

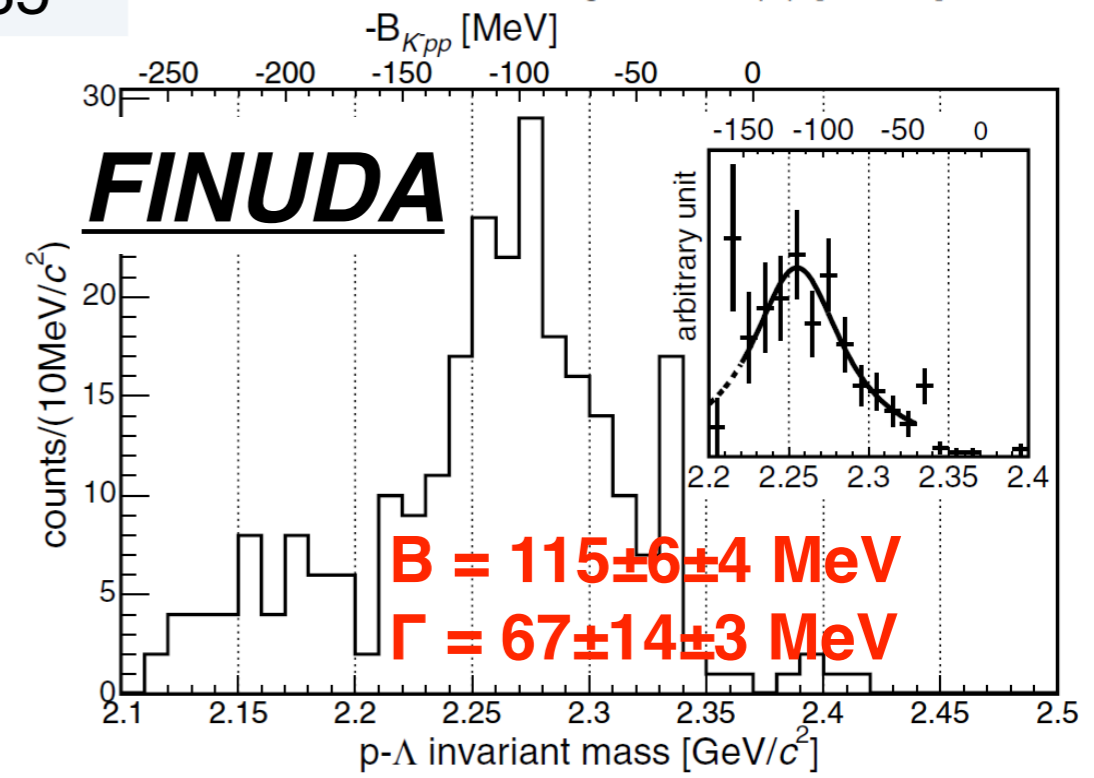
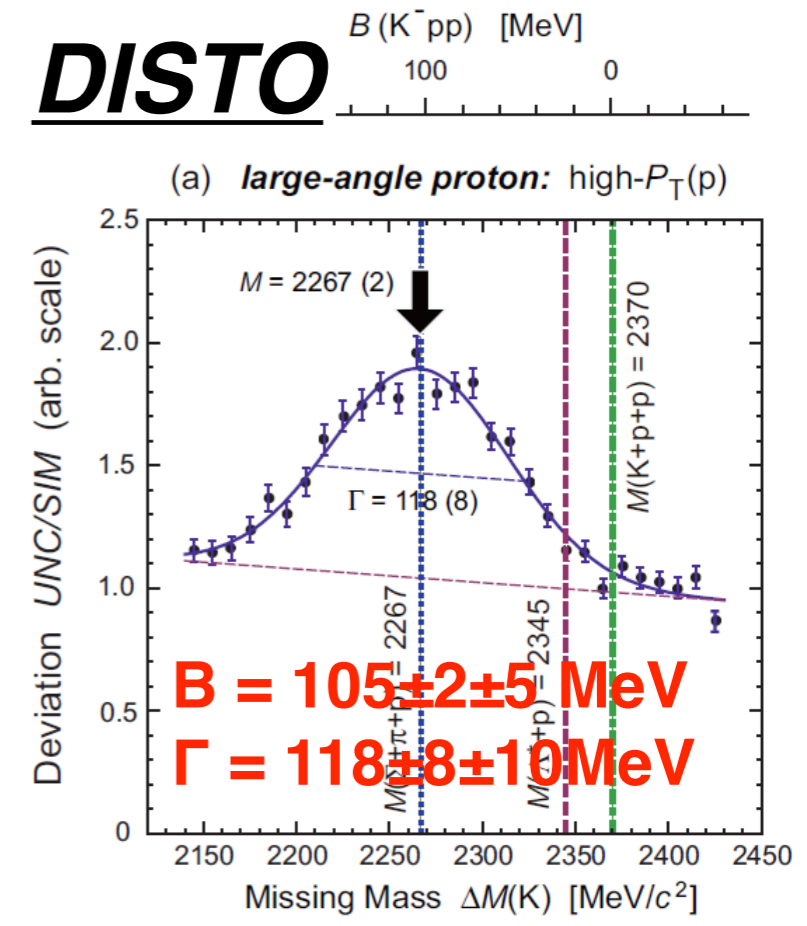
A search for the K - pp bound state in the ${}^3\text{He}(\text{inflight-}K^-, n)$ reaction at J-PARC

- Introduction
- J-PARC E15 1st stage physics run
- neutron spectrum
- Summary

Tadashi Hashimoto
for J-PARC E15 collaboration

The simplest kaonic nuclei $K\bar{n}N$

chiral & energy dependent	B.E.[MeV]	Γ [MeV]
N. Barnea, A. Gal, E.Z. Liverts(2012)	16	41
A. Dote, T. Hyodo, W. Weise(2008,09)	17-23	40-70
Y. Ikeda, H. Kamano, T. Sato(2010)	9-16	34-46
$\Lambda(1405)$ ansatz	B.E.[MeV]	Γ [MeV]
T. Yamazaki, Y. Akaishi(2002)	48	61
N.V. Shevchenko, A. Gal, J. Mares(2007)	50-70	90-110
Y. Ikeda, T. Sato (2007,2009)	60-95	45-80
S. Wycech, A.M. Green (2009)	40-80	40-85

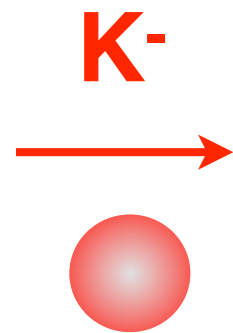


- Many theoretical calculations
- Little experimental information
- bound or not? B.E. and width?

