



## 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



## Generic goals of WP2

**New measurements** will be carried out to significantly **improve the accuracy of nuclear data** needed in **energy and non-energy modelling applications**, mainly in the field of **fission**, radiation protection, safety, sustainability and enhancement of nuclear technologies.

At the end of the project a number of **new high precision nuclear data sets will be available for the major actinides present in advanced reactor fuels**, to reduce uncertainties in new isotopes in closed cycles with waste minimization, to better assess the uncertainties and correlations in their evaluation.

The measurements to be carried out will **use extensively the instrumentation** (detectors, data acquisition systems), methodologies, new techniques and new facilities (n\_TOF EAR2 and NFS) **developed during the project and also for the CHANDA Project**.

**Strong links to WP1!**



## 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.

## CEA/LNHB (Laboratoire Nationale Henri Becquerel) – M. Kellet

- Task 2.4.3 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.
- MS26 “Completion of the measurements at the CEA-LNHB” M36
- Preparation of the D.2.15 Report on the of half-live and gamma-ray emission probabilities of beta emitters measurement (CEA) M40

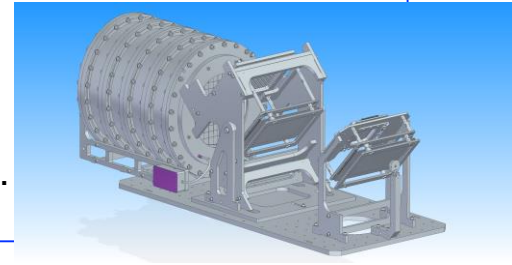
## CEA/IRFU (Institut de recherche sur les lois fondamentales de l'Univers) – D. Doré

- Task 2.5.1 CEA/IRFU will perform an innovative 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. FALSTAFF will measure the fragment kinetic energy and will identify the fragment mass after evaporation. FIPPS will measure the cascade of gamma-rays emitted by the fragments.
- MS12 “Completion of the measurements with FALSTAFF at ILL” M36
- Preparation of D.2.13 Report on fission yield studies with FALSTAFF at ILL (CEA) M48

## CEA effort in WP2: 7.1 PM

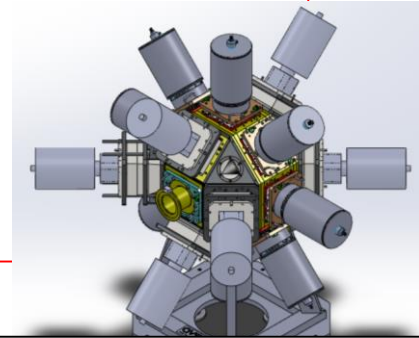
## Planning for the end of the first arm tests

- Energy loss measurement (Si detector) at Lohengrin in Fall 2019
- Analysis of 2019 data taking into account Lohengrin measurements
- Modifications of electronics, adding target support, monitoring (slow control).



## FALSTAFF at FIPPS (ILL)

- ✓ Direct comparisons with fission and de-excitation models
- ✓ Prompt gamma-ray spectra with a good identification of the atomic number and mass of the fragments
- ✓ Information on the angular momentum of the fission fragments



## TECHNIQUE

- One fragment stopped in the target, the other one free to leave it
- Identification (A,Z,E) of the flying fragments in FALSTAFF arm
- Detection of 2 gamma-rays in coincidence in FIPPS array

ILL permanent instrument  
-  $\gamma$ -ray spectrometer made of 8 HPGe clovers  
- beam :  $10^8$  n/s/cm<sup>2</sup> (thermal)

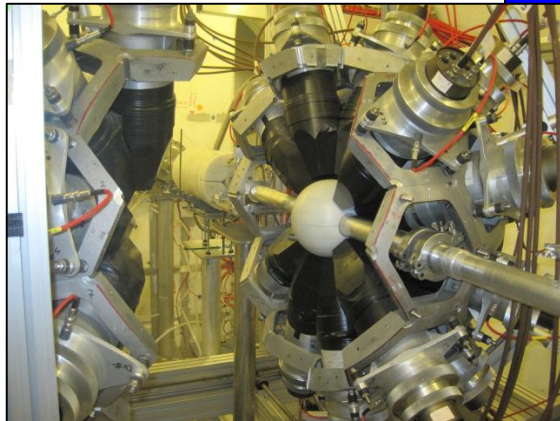
Expected rates :  $^{235}\text{U}$  - 200  $\mu\text{g}/\text{cm}^2$   
:  $5 \cdot 10^4$  fissions/s

- ❖ ILL long shutdown in 2020 or 2021 - not yet settled
- ❖ At some stage, FIPPS should move to another neutron guide to accommodate a gas filled magnet but planning is not yet fixed
- ❖ Falstaff experiment at NFS difficult to plan and have to be taken into account for FALSTAFF@FIPPS planning

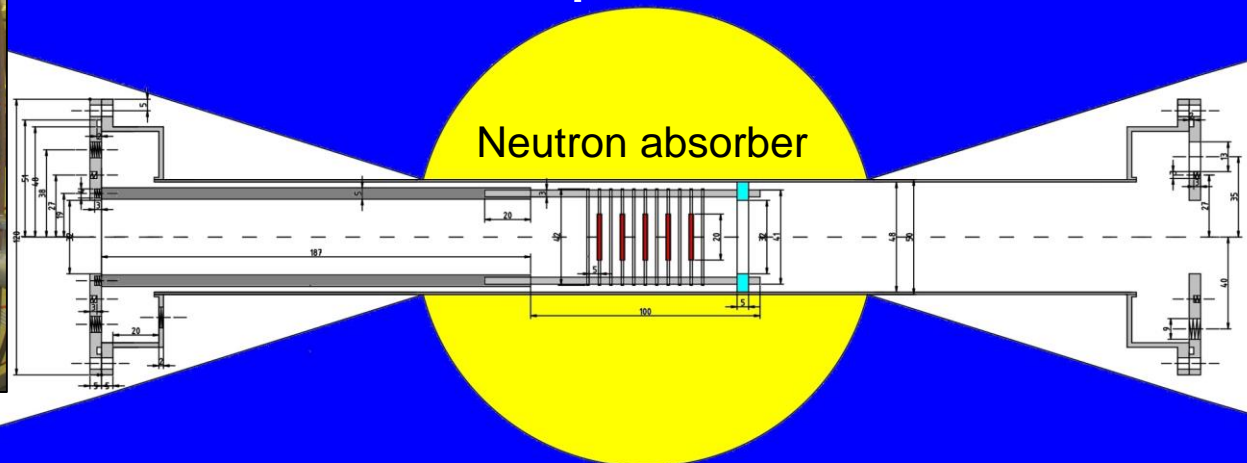


# CIEMAT (Centro de Investigaciones Energéticas, MedioAmbientales y Tecnológicas) – 14.3 PM, D. Cano-Ott

- Coordination of WP2
- Reporting and compilation of Task leader reports for the different reporting periods
- Task 2.2.1 CIEMAT will perform various cross section measurements in collaboration with, ULODZ and JRC at GELINA and n\_TOF on the high priority reactions  $^{239}\text{Pu}(n,g)$  and  $^{239}\text{Pu}(n,f)$ . Collaboration with ULODZ (fission) and JRC (production of the  $^{239}\text{Pu}$  targets)
- MS21 “Measurement of the  $^{239}\text{Pu}(n,g)$  at n\_TOF” M36
- Contribution to D.2.3 M40



