

The UK landscape for neutrinoless double-beta decay

Strategy, programme and next-generation opportunities

The slides are my interpretation and not official STFC position.

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Member of the UK $0\nu\beta\beta$ community / LEGEND

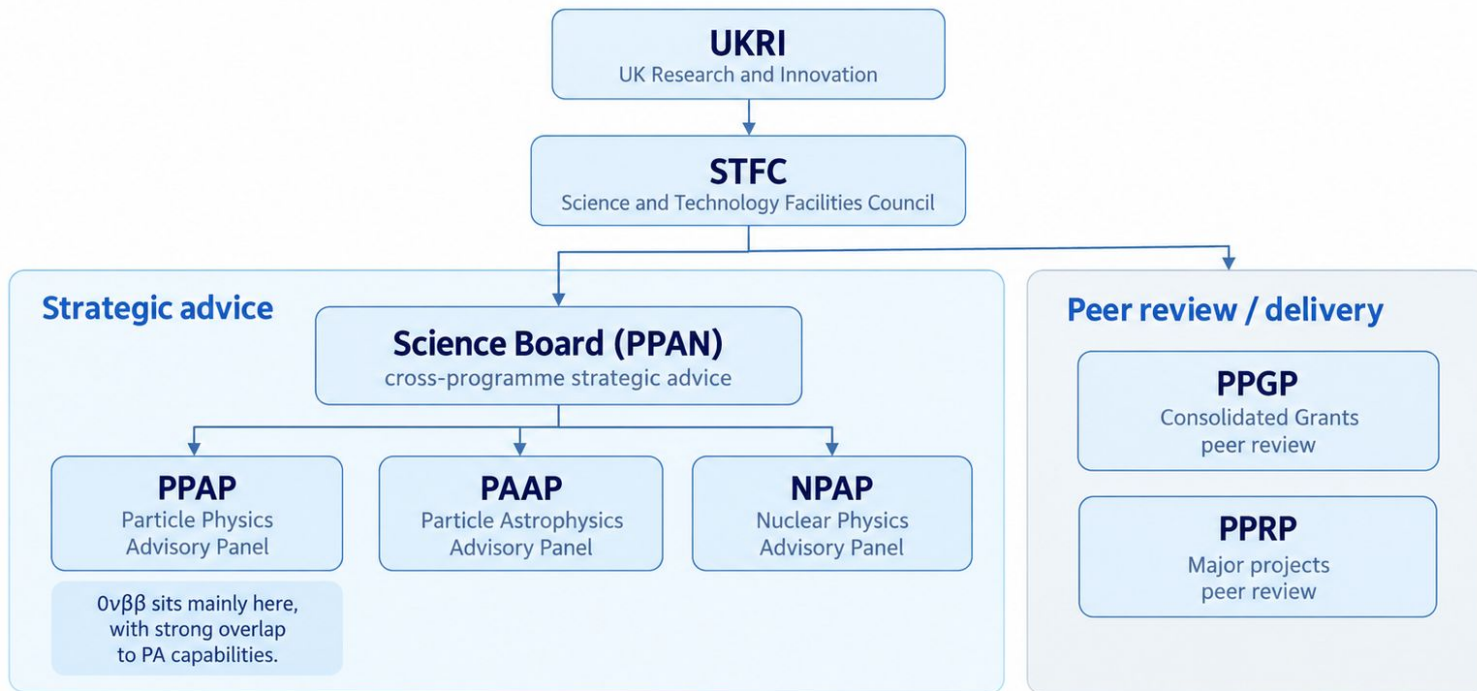
Workshop on next generation $0\nu\beta\beta$ searches in Xe

Manchester
16 September 2026

UK PPAN* Ecosystem

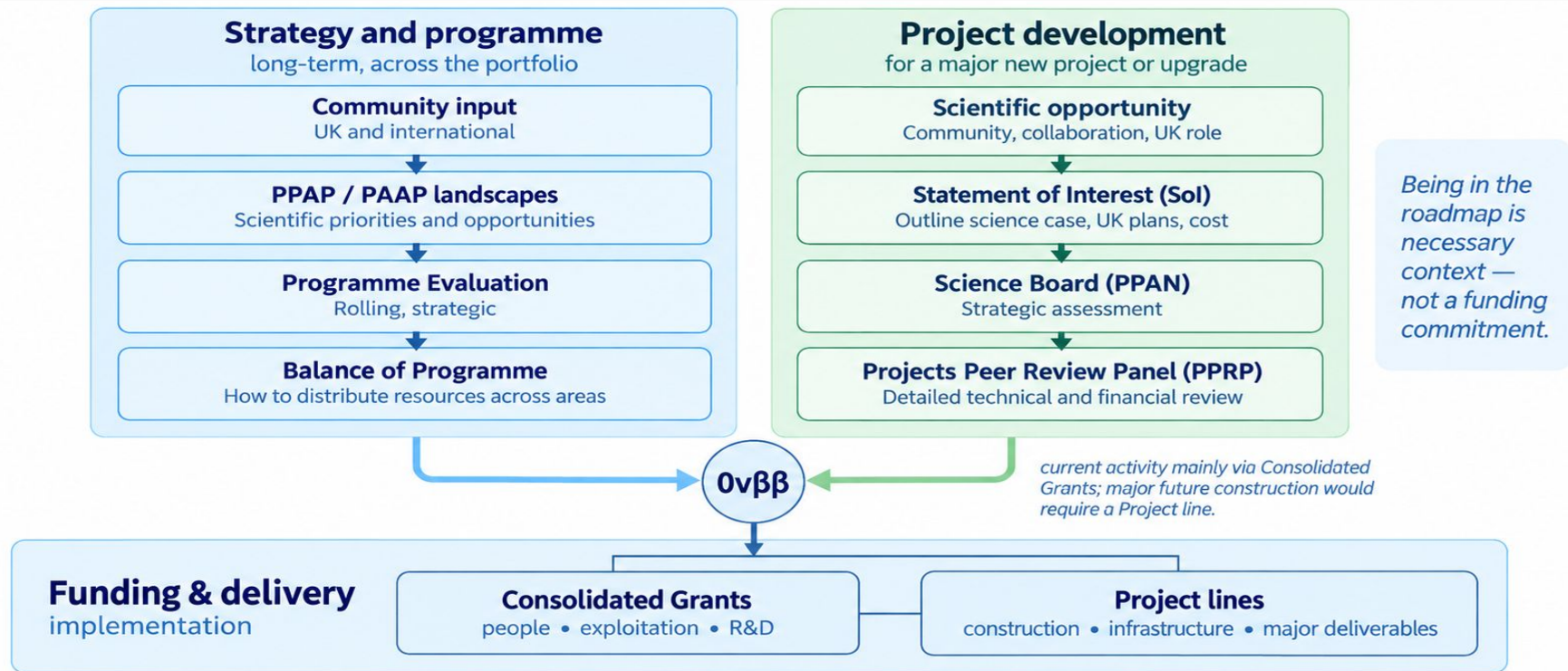
(Ruben's schematic, *not*
STFC official chart)

