ОБЪЕДИНЕННЫЙ
ИНСТИТУТ
ЯДЕРНЫХ
ИССЛЕДОВАНИЙ
ДУБНА

E15 - 9659

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Submitted to "Nuclear Physics"

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E15 - 9659

Захват отрицательяых пионов ядрами ртути, золота и платины

В настоящей работе сообщаются результаты исследования поглощения остановившихся отрицательных пионов в мишенях ртути, золота и платины. Из распределения остаточных ядер следует, что канал реакции (π^-, xn) доминирует над вылетом заряженных частиц. Множественность вылетающих при этом нуклонов достигает $x = 16$. Обнаружено преимущественное заселение высокоспиновых изомерных состояний ядер. Рассчитанные изомерные отношения сравниваются с соответствующими значениями из других типов реакций.

Работа выполнена в Лаборатории ядерных проблем ОИЯИ.

Препринт Объединенного института ядерных исследований
Дубна 1976

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E15 - 9659

Negative Pion Capture in Mercury,Gold and
Platinum Nuclei

The results of the irradiation of natural mercury, gold and platinum targets with stopped negative pions are reported. The product nuclei distributions indicate that the (π^-, xn) reaction dominates over reactions with charged particle emission. The neutron multiplicity after pion capture can be as large as $x = 16$.

Furthermore, the preferential population of high-spin isomeric states is observed. The extracted isomeric ratios are compared with those from other reactions.

Preprint of the Joint Institute for Nuclear Research
Dubna 1976

I. INTRODUCTION

As far back as 1974, in Dubna, the new phenomenon of the excitation of high-spin nuclear states /1/ was discovered while studying the capture of stopped negative pions by Pb and Bi heavy nuclei.

Further investigations have shown /2-6/ that the high production rate of high-spin metastable states appears also in the case of pion capture by Hg , Au , Pt and Ta nuclei.

These investigations have shown that as a result of negative pion capture very neutron-deficient isotopes are produced, i.e., there is a large multiplicity (up to 16) of emitted nucleons.

The present experiment is a continuation of the series of our investigations.

II. EXPERIMENTAL PROCEDURE

II.1. Irradiations

The experiments have been performed at the Dubna synchrocyclotron. Figure 1 shows the lay-out of the bio-medical beam where irradiations took place. The 670 MeV external proton beam of the intensity of 1.5×10^{12} particles per second is focused to the pion production target made of cooper. π^--mesons

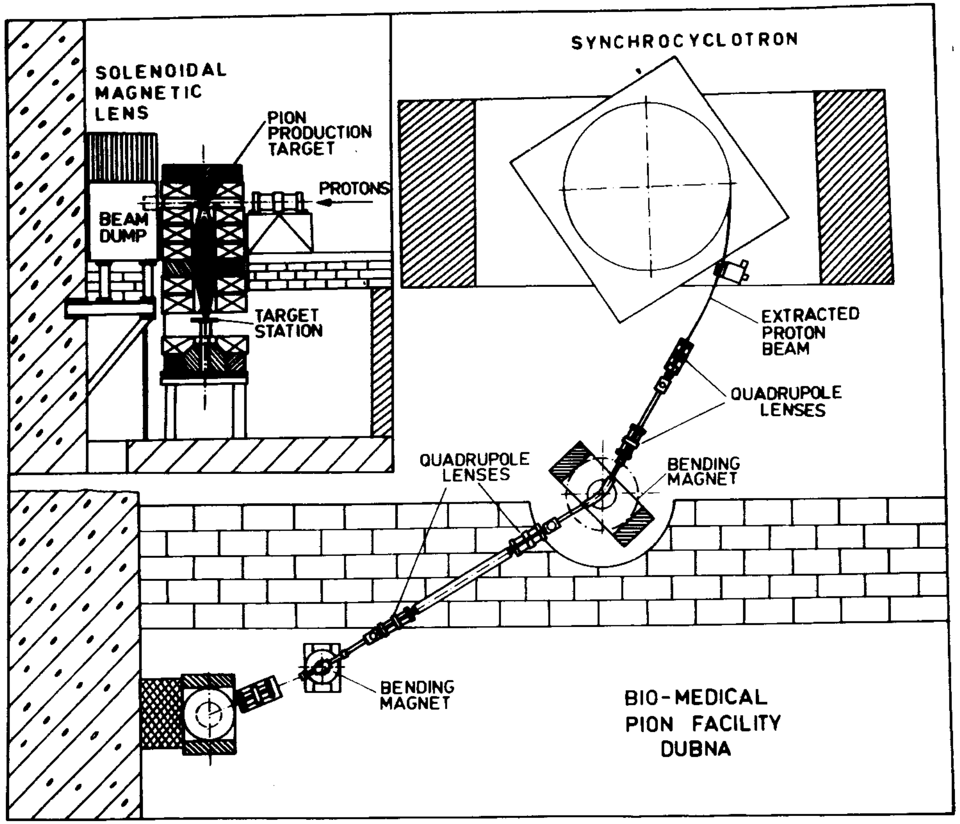

Fig. 1. Simplified scheme of the bio-medical pion beam.

of about 30 MeV were transported to the target station by means of a large acceptance solenoid magnetic coil. In this arrangement a stopping density for H_2O of $2x10^4$ pions per gramme and second has been reached/7/.

