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SCALE Open Mic

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ControlBUC

Automation of Criticality Calculations with Burnup Credit (BUC) under Flexible Power Operation (FPO)

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Impact of FPO on criticality analysis

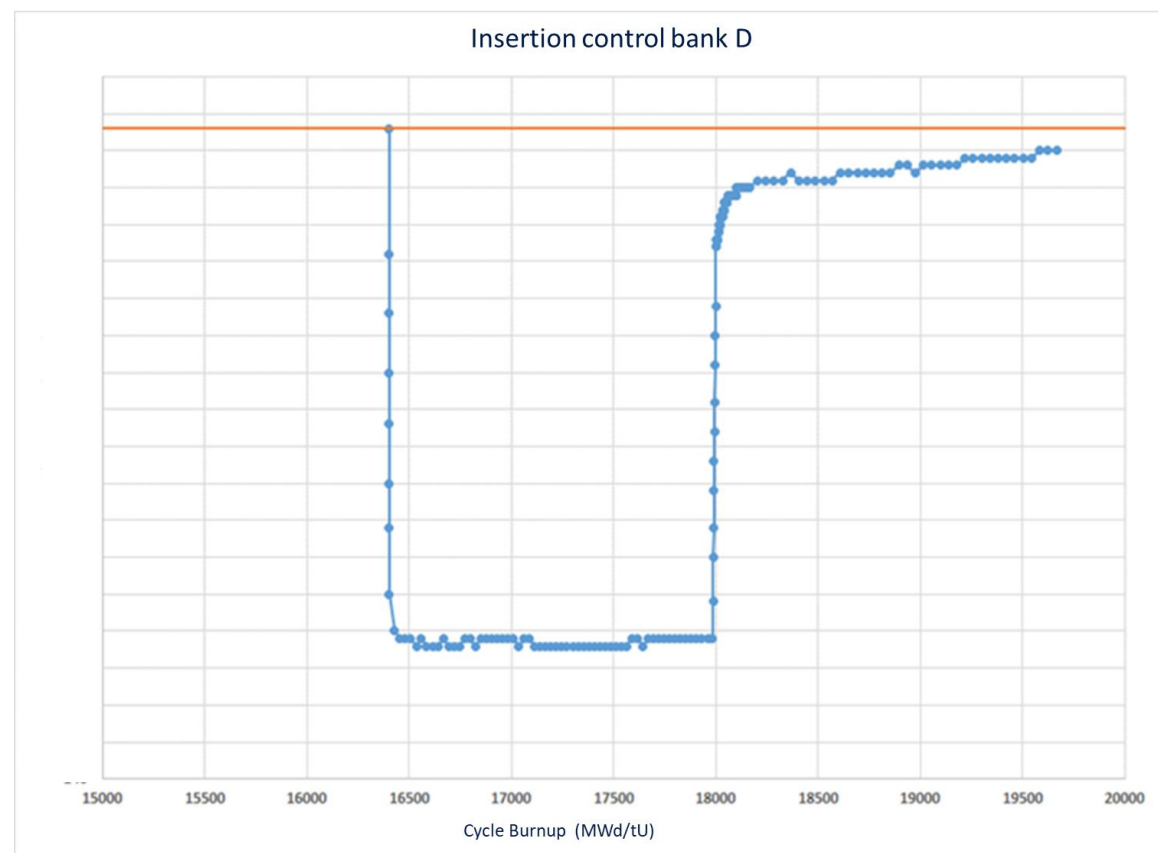
Methodology

ControlBUC

Results & Conclusions

Impact of FPO on criticality analysis

Flexible Power Operation (FPO)



