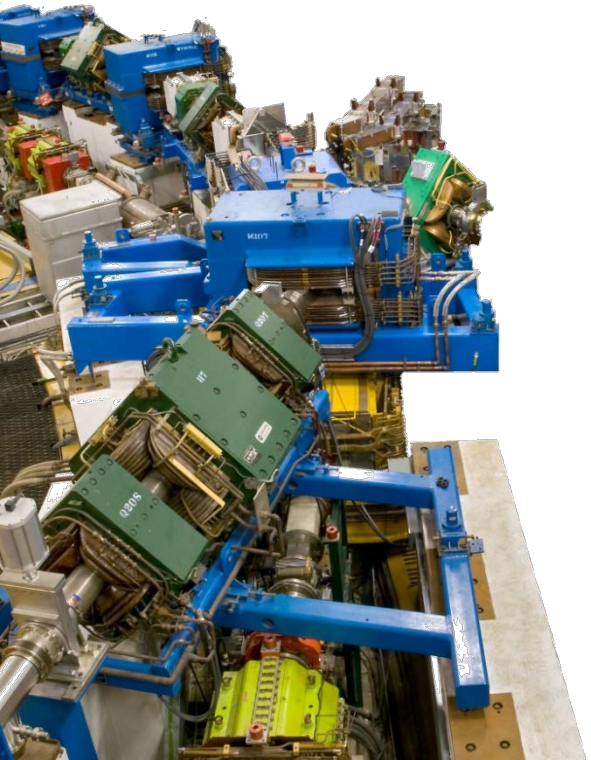
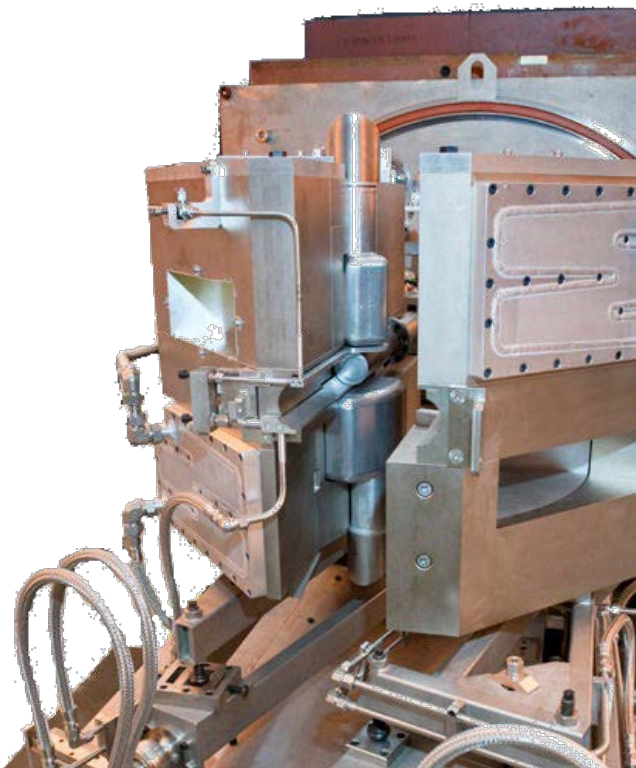
Introduction to the ISIS Accelerator and Targets



Rob Williamson

ISIS Accelerator Division



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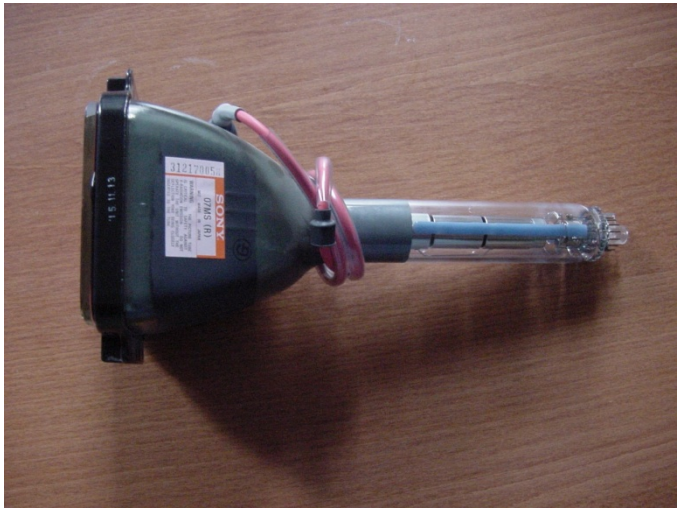
Three kinds of 'traditional' elementary particle:

