Measurement of Beta-delayed Neutrons of Rapid Neutron Capture Process (r-process) Isotopes with the BRIKEN Detector

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Rapid Neutron Capture Process (r-process)

- The r-process is a nucleosynthesis process and is responsible for about half of the abundance of elements heavier than iron in the solar system and for most of these abundances in very metal-poor stars

- The exact site of the r-process is still unconfirmed however the core collapse supernovae and neutron star mergers are the most likely candidates

- The probability of β-delayed neutron emission is one of the nuclear property to model the astrophysical nature of the r-process

β-delayed Neutron Emission

The process in which β-decay is followed by a neutron emission

- Example:

$$ {}^{A}_{Z}X \rightarrow {}^{A}_{Z+1}Y + e^{-} + \bar{\vartheta} $$

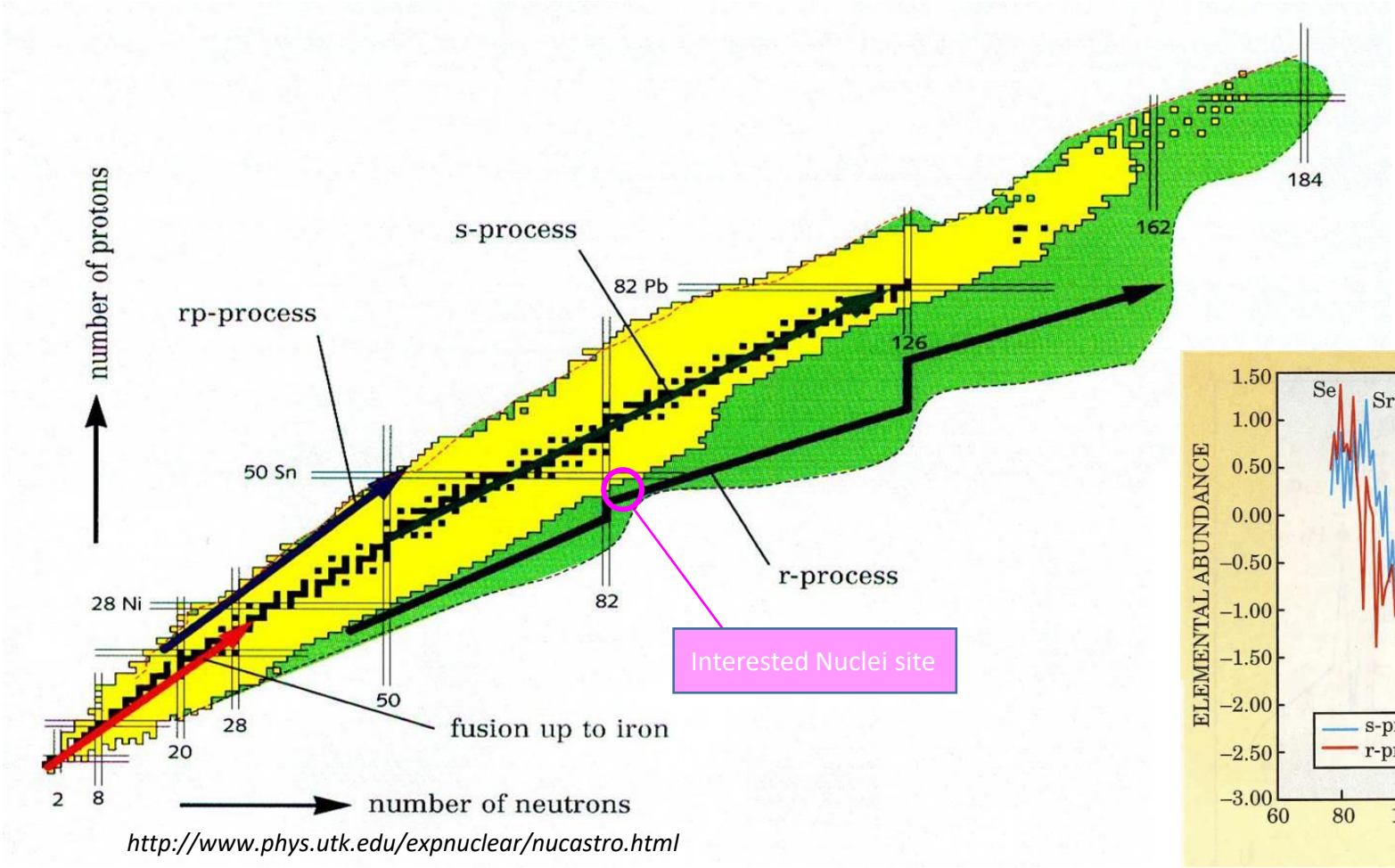
$$ {}^{A}_{Z+1}Y \rightarrow {}^{A-1}_{Z+1}Y + \mathrm{n} $$

