DIRECT MASS DETERMINATION OF RADIOACTIVE ISOTOPES IN FULL FUSION REACTIONS ^{40}Ar + ^{nat}Sm AND ^{40}Ar + ^{166}Er AND IN MULTINUCLEON TRANSFER REACTION ^{48}Ca + ^{242}Pu AT MASHA FACILITY

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Presentation outline

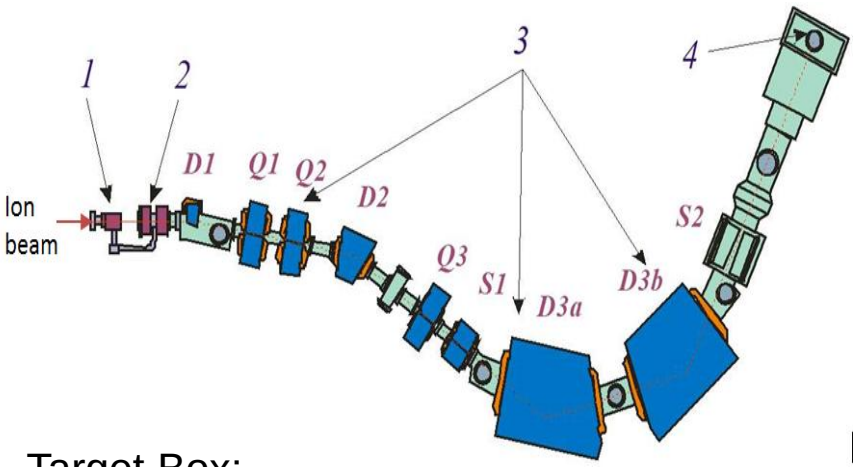
- Project aim
- Introduction
- Equipment Description
- Experimental Description
- Results and Conclusion
- Acknowledgement

Project aim: online Mass Analysis of radioactive isotopes

Introduction

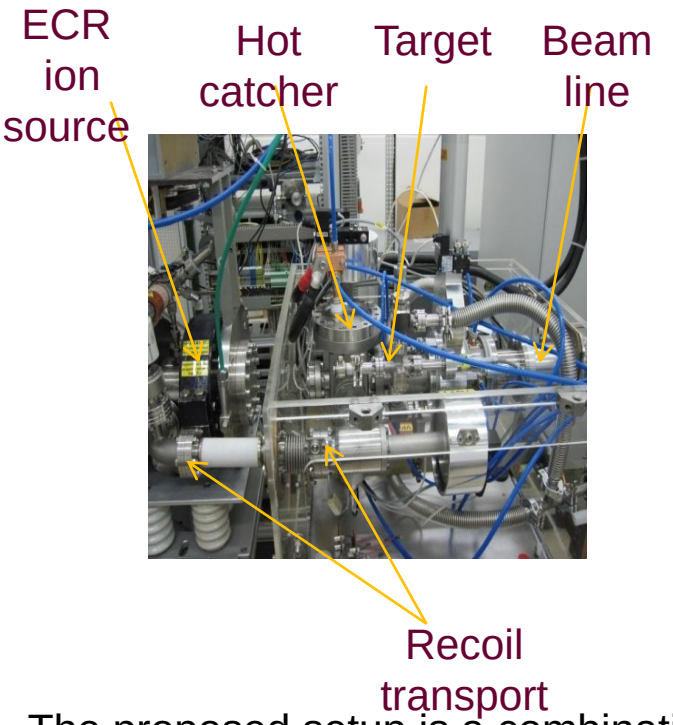
- Mass Analyzer of Super Heavy Atoms (MASHA) was built to identify super heavy elements by their mass-to-charge ratios is described.
- Elements 105-118 were synthesized in Dubna, at JINR and were later confirmed in other institutes.
- The masses of the isotopes are determined by detecting their alpha decay or spontaneous fission.
- Main goal of the experiments was to measure masses of elements 112 and 114 synthesized using this reaction $^{48}Ca + ^{242}Pu$ and $^{48}Ca + ^{244}Pu$
- The fusion reactions $^{40}Ar + ^{nat}Sm$ and $^{40}Ar + ^{166}Er$ to direct determination of radioactive isotope masses were used.
- TIMEPIX detector with a large possibilities and examples of using it introduced.

Equipment Description



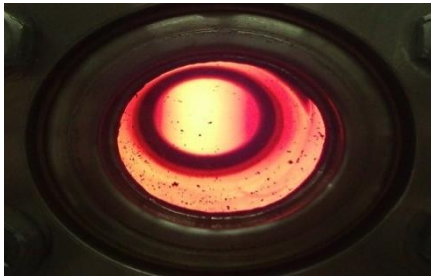
1 – Target Box;
2 – Hot Catcher;
3 – Mass Separator;
4 – DAQ in Focal Plane.

