東京大学
THE UNIVERSITY OF TOKYO

中国原子能科学研究院
中核集团 CNNC
CHINA INSTITUTE OF ATOMIC ENERGY

CNS Summer school 2023, August 4-10

Direct measurement of the cross section for ^{102}Pd(p, γ)^{103}Ag reaction in the p-process

Fulong Liu

2023. 08. 09

Yamaguchi Lab | CNS, The University of Tokyo

fulong@cns.s.u-tokyo.ac.jp

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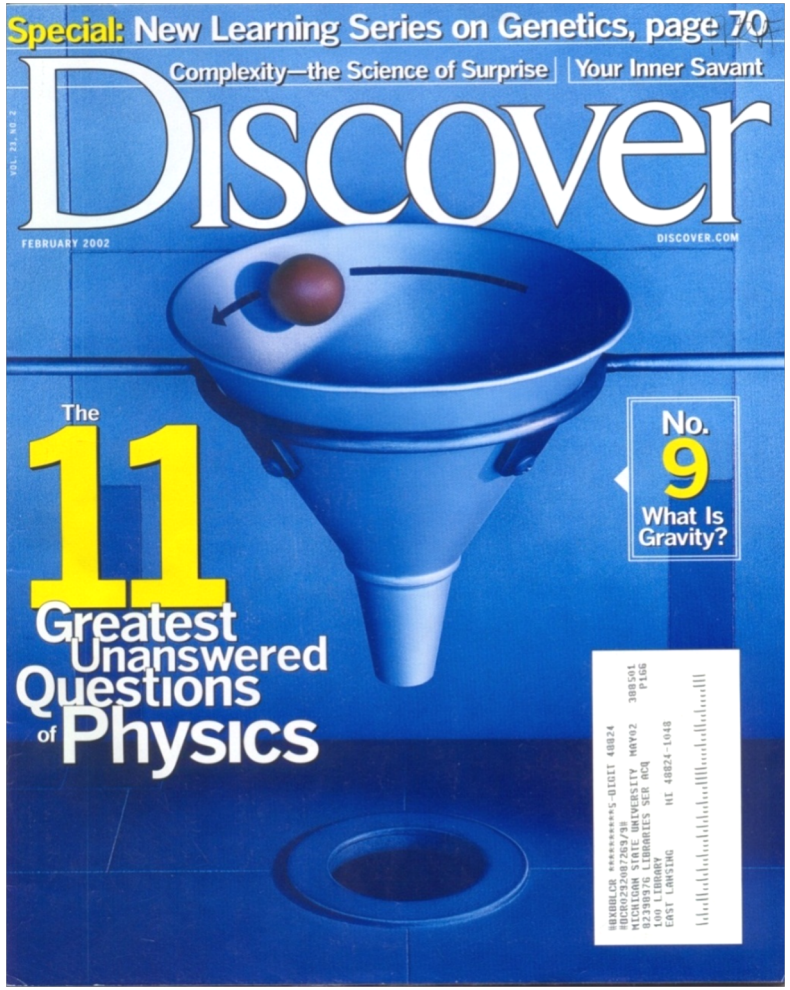
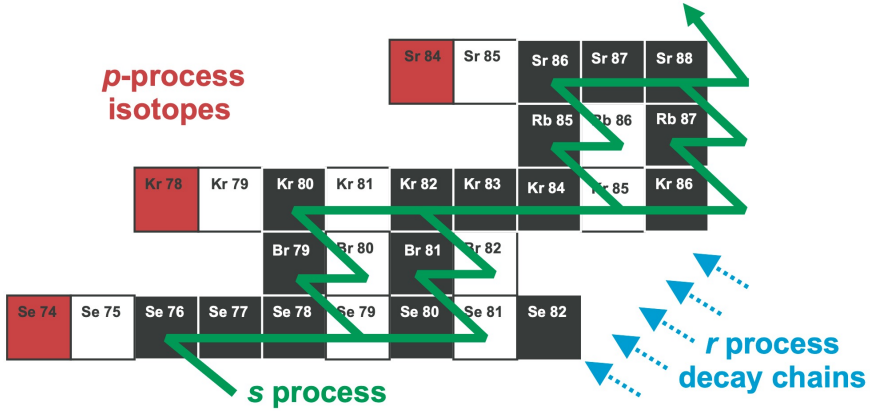
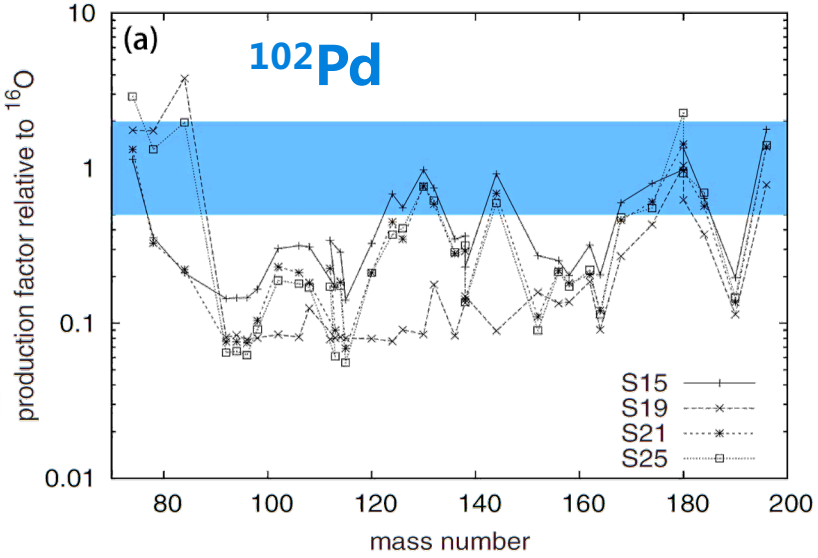
01 Introduction



In 2002, "Discover" reported 11 unsolved mysteries of physics

1. **What is dark matter?**
2. **What is dark energy?**
3. **How were the heavy elements from iron to uranium made?**





