# Status Report of E15

M.Iwasaki

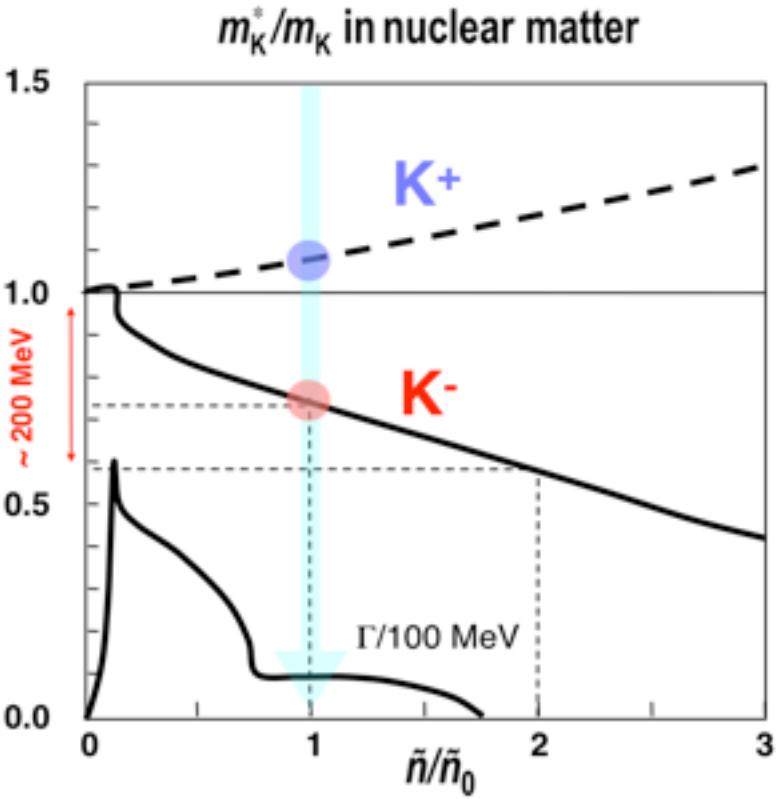
*for J-PARC E15 Collaboration*

- Introduction
- E15 experiment
- Status of E15
- Preliminary Results of Last Beam Time
- Conclusion

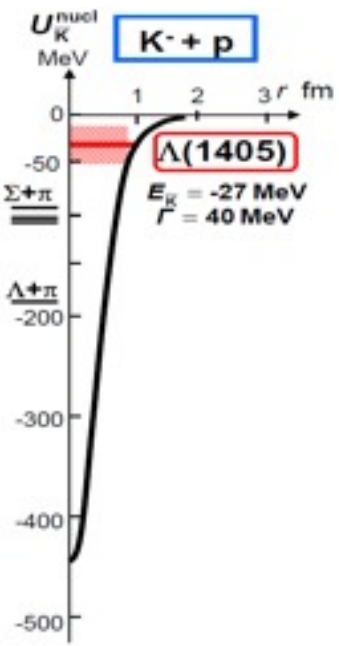
# Embedding $K^-$ in nucleus

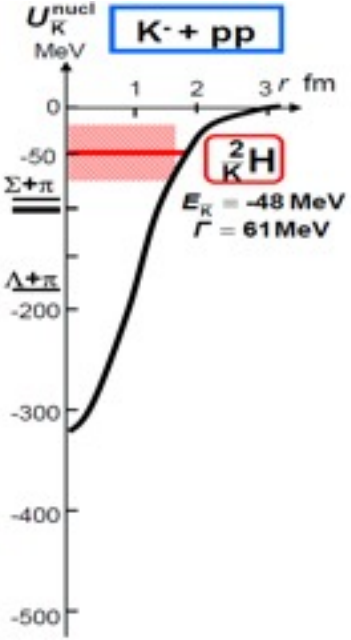
## Motivation of J-PARC E15

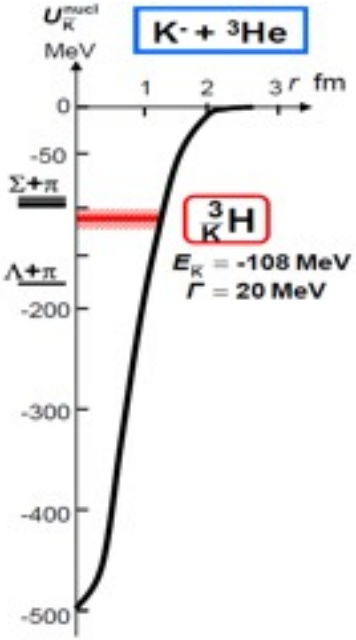
- understand $\bar{K}N$ interaction below threshold
- K mass modification / high density matter?




T. Waas, N. Kaiser & W. Weise, Phys. Lett. B379 (1996) 34.



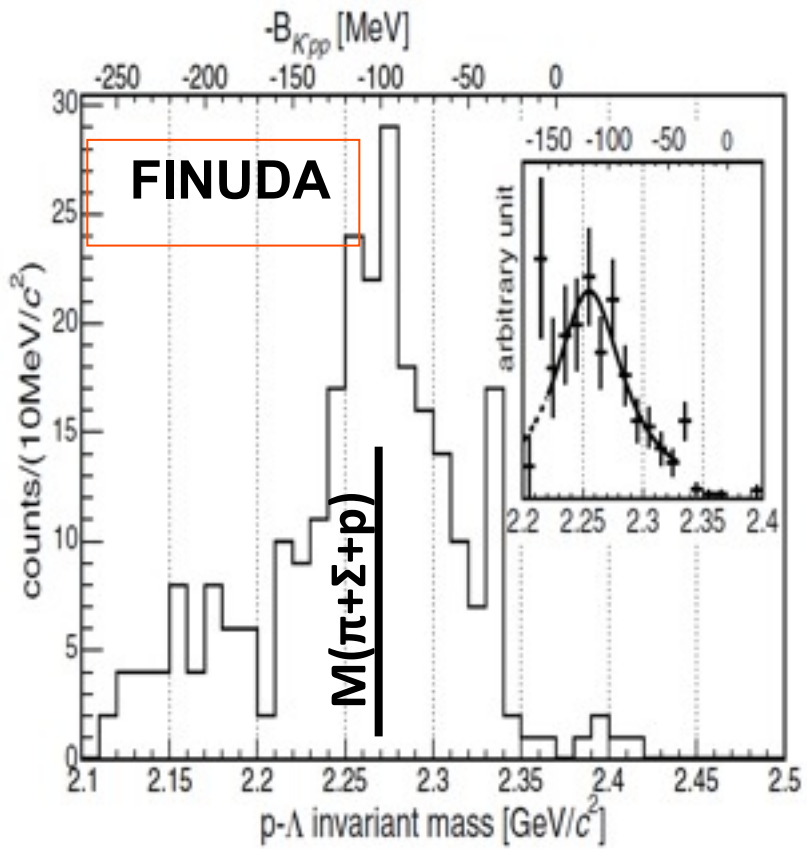




Y.Akaishi & T.Yamazaki, PLB535, 70(2002).

