On the Possibility of the Setup GAMS-4π Operation at Positive Coordinates of Block 27 Internal Targets of the IHEP Accelerator

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Abstract

The intensity of π^--meson beam at experimental setup GAMS-4π reaches $2 \cdot 10^7 \pi^-$/cycle when the target coordinates of the IHEP accelerator block 27 are positive. With negative coordinates it reaches about $5 \cdot 10^6 \pi^-$/cycle. During investigations the possibility of additional influence on the being extracted proton beam was found to make possible a simultaneous extraction of primary protons for the setups FODS-2 and SWD and π^--meson beam of higher intensity for GAMS-4π.

1 INTRODUCTION

The regime of simultaneous operation of three experimental setups with secondary beams under steering the primary proton beam onto three internal targets [1] of the IHEP accelerator (A-70) was realized for following conditions. The targets T24, T36, T45 installed respectively in the blocks 24, 36 and 45 of A-70 are on positive coordinates, and the targets T27, T35 of blocks 27 and 35 are on negative ones. Under these conditions the simultaneous extraction of accelerated protons to setup FODS-2 [2], SWD [3] of beam line 22 or SPHINX [4] of beam line 21 is possible also, that gives a simultaneity factor 4 of experimental setups operation with active streering the beam onto the targets. Taking into account the operation of 1–2 targets in "shadow" [1] (beam lines 18, 5N, 6) the simultaneity factor reaches a value of 6.

Requirement of T27 operation on positive coordinates contradicted to the already realized and mastered regimes of nonresonant slow extraction of protons on above mentioned setups of beam lines 21, 22 [2–4]. The cause of it was in technical possibilities of the slow ejection system equipment. During investigations of the new regime a possibility of influence on the proton beam to be extracted was found (by means of energizing an additional field ΔH_i in magnetic blocks 23, 29 of A-70) that allowed the beam to be jumped in the aperture of a setup-magnet of the straigt section 26 (SM-26) under a weakened strength of the SM-22 [5].

2 CALCULATIONS OF A NEW REGIME OF EXTRACTION

2.1 Extraction of secondary particles

During long period parameters of the accelerator (for example, the statute of its correction systems) and a beam (a betatron tune before extraction) as well as combination
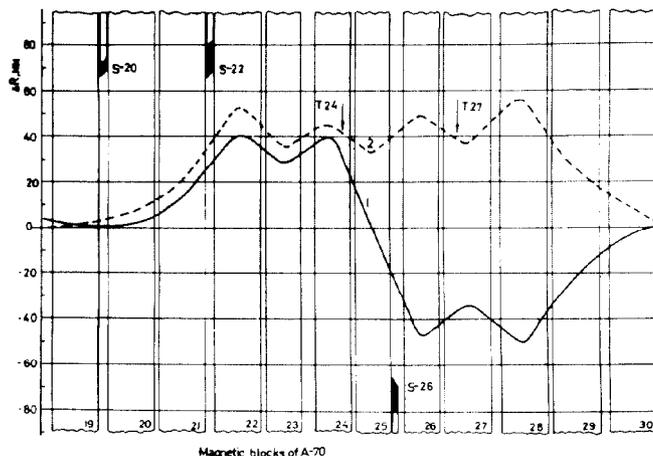
Figure 1: The form of the closed orbit local distortions under simultaneous operation of targets.

of closed orbit bumps were optimized for simultaneous operation of internal targets at the mentioned above working coordinates with fast or resonant slow extractions of a primary proton beam.

New working conditions of T27 were in need of check a possibility of simultaneous operation both T24 and T27 (as a main targets of beam lines 2 and 4) with other regimes under the simultaneity factor reached to be kept.

Fig.1 shows the form of local distortions (bumps) of a closed orbit at simultaneous operation of T24 and T27 in the previous ($R_{T27} < 0$, curve 1) and new ($R_{T27} > 0$, curve 2) regimes. Azimuths of the target installation in blocks 24 and 27 (T24, T27 respectively) are marked with the arrows. Coordinates of the septums of the SM-20, 22, 26 (S-20, 22, 26), limiting the A-70 vacuum chamber aperture, are seen respectively.

One can see that a new closed orbit bump (curve 2) allows proton beam to be moved onto T24 and T27 on their positive working coordinates. Experimental check up showed a compatibility of this regime of T27 with an operation of other internal targets.