Strategic advice and peer review bodies relevant to $0\nu\beta\beta$



*Particle Physics, Astronomy and Nuclear Physics

How UK Roadmap becomes a funded activity



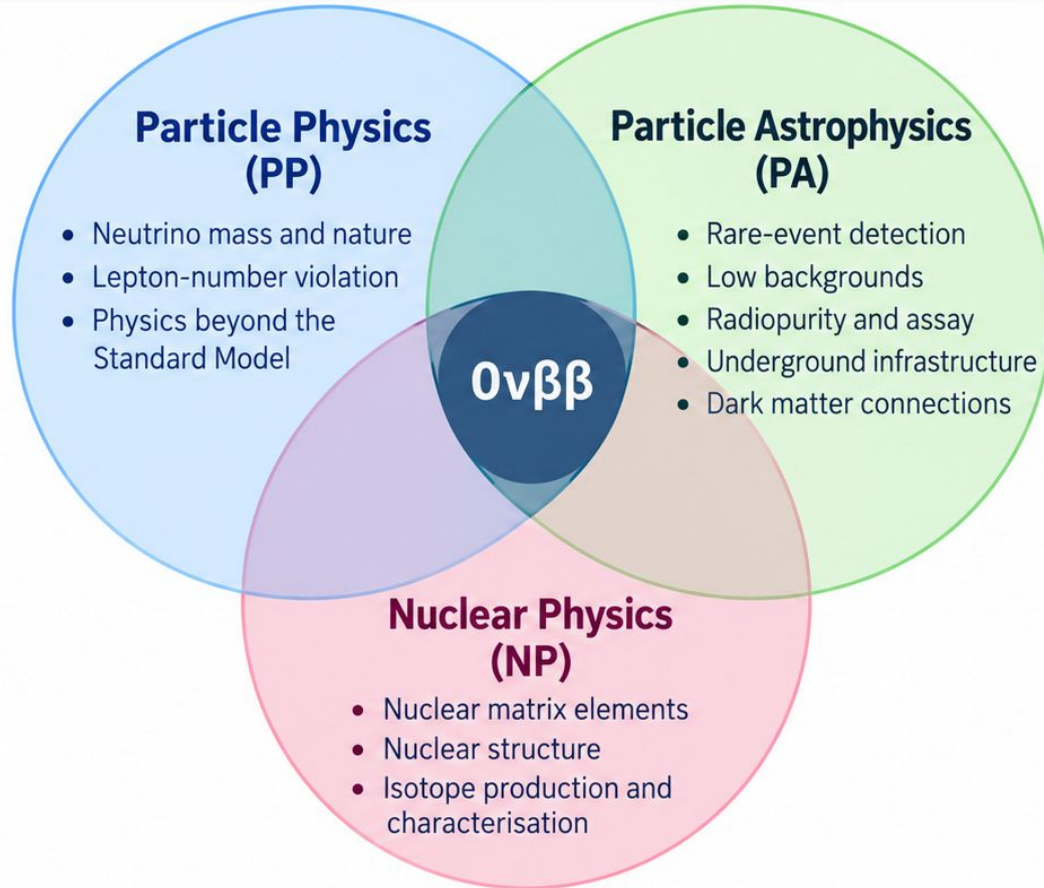
A roadmap identifies direction — it does not itself constitute a funding commitment.

Ovββ is recognised as UK strategic priority

PPAP 2021 Roadmap

[UK input to ESPP 2026](#)

$0\nu\beta\beta$ sits at intersection of UK science themes



UK:

Principally part of the particle-physics programme, with strong connections to PA and NP.

Europe:

Explicitly embedded in the APPEC astroparticle programme.

Experimentally, these boundaries are increasingly artificial.

