

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

*Neerajan Nepal, *Alfredo Estrade, **BRIKEN Collaborators

*Science of Advanced Materials Program, Central Michigan University, Mt Pleasant, MI 48859, United States

** <https://www.wiki.ed.ac.uk/display/BRIKEN/Collaboration+members+and+institutions>
nepal1n@cmich.edu

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Rapid Neutron Capture Process (r-process)

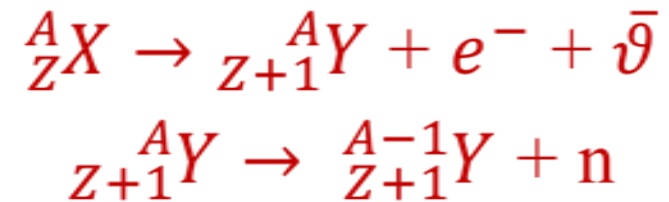
- The r-process is a nucleosynthesis process and is responsible for about half of the abundance of elements heavier than iron in the solar system and for most of these abundances in very metal-poor stars
- The exact site of the r-process is still unconfirmed however the core collapse supernovae and neutron 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:



- Condition:

$$Q_\beta > S_n$$

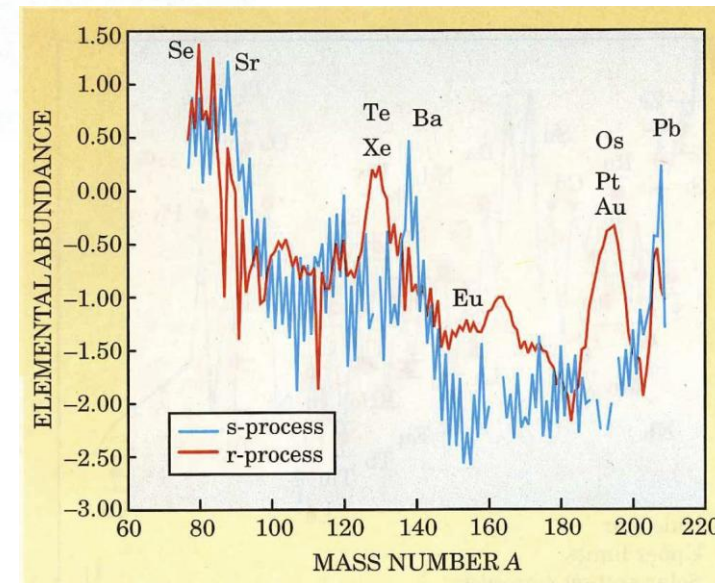
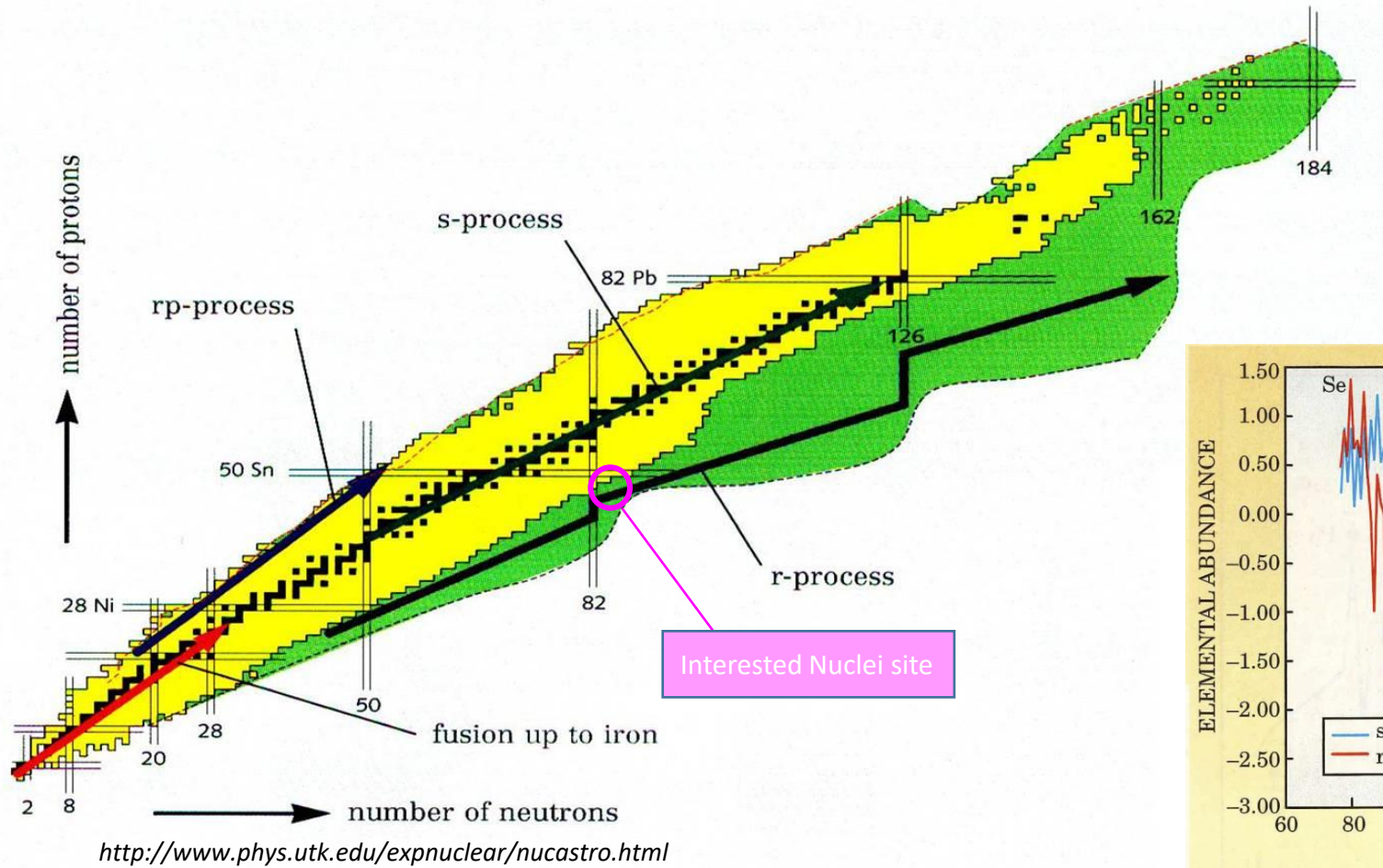
Where, Q_β is β -decay energy and S_n is the nuclear separation energy



