High Precision γ-ray Measurement and Evaluation of Radionuclides Relevant to Fusion Systems

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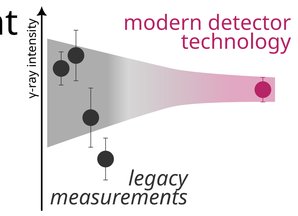
The Project in a Nutshell

Problem

Some key isotopes important for **fusion applications** rely on **outdated**, **inconsistent,** or **incomplete decay data**.



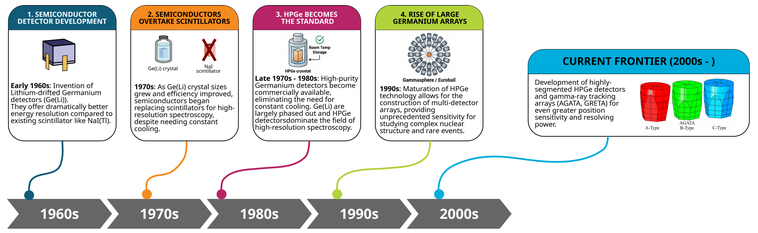
Approach

Remeasure selected **high-impact radionuclides** using modern detector technology to **reduce uncertainty** and resolve inconsistencies.

Impact

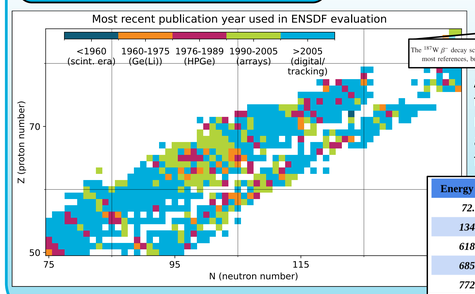
Quickly integrating new data into databases establishes a **robust decay data** foundation for activation-derived cross sections used in transport libraries, as well as decay heat and dose predictions in fusion energy systems.

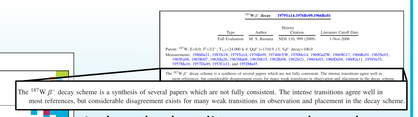
Current Decay Data Limitations



While measurement capabilities have evolved, most measurements of decay data for nuclides of interest for applications have been performed with legacy techniques, producing inconsistent and uncertain data.

The example of ^{187}W





A close look at literature values shows that transition intensities differ by as much as 10% for the strongest γ rays, and up to 25% when considering the full decay scheme.

Energy (keV)	Iγ (1986Ha21)	Iγ (1979Ya14)	Iγ (1976Br09)
72.0	47.2 (22)	39.6	51.0 (2)
134.3	40.7 (19)	33.5	40.5 (2)
618.4	30.5 (13)	29.9	28.7 (1)
685.8	114 (4)	133	125 (1)
772.8	17.7 (8)	20.8	18.9 (1)

Our Strategy for Better Decay Data

IDENTIFY LIMITATIONS IN EXISTING DATA

PRODUCE AND REMEASURE NUCLIDES WITH STATE-OF-THE-ART SPECTROSCOPY TECHNIQUES

PUBLISH AND INCLUDE RESULTS IN NUCLEAR STRUCTURE DATABASES

UPDATE EVALUATION

Production Pathways

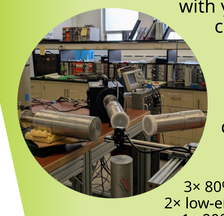
Neutron-rich nuclides will be produced via (n_{th},γ) reactions at the UMass Lowell Research Reactor (UMLRR), while other radionuclides will be produced via charged-particle-induced reactions at the BNL Tandem Van de Graaff (BTVG) facility.

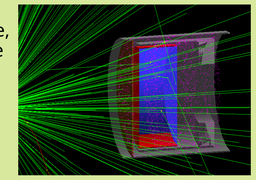
UMass Lowell Research Reactor

BNL Tandem Van de Graaff

Assay at the NNDC Decay Station

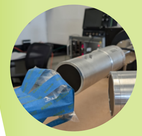
The NNDC Decay Station consists of a six-detector HPGe array for precision decay measurements. It combines excellent energy resolution over a broad energy range, with γ–γ coincidence capabilities to determine transition intensities and disentangle complex decay schemes.

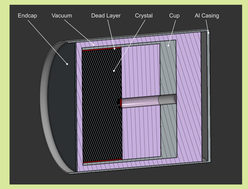




Modelling to develop a validated GEANT4-based *digital twin* of the array

3× 80% coaxial HPGe
2× low-energy planar BEGe
1× 200% coaxial HPGe

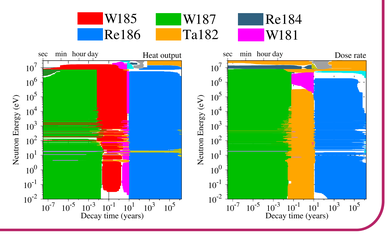




Identifying Fusion-Relevant Nuclides

Fusion-relevant radionuclides were identified using FISPACT-II inventory calculations, ranking nuclides by their contribution to decay heat, activity, and γ-dose under representative fusion neutron spectra.

^{187}W dominates the γ-dose and decay heat of irradiated tungsten for up to one month.



Project Timeline

FY26	FY27	FY28
^{187}W	^{184}Re, ^{183}Os, $^{194/196}$Au	Evaluation of the new decay data for ^{187}W, ^{184}Re, ^{183}Os and $^{194/196}$Au
(n,γ) on natural W	(p,n) on ^{184}W; (p,3n) on ^{185}Re; (p,n) on $^{194/196}$Pt	

assay at Gammasphere — assay at NNDC Decay Station

A staged campaign targeting high-impact radionuclides, with each measurement followed by rapid decay-data evaluation and dissemination.

Acknowledgements

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