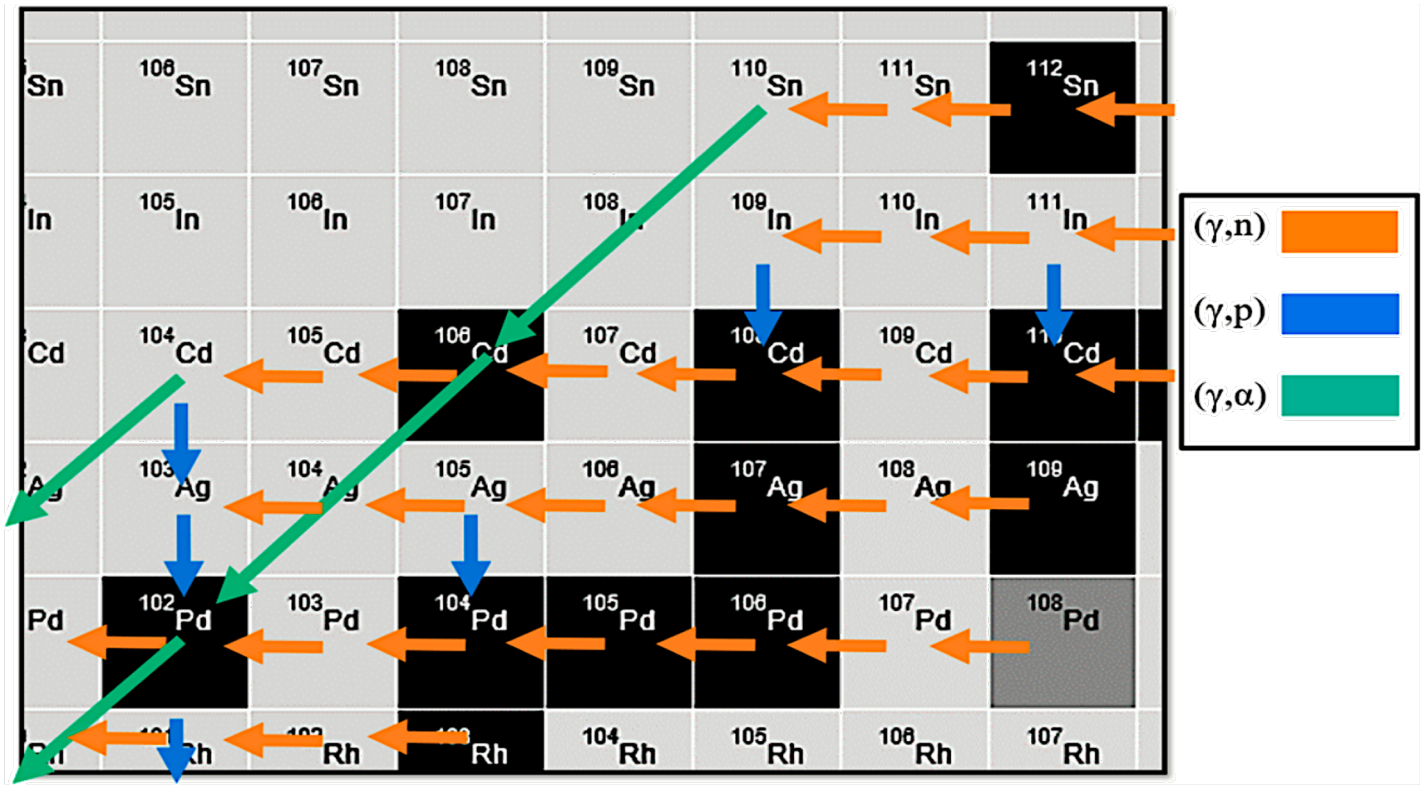
p-nuclei **: Mass between ^{74}Se-^{196}Hg, can not be synthesized through the s-process and r-process.**

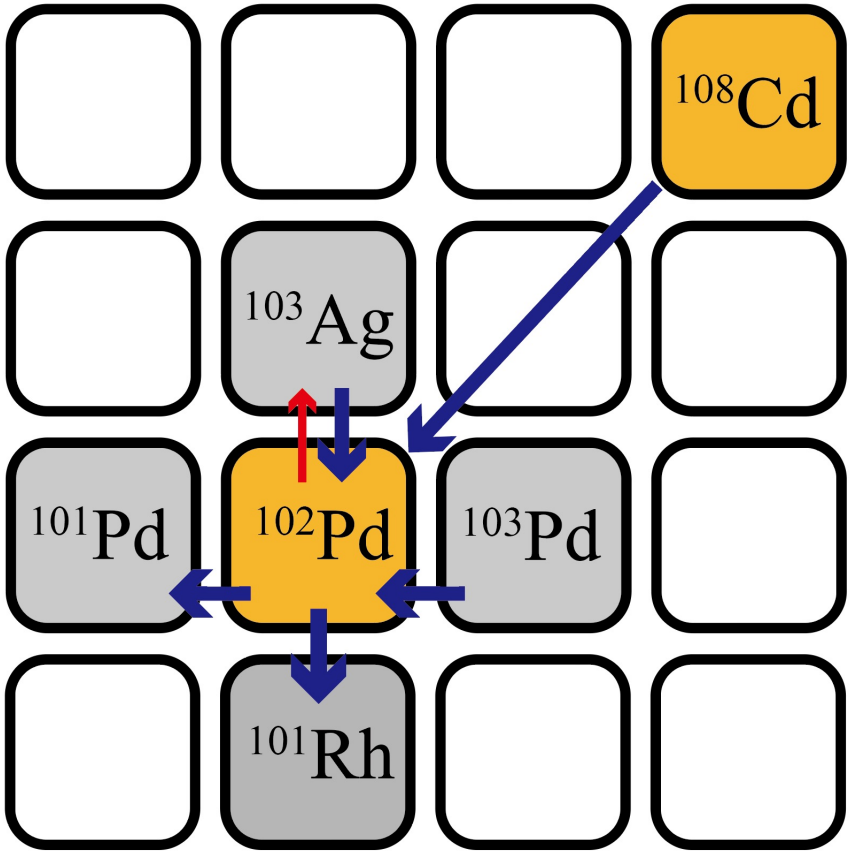
- **p-production factors relative to ^{16}O, Below A < 124 and between 150 < A < 165 the p-isotopes are severely underproduced.**

Reviews of modern physics, 83,157(2011).

