CERN STATUS

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1. Introduction

In this status report from CERN I will limit myself to the accelerators and similar devices, and even within this field I have to be selective and only report on the latest development around the CPS, the ISR and the SPS (Figure 1). The very interesting improvement programme on the CERN synchro-cyclotron I consider outside the scope of this paper.

2. Latest development around the CPS complex *)

The main activities are directed towards the use of an intermediate intensity ($4\text{-}5 \cdot 10^{12}$ p/p) as a step in the preparation of a 10^{13} p/p intensity.

We have in a recent test run used the improved 50 MeV Linac to feed the 800 MeV Booster; the PS has then accelerated from 800 MeV to 26 GeV/c $5 \cdot 10^{12}$ p/p. A high energy physics run is scheduled for November 1973, a neutrino experiment using the Heavy Liquid Chamber Gargamelle.

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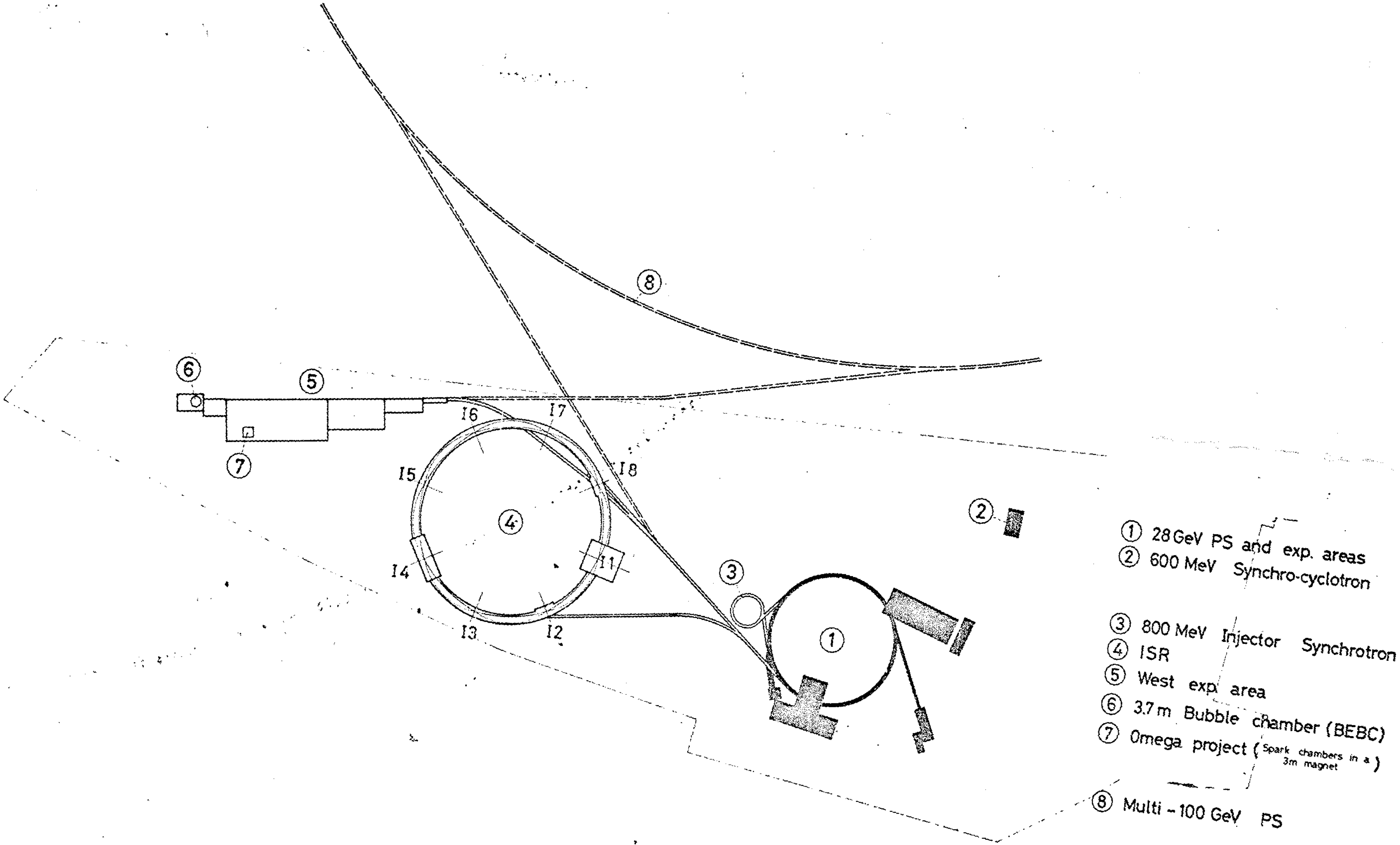
*) The information in this chapter supplied by P. Lefevre and H. Koziol.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① 28 GeV PS and exp. areas
② 600 MeV Synchro-cyclotron
③ 800 MeV Injector Synchrotron
④ ISR
⑤ West exp. area
⑥ 3.7 m Bubble chamber (BEBC)
⑦ Omega project (Spark chambers in a 3m magnet)
⑧ Multi - 100 GeV PS

Figure - 1

At present, with an average intensity of about $1.8 \cdot 10^{12}$ p/p, the PS feeds up to seven electronics experiments simultaneously whilst there is a total of 13 distributed in three experimental halls. There are two Hydrogen Bubble Chambers (2 m and BEBC) and a Heavy Liquid Chamber Gargamelle in different halls, two out of the three chambers are fed simultaneously with protons together with the electronics experiments. The ISR are fed with protons by sharing on a pulse to pulse basis with the 24 GeV physics experiments.

Studies and preparations are under way with the aim of reaching 10^{13} p/p and to increase the beam brightness. These projects are linked to the planned use of the PS as an injector for the 400 GeV SPS as well as its already established role of proton source for the ISR.

The emphasis will be put on achieving a high degree of reliability and it is in this perspective that one has started to study a new 50 MeV Linac and new poleface windings for the PS.

2.1 Linac

The efforts to improve performance and stability by proceeding to the overhaul of the entire RF system and modifying the modulators to avoid constant readjustments during operation have been successful. A stable beam of 50 mA and 80 μs duration can now be supplied within the required limits of emittance (20π mm mrad) and momentum spread (± 90 KeV).

However, it has also become clear that stretching further the performance of a machine designed initially for producing 10 mA during 10 μs cannot be achieved while keeping both a high degree of reliability and tight beam quality specifications. One has therefore started the design of a new machine which could overcome these limitations.

2.2 The 800 MeV Booster

The biggest single item in the improvement programme for the 28 GeV PS is the Booster synchrotron, which raises the injection energy from 50 MeV to 800 MeV. Its construction started at the beginning of 1968 and was terminated mid-1972. Running-in was taken up in May 1972 and is just bearing its first operational fruits.

2.2.1 Conception

With the present injection at 50 MeV the PS acceptance is completely filled and the intensity is space charge limited to about $2 \cdot 10^{12}$ p/p. For a given normalized emittance $\varepsilon\beta\gamma$, the space charge limit at 800 MeV is 8.3 times higher than at 50 MeV. Injection at 800 MeV is therefore expected to bring the PS to about 10^{13} p/p with only moderate increases in transverse and longitudinal emittance.

The Booster thus had to be designed to have a space charge limit approximately 8 times as high as that of the PS. This was obtained, roughly speaking, in the following way:

- Since the space charge limit is independent of the circumference of an accelerator, four synchrotrons, with a radius of 25 m ($\frac{1}{4}$ that of the PS) were stacked on top of each other.
- Another factor of two stems from the greater bunch length due to the slower acceleration.

The lay-out of the Booster is shown in Figure 2.

As injector the Booster shares with the PS the 50 MeV Linac, which is double-pulsed; to allow the Booster being run-in in parallel with normal PS operation.

