One Ring Mode of the Storage Ring Complex K4-K10.

O.N.Malyshev, I.N.Meshkov, Yu.Ts.Oganessian, A.M.Rodin, V.P.Sarantsev, S.I.Sidorchuk, S.V.Stepantsov, E.M.Syresin, G.M.Ter-Akopian and V.A.Timakov
Joint Institute for Nuclear Research, Dubna 141980, Russia

V.V.Parkhomchuk and A.N.Skrynsky
Budker Institute of Nuclear Physics, Novosibirsk 630090, Russia

V.F.Bykovsky
Center of Applied Physics and Technology, Lipetsk 398055, Russia

V.P.Belov, I.A.Shuckeylo, Yu.P.Severgin and M.N.Tarovik
Efremov Scientific Research Institute for Electric Physical Equipment, St.Petersburg 189631, Russia

Abstract

Storing radioactive ion beams (RIB's) just in the ring K4 are considered. Due to the primary beam spot size of some tenths of millimeter on the production target, the created secondary RIB of interest has a small transverse emittance not exceeding $15\pi\cdot mm\cdot mrad$. After monochromatization in a fragment separator the RIB momentum spread is additionally reduced down to $\approx 0.1\%$ by a debuncher. This decreasing the RIB phase space greatly contributes to shortening its electron cooling time on the ring K4 orbit. For an internal target of the thickness of $10^{14}\,cm^{-2}$, the RIB's luminosities from 10^{22} to $10^{28}\,cm^{-2}s^{-1}$ are reachable.

1. INTRODUCTION

The project of two heavy ion storage rings complex K4-K10 is described elsewhere [1,2,3,4]. The most recent upgrad of the whole complex is presented in [5]. To speed up the realization of the project its first stage which could be accomplished within two-three years is determined (Fig.1).

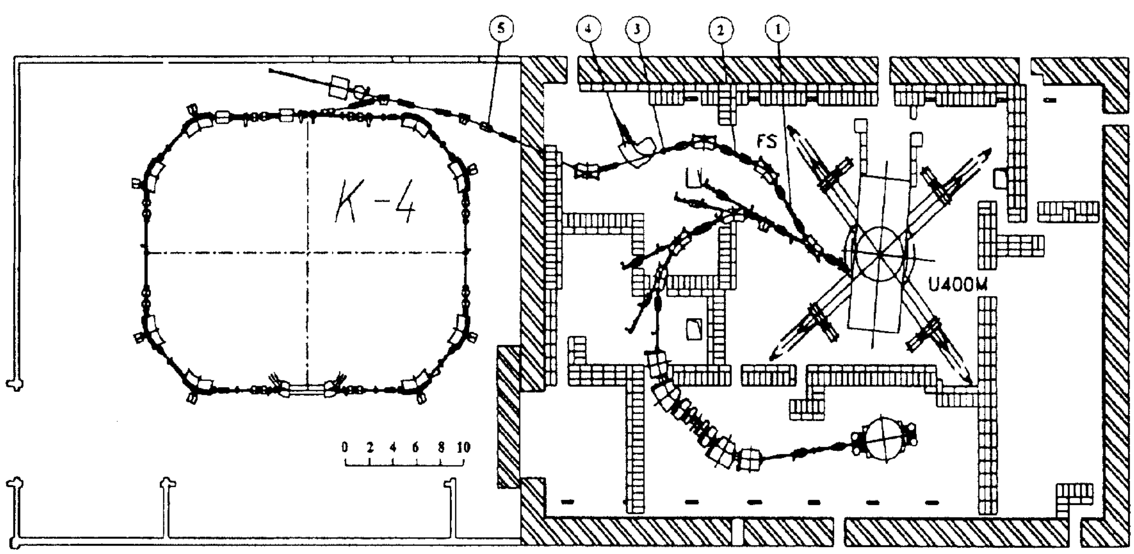

Fig.1. The general view of the latest upgrad of the storage complex K4-K10.
1 - RIB production target; 2 - intermediate focal plane;
3 - secondary experemental target; 4 - analysing magnet; 5 - debuncher.

It permits to providing high precision beams of exotic nuclei with mass numbers of A<50 in the energy range from few MeV to about 200 MeV/amu. Due to the electron cooling the beam quality will be improved to a level of a very high momentum resolution ($\Delta P/P = 10^{-6}$) and transverse emittance ($\varepsilon \approx 0.1\,\pi{\cdot}mm \cdot mrad$) for the nuclei having the lifetime of >50 ms. For the beams of nuclei with much shorter decay time, close to one millisecond, a considerable monochromatization down to a level of $\Delta P/P = 10^{-3}$ will be available by means of the beam debunching just before its injection into the ring. The peak primary beam intensities produced by the isochronous heavy ion cyclotron U400M greatly contribute to producing these RIB's.

