K中間子クラスターと高密度物質への展開

K^-ppクラスター実験研究の最前線

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Contents

- Studies of the K^-pp cluster
- Overview of the E15 experiment
- Preliminary results on E15 new data
- Summary

Situation of K^-pp bound state

▶ Theoretical calc.

Bound state exists

KbarN interaction model

E-dep. / E-indep.

▶ Experiments

Reports structure / ***NO structure***

J-PARC E27

$d(\pi^+, K^+)X$

DISTO

$pp \to \Lambda p K^+$

FINUDA

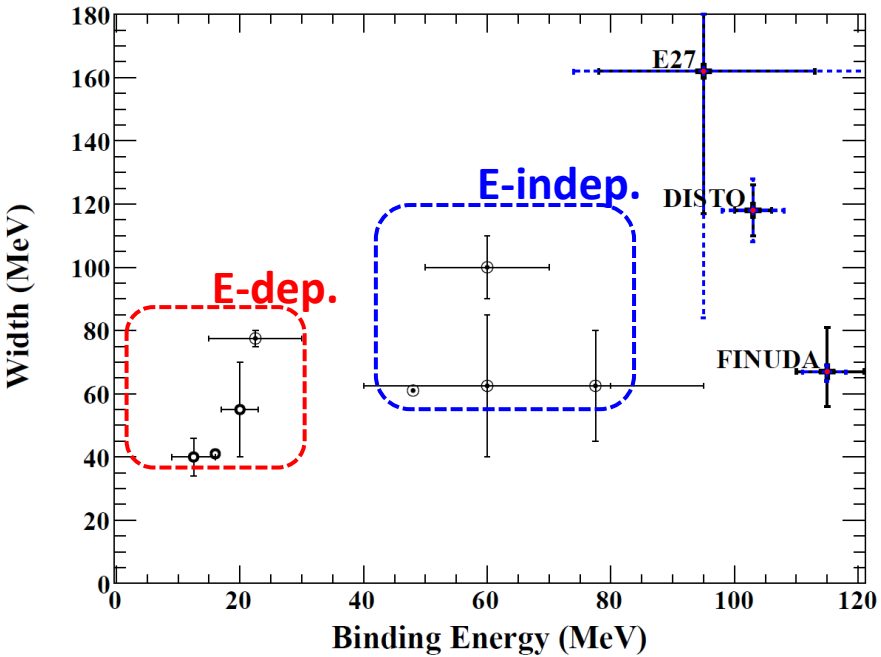
$(stopped\ K^-, \Lambda p)$

LEPS

$p(\gamma, \pi^- K^+)X$

HADES

$pp \to \Lambda p K^+$



Experimental studies on K^-pp cluster

J-PARC E15 experiment

- Momentum transfer is smaller than other experiments.
- Λpn final state is identified.

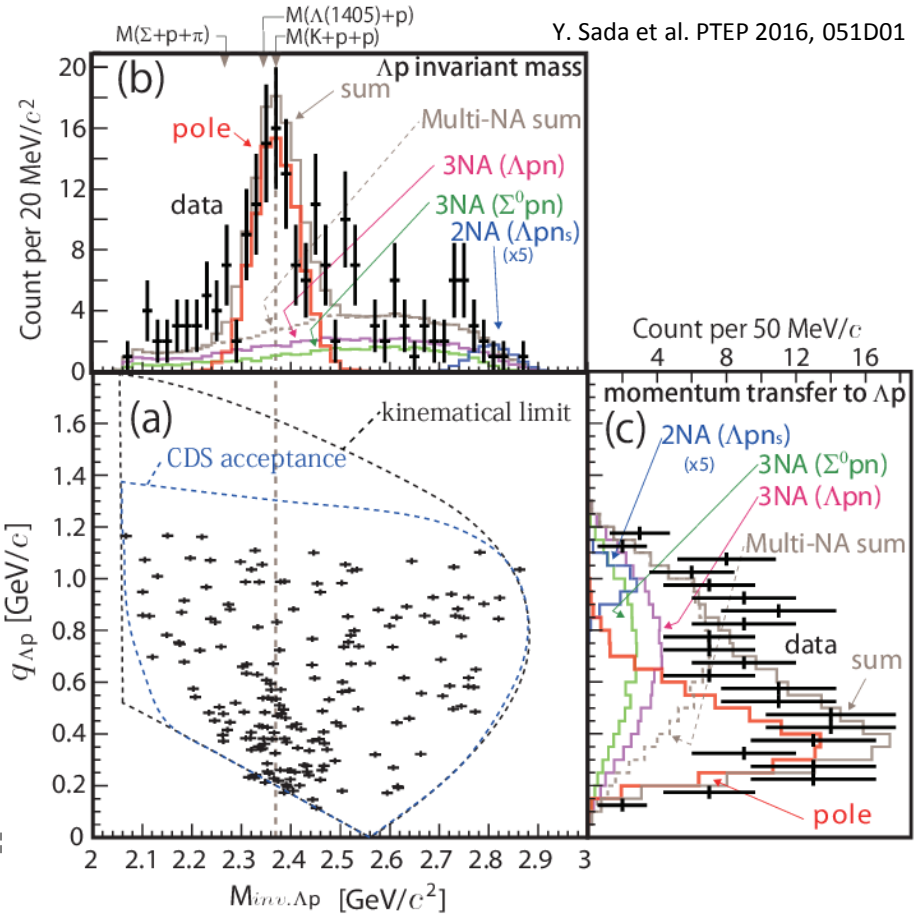
Experiment	Reaction	Momentum transfer (MeV/c)
FINUDA	$(K^-_{stopped}, \Lambda p)$	0
KLOE	$(K^-_{stopped}, \Sigma^0 p)$	0
DISTO	$pp \to K^+\Lambda p$	$300-400$
HADES	$pp \to K^+\Lambda p$	$500-700$
LEPS	$p(\gamma, \pi^- K^+)X$	$300-600$
J-PARC E27	$d(\pi^+, K^+)X_{\Lambda p/\Sigma^0 p}$	$500-700$
J-PARC E15	$(K^-_{in-flight}, \Lambda p)n$	$200-300$

