Overview of the ISIS-II Project

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ISIS-II Webinar

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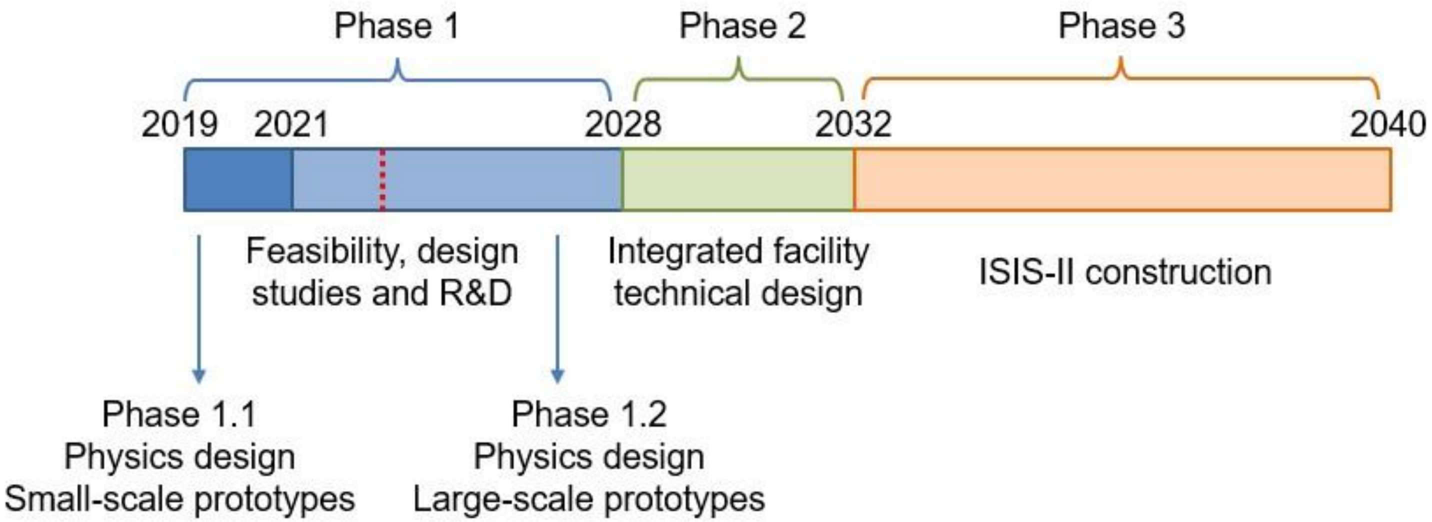
Science and Technology Facilities Council

ISIS Neutron and Muon Source

ISIS-II project

- Plans for a new facility are being developed to be ready for construction sometime after 2030 and operation in 2040. This will maintain and enhance the UK's neutron and muon provision, in a way complementary to the ESS, in order to continue to support the UK research community. ISIS-II is expected to be a multi-billion-pound facility.
- A project has been established to consider the requirements for ISIS-II and to explore the underpinning technologies.



- £5.1m UKRI infrastructure funding for ISIS-II Feasibility, Design Studies and R&D – 'Phase 1.2a' covers FY21/22 – FY24/25.
- A bid to complete Phase 1.2 is expected in summer 2025 but will now become part of an indicative bid for the full facility and involve DSIT scrutiny.
- Timeline and requirements for bid preparation are under discussion with STFC Executive Board.

ISIS Vision

“To lead the way in the development and exploitation of neutron and muon sources, science, instrumentation and technology, providing the UK materials research community (in both the physical and life sciences) with access to unique characteristics such as light element sensitivity, high penetration, non-destructive interactions, isotopic contrast enhancement and magnetic moment sensitivity, all of which are highly complementary to, but not delivered by alternative radiation e.g. X-rays.”

