

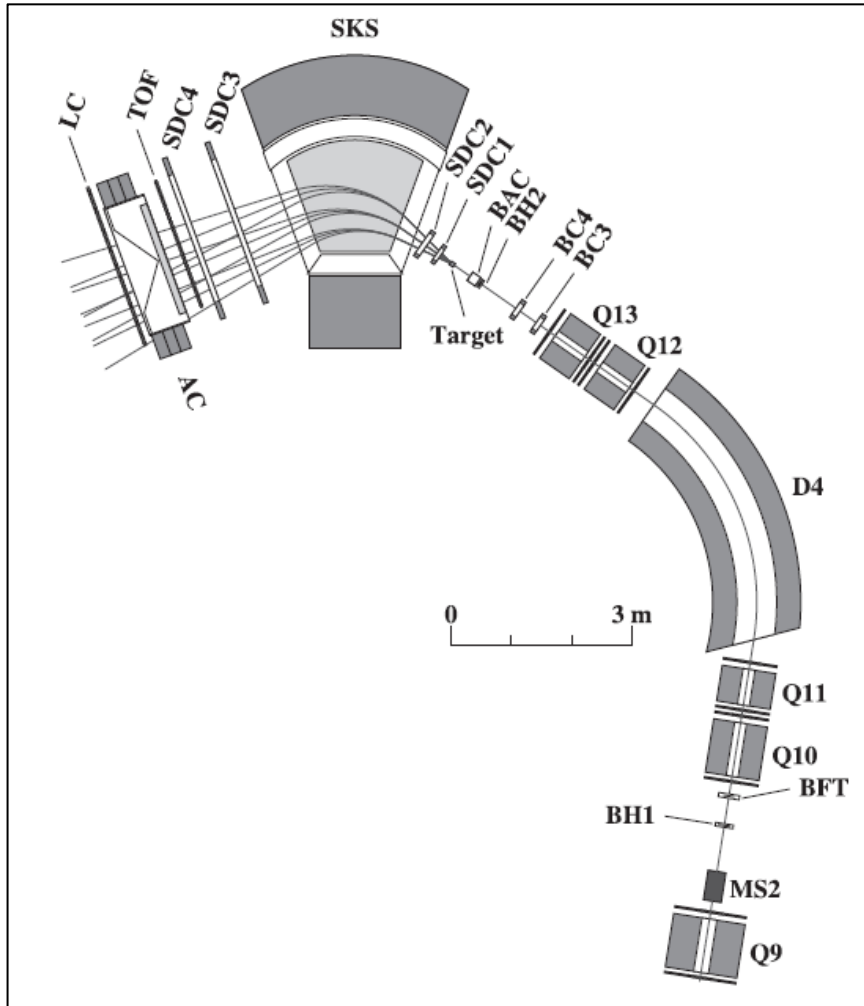
$^{12}\text{C}(K^-, K^+)$ reaction to study the Ξ -nucleus interaction at J-PARC

Result of J-PARC E05 and E42 experiments
and prospect of E70 experiment
HYP 2025, 2025/09/29-10/2

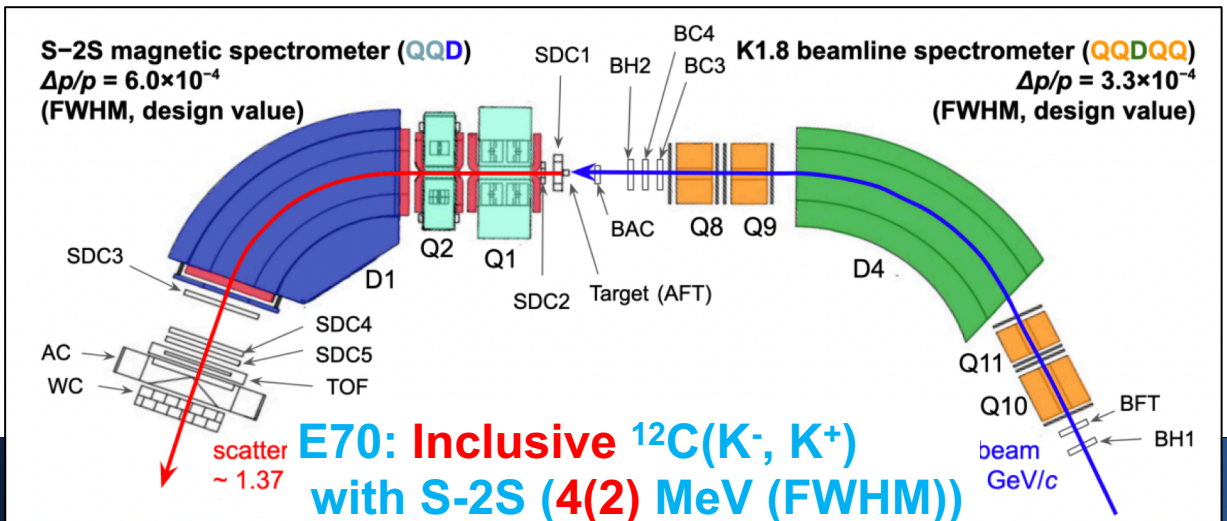
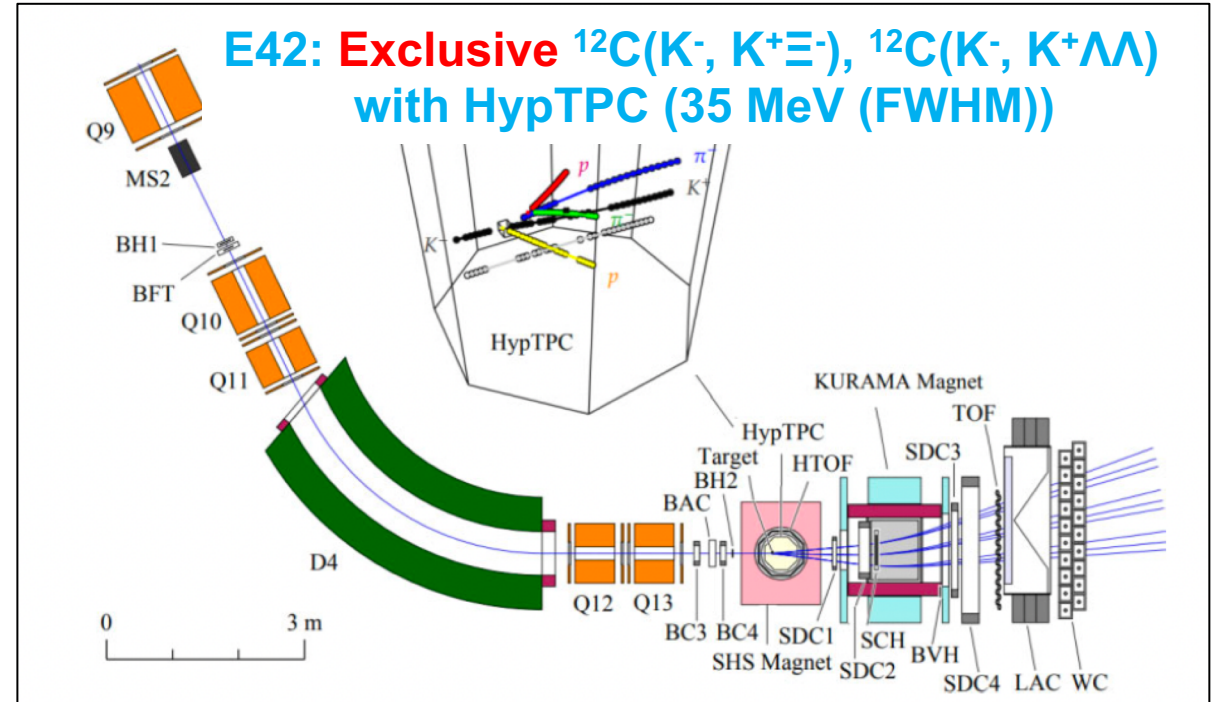
Yudai Ichikawa
(Tohoku University)

Contents: Experiments using $^{12}\text{C}(\text{K}^-, \text{K}^+)$ reaction at J-PARC

E05: Inclusive $^{12}\text{C}(\text{K}^-, \text{K}^+)$ with SKS (8MeV (FWHM))



E42: Exclusive $^{12}\text{C}(\text{K}^-, \text{K}^+\Xi^-)$, $^{12}\text{C}(\text{K}^-, \text{K}^+\Lambda)$ with HypTPC (35 MeV (FWHM))



E70: Inclusive $^{12}\text{C}(\text{K}^-, \text{K}^+)$ with S-2S (4(2) MeV (FWHM))

Contents

E05: Inclusive $^{12}\text{C}(K^-, K^+)$

Yudai Ichikawa *et al.*, PTEP 2024 9, 091D01 (2024).

PTEP

Prog. Theor. Exp. Phys. **2024** 091D01 (13 pages)
DOI: 10.1093/ptep/ptae133

Missing-Mass Measurement of the $^{12}\text{C}(K^-, K^+)$ Reaction at 1.8 GeV/c with the Superconducting Kaon Spectrometer

Yudai Ichikawa^{1,2,*}, Jung Keun Ahn³, Yuya Akazawa⁴, Kanae Aoki⁴, Elena Botta^{5,6}, Hiroyuki Ekawa⁷, Petr Evtoukhovitch⁸, Alessandro Feliciello⁵, Manami Fujita², Toshiyuki Gogami⁹, Shoichi Hasegawa², Tomoyuki Hasegawa¹⁰, Shuhei Hayakawa¹, Tomonori Hayakawa¹¹, Ryotaro Honda⁴, Kenji Hosomi², Ken'ichi Imai², Wooseung Jung³, Shunsuke Kanatsuki⁹, Shin Hyung Kim¹², Shinji Kinbara¹³, Kazuya Kobayashi¹¹, Jaeyong Lee¹⁴, Simonetta Marcello^{5,6}, Koji Miwa¹, Taejin Moon¹⁴, Tomofumi Nagae⁹, Yoshiyuki Nakada¹¹, Manami Nakagawa⁷, Takuya Nanamura², Megumi Naruki⁹, Atsushi Sakaguchi¹¹, Hiroyuki Sako², Yuki Sasaki¹, Susumu Sato², Kotaro Shirotori¹⁵, Hitoshi Sugimura¹⁶, Toshiyuki Takahashi³, Hirokazu Tamura^{1,2}, Kiyoshi Tanida², Zviadi Tsamalaidze⁸, Mifuyu Ukai⁴, and Takeshi O. Yamamoto²

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E42: Exclusive $^{12}\text{C}(K^-, K^+)$

WooSeung Jung *et al.*, PTEP 2025 9, ptaf064 (2025).

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DOI: 10.1093/ptep/ptaf064

Oct 1, PM 5:05~ Wooseung Jung (Kobayashi-hall)

Cross Section Measurements for $^{12}\text{C}(K^-, K^+ \Xi^-)$ and $^{12}\text{C}(K^-, K^+ \Lambda \Lambda)$ Reactions at 1.8 GeV/c

Woo Seung Jung¹, Yudai Ichikawa^{2,3}, Byung Min Kang¹, Jung Keun Ahn^{1,*}, Sung Wook Choi¹, Manami Fujita³, Takeshi Harada^{3,4}, Shoichi Hasegawa³, Shuhei Hayakawa², Kenneth Hicks⁵, Sang Hoon Hwang⁶, Ken'ichi Imai^{3,4}, Yuji Ishikawa², Shunsuke Kajikawa², Kento Kamada², Shin Hyung Kim⁷, Tomomasa Kitaoka², Jaeyong Lee⁸, Jong Won Lee¹, Koji Miwa^{2,9}, Taito Morino², Fumiya Oura², Tamao Sakao², Hiroyuki Sako³, Masayoshi Saito², Susumu Sato³, Toshiyuki Takahashi⁹, Kiyoshi Tanida³, Hirokazu Tamura^{2,3}, Mifuyu Ukai^{2,9}, Shunsuke Wada², Takeshi O. Yamamoto³, and Seongbae Yang¹

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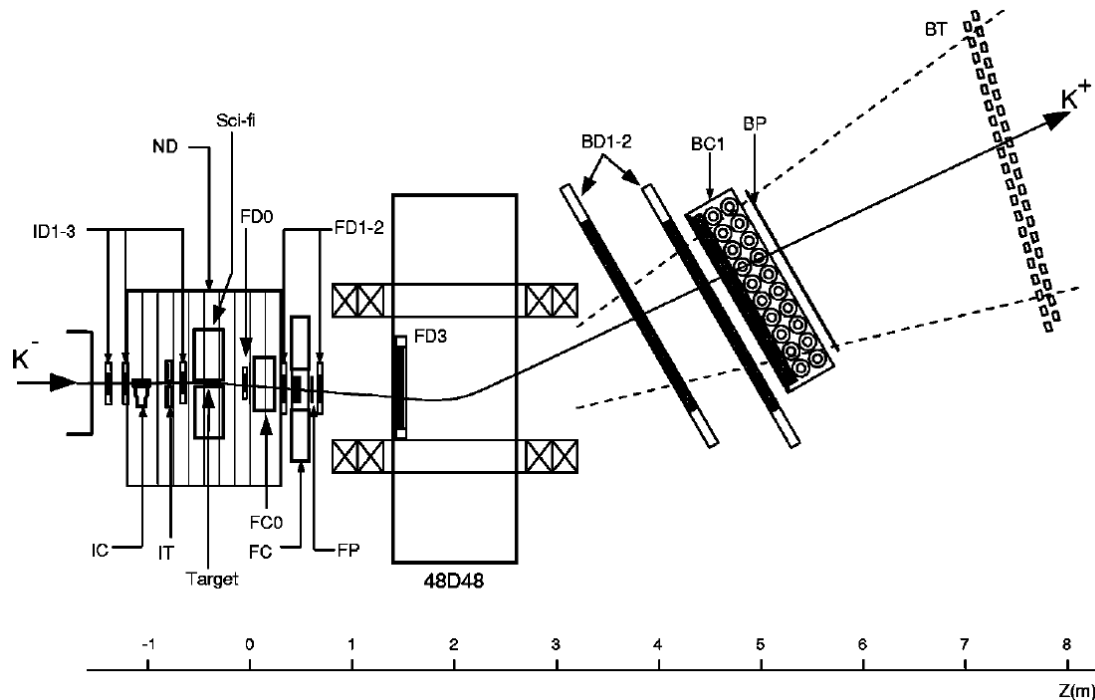
⁸Department of Physics and Astronomy, Seoul National University, Seoul 08826, Republic of Korea

⁹Institute of Particle and Nuclear Studies, [High Energy Accelerator Research Organization \(KEK\)](#), Tsukuba 305-0801, Japan

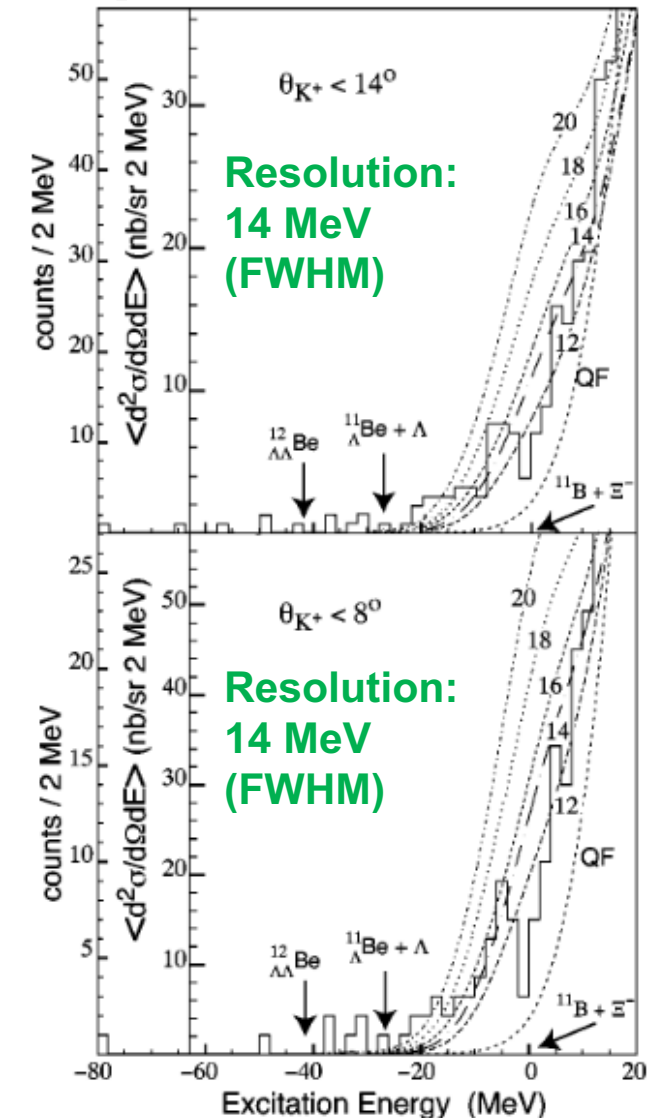
Received March 21, 2025; Revised April 21, 2025; Accepted April 26, 2025; Published May 13, 2025

Introduction BNL E885 experiment

$^{12}\text{C}(\text{K}^-, \text{K}^+)$ reaction @1.8 GeV/c



P. Khaustov et al., PRC 61 054603(2000).



$V_0^{\Xi} \sim -14 \text{ MeV}$

Introduction BNL E885 experiment

$$U_B(r) = -V_{0B}f(r) + V_{LSB}\left(\frac{\hbar}{m_\pi c}\right)(\mathbf{l} \cdot \mathbf{s})\frac{1}{r}\frac{df(r)}{dr} + U_{coulomb}(r),$$

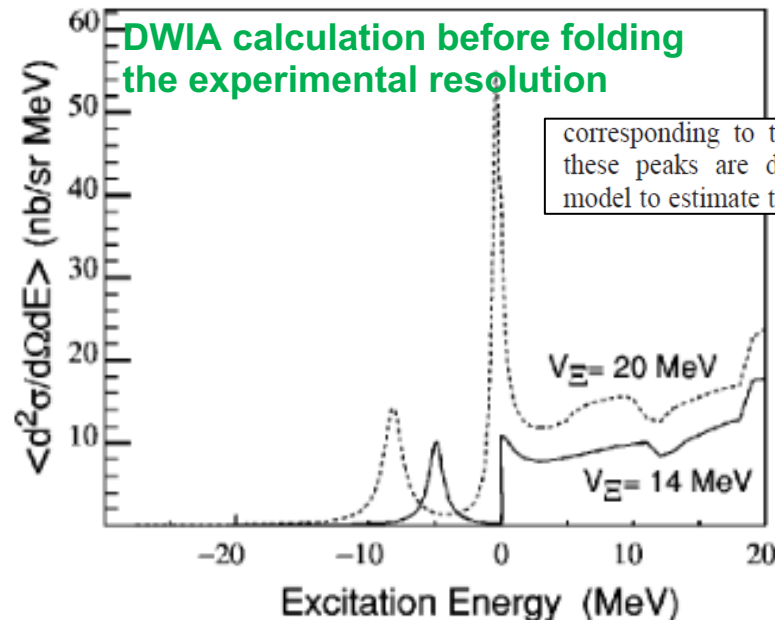
$$f(r) = (1 + e^{\frac{r-R}{a}})^{-1},$$

P. Khaustov Doctor thesis

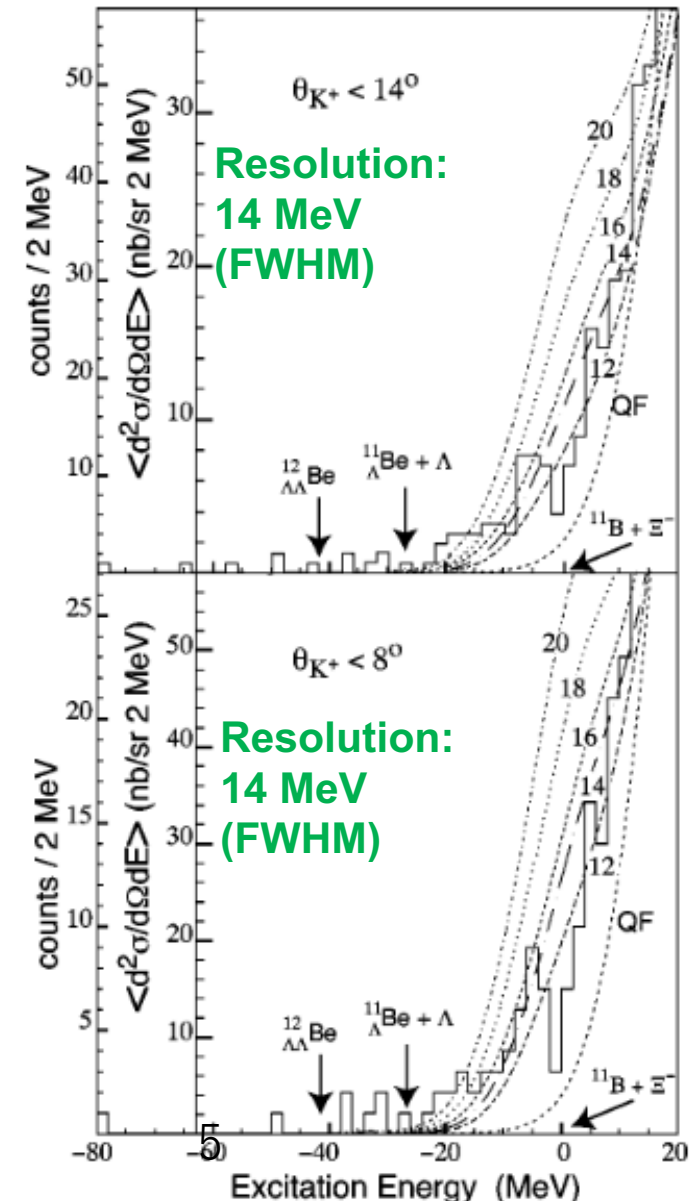
$$R = r_0(A - 1)^{1/3},$$

r_0 , fm	a , fm	$V_{0\Xi}$, MeV	$V_{LS\Xi}$, MeV	V_{0p} , MeV	V_{LSp} , MeV
1.1	0.65	20, 16	1	72.5	7

Maybe, they did not consider the imaginary part $W_0\Xi$.
The width of peaks are considered.
However, resolution will be more effective than Γ .



