

# Current Status

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# Status & To do

- Chapter.1 Intdocution was uploaded
- To brush up Chapter.4 Disussion
  - Decomposition of the  $K^- d \rightarrow n\pi\pi n$  reaction (Template fitting)
  - Comparison with Theoritical Calcs

データで得られたスペクトルだけでの議論  
宮川さんと DCC 法 (鎌野さん) による計算との単純な比較  
⇒ 宮川さんの方を棄却
  - Fitting assuming 2-step Reaction ⇐ new

$I = 0$  と  $I = 1$ 、干渉項への分解  
野海さんのフィットを私のデータだけに適応
  - Fitting with DCC method

スケールパラメーターを DCC 法に導入 ⇒ モデル.A を棄却  
干渉項を独立に動かす位相パラメーターを導入してのデモンストレーション
- To organize Appendix

他の人の解析 (特に野海さん)、検出器分解能

# Content

- ガウシアンでフィッティング → 明らかに左右非対称成分がある
- Mean と RMS を使う方法 → ピークじゃないテール部分に引っ張られる
- 左右非対称なエラーを持つガウシアンのようなもの

$$f_{fit}(x) = \begin{cases} A \exp\left(\frac{\sigma_h^2}{(x-M)^2}\right) & (x > M) \\ A \exp\left(\frac{\sigma_l^2}{(x-M)^2}\right) & (x < M) \end{cases}$$

- 全範囲でフィットするならまだテール成分に引っ張られている。  
→ 範囲を区切る。どの範囲が適当か?  
ピークの高さの割合でフィット範囲を決める。  
全領域、 $\exp(-3^2/2) \sim 3\sigma$  相当... $\exp(-1/2) \sim 1\sigma$  まで  $0.5\sigma$  刻み。  
フィットする  $\sigma$  の範囲を変えてみる。  
フィットによって  $M$  も  $\sigma_h/\sigma_l$  も変わるので範囲、 $X \times \sigma$  の  $X$  を決めて、繰り返し行い収束したところを使う。

# 結論

1.5 $\sigma$ 相当でカットしたところで  $\chi^2/NDF$  がサチレートしたとして  
(P.5,6 参照) この値で  $\Lambda(1405)$  の極と幅のエラーを決定する。

$$\text{Pole} = 1418.3_{-2.4}^{+7.5}(\text{fit})_{-1.2}^{+0.9}(\text{syst.}) + [-27.8_{-0.9}^{+9.5}(\text{fit})_{-2.2}^{+1.9}(\text{syst.})]i \text{ [MeV]}$$

$$\text{Pole} = 1418.3_{-2.2}^{+7.3}(\text{fit})_{-1.0}^{+1.2}(\text{syst.}) + [-27.8_{-0.7}^{+9.4}(\text{fit})_{-2.0}^{+1.9}(\text{syst.})]i \text{ [MeV]}$$

(FWHM でフィット範囲を決める)

$$\text{Pole} = 1418.3_{-2.3}^{+7.3}(\text{fit})_{-1.1}^{+1.0}(\text{syst.}) + [-27.8_{-0.8}^{+9.5}(\text{fit})_{-2.0}^{+1.9}(\text{syst.})]i \text{ [MeV]}$$

(イテレーションフィット)

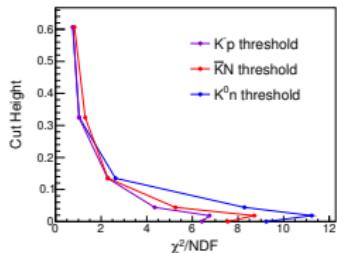
## Noumi's Parameter

$$\text{Pole} = 1417.7_{-7.4}^{+6.0}(\text{fit})_{-1.0}^{+1.1}(\text{syst.}) + [-26.1_{-7.9}^{+6.0}(\text{fit})_{-2.0}^{+1.7}(\text{syst.})]i \text{ [MeV]}$$

## To do

D 論にまとめる。

# Pole estimation w/ 2Gaussian

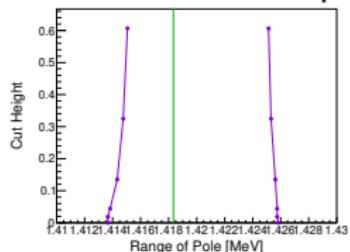


$\chi^2/NDF$  は  $e^{-\frac{1.5^2}{2}} \sim 1.5\sigma$  相当で  
安定 (サチレート)  
 $\rightarrow \sigma = 1.5$  が範囲として適當

