



## SANDA WP2

# New nuclear data measurements for energy and non-energy applications

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GOBIERNO  
DE ESPAÑA

MINISTERIO  
DE CIENCIA, INNOVACIÓN  
Y UNIVERSIDADES

**Ciemat**  
Centro de Investigaciones  
Energéticas, Medioambientales  
y Tecnológicas

SANDA kick off meeting, 9<sup>th</sup> – 10<sup>th</sup> of September



# List of participants

<b>Work package number</b>	<b>WP2</b> 23 institutions / 213 PMs			<b>Lead beneficiary</b>		CIEMAT	
<b>Work package title</b>	New nuclear data measurements for energy and non-energy applications						
<b>Participant number</b>	1	3	5	6	7	8	10
<b>Short name of participant</b>	<u>CIEMAT</u>	CEA	CNRS	CSIC	CVREZ	ENEA	IFIN-HH
<b>Person-months per participant</b>	14.3	7.1	21	14.4	11.7	15	11.2
<b>Participant number</b>	11	12	13	15	17	18	20
<b>Short name of participant</b>	IRSN	IST	JRC	JYU	NPI	NPL	NTUA
<b>Person-months per participant</b>	1.5	4	17.2	5	17.3	2.3	6
<b>Participant number</b>	22	23	27	29	30	31	33
<b>Short name of participant</b>	PTB	SCK	ULODZ	UMANCH	UOI	UPC	USC
<b>Person-months per participant</b>	4	2.2	12	10	6	1.8	10
<b>Participant number</b>	34	35					
<b>Short name of participant</b>	USE	UU					
<b>Person-months per participant</b>	10	9					
<b>Start month</b>	1			<b>End month</b>	48		

## WP2 Tasks

### Task 2.1: Neutron induced fission and charged particle production cross sections

Task coordinator: **UMANCH**, partners: **CNRS/CENBG, CNRS/LPCC, CVREZ, NPI-CAS, NTUA, UOI, UU**

2.1.1: Neutron induced fission cross sections

2.1.2: Neutron induced charged particle production cross sections

### Task 2.2: Neutron capture cross sections

Task coordinator: **ENEA**, partners: **CIEMAT, JRC, ULODZ, IRSN**

2.2.1. Capture measurements of fissile isotopes.

2.2.2. Capture measurement of stable isotopes.

### Task 2.3: Neutron elastic and inelastic scattering and neutron multiplication cross sections

Task coordinator: **IFIN-HH**, partners: **CNRS/IPHC, JRC**

## Task 2.4: Decay data measurements

Task coordinator: **CSIC**, partners: **CEA/LNHB, CNRS/Subatech, CSIC, JRC, SCK, UPC**

- 2.4.1. Beta decay measurements with TAGs.
- 2.4.2. Beta delayed neutron measurements.
- 2.4.3. Measurement of half-live and gamma-ray emission probabilities of beta emitters.

## Task 2.5: Fission yields measurements

Task coordinator: **UU**, partners: **CEA/IRFU, CNRS/LPSC, UJY, USC**

- 2.5.1. Fission yield studies in (n,f) reactions.
- 2.5.2. Fission yield studies in inverse kinematics.

## Task 2.6: New measurements for non-energy applications

Task coordinator: **USE**, partners: **IST, NPL, PTB**

- 2.6.1. Spectrum averaged cross sections for dosimetry.
- 2.6.2. Measurement of cross sections relevant for hadron therapy.
- 2.6.3. Measurement of beta+ emitters.

# Task 2.1: Neutron induced fission and charged particle production cross sections

Task coordinator: UMANCH, partners: CNRS/CENBG, CNRS/LPCC, CVREZ, NPI-CAS, NTUA, UOI, UU

