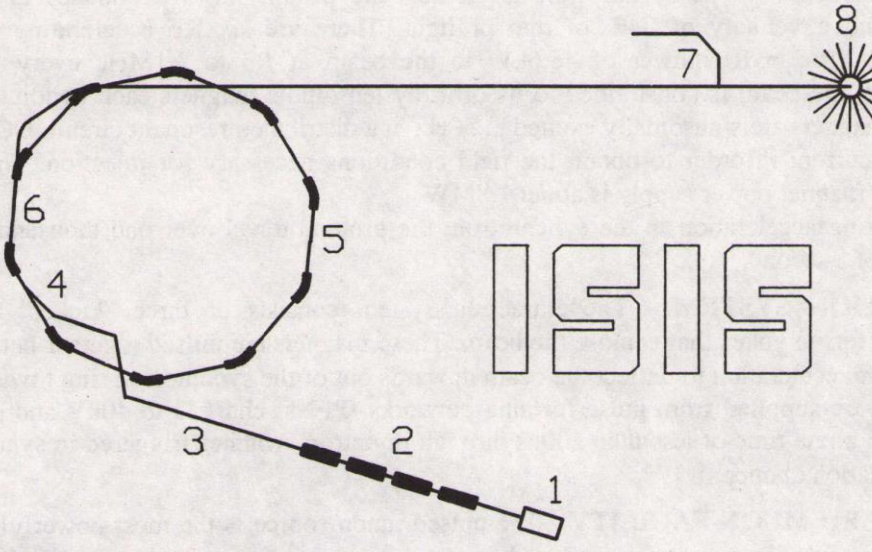
RAL
DESIGN & DISCOVERY
Open Days July 1990
RUTHERFORD APPLETON LABORATORY
SCIENCE AND ENGINEERING RESEARCH COUNCIL

ISIS - SPALLATION NEUTRON SOURCE

ISIS is the world's most intense pulsed neutron source. It consists of a 70MeV H^- linac, an 800MeV proton synchrotron, a target station producing bursts of fast neutrons by spallation and fission in a Uranium target and an array of moderators producing a variety of slow neutron energy spectra and pulse shapes. It supports a group of neutron scattering instruments covering a wide range of scientific fields in the study of condensed matter and a comprehensive system for data collection and reduction. The outline drawing shows the principal components of the Spallation Neutron Source.



1. **ION SOURCE AND PRE-INJECTOR** - The protons begin their journey towards the target as the nuclei of negatively charged Hydrogen ions (H^-). These are produced in a Penning type ion source by bombarding a Caesium coated surface with positive and neutral ions from a Hydrogen discharge. The H^- current required for full output is 40mA at a duty cycle of 2½% (50Hz X 500µs).

   The ion source platform is maintained at -665kV with respect to ground by a five stage Cockcroft-Walton multiplier. This potential difference accelerates the H^- ions towards the entrance of the Linear Accelerator (LINAC), where they will have attained a kinetic energy of 665keV and a velocity of about 4% of that of light.

2. **THE LINEAR ACCELERATOR** - The LINAC accelerates the H^- ion beam to an energy of 70MeV and a velocity of 37% of that of light. It consists of four evacuated "Alvarez" accelerating cavities, each fed with pulsed RF power of up to 2.5MW at 202.5MHz from a large triode valve. Drift tubes along the axes of the cavities are spaced so that the axial RF fields, seen by the ions in the gaps between the drift tubes, are always in phase so providing the accelerating force.

   Beam focusing is provided by quadrupole magnets incorporated into the drift tubes.

3. **BEAM TRANSPORT** - The 70MeV H^- ion beam from the LINAC injector is transported to the Synchrotron ring through a 47m long evacuated beam line. This line incorporates three horizontal and two vertical dipole bending magnets, 22 quadrupole focusing magnets, an RF debuncher cavity to reduce the beam energy spread and a number of diagnostic sensors to measure the intensity, position and profile of the beam.

4. **BEAM INJECTION** - The beam is steered into the inside of the synchrotron ring by a series of magnets. At a position where the H^- beam path is tangential to the orbit of the protons circulating in the ring, it is passed through a very thin Aluminium Oxide foil which strips off the two electrons from most (98%) of the H^- ions to leave a beam of protons. This "charge exchange" injection system which operates over about 250 revolutions of the proton beam provides a very efficient method of injecting into a synchrotron and enables ISIS to achieve its very high value of operating beam current.

   The foils are made at the laboratory. They are only 0.3 microns thick and are produced by dissolving away the Aluminium from a sheet of anodised Aluminium, to leave just the thin Aluminium Oxide film.

5. **SYNCHROTRON** - The synchrotron accelerates the protons in two bunches to an energy of 800MeV and a velocity of 84% of that of light. There are six RF accelerating cavities, each transferring a mean RF power of 48.6kW to the beam at 1.3 to 3.1MHz every 20ms. During acceleration, the beam is constrained to its orbit by ten dipole magnets each bending the beam by 36°. The magnets are sinusoidally excited at 50Hz in a distributed resonant circuit. DC bias is added to the AC current in order to obtain the field conditions necessary for injection. The total power input to the magnet power supply is about 1.8MW.

   During acceleration in the synchrotron, the protons travel over one thousand miles in one hundredth of a second.

6. **EXTRACTION SYSTEM** - The extraction system consists of three "kicker" magnets with rectangular ferrite yokes that enclose the beam. These magnets are pulsed together between bunches at the end of acceleration to deflect the beam upwards out of the synchrotron ring towards the target. The pulses are supplied from pulse forming networks (PFNs) charged to 40kV and discharging at 5000A with a rise time of less than 200ns through thyratron switches triggered in synchronism with the target station chopper.

7. **THE PULSED MUON FACILITY** - The pulsed muon source is the most powerful facility of its type in the world. The muons are produced from a thin graphite target in the proton beam. Muons are directed to the experimental apparatus by a beam line incorporating steering magnets and quadrupole focusing magnets.

   The facility is used by a worldwide community of scientists who use muons to probe the properties of solid state materials using the Muon Spin Resonance (μSR) technique. It is used also to investigate the catalysis of nuclear fusion and the properties of fundamental particles.

8. **TARGET STATION** - The proton beam is directed into a heavy-water cooled depleted Uranium target where fast neutrons, about 25 for each incident proton, are produced by both spallation and fission. At full intensity, these processes generate about 0.25MW of heat in the target. The fast neutrons escaping from the target are slowed down to the thermal energies required for the experiments by an assembly of four moderators and a reflector.

   A massive (5000 tonne) iron and concrete shield surrounds the target. Eighteen neutron beam holes are provided through the shield, each equipped with a 22 tonne iron and concrete shutter to open and close the beam line.

   Maintenance and replacement of the highly radioactive target, and the moderator and reflector components, are performed in a Remote Handling Cell incorporated in the Target Station.