

Final Technical Report

NUDAME

Neutron Data Measurements at IRMM

Transnational Access implemented as Specific Support Action

EURATOM

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A. ACTIVITY REPORT

1. Final report

1.1. SUMMARY OF THE ACTIVITIES AND MAJOR ACHIEVEMENTS

The NUDAME project promoted the trans-national access to the EC-JRC-IRMM accelerator facilities in order to endorse the neutron data requirements in the field of the management of radioactive waste or other fields of nuclear technologies and safety. It was the objective to offer within 3 years a total of 3000 supplementary data-taking hours to new external users.

The NUDAME project started officially on April 1, 2005 and ended on March 31, 2008. In line with the 'Description of Work' we

- composed a Programme Advisory Committee (PAC) with external high-level experts in the field. One of the external experts of the PAC is closely related with the NEA data bank. The two other members are high-level experts working in the relevant research fields in well-known international institutions.
- created the necessary means to promote access to our infrastructures.
- launched one Call for proposals per year.
- organised peer-reviewed selection of the best experiments.
- generated the necessary neutron beam-time for all approved experiments.
- optimised follow-up of all administrative matters related to the project.
- assessed user satisfaction.
- organised a general user meeting towards the end of the project.

The Calls for proposals proved to be successful with a high quality of research proposals and a large proportion of new users that were attracted. In total, 22 experiments were proposed. The majority of the proposals were guided by the high priority request list (HPRL) edited by the Working Party of Evaluation Co-operation (WPEC) of the OECD/NEA Nuclear Science Committee. The total requested beam time was 7456 hours, exceeding about 2.5 times the beam time which could be provided. As a result, out of 22 proposals 18 experiments have been approved, but with a drastically reduced beam time. 99 users participated in the experiments, 35 were supported by NUDAME, and the other users got financial support from their home institute. The institutes were (in alphabetical order): CEA Cadarache (F), CEA Saclay (F), CENBG Bordeaux (F), CEN Saclay (F), CTH Göteborg (S), Debrecen University (H), HAS-ATOMKI (H), IAEA Vienna (A), INFN Bari (I), IKK Vienne (A), INFN Bologna (I), INFN Frascati (I), IPN Orsay (F), IPHC / IRES Strasbourg (F), LPSC Grenoble (F), Örebro University (S), SCK/CEN Mol (B), TU Vienna (A), University of Barcelona (E), University of Perugia (I), University of Wien (A), WTC (GB). 90% of the supported users were first-time users. For the 18 experiments a total of 3289 beam hours was delivered. This was 44% of the beam time requested by the external users and almost 10% more than was foreseen in the Description of Work.

The project proceeded with no major deviations from the work programme. All 18 approved experiments were accomplished within the time span of the project, in line with the anticipated schedule. Many administrative procedures have been adapted and improved during the project (e.g.,

user access to the controlled areas, user access to the internet, etc.). Users had the opportunity to express their feedback via user questionnaires. Feedback was in general positive. Complaints were received about the time delays in the reimbursement procedure. Minor remarks on informatics support were tackled and solved.

A general user meeting was organised on February 21-22, 2008. The meeting was intended to finalise and close the NUDAME project. The external users that were supported by the project gathered to present results, to discuss open issues and to foster future collaborations. There were 43 subscribed participants. During the meeting there were 2 invited presentations and 15 scientific contributions from the experiments.

Inspired by the success of NUDAME, an Integrated Infrastructure Initiative has been launched in 2006 by the experimental nuclear data community. The I3 Project “European Facilities for Nuclear Data Measurements” (acronym: EFNUDAT) creates a consortium of European experimental facilities for nuclear data measurements. The consortium groups 10 partner institutes equipped with nuclear data research infrastructures. The Centre d’Etudes Nucléaires de Bordeaux-Gradignan (CENBG, France) is the coordinator. IRMM is actively involved in the EFNUDAT consortium, e.g. with two (out of six) members of the Management Board (Scientific Coordinator and Transnational Access Coordinator). Despite the fact that JRC-IRMM is a member of the EFNUDAT consortium but does not participate in the Trans-national Access Activities, in order to avoid the risk of double-financing with NUDAME. Based on the large experience gathered within NUDAME, IRMM was asked to coordinate the Trans-national Access Activities of EFNUDAT.

The NUDAME PAC made an assessment of the overall interest generated by the NUDAME project. This assessment revealed that the NUDAME project was indeed very successful. There was consensus in the PAC that the good response from the neutron data community to the NUDAME calls is a clear indication for the usefulness of such a programme. The PAC encouraged IRMM to propose a continuation and extension of NUDAME in the Euratom-FP7 programme. In view of the success of NUDAME and the positive appreciation by our own researchers and by the members of the PAC, we submitted to EURATOM a new proposal for a Trans-national Access project, entitled: “European facility for innovative reactor and transmutation neutron data” (acronym: EUFRAT). During the evaluation process the EUFRAT proposal was very well appreciated by the external referees. In their evaluation they highlighted the scientific value of the IRMM accelerators for the neutron data research community. The project is now in the status of the contract negotiations with RTD-EURATOM. Compared to NUDAME we enlarged substantially the scale of the new project. It is the objective of EUFRAT to offer for the next four years a total of 4500 hours of data-taking hours for external users. 3600 hours will be made available at the GELINA facility and 900 hours at the Van de Graaff accelerator. This number of additional beam hours corresponds to 27 'typical experiments' for external users at the IRMM facilities.

The major NUDAME activities will be discussed more in detail in the following paragraphs.

