NFRP 2018 - SANDA
SUPPLYING ACCURATE NUCLEAR DATA FOR ENERGY AND NON-ENERGY APPLICATIONS
2019-2023

WORKPACKAGE 1 –
Developments of new innovative detector devices

Maëlle Kerveno, CNRS/IPHC, Strasbourg (France)

Kick-off meeting, Brussels, 9-10 September 2019
OUTLINE

- WP description
- WP structure and partners
- WP commitments, milestones and deliverables
- WP efforts
OUTLINE

WP description

WP structure and partners

WP commitments, milestones and deliverables

WP efforts
WP 1 in SANDA: Developments of new innovative detector devices

Support the development of new measurement devices which allow high precision measurements for Energy and N.E. applications

- for an immediate use in the frame of WP2 (~1/3 of tasks)
- for more long term experiments which need more R&D
WP 1 Physics case

Better experimental knowledge of neutron induced reactions
Especially on actinides (Energy appl.) or for Non-Energy applications

Fission cross section
Fission products and their decay

(n,γ) cross section

Neutron spectrum (n,xn) reaction XS

(n,lcp) double differential cross section (N-E applications)
WP 1 Physics case

Better experimental knowledge of neutron induced reactions
Especially on actinides (Energy appl.) or for Non-Energy applications

Experimental challenges

For new evaluations
- new measurements with reduced uncertainties (even on already studied isotopes)
- new experiments more discriminating and binding for theoretical models

Actinide samples
- low mass samples: very efficient detector devices needed
- high resolution for particle discrimination

New facilities
- n_TOF EAR2, SPIRAL2/NFS

Instrumental work is needed!
OUTLINE

WP description

WP structure and partners

WP commitments, milestones and deliverables

WP efforts
WP 1 Structure

Fission cross section
Fission products and their decay

Fission

Capture

Neutron emission

(n,γ) cross section

Lcp production

Neutron spectrum (n,xn) react. XS

(n,lcp) double differential cross section (N-E application)
WP 1 Structure and tasks

**TASK 1**

Innovative devices from fission cross section to Fission products decay
Leader: CEA/DRF/IRFU - Frank Gunsing

**SUBTASK 1.1.1** new devices for fission cross section measurements
- development of a **micromegas Time Projection Chamber**
  Partner: CEA/DRF/IRFU; project leader: F. Gunsing; collab. TUW, JRC-Geel
- development of a **new Gaseous Proton Recoil Telescope**
  Partner: CNRS/CENBG; project leader: L. Mathieu; collab. CEA/DEN, CEA/DRF/IRFU, JRC-Geel

**SUBTASK 1.1.2** new devices for fission products studies
- development of a **new large gas cell** with electric field guidance for IGISOL
  Partner: JYU; project leader: H. Penttilä; collab. UU
- coupling of **FALSTAFF with FIPPS @ ILL**
  Partner: CEA/DRF/IRFU; project leader: D. Doré; collab. GANIL, ILL
- build a **new version of BELEN**
  Partner: UPC; project leader: F. Calvino; collab. IFIC
- **new measurement facility** dedicated to the **measurement of half-lives**
  Partner: CEA/LNE-LNHB; project leader: M. Kellet; collab. CNRS/SUBATECH, IFIC

Measurements planned in WP2
WP 1 Structure and tasks

TASK 2  Innovative devices for neutron emission studies
Leader: CERN – Massimo Barbagallo

SUBTASK 1.2.1  Build of a compact fast neutron spectrometer
Partner: CEA/DEN/CAD; project leader: R. Jacqmin; collab. -

SUBTASK 1.2.2  Development of Germanium detectors for (n,xn) measurements at n-TOF
Partner: CERN; project leader: M. Barbagallo; collab. UMANCH., NTUA, UOI., IFIN-HH

SUBTASK 1.2.3  Development of the SCONE detector
Partner: CEA/DAM; project leader: G. Belier; collab. -
WP 1 Structure and tasks

