

Fast ejected proton beam for Serpukhov

As reported in the previous issue, a delegation from the Institute of High Energy Physics, Serpukhov, came to CERN in June. One of the items on their agenda was to finalize some details concerning the fast ejection and external proton beam transport systems which CERN is supplying for the Serpukhov 70 GeV proton synchrotron as part of the CERN-Serpukhov collaboration. (See CERN COURIER vol. 7, page 123 for details of the Agreement between the two Laboratories and for a general explanation of fast ejection.)

For the moment, two fast ejection systems are planned for the 70 GeV machine — the so-called 'channel A' being provided by CERN, and 'channel B' being built at the Institute for Electrophysical Apparatus, Leningrad (sometimes less reverently known as Komar's Shop — it is directed by Professor E. G. Komar).

System A has evolved as follows: In the original publications it appeared as a two magnet system, using a fast kicker magnet and a septum magnet, both hydraulically plunged into the vacuum vessel of the machine, as were the first fast ejection magnets used on the CERN proton synchrotron. Preliminary studies on this basis were undertaken by CERN early in 1967. At a joint meeting of experts held in Serpukhov in June of that year, the Soviet scientists proposed a new layout with a stationary septum magnet at the inside of the orbit which would use local closed-orbit deformation to bring the beam in front of the septum shortly before ejection. This involves introducing additional magnetic fields in the ring so that the regular, quasi-circular, closed-orbit of the protons is locally distorted at the position of the septum magnet. Owing to their shape, these deformations are popularly called 'bumps'.

CERN presented a design study based on this layout in September 1967. Different possibilities were considered in this study and, in addition to the bump for the septum magnet another bump was proposed

to bring the proton beam into the gap of a stationary kicker magnet. This scheme would make it possible to benefit from the relatively high kick strength of a small aperture kicker, and to use an adapted version of the kicker at present used on the CERN machine (but without moving mechanism), thus saving the development time which is needed for these advanced types of pulsed magnets. On the basis of this proposal more detailed studies were made in the autumn of 1967.

It was found, however, that the creation of closed-orbit deformations requires substantial equipment and a prolonged study of their possible influence on the accelerator behaviour. Though results of the latter study were encouraging, the hope of eventually achieving higher energies than 70 GeV in the accelerator (an energy as high as 85 GeV has been quoted) resulted in the decision to work without bumps. An additional, intermediate, septum magnet with a hydraulic mechanism then became necessary.

This septum and the kicker will do the job of bending the proton trajectories into the other, stationary, septum magnet which completes the bending out of the ring. Using the additional septum also relaxes somewhat the parameters of the kicker magnet and provides some more flexibility in conjunction with the second ejection channel B.

The intermediate septum magnet and its hydraulic plunging mechanism will be provided by CERN. It is a common and essential element for both the systems A and B (they are physically very close together in the machine) and there has therefore been close liaison also with Komar's Shop in fixing the details of this magnet. The final layout was agreed jointly between Serpukhov, CERN and Leningrad at a meeting at Serpukhov in March.

The three magnets have the following preliminary parameters:

Kicker: located in straight section 16, hydraulically-plunged pole-pieces or full-aperture type, length about 3 m, angular deflection about 1 mrad, pulse length variable in steps of 0.15 μ s from 0.15 μ s to 5 μ s, up to 3 pulses possible within one acceleration cycle at intervals of 0.25 s.

Intermediate septum: located in straight

section 24, hydraulically plunged, length 2 to 3 m, angular deflection about 5 mrad, pulse duration about 200 μ s, same multi-pulse facilities as the kicker.

Septum: located in straight section 26, stationary, length about 3 m, angular deflection about 15 mrad, pulse duration about 200 μ s, same multi-pulse facilities as the kicker.

At a joint meeting of experts in November 1967, it was decided by CERN to supply also the external proton beam transport system, thus extending CERN's responsibility as far as (but not including) the target in the experimental hall. This beam transport system consists of several pulsed horizontal and vertical deflector magnets to bring the ejected proton beam to the target position, and a series of pulsed magnetic quadrupole lenses to squeeze the beam to a small spot (of cross-section 1.5 X 2 mm) on the target. This small spot size is dictated by the requirements of the radio-frequency separated beam, following the target.

A design study of this system was presented in March 1968 and agreement on the main specifications has been reached. The system will give the required spot size, the apertures of the lenses will be 70 mm in diameter, and four pulses during one accelerator cycle will be possible at intervals of 0.5 s.

