Measurement of Pionic ^{121}Sn Atom at RI Beam Factory

Kenta Itahashi

Advanced Meson Science Laboratory, RIKEN

for Pionic Atom Factory Project

RIKEN

INABE Naohito, ITAHASHI Kenta, KAMEDA Daisuke, KUBO Toshiyuki, NAKAMURA Masaki, TAKEDA Hiroyuki, UESAKA Tomohiro, YOSHIDA Koichi

SMI

SUZUKI Ken

The University of Tokyo

HAYANO Ryugo S., ITOH Satoshi, KAWASE Shoichiro, MIKI Kenjiro, NISHI Takahiro, NOJI Shumpei, OTA Shinsuke, TODOROKI Koichi

GSI

GEISSEL Hans, WEICK Helmut

University of Notre Dame

BERG Gerog P.A.

Osaka University

MATSUBARA Hiroaki, MICHIMASA Shin'ichiro

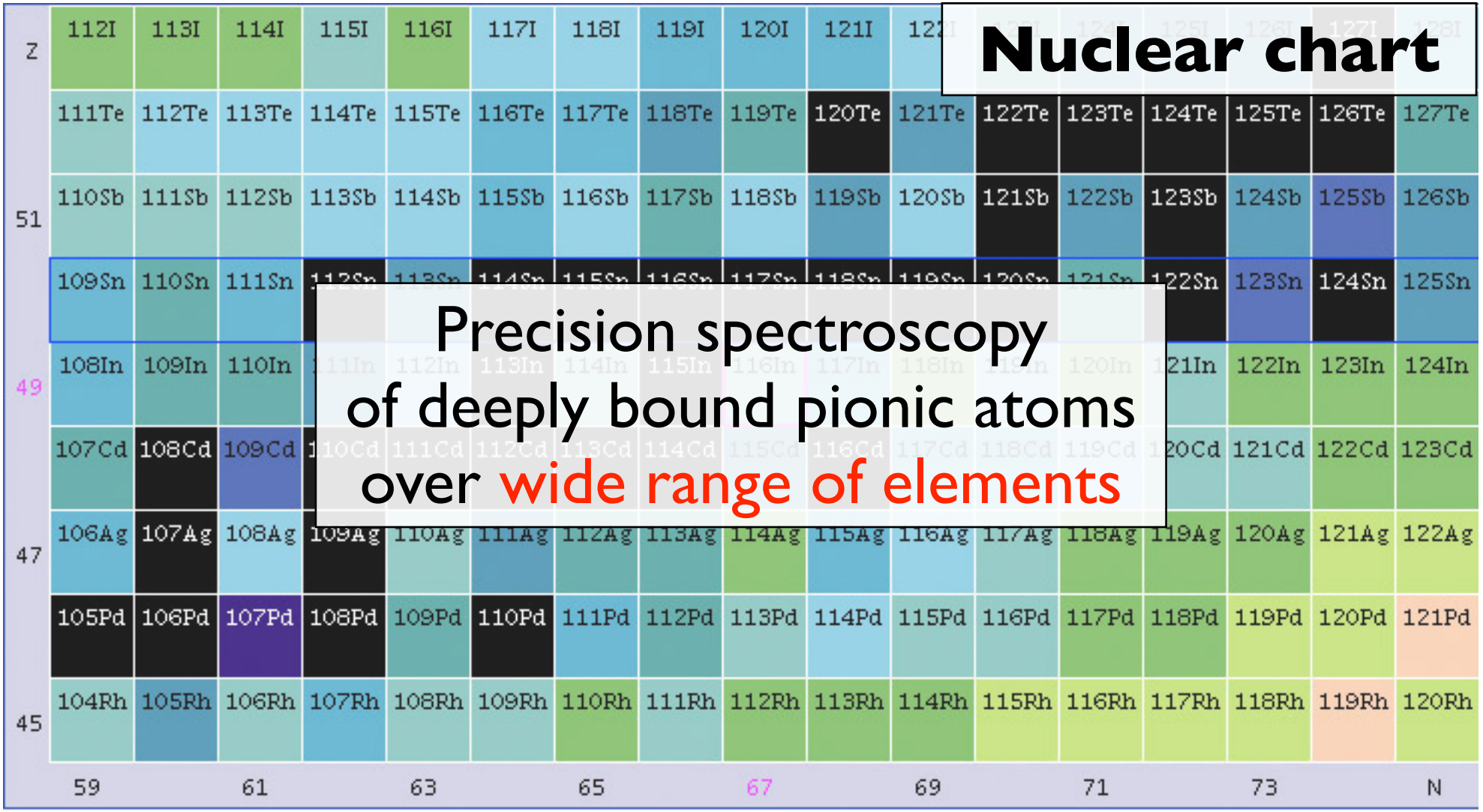
Tohoku University

TSUKADA Kyo

Nara Women's University

HIRENZAKI Satoru, IKENO Natsumi, YAMAGATA-SEKIHARA Junko

Pionic Atom Factory Project in RIBF



NNDC,BNL

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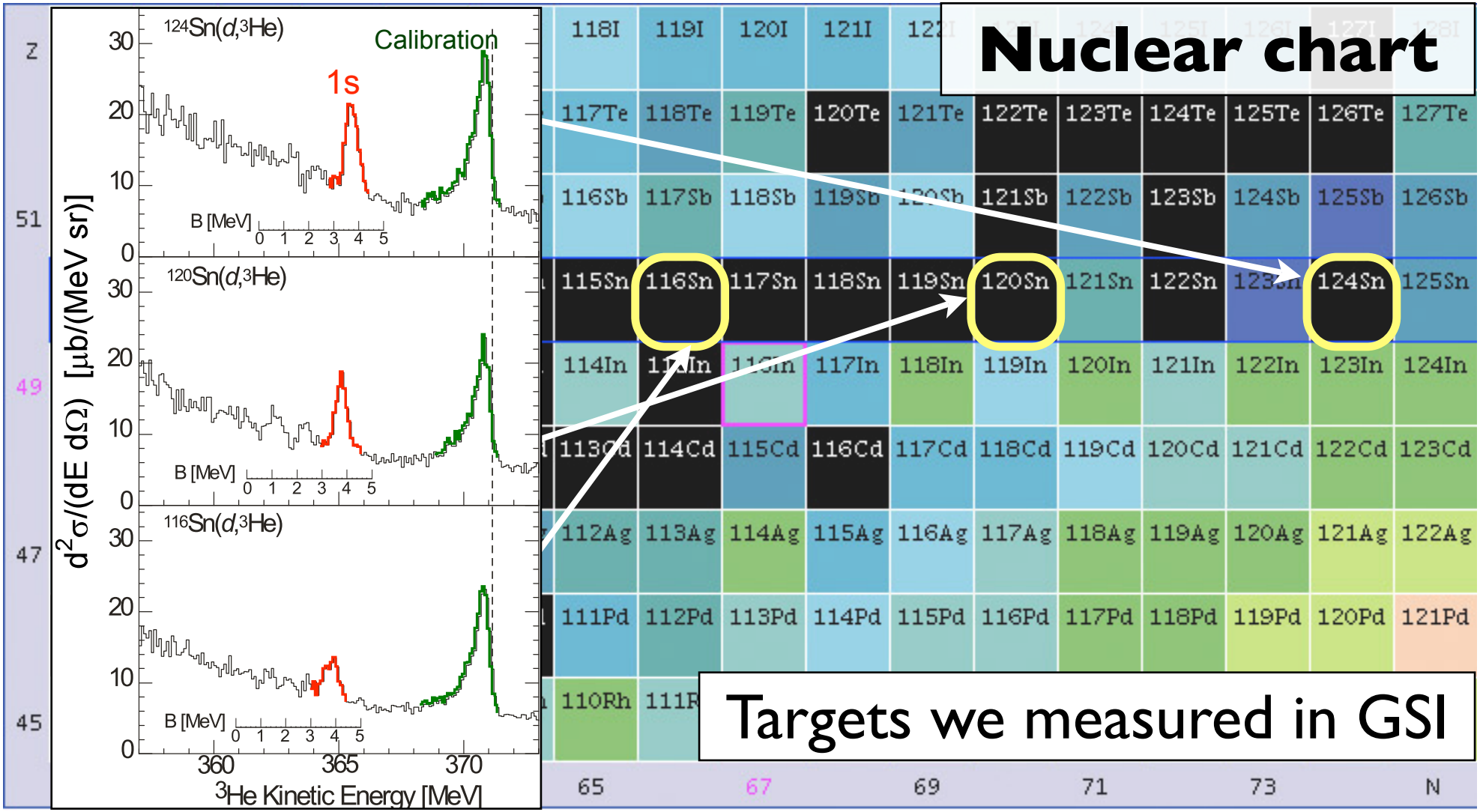
Pionic Atom Factory Project in RIBF



K. Suzuki et al.,
PRL92(04)072302.

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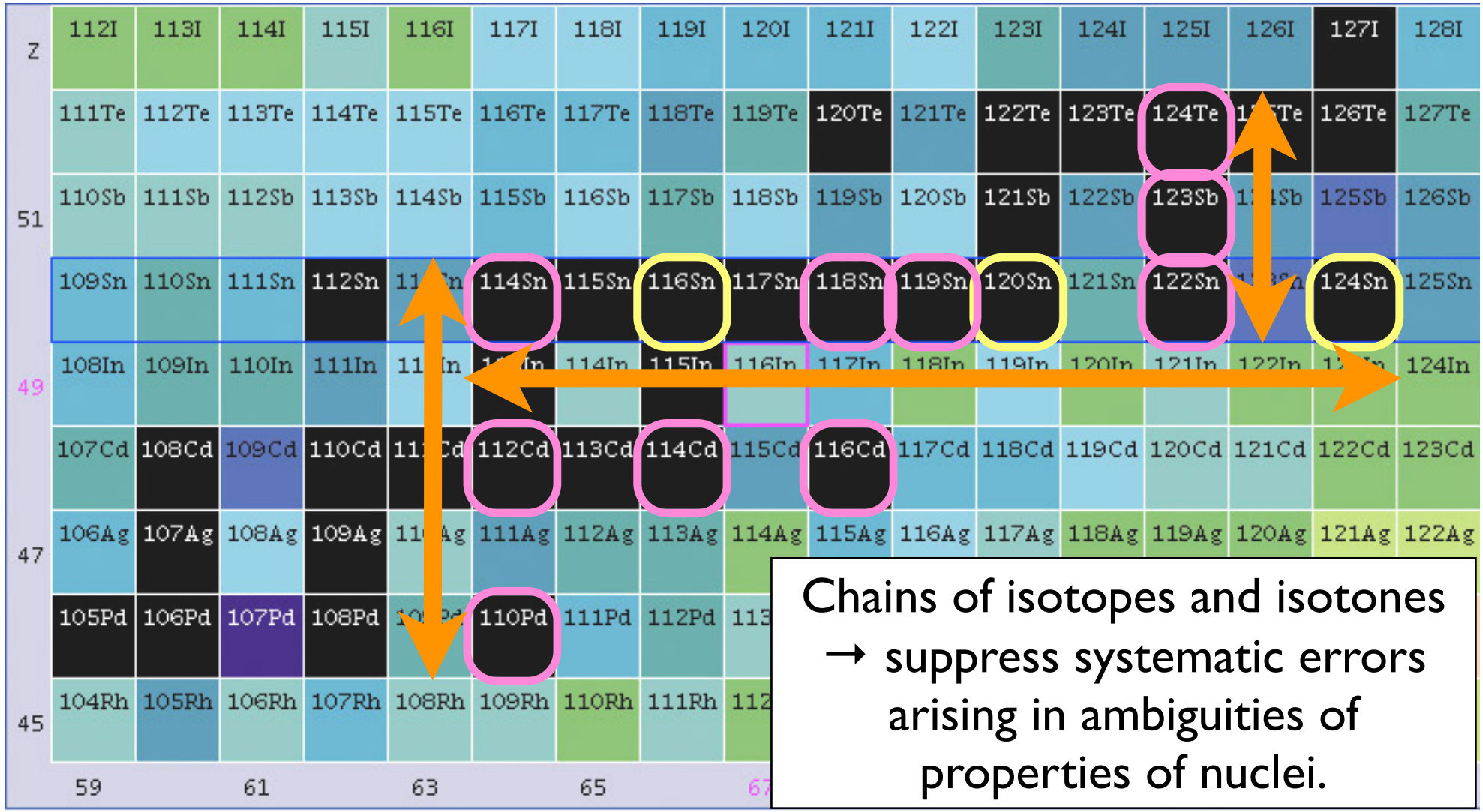

Chains of isotopes and isotones
→ suppress systematic errors arising in ambiguities of properties of nuclei.