# New data

## “Λp” invariant mass @ K⁻ at rest



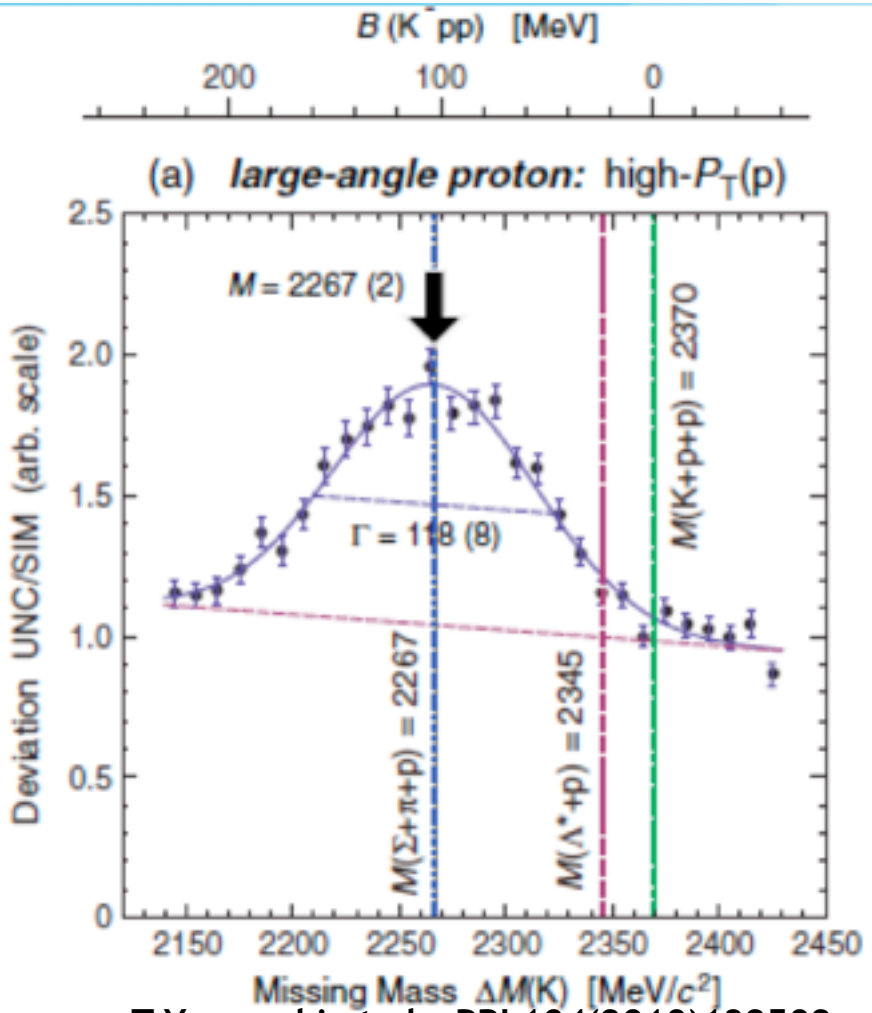

$B_K$ = 115±6±4 MeV

$\Gamma_K$ = 67±14±3 MeV

( $M_{ppK}$=2255±6±4 MeV )

## DISTO

p (p, K⁺) X @ T = 2.85 GeV




T.Yamazaki et al., PRL104(2010)132502

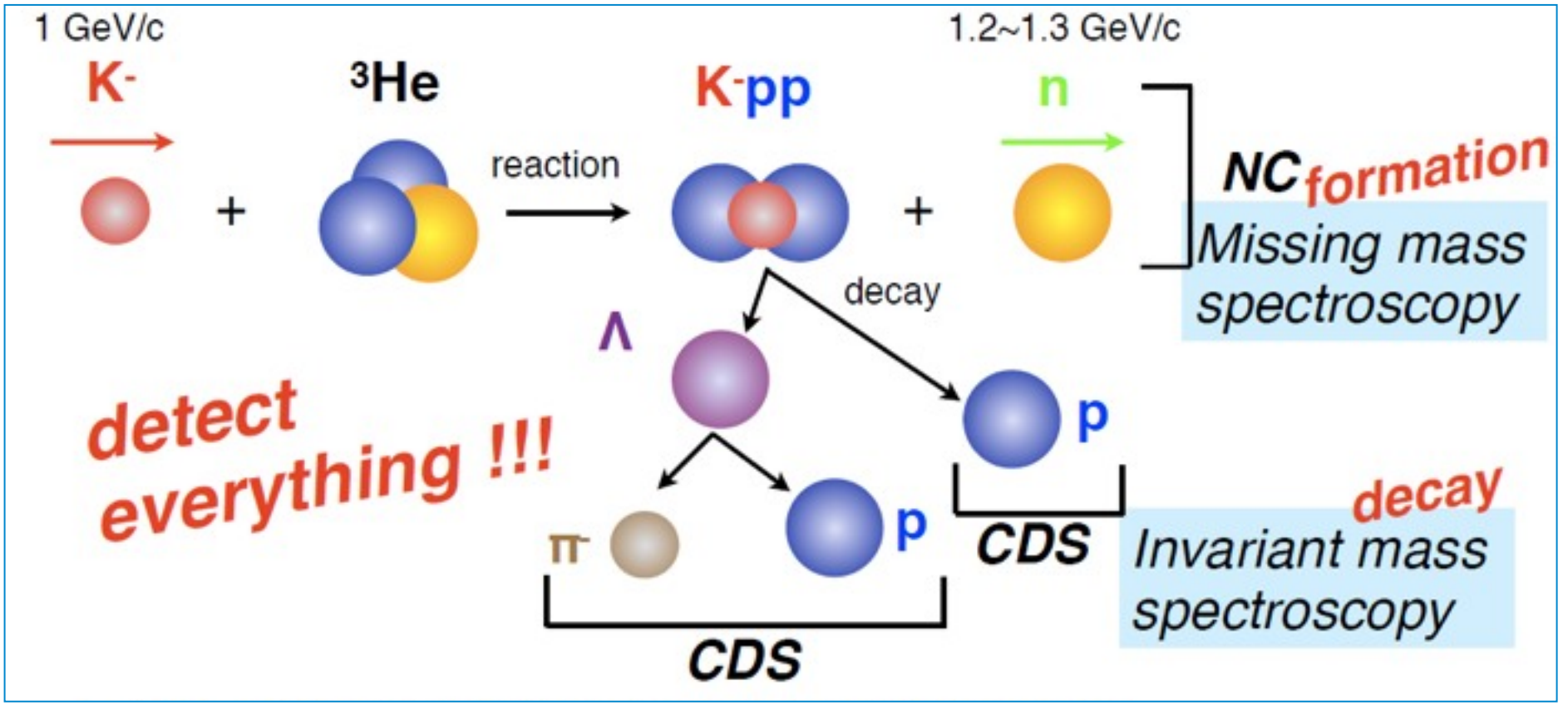
$M_x$=2267±3±5 MeV !

($B_K$ = 103±3±5 MeV)

$\Gamma_x$=118±8±10 MeV !