Subtask	Institution	Contact	Subject	Deliverables	Deliverable date & responsible	Milestones	Milestone date & responsible	Comment	Action	Delay
2.1.1: Neutron induced fission cross sections	CNRS/CENBG	B. Jurado	$^{239}\text{Pu}(n,f)$ , $^{241}\text{Pu}(n,g)$ and $^{241}\text{Pu}(n,f)$ cross sections via surrogate reactions	D2.1 Report on the (n,f) measurements	M48 & UMANCH			Is leaving SANDA and the activity will be cancelled		
	NTUA	R. Vlastou	Measurement of the $^{230}\text{Th}(n,f)$ cross section at the n_TOF EAR2			MS15 Measurement of the $^{230}\text{Th}(n,f)$ cross section at n_TOF	M36, NTUA	<b>COVID impact.</b> Delay in the characterisation of the samples.		<b>Delay of 6 months</b> in the D and MS.
	UMANCH	G. Smith	Measurement of the high priority $^{239}\text{Pu}(n,f)$ cross section.			MS17 Measurement of the $^{239}\text{Pu}(n,f)$ cross section at n_TOF	M36, UMANCH	<b>No delay reported.</b>		<b>No delay reported</b> on the $^{239}\text{Pu}$ measurement. The D2.1 will be delayed by other activities.
	UOI	N. Patronis	New measurement on the $^{241}\text{Am}(n,f)$ cross section at the n_TOF EAR2 facility			MS16 Measurement of the $^{241}\text{Am}(n,f)$ cross section at n_TOF	M36, UOI	Everything progresses well.		<b>No delays</b> in the D and MS.
	UU, JRC	S. Pomp	High accuracy measurement of the energy dependence of the nubar for the $^{235}\text{U}(n,f)$ cross section at JRC-Geel			MS12 Measurement of the energy dependence of the nubar with the MONET setup	M24, UU	<b>Strong COVID impact at GELINA. Enough time to recover.</b> Experiment could be done in 2021		<b>No delays</b> in the D and MS if the measurement can be carried out in 2021.
2.1.2: Neutron induced charged particle production cross sections	CNRS/LPCC	F. Lecolley		D2.2 Report on (n,chp)	M48 & CNRS/LPCC	MS18 Measurement of the $^{16}\text{O}(n,\alpha)$ cross section at NFS, GENESIS and AMANDE	M36, CNRS/LPCC	<b>Strong COVID impact on experiments at nELBE and GELINA. Enough time to recover.</b> Title of MS inconsistent with the answer of Lecolley.	Change the name of MS18.	<b>No delays</b> in the D and MS if the measurement can be carried out in 2021.
	CVREZ	M. Kostal	Activation measurements with well-known threshold reactions at a nuclear reactor.			MS11 Activation measurements for the extraction of prompt fission neutron spectra above 10 MeV	M24, CVREZ	<b>No delay reported.</b>		<b>No delay reported.</b>
	NPI-CAS	M. Majerle	Cross section data with a powerful array of hyper pure germanium detectors $\Delta E$ -E telescopes (Si)			MS19 Completion of the (n,chp) cross section measurements at NPI CAS with germanium Si detectors	M36, NPI-CAS	<b>No COVID impact.</b>	Modifications of the MS. Replacement of HPGe by Silicon telescopes.	<b>No delay expected</b> in the D and MS.
			Measurement on the							<b>No delay</b>

## Task 2.2: Neutron capture cross sections

Task coordinator: ENEA, partners: CIEMAT, JRC, ULODZ, IRSN

Subtask	Institution	Contact	Subject	Deliverables	Deliverable date & responsible	Milestones	Milestone date & responsible	Comment	Action	Delay
2.2.1. Capture measurements of fissile isotopes.	CIEMAT, ULODZ, JRC	D. Cano	$^{239}\text{Pu}(n,g)$ and $^{239}\text{Pu}(n,f)$ measurements at n_TOF and GELINA	D2.3 Report on the $^{239}\text{Pu}(n,g)$ , $^{92,94,95}\text{Mo}(n,g)$ cross section	M40 / ENEA	MS21 Measurement of the $^{239}\text{Pu}(n,g)$ at n_TOF	M36, CIEMAT	<b>Covid impact at the JRC labs, ULOdz and CERN.</b> Delays in the detector tests and sample preparation.		<b>No delay</b> in the MS, if the experiment is done in early 2022 and the simple is available.
2.2.2. Capture measurement of stable isotopes.	ENEA, IRSN	A. Mengoni	Measurement of the $^{92,94,95}\text{Mo}(n,g)$ cross sections at GELINA and n_TOF.	measurements at n_TOF and GELINA		MS22 Measurement of the Mo isotopes at GELINA and n_TOF	M34, ENEA	<b>Covid impact at the JRC lab and CERN.</b> Delay in the detector tests and sample preparation.	Change the list of isotopes to $^{94,95,96}\text{Mo}$	<b>Delay of 4-6 months</b> in the MS.