A special building is to be built close to the straight sections (no. 14 to no. 28) which will contain the magnets of the two ejection systems. It will house all the pulse generators and power supplies for the ejection and external proton beam transport systems A and B and other planned equipment, including the pulse generators and power supplies for a slow ejected beam channel. The building will also have a local control room but the details of its relationship with the main control room have not yet been decided.

The work at CERN on the fast ejection and external proton beam transport for Serpukhov has been assigned to the PS Department. The work on the ejection system is being carried out in the fast ejection group led by B. Kuiper. The beam transport system is being constructed by the pulsed beam transport group of the Nuclear Physics Apparatus Division led by B. Langeseth.

New buildings

A brief survey of the construction work the Technical Services and Buildings Division (SB) has on hand which is due to be finished in 1968 or 1969.

Booster

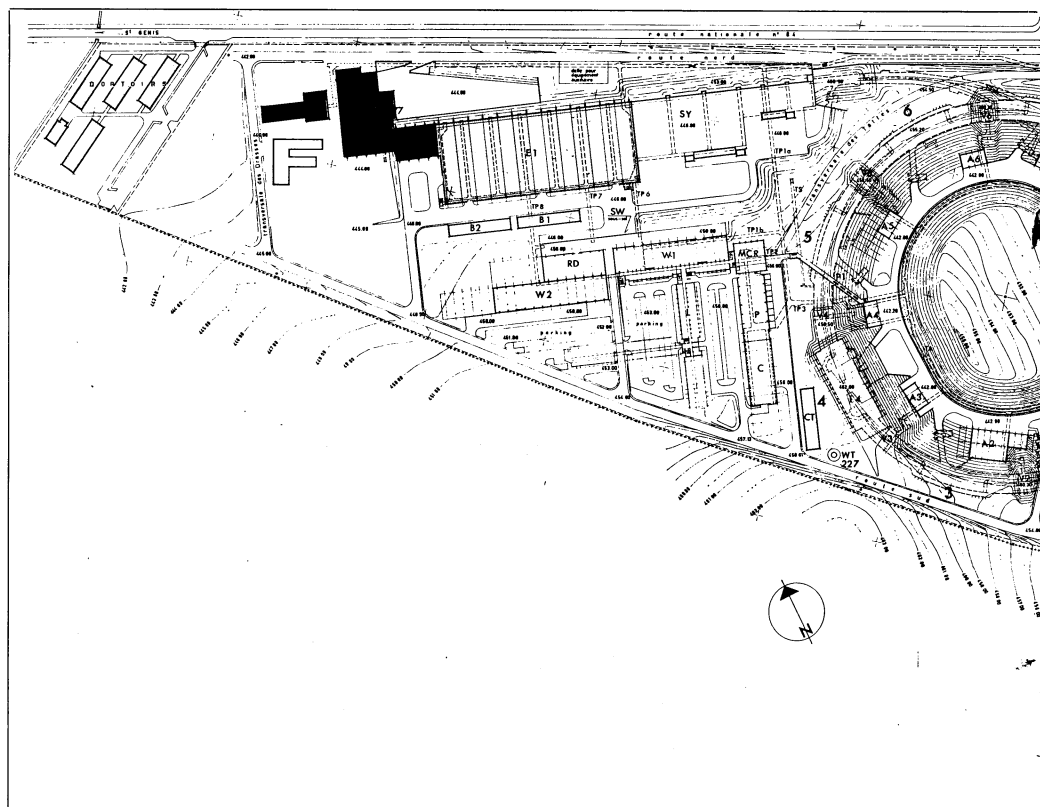
The work involves the construction of the ring tunnel for the booster, which is completely underground, and of the two tunnels linking it to the proton synchrotron. The excavations, which go down to a depth of 14 m have already been done. The concrete shielding forming the outer wall of the PS ring had to be pierced and a process very similar to thermit welding (see photograph) was used to cut five openings, ranging from a size of 3 m² to 40 m², in the concrete, which is between 40 and 65 cm thick at these points. (These openings give space for the passage of the beams, the sight-lines for aligning the magnets and access for the service staff.) This process was adopted because it allows fast, dust-free and, above all, vibration-free working. The SB Division will also construct the central buildings for the booster, to contain the control-rooms, the electricity and cooling-water supplies and the air conditioning units. The units of the booster magnet, the heaviest of which weigh between 15 and 20 tons, will be lowered into the tunnel via a shaft sunk close to the centre of the ring with a horizontal transfer tunnel.