P. Khaustov et al., PRC 61 054603(2000).



Theoretical study by Kohno

$\Gamma/2$ is assumed to be 2 MeV

BNL E885

W_0 is assumed to be 0 MeV

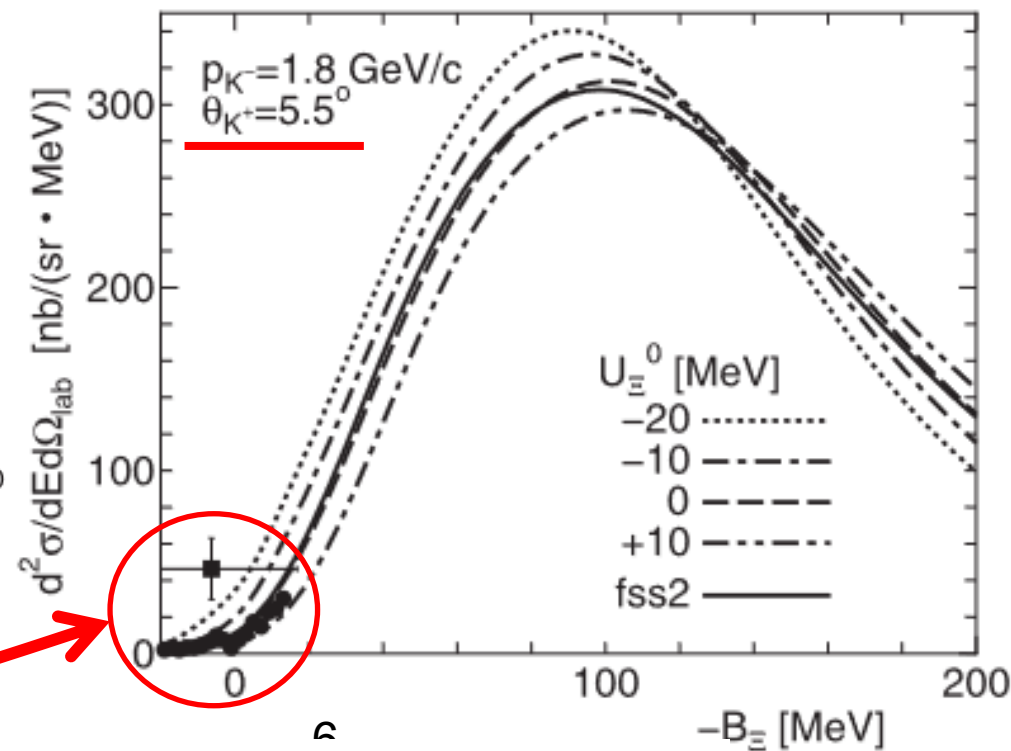
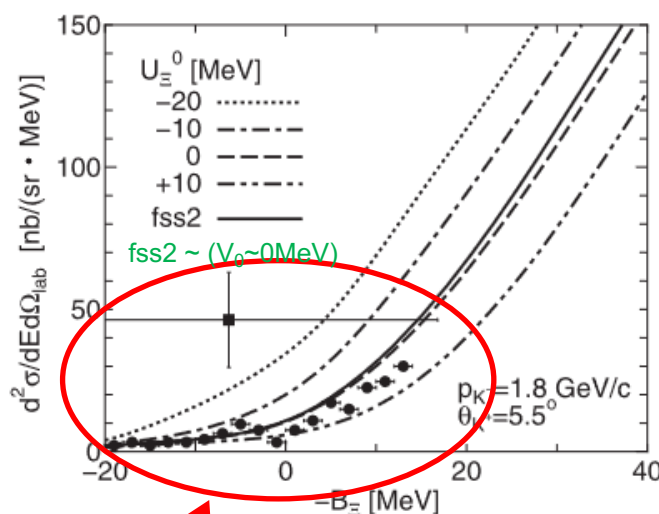
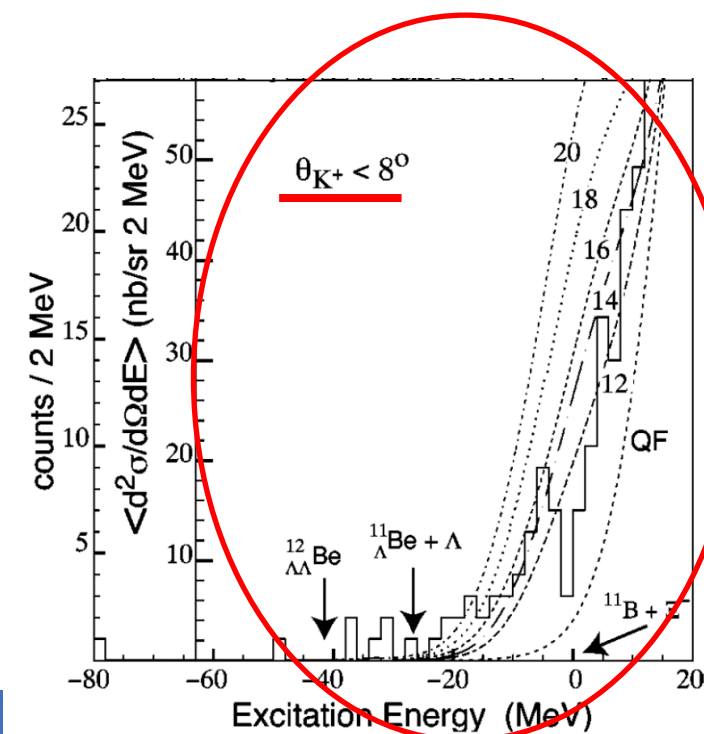
$V_0 \equiv \sim -14$ MeV

$$\sigma_{\Xi^- p \rightarrow \Lambda \Lambda} \sim 4.3 \text{ mb } (\sim 0.5 \text{ GeV}/c)$$

J.K. Ahn et al., PLB 663, 214 (2006) ($\Gamma_{\Xi} \sim 3 \text{ MeV}$)

$V_0 \equiv \sim 0$ MeV can also reproduce the data

Wide energy range and precise angle selection data is essential !!



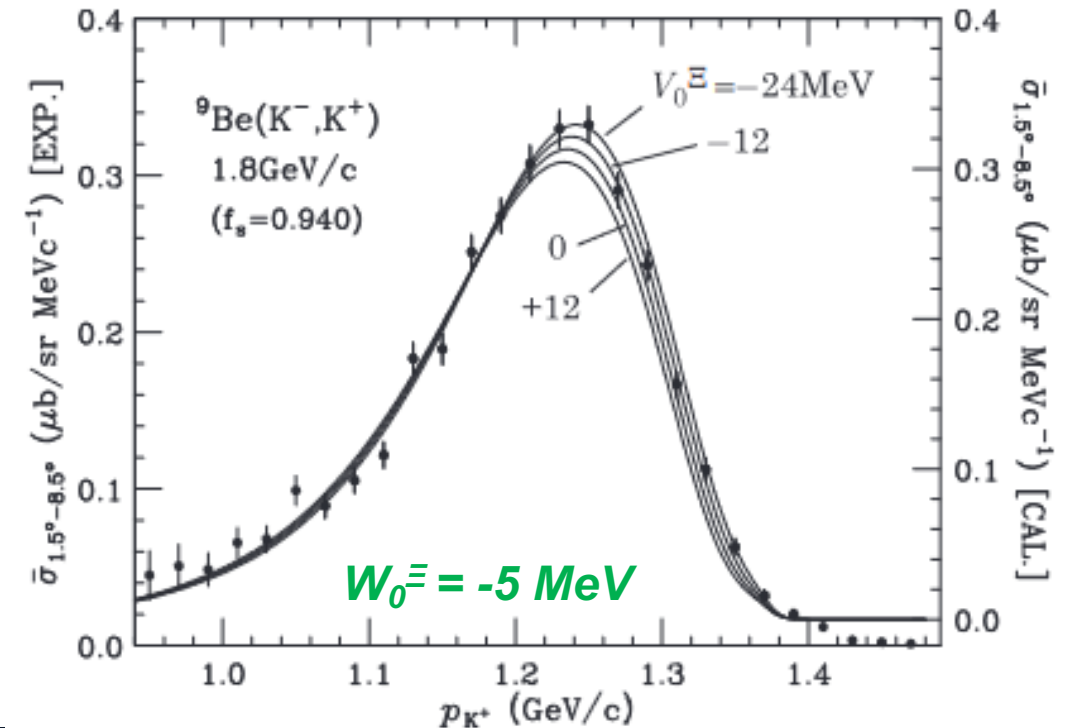
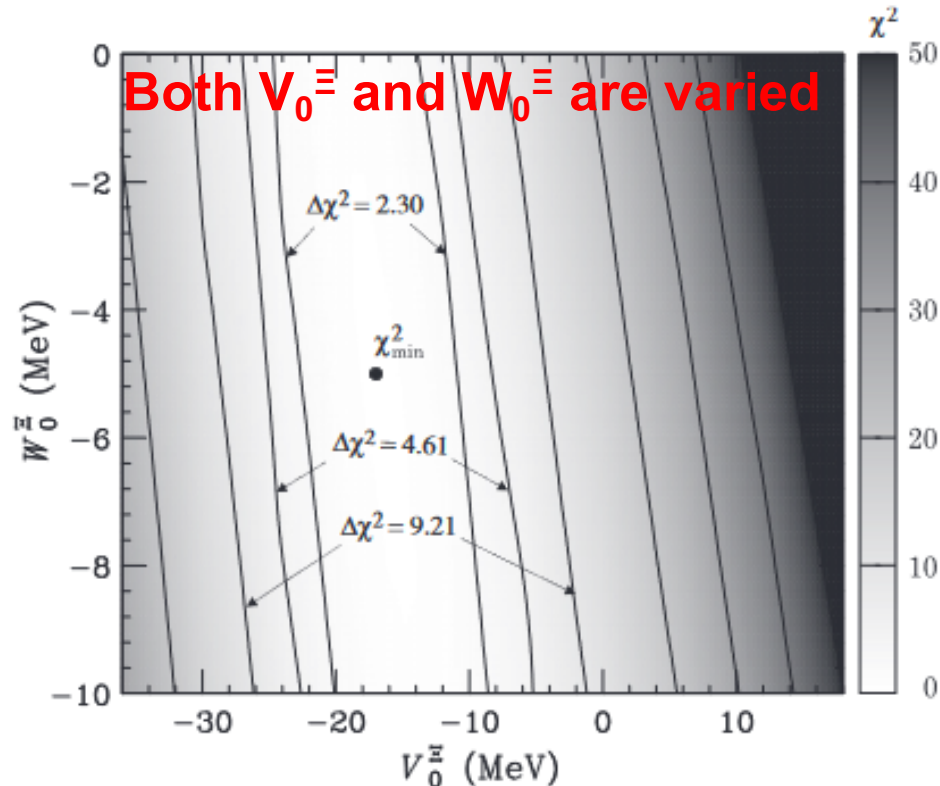
Recent theoretical study by Harada

T. Harada and Y. Hirabayashi, Phys. Rev. C **103**, 024605 (2021).

$$V_0^{\Xi} = -17 \pm 6 \text{ MeV} \text{ (} W_0^{\Xi} \text{ is difficult to determine)}$$

$$* W_0^{\Xi} = \underline{W_0(\Xi^- p \rightarrow \Xi^0 n)} + W_0(\Xi^- p \rightarrow \Lambda \Lambda)$$

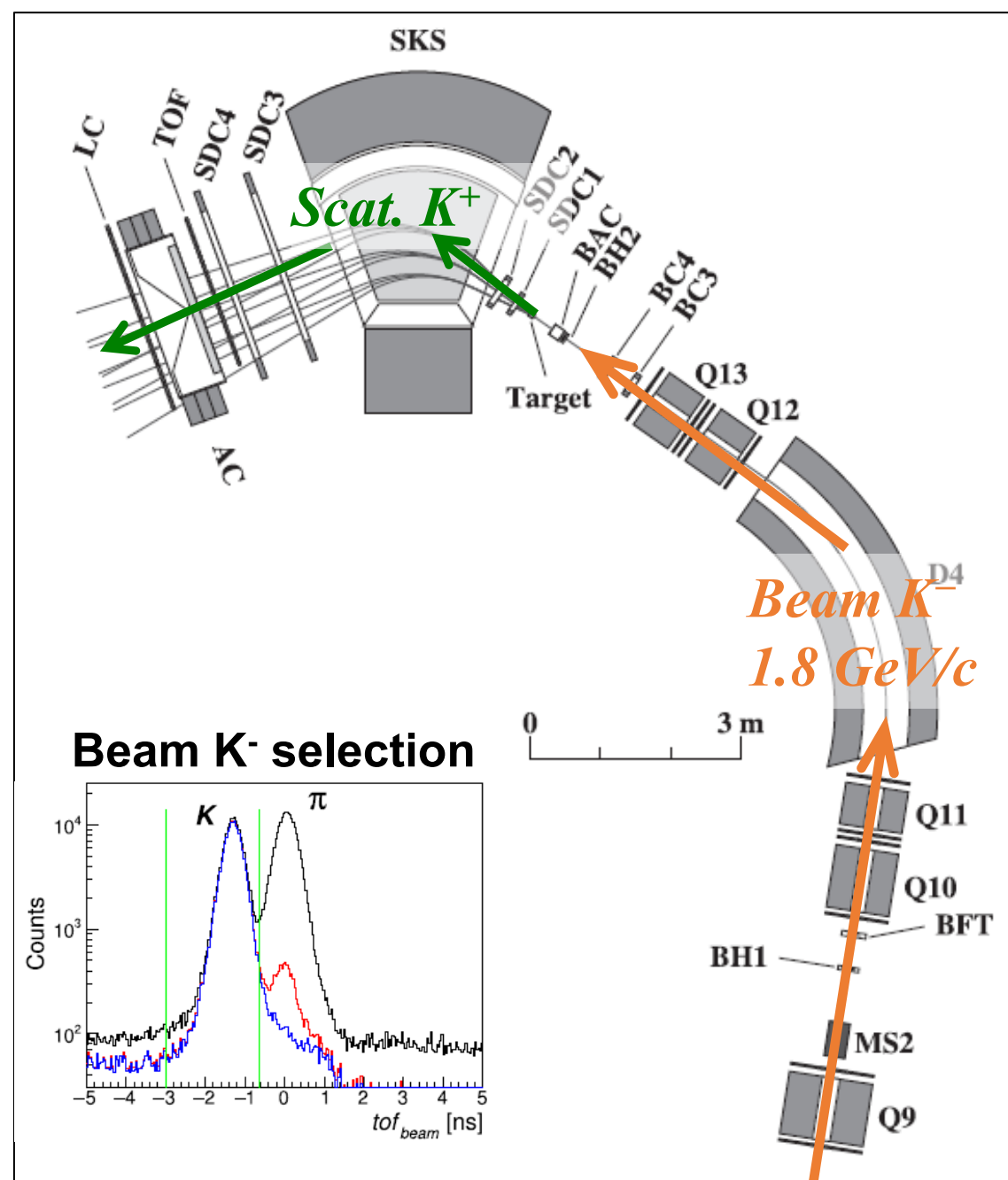
No sensitivity to Imaginary part from the inclusive analysis



J-PARC E05 EXPERIMENT

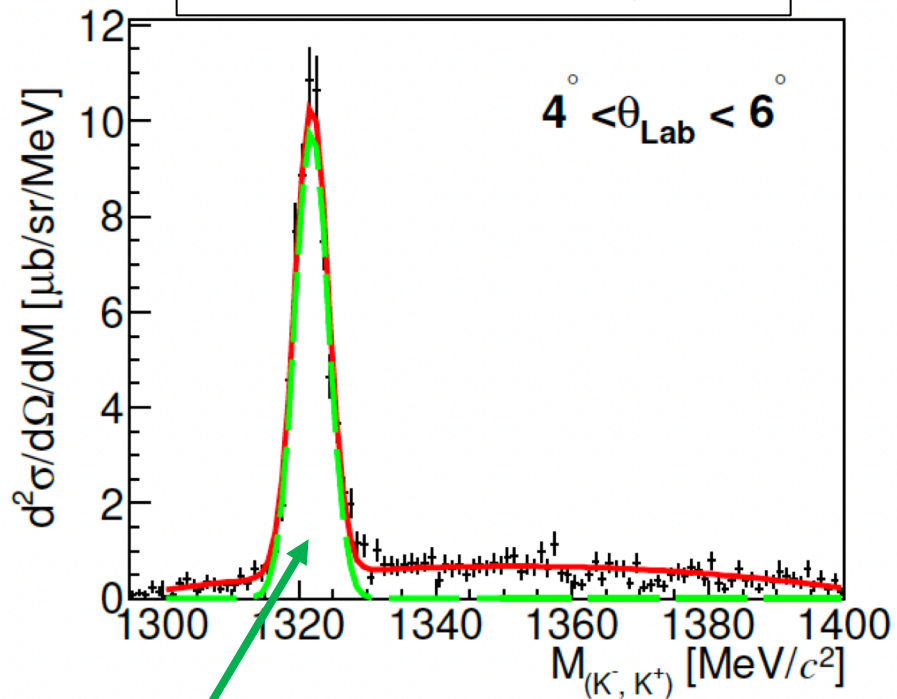
Yudai Ichikawa *et al.*,
PTEP 2024 9, 091D01 (2024).

Experiment	BNL E885	J-PARC E05	J-PARC E70
Resolution FWHM (MeV)	14	8	4(2)
Momentum range (GeV/c)	0.8-1.4	0.8-2.2	1.2-1.5



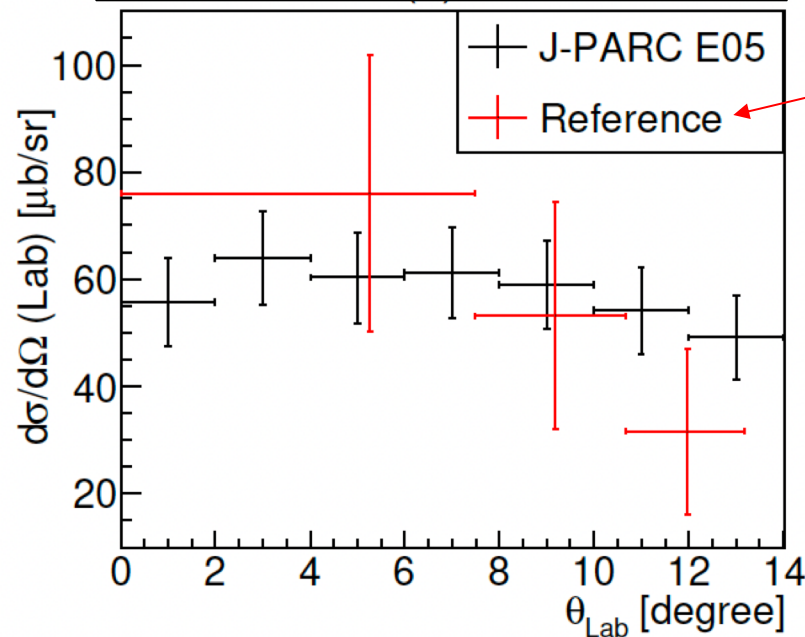
Elementary cross-section $p(K^-, K^+)\Xi^-$

$p(K^-, K^+)\Xi^-$ spectrum
with CH_2 target



$\Delta M = 5.8 \text{ MeV (FWHM)}$
 $\rightarrow \Delta B_{\Xi} = 8.2 \text{ MeV (FWHM)}$

