HORIZON 2020

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ENSAR2

EUROPEAN NUCLEAR SCIENCE AND APPLICATION RESEARCH 2

GRANT AGREEMENT NUMBER: 654002

D2.4

Report ON WORKSHOPS MONTHS 25-34(MAR18 – DEC18)

Version: 1.1
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Date: 30.04.2019

PROJECT AND DELIVERABLE INFORMATION SHEET

ENSAR2 Project Ref. №	654002
Project Title	European Nuclear Science and Application Research 2
Project Web Site	http://www.ensarfp7.eu
Deliverable ID	D2.4
Deliverable Nature	Report
Deliverable Level*	PU
Contractual Date of Delivery	March 31st, 2019
Actual Date of Delivery	April 30th, 2019[1]
EC Project Officer	Mina Koleva

* The dissemination levels are indicated as follows: PU – Public, PP – Restricted to other participants (including the Commission Services), RE – Restricted to a group specified by the consortium (including the Commission Services). CO – Confidential, only for members of the consortium (including the Commission Services).

DOCUMENT CONTROL SHEET

Document	Title: Report on workshops months 25-34	
	ID: D2.4	
	Version: 1.1	
	Available at: http://www.ensarfp7.eu/	
	Software Tool: Microsoft Office Word 2007	
	File: ENSAR_D2.4-v1-LT.docx	
Authorship	Written by:	L. Trache, IFIN-HH, C. Scheidenberger, JLU
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	Reviewed by:	K. Turzó, GANIL, France
	Approved by:	

DOCUMENT STATUS SHEET

Version	Date	Status	Comments
1.0	6 March 2019	For internal review	
		For internal review	
1.1	30 April 2019	Submitted on EC Participant Portal	The delay is only due to technical problems at coordinator level
		Final version	

Document Keywords

Keywords	ENSAR2, NUSPRASEN, workshops; nuclear structure, nuclear reactions, nuclear astrophysics, superheavy elements

[1] The delay is only due to technical problems at coordinator level.

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LIST OF ACRONYMS AND ABBREVIATIONS

ScC	Scientific Committee
SC	Steering Committee
WG	Working Group
NUSPRASEN	**Nu**clear **S**tructure **P**hysics, **R**eactions, **A**strophysics and **S**uperheavy **E**lements **N**etwork
NA	Networking Activity

EXECUTIVE SUMMARY

This is a report on the workshops planned and performed in the framework of the ENSAR2-WP2: NUSPRASEN in the period March 1, 2018 – December 31, 2018 (M25 – M34). NUSPRASEN is the Network Activity encompassing all physics subjects of the ENSAR2 project, therefore, the topics were quite different. Three workshops on precise topics and two nuclear astrophysics schools (part of ENNAS) were organized and supported in this time interval. We report briefly on each: (1) the EURISOL Town Meeting in July 2018, Pisa, Italy, (2) the workshop "Nuclear Physics in Stellar Explosions" in Sept. 2018, at Atomki, Debrecen, Hungary, (3) the Ganil Community Meeting in Oct. 8-12, 2018 in Caen, France, (4) the ECT workshop on "Indirect Methods in Nuclear Astrophysics" in Nov. 5-9, 2018 in Trieste, Italy, (5) the 15th Russbach School on Nuclear Astrophysics (in Russbach, Austria, March 2018), (6) the 28th Carpathian Summer School of Physics (in Sinaia, Romania, in July, 2018.*

INTRODUCTION

The NUSPRASEN workgroup set its agenda in first months of the ENSAR2 project. It was described in the midterm report, deliverable D2.2. At times this agenda had to be slightly altered in terms of timing of some events and also took into account new developments, needs and ideas. However, the main events were organized as in the original proposal plus those that were agreed upon after the consultations that NUSPRASEN SC opened in January 2017, as described in the D2.2 report.

The events planned in this period were, in time order:

- 15th **Russbach School on Nuclear Astrophysics**, March 18-24, 2018, Russbach, Austria
- **Carpathian Summer School of Physics 2018**, July 1-14, 2018, Sinaia, Romania
- **EURISOL Town Meeting**, July 2-4, 2018, Pisa (Italy)
- **WS on Explosive Nucleosynthesis**, Debrecen, Hungary; Sept. 12-14, 2018
- **WS on current and future experiments at GANIL**, Caen, France, Oct. 8-12, 2018
- **ECT* "Workshop on Indirect Methods in Nuclear Astrophysics"**, Trento, Italy, Nov. 5-9, 2018.

