

Measurement of $\pi^0\pi^\pm$ Photoproduction off the Deuteron with the A2 Experiment

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University
of Basel



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Motivation

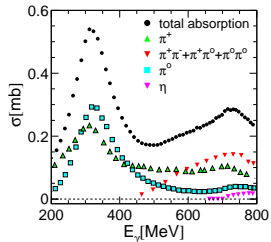
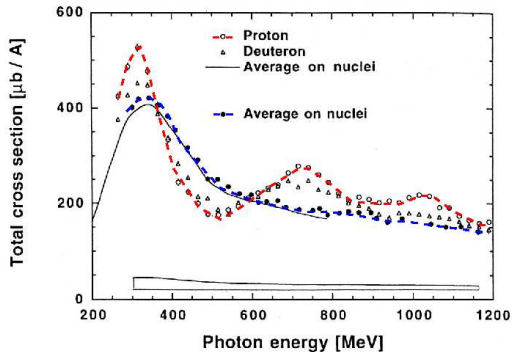
Photoproduction of pion pairs off nuclei

↔ Insight into low energy QCD

↔ In medium resonances of nucleons

↔ Particularly: intermediate state ρ forbidden for neutral state $\pi^0\pi^0$

Results from photoabsorption experiments:



(Source: Bianchi et al., Phys. Lett. B 325 (1994)
333-336 photoabsorption at INFN)

Theory

$$\gamma p(n) \longrightarrow \pi^+ \pi^0 n(n)$$

↔ 4 channels:

- direct
- via $\Delta^+ \longrightarrow \pi^+ n$
- via $\Delta^0 \longrightarrow \pi^0 n$
- via $\rho^+ \longrightarrow \pi^+ \pi^0$

$$\gamma n(p) \longrightarrow \pi^- \pi^0 p(p)$$

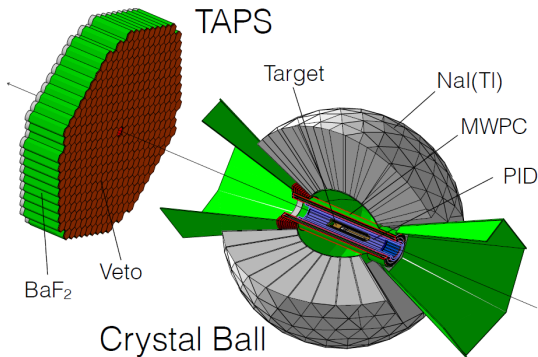
↔ 4 channels:

- direct
- via $\Delta^0 \longrightarrow \pi^- p$
- via $\Delta^+ \longrightarrow \pi^0 p$
- via $\rho^- \longrightarrow \pi^- \pi^0$

The ρ channel is forbidden for the uncharged $\pi^0 \pi^0$ final state (isospin conservation).

Experimental Setup

A2 Crystal Ball Experiment at MAMI

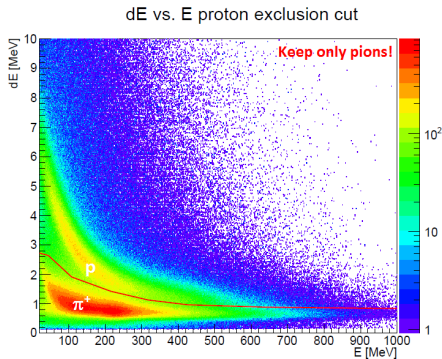


Analysis

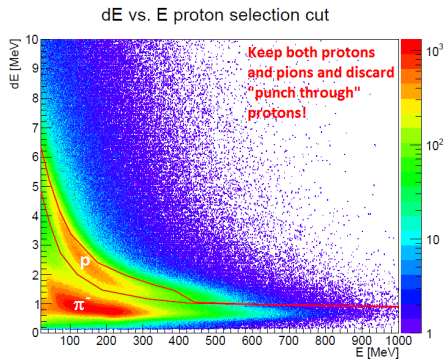
Cuts for event selection:

