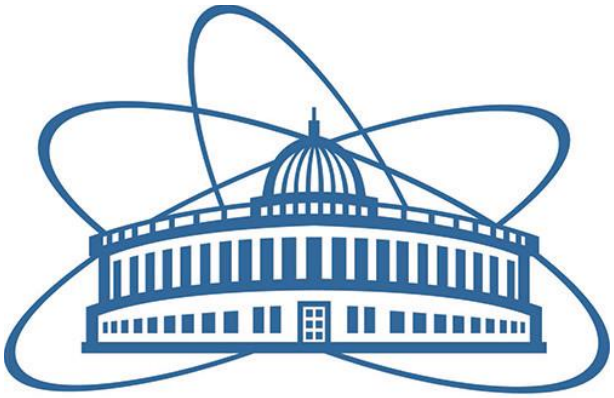

JOINT INSTITUTE
FOR NUCLEAR RESEARCH

Determination of masses of the super heavy elements in the experiments on synthesis of Cn and Fl using the reactions 48Ca + 242Pu and 48Ca + 244Pu

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1. Abstract

The study of heavy elements, which have a relatively short half-life, requires accurate knowledge of the branches of physics and chemistry, and the study of the nuclear part of atoms. When studying the element copernicium, both the cyclotron and the spectrometer are used due to the low half-life of this element. Mass Analyzer of Heavy Atoms (MASHA) can also be used to predict the existence of elements in the future.

2. Introduction

Element types classified as superheavy elements (SHE) have proton numbers (Z) of 104 or higher. Using particle accelerators, these elements are created by fusing the atomic nuclei of lighter elements. Throughout the past few decades, there have been a significant growth of chemical components. The fact that these man-made, heavy elements are found near the long-awaited superheavy elements at the extreme end of the Periodic Table is particularly interesting. While physical methods now dominate these findings, superheavy elements' chemistry is now starting to be established. The chemical characteristics of these elusive elements can be explored using sophisticated and incredibly sensitive techniques. Less than ten short-lived atoms, chemically separated one atom at a time, frequently offer critical details on fundamental chemical characteristics. These findings investigate the design of the far end of the Periodic Table and the ever more potent relativistic effects that affect its chemical characteristics.[1]

3.Over view

3.1 Copernicium

Sigurd Hofmann reported the discovery of element 112 in 1996, and the Gesellschaft für Schwerionenforschung (GSI) in Darmstadt, Germany, synthesised the first atoms of the element that year. Isotope-277 was created by irradiating lead for two weeks with zinc accelerated to 30,000 km/s. The half-life of isotope-277 was 0.24 milliseconds.Since then, other copernicium isotopes have been created. At the Joint Institute for Nuclear Research (JINR) in Dubna, Russia, where flerovium (element 114) was created, isotope-285 and isotope-284 were both observed as part of the decay sequence of livermorium (element 116).

The crust of the Earth does not normally contain copernicium. Other than for scientific research, there are no known isotope applications for copernicium.[2]

3.2 Flerovium

The crust of the Earth does not naturally contain flerovium. Flerovium was given that name in honour of the Joint Institute for Nuclear Research's Flerov Laboratory for Nuclear Reactions (JIRN). Flerovium was created in 1999 by a team of scientists from the Lawrence Livermore Laboratory in the United States and the Joint Institute for Nuclear Research in Dubna, Russia. They eventually produced 287Fl through cross-bombardments of 48Ca with both (even-A) 242Pu and (odd-A) 245Cm using nuclear reaction experiments. The synthesis of flerovium (atomic numbers 668 and 669) was confirmed by the observation of the intermediate nuclide 283Cn with known

decay properties. Other than for scientific research, there are no known isotopic applications for flerovium.[3]

4.Mass Analyzer of Super Heavy Atoms.