## Task 2.3: Neutron elastic and inelastic scattering and neutron multiplication cross sections

Task coordinator: IFIN-HH, partners: CNRS/IPHC, JRC

Subtask	Institution	Contact	Subject	Deliverables	Deliverable date & responsible	Milestones	Milestone date & responsible	Comment	Action	Delay
2.3 Neutron elastic and inelastic scattering and neutron multiplication cross sections	IFIN-HH, CNRS/IPHC, JRC	A. Negret	Inelastic cross section measurements of $^{239}\text{Pu}$ , $^{233}\text{U}$ , $^{14}\text{N}$ and $^{35,37}\text{Cl}$ .	D2.4 Report on the $^{239}\text{Pu}$ , $^{233}\text{U}$ , $^{14}\text{N}$ and $^{35,37}\text{Cl}$ inelastic cross section measurements at GELINA	M48 & IFIN-HH	MS23 Completion of the $^{239}\text{Pu}$ , $^{233}\text{U}$ , $^{14}\text{N}$ and $^{35,37}\text{Cl}$ (n,2n) inelastic and (n,2n) cross section measurements at GELINA	M40 & IFIN-HH	<b>Covid impact at JRC, IFIN-HH and IPHC.</b> Delays in the detector tests and sample preparation.		<b>Delay</b> in the MS of about 6 months. Only preliminary analysis will be available for the D2.4 at M48
	JRC	P. Schillebeeckx	Measurements of the branching ratio for $^{209}\text{Bi}$ , $^{208}\text{Pb}(n,\text{tot})$ and $^{238}\text{U}(n,\text{inel})$ cross sections at GELINA	D2.5 Report on the measurements of the branching ratio for $^{209}\text{Bi}$ , $^{208}\text{Pb}(n,\text{tot})$ and $^{238}\text{U}(n,\text{inel})$ cross sections at GELINA.	M48 / JRC	MS24 Completion of the branching ratio for $^{209}\text{Bi}$ , $^{208}\text{Pb}(n,\text{tot})$ and $^{238}\text{U}(n,\text{inel})$ cross section measurements at GELINA	M40 & JRC	<b>Covid impact at the JRC.</b> Delay in some of the measurements and data analysis.	Priorities at GELINA have been redefined to account for the delay in transmission measurements for Pb and the capture measurements for $^{209}\text{Bi}$ .	<b>No delay except for the <math>^{209}\text{Bi}</math> branching ratio measurement MS.</b>

## Task 2.4: Decay data measurements

Task coordinator: CSIC, partners: CEA/LNHB, CNRS/Subatech, CSIC, JRC, SCK, UPC

Subtask	Institution	Contact	Subject	Deliverables	Deliverable date & responsible	Milestones	Milestone date & responsible	Comment	Action	Delay
2.4.1. Beta decay measurements with TAGs.	CSIC, Subatech, UPC	A. Algora	High precision decay data for fission products.	D2.6 Report of the decay data measurements performed with DTAS and BELEN	M42 & CSIC			<b>COVID impact.</b> The experiments have been delayed. Delays in the contracts of posdocs.		<b>Delay 6-12 months</b> in the <b>D</b> if the measurement can be carried out in 2021.
2.4.2. Beta delayed neutron measurements.	UPC, CSIC	F. Calviño	New measurements with the BELEN detector and the GASIFIC data acquisition and develop a new technique for extracting low resolution energy spectra.	D2.7 Report on the development of a new technique for obtaining low resolution information on the beta delayed neutron energies with BELEN-like detectors.	M30 & UPC	MS25 Completion of the measurements with TAGS and BELEN	M40 & UPC	<b>COVID impact.</b> The experiments have been delayed. Delays in the contracts of posdocs.		<b>Delay 6 months</b> in the D2.6. <b>No delay</b> for in MS.
2.4.3. Measurement of half-live and gamma-ray emission probabilities of beta emitters.	CEA/LNHB	M. Kellet	CEA/LNHB will undertake half-life measurements of $^{106}\text{Ru}$ , $^{153}\text{Sm}$ , $^{166}\text{Ho}$ , $^{186}\text{Re}$ , $^{212}\text{Pb}$ , $^{225}\text{Ac}$ and $^{223}\text{Ra}$ using the existing and calibrated gamma spectroscopy facility at LNE-LNHB.	D.2.15 Report on the of half-live and gamma-ray emission probabilities of beta emitters measurement	M40 & CEA/LNHB	MS3 Completion of a new measurement facility by CEA/LNE-LNHB	M18 & CEA/LNHB	<b>COVID impact.</b> Reported to WP1. Clarify the allocation of the MS		<b>Delay of 6 months</b> (reported to WP1)
	JRC, SCK	P. Schillebeeckx.	New decay measurements on high priority isotopes defined in NFRP-2018-6			-				