# Experimental Principle

## A search for the simplest kaonic nucleus, $K^-pp$, using $^3He$(*in-flight* $K^-$,n) reaction



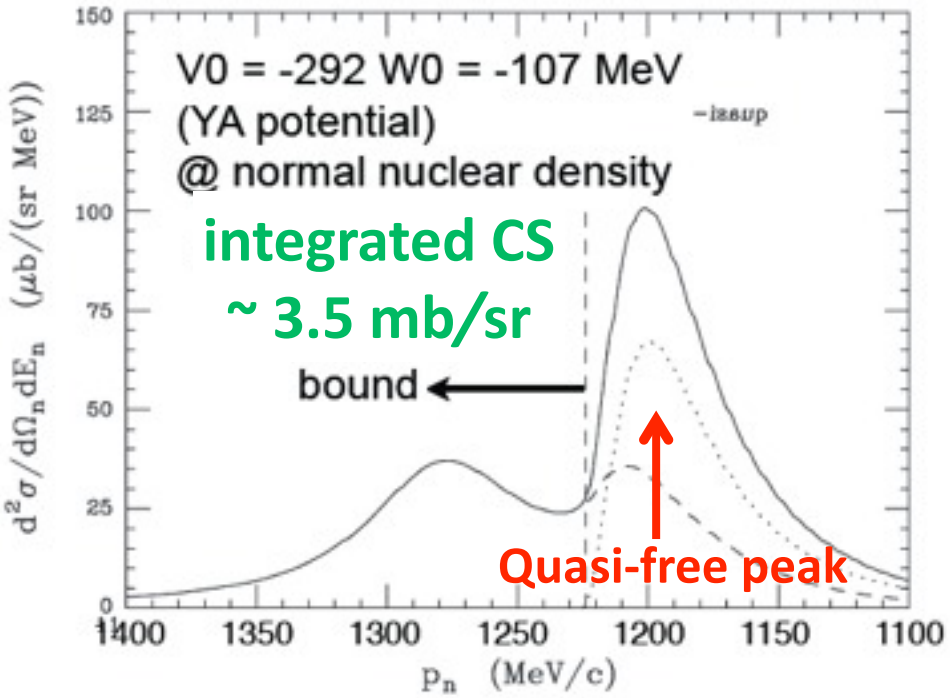

- two-nucleon absorption
- hyperon decays

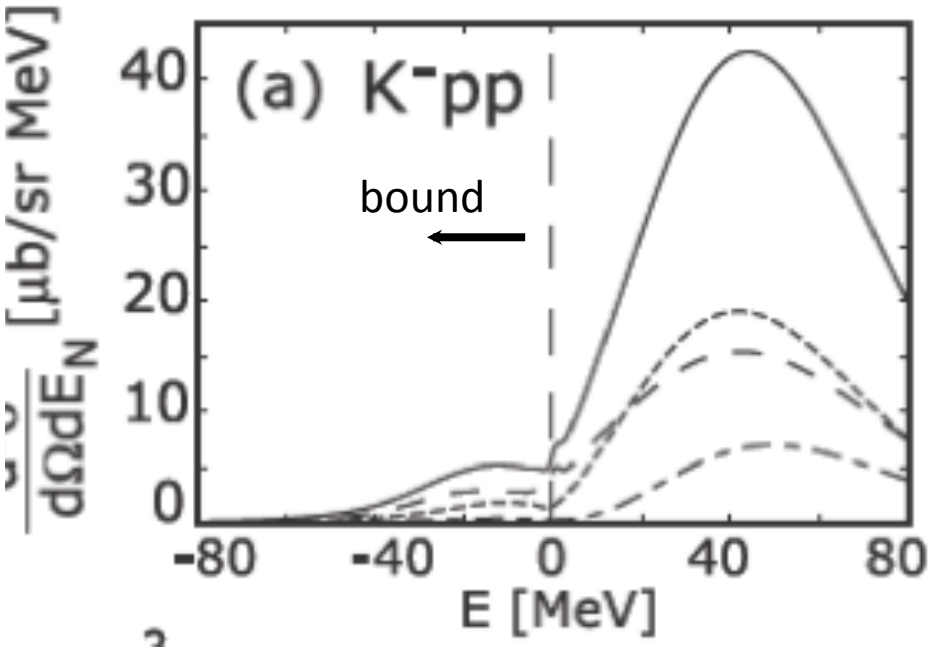
} CAN be discriminated kinematically

# 1: Semi-Inclusive $^3$He(K$^-$,n)

## *Calculated formation-spectra for $^3$He(in-flight K-,n)*

$K^- + {}^3He \rightarrow$ "K$^-$pp" + n @ $P_K$=1GeV/c, θ=0°



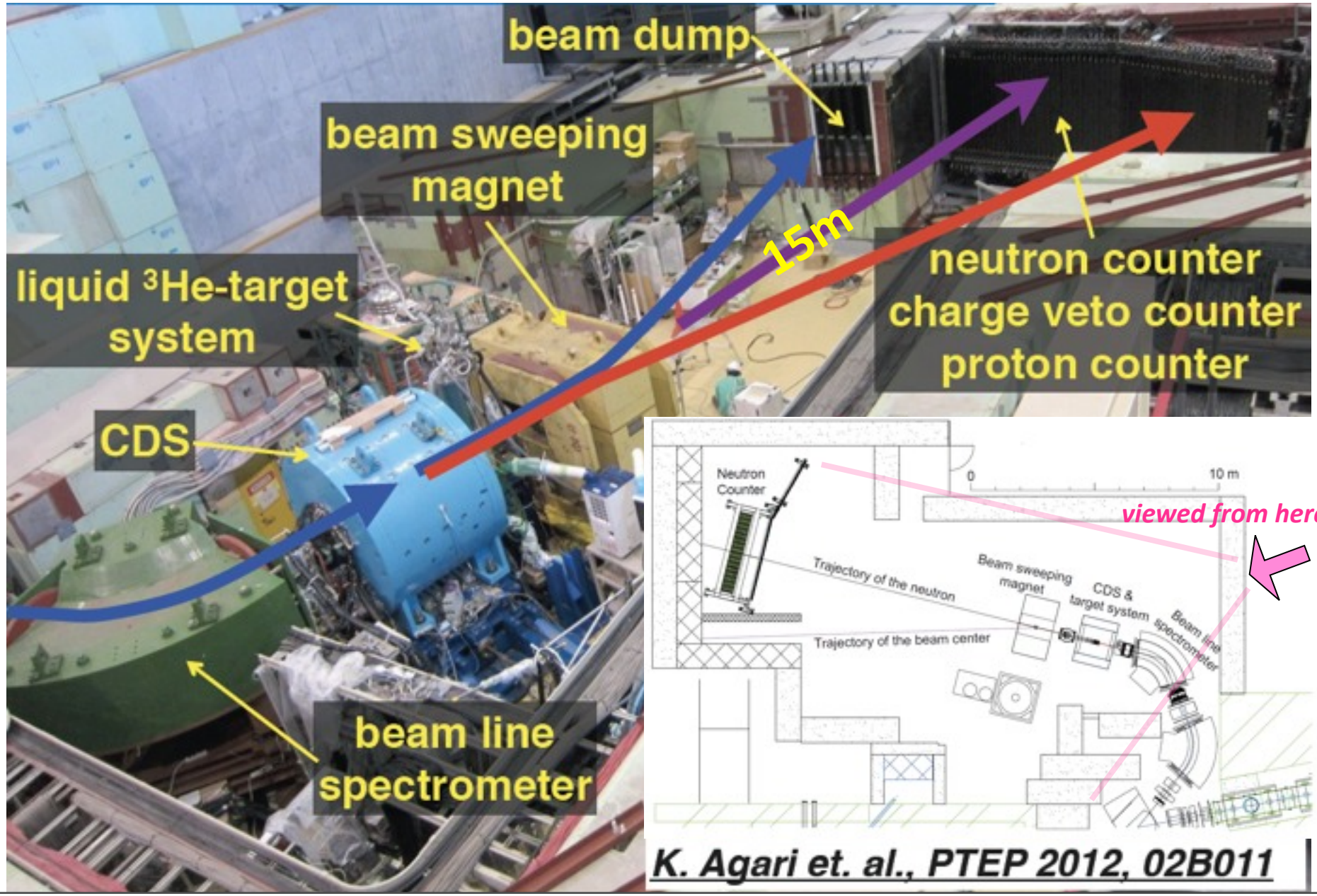

*T.Koike and T.Harada. , PLB652 (2007) 262*

**J. Yamagata-Sekihara, D. Jido, H. Nagahiro, and S. Hirenzaki**

PHYS. REV. C **80**, 045204 (2009)

**If right, we can measure the bound structure!**

# Experimental Setup



# Very preliminary results on $^{3}$He(K$^{-}$,n)

- 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 x $10^{9}$ |
| May, 2013 | 24 kW (30 Tppp, 6s cycle) | 88 hours | 4.0 x $10^{9}$ |

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

**E15$^{1st}$ is proposed as a first step using 2% of full E15**

**We could have data $\lesssim$ 50% of E15$^{1st}$**

**Inclusive $^{3}$He(K$^{-}$, n)X spectrum (w/ charged particle in CDS)**

( isospin ) **Inclusive $^{3}$He(K$^{-}$, p)X spectrum *in progress***

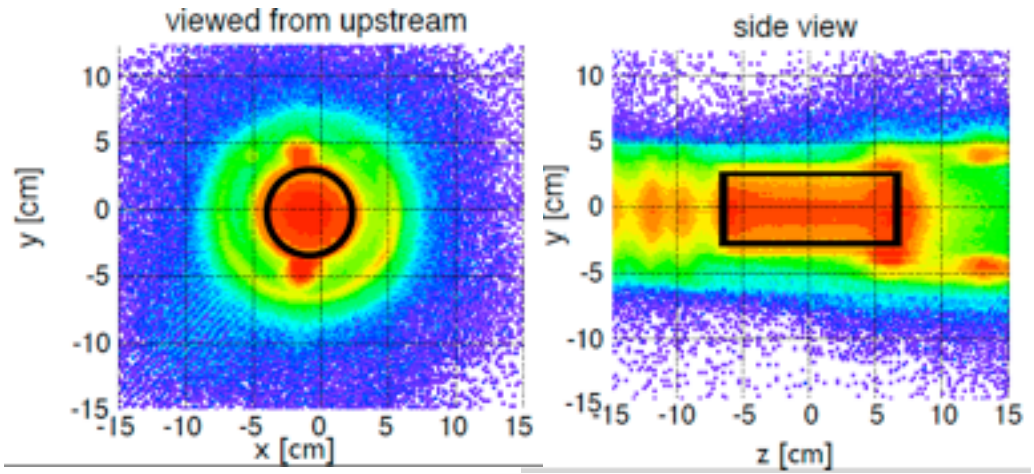
**Exclusive channel in $^{3}$He(K$^{-}$, n)X**

**$^{3}$He(K$^{-}$, n) Λp** ( *cf.* FINUDA / DISTO )

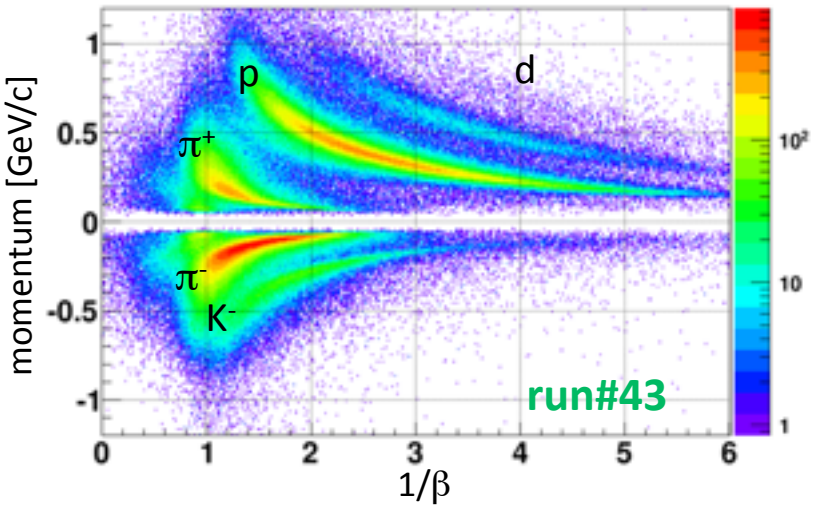
**$^{3}$He(K$^{-}$, n) $\Sigma^{\pm}\pi^{\mp}$ p *in progress***