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Pionic Atom Factory Project in RIBF

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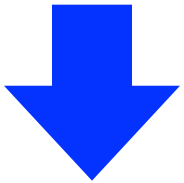
High quality spectroscopy



- Precise information on
  π - nucleus strong interaction
- Partial restoration Chiral symmetry
  in nuclear matter

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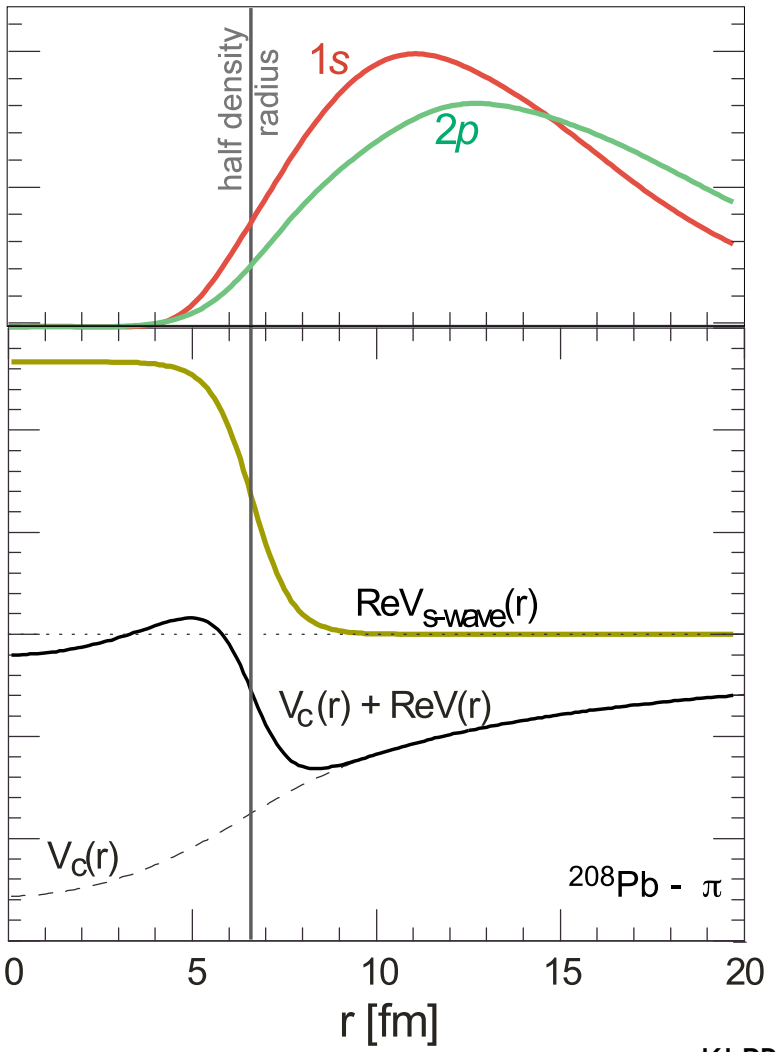
π-nucleus Strong interaction potential

$$V_{s\text{-wave}} = b_0\,\rho + b_1\,(\rho_n - \rho_p) + B_0\,\rho^2$$

Large overlap between pion and nucleus



high sensitivity to s-wave potential

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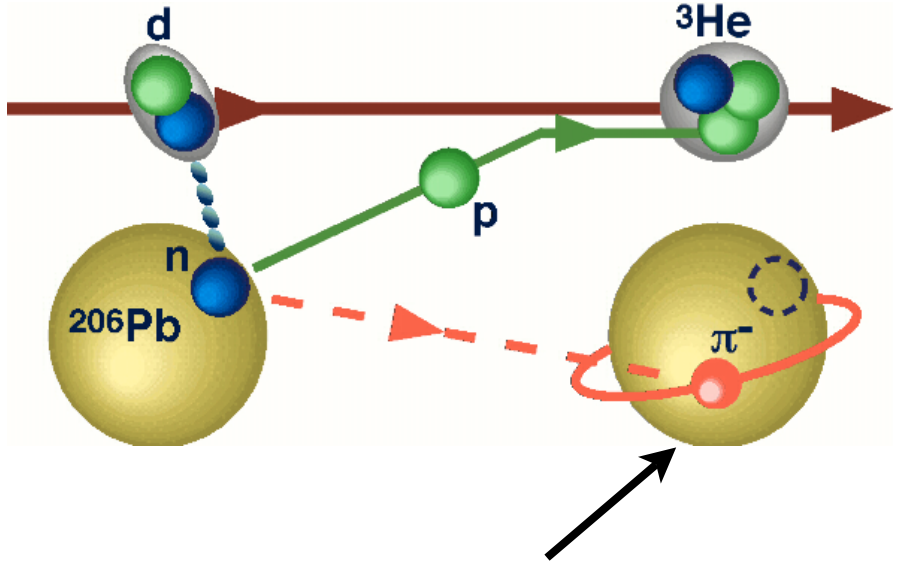
Experimental Method

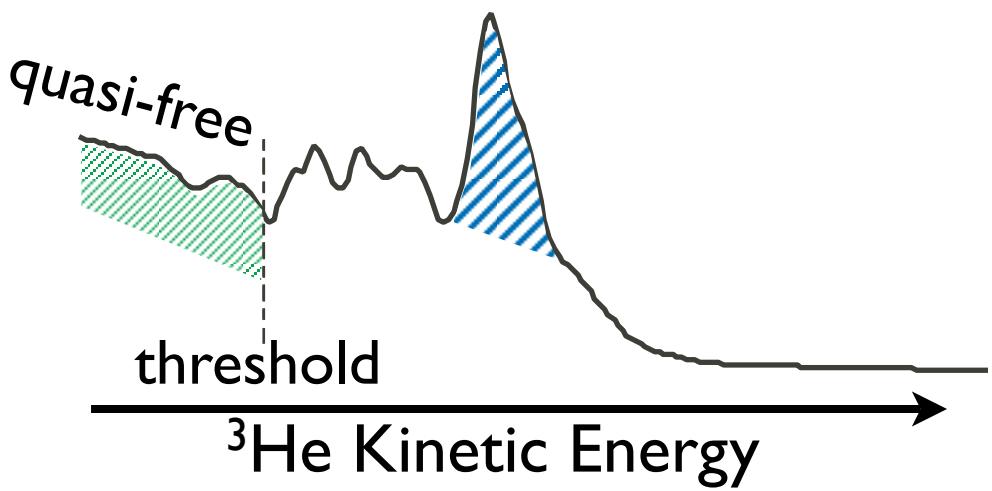
(d,^{3}He) nuclear reaction
to produce pionic atom directly



Pion bound state
(coupled with n hole)

Missing mass spectroscopy
to measure excitation spectrum

We are aiming at
300 keV (FWHM) resolution
at ~140 MeV excitation energy.



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Brief Report on Pilot Experiment

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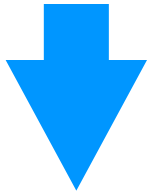
Pilot Experiment

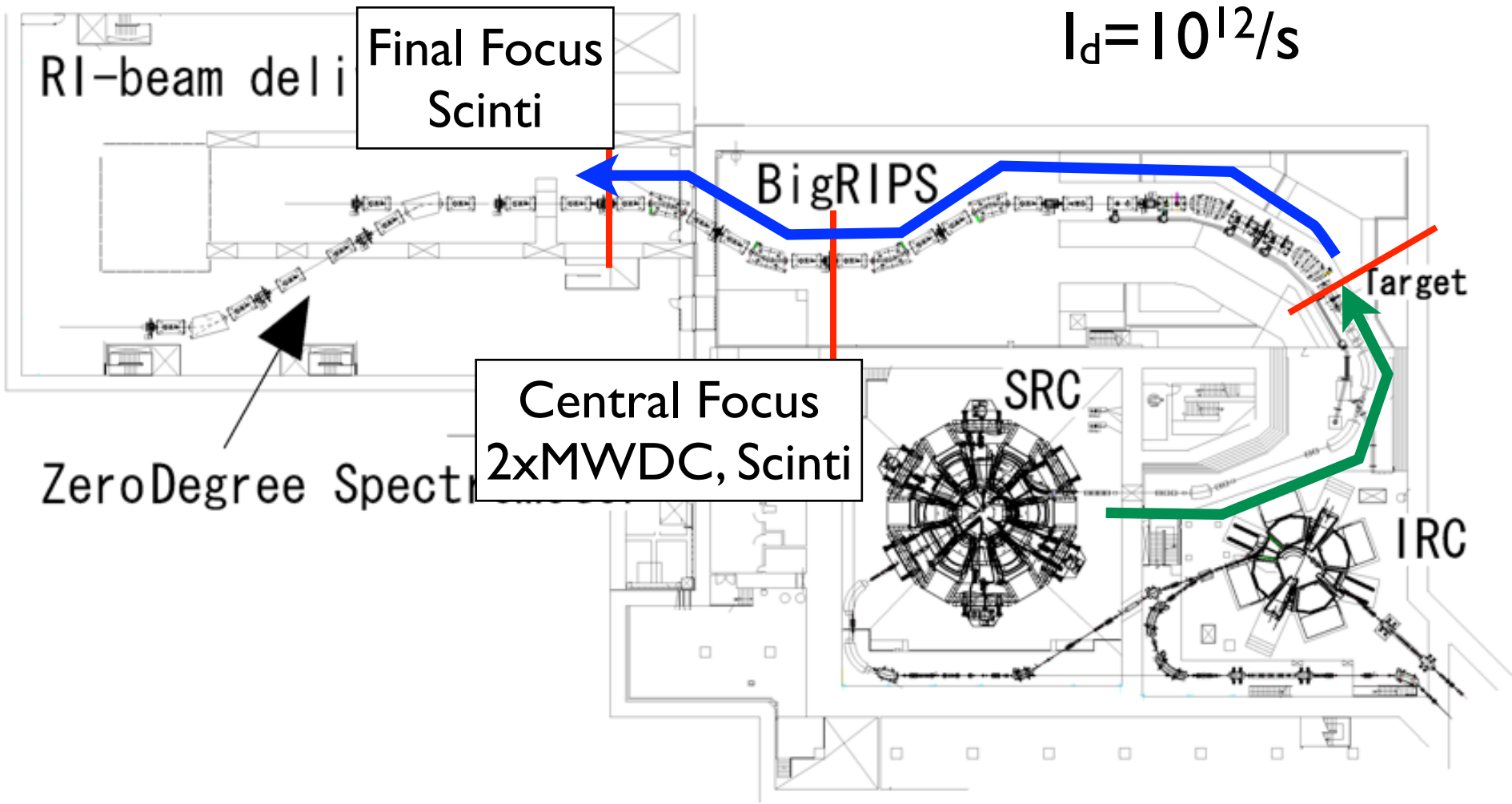
- Same experimental condition as main exp. for systematic study.
- Check if all system works.
- Trial for first measurement of pionic ^{121}Sn.



