Physics Cases and Instrumentation for the EURISOL-DF, next step towards Eurisol

Report of Contributions

Contribution ID: **2** Type: **Innovative Instrumentation for EURISOL-DF**

Instrumentation Physics Cases and for EURISOL- DF, the next step towards EURISOL

Starting from the commercialization of LaBr3:Ce scintillators, approximately 10 years ago, a new generation of high performing scintillator detectors began to be available (CeBr3, CLYC, CLLC, CLLBC, Co-Doped LaBr3, …). These new scintillators provide good energy resolution, much better than that provided by NaI, an excellent time response, large volumes (and therefore good detection and full energy peak efficiencies), particle identification, neutron spectroscopy in particular conditions and, potentially, they provide good position sensitivity which could be used to reduce the Doppler Broadening effect when used in reaction studies.
For example the CLYC scintillator (now available in 3"x3" volume) provides a much better energy resolution than NaI and an excellent timing. In addition Pulse Shape Discrimination (PSD) gives a very clean neutron identification. When the CLYC is enriched with 6Li it has very high efficiency for thermal neutron detection while if enriched with 7Li it permits the direct measurement of the neutron kinetic energy from the energy pulse signal.
These types of detectors, however, cannot compete with HPGe excellent high resolution and tracking performances (as for example AGATA) but, because of the much lower price, the simplicity of maintenance, the large volumes, the excellent time and PSD performances can be used in several physics case where HPGe are not optimal o more in general together with HPGe arrays. In particular, they can be used, for example, to measure i) high energy gamma rays (large volumes are important, ii) gamma rays in an extremely noisy background and thus the time resolution can be exploited for its reduction, iii) where the level density is low or where iv) neutron identification and spectroscopy is needed. In terms of physics cases scintillator can be used to measure collective properties of nuclei and first excited levels in extremely exotic nuclei where efficiency and 'time determination or PSD cleanliness are more important than energy resolution.

Primary author: Prof. CAMERA, Franco (Università di Milano and INFN section of MIlano)

Presenter: Prof. CAMERA, Franco (Università di Milano and INFN section of MIlano)

Contribution ID: **4** Type: **The formation and structure of r-process nuclei**

The formation and structure of r-process nuclei

The astrophysical rapid neutron capture process, the r process, has produced around half of the elements heavier than iron but yet its astrophysical sites are not well known. Neutron star (NS) mergers (either NS-NS or NS-black hole), which can eject synthesized material either dynamically during the merger or from the accretion disks around the central remnant, are currently considered as the most promising r-process sites. In addition to mergers, neutrino-driven winds from proton-neutron stars resulting from core-collapse supernovae may contribute via the weak r-process. Alternative scenarios, such as magnetorotational supernovae, have also been suggested to explain the observed r-process pattern in very old (low metallicity) stars for which the binary mergers evolve too slowly.

The formation of the r-process nuclei and the calculated r-process abundances depend strongly on the properties of neutron-rich nuclei, such as their binding energies (masses), beta-decay half-lives and neutron-capture rates. Recently, several r-process sensitivity studies on these properties have indicated that the nuclei near the closed neutron shells at N=82 and N=126 corresponding the second and third r-process peaks have the highest impact. In addition, the formation of the rare-earth peak is very sensitive both to nuclear structure effects in the mid-shell region around N=104 and to the astrophysical environment. In summary, increasing our knowledge of neutron-rich nuclei provides essential data both for understanding the evolution of nuclear structure as well as for constraining the r-process calculations and ultimately the r-process site(s).

In this talk, I will review the formation and structure of the r-process nuclei, and discuss possibilities within the EURISOL-DF and its partner facilities to further our knowledge on this topic.

Primary author: KANKAINEN, Anu (University of Jyväskylä)

Presenter: KANKAINEN, Anu (University of Jyväskylä)

Contribution ID: **5** Type: **Innovative Instrumentation for EURISOL-DF**

The (hot) r-process scenario: from reaction equilibria to kilonovae

The cosmic site of the rapid neutron capture process (r-process) is still unkown, although recent observational evidence supports compact binary mergers (CBMs) as the main source for r-process nuclei in our universe.
The very neutron-rich dynamical ejecta in CBMs host a hot r-process where local (n,g)-(g,n) equilibria are established, leading to robust nuclear compositions that primarily depend on the nuclear properties (e.g., masses).
When the local equilibria freeze out and the composition starts decaying to stability, late-time effects related to fission can alter the abundance pattern considerably. Finally, radioactive decays on timescales of days to weeks power an electromagnetic afterglow that could possibly be observed as a macronova/kilonova.
In this talk, the hot r-process scenario is reviewed on the example of dynamical CBM ejecta, with a focus on the impact of nuclear masses and reaction rates on observables.

Primary author: Dr EICHLER, Marius (TU Darmstadt)

Presenter: Dr EICHLER, Marius (TU Darmstadt)

Contribution ID: **7** Type: **Probing fundamental symmetries and interactions with RIBs**

Probing fundamental symmetries and interactions with RIBs

There are wide variety of experiments pursuing testing and probing fundamental symmetries requiring accelerator time. In this talk I will give an overview of a selection of these experiments focusing e.g. on Standard Model tests and neutrino physics through nuclear observables like half-life, decay branching ratios and atomic masses.

