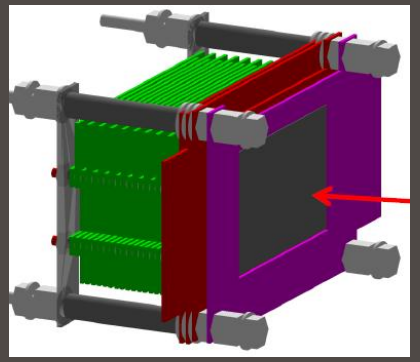
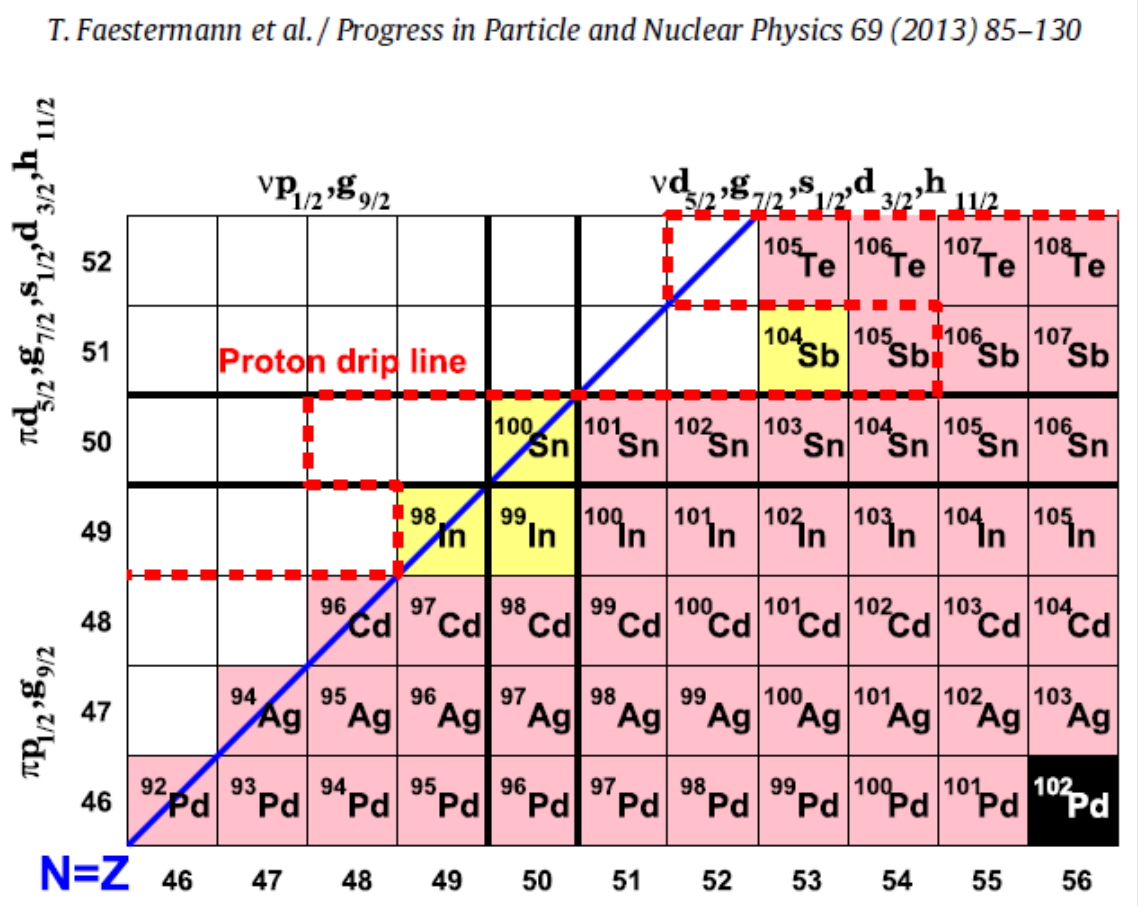
Gamma-ray Spectroscopy in the Vicinity of ^{100}Sn



Jason Park, UBC/TRIUMF
for the EURICA collaboration

Motivation

^{100}Sn: heaviest self-conjugate doubly magic nucleus ($N = Z = 50$)



Wealth of topics:

- Super-allowed Fermi/GT decays
- Isobaric analogue states, pn interaction
- High-spin isomers
- Proton dripline; βp, p-decay
- rp-process properties, i.e. $T_{1/2}$

Motivation

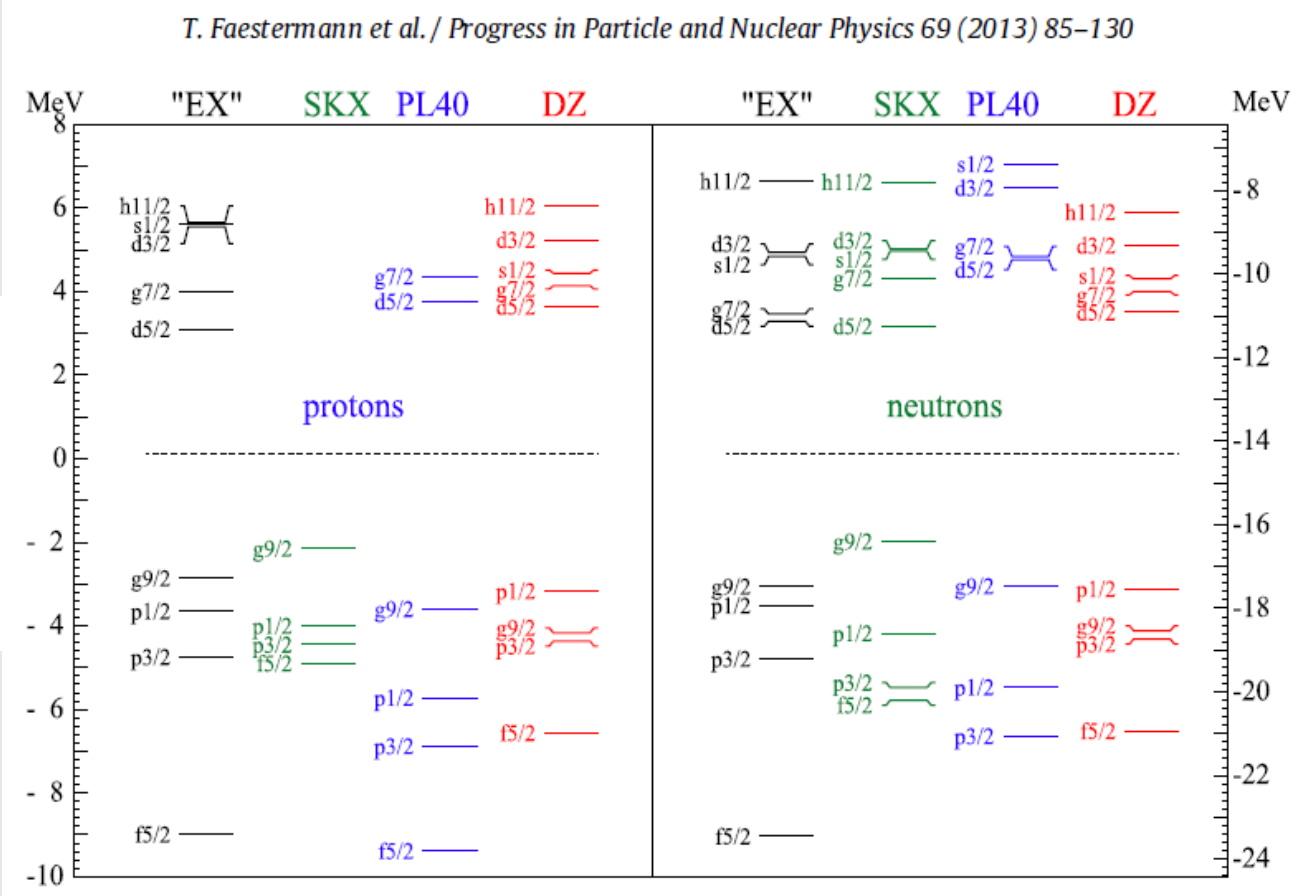
Single particle/hole energy predictions for ^{100}Sn

