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ISOLDE-Proposal submitted to the PSCC

Measurement of ß-Delayed Neutron Spectra from Fission Product Precursors

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During the last years considerable effort has been devoted to the investigation of ß-delayed neutrons from fission products. Delayed neutron data have been shown to be relevant to various aspects in nuclear physics, to the synthesis of heavy nuclides by astrophysical processes and to nuclear reactor applications.

With respect to nuclear physics, the study of ß-delayed neutrons has turned out to provide a unique way of learning about nuclear properties at medium excitation energy in nuclei far from the stability line. Besides yielding information on particle and gamma widths and level densities, the energy spectra of delayed neutrons are especially valuable because they probe the top part of the ß-strength function (S_β) in a very sensitive way. Our experiments have clearly indicated that structures in S_β are decisive for the physical understanding of different ß-decay properties of exotic nuclei /1/.

In this way, the shape of S_β is of considerable importance for any estimation of the ß-decay behaviour of nuclei relevant to calculations of astrophysical processes /2/. Furthermore, the study of high-resolution delayed neutron spectra represents the only way to obtain parameters for neutron resonances in nuclei far off ß-stability, and hence is of interest to predict cross sections for the inverse process, i.e. neutron-capture of radioactive isotopes in the astrophysical r- and nß-processes.

Delayed neutron characteristics also play an important role in various reactor applications through the direct part they have in the kinetic response of a reactor /3/. At the design level, neutron data characterize globally the reactor from the kinetics point of view. For the reactor operation, the delayed neutron parameters are needed either for the control rod calibration, or for the direct measurement of the core reactivity level. From the dynamics and safety (failure detection) point of view, the neutron properties are directly used to describe the transient neutronic phenomena issuing from reactivity changes which may result from any perturbation, e.g. in the cooling system. Concerning neutron spectral data, the low-energy parts which for a considerable number of precursors are not yet measured are of particular importance.

With these perspectives, we propose to measure - as an extension of our current programme - high-resolution delayed neutron spectra of fission products in the energy range 10 keV to ($Q_\beta - B_n$) using the beams already available at ISOLDE and also the targets under development. The precursor isotopes of interest are listed in Table 1, where also the relative importance for reactor technology (% $\bar{\nu}_d$ for $^{235}U(n_{th},f)$) is included /4/.

We foresee that our experiment could participate in several ISOLDE runs starting Sept. 1982. The measuring time required to obtain a spectrum of about 10^4 neutrons can be estimated to range from 1 to 25 h, depending on the isotope. The total beam time requirement will be about 25 shifts.

Our experiment requires low background conditions and low accoustic noise level. We therefore propose to carry out the measurements in the paraffine/Cd shielding cabin in UR9.

Since some of the important precusors will only become available in the course of new target/ion source developments, we propose to carry out these measurements jointly with the CERN ISOLDE group.

References

/1/ K.-L. Kratz et al., CERN 81-09 (1981) 317

/2/ H.V. Klapdor et al., Z. Physik A299 (1981) 213, and CERN 81-09 (1981) 341

/3/ IAEA-Report INDC(NDS)-107/G+Sp (1979)

/4/ T.L. England et al., Paper presented at the 183rd ACS meeting, Las Vegas, USA, March 1982

Table 1: Delayed neutron precursors of interest and their relative importance for reactor technology *)

Precursor	$T_{1/2}$/s/	% of $\bar{\nu}_d$	Precursor	$T_{1/2}$/s/	% of $\bar{\nu}_d$
$^{80}_{31}Ga$	1.66	0.01	$^{129}_{49}In$	1.0 2.5	0.18 0.09
^{81}Ga	1.23	0.05	^{130}In	0.58	0.07
^{82}Ga	0.60	0.08	^{131}In	0.28	0.03
$^{84}_{32}Ge$	1.2	0.18	$^{134}_{50}Sn$	1.04	0.11
^{85}Ge	0.23	0.05	$^{134}_{51}Sb$	0.85	0.01
$^{84}_{33}As$	5.6	0.02	^{136}Sb	0.82	0.20
^{86}As	0.9	0.53	^{137}Sb	0.48	0.59
^{87}As	0.73	1.72	$^{136}_{52}Te$	17.5	0.78
$^{88}_{34}Se$	1.52	0.10	^{137}Te	3.5	0.53
^{89}Se	0.41	0.34	^{138}Te	1.6	0.21
^{90}Se	0.56	0.15	$^{141}_{54}Xe$	1.7	0.03
$^{93}_{36}Kr$	1.29	0.58	^{142}Xe	1.2	0.10
^{94}Kr	0.21	0.71	^{143}Xe	1.0	0.04
^{95}Kr	0.5	0.04			
$^{99}_{38}Sr$	0.6	0.34			
^{100}Sr	1.05	0.04			
$^{98}_{39}Y$	0.65 2.0	0.09 0.24			
^{99}Y	1.4	4.8 (?)			
^{100}Y	0.76	1.67			
$^{105}_{40}Zr$	0.5	0.07			
$^{103}_{41}Nb$	1.5	0.16			
^{104}Nb	4.8	0.30			
^{105}Nb	2.8	0.42			
^{106}Nb	1.0	0.05			

*) So far, we have measured the neutron spectra of 29 medium-mass precursors which cover ≥80 % $\bar{\nu}_d$ for $^{235}U(n_{th},f)$.