ID: 1

Topic: IAEA General

IAEA activities in support of the accelerator-based research and applications

Sotirios Charisopoulos
IAEA

Abstract: Promotion of nuclear applications for peaceful purposes and related capacity building is among the missions of the IAEA. Hereby, accelerator applications and nuclear instrumentation is one of the thematic areas, where the IAEA supports its Member States in strengthening their capabilities to adopt and benefit from the usage of accelerators. In this context, the IAEA Physics Section implements various activities in support of accelerator-based research and applications that focus on
•promoting the utilization of accelerators in support of applied research in almost all fields with high societal and economic impact,
•enhancing utilization of existing accelerator infrastructures by enabling facility access for scientists from developing countries without such facilities,
•assisting scientists from developing countries in carrying out feasibility and infrastructure assessment studies and establishing new accelerator facilities.
•assisting Member States in installing, operating and maintaining their accelerator facilities and associated instrumentation, and

This presentation aims at disseminating the IAEA tools through which the Physics Section's activities in support of accelerator-based research and applications are implemented, with special focus on Coordinated Research Projects (CRPs), projects supported through IAEA's Technical Cooperation (TC) Programme, Technical Meetings and Training Activities.
CRPs bring together scientists from research institutes in both developing and developed Member States to collaborate on research topics of common interest, whereas the TC Programme is the IAEA's primary mechanism for transferring nuclear technology to Member States, helping them to address key development priorities in many areas of societal importance and economic growth. It is implemented primarily in the form of projects, which provide support through capacity building, knowledge-sharing and partnership-building as well as support for networking and procurement. Technical Meetings are technical events with up to 40 participants, organized in Vienna or in IAEA Member States, with the aim to enhance interaction among experts, share knowledge and expertise, establish scientific collaborations and create topical networks. IAEA's training activities aim at enabling participants to acquire specific knowledge, either theoretical or practical or both, on a given subject of interest. The gained knowledge permits trainees in better utilizing the resources available to them in their countries.
In the presentation, various examples of all types of IAEA's activities in support of accelerator-based research and applications as well as plans for the establishment of an accelerator facility at IAEA's Seibersdorf laboratories will be reported.

ID: 2

Topic: Hadron Structure, Phases of Nuclear Matter, QCDHadron Structure, Phases of Nuclear Matter, QCD

VCS and Nucleon Generalized Polarizabilities

Nikos Sparveris
Temple University

Abstract: The Generalized Polarizabilities (GPs) are fundamental quantities of the nucleon and as such they are extremely valuable for a complete understanding of the nucleon structure. The GPs can be explored through Virtual Compton Scattering and in analogy to the form factors for elastic scattering, which describe the charge and magnetization distributions, VCS gives access to the deformation of these distributions under the influence of an electromagnetic field perturbation as a function of the distance scale. Recent results from JLab and MAMI and future prospects will be discussed in this talk.

ID: 3

Topic: Hadron Structure, Phases of Nuclear Matter, QCDHadron Structure, Phases of Nuclear Matter, QCD

Photocouplings of hidden-charm pentaquarks

Roelof Bijker
ICN-UNAM

Abstract: We analyze the photocouplings of hidden-charm pentaquark configurations [1] in the framework of the deformed quark model in which we distinguish between the masses of the light quarks (u, d, s) and the heavy quarks [2]. The photocouplings are relevant to photoproduction experiments at JLab to try to excite hidden-charm pentaquarks with an electromagnetic probe.
[1] E. Ortiz-Pacheco, R. Bijker and C. Fernández-Ramírez, J. Phys. G 46, 065104 (2019).
[2] E. Ortiz-Pacheco and R. Bijker, in progress.

ID: 4

Topic: Hadron Structure, Phases of Nuclear Matter, QCDHadron Structure, Phases of Nuclear Matter, QCD

Observation of charmonium mass modification in hadron induced reactions and the gluon condensate in matter

Gyorgy Wolf
Wigner RCP

Abstract: We study the excitation function of the low-lying charmonium state: Ψ(3686) in hadron Au collisions taking into account their in-medium propagation. The time evolution of the spectral functions of the charmonium state is studied with a BUU type transport model. We calculated the charmonium contribution to the dilepton spectrum and show that for Ψ(3686) production there is a good chance to observe its in-medium modification with good resolution detectors. The best possibility for that is in antiproton induced reaction at PANDA, but in pion and proton induced reactions the effect is visible. From the in-medium modification we can obtain the value of the gluon condensate in matter.

ID: 5

Topic: Hadron Structure, Phases of Nuclear Matter, QCDHadron Structure, Phases of Nuclear Matter, QCD

The nuclear force and its application to few-nucleon, light nuclei and infinite systems

Varese Timóteo
UNICAMP

Abstract: I review the Effective Field Theory Approach to the nuclear force and show some applications to few-nucleon systems, light nuclei and nuclear matter.

ID: 6

Topic: Hadron Structure, Phases of Nuclear Matter, QCDHadron Structure, Phases of Nuclear Matter, QCD

Neutron beta decay: exploring limits of the Standard Model

Dinko Pocanic
University of Virginia

Abstract: This talk focuses on experimental studies of the basic properties and symmetries of the electroweak and strong interactions at intermediate and low energies. Although successful without parallel, the present (minimal) standard model (SM) based on the SU(3)_c x SU(2)_L x U(1)_Y gauge symmetries, is known to be incomplete, i.e., additional particles and phenomena must exist. Certain questions raised by our incomplete knowledge can be addressed at low energies through high precision measurements. Examples include: the number and the couplings of quark generations (the Cabibbo-Kobayashi-Maskawa quark mixing matrix, CKM), couplings of lepton generations (lepton universality), existence of non-(V-A) interactions, and supersymmetry. Such studies complement research at high energies in forming a comprehensive picture of the fundamental laws of nature at the smallest length scale.

Neutron beta decay is one of the most fundamental processes in subatomic physics. Its experimental study provides the most sensitive means to evaluate the ratio of axial-vector to vector coupling constants $\lambda = g_A/g_V$. The precise value of lambda is important in a number of applications of the theory of weak interactions, especially in astrophysics; e.g., a star's neutrino production is proportional to λ^2. Precise measurements of neutron beta decay parameters are important in the search for new physics. Measurement of the neutron decay rate Γ, or lifetime $\tau_n = 1/\Gamma$, in addition to λ, allows a determination of the CKM matrix element V_{ud} independent of nuclear models. We will explore several neutron decay parameters can be used to measure lambda. Precise knowledge of V_{ud} is essential for testing the unitarity of the three-generation CKM matrix. CKM unitarity, in turn, provides independent limits on certain processes and particles not included in the standard model of elementary particles and interactions, i.e., on new physics.

