ОБЪЕДИНЕННЫЙ
ИНСТИТУТ
ЯДЕРНЫХ
ИССЛЕДОВАНИЙ

Дубна

E13-98-106

V.Z.Maidikov*, V.V.Bashevoy

AN ALTERNATIVE BEAM LINE AT THE **U-400M** CYCLOTRON FOR **RIB** SEPARATION AND TRANSPORT TO THE **FOBOS** SPECTROMETER
(The Technical Proposal)

Submitted to the 15th International Conference on Cyclotrons and their Applications — CYCLOTRONS-98, June, 1998, Caen, France

*On leave from the Institute for Nuclear Research of the National Academy of Sciences of the Ukraine, Kiev, Ukraine

1998

Introduction.

The very high efficiency of the FOBOS 4-π spectrometer [1] is very suitable for different experiments performance with beams of radioactive nuclei having a rather low intensity. The existing beam-transport line from the U-400M cyclotron to the FOBOS, as it has been shown by the detailed analysis of its ion-optical parameters, have a very low efficiency for the RIB transport and it needs the modernization [2]. However, the U-400M cyclotron have another beam-extraction channel working in the beam charge-exchange mode of extraction, situated at the opposite side of the existing beam-transport line [3].

We have analyzed the possibility for this back-side beam extraction channel to be used for RIB separation and transport to the FOBOS setup. Results of this analysis are presented in this paper.

Initial conditions.

At the starting point of the design of new RIB separation and transport line we are limited by three main initial conditions:

1. The fixed position of the beam-extraction channel from the cyclotron and fixed position of the FOBOS spectrometer.

2. The fixed directions of the beam axis of the beam-extraction channel from cyclotron and the beam entrance to the FOBOS with fixed angle between these directions equal to 35°.

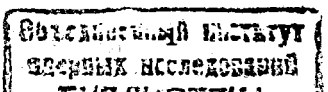
3. For the new beam-line channel design we may use only available standard magnetic elements similar to the ones of the main U-400M beam-transport line.

The aim of this work was to design the RIB separator with the maximum selectivity and maximum efficiency, for the adequate FOBOS operation, under the above mentioned initial conditions.

Description of the separator.

The scheme of the proposed separator for the back-side of the U-400M cyclotron is shown in Fig.1.

It is a symmetric achromat with the mirror symmetry about the point of the intermediate dispersive focus and the double focussing in the final achromatic focus. The main part of the separator consists of 4x35° bending magnets (the total bending angle being 140°),



providing the beam dispersion in the intermediate focus and compensation of this dispersion at the final focus. The beam focussing is provided by two triplets and two dublets of quadrupole lenses at the entrance and at the exit of each part of the separator. Thus the optical scheme of separator is F0QQQDDQQF1QQDDQQQF2. The dispersive intermediate focus is not stigmatic. At this point the horizontal focussing in the plane of separator dispersion is better than in the vertical direction. The momentum dispersion in the intermediate focus is 1.25 cm/%, the horizontal magnification - 0.6, vertical magnification - 2.75. At the final achromatic focal point the linear and the angular magnification coefficients in both horizontal and vertical directions are equal to the unity.

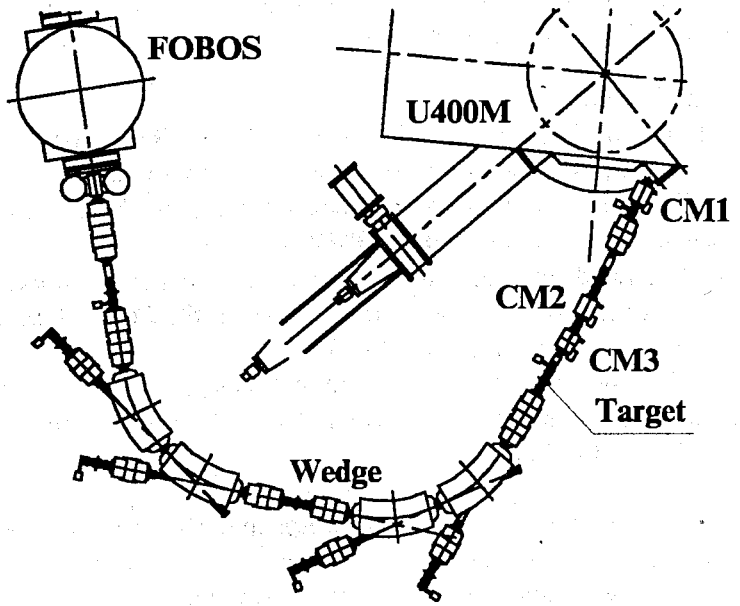


Fig. 1. Schematic drawing of the new U-400M RIB separator.

