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A temperature-based approach to estimate decay heat in sodium-cooled fast reactors and validate associated computational tools

Dr. Dorian Da Cunha

15 October 2026

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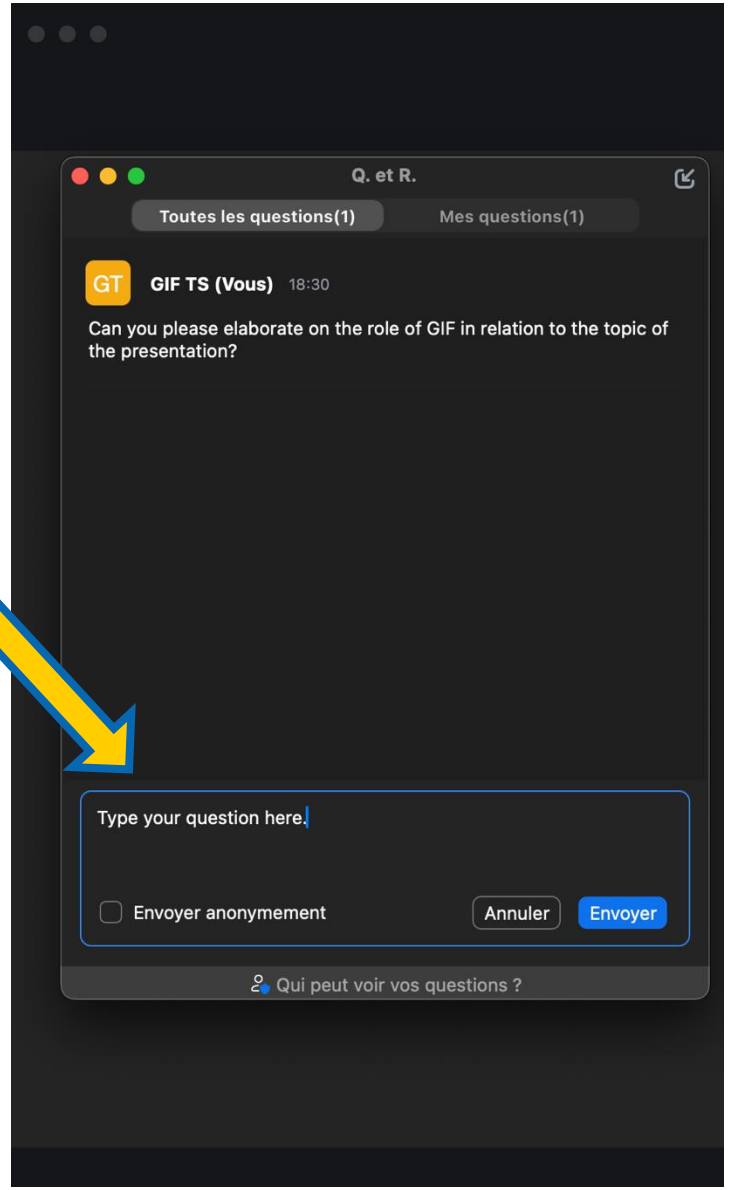
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Meet the Presenter



Dr. Dorian Da Cunha is a Research Engineer at the Commissariat à l'Energie Atomique et aux Energies Alternatives (CEA), in Cadarache, France where he currently works on optimizing the estimation of the quantities of interests for the fuel cycle of PWR.

He recently graduated from Aix-Marseille University, France. He holds a Master of Science in Physical Engineering and Embedded Systems from ENSICAEN as well as a Master's degree in Experimental Nuclear Physic from the University of Caen, in Normandy, France, where he was involved in the design of chain-reaction control devices for Molten Salt Reactors.

His Ph.D. research focused on the interpretation and analysis of decay heat measurements in sodium-cooled fast neutron reactors. He developed new methodologies for interpreting these experiments and comparing them to computed values in order to validate CEA Scientific Computation Tools.

Email: Dorian.DACUNHA@cea.fr

A temperature-based approach to estimate decay heat in sodium-cooled fast reactors and validate associated computational tools

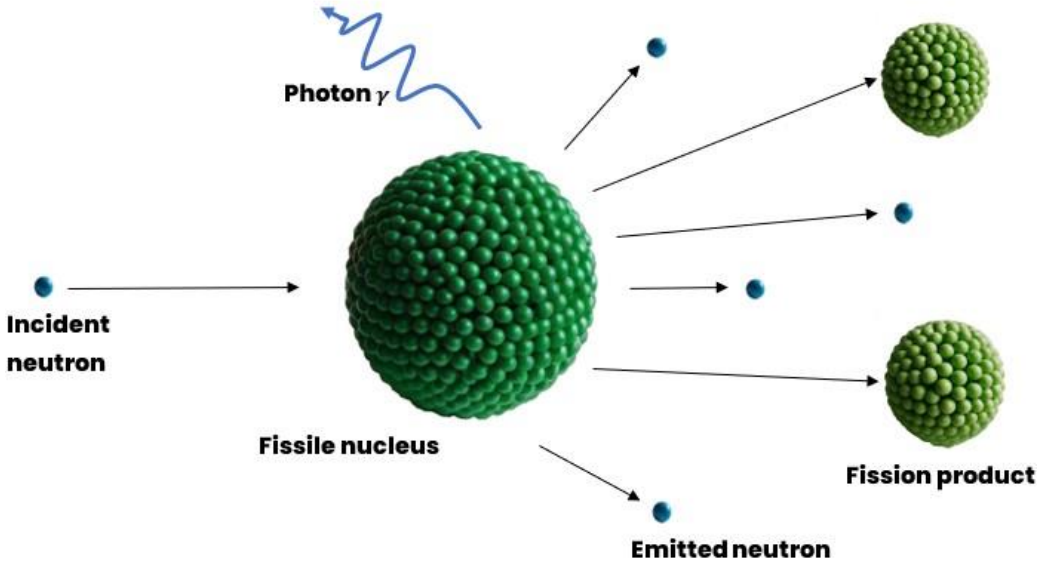
1. Decay heat
2. Computational tools and validation
3. Temperature-based approach

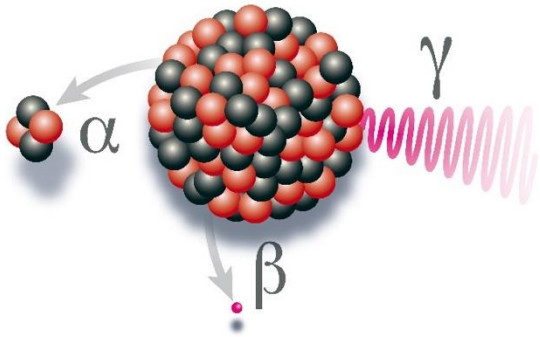
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Decay heat : from the physics to the computation

Decay heat





$$N_i(t) = N_i(0)e^{-\lambda_i t}$$ (law of large numbers)

$$DH_i\,(t) = N_i(t)\lambda_i \overline{E}_i$$

- N_i: quantity of radioisotope i
- λ_i: decay constate of radioisotope i $[s^{-1}]$
- $\overline{E}_i$: mean decay energy of radioisotope i $[J]$
- DH_i: decay heat from radioisotope i $[W]$

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Decay heat experiments

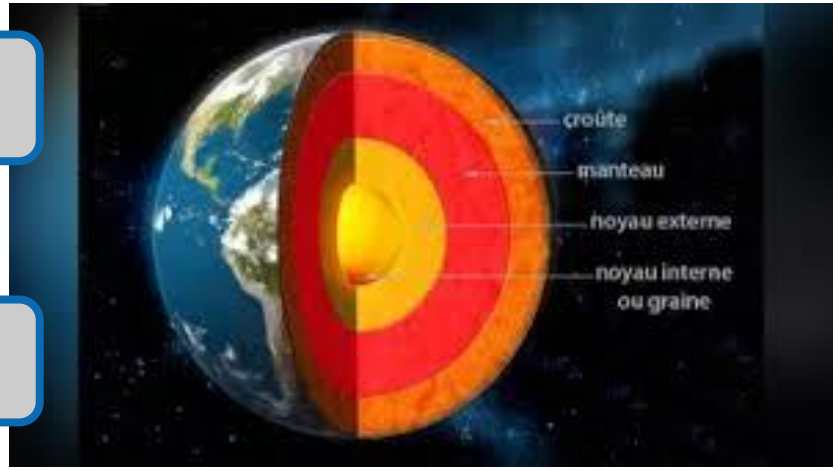


Radioisotope Thermoelectric Generator (spatial probe)



Pacemaker (1980's)

Geothermal energy



Earth magnetic field

Decay heat in a nuclear reactor

$$DH(t) = \sum_i N_i(t)\,\lambda_i \bar{E}_i\ [W]$$

- N_i: isotopic abundance
- λ_i: decay constant of radioisotope i $[s^{-1}]$
- $\bar{E}_i$: mean decay energy of radioisotope i $[J]$

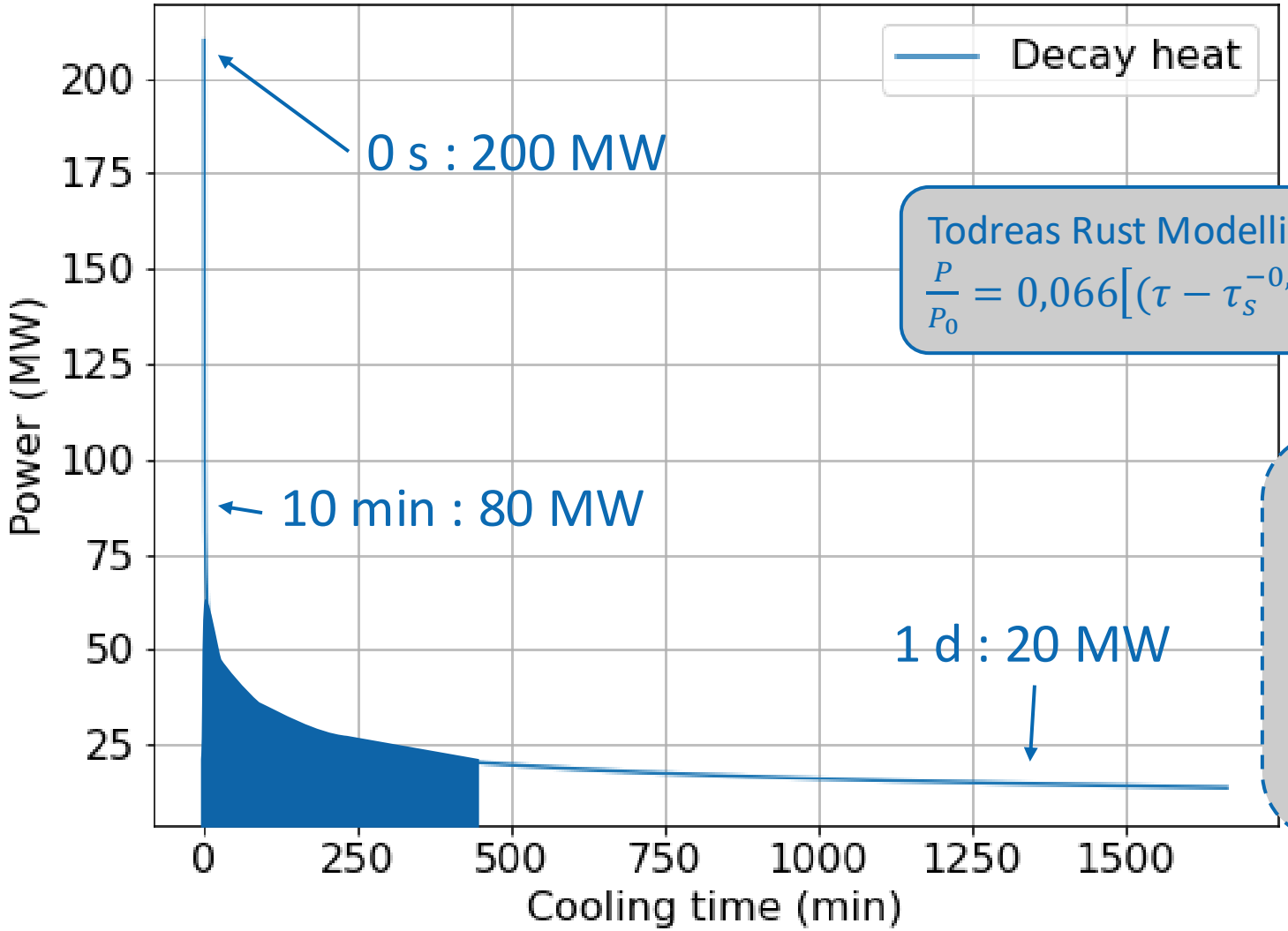
Source of energy (MeV)	U^{235}	U^{238}	Pu^{239}	Pu^{241}
Fission fragments	166.2	166.9	172.8	172.2
Neutrons	4.8	5.5	5.9	5.9
Prompt γ	8.0	7.5	7.7	7.6
γ from fission fragments	7.2	8.4	6.1	7.4
β from fission fragments	7.0	8.9	6.1	7.4
Neutrinos / Antineutrinos	9.6	11.9	8.6	10.2
Total energy released per fission	202.7	205.9	207.2	210.6

~6 to 8%

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Ordre of magnitude

Modelling of the decay heat of a 3300 MWth Pressurized Water Reactor



Todreas Rust Modelling

$$\frac{P}{P_0} = 0{,}066\left[(\tau - \tau_s^{-0,2})^{-0,2} - \tau_s^{-0,2}\right]$$

[Todreas, 1990]

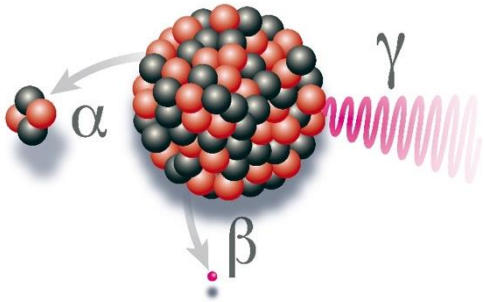


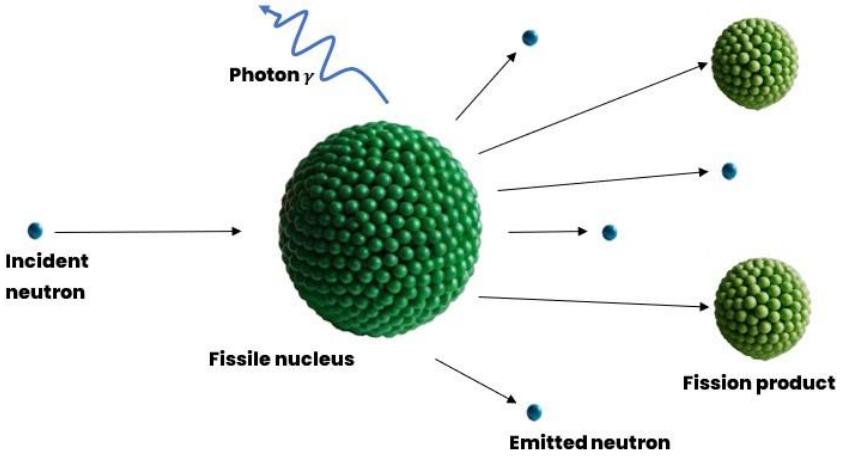
~600 GJ

≡

10 000+ ovens running for 8 hours

Decay heat in the fuel cycle





- Reactor — 0 s



©EDF

- Spent fuel pool



©IRSN

- Cask



©Cédric Helsly/Areva

- Reprocessing plant



©Larrayadieu Eric/Interlinks Image

100 000 years



©Andra

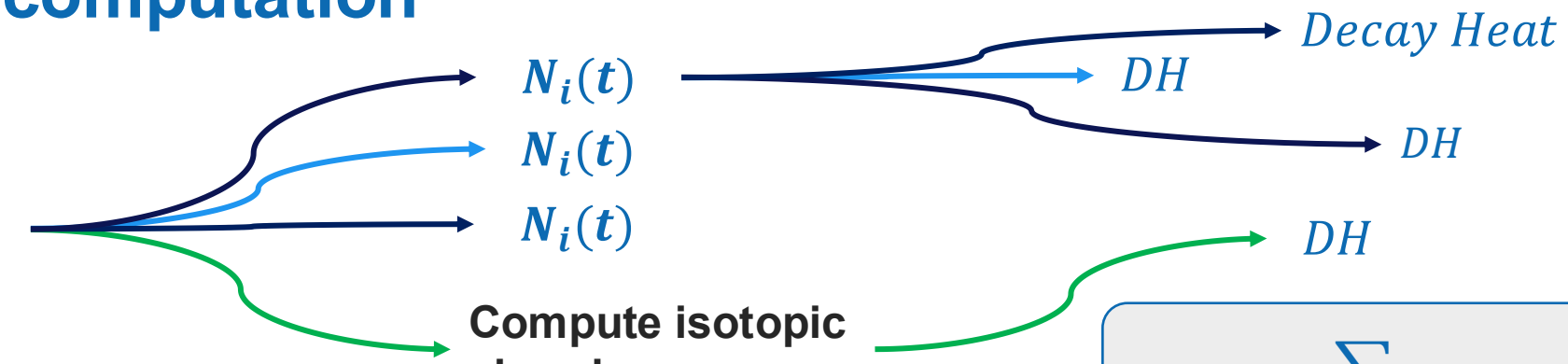
- Geological storage

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How do we compute decay heat ?

