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1. Introduction

During the last few years a considerable interest is observed in the predicted [1] new nuclear region of permanent deformation containing neutron-deficient nuclides with $50 < Z, N < 82$. This new region of deformation was confirmed both by experimental data obtained from in-beam spectroscopy [2-4] (even-even nuclei) and by theoretical calculations [5, 6]. The latter suggest that oblate shapes would be rather more stable than the prolate ones. Data of the excited states of odd-A nuclei may serve to test not only the existence of deformation but also to establish the sign of it.

The object of the present work was to obtain further information on the low-lying levels of ^{123}Cs and ^{125}Cs excited in the beta decay of ^{123}Ba and ^{125}Ba. These isotopes, about whose excited states not very much is known, belong to this new region of interest.

2. Experiment and Results

2.1. Barium-123

The sources used in this experiment were obtained in the $^{114}Sn(^{12}C, 3n)^{123}Ba$ reaction from a target, prepared of commercial separated ^{114}Sn isotope, irradiated for about 1 min. with carbon ions of optimal energy [7] (for this reaction) on the external beam of the heavy ion U-300 cyclotron. The carbon ion energy was reduced to the proper one by means of an aluminium foil set.

The gamma-spectra were studied with a 2.5 cc Ge(Li)-detector with a 0.7 keV resolution at 100 keV. One of these spectra is shown in Fig. 1. The observed gamma-

