

## **Raport stiintific sintetic pentru intregul proiect**

**Denumirea proiectului: Reactii nucleare induse de deuteroni la energii joase si medii:  
Analiza consistenta a mecanismelor de reactii directe si statistice**

[ [http://tandem.nipne.ro/~dante/projects/PN2P3\\_0450/index.html](http://tandem.nipne.ro/~dante/projects/PN2P3_0450/index.html) ]

Cod: PN-II-ID-PCE-2011-3-0450, Director: M. Avrigeanu, <http://www.researcherid.com/rid/B-6068-2011>

### **I. Raport stiintific**

*privind implementarea proiectului in perioada 1 ianuarie 2016 – 30 septembrie 2016*

**Etapa unica 2016: Analiza consistenta a interactiunii deuteronilor cu nucleele  $^{61,62,\text{nat}}\text{Ni}$  la energii joase**

#### **1.1. Analiza componentelor sectiunii eficace ale procesului de ‘breakup’ pentru interactiunea deuteronilor cu nucleele $^{61,64,\text{nat}}\text{Ni}$**

Obiectivul prezentei activitati a proiectului de fata, privind analiza consistenta a interactiilor deuteronilor cu nuclee de masa medie la energii joase, cu luarea in considerare a interactiilor directe, a fost atins prin obtinerea rezultatelor prezentate in principal intr-o lucrare prezentata oral<sup>1</sup> asupra importantei procesului de rupere (*‘breakup’* - BU) a deuteronilor in comparatie cu procesele statistice, cu urmatorul rezumat:

„**Abstract.** At present, increased deuteron-data needs follow the demands of on-going strategic research programs (ITER, IFMIF, SPIRAL2-NFS) that involve deuteron beams, while the corresponding experimental and evaluated data are less extensive and accurate than for neutrons. Moreover, the analysis of low-energy deuteron reactions in terms of usual reaction models is challenging due to the deuteron breakup (BU) as a result of its weak binding energy. Thus, the BU leakage of the initial deuteron flux reduces the total-reaction cross section that is shared among different outgoing channels. At the same time, unlike the elastic breakup (EB) in which the target nucleus stays in its ground state, a subsequent interaction between one of the deuteron BU nucleons and the target nucleus, which represents an inelastic BU or breakup fusion (BF) process, may finally lead through a secondary compound nucleus (CN) to enhancement of various reaction channels.

There are currently many efforts to improve the description of deuteron reactions also due to the use of  $(d,pf)$  surrogate reactions for neutron capture  $(n,\gamma)$  and induced fission  $(n,f)$  studies. Their common two-step approach endorses the BU and direct reactions (DR) phenomenological account of all available activation data for several structural materials and including fission competition. However, recent studies inferred that numerical calculations for deuteron reactions are beyond current capabilities. Conversely, the consistent account of the deuteron BU, DR, and CN mechanisms, following the explicit consideration of the former two, has recently been proved and forms the object of this work for nuclei from  $^{27}\text{Al}$  to  $^{93}\text{Nb}$ .”

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<sup>1</sup> M. Avrigeanu, V. Avrigeanu, and C. Costache, *Role of the direct processes in deuteron interactions with structural materials*, [ND2016 Int. Conf. on Nuclear Data for Science and Technology](#), 11-16/09 2016, Bruges, Belgium. EPJ Web of Conferences (*in press*).

## 1.2. Analiza sectiunilor eficace de activare ale deuteronilor cu nucleele <sup>61,62,64,nat</sup>Ni

Pe baza validarii astfel obtinute pentru descrierea procesului de 'breakup' inclusiv pentru nuclee din zona de masa atomica a izotopilor elementului Ni, ponderea principala a etapei de fata a reprezentat-o realizarea unei lucrari de sinteza<sup>2</sup> (primul autor fiind si autorul corespondent care a reprezentat intreaga colaborare ce a realizat respectiva lucrare, ale carei sectiuni de analiza si discutie a rezultatelor a revenit integral grupului IFIN-HH), asupra sectiunilor eficace de reactie ale deuteronilor la energii joase inclusiv cu nucleele <sup>61,62,64,nat</sup>Ni, cu urmatorul rezumat:

„**Background:** The high complexity of the deuteron-nucleus interaction due to the deuteron weak binding energy of 2.224 MeV is also related to a variety of reactions induced by the deuteron-breakup (BU) nucleons. Thus, specific noncompound processes as BU and direct reactions (DR) make the deuteron-induced reactions so different from reactions with other incident particles. The scarce consideration of only pre-equilibrium emission (PE) and compound-nucleus (CN) mechanisms led to significant discrepancies with experimental results so that recommended reaction cross sections of high-priority elements as, e.g., Ni have mainly been obtained by fit of the data. **Purpose:** The unitary and consistent BU and DR account in deuteron-induced reactions on natural nickel may take the advantage of an extended database for this element, including new accurate measurements of particular reaction cross sections **Method:** The activation cross sections of <sup>64,61,60</sup>Cu, <sup>65,57</sup>Ni, and <sup>55,56,57,58,58m,60</sup>Co nuclei for deuterons incident on natural Ni at energies up to 20 MeV, were measured by the stacked-foil technique and high resolution gamma spectrometry using U-120M cyclotron of CANAM, NPI CAS. Then, within an extended analysis of deuteron interactions with Ni isotopes up to 60 MeV, all processes from elastic scattering until the evaporation from fully equilibrated compound system have been taken into account while an increased attention is paid especially to the BU and DR mechanisms. **Results:** The deuteron activation cross-section analysis, completed by consideration of the PE and CN contributions corrected for decrease of the total-reaction cross section due to the leakage of the initial deuteron flux towards BU and DR processes, is proved satisfactory for the first time to all available data. **Conclusions:** The overall agreement of the measured data and model calculations validates the description of nuclear mechanisms taken into account for deuteron-induced reactions on Ni, particularly the BU and DR that should be considered explicitly.”

Importanta aparte a mecanismelor de reactie specifice interactiei deuteronilor cu nuclee din acelasi domeniu de mase atomice, aplicabile in egala masura izotopilor elementul Ni, au fost discutate si intr-o lucrare prezentata oral<sup>3</sup> la principala conferinta din domeniul datelor nucleare, cu urmatorul rezumat:

„**Abstract.** The basic role of the improvement of nuclear data for fusion has recently been pointed out with respect to the overall uncertainties on the measured yield of reaction-in-flight (RIF) neutrons with energies up to 30 MeV produced in warm, dense deuterium-tritium plasma. While the ultimate aim has been the improved cross sections for the reactions with thresholds above 15 MeV in order to determine the RIF neutrons yield, a detailed analysis has been proved necessary for the quasimonoenergetic neutrons produced by the <sup>2</sup>H(*d,n*)<sup>3</sup>He reaction at deuteron energies from 15 to 19 MeV. Beyond the usual neutron energy spread, the deuteron breakup (BU) has been proved significant at these energies and a related fractional contribution (FC) had to be carefully determined from neutron time-of-flight (NTOF) spectra. Finally, on the basis of the <sup>90</sup>Zr(*n,2n*)<sup>89</sup>Zr

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<sup>2</sup> M. Avrigeanu, E. Simeckova, U. Fischer, J. Mrazek, J. Novak, M. Stefanik, C Costache, and V. Avrigeanu, *Deuteron-induced reactions on Ni isotopes up to 60 MeV*, [Phys. Rev. C 94, 014606 \(2016\)](#). DOI:10.1103/PhysRevC.94.014606.

<sup>3</sup> V. Avrigeanu and M. Avrigeanu, *On the synergy of nuclear data for fusion and model assumptions*, [ND2016 Int. Conf. on Nuclear Data for Science and Technology](#), 11-16/09 2016, Bruges, Belgium. EPJ Web of Conferences (*in press*).

monitor reaction cross-section evaluation with assumed uncertainties below 3.5% in the energy range studied, well-improved cross sections have been obtained for certain reactions but less confidence for the  $^{94}\text{Zr}(n, \alpha)^{91}\text{Sr}$  reaction data. Several issues of this pioneering work are considered in the present work, looking also for making use of their synergy within fusion physics. First, a BU empirical parametrization is involved within the BU analysis of the NTOF spectrum. Second, the open questions underlined by an widespread study of the fast-neutron induced reaction on Zr isotopes [3], subsequent to the evaluation used formerly, are addressed in a consistent way. Third, a recent optical potential for  $\alpha$ -particles is used to understand the large discrepancy between the measured and calculated cross sections of the  $^{94}\text{Zr}(n, \alpha)^{91}\text{Sr}$  reaction. An improved physics modeling is thus leading to smaller uncertainties of the nuclear data for fusion while the RIF neutron spectra may also be used to support nuclear model assumptions.”