Objectives

- To maintain sufficient access for UK academic and industrial users to a world-leading science programme for advanced materials research, into the second half of the 21st century.
- To better deliver the priorities of the government's science, technology and industrial strategies, accelerating commercialisation and broader societal and economic impact in the UK, by maintaining UK influence over the shape of the materials science and engineering research agenda, and building UK skills to exploit these techniques.
- To maintain the UK's recognised leadership in the field of large science facilities and user support, which encourages and enables international collaboration and investment in the UK.
- To provide a science facility with reliable availability to users, in a sustainable and efficiently maintainable manner.
- To develop, attract and retain exceptional STEM talent and expertise in the UK.
- To provide a facility that minimises its environmental impact through its design principles and operating framework.

Options analysis

- Looked at all available options, taking into account key critical success factors based on strategic fit and meeting business needs, potential value for money, supplier capacity and capability, potential affordability and potential achievability.
- SWOT analysis carried out by ISIS-II Sponsorship Group.

Scope (What, where)		Solutions (How)	
Overarching/high level option (What)	Where	How will the overarching option be delivered?	
0. Close down the ISIS facility and cease the UK national facility based neutron and muon science programme	RAL	Close down the ISIS facility and divert funding to other areas of science.	
1. Business as usual/ do nothing - maintain current levels of investment in existing ISIS facility	RAL	BAU: operate and maintain existing ISIS facility	
2. Invest in substantial upgrade of the existing ISIS facility	RAL	Increased power - accelerator upgrade.	
3. Invest in a next generation, large scale, UK based neutron facility	a. RAL	Re-use of existing ISIS shell infrastructure	New short pulse source - existing Target technology
			New short pulse source - more ambitious Target technology
		Greenfield facility (will re-use some existing peripheral facilities)	New short pulse source - existing Target technology
			New short pulse source - more ambitious Target technology
			Long pulse source (ESS-style)
			Medium pulse source (ESS 100us proposal)
			New CW source
			Julich style HiCANS facility
			New reactor source
			New laser source
	b. Elsewhere in the UK	Greenfield facility	New short pulse source - low-risk Target technology
			New short pulse source - more ambitious Target technology
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			New CW source
			Julich style HiCANS facility
			New reactor source
			New laser source
4. Invest in next generation small scale UK based neutron facilities (compact source): one or multiple	a. RAL only, or RAL plus elsewhere	Multiple sub-options e.g. cyclotron	
	b. Elsewhere in the UK	Multiple sub-options e.g. cyclotron	
5. Invest further in overseas large scale neutron facilities	Non-UK	Invest in ESS	
		Invest outside Europe	

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Fails to meet CSF objective: Strategic Fit (capability and demand)	
Strengths	**Weaknesses**
Maintains a well-understood element of national scientific infrastructure. Environmental impact from new construction and/or materials will be minimal.	Once the current Endeavour Programme has been implemented, provides only limited opportunities to adapt to the evolving national and international science landscape. The facility will increasingly be overtaken in neutron science and technology by more modern competitor facilities. The aging infrastructure will rapidly lose relevance and appeal to the research community and the managed decline will lead to significant staff recruitment and retention issues. By 2050 ISIS will gradually have become obsolete.
Opportunities	**Threats**
	Any major technical failure requiring significant investment to correct is likely to be seen as a poor value for money due to the age and declining scientific impact of the facility.

- Reviewed and approved by ISIS-II Project Board in May 2023 (but remains a living document).

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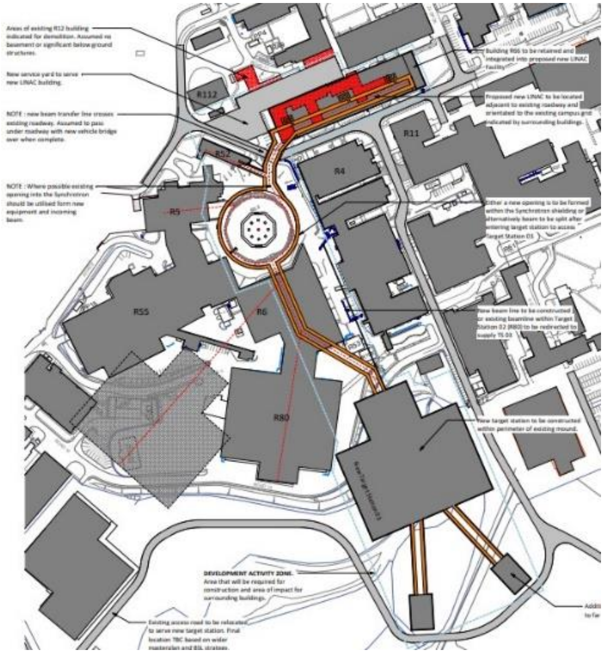
Outcomes