# CDS Performances

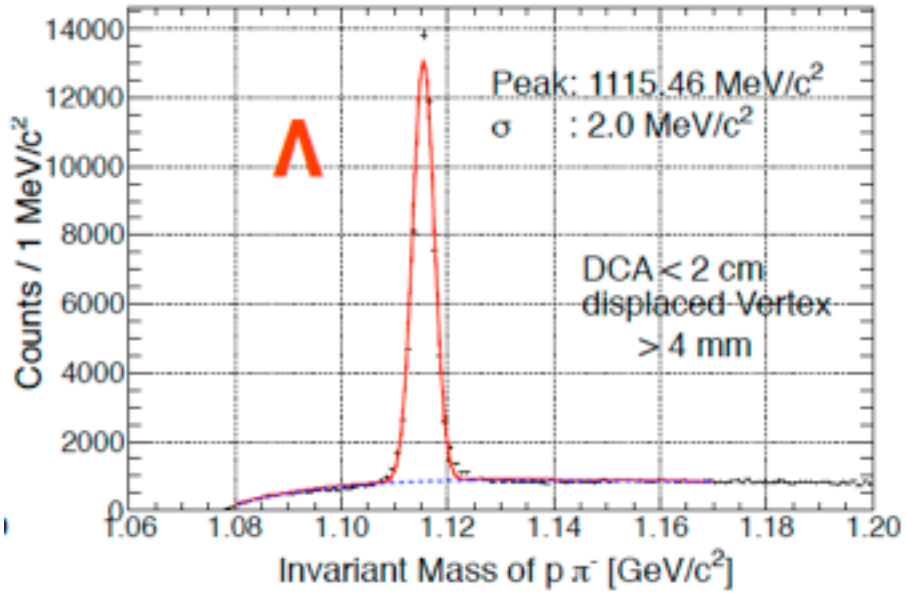
## event vertex



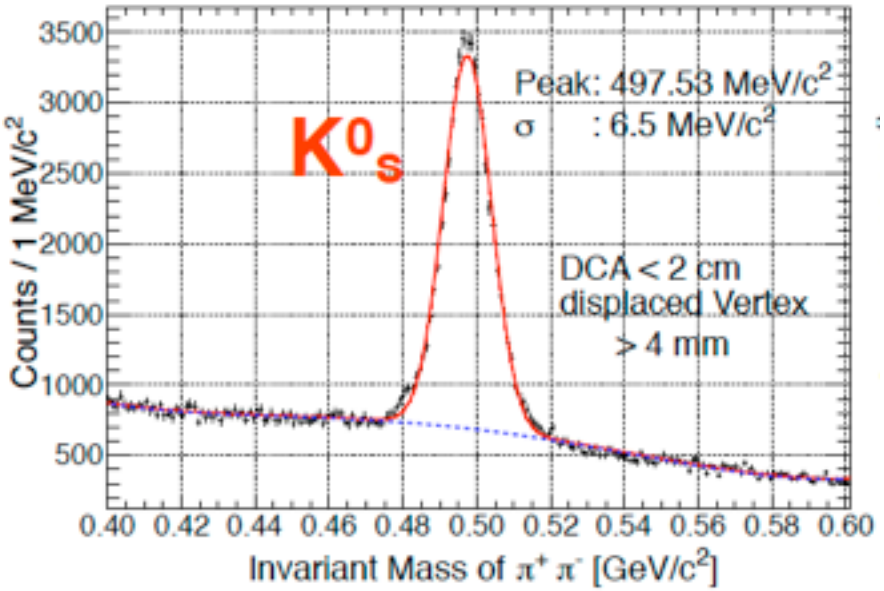

## pID in CDS




## pπ- invariant-mass spectra



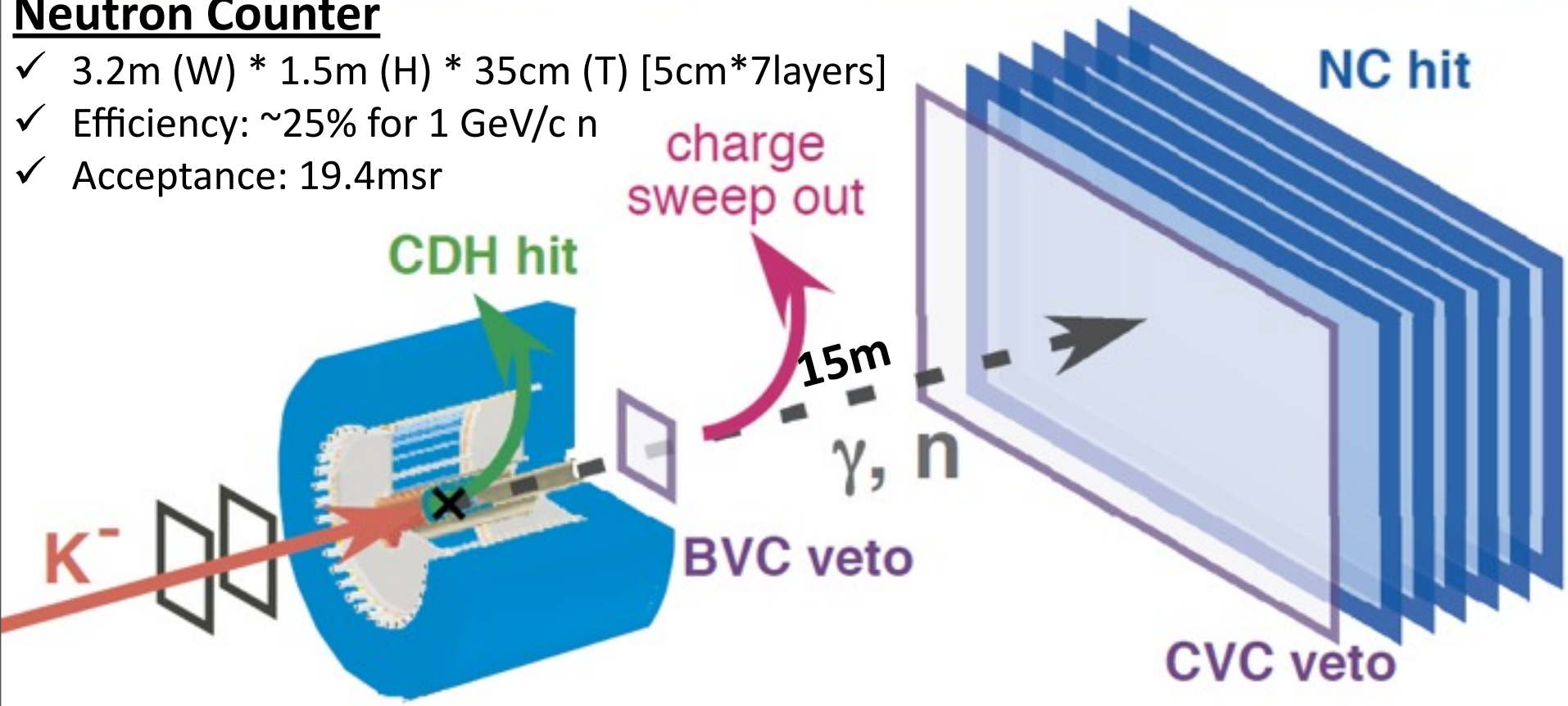

## π+π- invariant-mass spectra



# Forward Neutral Particles

## Neutron Counter

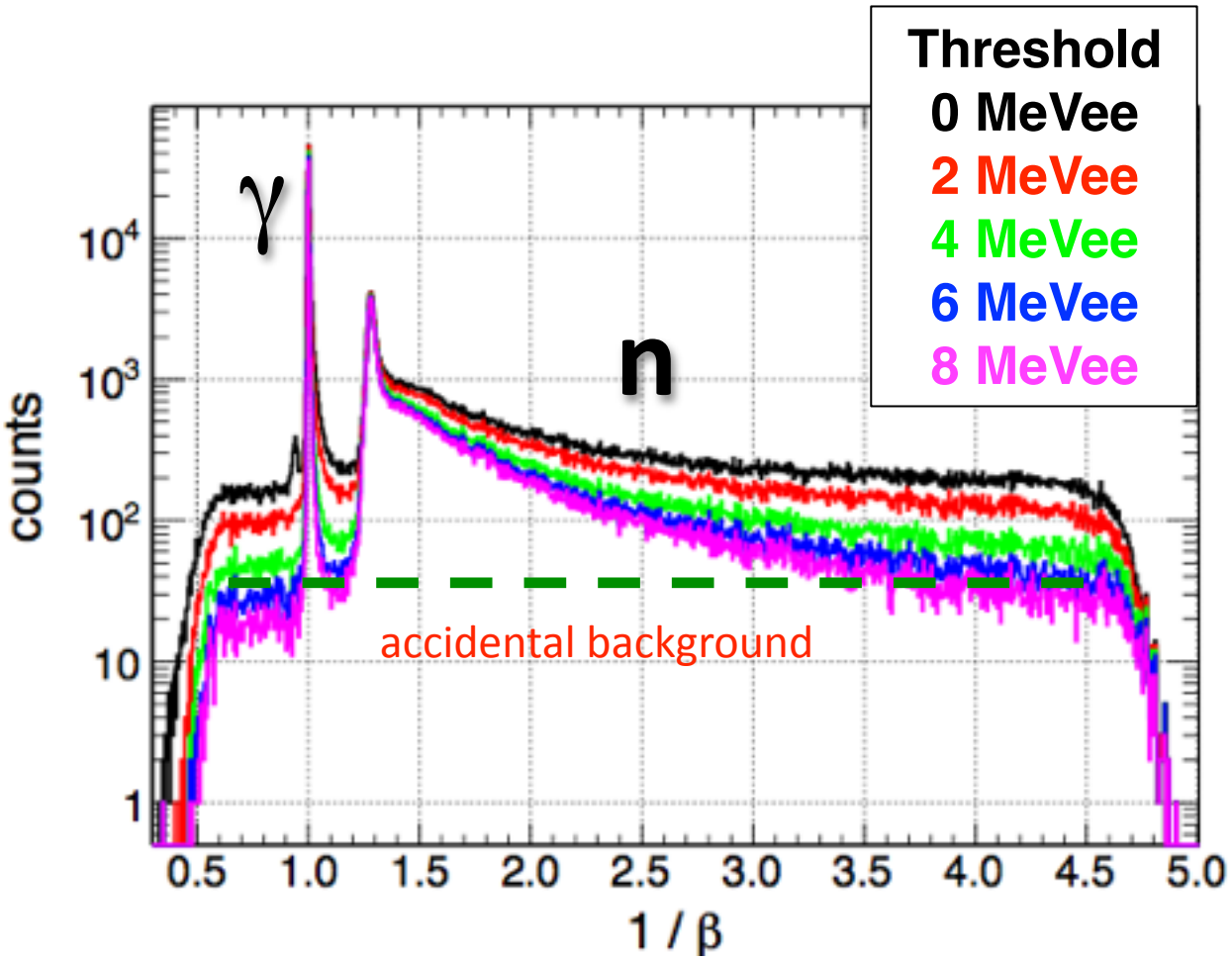
- ✓ 3.2m (W) * 1.5m (H) * 35cm (T) [5cm*7layers]
- ✓ Efficiency: ~25% for 1 GeV/c n
- ✓ Acceptance: 19.4msr




- Neutron momentum is determined by TOF method
- require at least 1 track in CDC to reconstruct the reaction vertex→ flight length

