Nuclear data needs:
Identifying the highest priorities for applications

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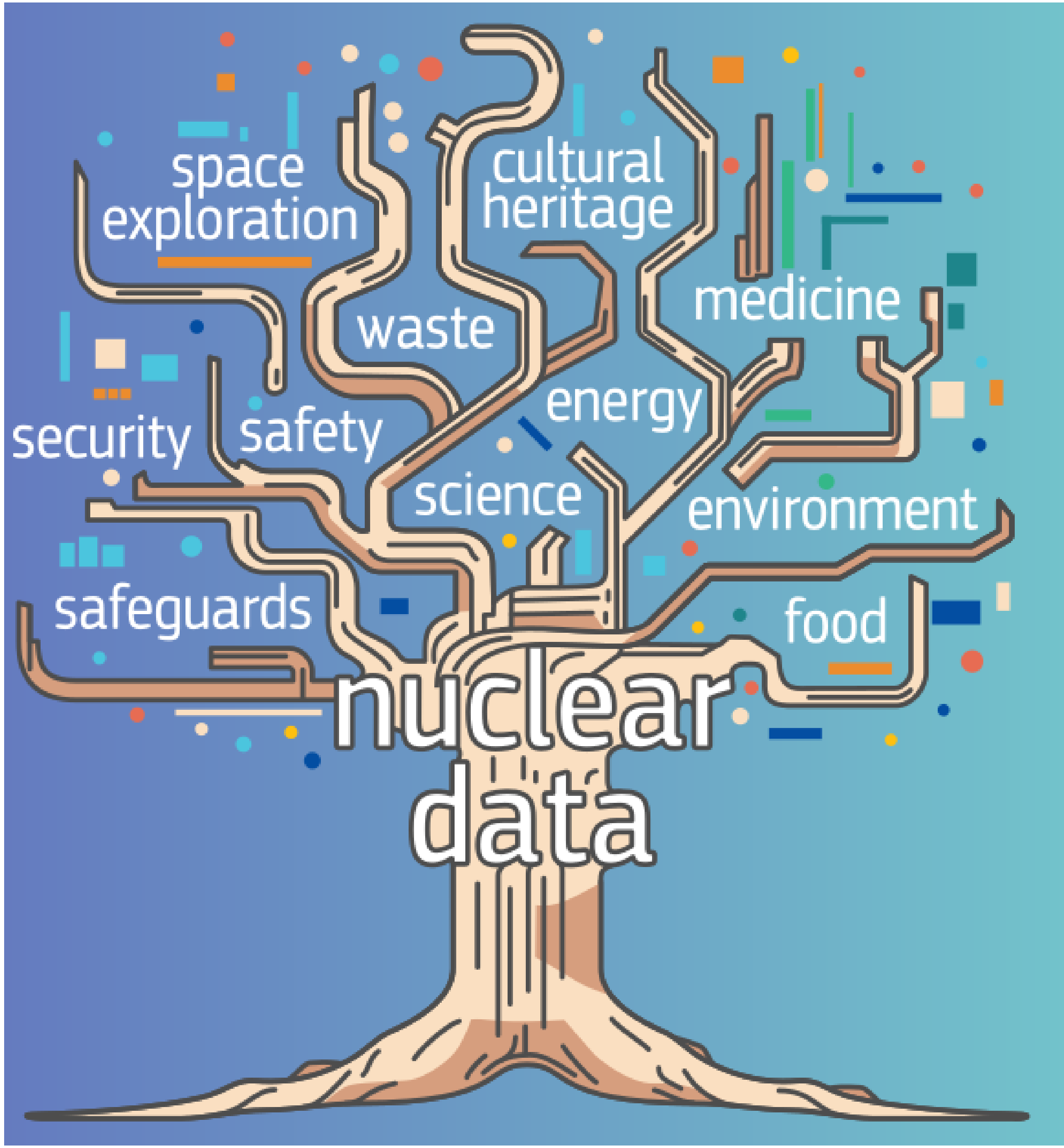
PND2-3 Nuclear Data for the Next Decade
Campus des Cordeliers, Sorbonne University, Paris, France

European Commission

Contents

- Developments in nuclear energy
- Our framework for establishing nuclear data needs
- Recent target uncertainties and sensitivity analyses
- The broader scope
- Skills in our field: who will help bring science to our needs for energy, independence & welfare?



Near and mid-term future (EU…)

Long Term Operation

Extending the lifetime of the existing fleet

Nuclear power plants

Building new nuclear reactors using established technologies

Effective Waste Management

Long and intermediate storage of spent fuel

Small Modular Reactors

Bringing a new generation of nuclear reactors to the market, **including small modular reactors**

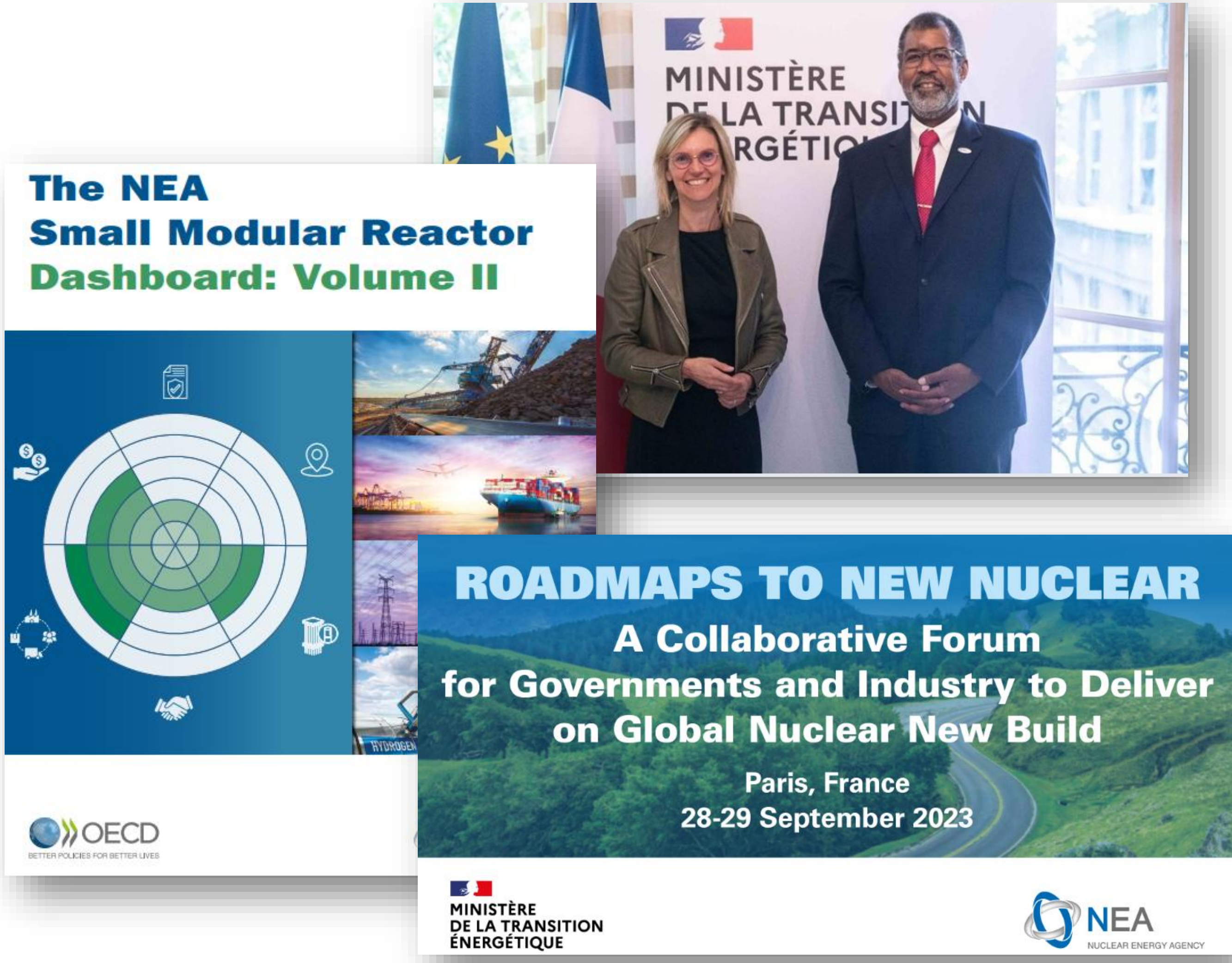
Adapted from a slide by Stefan Kopecky (JRC, Dir.G, 2026)

Global drivers for Nuclear Energy (M. Fleming, Side event ND GC 2023)

- NEA projections show that to successfully achieve net zero by 2050, nuclear energy capacity must at least double compared to current installed capacity.