β -delayed Neutron Emission

Why
N=82
?

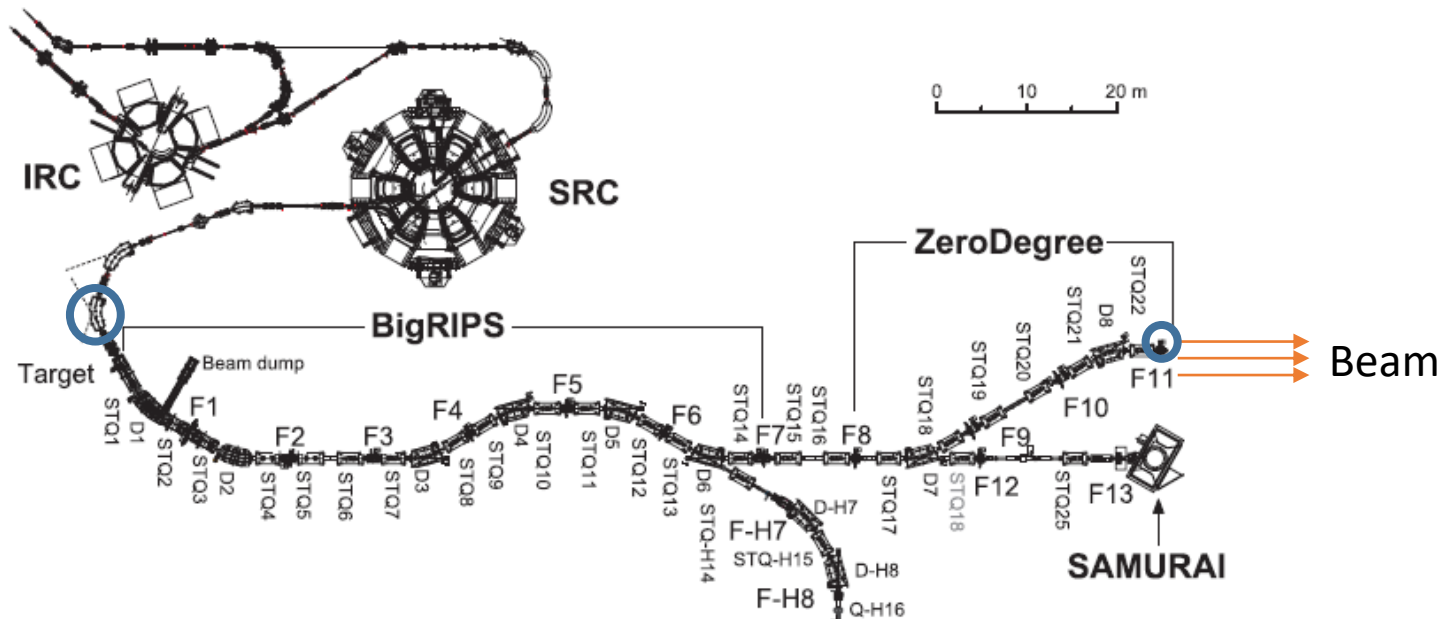
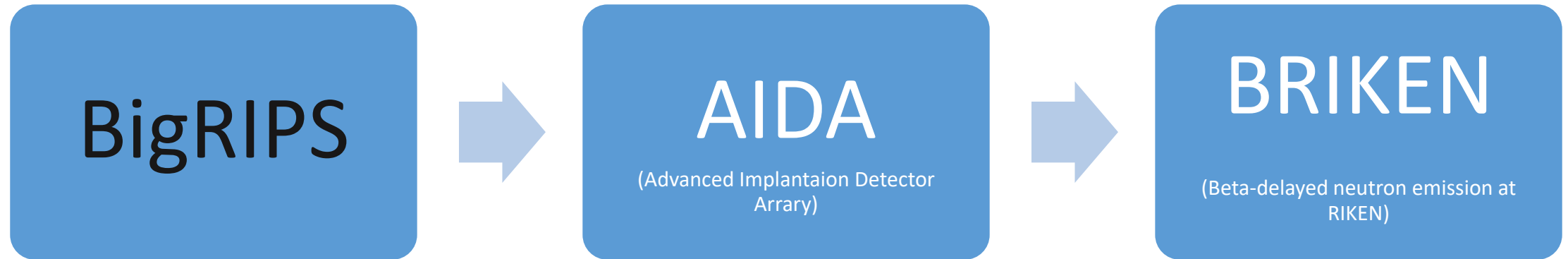
- Critical to understand the r-process abundance peak A=130
- Neutron rich nuclei
- Far from the stability region