Building at the centre of the PS ring

This is a hall with a floor area of some 600 m² in which it is intended to place the amplifiers feeding the PS accelerator cavities, the number of which will at the same time be reduced from fifteen to thirteen. These amplifiers are at present located in the PS tunnel. About half the floor area will be used for power supplies for the ejection system magnets. This new building will adjoin that already constructed at the centre of the ring which contains the r.f. control room, the beam observation controls and a maintenance laboratory for accelerator equipment.

New store (Hall 119)

The new store (see vol. 7 page 221) has a useful floor area of 2 400 m², sub-divided



in the following way :

- a semi-mechanised store measuring about 28 × 42 m, with a total volume of 13 000 m³, 43 % of which can be used for storage. Two fork-lift trucks travel between the banks of metal shelves where goods are arranged on some 2 500 pallets measuring 1.2 × 1.2 m. About 25 % of the total volume is at the disposal of the Divisions for the storage of equipment temporarily not in use. The store is served by the operators of the two fork-lift trucks and two storemen, who have two small electric trucks available for their own transport.
- a three-story building housing the stores administration and goods reception hall.

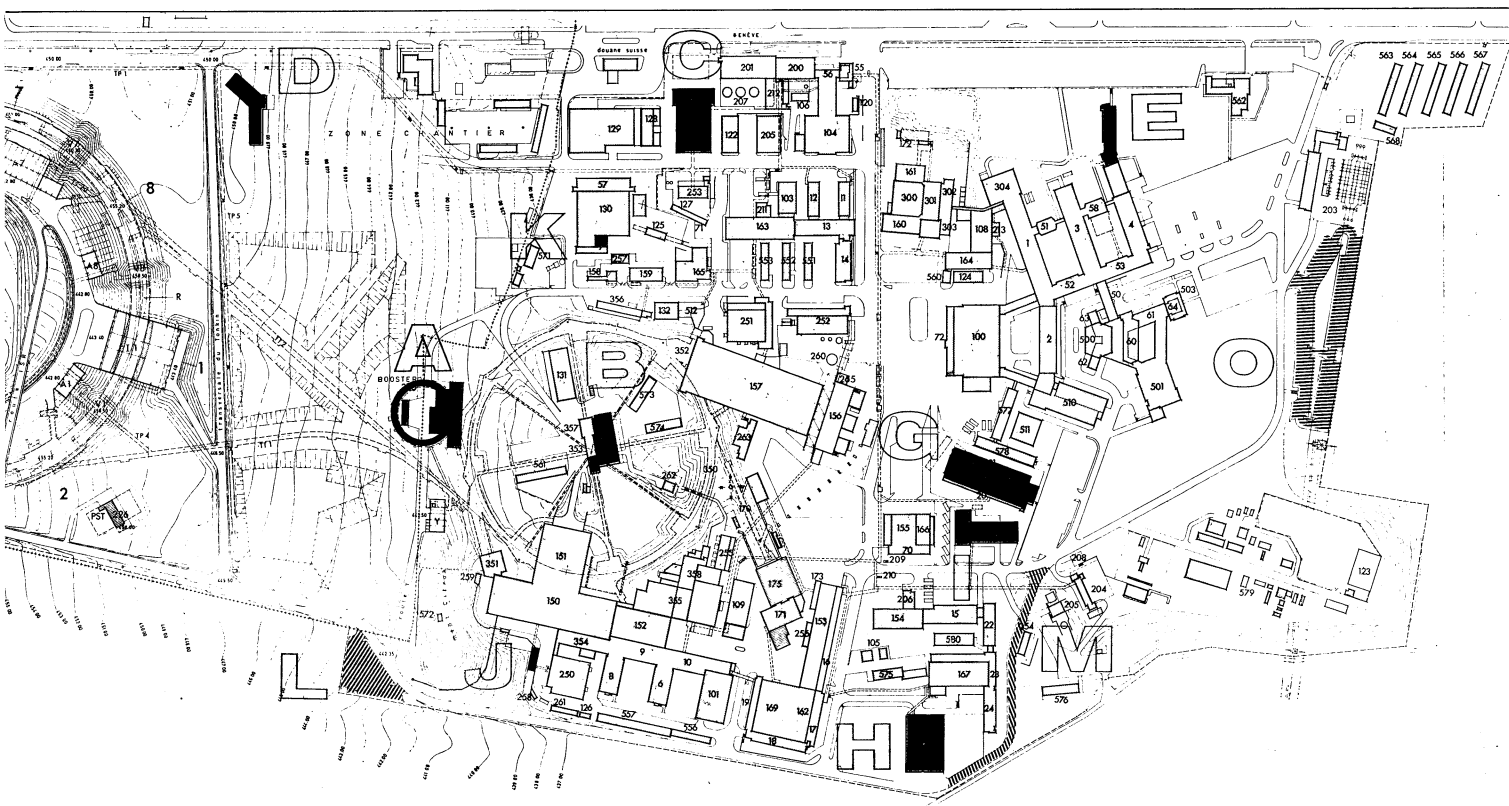
'Services' building on the ISR site

This is a new home for offices and sections of the SB Division including the Division administration, the Design and Projects Group, the Maintenance and Works Group (except for the maintenance workshops and the boiler-house) and the administra-

tion of the central workshops. It has three floors plus a basement and is constructed of prefabricated units so that further sections could easily be added later if other services are moved to this building.

Laboratory 5

This is an extension of Laboratory 4, having six floors and a basement. The sixth floor will contain twenty-nine individual bedrooms for those who have to spend a night at CERN on duty, or for certain visitors. It will thus be a kind of hostel. It will also be possible, if necessary, to convert the fifth floor, which will normally be divided into offices, into bedrooms. The floor of the ground floor will be removable to provide halls about 6 m high for the installation of computers if necessary. This building unfortunately takes away the area at present used as a football field but the footballers can console themselves with the thought that his field, which was in fairly bad condition and not of standard size, will be replaced by a better one on the ISR site.



