

# Evaluation of Decay Data for Actinides

Nuclear Spectroscopy Users' Forum

18<sup>th</sup> May 2010

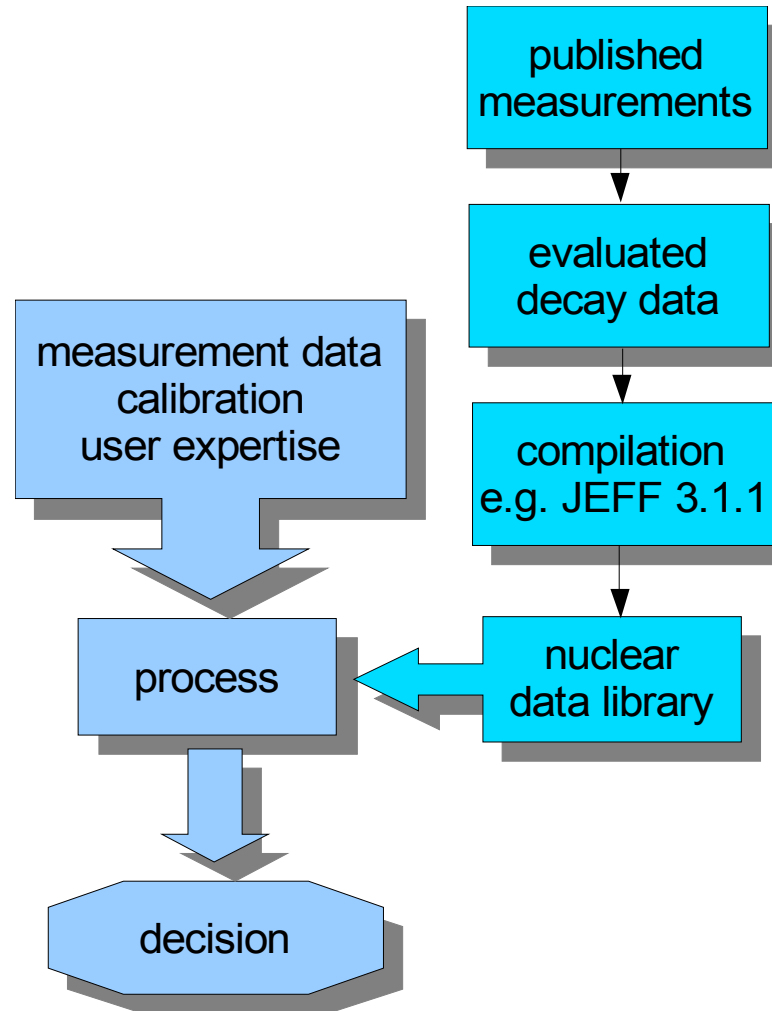
Andy Pearce, NPL

# Introduction

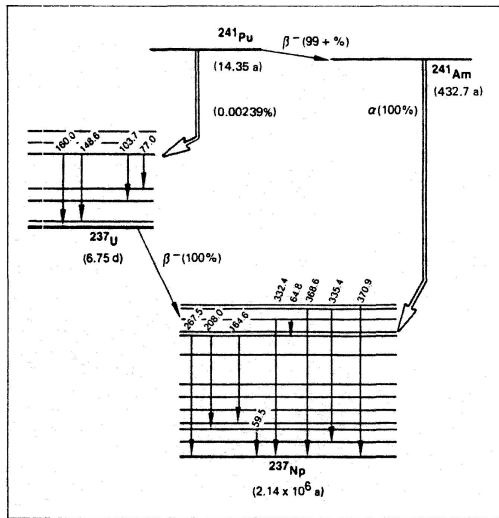


- Background to the project
  - aims of project
  - participants
  - methodology
- Project conclusions
- NPL's work
- Other things

# Requirement for nuclear data



# Overview of Project



TECHNICAL REPORTS SERIES No. 261

Decay Data  
of the Transactinium Nuclides

- IAEA Coordinated Research Programme (CRP) to provide improved decay data for actinides
- Scheduled to run from 2005-2009 (slight overrun)
- Planned project output: DDEP evaluations plus replacement for TECHREP-261