Below we shall give brief reports on each event in the list. Extended reports are available.

SECTION 1 TOPICAL WORKSHOPS

1.1 EURISOL Town Meeting

Website: https://agenda.infn.it/conferenceDisplay.py?ovw=True&confId=14402

The meeting took place in Pisa on July 2-4, 2018 with the goal to discuss and disseminate the recent progress, the ongoing physics and instrumentation developments, as well as the specific needs and future plans of the EURISOL community. These were recently expressed also by the EURISOL Distributed Facility initiative. This workshop was the subject of a detailed report D2.3 submitted in February 2019. We shall not repeat those details here, will only mention the main lines and results as the advancement of the EURISOL concept with the long-term goal of building a dedicated facility is of importance for the European nuclear physics community and, therefore, needs special attention. The organizers and the participants appreciated that it requires activities to continuously update the scientific case, shape the community, and strengthen the synergies with other facilities. A JRA EURISOL work package exists in

ENSAR2 and EURISOL networking activities were included in the NUSPRASEN network. The meeting was attended by 45 participants from 10 countries and consisted of 30 invited talks, several contributed posters and a round table. All slides presented at the meeting can be found at the EURISOL TM Web site https://agenda.infn.it/conferenceDisplay.py?ovw=True&confId=14402. After the meeting every speaker was asked to submit a short-written report on his/her contribution. These reports are included in the overall report from EURISOL TM, with D2.3.

1.2 The workshop "Nuclear Physics in Stellar Explosions"

Website: http://w3.atomki.hu/astro2018/
The workshop was organized in Sept. 12-14, 2018 at the Atomki institute, Debrecen, Hungary.

It is not difficult to understand the motivation behind this workshop: about 50% of the isotopes heavier than iron are synthesized in explosive nucleosynthesis scenarios. Namely, most probably the astrophysical r-process – which is probably still the least known nucleosynthesis scenario – takes place either in merging neutron stars or during the supernova explosion of massive stars. In such environment the temperature is of a few GK and the neutron density exceeds 10^{20} neutron/cm^3. Under such conditions the nucleosynthesis path runs far from the valley of stability, close to the neutron drip line. Furthermore, according to our current knowledge the stable proton-rich – so-called p-isotopes – are formed by photodisintegration reactions in the gamma-process and in series of rapid proton-capture reactions, close to the proton-drip line. This so-called rp-process takes place in X-ray burst. Nowadays, a large fraction of the isotopes involved into these nucleosynthesis scenarios can be produced in radioactive isotope beam facilities like RIKEN Nishina Center, FRIB or at FAIR/GSI. Furthermore, in order to study their properties, the development of cutting-edge detection systems is necessary. Therefore, the aim of the workshop was to review our knowledge on these nucleosynthesis processes and to discuss the current results in detector development and possible cooperation with high tech industry.

In 2.5 days of invited talks and presentations the workshop's topics were covered by 44 talks, sorted into 10 sessions. About 60 students, researchers and representatives from companies and research centers have attended the workshop from 10 European countries (including Croatia, Finland, France, Germany, Hungary, Romania, Spain, Swiss, Turkey and UK). ENSAR2 through its WP2-NUSPRASEN has granted the workshop partial financial support, that has been devoted for covering the local expenses (hotel staying + meal) of 29 participants. With the permission of the authors more than 80% of presentations are available at the webpage of the event (http://w3.atomki.hu/astro2018/#schedule). Furthermore, on the afternoon of Thursday the workshop participants visited the National Instruments factory and development center, located at Debrecen. This workshop was also supported logistically and financially by the COST action 016117 ChETEC "Chemical Elements as Tracers of the Evolution of Cosmos".

1.3 WS on current and future experiments at GANIL – GANIL Community Meeting

Website: https://gcm2018.sciencesconf.org/

The workshop took place in Caen, France on October 8th-12th, 2018 at the "Musée des Beaux Arts". This event was the first edition of a series of workshop that replaced the "Spiral2 week" meetings, and will be organized by GANIL. The purpose of the meeting was to bring together the whole low-energy nuclear physics community working with GANIL or similar facilities in Europe to discuss and define coherently future research programs. An important effort was made by the organizers to reach out to the international