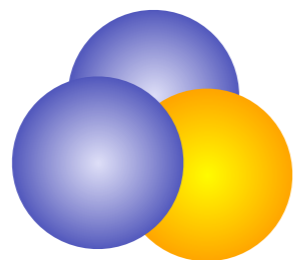
J-PARC E15 experiment

A search for the simplest kaonic nucleus $K\text{-}pp$

1 GeV/c



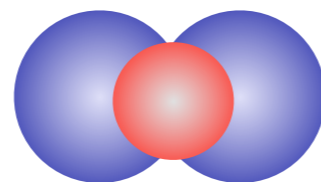
${}^3\text{He}$



reaction



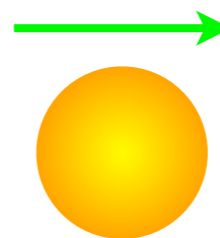
$K\text{-}pp$



+

1.2~1.3 GeV/c

n



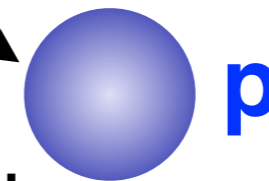
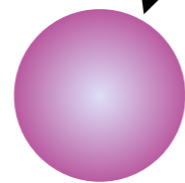
NC formation

Missing mass spectroscopy

detect everything !!!

decay

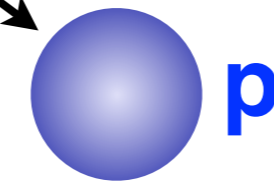
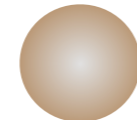
Λ



p

decay

π



p

CDS

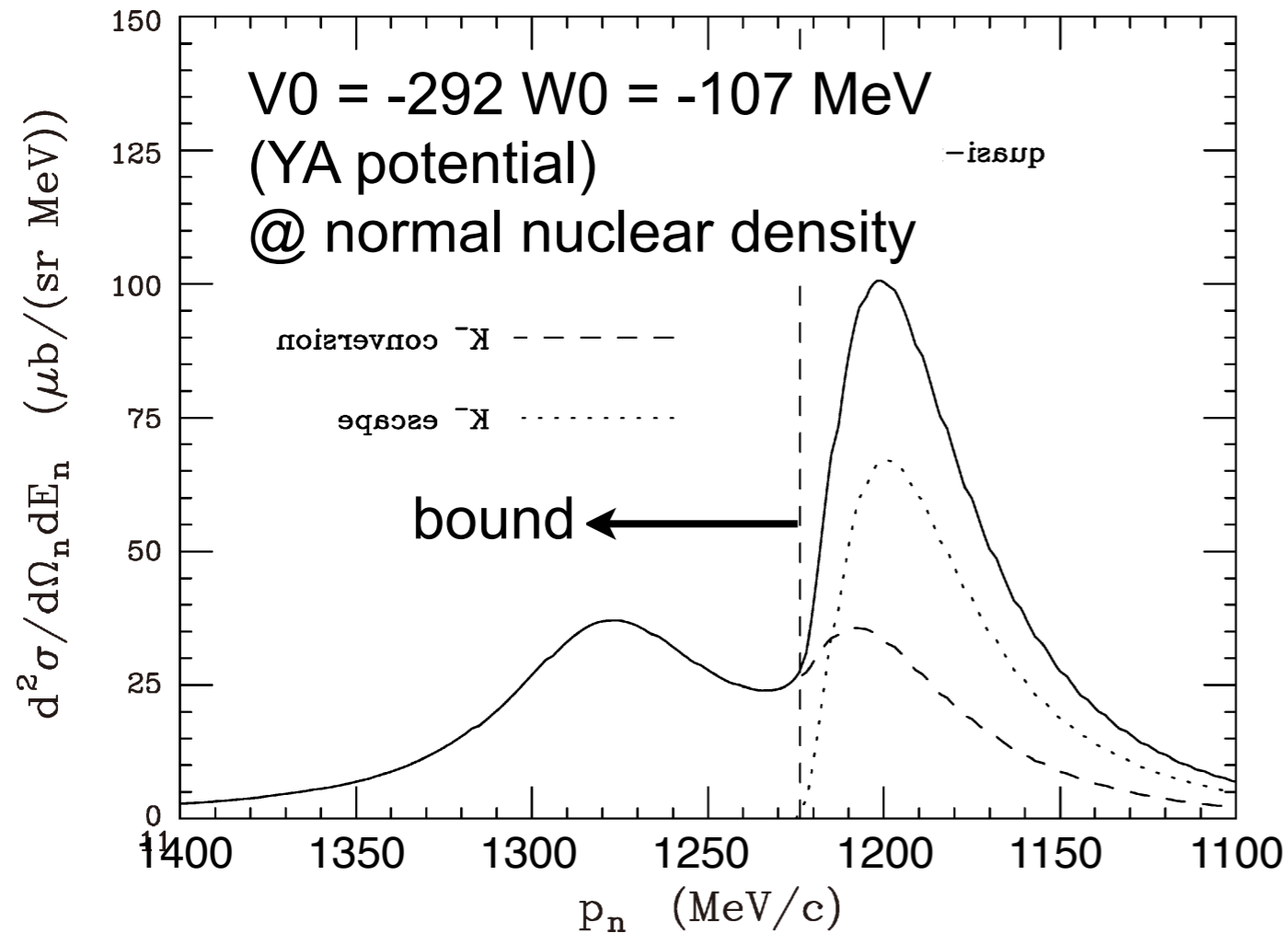
Invariant mass spectroscopy

CDS

- two-nucleon absorption should be suppressed.
- hyperon decays are kinematically separated. **low background**

