RUTHERFORD LABORATORY

Science Research Council

50 MeV Proton Linear Accelerator

NORMAL MAXIMUM BEAM CONDITIONS

Mean Beam Current	4 μA
Extract Pulse Length	200 μsec) 600 μsec
Repetition Rate	50 c/sec.) 25 c/sec
Energy	10, 30 and 50 MeV
Energy Resolution	200 KeV

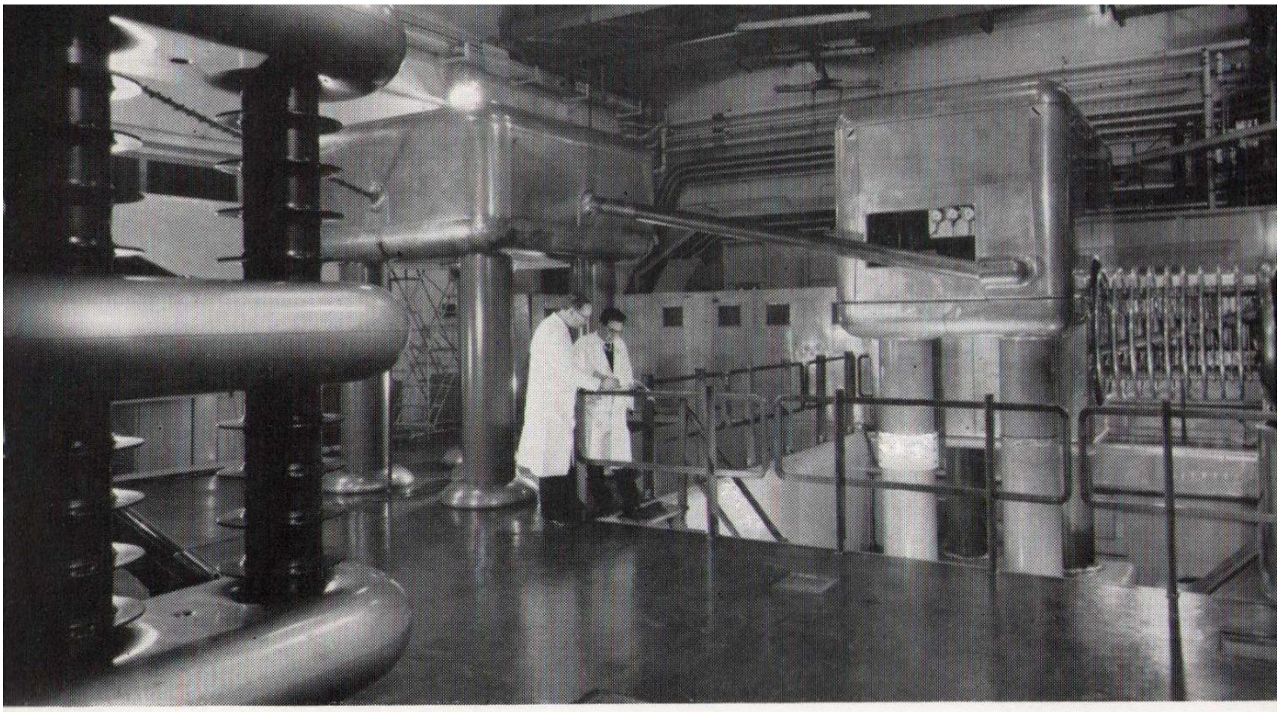
POLARIZED BEAM CONDITIONS

Mean Beam Current	10^9 protons/sec
Beam Polarization	50%

$n = \frac{1}{2}$ DOUBLE FOCUSING SPECTROMETER

Mean Particle Radius	40 inch
Scattering Angle Range	0° to 152°
Angular Resolution	2′ arc
Energy Resolution	80 KeV at 50 MeV 50 KeV at 30 MeV (mostly Beam Transport Resolution)

The machine is scheduled for over 6,000 hours of operation each year and achieved in 1966, for example, 5,600 hours of experimental running-time with the beam on target.

