β^- delayed neutron detector

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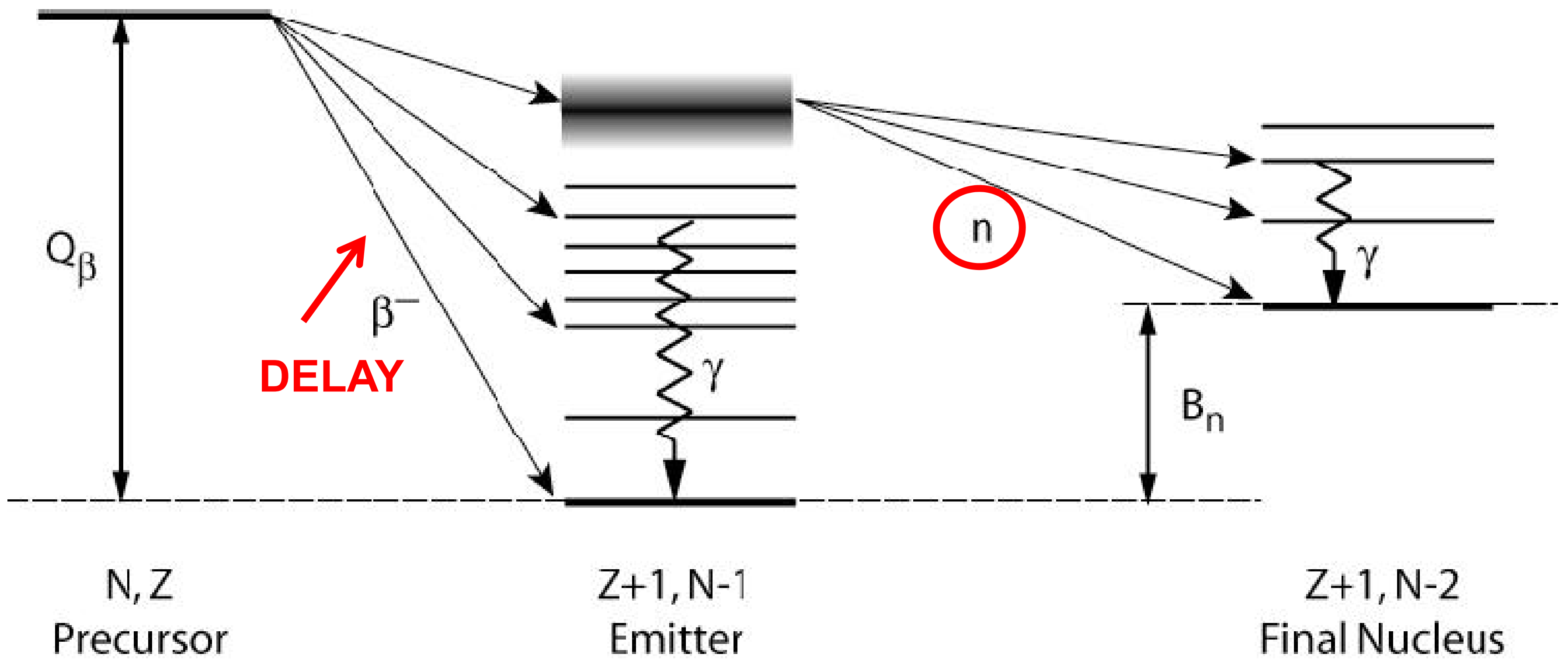
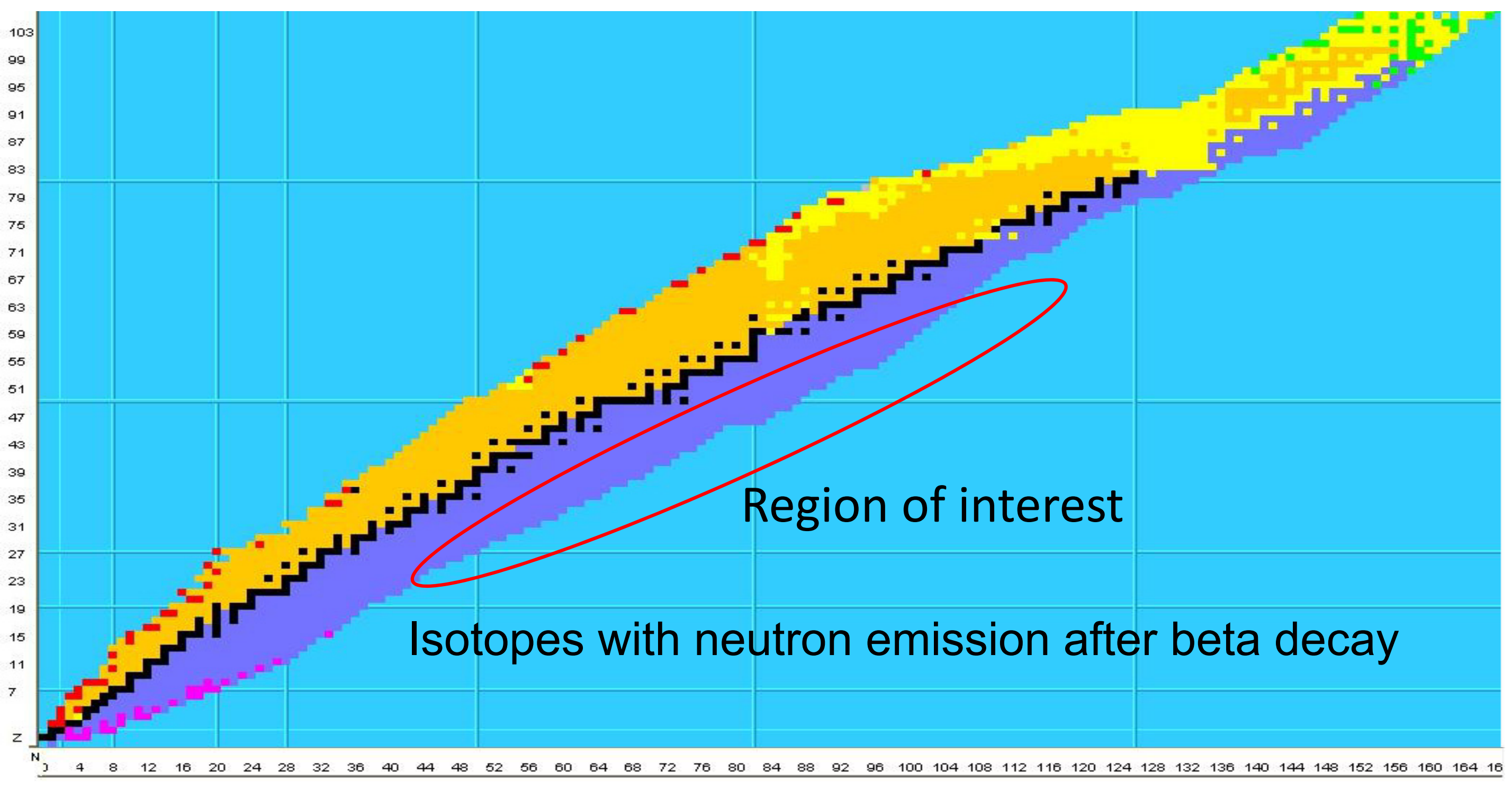
Main objective: To measure neutron emission probabilities after beta decay of neutron rich isotopes with relevance in basic nuclear physics and nuclear technology. For this purpose a neutron detector has been designed. This detector consists of a polyethylene array with 20 ^{3}He counters around the beam hole.