INTERNATIONAL ATOMIC ENERGY AGENCY, VIENNA, 1986

# Participating institutions

Institution	Country	Participating scientists
IAEA	-	*Mark Kellett ( <i>project officer</i> ), *Alan Nichols
LNHB	France	*Marie-Martine Bé ( <i>DDEP coordinator</i> ), Vanessa Chisté, Christophe Dulieu
ANL	US	*Filip Kondev
IFIN	Romania	*Aurelian Luca
KRI	Russia	*Valery Chechev, Nikolay Kuzmenko
NPL	UK	Arzu Arinc, *Andy Pearce
CIAE	China	*Xiaolong Huang, Baosong Wang
VECC	India	*Gopal Mukherjee
BNL	US	Edgardo Browne ( <i>peer review coordinator</i> )

# Radionuclides

Element	Isotopes	Element	Isotopes
Hg	$^{206}\text{Hg}$	Ac	$^{225}\text{Ac}$ , $^{227}\text{Ac}$ , $^{228}\text{Ac}$
Tl	$^{206-210}\text{Tl}$	Th	$^{228}\text{Th}$ , $^{229}\text{Th}$ , $^{231-234}\text{Th}$
Pb	$^{209-212}\text{Pb}$ , $^{214}\text{Pb}$	Pa	$^{231}\text{Pa}$ , $^{233}\text{Pa}$ , $^{234}\text{Pa}$ , $^{234\text{m}}\text{Pa}$
Bi	$^{210-215}\text{Bi}$	U	$^{232-239}\text{U}$
Po	$^{210-216}\text{Po}$ , $^{218}\text{Po}$	Np	$^{236-239}\text{Np}$ , $^{236\text{m}}\text{Np}$
At	$^{211}\text{At}$ , $^{215}\text{At}$ , $^{217-219}\text{At}$	Pu	$^{238-242}\text{Pu}$
Rn	$^{217-220}\text{Rn}$ , $^{222}\text{Rn}$	Am	$^{241-244}\text{Am}$ , $^{242\text{m}}\text{Am}$ , $^{244\text{m}}\text{Am}$
Fr	$^{221}\text{Fr}$ , $^{223}\text{Fr}$	Cm	$^{242-246}\text{Cm}$
Ra	$^{223-226}\text{Ra}$ , $^{228}\text{Ra}$	Cf	$^{252}\text{Cf}$

NPL provided evaluations of  $^{228}\text{Ac}$ ,  $^{232}\text{U}$ ,  $^{232}\text{Th}$ ,  $^{231}\text{Pa}$

# Evaluation Procedures

What is provided

- Half life
- Alpha energies, emission probabilities
- Beta energies, emission probabilities
- Gamma energies, emission probabilities
- Decay schemes
- Conversion coefficients
- Atomic data (fluorescence yields, X-ray emissions)
- Decay schemes
- Nuclear data: transition types, hindrance factors, logft, Q-values

# Evaluation Procedures

## DDEP methodology

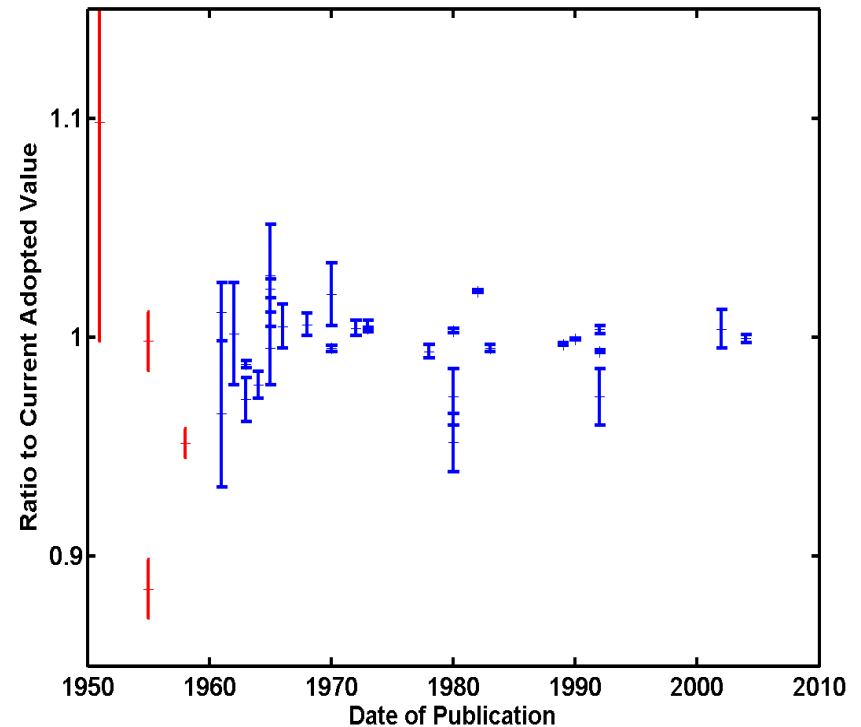
- Critical analysis of published results
- Data from open publications only
- Recommended values derived from analysis – usually LRSW weighted mean – of measured values
- Balance of decay scheme
- Certain values derived from compilations or calculations (e.g. total decay energy, conversion coefficients)
- Each evaluation peer-reviewed
- Published on website with associated evaluators comments
- Published in paper form as BIPM Monographie 5
- Typical evaluation: 3-6 months work