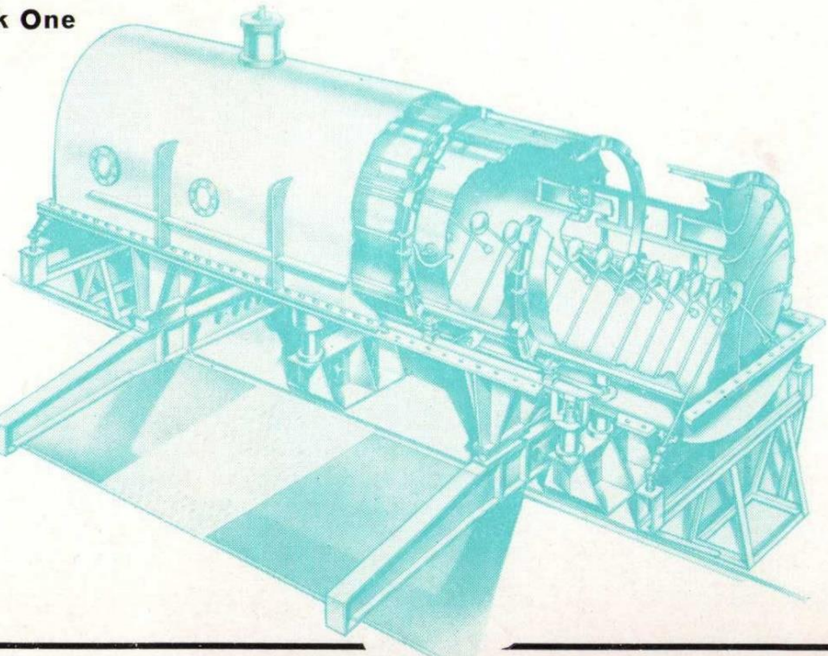


The earliest of the accelerators at the Rutherford Laboratory was the Proton Linear Accelerator which first operated in April 1960. This machine accelerates protons in a straight path unlike cyclotrons, synchrotrons, etc., which accelerate protons in circular orbits.

The protons are produced in a radio-frequency ion-source from which they are extracted and accelerated through the evacuated injector column to 0·5 MeV. They are then injected into the first of three evacuated tanks, having a total length of 100′. Each tank consists of a copper resonant cavity, excited at 200 Mc/s by pulsed R.F. power, which is enclosed in an outer cylindrical steel vacuum envelope pumped to maintain a pressure below 10^{-8} atmospheres, in order to prevent scattering of the proton beam and avoid voltage breakdown in the resonators. The injected 0·5 MeV protons are progressively increased in energy to 50 MeV by being accelerated by the R.F. field as they pass the gaps between hollow cylindrical electrodes spaced at intervals down the axis of each resonant cavity.

From the end of tank 3 the proton beam is transported to either of two experimental areas along evacuated flight tubes, in which it is contained by focusing quadrupole magnetic lenses. In each area a large bending magnet (weighing about 30 tons) is used to deflect the beam along any one of a number of beam lines, on each of which a different nuclear physics experiment can be set up.

Tank One



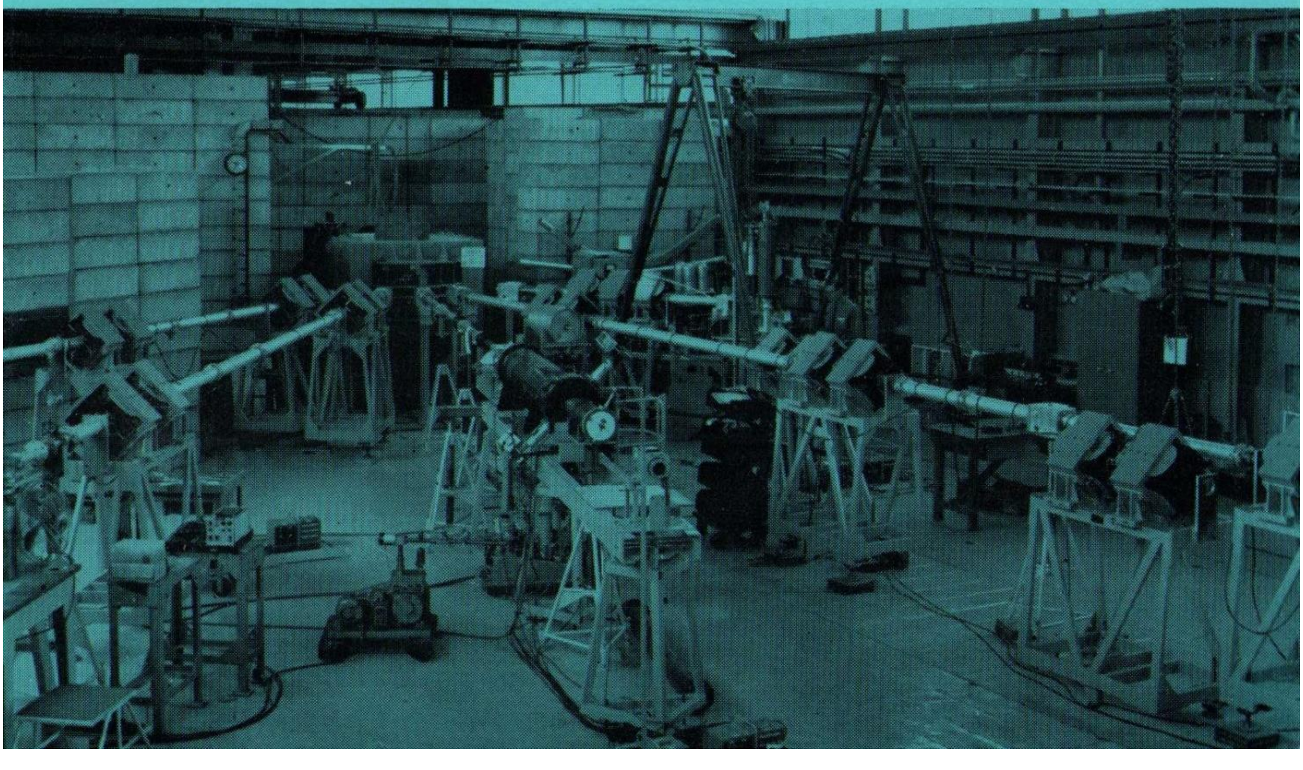
The P.L.A. 500 Kev Injector
(AJ 4135)