- Several NEA member countries are acting now to realise this deployment, including multilateral co-ordination at ministerial level.

- Multiple technologies are part of these roadmaps, including a wide variety of SMRs enjoying significant resource allocation.



Nuclear energy in Europe

EU and Brazil only major economies with more than 50% electricity from low-carbon sources

24% of total electricity produced in EU

France almost 2/3 in its mix from nuclear

Bulgaria, Czech Republic, Hungary, Poland, Romania concrete projects

Czech Republic, Poland, Slovakia, Slovenia, Sweden, Netherlands, Romania and France have declared intentions for new reactors

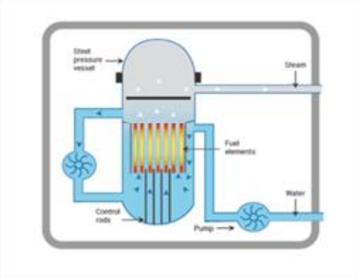
	PWR		BWR		PHWR		total	
	number	MWe	number	MWe	number	MWe	number	MWe
Belgium	5	3 908					5	3 908
Bulgaria	2	2 006					2	2 006
Czech	6	3 934					6	3 934
Finland	3	2 614	2	1 780			5	4 394
France	57	63 000					57	63 000
Hungary	4	1 916					4	1 916
Netherlands	1	482					1	482
Romania					2	1 380	2	1 380
Slovakia	5	2 308					5	2 308
Slovenia	1	688					1	688
Spain	6	6 059	1	1 064			7	7 123
Sweden	2	2 211	4	4 733			6	6 944
Total EU	92	89 126	7	15 77	2	1 380	101	98 083

Source: IAEA, 2025 [17]

Slide courtesy Stefan Kopecky (JRC, Dir.G, 2026)

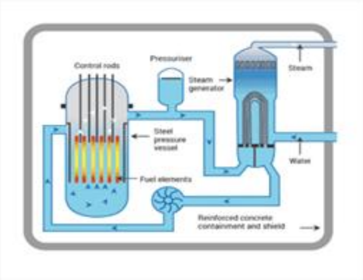
Main types of SMR

Boiling water reactor



Smaller, modular versions of traditional reactors using water as a coolant and neutron moderator.
The technology is well established, with licensing, fabrication, and supply chain close to demand of existing power plants

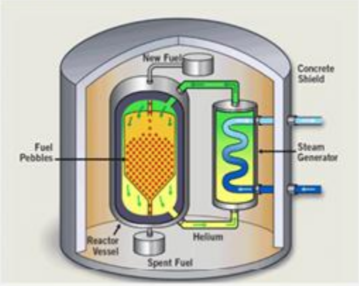
Pressurized water reactor



Smaller, modular versions of traditional reactors using water as a coolant and neutron moderator.

Integral pressurised water reactor
This is a self-contained design integrating all necessary components into a single vessel.

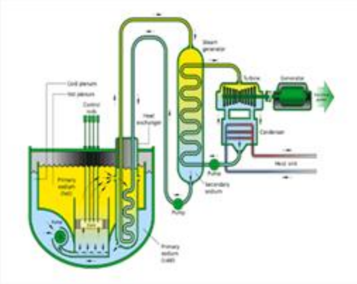
High temperature gas-cooled reactors



These use helium gas as a coolant and graphite as a moderator, suitable for industrial high-temperature applications.

In Europe, although the technology's original home, the supply chain for fuel, materials and components needs to be revived.

Liquid metal fast reactors

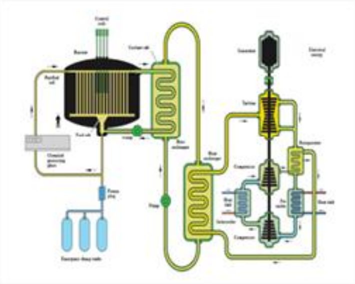


Liquid metals such as sodium and lead are utilised as coolants.

For sodium-cooled fast reactors, there is significant experience in Europe, (Phénix and Superphénix).

In the case of liquid lead-cooled reactors, little operational experience outside of Russia

Molten salt reactor



Use of liquid fuel, mostly a mixture of fluoride or chloride salts serving as both fuel and coolant, these reactors are ideally suited for operations at relatively high temperatures.

Several crucial challenges must be addressed before MSRs can deployed on a wide scale.

Slide courtesy Stefan Kopecky (JRC, Dir.G, 2026)

SMR - Europe

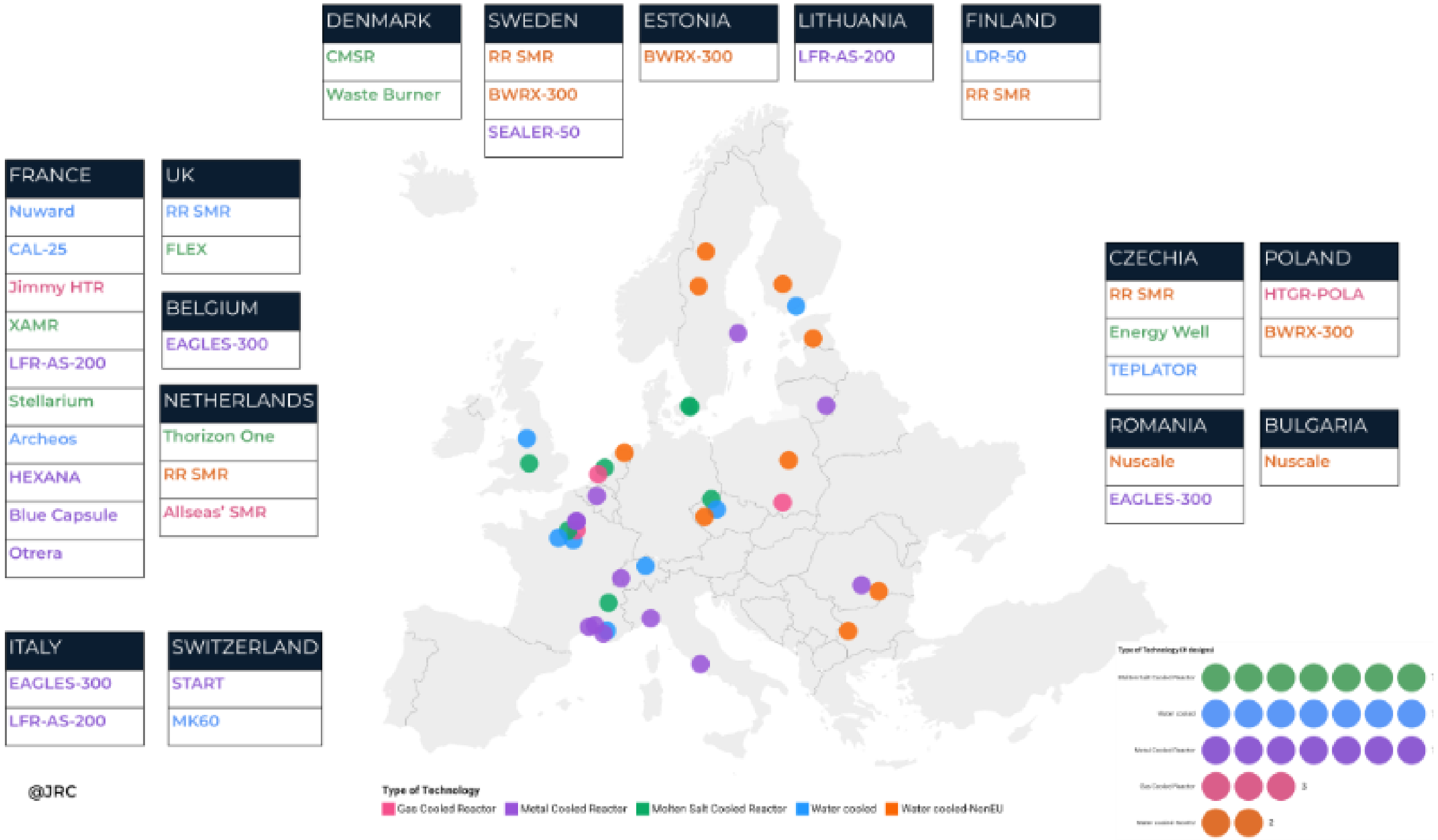
Industrial Alliance, first phase proposals