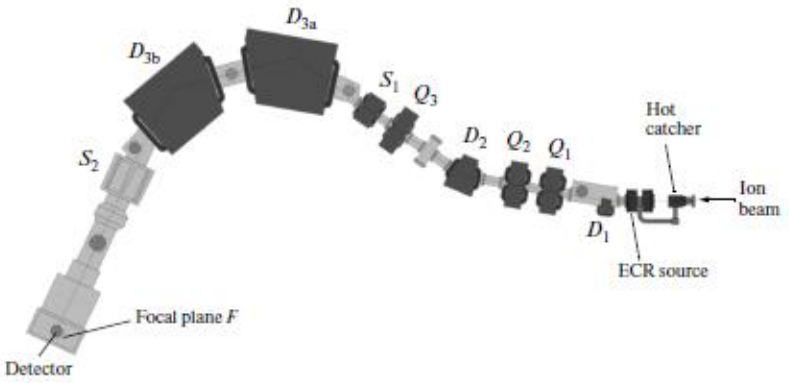


Fig. 1. Schematic diagram of the MASHA mass separator: (D_1, D_2, D_{3a}, D_{3b}) dipole magnets, (Q_1, Q_2, Q_3) quadrupole lenses, and (S_1, S_2) sextupole lenses. The detection system is in focal plane F of the separator.

The setup, the layout of which is shown in this Fig. consists of the target assembly with a hot catcher; an\sion source based on the electron cyclotron resonance (ECR); a magneto-optical analyzer (a mass spectromteter) composed of four dipole magnets(D1, D2, D3a,and D3b), three quadrupole lenses (Q1-Q3), and two sextupole lenses (S1, S2); and a detection system \slocated in the focal plane of the spectrometer. Comprehensive consideration was given to the mass spectrometer's ionoptical system in In this section, we outline several setup components and provide the findings of measurements of the essential separator features.[4]

4.1 **Ion Source**

For ionizing the atoms of nuclear reaction products, an ion source based on the ECR (the ECR source) with a 2.45GHz frequency of its microwave oscillator has been chosen. By choosing the microwave radiation's power, frequency, and buffer gas pressure in the ioniser chamber, the operating modes of the ECR source were

optimised. As a buffer gas, helium was used, and a controlled piezoelectric valve was used to manage its pressure.

4.2 A Target Assembly and a Hot Catcher

Products of full fusion reactions were introduced into the ECR source using a hot catcher. The hot catcher is a physical component of the target. The electrostatic induction sensor's split-type aperture and a Faraday cup make up the diagnostic system that the principal beam of heavy ions passes through before striking the target. The beam current fraction that does not enter the aperture hole is measured in each of the four sectors that make up the split aperture.

4.3 Detection and Control System

To change the ECR source's working modes, a specialised strip detector for monitoring low direct currents was created. It appears like a cop per multistrip construction on a fiber-glass plastic and is an identical replica of the frontal portion of the silicon detector. There are 192 total strips in the structure, with a 1.25 mm pitch. This detector was attached to the silicon detector using the vacuum-tight feedthrough after the mass spectrometer was tuned and calibrated. To measure the low currents, a unique multichannel electronic module was created for this detector. 64 channels are used in one module. A single channel's lower threshold is 60 pA, and its top limit is 5 A. The detectors and vacuum chamber have the electronic modules installed outside. A specialised interface card transmits the data from the modules straight to a personal computer.

The tests employ two separate data gathering routines, one for the silicon detector and the other for the strip detector that measures

low direct currents. One-dimensional energy spectra from each strip as well as two-dimensional spectra of the energy dependency on the strip number for each crystal can be seen using the software maintaining the silicon detector. The 192 currents on the focus plane can be seen in the strip detector's spectra, which is refreshed every second.