Aspecte caracteristice ale interaciilor la energii joase ale particulelor incarcate impun si acordarea unei atentii marite procesului de excitare Coulombiana. Analiza efectuata in acest sens in cadrul etapei unice din anul 2014 a fost finalizata prin publicarea formei finale a lucrarii<sup>4</sup> avand urmatorul rezumat:

„**Abstract.** The cross sections for nuclear reactions are generally consider to be well known in spite of many reactions for which the data are conflicting or incomplete to make the validation of different model calculations possible. The Coulomb-excitation process has been used for decades to obtain information related to the low-lying nuclear states. Besides the several hundreds of new observed states, the most important contribution of the Coulomb-excitation process has been the information obtained on electromagnetic transition rates between nuclear states. An analysis of the Coulomb-excitation cross sections for a series of medium and heavy nuclei is given in the present paper in order to eventually improve an alpha-particle optical potential.”

### **Stadiul implementarii si finalizarii proiectului**

Interesul semnificativ pe care il prezinta subiectul acestui proiect pentru cercetarile de fuziune nucleara pe plan mondial a condus si la preluarea si introducerea in formatul specific al bibliotecilor de date nucleare a rezultate obtinute in cadrul proiectului de fata. Acestea au fost prezentate in cadrul unui raport<sup>5</sup> prezentat in cadrul *NEA Nuclear Data Week, 25-28 April 2015*, organizata de catre OECD/NEA (Issy-les-Moulineaux, France). Aprecierea acordata acestor lucrari a asigurat continuarea activitatii echipei de cercetare a proiectului de fata in cadrul acordului cu nr. F4E-FPA-168/2011 (2012-2016) de tip „*Framework Partnership Agreement*” (FPA) al unui consortiu, incluzand grupul din IFIN-HH, cu agentia **Fusion for Energy** (F4E, <http://fusionforenergy.europa.eu/>) a Comisiei Europene. Finantarea acestui consortiu este inasa mai mult simbolica datorita costurilor majore ale realizarii ITER, astfel incat nu a existat o dubla finantare nationala/internationala ci una complementara a componentelor lucrarilor de cercetare fundamentala care formeaza si obiectul raportului de fata. Participarea la consortiu respectiv garanteaza, pe de alta parte, orientarea corespunzatoare a activitatii IFIN-HH inclusiv pe tematica proiectului de fata.

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<sup>4</sup> C. Manailescu, *On the Coulomb-excitation analysis for medium and heavy nuclei*, *Rom. Rep. Phys.* **68**, 169 (2016).

<sup>5</sup> M. Avrigeanu, *Progress on the analysis of deuteron-induced reaction mechanisms at low energies*, *EFFDOC-1285* ([https://www.oecd-neo.org/dbdata/nds\\_effdoc/effdoc-1285.pdf](https://www.oecd-neo.org/dbdata/nds_effdoc/effdoc-1285.pdf)), *NEA Nuclear Data Week, 25-28 April 2016* (<http://www.oecd-neo.org/dbdata/meetings/april2016/>), OECD/NEA, Paris, France.