- Condition:

$$ Q_{\beta} > S_{n} $$

Where, Q_{β} is β-decay energy and S_n is the nuclear separation energy

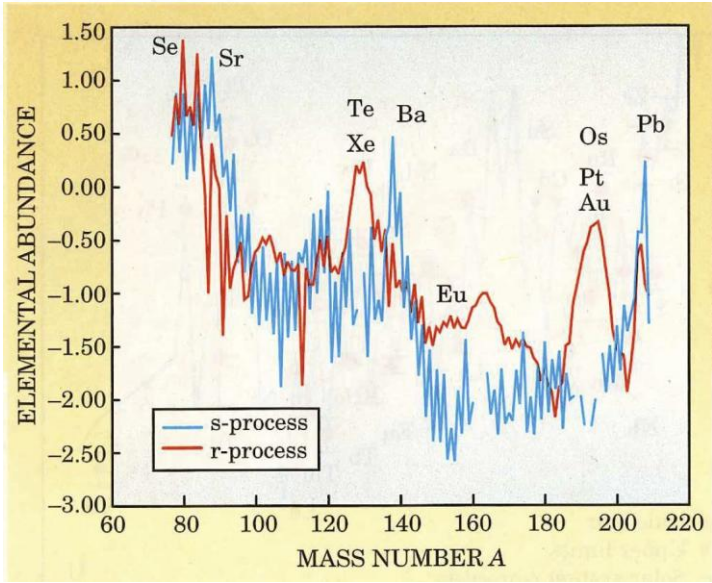
β-delayed Neutron Emission



http://www.phys.utk.edu/expnuclear/nucastro.html

Why N=82 ?

- Critical to understand the r-process abundance peak A=130
- Neutron rich nuclei
- Far from the stability region



R-process Nucleosynthesis in Supernovae, J.J. Cowan and F. Thielemann, Physics today, Oct 2004

