

Spallation reaction study for fission products in nuclear waste:

Cross section measurements for ^{137}Cs , ^{90}Sr and ^{107}Pd

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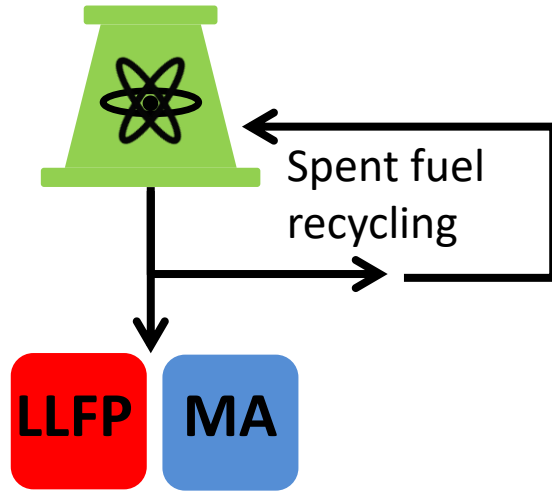
ND2016, Brugge, September 11 - 16, 2016



Content

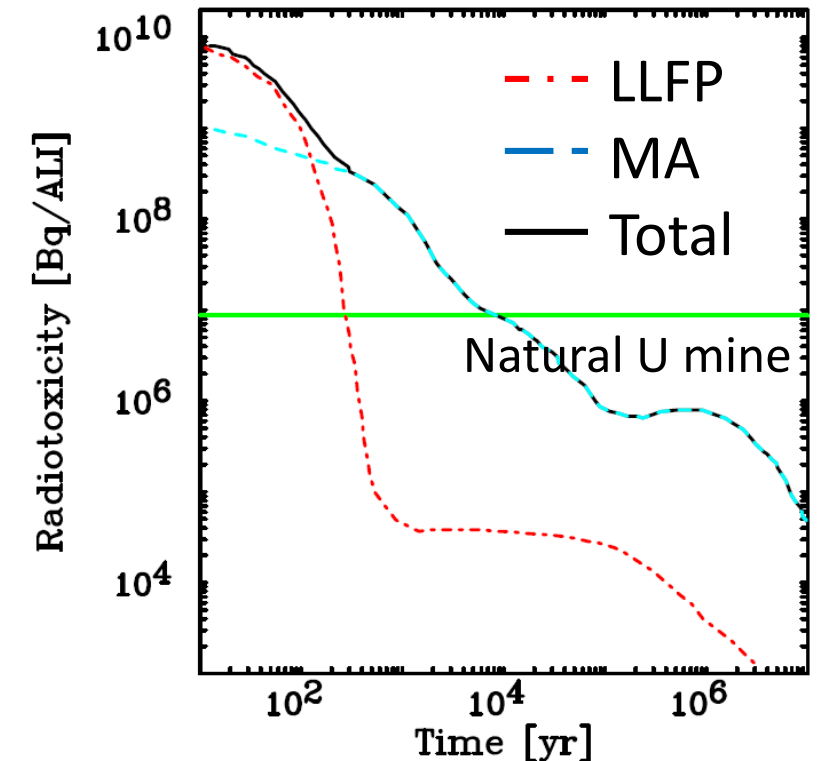
- Motivation
- Experiment details
- Results and discussion
- Summary

Motivation

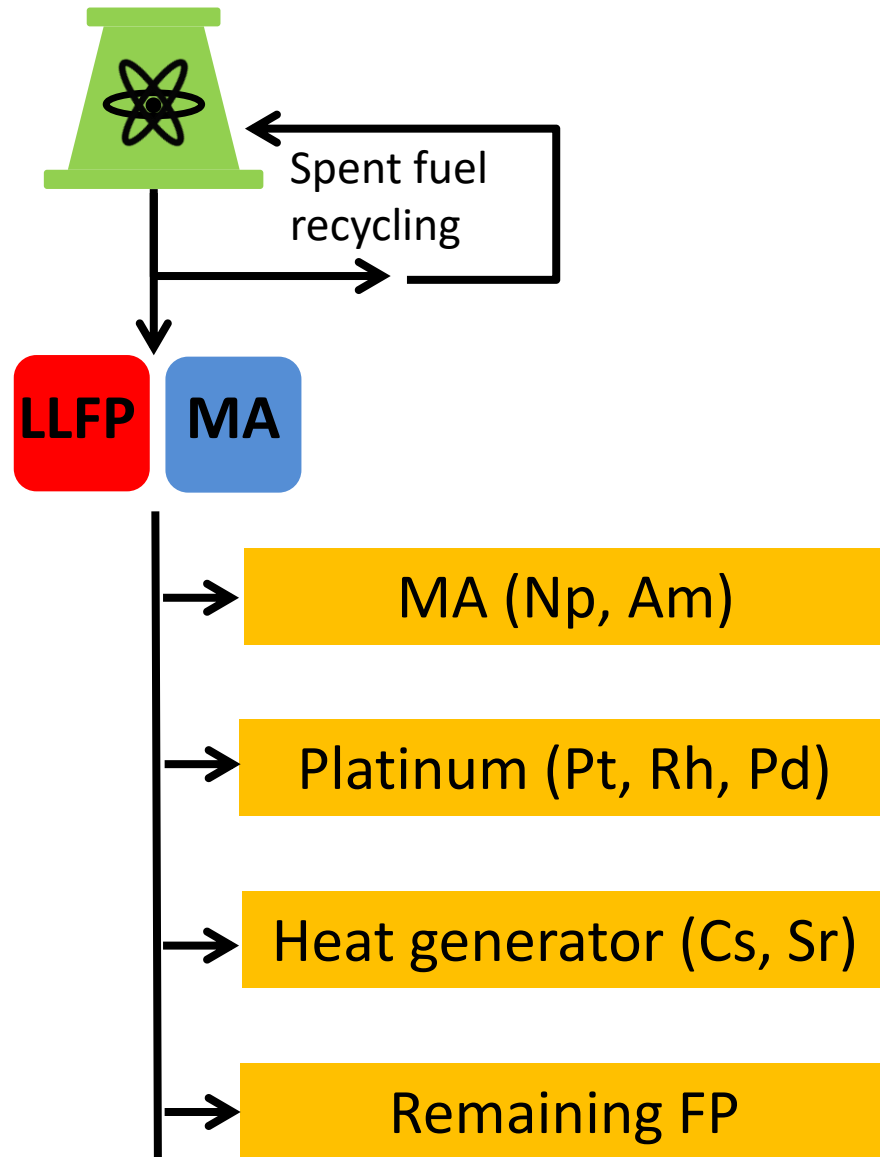


High-level radioactive waste

- Long-lived fission products
e.g. ^{137}Cs , ^{90}Sr , ^{107}Pd , ^{93}Zr ...
- Minor Actinide
e.g. $^{241,243}\text{Am}$, ^{237}Np ...