Primary author: ERONEN, Tommi

Presenter: ERONEN, Tommi

Contribution ID: **8** Type: **Probing fundamental symmetries and interactions with RIBs**

Identified applications of the ISOL@MYRRHA facility in phase 1

Studies of radioactive ion beams reveal promising possibilities for forefront research programs in various areas fundamental and applied physics. The ISOL@MYRRHA project suggests to incorporate an ISOL (isotope separation on line) installation into an Accelerated Driven System (ADS), called MYRRHA (a Multipurpose hYbrid Research Reactor for High-tech Applications) to be built in SCK-CEN (Mol, Belgium). The ISOL@MYRRHA will be particularly suited for high-precision, high-statistics experiments because of the peculiar availability of long uninterrupted beam times and the high reliability of the MYRRHA accelerator. In 2009, the physics program for ISOL@MYRRHA has been realized. Based on the revision and update of this proposal, we identify the physics cases suitable for the first phase of ISOL@MYRRHA, which will make use of 100-MeV proton beam of the MYRRHA accelerator. The research program encompasses topics in nuclear physics, fundamental interactions, solid-state and atomic physics, as well as applications for nuclear medicine. This presentation will discuss the scientific case of the ISOL@MYRRHA facility with emphasis on the physics cases that can be addressed in the first phase of the project.

Primary authors: Dr CHEREDNIKOV, Igor (SCK-CEN); Dr GHYS, Lars (SCK-CEN); Dr POPESCU, Lucia-Ana (SCK-CEN); BRIX COLLABORATION

Presenter: Dr CHEREDNIKOV, Igor (SCK-CEN)

Contribution ID: **9** Type: **Going to the limits of mass, temperature, spin and isospin with heavy Radioactive Ion Beams**

Dynamical aspects of nuclear structure under extreme conditions

Nucleus-nucleus collisions at low and intermediate energies allow one to produce nuclear systems under extreme conditions of excitation energy, density, spin and isospin asymmetry. During the dynamical evolution of these systems nuclear structure manifests itself with correlations between two and more particles that can be studied experimentally by good characterization of the collision event, provided by large solid angle detector setups, and by exploring invariant mass spectroscopy techniques and intensity interferometry. In this context the limits of nuclear existence as a function of a number of parameters can be studied and insights on the equation of state and the symmetry energy can be revealed.
In this field, nuclear structure and dynamics are strongly interconnected. Indeed, in the dilute and hot medium produced during the collisions structure properties of unbound and, often, exotic states can be studied. Some of these structure properties include decay energies, branching ratios and the spin of particle unbound states. Such in-medium properties probe a quantum N-body system composed by nucleons clusters dynamically evolving in a dilute and hot medium. They are thus sensitive also to the equation of state for asymmetric nuclear matter. Example of such studies that point to both dynamics and structure on nuclear systems under extreme conditions are presented with results from high resolution and high solid angle arrays, such as Indra@GANIL, Fazia@LNS, Lassa@MSU. Perspectives with radioactive beams at low and intermediate energies relevant for the Eurisol DF project will be discussed.

Primary author: Mr VERDE, Giuseppe (IPN Orsay & INFN Catania)

Presenter: Mr VERDE, Giuseppe (IPN Orsay & INFN Catania)

Contribution ID: **10** Type: **Innovative Instrumentation for EURISOL-DF**

Status and future prospects of the PHOENIX ECR Charge Breeder

Electron Cyclotron Resonance Ion Sources (ECRIS) are used as charge breeders (CB) to increase the charge state of Radioactive Ion Beams (RIB). ECRIS CB can easily capture and multiionize large intensities of incoming 1+ RIB; but the operating pressure of the plasma and the plasma interaction with the chamber wall generate ion beam background which can spoil the RIB signal. As a consequence, a high mass resolution is required downstream to separate the signal from the background. In order to facilitate and enhance the ECRIS CB usage, the LPSC team is committed to reduce the ion beam background from ECR charge breeder, increase the production of high charge state and improve 1+N+ RIB conversion efficiencies. The development plan to reach such goals is presented, consisting in the design of a modified PHOENIX CB equipped with a large plasma chamber, an improved magnetic confinement, an improved vacuum and a rationalized material use to reduce condensable contaminant elements as much as possible.

Primary authors: THUILLIER, Thomas; ANGOT, Julien (CNRS - IN2P3)

Co-authors: BAYLAC, Maud (LPSC); JACOB, Josua (LPSC / CNRS); BONNY, Laurent (LPSC / CNRS); SOLE, Patrick (LPSC / CNRS); LAMY, Thierry (LPSC Laboratoire de Physique Subatomique et de Cosmologie (LPSC))

Presenters: THUILLIER, Thomas; ANGOT, Julien (CNRS - IN2P3)

Contribution ID: **11** Type: **The formation and structure of r-process nuclei**

Spectroscopy investigation of the 78Ni region: Potential avenues for a joint effort within EURISOL-DF

The ISOL mode of production of radioactive ion beams (RIB) is —for the time being—the only one which can provide the beam optical qualities that allow employing the whole set of the most refined techniques for optical, mass, γ, particles spectroscopy and spectrometry. At very low beam energies, three main measurement domains, exploiting (*i*) beam manipulation by electromagnetic traps, (*ii*) interaction with the hyperfine field and (*iii*) spectroscopy of β-delayed emission products are areas of excellence of ISOL facilities. Furthermore, with post-accelerated beams, precise direct nucleon exchange reactions and multiple coulomb excitation measurements are achievable in the most favorable conditions. Precision is the main asset of measurements within ISOL RIB-production conditions. Not only precision of the measurement itself, but precision in the comparison with theory they can provide: unambiguous determination of the total angular momentum of the nuclear states, information of the configurations involved, or precise knowledge of the mass relationships between neighbor nuclei for instance, provide key, unique insights into the nuclear structure.