## Total Absorption Calorimeter



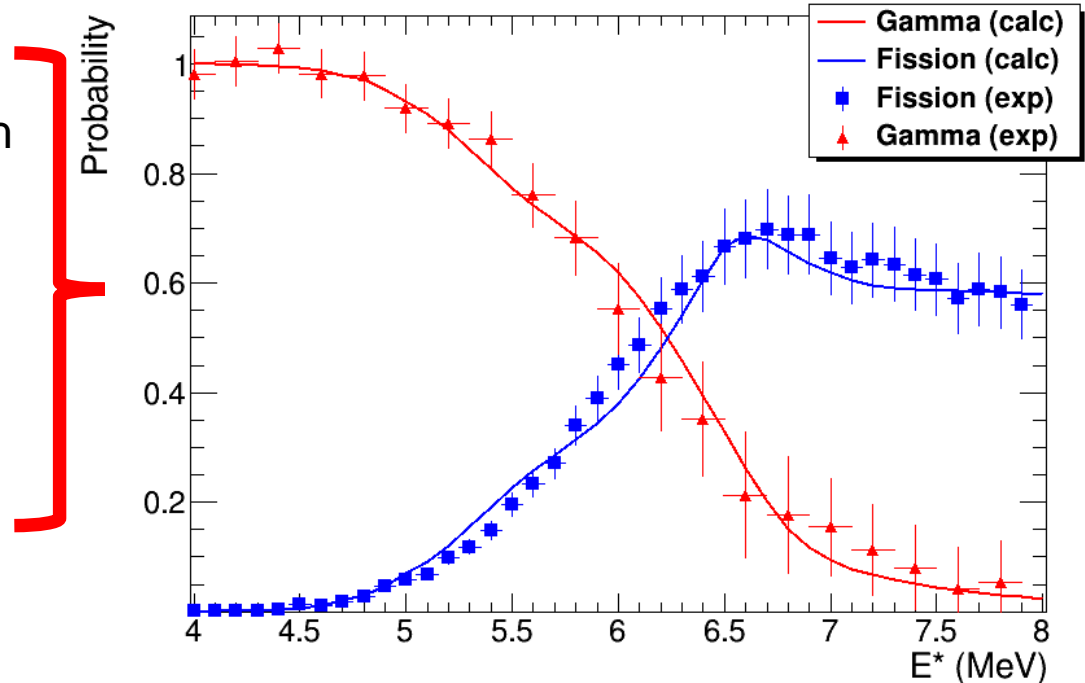
Combined fission (ULODZ) and capture cross section measurements: technique developed within CHANDA

# CNRS/CENBG (Centre d'Etudes Nucleaires Bordeaux Gradignan) – B. Jurado

- Task 2.1.1 CNRS/CENBG will apply the surrogate reaction analysis technique for providing new excitation functions and cross sections for the  $^{239}\text{Pu}(n,f)$ ,  $^{241}\text{Pu}(n,g)$  and  $^{241}\text{Pu}(n,f)$  reactions.
- Contribution to D.2.1 M48

$J\pi$  Distributions  $^{240}\text{Pu}^*$   
Calculated by M. Dupuis with  
JLM folding model + QRPA

Decay Probabilities of  $^{240}\text{Pu}$   
 $P(E^*, J, \pi)$   
With parameters tuned with  
neutron-induced data





## CNRS/IPHC (Institut de Physique Corpusculaire) – M. Kerveno

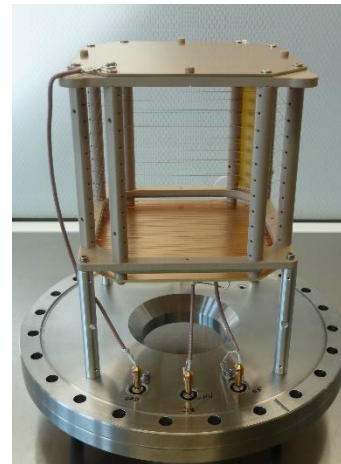
- Task 2.3 CNRS/IPCH will perform (in collaboration with IFIN-HH and JRC) neutron inelastic cross section measurements on several isotopes of interest for development of nuclear facilities:  $^{239}\text{Pu}$ ,  $^{233}\text{U}$ ,  $^{14}\text{N}$  and  $^{35,37}\text{Cl}$ .
- Contribution to D.2.4 M48

## CNRS/LPCC (Laboratoire de Physique Corpusculaire Caen) – F. Lecolley

- Task 2.1.2 CNRS/LPCC will perform a new measurement on the  $^{16}\text{O}(n,\alpha)$  reaction in the energy range from the threshold up to 20 MeV.
- MS18 “Measurement of the  $^{16}\text{O}(n,\alpha)$  cross section at NFS, GENESIS and AMANDE” M36
- Preparation of D.2.2 Report on the (n,chp) cross section measurements (CNRS) M48



**SCALP:**  
Scintillating  
ionization  
Chamber for  
ALpha particle  
Production in  
neutron induced  
reaction



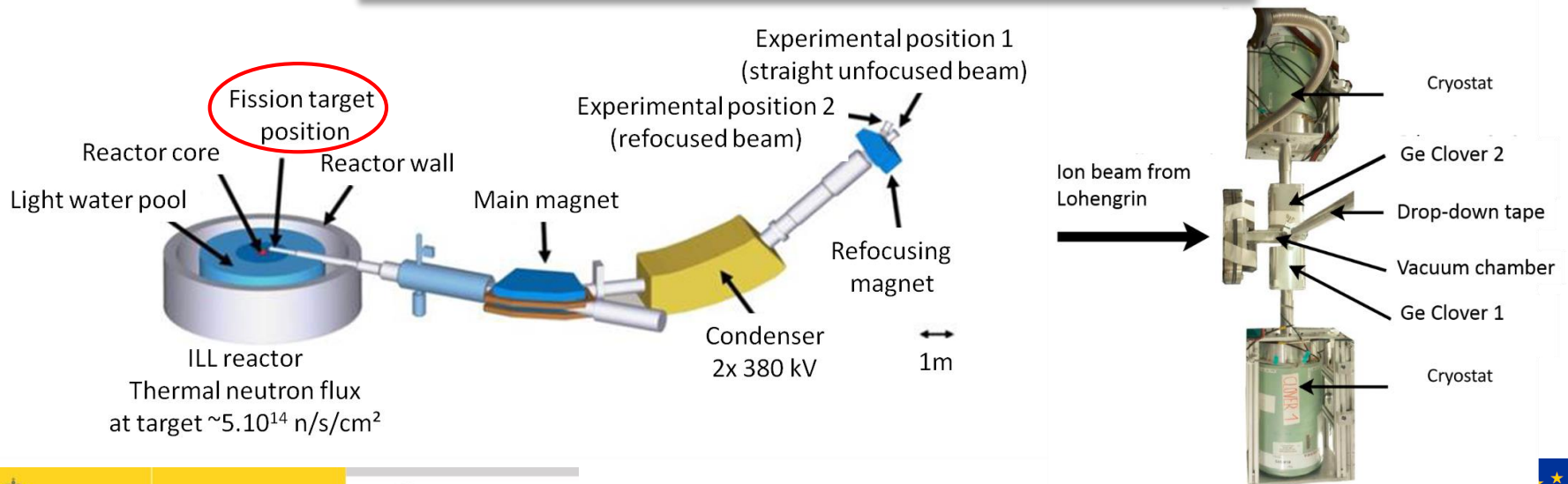
(n,alpha) cross section on  
 $^{16}\text{O}$ ,  $^{19}\text{F}$ ,  $^{12}\text{C}$

- at GELINA (Geel, Belgium) – 2019/2020
- at GENESIS (LPSC, Grenoble, France) – 2020
- at NFS (SPIRAL2 GANIL, Caen, France) – 2020/2021/2022

# CNRS/LPSC (Laboratoire de Physique Subatomique & Cosmologie) – G. Kessedjan

- Task 2.5.1 CNRS/LPSC will develop new program with the LOHENGRIN spectrometer at the Laue Langevin Institute (ILL) allowing to test deeply the assumption of the models used in the fission yield evaluations. The program will be the measurement of **kinetic energy dependency of yields, isomeric ratios or isotopic distributions**. The Gas Filled Magnetic spectrometer developed within will be used in the measurements coupled to the LOHENGRIN spectrometer for purification of the extracted beam.
- Preparation of D.2.12 Report on the fission yield studies with the LOHENGRIN spectrometer at ILL (CNRS) **M36**.

