Spectroscopic study of hyperon resonance below $\overline{K}N$ threshold via the $d(K^-,n)$ reaction

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  - d(K^-, n)"X" spectrum identified $\pi^{\mp}\Sigma^{\pm}$
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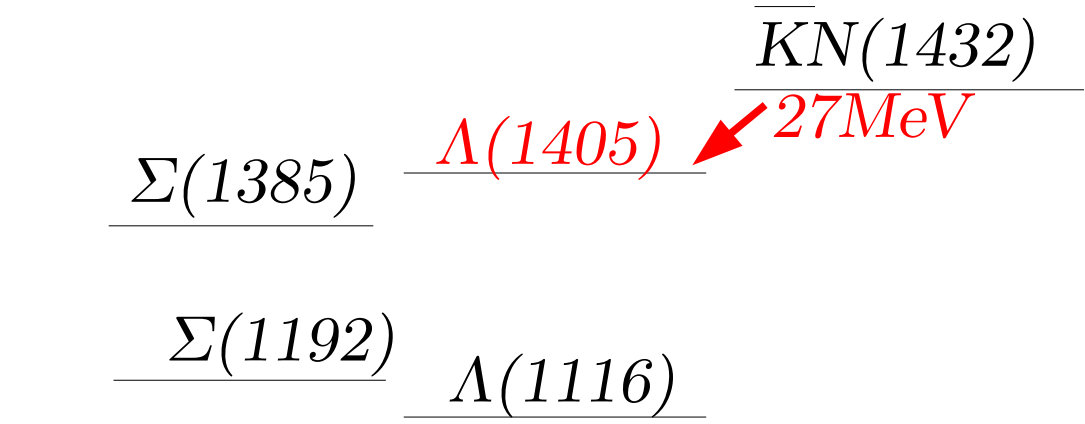
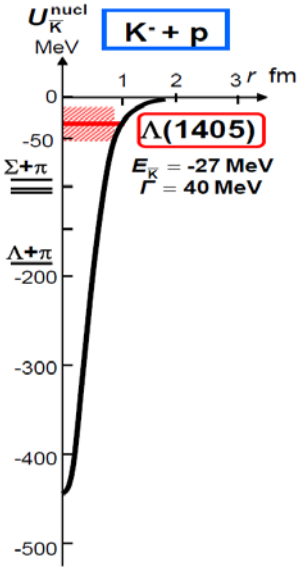
- Summary

Λ(1405)

PDG
- I(Jᵖ)=0($\frac{1}{2}^-$)
- mass $1405.1^{+1.3}_{-1.0}$ MeV
- Width = 50.5 ± 2 MeV

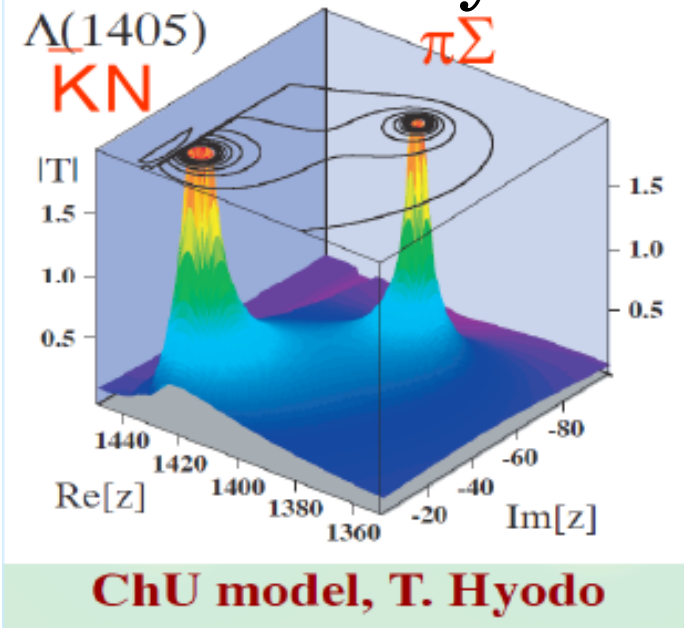


$\overline{K}N$ bound state



Y.Akaishi & T.Yamazaki
PLB535, 70(2002).

Two-poles of meson-baryon

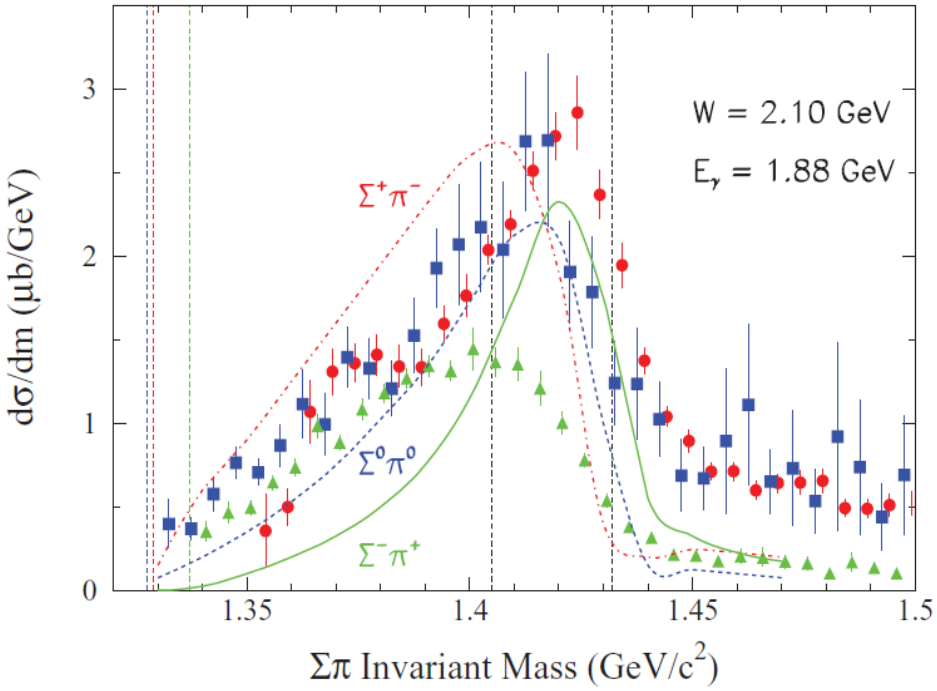


Recent experimental study of Λ(1405)

Line shapes of Λ(1405) have been reported.

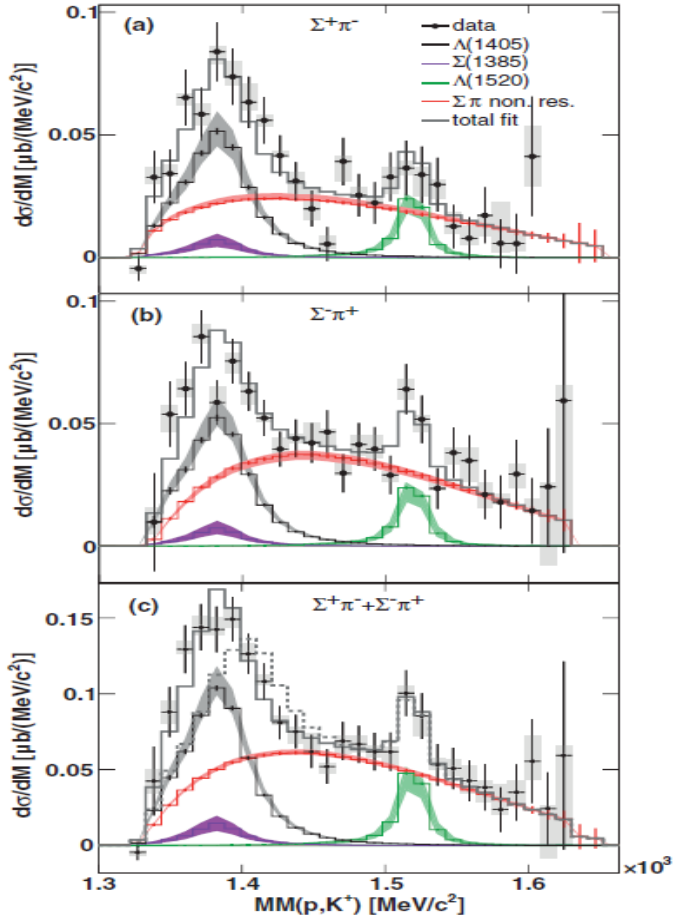
Photo-production

CLAS collaboration:
PRC87, 035206



pp collision

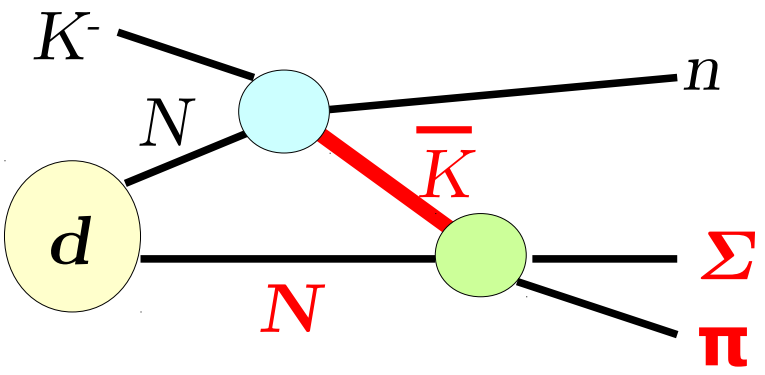
HADES collaboration:
PRC87, 025201



Kaon induced reaction is desired.

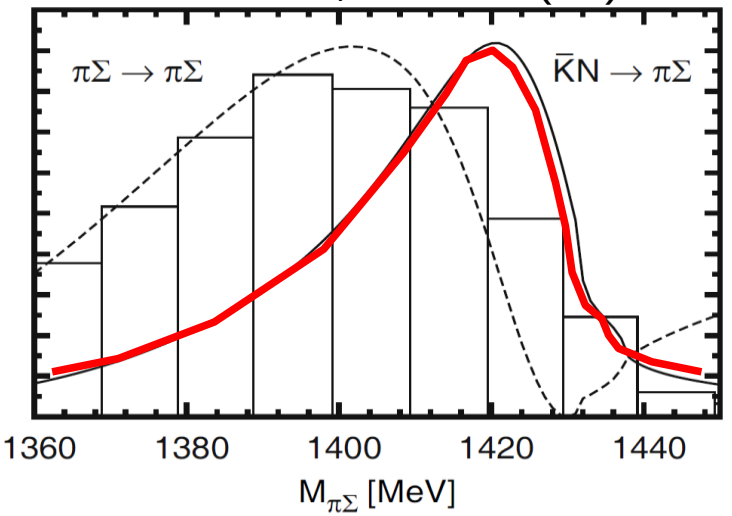
d(K^-, n) reaction

- The d(K^-, n) reaction measured at θ_n=0 is expected to enhance an S-wave $\bar{K}N \to \pi\Sigma$ scattering even below the $\bar{K}N$ threshold.