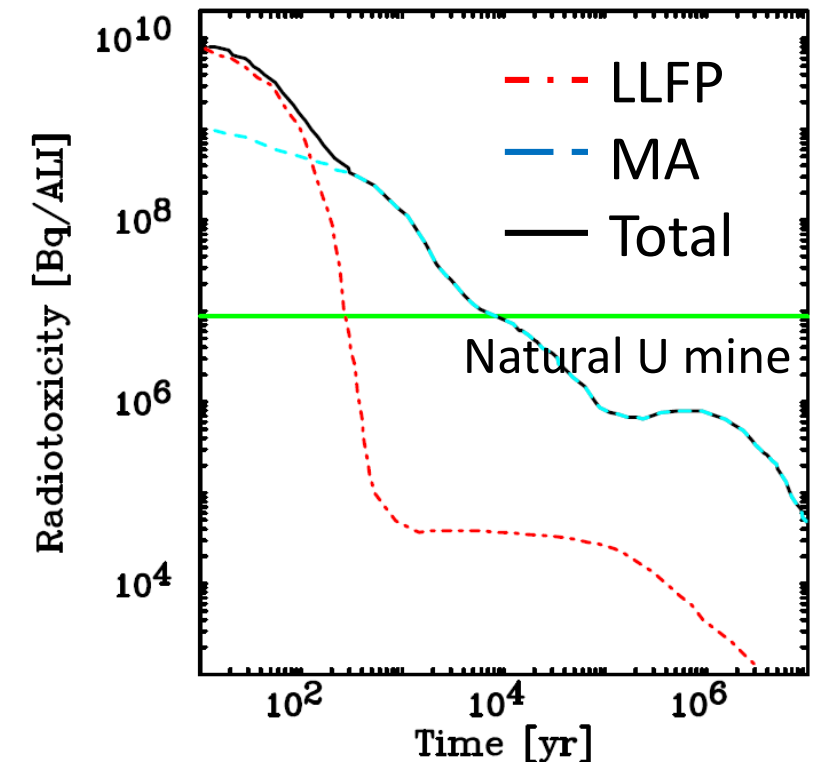


Partitioning and transmutation

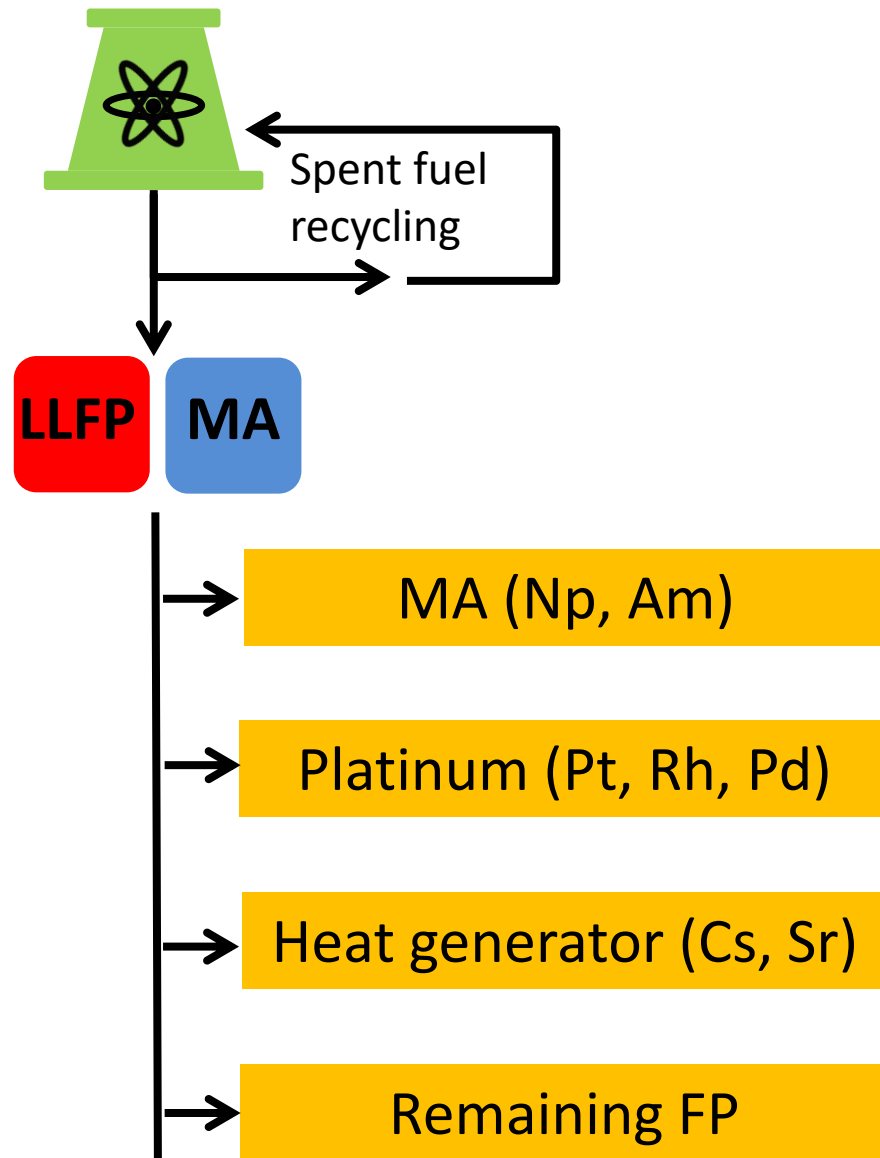


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Transmutation study on LLFP nuclei



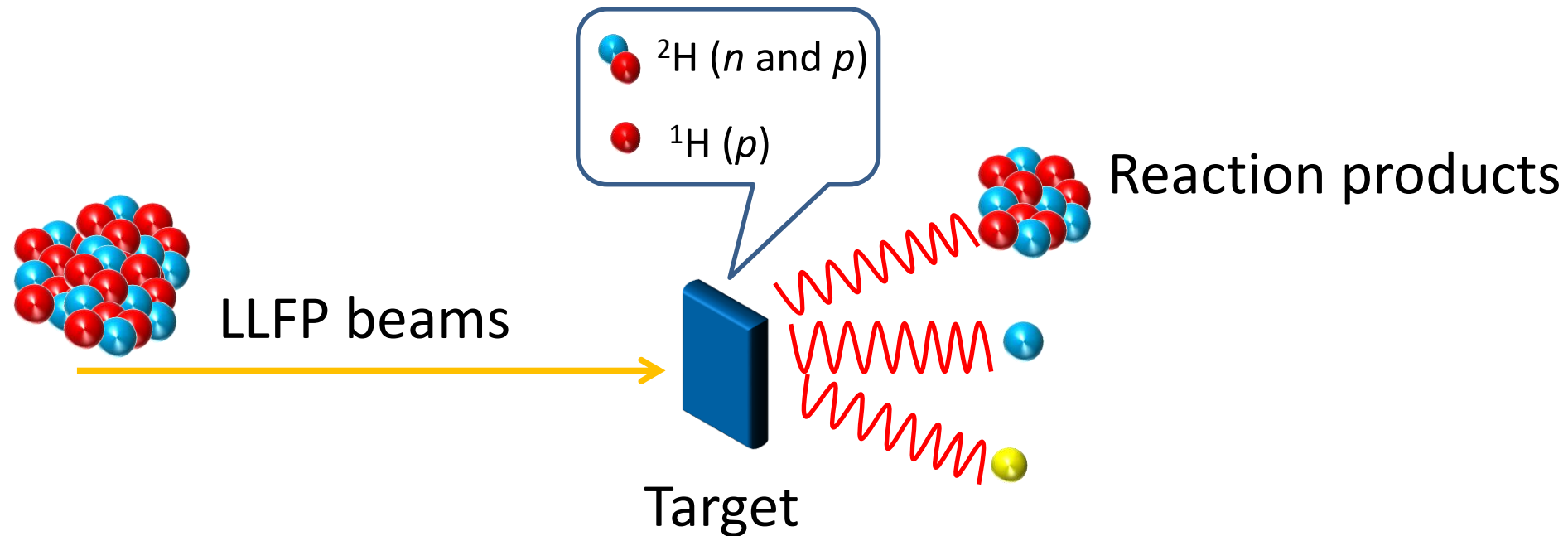
- ^{137}Cs , ^{90}Sr
Large radiotoxicity
- ^{107}Pd
Recovery of palladium metal

Nuclide	Half-life [year]	(n , γ) [b]
^{137}Cs	30.1	0.27
^{90}Sr	28.8	0.01
^{107}Pd	6.5×10^6	9.2