UK $0\nu\beta\beta$: continuity across technologies



Tracking
and topology



NEMO-3

2003 – 2011

SuperNEMO

2011 – 2020s

*Final phase
and legacy*

Scintillator



SNO+

2010 – present

High-purity
germanium



LEGEND

2016 –

LEGEND-200

2023 –

LEGEND-1000

2030s

Xenon



LUX / LZ

2010s – present

XLZD

2030s

Next-generation Xe

*A diverse and
long-standing UK
programme, building
capability across
multiple technologies.*

Enabling capability (common to all)

Low-background assay • Simulation • Detector development • Underground infrastructure (e.g. Boulby)

The UK programme today

1

SCIENCE

A broad and complementary portfolio

Dedicated $0\nu\beta\beta$

- LEGEND
- SNO+
- SuperNEMO / legacy

Xe / multipurpose rare-event physics

- LZ
- XLZD development
- emerging Xe opportunities

Enabling capability

- low-background assay
- simulation
- detector development
- underground infrastructure

Current activity mainly via Consolidated Grants

2

FUNDING

Two complementary routes

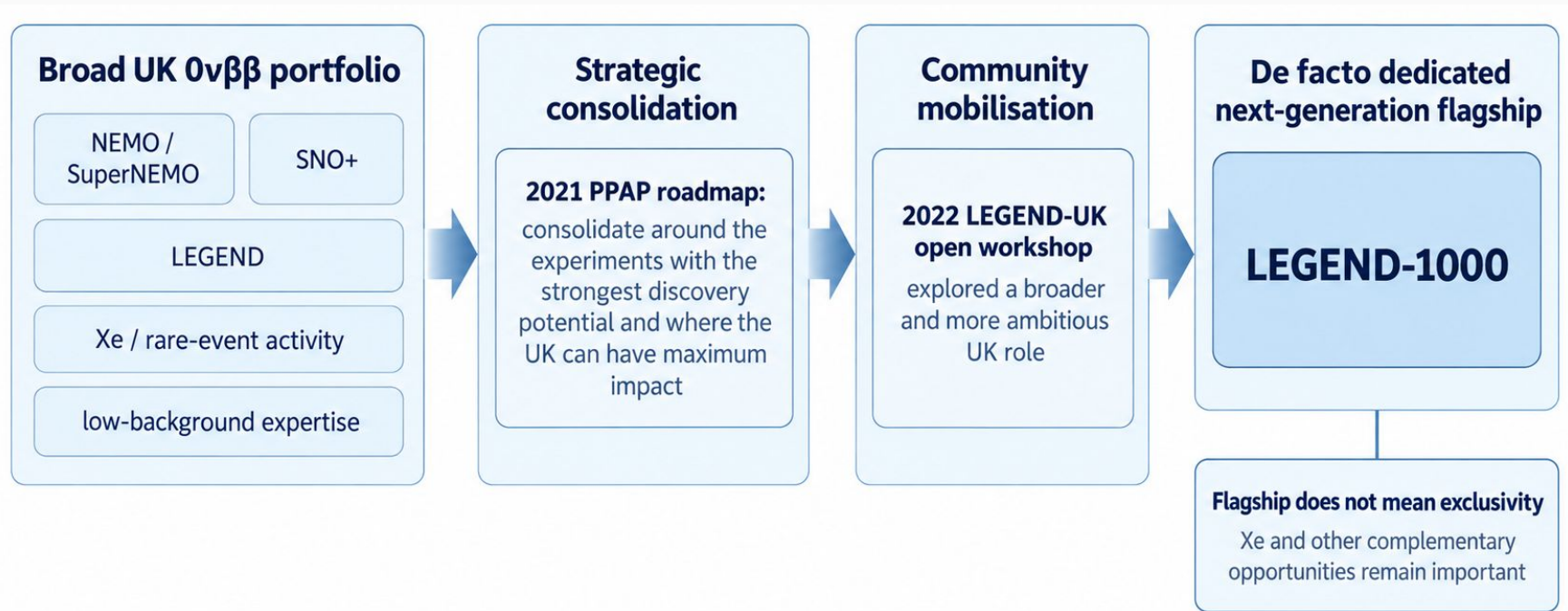
Consolidated Grants

people • exploitation • R&D

Project lines

major construction • infrastructure • major deliverables

Current UK next-generation flagship strategy



PPAP 2021 Roadmap

Particle Physics Advisory Panel

B. Allanach, A. Bevan, M. D'Onofrio, R. Jones,
M. Needham, K. Palladino, S. Pascoli, J. Pasternak,
Y. Peters, R. Saakyan

PPAP Roadmap 2021

16

infrastructure. There are also significant synergies in detector technologies with nuclear physics.

The UK has strong leadership and expertise in this area. It has had a major involvement in the NEMO-3/SuperNEMO and SNO+ experiments, and more recently in the LEGEND experiment. SuperNEMO will take first data in 2021 and run until 2025 reaching a sensitivity to the Majorana neutrino mass, $(m_{\beta\beta})$, at a level of 0.2-0.4 eV and, crucially, will provide unique measurements of $2\nu\beta\beta$ that will shed light on the underlying nuclear mechanism and potentially constrain the quenching of the weak axial-vector coupling, g_A . SNO+ will begin physics data taking in 2022 reaching a sensitivity of 40-150 meV in 5 years in its first phase. Further upgrades with higher Te loading and improvements in detector performance may allow this technology to push the sensitivity further towards 10 meV. The SNO+ has a broad science programme including solar neutrinos, reactor and geo anti-neutrinos, and supernova neutrinos. LEGEND-200 will start physics data taking in late 2021 and will reach a 3σ discovery sensitivity to $(m_{\beta\beta}) \sim 28$ -57 meV by 2026/7. Its next phase, LEGEND-1000 will require a new underground infrastructure. It will have a 3σ discovery sensitivity of 9-18 meV in 10 years of running fully covering the inverted neutrino mass ordering and exploring a significant range of the parameter space for the normal ordering. The UK has provided leading contributions to all three projects (tracking detector and radio-purity assays in SuperNEMO, Te-loading and calibrations in SNO+, detector characterisation and analysis framework in LEGEND).