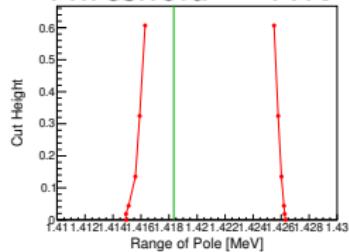
エラーの範囲は大きくは動かない

エラーの範囲 ( $1\sigma$  の下限値と上限値)

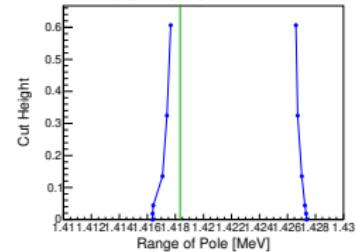
Threshold =  $K^- p$



Threshold =  $\bar{K}N$

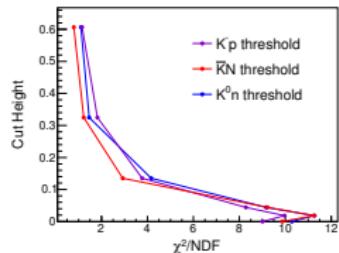


Threshold =  $K^0 n$



緑線はベストフィット ( $\bar{K}N$  による中心値)

# Width estimation w/ 2Gaussian

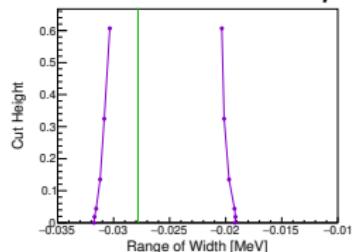


$\chi^2/NDF$  は  $e^{-\frac{1.5^2}{2}} \sim 1.5\sigma$  相当で  
安定 (サチレート)  
→  $\sigma = 1.5$  が範囲として適當

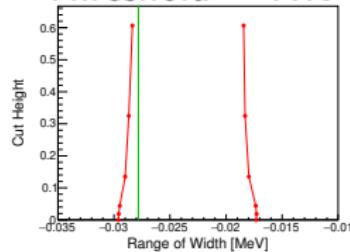
エラーの範囲は大きくは動かない

エラーの範囲 ( $1\sigma$  の下限値と上限値)

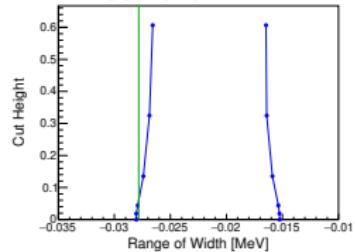
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Threshold =  $\bar{K}N$

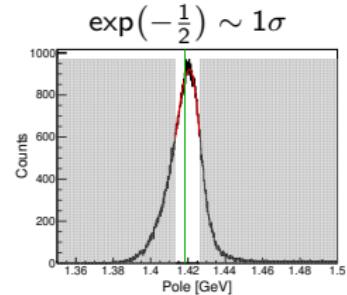
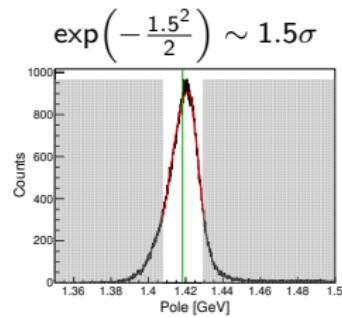
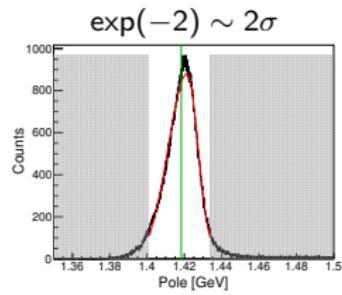
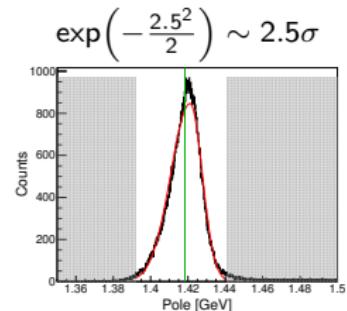
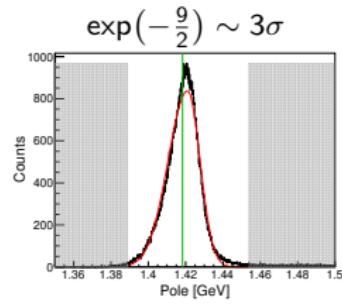
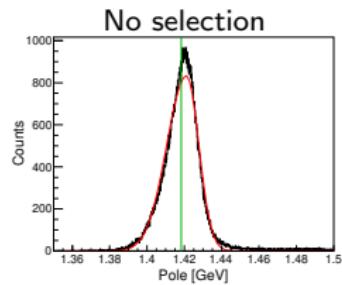


