Pion Identification Methods in the $\gamma p \longrightarrow n\pi^+$ Reaction

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For the MAX-Tagg Collaboration

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(2) Lunds Universitet/MAX-lab (4) Georgia Insititute of Technology
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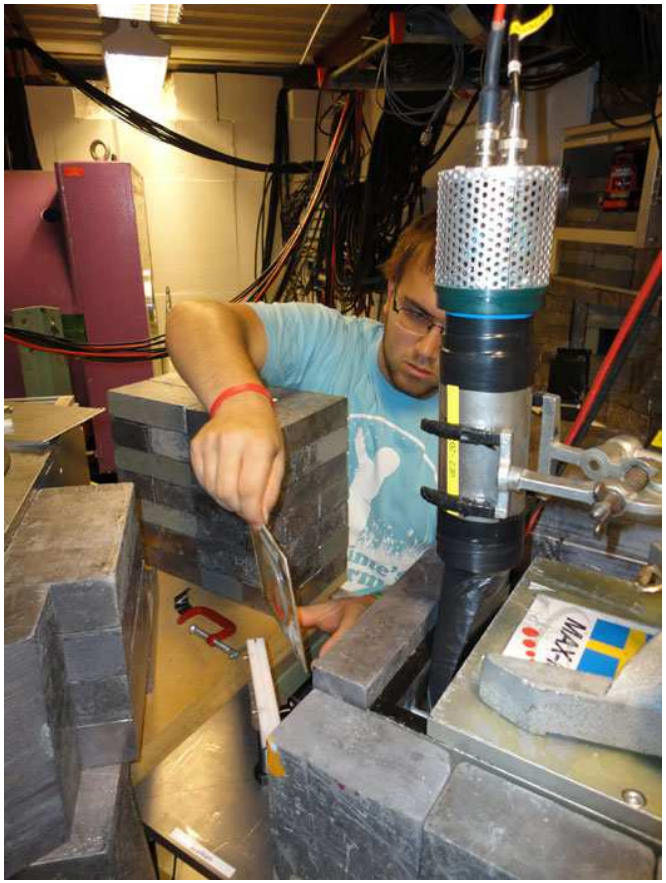
Outline

International Research Experience for Students (IRES)

Figure: 2010 IRES participants on one of Copenhagen's many bridges

IRES at Work



(a) Brian Smith from GW positioning the target for the xSAL counters

(b) Dan Kelleher from UMassD measuring distance to the detectors

Quarks

- Quarks are believed to be the elementary particle which make up protons and neutrons.
- Quarks are never found alone. They are found in groups of two or three (confinement)
- There are 6 flavors of quarks: up, down, charm, strange, top, bottom
- Baryons: Made up of three quarks (proton, neutron, etc.)
- Mesons: Made up of two quarks (pion, etc.)