## II. Raport stiintific sintetic pentru intregul proiect

privind implementarea proiectului in perioada octombrie 2011–30 septembrie 2016 (60 luni)

### Denumirea proiectului: Reactii nucleare induse de deuteroni la energii joase si medii: Analiza consistenta a mecanismelor de reactii directe si statistice

[ [http://tandem.nipne.ro/~dante/projects/PN2P3\\_0450/index.html](http://tandem.nipne.ro/~dante/projects/PN2P3_0450/index.html) ]

Cod: PN-II-ID-PCE-2011-3-0450, Director: M. Avrigeanu, <http://www.researcherid.com/rid/B-6068-2011>

#### 1. Obiectivele proiectului prevazute si realizate cu gradul de realizare total, pe ani de raportare

- 2011 - Analiza consistenta a interactiilor deuteronilor cu nuclee de masa medie la energii joase , cu luarea in considerare a interactiilor directe
- 2012 - Analiza componentelor sectiunii eficace ale procesului de ‘breakup’ pentru interactiunea deuteronilor cu nuclee de masa medie la energii incidente  $E < 60$  MeV
- 2013 - Analiza consistenta a interactiunii deuteronilor cu nucleele  $^{54,56}\text{Fe}$  la energii joase.
- 2014 - Analiza consistenta a interactiunii deuteronilor cu nucleele  $^{58,\text{nat}}\text{Fe}$  la energii joase
- 2015 - Analiza consistenta a interactiunii deuteronilor cu nucleele  $^{58,60}\text{Ni}$  la energii joase
- 2016 - Analiza consistenta a interactiunii deuteronilor cu nucleele  $^{61,62,\text{nat}}\text{Ni}$  la energii joase

#### 2a. Criterii de performanta - articole prevazute/publicate (7/9) in reviste cotate ISI, cu mentionarea proiectului in sectiunea „Acknowledgement”

1. **M. Avrigeanu\***, V. Avrigeanu, and A.J. Koning, *Investigation of deuteron breakup and deuteron-induced fission on actinide nuclei at low incident energies*, [Phys. Rev. C 85, 034603 \(2012\)](#). DOI: 10.1103/PhysRevC.85.034603.
2. M. Avrigeanu, **V. Avrigeanu\***, M. Diakaki, and R. Vlastou, *Isomeric cross sections of fast-neutron-induced reactions on  $^{197}\text{Au}$* , [Phys. Rev. C 85, 044618 \(2012\)](#). DOI: 10.1103/PhysRevC.85.044618.
3. **M. Avrigeanu\***, V. Avrigeanu, P. Bem, U. Fischer, M. Honusek, A.J. Koning, J. Mrazek, E. Simeckova, M. Stefanik, and L. Zavorka, *Low energy deuteron-induced reactions on  $^{93}\text{Nb}$* , [Phys. Rev. C 88, 014612 \(2013\)](#). DOI: 10.1103/PhysRevC.88.014612.
4. **M. Avrigeanu\*** and V. Avrigeanu, *Consistent analysis of the nuclear reaction mechanisms involved in the deuteron-induced activations at low and medium energies*, [Nucl. Data Sheets 118, 301 \(2014\)](#). DOI: 10.1016/j.nds.2014.04.064.
5. **V. Avrigeanu\*** and M. Avrigeanu, *Consistent treatment of ( $\alpha,x$ ) reaction cross sections and alpha-particle emission particularly in fast-neutron induced reactions*, [Nucl. Data Sheets 118, 262 \(2014\)](#). DOI: 10.1016/j.nds.2014.04.053.
6. **M. Avrigeanu\***, V. Avrigeanu, P. Bem, U. Fischer, M. Honusek, K. Katovsky, C. Manailescu, J. Mrazek, E. Simeckova, and L. Zavorka, *Low energy deuteron-induced reactions on Fe isotopes*, [Phys. Rev. C 89, 044613 \(2014\)](#). DOI: 10.1103/PhysRevC.89.044613.
7. **M. Avrigeanu\*** and V. Avrigeanu, *Role of breakup and direct processes in deuteron-induced reactions at low energies*, [Phys. Rev. C 92, 021601\(R\) \(2015\)](#). DOI: 10.1103/PhysRevC.92.021601.
8. **C. Manailescu\***, *On the Coulomb-excitation analysis for medium and heavy nuclei*, [Rom. Rep. Phys. 68, 169 \(2016\)](#). WOS:000373247900014 .
9. **M. Avrigeanu\***, E. Simeckova, U. Fischer, J. Mrazek, J. Novak, M. Stefanik, C Costache, and V. Avrigeanu, *Deuteron-induced reactions on Ni isotopes up to 60 MeV*, [Phys. Rev. C 94, 014606 \(2016\)](#). DOI: 10.1103/PhysRevC.94.014606.