➡ $2NA$ background

➡ $N^* \to \Lambda K^+$ decay

J-PARC E15 experiment

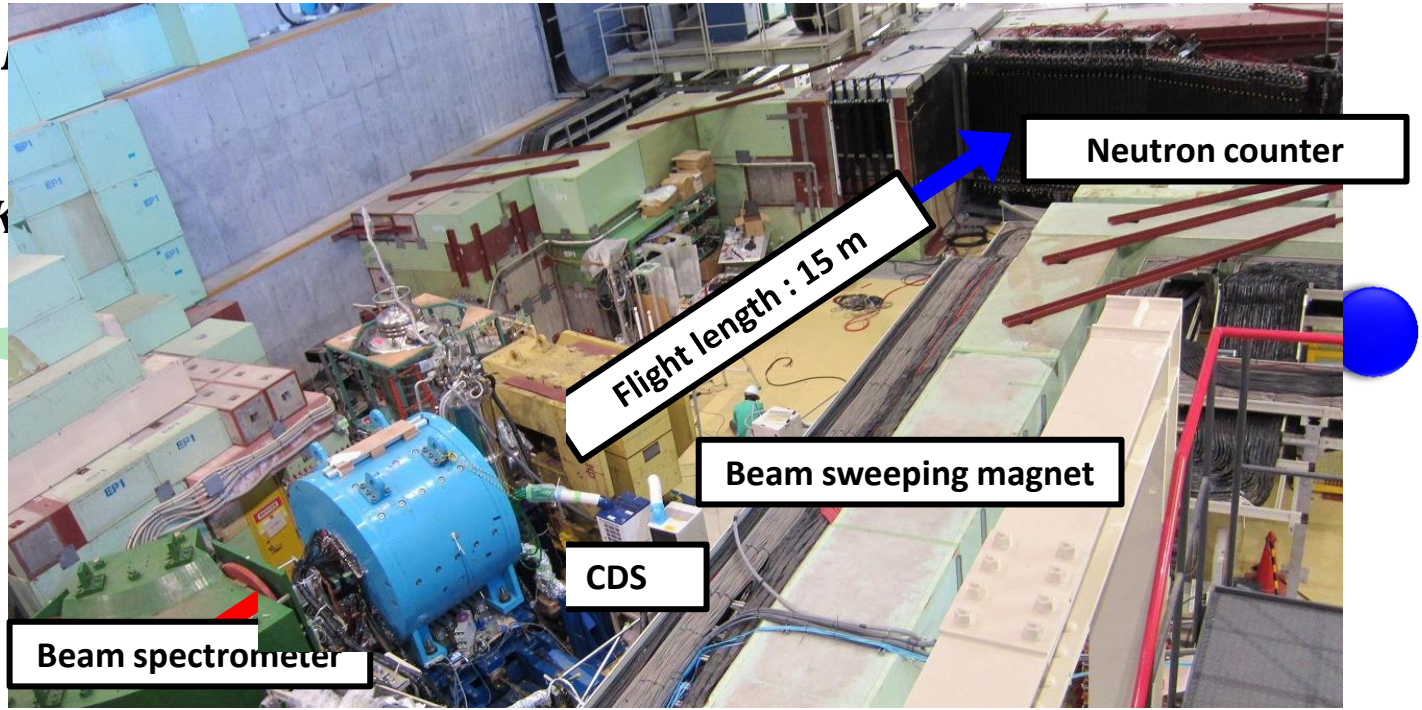
- K^-pp search with (K^-, n) reaction
  - We have reported the structure around K^-pp mass threshold in $^3He(K^-, \Lambda p)n$ reaction
- Study with higher statistics data



J-PARC E15 Experiment

Searching for K^-pp

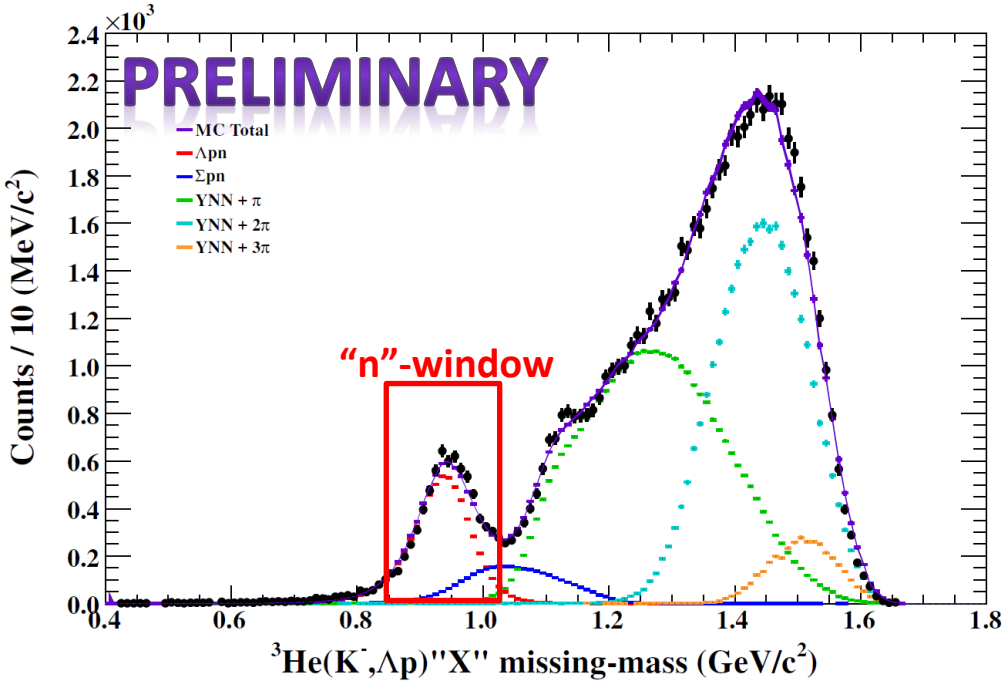
- (Λ
- K



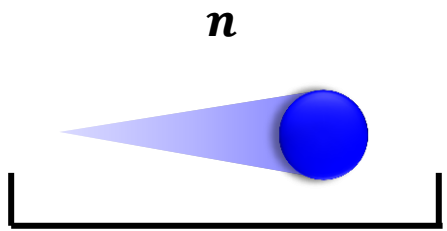
$^3\mathrm{He}(K^-, \Lambda p)n$ Analysis

