

STATUS OF AN ACCELERATOR MASS-SPECTROMETER PROJECT FOR SD RAS

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Present status of an accelerator mass spectrometry (AMS) facility at BINP is described. The AMS facility with addition electric and magnetic analyzers into a terminal of a tandem accelerator is designed for precise analyses of carbon isotopes at extremely low concentration levels.

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1. INTRODUCTION

The status of the BINP AMS facility and the recent development are described. The construction work started in 2003, and the project has been presented previously [1]. Fig.1 shows the layout of the AMS facility.

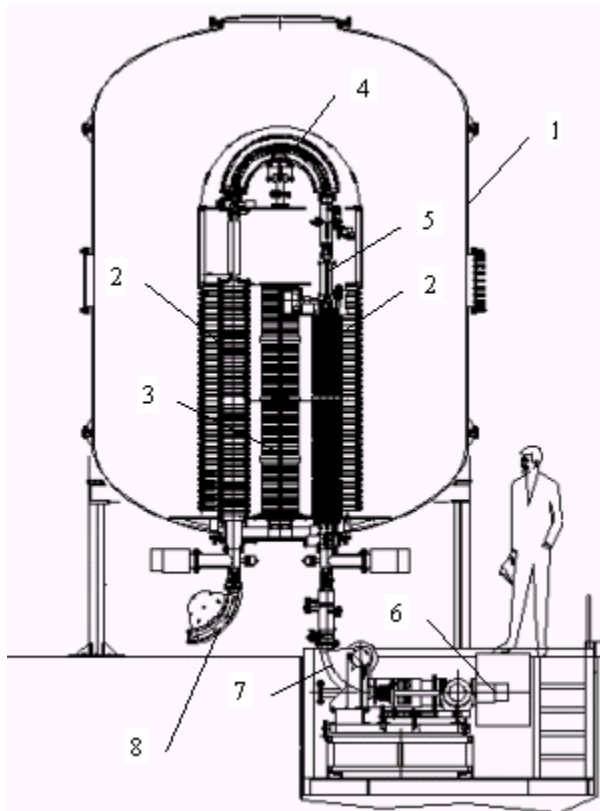


Fig.1. AMS facility layout:

1 – pressure tank; 2 – accelerator tube; 3 – cascade generator; 4 – combined filter; 5 – magnesium vapors stripper; 6 – ion source; 7 – low-energy magnetic analyzer; 8 – high-energy magnetic analyzer

The AMS is based on an electrostatic tandem accelerator. The most distinguishing feature of our AMS machine is the use of additional separator of ion beam, located inside the terminal. The addition of electric and magnetic analyzers can essentially decrease the background. Interfering isobaric molecules are destroyed by collisions in the stripper into the terminal and selected

immediately after stripping process. It is important to decrease the background from molecular fragments before the second acceleration stage because otherwise they can obtain large energy spread by recharging on residual gas into electric field. The ions in charge state 3+ will be used for isotope analysis because the molecules in charge state 3+ are unstable. The next important distinguishing feature is magnesium vapors stripper instead of the gas stripper. Therefore, it is not necessary to use additional turbo-molecular pump for good vacuum condition outside the magnesium vapors stripper.

2. INJECTION SYSTEM

A photograph of the injection system is shown in Fig. 2.

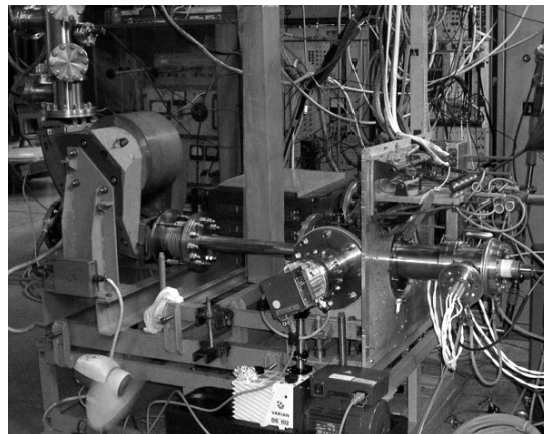


Fig.2. Injection system

The AMS system has two ion sources. The sputter ion source is required for analysis of solid samples. The gas ion source is needed for direct analysis of gas samples and for system adjustment. The injection energy of the extracted negative ions is 15 keV. The ion beam extracted from the source passes through a double focusing 90° analyzing magnet, with 40 cm radius and 2.5 cm pole gap. The position and angles of extracted beam are slightly corrected by four pairs of electrostatic plate. During radiocarbon measurements the carbon isotopes will be passed through magnet by additional voltage applied to the vacuum chamber of magnet. The stable isotope currents are measured during time of the injection of the radioisotope beam by offset Faraday cups placed

