Neutron Beams at Birmingham: HF-ADNeF

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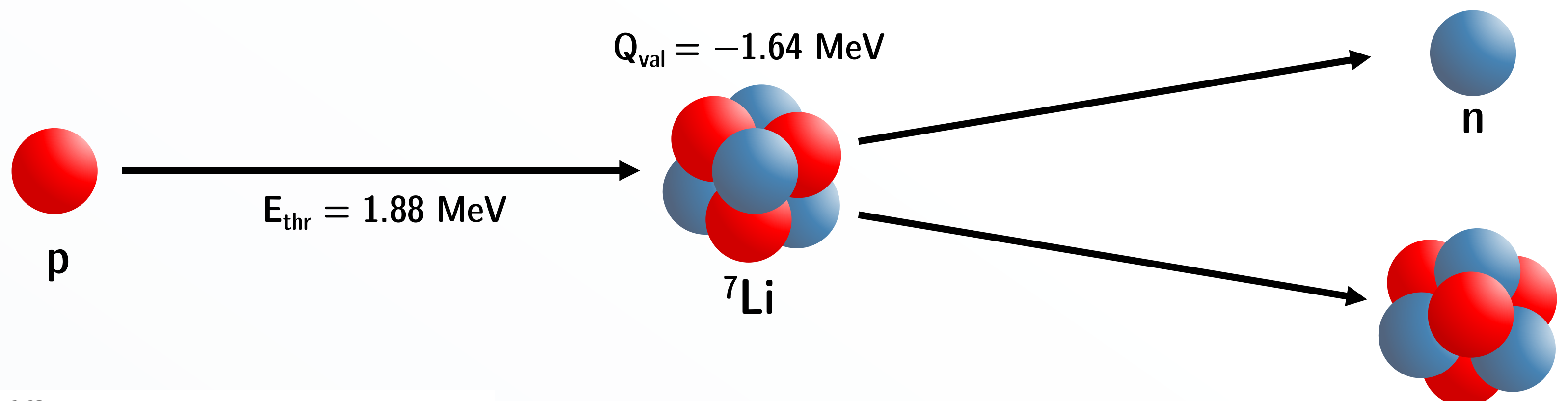
Introduction

The role of neutrons in many fundamental physical processes is an important aspect to further understand many unanswered questions in nuclear physics. However, due to the absence of any electrical charge, it is impossible to accelerate neutrons using conventional methods. Subsequently, utilisation of high-intensity neutron beams for controlled studies and research purposes has proven to be non-trivial without access to research reactors. With the completion of the new **H**igh-**F**lux **A**ccelerator **D**riven **Ne**utron **F**acility (HF-ADNeF) [1] at the University of Birmingham, this historic obstacle looks to have been removed.

Neutron Production

Unlike previous neutron facilities which generated neutrons through methods such as fission or spallation [2,3], HF-ADNeF is driven by a hyperion-type accelerator from Neutron Therapeutics [4]:

- >30 mA 0.4 - 2.6 MeV proton beam.
- Rotating lithium target – 1 m diameter, comprising 16 water-cooled 10x10 cm^2 petals.
- $^7Li(p,n)^7Be$ ($Q = -1.64$ MeV, $E_{thr} = 1.88$ MeV).
- Neutrons are forward focused with energies between 0.1 - 0.9 MeV.