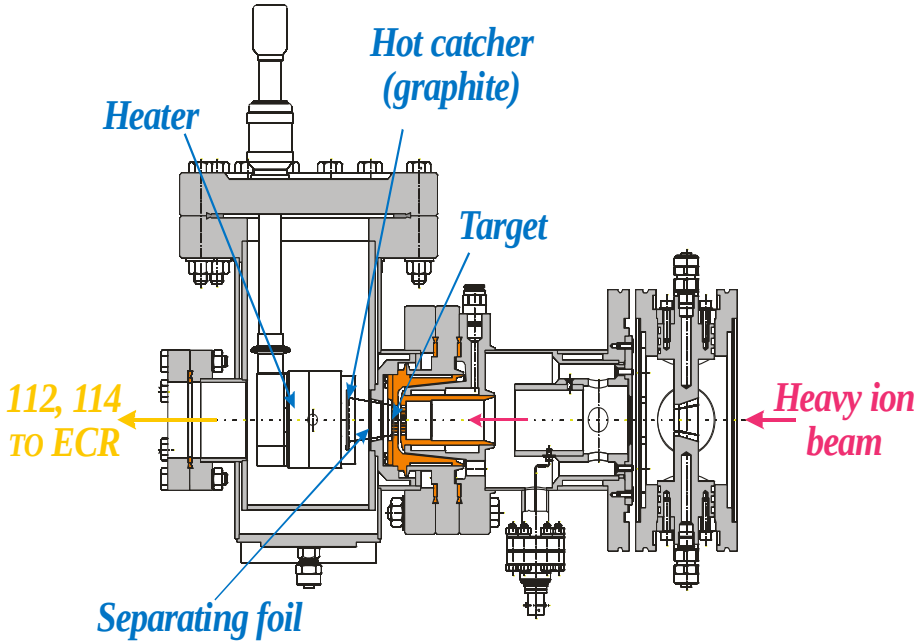
The analyzer includes four dipole magnets (D1,D2,D3a,D3b), three quadrupole lenses (Q1,Q2,Q3), two sextupole lenses (S1,S2) and focal plane detector system.



The proposed setup is a combination of the so-called Isotope Separator Online (ISOL) method of synthesis and separation of radioactive nuclei with the classical method of mass analysis, allowing mass identification of the synthesized nuclide in the wide mass range.

Target and Hot Catcher system



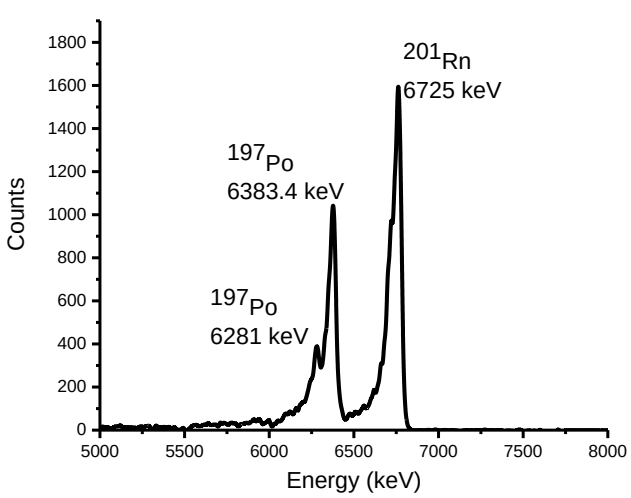


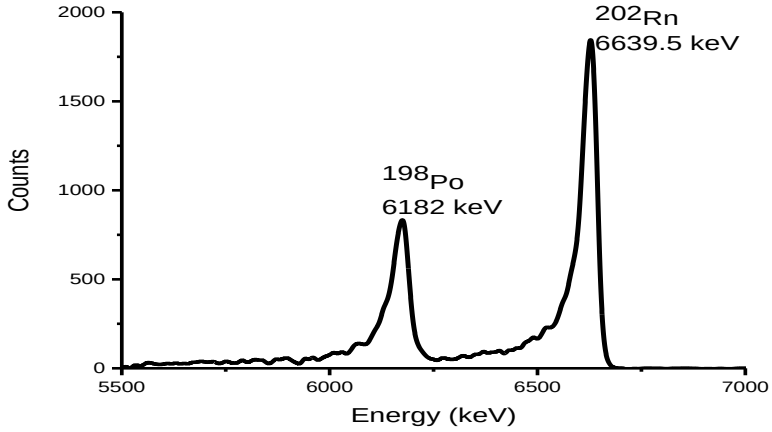
Material of the catcher – flexible graphite
Operating temperature of hot catcher – 1800-2000°C
Delivery time of nuclides to the ECR ion source ~ 2 s