Targets expected:  $^{235}\text{U}$ ,  $^{239,241}\text{Pu}$ ,  $^{241}\text{Am}$  and  $^{245}\text{Cm}$



## CNRS/Subatech – M. Fallot

- Task 2.4.1 CNRS/Subatech (in collaboration with **CSIC**) will measure high precision **decay data for fission products from major and minor actinides** present in working and future advanced reactor fuels. A proven combination of the total absorption gamma spectroscopy technique (**TAGS**) and high-resolution radioactive beam purification schemes techniques will be applied. The DTAS detector and the GASIFIC data acquisition system will be used in the measurements.
- Contribution to D.2.6 **M42**

**Combined effort of CNRS: 21 PM**



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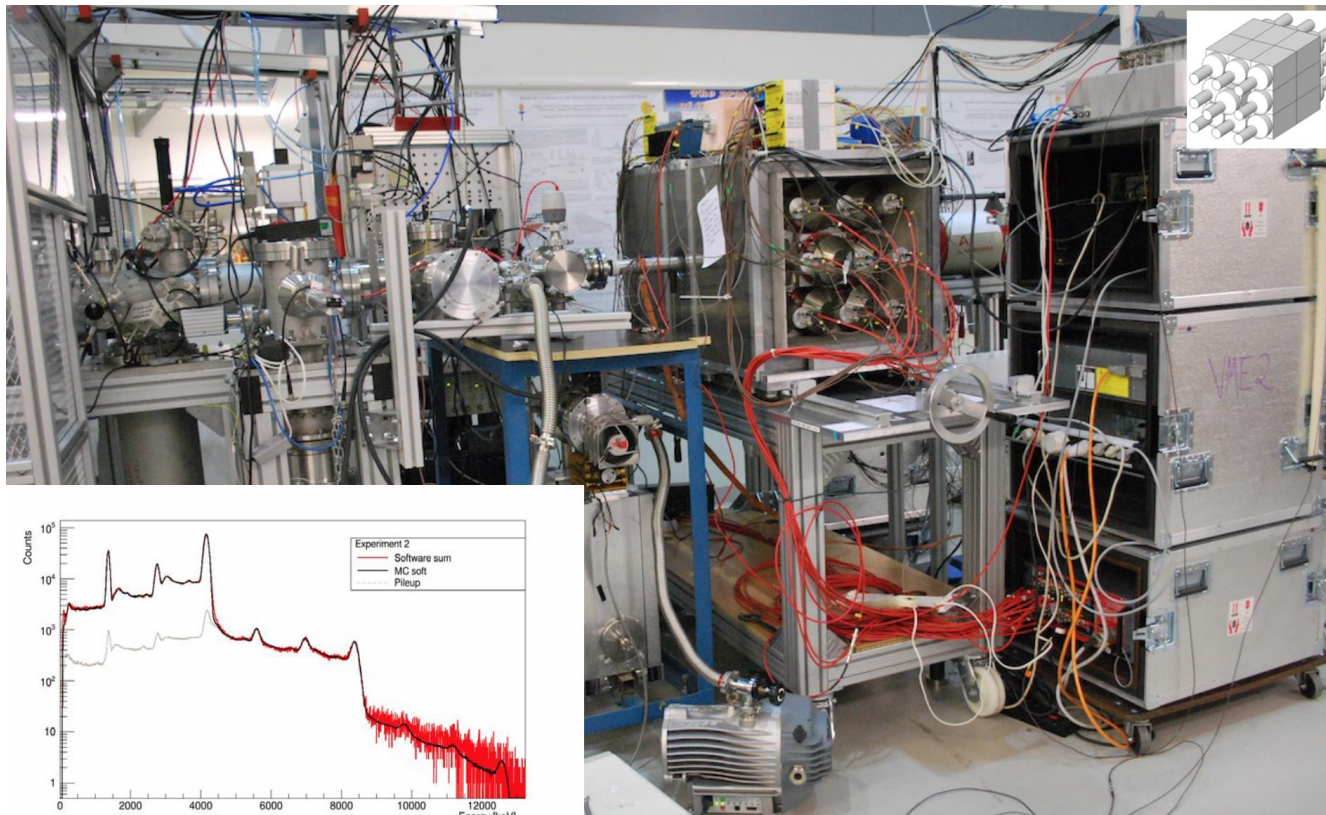
SANDA kick off meeting, 9<sup>th</sup> – 10<sup>th</sup> of September



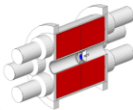
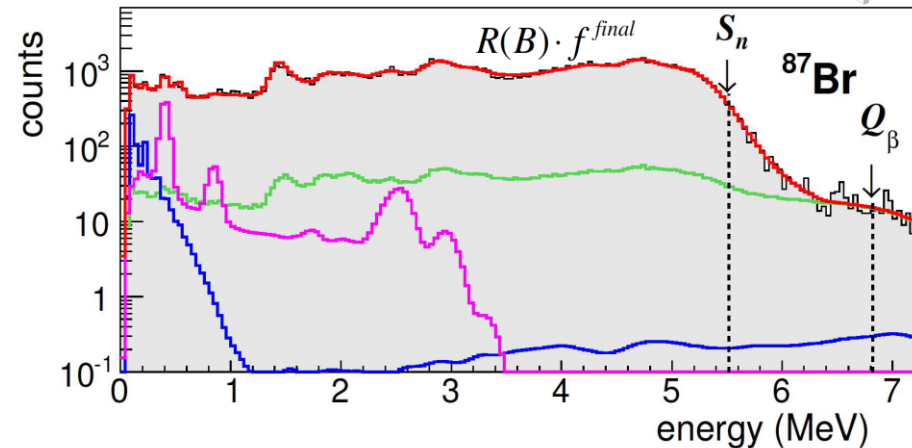
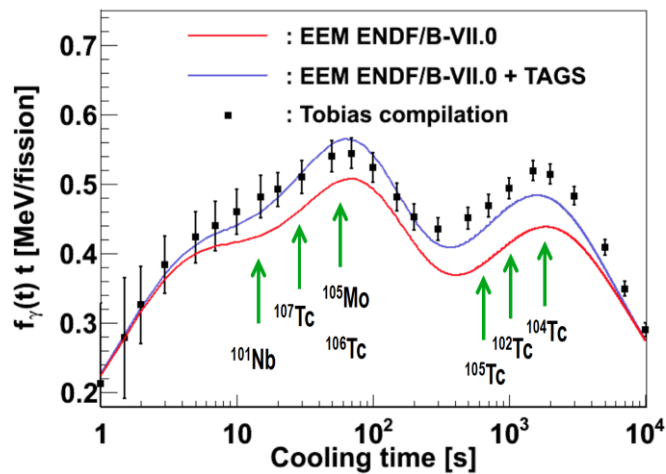
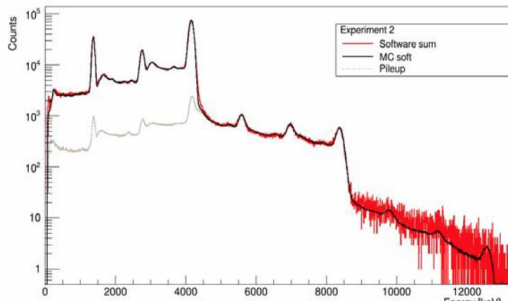
## CSIC (Consejo Superior de Investigaciones Científicas) – 14.4 PM, A. Algora

- Coordination of Task 2.4
- Preparation of Task reports for the different reporting periods.
- Task 2.4.1 CSIC (in collaboration with CNRS/Subatech) will measure **high precision decay data for fission products** from major and minor actinides present in working and future advanced reactor fuels. A proven combination of the total absorption gamma spectroscopy technique (TAGS) and high-resolution radioactive beam purification schemes techniques will be applied. The DTAS detector and the GASIFIC data acquisition system will be used in the measurements.
- Task 2.4.2 CSIC and UPC will perform **new measurements with the BELEN detector and the GASIFIC data acquisition.**
- MS25 “Completion of the measurements with TAGS and BELEN” **M40**
- Preparation of the D.2.6 Report of the decay data measurements performed with DTAS and BELEN (CSIC) **M42**