3 day-beamtime in Oct/2010

RIBF/RIKEN (= Experiment site)

(d,^{3}He) @ Td = 250 MeV/u
I_d=10^{12}/s



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Detector Installation

(~1000 ch within 24 hrs!)

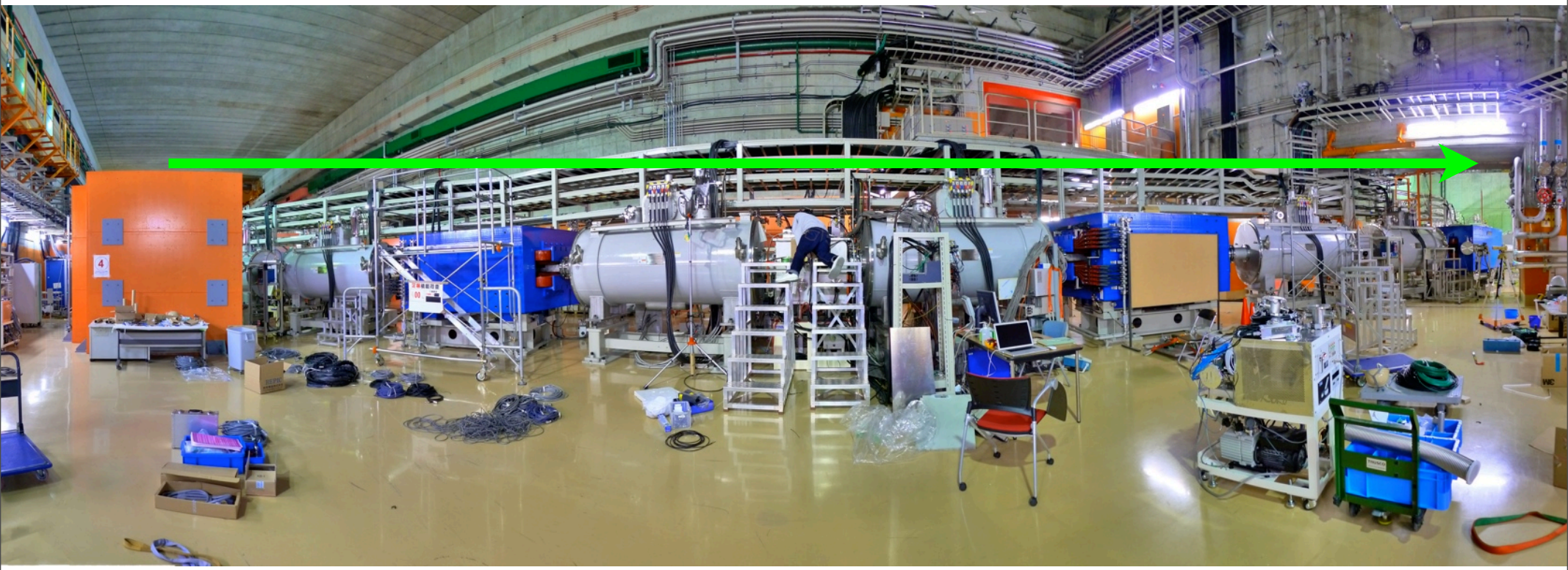

photo by K. Suzuki

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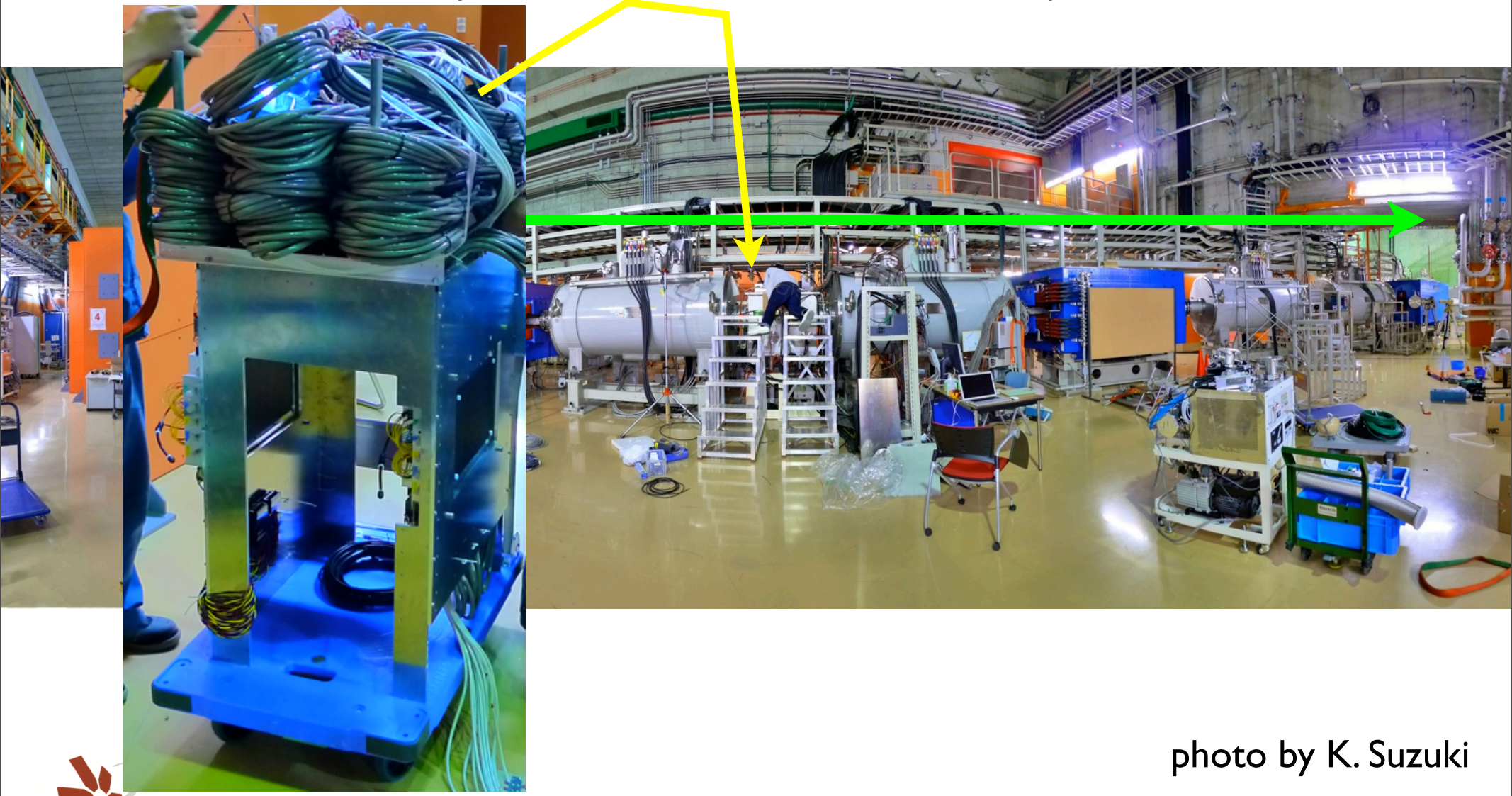
(~1000 ch within 24 hrs!)



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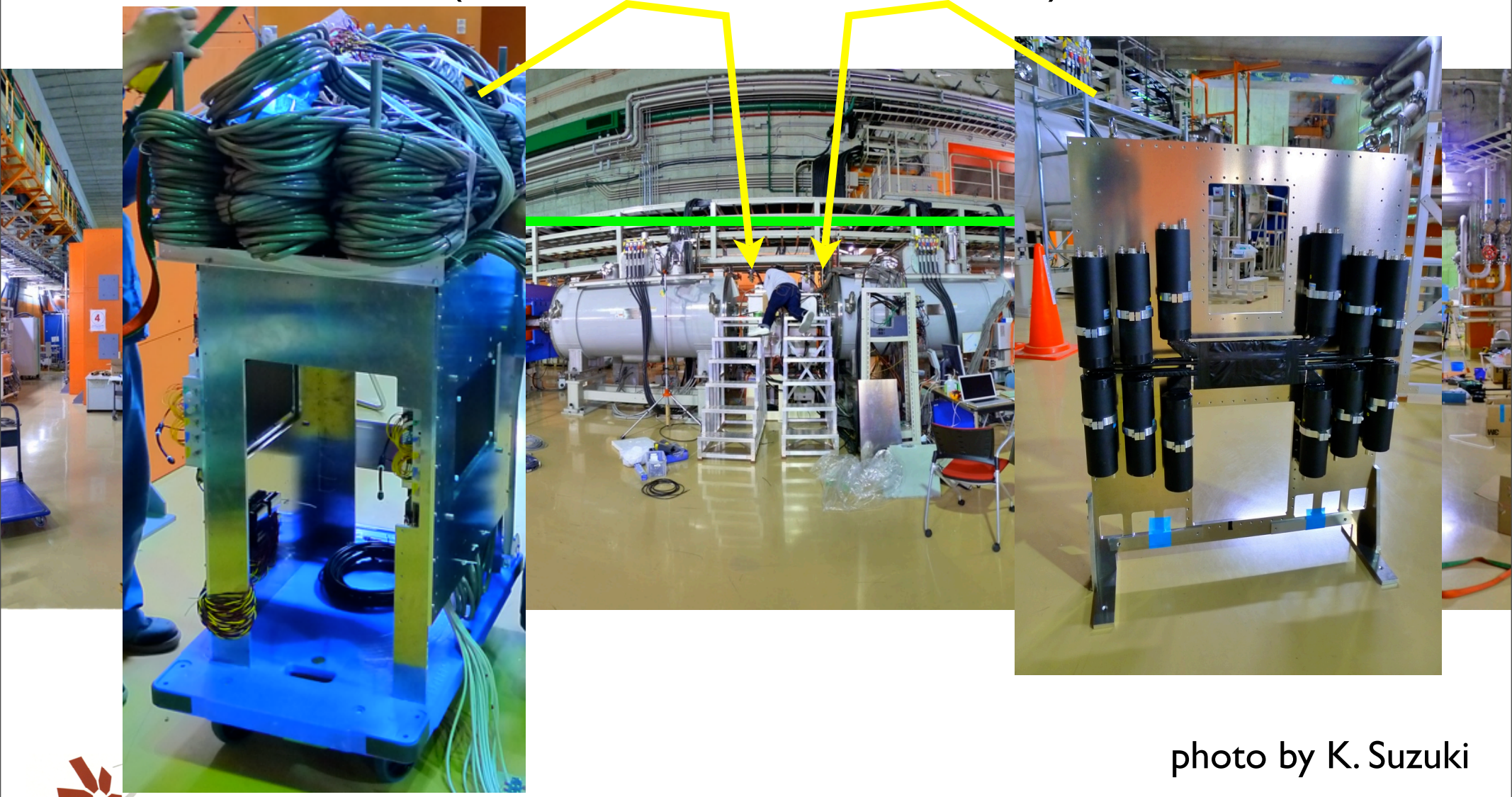

