

Fast ejection

From information supplied by B. Kuiper

'Mastodont !' — exclaimed Kyril Petrovic Myznikov on entering the Cesar Hall at CERN in April of this year where the delay-line pulse generators for the Serpukhov kicker magnet were in full assembly. (Myznikov is Head of the Division responsible for beam extraction, targetting and high energy performance at IHEP.) This echoed the reaction of many visitors in particular those who think of ejection as a form of gadgetry. Indeed, the technique has come a long way since the first proton beam was extracted from the PS in 1963 (see vol. 3, pp. 63 and 79) using equipment designed by the same group. The Serpukhov full aperture kicker magnet system, for example, has a stored pulse energy of around 20 kJ, roughly 45 times the energy of the first PS kicker and more than 8 times the energy of the next generation full aperture kicker magnet (FAK) project, presently being discussed for the PS.

This sets the scale of the project; the size is due partly to the higher particle energy and longer pulse length (accelerator circumference), partly to the size of the aperture and partly to the limited length of the straight sections. Moreover the performance required is very complex. The specification calls for the ejection of three proton bursts per acceleration cycle into three different beam channels with, at choice, three different numbers of proton bunches and three different ejection times and energies. This has important consequences in most parts of the ejection system, i. e. in all power supplies, in the two septum magnet systems, in the moving mechanism, in the vacuum system and in the electronics.

Unlike the pulsed proton beam transport system and the radio frequency particle separators which may be treated in a relatively independent manner once the interface conditions are set-

1. Beam characteristics at ejection are to be processed by a minicomputer. Jacques Nuttall and Fabio Fabiani are checking hardware with software.

2. The ten full aperture kicker magnet modules are contained in a 3 m vacuum tank, shown on its platform. Bernard Féral adjusts the resistor boxes. The high voltage pulses arrive over 120 m of special cables.

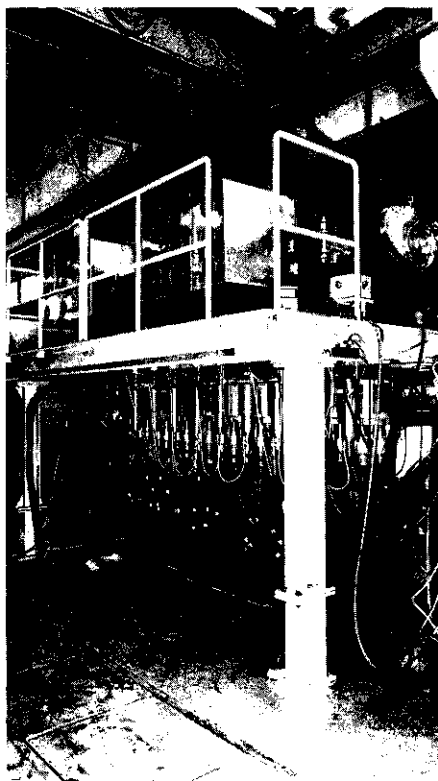
3. A pulse generator of one of the two septum magnets shown in front of the power modules of its charging supply. Herman van Breugel inspects storage capacitors.

tled, the fast ejection system has to become an integrated part of the accelerator. All the proton distribution equipment is concentrated in a small fraction of its circumference between straight sections 16 and 28 (see vol. 10, p. 31). Three fast ejection channels A, B and C and two slow ejection channels B and D are there interlaced with a number of secondary beam channels using internal targets.

The situation entails a large number of spatial constraints and problems of compatibility of construction and of performance of the various systems with each other and with the accelerator. Part of these constraints became evident only gradually as the design of some of these channels evolved simultaneously with the CERN system. It is also obvious that this concentrated mixture of systems and responsible groups provides a highly fertile ground for endless discussions on who is doing what to the beam, unless there is



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1. CERN 192.8.71



2. CERN 182.8.71

3.

To the right — accelerator parameters. Below — important dates in the fast ejection project and components of the system with a schematic drawing, alongside, of the system as it will be incorporated in the Serpukhov accelerator.

DATES

End	1966	First technical discussion on ejection
July	1967	Agreement signed in Moscow
Sept	1967	Draft design study presented
Jan	1969	General start of technical work for Serpukhov
March	1969	Final design study presented and signed by both parties
Year	1969	Prototypes and design
Year	1970	Construction and fabrication
Year	1971	Assembly, tests and transport to Serpukhov
Early	1972	First ejection (hopefully)

EJECTION REQUIREMENTS

Ejection capability from 30 to 76 GeV (different per shot) of 1 to 30 bunches of protons (different per shot) with up to 3 shots per cycle at 250 ms interval into different channels.

