Determination of isotopes in full fusion reactions of $^{40}Ar + ^{148}Sm$, $^{40}Ar + ^{166}Er$ and multi-nucleon transfer reaction of $^{48}Ca + ^{242}Pu$ by alpha spectrometry

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Outline

I. Introduction into the experimental setup

II. Mass Analyzer of Super Heavy Atoms (MASHA)

III. Ion source

IV. Alpha Multi-Strip Detector

V. Reaction $^{40}Ar + ^{148}Sm$

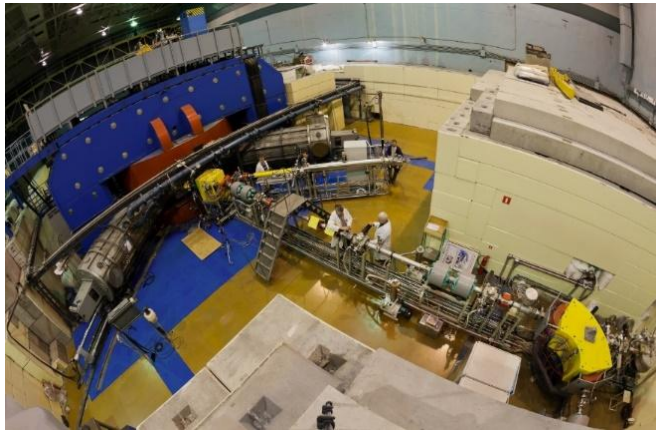
VI. Reaction $^{40}Ar + ^{166}Er$

VII. Reaction $^{48}Ca + ^{242}Pu$ (Multinucleon Transfer)

VIII. Use of TIMEPIX in MASHA experiment

IX. Conclusion

Introduction into the experimental setup



U-400M Cyclotron

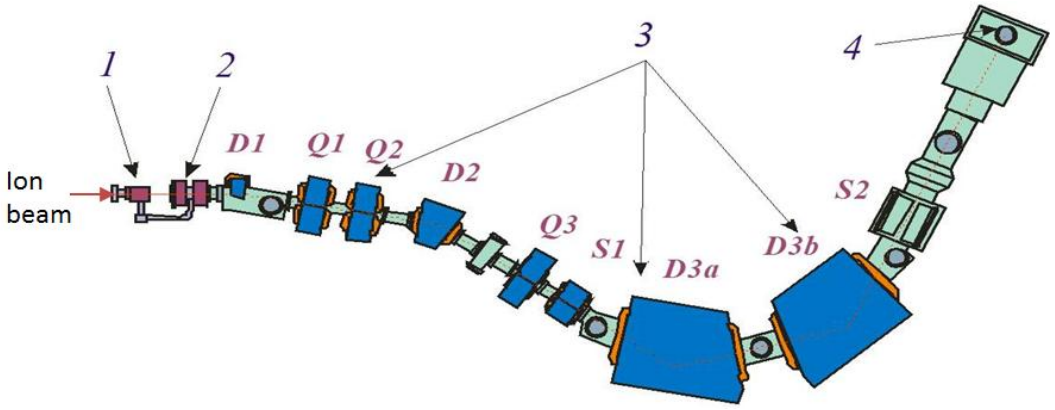
Mass separator

Mass separator

Mass Analyzer of Super Heavy Atoms (MASHA)

Parameters of ion optical system

- Range of energy variation - 15-40 keV
- Range of *Br* variation - 0.08-0.5 Tm
- Mass acceptance - +/-2.8 %
- Angular acceptance - +/-14 mrad
- Diameter the ion source exit hole - 7.0 mm
- Horizontal magnification at F1/F2 - 0.39/0.68
- Mass dispersion at F1/F2 - 1.5/39.0 mm/%
- Linear mass resolution at F1 - 75
- Mass max resolution at F2 - 3000



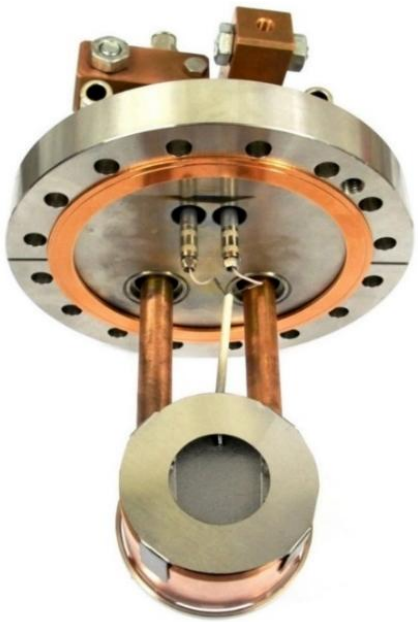
1 – Target Box
2 – Hot Catcher
3 – Mass Separator
4 – DAQ in Focal Plane

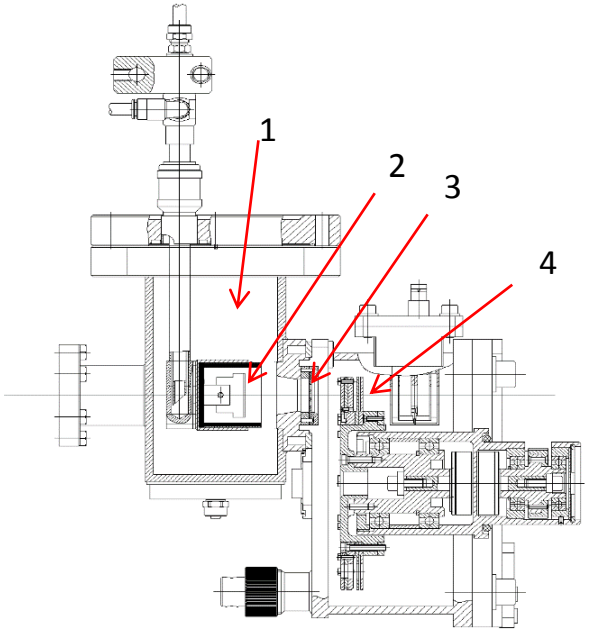
Mass Analyzer of Super Heavy Atoms (MASHA)

Target & Hot Catcher

Principles

- Separates beam from reaction product
- ISOL methodic
- Thermalises Products
- Products drift to ion source



