Direct measurement of the $\bar{K}N \to \pi\Sigma$ scattering amplitude below the $\bar{K}N$ threshold employing the $d(K^-, N)"\pi\Sigma"$ reaction

Kentaro Inoue

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Current Status

- 1 章 Introduction (終了)
- 4 章 Discussion、5 章 Conclusion.
  校正中、絵の用意、数値 (χ^2 やフィット値) の確認
  $\rightarrow$ $d(K^-, n)$" nK^0" の 2-step
  $\rightarrow$ 理論との比較に宮川さんの論文を追加
- 2 章 Experimental Setup、3 章 Analysis.
  要文章、校正

Template fitting procedure

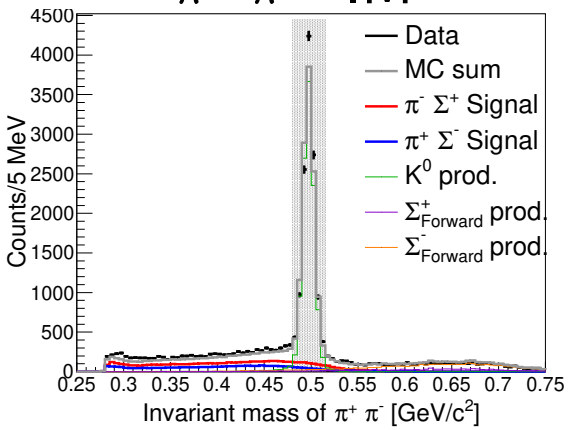
1. Fitting to evaluate background.
   Fitting invariant masses of $n_{forward}\pi^+$, $n_{forward}\pi^-$, and $\pi^+\pi^-$ for $\Sigma^+_{forward}$, $\Sigma^-_{forward}$, and K^0 peaks, respectively.
   $\Rightarrow$ Event Sample $d(K^-, n\pi^-\pi^+)$"n"
2. Fitting to separate $\pi^-\Sigma^+$ and $\pi^+\Sigma^-$ modes.
   Fitting missing masses of $d(K^-, n\pi^-)$ and $d(K^-, n\pi^+)$ for missing Σ^+ and Σ^- peaks, respectively.
   $\Rightarrow$ Event Sample $d(K^-, n\pi^-\pi^+)$"n" w/ Rejection of K^0 and $\Sigma^\pm_{forward}$
3. Fitting to decompose $d(K^-, n)$"nK^0" events.
   1. Quasi-elastic (1-step) $K^-p \to K^0n$
   2. 2-step scattering
   3. direct-$\Lambda(1520)$ production.

Fitting Order: $(\textcircled{1} \to \textcircled{2}) \times 5\text{iteration} \to \textcircled{3} \to \textcircled{2}$

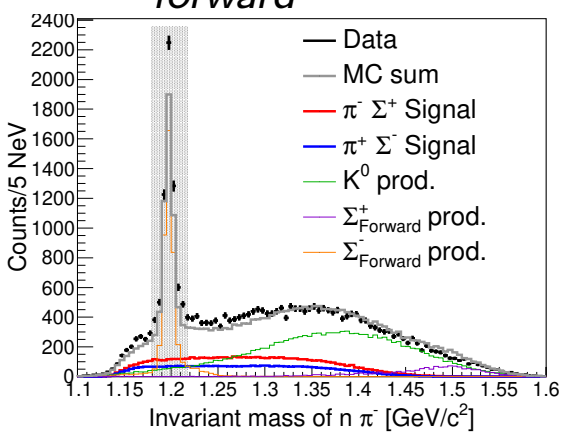
Template fitting to evaluate background

$d(K^-, n\pi^-\pi^+)$"n" event.

