Study of Y* in nuclei through the C(K^-, π^+)X spectrum at 1.8 GeV/c in the J-PARC E05 experiment

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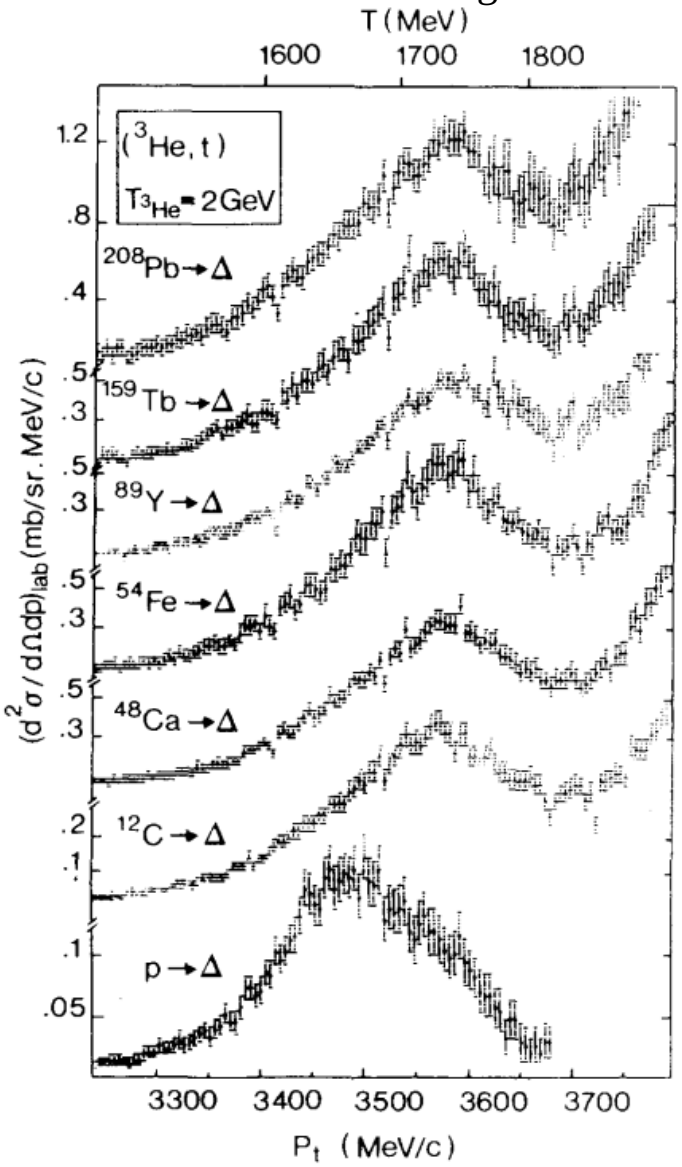
Decuplet baryons in nuclei

The behavior of Δ particle in nuclei have been studied by π or nucleus induced reaction from 1970s.
The experimental peak structure was explained by theoretical treatment based on the Δ-hole model using,

- ΔN interaction
- Escape potential
- Spreading potential
- Self energy
- Pauli blocking effect in nucleus

What's happened if Y* is introduced in nuclei via the K^- induced reaction ?

Δ resonance peak structure on nuclear targets



D. CONTARDO et al., Phys. Lett. B 186, 312 (1986)

J-PARC E05 experiment pilot run

Search for bound state of Ξ^- hypernuclei via the **(K^-, K^+)** reaction at the K1.8 beam line in the J-PARC hadron facility.

List of data sets

- (K^-, K^+)
- **(K^-, π^+) (My talk)**
- (K^-, p)

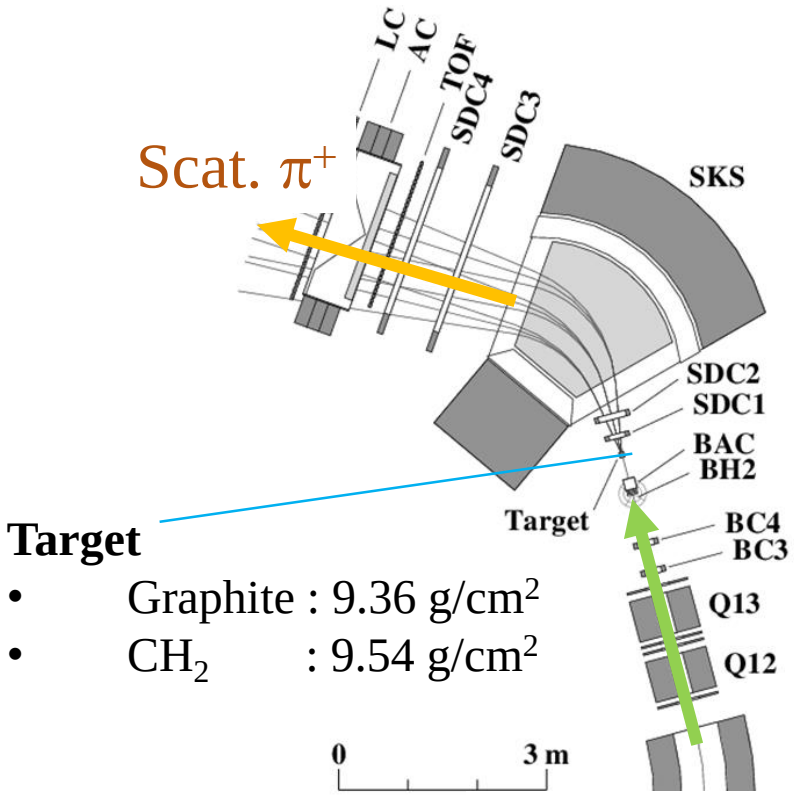
Divided by 3
in the case of (K^-, π^+)

