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

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Abstract

Graphing and calibration of strip detector of various results from fusion reactions of ^{40}Ar+^{148}Sm, ^{40}Ar+^{166}Er and ^{48}Ca+^{242}Pu that yield to superheavy elements (SHE) in MASHA facility with cross-section of units of the nanobarns, with a constant, pre-determined separation efficiency by the materials of the hot catcher and its physical and chemical properties.

Introduction

Here we discuss and analyse the data obtained from the experiments performed at JINR by bombarding targets like ^{144}Sm, ^{166}Er and ^{242}Pu by accelerated ions. which results in the full fusion reactions leading to Hg and Rn used because: 1. Products are volatile; 2. Hg is a homologue of a ^{112}Cn, so it keeps itself like SHE. 3. The yields of it is many orders higher, so it's applicable to get statistics in a relatively short time.

Installation (Main Parts and Description)

Ion-Optical Layout: A magneto-optical mass-to-charge ratio analyzer consists of: I. four dipole magnets (D1, D2,D3a, D3b) II. three quadrupole lenses (Q1, Q2, Q3) III. two sixtupile lenses (S1, S2) IV. Focal plane detector system.[1]
Target box (Rotating targets + hot catcher): uses a block of rotating targets, assembled into cassettes, the disc rotates at frequency of 25 Hz, the rotating target used in this case yields to higher efficiency and heat distribution. The Ion beam collide with the target, then the reaction products are stopped in a graphite foil heated up to 1500-2000 K. the products then are diffused in the form of atoms to the vacuum chamber and ejected to the (ECR Ion source)[1][4].
Electron Cyclotron Resonance (ECR) Ion source: After the atoms are ejected from the hot catcher they are ionized to the state (Q=+1) then accelerated by a three-electrode electrostatic lens to 40KeV. Operates at microwave generator frequency of 2.45GHz.
Detectors and control system: Consists of multiple detectors: (1) a multi-strip copper structure fixed on the surface of glass-cloth laminate. It has an area of 240×35 mm^2 and consists of 192 strips with a pitch of 1.25 mm. (2)upper and lower detectors have 64 strips. (3)The left and right lateral ones each had 16 strips. All detectors had the same thickness of 300 μm. At the entrance their dead layer thickness was no more than 50 nm The standard bias of the detectors was -40 V. They are used to determine the energies of the emitted alpha and the fission. (more illustrations in [1],[2])

Method

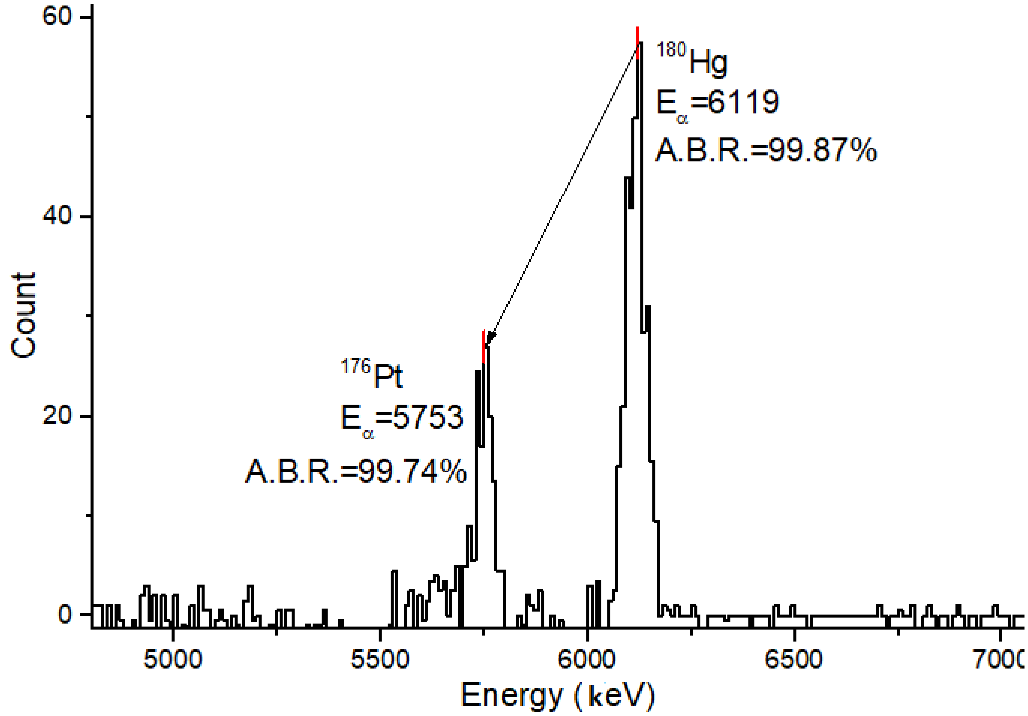
The beam is accelerated with the U400M cyclotron then goes through the target box where it reacts with the rotating target then the not interacted beam and the reaction products are stopped by the hot catcher. The reaction products diffuse to the vacuum pipe making their way to the ECR. after the Ionization the mass-to-charge ratio is determined using (D3a and D3b). additional information is carried out by the detectors since the reaction products tend to Alpha-disintegrate (Undergo several alpha-decay and usually ends up with spontaneous fission (SF))[3], the Alpha Energies are detected as the count of Alpha particles, finally a matrix of Alpha Energies Vs. strip number is formed. Where the strip number is corresponding to Mass number. [1],[4]

