

Decay Spectroscopy around ^{78}Ni (Proposal RIBF-010)

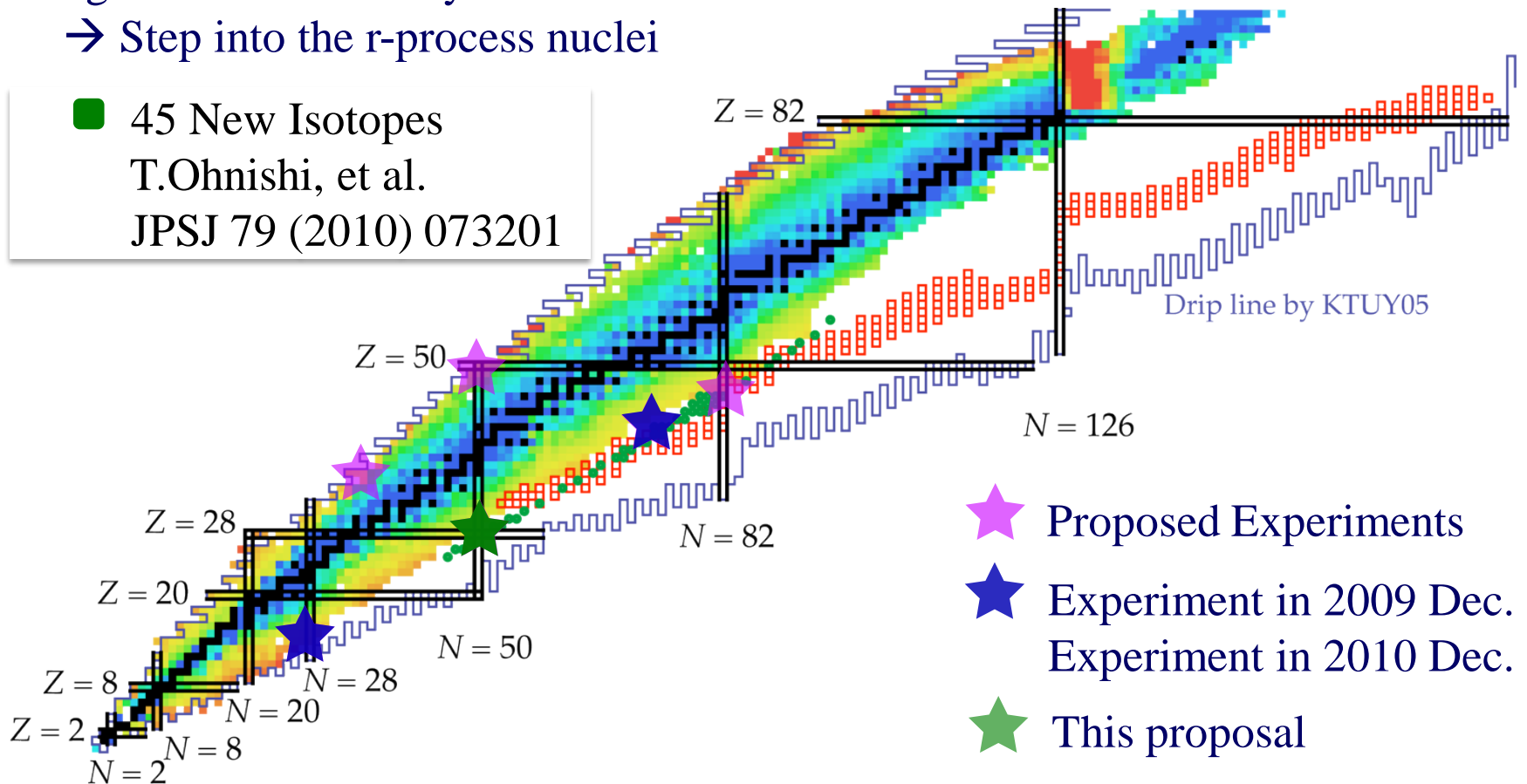
Shunji Nishimura
RIKEN

Beta-Decay Experiments at RIBF

Highest beam intensity of ^{238}U -beam

→ Step into the r-process nuclei

■ 45 New Isotopes
T. Ohnishi, et al.
JPSJ 79 (2010) 073201



Decay Spectroscopy

◆ Nuclear structure

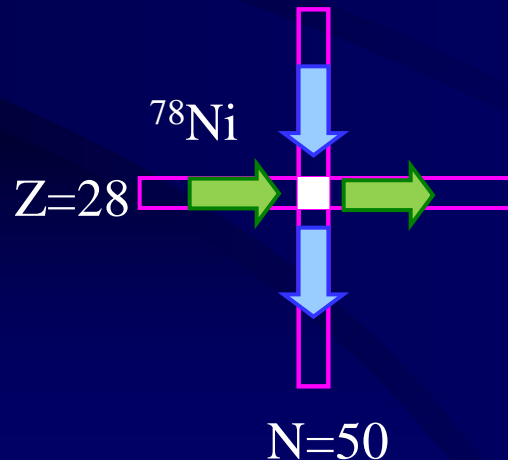
- ✓ New magic number?
- ✓ Disappearance?
- ✓ Shell quenching?
- ✓ Deformation?