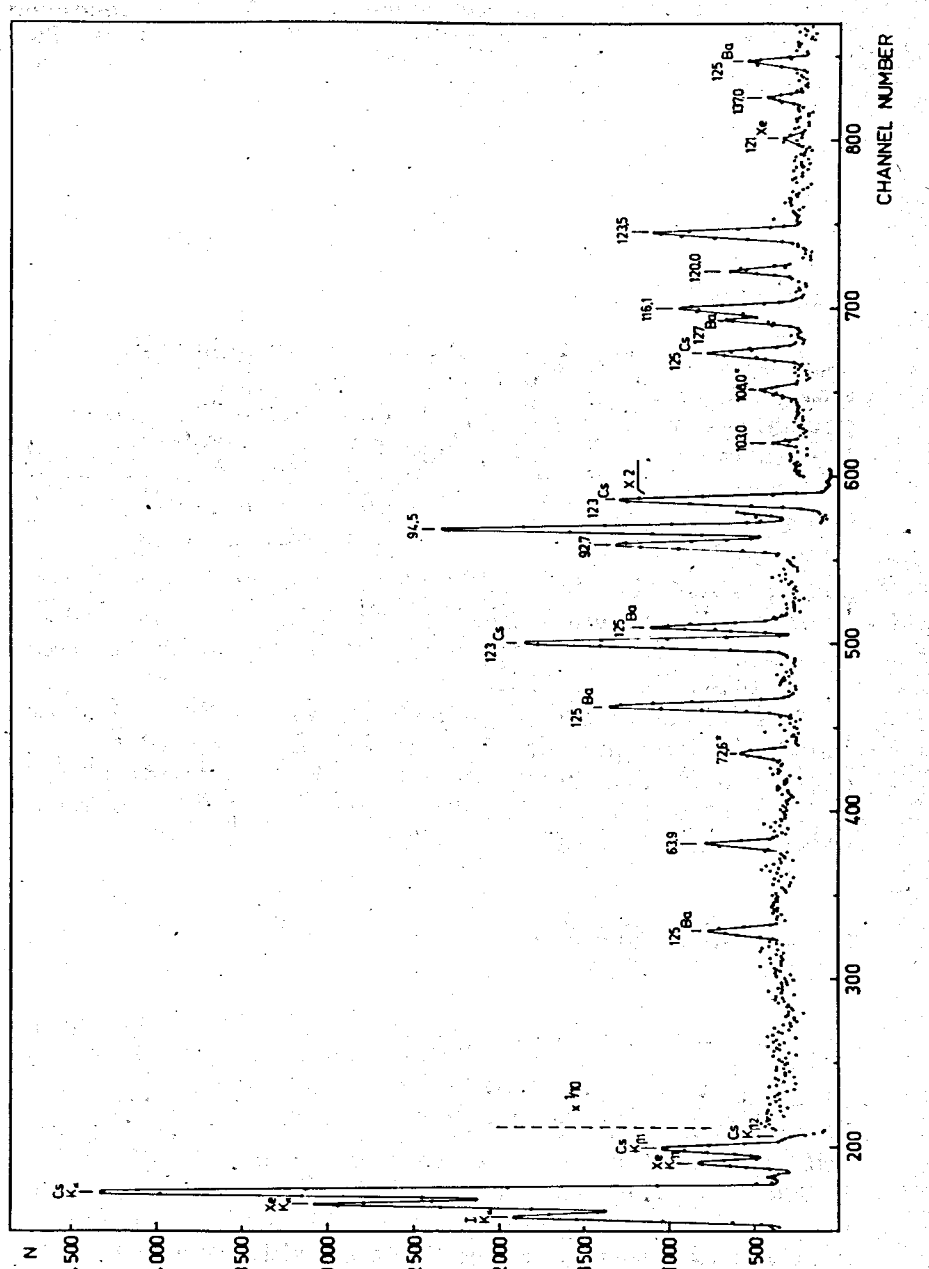

Fig. 1. Single gamma-ray spectrum of ^{123}Ba observed from a ^{114}Sn target bombarded with ^{12}C ions. Two long-lived gamma-rays marked by asterisk have not been assigned.