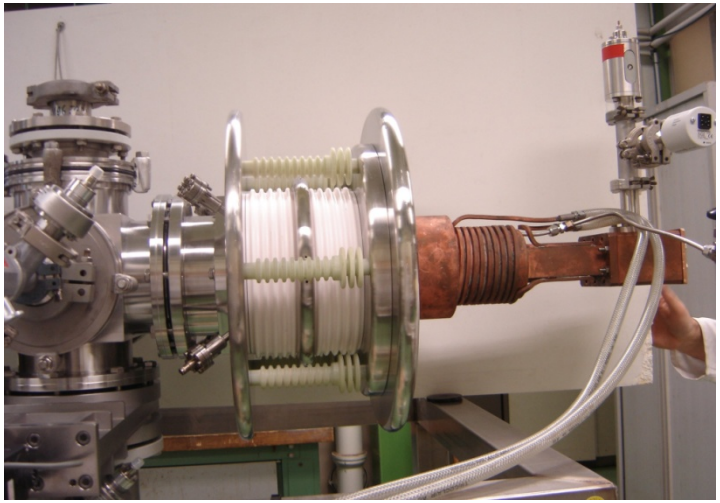
- **Electrons (in atom, ≈ eV)**
- **Protons (in (hydrogen) atom, ≈ eV)**
- **Neutrons (in nucleus, ≈ MeV)**

Many more resources required for producing neutrons than electrons or protons

Electron source



Proton source



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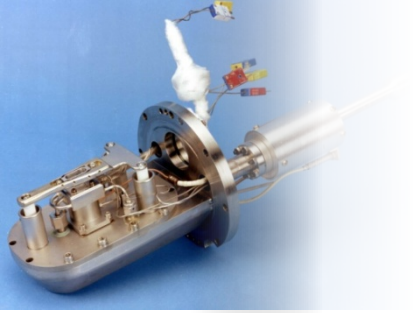
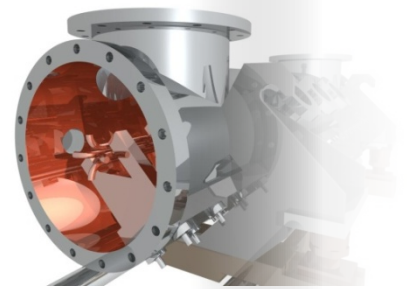
Neutron Source

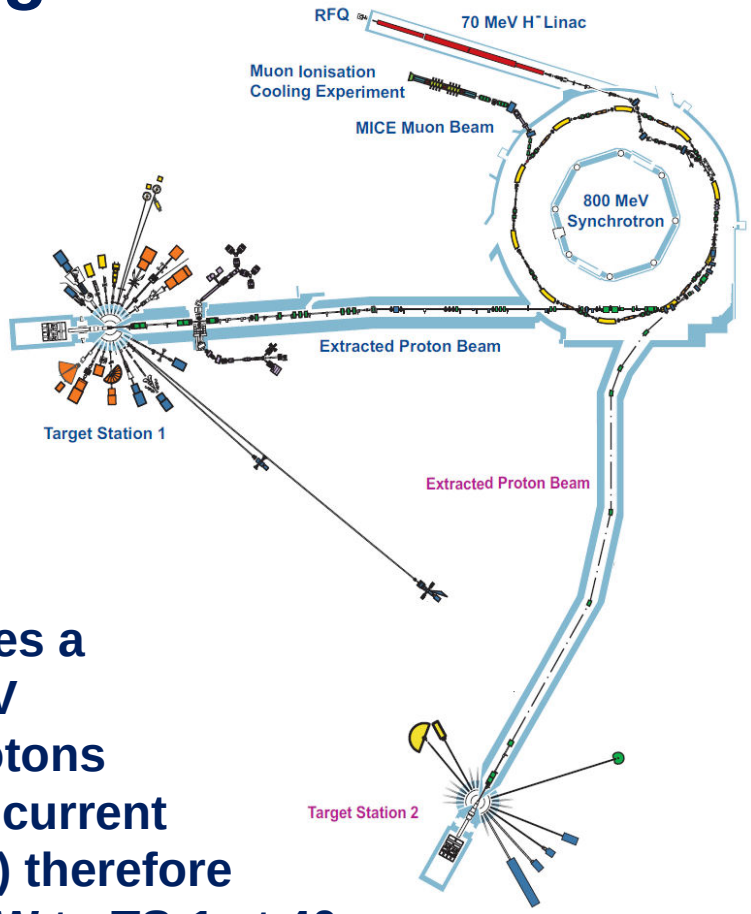
www.particlezoo.net





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× 10^{13} ppp) therefore 184 kW on target (148 kW to TS-1 at 40 pps, 36 kW to TS-2 at 10 pps)