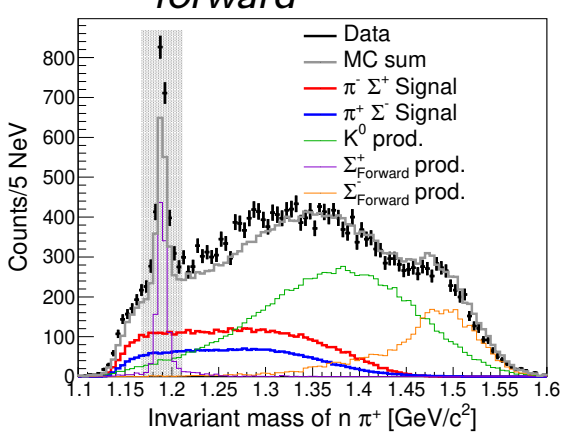
$\pi^+\pi^-$ IM



$n_{forward}\pi^+$ IM



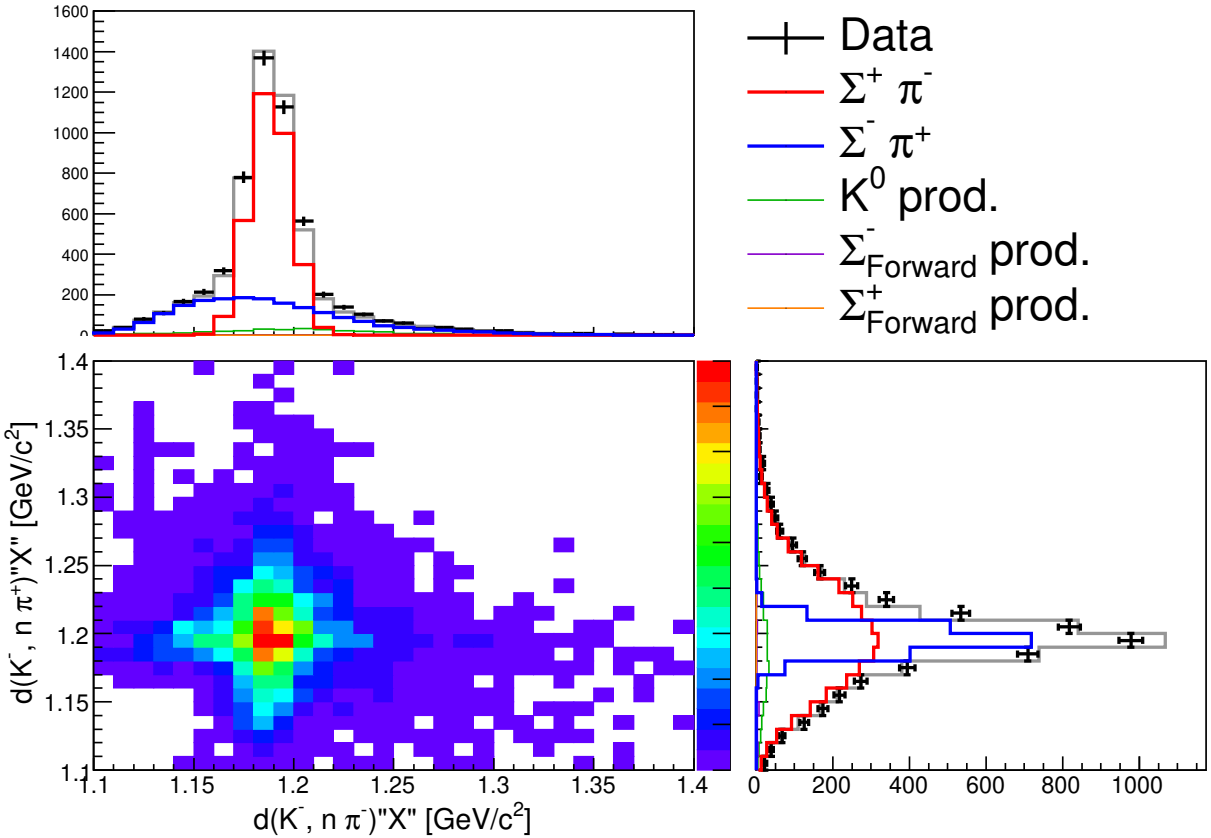
$n_{forward}\pi^-$ IM



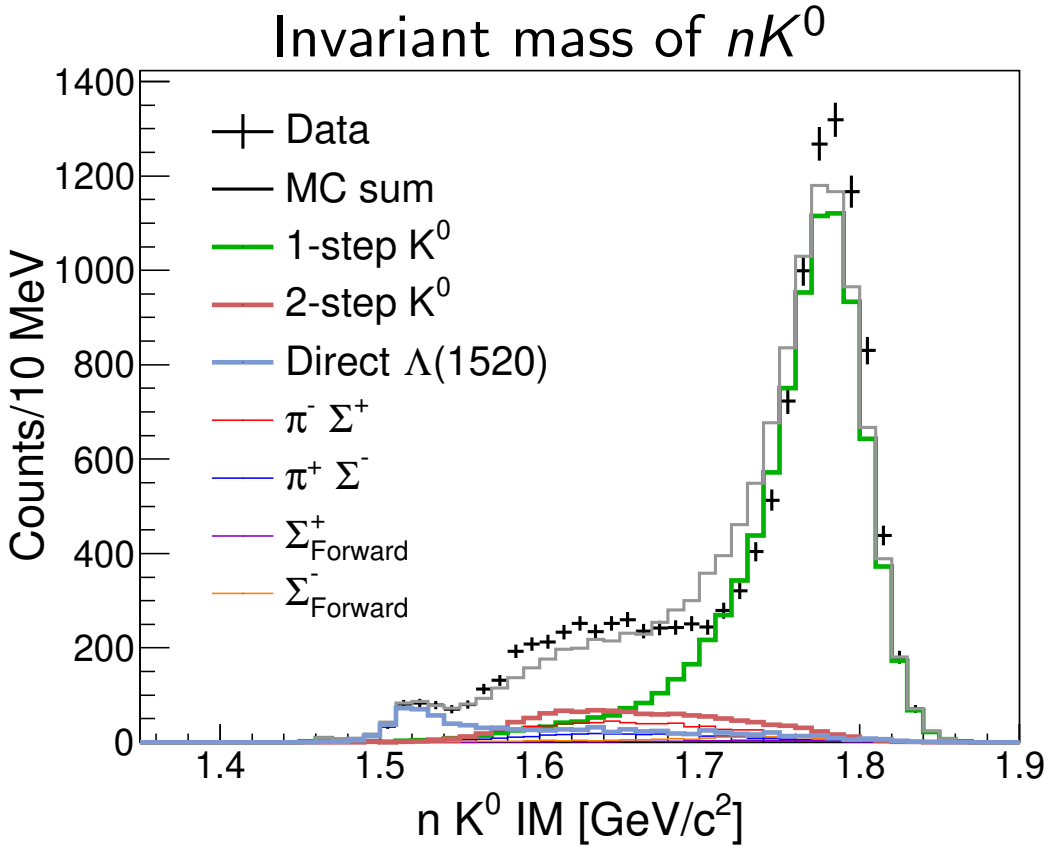
Each spectra are well reproduced.