Partly inserted
CRs

Power
variation

Criticality Analysis

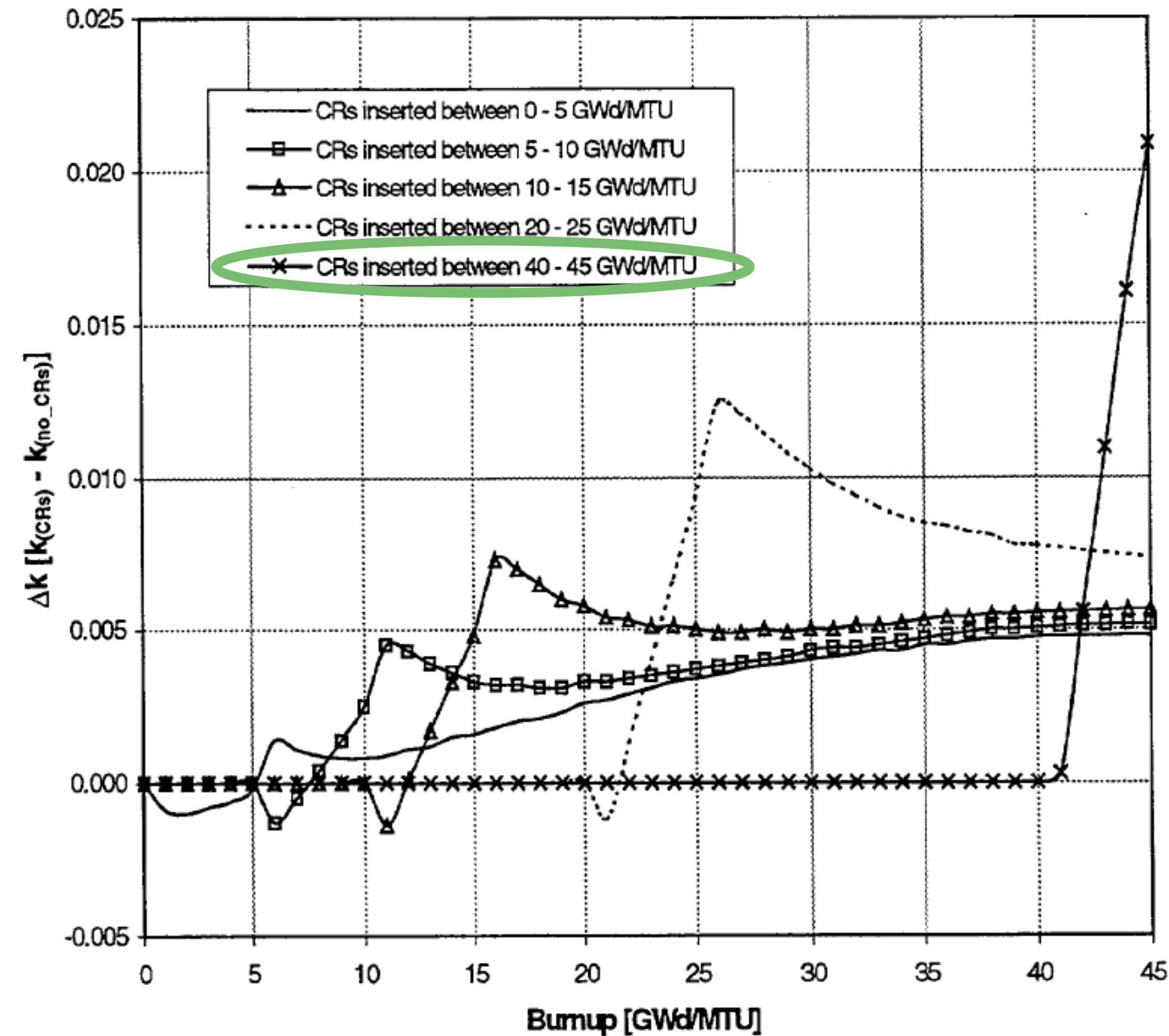
Differences

Axial burnup profile

Isotopic composition since the
neutron spectrum is harder

Impact of FPO on criticality analysis

NUREG/CR-6759 rev.0 “Parametric Study of the Effect of Control Rods for PWR Burnup Credit “, February 2002