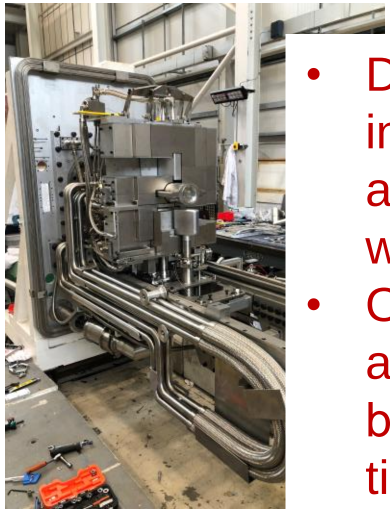
- The detailed options analysis has identified a greenfield facility on the RAL site (with re-use of some existing peripheral facilities) as the optimal solution, with a sub-optimal alternative of an upgrade to the existing ISIS facility by using a new linac to increase injection energy into the present synchrotron and building an additional target station. Both options are based around two target stations on day one, with one at high rep rate (~30 - 40 Hz) and the other at low rep rate (~10 - 15 Hz).



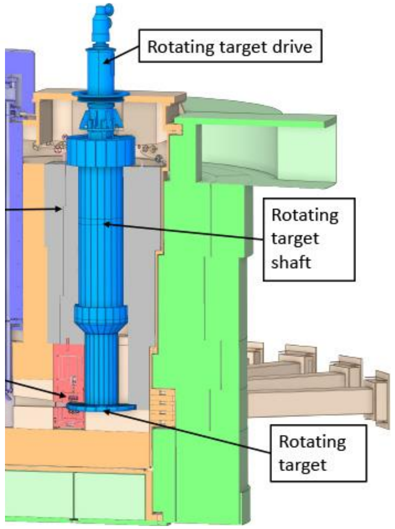
- Extensive work with Estates and Architects team to look at siting options and initial costings.

Target Technology

Low-risk target technology
(similar to ISIS multi-plate fixed target)



More ambitious target technology
(similar to ESS or SNS rotating target concept)



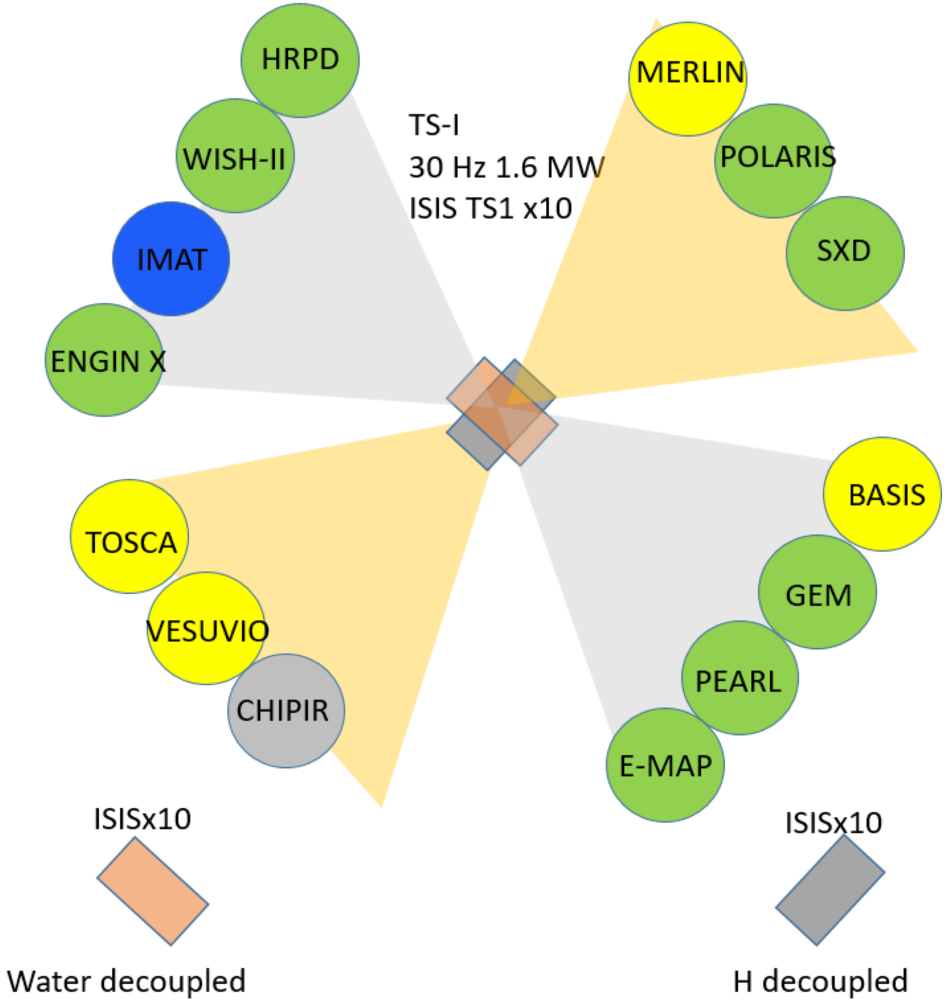
- Does the science reach generated by increased gain justify taking on board the additional risk, complexity and cost associated with more ambitious target technology?
- Or do we risk compromising ISIS-II by not adopting a technology that may well have become the 'industry standard' within the timescale of the ISIS-II project?