2.2 Nonresonant slow extraction [2–4]

To get the clear answer about a compatibility of working regimes of the experimental setup GAMS-4π with π^--mesons generated by T27 on positive coordinates and the setups FODS-2, SWD, SPHINX with primary protons in the same cycle of A-70, an analisis of the required dis-
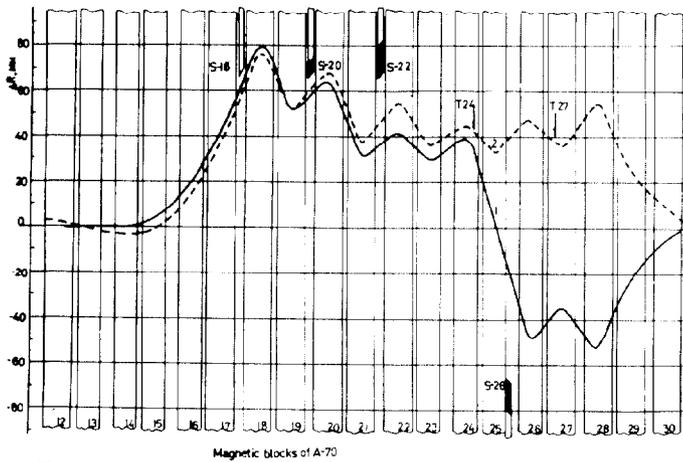
Figure 2: Form of the closed orbit bumps at simultaneous operation of NRSE and internal targets of the A-70. S-18,20,22,26 are the septums of the appropriate septum-magnets.

Figure 3: The trajectories of a proton beam being extracted in NRSE regime (a current of the SM-22 is a calculated one) simultaneously to internal targets operation. 1—T27 on negative coordinates; 2—on positive ones.

placement of the circulating beam centre before extraction in the regions of septum-magnets SM-18, 20 (the straight sections 18, 20) and T24, T27 was necessary.

First requirement determines a working intensity of protons extracted to the setups FODS-2 and SWD. An intensity requirement of the setup SPHINX is less hard and a bump could be of lower current during it's operation.

Second requirement determines a possibility of getting the maximum spill of the secondary particles beam extracted from new coordinates of the internal targets.

The beam is moved towards septums of the septum-magnets by bumps formed with a current of additional windings of blocks 15, 21, 27 and 16, 22 [6]. Calculations show that during simultaneous operation of bumps in the SM-18, SM-20 region with bumps moving the beam towards T24 and T27 the requirements mentioned above are fulfilled. Resulting local distortions of the closed orbit that correspond to regimes of simultaneous operation of a non-resonant slow extraction (NRSE) and the internal targets T24 and T27 are shown in fig.2. Curve 1 corresponds to the previous regime of T27 operation (on negative coordinates), curve 2 — to the new one (on positive coordinates). One can see that the received deflections of a beam centre of gravity satisfy the requirements of a beam interaction with the targets as well as jumping the particles into septum-magnets aperture during their simultaneous operation.

2.3 Simultaneous extraction of protons and secondaries

Without trajectory correction. Fig.3 shows the calculated trajectories of a proton beam extracted at NRSE corresponding to the above conditions of scattering and jumping the beam. It is seen that in spite of principal possibility of simultaneous operation of NRSE with internal targets this regime turned to be not realized in
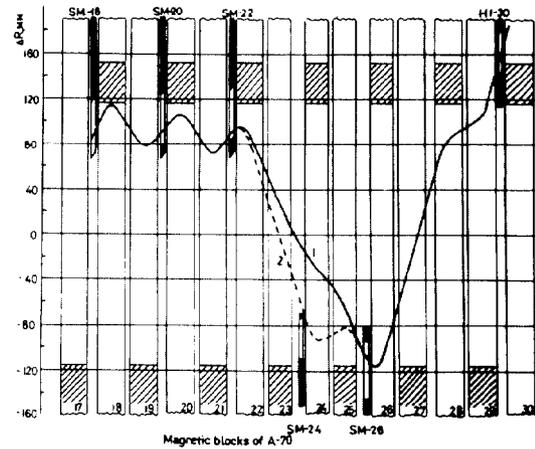
the concrete geometry of A-70 because of:
— limitation of the A-70 aperture since the SM-24, used for fast ejection of a proton beam, is installed on the coordinate $R = -70$ mm; and
— a current limitation of the SM-22.

The values of the current of the slow extraction system septum-magnets for two above mentioned regimes of the T27 operation are given in the table 1.

Table 1. Current of the septum-magnets for two regimes of T27.

Coordinates of the T27	Current of the septum-magnets, A			
	SM-18	SM-20	SM-22	SM-26
negative	1600	4000	3300	7500
positive	1600	4000	7920	3460

One can see from the table that operation of T27 on positive coordinates makes the SM-26 regime easier while the regime of the SM-22, making the "sharing" functions in the existing scheme of extraction [7], is significantly hardened. It was the main obstacle of realization the common regime of operation since the technical current limit of the SM-22 (after tests before installation into the A-70 ring) was accepted 6000 A instead of designed 8000 A. In fact, the working current limit of the SM-22 is taken 4500 A.