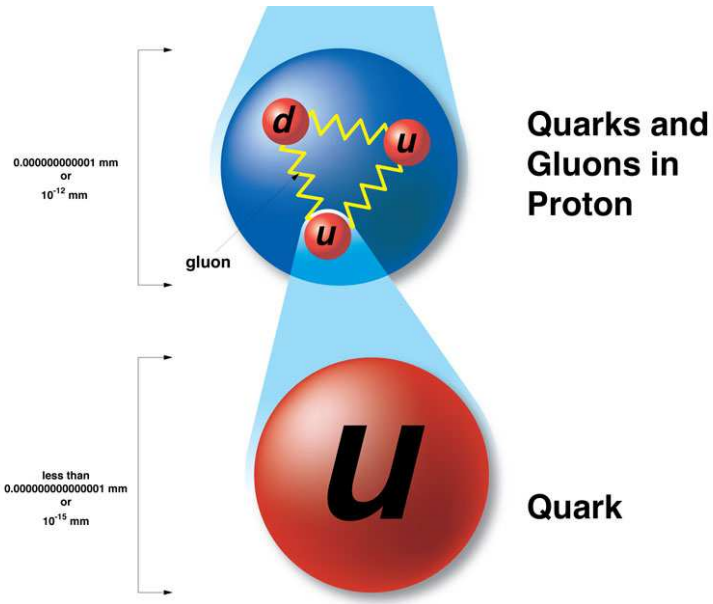


Figure: The quark make-up of a proton

Pion Photoproduction

- By studying pion photoproduction we can gain an understanding of the properties of the nucleon in terms of the quark structure.
- Pion photoproduction is an ideal reaction to study since it is possible to get high-quality experimental measurements as well as make theoretical predictions that fully describe the process.
- The four fundamental reactions are:

$$\gamma p \rightarrow n\pi^+ \qquad \gamma n \rightarrow p\pi^- \qquad \gamma p \rightarrow p\pi^0 \qquad \gamma n \rightarrow n\pi^0$$

- Pion photoproduction involves the reaction of a high-energy photon with a baryon such as a proton or neutron.

Pion Photoproduction (Continued)

- In the $\gamma p \rightarrow n\pi^+$ reaction the photon interacts with the proton in a manner that creates two quarks. The quarks then rearrange themselves, and two are ejected as a π^+. The remaining quarks form a neutron.

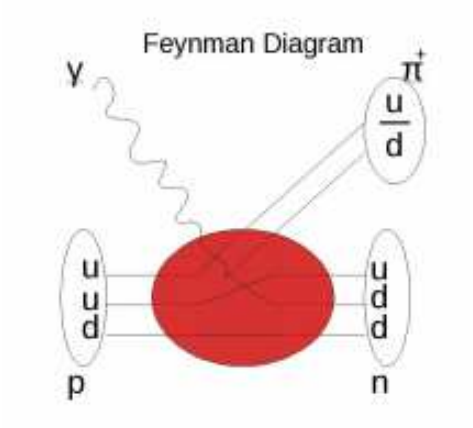


Figure: Feynman diagram for positively charged pion photoproduction

- Pion photoproduction is an ideal reaction to study because it involves the directly rearrangement of the quark in nucleon.

Measurement Setup

Figure: The exerimental setup at MAX-lab

ΔE vs E Difficulties

Due to their different masses, protons, electrons and pion will appear in different regions when plotting ΔE vs E. However, the raw ΔE vs E graph is ineffective at isolating pions because the protons and electrons background swamps the pion events.

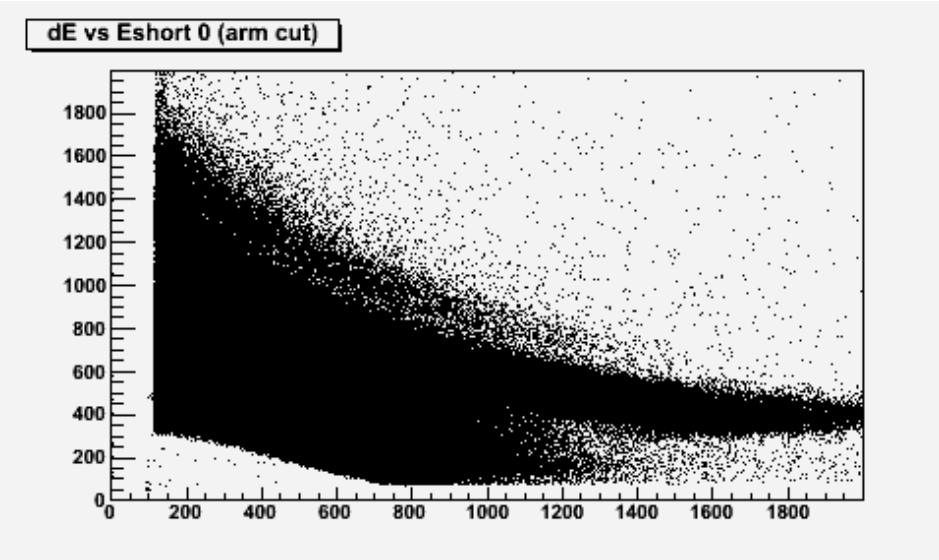


Figure: Where are the pions?