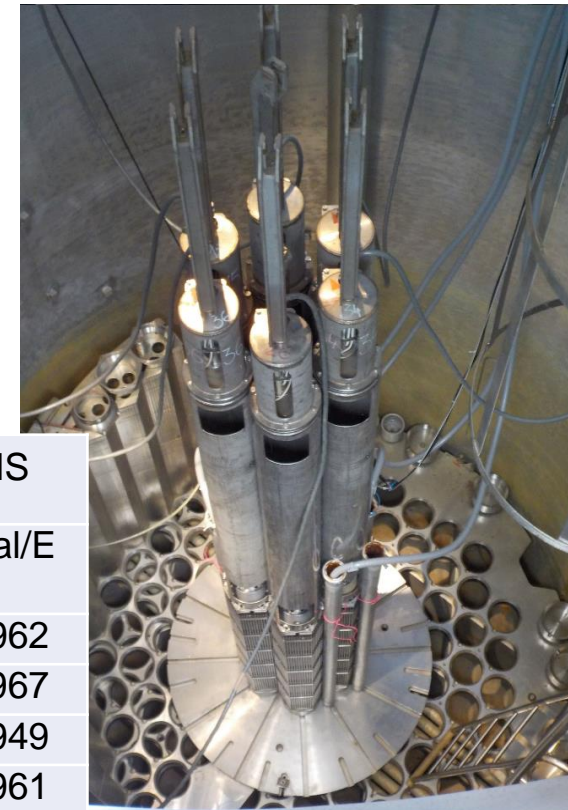
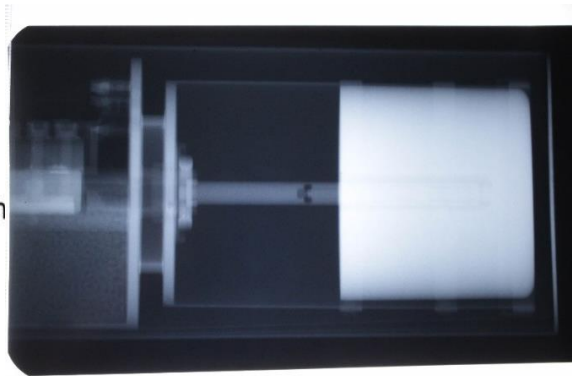
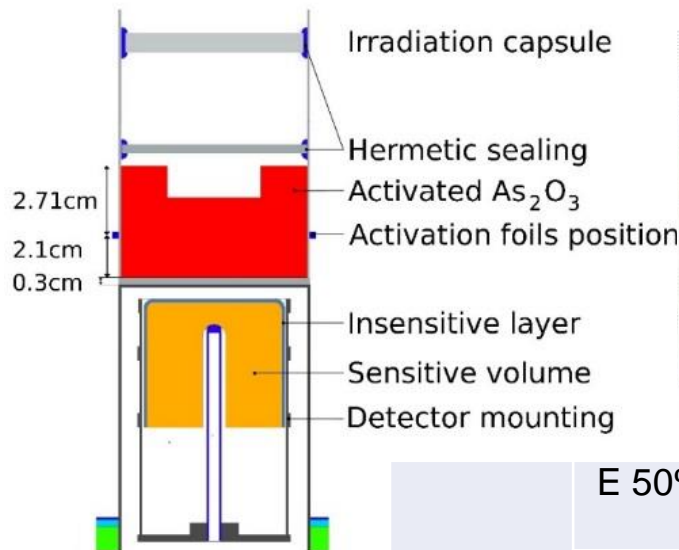


Isotopes of interest:  
As, Br, G, Y, In, Sn,  
and Nb.



## CVREZ (Centrum Vyzkumu REZ S.R.O.) – 11.7 PM, M. Kostal

- Task 2.1.2 CVREZ will obtain information on **the prompt fission neutron spectra** above 10 MeV by performing activation measurement with well-known threshold reactions at a nuclear reactor.
- MS11 “Activation measurements for the extraction of prompt fission neutron spectra above 10 MeV” M24



	E 50%	SACS	Unc.	CIELO PFNS	
	[MeV]	[mb] ( $^{235}\text{U}$ PFNS)	[%]	Eval. [mb]	Eval/E
$^{75}\text{As}(n,2n)$	12.913	0.3259	4.4	0.3135	0.962
$^{89}\text{Y}(n,2n)$	13.896	0.1701	2.6	0.1645	0.967
$^{90}\text{Zr}(n,2n)$	14.19	0.1056	2.8	0.1002	0.949
$^{23}\text{Na}(n,2n)$	15.181	0.00391	4.9	0.00376	0.961

## ENEA (Ente per le Nuove Tecnologie l'Energia e l'Ambiente) – 15 PM, A. Mengoni

- Coordination of Task 2.2
- Preparation of Task reports for the different reporting periods.
- Task 2.2.1 ENEA will measure the  $^{92,94,95}\text{Mo}(n,g)$  cross sections at GELINA and at the n\_TOF facility with the high performance total energy detectors. The data will be part of an evaluation done in WP4 by IRSN.
- MS22 “Measurement of the Mo isotopes at GELINA and n\_TOF” M34
- Preparation of the D.2.3 Report on the  $^{239}\text{Pu}(n,g)$ ,  $^{92,94,95}\text{Mo}(n,g)$  cross measurements at n\_TOF and GELINA (ENEA) M40





# IFIN-HH (Institutul national de cercetare–dezvoltare pentru Fizica si Inginerie nucleara Horia Hulubei) – 11.2 PM, A. Negret

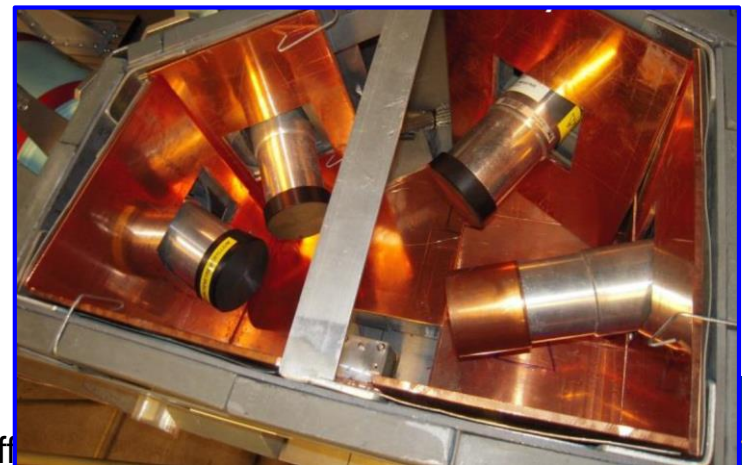
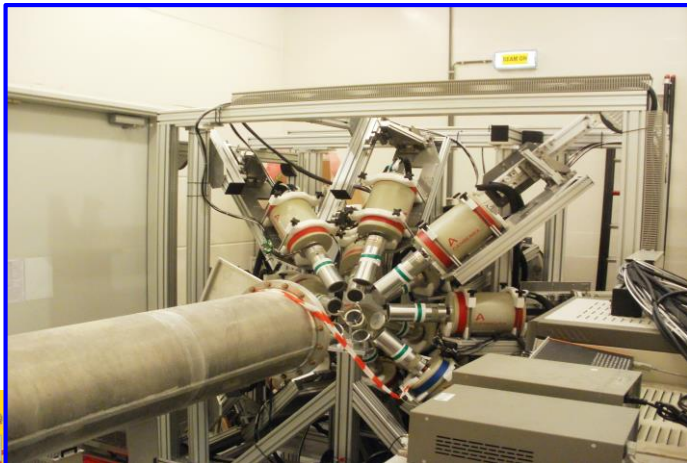
- Coordination of Task 2.3
- Preparation of Task reports for the different reporting periods.
- Task 2.3 IFIN-HH will perform (in collaboration with CNRS/IPCH and JRC) neutron inelastic cross section measurements on several isotopes of interest for development of nuclear facilities:  $^{239}\text{Pu}$ ,  $^{233}\text{U}$ ,  $^{14}\text{N}$  and  $^{35,37}\text{Cl}$ .
- 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
- Preparation of the D.2.4 Report on the  $^{239}\text{Pu}$ ,  $^{233}\text{U}$ ,  $^{14}\text{N}$  and  $^{35,37}\text{Cl}$  inelastic cross section measurements at GELINA (IFIN-HH) M48

