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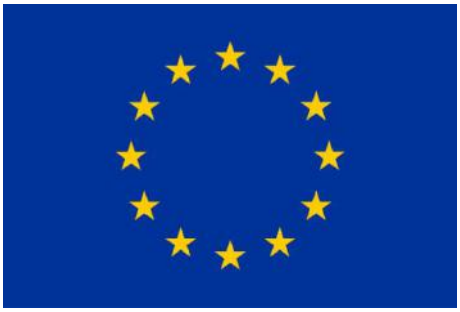

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EUROPEAN NUCLEAR SCIENCE AND APPLICATION RESEARCH 2

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REPORT ON WORKSHOPS IN MONTHS 1-12

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Disclaimer

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LIST OF ACRONYMS AND ABBREVIATIONS

ScC	Scientific Committee
SC	Steering Committee
WG	Working Group
NUSPRASEN	Nuclear Structure Physics, Reactions, Astrophysics and Superheavy Elements Network
NA	Networking Activity

EXECUTIVE SUMMARY

This is a report about the start of the works of ENSAR2-WP2: NUSPRASEN and on the first workshops organized or supported by it between March 1, 2016 and February 28, 2017. Explicitly is about the setup of organisms of NA2, the setup of its website and its working rules. Then we report on the NUSPRASEN workshop 1 (organized at CERN ISOLDE on Dec. 6, 2016) and the two ENNAS nuclear astrophysics schools it has co-financed (the 13th Russbach School on Nuclear Astrophysics in Russbach, Austria, March 2016 and the 27th Carpathian Summer School of Physics in Sinaia, Romania, in June – July 2016).

INTRODUCTION

The ENSAR2 start on March 1, 2016 has found the NUSPRASEN workgroup with an agenda partly fixed, partly to be agreed upon. And the participants had to work on adapting the initial agenda to the current timing. The first months were spent in setting up the working committees, their roles and the rules to follow in taking decisions.

SECTION 1 STARTUP ACTIVITIES, STEERING COMMITTEE AND ADJUSTED WORKSHOP PLAN

Steering Committee:

The Steering Committee (SC) was set up, which aims at coordinating and organizing the different activities and tasks. It comprises the following members: Angela Bonaccorso (U.Pisa, Italy), Maria Borge (CERN, Switerland), Peter Dendooven (KVI-CART, The Netherlands), Zsolt Fülop (Atomki, Hungary), Rodi Herzberg (U.Liverpool, UK), Ari Jokinen (U.Jyväskylä, Finland), Denis Lacroix (IPN-Orsay, France), Silvia Lenzi (U.Padova, Italy), Adam Maj (U.Cracow, Poland), Christoph Scheidenberger (JLU), Livius Trache (IFIN-HH, Romania).

The main goal of the activity is to organize meetings and workshops as outlined in the Grant Agreement. The SC will oversight and steer the whole networking activity as such. The SC will set up individual Scientific Committees (ScC's) for every planned event; these ScC's will comprise experts of the topical focus of the individual event and some NUSPRASEN SC members as liaison persons.

Adjusted workshop plan:

In its first meeting, the planned activities were discussed, on the basis of the NUSPRASEN work packaged description. There were events planned in the proposal and events that were to be decided later. In addition, the general new idea to attach at least some of the workshops to the regular collaboration meetings of the major facilities in Europe was accepted, in order to enhance participation mutually and to use all resources efficiently. A collection of possible events was prepared and the SC has elaborated an adjusted draft schedule of events. Especially the first events required additional adjustments: given the start of the project later than originally assumed, one could neither have the first workshop as a well prepared standalone event, nor in the middle of the summer holiday season, which had been the case if the original work plan had been pursued, not accounting for the delayed start of ENSAR2; therefore, it was decided to postpone it towards the end of 2016 and to have it, organizationally, as a satellite of one of the regular events of the European community of nuclear physics at low and intermediate energies, which the ENSAR2 consortium represents. Between the proposals we have chosen to schedule it on Dec. 6,

2016 in Geneva, such that many people could attend it and then join the CERN ISOLDE workshop of Dec. 7-9.
Besides, two nuclear astrophysics schools part of ENNAS were planned to be supported by NUSPRASEN as co-sponsor in 2016: the Russbach School of Nuclear Astrophysics 2016 and the Carpathian Summer School of Physics 2016. Both events took place at their traditional times and were not influenced (timewise) much by NA2 timing.

Below we report on these three events using the minutes and reports sent by the organizers to the Steering Committee of NUSPRASEN.

