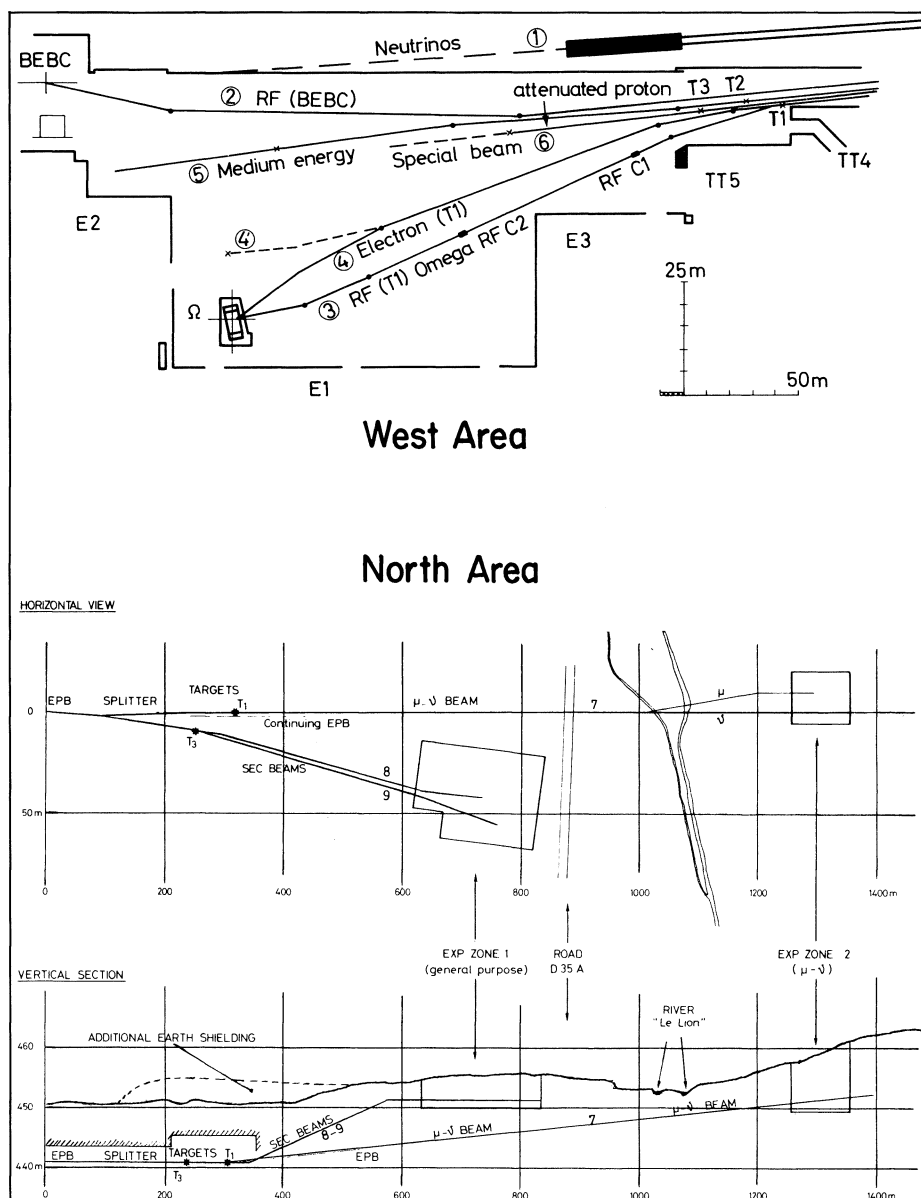


Recommended beams and facilities for the first two years of SPS operation:
In the West Area, with the possible exception of the neutrino beam to BEBC, the secondary beams would be drawn from an ejected proton beam of 200 GeV peak energy. Beams would be — a neutrino beam for BEBC produced underground, r.f. separated beam for BEBC, superconducting r.f. separated beam for Omega, electron/photon facility, medium energy charged beam, special beam (such as hyperons or neutrals).

In the North Area, a slow ejected proton beam only is foreseen of energy up to 400 GeV feeding two zones. Experimental zone 2 would have a high energy muon beam and the possibility of using the associated neutrino flux in electronics experiments. Experimental zone 1 would have a high energy, high resolution secondary beam and another charged particle beam with enough flexibility to serve many experiments.



using the existing CERN facilities, plus the task of making recommendations on such things as beams, major detectors etc. . . as the situation, mapped out by the ECFA Working Group, evolves further.