Threshold =  $K^0 n$

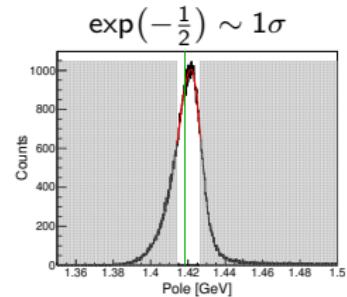
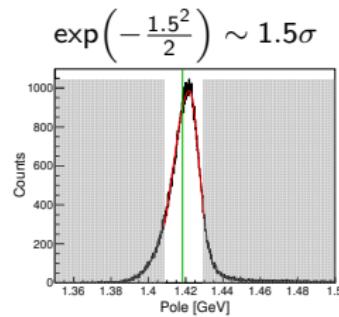
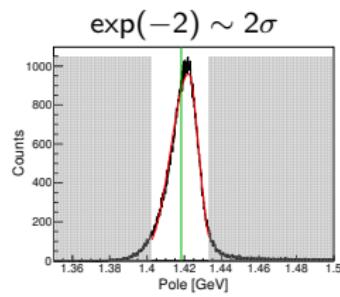
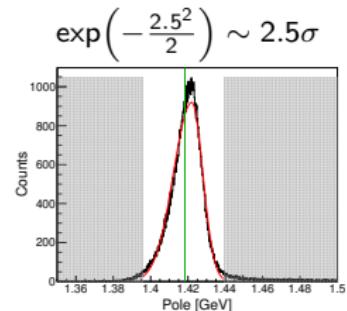
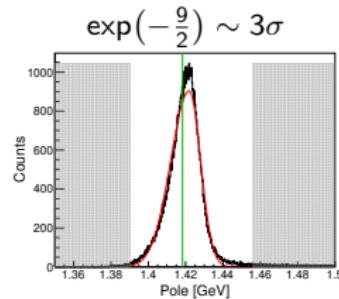
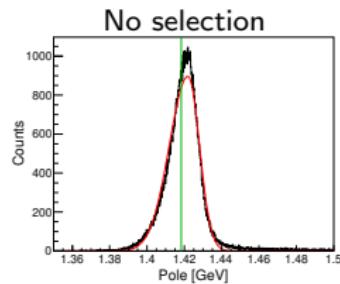


緑線はベストフィット ( $\bar{K}N$  による中心値)

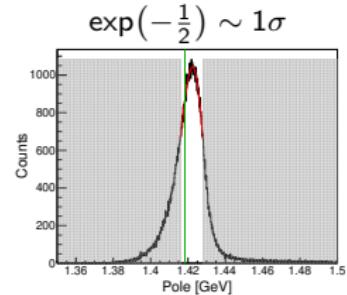
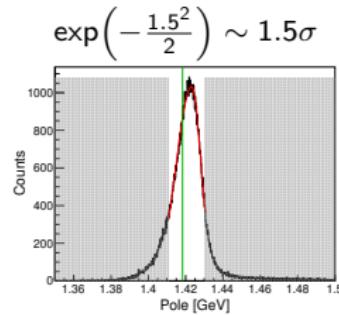
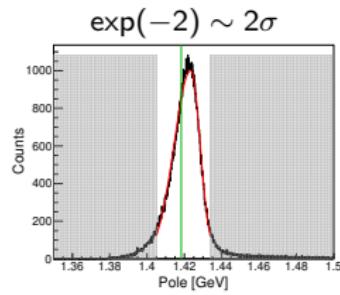
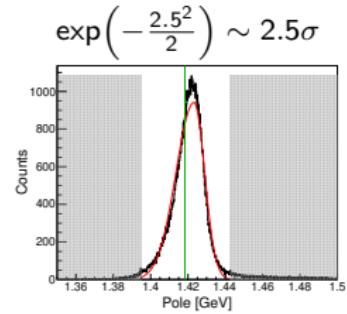
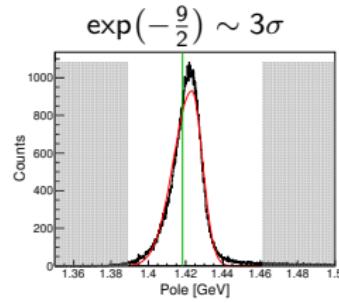
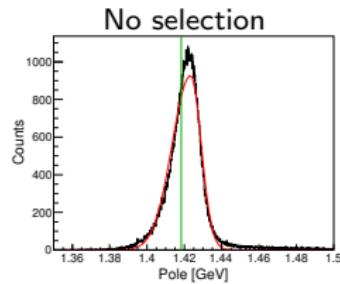
# $\Lambda(1405)$ Pole Fitting w/ $K^- p$ threshold