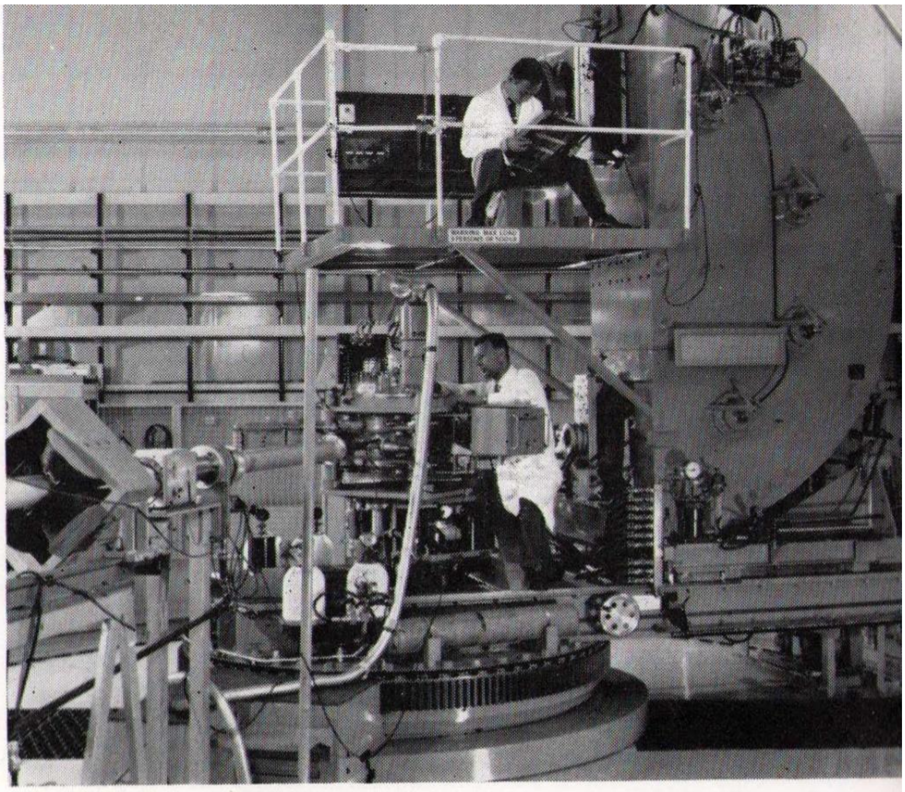
In full operation a mean proton current of 5 micro-amperes (3×10^{13} protons/sec), corresponding to a peak pulse current of 0·5 milliamperes has been exceeded and present development work will improve this figure. Careful attention has been paid to stabilization of mean energy, which remains accurately constant over long periods, an important factor in nuclear research.

The machine provides experimental facilities for physicists, from the Universities and the Science Research Council, to carry out experiments on nuclear structure and nuclear reactions. Further support is given, by the Rutherford Laboratory, in providing design, manufacture and installation of experimental equipment.

