Spectroscopic study of the Λ(1405) via the d(K-,n) reaction

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A chiral unitary model claims that the Λ(1405) consists of two states (KbarN state and πΣ state). Experimental study of KbarN coupled to the Λ(1405) is desired. We proposed to study the Λ(1405) resonance via the d(K-,n) reaction at the J-PARC (J-PARC E31)[1]. In this reaction, a neutron is kicked by an incident kaon at a forward angle and the kaon is slow down to form the Λ(1405) with a residual nucleon. We measure the Λ(1405) spectrum in a missing mass of the d(K-,n) reaction. we also identify the three decay modes of the Λ(1405), $\Sigma^-\pi^+$, $\Sigma^+\pi^-$, and $\Sigma^0\pi^0$ to decompose scattering amplitudes of I=0, 1 and the their interference term in the spectrum. In this contribution, an overview of the experiment and the status will be presented.

Study background and motivation of Λ(1405)

Λ*(1405) [uds]

$I = 0, J^p = \frac{1}{2}^-$,

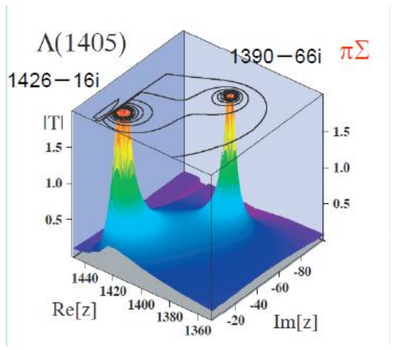
m=1405.1$\pm^{1.3}_{1.0}$(MeV)<N*(1440)

$\Gamma = 50 \pm 2$(MeV) (PDG-2011)

3 quarks ?
5 quarks ?

meson-baryon ?

Λ(1405) is described by superposition of two states (KbarN state and πΣ state).



[2]

・Such a meson-baryon molecular state provide important information to understand mechanism of formation of hadrons from quarks.

Experiment E31 in J-PARC at K1.8 beam line

・We measure the Λ(1405) spectrum in a missing mass of the d(K-,n) reaction, so forward scattered neutron is detected.

$$MM(Y) = \sqrt{(P_d + P_{K-} - P_n)^2}$$

・We identify the three decay modes to decompose scattering amplitude I=0,I=1 and interference term from the invariant-mass spectra.Then I=0 contributions is projected out.

Strategy of investigation of Λ(1405) as KbarN

The spectra of the Λ(1405) depend on the channels. If Λ(1405) is generated dynamically in KbarN scattering , It is expected that the resonance position would be ~1420 MeV.

We study (K-,n) reaction on deuteron target.

K- + d → reaction → Λ*[K-p] + n

Λ(1405) is located below the KbarN threshold

neutron takes energy out from kaon so that Λ(1405) resonance state is realized virtually .

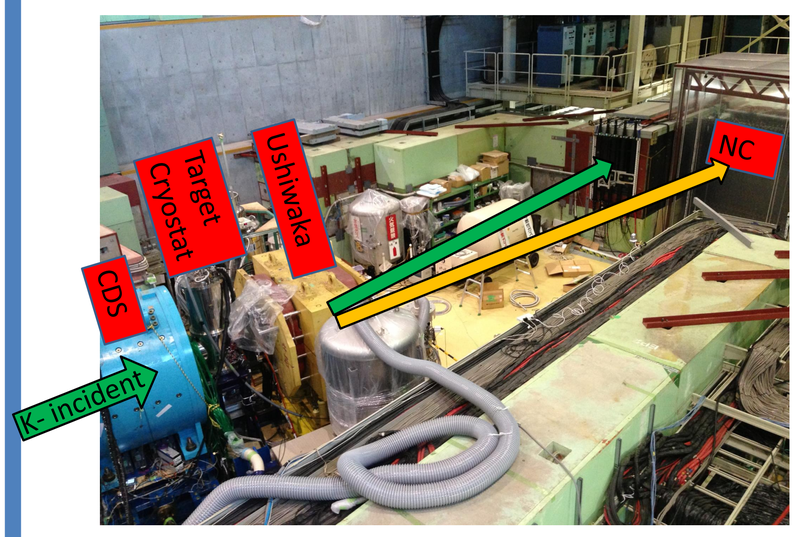
KbarN Threshold 1432 MeV

Λ(1405)

