Photon energy dependence of $\Lambda(1405)$ production

Riken, Radiation Lab.
M. Niiyama for LEPS TPC Collaboration
(PRC 78, 035202, 2008)

Contents

1. Experimental data of $\Lambda(1405)/\Sigma(1385)$ from LEPS
2. Analysis
3. Lineshape of $\Lambda(1405)$ in charged $\Sigma\pi$ mode
4. Photon energy dependence of differential cross section of $\Lambda(1405)/\Sigma(1385)$ production
5. Summary and prospects

Experimental data of $\Lambda(1405)/\Sigma(1385)$ from LEPS

- $\gamma p \rightarrow K^+ \Lambda(1405)/\Sigma^0(1385) \rightarrow K^+ \Sigma^{\pm}\pi^{\mp}$

  JK.Ahn et al. Nucl.Phys.A721:715-718,2003.

  Lineshapes of $\Lambda(1405)$ were different in two decay modes.

- $\gamma p \rightarrow K^+ \Lambda(1405)/\Sigma^0(1385) \rightarrow K^+ \Sigma^{\pm}\pi^{\mp}$

  M.Niiyama et al. PRC 78, 035202, 2008

  Lineshapes of $\Lambda(1405)$ were different in two decay modes.

  Photon energy dependence of $\Lambda(1405)$ production.

  Contamination of $\Sigma(1385)$ was estimated from $\Lambda\pi$ decay mode.

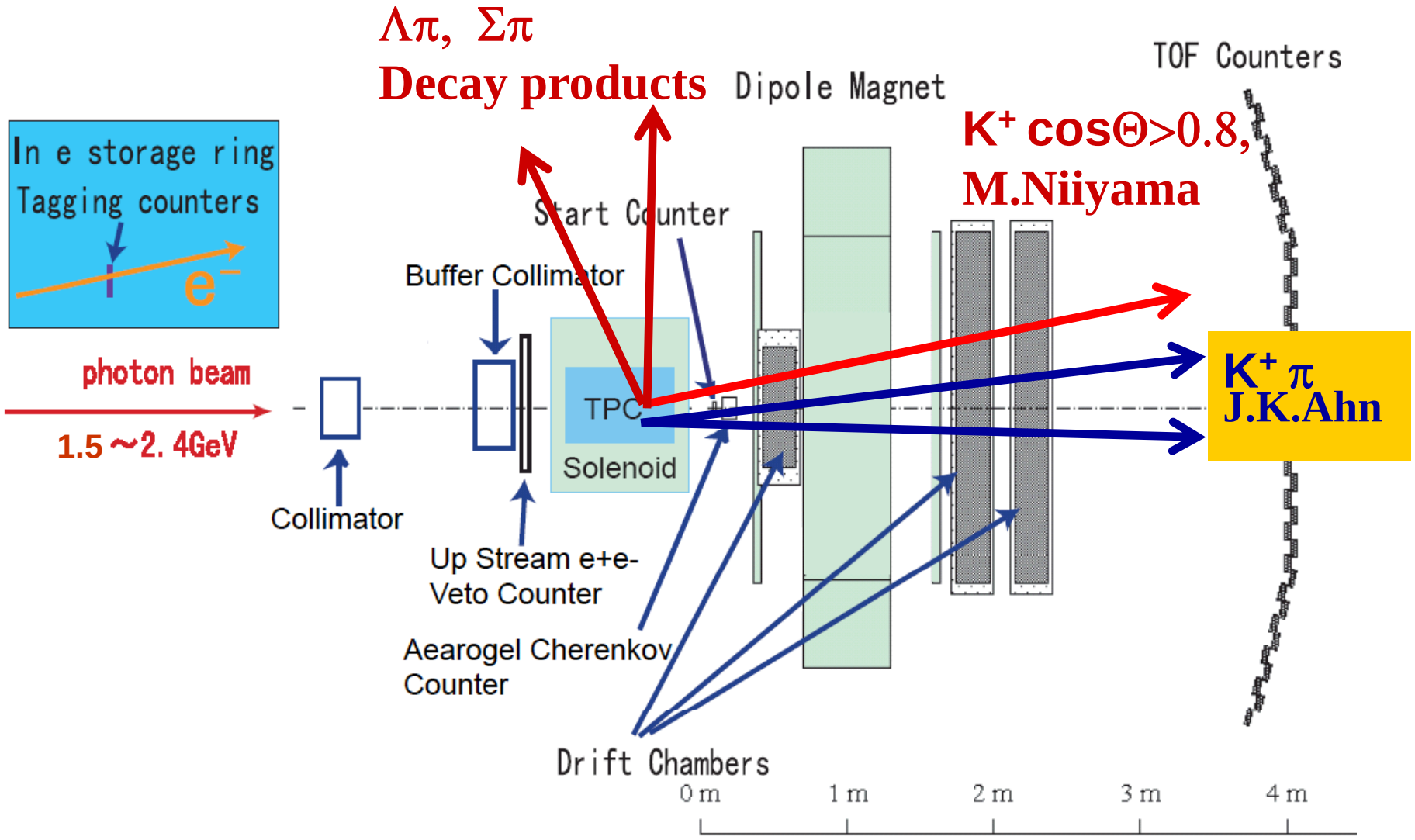
- $\gamma n \rightarrow K^+ \Sigma^-(1385) \rightarrow K^+ \pi^-\Lambda$

  K.Hicks et al., PRL102, 012501(2009)

- $\gamma p \rightarrow K^+ X$, $X=\Lambda(1405)/\Sigma^0(1385)$

  D.S.Ahn next talk (t-dependence)

Setup in SPring-8/LEPS



Beam Time

2004 Apr – Jul、Sep – Dec Forward spectrometer + TPC

CH_2 9×10^{11} photons C 5×10^{11} photons

Production ratio Λ(1405)/Σ(1385)

- K^+ in forward spectrometer $0.8<\cos\theta_{kCM}<1$

$$\gamma\, p \rightarrow K^+ \Sigma(1385) \rightarrow K^+ \Lambda\, \pi^0 \rightarrow K^+\, p\pi^-\, \pi^0$$

$$\gamma\, p \rightarrow K^+ \Lambda(1405) \rightarrow K^+ \Sigma^{\pm}\, \pi^{\mp} \rightarrow K^+\, \pi^+\, \pi^-\, n$$