◆ Astrophysical interest

- ✓ R-process path
- ✓ Seed nuclei (^{78}Ni)

Systematic study of

- Decay curve ($T_{1/2}$)
- First excited states $E(2+)$
- Neutron emission prob.
- Isomeric states
- Q_{beta}



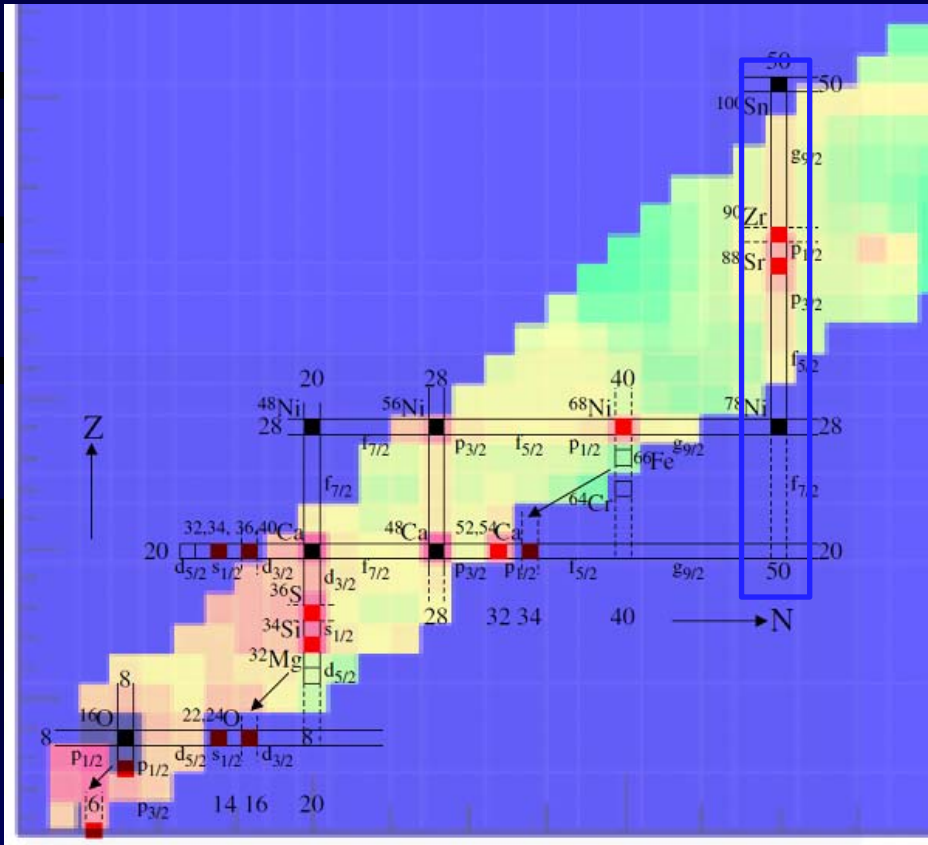
(1) Nuclei ($N < 50$)

(2) Nuclei ($N = 50$)

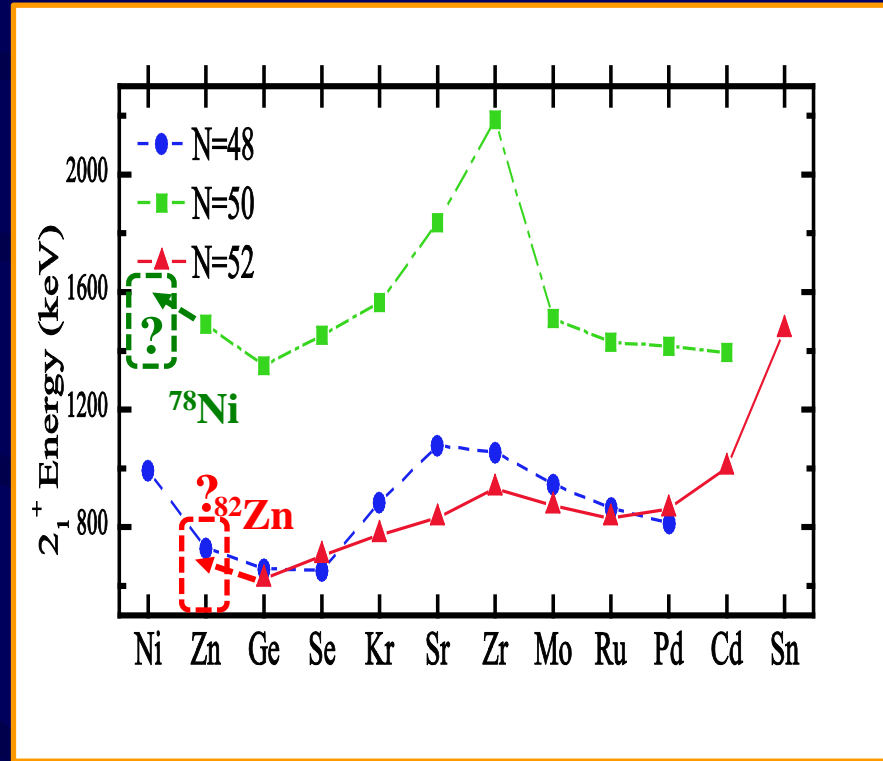
(3) Nuclei ($N > 50$)

Motivation

H.Grawe, et al. Eur. Phys. J A 25 (2005) 357 & E(2+)