The targets were prepared as metallic plates about 1 g/cm^2 thick and about 50 cm^2 area, in the case of mercury H_2Opowder was pressed into a thin-walled plastic capsule having the same dimensions.

The targets were wrapped with a layer of 1 mm Gd foil in order to suppress reactions induced by slow neutrons. The irradiation time was chosen to correspond to half-lives of product nuclei expected.

II.2. Measurement and Spectra Evaluation

After irradiations the targets were transported to the measurement room. No chemical separation was carried out. Therefore, the full product nuclei spectrum could be studied and decayes as short as 1 minute were registered.

The spectra were measured with a Ge(Li)-detector spectrometer. For each target a few series of successive spectra were recorded and stored on the magnetic disk of the HP-2116 computer. In the course of the experiment a fast preliminary analysis of the spectra was performed/8/. After the experiment the spectra were recorded on the magnetic tape and the final analyses was performed using the BESM-6 computer with the help of the SIMP computer code/9/. Figure 2 shows typical spectra for the studied targets. For the identification of the reaction products the energies of gamma-rays and their known intensity ratios were used/10/. In some cases the assignment was verified by the decay period of the γ-activity in the successive spectra (see Fig. 3). The γ-ray intensities must be corrected for self-absorption in a thick target. A Monte Carlo programme was

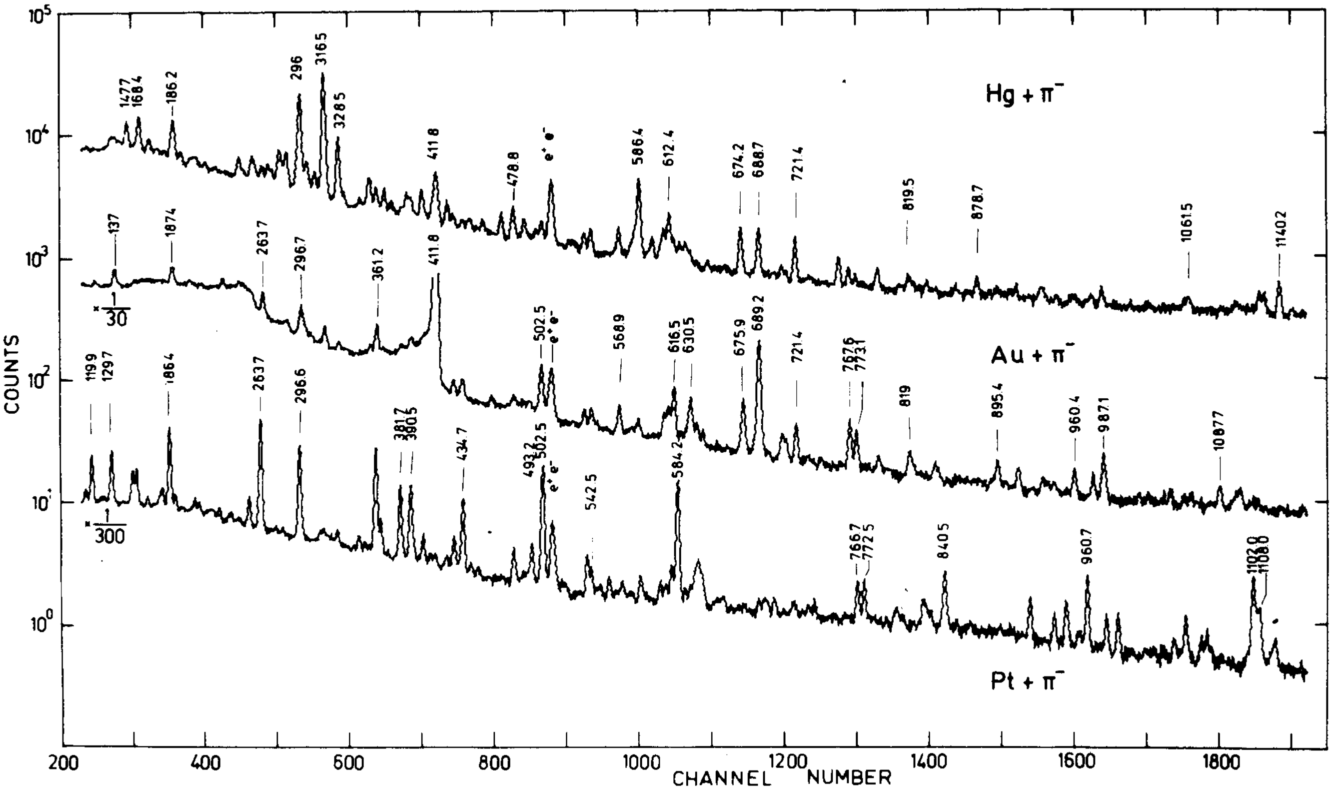

Fig. 2. Typical gamma-ray spectra from the pion irradiated Hg, Au and Pt targets.