**TASK 3**

Innovative devices for capture cross section measurement on actinides
Leader: CIEMAT - Emilio Mendoza

- Development of **CLYC detector for \((n,\gamma)\) XS measurements** \(@\text{EAR2 n\_TOF}\)
  Partner: CIEMAT; project leader: E. Mendoza; collab. USE
- Extend the **i-TED technique** for measurement on **actinides** \(@\text{EAR2 n\_TOF}\)
  Partner: UPC; project leader: F. Calvino; collab. - IFIC
WP 1 Structure and tasks

**TASK 4**

**Detectors for non-energy application**

Leader: PTB – Ralf Nolte

- **Doub. Diff. XS (n,lcp) measurements @ n_TOF from 20 to 200 MeV**
  Partner: HZDR; project leader: A. Junghans; collab. PTB
- **Doub. Diff. XS (n,lcp) measurements @ n_TOF from 20 to 200 MeV**
  Partner: PTB; project leader: R. Nolte; collab. HZDR

**Measurement planned in WP2**
WP structure and partners

**Summary**

- **8 partners** (CEA, CERN, CIEMAT, CNRS, HZDR, JYU, PTB, UPC)
- **WP 1**
  - 80.8 pm, 476 k€
  - 4 tasks

**TASK 1** 2 subtasks, 4 partners (CEA, JYU, CNRS, UPC)

**TASK 2** 3 subtasks, 2 partners (CEA, CERN)

**TASK 3** 0 subtask, 2 partners (CIEMAT, UPC)

**TASK 4** 0 subtask, 2 partners (PTB, HZDR)
OUTLINE

- WP description
- WP structure and partners
- WP commitments, milestones and deliverables
- WP efforts
Deliverable 1.1 (CNRS)
“Report on the study and construction of new devices for precise fission cross section measurements”

Development of a micromegas Time Projection Chamber for cross section measurements

Taken advantage of the expertise of CEA/IRFU on the development and use of the MicroMegas detector technology for precise \( (n,f) \) XS measurements

**COMMITMENTS :**
Use of micromegas as “Transparent” XY beam detector exploiting strip timing (TPC mode) to measure angular distributions of \( (n,f) \) and \( (n,lcp) \) cross sections

**Program :**
- Detailed simulations of detector geometry, particle's interactions and trajectories ✴
- Simulation of a physics case
- Preliminary detector design including field degrader
- Contribution for report subtask 1.1.1
**WP commitments, milestones and deliverables**

---

**Deliverable 1.1 (CNRS)**

“Report on the study and construction of new devices for precise fission cross section measurements”

---

**Development of a new Gaseous Proton Recoil Telescope (GRPT)**

Taken advantage of the work already performed in CHANDA in view of the measurement of the quasi-absolute fission cross section measurement of $^{242}\text{Pu}(n,f)$ relative to $\text{H}(n,p)$ scattering between 200 keV and 2 MeV

**COMMITMENTS:**

Completion of the GRPT (in view of measurement with 5% accuracy below 1 MeV)

---

**Program:**

- End of the construction of the GRPT 2021
- Commissioning 2021-2022
- Ready for measurement 2022-2023

---

**GRPT prototype**
Deliverable 1.2 (JYU)  
"Report on the design of the large gas cell for IGISOL"

**development of a new large gas cell with electric field guidance for IGISOL**

Taken advantage of the work already performed in CHANDA for the development of a proton to neutron converter at IGISOL for **neutron fission induced studies**

**COMMITMENTS:**
Study of a new stopping gas cell with better ions stopping efficiency and faster transport. (expected overall improvement of efficiency of the order of 100)

**Program:**
- Study, comparison of all the possible technical solutions for gas filled stopping cells with electric field guidance.
- Simulations of the performances (fission product stopping, ion survival) and optimization of cell dimensions, electrode structure and voltage in the IGISOL environment. 🌟
- Technical drawing of the new gas cell
Deliverable 1.3 (CEA)
"Report on the performances of new devices for precise study of fission products and their decay in view of measurements"