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\*Autor corespondent

**2b. Criterii de performanta – contributiile orale/invitate la conferinte internationale prevazute/realizate (10/14), cu mentionarea proiectului in „Acknowledgement” (pentru reviste/volume necotate ISI)**

1. M. Avrigeanu, V. Avrigeanu and F.L. Roman, *Deuteron-induced reaction mechanisms at low energies*, *Third Int. Workshop on Compound Nuclear Reactions and Related Topics* (CNR\*11), 19 - 23 September 2011, Prague, Czech Republic. [EPJ Web of Conferences \*\*21\*\*, 07003 \(2012\) 1-11](#). DOI: 10.1051/epjconf/20122107003.
2. M. Avrigeanu and V. Avrigeanu, *Consistent analysis of all-inclusive deuteron-induced reactions at low energies*, *13th Int. Conf. on Nuclear Reaction Mechanisms*, 11 - 15 June 2012, Varenna, Italy. [CERN-Proceedings-2012-002, pp. 187-193](#).
3. V. Avrigeanu and M. Avrigeanu,  *$\alpha$ -particle Optical Potentials for Nuclear Astrophysics (NA) and Nuclear Technology (NT)*, *Carpathian Summer School of Physics 2012: Exotic Nuclei and Nuclear/Particle Astrophysics (IV). From Nuclei to Stars*, June 24 - July 7, 2012, Sinaia, Romania. [AIP Conf. Proc. \*\*1498\*\* \(2012\) 169-177](#), DOI: 10.1063/1.4768492.
4. V. Avrigeanu and M. Avrigeanu, *Consistent account of fast neutron induced alpha-particle emission*, [2013 Int. Conf. on Nuclear Data for Science & Technology](#), March 4-8, 2013, New York, USA.
5. M. Avrigeanu and V. Avrigeanu, *Consistent analysis of the nuclear reaction mechanisms involved in the deuteron-induced activations at low and medium energies*, [2013 Int. Conf. on Nuclear Data for Science & Technology](#), March 4-8, 2013, New York, USA.
6. V. Avrigeanu and M. Avrigeanu, [Radiative strength function low-energy enhancement within Enhanced Generalized Lorentzian model](#), *4th Workshop on Nuclear Level Density and Gamma Strength*, May 27-31, 2013, Oslo, Norway.
7. M. Avrigeanu and V. Avrigeanu, *Direct processes effects on deuteron activation cross sections*, *XX Int. School on Nuclear Physics, Neutron Physics and Applications*, 16-22 Sept. 2013, Varna, Bulgaria. [J. Phys. Conf. Ser. \*\*533\*\*, 012004 \(2014\) 1-4](#), DOI: 10.1088/1742-6596/533/1/012004.
8. M. Avrigeanu, V. Avrigeanu, and C. Manaiescu, [Reaction mechanisms involved in the deuteron interaction with medium mass nuclei](#), Proc. [33rd Int. Workshop on Nuclear Theory, 22-28 June 2014, Rila, Bulgaria](#), A. Georgieva, N. Minkov (Eds.), Heron Press, Sofia, 2014, pp. 132-141.
9. M. Avrigeanu, V. Avrigeanu, and C. Manaiescu, *On reaction mechanism involved in the deuteron-induced surrogate reactions on actinides*, *Carpathian Summer School of Physics 2014: Exotic Nuclei and Nuclear/Particle Astrophysics (V)*, 13-26 July, 2014, Sinaia, Romania. [AIP Conf. Proc. \*\*1645\*\* \(2015\) 139-147](#), DOI: 10.1063/1.4909568.
10. M. Avrigeanu and V. Avrigeanu, [On the level density models analysis based on deuteron-induced reactions](#), *5th Workshop on Nuclear Level Density and Gamma Strength*, May 18-22, 2015, Oslo, Norway.
11. M. Avrigeanu and V. Avrigeanu, *Role of the direct mechanisms in the deuteron-induced surrogate reactions*, *14th Int. Conf. on Nuclear Reaction Mechanisms*, 15 - 19 June 2015, Varenna, Italy. [CERN-Proceedings-2015-001, pp. 203-208](#).
12. M. Avrigeanu and V. Avrigeanu, *On deuteron interactions within surrogate reactions and nuclear level density studies*, *XXI Int. School on Nuclear Physics, Neutron Physics and Applications*, 6-12 Sept. 2015, Varna, Bulgaria. [J. Phys. Conf. Ser. \*\*724\*\*, 012003 \(2016\) 1-7](#), DOI: 10.1088/1742-6596/724/1/012003.
13. M. Avrigeanu, V. Avrigeanu, and C. Costache, *Role of the direct processes in deuteron interactions with structural materials*, [ND2016 Int. Conf. on Nuclear Data for Science and Technology](#), 11-16/09 2016, Bruges, Belgium. EPJ Web of Conferences (in press).
14. V. Avrigeanu and M. Avrigeanu, *On the synergy of nuclear data for fusion and model assumptions*, [ND2016 Int. Conf. on Nuclear Data for Science and Technology](#), 11-16/09 2016, Bruges, Belgium. EPJ Web of Conferences (in press).