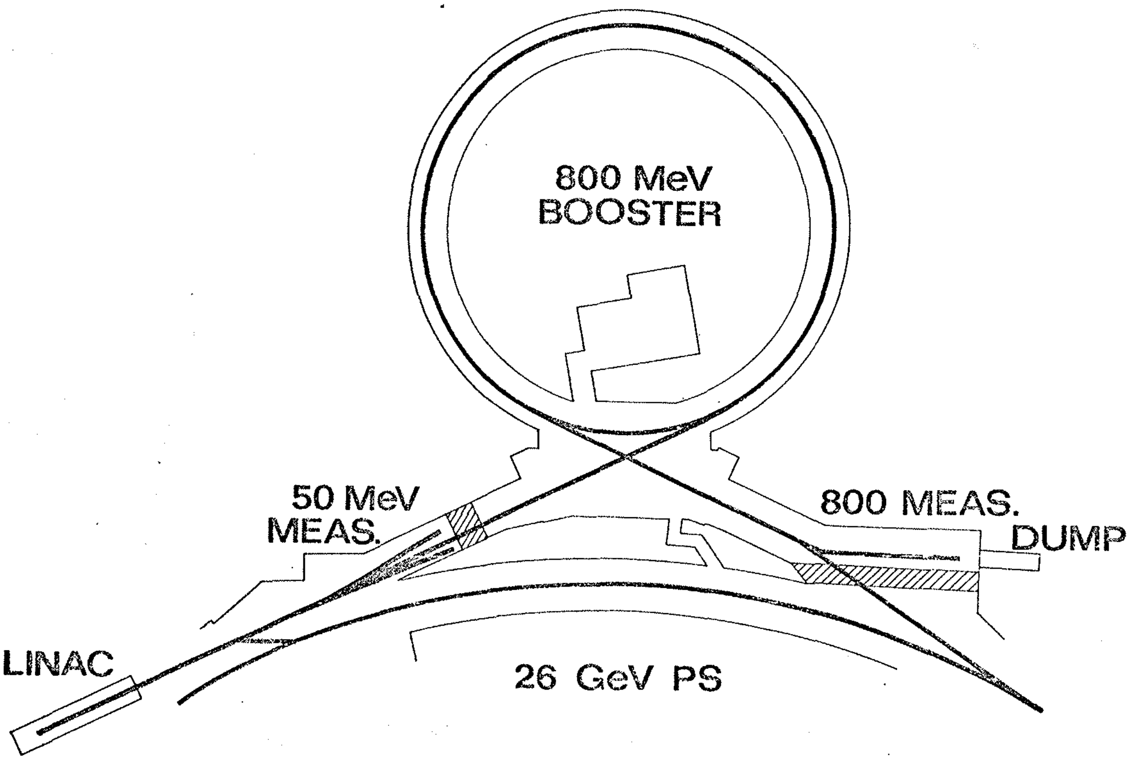

Figure - 2

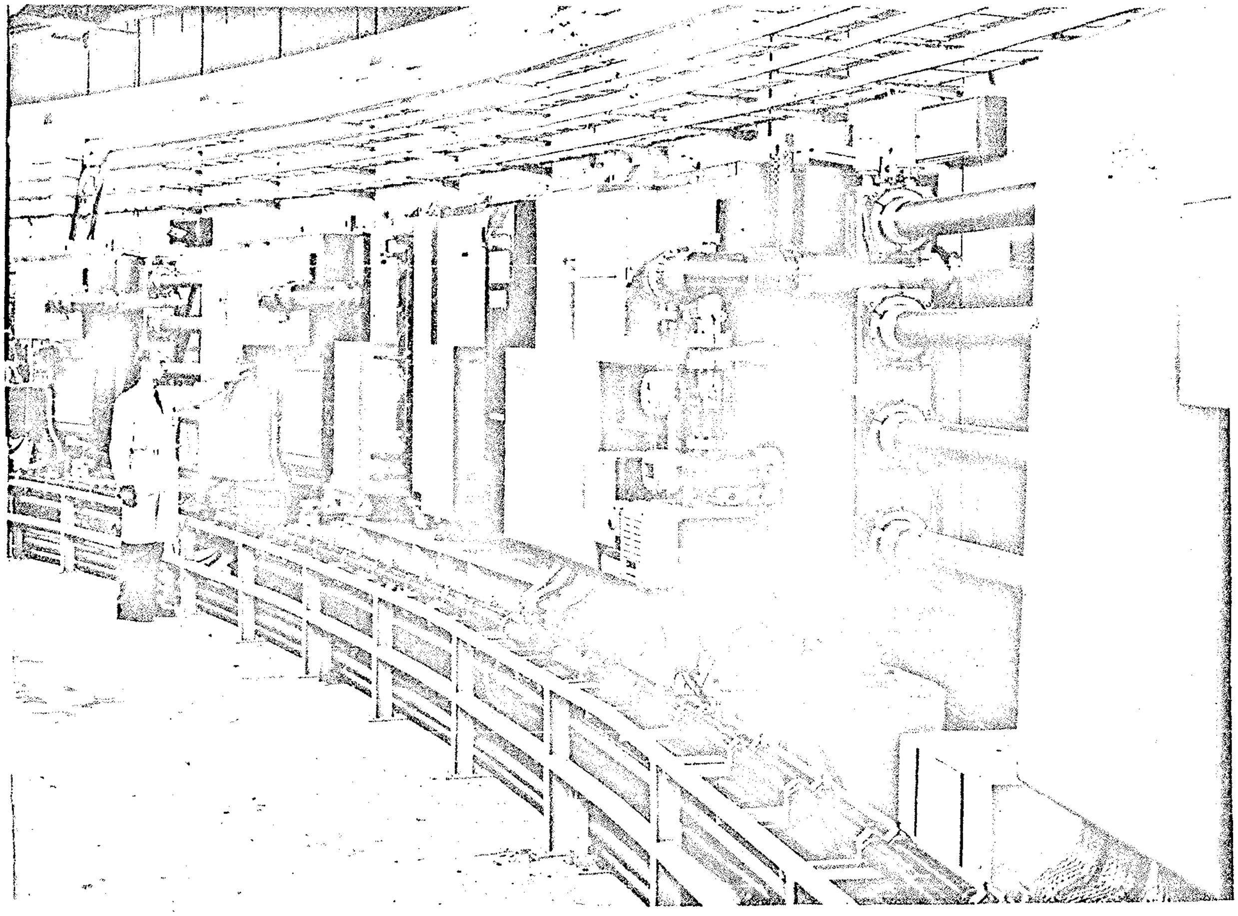

Figure - 3

After acceleration to 800 MeV in 0.6 sec the four beams are ejected sequentially, recombined vertically and transferred to the PS to fill its circumference in a single turn injection. The accelerating frequency in the Booster being equal to that of the PS, the longitudinal density is preserved in a bunch-to-bunch transfer.

2.2.2 Description

A system of vertical kicker, septum and bending magnets distributes the 100 μs linac beam to the four rings, to fill one after the other in multiturn injection of up to 15 turns.

The four separated function synchrotrons have common 4-gap bending and quadrupole magnets - powered directly from the mains grid - and mostly independent sets of correction elements (dipole to octupole). Figure 3 is a photograph of the Booster tunnel.

A single ferrite tuned cavity per ring performs the acceleration. The four RF systems are largely independent until synchronization on the flat top prior to ejection.

The single turn ejection is performed with a fast kicker and septum magnet and is staggered from ring to ring by one revolution period.

A vertical recombination system, consisting of bending, septum and fast rising kicker magnets, brings all beams to the level of Ring 3 for transfer to the PS (Figure 4).

2.2.3 Present performance

As much as $5.6 \cdot 10^{12}$ protons could be accepted in 15-turn injection in one ring, for normal operation about $2 \cdot 10^{12}$ p/p are injected in six to ten turns only, to limit the emittance to its nominal emittances is subject to an increase in the linac current.

PS BOOSTER, RECOMBINATION SCHEME

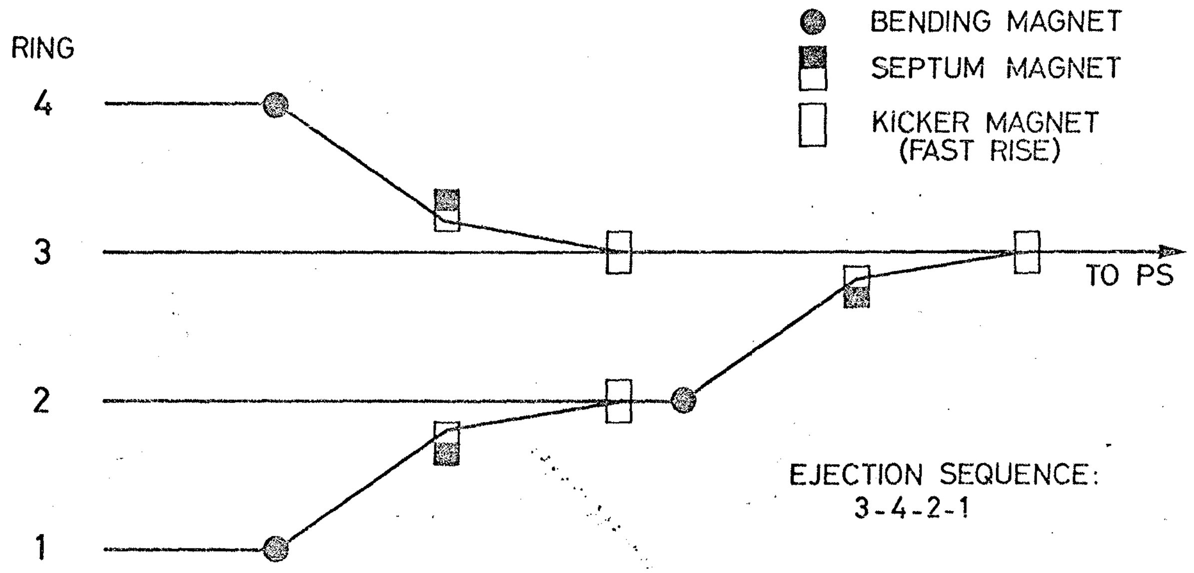

Figure - 4

RF trapping efficiency at 3 • 10^{12} p/p and with a linac energy spread of ± 100 KeV is above 90% and the nominal intensity of 2.5 • 10^{12} p/p per ring at 800 MeV has been exceeded.