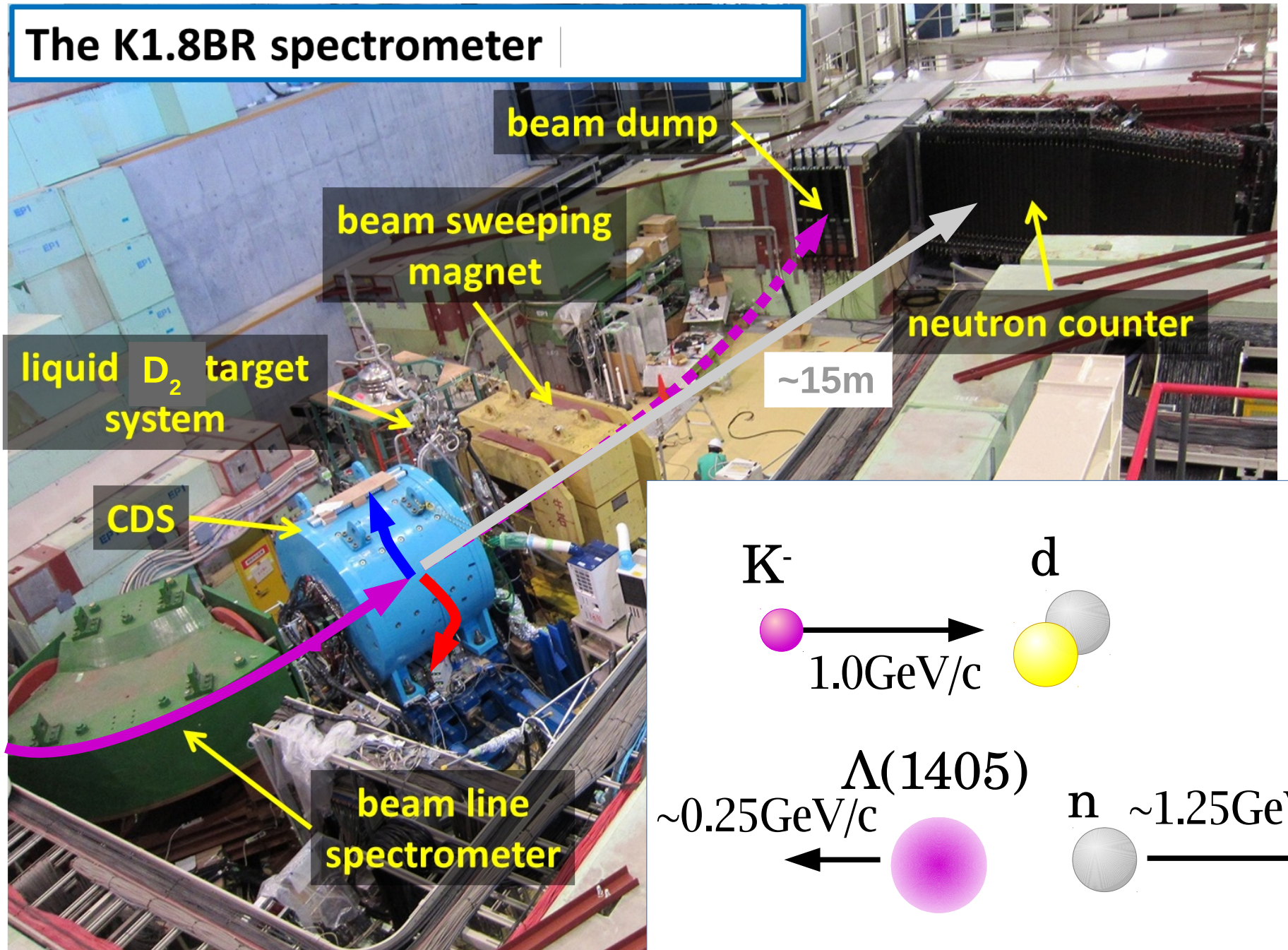


Chiral Unitary Model

D. Jido et al., NPA725(03)181

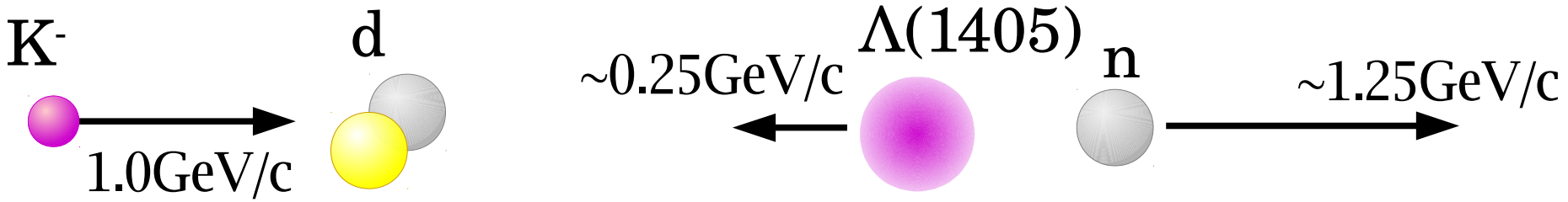


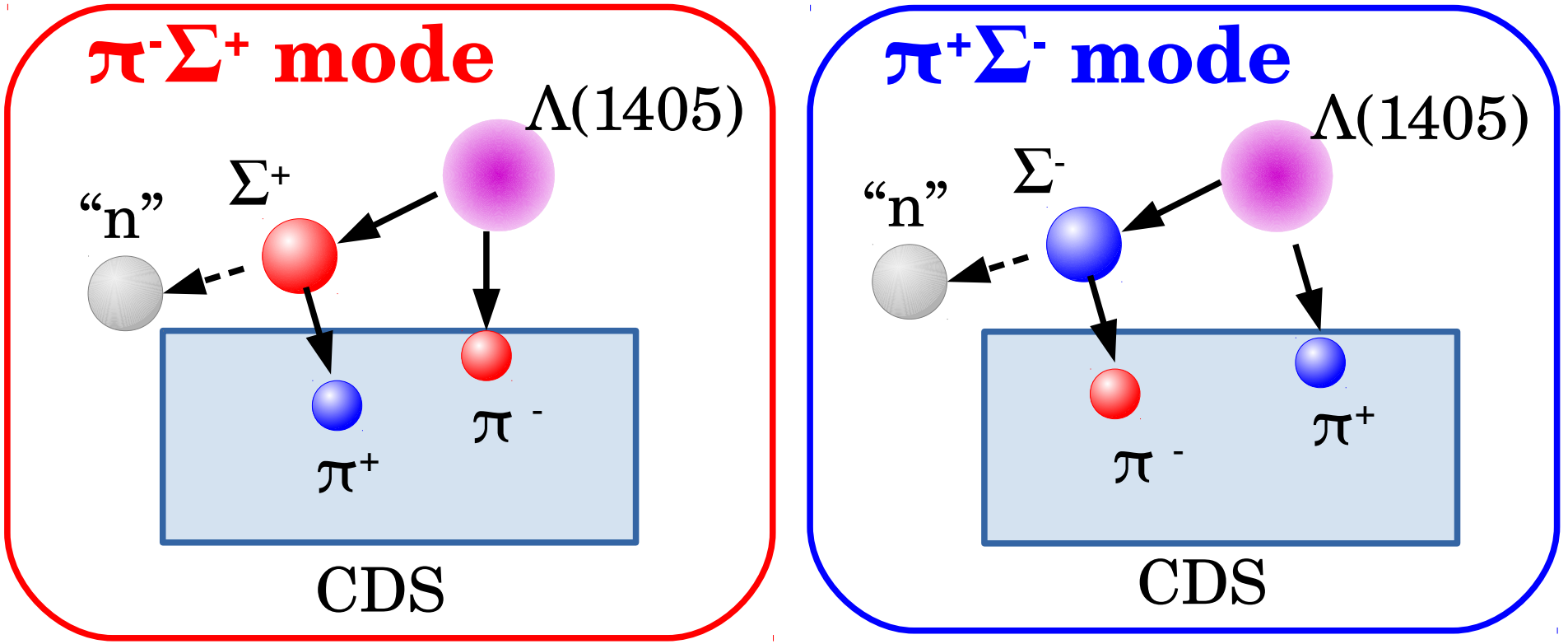
Experimental Setup



Experimental Setup

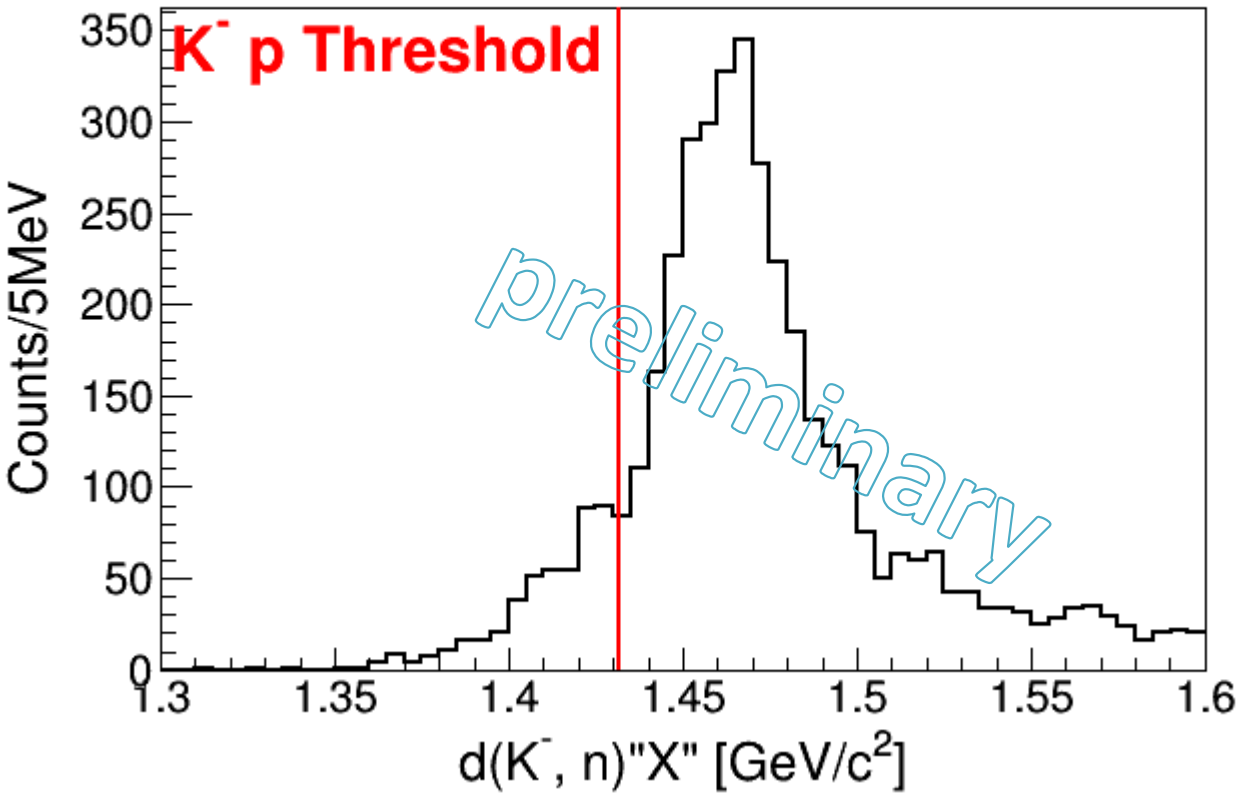
NC

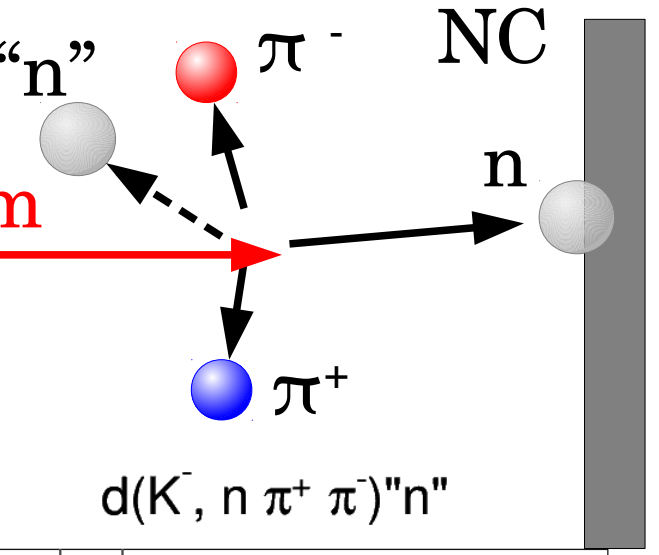


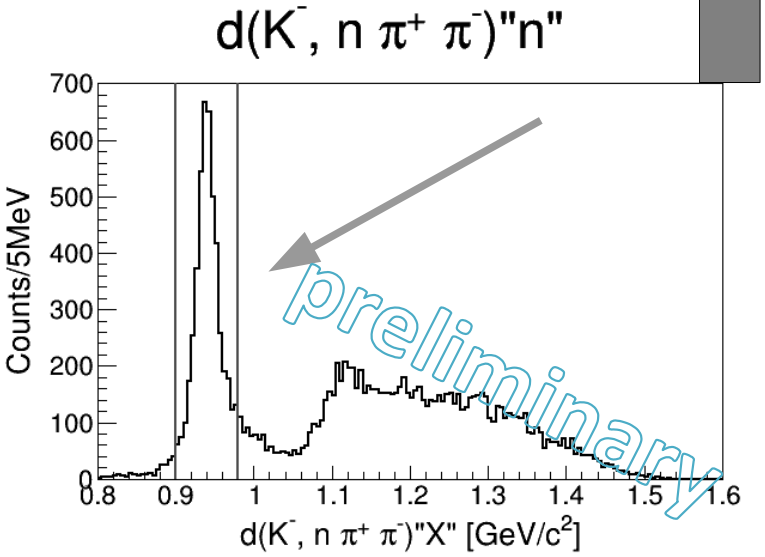


$K^- d \rightarrow n \pi^+ \pi^- n$ events was identified.

$K^- d \to n \pi^+ \pi^- n$ events







Expected contributions in $K^- d \to n \pi^+ \pi^- n$ events are

Signal : Backward $\Lambda(1405)$ production.

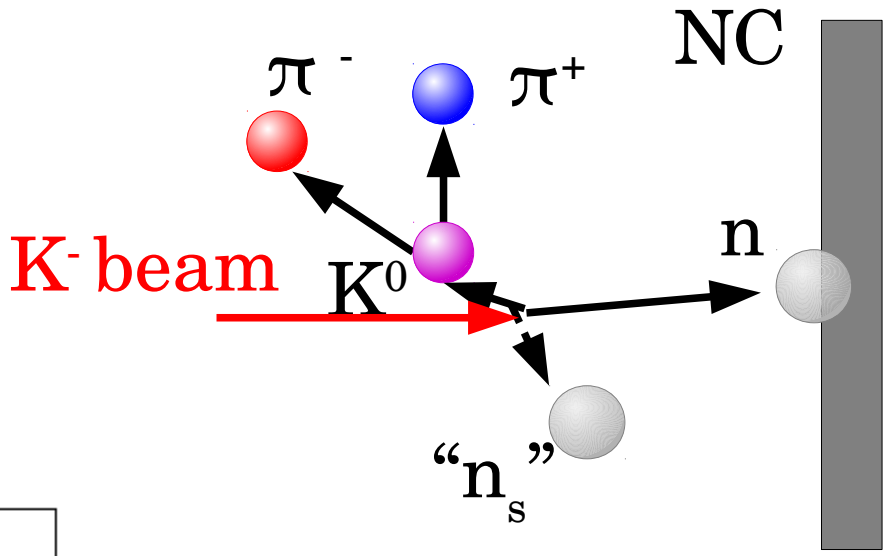
BG processes :

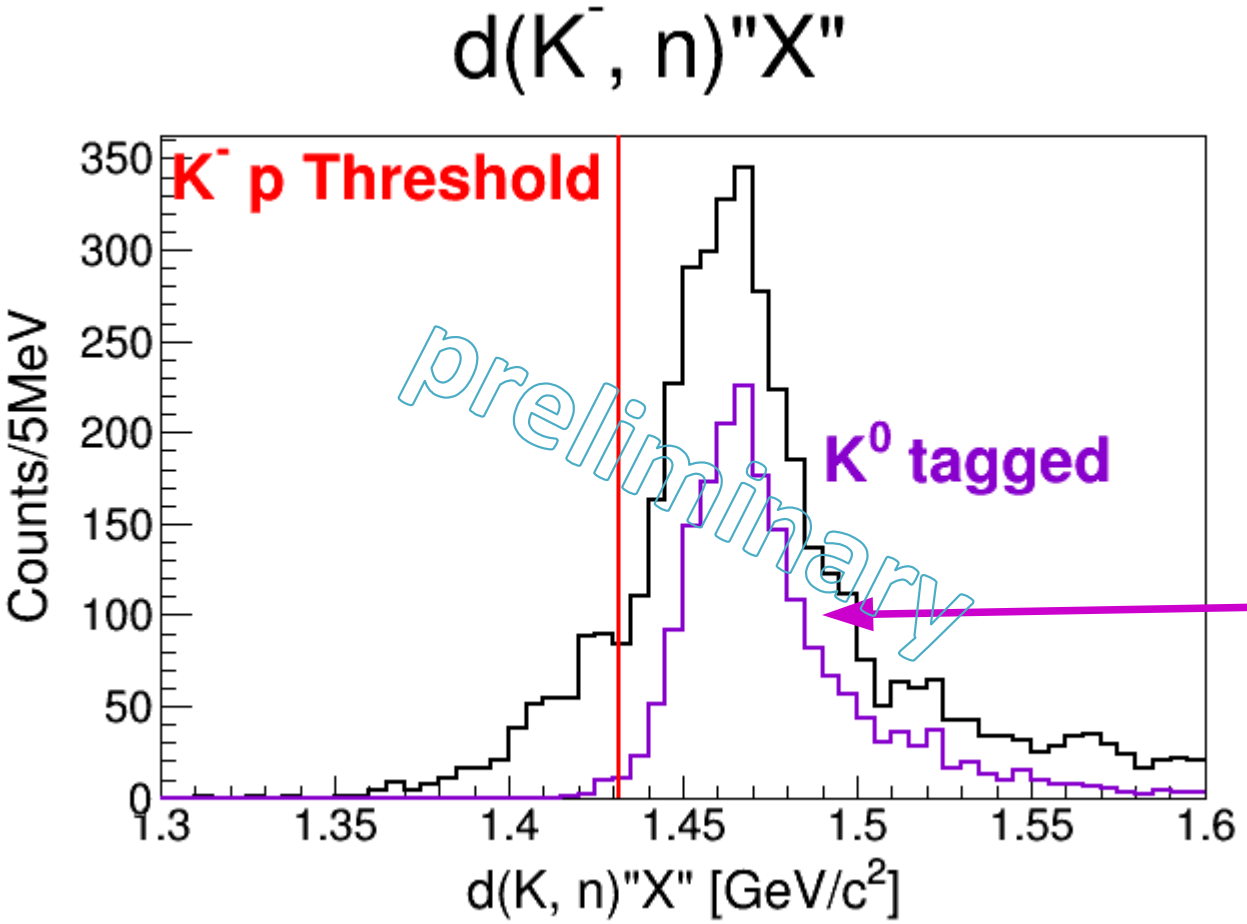
1.) Quasi-free K^0 production. ($K^- d \to K^0 n n_S$)

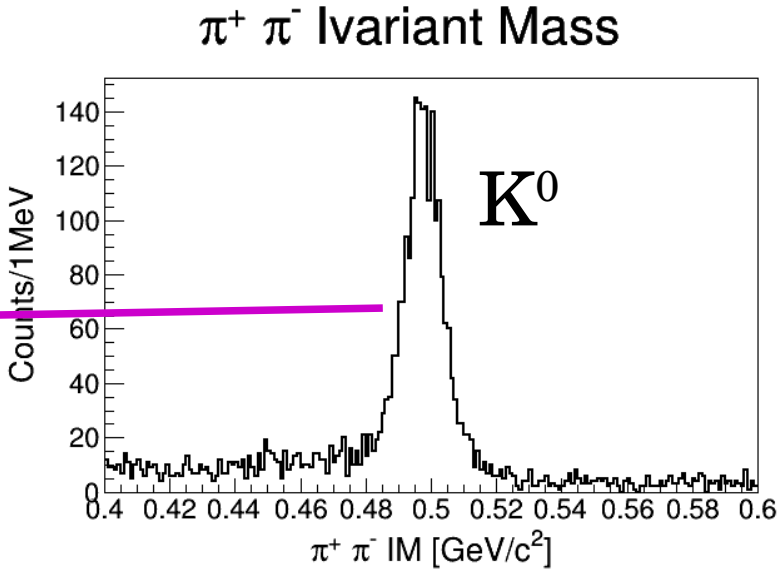
2.) Σ production in a forward direction. ($K^- d \to \pi^{\mp}\Sigma^{\pm} n$)