$d\sigma/d\Omega$ of Ξ^- production
at 1.8 GeV/c

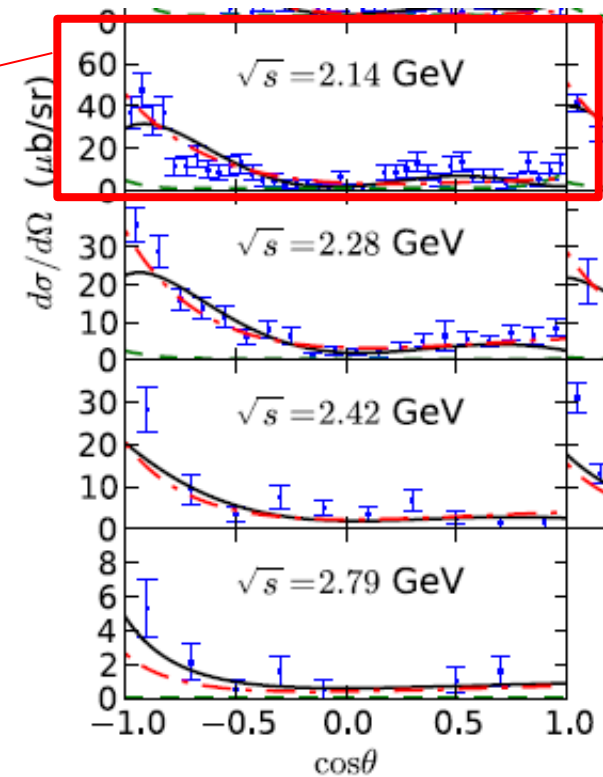


Eur. Phys. J. A (2011) 47: 109
DOI 10.1140/epja/i2011-11109-1

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PHYSICAL JOURNAL A

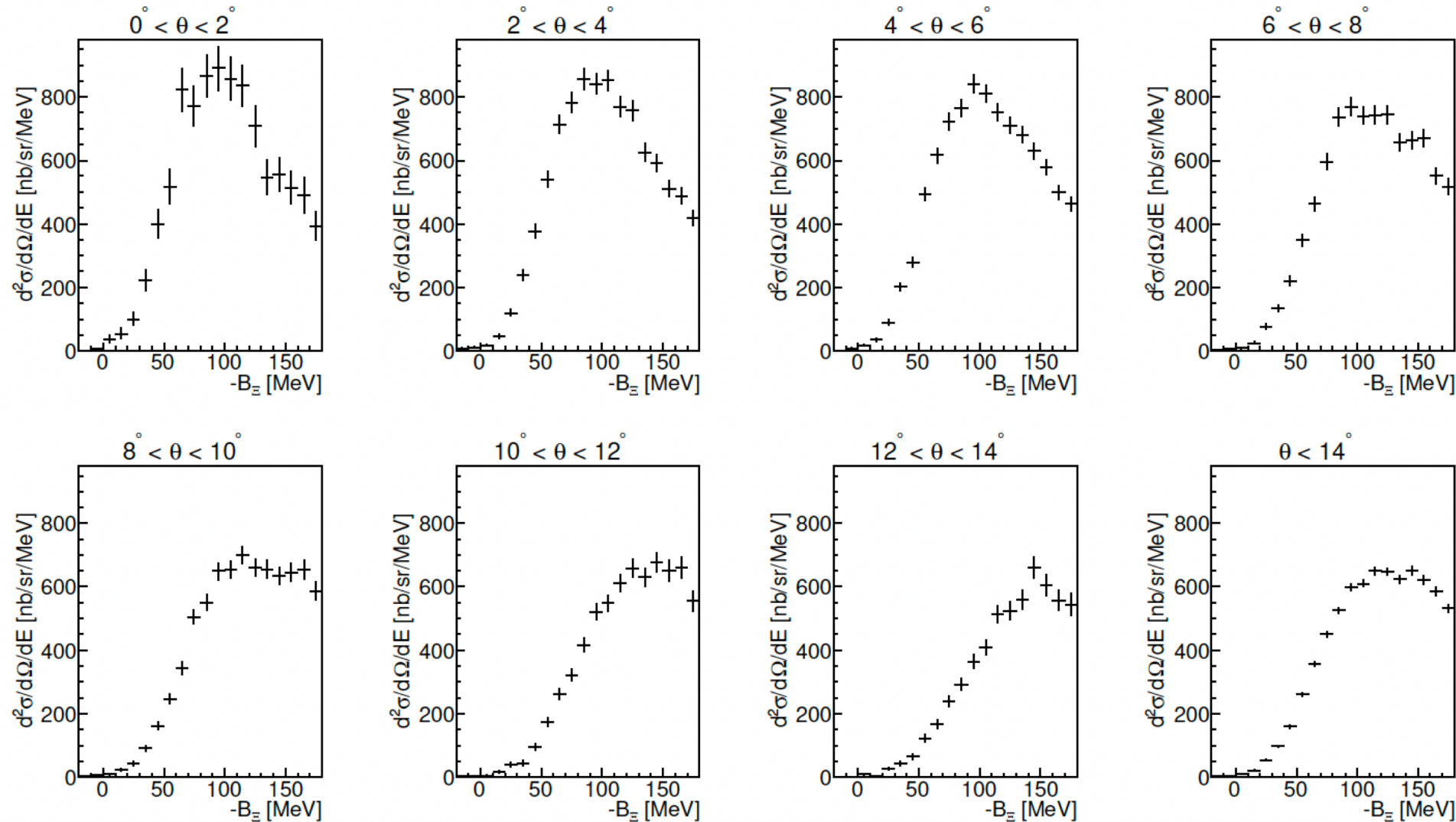
Regular Article – Theoretical Physics

Phenomenological model for the $\bar{K}N \rightarrow K\Xi$ reaction

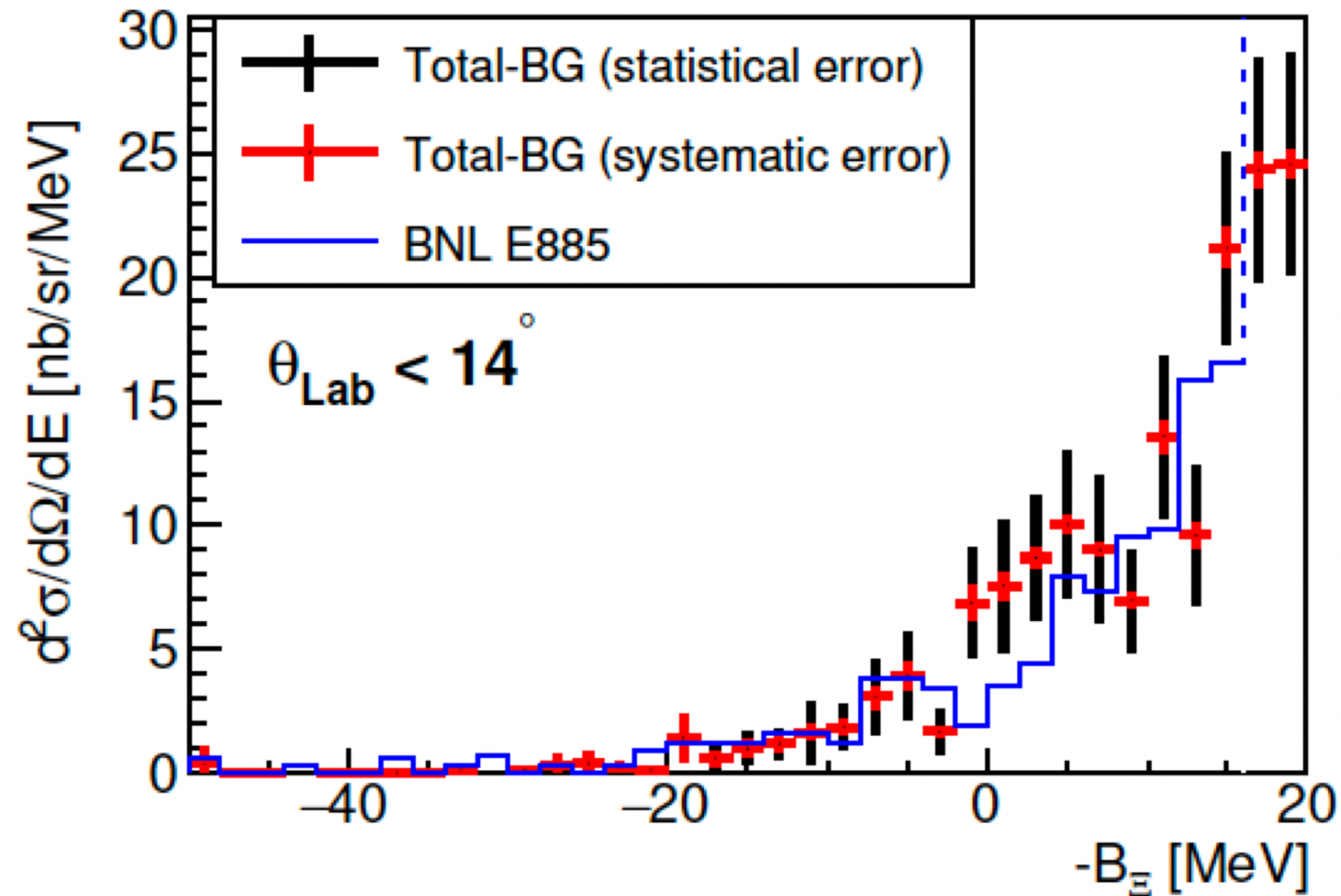


E05 $^{12}\text{C}(\text{K}^-, \text{K}^+)$ spectrum

➡ (V_0^{Ξ}, W_0^{Ξ}) will be determined in high precision



$^{12}\text{C}(\text{K}^-, \text{K}^+)$ spectrum near threshold



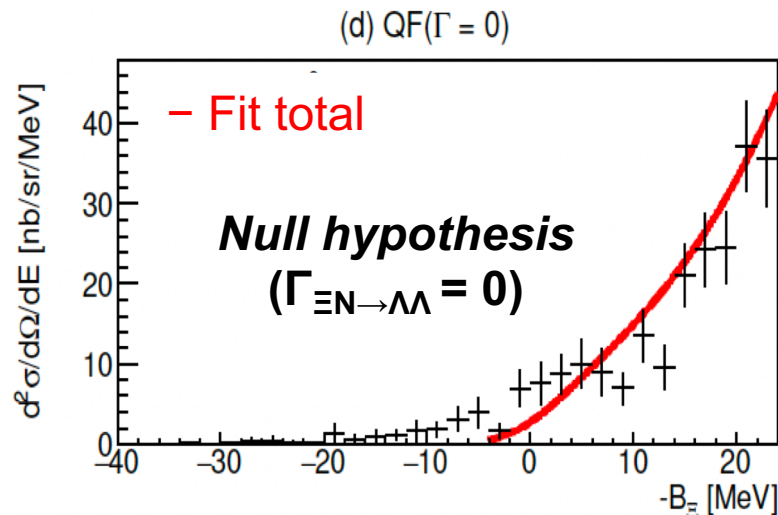
Model Assumption for Spectrum fitting

Model	Function	Assumption
(a)	$QF(\Gamma = 0) + 1 \text{ Gaus}$	1 state with visible $\Gamma_{\Xi N \rightarrow \Lambda \Lambda}$
(b)	$QF(\Gamma = 0) + 2 \text{ Gaus}$	2 states with negligible $\Gamma_{\Xi N \rightarrow \Lambda \Lambda}$
(c)	$QF(\Gamma \neq 0) + 1 \text{ BW}$	1 state with visible $\Gamma_{\Xi N \rightarrow \Lambda \Lambda}$
(d)	$QF(\Gamma = 0)$	Null hypothesis with negligible $\Gamma_{\Xi N \rightarrow \Lambda \Lambda}$
(e)	$QF(\Gamma \neq 0)$	Null hypothesis with visible $\Gamma_{\Xi N \rightarrow \Lambda \Lambda}$

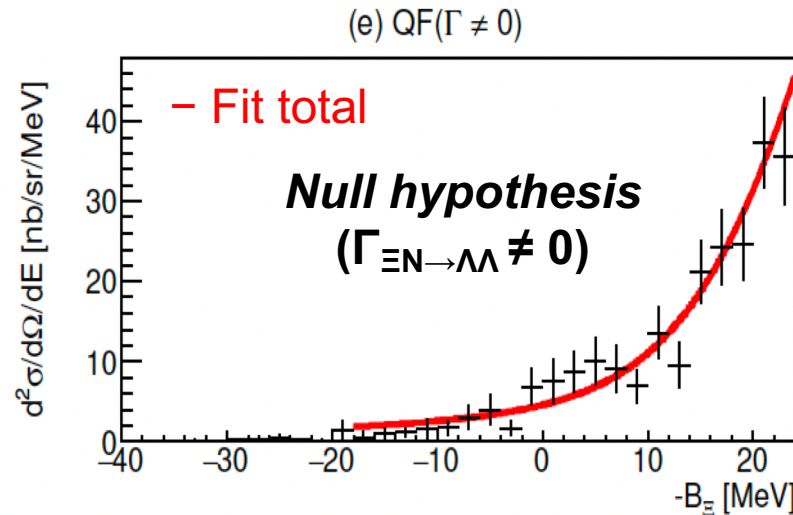
Results with Null hypothesis

Model	Function	Assumption
(a)	$QF(\Gamma = 0) + 1 \text{ Gaus}$	1 state with negligible $\Gamma_{\Xi N \rightarrow \Lambda \Lambda}$
(b)	$QF(\Gamma = 0) + 2 \text{ Gaus}$	2 states with negligible $\Gamma_{\Xi N \rightarrow \Lambda \Lambda}$
(c)	$QF(\Gamma \neq 0) + 1 \text{ BW}$	1 state with visible $\Gamma_{\Xi N \rightarrow \Lambda \Lambda}$
(d)	$QF(\Gamma = 0)$	Null hypothesis with negligible $\Gamma_{\Xi N \rightarrow \Lambda \Lambda}$
(e)	$QF(\Gamma \neq 0)$	Null hypothesis with visible $\Gamma_{\Xi N \rightarrow \Lambda \Lambda}$

Convolved by Gaus ($\Gamma = 0$)

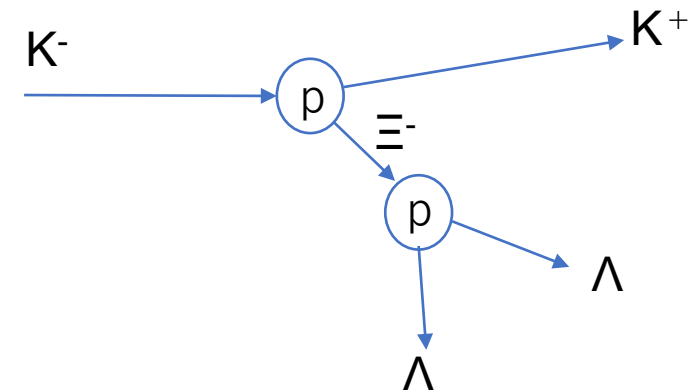


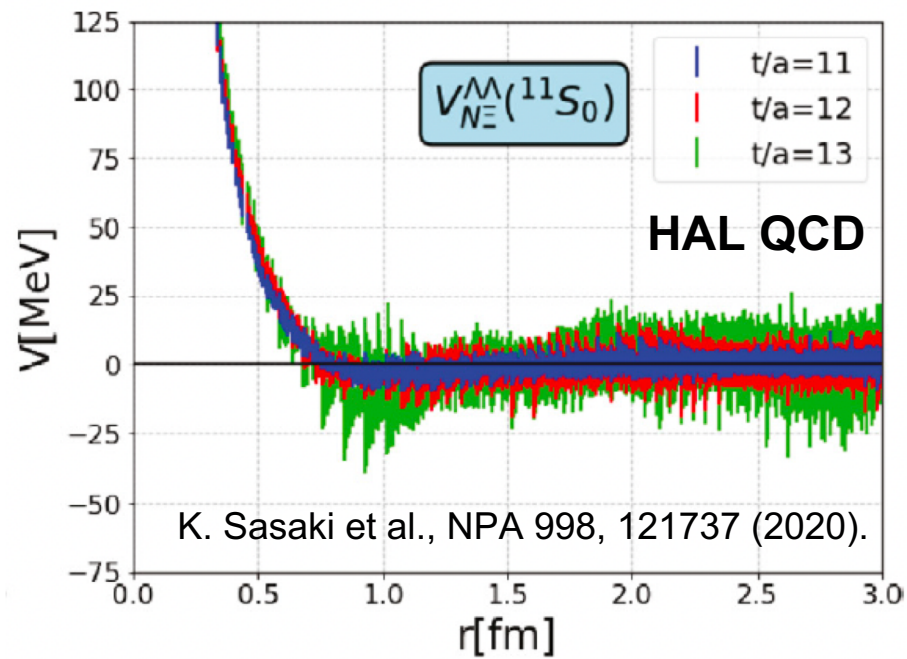
Convolved by Voigt ($\Gamma \neq 0$)



QF function

$$h(B'_{\Xi}) = C \sqrt{B'_{\Xi}} \exp(\alpha B'_{\Xi} + \beta B'^2_{\Xi})$$

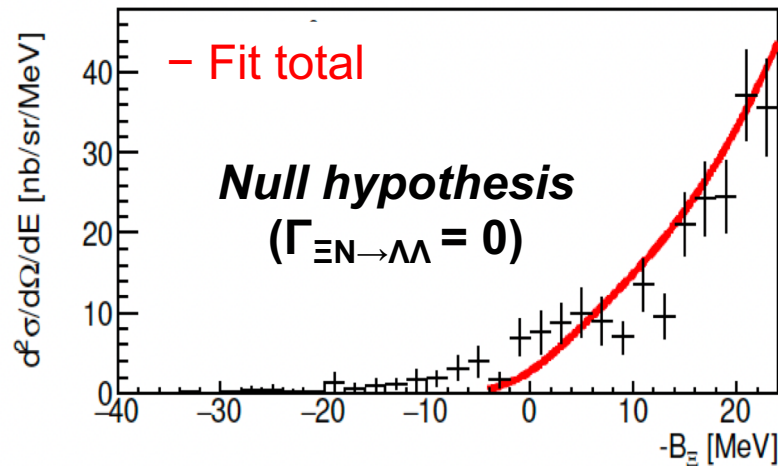




Almost 0 except for short range part
 $\rightarrow$ ΞN - $\Lambda\Lambda$ coupling is weak at low energy

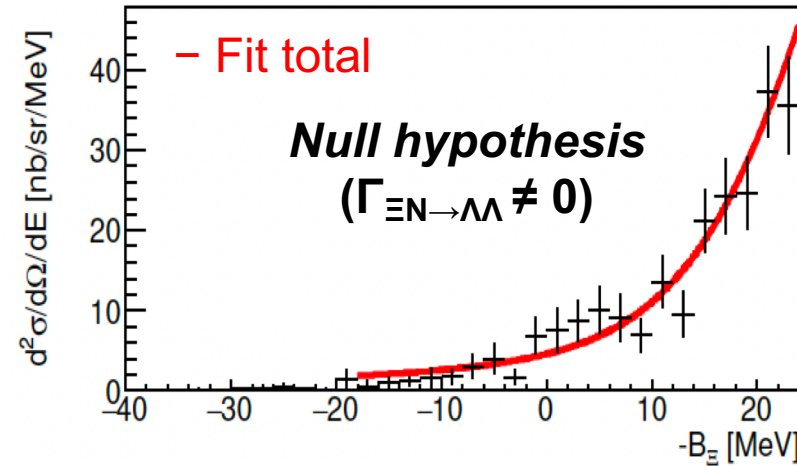
Convolved by Gaus ($\Gamma = 0$)

(d) QF($\Gamma = 0$)



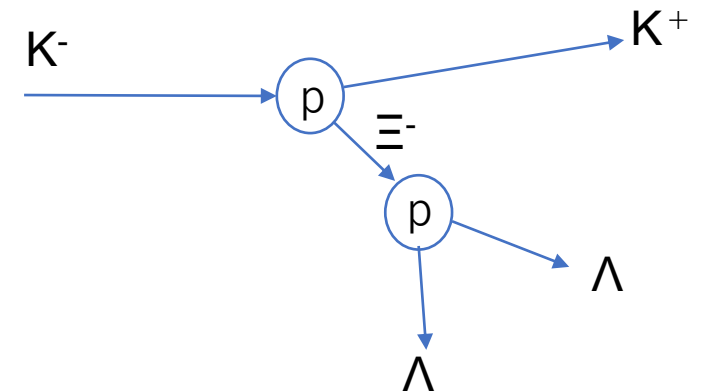
Convolved by Voigt ($\Gamma \neq 0$)

(e) QF($\Gamma \neq 0$)



QF function

$$h(B'_{\Xi}) = C \sqrt{B'_{\Xi}} \exp(\alpha B'_{\Xi} + \beta B'^2_{\Xi})$$

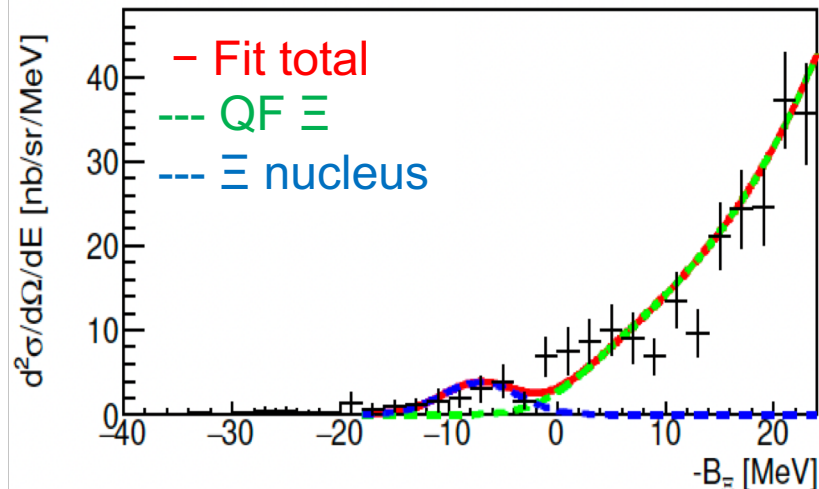


Results with Ξ -hypernucleus (1 state)

Model	Function	Assumption
(a)	QF($\Gamma = 0$) + 1 Gaus	1 state with negligible $\Gamma_{\Xi N \rightarrow \Lambda \Lambda}$
(b)	QF($\Gamma = 0$) + 2 Gaus	2 states with negligible $\Gamma_{\Xi N \rightarrow \Lambda \Lambda}$
(c)	QF($\Gamma \neq 0$) + 1 BW	1 state with visible $\Gamma_{\Xi N \rightarrow \Lambda \Lambda}$
(d)	QF($\Gamma = 0$)	Null hypothesis with negligible $\Gamma_{\Xi N \rightarrow \Lambda \Lambda}$
(e)	QF($\Gamma \neq 0$)	Null hypothesis with visible $\Gamma_{\Xi N \rightarrow \Lambda \Lambda}$

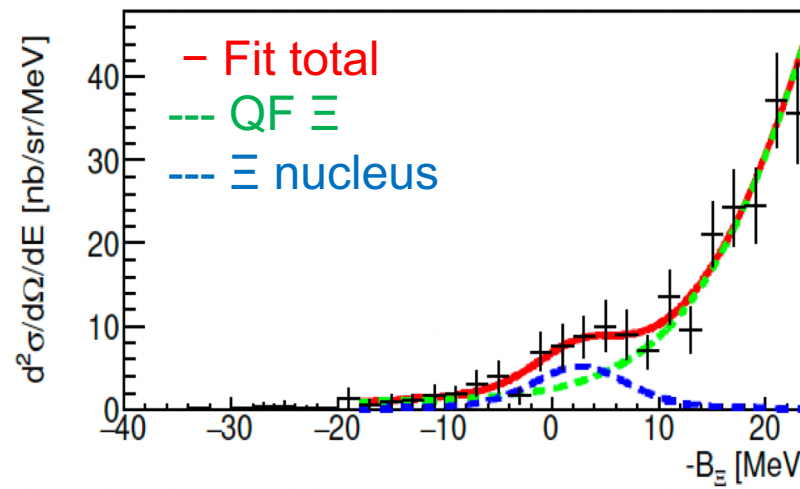
Convolutd by Gaus ($\Gamma = 0$)

(a) QF($\Gamma = 0$) + 1Gaus



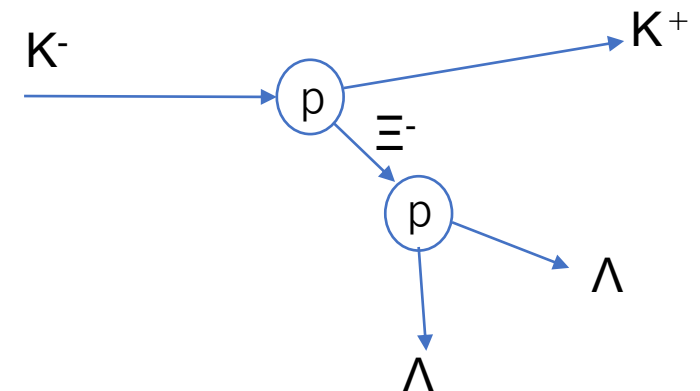
Convolutd by Voigt ($\Gamma \neq 0$)

(c) QF($\Gamma \neq 0$) + 1BW



QF function

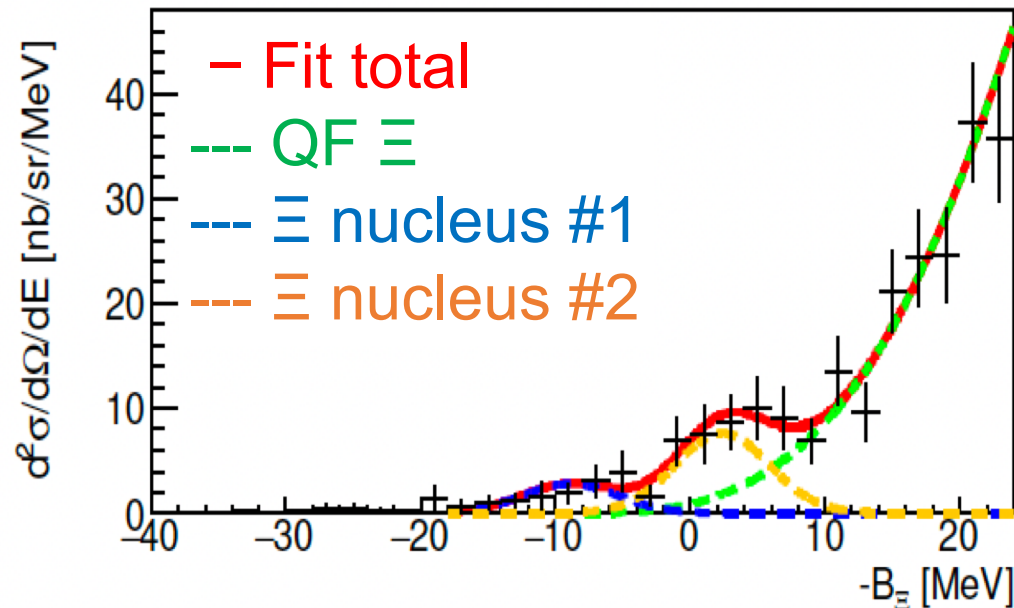
$$h(B'_{\Xi}) = C \sqrt{B'_{\Xi}} \exp(\alpha B'_{\Xi} + \beta B'^2_{\Xi})$$



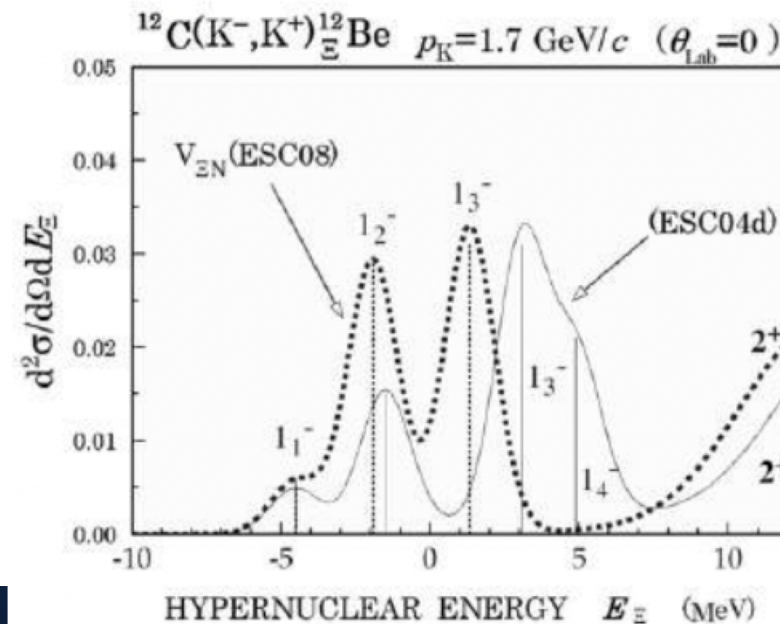
Results with Ξ -hypernucleus (2 states)

Model	Function	Assumption
(a)	QF($\Gamma = 0$) + 1 Gaus	1 state with negligible $\Gamma_{\Xi N \rightarrow \Lambda \Lambda}$
(b)	QF($\Gamma = 0$) + 2 Gaus	2 states with negligible $\Gamma_{\Xi N \rightarrow \Lambda \Lambda}$
(c)	QF($\Gamma \neq 0$) + 1 BW	1 state with visible $\Gamma_{\Xi N \rightarrow \Lambda \Lambda}$
(d)	QF($\Gamma = 0$)	Null hypothesis with negligible $\Gamma_{\Xi N \rightarrow \Lambda \Lambda}$
(e)	QF($\Gamma \neq 0$)	Null hypothesis with visible $\Gamma_{\Xi N \rightarrow \Lambda \Lambda}$

(b) QF($\Gamma = 0$) + 2Gaus



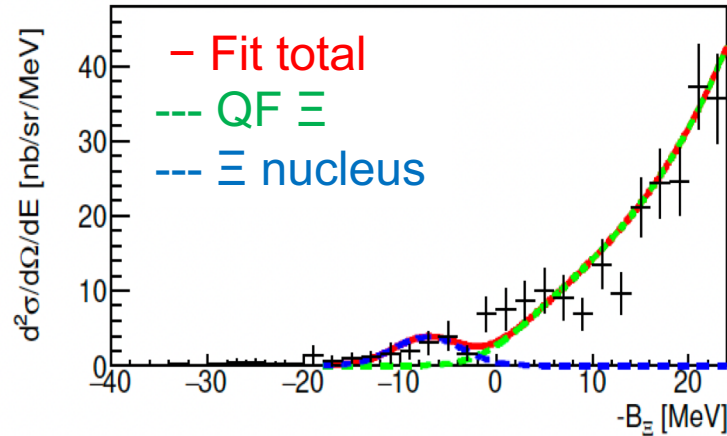
T.Motoba and S.Sugimoto, NPA835 223 (2019).