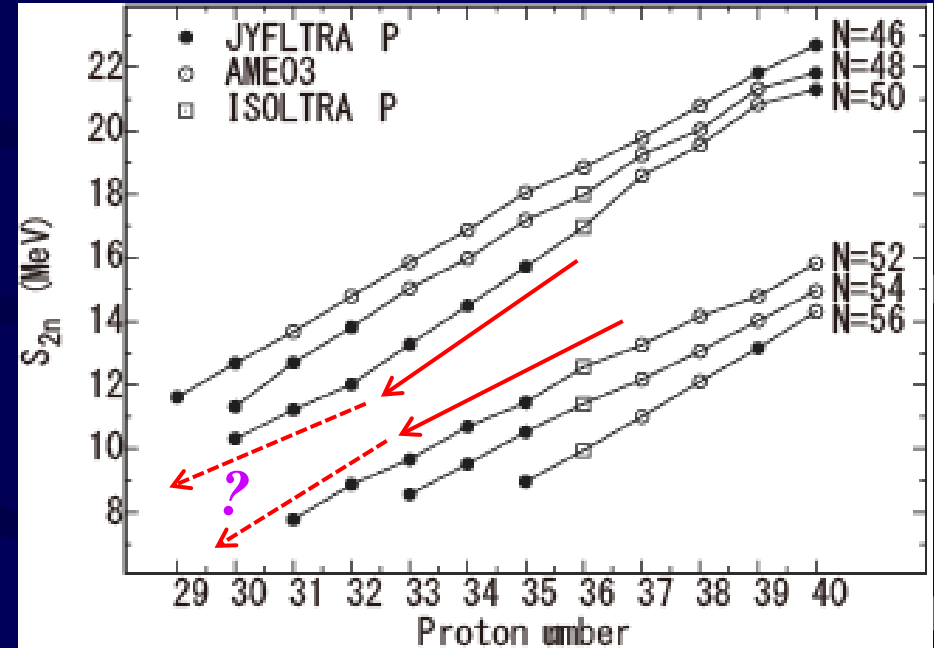
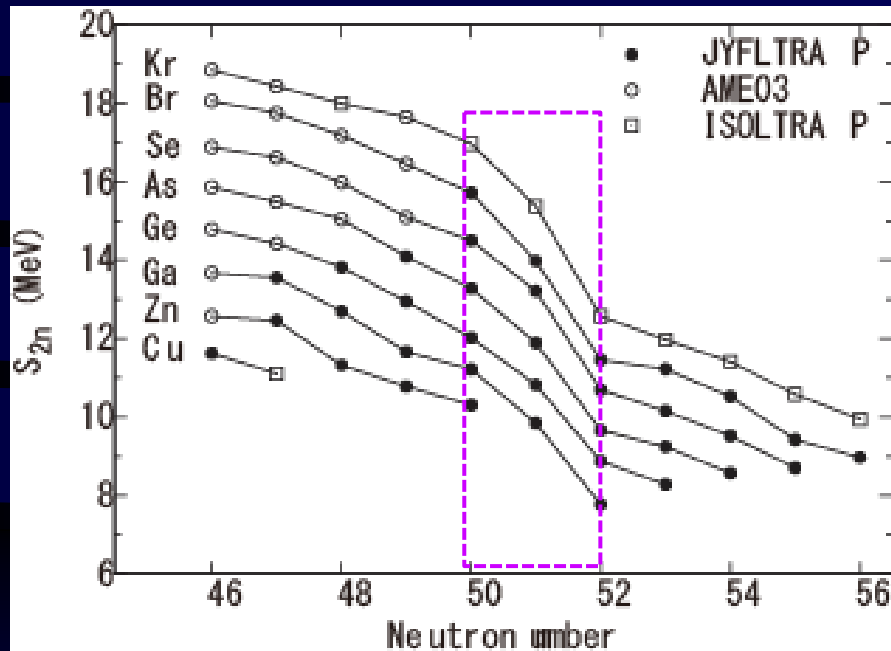


Winger, et al. PRC81 (2010)