EX: extrapolation

SKX: Self-consistent mean field + Skyrme

PL40: relativistic mean field

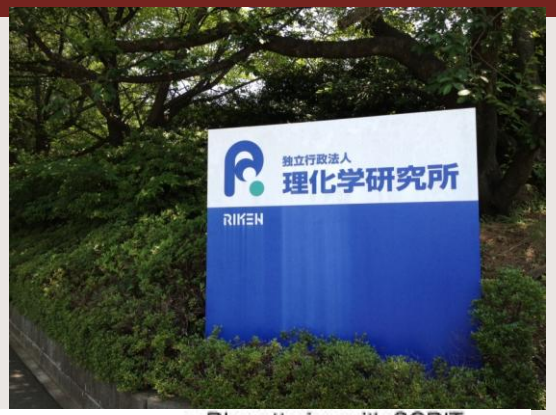
DZ: monopole shell model



Global approaches have less predictive power for local properties

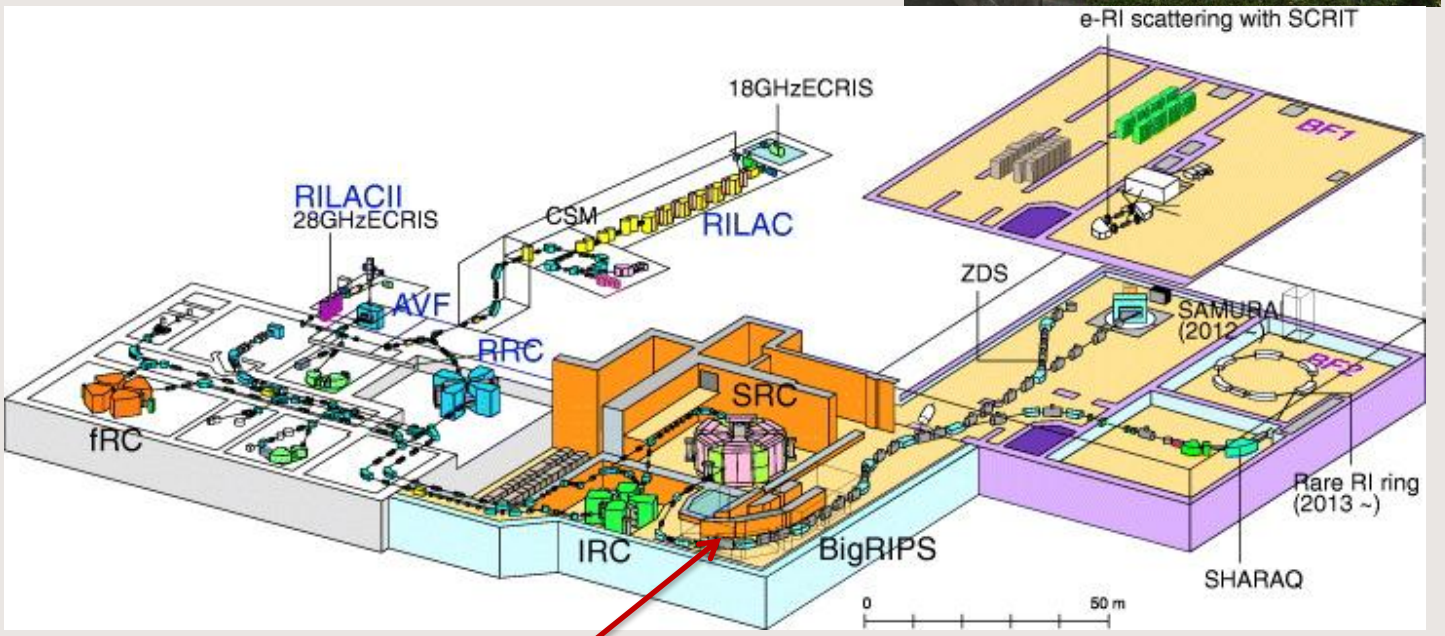
Experiment facility

RIKEN Nishina Center, Japan
June 18 – 28, 2013



Radioactive Isotope Beam Factory (RIBF)

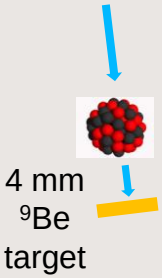
RIKEN NISHINA CENTER



^{124}Xe on ^{9}Be target

Isotope production & identification

RIKEN SRC



^{124}Xe beam
345 MeV/u
38 pnA (4.4×10^{9}/s)

4 mm
^{9}Be
target

Isotope production & identification

RIKEN SRC

^{124}Xe beam
345 MeV/u
38 pnA (4.4×10^{9}/s)

4 mm
^{9}Be
target

Fragmentation reaction

$$^{124}\mathrm{Xe} + {}^{9}\mathrm{Be} \rightarrow \begin{cases} {}^{100}\mathrm{Sn} + \ldots \\ {}^{99}\mathrm{Cd} + \ldots \\ \ldots \end{cases}$$

Tag isotope's *A* and *Z* event-by-event

Isotope production & identification

RIKEN SRC

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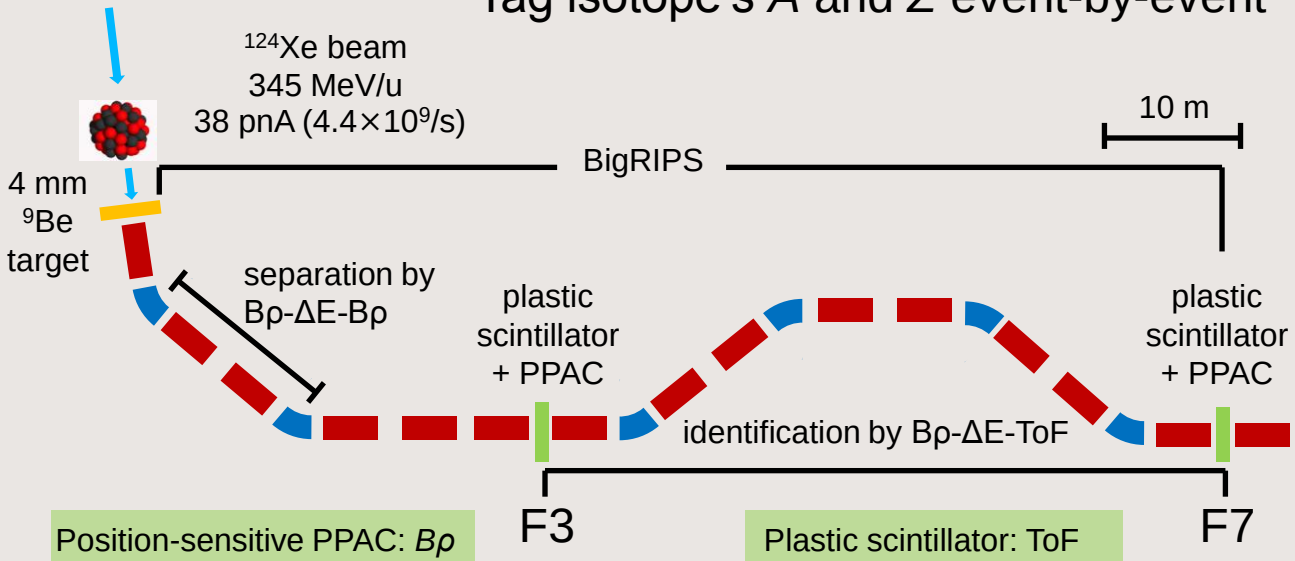