**3. Impactul rezultatelor obtinute**



Suplimentar aspectului de **cercetare fundamentala**<sup>6</sup> a tematicii<sup>7</sup> si rezultatelor proiectului de fata, interesul semnificativ pe care il prezinta subiectul acestui proiect pentru cercetarile de **fuziune nucleara** pe plan mondial a condus si la preluarea<sup>8,9</sup> si introducerea in formatul specific al bibliotecilor de date nucleare a rezultatelor obtinute in cadrul proiectului de fata. Acestea au fost prezentate in cadrul unor rapoarte prezentate in cadrul *NEA Nuclear Data Weeks* organizate de catre OECD/NEA (Issy-les-Moulineaux, France), mentionate in rapoartele de etapa ale acestui proiect. Aprecierea acordata acestor lucrari a asigurat continuarea activitatii echipei de cercetare a proiectului de fata in cadrul acordului cu nr. F4E-FPA-168/2011 (2012-2016) de tip „*Framework Partnership Agreement*” (FPA) al unui consortiu, incluzand grupul din IFIN-HH, cu agentia **Fusion for Energy** (F4E, <http://fusionforenergy.europa.eu/>) a Comisiei Europene. Finantarea acestui consortiu este insa mai mult simbolica datorita costurilor majore ale realizarii ITER, astfel incat nu a existat o dubla finantare nationala/internationala ci una complementara a componentelor lucrarilor de cercetare fundamentala care formeaza si obiectul raportului de fata. Participarea la consortiul respectiv garanteaza, pe de alta parte, orientarea corespunzatoare a activitatii IFIN-HH inclusiv pe tematica proiectului de fata.

Referintele [2a.1-2a.7, 2a.9] reprezinta lucrarile realizate cu finantarea integrala la nivel national in cadrul proiectului de fata, avand inclusa in sectiunea „*Acknowledgement*” si mentiunea finantarii unice la nivel national prin acest proiect. Acesta mentiune este inclusa si in sectiunile corespunzatoare ale paginii proprii a proiectului, avand adresa [http://tandem.nipne.ro/~dante/projects/PN2P3\\_0450/index.html](http://tandem.nipne.ro/~dante/projects/PN2P3_0450/index.html). Absenta unei suprapunerii cu rezultatele altor proiecte realizate anterior de acelasi grup poate fi constata din paginile tuturor acestor proiecte PN-II, reunite in pagina <http://tandem.nipne.ro/~dante/projects.html>, precum si cu proiectul PN-09-37-01-05 al departamentului propriu (DFN) din cadrul IFIN-HH. In cadrul