PWR:
CityHeat (Calogena, Steady Energy)
Nuward (EDF)
NuScale VOYGR™ SMR (RoPower Nuclear S.A)
Project Quantum (Last Energy, suspended)
Rolls-Royce SMR (Rolls-Royce SMR Ltd)

BWR:
European BWRX-300 SMR (OSGE)

LFR:
EAGLES (Ansaldo, ENEA, RATEN, SCK-CEN)
European LFR AS Project (newcleo)
Jointly: LEANDREA @ sck-cen

MSR:
Thorizon One (Thorizon)

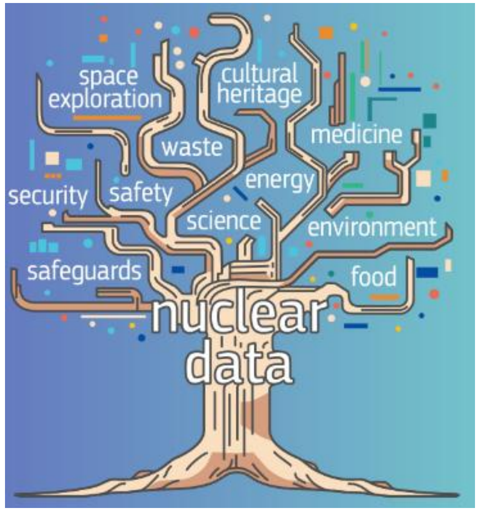


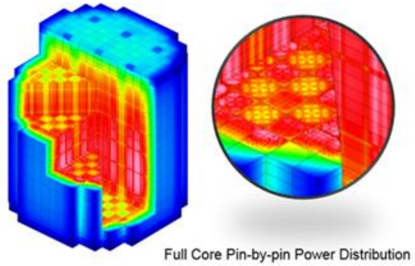
Source: JRC, 2025, using data from [45] [46] [47] [48] [49]

Slide courtesy Stefan Kopecky (JRC, Dir.G, 2026)

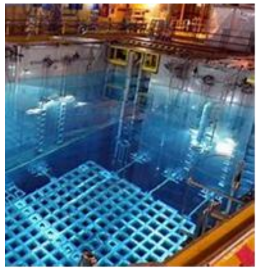
Role of nuclear data for tomorrow's solutions

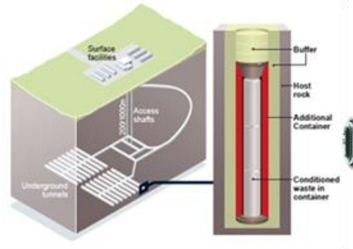
- Modelling is needed at every step of development
  - Scoping, design, testing, operation, safety analyses, spent fuel management
  - Allows savings and shortens development
- **Good data are essential for good modelling**
- Awareness of how data affect design and operation

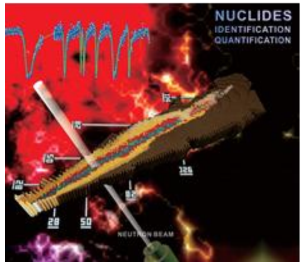


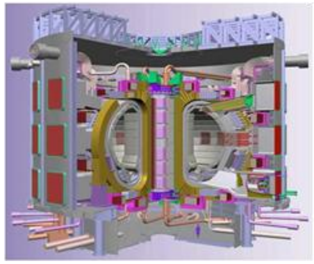


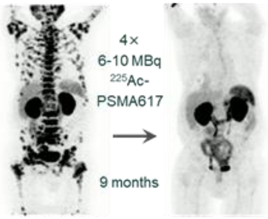
Full Core Pin-by-pin Power Distribution





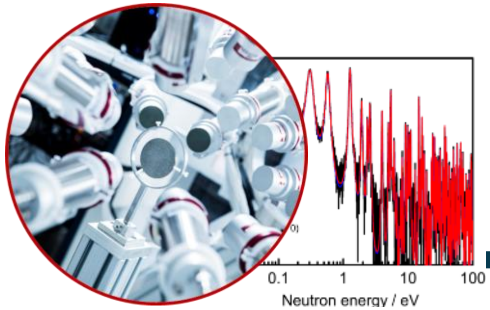


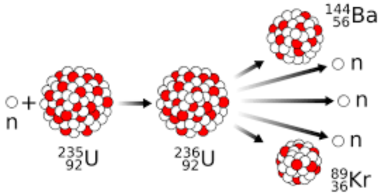


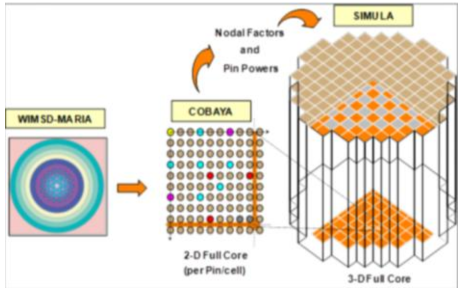


[C. Kratochwil *et al.*, J. Nucl. Med. **57** (2016) 1941]

Developing nuclear data for applications







Measured data

Theory

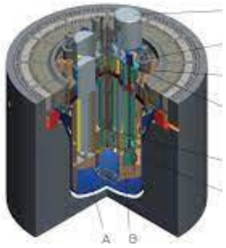
Benchmarks

Database

Research & Development

Industry

Regulatory bodies



New questions

Collect new data

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The pipeline (M. Fleming, Side event ND GC 2023)

- 'The pipeline' (source: D. Brown) is exceptionally relevant for illustrating how data projects develop products – but let's build in the user community more:

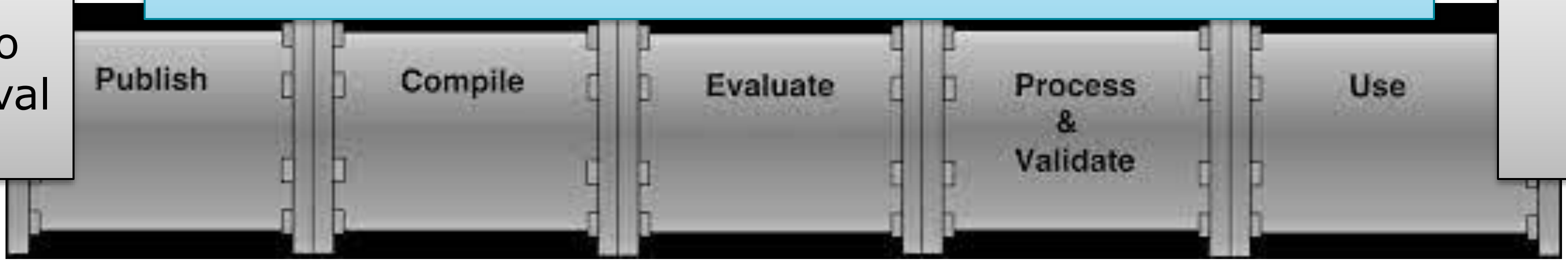
End-user community

Work with users to identify ND-related issues

Quantify needs in terms of targets

S/U analysis to prioritize exp/eval

Preserve everything required to understand and reproduce the evaluation



Integrate into simulation systems

Adjust or provide support for it

Document the application impact(s)

Framework for establishing nuclear data needs

Target applications

- Interests of stakeholders
- Analysis of foreseen innovations
- Quantitative understanding of data needs
- What is known already?
- High priority request list for nuclear data HPRL

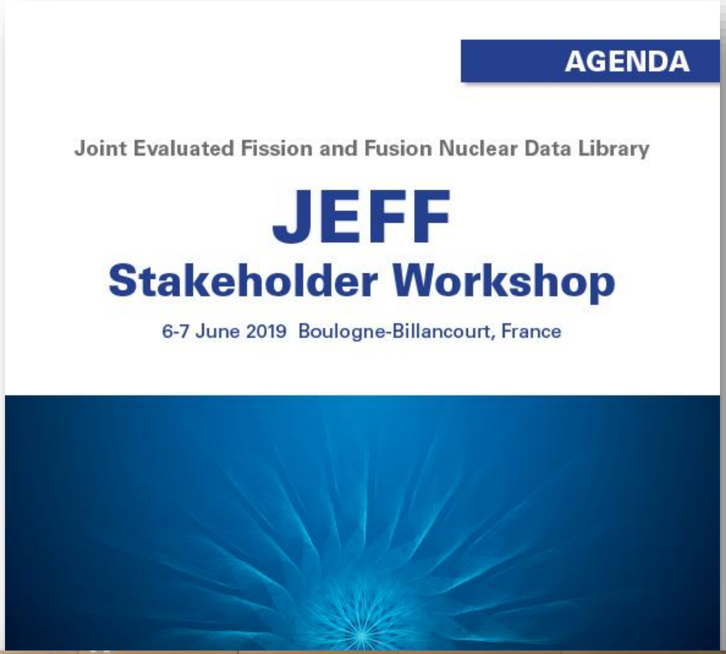
Getting quantitative about needs

- Target uncertainties
- Modeling
- Sensitivity analysis
- Uncertainty quantification

Stakeholder / user engagement (M. Fleming, Side event ND GC 2023)

- Last user engagement in 2019 Stakeholder meeting
  - ✓ Several user communities engaged for the first time
  - ✓ New issues raised and bilateral exchanges to quantify/address problems
  - ✓ Request: maximize participation from end-user communities to bring new perspectives / needs

- Latest stakeholder meeting 20 September 2023
  - ✓ Topics considering:
    - Advanced reactors / fusion
    - Materials modelling
    - Source facilities
    - Waste and handling
    - Medical applications / isotopes
    - Facility design
    - Exploration…
  - ✓ Necessary to conduct routinely and translate stakeholder engagement into quantifiable targets



Examples of codes using JEFF

Transport

- APOLLO (ERANOS)
- CASMO
- COBAYA
- CRISTAL
- CRONOS
- GEANT-4
- FLUKA

Transport

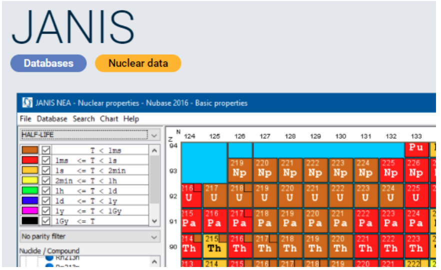
- MCBEND
- MCNP
- MONK
- MORET
- SCALE
- SERPENT
- TRIPOLI-4
- WIMS

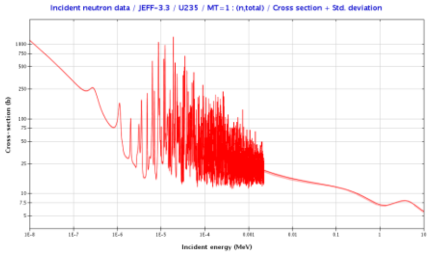
Depletion

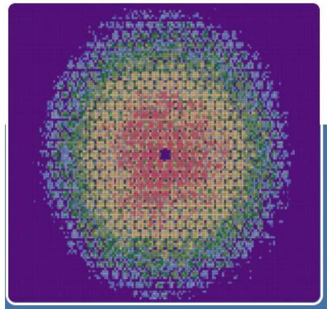
- ALEPH
- CESAR
- DARWIN
- EVOLCODE
- FISPACT-II
- FISPIN
- MENDEL
- VESTA

Processing

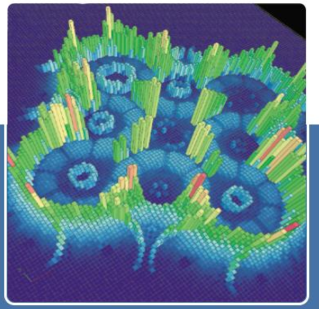
- AMPX
- CALENDF
- FIZCON
- FRENDY
- GAIA
- GALILEE
- NJOY
- PREPRO
- PSYCHE
- SANDY
- STANEF







Computer Program Services (CPS)



Nuclear Data Services (NDS)

DATA BANK

NEA NUCLEAR ENERGY AGENCY

Working with our partners

Structured collaboration
- JEFF project (OECD-NEA Databank)
- WPEC OECD-NEA Science
- IAEA NDS CRPs, DDPs, CMs

European projects
- Fission: APRENDE, SANDA, ARIEL, ENEN2plus, EURAD, OFFERR…
- Fusion: EUROfusion ND WP
- Horizon Europe: EURO-LABS

APRENDE

EUROfusion

EURO-LABS
EUROPEAN LABORATORIES FOR ACCELERATOR BASED SCIENCES

5:15 – 5:40 PM
Current Initiatives and Future Trends in WPEC Nuclear Data Activities
Speaker
Dr Anastasia Georgiadou (NEA)

NEA
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High priority requests – sensitivity analysis

PND2-2, 2014, SG26, Salvatores, Palmiotti, Aliberti, Ishikawa, McKnight…

Since then: CHANDA, SANDA, APRENDE, WANDA, ORNL, SG46, Cabellos, Hursin et al. (Salvatores, Palmiotti)…

Sensitivity analysis

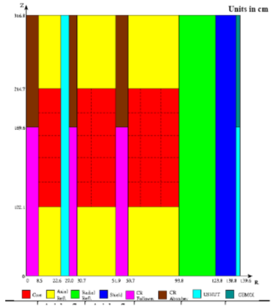
Quantitative underpinning of requests

System modeling

$\mathbf{Q} = \mathbf{f}(p)$

- **A simple principle…**
- **Conceptual systems**
- **Good understanding**

- **Future**
  Better capabilities
  More modeling
  Actual designs (design dependence!)
  Better feedback from experiments



Multiplication factor (BOL)	300 pcm
Power peak (BOL)	2%
Burn-up reactivity swing	300 pcm
Reactivity coefficients (coolant void and Doppler – BOL)	7%
Major nuclide density at end of irradiation cycle	2%
Other nuclide density at end of irradiation cycle	10%

Sensitivity analysis

Back propagation method

- **System constraints**
- **Sensitivity coefficients**
- **Leave a domain of acceptable uncertainties**
- **Use the freedom to find the best route to achieve the final goal**
- **Cost function minimization**

System uncertainty limits L_i:

$$r_i(\mathbf{Q}) < L_i \quad \text{for } 1 \le i \le k$$

Equivalently for the parameters:

$$\sum_{a,b} S_{ia} S_{ib} C_{ab}(\mathbf{p}) r_a(\mathbf{p}) r_b(\mathbf{p}) < L_i^2, \quad i = 1..k$$

For each Q_i an ellipsoid in $\mathbf{r}(\mathbf{p})$-space

$$\min\left(\sum_a \frac{\lambda_a}{r_a^2(\mathbf{p})}\right)$$

The cost parameters λ_a may be changed according to the relative difficulty of obtaining low uncertainties for the parameter p_a.