- Power limit of ~500 kW per target station (limits overall facility power to ~1 MW, with <×5 gain on many instruments)
- Many years of operational experience at ISIS
- Relatively easy to change in event of failure
- Should maximise availability
- Minimal complexity
- Minimal surrounding infrastructure

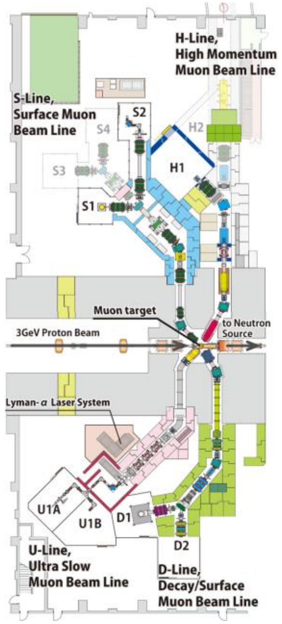
- Could realise overall facility power of 2.4 MW, giving at least ×10 gain on all instruments
- No operational experience until late 2020s
- Considerably more complex – lots that could go wrong, and not obvious how to change quickly in event of failure
- May compromise overall facility availability
- More surrounding infrastructure increases cost and may decrease space for beamlines

High repetition rate target options

- New 30 Hz 1.6 MW target station
- High resolution target station
- Same or better resolution as current TS1
- Expect gains to be proportional to power
- Decoupled Water and Hydrogen moderators
- Flux gain of 10 over current TS1 at same resolution