Detector Tagger Coicidences

To ensure the data is in the energy range we can measure the data is cut to include only those events which have a photon (from the tagger) associated with the measured event.

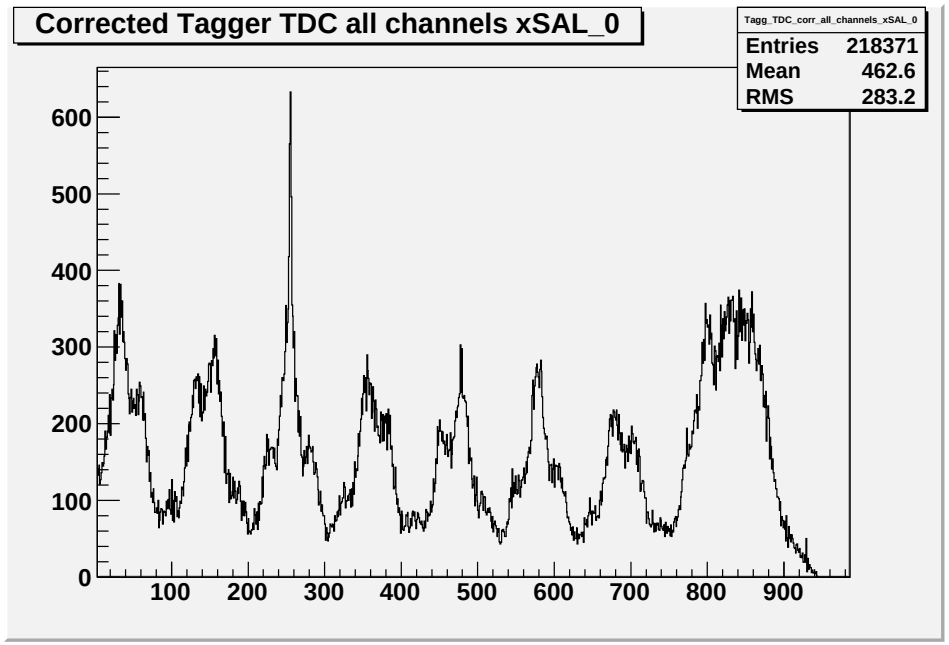


Figure: Prompt peak on top of background

E long and E short

A pion decays into a muon, which gives off some extra energy. Using different charge to digital converter (QDC) timing, the pion decay can be recorded in the long gate QDC and not the short gate QDC.