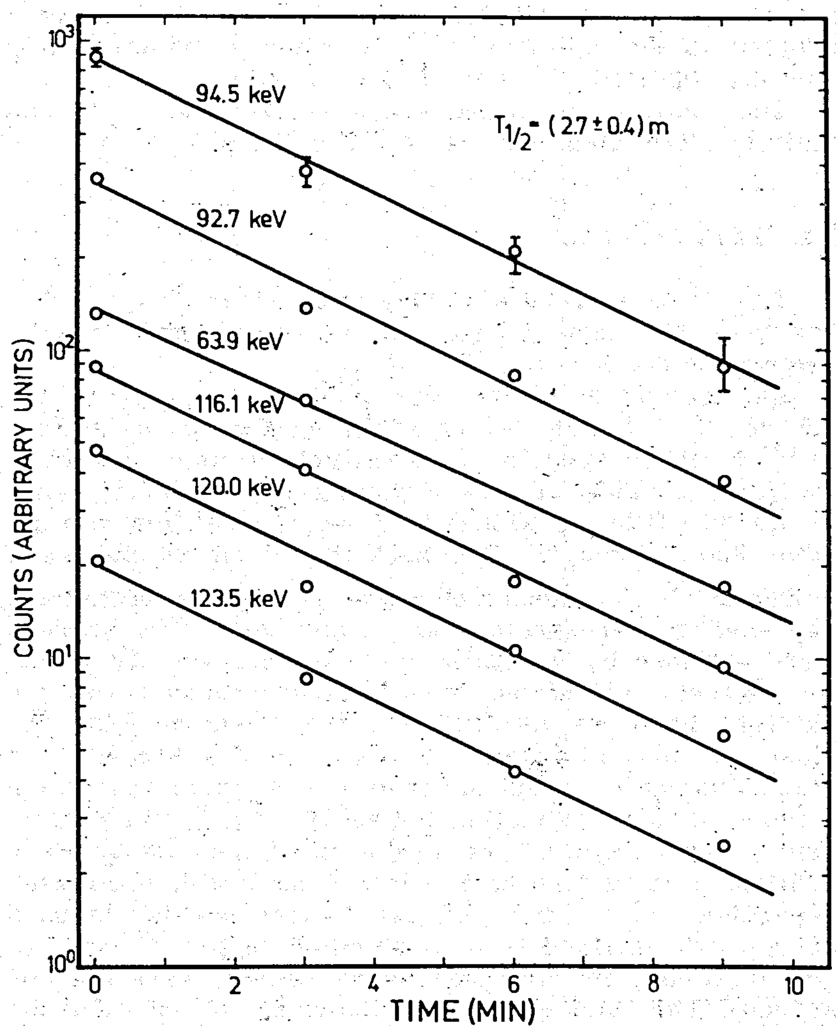

Fig. 2. Decay curves of the gamma-rays assigned to ^{123}Ba

rays were identified by comparing their energies and lifetimes with those of known isotopes which could appear in the spectra as well as a decay product of ^{123}Ba and as reaction products with an admixture of other tin isotopes in the target material. Seven of these gamma-rays (Fig.2) decayed with the same half-life of 2.7 min which one could not assign to any of known isotopes. This value has been adopted as the half-life of ^{123}Ba which is in agreement with the reported /8/ one of (2 $\pm$0.5) min.

The energies of gamma-rays assigned to ^{123}Ba and their relative intensities are given in Table 1.

2.2. Barium-125

The ^{125}Ba sources were obtained with the $^{117}Sn($ C, 4n$)^{125}Ba$ reaction. The experimental procedure used here was the same as in the case of ^{123}Ba.

An example of gamma-ray spectra obtained with the 2.5 cc Ge(Li) detector is shown in Fig. 3. In contrast to ^{123}Ba these spectra are relatively simple. A careful analysis revealed a group of gamma-rays with a half-life of 3.5 min (Fig. 4) which could not be identified with the other known isotopes. To check that these gamma-rays belong to ^{125}Ba, supplementary measurements of gamma-ray spectra were performed. In this case ^{125}Ba sources were obtained by the spallation reaction from CeO_2 and Ta targets irradiated with 660 MeV protons on the external beam of the JINR synchrocyclotron. After the chemical separation the ^{125}Ba source was prepared by electromagnetic isotope separation of the barium fraction using a surface ionization ion source /9/. All the prominent gamma-rays of the group mentioned above were confirmed in the spectra obtained both with the mass-separated ^{125}Ba and with the mass-separated isobars of A = 125 obtained from a tantalum target /29/ (intense γ-transitions, in the high energy region, were not observed). This fact allows the authors to conclude that the found group of the gamma-transitions, listed in Table 2, belongs to ^{125}Ba.

Table 1

Gamma-rays observed in the decay of ^{123}Ba. Energy uncertainties do not exceed 0.6 keV

Energy E_γ (keV)	63.9	92.7	94.5	116.1	120.0	123.5	137.0
Rel. int. I_γ	14±4	51±5	100	54±8	27±4	69±6	23±7