## GAINS: $^{14}\text{N}$ , $^{35,37}\text{Cl}$ .

- 12 large volume HPGe detectors
- Flight Path: 100 m

## GRAPhEME: $^{233}\text{U}$ , $^{239}\text{Pu}$ .

- 5 HPGe planar + 1 segmented detectors
- Flight Path: 30 m



SANDA kick off



## IRSN (Institut de Radioprotection et de Surete Nucleaire) – 1.5 PM, I. Duhamel

- Task 2.2.1 Collaboration with ENEA in the  $^{92,94,95}\text{Mo}(n,g)$  cross section measurements at GELINA and at the n\_TOF facility.
- Contribution to D.2.3 M40

## IST-ID (Instituto Superior Técnico) – 4 PM, P. Vaz

- Task 2.6.3 IST will carry out (in collaboration with PTB) the **measurement of double-differential charged-particle emission cross sections** will be carried out at the CERN n\_TOF facility in the neutron energy range from 20 MeV to 200 MeV. Part of the necessary equipment will be developed by HZDR within WP1.
- Contribution to D.2.10 M48

## JRC (Joint Research Centre Geel) – 17.2 PM, P. Schillebeeckx

- Task 2.2.1 JRC will prepare and deliver the  $^{239}\text{Pu}$  **samples** necessary for the measurement of the  $^{239}\text{Pu}(n,g)$  and  $^{239}\text{Pu}(n,f)$  cross sections, to be carried out in collaboration with CIEMAT and ULODZ at GELINA (fission) and n\_TOF (fission and capture) in combination with the Total Absorption Calorimeter.
- Task 2.3 JRC will perform (in collaboration with IFIN-HH and CNRS/IPCH) **neutron inelastic cross section measurements** on several isotopes of interest for development of nuclear facilities:  $^{239}\text{Pu}$ ,  $^{233}\text{U}$ ,  $^{14}\text{N}$  and  $^{35,37}\text{Cl}$ .
- Task 2.3 JRC will perform high accuracy 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.
- Task 2.4.3 JRC will perform (in collaboration with SCK) new **decay measurements** on high priority isotopes defined in NFRP-2018-6. Data for  $^{244}\text{Cm}$  production and neutron emission rates. Decay data for decay heat prediction.
- MS12 “Measurement of the energy dependence of the nubar with the MONET setup” **M24**
- 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**
- Contribution to D.2.3 **M40**
- Contribution to D.2.4 **M48**
- Preparation of the D.2.5 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. (JRC) **M48**

## JYU (University of Jyväskylä) – 5 PM, H. Penttillä

- Task 2.5.1 JYU has begun to apply a pioneering technique called Phase-Imaging Ion-Cyclotron-Resonance (PI-ICRS) for **determining isomeric yield ratios (IYR) in fission**. In a CHANDA-supported experiment isomeric ratios of neutron rich indium and cadmium isotopes in proton-induced fission were measured. JYU will develop a method based on the PI-ICR technique for general fission product yield studies.
- Preparation of the D.2.8 Report on the method based on the PI-ICR technique for general fission product yield studies at JYFL (JYU) **M36**

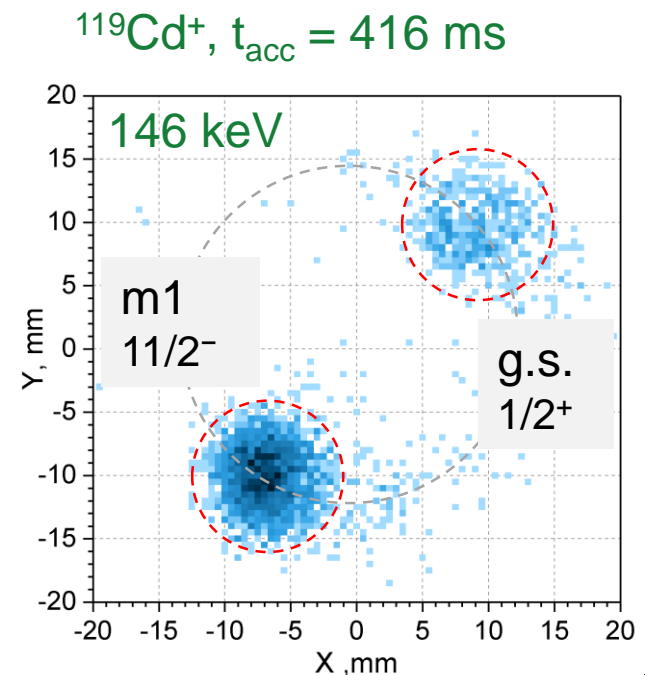
The necessary resolution can be reached with the second trap (**precision trap**) and PI-ICR (Phase-Imaging Ion-Cyclotron Resonance) technique

**PRL 110, 082501 (2013)**

**EPJA 54, 154 (2018)**

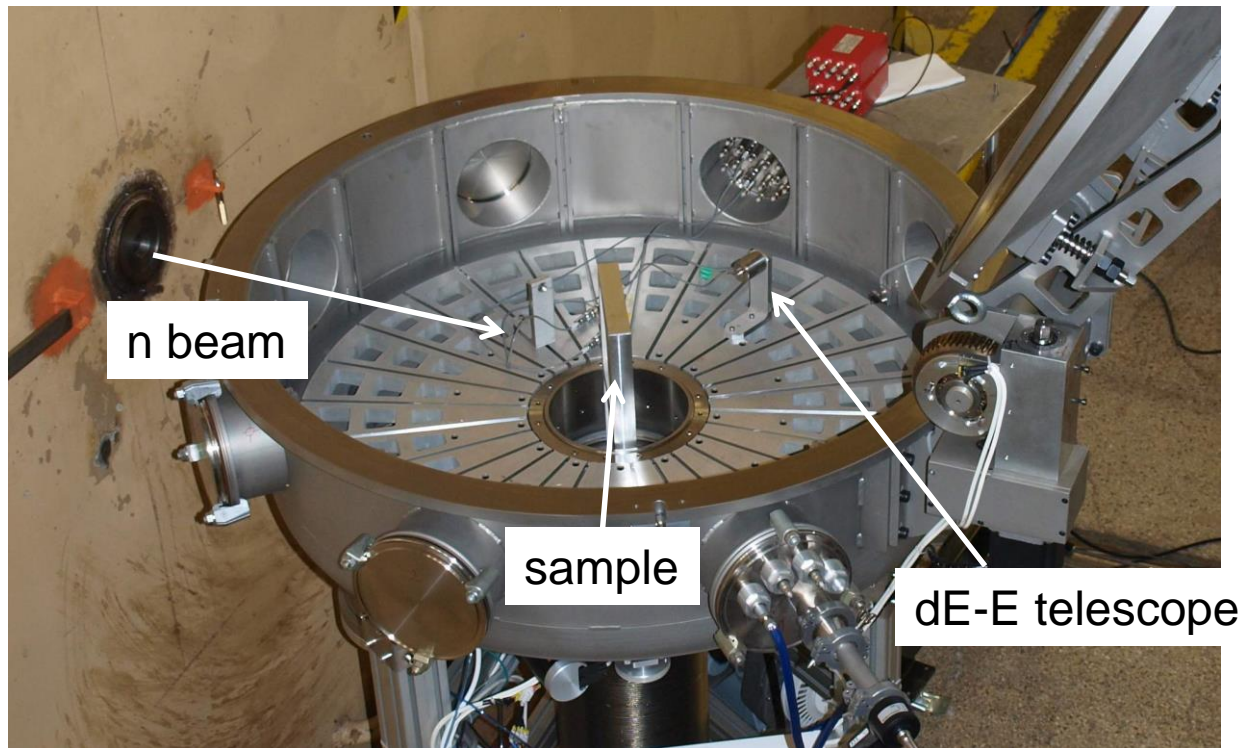
Technique has already applied to resolve isomers to deduce isomeric yield ratios