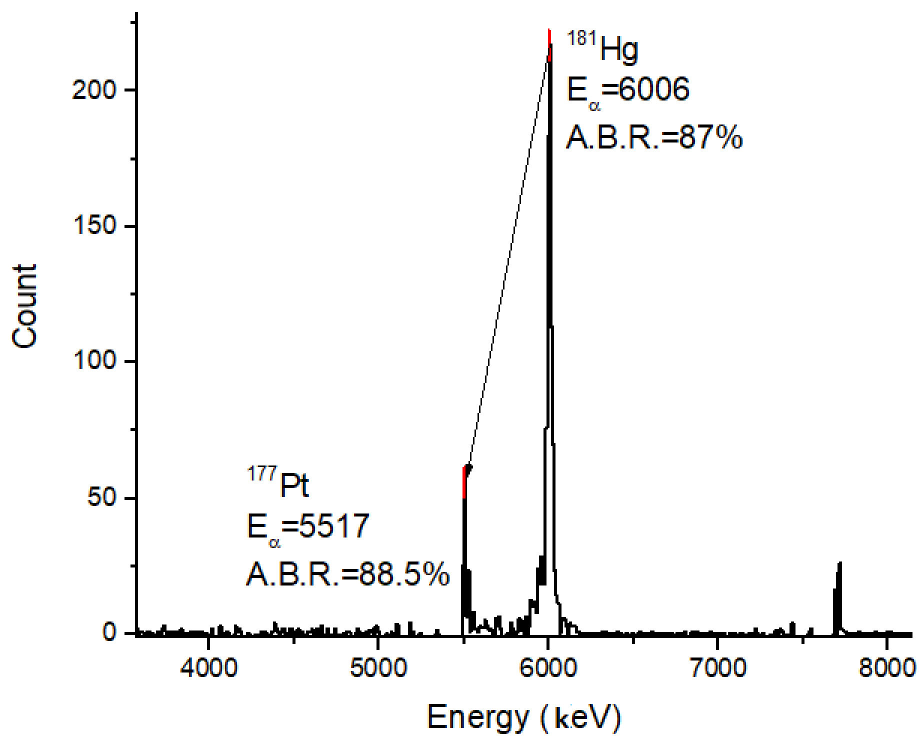
Task

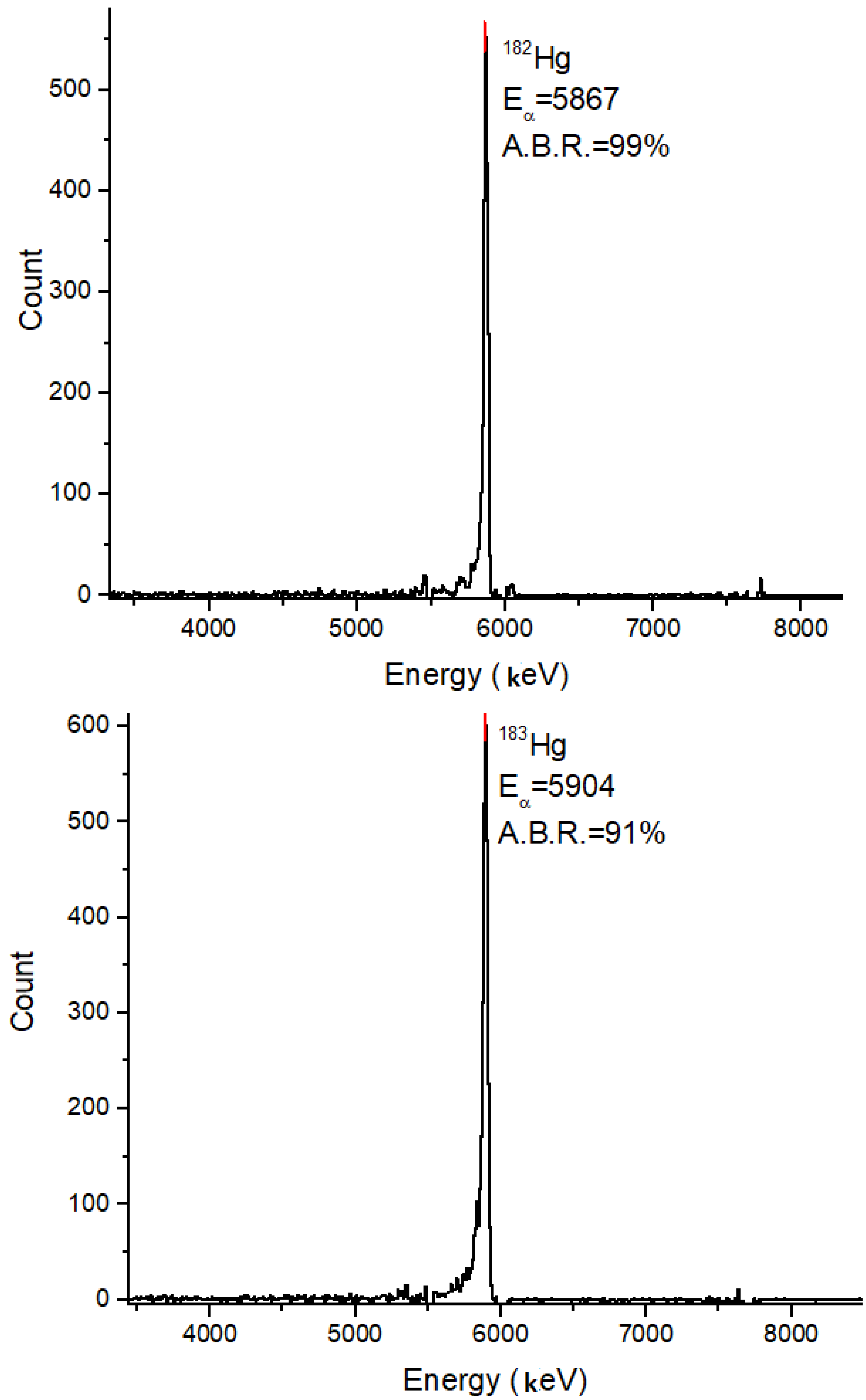
Is to graph and analyse the data obtained from the detectors as well as writing down the alpha branching ratios for every possible alpha emitter for three different reactions obtained at the MASHA facility, doing the calibration of the strip detectors and graphing the results as a heat map.