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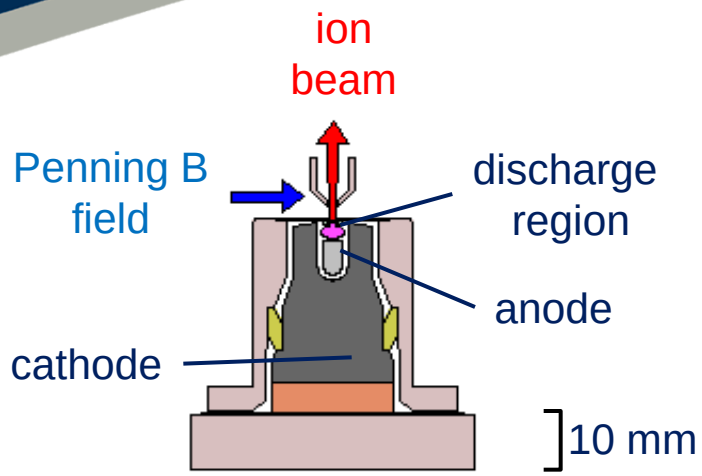
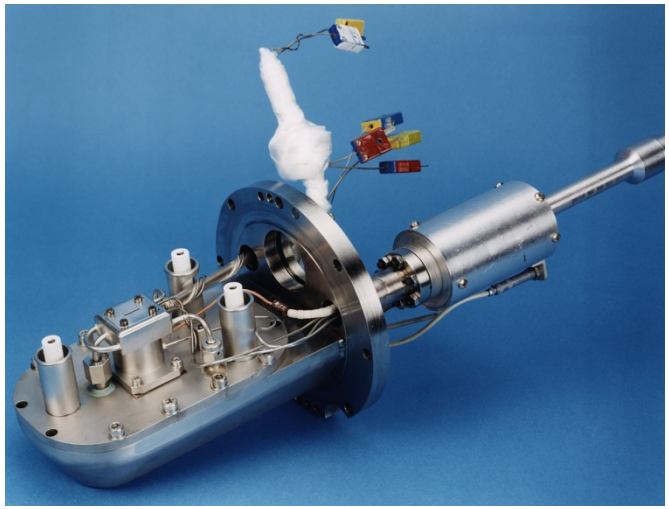
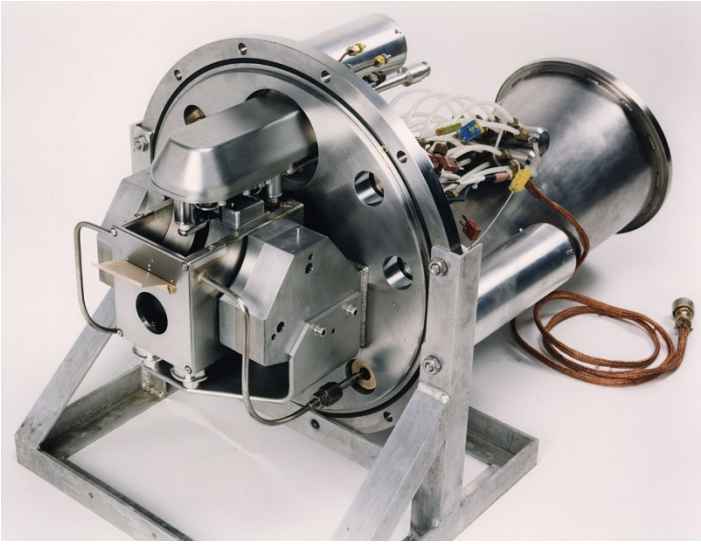
H^- ion source



- 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





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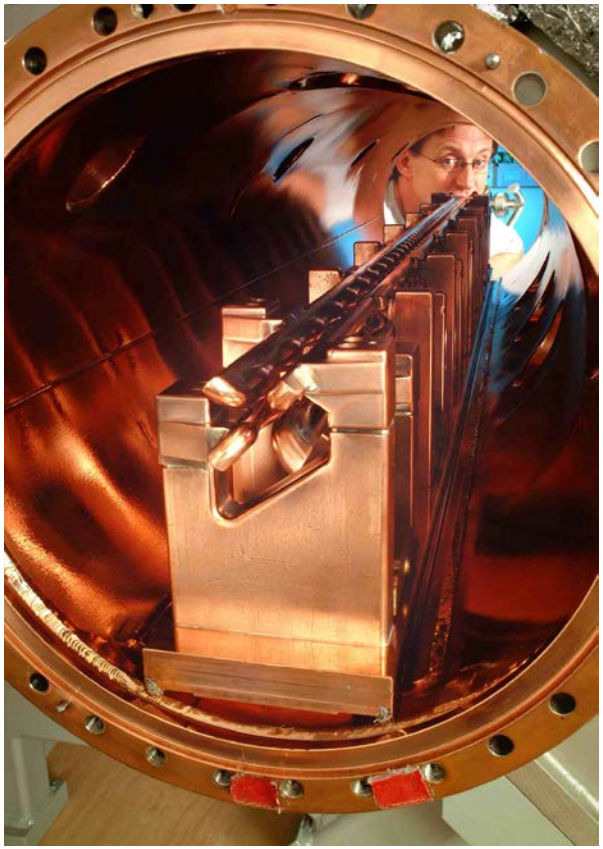
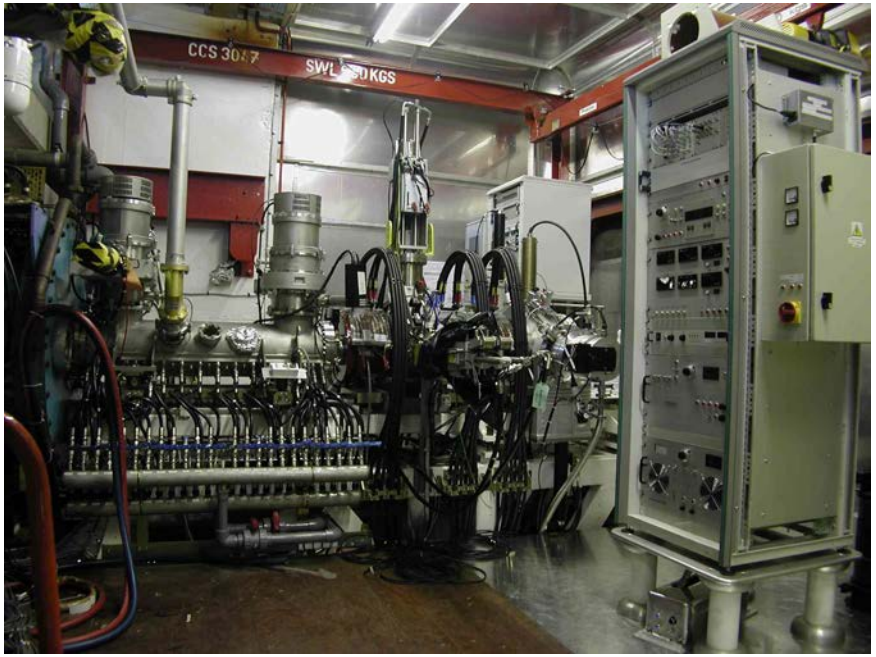
RFQ Accelerator