Data summary

Target	beam mom. (GeV/c)	Effective # of K^- (G kaons)
CH_2	1.5	2.85
CH_2	1.6	2.89
CH_2	1.7	2.69
CH_2	**1.8**	**9.53**
CH_2	1.9	1.17
Graphite	**1.8**	**74.8**

Inclusive (K^-, π^+) spectra at 1.8 GeV/c
($2 < \theta_{K\pi} < 14$ deg. in lab sys.)

SKS-Minus system

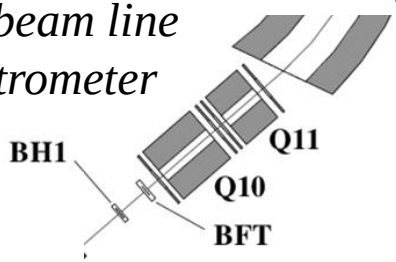


Target

- Graphite : 9.36 g/cm^2
- CH_2 : 9.54 g/cm^2

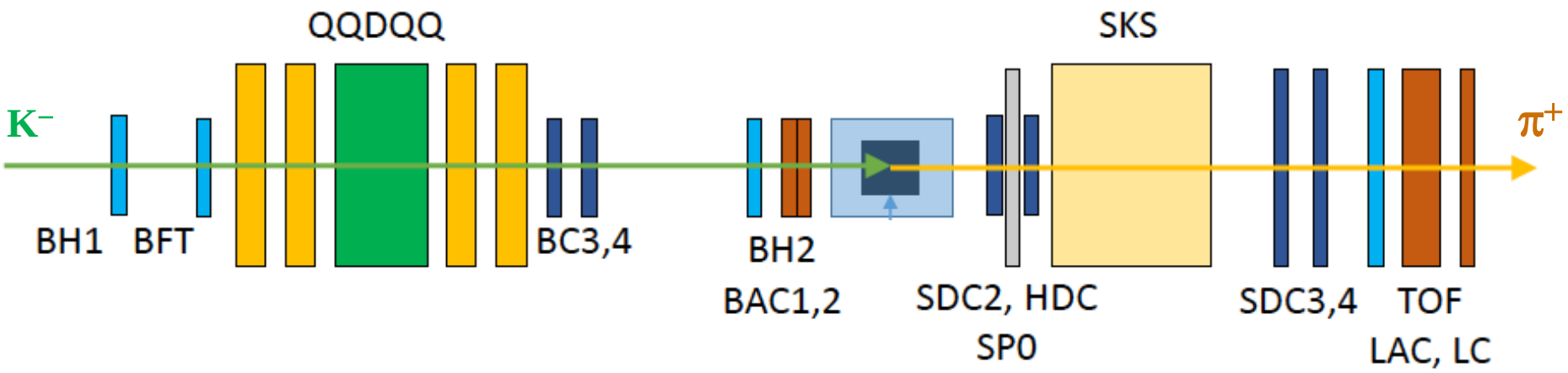
Beam K^-
(600 K/spill)