At present, transverse emittance blow-up limits the intensity contained in the nominal emittance at 800 MeV to approximately 1.2 • 10^{12} p/p per ring, still sufficient for the intermediate intensity operation of the PS. Excess emittance can be shaved away before transfer to the PS. The blow-up seems to be due to the simultaneous action of stop bands covered by the incoherent Q-spread in the beam. The compensation of the stop bands is under study.

In experimental runs over 6 • 10^{12} p/p in the four recombined beams were transferred to the PS. The equalization of the four rings in intensity and emittances and the precise recombination of the four beams into one is nearing a satisfactory state. The present performance is summed up in Table I.

Table I

CERN PS Booster, present performance (Oct. 1973)

Highest intensities in 10^{12} p/p	Best ring	Sum of 4 rings
Coasting after 15-turn injection (nominal	5,6	
Coasting after 24-turn injection	7,3	
Accelerated to 800 MeV	2,6	77
Within nominal vertical emittance of 9π mm mrad at 800 MeV	1,3	4,5
Accelerated in the PS to 26 GeV	1,3	5,2
Emittances at 800 MeV (∿ 1,6 • 10^{12} p/p/ring)		
Horizontal (mm mrad)	25π	30π
Vertical (mm mrad)	18π	26π
Longitudinal (mrad)	6	10

2.2.4 Outlook

In 1974 the Booster will be made to deliver reliably a beam to the PS during the periods of operation at the intermediate intensity level of $4\text{-}5 \cdot 10^{12}$ p/p. In parallel, the development towards 10^{13} p/p will continue, first with the Booster alone and later, in an experimental way, with the PS, so that the latter can reach its performance as an injector for the 400 GeV SPS.

2.3 Proton synchrotron

A maximum of $5.23 \cdot 10^{12}$ p/p have been accelerated from 800 MeV to 26 GeV/c (compared to about half this figure with direct 50 MeV injection).

2.3.1 Injection

The computer controlled inflection system constituted by a magnetic septum magnet and a fast kicker assisted by four orbit bumpers has performed well.

- With a beam collimated to the nominal emittance ($E_V = 9\pi$ mm mrad - $E_H = 27\pi$ mm mrad) a lossless trapping has repeatedly been achieved both in the transverse and in the longitudinal planes.
- With a non-collimated beam one has still a 30% loss at injection but decreasing as the transverse matching is improved and the differences between the four PSB rings are reduced.

2.3.2 Acceleration

The injected beam has been accelerated without losses up to the top machine energy.

- Longitudinal instabilities are avoided by a careful optimization of the value of the accelerating voltage. Voltage reduction is necessary to introduce enough Landau damping in the Synchrotron motion.

- Transition is crossed without losses nor longitudinal blow-up thanks to the use of the γ_t-jump. A system of 14 quadrupole lenses grouped in 4 doublets and 2 triplets are pulsed at transition to achieve a fast crossing of $\gamma_{transition}$ and avoiding the onset of negative cross instability. The lenses are arranged in such a way in the PS lattice that a large change in γ can be achieved without significantly modifying the betatron tune.

- Transversally, the vertical head-tail instability is damped by octupoles. Below 10 GeV/c, after the dilution due to the yet imperfect matching there is no noticeable blow-up. However, between 10 and 26 GeV/c there is an, as yet unexplained, vertical emittance increase by a factor 1.6.

So far, one has achieved a longitudinal density twice as large as with a 50 MeV injected beam, but with also a higher vertical emittance at 26 GeV/c.

2.3.3 Extraction

Both fast and slow extraction of the intermediate intensity beam have been made with extraction efficiencies similar to those obtained with a lower intensity beam directly injected from the Linac.

- Fast extraction is performed so far with a partial aperture plunging kicker. Efficiencies of (∼ 97% ± 2%) have already been achieved.

- Slow ejection uses the 1/3 integer resonance produced by a semi-quadrupole magnet (SQUARE scheme); the beam is then extracted through a channel constituted by a foil electrostatic septum and two magnetic septa. The first tests have readily allowed to extract 90% to 93% of the beam.

2.3.4 Future plans

Although the CPS complex can now readily operate at the intermediate intensity level, a certain number of improvements, most of them are planned or under way, are still needed to achieve reliable operation at 10^{13} p/p.

- A new Linac, as already mentioned, capable of delivering reliably a 50 to 150 mA beam of 200 to 70 μs duration in the 100 mA transverse emittance smaller than 25π mm mrad and an energy spread of ± 150 KeV.

- A strenghtening of the PS magnet and a renewal of its poleface windings to make it more radiation resistant.

- A more elaborate system of low energy corrections. Straight and skew sextupoles are being added to the existing sets of vertical dipoles, backleg windings, straight and skew quadrupoles.

- Stronger high energy corrections to control the betatron tune and the chromativity during the whole accelerating cycle and stronger octupoles to damp instability. If for the next few years these corrections are achieved by lenses, for the long term one is studying a solution which would make use of the new poleface windings to create the correcting multipolar fields.

3. The Intersecting Storage Rings (ISR) *)

3.1 Operations

During the last few years, the ISR has been in operation for about 3000 hours/year on the average. Of this time 60% was used for colliding-beam physics, 23% for development and 17% for start-up, filling, adjustments and luminosity measurements in preparation of physics runs.

The typical cycle of operation for physics consisted of daily fills followed by about 15 to 20 hours of circulating beams, but there also were regular runs with beams circulating for up to 46 hours. The overall ISR usage is roughly 10% of the total number of protons accelerated in the PS.

The normal range of operating momenta is from 11.5 to 26 GeV, the equivalent of 300 to 1500 GeV/c on a fixed target. On some occasions beams were accelerated in the ISR to 31.4 GeV/c and thus provided for colliding-beam physics at a momentum equivalent to just over 2000 GeV/c.

The complexity of the vacuum system and the demands on this system's performance have increased since the ISR started in 1970/71. Many more machine components have been installed and the chambers around the beam intersections have all been rebuilt - some of them more than once - and become much more complex. There have been many bakeouts. The bakeout has been hardened to 24 h at 300° C and the average pressure lowered to about 3×10^{-11} torr.

On two occasions we failed to prevent high intensity beams from going astray and burning holes in thin wall parts of the chamber. This did not result in more than a few days' interruption.

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*) This chapter is essentially an updated and abreviated version of the contribution given by W. Schnell to the 1973 Particle Accelerator Conference, San Fransisco.

The luminosity suitable for physics has increased steadily until recently. During long periods the average value taken over the full duration of all runs was well above 10^{30} cm^{-2} s^{-1}. In December 1972 the original design figure of 4×10^{30} cm^{-2} s^{-1} was surpassed for the first time, with currents in the two rings of 11 and 12 A.

About ten experiments were completed since the machine started up and eleven other groups are taking data in the six colliding beam areas equipped for that purpose, and preparations are under way for about ten new experiments.

3.2 Performance and beam behaviour

Ever since the start we have found our luminosity limited by two main effects; a third one is likely to become important in the near future.

The most important one of these effects is a beam-induced deterioration of the vacuum. Ions originating from collisions with the residual gas are driven into the chamber walls by the beam's electrostatic potential, which is about 1.5 kV at 10 A beam current. The ions liberate gas molecules from the surface layers adsorbed at the walls. It is easy to show that with such a process, where the pressure rise is proportional to the product of beam current and pressure, one has a critical current, above which the equilibrium pressure rises to infinity.