Results

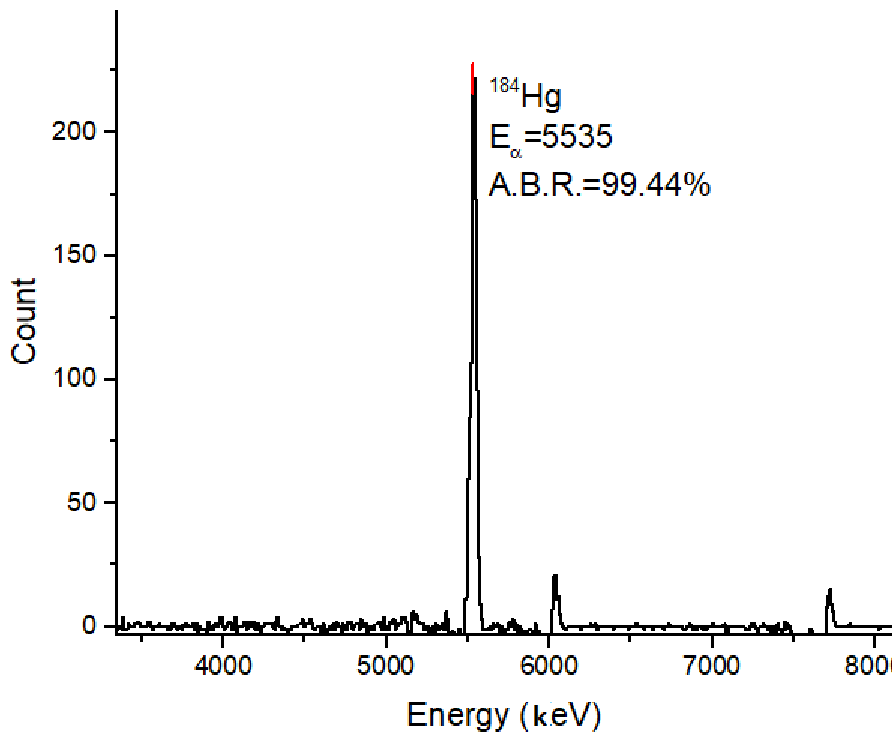
0.1 $^{40}Ar+^{148}Sm$:



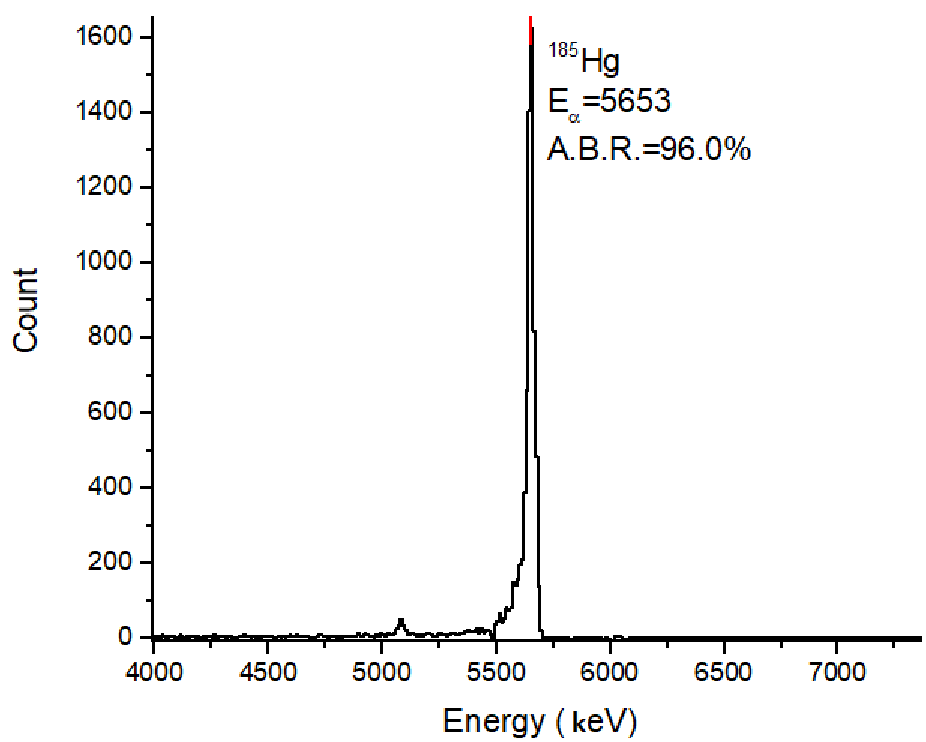




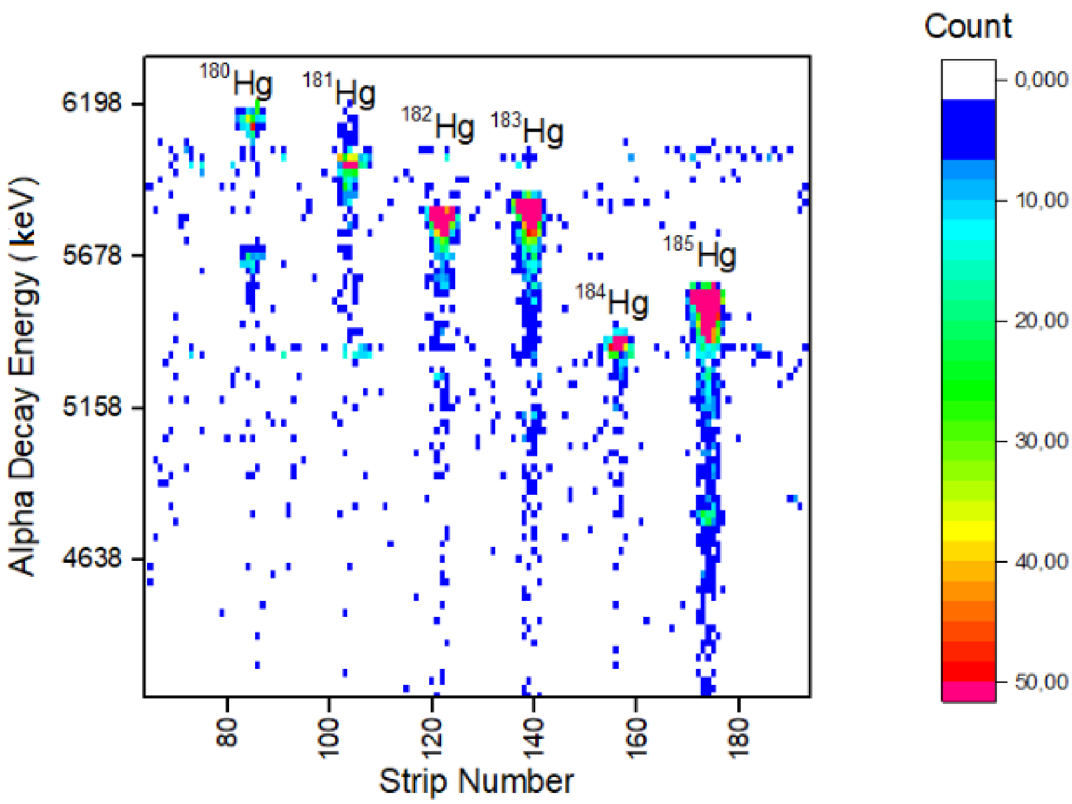
^{182}Hg
E_α=5867
A.B.R.=99%
Count
Energy (keV)
^{183}Hg
E_α=5904
A.B.R.=91%
Count
Energy (keV)



^{184}Hg
E_{α}=5535
A.B.R.=99.44%
Count
Energy (keV)

