Nuclear Data Activities in Euratom

Roger GARBIL
European Commission
DG Research and Innovation
Head of Euratom Fission Research
Roger.Garbil@ec.europa.eu

Consultant's Meeting on Comprehensive European plan to acquire and curate nuclear data, IAEA Headquarters, Vienna, 25-27 April 2023

Brief Overview of Euratom Research and Training fission

- R&D, WPs, WP2023-25, ND projects

EU/Euratom Fission Nuclear Data Activities … More and better quality data

Innovative Systems, Spent Fuel inventories, OECD/NEA, SMRs, Gen-IV and SNETP SRiA

Nuclear Data

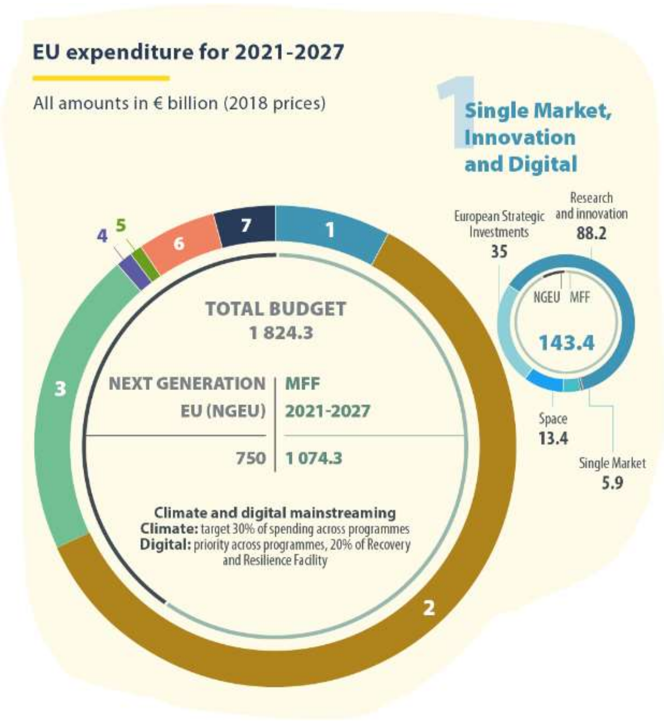
- R&D needs, Technical Achievements, Strategic Perspectives
- Success stories, lessons learnt, remaining challenges
- Impact and possible follow-up actions

EU Technology Platforms or Partnerships, SNETP, EERA JPNM, EURAD RWM

EU/Euratom FISA / EURADWASTE conferences' proceedings

Future Perspectives

FP9 (2021-27) Horizon Europe Budget: EUR 90 billion

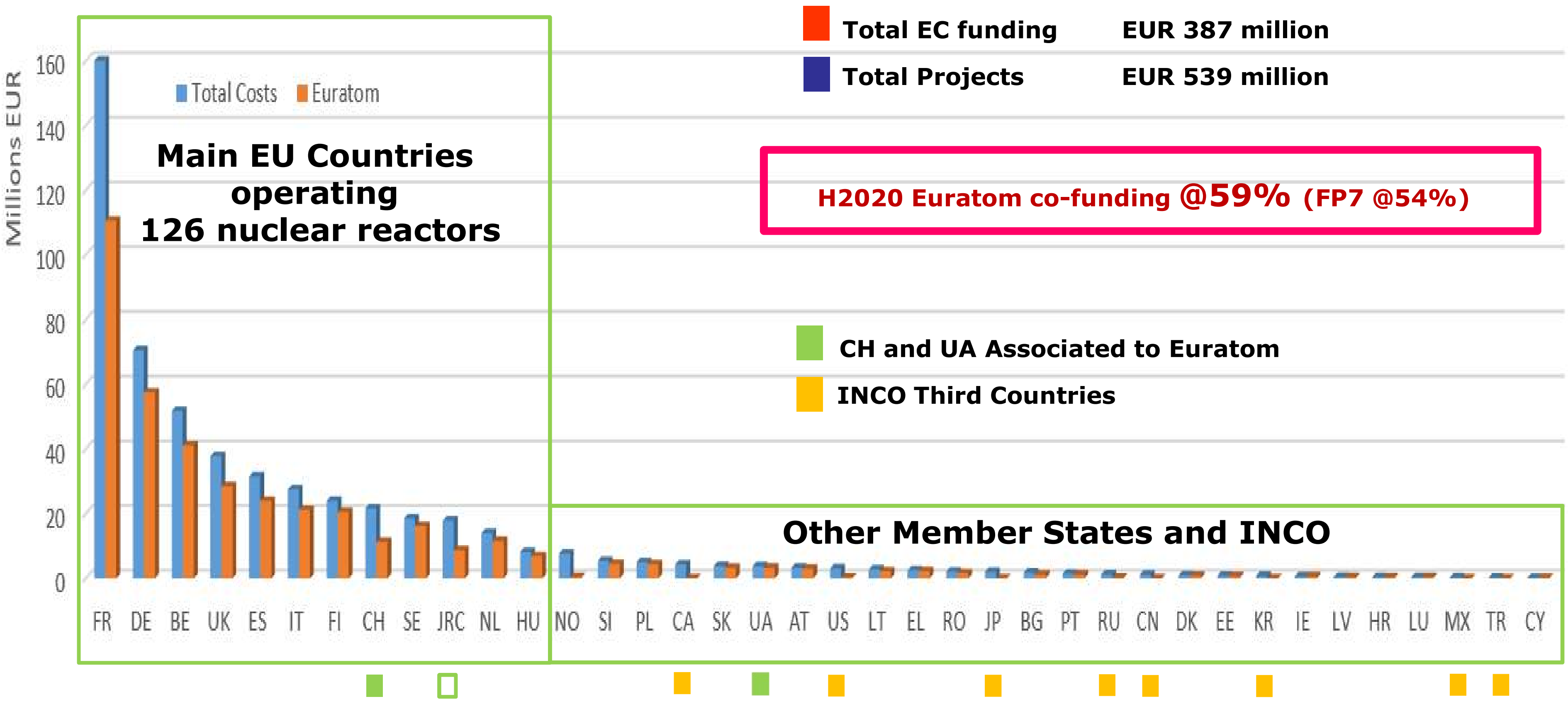


Euratom Research and Training	*(7 years)* *EUR 1,980 million*	**(5 years)** **EUR 1,380 million**
Indirect RTD		
• Fusion R&D	*809*	**583**
• Fission R&D Safety and radiation protection	*370*	**266**
Direct JRC		
• Fission Safety and safeguards	*802*	**532**

ITER (a dedicated EC Regulation, 7 years)	**EUR million**
	5,600

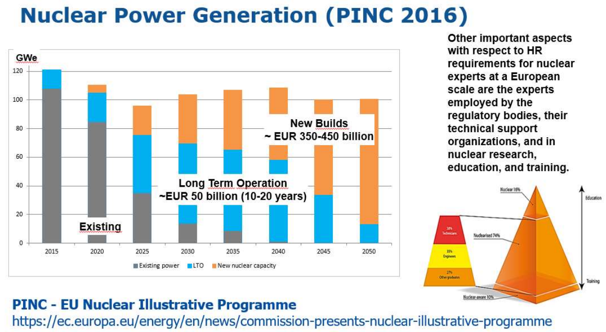
EU Council PRESS RELEASE
EURATOM https://www.consilium.europa.eu/en/press/press-releases/2020/12/18/euratom-research-and-training-programme-council-reaches-political-agreement/pdf
ITER https://www.consilium.europa.eu/en/press/press-releases/2020/12/18/fusion-energy-political-agreement-in-the-council-on-iter-financing/pdf
EU Council COREPER AGREED TEXT
EURATOM https://www.consilium.europa.eu/media/47674/st14206-en20.pdf
ITER https://www.consilium.europa.eu/media/47673/st14217-en20.pdf

EURATOM Fission H2020 (2014-20)



A total of 97 projects co-funded within two 2-years' calls
in addition to JHR (EUR 21 million *) and InnovFin (EUR 20 million)
* Access rights to JHR totalising EUR 32.5 million, 5.15% of irradiation time

EURATOM Fission Work Programmes



~ 20%

Waste Management and Geological disposal

- Decommissioning

~ 40%

Reactor systems

- Safety of existing nuclear installation (Gen II-III)
- Advanced nuclear systems for increased safety (Gen-IV)
- Partitioning, Transmutation and closed fuel cycle
- Cross-cutting aspects (e.g. fuels, materials, simulation, nuclear data)
- Other applications (e.g. cogeneration, support to Research Reactors)

~ 20%

Radiation protection

- Non-power applications

~ 20%

Research infrastructures
Training and mobility
Cross-cutting INCO

Grand Total:
Euratom Fission RTD ~ 50 Mi€ / Year
Euratom Fission JRC ~ 50 Mi€ / Year
Total ~ 10 % EU Public&Private Fission R&D