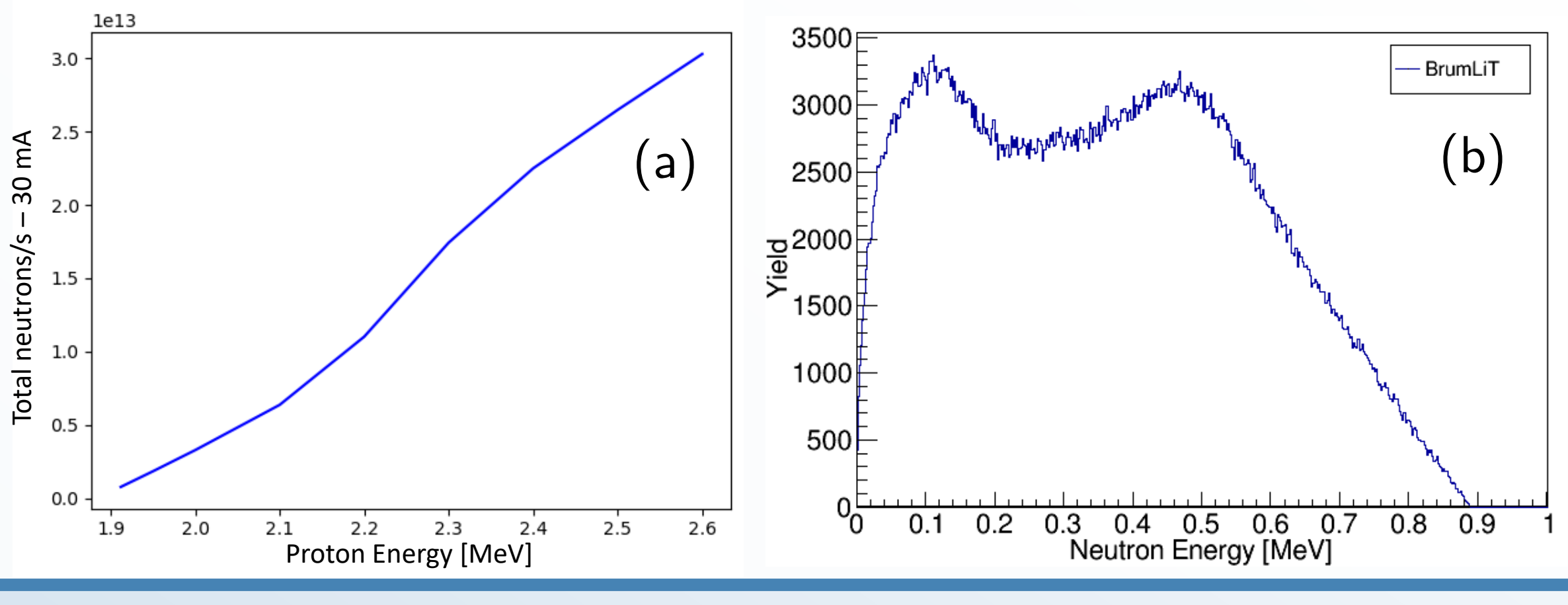


Figure 1: (a) Neutrons per second as a function of proton energy for a 30 mA beam current. (b) Neutron energy yield for 2.6 MeV proton generated using GEANT4.