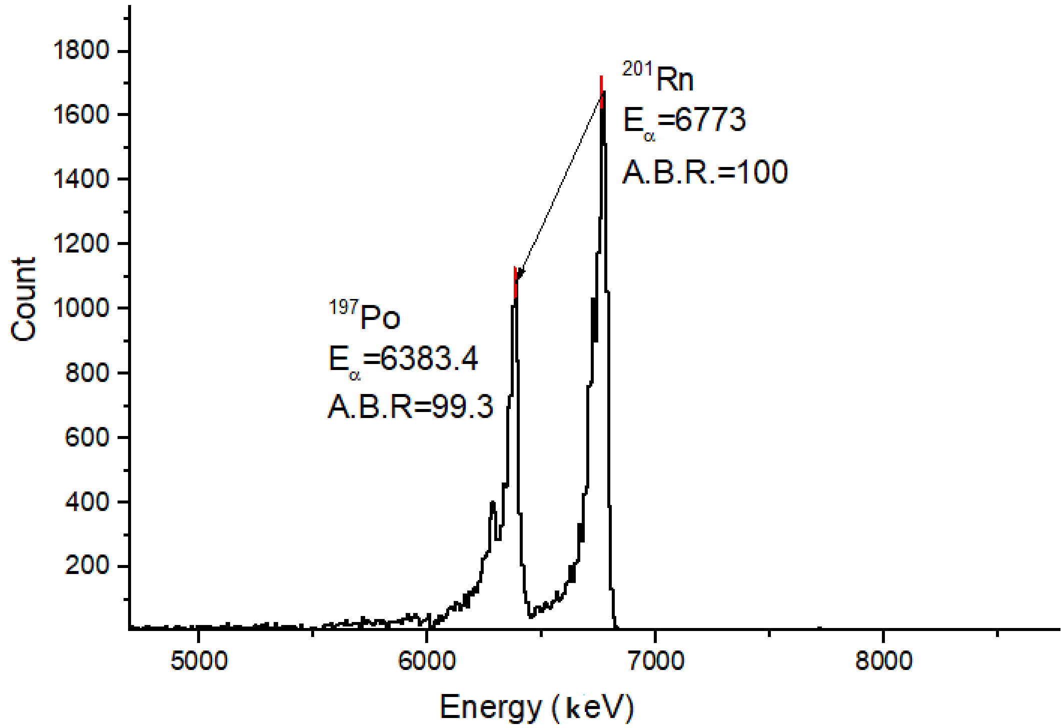


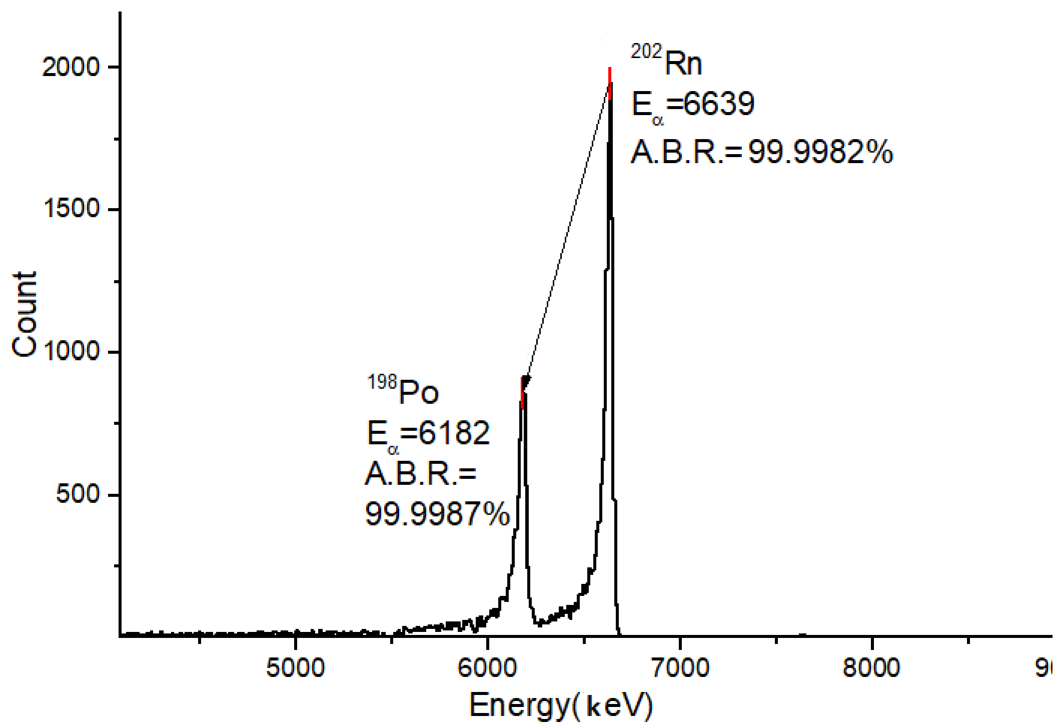
^{185}Hg
E_{α}=5653
A.B.R.=96.0%
Count
Energy (keV)

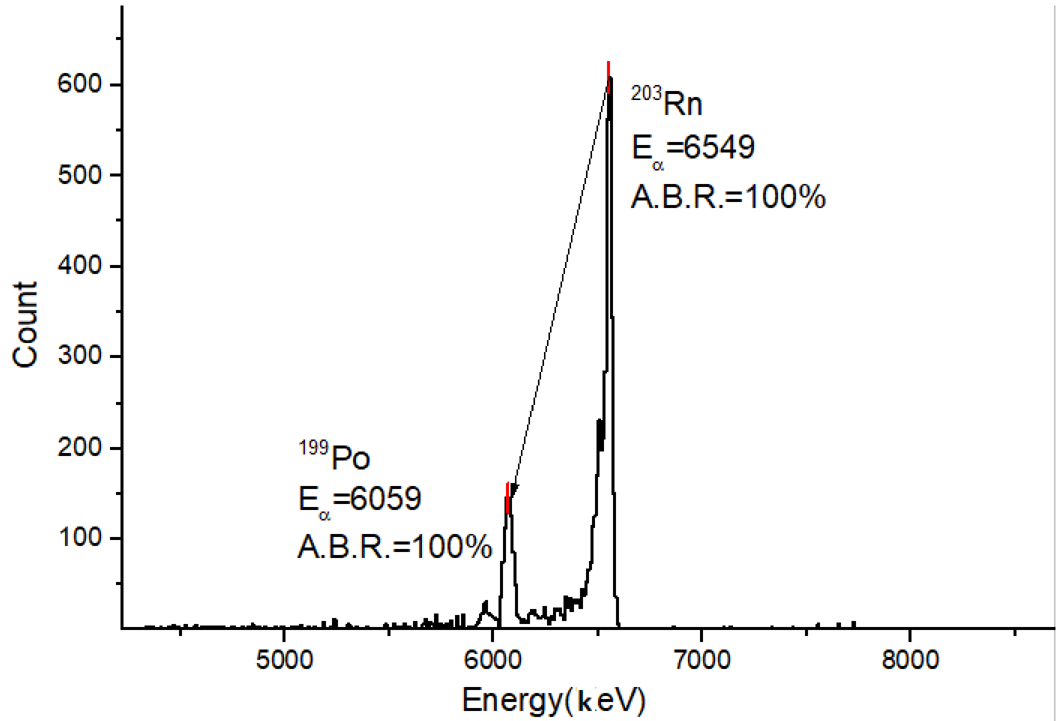


Count
0,000
10,00
20,00
30,00
40,00
50,00
^{180}Hg
^{181}Hg
^{182}Hg
^{183}Hg
^{184}Hg
^{185}Hg
6198
5678
5158
4638
Alpha Decay Energy (keV)
80
100
120
140
160
180
Strip Number

