**P-21  Study of double delta photoproduction on the deuteron target**

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**Introduction**

Nuclear photon absorption

When photon beam impinged on the nucleus,
* nucleus is excited at the photon energy 1 MeV - 150 MeV.
* single nucleon (general term of proton and neutron) is excited at the photon energy 150 MeV -.

The difference of photon absorption reaction with two energy region.

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**Nucleon resonance**

The nucleon resonances are the excited states of nucleon.
These emit mesons ($\pi$ or $\eta$ etc.) and decay. Delta particle is one of the nucleon resonances and decay for $\pi N$. The life time is very short $10^{-23}$ s. The mass is 1232 MeV.

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**Experiment**

Neutral Kaon Spectrometer 2 (NKS2)
Measurement of the velocity and momentum of the charged particle
Component :
* Dipole magnet : Momentum analysis
* Hodoscope : Time of flight
* Drift chamber : Detection of track
Right figure : NKS2 seen from the photon beam down stream

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**Analysis**

Identification for $\pi^*$, $\pi$ and proton
- Using of the velocity $\beta$ and momentum $p$ of the charged particle, the particle mass is calculated.
  
  $$m^2 = p^2(\beta^2 - 1)$$

Selection of $yd$ $\rightarrow$ $\pi^*\pi p n$ reaction
- Missing particle : Non detected particle. From energy-momentum conservation, the mass of missing particle is calculated and the neutron is identified.
  
  $$M_n^2 = E_x^2 - P_n^2$$
  $$E_x = E_x + M_x - (E_x + E_x + E_p)$$
  $$P_n = P_x - (P_x + P_n + P_p)$$

$M$ : Particle mass
$E$ : Particle energy
$P$ : Particle momentum
*A lower index expresses the kind of particles.

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**Double delta photoproduction process on the deuteron**

Double delta excitation in the intermediate state of $\pi^*\pi^*$ photoproduction process. Since the wave length for photons is smaller than the average internucleon spacing for deuteron, it is wonderful that two nucleons excite.

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**Result**

Double delta excitation
- Invariant mass : From energy-momentum conservation before and after decay, the mass of particles before decay are calculated. For example, since the delta particles are decayed for $\pi$ and $N$,
  $$M_\Delta^2 = (E_\Delta + E_\Delta) - (P_\pi + P_\pi)$$
  
  - A lower figures are the invariant mass distribution $\pi N$.
  - Right side top : Invariant mass of $\pi p$.
  - Right side bottom : Invariant mass of $\pi n$.
  - From left side figure -> double delta excitation.

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**Summary**

- Double delta photoproduction is the process which excited double delta in the intermediate state.
- The experiment is carried out at ELPH.

- $\pi^*$, $\pi$ and proton were detected using NKS2.
- Neutron was identified using the missing mass.
- Double delta excitation in the intermediate state was shown using the invariant mass distribution $\pi^* p$ and $\pi n$. 