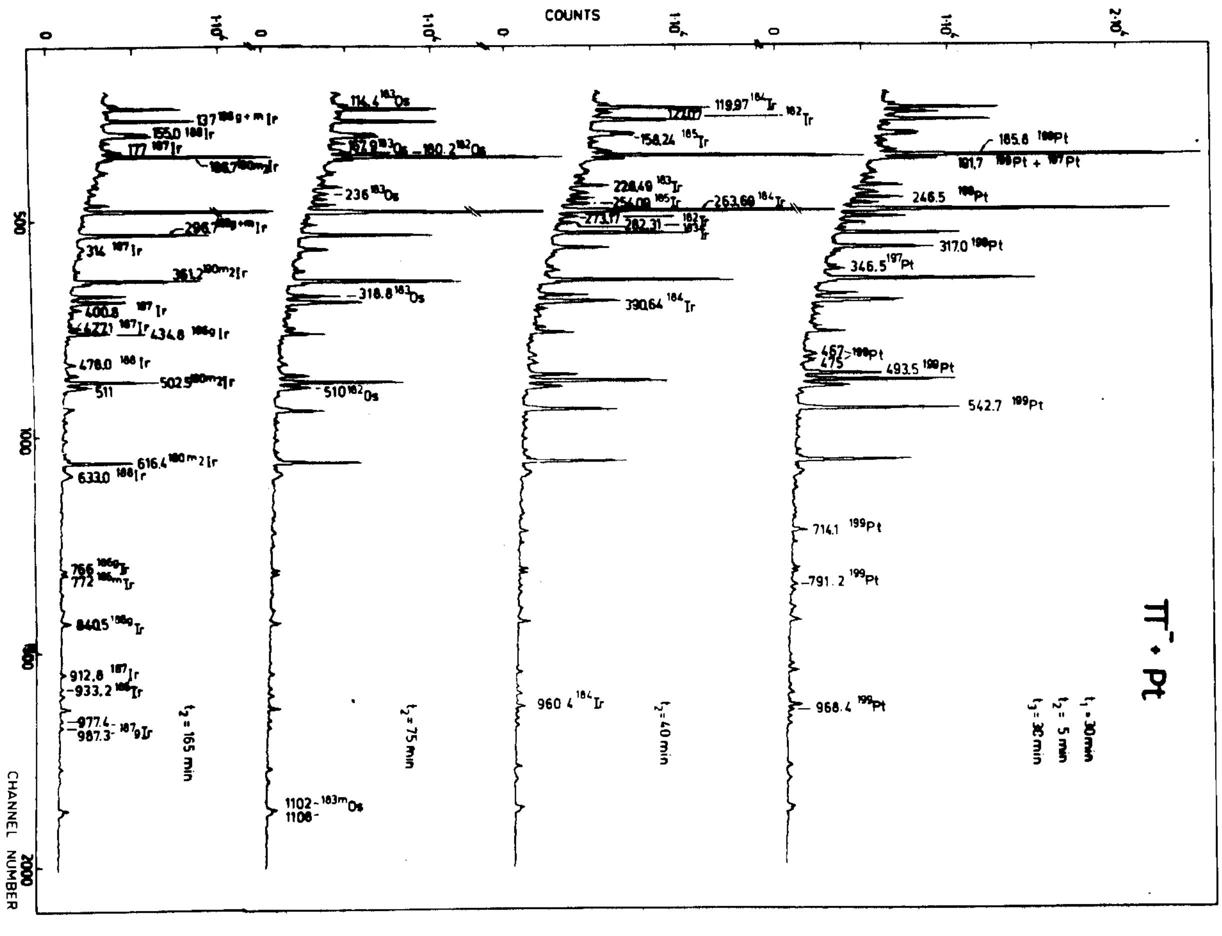

Fig. 3. Successively measured gamma-ray spectra from the Pt target.

used for the calculation of gamma-ray absorption in the true experimental geometry of the target and the detector crystal. The width of the π^--stop distribution and the beam profile, earlier determined with nuclear emulsions /11/, has lead to an approximate uniform activity distribution over the target. The gamma-ray absorption cross sections from ref./12/ have been used in the calculations. The self-absorption coefficients determined in this manner could be experimentally proved by using the yields of ^{182}Ta and ^{199}Pt which are produced by the (n,γ) reaction. Figure 4 shows the good agreement of the experimental yield with the calculated self-absorption coefficients.

III. EXPERIMENTAL RESULTS

III.1. Hg + π^-

Table 1 summarizes the identified isotopes of Au, Pt and Ir produced in the bombardment of a natural Hg-target (A = 201) with negative pions. A broad mass range is covered by the observed isotopes, that means a large number of nucleons (up to 16) is carried away following π^--absorption. The light Pt- and Ir-isotopes with A = 185...189 are produced in the decay of the corresponding Au isotopes formed in the Hg(π^-,xn)reaction. This was confirmed by the registered time behaviour of the related gamma-ray intensities.