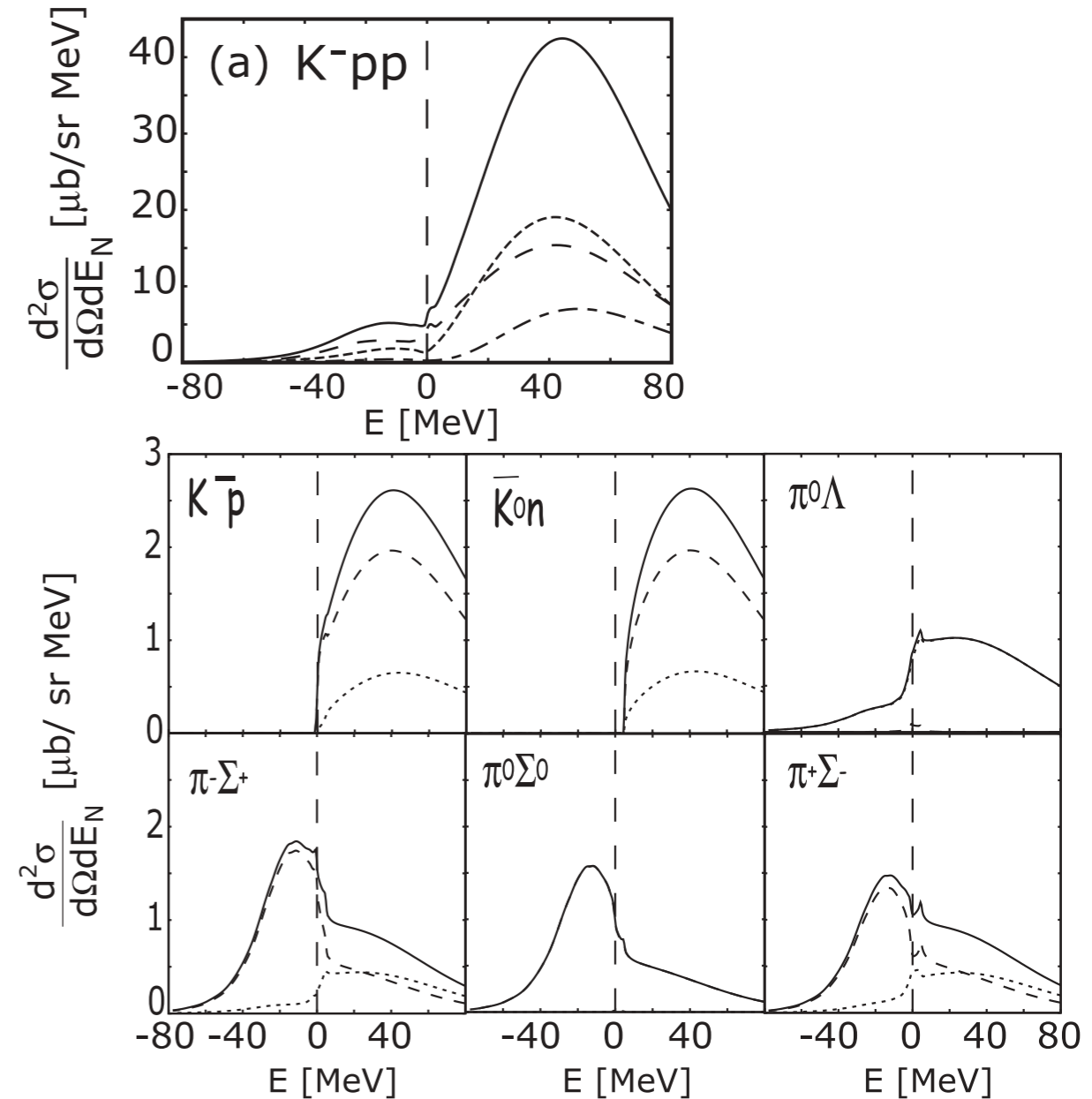
Theoretical calculations on ${}^3\text{He}(\text{K}^-, \text{n})$

$\text{K}^- + {}^3\text{He} \rightarrow \text{"K-pp"} + \text{n} @ P_{\text{K}}=1\text{GeV}/c, \theta=0^\circ$



T.Koike and T.Harada. , PLB652 (2007) 262

**cross section
may be > mb/sr**



*J. Yamagata-Sekihara et. al.,
Phys. Rev. C 80, 045204 (2009)*

**Σ tag may enhance the
structure in bound region.**

J-PARC E15 1st stage physics run

- **Expected physics output**

- $^3\text{He} (\text{K}^-, \text{n}), [\text{ \& } \Lambda\text{pn}]$
- $^3\text{He} (\text{K}^-, \text{p}), [^3\text{He} (\text{K}^-, \text{d})]$
- multi-nucleon absorption, hyperon production etc...

- **Accumulated data**

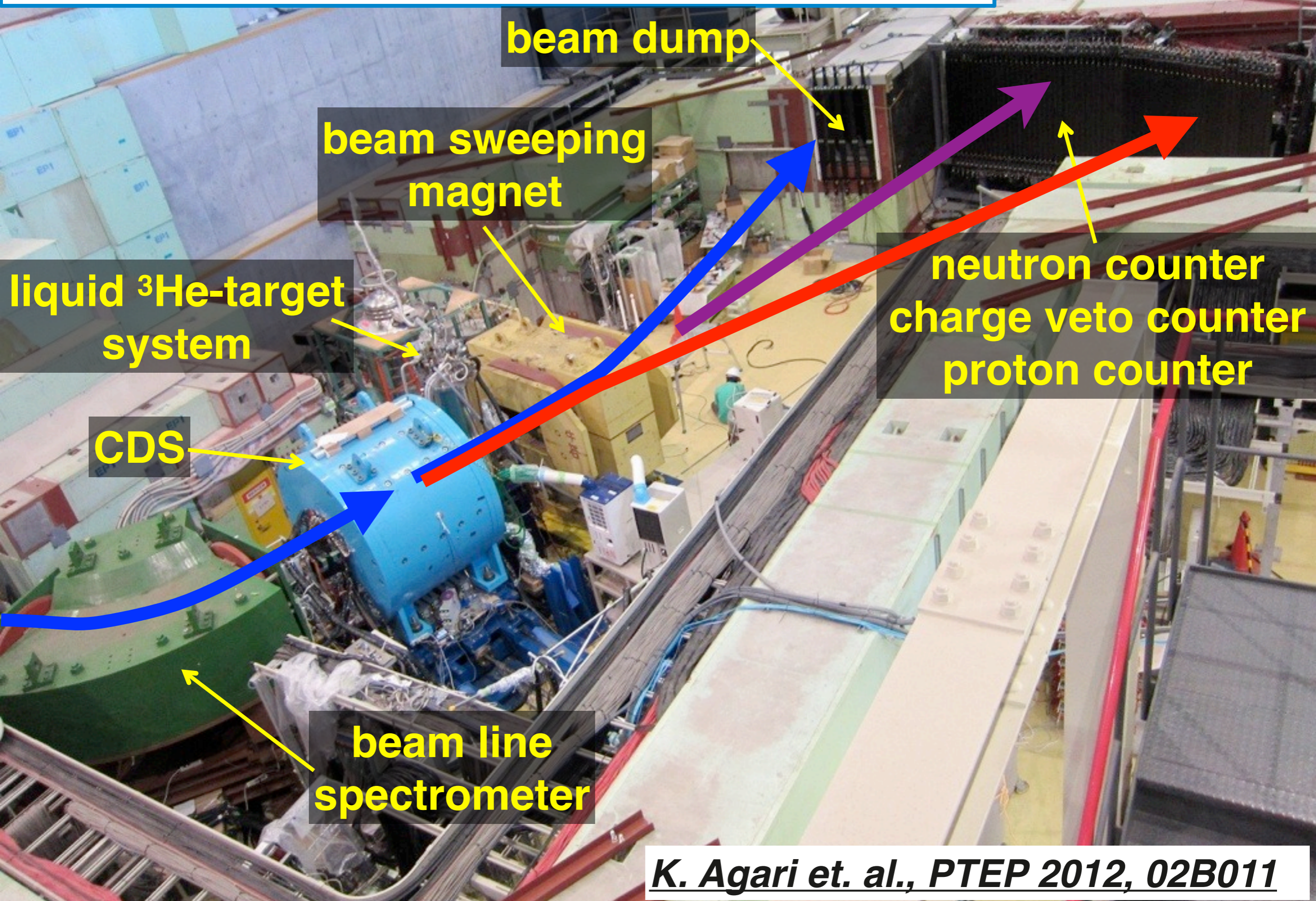
- w/ liquid helium-3 target: ~1% of original proposal

period	primary beam intensity	duration	Kaons on target
March, 2013	14.5 kW (18 Tppp, 6s cycle)	30 hours	0.9×10^9
May, 2013	24 kW (30 Tppp, 6s cycle)	88 hours	4.0×10^9

production target: Au 50% loss, spill length: ~2s, spill duty factor: ~45%

- target empty run, beam-through run, pion scattering run....