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

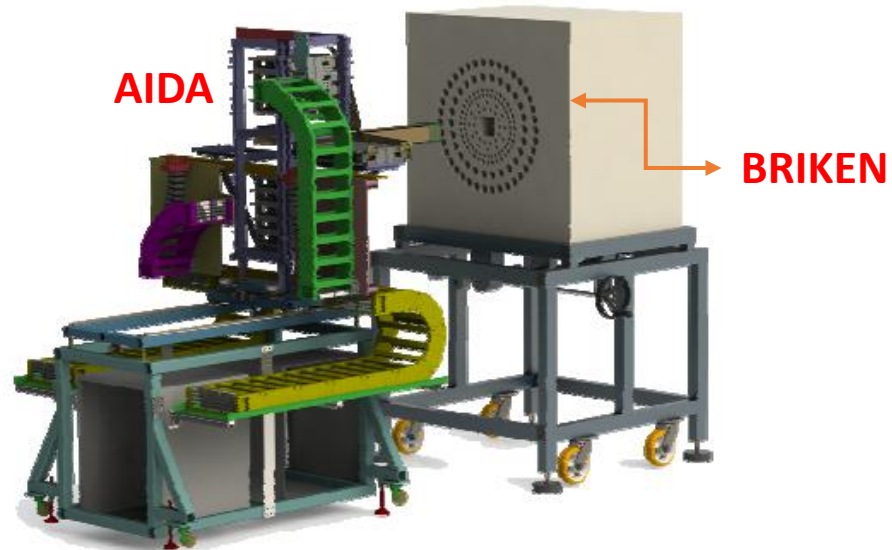
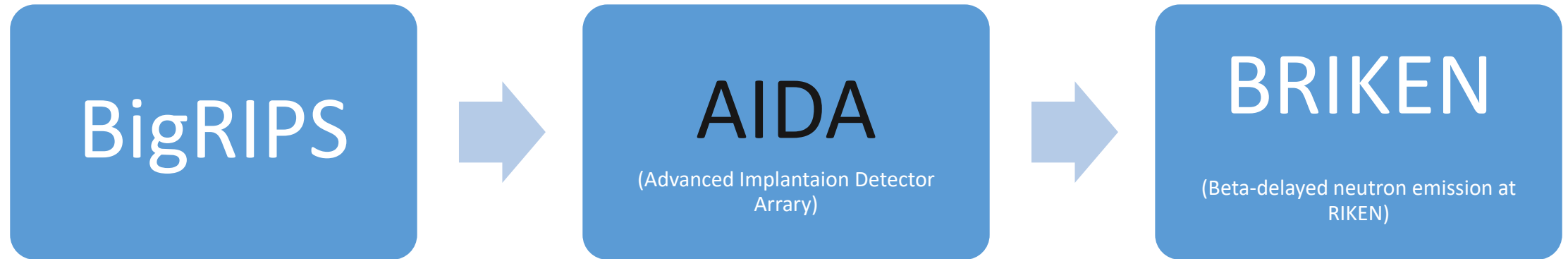