*energy-loss correction for K*

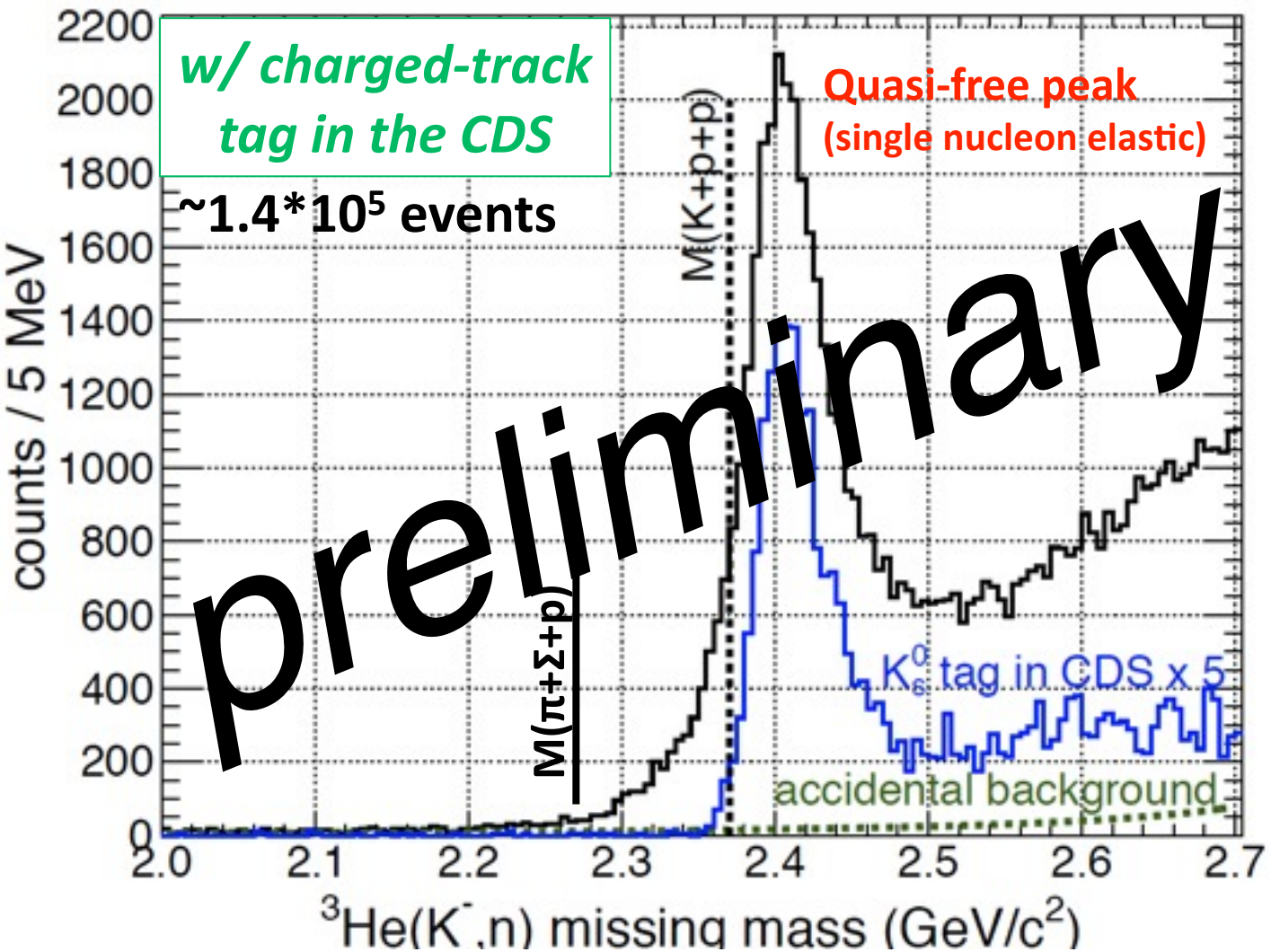
# Forward Neutral Particles




- ✓ **Set threshold to 5 MeVee**
- ✓ good S/N ratio of ~100 @ QF neutron peak
- ✓ **$\sigma_{TOF}$ ~ 160ps → $\sigma_{M.M.}$ ~ 10MeV/c² @ 1GeV/c**

# Preliminary Result 1: $^3$He(K$^-$,n)

## Semi-inclusive $^3$He(K$^-$,n) $\sigma_{M.M.}$~ 10MeV/c$^2$ @ 1GeV/c



# Inclusive $^3$He($K^-$, n)X spectrum

(w/ charged particle in CDS)

## Neutron events in sub-threshold region!

below Kpp (= 2730.2 MeV/$c^2$)