- PID versus CB energy ("dE-E cut")
- Invariant mass of the π^0 reconstructed from $\gamma\gamma$
- Missing mass
- Coplanarity of the final state
- Kinematic reconstruction check

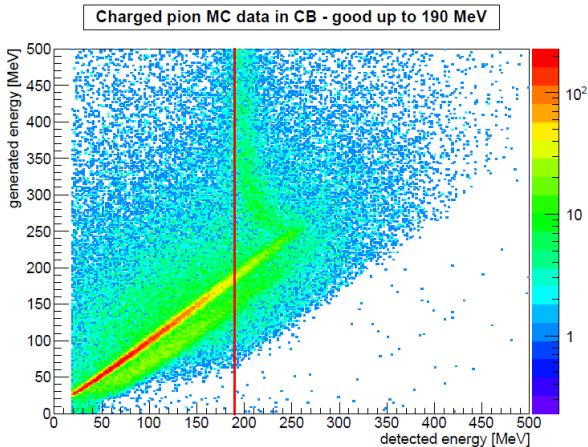
Charged particle identification:



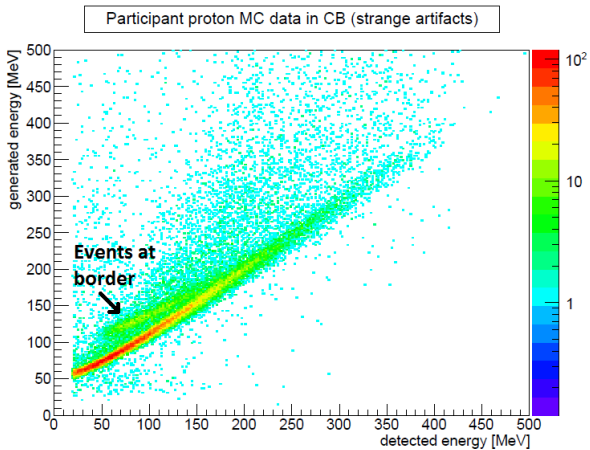
π^+ channel data



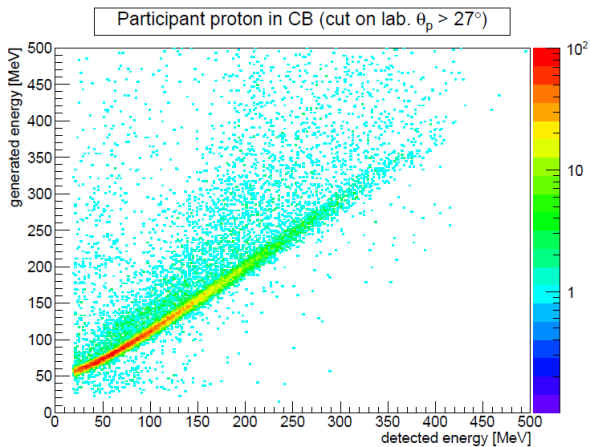
π^- channel data



π^+ channel MC – cut on "punch through" energy range



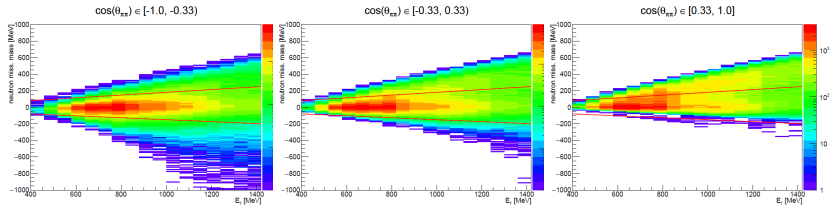
π^- channel MC



π^- channel MC

$$\sqrt{(p_{\text{Beam}}^4 + p_{\text{Target}}^4 - p_{\pi^+}^4 - p_{\pi^0}^4)^2} - m_{n(\text{part.})} \stackrel{!}{=} 0$$