Decay heat computation



Reproduce the irradiation history

ϕ : neutron flux

Compute isotopic abundances

$$DH = \sum_i N_i(t)\,\lambda_i \bar{E}_i [W]$$

Solve the Boltzmann equation

$$\frac{1}{v}\frac{\partial\psi(\vec{r},E,\vec{\Omega},t)}{\partial t} = \left[-\left[D_{is}(\vec{r},E,\vec{\Omega},t)+\vec{\nabla}\vec{\Omega}\right]\psi(\vec{r},E,\vec{\Omega},t) + S_c(\vec{r},E,\vec{\Omega},t)\psi(\vec{r},t) + S_{fission}(\vec{r},E,\vec{\Omega},t)\phi(\vec{r},t) + S_d(\vec{r},E,\vec{\Omega},t) + S_{ext}(\vec{r},E,\vec{\Omega},t)\right]\partial\vec{r}.\partial E.\partial\vec{\Omega}.\partial t$$

Solve Bateman equations

$$\frac{\partial N_i(t)}{\partial t} = \sum_F \int_E N_F \sigma_F^f \phi Y_{F\to i} + \sum_{j=1}^{i-1}\left[\left(\lambda_{j\to i} + \sigma_{j\to i}^c \phi\right)N_j(t) - \left(\lambda_i + \sigma_i^c \phi\right)N_i(t)\right]$$

- N: isotopic composition
- σ_i^k: cross section of isotope i for reaction k
- ϕ: neutron flux
- $Y_{F\to i}$: fission yield of isotope i from fissile isotope F
- $\lambda_{j\to i}$: partial decay constant of isotope j towards isotope i
- $\bar{E}_i$: mean decay energy of isotope i

We need a robust framework

The Verification Validation and Uncertainty Quantification process (VVUQ)

Scientific Computing Tool (SCT)

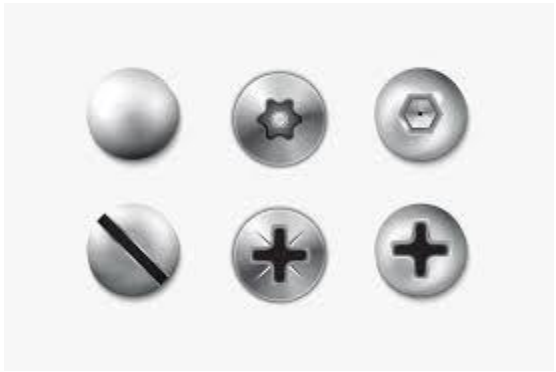


Guide n°28 of ASNR (french safety regulation body)

The Verification Validation and Uncertainty Quantification process (VVUQ)

Scientific Computing Tool (SCT)



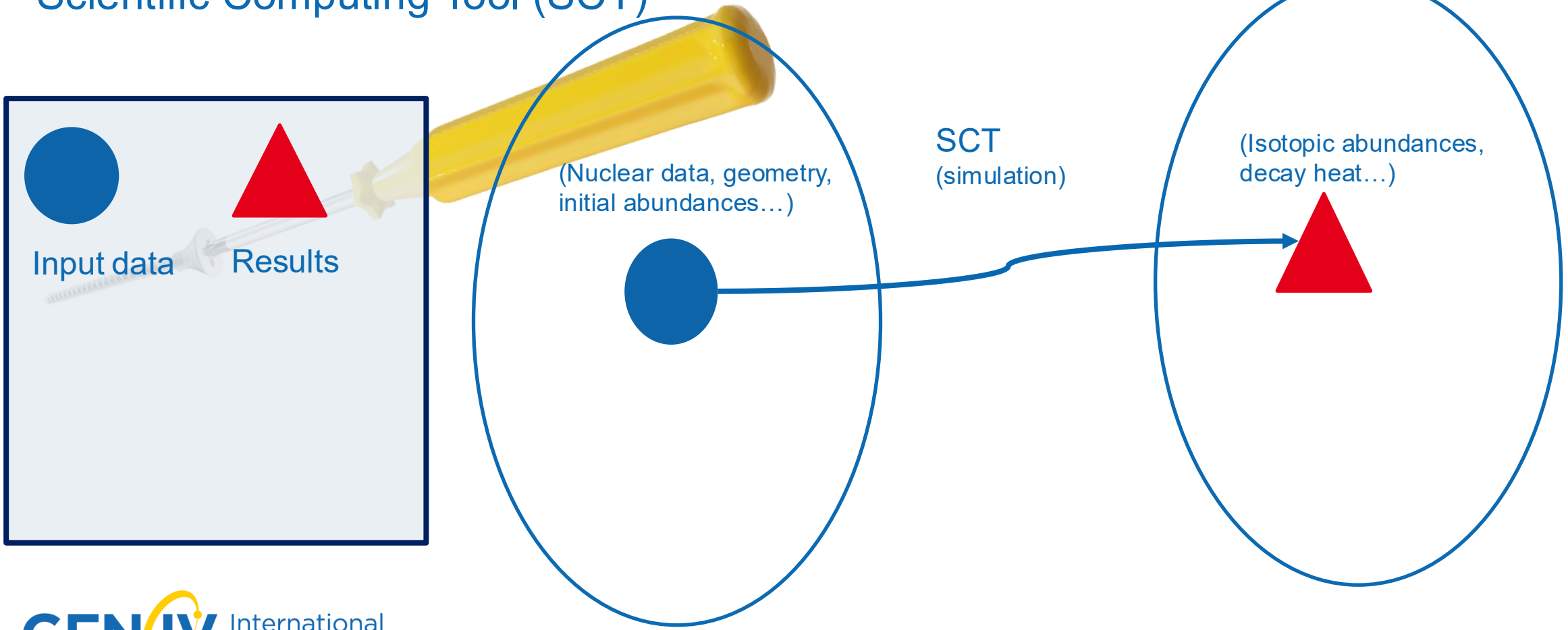


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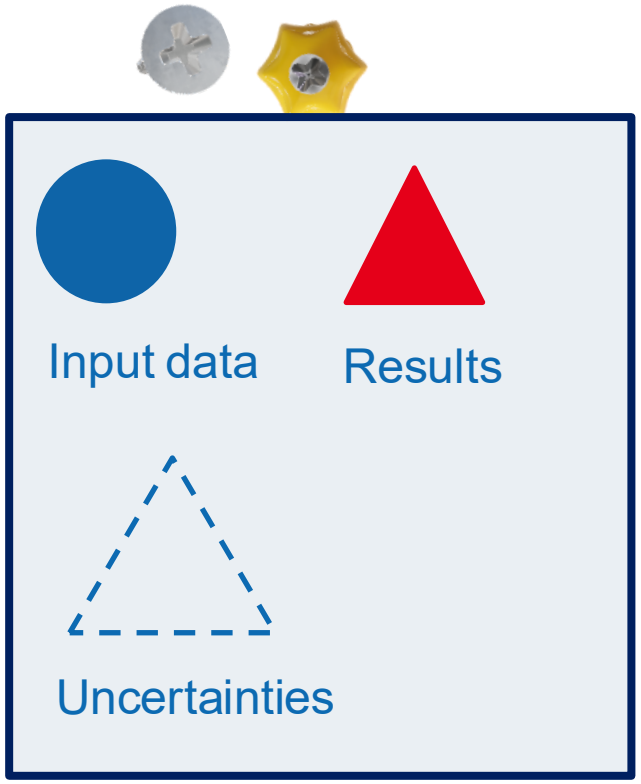
Scientific Computing Tool (SCT)

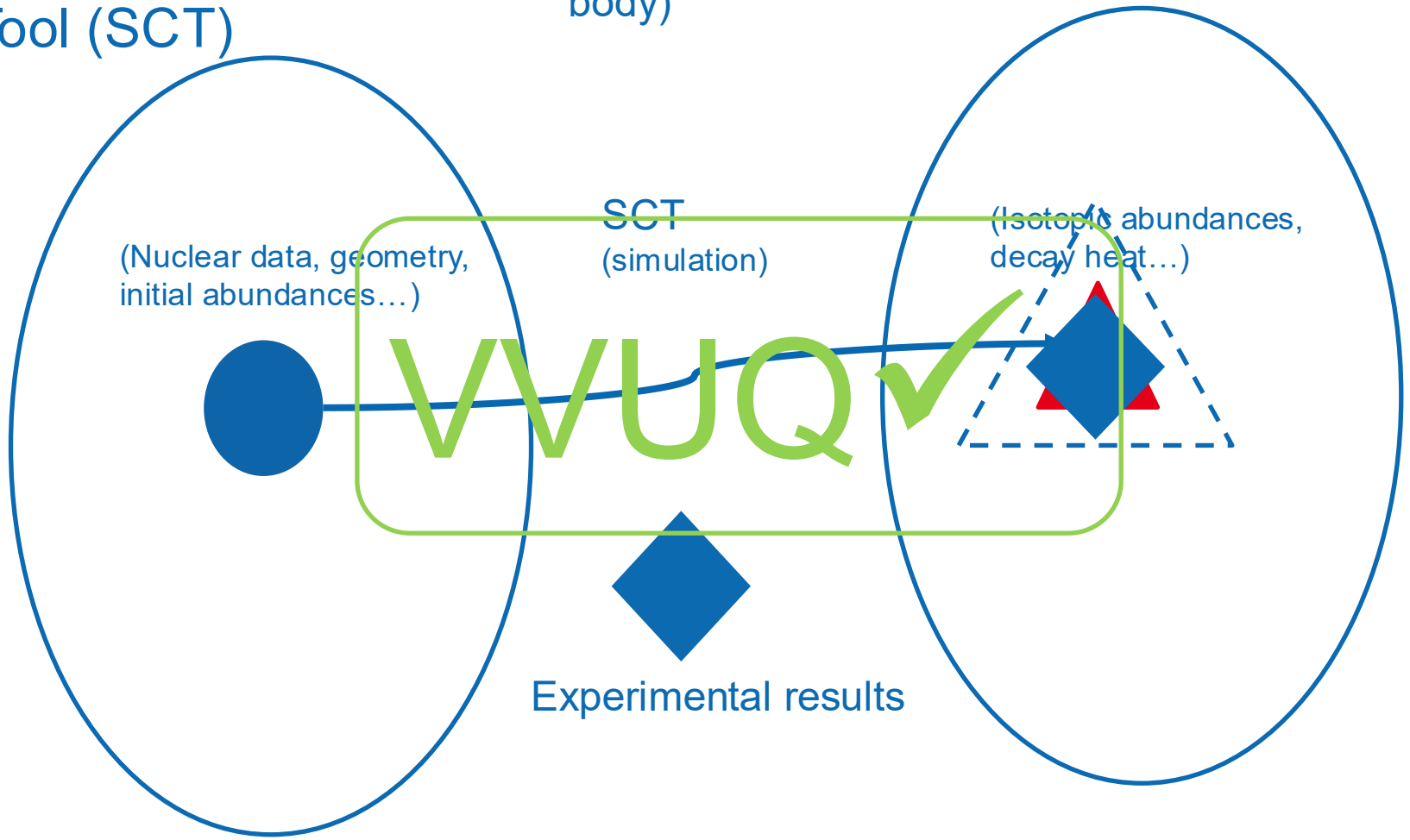


The Verification Validation and Uncertainty Quantification process (VVUQ)

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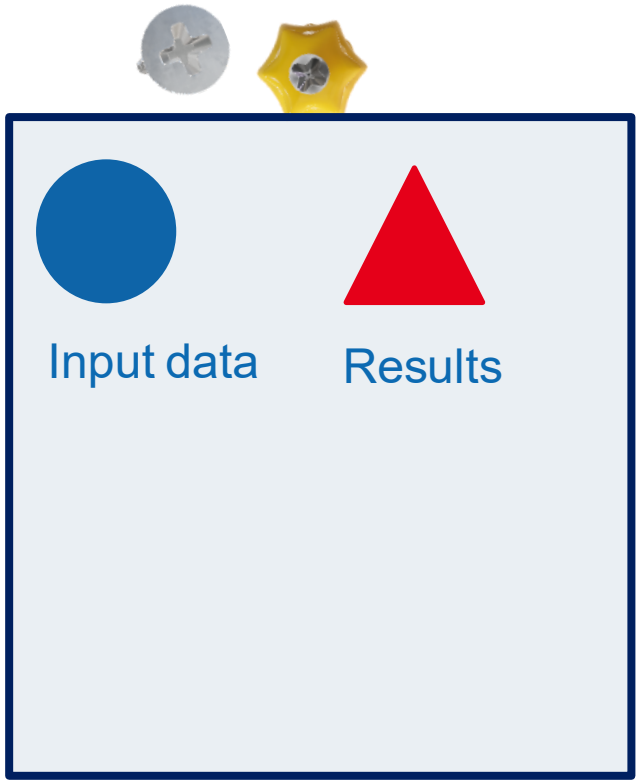




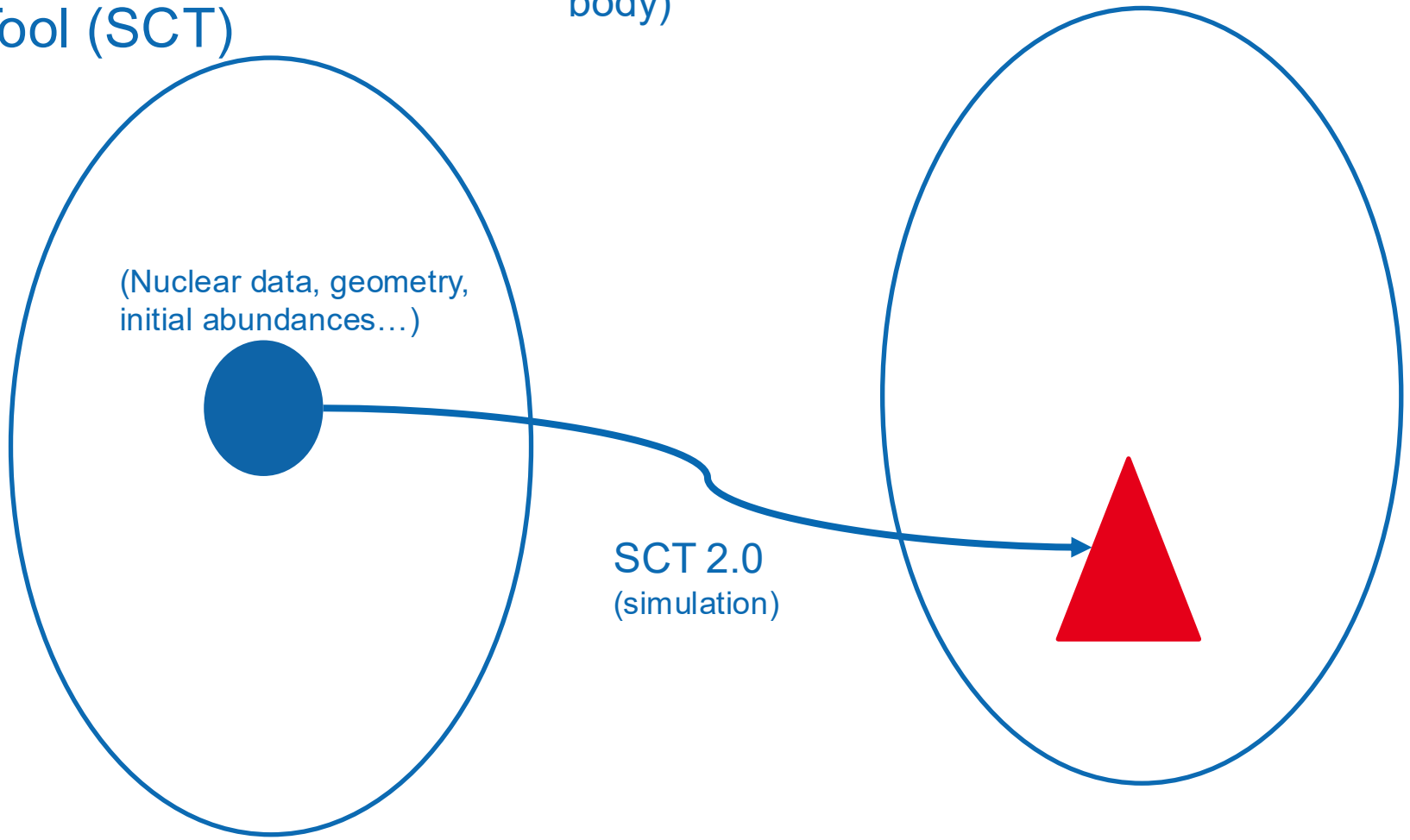
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The Verification Validation and Uncertainty Quantification process (VVUQ)

Scientific Computing Tool (SCT)



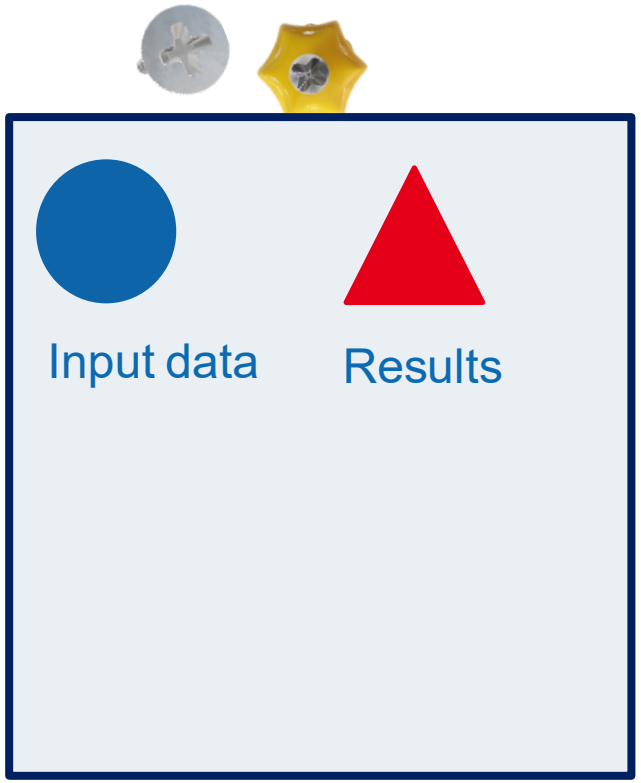
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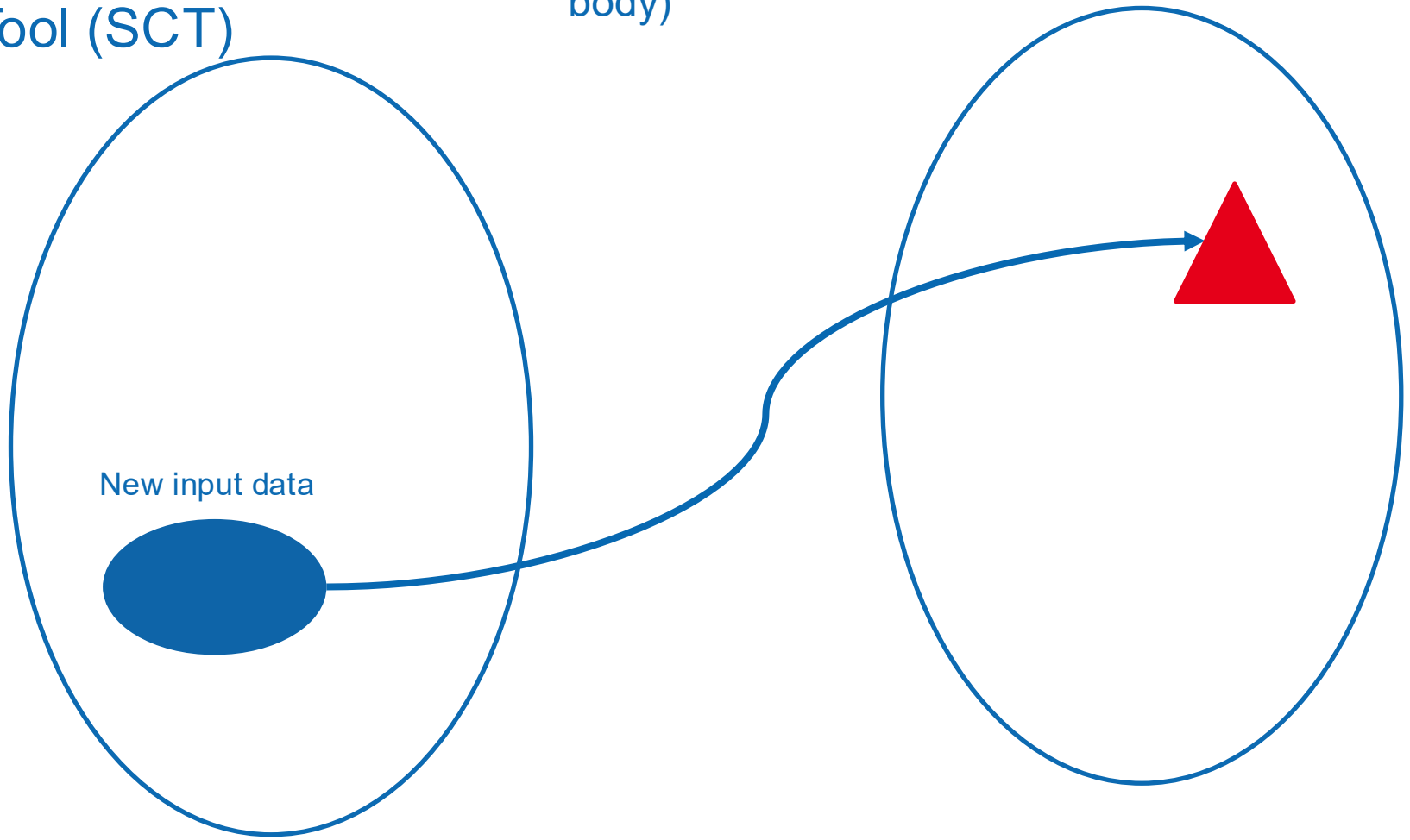


