

# Follow up of SG-26 in Europe

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# Overview

- Nuclear data activities
  - Individual institutes, typically driven by other priorities
  - JEFF
    - Common interests
    - Individual contributions
  - GEDEPEON
    - CEA, CNRS, open
  - Participation IAEA-CRPs
  - THOREA
    - Recent British initiative for Th/U cycle: data?
- Competitive projects DG-RTD
  - EUROTRANS
  - EFNUDAT
  - EUFRAT
  - CANDIDE
  - ANDES
- European MetrologyRP,
  - New, limited scope
  - Experience with accurate measurements and uncertainty evaluation
  - Fluence and radioactivity oriented community

# EUROTRANS

- EUROTRANS/NUDATRA
- Effectively stopped but awaiting end of EUROTRANS project 31 March 2010.
- Measurements for ADS based on prior sensitivity studies along the methods used by SG26.
- Some bearing on ADMAB (Pb, Bi, MAs).
- However, Pb and Bi inelastic OK compared w. Aliberti 2004, only borderline for SG26
- Good results from transfer technique for fission cross sections of Cm isotopes
- Number of new evaluations for Pb, Bi, MA
- Fuel cycle oriented sensitivity studies

# EFNUDAT, EUFRAT

- TAA experiments, nuclear data for transmutation
- PFNS U-235, Hamsch/Budapest
- Validation surrogate method for capture, Hamsch/IPNO/CENBG
- FF spectrometry fission gamma-rays, Oberstedt/Budapest
- Many other issues related to reactor physics, nuclear modelling, detector and neutron field calibrations
- EUFRAT:
  - many diverse issues, Zr, W, Hf, TH/U cycle, ADS, calibrations, methods
- EFNUDAT and EUFRAT
  - engage a wider audience, often from fundamental physics in measurements for energy applications
  - Perform some work related to HPRL

# CANDIDE

- Recommendations from SG26, EUROTRANS/NUDATRA other concerns related to HPRL, decay heat, fission neutron spectrum, elastic scattering,...
- Guidelines for short and medium term development of nuclear data
- Quality control
- data production methodology
- Covariances
- Promotion of new high quality experiments, both microscopic and integral

# Accurate Nuclear Data for nuclear Energy long term Sustainability



WP1 Measurements for advanced reactor systems (Plompen)

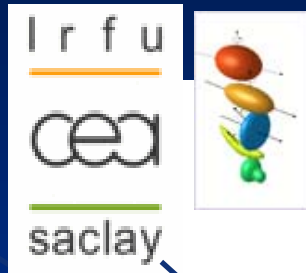
WP2 Nuclear data evaluations and covariances (Koning)

WP3 Integral experiments for validation and constraints of nuclear data (Bernard)

WP4 High energy model validation in the 150-600 MeV domain (Leray)

WP5 Management, coordination, dissemination, training (Gonzalez)

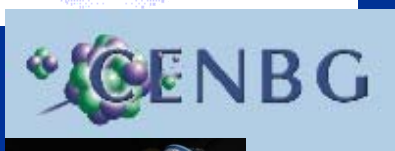
# WP1 participants



CEA DIF



**JYVÄSKYLÄN YLIOPISTO**  
University of Jyväskylä










# WP1 specific objectives

- Neutron inelastic scattering
  - $^{238}\text{U}(n,n'\gamma)$  IPHC, Dessagne e.a.
  - Non-actinides: Na, Fe, Zr, Mo, IRMM, Plompen
  - Covariances, IFIN-HH, Negret
- Capture and total
  - $^{238}\text{U}$ ,  $^{241}\text{Am}$ , transfer for Cm
  - CEA, CIEMAT, INFN, IRMM, CENBG, IPNO, ITN (n\_TOF)
- Fission
  - $^{240,241}\text{Pu}$ ,  $^{241,243}\text{Am}$ ,  $^{245}\text{Cm}$ , CEA, CIEMAT, INFN, IRMM, ITN (n\_TOF)
  - $^{238}\text{Pu}(n,f)$  by  $^{237}\text{Np}(^3\text{He},pf)$  CENBG, IPNO
  - FY Np, Pu, Am, GANIL
- FP decay data for kinetics and decay heat
  - $^{88}\text{Br}$ ,  $^{94,95}\text{Rb}$ ,  $^{137}\text{I}$
  - TAGS
  - Delayed neutron yields
  - JYU, CIEMAT