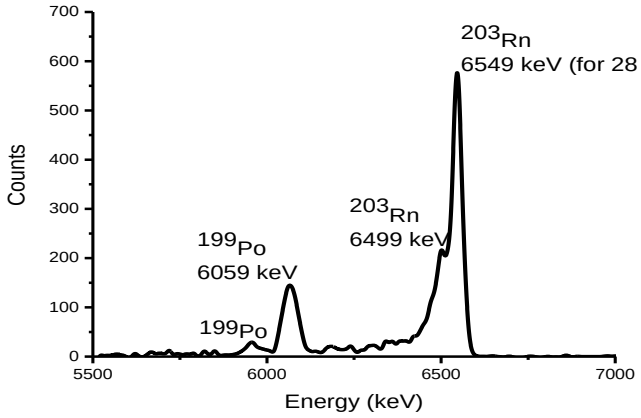
Experiment description

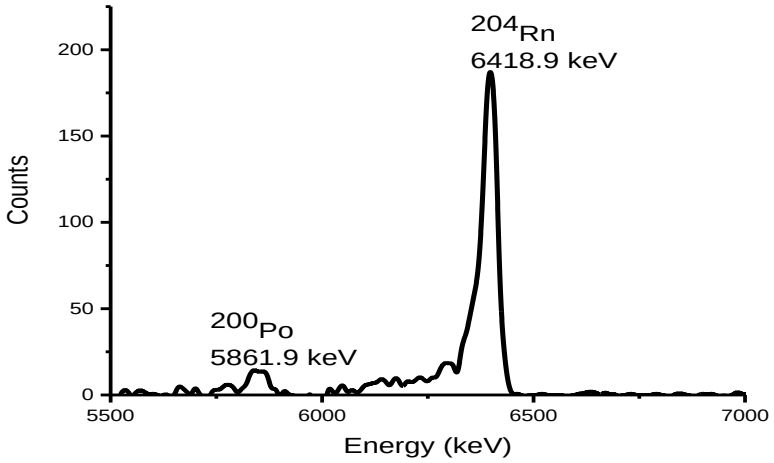
To gain data for calibration of focal strip detector using the fusion reaction $^{40}Ar + {}^{nat}Sm$ and $^{40}Ar + {}^{166}Er$