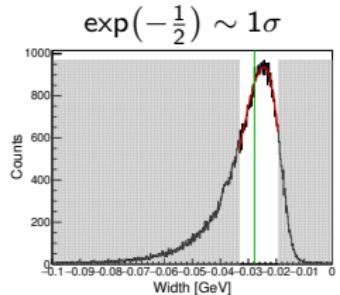
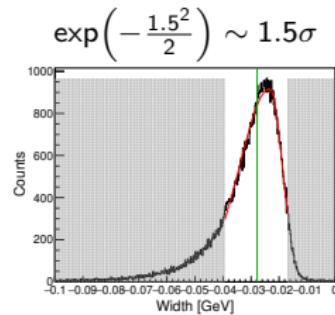
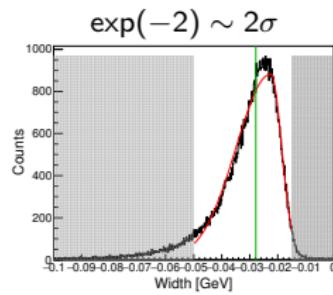
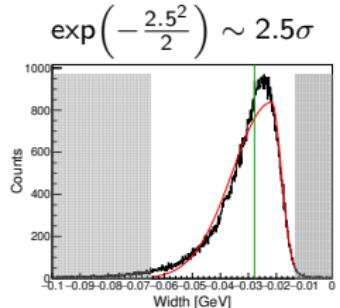
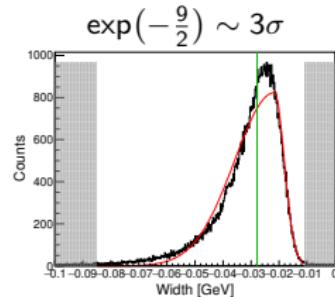
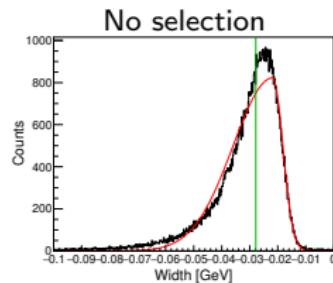
# $\Lambda(1405)$ Pole Fitting w/ $\bar{K}N$ threshold



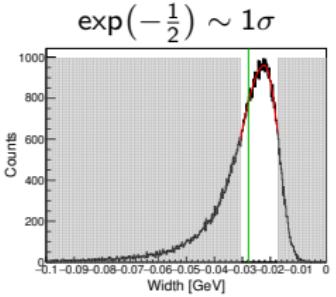
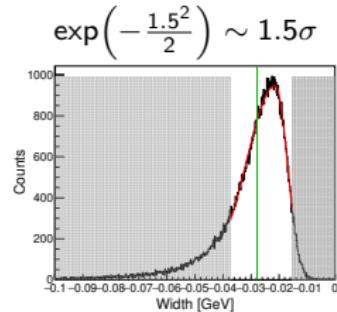
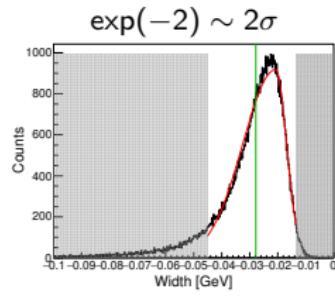
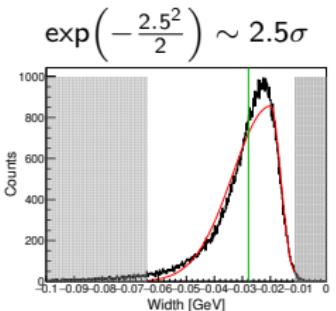
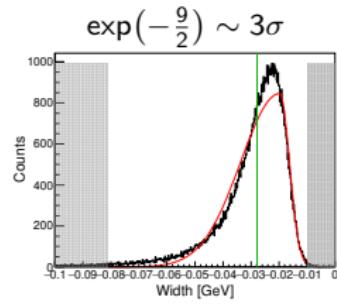
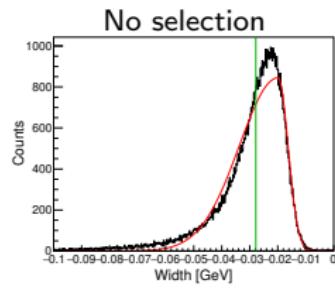
# $\Lambda(1405)$ Pole Fitting w/ $K^0 n$ threshold