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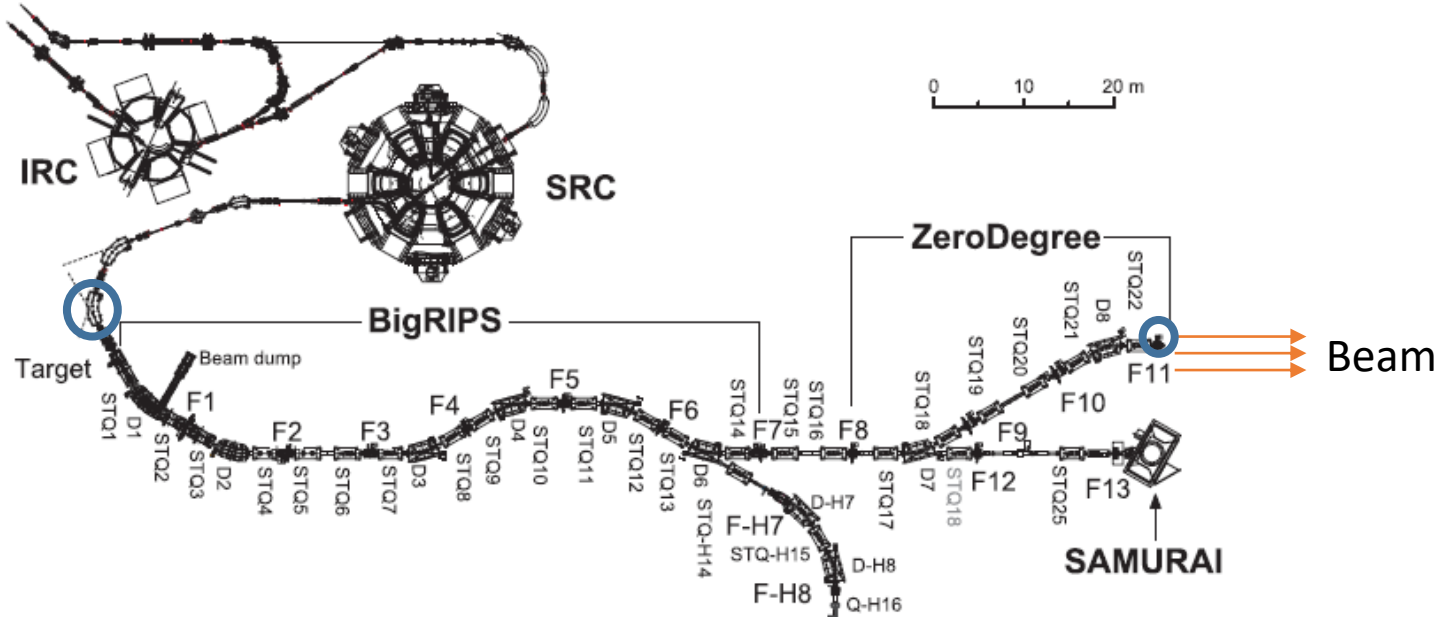
Experimental Setup

BigRIPS → **AIDA** (Advanced Implantaion Detector Arrary) → **BRIKEN** (Beta-delayed neutron emission at RIKEN)



Nuclei of interest will be produced by the fission of ^{238}U beam using Be target at 345 MeV/nucleon

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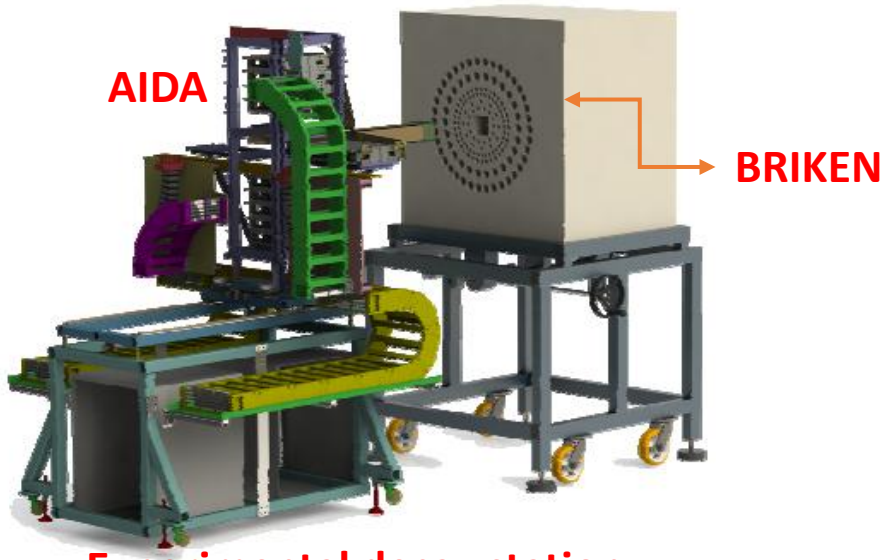
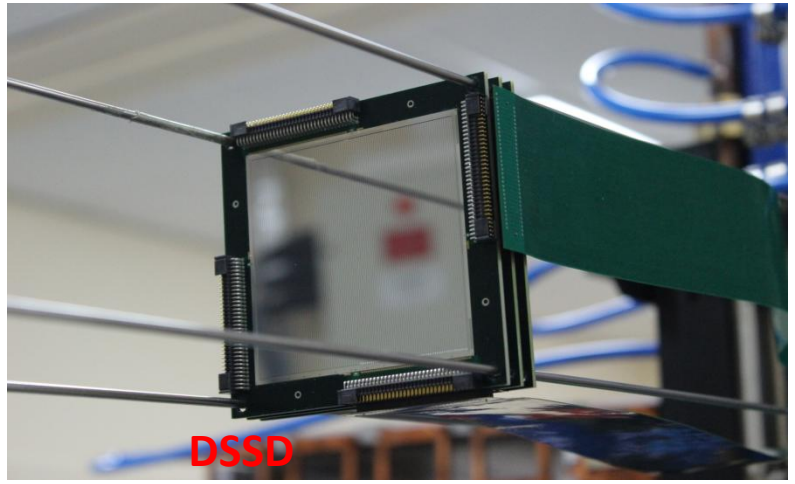