Presently, there is an ongoing effort between Europe and USA, to coordinate the selection of 2-3 future "tonne-scale" $0\nu\beta\beta$ projects. In Europe, the Astroparticle Physics European Consortium (ApPEC) has identified a roadmap for the field focusing on the most prominent projects with strong European leadership: CUPID, LEGEND and NEXT. In the US, the Department of Energy initiated a portfolio review in summer 2021 to select the next $0\nu\beta\beta$ project for funding among CUPID, LEGEND and nEXO. A joint North American - European summit is planned for Sep-Oct 2021 at LNGS to coordinate the funding effort across the Atlantic.

Recommendation 6.3: The study of the neutrino mass nature (Dirac or Majorana) and its absolute value is one of the other key priorities of the field. The UK should continue to support its current engagement with $0\nu\beta\beta$ experiments entering the exploitation phase. Going forward, the UK should leverage its expertise and technical capabilities to actively engage with international strategies, being formulated in Europe (ApPEC), the US (DOE) and Asia, that aim to cover the inverted neutrino mass ordering parameter space, and should consolidate around the $0\nu\beta\beta$ experiments with the most promising discovery potential on the shortest timescale, and where the UK can have the maximum impact.

While the main focus of the $0\nu\beta\beta$ field is currently on covering the inverted ordering of neutrino masses (10-20 meV), the technology used in these upcoming experiments may not always be scalable to increase the sensitivity further to address the normal ordering scenario (1-10 meV). A rigorous R&D programme is necessary to understand modifications needed for existing technologies, or to identify completely new techniques that can lead to <10 meV sensitivity in case of the absence of a signal in the next generation experiments.

The most model independent way of measuring the neutrino mass is by analysing electron spectra near the end point of a beta decay. The effective electron neutrino mass measured by this method can not be smaller than 50 meV and 9 meV for the inverted ordering and normal ordering respectively (while the current upper limit from the KATRIN experiment is 0.8 eV). The UK has become involved in those studies under the recently established UKRI QTFP programme. The long term aspiration of the programme is to capitalise on recent advances in quantum sensors

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Strategy Summary

The observation of neutrinoless double-beta decay (NDBD) would constitute a landmark discovery in particle physics, setting the foundations for the development of a long-sought theory of fermion masses and the explanation for why our universe contains more matter than antimatter.

Over the last 20 years, the UK community has pursued a multi-pronged experimental approach to discover NDBD, which has enabled the UK to act as a driving force in the field, with recognised intellectual leadership. This document summarises the UK NDBD community's strategy for the near- (<5 years), medium- (5-15 years) and long-term (>15 years) future.

The strategy can be summarised in four points:

- 1) Continued support for the exploitation of LEGEND-200, SNO+ and the SuperNEMO Demonstrator, recognising the unique near-term physics programmes of each experiment and building on substantial prior UK investment.
- 2) Support the construction of LEGEND-1000 in the near term as the highest priority project in the USA and Europe, ensuring UK leadership in an experiment that will have $> 3\sigma$ discovery sensitivity for Majorana neutrinos in the inverted neutrino mass ordering range in the medium term.
- 3) Support the development and implementation of higher loading phases of SNO+, which will provide complementary sensitivity with a different isotope in the medium term and lay foundations for a technique that might be extended to the normal mass ordering in the longer term.
- 4) Exploit cross-field scientific and technological synergies with the XLZD dark matter community and explore strategic R&D opportunities offered by complementary technologies, such as NEXT, to further strengthen the main programme in the medium term, while continuing to support blue-skies R&D into new technologies able to reach sensitivities beyond the inverted mass ordering in the long term.

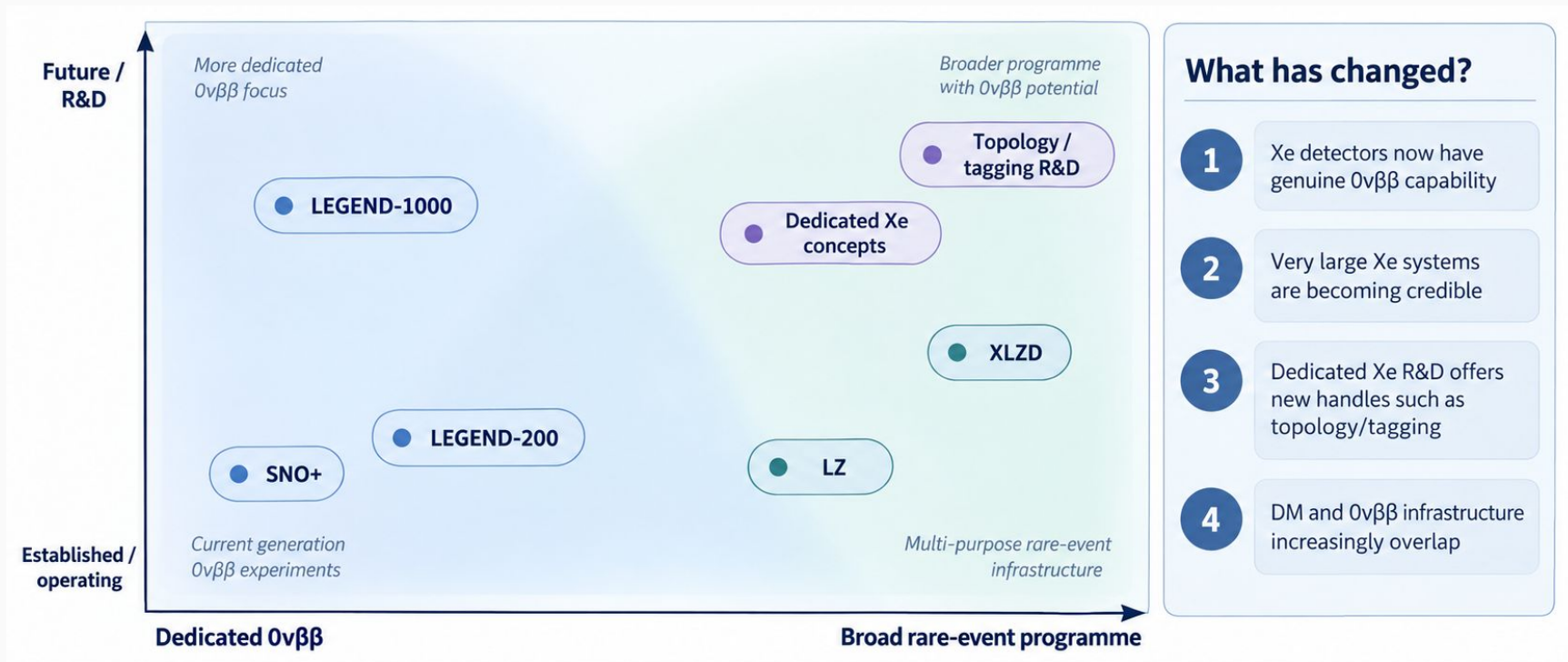
The rest of the document gives the background to this strategy in terms of the science case, international activities, funding landscape and the current UK programme.

