Italian National Agency for New Technologies,
Energy and Sustainable Economic Development

TAR update

Application to ALFRED

WPEC/SG46- "Target Accuracy Requirements meeting"
April 14, 2021, videoconference

Giacomo Grasso – FSN-SICNUC-PSSN

Disclaimer

The ALFRED project deals with the design of a demonstration reactor. Because of the innovative nature of the lead technology:

- relevant uncertainties are anticipated, whose assessment is part of the goals of ALFRED;
- degrees of freedom to allow extensive testing are required as part of the goals of ALFRED.

→ The ALFRED design includes margins that largely accommodate uncertainties and shifts in the operational points.

Accuracies on integral parameters

Reference values

Before assessing the design of the ALFRED core, a thorough analysis was performed in order to evaluate the uncertainties on the main integral core parameters.

Accuracies on integral parameters

Reference values

The original estimate (made by means of the BOLNA covariance matrix and JEFF-3.1.1 nuclear data) provided the starting reference to fix the design margins. Then, a new estimate was done by means of nuclear data and covariances taken from the ENDF/B-VIII.0.

Integral parameter	Initial estimate	Refined estimate
k_{eff} at BOL	1190 pcm	768 pcm
Power peak		0.264%
Absorbers worth	2.95%	1.08%
β_{eff}	0.90%	0.84%
Fuel Doppler effect	3.89%	2.94%
Coolant density effect	22.9%	14.7%
Axial fuel expansion		0.753%

Accuracies on integral parameters

Target requirements

After fixing the current accuracies on the key integral parameters, a study was conducted to discuss which could be the benefits to ALFRED from disposing of estimates affected by a lower uncertainty.

In all discussions, the main consideration raised in the opening disclaimer held as reference.

Accuracies on integral parameters

Target requirements

The conclusion of the study highlighted that almost all integral parameters investigated are already known at a degree of accuracy that does not impact with the scope and role of ALFRED.

Only for the k_{eff} an improvement could be sought.

Integral parameter	Previous statement (generic LFR)	Current statement (ALFRED)
k_{eff} at BOL	330	435
Power peak	0.16%	none (0.264%)
Absorbers worth		none (1.08%)
β_{eff}		none (0.84%)
Fuel Doppler effect	1.54%	none (2.94%)
Coolant density effect	1.88%	none (14.7%)
Axial fuel expansion		none (0.753%)

Accuracies on nuclear data

Cost parameters

The step forward was to derive, from the TAR on the k_{eff}, the corresponding TARs on the underlying nuclear data.

To make this derivation useful to inform the HPRL, cost parameters for the refinement were included, using the same three sets already established in SG26.

Isotopes and reactions	Set A	Set B	Set C
^{235}U, ^{238}U, ^{239}Pu - capture, fission, ν	1	1	1
Other fuel isotopes - capture, fission, ν	1	2	2
Non-fuel isotopes – capture	1	1	1
All isotopes - elastic scattering	1	1	1
All isotopes - inelastic scattering	1	3	10

Accuracies on nuclear data

Target requirements

The inversed problem to derive the TARs on nuclear data was solved with the three sets of cost parameters, using a 33-energy groups structure.

All TARs on integral parameters and nuclear data, with discussions on their derivation and on the anticipated consequences, «could» be found in a paper submitted for the special issue of Annals of Nuclear Energy in honor of Massimo:

D. M. Castelluccio *et al*. Nuclear data target accuracy requirements for advanced reactors: the ALFRED case.

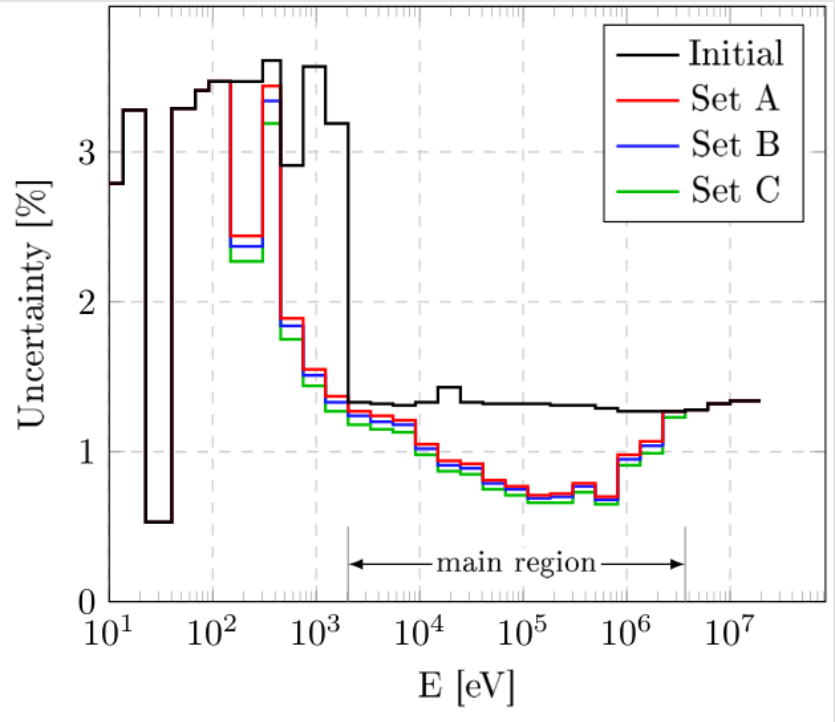
Accuracies on nuclear data

Target requirements

^{239}Pu fission

In the main energy region of interest for ALFRED (2 keV – 4 MeV), is requested to change from the current ~ 1.3% to a range of values below 1% with a minimum around 0.7%.