$K^- d \rightarrow n \pi^+ \pi^- n$ events

1.) $K^- d \rightarrow K^0 n n_s$



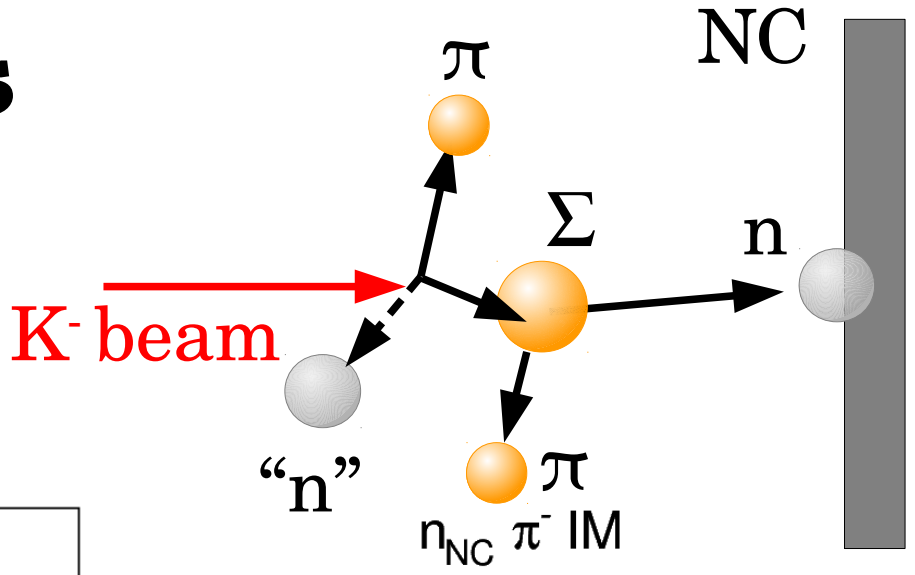


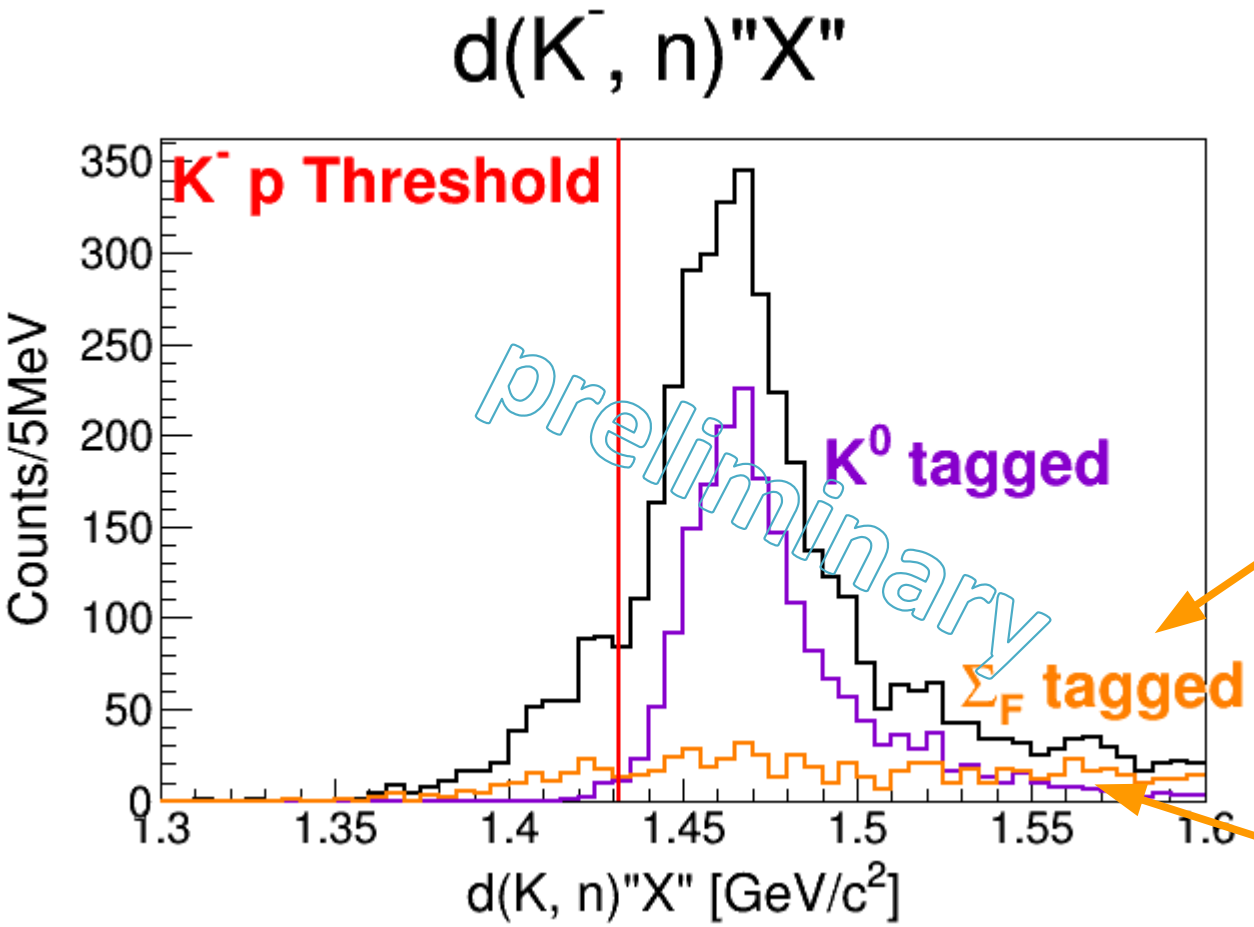


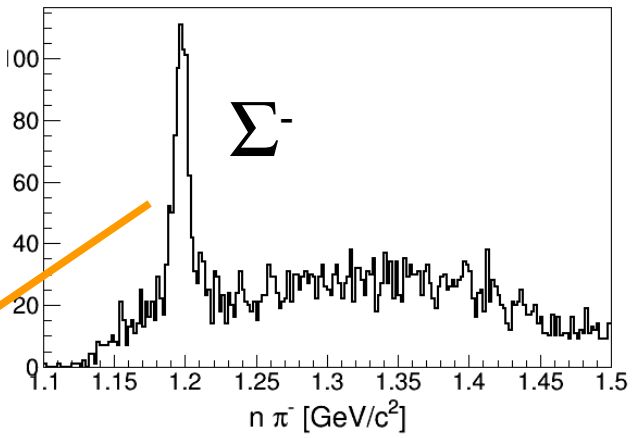
$K^- d \to n \pi^+ \pi^- n$ events

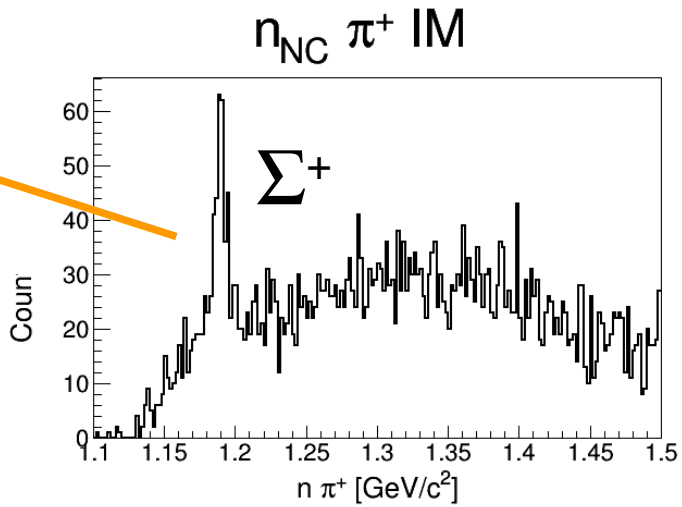
1.) $K^- d \to K^0 n n_s$

2.) $K^- d \to n \pi \Sigma_{Forward}$



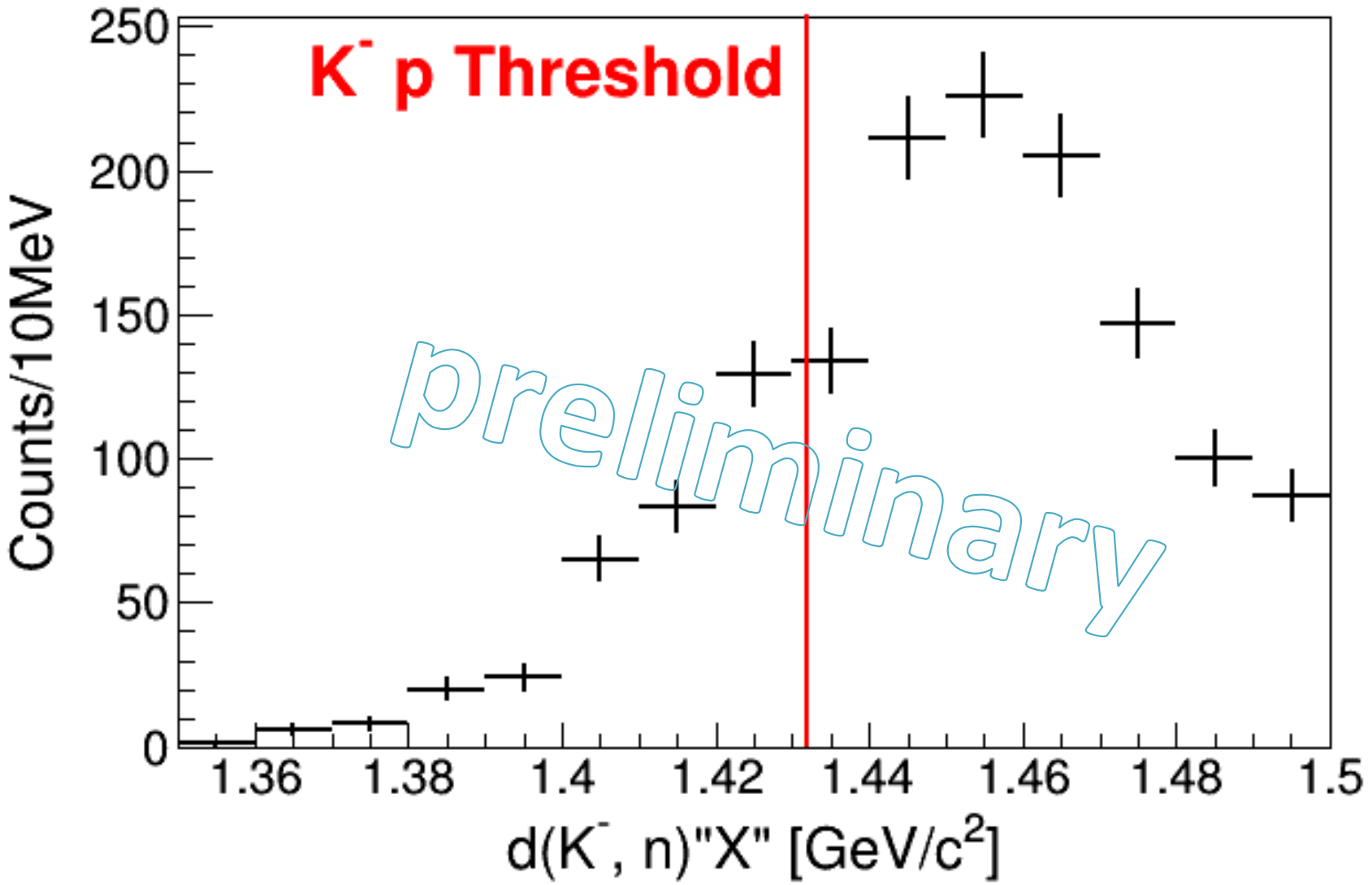






These two contributions are removed.

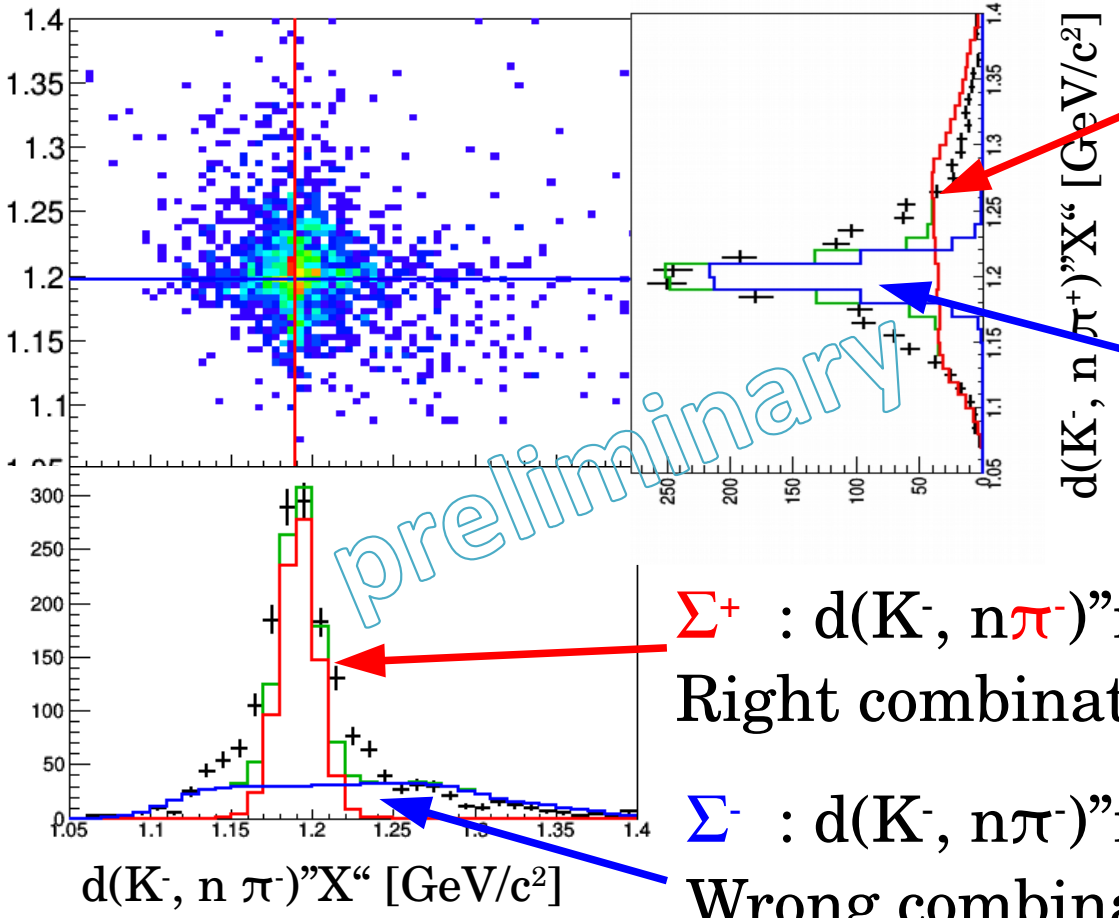
d(K⁻, n)"$X_{\pi^{\mp}\Sigma^{\pm}}$" Spectrum



Both $\pi^- \Sigma^+$ mode and $\pi^+\Sigma^-$ mode are included.

To be separated.

$\pi^-\Sigma^+$ and $\pi^+\Sigma^-$ mode identification

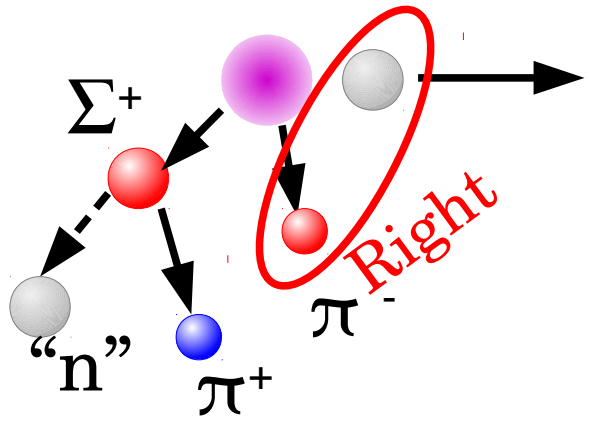


Σ^+ : d(K$^-$, nπ^+)"π^-n"
Wrong combination of nπ

Σ^- : d(K$^-$, nπ^+)"π^-n"
Right combination of nπ

Σ^+ : d(K$^-$, nπ^-)"nπ^+"
Right combination of nπ

Σ^- : d(K$^-$, nπ^-)"nπ^+"
Wrong combination of nπ

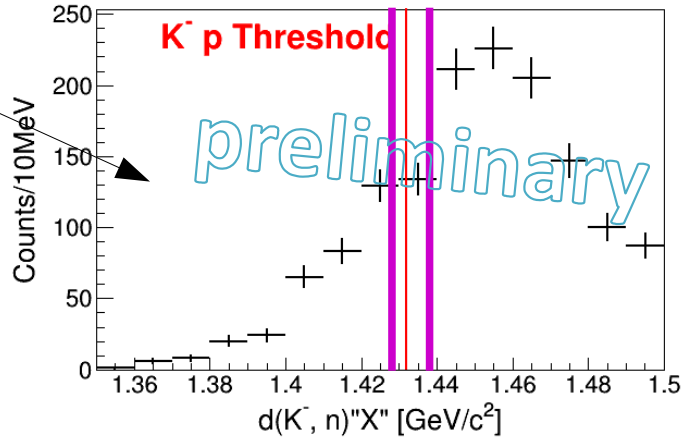


Distributions are estimated by a MC sim.
Distributions depend on the missing mass of the d(K$^-$, n)"$X_{\pi\Sigma}$"

Fitting for $\pi^-\Sigma^+$/$\pi^+\Sigma^-$ mode separation

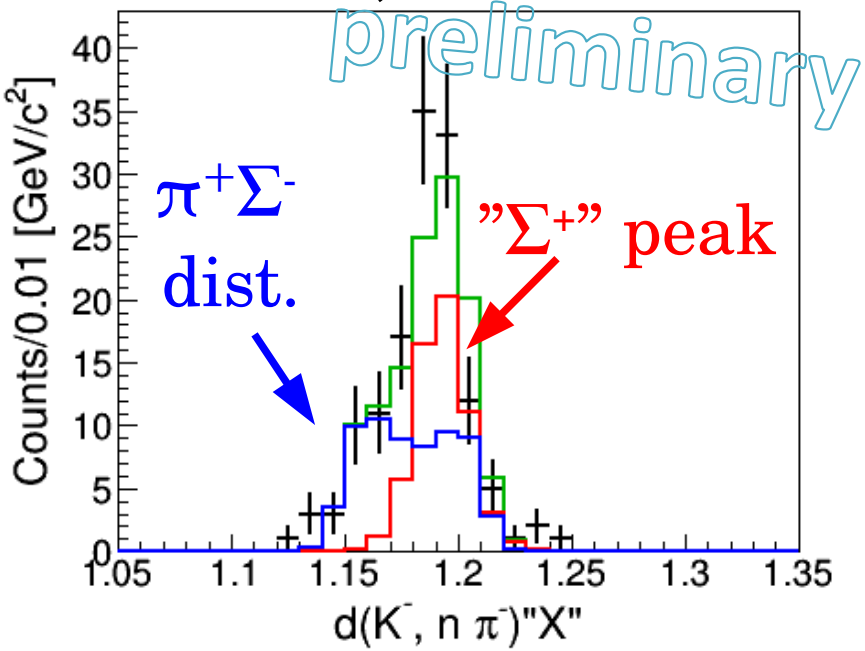
Fittings are done bin by bin.

Two free parameters
1.) Number of $\pi^-\Sigma^+$ events
2.) Number of $\pi^+\Sigma^-$ events

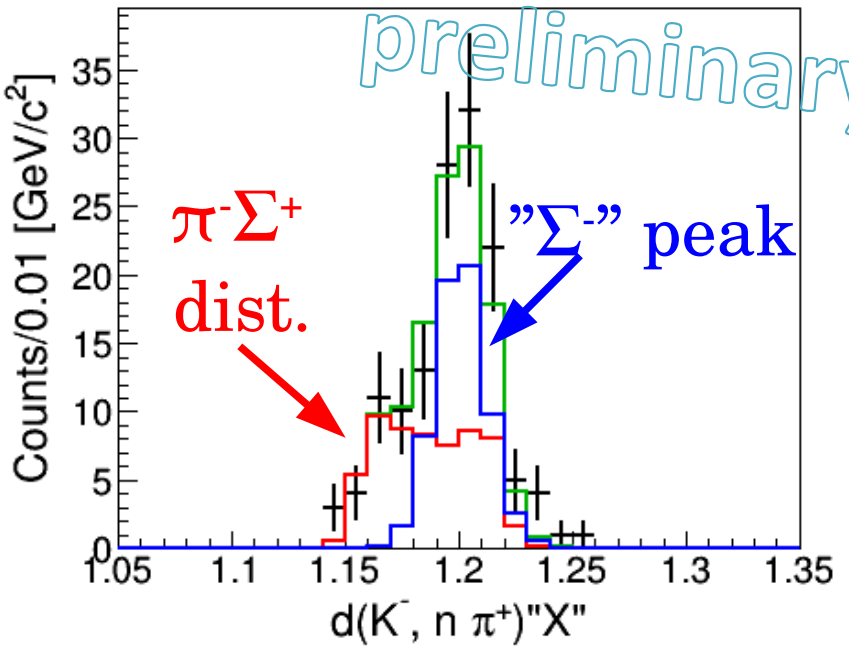


Example : MM=1.43~1.44 [GeV/c²]

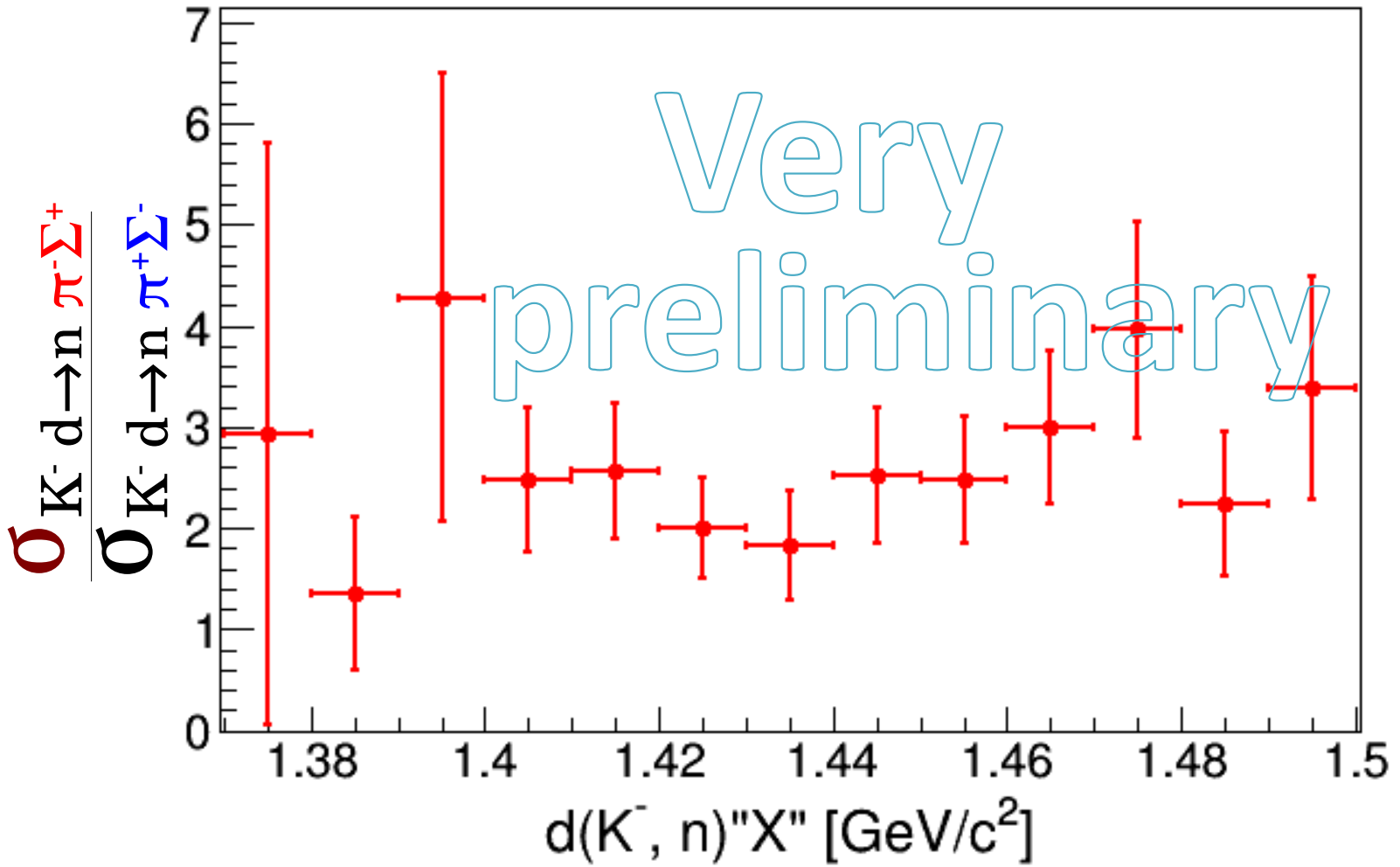
d(K⁻, n π^-)"X"



d(K⁻, n π^+)"X"



Cross section ratio of $\pi^-\Sigma^+$ to $\pi^+\Sigma^-$



The $K^- d\to n\,\pi^-\Sigma^+$ mode is dominant.

