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PROGRESS REPORT

on

THE FAST EJECTION SYSTEM FOR CHANNEL A

of the

SERPUKHOV 70 GEV PROTON SYNCHROTRON

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1. GENERAL

A first status report of the fast ejection system for Channel A has been given[1] in October, 1968. The present report gives the progress made since that date.

As planned, a detailed design study[2], based on the new layout[3] proposed and adopted early in 1968, has been presented and adopted[4] in February, 1969. The minimum performance and parameters of the system are included in chapter 1 of above design study. The remaining chapters illustrate the plans and thinking at the moment of editing. Details thereof may be subject to some change during the elaborations of the project.

2. BEAM OPTICS

After adoption of the final trajectory and target position in October, 1968, the beam angle at the target was corrected once more[5] during the February meeting such that the trajectory now lies somewhat inward with respect to the one proposed earlier[6]. The trajectory keeps due account of the space required in straight section 28 for the vacuum tank of septum magnet SM 28 (channel B) and its magnetic shielding. The horizontal deflectors of the external proton beam transport will be kept entirely as a reserve.

The influence of the tolerances of the parameters of accelerator, ejection and beam transport on the performance of channel A have been once more examined at the February meeting. This was done in the light of studies produced in Serpukhov[7] and CERN[8] and considering the newly measured accelerator minimum beam emittance of $\sim 2\,\pi\times10^{-6}$ m.rad[9], which is twice the value for which both beam transport and ejection were designed. For the beam transport it is presently being studied[10] how to accommodate this emittance in the adopted apertures, accepting some measure of defocusing at the target. In the ejection system this will use up a good deal of the reserves of kick, foreseen in the design. Means are being studied to adopt the apertures of the magnets to accommodate this new beam diameter more easily.

IHEP has proposed an improvement programme for the accelerator[11] in order to increase the now very small radial position-range between two adjacent non-linear resonances in which the above mentioned minimum emittance may be maintained. It was agreed to be useful to attempt to end up with a "constant Q" accelerator in which the above range would be very wide, since such a situation would facilitate the beam gymnastics for targetting and ejection.

Calculations performed at CERN[12] using a computer programme[13] that takes into account the saturation phenomena in iron, have led to a field table representative for the 85 GeV operation of the accelerator. This field table allows prediction of the pole face winding corrections required. It may also allow to judge the prospects of using the ejection at that energy.

Since due to the low synchrotron frequency on the flat top RF beam steering would have a rather slow response, the IHEP considers to do the beam gymnastics during ejection by means of local closed orbit deformations (bumps). CERN will formulate the requirements for a convenient operation of the ejection system.

3. BUILDING AND LAYOUT

After formulation of the space requirements for ejection and beam transport by CERN in April 1968[14], preliminary drawings of the ejection building have been submitted by IHEP for discussion with CERN in October 1968 and in February 1969. Specifications have been submitted by CERN for the required utilities[15], for facilities in the building, such as the electromagnetic shielding[16] around the equipment rooms and the local control room, for the probable layout of the equipment in the rooms[17], for the connection cables[18] and for the hydraulic tubing[19]. Agreement has been reached in February 1969 on basis of above documentation so that since that date nothing stands in the way of proceeding with the construction of the ejection building.

It is being realized that the progress in the construction of the ejection building must be compatible with the general planning of channel A and the RF separated beam for the Mirabelle bubble chamber physics programme.

4. CONTROL PHILOSOPHY

A crucial decision[20] has been taken by IHEP early this year on the "control philosophy", i.e. from what place to operate the ejection systems. It was decided to do all operations related to the beam utilization, i.e. ejection, targetting and concomitant beam gymnastics from the local control room in the ejection building and to repeat only a small number of displays (hence no controls) of the ejection in the main control room. A choice on the latter will be taken jointly on the basis (amongst others) of CERN proposals. The decision implies that a sufficient number of accelerator controls and displays must be repeated in the local control room. The precise choice of these is still under study. The above decision has been taken after due consideration of the present situation and probable future evolution at Serpukhov and taking account of some considerations made at CERN[21].