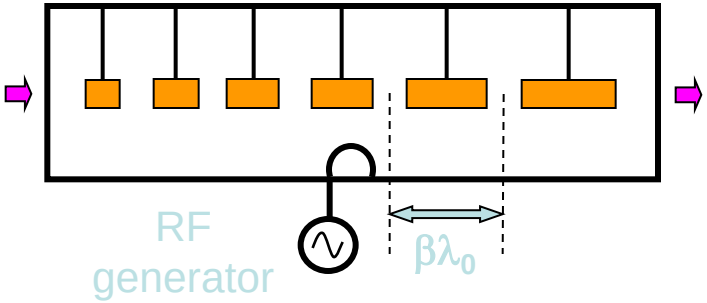




- 35 kV DC accelerates H^- from ion source to 35 keV
- RFQ accelerates H^- from 35 keV to 665 keV
- Creates ≈ 1 ns long bunches of H^- at 202.5 MHz
- Compact, low external voltage structure

Linear Accelerator

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



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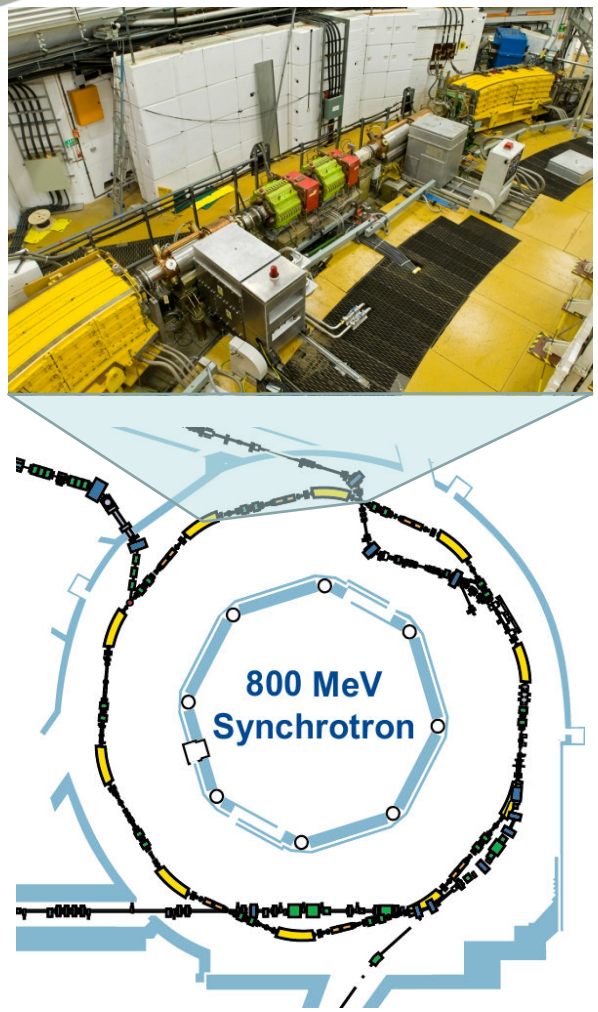
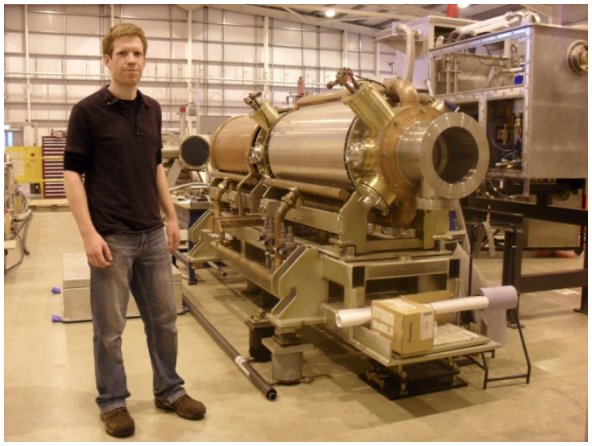
Synchrotron