Rep. Prog. Phys. 76 (2013) 066201.

01 Introduction

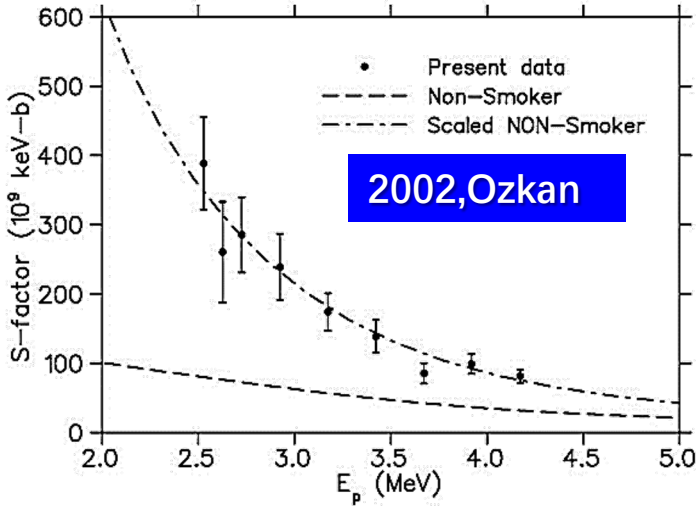




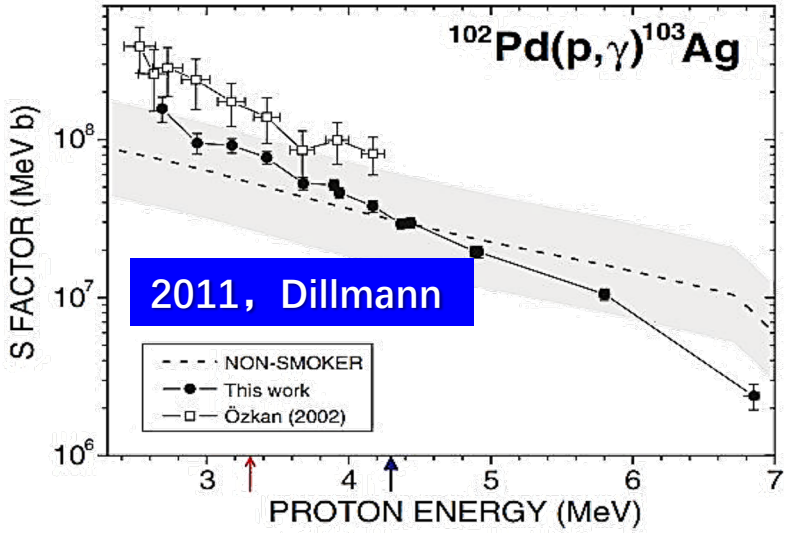
- The latest research shows that the reverse reaction of ^{102}Pd(p,γ) is one of the important constructive reaction of ^{102}Pd, and it is also one of the destruction reactions of ^{102}Pd

Physical Review C, 2020, 102，055806. *Physics Reports, 384,1-84(2003).* *Rep. Prog. Phys.76 ,066201(2013).*

01 Introduction

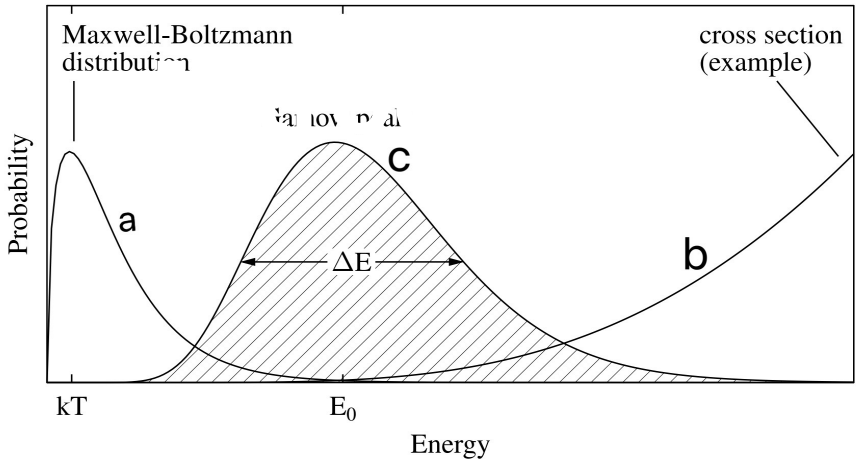


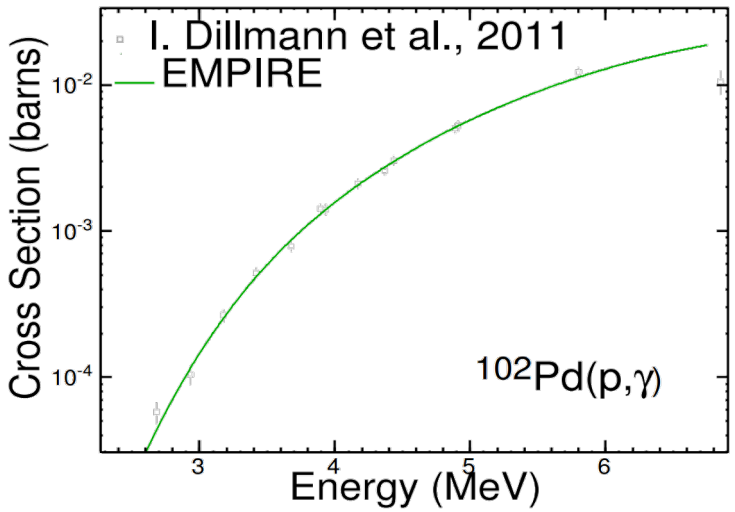
Nuclear Physics A, 2002, 710(3-4): 469-485