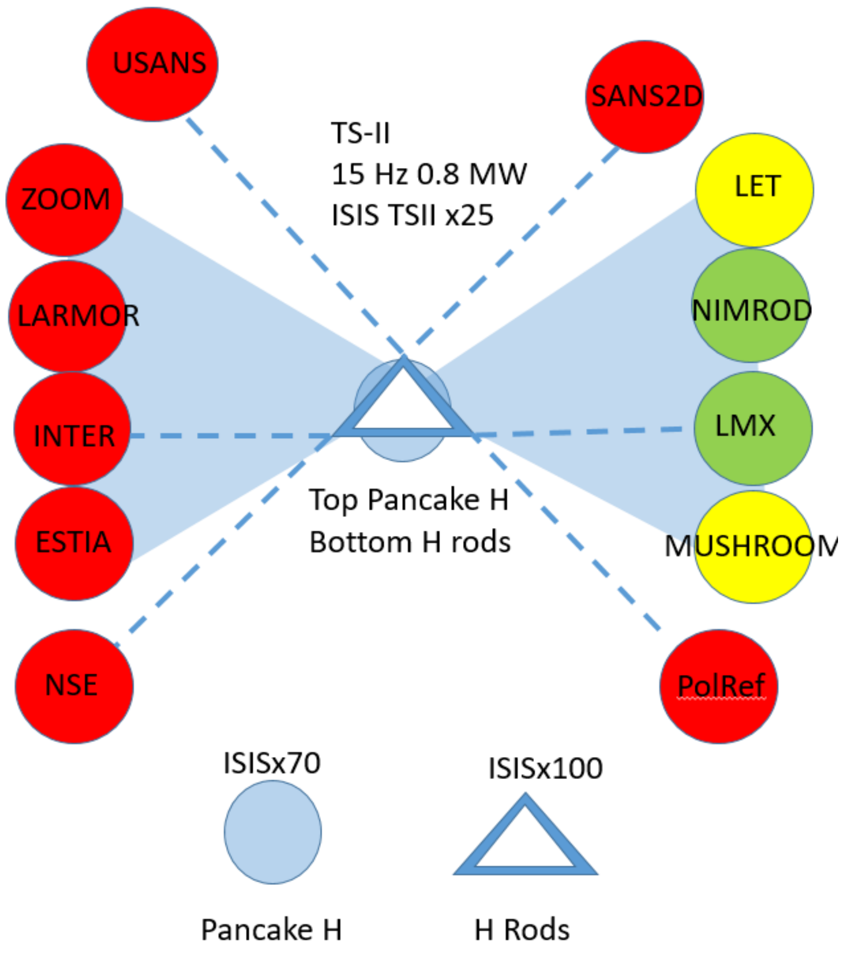


- Muon production could be from an intermediate target as in ISIS TS1, but with 4 (rather than 2) beamlines from the target as at J-PARC



Low repetition rate target options

- TS2 - 15 Hz 0.8MW
- TS2 would focus on cold neutrons and high brightness
- The preliminary concept looks a lot like SNS Second Target Station.
- This would give gains of 70-100