Website and logo:
An activity website was created, where basic information on NUSPRASEN is displayed (activity goals, past and future events, organization, integration in ENSAR-2), and an activity logo was prepared. Both, NUSPRASEN website and logo are found at http://www.uni-giessen.de/fbz/fb07/fachgebiete/physik/einrichtungen/2pi/ag/ag-scheidenberger/NUSPRASEN .

SECTION 2 THE NUSPRASEN WORKSHOP 1 AT CERN ISOLDE, DEC. 6, 2016

NUSPRASEN workshop 1 has taken place at CERN in the Council Chamber, on **6. Dec. 2016**, as a satellite meeting of the annual ISOLDE workshop. This has ensured minimal extra organizational effort and maximal attendance. Number of participants was 50-60 and all presentations were invited on topics agreed by the Scientific Committee of the event: Scientific Committee: Maria J. Garcia Borge, Zsolt Fülop, Silvia Lenzi, Riccardo Raabe, Christoph Scheidenberger, Livius Trache, Jennifer Weterings. Several presentations were made (10), followed by discussions. At the suggestion of the committee members at this workshop an extra attention was given to nuclear astrophysics.

The website of the meeting was available in advance for the information of the participants, for registration and further details: https://indico.cern.ch/event/577013/overview . It also includes the "Book of Abstracts".

The event was chaired by C. Scheidenberger. The notes below describe in detail the scientific points treated and the opinions of the participants. The event was a success, in form and substance.

Joaquin Gomez Camacho: Theory, astrophysics and small accelerators for ENSAR-2

The EPM (Equivalent Photon Method) can be used in different time-scales and excitation energies at various energy regimes (e.g. HIE-ISOLDE, GANIL, GSI). In general, this allows to tune strength (scattering angle) and time scales (energies). From a theory point of view, the EPM cannot describe low-energy Coulex experiments properly, as higher-order couplings are very important and a multi-channel calculation is required: EPM underestimates B(E2) values obtained at HIE-ISOLDE energies, (X)CDCC calculations should be used to analyse the data.

Opportunity: study electric susceptibility of nuclear media as a function of collision time.

Inclusive Coulomb break-up as a tool for astrophysics: can one directly measure astrophysical reaction rates? Measurements of inclusive Coulomb breakup at energies below the barrier and at forward angles should allow to estimate stellar temperatures. The region down to 2 GK can be probed with this method.

Small scale facilities in ENSAR-2: solid He targets for experiments with exotic beams are mentioned as an opportunity. Various target techniques are presented. Example of (4He,6He) to check long-range n-n correlations is given.

Alex Murphy: Direct and resonant reaction studies for nuclear astrophysics at HIE-ISOLDE

REX-ISOLDE capabilities are well matched to the needs of nuclear astrophysics, and presently there is more topics in reach. Several examples are given:

1) for the study of thermonuclear runaways in Novae and X-ray bursts: specific nuclear reactions can affect explosion onset, ejecta abundances, etc., e.g. the reaction 14O(a,p)17F, which may trigger break-out from hot CNO cycles, is expected to be dominated by a single 1^- resonance. Set up is CD system with MINIBALL array.

2) CC-Supernovae: general interest in these exciting events, lots of nuclear observables needed for understanding and modelling.

3) 44-Ti yield is consistently larger than predicted by models; with respect to nu-p process: 59Cu(p,alpha) is presently unmeasured. IS-554 is an approved ISOLDE proposal to address the cosmological lithium problem (7Li does not match observation).

Aurora Tumino: Trojan horse method for resonant reactions in nuclear astrophysics including recent results

Basic features of Trojan horse method, its application to resonant reactions, and two examples are presented: 18F(p,a)15O (= first Trojan Horse reaction with radioactive beam), experiments performed at RIKEN and TAMU; 12C(12C,a)20Ne, S-factor needs to be extrapolated over 3 orders of magnitude, and further uncertainties arise from resonances known in this region; further measurements down to 1 MeV will be important. In resonant reactions, the standard R-matrix approach cannot be applied to extract resonance parameters: instead, modified R-matrix is introduced. Advantages: measure down to zero energy, not affected by electron screening, calculation consistent with S(E)-factors.

Livius Trache: Recent results and future opportunities in laboratory nuclear astrophysics

Current directions comprise „direct measurements“ (like direct or inverse reactions) and „indirect methods“ (like Trojan horse or reactions with RIBs in „inverse kinematics“).

Installations: various opportunities at different facilities are outlined, the complementarity of different instrumental approaches for the interdisciplinary field of nuclear astrophysics and the large variety of needed nuclear physics input is stressed. Reliable theories are essential and provide valuable input to network calculations.