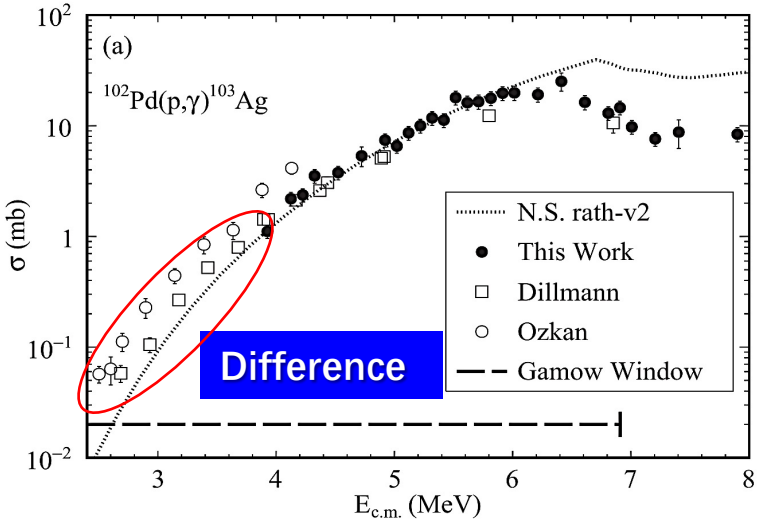
Physical Review C, 2011, 84(1): 015802

Sonnabend K ., Ph. D. thesis





Nuclear Data Sheets, 2014,120: 180-183.

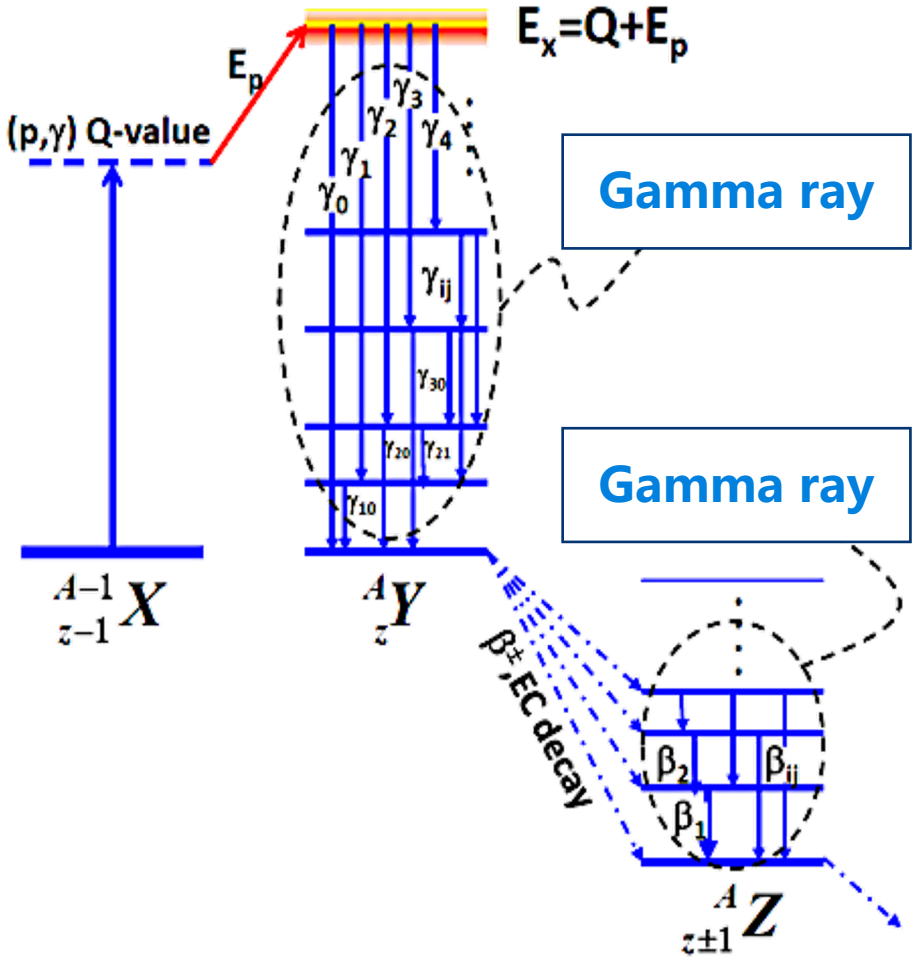


Physical Review C, 2020, 102，055806.

- **Experimental data for the lower energy region of greatest concern in nuclear astrophysics are lack**
- **Several times differences between the different experimental values**

02 Experiment setup

Experimental method :



On Line

$$\frac{dN}{dt_b} = \sigma(E)P\emptyset - \lambda N$$

$$N = \frac{\sigma(E)P\emptyset}{\lambda}\left(1 - e^{-\lambda t_b}\right)$$

Online section

$$n_\gamma = Ne^{-\lambda t_w}\left(1 - e^{-\lambda t_m}\right)\varepsilon_\gamma \eta_\gamma$$

$$\sigma(E) = \frac{\lambda n_\gamma}{P\emptyset(1 - e^{-\lambda t_b})e^{-\lambda t_w}(1 - e^{-\lambda t_m})\varepsilon_\gamma \eta_\gamma}$$

