The *r-process* and the Universe nucleosynthesis

New measurements for relevant data around N=126

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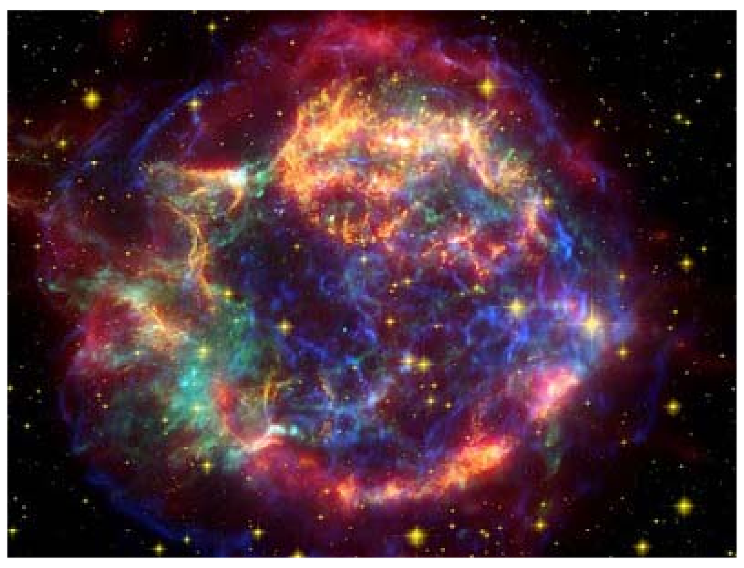
The quest for the origin of the elements…

What are the limits of the nuclear existence?

Which is the heaviest element that can be produced?

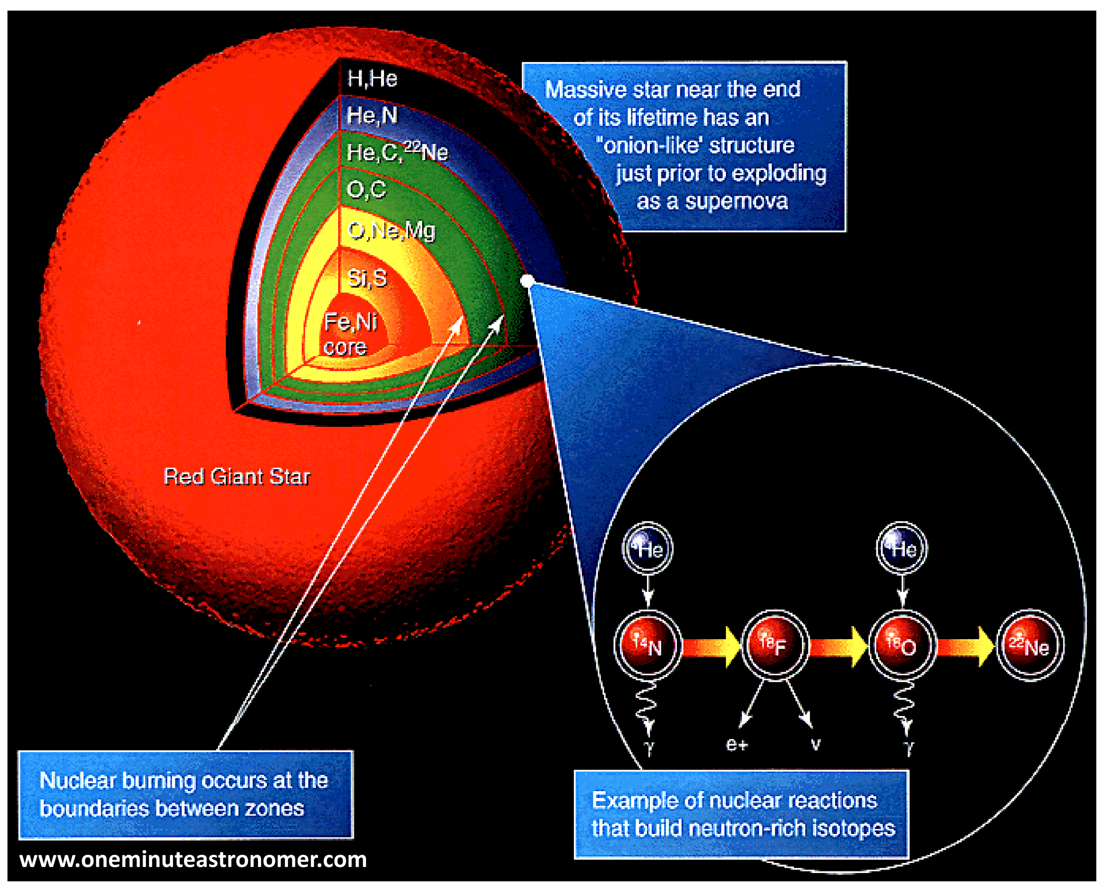
How have been the elements and isotopes in the Universe synthesized?