Template Fitting to separate $\pi^-\Sigma^+$ and $\pi^+\Sigma^-$

$d(K^-, n\pi^+\pi^-)$"n" w/ K^0 and Rejection of $\Sigma^{\pm}_{forward}$ events.
Fitting is performed bin-by-bin of $d(K^-, n)'$.
Figure shows sum of all bins.



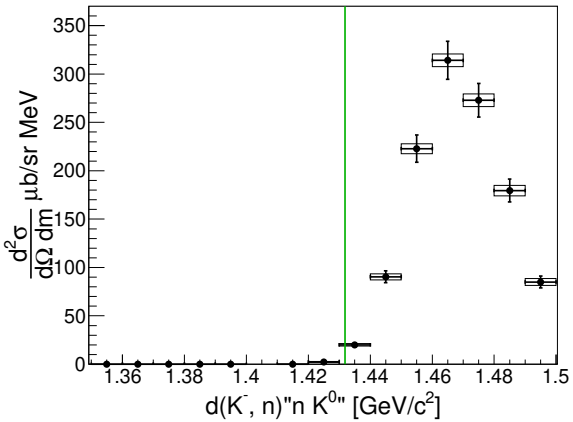
Template fitting to decompose K^0 production



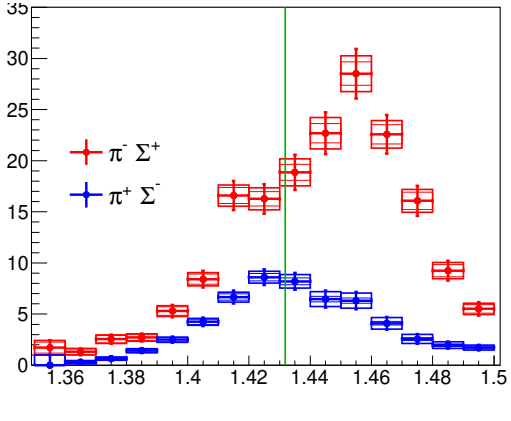
2-step like component is seen about 11.5%.
Direct-$\Lambda(1520)$ prod. is seen about 7.7%.

Obtained Cross Sections

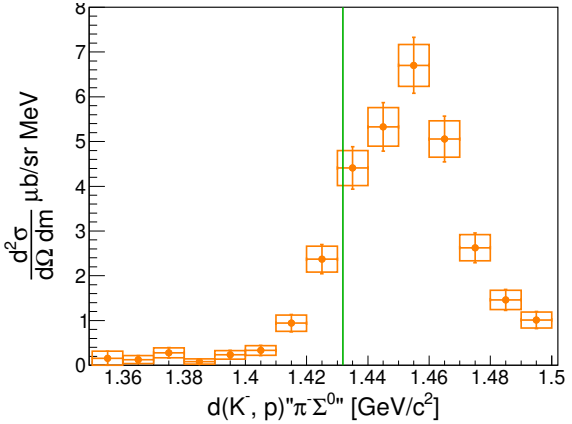
$d(K^-, n)"nK^0"$
Prove this reaction



$d(K^-, n)"\pi^{\mp}\Sigma^{\pm}"$
$I = 0, 1$ and interfer



$d(K^-, p)"\pi^-\Sigma^0"$
Pure $I = 1$



$d(K^-, n)"nK^0"$ for studying present reaction.

About 10% includes 2-step reaction.

$d(K^-, p)"\pi^-\Sigma^0" \Rightarrow$ **Pure $I = 1$**

Spectra shape is similar to Quqsi-elastic.