# Radionuclide specific results (NPL)

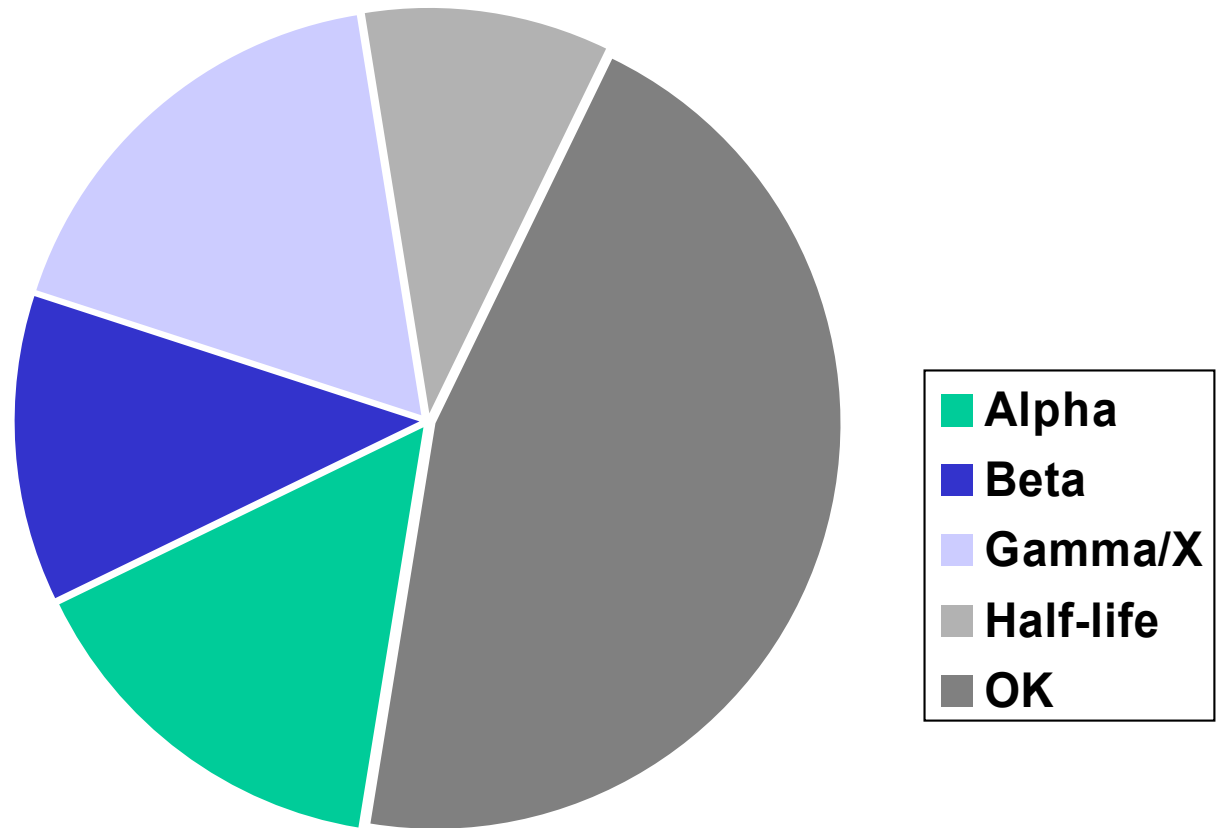
Radionuclide	Issues	Status
$^{228}\text{Ac}$	Only one measurement of half-life Adopted decay scheme implies unrealistic beta branching ratios – missing gammas?	Online
$^{231}\text{Pa}$	Insufficient data for low energy gammas Gamma and alpha emissions inconsistent	Submitted, awaiting peer review
$^{232}\text{Th}$	Generally OK	Online
$^{232}\text{U}$	Generally OK	Online