# Priority needs for advanced




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

			Energy Range	Current Accuracy (%)	Target Accuracy (%)
U238	 $\sigma_{inel}$		6.07 ÷ 0.498 MeV	10 ÷ 20	2 ÷ 3
	 $\sigma_{capt}$		24.8 ÷ 2.04 keV	3 ÷ 9	1.5 ÷ 2
Pu241	$\sigma_{fiss}$		1.35MeV ÷ 454 eV	8 ÷ 20	2 ÷ 3 (SFR,GFR, LFR) 5 ÷ 8 (ABTR, EFR)
Pu239	$\sigma_{capt}$		498 ÷ 2.04 keV	7 ÷ 15	4 ÷ 7
Pu240	 $\sigma_{fiss}$		1.35 ÷ 0.498 MeV	6	1.5 ÷ 2
	$\nu$		1.35 ÷ 0.498 MeV	4	1 ÷ 3
Pu242	 $\sigma_{fiss}$		2.23 ÷ 0.498 MeV	19 ÷ 21	3 ÷ 5
Pu238	 $\sigma_{fiss}$		1.35 ÷ 0.183 MeV	17	3 ÷ 5
Am242m	$\sigma_{fiss}$		1.35MeV ÷ 67.4keV	17	3 ÷ 4
Am241	 $\sigma_{fiss}$		6.07 ÷ 2.23 MeV	12	3
Cm244	$\sigma_{fiss}$		1.35 ÷ 0.498 MeV	50	5
Cm245	 $\sigma_{fiss}$		183 ÷ 67.4 keV	47	7