1.2. MANAGEMENT OVERVIEW

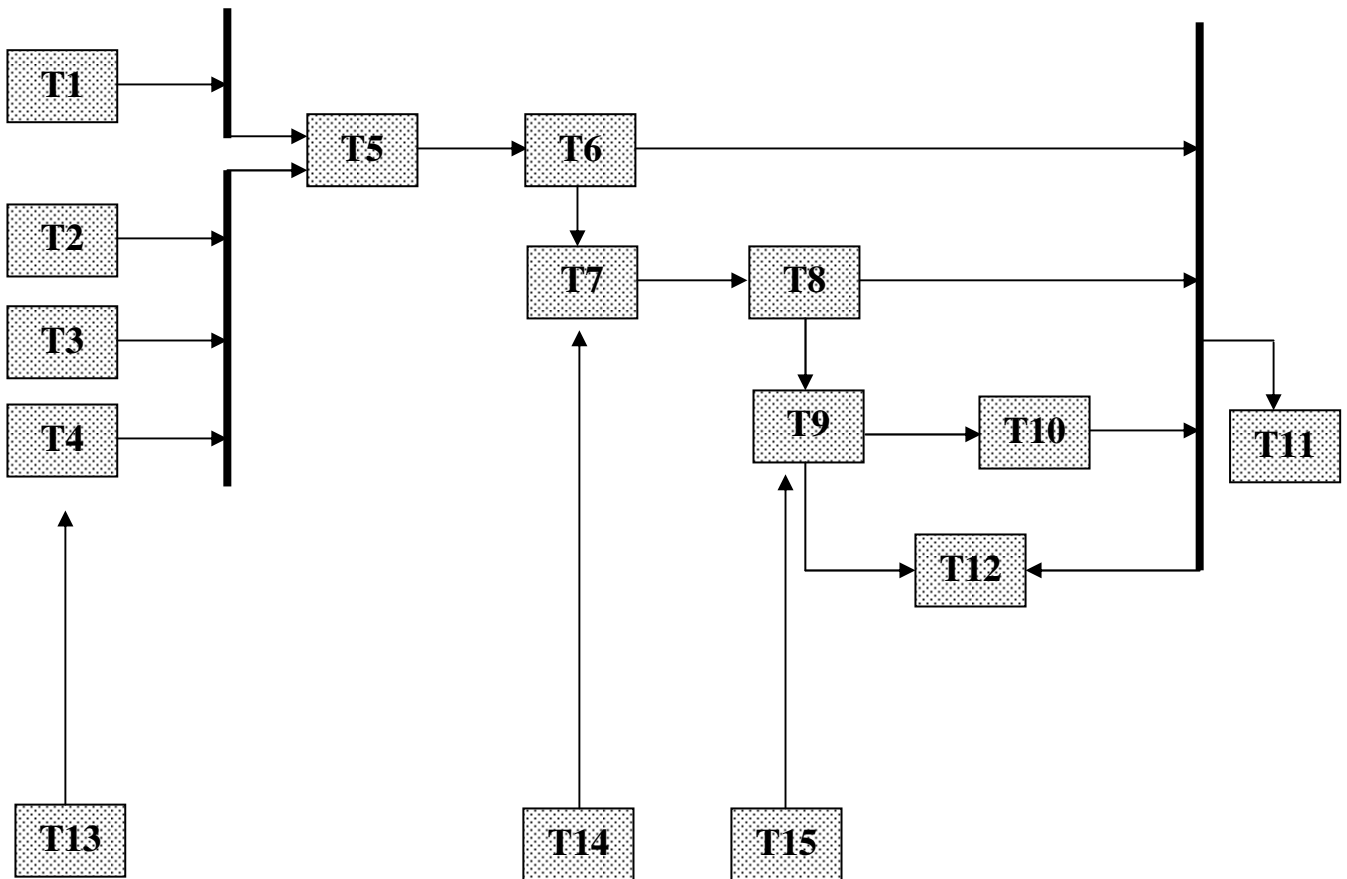
The table below lists the different work packages and the activities that were planned for the whole duration of the project. The tasks that have been finalised are indicated in bold. The graph shows the different activities with their interdependencies. The finished activities are dashed. As can be seen from the tables and graph, all planned tasks have been accomplished. It is clear that Task 11 (reporting and publications) is an ongoing task, beyond the duration of the project. It will evolve further in the future as the analysed results of the different experiments will be published.

<i>WP1</i>	<i>Call for proposals and their evaluation</i>	
	Objectives	<ul style="list-style-type: none"> - organise an efficient way of attracting high-quality research projects. - develop an effective method of publication of the 'Call for Proposals' that can address the maximum of potential users. - guarantee a transparent, impartial and effective selection of the proposals
	Description of activities	<p>T1 : Composition of the PAC T2 : Elaboration of a proposal template T3 : Development of a trans-national access web-site T4 : Organisation of first call of proposals T5 : First PAC meeting and approval of first series of experiments T7 : Second PAC meeting T9 : Third PAC meeting</p>

<i>WP2</i>	<i>Experimental sessions</i>	
	Objectives	- execution of the experiments approved by the PAC
	Description of activities	<p>T6 : First series of experiments T8 : Second series of experiments T10 : Third series of experiments</p>

<i>WP3</i>	<i>Dissemination of results</i>	
	Objectives	<ul style="list-style-type: none"> - optimal dissemination of the results obtained within the project - contribute at maximum to the visibility of the trans-national access programme.
	Description of activities	<p>T11 : Reporting and publications T12 : Organisation of user meeting</p>

<i>WPM</i>	<i>Project management</i>	
	Objectives	<ul style="list-style-type: none"> - detect possible deficiencies in the project realisation - define corrective actions to be implemented by the Local Steering Committee (LSC).
	Description of activities	<p>T13 : Kick-off meeting T14 : First annual review T15 : Second annual review</p>



In the following the different work packages are discussed more in detail.

1.2.1. WPM - Work package Management

Task 13 – Organisation of a Kick-off meeting

A Kick-off Meeting with all A-grades from the IRMM Neutron Physics Unit was organised in April 2005 to initiate the necessary steps needed to guarantee a smooth execution of the NUDAME project in accordance with the contract. The following items were elaborated:

- decision on the composition and the procedures of the Programme Advisory Committee (see Task 1)
- organisation of an efficient first call for proposals (see Task 4)
- development of the website and other forms of publicity (see Task 2 and Task 3)
- internal organisation of user access (role of local contact, involvement of administration, invitation and reimbursement procedures).

A meeting between representatives of the Neutron Physics and the Management Support Unit was organised on November 23, 2005 to streamline all administrative procedures for inviting and reimbursing participants to the NUDAME project (experimentalists and PAC members).

Task 14 – First annual review

See first annual report submitted to RTD.

Task 15 – Second annual review

See second annual report submitted to RTD.

1.2.2. WP1 – Call for proposals and their evaluation

Task 1 – Composition of the PAC

The Programme Advisory Committee (PAC) was composed of

(1) the chairman:

- Prof. dr. Peter Rullhusen, Unit Head, IRMM, Geel, Belgium

(2) three external independent international experts in the neutron research fields:

- Prof. dr. Tamas Belgya, Head of Department of Nuclear Research, Institute of Isotopes, Hungarian Academy of Sciences, Budapest, Hungary
- Prof. dr. Bernhard Haas, Directeur de Recherches, Centre National de la Recherche Scientifique/Institut National de Physique Nucléaire et de Physique des Particules, Centre d'Etudes Nucléaires de Bordeaux-Gradignan (CENBG), Bordeaux, France
- Dr. Arjan Koning, Department Fuel, Actinides and Isotopes at the Nuclear Research & Consultancy Group (NRG), Petten, The Netherlands

(3) the two action leaders of the IRMM Neutron Physics unit:

- Dr. Franz-Josef Hambsch, action Leader, IRMM, Geel, Belgium
- Dr. Arjan Plompen, action Leader, IRMM, Geel, Belgium

(4) the two responsables of the accelerator facilities, contributing to the PAC meetings as advisors:

- Dr. Goeran Loevestam, responsible Van de Graaff facility, IRMM, Geel, Belgium
- Prof. dr. ir. Wim Mondelaers, responsible GELINA facility, IRMM, Geel, Belgium

Task 2 – Elaboration of a proposal template

A template for the submission of the proposals was made up. Each proposal had to be composed of:

- an application form summarising the essential data of the proposal
- and a detailed description of the proposal (max. 3 pages) containing
 - the context and the goals of the measurements,
 - the contribution of the different researchers to the experiment,
 - the schedule of the work,
 - quantitative estimates of fluxes and beam times,
 - special support services that were needed,
 - a description of equipment that was needed or had to be imported.