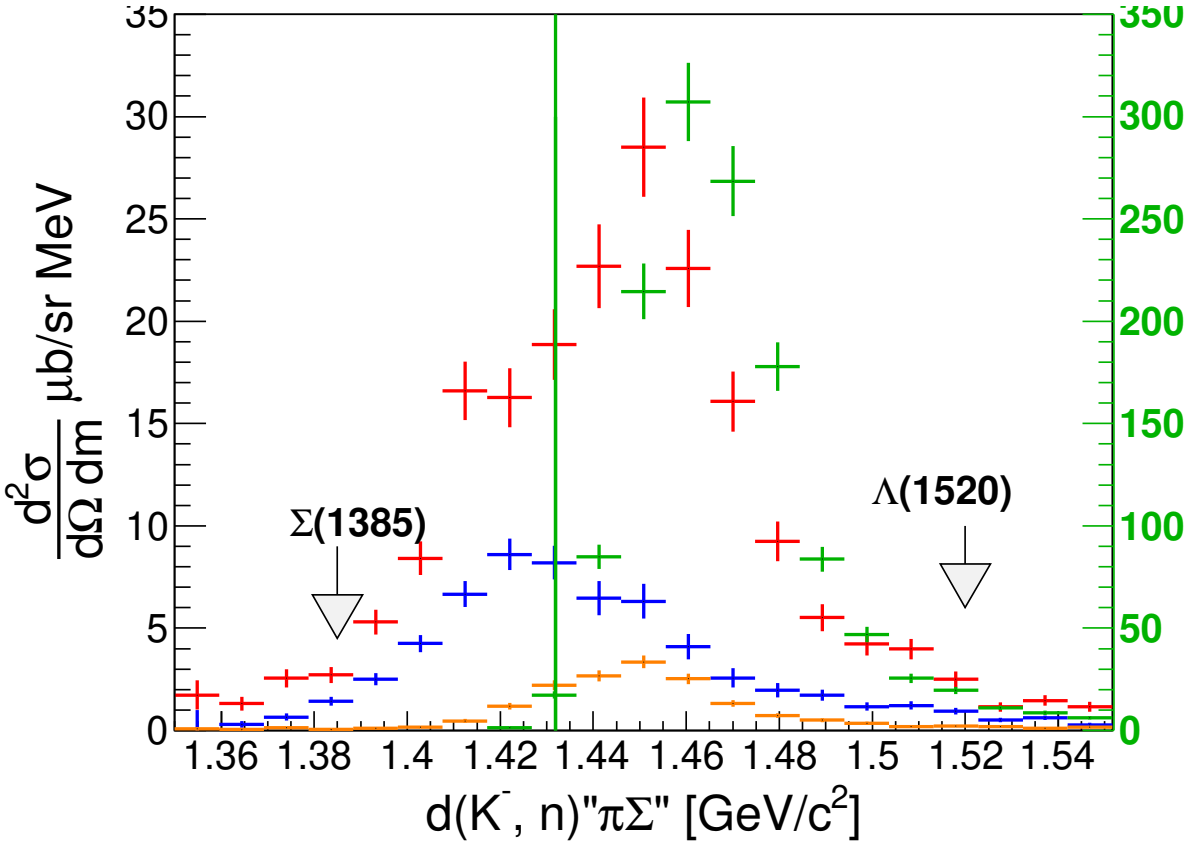
No pole around the $\bar{K}N$ threshold

$d(K^-, p)"\pi^{\mp}\Sigma^{\pm}" \Rightarrow$ **Main Signal**

Struvture below $\bar{K}N$ threshold is cntrobution from $I = 0(\Lambda(1405)$.

Interference term (difference of $\pi^-\Sigma^+$ and $\pi^+\Sigma^-$) of $I = 0, 1$ is observed.

Obtained Cross Section



$d(K^-, n)"nK^0"$ is scaled to 1/10.

No structure around $\Sigma(1385)$ ($P-$wave) and $\Lambda(1520)$ ($D-$wave).

$\Rightarrow$ **S-wave dominant.**

$I = 0$ ($\pi^-\Sigma^+$ and $\pi^+\Sigma^-$) has excess below the $\bar{K}N$ threshold.

Theoritical Calculation for J-PARC E31

Dynamical Coupled Channel by Kamano et el.

Continuous scattering amplitude in the whole region from $\bar{K}N$ threshold to W=2.1 GeV/c.

Below threshold predicted by extrapolation.

Model.A

Model.B

H. Kamano et el., Phys. ReV. C**94**, 065205 (2016).

Faddev approch by Miyagawa et el.

Fist scattering use recet Partical Wave Analysis.

Second scattering use various analysis based on Chiral Analysis.

Based on SHIDDARTA data.

E-dependece model by AGS equation.