Another cause — a limitation of the A-70 aperture in the region of the SM-24 is clear from fig.3: taking into account dimension of an extracted beam one can see it to be cut on the SM-24 septum.

With correction of NRSE trajectory. It was possible to decide the given task by means of a trajectory correction by a closed orbit bump to be formed with additional fields $\triangle H_i$ in blocks 23 and 29 of A-70. Calculations show that:
— the additional bump makes easier a jump of a beam into the SM-26 gap under limited current of the SM-22;
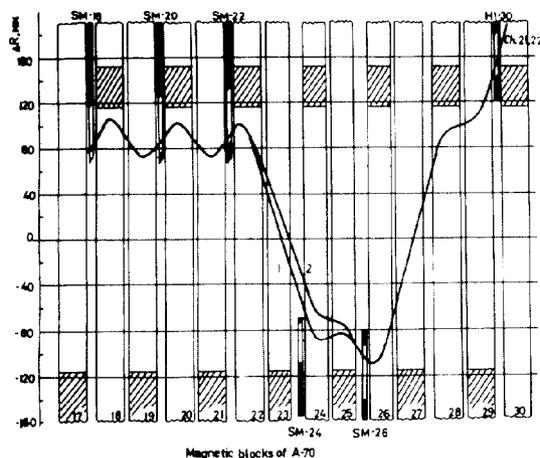
Figure 4: The corrected trajectories of a proton beam extracted in NRSE regime simultaneously to internal targets operation at positive coordinate of T27.

— one succeeds to go round the "narrow" space into an accelerator vacuum chamber made by a septum of the SM–24.

Fig.4 shows the corrected trajectories of a proton beam extracted by NRSE simultaneously with the targets T24 and T27 operation; T27 is on the positive coordinates. Curve 1 corresponds to an influence of additional field $\triangle H/H_0 \approx 1\%$ under a current of the SM–22 $\sim$ 5400 A, curve 2 — to $\triangle H/H_0 \approx 4\%$ and a current of $\sim$ 4000 A, respectively. One can see that within technical possibilities of the existing systems of A–70 (a current of SM–22 $\leq$ 6000 A, $\triangle H/H_0 \leq 4\%$ — it corresponds to 200 A into additional windings of blocks 23, 29) extraction of protons is being done. It makes possible for the target T27 of the experimental setup GAMS–4π to interact with the primary beam on its positive coordinates.

3 EXPERIMENTAL RESULTS

Preliminary results of the intensity measurements on the setup GAMS–4π show that, comparing to the regime of the T27 operation on negative coordinates, intensity into a beam line increased with the factor 1.5.

Fig.5 shows the dependence of an intensity into beam line 22 in relative figures versus the SM–22 current at additional energizing a field in the windings of blocks 23, 29 $\triangle H/H_0 = 4\%$. It is seen that at a current $\sim$ 3800 A the maximum of intensity is reached (under optimum tuning it is $\geq 10^9$ proton/cycle), the extracting trajectory corresponds to curve 2 of fig.4. Experimental value of the current in this regime proved to be in a good agreement with the calculated one.

4 CONCLUSION

Investigations a possibility of operation of the block 27 internal targets, distined for generation of secondary particles for experimental setup GAMS–4π, on positive coor-

Figure 5: Experimental dependence of the number of particles into beam line 22(in relative units) versus the SM–22 current.
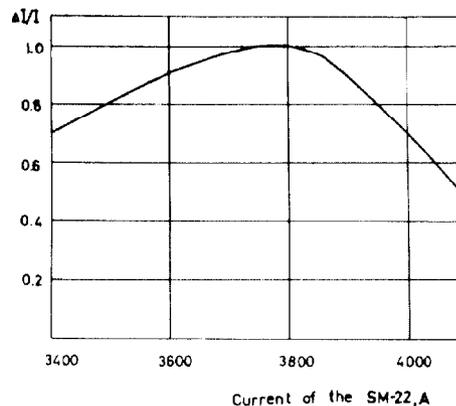
dinates showed that:

1. The existing systems of steering a beam onto internal targets allow one to organize a simultaneous interaction of an accelerated beam with a few targets including the regime of the T27 operation on positive coordinates relatively to the central orbit.

2. Operation of T27 on positive coordinates impedes non-resonant slow extraction of protons to the experimental setup SPHINX (beam line 21), FODS-2, SWD (beam line 22) made in parallel to the internal targets operation.

3. A lockal distortion of the closed orbit, decreasing the SM–22 current and making possible parallel extraction of secondaries and primary protons for various experiments in the new regime of T27, was calculated and realized.

4. Common regime of operation needs a correction of other targets working coordinates when the coordinate of T27 is changed.

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