- 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



Synchro*tron because strength of magnetic field and frequency, amplitude and phase of RF all have to be *synchronised.

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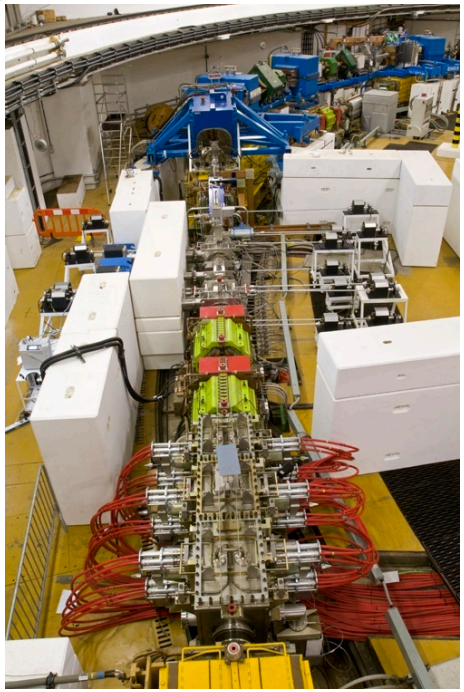
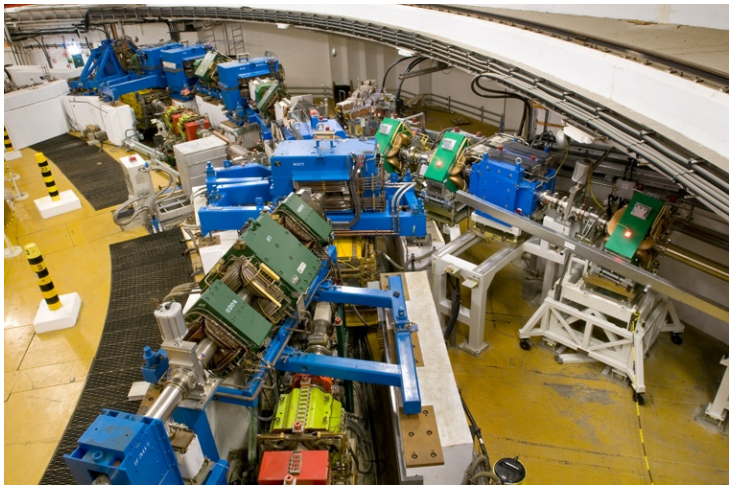
Extracted Proton Beamlines





- 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

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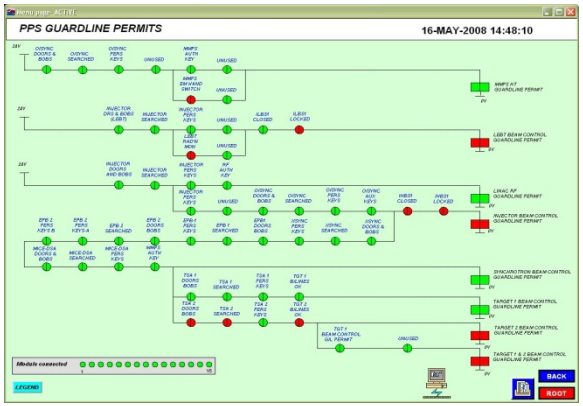
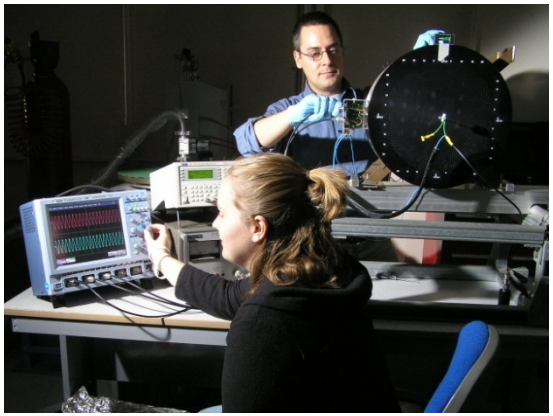
And Not Forgetting...