Offline Section

N: Number of ^{103}Ag

t_b : Beam time

$\sigma(E)$: Cross section

P: Density of target

$\emptyset$: Beam intensity

$$P = \frac{T_{tar} N_A A_{Dy}}{M_{tar}}$$

λ: Decay constant

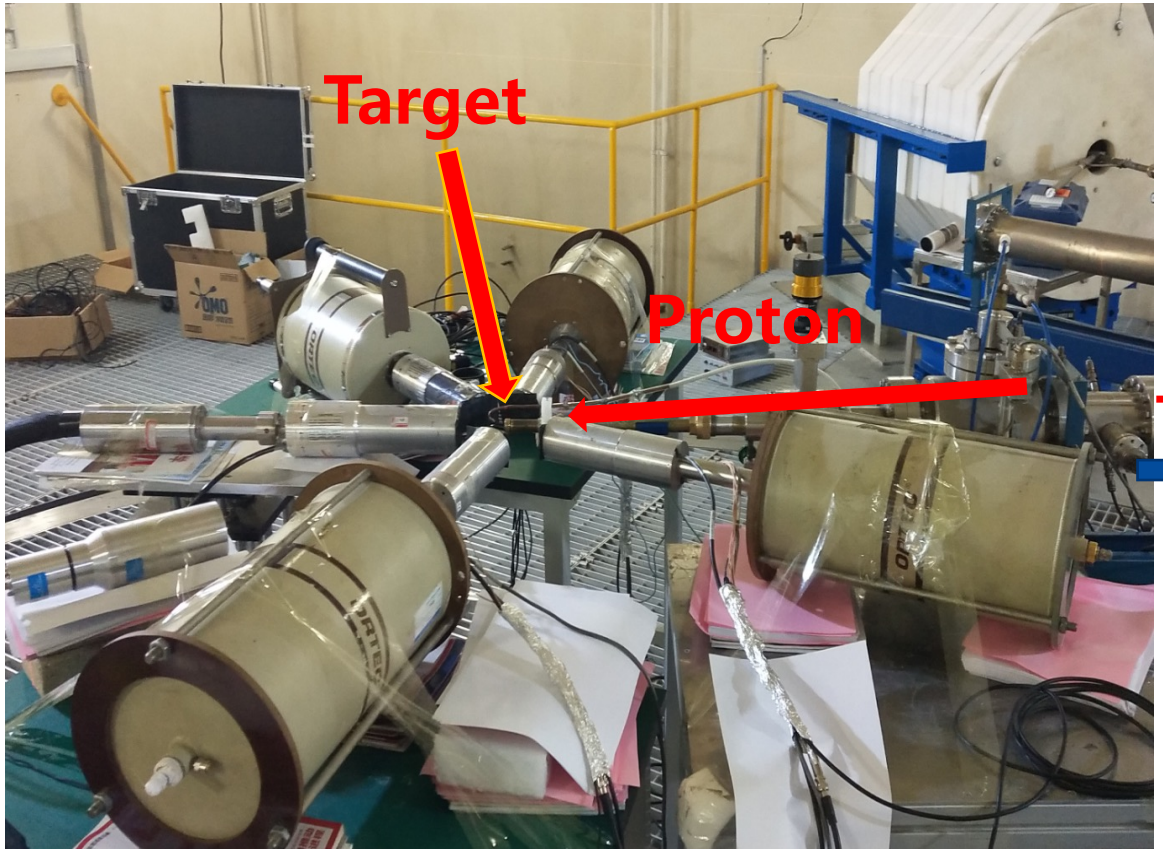
n_γ : **Number of γ rays**

ε_γ: **Detector efficiency**

η_γ: Branching ratio

Activation

02 Experiment setup



Target

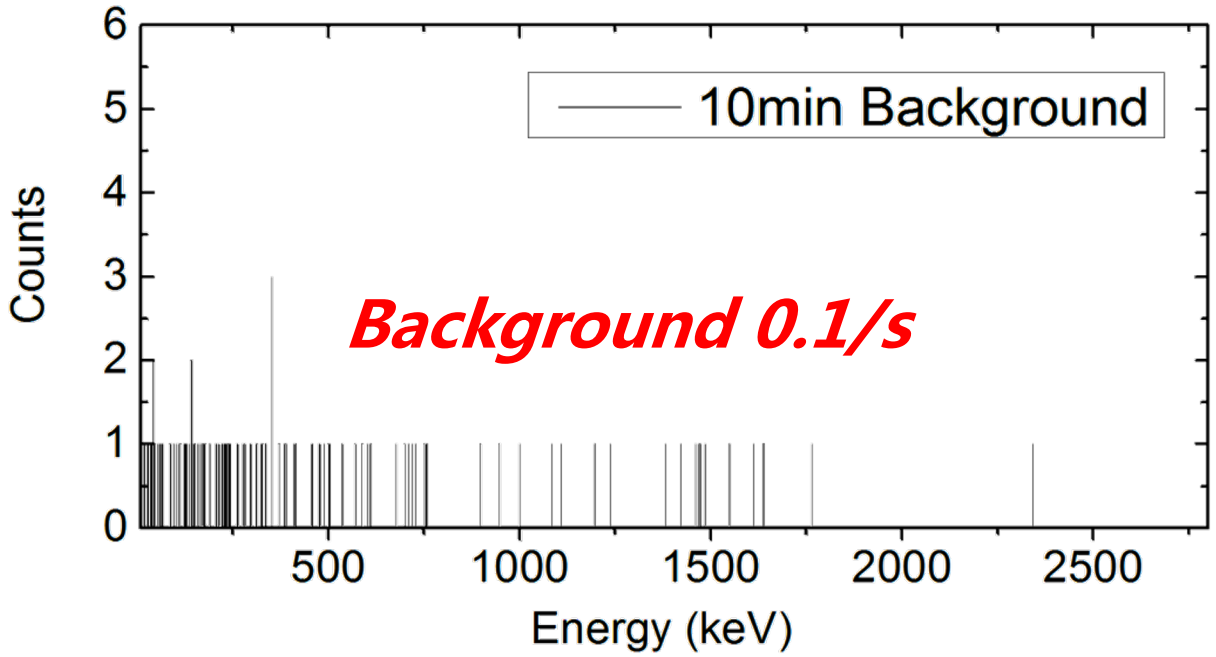
- 2×1.7 MV Tandem accelerator
- 1.9-3.2 MeV　6 μA

- The low background anti-muon and anti-Compton spectrometer.