Summary

We measured the exclusive $d(K^-, n)\pi^{\mp}\Sigma^{\pm}$ spectrum at the K1.8BR beam line.

- This spectrum includes the $\overline{K}N \rightarrow \pi\Sigma$ scattering data below the $\overline{K}N$ threshold.

We obtain the cross section ratio of $K^-d \rightarrow n\pi^-\Sigma^+$ to $K^-d \rightarrow n\pi^+\Sigma^-$.

- We found that the $K^-d \rightarrow n\pi^-\Sigma^+$ mode is dominant.

This reaction will provide important information on the $\overline{K}N$ interaction.

We will continue experiment to increase 20 times more statistics.

- We will be able to measure not only $\pi^{\mp}\Sigma^{\pm}$ mode but also $\pi^0\,\Sigma^0$ mode.

The J-PARC E31 Collaboration

S. Ajimura[1], G. Beer[2], M. Bragadireanu[4], P. Buehler[4], L. Busso[5], M. Cargnelli[4], S. Choi[3], C. Curceanu[8], S. Enomoto[14], D. Faso [5], H. Fujioka [13], Y. Fujiwara [12], T. Fukuda [11], C. Guaraldo [8], R. S. Hayano [12], T. Hashimoto [9], T. Hiraiwa[1], M. Iio [14], M. Iliescu[8], K. Inoue [1], N. Ishibashi[7], Y. Ishiguro [13], T. Ishikawa [12], S. Ishimoto [14], T. Ishiwatari [4], K. Itahashi[9], M. Iwai [14], M. Iwasaki [9,10], S. Kawasaki [1], P. Kienle [15], H. Kou [10], Y. Ma [9], J. Marton [4], Y. Matsuda [12], Y. Mizoi[11], O. Morra [5], T. Nagae [13], H. Noumi [1], H. Ohnishi [9], S. Okada [9], H. Outa [9], K. Piscicchia [8], L. Poli Lener[8], A. Romero Vidal [8], Y. Sada [1], A. Sakaguchi [7], F. Sakuma [9], M. Sato [9], M. Sekimoto [14], H. Shi [12], K. Shirotori [1], D. Sirghi[8], F. Sirghi[8], S. Suzuki[14], T. Suzuki[12], H. Tatsuno[8], M. Tokuda[10], D. Tomono[9], A. Toyoda[14], K. Tsukada[16], E. Widmann[4], O. Vazquez Doce[8], T. Yamaga[1], T. Yamazaki[9,12], K. Yoshida[7], H. Yim[3], J. Zmeskal[4] .

1. Research Center for Nuclear Physics, Osaka University, Japan

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5. INFN Sezione di Torino, Italy , 6.Universita' di Torino, Italy

7. Osaka University, Japan, 8. Laboratori Nazionali di Frascati dell'INFN, Italy

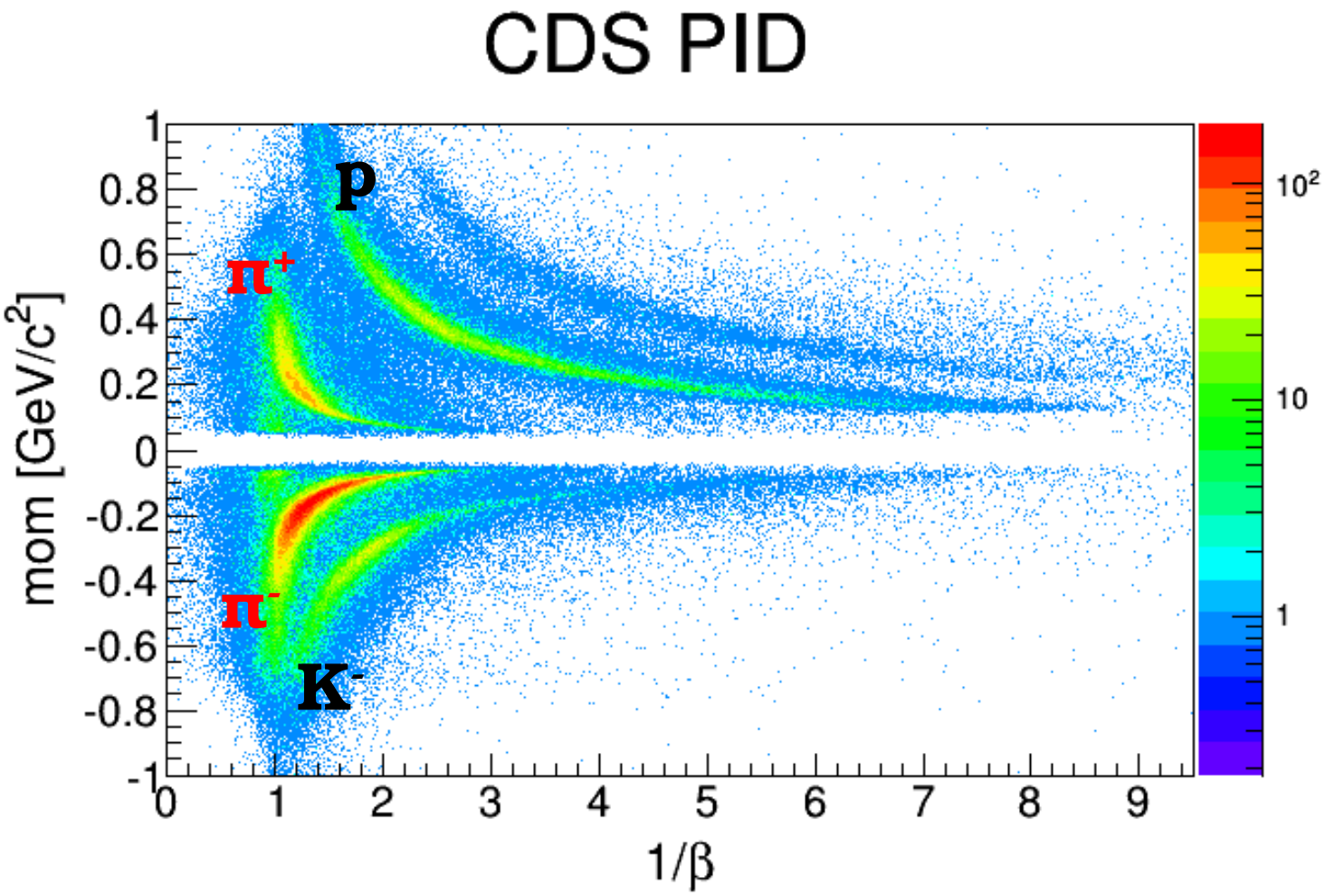
9. RIKEN, Japan, 10. Tokyo Institute of Technology, Japan

11. Osaka Electro-Communication University, Japan, 12. University of Tokyo, Japan

13. Kyoto University, Japan, 14. High Energy Accelerator Research Organization (KEK), Japan

15. Technische Universitat Munchen, Germany, , 16. Tohoku University, Japan

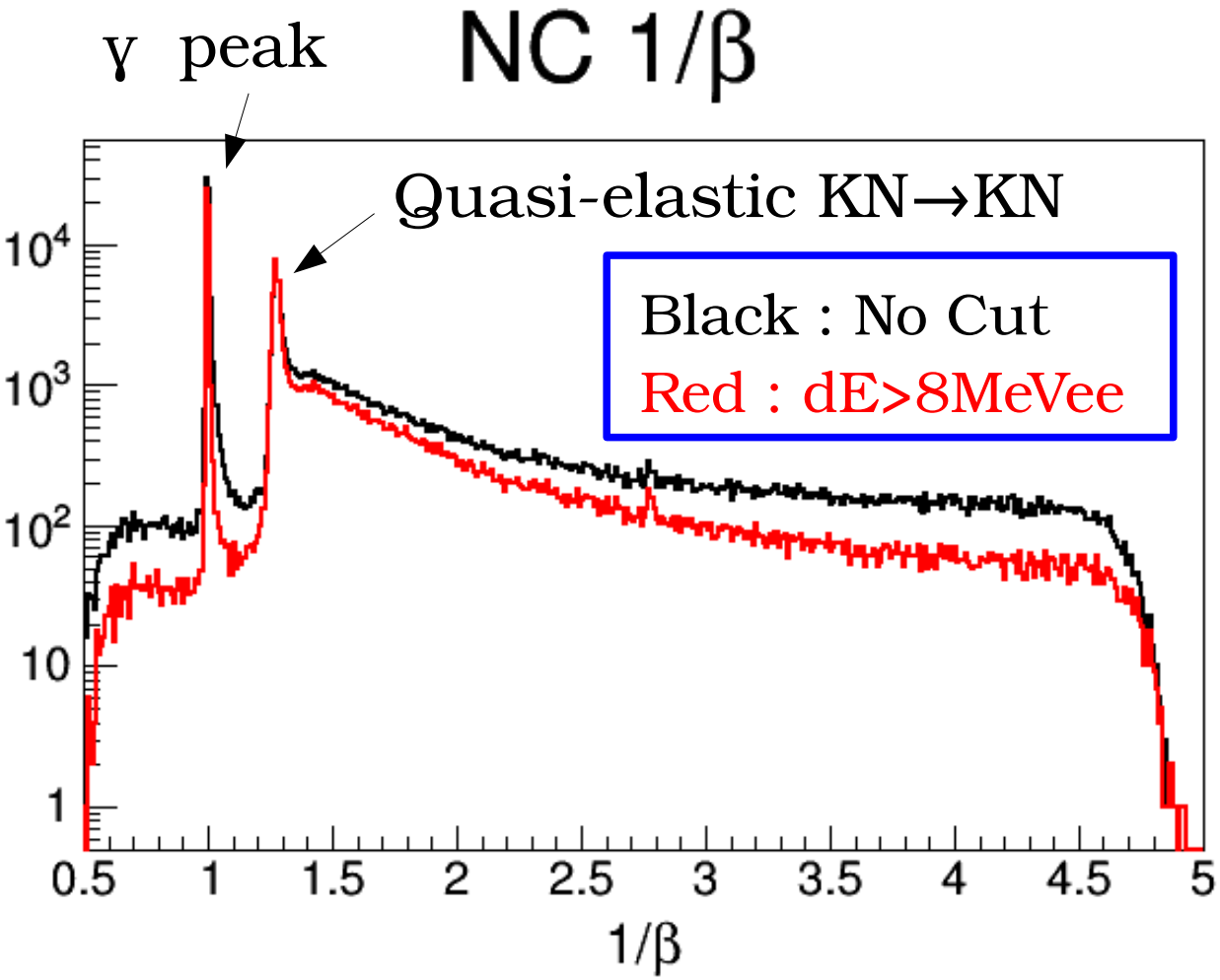
Detector performance---CDS



CDS successfully identify π^-, K^-, π^+, p.

Back up

Detector performance---CDS

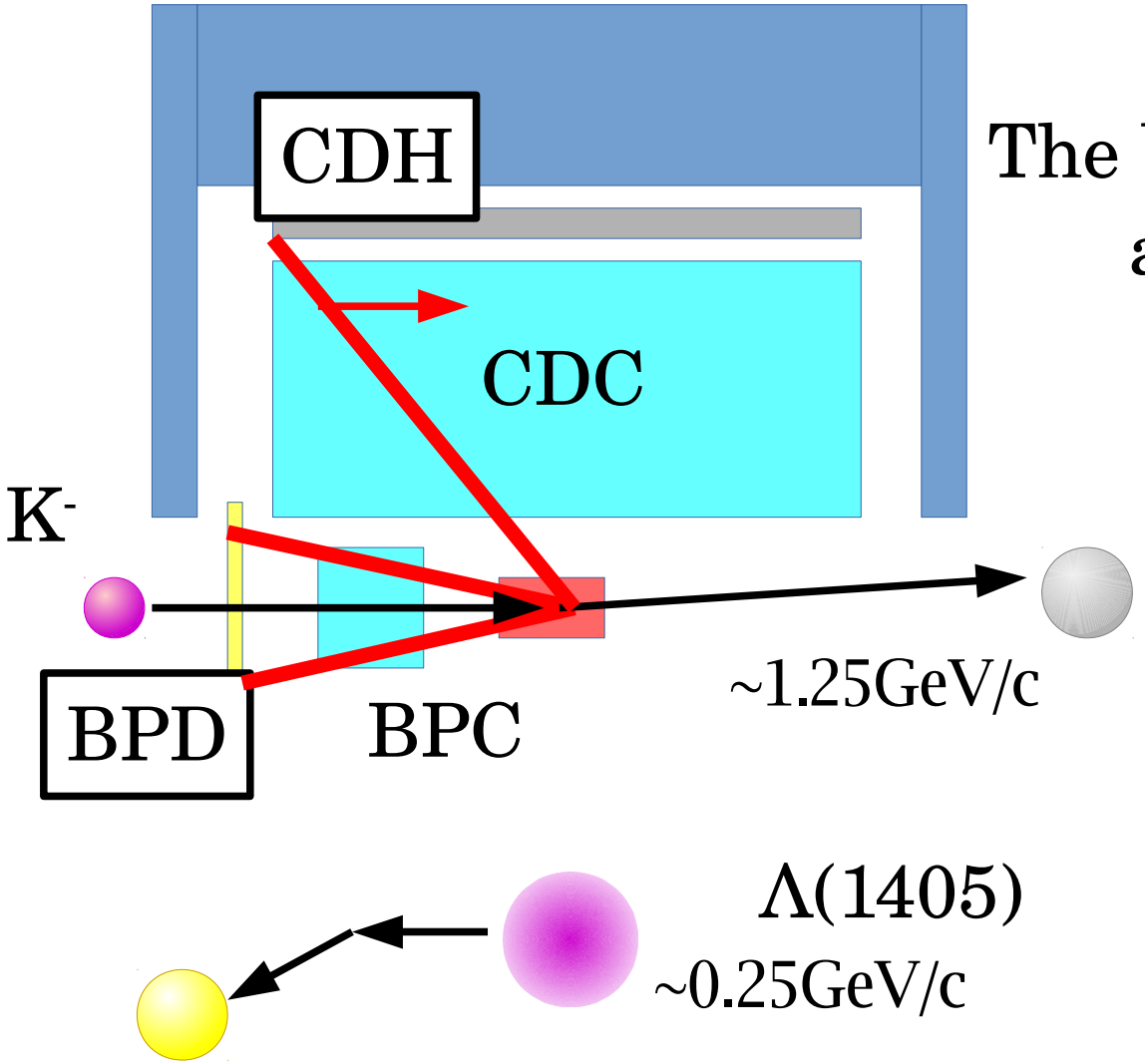


NC time resolution is estimated by 160ps at γ peak.
Quasi-elastic peak is clearly seen.

Neutral mode

I=0 : Λ(1405) $K^- d \rightarrow n\pi^0\Sigma^0 \rightarrow n\pi^0\gamma\Lambda \rightarrow n\pi^0\gamma p\pi^-$

I=1 : Σ(1385) $K^- d \rightarrow n\pi^0\Sigma^0 \rightarrow n\pi^0 p\pi^-$ Detect



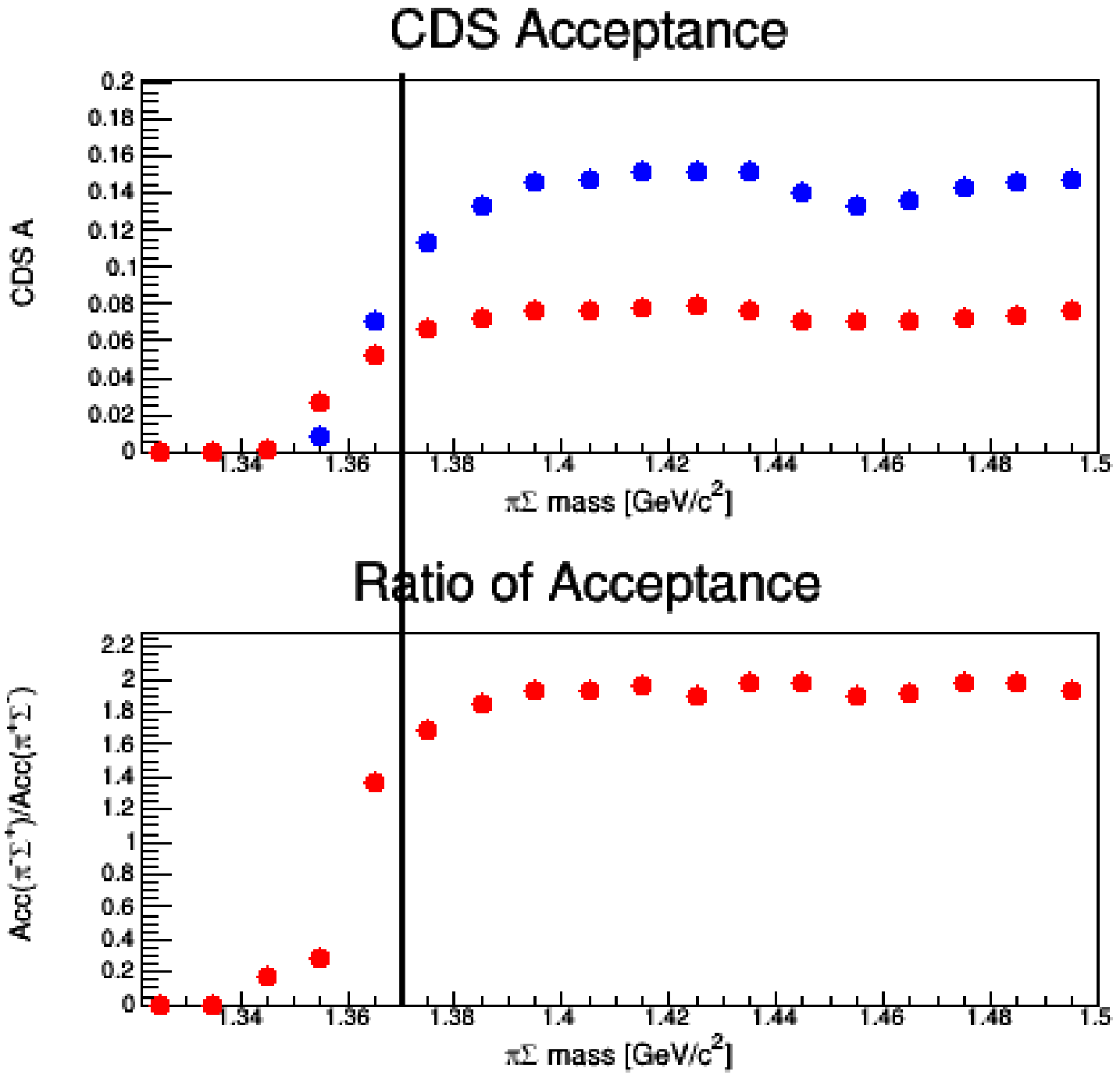
The backward scattered proton acceptance is too small.