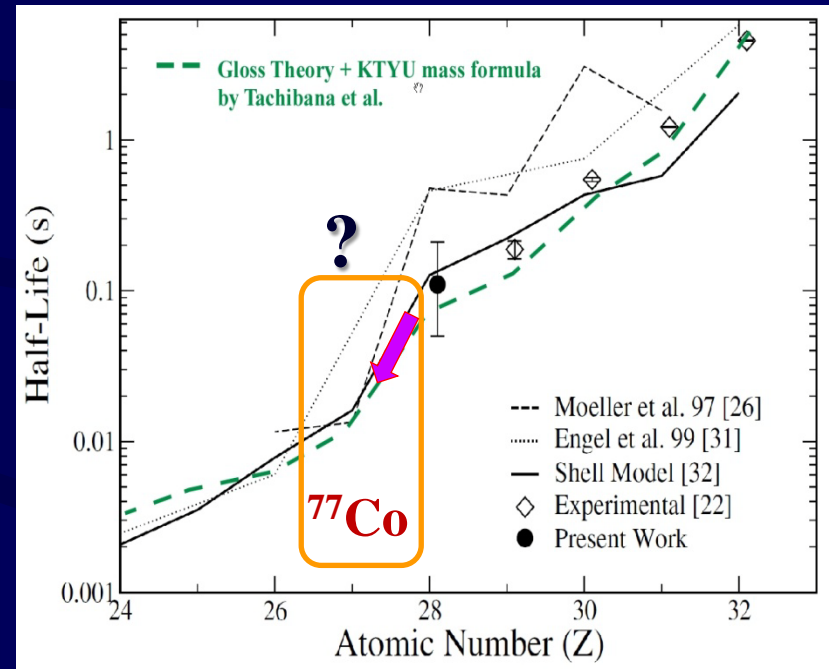
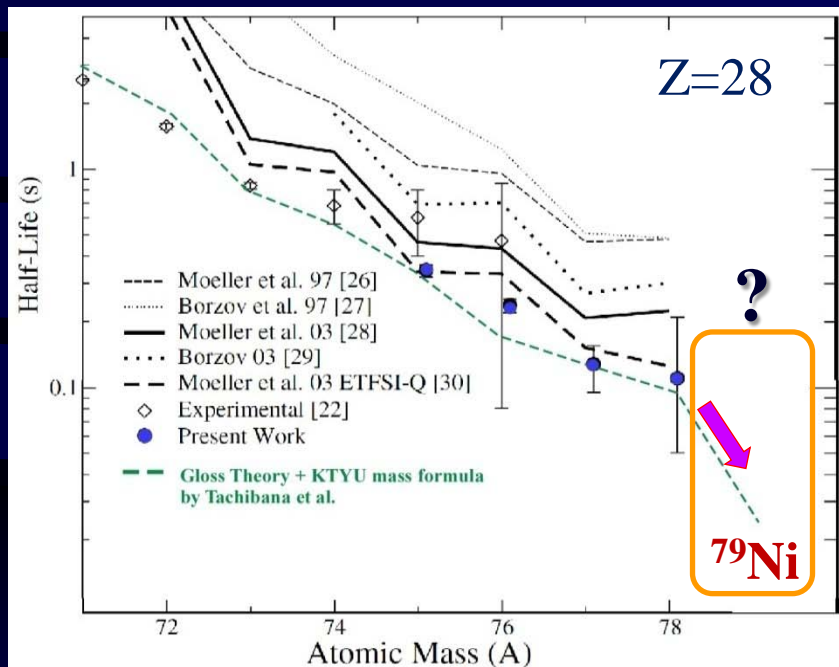
Mass Measurement

J.Hakala, et al., PRL101, 052502 (2008) @ IGISOL



Half-lives beyond ^{78}Ni

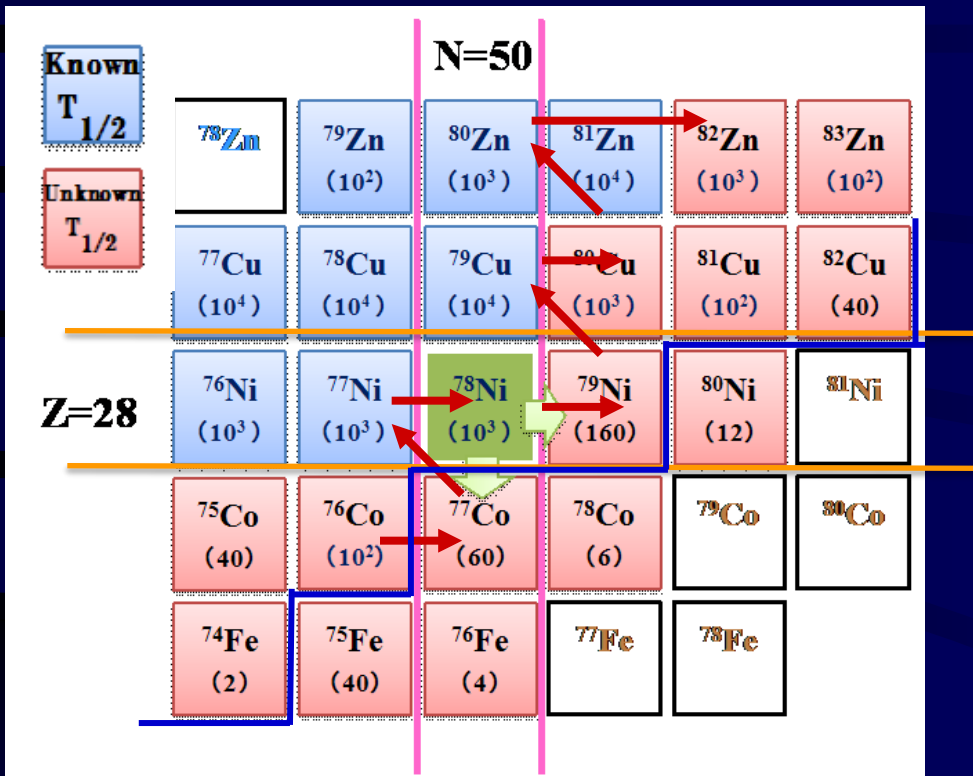
P.T.Hosmer et al., PRL 94, 112501(2005) mod.