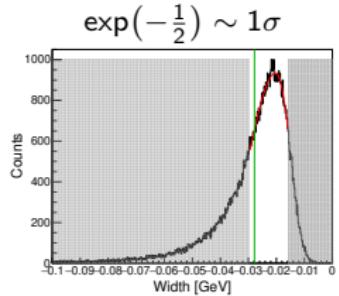
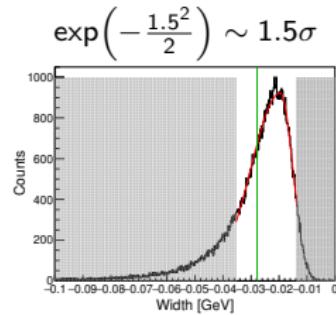
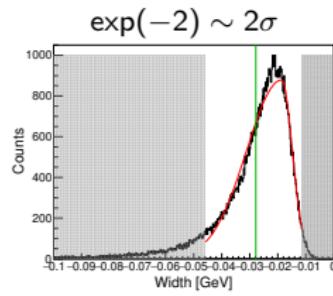
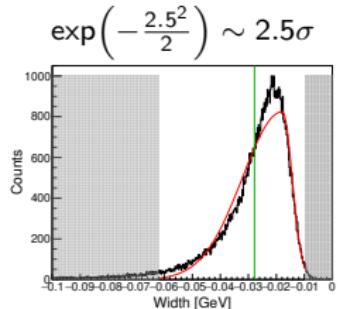
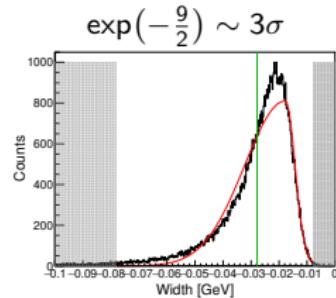
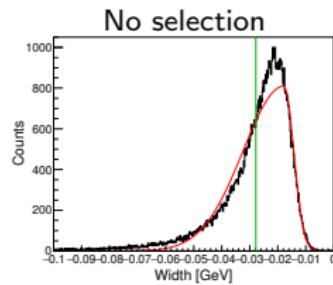
# $\Lambda(1405)$ Width Fitting w/ $K^- p$ threshold



# $\Lambda(1405)$ Width Fitting w/ $\bar{K}N$ threshold



# $\Lambda(1405)$ Width Fitting w/ $K^0 n$ threshold



# Back Up

# Fitting Function

$$\frac{d\sigma}{dM_{\pi\Sigma} d\Omega_n} = \left| \langle n_{\theta=0} \pi\Sigma | T_2(\bar{K}N_2, \pi\Sigma) G_0(\bar{K}, N_2) T_1(K^- N_1, \bar{K}N) | K^- \Phi_d \rangle \right|^2$$

(Factrization)  $\Rightarrow \left| T_2(\bar{K}N_2, \pi\Sigma) \right|^2 F_{res}(M_{\pi\Sigma})$

1-step Scattering (using numerical data by Noumi)

$$F_{res}(M_{\pi\Sigma}) = \left| \int G_0(\bar{K}, N_2) T_1(K^- N_1, \bar{K}N) \psi_d(p) d^3 p_N \right|^2$$

$G_0(\bar{K}, N_2)$ :Green Function

$T_1(K^- N_1, \bar{K}N)$ :Partical Wave Analysis G. P. Gopal et al., Nucl. Phys. B 119, 362 (1977).

$\psi_d(x)$  : Wave function of fermi motion in deuteron

# Fitting Function

2-step Scattering refer L. Lesniak, arXiv:0804.3479v1, 2008.

$$T_2^I(\bar{K}N, \bar{K}N) = \frac{A^I}{1 - iA^I k_2 + \frac{1}{2}A^I R^I k_2^2}$$

$$T_2^I(\bar{K}N, \pi\Sigma) = \frac{e^{i\delta^I}}{\sqrt{k_1}} \frac{\sqrt{\mathbf{Im}A^I - \frac{1}{2}|A^I|^2 \mathbf{Im}R^I k_2^2}}{1 - iA^I k_2 + \frac{1}{2}A^I R^I k_2^2}$$