European Commission

Euratom 1-12 (Fission) and Other Actions (including Fusion)	EUR million EC contr./prop	Total Budget (indicative)	Proposals (indicative)
1 RIA - Safety of operating nuclear power plants and research reactors	5	20	4
2 IA - Safety of Light Water Small Modular Reactors (LW-SMRs)	15	15	1
3 RIA - Safety of advanced and innovative nuclear designs	4	12	3
4 COFUND - Co-funded European Partnership for research in nuclear materials	20	20	1
5 RIA - Partitioning and Transmutation of minor actinides towards industrial applications...........	5	5	1
6 RIA - Improved nuclear data for energy and non-energy applications of ionising radiation	4	4	1
7 COFUND - Co-funded European Partnership on Radioactive Waste Management	20	20	1
8 IA - Innovative technologies for safety and excellence in decommissioning	2	4	2
9 IA - Safety of LEU fuel for research reactors – securing the supply of medical radioisotopes	7	7	1
10 IA - Nuclear and radiation techniques for EU strategic autonomy, circular economy and climate change policies	2.3	7	3
11 IA - Harnessing innovation in nuclear science, technology and radiation protection	3.5	7	2
12 CSA - Preparatory phase for a EU production capability to secure a supply of HALEU............	1	1	1
Other Actions: FISA2025-EURADWASTE’25, early June 2025, under Polish Presidency of EU Nuclear Innovation Prizes 2025 (RS, RWM, RADIOPRO), SOFT Prizes 2024 & 2026 Contribution to the GIF Secretariat for the Generation-IV International Forum E&T and networking actions to strengthen Ukrainian and EU nuclear research MSCA in nuclear research and training Fusion IFMIF-DONES and industrial expertise for DEMO External Experts and communication		0.3 0.3, 0.1 x2 0.15 x3 0.75 2 1.25, 3 0.75, 0.3	
Overall Euratom Fission 2023-25 Call indicative budget, 152 EUR million, (includes budget return back to fusion budget line after call 2021-22 amendment on VVER Fuel supply EUR 10 million and EUR 20 million to Partnership PIANOFORTE)		132 (fission)	21

https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/home

Horizon Europe Euratom Call 2023-25: Overview Schedule

Event	Date
Publication of the Call 2023-25	**03/2023**
Submission Call open................................	**03/2023**
Deadline	**11/2023**
Evaluations	**11/2023 – 12/2023**
Communication of outcomes	**02/2024**
Negotiations/Finalisation of Grants	**02 – 05/2024**
Grant Agreement signature........................	**06/2024**
First projects expected to be launched	**06/2024**
Total budget of around **EUR ~150 million**	

EC Funding and Tenders portal
https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/home

European Commission

Implementation of Euratom Fission WPs

- 2-years' basis work programmes & calls for proposals
- Evaluation by independent experts
- Main criterion: scientific and technical excellence, impact, quality of implementation
- Range of funding schemes promoting integration
- Shared cost & leverage effect of EU funding

- **Coordination and Support Actions (CSA)**
  - Networking Activities (NA) to optimise the use of the facilities and dissemination of results
  - Transnational Access Activities (TNA) for external users
  - Joint Research Activities(JRA) to raise the performance of the facilities and the efficiency of their use.
  - Continuous open call for proposals evaluated on a six months or yearly basis
  - Promote networking and coordination-type activities or
  - Provide support for such aspects as dissemination of programme results or pilot studies for possible future collaborative projects.
- **Research Innovation Collaborative Projects (RIA)**
  - R&D activities amongst European partners (e.g. industry, research institutes and organisations, and academia)

European Commission

Latest Funded Euratom Nuclear Data projects

Accelerator and Research reactor Infrastructures for Education and Learning

ARIEL

SANDA

SANDA

Supplying Accurate Nuclear Data for energy and non-energy Applications

HORIZON2020

ARIEL factsheet

CORDIS
EU research results

Grant agreement ID: 847594

Funded under:
H2020-Euratom-1.8 (NFRP-2018-7)

EC budget contribution:
2 M€

Coordinated by:
HZDR

Project type:
Coordination & Support Action

Partners:
25 from 15 countries

Project duration:
54 months

Start /End date:
September 1, 2019 – **February 29, 2024**

Management Board (MB):
A. Junghans (HZDR), A. Plompen (JRC), R. Nolte (PTB), C. Guerrero (USE), H. Penttilä (JYU)
Project Advisory Committee (PAC):
D. Cano-Ott (CIEMAT), R. Capote (IAEA), R. Jacqmin (CEA), M. Kerveno (CNRS), G. Van den Eynde (SCK*CEN)

Accelerator and Research reactor Infrastructures for Education and Learning

ARIEL

European Commission

Horizon 2020
European Union funding
for Research & Innovation

www.ariel-h2020.eu

Accelerator and Research reactor Infrastructures for Education and Learning

ARIEL

European Commission

ARIEL Objectives

Provide young scientists, researchers and experts with access to high quality nuclear research and training facilities.

Experiments in international teams: Hands-on training for students in the graduate and postgraduate level - lead to PhD and master theses.

- Integration of the full nuclear data cycle by collaboration with JEFF (OECD/NEA), IAEA, and TSO's e.g. IRSN
- Collaboration with research reactor facilities MTK-EA, JGU, SCK*CEN, ILL, CVR
- Increase number of students in the nuclear data field; especially with the help of ENEN
- Increase support for early stage researchers
- Inclusion of technical staff (engineers, operators) in ARIEL activities