Measurement

$^3\mathrm{He}(K^-, \Lambda p)$"X" missing-mass

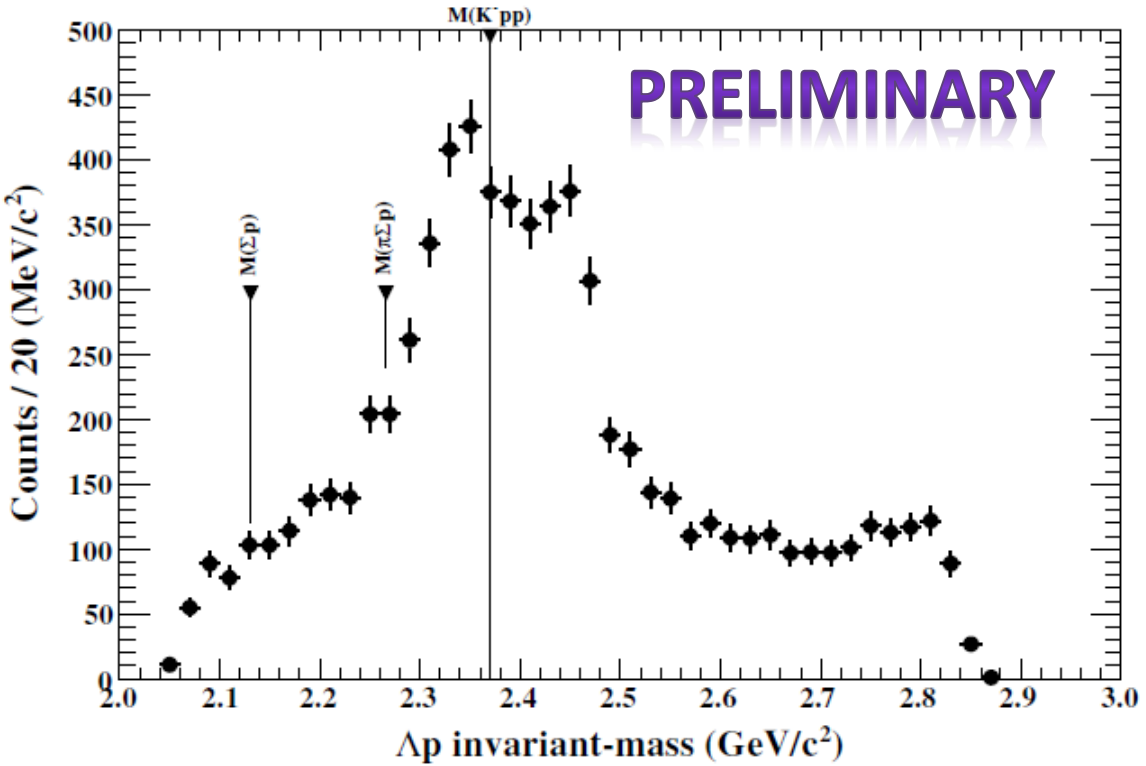


- $0.85 - 1.03\ GeV/c^2$ region is selected as neutron.



Analysis for the $^3\mathrm{He}(K^-, \Lambda p)n$ reaction

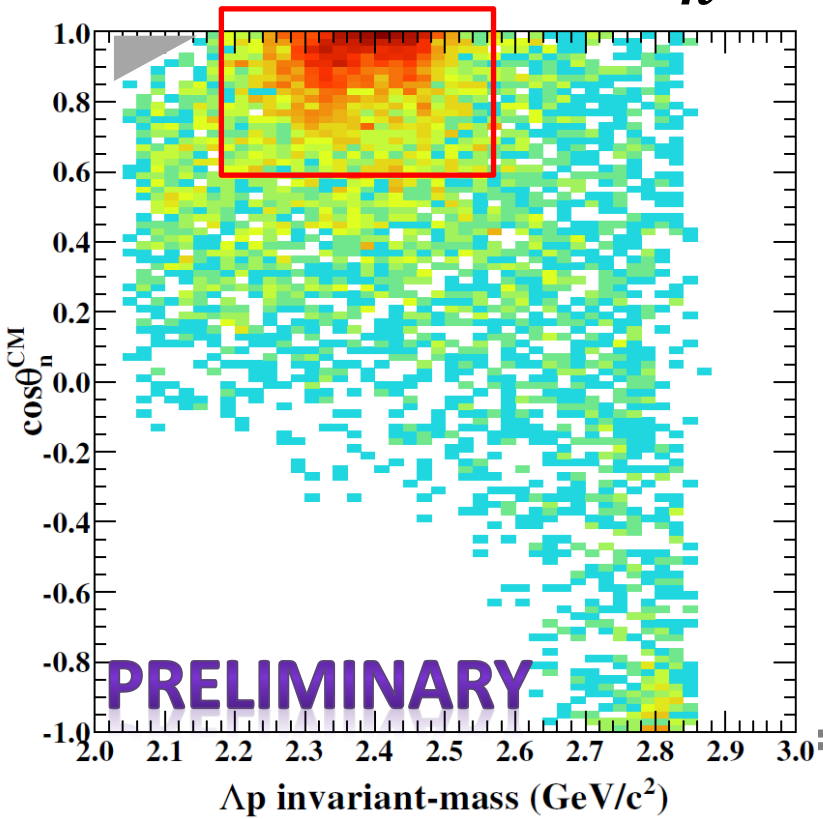
Final spectrum of Λp invariant-mass



- Continuum contribution
- Peak structure around K^-pp mass-threshold
  - » Contribution from other material can not make the structure
  - » The peak structure can not seen in “Mixed event analysis”

Results and Discussion

Relation of $\cos\theta_n^{CM}$



$$\cos\theta_n^{CM} = \frac{\mathbf{p}_{K^-}^{CM} \cdot \mathbf{p}_n^{CM}}{|\mathbf{p}_{K^-}^{CM}| \cdot |\mathbf{p}_n^{CM}|}$$

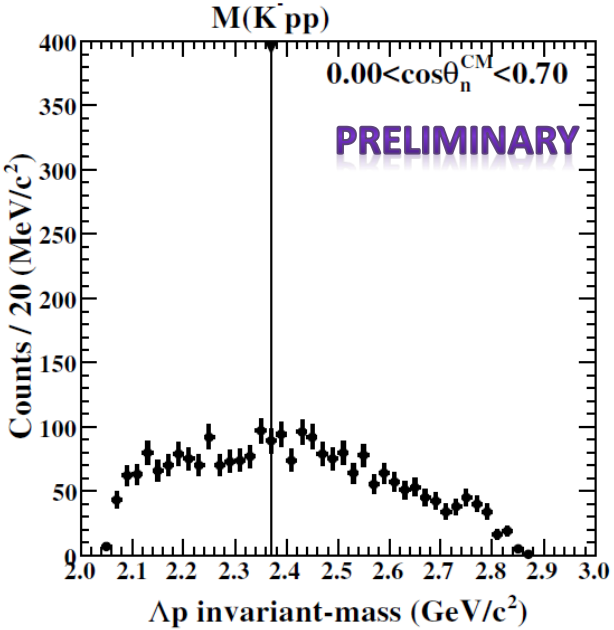
- **Continuum contribution**
  - **Distributed widely**
- **Peak structure**
  - **Only forward emission angle region**