At the target position distance of 65 cm from the entrance of the first quadrupole triplet and the inner ion guide vacuum chamber diameter of 6.3 cm, the angular acceptance of the separator is $\Delta\Theta = \pm 15$ mrad in the horizontal plane and $\Delta\varphi = \pm 15$ mrad in the vertical plane.

The momentum acceptance of the separator with this vacuum chamber diameter is $\Delta P/P = \pm 0.5\%$.

The envelopes of ion trajectories in the separator in horizontal and vertical planes are shown in Fig. 2. Horizontal and vertical dimensions of the beam in the separator do not exceed ± 3 cm. The total separator length along the beam axis is 18 m. The whole beam line length from the production target to the target of the FOBOS spectrometer is 23.5 m.

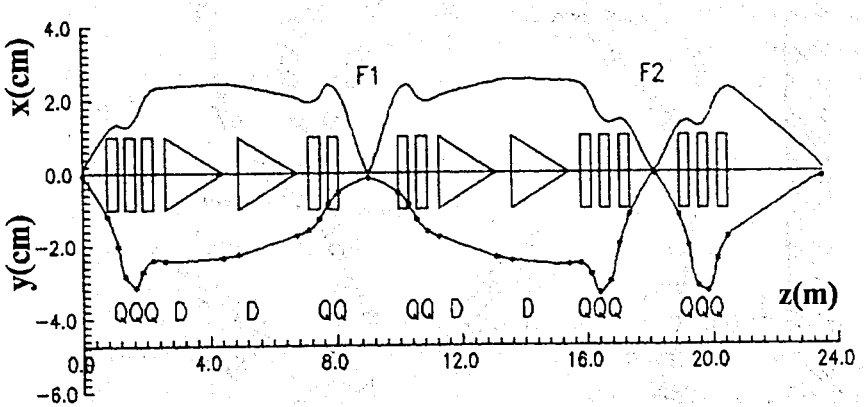


Fig. 2. Beam profile along the separator in the horizontal (X) and vertical(Y) planes for 1-mm target size in diameter and no beam momentum spread.

The beam extracted from the cyclotron is focused on the RIB production target, placed in the initial point of separator, by means of the standard for the U-400M beam preparation system, consisting of the correcting magnet CM1 and doublet of quadrupole lenses. An additional pair of correcting magnets CM2, CM3 in front of the RIB production target makes it possible to separate the secondary beam, emitted from the production target, at different angles in the angular interval ± 5° with respect to the primary beam direction.

The RIB separation at the distinct from the 0° angle permits one to decrease significantly the contaminations of the primary beam particles in the secondary beam and to choose the compromise conditions between the maximum RIB yield and the minimum of background contaminations.

The final focus of the separator is transmitted to the FOBOS target by means of the quadrupole triplet.