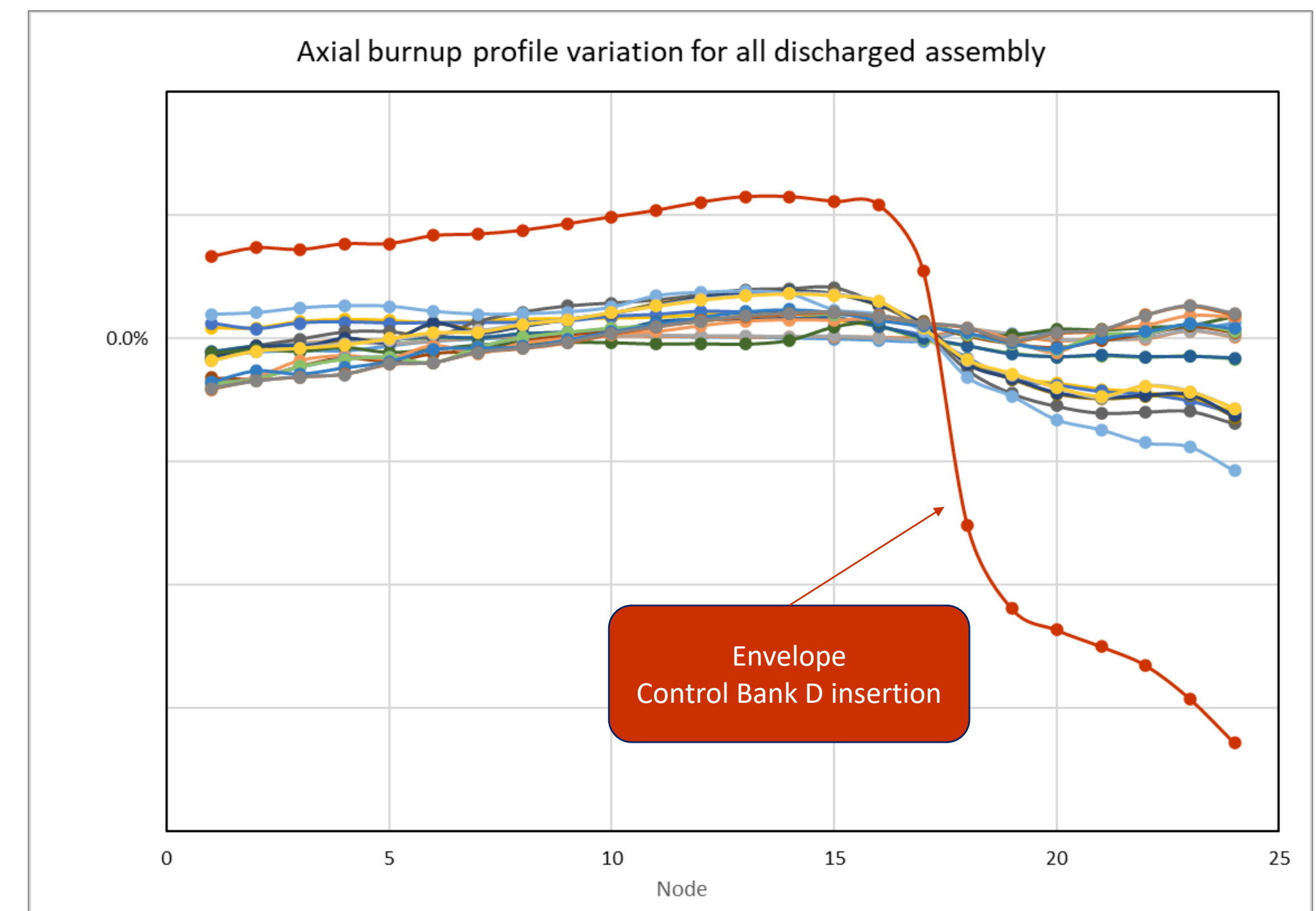
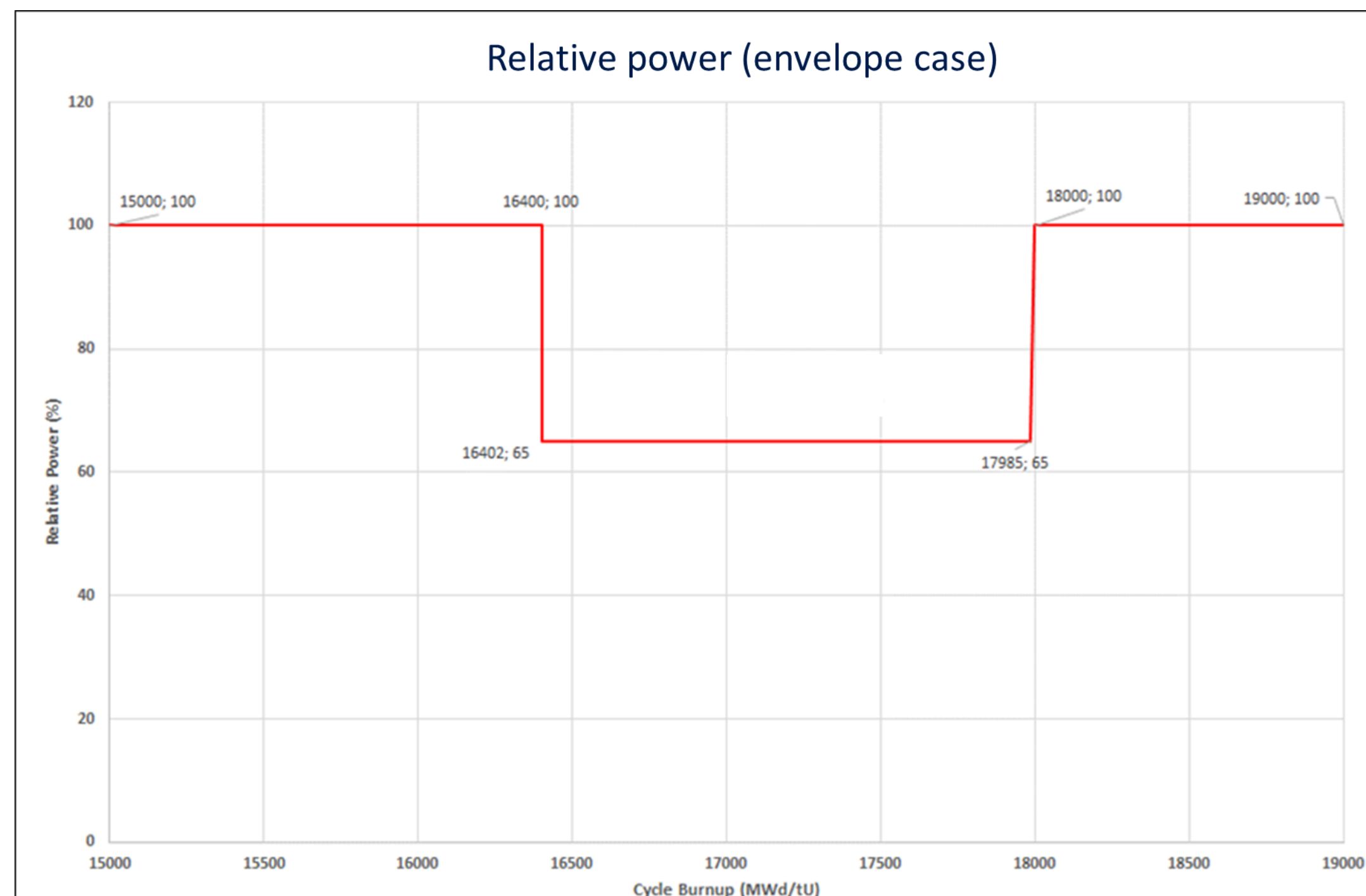
The effect is greater the higher the burnup in which the control rod is inserted

Figure 11 Comparison of Δk values as a function of burnup for 5 GWd/MTU CR exposures at various times during the burnup with initial fuel enrichment of 4 wt % ^{235}U . The results correspond to Westinghouse 17 x 17 fuel and B₄C CRs.