Task 3 – Development of a transnational access web-site

On May 25, 2005 the NUDAME website was uploaded on the external IRMM website (<http://www.irmm.jrc.be/html/homepage.htm>) and became accessible for all potential external users. All proposals and the minutes of the PAC meetings were published on the web-site in a

zone with limited access. Only PAC members and group leaders of research groups that had submitted a proposal, had access to this password-protected information.

Task 4 – Organisation of the first call for proposals

The first meeting of the PAC was scheduled on July 5, 2005. In order to speed up the procedures, the first Call for Proposals was launched informally during month 1 of the project. To increase its efficiency the first Call was accompanied by an electronic mail action, addressing mainly researchers indicated by our own staff. In addition we contacted those research groups that had submitted an expression of interest for the NUDAME proposal. At the time of the official launch of the website and thus also of the Call, the A-grades of the NP-Unit were asked to draw the attention of a maximum of their research contacts to the new opportunities of access that were offered. To allow ‘late-comers’ to prepare their proposal, the deadline for submission was postponed until June 27, 2005.

Task 5 – First PAC meeting and approval of first series of experiments

The Programme Advisory Committee of NUDAME met for the first time on July 5, 2005. During this first PAC meeting proposals were evaluated for the period September 2005 – March 2006. The PAC discussed and agreed on the methods of project evaluation and on the funding scheme. During the first PAC meeting it became clear that additional information could be needed beyond what was available from the proposals. A possible solution could be a “defence” of the proposals by the spokesmen at the PAC meetings. However, in order to save budget in favour of support of experiments, it was decided that at the following PAC meetings the local contacts mentioned in the proposals had to be invited for giving more detailed explanations on the proposed experiments.

The PAC decided to adopt the following numbers to be used as guidelines in their decisions: a yearly average of 5 experiments of 2 weeks (200 h beam time), with support for 2 external scientists per experiment, a flat rate of 100 € / day for the daily allowance per external scientist and a contribution of up to 250 € for the travel costs per person. Concerning the duration of an experiment, some flexibility is possible but to allow a maximum of participants, taking into account the limited budget, priority is given to short experiments of 1-2 weeks and longer experiments will be approved only in exceptional cases, or they will be supported for a fraction of the beam time that is needed.

Five experimental proposals were submitted. The total requested beam time for PAC1 was 2726 hours, distributed as follows: GELINA 40 Hz (1300 hours), GELINA 800 Hz (1100 hours) and the Van de Graaff facility (326 hours).

Already at this first call for proposals there was a considerable overbooking and the PAC could allocate only 25% of the requested beam time, spread over four experiments. The evaluation resulted in the following conclusions:

- PAC 1/1:** High-resolution capture and transmission measurements of ^{nat}Hf (G. Noguère, CEA Cadarache) – two weeks of beam time at the GELINA facility
- PAC 1/2:** $^{243}\text{Am}(n,f)$ in the 0.7 – 10 MeV energy range (B. Jurado, CENBG) – two weeks of beam time at the Van de Graaff facility
- PAC 1/3:** Search for isomeric fission of ^{235}U (A. Oberstedt, Univ. Örebro) – not supported
- PAC 1/4:** Experimental validation of a multi-sphere spectrometric system used for radiation protection applications around high-energy electron accelerators and medical linacs (R. Bedogni, INFN) – one week of beam time at the Van de Graaff facility
- PAC 1/5:** Capture and Transmission on ^{nat}Cd (A. Trkov, IAEA) – two weeks of beam time at the GELINA facility.

Task 7 – Second PAC meeting and approval of second series of experiments

The second meeting of the PAC took place on February 3, 2006.

The PAC decided to:

- restrict support to a maximum of € 3500.- per experiment in view of the large number of applications and in order to maximise the number of projects that can be supported.
- reimburse also equipment transport costs, provided that the total transport costs are equivalent to the normal personal travel costs of two scientists.
- ask the group to provide a short report after completion of an experiment and to fill in an evaluation form.

The committee discussed also how to handle cases where approved experiments could not be carried out as planned because of failure of an accelerator. After consultation of the administration of IRMM it was decided that the highest priority would be given for achieving the planned experiment by allocating new beam time in the same or during the next period. Additional costs which may have occurred (e.g. because of late cancellation of flights) had to be reimbursed against proof.

Eleven experimental proposals were submitted. The total requested beam time for PAC2 was 2458 hours, distributed as follows: GELINA 40 Hz (1200 hours), GELINA 800 Hz (400 hours) and Van de Graaff facility (858 hours).

As a result of the evaluation the PAC accepted eight experiments. As for the first call, considerably more time was requested than could be allocated. The PAC could assign only 50% of the requested beam-time:

- PAC 2/1:** Transmission measurements on ^{241}Am (G. Noguère, CEA Cadarache) – not supported
- PAC 2/2:** Capture measurements on ^{241}Am (O. Bouland, CEA Cadarache) – not supported
- PAC 2/3:** Capture measurements on ^{242}Pu (G. Noguère, CEA Cadarache) – not supported
- PAC 2/4:** ^{233}U capture-to-fission ratio (B. Jurado, CENBG Bordeaux) – two weeks of beam time at GELINA
- PAC 2/5:** Test of data acquisition with C_6D_6 detectors using fast signal digitisers (G Tagliente, INFN Bari) – one week of beam time at GELINA.
- PAC 2/6:** $^{235}\text{U}(n,2n)$ (Ph. Dessagne, IReS Strasbourg) – one week of beam time at GELINA
- PAC 2/7:** Validation of ^3He counter and Bonner spheres (C. Domingo, Barcelona) – one week of beam time at the Van de Graaff accelerator.
- PAC 2/8:** $^{241}\text{Am}(n,2n)$ measurements (O. Bouland, CEA Cadarache) – two weeks of beam time at the Van de Graaff facility.
- PAC 2/9:** Leakage spectrum measurements on Pb and Bi (J. Csikai, Debrecen) – two weeks of beam time at the Van de Graaff facility.
- PAC 2/10:** Fission decay of shape isomer in ^{235}U (A. Oberstedt, Örebro) – two weeks of beam time at the Van de Graaff facility.
- PAC 2/11:** Short-lived activation cross-sections on $^{206,207}\text{Pb}$ (A. Pavlik, Vienna) – one week of beam time at the Van de Graaff facility.