users of the GANIL installation. The scientific program was organized around reviewing the state-of-the-art of the user research fields and the physics programs that they may develop in the upcoming 5-year time period at GANIL. To this end, a limited number of speakers were invited to, de-facto, act as spokesperson representative of a larger community. The presentations covered both experimental and theoretical programs related to GANIL covering the main topics identified by the organizers (Study of the N~Z nuclei, Nuclear structure at the shell closures, Nuclear dynamics, Study of Heavy Elements (Z>92), Application to the Nuclear Astrophysics, Atomic Physic, Giant collective modes, Phenomena at the particle threshold, Fundamental interactions). The status of the infrastructures (accelerators, spectrometers and instrumentation) was reviewed to disseminate to the conveners the progress of upgrade phase of GANIL. For every physics topic, a series of talks were given with the intent to answer/review:

- Open questions in the field
- SPIRAL2 Phase1 physics program
- Cyclotrons/SPIRAL1 physics program
- Challenges for nuclear physics theory (where applicable)

The NUSPRASEN sponsorship has enhanced the internationalization of the theory keynote speakers (43% non-FR of which 66% EU members) and by calling on the sponsored conveners to write a short scientific report based on their presentation, which will serve in a second step for the long-range plan of GANIL in the EU context. The goal of these scientific reports was to present the current status and future avenues of the different fields of nuclear physics covered during the GCM conference. The reports are currently being drafted and will be disseminated shortly to the nuclear physics international community. A major impact of this initiative is to contribute to the upcoming GANIL perspective for the next decade. These reports will essentially be early on material to the GANIL prospective developments.

Another positive benefit of the present initiative concerns fostering science. The NUSPRASEN initiative has positively impacted exchange between the keynote speakers and the main actors of their respective fields during the preparation of both their oral presentation and their report with the aim to present a broad picture of nuclear physics today.

1.4 ECT* “Workshop on Indirect Methods in Nuclear Astrophysics”

Website: https://indico.ectstar.eu/event/27/overview

The workshop was organized in Nov. 4-9, 2018 at the European Centre for Theoretical Studies in Nuclear Physics and Related Areas ECT*, Trento, Italy. ECT* is TNA10 in ENSAR2. The activity was proposed by an international group in May 2017 and approved by the ECT* Board in July, the same year. It proposed to bring together physicists working in various fields of, or close to, nuclear astrophysics. Theoreticians and experimentalists were to meet with the purpose of identifying stellar scenarios needing nuclear reaction data that make sizable difference in stellar evolution and the optimal methods to obtain them, to identify the most promising indirect methods in nuclear astrophysics, to discuss their specifics and to assess their reliability. Such discussions are crucial for reliably using indirect methods for nuclear astrophysics and even to validate the very existence of many Rare Isotope Beams facilities which rely on

them as one of as their main areas of research. Similarly, we wanted to review the importance of nuclear physics in cosmology and stellar evolution was another important objective.

The meeting succeeded in its major intention: to reunite scientists working in nuclear astrophysics, a research domain that now consists or is close to: nuclear physics for astrophysics, stellar dynamics, nucleosynthesis modeling, specific astronomy observations, cosmology. Talks were given to review the status of different subjects of common interest, as well as talks on detailed specific cases encountered in the use of indirect methods for nuclear astrophysics. There were talks on: nuclear astrophysics for practitioners, nuclear data needs, stellar dynamics, nucleosynthesis modeling, observations. Existing indirect methods in nuclear astrophysics were discussed: "the list" of indirect methods, their specifics, assessment of problems with their use, importance of calculated absolute values, codes, etc. Review of experimental methods, equipment and specifics as well as new facilities, including RIB facilities, and their nuclear astrophysics programs, were included. New directions were touched upon.

Over 30 participants registered to this event. 26 presentations of over 45 min each were given. The participants were mostly from Europe, but we had a reasonably large number of participants from USA, and from Japan and China. Three late cancellations were motivated by personal problems of the registrants (one each from China, Spain and USA). Two of their talks were successfully covered by other participants. The participants were mostly senior level scientists, but we had also 4 young students, of which 2 have presented communications of 20 min each. Among participants 7 were females.

The website of the event https://indico.ectstar.eu/event/27/overview was open in time by the ECT* staff and completed by our colleague dr. Alexandra Spiridon (IFIN-HH). Most of the lectures were posted online during the workshop https://indico.ectstar.eu/event/27/timetable/#20181105.detailed and will be completed with the materials that the authors agree to be made public.