Planned NA activities in NUSPRASEN were presented.

Gabriel Martinez-Pinedo: Exotic nuclei in supernova evolution and r-process nucleosynthesis

Electron capture rates in CC supernova, challenging for theory, especially beyond N=40 (where EC transitions are suppressed, but correlations and finite temperatures counteract). Most relevant are nuclei around N=50. Various sites for r-process nucleosynthesis are discussed (CC supernova, n-star mergers, black-hole accretion disks). Fission yields play an important role in determining the final abundance pattern of dynamical ejecta.

Frederic Nowacki: Shell model far from stability: islands of inversion mergers

„Islands of inversion“ (n-rich isotopes around N=20...28 and N=40...50) are important to study, as in both cases the established islands of inversion (around N=20 and N=40) extend further up to the next magic neutron numbers. 78-Ni is of particular interest. Excitation energies (E_2+), BE2 values, binding energies are needed in the whole area to understand the development of collectivity. The physics around these magic or semi-magic closures depends on subtle balances between spherical mean field and the very large correlation energies of the open-shell configurations.

Gerda Neyens: Nuclear structure studies by the measurement of nuclear spins, moments and charge radii via collinear laser spectroscopy: results and perspectives

Collinear laser spectroscopy is a powerful technique, that can deliver nuclear moments, spins and mean square charge radii (relative to absolutely known ones) even for weak ion beams (intensities of several 10’s of ions per second). Various complementary measurement schemes exist (collinear, in cell, in jet, ISCOOL, etc., each adapted to production method/sensitivity/resolution/etc.). Experimental campaigns in last 15 years at ISOLDE yielded a wealth of nuclear structure physics results: shape coexistence/deformation, shell evolution (N=50 to beyond N=82), shell structure around Z=20/N=32 and close to 78-Ni and 100-Sn.

Future plans aim at transition regions between/towards closed shells, exotic doubly-magic nuclei, neutron-deficient proton emitters. Generally speaking, other probes are needed to complement the physics interpretation, as each observable probes different aspects of the nuclear structure: Coulex and transfer reactions, masses, decay spectroscopy, lifetime measurements, moments of exited states.

Sophie Peru: Mean field description on collective modes up to octupole in deformed nuclei

No further comments or observations.

Alejandro Algora: Shape effects from total absorption measurements

Shapes, nuclear moments, radii and gamma-ray spectroscopy yield very important nuclear structure information. Beta decay provides additional information and the strength distribution in the daughter nucleus depends on the shape of the parent. Total absorption spectrometers are highly efficient devices and avoid (largely) the incomplete solid angle coverage of germanium detectors, and thus the problem of beta-feeding (Pandemonium effect). Several examples are discussed: n-deficient Kr, Hg and Pb isotopes have been studied experimentally. Challenge: n-rich nuclei, where the neutron emission competes with (or even can exceed) gamma-ray de-excitation; this requires additional neutron detection via 4pi neutron

counters and/or ToF spectrometers for neutrons (as for instance BRIKEN setup for beta-delayed neutron measurements at BigRIPS)

Magdalena Zielinska: Recent achievements and future developments in Coulomb excitation studies

Coulomb excitation (Coulex), the population of excited states via purely electromagnetic interaction, is a well-established and widely used method to study transition probabilities, quadrupole moments and non-yrast states in exotic nuclei. Many nuclei/cases have been studied at HIE-ISOLDE already. Recent examples are presented (shape coexistence around N=60/100-Zr, deformation of 96-Sr, quadrupole moments and transition probabilities in 98-Sr, and several others)

Future developments and possibilities with HIE-ISOLDE and new detectors are addressed: a) the emission of conversion electrons can become very strong for E2 and M1 transitions in heavy nuclei; a new detector system for in-beam measurements (SPEDE) has been commissioned recently; b) a segmented silicon detector for Coulex experiments at SPES was commissioned at ISOLDE in July 2016.

CS/All: discussion and conclusion

General discussion, was felt very useful, new ideas for proposals were brought up, appreciated by community, the format (satellite) very synergetic and efficient and useful!!!
Call for proposals is strongly supported! (Pawel)
Livius: sum of physics/coherence is important
Maria: mixing of communities and ENSAR2-activities is important and stimulating
Thomas: what's next workshop?
Joaquin: integrate small facilities (into call)
Use ECT* for applications!
Also the „short but complete" format (with few, but high-level talks, theory-experiment, structure-astro-reactions) was received as very positive!