Review: Annals Nuclear Energy 212(2025)110806 Ryzhkov et al.

NEA Nuclear Data High Priority Request List - HPRL

The NEA Nuclear Data High Priority Request List (HPRL) is a compilation of the most important nuclear data reque
on International Nuclear Data Evaluation Co-operation (WPEC) . The purpose of the list is to provide a guide for tho
programmes.

Use the links below to display corresponding lists:

- All requests
- High priority requests (HPR)
- General requests (GR)
- Special purpose quantities (SPQ)
- Standard (STD)
- Dosimetry (DOS)

Renewed format

- 43 requests before 2015 (before PND2-2)
- 78 new entries since then
- 14 new high priority requests
- 30 open high priority requests

ID	Type	Target	Reaction	Quantity	Energy		Accuracy (%)	Status	Last update
					Min	Max			
98	H	24-Cr-53	(n,g)	SIG	1 keV	100 keV	8-10	Archived	2025-Jun-05
120	H	95-Am-241	(n,g)Am-242g,m	BR	0.2 eV	1.5 eV	5	Work in progress	2023-Jun-06
121	S	8-O-16	(n,xα)	DE	20 MeV	200 MeV	10	Work in progress	2023-May-20

HPRL - High priority entries

68-Er-167	(n,g)	SIG RP	2	LWR
94-Pu-239	(n,tot)	SIG	1	LWR
64-Gd-157	(n,g) , (n,tot)	SIG	4	LWR
64-Gd-155	(n,g) , (n,tot)	SIG	4	LWR
94-Pu-239	(n,f)	nubar	1	LWR
24-Cr-50	(n,g)	SIG	8-10	LWR
1-H-2	(n,el)	DA/DE	5	LWR

3-Li-0	(d,x)H-3	SIG TTY	10	Fusion	IFMIF-DONES
3-Li-0	(d,x)Be-7	SIG	10	Fusion	IFMIF-DONES
19-K-39	(n,p) , (n,np)	SIG	10	Fusion	IFMIF-DONES

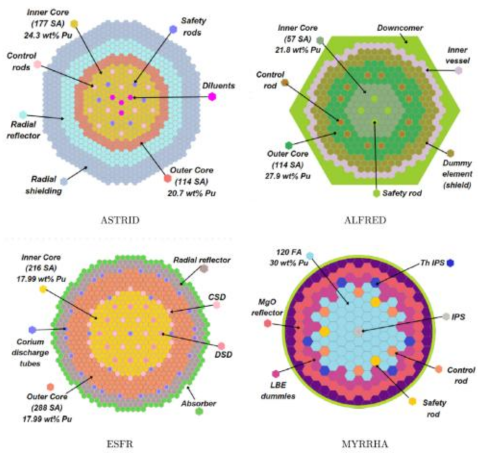
17-Cl-35	(n,p)	SIG	5-8	MSR	GenIV
96-Cm-245	(n,f)	SIG	3-43	MAB	GenIV
96-Cm-244	(n,f)	SIG	2-20	MAB	GenIV

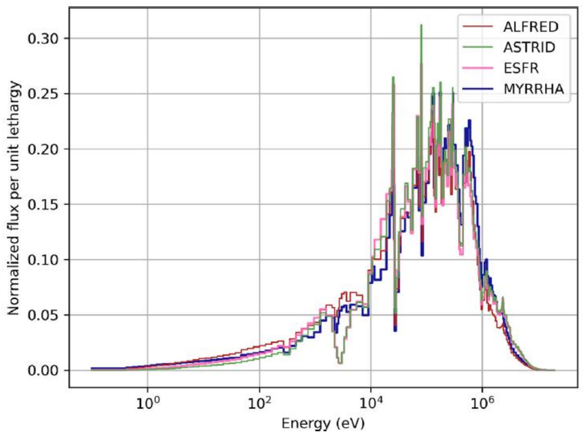
95-Am-241	(n,g)Am-242g,m	BR	5	LWR	GenIV
94-Pu-240	(n,f)	SIG	2-13	LWR	GenIV
94-Pu-241	(n,f)	SIG	2-12	LWR	GenIV
26-Fe-56	(n,inl)	SIG	2-13	LWR	GenIV
94-Pu-241	(n,g)	SIG	2-15	LWR	GenIV
94-Pu-239	(n,g)	SIG	1-11	LWR	GenIV
92-U-238	(n,inl)	SIG	2-12	LWR	GenIV
95-Am-241	(n,g) , (n,tot)	SIG	2-5	LWR	GenIV
8-O-16	(n,a) , (n,abs)	SIG	5-12	LWR	GenIV

94-Pu-242	(n,f)	SIG	4-15	FR	GenIV
94-Pu-240	(n,f)	nubar	1-3	FR	GenIV
95-Am-242m	(n,f)	SIG	3-8	FR	GenIV
95-Am-241	(n,f)	SIG	1-7	FR	GenIV
94-Pu-238	(n,f)	SIG	3-24	FR	GenIV

Recent sensitivity analyses & uncert. quantif.

- Cabellos & Garcia-Herranz, EPJ woc 294 (2024) 05003, UPM/WPEC-46
- Panizo et al., PNE 172 (2024) 105207 and predecessors
- Bostelman, Ilas, Wieselquist, Frontiers in Energy Research 2023 (ORNL/TM 2021, NUREG/CR-7289)





- SG-46: ALFRED, JSFR, MCRE, MOLTEX, MYRRHA, ASTRID, ESFR, NUSCALE
- ESFR, ASTRID, ALFRED, MYRRHA
- HTR-10, UCB m1 PB-FHR, MSRE, INL Design A, EBR-II, ABR-1000 benchmarks for pebble-bed HTGR, FHR, Graphite-moderated MSR, HPR, SFR
- Works consider k, void reactivity, temperature coefficient, beta-eff, prompt-generation time
- Besides quantification many observations on missing (uncertainty) data and differences: missing robustness

Some results (PNE 172 (2024) 105207)

Table 1
Summary S/U table for ESFR, ASTRID, ALFRED calculated with SCALE and MYRRHA calculated with SUMMON.

Reactor	Response	Value	Target accuracy	Uncertainty [%]	TA achieved
ESFR	k_{eff}	1.004 99(9)	0.2% = 200 pcm	1.0376(3)	NO
	Coolant density[a]	305(12) pcm	5%	25.69(12)	NO
	Doppler +300 K	−140(11) pcm	5%	4.25(54)	YES
	Control	−5028(13) pcm	3%	1.96(1)	YES
ASTRID	k_{eff}	1.007 79(8)	0.2% = 200 pcm	0.9698(2)	NO
	Coolant density	−536(12) pcm	5%	15.78(5)	NO
ALFRED	k_{eff}	0.999 04(10)	0.435% = 435 pcm	0.8768(2)	NO
	Coolant density	193(13) pcm	5%	6.8(3)	NO
	Doppler +300 K	−112(14) pcm	5%	6.9(6)	NO
	Doppler −300 K	188(13) pcm	5%	3.6(3)	YES
MYRRHA	k_{eff}	1.015 42(3)	300 pcm	0.762(1)	NO
	β_{eff}	337(1) pcm		1.26(4)	
	Doppler −200 K	114(4) pcm		5(1)	
	Coolant density	1901(4) pcm		2.0(2)	
	Control (BD)	2709(4) pcm		2.0(1)	
	Control (BD+GS)	4124(4) pcm		1.86(6)	

Some results (EPJwoc 294(2024)05003)

Table 6. Top reactions for the uncertainty reduction using JEFF-3.3 evaluation based on a joint "keff" values for ALFRED, ASTRID, ESFR and JSFR.