Task 9 – Third PAC meeting and approval of third series of experiments

The third meeting of the PAC took place on January 25, 2007.

The PAC discussed the following subjects:

- overview of the project status.
- evaluation and selection of the new proposals as a result of the third Call.
- organisation of a user meeting at the end of the project.
- provisional overall assessment of the NUDAME project.

Six experimental proposals were submitted. The total requested beam time for PAC3 was 1720 hours, distributed as follows: GELINA 800 Hz (1400 hours) and Van de Graaff facility (320 hours).

As for the previous calls, considerably more time was requested than could be allocated. As a result of the positive evaluation of all six proposals the PAC accepted all experiments, but with a substantially reduced beam time. The PAC assigned only 60% of the requested beam-time:

PAC 3/1: Capture measurements on enriched Hf samples (C. Dean, Winfrith Technology Centre) – two weeks of beam time at GELINA.

PAC 3/2: $^{235}\text{U}(n,n'\gamma)$ and $^{235}\text{U}(n,2n\gamma)$ reaction cross sections (Ph. Dessagne, IReS Strasbourg) – two weeks of beam time at GELINA.

PAC 3/3: Accurate measurements of neutron cross sections of tungsten isotopes (S. Marrone, INFN Bari) – two weeks of beam time at GELINA, using two measurement stations simultaneously.

PAC 3/4: Population of the super-deformed ground state in ^{235}U – a feasibility test (A. Oberstedt, Örebro) – two weeks of beam time at GELINA.

PAC 3/5: Very short-lived activation cross sections from inelastic scattering on $^{206,207}\text{Pb}$ (A. Pavlik, Vienna) – two weeks of beam time at VdG.

PAC 3/6: testing and calibration of neutron dosimeters for radiation protection in the nuclear industry and space applications (F. Vanhavere, SCK Mol) – one week of beam time at VdG.

1.2.3. WP2 – Experimental sessions

Task 6– First series of experiments

Four experiments were approved during the first PAC meeting. They have been accomplished as follows:

- 21/01/06 – 28/01/06:
Experimental validation of a multi-sphere spectrometric system used for radiation protection applications around high-energy electron accelerators and medical linacs
Spokesperson: R. Bedogni, INFN Frascati
- 13/03/06 – 17/03/06 and 11/12/06 – 22/12/06:
High-resolution capture and transmission measurements of $^{\text{nat}}\text{Hf}$
Spokesperson: G. Noguère, CEA Cadarache
- 06/03/06 – 17/03/06:
Capture and Transmission on $^{\text{nat}}\text{Cd}$
Spokesperson: A. Trkov, IAEA Vienna
- 20/03/06 – 31/03/06:
 $^{243}\text{Am}(n,f)$ in the 0.7 – 10 MeV energy range
Spokesperson: B. Jurado, CENBG Bordeaux

More details of the individual experiments are given in 1.3.

Task 8– Second series of experiments

Eight experiments have been, approved during the second PAC meeting. They have been accomplished as follows:

- 11/09/06 – 22/09/06:
Fission decay of shape isomer in ^{235}U
Spokesperson: A. Oberstedt, Örebro University
- 09/10/06 – 15/10/06:
Short-lived activation cross-sections on $^{206,207}\text{Pb}$
Spokesperson: A. Pavlik, University of Vienna
- 23/10/06 – 27/10/06 and 11/12/06 – 15/12/06:
Test of data acquisition with C_6D_6 detectors using fast signal digitisers
Spokesperson: G Tagliente, INFN Bari
- 27/01/07 – 11/02/07:
Leakage spectrum measurements on Pb and Bi
Spokesperson: J. Csikai, Debrecen University
- 26/02/07 – 02/03/07 and 18/06/07 – 22/06/07:
 $^{241}\text{Am}(n,2n)$ measurements
Spokesperson: O. Bouland, CEA Cadarache
- 05/03/07 – 11/03/07:
Validation of ^3He counter and Bonner spheres
Spokesperson: C. Domingo, University of Barcelona
- 04/06/07 – 08/06/07:
 $^{235}\text{U}(n,2n)$
Spokesperson: Ph. Dessagne, IReS Strasbourg
- 20/02/08 – 04/03/08:
 ^{233}U capture-to-fission ratio
Spokesperson: B. Jurado, CENBG Bordeaux

More details of the individual experiments are given in 1.3.

Task 10– Third series of experiments

Six experiments have been, approved during the third PAC meeting. They have been accomplished as follows:

- Testing and calibration of neutron dosimeters for radiation protection in the nuclear industry and space applications
Spokesperson: F. Vanhavere, SCK, Mol
05/11/07 – 09/11/07
- Very short-lived activation cross-sections from inelastic scattering on $^{206,207}\text{Pb}$
Spokesperson: A. Pavlik, University of Vienna
12/11/07 – 23/11/07
- $^{235}\text{U}(n, n'\gamma)$ and $^{235}\text{U}(n,2n\gamma)$ reaction cross sections
Spokesperson: Ph. Dessagne, IReS Strasbourg
19/11/07 – 23/11/07 and 04/02/08 – 08/02/08
- Population of the superdeformed ground state in ^{235}U
Spokesperson: A. Oberstedt, Örebro University
21/01/08 – 08/02/08
- Accurate measurements of neutron cross sections of tungsten isotopes

Spokesperson: S. Marrone, INFN Bari
10/02/08 – 22/02/08

- Capture Measurements on enriched Hf samples
Spokesperson : C. Dean, Winfrith Technology Centre
17/02/08 – 29/02/08

More details of the individual experiments are given in 1.3.

1.2.4. WP3 – Dissemination of results

Task 11– Reporting and publications

Dissemination of results to the research community.