The members are: J.B. Adams, J.V. Allaby, U. Amaldi, G. Brianti, R. Budde (Secretary), I. Butterworth, P. Carlson, P. Falk-Vairant, L. Foa, W. Jentschke, P. Lehmann (Chairman), C. Llewellyn-Smith, E. Lohr-

mann, J. Meyer, D.H. Perkins, C. Peyrou, E. Picasso, C. Rubbia, H. Schopper, P. Söding, J. Steinberger, D. Treille and R.T. Van de Walle. The first meetings of the Committee have been held and a call for 'letters of intent' has gone out as a first step towards establishing the initial experimental programme. An open information meeting on the SPS and its experimental facilities has been called for 26 April.

Back in action

The proton synchrotron and the intersecting storage rings spent the first two months of this year in a long shutdown for general maintenance and for some important modifications. These were described in the January issue page 7. The machines have now settled down again after being switched on towards the end of February and this is a brief review of their post-shutdown performance. The information was pulled together towards the end of March so, by the time of publication, some of the performance figures which are given may be exceeded but they nevertheless give a good idea of how the machines are ticking over.

At the PS there had been considerable upheaval in the linac and modifications of one sort or another had involved tampering with half the magnet ring. Nevertheless the switch-on went remarkably smoothly. The programme leading to the scheduled time for feeding protons to the experiments went as planned. For a change, few trivial faults halted progress and the machine physicists (who described it as the most 'intellectually satisfying' switch-on yet) were able to concentrate on mastering the beam in the new magnetic field conditions. After ring components have been displaced/reinstalled/added/removed the field conditions are always slightly different and unknown; the settings of the correction elements in particular have to be adjusted to reach optimum performance again.

This commissioning was greatly helped by the stability of the beam from the linac and its reliability. It seems that the clean-up of the r.f. systems powering the linac tanks has been successful.

Traditionally the experimental programme is restricted after a long shutdown — the demands on per-

The cultural commission of the French Senate visited CERN on 4 April. About twenty visitors were welcomed by the Directors General of Laboratory I and Laboratory II. They toured the CERN site seeing experiments at the 28 GeV proton synchrotron and the Intersecting Storage Rings and also saw the work under way on the SPS site in Laboratory II. In the photograph R. Turley is describing the use of a separated kaon beam in the South Hall of the proton synchrotron to a small group from the commission.



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formance are kept modest to allow time for the machine to be brought back to its peak. But this year as demanding a programme as ever mounted began immediately with protons going to BEBC, to Omega, to counter experiments, to the 2 m bubble chamber and to the ISR. A variety of peak energies were needed; fast and slow ejection in various combinations with internal targets were in action. And with all this, the fault rate was below 5 % which is better than is usual.

To crown the success a record proton beam intensity of 2.36×10^{12} protons per pulse was reached and the average intensity during the first run was 1.73×10^{12} .

To push the intensity of the PS much higher, requires the operation of the 800 MeV Booster to provide an intermediate stage of acceleration between the 50 MeV linac and the

synchrotron ring. Prior to the shutdown, the running in had been hindered by the performance of the linac — the Booster requires much more of the linac (100 mA beams over 100 μ s with low energy spread) than the synchrotron ring.

Nevertheless, in December at the very hour that the shutdown was scheduled to start, Ring 3 of the four-ring Booster succeeded, intermittently, in accelerating 2.55×10^{12} protons per pulse to 800 MeV. During the same run 1.7×10^{12} protons were fed to the PS ring. The beam quality was not very good (large emittance and longitudinal bunch oscillations) since there had not been sufficient time to optimize Booster conditions and only about 8.5×10^{11} protons in five bunches were taken intermittently to transition energy in the PS. However, this corresponds to 3.4×10^{12} if the four Booster rings had been in action to provide twenty bunches, which is a

higher intensity than the PS has yet handled at GeV energies.

Much remains to be done to improve this performance, to improve reliability and to improve beam quality from the Booster. Progress seems to depend crucially on achieving the required beams from the linac and it is therefore encouraging that since the shutdown there have been several runs with good quality linac beams of low energy spread. This has made it possible to achieve stable multi-turn injection into a Booster ring. Between eleven and fifteen turns have been injected and r.f. trapping efficiencies varying between 80 and 95 % (95 % being the theoretical maximum) were achieved giving 3×10^{12} protons in a ring. It has not yet been possible to study multi-turn injection in detail because it is necessary to know the injected beam emittance and the emittance measuring station is temporarily out of action.

The high intensity beam with low energy spread also, as is to be expected, led to beam instabilities. These need to be carefully observed and this will be helped by the use of ionization beam scanners which are now being installed. The IBS will make it possible to watch the growth of an instability which is a good clue to its nature. Many correction elements exist in the Booster rings to cure instabilities.