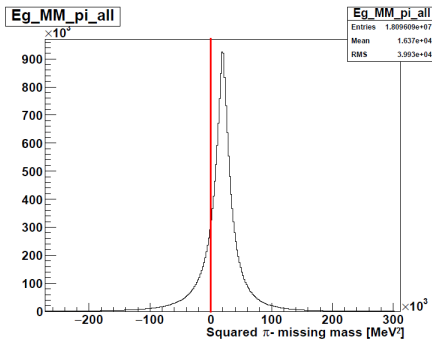
π^+ channel data



Spectator omitted \Rightarrow broadened peak through Fermi smearing

$$\sqrt{(p_{\text{Beam}}^4 + p_{\text{Target}}^4 - p_{\pi^0}^4 - p_{p(\text{part.})}^4)^2 - m_{\pi^-}^2} \stackrel{!}{=} 0$$

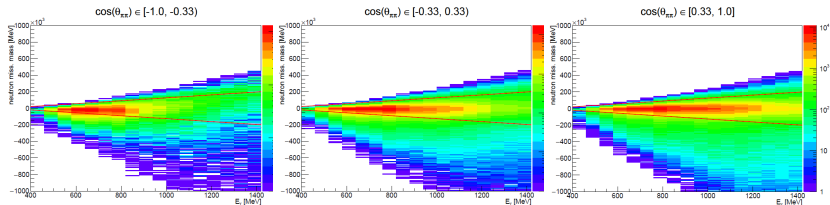
π^- channel MC



Fermi smearing > missing mass of system!

$$(p_{\text{Beam}}^4 + p_{\text{Target}}^4 - p_{\pi^0}^4 - p_{p(\text{part.})}^4)^2 - m_{\pi^-}^2 \stackrel{!}{=} 0$$

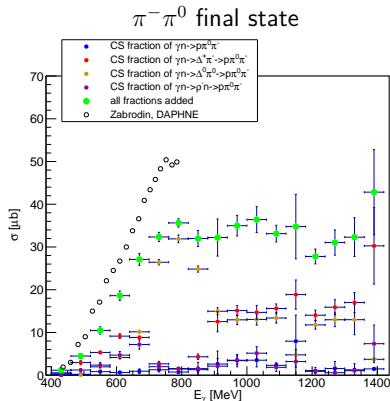
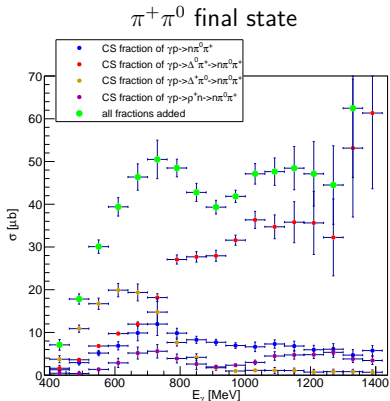
π^- channel data



\Rightarrow Cut on squared missing mass instead

Results

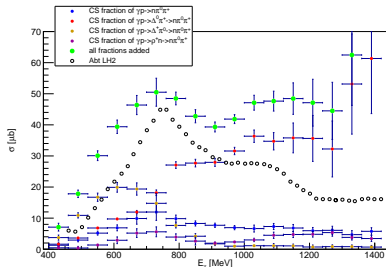
Preliminary cross sections



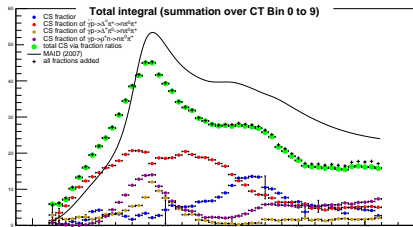
(π^- channel DAPHNE data: A. Zabrodin *et al.*, PRC 55 R1617 (1997))

Comparison to $\pi^+\pi^0$ production off free proton:

$\pi^+\pi^0$ off deuteron



$\pi^+\pi^0$ off proton



(Proton data: S. Abt, preliminary result)