Delayed neutron emission after beta decay



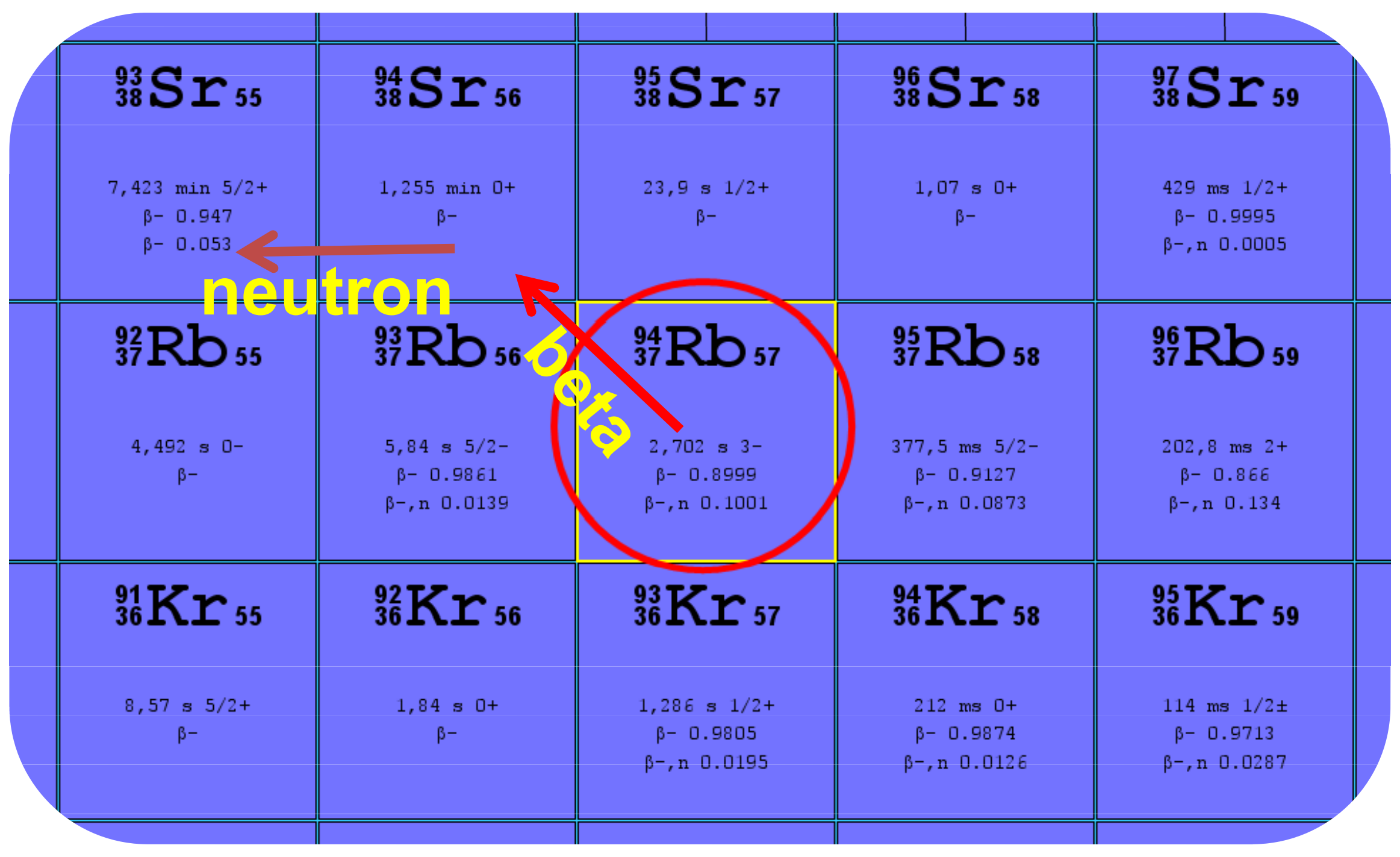
Current focus: study of fission products of technological interest.

Why do we want to study this?

Nuclear structure: Study different aspects of the decay of these nuclei. Provide information about their decay mechanism and structure.

Astrophysical r-process: The delayed neutron emission modulates the element abundance curve in stellar nucleosynthesis. The experimental data from β-delayed neutron emission represents an important input to r-process model calculations.