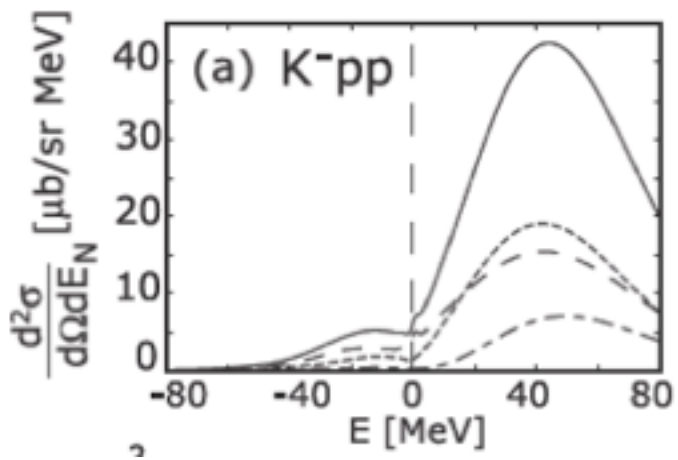
beyond experimental resolution

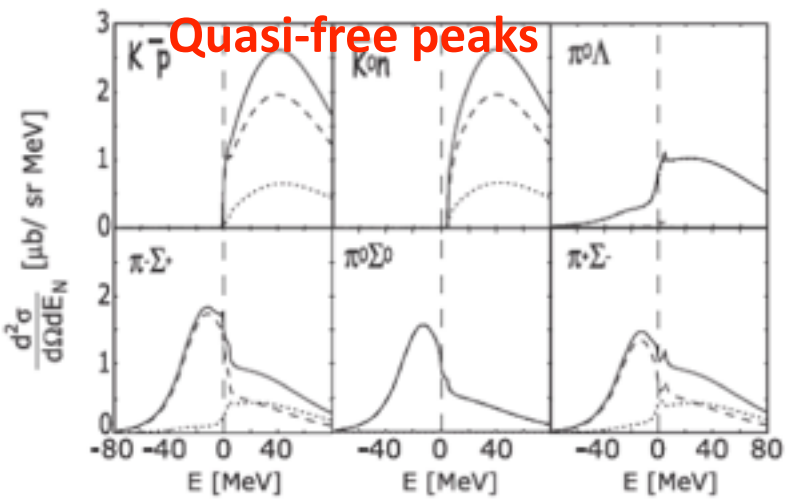
$\bar{K}$N attraction / strong imaginary part exist

## Exclusive analysis by specifying final state

PHYS. REV. C **80**, 045204 (2009)

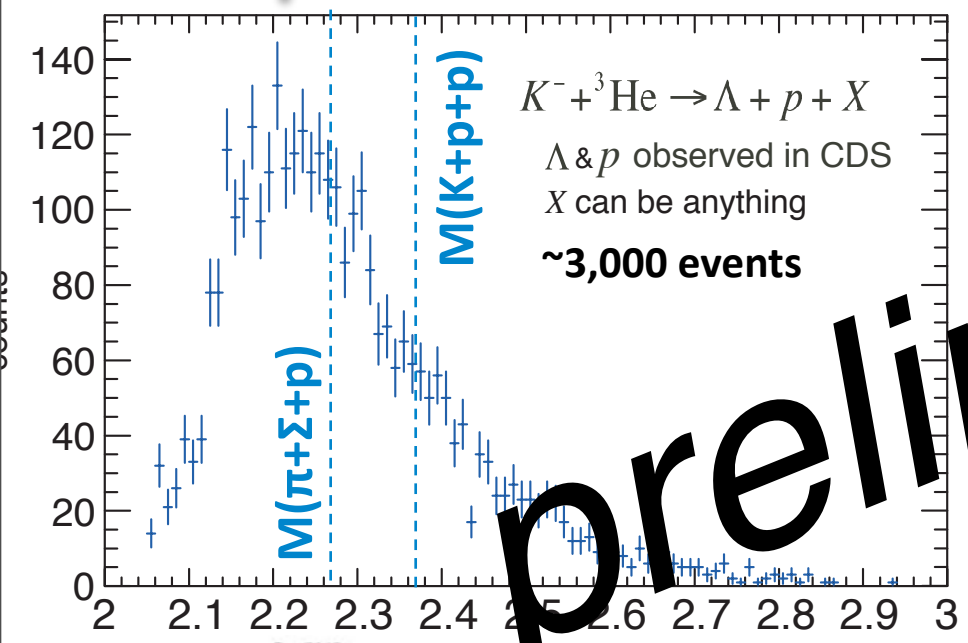
**J. Yamagata-Sekihara, D. Jido, H. Nagahiro, and S. Hirenzaki**

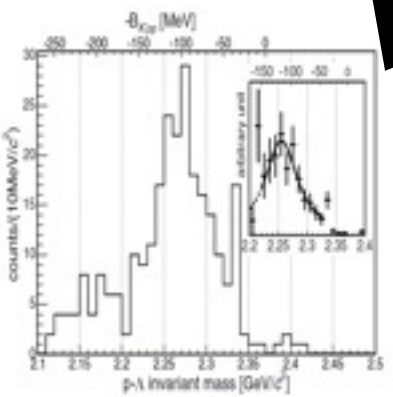


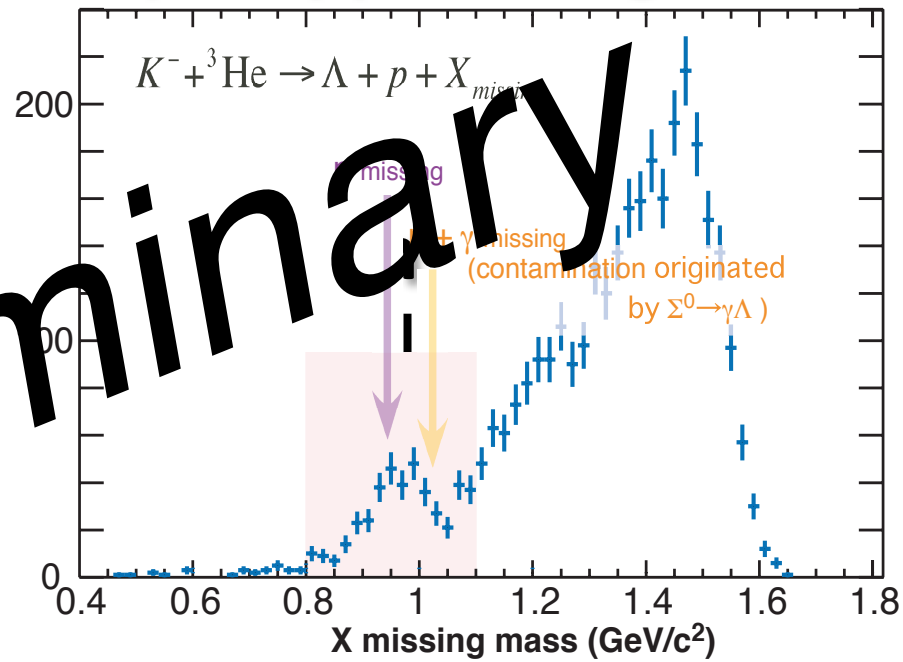
# Preliminary Result 2: $^3$He(K$^-$,Λp)