Experimental Setup

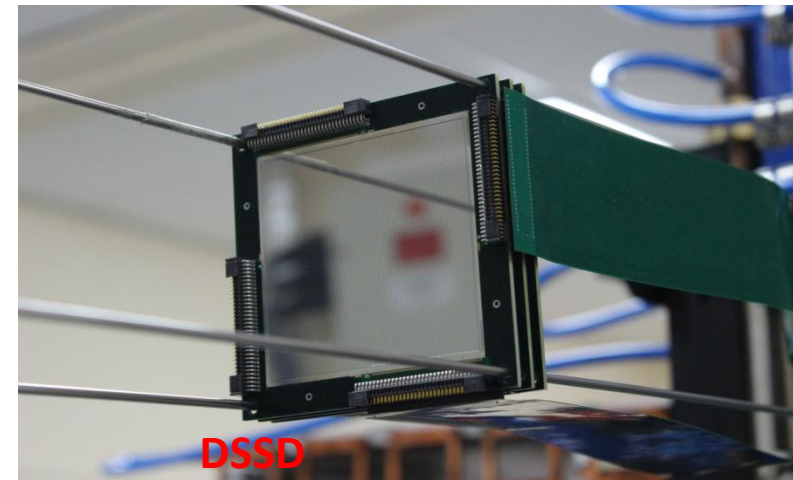


Nuclei of interest will be produced by the fission of ^{238}U beam using Be target at 345 MeV/nucleon

Experimental Setup



Experimental decay station



Experimental Setup

BigRIPS



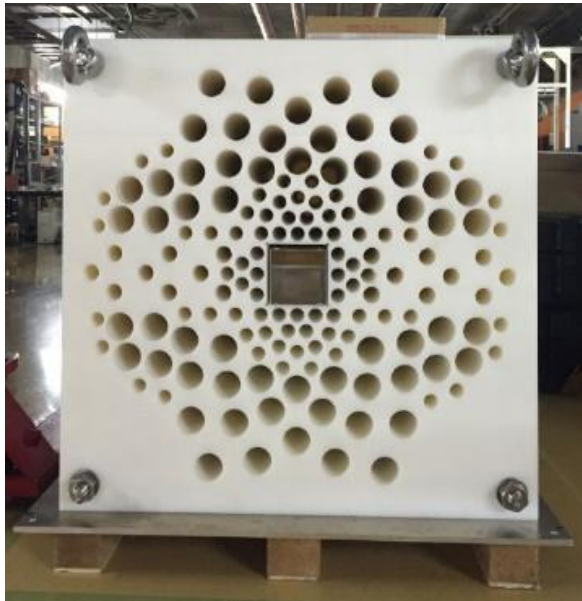
AIDA

(Advanced Implantation Detector Array)