The ^{78}Ni region is in the present focus of nuclear structure investigations worldwide. While it is clear that fragmentation facilities remain (and will remain for a while) unchallenged for first, discovery spectroscopy, cutting edge experiments continue to be performed at European presently operated ISOL facilities, like ISOLDE/CERN, IGISOL/JYFL and ALTO, in this mass region, with the highest level of scientific outputs. For instance, the first experimental evidence of shape coexistence in the ^{78}Ni could not have been understood without joining information from mass measurement at IGISOL, laser spectroscopy at ISOLDE, and EC spectroscopy at ALTO. Starting from this recent example I will elaborate further what could be a possible way towards a joint, ISOL-based investigation effort to understand the $N = 50$ shell gap evolution and the structure of the ^{78}Ni region, extended also to possibilities offered by high-quality post-accelerated beams at HIE-ISOLDE and SPES.

Primary author: Dr VERNEY, David (Institut de Physique Nucléaire, CNRS-IN2P3, Univ. Paris-Sud, Université Paris-Saclay)

Presenter: Dr VERNEY, David (Institut de Physique Nucléaire, CNRS-IN2P3, Univ. Paris-Sud, Université Paris-Saclay)

Contribution ID: **12** Type: **Physics of Light Exotic Nuclei**

CERN-MEDICIS, an overview.

Approximately half of CERN protons are directed onto ISOLDE targets, producing radioactive beams by online mass separation for a wide range of studies in fundamental and applied physics. However, the vast majority of these protons end up being sent to a beam dump. The CERN-MEDICIS project envisages to re-use this fraction of (otherwise) lost protons to irradiate various types of secondary targets, retrieving them later for isotope collections for R&D in life sciences and medical applications.

The construction of a dedicated facility is nearing completion, and isotope production will start progressively from the end of 2017 onward. It is expected to provide GBq-level of isotope batches, purified by electromagnetic mass separation combined with chemical methods, collected on a weekly basis. Different institutes distributed across Switzerland, and other countries in Europe, have joint a starting collaboration that regroups various fields of expertise to perform so called translational research in medicine.

The FLUKA Monte Carlo particle transport and interaction code was used at every stage of the project, from early target design and isotope inventory to shielding calculations for the facility at every design stage. The current work details some of the different simulations performed throughout the different stages of the project.

Primary authors: Mr AUGUSTO, Ricardo (CERN & LMU); CERN-MEDICIS COLLABORATION

Presenter: Mr AUGUSTO, Ricardo (CERN & LMU)

Contribution ID: **13** Type: **Going to the limits of mass, temperature, spin and isospin with heavy Radioactive Ion Beams**

Nuclear Fragment production and identification at Fermi energies

The efficient detection and the good identification of the many nuclear species emitted in heavy-ion reactions at Fermi energies are important to disentangle the various reaction mechanisms and to progress in the knowledge of the nuclear equation of state and in the search of in-medium effects on the decay properties.
Due to the rich variety of fragments and their wide emission phase space, it is valuable the use of detectors well performing in terms of isotopic discrimination and angular coverage, possibly in a flexible way. Such features can represent a bonus not only for current or short-term studies but also in view of next RIB facilities, in particular these reaching the typical cyclotron energies.
The european FAZIA collaboration (France, Italy, Poland) has developed in the recent past a new kind of detector module, offering unprecedented detection capability and original solutions as far as the front-end-electronics, the slow-control and the DAQ systems are concerned. 12 FAZIA modules are in construction, each of them being made of 16 three-layer solid-state telescopes, for a total of 192 devices

Primary author: Dr CASINI, Giovanni (INFN SEzione di Firenze)

Presenter: Dr CASINI, Giovanni (INFN SEzione di Firenze)

Contribution ID: **14** Type: **Physics and astrophysics of neutron deficient nuclei**

$alpha$-elastic scattering in inverse kinematics for the astrophysical p-process

Over the past years, several sensitivity studies [1 - 4] have been performed in order to identify the uncertainties caused by the nuclear input in reaction networks aiming at describing the production of the p-nuclei. All studies indicated a strong dependence of the final abundance distribution of the heavy p-isotopes on the α-nuclear potential, highlighting the strong need of characterising α-particle induced reactions. Despite the astrophysical p-process, α-particle induced reaction cross sections play an essential role under certain r-process conditions [5 - 7], and well as in the αp-process [8].