Scientifically the most important achievements are presented above. The most important one, we stress again, was that specialists in various subjects met and talked. As the realm of nuclear astrophysics gets richer now, it is of paramount importance that we cooperate closely and that new connections are being formed among the specialists in its different sub-fields. Same importance has the fact that also theoreticians and experimentalists were talking to each other.

Another one important consequence may be considered that at the end of the workshop the participants decided to have another proposal for an ECT* workshop on key reactions in nuclear astrophysics and that a group of initiative was setup already.
The assistance from the local support staff of ECT* was excellent.
The support under ENSAR2 Networking Activity NuSPRASEN and TNA10 ECT* was an important contribution to the success of the workshop.

SECTION 2 THE EUROPEAN NETWORK OF NUCLEAR ASTROPHYSICS SCHOOLS CO-SPONSORED IN 2018

The European Network of Nuclear Astrophysics Schools (ENNAS) exists since 2012 and consists of an understanding between the organizers of three schools of tradition in Europe to associate in order "to correlate the topics and timings of the schools such that these schools become regular and well-established staples of the scientific environment in Europe and in the world" (citations from the MoU

signed). More on ENNAS is in the previous report D2.2. ENSAR2 supports these schools through NUSPRASEN, as co-sponsor, providing what the Organizers call “seed money”. This helps the Organizers to call for and obtain the support of other sponsors.

Two of ENNAS schools took place in the reporting period. We enclose below excerpts from the reports of their organizers on schools’ proceedings and results.

2.1 the 15th Russbach School on Nuclear Astrophysics in Russbach

Website https://indico.ph.tum.de/event/3845/

It was organized this year in the same village of Rußbach am Paß Gschütt, southeast of Salzburg, Austria. The school took place from **March 18 (arrival and registration)** to **March 24 (departure)** 2018 and was organized by a group from three institutions: GANIL, Caen, France, Universität Mainz and Technische Universität München, Germany. This winter / spring school was started in 2004 within the Helmholtz "Virtual Institute of Nuclear Structure and Astrophysics" (VISTARS; Director K.-L. Kratz)). Since 2014, it is endorsed by the European Physical Society through its Nuclear Physics Board as part of the "European Network of Nuclear Astrophysics Schools" (ENNAS). In the intervening time, the school has successfully grown and broaden so that its organization now also directly includes GANIL (O. Sorlin) and the Technische Universität München & Universe Excellence Cluster (S. Bishop).

In keeping its tradition, the 15th Russbach school has again brought together specialists from various sub-fields of "nuclear astrophysics", i.e. experimental and theoretical astronomy, astrophysics, nuclear physics and cosmochemistry, with the aim to raise mutual interest and to teach under- and post-graduate students, young postdocs, as well as senior scientists who want to be introduced to this interdisciplinary research field.

Apart from ENSAR2 (this year; 3500 Euro), the Excellence Cluster of TUM & LMU at Munich (this year; 3000 Euro), GANIL (this year; 4000 Euro) and IN2P3 (this year; 1000 Euro). With the end of the Excellence Cluster, we have just been informed this part of the financial support from TU Munich is no longer available in 2019. After the loss last year of the support from the University of Basel due the retirement of Prof. Thielemann, *the contribution from ENSAR2 was absolutely essential to keep the viability of the school*. The funds were used in priority to support all undergraduate and PhD students, as well as most of the young(er) postdocs for their twin-room accommodation, half board (breakfast & dinner) and the coffee breaks. In addition, one accommodation grant to senior scientist was given. No travel costs were reimbursed.

The school was hosted at the two hotels "Ausswinkl" (accommodation, breakfast, dinner) and "Waldwirt" (accommodation, breakfast, coffee breaks, rent of lecture room).

In 2018, there were in **total 63 participants** from altogether 10 countries – from Japan, USA, Iran to European countries as Italy, Germany, France, Romania, Hungary, Slovenia & Germany. 23 invited scientists gave **lectures** of 40 to 60 min, each; and 24 PhD students presented a total of **shorter contributions** of 15 min, each. Two lecturers cancelled at the very last moment.

By tradition of the Russbach school, there was no proceedings. However, the voluntarily handed in pdf-files of the contributions are available at the school’s website https://indico.ph.tum.de/event/3845/ .