## Task 2.5: Fission yields measurements

Task coordinator: UU, partners: CEA/IRFU, CNRS/LPSC, JYU, USC

Subtask	Institution	Contact	Subject	Deliverables	Deliverable date & responsible	Milestones	Milestone date & responsible	Comment	Action	Delay
2.5.1. Fission yield studies in (n,f) reactions.	JYU, UU		Develop a method based on the PI-ICR technique for general fission product yield studies	D2.7 Report on the method based on the PI-ICR technique for general fission product yield studies at JYFL	M36 & JYU			Strong COVID impact on the lab. <b>Enough time to recover.</b>		<b>No delays</b> in the <b>D</b> and <b>MS</b> .
	CEA/IRFU	D. Doré	Experiment on $^{235}\text{U}$ at the research reactor of the ILL by coupling the first arm of FALSTAFF to the brand new FIPPS gamma-ray spectrometer.	D.2.13 Report on fission yield studies with FALSTAFF at ILL <b>(not possible)</b>	M48 & CEA/IRFU	MS12 Completion of the measurements with FALSTAFF at ILL <b>(not possible)</b> / MS1 Completion of the simulation for the coupling of FALSTAFF and FIPPS at ILL	M36 & CEA/IRFU M12 & CEA/IRFU	<b>Not COVID related.</b> Measurement at ILL is not possible due to changes in the long shutdown. Alternative proposal submitted to NFS. Outcome will be known in 2021.	Replacement of the experiment in MS12 (2021) and D2.13 to the one at NFS	<b>No delays</b> in <b>MS</b> and <b>D</b> if NFS beam is Ok,
	CNRS/LPSC	G. Kessedjan	Measurement of kinetic energy dependency of fission yields, isomeric ratios or isotopic distributions at ILL (LOHENGRIN)	D2.12 Report on the fission yield studies with the LOHENGRIN spectrometer at ILL	M36 & CNRS/LPSC			<b>No problem reported.</b>		<b>No delay reported.</b>
2.5.2. Fission yield studies in inverse kinematics.	USC	J. Benlliure	Perform an experiment to demonstrate the use of (p,2p) as surrogate reactions for fission experiments.	D.2.14 Report on fission yield studies in inverse kinematics at FAIR	M34 & USC	MS14 Completion of the measurement on the (p,2p) fission induced reactions at FAIR	M30 & USC	<b>No problem reported.</b>		<b>No delay reported.</b>