- Items addressed by ANDES WP1 are marked

# Priority needs for advanced

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

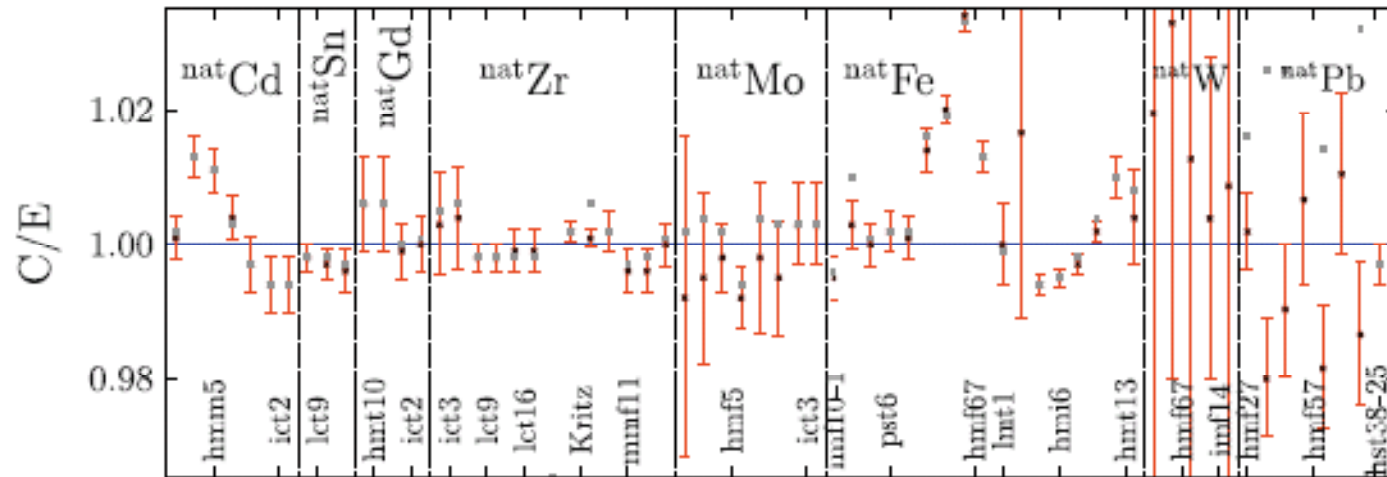
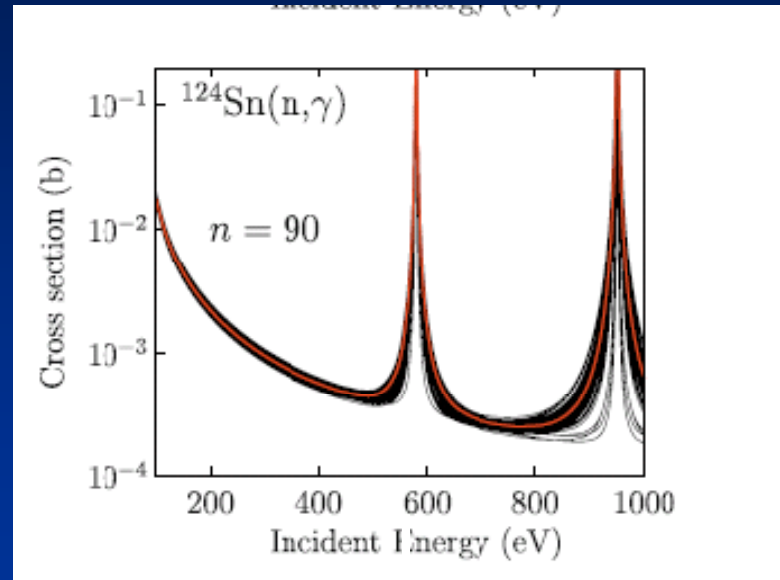
		Energy Range	Current Accuracy (%)	Target Accuracy (%)
Fe56	 $\sigma_{\text{inel}}$	2.23 ÷ 0.498 MeV	16 ÷ 25	3 ÷ 6
Na23	 $\sigma_{\text{inel}}$	1.35 ÷ 0.498 MeV	28	4 ÷ 10
Pb206	$\sigma_{\text{inel}}$	2.23 ÷ 1.35 MeV	14	3
Pb207	$\sigma_{\text{inel}}$	1.35 ÷ 0.498 MeV	11	3
Si28	 $\sigma_{\text{inel}}$	6.07 ÷ 1.35 MeV	14 ÷ 50	3 ÷ 6
	$\sigma_{\text{capt}}$	19.6 ÷ 6.07 MeV	53	6

- Items addressed by ANDES WP1 are marked

Besides these needs from the work of Subgroup 26 of the OECD-NEA there is work on needs that were established by IP-EUROTRANS and CANDIDE and by Subgroup 25 “Assessment of fission product decay data for decay heat calculations”

This WP1 is inline with recommendations in the Strategic Research Agenda for improving basic nuclear data to improve modelling and simulation of advanced reactor systems