Accelerator and Research reactor Infrastructures for Education and Learning

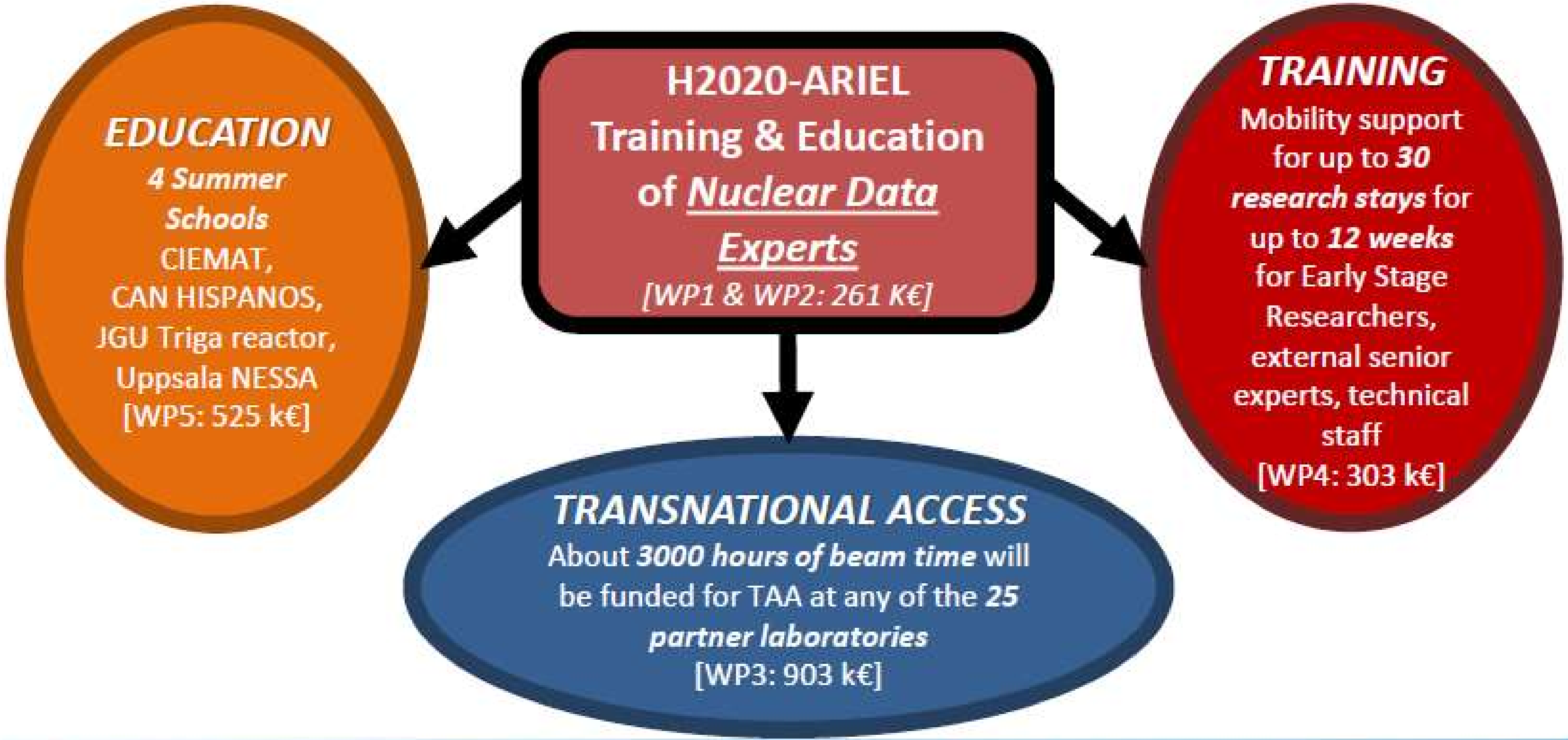
ARIEL

SUMMARY OF H2020-ARIEL FACILITIES AVAILABLE FOR TAA		ACCELERATORS																			RESEARCH REACTORS				
		e⁻ BEAMS		ION BEAMS																					
		nELBE@HZDR	GELINA@JRC	MONNET@JRC	n_TOF@CERN	AIFIRA@CNRS	ALTO@CNRS	GENESIS@CNRS	NFS@GANIL	CEA-DAM	FNG@ENEA	PTB	FNG@NPI	HISPANOS@CNA	NESSA@UU	U. Oslo	NPL	IFIN-HH	JYU	AMANDE@IRSN	BRR@MTA-EK	BR1@SCK-CEN	TRIGA@JGU	LR-0/LVR-15@CVR	RHF@ILL
Neutrons	Cold (<25 meV)																				■		■		■
Neutrons	Thermal (‹E_n›=25 meV)		■	■										■			■			■	■	■	■	■	■
Neutrons	Epithermal (25 meV – 100 keV)		■	■	■	■				■		■		■			■			■	■	■	■	■	■
Neutrons	Fast (0.1-20 MeV)	■	■	■	■	■	■	■	■	■	■	■	■	■	■		■			■	■	■	■	■	■
Neutrons	Very fast (>20 MeV)				■				■				■												
Neutrons	Pulsed beam	■	■	■	■		■		■	■		■	■	■	■					■			■		
Neutrons	Time-of-flight	■	■	■	■		■		■	■		■	■	■						■					
Charged particles						■	■									■		■							
Radioactive beam							■												■						■

Accelerator and Research reactor Infrastructures for Education and Learning

ARIEL

European Commission



Accelerator and Research reactor Infrastructures for Education and Learning

ARIEL

European Commission

SANDA

SUPPLYING ACCURATE NUCLEAR DATA FOR ENERGY AND NON-ENERGY APPLICATIONS

H2020 Grant Agreement number: 847552

A project for the EURATOM WP2018 for NFRP-2018-4

Project Start date: 01/09/2019

Duration: 48 months

Requested contributions: 3.5 MEuros

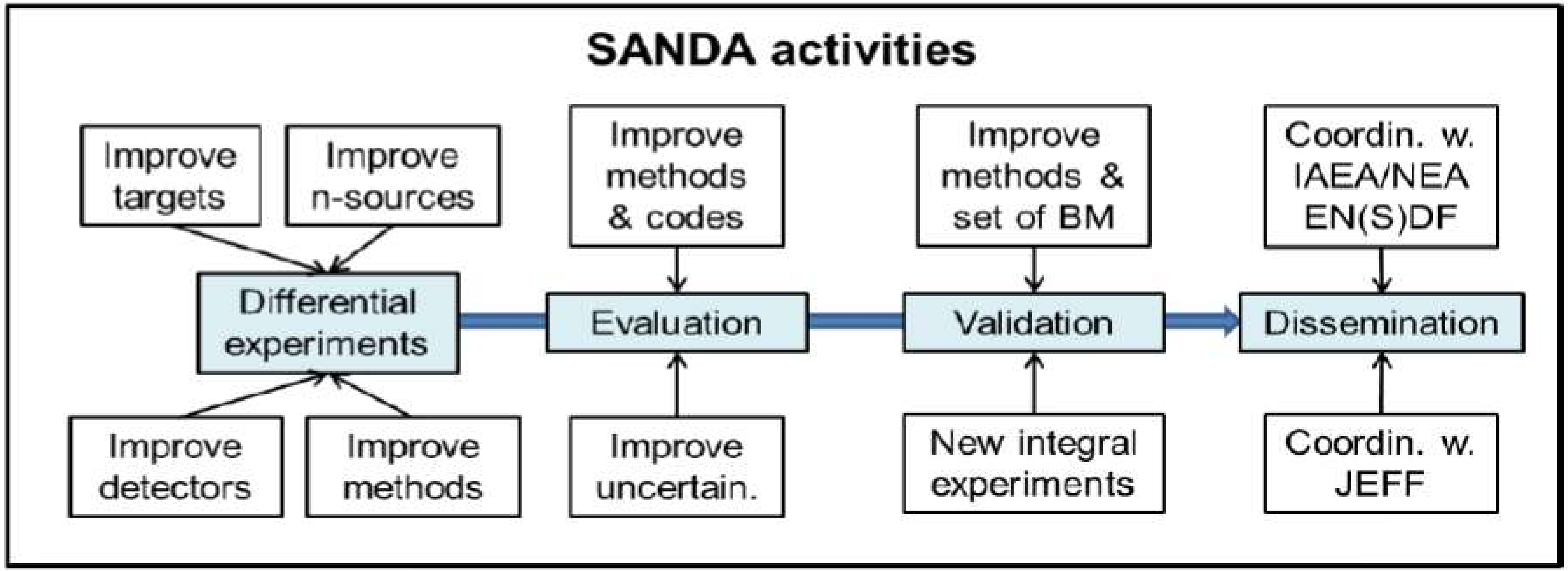
35 Partners: *CIEMAT*, Atomki, CEA, CERN, CNRS, CSIC, CVREZ, ENEA, HZDR, IFIN-HH, IRSN, IST-ID, JRC, JSI, JYU, KIT, NPI, NPL, NRG, NTUA, PSI, PTB, SCK-CEN, Sofia, TUW, UB, ULODZ, UMAINZ, UMANCH, UOI, UPC, UPM, USC, USE, UU.

from 18 countries (Au, Be, Bu, Cz, Fi, Fr, Ge, Gr, Hu, It, Ne, Pol, Por, Ro, Sln, Sp, Sw, UK)

Coordinator: CIEMAT

European Commission

SANDA activities



- Relevant experiments for microscopic nuclear data improvement of nuclear safety
- Full nuclear data cycle: Nuclear data evaluation and validation
- NEA/OECD and IAEA high priority lists

Nuclear data measurements

- average **neutron multiplicity** of $^{235}U(n,f)$ and the **fission cross sections** of the $^{230}Th(n,f)$, $^{241}Am(n,f)$ and $^{239}Pu(n,f)$ reactions;
- **neutron capture cross sections** of the $^{239}Pu(n,\gamma)$ and $^{92,94,95}Mo(n,\gamma)$ reactions;
- neutron **elastic and inelastic scattering** and **neutron multiplication** cross sections for the nuclides ^{14}N, $^{35,37}Cl$, ^{209}Bi, ^{233}U, ^{238}U and ^{239}Pu;
- **decay data** of ^{95}Rb, $^{100gs}Nb$, ^{102m}Nb, ^{103}Tc, ^{140}Cs with Total Absorption Gamma-ray spectrometry and of ^{106}Ru, ^{153}Sm, ^{166}Ho, ^{186}Re, ^{212}Pb, ^{225}Ac and ^{223}Ra half-lives and branching ratios for reactor and medical applications;
- **fission yields** and related distributions from neutron induced fission of ^{235}U at LOHENGRIN (ILL) and PI-ICR at IGISOL and (p,2p) inverse kinematics fission reactions for ^{238}U and ^{237}Pa;
- **spectrum-averaged cross sections** for the $^{117}Sn(n,inl)^{117m}Sn$ and $^{60}Ni(n,p)$ reactions in a ^{252}Cf spectrum for **dosimetry**, ^{12}C double differential cross sections relevant for hadron therapy and the production cross sections of $\beta+$ emitters ^{11}C, ^{13}N, ^{15}O, ^{30}P for proton-induced reactions up to 250 MeV energy (non-energy applications);

European Commission

Summary: Euratom Nuclear Data projects funded

- **FP4 (1994-1998) & FP5 (1998-2002) projects**
  - ➔ Total funding: **€10M / **Euratom contribution: **€4.6M**

N-TOF-ND-ADS
HINDAS

- **FP6 (2002-2006) projects**
  - ➔ Total funding: **€6.3M** / Euratom contribution: **€5.6M**

EFNUDAT
CANDIDE
NUDAME

- **FP7 (2007-2013) projects**
  - ➔ Total funding: **€7.9M / **Euratom contribution: **€4.5M**