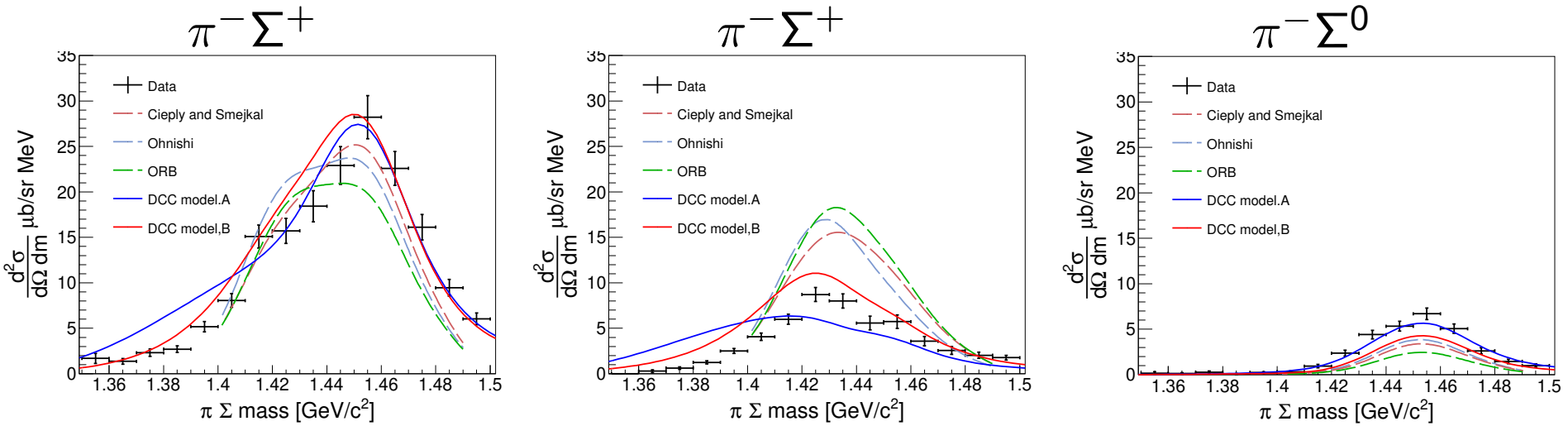
(by Ohinish et. el.)

Histrical Analysis by ORB.

Oset, Ramos, and Bennhold

K. Miyagawa, J. Haidenbauer, and H. Kamada Phys. Rev. C **97**, 055209 (2018).

Comparison Data and Theoritical Calc



Experimental resolusion is convolved.

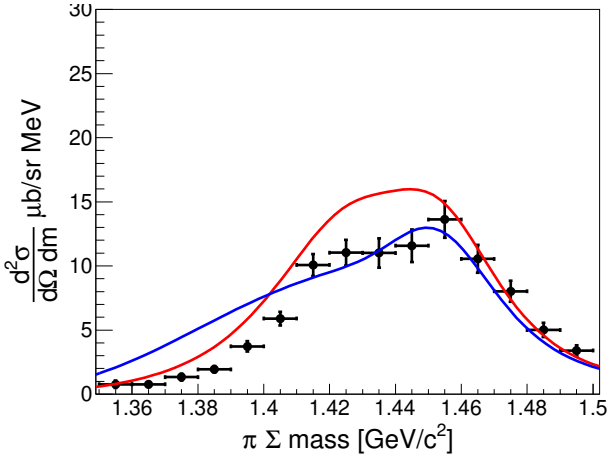
Solid and dashed line represent DCC and Miyagawa's calc.

Absolute value is consistent with data and theoritical calc, especially DCC.

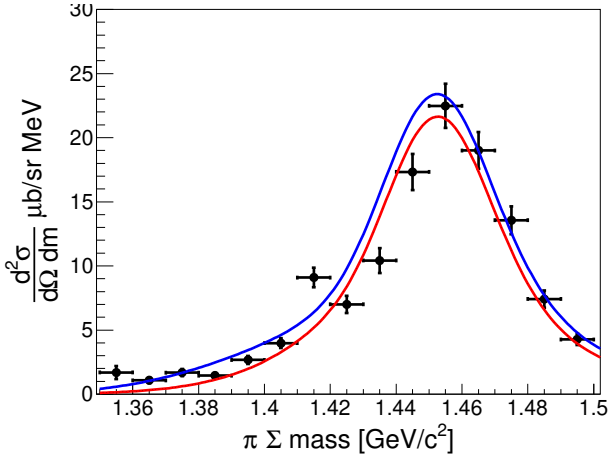
Model.A can not explained large tail below the threshold.

Decomposition to each contribution

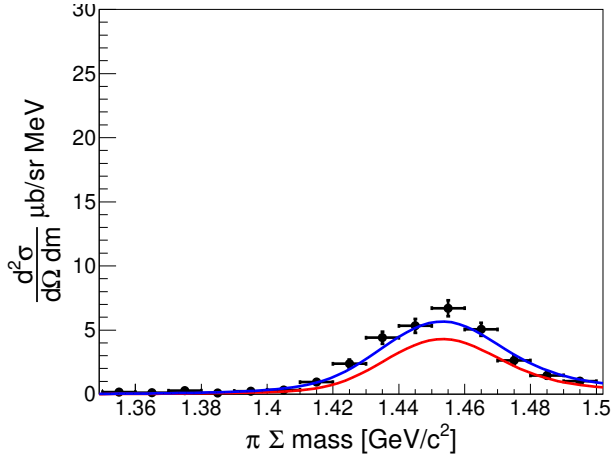
$I = 0$ term



Interferance term



$I = 1$ term



The tail of $I = 0$ in Model.A don't match data.