			SG26 - No correlations				SG46 - with correlations		
keff			A	B	C		A	B	C
Reaction	EG	Current (%)	Target (%)	Target (%)	Target (%)		Target (%)	Target (%)	Target (%)
240Pu (n,f)	2	8.4	1.2	**1.0**	1.4		1.1	**1.2**	1.2
240Pu (n,f)	4	25.4	**3.1**	3.6	3.5		2.2	2.5	2.4
238U(n,γ)	4	2.0	0.7	0.7	0.6		0.4	0.4	0.4
240Pu (n,f)	3	14.9	**2.5**	**3.0**	**2.9**		1.9	2.2	2.1
239Pu (n,f)	4	1.0	0.5	0.5	0.5		0.3	0.3	0.3
238U (n.n')	2	7.4	1.3	1.7	2.0		1.0	1.2	1.5
240Pu(n,γ)	4	7.2	1.8	1.4	2.2		1.5	1.8	1.7
239Pu (PFNS)	1	5.5	1.2	1.2	1.1		0.7	0.3	0.7
240Pu (n,f)	1	6.3	2.0	2.2	2.3		1.5	1.7	1.6
239Pu(n,γ)	4	3.1	1.5	1.4	1.4		0.6	0.6	0.6

- Extract hides the many results that were obtained by UPM and more generally SG-46
- Important are the ability to use new tools by a new generation of scientists for SA/UQ, actualize the designs to current interests, study all parameters of interest, assess the robustness and deficiencies of data, uncertainties and their correlations

Some results (Frontiers in Energy Research 2023 (ORNL/TM 2021, NUREG/CR-7289)

TABLE 3 INL Design A HPR uncertainties[†] in quantities of interest due to nuclear data uncertainty, for different ENDF/B library versions.

Quantity	VII.0 (%)	VII.1 (%)	VIII.0 (%)	$\frac{\text{VII.1}}{\text{VII.0}} - 1$	$\frac{\text{VIII.0}}{\text{VII.1}} - 1$
k_{eff}	2.01	2.08	0.98	3.4%	−53.0%
$\Delta\rho$ fuel temperature	8.77	6.59	4.34	−24.9%	−34.1%
$\Delta\rho$ grid radial expansion	1.40	1.68	1.49	19.9%	−11.3%
$\Delta\rho$ fuel axial expansion	2.92	2.69	2.00	−8.0%	−25.7%

Reactor type	Key nuclear data	Missing/discrepant/additional data, important data changes
Thermal spectrum, pebble-bed HTGR*	**Fuel:** ^{235}U $\bar{\nu}$, ^{235}U χ, ^{235}U fission, ^{235}U (n,γ), ^{238}U (n,γ), ^{28}Si (n,γ), ^{28}Si elastic **Moderator:** ^{12}C/graphite: (n,γ), elastic, inelastic, ^{10}B (n,α)	No thermal scattering data uncertainties for graphite
Thermal spectrum, FHR	**Fuel:** $\bar{\nu}$, fission, and (n,γ) of ^{235}U, ^{239}Pu, and ^{241}Pu, (n,γ) of ^{238}U and ^{240}Pu **Coolant:** ^{7}Li (n,γ), ^{7}Li elastic, ^{6}Li (n,t) ^{19}F (n,γ), ^{19}F elastic, ^{9}Be elastic **Moderator:** ^{12}C/graphite (n,γ) and elastic	No thermal scattering data uncertainties for graphite components
Thermal spectrum, graphite-moderated MSR*	**Fuel/coolant:** ^{235}U $\bar{\nu}$, ^{235}U fission, ^{235}U (n,γ), ^{238}U $\bar{\nu}$, ^{238}U fission, ^{238}U (n,γ), ^{238}U elastic, ^{19}F elastic, ^{19}F (n,γ), ^{7}Li (n,γ), ^{6}Li (n,γ), ^{6}Li (n,t) **Moderator:** ^{12}C/graphite (n,γ) and elastic **Structure:** Structure: ^{58}Ni elastic, ^{58}Ni inelastic, ^{58}Ni (n,γ), ^{58}Ni (n,p)	No thermal scattering data uncertainties for graphite or salt components
Fast spectrum, molten chloride MSR	**Fuel and coolant salt:** $\bar{\nu}$ and fission of ^{235}U, ^{238}U, ^{239}Pu, ^{240}Pu, ^{241}Pu, ^{238}U (n,γ), ^{238}U inel., ^{239}Pu (n,γ), ^{37}Cl inelastic, ^{37}Cl elastic, ^{23}Na inelastic, ^{23}Na elastic, ^{35}Cl (n,p), ^{35}Cl (n,γ) **Reflector:** ^{24}Mg elastic	Angular scattering distribution uncertainties: limited availability and usability; ^{238}U inelastic scattering uncertainty ENDF/B-VII.1 vs. VIII.0
Fast spectrum, oxide and metal fueled HPR*	**Fuel:** ^{235}U $\bar{\nu}$, ^{235}U fission, ^{235}U (n,γ), ^{238}U $\bar{\nu}$, ^{238}U fission, ^{238}U (n,2n), ^{16}O elastic; elastic and inelastic scattering, as well as (n,γ) of ^{238}U, ^{90}Zr, ^{91}Zr, ^{92}Zr, ^{94}Zr, ^{96}Zr **Coolant:** ^{23}Na elastic, ^{23}Na inelastic, ^{39}K capture, ^{39}K (n,p), ^{39}K elastic **Structure:** ^{56}Fe (n,γ), ^{56}Fe elastic, ^{56}Fe inelastic, ^{27}Al elastic, ^{9}Be elastic, ^{16}O elastic, ^{10}B (n,γ), ^{10}B (n,α)	Angular scattering distribution uncertainties: limited availability and usability No thermal scattering data uncertainties for BeO; ^{235}U (n,γ) uncertainty ENDF/B-VII.1 vs. VIII.0
Fast spectrum, metal and oxide fueled SFR	**Fuel:** $\bar{\nu}$ and fission of ^{238}U, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, ^{242}Pu, ^{241}Am, ^{242m}Am, ^{243}Am, ^{245}Cm; ^{238}U (n,γ), ^{238}U inelastic, ^{239}Pu (n,γ), ^{241}Am (n,γ), ^{243}Am (n,γ), ^{16}O elastic **Coolant:** ^{23}Na elastic, ^{23}Na inelastic **Structure/Reflector:** ^{52}Cr elastic; elastic and inelastic scattering as well as (n,γ) of ^{56}Fe, ^{52}Cr, ^{90}Zr, ^{91}Zr, ^{92}Zr, ^{94}Zr, ^{96}Zr	Angular scattering distribution uncertainties: limited availability and usability ^{238}U inelastic scattering uncertainty between ENDF/B releases
All concepts	Fission yields, decay constants, branching ratios, energy release per fission, fission spectra, fission products (e.g., Xe, Sm, Gd), fission and capture of actinides that build up during depletion	Missing correlations between $\bar{\nu}$, fission and χ; ^{235}U/^{239}Pu $\bar{\nu}$ and fission uncertainty ENDF/B-VII.1 vs. VIII.0 Missing $\bar{\nu}$ uncertainty for ^{242}Am, ^{244}Am, ^{244m}Am, ^{243}Pu, ^{237}U, ^{239}U, ^{240}U, ^{241}U