Results and Discussion

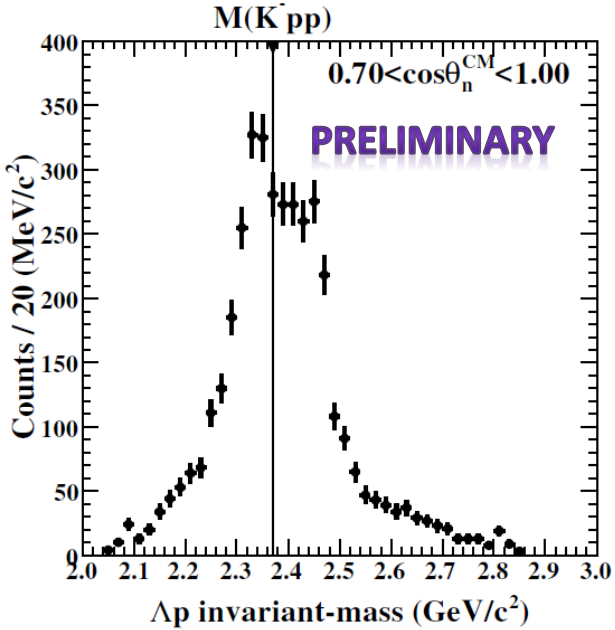
Fitting the spectrum

Pickup the peak structure

Continuum



Peak + Continuum

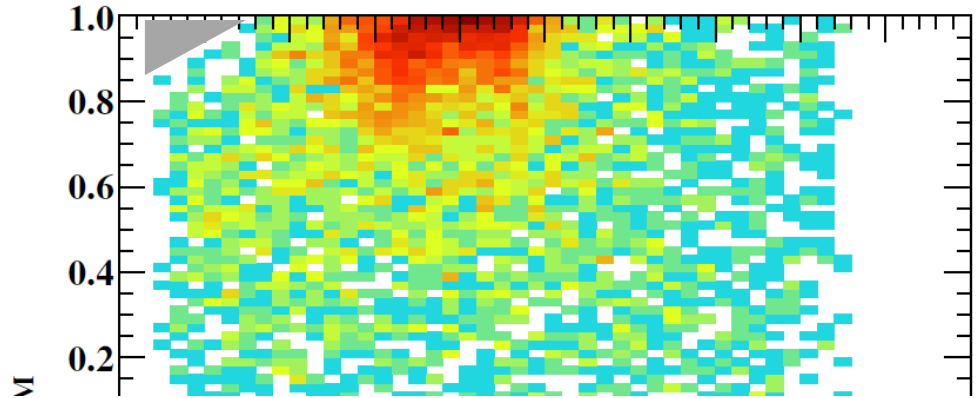


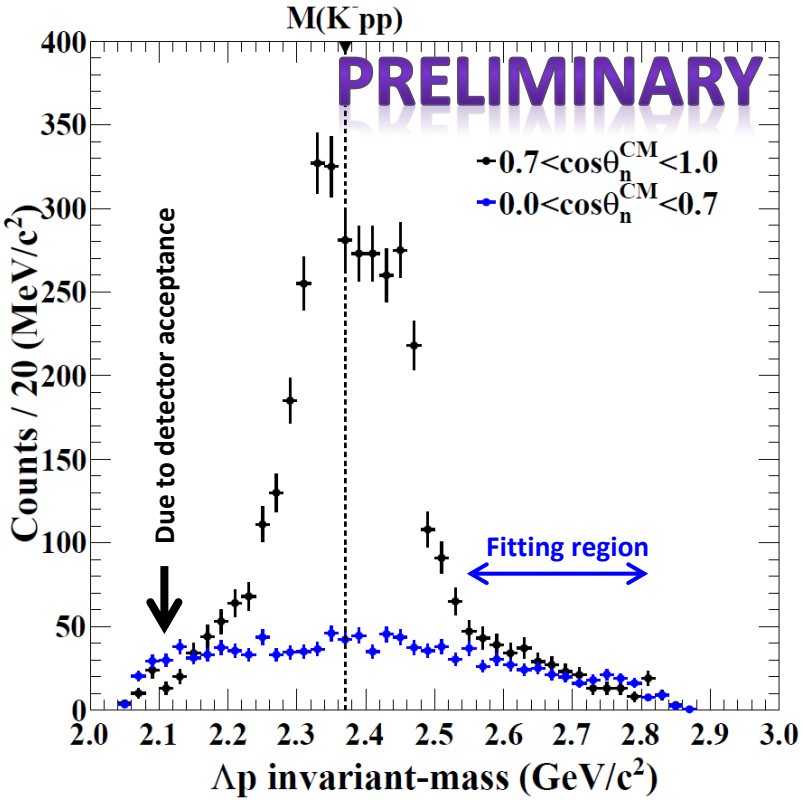
Results and Discussion

Fitting the spectrum

Pickup the peak structure

- Peak = $0.7 < \cos\theta_n^{CM} < 1.0$
  $- 0.47 \cdot (0.0 < \cos\theta_n^{CM} < 0.7)$