What is the site(s) in the Universe for the r-process nucleosynthesis?

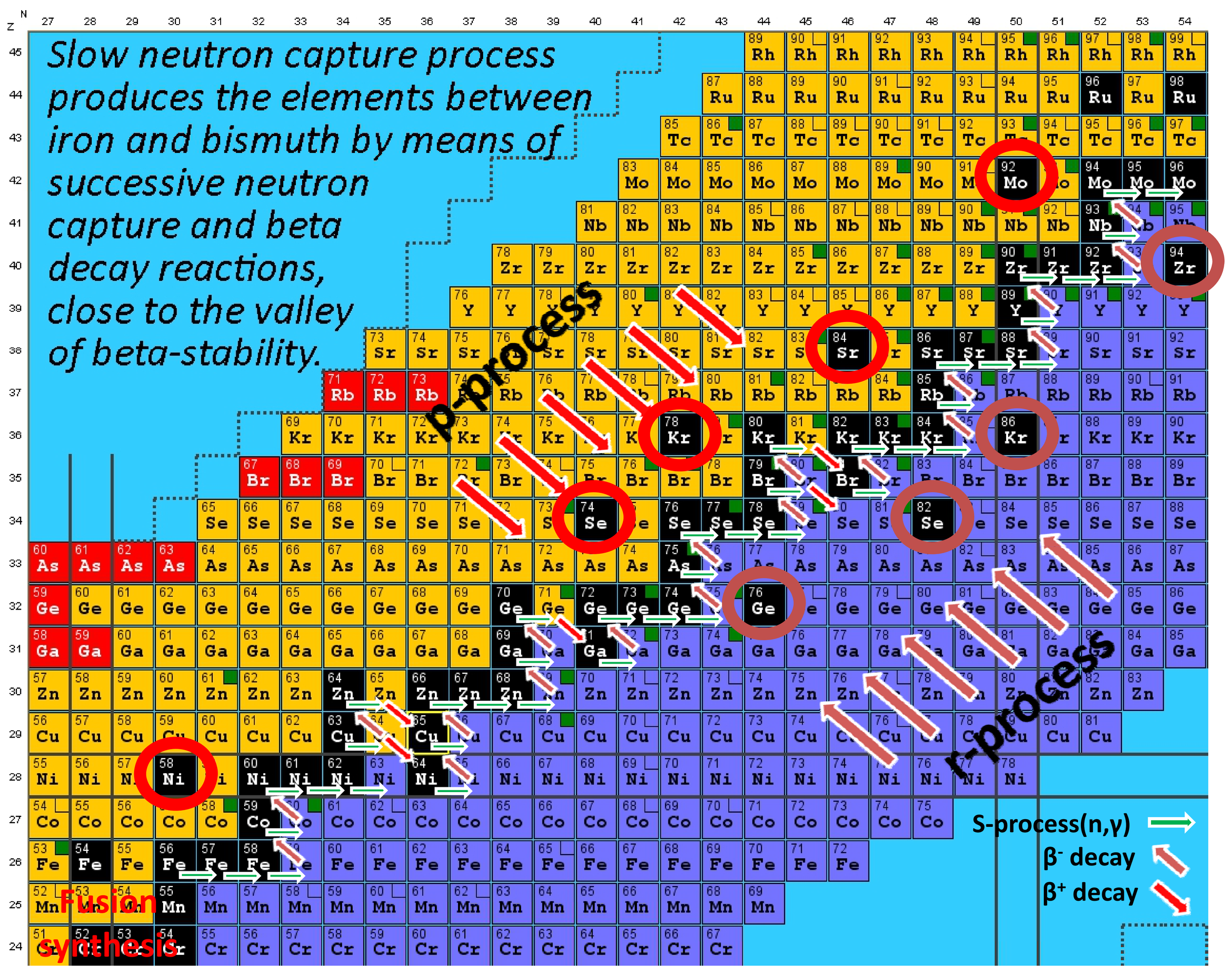


The nucleosynthesis of light elements is produced in common stars via nuclear fusion processes