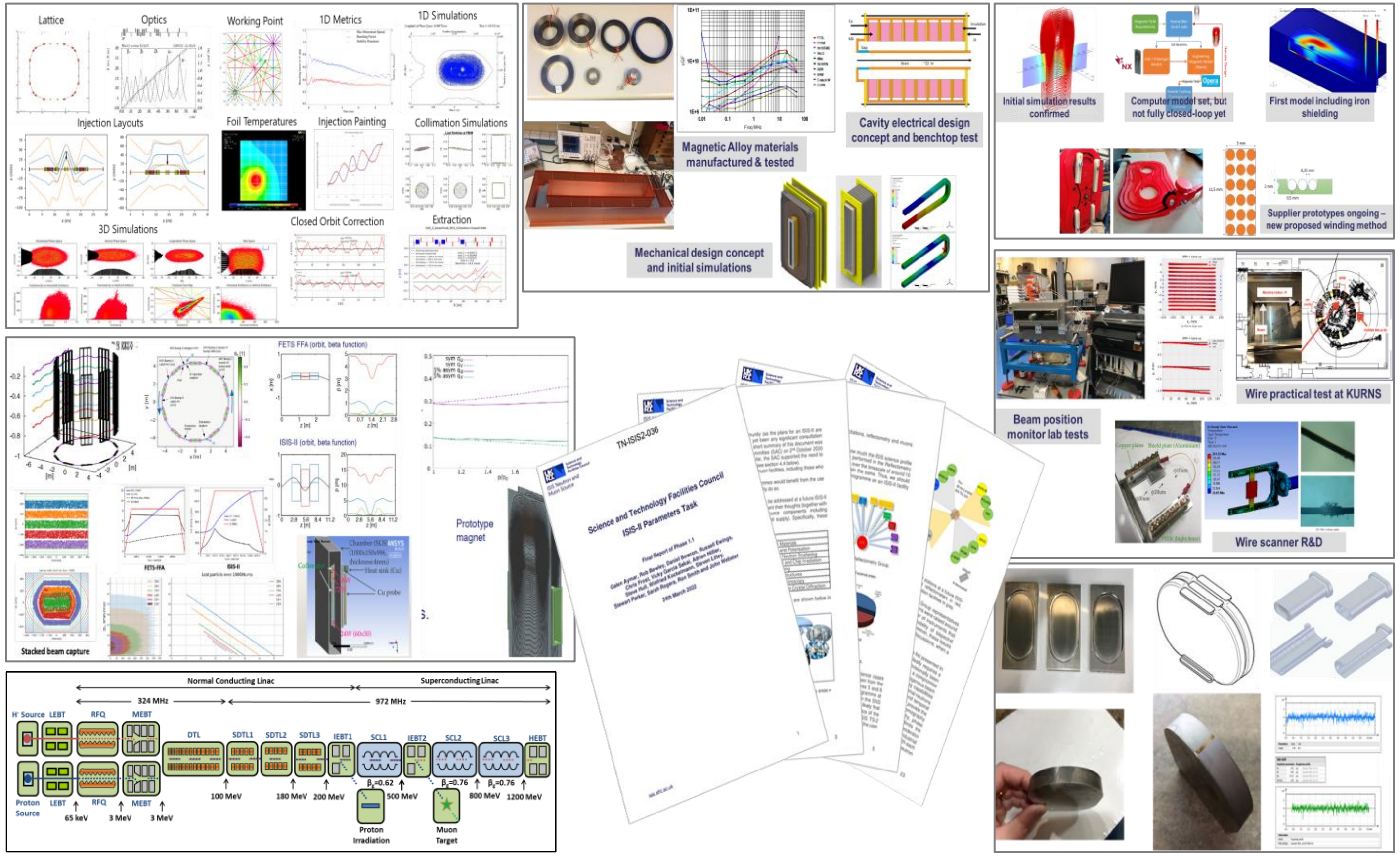
Accelerator options

- Low energy linac with rapid cycling synchrotron (RCS) to bunch compress and accelerate up to 1.2 GeV
  - Like ISIS and J-PARC
- Full energy linac with accumulator ring (AR) to bunch compress at 1.2 GeV
  - Like SNS
- Low energy linac with fixed-field alternating-gradient accelerator (FFA) to bunch compress and accelerate up to 1.2 GeV
  - Untried at high intensity, will require test ring (Phase 1.2b)
- Fall back option: 180 MeV linac upgrade to ISIS
  - Like CSNS upgrade

- Also considering muon production and proton irradiation capability in the linac.
  - Rather than (or in addition to) muon production from an intermediate target after the compression ring as in ISIS TS1, options are being considered at ~500 MeV in the linac, possibly driven by a proton pulse train interleaved with the H^- pulse train.
  - Protons at ~200 MeV in the linac, again possibly driven by interleaved protons.

Accelerator R&D

- Progression of all accelerator and target designs, in particular those for a novel Fixed-Field Alternating Gradient (FFA) accelerator, to the point were two types of FFA magnet are ready to be prototyped.



- 1.25 MW, 50 Hz, 1.2 GeV RCS and AR greenfield designs look reasonable.
- 2.4 MW, 45 Hz – stacked rings or higher energy?
- Prototype FFA demonstrator.
  - Machine and beam dynamics progress.
  - Prototype magnet, RF and diagnostics under development.
- 180 MeV injection: shown to be feasible but parked for the time being (with approval of ISIS-II Project Board).

Other significant outputs to date

- Progress in understanding the science drivers that will inform accelerator and target design choices and form the basis of the Science Case to support the ISIS-II Business Case. Go ahead given at ISIS-II Project Board in December 2023 to begin wider consultation with neutron user community.
  - Sarah's talk
- Development of an ISIS-II specific sustainability strategy and action plan based on Life Cycle Assessment. Comprehensive meeting with ASTeC to establish and promote common ground on accelerator sustainability issues. Visits to SNS, ESS, J-PARC, DESY, PSI, ILL, CERN, ESRF to discuss approach to sustainability.
  - Hannah's talk