## Task 2.6: New measurements for non-energy applications

Task coordinator: USE, partners: IST, NPL, PTB

Subtask	Institution	Contact	Subject	Deliverables	Deliverable date & responsible	Comment	Action	Delay
2.6.1. Spectrum averaged cross sections for dosimetry.	NPL	N. Hawkes	Spectrum-averaged benchmark measurements of the activity induced in foils by neutrons from a $^{252}\text{Cf}$	D.2.9, Report on the spectrum averaged cross sections for dosimetry (NPL)	M44 & NPL	No problem reported.		No delay reported.
2.6.2. Measurement of cross sections relevant for hadron therapy.	PTB, ITN	R. Nolte	Measurement of double-differential charged-particle emission cross sections will be carried out at n_TOF	D.2.10 Report on the measurement of double-differential charged-particle emission cross sections at the CERN n_TOF facility in the neutron energy range from 20 MeV to 200 MeV.	M48 & PTB	No problem reported.		No delays in the D if the measurement can be carried out at n_TOF in early 2022.
2.6.3. Measurement of beta+ emitters.	USE	C. Guerrero	Production cross sections of beta+ emitters used for range verification in proton therapy.	D.2.11 Report on the production cross sections of beta+ emitters used for range verification in proton therapy.	M30 & USE	Not COVID related. Measurement corresponding to long-lived isotopes ( $t_{1/2} > 5$ minutes) completed in Dresden. Problem with the KVI AGOR cyclotron.	Conversations for carrying out the measurement at the Quironsalud Cyclotron (Madrid).	No delays in the D if the measurement can be carried out at Quironsalud.

	Delayed Deliverables	Delayed Milestones	Actions
<b>Task 2.1 Fission and charged particle reaction cross sections</b>			
<i>2.1.1: Neutron induced fission cross sections</i>	<b>D2.1 delayed 6 months due to the <sup>230</sup>Th measurement</b>	<b>MS15 delayed 6 months due to the <sup>230</sup>Th measurement</b>	<b>CNRS/CENBG wants to leave SANDA.</b>
<i>2.1.2: Neutron induced charged particle production cross sections</i>	<b>None</b>	<b>None</b>	<b>Change the name of MS18 by adding other facility names. Change the titles of MS19 by replacing "HPGe" by "Silicon telescopes".</b>
<b>Task 2.2 Neutron capture cross sections</b>			
<i>2.2.1. Capture measurements of fissile isotopes</i>	<b>None</b>	<b>None</b>	
<i>2.2.2. Capture measurement of stable isotopes</i>	<b>None</b>	<b>MS22 delayed 4-6 months.</b>	<b>Change list of isotopes to be measured to <sup>94,95,96</sup>Mo</b>
<b>Task 2.3 Neutron elastic and inelastic scattering and neutron multiplication cross sections</b>	<b>None</b>	<b>MS23 delayed 6 months. MS24 will be delayed only of the <sup>209</sup>Bi branching ratio data.</b>	<b>Only preliminary data will be presented in D2.4. MS23 will be delayed about 6 months. Change beam time priorities at JRC-Geel</b>
<i>2.4.1. Beta decay measurements with TAGS</i>	<b>D2.6 will be delayed 6 - 12 months</b>	<b>None</b>	
<i>2.4.2. Beta delayed neutron measurements</i>	<b>D2.6 will be delayed 6 - 12 months</b>	<b>None</b>	
<i>2.4.3. Measurement of half-live and gamma-ray emission probabilities of beta emitters.</i>	<b>None</b>	<b>None</b>	

	Delayed Deliverables	Delayed Milestones	Actions
<b>Task 2.5 Fission yields</b>			
<i>2.5.1. Fission yield studies in (n,f) reactions</i>	None	None	Replacement of the experiment in MS12 (2021) and D2.13 with the one at NFS
<i>2.5.2. Fission yield studies in inverse kinematics</i>	None	None	
<b>Task 2.6 Non energy applications</b>			
<i>2.6.1. Spectrum averaged cross sections for dosimetry</i>	None	None	
<i>2.6.2. Measurement of cross sections relevant for hadron therapy</i>	None	None	
<i>2.6.3. Measurement of beta+ emitters</i>	None	None	Move the measurement foreseen at KVI to a different facility (Quironsalud)

In general, we are doing not too bad taking into account the situation. However, the situation may change if the pandemic continues. Some of the problems faced are not related to COVID.

At present, the reported delays are at the level of 6 months.

Major sources of risk that have been identified so far:

- Availability of beam time at the different facilities due to COVID and allocation to the experiments (prioritisation).
- Approval of proposals.
- Availability of samples.
- Mobility between high COVID – low COVID areas.
- Hiring of personnel on time.

Not reported except for a few cases: impact on the budget needs to be evaluated.