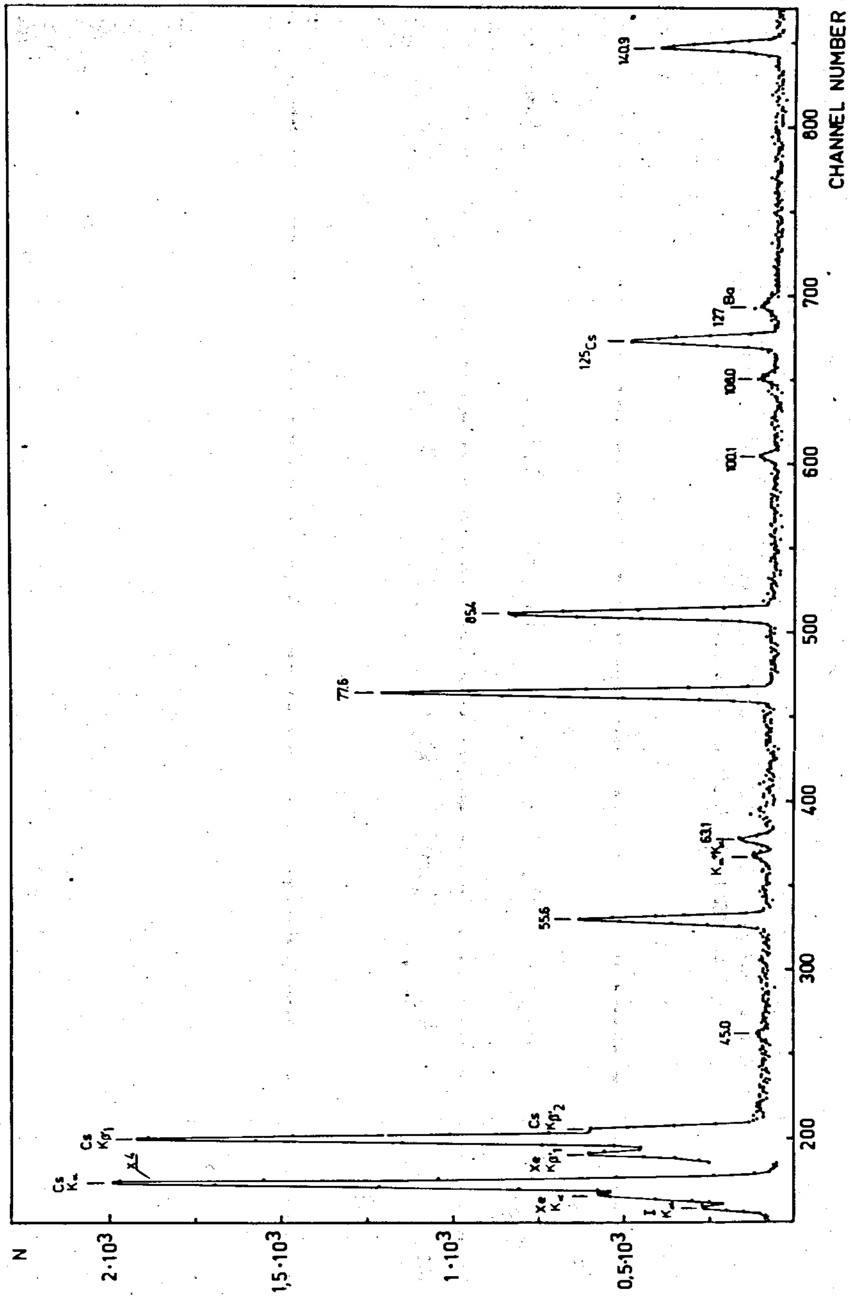

Fig. 3. Singles gamma-ray spectrum of ^{125}Ba observed from a ^{114}Sn target bombarded with ^{12}C ions.