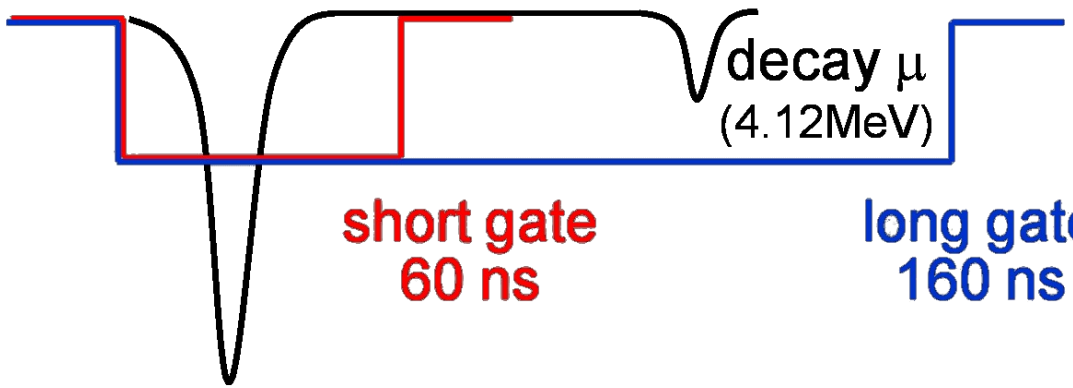
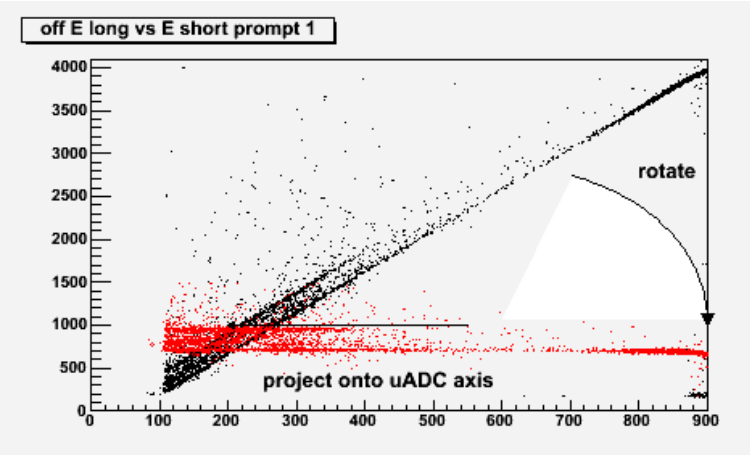


Figure: Illustration of short and long gate QDC

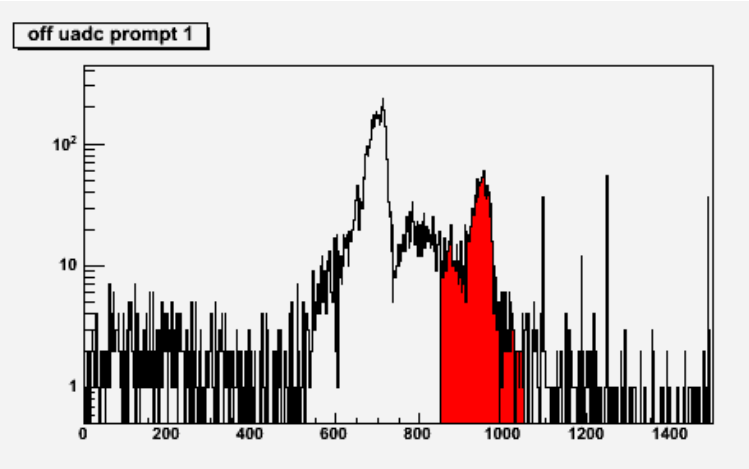
Comparing the values recorded in these gates provides a way to reject almost all the background events.

μQDC cut

By plotting the value recorded in the long vs the short gate QDC, the pion events appear as a second line offset from the background events. We rotate, then project and finally cut on the μQDC plot. This cut is used to isolate candidate pion events.



(a) E long vs E short: the red shows the rotated plot



(b) Projection of the rotated plot: the red shows the cuts on the data to isolate pions

ΔE vs E short cut

Based on the results of the μQDC cut, the ΔE vs E now clearly shows the pion events. Additional cuts can be made to exclude the small number of protons and electrons that pass the μQDC cut.