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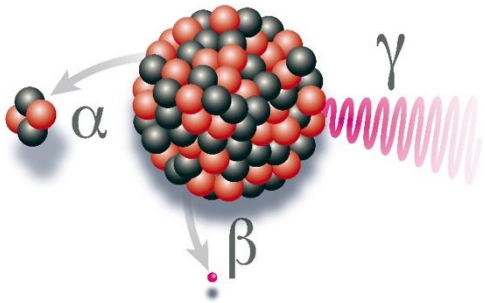
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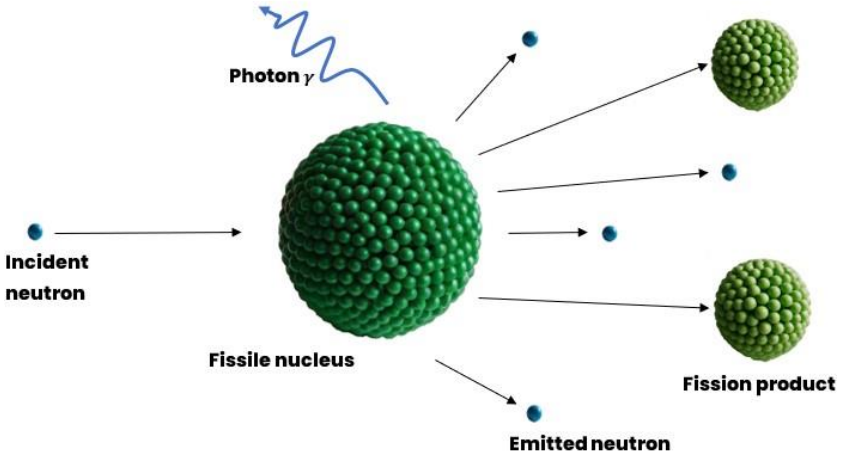
Scientific Computing Tool (SCT)





Decay heat in the fuel cycle





- Reactor — 0 s



©EDF

- Spent fuel pool



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- Cask



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- Reprocessing plant



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100 000 years



©Andra

- Geological storage

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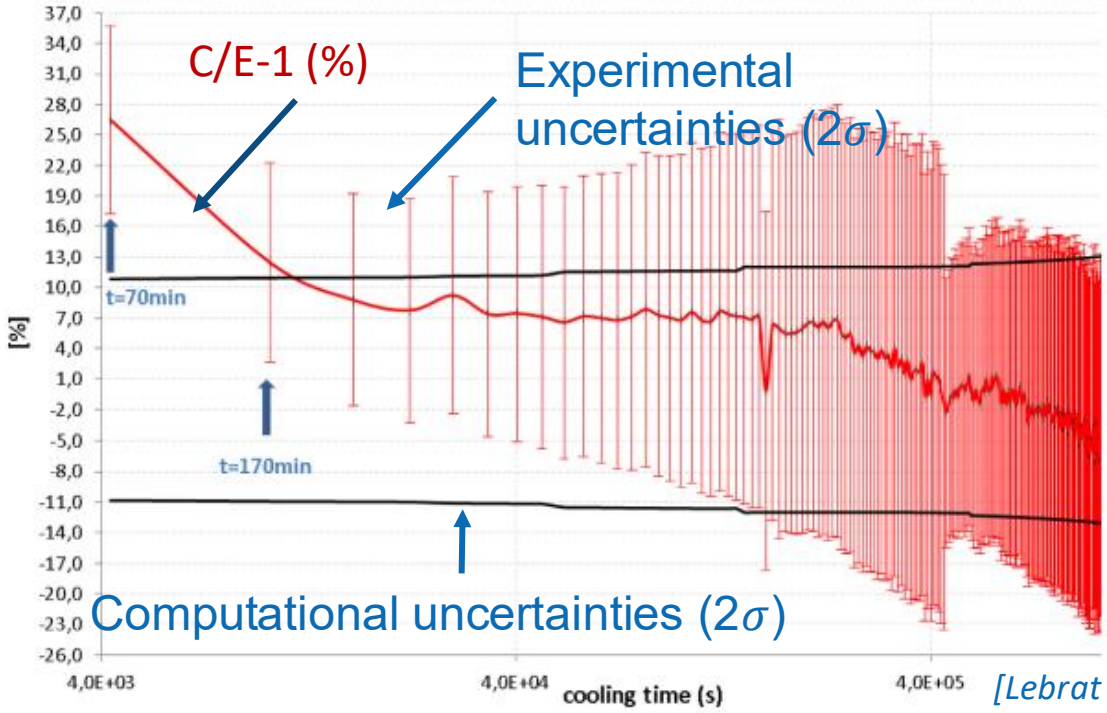
What about Sodium-cooled Fast neutron Reactors ?

Puirex 2008

Measurement	Cooling time	Discrepancy C/E-1 (%)	Uncertainty E(1σ-%) C(1σ-%)	Code Library	Date of computation
Phenix 2008 (Brau, 2008)	1,5 h to 12 d	-8 to +15	5 to 11 5	DARWIN JEFF 3.1.1	2012 (Benoit, 2012a)
		-6 to +26	5 to 11 2,5 to 4,7	DARWIN2 JEFF 3.1.1	2018 (Lebrat et al., 2018)

- Experimental measurements of SFR decay heat
- Unexplained calculation-to-experiment discrepancy

- Understand the discrepancies
- Value this experiment



[Lebrat et al., 2018]

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	Measurement	Cooling time	Discrepancy C/E-1 (%)	Uncertainty E(1σ-%) C(1σ-%)	Code Library	Date of computation
Phénix	Phenix 1979 (Desprets, 1979)	7 to 36 h	+6 to +18	~9,5 6	Code (Costa, 1972) SPNR (Cazalet,1979)	1979 (Desprets, Costa 1979)
			+6 to +20	8,9 to 9,8 7 to 13,5	MECCYCO JEF1	1992 (Gillet 1992)
	Phenix 1982 (Guidez, 1983)	6 to 28 h	-12 to -8	-8 to 8 ?	Code PHENIX	1983
	Phenix 1993 (Martin 1993)	6 to 72 h	+5 to +17	10 8	MECCYCO JEF1	1993 (Gillet, 1993)
	Phenix 2008 (Brau, 2008)	1,5 h to 12 d	-8 to +15	5 to 11 5	DARWIN JEFF 3.1.1	2012 (Benoit, 2012a)
			-6 to +26	5 to 11 2,5 to 4,7	DARWIN2 JEFF 3.1.1	2018 (Lebrat et al., 2018)
Superphénix	SPX 1987 (Favet, 1987)	3 to 26 h	-9 to -3	7 to 13,5 4,1 to 4,5	MECCYCO JEF1	1988 (Gillet, 1988)
			-15 to -7	7 to 13,5 3,5 to 6,5	MECCYCO JEF1	1988 (Gillet, 1988)
			-15 to -10	6,7 to 12,5 3,3 to 4,8	MECCYCO JEF1	1996 (Gillet, 1996)
			-20 to -8	7 to 13 7 to 14	APOLLO3-MENDEL JEFF 3.1.1	2020 (Calame et al. 2020)
	SPX 1996 (Gody, 1997)	3 to 52 h	-2 to +3	3,6 to 6,8 4,6 to 3,5	MECCYCO JEF1	1998 (Bernardin, 1998)
			-10 to -5	3,6 to 6,8 ?	DARWIN JEF2.2	2002 (Bourdot, 2002)

- No clear bias identified as it does not have a specific trend

- Study the Puirex measurement

- ☐ Understand the discrepancies
- ☐ Value these experiments
- ☐ Determine if it can bring information for PWR MOX fuels

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The Phénix reactor: a quick overview

An old and complex history

- SFR
- 560 MWth
- Demonstrator
- Marcoule, France



©CNES

under renovation

1969 — First concrete

1973 — First criticality

1979 — DH measurement n°1

1982 — DH measurement n°2

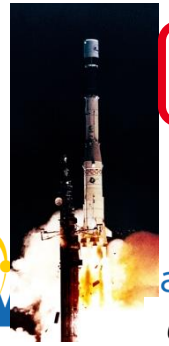
DH measurement n°3

1993 — New operating mode at 350 MWth approved by ASN

2003 — Restart

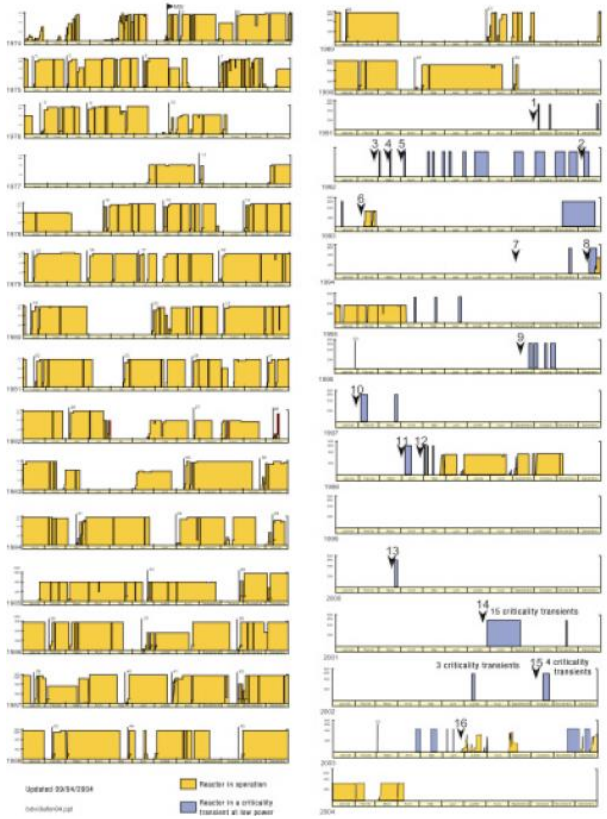
2008 — DH measurement n°4 Puirex 2008

2010 — THE END



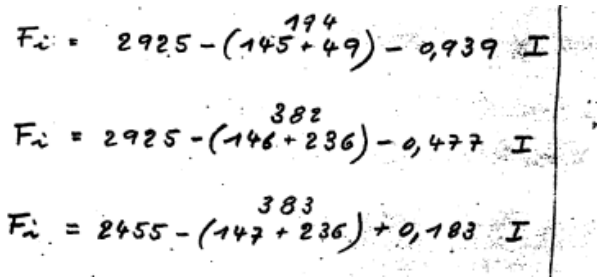
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An old and complex history



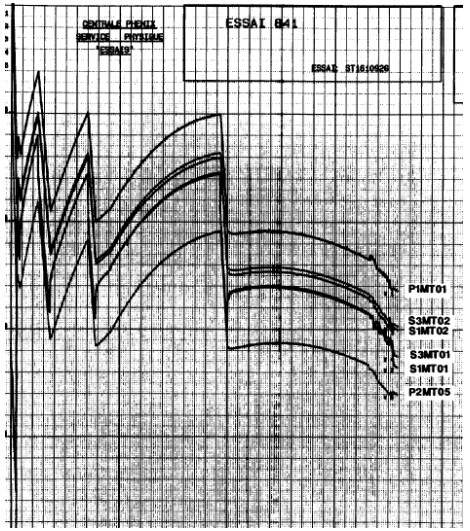
Irradiation history of Phénix from 1973 to 2004

[Sauvage, 2004]



Estimation of the specific heat of the reactor

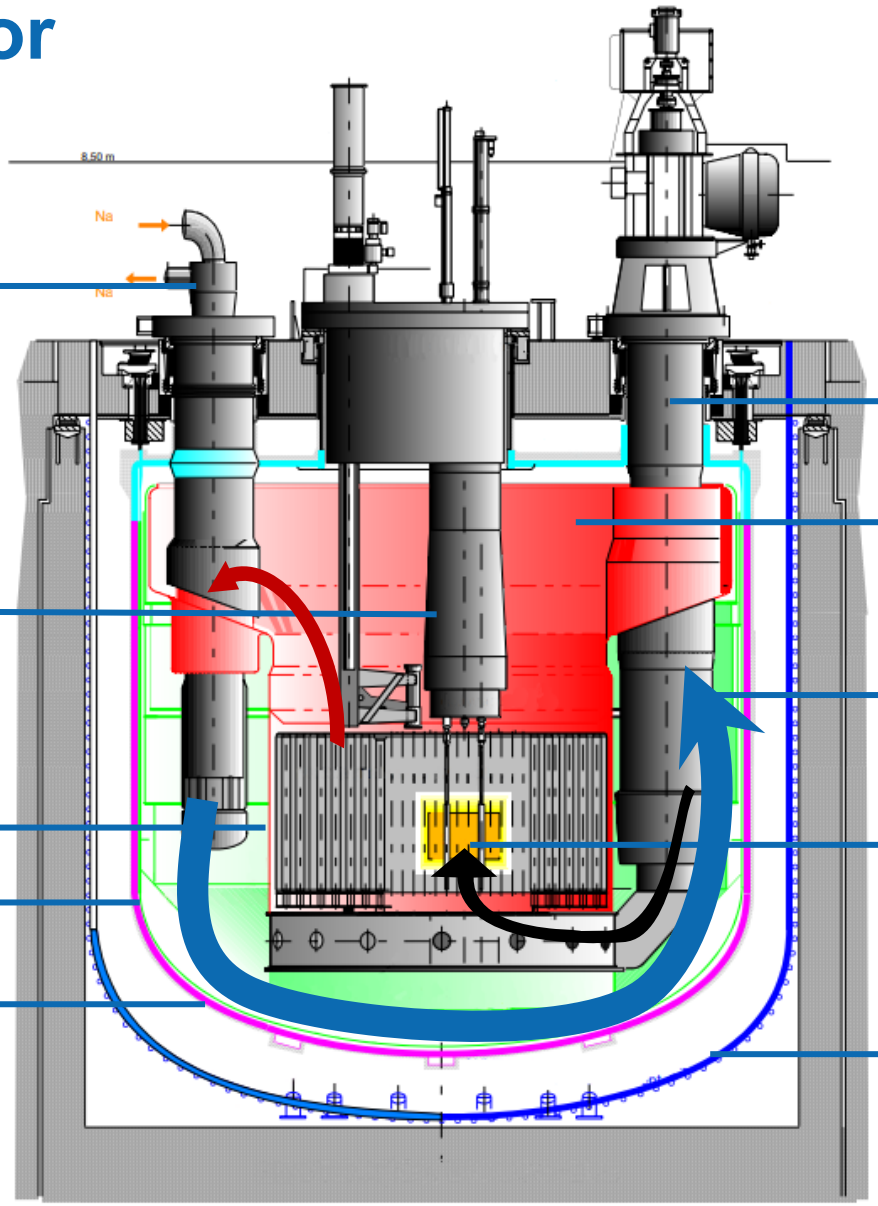
[Kayser, 1973]



Experimental results

[Martin, 1993]