# Uncertainty propagation from nuclear data to reactors

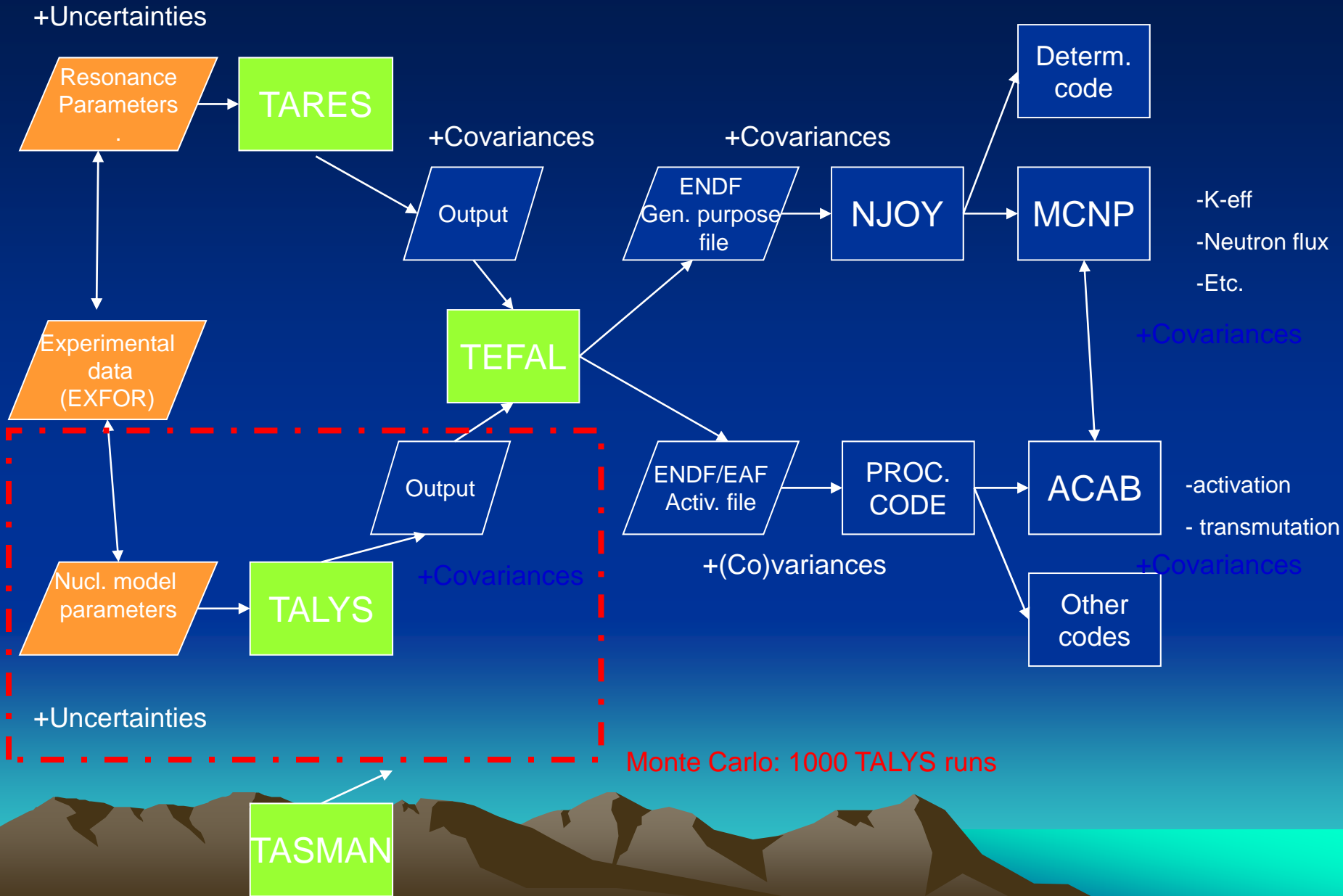


# ANDES WP2 Activities

- Non-fission nuclear data library + covariance production relatively well under control.
- Actinide data by far most important in any fission application, hence.....
- Improve methods for actinide evaluation:
- URR + fast neutron range: develop consistent fission model + parameters that can be applied on all actinides.
- Integrate theoretical and experimental covariance data for actinides into consistent data library.
- Implement Unified Monte Carlo or similar approach to produce credible covariance data.
- Results: new, consistent covariance data for one major and one minor (Am-241) actinide, release of new TALYS code.