The NUDAME project just being finished, the majority of the results of the experiments are still under analysis. Nevertheless, results achieved during several research activities within NUDAME have already been presented in publications in journals, proceedings of conferences and in scientific reports:

- Oberstedt, S. Oberstedt, M. Gawrys, and N. Kornilov, “Identification of a shape isomer in ^{235}U ”, Phys. Rev. Lett. 99, 042502 (2007).
- G. Noguere et al., "Low Neutron Energy Cross Sections of the Hf Isotopes", NEA Databank, JEF/DOC-1077 (2005)
- G. Noguere et al., "Revision of the Resolved Resonance Range of the Hafnium Isotopes for JEFF-3.1", Technical Note CEA- SPRC/LEPh/05-201 (2005).
- G.Kessedjian, M.Aïche et al.: "Quasi-absolute neutron-induced fission cross section of ^{243}Am " Proceedings of NEMEA-3, Borovets, Bulgaria, October 2006
- M.Aïche, G.Kessedjian et al.: "Quasi-absolute neutron-induced fission cross section of ^{243}Am "
- Proceedings of the International Conference on Nuclear Data for Science and Technology ND2007, Nice, France, Nice, France, April 2007
- G. Noguere et al., " Production of Multigroup Data Covariance in the Resonance Region by Monte-Carlo Calculations", Proceedings of PHYSOR-2006 Topical Meeting on Reactor Physics, Vancouver, BC, Canada, 2006.
- G. Noguere et al., Proceedings of the International Conference on Nuclear Data for Science and Technology ND2007, Nice, France, 2007.
- S. Oberstedt, G. Lövestam, A. Oberstedt, M. Gawrys, A. Plompen, and V. Semkova, “Research on isomer decay with the NEPTUNE spectrometer”, Proceedings of ND-2007 – International Conference on Nuclear Data for Science and Technology, Nice, France, April 22-27, 2007, in press.
- S. Oberstedt, F.-J. Hamsch, N. Kornilov, G. Lövestam, A. Oberstedt, and M. Gawrys, “Shape isomers – a key to fission barriers”, Proceedings of Seminar on Fission VI, Corsendonk Priory, Belgium, Sept 18-21, 2007, eds. C. Wagemans, J. Wagemans and P. D’hondt, World Scientific, in press.
- W. Mondelaers "NUDAME - EURATOM Trans-national Access programme", Scientific report 2007, Neutron Physics Unit, EC-JRC IRMM (2008)
- Pavlik et al., "Measurement of short-lived activation cross-sections from inelastic neutron scattering on lead", Scientific report 2007, Neutron Physics Unit, EC-JRC IRMM (2008)
- P. Dessagne et al. "Measurement of the $^{235}\text{U}(n, 2n)$ reaction cross sections", Scientific report 2007, Neutron Physics Unit, EC-JRC IRMM (2008)
- Oberstedt et al. "Population of the super-deformed ground state in ^{235}U - a feasibility study", Scientific report 2007, Neutron Physics Unit, EC-JRC IRMM (2008)
- B. Jurado et al. "Measurement of the ratio between the capture and the fission cross sections of ^{233}U ", Scientific report 2007, Neutron Physics Unit, EC-JRC IRMM (2008)

- C. Domingo et al. "Validation of the response functions of the active (^3He detector) and passive (^{197}Au foils activation) UAB Bonner Sphere Spectrometers", Scientific report 2007, Neutron Physics Unit, EC-JRC IRMM (2008)
- F. Vanhavere et al. "Testing and calibration of neutron dosimeters for radiation protection in the nuclear industry and space applications", Scientific report 2007, Neutron Physics Unit, EC-JRC IRMM (2008)

Several other publications are at the moment under preparation:

- R. Bedogni, A. Esposito, C. Domingo, M.J. Garcia, G. Lovestam "Testing Bonner Sphere Spectrometers in the JRC-IRMM monoenergetic neutron beams". This paper will connect the BSS experiments done in the NUDAME framework by INFN-LNF and UAB (Barcelona, Spain)
- G. Noguere et al., "Evaluation of the Unresolved Resonance Range of the Hf isotopes with TALYS"
- C. Domingo, M.J. García, K. Amgarou, J. Castelo, E. Morales "Measurements in quasi-monoenergetic neutron beams at the EC-IRMM Van-der-Graaf accelerator for calibration of the UAB PADC based neutron dosimeters". To be presented at the 24th International Conference of Nuclear Tracks in Solids (Bologna, 1-5 September 2008). Submitted to Radiation Measurements
- C. Domingo, R. Bedogni, M.J. Garcia, A. Esposito, G. Lövenstam "Comparative study of the response of the UAB, INFN-LNF and IRMM instruments to monoenergetic neutron beams". In preparation. To be submitted to Nuclear Instruments and Methods A
- Fenyvesi, L. Oláh, J. Csikai, A. Plompen, R. Jaime, G. Lövestam, V. Semkova Leakage spectrum measurements on Bismuth at 8 MeV and 18 MeV neutron energies Paper in preparation and to be submitted to Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment
- G. Noguere et al. "Evaluation of the Unresolved Resonance Range of the Hf isotopes with TALYS"

The NUDAME experiments have also been presented at the NUDAME user meeting (see Task 12). There were also presentations at other conferences and workshops:

- S. Oberstedt, A. Oberstedt, and M. Gawrys, "Search for the shape isomer in ^{235}U ", Giessen, Germany: Spring Meeting of the German Physical Society, of Nuclear Physics Division, 12.-16. 03. 2007
- S. Oberstedt, G. Lövestam, A. Oberstedt, M. Gawrys, A. Plompen, and V. Semkova, "Research on isomer decay with the NEPTUNE spectrometer", Nice, France: ND2007 International Conference on Nuclear Data for Science and Technology, 22.-27. 04. 2007
- S. Marrone et al., Accurate measurement of neutron cross sections of the tungsten stable isotopes, to be presented at Ulaanbaatar Conference on Nuclear Physics and Applications that will be held in Ulaanbaatar (Mongolia) on 8 to 11 September
- S. Oberstedt, F.-J. Hamsch, N. Kornilov, G. Lövestam, A. Oberstedt, and M. Gawrys, "Shape isomers – a key to fission barriers", Corsendonk Priory, Belgium: Seminar on Fission Pont d'Oye VI, 18.-21. 09. 2007
- A. Oberstedt, "Discovery of the shape isomer in ^{235}U ", Göteborg, Sweden: Svenskt Kärnfysikermöte XXVII, 13.-14. 11. 2007
- Vanhavere, F., Spurny, F., Jadrníčková, I., et al. Dosimetry of Biological Experiments in Space (DOBIES) with Luminescence (OSL and TL) and Track Etch Detectors SSD 15, Delft, July 8 -13, 2007
- G.Kessedjian, M.Aïche et al.:"Quasi-absolute neutron-induced fission cross section of ^{243}Am " NEMEA-3, Borovets, Bulgaria, October 2006
- G.Kessedjian et al. "Quasi-absolute neutron-induced fission cross section of ^{243}Am " Rencontres Jeunes Chercheurs (RJC) december 2006, les Houches, France,