Reaction study for LLFP at RIKEN

Inverse kinematics

- Proton and deuteron
- Different reaction energy

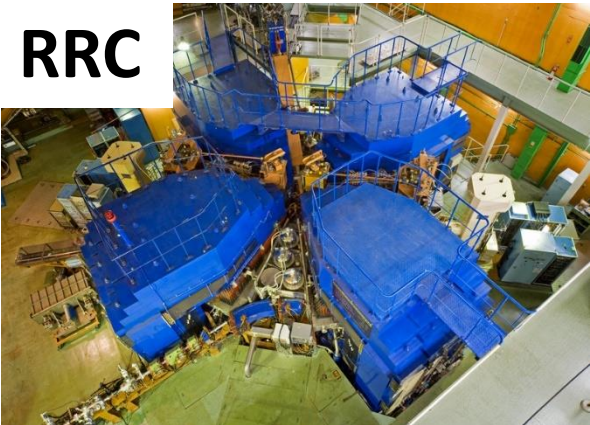


- S. Kawase, R226 (Sept. 14, Morus) ${}^{93}\text{Zr}$
- K. Nakano, S441 (Sept. 15, Mozart) ${}^{93}\text{Nb}$

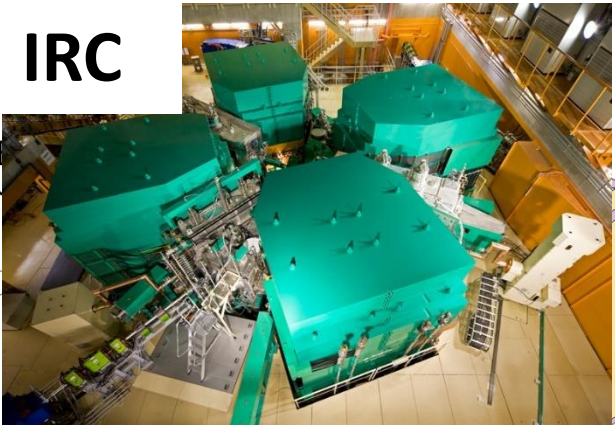
Experiment

Radioactive Isotope Beam Factory (RIBF)

RRC



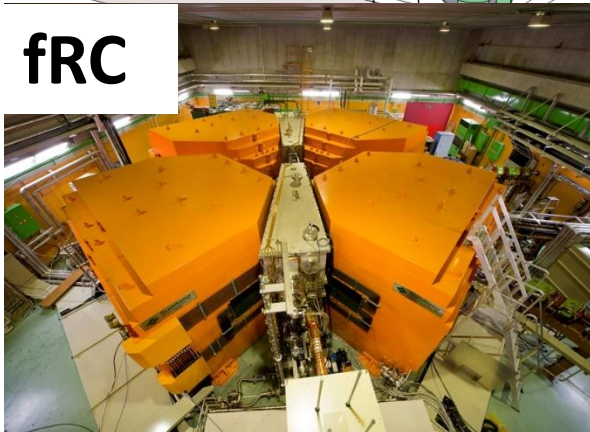
IRC



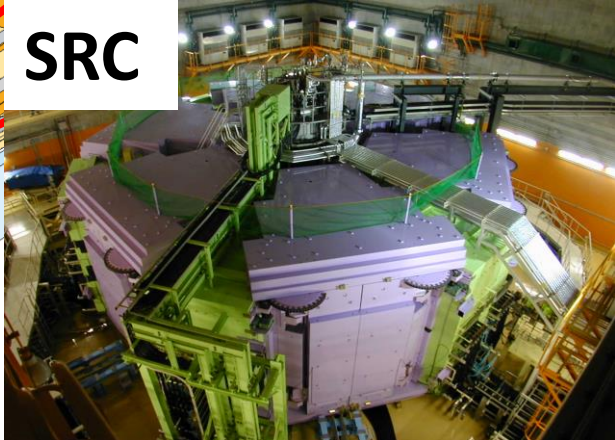
with SCRIT

SAMURAI (construction)