2000 Dec-Jun Only forward spectrometer

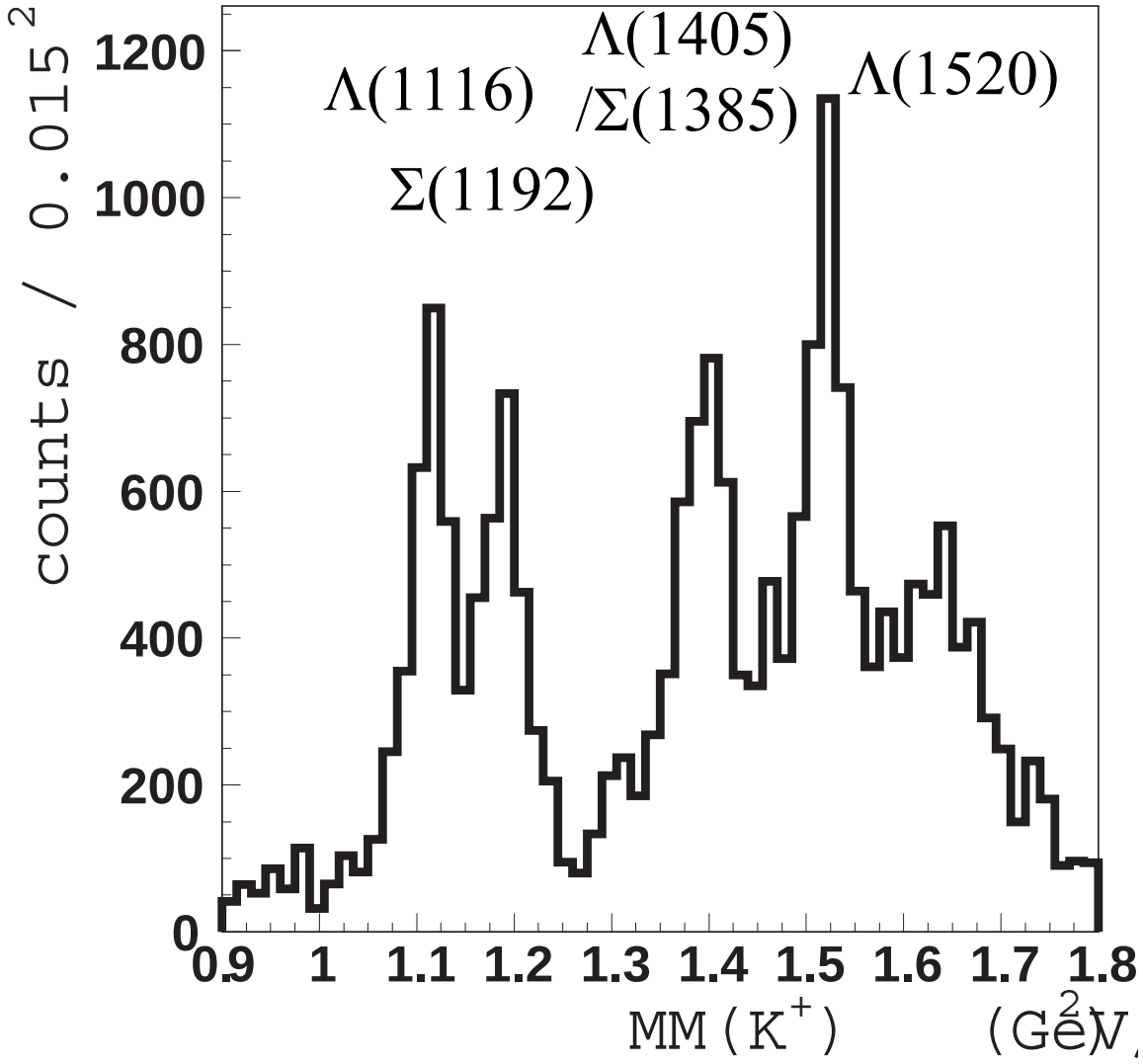
Liquid H_2 2×10^{12} photons

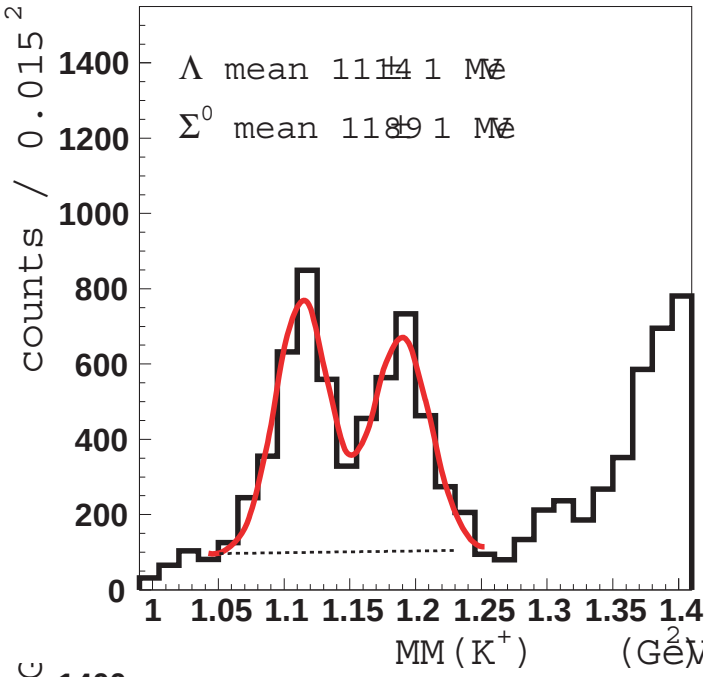
Absolute value of the cross section

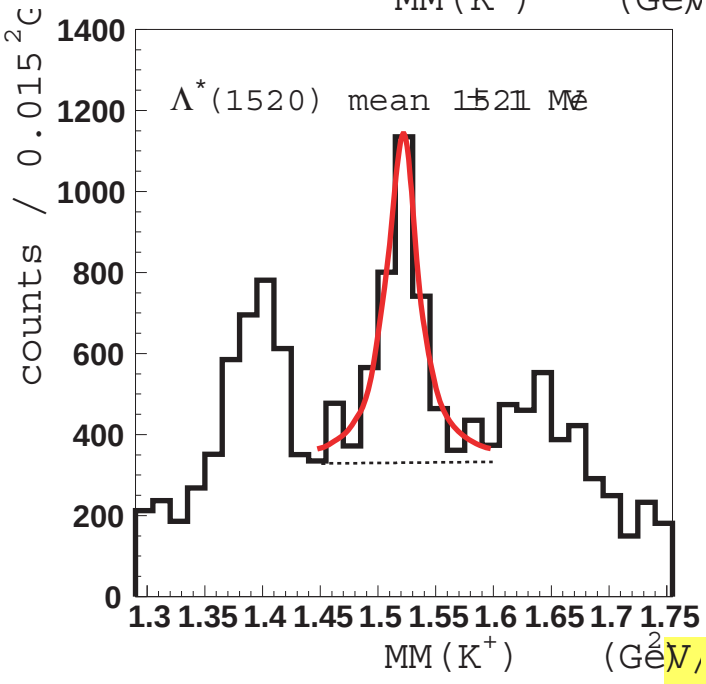
$0.8<\cos\theta_{kCM}<1$, $1.5<E\gamma<2.0$ GeV, $2.0<E\gamma<2.4$ GeV

Missing mass of $p\,(\gamma, K^+)\,X$

K^+'s were detected by Spectrometer







Σ(1385) photoproduction

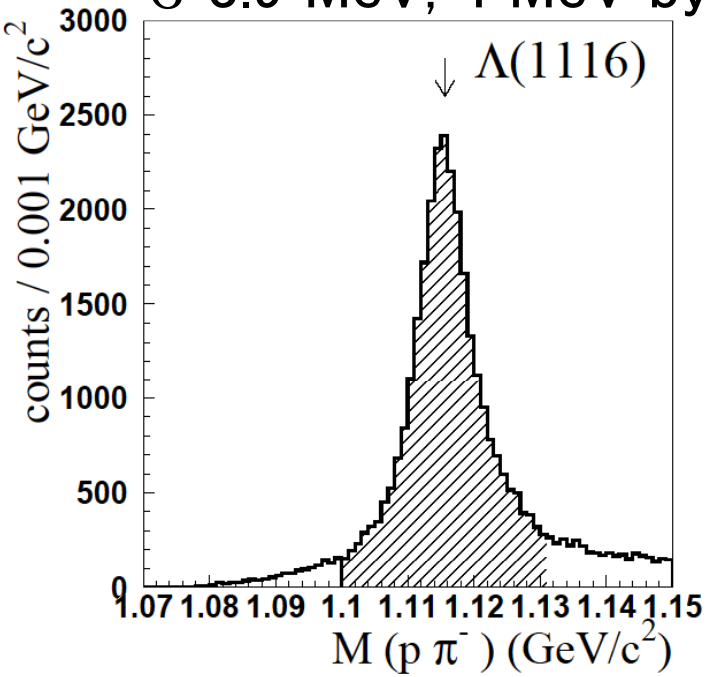
$$\gamma\, p \rightarrow K^+ \Sigma(1385) \rightarrow K^+ \Lambda\, \pi^0 \rightarrow K^+ p\pi^- \pi^0$$