A pool-type reactor



Heat exchanger

Rotating cap

Primary vessel

Main vessel

Double layer vessel and insulator

Primary pump

Hot sodium

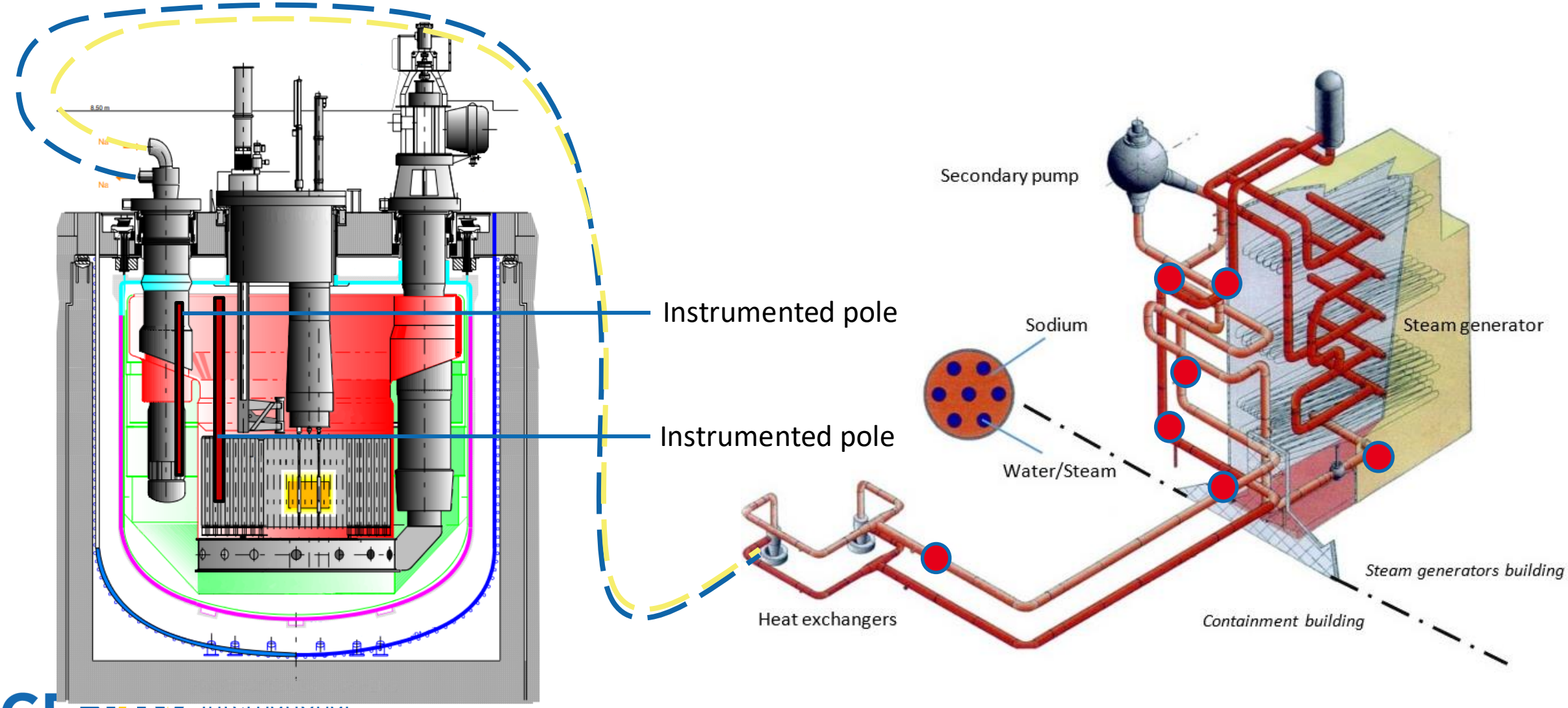
Cold sodium

Core

Containment vessel and last resort circuit

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Intermediate loops



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The Puirex 2008 experiment

A temperature-based method to estimate decay heat

Reactor considered as a calorimeter
Hypothesis: a spatially uniform temperature

Heat balance:
1st law of thermodynamics

$$I(\theta)\frac{\partial\theta}{\partial t} = \sum Sources - \sum Leakages + DH$$

[Appere, 1998]

θ: measured temperature

$I(\theta)$: specific heat

$\frac{\partial\theta}{\partial t}$: temporal derivative of the temperature

$Sources$: heat sources

$Leakages$: heat leakages

Empirical or semi-empirical models

$$\frac{d\theta}{dt} = \frac{DH + Sources(\theta) - Leakages(\theta)}{I(\theta)}$$

$$\frac{d\theta}{dt} = \frac{\overline{\theta t} - \bar{\theta}\bar{t}}{\sqrt{\bar{t^2} - \bar{t}^2}} = \frac{Cov(\theta, t)}{Var(t)}$$

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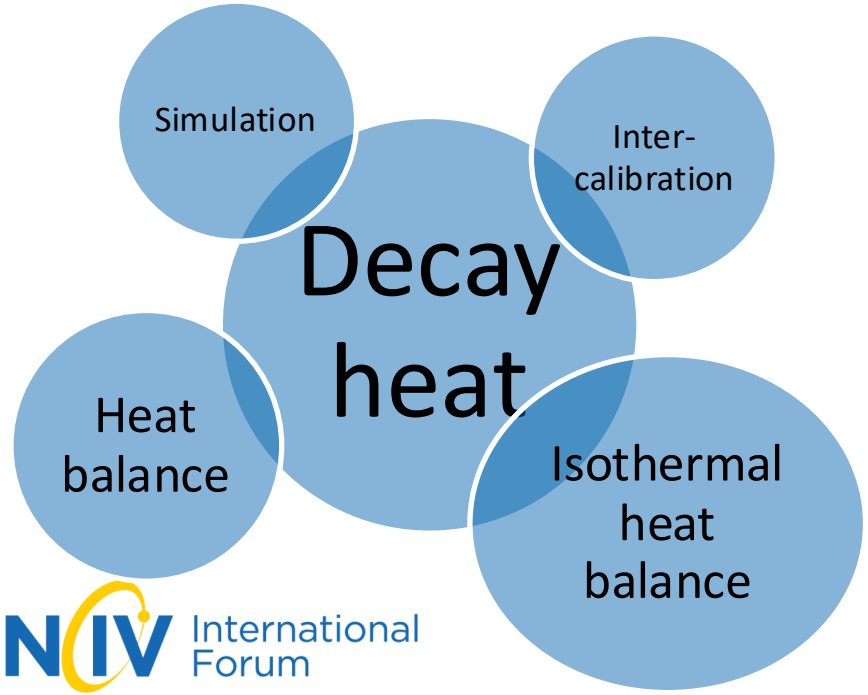
$$DH = I(\theta)\frac{\partial \theta}{\partial t} - \sum Sources + \sum Leakages$$

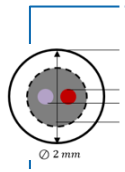
Previous experiments

$Sources$: heat sources
$Leakages$: heat leakages
$I(\theta)$: specific heat

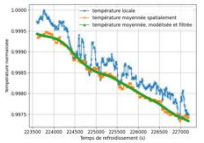
Decay heat measurement

$\frac{\partial \theta}{\partial t}$: temporal derivative of the temperature
θ: measured temperature

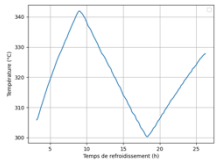




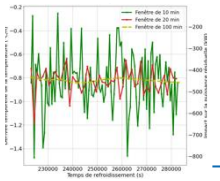
Acquisition/selection



Smoothing



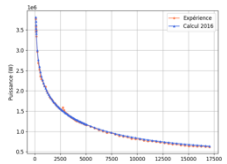
Filtering



Linear regression



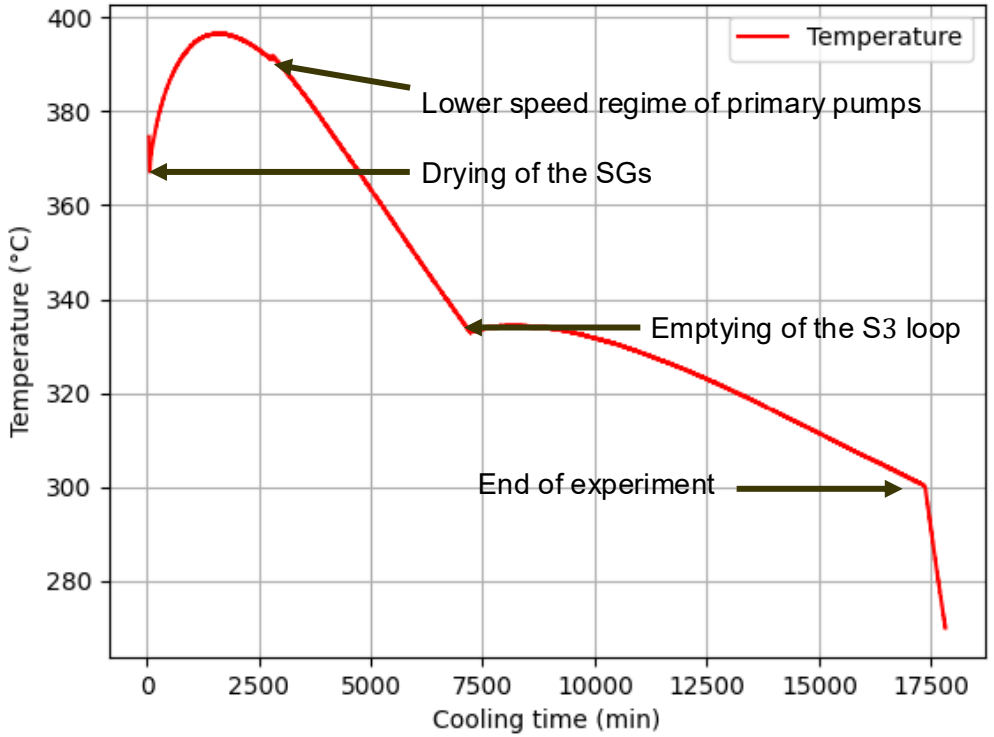
Thermal modelling



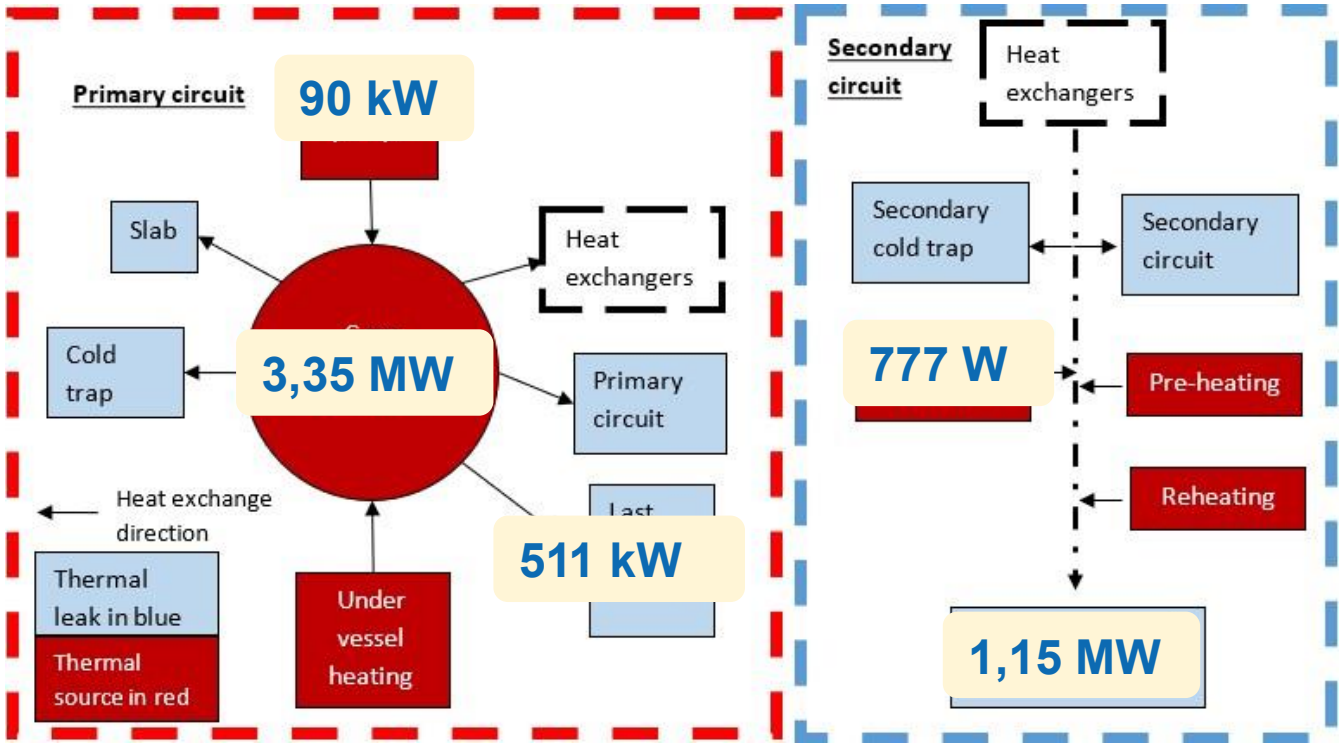
Decay heat

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The Puirex experiment

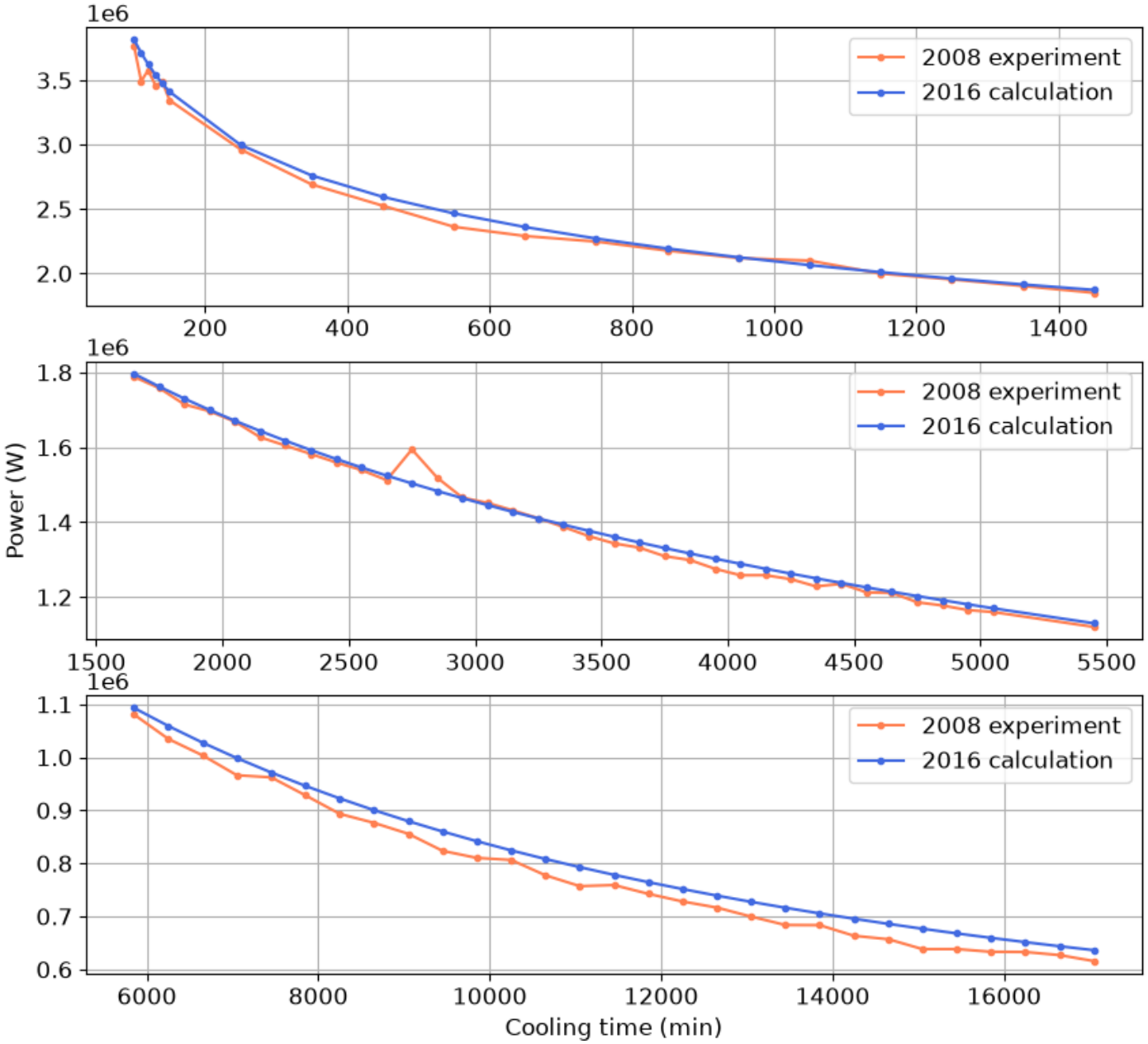


Mean primary sodium temperature



$$I(\theta)\frac{\partial \theta}{\partial t} = 1,78\ MW$$

Power distribution during Puirex experiment at $t = 150$ min after the chain reaction stopped

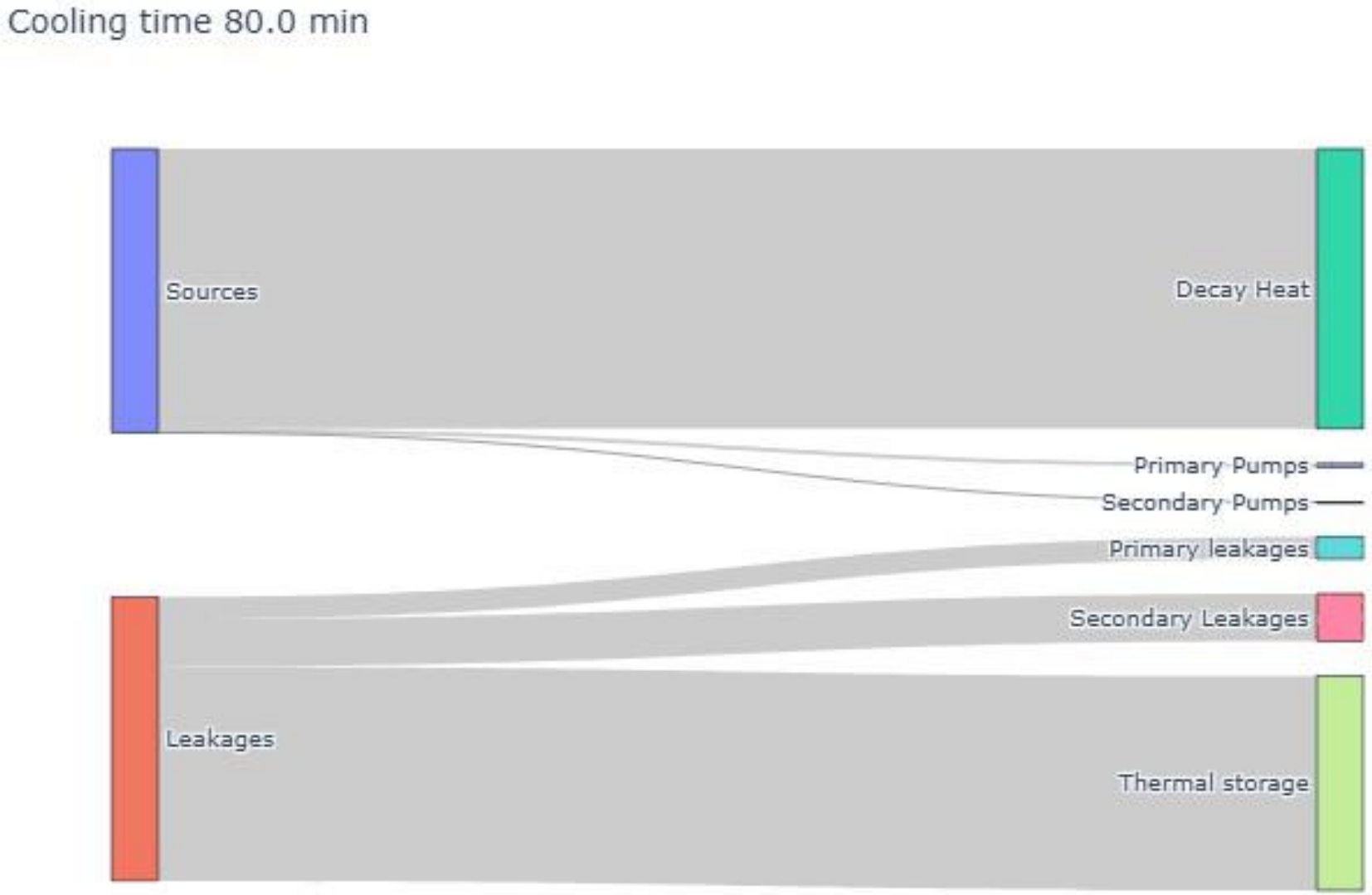


- Calculation/experiment comparison times change (misunderstanding)
- Dynamic calculation of the time derivative (limit noise - retain important information - minimize post-processing)
- Thermal model modifications (secondary leakage model)