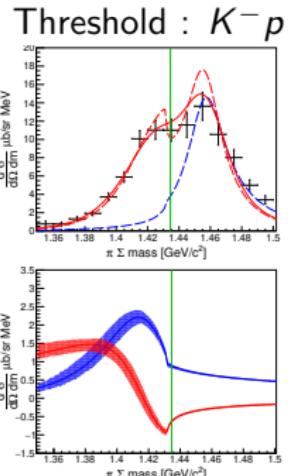
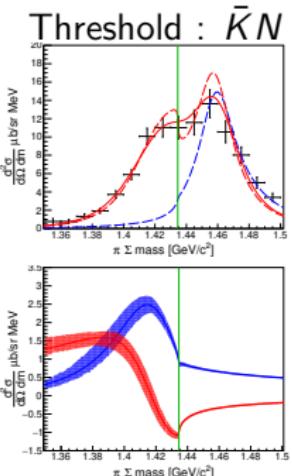
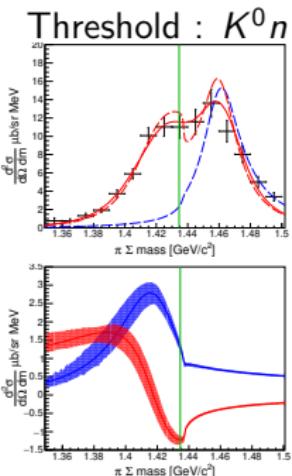
$$T_2^I(\pi\Sigma, \pi\Sigma) = \frac{e^{i\delta^I}}{k_1} \frac{\sin \delta^I + i\mathbf{Im}(e^{-i\delta^I} A^I) k_2 - \frac{1}{2}\mathbf{Im}(e^{-i\delta^I} A^I R^I) k_2^2}{1 - iA^I k_2 + \frac{1}{2}A^I R^I k_2^2}$$

$A^I$  : Scattering Length

$R^I$  : Effective Range

$\delta^I$  : Phase

# Fit $I = 0$ spectra



|              |                     |
|--------------|---------------------|
| $\chi^2/NDF$ | $15.3/10=1.53$      |
| Scale        | $0.0367 \pm 0.0053$ |
| $Re(A)$      | $-1.13 \pm 0.13$    |
| $Im(A)$      | $0.789 \pm 0.152$   |
| $Re(R)$      | $-0.160 \pm 0.402$  |
| $Im(R)$      | $-0.333 \pm 0.155$  |

|              |                     |
|--------------|---------------------|
| $\chi^2/NDF$ | $19.7/10=1.97$      |
| Scale        | $0.0373 \pm 0.0047$ |
| $Re(A)$      | $-1.05 \pm 0.12$    |
| $Im(A)$      | $0.863 \pm 0.155$   |
| $Re(R)$      | $-0.220 \pm 0.398$  |
| $Im(R)$      | $-0.424 \pm 0.164$  |

|              |                     |
|--------------|---------------------|
| $\chi^2/NDF$ | $26.3/10=2.63$      |
| Scale        | $0.0377 \pm 0.0042$ |
| $Re(A)$      | $-0.953 \pm 0.113$  |
| $Im(A)$      | $0.937 \pm 0.161$   |
| $Re(R)$      | $-0.270 \pm 0.401$  |
| $Im(R)$      | $-0.525 \pm 0.183$  |

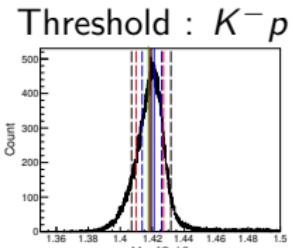
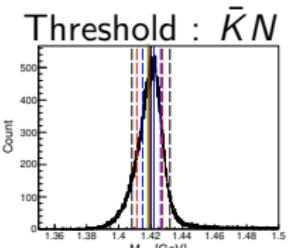
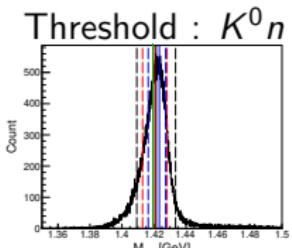
## Noumi fitting values

$$a_{\bar{K}N}(I=0) = [-1.12 \pm 0.11(\text{fit})^{+0.10}_{-0.70}(\text{syst.})] + [0.84 \pm 0.12(\text{fit})^{+0.08}_{-0.07}(\text{syst.})]i[\text{fm}]$$

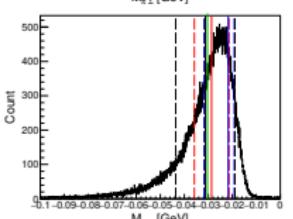
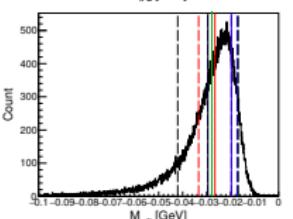
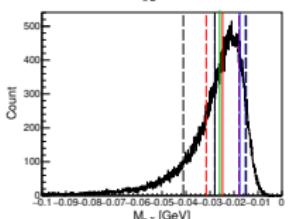
$$r_{\bar{K}N}(I=0) = [-0.18 \pm 0.31(\text{fit})^{+0.08}_{-0.06}(\text{syst.})] + [-0.40 \pm 0.13(\text{fit}) \pm 0.09(\text{syst.})]i[\text{fm}]$$