We will focus on the status of determination of λ and $V\{ud\}$ in neutron beta decay, as well as of limits on accessible non-(V-A) extensions of the SM. We will focus in particular on the Nab experiment currently in final stages of construction at the Spallation Neutron Source, Oak Ridge National Laboratory, in the US.

ID: 7

Topic: Precision Measurements with Nuclei, Fundamental Interactions and Neutrinos.

WISArD: Weak Interaction Studies with 32Ar Decay

Xavier Fléchard
Normandie Univ, ENSICAEN, UNICAEN, CNRS/IN2P3, LPC Caen, 14000 Caen, France

Abstract: Precision measurements in nuclear and neutron beta decay are competitive tools to search for new physics and improve various tests of the standard model (SM) in the electroweak sector. For a collection of well chosen transitions, they yield constraints that are complementary to high energy physics experiments [1]. In particular, the beta-neutrino angular correlation aβν provides direct access to possible contributions of scalar (S) or tensor (T) couplings, involving other particles than the W± bosons associated to the standard vector(V) - axial-vector(A) couplings of the weak interaction. The value of aβν can be inferred either from a direct measurement of the daughter nucleus recoil energy or by observing the kinetic energy shift of secondary particles emitted after the decay. Both techniques have been applied for pure Fermi and pure Gamow-Teller (GT) transitions, yielding precisions on aβν of the order of 5.10−3 . One of the most precise measurement so far was obtained by measuring the recoil broadening of beta-delayed protons following the decay of 32Ar towards its isobaric analogue state of 32Cl [2]. The WISArD project propose new measurements in the proton-delayed beta decay of 32Ar, based on the kinetic energy shift of protons emitted in parallel or anti-parallel directions with respect to the positron [3]. A proof of principle experiment performed at ISOLDE-CERN provided simultaneous measurements for the superallowed 0 + → 0 + transition followed by 3356 keV proton emission and for a GT transition followed by 2123 keV proton emission. Preliminary results are found in agreement with the Standard Model, with a precision of ~ 4*10−2 limited by statistics for the Fermi transition. A careful analysis of the data shows that future measurements can reach the precision level of 10−3 for both pure Fermi and pure Gamow-Teller decay channels, providing new constraints on scalar and tensor weak interactions.
[1] M. Gonzalez-Alonso, O. Naviliat-Cuncic, N. Severijns, Prog. Part. Nucl. Phys 104 165 (2019).
[2] E. G. Adelberger et al., Phys. Rev. Lett.83 1299 (1999).
[3] B. Blank, et al., CERN-INTC-2016 (2016).

ID: 8

Topic: Precision Measurements with Nuclei, Fundamental Interactions and Neutrinos.

Search for neutron electric dipole moment at PSI

Gilles Ban
Laboratoire de physique corpusculaire de caen CNRS ENSICAEN UNICAEN

Abstract: The Standard Model (SM) of Particle Physics predicts a neutron Electric Dipole Moment (nEDM) several orders of magnitude below the current best experimental limit dn < 2.9 × 10−26 e.cm (90% CL [1]). The nEDM breaks both Time Reversal and Parity symmetry. Many extensions of the SM predict nEDM values at the level of the current experimental sensitivity. Thus, the nEDM search is a probe for physics beyond the SM. At the Paul Scherer Institut (Switzerland) UCN source We have carried out a room temperature experiment with a single chamber and we are presently constructing a next generation spectrometer with two chambers. We will present the results of the first experiment and the ongoing effort to reach the 10-27 e.cm domain.

ID: 9

Topic: HEP, QCD

Photon-induced collisions and Quantum Entanglement at the LHC

Daniel Tapia Takaki
University of Kansas

Abstract: In this talk, we will discuss the latest CERN LHC results on photon-induced collisions that predominantly occur ultra-peripheral heavy-ion collisions. We will also discuss new directions in this field, including novel ways to use quantum mechanics in collider physics.

ID: 10

Topic: Astrophysics and Cosmology

PoGO+: from Monte Carlo simulations to Neutron Star and Black Hole observations

Maxime Chauvin
Inserm, UMR 1037 (CRCT)

Abstract: PoGO+ is a telescope built to observe X-rays emitted by astrophysical objects like Neutron Stars and Black Holes. It is designed to measure polarisation thanks to a specific arrangement of detectors. The telescope design has been developed and optimised with Geant4 Monte Carlo simulations before being built at KTH, Sweden. In 2016, the telescope was launched with a helium filled balloon to reach an altitude of 40 km needed for the observations. The successful flight lasted for 7 days from Sweden to Canada and allowed the detection of polarisation from the Crab pulsar and the Cygnus X-1 black hole.

ID: 11

Topic: Astrophysics and Cosmology

Alpha Decay in an Astrophysical Environment

Jhoan Pérez
University of Los Andes, Colombia.

Abstract:

There is a particular interest in alpha decay in part due to the role played by alpha decay in spectroscopy of unstable nuclei or in more complex processes that take place in astrophysical environments. However, the alpha decay half-lives which are usually used in astrophysical calculations are those obtained from measurements or models which fit the half-lives in a laboratory on earth. We studied alpha decay in an astrophysical environment [1] by including the temperature dependence in the calculation of half-lives. In order to do this calculation, we had to first establish the connection between the nuclear temperature [2] and ambient temperature. The calculations of half-lives were performed within a pre-formed cluster model which is found to be in good agreement with experimental data.

INTRODUCTION

OBJECTIVES

1.) Study the connection between ambient temperature and nuclear temperature.
2.) Analyze the effects of temperature in the alpha decay half-lives.

METHODOLOGY

Temperature effects on alpha decay half-lives for several nuclei are calculated within the JWKB approximation, by using the well-established density dependent double folding model for the potential between the alpha and daughter nucleus [3]. The temperature dependence is includedby using effective Q-values of the tunneling alpha and temperature dependent nuclear densities. Limitations of existing models in literature [4] are discussed in view of the results obtained.

RESULTS

The alpha decay half-lives are in general reduced on including the effects of temperature. The reduction for example, for a decay of 212Po is about a factor of 2 at an ambient temperature of 1.2 GK. The main effect of reduction comes through the use of an effective Q-value. The temperature dependent densities cause only a small reduction.

CONCLUSION

It is found that at low ambient temperatures (T) of a few MK, the nuclear temperature (Tn) for heavy nuclei is bigger than the corresponding ambient temperature. However, Tn decreases with increasing T and eventually equals T for temperatures of a few GK. The behaviour is however sensitive to the type of nuclear level density used. Since the alpha decay process is modified due to the inclusion of temperature, the effects of temperature may be relevant when alpha decay half-lives enter as an input in astrophysical calculations such as the abundance of elements.

[1]
O.L. Caballero, G.C. McLaughlin and R. Surman, \emph{Astrophys. J} {\bf 170} 745 (2012).