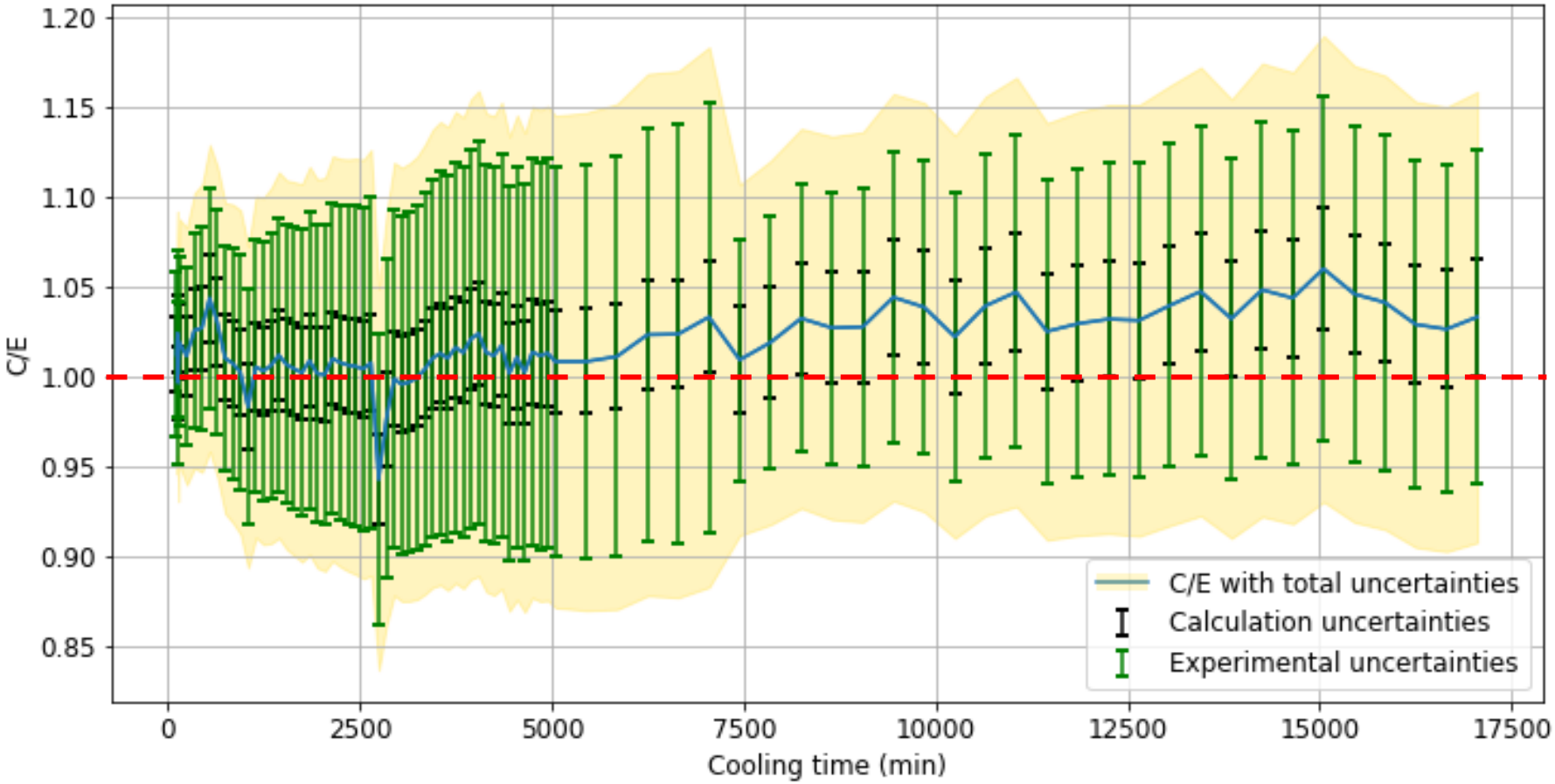
- Previous and old models (ETNa)
- Others were constantly being improved (Bilther)

 A much better global coherence

Heat balance decomposition



Calculation to Experiment discrepancy

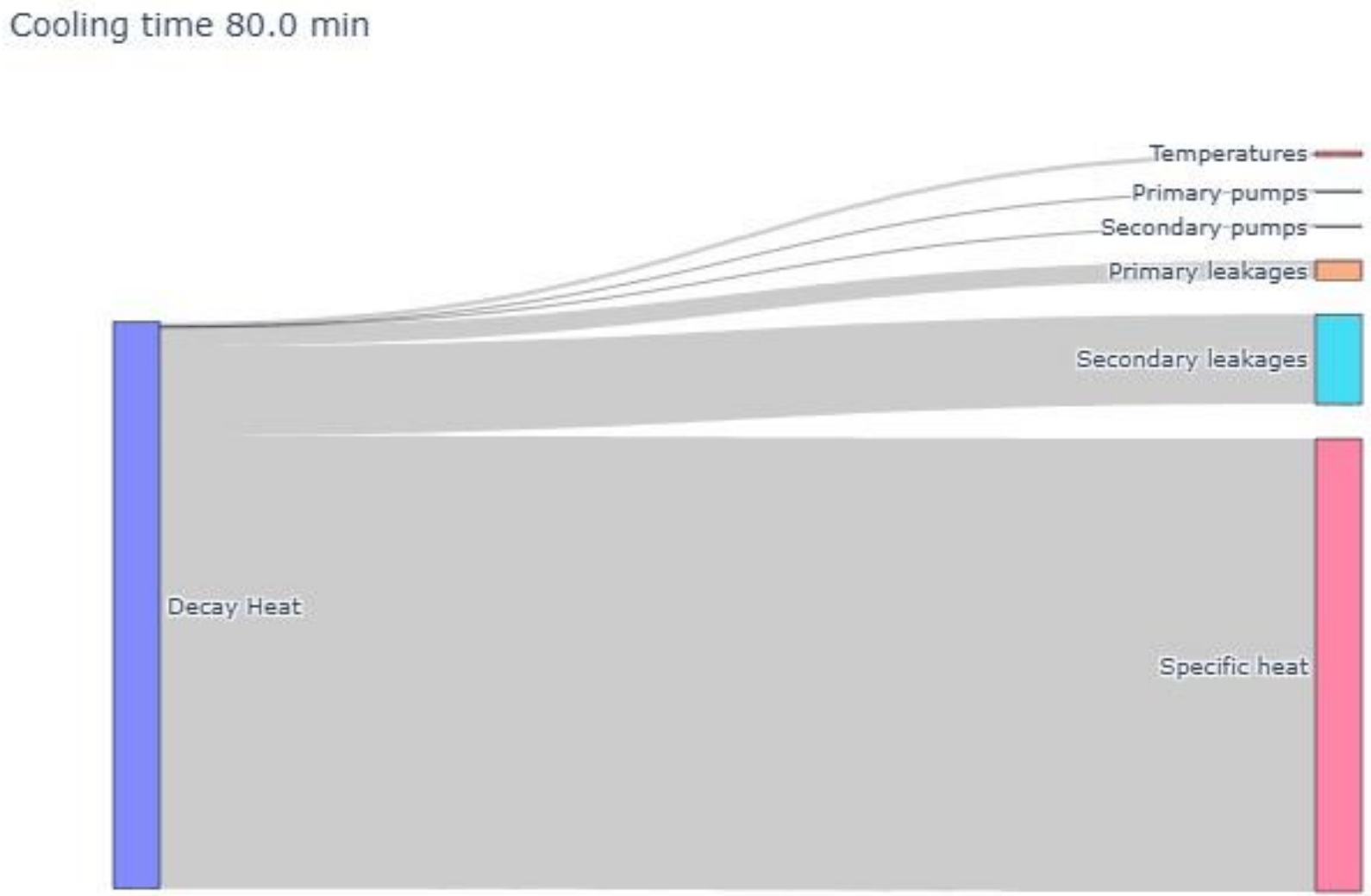


- Given the measurement uncertainties, there is little value in continuing to question the presence of bias.

- Computation uncertainties (nuclear data) [Benoit, 2012b]
- Measurement uncertainties [Benoit, 2012a]
  [Brau, 2008]

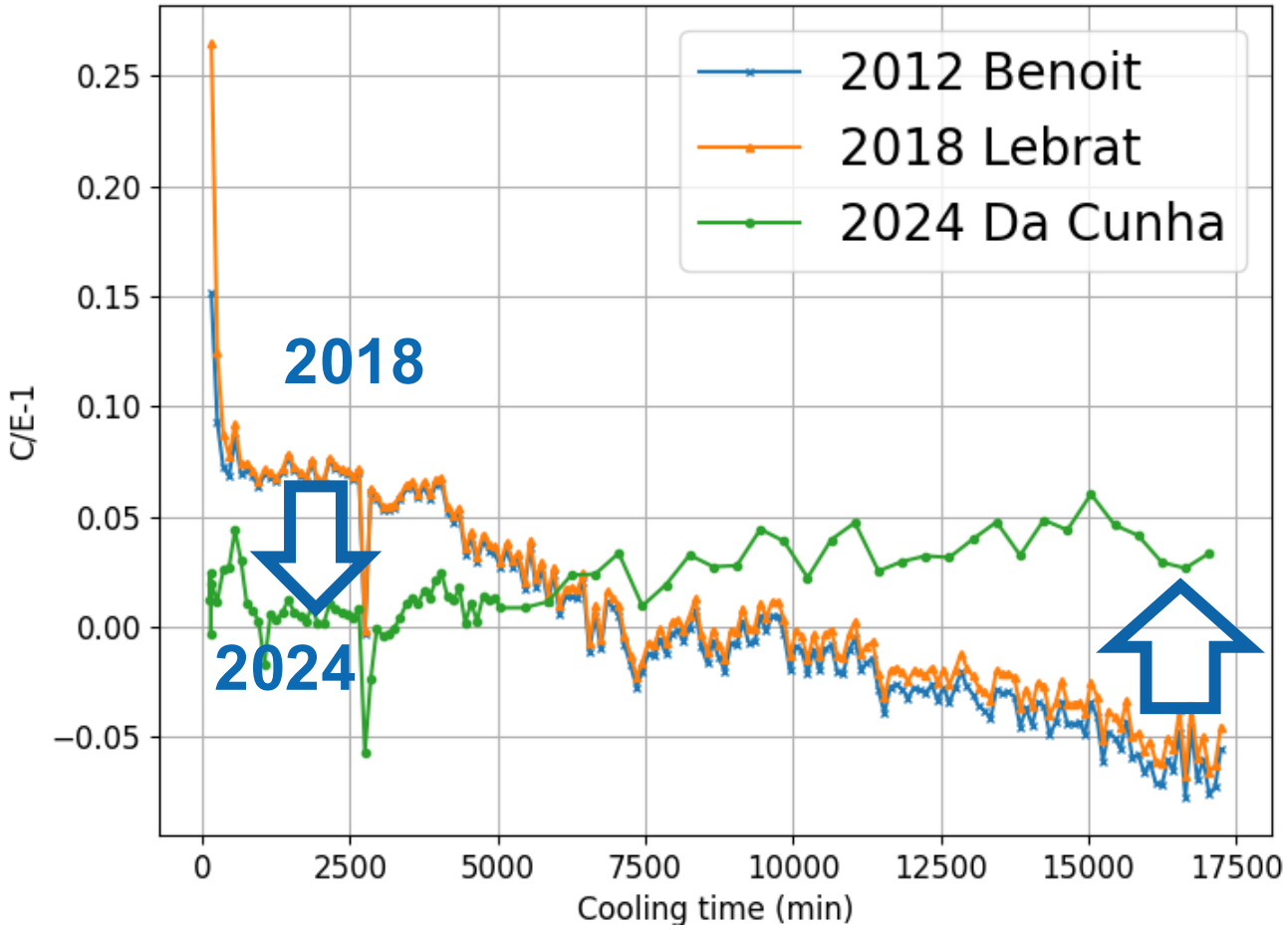
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Sources of uncertainties



Conclusion on the Puirex experiment

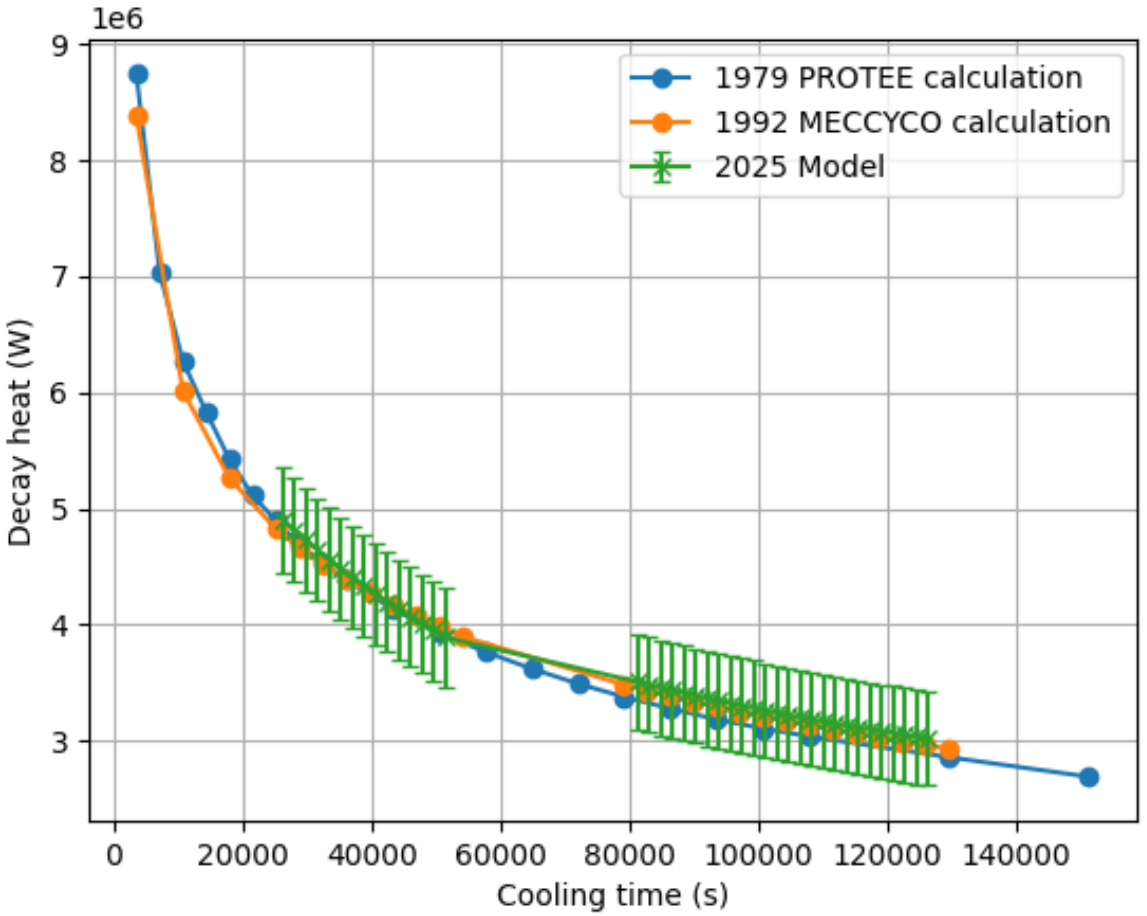
- Very significant improvement of the discrepancy at short cooling times
- Presence of a long-term bias but less significant

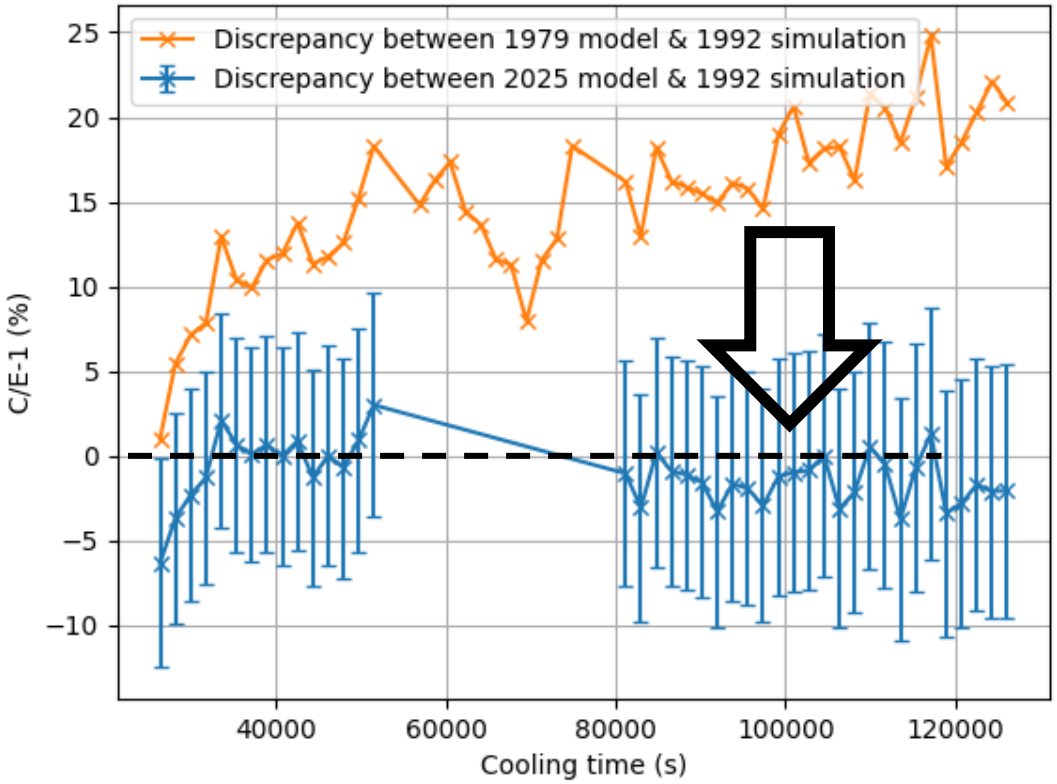


The feedback for the other experiments

	Measurement	Cooling time	Discrepancy C/E-1 (%)	Uncertainty E(1σ-%) C(1σ-%)	Code Library	Date of computation
Phénix	Phenix 1979 (Desprets, 1979)	7 to 36 h	+6 to +18	~9,5 6	Code (Costa, 1972) SPNR (Cazalet,1979)	1979 (Desprets, Costa 1979)
			+6 to +20	8,9 to 9,8 7 to 13,5	MECCYCO JEF1	1992 (Gillet, 1992)
	Phenix 1982 (Guidez, 1983)	6 to 28 h	-12 to -8	-8 to 8 ?	Code PHENIX	1983
	Phenix 1993 (Martin, 1993)	6 to 72 h	+5 to +17	10 8	MECCYCO JEF1	1993 (Gillet, 1993)
	Phenix 2008 (Brau, 2008)	1,5 h to 12 d	-8 to +15	5 to 11 5	DARWIN JEFF 3.1.1	2012 (Benoit, 2012a)
			-6 to +26	5 to 11 2,5 to 4,7	DARWIN2 JEFF 3.1.1	2018 (Lebrat et al., 2018)
Superphénix	SPX 1987 (Favet, 1987)	3 to 26 h	-9 to -3	7 to 13,5 4,1 to 4,5	MECCYCO JEF1	1988 (Gillet, 1988)
			-15 to -7	7 to 13,5 3,5 to 6,5	MECCYCO JEF1	1988 (Gillet, 1988)
			-15 to -10	6,7 to 12,5 3,3 to 4,8	MECCYCO JEF1	1996 (Gillet, 1996)
			-20 to -8	7 to 13 7 to 14	APOLLO3-MENDEL JEFF 3.1.1	2020 (Calame et al. 2020)
	SPX 1996 (Gody, 1997)	3 to 52 h	-2 to +3	3,6 to 6,8 4,6 to 3,5	MECCYCO JEF1	1998 (Bernardin, 1998)
			-10 to -5	3,6 to 6,8 ?	DARWIN JEF2.2	2002 (Bourdot, 2002)