5. KICKER MAGNET

Two full size low voltage models, (a lumped inductance and a delay line type), of full aperture kicker magnet modules have been constructed and tested. These models served to study the response in time, i.e. rise time and flat top. Measurement results are close to predictions.

A high voltage prototype full aperture kicker magnet of the lumped inductance type has been constructed and has endured 2×10^6 pulses in vacuum at design voltage (80 kV on the line). This prototype serves to study voltage problems and the attainable field levels. A high voltage delay line prototype is due for August.

A full size prototype delay line pulse generator with its triggers is in production and will be tested as from August. Apart from providing pulses for the kicker magnet this prototype will serve to study the behaviour of the switching spark gaps. The capacitor bank for the delay line is due for delivery in July. A prototype charging supply, permitting operation at a rate of two pulses per second, has been ordered and is expected to be delivered in July.

6. SEPTUM MAGNET

A prototype septum magnet of 1 m length and an aperture of $50 \times 25\ mm^2$ has been designed and is now in production. This prototype will serve to study the field distortions caused by saturation. Due to the high nominal field in SM26, saturation raises problems for obtaining the required field homogeneity. The results of the measurements should guide us in correcting the inhomogeneities by acting on the septum configuration or/and on the shape of the polifaces. The septum magnet will also be placed in a vacuum tank with a prototype of the finally planned high current feedthrough.

A pulse generator using H.V. storage capacitors and ignitron switches is in an advanced stage of construction. So are the triggers for these.

A charging power supply that, like for the kicker magnet, will permit pulsing twice per second has been ordered and delivery is due for July.

A programme of precision field measurements is now under preparation and it is hoped to start the detailed study of the prototype in August.

7. HYDRAULIC ACTUATOR

A prototype hydraulic actuator has been designed and is now under construction. Assembly of it will be started by end of July and measurements are due to start in August.

The prototype is meant to study questions of response, stability, static and dynamic precision.

The pumping station and the servo amplifier will be borrowed from the MPS division and have already been delivered.

8. VACUUM

Prototypes of the turbo molecular and sputter ion pumps meant to be mounted on all the ejection magnet tanks have been delivered, as well as the necessary accessories. A few of these have already or will soon be mounted on the prototype kicker magnet and prototype septum magnet vacuum tank. They serve to test the magnets under real conditions and in parallel to study outgassing rates and pump-down times.

The kicker magnet prototype vacuum tank is now under vacuum and has been tested with the magnet for more than a month. The tank for the prototype septum magnet is due in a few weeks.

Agreement[22)] was reached in February 1969 on the division of responsibilities for the vacuum. CERN will supply the vacuum tanks for the fast ejection magnets, together with the pumping system and accessories, including the section valves. IHEP will supply the rest, in particular the enlarged doughnut chambers, the bifurcation chamber and the modified boxes for the electrostatic position pickup electrodes.

Detailed engineering drawings of the ejection vacuum tanks and the layout in the straight sections, SS 16, SS 24, SS 26 and SS 28 have been made by CERN and presented to IHEP in February 1969. These serve as proposals on the basis of which IHEP will study the layout in these straight sections and prepare engineering drawings of the modified doughnut chambers and housings for the electrostatic position pickup electrodes. These drawings will be submitted to CERN for agreement.

A start has been made with systematic endurance tests on prototypes of sealing bellows for the mobile septum magnet. A special cycling mechanism, constructed for this purpose, operates continuously since a month.

9. ELECTRONICS

Timing, control and interlock systems for the above prototype programs have been designed and are presently being produced.

The design of the final electronics for the Serpukhov fast ejection system is in an advanced stage. In particular the design of a large part of the digital circuits have been completed and the construction of prototypes is to begin soon.

A prototype circuit of the measurement and digitalization of the proton beam intensity bunch by bunch has been completed and operated satisfactorily in the laboratory. Using the above circuit, prototypes of an electrostatic position pickup electrode and a current transformer will be studied in a specially reserved vacuum tank in the CPS.

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