[2]
T. Ericson, \emph{Advances in Physics}, {\bf 9} 425 (1960).
[3]
N. G. Kelkar and M. Nowakowski, \emph{J. Phys. G} {\bf 43} 105102 (2016);
J.E. Perez Velasquez, N.G. Kelkar and N.J. Upadhyay, \emph{Phys. Rev. C} {\bf 99} 024308 (2019).
[4]
F.A. Perrone and D.D. Clayton, \emph{Astrophysics and Space Science}, {\bf 11} 451 (1971).

ID: 12

Topic: Astrophysics and Cosmology

Temperature effects on nuclear masses, reactions and abundances

José Trujillo
Universidad de los Andes

Abstract:

Introduction:
Nuclear reactions depend on the masses and energies of the nuclei involved. However, noticing the relation between excitation energies of nuclei and the temperature of the environment in which the nuclei are found, it seems reasonable to consider the temperature dependence of masses in astrophysical environments.
In this work we will take into account the effects of temperature on the masses and then on the reactions involved in primordial nucleosynthesis.
It is expected that changing the reaction rates will alter the distribution of abundances of nuclear species. The Big Bang nucleosynthesis is responsible for the production of light elements, however, the models based on Boltzmann statistics hadn't been able to explain the observed abundance of Lithium 7. With the inclusion of temperature dependent masses (and binding energies) and assuming nuclear statistical equilibrium (NSE), we calculate the abundance for Lithium at different temperatures.

Objectives:
- Calculate light nuclear masses depending on temperature.
- Calculate the reaction rates involved in primordial nucleosynthesis.
- Compare the abundance of Lithium 7 assuming NSE and including the temperature dependence of binding energies.

Methodology
First we pick the best mass model for the light nuclei involved in the reactions. We fit a regression of excited levels of energy with the equation of the mass model, where the parameters of the model now depend on temperature.
With the masses depending on temperature we calculate the new Q-values and use the algebraic expressions for reactions rates from Caughlan and Fowler (1988). With the NSE for abundances, and going from nuclear mass to binding energy, we calculate the relation between new and old abundance for Lithium 7.

Results:
We observe that, in general, increasing the temperature increases the mass because of a reduction in the binding energy. Changes in the masses also generate changes in the Q-values that depend specifically on the nucleus. For a small range of temperatures, the relation of the new Lithium abundance with the old one gives a factor close to 0.25, which would help to reduce the ratio between the prediction and observed abundance, which is 3.

Conclusions:

The present calculations demonstrate the sensitivity of the reaction rates to a temperature dependent mass and their relevance for the abundance of elements produced in the primordial nucleosynthesis. Systematic inclusion of these effects in the abundance evolution networks is important and remains to be done in the future.

G. Caughlan and W. Fowler. Thermonuclear reaction rates. Atomic Data and Nuclear Data Tables, 40:283{334, 1988.

ID: 13

Topic: Astrophysics and Cosmology

A solution of the Flyby Anomaly riddle

Eduardo Greaves
Universidad Simón Bolívar

Abstract: We postulate that the Flyby Anomaly is a consequence of the method used to measure the velocity of the probes by means of the Doppler Effect. On the Earth reference system energy is conserved during the maneuver, however, NASA and ESA measurements on a number of spacecraft show small, but significant, inconsistent anomalous values: positive, null or negative. The phenomenon remains unexplained since 2009. The speed of spacecraft during energy assistance maneuvers is measured by the Doppler Effect Vo = (^ f / f) c' where Vo is the radial velocity, ^ f is the shift of the frequency f emitted by the probe and conventionally c' is equal to c the speed of light as established on the surface of Earth. According to the Céspedes-Curé hypothesis, the movement through variable gravitational energy density fields produces slight variations of the refractive index n' of space and therefore of the speed of light c' which leads to unaccounted corrections to the Doppler data that are based on a constant c. On the basis of this hypothesis we are able to predict accurately the measured Flyby Anomaly with data of the incoming and outgoing measurement points of the hyperbolic orbit of the spacecraft

ID: 14

Topic: Nuclear Structure, Nuclear Reactions and Exotic Nuclei.

Nuclear structural evolution exploiting multiple perspectives and correlations of observables: Application to the r-process

Richard Casten
Yale University and MSU-FRIB

Abstract: Two critical issues in nuclear structure today are the evolution of structure with nucleon number, and innovative ways to discern structure in exotic nuclei with minimal data. This talk will focus on the value of exploiting multiple perspectives to extract structural information, on identifying unique observables, on correlations of diverse observables, and on avoiding some pitfalls in comparisons with models. A number of examples will be given, culminating in a discussion of a new approach to understanding and predicting the r-process.

ID: 15

Topic: Nuclear Structure, Nuclear Reactions and Exotic Nuclei.

Discrete symmetries in the cluster shell model

Roelof Bijker
ICN-UNAM

Abstract: I present the Cluster Shell Model which is an analogue of the Nilsson model, but for cluster potentials [1,2,3]. Special attention is paid to the consequences of the discrete symmetries of the geometric configuration of alpha particles for the cases of the dumbbell, triangle and tetrahedron. Each of these configurations is characterized by a special structure of the rotational bands which can be used as a fingerprint of the underlying geometric configuration. As an application I present an analysis of the energies and electromagnetic form factors and transition rates of 13C in the framework of the Cluster Shell Model, and discuss the evidence for triangular D'(3h) symmetry in this nucleus [4,5]. These results are based entirely on symmetry considerations and, as such, provide benchmarks for microscopic calculations of the cluster structure of light nuclei.

[1] V. Della Rocca, R. Bijker and F. Iachello, Nucl. Phys. A 966, 158 (2017).
[2] V. Della Rocca and F. Iachello, Nucl. Phys. A 973, 1 (2018).
[3] R. Bijker and F. Iachello, Progr. Part. Nucl. Phys. (2019), in press [arXiv:1903.04076].
[4] R. Bijker and F.Iachello, Phys. Rev. Lett. 122, 162501 (2019).
[5] R. Bijker and A.H. Santana-Valdés, Eur. Phys. J. ST , in preparation.

ID: 16

Topic: Nuclear Structure

Particle-Hole States of the Cluster Shell Model in 8Be

Moshe Gai
University of Connecticut

Abstract: We discuss the first application of the Cluster Shell Model (CSM) of Della Rocca and Iachello to particle-hole (p-h) states in 8Be. We demonstrate a few essential features of the CSM in 8Be: 1) All predicted p-h states of the CSM, and only the predicted p-h states, are observed near thresholds and up to 19.5 MeV in 8Be. 2) The states are observed in the predicted order, with positive parity states below negative parity states. 3) Some of the p-h states are already known to have the rotational structure predicted for the deformed p-h states. 4) The rotational structures observed at high excitations in the p-h bands in 8Be, resemble the ground state bands of 8Be, 9Be and 9B, with similar moment of inertia. We examine the observed B(M1)s and B(E2)s in these nuclei including the iso-baric Analog of transition in 8B. We discuss the observed rotational structure in 8Be as a challenge to ab-initio calculations that searched for emerging rotational structures at high excitations in beryllium nuclei, and reveal rotational structure at high excitations in 10Be and 12Be but not in 8Be.