This effect has been thoroughly studied by now. One remedy applied is to reduce the surface coverage by adsorbed molecules. As a first step we have adopted baking at 300° C for 24 h everywhere and every time a sector has been exposed to atmospheric pressure, instead of only 6 h at 200° C as used earlier. Surface treatment with ions from a glow discharge is applied to parts of the chamber where the pumping speed is small and difficult to increase. This is done in the laboratory, prior to installation. The beneficial effect seems to survive a few hours at atmospheric pressure. Keeping the entire system in the 10^{-11} torr range of pressures also contributes to reducing the amount of beam-induced outgassing. In clean parts of the vacuum system we actually observe beam-induced pumping, i.e. the number of molecules desorbed per incident ion is smaller than one.

The other, more universal, remedy is to increase the distributed pumping speed by means of a large number of additional titanium sublimation pumps. About 500 such pumps have been installed. As a result, the critical current had increased from about 4 A around the middle of 1971 to about 20 A in both rings.

The second limitation is transverse instability due to the resistivity and inductance of the chamber walls. Stability is provided by Landau damping via the spread in betatron frequencies. To make this spread large enough we have to apply a rather large sextupole component to the magnetic field. This remedy is limited, however, by the necessity of keeping low order non-linear resonances outside the momentum range occupied by the stacked beam. Figure 5 shows a few typical working lines in the plane of horizontal and vertical betatron wave numbers, Q_V, Q_H, measured at low beam intensity. As a refinement, some of these lines are curved to counteract the influence of the beam's space charge. This is obtained by a suitable distribution of the currents in the poleface windings. Since it is the local value of dQ/dp that determines stability, the threshold is somewhat increased by keeping the working line straight at high intensity.

At the highest intensities the line marked 5C, providing $\Delta Q \sim 0.1$ across the stack, is required for stability with a reasonable safety margin. This line includes a number of 5th order resonances. Their effect is noticeable.

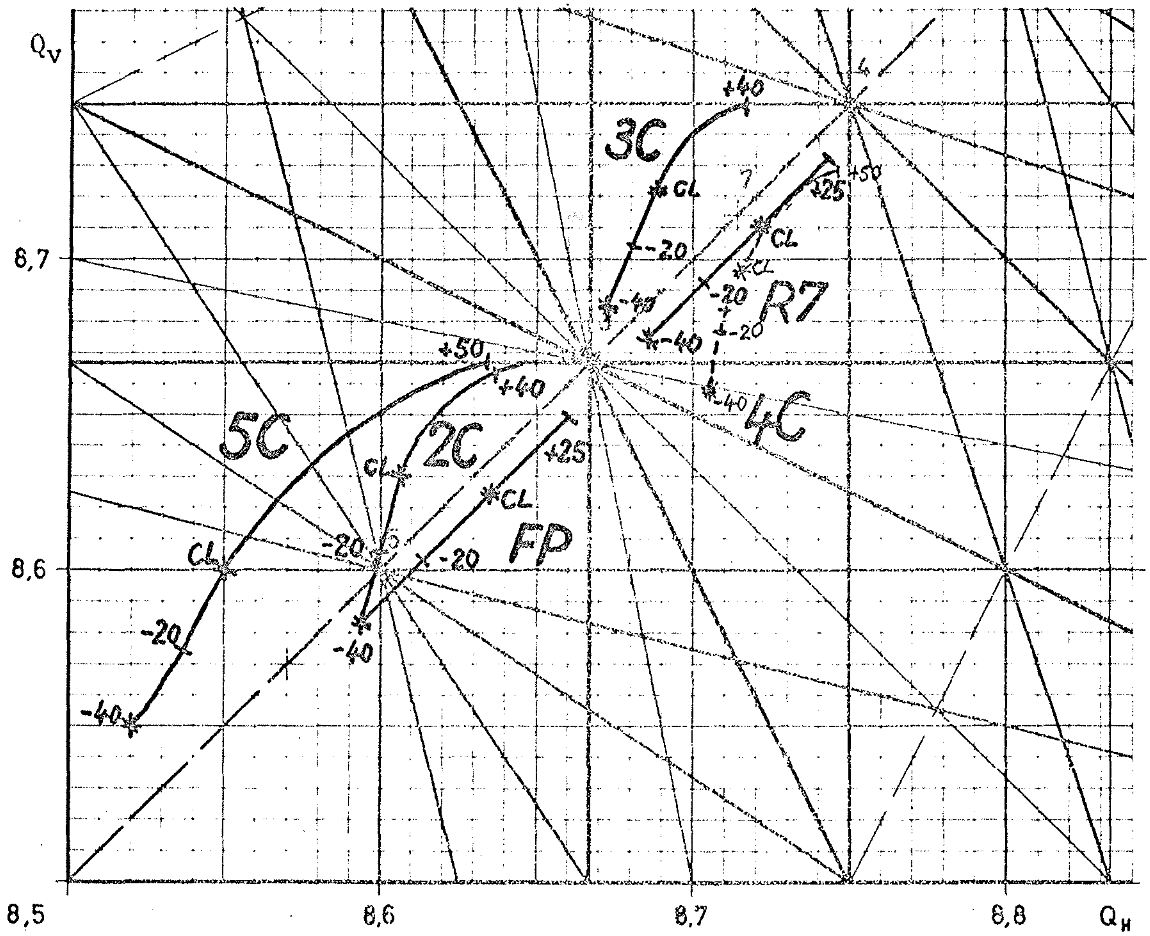

Figure - 5

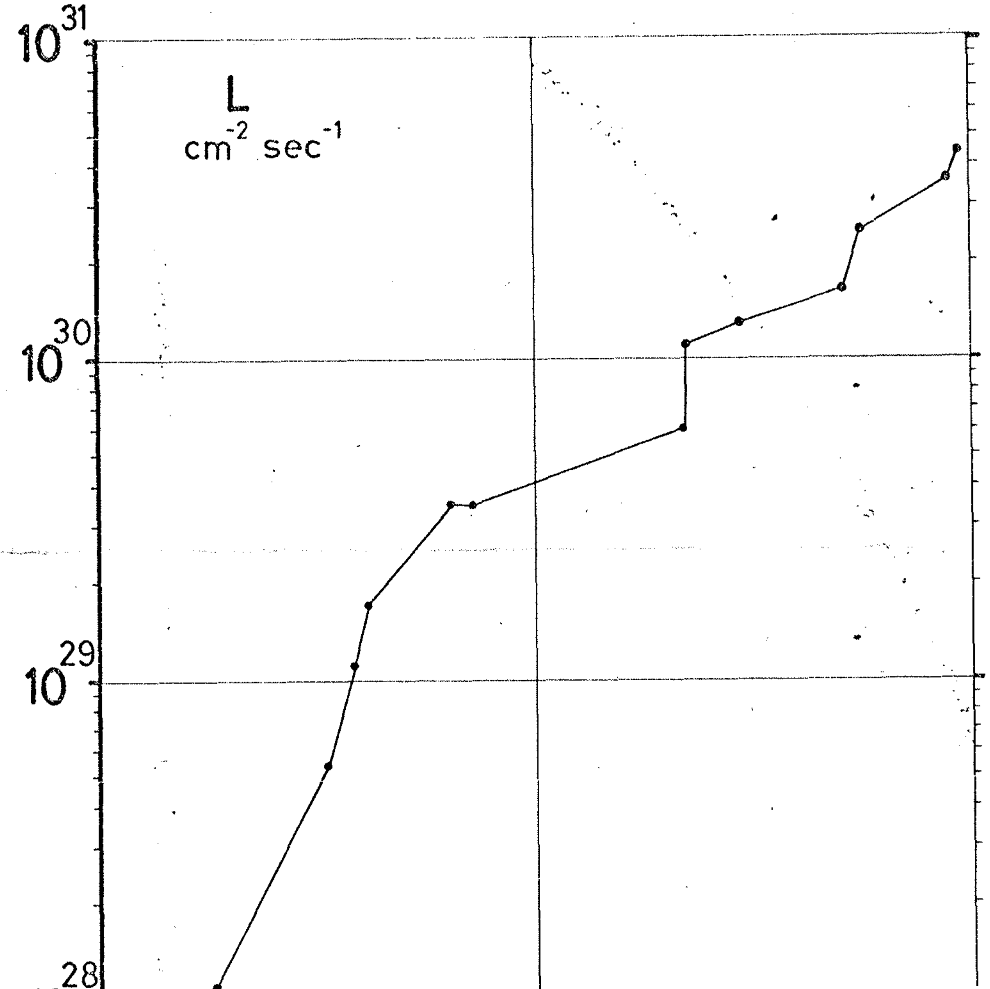

Figure - 6

The third problem, which is not a serious limitation yet, is longitudinal instability of the injected beam, leading to dilution by roughly a factor of two, in phase plane density.