Results and Discussion

Fitting the spectrum

Pickup the peak structure

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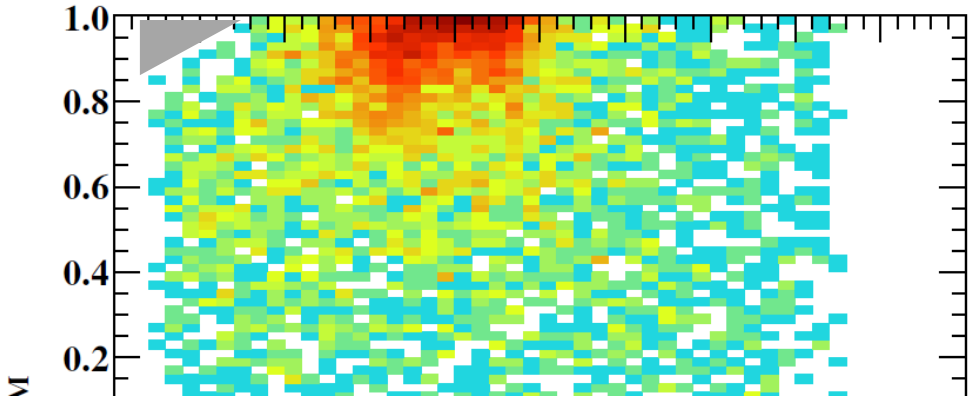
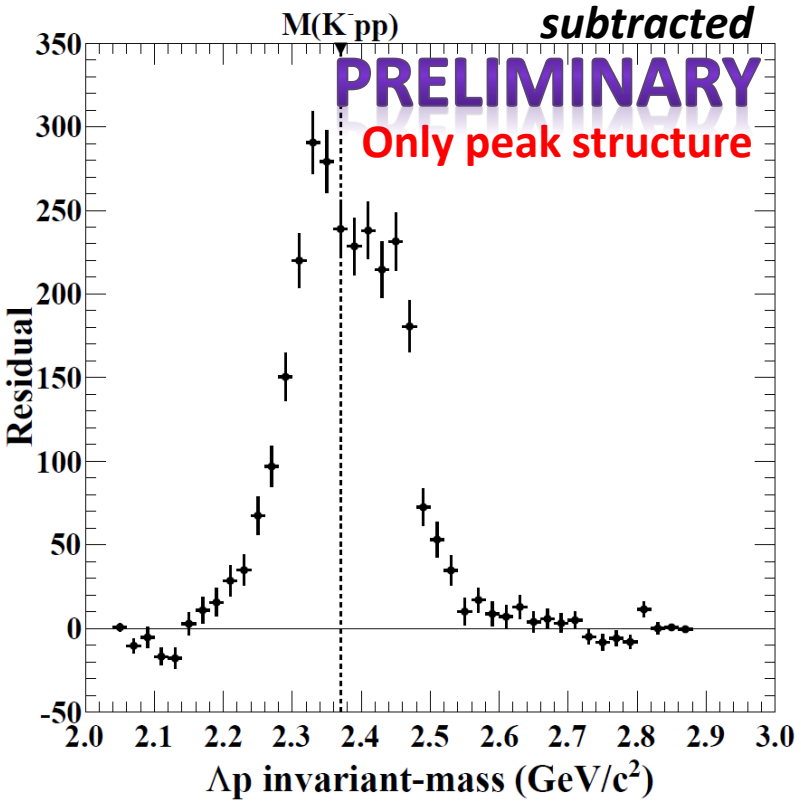
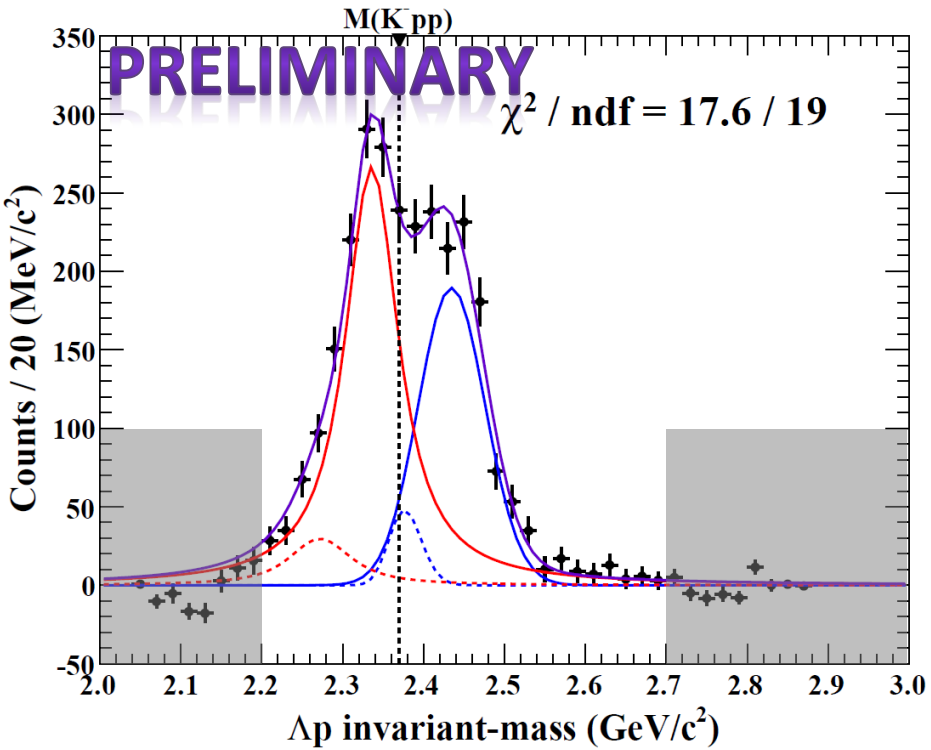




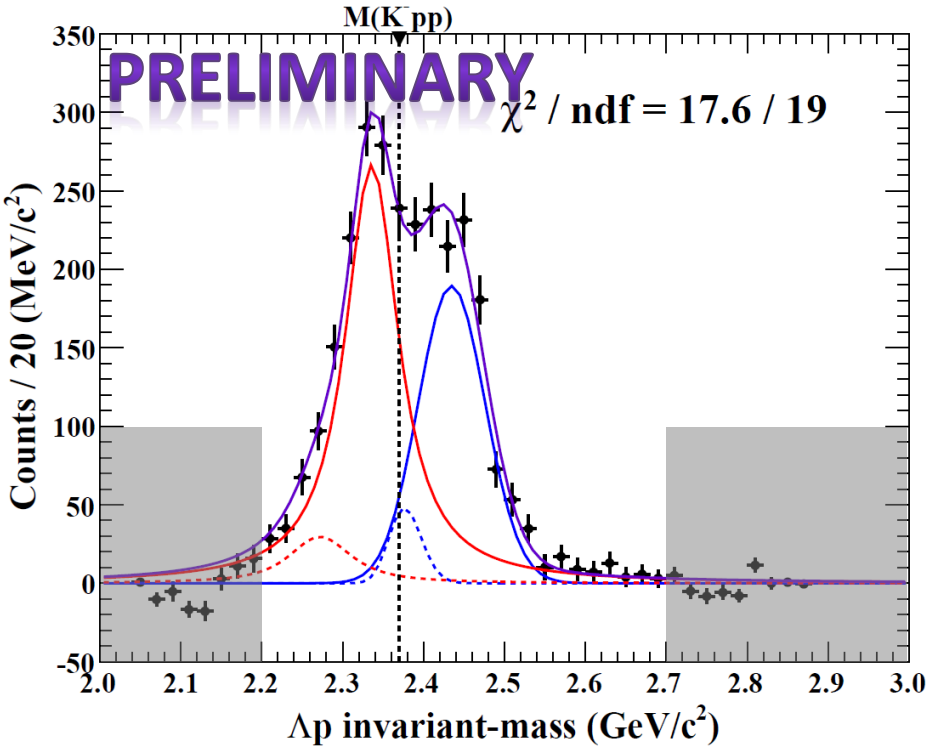
Results and Discussion

- Fitting the spectrum including $\Sigma^0 pn$
  - Solid : Λpn
  - Dotted : $\Sigma^0 pn$
- Mass position and width
  - » $M \sim 2330\ MeV/c^2$
  - » $\Gamma \sim 70\ MeV/c^2$
  - Mass position does not changed.
  - Width is slightly changed to smaller value.