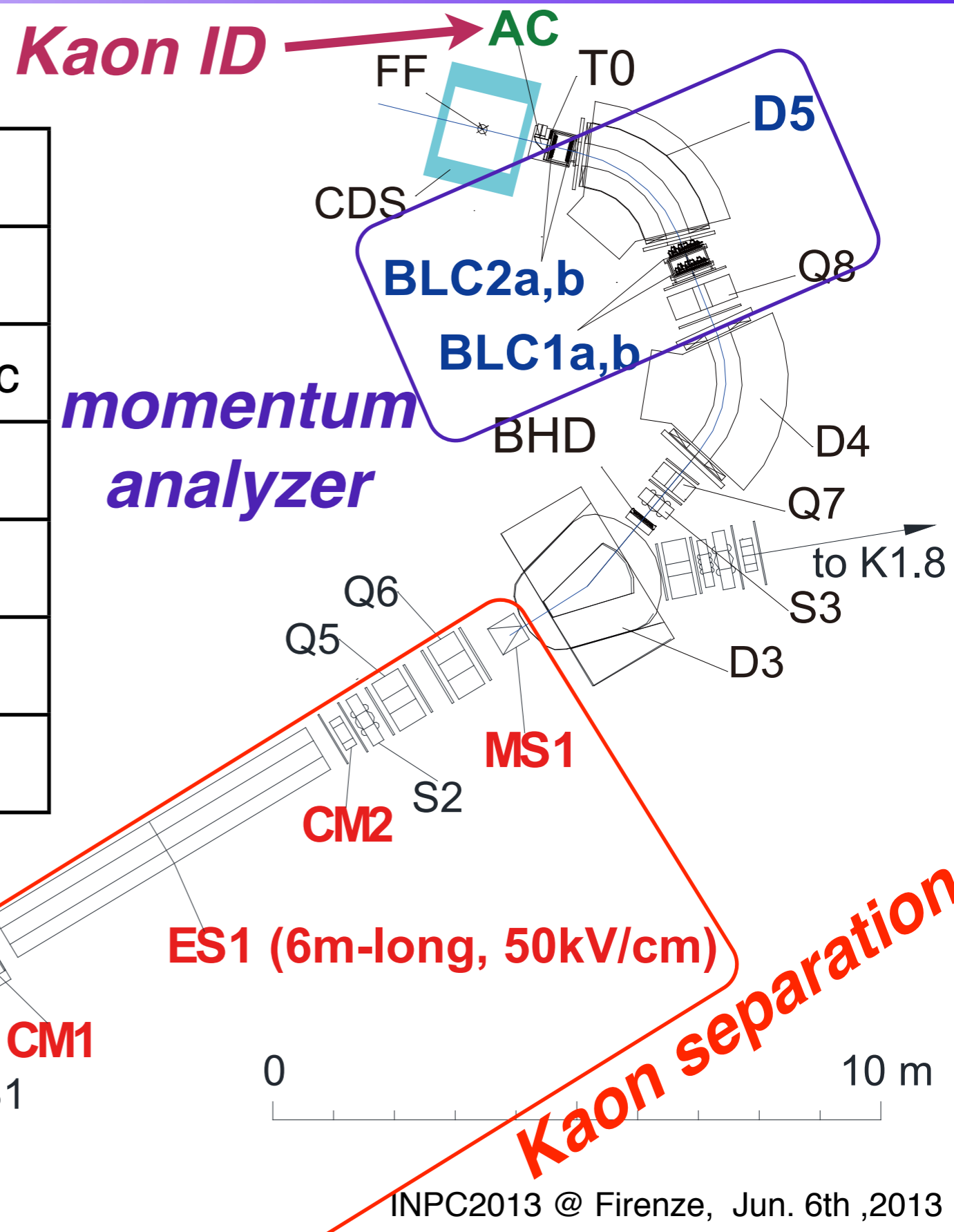
the J-PARC K1.8BR spectrometer



K. Agari et. al., PTEP 2012, 02B011

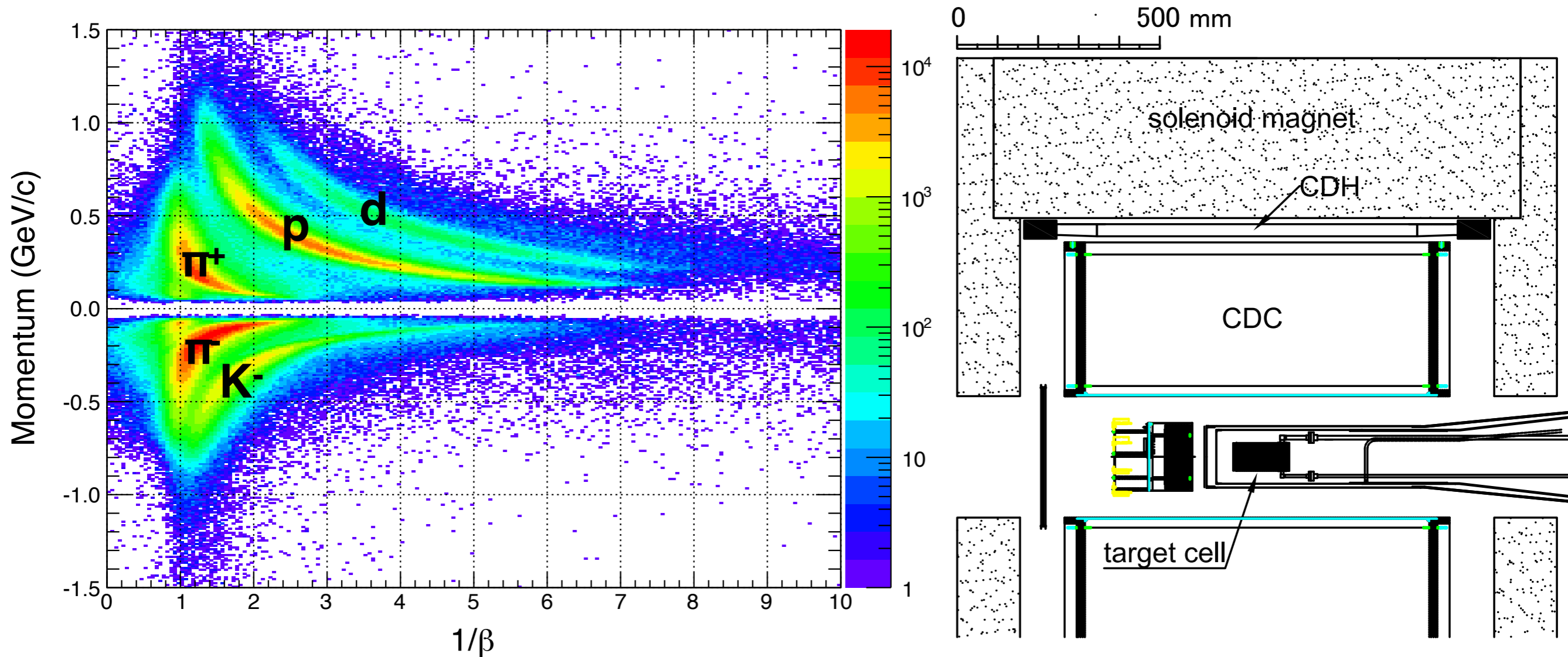
Kaon beam quality @ J-PARC K1.8BR

beam momentum	1 GeV/c
momentum bite	~ 3%