# Pole Parameters (前回と同じ)

Pole



Width



$\chi^2/NDF$

$15.3/10=1.53$

Scale

$0.0367 \pm 0.0053$

$M_{\pi\Sigma} [\text{GeV}]$

$1.4193^{+0.0089}_{-0.0064}$

$\Gamma [\text{GeV}]$

$0.0259^{+0.0080}_{-0.0057}$

Green : Best Fit

$19.7/10=1.97$

$0.0373 \pm 0.0047$

$1.4183^{+0.0090}_{-0.0070}$

$0.0278^{+0.0081}_{-0.0055}$

$26.3/10=2.63$

$0.0377 \pm 0.0042$

$1.4176^{+0.0094}_{-0.0077}$

$0.0303^{+0.0089}_{-0.0055}$

値は  $A, R$  の Bet Fit の値で計算、エラーは Gaussian の  $\sigma$  で評価

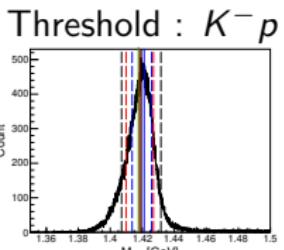
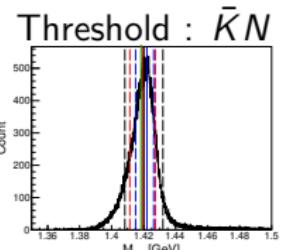
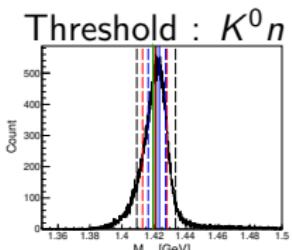
つまり、左右対称なエラーで評価

Noumi's parameter

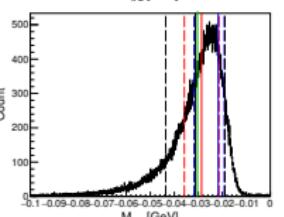
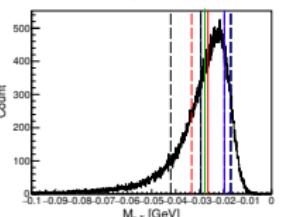
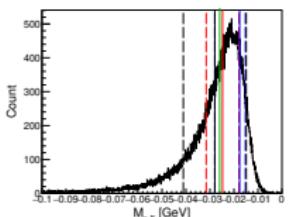
$$\text{Pole} = 1417.7^{+6.0}_{-7.4}(\text{fit})^{+1.1}_{-1.0}(\text{syst.}) + [-26.1^{+6.0}_{-7.9}(\text{fit})^{+1.7}_{-2.0}(\text{syst.})]i \text{ [MeV]}$$

# Pole Parameters (いろいろなフィット)

Pole



Width



Green : Best Fit

$K^0 n$

$\bar{K}N$

$K^- p$

|                       |            | $K^0 n$                | $\bar{K}N$             | $K^- p$                |
|-----------------------|------------|------------------------|------------------------|------------------------|
| $M_{\pi\Sigma}$ [GeV] | Gaussian   | $1420.5 \pm 7.6$       | $1419.3 \pm 8.0$       | $1418.4 \pm 8.6$       |
|                       | 2-Gaussian | $1423.4^{+4.0}_{-7.0}$ | $1422.1^{+4.2}_{-7.1}$ | $1421.2^{+4.7}_{-7.5}$ |
|                       | Mean/RMS   | $1421.4 \pm 12.4$      | $1420.2 \pm 11.9$      | $1419.3 \pm 12.3$      |
| $\Gamma$ [GeV]        | Gaussian   | $-24.7 \pm 6.8$        | $-26.5 \pm 6.8$        | $-28.6 \pm 7.2$        |
|                       | 2-Gaussian | $-17.6^{+2.4}_{-10.4}$ | $-19.7^{+2.4}_{-9.8}$  | $-21.7^{+2.5}_{-10.0}$ |
|                       | Mean/RMS   | $-28.0 \pm 13.1$       | $-29.4 \pm 12.6$       | $-31.2 \pm 12.4$       |

# Pole Parameters の見解

- 値は  $A, R$  の Best Fit のものを使うべきだろう。
- エラーはダブルガウシアン、ガウシアン、RMS の順で大きくなる。  
→ RMS はテールの成分が入るためガウシアンの 2 倍ほどになる  
過大評価になっていないか？
- 「のヒストグラムはだいぶガウシアンからズれている。  
→ ガウシアン、ダブルガウシアン、Mean と RMS で大きくエラーが  
変わる。

