Nuclear Industry Data Needs

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University of Manchester
Industrial nuclear data:

Data which underpin the safety and economics of industrial nuclear operations and processes

Worldwide endeavour

No single country has funding and expertise to do this alone.
Experimental measurements (differential & integral)
- National Labs
- Research Institutes
- Universities

EXFOR (reaction data)
CINDA (bibliographic info)

Evaluation Projects
- USA: ENDF/B-VII.1
- EU (Mostly): JEFF 3.1.2
- JAPAN: JENDL 4.0
- CHINA: CENDL 3.1
- RUSSIA: ROSFOND-2010

Peer review
Publish in standard format
Openly shared

Reaction cross sections
Half-lives
Decay data
Reaction mechanisms

International network cooperating under auspices of IAEA for collection, compilation, & dissemination of data

NRDC
Nuclear Reaction Data Centres (NNDC, NEA, RNDC, IAEA-NDS)
The Joint European Fission Fusion (JEFF) data library

**OECD** (Organization for Economic Cooperation and Development)

**NEA** (Nuclear Energy Agency) (31 members including UK)

Coordinates **JEFF**

Nuclear Data Bank (separate subscription, UK still in)

**WPEC** (Working Party on Evaluation Cooperation) (Assesses nuclear data needs and initiates joint evaluation or measurements efforts)

**High Priority Request List** (long-term subgroup)

**Short-term subgroups** – set up when particular problems are flagged-up. Key people are found to consider data, evaluations and report back. May place recommendation on High Priority Request List.

**WPEC37** – only one with UK coordinator
### UK contributions to international effort

#### Experimental measurements

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#### Evaluation, Validation, Codes

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<th>Institution</th>
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<tr>
<td>NNL</td>
<td>(Robert Mills, Kevin Hesketh, Deb Hill)</td>
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<td>AMEC (Winfirth)</td>
<td>(Ray Perry, Paul Smith and ANSWERS team)</td>
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<tr>
<td>CCFE</td>
<td>(Jean-Christophe Sublet)</td>
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<td>AWE</td>
<td>(Bruce Thom)</td>
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<tr>
<td>NPL</td>
<td>(Decay data and Standards Group – Steve Judge)</td>
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<tr>
<td>Imperial College</td>
<td>(Matt Eaton – processing of covariance data)</td>
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Long time (~5 years) to develop new version of JEFF

Customer need for calculation

Is Codes/Data adequate?

no

yes

no

Larger safety margin

Results for customer

Validate against integral experiments

Sensitivity study: is validation adequate?

no

yes

Carry out calculations

Process evaluated file for application

 Publish evaluated file

 Evaluate

New nuclear data needed by method

New integral experiments required

New methods developed and programmed

Perform integral measurements

Perform differential measurements

Analyse and report results in open literature

Review of existing data

Evaluation

Process evaluated files for new method

New code development required

New nuclear data required

Plant operator, SLC

Contractor (eg NNL, AMEC)

Source code holder (eg NNL, AMEC, ORNL, LANL)

International institutes/facilities, universities (JEFF, WPEC, IAEA, NEA, CERN, EC-JRC, LANL....)

Picture from NNL: C. Zimmerman, R. Mills
UK nuclear data need

Thermal reactor current operations
(reprocessing, waste calculations, transport safety of irradiated fuel, decommissioning)

JEFF data needed for inventory codes and decay heat (FISPIN, FISPACT), shielding codes (eg MCBEND), criticality codes (eg MONK), Reactor codes (WIMS), radwaste heat production codes

Envelope of operation has not changed significantly for some decades and applications of nuclear data (with optimised guesses when data are not available) works well for applications for which it was validated
UK nuclear data need

Data for future operations
(Gen-III future build, Gen-IV, use of MOX, graphite waste, repository)

New data needed for reactor design codes, safety codes, criticality codes

Extended envelope of operation - the compensating errors may not work in new applications

Heat of irradiated UOX and MOX fuel in a repository
**GEN-IV:** nuclear cross-sections vitally important for understanding advanced technologies such as transmutation of minor actinides in either fast reactors or accelerator driven systems. 