mom resolution @ 1 GeV/c	2.2 MeV/c
kaon / spill @ 24 kW	150 k
total beam / spill @ 24 kW	480 k
k/ π ratio	0.45
T1-FF length	31.3 m



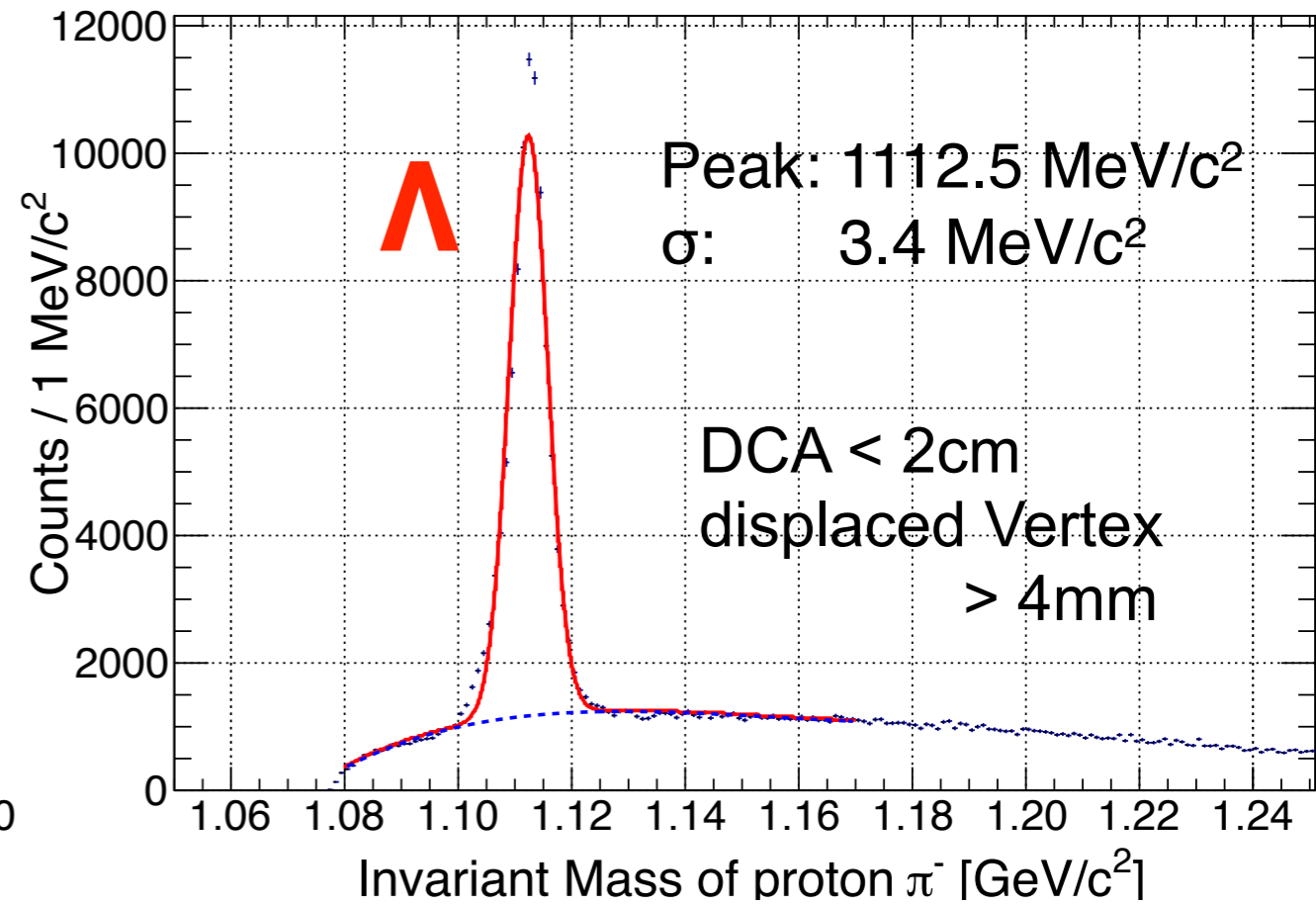
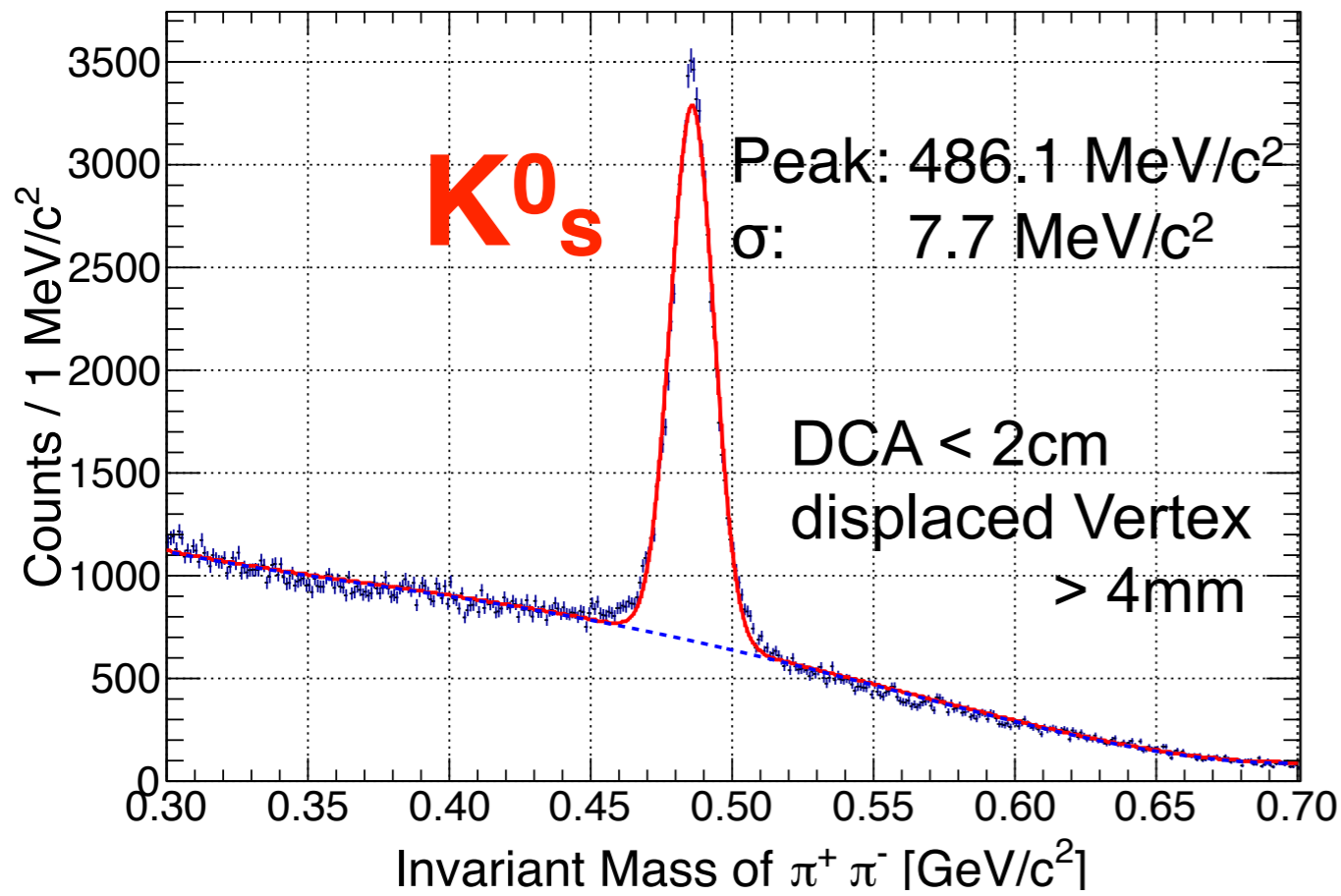
proton →