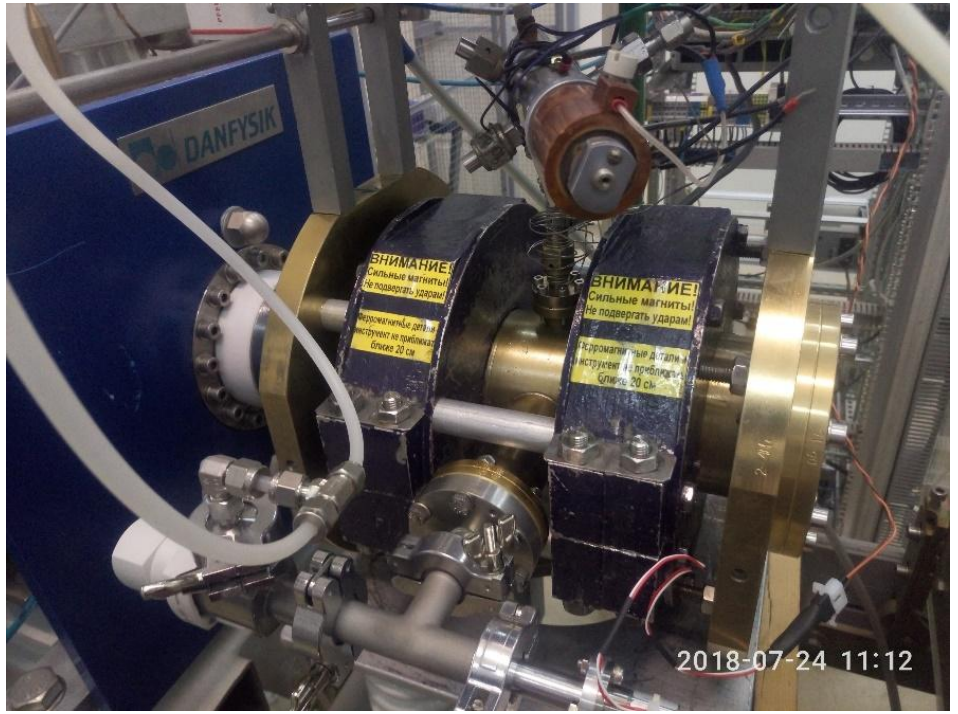


1 – Catcher camera
2 – Graphite stopper (~1800 K)
3 – Division foil
4 – Rotating target

ECR Ion source

Principles

- Ionizes products to +1 state
- Energy of ions 38 keV up to 50 keV
- UHF wave (2.45 GHz)



