Introduction to the ISIS Accelerator and Targets

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Three kinds of ‘traditional’ elementary particle:
- Electrons (in atom, ≈ eV)
- Protons (in (hydrogen) atom, ≈ eV)
- Neutrons (in nucleus, ≈ MeV)

Many more resources required for producing neutrons than electrons or protons
Neutron Source

www.particlezoo.net
ISIS Accelerators and Targets

- H⁻ ion source (17 kV)
- 665 kV H⁻ RFQ
- 70 MeV H⁻ linac
- 800 MeV proton synchrotron
- Extracted proton beam lines
- Targets
- Moderators

The accelerator produces a pulsed beam of 800 MeV (84% speed of light) protons at 50 Hz, average beam current is 230 µA (2.9×10¹³ ppp) therefore 184 kW on target (148 kW to TS-1 at 40 pps, 36 kW to TS-2 at 10 pps)
**H⁻ ion source**

- Hydrogen gas
- Arc, ≈ 50 A arc current
- Plasma
- Caesium to lower work function
- 50 mA of H⁻ ions in a 200 μs pulse at 50 Hz
RFQ Accelerator

- 35 kV DC accelerates H\(^-\) from ion source to 35 keV
- RFQ accelerates H\(^-\) from 35 keV to 665 keV
- Creates \(\approx 1\) ns long bunches of H\(^-\) at 202.5 MHz
- Compact, low external voltage structure
Linear Accelerator

- 4-section (-tank) drift tube linac
- Acceleration to 70 MeV by 202.5 MHz RF
- Each tank $\approx 10$ m long, $\approx 1$ m diameter.
- Hide particles inside drift tubes while sign of oscillating accelerating field wrong
Synchrotron

- Circular machine 70 – 800 MeV
- Magnets to bend particles round in circle
- RF electric fields to accelerate particles
- H⁻ ions stripped to protons when injected
- Fifty 10 ms acceleration cycles per second

Synchrotron because strength of magnetic field and frequency, amplitude and phase of RF all have to be synchronised.
• Kickers powered by PFNs 0-5,000 A in < 200 ns
• Extract septum runs at ≈ 9,000 A DC
• 800 MeV beam runs to target via EPB with DC magnets
• 1 in 5 pulse pairs sent to TS-2 by kicker and septum magnets
And Not Forgetting...

- Vacuum technology
- Beam diagnostics
- Controls
- Interlocks
• $\approx 2.3 \times 10^{13}$ (4 µC) ppp on to TS-1 tantalum coated tungsten target (40 pps)
• $\approx 15$–$20$ neutrons/proton, $\approx 4 \times 10^{14}$ neutrons/pulse
• Primary neutrons from spallation: evaporation spectrum ($E \approx 1$ MeV) + high energy tail

**TS-1 Target**
**Fig. 31:**
The target, reflector and moderator assembly (TRAM) (85RC2936).
• But want meV, not MeV
• Moderation - elastic nuclear scattering - low A
• Liquid hydrogen (20K), Methane (100K), Water (23°C)
• Solid tungsten cylinder, tantalum coated, heavy water surface cooled, 68 × 307 mm
1) Replace ISIS linac with a new ≈ 180 MeV linac (≈ 0.5MW)

2) Based on a ≈ 3.2 GeV synchrotron fed by bucket-to-bucket transfer from ISIS 800 MeV synchrotron (1MW, perhaps more)

3) Synchrotron design also accommodates multi-turn charge exchange injection to facilitate a further upgrade path where the synchrotron is fed directly from an 800 MeV linac (2 – 5 MW)