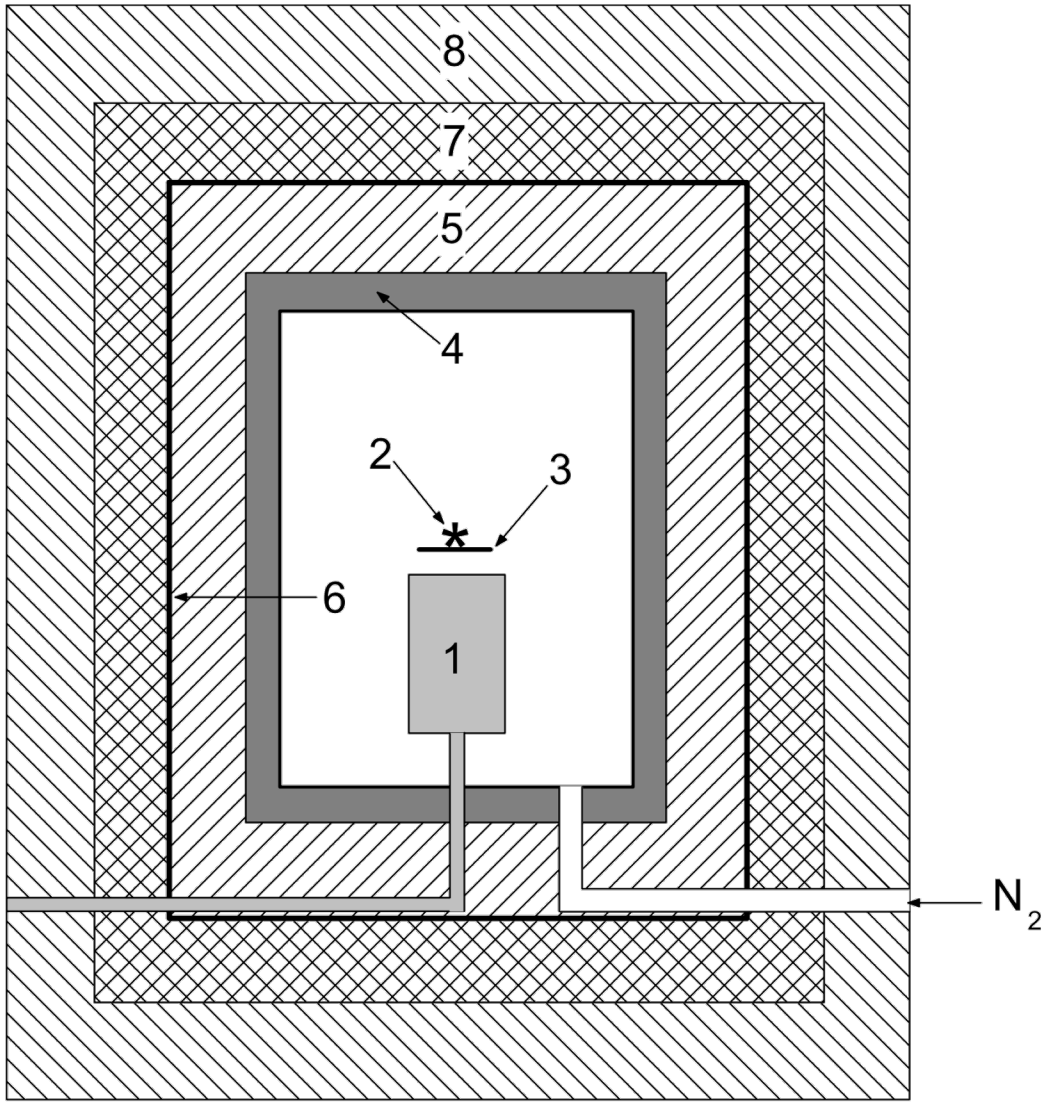
02 Experiment setup

Schematic of the low-background setup

1 is the HPGe detector, 2 the source, 3 the acrylonitrile butadiene styrene (ABS) plastic holder, 4 the copper liner, 5 the inner lead ring, 6 the cadmium absorber, 7 the plastic scintillator, and 8 the outer chamber.