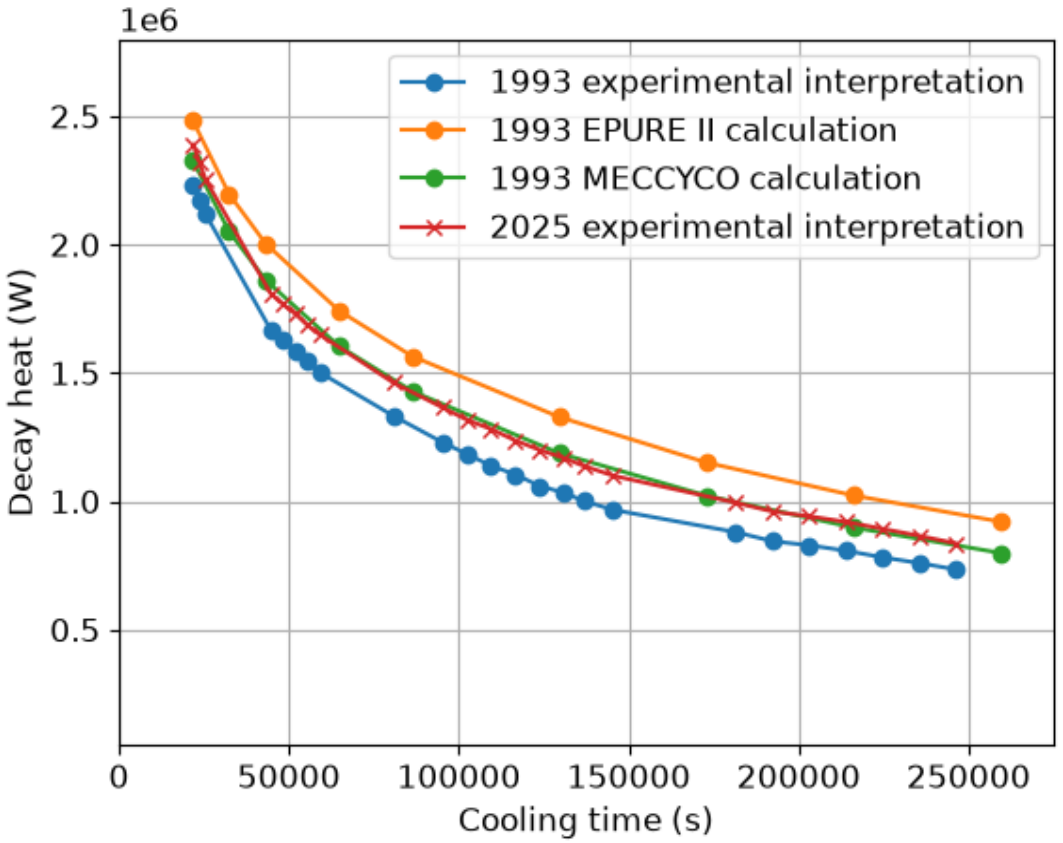
The 1979 experiment

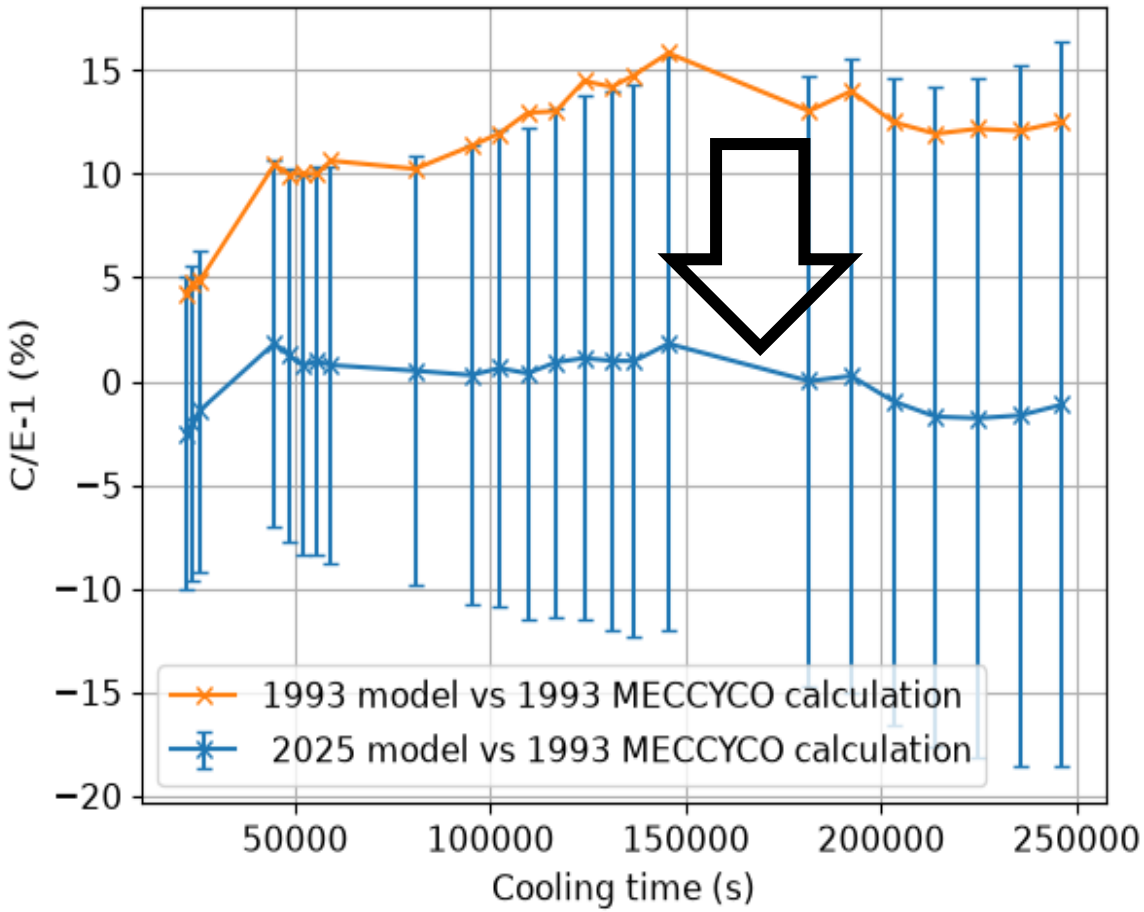




- Significant improvement at short cooling times
- Bias at the beginning of the experiment (30 000 s)