E31 proposal

mode	Acce.
$\pi^-\Sigma^+$	**0.32**
$\pi^+\Sigma^-$	**0.16**
$\Pi^0\Sigma^0$	**0.015**

$\pi^0\Sigma^0$:π $\Sigma^\pm$ ~ 1/32

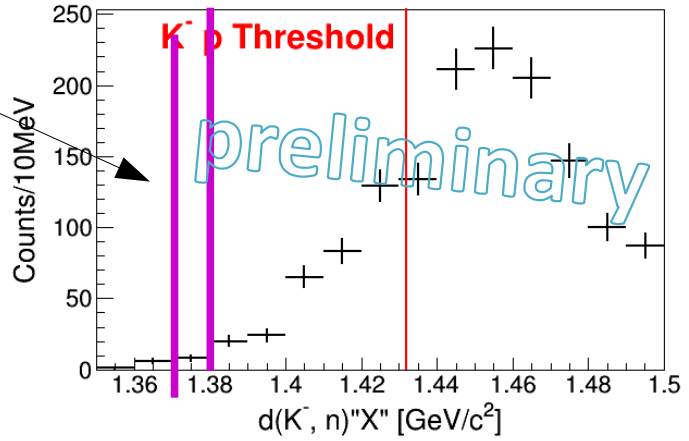
Reaction : $K^- d \rightarrow \Lambda(1405)\, n$: n=0 deg



Fitting for $\pi^-\Sigma^+$/$\pi^+\Sigma^-$ mode separation

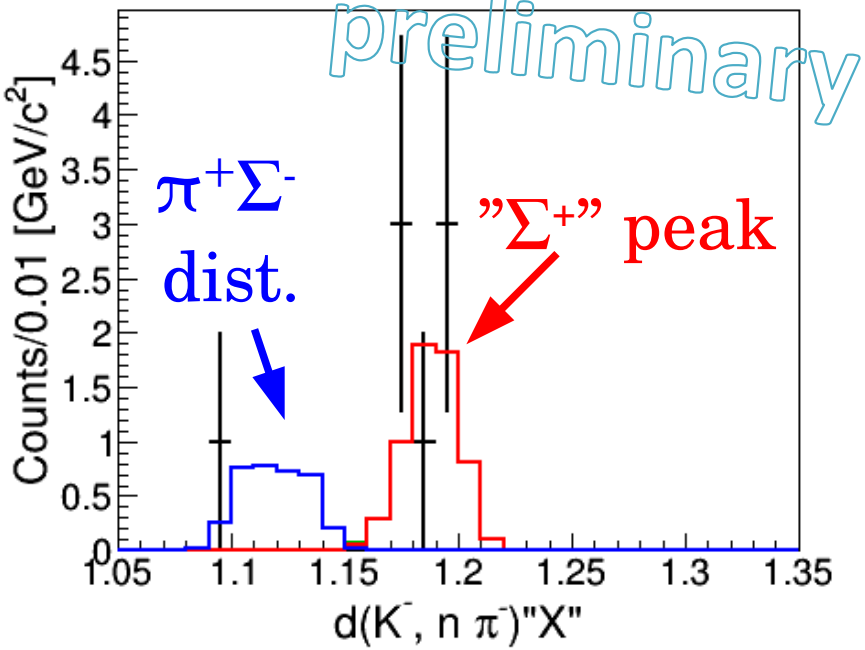
Fittings are done bin by bin.

Two free parameters
1.) Number of $\pi^-\Sigma^+$ events
2.) Number of $\pi^+\Sigma^-$ events

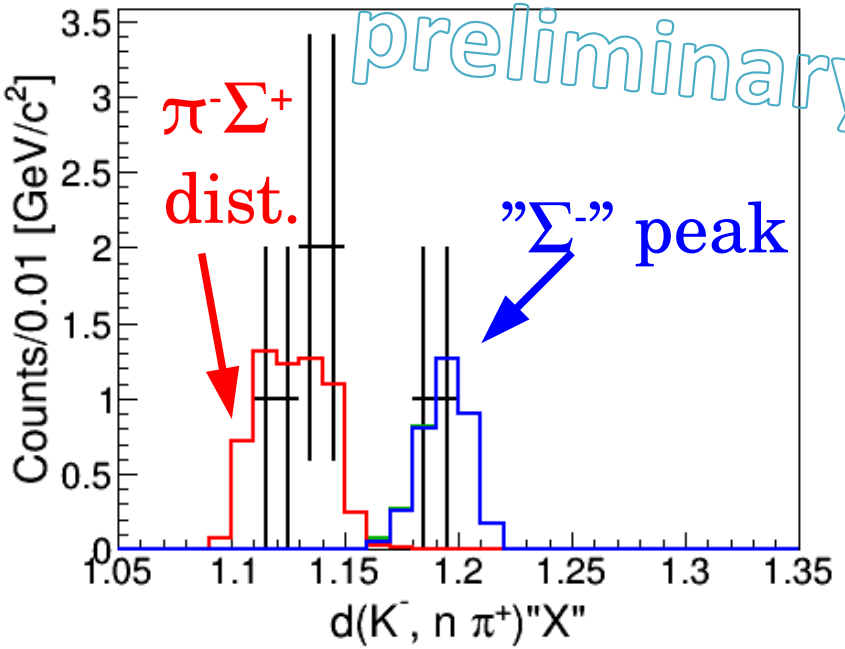


Example : MM=1.37~1.38 [GeV/c^2]

d(K^-, n π^-)"X"



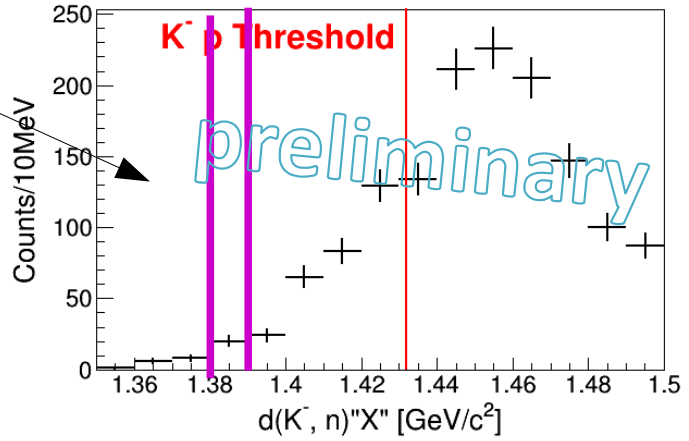
d(K^-, n π^+)"X"



Fitting for $\pi^-\Sigma^+$/$\pi^+\Sigma^-$ mode separation

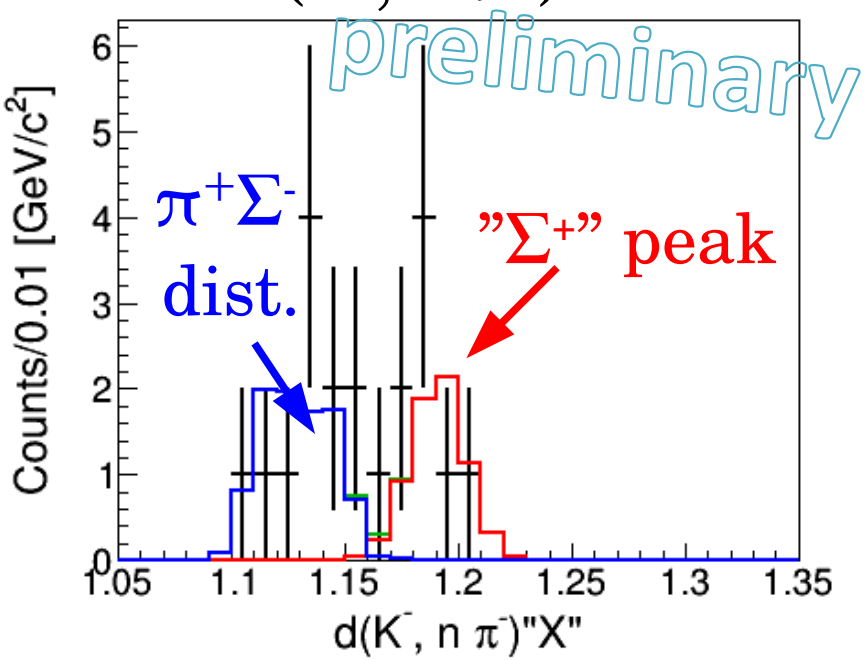
Fittings are done bin by bin.

Two free parameters
1.) Number of $\pi^-\Sigma^+$ events
2.) Number of $\pi^+\Sigma^-$ events

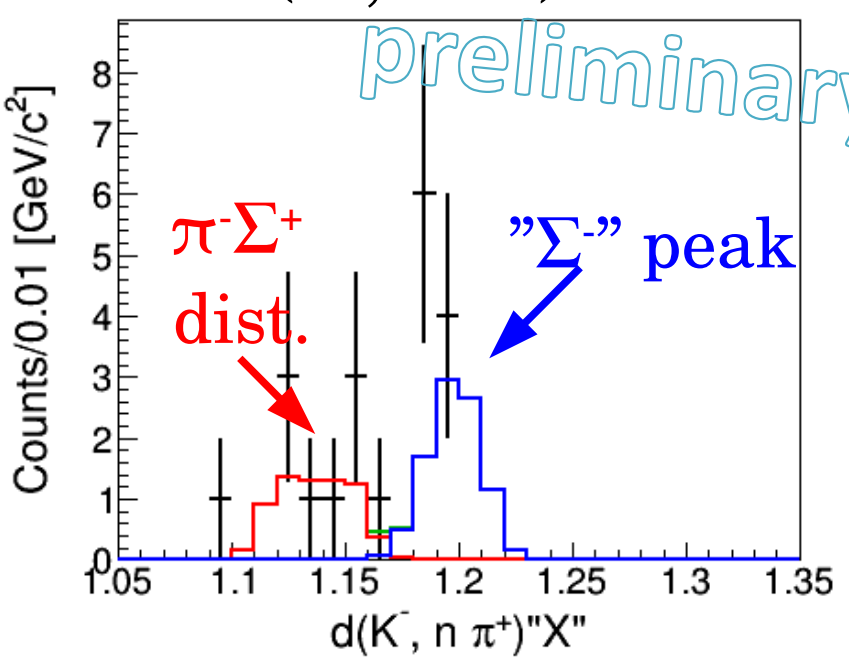


Example : MM=1.38~1.39 [GeV/c^2]

d(K^-, n π^-)"X"



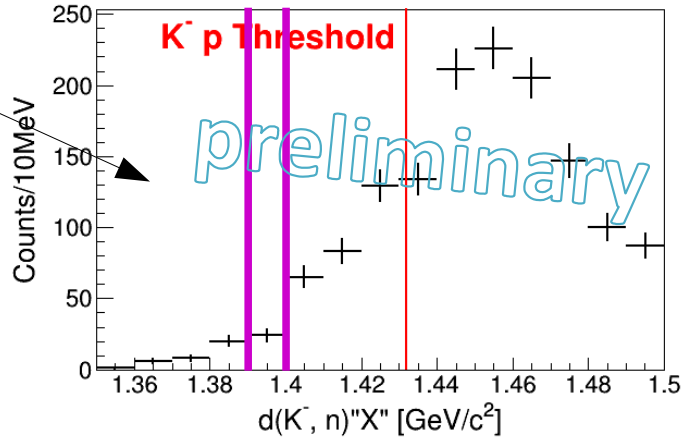
d(K^-, n π^+)"X"



Fitting for $\pi^-\Sigma^+$/$\pi^+\Sigma^-$ mode separation

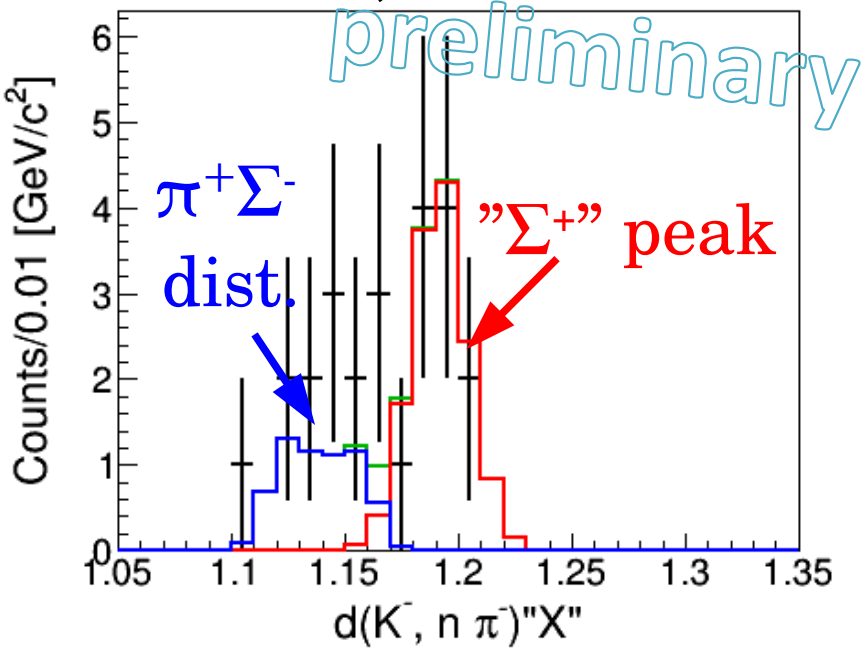
Fittings are done bin by bin.

Two free parameters
1.) Number of $\pi^-\Sigma^+$ events
2.) Number of $\pi^+\Sigma^-$ events

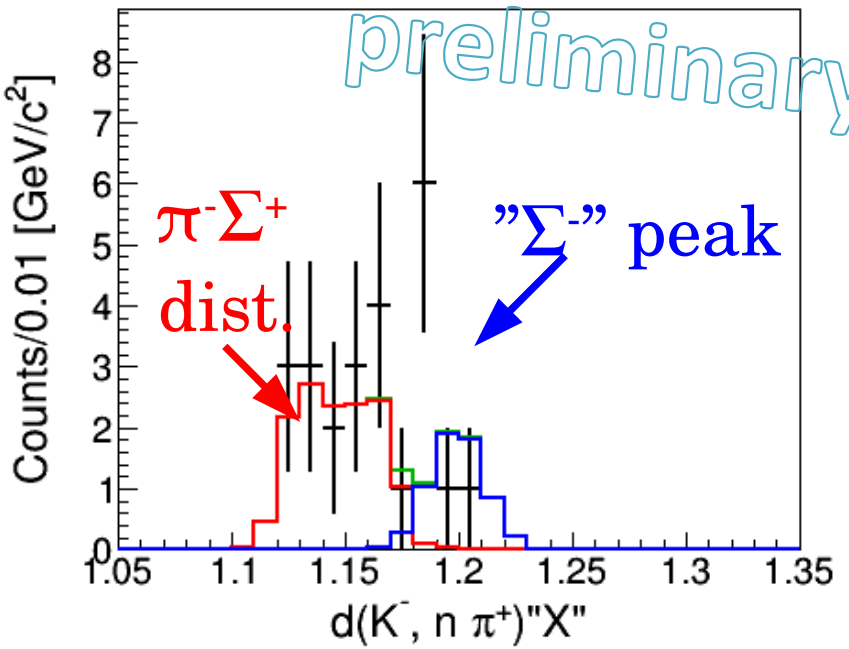


Example : MM=1.39~1.40 [GeV/c^2]

d(K^-, n π^-)"X"



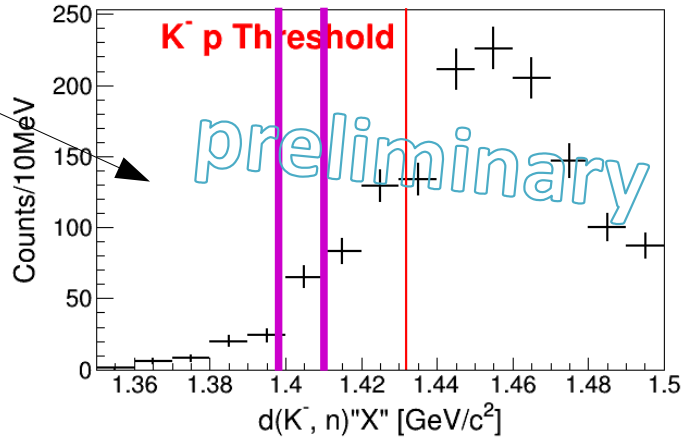
d(K^-, n π^+)"X"



Fitting for $\pi^-\Sigma^+$/$\pi^+\Sigma^-$ mode separation

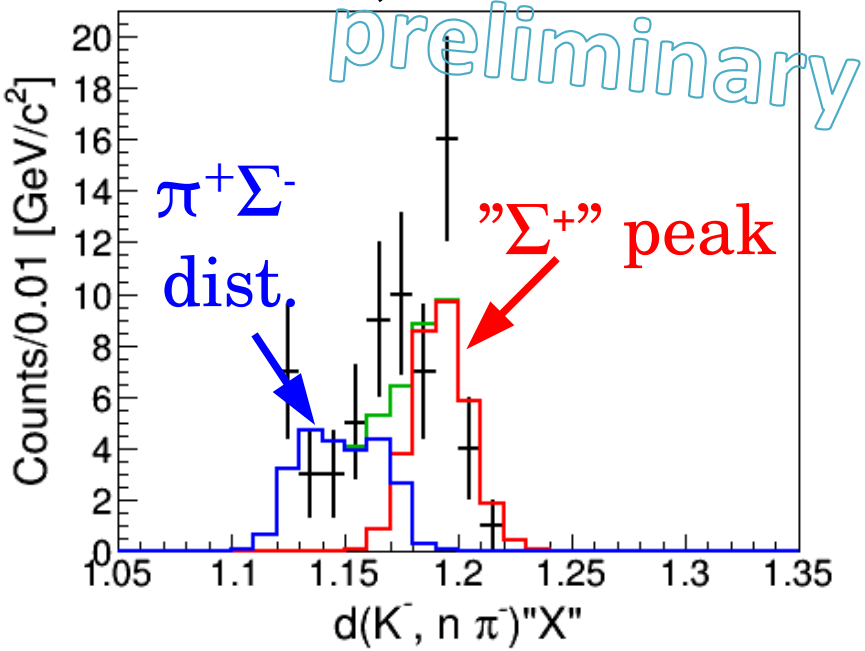
Fittings are done bin by bin.