## Λp invariant mass

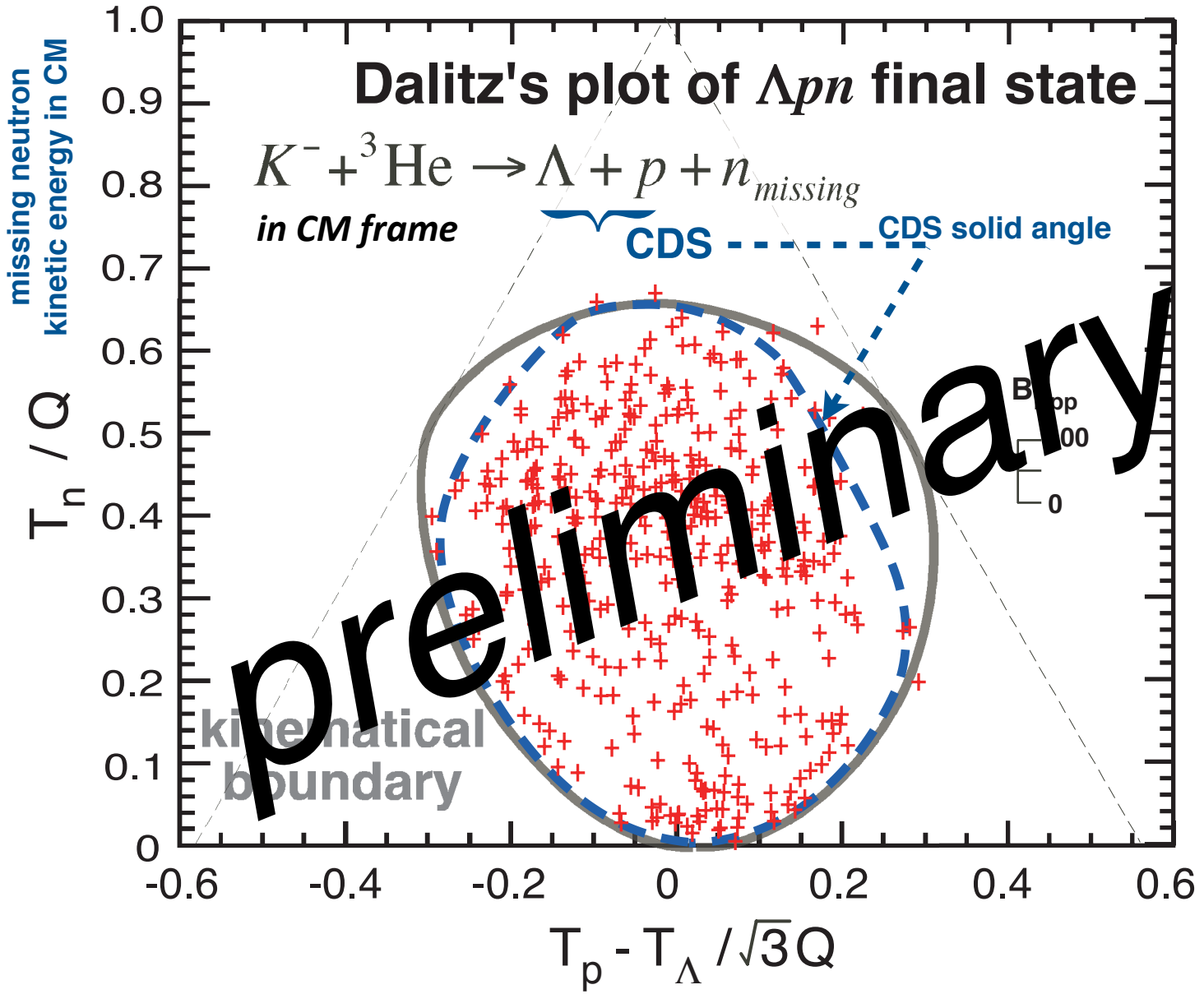


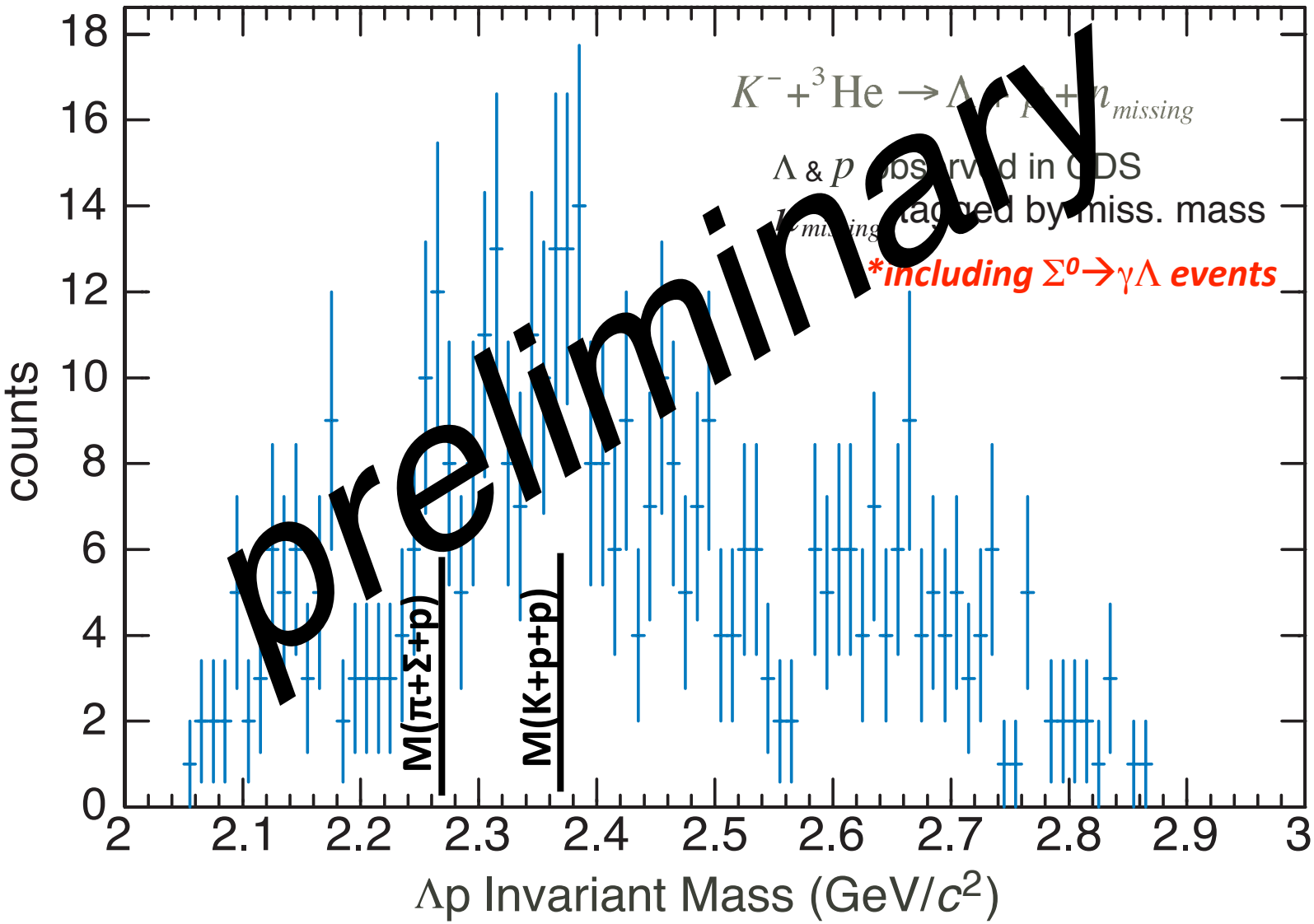
## $^3$He(K$^-$,Λp) missing mass




preliminary


Dalitz's plot of Λpn final state
$K^- + {}^3\mathrm{He} \rightarrow \Lambda + p + n_{missing}$
in CM frame
CDS
CDS solid angle
missing neutron kinetic energy in CM
$T_n / Q$
$T_p - T_\Lambda / \sqrt{3} Q$
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
kinematical boundary
preliminary

# Λp invariant mass spectrum



# Conclusion

## Semi-inclusive n spectrum

$^3$He(K$^-$,n)X missing mass obtained clearly

$\bar{K}$N attraction / strong imaginary part exist

$^3$He(K$^-$,p)X is in progress

## Exclusive channel

$^3$He(K$^-$,n)$\Lambda$p channel was examined

$^3$He(K$^-$,n)$\Sigma^{\pm}\pi^{\mp}$p, ... is in progress

Need substantially more statistics!