5. Method

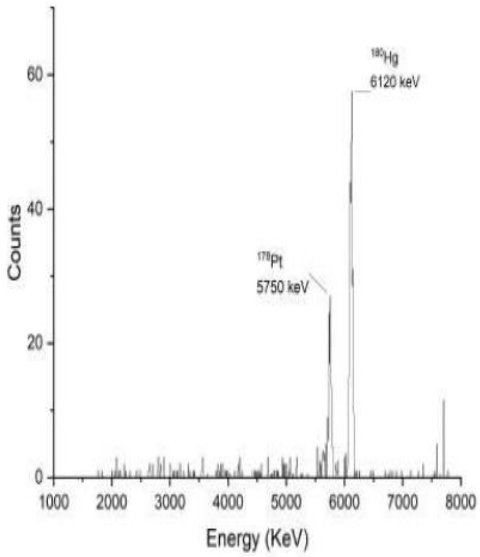
The programme Origin was used to evaluate the data obtained (Origin-Lab Corporation)

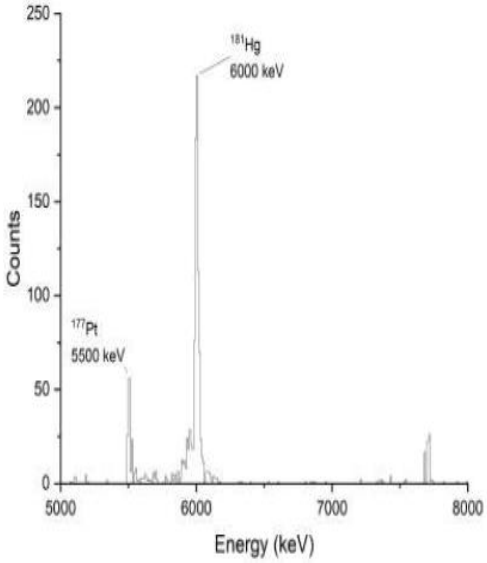
The breakdown of alpha particles is found to modify the masses of the reactants and products, and the half-life of each product is investigated.

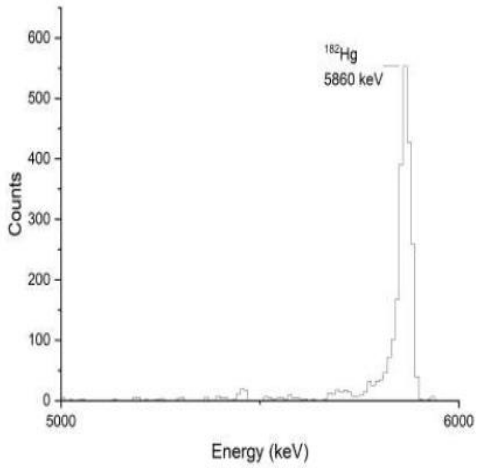
6. Reaction

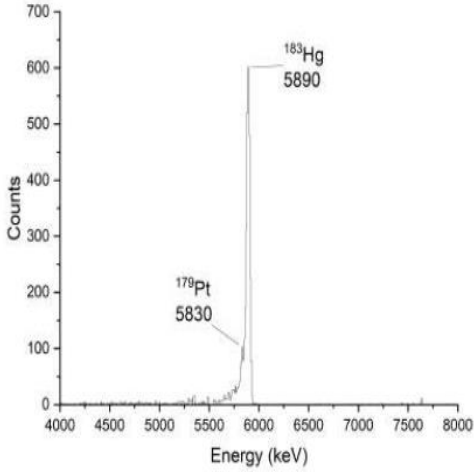
The three reactions (40 Ar+148Sm, 40 Ar+166Er, and 48 Ca+242Pu) will be used to investigate the synthesis of Hg and Rn. Each isotope's spectrum is plotted and further analysed, and a heat map for each reaction is created to show the data.[6],[7]

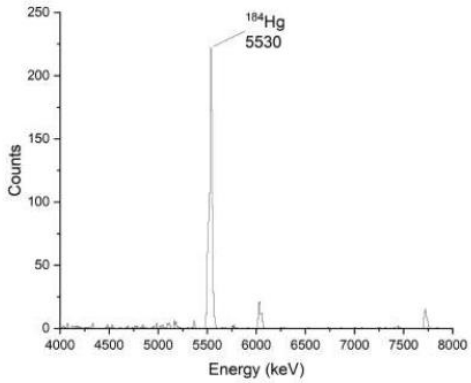
6.1 $^{40}Ar + ^{144}Sm \rightarrow ^{188-xn}Hg + xn$