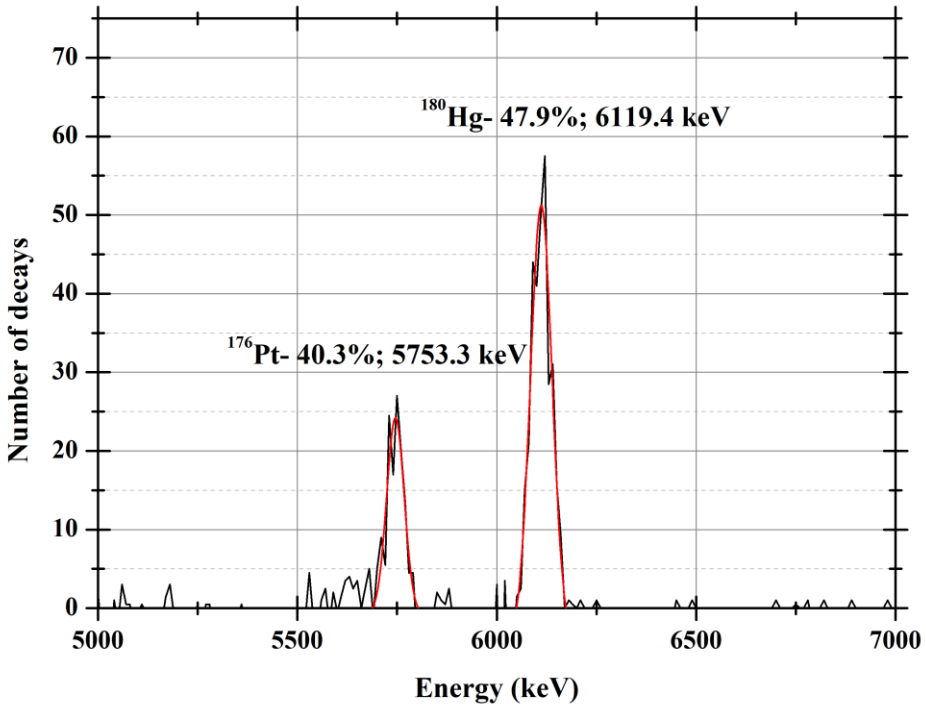
Alpha Multi-Strip Detector

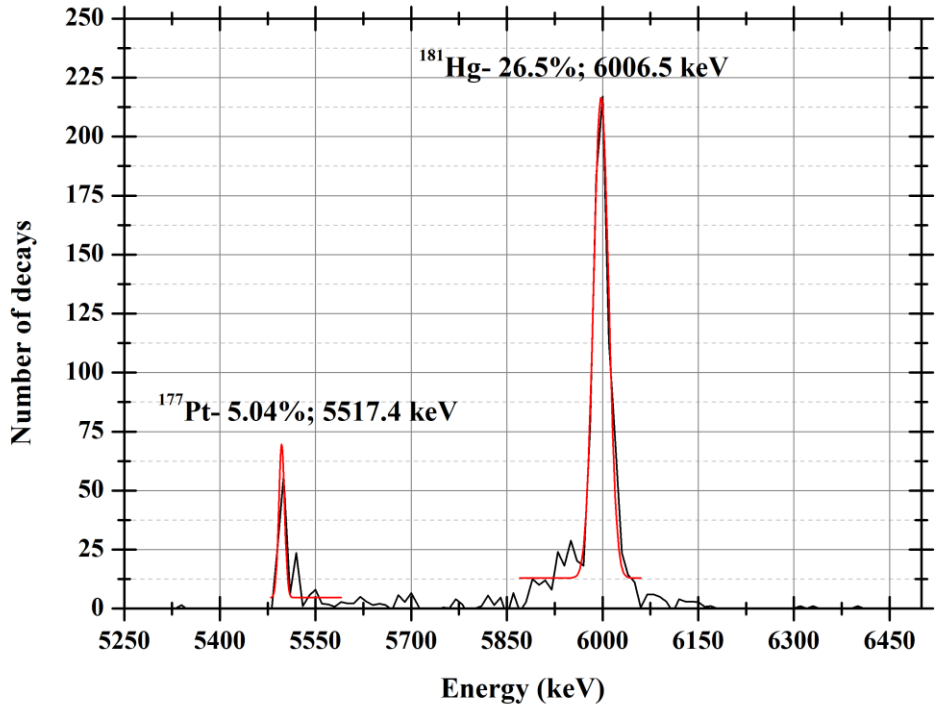
Parameters

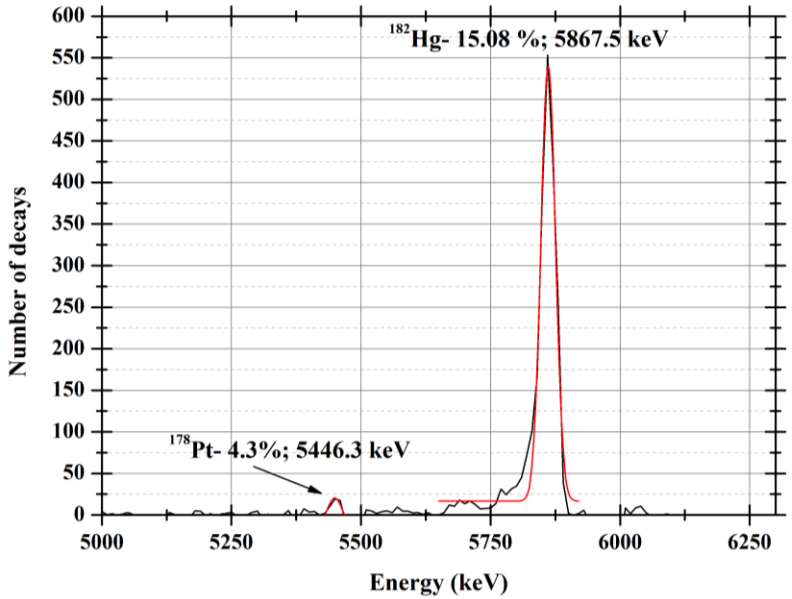
- Silicon detector well-type
- Front: 3 crystals 64 strips each Pitch 1.25 mm
- Side: 4 crystals each side 16 strips, pitch 4 mm
- Latter: 1 crystal similar to side ones
- Energy resolution ~25 keV

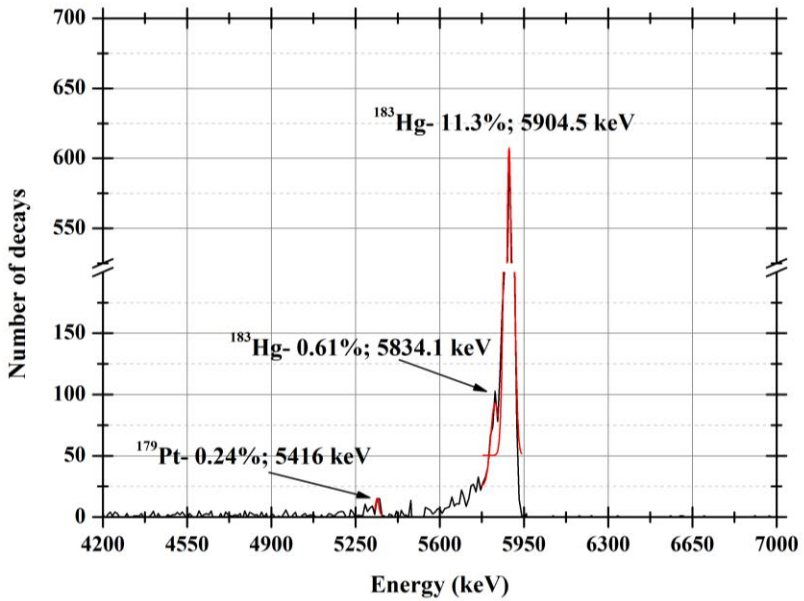
Reaction ^{40}Ar + ^{148}Sm

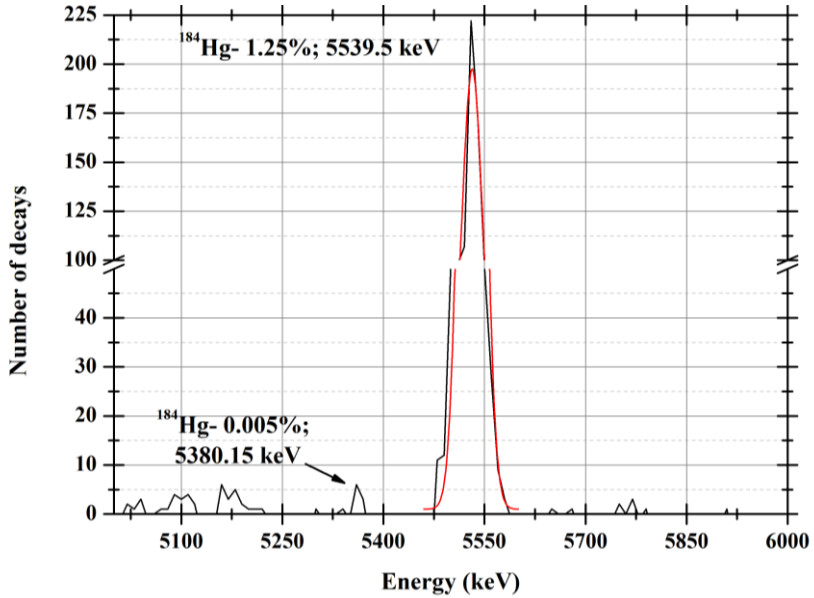
$$^{40}_{18}Ar + {}^{148}_{62}Sm \longrightarrow {}^{185-x}_{80}Hg + (3+x)\,n^0 \quad |x \in \{0,1,2,3,4,5\}$$