$$\frac{d\sigma}{d\Omega dM}(\pi^{\mp}\Sigma^{\pm}) \propto \left| C_1^0 T_2^{I=0} \mp C_1^1 T_2^{I=1} \right|^2$$

$$= \left| C_1^0 T_2^{I=0} \right|^2 + \left| C_1^1 T_2^{I=1} \right|^2 \mp 2\mathrm{Re}(C_1^0 C_1^1 T_2^{I=0} T_2^{I=1})$$

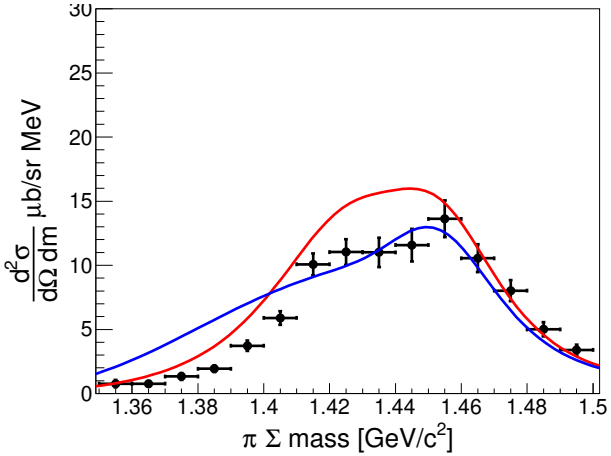
$$\frac{d\sigma}{d\Omega dM}(\pi^{-}\Sigma^{0}) \propto \left| C_1^1 T_2^{I=1} \right|^2$$

$T_1^{I=1,0}$ represents first scattering factor.

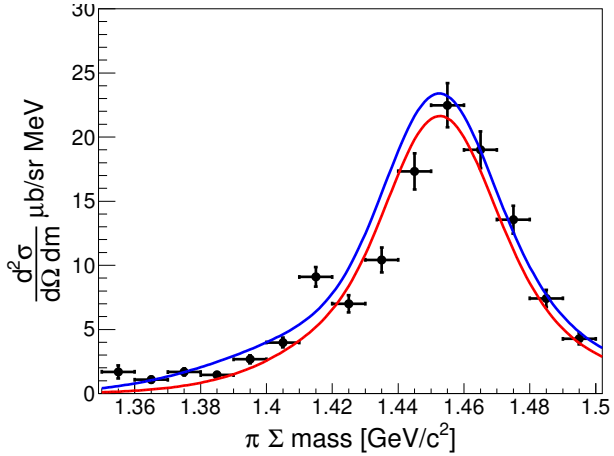
$$C_1^0 = \frac{3T_1^{I=0} - T_1^{I=1}}{4\sqrt{3}},\ C_1^1 = \frac{T_1^{I=0} + T_1^{I=1}}{4}$$

Decomposition to each contribution

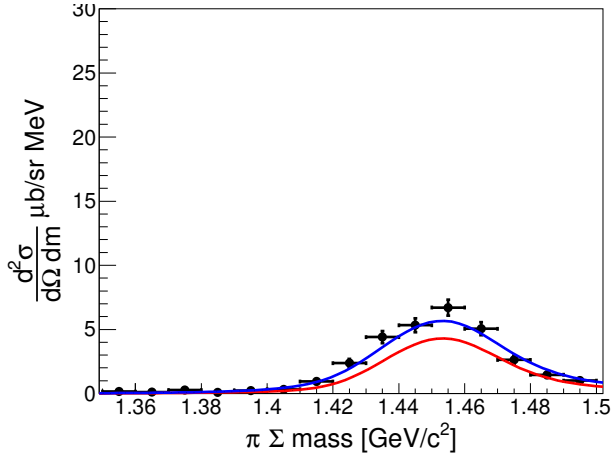
$I = 0$ term



Interferance term



$I = 1$ term



The tail of $I = 0$ in Model.A don't match data.

. Interference term is well matched both Model.A and Model.B.
Model.B is more similar spectral shape,
especially below the $\bar{K}N$ threshold of $I = 0$.