ID: 17

Topic: Nuclear Structure

Isomeric states in the A=70 mass region

Nilberto Medina
Instituto de Física - Universidade de São Paulo, São Paulo, Brazil.

Abstract: Nuclei in the A = 70 mass region are the object of various investigations since a rich variety of nuclear structure properties and shapes can be observed [1]. In this work, isomeric excited states for odd-odd 66,68Ga, 68As nuclei and the even-odd 67Ge nucleus[2,3] are presented. The experiments were performed in the “Laboratorio Aberto de Física Nuclear” of the Physics Institute of the São Paulo University. The isomeric states lifetimes were measured with the SISMEI system [4]. Delayed coincidence between evaporated particles in a nuclear reaction and the delayed gamma-rays emitted from the isomeric state was used to measure lifetimes. SISMEI is composed of plastic scintillators for particle detection, hiperpure germanium detectors (HPGe) and sodium iodide (NaI(Tl)) for gamma-ray detection, coupled to a coincidence system, located on 30A beam line of the São Paulo 8UD Pelletron accelerator. The obtained experimental results for those nuclei and the known values were compared with the results of the Large Scale Shell Model, using the Antoine Code [5], and the residual interactions: JUN45 and FPG, to describe excitations to the g9/2 orbital. REFERENCES [1] R.A. Haring- Kay et al., Phys. Rev. C 92, 044325 (2015). [2] P. R. P. Allegro, PhD thesis USP (2013). [3] R. Escudeiro, Master thesis USP (2018). [4] D.L. Toufen et al., Rev. Sci. Instr. 85(7) 073501 (2014). [5] E. Caurier et al., Reviews of Modern Physics, vol. 77, pp. 427-488 (2005). [6] Honma, H. et al., Phys. Rev. C 80, 064323 (2009). [7] K. Sieja and F. Nowacki, Phys. Rev. C 81, 061303(R) (2010).

ID: 18

Topic: Nuclear Structure

Microscopic tri-axial rotor-cranking model: slow-wobbling

Parviz Gulshani
NUTECH Services

Abstract: A microscopic quantum ideal rotor-model intrinsic Hamiltonian for tri-axial rotation is derived from the nuclear Schrodinger equation by applying a rotationally-invariant rotation operator to a deformed nuclear ground state. This Hamiltonian is obtained only when a rigid-flow prescription is used to define the three rotation angles in the rotation operator so that the Hamiltonian becomes effectively independent of the angular momentum operator. Using Hartree-Fock variational and second quantization methods, the rotor Hamiltonian is transformed into that of a self-consistent tri-axial cranking model (MSCRM-3) with a self-consistently and microscopically defined angular-velocity vector, plus residual terms associated with the square of the angular momentum operator and with a two-body interaction. The approximations and assumptions underlying the conventional cranking model are revealed. In particular, it is shown that the conventional cranking-model Hamiltonian is not purely intrinsic because it does not use rigid-flow kinematic moments of inertia. It also ignores the HF exchange term of the one-body part and other residual parts of the square of the angular momentum operator, which are shown to have a negligible impact. For a self-consistent deformed harmonic oscillator potential, the MSCRM-3 Schrodinger equation is transformed into that of a uni-axial cranking model plus local potential-energy cross terms using a rotation of the co-ordinate system. It is shown that uniform rotation, where the angular-momentum vector is aligned with the angular-velocity vector, is not generally possible. However, for a slow-wobbling rotation, an approximate uniform rotation becomes possible. In this limiting wobbly motion, the potential-energy cross terms are negligibly small, and the angular-momentum vector becomes nearly aligned with the rotation-angle vector. In this approximate regime the uni-axial cranking-model equation is solved analytically using a generalization of the isotropic-velocity-distribution condition of Bohr-Mottelson and Ripka-Blaizot-Kassis. The ground-state rotational-band excitation energy and quadrupole moment are calculated and compared with the measured data in Ne-20. The model predicts well the rotational excitation energy in Ne-20 and the hitherto mysterious decrease in the excitation energy-level spacing with increasing angular momentum. The energy-level spacing decreases with the angular momentum because the generalized isotropic-velocity distribution condition and the associated slow-wobbly rotation allow the intrinsic energy to decrease much more than that in the conventional (including the more restrictive Ripka-Blaizot-Kassis) cranking models. The nuclear shape is predicted to be approximately axially-symmetric oblate and to become exactly axially symmetric at the band termination. Therefore, the Hamiltonian possesses an approximate D2 symmetry and hence the wavefunction signature is approximately conserved. Therefore, the rotational states have approximately even angular momenta, in agreement with the measurement. The model also predicts reasonably well the nuclear quadrupole moment and the sharp drop in quadrupole moment near the band termination in . The impact of the residual of the square of the angular momentum and a separable quadrupole-quadrupole two-body interaction is studied in the Tamm-Dancoff approximation using the eigenstates of the self-consistent cranking model as the particle-hole basis states. These residual interactions are found to have negligible impact on the cranking model results. Further detail is presented in: P. Gulshani, arXiv:1909.07169 [nucl-th], September 16, 2019.

ID: 19

Topic: Nuclear Structure

Fundamental Interactions from Lattice QCD

Henry J. Monge-Camacho
University of North Carolina at Chapel Hill

Abstract: Nuclear Physics experiments provide promising tests for searches of new physics beyond the Standard Model. Therefore, understanding low-energy nuclear phenomena from the theory is thus fundamental to interpret and improve the experiments. This requires calculations of nuclear physics quantities such as nuclear matrix elements, nuclear form factors and others, and when strong interactions are involved, Lattice QCD, a non-perturbative tool must be employed. In this talk, I will present first our calculation of nucleon axial charge gA, which measures the strength of the coupling of the axial current of the standard model to the nucleon, and thus controlling the rate of beta decay. Then, the calculation of nuclear matrix elements for neutrinoless double beta decay short-range contributions.

ID: 20

Topic: Nuclear Reactions.

How nuclear reactions allow to study the nuclear matter?