CHANDA
ERINDA
EUFRAT

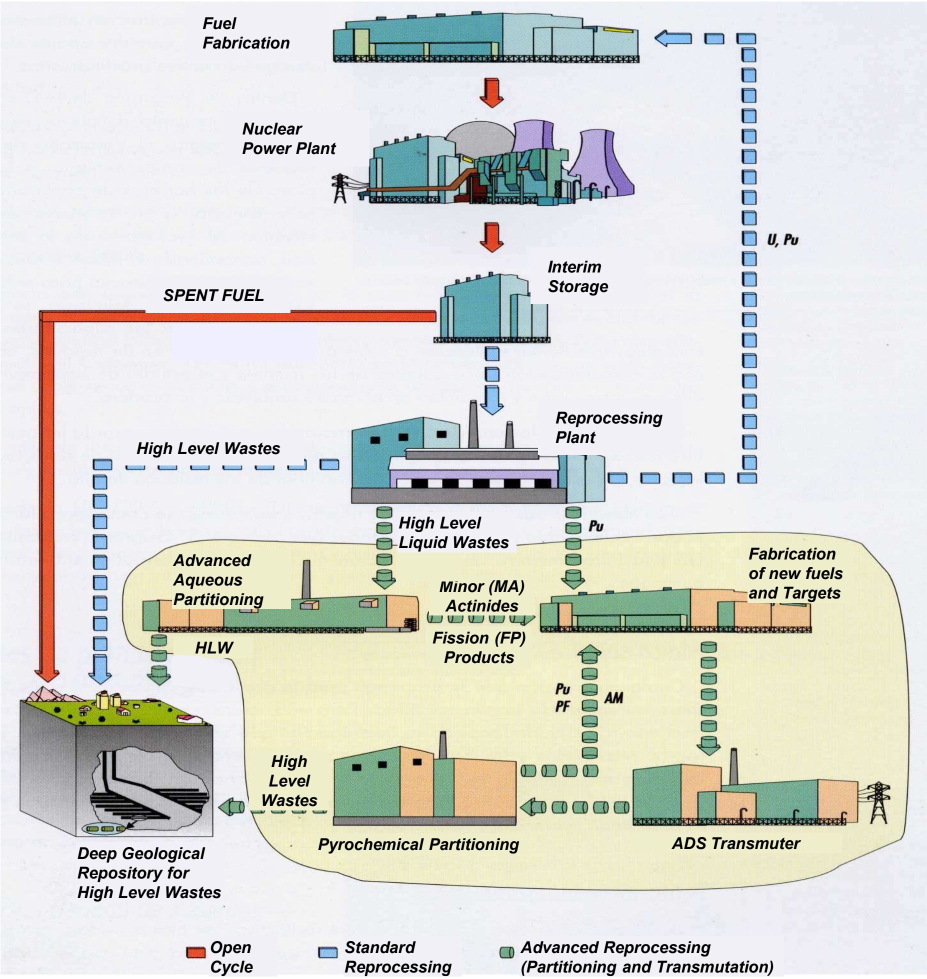
- **Horizon 2020 (2014-2020) projects** (to date, committed or spent)
  - ➔ Total funding: **€6.6M** / Euratom contribution: **€5.5M**

SANDA
ARIEL
EUFRAT

- **Horizon Europe (2021-2027) projects** (within call for proposals, WP2023-25)
  - ➔ Total funding: **€?.?M / **Euratom contribution: **€4M**

??
EUFRAT

Euratom Fission…More and better quality data



Reactors: **(Δ<0.5%)**

Performance: Reaction rates, Power distribution, Flux, Energy Spectrum

Safety: Criticality, Feedbacks, Reactivity coeffs, Damage, Shielding

Waste: Isotopic evolution, activation

Storage, Reprocessing and Fabrication plants: **(Δ<5%-10%)**

Isotopic composition !!!

Radioactivity, Neutron emissions, Decay Heat,

Proliferation interest

Radiotoxicity, Dose to Public and Environment

Effective capacity

European Commission

Euratom Fission…More and better quality data

- New nuclear systems and new nuclear fuel cycles are needed to improve the **long term sustainability of nuclear energy (waste minimization & resources utilization).**

- But few experimental and demonstration facilities are available to validate these concepts and to optimize their designs.
  - ➔ A simulation is much easier, cheaper and faster to realize than a real experiment.
  - ➔ Although simulations cannot replace experimental validation they can minimize number and costs of the experiments.
  - ➔ Simulations should be used to optimize experiments

European Commission

Euratom Fission…More and better quality data

- ➔ **Good simulations ⇒ Good nuclear data (and good programs)**
- ➔ **Uncertainties (errors) in the nuclear data induce uncertainties in the simulation results**

- Simulation is and will continue to be for a many years crucial for reactor and fuel cycle analysis
  - ➔ The **basis of the evaluation and extrapolation of performances, viability, costs and safety of the proposed devices** both for transmutation and for new fast reactors.

Euratom Fission …Gen-IV and innovative systems

- New characteristics of advance reactors (GEN-IV or Transmutation reactor - Critical or Subcritical (ADS))
- In all cases
  - ➔ New fuels: High content in minor actinides and high mass Pu isotopes
  - ➔ Very high Burn-up per irradiation cycle
- Most Frequently
  - ➔ Fast neutron flux spectrum
  - ➔ Subcritical configurations + Spallation sources
- New Technologies
  - ➔ Coolant e.g. Molten Lead or Pb/Bi
  - ➔ Fuel matrix: Inert matrix, etc..

Spent nuclear fuel from NPPs worldwide

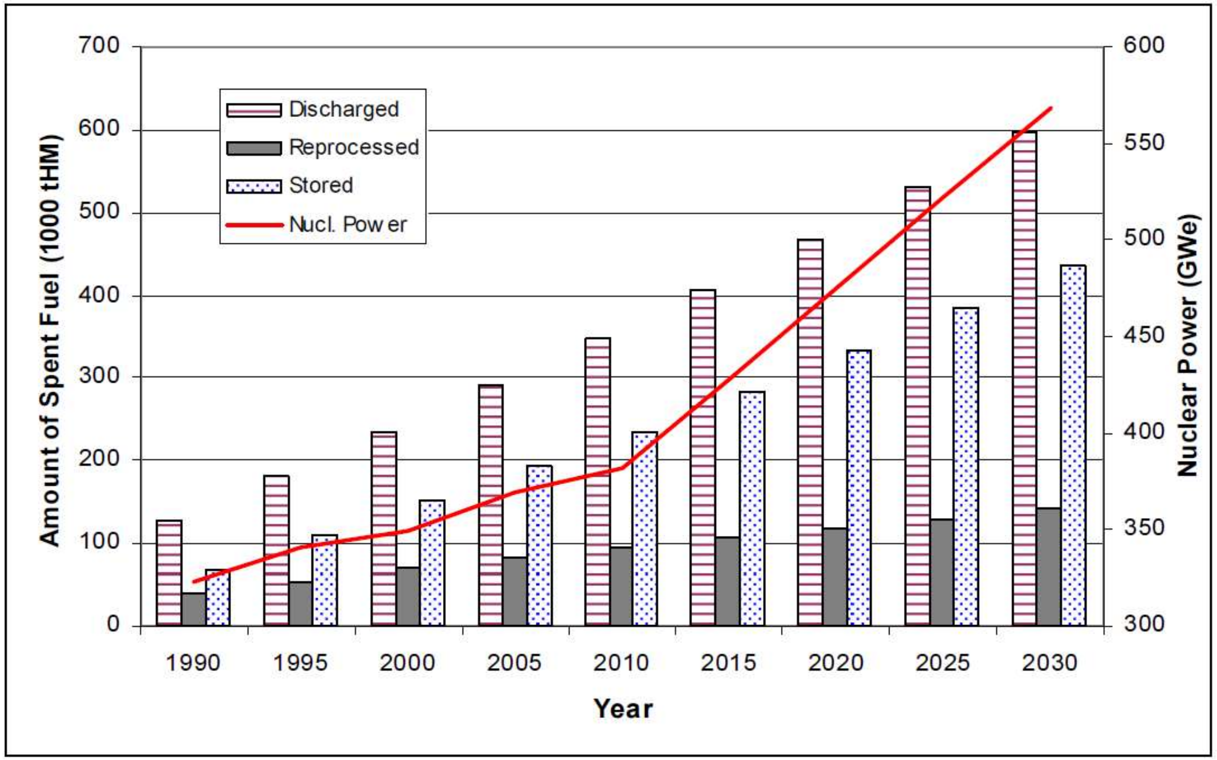


Fig. 14. Cumulative spent fuel discharged, stored and reprocessed from 1990 to 2030.