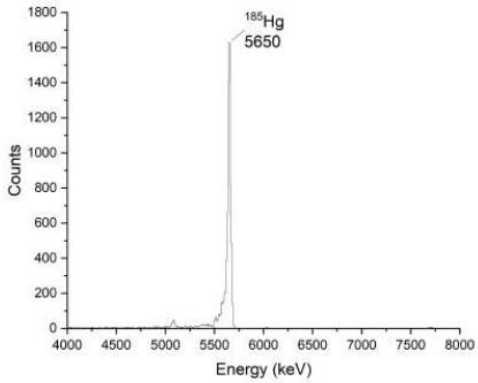

Counts
Energy (KeV)
180Hg
6120 keV
179Pt
5750 keV

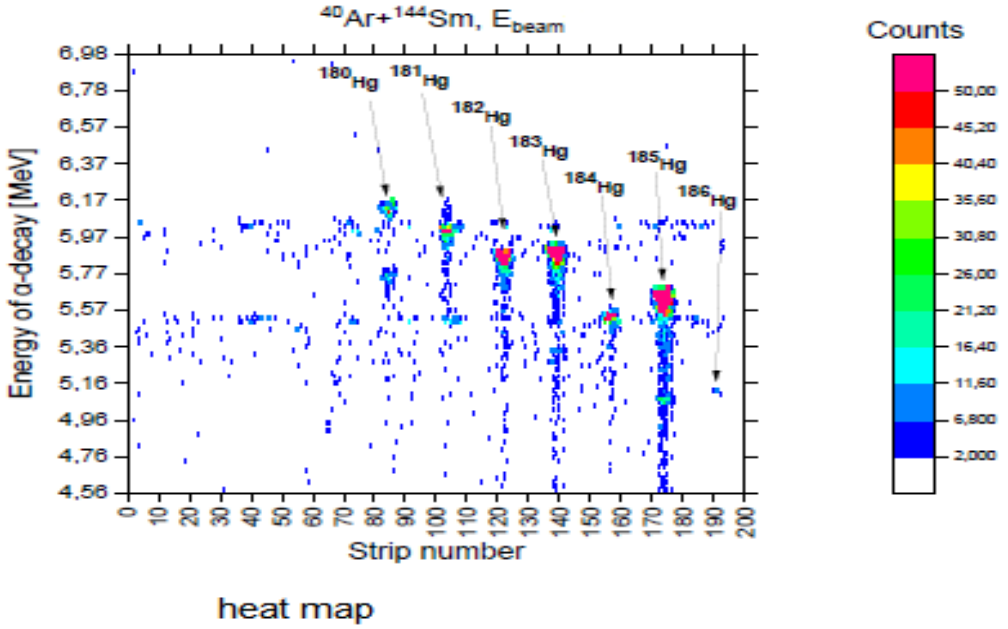

Counts
Energy (keV)
181Hg
6000 keV
177Pt
5500 keV


Counts
Energy (keV)
182Hg
5860 keV


Counts
Energy (keV)
183Hg
5890
179Pt
5830

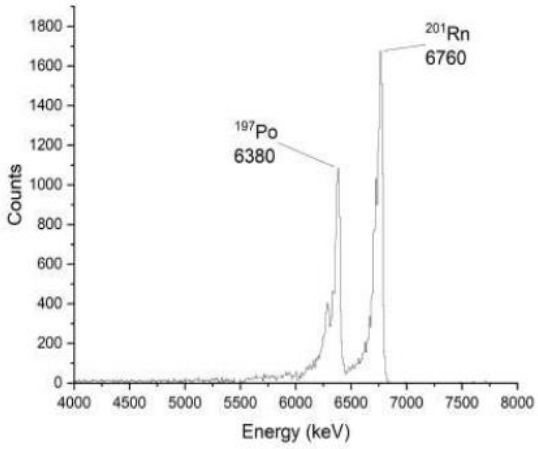


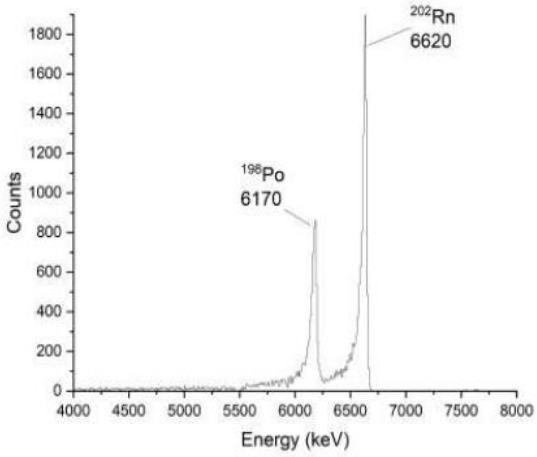


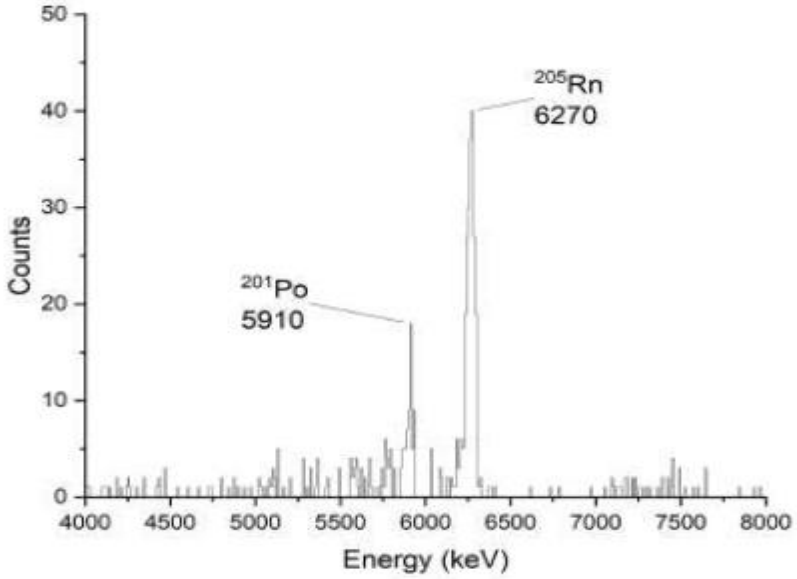