K1.8 beam line spectrometer

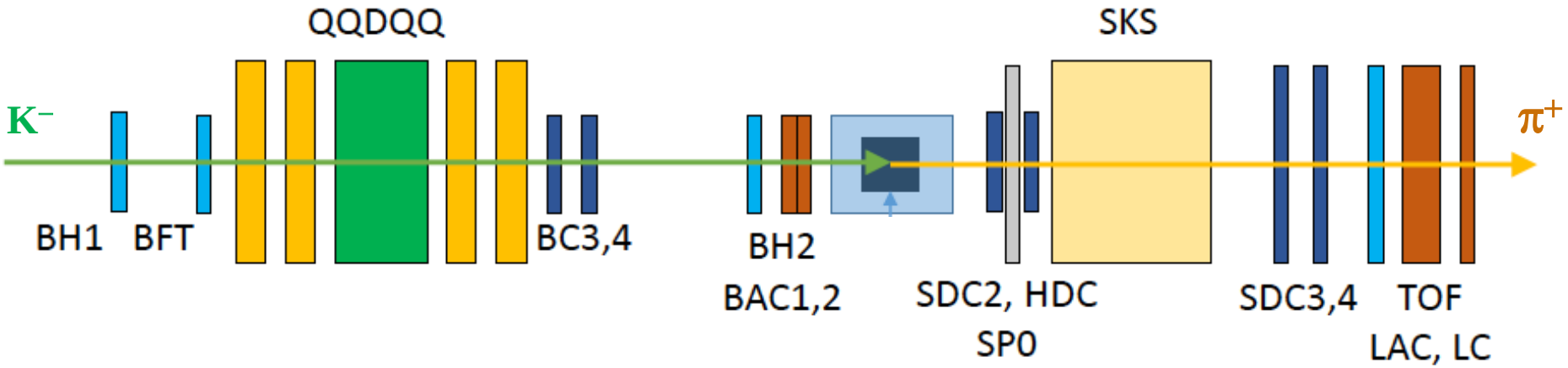


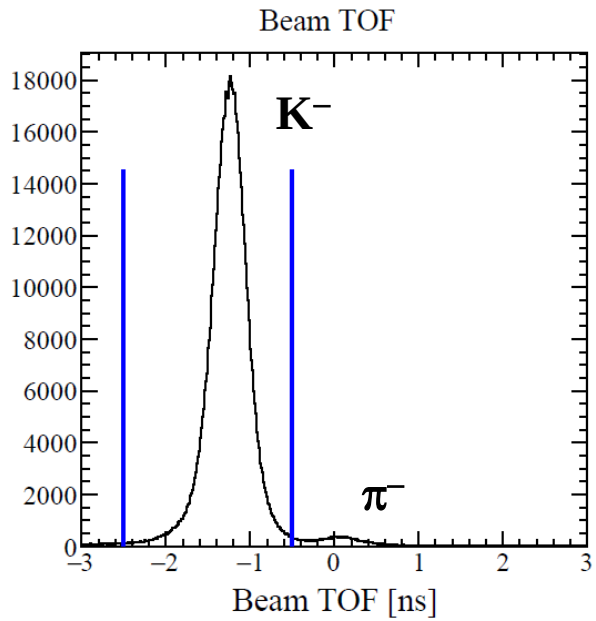
J-PARC
K1.8 beam line

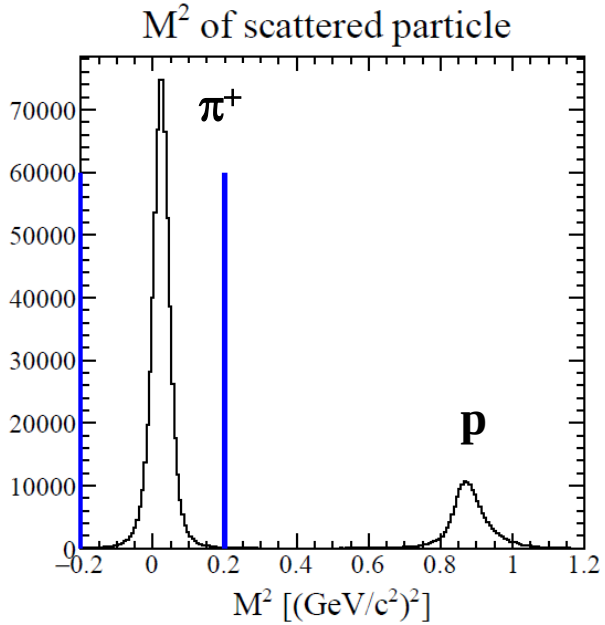
Analysis procedures



Analysis procedures