BRIKEN

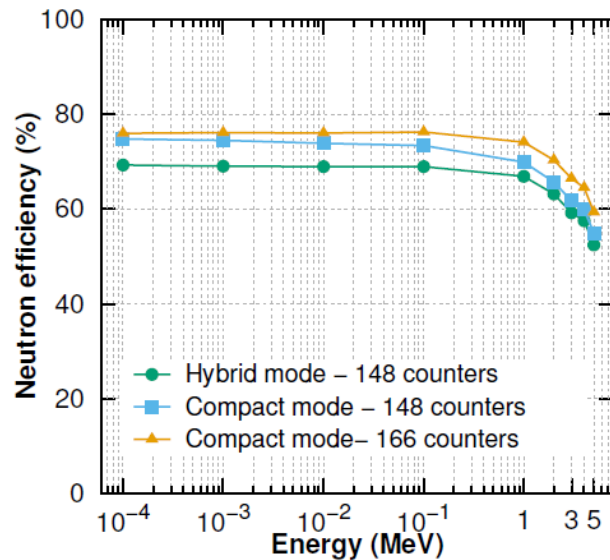
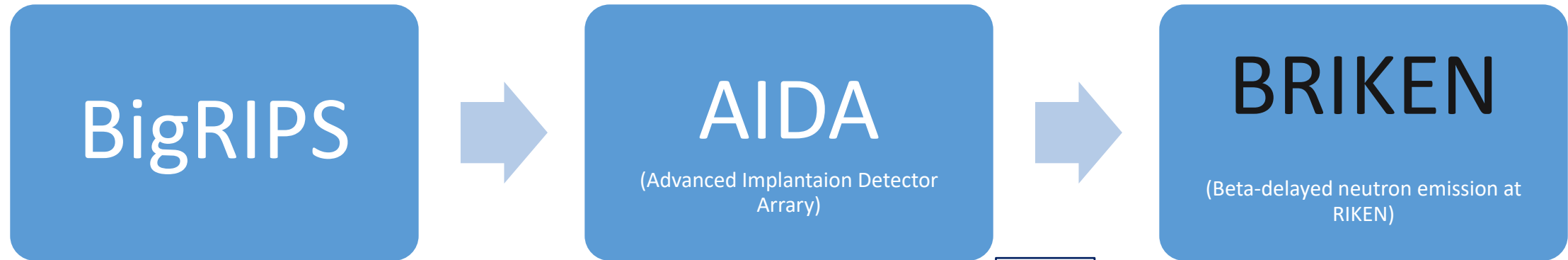
(Beta-delayed neutron emission at RIKEN)



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



Experimental Setup

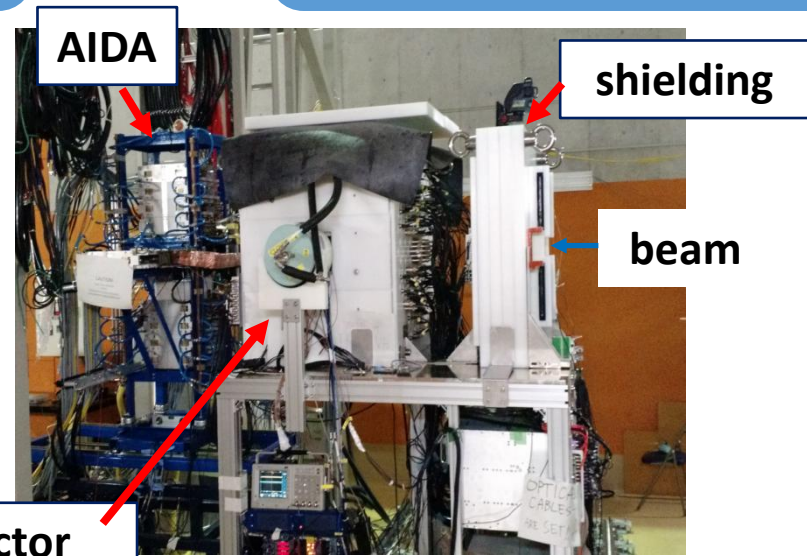


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$$P_n = \frac{\bar{\epsilon}_\beta N_n}{\bar{\epsilon}_n N_\beta}$$