- M.Aïche, G.Kessedjian et al.: "Quasi-absolute neutron-induced fission cross section of ^{243}Am " ND2007, Nice, France, April 2007
- G.Kessedjian et al. "Quasi-absolute neutron-induced fission cross section of ^{243}Am " Société Française de Physique (SFP), July 2007, Grenoble, France,
- G.Kessedjian et al. "Quasi-absolute neutron-induced fission cross section of ^{243}Am ", Seminar: SUBATECH, dec. 2007, Nantes, France,
- B. Jurado et al. "Quasi-absolute neutron-induced fission cross section of ^{243}Am ", GEDEPEON, dec.2007, Paris,
- G.Kessedjian et al. "Quasi-absolute neutron-induced fission cross section of ^{243}Am ", Seminar: CEA Bruyères-le-Châtel, fev. 2008, France,
- B. Jurado, G. Kessedjian, et al.: "Minor Actinides neutron-induced fission cross sections" EFNUDAT Workshop, Dresden Germany, February 2008
- G. Noguere et al., " Production of Multigroup Data Covariance in the Resonance Region by Monte-Carlo Calculations", Topical Meeting on Reactor Physics PHYSOR-2006, Vancouver, BC, Canada, 2006.
- A. Pavlik, I. Fabry, R. Jaime, N. Kornilov, S. Oberstedt, A.J.M. Plompen, V. Semkova, P. Baumann, P. Dessagne, M. Kerveno, G. Rudolf, E. Jericha, "Messung von Produktionsquerschnitten für Isomere in ^{206}Pb und ^{207}Pb ", Annual Meeting of the Nuclear and Particle Physics Section of the Austrian Physical Society, Langenlois, Austria, 24 – 26 Sep 2007.

The NUDAME project was presented at the different JEFF meetings that were organised during the period 2005 - 2008.

It is the objective that the results of a number of NUDAME experiments are communicated to validated nuclear data libraries which are used by industry, research laboratories, or regulatory bodies. The databanks relevant for NUDAME are organised by the Nuclear Energy Agency of the Organisation for Economic Cooperation and Development and by the Nuclear Data Section of the International Atomic Energy Agency. Of particular importance are the Joint Evaluated Fission and Fusion file (JEFF) and the Experimental Nuclear Reaction Database (EXFOR). Several NUDAME data have already been transmitted to EXFOR.

The analysis of the results of the NUDAME experiments will be part of (at least) 6 PhD theses. In a period where the nuclear research community is confronted with a declining number of young researchers, NUDAME has sought actively contact with young students from universities and schools. To spread the knowledge and know-how gained within our working programme and within NUDAME we made extensively use of the JRC traineeship for graduate and post-graduate students. Traineeships in cross-section measurements and nuclear data research were offered at the accelerator facilities for graduate students preparing their thesis and for post-graduate students aiming at their first working experience in the nuclear field. Students came from the Universities of Örebro, Vienna, Milano, Bologna, Rome and Gent. We organised also an advanced course for nuclear engineering students on 'Accelerators and time-of-flight techniques' within the framework of the 'European Master of Science in Nuclear Engineering' of BNEN. BNEN is the Belgian Nuclear Higher Education Network put in place to maintain and further develop a high quality education programme in nuclear engineering in Belgium. Training sessions were also given to nuclear students as part of the SPERANSA programme (Stimulation of Practical Expertise in Radiological and Nuclear Safety) of the CHERNE (European Collaboration for Higher Education and Research in Nuclear Engineering and Radiological Protection) network. SPERANSA is a bi-annual ERASMUS intensive programme (IP) project for students of 6 European nuclear engineering institutions. During these courses we focused also on the general context of our work and on the international collaborations within NUDAME.

Dissemination of results to the wider public.

IRMM is part of the Joint Research Centre of the EC. This implies that there are regular high-level visits of European decision-makers and scientists of all sorts of disciplines. Guided tours of the

GELINA and VdG facilities are a standard item during these visits. These visits and guided tours were the ideal occasions to describe the general context of our work and, more in particular, to emphasise on the importance of transnational collaboration within the NUDAME project. This was also done during the IRMM 'Open weekends'. IRMM opened in 2005 and 2007 the institute for the wider public in the framework of the 'Open business factories weekends' organised in Belgium. Visitors made a guided tour of the GELINA and VdG facilities. They got a thorough explanation, adapted to the grand public, of current nuclear issues and their public impact. Also the European context of our work was discussed. These events were very successful. During the last 'Open weekend', more than 1000 visitors visited our facilities.

Task 12– Organisation of user meeting

After execution of all experiments, a general user meeting was organised at IRMM in Geel on February 21-22, 2008 in the form of a two-day workshop. This general user meeting was intended to finalise and close the NUDAME project. The user meeting gathered the external users that were involved in the NUDAME experiments in order to present results, to discuss open issues and to foster future collaborations. The user meeting also concentrated on the outcome of the project and on the lessons to be learnt from that. All users that were supported by NUDAME were invited. Members of the Programme Advisory Committee and other experts in the field also participated. There were 43 subscribed participants.

There were two invited presentations:

- EURATOM FP7 Research Activities in P&T and GenIV reactor systems (V. Bhatnagar, RTD, Brussels (BE))
- Needs for new neutron measurements (A. Koning, NRG, Petten (NL))

In addition there were 14 scientific contributions from the experiments:

- Measurement of the $^{235}\text{U}(n, 2n\gamma)$ cross section (P. Dessagne, IPHC, Strasbourg (FR))
- Neutron-induced fission cross section of ^{243}Am in the 0.7 – 10 MeV energy range (M. Aiche, CENBG, Bordeaux (FR))
- Measurement of the neutron-induced total and capture cross section for natCd in the thermal and resolved resonance region (M. Moxon, University of Birmingham (GB))
- High-resolution capture and transmission measurements of natHf (G. Noguerra, CEA-Cadarache (FR))
- Capture cross section measurements of isotopic enriched Hf samples (T. Ware, University of Birmingham (GB))
- Leakage spectrum measurements on Pb and Bi (L. Olah, Debrecen University (HU))
- Measurements of short-lived activation cross-sections from inelastic scattering on lead (E. Jericha, Techn. Universität Wien (AT))
- Search for the fission decay-mode of the super-deformed ground state in ^{235}U (A. Oberstedt, Örebro University (SE))
- High-resolution (n,2n) measurements on the ^{241}Am (C. Sage, JRC-IRMM, Geel (BE))
- Accurate measurement of neutron cross sections of tungsten stable isotopes (S. Marrone, INFN, Bari (IT))
- Population of the super-deformed ground state in ^{235}U – a feasibility test (A. Oberstedt, Örebro University (SE))
- Optimisation of the data acquisition of a detection set-up for capture cross section measurements using fast digitisers (L.C. Mihaeescu, JRC-IRMM, Geel (BE))
- Validation of the response functions of the active (^3He detector) UAB Bonner sphere detectors (C. Domingo, Universitat Barcelona (ES))
- Testing and calibration of neutron dosimeters for radiation protection in the nuclear industry and space applications (F. Vanhavere, SCK-CEN, Mol (BE))

The scientific contributions were followed by a general overview of the Transnational Access Activities in NUDAME, EUFRAT and EFNUDAT (W. Mondelaers, JRC-IRMM, Geel (BE)). The workshop was closed with a discussion and conclusions. The workshop dinner was organised at Hotel Corsendonck, where also the majority of the workshop participants were housed.