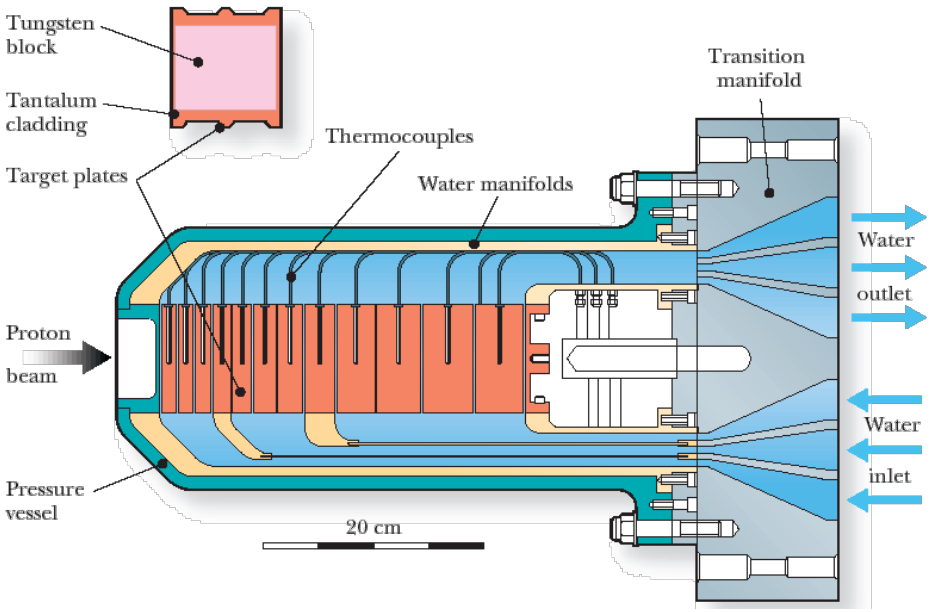


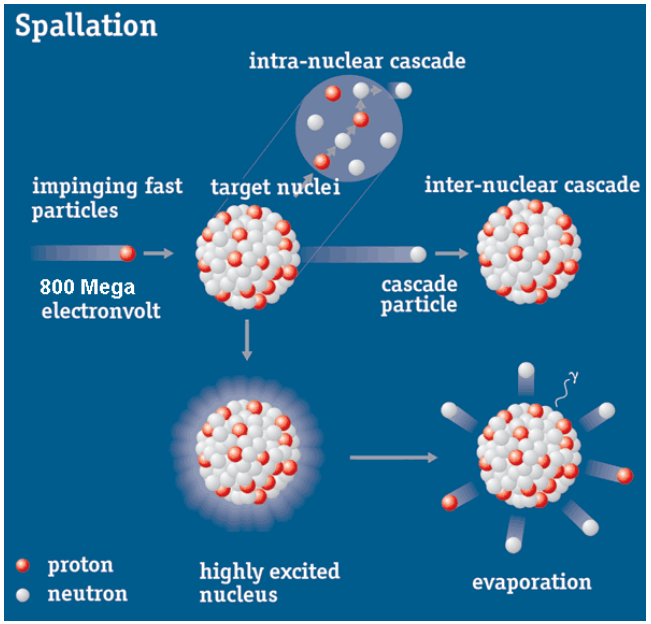
- Vacuum technology
- Beam diagnostics
- Controls
- Interlocks



TS-1 Target

- ≈ 2.3×10^{13} (4 μC) ppp on to TS-1 tantalum coated tungsten target (40 pps)
- ≈15–20 neutrons/proton, ≈ 4×10^{14} neutrons/pulse
- Primary neutrons from spallation: evaporation spectrum (E ≈ 1 MeV) + high energy tail





