General progress of ANDES WP2: Uncertainties and covariances of nuclear data

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Introduction

Uncertainty estimation and covariance data is a top priority in reactor and fuel cycle analysis:

- Answers alone are not enough, we also need to quantify the quality of the answers!
- The precision of all data we use must be provided in computational form for applied calculations
- Enables safe nuclear designs in a cost-effective manner
- Needed for uncertainty propagation in reactor simulation
- Gives reactor physicists a means to post-adjust data to integral measurements
- Good covariance data, if combined with a reliable sensitivity study, gives the best justification for new differential measurements.

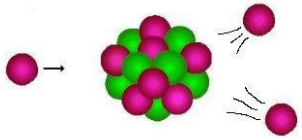
Safety and sustainability – nuclear data

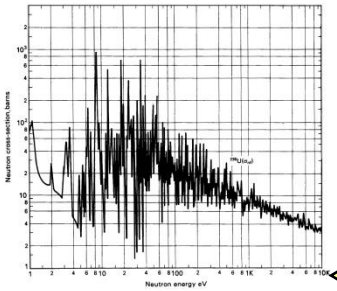
Starting point: basic nuclear data for reactor and fuel cycle analyses have uncertainties

Required: insight in how uncertainty of nuclear data is propagated to nuclear energy safety and sustainability issues.

Observation: the world is working hard to yield answers to this within 10-20 years.

Claim ANDES project: it can be done faster than that





Measurements ± uncertainty

TALYS

[Download TALYS-1.4!](www.talys.eu)

www.talys.eu

Nuclear data

Reactor physics code (MCNP,etc)

Statical reactor behavior

Transient code

Dynamical reactor behavior

Objectives

Enhance the European capability to produce uncertainty data for isotopes important for advanced reactors

Three aspects of nuclear data evaluation come together:

- Uncertainty evaluation of experimental data
- Uncertainty evaluation of data from models
- A proper theoretical treatment and evaluation of nuclear reactions on actinides (especially fission models) and its relation with 1. and 2.

In addition:

- Covariance data for radioactive decay and fission yield data
- Use all of the above in processing, reactor and fuel cycle codes.

In ANDES-WP2, all this is organized in 5 tasks

Partner list

- CEA-DAM (Bauge): experimental uncertainty methods + TALYS fission model development
- CEA-CAD (de Saint-Jean): CONRAD resonance code
- Univ Bucharest(Sin): Fission modeling
- NRG (Koning): TALYS nuclear model code, production of nuclear data libraries + covariances, RRR+URR+fast neutrons, applied (benchmarking) criticality, shielding and reactor calculations
- UNED/UPM (Cabellos): Uncertainty propagation for back-end of the fuel cycle, apply covariance data in activation code.
- NNL (Mills): Covariances for fission yield and decay data, spent fuel inventory and decay heat calculations
- TUW (Leeb): uncertainty methods: GENEUS
- CIEMAT (Gonzalez): fuel cycle codes

Task 2.1 : Scientific coordination

Task leader: NRG

- Monitoring of progress by all WP2 partners
- Several partners: new post-docs or PhD students have started in 2011
  - Univ Wien PhD finishes in May 2012
  - BRC postdoc started in 2011
  - UPM PhD visited NRG for 3 months and finishes in 2013
- NRG: Some delay due to personnel problems in 2011:
  - Relatively larger effort in 2012-2013
- NNL: Some delay due to personnel problems in 2012
- Global progress of WP2 on schedule

Task 2.2:Covariance tool development

TASK leader: TU Wien

- Experimental covariance tool (CEA-DAM)
  - Post-doc has started in 2011
  - Software under development (implementation of covariance formulae + EXFOR interface)
  - Presentation by Suzanne Varet
- CONRAD (CEA-DEN) evaluation tool
- GENEUS evaluation tool (TU Wien):
  - PhD project being finalized
  - Presentation by Helmut Leeb

Task 2.3 Covariance data evaluation

TASK leader: NRG

Covariance evaluation for actinides:

- Complete in ENDF-6 format
- Improved new complete evaluation of Pu-239 including full covariance data. This is an importance case for
  - Total Monte Carlo uncertainty propagation for WP2 and 3.
  - The TENDL-2011,2012…library
  - Automatic optimization using integral benchmarks (WP3)
- Presentation by Arjan Koning

Task 2.4: Covariances for activation, decay and fission yields

Task leader: UPM

NNL: Fission yield and decay data

- ACAB methods for these data investigated
- See presentation of Oscar Cabellos + Daniel Cano Ott
- Method available for including each individual fissioning system. Correlations with decay data and time dependence are being studied
- Some delay due to personnel problems, but M24 will be delivered in time.
- See presentation of Robert Mills

UPM: Covariance data for spent fuel inventories and decay heat:

- See presentation of Carlos Javier Diez

Task 2.5: Application to advanced reactors

Task leader: CIEMAT

(Use covariance files in reactor and fuel cycle codes for designs from other EU projects. Determine uncertainty for most important parameters)

- System of reference: industrial-scale transmutation facility EFIT
  - core cooled by pure lead, thermal power 400 MW,
  - initial total mass of actinides 2.074 tonnes (21.7% MA)
  - 150 GWd/tHM discharge burn-up corresponding to an equilibrium cycle (~778 irradiation days).

Use Total Monte Carlo with ACAB code to get full uncertainties of inventories, using random ENDF-6 libraries and EAF (European Activation File) libraries. (in progress)

Deliverables and milestones

D2.1: Activation data libraries for Monte Carlo uncertainty propagation in fuel cycle code ACAB (M12)(NRG, CIEMAT, UPM) DONE

D2.2: Report on evaluation of 239Pu/238U and 241Am. (M30) (CEA/DEN,NRG,UB)

D2.3: Software package for experimental covariance matrix (M30) (CEA-DAM)

D2.4: Evaluated ENDF formatted file for 239Pu/238U and 241Am. (M36) (NRG, UB)

D2.5: Report with transmutation calculations for advanced reactors with new covariance data + updated sensitivity tables. (M36) (UPM,NNL, CIEMAT)

D2.6: Report on the impact of uncertainties of the fission product nuclear data on the inventory of the irradiated fuel for ACAB (UPM, CIEMAT, NNL) (M36)

Deliverables and milestones

M2.1: Report on extension of GENEUS code package including TALYS++. Especially the details on the evaluation of covariance matrices for the prior for fission observables will be given. (M24) (TUW) Done

M2.2: Report on the usability of Monte Carlo uncertainty propagation in fuel cycle codes, and comparison with conventional approach (M24) (UPM/UNED,NRG, CIEMAT). Being finalized

M2.3: An upgraded ACAB code, which now will deal with cross-channel and cross-nuclide correlations. (M24) (UPM/UNED) Done

M2.4: New computational method for the use of covariance information of reaction, decay and fission yield data in an inventory calculation (M24) (NNL). Being finalized

M2.5: A new release of CONRAD (M36) (CEA/DEN)

M2.6: A new release of TALYS, publicly available on the TALYS website (M36) (NRG, CEA-DAM)

Conclusions

- WP2 on uncertainty data well underway
- Some delay for NRG and NNL, but this can probably be accounted for in 2012-2013.