Histograms for ^{201,202,203} and ^{204}Rn isotopes

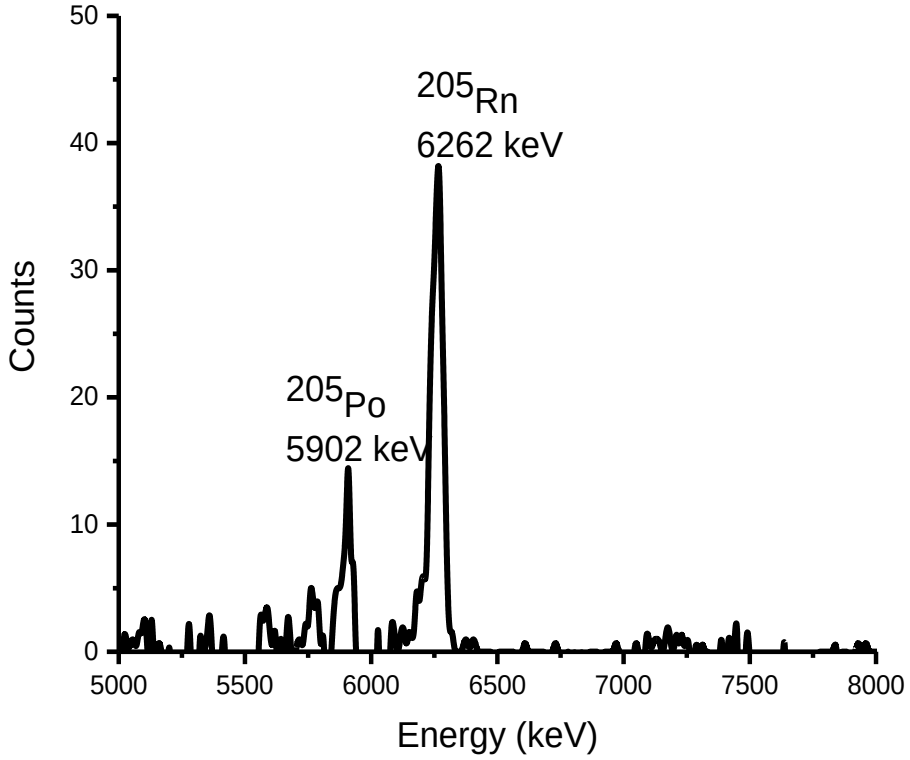




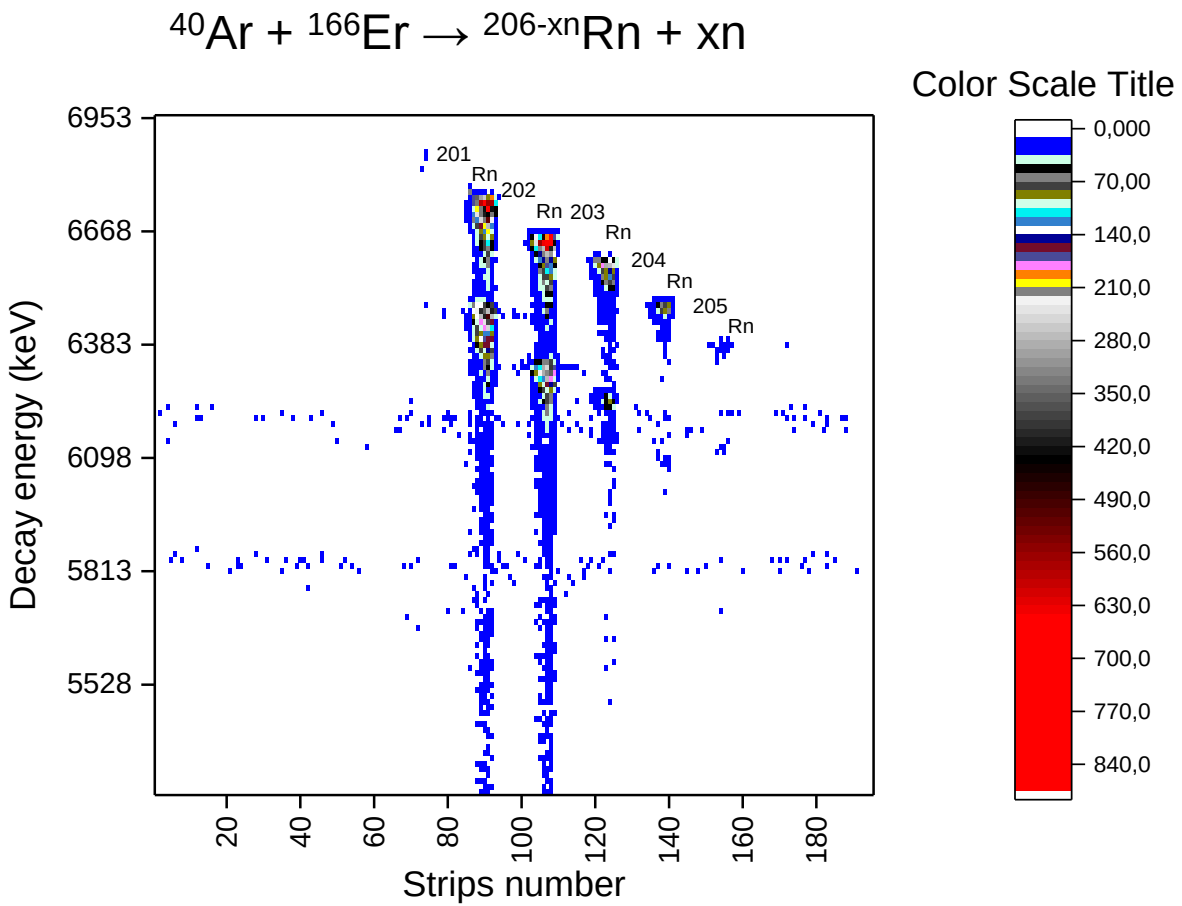




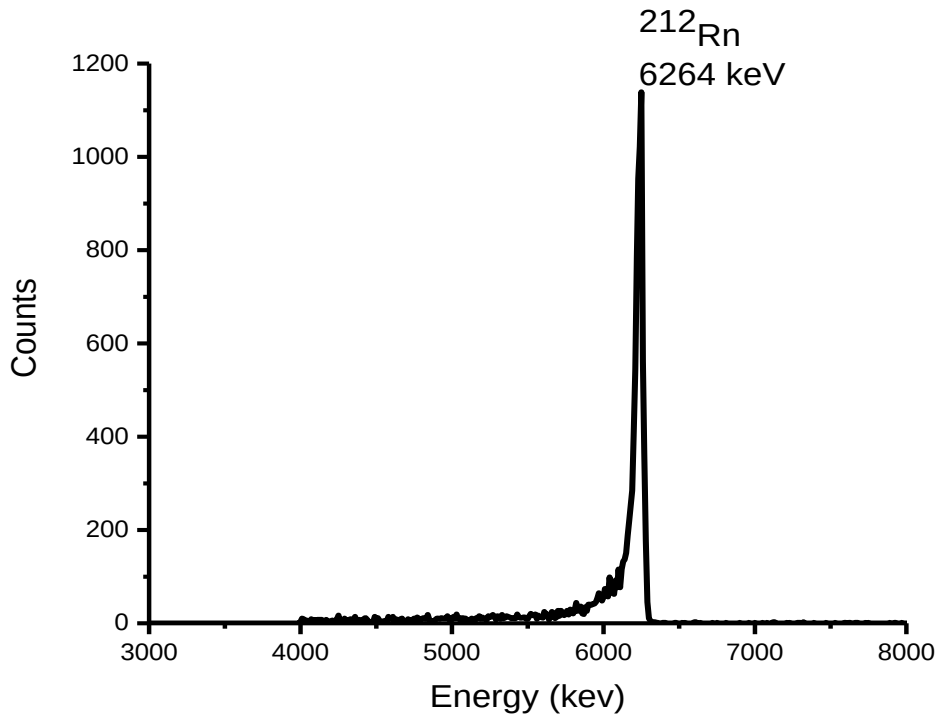