On the other hand, the decay of the high spin isomer ^{190m}Ir was recorded. This isomer cannot be populated in the beta-decay of ^{190}Pt. An identical situation is observed for ^{194m}Ir (E_γ = 328.6 keV). In the gamma-ray

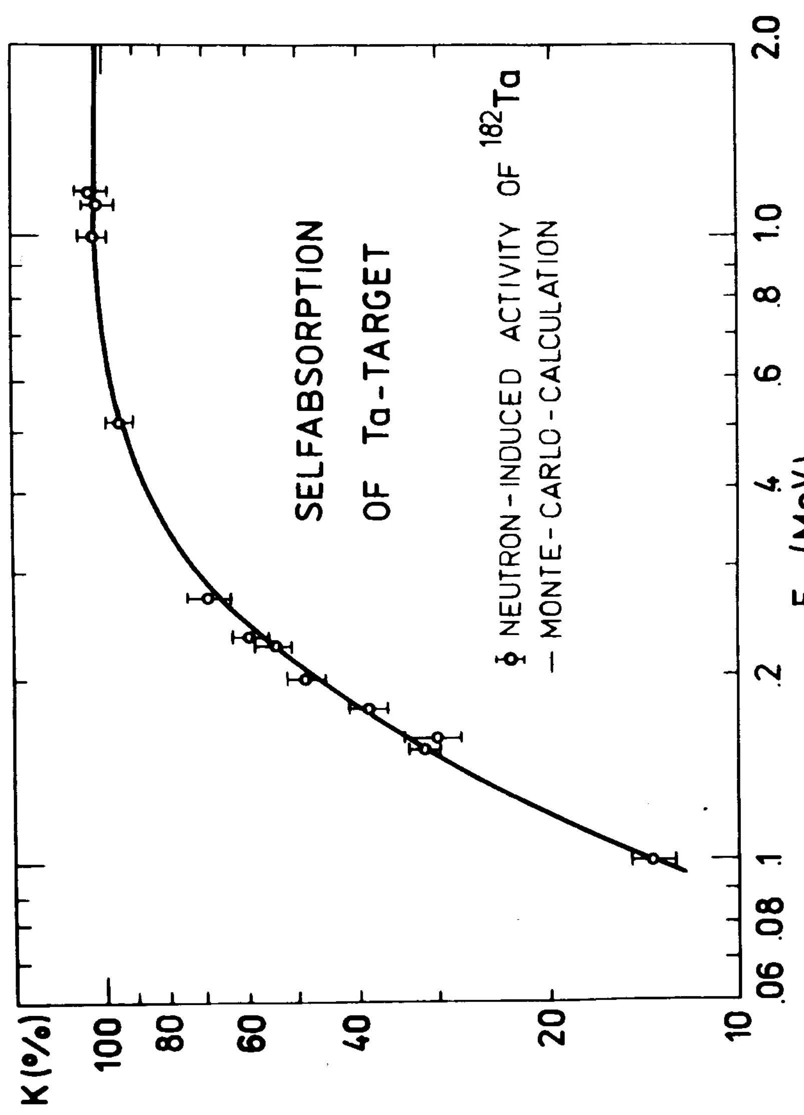

Fig. 4. The coefficients of gamma-ray self-absorption in the Ta-target.

Table 1. Isotopes (isomers) produced in the Hg + π^- reaction

A	Au $T_{1/2}$	Au J^π	Au E_γ(keV)	Pt $T_{1/2}$	Pt J^π	Pt E_γ(keV)	Ir $T_{1/2}$	Ir J^π	Ir E_γ(keV)
1	2	3	4	5	6	7	8	9	10
200	48m 19h	1^- 12^-	367.9 1225.5 120.3 133.2 137.3 144.6 255.9 332.8 368.0 497.8 579.3 759.5	11.5h	0^+	not observed			
199	3.1d	$3/2^+$	158.4 208.2	31m 14s	$5/2^-$ $13/2^+$	not observed			
198	2.7d 2.3d	2^- 12^-	411.8 675.9 97.2 180.3 204.1 214.9 333.8	∞	0^+		50s	?	not observed
197	∞ 7s	$3/2^+$ $11/2^-$	not observed	18h 80m	$1/2^-$ $13/2^+$	not observed 346.6	7m	?	not observed
196	6.2d 9.7h	2^- 12^-	333.0 355.7 426.0 668.7 137.7 147.7 168.3 174.9 188.2 264.0 285.5 316.2	∞	0^+		52s 1.4h	$(0.1)^-$ (11)	not observed
195	0.5y 30s	$3/2^+$ $11/2^-$	not observed	∞ 4d	$1/2^-$ $13/2^+$	not observed	2.5h 3.8h	$3/2^+$ $11/2^-$	not observed
194	39h	1^-	293.5 328.5 528.9 622.1 645.3 948.4	∞	0^+		19h 0.5y	1^- (11)	328.6
193	18h 4s	$3/2^+$ $11/2^-$	112.5 173.5 186.2 255.6 268.2 not observed	50y 4.3d	$1/2^-$ $13/2^+$	not observed	∞ 12d	$3/2^+$ $11/2^-$	not observed
192	5h	1^-	295.9 308.5 316.5 468.0 582.6 593.3 604.3 612.4 759.1 878.7 1061.5 1122.7 1126.9 1140.2 1422.9 1576.7 1723.1	∞	0^+		74d 1.4m 0.7y	4^- 1^+ 9^+	not observed

Table 1 (continued)