Science Case

The observation of neutrinoless double-beta decay (NDBD) would constitute a landmark discovery in particle physics. This lepton-number-violating nuclear transition, which would result in the net creation of matter-particles (i.e., two leptons) without their balancing antiparticles, is predicted by leading theories to explain the mysterious origin of neutrino masses (which is not accounted for in the Standard Model)

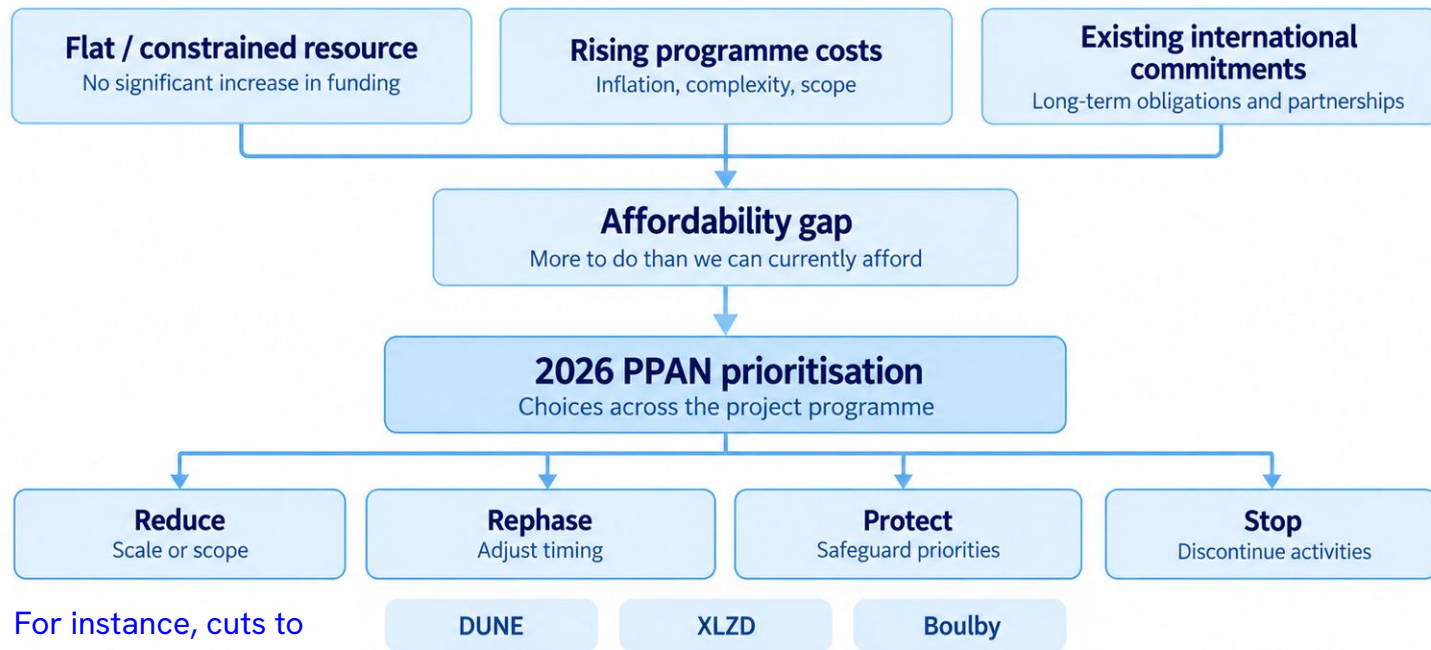
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Evolving Landscape