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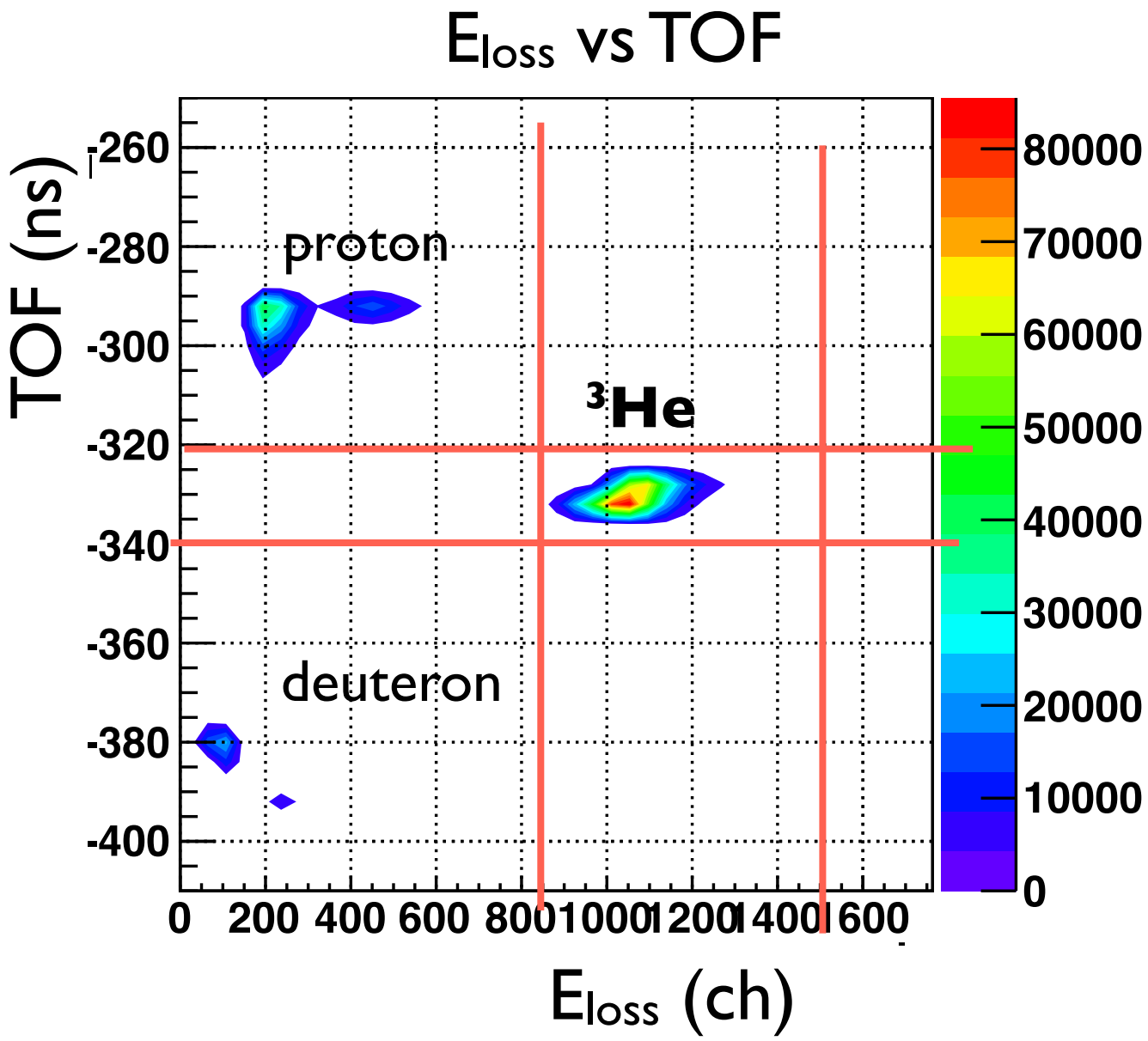
Particle Identification



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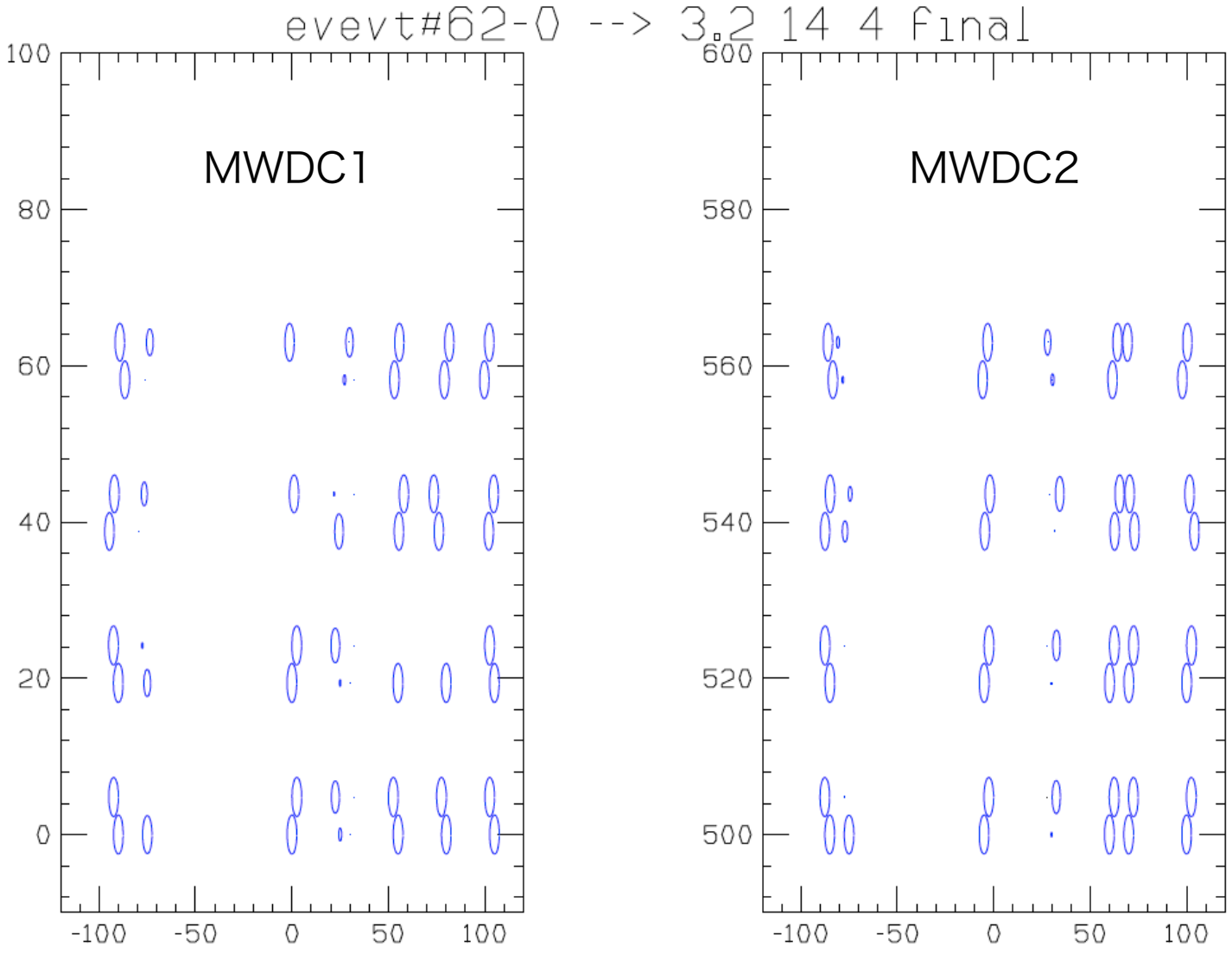
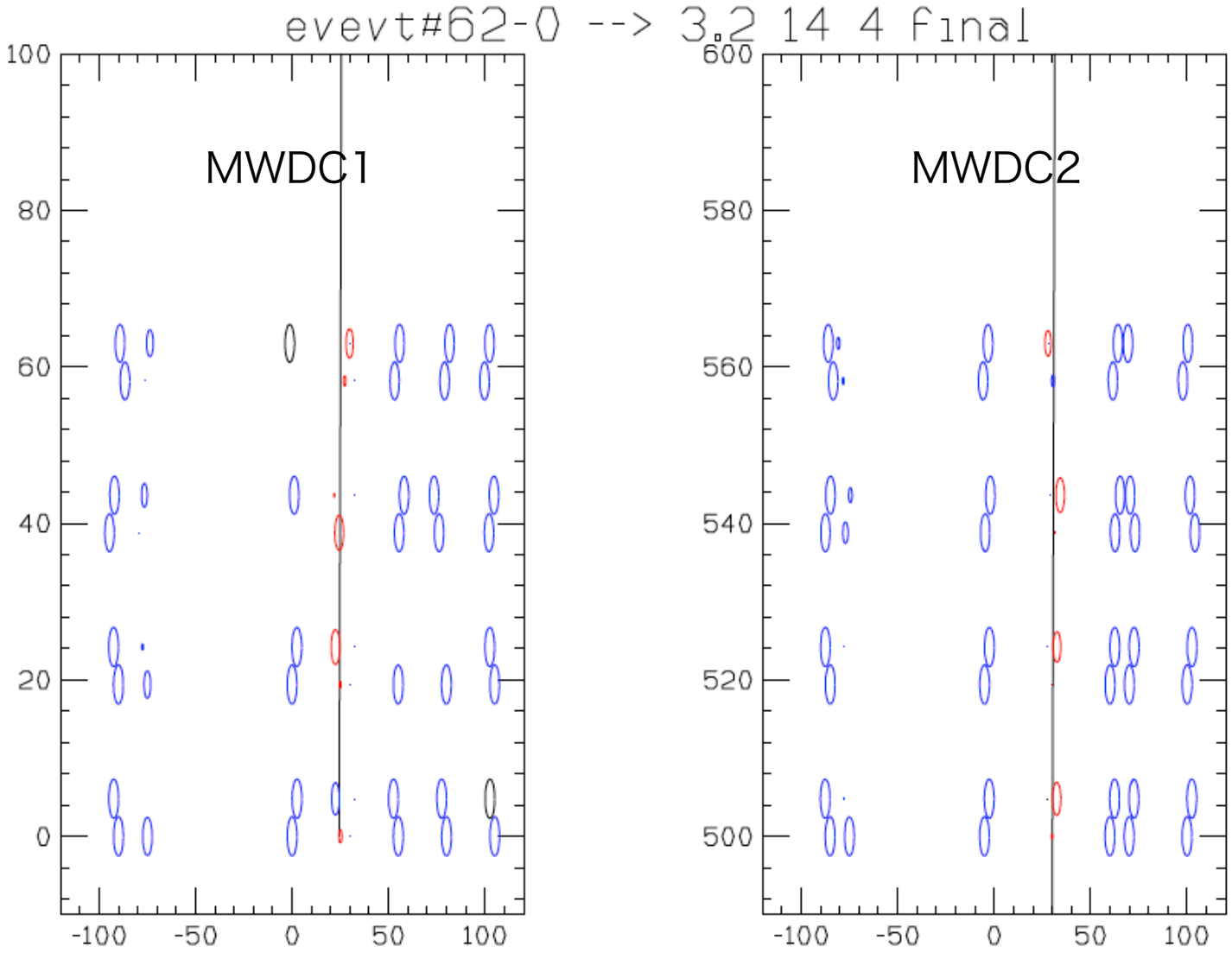
Typical Event