Nuclear reactor safety: Delayed neutron emission after fission is key to the safety and sustainability of the fission chain in the nuclear power reactor. New data is needed in the context of the nuclear fuel that will be used in the next generation of reactors.

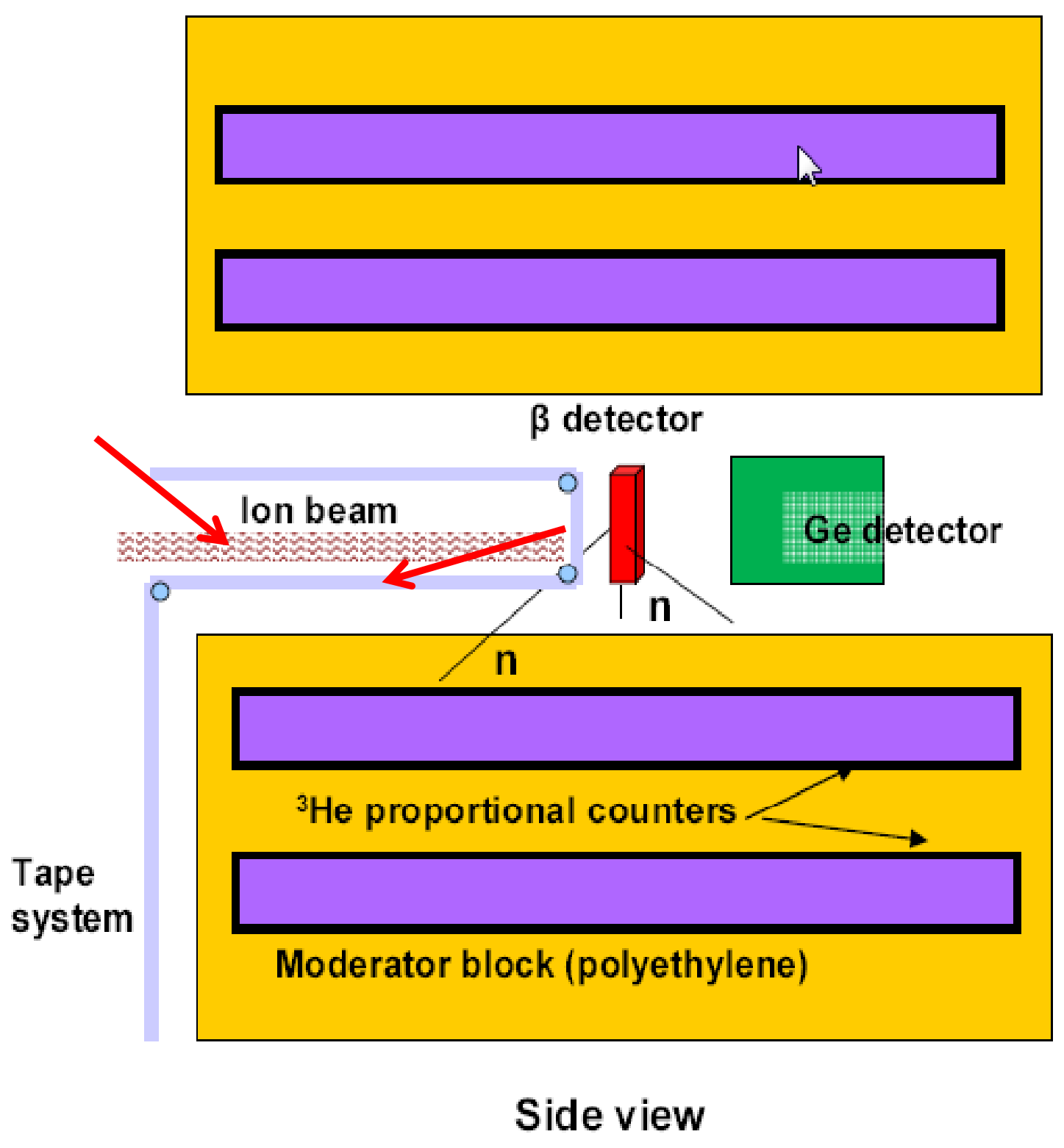


$^{93}_{38}$Sr$_{55}$ 7,423 min 5/2+ β- 0.947 β- 0.053	$^{94}_{38}$Sr$_{56}$ 1,255 min 0+ β-	$^{95}_{38}$Sr$_{57}$ 23,9 s 1/2+ β-	$^{96}_{38}$Sr$_{58}$ 1,07 s 0+ β-	$^{97}_{38}$Sr$_{59}$ 429 ms 1/2+ β- 0.9995 β-,n 0.0005
$^{92}_{37}$Rb$_{55}$ 4,492 s 0- β-	$^{93}_{37}$Rb$_{56}$ 5,84 s 5/2- β- 0.9861 β-,n 0.0139	$^{94}_{37}$Rb$_{57}$ 2,702 s 3- β- 0.8999 β-,n 0.1001	$^{95}_{37}$Rb$_{58}$ 377,5 ms 5/2- β- 0.9127 β-,n 0.0873	$^{96}_{37}$Rb$_{59}$ 202,8 ms 2+ β- 0.866 β-,n 0.134
$^{91}_{36}$Kr$_{55}$ 8,57 s 5/2+ β-	$^{92}_{36}$Kr$_{56}$ 1,84 s 0+ β-	$^{93}_{36}$Kr$_{57}$ 1,286 s 1/2+ β- 0.9805 β-,n 0.0195	$^{94}_{36}$Kr$_{58}$ 212 ms 0+ β- 0.9874 β-,n 0.0126	$^{95}_{36}$Kr$_{59}$ 114 ms 1/2± β- 0.9713 β-,n 0.0287