Recent developments in target production [9,10] allow for the measurement of α-particle induced reactions in inverse kinematics, opening a new window in the study of α-nuclear interactions with exotic beams at low energies. Due to the lack of experimental data in the region around the heavy p-nuclei, uncertainties in the astrophysical modelling of the p-process are still dominated by the α-nuclear potential. The use of radioactive beams in this mass region at energies around the Coulomb barrier surrounded by position-sensitive charged particle detectors provides an unique opportunity to validate models and to reduce the uncertainties in the nuclear potential, and consequently of the astrophysical modelling.

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Primary author: GALAVIZ REDONDO, Daniel (LIP Laboratorio de Instrumentacao e Fisica Experimental de Part)

Presenter: GALAVIZ REDONDO, Daniel (LIP Laboratorio de Instrumentacao e Fisica Experimental de Part)

Contribution ID: **15** Type: **Innovative Instrumentation for EURISOL-DF**

The EURISOL facility - radiation protection and radiation shielding issues - A review

The EURopean Isotope Separation On-Line Radioactive Ion Beam (EURISOL) is the next-generation facility for the production of Radioactive Ion Beams (RIBs) using the ISOL method in the European Union.
To produce the RIBs in the EURISOL facility a proton beam of 1 GeV (4 MW power) impinges on a converter, generating, through spallation reactions, intense neutron fluxes with peak values of the order of 5x1015 neutrons/cm2/s.
The design of the EURISOL facility and associated infrastructures as well as instrumentation involves the consideration of scientific, technological and engineering leading-edge and multidisciplinary topics due to the exposure of of the system components to extremely high neutrons fluxes and doses. Therefore, the system needs to be carefully designed from the radiological protection and safety point of view, taking into account the thermal and mechanical properties of the structural materials and the requirements for handling and maintenance of the critical components (targets), during operation and after shutdown. This paper provides a review of the neutron fluxes and radiation doses measured in current generation facilities and presents an estimation of the fluxes and doses foreseen for the EURISOL facility.

Primary authors: Prof. MIRAGAIA TRANCOSO VAZ, Jose Pedro (Instituto Superior Técnico); Mr LUÍS, Raul (Instituto de Plasmas e Fusão Nuclear); ROMANETS, Yuriy (Instituto Superior Tecnico (IST))

Presenter: ROMANETS, Yuriy (Instituto Superior Tecnico (IST))

Contribution ID: **16** Type: **Physics of Light Exotic Nuclei**

Physics with light exotic beams

The region of the nuclear chart corresponding to light nuclei has, over the years, yielded many surprising results, among others the discovery of the halo structure in the neutron dripline nuclei. This region of the nuclear chart is also rich of many other phenomena like the appearance of molecular-like structures where α-particle-clusters are bound together by the exchange of neutrons or the existence of cluster configurations where at least one of the clusters is a weakly bound nucleus.
The availability of post-accelerated radioactive ion beams in the 1-20 MeV/u region will open new opportunities to study the atomic nucleus as nuclear reaction studies below and above the Coulomb barrier will become possible. These studies should result in physics observables that can be compared to state-of-the-art theory and advance our understanding of the nuclear structure and reaction dynamics.
In this talk an overview of some of the new phenomena involving light exotic RIBs will be given and future perspectives discussed.

Primary author: Dr DI PIETRO, Alessia (INFN-Laboratori Nazionali del Sud)

Presenter: Dr DI PIETRO, Alessia (INFN-Laboratori Nazionali del Sud)

Contribution ID: **17** Type: **Innovative Instrumentation for EURISOL-DF**

New detection systems for direct reaction studies in Europe

In the experimental study of direct reactions with radioactive-ion beams, several techniques can be implemented for the detection of the reaction residues, such as highly segmented Silicon detectors, active target, or a solenoid with its associated detection. I will briefly present and discuss the 3 techniques which are currently the subject of ambitious developments in Europe.

Primary author: BEAUMEL, Didier (IPN Orsay)

Presenter: BEAUMEL, Didier (IPN Orsay)

Contribution ID: **18** Type: **Going to the limits of mass, temperature, spin and isospin with heavy Radioactive Ion Beams**

Search for shape isomers by using sub-barrier transfer reactions with radioactive beams

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For the collaboration:
S. Leoni et al., *University of Milano and INFN sez.-Milano, Italy*
B. Fornal et al., *Institute of Nuclear Physics PAN, Krakow, Poland*
N. Marginean et al., *IFIN HH, Bucharest, Romania*
M. Sferrazza, *Universitè libre de Bruxelles, Bruxelles, Belgium*
T. Otsuka et al., *University of Tokyo, Tokyo, Japan*