Buildings under construction by SB Division

NAME	REF. ON PLAN	BUILDING NUMBER	CONSTRUCTION DATES	CLIENT DIVISION	AREA COVERED	STAFF HOUSED	MAIN CONTRACTORS
New stores Hall and offices	C	73-119	1967 - 1968	FIN	2400 m ²	50	S.A.C. DEXION Ltd MUNCK (crane)
Hall 168 Hall + 2 office wings	G	20-21-168	1967 - 1968	NP	2800 m ²	100 à 125	S.A.C. MULLER HAUSMANN
GODET workshop	I	102	1967 - 1968	SB	350 m ²	18	S.A.C.
Hall 174	H	174	1968	PS-SI	1450 m ²	70	S.A.C. MULLER DURISOL
Booster tunnel Auxiliary buildings	A	360 361	1968 - 1969 1969 - 1970	SI	~ 4 000 m ²	— —	S.A.C. MULLER VIAT (excavation)
Labo 5	E	5	1968 - 1969	PE-FIN-DI	3000 m ²	150 à 200	S.A.C.
Services building	D	54	1968 - 1969	SB	3400 m ²	180	S.A.C.
Central building (r.f. hall)	B	359	1969	PS	700 m ²	35	S.A.C. MULLER
South Hall convertors	J	264	1968	PS	100 m ²	—	S.A.C. - MULLER
Safety Group	K	7	1968 - 1969	DI-SY	100 m ²	10	S.A.C. - MULLER
BEBC: Hall E 2 Services building Assembly workshop Bubble chamber hall Compressor hall	F	190 AM 110 L 36 191 276-277	1968 - 1969 1968 - 1969 1968 - 1969 1969 1969	TC TC TC TC TC	1000 m ² 1800 m ² 450 m ² 1200 m ² 1500 m ²	20 100 25 — —	S.A.C. - MULLER S.A.C. S.A.C. - MULLER DURISOL

Cutting through the concrete wall of the proton synchrotron tunnel to make the aperture for connecting the booster.

Assembly at Saclay of the superconducting coils for the polarized proton target used in an experiment at CERN. This superconducting magnet is one of the biggest in operation in the world. The central large aperture, which can be seen, is that through which the target is inserted. The struts between the coils have to withstand an attractive force of about 20 tons when the coils are powered. When in operation the coils stand vertical (turned through 90° with respect to their position in the photograph). (Photo Saclay)

Large European Bubble Chamber complex

This consists of an area of 6 000 m² which will house the 3.7 m European bubble chamber and its auxiliary equipment. The foundations, on piles, are complete, and work on the main building has begun. Anchoring the slab which will take the forces caused by the movement of the expansion system, whose mass (1000 kg) will be subjected to accelerations of up to 200 g, has presented special problems.