Quelle: IAEA-TECDOC-1613, April 2009 based on the median of the IAEA-RDS-1 Nuclear power estimate

OECD/NEA WPEC-26 Data needs for FR & ADS

Table 32. Summary of Highest Priority Target Accuracies for Fast Reactors

		Energy Range	Current Accuracy (%)	Target Accuracy (%)
U238	σ_{inel}	6.07 ÷ 0.498 MeV	10 ÷ 20	2 ÷ 3
	σ_{capt}	24.8 ÷ 2.04 keV	3 ÷ 9	1.5 ÷ 2
Pu241	σ_{fiss}	1.35MeV ÷ 454 eV	8 ÷ 20	2 ÷ 3 (SFR,GFR, LFR) 5 ÷ 8 (ABTR, EFR)
Pu239	σ_{capt}	498 ÷ 2.04 keV	7 ÷ 15	4 ÷ 7
Pu240	σ_{fiss}	1.35 ÷ 0.498 MeV	6	1.5 ÷ 2
	ν	1.35 ÷ 0.498 MeV	4	1 ÷ 3
Pu242	σ_{fiss}	2.23 ÷ 0.498 MeV	19 ÷ 21	3 ÷ 5
Pu238	σ_{fiss}	1.35 ÷ 0.183 MeV	17	3 ÷ 5
Am242m	σ_{fiss}	1.35MeV ÷ 67.4keV	17	3 ÷ 4
Am241	σ_{fiss}	6.07 ÷ 2.23 MeV	12	3
Cm244	σ_{fiss}	1.35 ÷ 0.498 MeV	50	5
Cm245	σ_{fiss}	183 ÷ 67.4 keV	47	7
Fe56	σ_{inel}	2.23 ÷ 0.498 MeV	16 ÷ 25	3 ÷ 6
Na23	σ_{inel}	1.35 ÷ 0.498 MeV	28	4 ÷ 10
Pb206	σ_{inel}	2.23 ÷ 1.35 MeV	14	3
Pb207	σ_{inel}	1.35 ÷ 0.498 MeV	11	3
Si28	σ_{inel}	6.07 ÷ 1.35 MeV	14 ÷ 50	3 ÷ 6
	σ_{capt}	19.6 ÷ 6.07 MeV	53	6

Highest priority targets

➔ fast neutron spectrum

➔ U,Pu + minor actinides

structural & coolant materials

- neutron induced fission
- neutron capture
- neutron inelastic scattering

http://www.nea.fr/html/science/wpec/volume26/volume26.pdf

https://www.oecd-nea.org/jcms/pl_14440/international-evaluation-co-operation-volume-26?details=true

Sustainable Nuclear Energy Technology Platform SNETP

……More and better quality data

- **Availability of accurate nuclear data (cross sections, decay constants, branching ratios, etc.) is the basis for precise reactor calculations both for current (applications to higher burn-up, plant life extension) and new generation reactors.**
  - ➔ *Additional experimental measurements and their detailed analysis and interpretation are required in a broad range of neutron energies and materials. This is particularly true for fuels containing minor actinides for their transmutation in fast spectra*

SNETP SRiA https://snetp.eu/wp-content/uploads/2021/09/SRIA-SNETP-1.pdf

Nuclear Data R&D - ND needs

- Nuclear data and associated tools are a critical element of the nuclear energy industry and research. They play an essential role in the **simulation** of nuclear systems or devices for nuclear energy and non-energy applications, for the **calculation of safety and performance parameters** of existing and future reactors and other nuclear facilities, for the **innovation of the design** of those nuclear facilities and the innovation on radioactive devices and use of radioactive materials in non-energy applications, and for the **interpretation of measurements** in these facilities.

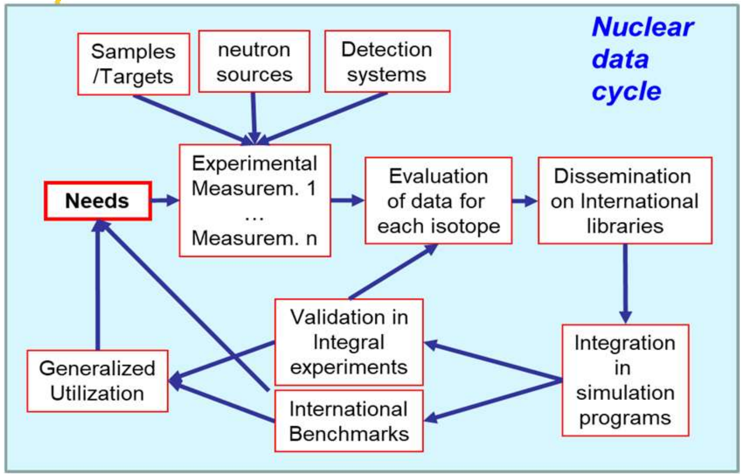
- Nuclear Data, ND, is often not visible for applications that rely on the huge data sets of nuclear cross sections, branching ratios, fission yields,… .

- However, in many cases they are the limiting factor for the accuracy of the codes in those applications.

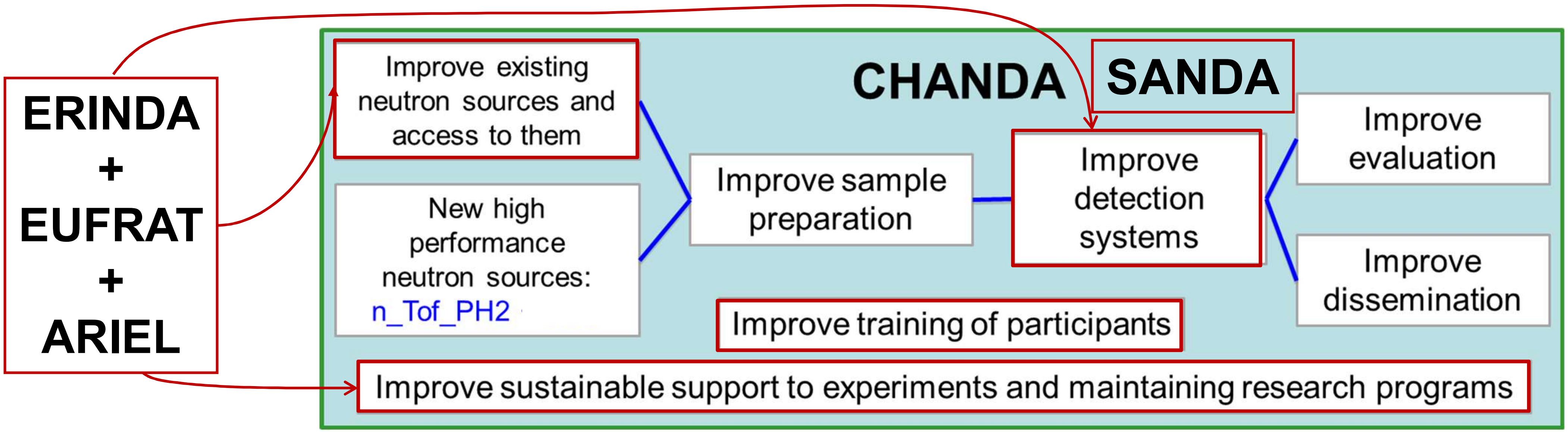
- So, there are continuous requests of new or better nuclear data, coming from:
  - new levels of safety, new safety criteria and scenarios,
  - new reactor designs or new applications or new modes of operations of present reactors,
  - innovative solutions for waste management and
  - from pending requests, not feasible in the past, that can be addressed with the present R&D on nuclear data and tools.

- These requests are regularly evaluated and maintained in high priority request lists IAEA and NEA/OECD.

