Nuclear Data for ATF: A UK Perspective

Allan Simpson, 20th May 2020

NATIONAL NUCLEAR LABORATORY

INTRODUCTION

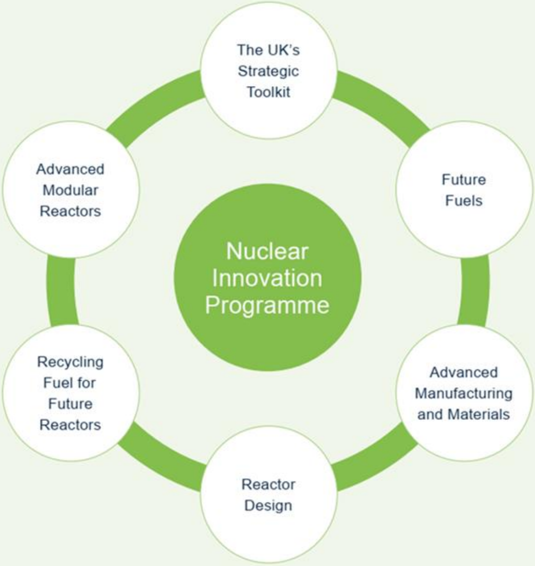
- About NNL and the Advanced Fuel Cycle Programme
- Drivers for Advanced Technology Fuel
- Impacts on Nuclear Data
- Initial analysis and next steps

ABOUT NNL

- NNL is the UK's national nuclear laboratory which operates on an autonomous commercial basis
- NNL is owned by the UK government and has three roles given to it by the government
- NNL operates world leading facilities doing world class science
- Over 10,000 person years of nuclear industry experience across the whole fuel lifecycle
- 6 locations across the UK including high active laboratories
- Principal customers include: Sellafield Ltd, EDF Energy, Ministry of Defence, BEIS, Westinghouse, US Department of Energy, Nuclear Decommissioning Authority (NDA)

NUCLEAR INNOVATION PROGRAMME

£180 million 5 year Government programme



Future Fuels
Making more efficient and safer fuels for current and future reactors

Advanced Manufacturing and Materials
State of the art techniques embedded in the supply chain, reducing the cost of nuclear projects

Reactor Design
Digital tools to design and build future generations of reactors in an accelerate[d] and cost effective way

Recycling Fuel for Future Reactors
Sustainability through fuel recycling and waste minimisation

Advanced Modular Reactors
Moving next generation technologies towards commercialisation

The UK's Strategic Toolkit
Tools to critically assess emerging technologies, providing a policy evidence base

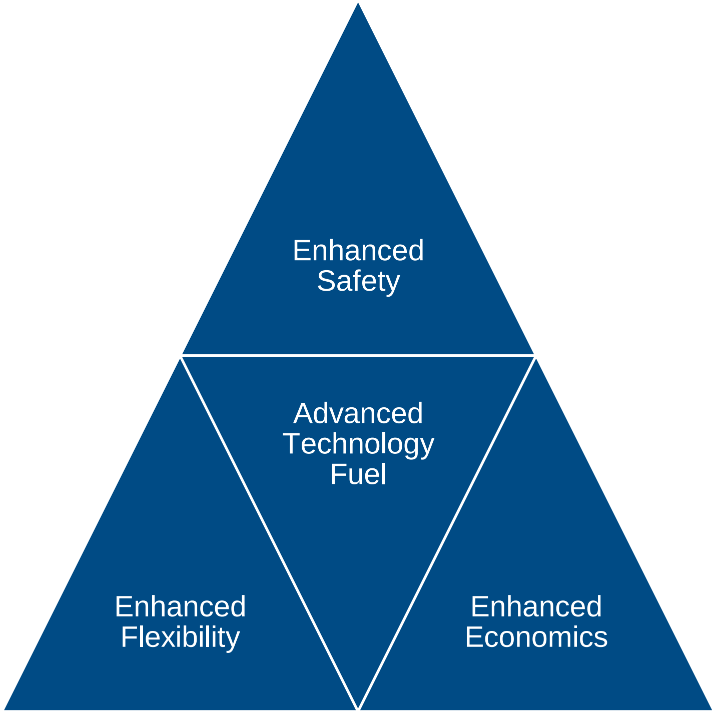
"the first significant public investment in future civil nuclear fission (energy generation) research and innovation for a generation"
NIRAB 2019