Facility Overview

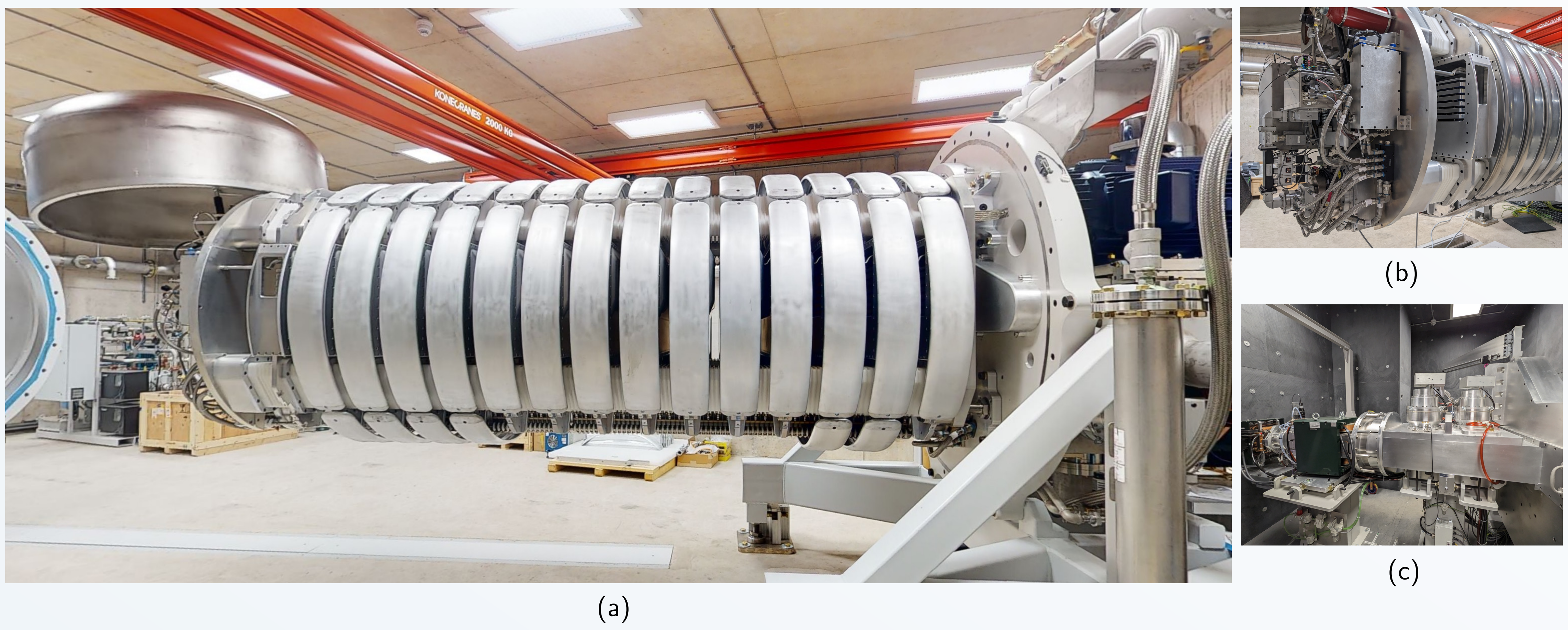


Figure 2: A picture of (a) the hyperion-type proton accelerator with pressure vessel retracted highlighting the 14 high-voltage power-supply stages responsible for accelerating the ionised hydrogen produced from the ECR (electron cyclotron resonance) ion source (b) up to 2.6 MeV. These protons are then directed towards the neutron target by a dipole switching magnet (c). Note grey borated polyethylene lines the walls of both the target room and beam switching areas for increased neutron absorption, also pictured in (c).