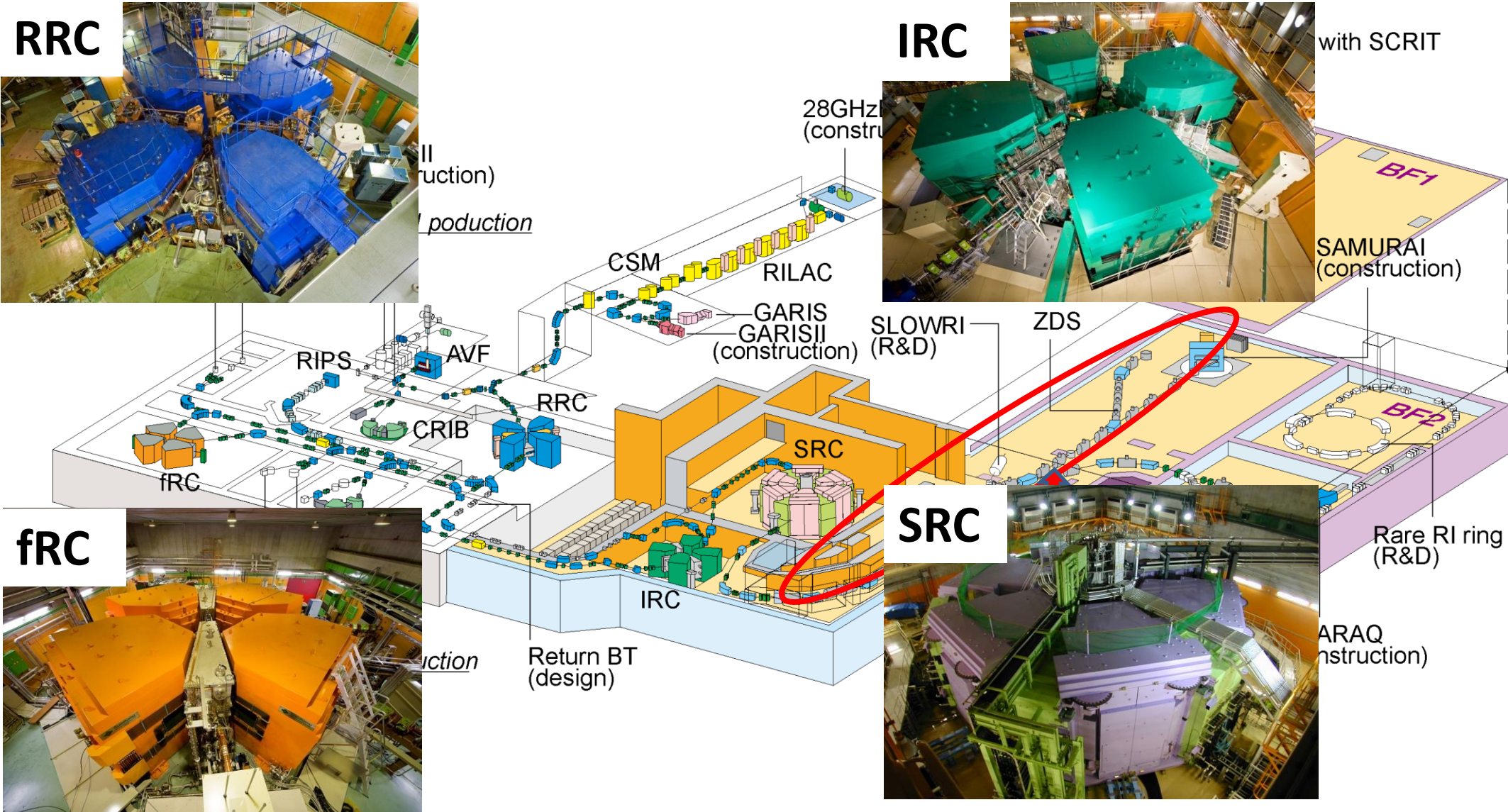
fRC



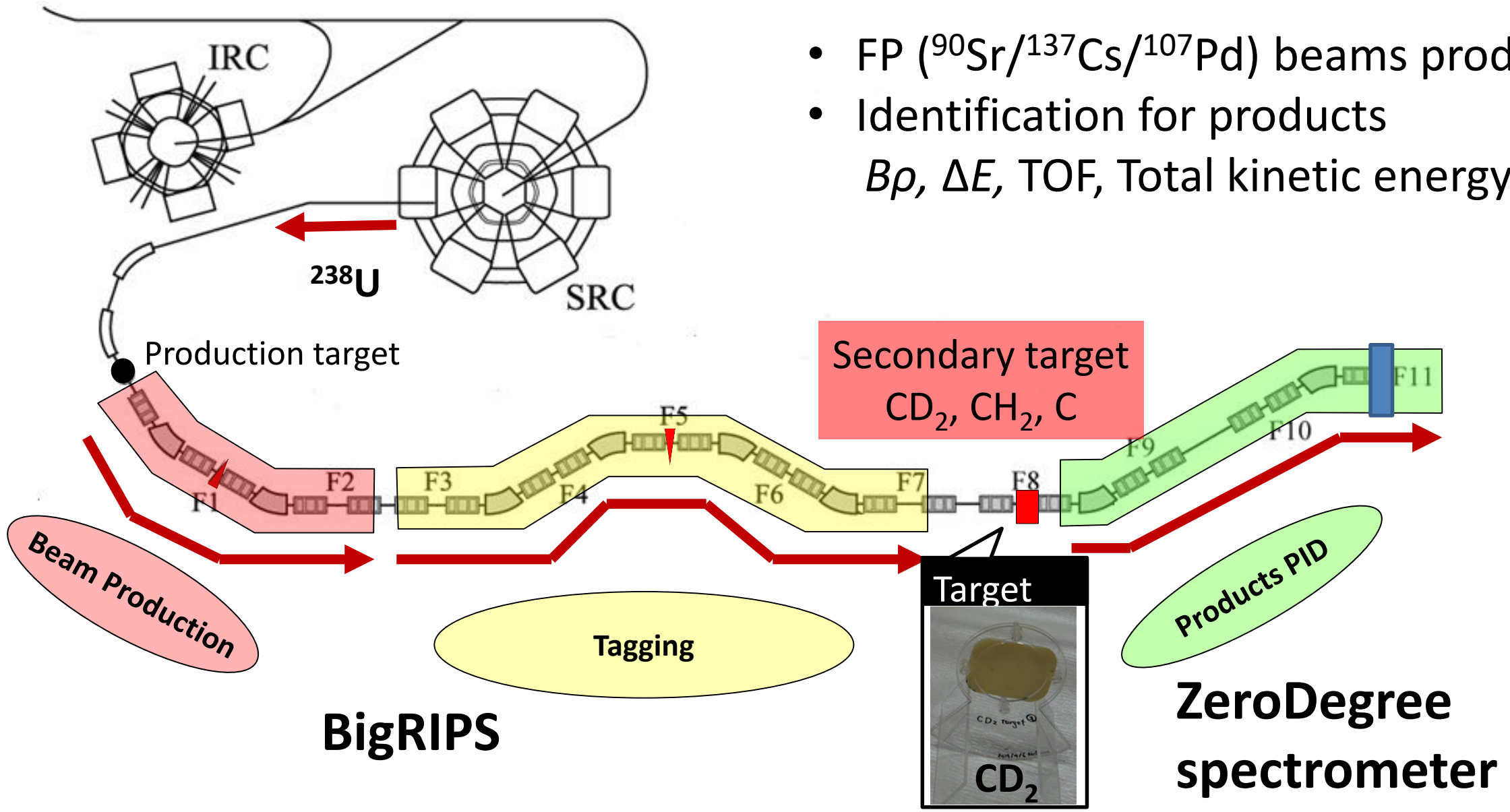
SRC



ARAQ (construction)

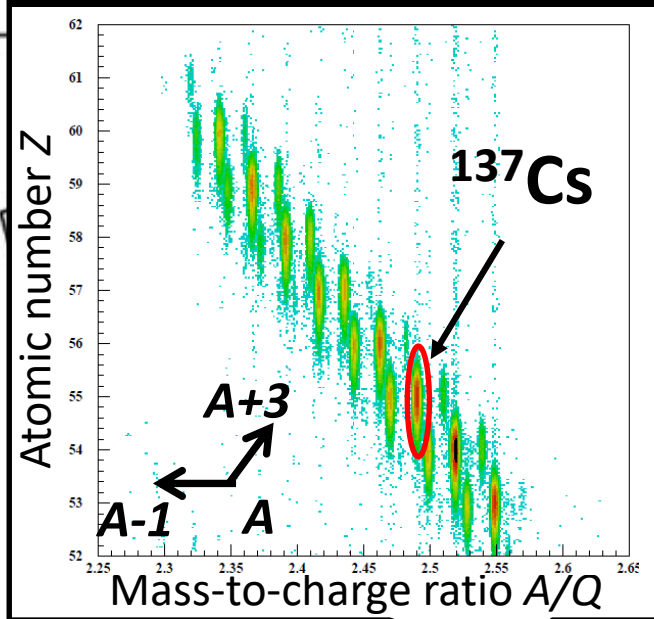


Experimental setup



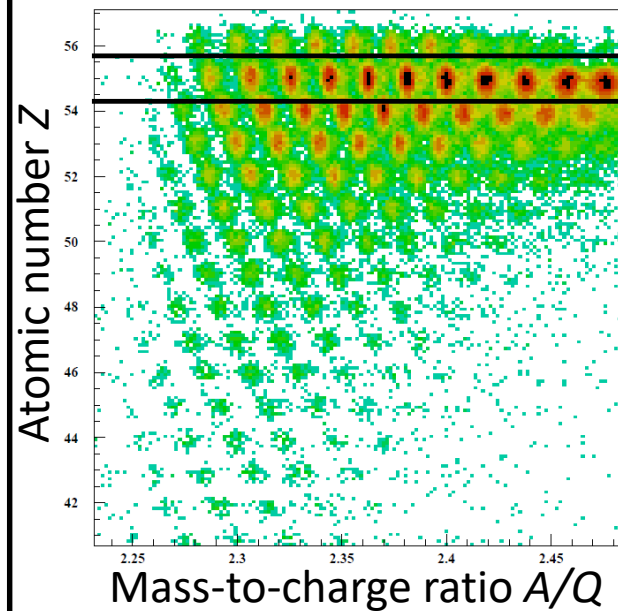
^{137}Cs

Projectile PID@BigRIPS

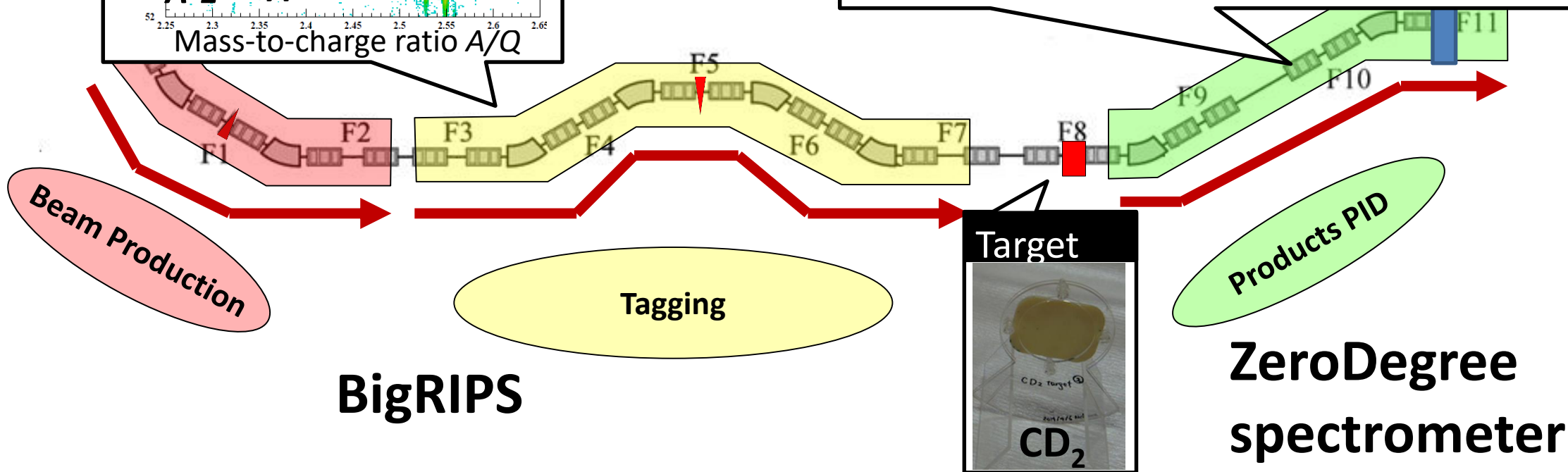
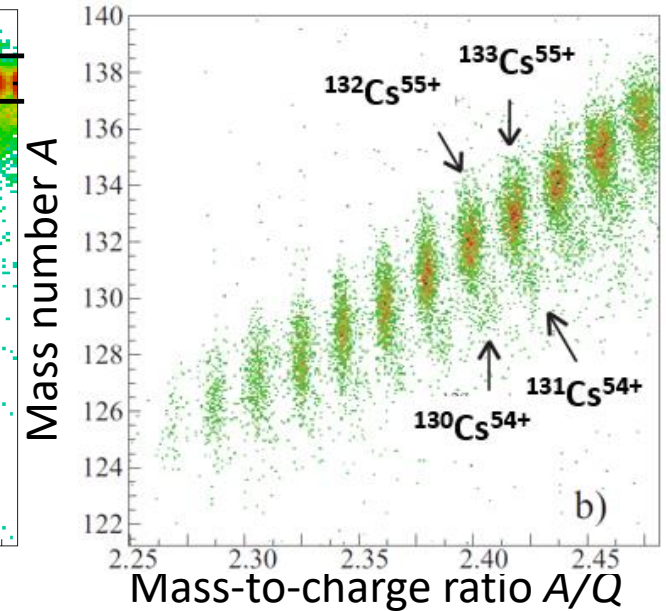