# Nuclear data scheme + covariances



# ANDES WP2 Activities

- More reliable covariance data for fuel cycle calculations:
- Produce ENDF/EAF data libraries for activation calculations
- Apply in activation software such as ACAB
- Assess whether Total Monte Carlo is possible
- Covariance data for spent fuel inventories and decay heat:
- Initial studies on how to generate and use covariances for radioactive decay data and fission yield data.
- Generate some initial (crude) covariance data to test methodology.
- Apply these initial data to inventory calculations, in particular to decay heat. The associated software (FISPIN,DARWIN,ACAB) needs to be extended.



# WP3: Integral experiments for validation and constraints of nuclear data



## Objectives:

- Agree on a **common methodology to use the integral experiments** to validate and constraints the nuclear data improvement.
- Define and **share these methodology** between the participants,
- Apply it to different kind of integral experiments mainly of public domain
- At the end of the project at least an **estimation of the impact of the new evaluations** of covariance **provide in WP2** to the knowledge of the neutronic behaviors measured in the integral experiments that have been analyzed.
- Provide to end users improved uncertainties on neutronic behaviors due to Nuclear Data

## Participants

CEA/CAD (F), NRG (NL), JSI (SL), CNRS (F), CIEMAT (E), SCK-CEN (B)

## Activities of this WP :

Integral experiment analysis  
Validation of nuclear data

**Coordinator:** CEA/CAD.

**Duration:** 36 months

# WP3: Integral experiments for validation and constraints of nuclear data

TASKS : **Scientific** coordination by CEA Cadarache



**Task 3.2:** Definition a common validation process for the ND based on integral experiments analysis (to be used in the task 3.3)

A meeting will be organized with all the WP3 participants to define this common process in the first 3 months of the project to be able to begin with the analysis of the experiments in Task 3.3



**Deliverable 3.1:** Report on definition of the generic strategy for verification/validation benchmark

# WP3: Integral experiments for validation and constraints of nuclear data

TASKS : **Scientific** coordination by CEA Cadarache



## Task 3.3 : Analysis with the previous defined process of Integral Experiments (1/2)

### SubTask 3.3.1: MUSE Ref Core characterization (CEA +CIEMAT)

- This experiment is available via the MUSE project of **FP5 of EURATOM**
- **Neutronic behaviors** : Keff, Spectral indices, reaction rates of Na cooled Fast reactor with **steel reflector**.

### SubTask 3.3.2: ZPPR10A experiment proposed in IRPHE data base of NEA data Bank (JSI + CEA)

- This experiment is available **IRPHE of the NEA data bank**
- **Neutronic behaviors** : Keff, Spectral indices, and **sodium void effects**.

### SubTask 3.3.3: PROFIL experiments made in PHENIX on separate isotopes irradiation (CEA, CNRS, CIEMAT)

- This experiment is available **via CEA** (it is part of the work the CEA will do in this task)
- **Neutronic behaviors** : separated irradiated samples of different isotopes : **Actinides and Minor Actinides** : Post irradiated chemical analysis of the samples; information on Capture cross sections.

# WP3: Integral experiments for validation and constraints of nuclear data



TASKS : **Scientific** coordination by CEA Cadarache

## Task 3.3 : Analysis with the previous defined process of Integral Experiments (2/2)

**SubTask 3.3.4:** A large criticality and shielding benchmark used for validation of JEFF-3.1 from ICSBEP (NRG, SCK-CEN, CEA)

- These experiments are available via **ISCBEP data bank**
- **Neutronic behaviors** : Keff, Spectral indices

**SubTask 3.3.5:** A problem based on data GUINEVERE VENUS-F experimental facilities at SCK-CEN laboratories (SCK-CEN, CIEMAT)

- These experiments are available via project **EUROTRANS of EURATOM**
- **Neutronic behaviors** : Keff, Spectral indices, ... of a **lead cooled uranium core**.