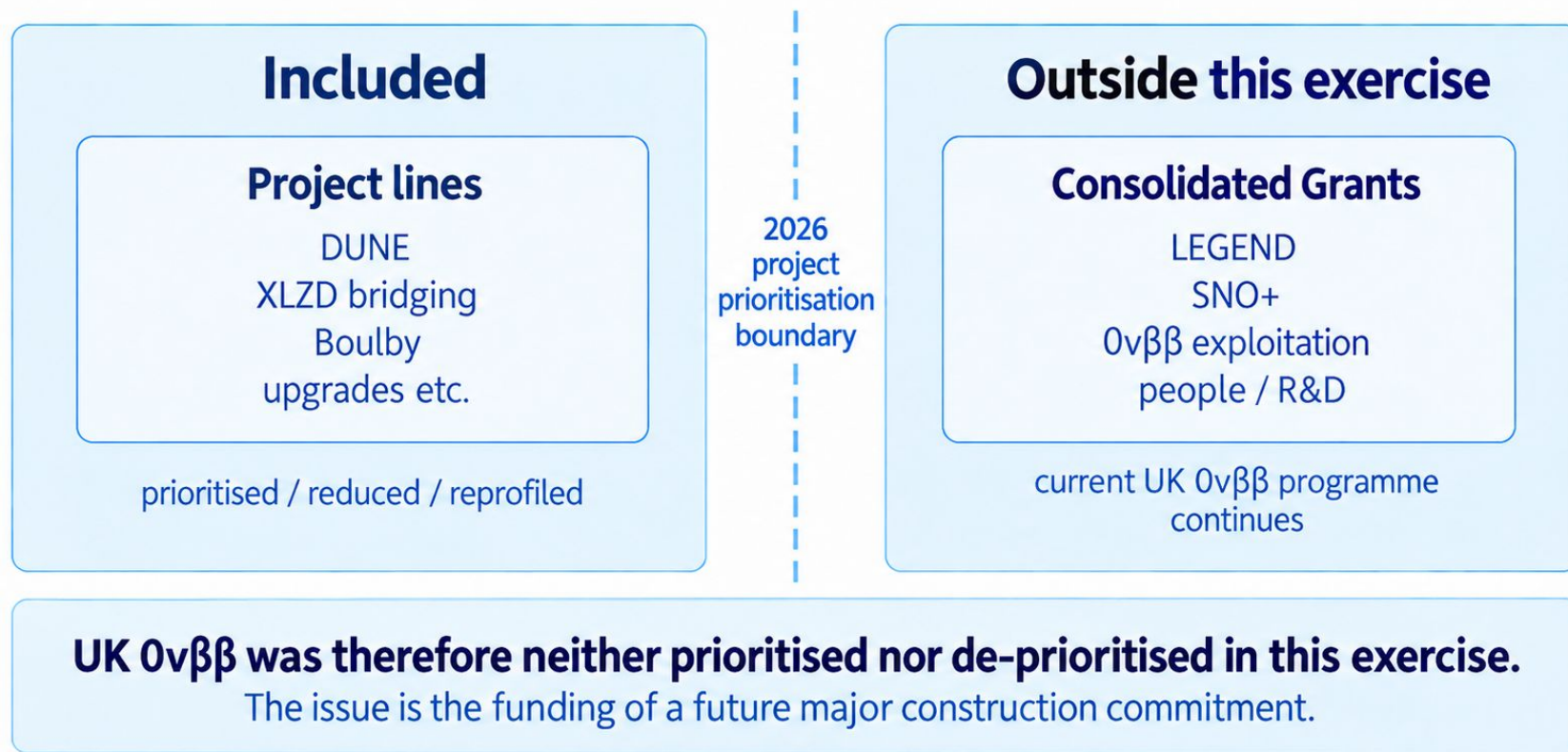
What should be UK's $0\nu\beta\beta$ programme in the 2030's?

The 2026 funding “reality”

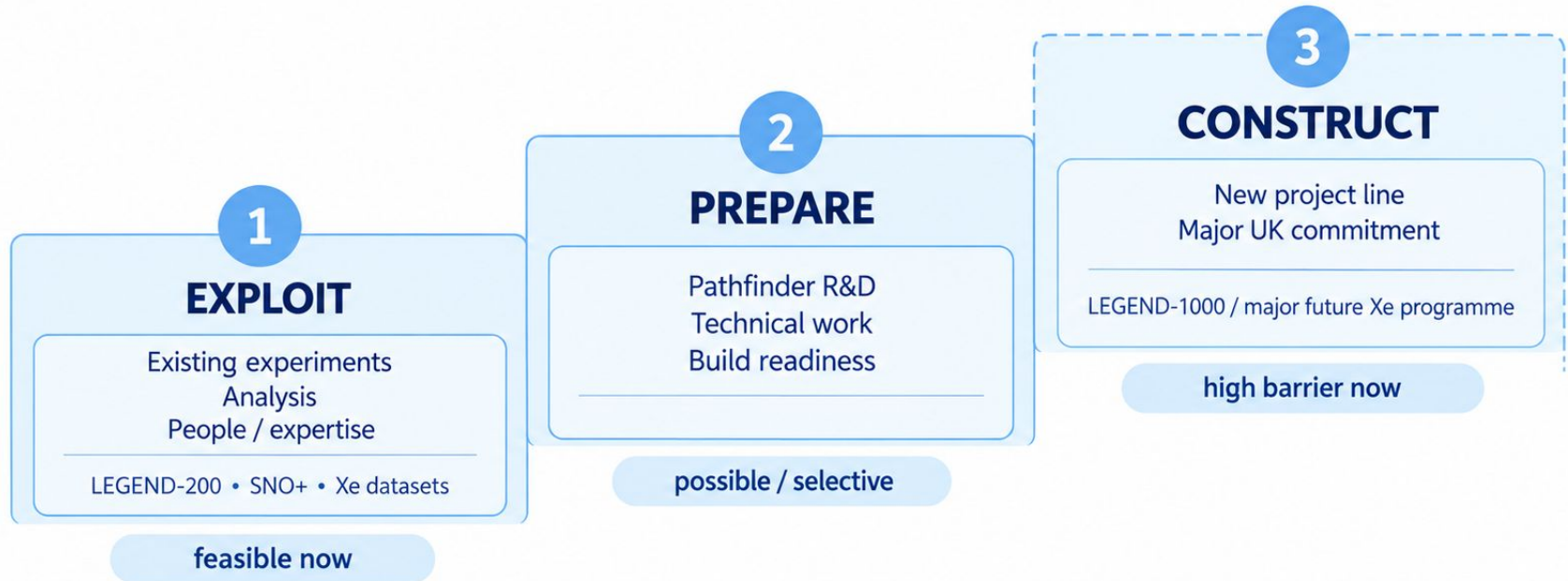


- **Several-month exercise led by STFC Science Board (PPAN)**, informed by community input and the advisory panels (PPAP, PAAP, NPAP, AAP, SSAP)
- **Science Board (PPAN) produced recommendations** (May-Jun)
- **STFC Executive took the final decisions and published the outcomes** (July)
- **Science Board report expected to be released shortly** (Sep)

What was prioritised?