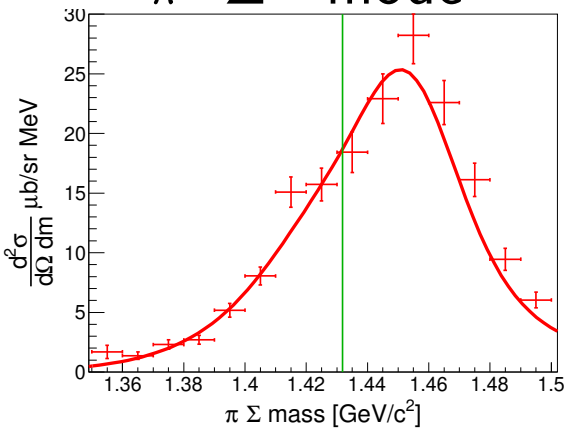
Conclusion

- We measured $K^-, n)"\pi^{\mp}\Sigma^{\pm}"$, $d(K^-, p)"\pi^-\Sigma^-$, and $d(K^-, n)"nK^0"$ spectra.
  $\Rightarrow$ $d(K^-, n)"nK^0"$ including 2-step reaction about 40[mb] at the QE.
  $\Rightarrow$ $d(K^-, p)"\pi^-\Sigma^0"$ is very similar to QE shape.
  No pole near the $\bar{K}N$ threshld .
  $\Rightarrow$ $d(K^-, n)"\pi^{\mp}\Sigma^{\pm}"$ is seen exess below the $\bar{K}N$ threshold.
  $\Lambda(1405)(I = 0)$ contribution.
  $\Rightarrow$ Interference term (difference of $\pi^-\Sigma^+$ and $\pi^+\Sigma^-$) is observed.
- Comparison w/ Theoritical calculations.
  The strength is consistent with Calculations.
  The shape can be explained by $I = 0$, $I = 1$, and interference term.
  $\Rightarrow$ This result provides information of $\bar{K}N \to \pi\Sigma$ scattering below the $\bar{K}N$ threshold.