- Shorter Half-lives for ^{79}Ni and ^{77}Co ?
 - How far can we go for $T_{1/2}$ measurement ?
- Production Yield

Production Yield in Proposal

U-beam int. : 2 pnA is required



New isotopes produced at RIBF

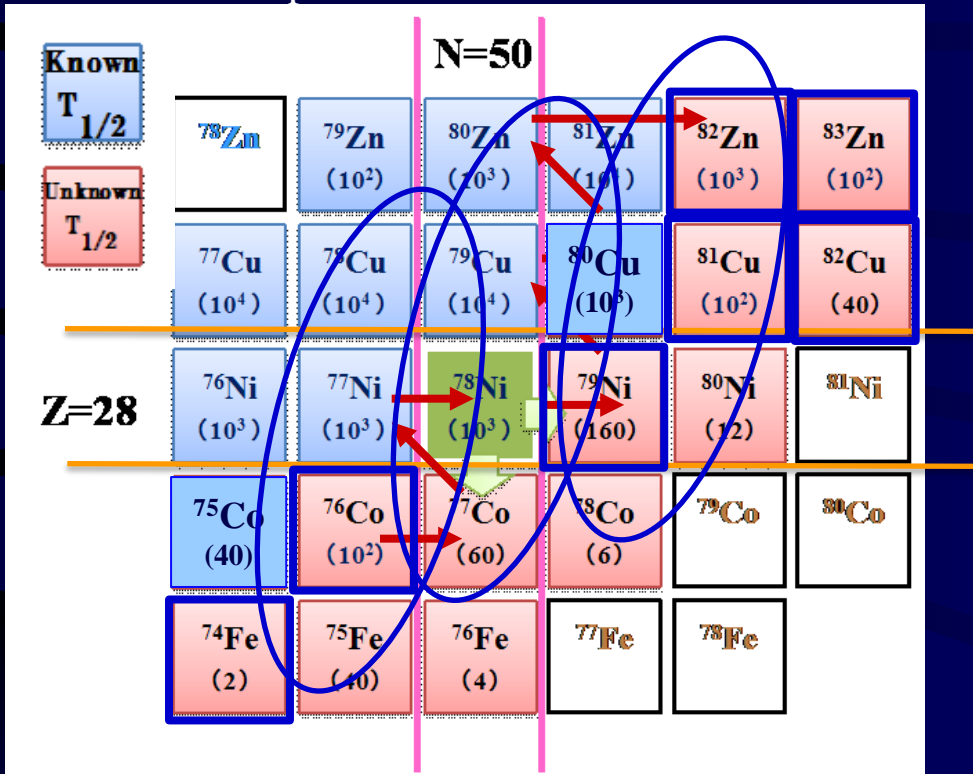
- ^{87}Ga (10)
- ^{84}Zn (22), ^{85}Zn (1)
- ^{81}Cu (36), ^{82}Cu (2)
- ^{79}Ni (3)
- ^{76}Co (5)
- ^{73}Fe (4), ^{74}Fe (1)

Red ... No decay information

Realistic Production Yield

T. Ohnishi, et al JSPJ (2010)

U beam int. $\sim 2\text{pnA}$



^{79}Ni : 3 events

Beam int. $0.2 \rightarrow 5\text{pnA}$ (x25)

Time $25\text{h} \rightarrow 3\text{days}$ (x2.88)

Optics $1 \rightarrow 0.5$ (x0.5)

Detection Effi. $1 \rightarrow 0.7$ (x0.7)

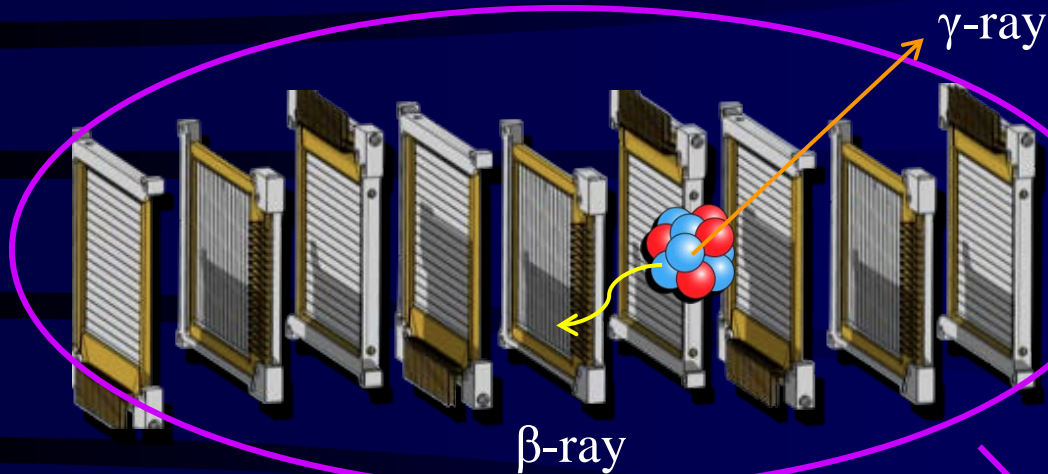
DAQ $0.87 \rightarrow 0.98$ (x1.13)

$$3\text{ events} \times 25 \times 2.88 \times 0.5 \times 0.7 \times 1.13 = 85\text{ events}$$

Production yield is $1/5 \sim 1/10$ of what we expected in 2007 ?

Total 7.5 days is approved.
 One setting is desired for beam optics.