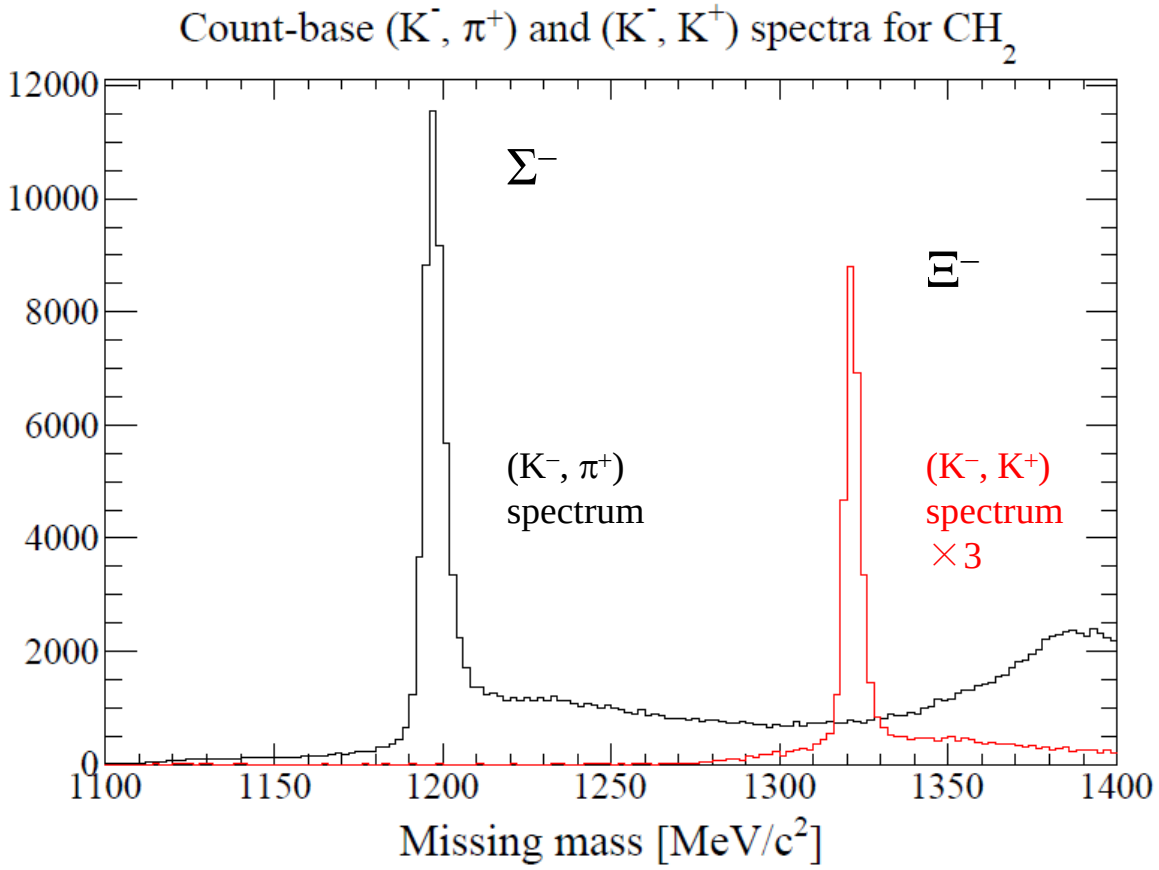






Beam K^- and scattered π^+ were clearly identified owing the spectrometer systems.

Analysis procedures



Spectrometer systems were calibrated by using these two peaks.