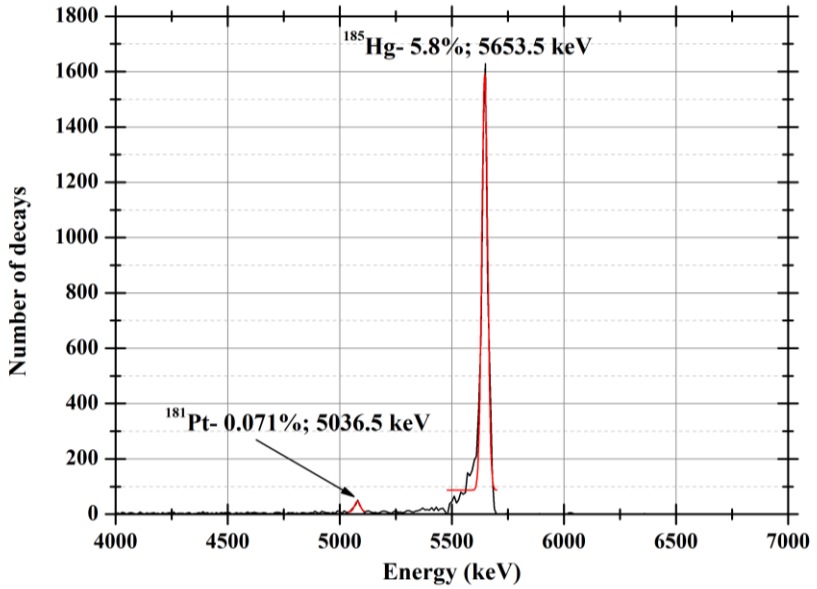




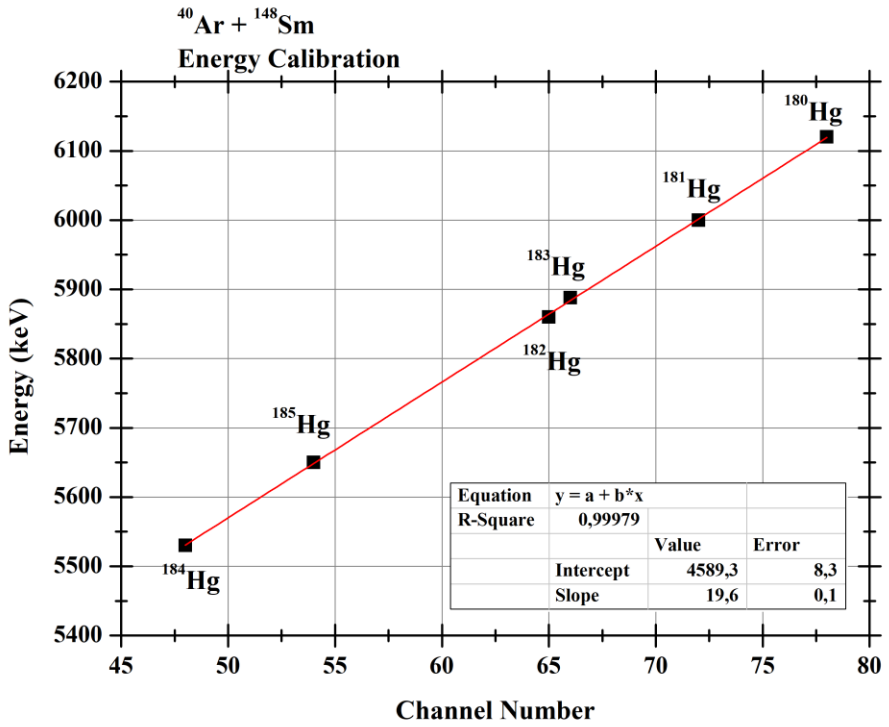

^{182}Hg- 15.08 %; 5867.5 keV
^{178}Pt- 4.3%; 5446.3 keV
Number of decays
Energy (keV)

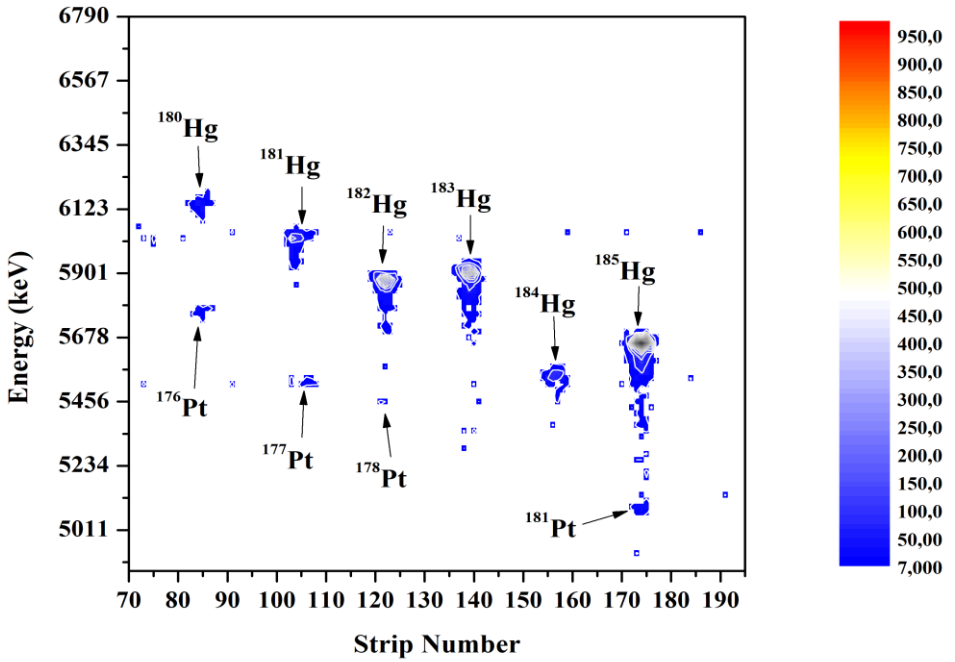

^{183}Hg- 11.3%; 5904.5 keV
^{183}Hg- 0.61%; 5834.1 keV
^{179}Pt- 0.24%; 5416 keV
Number of decays
Energy (keV)


^{184}Hg- 1.25%; 5539.5 keV
^{184}Hg- 0.005%;
5380.15 keV
Number of decays
Energy (keV)


^{185}Hg- 5.8%; 5653.5 keV
^{181}Pt- 0.071%; 5036.5 keV
Number of decays
Energy (keV)

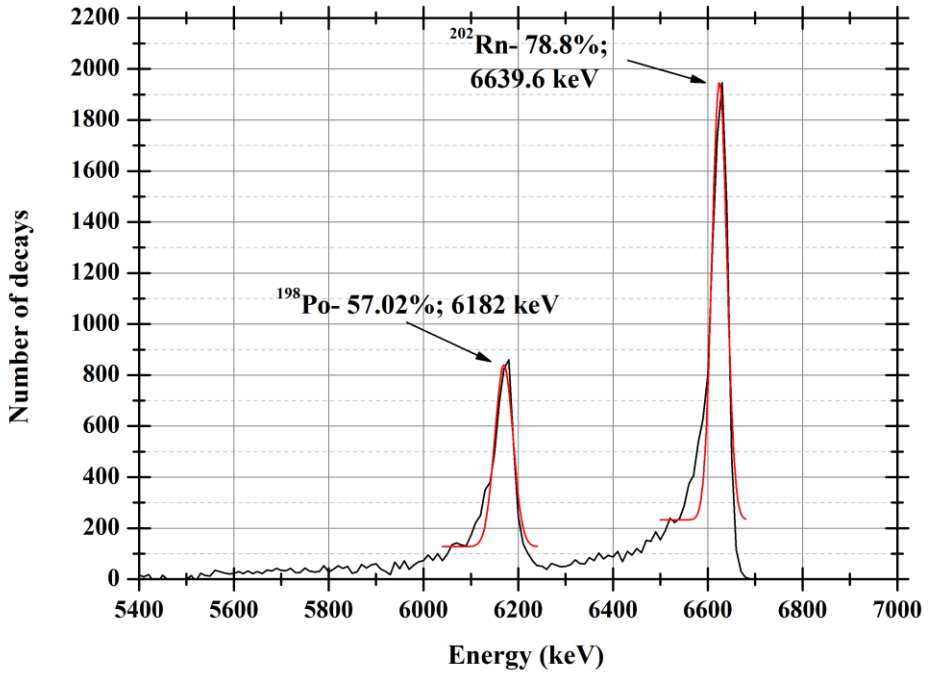
Reaction $^{40}Ar + ^{148}Sm$
Energy Calibration & Matrix