SRC

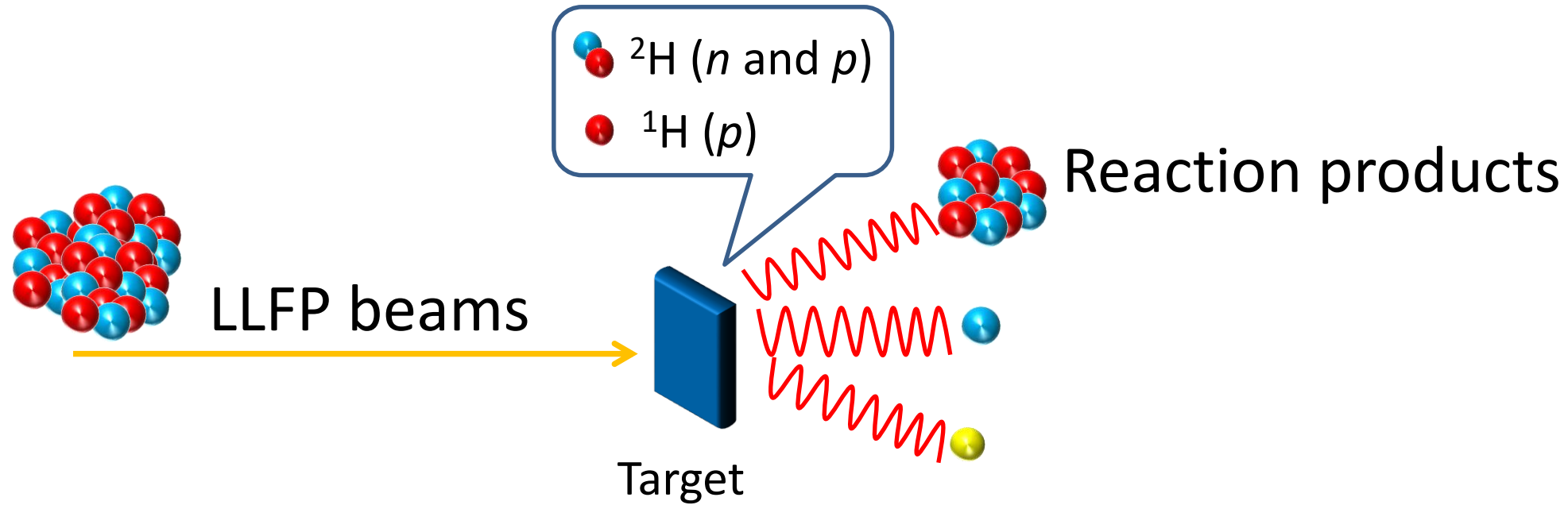
Ejectile PID@ZeroDegree



Charge-state ID

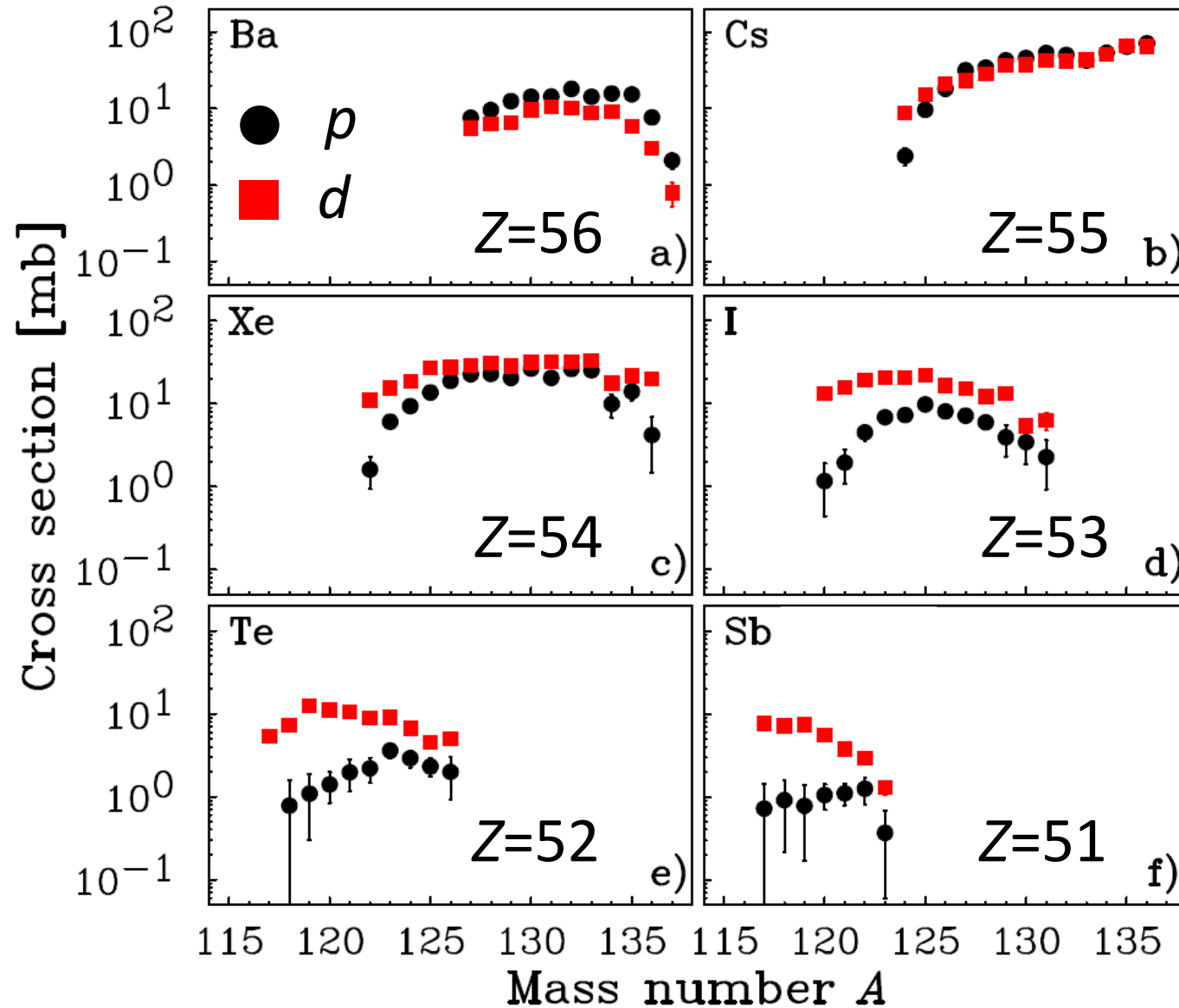


Isotopic distribution cross section

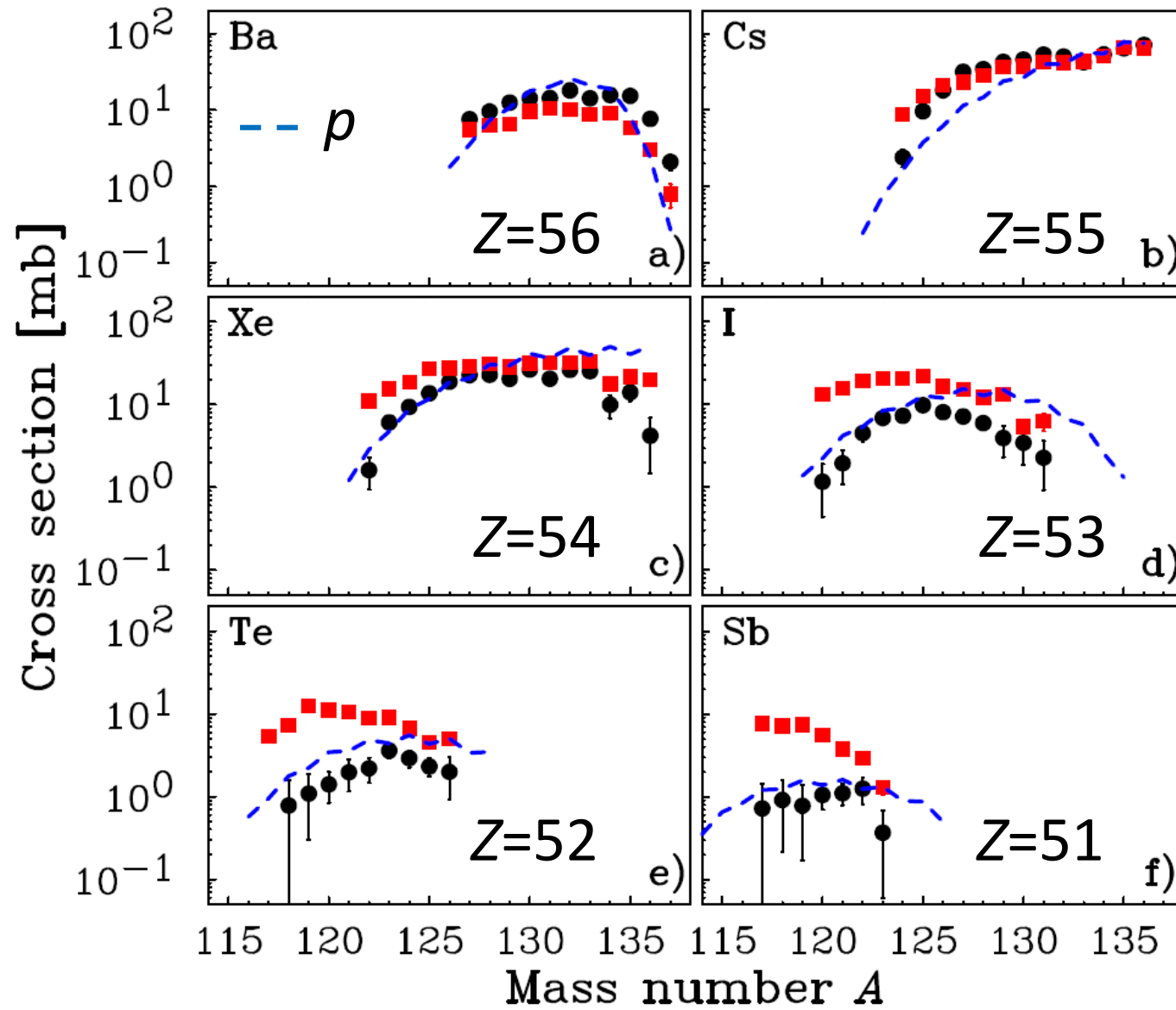


$$\sigma = \frac{Yields}{N_{beam} \times n_{target}}$$

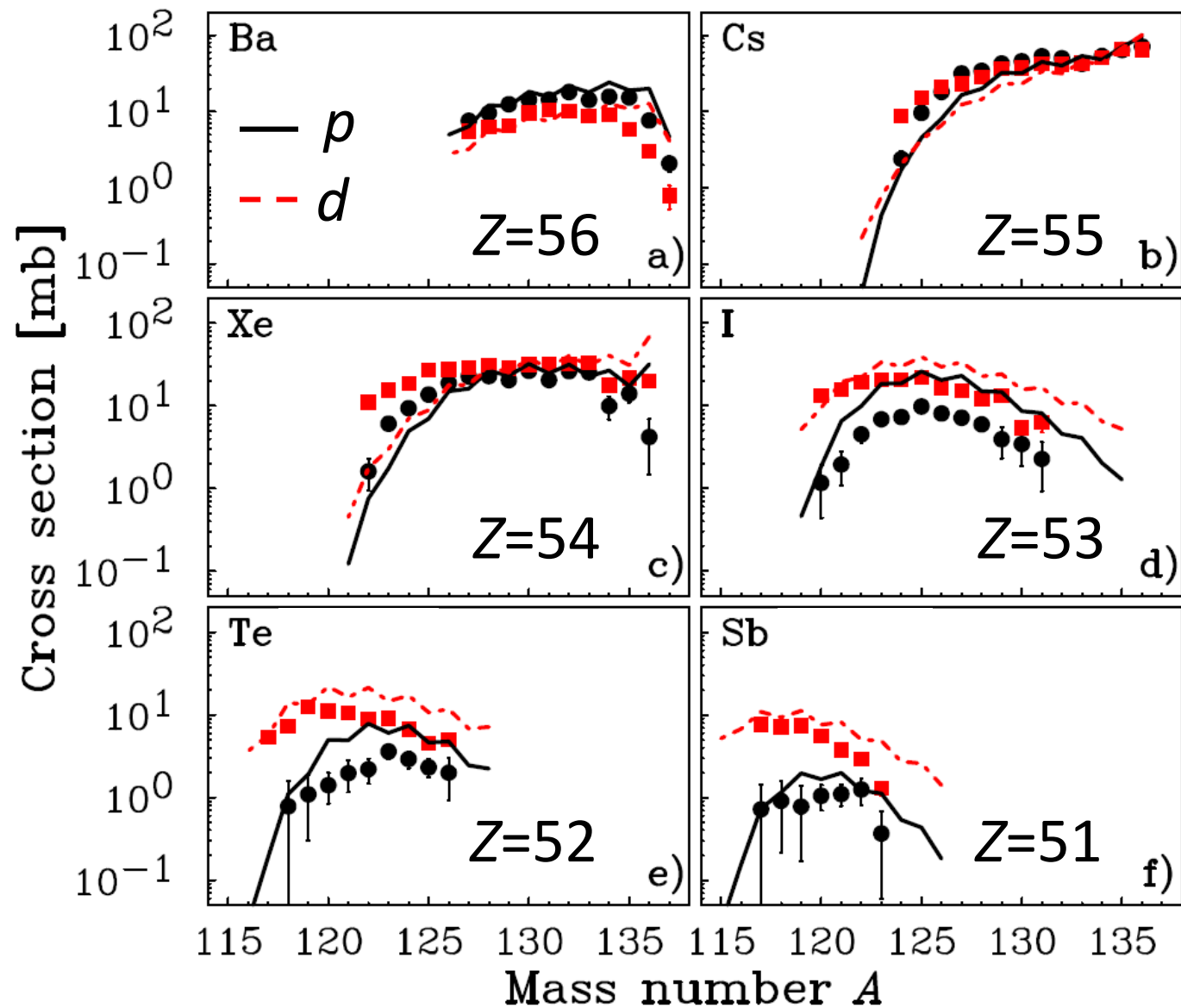
Cross sections for ^{137}Cs on p and d



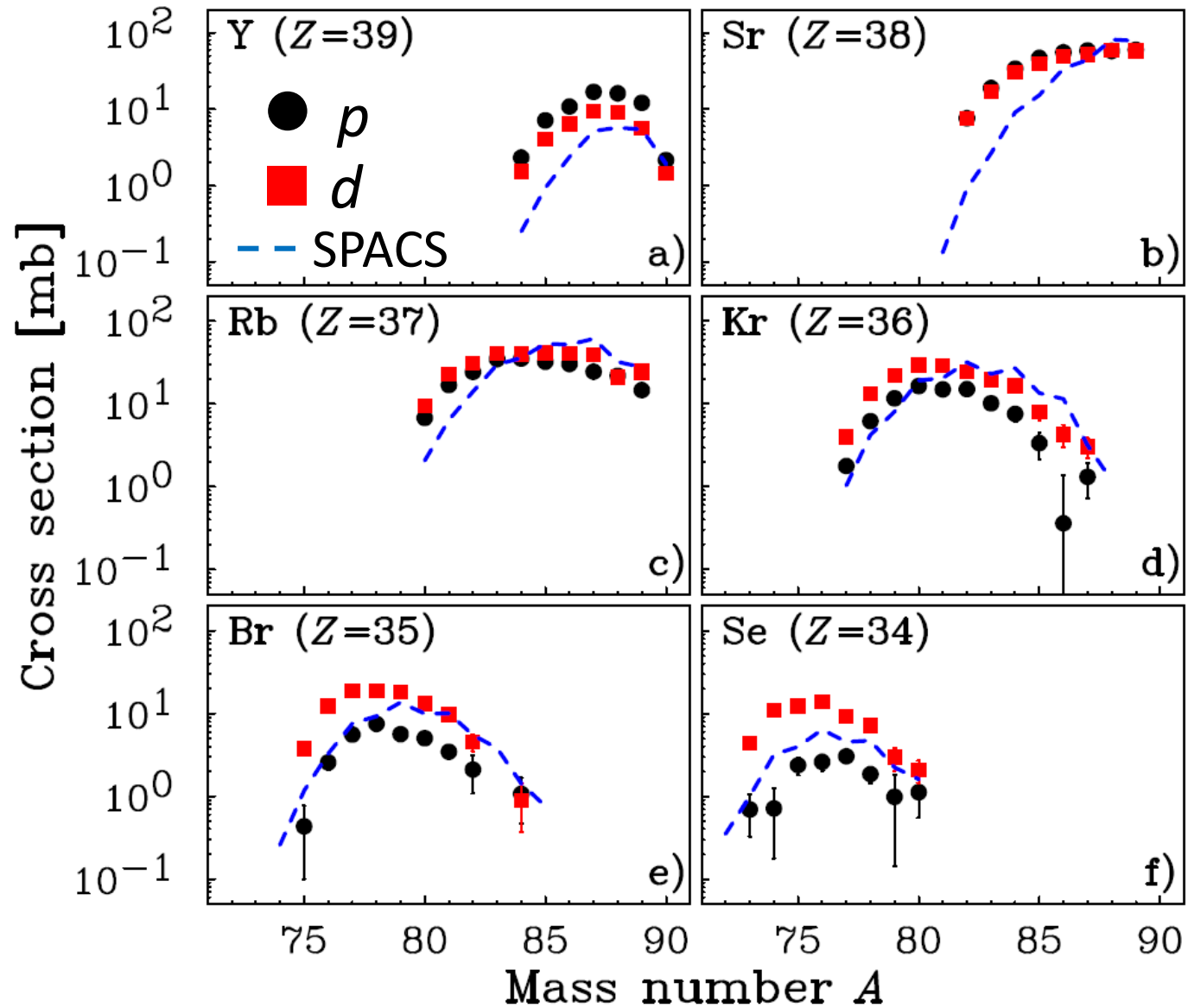
SPACS



Intra-nucleon cascade and evaporation by PHITS

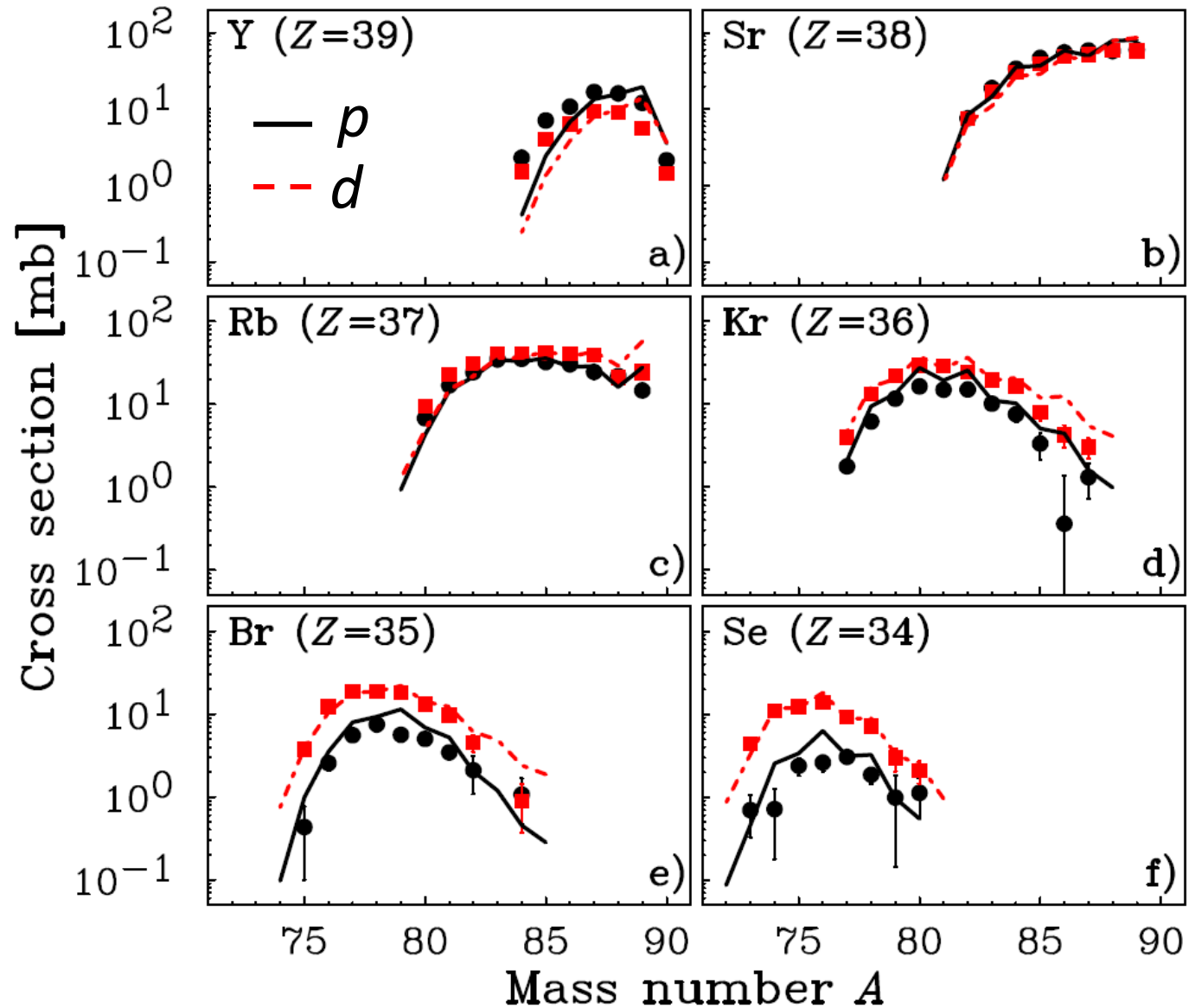


Cross sections for ^{90}Sr on p and d