The phenomenon of shape isomerism is related to the existence of a high barrier in the nuclear potential energy surface (PES), separating the primary energy minimum (the ground state) from a secondary energy minimum at large deformation. Shape isomers at spin zero have clearly been observed, so far, only in actinide nuclei - they decay mainly by fission, although in two cases, ^{236}U and ^{238}U, gamma-ray branches with very retarded transitions are known [1,2]. Recently, we have identified a shape-isomer-like structure at spin zero in a very light nucleus ^{66}Ni by using gamma-ray spectroscopy and employing the two-neutron transfer reaction induced by an ^{18}O beam on a ^{64}Ni target, at the sub-Coulomb barrier energy –the experiment was performed at the Tandem Accelerator Laboratory of the IFIN HH in Bucharest [3]. The study was inspired by various mean-field theoretical approaches [4,5,6] as well as by the state-of-the-art Monte Carlo Shell Model Calculations [3]: the ^{66}Ni nucleus turned out to be the lightest nucleus for which all models indicate the existence of a pronounced secondary prolate PES minimum. Our finding, by showing that shape isomerism is characteristic not only for very heavy nuclei, sheds light on the microscopic origin of nuclear deformation.
Shape isomerism at spin zero is expected to be a more common phenomenon. In fact, the mentioned mean-field theoretical models [4-6], as well as the recently published macroscopic-microscopic calculations [7], predict relatively deep secondary PES minima in nuclei in few other regions of the nuclear chart. For example, such minima associated with a sizable deformation should exist in nuclei Pt, Hg and Pb with neutron number around N=110, and in Pd, Cd and Sn with N$\sim$66. A possibility will be discussed for identifying gamma decay out of these minima, by employing two- and one-neutron or two- and one-proton sub-barrier transfer reactions induced by radioactive beams of Tl from HIE-ISOLDE and Ag from SPES, on stable targets.

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Primary author: FORNAL, Bogdan (IFJ PAN, Krakow)

Presenter: FORNAL, Bogdan (IFJ PAN, Krakow)

Contribution ID: **19** Type: **Physics and astrophysics of neutron deficient nuclei**

Microscopic description of proton emitters

1 India Institute of Technology, Roorkee, India
2 CeFEMA/Instituto Superior Técnico, Lisboa, Portugal
3 INFN and Dep Fisica, University of Padova, Italy
4 Technical University of Munich, Germany

Explaining the properties of exotic nuclei is a challenging task, but one can obtain information about the nuclear structure and the residual interaction, at the limits of stability. We undertake such investigation pertaining to proton emitting nuclei with the aid of available data. Apart from building a robust nuclear model, this task is motivated by other crucial implications of proton emitters in nucleosynthesis and in astrophysics [1,2,3]. Microscopic studies of proton emission can provide detailed information about the structure and decay, in a unified way. With such studies, in most of the cases, we can unambiguously ascertain the configuration of the proton emitting states.

In a microscopic approach, the decay width is calculated from the overlap of parent (particle+core) and daughter (core) wave functions. In this regard, with the inclusion of Coriolis interaction, the nonadiabatic quasiparticle approach is quite successful to unveil the structure and decay properties of proton emitters [4,5,6]. The recent extensions of our approach are multifaceted including the cases of odd-odd nuclei and triaxial nuclei [7,8]. For the first time the covariant density functional theory has been utilized to calculate the decay width of proton emitters [9]. Having such a versatile tool, employing microscopic meson-baryon interactions and well tested by explaining low lying exited states in exotic nuclei, opens up new avenues in the understanding of nuclear forces.

The progress in this direction will be reviewed, having in mind possible applications to future data obtained in the facilities discussed in the meeting.

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Primary authors: ARUMUGAM 1, Paramasivan (India Institute of Technology Roorkee, India); Prof. FERREIRA 2, Lidia S. (CeFEMA/Instituto Superior Técnico); MAGLIONE 3, Enrico (INFN and Dep Fisica, Univ Padova, Italy); RING 4, Peter (Technical University Munich, Germany)

Presenter: ARUMUGAM 1, Paramasivan (India Institute of Technology Roorkee, India)

Contribution ID: **20** Type: **Innovative Instrumentation for EURISOL-DF**

Neutron detectors for new physics opportunities

Neutron detectors are used extensively at almost every nuclear research facility across Europe and play a key role in the investigation of nuclear phenomena: in nuclear structure, for decay studies and as ancillary detectors for powerful in-beam spectroscopy arrays; in nuclear reactions, for the identification of the reaction channels and reconstruction of the complete kinematics; in nuclear astrophysics, for determining the neutron emission probabilities; in nuclear medicine and radioprotection, as radiation monitors and dosimeters; in material science, for neutron imaging techniques; in nuclear technologies and security applications, for the identification of fissile materials and cargo inspection.

The physics oppportunities and characteristics of the new or upgraded facilities are demanding more powerful instrumentation which exploits their full potential. An overview of the actual neutron detection techniques and the last generation of detectors in operation worldwide will be provided. In addition, a highlight on various neutron detector R&D programs and related areas will be presented. As a summary, a global view of what instrumentation could be available or constructed for EURISOL-DF will be provided.

Primary author: Dr DANIEL, Cano Ott (CIEMAT)

Presenter: Dr DANIEL, Cano Ott (CIEMAT)

Contribution ID: **21** Type: **Physics and astrophysics of neutron deficient nuclei**

Physics and astrophysics of neutron deficient nuclei

The neutron deficient nuclei around the N=Z line are the ideal laboratory to investigate some part of the nuclear interaction like pairing, shell closure and the degrees of freedom related to the nuclear deformation. In addition, some of the N=Z nuclei close to the proton drip-line are waiting point of astrophysical processes and their nuclear structure is relevant in the predictive power of such calculations. In this presentation, nuclear structure of nuclei in the region of the Se-Kr to Pd will be discussed in the framework of the shape coexistence.