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

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



BRIKEN detector



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

Ba (56)	Ba128	Ba129		Ba131		Ba133													Ba139	Ba140	Ba141	Ba142	Ba143	Ba144	Ba145	Ba146	Ba147	Ba148	Ba149	Ba150	Ba151	Ba152
Cs (55)	Cs127	Cs128	Cs129	Cs130	Cs131	Cs132			Cs134	Cs135	Cs136	Cs137	Cs138	Cs139	Cs140	Cs141	Cs142	Cs143	Cs144	Cs145	Cs146	Cs147	Cs148	Cs149	Cs150	Cs151						
Xe (54)		Xe127							Xe133		Xe135		Xe137	Xe138	Xe139	Xe140	Xe141	Xe142	Xe143	Xe144	Xe145	Xe146	Xe147	Xe148	Xe149	Xe150						
I (53)	I125	I126		I128	I129	I130	I131	I132	I133	I134	I135	I136	I137	I138	I139	I140	I141	I142	I143	I144	I145	I146	I147	I148	I149							
Te (52)				Te127		Te129		Te131	Te132	Te133	Te134	Te135	Te136	Te137	Te138	Te139	Te140	Te141	Te142	Te143	Te144	Te145	Te146	Te147	Te148							
Sb (51)		Sb124	Sb125	Sb126	Sb127	Sb128	Sb129	Sb130	Sb131	Sb132	Sb133	Sb134	Sb135	Sb136	Sb137	Sb138	Sb139	Sb140	Sb141	Sb142	Sb143	Sb144	Sb145	Sb146	Sb147							
Sn (50)		Sn123		Sn125	Sn126	Sn127	Sn128	Sn129	Sn130	Sn131	Sn132	Sn133	Sn134	Sn135	Sn136	Sn137	Sn138	Sn139	Sn140	Sn141	Sn142	Sn143	Sn144	Sn145	Sn146							
In (49)	In121	In122	In123	In124	In125	In126	In127	In128	In129	In130	In131	In132	In133	In134	In135	In136	In137	In138	In139	In140	In141	In142	In143	In144	In145							
Cd (48)	Cd120	Cd121	Cd122	Cd123	Cd124	Cd125	Cd126	Cd127	Cd128	Cd129	Cd130	Cd131	Cd132	Cd133	Cd134	Cd135	Cd136	Cd137	Cd138	Cd139	Cd140	Cd141	Cd142	Cd143	Cd144							
Ag (47)	Ag119	Ag120	Ag121	Ag122	Ag123	Ag124	Ag125	Ag126	Ag127	Ag128	Ag129	Ag130	Ag131	Ag132	Ag133	Ag134	Ag135	Ag136	Ag137	Ag138	Ag139	Ag140	Ag141	Ag142	Ag143							
Pd (46)	Pd118	Pd119	Pd120	Pd121	Pd122	Pd123	Pd124	Pd125	Pd126	Pd127	Pd128	Pd129	Pd130	Pd131	Pd132	Pd133	Pd134	Pd135	Pd136	Pd137	Pd138	Pd139	Pd140	Pd141	Pd142							
Rh (45)	Rh117	Rh118	Rh119	Rh120	Rh121	Rh122	Rh123	Rh124	Rh125	Rh126	Rh127	Rh128	Rh129	Rh130	Rh131	Rh132	Rh133	Rh134	Rh135	Rh136	Rh137	Rh138	Rh139	Rh140	Rh141							
Ru (44)	Ru116	Ru117	Ru118	Ru119	Ru120	Ru121	Ru122	Ru123	Ru124	Ru125	Ru126	Ru127	Ru128	Ru129	Ru130	Ru131	Ru132	Ru133	Ru134	Ru135	Ru136	Ru137	Ru138	Ru139	Ru140							
	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96							

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Advisor: Dr. Alfredo Estrade, *Central Michigan University, MI 48858, USA*

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¹*Universitat Politècnica de Catalunya (UPC), Barcelona, Spain*

²*Instituto de Física Corpuscular (CSIC-University of Valencia), Valencia, Spain*

³*RIKEN Nishina Center, 2-1 Hirosawa, Wako-shi, Saitama 351-0198, Japan*

⁴*Physics Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee 37830, USA*

⁵*Department of Physics and Astronomy, University of Tennessee, Knoxville, Tennessee 37966, USA*

⁶*JINPA, Oak Ridge National Laboratory, Oak Ridge, Tennessee 37831, USA*

⁷*TRIUMF, Vancouver, British Columbia V6T2A3, Canada*

⁸*University of Edinburgh, EH9 3JZ Edinburgh, United Kingdom*

⁹*Department of Physics, University of Surrey, Guildford GU2 7XH, United Kingdom*

¹⁰*Department of Physics, University of Liverpool, Liverpool L69 7ZE, UK*

¹¹*STFC Daresbury Laboratory, Daresbury, Warrington WA4 4AD, UK*

¹²*STFC Rutherford Appleton Laboratory, Chilton OX11 0QX, UK*

¹³*National Superconducting Cyclotron Laboratory, Michigan State University, East Lansing, Michigan 48824, USA*

¹⁴*Joint Institute for Nuclear Astrophysics, Michigan State University, East Lansing, Michigan 48824, USA*

¹⁵*Institute for Nuclear Research (MTA Atomki), H-4001 Debrecen, POB.51., Hungary*

¹⁶*Department of Physics, University of Notre Dame, Notre Dame, IN 46556 USA*

¹⁷*Faculty of Physics, University of Warsaw, PL-02-093 Warsaw, Poland*

¹⁸*National Physical Laboratory, NPL, Teddington, Middlesex TW11 0LW, United Kingdom*

¹⁹*Joint Institute for Nuclear Research, Joliot-Curie 6, 141980 Dubna, Moscow Region, Russia*