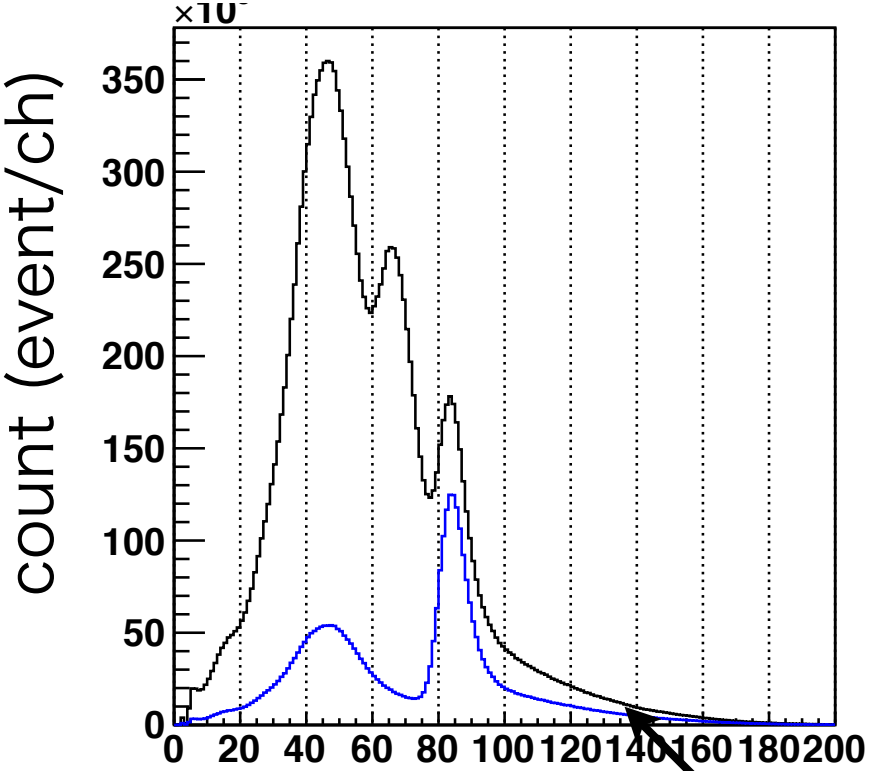
7 tracks in 200 ns = 35 MHz

^{3}He Track is reconstructed

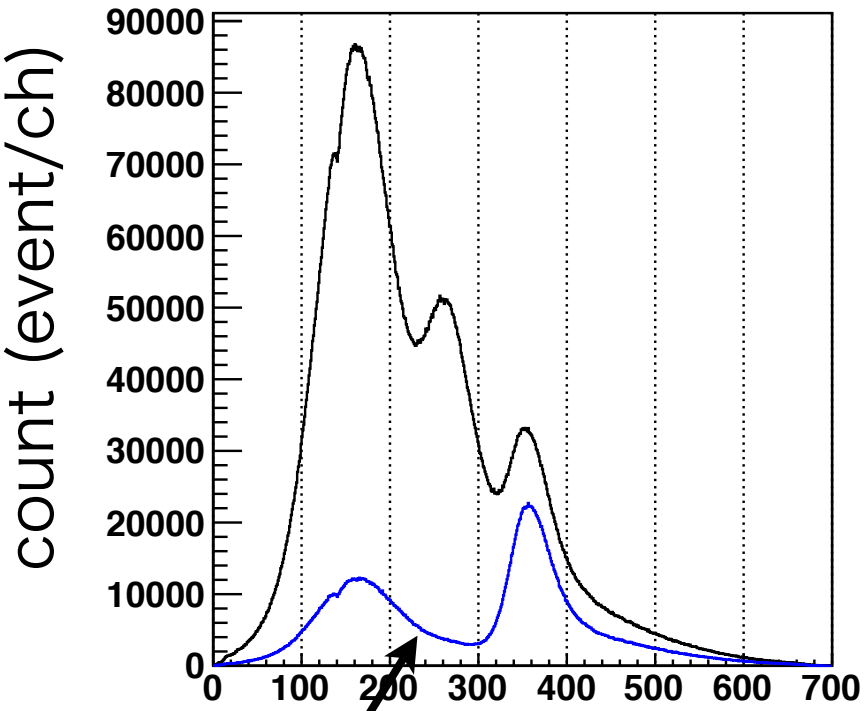


Particle ID by MWDC itself

ToT of MWDC1



ToT of MWDC2

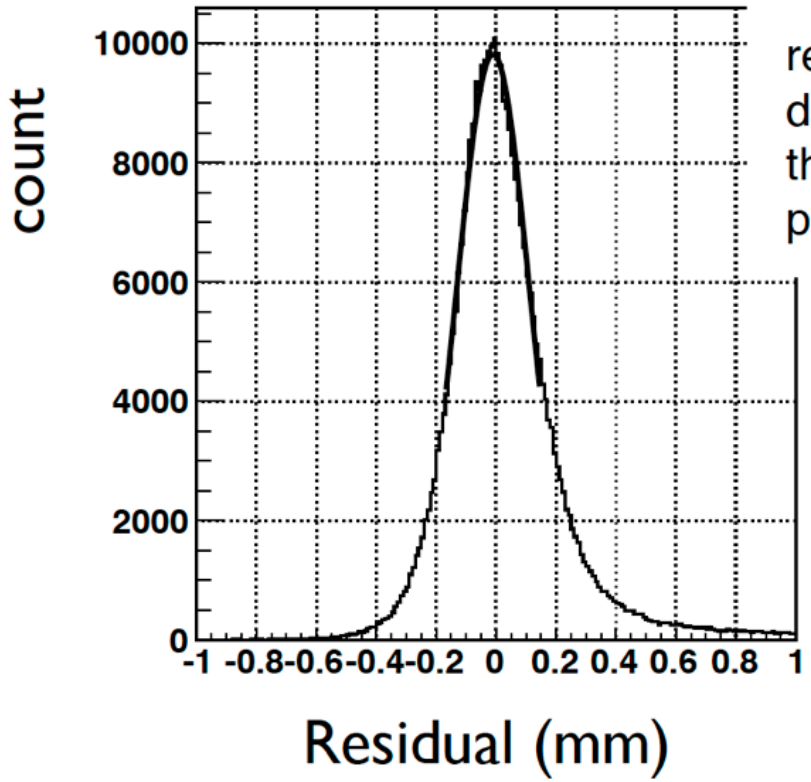


when ^{3}He is detected by scintillators

Overview of the so far analysis

MWDC analysis

residual distribution of plane 1



residual:
defined as the distance between the position of the track on the plane and hit position of the plane

resolution ~ 0.12 mm (σ)
~ 0.28 mm(FWHM)

cf. designed value;
0.3 mm (FWHM)

→ overall
0.13mm (FWHM)

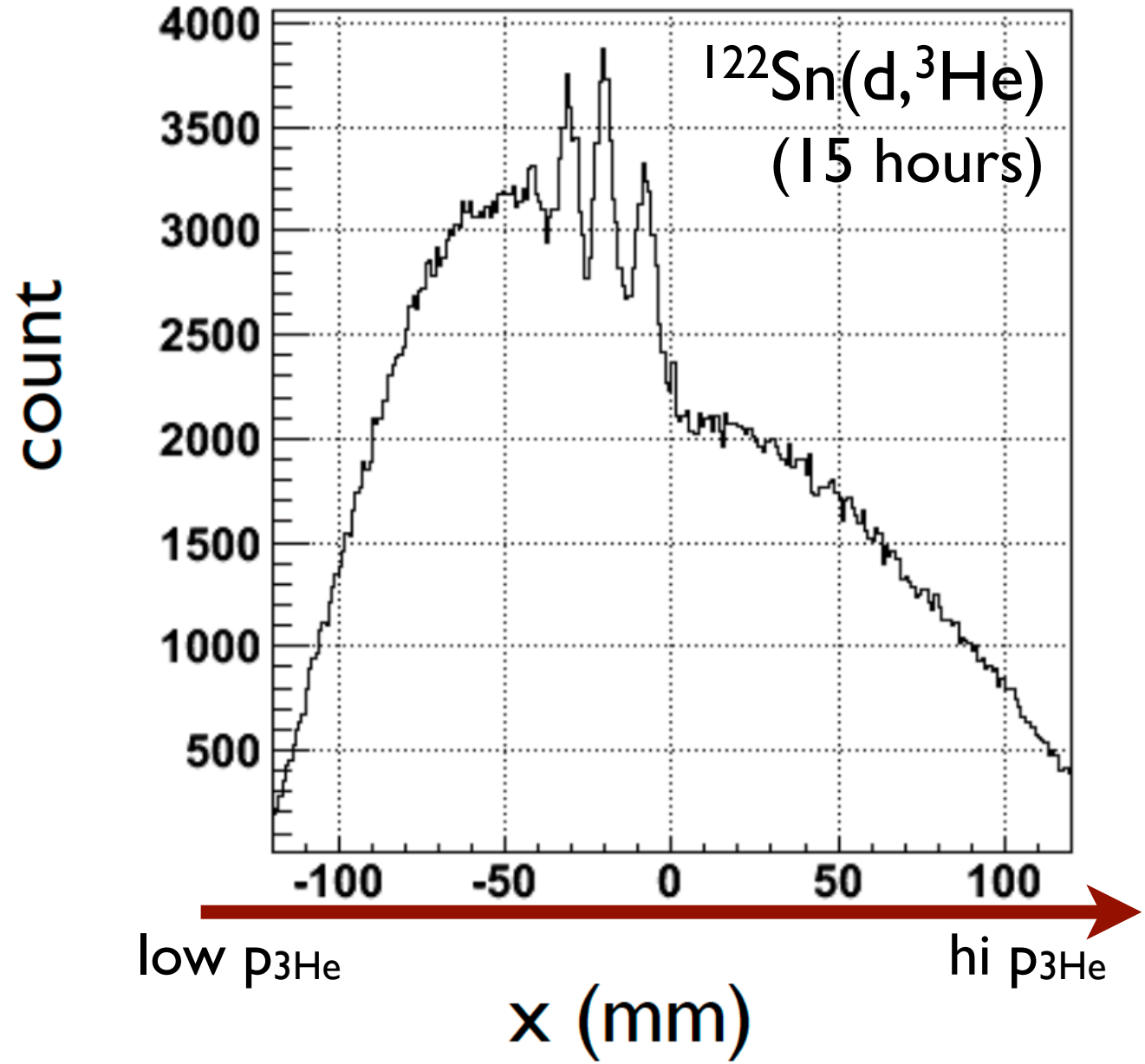
tracking efficiency by MWDC ~ 95 %

cf) % of ^{3}He event in tracked event ～ 97%

Focal Plane ^{3}He Spectrum

(acceptance uncorrected)

We expected
1s and 2s peaks...