Primary author: CLEMENT, Emmanuel (GANIL)

Presenter: CLEMENT, Emmanuel (GANIL)

Contribution ID: **22** Type: **The formation and structure of r-process nuclei**

Experimental studies related to the r and i-process nucleosynthesis

The r-process nucleosynthesis is responsible for the production of about half of the nuclei beyond Fe in the universe. The location for their formation is still debated, but seems to originate from neutron star mergers. From the observation of r abundance peaks connected to shell closure, it is clear that the structure of some key nuclei located there plays an essential role to understand the r-process nucleosynthesis, to better constrain its condition in terms of time scale, temperature and neutron density. Recent observations in metal-poor stars, as well as in few dwarf galaxies, reveal (weakly mixed) signatures of early r-process signatures, which should be confronted to stellar processes and chemical evolution. Besides the main component of the r process, an intermediate component (i process) has been identified recently, pointing to the production of nuclei in neutron density conditions between the slow process and the r process. If confirmed, this discovery will enlarge the need of experimental nuclear data in between the valley of stability and the nuclear drip line. After a brief introduction on the recent stellar observations and on the processes that can produce and eject neutron-rich nuclei, I will focus on the properties that should and can be studied in terrestrial laboratories to reach a better understanding of r and i process nucleosynthesis, such as in particular neutron capture cross sections and beta-decay studies.

Primary author: Dr SORLIN, olivier (GANIL)

Presenter: Dr SORLIN, olivier (GANIL)

Contribution ID: **23** Type: **Physics of Light Exotic Nuclei**

Light nuclei, challenges and experimental tools

Light nuclei are a great playground for Nuclear Physics Studies. It is a very attractive field of research as one can reach at the different Facilities all the bound isotopes for each chemical element and even peer in the unbound systems. In addition, the Q-beta value for many of these nuclei reach values near 20 MeV opening a large window for beta-decay studies. Due to their different chemical properties, their study has been in different facilities being the ISOL –ones those where the high-resolution studies can be done due to the good beam optics and higher intensities of the radioactive beams.
Near the dripline the light nuclei reach the most asymmetric N/Z bound systems. Therefore, the most exotic beta-decay have been observed in these nuclei. The recent process in beta-delayed multi-particle emission will be revised with emphasis in the experimental tools.
Furthermore, some of these light nuclei enter in the CNO and other cycles responsible for the abundances of elements below iron. Many of the nuclei participating in these processes have extremely complex decays that involve multiple decay modes. A good knowledge of the different decay branches is of great interest for nuclear astrophysics. The relatively low Q-value for particle emission made the population of levels close to particle emission available by beta decay. At the threshold of particle emission, the interplay of nuclear forces combined with structure, and electromagnetic interaction is determined by the partial decay branches for charged particles and gamma-emission. The partial decay widths have been addressed in a few cases.
The discovery of the halo structure in some of the light systems gave an extra push to the field. The importance of the continuum in the modeling of the reaction process with these nuclei have been clearly established. In fact, the beta-delayed deuteron emission by the halo nuclei also required the contribution from the continuum. To elucidate this anomalous decay beta delayed proton emission has been studied from the 1n-halo 11Be. In addition, the structure of the 2n-halo nuclei can only be understood from the 1n-less processor which structure, i.e. 10Li or 13Be, for instance, are still an open question.
In this presentation, I will present a few examples of results from ISOLDE with emphasis in the advantages of ISOL-method to do this type of studies

Primary author: Prof. G. BORGE, Maria J. (IEM-CSIC)

Presenter: Prof. G. BORGE, Maria J. (IEM-CSIC)

Contribution ID: **24** Type: **Physics and astrophysics of neutron deficient nuclei**

Probing isospin non-conserving forces in nuclei through studies of isospin triplets

Isospin symmetry is fundamental in nuclear physics. In the case that the proton and neutron were identical particles with the same charge, then excited states in mirror nuclei would have identical excitation energies. In reality, the pp-, nn- and np-interactions are not identical which leads to small differences in excitation energy of states of order of 10s of keV. These small differences provide important insights into the details of the nuclear force. For T=1 isospin triplets, it is possible to construct mirror energy differences (MED) - the difference between excitation energies in the Tz = -1 and +1 nuclei, and triplet energy differences (TED) which incorporate the differences between excitation energies in all three systems. For TED, which are isotensor energy differences, the single-particle contributions cancel. Since contributions involving Coulomb effects are readily calculable, TED are particularly sensitive to additional terms such as isospin non-conserving (INC) components.

The study of TED has been pushed to higher masses through the first study of the excited states of the Tz = -1 nuclei, 66Se, 70Kr and 74Sr. The states were identified using the technique of recoil-beta-tagging (RBT). The TED obtained for A=66, 70 and 74 have been compared with shell model calculations using the JUN45 interaction. In order to reproduce the observed TED, it is necessary to incorporate an INC component as in the f7/2 shell. This points to the universal nature of the INC contribution and suggests it may have a similar magnitude irrespective of the orbitals involved.