◆ coupling of FALSTAFF with FIPPS @ ILL

Taken advantage of the work already performed in CHANDA for the building of the new device FALSTAFF for actinide fission fragments studies

COMMITMENTS:
Prepare a new setup by coupling FALSTAFF and FIPPS @ ILL to provide new nuclear data for fission modeling improvements (fission and deexcitation models, prompt γ-ray spectra with FF A & M, FF angular momentum)

Program:
- Simulations of the coupling of FALSTAFF (fragment kinetic energy and fragment mass after evaporation) and FIPPS (γ-ray cascades from FF)
- Evaluation of performances in view of the measurement at ILL

WP2

First arm of FALSTAFF Energy and TOF detectors

WP commitments, milestones and deliverables
WP commitments, milestones and deliverables

Deliverable 1.3 (CEA)  
"Report on the performances of new devices for precise study of fission products and their decay in view of measurements"

- build a new version of BELEN

Taken advantage of the development performed in CHANDA of the versatile neutron detector BELEN dedicated to beta delayed neutron studies

**COMMITMENTS:**
Optimize the BELEN detector to obtain a device with very high efficiency capability for Pn and low resolution energy spectra measurements

**Program:**
- MCNP or GEANT4 simulations of the BELEN matrix responses
- Production of new unfolding codes for Bonner Spheres systems ✜
- Design an optimized geometry for effective rings
- Evaluation of performances in view of the measurement at IGISOL

WP2

WP commitments, milestones and deliverables

Deliverable 1.3 (CEA)
"Report on the performances of new devices for precise study of fission products and their decay in view of measurements"

◆ New measurement facility dedicated to the measurement of half-lives

Taken advantage of the expertise of the CEA/LNE-LNHB group in decay data evaluation and metrology activities

COMMITMENTS:
Prepare and commission a new measurement facility dedicated to the measurement of half-lives for a range of radionuclides.

Program:
- Developing an automated sample changer for use with an ionization chamber
- Creating the necessary command modules in the LabView environment ✰
- Commissioning of the device in view of measurement in WP2
Deliverable 1.4 (CEA)
“Report on the commissioning of a compact broad-band fast neutron spectrometer”

 развития of a compact broad-band fast neutron spectrometer
Provide a neutron spectrometer useable in many applications

COMMITMENTS:
Construction of a compact broad-band fast neutron (10 keV – 10 MeV) spectrometer based on a solid organic scintillator (stilbene detector) with its associated electronics

Program:
- Improvement of the PSD procedure
- Study of the anisotropy at very low neutron energy (< 100 keV)
- Calculation of the response matrix
- Tests and commissioning at neutron facility (AMANDE, PTB, ...)

From Augusto Di Chicco, proceedings of ANIMMA 2019 conference
WP commitments, milestones and deliverables

Deliverable 1.5 (CEA)
“Report on the performance of the SCONE setup at NFS”

- Development of the SCONE setup for \( (n,xn) \) reaction studies at NFS

Taken advantage of the expertise of CEA/DAM for \( (n,xn) \) reactions experimental studies with a new high efficiency detector

**COMMITMENTS:**
Development of a **new neutron counter based on plastic scintillator** bars wrapped with Gd loaded material (SCONE) for measurements at **NFS facility**

**Program:**
- Final assembly of SCONE (~900 EJ200 plastic scintillator bars)
- Installation at NFS
- Commissioning of the setup
Deliverable 1.6 (CERN)

“Report on the performance of the HPGe equipped with newly developed electronics”

- Development of Germanium detectors for \((n,xn)\) measurements at n-TOF

Taken advantage of the high flux of the CERN/n_TOF facility to study fast neutron reactions

**COMMITMENTS:**

Development of a new 4 HPGE setup with newly developed electronics to overcome the huge \(\gamma\)-flash preceding the neutron beam