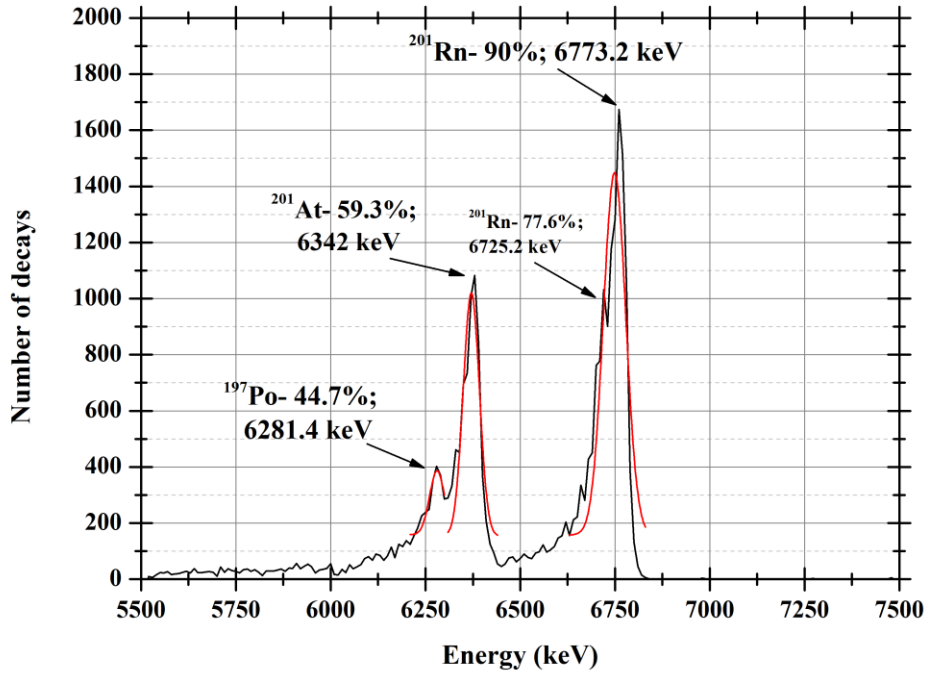


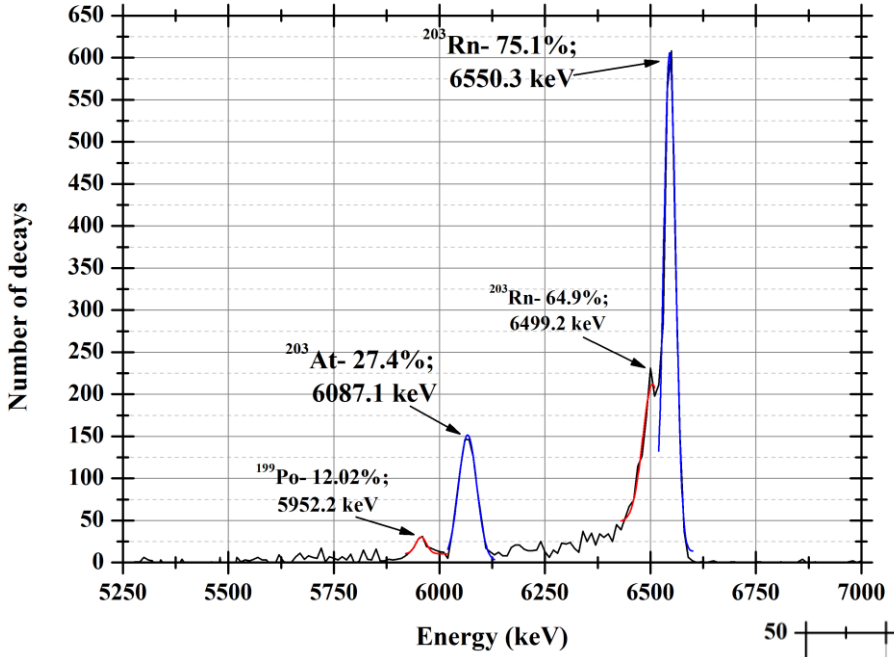


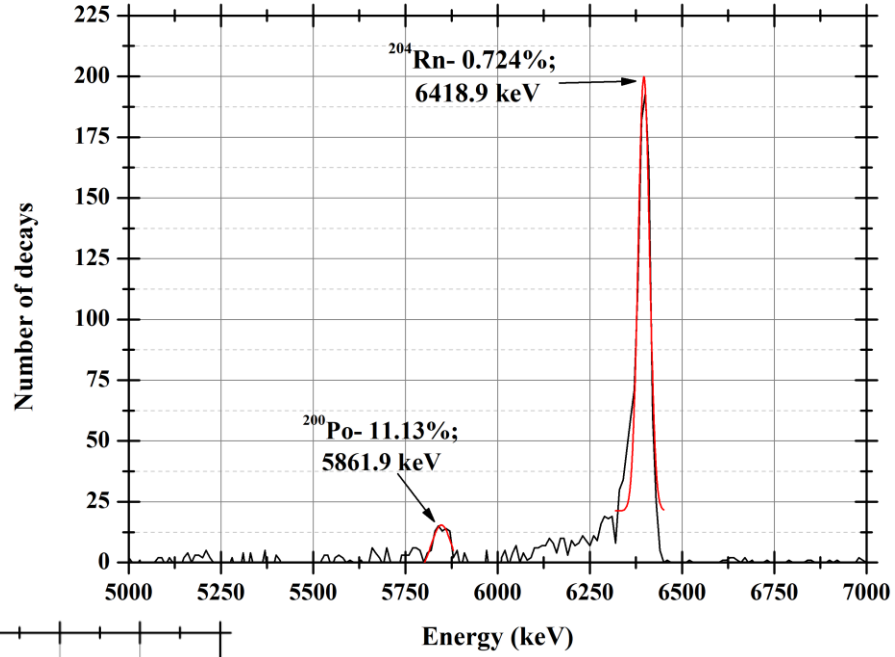
Reaction ^{40}Ar + ^{166} Er

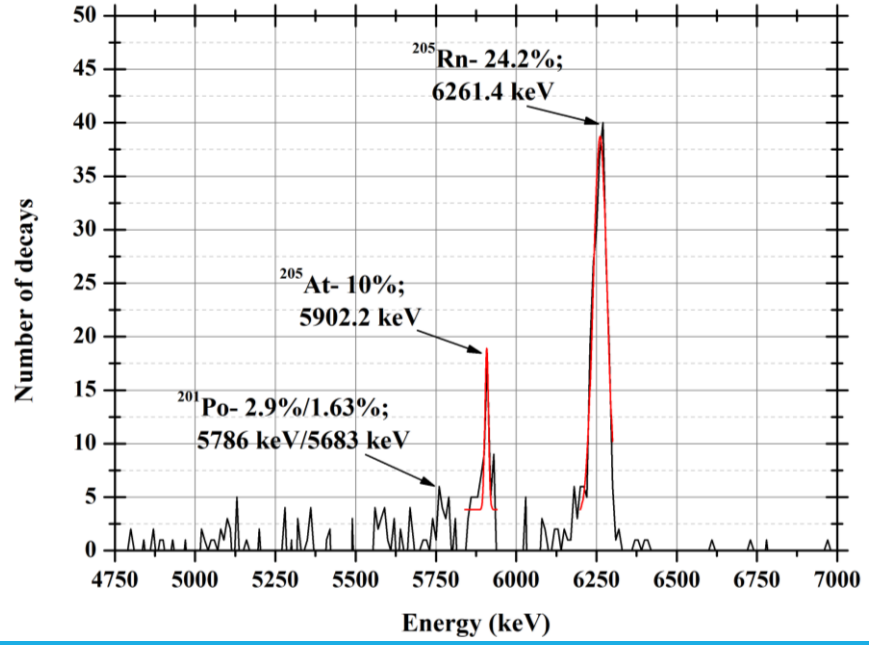
$$^{40}_{18}Ar + {}^{166}_{68}Er \longrightarrow {}^{205-x}_{86}Rn + (1+x)\,n^0 \quad |x \in \{0,1,2,3,4\}$$