Since we have horizontal aperture to spare, we are able to alleviate all three effects by scraping away vertically a fraction of the injected beam so as to obtain a given current at reduced effective beam height and reduced particle density in momentum space. We call it "shaving". About 50% in luminosity was gained in this way. As already mentioned, we have reached, so far, a luminosity of 4.4×10^{30} cm^{-2} s^{-1} with h_e = 3.2 mm, and acceptable decay rates and background.

Figure 6 shows the development of ISR luminosity since the start of regular operation in the spring of 1971.

3.2.3 Beam decay and background

Ideally, the beams should decay because of gass scattering only. Instead, when we started in 1970, we observed alarming loss rates, such as 0.5 min^{-1} at 1 A beam current, not compatible with gas scattering even at the higher pressures we had then. We soon found that this anomalous decay did depend on vacuum after all, and on the clearing of space charge produced by electrons that are created by ionization. Dramatic improvements were obtained by lowering the pressure and by installing more electrostatic clearing electrodes in addition to the large number already present from the beginning. The explanation seems to be instability of the coupled oscillation of protons and electrons. We have, in fact, observed bursts of proton oscillations at the right frequency (about 100 Mz at 10 A beam current) and repetition rate. As the vacuum and clearing were gradually improved, these oscillations became weaker, and their repetition period longer. The effect is nevertheless still noticeable.

The present status is that decay rates compatible with nuclear scattering have occasionally been observed with beams as high as 8 A. Most of the time decay rates are higher and the blow-up of h_e is always faster than compatible with Coulomb scattering by about an order of magnitude. In practice the half life of luminosity is about 30 h.

Background radiation due to beam-gas and beam-wall collisions has improved together with the beam life and is, in general, very low. Indeed, our motivation for trying to reduce beam decay has nearly always been reduced background rather than increased beam life. The "shaving" of the injected beam has been found to lead to an additional improvement. At best, the background is compatible with the local pressure - about 10^{-11} torr - in the intersection regions.

On the other hand, it has turned out that it would be difficult to reconcile high decay rates with low background by means of periodic scraping. The difficulties with heavy scraping of stacked beams are not fully understood. Secondary electrons generated by lost protons may be a possible explanation. We do remove low density halos from the beam by scraping. This usually improves the background by a small factor for several hours.

Much of the remaining decay and background may be explained by diffusion processes which can gradually change the momentum of particles and drive them into high-order non-linear resonances. One such diffusion process can be multiple Coulomb scattering between the protons of the same beam ("intra-beam scattering").

Arnold diffusion, driven by azimuthal variation of neutralisation or by beam-beam interaction had been invoked in the past, to explain beam decay. We have not observed any positive evidence for this.

An experiment with a 2 GeV beam has not given conclusive results, but will be repeated. We are also installing a special non-linear lens to study this effect.

3.2.4 Acceleration to 31.4 GeV/c

The maximum particle momentum currently available from the PS is 26 GeV/c. At the price of much reduced luminosity, we have accelerated stacked beams from about 26 GeV/c to 31.4 GeV/c, the maximum our magnet power supplies can provide. The maximum luminosity achieved was 4×10^{29} cm^{-2} s^{-1}. Phase displacement acceleration was used for this.

During the acceleration process the shape and location of the magnetic working line must be kept constant while the field increases and saturation worsens. This is done by means of the poleface windings, the currents of which are continuously regulated by the controls computer.

3.2.5 Conclusion

We have still not found any new or fundamental limitation to the performance of our machine. The limitations we have require time and effort to be gradually removed, but they are well understood and a development programme dealing with them is under way. We believe, therefore, that there is ample room for future growth, first with the machine as it is, later with some local modifications of the magnet structure. One may also conclude in a more general way that future projects of colliding beam facilities involving protons can now be put on a rather safe basis.

4. The SPS programme *)

Figure 7 illustrates the SPS layout superposed on an aearial view of the Swiss-French border in the neighbourhood of CERN. The sketch shows the 10-14 GeV/c injection line from the CERN PS, and ejection lines to the existing West Experimental Area in CERN Lab I and to the planned North Experimental Area. The SPS staff are now installed in the new Laboratory II at Prévessin (France), clearly marked by the cross-shaped buildings between the 2.2 km diameter SPS ring and the Northern ejection line.

The SPS programme is well under way. All the major accelerator components have been designed and specified, and orders have been placed. For some equipment - notably the main magnets - delivery has already begun. In general, progress is in line with planning, and costs are within the original estimates.

Last summer, the decision was made to proceed to a full magnet ring, without an intermediate halt at 200 GeV. This choice was reached after careful consideration of the different alternatives envisaged in the original design study, including the superconducting "missing-magnet" option. It emerged as the most attractive option on grounds of cost and timescale, giving the prospect of a full 300 GeV machine within the original budget, machine completion in 1976, and North Area operation in 1978. (Although the programme is still referred to as 300 GeV, the SPS should have full 400 GeV capability.)

4.1 Tunnel operations

The SPS will be sited in a 4 m diameter tunnel som 40 m - 60 m down in the sedimentary "molasse" rock underlying this region. In addition, the injection and ejection tunnels constitute a large fraction of the total mining operation, which is on the critical path of the programme.

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*) The information in this chapter supplied by N.M. King.

Figure - 7

Despite early delays in getting the Robbins boring machine underway, and subsequent snags such as encountering unexpected gas pockets, progress has been satisfactory, and two of the six machine sectors have been successfully completed. At the end of each sector, the centre of the tunnel was within a few centimetres of the intended position - an excellent demonstration of the accuracy achieved by the underground survey and guidance system, based on geotheodolite survey and laser beam guidance.

If no serious snags arise, the third sector should be complete by the end of this year, so that half of the machine circumference should then be bored. At this stage, final concreting of the early sections can begin, while the Robbins machine tunnels on around the second half of the ring.

Figure 8 illustrates this vital and fascinating aspect of SPS construction.

4.2 Main ring Magnets

The SPS lattice includes 744 dipole magnets and 216 quadrupoles. There are two types of 6.26 m long dipoles with different apertures, and steel half-cores for both types are arriving steadily. About 200 half-cores have been delivered, and the present rate is about 12 per week. The production rate of coils is improving, and delivery is now about 6 per week, rising to 8 per week by the end of the year. So far, 21 complete dipoles have been assembled, with complete assembly and installation scheduled for September 1975.

Coil positional measurements are first carried out on a flat bed-plate, with particular emphasis on the critical inner coils, thus determining the shims to be inserted in the half-core. The coil block is then laid in its lower half-core (see Figure 9), the vacuum chamber is installed, and the upper-core is lowered on top.

Figure - 8

Head of Robbins machine breaks through into Pit 3 having bored one third of the SPS circular tunnel.

During welding, the two halves are held together by magnetic field from a simple coil through the aperture, while the structure is held and pre-cambered by a system of hydraulic clamps.

The complete magnet is then swung out to the measuring bay, where mechanical measurements are made and its magnetic properties are compared with a standard dipole under pulsed conditions. Shims are added or removed from the pole-ends to achieve magnet-to-magnet uniformity.

Integrated field measurements are carried out using a stack of 9 coils - 5 on the median plane, plus 2 above and 2 below at each side of the aperture. Measurements carried out so far show properties within the specified tolerances and in agreement with theoretical predictions.

The first completed production quadrupole (3 m long), has now been delivered, and measurements are in progress.

4.3 Main power supplies and RF system

Contracts for all major components of the main power supply and the RF system have been placed, and in most cases manufacture is under way. Figure 10 illustrates a short two-drift-tube section of RF Cavity constructed at CERN for test purposes. Tests are also under way using a cavity in the PS ring to study multipactoring effects, and for partial pre-bunching of the PS beam at 200 MHz.

4.4 Ejection equipment

A large number of different components are being developed for beam transfer and ejection - kicker magnets, sextupoles, septa, etc. The main items of slow ejection equipment - electrostatic septa (Figure 11), thin magnetic septa, and thick-septum ejection magnets, are being developed and constructed at CERN.