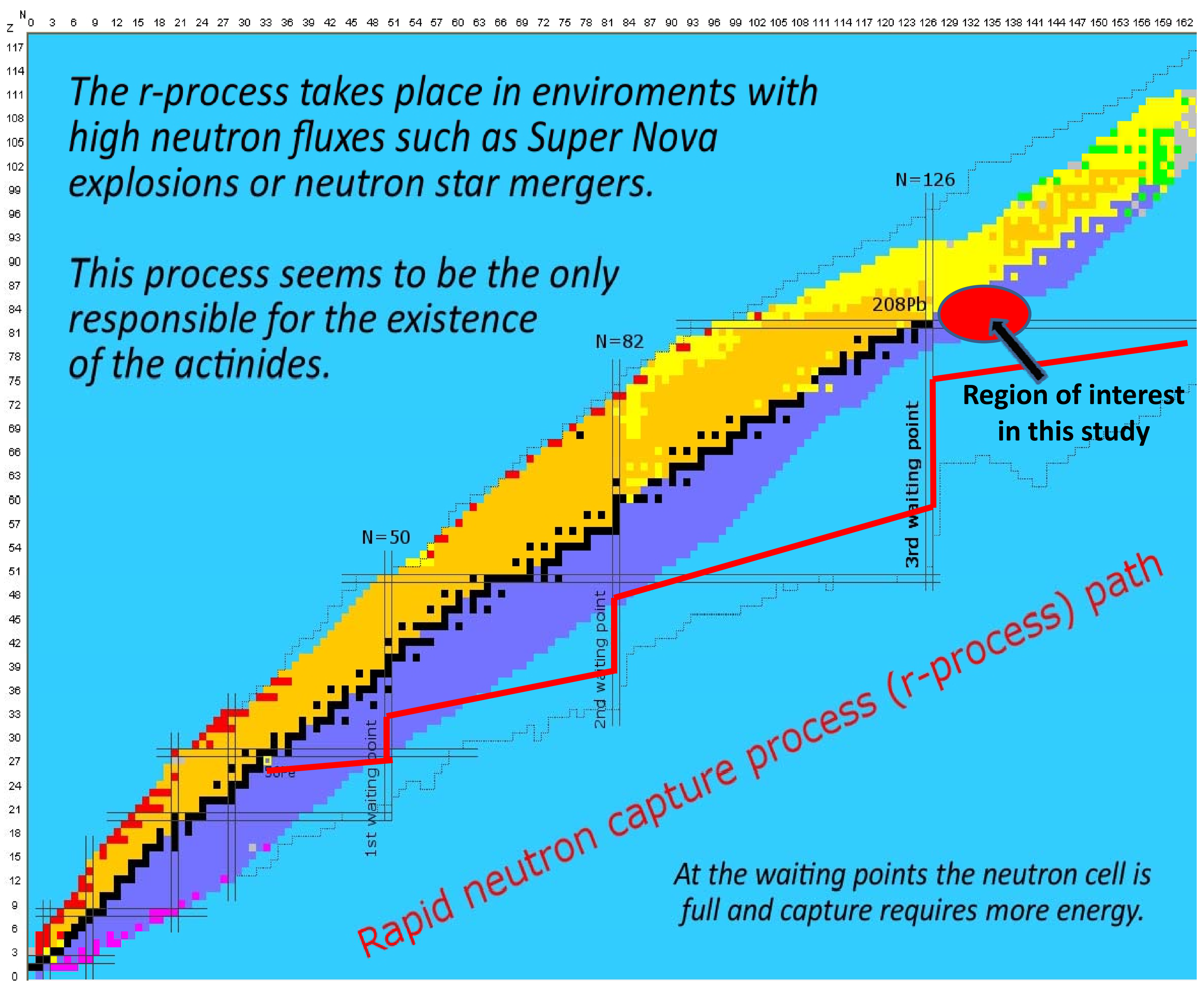
Fusion up to iron is possible according to binding energy per nucleon