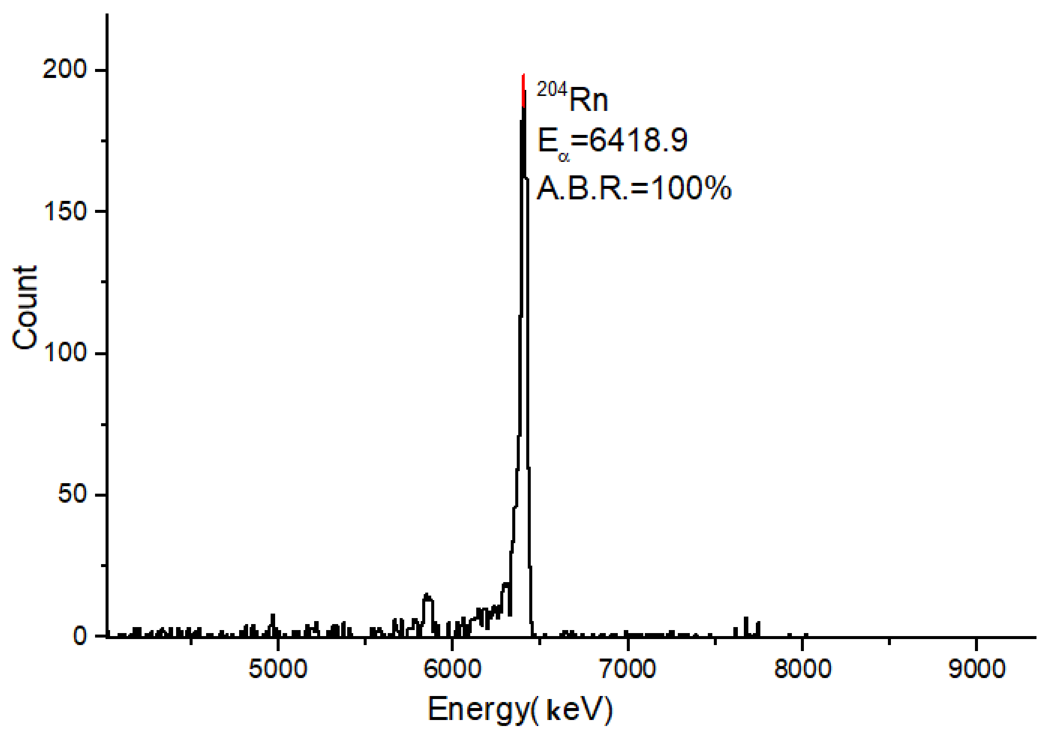
0.2 $^{40}Ar+^{166}Er$:



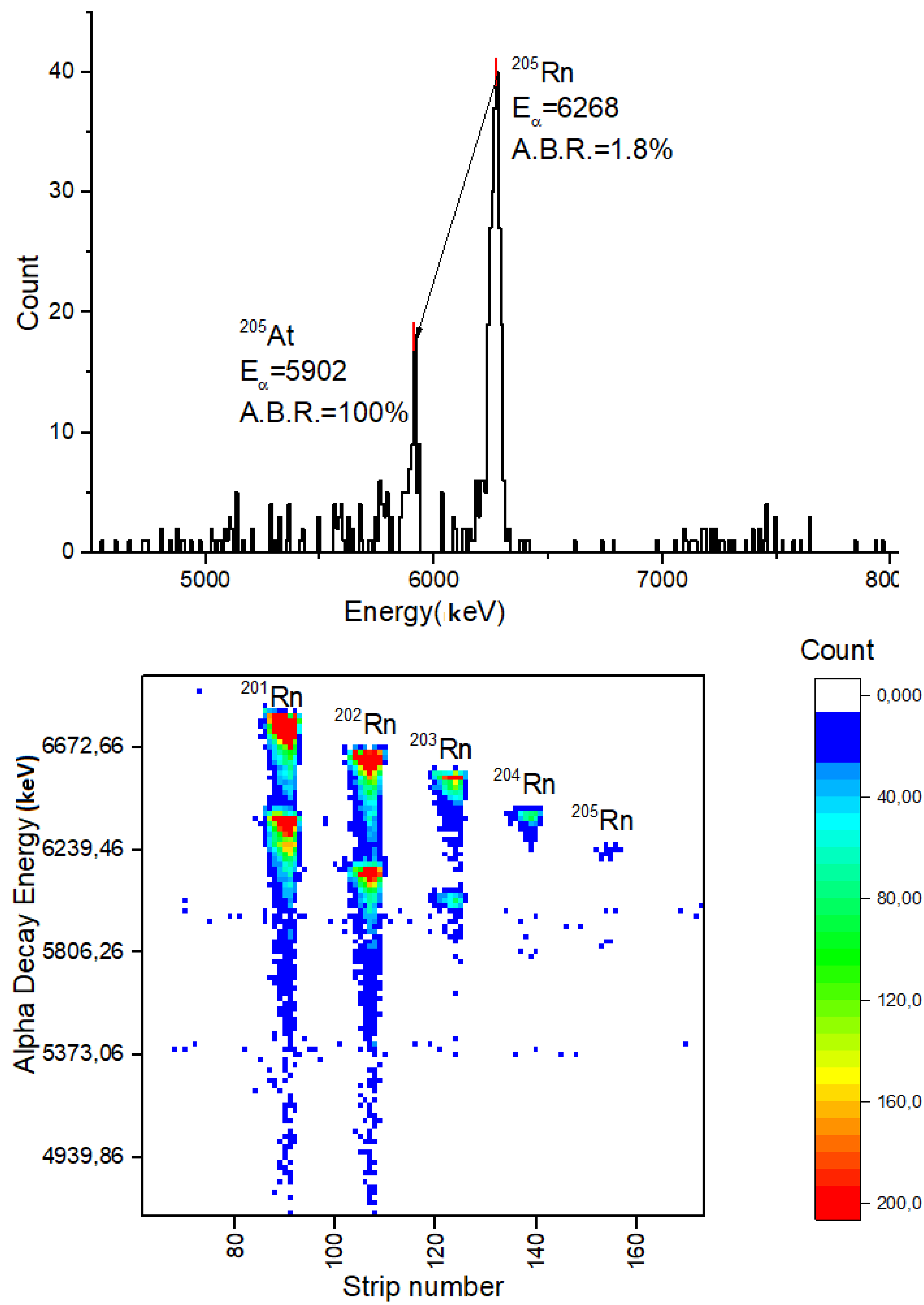




203Rn
Eα=6549
A.B.R.=100%
199Po
Eα=6059
A.B.R.=100%
Count
600
500
400
300
200
100
5000
6000
7000
8000
Energy(keV)

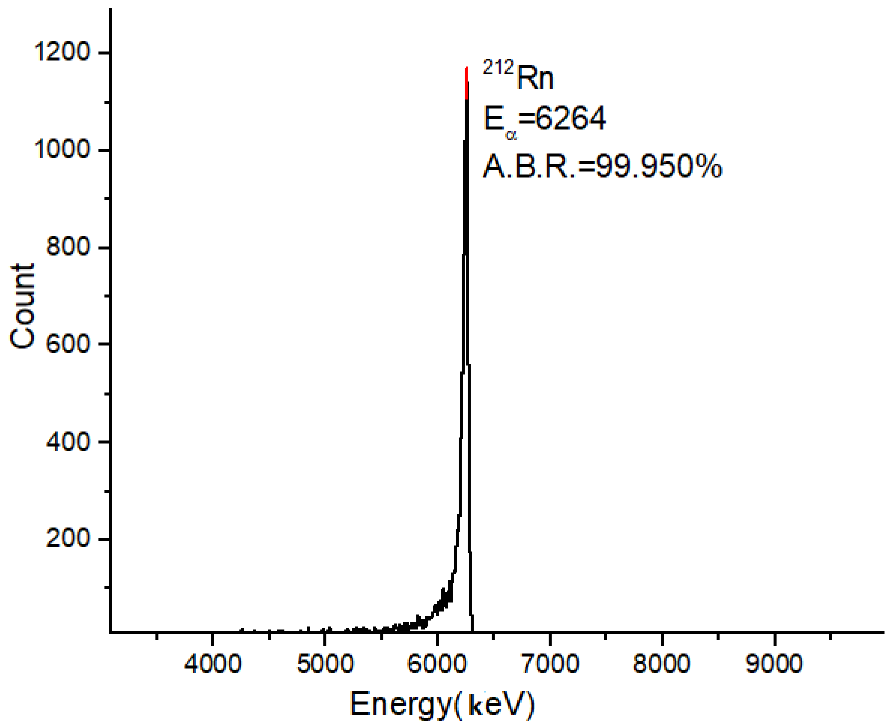


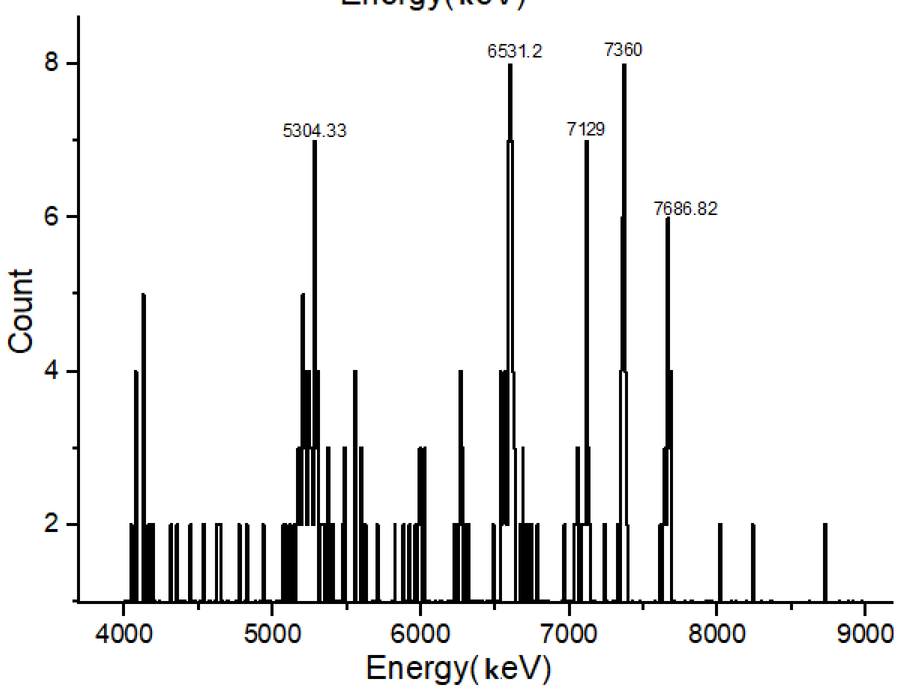
204Rn
Eα=6418.9
A.B.R.=100%
Count
200
150
100
50
0
5000
6000
7000
8000
9000
Energy(keV)