Summary

- Preliminary cross sections for both mixed charge double pion production channels
- Low energy region comparable to $\pi^+\pi^0$ off free protons
- Detection efficiency problem for higher energy $\Delta^{0/+}\pi^\pm$ intermediate channel still needs further investigation

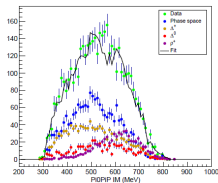
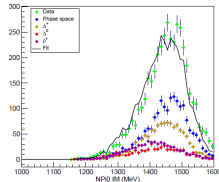
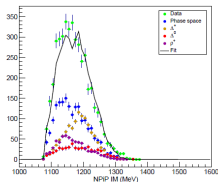
Outlook

- Consider influence of possible background channels
- Analyze and compare available data of other deuterium beamtimes
- Study the differences to the production off the free proton in detail
- Analyze production off heavier nuclei with liquid helium data

Questions?

Invariant mass fit

Example for $\cos(\theta) \in [0.4, 0.6]$ and $E_\gamma \in [1060, 1120]$:



Analyzed data set

- Target: Liquid Deuterium
density: 0.14741 b^{-1} , length: 3.02 cm
- Trigger: M2+ (two or more particles in CB)
- CB energy sum: 300 MeV
- Electron beam energy: 1557.5 MeV
- Photon tagger range: 400 MeV to 1400 MeV

Detected particles

$$\gamma p(n) \longrightarrow \pi^+ \pi^0 n(n)$$

↪ detected particles:

- 1 charged:
 - π^+
- 3 uncharged:
 - $\pi^0 \longrightarrow \gamma\gamma$ (98.823 %)
 - neutron participant

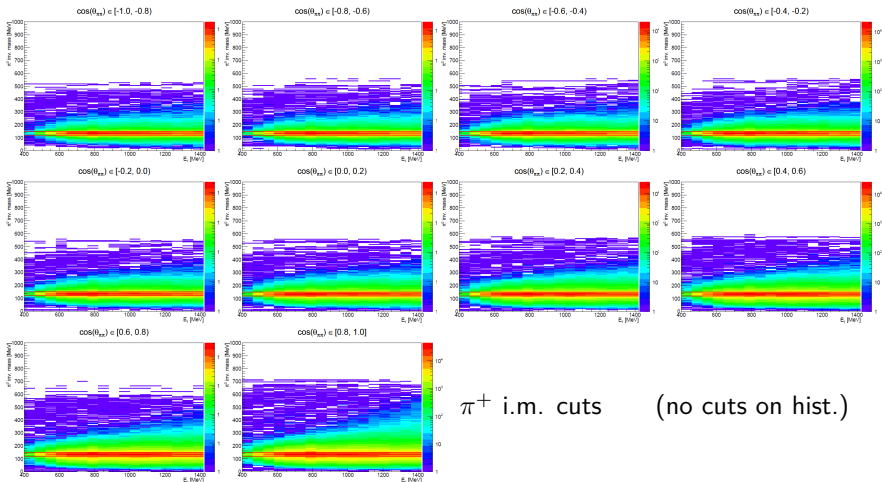
$$\gamma n(p) \longrightarrow \pi^- \pi^0 p(p)$$

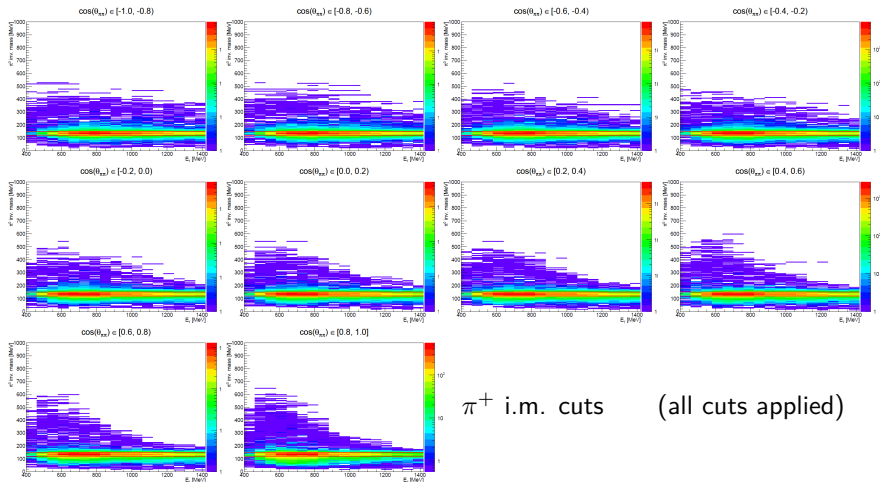
↪ detected particles:

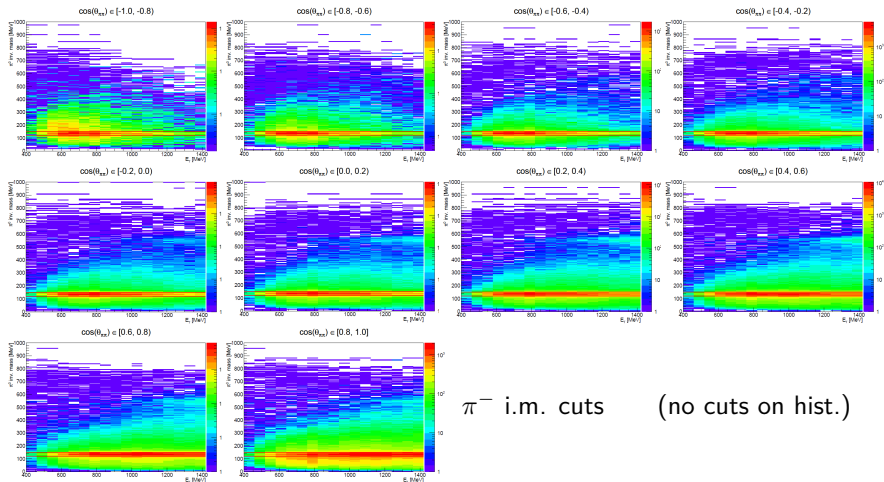
- 2 charged:
 - π^-
 - proton participant
- 2 uncharged:
 - $\pi^0 \longrightarrow \gamma\gamma$ (98.823 %)

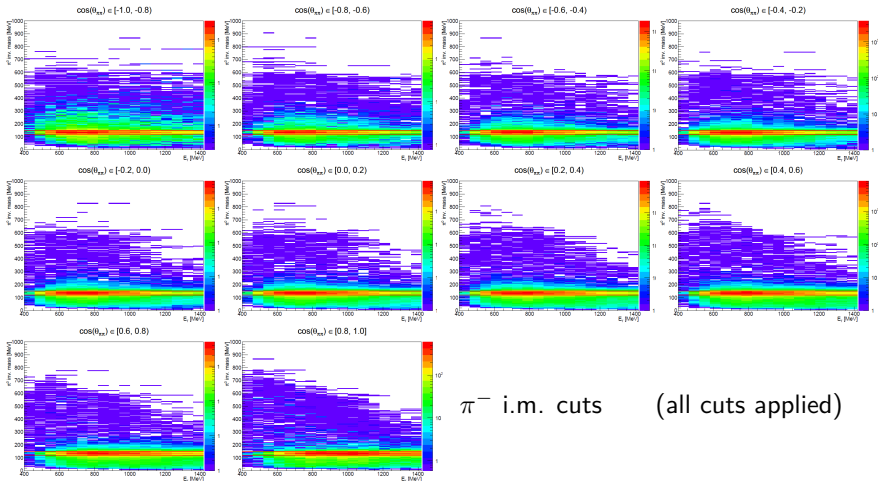
Further selection of events necessary through cuts and corrections