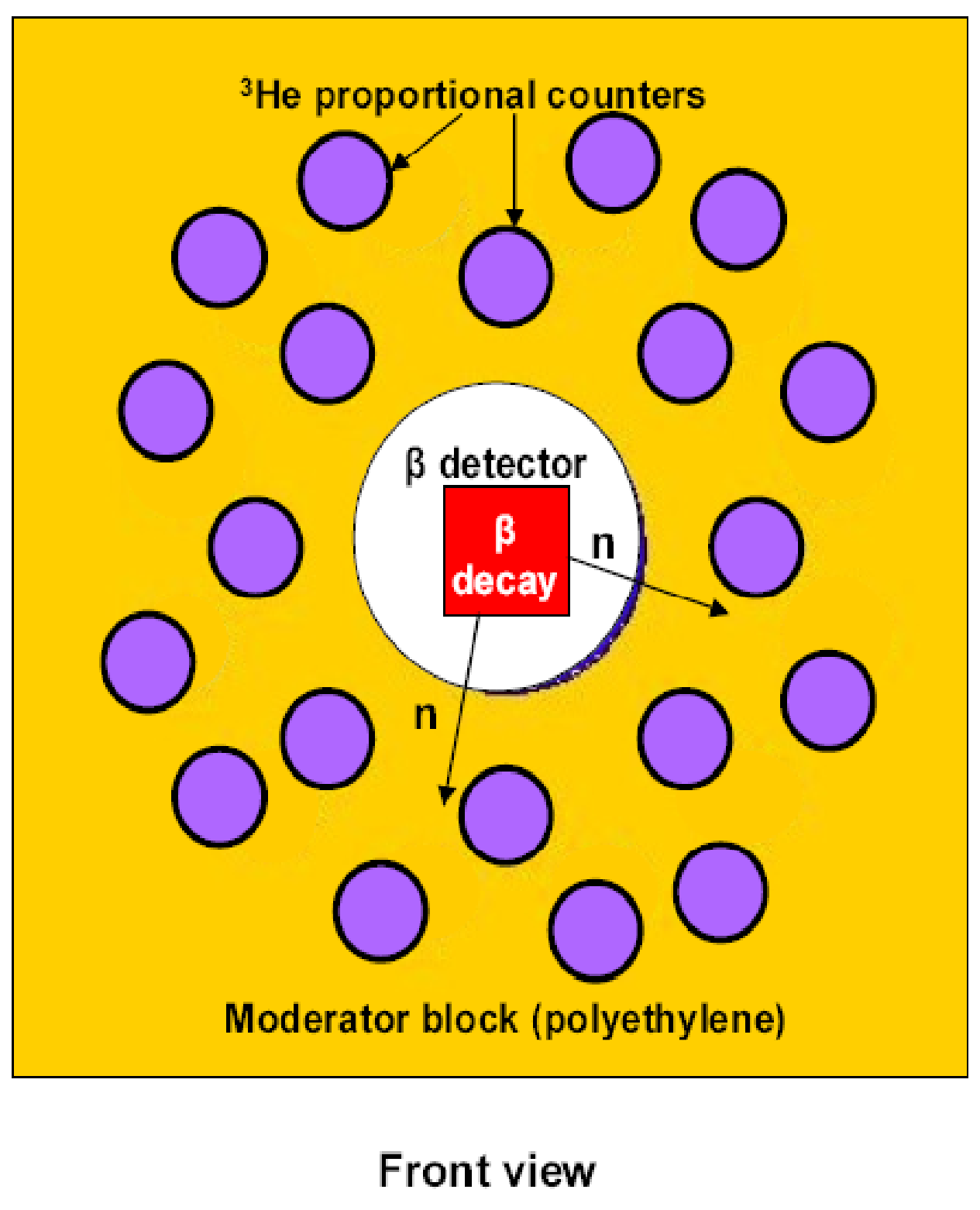
Example decay of ^{94}Rb

Detector characteristics

The neutron detector consists of 20 ^{3}He counters in 2 rings embedded in a polyethylene matrix