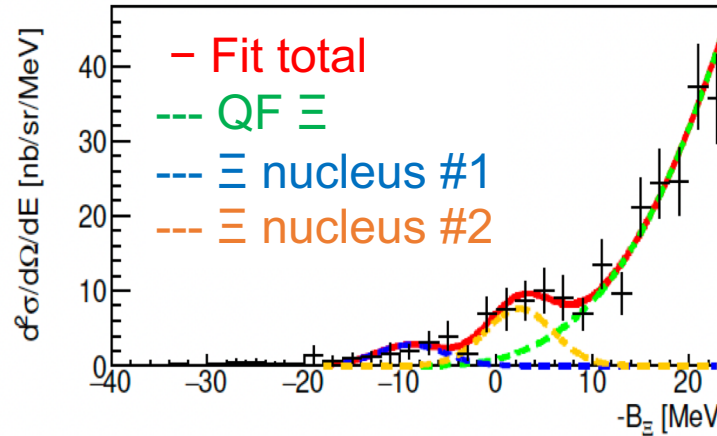
2 or 3 states are predicted due to core ^{11}B excitation and spin-spin (Ξ - ^{11}B) interaction.

Summary of the Spectrum Fitting

(a) QF($\Gamma = 0$) + 1Gaus



(b) QF($\Gamma = 0$) + 2Gaus



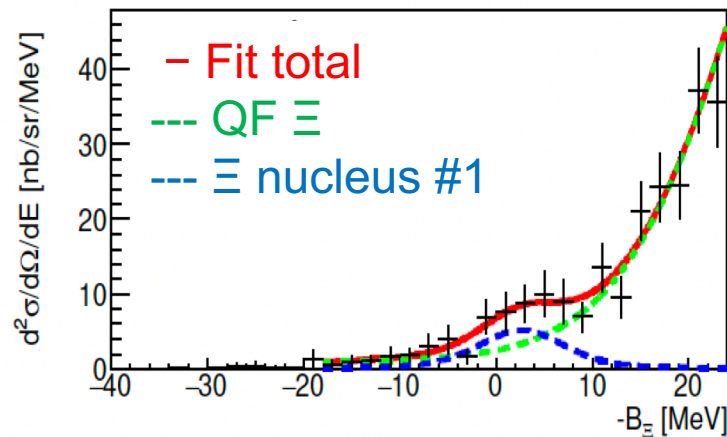
QF function

$$h(B'_\Xi) = C \sqrt{B'_\Xi} \exp(\alpha B'_\Xi + \beta B'^2_\Xi)$$

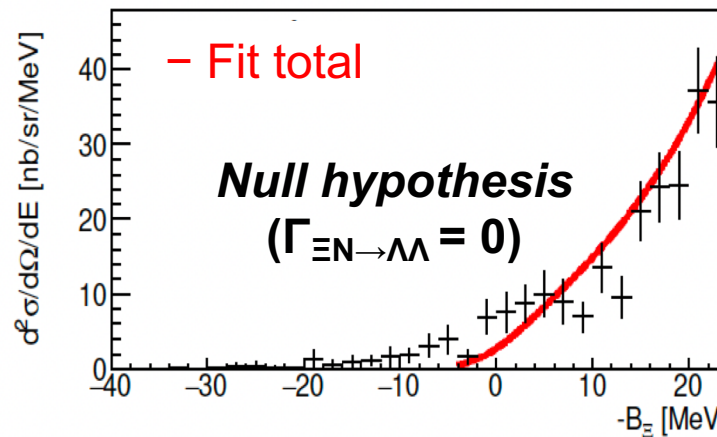


Convolved by Gaus ($\Gamma = 0$)
Convolved by Voigt ($\Gamma \neq 0$)

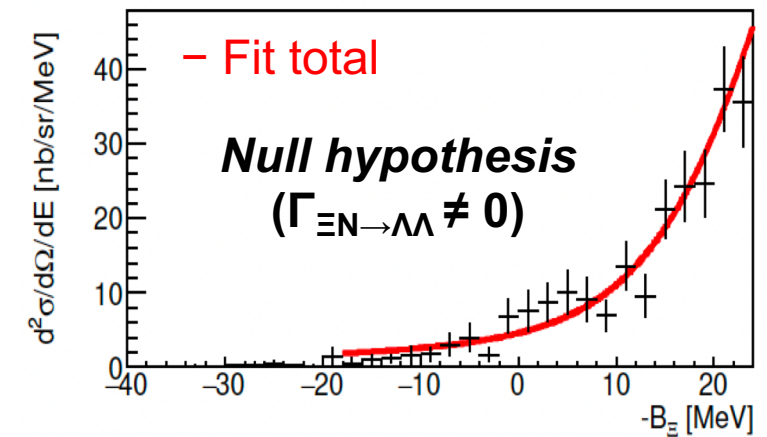
(c) QF($\Gamma \neq 0$) + 1BW



(d) QF($\Gamma = 0$)

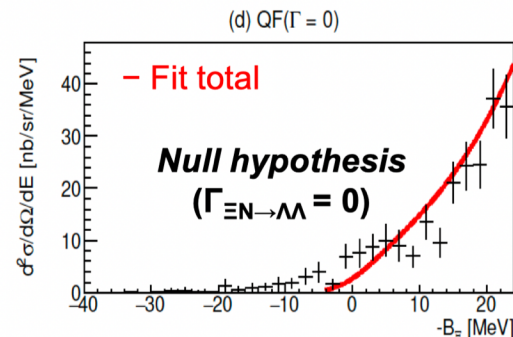
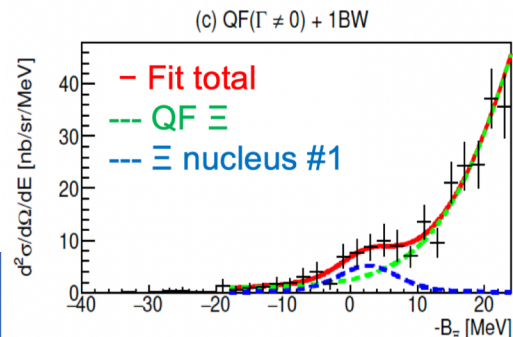
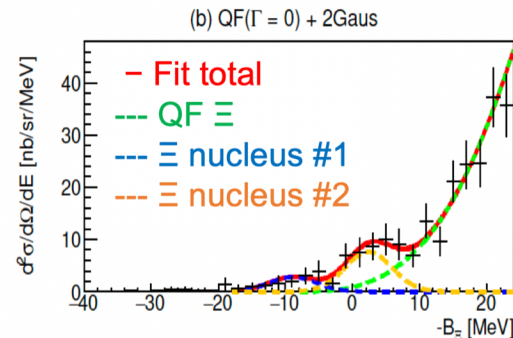
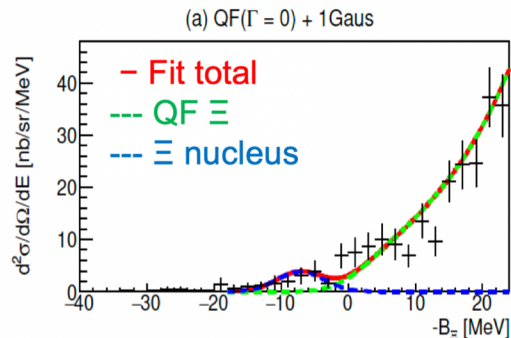


(e) QF($\Gamma \neq 0$)



Summary of the Spectrum Fitting

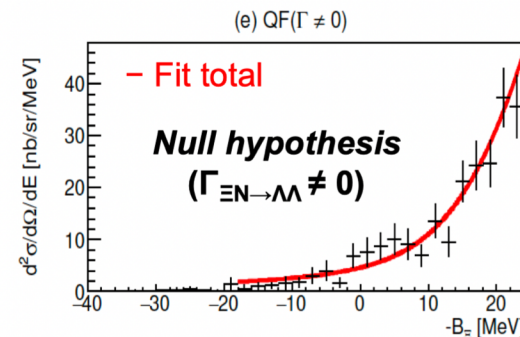
Function	χ^2/ndf (ndf)	P -value	Fitting parameters (MeV)
(a) QF($\Gamma = 0$) + 1Gaus	1.83 (23)	0.00896	$B_{\Xi} = 7.1 \pm 1.5$ (stat.) $^{+2.4}_{-6.1}$ (syst.)
(b) QF($\Gamma = 0$) + 2Gaus	0.849 (22)	0.665	$B_{\Xi}^{1st} = 8.9 \pm 1.4$ (stat.) $^{+3.8}_{-3.1}$ (syst.) $B_{\Xi}^{2nd} = -2.4 \pm 1.3$ (stat.) $^{+2.8}_{-1.2}$ (syst.)
(c) QF($\Gamma \neq 0$) + 1BW	0.954 (23)	0.524	$B_{\Xi} = -2.7 \pm 2.2$ (stat.) $^{+0.5}_{-0.7}$ (syst.) $\Gamma = 4.1 \pm 2.1$ (stat.) $^{+1.2}_{-0.7}$ (syst.)
(d) QF($\Gamma = 0$)	2.49 (19)	0.000332	
(e) QF($\Gamma \neq 0$)	1.39 (25)	0.0914	$\Gamma = 8.7 \pm 1.1$ (stat.)



QF function

$$h(B'_{\Xi}) = C \sqrt{B'_{\Xi}} \exp(\alpha B'_{\Xi} + \beta B_{\Xi}^2)$$

Convolved by Gaus ($\Gamma = 0$)
Convolved by Voigt ($\Gamma \neq 0$)



$B_{\Xi}^{\text{Theory}} = 8.4$ MeV
($\Gamma = 0.89$ MeV)
E. Friedman and A. Gal,
PLB 820, 136555 (2021).

Further experiments of E05 at J-PARC

E05: **Inclusive** $^{12}\text{C}(\text{K}^-, \text{K}^+)$
with SKS (**8 MeV** (FWHM))

*Decay particle
measurement*

Resolution improvement

E42: **Exclusive**
 $^{12}\text{C}(\text{K}^-, \text{K}^+ \Xi^-)$, $^{12}\text{C}(\text{K}^-, \text{K}^+ \Lambda\Lambda)$
with HypTPC (35 MeV (FWHM))

E70: **Inclusive** $^{12}\text{C}(\text{K}^-, \text{K}^+)$
with S-2S (**4(2) MeV** (FWHM))

J-PARC E42 experiment

PTEP

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DOI: 10.1093/ptep/ptaf064

Cross Section Measurements for $^{12}\text{C}(K^-, K^+ \Xi^-)$ and $^{12}\text{C}(K^-, K^+ \Lambda\Lambda)$ Reactions at 1.8 GeV/c

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Exclusive
 $^{12}\text{C}(K^-, K^+ \Xi^-)$, $^{12}\text{C}(K^-, K^+ \Lambda\Lambda)$

WooSeung Jung *et al.*, PTEP 2025 9, ptaf064 (2025).

Oct 1, PM 5:05~

Wooseung Jung (Kobayashi-hall)

E42



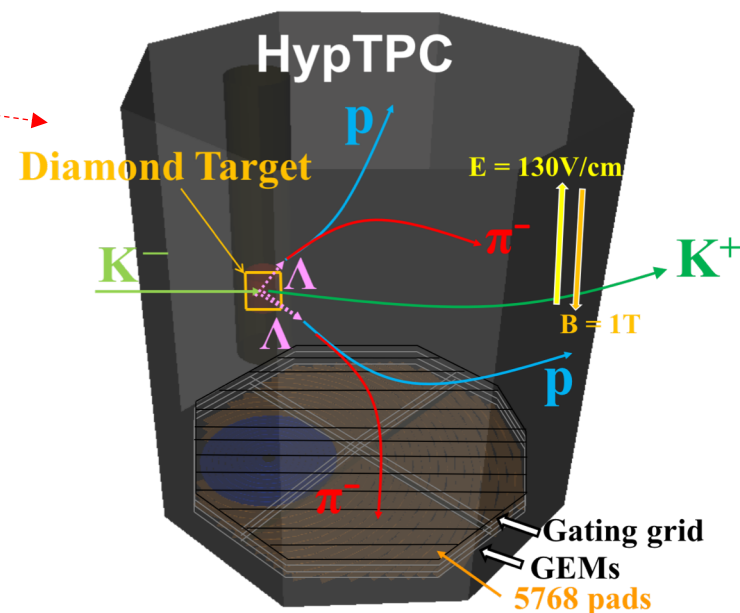
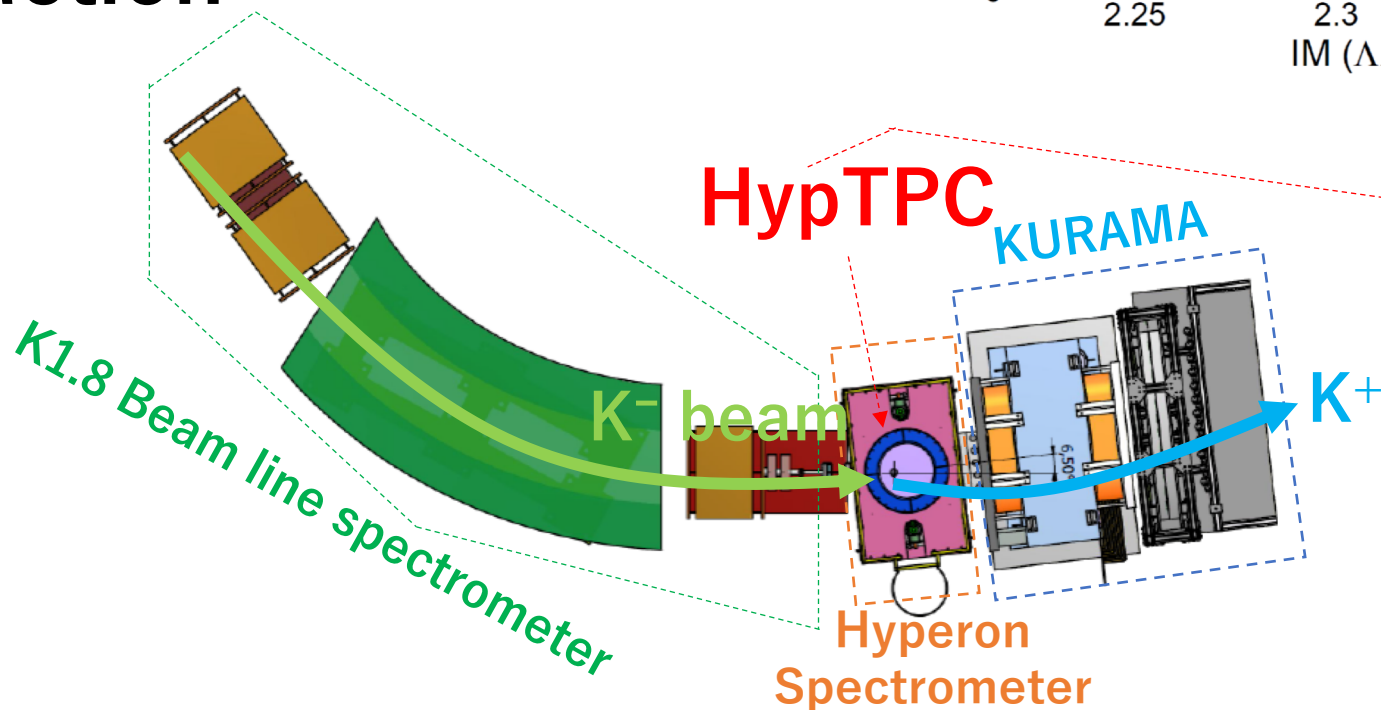
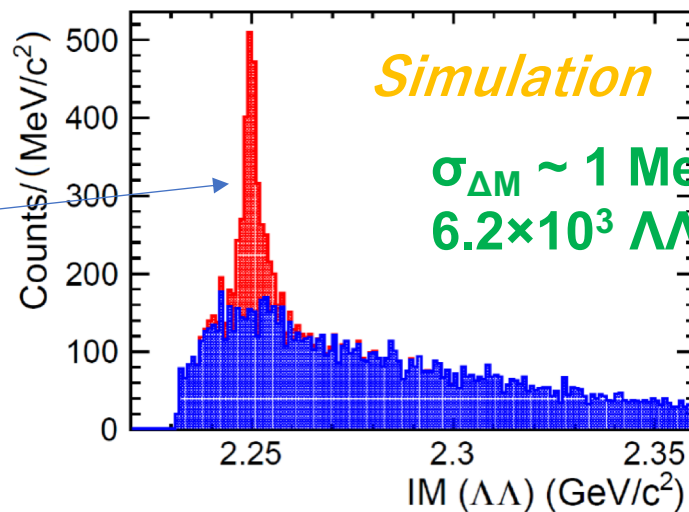
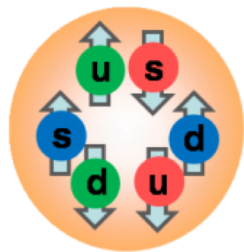
J-PARC E42 (H-dibaryon search)

$K^- + \text{"pp"} \rightarrow H K^+, H \rightarrow \Lambda\Lambda, \Lambda p \pi^-, \Xi^- p$ (Invariant-mass spectroscopy)

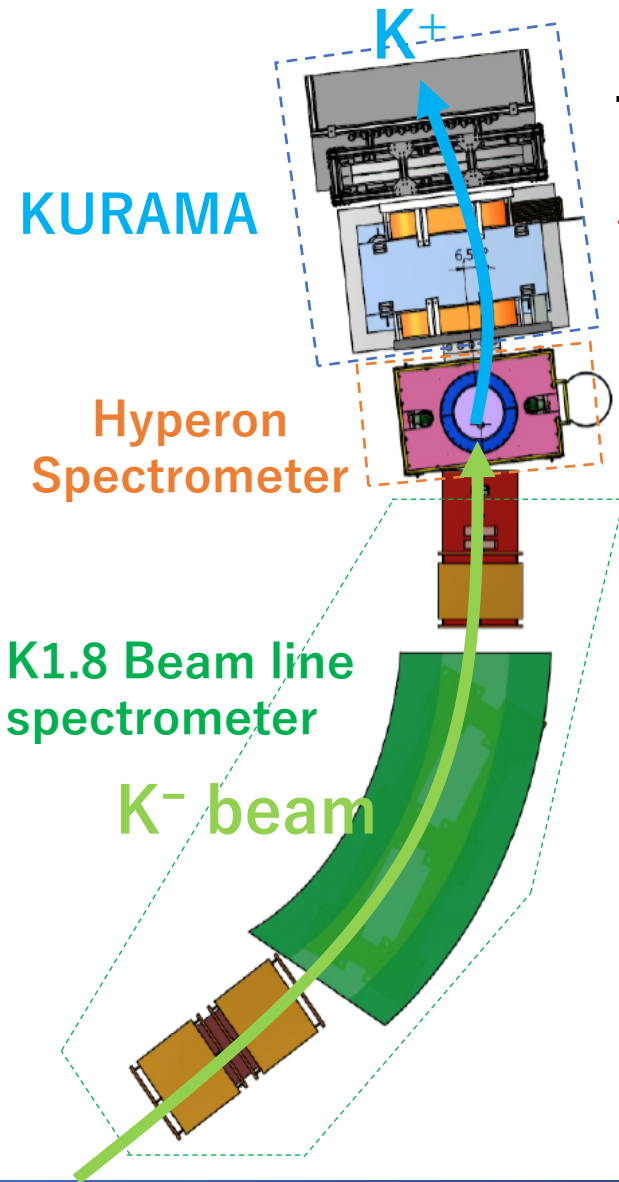
Completed
June 29, 2021

$^{12}\text{C}(K^-, K^+)$
reaction

H-dibaryon



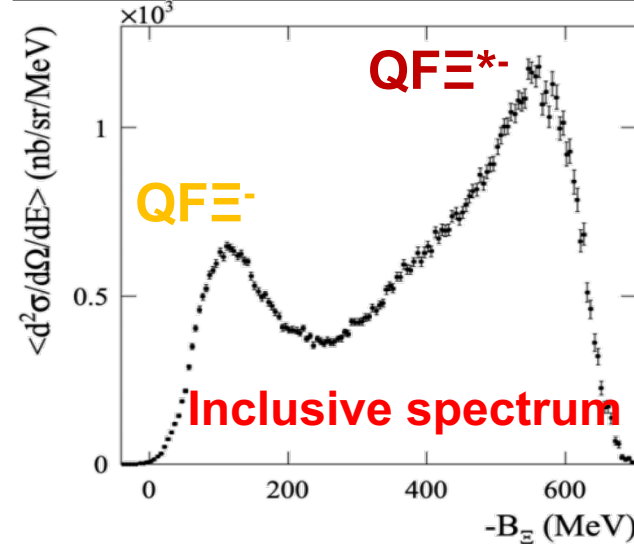
E42 byproduct: $^{12}\text{C}(\text{K}^-, \text{K}^+ \Xi^-)$, $^{12}\text{C}(\text{K}^-, \text{K}^+ \Lambda\Lambda)$