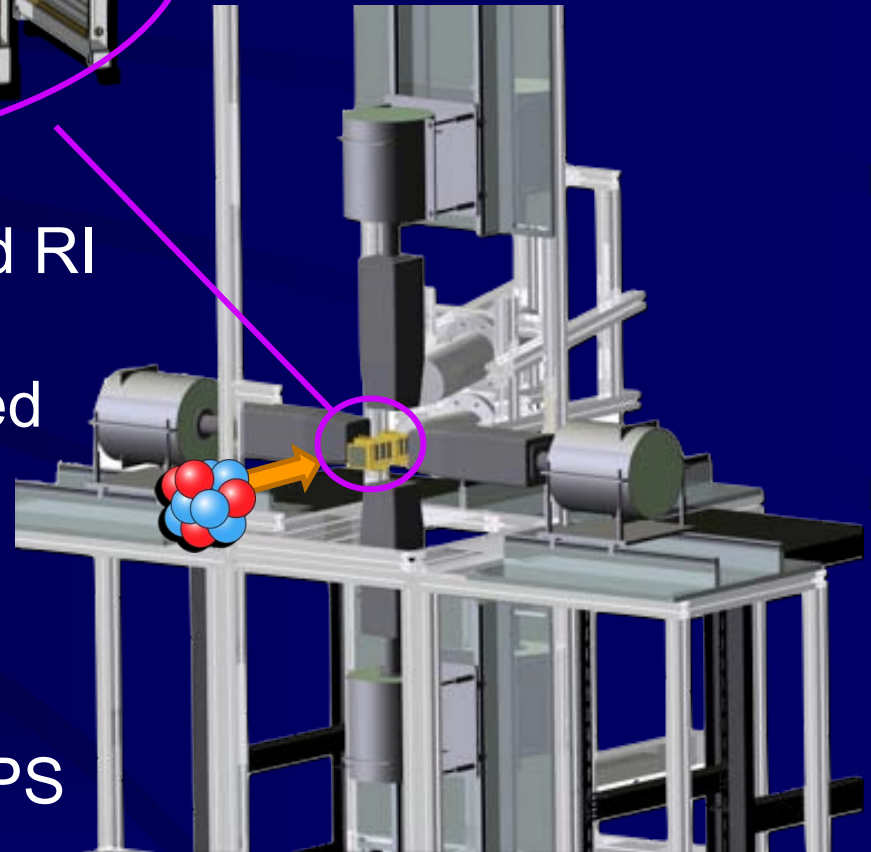
Experimental Setup : Ready



- RI & β -ray detection
 - 9 DSSDs ($50 \times 50 \times 1 \text{ mm}^3$)
 - 16 x 16 strips
 - ~ 2000 pixels in total

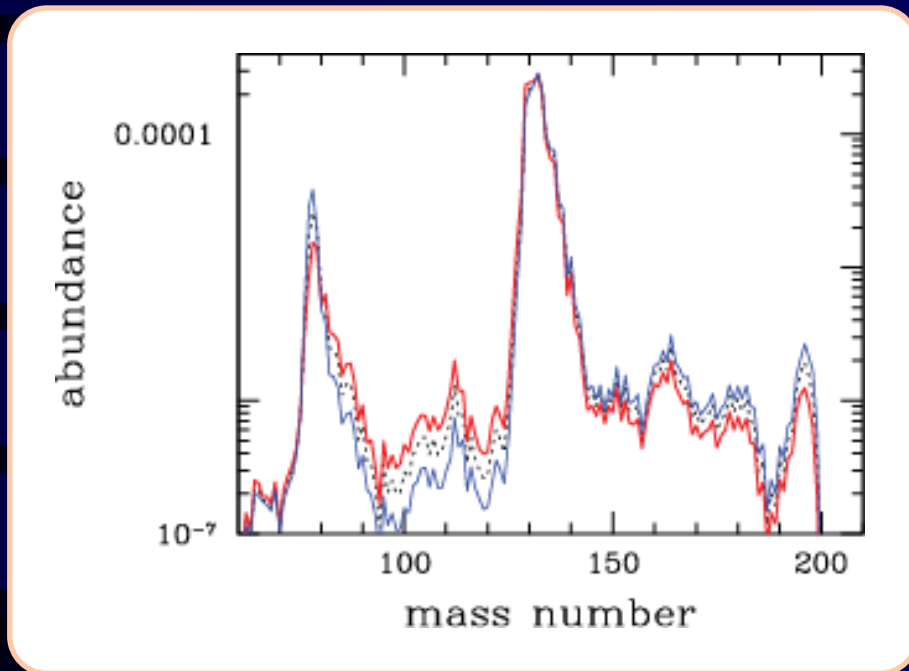
➤ The implantation of an identified RI is associated with the following β -decay events that are detected in the same DSSSD pixel

➤ ΔE -TOF-B ρ method using the focal plane detectors in BigRIPS



Abundance with different $T_{1/2}$ of ^{78}Ni

P.Hosmer, PRC82 (2010)



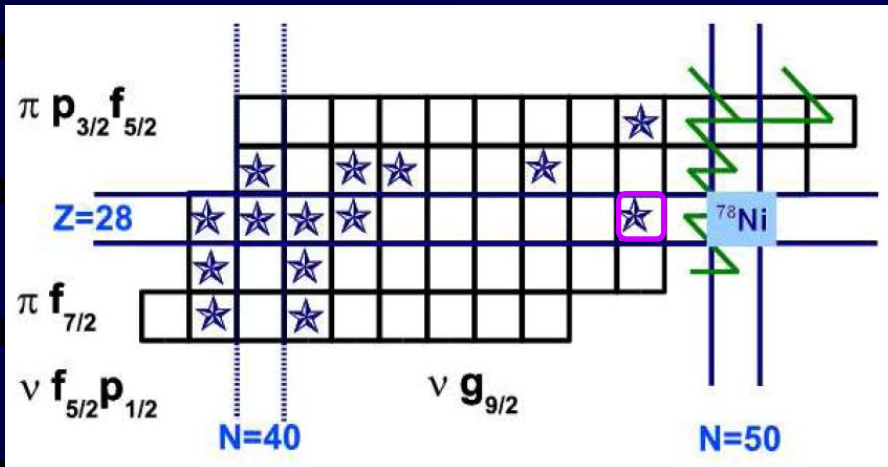
Red : ^{78}Ni $T_{1/2} = 110\text{ms}$
Blue : $T_{1/2} = 224\text{ms}$
Black: $T_{1/2} = 477\text{ms}$

Half-lives of isotopes around the ^{78}Ni are important !?