Results and Discussion

Fitting for sliced spectra



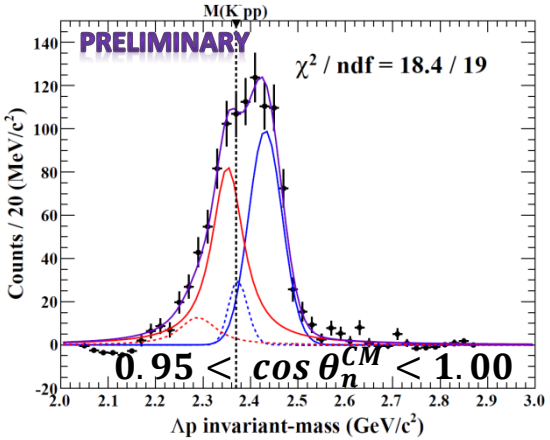
$$0.7 < \cos\theta_n^{CM} < 1.0$$

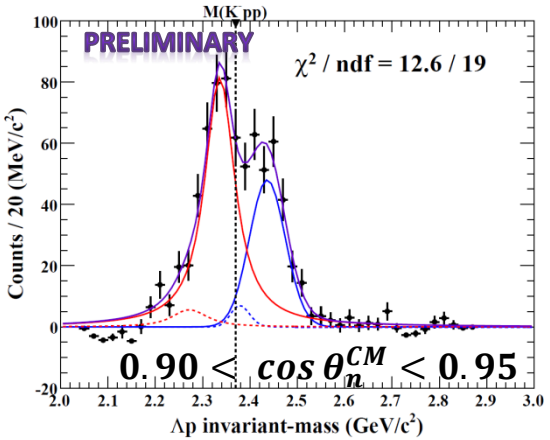
Applying the fitting for,

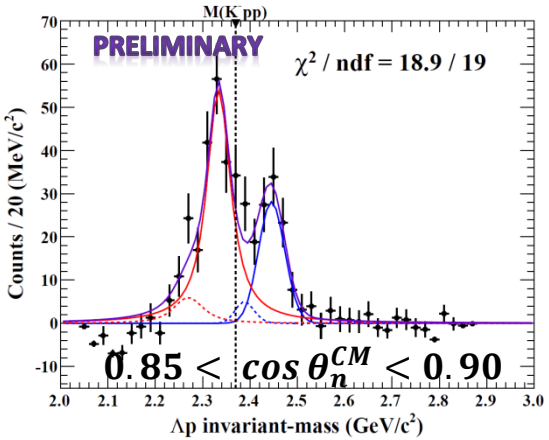
$$0.95 < \cos\theta_n^{CM} < 1.00$$
$$0.90 < \cos\theta_n^{CM} < 0.95$$
$$0.85 < \cos\theta_n^{CM} < 0.90$$
$$0.80 < \cos\theta_n^{CM} < 0.85$$
$$0.75 < \cos\theta_n^{CM} < 0.80$$

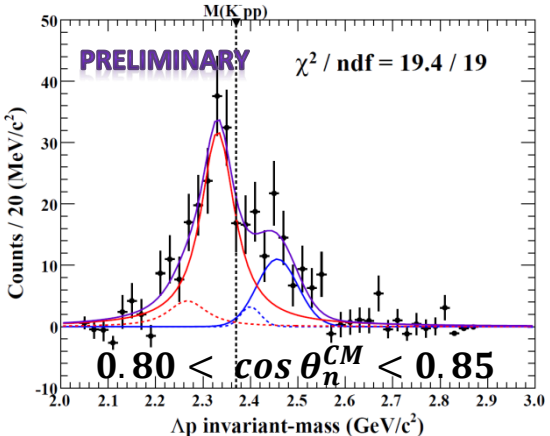
To check the peak position and width of peaks below and above the threshold

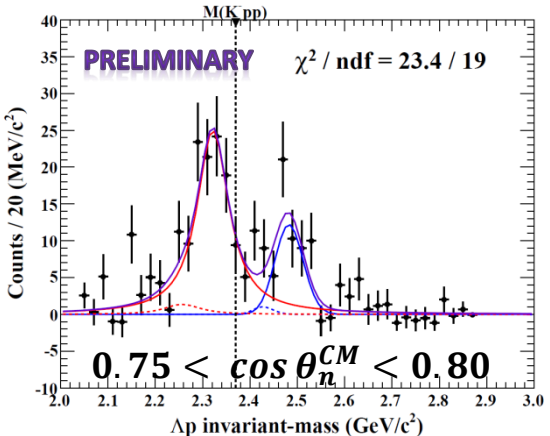
Results and Discussion







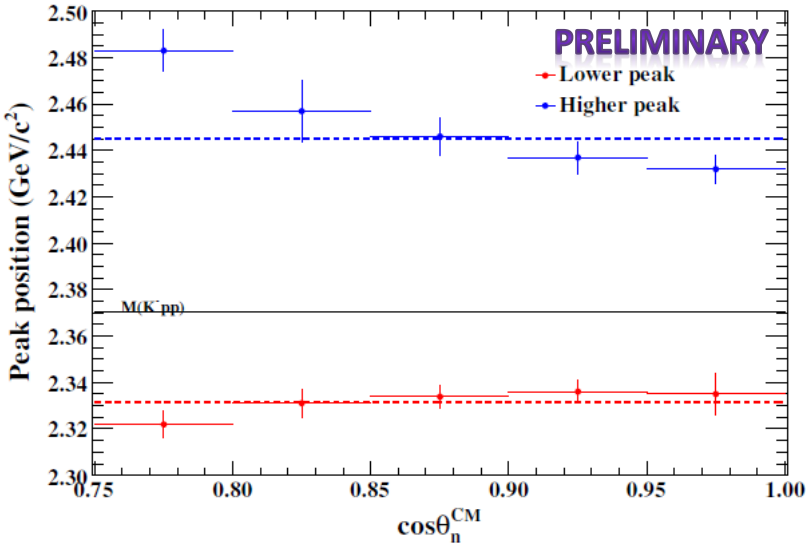




Results and Discussion

Peak positions

- Lower peak (Breit-Wigner) : constant
- Higher peak (Gaussian) : depends on $\cos\theta_n^{CM}$



$\sim 2450\ MeV/c^2$
$\chi^2/ndf = 24.7/4$

NOT constant
$\propto \cos\theta_n^{CM}$

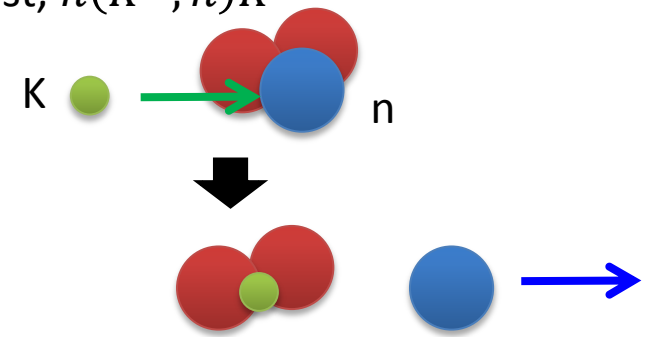
$\sim 2330\ MeV/c^2$
$\chi^2/ndf = 3.71/4$

Constant

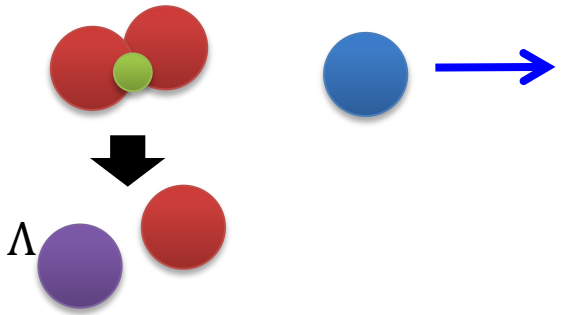
Results and Discussion

- **Assuming**
  - **The "QF" peak position can be estimated by,**
    - $M_{QF} = 2M_p + M_{K^-} + \frac{q^2}{2M_{K^-}}$
      - » q : momentum transfer
      - » M_{K^-} : mass of Kaon