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Target Assembly

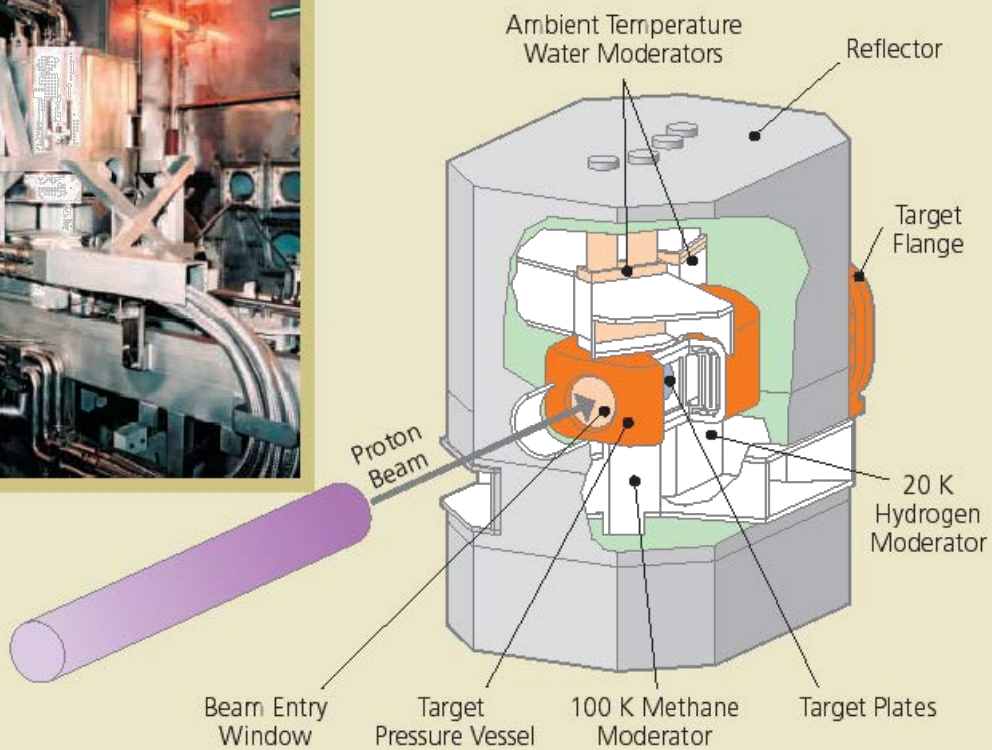
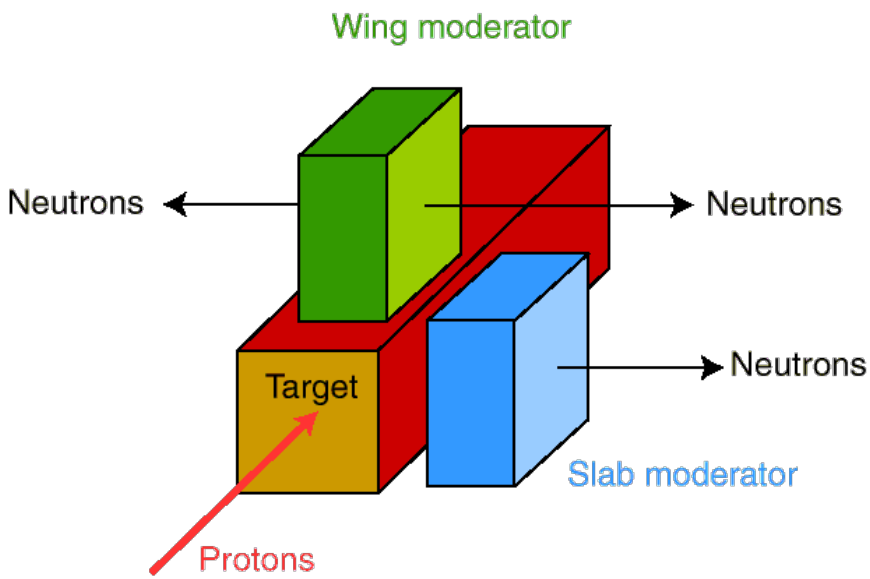
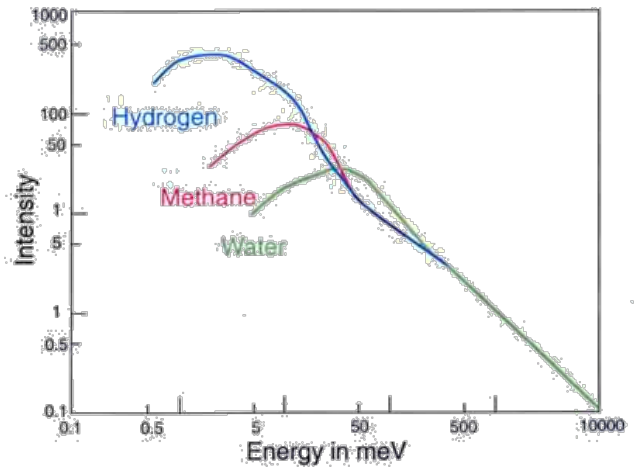


Fig. 31:
The target, reflector and moderator assembly (TRAM) (85RC2936).

Moderators

- But want meV, not MeV
- Moderation - elastic nuclear scattering - low A
- Liquid hydrogen (20K), Methane (100K), Water (23°C)





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TS-2 Target

- **Solid tungsten cylinder, tantalum coated, heavy water surface cooled, 68 × 307 mm**