Position-sensitive PPAC: *Bρ*

$$B\rho = \frac{p}{q} = \beta\gamma m_u c \frac{A}{q}$$

Plastic scintillator: ToF

$$\beta = \frac{1}{c}\frac{L}{\mathrm{ToF}}$$

Isotope production & identification

RIKEN SRC

Fragmentation reaction

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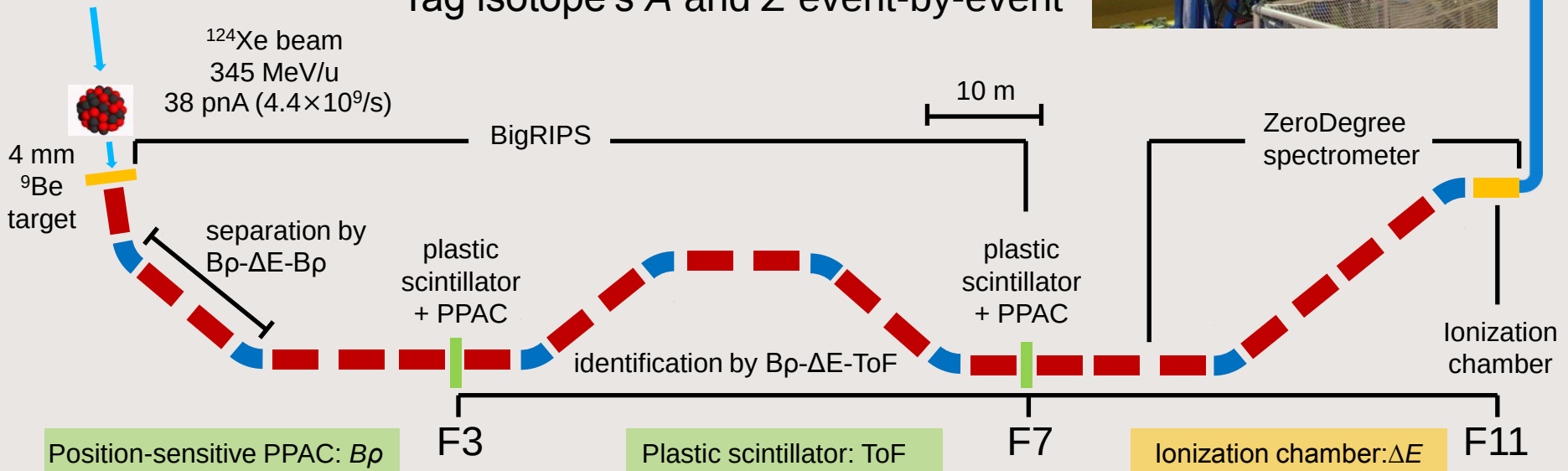
Tag isotope's *A* and *Z* event-by-event

EURICA + WAS3ABI



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$$B\rho = \frac{p}{q} = \beta\gamma m_u c \frac{A}{q}$$

Plastic scintillator: ToF

$$\beta = \frac{1}{c}\frac{L}{\mathrm{ToF}}$$

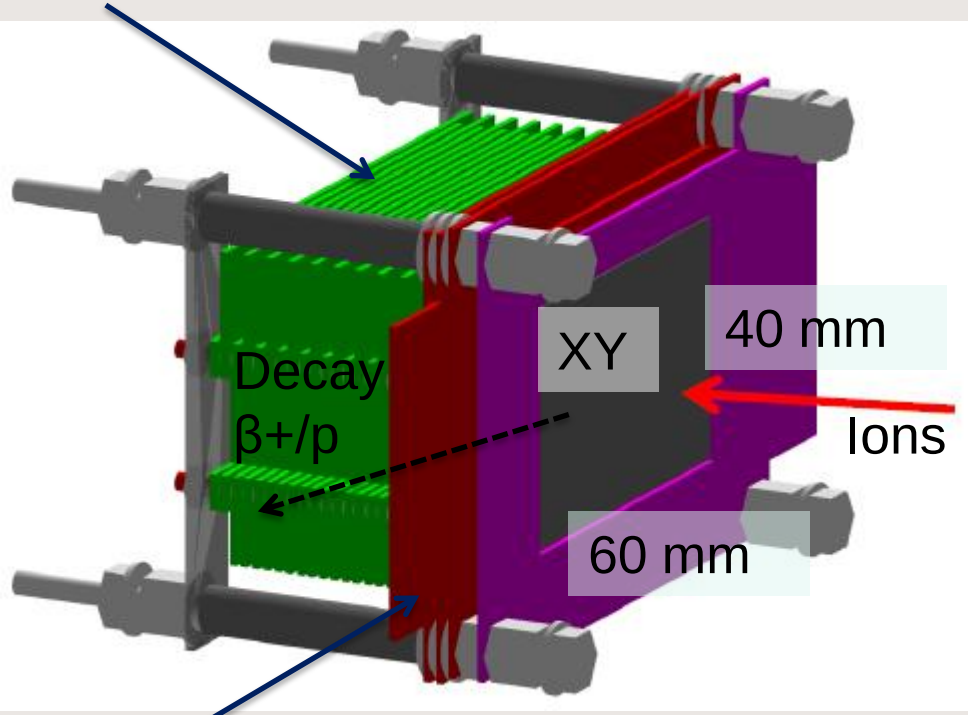
Ionization chamber: ΔE

$$\Delta E \propto \frac{Z^2}{\beta^2}$$

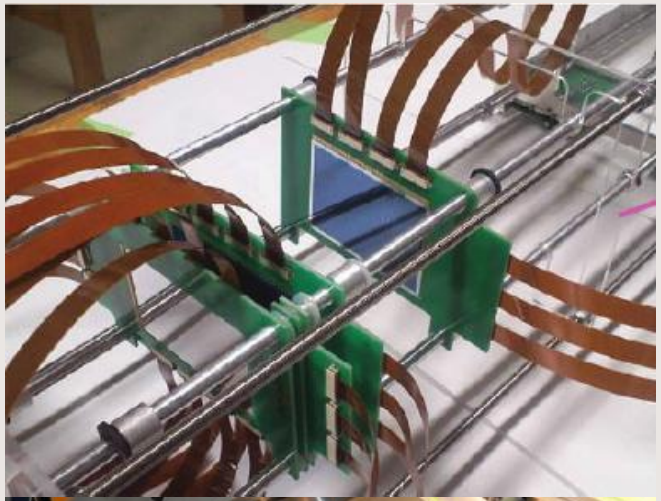
Detector system – WAS3ABI

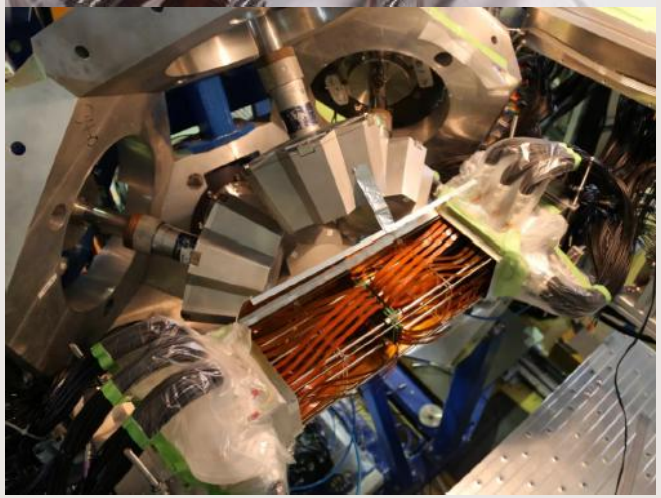
Wide-range Active Silicon-Strip Stopper Array for Beta and Ion detection