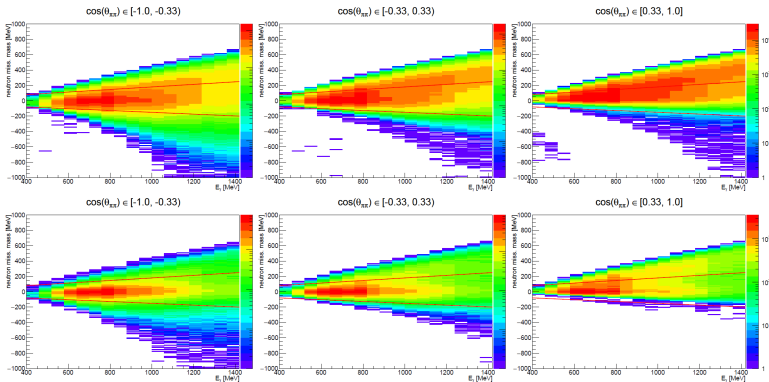
All cuts



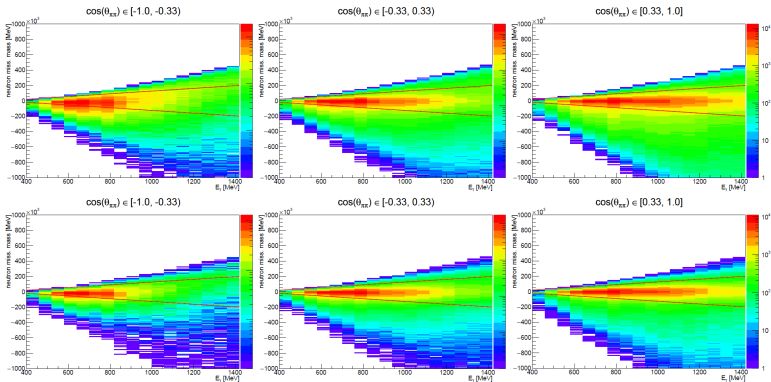




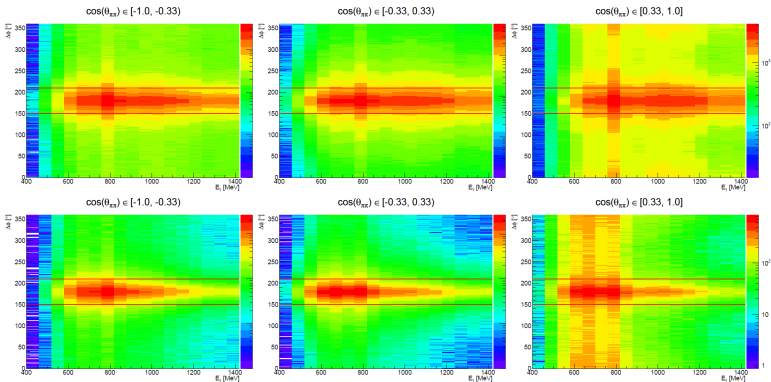




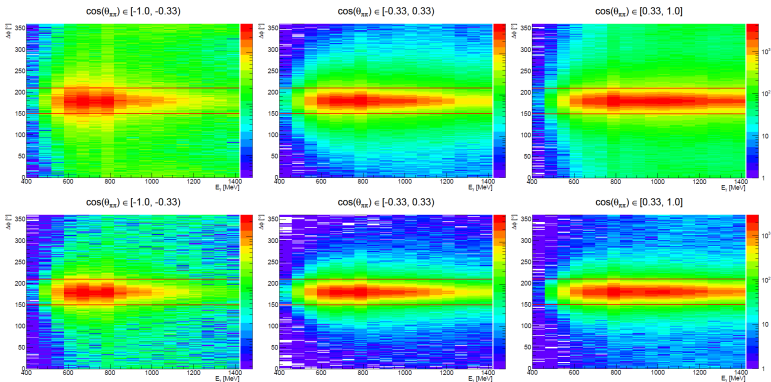
π^+ m.m. cuts (upper row without, lower with all cuts applied)



π^- m.m. cuts (upper row without, lower with all cuts applied)



π^+ cop. cuts (upper row without, lower with all cuts applied)



π^- cop. cuts (upper row without, lower with all cuts applied)