Two free parameters
1.) Number of $\pi^-\Sigma^+$ events
2.) Number of $\pi^+\Sigma^-$ events

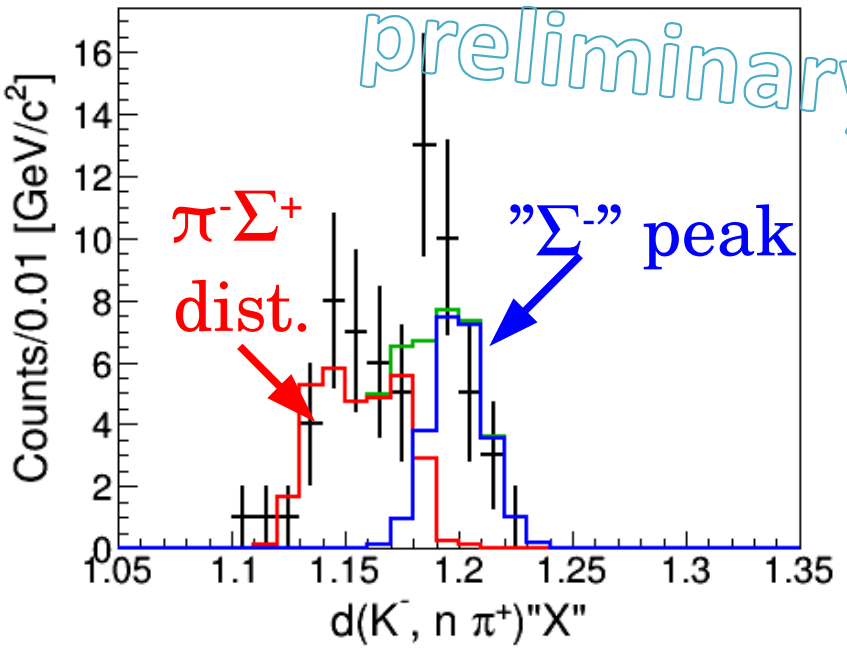


Example : MM=1.40~1.41 [GeV/c^2]

d(K^-, n π^-)"X"



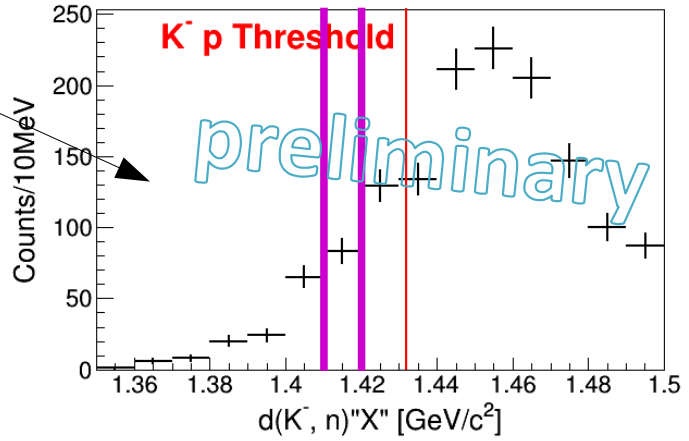
d(K^-, n π^+)"X"



Fitting for $\pi^-\Sigma^+$/$\pi^+\Sigma^-$ mode separation

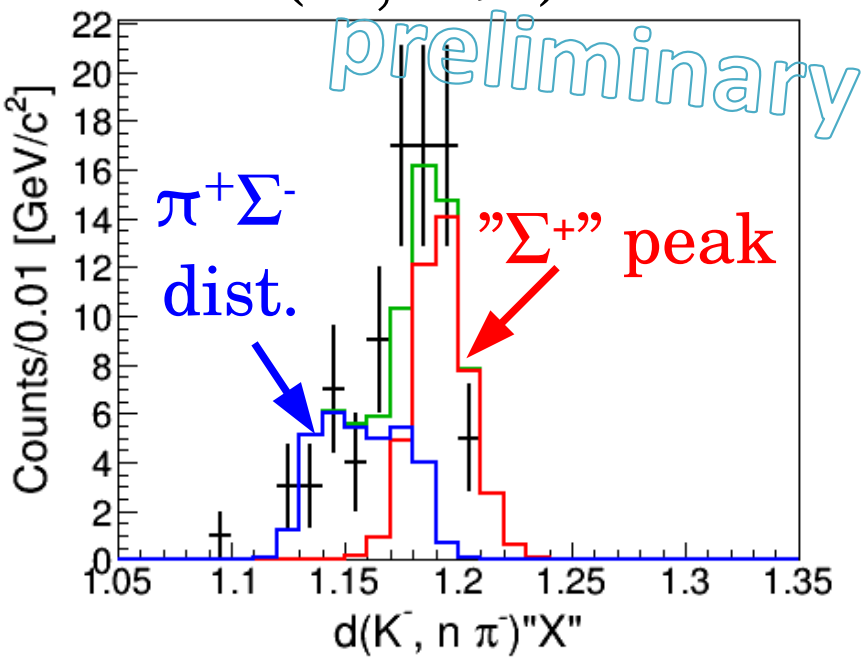
Fittings are done bin by bin.

Two free parameters
1.) Number of $\pi^-\Sigma^+$ events
2.) Number of $\pi^+\Sigma^-$ events

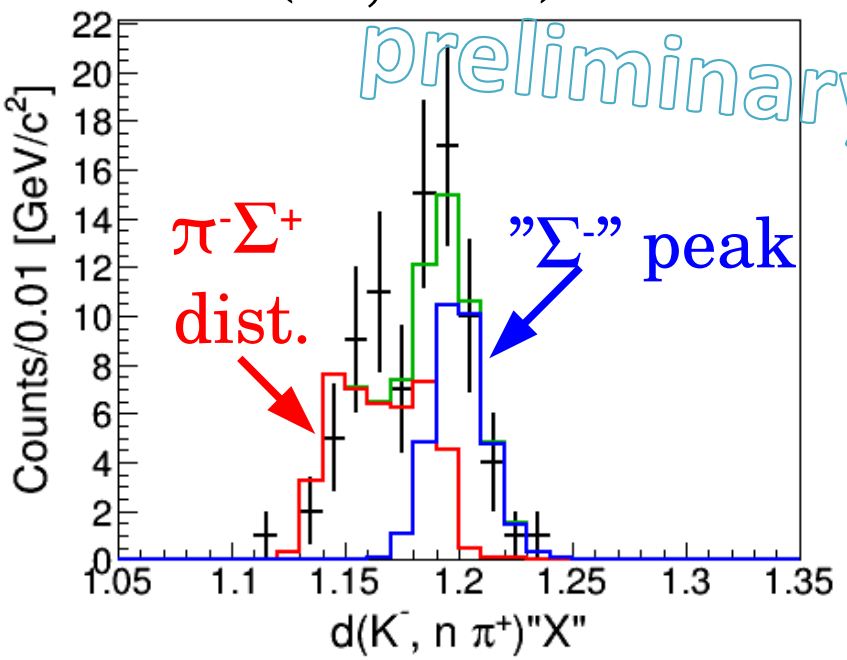


Example : MM=1.41~1.42 [GeV/c^2]

d(K⁻, n π^-)"X"



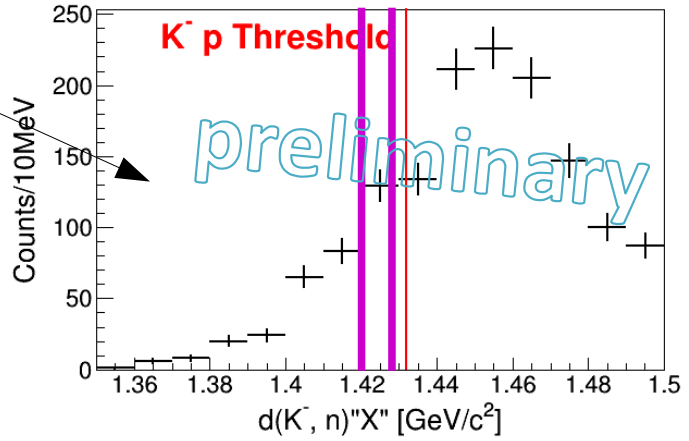
d(K⁻, n π^+)"X"



Fitting for $\pi^-\Sigma^+$/$\pi^+\Sigma^-$ mode separation

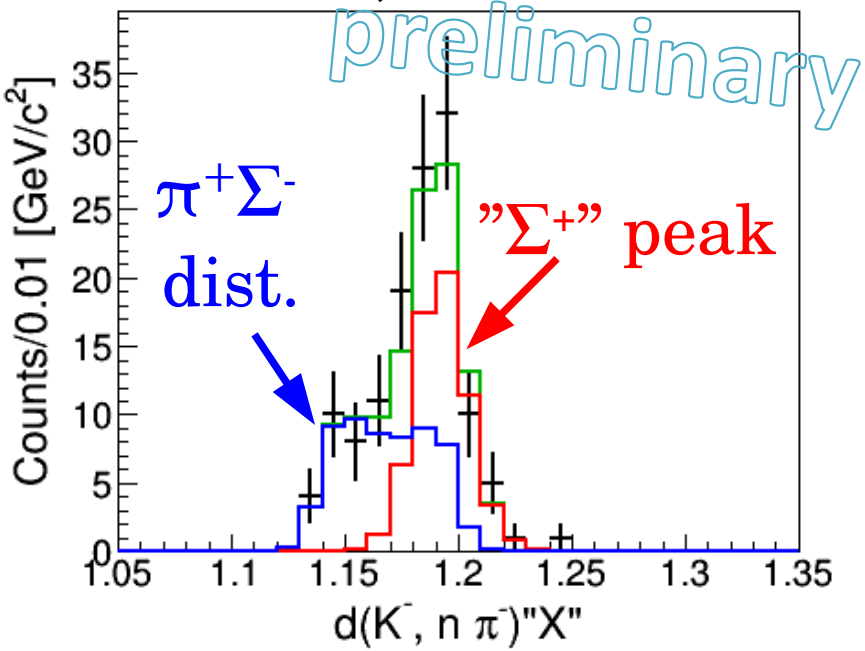
Fittings are done bin by bin.

Two free parameters
1.) Number of $\pi^-\Sigma^+$ events
2.) Number of $\pi^+\Sigma^-$ events

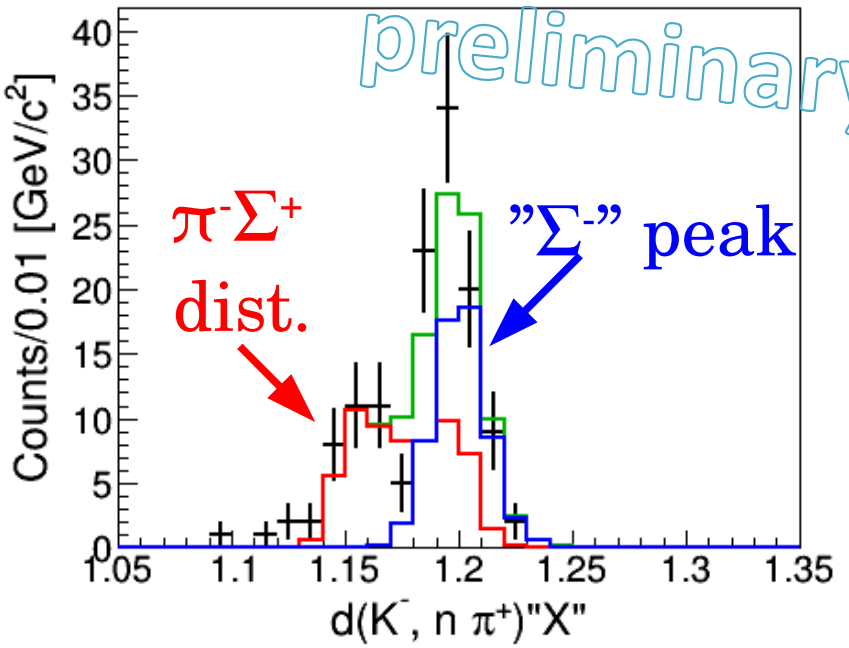


Example : MM=1.42~1.43 [GeV/c²]

d(K⁻, n π^-)"X"



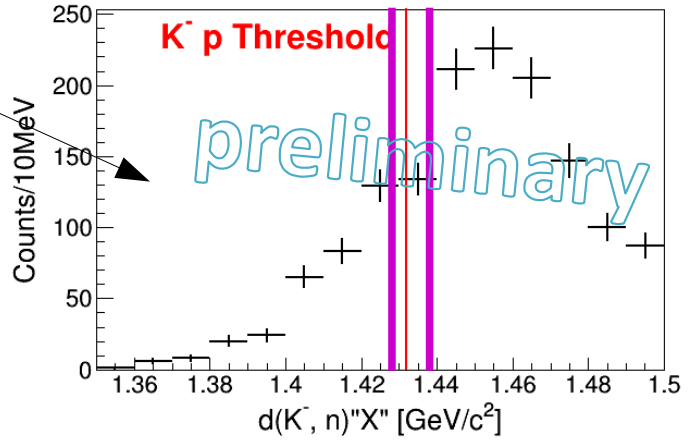
d(K⁻, n π^+)"X"



Fitting for $\pi^-\Sigma^+$/$\pi^+\Sigma^-$ mode separation

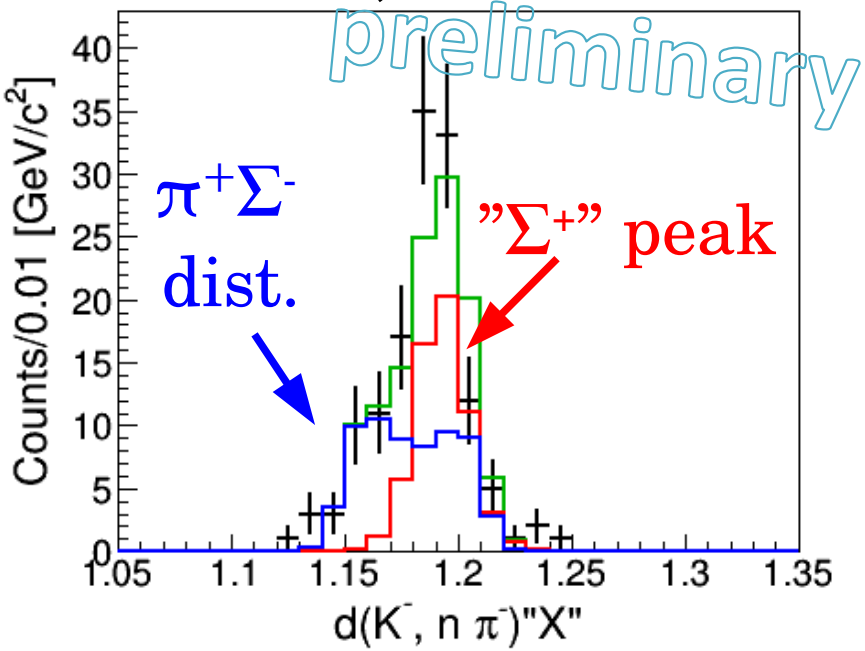
Fittings are done bin by bin.