E42 can **decompose** $^{12}\text{C}(\text{K}^-, \text{K}^+)$ inclusive spectrum to Ξ^- escape/ $\Xi^- p \rightarrow \Lambda\Lambda$ conversion spectra

→ **Sensitive to $W_0 \Xi^-$ (Im) !!**

$^{12}\text{C}(\text{K}^-, \text{K}^+)$ inclusive spectrum



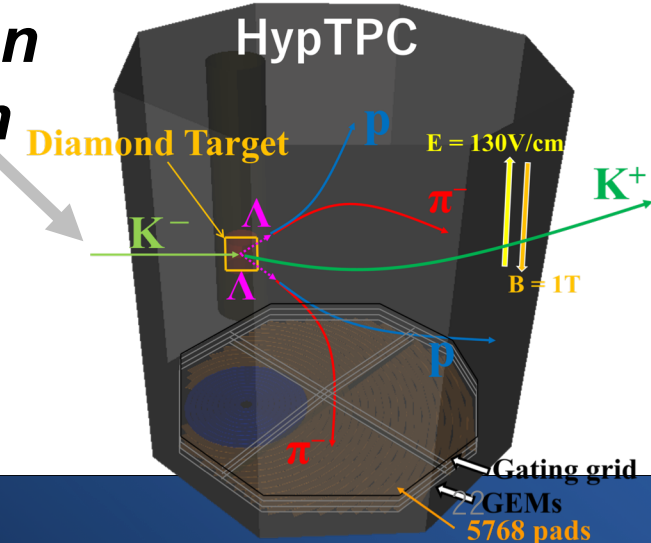
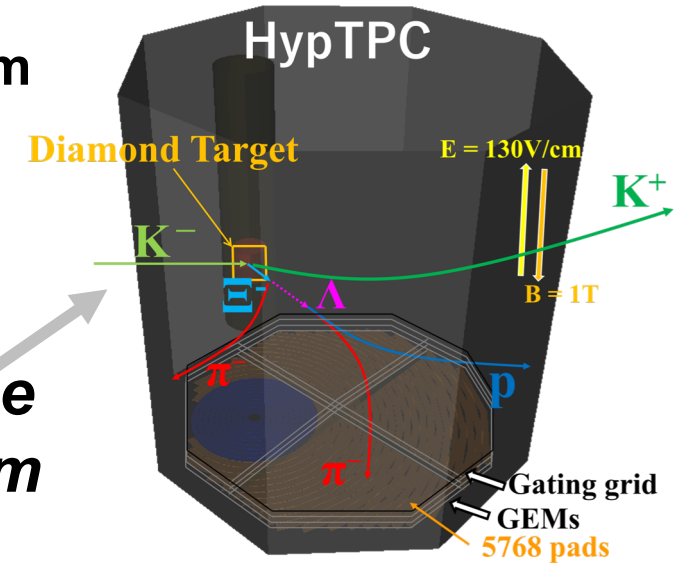
QF Ξ^- : $\text{K}^- \text{ "p"} \rightarrow \Xi^- \text{K}^+$

QF Ξ^{*-} : $\text{K}^- \text{ "p"} \rightarrow \Xi^*(1535) \text{K}^+$

$\text{K}^- \text{ "p"} \rightarrow \Xi \pi \text{K}^+$

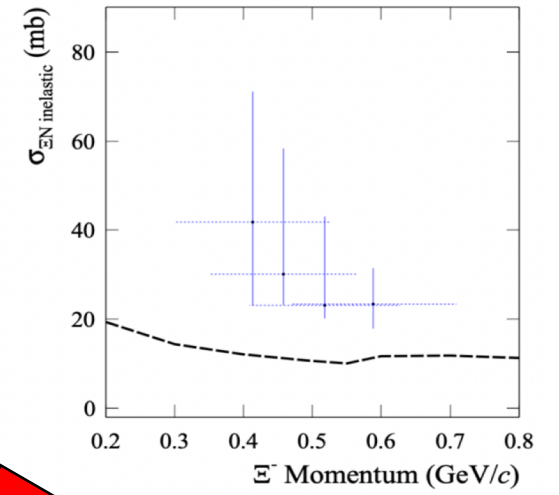
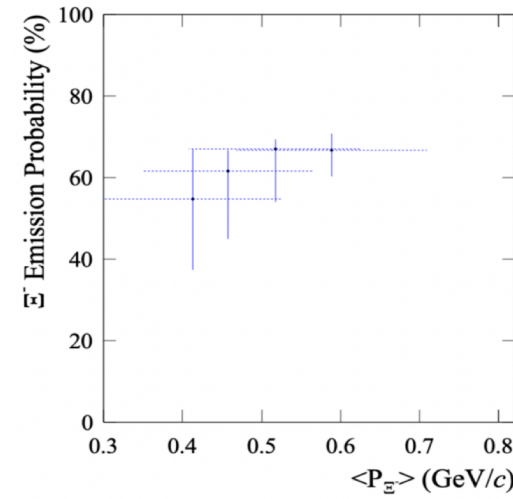
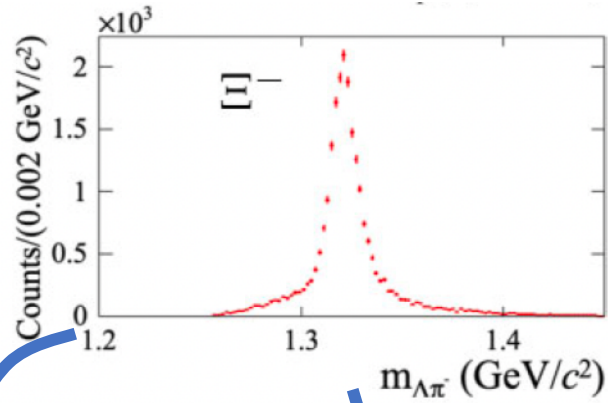
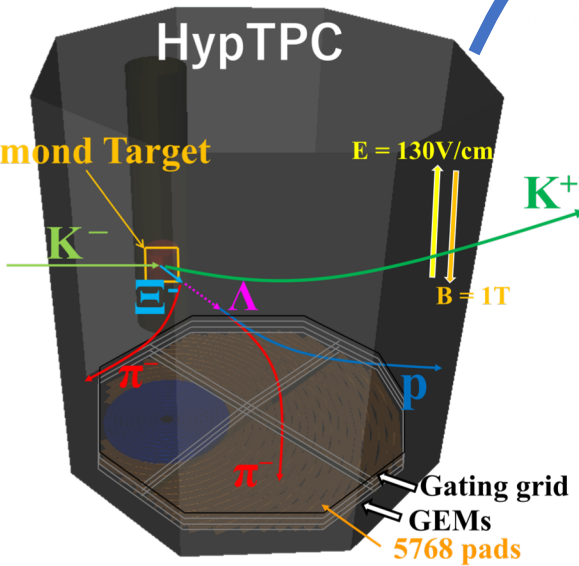
Ξ^- escape spectrum

$\Xi^- p \rightarrow \Lambda\Lambda$ conversion spectrum

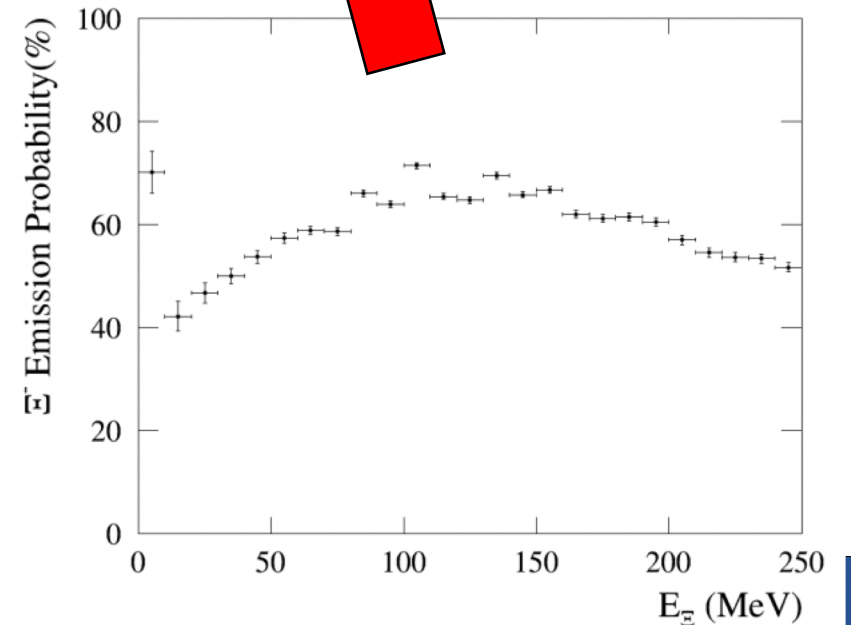
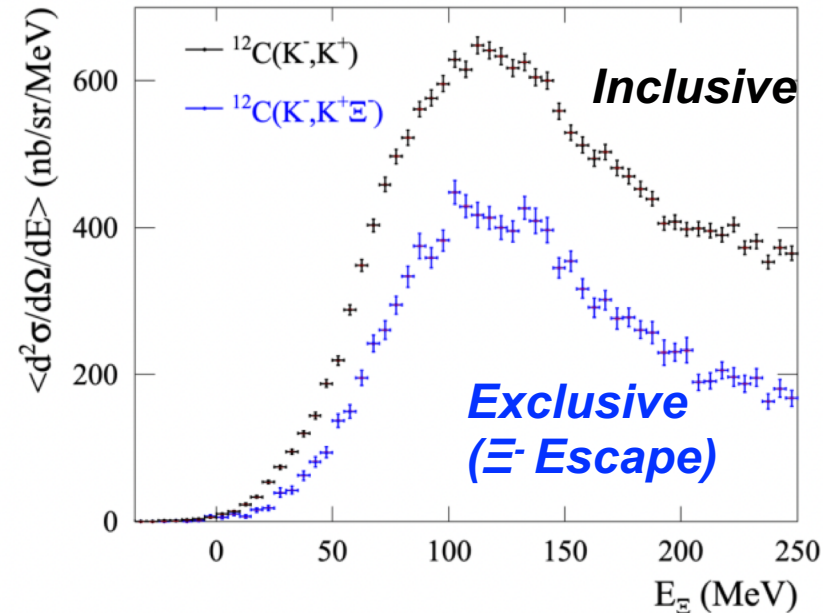


$^{12}\text{C}(\text{K}^-, \text{K}^+ \Xi^-)$: Escape Ξ^-

Ξ^- escape

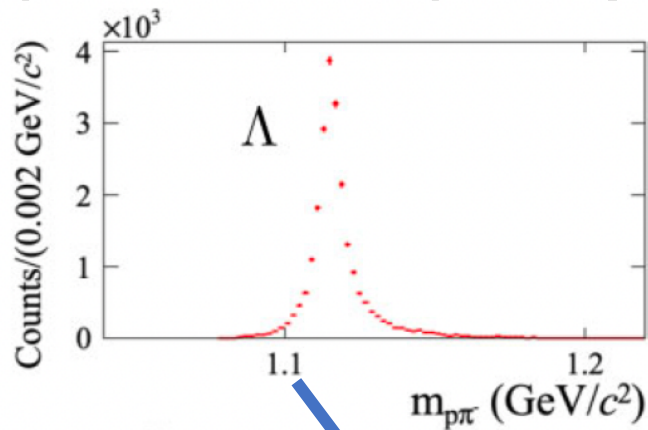
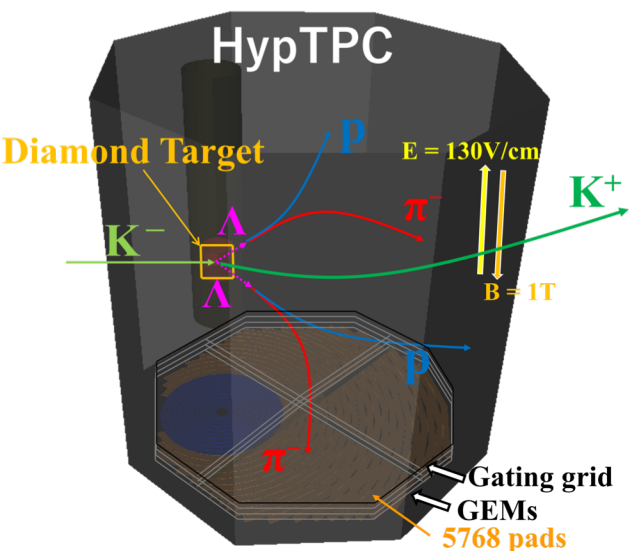


$$N_{\Xi N} = \int_0^\infty 2\pi b db \int_{-\infty}^{+\infty} dz \rho(\sqrt{b^2 + z^2}) F(b, z) \left[1 - \exp \left\{ -\bar{\sigma}_{\Xi N} \int_z^{+\infty} dz' \rho(\sqrt{b^2 + z'^2}) \right\} \right]$$

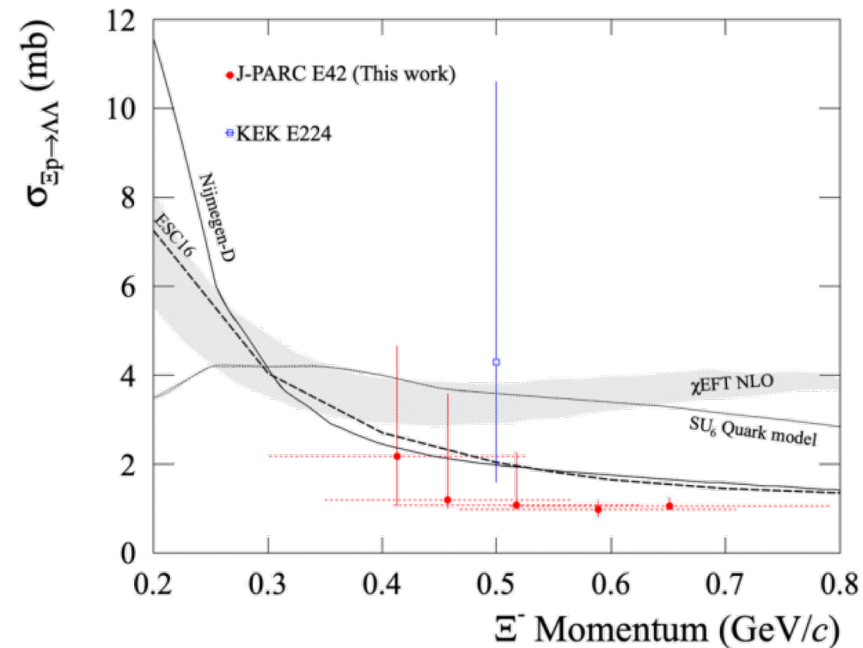
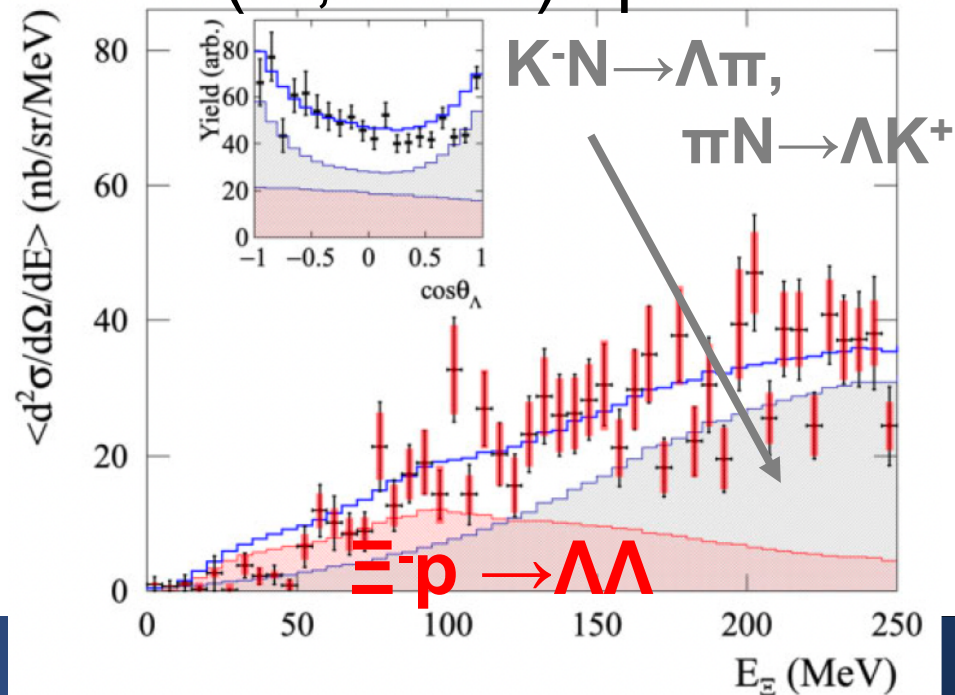


$^{12}\text{C}(\text{K}^-, \text{K}^+ \Lambda \Lambda): \Xi^- p \rightarrow \Lambda \Lambda$ conversion

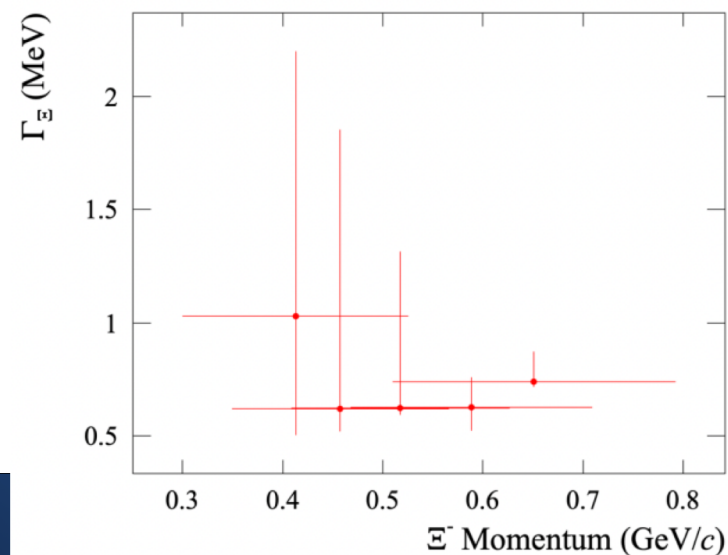
Λ conversion



$^{12}\text{C}(\text{K}^-, \text{K}^+ \Lambda \Lambda)$ spectrum

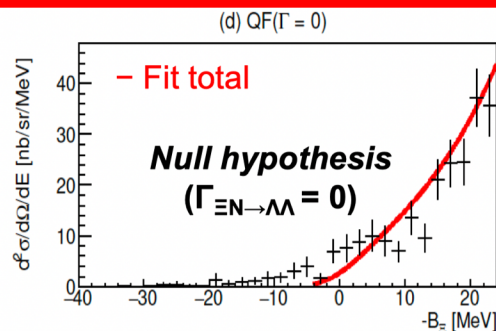
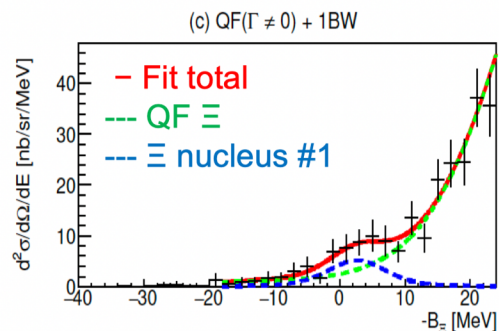
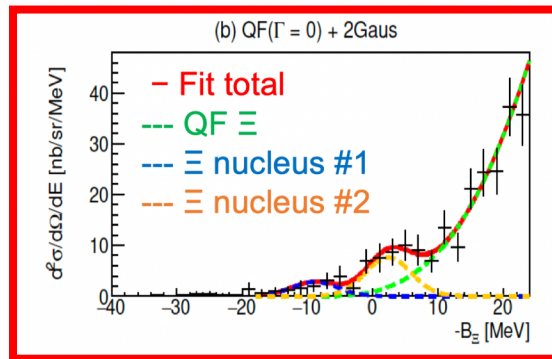
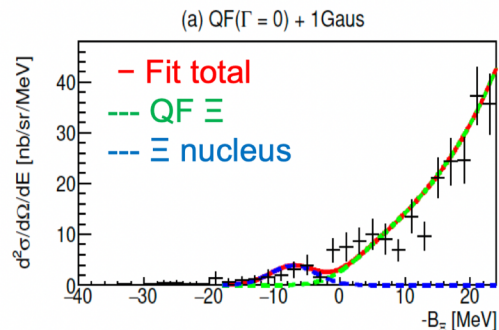


$$\Gamma_{\Xi} \approx (v\sigma)_{\Xi^- p \rightarrow \Lambda \Lambda} \cdot (\rho_0/2)$$



Feedback to E05 result

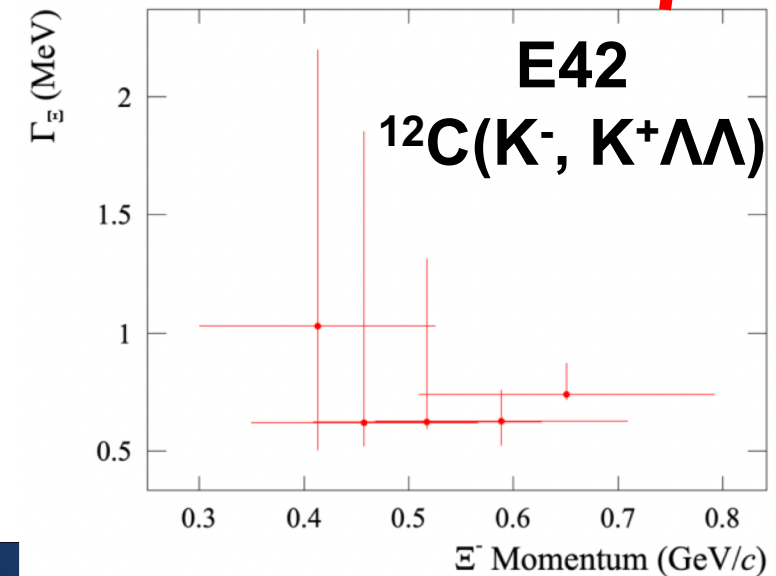
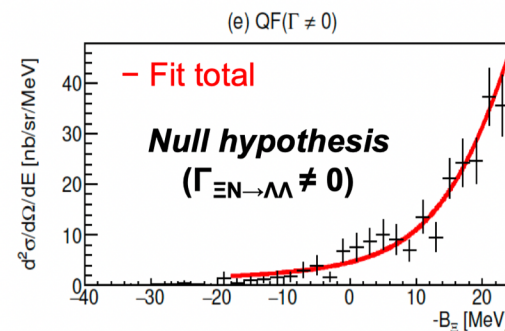
Function	χ^2/ndf (ndf)	P -value	Fitting parameters (MeV)
(a) QF($\Gamma = 0$) + 1Gaus	1.83 (23)	0.00896	$B_{\Xi} = 7.1 \pm 1.5$ (stat.) $^{+2.4}_{-6.1}$ (syst.)
(b) QF($\Gamma = 0$) + 2Gaus	0.849 (22)	0.665	$B_{\Xi}^{1st} = 8.9 \pm 1.4$ (stat.) $^{+3.8}_{-3.1}$ (syst.) $B_{\Xi}^{2nd} = -2.4 \pm 1.3$ (stat.) $^{+2.8}_{-1.2}$ (syst.)
(c) QF($\Gamma \neq 0$) + 1BW	0.954 (23)	0.524	$B_{\Xi} = -2.7 \pm 2.2$ (stat.) $^{+0.5}_{-0.7}$ (syst.) $\Gamma = 4.1 \pm 2.1$ (stat.) $^{+1.2}_{-0.7}$ (syst.)
(d) QF($\Gamma = 0$)	2.49 (19)	0.000332	
(e) QF($\Gamma \neq 0$)	1.39 (25)	0.0914	$\Gamma = 8.7 \pm 1.1$ (stat.)