**Program:**

- Efficiency and energy resolution characterization of standards and prototype detector (with “isolated” preamp) by GEANT 4 simulations
- Develop and benchmark the PSA code
- Determination of the better choice for the Ge crystal (GEANT 4, FLUKA simulations) and RC or TRP preamps
- Tests of the setup at CERN/n_TOF
Deliverable 1.7 (CIEMAT)

“Report on the development and performances of the new detectors for capture cross section measurements at n-TOF”

- development of s-TED detector for \((n,\gamma)\) XS measurements @ EAR2 n_TOF

Taken advantage of the CIEMAT experience with scintillators (organic and inorganic) acquired in the CHANDA project for \((n,\gamma)\) measurement at n_TOF EAR2

**COMMITMENTS:**

Design and test a total energy detector prototype based on segmented CLYC inorganic scintillator adapted to the very demanding characteristics (high counting rates) of the n_TOF EAR2 experimental area and for meas. with actinide samples

**Program:**

- Characterization of a CLYC prototype detector (source meas. vs MC simulations)
- Test experiment at CIEMAT & CNA (tof) in Seville for neutron detection efficiency determination
- Optimization of the design (crystal size, PMT...)
- Test measurements at CERN on Au sample
**Deliverable 1.7 (CIEMAT)**

“Report on the development and performances of the new detectors for capture cross section measurements at n-TOF”

- extend the i-TED technique for measurement on actinides @ EAR2 n_TOF

Taken advantage of the work performed on **i-TED technique for (n,γ) cross section meas.** in astrophysics field

**COMMITMENTS:**
Developed an i-TED (imaging total energy detector) for radiative capture measurement with highly radioactive sample at EAR2 n_TOF

**proposed i-TED setup**

From C. domingo-Prado, NIMA825 (2016) 78

**Program:**
- Preparation and commissioning of i-TED at EAR2 n_TOF
- Experimental benchmark at EAR2 n_TOF
- Recommendation on actinides of the NEA HPRL that can be studied with i-TED
WP commitments, milestones and deliverables

Deliverable 1.8 (PTB)
“Report on the development and performances of the new detectors for non-energy applications”

- Double Diff. XS $(n, lcp)$ measurement @ EAR1 n_TOF from 20 to 200 MeV

Taken advantage of the demonstration that the neutron-induced emission of light charged particles can be done up to 200 MeV at EAR1 n_TOF ($^{235}$U(n,f)/$^1$H(n,n) exp.)

**COMMITMENTS:**
Development of a scattering chamber and detector telescopes for H and He ions detection useable at EAR1 n_TOF (good resol., low thresholds, high max. neut. Energy)

**Program:**
- ΔE & E detectors and PreAmps developments
- Design and construction of a compact vacuum chamber
- Test measurements with prototype det. and electronics (beam facilities HZDR and PTB), final test at a spallation source

WP2
Summary: SANDA-WP1 Gantt chart

WP commitments, milestones and deliverables

Kick-off meeting, 9-10/09/2019 - Brussels, Belgium
Maëlle Kerveno
OUTLINE

WP description

WP structure and partners

WP commitments, milestones and deliverables

WP efforts
## WP efforts

### Partners

<table>
<thead>
<tr>
<th>partners</th>
<th>budget</th>
<th>pm</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEA</td>
<td>195 000 €</td>
<td>36.1</td>
</tr>
<tr>
<td>CNRS</td>
<td>32 000 €</td>
<td>4.5</td>
</tr>
<tr>
<td>CERN</td>
<td>55 000 €</td>
<td>1.2</td>
</tr>
<tr>
<td>CIEMAT</td>
<td>60 000 €</td>
<td>13.3</td>
</tr>
<tr>
<td>UPC</td>
<td>35 000 €</td>
<td>6.5</td>
</tr>
<tr>
<td>JYU</td>
<td>50 000 €</td>
<td>9</td>
</tr>
<tr>
<td>PTB</td>
<td>23 000 €</td>
<td>5.7</td>
</tr>
<tr>
<td>HZDR</td>
<td>26 000 €</td>
<td>4.5</td>
</tr>
<tr>
<td>TOTAL</td>
<td>476 000 €</td>
<td>80.8</td>
</tr>
</tbody>
</table>