Nuclear Data R&D



In order to have nuclear data available to applications several steps are needed in what is known as the nuclear data cycle



Nuclear Data R&D - ND needs

- Producing high quality data requires a combination of many different know-hows (target production, detectors, neutron sources, analysis, evaluation, nuclear theory, nuclear reactors, simulation codes, …).
- In Europe, the necessary expert know-how is widely distributed within many research teams, and most of these teams specialize only on one or few components of the nuclear data cycle.
- So, to provide the nuclear data needed, a very well structured wide and well synchronized collaboration between the key EU expert institutions is needed.
- The EURATOM framework program has been instrumental during the FP7 and before, to nucleate large pan-European collaborations of laboratories like CHANDA.
- It has also facilitated the setup of frameworks for easy and efficient transnational access to experimental facilities needed for those activities, like the competitive proposal ERINDA and the direct JRC action EUFRAT

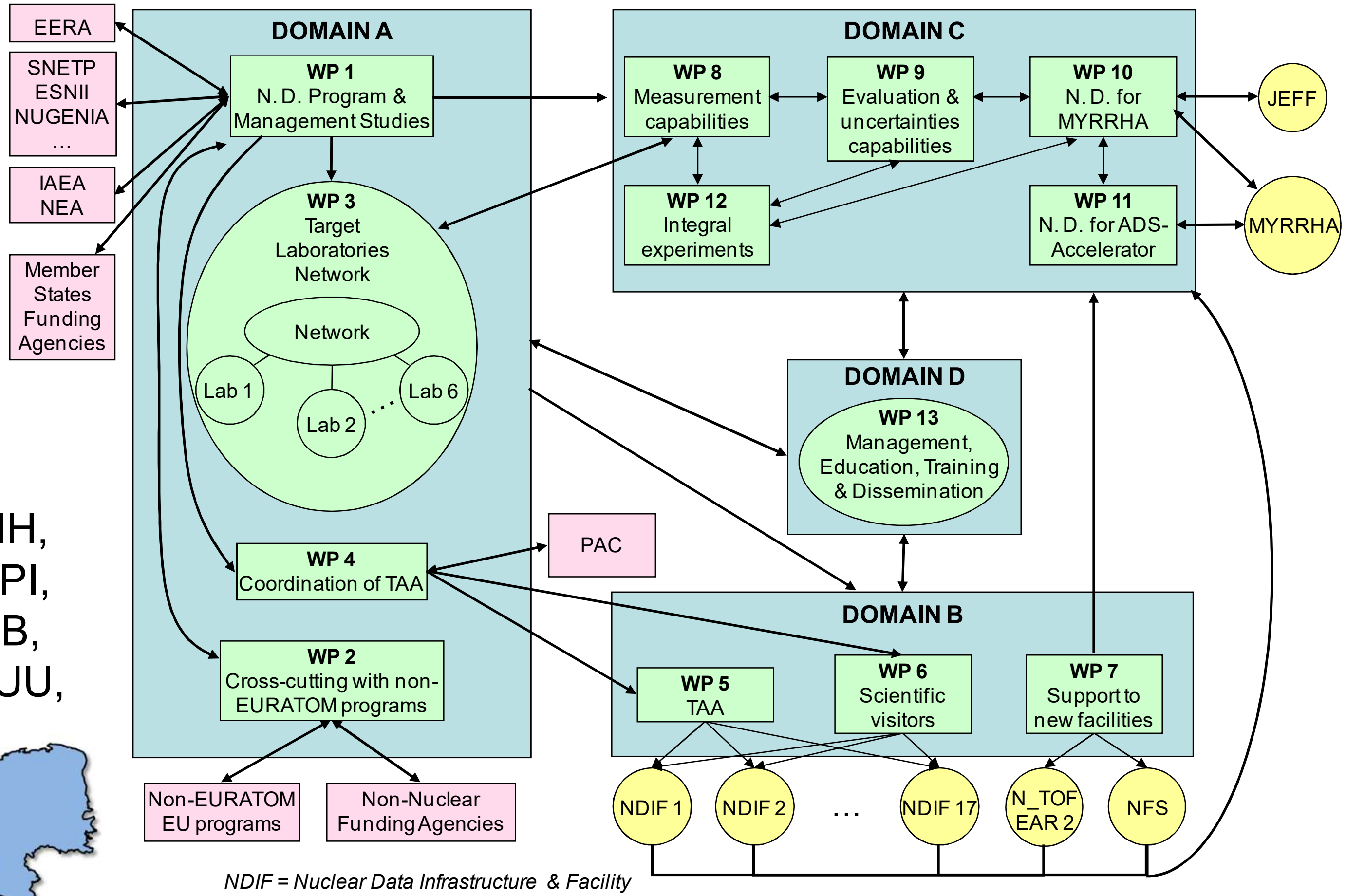
European Commission

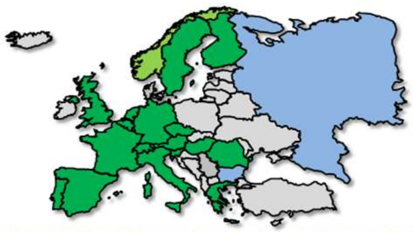
The projects: CHANDA http://www.chanda-nd.eu/

SOLVING CHALLENGES IN NUCLEAR DATA FOR THE SAFETY OF EUROPEAN NUCLEAR FACILITIES

Start: 1 Dec. 2013,
Duration proposed: 54 months.
EU funding: 5.4 MEuro.

Participants:
CIEMAT, ANSALDO, CCFE, CEA, CERN, CNRS, CSIC, ENEA, GANIL, HZDR, IFIN-HH, INFN, IST-ID, JRC, JSI, JYU, KFKI, NNL, NPI, NPL, NRG, NTUA, PSI, PTB, SCK, TUW, UB, UFrank, UMainz, UMan, UPC, UPM, USC, UU, UOslo. +*U.Seville*





CHANDA: 36 participants (18 countries)

European Commission

The projects: ERINDA http://www.erinda.org/

- The ERINDA project (European Research Infrastructures for Nuclear Data Applications) has coordinated the EU efforts to exploit up-to-date neutron beams for novel research on advanced concepts for nuclear fission reactors and the transmutation of radioactive waste.
- ERINDA offered the nuclear data research infrastructures of 13 partners (HZDR, JRC-GEEL, CERN, CENBG, IPNO, UU-TSL, PTB, NPI, IKI, IFIN-HH, NPL, FRANZ and CEA).
- The ERINDA facilities included different neutron sources and methods for nuclear data measurement, in particular:
  1. **Time of flight facilities for fast neutrons**: nELBE (HZDR); n_TOF (CERN); GELINA (JRC);
  2. **Charged-particle accelerators**: electrostatic accelerators in Bordeaux, Orsay, Bucharest and Dresden, neutron reference fields at PTB and NPL, cyclotrons in Řež , Jyväskylä, Oslo and Uppsala with neutron energy range up to 180 MeV, and pulsed proton linear accelerator in Frankfurt;
  3. **Research reactors:** Budapest and Řež cold neutron beam, Prompt Gamma Activation Analysis.
- 3015 hours of beam time, 26 experiments, 16 short term visits (106 weeks)
- Pool of facilities open to user proposals to be selected by independent PAC.
- Four European scientific meetings in Dresden, Prague, Jyväskylä and Geneva.

The projects: EUFRAT https://ec.europa.eu/jrc/en/eufrat

- Since 2005 JRC-Geel offers access to its nuclear research infrastructure for external users.
- Since the beginning of 2014 as an institutional project entitled "European Facilities for Nuclear Reaction and Decay Data Measurements (EUFRAT).
- The nuclear infrastructure at JRC-Geel includes:

1. **the GELINA** research infrastructure, which combines a white neutron source produced by a 150 MeV linear electron accelerator with a high-resolution neutron time-of-flight facility;
2. **the MONNET** research infrastructure for the production of continuous and pulsed proton-, deuteron- and helium ion beams is based on a 3.5 MV Tandem accelerator and serves for the production of well-characterised quasi mono-energetic neutrons;
3. **the RADMET** radionuclide metrology laboratories, which are used for radioactivity measurements;
4. **an ultra low-level radioactivity laboratory**, which is hosted in the deep-underground facility HADES of the SCK•CEN; and
5. **a laboratory for the preparation and characterisation of samples and targets** needed for nuclear data measurements.

European Commission

Nuclear Data R&D- Technical Achievements

- Improving the facilities: nELBE, IGISOL, JRC-Geel, n_TOF EAR2, LICORNE and PTB PIAF.
- Integrating and developing target fabrication capabilities: PSI, U.Mainz and JRC-Geel labs.
- New methods for cross section measurements: new detectors (micromegas, DELCO, SCONE, DTAS, BELEN, BRIKEN, FALSTAFF, STEFF), facilities (n_TOF EAR2, AFIRA, GAINS and GRAPhEME).
- Comprehensive developments for concurring reactions:capture, fission, inelastic, (n,xn), (n,chp).
- New and improved evaluation models and tools:TALYS-1.9 EXFOR and ND for FF, and CONRAD.
- Systematic and comprehensive uncertainties and correlation libraries in the evaluation: ^{181}Ta.
- Validation and improvement of data using integral experiments: different uncertainty propagation methods, integral data assimilation methodologies between the "all deterministic" and the "Full MC".
- Fast and comprehensive dissemination of results: contacts with IAEA, NEA, JEFF, CIELO.
- Comprehensive tools for transport problems including high energy particles: better INCL-ABLA.
- Publication of results for specialized users and training young scientists: 125 peer reviewed publications, 30 PhD theses and 18 Master theses from CHANDA + 77 publications from ERINDA.
- Transnational access to experimental facilities to perform measurements and training.