There is now more pressure to bring the Booster into service since higher intensities would be a great advantage for the neutrino experiments in Gargamelle. Everyone is breathing heavily about a possible unification of electromagnetic and weak interactions via gauge theory (see vol. 12 page 315). One of the strong predictions of the theory is that neutrino-electron scattering should take place and a single candidate for such an event has been isolated in the photographs taken during the last neutrino experiments

A view inside part of the control room of the 3.7 m European bubble chamber, BEBC. This gives an idea of the complexity of the many systems involved in the operation of the chamber. Last month we reported the first tracks taken in BEBC. A hydrogen leak had interrupted the tests but it proved possible to repair this quickly and operation continued at steadily increasing field levels up to 2.6 T. No troublesome effects appeared due to eddy currents in the metal piston which is temporarily replacing the plastic piston. The chamber has now been 'warmed up' again to receive the last touches before the physics programme is launched in about two months' time.

in Gargamelle. This whets the appetite but is certainly not sufficient by itself. An extension of the neutrino experiments, preferably with the highest intensity the PS can provide, is receiving high priority. It is hoped that the Booster will be able to contribute to the PS intensity before the end of this year.

At the ISR modifications and additions, which were introduced to improve the performance of the rings still further, together with new installations for experiments affected a large fraction of the machine. Despite the widespread alterations, operation was resumed without delay after the shutdown — within three hours of switching on, beams were circulating in both rings.

The major upheaval was in connection with the vacuum system. As mentioned many times before, it is the pressure rises which can occur in the rings which limit the machine performance. Prior to the shutdown the pressure had already been pushed far below the design value and this was a crucial factor on the way to achieving design luminosity in December of last year. But the phenomenon of 'pressure bumps' — local rises in pressure due to gas desorption from the chamber walls induced by ion bombardment — was still a troublesome limitation.

Both rings were completely fitted out with titanium sublimation pumps during the shutdown. This has improved the average pressure and has lifted the critical current for the run-away rise of pressure by several amperes. Glow discharge cleaning of chamber walls has also worked well and two new intersection chambers, at I-6 and I-7, were introduced without problem.

The benefits were immediately apparent. Soon after restarting the machine, the previous peak currents



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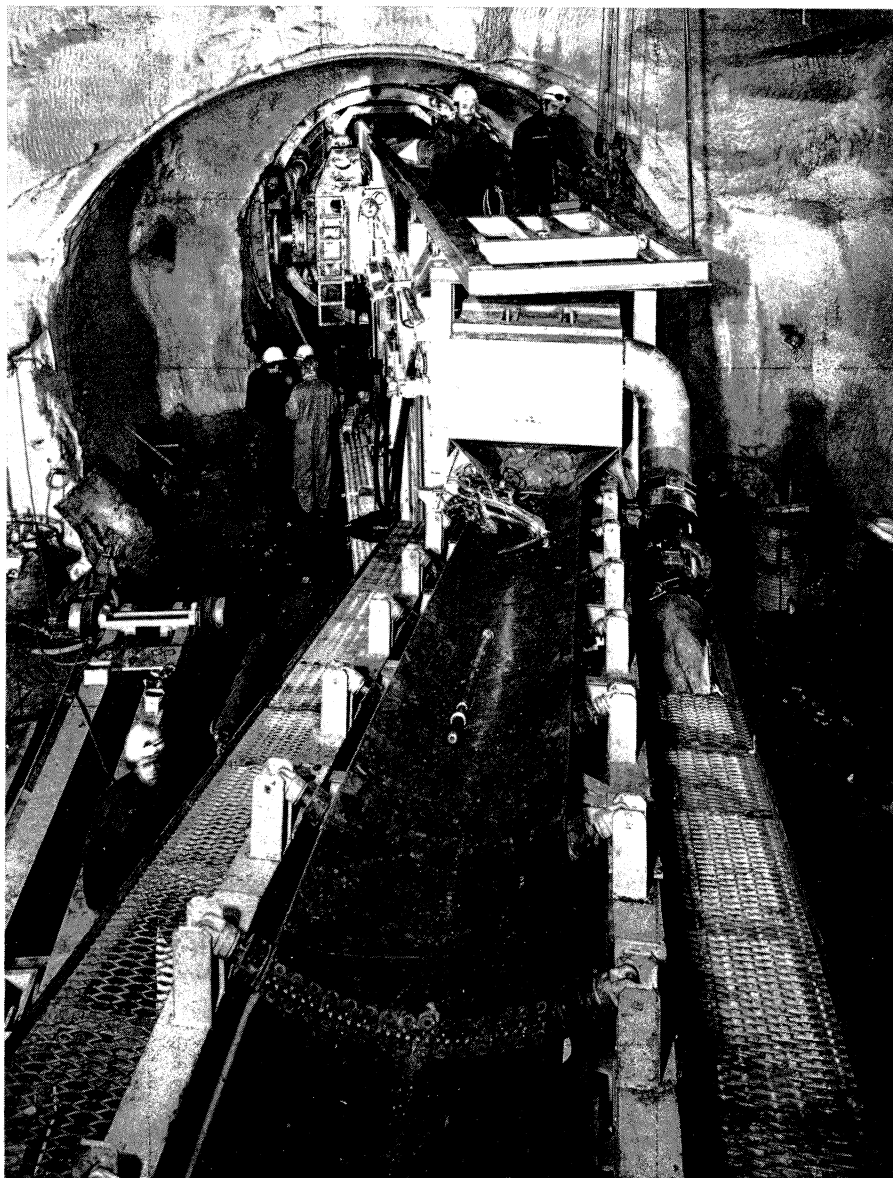
were exceeded — the record in Ring I now stands at 18.7 A (compared to 14.5 A) and in Ring 2 at 17.2 A (compared to 14.0 A). It was also possible to reach design luminosity again under different conditions to those prevailing in December (higher currents and larger beam heights) and physics runs have been possible with a current as high as 12.5 A in Ring I.