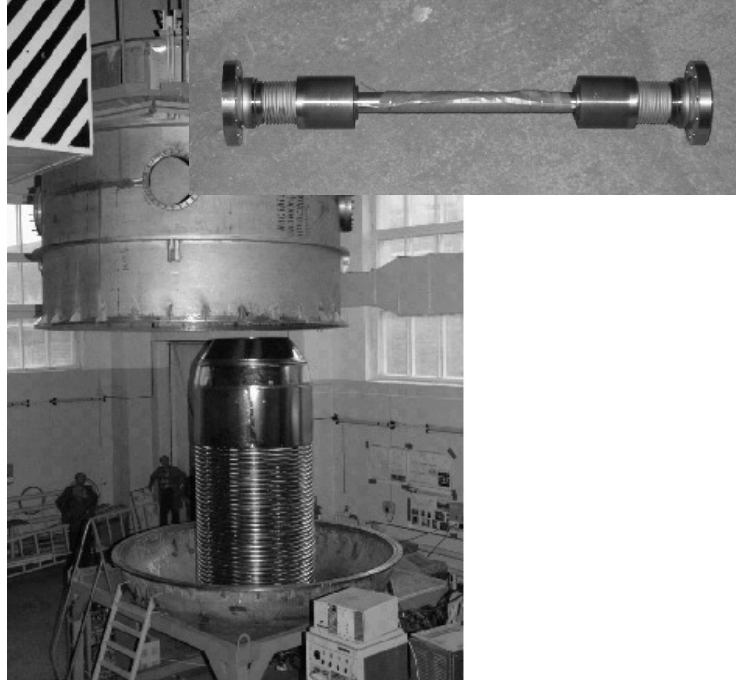
after injection magnet. In order to set up the size and position of injection beam into the stripper channel, the system of three-electrode electrostatic lenses and electrostatic dipoles are manufactured and will be placed at the entrance of the accelerating tube. The vacuum of the injection channel is kept better than $5 \cdot 10^{-6}$ Torr by 400 l/s ion pump. A new 250 l/s turbo-molecular pump is now installed just behind ion sources. The beam-line from ion source to accelerator tube is completed and tested.

3. TANDEM ACCELERATOR

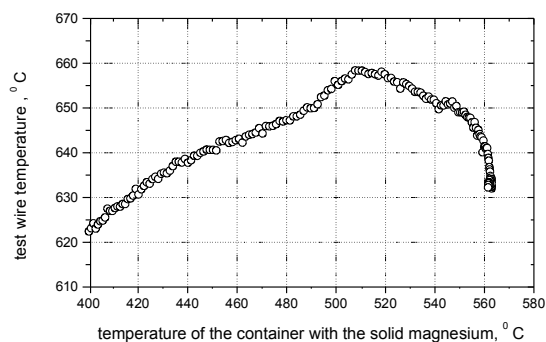
The AMS tandem accelerator is a folded type vertical machine with 180° bending system in the high voltage terminal. A photograph of the tandem accelerator is shown in Fig.3.

Fig.3. Tandem accelerator

The negative ions will be accelerated to the positively charged high voltage terminal and stripped to 3+ state in charge exchange target. Then they pass through the 180° combined bend and then again are accelerated into the high energy accelerating tube to the ground potential. The two accelerating tubes and cascade generator are enveloped by shielded column, which is 200 cm high and 140 cm outside diameter of shielding rings, and placed into a pressure tank. The dimensions of pressure tank are 4.6 meters high and 3.2 meters diameter. The accelerating tube consists of five sections, with 21 mm electrode step. The electrodes are divided by ceramic rings with 18 cm inner diameter. The channel aperture of accelerator tube is 3 cm. Resistor chains achieve the potential gradients across the columns and tube electrode gaps. The maximal designed gradient in the tube is a little larger than 10 kV/cm. The accelerating voltage is generated by the symmetrical cascade generator with a resonance frequency around 20 kHz. The project terminal voltage has value 2 MV, with SF₆ insulating gas, at 1.7 atm pressure. At present, while in the commissioning phase, the accelerator is used with air at 1 atm pressure as insulating gas instead of sulfur hexafluoride gas. The maximal terminal voltage of 500 kV was demonstrated during the installation period, with air being the insulating gas. The SF₆ gas is now stored in the external tanks. The gas transfer system with the compressor and the dryer containing silica gel is completed. The accelerating tubes, the cascade generator, the shielded column, and the terminal shell are also installed into the tandem tank.



4. MAGNESIUM VAPORS STRIPPER



The use of magnesium vapors stripper allows obtaining the vacuum level in accelerating tubes being comparable with systems with solid targets because the magnesium vapor is condensed into the special containers at the room temperature, which are placed at the entrance and exit of the stripper tube. Solid targets at these energies have a short lifetime and therefore are not applied usually. The high gas flow into the high-energy tubes leads to large energy spread in the beam thus limiting the sensitivity and accuracy of a spectrometer. The magnesium vapors stripper was manufactured and is shown in Fig.3.