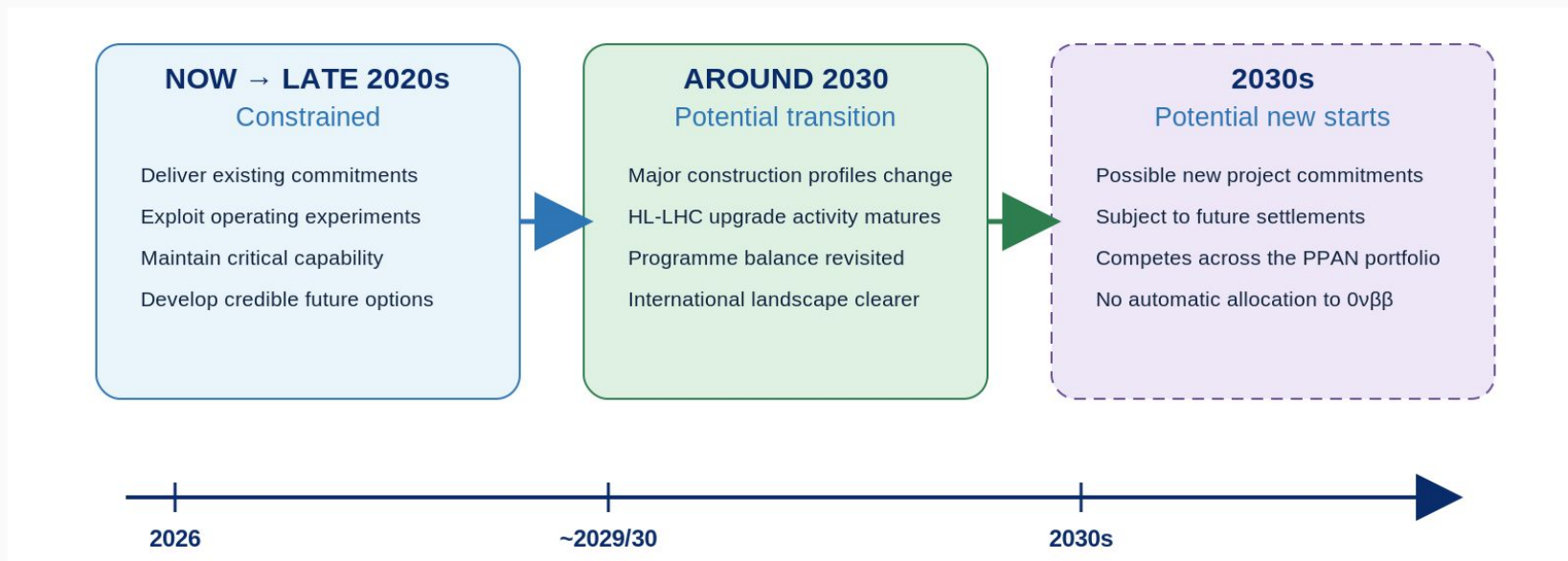


What does it mean for UK $0\nu\beta\beta$?



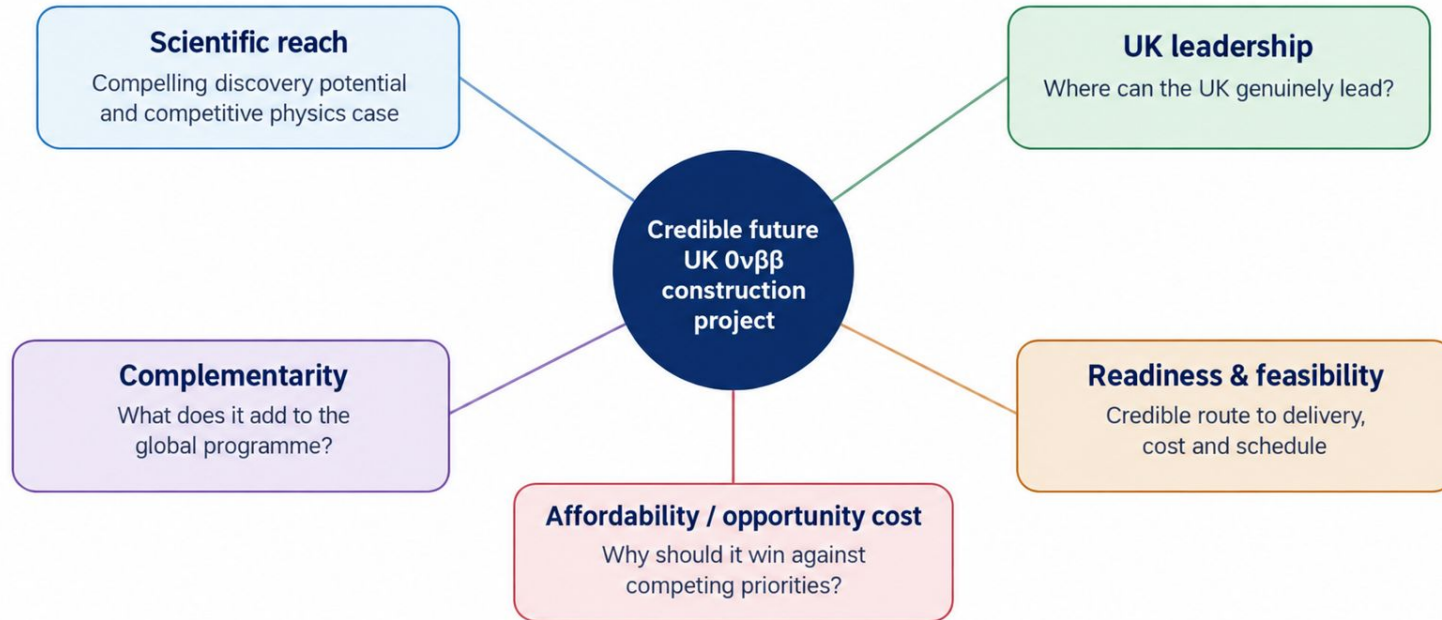
- **Near-term priority: protect capability** — Boulby, low-background expertise, people
- **Near-term constraint: very limited headroom for a new major construction project**