1.3. TRANSNATIONAL ACCESS ACTIVITY : USER-PROJECTS

Short overview of experiments at GELINA

User-project	PAC 1/1
Title	High-resolution capture and transmission measurements of ^{nat} Hf
Institute(s)	CEA, Cadarache, France
Group Leader	G. Noguère (CEA)
Supported users	G. Noguère (CEA)
Other users	J.M. Pallau (CEA) O. Litaize (CEA)
IRMM contact	P. Schillebeeckx
Approved	2 weeks: 1 week capture at FP14_60m with C6D6 1 week capture at FP5_15m with Ge
Experiment	13 – 17 March 2006 11 – 22 December 2006
Beam time delivered	260 hours
Travel costs	665,63 €
Daily allowances	100,00 €
Total direct costs	765,63 €

User-project	PAC 1/5
Title	Capture and transmission measurements on ^{nat}Cd
Institute(s)	IAEA, Vienna, Austria TH Delft, The Netherlands
Group Leader	A. Trkov (IAEA)
Supported users	M. Moxon (TH Delft)
Other users	A. Borella (CEA) F. Gunsing (CEA) A. Trkov (IAEA)
IRMM contact	P. Schillebeeckx
Approved	2 weeks: 1 week capture at FP15_30m 1 week transmission at FP3_50m and FP2_30m
Experiment	5 – 9 December 2005 (capture) 6 – 17 March, 2006 (transmission)
Beam time delivered	206 hours
Travel costs	587,79 €
Daily allowances	2500,00 €
Total direct costs	3087,79 €

User-project	PAC 2/4
Title	^{233}U capture-to-fission ratio
Institute(s)	CEN Bordeaux-Gradignan (France) with IPN Orsay, LPSC Grenoble and CEN Saclay (France)
Group Leader	B. Jurado (CENBG)
Supported users	B. Jurado (CENBG) M. Aiche (CENBG)
Other users	M. Aiche (CENBG) G. Barreau (CENBG) S. Czajkovsky (CENBG) D. Dassie (CENBG) B. Haas (CENBG) A. Bidaud (CENBG) L. Mathieu (CENBG)
IRMM contact	P. Schillebeeckx
Approved	2 weeks
Experiment	20 February 2008 – 4 March 2008
Beam time delivered	181 hours
Travel costs	489,60 €
Daily allowances	1800,00 €
Total direct costs	2289,60 €

User-project	PAC 2/5
Title	C₆D₆ detectors and fast signal digitisers
Institute(s)	INFN, Bari (Italy) CEA (Saclay)
Group Leader	G. Tagliente (INFN)
Supported users	G. Tagliente (INFN)
Other users	F. Gunsing (CEA) E. Berthoumieux (CEA) N. Colonna (INFN) S. Marrone (INFN)
IRMM contact	P. Schillebeeckx
Approved	one week
Experiment	23 – 27 October 2006 and 11 -15 December 2006
Beam time delivered	166 hours
Travel costs	789,53 €
Daily allowances	1100,00 €
Total direct costs	1889,53 €

User-project	PAC 2/6
Title	$^{235}\text{U}(n, 2n)$ cross section
Institute(s)	IReS, Strasbourg, France
Group Leader	Ph. Dessagne (IReS Strasbourg)
Supported users	E. Chambit (IReS Strasbourg) Ph. Dessagne (IReS Strasbourg) M. Kerveno (IReS Strasbourg) J.-C. Thiry (IReS Strasbourg)
Other users	G. Rudolf (IRES Strasbourg) P. Baumann (IRES Strasbourg) H. Karam (IHRES Strasbourg) A. Pavlik (U Wien) E. Jericha (TU Wien)
IRMM contact	A. Plompen
Approved	one week
Experiment	04 – 08 June 2007
Beam time delivered	99 hours
Travel costs	688,00 €
Daily allowances	1800,00 €
Total direct costs	2488,00 €

User-project	PAC 3/1
Title	Capture cross section measurements on isotopic enriched Hf samples
Institute(s)	CERCO Ltd, United Kingdom CEA Cadarache, France
Group Leader	C. Dean (SERCO)
Supported users	M. Moxon (Birmingham) T. Ware (University of Birmingham)
Other users	G. Noguere (CEA Cadarache)
IRMM contact	P. Schillebeeckx
Approved	2 weeks
Experiment	17 – 29 February 2008
Beam time delivered	197 hours
Travel costs	676,18 €
Daily allowances	2200,00 €
Total direct costs	2876,18 €

User-project	PAC 3/2
Title	Measurement of the $^{235}\text{U}(n, n'\gamma)$ and $^{235}\text{U}(n, 2n\gamma)$ reaction cross sections
Institute(s)	IReS, Strasbourg, France
Group Leader	Ph. Dessagne (IPHC Strasbourg)
Supported users	Ph. Dessagne (IPHC Strasbourg) M. Kerveno (IPHC Strasbourg) J.-C. Thiry (IPHC Strasbourg)
Other users	G. Rudolf (IPHC Strasbourg) E. Chambit (IPHC Strasbourg) P. Baumann (IPHC Strasbourg) H. Karam (IPHC Strasbourg) C. Santos (IPHC Strasbourg) A. Pavlik (U Wien) E. Jericha (TU Wien)
IRMM contact	A. Plompen
Approved	2 weeks
Experiment	19 – 23 November 2007 and 4 – 8 February 2008
Beam time delivered	198 hours
Travel costs	0,00 €
Daily allowances	1600,00 €
Total direct costs	1600,00 €

User-project	PAC 3/3
Title	Accurate measurements of neutron cross sections of the tungsten stable isotopes
Institute(s)	INFN, Bari, Italy CEA, Saclay, France Univ. Perugia, Italy
Group Leader	S. Marrone (INFN, Bari)
Supported users	S. Marrone (INFN, Bari) S. Palmerini (Univ. Perugia)
Other users	F. Gunsing (CEA Saclay) E. Berthoumieux (CEA Saclay) N. Colonna (INFN, Bari) G. Tagliente (INFN, Bari) C. Massimi (INFN, Bologna)
IRMM contact	P. Schillebeeckx
Approved	2 weeks
Experiment	10 – 22 February 2008
Beam time delivered	192 hours
Travel costs	703,76 €
Daily allowances	2200,00 €
Total direct costs	2903,76 €