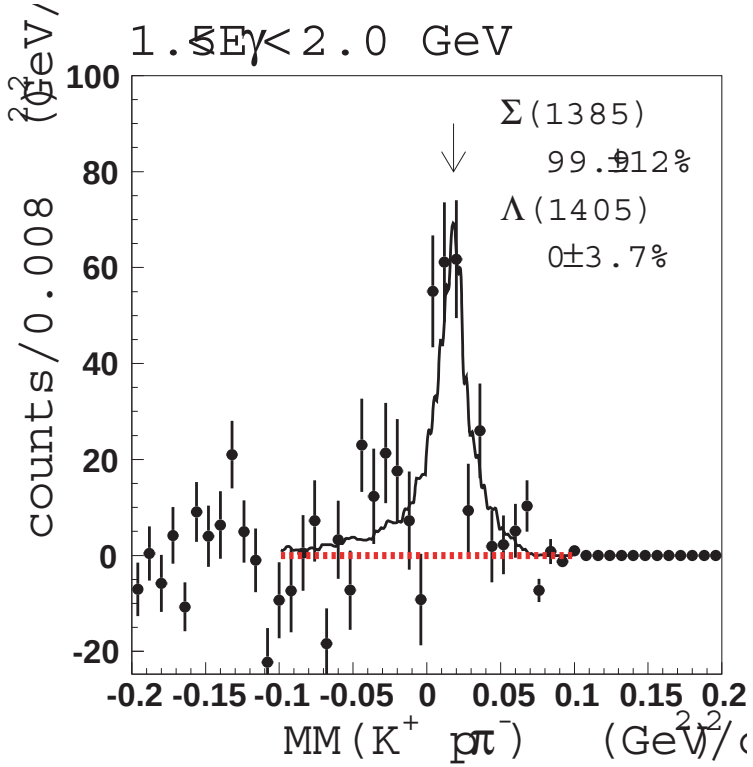
spectrometer

TPC

1115.4±0.4 MeV

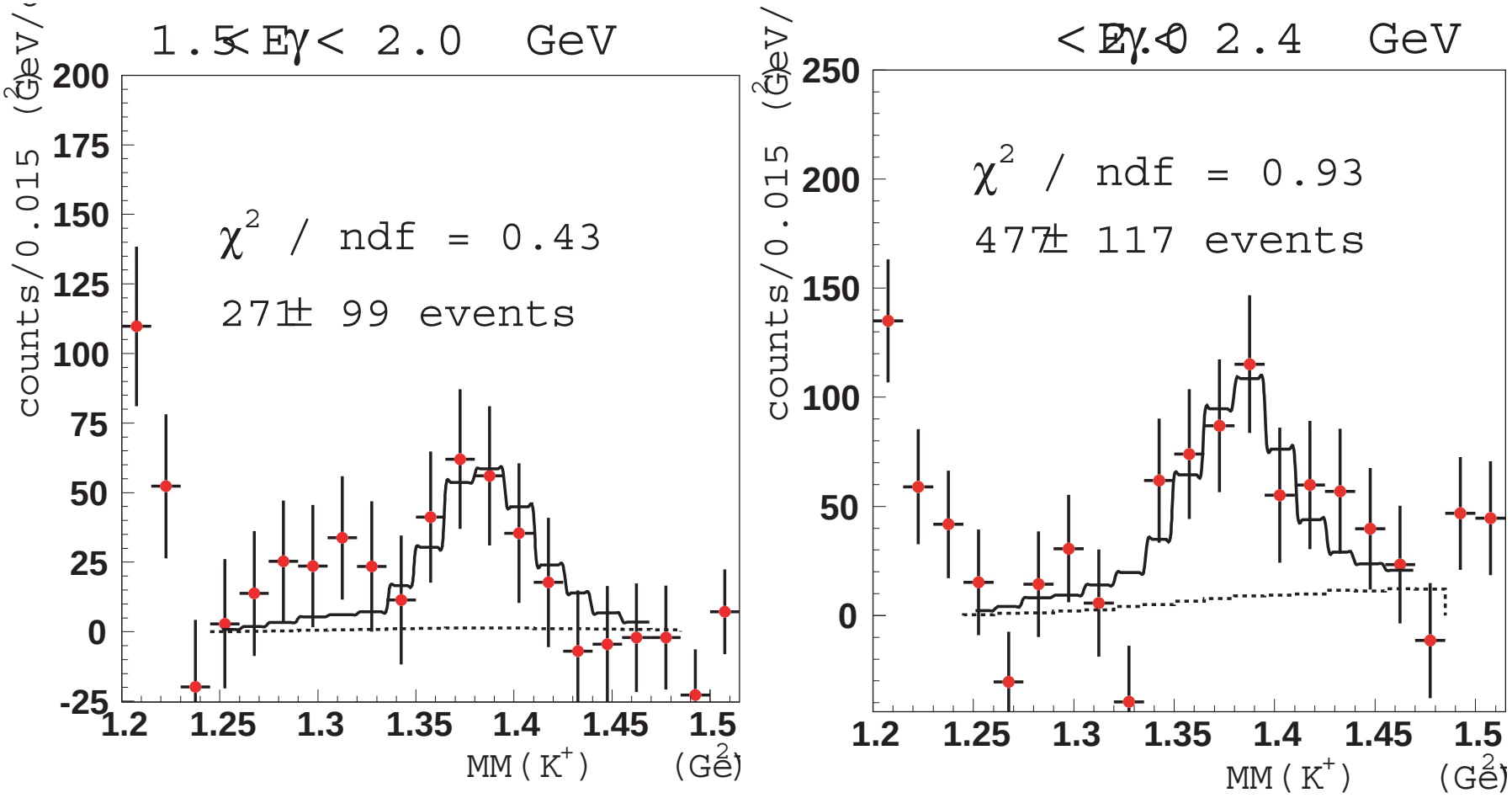
σ 3.9 MeV, 4 MeV by MC





- Contamination $\gamma\, p \rightarrow K^+ \Lambda(1405) \rightarrow K^+\Sigma^0\, \pi^0 \rightarrow K^+ \Lambda\gamma\pi^0$
- Contamination $\gamma\, p \rightarrow K^+ \Sigma(1385) \rightarrow K^+\Sigma^+\, \pi^- \rightarrow K^+ p\pi^0\, \pi^-$

Σ(1385) production



Λ(1405) production

Spectrometer TPC

$$\gamma\, p \rightarrow K^+\, \Lambda(1405) \rightarrow K^+\Sigma^{\pm}\, \pi^{\mp} \rightarrow K^+\, \pi^+\, \pi^-\, n$$

peak 945±1 MeV

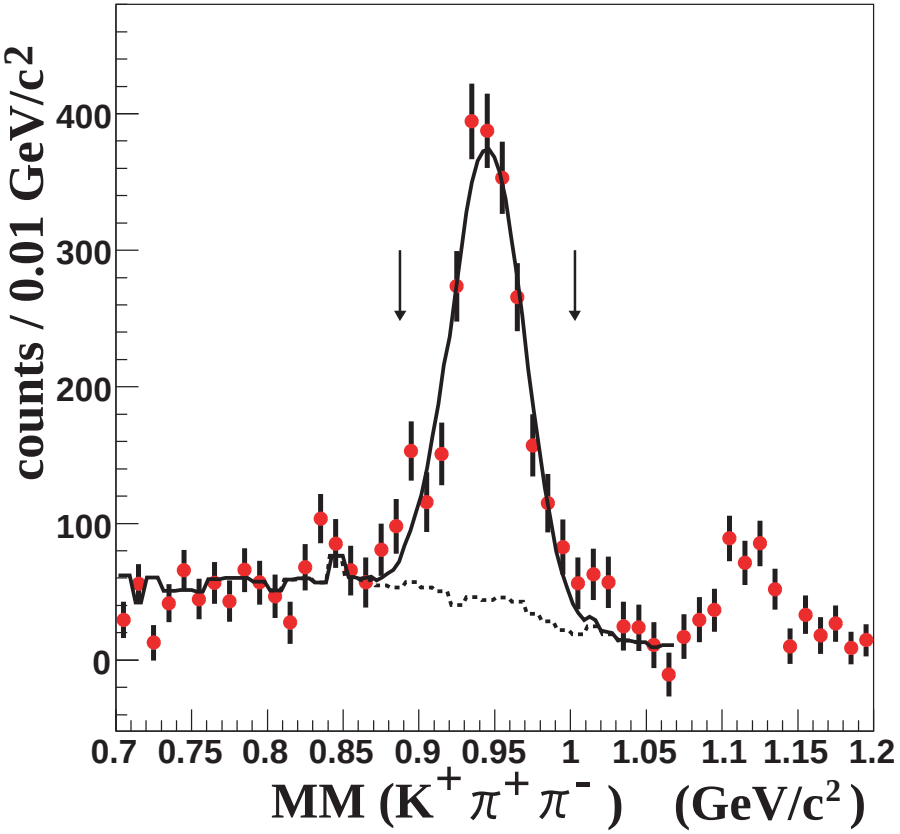
rms 17 ± 2 MeV (20 MeV by MC)