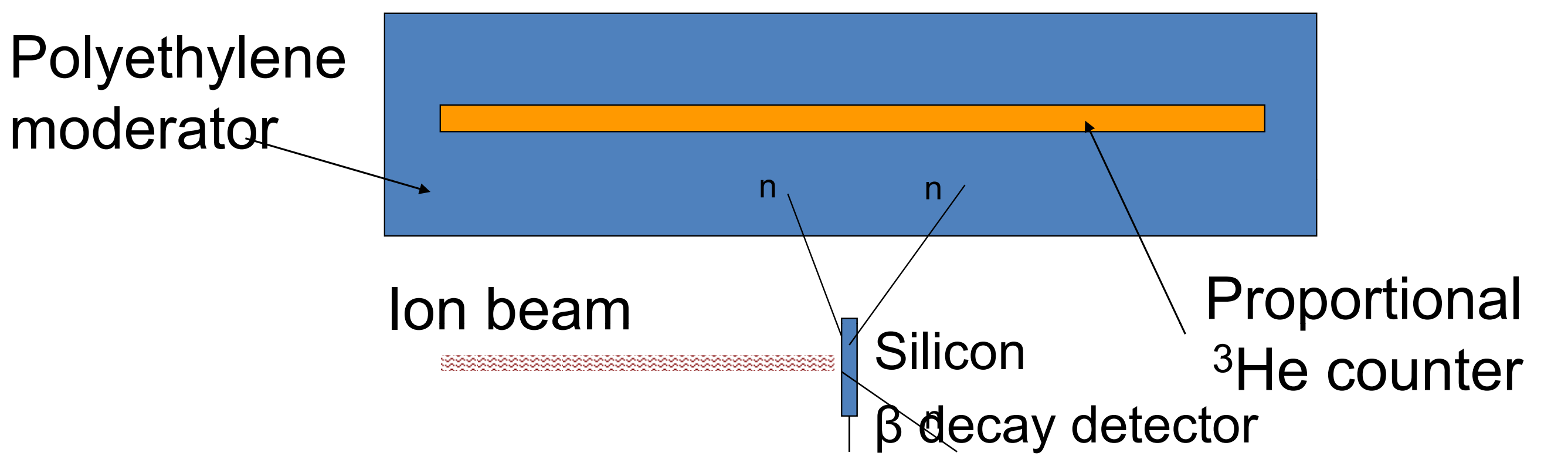
Side view



Front view

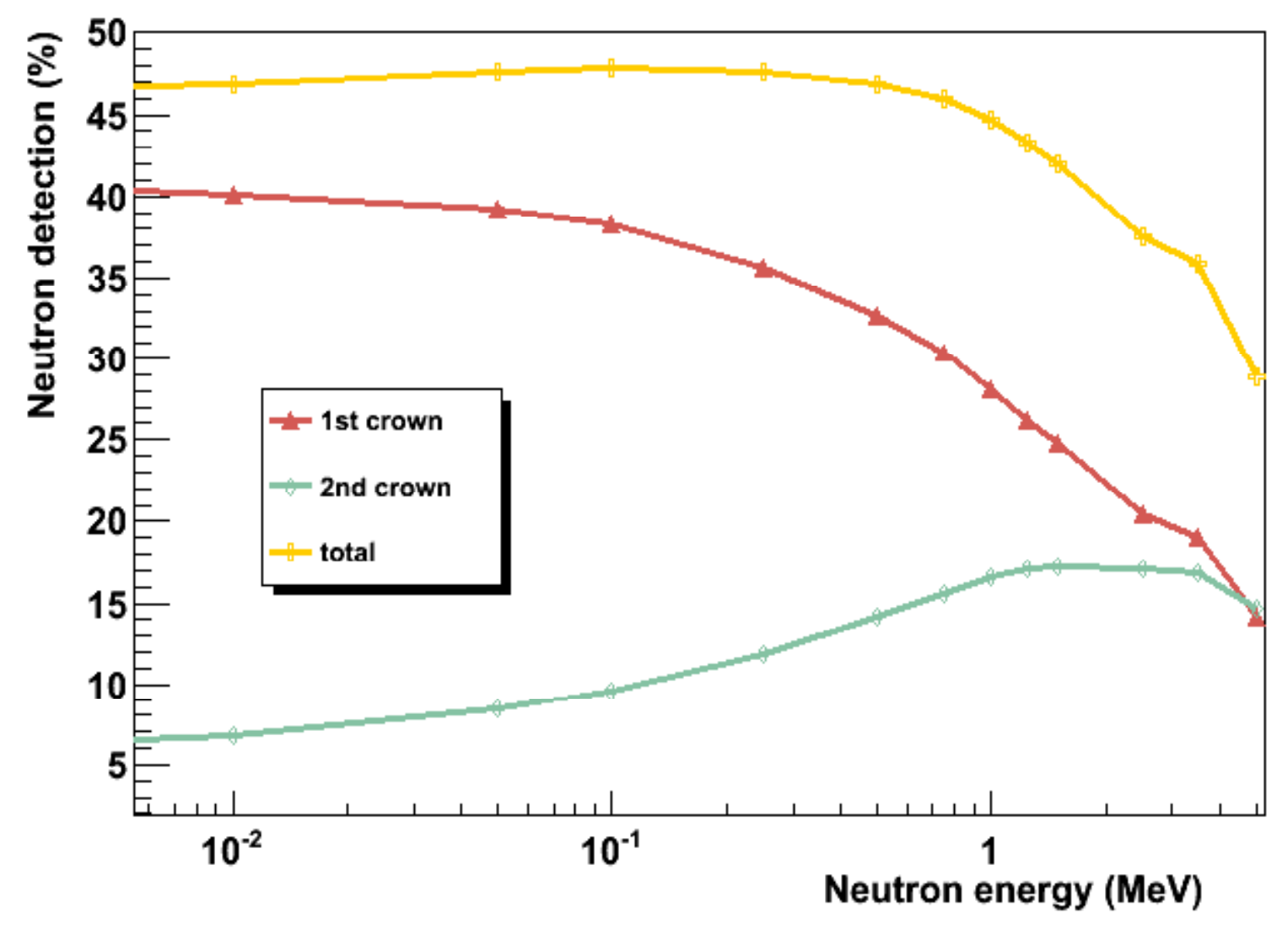
The mechanism for neutron detection is based on the detection of the products of the reaction:

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

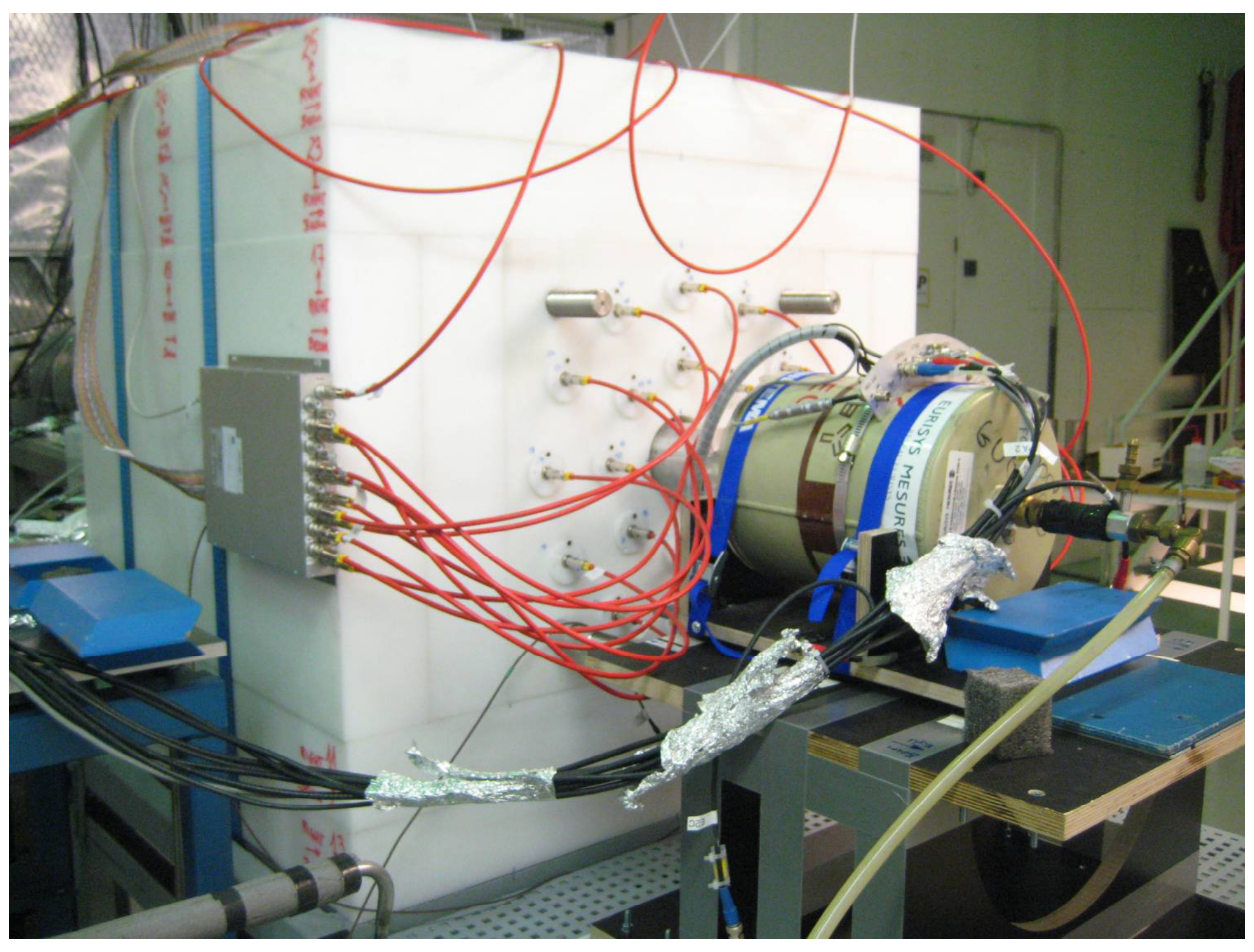


The cross section of the above reaction increases as the neutron energy decreases; therefore the use of the polyethylene moderator in order to decrease the neutron energy

Neutron detection efficiency according to MCNPX simulation.



First experiment at JYFL, Finland



A pure beam of ions of the nucleus of interest was obtained using IGISOL + JYFLTRAP. This beam was implanted on a tape (in front of a Si detector) for 3 $T_{1/2}$ and left decay for 7 $T_{1/2}$ before moving the tape. From silicon (Fig.1) and ^{3}He spectra (Fig.2) obtained, the growth (implant) and decay curves were constructed (Figs.3&4). In the analysis, these curves will be fitted to the Bateman equations. A further plot was constructed showing the neutrons in coincidence with the beta decay within a 1ms window from the beta detection (Fig.5).

A Ge detector was also used to check the gamma rays in coincidence and to identify the implanted ions.