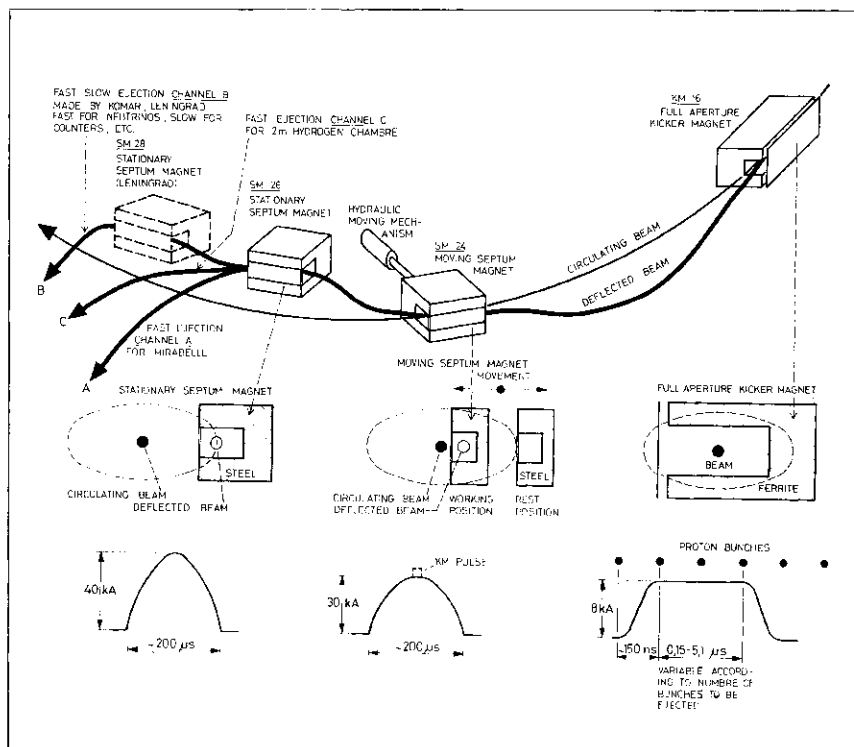
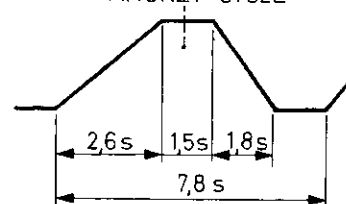
COMPONENTS

- Full aperture kicker: KM 18 - $14 \times 10 \text{ cm}^2$ aperture, 3 m long with 0.1 T field giving 1 mrad deflection at 70 GeV; plus pulse generators and power supplies.
- Two septum magnets: SM 24 - $3.5 \times 3 \text{ cm}^2$ aperture, 1.5 m long with 1 T field giving 4 mrad deflection at 70 GeV and SM 26 (mobile) - $6 \times 3 \text{ cm}^2$ aperture, 3 m long with 1.4 T field giving 15 mrad deflection at 70 GeV; plus pulse generators and power supplies.
- Three vacuum tanks for magnets.
- Three vacuum systems and controls.
- One hydraulic moving mechanism plus pump station and controls.
- Programming and timing system.
- Beam diagnostic system (pick-ups, on-line computer and data display).
- General control and interlock system.
- Pulse monitoring system.

ACCELERATOR :

ENERGY	76	GeV
INTENSITY	10^{12}	ppp
REVOLUTION TIME	5	μs
BUNCH NUMBER	30	
AVERAGE RADIUS	227	m
BEAM DIAMETER	20	mm

MAGNET CYCLE



adequate beam diagnostic equipment specially tailored to yield the relevant beam information at the crucial points. All these factors helped define the scope of the project.

The system as a whole had to be assembled and tested at CERN before shipment, control flexibility had to be included to ensure compatibility and adequate beam diagnostics had to be provided to avoid ambiguous interpretations. Interfaces between the contracting parties had to be defined such as to minimize discussions.

The project also presented many unexpected aspects which together with the substantial technological extrapolations necessary and the short time available, have caused the group members many headaches. Moreover, activities have been complicated by the language problem, different standards and working habits and slow communications. Nevertheless these were accepted as a challenge both at the

technical and personal level.

Indeed such an effort by the relatively large number of persons involved would have been impossible without repeated proof of the goodwill of all parties involved and the exercise of patience and understanding, on both sides, and personal motivation going beyond simply making an ejection system for an accelerator.

The tangible result of the endeavour is now conspicuous in the Cesar Hall in terms of closely packed, bulky (and noisy) steel constructions and a series of well filled electronic racks in a mockup control room in building 15. The equipment has been practically completed and is in the last stages of assembly and testing.

In retrospect, the time of two and a half years for prototyping, design, construction, installation and testing has been very close to the limit. Normally such a project would go in parallel with a larger one and the timescale

would be more comfortable. It has only been possible because of: (i) the group's previous project and ejection experience, in particular constructing the Straight Flush facilities (vol. 8, p. 175) the principles of which have been followed for the Serpukhov equipment; (ii) a typical project group structure, with complete priority on the services of a number of designers, draftsmen, mechanics, machine tools and electro-nicians with their laboratory; (iii) a closely watched, flexible planning which could constantly be adapted to changing conditions of delivery and testing.