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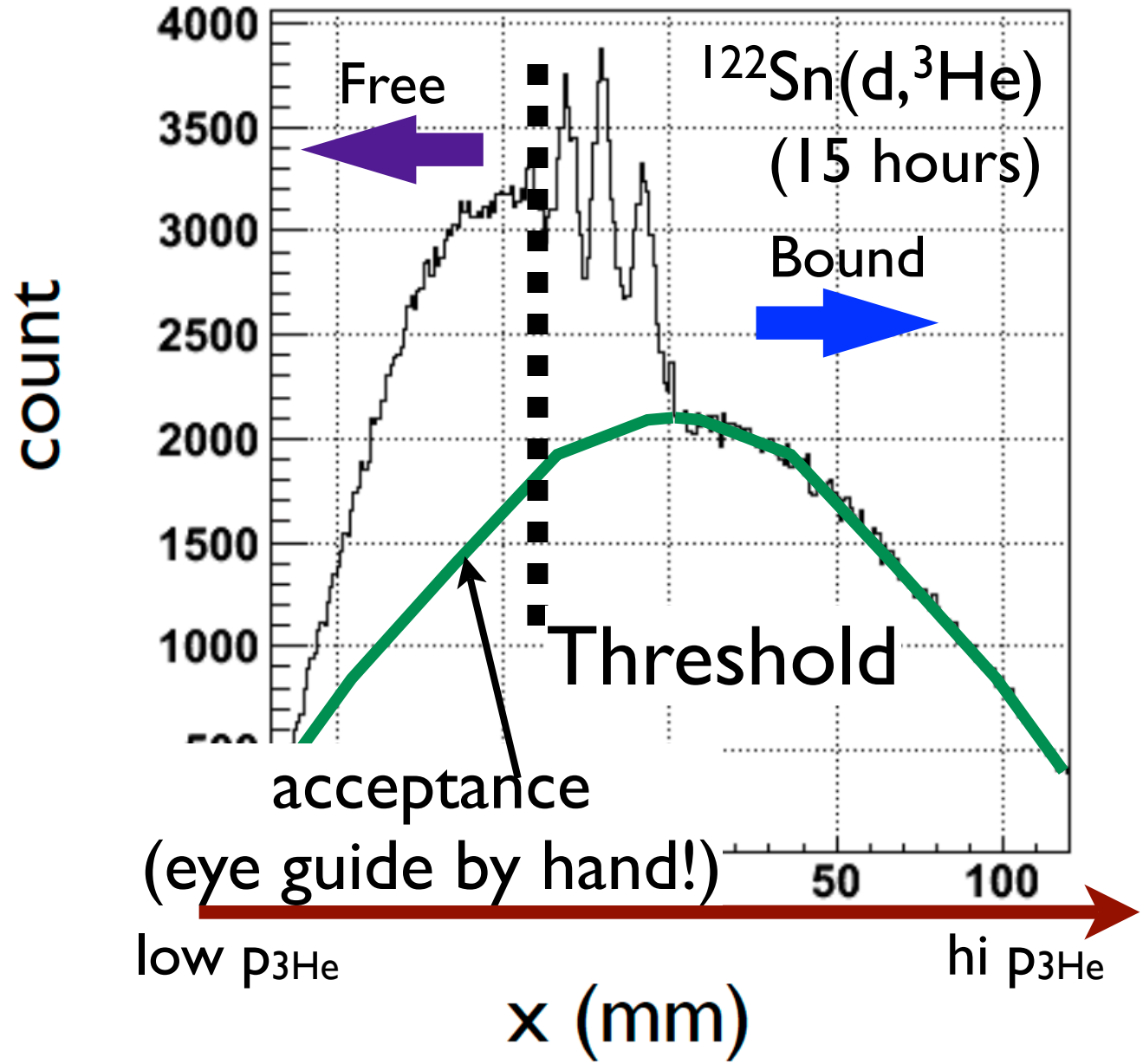

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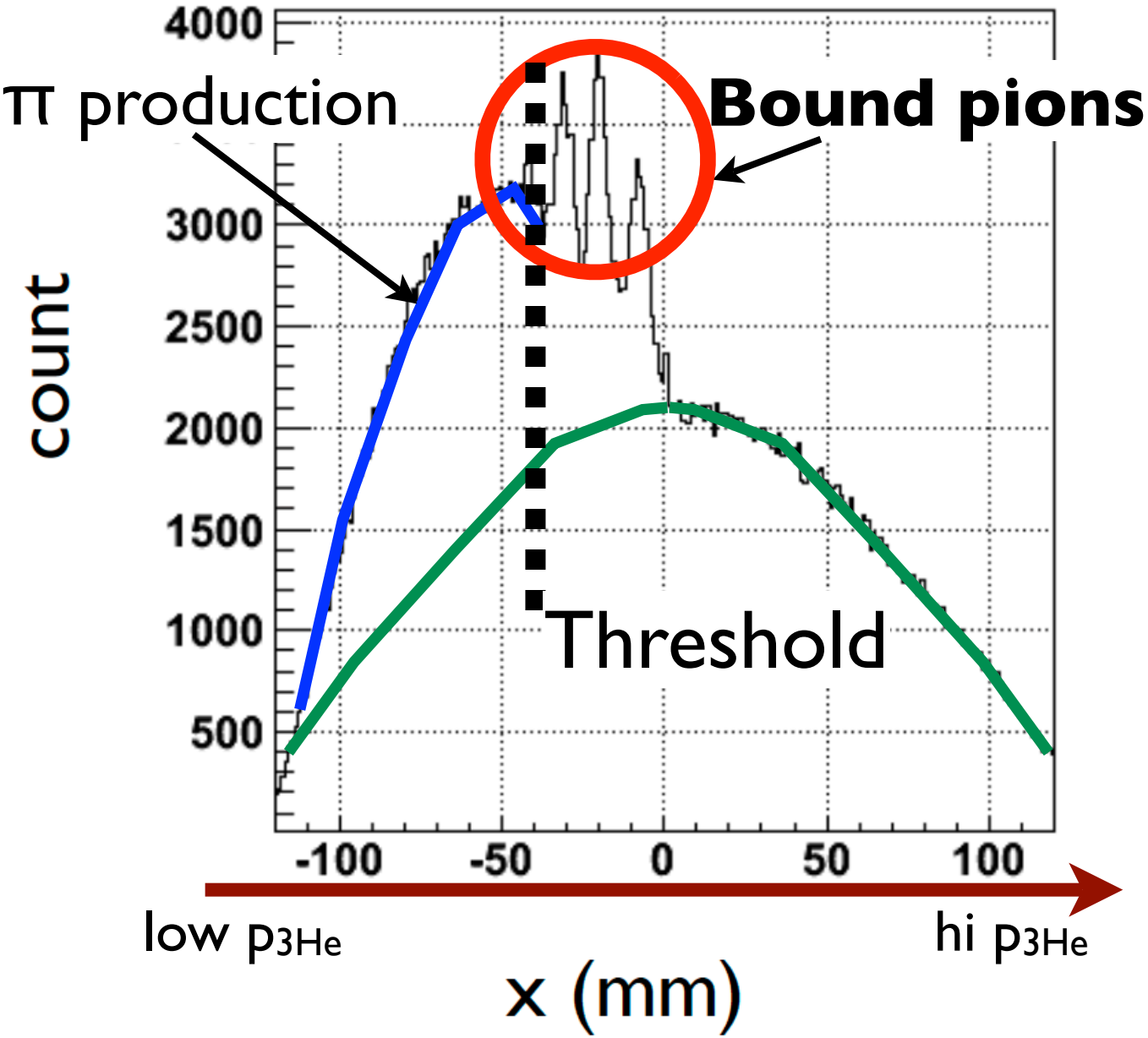