**PRC 99, 014617 (2019)**



## NPI-CAS (Ustav Jaderne Fyziky av cr) – 17.3 PM, M. Majerle

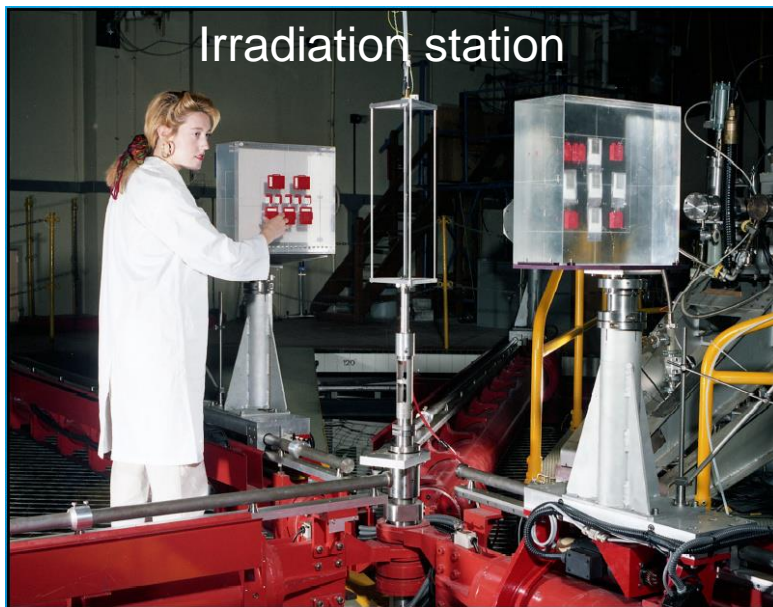
- Task 2.1.2 NPI CAS will provide new (n,chp) cross section data with a powerful array of hyper pure germanium detectors **dE-E telescopes (Si)** on a rotating table constructed recently.
- MS19 “Completion of the (n,chp) cross section measurements at NPI CAS with germanium Si detectors” **M36**





## NPL (National Physics Laboratory) – 2.3 PM, N. Hawkes

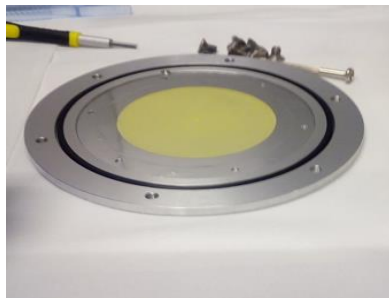
- Task 2.6.1 NPL will perform spectrum-averaged benchmark measurements of the activity induced in foils by neutrons from a  $^{252}\text{Cf}$  source via the  $^{117}\text{Sn}(n,\text{inl})^{117\text{m}}\text{Sn}$  and  $^{60}\text{Ni}(n,\text{p})$  reactions.
- Preparation of D.2.9, Report on the spectrum averaged cross sections for dosimetry (NPL) **M44**



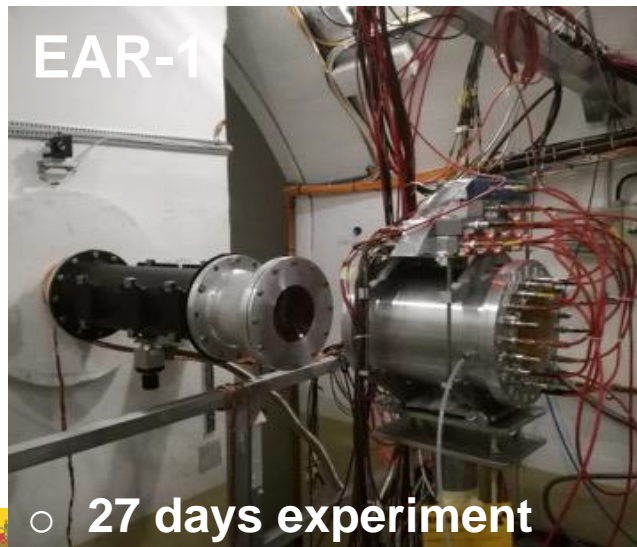
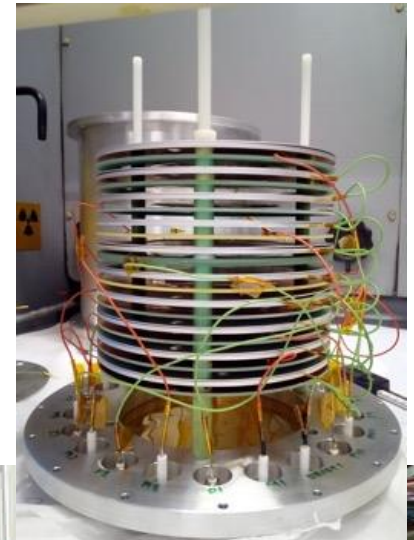
$^{252}\text{Cf}$  spectrum-averaged cross sections: at least one of  $^{117}\text{Sn}(n,\text{inl})^{117\text{m}}\text{Sn}$  and  $^{60}\text{Ni}(n,\text{p})$ . Both are in the NEA High Priority Request List.

# NTUA (National Technical University of Athens) – 6 PM, R. Vlastou

- Task 2.1.1 The NTUA will perform a new measurement of the poorly known  $^{230}\text{Th}(n,f)$  cross section at the n\_TOF EAR2 facility
- MS15 “Measurement of the  $^{230}\text{Th}(n,f)$  cross section at n\_TOF” M36
- Contribution to D.2.1 M48



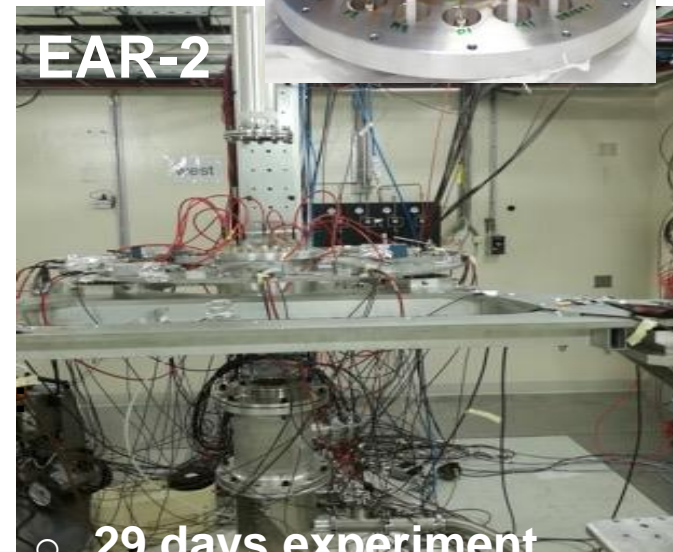
Highly enriched samples of  $^{230}\text{Th}$  have been provided for the measurements by **JRC-Geel**.



