OPERATION OF SYNCHROTRON "PAKHRA" IN SYNCHROTRON RADIATION SOURCE MODE

V.A. Karpov, G.G. Subbotin, A.V. Serov, P.N.Lebedev Physical Institute RAS
V.V. Mikhailin, Moscow State University

Abstract

Upgrade of power system has allowed to implement a new operation mode of the synchrotron "Pakhra". With this mode magnetic field stays constant within t = 380 ms after achieving the maximum value. Time of increase of the magnetic field is 10 ms. Thus electrons move with a constant energy for 95% of synchrotron cycle . Repetition rate of magnetic cycles is 2.5 Hz. Results of experimental researches of particles dynamics peculiarities in this mode for energies 175 and 220 Mev has been described.

Synchrotron consists of four bending magnets and the straight sections between the magnets. The orbit radius in the magnets is R_0 = 400cm, length of each straight section is L = 190cm. Synchrotron injector is a microtron for energy 7.4 MeV operating under the first type of acceleration. Injector current equals 40 mA with impulse duration 4 mcs. After extraction from the microtron the beam is formed in an electron-optical channel and is injected in the synchrotron with the help of a magnetic inflector.

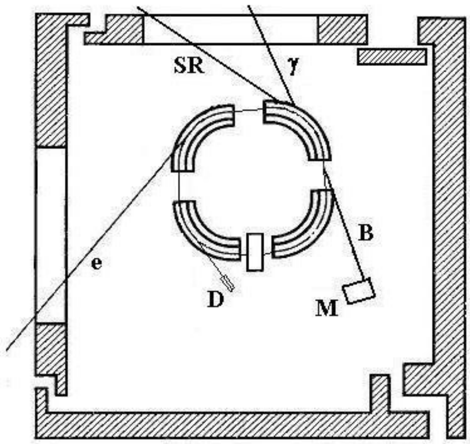

Figure1: The layout of the synchrotron "Pakhra". M – microtron, B – beam forming line, D - radiation detector, e – electron beam channel, - gamma-ray channel, SR- channel of synchrotron radiation

In case of usual operational mode the current in windings of the synchrotron magnet has two components: direct current I_0 and alternating current $I_\sim$ with frequency f = 50 Hz. Current amplitudes I_0 and $I_\sim$ can be controlled independently. The period of an acceleration cycle is about 17 ms, electrons are accelerated up to maximum energy for 8 ms. The time dependence of magnetic field of the synchrotron is shown in Fig 2a. The accelerating cavity of the synchrotron operates at frequency of 55 MHz.

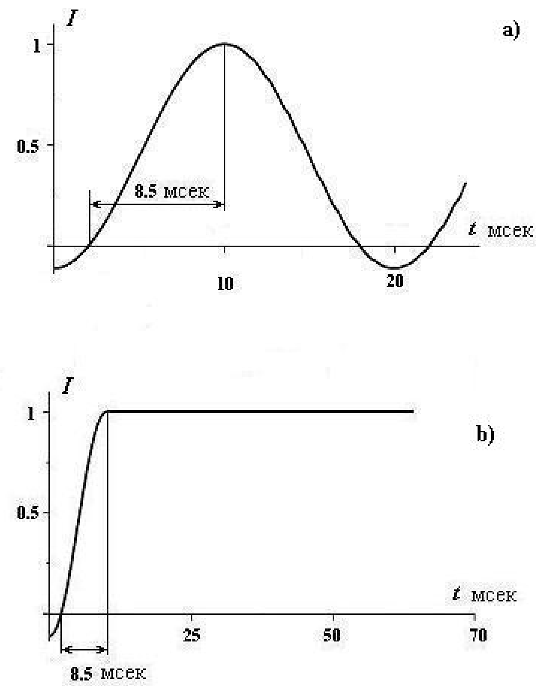

Figure2: The dependence from the time of the current flowing though the magnet in old a) and new b) power system.

Beside the extracted electron beam and the gamma-ray beam it is intended of use synchrotron radiation and for this aim a channel for research with VUV-radiation is build.