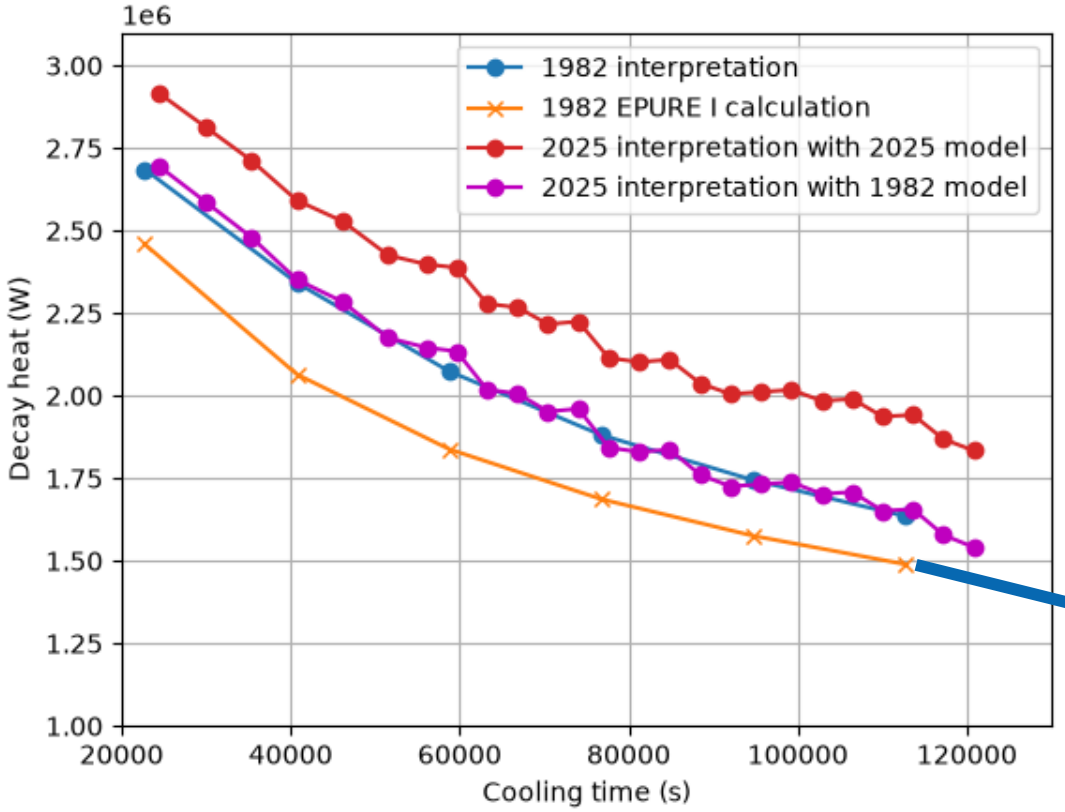
The 1993 experiment

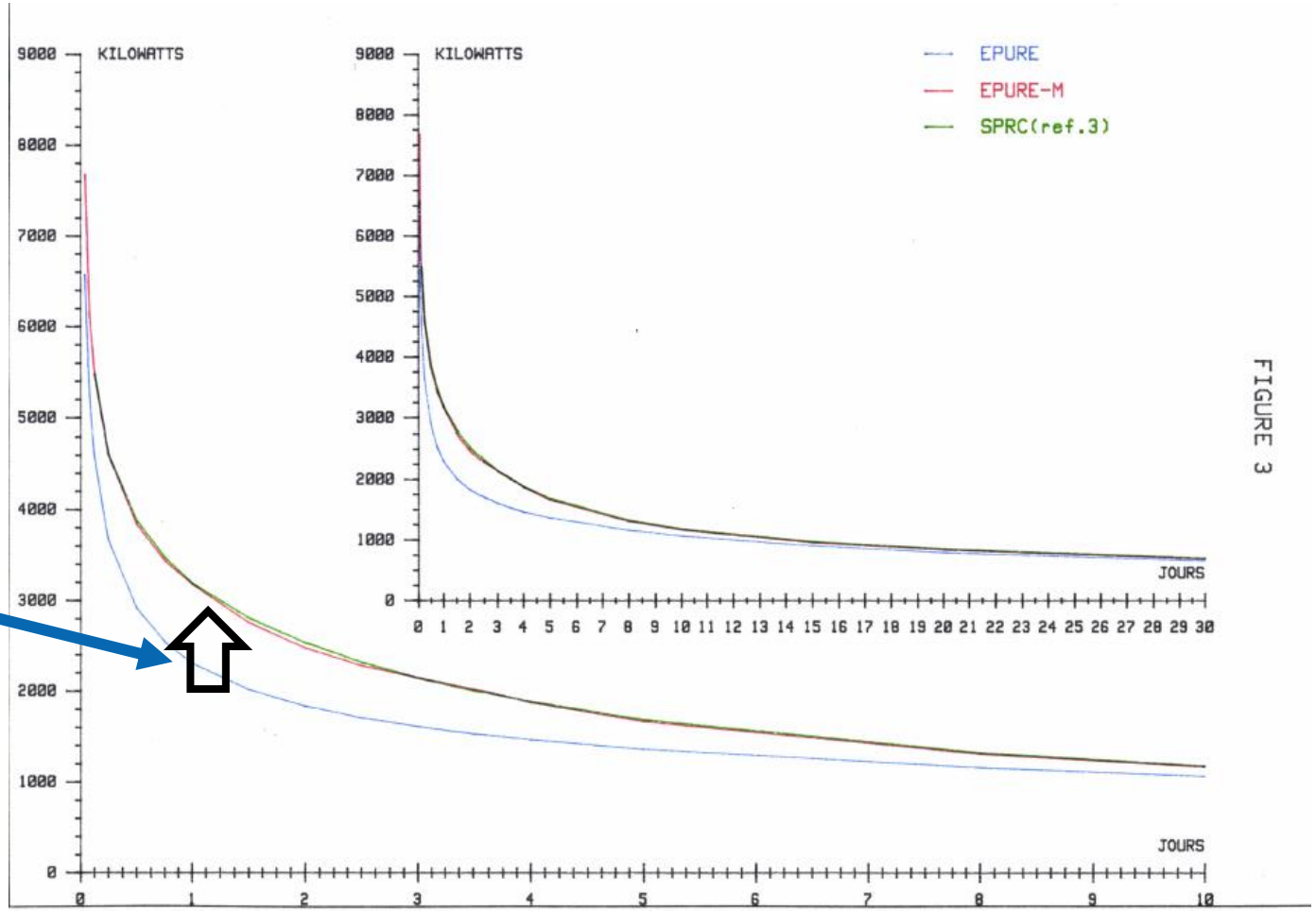




- Very significant improvement of the Calculation/Experiment discrepancy

The 1982 experiment

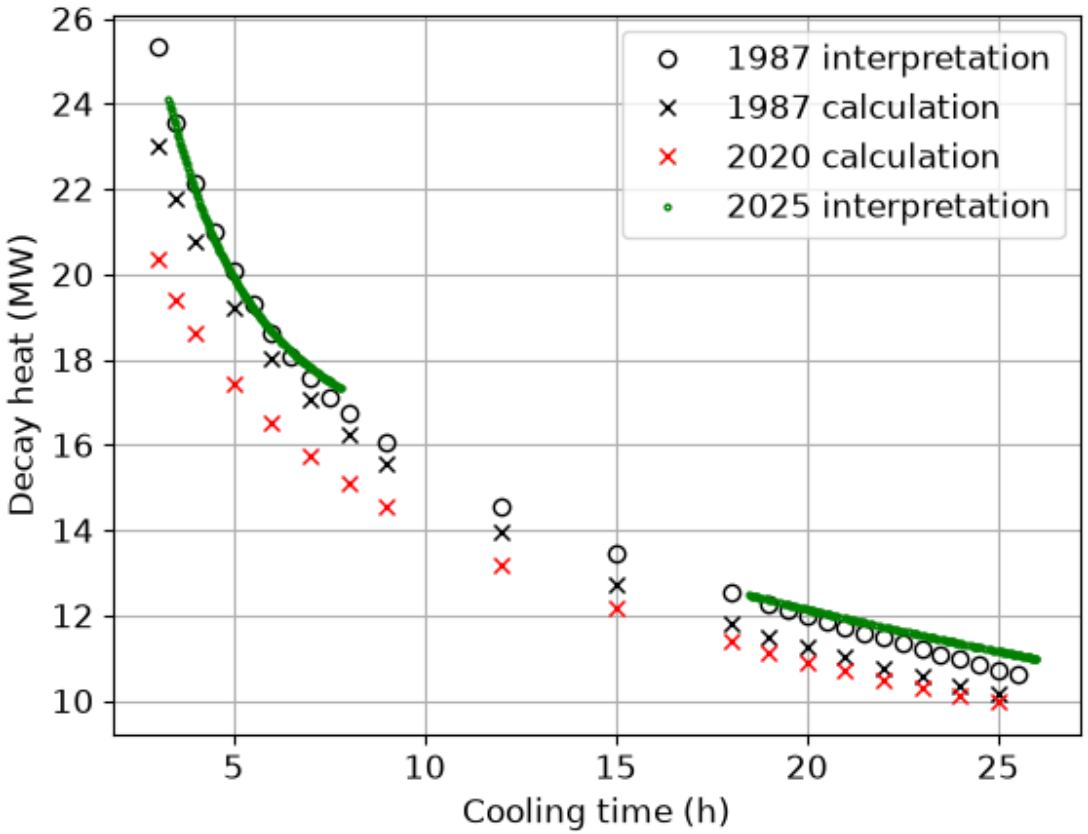




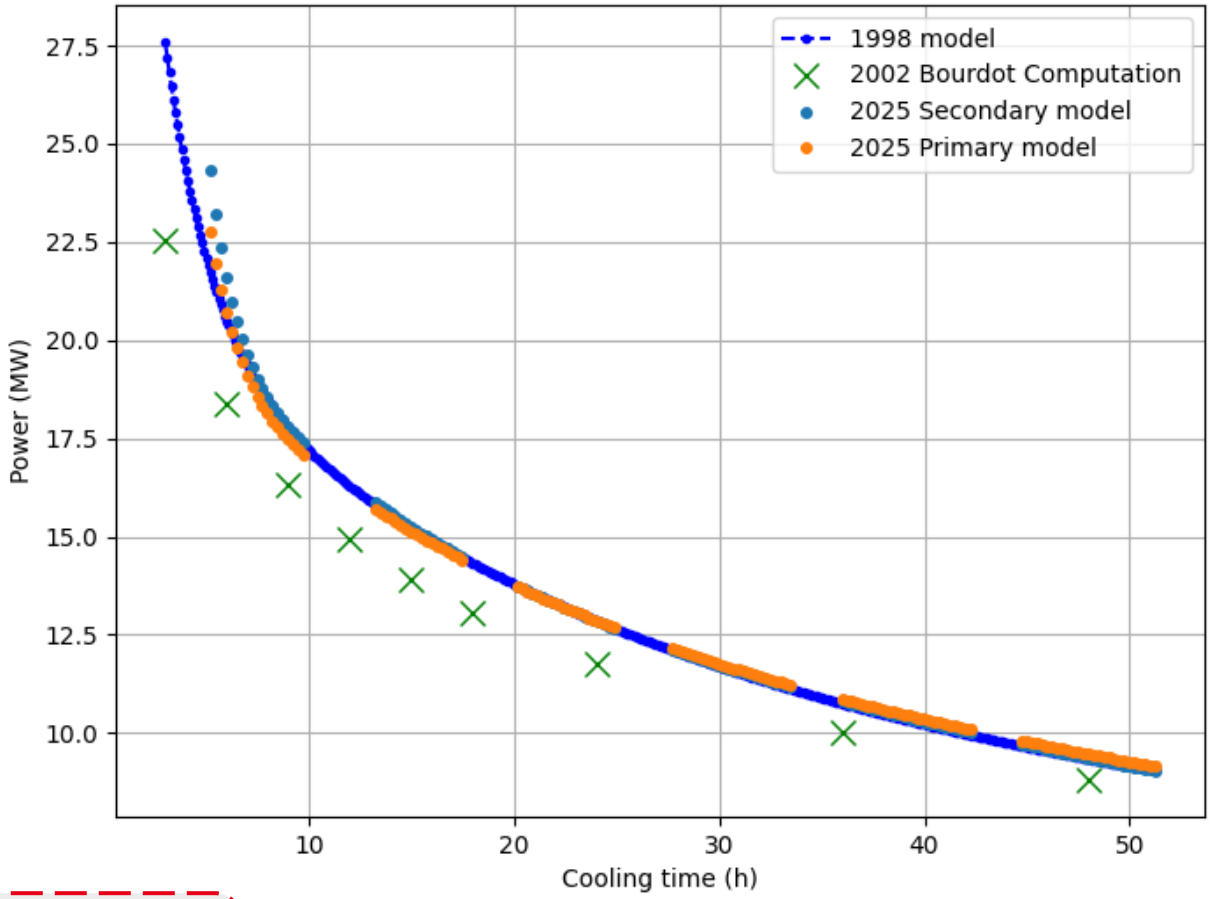
- Worsening of the Calculation/Experiment discrepancy

- Invalid result (computed with an operational code recalibrated afterwards)

Superphénix experiments



1987 case



1996 case

- Unchanged C/E
- A thermal model to review

Conclusions on reinterpreting the experiments

	Measurement	Cooling phase	Discrepancy $C/E-1$ (%)	Uncertainties E (1σ - %) C (1σ - %)	Code Library	Date of interpretation
Phénix	Phenix **1979** (Desprets & Costa, 1979)	7 to 36 h	**+6 to +18**	~9,5 6	PROTEE (Costa et al., 1981) (Costa & Mougniot, 1972) (Cazalet, 1979)	1979 (Desprets & Costa, 1979)
			+6 to +20	8,9 to 9,8 7 to 13,5	MECCYCO JEF1	1992 (Gillet G. , 1992)
			−6,4 to +2,8	6,2 to 7,5 7 to 13,5	MECCYCO JEF1	2025 (Da Cunha, submitted)
	Phenix **1982** (Guidez & Carminati, 1983)	6 to 28 h	**−12 to −8**	8 ?	Epure	1983
			−23,8 to −17,4	6,2 to 8,6 ?	Epure	2025 (Da Cunha, submitted)
	Phenix **1993** (Martin & Mellano, 1993)	6 to 72 h	**+5 to +17**	10 8	MECCYCO JEF1	1993 (Gillet G. , 1993)
			−2,5 to +1,8	7,5 to 17,5 8	MECCYCO JEF1	2025 (Da Cunha, submitted)
	Phenix **2008** (Auban, 2008)	1,5 h to 12 d	**−8 to +15**	5 to 11 5	DARWIN JEFF 3.1.1	2012 (Benoit, 2012a)
			−6 to +26	5 to 11 2,5 to 4,7	DARWIN2 JEFF 3.1.1	2018 (Lebrat et al., 2018)
			−1 to +6	4,5 to 12 2 to 3,4	DARWIN2 JEFF 3.1.1	2024 (Da Cunha et al., 2024)

Phénix

- Improvement of the thermal model
- Much better coherence between measurements and calculations

Superphénix

- An industrial reactor (different goal and much more complex)
- Less feedback than Phénix
- Probably a thermal model to review

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Extending the validation domain

Decay heat validation

PWR UOX decay heat calculations

APOLLO2/DARWIN2

SFR MOX decay heat calculations

ERANOS/DARWIN2

PWR MOX decay heat calculations

Improved results after re-analysis of a decay heat experiment in French SFR



PWR with MOX fuels

Requires validation

Can we use SFR experiments to validate PWR MOX calculations ?

Experimentally validated

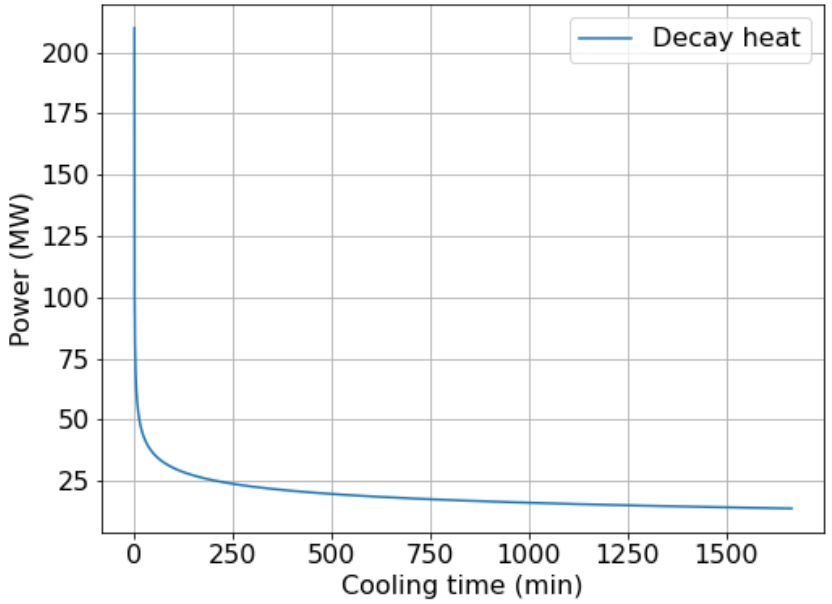
Lack of measurement to validate

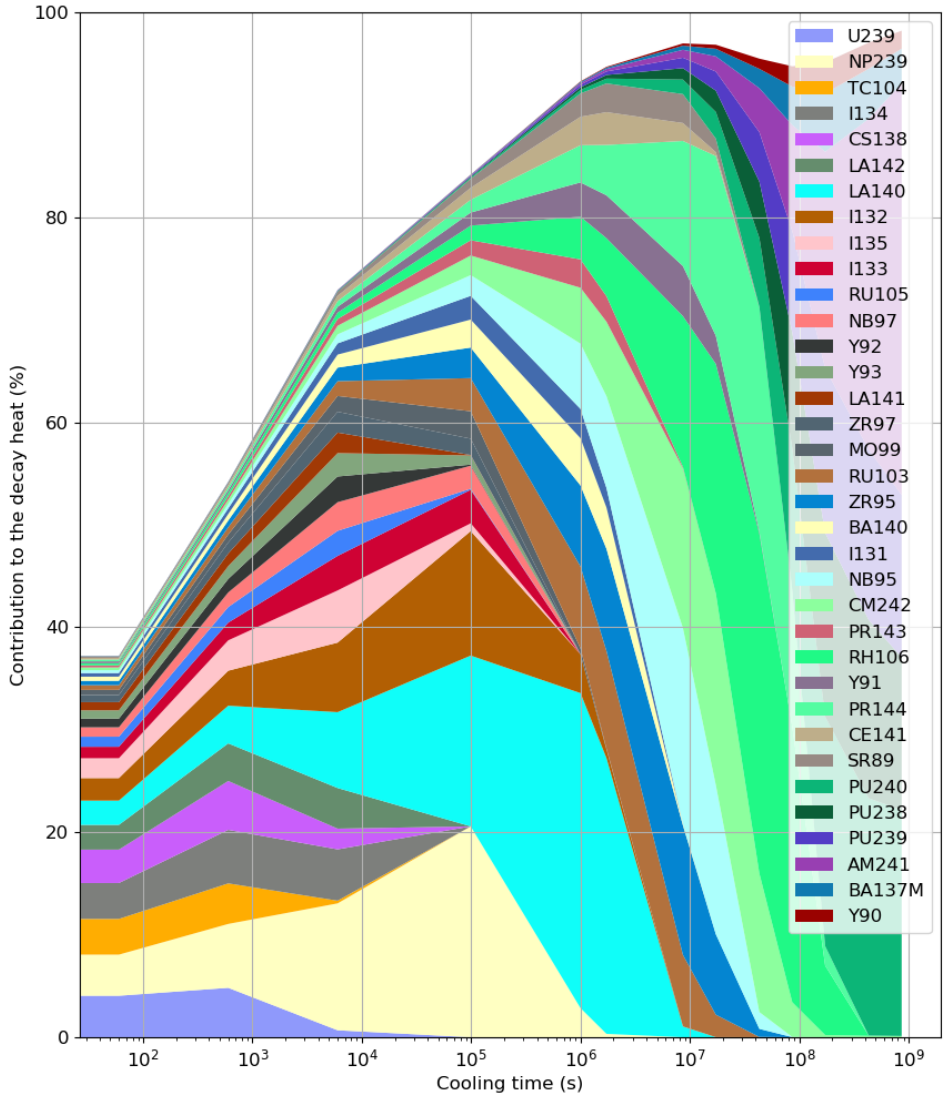
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Study of the decay heat breakdown

$$DH(t) = \sum_i N_i(t)\,\lambda_i \bar{E}_i\ [W]$$

- N_i: isotopic abundance
- λ_i: decay constant of radioisotope i $[s^{-1}]$
- $\bar{E}_i$: mean decay energy of radioisotope i $[J]$





$$\alpha_i(t) = \frac{N_i(t)\lambda_i \bar{E}_i}{\sum_i N_i(t)\,\lambda_i \bar{E}_i}$$

- **Isotopes contributing at least 2% of DH**
- **53 radionuclides**
  - ERANOS→PEPIN 2

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A similarity factor

$$DH_A = \sum_i N_i(t)\,\lambda_i \overline{E_i}$$

$$DH_B = \sum_j N_j(t)\,\lambda_j \overline{E_j}$$

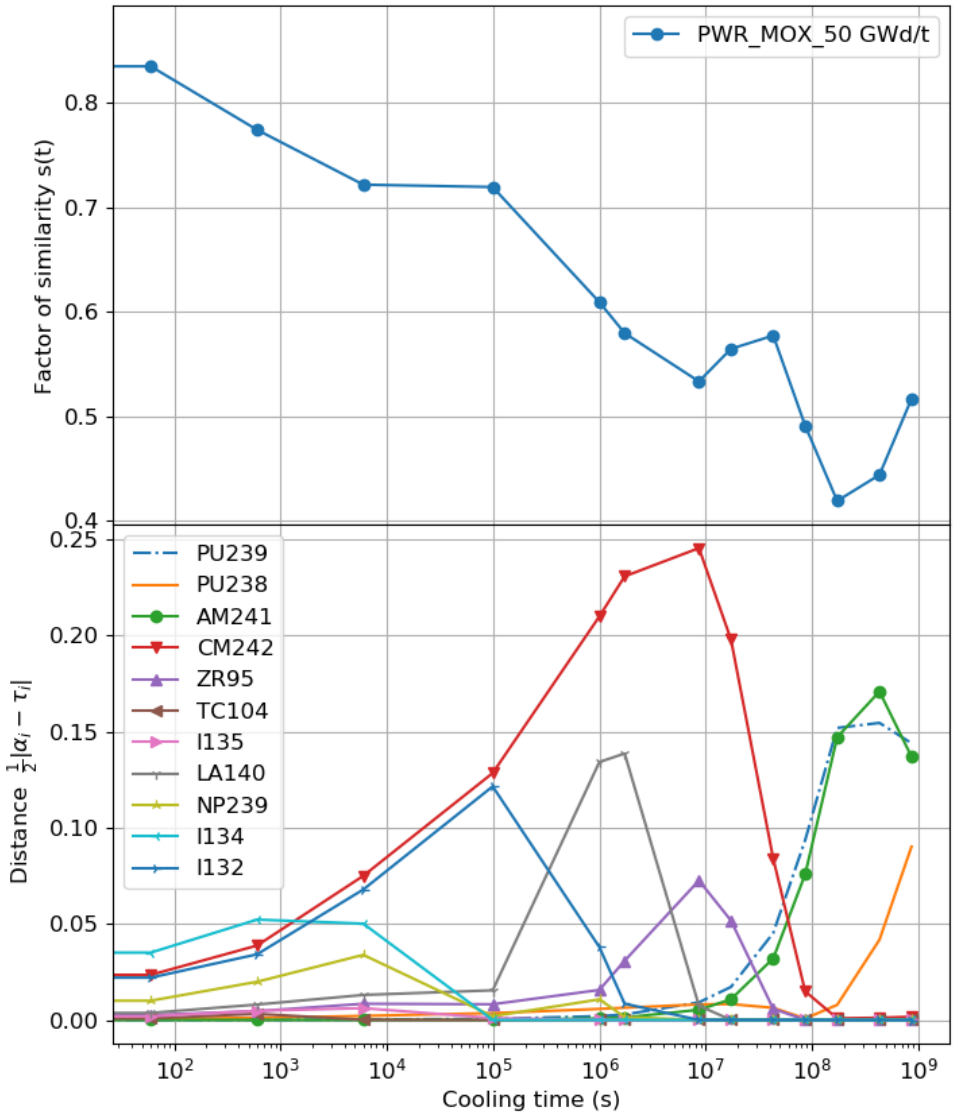
$$\alpha_i(t) = \frac{N_i(t)\lambda_i \overline{E_i}}{\sum_i N_i(t)\,\lambda_i \overline{E_i}}$$

$$\tau_i(t) = \frac{N_i(t)\lambda_i \overline{E_i}}{\sum_j N_j(t)\,\lambda_j \overline{E_j}}$$

$\alpha_i(t)$: Relative contribution of radioisotope i to an application A
$\tau_i(t)$: Relative contribution of radioisotope i to an application B

$$s(t) = 1 - \frac{1}{2}\sum_i |\alpha_i(t) - \tau_i(t)|$$

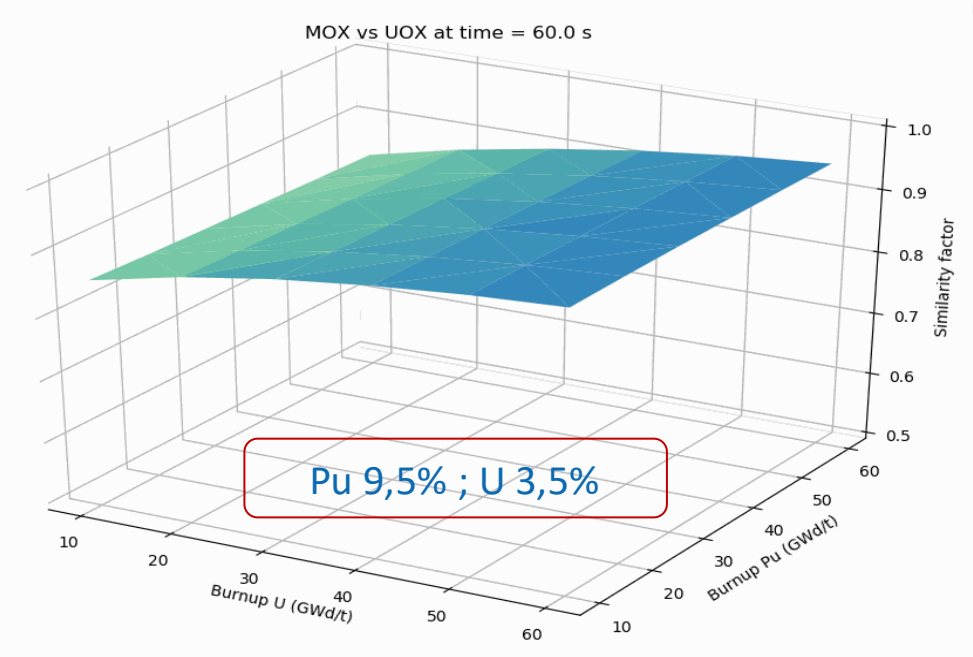
- Good representation of physical differences
- Intuitive
- Easy to implement