One dimensional spectra ^{205}Rn isotope



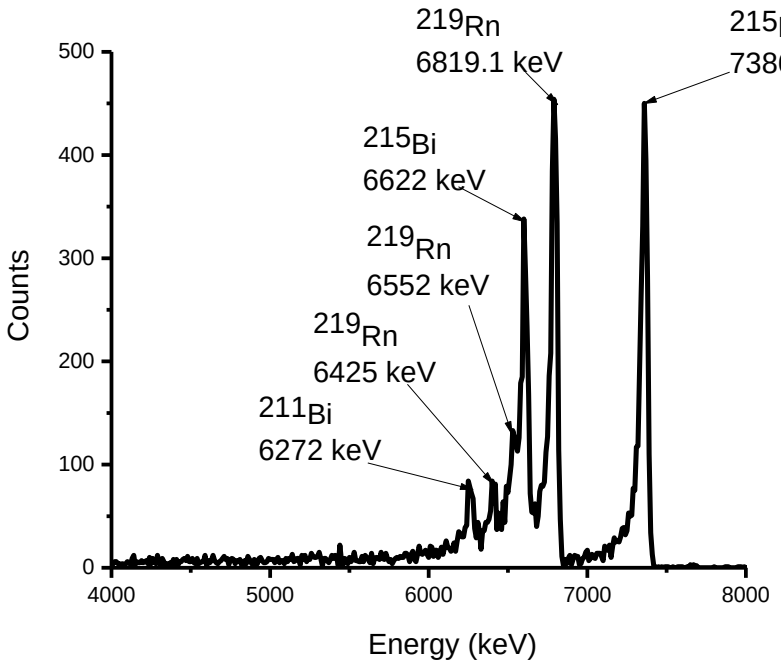
Two dimensional plot for alpha particles energy of Radon isotopes