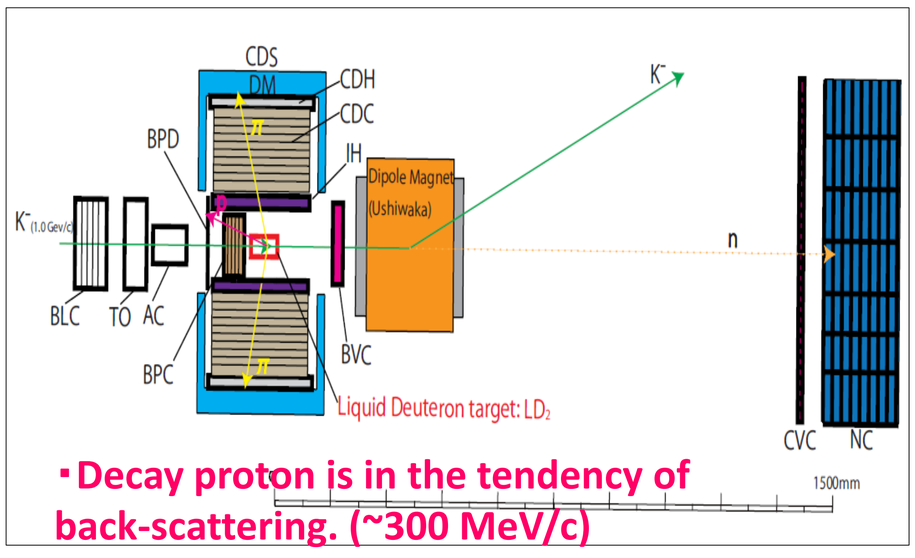
Detector System

・NC : TOF of kicked neutron. dt~120 ps σ_{mm}~10 MeV/c^2
・CDH : TOF of decay $\pi^{\pm}$. dt~71 ps
・CDC : Tracking of decay $\pi^{\pm}$. dx~200 μm
・BPD : TOF of decay proton. dt~200 ps
・BPC : Tracking of decay proton. dx~150 μm

BPC is also used for measuring the vertex of the hyperon decay[3].



K1.8BR Area



・Decay proton is in the tendency of back-scattering. (~300 MeV/c)

Detector System

Identification of every decay mode

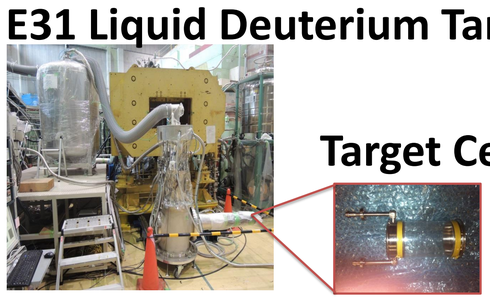
Decay mode of hyperon(Y) generated by the reaction d(K-,n)

						Detection eff[%]/misID[%]
Y →	π^0, Σ^0	→ π^0, γ, Λ	→ π^0, γ, π^-, p	$(I = 0\ only)$	①	~1.5/~0.1
→	π^+, Σ^-	→ π^+, π^-, n		$(I = 0,1)$	②	~25/~10
→	π^-, Σ^+	→ π^-, π^+, n		$(I = 0,1)$	③	~25/~10
		→ π^-, π^0, p		$(I = 0,1)$	④	
→	π^0, Λ	→ π^0, π^-, p		$(I = 1\ only)$	⑤	

- ①←→④,⑤ identified by the missing mass of Y and $(\pi^- + p)$.
- ①,⑤←→④ identified by the invariant mass of π^- and p.
- ②, ③←→①, ④,⑤ identified by detecting $\pi^{\pm}$.
- ②←→③ identified by the missing mass of Y and π^+ and Y and π^-.

Target System

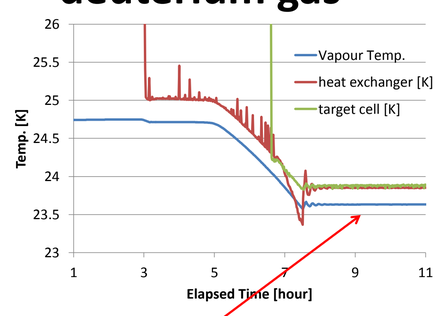
E31 Liquid Deuterium Target



Target Cell

The cooling test has been finished successfully !!

Liquefaction of deuterium gas



Stable @ 23.8K

Summary

・It is obtaining the mass spectrum of Λ(1405) and proving whether a chiral unitary model is right as a structual model of Λ(1405) from the mass and decay width.
・All the decay modes of the hyperon generated by the reaction can be identified
・Preparation of the experiment is complete.

Reference
[1] J-PARC E31 proposal : http://j-parc.jp/NuclPart/pac 0907/pdf/Noumi.pdf
[2]T.Hyodo and A.Weise,Phys.RevC77,035204(2008)
[3]PTEP arXiv:1206.0077v1

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