SECTION 3 THE EUROPEAN NETWORK OF NUCLEAR ASTROPHYSICS SCHOOLS CO-SPONSORED IN 2016

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 of the schools such that we assure best coverage and avoid unnecessary overlaps, while keeping their characteristics. Will set a network advisory committee to assist with this task;
- To correlate the timing of the schools such as they better serve the communities of scientists and of physics and astronomy students;
- To correlate the efforts to obtain seed money to fund these schools, by lobbying the EPS, EC funding sources, the national funding agencies, own institutions and any other sources, such that these schools will become regular and well established staples of the scientific environment in Europe and in the world."

To collaborate for providing the community with a coherent good coverage of nuclear astrophysics science: from the structure of exotic nuclei, to experimental and theoretical nuclear physics for

astrophysics, cosmochemistry, nucleosynthesis and star evolution modelling. To attract not only the best speakers, but be attractive for students and careful for their formation as the future generation of scientists in the field.

The ENNAS Memorandum of Understanding was signed in June 2012 by representatives of 7 institutions. The current members of ENNAS are:

- the **Russbach School on Nuclear Astrophysics, RSNA** (Russbach am Pass Gschütt, Austria)
- the **Carpathian Summer School of Physics, CSSP** (Sinaia, Romania)
- the **European Summer School on Experimental Nuclear Astrophysics, ESSENA** (Santa Tecla, Italy).

ENSAR2 supports these schools through NUSPRASEN, as co-sponsor. In the first 12 months of operation of ENSAR2, two such schools were supported:

- *the 13th Russbach School on Nuclear Astrophysics in Russbach, Austria, March 2016 and*
- *the 27th Carpathian Summer School of Physics in Sinaia, Romania, in June – July 2016.*

We enclose below the reports of their organizers on schools' proceedings and results.

Report to ENSAR2 – ENNAS - 13th Russbach School on Nuclear Astrophysics

From March 06 (arrival) to March 12 (departure) the "13th Russbach School on Nuclear Astrophysics" took place in Austria, region Dachstein West, at the village of Russbach am Pass Gschütt. 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 13th 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 postgraduate students, young postdocs, as well as senior scientists who want to be introduced to this interdisciplinary research field.
Apart from ENSAR2 (starting this year; 4000 Euro), from 2007 on the Russbach school has been sponsored by the University of Basel (5000 Euro), the Excellence Cluster of TUM & LMU at Munich (4000 Euro), GANIL (4000 Euro) and IN2P3 (2000 Euro). The funds were predominantly used 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, a limited number of accommodation grants to senior scientists from distant countries, e.g. USA, Japan & Australia 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).

This year, there were in **total ~60 participants** from 4 continents (from altogether 20 countries – from China, Japan & Iran to USA, and from Australia to Italy, France & Germany). 25 invited scientists gave **33 lectures** of 45 to 60 min, each; and 22 PhD students and young postdocs presented a total of **22 shorter contributions** of 20 to 40 min, respectively.

By tradition of the Russbach school, there will be no proceedings. However, the voluntarily handed in pdf-files of the contributions will soon be available at the conference website: http://www.universe-cluster.de/russbach2016. In addition, the 2015 site with program and lecture repository can also be seen at: http://www.universe-cluster.de/russbach2015.
The sponsors of the event are acknowledged below.

ENSAR2 has contributed with 4,000 euros to the event financing, through NUSPRASEN.

Prof. Karl-Ludwig Kratz
Dr. Olivier Sorlin
Prof. Shawn Bishop
Schools' co-directors
April 2016

Report on the Carpathian Summer School of Physics 2016

This edition of the Carpathian schools was held on June 26th – July 9th , 2016, in Sinaia, Romania. It was the 27th edition of a tradition that begun in 1964. This year the title of the event was:
"Exotic Nuclei and Nuclear/Particle Astrophysics (VI). Physics with small accelerators"
and was the **6th** in the latest series with the same title organized in Mamaia (2005) and Sinaia (2007, 2010, 2012 and 2014). This school is part of the European Network of Nuclear Astrophysics Schools (ENNAS), together with the **European Summer School on Experimental Nuclear Astrophysics, ESSENA** (Santa Tecla, Italy) and the **Russbach School on Nuclear Astrophysics, RSNA** (Russbach am Pass Gschütt, Austria). ENNAS is endorsed by the Nuclear Physics Board of EPS and is supported by ENSAR2, a project of the European Horizon 2020 program. These schools' organizers have created an established and recognized network of periodic events that responds to the need of preparing and educating the younger generations of physicists in the cross disciplinary fields of nuclear physics and astrophysics. Through consultations and somewhat overlapping International Advisory Committees we correlate and complement the topics of the schools, while keeping the specifics each has/had. As such, students from across Europe, and many times from other continents, can count on finding regular events to use in their preparation for scientific careers. Moreover, the settings of this school, and of the other

two, offer the opportunities for a good and direct dialogue between generations, in many cases better and more diverse than those of the class rooms, or established campuses.