QF function

$$h(B'_{\Xi}) = C \sqrt{B'_{\Xi}} \exp(\alpha B'_{\Xi} + \beta B'^2_{\Xi})$$

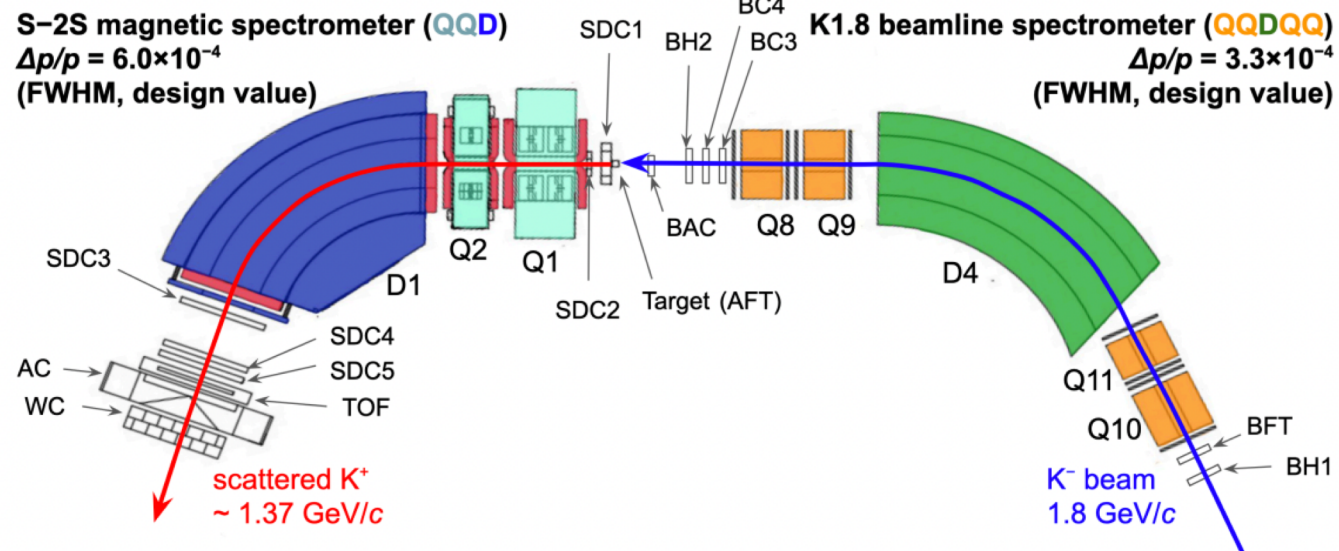
Convolved by Gaus ($\Gamma = 0$)
Convolved by Voigt ($\Gamma \neq 0$)



Further experiments of E05 at J-PARC

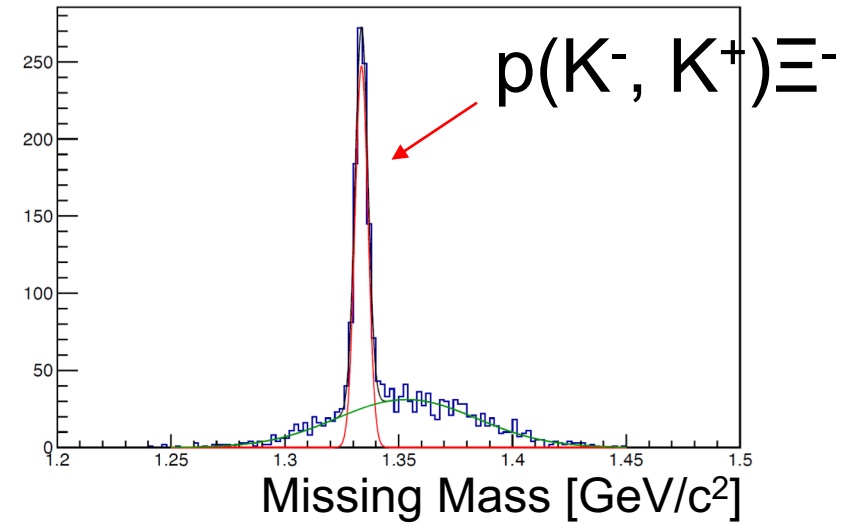
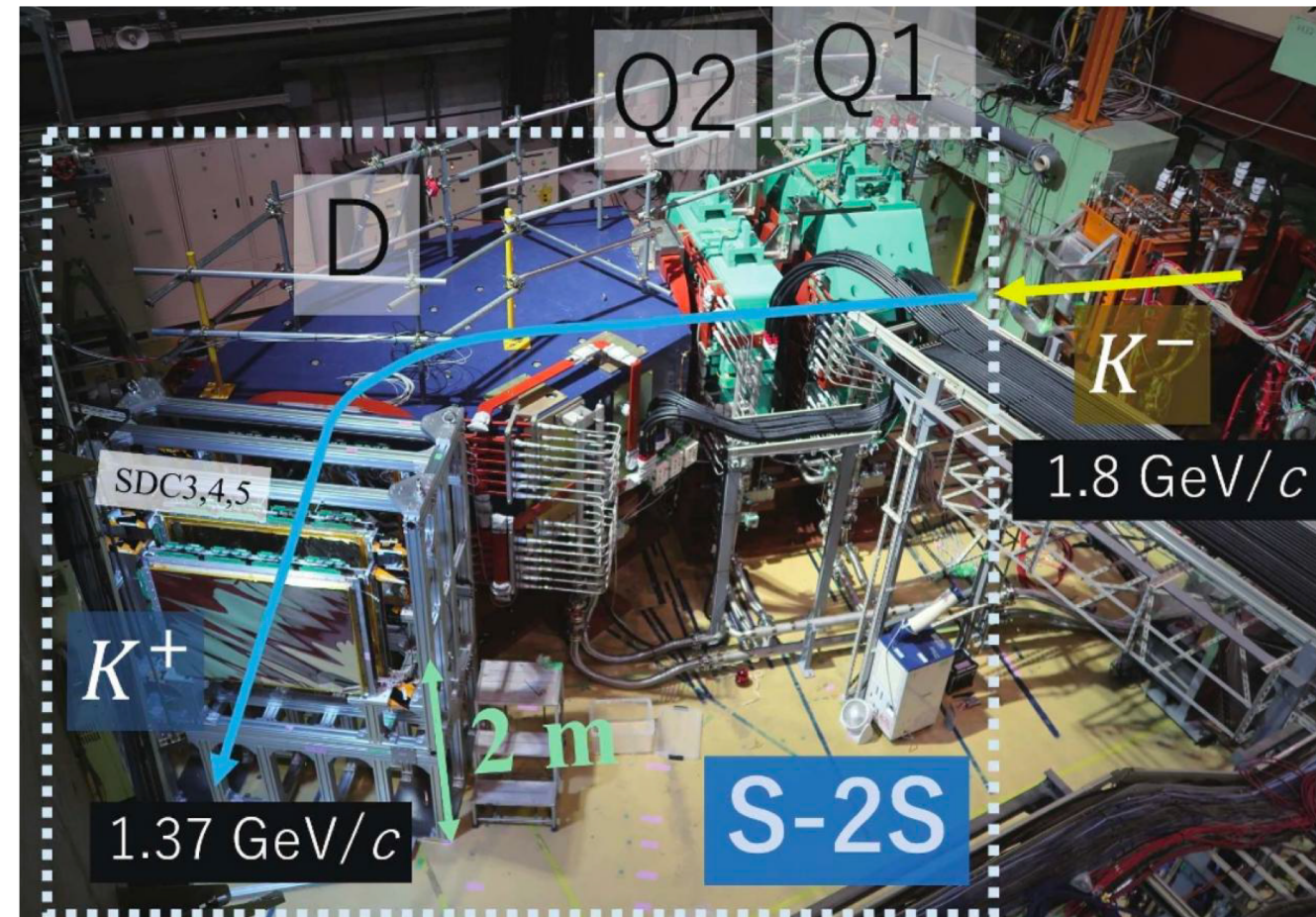
**E05: Inclusive $^{12}\text{C}(\text{K}^-, \text{K}^+)$
with SKS (8 MeV (FWHM))**

Resolution improvement



**E70: Inclusive $^{12}\text{C}(\text{K}^-, \text{K}^+)$
with S-2S (4(2) MeV (FWHM))**

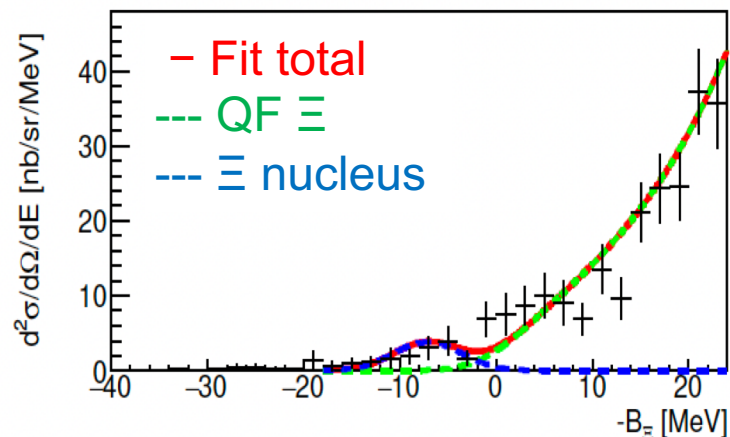
E70: Inclusive $^{12}\text{C}(\text{K}^-, \text{K}^+)$ with S-2S (4(2) MeV (FWHM))



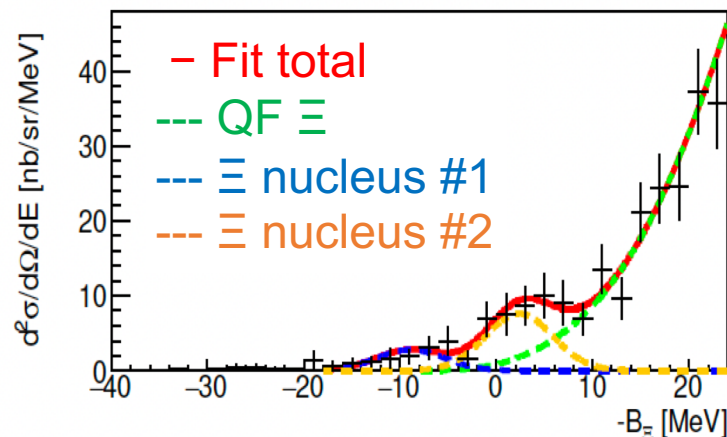
Completed in May 2025

E05 Spectrum Fitting

(a) QF($\Gamma = 0$) + 1Gaus



(b) QF($\Gamma = 0$) + 2Gaus



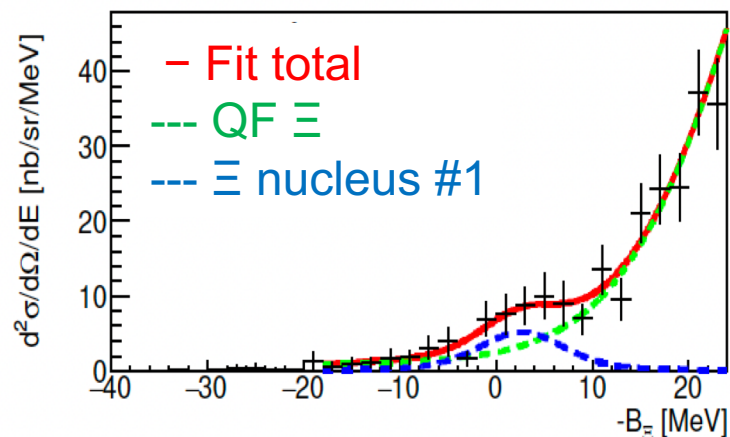
QF function

$$h(B'_\Xi) = C \sqrt{B'_\Xi} \exp(\alpha B'_\Xi + \beta B'^2_\Xi)$$

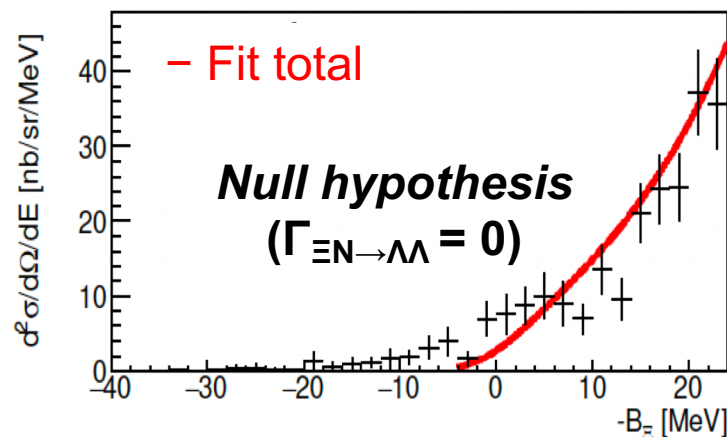


Convolved by Gaus ($\Gamma = 0$)
Convolved by Voigt ($\Gamma \neq 0$)

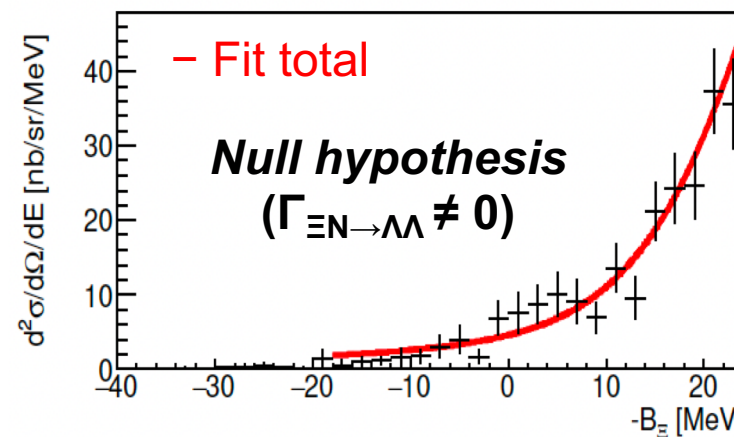
(c) QF($\Gamma \neq 0$) + 1BW



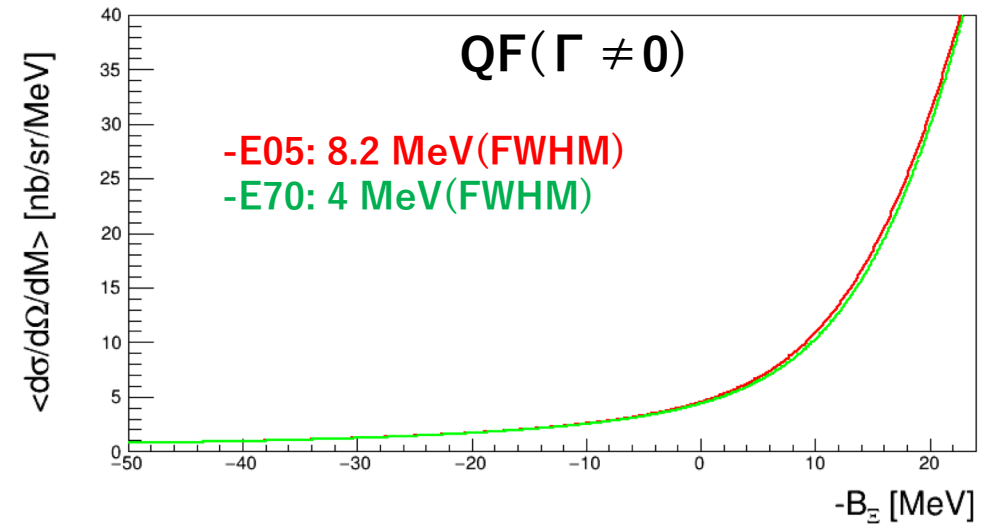
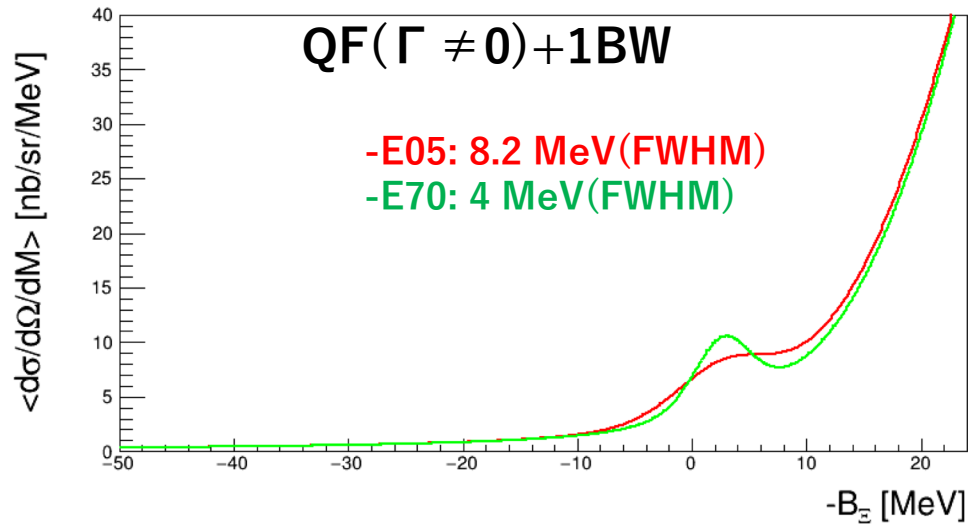
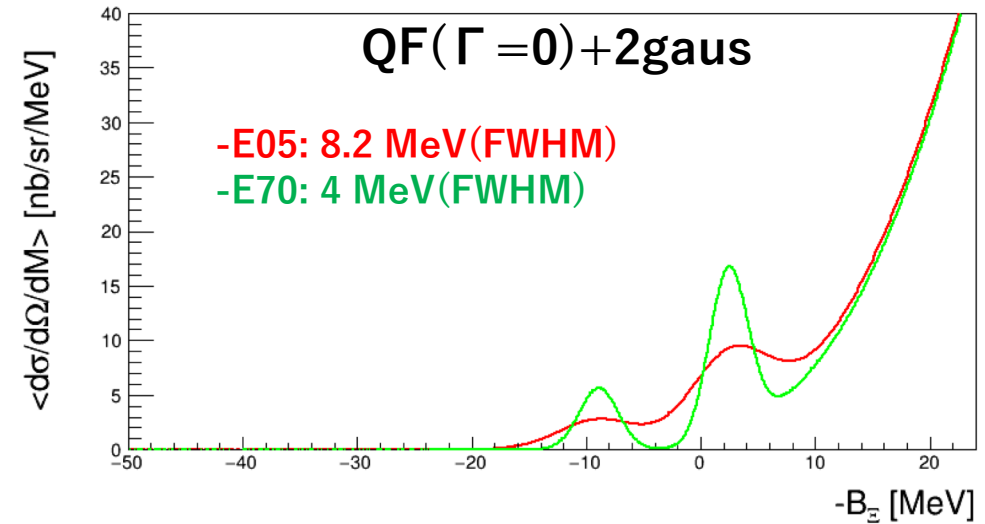
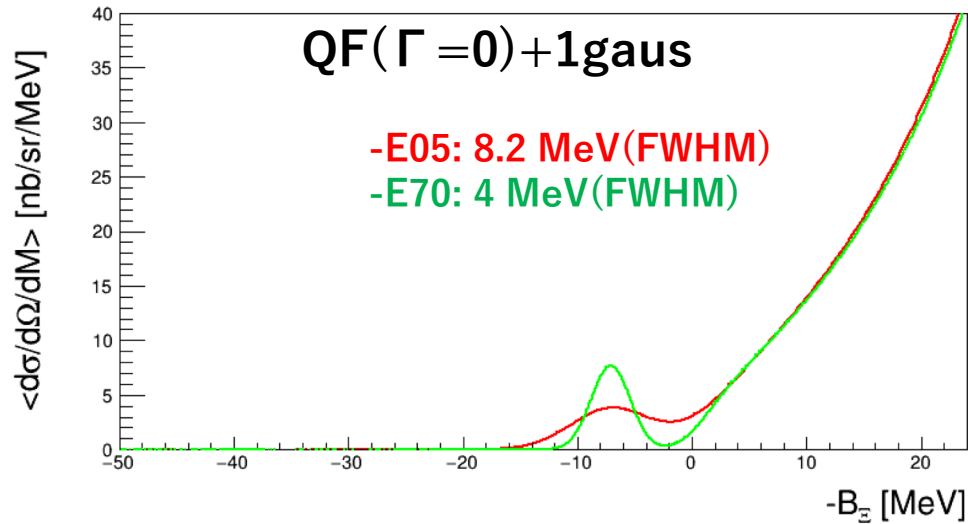
(d) QF($\Gamma = 0$)



(e) QF($\Gamma \neq 0$)