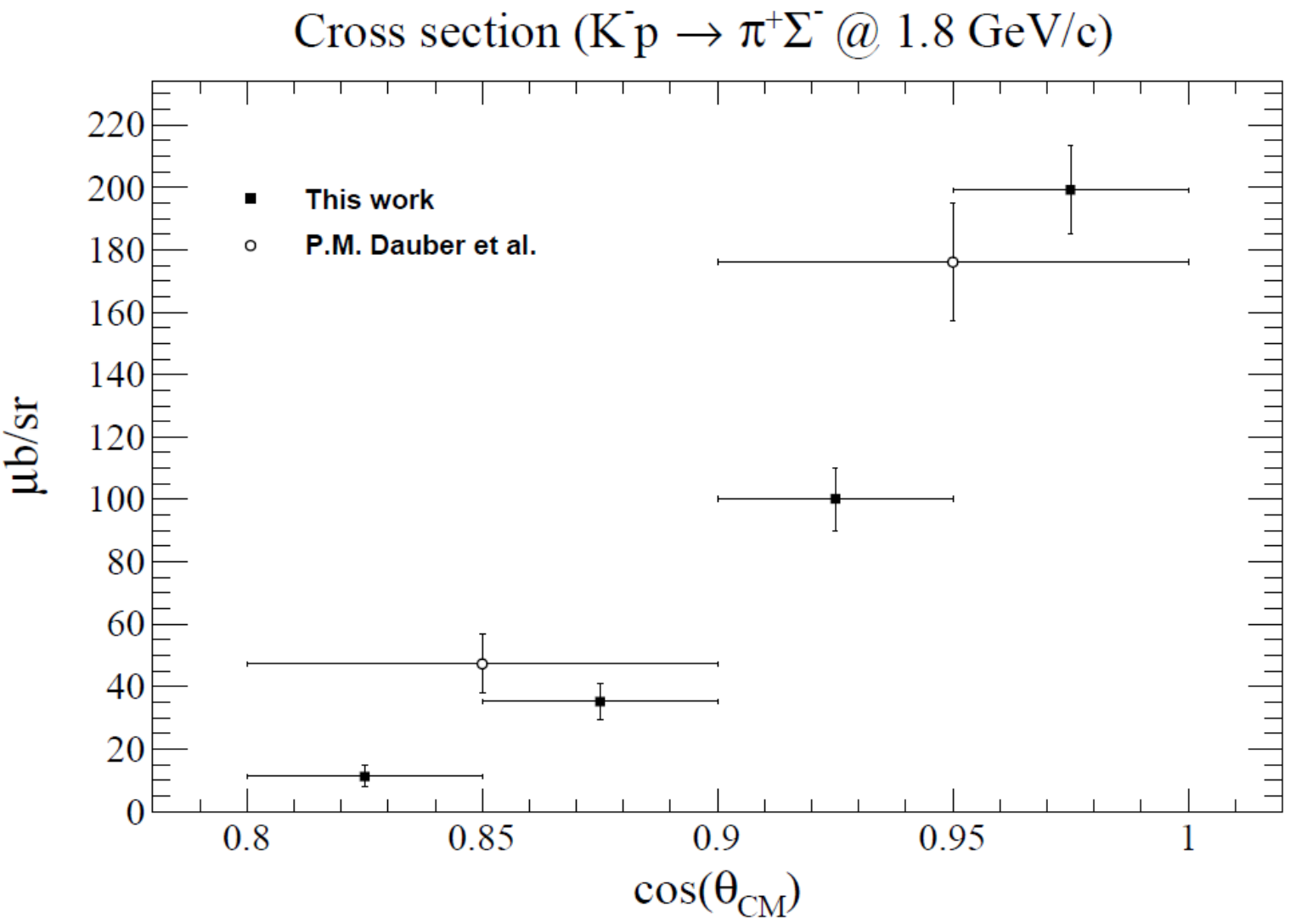
Evaluate those two using Σ^- peak

Experimental resolution
- 7 MeV (FWHM)

Differential cross section of
$K^- p \rightarrow \pi^+ \Sigma^-$

(Validity of the analysis procedure)

Differential cross section of $K^- p \rightarrow \pi^+ \Sigma^-$

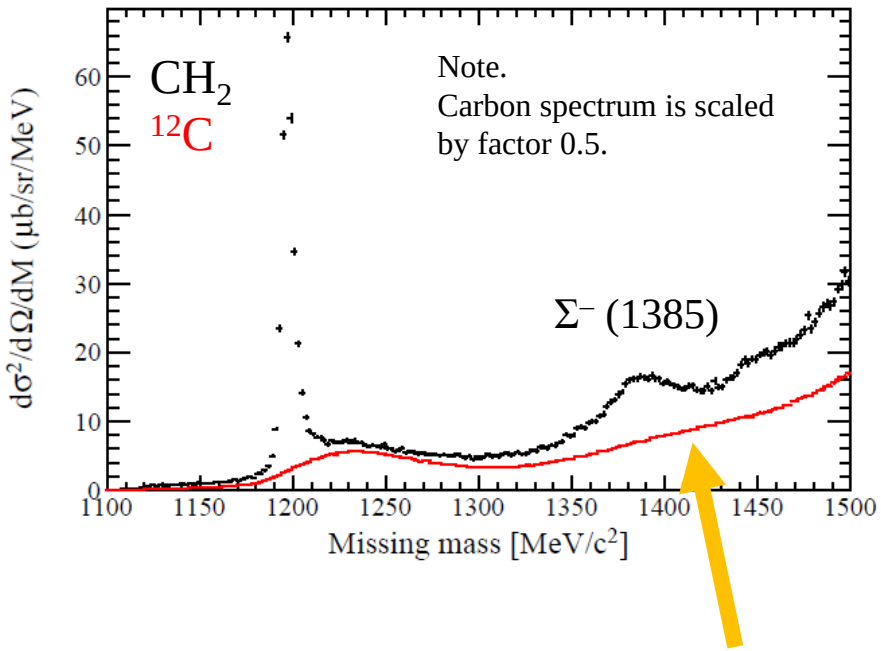


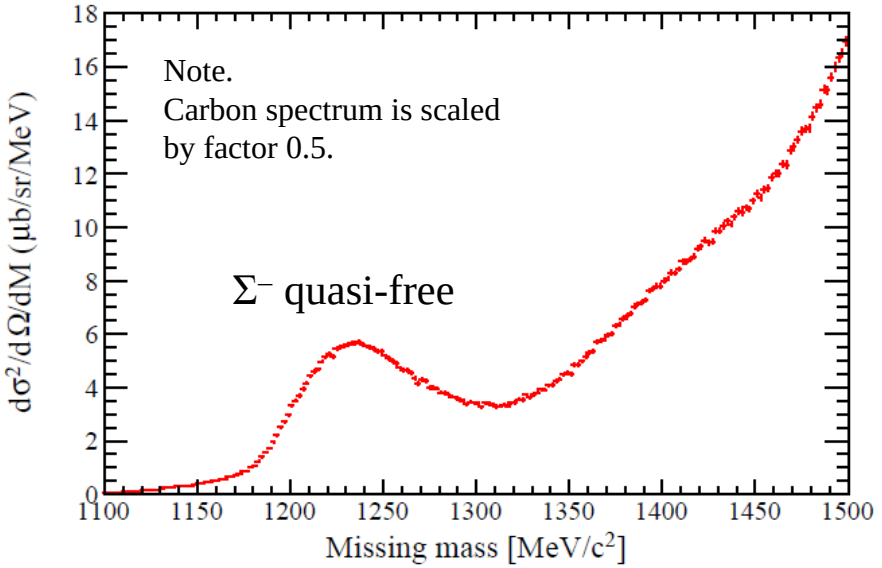
Our experimental data agree well with the past experimental data.

Results and discussion

CH_2 and Carbon spectrum

The (K^-, π^+) spectra for CH_2 and carbon targets.
p = 1.8 GeV/c, $2 < \theta_{K\pi} < 14$ deg. in lab sys.
(Assuming that proton at reset is a target.)