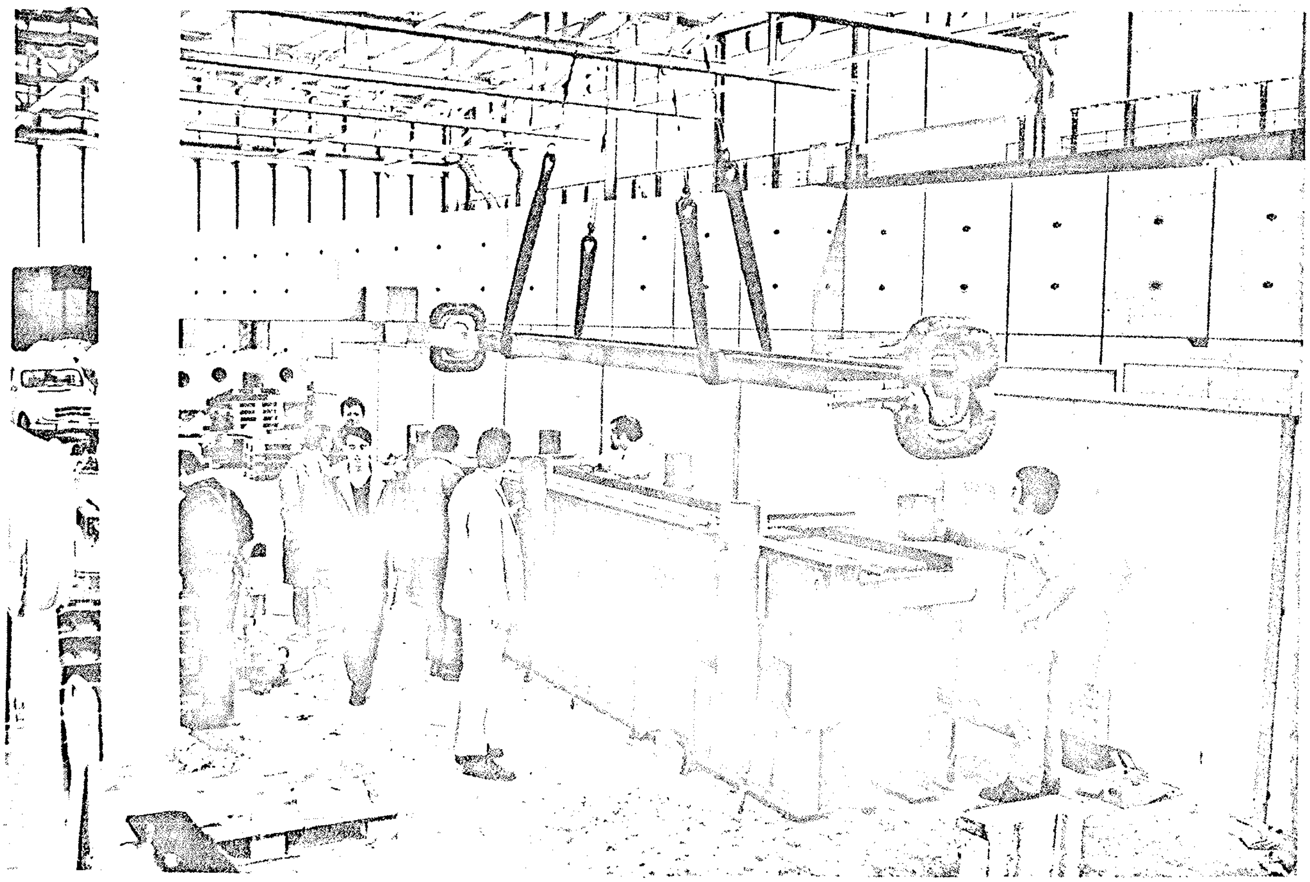
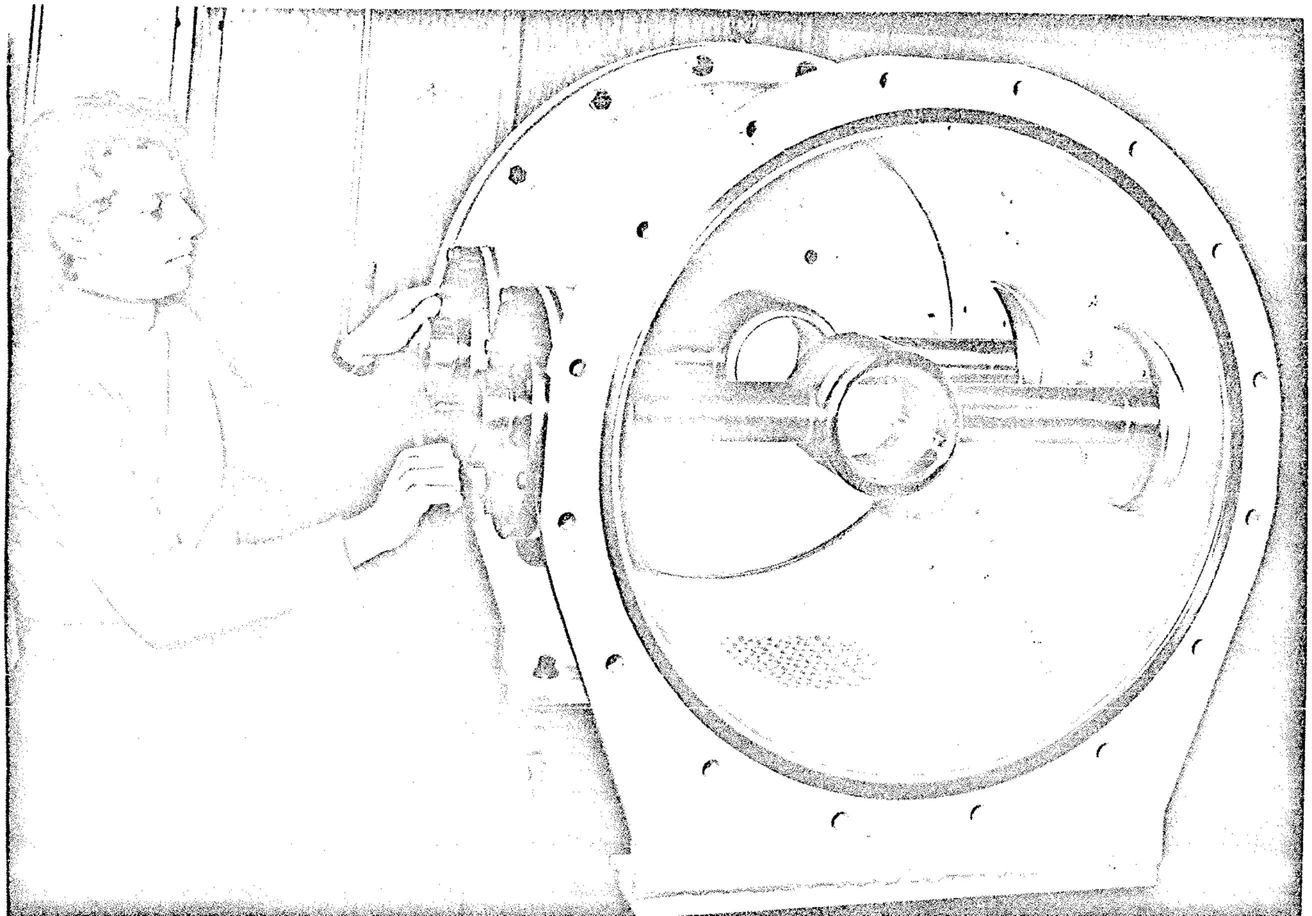


Figure - 9



The thin-wire electrostatic septum is a particularly interesting device. Figure 11 shows a short prototype section of the wire electrode, using 0.15 mm wires held in tension by a system of hooked springs. Should a wire break during operation, its spring ensures that it is snapped out of the beam. The wires are pre-wound on a separate frame which is readily located over the face of the device and clamped at the sides, making replacement a relatively fast operation. Fields in excess of 100 kV/cm have been achieved consistently.

4.5 Machine dynamics and ejection possibilities

Figure 12 illustrates the SPS resonance diagrams with two possible working points and paths to third-integer ejection. The lower working point is currently favoured, with nominal tunes of $Q_H = 27.6$ and $Q_V = 27.55$. Third-integer ejection will be used for slow spills in excess of, say, 50 ms; but for shorter spills (say several ms), half-integer ejection at $Q_H = 27.5$ has been studied. Integral-resonance ejection at $Q_H = 28$ is also possible, and holds the prospect of shorter spill times, but more resonance lines will have to be crossed to reach the integer.