○ 27 days experiment

**Detectors :**  
A **Micromegas (Micro-MESH Gaseous Structure)** will be used.

**Reference Reactions**  
 $^{235}\text{U}(n,f)$  and  $^{238}\text{U}(n,f)$



○ 29 days experiment

SANDA kick off meeting, 9

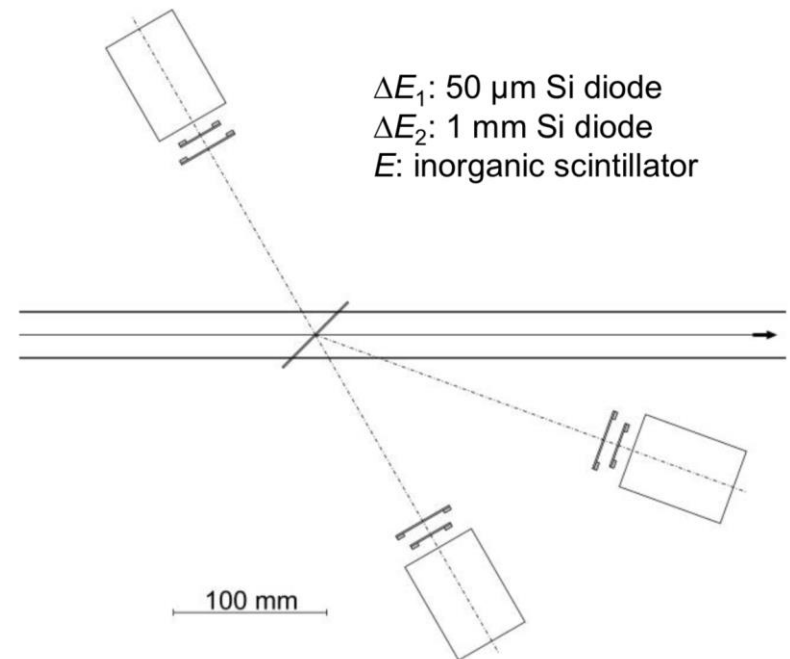
18-19 September

## PTB (Physikalische Technische Bundesanstalt) – 4PM, R. Nolte

- Task 2.6.3 PTB will carry out (in collaboration with IST-ID) the measurement of **double-differential charged-particle emission cross sections** will be carried out at the CERN n\_TOF facility in the neutron energy range from 20 MeV to 200 MeV. Part of the necessary equipment will be developed by HZDR within WP1.
- Preparation of the 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. (PTB) **M48**

### High-Energy DDX for $^{12}\text{C}(n, \text{lcp } x)$ at n\_TOF EAR

- n\_TOF area 1 (183 m station)
- $3 \times 10^{18}$  protons on spallation target (~30 days)
- Sample: 225 mg/cm<sup>2</sup> C
- Development of DE-DE-E telescopes in WP1



## **SCK (Belgian Nuclear Research Centre) – 2.2 PM, A. Stankovskiy**

- Task 2.4.3 SCK will perform (in collaboration with JRC) new decay measurements on high priority isotopes defined in NFRP-2018-6.

## **ULODZ (University of Lodz) – 12 PM, J. Andrzejewski**

- Task 2.2.1 ULODZ will develop a new ionization chamber and test it in a  $^{239}\text{Pu}(n,f)$  measurement at JRC in collaboration with CIEMAT and JRC.
- Contribution to D.2.3 M40

## **UMANCH (University of Manchester) – 10 PM, G. Smith**

- Coordination of Task 2.1
- Preparation of Task reports for the different reporting periods.
- Task 2.1.1 The UMANCH will perform a new measurement of the high priority  $^{239}\text{Pu}(n,f)$  cross section. The measurement will be carried out with the STEFF spectrometer at the n\_TOF EAR2 facility.
- MS17 "Measurement of the  $^{239}\text{Pu}(n,f)$  cross section at n\_TOF" M36
- Preparation of D.2.1 Report on the (n,f) cross section measurements (UMANCH) M48



## UOI (University of Ioannina) – 6 PM, N. Patronis

- Task 2.1.1 The UOI will carry out a 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
- Contribution to D.2.1 M48

## UPC (Universidad Politécnica de Cataluña) – 1.8 PM, F. Calviño

- Task 2.4.2 UPC and CSIC will perform new measurements with the BELEN detector and the GASIFIC data acquisition and develop a new technique for extracting low resolution energy spectra with long counters following the Bonner sphere principle.
- Preparation of the D.2.7 Report on the development of a new technique for obtaining low resolution information on the beta delayed neutron energies with BELEN-like detectors. (UPC) M30
- Contribution to D.2.6 M42

## USC (Universidad de Santiago de Compostela) – 10 PM, J. Benlliure

- Task 2.5.2 USC will perform an experiment to demonstrate the use of (p,2p) as surrogate reactions for fission experiments and identify key nuclei accessible by the new FAIR facility for **fission** experiments induced by **(p,2p) reactions**. The experiment will allow investigating the fission of  $^{233}\text{Pa}$ , determining the resolution achieved in excitation energy of the fissioning compound nucleus and the possibility to determine fission barriers.
- MS14 “Completion of the measurement on the (p,2p) fission induced reactions at FAIR” **M30**
- Preparation of the D.2.14 Report on fission yield studies in inverse kinematics at FAIR (USC) **M34**

Coupling CALIFA-tracker + GLAD + NeuLAND + SOFIA

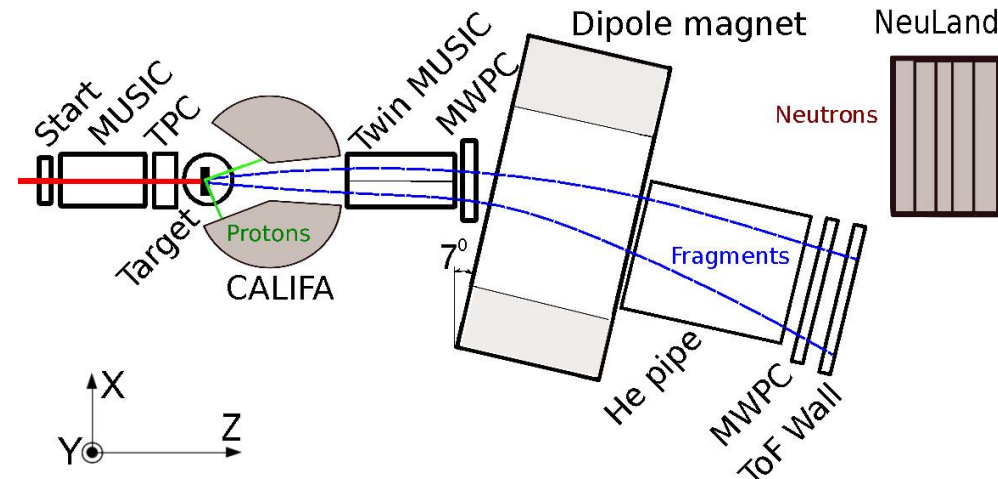
SOFIA@R3B

Characterization of the fissioning nucleus (A, Z, E\*) → (p,2p) with CALIFA+tracker

Characterization of both fission fragments (A, Z, TKE,) → SOFIA

Neutrons, gammas and light-charged particles → NeuLAND + CALIFA

Beam time granted: 21 shifts main, 15 shifts parasitic in spring 2020



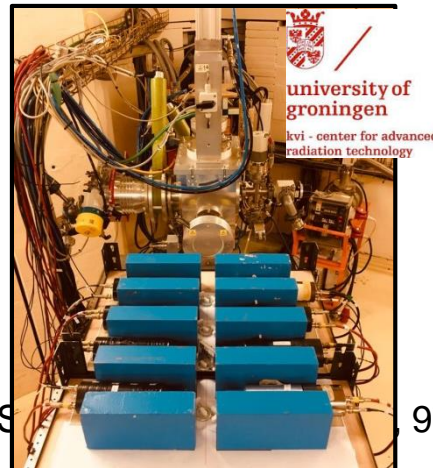
## USE (Universidad de Sevilla) – 10 PM, C. Guerrero