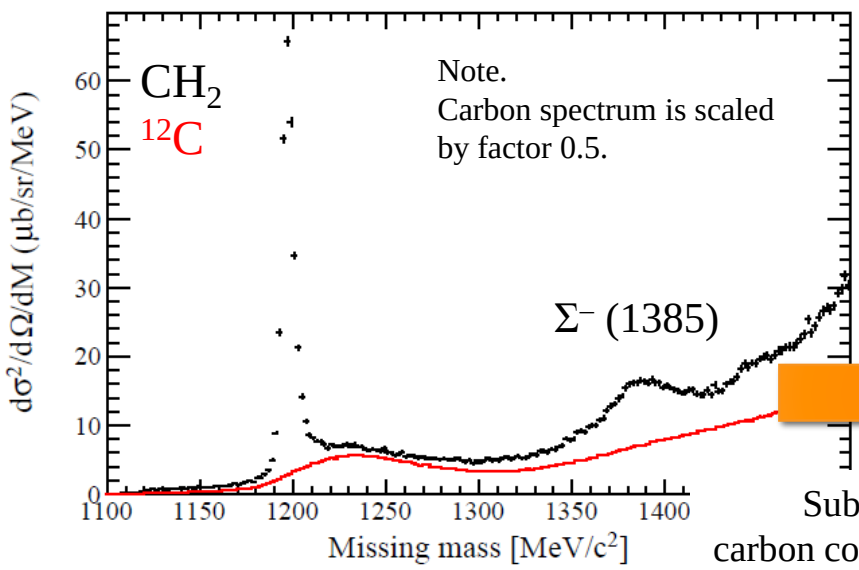




Almost no peak structure for Σ^- (1385) is seen in the carbon spectrum.
Σ^- (1385) in nucleus is quite broadened.

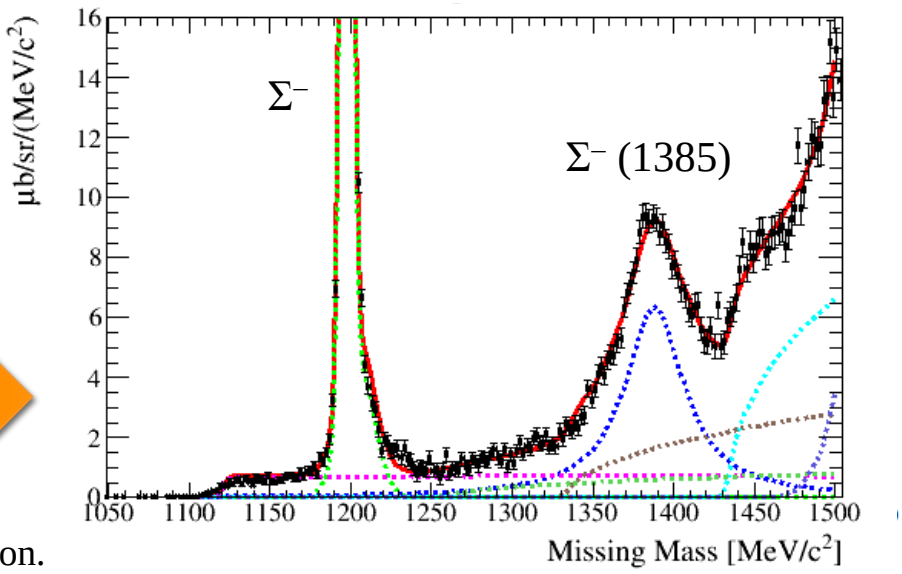
Background components

The (K^-, π^+) spectra for CH_2 and carbon targets.
p = 1.8 GeV/c, $2 < \theta_{K\pi} < 14$ deg. in lab sys.
(Assuming that proton at reset is a target.)



Subtract
carbon contribution.

Subtracted spectrum
(Proton contribution)



List of BG

- $\Lambda\pi^-\pi^+$
- $\Sigma^-\pi^0\pi^+$
- $K^-n\pi^+$
- K^0n, $K^0 \rightarrow \pi^-\pi^+$
- $K^0n\pi^0$, $K^0 \rightarrow \pi^-\pi^+$

Note.
Relative amplitude of each PDF are phenomenologically determined by Roofit.

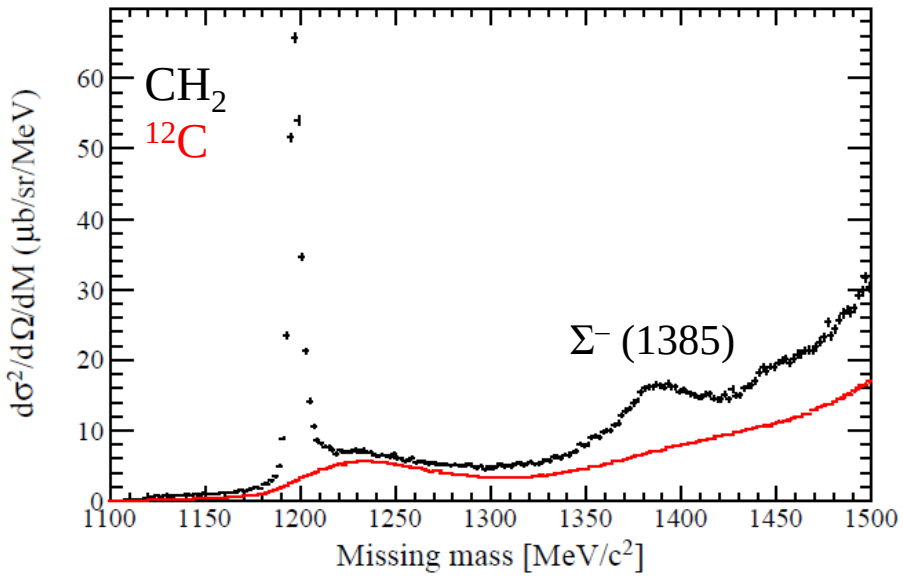
These background components contribute to the carbon spectrum, but, significant contribution from Σ^- (1385) is also seen.