Many improvements have been made to the P.L.A. since its first operation, in particular a Polarized Proton Ion-source, a Double Focusing Spectrometer, and Time of Flight apparatus have been installed. The polarized proton ion source enables a beam of protons, in which the proton spin directions are selected to be predominantly in either the vertical, transverse, or longitudinal direction, in contrast to an unpolarized beam in which the proton spins are randomly oriented. Time of flight apparatus enables very accurate energy measurements to be made of neutron spectra from a wide range of elements bombarded by protons. By radio-frequency deflection of the proton beam before the first accelerating tank of the P.L.A., bursts of protons less than 1 nsec wide (10^{-9} seconds) and spaced by 180 or 360 nsec can be obtained at the target. Flight paths of 10 or 6 metres can be used and measurements made at angles between 0° and 85° in 5° steps with an overall time resolution of better than 1·5 nsec. Another precise device used to measure the energies of charged particles is the Double Focusing Spectrometer.

Experimental Area showing Bending Magnet and Beam Lines (HL 11963)

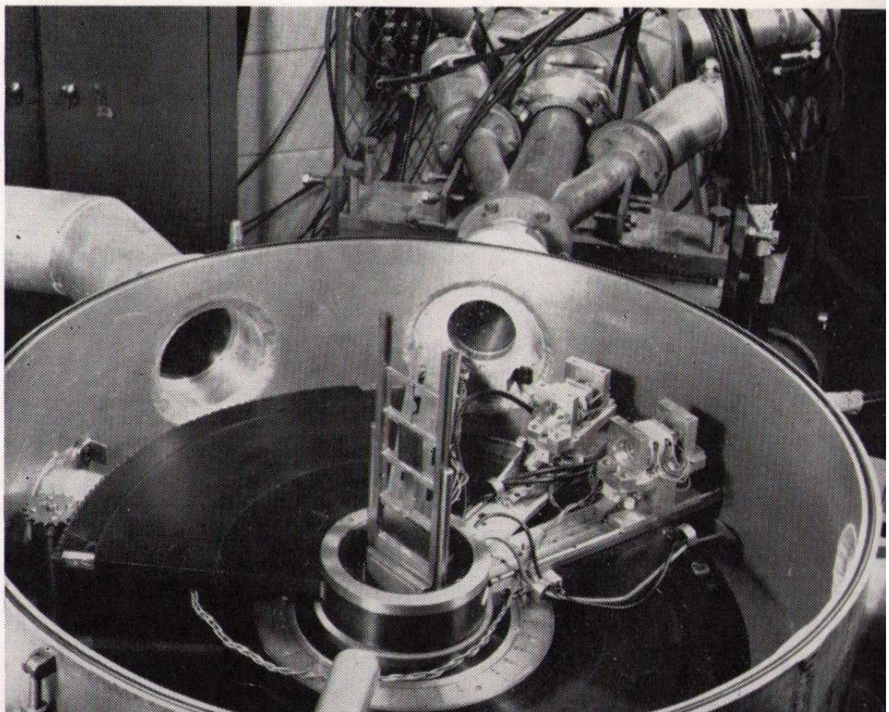


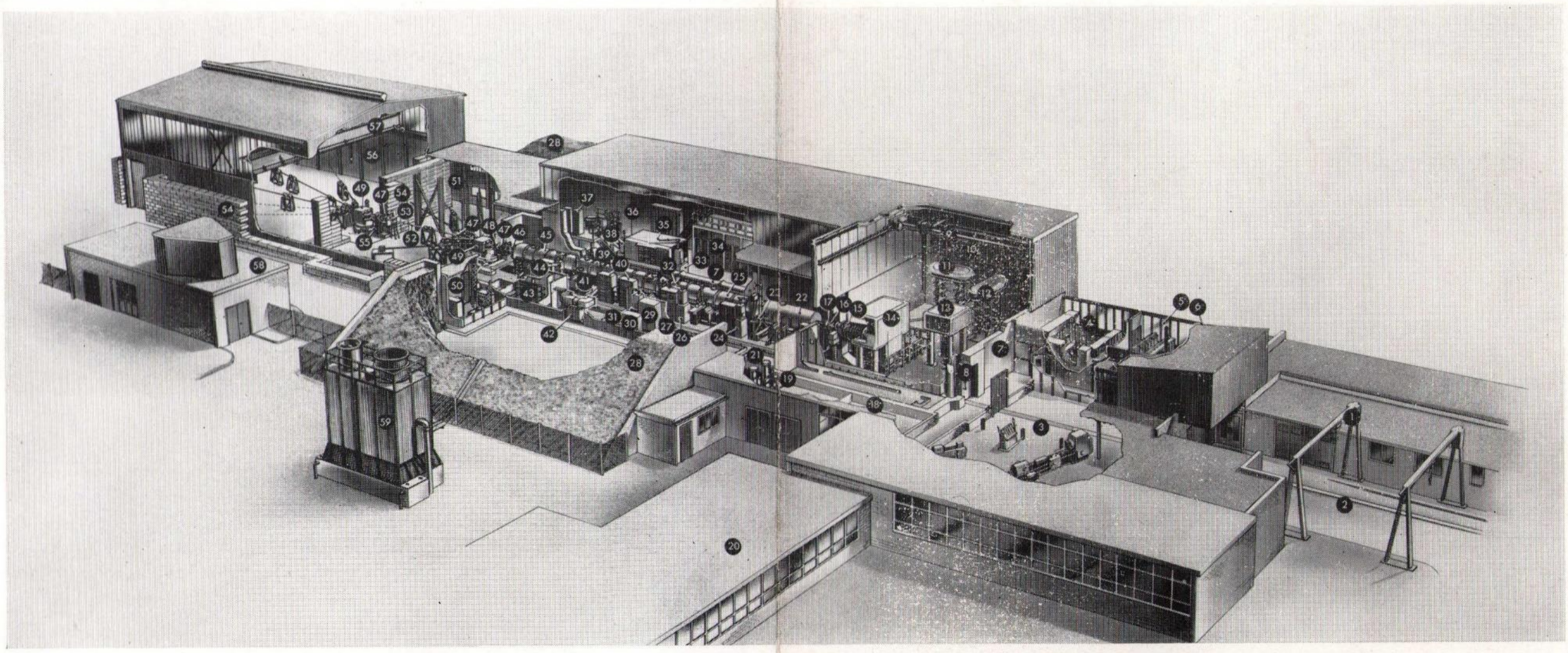


Double Focusing Spectrometer (AJ 4138)

A higher energy resolution is obtained in the beam incident upon the target, than that given by the P.L.A., by the use of a combination of slit-apertures and a bending magnet to select a range of energies. Many detector and particle identification systems have been used consisting of solid-state counters, scintillation counters, and acoustic spark chambers. This spectrometer has proved very valuable and is now used for nearly half of the available machine time by several teams of experimenters.