Cylindrical Detector System



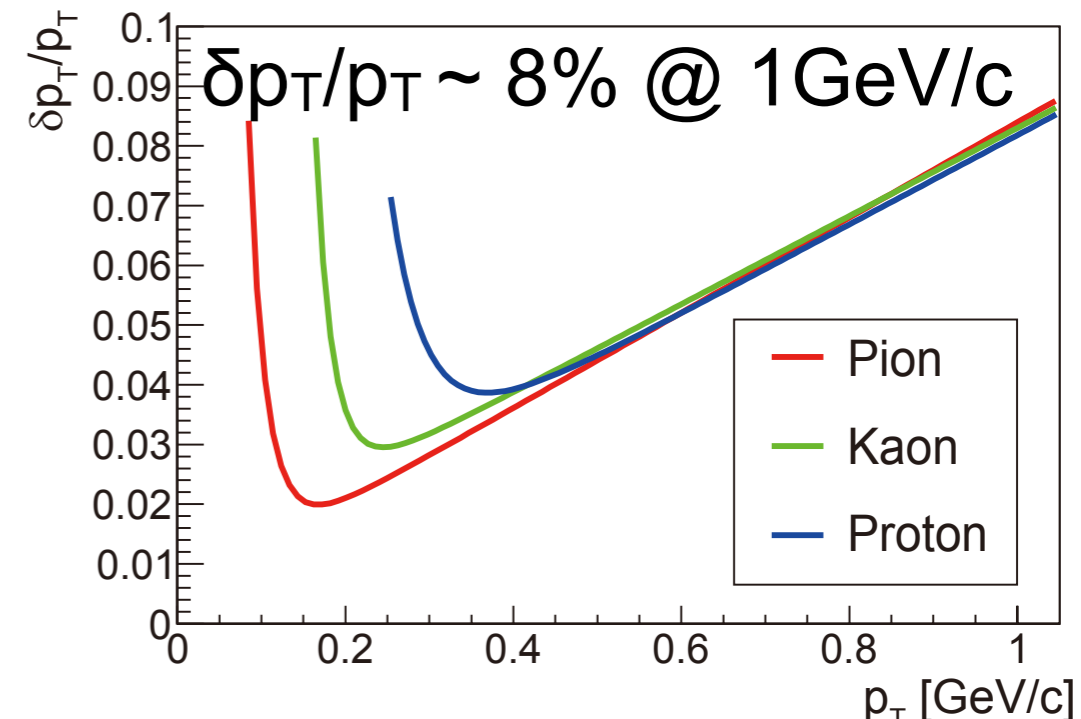
- **CDC (15 layers 1816 ch) + CDH (36 seg)**
 - cover 60% of solid angle.
 - particle ID successfully done.
 - Kaon elastic event, deuterons are seen.