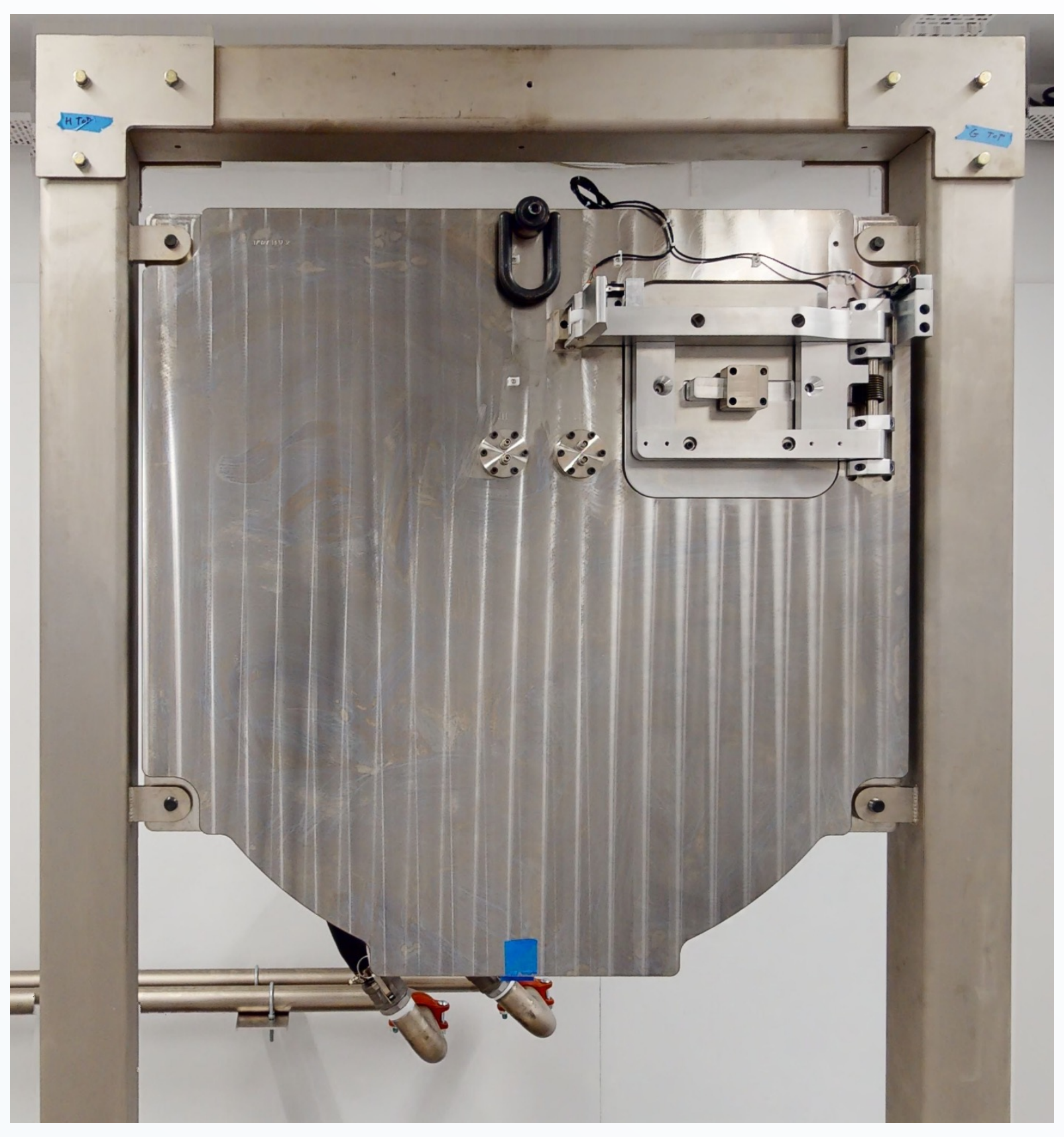


Figure 3: The titanium neutron target structure in which the water-cooled lithium-on-copper target petals rotate. User end stations are positioned here to utilise the high-flux fast neutron beam.

Applications

The high-flux neutrons produced at the facility have a wide range of possible applications due to the nature of the beam itself. Some such applications include:

- Nuclear astrophysics – *s* process, *i* process
- Nuclear structure investigations
- Medical physics – BNCT [5], radiobiology/cell irradiation & response, radioisotope production [6]
- Nuclear energy industry (fission & fusion) – material research, neutron capture cross sections
- Space research – satellite material testing, radiation effects
- Nuclear waste management – material radiation effects, storage methods
- Nuclear Metrology
- High power target development

Lithium Petals

Figure 4: One of 16 micro-channel water-cooled copper petals on to which lithium is directly bonded for neutron production [7,8]. The total heat removed is approximately 100 kW, caused by incident protons stopping within the lithium layer.