Focal Plane ^{3}He Spectrum

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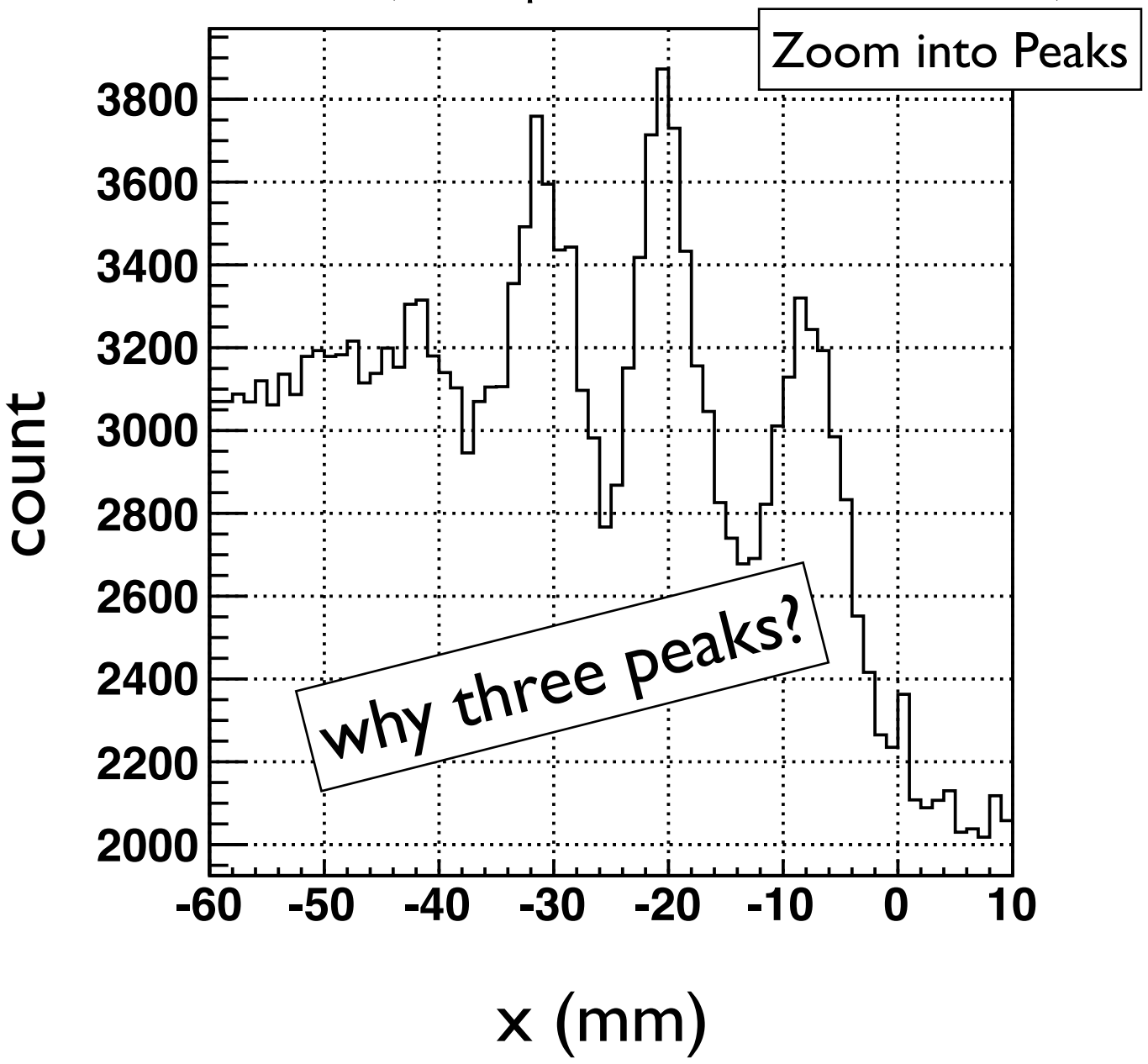
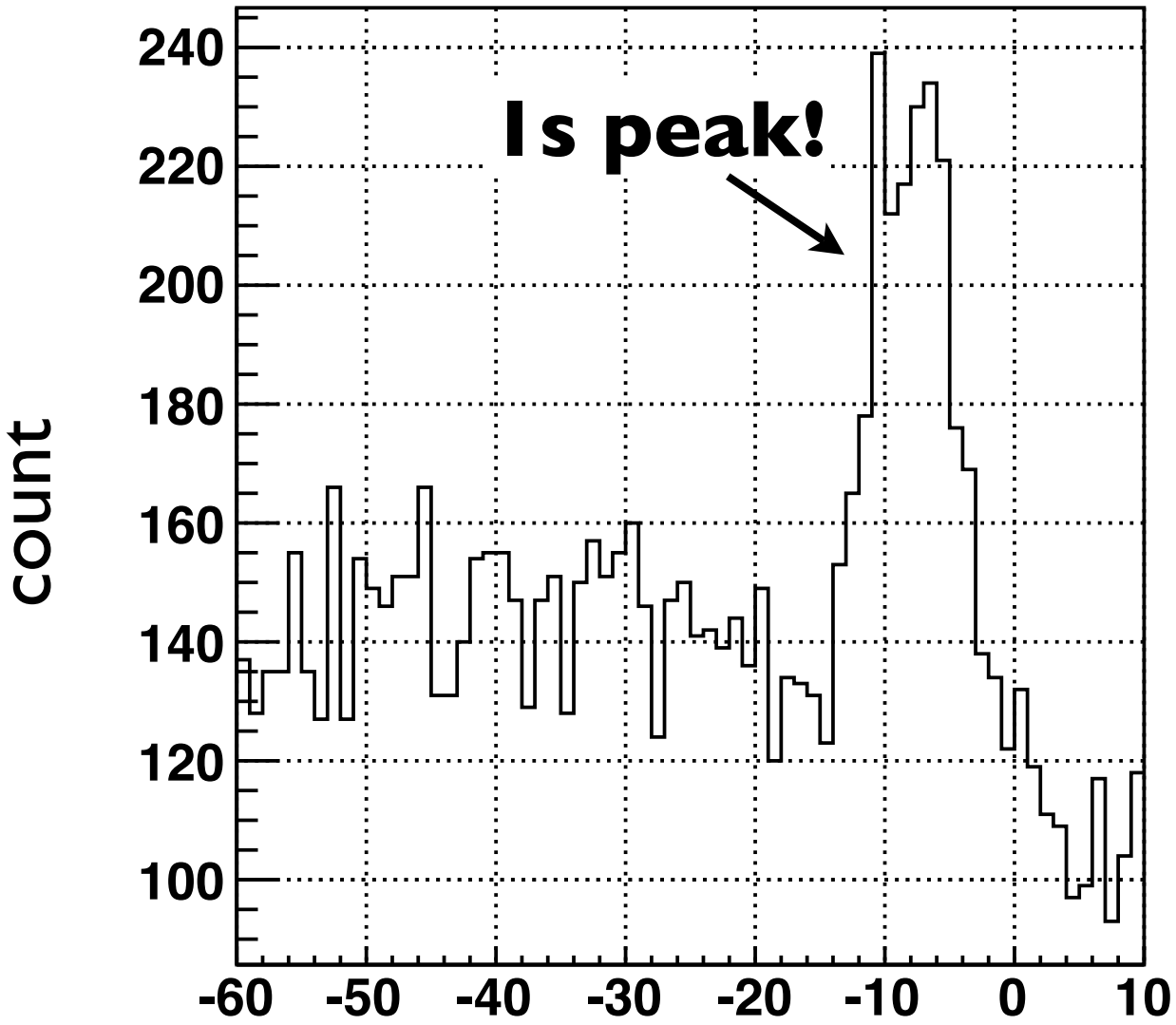


Focal Plane ^{3}He Spectrum

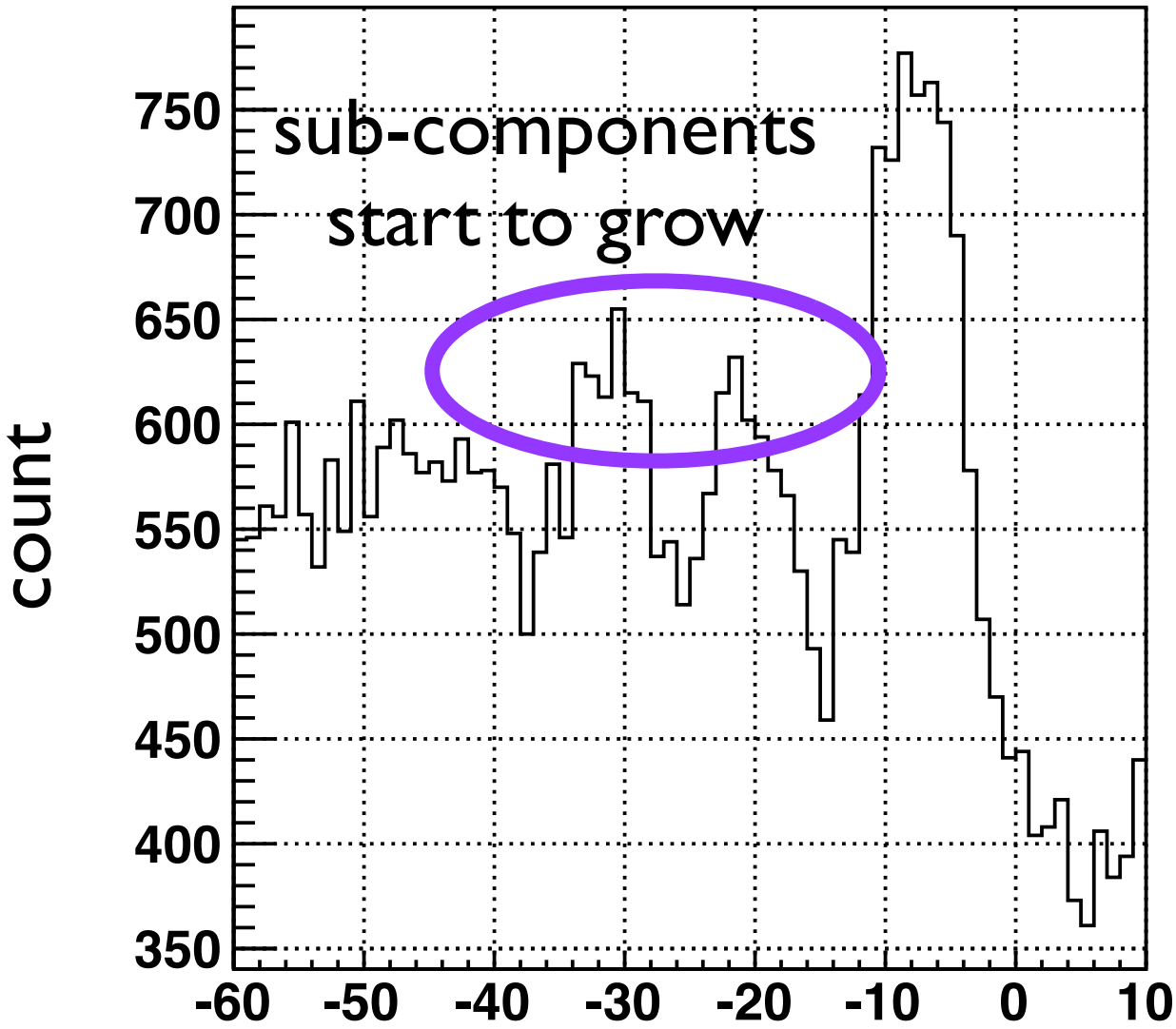
(acceptance uncorrected)