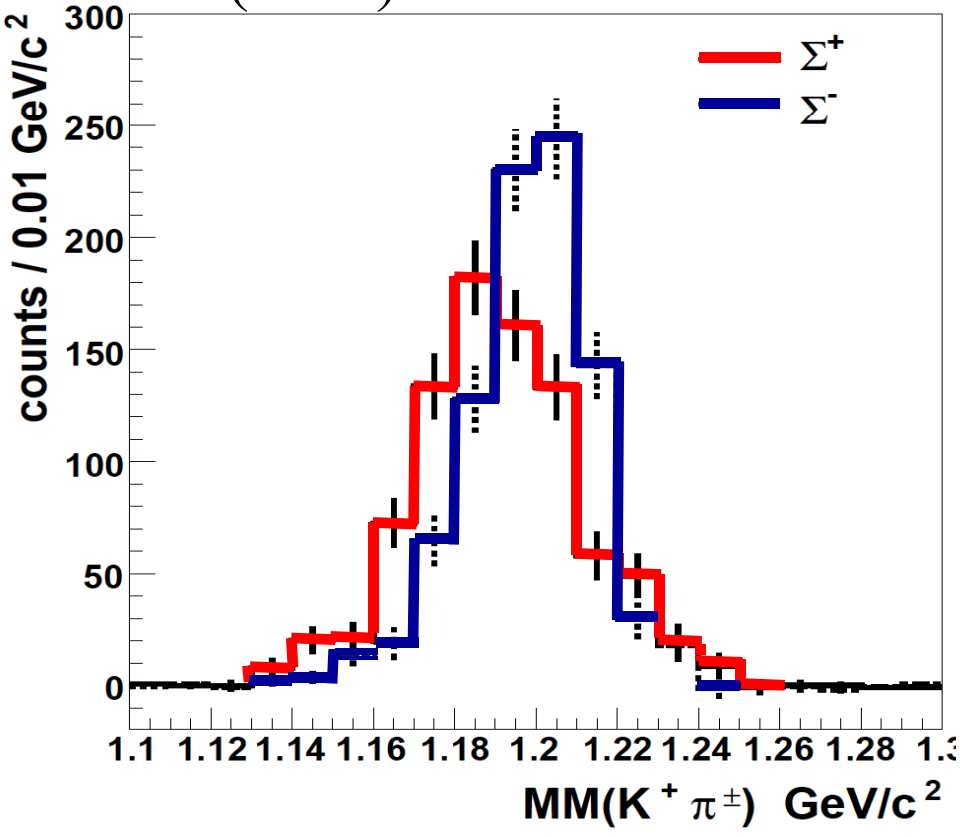
kinematic fit with two constraints

$MM(K\pi\pi) = n, \quad MM(K\pi) = \Sigma$

$\Sigma^+(1189) = 1191 \pm 1$ MeV

$\Sigma^-(1197) = 1199 \pm 1$ MeV

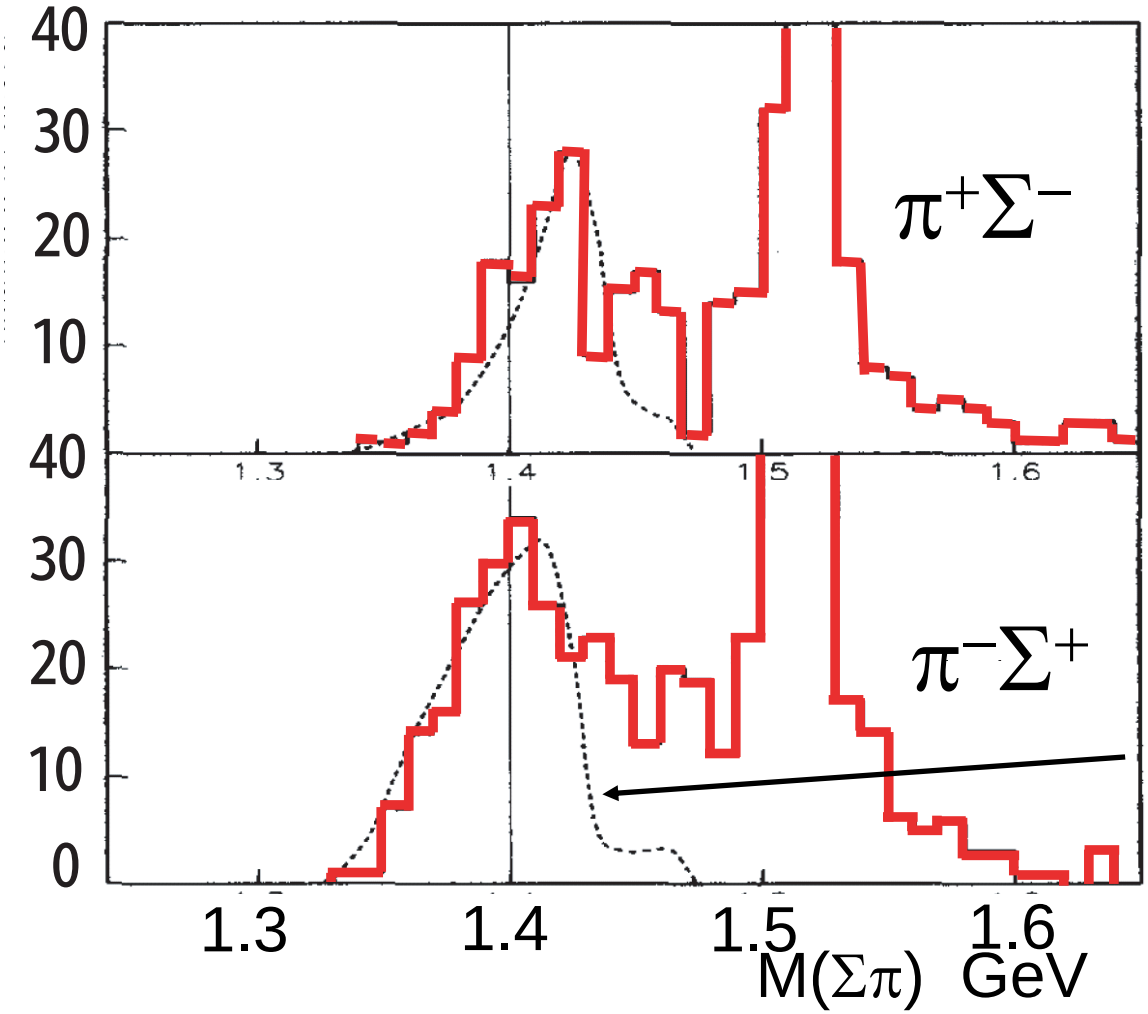




Lineshape of Λ(1405)