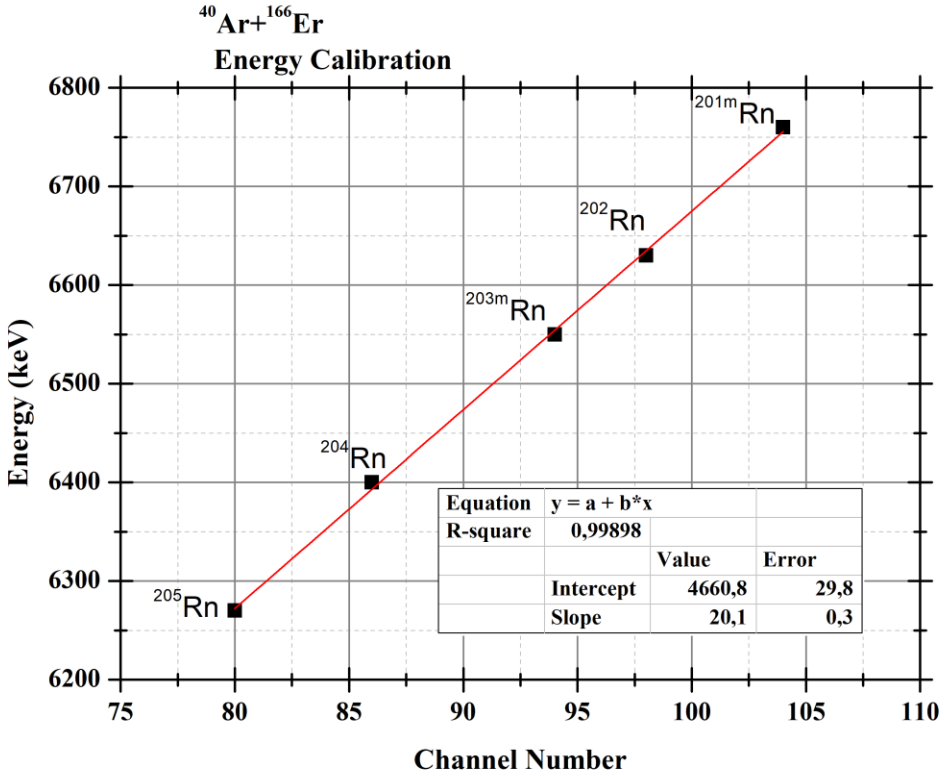


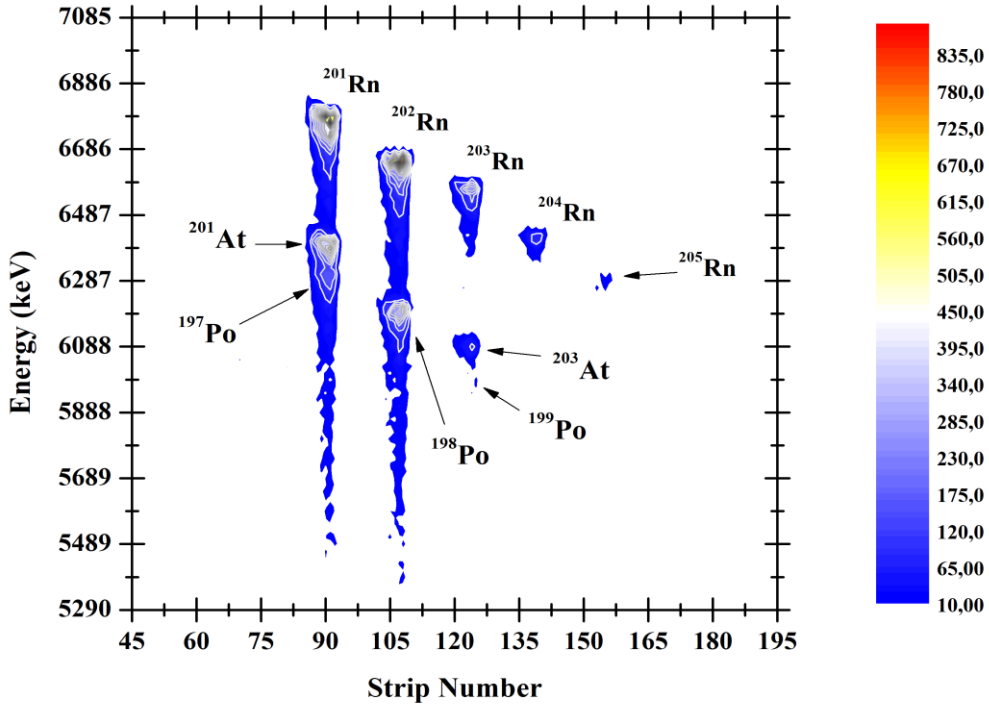

^{203}Rn- 75.1%;
6550.3 keV
^{203}Rn- 64.9%;
6499.2 keV
^{203}At- 27.4%;
6087.1 keV
^{199}Po- 12.02%;
5952.2 keV
Number of decays
Energy (keV)