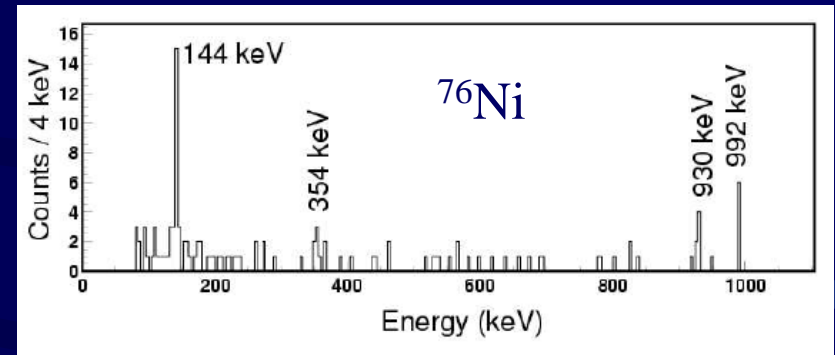
$^{74-75}\text{Fe}$, $^{76-78}\text{Co}$, $^{78-80}\text{Ni}$, $^{80-81}\text{Cu}$

Isomer near ^{78}Ni

R.Grzywacz, EPJA 25 (2005) 89.
M.Sawicka, et al. EPJA 20 (2004) 109.



C.Mazzocchi, PLB 622 (2005)



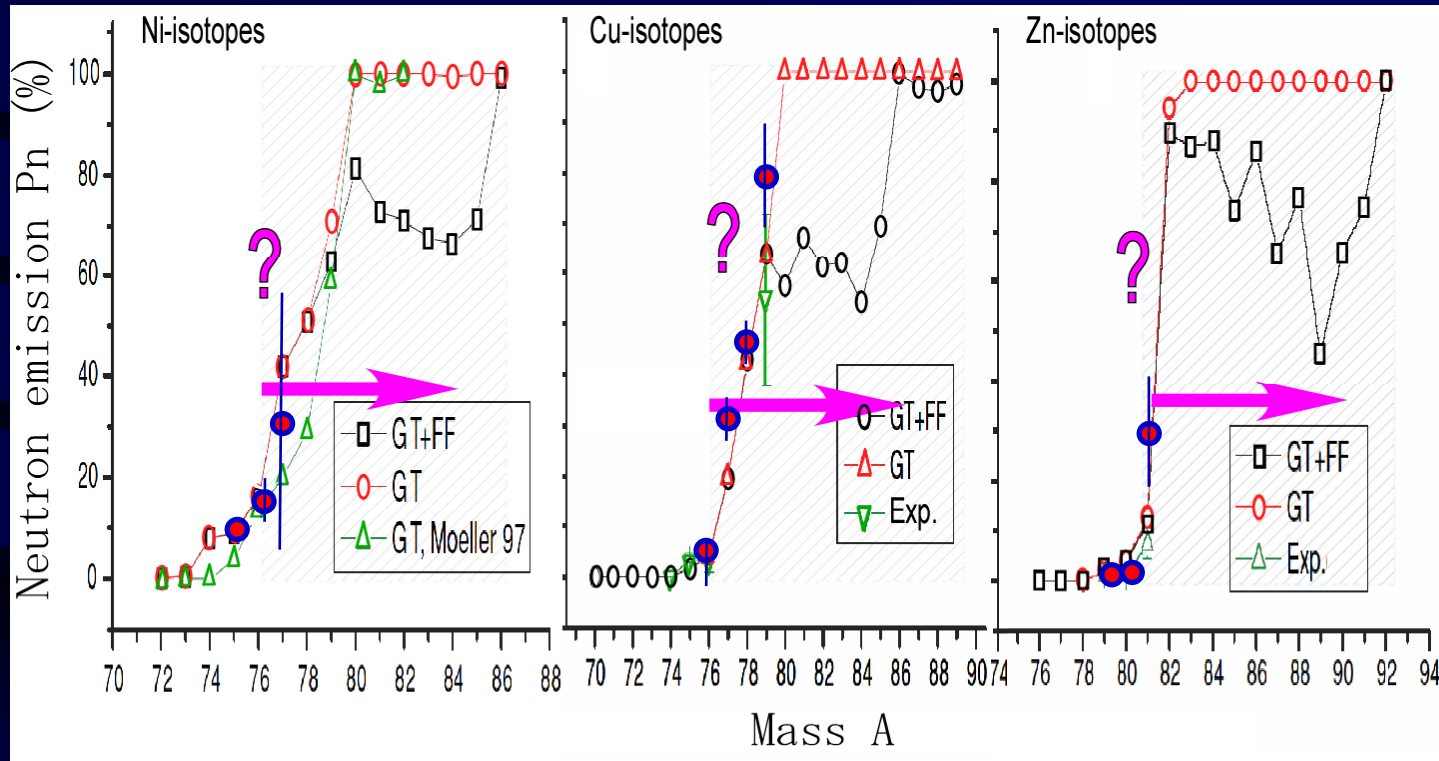
590^{+180}_{-110} ns 8^+ isomer

E(U)RICA is very powerful device for isomer search.