Potential future headroom



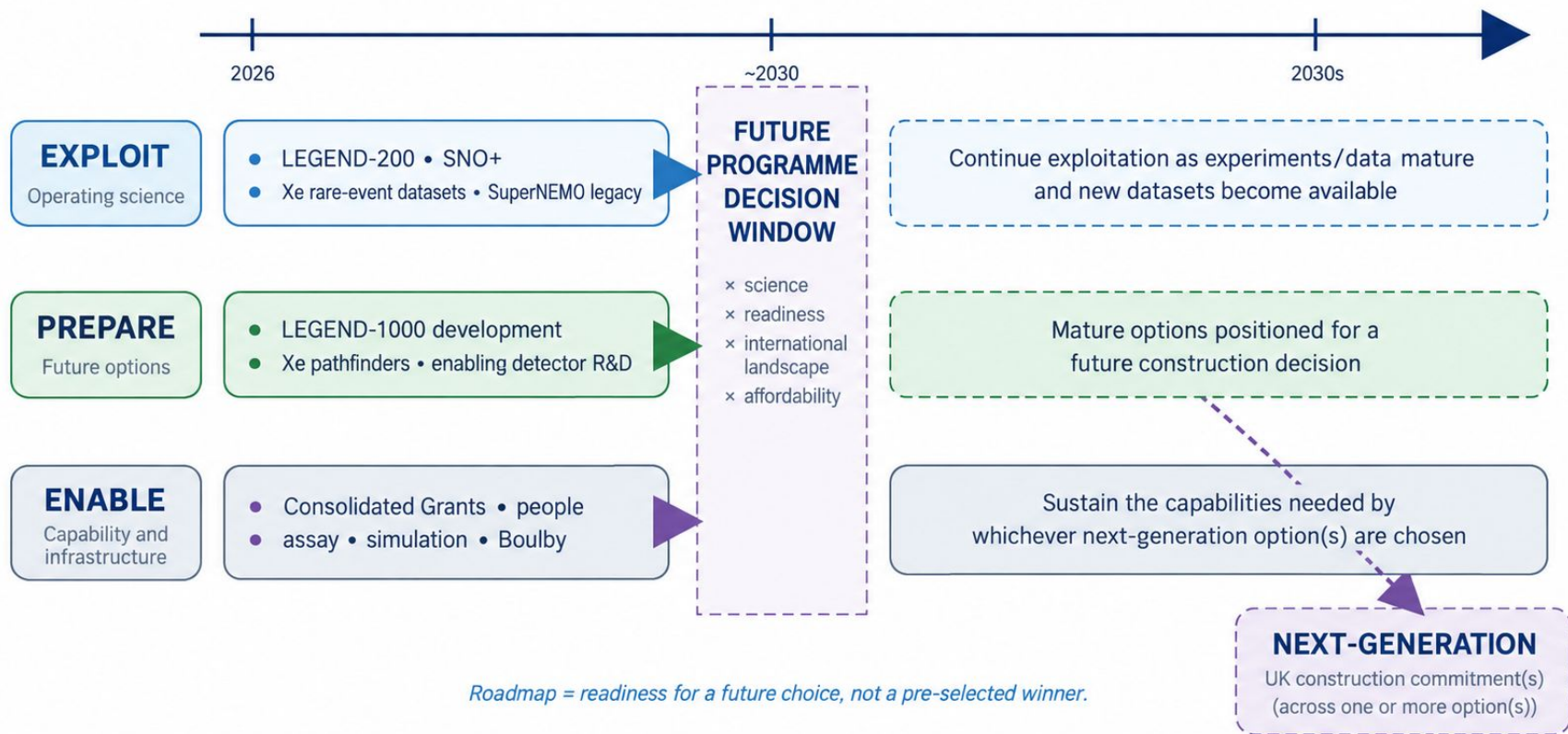
- **Maturing commitment may create headroom (eg HL-LHC upgrades, DUNE, ...)**
- **Released resource is competed across particle physics. And in fact across PPAN**

Future UK $0\nu\beta\beta$ project criteria



Any future UK $0\nu\beta\beta$ project must clear a very high bar in a highly resource-constrained environment

A possible UK $0\nu\beta\beta$ Roadmap



Take-home



- The UK has a long-standing and technologically broad $0\nu\beta\beta$ programme
 - Strong overlap between particle, nuclear and particle astro-physics
 - Current $0\nu\beta\beta$ activity is supported through Consolidated Grants and was not itself part of the 2026 prioritisation
 - A major next-generation construction project is a different funding question
- The priority now is to exploit what we have, **protect capability and infrastructure**, and mature credible options so that the UK can make a strong choice when programme headroom re-emerges.