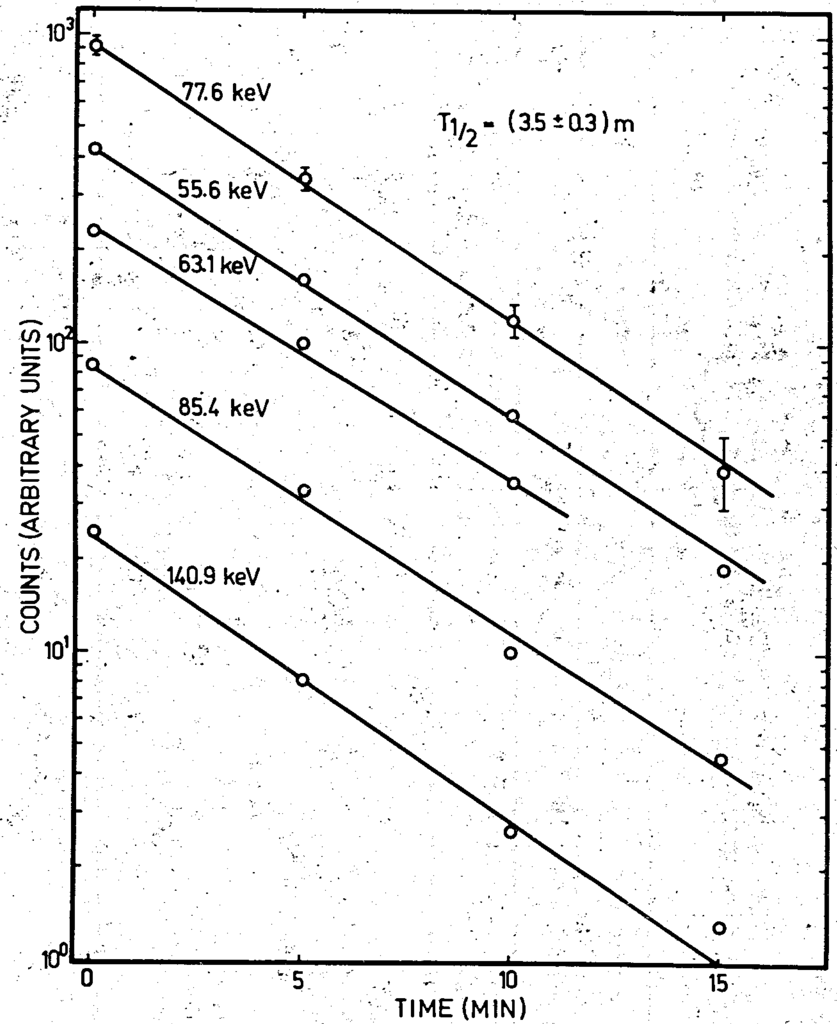

Fig. 4. Decay curves of the gamma-rays assigned to ^{125}Ba .

Table 2

Gamma-rays observed in the decay of ^{125}Ba. Energy uncertainties in the present work do not exceed 0.6 keV

Present work $T_{1/2} = (3.5 \pm 0.4)$ min		Reference /10/ $T_{1/2} = (3 \pm 0.5)$ min		Reference /10/ $T_{1/2} = (8 \pm 1)$ min	
Energy E_γ(keV)	Rel.intensity I_γ	Energy E_γ(keV)	Rel.intens. I_γ	Energy E_γ(keV)	Rel.intens. I_γ
				20	
45.0	~3				
55.6	48 ± 4	56 ± 3	5		
63.1	8 ± 1				
77.6	100	76 ± 2	100		
85.4	82 ± 8	84 ± 2	86		
100.1	6 ± 3				
108.0	8 ± 2				
140.9	86 ± 8	141 ± 2	42		

The value of 3.5 min adopted here as the half-life of ^{125}Ba should be compared with the values of (3±0.5) and (8±1) min published in ref. /10/ as the half-lives of two isomeric states of ^{125}Ba. The first one is in agreement with the value obtained in the present work. The 8 min activity (in the 5-200 keV energy region) in this experiment, was not observed.

3. Decay Schemes and Discussion

3.1. Barium-123

In experiments with heavy ion reactions an isomeric states with half-life of 1.6 sec was revealed in ^{123}Cs. This state is depopulated by two gamma-transitions of energies (63 ± 0.5) and (95.5 ± 0.5) keV of the same type of M1 + E2 multipolarity /11/. A careful analysis of the energy and intensity of the observed gamma- and KX-rays in the decay of ^{123}Ba (Table 1) makes it possible to conclude that very likely the 63.9 keV gamma-transition can be identified with the gamma-ray of energy 63 keV observed in ref. /11/. Basing on this information we assumed that the first excited state of ^{123}Cs is depopulated by this transition. The two additional levels shown in Fig. 5 were included in the decay scheme on the basis of the intensity and energy sum rules only.

The spin and parity of the ground state of the neighbouring odd-A cesium isotopes is 1/2+ /12-14/ By analogy to that one can expect that ^{123}Cs nucleus will continue this trend. Such a conclusion seems to be confirmed experimentally by works devoted to the investigations of the decay of ^{123}Cs /15/ and the excited states of ^{123}Xe /16/. However, in our gamma-spectra of ^{123}Ba obtained both in the (HI,xn) reaction and in the spectra obtained with mass-separated isobars of A=123 there appeared, beside the strong 97.3 keV gamma-ray, a 83.3 keV gamma-transition which depopulates the second excited state of ^{123}Xe of the 5/2$^+$ spin value /16/. Because the assignment of this transition has not yet been established (work continued), the 3/2$^+$ value for the ground state of ^{123}Cs cannot be excluded.