Neutron Emission

I.N.Borzov Phys. Rev. C71 (2005) 065801

+ P.Hosmer, PRC82 (2010)



Neutron emission prob. (P_n) goes up dramatically ?

^3He long counters will be feasible for this kind of measurement.

Summary

Physics Goal :

New isotopes ... ^{77}Co , ^{75}Fe , ^{80}Ni , ...

First $T_{1/2}$... $^{74-75}\text{Fe}$, $^{76-77}\text{Co}$, $^{79-80}\text{Ni}$, $^{81-82}\text{Cu}$, $^{82-83}\text{Zn}$, ...

First $E(2+)$ of ^{82}Zn and ^{78}Ni ... almost impossible without E(U)RICA

→ E(U)RICA is also powerful for Isomer search !

Q_{beta} , P_n ... It depends on experimental setup

Production Yield :

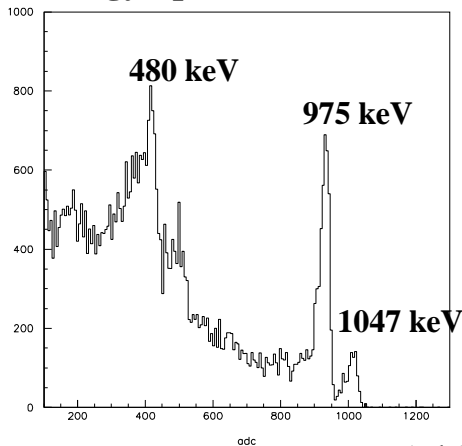
Production yield around ^{78}Ni region seems to be $1/5 \sim 1/10$ lower than expected ..

- **Beam optics : single condition** (for 7.5 days)
- **5pnA of U-beam** (expected beam intensity)

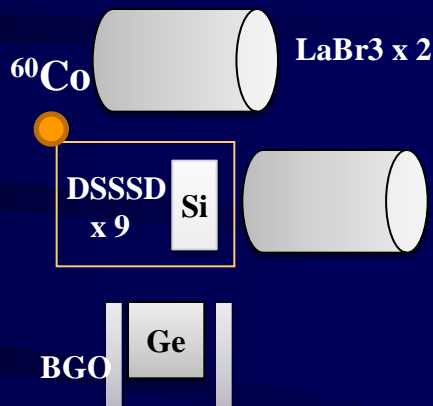
Thank you.

High Efficiency Beta Counting System (Energy threshold ~ 20 keV)

Energy Spectrum of ^{207}Bi (EC)

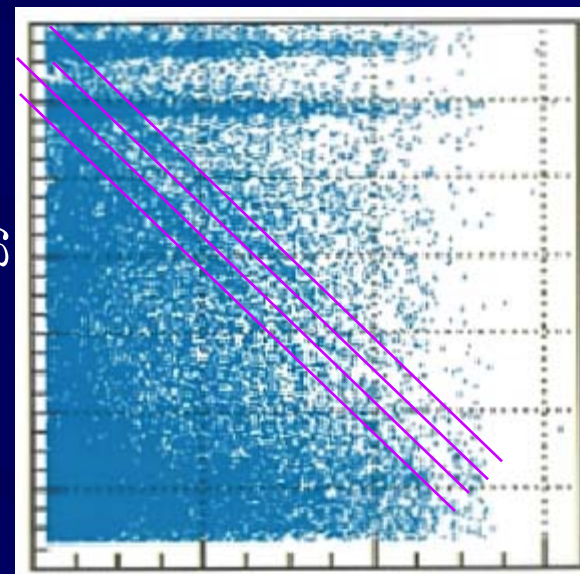


(ch)

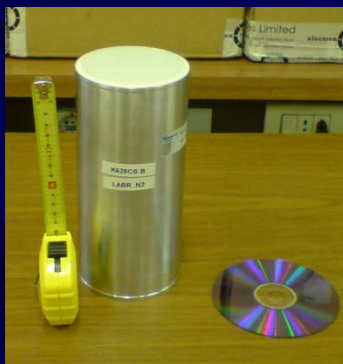
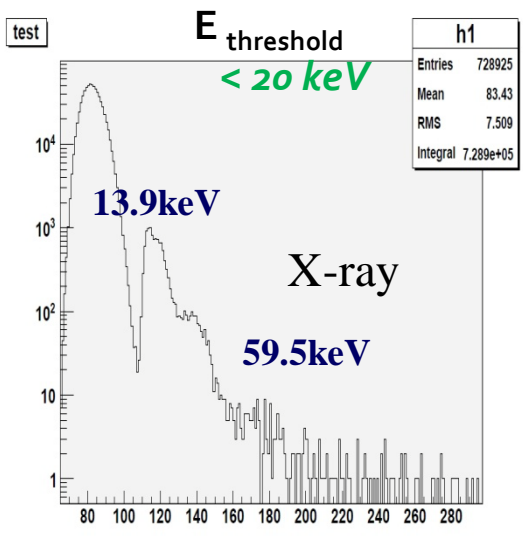


Energy calibration using
Compton scattering

Energy in LaBr_3



Energy in DSSSD
(strip # i)



From Milano group