At first, $n(K^-, n)K^-$

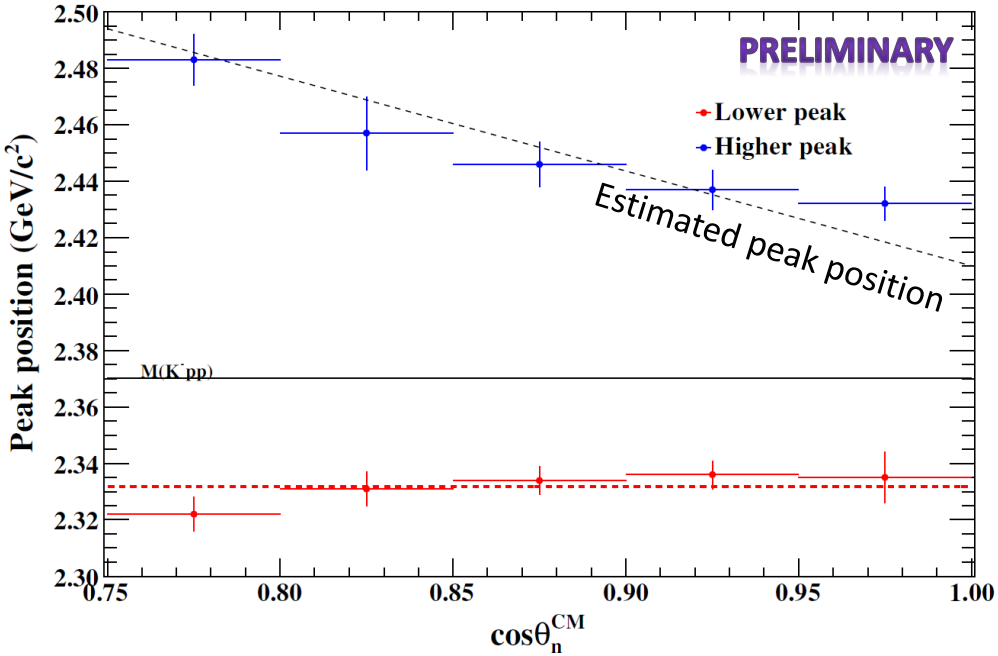


Second, $ppK^- \rightarrow \Lambda p$ conversion



Results and Discussion

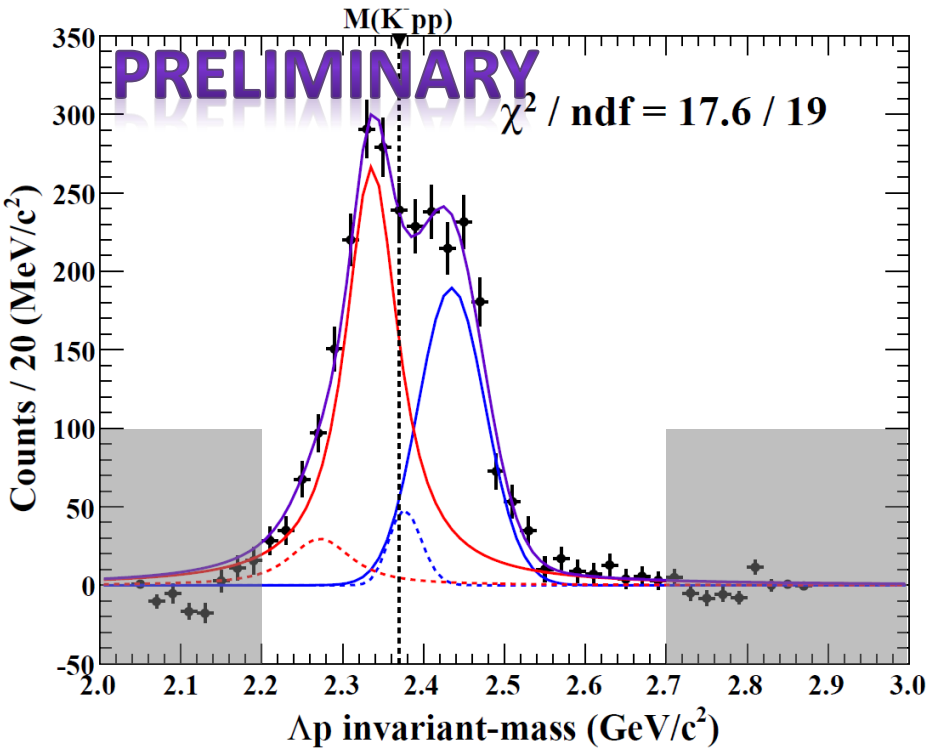
Peak positions



- **Higher peak**
  - Peak position moves.
  - "QF" process
- **Lower peak**
  - Peak position does not move
  - Could be resonant state

