SHIELDING OF THE GATCHINA ISOCHRONOUS H^- CYCLOTRON[1]

N. K. Abrosimov, Yu. T. Mironov, G. A. Riabov

Gatchina Isochronous H^-Cyclotron (GIC) is installed in an experimental hall of the PNPI synchrocyclotron (SC) operating at present. Biological shielding should provide a possibility of a joint operation of the both accelerators simultaneosly [1].

Creation of the biological shielding as well as the GIC arrangement are mainly problems of diminution of expenditures. 30% of expenses are connected with suitable accelerator building works, 40% of which fall to concrete shielding construction. Variants of the cyclotron arrangement were considered in existing PNPI buildings and in a special hangar with movable shielding. The choice of the GIC arrangement in the experimental hall of the PNPI SC ensures more than 70% expense diminution for the biological shielding since the part of the high effective SC shielding is used. Moreover it is possible to utilyze at most the existing SC infrastructure, i.e. electric power, water colling, ventilation systems, a bridge crane for 30 tons, etc.

In order to provide the radiation safety at the GIC arrangement area during the usual operation of the PNPI SC the shielding wall has been built. It separated the GIC-area from

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the rest of the experimental hall where the PNPI SC proton and meson beams were extracted. The usual operation of the PNPI SC implies that the number of inelastic beam interactions is no more than 10^{10} s^{-1} in experimental hall. The SC operation is forbidden when beam losses are larger than the mentioned value. Thereto the biological shielding separating the main SC hall from the GIC-area has been improved in places shown by position 2 in the figure by installation of the movable concrete screens ~1 m thick. It has provided the dose rate reduction in position 2 from $3.3 \cdot 10^{-8}$ to $1.4 \cdot 10^{-9}$ $Sv \cdot s^{-1}$ for the most unfavourable situation when the total proton beam of the SC is scattered in the main hall.

To define the dimensions of the shielding wall separating the GIC-area a modelling was carried out using a wall mockup. The experimental geometry with the mockup is presented in the figure by CB (main picture plane view and on setting-inside view).

During the modelling the proton beam was scattered with targets T1 and T2 placed in beam line P3 the nearest to the GIC-area. Target sizes were chosen to be the same as for the main body of the SC intemediate beam shutter [2].

For comparison with the measurements estimations of certain important quantities were made. Results of the calculation and experimental measurements are shown in Table 1.

Table 1

*Radiation levels near the wall mockup**

Position	Neutrons**				Gamma radiation and charged particles
	E >20 MeV		$E \leq$ 20 Mev***		
	experiment	calculation	experiment	calculation	experiment
A	(514)	(496)	921	840	—
B	33.4(64.5)	27.8(54)	22.4	—	8.3

* For $2.25 \cdot 10^{11}$ s−1 enelastic interactions in a target.

** Dose rate, 10^{-9} $Sv \cdot s^{-1}$, in parenthesis flux density, $cm^2 \cdot s^{-1}$.

*** At position C experimental dose rates are equal to 211 and 344. A low value is obtained when the target was placed in the position T2.

According to model experimental data the basic concrete wall dimensions were chosen 1.2 m for the thickness and 4.6 m for the height. The total height of the experimental hall is 12.5 m, the crane clearance is 5 m, therefore the crane displacement remained possible after creation of the shielding wall. The calculated estimations of radiation levels behind the created wall are given in Table 2.

Table 2

*Calculated radiation levels at GIC-area**

Dose rate, 10^{-9} $Sv \cdot s^{-1}$		
From direct penetration	From scattering above wall	Total
1.1 -1.3	6.1–10.5	7.2–11.8**

* For beam losses accompanied by $10^{10} s^{-1}$ inelastic interactions.

** A low value corresponds to beam losses near the external wall of the experimental hall, a largger — to beam losses near inner wall, which separates the main SC hall.

Arrangement of the shielding wall is presented in the Fig. by position 3. Two neutron monitors of standart type UDBN-02R are connected with SC safety circuits. It ensures automatic shut-down of the SC beam if the radiation level exceeds $8 \cdot 10^{-9}$ Sv·s^{-1}.