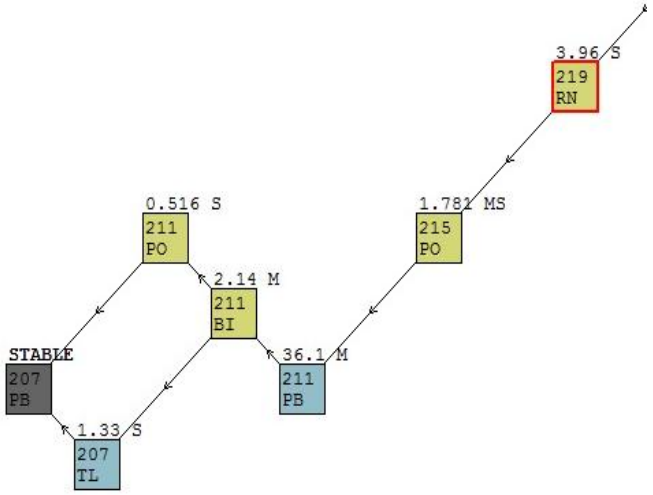


One dimensional plot for spectre of ^{212}Rn

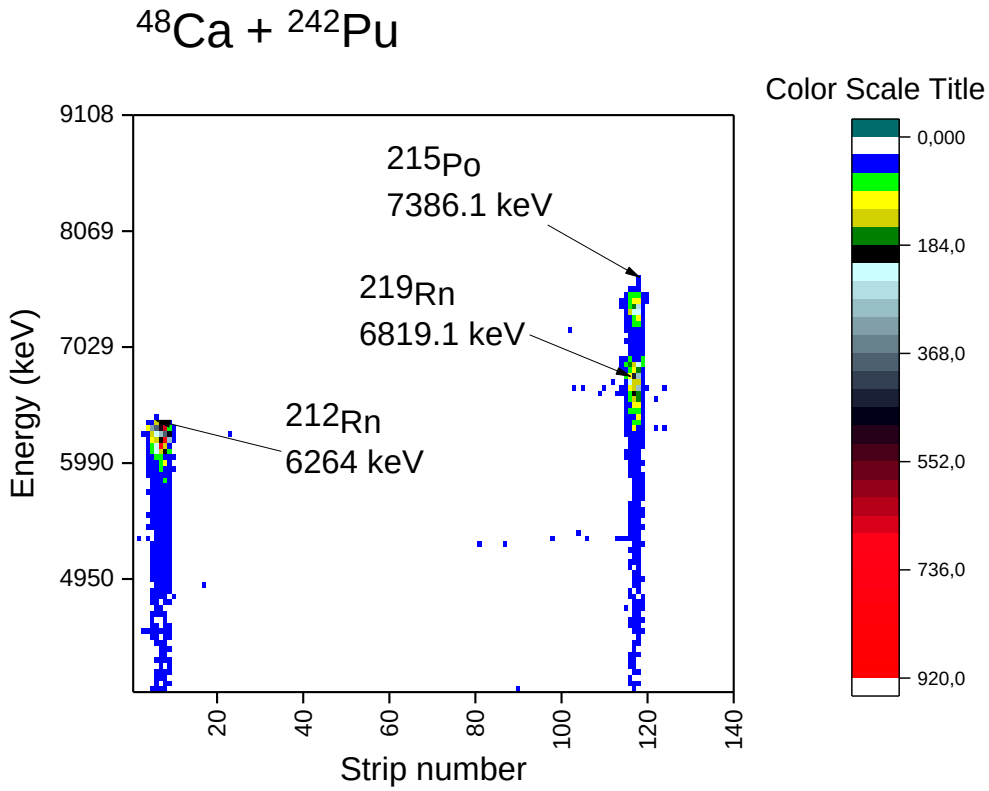


One dimensional plot for spectre of ^{219}Rn and its decay chain



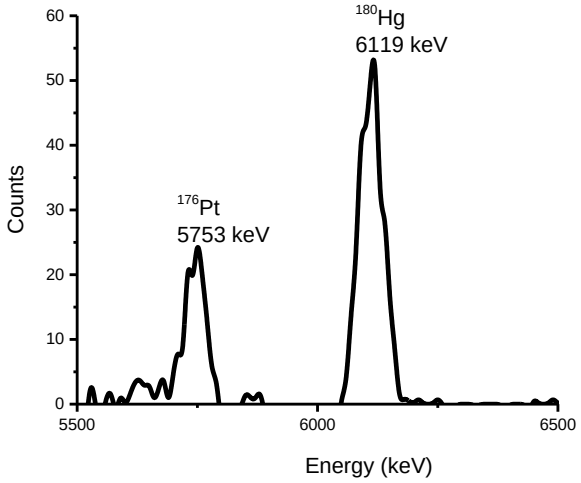


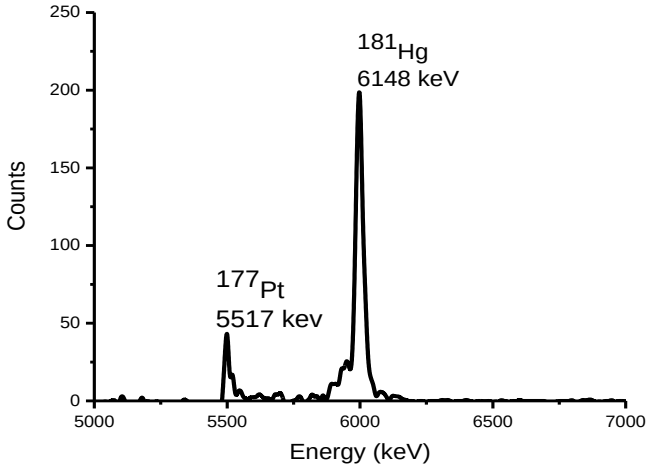
Two dimensional plot for alpha particle energy from ^{212}Rn to ^{219}Rn

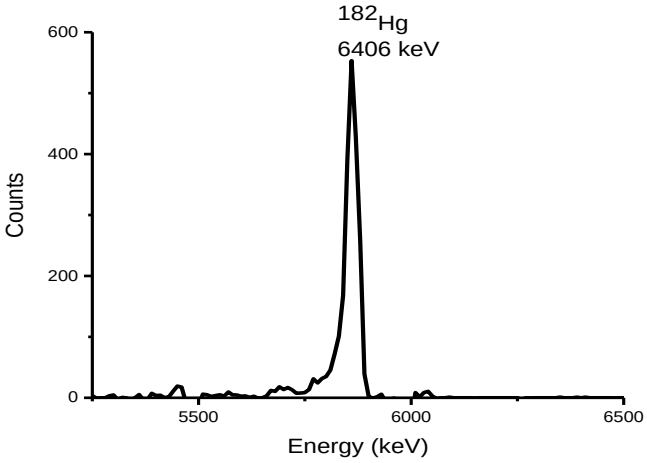


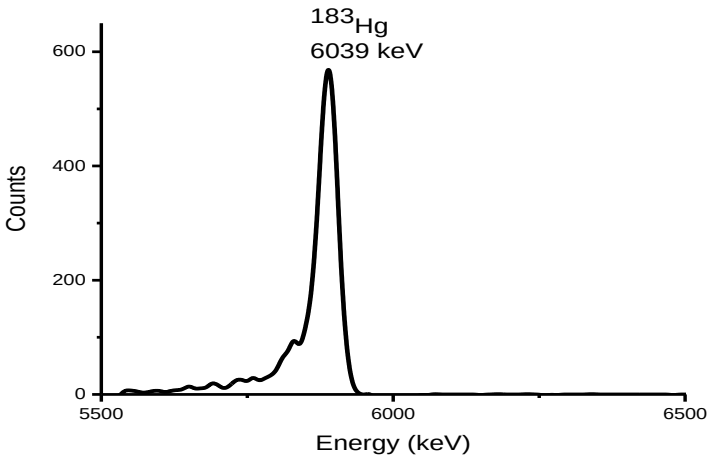
Rn Isotopes	Half life
212	23.9 s
213	19.5 ms
214	0.7 μs
215	2.3 μs
216	45 μs
217	0.54 ms
217	34 ms
218	35 ms
219	3.96 s