J.K.Ahn *et al.* *Nucl. Phys.* **A721** (2003)

$$\gamma p \to K^+ \Lambda(1405) \to K^+ \Sigma^{\pm} \pi^{\mp}$$



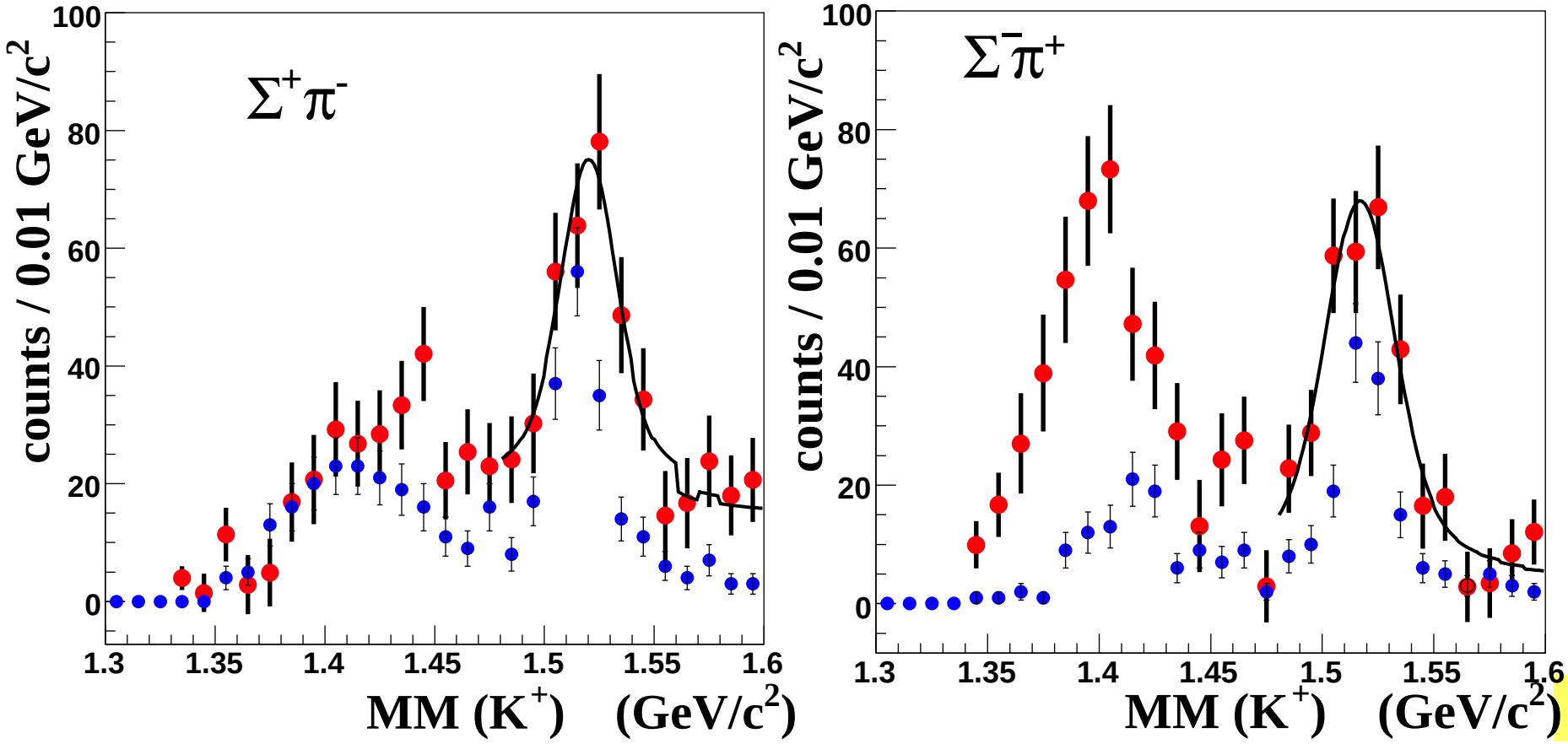
崩壊モードによって
Λ(1405)のピーク位置
が異なる。

Model計算
Nacher
PLB455(1999)

Lineshape of Λ(1405)

Peak position is defferent in two decay modes
Different from J.K.Ahn's measurement

● This work ● measurement by J.K.Ahn

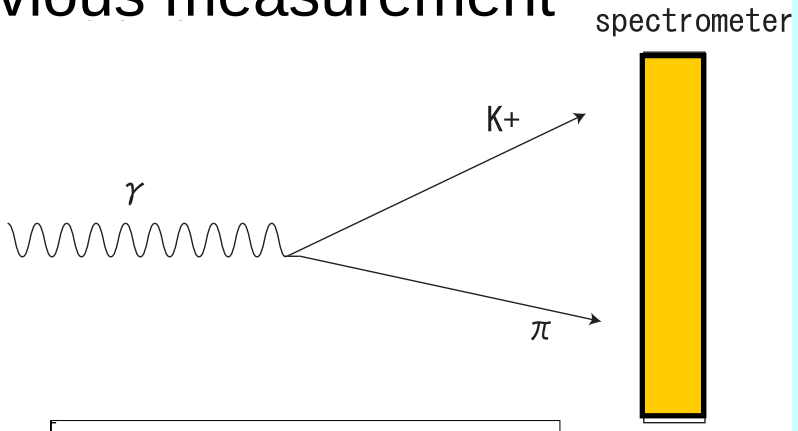


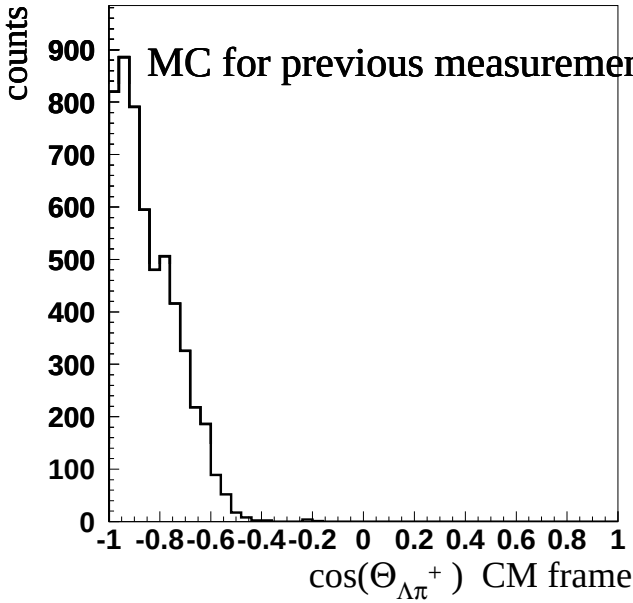
Interference between isospin 0 and 1 amplitudes

$$\sigma_{\Sigma^+\pi^-} = \frac{1}{2}|T^{(1)}|^2 + \frac{1}{3}|T^{(0)}|^2 + \frac{2}{\sqrt{6}}\mathrm{Re}(T^{(0)}T^1)$$

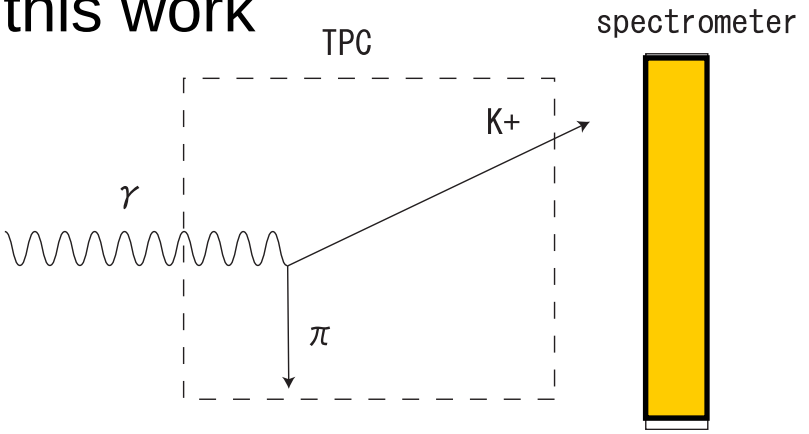
$$\sigma_{\Sigma^-\pi^+} = \frac{1}{2}|T^{(1)}|^2 + \frac{1}{3}|T^{(0)}|^2 - \frac{2}{\sqrt{6}}\mathrm{Re}(T^{(0)}T^1)$$