1	2	3	4	5	6	7	8	9	10
191	3.2h	$3/2^-$	136.1 194.1 244.4 277.9 284.0 386.9 390.4 399.6 408.3 421.5 478.8 487.5 525.9 586.4 620.3 674.2 702.0 732.5	2.8d	$1/2^-$	not observed	∞	$3/2^+$	
	1s	$11/2^-$	not observed				5s	$11/2^-$	not observed
190	42m	1^-	296.0 302.0 597.9 605.5 616.4	∞	0^+		11d 1.2h	4^+ 7^+	not observed
							3.2h	11^-	186.7 361.2 502.5 616.7
189	28m 4.5m	$3/2^+$ $11/2^-$	166.6 215.9 440.0 not observed	11h	$3/2^-$	141.2 203.8 223.3 243.5 300.5 317.7 544.9 568.9 607.6 627.1 721.4 792.7	13d	$3/2^+$	not observed
188	8m	?	not observed	10d	0^+	not observed	41h	2^-	not observed
187	8m	?	not observed	3h	?	106.4 179.5	11h	$3/2^+$	187.4 400.8 427.1 501.5 977.4 1112.0
186	12m	?	not observed	3h	0^+	689.2	16h 1.7h	5 2^-	137.2 296.7 434.0 630.3 636.2 767.3 773.1
185	6.8m 4.2m	? ?	not observed	1.2h 33m	? ?	not observed	14h	?	100.7 119.6 153.6 158.3 222.3 223.8 254.4 300.4 539.4

spectrum a few rather intense lines with half-lives from 1 to 4 hours and the energies $E = 374.1$, 709.2, 819.6, 1569.3, 1714.9, 1827.9, 1920.6 and 2270.9 keV could not be assigned. It is possible that they stem from the decay of unknown isomeric states. Because of the lack of data on absolute intensities for the γ-transitions of many neutron-deficient platinum and iridium isotopes it is impossible to construct the isotopic yield curve as has been done in ref./1/ for Tl -isotopes.

However, in cases where the absolute intensities of gamma-transitions are established, one can make some conclusions concerning the probabilities of different reaction channels. To get some knowledge about the dependence of residual nuclear spin on the number of emitted neutrons, isomeric ratios for Au isotopes with $A = 196$, 198 and 200 were determined. They are given in Table 2 together with the energies of gamma-transitions which have been used for this purpose. As can be seen, the $I^\pi = 12^-$ isomers were strongly populated in the $Hg(\pi^-, xn)$ reaction and the isomeric ratio grows with increasing the number of emitted neutrons.

Table 2

Isomeric ratios of the $Hg(\pi^-, xn)Au$ reaction

Isotopes	σ_m/σ_g	E(keV)	
		g	m
^{200}Au	0.16 ± 0.05	1225.5	579.3
^{198}Au	0.20 ± 0.05	411.8	214.9
^{196}Au	0.35 ± 0.07	355.7	147.7

Table 3. Isotopes (isomers) produced in the $Au + \pi^-$ reaction

A	Pt			Ir			Os		
	$T_{1/2}$	J^π	E_γ(keV)	$T_{1/2}$	J^π	E_γ(keV)	$T_{1/2}$	J^π	E_γ(keV)
1	2	3	4	5	6	7	8	9	10
196	∞	0^+		52s 1.4h	$(0,1)^-$ $(10,11)$	not observed			
195	∞ 4d	$1/2^-$ $13/2^+$	not observed	2.3h 4.2h	$3/2^+$ $11/2^-$	not observed	6.5m	?	not observed
194	∞	0^+		19h 0.5y	1^- (11)	328.5 not observed	6y	0^+	not observed
193	50y 4.3d	$1/2^-$ $13/2^+$	not observed	∞ 12d	$3/2^+$ $11/2^-$	not observed	31h	$3/2^-$	not observed
192	∞	0^+		74d 1.4m 0.7y	4^- 1^+ 9^+	not observed	∞ 6s	0^+ 10^-	not observed
191	3d	$1/2^-$	538.9	∞ 5s	$3/2^+$ $11/2^-$	not observed	15.4d 13h	$9/2^-$ $3/2^-$	not observed
190	6.10^{11}y	0^+		11d 1.2h 3.2h	4^+ 7^+ 11^-	not observed 187.4 361.2 502.5 616.7	∞ 9.9m	0^+ 10^-	187.4 361.2 502.5 616.7
189	11h	$3/2^-$	94.3 243.5 317.7 544.9 568.9 607.6 721.4 792.7 1457.8	13d	$3/2^+$	not observed	∞ 6h	$3/2^-$ $9/2^-$	not observed
188	10d	0^+	not observed	41h	2^-	not observed	∞	0^+	

Table 3(continued)

1	2	3	4	5	6	7	8	9	10
187	3h	?	106.4 110.1 122.0 201.8 284.9 304.8 709.2 819.3 895.4	11h	3/2⁺	1874 400.8 427.1 501.4 610.8 912.8 9274 9873	∞	1/2⁻	
186	3h	0⁺	611.5 689.2	16h	5	137.2 296.7 434.8 630.5 7673 773.1	∞	0⁺	
				17h	2⁻	137.2 296.7 434.8 773.1 9871			
185	12h	?	461.0 641.0 254.0	14h	?	254.4	94d	1/2⁻	not observed
184	20m	0⁺	not observed	3.2h	?	120.0 263.7 390.6 841.0 960.4	∞	0⁺	
18.	7m	?	not observed	58m	?	228.5	12h 9.9h	9/2⁺ 1/2⁻	114.4 381.8 1102 1108