Differential nuclear data measurements at CHANDA

(n,f) cross sections	**(n,n), (n,xn) and (n,n'γ) cross sections**
$^{240, 242}$Pu(n,f)	^{nat}Fe(n,n)
^{237}Np(n,f)	^{nat}C(n,n)
^{235,238}U(n,f)	^{238}U(n,n'e^{-})
(n,γ) cross sections	^{48}Ti(n,n'γ)
^{235}U(n,γ)	^{7}Li(n,n'γ)
^{242}Pu(n, γ)	^{233}U(n,n'γ)
^{238}U(^{3}He,^{4}He)^{237}U, ^{238}U(^{3}He,t)^{238}Np, ^{238}U(^{3}He,d)^{239}Np	

Decay data	
^{95}Rb, ^{95}Sr, ^{96}Y, ^{96m}Y, ^{98}Nb, ^{98m}Nb, ^{99}Y, ^{100}Nb, ^{100m}Nb, ^{102}Nb, ^{102m}Nb, ^{103}Mo, ^{103}Tc, ^{108}Mo, ^{137}I, ^{138}I, ^{140}Cs, ^{142}Cs	γ ray and β decay emission probabilities with TAGS at JYFL
^{98,98m,99}Y, ^{135}Sb, ^{138}Te, ^{138,139,140}I	Neutron emission probabilities with the BELEN detector at JYFL

Fission yields	
^{238}U(n,f)	Penning trap at JYFL
^{233,235}U(n,f)	Isobaric beams at ILL
^{239,241}Pu(n,f)	Isobaric beams at ILL
^{235}U(n,f)	STEFF spectrometer at n_TOF/EAR2
^{235}U(n,f)	Orphee reactor at CEA/Saclay
^{238}U, ^{239}Np, ^{240}Pu, ^{244}Cm, ^{250}Cf	VAMOS spectrometer at GANIL
^{234,235,236,236}U(g,γ)	FRS spectrometer at GSI
^{238}U(n,f)	LICORNE + MINIBALL at IPN/Orsay

Example of the huge set of results and activities covered by these projects a table with the differential nuclear data measurements carried out within CHANDA

Nuclear Data R&D - Strategic perspectives

- Inclusive approach including: EU countries (18), institutions with relevant know-how (36), , and opening the pooling system for transnational access to all laboratories (18).
- Synchronizing the priorities of the different teams to the EURATOM calls, is an efficient way to address significant challenges. The visibility and impact of the European ND research has improved significantly during the last decade and can compete with USA, Russia or Japan.
- The pan-European collaborations also guarantee the survival of the ND research teams, maintaining Nuclear Data know-how in EU, and are more flexible to respond efficiently to evolving problems or programs with a large variety of different topics.
- Efficient collaboration of teams with well identified capacities allows mobilizing the national resources and replaces unnecessary competition with complementarity.
- Internal competition both during the preparation of the proposals, by the pooling of the access to facilities and by selection of special actions defined within the project duration had been used to maintain high standards of quality and relevance.
- Collaboration with international bodies (NEA/OECD & IAEA) and with TNA projects.

Nuclear Data R&D - Success stories

- Measuring the same isotope and reaction in 2 different facilities to reduce systematic effects: Capture on ^{238}U and ^{241}Am measured at GELINA and n_TOF with C_6D_6 and total absorption calorimeter.
- Within EUFRAT, studies of (n,n'γ) reactions in support to fast reactor developments are carried out at GELINA using the GRAPhEME and GAINS γ-ray spectrometers.
- With support from ERINDA, CHANDA and NEA the GEF code was developed to be a state of the art phenomenological model to give a general description of all fission observables.
- Joint experiments in integral and differential facilities using same samples of isotopes of interest for the safety of nuclear systems or difficult to fabricate targets.
- Complementarity of the transmission and capture cross section measurement stations of GELINA are used to determine neutron induced interaction cross section data in the resonance region in support to criticality safety analysis in out-of-reactor applications.
- The organization of a network of radioactive samples/target producers/users. The list of targets produced included isotopes as ^{7}Be, ^{10}Be, ^{10}B, ^{13}C, ^{44}Ti, $^{70,72,73,74,76}Ge$, ^{91}Nb, ^{147}Pm, ^{171}Tm, ^{204}Tl, ^{230}Th, ^{233}U, ^{235}U, ^{237}Np, ^{238}U, ^{239}Pu, ^{240}Pu, ^{241}Am, ^{242}Pu and ^{252}Cf (45 targets).

European Commission

Nuclear Data R&D - Lessons learnt

- There is a continuous request of new or improved nuclear data that will require supporting R&D on ND still for many years.
- To be effective the R&D program on ND has to cover many aspects in a holistic inclusive and comprehensive way.
- Large, widely distributed collaborations, well-coordinated inside inclusive projects, allow performing the required R&D in an efficient way, maintaining the know-how in Europe by aggregation of many, widely distributed, small and medium research teams.
- The EURATOM financial support allows aggregating these collaborations focusing the research each time around the topics identified on the EURATOM calls, normally well aligned with the high priority request list for nuclear data of the international organizations.
- The EURATOM projects have been very successful to produce the expected results, a large number of publications and PhD theses and to enhance the relevance and visibility of the European nuclear data R&D at global level

European Commission

Nuclear Data R&D - Remaining challenges

- Use of the tools developed within SANDA, ARIEL, CHANDA, ERINDA, EUFRAT and previous projects to deliver more ND needed for safety, industry and society.
- Widen the existing tools to produce data needed for medical and other non-energy applications of Nuclear Data.
- Reply to new ND needs and continue improving the uncertainty and correlation libraries.
- Validation and verification towards a generic purpose ND library, not as criticality oriented as the present library verification tools.
- Further development and integration of ND know-how in research and final user tools.
- Continue maintaining the know-how in Europe by aggregation of many and widely distributed small and medium research teams.
- Continue supporting the ND facilities and neutron sources.

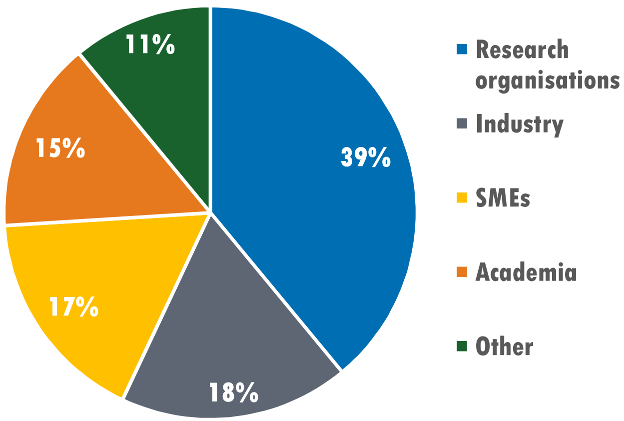
European Commission

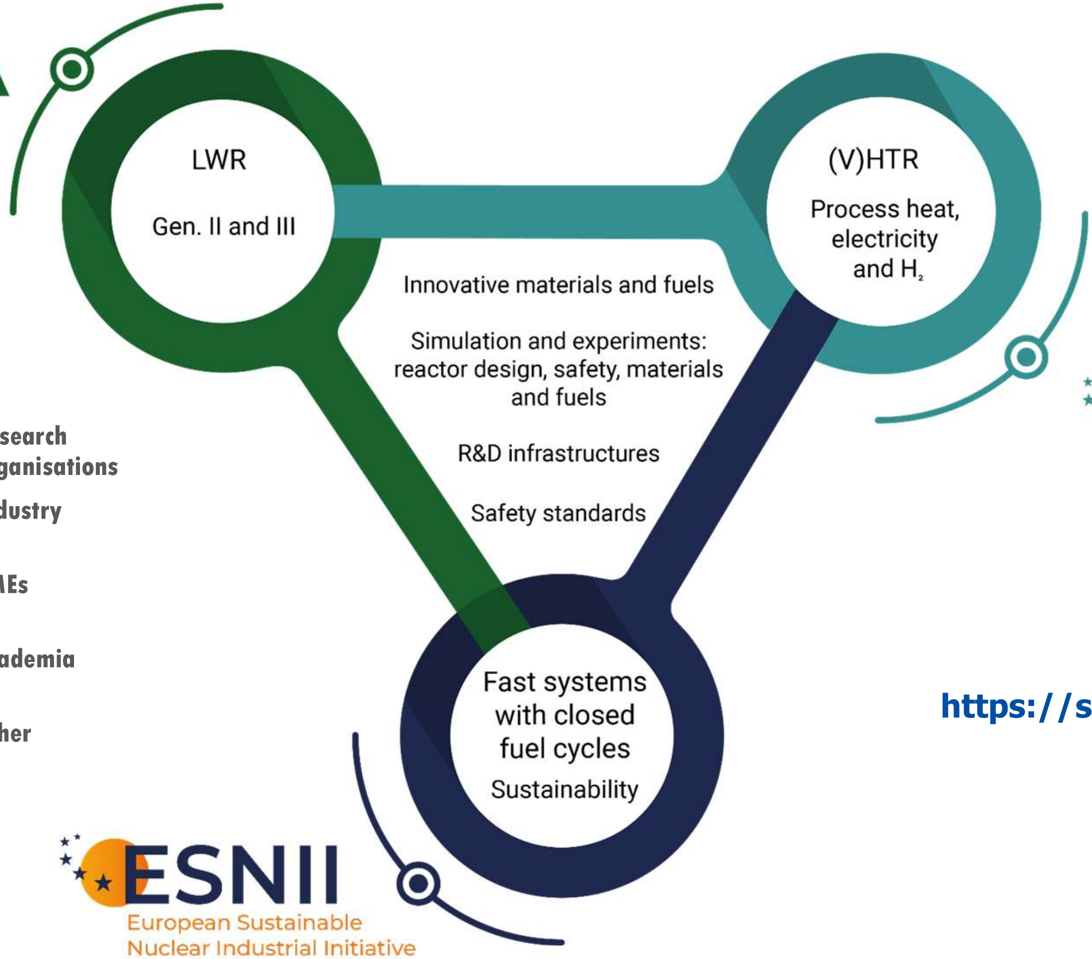
Nuclear Data R&D - Impact and possible follow-up actions