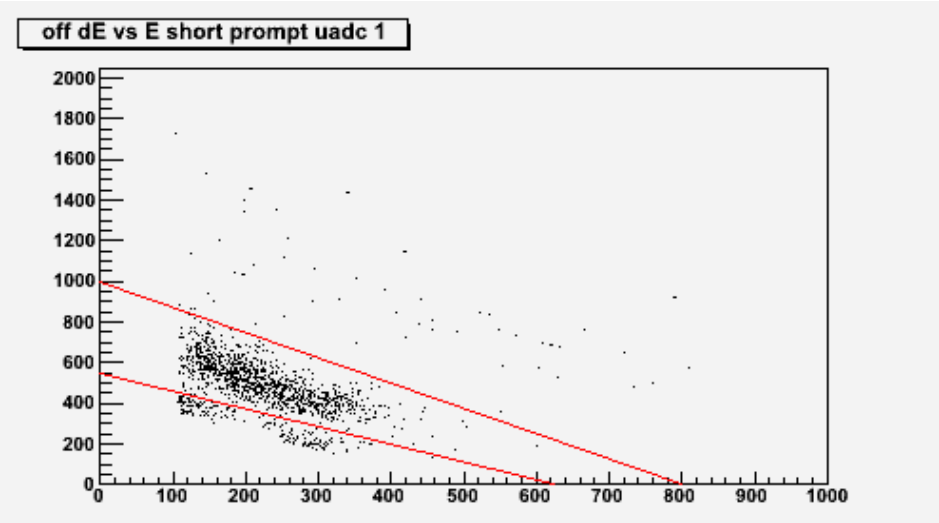
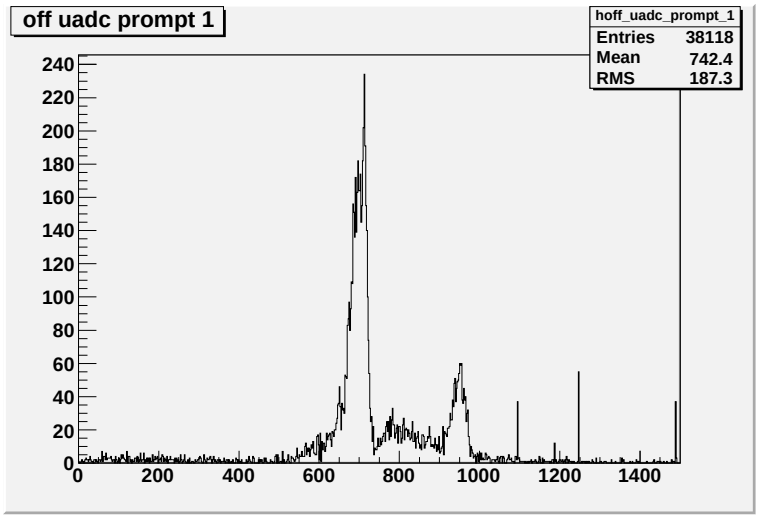


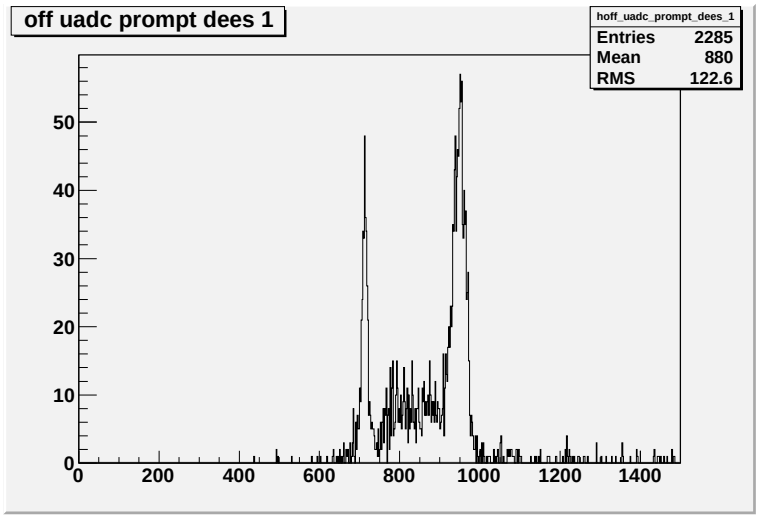
Figure: The results of the μQDC cut. The red lines show the cuts made on the original data to select pion events

Future Work

- Using the new ΔE vs. E cut to select the pion events, the μQDC cut can be refined.
- Iterations of these cuts will optimize the pion identifcation.



(a) μQDC before the ΔE vs E cut



(b) μQDC after the ΔE vs E cut

Acknowledgement

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