III.2. Au + π^-

Pt , Ir and Os isotopes identified after irradiating an Au target with negative pions are summarized in Table 3. In the spectrum there are intense gamma-transitions (E = = 411.8, 675.9, 1087.7 keV) from ^{198}Au which are excited by the(n,γ) reaction owing to the large resonance integral for neutron capture (I_r = 1558 barn). The observed mass distribution shows that up to 14 nucleons are emitted in the pion absorption process. The isotopes of Ir and Os with A = 189 are most likely the beta-decay products of Pt - isotopes. The ^{190}Ir and ^{194}Ir isotopes, however, cannot be produced in the beta-decay, they are therefore products of the primary pion induced reaction (see, Section IV).

III.3. Pt + π^-

Table 4 presents the results of the Pt - target irradiations. The major part of the observed γ-rays belongs to Ir isotopes. Again the number of emitted neutrons reaches 15. In addition to Ir nuclei, Os isotopes with A = 182, 183 and 190 were registered. They are daughter products of Ir -isotopes. No gamma-ray pattern connected with one of the Re isotopes could be identified. For the gamma-rays of the energies of 208.0, 308.2, 351.8, 569.0, 696.7, 822.1, 942.7 and 1062.7 keV no assignment of known isotopes could be made. Otherwise, it cannot be excluded that these lines belong to the decays of yet unknown isomers. On one case where the Pt target without the surrounding Gd layer was exposed to the beam numerous

Table 4. Isotopes (isomers) produced in the Pt + π^- reaction.

A	Ir			Os			Re		
	$T_{1/2}$	J^{π}	E_{γ}(keV)	$T_{1/2}$	J^{π}	E_{γ}(keV)	$T_{1/2}$	J^{π}	E_{γ}(keV)
1	2	3	4	5	6	7	8	9	10
196	52s 1.4h	$(0.1)^-$ (10,11)	not observed 355						
195	2.3h 4.2h	$3/2^+$ $11/2^-$	99.0 129.8 172.3 211.5 239.5 251.7 319.8 359.0 364.8 427.0 432.8 684.5	6.5m	?	not observed			
194	19h 0.5y	1^- (10,11)	328.5 not observed	6y	0^+	not observed			
193	∞ 12d	$3/2^+$ $11/2^-$	not observed	31h	$3/2^-$	not observed			
192	74d 1.4m 0.7y	4^- 1^+ 9^+	not observed	∞ 6s	0^+ 10^-	not observed	16s	?	not observed
191	∞ 5s	$3/2^+$ $11/2^-$	not observed	15d 13h	$9/2^-$ $3/2^-$	not observed	9.8m	?	not observed
190	11d 1.2h 3.2h	4^+ 7^+ 11^-	186.7 407.2 518.4 557.8 605.3 not observed 186.7 361.2 502.5 616.4	∞ 9.9m	0^+ 10^-	186.7 361.2 502.5 616.4	2.8m 2.8h	$3,4^-$?	not observed
189	13d	$3/2^+$	not observed	∞ 6h	$3/2^-$ $9/2^-$	not observed	24h	$5/2^+$	not observed
188	41h	2^-	155.0 478.0 633.0	∞	0^+		17h	1^-	not observed

Table 4 (continued)

1	2	3	4	5	6	7	8	9	10
187	11h	$3/2^+$	177.7 187.4 314.2 323.1 400.9 427.1 491.7 501.5 610.9 725.7 799.9 912.8 977.4 987.3	∞	$1/2^-$		∞	$5/2^+$	
186	16h 1.7h	5 2^-	137.2 296.7 364.9 420.7 434.8 584.4 622.1 630.3 636.2 767.3 773.1 841.3 933.2 1057.1 137.2 296.7 630.3 773.1	∞	0^+		∞ 90h	8^+ 1^-	
185	14h	?	158.2 254.1	94d	$1/2^-$	not observed	∞	$5/2^+$	
184	3.2h	?	120.0 263.7 390.6 960.4	∞	0^+		38d 0.4y	3^- 8^+	not observed
183	58m	?	228.5 282.3	12h 9.9h	$9/2^+$ $1/2^-$	114.4 167.3 236.2 381.8 1102 1108	71d	$5/2^+$	not observed
182	15m	(3)	127.1 273.2	22h	0^+	180.2 510.2	64h 13h	$6,7^+$ 2^+	not observed

gamma-transitions from the odd Pt isotopes produced via the (n,γ) reaction were recorded: ^{191}Pt (538.8 keV), ^{193}Pt(135.5 keV), ^{195}Pt (99 keV), ^{197}Pt (191.7, 346.5 keV), ^{199}Pt (185.5, 191.7, 219.4, 246.5, 317.0, 323.5, 417.5, 467.0,...keV). As has been mentioned earlier, the intensities of the ^{199}Pt-transitions were used to check the calculated self-absorption coefficients. In the Pt(π^-,xn) reaction the high spin isomers in ^{186}Ir and ^{109}Ir with $I^\pi = 11^-$ are strongly populated. From the intensity ratio of the gamma-transitions in the ^{190m}Ir decay ($T_{1/2} = 3.2$ h, E_γ 361.2 and 616.4 keV) and ^{190g}Ir ($T_{1/2} = 12$ d, $E = 518.5$ keV) the isomeric ratio $\sigma_m/\sigma_g = 0.25$ (5) was determined. Since the gamma-transition intensities for ^{186}Ir are uncertain, only an estimate of 0.2 can be given in this case for the isomeric ratio.