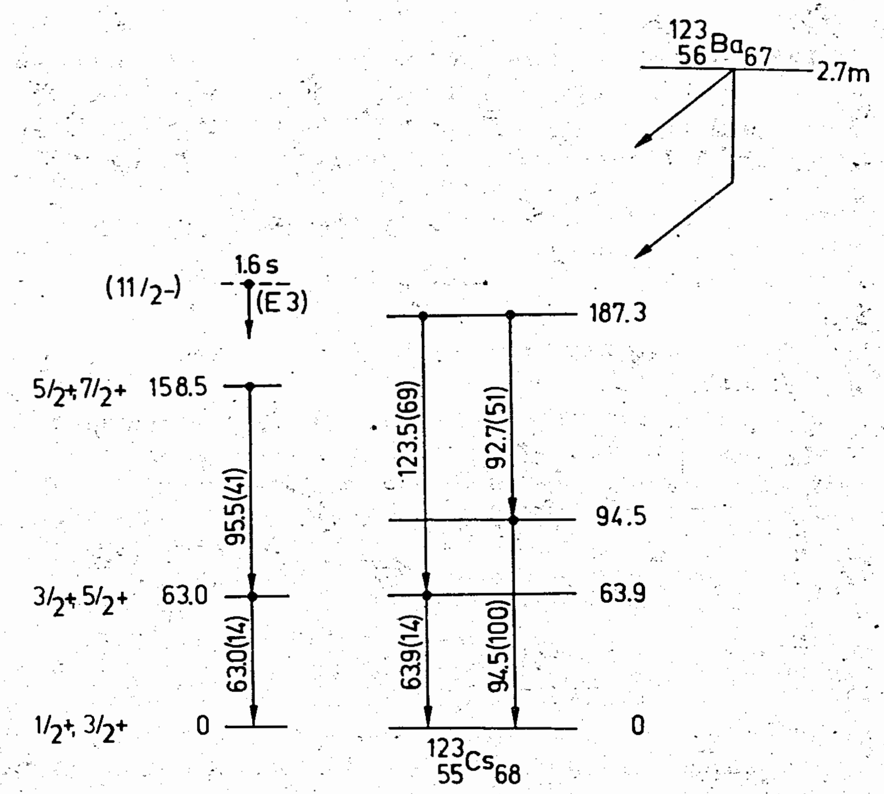

Fig. 5. Decay scheme proposed for ^{123}Ba .

Including the present data one can conclude that the isomeric state /11/ is associated with the cascade given on the left in Fig. 5. The spin assignments for the excited states follow from the multipolarity and a weak cross-over transition (unobserved in ref. /11/).

In the last years an $11/2^-$ isomeric state was found in ^{127}Cs /18/. Such a state could explain the existence of 1.6 sec activity in ^{123}Cs if one assumed the spin sequence given on the left in Fig. 5.

3.2. Barium-125

In the case of ^{125}Ba β^+-gamma coincidence experiments were carried out using a NE 102 (2.5 x 1 cm) plastic detector as the gating crystal and a 27 cc Ge(Li) one to obtain the coincidence gamma-spectra /19/. Fig. 6 shows coincidence spectra with an integral gate set above 500 keV. The upper (A) spectrum represents a prompt- and the lower one (B) a 10 ns delayed coincidence spectrum, respectively. From these spectra it is seen that only one of the observed gamma-rays of energy 85.4 keV is delayed relative to the β^+-decay. This implies the existence of an excited state of the same energy. Furthermore, from the relative intensities of the observed two gamma-rays (77.6 and 85.4 keV) in these spectra the half-life of this level was estimated roughly to be about 20 ns what is in agreement with transitions of the E2 type in the neighbouring odd-mass Cs isotopes /20, 23/. Basing on these facts and taking into consideration the energy and intensity balance, a decay scheme for ^{125}Ba was constructed (Fig. 7).