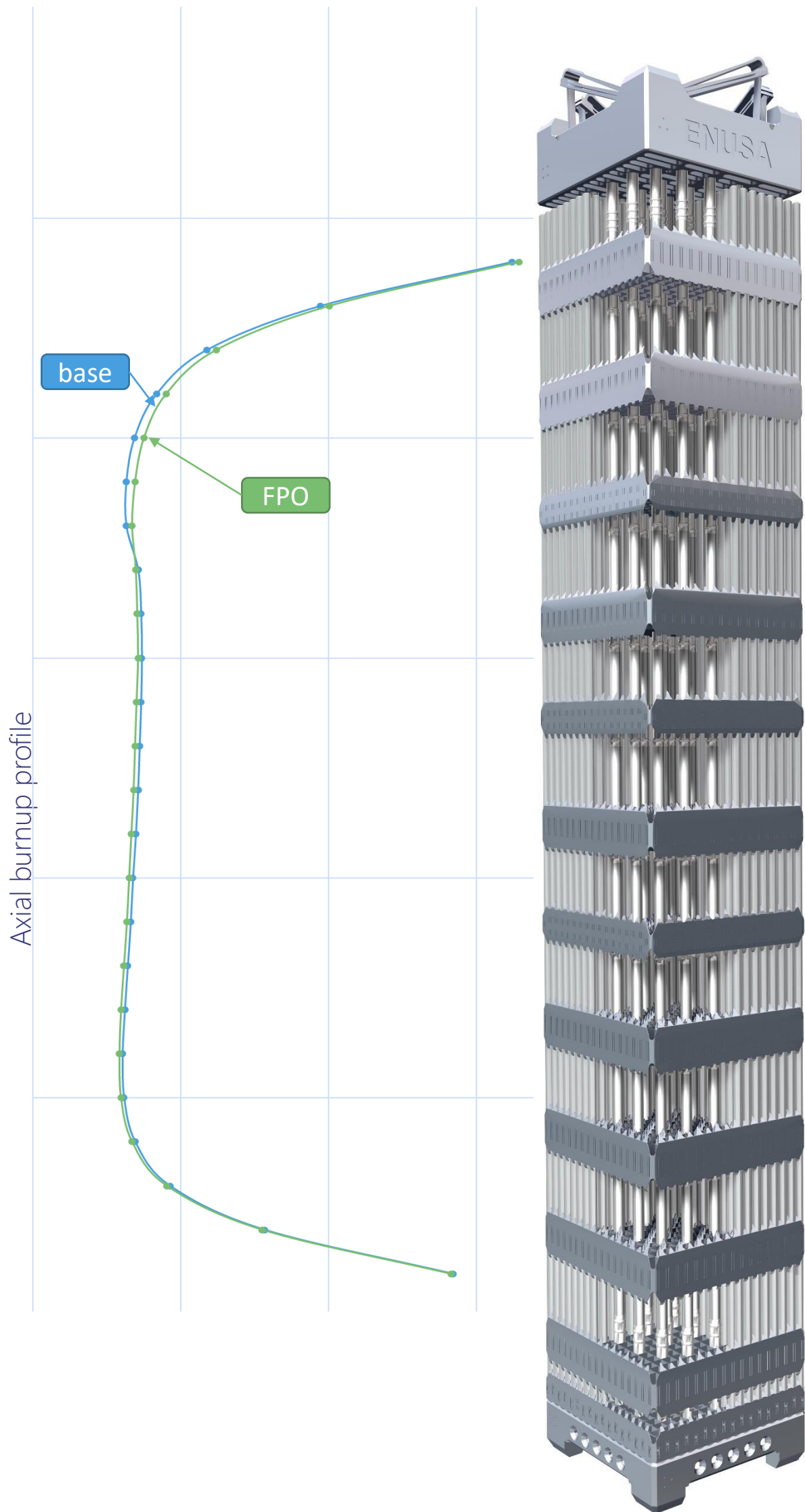
Impact of FPO on criticality analysis

Criticality Analysis

Envelope scenario



Methodology



T1 – CRout + nodal relative power1

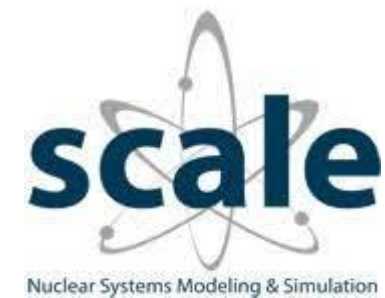
T2 – CRin + nodal relative power2

T3 – CRin + nodal relative power3

T4 – CRout + nodal relative power4

1 irradiation history per node
Capture effects

Criticality Analysis



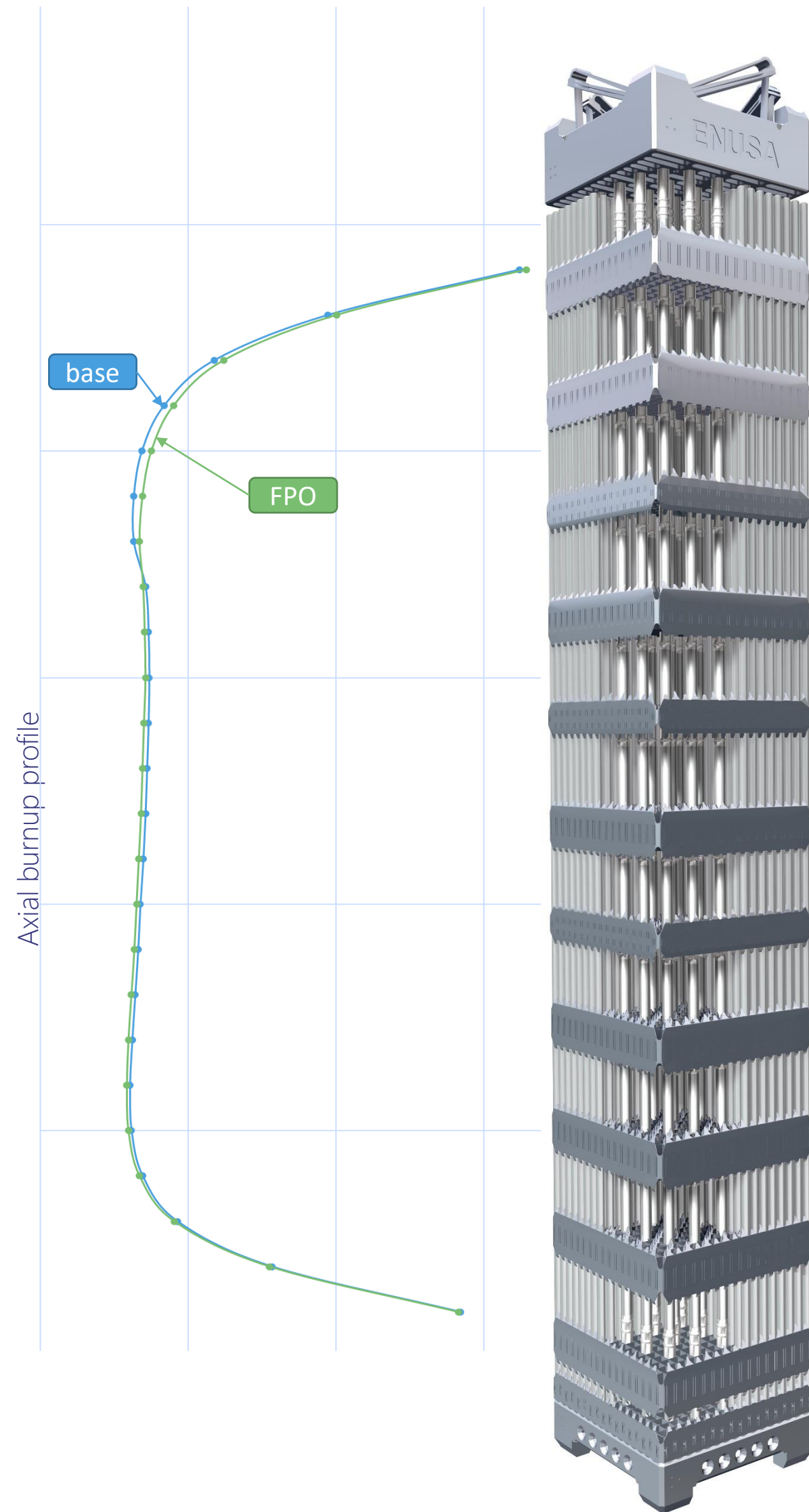
STARBUCS

Used in ENUSA for criticality analysis PWR BUC

Simulates the axial burnup profile using only one ORIGEN library (the same enrichment and irradiation conditions)

Unable to simulate different irradiation histories **per node** (CR + Relative Power)

Methodology



Methodology

TRITON

Simulation of each node irradiation condition
(CR_{in}/CR_{out} + variation of relative power)
Save the cross-section library for each node