2.2 Carpathian Summer School of Physics, CSSP18

Website: http://cssp18.nipne.ro/

The **Carpathian Summer School of Physics 2018 (CSSP18)** was held July 1st - 14th, 2018, in Sinaia, Romania, with **"Horia Hulubei" National Institute for Physics and Nuclear Engineering (IFIN-HH) Bucharest-Magurele** the sole institutional organizer of the school. It was the 28th edition of a long tradition. This year the title of the event was: **"Exotic Nuclei and Nuclear/Particle Astrophysics (VII). Physics with small accelerators"** and was the **7th** in the latest series with the same title organized in Mamaia (2005) and Sinaia (2007, 2010, 2012, 2014 and 2016) and keeping the topic "Physics with small accelerators", which was added in 2016. The additional flavor brought by the explicit inclusion of subjects related to physics with small accelerators (fundamental or applied research) turned out to be a plus again, because of the exchange of ideas that was facilitated thru the presence of people, experts or beginners, with different competences and interests.

The format of the latest editions was kept: the **first week** of the event was closer to a school-like format defined by a series of courses up to 2 hours each, aimed at graduate students, post-docs and young researchers. The **second week** had a conference-like format, with 1 hour invited lectures. Students and young researchers gave 20 min. short communications (distributed over both weeks). The first day (July 2nd) was dedicated to introductory lectures. Most of the topics related to applications were concentrated in the first week, which included also two days (July 5-6) reserved for the special sessions *"ELI-NP. Status and Perspectives"*. On this occasion many laser specialists from ELI-NP and from outside Romania, have joined the school.

Topics announced were like the ones of past editions, including accelerator applications explicitly:

- **Exotic nuclei**
- **Nuclear physics with RIBs**
- **Nuclear physics for astrophysics**
- **Stellar evolution. Neutron stars and supernovae**
- **Astroparticle physics**
- **Stellar and laser induced plasmas**
- **Physics at ELI-NP**
- **Applications at small accelerators**
- **Nuclear astrophysics with small accelerators**
- **Instrumentation**
- **Accelerators for medical treatments, radioisotope production and industrial applications**

Students from Romania, from the surrounding regions and all countries were invited to attend. A limited number of stipends (8 full + 4 partial) to cover the local expenses for students were available. In total there were 92 participants:

- 58 from Romanian institutions: 4 institutes, 2 universities and 2 companies
- 34 from institutions outside the country: 12 institutes and 21 universities

who presented 70 lectures and 18 student communications (oral, 20 minutes each).
On Saturday July 7 we had the traditional outreach session of the school with the subject: ***"How one prepares the next generation of scientists in the age of instant communication",*** where we invited guests from Romanian academia and media representatives.

Sponsors of the school were *IFIN-HH as organizing institution*, the *Romanian Ministry for Research and Innovation (MCI)*, ENSAR2 through *the NUSPRASEN network*, and the exhibitors *CAEN, Wiener, Canberra, Coralgon, Pfeiffer, BSI, Bruker, Total SpectruM, iseg, Quantech Works*.

CSSP18 was declared a success by all participants, appreciated both for the quality of science and organization. Participants recommended during the discussions in the Closing session, on Friday, July 14th:

- To continue this school with a new edition in 2020
- To continue its affiliation with ENNAS

See the website for the closing remarks:
http://www.nipne.ro/indico/getFile.py/access?sessionId=95&resId=0&materialId=0&confId=368

The volume of the Proceedings of CSSP18 was prepared and submitted for publication to the prestigious "AIP Conference Proceedings" series of the American Institute of Physics AIP Conference Proceedings, in Open Access. It is production right now and will be published by March 2019 as vol. 2076.

EVENTS PLANNED FOR 2019

In 2019 we have similar events planned. Among them:

16th Russbach School on Nuclear Astrophysics, March 10-17, 2019, **Russbach**, Austria

10th European School on Experimental Nuclear Astrophysics, Sep. June 16-23, **Catania**, Italy

All the above have only partial support from NUSPRASEN.

CONCLUSION AND OUTLOOK

The NUSPRASEN activity was in full swing in 2018. Its SC monitors the ongoing activities and prepares the future events in due time. The complete work plan has been established, completed and is regularly updated. All ongoing activities are in line with the schedule and the spending are in line with the planned budgets. The network website remains operational. Several workshop events, four in total, and two schools have taken place, Overall, the scheduled milestones have been reached and the one deliverable, D2.3, which was due in the reporting period, was submitted and accepted. The close interaction with facility/collaboration meetings is useful and increases synergies among the ENSAR2 work packages. More positive effects on community-facility interaction and user-group formation can be expected.