Nuclei beyond iron (Fe) are produced by means of neutron capture reactions, s-process (slow) and r-process (rapid), and beta decays



Site of s-process has been clearly identified as the asymptotic Giant Branch stars



EXPERIMENT: Measurement of β-delayed neutrons around the third r-process peak (2011)

The aim: to obtain **half lives ($T_{1/2}$)** and **β-delayed neutron emission probability (P_n)** of nuclei around the region N=126

The delayed neutron emission modulates the abundance curve in stellar nucleosynthesis. New experimental data will give an important input to r-process model calculations and will extend limits of nuclei chart

Beam characteristics

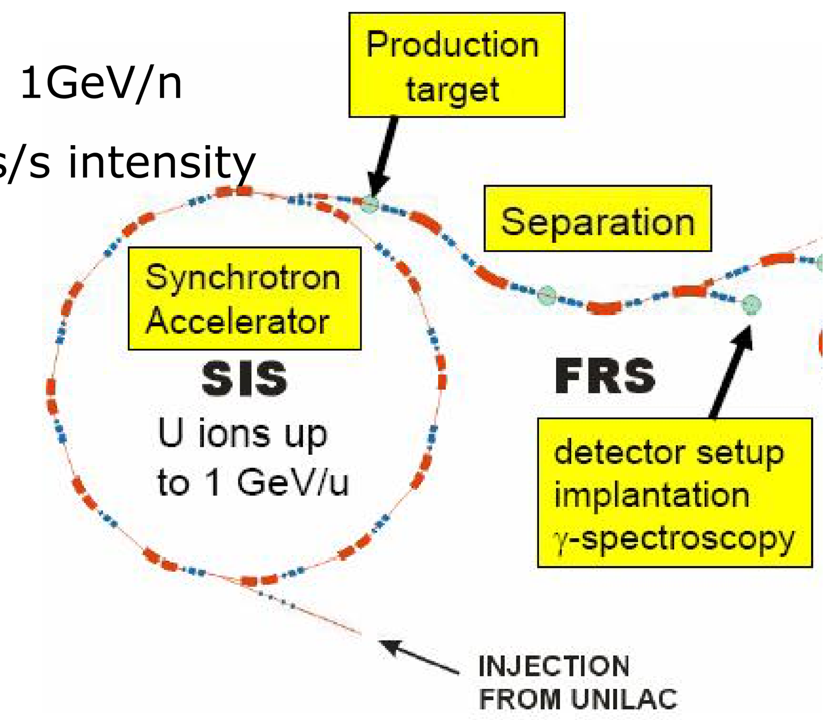
RIB facility of GSI - Darmstadt (Germany)

^{238}U beam 1GeV/n

$2x10^9$ ions/s intensity

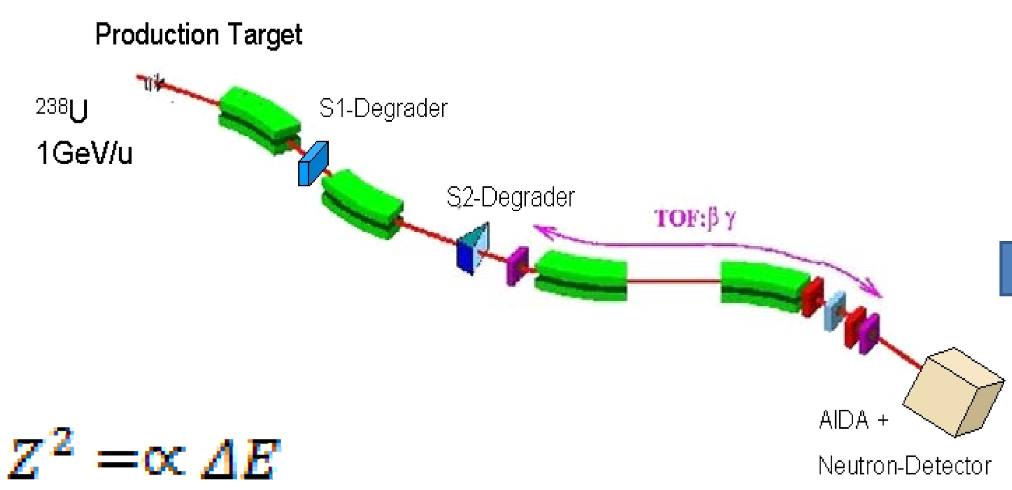
1.6 g/cm^2

Be target



Separation method:

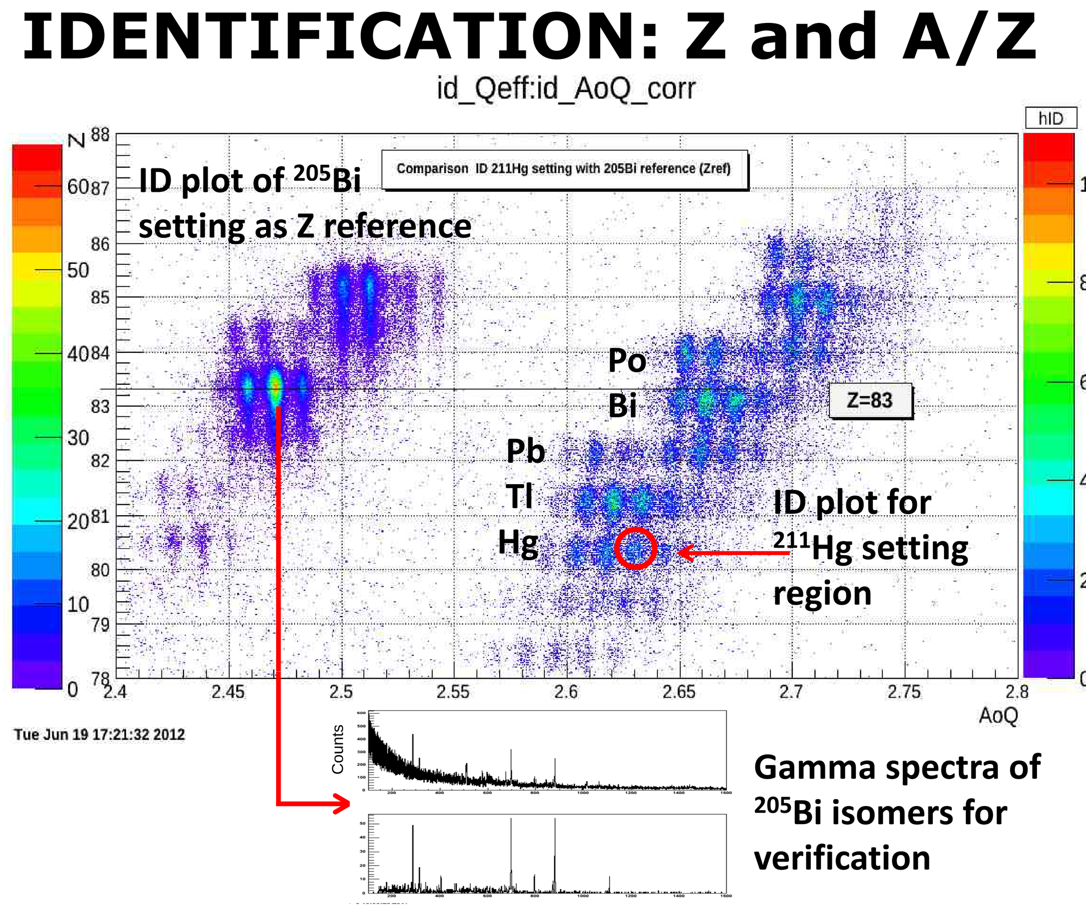
Bρ - Time of Flight - Bρ



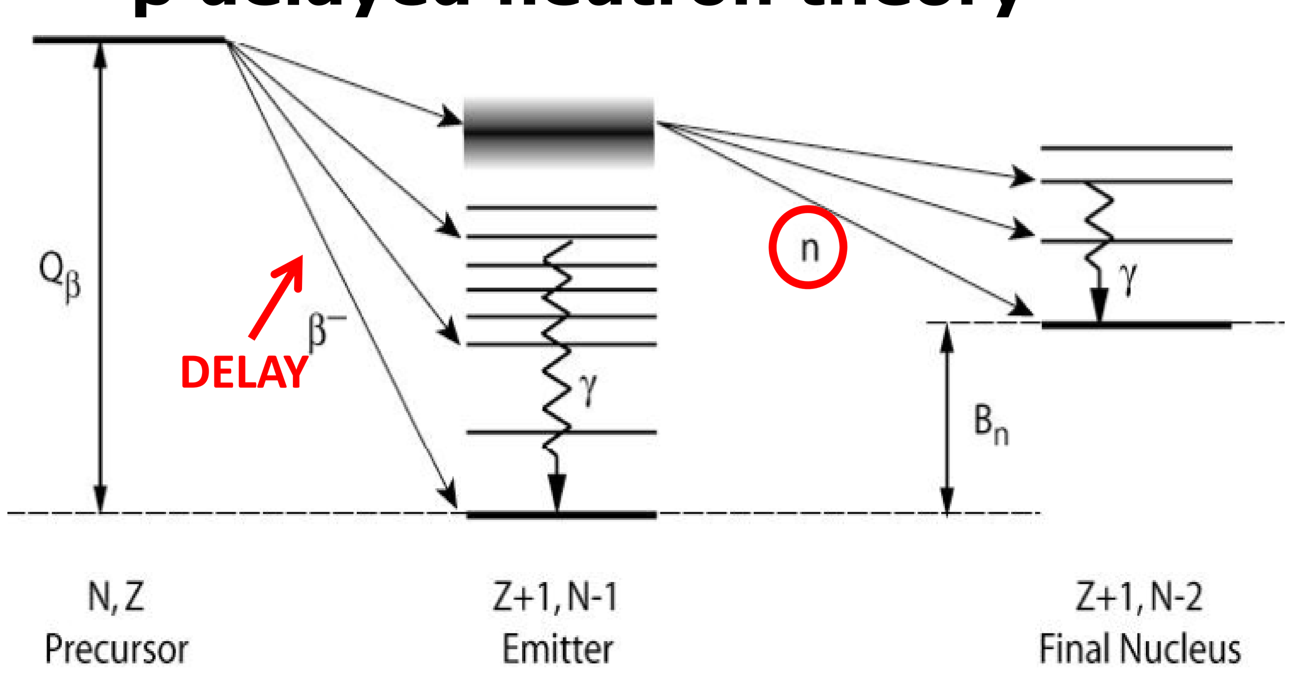
$$Z^2 \propto \Delta E$$