# The J-PARC E15 Collaboration

http://ag.riken.jp/J-PARC/collaboration/

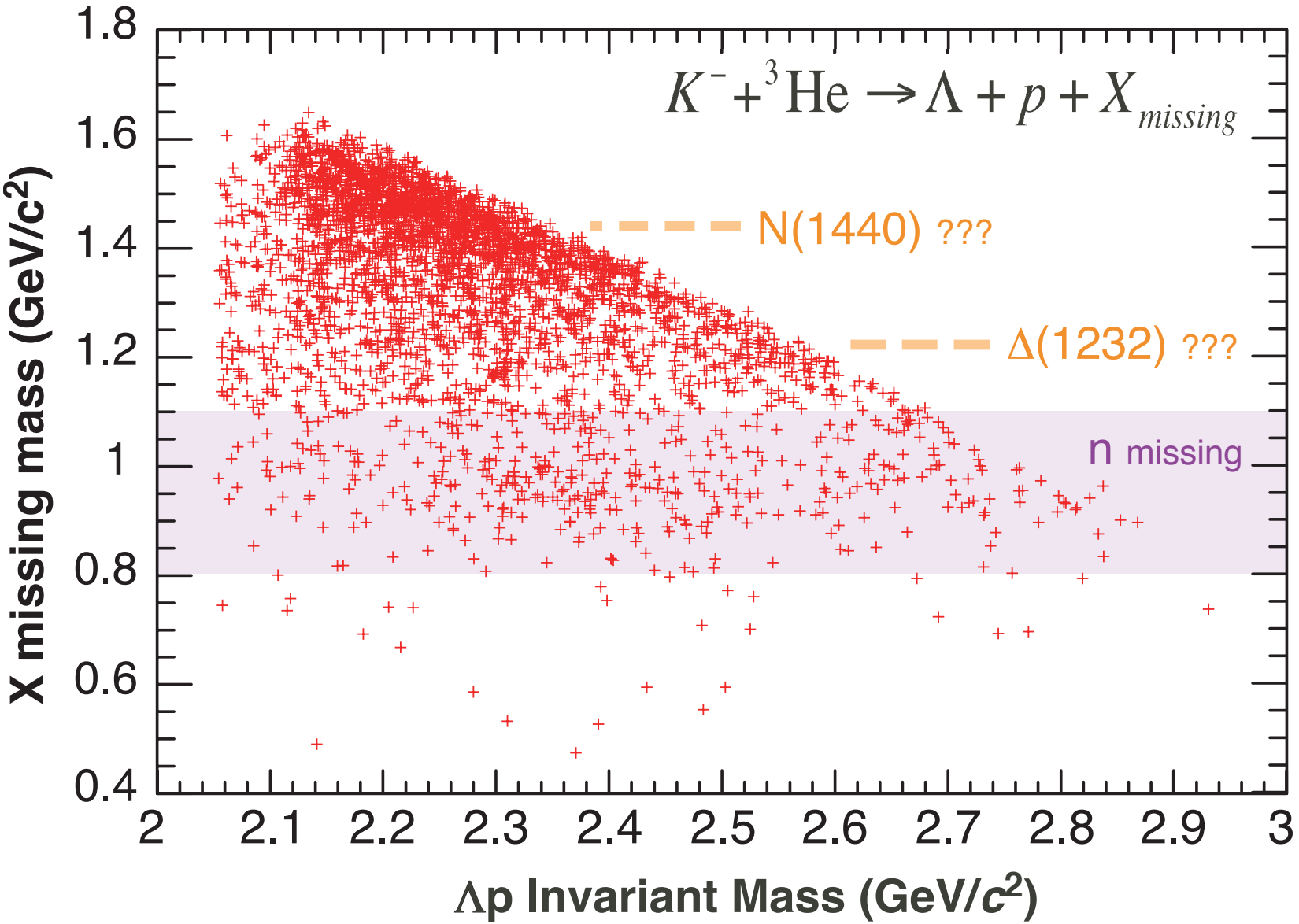

S. Ajimura[a], G. Beer[b], H. Bhang[c], M. Bragadireanu[e], P. Buehler[f], L. Busso[g,h], M. Cargnelli[f], S. Choi[c], C. Curceanu[d], S. Enomoto[i], D. Faso[g,h], H. Fujioka[j], Y. Fujiwara[k], T. Fukuda[l], C. Guaraldo[d], T. Hashimoto[k], R. S. Hayano[k], T. Hiraiwa[j], M. Iio[o], M. Iliescu[d], K. Inoue[i], Y. Ishiguro[j], T. Ishikawa[k], S. Ishimoto[o], T. Ishiwatari[f], K. Itahashi[n], M. Iwai[o], M. Iwasaki[m,n*], S. Kawasaki[i], P. Kienle[p], H. Kou[m], Y. Ma[n], J. Marton[f], Y. Matsuda[q], Y. Mizoi[l], O. Morra[g], T. Nagae[j$], H. Noumi[a], H. Ohnishi[n], S. Okada[n], H. Outa[n], K. Piscicchia[d], M. Poli Lener[d], A. Romero Vidal[d], Y. Sada[j], A. Sakaguchi[i], F. Sakuma[n], M. Sato[k], A. Scordo[d], M. Sekimoto[o], H. Shi[k], D. Sirghi[d,e], F. Sirghi[d,e], K. Suzuki[f], S. Suzuki[o], T. Suzuki[k], H. Tatsuno[d], M. Tokuda[m], D. Tomono[n], A. Toyoda[o], K. Tsukada[r], O. Vazquez Doce[d,s], E. Widmann[f], T. Yamazaki[k,n], H. Yim[t], and J. Zmeskal[f]

(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) Laboratori Nazionali di Frascati dell' INFN, I-00044 Frascati, Italy
(e) National Institute of Physics and Nuclear Engineering - IFIN HH, Romania
(f) Stefan-Meyer-Institut für subatomare Physik, A-1090 Vienna, Austria
(g) INFN Sezione di Torino, Torino, Italy
(h) Dipartimento di Fisica Generale, Universita' di Torino, Torino, 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) Department of Physics, Tokyo Institute of Technology, Tokyo, 152-8551, Japan
(n) RIKEN Nishina Center, RIKEN, Wako, 351-0198, Japan
(o) High Energy Accelerator Research Organization (KEK), Tsukuba, 305-0801, 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

(*) Spokesperson
($) Co-Spokesperson

# Thank you !

# backup


$K^- + {}^3\mathrm{He} \rightarrow \Lambda + p + X_{missing}$
N(1440) ???
Δ(1232) ???
n missing
X missing mass (GeV/c²)
Λp Invariant Mass (GeV/c²)
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
2
2.1
2.2
2.3
2.4
2.5
2.6
2.7
2.8
2.9
3

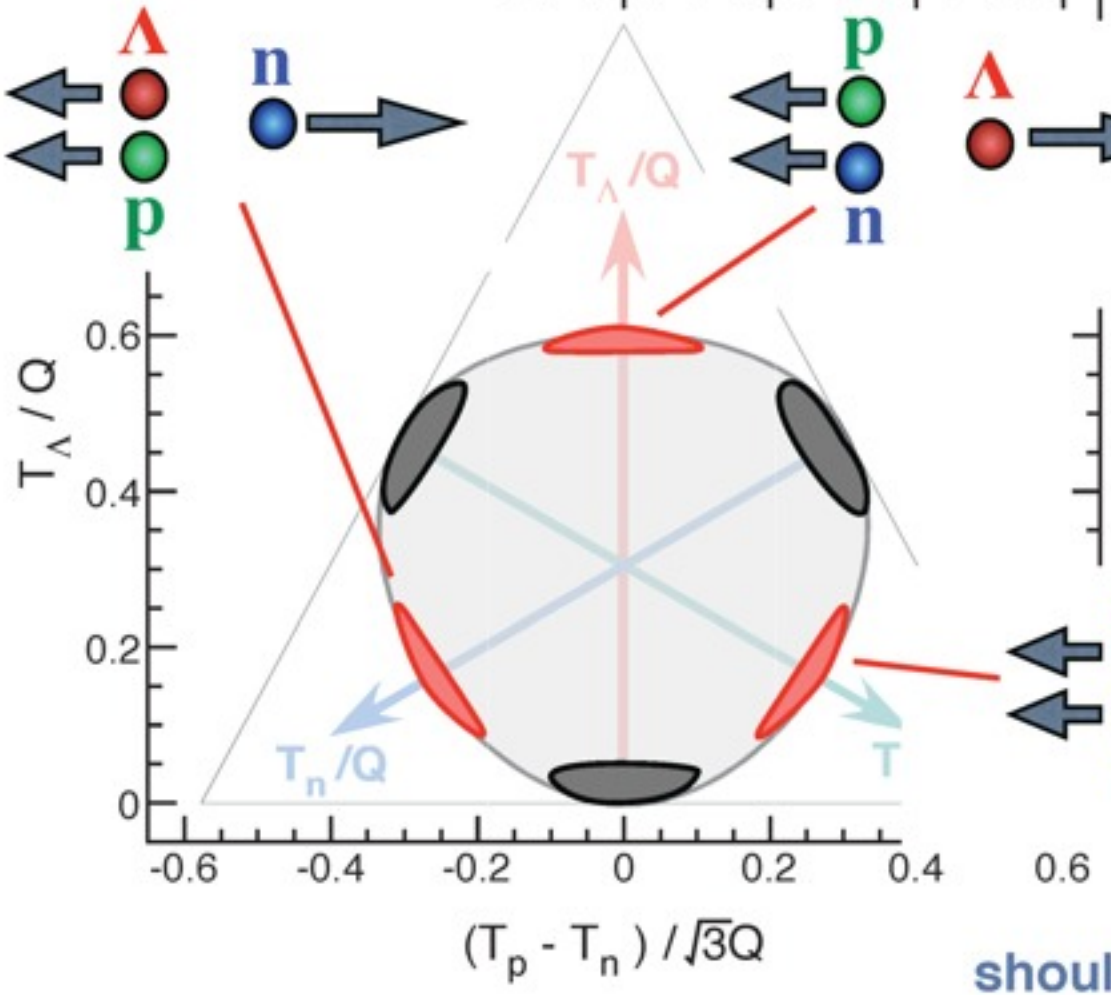
# Λpn events Two Nucleon Correlation

D. Gotta, et al, PL 112B, 129 (1982)

π absorption on $^3$He at rest


another remarkable message
FSI on $^3$He is week!

3-body Phase Space (Dalitz's plot) at CM




two-nucleon correlation
can be studied
should be week @ 1GeV/c, though