But this does not cover all interests…

Spent fuel management

- SA, Fiorito et al. ANE161(2021)108415 – Exploratory work for methodology – establishing key nuclide cross sections and energy ranges for fuel inventory EOL
- EURAD, EURAD2 projects – decay heat, reactivity, dose rates (PSI, CEA, CLAB, SCK CEN…)
- Tight requirements, target/established uncertainty about 2%; Predominantly a need for **robustness.**
- Data: FY, some actinide capture cross sections (capture U-238, Pu-240, Am-241... – inventory)

Fusion

- Main nuclear data related concerns
  - Tritium breeding
  - Radiation damage
  - Shielding
  - Activation
- Approach
  - Emphasis on developing computational tools
  - Developing benchmarks for relevant tests of above
  - Sensitivity tools developed
  - Prioritization of data by expert judgement

JEFF-4.0 release – 20 June 2025

NEA Data Bank GitLab platform

Search

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Nuclear data
- Meetings
  - Nuclear Data Weeks (NDW)
  - Technical Dedicated Sessions (TDS)
    - Burnup issue
    - Iron
    - Big 3
    - Validation
    - Fission Yields
    - Random files
  - Co-ordination Group (CG)
- JEFDOCS and EFFDOCS
- Official JEFF Releases
  - Overview
  - JEFF-4.0
  - JEFF-3.3

Joint Evaluated Fission and Fusion (JEFF) Library version 4.0

The JEFF-4.0 nuclear data library combines the available experimental and theoretical knowledge of nuclear reactions and nuclear decay in standard format nuclear data files that ensure serving a wide user community. JEFF-4.0 aims at being a general-purpose library suitable not only in the nuclear energy and nuclear fusion domains but also for domains such as space and earth exploration, medical isotope production and nuclear science.

The main emphasis of development of the JEFF-4.0 library is on neutron-induced reaction data, but the library also incorporates significant updates on the fission yields, the proton-induced reaction data and the decay data. The JEFF-4.0 library was released in June 2025.

Latest official release

The JEFF-4.0 nuclear data library is the latest official release from the JEFF project.

Table of contents

5:40 – 6:05 PM **The JEFF-4.0 Nuclear Data Library: Status and Perspectives**

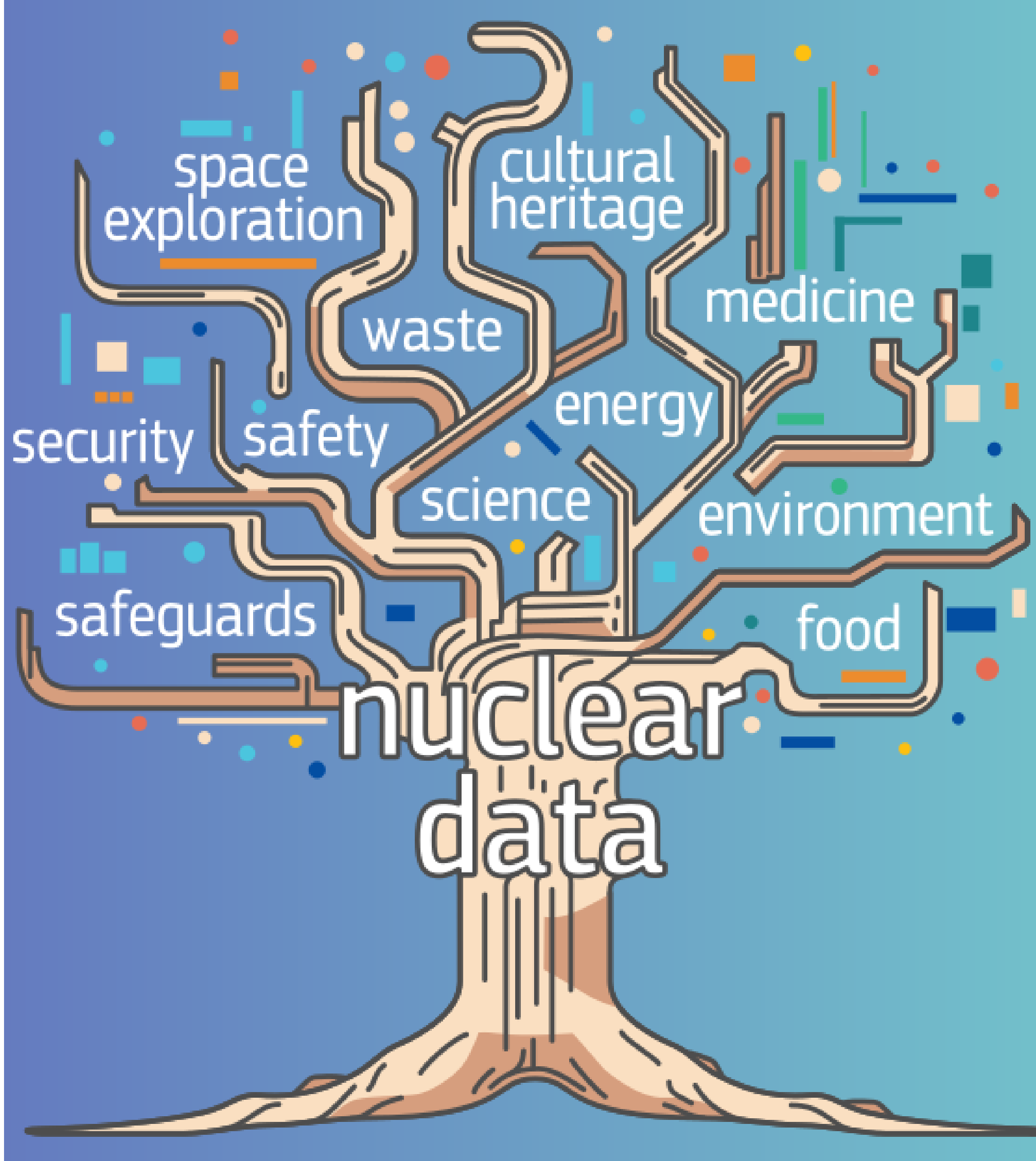
Speaker
Dr Antonio Jiménez-Carrascosa (NEA)

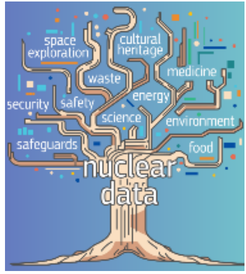
Thursday 12-3

JEFF-4.x objectives

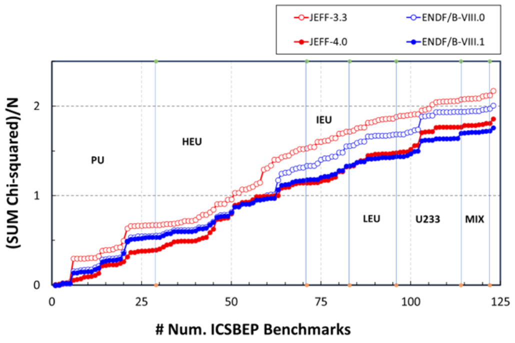
To evolve from stakeholder interest

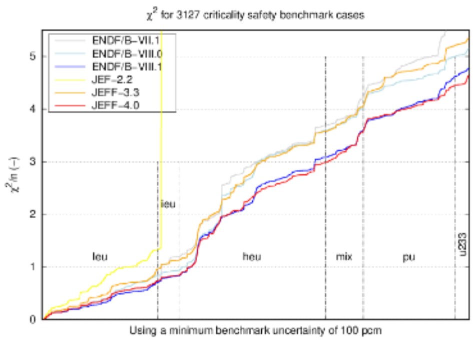
- General purpose file
- Improved performance for
  - Light water reactors: burnup, inventory, power map…
  - Advanced reactors (smr/amr; Pb/Bi, Na, msr)
  - Broader scope of benchmarking
  - Better quality assurance
    - Methods
    - Development platform
    - Faster return of feedback