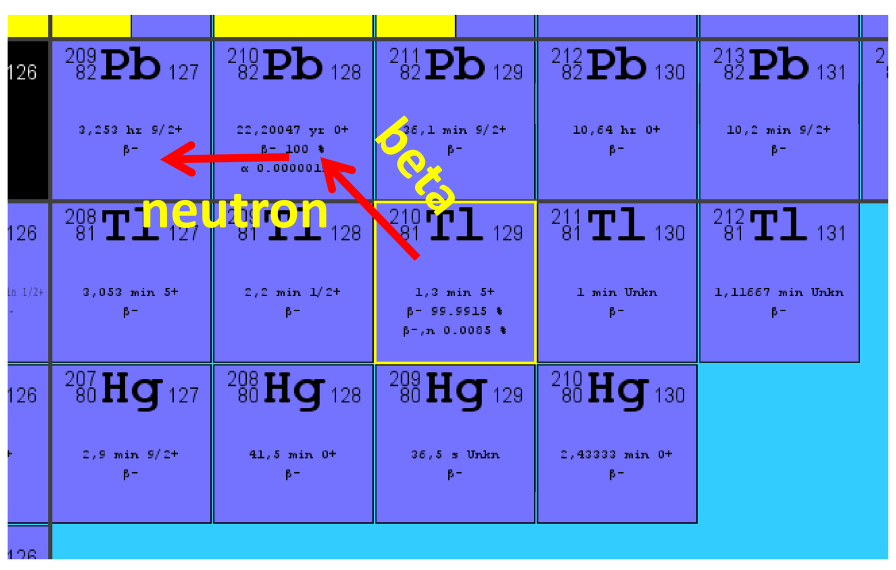
$$B\rho = \frac{m}{q} * v = \frac{A}{Q} * \left(\frac{L}{ToF}\right) \rightarrow \frac{A}{Q} = B\rho * \left(\frac{ToF}{L}\right)$$