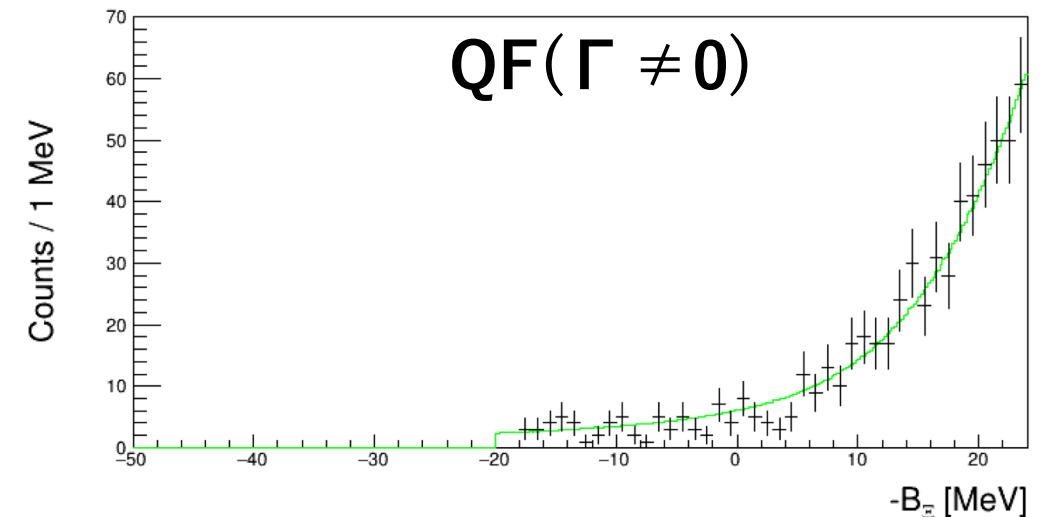
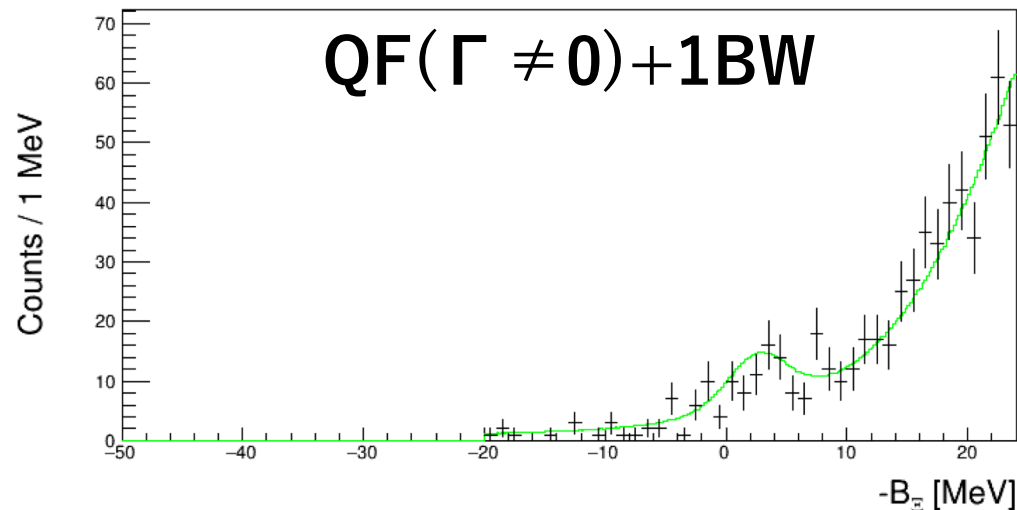
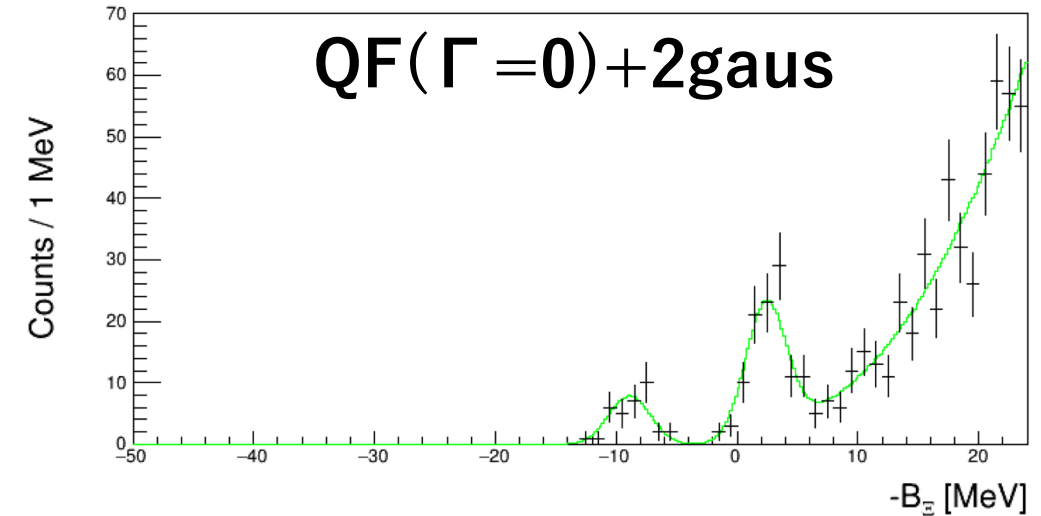
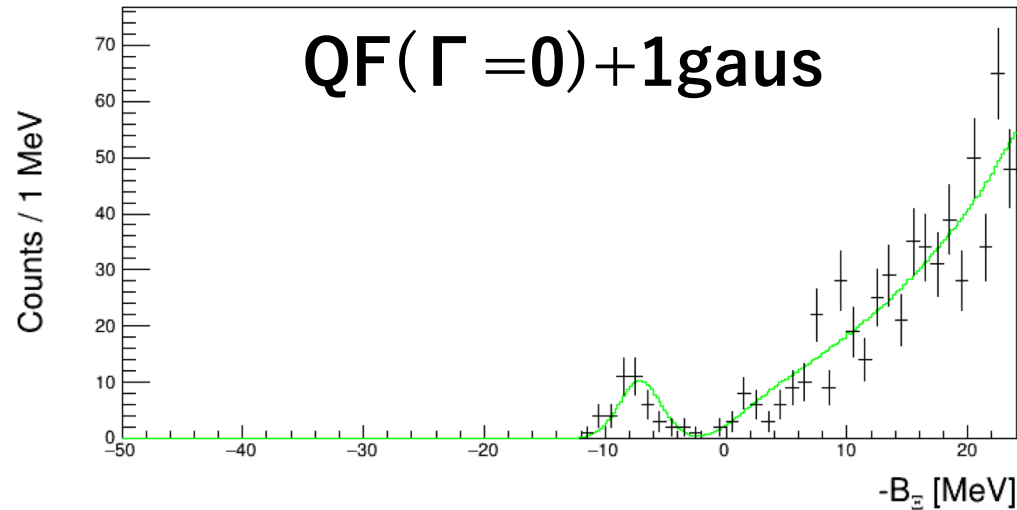


Comparison between E05(8.2 MeV) and E70(4 MeV)



Simulated spectra with E70(4 MeV) condition

Peak structure should be prominent!!

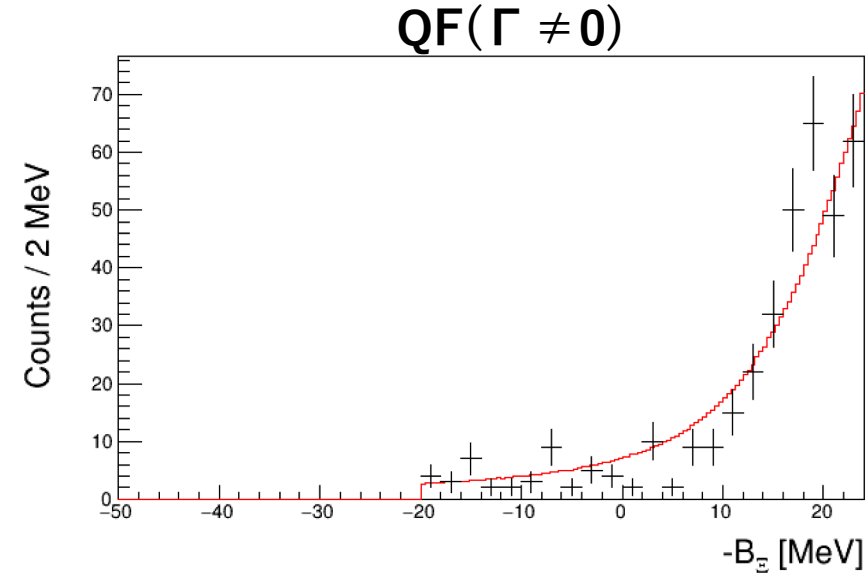
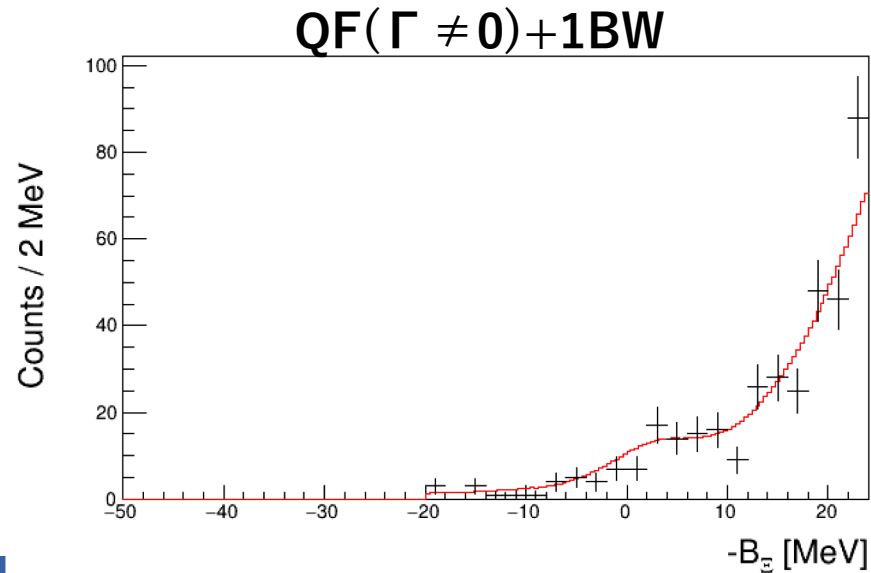
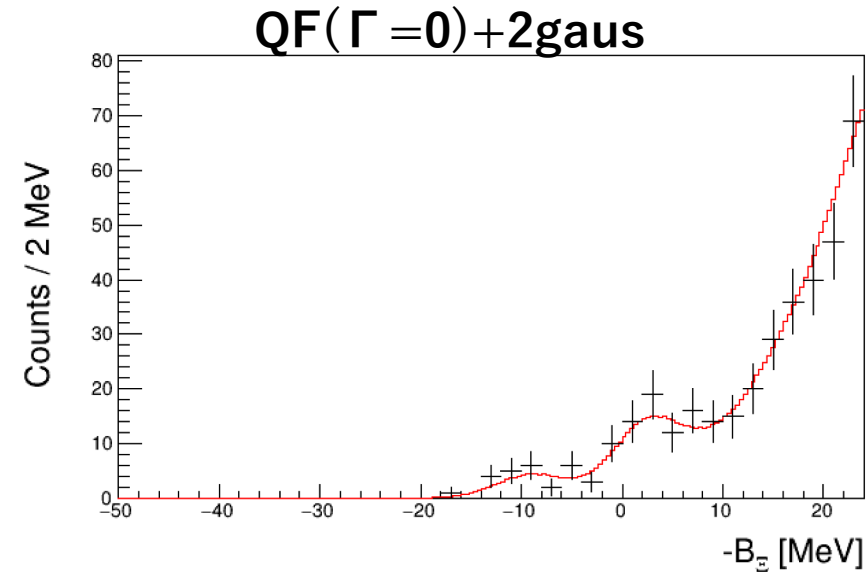
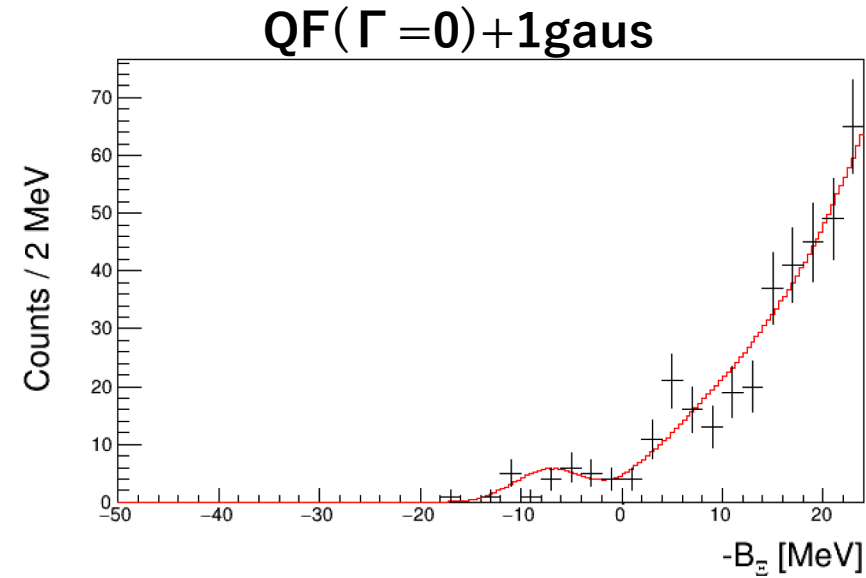


Summary

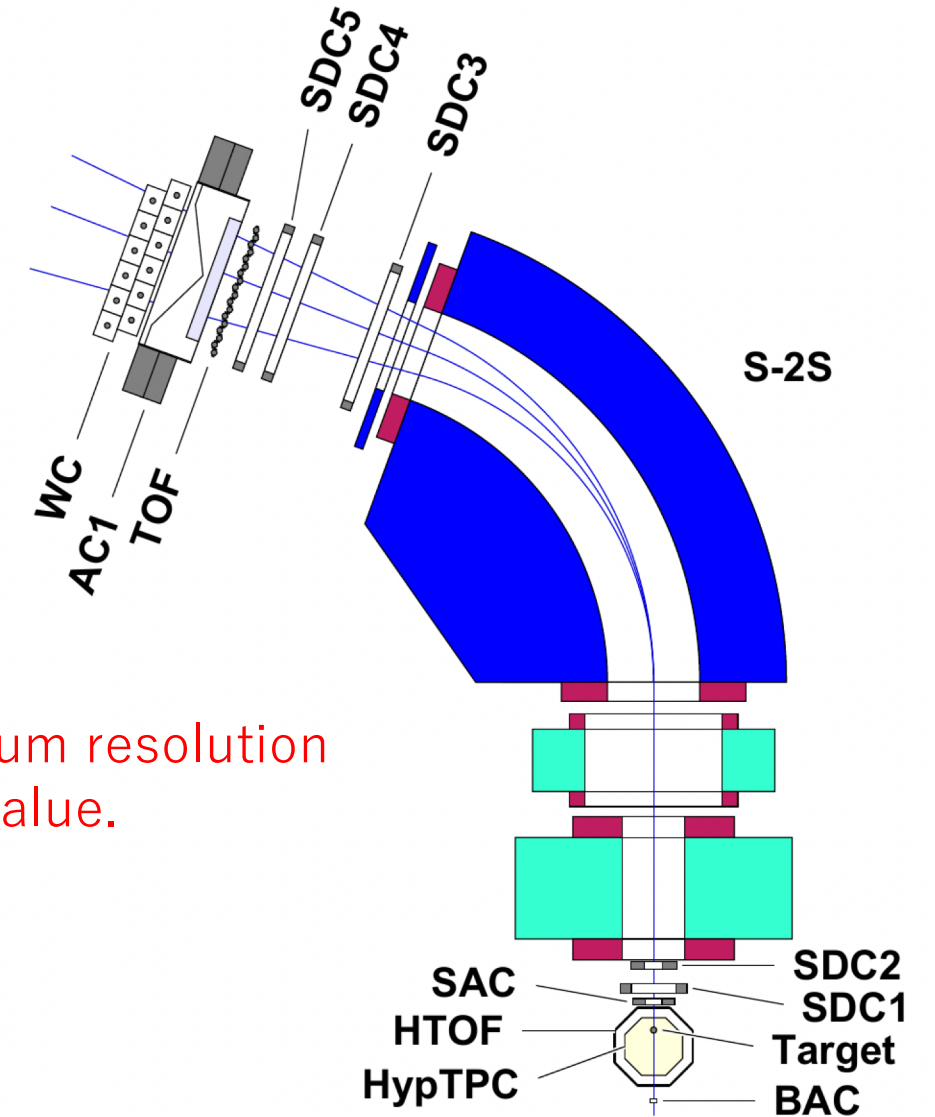
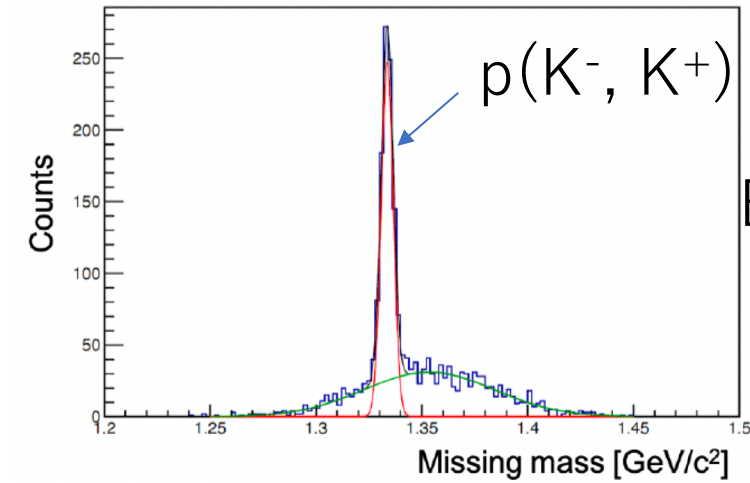
- J-PARC E05: Inclusive $^{12}\text{C}(\text{K}^-, \text{K}^+)$ with 8 MeV (FWHM) resolution
 - We showed the wide energy-range spectrum (Carbon graphite target).
 - We have performed spectrum fitting around the threshold region.
 - (b) $\text{QF}(\Gamma=0) + 2\text{Gaus}$ and (c) $\text{QF}(\Gamma\neq 0) + 1\text{BW}$ are likely.
 - The peak structures will be prominent with E70's resolution, 2MeV.
- J-PARC E42: Exclusive $^{12}\text{C}(\text{K}^-, \text{K}^+\Xi^-)$ and $^{12}\text{C}(\text{K}^-, \text{K}^+\Lambda\Lambda)$ with HypTPC
 - We measured escape Ξ^- and $\Xi^-p \rightarrow \Lambda\Lambda$ conversion spectrum.
 - $\sigma_{\Xi^-p \rightarrow \Lambda\Lambda} \leq 2\text{mb}$ corresponds to $\Gamma_{\Xi} \leq 1\text{ MeV}$.
 - This result favors (b) $\text{QF}(\Gamma=0) + 2\text{Gaus}$ model in E05.
- J-PARC E70: Inclusive $^{12}\text{C}(\text{K}^-, \text{K}^+)$ with 4(2) MeV (FWHM) resolution.
 - With better E70 resolution we should clearly see the Ξ -nucleus peak structures.

Back up

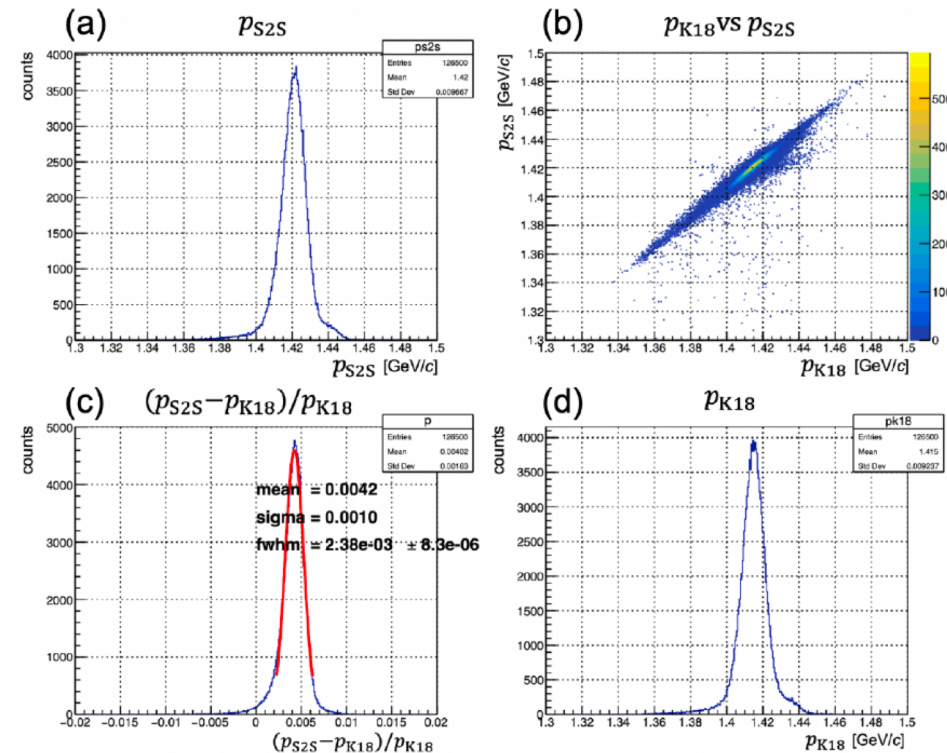
Simulated spectra with **E05(8.2 MeV)** condition



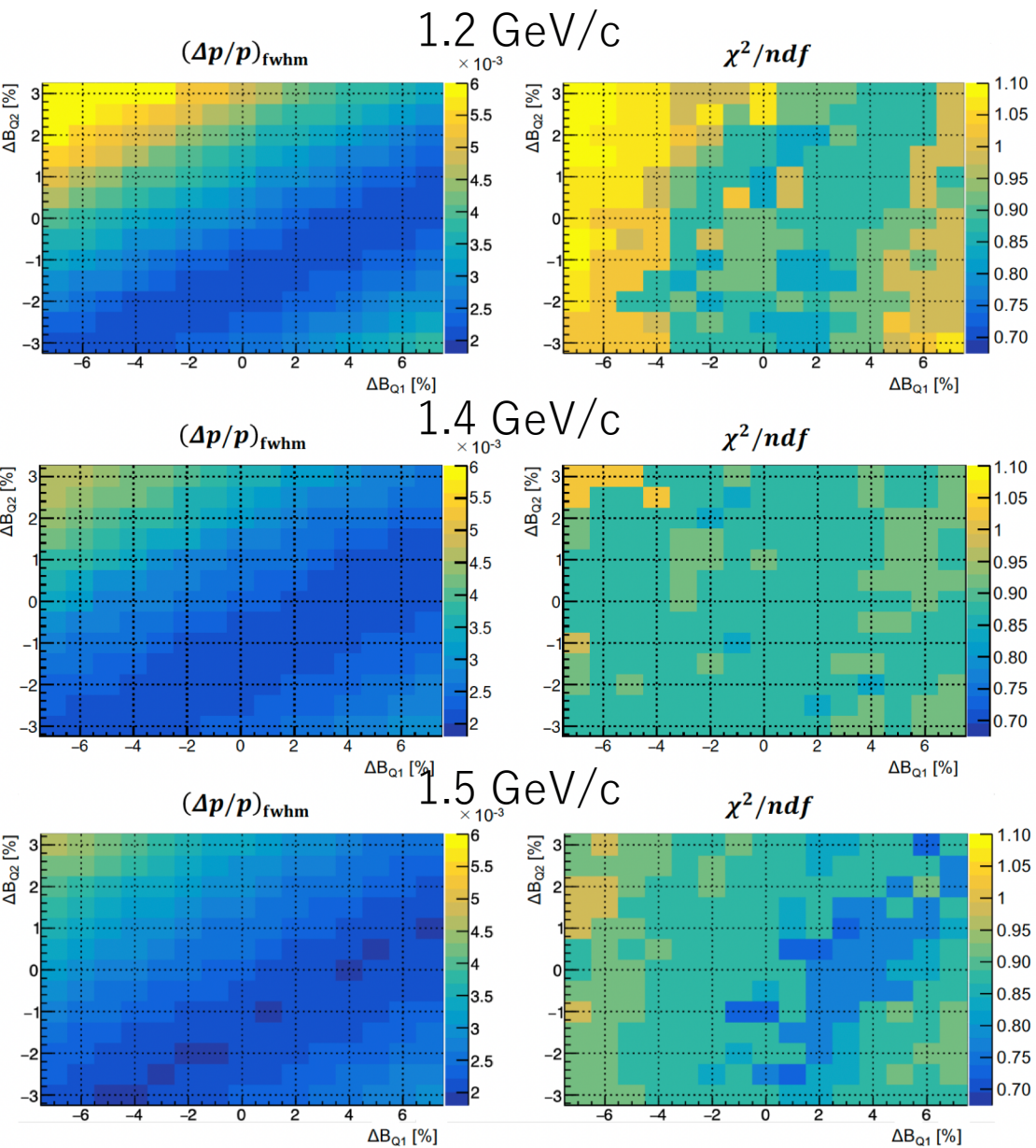
S-2S analysis (E70)