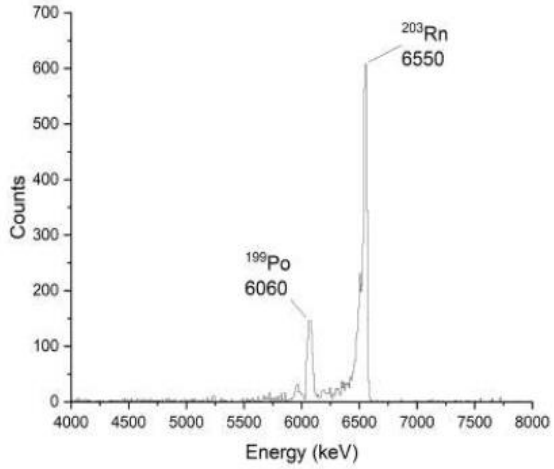
heat map

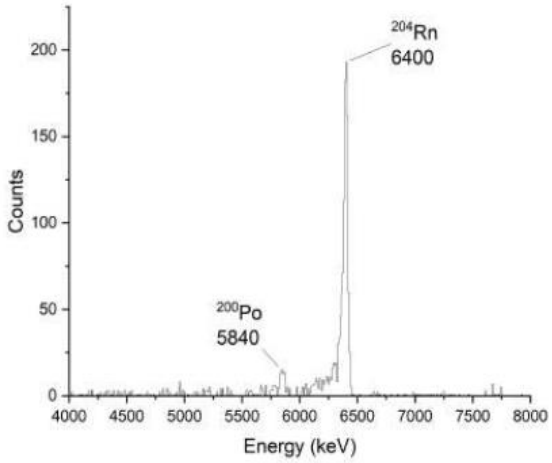
6.2 40Ar + 166Er → 206-xnRn + xn

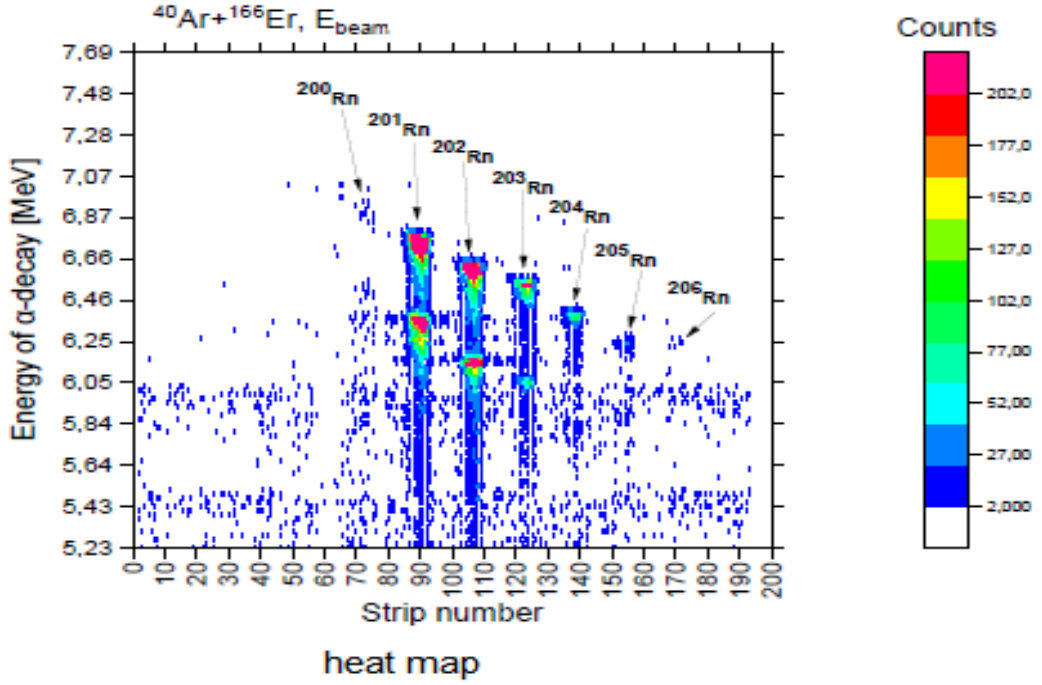

Counts
Energy (keV)
^{201}Rn
6760
^{197}Po
6380


Counts
Energy (keV)
^{202}Rn
6620
^{198}Po
6170

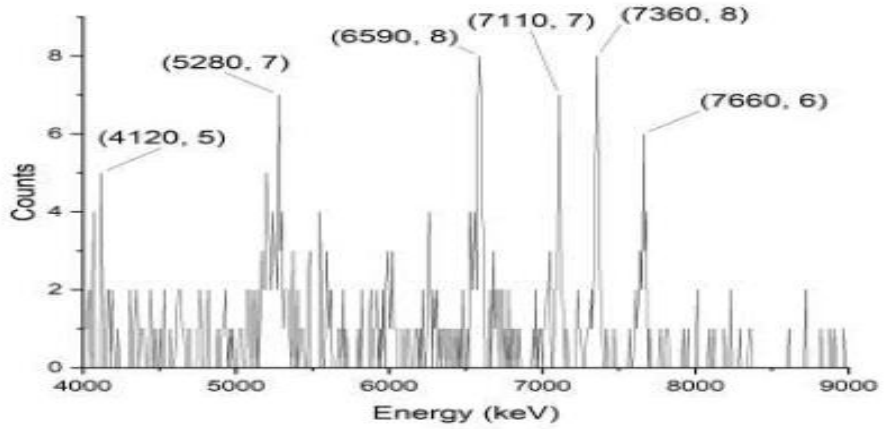

Counts
Energy (keV)
^{205}Rn
6270
^{201}Po
5910

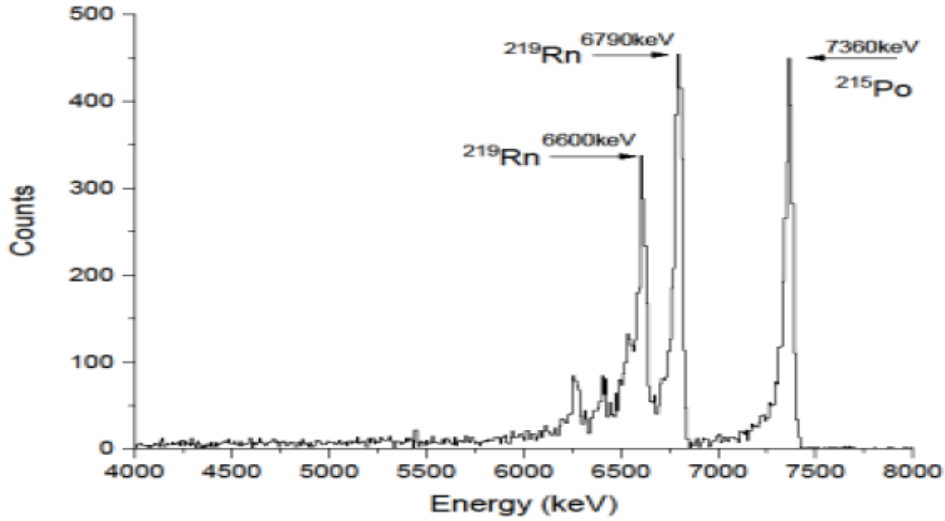