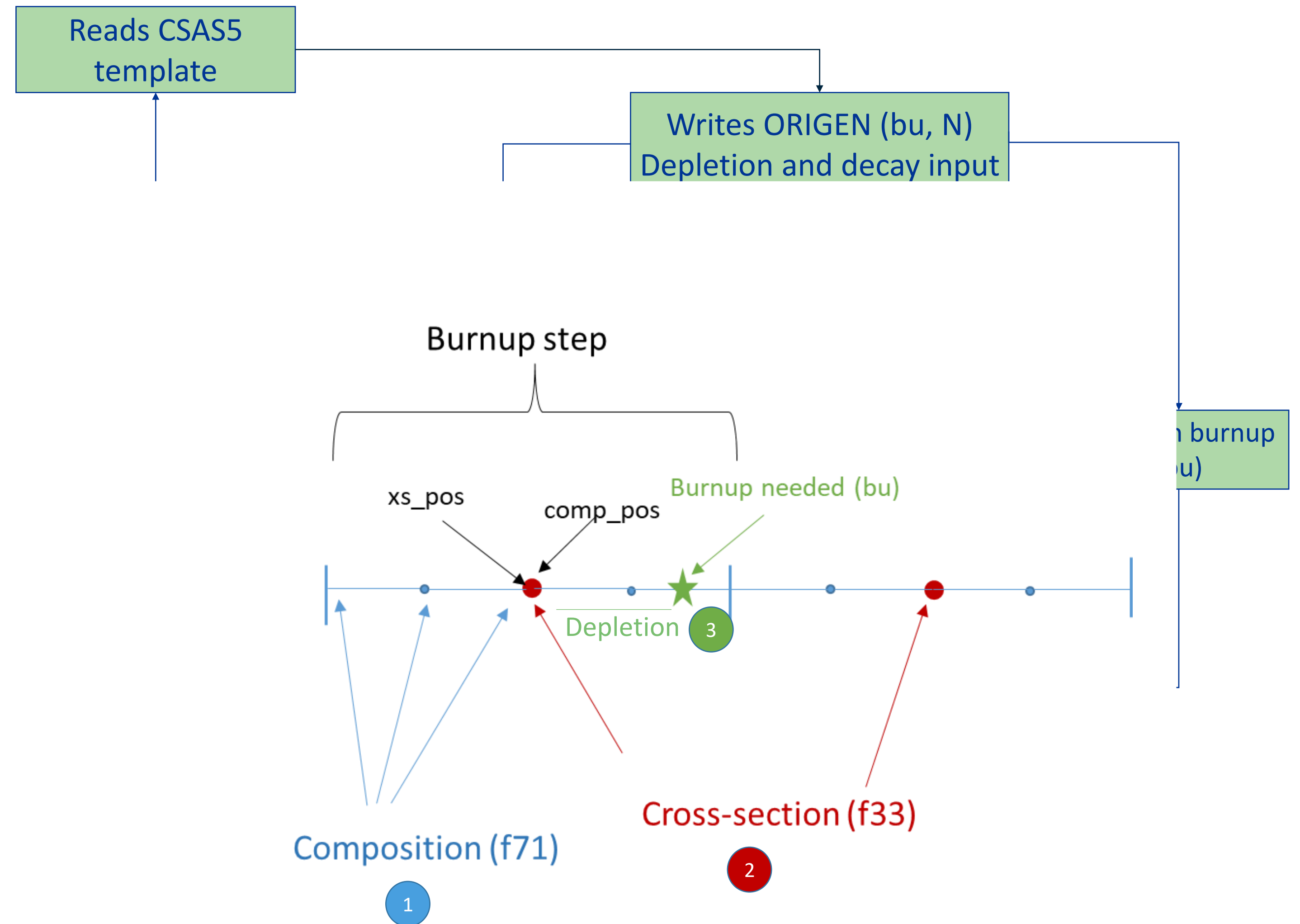
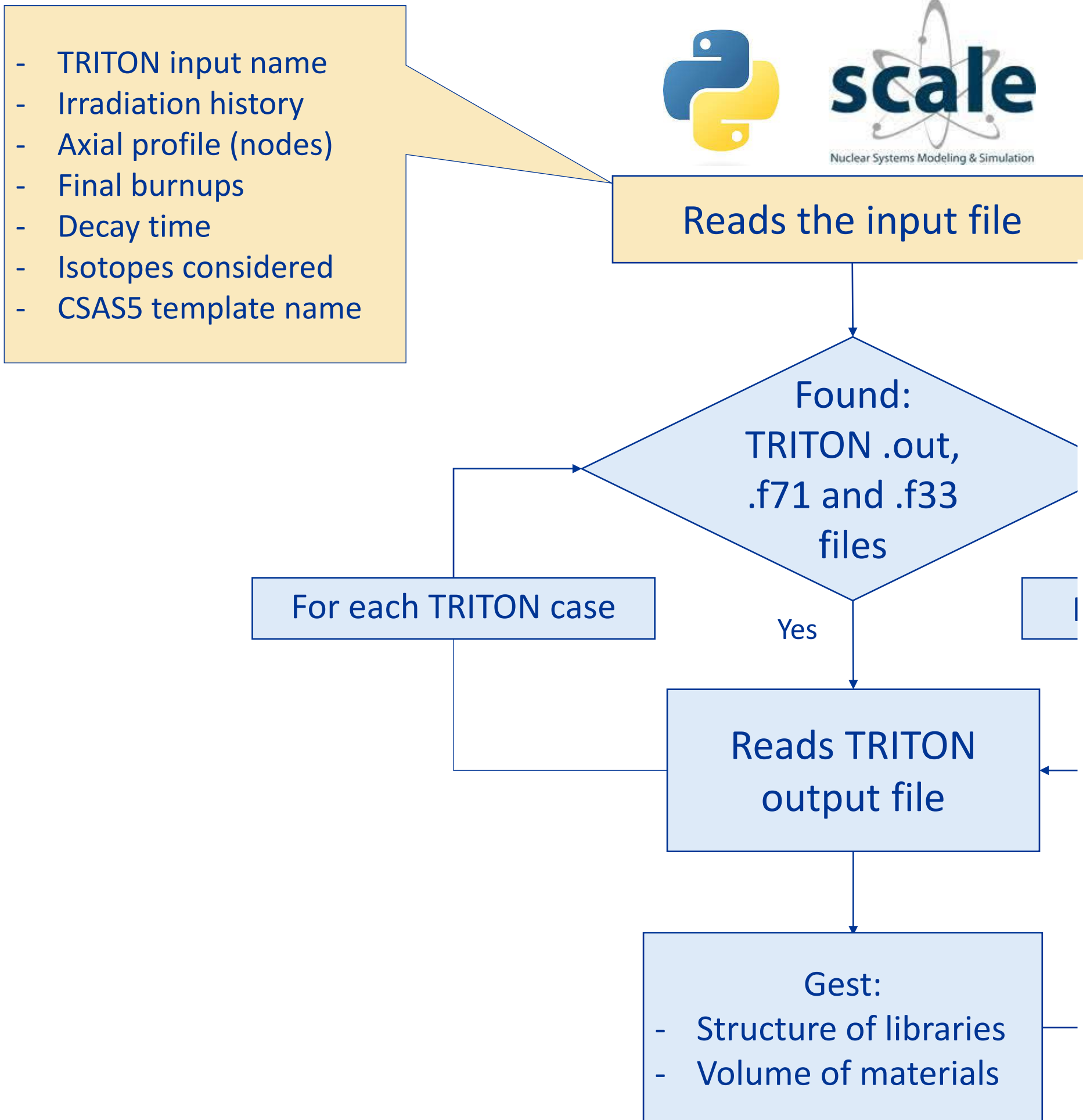
ORIGEN