SSSD: 10×(7 strips, 1 mm thick)



DSSD: 3×(60×40 strips, 1 mm thick)

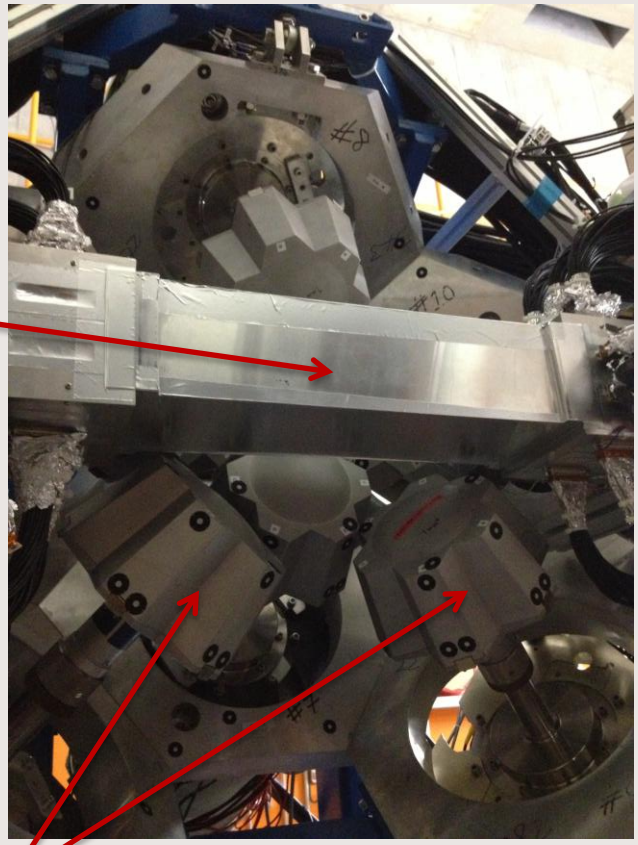


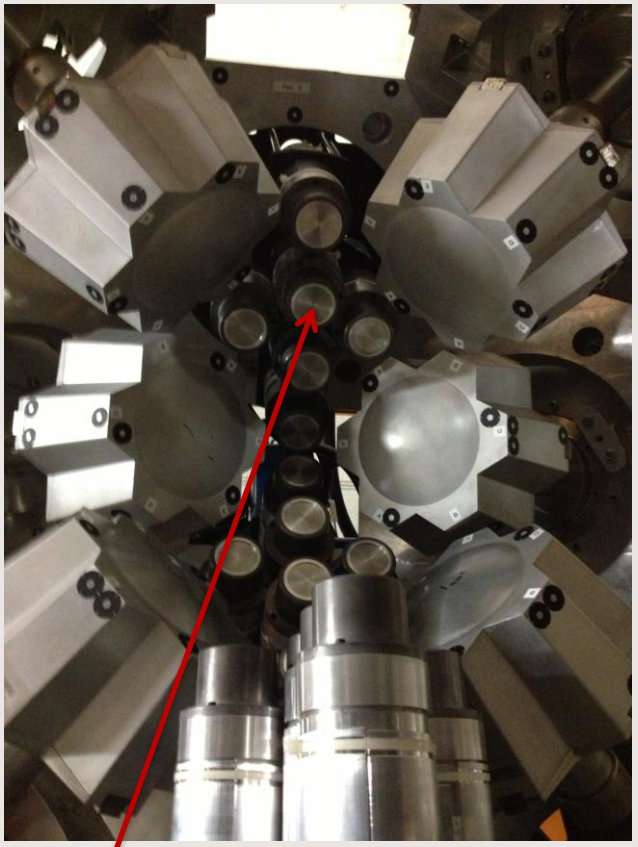


Detector system – EURICA

EUroball-RIKEN Cluster Array: HPGe clusters + $LaBr_3(Ce)$ detectors

Encased WAS3ABI

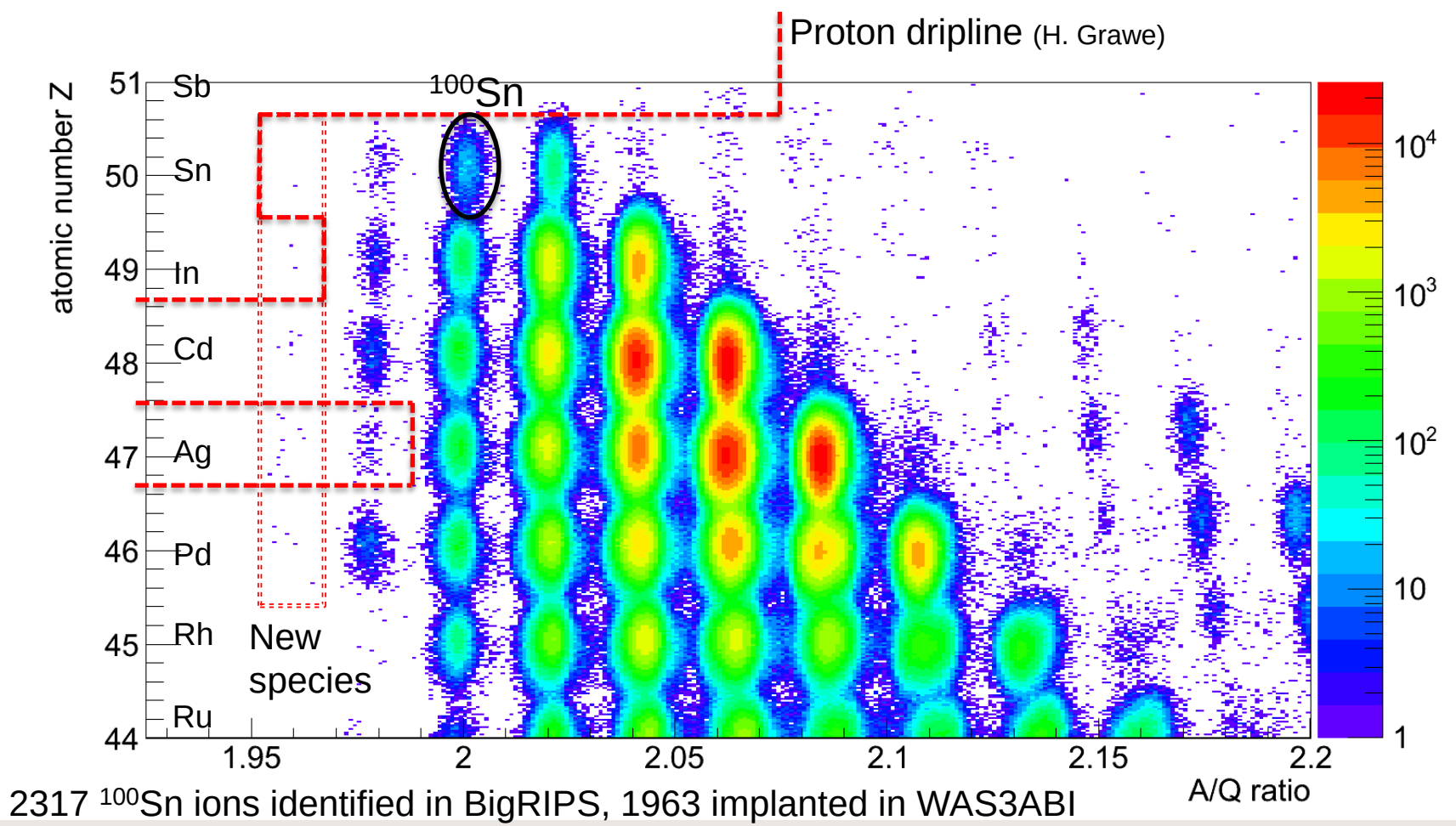




12×7 HPGe crystals
(15% efficiency at 661 keV)