2. Main Characteristics Of The Mode

The beam injection line into the storage ring K4 branches off the initial part of the main line of the beam extracted from U400M. Immediately after the splitting the beam is focused on a target where secondary beams are produced. Applying for focusing, as the estimations showed, the superconducting solenoid with the length of 0.75 m, the magnetic field of 7 T and the diameter of the field region of 12 cm allows getting the primary beam spot size of down to 2 mm. Secondary beams escaping from the target are captured by the fragment separator (FS). The FS consists of two 35 degree dipole magnets and four doublets of quadrupole lenses the same kind as were used at assembling the main extraction line of the cyclotron U400M. Though the last circumstance greatly limits the transverse and longitudinal acceptances of the fragment separator the using of standard quadrupoles makes more cheaper the FS designing and building-up. There exists the mirror symmetry with respect to the intermediate focal plane where a beam monochromatization by means of appropriate momentum loss degrader is possible. The maximum rigidity of the FS is 3.7 T*m. In Fig.2 the FS angular acceptance as a function of excitation of the channel, in this case in terms of the value of the pole tip magnetic field of the lens Q4, is presented for three initial transverse dimensions of RIB sources on the production target.

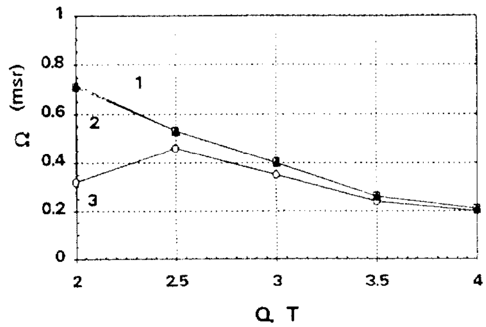

Fig.2. FS solid angle in dependence on exication mode.
$x_0 = y_0 = \pm 0.50\ cm\,(3)$;
$\pm 0.25\ cm\,(2)$; $\pm 0.10\ cm\,(1)$.

The best energy monochromaticity being reachable with monochromatic degrader and calculated with taking into account the aberrations up to the second order is given in Fig.3 for three RIB momentum spreads. The FS momentum acceptance is about $\approx 3\%$.

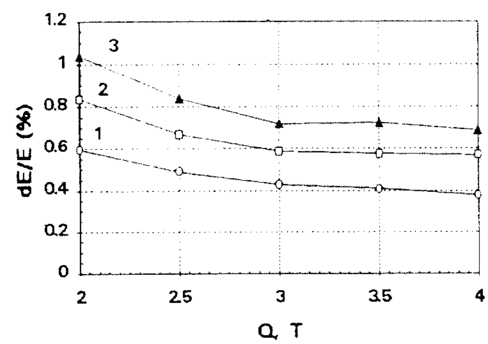

Fig.3. FS energy monochromaticity dE/E
$(dp/p)_{source} = \pm 1.0\%\,(1)$;
$\pm 1.5\%\,(2)$; $\pm 2.0\%\,(1)$

A further amelioration of the RIB monochromaticity would be possible by means of the beam debunching. In this case the amplitude of the RF voltage of 200kV, applied to the debuncher, is enough if one works on the second RF harmonic of the cyclotron U400M. Thus, the reduction of the RIB initial momentum spread ($\approx 3\%$) by a factor of about some tens it seems to be realistic. In Table the parameters of some exotic beams which will be obtained after the completion of the first stage of the project K4-K10 are presented.

Exotic Beams in K4.

BEAMS	$T_{1/2}$ (sec)	$\left\|N - N_{drip}\right\|$	E_{inj} (Mev/amu)	E_{max} (Mev/amu)	NUMBER OF IONS ON ORBIT	L $\left(s^{-1}cm^{-2}\right)$
^{6}He	0.808	2	42	80	10^{4}	10^{24}
^{8}He	0.122	0	43	50	10^{2}	10^{22}
^{8}Li	0.84	3	41	105	10^{4}	10^{24}
^{9}Li	0.178	2	44	80	10^{3}	10^{23}
^{11}Be	13.8	3	44	100	10^{5}	10^{25}
^{12}B	0.02	5	40	125	10^{5}	10^{25}
^{16}C	0.75	6	42	105	10^{3}	10^{23}
^{14}O	70.6	2	36	225	10^{5}	10^{25}
^{24}Ne	225	8	20	125	10^{6}	10^{26}
^{28}Mg	7×10^{4}	12	20	130	10^{7}	10^{27}
^{38}S	1×10^{4}	14	17	130	10^{7}	10^{27}
^{44m}Sc $\left(J^{p} = 6^{+}\right)$	2×10^{5}	9	22	160	10^{8}	10^{28}

3. REFERENCE.

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