- The results of the nuclear data projects, SANDA, ARIEL, CHANDA, ERINDA and EUFRAT have contributed to the improvement of ND for major isotopes and minor but critical isotopes (for safety, waste management and future concepts) covering the most critical reactions and data needs.
- These better data enable more reliable simulation and evaluation capabilities that contribute to improve safety and efficiency of the present European reactors. In addition, making available more complete nuclear data and uncertainty libraries help to progress towards BEPU calculation, to become available for safety assessment, design and operation.
- All this elements will help to support science based decision for the energy policies.
- SANDA, with 35 partners, focused on delivering new data to the end users and to cover energy and non-energy applications, and
- ARIEL, with 23 partners, to provide transnational access for nuclear data experiments that can be used for training and education in the nuclear field.

SNETP Three Pillars

Categories of membership





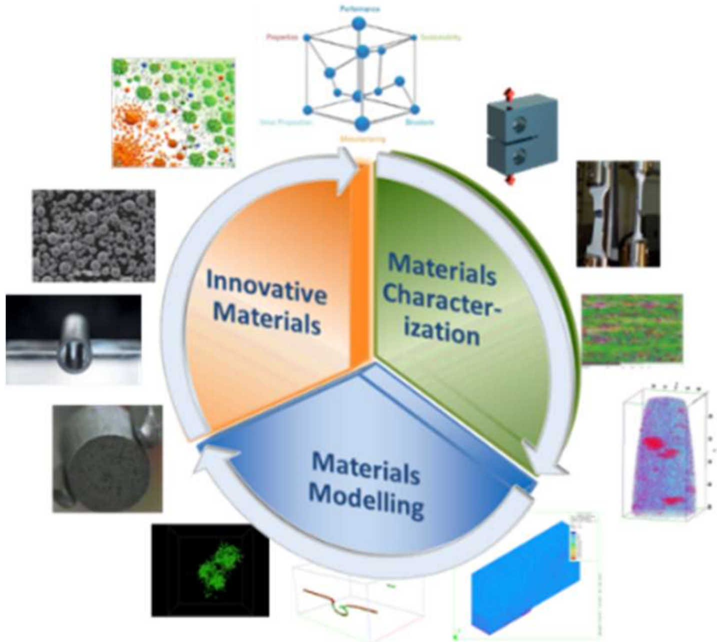
https://snetp.eu/

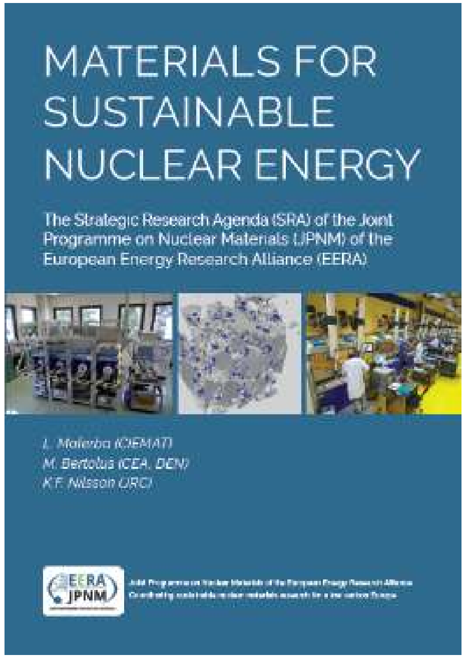
SNETP Sustainable Nuclear Energy Technology Platform

EERA Joint Programme on Nuclear Materials

Overarching objective:

improve **safety & sustainability** of nuclear energy, focusing on **materials issues**





More than 50 organisations from 17 countries contribute to at least one of the 6 subprogrammes of the EERA JPNM devoted to qualification, modeling and development of structural and fuel materials:

http://www.eera-jpnm.eu

GEMMA M4F INSPYRE European Commission

eurad
European Joint Programme on Radioactive Waste Management

About | Implementation | News | Events | Publications | Training/Mobility | Working area

R&D | Strategic studies | Knowledge management | Interacting with Civil Society

eurad
European Joint Programme on Radioactive Waste Management

EURAD | 1st Annual event 16-18/03/2021

igd-tp
safe solutions for radioactive waste

PREDIS
EU-project PREDIS
Pre-disposal management of radioactive waste

EURAD https://www.ejp-eurad.eu/

PREDIS https://predis-h2020.eu

IGDTP https://igdtp.eu/

European Commission

Perspectives

- Euratom experience with FP is **a consistent success in pursuing excellence** in nuclear science research and technology
- **Close collaboration between** EC, MSs, OECD/NEA and IAEA, GIF, WNA, International Frameworks agreements
- **Stakeholders structured dialogue** on R&D policy, safety improvements, holistic approach and early involvement in decision making
- **Industry driven ETPs, Fora** are being capitalised

Conferences' Proceedings FISA 2019 / EURADWASTE '19 … available!

Publications Office of the European Union

Keep in touch

- ec.europa.eu/
- europa.eu/
- @EU_Commission
- @EuropeanCommission
- European Commission
- europeancommission
- @EuropeanCommission
- EUTube
- EU Spotify

FISA 2019 Proceedings
https://op.europa.eu/en/publication-detail/-/publication/9cfc43f8-cbc7-11ea-adf7-01aa75ed71a1/language-en/format-PDF/source-140481060

EURADWASTE '19 Proceedings
https://op.europa.eu/en/publication-detail/-/publication/fe1b968b-cbc8-11ea-adf7-01aa75ed71a1/language-en/format-PDF/source-140505052

edp open

EPJ N Nuclear Sciences & Technologies

EPJ N Topical issues https://www.epj-n.org/
- **TOPICAL Edition** https://www.epj-n.org/component/toc/?task=topic&id=1234
- **AWARDS Selection** https://www.epj-n.org/component/toc/?task=topic&id=1169

romania2019.eu

Romanian Presidency of the Council of the EU in 2019 Conferences http://fisa-euradwaste2019.nuclear.ro/
FISA 2019 Presentations http://fisa-euradwaste2019.nuclear.ro/fisa/
EURADWASTE '19 Presentations http://fisa-euradwaste2019.nuclear.ro/euradwaste/

FISA 2022 – EURADWASTE’22, 30.05-02.06, Lyon (FR)

- The FISA 2022 – EURADWASTE’22 Conferences were successfully organized during the French Presidency from 30th of May to 2nd of June 2022 in Lyon, with CEA. More than 500 nuclear actors participated to the event on fission safety of reactor systems (FISA) and radioactive waste management (EURADWASTE) including high-level institutional representatives (cf. IAEA DG, NEA/OECD DG, Commission Directors, National representatives).
- The results of almost 80 Euratom R&T projects were presented. In the frame of the 2022 European Year of Youth, an effort was made to attract young talents in the nuclear field. Several Prizes were also awarded. Stands and Euratom project posters were also present.
- Proceedings of the conferences will be published early 2023

https://www.sfen.org/evenement/fisa-2022-euradwaste-22/

Publications – CORDIS (EC R&D Information Service)

View all H2020 Euratom projects summaries
and public deliverables on CORDIS

https://cordis.europa.eu/

H2020 Euratom projects (All)

https://cordis.europa.eu/search?q=contenttype=%27project%27%20AND%20(programme/code=%27H2020%27%20OR%20programme/code=%27H2020-Euratom%27)%20AND%20(%27euratom%27)&p=1&num=100&srt=Relevance:decreasing

… Latest relevant projects summaries !

Thank You!

European Commission