Fig.4. Magnesium vapors stripper

The stripper channel has a length of 30 cm and the inner diameter of 3 mm. The stripper tube is enveloped by the container with the solid magnesium. When the container is heated, the magnesium vapors follow from the container through the small holes to the stripper tube. In order to check the efficiency of the magnesium vapor stripper, the elegant experiment was performed. In this experiment, a thin tungsten wire is strained along the stripper tube axis. The container with the solid magnesium is heated by current flowing through it. The test wire temperature is varied as shown in Fig.5.

Fig.5. The test wire temperature as a function of the container temperature with the solid magnesium

At first, the wire temperature increases with increasing the stripper tube temperature by exchange of ther-

mal radiation energy between the wire and stripper tube. Then the temperature of wire reduces because the wire is cooled by thermal conductivity of the magnesium vapor, which pressure is increased dramatically with increasing of the magnesium heating temperature. The magnesium vapors pressure is $\sim 10^{-10}$ Torr at room temperature and rises up to $\sim 5 \cdot 10^{-2}$ Torr at $\sim 500^\circ\text{C}$. The temperature range of 450 to 500°C provides the sufficient thickness of target for radiocarbon dating measurements. The previously developed analogue of such target has worked for more than 500 hours on the electron cooling investigation facility [2].

5. HIGH ENERGY BEAM SELECTION

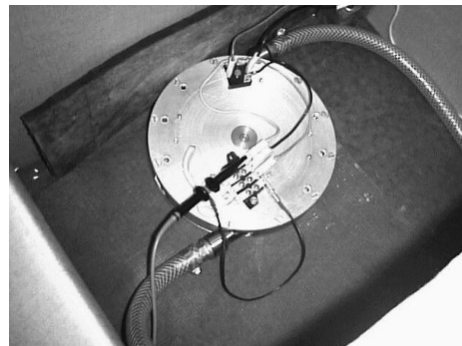
The filter with electric and magnetic fields will be mounted immediately behind the magnesium stripper, both have 40 cm radius and 180° bending angle. The electrostatic plates are placed into the magnet. The distance between the electrostatic plates is 1 cm, these plates are of spherical form, thus providing a double focusing of a beam. The magnet has uniform field in the gap with 600 Gs maximal field that is quite enough for mass selection. The 90 % of centripetal force are obtained by electrostatic field, with ~ 30 kV/cm maximal field at 2 MV accelerating voltage. The most fractions of the unwanted particles should be removed by this selector. This terminal selector is now under construction. For better background filtration, the next 90° analyzing magnet will be placed at the exit of the tandem accelerator. The carbon radioisotope particles will be measured by a silicon surface barrier detector placed at the end of beam line [1].

6. CONTROL SYSTEM

The fully computer controlled system is designed and partly manufactured. The software used for the control system is based on the LabVIEW. The system is equipped with ADAM and CAMAC modules. The experiment parameters and running conditions are displayed on-line. These data are stored in a database and can be used as initial values for the beam tuning. All devices at high voltage potentials are controlled through an optical ADAM link system in communication with the computer. The gaseous turbine will be placed into

the tandem terminal for powering the equipment into terminal. The turbine will be rotated by compressed air flowed from the compressor, which will be placed at ground potential. The prototype of such turbine was made and tested. A photograph of the gaseous turbine is shown in Fig.6.

Fig.6. Gaseous turbine



The power – 500 W is obtained. The efficiency factor of turbine is about 10%. In is sufficient for powering of the all equipment into tandem terminal. New turbine with 20% efficiency factor was designed.

SUMMARY

The low-energy line is installed and in operation. By the end of 2005, a beam will be accelerated to the high voltage terminal. The work on a high-energy line will be started in the 2006 year.

ACKNOWLEDGMENTS

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* www.fasie.ru
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СОСТОЯНИЕ РАБОТ ПО ПРОЕКТУ УСКОРИТЕЛЬНОГО МАСС-СПЕКТРОМЕТРА ДЛЯ СО РАН

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Рассмотрено текущее состояние работ по созданию в ИЯФ им. Г.И.Будкера ускорительного масс-спектрометрического комплекса (AMS). Комплекс AMS с дополнительным электрическим и магнитным анализаторами, расположенными в области терминала tandemного ускорителя, предназначен для прецизионного анализа предельно низкой концентрации изотопов углерода.

СТАН РОБІТ ІЗ ПРОЕКТУ ПРИСКОРЮВАЛЬНОГО МАС-СПЕКТРОМЕТРА ДЛЯ СВ РАН

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Розглянуто поточний стан робіт з створення в ІЯФ ім. Г.І. Будкера прискорювального мас-спектрометричного комплексу (AMS). Комплекс AMS с додатковим електричним і магнітним аналізаторами, розташованими в області терміналу tandemного прискорювача, призначений для прецизійного аналізу гранично низької концентрації ізотопів вуглецю.