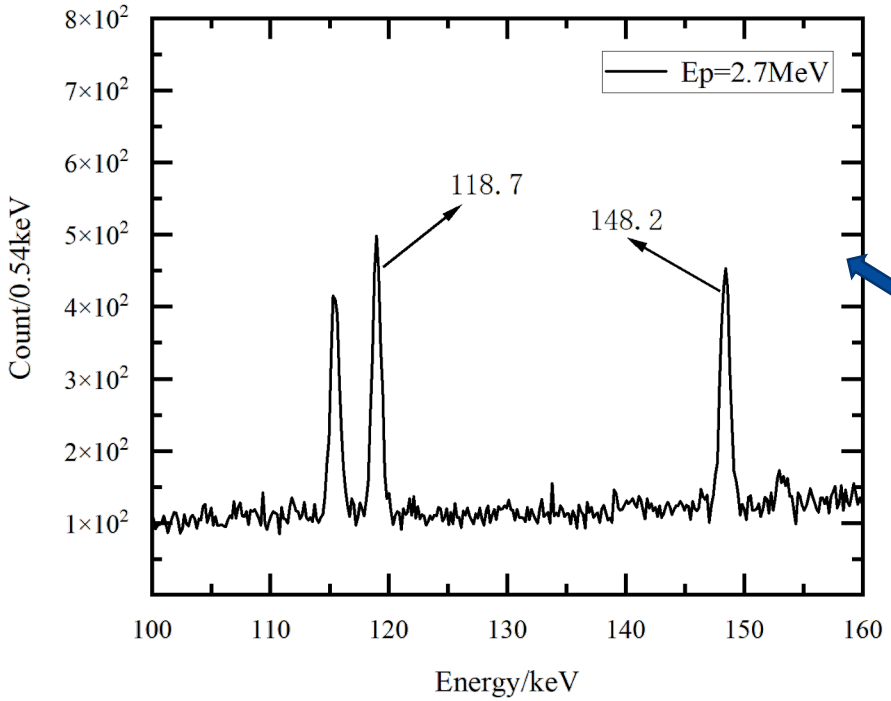


Background 0.1/s



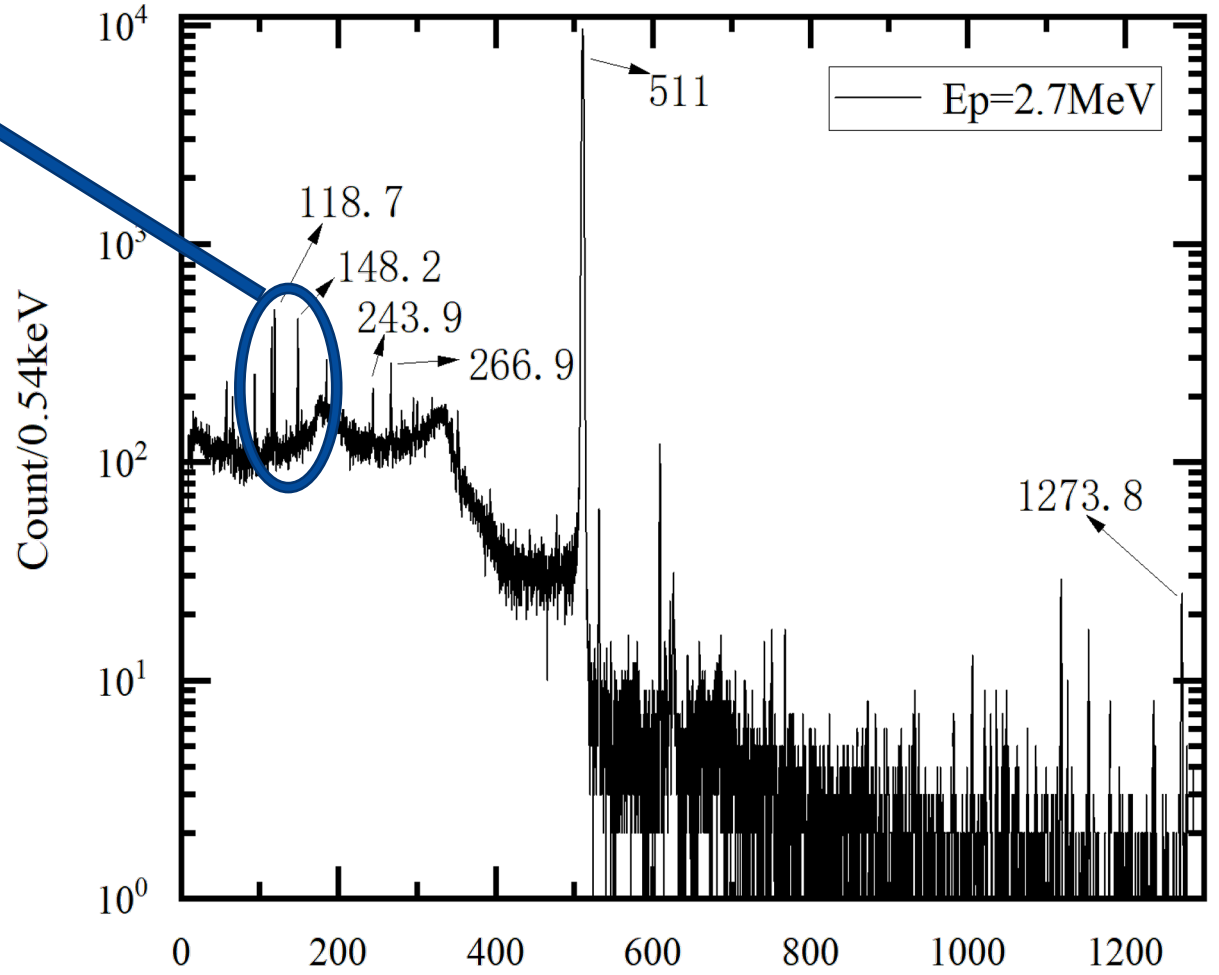
He L C, et al.NIM-A, 2018, 880: 22-27.