INDUSTRY RECCOMENDATIONS

> *whilst adequate for current reactor systems, existing nuclear data is not adequate for the assessment of advanced fuels (in current reactors); advanced reactors (Gen-IV and beyond); and for understanding the wastes arising from these systems. This project area will focus on new data, better accuracy and understanding of its uncertainties and their correlations, and how best to use these data on modern computing platforms with more efficient methods.*

DRIVERS FOR ATF

- ATF – 'Accident Tolerant Fuel' borne out of the Fukushima Daichii Accident
- Initial focus on safety, however UK research programmes have moved to recognise what would drive operators to adopt ATF
- Fuel needs to be attractive to reactor operators, so production routes and cost need to be comparable with UOx
- Lends itself to fuels that can reach higher burnup to account for higher cost

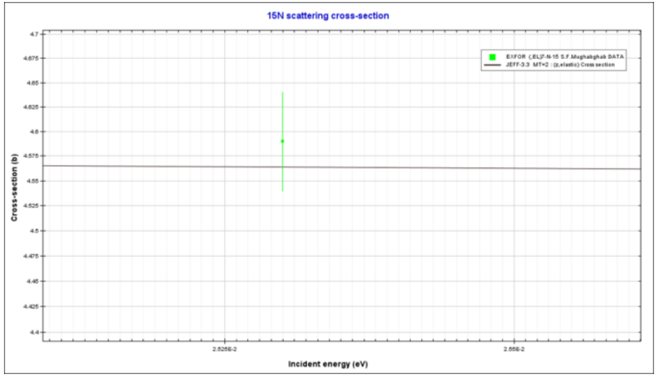


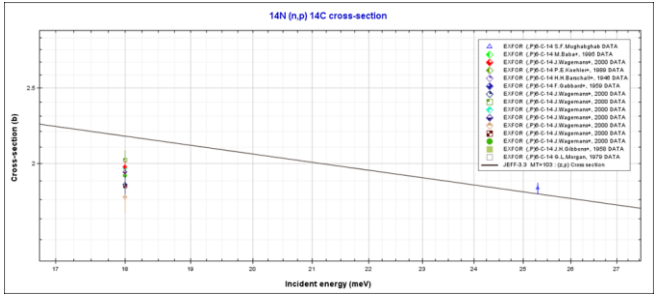
EVOLUTION OF ATF

- Most initial research has been around specific fuel and clad types, including Uranium Silicide
- Production routes for Uranium Silicide have been difficult to prove
- This has driven UK research programmes to switch to Uranium Nitride fuels, with potential for fast reactors
- For the underpinning data, this has been a big change
- Furthermore, nuclear data has a key role to play in selecting ^{15}N enrichment

REVIEW OF THE DATA

- There are no criticality or reactor benchmarks that allow the current nuclear data to be verified for nitride fuels.
- The nitrogen scattering cross-sections for 14N and 15N in the thermal range have little justification
- The 14N (n,p) cross-section measurements differ by about 5% and this is the major source of neutron absorption in nitrogen, reducing the confidence in existing basic nuclear data.
- The 14N capture cross-section differ by 7% but is a small component to the total neutron absorption.
- **Current data would not be suitable for fuel qualification under the UK regime**





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NEXT STEPS

Review of nitrogen cross section

- *Nuclear data is well optimised for existing oxide fuels and their modelling in reactor physics codes. Development of nitride fuels means that work is required to understand the quality of existing data for nitride fuels such that the accurate modelling of nitride fuels in reactors can be underpinned and justified to regulators*

Code validation for nitride fuels

- *The process of code validation provides confidence in code performance when used to model particular scenarios. Validating the WIMS code for nitride fuels at fast and thermal energies will ensure it is ready to support more complex fuel performance and reactor physics modelling when needed later in the programme. This modelling is a key part of building a safety argument to irradiate such fuels, which is needed for fuel qualification*

Benchmark experiments

- *Ultimately code validation is going to require benchmarks that can be used for comprehensive validation.*

Irradiation data

CONCLUSIONS

- Nuclear Data is fundamental to the successful deployment of ATF
- Recognition of this fact in the wider industry is variable
- Early involvement and engagement with industry needs is key
- We need irradiation data!