Silicon detector was located in front of the tape

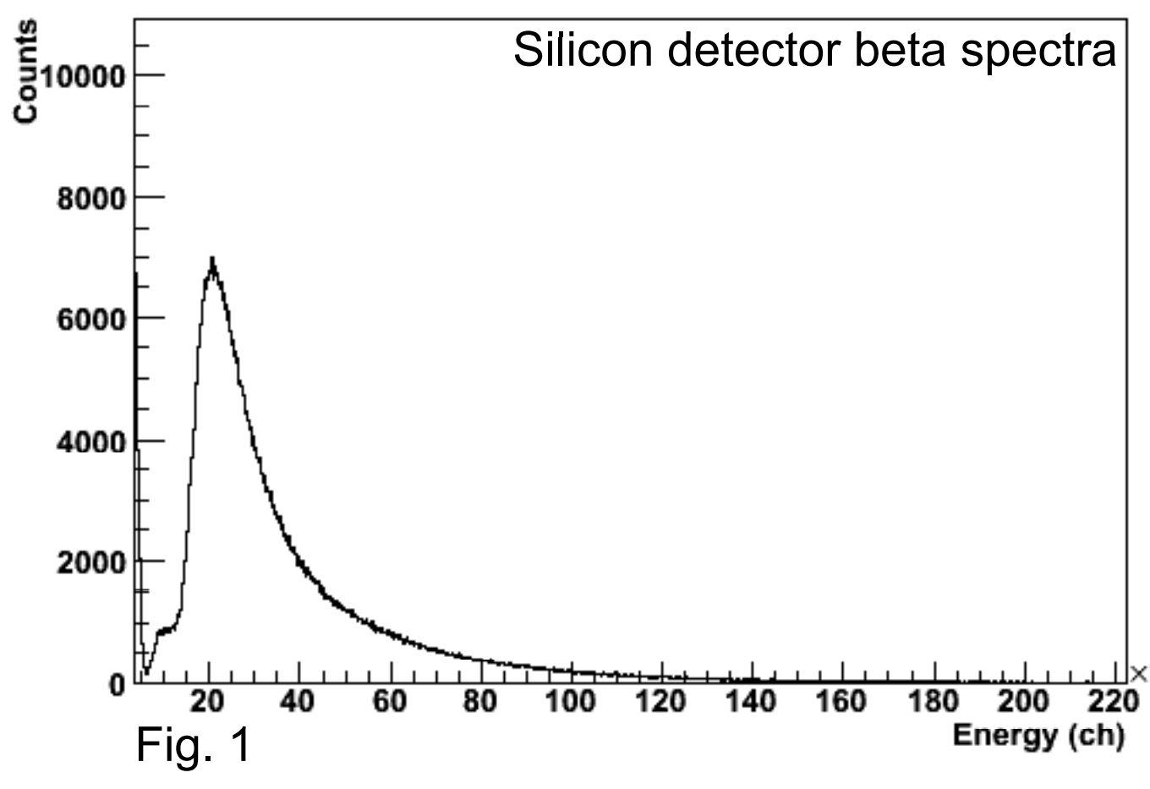


Fig. 1

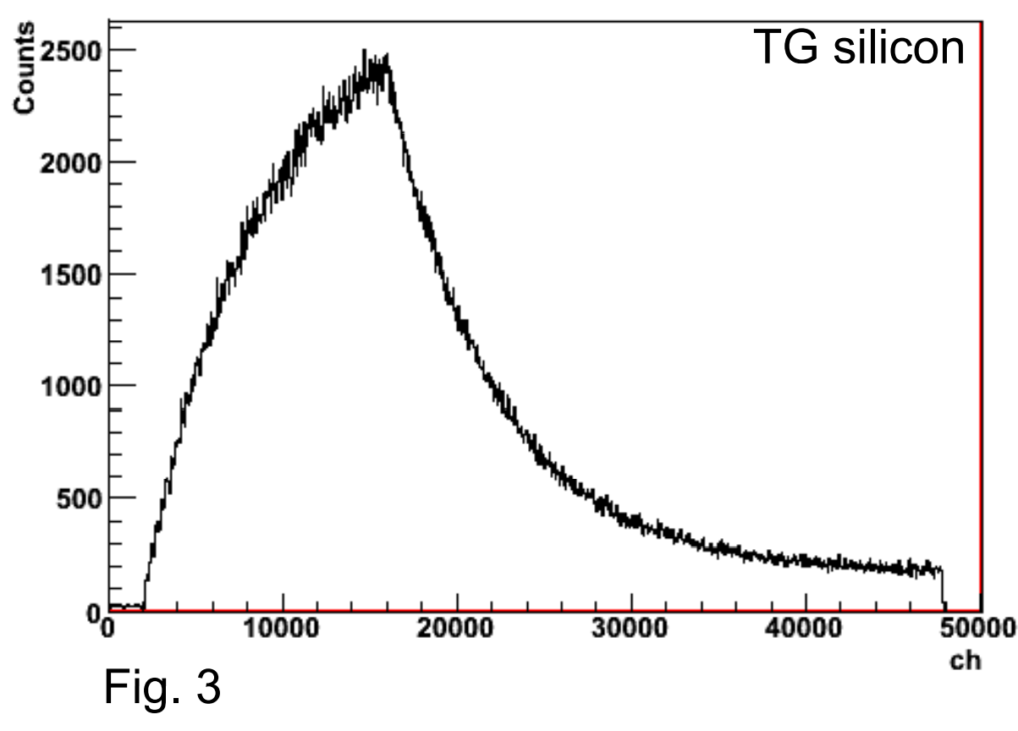


Fig. 3

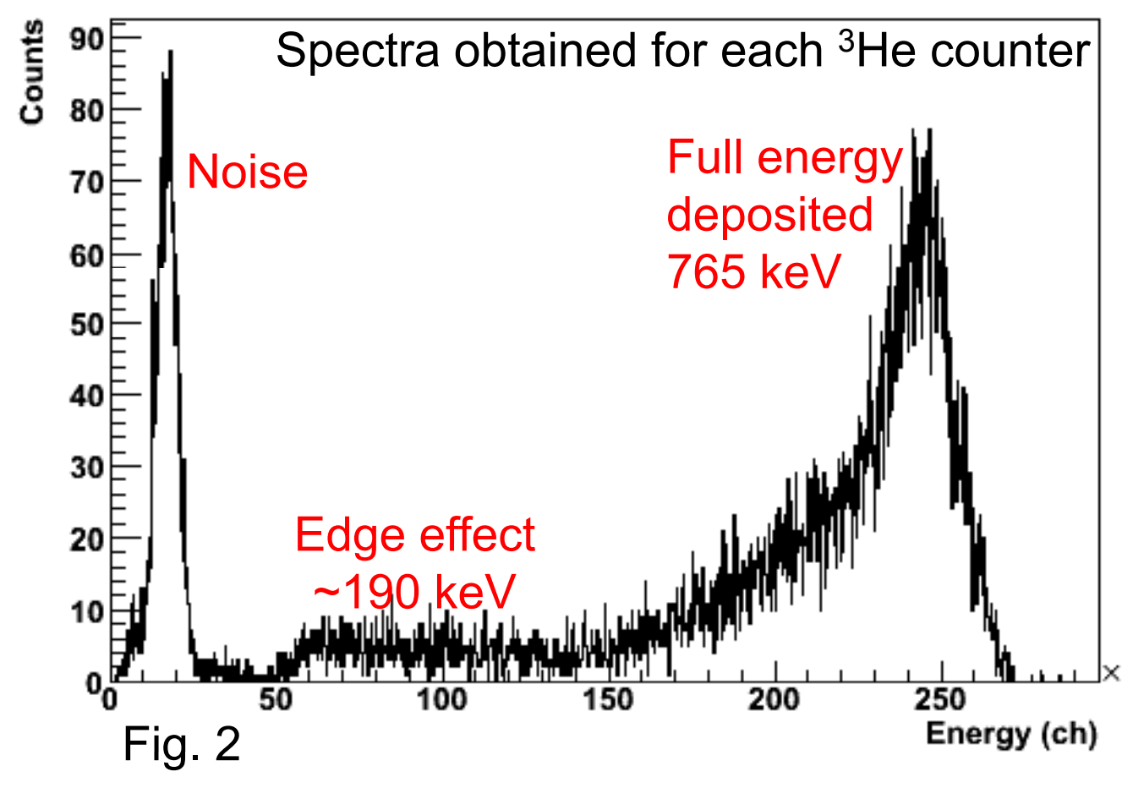


Fig. 2