- Coordination of Task 2.6
- Preparation of Task reports for the different reporting periods.
- Task 2.6.1 USE will perform measurements of production cross sections of beta+ emitters used for range verification in proton therapy. The list of isotopes covers the high priorities of IAEA:  $^{11}\text{C}$ ,  $^{13}\text{N}$ ,  $^{15}\text{O}$ ,  $^{30}\text{P}$  produced by protons with energies up to 250 MeV. The gamma-ray detection set-up will consist of a medical PET scanner, or equivalent, and successful preliminary tests have been carried out already at CNA. Other recently proposed isotopes for range verification, with shorter half-lives such as  $^{10}\text{C}$ ,  $^{12}\text{N}$ ,  $^{38\text{m}}\text{K}$  and  $^{29}\text{P}$  will be considered along the project.
- Preparation of D.2.11 Report on the production cross sections of beta+ emitters used for range verification in proton therapy. (USE) **M30**

Production below 18 MeV  
@CNA (+PET)



Production of short-lived ( $^{12}\text{N}$ ,  $^{29}\text{P}$   
and  $^{38\text{m}}\text{K}$ ) up to 230 MeV  
@KVI-AGOR (+ array of  $\text{LaBr}_3$ )



Production of long-lived ( $^{11}\text{C}$   
and  $^{13}\text{N}$ ) up to 230 MeV  
@ICP Orsay (+ PET)



Proposal submitted

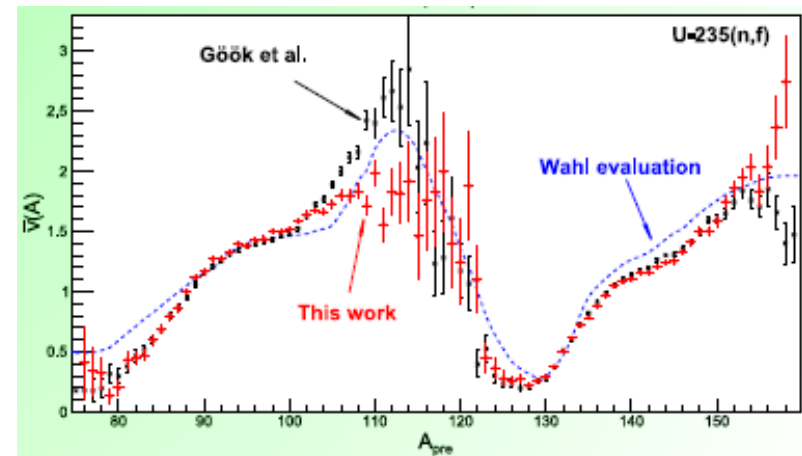
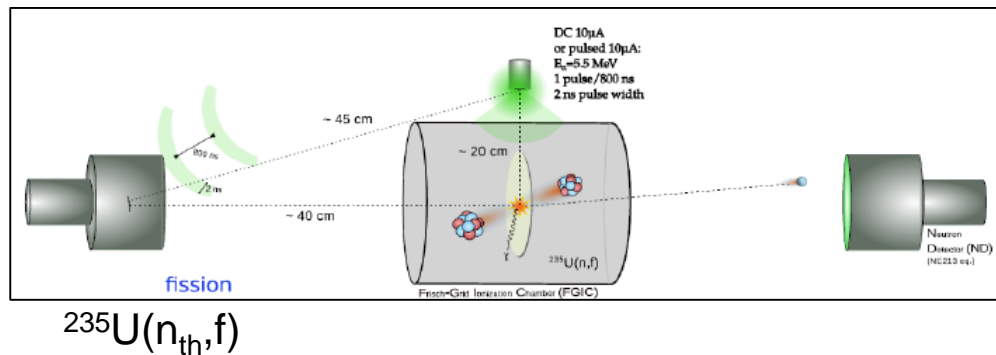
9<sup>th</sup> – 10<sup>th</sup> of September



## UU (Uppsala Universitet) – 9 PM, S. Pomp

- Coordination of Task 2.5
- Preparation of Task reports for the different reporting periods.
- Task 2.1.1 UU will perform a high accuracy measurement of the energy dependence of the **nubar** for the  $^{235}\text{U}(n,f)$  cross section at JRC-Geel.
- Task 2.1.2 UU will perform a new measurement on the  $^{\text{nat}}\text{C}(n,lchp)$  reaction at NFS facility and provide high quality data for improving cross section standards.
- Task 2.5.1 The UU will perform **fission yield** measurements as a follow up of the developments achieved with CHANDA. Independent fission yields in neutron induced fission will be performed using the IGISOL/JYFLTRAP facilities at JYU.
- MS19 “Measurement of the  $^{\text{nat}}\text{C}(n,lchp)$  at NFS” M42
- Contribution to D.2.1 M48

$^{235}\text{U}(n,f)$  at 5 MeV in 2020



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

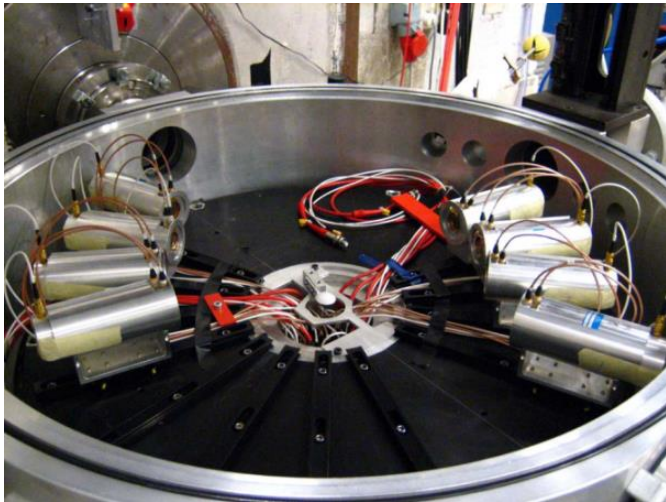


Long term goal: Study DDX for  $^{nat}\text{C}(n, \text{lcp})$  in the 10 to 30 MeV range;

Facility: **NFS**; approved experiment

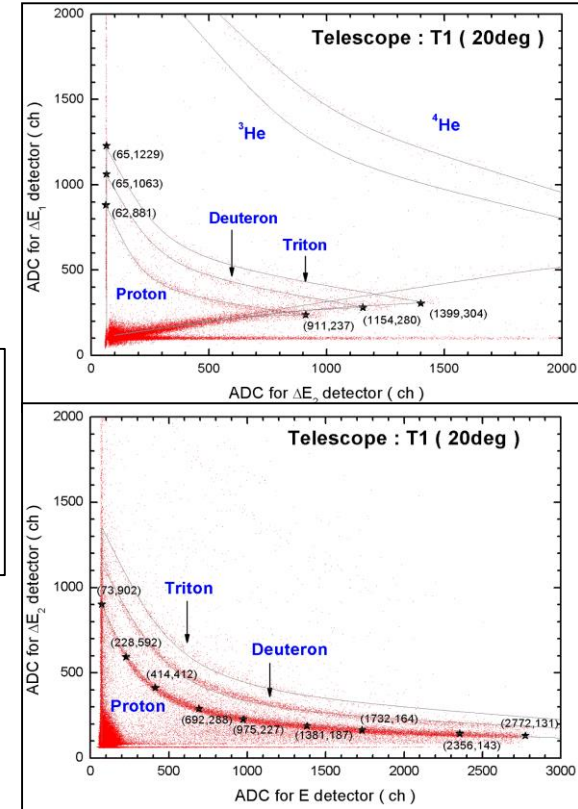
Instrument: **Medley** chamber

When: Initially we will run at QMN (30 MeV), depending on NFS commissioning;



Evacuated chamber  
DE-DE-E technique + angles  
⇒ double differential xs  
(DDX)

Example of exp. data from  
previous measurement  
at high energy:



*Tippawan et al., Phys. Rev. C 79, 064611 (2009).*



# 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		