Obtained Σ^- (1385) parameters

- Mean: 1388 ± 4 MeV/c²
- Γ: 44 ± 18 MeV

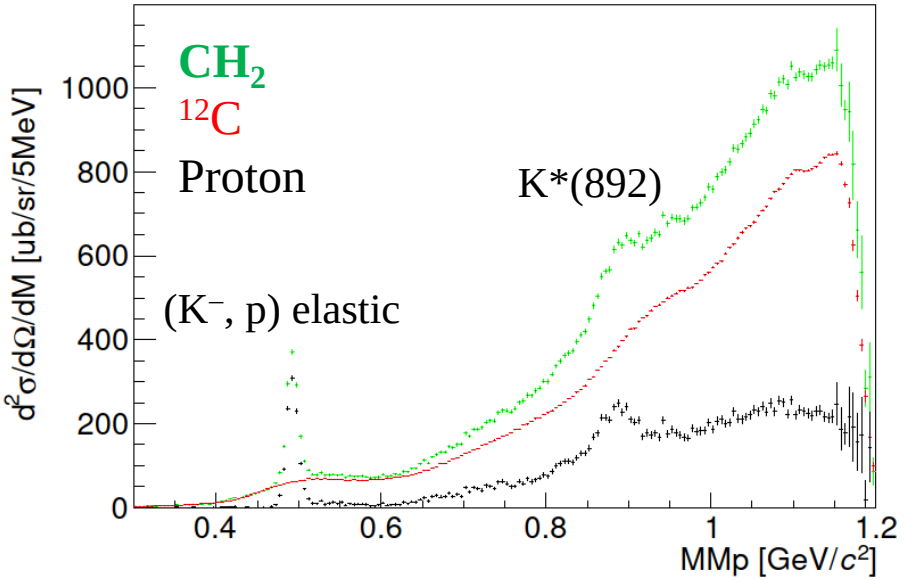
Comparison with K*(892) in carbon

The **(K^-, π^+)** spectra for CH_2 and carbon targets.
(Assuming that proton at reset is a target.)



PDG value Σ^- (1385)
- Mean: 1386.2±0.5 MeV/c^2
- **Γ: 39.4±2.1 MeV**

The **(K^-, p)** spectra for CH_2 and carbon targets.
(Assuming that proton at reset is a target.)



PDG value K*(892)
- Mean: 891.6±0.26 MeV/c^2
- **Γ: 50.8±0.9 MeV**

The width of K*(892) in free space is broader than that of Σ^- (1385), however, the bump structure still exists in the (K^-, p) spectrum.

Interpretation

Structure of decuplet baryons

Recently, compositeness of decuplet baryons are theoretically discussed, that is, its structure is **not perfect 3 quark state**.

E.g. π could effect in $\gamma N \rightarrow \Delta$ form factors [1].

Furthermore, the CLAS collaboration reported that decay with ratio as

$$R_{\Lambda\pi}^{\Lambda\gamma} = \frac{\Gamma[\Sigma^0(1385)\rightarrow\Lambda\gamma]}{\Gamma[\Sigma^0(1385)\rightarrow\Lambda\pi^0]} = 1.42 \pm 0.12(\text{stat})^{+0.11}_{-0.07}(\text{sys})\%.$$

and was **1.5-3 times larger than the prediction of consistent quark models [2].**

It indicate that Σ^- (1385) in nuclei may be strongly converted from Y*N to YN due to striping out cloud π.