Magda Cicerchia
Università di Padova - INFN LNL

Abstract: We are all familiar with the terminology “nuclear reactions”. However, it is important to highlight that through the study of the nuclear reactions it is possible to have a detailed information on nuclear matter behavior, structure and composition. Playing with nuclear reactions, two main items can be distinguished: firstly, the nuclear reactions can be used as a tool to populate the excited nuclei; the properties of the excited system can study through its decay to the fundamental state. Secondly, the study of the nuclear reactions themselves allow to understand the interplay between different mechanisms which may compete as a function of different parameters in the entrance channel (energy, mass asymmetry, centrality, mass of the involved partners etc.) to get information on the gross properties of nuclear matter like its viscosity and its behavior as a function of the temperature, excitation energy, density, angular momentum, isospin. Taking in mind this second point, I would like to show you some of the most recent results of the experiments carried out and analyzed by the NUCL-EX Collaboration (INFN, Italy).

ID: 21

Topic: Nuclear Reactions.

Systematical optical potential for stable, weakly bound and exotic nuclei reactions

Marcos Alvarez
University of Seville

Abstract: Introduction: Nuclei present cluster structures. Light, strongly or weakly bound, stable or exotic, nuclei such as 6He; 6,7Li; 7,8,9Be; 12,13,14C; 16,18O; among others (isotopes and nuclei), can be considered as results of n; 1,2,3H and 3,4He combinations. It has been evidenced by experimental observations on break-up or transfer reactions. Thus, to describe stable, weakly bound and exotic nuclei reactions, with the same theoretical approach, is extremely challenging in nuclear physics. Studying reactions involving weakly bound stable nuclei is a crucial step in between studying reactions with stable and exotic nuclei and towards a better understanding of the latter. Objectives: This work reports on systematical measurements and optical model (OM) analysis to describe the elastic scattering angular distributions of 4,6He; 6,7,9,11Li; 9,11Be; 12C; 16,18O projectiles on different heavy targets. Methodology: We apply an optical potential (OP) composed by the nuclear microscopic double folding Sao Paulo potential (SPP), derived from the nonlocal nature of the interaction. In addition, we study the effect of Coulomb dipole polarization (CDP) potential, derived from the semi-classical theory of Coulomb excitation. Within this approach, we study OP (real and imaginary) strengths as a function of the system. Results: Our OP approach establishes a common basis for stable, weakly bound and exotic nuclei reactions, accounting for important differences in their reaction mechanisms, which shows to be directly related to their structural properties. Trivial local equivalent potentials (TELP), extracted from continuum discretized coupled channel (CDCC) calculations, corroborate the main results.

ID: 22

Topic: Nuclear Reactions.

Nuclear reactions involving weakly bound projectiles

Leandro Gasques
University of Sao Paulo

Abstract: The main results of several experiments performed at the 8 MV Pelletron accelerator installed at the Open Laboratory of Nuclear Physics at the University of Sao Paulo will be discussed. A systematic study involving weakly bound nuclei is currently in progress. Coupled-reaction-channels have been performed using the Sao Paulo potential as the bare interaction.

ID: 23

Topic: Nuclear Reactions.

Nuclear reactor antineutrinos, hard to detect, but with a traceable lineage

Alejandro Sonzogni
National Nuclear Data Center, Broohaven National Laboratory

Abstract: Nuclear reactors are prolific sources of electron antineutrinos, producing about 10E21 antineutrinos per second for a typical power reactor. These electron antineutrinos are produced by the beta-minus decay of the more than 800 neutron-rich fission fragments, which are the debris from the main source of energy generation in a reactor, the neutron induced fission of actinide nuclides. These antineutrinos are also the only radiation escaping from a safely operating reactor.
Nuclear reactors have been an essential tool to study the weak interaction. Their large antineutrino flux was capitalized by Cowan and Reines to discover antineutrinos in 1956, more than 25 years after they were first hypothesized by Pauli in 1930 to explain the continuum electron spectra observed following beta-minus decay. In the last few years, the transformation of electron antineutrinos into the other flavors was beautifully measured by three large-scale experimental efforts, Daya Bay, Double Chooz and RENO. These experiments also confirmed a deficit of antineutrinos of about 5% at short distances that had been revealed in a 2011 re-analysis of the conversion procedure to obtain antineutrino spectra from the measured electron spectra. This intriguing deficit, as well as a spectrum distortion, has triggered a new generation of very-short distance reactor experiments, such as NEOS (Korea), DANSS (Russia), STEREO (France), PROSPECT (USA), and SoLid (Belgium), whose first results are beginning to be made public. There are no signs of slowing down in the field of nuclear reactor antineutrinos, as the largest experiment to date, JUNO, should be ready for data taking by 2021. JUNO will feature a 20 kTon detector at 53 km from A 27 GW nuclear power plant in China.
The antineutrino spectrum produced in a nuclear reactor is calculated as the sum of the spectra produced by each of the nuclear fuels, 235,238U and 239,241Pu, weighted by the respective fission fractions. Nuclear data activities started in Brookhaven National Laboratory in 1952, in a group that would eventually become the National Nuclear Data Center (NNDC) in 1977. Using the databases that the NNDC manages, the antineutrino spectra for each nuclear fuel can be calculated in what is commonly known as the ‘summation method’. In this talk, we will present what we have learned using the summation method, such as antineutrino yield systematics, main contributors and their signature in both electron and antineutrino spectra, as well as sensitivity studies to identify nuclides with deficient knowledge for future experiments. Finally, the development of fission yield correlations matrices will be discussed, which are crucial in obtaining summation uncertainties that may impact the Reactor Antineutrino Anomaly.

ID: 24

Topic: Nuclear Reactions.

Extended quantum diffusion approach to reactions of astrophysical interests

Adamian Gurgen Grigorievich
Joint Institute for Nuclear Research

Abstract: Fusion reactions at energies near and below the Coulomb barrier have been an object of extensive experimental and theoretical studies in the past decades. In the present work we extend our approach to describe the capture (fusion) of light and medium-mass nuclei at energies well below the Coulomb barrier.

We consider of friction, depending on the bombarding energy of colliding nuclei. In the collisions of light nuclei at low energies, the external turning point is located far from the Coulomb barrier. This means weak overlap of nuclear surfaces and, correspondingly, small friction. Using the extended approach, we compared the calculated capture cross-sections with the available experimental data. In all cases we obtain a good description of the experiment. In the limit of weak friction, which corresponds to extreme sub-barrier energies, the analytic expression for the capture probability is obtained. This simple expression can be applied to the reactions of astrophysical interest. They determine the reaction rates from which, in turn, the astrophysical S-factors are derived. The strong decline of fusion cross sections at sub-barrier energies introduces considerable hindrance factors of stellar burning rates and moreover, leads to severe experimental problems, inhibiting the measurements in many cases. This demands for reliable theoretical methods, allowing to extrapolate into the experimentally inaccessible regions at extreme sub-barrier energies.

ID: 25

Topic: Nuclear Reactions.