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<sup>6</sup> X. Ledoux, M. Aiche, M. Avrigeanu, V. Avrigeanu, L. Audouin, E. Balanzat, B. Ban-d'état, G. Ban, G. Barreau, E. Bauge, G. B'élier, P. Bem, V. Blideanu, C. Borcea, S. Bouffard, T. Caillaud, A. Chatillon, S. Czajkowski, P. Dessagne, D. Dor'é, M. Fallot, F. Farget, U. Fischer, L. Giot, T. Granier, S. Guillous, F. Gunsing, C. Gustavsson, B. Jacquot, K. Jansson, B. Jurado, M. Kerveno, A. Klix, O. Landoas, F.R. Lecolley, J.L. Lecouey, M. Majerle, N. Marie, T. Materna, J. Mrazek, F. Negoita, J. Novak, S. Oberstedt, A. Oberstedt, S. Panebianco, L. Perrot, A.J.M. Plompen, S. Pomp, J.M. Ramillon, D. Ridikas, B. Ross'é, G. Rudolf, O. Serot, S.P. Simakov, E. Simeckova, A.G. Smith, J.C. Sublet, J. Taieb, L. Tassan-Got, D. Tarrío, A. Takibayev, I. Thfoin, I. Tsekhanovich, and C. Varignon, *The Neutrons for Science Facility at SPIRAL-2*, [Nucl. Data Sheets 120 \(2014\) 253–256](#). DOI: 10.1016/j.nds.2014.08.097; [ND2016 Int. Conf. on Nuclear Data for Science and Technology](#), 11-16/09 2016, Bruges, Belgium. EPJ Web of Conferences (*in press*).

<sup>7</sup> [http://tandem.nipne.ro/~dante/projects/PN2P3\\_0450/impact.html](http://tandem.nipne.ro/~dante/projects/PN2P3_0450/impact.html)

<sup>8</sup> U. Fischer, M. Avrigeanu, V. Avrigeanu, O. Cabellos, I. Kodeli, A. Koning, A.Yu. Konobeyev, H. Leeb, D. Rochman, P. Pereslavitsev, P. Sauvan, J.-C. Sublet, A. Trkov, E. Dupont, D. Leichtle, and J. Izquierdo, *The Activities of the European Consortium on Nuclear Data Development and Analysis for Fusion*, [Nucl. Data Sheets 120 \(2014\) 226–229](#). DOI: 10.1016/j.nds.2014.07.053.

<sup>9</sup> U. Fischer<sup>1,\*</sup>, M. Avrigeanu<sup>2</sup>, V. Avrigeanu, O. Cabellos, N. Dzysiuk, A. Koning, A. Konobeev, I. Kodeli, H. Leeb, D. Leichtle, L. Packer, D. Rochman, P. Pereslavitsev, and P. Sauvan, *Nuclear Data for Fusion Technology – The European Approach*, [ND2016 Int. Conf. on Nuclear Data for Science and Technology](#), 11-16/09 2016, Bruges, Belgium. EPJ Web of Conferences (*in press*).

proiectului PN mentionat pot fi constata rezultatele distincte<sup>10,11,12,13</sup>, obtinute la un nivel comparabil, pe tematica unei propuneri de proiect PN-II-ID-PCE-2011-3/4 nefinantate in final.

#### **4. Resurse – Nerealizari/dificultati intampinate in derularea proiectului**

O precizare importanta priveste imposibilitatea de a urma si in anul 2015 recomandarea de „intensificare a activitatii de publicare cu implicarea tinerilor cercetatori”, care a reprezentat singura deficientea consemnata in „Fisa de evaluare intermediara a stadiului implementarii” proiectului, disponibila<sup>14</sup> si pe pagina proprie a proiectului, pentru care s-a acordat calificativul B<sup>+</sup> si s-a recomandat proiectul pentru prezentarea publica a rezultatelor in vederea „clarificarii contributiei tinerilor cercetatori la activitatea de publicare” (punctul de vedere al directorului de proiect privind evaluarea respectiva, disponibil si pe pagina proprie a proiectului<sup>15</sup>, in dezacord cu aspectele critice mentionate mai sus, a fost inclus integral si in prezentarea<sup>16</sup> publica a rezultatelor care a avut loc in cadrul sedintei publice<sup>17</sup> din 18.06.2014). In fapt recomandarea mentionata a fost oricum satisfacuta prin listele de autori ale lucrarilor realizate in perioada 17.06.2013-19.06.2014, perioada in care pozitia de post-doc vacanta in cadrul echipei proiectului a fost ocupata de catre [Dr. C. Manailescu](#), in urma anuntului public<sup>18</sup> pe site-ul [www.euraxess.ro](http://www.euraxess.ro).