^{204}Rn- 0.724%;
6418.9 keV
^{200}Po- 11.13%;
5861.9 keV
Number of decays
Energy (keV)

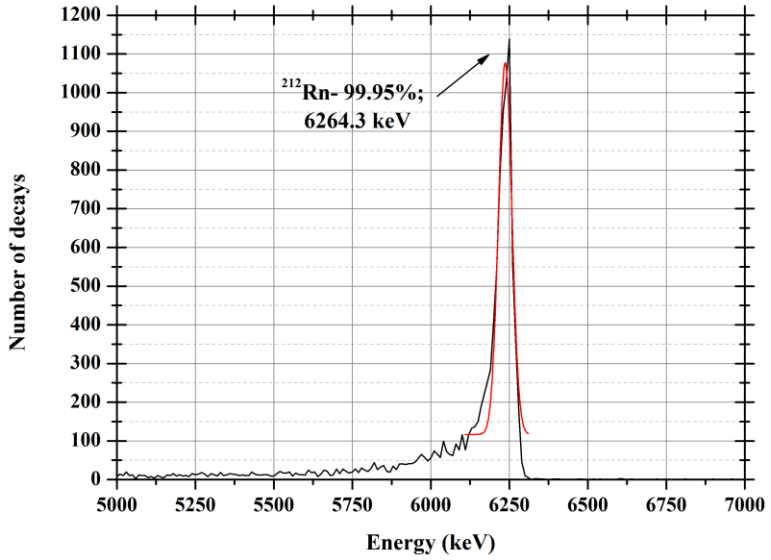

^{205}Rn- 24.2%;
6261.4 keV
^{205}At- 10%;
5902.2 keV
^{201}Po- 2.9%/1.63%;
5786 keV/5683 keV
Number of decays
Energy (keV)

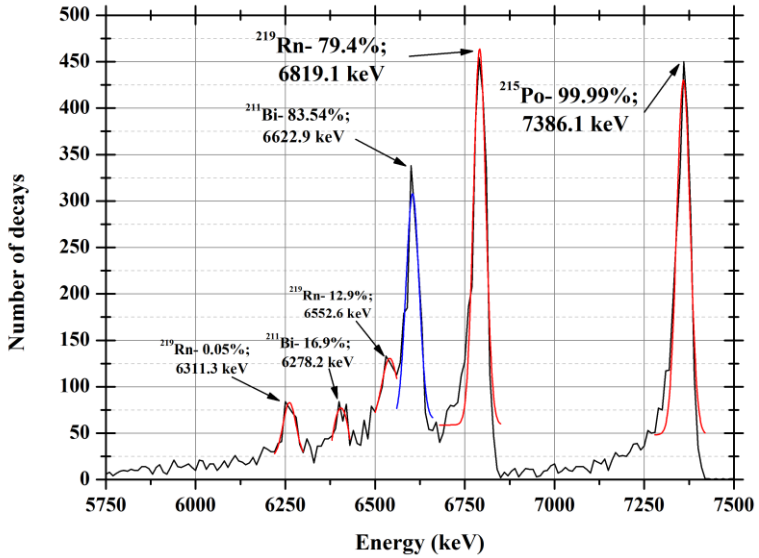
Reaction $^{40}Ar + ^{166}Er$
Energy Calibration & Matrix