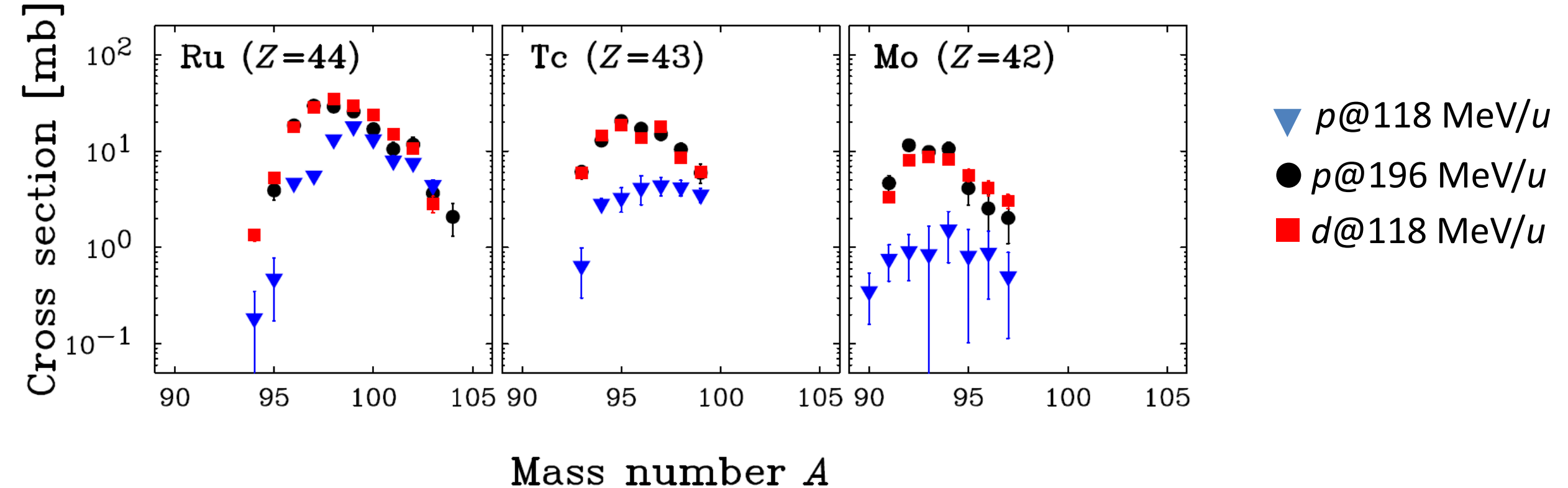


Comparison with PHITS

PHITS: Particle and Heavy Ion Transport code System

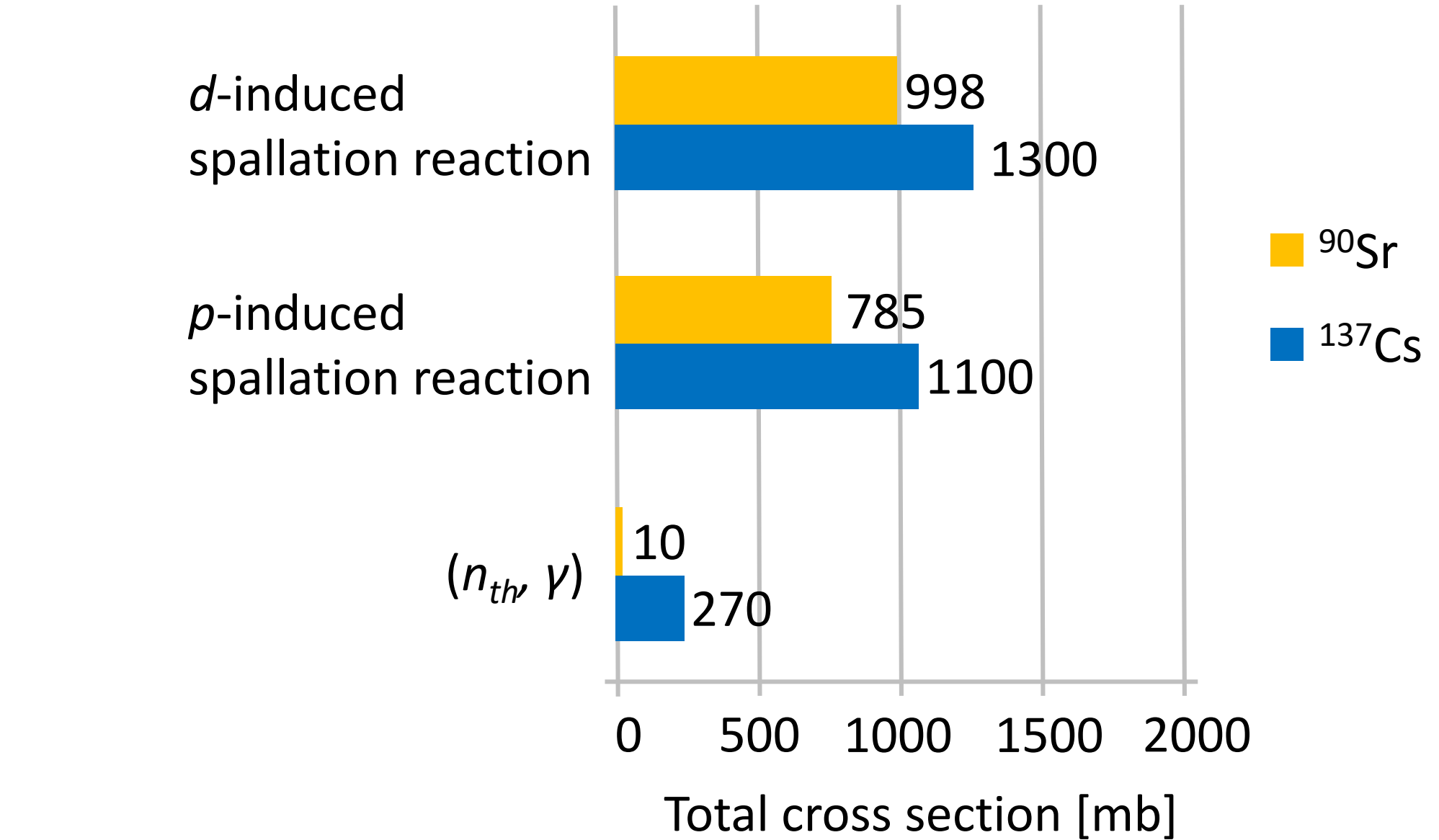


Cross sections for ^{107}Pd



σ_d at 118 MeV/ u is similar to σ_p at 196 MeV/ u

Potential of spallation for LLFP transmutation I



Potential of spallation for LLFP transmutation II



	Cross section	Half life [year]
^{135}Cs	64 mb	2.3×10^6



	Cross section	Half life [year]
^{79}Se	1 mb	6.5×10^4

Total cross section for ^{107}Pd

	Cross section [barn]
Spallation	1
(n, γ)	9.2

Transmutation rate depends on
Cross section and Flux

Summary

- Spallation reactions for LLFP nuclei using inverse kinematics at RIBF
- Cross sections on p and d for ^{137}Cs , ^{90}Sr and ^{107}Pd
 - Target dependence
 - Energy dependence
- Comparison with spallation models
- Potential for the transmutation on LLFP
 - Total spallation cross section
 - Reduction in the radiotoxicity
 - Production of other LLFP at different reaction energies
- Collaboration with nuclear engineering

Collaborators

RIKEN Nishina Center

HW, H. Otsu, H. Sakurai, S. Chen, N. Chiga, P. Doornenbal, T. Ichihara, T. Isobe, S. Kubono, G. Lorusso, T. Matsuzaki, Y. Shiga, P.-A. Söderström, Y. Watanabe, K. Yoshida, N. Fukuda, H. Suzuki, H. Takeda, Y. Shimizu, D. S. Ahn, T. Sumikama, H. Sato, M. Uesaka, T. Kubo

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ImPACT Program

Reduction and Resource Recycling of
High-level Radioactive Wastes through Nuclear Transmutation

<http://www.jst.go.jp/impact/en/program/08.html>

Thank you