Within the first few weeks of operation the ISR, like the PS, was called upon to pull out practically all its tricks for the purposes of the experimental programme. It operated at all four standard energies, and had two runs with a 22 GeV beam in collision with a 11.5 GeV beam, and a run with beams accelerated in the ISR to 31.4 GeV. In general, performance of the storage rings is even more stable than before.

Among the other modifications carried out during the shutdown we

will mention only a few: In the transfer tunnels where beam is brought to the ISR there has been a substantial rearrangement of the magnet powering scheme so as to reduce the number of power supplies linked to the beam-line which will later be shared by the SPS. It simplifies the task of changing the magnet fields from pulse to pulse which will be needed when the PS is feeding both the ISR and the SPS. The new arrangement is working well. The main magnet power supplies for the two rings were also modified — new controls brought them under the ISR computer so that only the final adjustment is now done manually. This is particularly useful when accelerating beam in the ISR — the main magnets plus the auxiliary magnets can now track together to increasing fields controlled by the computer.

Finally, further beam observation equipment has been installed. A beam



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The 'mole' is on its 7 km journey boring out the tunnel for the SPS. The head of the machine is just visible where it is cutting into the rock face and the conveyor belt for removing the spoil is clearly seen since it is still in the enlarged section of the tunnel where the whole machine was assembled.

loss detection system, using ionization chambers distributed round both rings, is now available but so far has not been called into action — there is not sufficient beam loss! The system will be useful particularly in machine studies and will be linked to the computer in a few months' time. Sodium gas curtain beam profile detectors (see vol. 11, page 324) are now installed in both rings. There are problems in Ring 2 but the Ring 1 detector is in action and has given some remarkable pictures of beam profiles when the beam consisted of two or three separate stacks for spectrometer calibration.

Magnets and quadrupoles for g-2

Components of the small muon storage ring, which will be used in the third

series of measurements at CERN on the 'g-2' of the muon, are now being tested. The experiment, being carried out by a CERN, Daresbury, Mainz collaboration, aims to achieve an accuracy of some parts per million in measuring 'g-2' and hence is one of the most precise ever to be undertaken. This requires great care in the design and testing of all components.

To recall the major features: The 'g-2' (or anomalous magnetic moment) of the muon is brought about by quantum electrodynamic effects. Thus its precise measurement is a refined test of the validity of the theory of quantum electrodynamics. At the same time, examining muon properties to such fine detail is a search for minute differences between the behaviour of the muon and the electron. The measurement will be done by observing the muon in the magnetic field of a storage ring 14 m in diameter. The principle of the experiment is similar

to its predecessor (described in vol. 6, page 152) but with the important refinement that the muons will circulate in a nearly uniform magnetic field and will be focused in the vertical direction by electrostatic quadrupoles. The selection of a 'magic' muon energy ensures that its magnetic moment is not sensitive to the electric field. This, together with other improvements in technique, should make it possible to improve the accuracy by a factor of ten.

The magnetic field in the ring will be just below 1.5 T and its azimuthal average value should be constant to a few parts in 10^5 over the region in which the muons move. There will be an optical alignment system, a highly stable power supply, compensation windings controlled by NMR probes in each of the forty magnet blocks and a heat regulation system. But the first step is to bring the magnet blocks themselves to as near uniformity as possible.

The first four magnet blocks have been delivered to CERN and have been installed in a shimming bank. The magnetic field is measured by a coil probe linked to a computer and the first series of adjustments has been completed. An air gap of about 2.5 mm has been introduced behind the pole at the centre of the magnet, wedges have been added at the ends of the blocks so as to reduce distortion of the field where the poles join together, iron plates have been added to the front and on the top and bottom of the blocks. Working patiently through these adjustments has brought the field to the desired uniformity to better than one part in a thousand.

The stage of measurement which is now beginning on the same blocks is intended to push the uniformity of the average azimuthal field in each block to better than one part in ten thousand. This will involve grinding metal off the