THE BIOLOGICAL SHIELDING FOR STORAGE RINGS OF NICA PROJECT

V.Ju.Shegolev, B.V.Florko, JINR, 141980 Dubna, Moscow region

Abstract

Intermediate results of biological shielding of calculations for storage rings are presented. ^{238}U ions are accelerated in nuclotron up to the energy 3,5 GeV/nucleon and extracted to storage rings. The beam intensity of the order makes about $5*10^{10}$ pps. Beam losses due to collisions with residual gas and on elements of the construction of a path both in work and adjustment modes were considered in calculation.

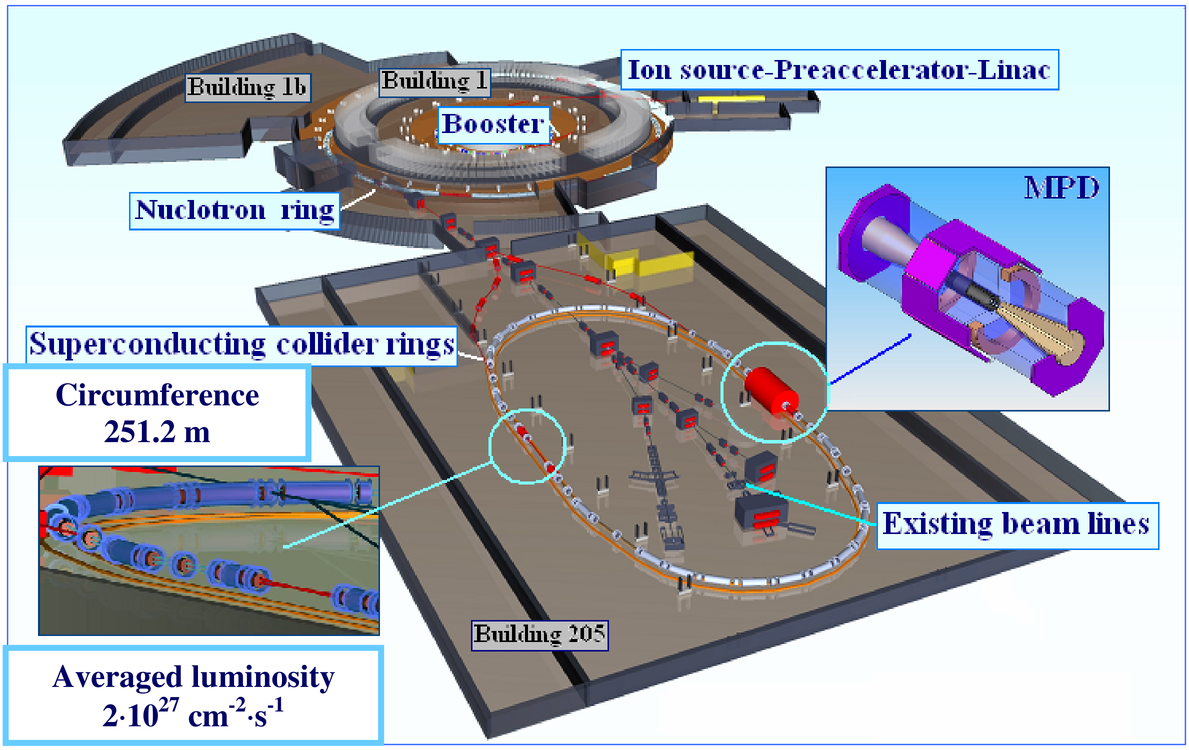

Figure 1.General plan of NICA installation

A BRIEF DESCRIPTION OF THE INSTALLATION

The beam of accelerated up to the energy E=3,5 GeV/nucleon with the intensity of about $2,5*10^{9}$ ions are extracted 20 times by turns in each ring. As a result we have $5*10^{10}$ ions in each ring in two minutes. After interaction the beams are utilized in traps. The cycle takes about 140 seconds.

SOURCES OF SECONDARY RADIATION

Storage rings are considered in the given work as a source of secondary radiation. The point of interaction and beam traps aren’t taken into account.

It is possible to point out some sources of secondary radiation in storage ring:

1) Beam losses due to ionization of residual gas and at her reasons at the work mode.
2) Local beam losses due to scattering from constructional elements.

1. Let us consider a first source of secondary radiation.

At work mode uniform beam losses along the perimeter of the ring of a length of 251 m at the rate $2*10^{-7}$ c^{-1} and intensity of $2*5*10^{10}$ pps make 80 pps/m.

The yield of the secondary neutrons per one incident ^{238}U ion interacting with thick Cu target at energy 3,5 GeV/nucleon was calculated with the use of FLUKA 2006 code[1]. The yield of secondary neutrons was appeared to be is S=8650 neutron/ion. The secondary neutrons energy spectrum is shown in Fig. 2.

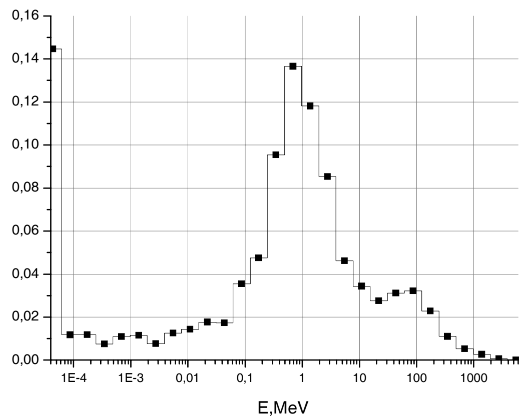

Figure 2. The secondary neutrons energy spectrum at for collision of 238U ions at the energy E=3,5 GeV/nucleon with accelerator chamber walls calculated for the case of thick Cu target.