IDENTIFICATION: Z and A/Z



β delayed neutron theory

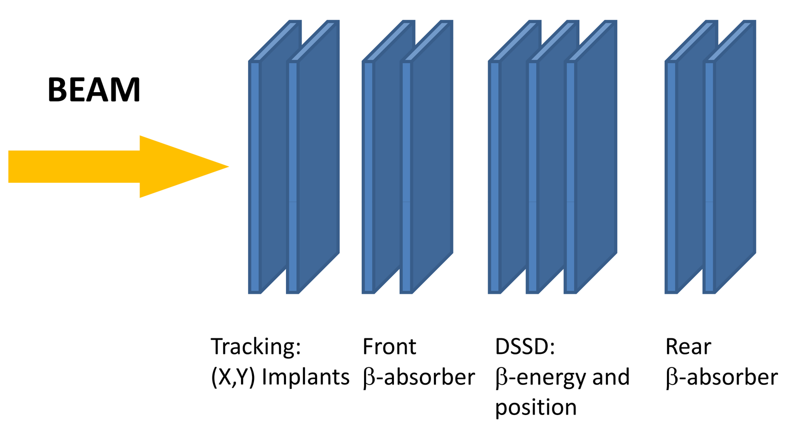


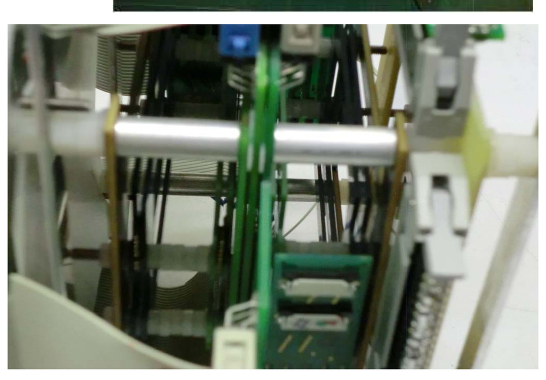


Example of β delayed neutron decay

Implantation and β detector

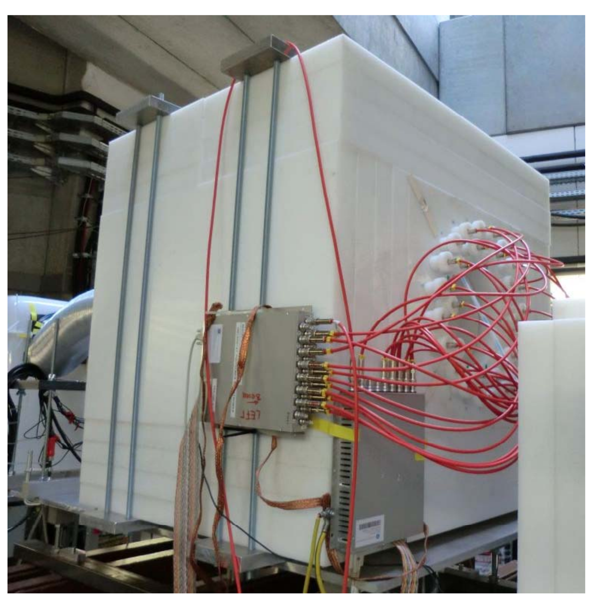
Based on DSSD silicon layers





SIMBA detector

Beta deLayEd Neutron detector (BELEN)

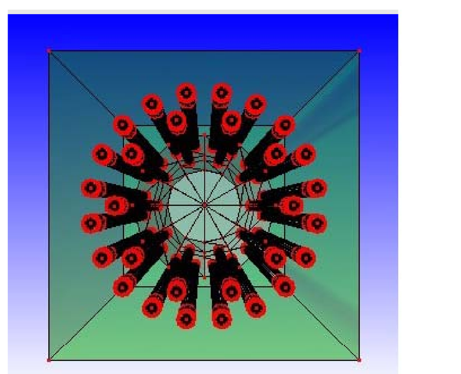


Designed by GRETER research group (UPC)