This is anticipated to be quite challenging from an experimental point of view.



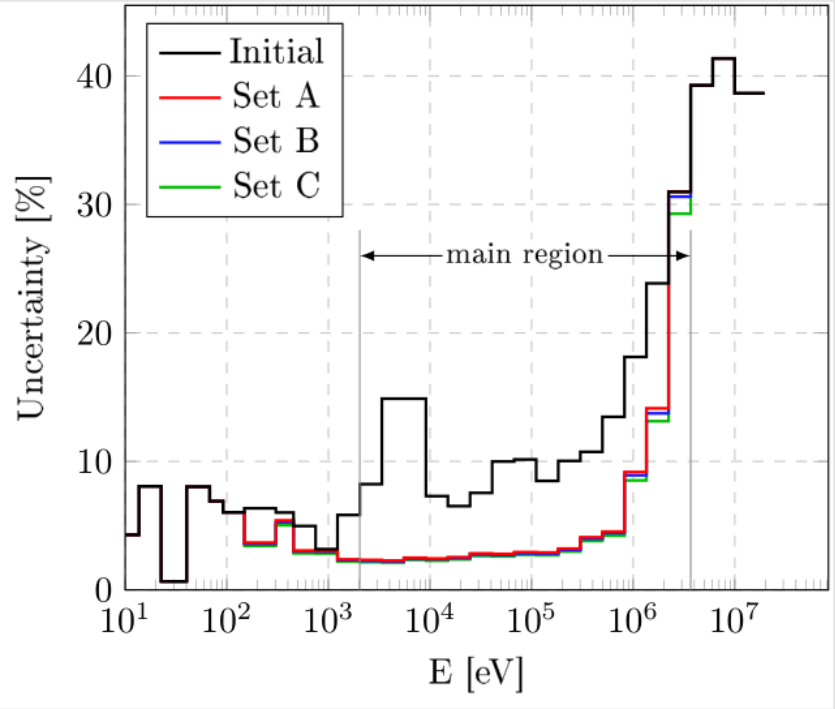
Accuracies on nuclear data

Target requirements

^{239}Pu capture

One of the reactions requested to be reduced the most, starting from a relatively high initial uncertainty (10 – 20%) while targeting an accuracy around 2% and 4% in the same range.

Although challenging, uncertainties below 10% are not uncommon and could be attained even for events in the presence of fission (e.g., with tagging techniques, n_TOF case).



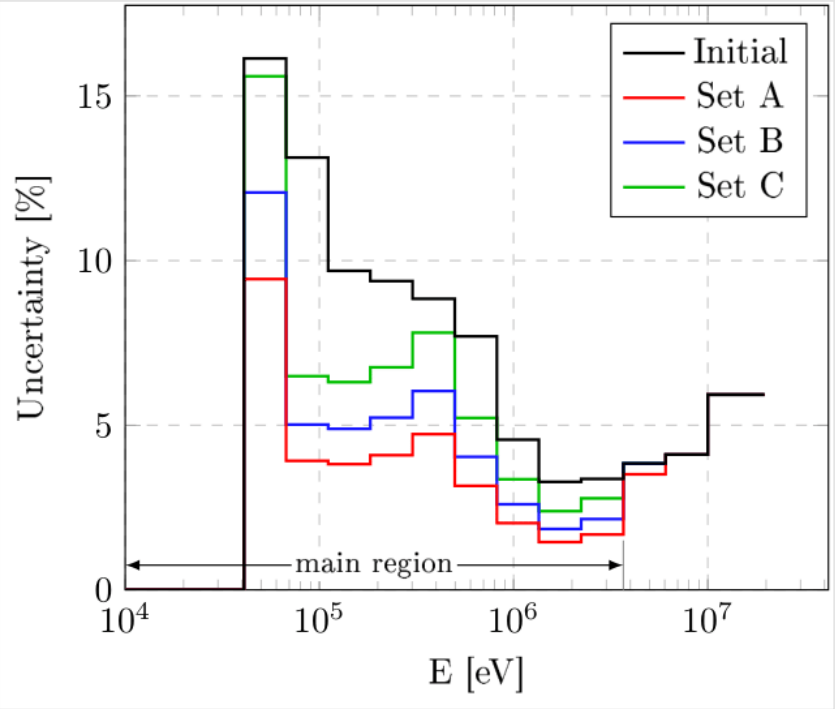
Accuracies on nuclear data

Target requirements

^{238}U inelastic scattering

Requested to target a visible reduction, also depending on the considered Set of cost parameters, in the energy region close to the threshold.

A more accurate experimental determination of the cross-section is not easily achievable, suggesting that Set C values should be the more realistic ones.



Giacomo Grasso
giacomo.grasso@enea.it