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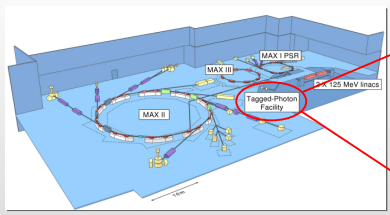
Overview

Near-threshold pion photoproduction experiments are a direct probe of quark structure, and are one of the few ways to explicitly test predictions made at low energies by QCD based effective theories.

Aside from the $\gamma p \rightarrow \rho \pi^0$ channel which has been thoroughly studied, few data exist in this region.

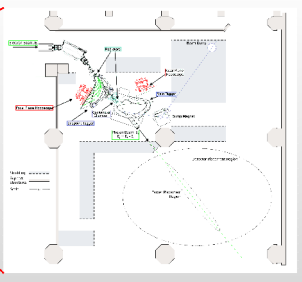
The PIONS@MAX-lab group has a series of near-threshold pion photoproduction experiments planned, including measurements of the **angular distribution of the $\gamma p \rightarrow n \pi^+$ channel**, and the **total cross section for the $\gamma n \rightarrow p \pi^-$ channel**.

Experiments at MAX-lab



- Maximum electron energy: 250 MeV (design) ~ 200 MeV (currently)
- Duty Factor: 50-80%
- Current: ~ 20 nA
- Beam emittance at radiator: 0.25 mm mrad

Tagged Photon Facility



Current arrangement of the Endpoint and Main Taggers, possible positions of the Focal Plane Hodoscope, target and detector regions.

Experimental Measurements

$\gamma p \rightarrow n \pi^+$

- measurement of $d\sigma/d\Omega$
- various θ_{cm} positions
- E_γ from threshold of ~150 MeV, to ~200 MeV
- Extraction of p-wave components

$$\frac{d\sigma}{d\Omega} = \left(\frac{q}{k}\right) \left[|E_{0+}|^2 + |p\text{-wave}|^2 \right]$$

$\gamma n \rightarrow p \pi^-$

- measurement of total cross section
- first measurement to be done close to threshold

World Data Sets

- Most measurements at least 20 years old
- Very little data near threshold!
- Incomplete energy and angular coverage

$\gamma p \rightarrow n \pi^+$

- below 200 MeV -- 117 data points
- within 5 MeV of threshold
- 45 data points from 1 measurement
- between 5 & 20 MeV of threshold
- 0 data points

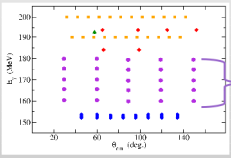
$\gamma n \rightarrow p \pi^-$

- below 200 MeV -- 60 data points
- within 5 MeV of threshold -- 0 data points
- between 5 & 20 MeV of threshold
- 12 data points from 1 unpublished measurement

Program Goals

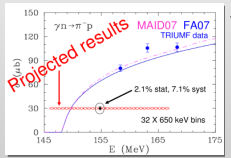
- Fill in large gaps in the world data sets

$\gamma p \rightarrow n \pi^+$



- Kinematical coverage of (γ, π^+) data below 200 MeV
Planned coverage range

$\gamma n \rightarrow p \pi^-$

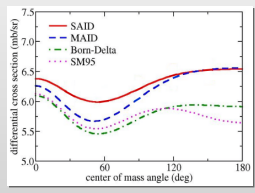


- Measurements of $\sigma(\gamma n \rightarrow p \pi^-)$ below 200 MeV, along with predictions from the MAID-07 and SAID-FA07 models.

Partial Wave Analysis

- For theoretical calculations, absence of data means:
 - calculations only to leading order $O(p^2)$
 - partial wave analyses are poorly constrained
 - large differences between MAID and SAID, for both $\gamma p \rightarrow n \pi^+$ and $\gamma n \rightarrow p \pi^-$

Example of differential cross section predictions from PWAs for $\gamma p \rightarrow n \pi^+$ at E_γ of 170 MeV



Experimental Setups

$\gamma p \rightarrow n \pi^+$

4 setups, 2 detection methods

- Range Telescopes

- 2, 5-layer $\Delta E-E$ telescopes
- use long & short gate ADC to search for $\pi^+ \rightarrow \mu^+$ decay

- CsI/SSD

- $\Delta E-\Delta E-E$ telescope
- 2 thin SSDs, 1 thick CsI(Tl) crystal
- use Flash ADC to search for π^+ decay
- $\pi^+ \rightarrow \mu^+ + \nu$ 26.0 ns, μ^+ energy: 4.12 MeV
- $\mu^+ \rightarrow e^+ + 2\nu$ 2.197 μ s, e^+ energy: ~5-50 MeV
- Possible construction of a second CsI/SSD Telescope
- investigate addition of a neutron detector

- PAC approved beamtime June 2009

- xSAL telescope

- 2, plastic scintillator $\Delta E-E$ telescopes
- use long & short gate ADC to search for $\pi^+ \rightarrow \mu^+$ decay

- Ge6 array

- 5 High Purity Germanium detectors
- combined with double sided silicon strip detectors
- 5 high resolution $\Delta E-\Delta E-E$ telescopes

$\gamma n \rightarrow p \pi^-$

Detection via 2 step process

- deuterium target
- produce pions via $\pi^- d \rightarrow 2n$
- capture of the π^- $\pi^- d \rightarrow 2n + \gamma$
- The γ in the second capture reaction is ~monochromatic, with $E_\gamma \sim 128$ MeV

- 3 large NaI detectors for γ detection, ~40 msr
- 2 arrays of neutron detectors
- 16 element NORDBALL liquid scintillator ~ 545 msr
- 10 element plastic scintillator TOF array ~ 670 msr

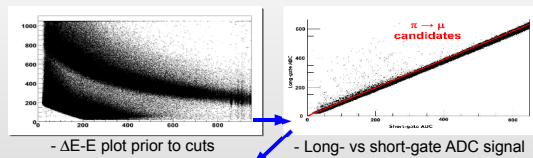
- PAC approved beamtime ~late 2009

Preliminary Results

$\gamma p \rightarrow n \pi^+$ commissioning run in early 2008

xSAL telescope

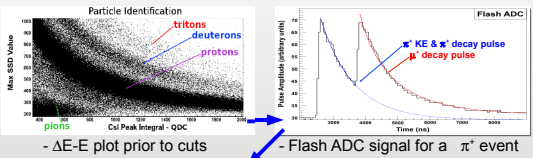
use of long and short gate ADCs to check for additional energy deposit from $\pi^+ \rightarrow \mu^+$ decay



- $\Delta E-E$ plot prior to cuts
- Long- vs short-gate ADC signal
- $\Delta E-E$ plot after event selection
- clear separation of particles

CsI/SSD telescope

use of Flash ADC to look for pulses from both π^+ & μ^+ decays

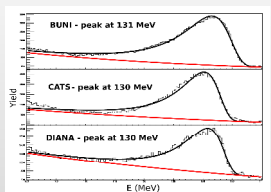


- $\Delta E-E$ plot prior to cuts
- Flash ADC signal for a π^+ event
- clear separation of particles $\Delta E-E$ plot after event selection
- ~9500 π^+ events selected have expected μ^+ life time

Preliminary Results

$\gamma n \rightarrow p \pi^-$ test in late 2008

Very preliminary tests during a Compton scattering experiment



- Energy of photons emitted in π^- capture reaction, $\pi^- d \rightarrow 2n + \gamma$, as measured by 3 different detectors is as expected
- This test bodes well for the upcoming dedicated beamtime

Acknowledgments

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