$\theta_{reaction}$<5 mrad

Focal Plane ^{3}He Spectrum

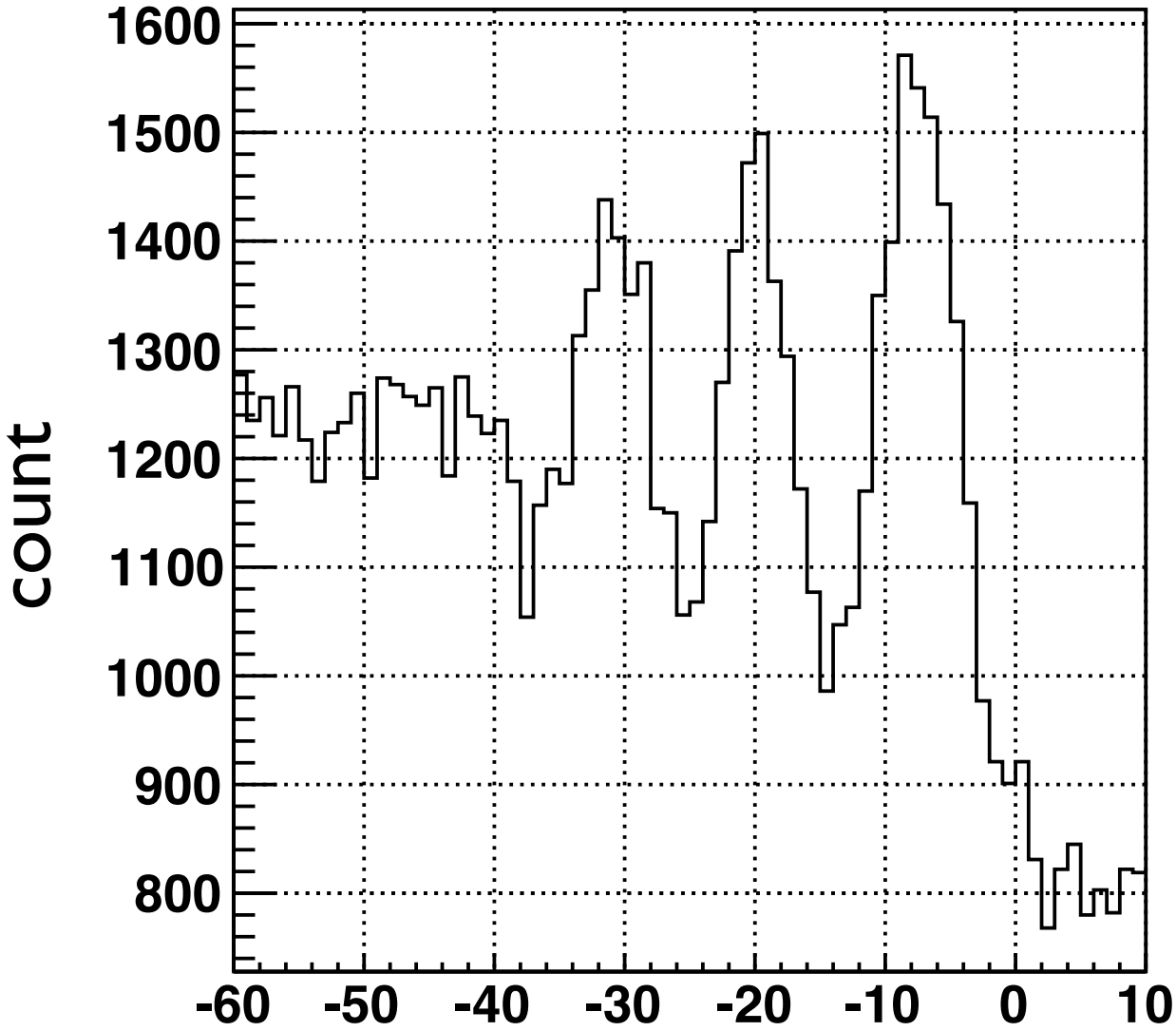
(acceptance uncorrected)



$\theta_{reaction}$<10 mrad

Focal Plane ^{3}He Spectrum

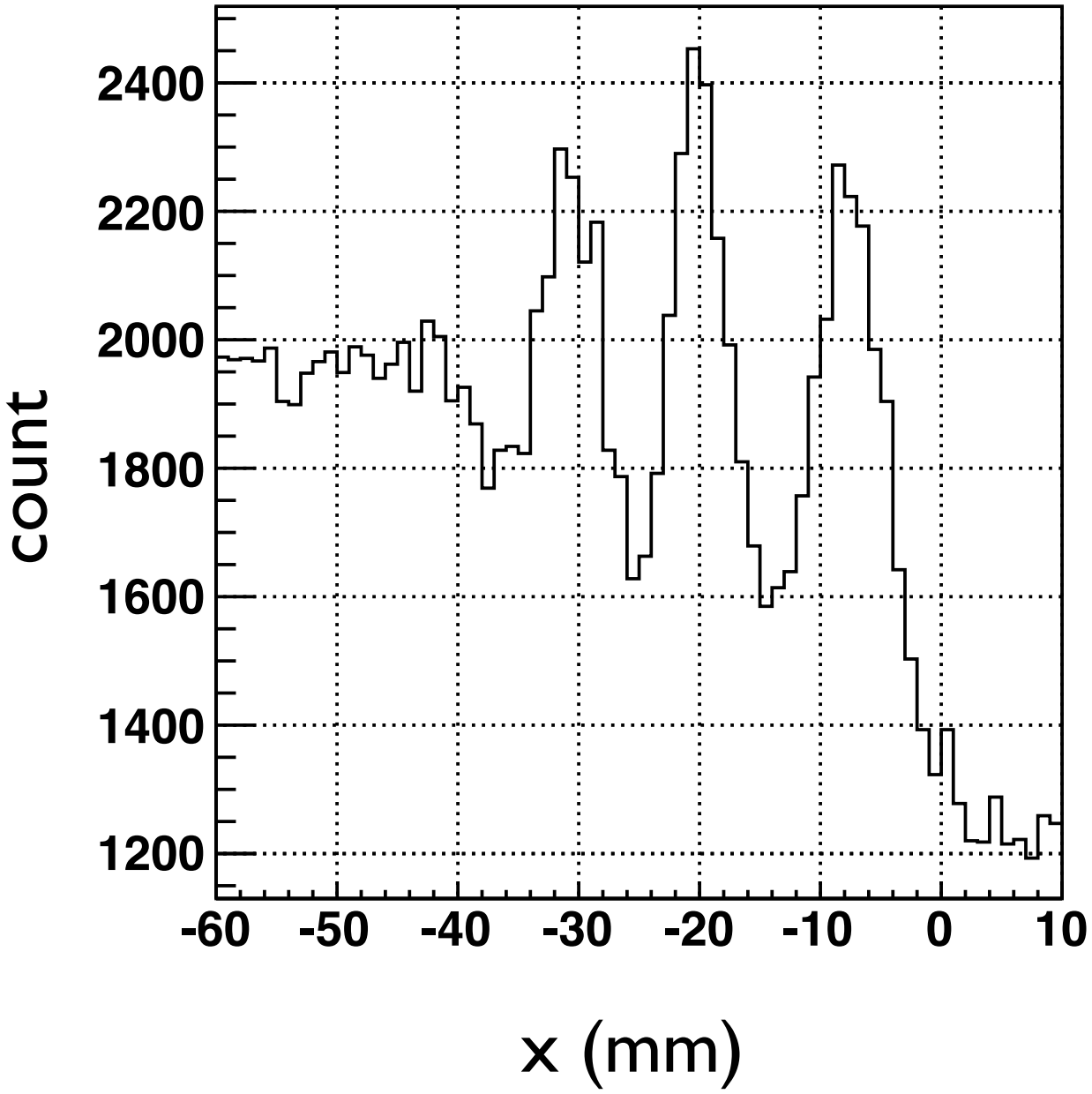
(acceptance uncorrected)



$\theta_{reaction}$<15 mrad

Focal Plane ^{3}He Spectrum

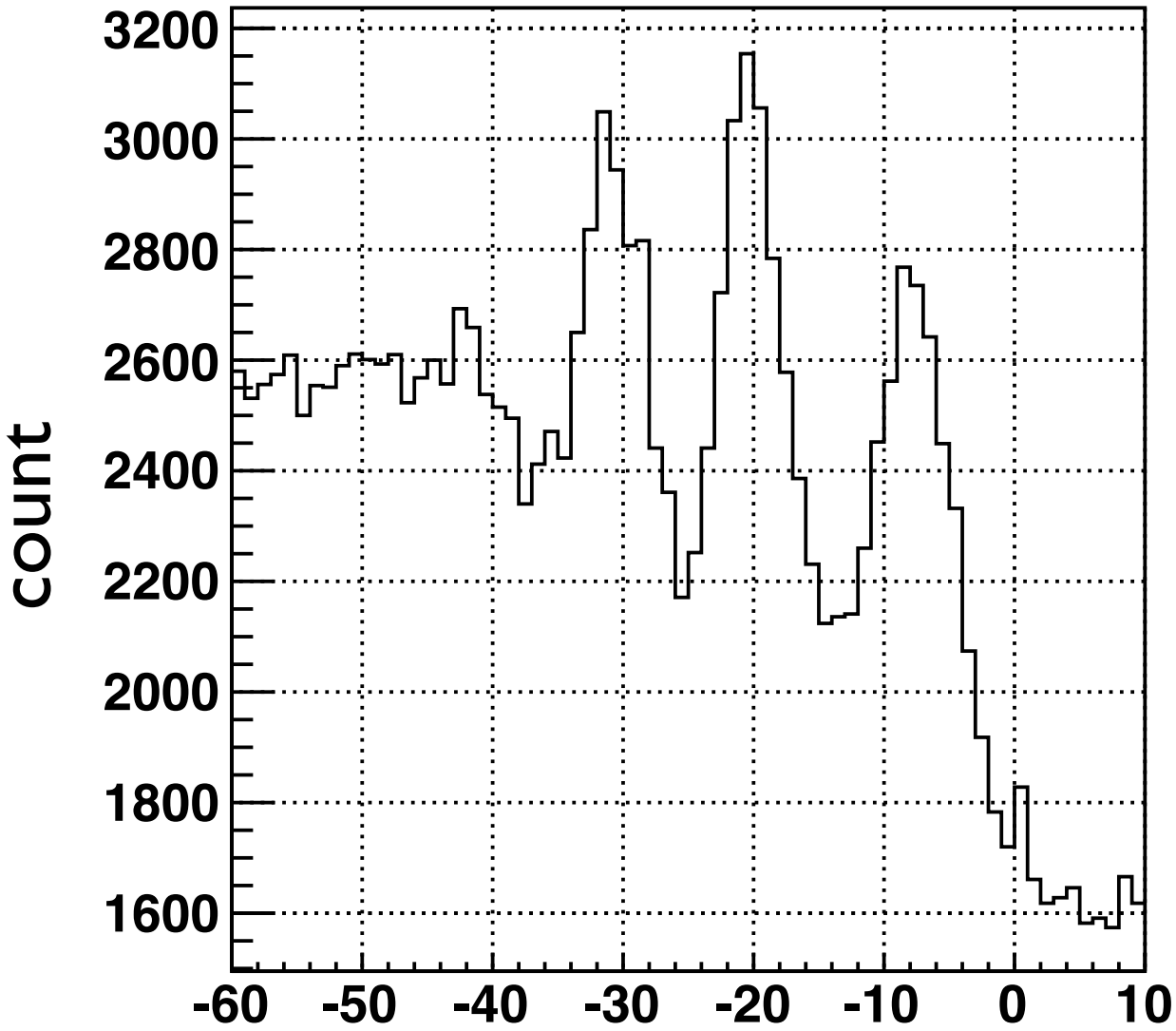
(acceptance uncorrected)



$\theta_{reaction}$<20 mrad

Focal Plane ^{3}He Spectrum

(acceptance uncorrected)



sub-components have almost same strengths as 1s

$\theta_{reaction}$<25 mrad

We are observing for the first time angular dependence (= momentum transfer dependence) of pionic atom production cross section

Analysis is in progress...

1. Higher order aberration correction
2. Calibration of abscissa
3. Acceptance correction
4. Deduction of B and Γ

...

Finalized soon.

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Summary

- We have performed first pionic atom production experiment in RIBF, and proved that we can accumulate statistics rapidly thanks to the high beam intensity.
- We have successfully measured for the first time the 1s pionic ^{121}Sn as a distinct peak.
- Angular dependence of pionic atom production cross section is also observed for the first time.
- Now, we took a certain step toward precise and systematic spectroscopy of deeply bound pionic atoms. Our first main experiment to measure isotope- (or isotone-) chain will be scheduled in the near future.

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