18×$LaBr_3(Ce)$ detectors
for short-lived isomer half-lives

Isotope production (8.5 days of beam)



2317 ^{100}Sn ions identified in BigRIPS, 1963 implanted in WAS3ABI

- Previous record for ^{100}Sn was 259 (163 implanted) at GSI, Darmstadt, Germany in 2008 (C. B. Hinke et al., Nature 486, 341 (2012))

Analysis list

Topics	Research institutions
^{100}Sn decay spectroscopy ($T_{1/2}$, Q_β, ^{100}In gamma-rays)	TUM, cross-check analysis by TRIUMF
$T_{1/2}$ of new isotopes ^{99}Sn, ^{98}Sn, ^{97}In, etc	RIKEN
Isomers, isomeric ratios in ^{99}In, ^{100}Sn, $^{96/97}$Cd	GANIL
^{98}In Fermi/GT decay $T_{1/2}$, search for proton decay	TU Darmstadt
^{101}Sn βp decay analysis for ground state spin	RIKEN
Q_β values for B_{GT} in $^{96/98}$Cd	TUM
Gamma-ray spectroscopy of abundant species for nuclear structure (^{97}Cd, etc)	TRIUMF

Analysis list

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^{98}In F… decay	
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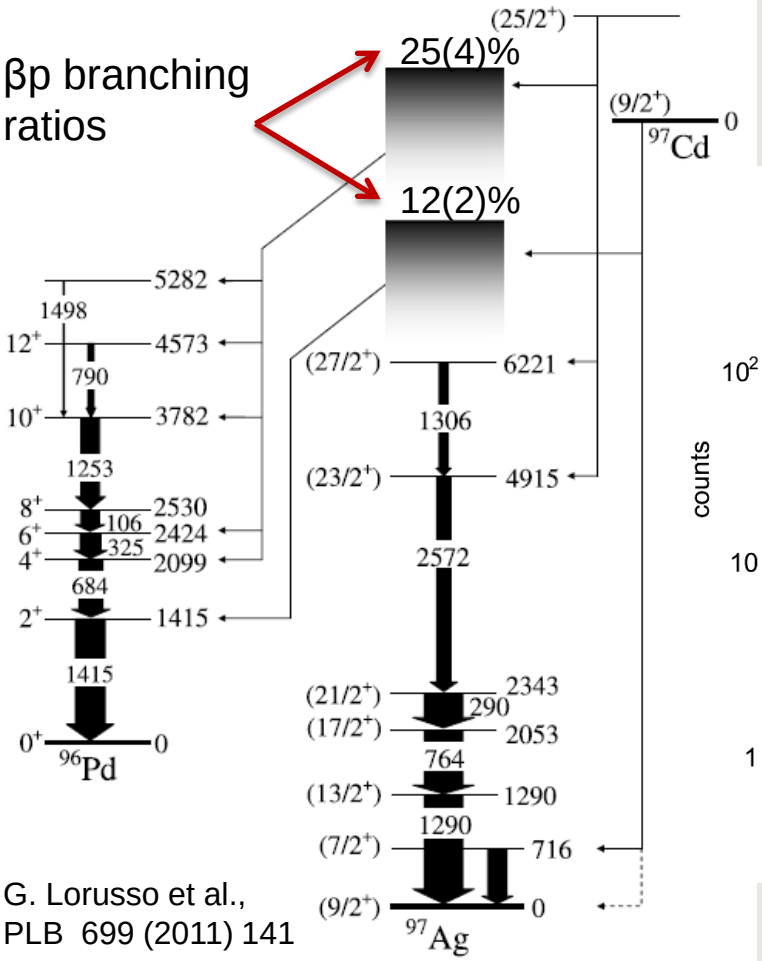
Q_β values for B_{GT} in $^{96/98}$Cd	TUM
Gamma-ray spectroscopy of abundant species for nuclear structure (^{97}Cd, etc)	TRIUMF

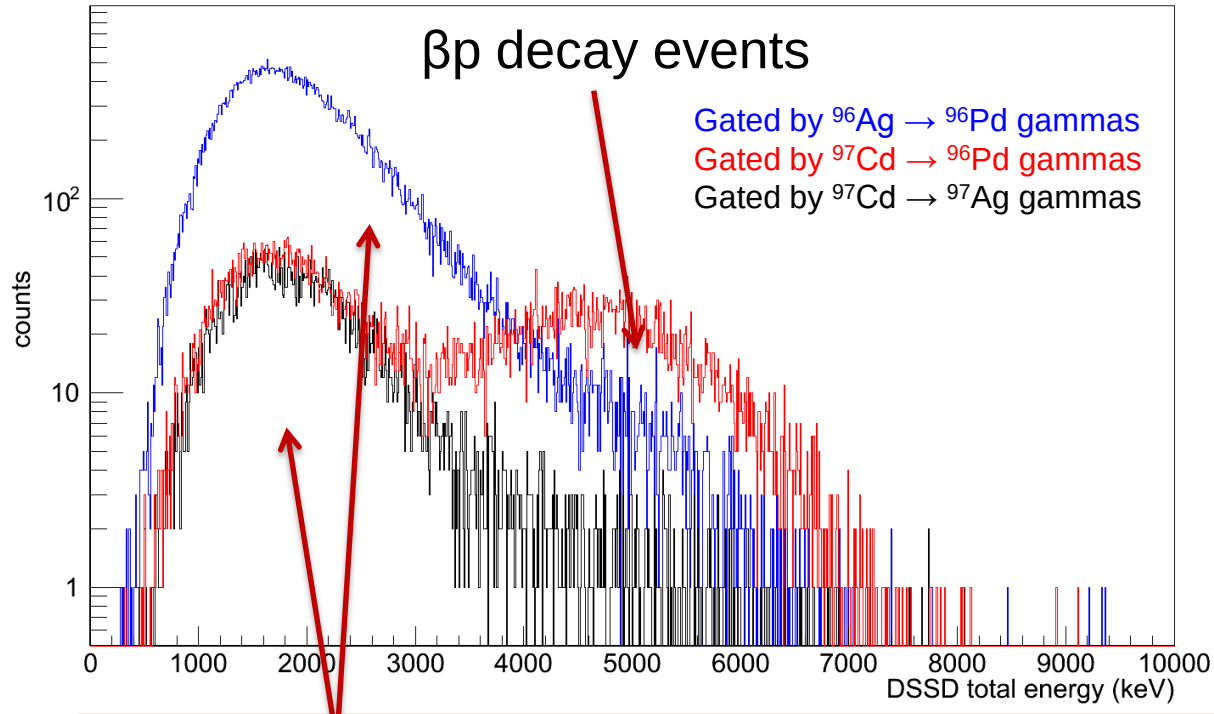
Preliminary results for:
^{97}Cd → ^{97}Ag (β decay)/^{96}Pd (βp decay) gammas,
^{100}Sn → ^{100}In β-delayed gammas