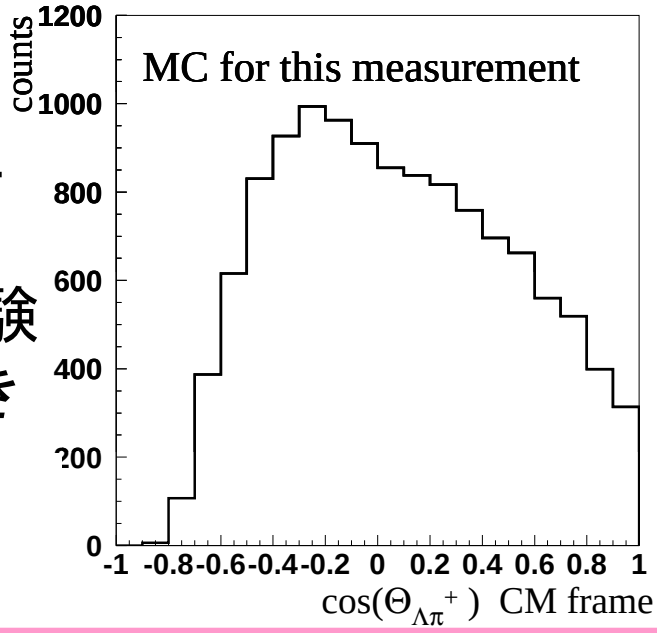
previous measurement





this work



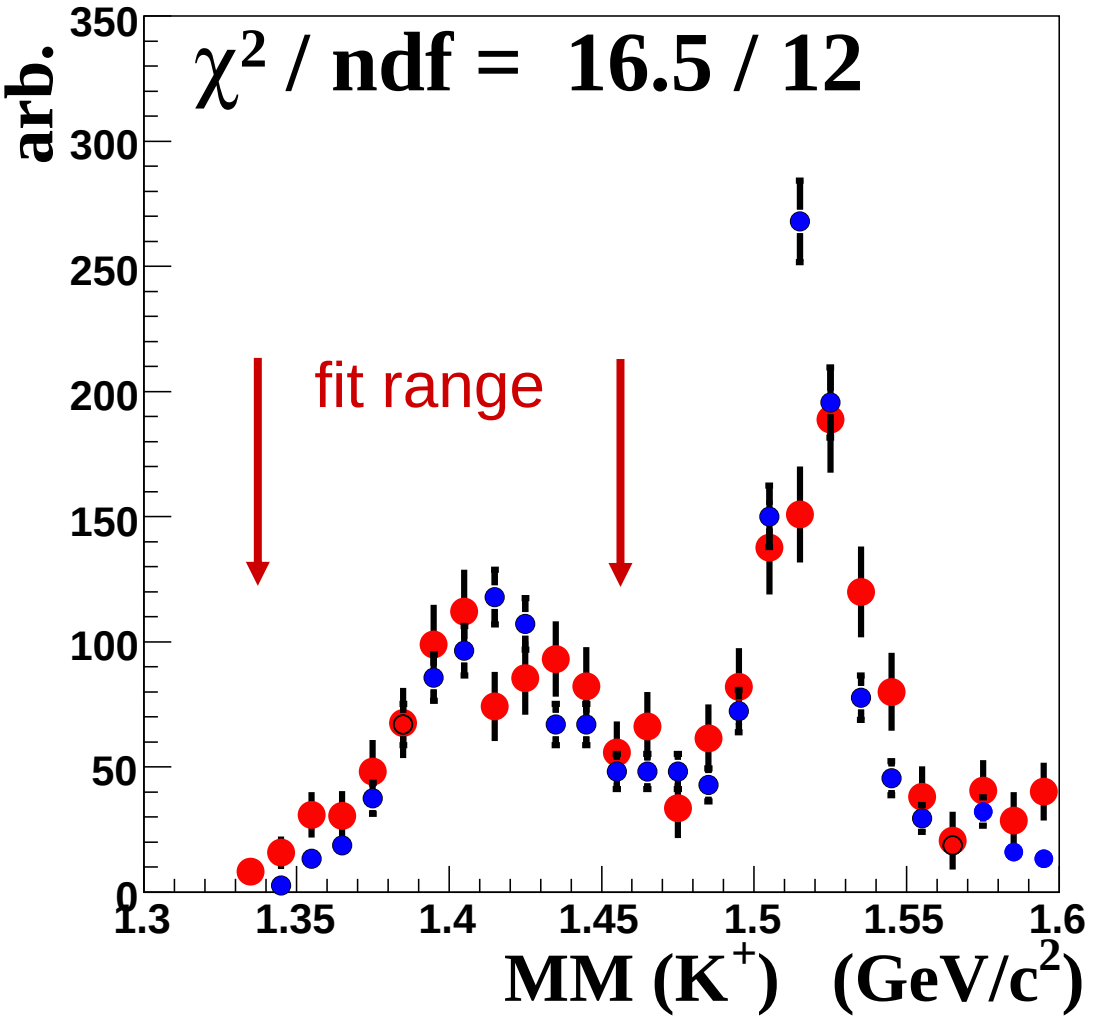


Isospin 干渉項に角度依存性があれば、二つの実験データを説明できる。

Lineshape of Λ(1405)

The interference term is canceled by summing $\Sigma^+\pi^-$ and $\Sigma^-\pi^+$ spectra.
The summed spectrum is consistent with J.K.Ahn's data