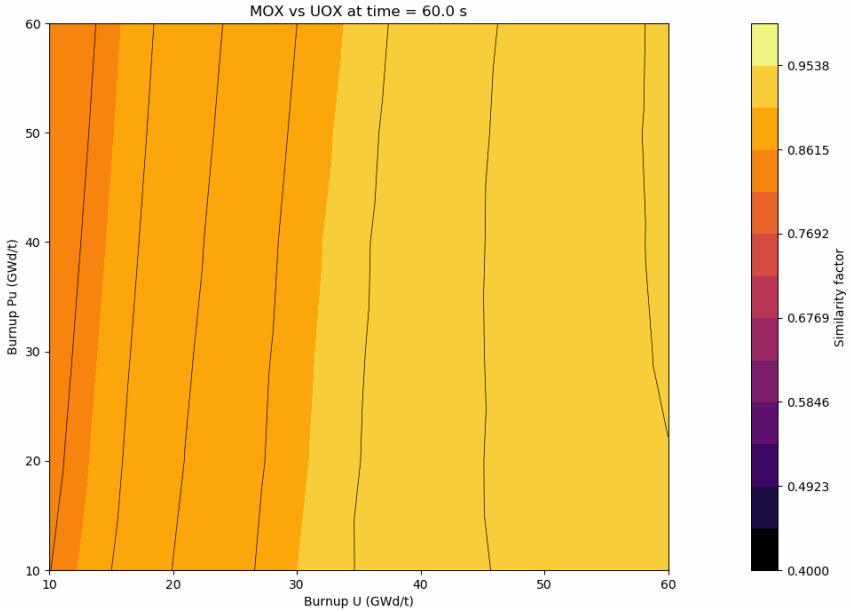


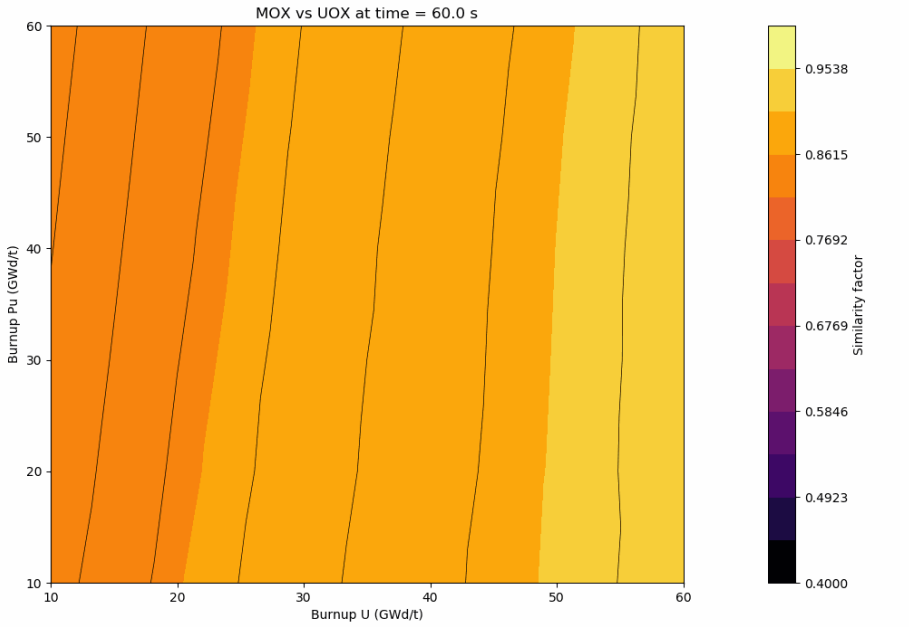
Phénix fuel at 10 GWd/t vs PWR MOX fuel at 50 GWd/t

Characteristics of this similarity factor

- High-dimension problem (%Pu, %U, BU)
- 216 000 comparison points (MOx PWR vs UOx PWR)
- Determine the main quantities of interest

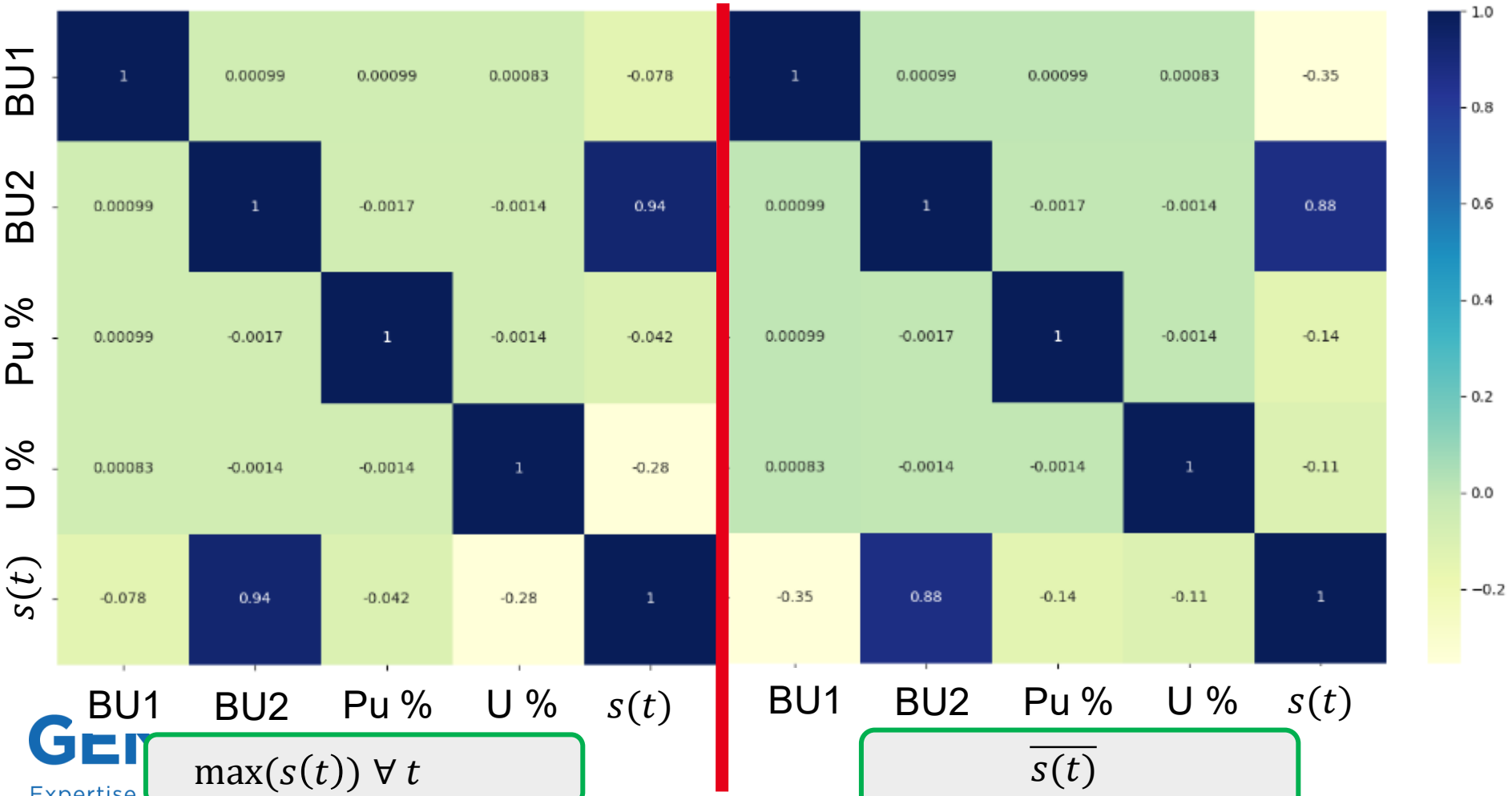






Characteristics of this similarity factor

- *Main factor: UOx burnup*



$\max(s(t))\ \forall\ t$

$\overline{s(t)}$

UOx
- *Low enrichment*
- *High burnup*

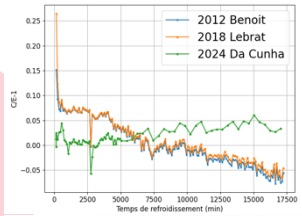
MOx
- *Low Pu enrichment*
- *Low burnup*

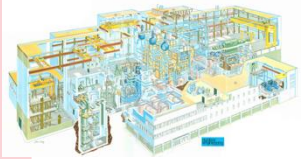
- *Promising factor*
- *Study it for SFR*

Conclusions

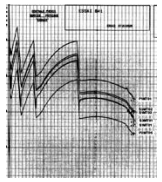
Experiments

- **Discrepancies for four experiments explained and reduced**
- **Six** experiments and two reactors studied
- An experimental data base restored



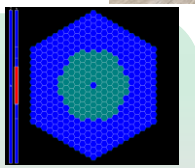




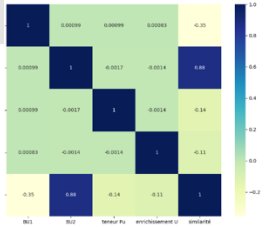


Simulation

- An SCT under VVUQ process (APOLLO3-MENDEL)
- A study regarding transposition for decay heat calculation



Theory



Outlooks

- Refine thermal model uncertainties
- Study SPX thermal balances and review thermal models and uncertainties

- Modelling of the Puirex experiment with APOLLO3
- Modelling of the 1982 experiment
- Complete the parametric study of the factor $s(t)$ with SFR fuels
- Studying the properties of coupled Bateman-Boltzmann equations with the aim of transposing a distance

[Appere, 1998] Private communication
[Benoit, 2012a] Benoit, J.-C., « Développement d'un code de propagation des incertitudes des données nucléaires sur la puissance résiduelle dans les réacteurs à neutrons rapides »,Ph.D dissertation, [nucl-th], Paris Sud Univ., Paris, 2012
[Benoit, 2012b] Benoit, J.-C. (2012). Decay Heat of Sodium Fast Reactor : Comparison of Experimental Measurements on the Phenix reactor with Calculations performed with the French DARWIN package. PHYSOR. Knoxville.
[Bestion, 2024] Bestion, D'Auria, Carnevali & Ciechocki. (2024). On some ways to improve BEPU methodologies Part1: guidelines on PIRT - transient analysis - scaling analysis - IET and set design. Best Estimate Plus Uncertainty International Conference. Lucca, Tuscany, Italy.
[Bernardin, 1998] Private communication
[Bourdot, 2002] Private communication
[Brau, 2008] Private communication
[Calame, 2020] A. Calame et al., Analysis of a decay heat experiment in Superphénix fort the experimental validation of the Darwin3 package
[Cazalet, 1979] Private communication
[Costa, 1972] Private communication
[da Cunha et al., 2024a] D. da Cunha, F. Nguyen, J.-F. Lebrat, C. Le Niliot, "Revisited analysis of the PUIREX 2008 Decay Heat experiment in the Phénix Sodium Fast Reactor", *Annals of Nuclear Energy*, accepted on the 8th of April, 2024
[da Cunha et al., 2024b] Da Cunha D., Lebrat, J-F., Nguyen, F., « A numerical study of the similarity between the decay heat of PWR and SFR MOX fuels », *PHYSOR2024*
[Desprets, 1979] Private communication
[Desprets, Costa, 1979] Private communication
[Favet, 1987] Private communication
[Gillet, 1988a] Private communication
[Gillet, 1988b] Private communication
[Gillet, 1992] Private communication
[Gillet, 1993] Private communication
[Gillet, 1996] Private communication
[Glasstone 1967] Samuel Glasstone and Alexander Sesonske, Nuclear Reactor Engineering, Van Nostrand Reinhold, 1967 (2rd edition).
[Gody, 1997] Gody, Compte rendu d'essai, mesure de puissance résiduelle, note NERSA
[Guidez, 1983] Private communication
[Lebrat, et al., 2018] J.-F. Lebrat, Uncertainty assessment on the calculated decay heat of the ASTRID basic design core based on the DARWIN-2.3 package, Ann. Nucl. Eng., Vol.120, pp.378-391
[Martin, 1993] Private communication
[Todreas, 1990] Neil E. Todreas and Mujid S. Kazimi, Nuclear Systems I, Thermal Hydraulic Fundamentals, Hemisphere Publishing Corporation, 1990, ISBN 0-89116-935-0 (v. 1)

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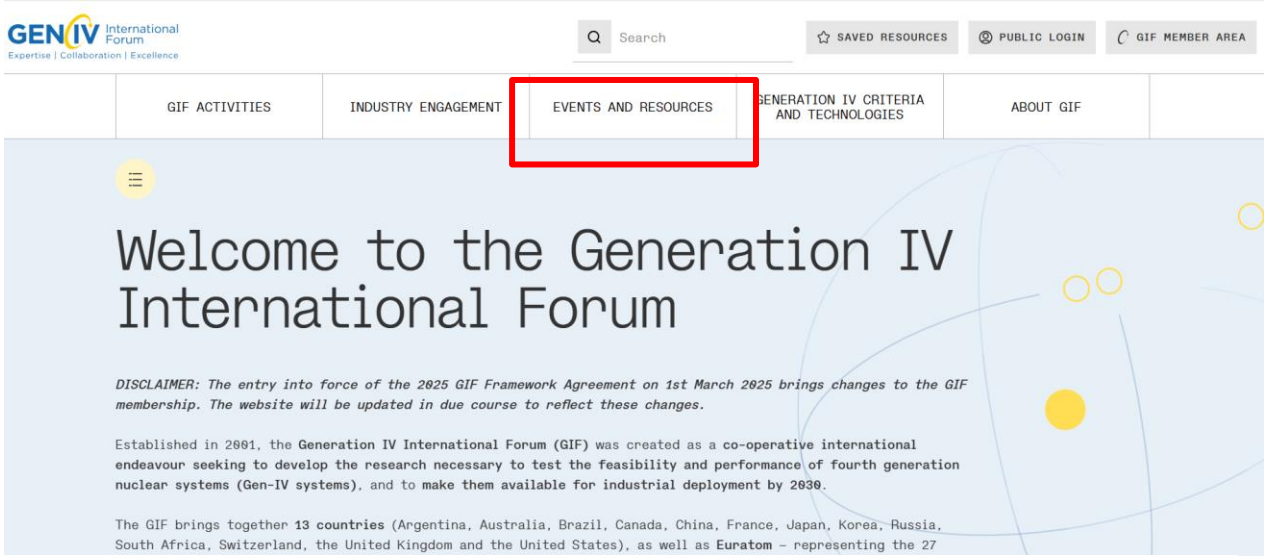
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Date	Title	Presenters/Moderators
12 November 2026	MELCOR: The evolution of nuclear safety analysis technology to enable nuclear innovation	Christian Matthew and David Luxat, Sandia National Laboratory, USA
16 December 2026	Pyrochemistry for Advanced Nuclear Fuel Cycles: From Spent Fuel Recycling to Molten Salt Reactor Fuels	Pavel Soucek, Joint Research Center Karlsruhe, Germany
January 2027	Joint GIF IAEA Webinar on Challenges and Opportunities for 21st-century SFRs	Moderators: Bo Feng from Argonne National Laboratory and Patricia Paviet from Pacific Northwest National Laboratory

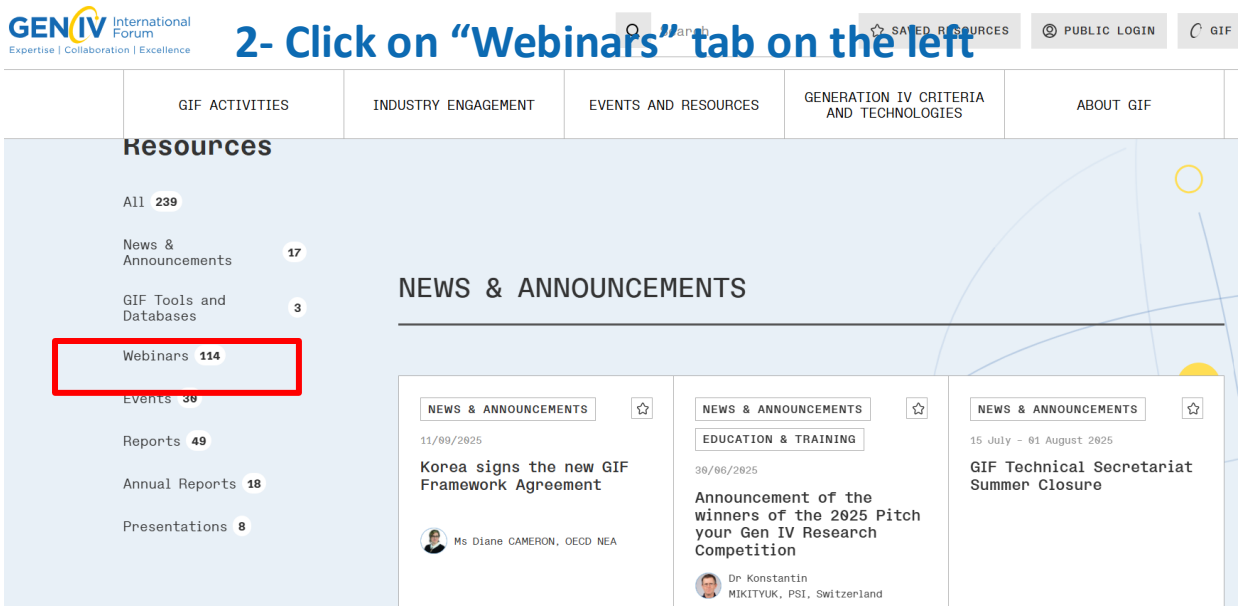
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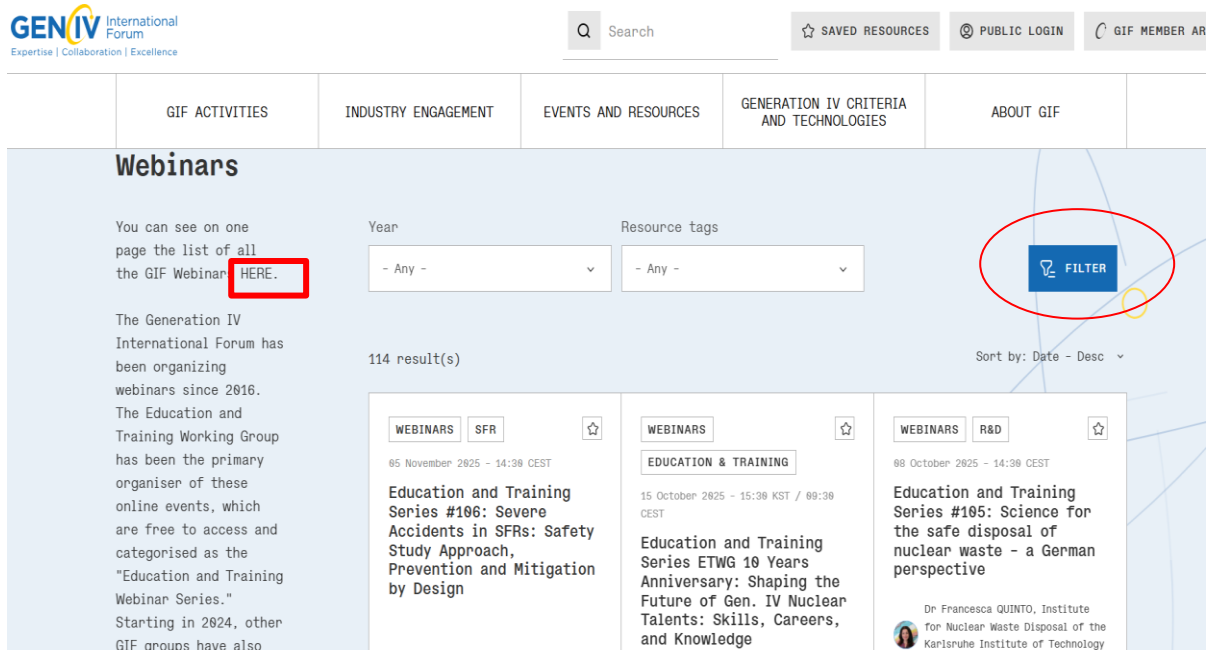
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