Insa in conditiile reducerii cu 50% a suportului financiar prevazut pentru perioada 01.01-30.09.2014<sup>19</sup> in cadrul propunerii de proiect, fondurile disponibile in cadrul proiectului - distribuite in mod egal intre principalii membri ai echipei de cercetare, in conformitate cu nivelurile de salarizare mentionate de asemenea in propunerea de proiect (respectiv nivelul PD/POSDRU in cazul Dr. C. Manailescu) - au acoperit numai perioada 01.01.-19.06.2014, data de la care sustinerea financiara a angajarii Dr. C. Manailescu nu a mai fost posibila. In concluzie, pierderea in fapt a angajarii cercetatorului post-doc, ca urmare a reducerii sustinerii financiare aprobate initial, precum si absenta sa din lista de autori a lucrarilor realizate ulterior nu sunt imputabile echipei proiectului. Pe de alta parte este de remarcat contributia voluntara si in afara programului regulat de lucru al IFIN-HH a Dr. C. Manailescu si drd. C. Costache, in conditiile angajarii si finantarii acestora in cadrul altor proiecte de cercetare, la realizarea lucrarilor ce au condus la publicarea referintelor [2a.8,2a.9,2b.13].

Director proiect,

  
Marilena Avrigeanu

<sup>10</sup> V. Avrigeanu, M. Avrigeanu, and C. Manailescu, *Further explorations of the  $\alpha$ -particle optical model potential at low energies for the mass range  $A \approx 45-209$* , [Phys. Rev. C \*\*90\*\*, 044612 \(2014\)](#). DOI: 10.1103/PhysRevC.90.044612.

<sup>11</sup> V. Avrigeanu\* and M. Avrigeanu, *Consistent optical potential for incident and emitted low-energy alpha particles*, [Phys. Rev. C \*\*91\*\*, 064611 \(2015\)](#). DOI: 10.1103/PhysRevC.91.064611.

<sup>12</sup> V. Avrigeanu and M. Avrigeanu, *Analysis of uncertainties in alpha-particle optical-potential assessment below the Coulomb barrier*, [Phys. Rev. C \*\*94\*\*, 024621 \(2016\)](#). DOI: 10.1103/PhysRevC.94.024621.

<sup>13</sup> V. Avrigeanu, M. Avrigeanu, and C. Manailescu, *Coulomb excitation effects on alpha-particle optical potential below the Coulomb barrier*, Report [arXiv:1605.05455](https://arxiv.org/abs/1605.05455), 18 May 2016.

<sup>14</sup> [http://tandem.nipne.ro/~dante/projects/PN2P3\\_0450/rapoarte/Fisa de evaluare AM-2013.pdf](http://tandem.nipne.ro/~dante/projects/PN2P3_0450/rapoarte/Fisa_de_evaluare_AM-2013.pdf)

<sup>15</sup> [http://tandem.nipne.ro/~dante/projects/PN2P3\\_0450/rapoarte/Punct vedere Eval-Int ID-PCE-2011-0450.pdf](http://tandem.nipne.ro/~dante/projects/PN2P3_0450/rapoarte/Punct_vedere_Eval-Int_ID-PCE-2011-0450.pdf)

<sup>16</sup> [http://tandem.nipne.ro/~dante/projects/PN2P3\\_0450/rapoarte/ID\\_0450\\_2014-UEFISCDI.ppt](http://tandem.nipne.ro/~dante/projects/PN2P3_0450/rapoarte/ID_0450_2014-UEFISCDI.ppt)

<sup>17</sup> <http://uefiscdi.gov.ro/articole/3752/Sedinte-publice-de-prezentare-a-rezultatelor-obtinate.html>

<sup>18</sup> <http://ec.europa.eu/euraxess/index.cfm/jobs/jobDetails/33772294>

<sup>19</sup> [http://tandem.nipne.ro/~dante/projects/PN2P3\\_0450/resources.html](http://tandem.nipne.ro/~dante/projects/PN2P3_0450/resources.html)