An upgrade of power supply system of the magnet is required for the operation mode of the synchrotron. In the new mode the magnet is excited by direct current I_0 and by pulse current I_{im} with duration 10 ms. Frequency of pulses sequence may change from 10 Hz to 0.2 Hz. Pulse current and direct current are oppositely directed in magnet windings. With this power supply system the magnet field stays constant during long time (from 100 ms for a repetition rate of 10 Hz up to 5 s for 0.2 Hz) upon getting the maximum value. In the latter case electrons in the synchrotron chamber will have constant energy during 99.8% of acceleration cycle time. Such operation mode of the synchrotron can be called "quasi-storage" mode. Fig 2b shows the temporal profile of the magnetic field.

Power supply system allows to change currents in the synchrotron magnet sufficiently easy. Under such changes electrons energy in the "quasi-storage" mode may vary from 50 Mev to 650 Mev, and the wave length for which maximum of synchrotron radiation is achieved – from 8 mkm to 3,5 nm.

To get a more stable acceleration process the energy of electrons injected into the synchrotron has been increased. For this purpose the microtron-injector was transferred to the second acceleration mode, where energy of electrons increased from 7,4 Mev to 11,5 Mev.

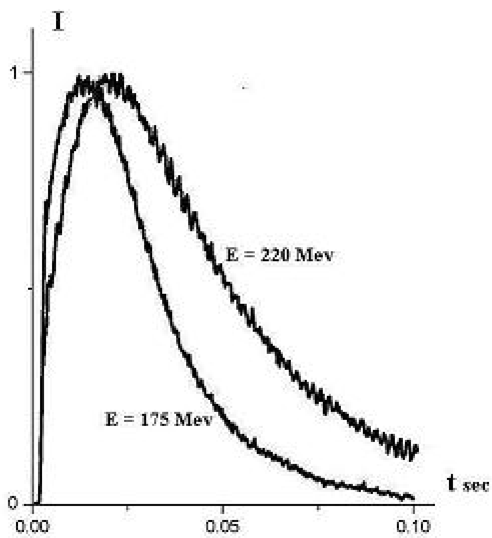

Figure3: Temporal profiles of currents to different energy.

Investigations of the new synchrotron mode has been carried out. Experiments were carried out with particle energy 175 and 220 Mev with the repetition rate of 2.5 Hz. Particle energy has achieved its maximum value at t ~ 5 ms and stayed constant during t ~ 390 ms.

Fig.3 shows a dependence of the accelerated current versus time. It should be mentioned that the decay time equals 30 ms for the energy 175 Mev and 50 ms for the energy 220 Mev. This dependence of the decay time on energy outlines the main reason of decreasing of the accelerated current with time. The current decrease is caused by scattering of particles by residual gas. The time dependence of transversal sizes of the bunch is due to the same reason. Fig.4 illustrates the time dependence of radial transversal size of the bunch.

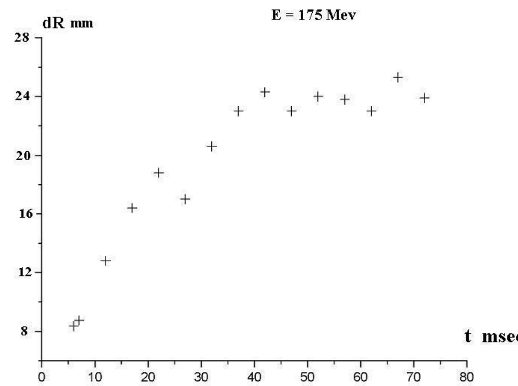

Figure4: Time dependence of radial transversal size of the bunch.

Preliminary evaluation demonstrates that the current decay time should be 500 ms for the energy 650 Mev.

Now we plan to improve vacuum in the synchrotron chamber.

Authors would like to express their appreciation to A.N. Lebedev for support provided to transferring of the synchrotron “Pakhra” to the new operation mode and for constant and effective discussions of running results.

This work was supported by Russian Foundation for Basic research (Grant 05-08-33689).