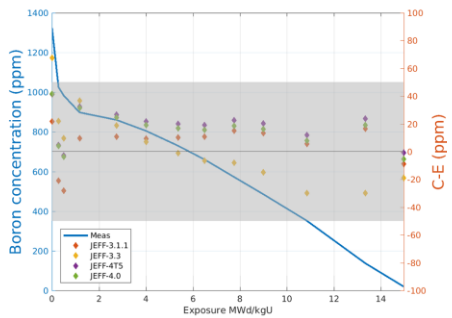


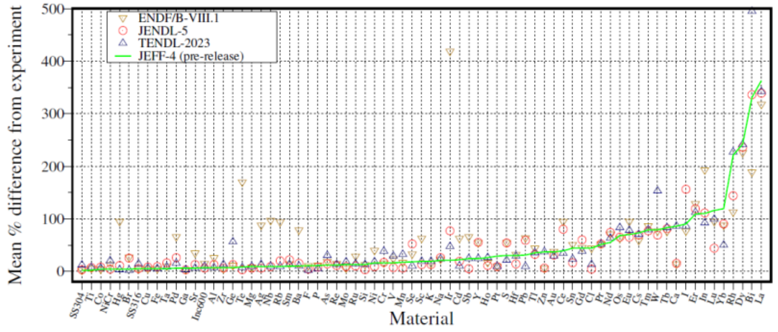


Nuclear energy, physics and engineering have many facets
Nuclear data play an important role in each

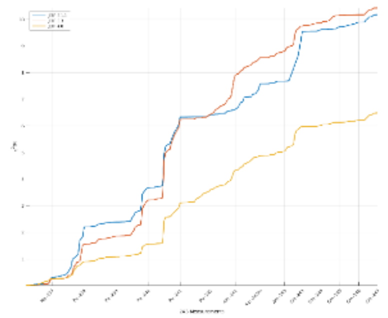


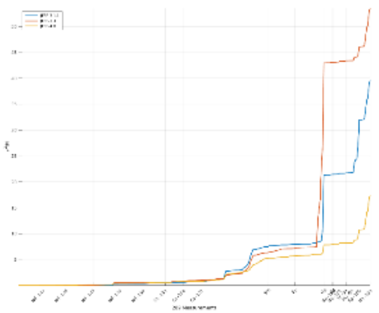


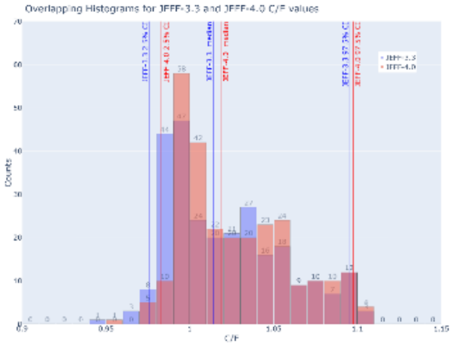


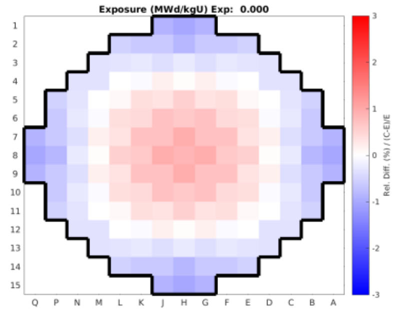


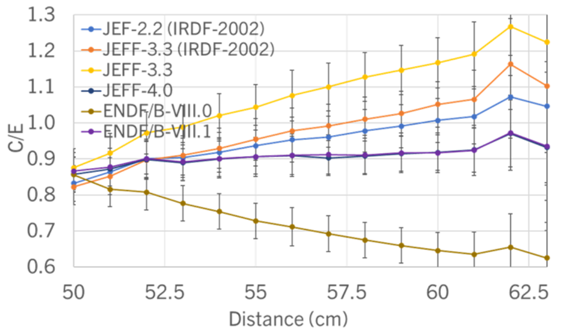
Criticality-Mosteller | Criticality-ICSBEP | Reactivity vs burnup | Fusion decay heat











SNF actinide inventory | SNF FP inventory | SNF decay heat | PWR power map | Fe shielding benchmark

Clean Energy Technology Observatory 2025 conclusions

Strength Existing capacity

Around 98 GW of nuclear power already operating in the EU contributing roughly €250 bn a year and supporting half a million jobs

Opportunity SMRs

Small Modular Reactors, slated to start operating in the early 2030s, could add 17–53 GWe of capacity by 2050.

Challenge Capital, supply-chain and skills gaps

new plant designs and builds demand financing, strengthened supply chain, and a skilled workforce – essential to ensure technological autonomy

R&D needs

across all aspects of nuclear fission technology; spanning the front end of the fuel cycle (e.g., advanced nuclear fuels), reactor technology, and the back end (spent fuel reprocessing and long-term waste management, including partitioning and transmutation)

Deployment

alongside economic and technological considerations, public acceptance will be a decisive factor

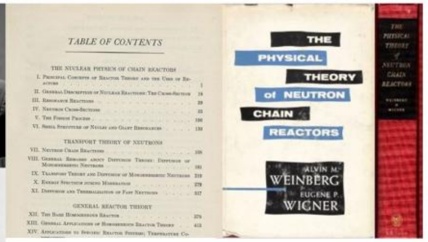
Slide courtesy Stefan Kopecky (JRC, Dir.G, 2026)

Summary

- The development of reliable predictions with credible uncertainty margins is progressing steadily.
- Codes, benchmarking and data libraries are taking major steps forward.
- AI and ML may prove accelerators.
- Data or code – where is the balance?
- Testing is essential for innovative ideas.
- Expert judgement is critical for decisions.
- Many promising developments to meet the challenges of today and tomorrow
- Who will help us further them?

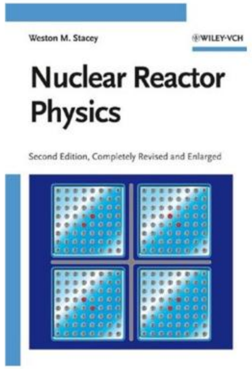
The physical theory of neutron chain reactors

Alvin M. Weinberg and Eugene P. Wigner, University of Chicago Press (1958)



Nuclear Reactor Physics

Weston M. Stacey, Wiley-VCH, 2nd ed. (2007)



$$\frac{1}{v}\frac{\partial f}{\partial t} + \Omega\cdot\nabla f + \Sigma_T f = S + \int dE' d\Omega' \, f(E',\Omega')\Sigma_s(E'\to E, \Omega'\to\Omega)$$

$$S = S_{PF} + S_{dn} + S_{\alpha n} + S_{ext}$$

$$S_{PF} = \sum_i N_i \int dE' \, f(E')\overline{\nu}_i(E')\sigma_{F,i}(E') f_{P,i}(E',E)$$

$$\Sigma_s(E\to E', \Omega\to\Omega') = \sum_i N_i \frac{d^2\sigma_{s,i}}{dE' d\Omega'}(E, E', \Omega\cdot\Omega')$$

$$\Sigma_T = \sum_i N_i \sigma_{T,i}$$

$$\frac{dN_i}{dt} = -\lambda_i N_i - r_i N_i + \sum_{i\neq i}\{\lambda_{j\to i} + r_{j\to i}\} N_j$$

Thank you

The author received permission for reproduction of the graphs … (to do)

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