Experimental decay station



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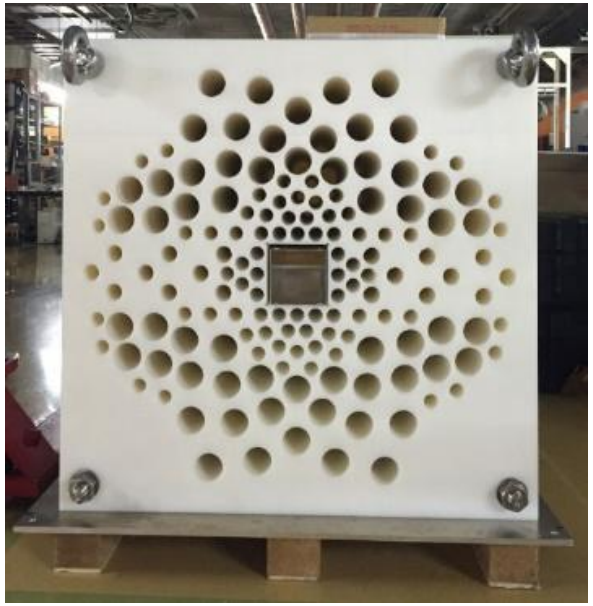

- Made up of ^{3}He counter embedded in a polyethylene matrix
- $^{3}He + n \rightarrow p + {}^{3}H + 765$ KeV

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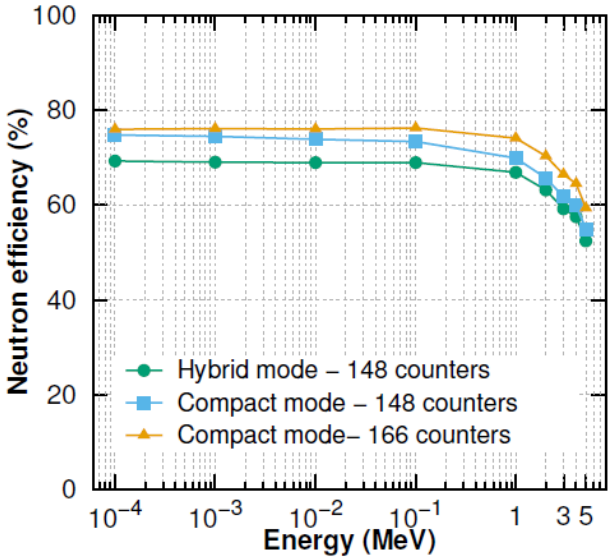
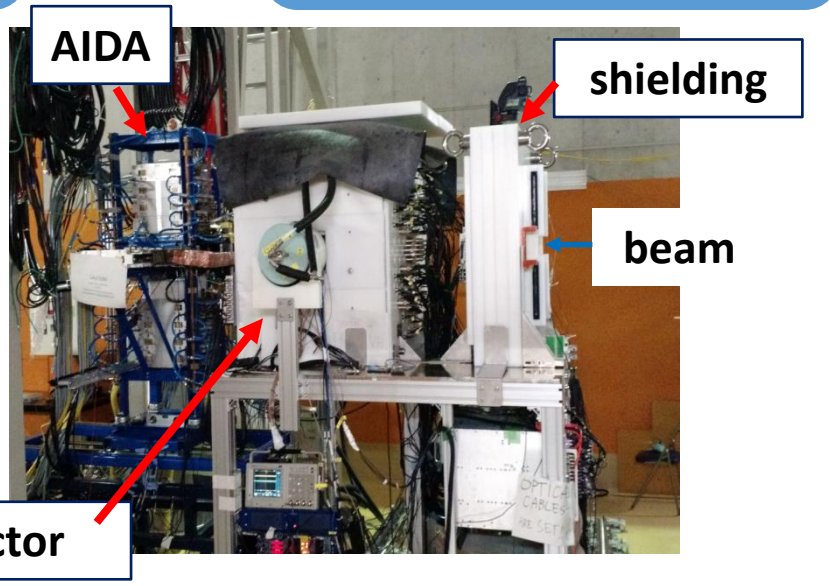