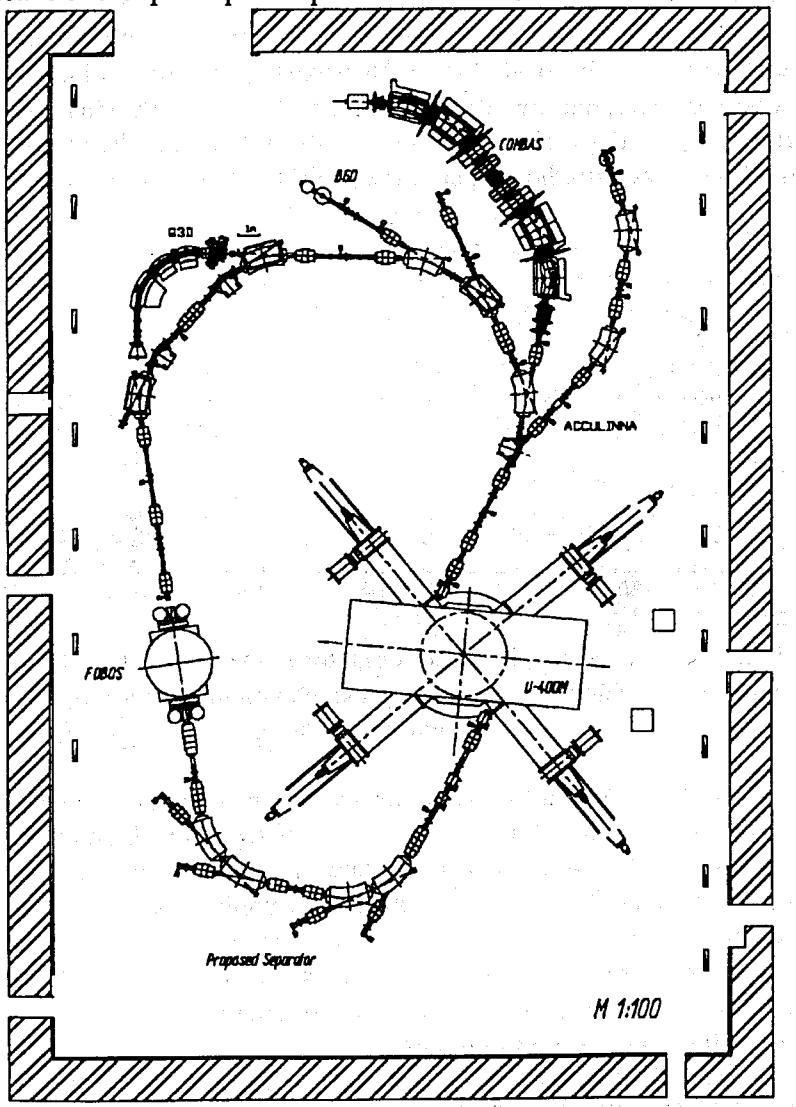


Fig.3. The U-400M beam switchyard layout with the back-side beam line with the new separator.

The proposed new beam line may serve also as an economic alternative to the existing U-400M beam transport line to the FOBOS setup. It consists of 4 bending magnets as compared to 8 magnets in the existing beam line, and 15 quadrupole lenses contrary to 22 lenses. Moreover, it permits to create 4 additional experimental areas at the U-400M back-side on straight outlets of each bending magnet, as it shown at the lower part of Fig. 1, 3. Some part of each beam lines could serve also as a magnetic analyzer of charged particles emitted from the FOBOS target at the 0° direction. In principle, one could plan the colliding beams experiments performing using both beam lines or to close both beam lines into the storage ring around the cyclotron.

Resume

The first order ion-optic calculations performed together with the graphical modeling permits us to propose a new variant of the beam-transport line from the back-side of the U-400M cyclotron to the FOBOS spectrometer. This beam line could be built in a rather short time without large financial expenditures from available magnetic and vacuum elements. The new beam line could even be considered as an economic alternative to the existing beam line and as a RIB separator.

This work is the result of the pre-design R&D aimed to develop the U-400M cyclotron facilities for the RIB experiments performance with the FOBOS spectrometer.

The ion-optical calculations of the new separator parameters were performed using the TRANSPORT computing code (version of 1975) [4] on the 386PC/AT computer. Graphical modeling was made on the SUNSPARCstation [5] in the AutoCAD environment [6].

Acknowledgments

One of the authors (V.Z.M.) is very indebted to Dr.V.N.Melnikov for the computing code presentation, valuable help with the computing procession and very useful discussions.

References

1. H.-G.Ortlepp et al., Print ZFK -734, Rossendorf 1990 Status Report FZR 92-11, Rossendorf 1992
2. V.Z.Maidikov et al., Heavy Ion Physics. VI Internat. School-Seminar Abstracts. Dubna 1997, p. 207; and to be published
3. G.G.Gulbekyan et al. Heavy Ion Physics. JINR FLNR Sci. Rep. 1991 - 1992, Dubna 1992. p. 273
4. K.L.Browne et al., CERN Report 80-04, 1980
5. Sun Microsystems Inc. Site, http://www.sun.com
6. AutoCAD Reference Manual, AutoDesk, June 1992

Received by Publishing Department
on April 23, 1998.