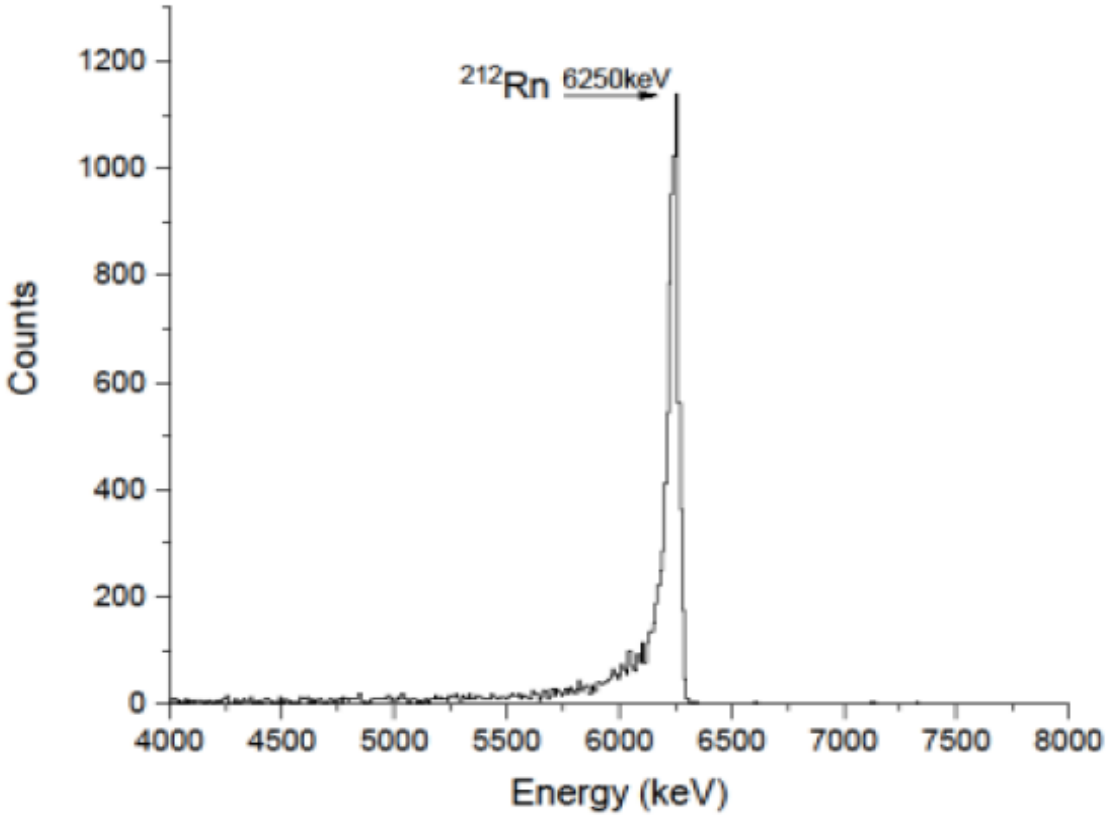


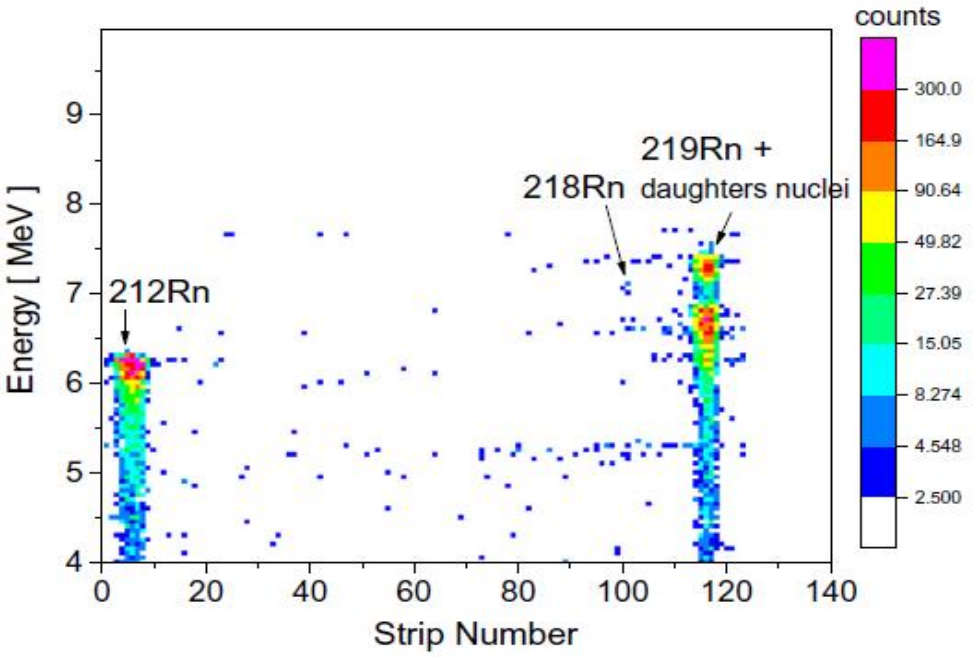


6.3 48Ca + 242Pu → Rn


(4120, 5)
(5280, 7)
(6590, 8)
(7110, 7)
(7360, 8)
(7660, 6)
Counts
Energy (keV)


219Rn 6790keV
7360keV
215Po
219Rn 6600keV
Counts
Energy (keV)


^{212}Rn 6250keV
Counts
Energy (keV)
0
200
400
600
800
1000
1200
4000
4500
5000
5500
6000
6500
7000
7500
8000


counts
300.0
164.9
90.64
49.82
27.39
15.05
8.274
4.548
2.500
219Rn +
daughters nuclei
218Rn
212Rn
Energy [MeV]
Strip Number
4
5
6
7
8
9
0
20
40
60
80
100
120
140

Heat map

7. Conclusion

After studying the merger of heavy elements, this opens the door to predicting the presence of elements that can be absorbed by the periodic table, and may lead us to discover new orbits, and this will depend on the extent of the existence of modern technology.

8. Acknowledgments

Investigations. I would especially like to thank my boss, Vyacheslav Vedeneyev, for having me, for his support of my work, and for the "jinr" institute. It was a remarkable encounter

9.Reference

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3-https://pubchem.ncbi.nlm.nih.gov/element/Flerovium#section=Description

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