- There is a 10% uncertainty on capture cross-sections in the fast spectrum of the most important isotopes (U-235, U-238, Pu-239).
- Fission cross sections needed for Am-241,242, Cm-244,245, Pu-240,241,242
**Experimental measurements**

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Currently funded under single EPSRC grant (Fission Energy Call)

UK universities have access to unique international facilities and equipment
Produced by (D,T) reaction

- UK primary standard for 14 MeV neutrons produced by (D,T) reaction

Slide provided by Lee Packer, CCFE
Experimental activities: foil irradiation and measurements at ASP

Short- and medium-lived reaction product measurements using HPGe detector

Fast sample extract system (poly tube + compressor)

Slide provided by Lee Packer, CCFE
Decay Heat Measurements Using a Total Absorption Spectrometer (TAS)

The pandemonium effect in beta decay

S Rice, E Valencia, A Algora, JL Taín, PH Regan, Z Podolyák, J Agramunt, W Gelletly and AL Nichols

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TABLE V. Results of the average $\beta$ and $\gamma$ energies and their comparison with databases. The difference is calculated with respect to the JEFF-3.1 database.
Unique features of Jyväskylä Accelerator Laboratory, Finland:
• “IGISOL” ion source – provides even refractory elements in 1 ms
• Penning trap – can separate isobars (and even isomers) by exact mass and deliver to TAS detector
Manchester & York: neutron cross-section measurements

Members of n_TOF Collaboration (40 institutions including 13 Nat Labs)
The n_TOF Facility at CERN

- **Linac 50 MeV/c**
- **Booster 1.4 GeV/c**
- **Proton Beam 20 GeV/c 7x10^{12} pps**
- **Pb Spallation Target**
- **Neutron Beam**
- **n_TOF 185 m flight path**
- **PS 20 GeV/c**

**The n_TOF Facility at CERN**
An array of 40 BaF$_2$ detectors measure the neutron-capture events.
Neutron Capture Cross-section measurement of $^{238}\text{U}$
(aiming at very high accuracy)

NEA request to measure $^{238}\text{U}(n,\gamma)$ cross section with 2% accuracy from 100 eV to 25 keV

Hands on work at the n_TOF facility, CERN measuring a $^{238}\text{U}$ sample

Isotopic purity $^{238}\text{U}$: 99.99%

University involvement:
• **Manchester** – $^{238}\text{U}(n,\gamma)$ measurement (above)
• **York** – $^{236}\text{U}(n,\gamma)$ measurement
Manchester will install its fission fragment spectrometer at n_TOF

Measures $\gamma$-ray Energy and Multiplicity

- Response to NEA High Priority Request of more accurate knowledge of heating caused by gamma emission in the next generation of nuclear reactors
- Coincidence with emission of prompt gamma rays as a function of the fragment mass and energy
- Investigates the fission process at different neutron energies
- Technique validated at the ILL measuring with thermal neutrons
STEFF
SpecTrometer for Exotic Fission Fragments

Solid angle 60 mstr

Will be positioned on a new high-flux neutron beam line (from 2014)
Final Comments:

During 1960s and 1970s UK pioneered development of nuclear data libraries (AEA Harwell and Winfrith).

In 1980s UK joined JEFF, funding was cut, contribution to research work was stopped.

UK is the only country with no government funding to support nuclear data involvement. Not on Beddington or ONR radar.

Current EPSRC funding of university groups stops next year.

UK has no coordinated national programme. UKNSF (Nuclear Science Forum) did at least keep UK interested parties informed of what was going on.

UK nuclear data expertise resides in very few people – vulnerable.

NNL is to host the new Nuclear Innovation and Research Office – perhaps NIRO should take over this coordinating role?