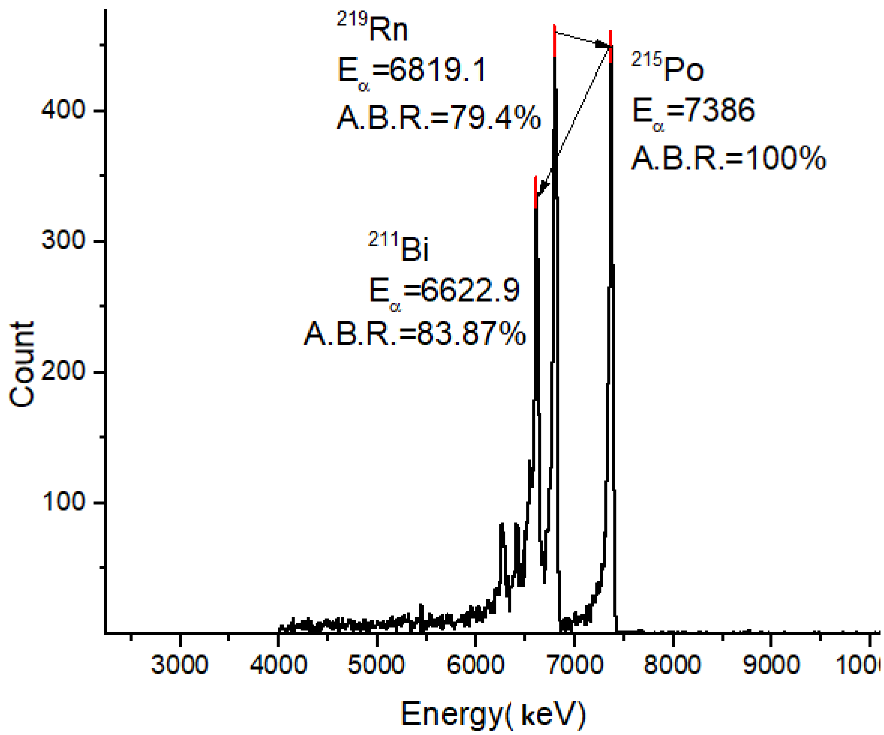
Count
Energy(keV)
205Rn
Eα=6268
A.B.R.=1.8%
205At
Eα=5902
A.B.R.=100%
0
10
20
30
40
5000
6000
7000
Alpha Decay Energy (keV)
Strip number
201Rn
202Rn
203Rn
204Rn
205Rn
6672,66
6239,46
5806,26
5373,06
4939,86
80
100
120
140
160
Count
0,000
40,00
80,00
120,0
160,0
200,0

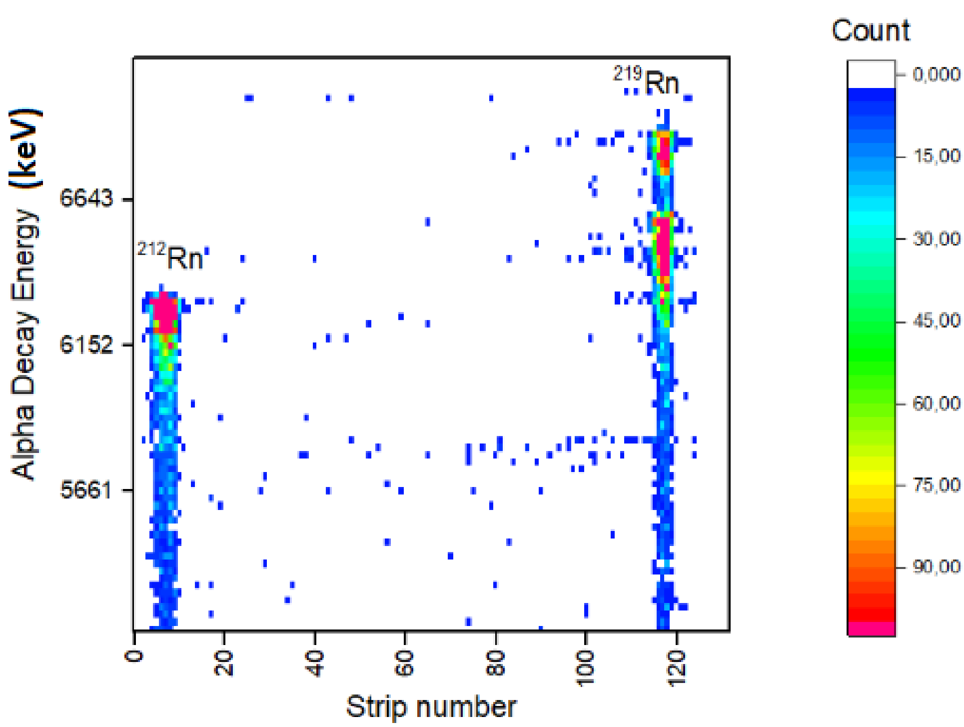
0.3 $^{48}Ca+^{242}Pu$:





Alpha Decay Energy [^{218}Rn]: 7129, Alpha Branching Ratio: 99.87, Alpha Decay Energy [^{218}Rn]: 6531.2, Alpha Branching Ratio: 0.127, Alpha Decay Energy [^{214}Po]: 7686.82, Alpha Branching Ratio: 99.9895, Alpha Decay Energy [^{210}Po]: 5304.44, Alpha Branching Ratio: 100





Notes: The noise in the graphs of the alpha Energies are due to incomplete Alpha emission Energies.[1] In the last heat map 213-217 Rn do not exist in the matrix graph because their half lives are less than 0.5 ms [3]

Conclusion

The mass-separator MASHA is built to identify the superheavy elements by their mass-to-charge ratio and gaining additional information about them using the detector system. After a complete fusion reaction with the target is done then stopped by the hot catcher, and the reaction products get ionised and defused in the vacuum tube till they reach the detectors.

Acknowledge

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