Primary author: JENKINS, David Gareth (University of York (GB))

Presenter: JENKINS, David Gareth (University of York (GB))

Contribution ID: **25** Type: **Innovative Instrumentation for EURISOL-DF**

The EURISOL-Distributed Facility Initiative

GANIL, Caen France
On behalf of the EURISOL Steering Committee

The EURISOL project is together with FAIR, one of the major aims of the Nuclear Physics community in Europe. In order to reach the long-term goal of EURISOL a new European strategy is proposed with an intermediate and ambitious step: EURISOL Distributed Facility (EURISOL-DF), http://www.eurisol.org/eurisol_df/).

The goals of EURISOL-DF are:
• implement a new scientific policy tackling major problems in nuclear physics at ISOL-based European facilities;
• develop R&D on RIB production and instrumentation towards;
• promote user driven policy with an important role played by the EURISOL User Group and the EURISOL Instrumentation Coordination Committee in order to organise and optimize the campaigns of travelling detectors and arrays;
• have EURISOL-DF included on the ESFRI list by 2020 and attract additional member states and EU funds;
• establish a joint strategy in education and training in nuclear science (eg. organising joint summer schools, hands on training, topical workshops and conferences);
• develop EURISOL as a single site facility as a long-term goal.

The EURISOL-DF membership will be open to all European RIB ISOL facilities. The core facilities of the new distributed infrastructure will be GANIL-SPIRAL2, CERN-ISOLDE, INFN-SPES and ISOL@MYRRHA as a candidate for the future core member.
EURISOL-DF will closely collaborate with the FAIR facility and other ISOL facilities worldwide and it will strongly interact with the EURISOL User Group and the EURISOL Joint Research Activity in the Horizon 2020 ENSAR 2.
The EURISOL-DF initiative is coordinated by the EURISOL Steering Committee representing partners who signed the EURISOL Memorandum of Understanding, namely GANIL (France), CERN/ISOLDE, COPIN (Poland), SCK-CEN for Belgian EURISOL Consortium (BEC), INFN (Italy) and JYFL (Finland).

Primary author: Prof. LEWITOWICZ, Marek (GANIL, Caen France)

Presenter: Prof. LEWITOWICZ, Marek (GANIL, Caen France)

Contribution ID: **26** Type: **Innovative Instrumentation for EURISOL-DF**

Introduction to EURISOL

Yorick Blumenfeld
Institut de Physique Nucléaire, 91406 Orsay Cedex, France

This talk will give a brief history of the EURISOL concept through
a summary of the conclusions of the various European contracts devoted to the ultimate ISOL facility. The story started with a feasibility study project in the fifth framework program between 2000 and 2004. It was followed by the most ambitious undertaking, the EURISOL Design Study (2005 - 2009) which delivered a detailed layout of the future facility.
The physics case was updated through the EURISOL network within the ENSAR contract and currently R&D work on targets and charge breeders is progressing within the EURISOL JRA of ENSAR2.

I will also give some thoughts on how cooperation within the EURISOL Distributed Facility will help to progress towards the final goal.

Primary author: BLUMENFELD, Yorick (Institut de Physique Nucléaire,)

Presenter: BLUMENFELD, Yorick (Institut de Physique Nucléaire,)

Contribution ID: **27** Type: **Physics and astrophysics of neutron deficient nuclei**

Structure of heavy neutron-deficient nuclei near the proton drip line

The advent of highly selective radioactive correlation techniques using electromagnetic separators has extended spectroscopic investigations to heavy nuclei beyond the proton drip line. This has led to improvements in our understanding of a broad range of structural phenomena from proton radioactivity to the emergence of collective behaviour outside the N=Z=82 closed shell. However, spectroscopic studies of the most neutron-deficient nuclides remain challenging due to the rapid fall in decay half-lives and production cross sections. The observable limits for heavy nuclei that decay predominantly by ground-state proton emission may, in some cases, have already been reached using conventional techniques. Recent discoveries of high-lying isomers that have enhanced stability against proton radioactivity indicate that many open questions still remain concerning the ultimate limits to nuclear binding beyond the expected boundaries of the nuclear landscape.

Considerable progress has also been made in identifying excited states in the heavy neutron-deficient nuclei through in-beam gamma-ray spectroscopy experiments. This has allowed the variation of excited states to be extended over a broad range of nuclides and the provided some invaluable insights into the evolution of collective behaviour. Recent experiments employing fusion evaporation reactions with stable beams and targets have revealed some intriguing results that have yet to be explained such as measured ratios of reduced transition probabilities that appear to be inconsistent with collective model predictions.

This contribution provides a selective review of these themes, highlights the limitations of our current experiments and presents challenges and opportunities that might be addressed by the future EURISOL distributed facility.