The tolerances on $\Delta Q/Q$ are severe in a large machine like the SPS: the circles shown around the working points of Figure 12 represent a radius of 0.01 in Q. Strict control of chromaticity is therefore essential to the operation of the machine, and for this purpose 72 programmed sextupole magnets will be located in the lattice, sited so as to avoid driving the third-order resonances and the second-order resonances for off-momentum protons.

There will also be 6 correction octupoles (one per superperiod), and space has been reserved for further multipoles should these be required.

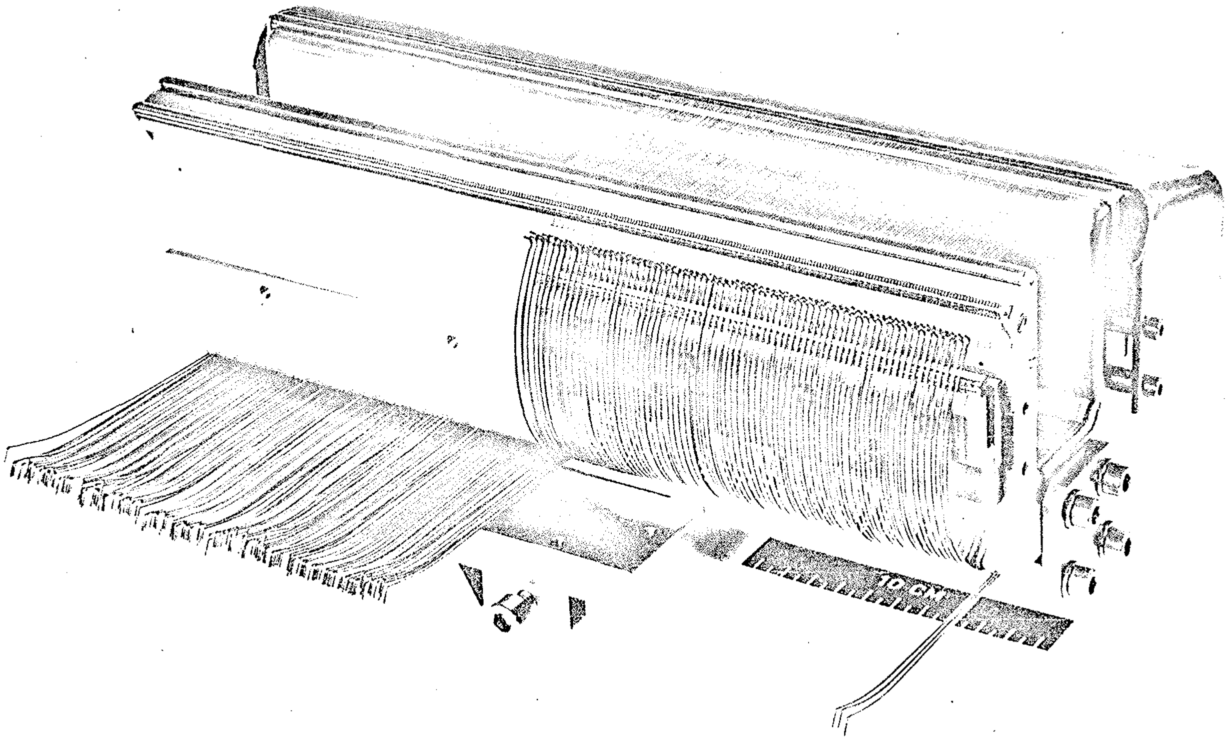


Figure - 11

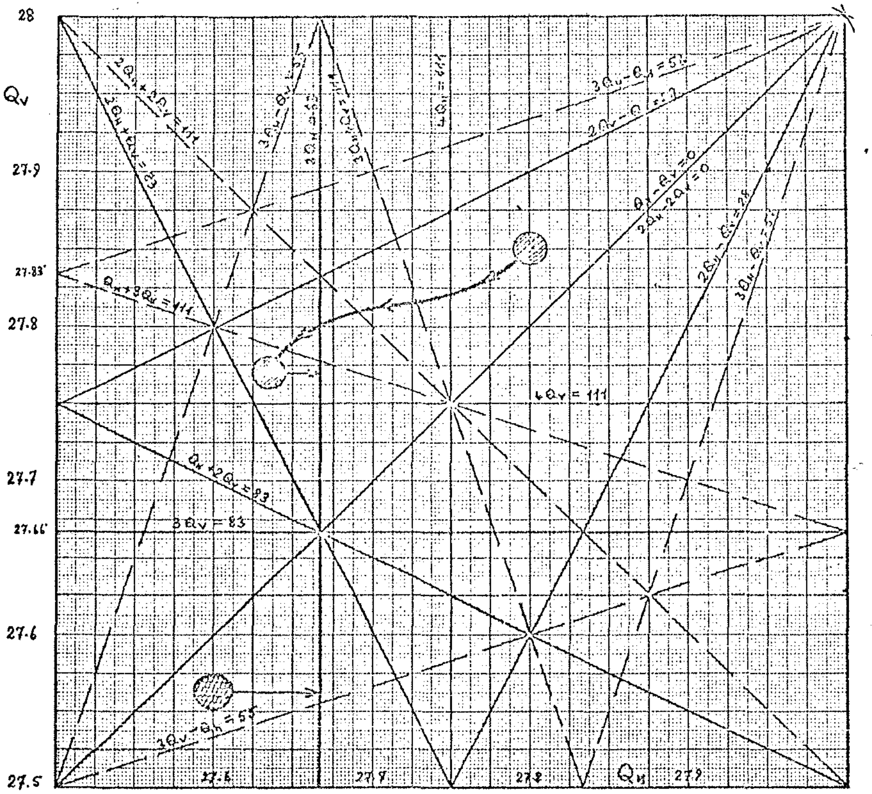


Figure - 12

Closed orbit control will be effected by a sensor and dc correcting dipole in each half-period of the machine. The dipole currents will be determined by computer initially to correct the closed orbit at injection: if significant changes in closed orbit are apparent during current rise, a compromise correction may have to be determined.

The closed orbit sensors can also be used for Q measurement in conjunction with a coherent beam kick, using fast Fourier transform electronics. The complete arrangement of diagnostic devices has not been finally determined, but a range of different instruments is being developed at CERN.

