Determination of masses of super heavy isotopes at MASHA setup. Spectroscopic investigation of nuclides near N=126 neutron shell closure.

1. **Introduction:**

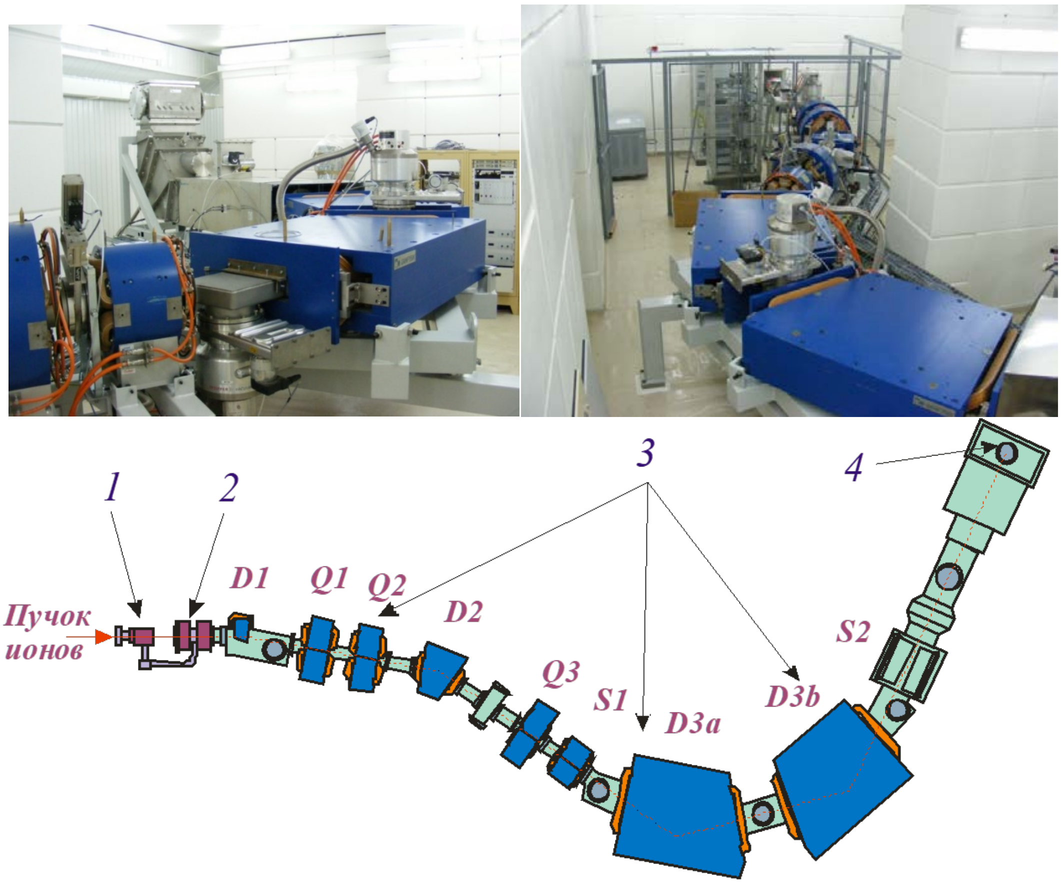
   MASHA facility was built for identification of superheavy elements (SHE) by their mass-to-charge ratios. The yields of SHE in full fusion reactions $^{48}Ca + {}^{238}U$, $^{48}Ca + {}^{242}Pu$, $^{48}Ca + {}^{244}Pu$ is very low due to its low cross-sections of several nanobarns. That is why the reactions of Hg formations as the possible homologue of 112 and 114 and Rn as an inert gas were used for the test experiments. The separation efficiency of mercury could predict the separation efficiency of superheavy elements and thus predict its expected yields. The Isotope Separation OnLine (ISOL) method is widely used in mass analysis for determination of short-lived isotopes. It is based on cooling and stopping the reaction products, making possible their magneto-optic and electrostatic analysis, as well as their separation from the primary beam in the non-interruptible "online" mode. The experiment aimed at studying a new carbon nanomaterials application was performed on the U-400M heavy ion beam at MASHA facility, FLNR, JINR. The work on the project means the analysis of real data collected from the experiments of full-fusion reactions neutron evaporation residues and multinucleon transfer reaction using the α-decay chains from the position sensitive Si detector. The use of the special hybrid pixel detector TIMEPIX with the MASHA setup for neutron-rich Rn isotopes identification also exists.

2. **Main part, preliminary task:**

   To perform the mass measurement and determination of short-lived isotopes of Hg (as the homologue to SHE), Rn and its daughter nuclei by α-decay chains at position sensitive Si detector. Simultaneous yield measurements of Cn, Fl, and Hg. Semiconductor detector calibration using gained data from an experiment of complete fusion reactions $^{148}Sm(^{40}Ar, xn)^{188-x}Hg$, $^{166}Er(^{40}Ar, xn)^{206-x}Rn$ and multinucleon transfer reaction $^{244}Pu(^{48}Ca, xn)^{219-x}Rn$.

3. **Description of the project:**

3.1. Photo and plan of MASHA setup.



1. Target, hot catcher. 2. ECR based ion source. 3. Analyzing magnets. 4. Position sensitive Si detector chamber.

3.2. Get acquainted with works performed in FLNR, at MASHA setup. Get and analyze α-spectra from gathered data in real irradiation experiment with heavy ions using the OriginPro software. Perform the calibration of the position sensitive strip detector by means of two-dimensional spectra of the α-active isotopes of mercury and radon.

3.3. The results of work should be formalized in the individual report, consisting of brief abstract, introduction, motivation, setup description, main part with graphs, results discussion, conclusion and list of used sources. In addition by the demand of the University Centre of JINR it might be the defense of results lies in mutual preparation of presentation.

4. The requirements for the students.

English knowledge at least at B1 level;
knowledge in acceleration technology;
principles of nuclear reaction physics;
principles of semiconductor detectors work;
parts used at MASHA installation;
principles of mass-to-charge spectrometry;
knowledge of superheavy elements production at accelerators;
neutron evaporation residues reactions of complete fusion reactions;
fluent use a chart of nuclides;
OriginPro software to construct graphs and analyze it.

5. **Recommended literature**.

1. Chemical identification of Dubnium as a decay product of element 115 produced in the reaction $^{48}Ca + ^{243}Am$. S.N. Dmitriev, Yu.Ts. Oganessyan, V.K. Utyonkov et al. Dubnium as a decay product.
2. Chemical characterization of element 112. R. Eichler, N. V. Aksenov, A. V. Belozerov et al. Nature. Letters. Vol. 447, May 2007.
3. The current status of MASHA setup. V. Yu. Vedeneev, A.M. Rodin, L.Krupa. Hyperfine Interactions 238:19 (2017).
4. MASHA Separator on the Heavy Ion Beam for Determining Masses and Nuclear Physical Properties of Isotopes of Heavy and Superheavy Elements. A.M. Rodin, A.V. Belozerov, D.V. Vanin. Instruments and Experimental Techniques, 2014, Vol. 57, No. 4, pp. 386–393. © Pleiades Publishing, Ltd., 2014.

6. **Number of students:**
   4-6 in team or individually.

7. **Head of the project for students:**

Vedeneev Viacheslav Yurievich, junior research scientist, sector of mass-spectrometry and laser spectroscopy of heavy nuclides, Flerov Laboratory of Nuclear Reactions.