Hall 168

The total floor area of this building, 2 800 m², is divided into 1 200 m² for the hall proper and 1 600 m² for offices. It will be used mainly by the Nuclear Physics Division. A point of interest is that the hall, which is an extension to the East experimental hall, could, if required, be used for experiments supplied by an extension of the beams from the PS.

Hall 174

This hall will be used by groups of the MPS Division for work on the booster equipment, Gargamelle, equipment for

Serpukhov, etc. Its construction has involved the disappearance of a 600 m² car park.

Extension to the Surface Treatment Workshop

Here, areas to house the serial-changer radiography installations and those for the manufacture of printed circuits and also a chemical laboratory are being built. They need to be fitted with a special ventilation system. It is known as the 'Godet workshop'.

Other work

This includes smaller-scale operations, like the construction of a hall to house the rectifiers supplying the South hall of the PS (at J on the plan) and of a building serving as an experimental hall for the General Safety Group (at K on the plan). Moreover, three car parks are projected: one at 'Mont Citron' (O on the plan), providing space for about seventy vehicles, which is due to be finished in the autumn of 1968; one under the high-voltage line (L on the plan), due to be finished at the end of 1968, which will provide space

for about 208 vehicles; and the SC car park with some 95 spaces, which is due for completion in the spring of 1969.

Finally, the construction of a road (M on the plan) will provide more direct access to the ISR site from the CERN entrance, and work is scheduled to start on it at the end of 1968.

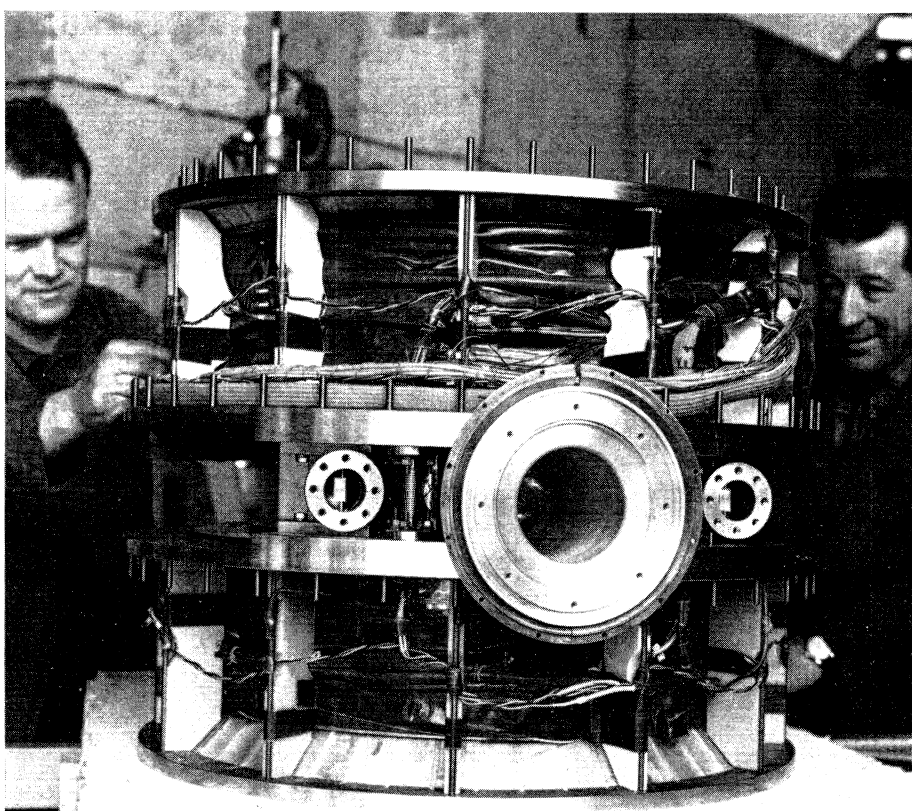
Saclay polarization experiment

In the experimental programme of the proton synchrotron prior to the shut down, three experiments, (briefly described in vol. 7, page 65 and vol. 8, page 73) were studying pion-proton scattering using polarized proton targets (see vol. 7, page 28).