03 Experimental results

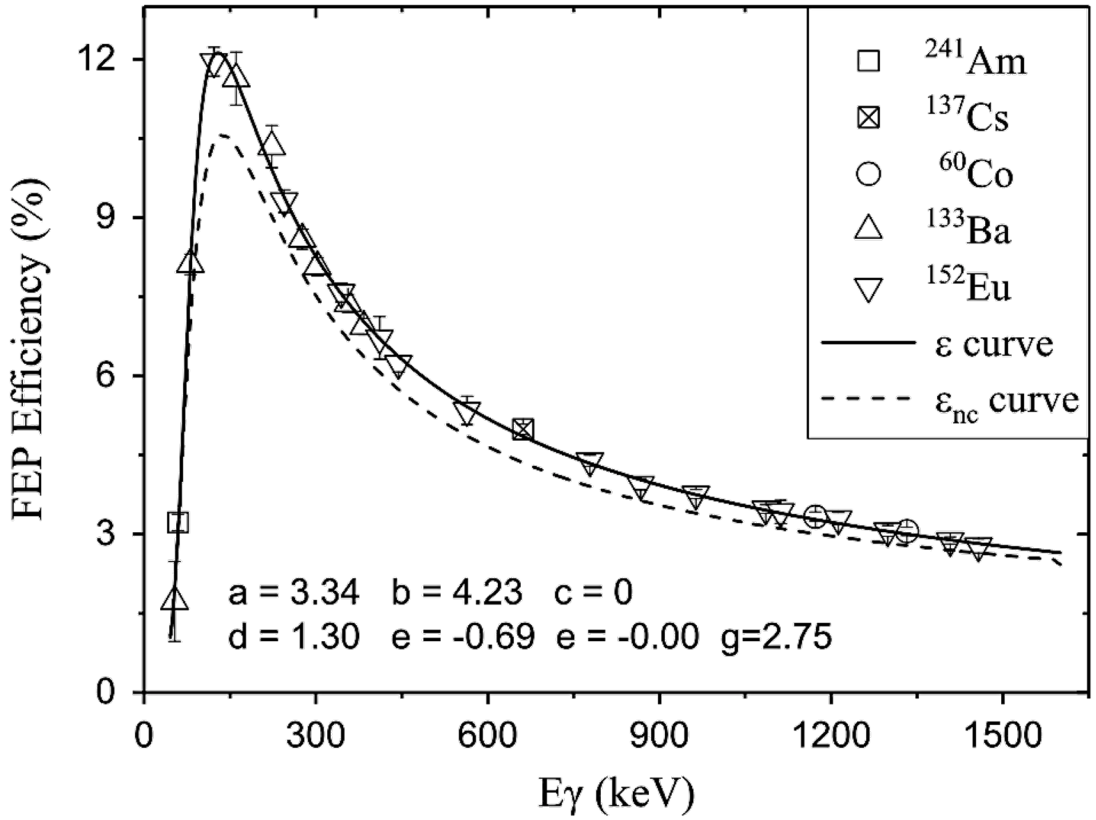


$^{103}Ag^{g+m}$	65.7(7)min
118.7	31.2(7)
148.2	28.3(5)
243.9	8.5(5)
266.9	13.4(4)
1273.8	9.4(3)

Typical energy spectrum at a proton energy of 2.7 MeV



03 Experimental results

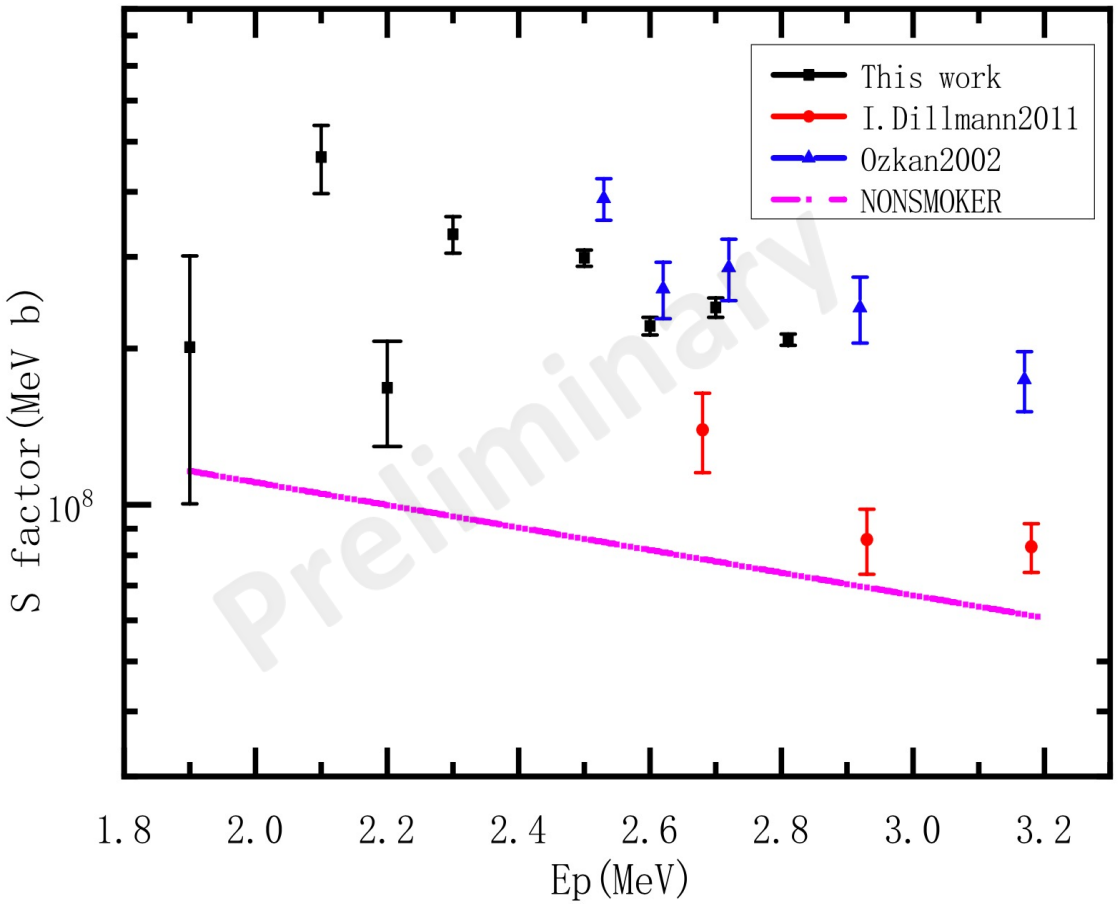


Fit Formula for Detection Efficiency Curve:

$$\ln\varepsilon_\gamma = a_0 + a_1\times(lnE) + a_2\times(lnE)^2 + \cdots$$

$$\varepsilon_\gamma = exp\left\{\left[(a+bx+cx^2)^{-g} + (d+ey+fy^2)^{-g}\right]^{-\frac{1}{g}}\right\}$$

Dashe line: without the efficiency correction.



S-factor as a Function of Energy

Summary

1. ^{102}Pd(p,γ) is one of the important reaction associated with the abundance ^{102}Pd.
2. New cross section data of ^{102}Pd(p, γ) reaction at 1.9 MeV-3.2 MeV region had been obtained by using the activation method and the anti-Compton anti-Muon low background detector, and extended it to the lowest energy region at present.

Thanks for your attention !

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