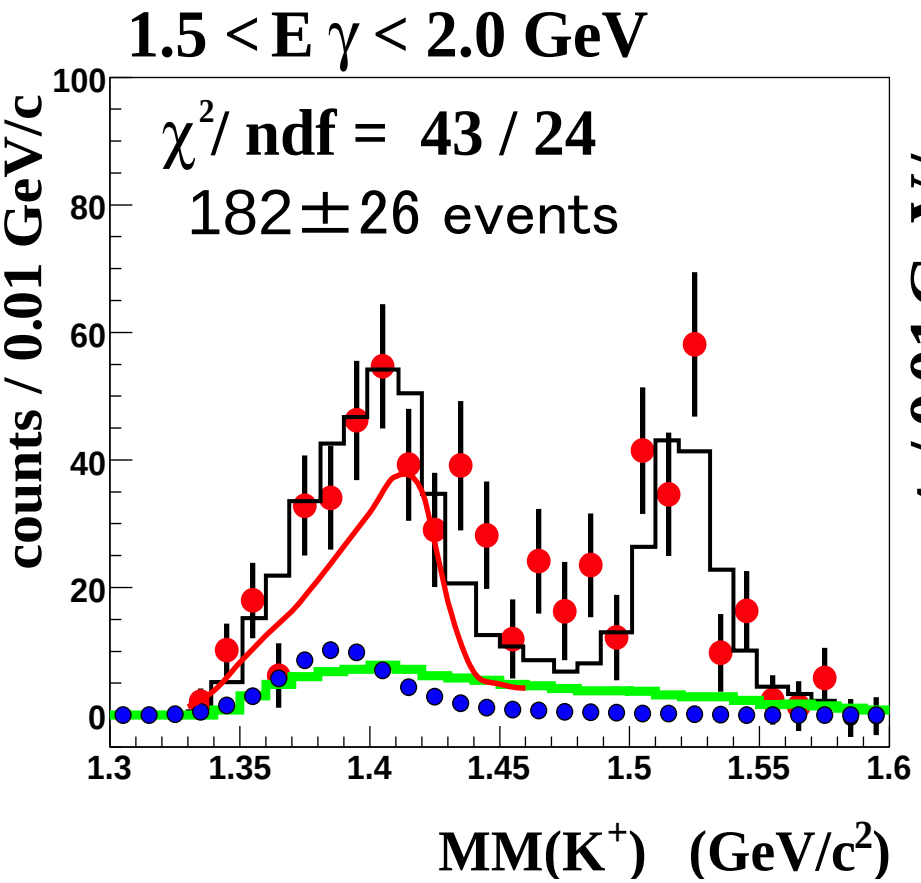
- This work
- J.K.Ahn

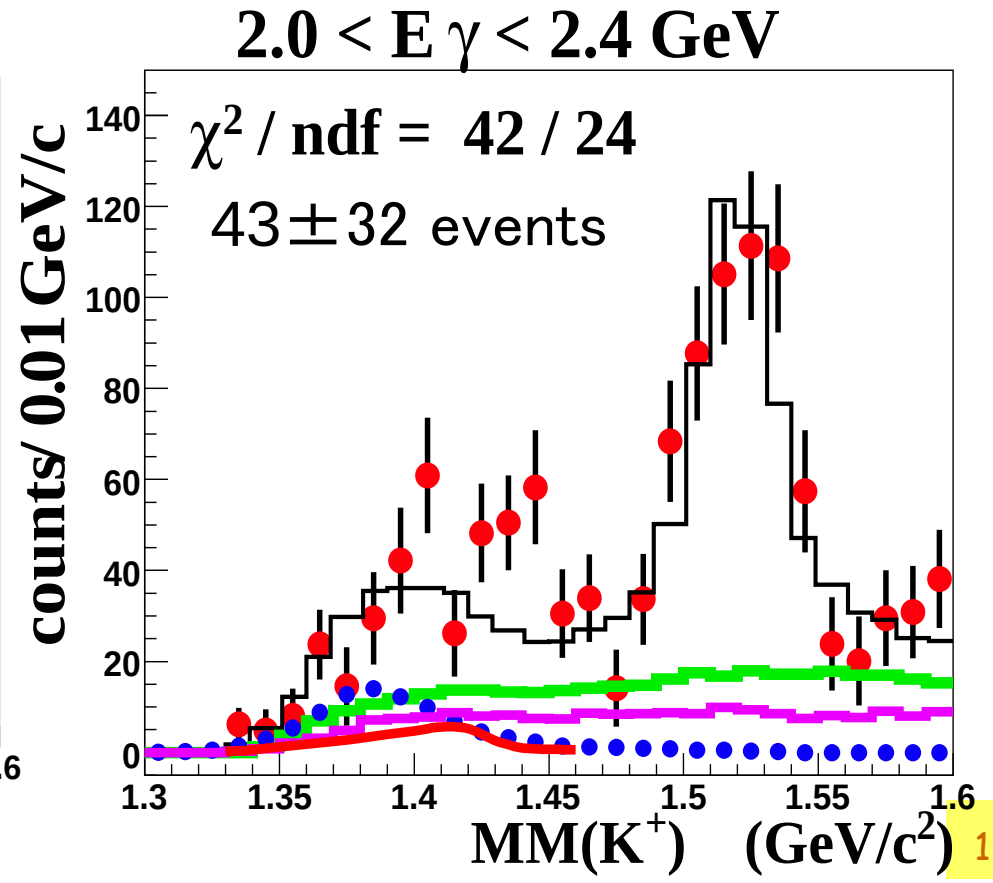


Comparison with chiral Lagrangian+coupled unitary (Nacher et al.)

- data
- $\Sigma(1385)$ ($\Lambda\pi^0$ mode)
- $\Sigma\pi$ phase space
- $K^*(892)\Sigma^+$
- theoretical model

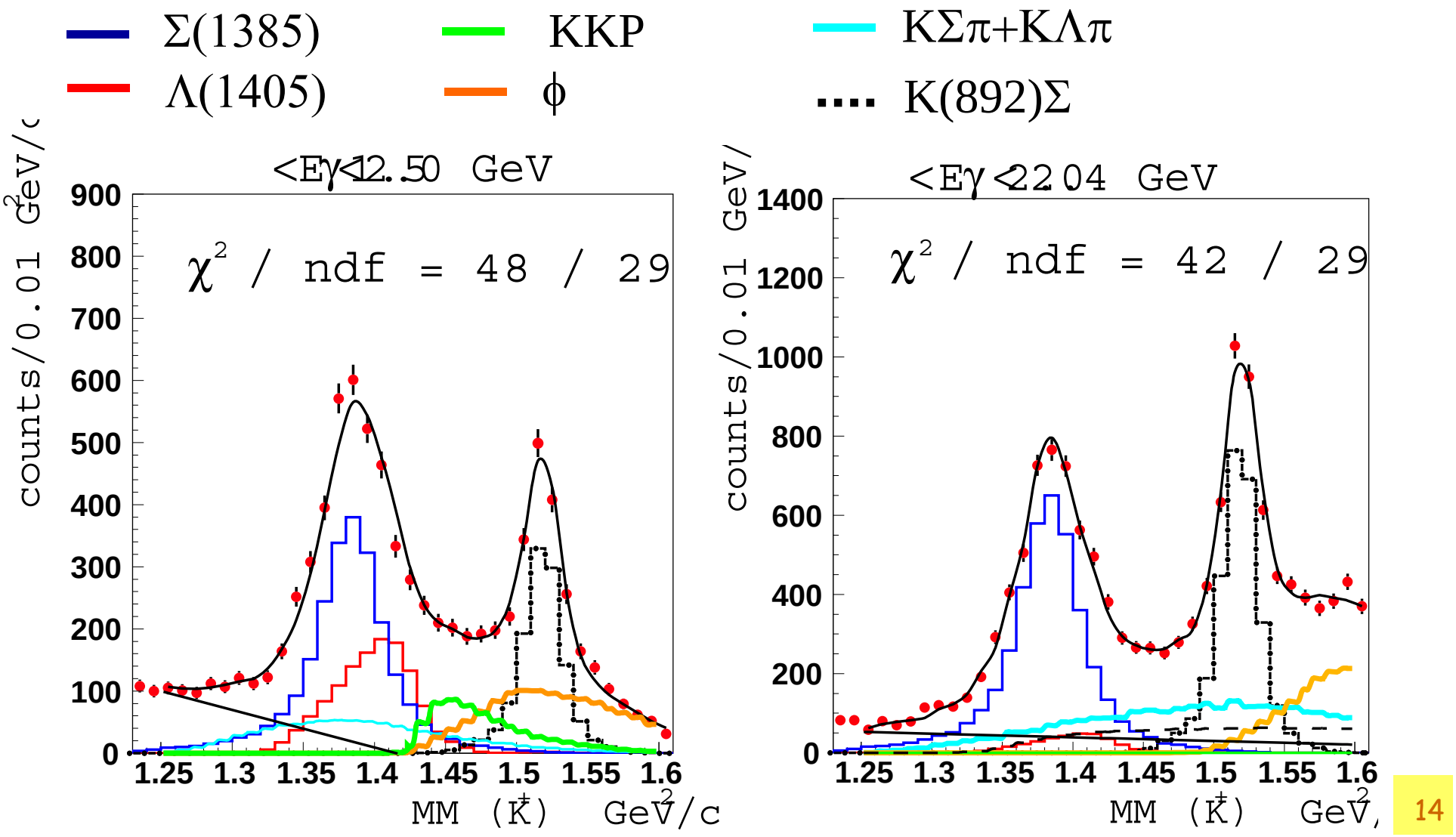
$\Lambda^*/\Sigma^* = 0.54 \pm 0.17$ (1.5<Eγ<2.0)
0.074 ± 0.076(2<Eγ<2.4)





Absolute values of the differential cross section

Extract absolute values of the differential cross section of Λ(1405), Σ(1385) using obtained ratio of Λ(1405)/Σ(1385) ($0.8<\cos\theta_{kCM}<1$)