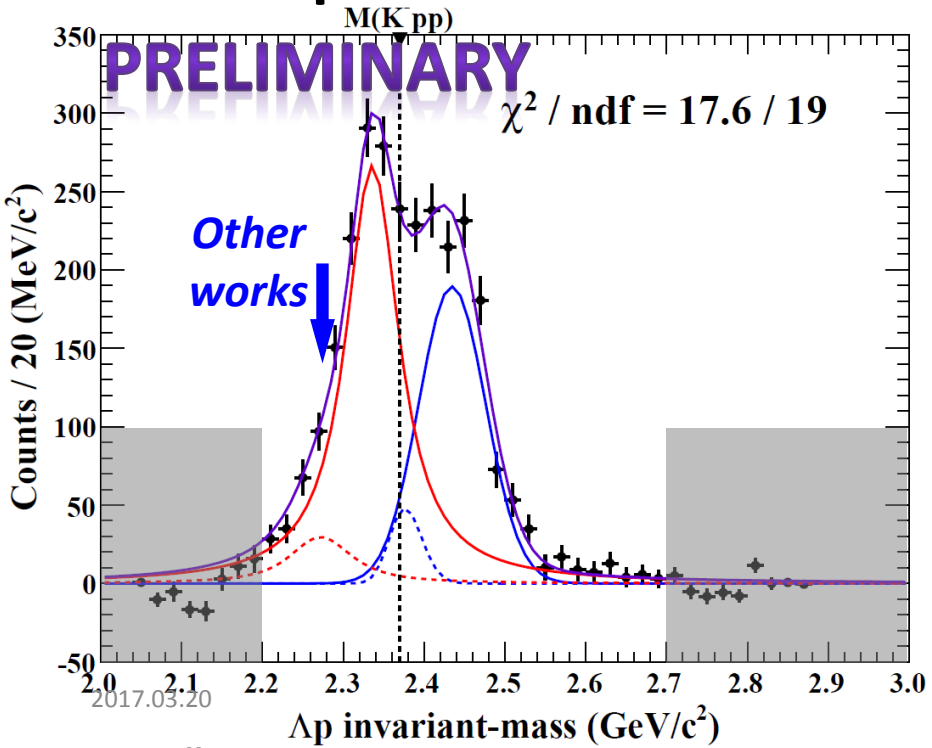
Results and Discussion

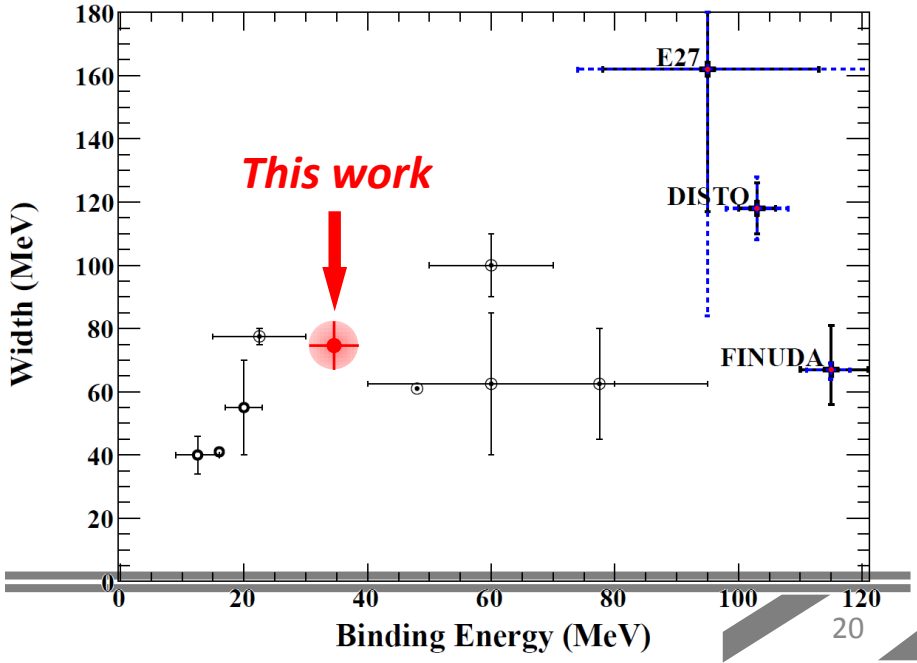
- K^-pp bound system
  - Quantum number
    - Strangeness : $S = -1$
    - Baryon number : $B = 2$
  - The lower peak could be K^-pp bound state



Comparison with previous experimental results

- Deep (B.E.:100 MeV) state is not observed.
- Peak position and width close to theoretical works.

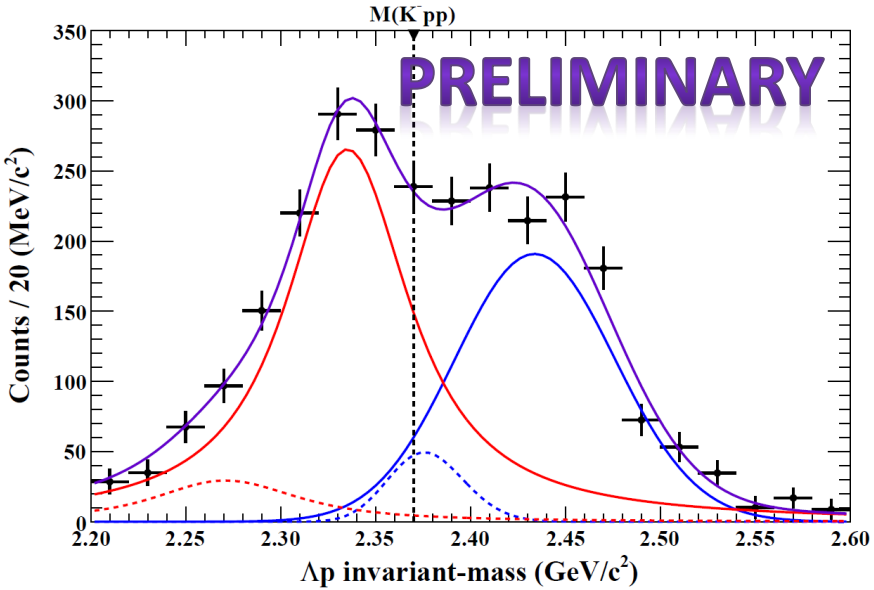




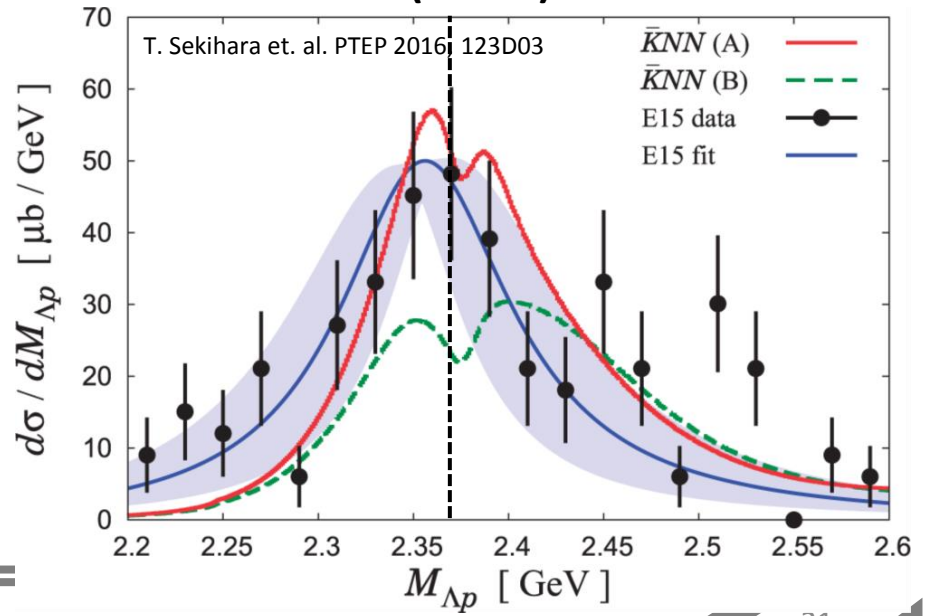
Comparison with theoretical calculation

- Spectrum shape is similar.
- Peak position is slightly deep in the Exp.

E15 result



Theoretical calc. (Chiral)



Summary

- $IM(\Lambda p)$ spectrum in the $^3He(K^-, \Lambda p)n$ reaction has two peaks below and above the Kpp threshold.

- The peaks can be fitted by Breit-Wigner and Gaussian distribution.
  - Assuming that the Breit-Wigner resonance for the lower peak, the mass and width are found to be…
    - Mass : $\sim 2330\ MeV/c^2$
    - Width : $\sim 70\ MeV/c^2$
      - These values will be finalized in near future.

Future plan of E15

- **Higher statistics**
  - J^{π} study
- **Neutron detection**
  - $K^{-}ppn$ cluster study
- **Gamma ray detection**
  - $\pi\Sigma\mathrm{N}$ decay mode study

Thank you for your attention

~ The E15 collaboration ~

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