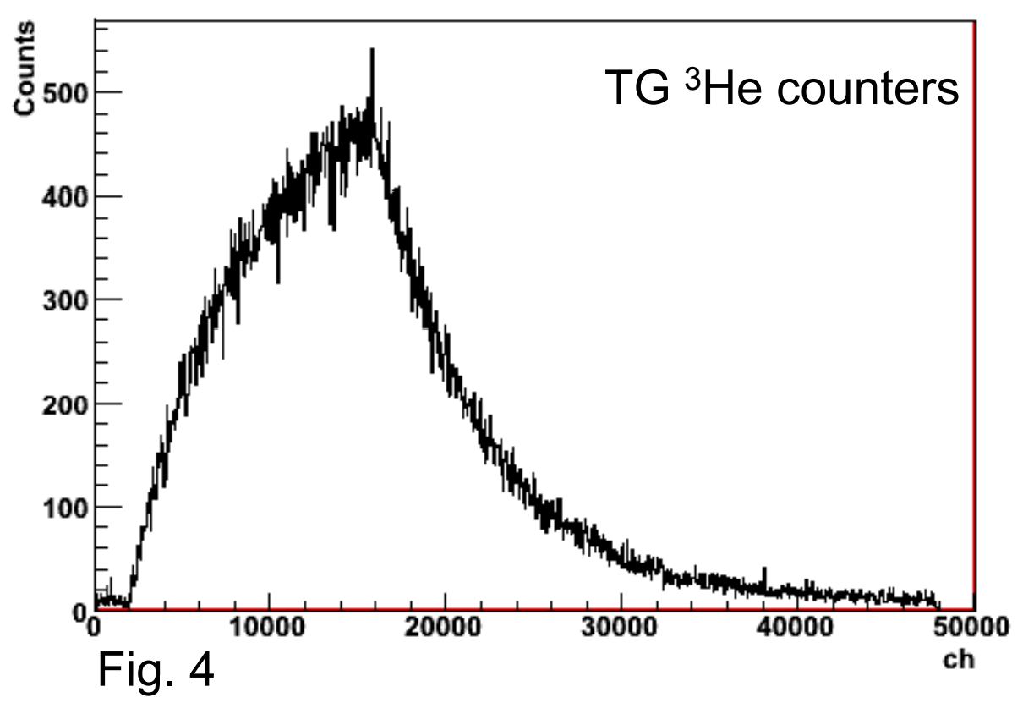


Fig. 4

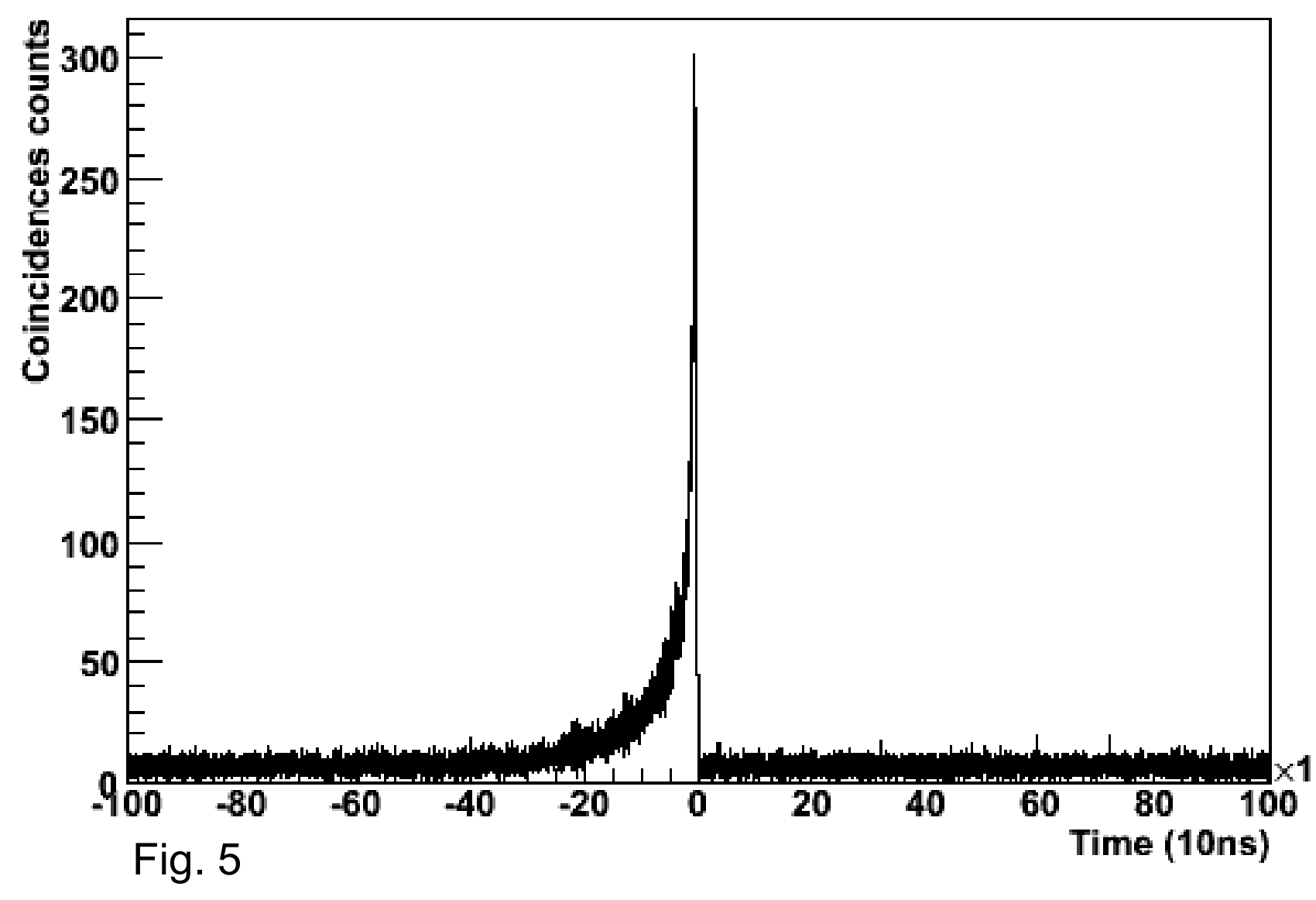


Fig. 5

The neutron emission probability is calculated from:

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