This year we added additional flavour to the event through the explicit inclusion of subjects related to physics with small accelerators, fundamental or applied research subjects.

We remained faithful to the successful format of the latest editions: 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).

For this edition **"Horia Hulubei" National Institute for Physics and Nuclear Engineering (IFIN-HH) Bucharest-Magurele** was the sole organizer of the school.

Topics announced were similar to the ones in 2014, but included accelerator applications explicitly:

- **Exotic nuclei**
- **Nuclear physics with RIBs**
- **Nuclear physics for astrophysics**
- **Stellar evolution. Compact 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 (22) to cover the local expenses for students were available. In total there were 126 participants:

- 53 invited lecturers
- 55 students, who presented 23 oral communications.

(if you wonder why the numbers do not sum up, is because some were short term participants, who did not fit in either category). Two days (June 31st – July 1st) have been reserved for the special sessions *"ELI-NP. Status and Perspectives"*. Saturday July 2 we had the traditional outreach session of the school with the subject *"JINR Dubna at 60 and the internationalization of science"*, which was honoured by the participation of Prof. Mikhail Itkis, deputy director of JINR Dubna, Prof. B. Sharkov, scientific director of FAIR Darmstadt, prof. K. Langanke, scientific director of GSI Darmstadt, prof. I.I. Ursu, vice-president of ANCSI, Bucharest, other guests from Romanian academia, public and media representatives. The day was concluded with the traditional conference dinner, at a remote place in the mountains ("At Kingdom's Gate", Paraul Rece), where we found a nice sunset waiting for the buses who started from a rainy afternoon in Sinaia.
Between June 30 and July 2 a number of exhibits were open in the framework of the school: "JINR at 60" and exhibits from the 7 sponsors.

Sponsors of the school were *IFIN-HH as organizing institution*, the *Romanian National Authority for Scientific Research and Innovation (ANCSI)*, ENSAR2 through *the NUSPRASEN network*, and the exhibitors CAEN Quantech Works; Canberra Packard; *eNformation*; RomTek ELECTRONICS, WIENER CORALGON Instruments, Iseg; SERTO, SAES group, PFEIFFER VACCUM; tryamm. The event was endorsed by the European Physical Society, through its Nuclear Physics Board. Moreover, most of the participants were supported by their respective institutions, a fact which contributed to existence and the success of the school and which makes these institutions be our sponsors too.

One sign of appreciation was that CSSP16 was a success, appreciated both for the quality of science and organization. Participants recommended:

- To continue this school with a new edition in 2018
- To continue its affiliation with ENNAS
- The future editions to concentrate on physics at FAIR and ELI-NP.

The Proceedings of CSSP16 is being published again with the prestigious "AIP Conference Proceedings" series of the American Institute of Physics. With all the changes that the whole publishing environment goes through, due to the changes in the supporting media (from paper to electronic support) and to the changes in mores (fast and lots, competing with peer review), we could collect fewer articles (~50) than expected, especially from the young contributors. However, we believe that we could put together an interesting volume. The volume of the Proceedings starts with the information about the event and after that, the actual content is divided in three main parts:

- Part I Lectures
- Part II Communications
- Part III Closing matter

The lectures were grouped in chapters according to their subjects, as much as possible, even if they did not follow the original placement in school's sessions. The communications were ordered alphabetically after the name of the first author. Two communications were moved to the ELI-NP chapter to round that chapter.

ENSAR2 has contributed with 6,000 euros to the event financing, through NUSPRASEN. The funds were used to award fellowships to students (local costs only, no transportation).

Livius Trache, chair
On behalf of the CSSP16 Organizing Committee
Bucharest, December 2016

CONCLUSION AND OUTLOOK

The setup of the NUSPRASEN activity is completed: SC was established, website has been set up, complete work plan has been drafted. Also several activity events have taken place (kick-off meetings, schools in nuclear astrophysics, first workshop). Milestones have been reached (with minor delays, the reasons of which are explained above). The Steering Committee is active in the organization of the

different initiatives and meeting. Towards the end of the reporting period, a “call for proposals” was launched, which is an activity that will support to put the workshop program on an even broader basis within the ENSAR-2 community; the outcome will be reported in the next report.