Angular distribution of secondary neutrons for the same case is shown in Fig. 3.

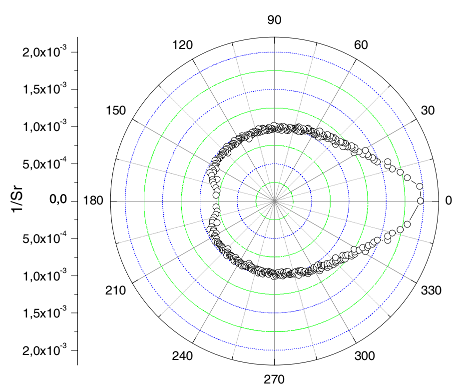

Figure 3. Angular distribution of secondary neutrons (see explanations in the text).

The dose rate was calculated by folding of the neutrons dose factor (RSN-99 Table 8.8) with a secondary neutrons spectrum. Equivalent dose rate from such a linear source on 1 m distance (without biological shielding) was estimated as 0,8 mrem/hour.

A conservative estimation of the expected uniform beam losses along the perimeter of the storage ring of the length of 251 m was found to be about $2*10^{-5}$ s^{-1}. Beam loss make $8*10^{3}$ pps/m at the beam intensity $2*5*10^{10}$ ions. The calculated equivalent dose rate from such a linear source at the distance of 1 m is about 80 mrem/hour. The attenuation factor up to the allowed 1,2 mrem/hour level for rooms intended for temporary stay of the group A personnel is 67. Such an attenuation factor is provided with ordinary concrete shielding of the 102 cm thickness.

Ordinary concrete attenuation properties was calculated with the use of MCNPX code[2] for a linear source of neutrons described above. The attenuation of neutron dose rate for ordinary concrete is shown in Fig. 4. Geometrical attenuation was not taken into account.

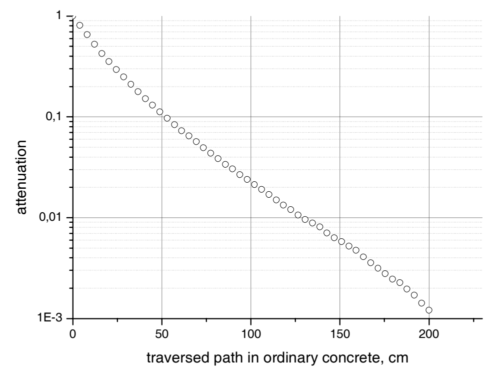

Figure 4. The attenuation of neutron dose rate for ordinary concrete (see explanations in the text).

2.

At the adjustment mode $5*10^{7}$ ions in the channel and local beam losses due to scattering from constructional elements we receive an equivalent dose rate from such linear source on 1 m distance (without biological shielding) was estimated as $3,5*10^{3}$ mrem/hour for a cycle of a beam life in a storage ring about 140 s on the average. The attenuation factor up to allowed 1,2 rem/hour level for temporary stay of the group A personnel is $3*10^{3}$. Such an attenuation factor is provided with ordinary concrete shielding of the 212 cm thickness.

Another task is to calculation of dose rate on 30 m distance from the storage ring. Calculation was performed with the use of MCNPX code.

The main sources of neutrons at these distances are rescattering of neutrons in atmosphere (sky shine). Let us consider again two neutron sources for two operation modes.

Work mode. Neutrons dose rate from the beam losses on residual gas with rate 2*10-7 s-1 on 30 m distance from a storage ring will be $4*10^{-5}$ mrem/hour (without the upper shielding). At the beam losses on residual gas with rate $2*10^{-5}$ s^{-1} such a value will be $4*10^{-3}$ mrem/hour. The allowed level for population is $6*10^{-3}$ mrem/hour.

Adjustment mode. A neutrons dose rate from local beam losses in an adjustment conditions of $5*10^{7}$ ions/140s at 30 m distance from a storage ring (without the upper shielding) 0,1 mrem/hour (allowed level for population is $6*10^{-3}$ mrem/hour). Therefore, necessary attenuation factor makes k=17. This attenuation factor can be provided with the upper shielding ordinary concrete thickness of 0,6 m.

CONCLUSIONS

The presented estimations of biological shielding for storage ring of NICA project show shielding can be housed in the existing building № 205.

REFERENCES

[1] Fasso`, A. Ferrari, J. Ranft, and P.R. Sala,"FLUKA: a multi-particle transport code",CERN 2005-10 (2005), INFN/TC_05/11, SLAC-R-773.
Fasso`, A. Ferrari, S. Roesler, P.R. Sala, G. Battistoni, F. Cerutti, E. Gadioli, M.V. Garzelli, F. Ballarini, A. Ottolenghi, A. Empl and J. Ranft, "The physics models of FLUKA: status and recent developments",Computing in High Energy and Nuclear Physics 2003 Conference(CHEP2003), La Jolla, CA, USA, March 24-28, 2003, (paper MOMT005) eConf C0303241 (2003), arXiv:hep-ph/0306267

[2] http://mcnpx.lanl.gov/