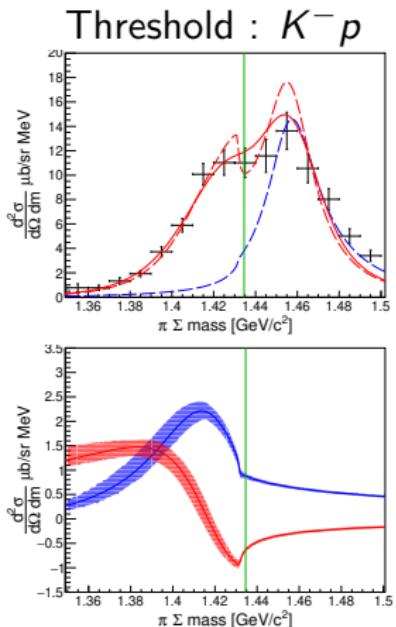
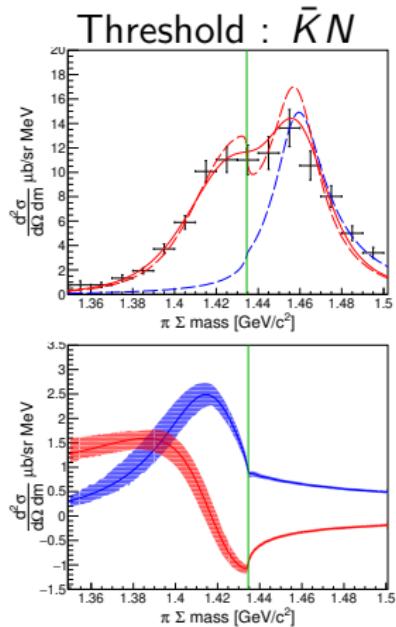
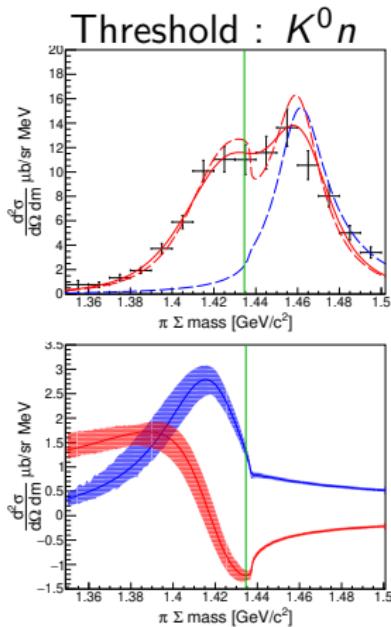
Fit の違いによるエラーの差は系統誤差として取り込む。

→ その際、RMS の値を採用するかどうか？

Mean/RMS を採用した場合、すべてこの手法でエラーが決まる。

2-Gaussian のみを追加する場合、 $M_{\pi\Sigma}$  には影響しない

# Fit /0 spectra



# Parameters about the $\Lambda(1405)$

| Model                      | $a_{\bar{K}N}(I = 0)$<br>fm | $a_{\bar{K}N}(I = 1)$ | Pole1        | Pole2        |
|----------------------------|-----------------------------|-----------------------|--------------|--------------|
| Miyagawa's calc            |                             |                       |              |              |
| Histrical                  | $-1.72 + 0.89i$             | $0.52 + 0.64i$        | $1426 - 16i$ | $1390 - 66i$ |
| Ohinishi                   | $-1.89 + 1.11i$             | $0.45 + 0.53i$        | $1429 - 15i$ | $1344 - 49i$ |
| Cleply                     | $-1.61 + 1.02i$             | $0.60 + 0.50i$        | $1433 - 25i$ | $1371 - 54i$ |
| SHIDDARTA value is imposed |                             |                       |              |              |
| DCC Model                  |                             |                       |              |              |
| Model.A                    | $-1.37 + 0.67i$             | -                     | $1432 - 75i$ | $1372 - 59i$ |
| Model.B                    | $-1.62 + 1.02i$             | -                     | $1428 - 31i$ | $1397 - 98i$ |

Best Model

## Noumi's analysis

$$a_{\bar{K}N}(I = 0) = [-1.12 \pm 0.11(\text{fit})^{+0.10}_{-0.70}(\text{syst.})] + [0.84 \pm 0.12(\text{fit})^{+0.08}_{-0.07}(\text{syst.})]i$$

$$(r_{\bar{K}N}(I = 0) = [-0.18 \pm 0.31(\text{fit})^{+0.08}_{-0.06}(\text{syst.})] + [-0.40 \pm 0.13(\text{fit}) \pm 0.09(\text{syst.})]i)$$

$$\text{Pole} = 1417.7^{+6.0}_{-7.4}(\text{fit})^{+1.1}_{-1.0}(\text{syst.}) + [-26.1^{+6.0}_{-7.9}(\text{fit})^{+1.7}_{-2.0}(\text{syst.})]i$$

# Parameters about the $\Lambda(1405)$