### Deliverables

<table>
<thead>
<tr>
<th>D.1.1</th>
<th>D.1.2</th>
<th>D.1.3</th>
<th>D.1.4</th>
<th>D.1.5</th>
<th>D.1.6</th>
<th>D.1.7</th>
<th>D.1.8</th>
</tr>
</thead>
<tbody>
<tr>
<td>14.6 pm</td>
<td>9 pm</td>
<td>16.1 m</td>
<td>5 pm</td>
<td>1.2 pm</td>
<td>9 pm</td>
<td>15.8 pm</td>
<td>10.2 pm</td>
</tr>
</tbody>
</table>
### WP1 Work document

**Task 1.1: innovative devices from fusion cross section to fission products decay**

<table>
<thead>
<tr>
<th>Subtask</th>
<th>Description</th>
<th>Deliverables</th>
<th>Milestones</th>
<th>Deliverables &amp; responsible</th>
<th>Milestones &amp; responsible</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1.1</td>
<td>Report on the design and construction of a large gas transmission pipe</td>
<td>M34</td>
<td>CEA</td>
<td>M24</td>
<td>CEA/BRU/</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>M24</td>
<td>CEA/</td>
</tr>
</tbody>
</table>

**Task 1.2: innovative devices for neutron emission studies**

<table>
<thead>
<tr>
<th>Subtask</th>
<th>Description</th>
<th>Deliverables</th>
<th>Milestones</th>
<th>Deliverables &amp; responsible</th>
<th>Milestones &amp; responsible</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2.1</td>
<td>Report on the performance of the new detector developed for the GDR experiment</td>
<td>M35</td>
<td>CEA</td>
<td>M24</td>
<td>CEA/</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>M24</td>
<td>CEA/</td>
</tr>
</tbody>
</table>

**Task 1.3: innovative devices for capture cross section measurement on activities**

<table>
<thead>
<tr>
<th>Subtask</th>
<th>Description</th>
<th>Deliverables</th>
<th>Milestones</th>
<th>Deliverables &amp; responsible</th>
<th>Milestones &amp; responsible</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.3.1</td>
<td>Report on the performance of the new detector developed for the GDR experiment</td>
<td>M35</td>
<td>CEA</td>
<td>M24</td>
<td>CEA/</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>M24</td>
<td>CEA/</td>
</tr>
</tbody>
</table>

**Task 1.4: detectors for non-energy application**

<table>
<thead>
<tr>
<th>Subtask</th>
<th>Description</th>
<th>Deliverables</th>
<th>Milestones</th>
<th>Deliverables &amp; responsible</th>
<th>Milestones &amp; responsible</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.4.1</td>
<td>Report on the performance of the new detector developed for the GDR experiment</td>
<td>M35</td>
<td>CEA</td>
<td>M24</td>
<td>CEA/</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>M24</td>
<td>CEA/</td>
</tr>
</tbody>
</table>

**Task 1.5: detectors for non-energy application**

<table>
<thead>
<tr>
<th>Subtask</th>
<th>Description</th>
<th>Deliverables</th>
<th>Milestones</th>
<th>Deliverables &amp; responsible</th>
<th>Milestones &amp; responsible</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5.1</td>
<td>Report on the performance of the new detector developed for the GDR experiment</td>
<td>M35</td>
<td>CEA</td>
<td>M24</td>
<td>CEA/</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>M24</td>
<td>CEA/</td>
</tr>
</tbody>
</table>

---

**Hoping**

- a fruitful collaboration,
- Efficient cooperation for reporting,
- AND
- Nice and significant results !!!

Thank you for your attention...

---

Kick-off meeting, 9-10/09/2019 - Brussels, Belgium

Maëlle Kerveno