Two of these experiments, numbered S48 (now completed) and S59, involved the measurement of the probability of interaction (the differential cross-section) with the protons polarized perpendicular to the plane of scattering. The third, S54, consisted of measuring the polarization parameters with the protons polarized within the plane of scattering. It was carried out



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by a Saclay team and required more complex equipment because

- it involved two successive scatterings: primary pions on the polarized target and recoil protons on a carbon target;
- superconducting coils had to be used to create the magnetic field for the polarized target;
- it required fast electronic circuits of modern design, developed two years ago, with a response time less than 130 ns.

The last two features are worth describing. In order to detect the scattering in the plane containing the polarization vector, the magnet surrounding the target had to allow particles to pass freely not only in the usual air-gap perpendicular to the magnetic field but also in directions close to the axis of the field. Ironless coils satisfy this condition, but, to reduce their bulk, they have to be wound with superconducting wire carrying a very high current density. These coils, operating at liquid helium temperature (4°K), were designed and constructed by the Magnet and Cryogenics Groups at Saclay and are the biggest in operation in Europe with the exception of the BRARACOURCIX test assembly (see vol. 8, page 23). They generate a field of 25 kG within a volume large enough to contain a 6.5 cm long target.

The electronic system had to distinguish the events to be studied, the scattering of primary pions on the polarized protons in the target, from the background arising from the scattering of primary pions on unpolarized protons. In fact, the LMN crystal forming the target contains only about 6% polarizable free protons, and the probability of the incoming pion striking an unpolarized proton is about seven times greater. Some background can be eliminated by rejecting events in which the incoming pion, the recoil proton and the emergent pion are not co-planar; this involves finding the exact geometrical configuration of each event. Banks of scintillation counters were used to detect the paths of the three particles and signals from the counters were fed into a logic circuit consisting of fast coincidence matrices in the form of integrated circuits. Only those events which satisfied the

required geometrical conditions could trigger the high voltage pulse to the wire chambers positioned in the path of the recoil protons. The time limit of 130 ns for the electronics is dictated by the very brief period, (less than 400 ns) which is available between the moment when the scintillation counters detect the particles and that when the wire chambers no longer give sparks in the wake of the charged particles. (The ionisation produced by the charged particles in the chambers persists for only 400 ns.) The remaining 270 ns are needed to pass signals along wires, for the response time of the pulsed power supplies and so on.

The whole of the equipment has been operational since March, 1968. It has recorded several hundred thousand events using negative pions of momentum 6 GeV/c to measure the polarization parameter 'A'. Work is currently in hand on the reconstruction of the tracks and on finding the asymmetry in the proton-carbon scattering. The analysis of this first measurement will probably be completed before the end of the year.

The experiment will continue during 1969, first measuring the polarization parameter R with the same momentum pion beam, before moving to higher energy to repeat the measurements.

'Measurements of the parameters A and R in pion-proton scattering between 5 - 18 GeV/c'
B. Amblard, P. Autones, R. Beurtey, G. Cozzika, J. Deregél, Y. Ducros, J.M. Fontaine, M. Hansroul, A. Lesquen, J.P. Merlo, G. Movchet, J. Rieubland, T.C. Raoul, L. Van Rossum.

USAEC Citation

On 10 June, the United States Atomic Energy Commission presented a 'Special Recognition Citation' for 'the outstanding scientific contribution to the development of nuclear energy' made by the team of Frederic Joliot, Hans Halban, Lew Kowarski and Francis Perrin.

The citation reads 'The experimental research performed by this team in 1939 and 1940, as well as theoretical considerations put forward by Francis Perrin, played a major role in early research on nuclear fission. Their discoveries concerning neutron emission in the fission process and their determination of critical cross-sections of nuclear fuels and mo-

derators served to help establish the possibility of a self-sustaining chain reaction. Their dedication to their task in the face of war-time adversity resulted in the successful conduct of an important experiment at Cambridge, England in 1940 which provided experimental evidence that a homogeneous heavy-water uranium oxide mixture would support a chain reaction.

The contribution made by this group of devoted French scientists towards the early development of nuclear reactors, capable of producing fissionable materials and useful energy deserves the highest praise'.

Two of the group have been intimately involved in CERN since its creation. Professor Kowarski was one of the first members of the team which did the preliminary planning from 1952 before the Organization came formally into being and has worked for CERN ever since. (A fuller story of his life can be found in CERN COURIER vol. 7, page 11.) Professor Perrin has been one of the French delegates to the CERN Council from its very beginning.



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