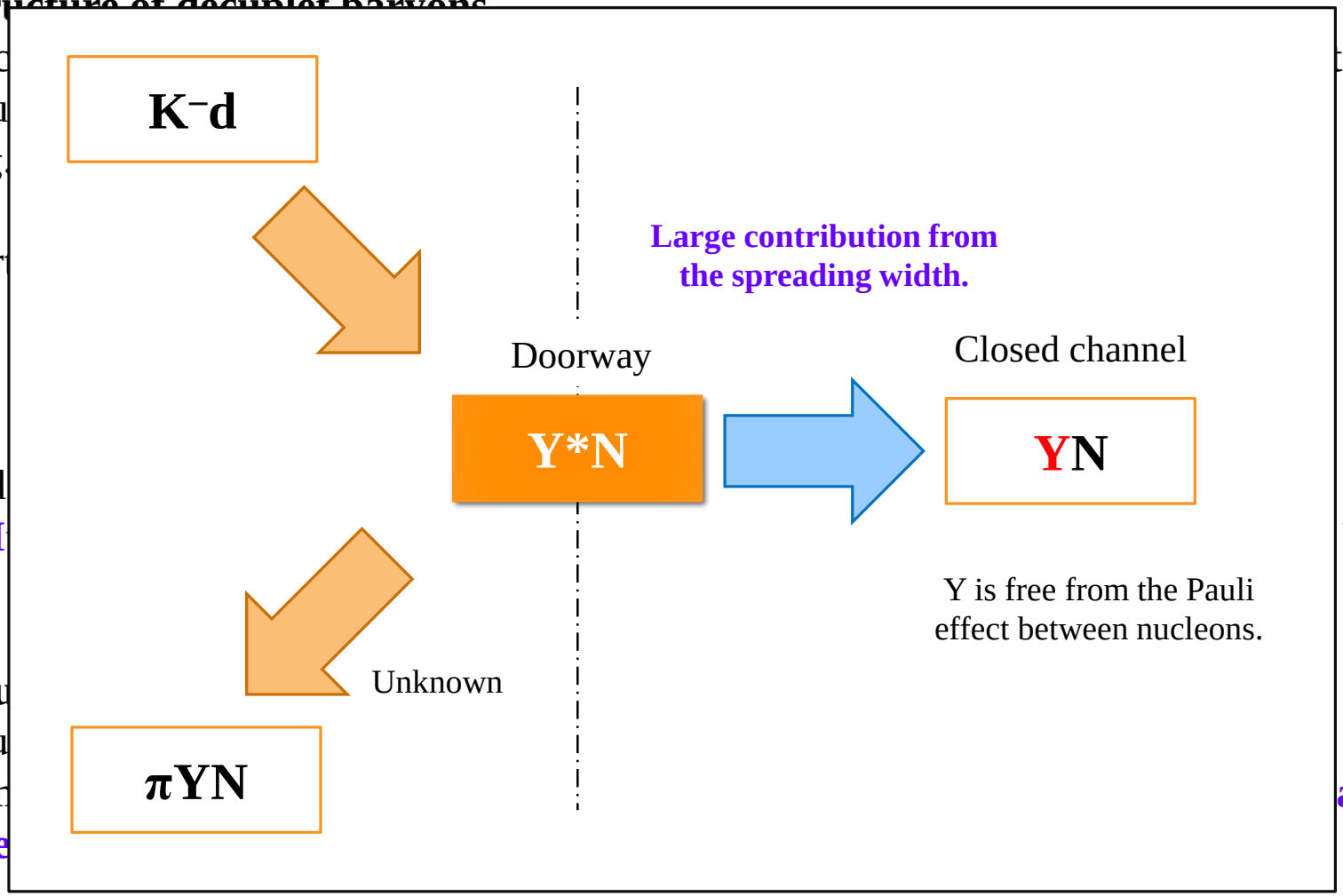
Pauli blocking effect

Pauli blocking effect makes the width narrower in the case of Δ in nuclei.

It may be suppressed for the Y*N system because converted **Y is free from the Pauli effect between nucleons.**

[1]. B. Juli´a-D´ıaz et al., PRC 75, 015205 (2007)
[2]. D. Keller et al. PRD 83, 072004 (2018)

Interpretation



[1]. B. Juli´a-D´ıaz et al., PRC 75, 015205 (2007)
[2]. D. Keller et al. PRD 83, 072004 (2018)

Future experiment

We discussed Σ^- (1385) in nuclei only from the inclusive (K^-, π^+) spectrum.
Exclusive one should be taken by identifying the final state in order to separate the escape width from other components.
Decay particle detector surrounding the target is necessary.

By measuring the **A dependence of Y* in nuclei**, we may extract the information of spreading potential of Y* in nuclei.

Such the experiment should be performed in J-PARC in the future.

Summary

- So far, Δ resonance exited in nuclei have been discussed by the Δ-hole model using several potential parameters. Then, what's happened if Y* is introduced in nuclei.

- We performed the J-PARC E05 experiment, which was search for bound state of Ξ^- hypernuclei via the (K^-, K^+) reaction. We took data for the (K^-, π^+) reaction simultaneously.

- In the CH2 spectrum, Σ^- and Σ^- (1385) peaks are clearly observed, however, the peak structure of Σ^- (1385) in the carbon spectrum almost disappeared. Σ^- (1385) in nuclei is quite broadened.
- Even K*(892), which has broader the natural width, can be seen as the bump structure in the (K^-, p) spectrum.

- By considering the recent work for studying the compositeness of , this behavior is interpreted as a large contribution from the spreading potential caused by stripping out could π. On the other hand, Pauli effect may be suppressed because Y is free from the Pauli effect between nucleons.

- In future, we should perform other experiment with the surrounding detectors and measure the A dependence.