^{97}Cd decay spectroscopy



G. Lorusso et al.,
PLB 699 (2011) 141

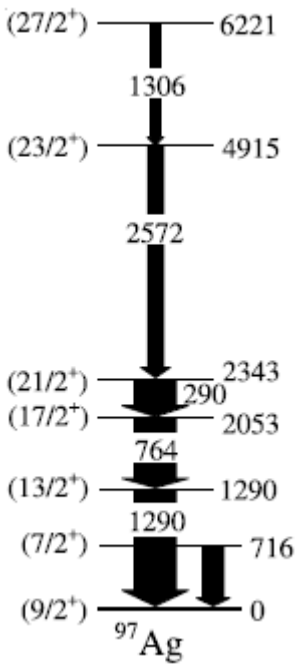
Decay event ΔE in DSSD

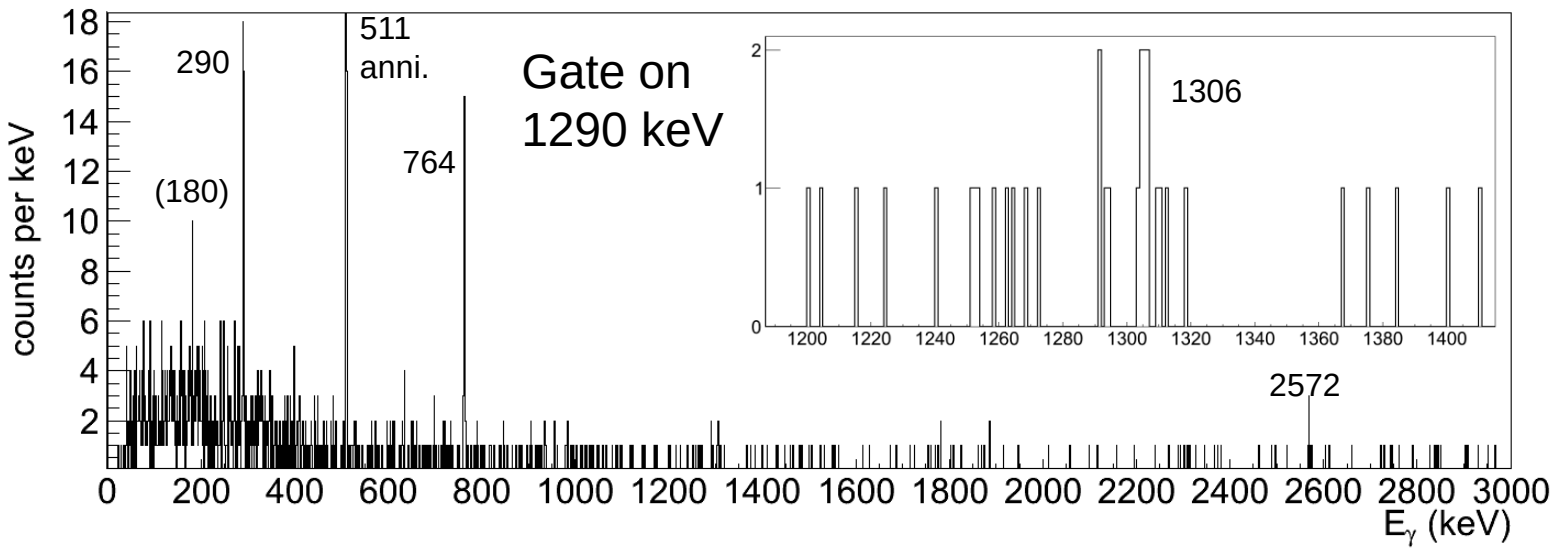


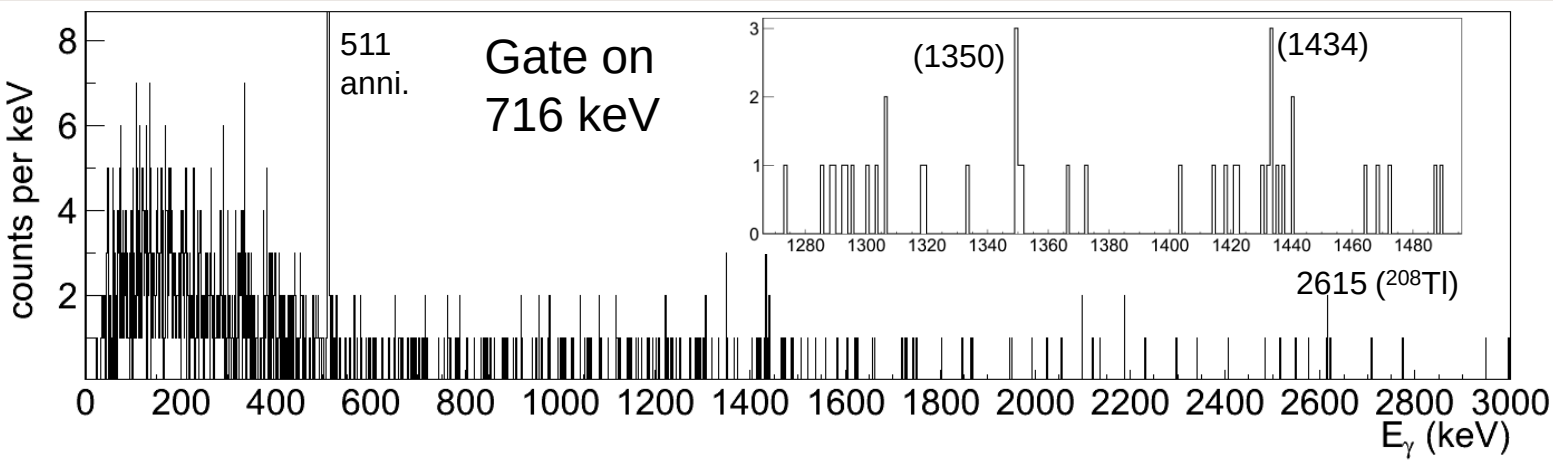
β decay events

^{97}Cd → ^{97}Ag β-delayed γ-ray spectroscopy

G. Lorusso et al.,
PLB 699 (2011) 141

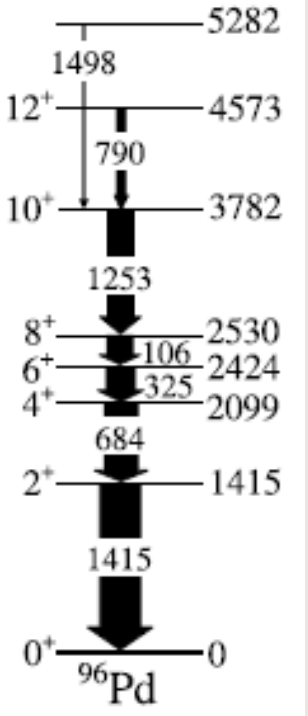