Primary author: Prof. JOSS, David (Oliver Lodge Laboratory, University of Liverpool)

Presenter: Prof. JOSS, David (Oliver Lodge Laboratory, University of Liverpool)

Contribution ID: **29** Type: **not specified**

PARIS - Photon Array for Studies with Radioactive Ion and Stable beams

Author:
Michał Ciemała
M. Ciemała1, A. Maj1, P. Bednarczyk1, M. Kmiecik1, B. Wasilewska1, M. Zięblinski1, S. Brambilla2, F. Camera2, A. Mentana2, I. Matea3, O. Dorvaux4, S. Kihel4, O. Stezowski5, Ch. Schmitt4, I. Mazumdar6 V. Nanal6, C. Gosh6, D. Jenkins7, P. Napiorkowski8
on behalf of the PARIS collaboration
1 Institute of Nuclear Physics PAN, Krakow, Poland
2 INFN Sezione di Milano, I-20133 Milano, Italy and University of Milano, Italy
3 IPN Orsay, France
4 IPHC and Universit´e de Strasbourg, B.P. 28, F-67037 Strasbourg Cedex 2, France
5 IPN Lyon, France
6 Tata Institute of Fundamental Research, 400005 Mumbai, India
7 University of York, UK
8 University of Warsaw, Poland

Radioactive ion beam facilities, which are being under development, as SPIRAL2, SPES, HIE-ISOLDE, and therefore EURISOL DF, need adequate novel experimental detection systems. The proposed Photon Array for Studies with Radioactive Ion and Stable Beams (PARIS) is being developed to work in these facilities. PARIS is a large array of phoswich detectors expected to measure γ rays over a wide range of energy from few hundred keV to 40 MeV. It is envisaged to serve the dual purpose of a high-energy gamma-ray spectrometer and a spin-spectrometer, capable of determining the multiplicity of low energy (100 keV to few MeV) discrete γ rays associated with a specific reaction. Upon completion PARIS is envisaged to be an array of 216 phoswich detectors. The front section of each phoswich detectors is a cubic (2x2x2) Lanthanum Bromide crystal optically coupled to a 6 long square bar of NaI(Tl) of matching cross section. Each of these detectors is to be read by a single photomultiplier tube (PMT) of 2"diameter that would allow close packing of such detectors. It is planned to combine 9 phoswich detectors in a square (3x3) close packed geometry forming a single cluster [1-4].
The project is to be executed in a phased manner with the completion of one cluster in the first phase (PARIS prototype) and five clusters by the end of the second phase (PARIS demonstrator). The third phase will see the completion of 12 clusters. In its final configuration, commissioned by the end of the fourth phase, PARIS is envisaged to have clusters covering 4π solid angle around the target. A variety of experiments in nuclear structure and reaction dynamics are foreseen to be pursued with PARIS using both stable and radioactive ion beams. The various physics cases include studies of giant dipole resonances (GDR) in excited nuclei, exotic shape-phase transitions, Coulomb excitation, heavy ion radiative capture, reaction dynamics around and above the barrier etc.
In the poster the main idea of PARIS concept will be described, together with information on the PARIS clusters use in the first experiments, as well as planned use of PARIS in EURISOL-DF facilities.

[1] Maj A. et al. Acta Phys. Pol B, 40:565, 2009;
[2] Zieblinski M. et al. Acta Phys. Pol B, 44:651, 2013;
[3] B. Wasilewska and al. in: O. Roberts, L. Hanlon, S. McBreen (Eds.) Applications of Novel Scintillators for Research and Industry, Iop Publishing Ltd, Bristol, 2015;

[4] Gosg C. et al, JINST 11 P05023 (2016).

Presenter: Dr CIEMALA, Michal (Institute of Nuclear Physics PAN, Krakow, Poland)

Contribution ID: **30** Type: **Innovative Instrumentation for EURISOL-DF**

Two important items for reaction studies and link to structure

Presenter: Prof. PAGANO, Angelo (LNS/INFN, Catania)

Contribution ID: **31** Type: **The formation and structure of r-process nuclei**

The formation and structure of r-process nuclei

Presenter: Prof. FRAILE, Luis Manuel (Univ Complutense)

Contribution ID: **32** Type: **Physics and astrophysics of neutron deficient nuclei**

Physics and astrophysics of neutron deficient nuclei

Presenter: Prof. PAGE, Robert (Univ Liverpool, Uk)

Contribution ID: **33** Type: **not specified**

Panels I and III

Presenter: JOKINEN, Ari (Univ Jyvaskyla)

Contribution ID: **34** Type: **not specified**

Panel VI

Presenters: Prof. MOORE, Iain (Univ Jyvaskyla); Prof. FADI, Ibrahim (IPM Orsay); Prof. VAZ, Pedro (CTN/IST); Prof. RAAB, Riccardo (KU, Leuven)

Contribution ID: **35** Type: **not specified**

Concluding remarks

Presenter: Prof. NEYENS, Gerda (ISOLDE, CERN)

Contribution ID: **36** Type: **not specified**

Overview of Topic IV

Presenter: Prof. MAY, Adam (Univ Krakow)

Contribution ID: **37** Type: **Going to the limits of mass, temperature, spin and isospin with heavy Radioactive Ion Beams**

Going to the limits of mass, temperature, spin and isospin

Presenter: Prof. JUNGKLAUS, Andrea (CSIC, Madrid)

Contribution ID: **38** Type: **not specified**

Poster Conclusions

Presenter: Prof. MOORE, Iain (Univ Jyvaskyla)

Contribution ID: **39** Type: **Physics of Light Exotic Nuclei**

Physics of light nuclei

Presenter: Prof. ALAMANOS, Nicolas (CEA/IRFU)

Contribution ID: **40** Type: **not specified**

Light nuclei - discussion

Presenter: Prof. RUBIO, Berta (Univ Valencia)