A Typical Scattering Chamber showing Targets and Detectors (HL 4936)





50 MeV Proton Linear Accelerator

KEY

1. Unloading gantry
2. Railway
3. Workshop
4. Control room
5. Counting room No. 1
6. Counting room No. 2
7. Concrete shielding wall
8. Concrete doors
9. $1\frac{1}{2}$ ton crane
10. Injector room
11. Cockcroft-Walton high voltage generator
12. Filter stack
13. Ion source power supply platform
14. Polarised proton source bun
15. Injector column
16. Beam deflecting electrodes (T.O.F.)
17. Buncher
18. Laboratory workshop
19. Water softening plant room
20. Crew room
21. Modulator cubicles
22. Tank 1
23. Tank R.F. feed line
24. Valve A cubicle (Tank 1 main R.F. amplifier)
25. Tank 2
26. Valve C cubicle (Tank 2 main R.F. amplifier)
27. R.F. drive
28. Earth bank shielding
29. Valve B cubicle (High power R.F. drive amplifier)
30. Foster regulator
31. R.F. power dividing network
32. R.F. power combining bridge
33. Valve E (Tank 3 main R.F. amplifier)
34. Power supplies for beam transport system
35. Tank 3 R.F. amplifier cubicle for valves E and F
36. Auxiliary plant room
37. Bending magnet supply stabiliser
38. Valve F (Tank 3 main R.F. amplifier)
39. Generator supplying bending magnet
40. Local control racks
41. Vacuum pumping unit
42. Modulating cooling refrigerator
43. Pulse forming network
44. Valve D cubicle (Tank 2 main R.F. amplifier
45. Tank 3
46. Beam monitor
47. Beam focussing quadrupoles
48. High speed shut-off valve and vacuum pump
49. Beam bending magnet
50. Modulator E.H.T. supply transformer
51. Experimental area No. 1
52. Beam transport pipes
53. Beam stop
54. Concrete block wall
55. Vacuum pumping unit
56. Experimental area No. 2
57. 10 ton crane
58. Pump house
59. Cooling towers

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