Cylindrical Detector System

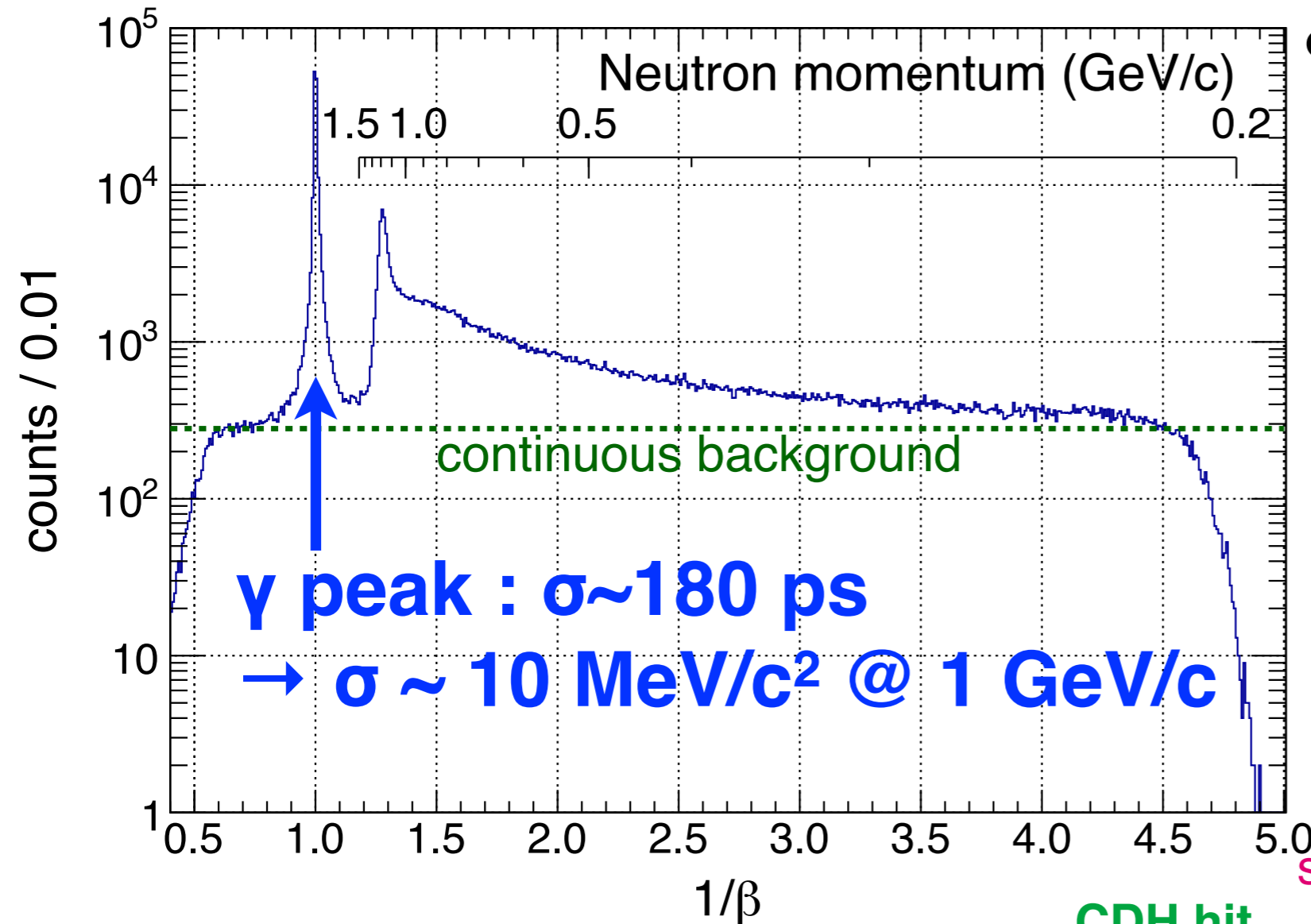


- **Design performance was achieved**

- Peak positions and widths are consistent with a simulation.
- Vertex resolution: xy ~ 2mm, z ~ 5mm
- ~ 10 MeV/c² resolution for Λp invariant mass