A. Tarifeno-Saldivia et. al.

$$P_n = \frac{\bar{\varepsilon}_\beta}{\bar{\varepsilon}_n} \frac{N_n}{N_\beta}$$

Where, N_n is the delayed neutrons in a neutron detector and N_β is the registered β-decays of an specific nucleus in a β detector

We already did one test on the second week of November, 2016



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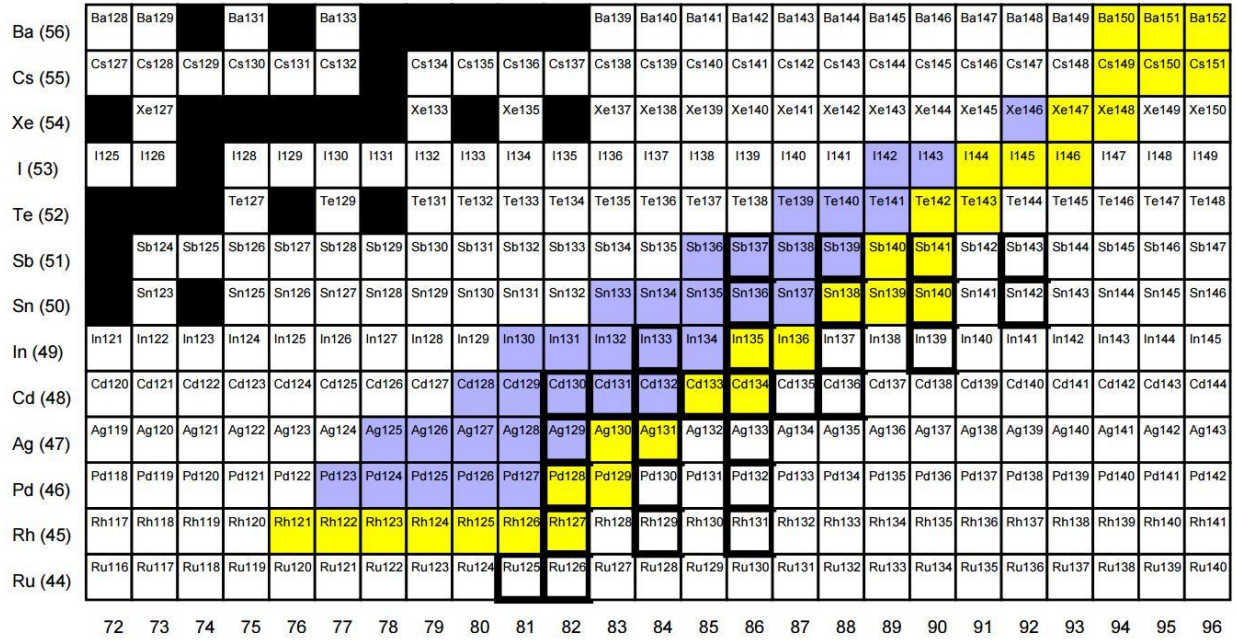
Goals of the Experiment

- To measure experimental P_n – values for the neutron-rich nuclei in the site of Sn^{132}
- It will provide a basis for building systematics of β-delayed neutron emission probabilities beyond N=82
- It will greatly improve the reliability of r-process modeling



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