Two free parameters
1.) Number of $\pi^-\Sigma^+$ events
2.) Number of $\pi^+\Sigma^-$ events

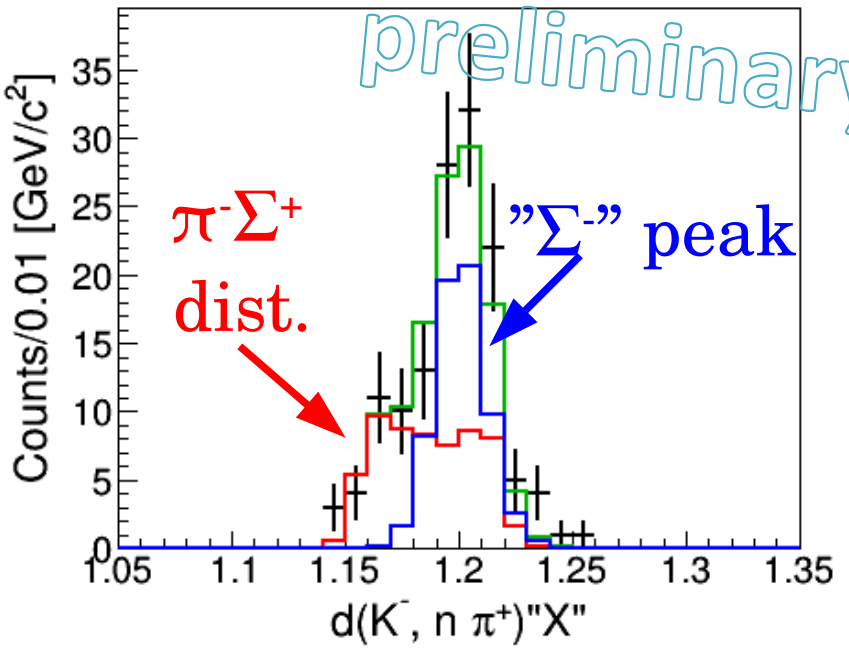


Example : MM=1.43~1.44 [GeV/c²]

d(K⁻, n π^-)"X"



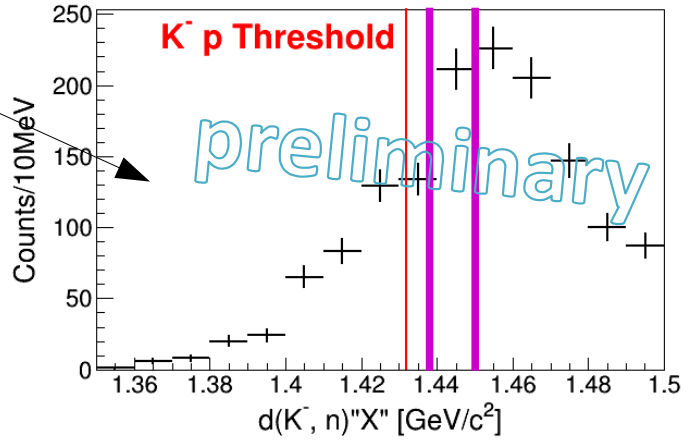
d(K⁻, n π^+)"X"



Fitting for $\pi^-\Sigma^+$/$\pi^+\Sigma^-$ mode separation

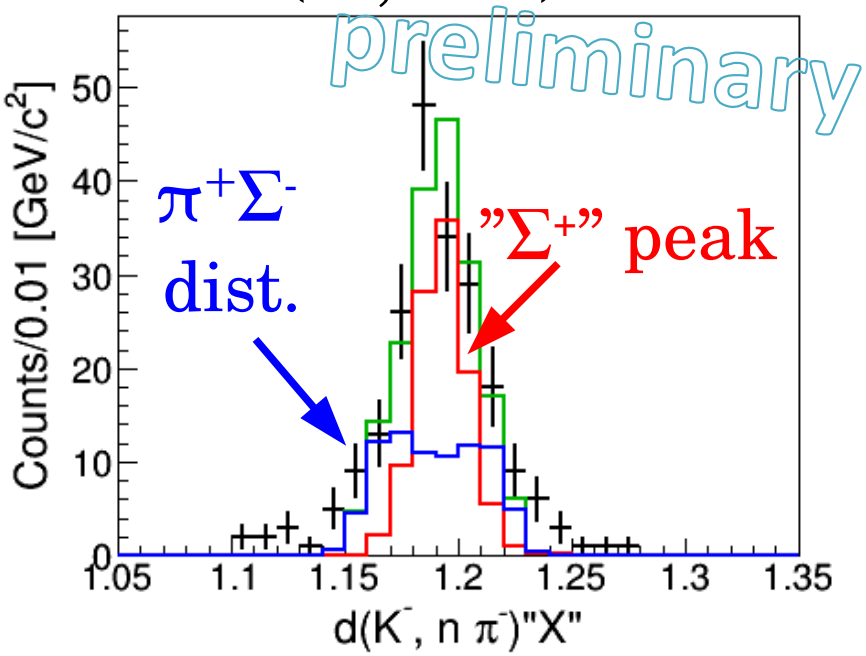
Fittings are done bin by bin.

Two free parameters
1.) Number of $\pi^-\Sigma^+$ events
2.) Number of $\pi^+\Sigma^-$ events

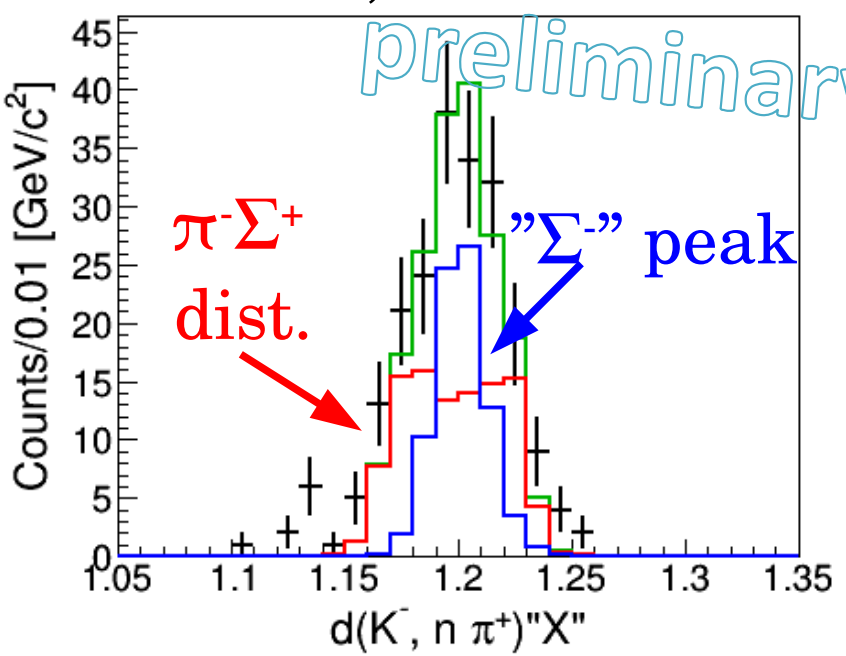


Example : MM=1.44~1.45 [GeV/c²]

d(K⁻, n π^-)"X"



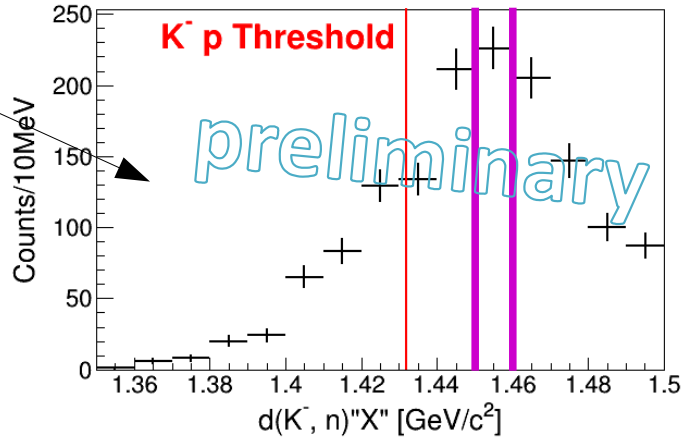
d(K⁻, n π^+)"X"



Fitting for $\pi^-\Sigma^+$/$\pi^+\Sigma^-$ mode separation

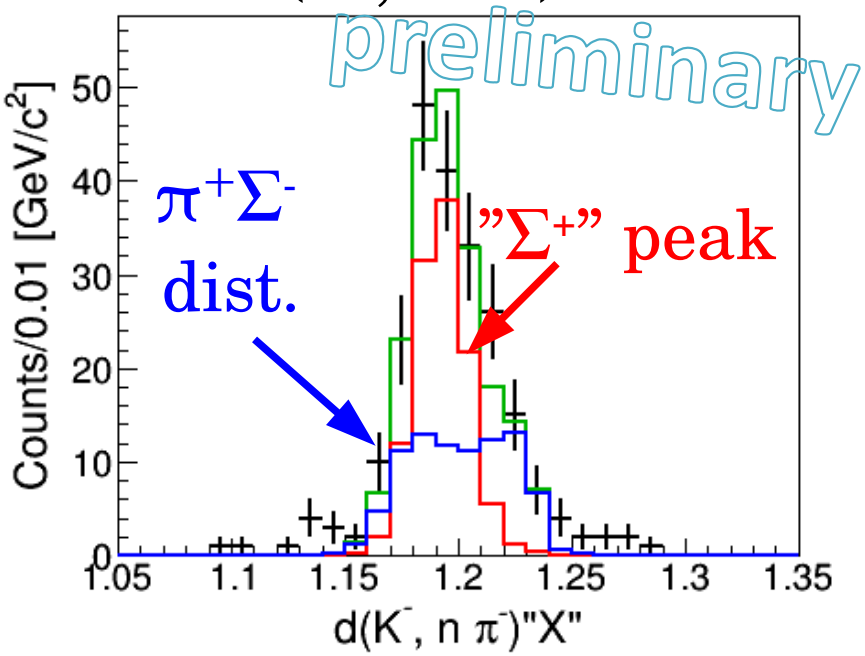
Fittings are done bin by bin.

Two free parameters
1.) Number of $\pi^-\Sigma^+$ events
2.) Number of $\pi^+\Sigma^-$ events

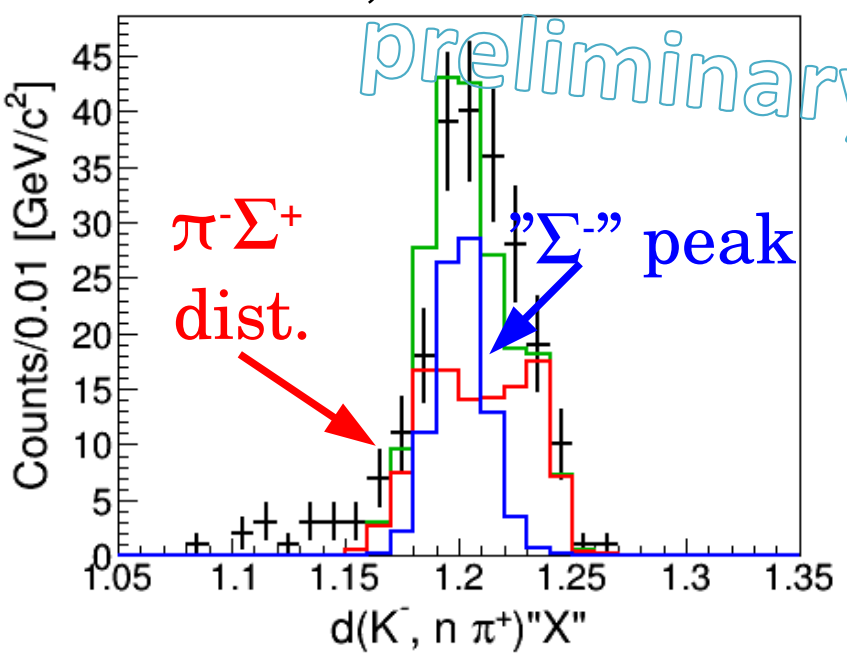


Example : MM=1.45~1.46 [GeV/c^2]

d(K⁻, n π^-)"X"



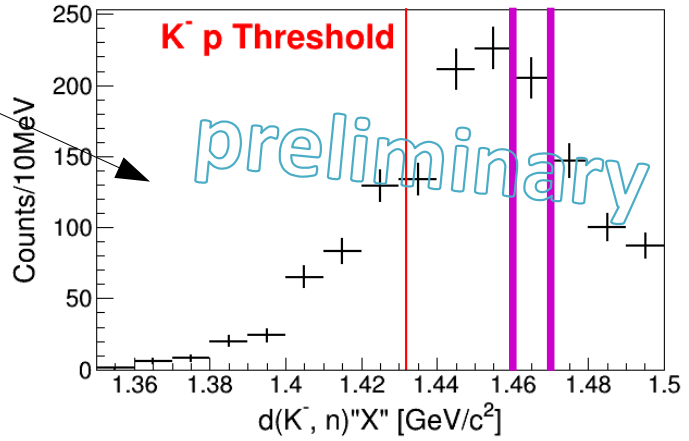
d(K⁻, n π^+)"X"



Fitting for $\pi^-\Sigma^+$/$\pi^+\Sigma^-$ mode separation

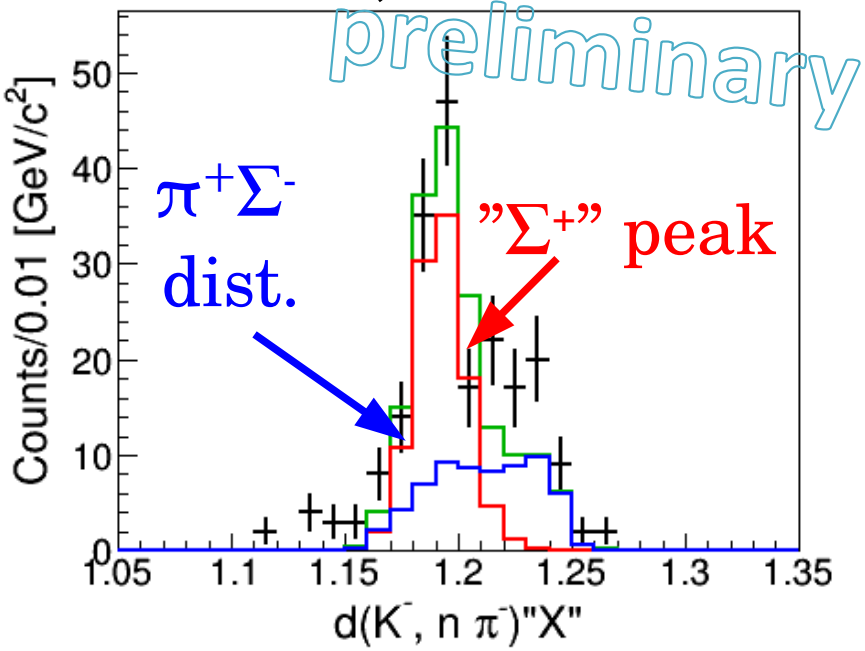
Fittings are done bin by bin.

Two free parameters
1.) Number of $\pi^-\Sigma^+$ events
2.) Number of $\pi^+\Sigma^-$ events

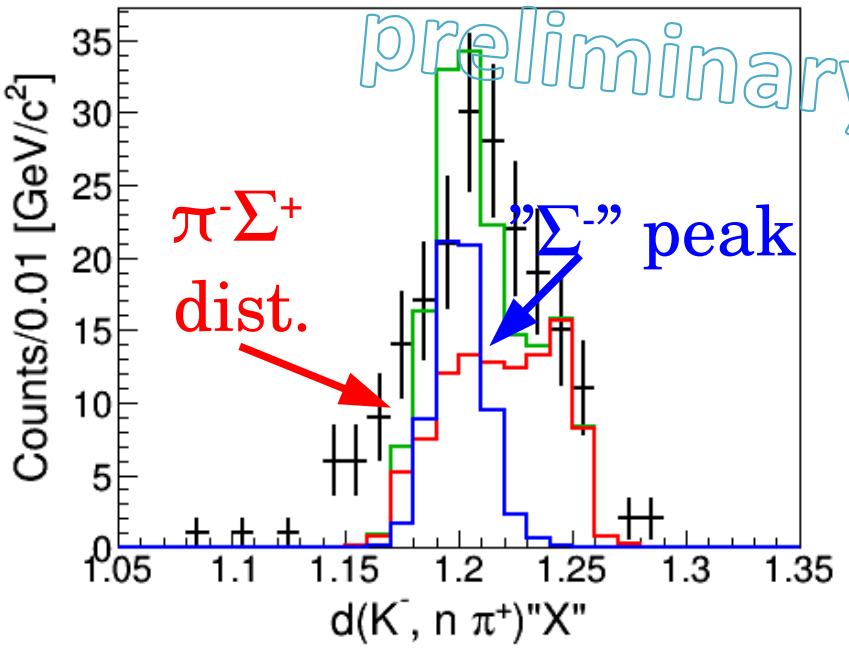


Example : MM=1.46~1.47 [GeV/c^2]

d(K^-, n π^-)"X"



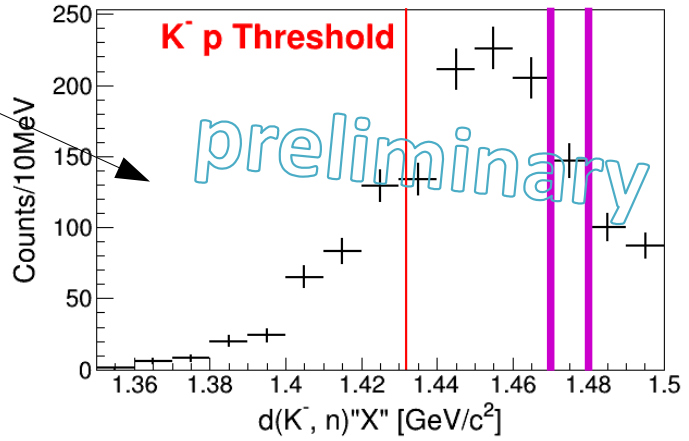
d(K^-, n π^+)"X"



Fitting for $\pi^-\Sigma^+$/$\pi^+\Sigma^-$ mode separation

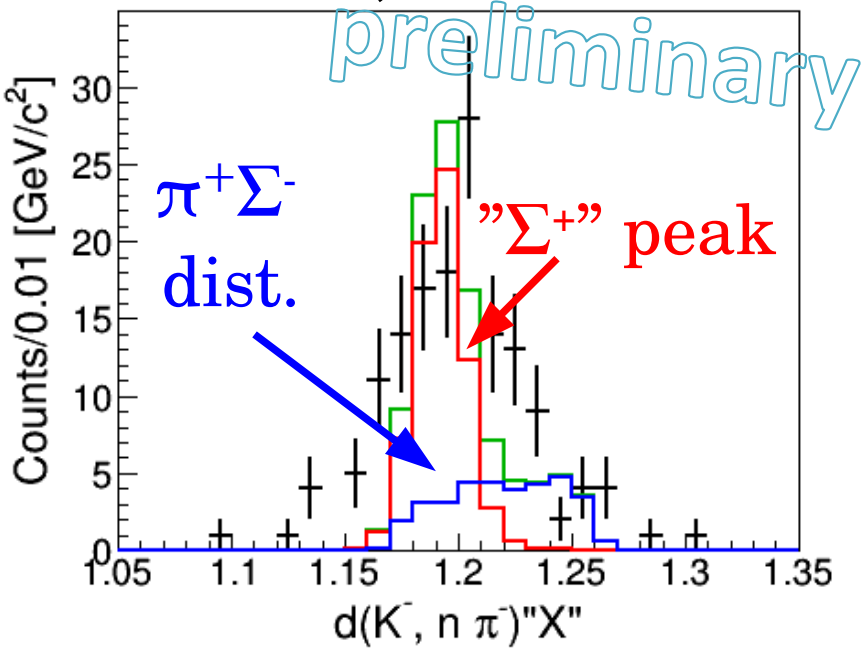
Fittings are done bin by bin.