Emission of light charged particle in fusion and quasifission reactions

N. V. Antonenko
Joint Institute for Nuclear Research

Abstract: The light charged particle evaporation from the compound nucleus and from the complex fragments in the reactions 32S+100Mo, 121Sb+27Al, 40Ar+164Dy, and 40Ar+{nat}Ag is studied within the dinuclear system model. The possibility to distinguish the reaction products from different reaction mechanisms is discussed.

From the comparison of the calculated light charged particle (LCP) multiplicities and experimental data, we show the possible overlap of the decay products from different reaction mechanisms. With increasing the bombarding energy the ratio of the LCP multiplicity from the fission-like fragments to the LCP multiplicity from the compound nucleus increases due to the increase of fission and quasifission probabilities. The simultaneous description of the LCP multiplicities and of the production cross sections of the evaporation residues and complex fragments gives us a chance to distinguish the reaction products from different reaction mechanisms. The calculated LCP multiplicities show weak dependence on the reasonable variation of the level density parameter, and stronger dependence on the Coulomb barrier heights.

The influence of the entrance channel charge (mass) asymmetry and bombarding energy on the characteristics of spin distribution of reaction products was studied within the dinuclear system model.

ID: 26

Topic: Nuclear Reactions.

Correlation between mass yield and the oversize of measured average prompt neutron multiplicity as a function of the mass of fragments from low energy fission of actinides

Modesto Montoya
Universidad Nacional de Ingeniería

Abstract: There are several different results (obtained by the experimental double energy method (2E)) on the average prompt neutron multiplicity (νave) as a function of the masses (μ, μ') calculated from the measured kinetic energies (e,e') of the complementary final fragments from the reactions 233U(nth, f), 235U(nth, f) and 252Cf(sf) [1–9] and 239Pu(nth, f) [10–13], respectively. These results show a peak of the νave curve in the mass symmetric region of the light fragments. A Monte Carlo simulation is performed to reproduce the curve νave(μ) for each of these reactions [14,15]. The input data (based on experimental results) consist of the yield (Y), a Gaussian distribution of the kinetic energy (E,E') and a sawtooth approach of the average prompt neutron multiplicity (νaves) and a parameter α (defined as the inverse slope of the ν(TKE)) as a function of the masses (A, A') of complementary primary fragments. Based on experimental results from the reaction 252Cf(sf) [16], an anti-correlation factor between νave(A) and νave(A') is introduced. As a result of the simulation, it is shown that i) νave-νaves is correlated with FR, where R(A) =Y(A+1)/ Y(A) and F(A)=(1-νaves (A)/A)/ (1-νaves (A')/A') ii) the oversize of νave relative to νaves in the region of light fragment mass near the symmetric fission is due to the interplay of the prompt neutron emission and the slope of the mass yield curve iii) the magnitude of the oversize of νave relative to νaves is strongly dependent of α(A).

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ID: 27

Topic: Nuclear Reactions.

Recent results of Radioactive Ion Beams in Brasil (RIBRAS)

Alinka Lépine-Szily
Universidade de Sao Paulo Instituto de Fisica

Abstract: Recent experimental results obtained at RIBRAS on nuclear reactions with 7Be, 6He and 8B beams on light and medium mass nuclei will be presented. Elastic scattering, inelastic scattering and neutron transfer reactions had their anguar distributions measured at several energies. Comparison with theoretical calculations will be discussed. Future plans using upgrades in detection systems will be presented.

ID: 28

Topic: Medical Physics

The importance of accurate dosimetry: role of medical physicist

Paula Toroi
IAEA

Abstract: Accurate radiation dose measurements are needed whenever ionizing radiation is used and people are potentially exposed. This is highlighted in the medical use of radiation, particularly in radiation therapy, where successful treatment depends critically on the accuracy of dose delivery to the patient. Accurate patient dosimetry is important also in diagnostic imaging, as this medical application is responsible for most of the man-made radiation burden. In addition, r adiation exposure assessment of radiation workers is normally a legal requirement and consistent measurements are essential. For all fields of radiation dosimetry, different dose levels and limits arein use and typically they are based on international studies and recommendations. Therefore, the measurements must be comparable and consistent worldwide.

Accuracy and consistent measurement results are accomplished by using proper methods and calibrated equipment for the measurements. The measurements should be performed following the national and international Codes of Practice to achieve comparable measurement results among different hospitals and countries. The equipment used for radiation measurements need to work properly and must be calibrated regularly against measurement standards for relevant quantities so that they are traceable to the to the International Systems of Units. Calibrations are normally provided by secondary standard dosimetry laboratories (SSDLs). The IAEA together with the World Health Organization coordinates the IAEA/WHO SSDL Network which aims to support countries to achieve high quality dosimetry measurements.

Medical physicists are health professionals and they are responsible to ensure the safety, quality and effectiveness of diagnosis and treatment that employs radiation. Such professionals play an important role in ensuring the radiation beams used in diagnostics and treatment are appropriateand the amount of radiation is adequately measured according to international guidelines, using equipment that is calibrated and traceable to standards. The roles and responsibilities, and education and training requirements for clinically qualified medical physicist (CQMP) are defined in details in the publication titled IAEA Human Health Series No. 25 (2013), also available in Spanish (2014). More information related to Medical Physics can be found on the IAEA Human Health Campus.

ID: 29

Topic: Medical Physics

Validation of a Geant4 based Monte Carlo code for voxelized geometries for patient oriented mammography dosimetry

Rahel-Debora Werner
University of Halle-Wittenberg

Abstract:

Introduction

The glandular tissue has the highest risk of radioinduced carcinogenesis compared to the other mammary tissues. This risk is relate to the mean glandular dose (MGD), which is the mean dose delivered to the glandular tissue of the breast. This quantity cannot be measured directly but must be determined via a measured incident air kerma and an appropriate conversion factor.

Objectives

This work presents a preliminary validation of a Monte Carlo radiation transport code capable of simulating radiation transport on voxelized structures using measurements of field size and depth dose.

Methodology

Field size and depth dose were measured at Physikalisch-Technische Bundesanstalt (PTB) Braunschwei for mammography tungsten spectra of 30 kVp and 50kVp. Four different collimators were used to vary the field size between 0.94 cm and 4.74 cm of aperture radius. Depth dose was measured between 0 cm and 2 cm depth using a PTW PMMA phantom and two PTW ion chambers.

Monte Carlo simulations were performed using the Geant4 toolkit (EM standard physics) for the two quantities of interest, and reproducing the experimental setups used. The simulations were developed using available Geant4 application for simulation of DICOM voxel images and using in-house code developed to allow the Geant4 DICOM application to use other sources of voxel structures as input, including the case of non-DICOM voxel geometries.