Isotopic composition for the burnup of each node

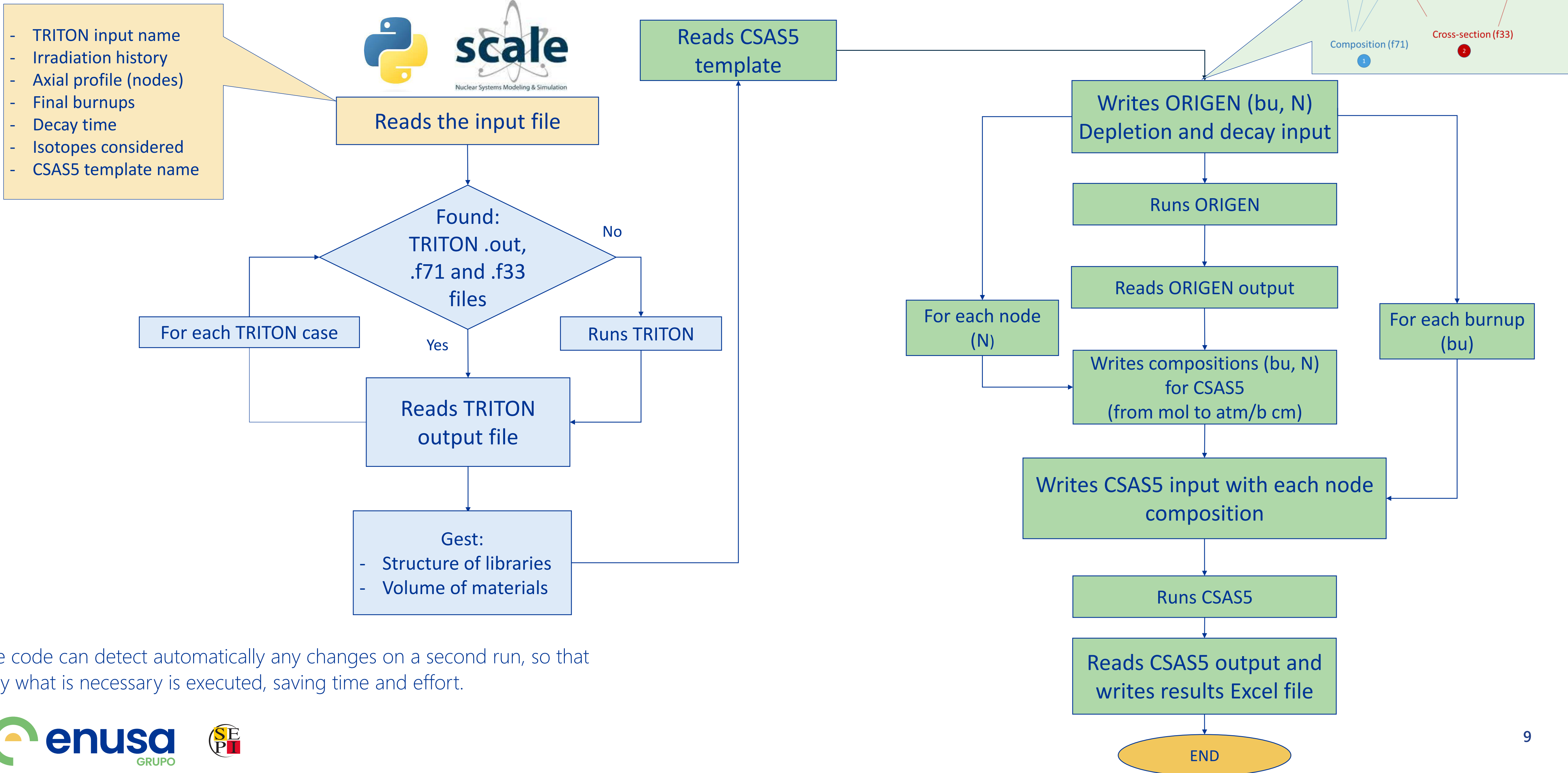
CSAS5

k_{eff} of the spent fuel

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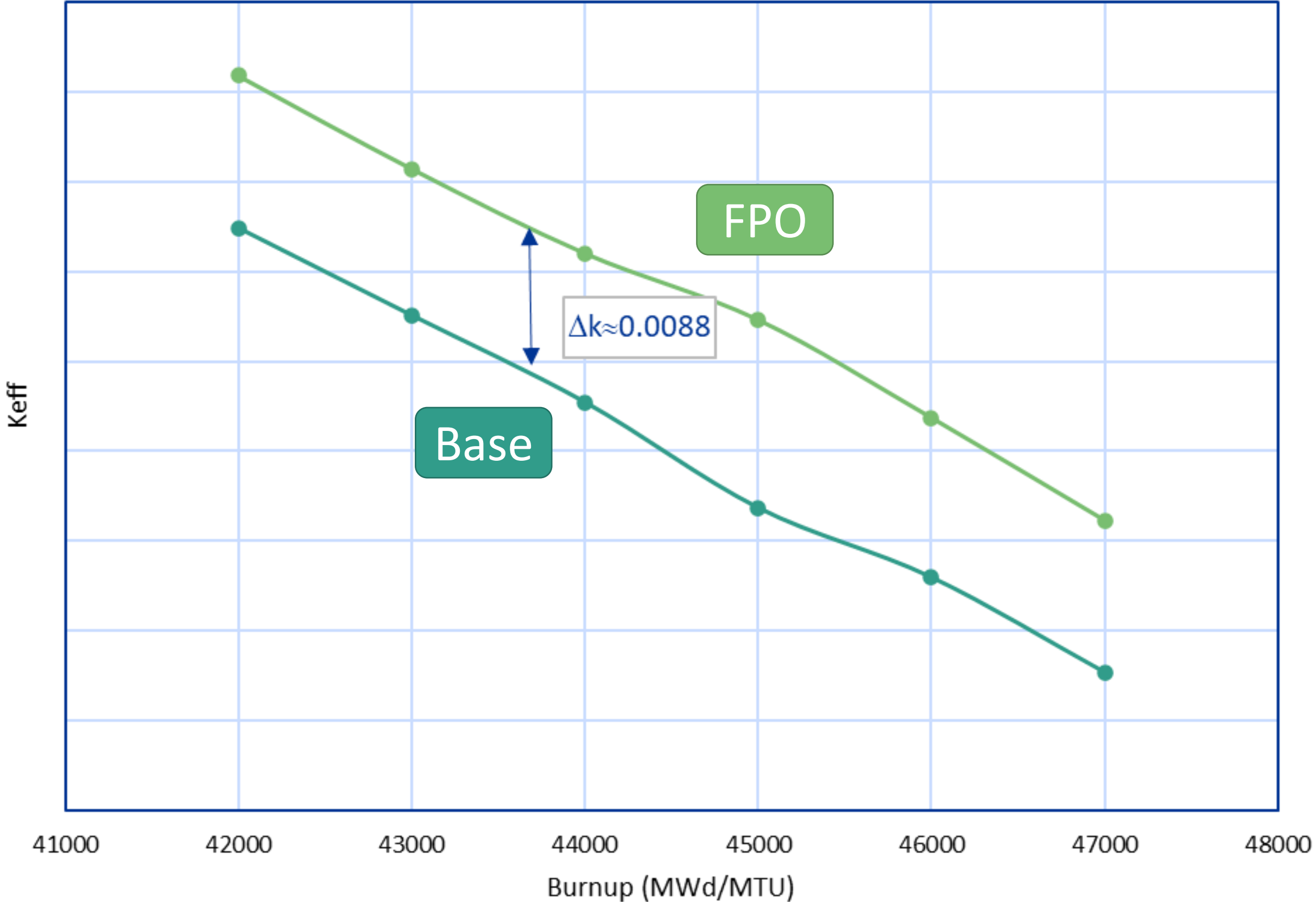
ControlBUC



The code can detect automatically any changes on a second run, so that only what is necessary is executed, saving time and effort.

Results

FPO impact



Conclusions

ControlBUC

- Tool developed in Python and validated at ENUSA to perform criticality analysis calculations automatically using the SCALE package codes (6.1 and 6.2).
- User-friendly and helps to reduce the work time and possibility of user-errors.
- It can be used in multiple types of criticality analysis:
 - FPO
 - PWR BUC with more than one fuel mixture
 - BWR at the peak reactivity (PeakBUC)

Thank you for your attention

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