In particular, prototype studies have overlapped for a long period with the final design and construction activities and the results have been fed back into the latter. Although this last factor has inevitably entailed some waste, it has proved the more economical way, considering the available time and the general context of the project.

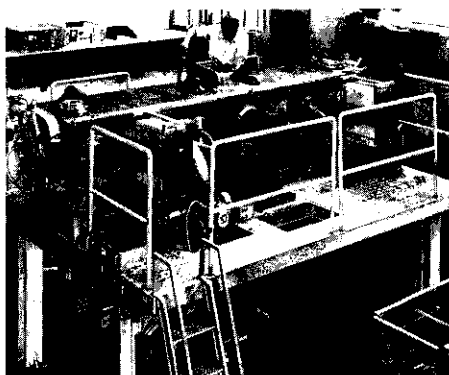
4. Vacuum tank for the stationary septum magnet being inspected by Albert Bertuol and Mario Minella.

5. The end of a septum magnet with connection between inner conductor and septum of single loop excitation winding.

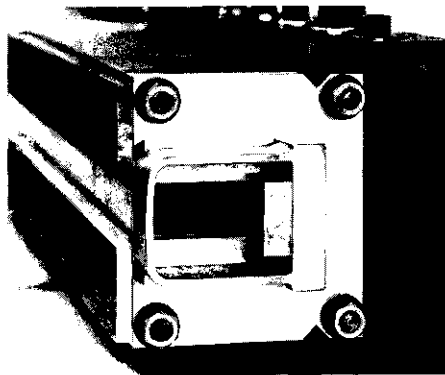
6. The fast ejection is linked to the accelerator synchronization pulse trains by a complex programming and timing system that coordinates ejection, beam transport, separators and bubble chamber operations. Tasios Kitsakis is testing its high level output stages.

7. The ten kicker magnet modules are powered separately by ten delay line pulse generators which are paired into five structures. René Bonvin closes a cover in front of the high pressure sparkgap switches.

8. The mobile septum magnet moves inside a 3 m long vacuum tank, shown together with the electrohydraulic servoactuator and precision magnet guiding system. Alain Bertuol places a TV camera to monitor the motion from the mockup control room.



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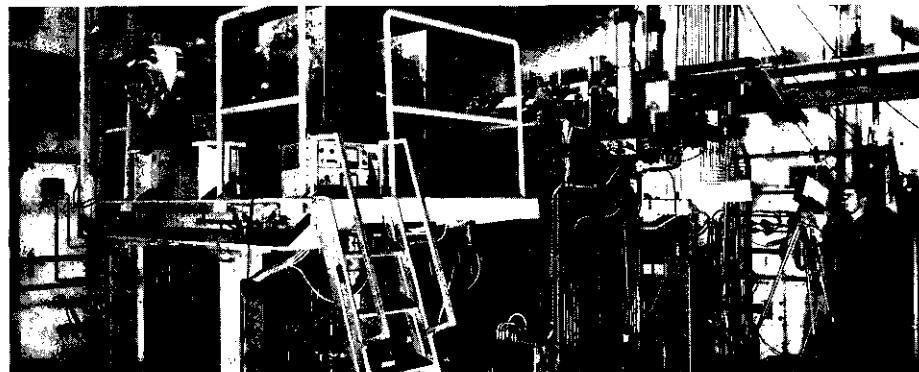
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Active preparations are now being made for shipment of the equipment to Serpukhov. This in itself is a sizable and delicate problem since the 120 tons and 350 m³ of equipment must be largely disassembled and carefully packed. In order to limit the number of handlings, trucks of a Soviet transport firm will be loaded at CERN then unloaded at IHEP. Transport of the complete ejection system will take six weeks, trucks leaving at a rhythm of two or three per week.

Transport will overlap with the first stages of installation at IHEP. A detailed planning including each operation has been established and foresees a period of three months for disassembly, packing, transport, and reassembly at IHEP. The two last months of these coincide with a long accelerator shut-down. In the fourth month the accelerator will be started up again but there will be access on request to the ring tunnel for the ejection group so as to complete the overall tests of the equipment before first ejection attempts.

In the early stages of the discussions it had been hoped to install the ejection system at the Serpukhov accelerator, using only a fraction of the construction crew for supervision and having by that time sufficient IHEP collaborators trained and familiar with the whole system. For various reasons it has now been decided that practically the whole ejection group will go to Protvino and that the installation of the equipment will be done largely by them. IHEP has had a substantial task in providing the building and services and making all the necessary preparations. A small team of CERN ejection specialists will run the system in for another three months until CERN is satisfied with the performance attained. Active training of Russian specialists will start simultaneously with installation and the moment of hand-over will be at the end of the running-in period.