Results

In the case of the field size effect comparison, the maximum relative difference between experiment and simulation was 2.11%. On the other hand, for the depth dose study, the average relative difference between the experimental data and its corresponding simulation was under 2.95% for all cases. The maximum relative difference was 5.60%.

A comparison between these results and other published data showed that our results are below the values reported in the literature for similar studies.

Conclusion

The Monte Carlo simulations used in this study have been shown to provide accurate estimations of the quantities relevant to the calculation of MGD. In addition, we have shown that our in-house code extends the use of the available DICOM Geant4 application to include other voxelized geometries.

ID: 30

Topic: Medical Physics

Determination of glandular tissue thickness in film mammography

Marco A. Rodriguez-Jiron
University of Costa Rica

Abstract:

Introduction

The amount of glandular tissue in breast that is irradiated during a screening mammogram is linked to the risk of radioinduced carcinogenesis. Automated estimates of glandular percentage for individual mammograms are widely available for digital mammography systems, however, accurate determination of glandular tissue in film mammograms is of relevance to developing countries, where analog mammography machines are still prevalent.

Purpose

Develop a method to determine the relationship between film optical-density and thickness of glandular breast tissue using materials available in developing countries.

Method

A phantom was developed using acrylic slabs. The slabs were cleaned to remove all residues from the acrylic surfaces prior to usage. The phantom was made in a staircase-shape array, with step height varying from 0.0 cm to 6.0 cm. The correlation between acrylic height, breast tissue and optical density was studied using measurements of optical density at points corresponding to different acrylic heights. The phantom images were acquired on a Kodak Mammography film using a 20 keV Mo/Mo x-ray source with RQR8 filter. The optical density at each point of interest was measured using a PTW spectrophotometer.

Results

Optical density was found to decrease exponentially with acrylic height. This behavior is consistent with the expected behavior of optical density due to the beam attenuation by breast tissue. The maximum error found for our imaging system was below 1% across all thicknesses studied.

Conclusion

The proposed phantom design provides a way to determine the relationship between optical density and thickness of glandular breast tissue. The proposed design has the added advantage that can be constructed using existing materials, which makes it particularly useful in clinical settings with limited resources.

ID: 31

Topic: Medical Physics

Variability range of primary and scatter signal in DECT detectors

Daniel Arroyo-Portilla
University of Costa Rica

Abstract:

Introduction

The amount and distribution of the primary and scatter radiation that reaches the detectors in a CT scanner has a direct impact in the clinical usability of the image reconstructed. The amount of radiation that reaches each detector depends on both the geometrical and material characteristics of the CT scanner, as well as the image acquisition parameters and patient characteristics.

Objective

Determine the range of variation of total signal that reaches CT detectors in a computational simulation of a commercial CT scanner, using radiation transport Monte Carlo methods, as a study of the characteristics of a particular scanner configuration.

Methodology

The geometry was based on that of a commercially-available CT scanner. The gadolinium oxysulfide detectors are separated by highly-attenuating septa. In this exploratory study, two sets of monoenergetic beams were used, 45 keV and 80 keV. These values are representative of the typical energies used in clinical image acquisition. The original geometry was varied by including a XXX cm diameter water cylindrical phantom, to represent a patient, as well as varying the material used in the septa, including the extreme cases of air and lead. The amount of energy deposited in the crystals was compared for the different geometric cases.

Results

In the presence of a water phantom, the amount of radiation from a 45 keV source that reaches the detectors decreased as much as a factor of 1.34 for the central axis detectors, and as much as 3.12 in the case of the detectors located in the extremes of the fan beam. In the case of an 80 keV, these factors were 1.21 and 3.00 respectively.

Conclusion

Our results suggest that the alignment of the septa with respect to the source position is an important factor to consider in the determination of the radiation profile that reaches the CT detectors.

ID: 32

Topic: Medical Physics

OpenDose: free online resources for Nuclear Medicine dosimetry

Maxime Chauvin
Inserm, UMR 1037 (CRCT)

Abstract: Dosimetry in Nuclear Medicine uses a common formalism (MIRD) using pre-calculated reference Specific Absorbed Fractions and S Values. Such data is generated with Monte Carlo simulations for specific models and radioisotopes and is often computationally intensive. OpenDose is an international collaboration to generate, verify and disseminate reference dosimetric data. Using a common framework, every team provide reproducible data, with every value associated with uncertainty. The dosimetric data is then processed and stored in a SQL database and accessed through a newly created website. The website is designed to give the Nuclear Medicine community a free and easy access to dosimetric data as well as open software and education material.

ID: 33

Topic: Medical Physics

Improvement of early detection of breast cancer through collaborative multi-country efforts: Observational clinical study

Patricia Mora

Abstract: Introduction: The incidence and mortality rates from breast cancer are rising worldwide and particularly rapidly across the countries with limited resources. Due to lack of awareness and screening options it is usually detected at a later stage. Breast cancer screening programs and even clinical services on breast cancer have been neglected in such countries particularly due to lack of available equipment, funds, organizational structure and quality criteria. Materials and methods: A harmonized form was designed in order to facilitate uniformity of data collection. Baseline data such as type of equipment, number of exams, type and number of biopsy procedures, stage of cancer at detection were collected from 10 centers (9 countries: Bosnia-Herzegovina, Costa Rica, Egypt, India, North Macedonia, Pakistan, Slovenia, Turkey, Uganda) were collected. Local practices were evaluated for good practice and specific interventions such as training of professionals and quality assurance programs were identified. The centers were asked to recapture the data after a 2-year period to identify the impact of the interventions. Results: The data showed increase in the number of training of relevant professionals, positive changes in the mammography practice and image guided interventions. All the centers achieved higher levels of success in the implementation of the quality assurance procedures. Conclusion: The study has encountered different levels of breast imaging practice in terms of expertise, financial and human resources, infrastructure and awareness. The most common challenges were the lack of appropriate quality assurance programs and lack of trained skilled personnel and lack of high-quality equipment. The project was able to create higher levels of breast cancer awareness, collaboration amongst participating centers and professionals. It also improved quality, capability and expertise in breast imaging particularly in centers involved diagnostic imaging.

ID: 34

Topic: Medical Physics

Approach to the Characterization of the Neutron Capture Reaction by Boron via Geant4

Robinson Steven Medina
Universidad Distrital Francisco José de Caldas

Abstract: Currently, one of the most promising therapies for cancer treatment is BNCT which consists of the combination of two principal steps: (1) a suitable beam of epithermal neutrons and (2) a boron compound (10-B) which is to be stored principally in the tumoral cells. In BNCT, the main reaction (94% branching ratio) produces Lithium ions, alpha particles, and gamma rays [10 B + n -> 7 Li (0.84MeV) + 4 He (1.47MeV) + γ (0.48MeV)]; a less likely reaction (6% branching ratio) produces 7 Li (1.013MeV) + 4 He (1.7MeV) without gamma radiation. In this work, we study the above processes through a simulation in GEANT4. In order to do so, a beam of neutrons with energy of the order of few eV (0.025 eV to 1 eV) is defined and a phantom with water and boron-enriched is used as a target. Besides the electromagnetic standard physics packages, we are using the G4HadronPhysicsQGSP_BIC_HP library to handle the epithermal neutrons. Preliminary results for the simulation reproduce the correct branching ratios along with the corresponding energies for all the particles involved. Lithium ions and alpha particles are observed to be emitted back to back in the laboratory system.

