL counters were plastic scintillator ΔE-E telescopes. A CH_2 target provided the the target proton with a C target used to determine the background subtraction.

Pion Identification

One difficulty in these measurements is isolating the pion events from the large background due to protons and electrons. The standard particle identification method based on Δ-E vs E information shows the pion events swamped by background, as shown in Fig. (a) below.



(a) dE vs. E short before the *particle type* cut was applied (b) dE vs. E short after the *particle type* cut was applied

To solve this issue, the pion events were identified by searching for the 4.12 MeV muon emitted when the pion decays. By using two differently gated QDC units (long and short), this decay is identified through the extra energy deposited in the long-gate QDC compared with the short-gate QDC.

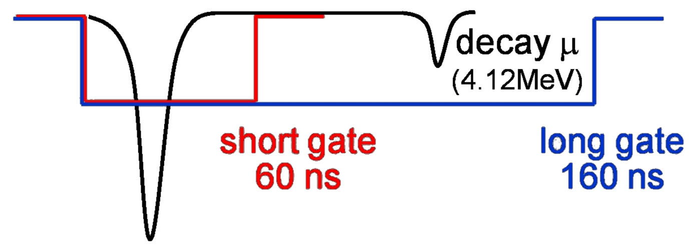
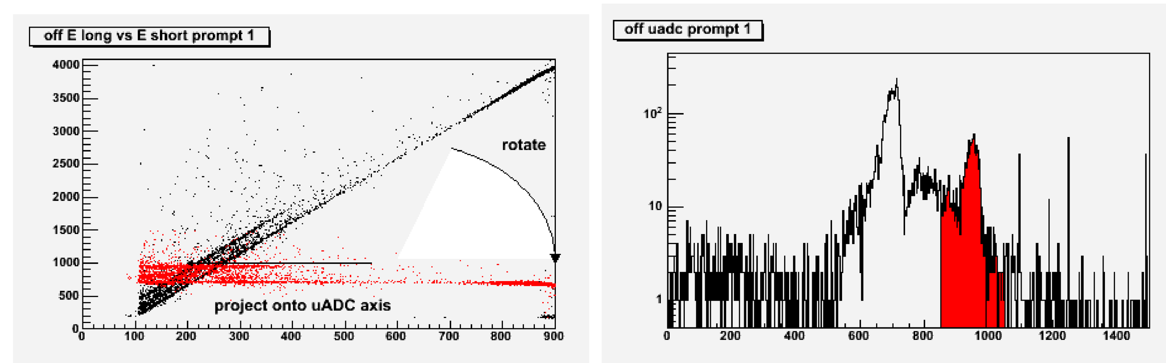


Figure 4: Illustration of the energy deposited in the long gate and short gate QDCs from the $\pi \rightarrow \mu$ decay

By plotting the energy recorded in the long vs short gate QDC, the pion decay presents itself as an event offset from the background events. This graph was then rotated such that event lines were parallel to the X-axis (see Fig a) below).



(a) long vs short gate QDC. The red denotes the rotated plot (b) Projection of the long vs short QDC into a 1D histogram. The red shown the analysis cut used to select the candidate pion events

This rotated plot was then projected to create a 1-dimensional *particle type* histogram. The candidate pion events appear as the small bump on the right side of this histogram. By selecting these events with an analysis cut on this *particle type*, a subset of events containing predominately pions can be created.

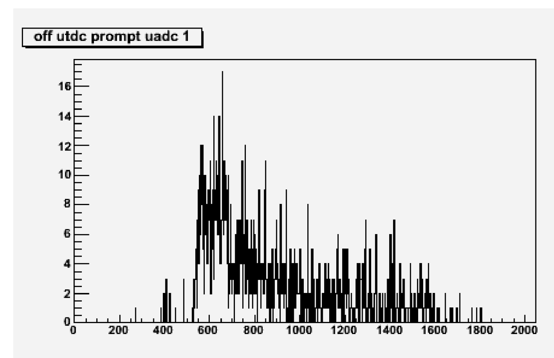


Figure 5: Time distribution of candidate pion events. This shows a mean life of 26ns.

The pion event identification was validated by fitting a decay curve to the time distribution of the second peak recorded in the long-gate QDC. The fit has a mean life of 26 ns, consistent with the known lifetime of the $\pi \rightarrow \mu$ decay.

Future work

The pion yield will be determined using the data recorded during two run periods at MAX-lab (June 2009 and June 2010) in order to extract cross section and angular distributions for the $\gamma p \rightarrow \pi^+ n$ reaction.

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