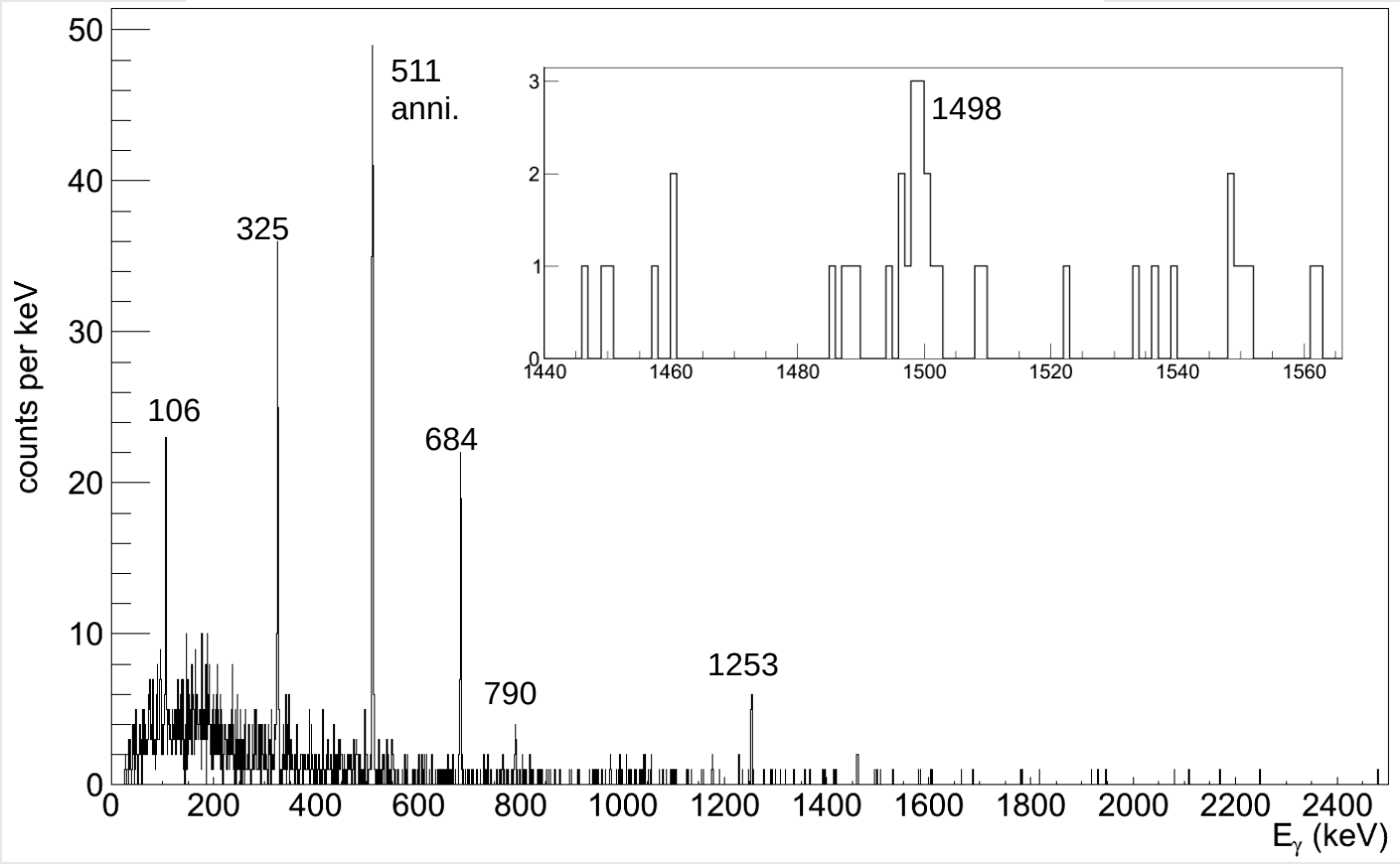


$^{97}Cd \rightarrow {}^{96}Pd$ (βp decay) γ-ray spectroscopy

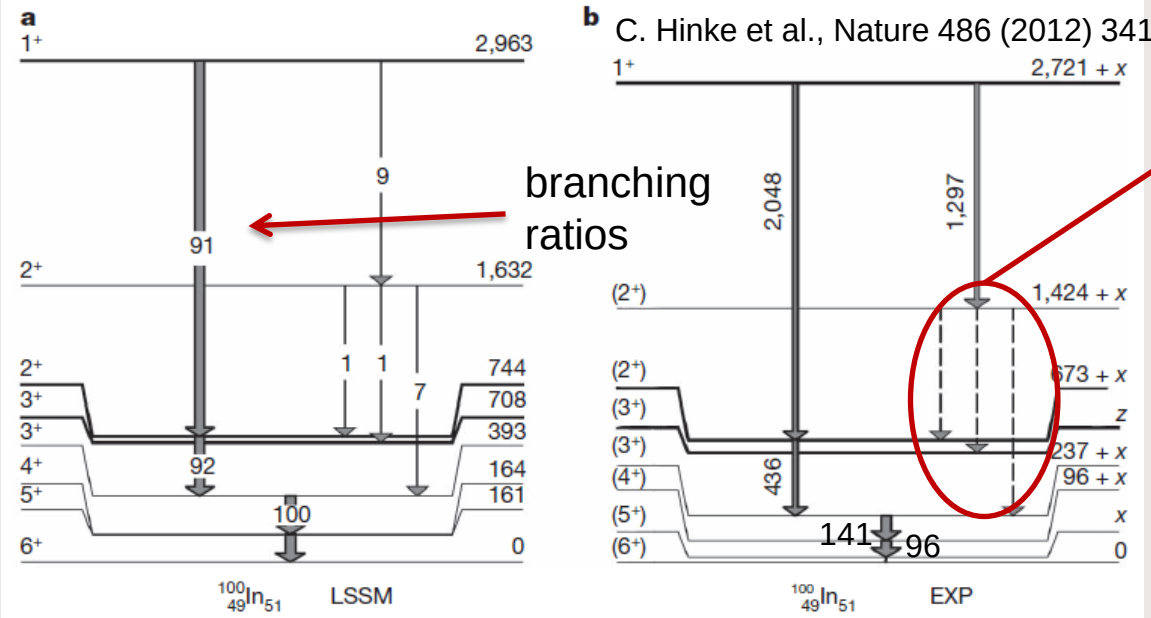
G. Lorusso et al.,
PLB 699 (2011) 141



Gate on 1415 keV ground state transition



Proposed level scheme of ^{100}In



branching ratios

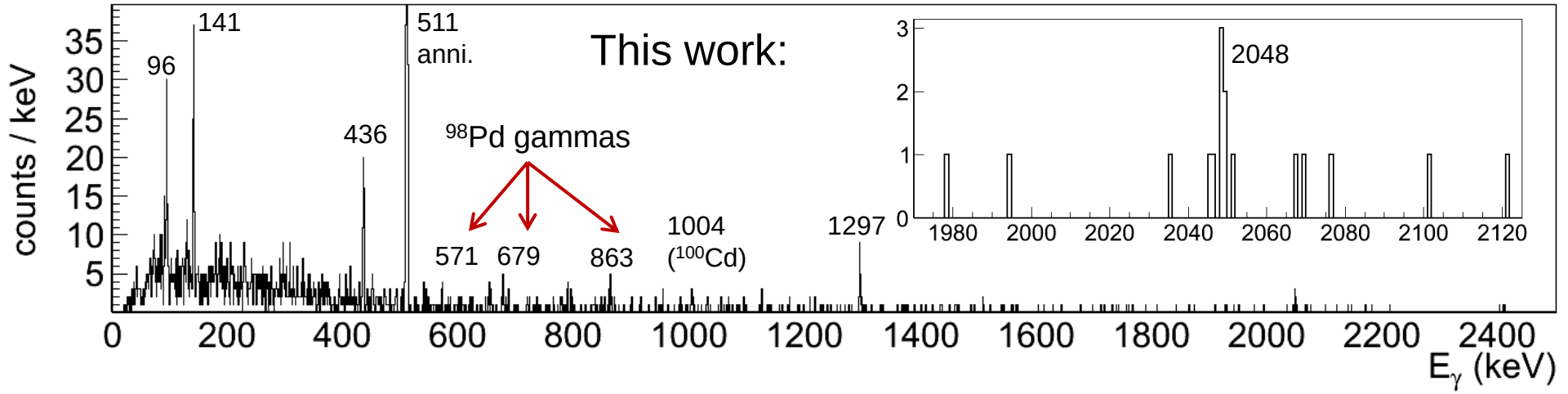
C. Hinke et al., Nature 486 (2012) 341

GSI results:

Transitions (751, 1187, g.s. transition, etc) not observed

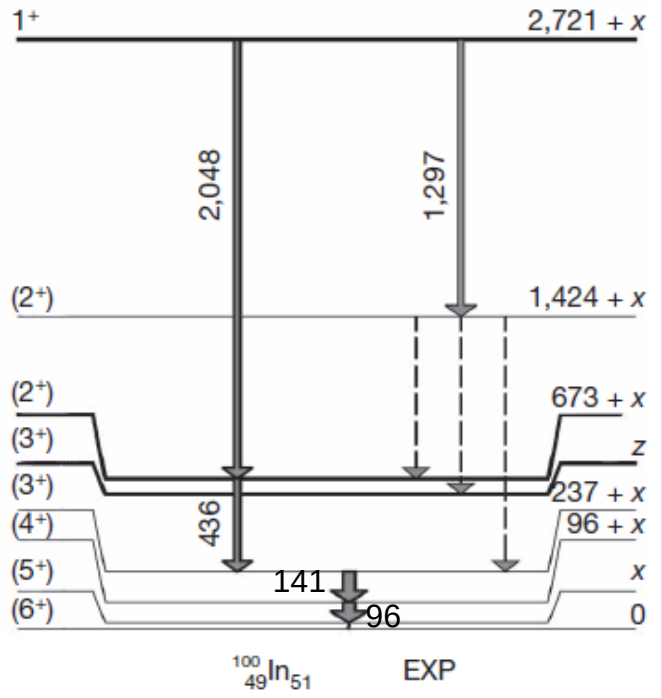
Most of level scheme built to resemble LSSM output

Real coincidence observed between 96/436 keV only



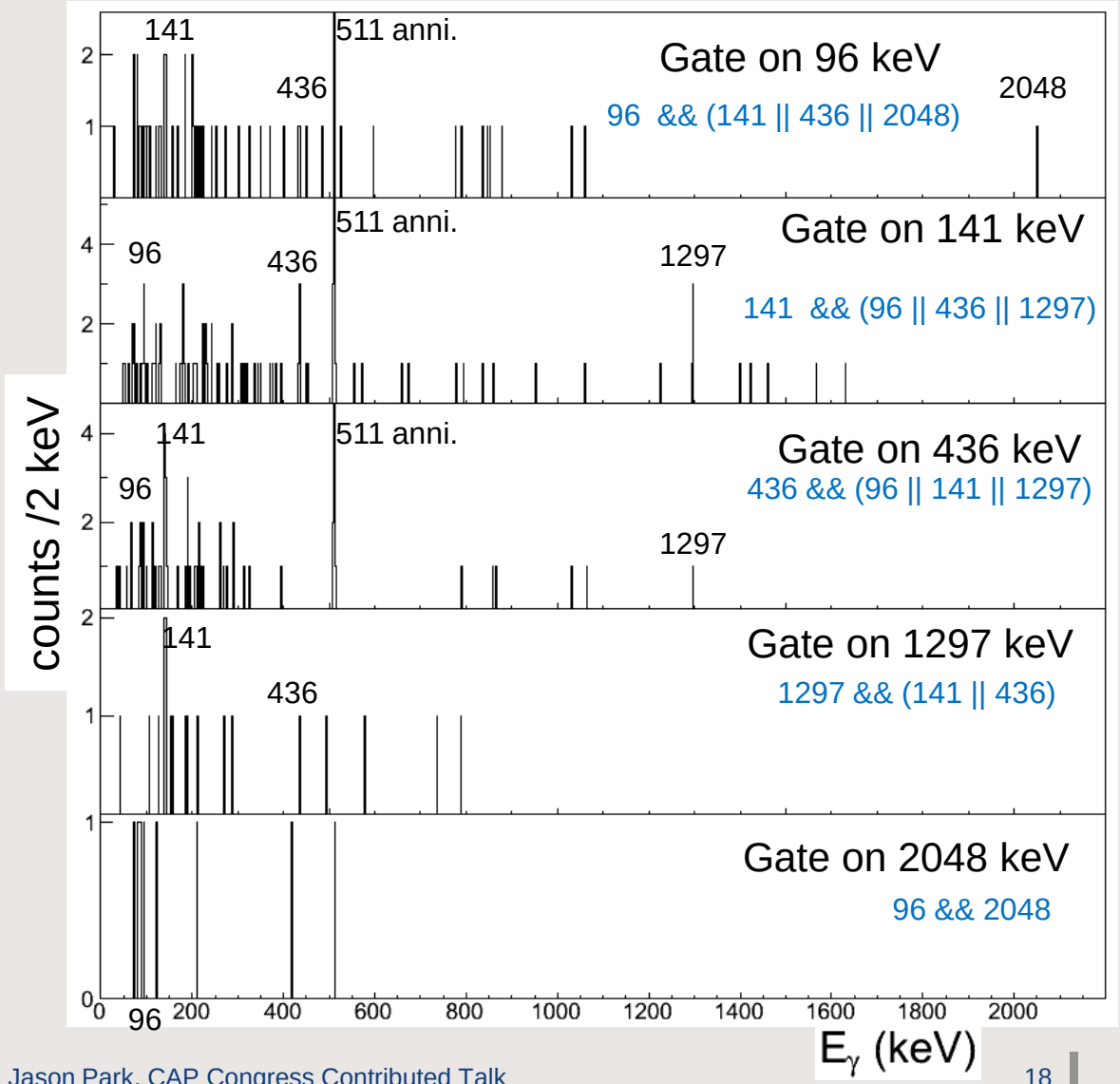
^{100}In γ–ray coincidences

C. Hinke et al., Nature 486 (2012) 341



Previously unobserved transitions still not found

No coincidence between 2048 and 141 or 436, but with 96 (?)



EURICA collaboration

J. Park[1, 2], R. Krücken[1, 2], R. Gernhäuser[3], M. Lewitowicz[4], S. Nishimura[5], H. Sakurai[6], H. Baba[5], B. Blank[7], A. Blazhev[8], P. Boutachkov[9], F. Browne[10], I. Čeliković[4], P. Doornenbal[5], T. Faestermann[3], Y. Fang[11], G. de France[4], N. Goel[9], M. Górska[9], S. Ilieva[12], T. Isobe[5], A. Jungclaus[13], G. D. Kim[14], Y.-K. Kim[14], I. Kojouharov[9], M. Kowalska[15], N. Kurz[9], G. Lorusso[5], D. Lubos[3], K. Moschner[8], I. Nishizuka[16], Z. Patel[17], M. M. Rajabali[1], S. Rice[17], H. Schaffner[9], L. Sinclair[18], P.-A. Söderström[5], K. Steiger[3], T. Sumikama[16], Z. Wang[1], H. Watanabe[19], J. Wu[13], and Z. Y. Xu[6]

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6. University of Tokyo, Japan
7. CENBG, France
8. University of Cologne, Germany
9. GSI, Germany
10. Brighton University, UK
11. Osaka University, Japan
12. TU Darmstadt, Germany
13. IES CSIS, Spain
14. Institute for Basic Science, Korea
15. CERN, Switzerland
16. Tohoku University, Japan
17. Surrey University, UK
18. University of York, UK
19. Beihang University, China

TRIUMF

Canada's national laboratory for particle and nuclear physics
Laboratoire national canadien pour la recherche en physique nucléaire et en physique des particules

Thank you!
Merci

TRIUMF: Alberta | British Columbia | Calgary | Carleton | Guelph | Manitoba | McGill | McMaster | Montréal | Northern British Columbia | Queen's | Regina | Saint Mary's | Simon Fraser | Toronto | Victoria | Winnipeg | York

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