- |                         |   |
|-------------------------|---|
| <u>Deliverable 3.2:</u> | Report on analysis of MUSE experiment and C/E + sensitivity vectors       |
| <u>Deliverable 3.3:</u> | Report on analysis of the ZPR experiment and C/E + sensitivity vectors    |
| <u>Deliverable 3.4:</u> | Report on analysis of the PROFIL experiment and C/E + sensitivity vectors |
| <u>Deliverable 3.5:</u> | Report on criticality benchmark experiment and C/E + sensitivity vectors  |
| <u>Deliverable 3.6:</u> | Report on GUINEVERE experimental data and C/E + sensitivity vectors       |

# WP3: Integral experiments for validation and constraints of nuclear data



TASKS : **Scientific** coordination by CEA Cadarache

Task 3.4 : **Determination of the nuclear data trends and analysis of the impact of the new evaluations on the uncertainties on the neutronics behaviour on the integral experiments used in Task 3\_(Participant: ALL)**

**SubTask 3.4.1:** **Provide Trends on ND using the C/E and S** of Task 3.3, Covariance matrices on ND (first use the existing one: BOLNA) and provide a recommendation on Nuclear Data validity

**SubTask 3.4.2:** **Analyze the impact of the new evaluations** with Covariance coming **from WP2** and estimate the impact on the C/E and uncertainties of the experiments used in Task 3.3.



Deliverable 3.7: Report on the analysis of constraints on nuclear data and resulting trends with respect to the use the C/E and Sensitivity data coming from the integral experiments

Deliverable 3.8: Report on the analysis of the impact of the new evaluations with Covariance coming from WP2 and estimate the impact on the C/E and uncertainties of the integral experiments

# WP4 - High energy model validation in the 150-600 MeV domain



## ADS as an option to reduce minor actinides amounts in dedicated systems

↪ ADS demonstrator: MYRRHA : 600 MeV - 2.5 mA or 350 MeV - 5 mA proton beam onto a liquid Pb-Bi spallation target

↪ **Necessity of reliable and validated simulation tools**

### General objectives:

- To identify remaining deficiencies of the nuclear models used in high-energy transport codes between 150 and 600 MeV
- **to use/do a few specific experiments to solve the identified problems**
- to further improve the models, with emphasis on improvements having an impact on key parameters of ADS (defined with end-users)
- **to do a few specific integral validation experiments**
- **to assess the uncertainty with which quantities related to high-energy reactions can be predicted**

# WP4 – List of Tasks

- **Task 4.1:** State-of-the-art of high-energy model predicting capability in the 150-600 MeV domain (**CEA/DSM, ULG, GSI, USC**)
- **Task 4.2:** SPALADIN p+Pb at 500 MeV : measurement of the fission fragments and light evaporation residues in coincidence with light ions (**USC, CEA/DSM, GSI**)
- **Task 4.3:** Measurement of neutron-induced light ion cross-sections at 175 MeV on Fe, Bi and U (**UU, CNRS/Caen**)
- **Task 4.4:** Improving of the predicting capabilities of the simulation tools in the 150-600 MeV in order to reduce the uncertainties on key parameters of the demonstration facility spallation target (**ULG, CEA/DSM, GSI, CEA/DAM, NRG**)
  - ↳ Sub-task 4.4.1: Improving the high-energy models
  - ↳ Sub-task 4.4.2: High-Energy Evaluated Nuclear Data Files generated from the TALYS+BRIC reaction code as an alternative to models
- **Task 4.5:** Validation on the results from the post irradiation analysis of MEGAPIE samples (**PSI, CEA/DSM**)

# WP4 – Final expected achievements



## High-energy simulation tools

- **specifically improved in the 150-600 MeV domain for the design of an ADS demonstration facility (MYRRHA)**
- **validated on appropriate elementary and integral data**
- **whose remaining deficiencies are sufficiently small to only affect marginally the calculations of the key parameters of MYRRHA**

# Conclusion

- ANDES is a promising new initiative in which the main EU nuclear data developers participate
- Coordination with other regions should be stimulated eg through
- SG-31, 33.
- European Metrology community: EMPR METROFISSION ?