The spin and parity of the ground state of ^{125}Cs has been found to be $1/2^+$ /13,14/. According to systematics of the excited states of odd- A cesium nuclei /21 - 24/ and the present data the spin for the 85.4 keV is very likely to be $5/2^+$. A rough estimation of the log ft values (Q_{β^+} value was taken from ref. /17/) for the beta-decay to the proposed levels indicates that these transitions are consistent with an allowed character in this mass region. The transition intensities calculated on the basis of theoretical conversion coefficients /25/ and gamma-ray intensities (assuming MI character as the lowest of the possible multipolarities for the 55.6 and E2 one for 85.4 keV transitions) indicate that the second excited state, within the statistical error limits, is not populated in the β -decay. From all these facts it follows that the spins of the 140.9 keV levels and of the ground state of ^{125}Ba are likely to be $3/2^+$ and $1/2^+$, respectively.

Taking into account a general trend of the levels given by pairing + quadrupole force model for odd-mass

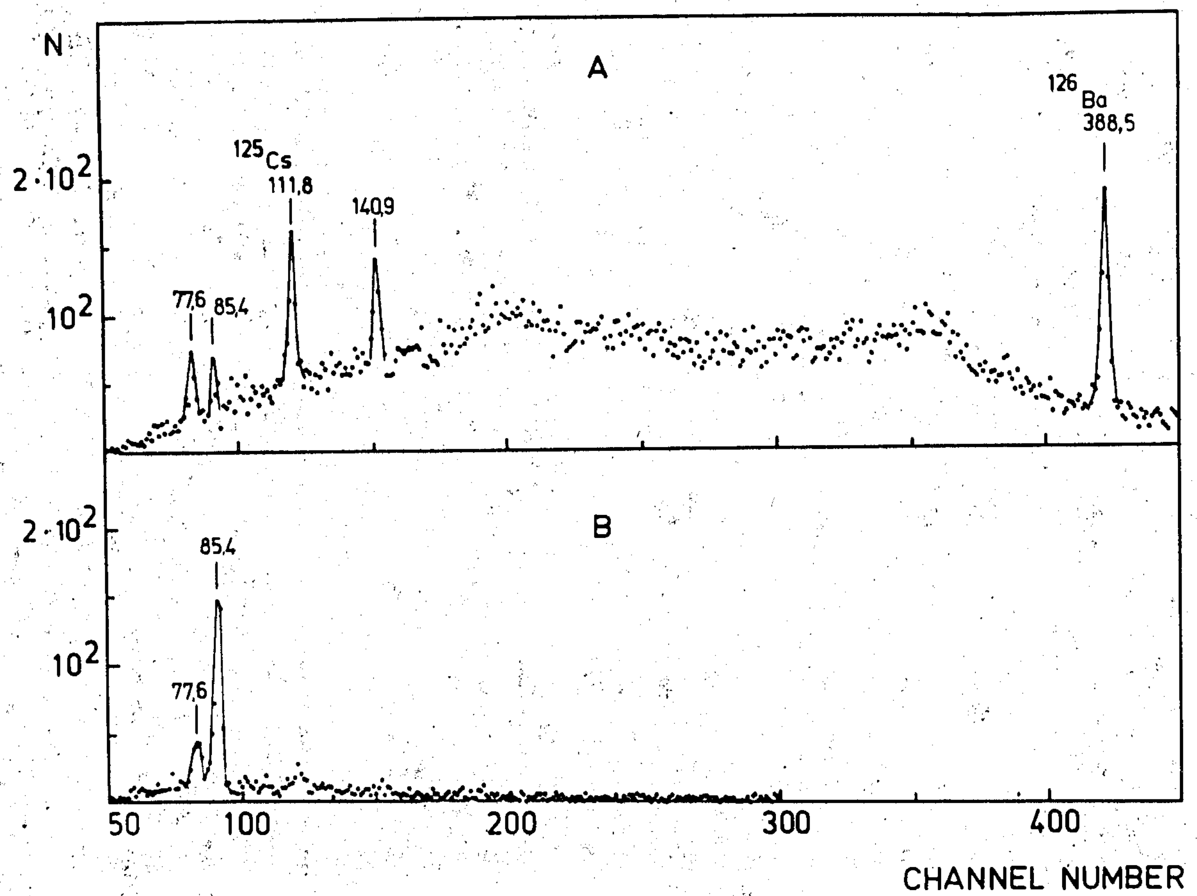

Fig. 6. Gamma-ray spectra in coincidence with a continuous β^+-spectrum at the energy > 500 keV. A) the prompt coincidence spectrum, B) 10 ns delayed coincidence spectrum.

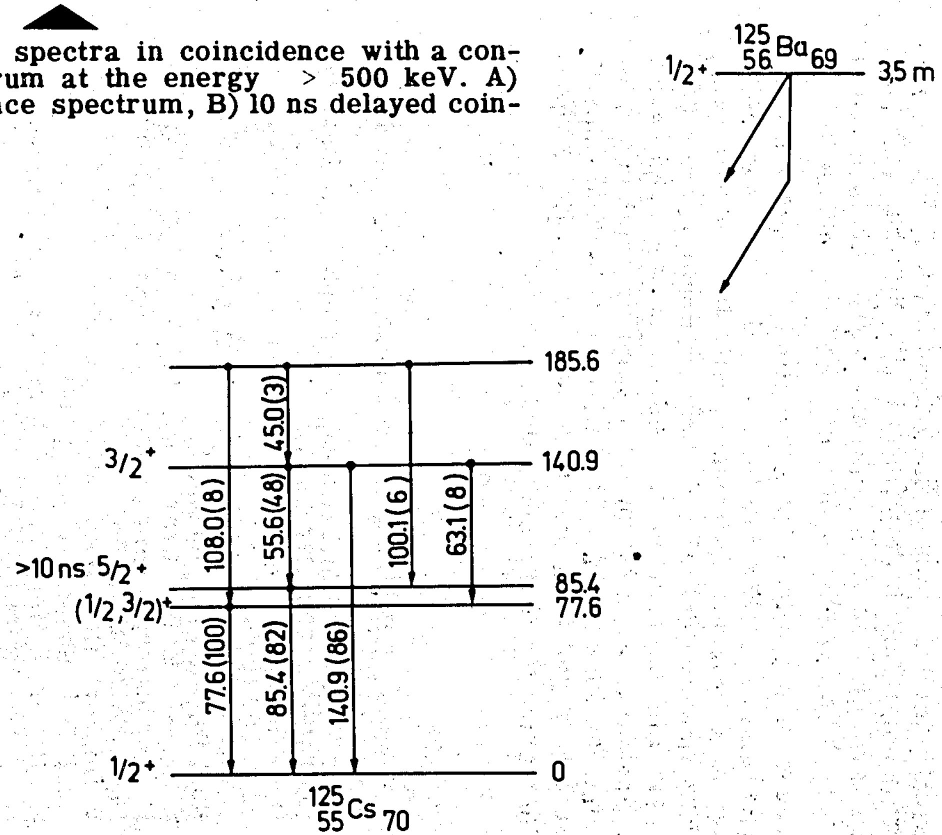

Fig. 7. Decay scheme proposed for ^{125}Ba.

cesium isotopes [26], one can see that this model is able to explain the $1/2^+$ spin of the ground state of ^{125}Cs. The experimental data of the ground states for odd Cs isotopes are also in good agreement with the theoretical ones [14, 27] predicted by the Nilsson model [28]. However, a more detailed calculation [6] gives a level sequence, for the few excited states of ^{125}Cs, far from being in satisfactory agreement with the observed one.

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