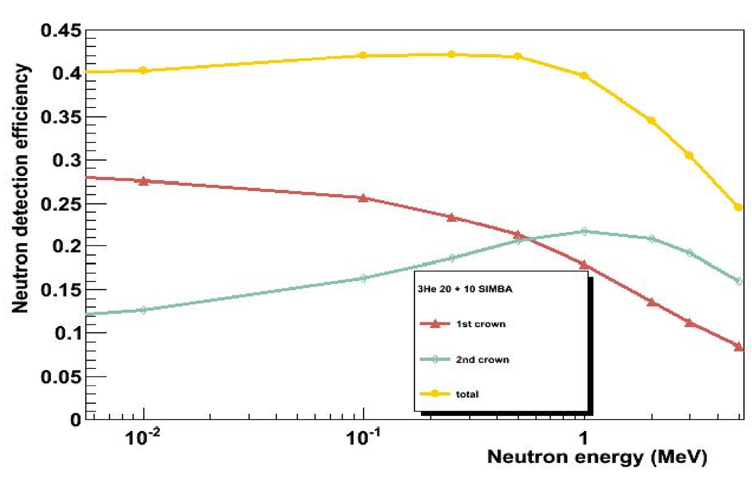
Based on ^3He counters with the reaction:

$^3He + n \rightarrow {}^3H + {}^1H + 765\ keV$

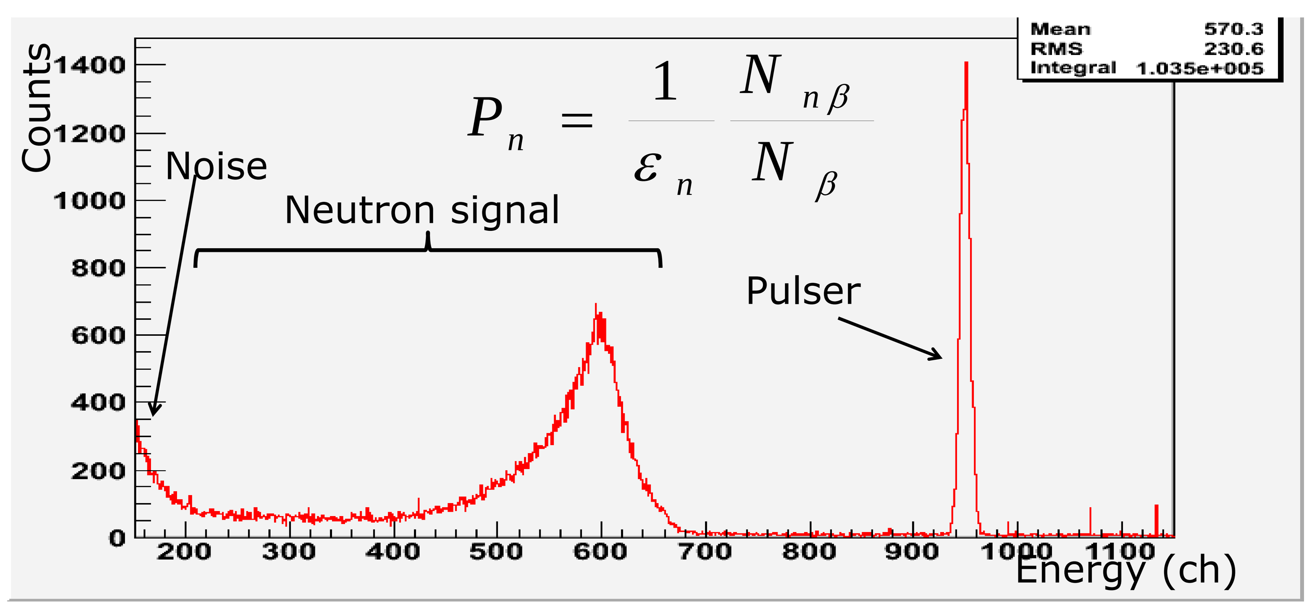
30 ^3He counters for this experiment



Neutron detector efficiency



Neutron spectra obtained



$$P_n = \frac{1}{\varepsilon_n} \frac{N_{n\beta}}{N_\beta}$$

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