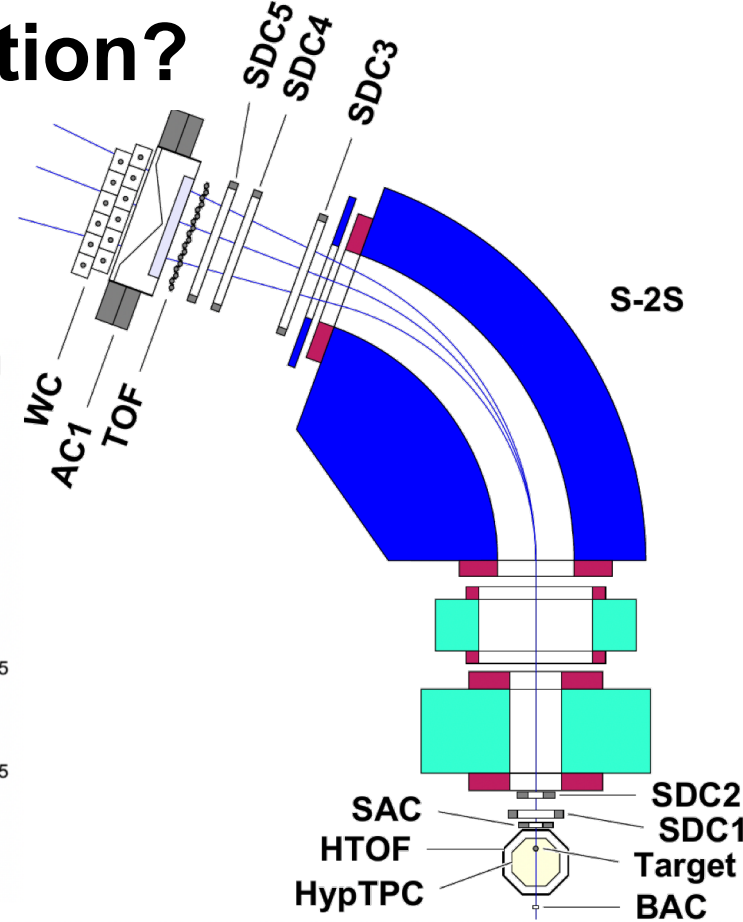
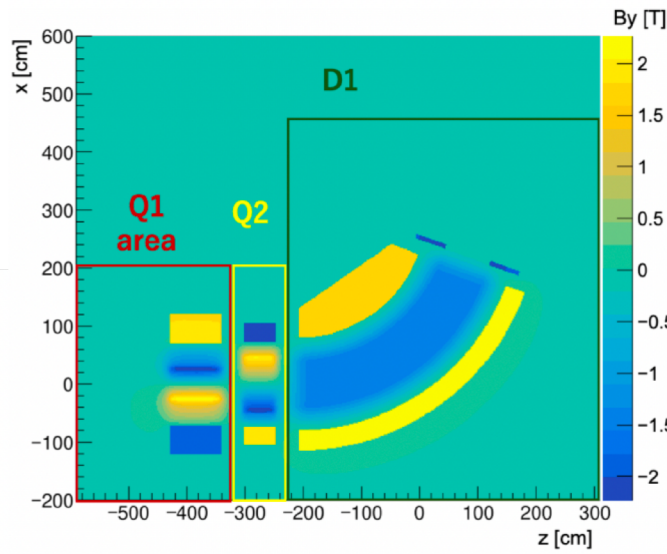
However, the momentum resolution is worse than design value.
(2 – 3 times worse)



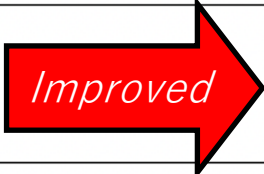
What is the reason of worse momentum resolution?



We scale the calculated B-field map for the Runge-Kutta analysis.



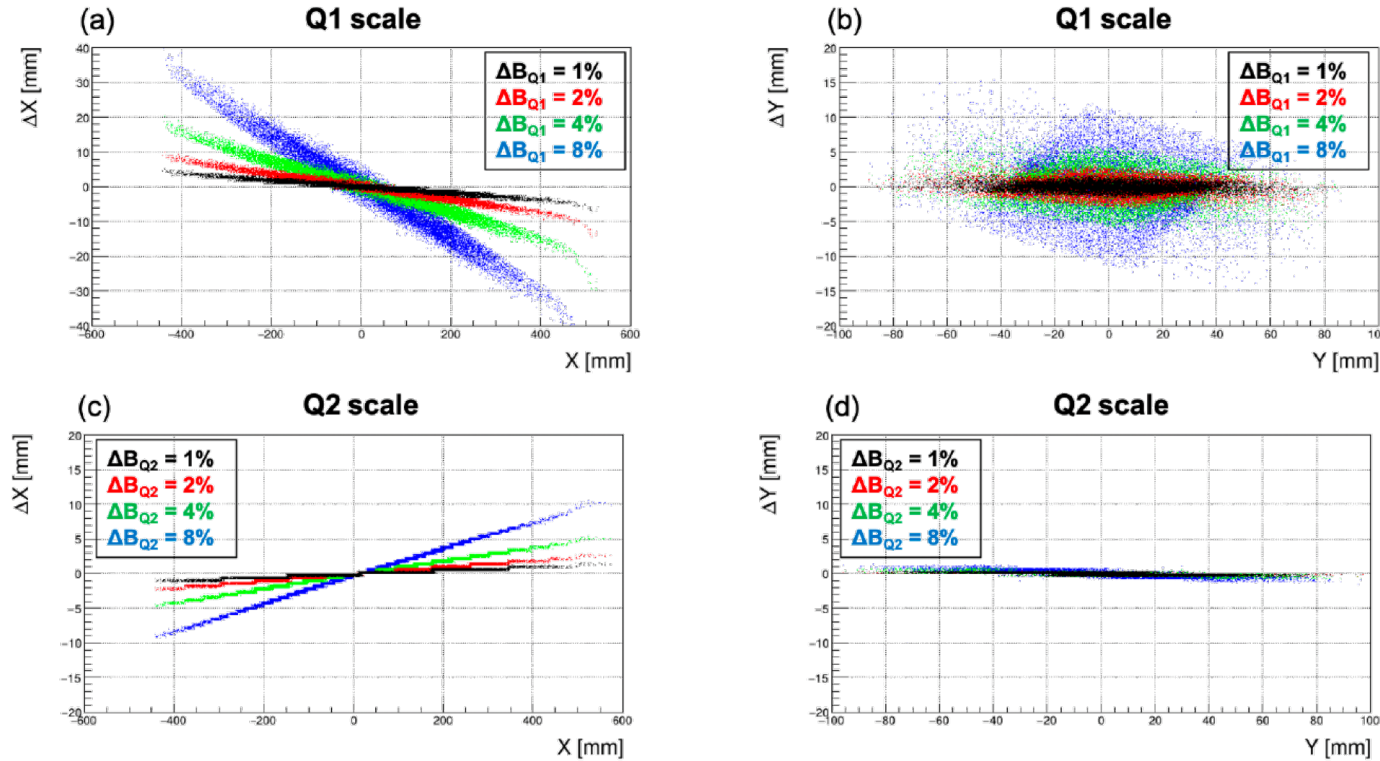
Beam momentum [GeV/c]	$\Delta p/p \times 10^{-3}$ (FWHM)	
	Before adjustment	After adjustment
1.2	2.6	2.1
1.4	2.4	2.0
1.5	2.2	2.0



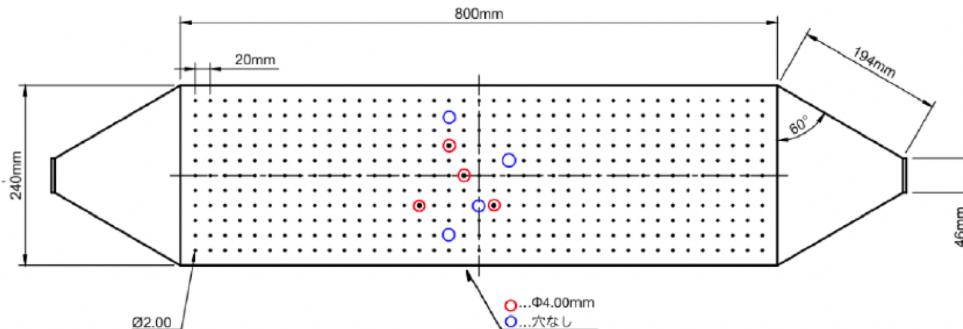
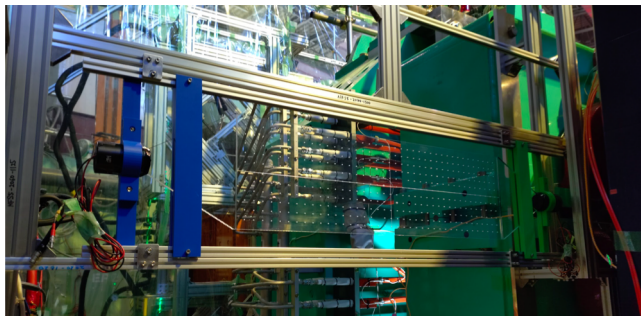
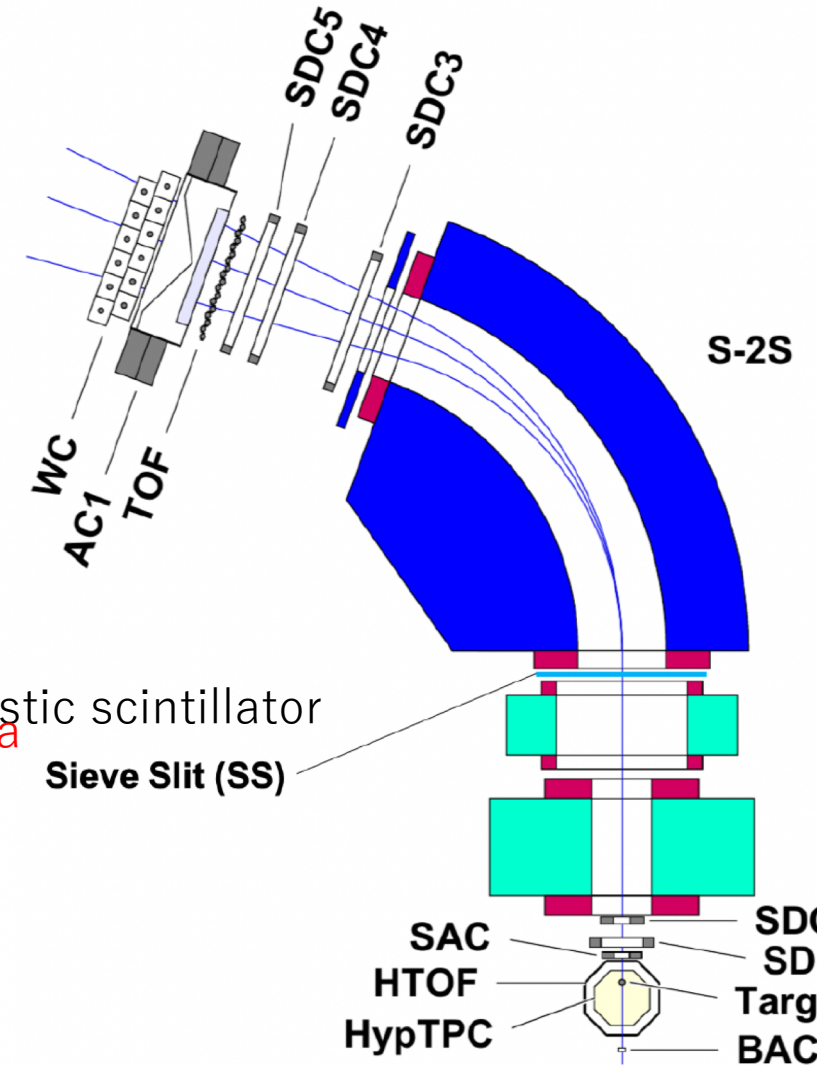
Inconsistency of calculated B-filed map will be the reason of worse resolution.

Calculated B-field adjustment to improve the momentum resolution

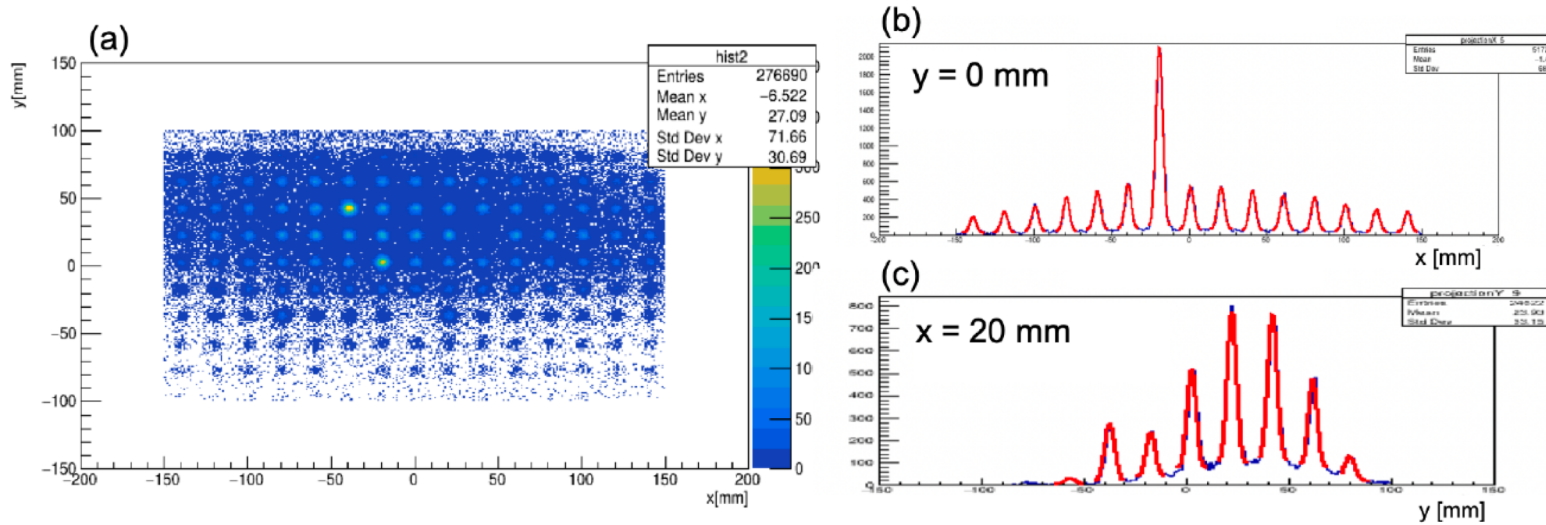
Position difference due to the magnetic field at SS (Simulation)



→ Inconsistency of calculated B-field map can be study with ON/OFF data

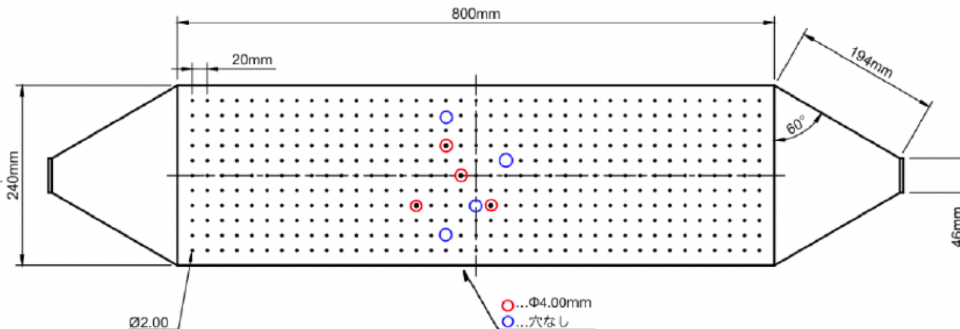
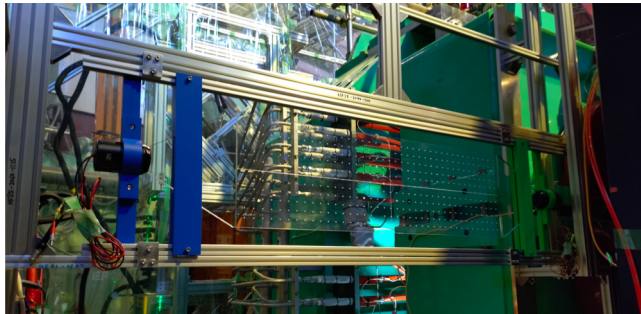
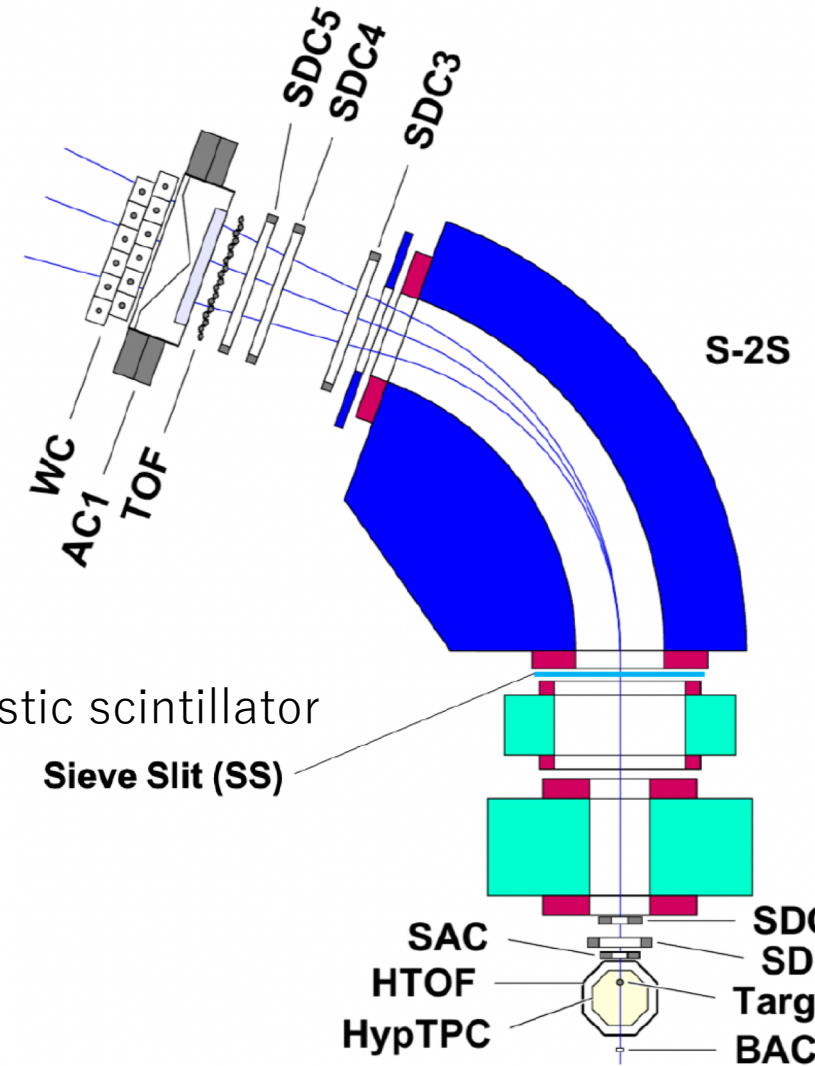


Calculated B-field adjustment to improve the momentum resolution



We took only magnet off data due to strong field around fine-mesh PMT.

→ Further test with **MPPC** in next beamtime.



Experiments related to Ξ -A interaction study

Ξ -A potential:

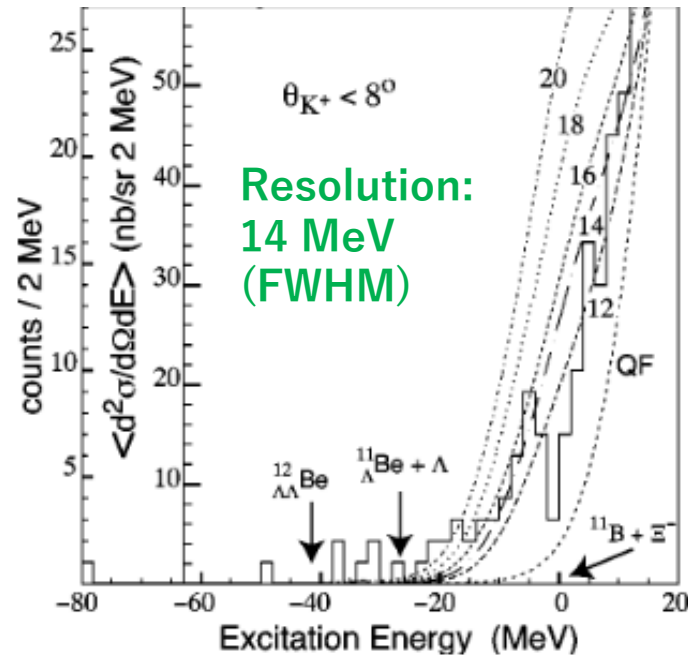
$$U_{\Xi}(r) = V_{\Xi}(r) + iW_{\Xi}(E, r)$$

$$= [V_0^{\Xi} + iW_0^{\Xi}g(E)]f(r)$$

$V_0^{\Xi}(\text{Re})$: Interaction strength of Ξ -A
 $W_0^{\Xi}(\text{Im})$: Absorption strength
 (Ξ -p $\rightarrow$ $\Lambda\Lambda$, Ξ -p $\rightarrow$ Ξ^0n)

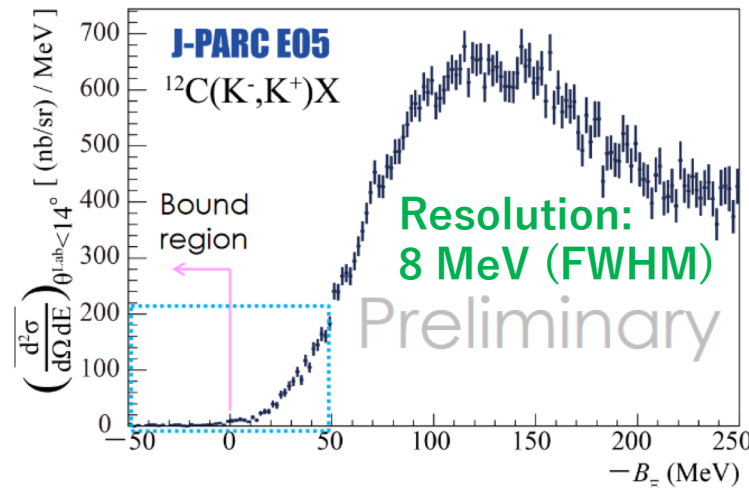
BNL E885

$^{12}\text{C}(\text{K}^-, \text{K}^+)$ inclusive spectrum
 $\rightarrow V_0^{\Xi} \sim -14$ MeV by neglecting W_0^{Ξ}



J-PARC E05/E70

$^{12}\text{C}(\text{K}^-, \text{K}^+)$ inclusive spectrum
 with wide B_{Ξ} range is taken.



**Best resolution 2 MeV
 will be achieved in E70**