One dimensional Spectra of ^{180,181,182} and ^{183}Hg

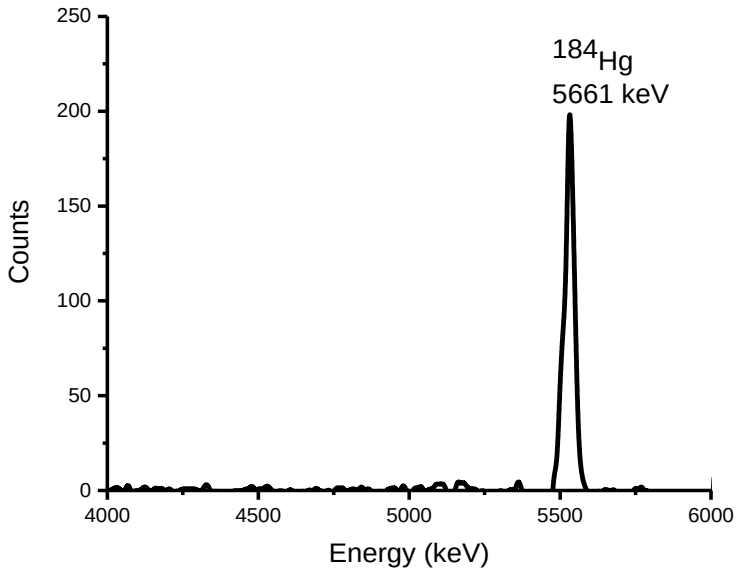


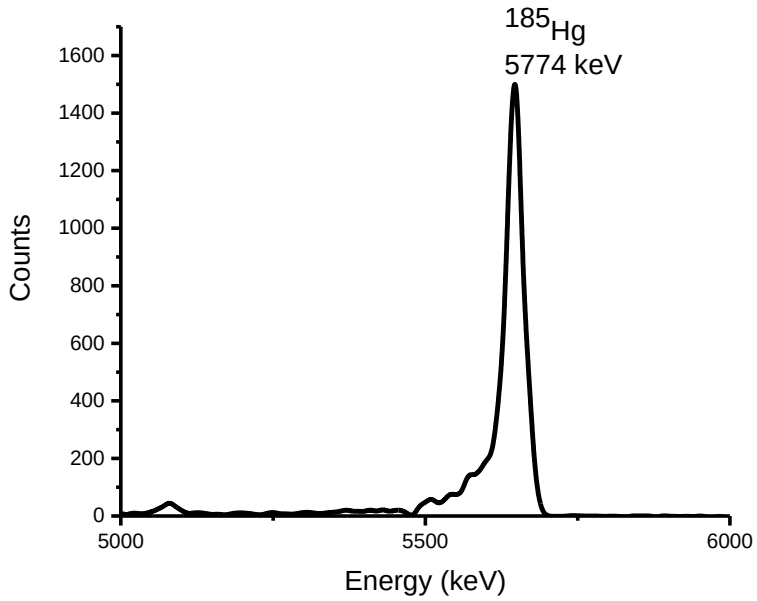






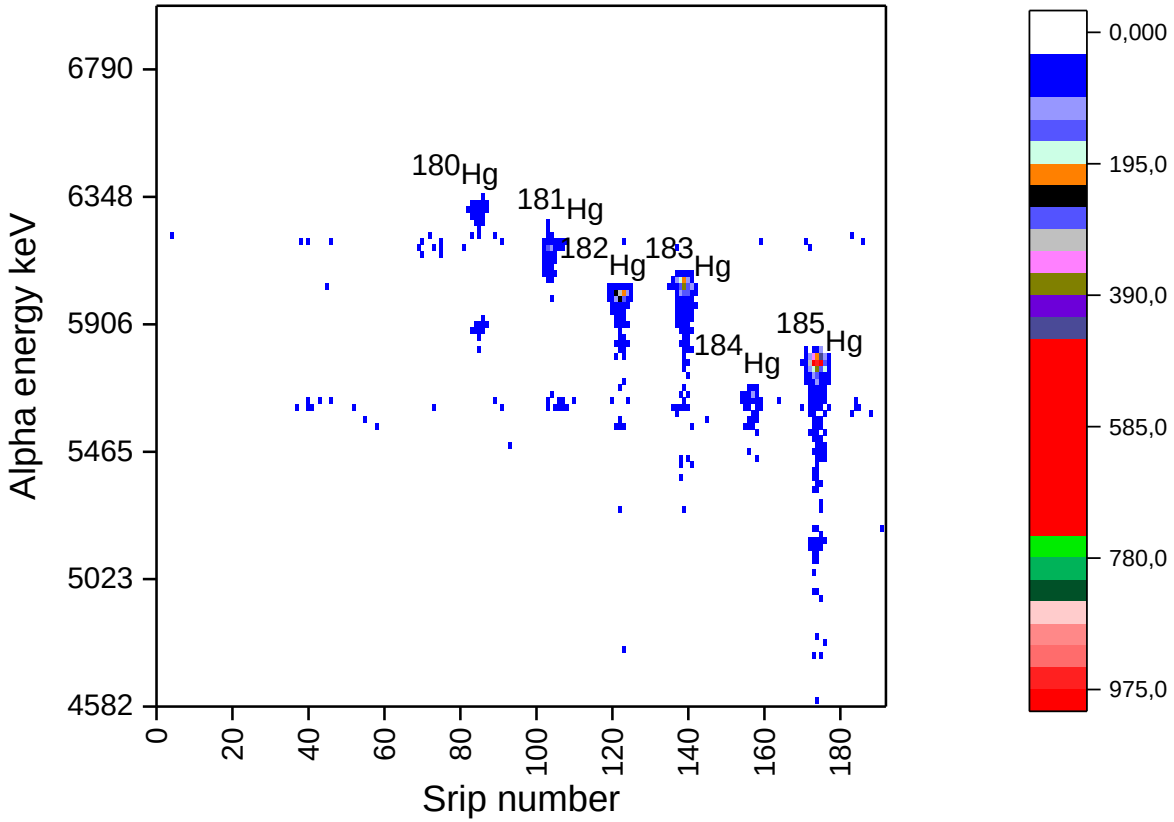
One dimensional spectra of ^{184}Hg and ^{185}Hg