User-project	PAC 3/4
Title	Population of the super deformed ground state in ^{235}U – a feasibility test
Institute(s)	Örebro University (Örebro, Sweden) Chalmers TH (Göteborg, Sweden)
Group Leader	A. Oberstedt (Örebro University)
Supported users	A. Oberstedt (Örebro University)
Other users	A. Göök (Örebro University) M. Gawrys (Göteborg, Sweden)
IRMM contact	S. Oberstedt
Approved	2 weeks
Experiment	21 January – 08 February 2008
Beam time delivered	152 hours
Travel costs	431,36 €
Daily allowances	1100,00 €
Total direct costs	1531,36 €

Short overview of experiments at VdG

User-project	PAC 1/2
Title	$^{243}\text{Am}(n,f)$ in the 0.7 – 10 MeV energy range
Institute(s)	CENBG, Bordeaux, France IPNO, Orsay, France
Group Leader	B. Jurado (CENBG)
Supported users	Beatriz Jurado (CENBG) Gregoire Kessedjian (CENBG)
Other users	Mourad Aiche (CENBG) Gérard Barreau (CENBG) Adrien Bidaud (CENBG) Serge Czajkowsky (CENBG) Danielle Dassie (CENBG) Bernard Haas (CENBG) Ludovic Mathieu (CENBG) Charles-Olivier Bacri (IPNO) Claude Stephan (IPNO) Laurent Tassan-Got (IPNO) Jonathan Wilson (IPNO)
IRMM contact	F.J. Hambsch
Approved	2 weeks
Experiment	20 – 31 March 2006
Beam time delivered	310 hours
Travel costs	412,90 €
Daily allowances	1900,00 €
Total direct costs	2312,90 €

User-project	PAC 1/4
Title	Experimental validation of a multi-sphere spectrometric system used for radiation protection applications around high-energy electron accelerators and medical linacs
Institute(s)	INFN, Frascati, Italy
Group Leader	R. Bedogni (INFN)
Supported users	R. Bedogni (INFN) A. Esposito (INFN-LNF) M. Chiti (INFN-LNF)
Other users	A. Esposito (INFN-LNF) M. Chiti (INFN-LNF)
IRMM contact	G. Lövestam
Approved	1 week
Experiment	21 – 28 January 2006
Beam time delivered	77 hours
Travel costs	0,00 €
Daily allowances	1200,00 €
Total direct costs	1200,00 €

User-project	PAC 2/7
Title	Bonner Sphere Spectrometers
Institute(s)	Departament de Fisica (Barcelona, Spain)
Group Leader	C. Domingo (Universitat Autònoma de Barcelona)
Supported users	M. J. Garcia C. Domingo
Other users	F. Fernandez (U. Barcelona)
IRMM contact	G. Lövestam
Approved	one week
Experiment	5 – 11 March 2007
Beam time delivered	90 hours
Travel costs	713,49 €
Daily allowances	1200,00 €
Total direct costs	1913,49 €

User-project	PAC 2/8
Title	²⁴¹Am (n, 2n) measurements
Institute(s)	CEA – Cadarache CEA Gif-sur-Yvette IRES Strasbourg
Group Leader	O. Bouland (CEA)
Supported users	F. Gunsing (CEA-DIF) G. Noguerre (CEA-Cadarache) O. Bouland (CEA-Cadarache)
Other users	G. Rudolf (IRES Strasbourg)
IRMM contact	A. Plompen
Approved	two weeks
Experiment	26 February – 2 March 2007 18 – 22 June 2007
Beam time delivered	180 hours
Travel costs	1850,92 €
Daily allowances	1300,00 €
Total direct costs	3150,92 €

User-project	PAC 2/9
Title	Leakage spectrum measurements for Bismuth and Lead
Institute(s)	DU-IEP (Debrecen, Hungary) HAS-Atomki (Debrecen, Hungary)
Group Leader	J. Csikai (DU-IEP)
Supported users	L. Olah (IEP, Debrecen) A. Fenyvesi (HAS, Debrecen)
Other users	J. Csikai (DU-IEP)
IRMM contact	A. Plompen
Approved	two weeks
Experiment	27 January - 11 February 2007
Beam time delivered	220 hours
Travel costs	1050,20 €
Daily allowances	2600,00 €
Total direct costs	3650,20 €

User-project	PAC 2/10
Title	Fission decay-mode in superdeformed ^{235}U
Institute(s)	Örebro University (Örebro, Sweden) Chalmers TH (Göteborg, Sweden)
Group Leader	A. Oberstedt (Örebro University)
Supported users	A. Oberstedt (Örebro University) M. Gawrys (Göteborg, Sweden)
Other users	E. Wigren (Örebro University)
IRMM contact	S. Oberstedt
Approved	two weeks
Experiment	11 – 22 September 2006
Beam time delivered	332 hours
Travel costs	969,37 €
Daily allowances	2600,00 €
Total direct costs	3569,37 €

User-project	PAC 2/11
Title	Short-lived activation cross-section on ^{206,207}Pb
Institute(s)	U. Wien (Austria) TU Wien (Austria) IReS Strasbourg (France)
Group Leader	A. Pavlik (University of Wien)
Supported users	A. Pavlik (U. Wien) E. Jericha (TU Wien)
Other users	G. Rudolf (IReS Strasbourg) M. Kerveno (IReS Strasbourg) Ph. Dessagne (IReS Strasbourg)
IRMM contact	A. Plompen
Approved	one week
Experiment	9 – 15 October 2006
Beam time delivered	109 hours
Travel costs	497,46 €
Daily allowances	1200,00 €
Total direct costs	1697,46 €

User-project	PAC 3/5
Title	Very short-lived activation cross sections from inelastic scattering on ^{206,207}Pb
Institute(s)	U. Wien (Austria) TU Wien (Austria) IPHC Strasbourg (France)
Group Leader	A. Pavlik (University of Wien)
Supported users	A. Pavlik (U. Wien) E. Jericha (TU Wien)
Other users	G. Rudolf (IPHC Strasbourg) P. Baumann (IPHC Strasbourg) M. Kerveno (IPHC Strasbourg) Ph. Dessagne (IPHC Strasbourg)
IRMM contact	A. Plompen
Approved	two weeks
Experiment	12 – 23 November 2007
Beam time delivered	220 hours
Travel costs	314,32 €
Daily allowances	2200,00 €
Total direct costs	2514,32 €

User-project	PAC 3/6
Title	Testing and calibration of neutron dosimeters for radiation protection in the nuclear industry and space applications
Institute(s)	SCK (Mol, Belgium)
Group Leader	F. Vanhavere (SCK, Mol)
Supported users	none
Other users	F. Vanhavere (SCK, Mol) J.L. Genicot (SCK, Mol) F. Mastroleo (SCK, Mol)
IRMM contact	G. Lövestam
Approved	one week
Experiment	5 – 9 November 2007
Beam time delivered	100 hours
Travel costs Daily allowances Total direct costs	There were no costs related with this experiment