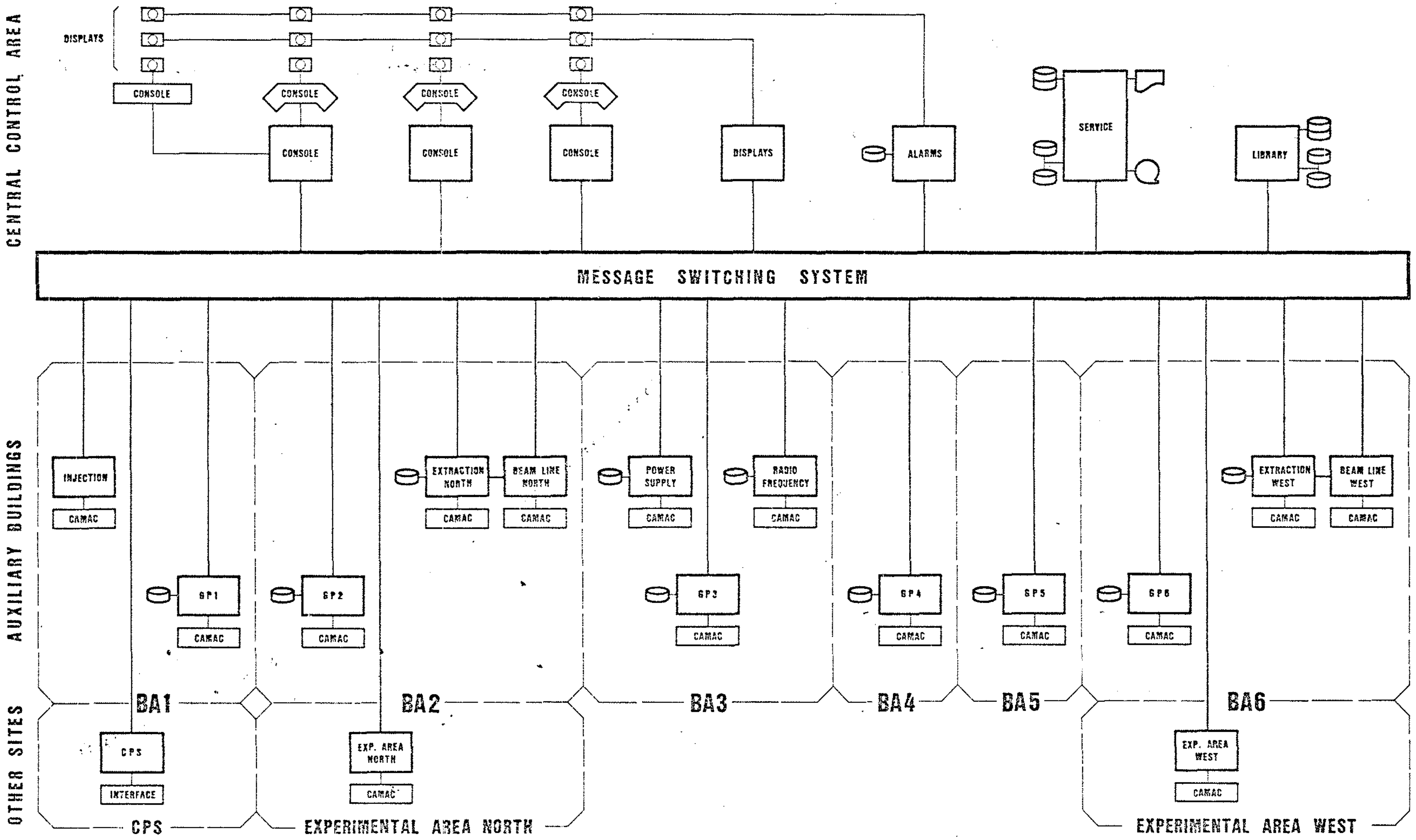
4.6 Control system

SPS operation will be carried out under computer control, using a complex system of 24 Nord 10 computers. Figure 13 is a block diagram showing the arrangement of computers to serve the various machine functions, and the vital message control system which links them together. To date, 8 computers have been received.

4.7 Experimental facilities

Figure 14 shows the schematic arrangement of primary beams and targets in the two experimental areas.

For the existing West Experimental Area, both fast and slow extraction modes are required. Three targets in the West Hall itself will be fed by a 200 GeV slow beam. Two underground neutrino targets can be illuminated by slow or fast beams of energy up to 400 GeV, to provide narrow and wide band beams to BEBC and for counter exploitation. Also in the underground switchyard, a 200 GeV fast beam can be directed onto a target for an RF separated beam to BEBC.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ALARMS
SERVICE
LIBRARY
MESSAGE SWITCHING SYSTEM
AUXILIARY BUILDINGS
INJECTION
CAMAC
GP1
CAMAC
GP2
CAMAC
EXTRACTION NORTH
CAMAC
BEAM LINE NORTH
CAMAC
POWER SUPPLY
CAMAC
RADIO FREQUENCY
CAMAC
GP3
CAMAC
GP4
CAMAC
GP5
CAMAC
GP6
CAMAC
EXTRACTION WEST
CAMAC
BEAM LINE WEST
CAMAC
BA1
BA2
BA3
BA4
BA5
BA6
OTHER SITES
CPS
INTERFACE
EXP. AREA NORTH
CAMAC
EXP. AREA WEST
CAMAC
CPS
EXPERIMENTAL AREA NORTH
EXPERIMENTAL AREA WEST

Figure - 13

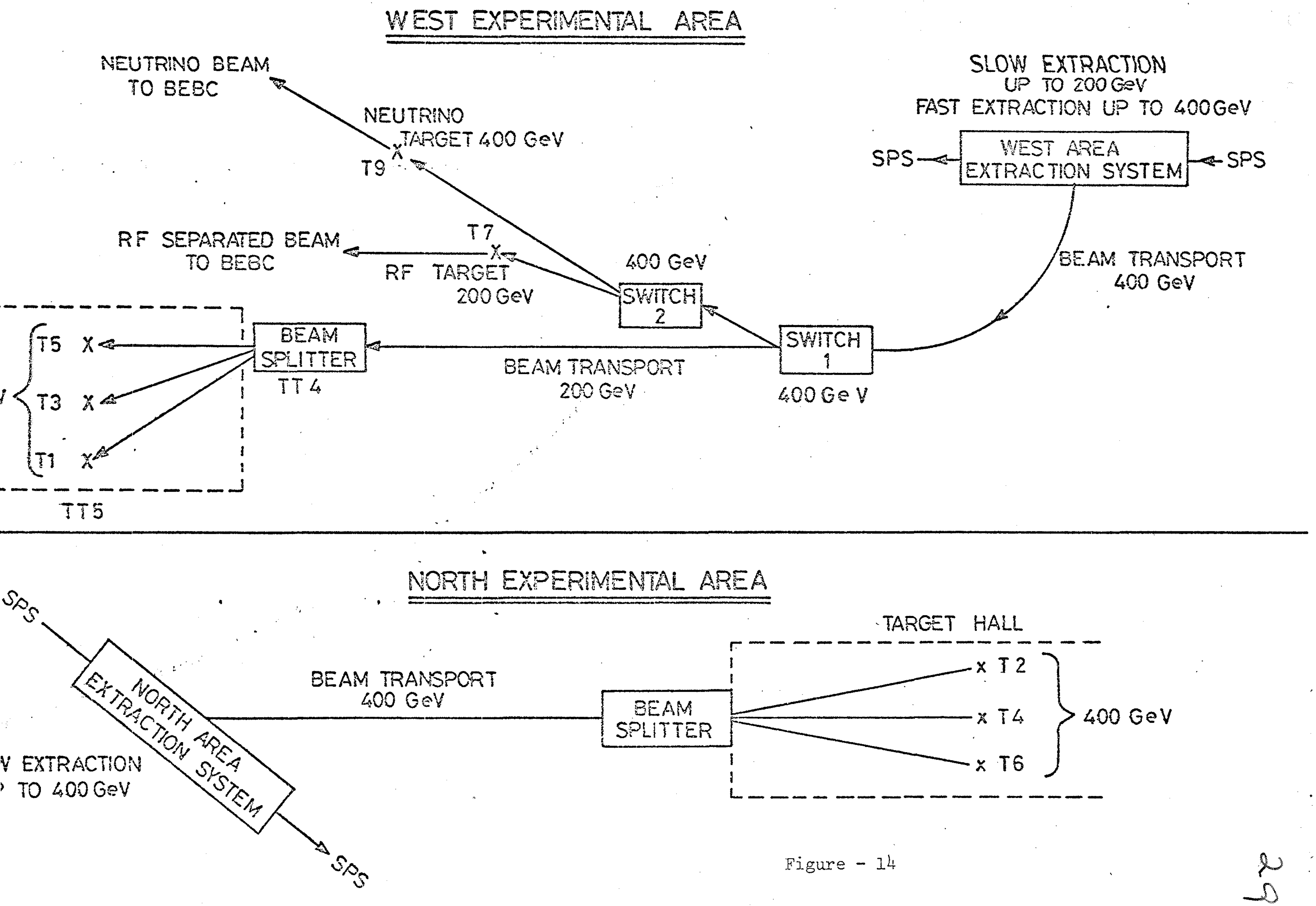
WEST EXPERIMENTAL AREA
NEUTRINO BEAM TO BEBC
NEUTRINO TARGET 400 GeV
T9
SLOW EXTRACTION UP TO 200 GeV
FAST EXTRACTION UP TO 400 GeV
SPS
WEST AREA EXTRACTION SYSTEM
SPS
RF SEPARATED BEAM TO BEBC
T7
RF TARGET 200 GeV
400 GeV
SWITCH 2
BEAM TRANSPORT 400 GeV
T5
T3
T1
BEAM SPLITTER
TT 4
BEAM TRANSPORT 200 GeV
SWITCH 1
400 Ge V
TT5
NORTH EXPERIMENTAL AREA
SPS
NORTH AREA EXTRACTION SYSTEM
SPS
BEAM TRANSPORT 400 GeV
BEAM SPLITTER
TARGET HALL
T 2
T4
T6
400 GeV
V EXTRACTION
TO 400 GeV

Figure - 14

In the North Experimental Area, there is no requirement for a fast extracted beam. The slow beam of up to 400 GeV energy is transported to a beam splitter area about 10 m below ground level, and then focused onto three targets, with flexible sharing possibilities. Altogether, it is planned to have seven secondary beams, plus one proton beam, emerging from these targets to supply two experimental zones. Zone 1 is a general purpose zone; Zone 2, as yet not finalised, is proposed as a muon and high flux proton area.

Both experimental areas can be fed with protons on the same machine cycle. However, since further acceleration is excluded once part of the beam has been extracted in the slow mode, a double cycle is required when protons of different energy are requested in the two areas.