Two free parameters
1.) Number of $\pi^-\Sigma^+$ events
2.) Number of $\pi^+\Sigma^-$ events

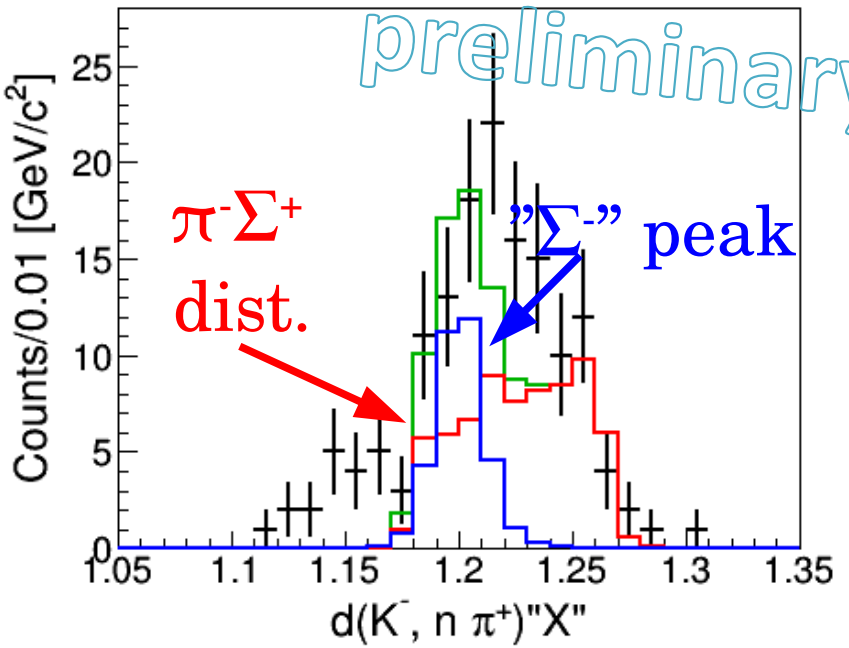


Example : MM=1.47~1.478 [GeV/c²]

d(K⁻, n π^-)"X"



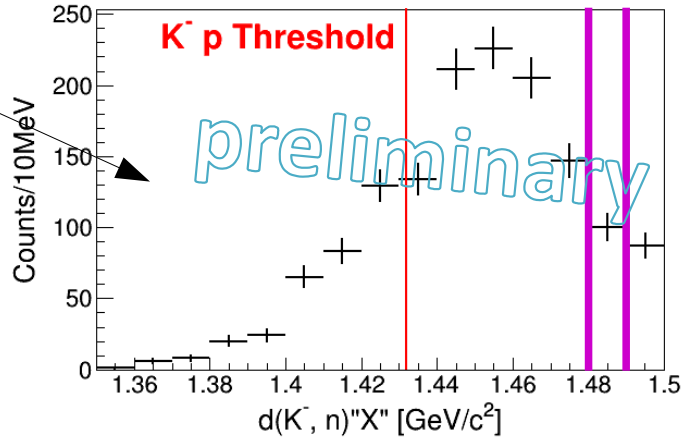
d(K⁻, n π^+)"X"



Fitting for $\pi^-\Sigma^+$/$\pi^+\Sigma^-$ mode separation

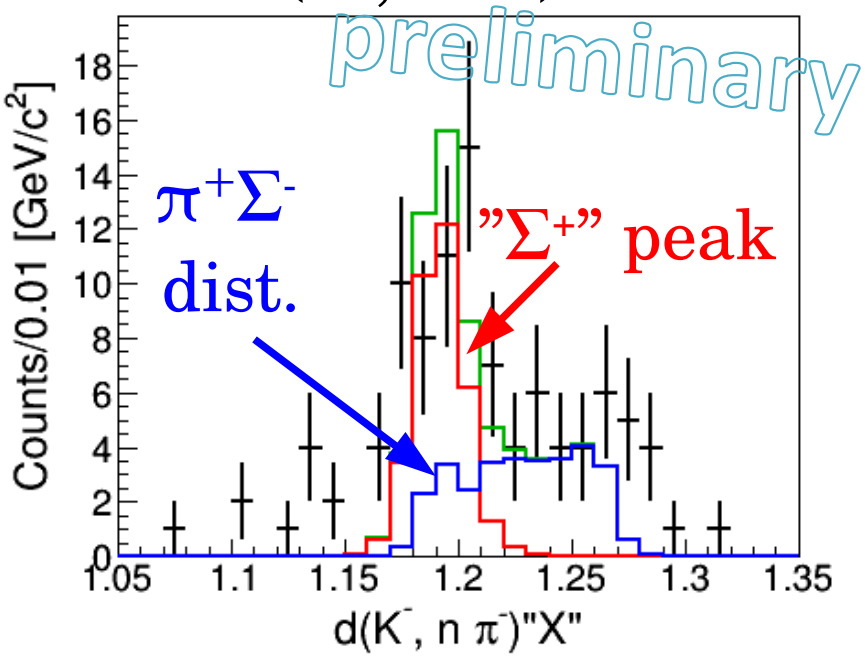
Fittings are done bin by bin.

Two free parameters
1.) Number of $\pi^-\Sigma^+$ events
2.) Number of $\pi^+\Sigma^-$ events

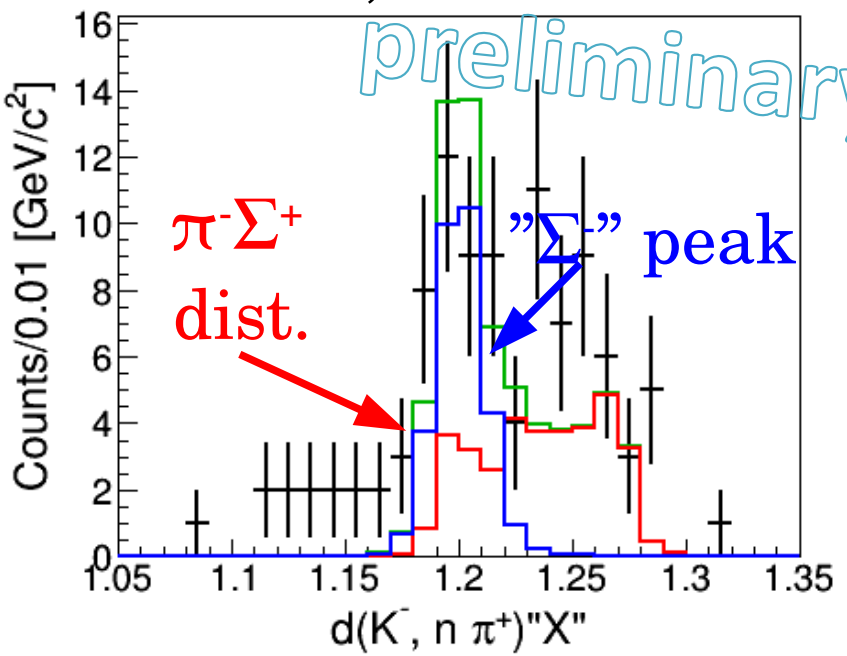


Example : MM=1.48~1.49 [GeV/c^2]

d(K^-, n π^-)"X"



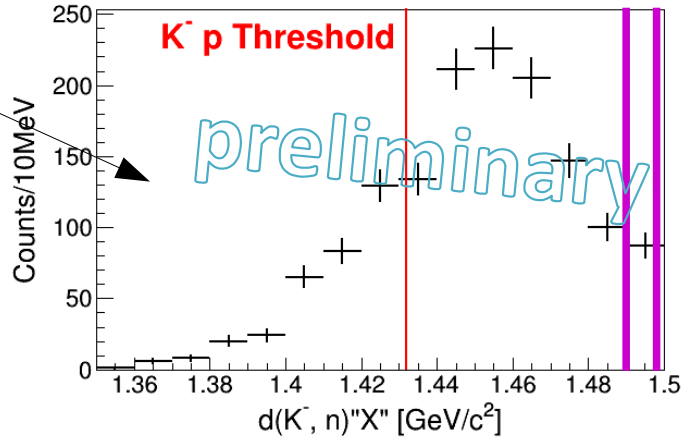
d(K^-, n π^+)"X"



Fitting for $\pi^-\Sigma^+$/$\pi^+\Sigma^-$ mode separation

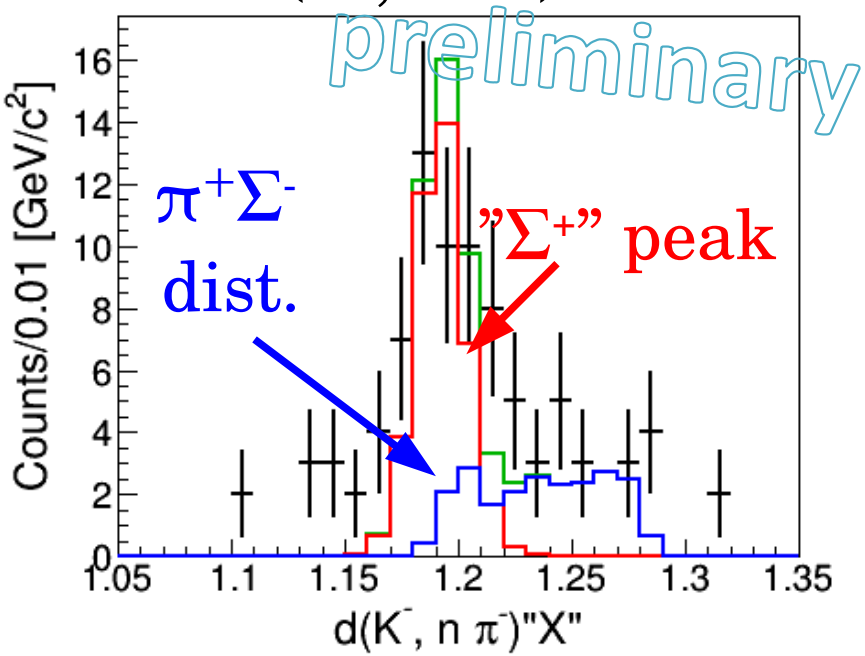
Fittings are done bin by bin.

Two free parameters
1.) Number of $\pi^-\Sigma^+$ events
2.) Number of $\pi^+\Sigma^-$ events

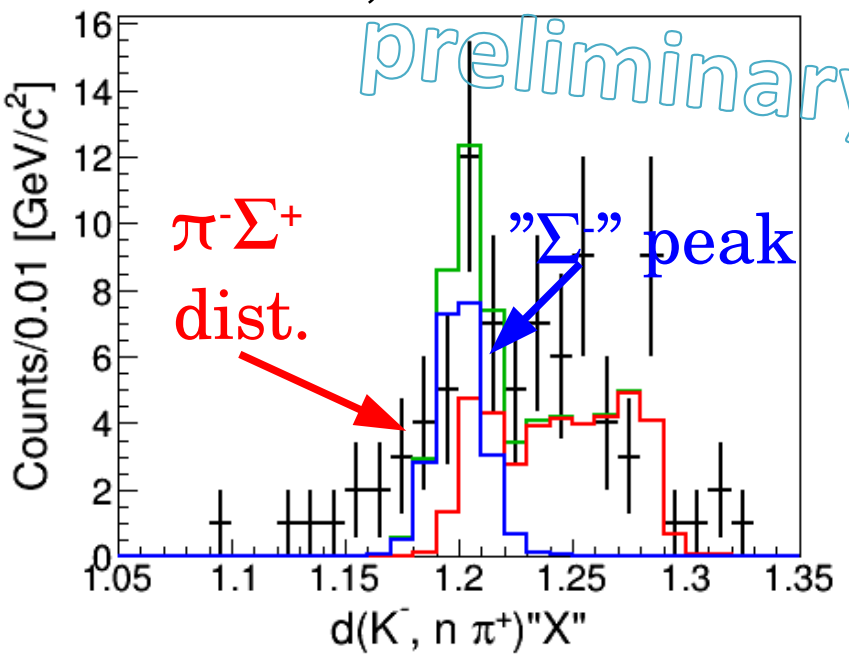


Example : MM=1.49~1.50 [GeV/c^2]

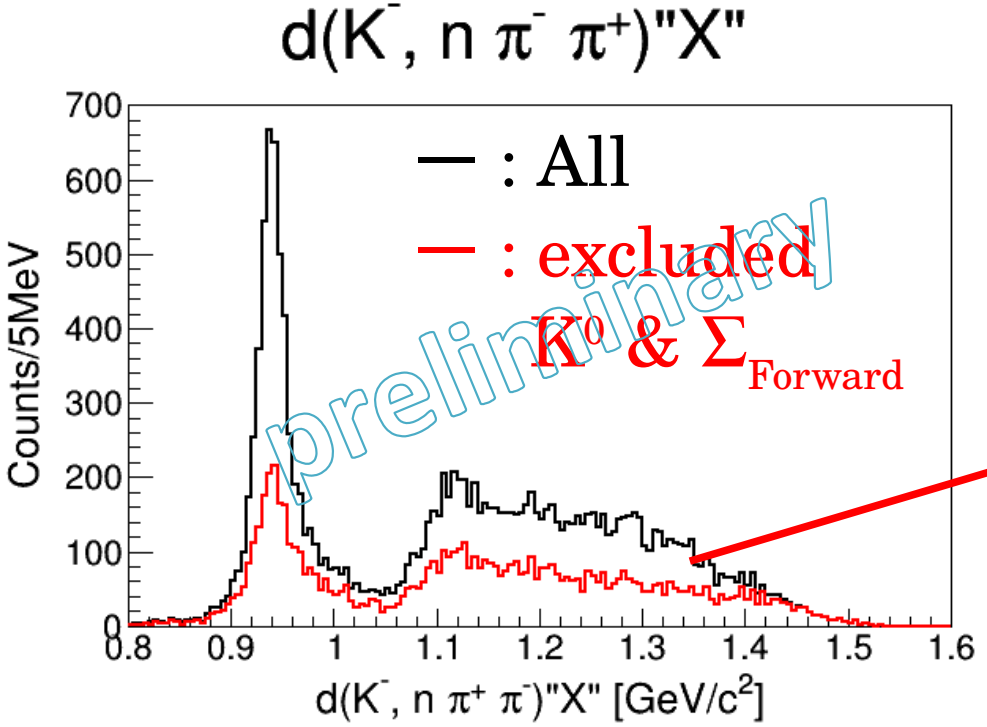
d(K⁻, n π^-)"X"

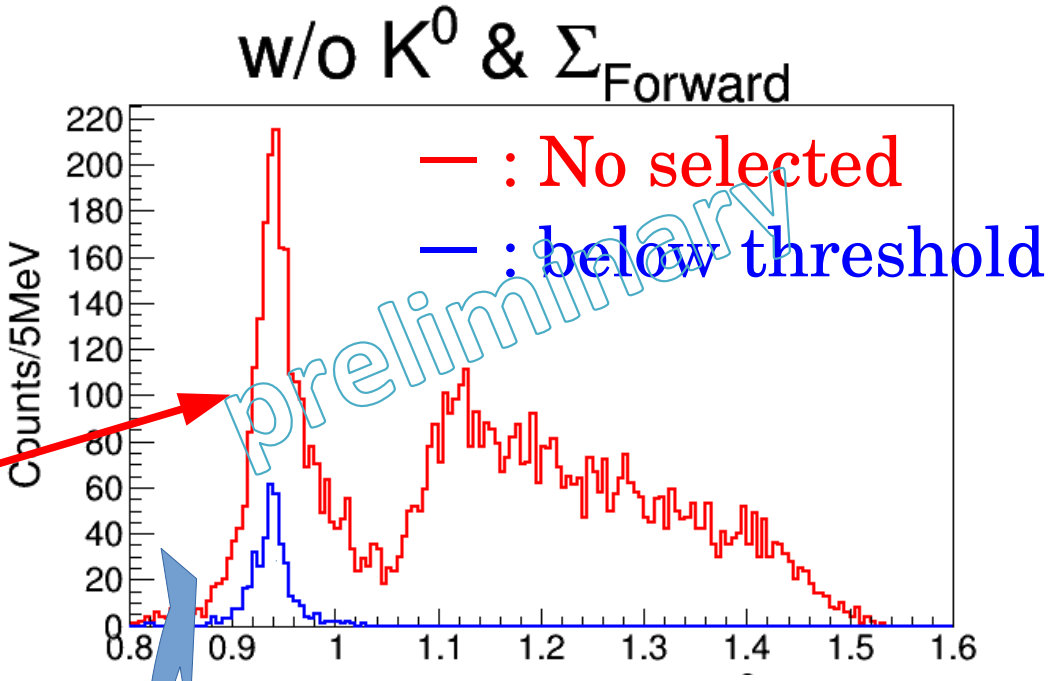


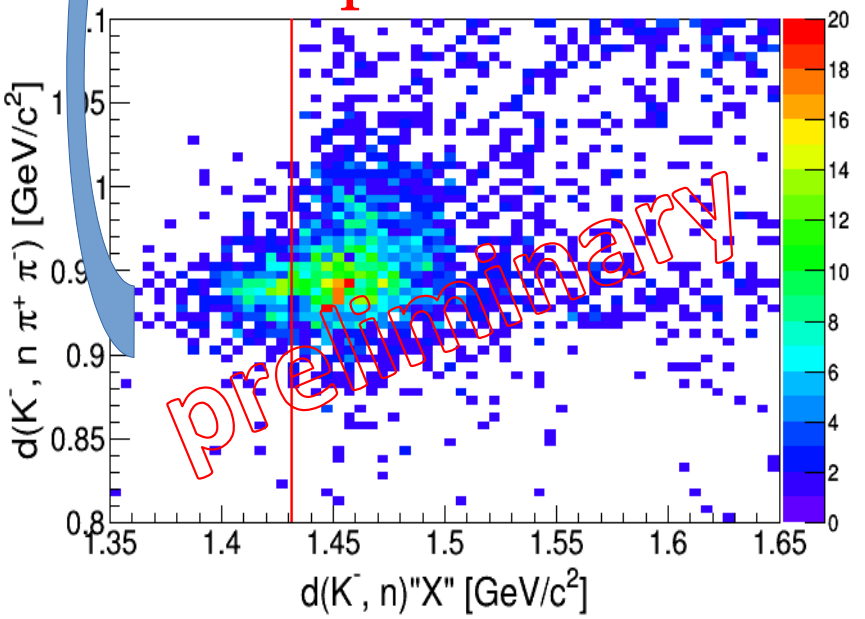
d(K⁻, n π^+)"X"



$K^- d \to n \pi^+ \pi^- n$ events







d(K⁻, n $\pi^+ \pi^-$)"n" has a tail.
In the region below threshold,
The tail isn't seen.

This tail should to be removed.