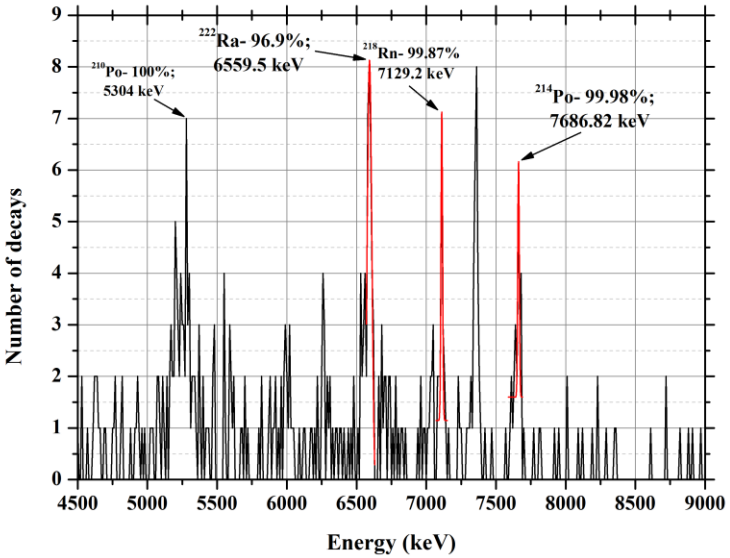




Reaction $^{48}Ca + ^{242}Pu$
Multi-nucleon Transfer



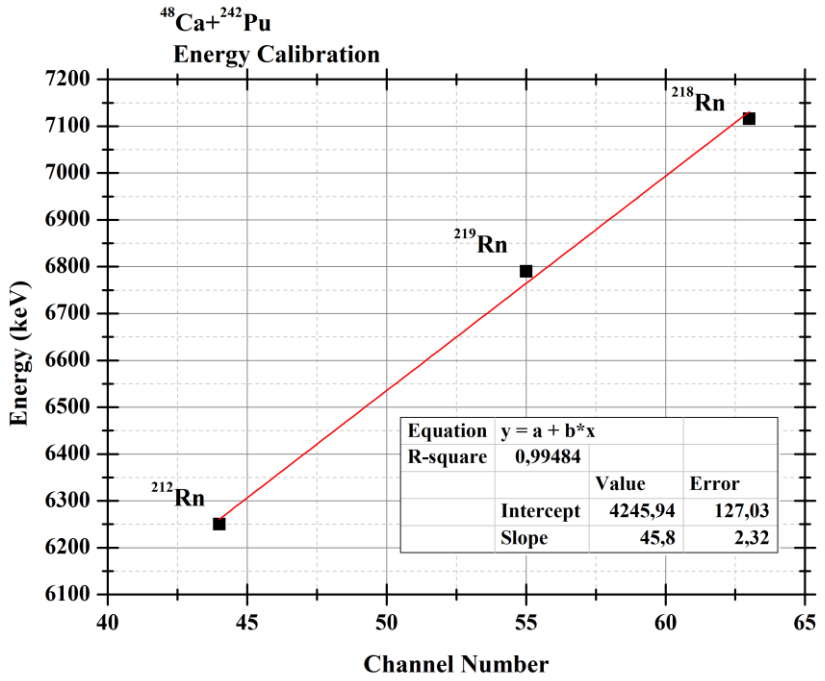


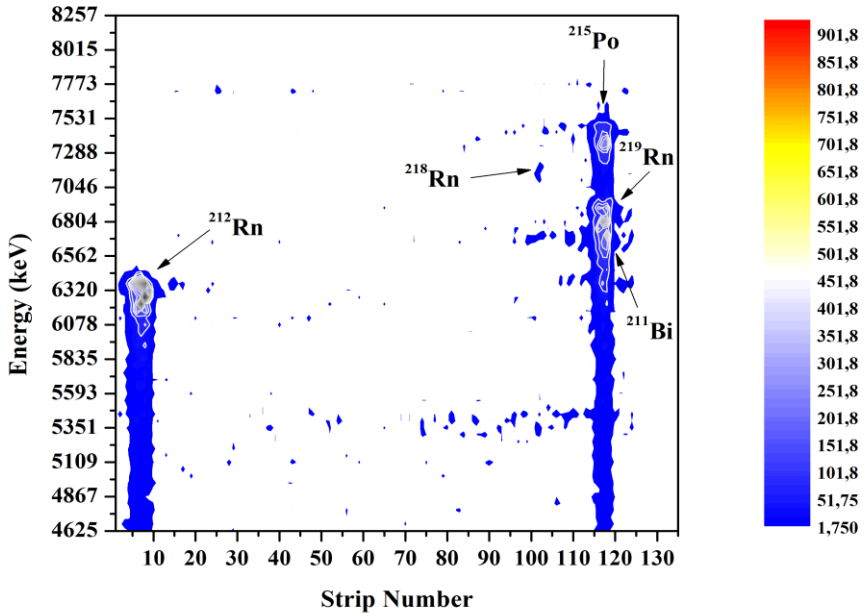


Reaction $^{48}Ca + ^{242}Pu$

Multi-nucleon Transfer

Energy Calibration & Matrix





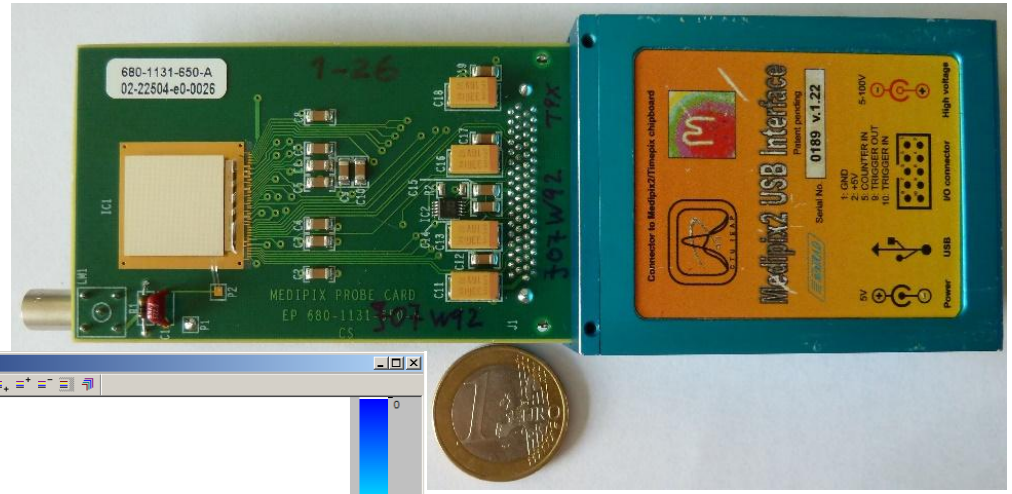
Element	^{212}Rn	^{213}Rn	^{214}Rn	^{215}Rn	^{216}Rn	^{217}Rn	^{218}Rn	^{219}Rn
$T_{1/2}$	23.9 m	19.5 ms	0.27 µs	2,30 µs	45 µs	0,54 ms	35 ms	3,96 s

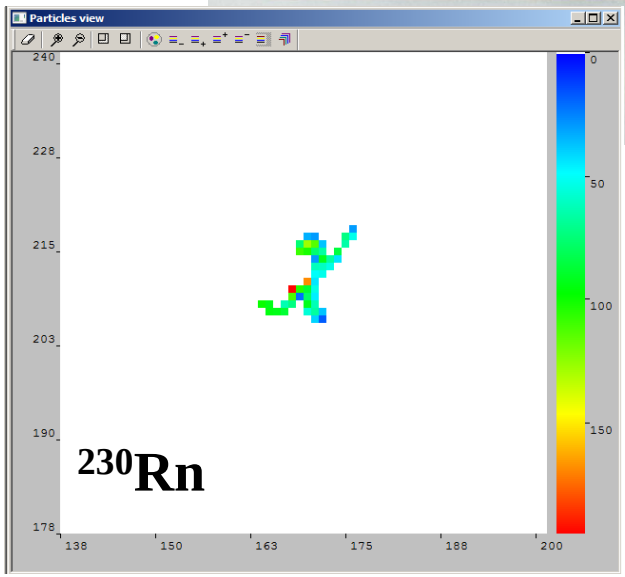
Use of TIMEPIX in MASHA experiment

- Sensitive area 14x14 mm
- 256x256 pixels. Silicon sensor 300 μm thickness
- Each pixel has its own preamplifier and digitizer
- Can detect any type of radiation: α-, β-particles, fission fragments and electromagnetic radiation (γ- and X-rays)

β – decay chain

^{230}Rn - ^{230}Fr – ^{230}Ra – ^{230}Ac – ^{230}Th





Conclusion

- The calibration of strip detector was performed using pre-recorded data in the full fusion and multinucleon transfer reactions
- Energy calibration was performed using α peaks of the known decay chains of Hg and Rn isotopes
- The TIMEPIX detector could be used in the future for more types of decay not only α-decays