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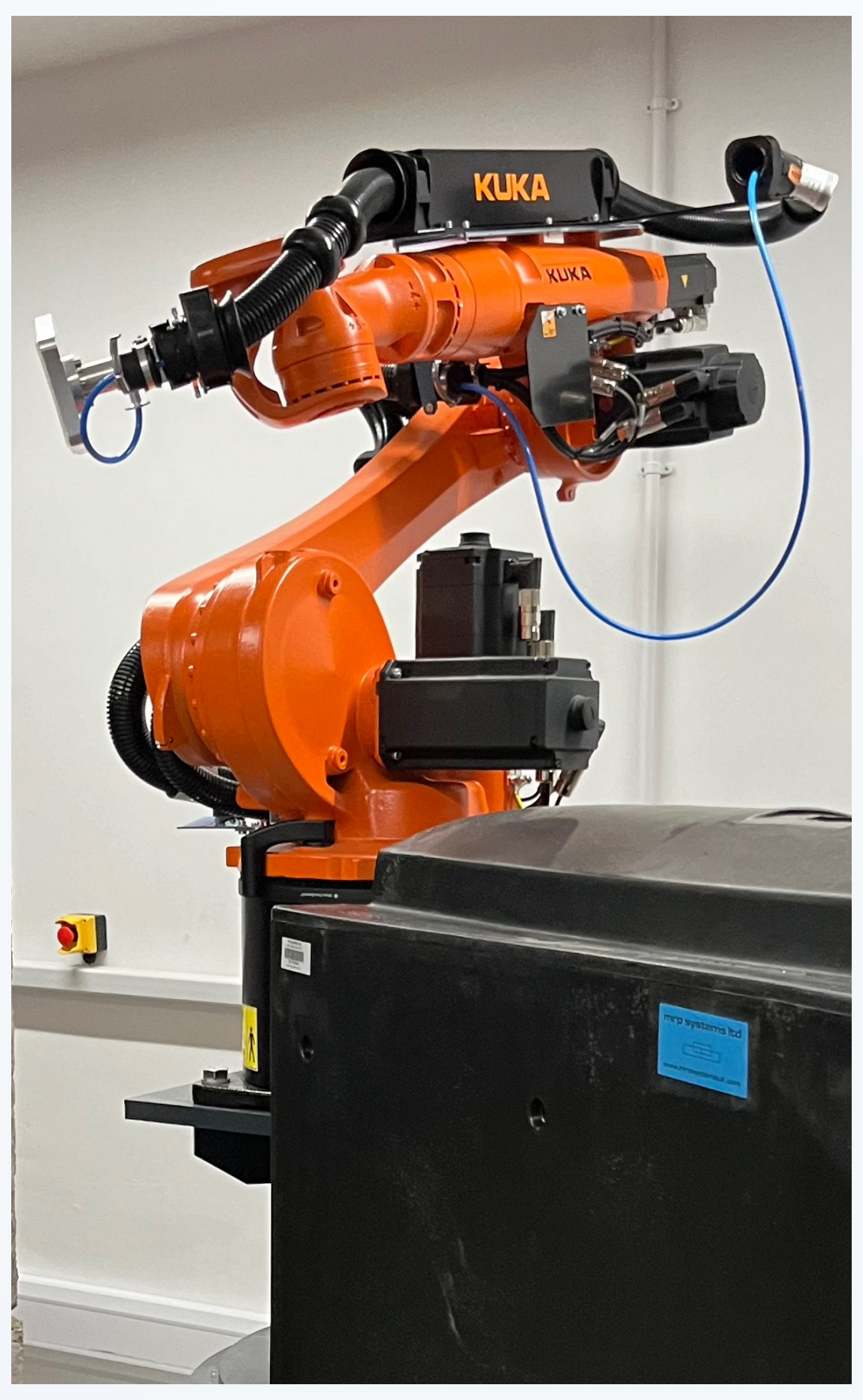

Figure 5: **T**arget **W**heel **E**xchanger **A.K.A. TWEAK**. Due to the high activity ^7Be which builds up over time from the (p,n) exchange reaction, a petal removal and exchanging robot is required to replace lithium-depleted targets in order to maintain the high neutron flux over long (>1000 hrs) operation time.

Acknowledgements

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