As the SC beam operation time per year does not exceed 6000 hours one may assert that the presented minimum of shielding efforts is sufficient to keep SC routine practice and provide radiation safe working conditions at the GIC-area, dose rate averaging per year being no more than $7 \cdot 10^{-9}$Sv·s^{-1}. The latter value corresponds to adopted state standarts.

The limited shielding wall height leads to predominating influence of scattering radiation above barrier at the GIC-area. The reduction of this influence is the aim of further studies.

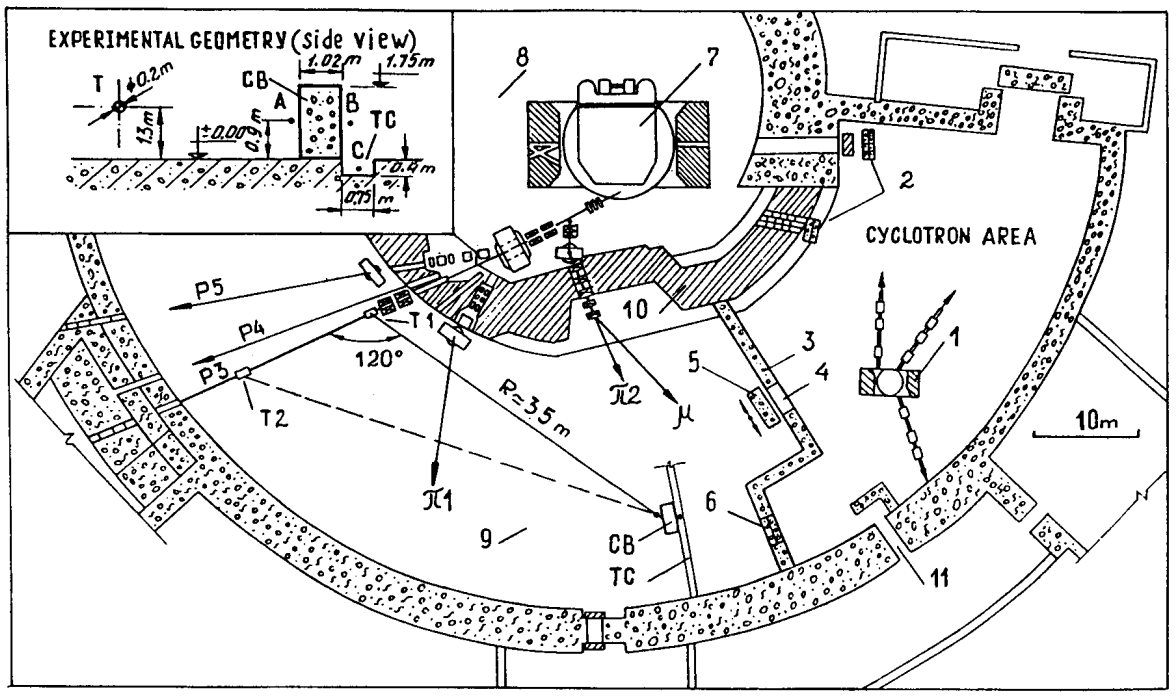

Fig. Schemes of cyclotron arrangement and experimental geometry for modelling shielding wall.
1 — cyclotron (GIC), 2 — additional shielding, 3 — shielding wall for the GIC area, 4 — opening for crane passage closed by a wheeled block, 5, 6 — crane cargo opening, 7 — syncrocyclotron (SC), 8 — main SC hall, 9 — experimental SC hall, 10 — iron block shielding, 11 — GIC area entrance; T1 — *Fe* target ⌀200 × 380 mm in the first position, T2 — target in the second position, CB — concrete block wall mockup of dimensions 2.40 × 1.75 × 1.08 m^3, TC — technological channel, P3,P4,P5 — proton beam lines, $\pi 1$, $\pi 2$, μ — meson beam lines. On setting-in: A, B, C — detector positions

REFERENCES

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