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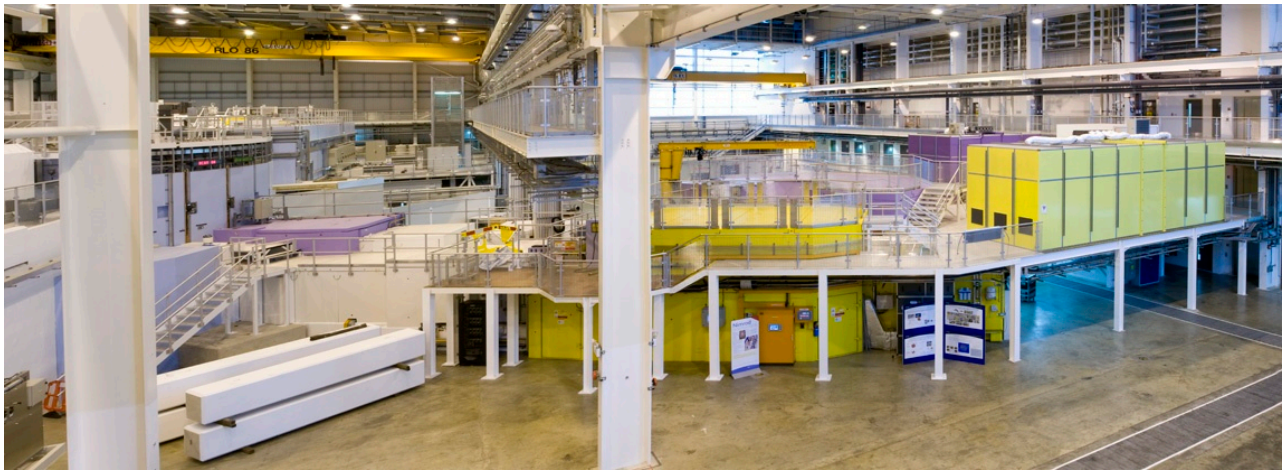
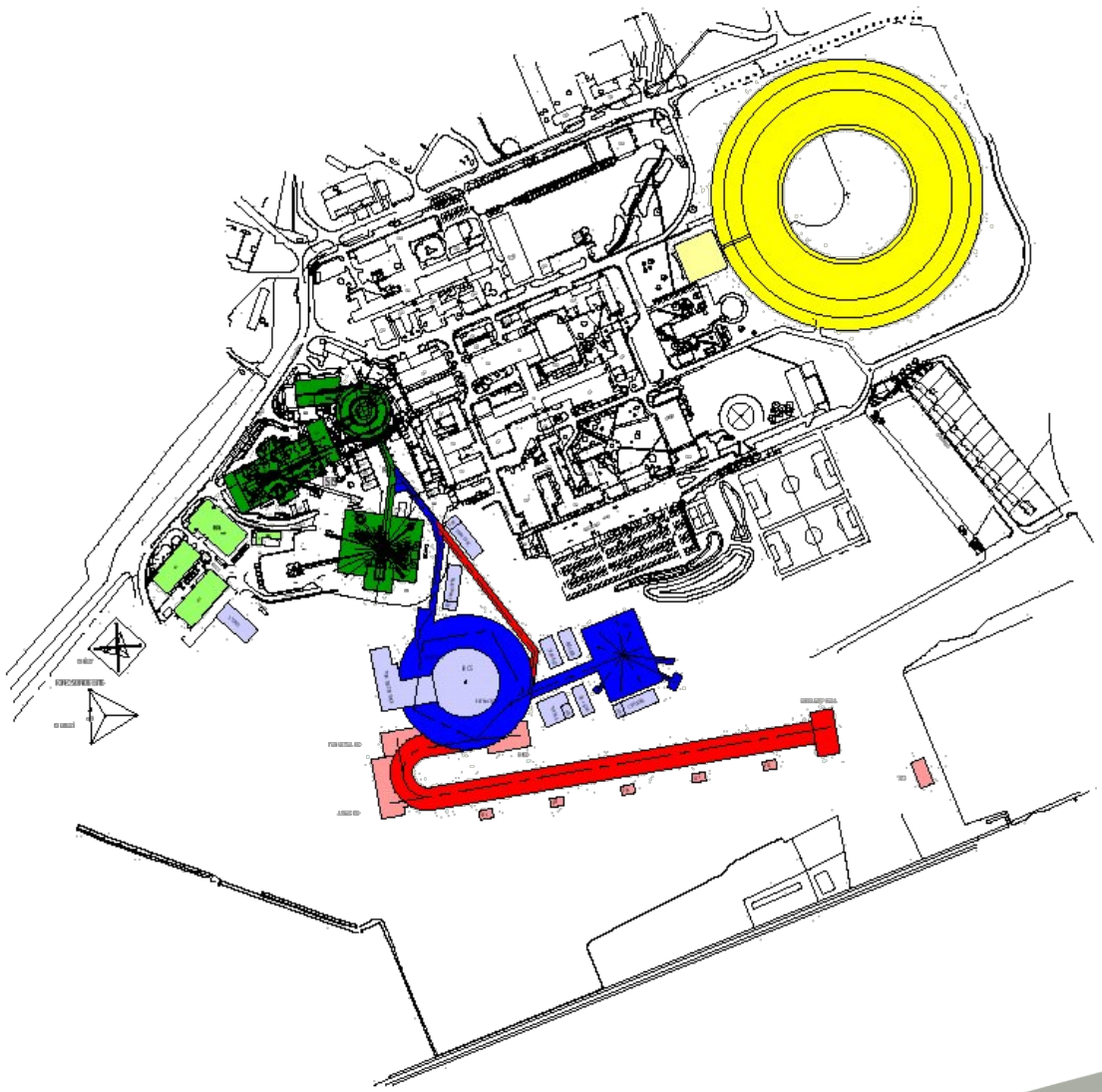


ISIS MW Upgrades



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)