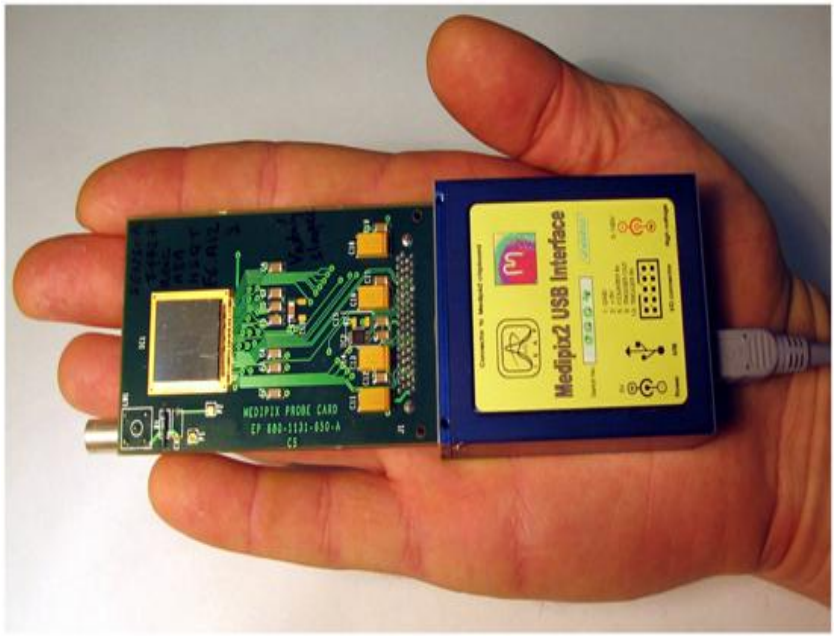


Two dimensional plot for alpha particle energy of Hg isotopes

$^{40}Ar + {}^{nat}Sm \rightarrow {}^{nat\text{-}xn}Hg + xn$

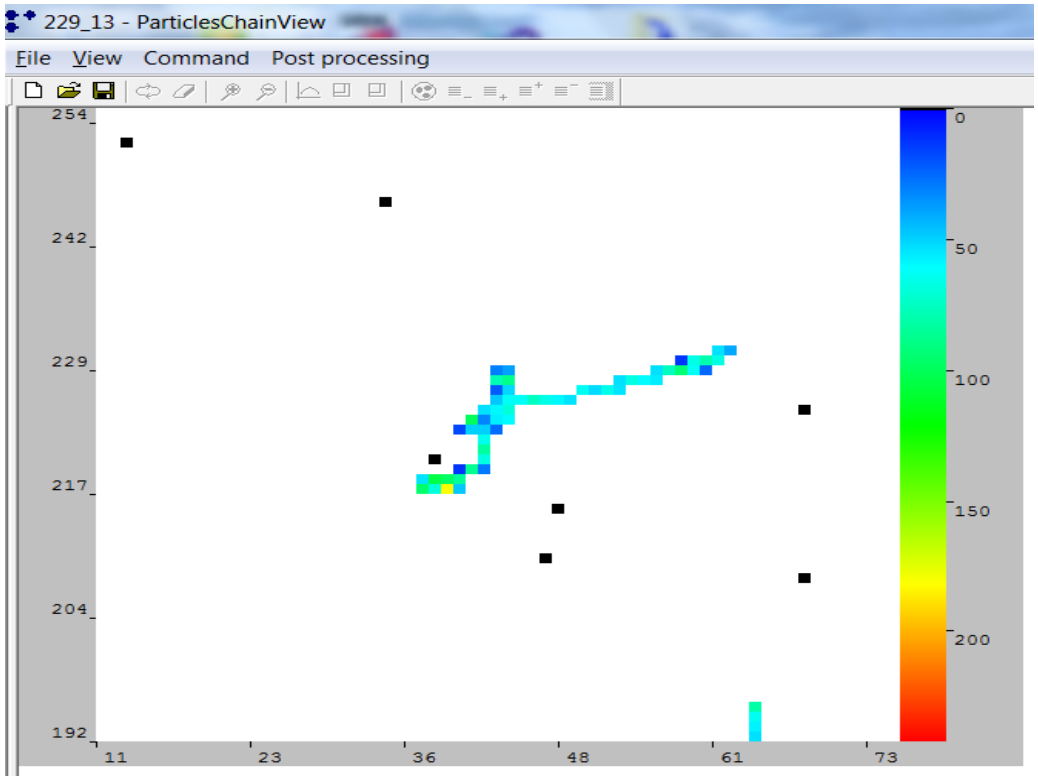


The experiment of production neutron rich Radon isotope using TIMEPIX detector



- Sensitive area 14*14 mm
- 256*256 pixels. Silicon sensor 300 mkm 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).

The experiment of production neutron rich Radon isotope using TIMEPIX detector



$^{229}Rn \longrightarrow {}^{229}Fr \longrightarrow {}^{229}Ra \longrightarrow {}^{229}Ac \longrightarrow {}^{229}Th$

Results and Conclusion

- Isotopes of Radon and Mercury were produced and measured by the alpha radiation spectra in the complete fusion reactions $^{40}Ar + ^{nat}Sm$ and $^{40}Ar + ^{166}Er$.
- The calibration of focal strip detector was carried out using Rn and Hg isotopes.
- Mercury is similar to number of properties, like with respect to the adsorption energy to the surface with the elements 112 and 114.
- The spectra of the alpha particles energies after decay can provide more insight on the properties of Copernicium and Flerovium elements.
- Relative yields of the Rn and Hg isotopes indicate a reliable efficiency of the MASHA.
- TIMEPIX detector have been demonstrated for future use in the mass-separator MASHA, like in the experiment of production of the neutron rich radon isotopes.
- Experiments carried in mass spectrometer MASHA provide information about yields of isotopes (if interested for the future production), cross section and online identification of that isotope.

Acknowledgements

Thank You !