# Availability of data

- Sparse data can make life difficult for evaluators
- Sometimes only one measurement is available of half lives or gamma emissions, often all available data is from 1950s-60s
- Example with  $^{209}\text{Po}$ : ENSDF value 102 (5) years from 1956An05; Collé et al (2007) report this *may* be 25 % in error



# Radionuclides (those requiring more mmts)



# Summary

- Data for 95 actinides/decay daughters evaluated and being added to the Decay Data Evaluation Project
- Data for around 1/3 of radionuclides could be improved through new measurements

# Decay data recommended by NPL

- **DDEP/BIPM Monographie 5**
  - [www.nucleide.org/DDEP\\_WG/DDEPdata.htm](http://www.nucleide.org/DDEP_WG/DDEPdata.htm)
  - [www.bipm.org/en/publications/monographie-ri-5.html](http://www.bipm.org/en/publications/monographie-ri-5.html)
- **IAEA STI/PUB/1287**
  - [www-nds.iaea.org/xgamma\\_standards/](http://www-nds.iaea.org/xgamma_standards/)
- **NUDAT**
  - [www.nndc.bnl.gov/nudat2/](http://www.nndc.bnl.gov/nudat2/)

# Useful compilations:

**LARAWEB:**

[laraweb.free.fr/](http://laraweb.free.fr/)

**JANIS (for JEFF database):**

[www.nea.fr/janis/](http://www.nea.fr/janis/)

That's all...

# Allocation of radionuclides

Institution	Radionuclides
IAEA	$^{228}\text{Th}$ , $^{242,242\text{m},244,244\text{m}}\text{Am}$ , $^{208}\text{Tl}$ , $^{212,215}\text{Bi}$ , $^{212,216}\text{Po}$ , $^{211,219}\text{At}$ , $^{219,220}\text{Rn}$ , $^{224}\text{Ra}$
LNHB	$^{243}\text{Am}$ , $^{234,238}\text{U}$ , $^{252}\text{Cf}$ , $^{210}\text{Tl}$ , $^{210,214}\text{Pb}$ , $^{210,214}\text{Bi}$ , $^{210,214,218}\text{Po}$ , $^{218}\text{At}$ , $^{218,222}\text{Rn}$ , $^{226}\text{Ra}$
ANL	$^{243,245,246}\text{Cm}$ , $^{206}\text{Hg}$ , $^{206,207,209}\text{Tl}$ , $^{209,211}\text{Pb}$
IFIN	$^{234}\text{Th}$ , $^{236}\text{U}$ , $^{211}\text{Bi}$ , $^{211}\text{Po}$ , $^{228}\text{Ra}$
KRI	$^{233}\text{Th}$ , $^{233}\text{Pa}$ , $^{237,239}\text{U}$ , $^{236,236\text{m},237,238,239}\text{Np}$ , $^{238,239,240,241,242}\text{Pu}$ , $^{241}\text{Am}$ , $^{242,244}\text{Cm}$ , $^{227}\text{Ac}$
NPL	$^{232}\text{Th}$ , $^{231}\text{Pa}$ , $^{232}\text{U}$ , $^{228}\text{Ac}$
CIAE	$^{231}\text{Th}$ , $^{234,234\text{m}}\text{Pa}$ , $^{235}\text{U}$ , $^{221-223}\text{Fr}$ , $^{217}\text{At}$ , $^{217}\text{Rn}$ , $^{213}\text{Bi}$ , $^{213}\text{Po}$ , $^{225}\text{Ra}$ , $^{225}\text{Ac}$
VECC	$^{229}\text{Th}$ , $^{233}\text{U}$