IV. DISCUSSION

IV.1. Emission of Charged Particles

The emission of the charged particles (p,d and t) following π^--absorption is usually studied employing the direct registration of these particles /13,14/. Since the main interest of these investigations was focused on the possibility of π^--absorption by alpha-clusters in the nucleus, the registration threshold was as high as 17 to 24 MeV (ref./13/) and 6 to 9 MeV (ref. /14/). The probability of charged particle emission may, for that reason, be higher than that reported in /13,14/. The method presented in this paper based on the registration of residual

nuclei has essentially no threshold. This type of experiment may, therefore, be more sensitive to the determination of the probability of charged particle emission following π^--capture.

Since the majority of the observed isotopes with Z-2 and Z-3 (Z is the atomic number of the target nucleus) can be explained as decay products from isotopes with Z-1, it is evident that the emission of charged particles is, in general, small compared with neutron emission. The small probabilities for charged particle emission measured by means of particle registration are therefore not caused by the experimental thresholds used but may be explained in terms of the high Coulomb barrier in heavy nuclei and small absorption probabilities for pions by alpha-clusters and pp-pairs in comparison with np-pairs.

However, in two cases the identified isotopes with Z-2 and Z-3 can only be formed in negative pion absorption accompanied by the emission of single-charged particles (p,d,t).

The ^{190}Ir and ^{194}Ir isotopes detected in the Au + π^- runs cannot be produced via the β-decay from Pt and Os, respectively, ^{190}Pt has the half-life of 6×10^{11} years and ^{194}Os cannot be reached in the ^{197}Au+π^- reaction. At present long-lived isomers in the even Pt-isotope which could undergo β-decay are not known, but the existence of such isomers with probably high spin cannot be excluded /6/.

The emission of p,d and t particles can be understood as governed by the capture of the pion to alpha-clusters or pp-pairs in the $\pi^- + \alpha \rightarrow p3n$, $d2n$, tn or $pp + \pi^- \rightarrow np$ reactions.

Our results allow one to point out the following features:

- The yields of the neighbouring isotopes ^{189}Pt and ^{190}Ir from the Au+π^-experiment with neutron and charged particle emission, respectively, are compared. The ratio Y_{Ir}/Y_{Pt} = =1.2 (1) shows that despite the small total probability in single cases charged particle emission can compete with neutron emission.
- The $I^{\pi}=11^-$ isomeric state population indicates also in the case of ^{190}Ir produced in the Au+π^- reaction that the excitation of high-spin states takes place not only in neutron emission alone but also in the charged particle one. The experimental facts emphasize the importance of direct processes for the formation of high-spin states.
- The ^{190}Ir and ^{194}Ir isotopes observed as products of the Hg+π^- reaction cannot be formed in a series of radioactive decays from Z-1 or Z-2 nuclei. The reactions of $(\pi^-, \alpha xn)$ or $(\pi^-, ppxn)$ type should occur to yield these nuclei. The emission of alpha-particles in pion absorption has been earlier discussed /15/ only for light nuclei.

IV.2. Isomeric Ratios

From the comparison of experimental isomeric yields in the reactions of the known brought-in angular momentum and pion capture, an estimate for the angular momentum of the nucleus remaining after pion absorption can be made. Since the isomeric ratios in Au in the reactions Hg(π^-, xn) with $\sigma_m/\sigma_g = 0.35$ and ^{192}Os(^{11}B, α3n) $\sigma_m/\sigma_g = 0.36$ /16/ are almost the same, the nucleus after pion absorption should acquire about the same amount of the angular momentum I = 15ħ. The isomeric ratio for ^{190}Ir from the Pt(π^-, xn) reaction $\sigma_m/\sigma_g = 0.25$ (5) is one order of magnitude larger than that from the ^{190}Os(d, 2n)-reaction $\sigma_m/\sigma_g = 0.025$ where the deuteron brings into the system about I = 5ħ only /16/. This fact indicates that the product nuclei after pion absorption start their de-excitation path from the states with a sufficiently high angular momentum. The earlier reported unusually high isomeric ratio for ^{198}Tl in the Pb(π^-, xn) reaction of $\sigma_m/\sigma_g = 5.0$ /1/ can be interpreted as due to the moderate spin of $I^{\pi} = 7^+$ for ^{198m}Tl where most of the de-excitation paths may be trapped.

The result presented in this paper confirms again the intensive excitation of high spin states in product nuclei after π^--absorption.