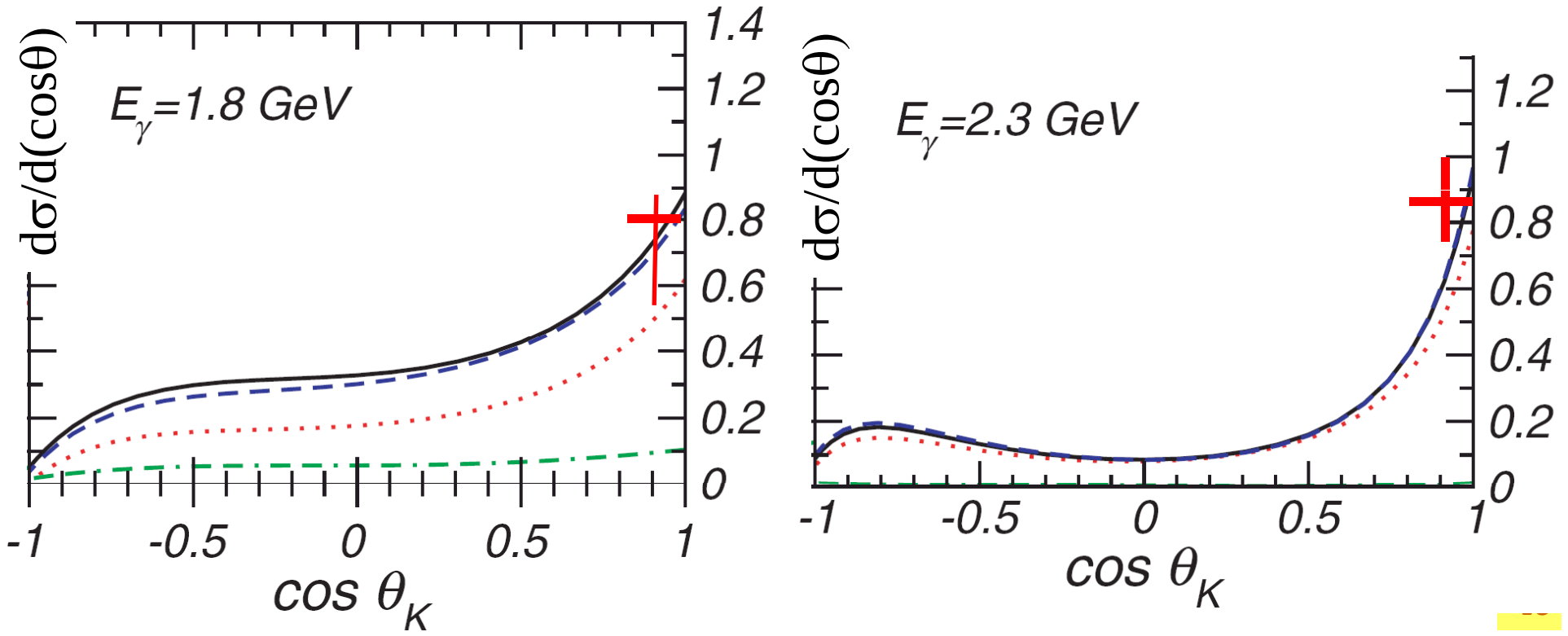


Differential cross section of Σ(1385) production

1.5<Eg<2 GeV $0.80 \pm 0.092\ ^{+0.062}_{-0.27}$ μb

2.0<Eg<2.4 GeV $0.87 \pm 0.064\ ^{+0.13}_{-0.067}$ μb

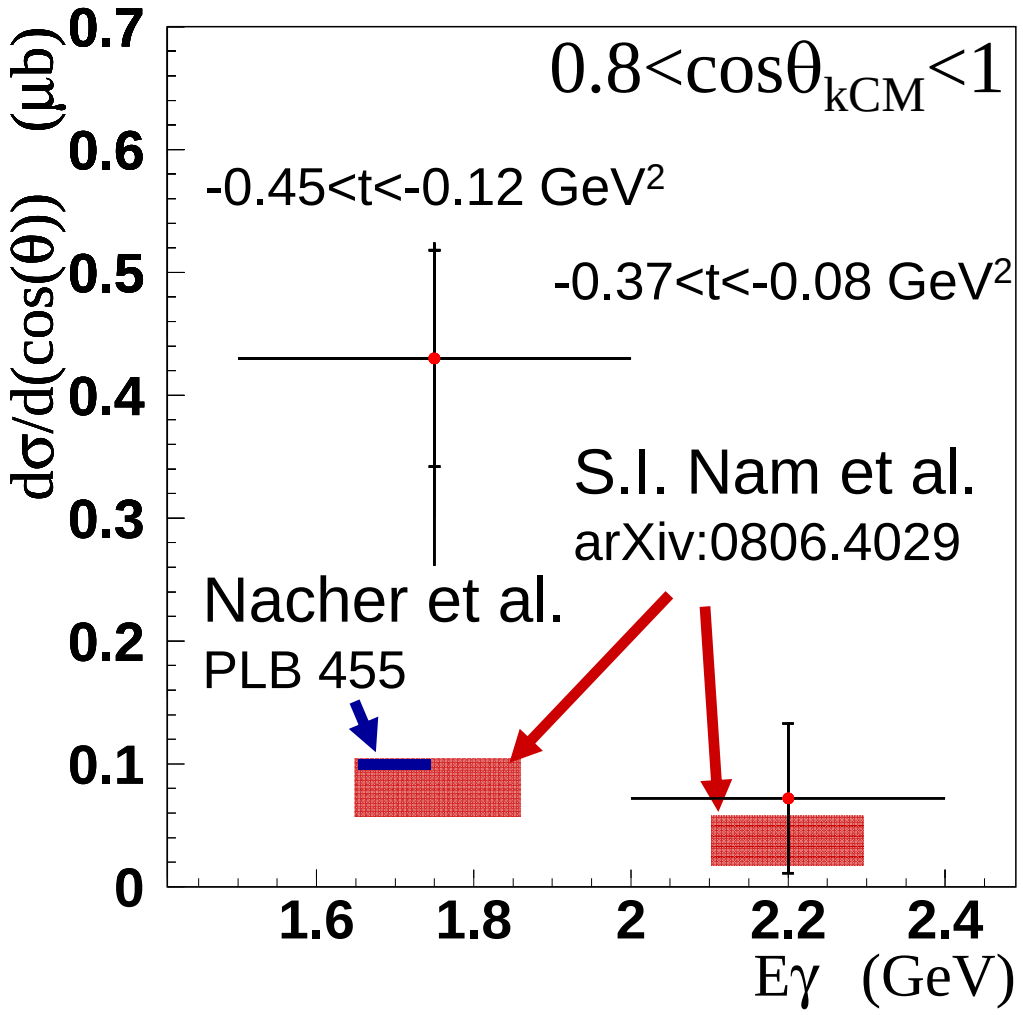
Consistent with theoretical calculation using effective Lagrangian (∼0.8μb, 0.8<cosθ<1) by Oh et al.



Differential cross section of Λ(1405) production

1.5<Eg<2 GeV $0.43 \pm 0.088^{+0.034}_{-0.14}$ μb

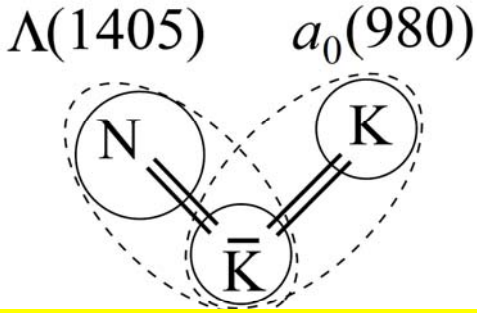
2.0<Eg<2.4 GeV $0.072 \pm 0.061^{+0.011}_{-0.0056}$ μb



$K\bar{K}N$ bound state proposed by D.Jido and Y.En'yo PRC 78, 035203(2008)

M ~ below KKN threshold (1930 MeV)

Γ ~ 90 MeV



We need more data

Summary and prospects

- We measured Λ(1405) and Σ(1385) photoproduction at Eγ = 1.5–2.4 GeV. We obtained the ratio of Λ(1405)/Σ(1385) by detecting the decay products.
- The lineshapes of Λ(1405) are deffenent in $\Sigma^+\pi^-$ and $\Sigma^-\pi^+$. The angular dependence of the interference term is suggested.
- The production cross sections were obtained in **$0.8<\cos\theta_{KCM}<1$**, **$1.5<E\gamma<2$ GeV**, **$2<E\gamma<2.4$ GeV**.

  Σ(1385) **~0.8 μb**

  Λ(1405) **~ 0.4 μb (in $E\gamma<2$ GeV)**, **~ 0.1 μb (in $2<E\gamma$)**
- The photon energy dependence of Λ(1405) and Σ(1385) suggests that form factors and/or production mechanism is largely different.
- Λ(1405) and Σ(1385) photoproduction from cleaner and higher statistics data will be shown by next summer.
- t-dependence of production cross section of Λ(1405)/Σ(1385) (mixed) will be shown next talk.

backup

Discussion : yield of Λ(1405)

1.33<MM(K^+)<1.44 GeV での strength

Λ(1405)/Σ(1385)

0.80±0.23 (1.5<Eγ<2 GeV),　0.50±0.14 (2<Eγ<2.4 GeV)

Σ(1385) とK(892)の寄与を引くと、

0.65±0.19 (1.5<Eγ<2 GeV), 0.35±0.12 (2<Eγ<2.4 GeV)