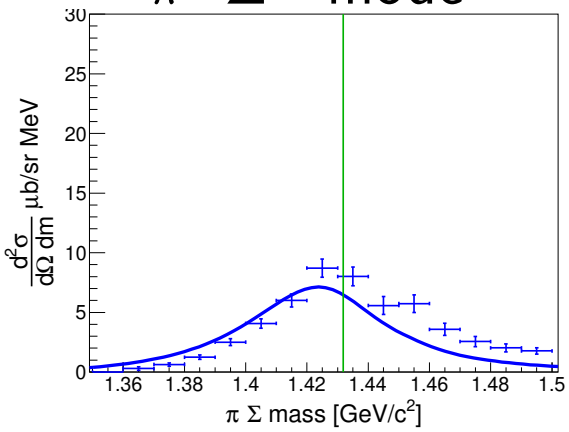
BACK UP

DCC Model.B Fit by Scaling Factor

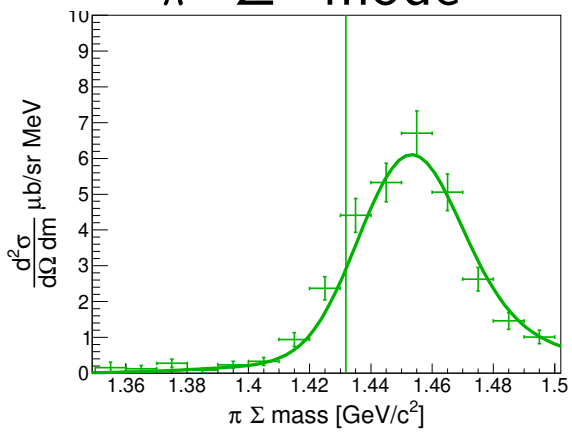
$\pi^-\Sigma^+$ mode



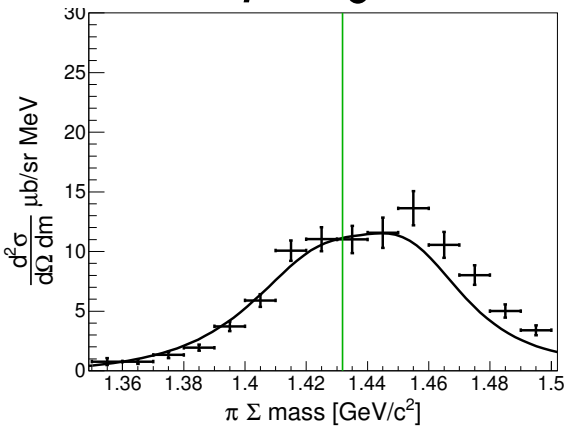
$\pi^+\Sigma^-$ mode



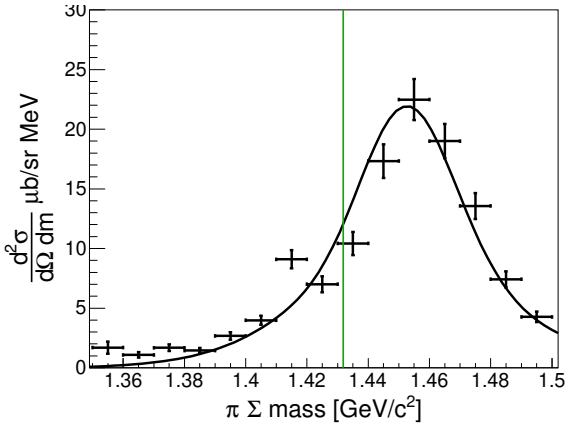
$\pi^-\Sigma^0$ mode



$I = 0$



Interfer



$\chi^2/NDF \sim 5.25$

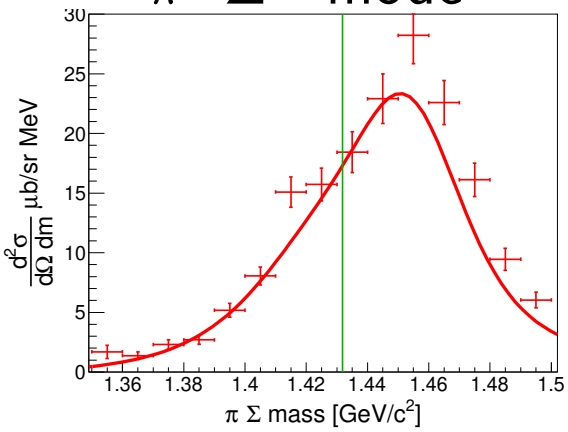
$Scale_{I=0} = XXX$

$Scale_{I=1} = XXX$

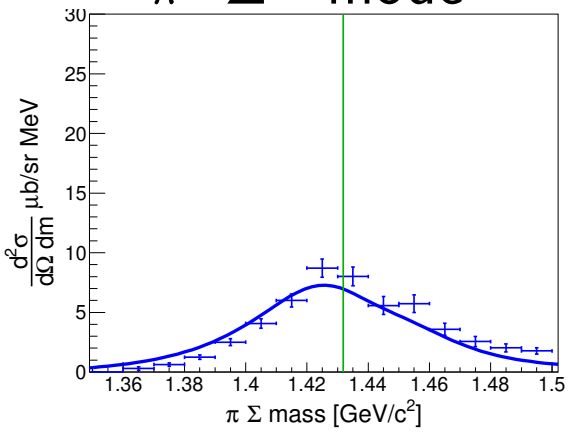
F_{phase} : $Fixed$

DCC Model.B Fit w/ Phase factor

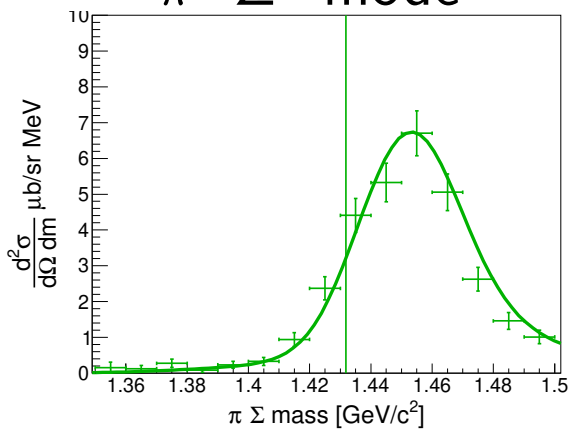
$\pi^-\Sigma^+$ mode



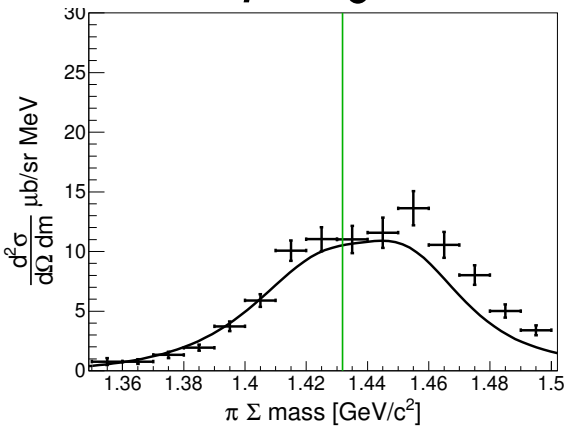
$\pi^+\Sigma^-$ mode



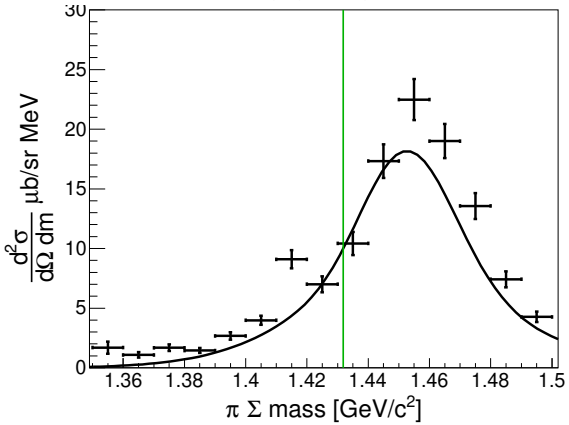
$\pi^-\Sigma^0$ mode



$I = 0$



Interfer



$\chi^2/NDF \sim 4.56$

$Scale_{I=0} = XXX$

$Scale_{I=1} = XXX$

$F_{phase} : XXX$

Parameters of Theoritical Calculation

Model	$a_{\bar{K}N}(I=0)$	$a_{\bar{K}N}(I=1)$	Pole1 (MeV)	Pole2 (MeV)
TW1	$-1.61+i1.02$	$0.60+i0.50$	$1433-i25$	$1371-i54$
Ohnishi	$-1.89+i1.11$	$0.45+i0.53$	$1429-i15$	$1344-i49$
ORB	$-1.72+i0.89$	$0.52+i0.64$	$1426-i16$	$1390-i66$
DCC Model.A	$-1.37+i0.67$	-	$1432-i75$	$1372-i56$
DCC Model.B	$-1.67+i1.02$	-	$1428-i31$	$1397-i98$

あんちょこ (バックアップ用)