Recently reported measurements of Ebersold et al. /17/ are in good agreement with this conclusion. In these in-beam experiments after the irradiation of ^{175}Lu and ^{165}Ho targets the rotational bands of the even Yb-and Dy-isotopes could be followed up to the terms with I = 12ħ. Finally, one can see from Table 2 that for identical spin and parity of the isomeric states the isomeric ratio depends on the number of emitted neutrons. This dependence has been established by using a natural target, therefore, quantitative conclusions cannot be made. The observed fact, however, evidences for a rather complex mechanism of forming the product nuclei angular momentum distribution in the pion absorption reaction.

ACKNOWLEDGEMENTS

The authors are grateful to Profs. V.P.Dzhelepov and L.I.Lapidus for the support of this investigation. Thanks are due to Dr. O.V.Savchenko for providing excellent experimental conditions at the bio-medical beam facility. The clarifying discussions with Prof. V.G.Soloviev, Dr. A.C.Iljinov and S.E.Chigrinov are greatly acknowledged.

REFERENCES

1. V.S.Butsev, Dz.Ganzorig, S.M.Polikanov, D.Chultem. XXV Meeting on Nuclear Spectroscopy and Nuclear Structure, Leningrad, 1975, p. 150.
2. V.S.Butsev, Yu.K.Gavrilov, Dz.Ganzorig, S.M.Polikanov, D.Chultem. JETP Lett., 21, 400 (1975), JINR, E6-8535, Dubna, 1975.
3. V.S.Butsev, J.Vandlik, Ts.Vylov, Dz.Ganzorig, L.Gumnerova, M.G.Zaitseva, S.M.Polikanov, O.V.Savchenko, D.Chultem. JINR, P6-8541, Dubna, 1975.
4. S.R.Avramov, V.S.Butsev, D.Chultem, Yu.K.Gavrilov, Dz.Ganzorig, S.M.Polikanov. VI Int. Conf. on High Energy Physics and Nuclear Structure, Santa-Fe, 1975, Contributed Papers, p. 190. V.M.Abazov, V.S.Butsev, Yu.K.Gavrilov, Dz.Ganzorig, S.M.Polikanov, E.P.Cherevatenko, D.Chultem. XIV Meeting on Nuclear Spectroscopy and Nuclear Theory, Dubna, 1975, p. 154.
5. S.R.Avramov, V.S.Butsev, Yu.K.Gavrilov, Dz.Ganzorig, S.M.Polikanov, W.D.Fromm, D.Chultem. XIV Meeting on Nuclear Spectroscopy and Nuclear Theory, Dubna, 1975, p. 141.
6. V.S.Butsev, Yu.K.Gavrilov, Dz.Ganzorig, D.Chultem. XIV Meeting on Nuclear Spectroscopy and Nuclear Theory, Dubna, 1975, p. 156.
7. V.M.Abazov, V.P.Dzhelepov, E.S.Kuzmin, A.G.Molokanov, O.V.Savchenko, E.P.Cherevatenko, G.P.Reshetnikov. JINR, P13-8079, Dubna, 1974.
8. S.R.Avramov, V.S.Butsev, A.V.Gusev, W.D.Fromm. JINR, 10-9095, Dubna, 1975. W.D.Fromm. JINR, 10-9094, Dubna, 1975.
9. S.R.Avramov, V.M.Tsupko-Sitnikov. XIV Meeting on Nuclear Spectroscopy and Nuclear Thepry, Dubna, 1975, p. 161.
10. Atomic Data and Nuclear Data Tables, 13, No. 2,3 (1974).
11. Yu.A.Batusov, D.Chultem, Dz.Ganzorig, O.Otgonsuren. JINR, P15-8917, Dubna, 1975.
12. W.I.Veigele. Atomic Data, 5, 51 (1973). E.Storm, H.I.Israel. Nuclear Data Tables, 7, 565 (1970).
13. Yu.G.Budyashov, V.G.Zinov, A.D.Konin, A.M.Chatrchian. JETP, 62, 21 (1972).
14. P.S.Castleberry, L.Coulson, R.C.Minehart, K.O.H.Ziock. Phys.Lett., 34B, 57 (1971).
15. D.Ashery, M.Faider, Y.Shamai, S.Covachi, M.A.Moinester, A.I.Yavin, E.Alster. Phys.Rev.Lett., 32, 943 (1974). H.Ulrich, E.T.Boschitz, H.D.Engerhardt, C.W.Lewis. Phys.Rev.Lett., 33, 433 (1973).

V.G.Lind, H.S.Plendl, H.O.Funsten, W.E.Kossler, B.E.Lieb, W.F.Lankford, A.E.Buffa. Phys.Rev.Lett., 32, 479 (1974).

16. G.N.Flerov, Yu.P.Gangrski, B.N.Markov, A.A.Pleve, S.M.Polikanov, H.Jungclaussen. Yad.Fiz., 6, 17 (1967).
17. P.Ebersold, B.Aas, W.Dey, R.Eichler, H.J.Leisi, W.W.Sapp, H.K.Walter. Phys. Lett., 58B, 428 (1975).

Received by Publishing Department
on March 29, 1976.