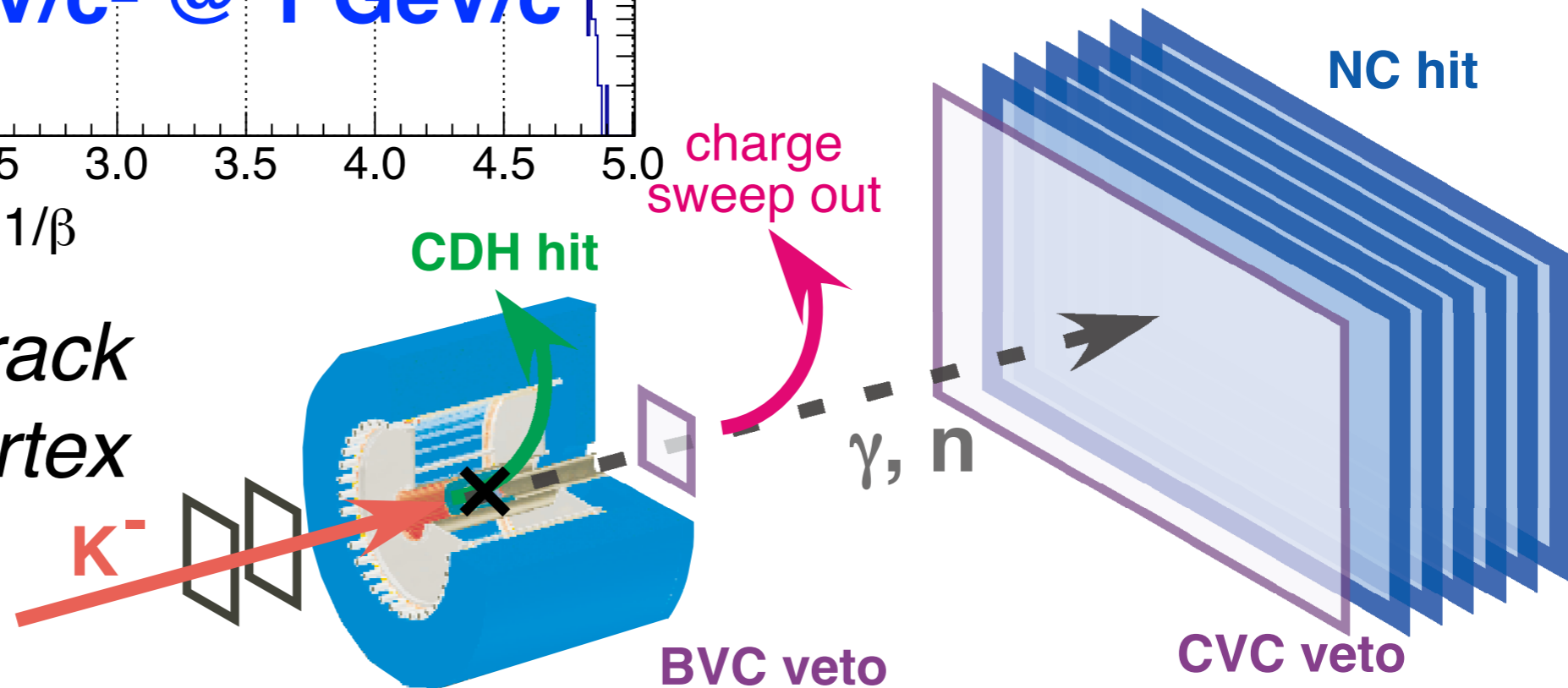


Forward Neutral particles

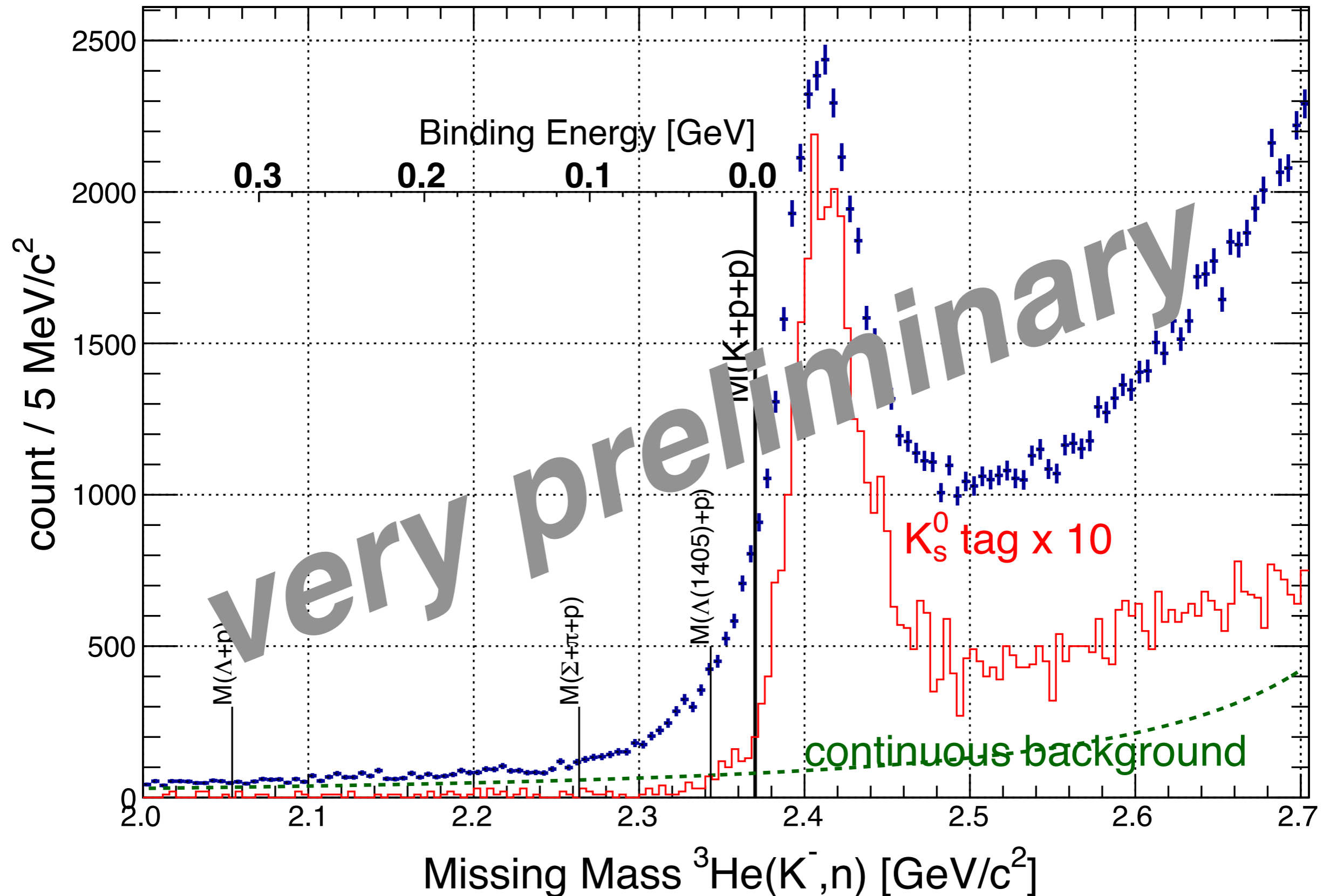


- **Neutron Counter**
 - **W 3.2 m x H 1.5 m**
 - **T 5 cm x 7 layers**
 - **~ 30% eff. @ 1 GeV/c**
 - **acceptance: 19.4 msr**
 - $\pm 6.2^\circ$ (horizontal)
 - $\pm 2.9^\circ$ (vertical)

require 1 charged track to determine the vertex



Inclusive neutron spectrum at forward angle



Summary

- **We have performed J-PARC E15 1st stage physics run to search for the K-pp bound state.**
 - **$\sim 5 \times 10^9$ kaons were irradiated on ^3He**
 - **$\sim 300 \times 10^3$ neutrons from $^3\text{He}(K^-,n)$ reactions were obtained.**
- **Quasi-free peak was clearly seen in the semi-inclusive $^3\text{He}(K^-,n)$ spectrum.**
- **Further analysis results will appear soon !!**
 - **hunt small “K-pp” signal by reducing background, tagging decay particles etc...**
 - **Λ_{pn} dalitz plot, forward proton channel, hyperon production**
 - **and so on...**

S. Ajimura^a, G. Beer^b, H. Bhang^c, M. Bragadireanu^d, P. Buehler^e, L. Busso^{f,g},
M. Cargnelli^e, S. Choi^c, C. Curceanu^h, S. Enomotoⁱ, D. Faso^{f,g}, H. Fujioka^j, Y. Fujiwara^k,
T. Fukuda^l, C. Guaraldo^h, T. Hashimoto^k, R. S. Hayano^k, T. Hiraiwa^a, M. Iioⁿ, M. Iliescu^h,
K. Inoueⁱ, Y. Ishiguro^j, T. Ishikawa^k, S. Ishimotoⁿ, T. Ishiwatari^e, K. Itahashi^m, M. Iwaiⁿ,
M. Iwasaki^{o,m*}, Y. Kato^m, S. Kawasakiⁱ, P. Kienle^p, H. Kou^o, Y. Ma^m, J. Marton^e,
Y. Matsuda^q, Y. Mizoi^l, O. Morra^f, T. Nagae^{j†}, H. Noumi^a, H. Ohnishi^m, S. Okada^m,
H. Outa^m, K. Piscicchia^h, M. Poli Lener^h, A. Romero Vidal^h, Y. Sada^j, A. Sakaguchiⁱ,
F. Sakuma^m, M. Sato^m, A. Scordo^h, M. Sekimotoⁿ, H. Shi^k, D. Sirghi^{h,d}, F. Sirghi^{h,d},
K. Suzuki^e, S. Suzukiⁿ, T. Suzuki^k, K. Tanida^c, H. Tatsuno^h, M. Tokuda^o, D. Tomono^m,
A. Toyodaⁿ, K. Tsukada^r, O. Vazquez Doce^{h,s}, E. Widmann^e, B. K. Wuenschek^e,
T. Yamagaⁱ, T. Yamazaki^{k,m}, H. Yim^t, Q. Zhang^m, and J. Zmeskal^e
(J-PARC E15 Collaboration)

- (a) *Research Center for Nuclear Physics (RCNP), Osaka University, Osaka, 567-0047, Japan*
- (b) *Department of Physics and Astronomy, University of Victoria, Victoria BC V8W 3P6, Canada*
- (c) *Department of Physics, Seoul National University, Seoul, 151-742, South Korea*
- (d) *National Institute of Physics and Nuclear Engineering - IFIN HH, Romania*
- (e) *Stefan-Meyer-Institut für subatomare Physik, A-1090 Vienna, Austria*
- (f) *INFN Sezione di Torino, Torino, Italy*
- (g) *Dipartimento di Fisica Generale, Università' di Torino, Torino, Italy*
- (h) *Laboratori Nazionali di Frascati dell' INFN, I-00044 Frascati, Italy*
- (i) *Department of Physics, Osaka University, Osaka, 560-0043, Japan*
- (j) *Department of Physics, Kyoto University, Kyoto, 606-8502, Japan*
- (k) *Department of Physics, The University of Tokyo, Tokyo, 113-0033, Japan*
- (l) *Laboratory of Physics, Osaka Electro-Communication University, Osaka, 572-8530, Japan*
- (m) *RIKEN Nishina Center, RIKEN, Wako, 351-0198, Japan*
- (n) *High Energy Accelerator Research Organization (KEK), Tsukuba, 305-0801, Japan*
- (o) *Department of Physics, Tokyo Institute of Technology, Tokyo, 152-8551, Japan*
- (p) *Technische Universität München, D-85748, Garching, Germany*
- (q) *Graduate School of Arts and Sciences, The University of Tokyo, Tokyo, 153-8902, Japan*
- (r) *Department of Physics, Tohoku University, Sendai, 980-8578, Japan*
- (s) *Excellence Cluster Universe, Technische Universität München, D-85748, Garching, Germany*
- (t) *Korea Institute of Radiological and Medical Sciences (KIRAMS), Seoul, 139-706, South Korea*