ID: 35

Topic: Medical Physics

Approach to the Characterization of the Neutron Capture Reaction by Gadolinium via Geant4

J. Alfonso Leyva
Pontificia Universidad Javeriana

Abstract: Geant4 as a computational tool for the simulation of radiation-matter interaction, is used in this work to characterize the final state of the neutron capture reaction by Gadolinium-157 (reaction currently being studied worldwide for its application, mainly in cancer treatment). The final state of the neutron capture by Gadolinium-157 consists of a sequence of complex decay transitions that generate gamma rays, x-rays, internal conversion electrons (IC), Auger electrons and the recoiling nucleus (Gadolinium-158). The simulation carried out in this work implements a 25 meV monoenergetic neutron beam and a homogeneous target enriched in Gadolinium-157. The physics list includes hadronic processes and radioactive decay processes. Preliminary results using Geant4 version 10.5.p01 indicate that the number of electrons produced by neutron capture is ~ 0.104 with an energy range between 29 keV and 1.3 MeV. The number of photons per neutron capture is ~ 2.936 and their energy distributes between 199 eV and 7.9 MeV.
Since overall our results are in close agreement with experimental data already reported in the literature, we have carried out a series of simulations and we have characterized the angular distributions of the particles in their final state, obtaining a complete description of the kinematics of these particles with Geant4.

ID: 36

Topic: Super Heavy Elements

Superheavy Element Research at GSI

Michael Block
GSI

Abstract: The investigation of superheavy elements (SHE) that do not occur naturally on earth is a key research topic at the GSI Helmholtzzentrum in Darmstadt. Since the prediction of long-lived superheavy nuclei in the region Z ≈ 114, N ≈ 184 in the late 1960s worldwide efforts to synthesize ever heavier elements were initiated. In the following decades new element up to 118 were discovered, the six elements with Z=107-112 at the GSI, completing the 7th row of the Periodic Table of elements. However, there are still many open questions: what is the heaviest element that may exist? How do relativistic effects change the structure of the periodic table? Are SHE produced in stellar nucleosynthesis? At the GSI in Darmstadt we perform a comprehensive research program trying to answer these questions and to address all aspects of this multifaceted science field.
Within the FAIR phase-0 program several experiments are performed to investigate the atomic, chemical, and nuclear properties of SHE to get a better understanding of these exotic elements. Recent highlights comprise laser spectroscopy of No (Z=102) isotopes and high-precision mass measurements up to Rf (z=104). These experiments shed light on the strength and extension of nuclear shell effects, the occurrence of low-lying isomeric states, and provide access to the shape and size of the heaviest nuclei. In my contribution, I will present select results from the FAIR phase0 campaigns in 2018-2019 and discuss the plans for 2020.

ID: 37

Topic: Nuclear Analytical Techniques and Applications

X-Ray Effects on GaN-based High Mobility Electron Transistors (HEMT)

Marcilei Guazzelli
Centro Universitário FEI

Abstract: High Electron Mobility Transistor (HEMT) is a new generation of electronic devices that take advantage of heterostructures formed of wide band gap materials such as AlGaN/GaN [1,2,3,4]. As a heterojunction field-effect device, GaN-based HEMT owes its promising features to the high mobility of the 2D electron gas (2DEG) confined in a quantum well formed in the junction between two semiconductor materials, one (AlGaN) with a wide bandgap (Eg=6.2 eV), the other (GaN) with a narrower bandgap (Eg=3.4 eV) [1,2]. The characteristics of these transistors are required for several important functions, such as long-distance signal transmission or high-level power levels, being used on radar and satellite [2, 3]. Faced with the possibility of more robust such devices as the effects of ionizing radiation, this new technology can reduce the need to replace detectors based on Si, in applications such as the CERN Large Hadron Collider (LHC), which currently detectors are replaced at least once per year. Considering the applications that can be improved with the use of GaN HEMT (High Electron Mobility Transistor), to expose it to the effects of ionizing radiation is crucial. Therefore, is very important to know the behavior of these new technological devices in relation to the accumulation of Total Ionizing Dose (TID) and Single Event Effect [4]. The COTS power transistors based in GaN were exposed to TID effects by 10-keV X-rays. These HEMTs were tested in the On- and Off-state bias-condition. Switching tests were performed before, during and after irradiation. The devices were characterized at temperatures ranging from -50oC to +75oC. The results indicate that the GaN-technology is a great candidate to be used in harsh environments.

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ID: 38

Topic: Nuclear Analytical Techniques and Applications

Ambient Thermal Neutron Yield due to Soil Gas Radon Space-Time Variability

László Sajó-Bohus
Universidad Simon Bolivar, Nuclear Laboratory

Abstract: Introduction: ambient thermal neutrons of terrestrial origin are mainly related to alpha-decay of radioactive-gas. Interactions between the alpha particles and matter producing neutrons of importance mainly in a moderating media e.g. when diffusion occurrence take place in moisture rich subsoil. It has been reported that cosmic-ray neutron spectrum near the surface has a Rn related thermal component. Objectives: determine dose rate due to ambient Rn-neutron particularly at the thermal energy interval in places where hot spot of soil radon gas concentration is around or above > 40kBq.m-3. Methodology: dose rate is determined applying MC-simulation in selected hot spot area. Space-time variability of radon soil gas concentration and consequent ambient thermal neutron dose is obtained by simulation to assess thermal neutron impact in radon related dosimetry.
Results: outdoor enviromental dose rate of 1.9 pSv/h is found for the thermal energy group of ambient neutron background in that the thermal neutron flux is (1.9 x 10-3) cm-2. s-1 .
Conclusion: The ambient neutron spectrum thermal component has to be determined in those cases where very low radiation background is required and where soil gas radon concentration is relatively high as at site of hot spot observed in a geologically defined area at 2750 meters above sea level UPTC-Tunja, Colombia.

ID: 39

Topic: Nuclear Analytical Techniques and Applications

Radioisotope correlations as a tool for assessing NORM and TENORM production, dynamics and impact: two study cases

Haydn Barros
Nuclear Physics Laboratory - Simon Bolivar University

Abstract: NORM in two Venezuelan Industries have been investigated with the objective of assess the radioactivity levels, the possible contamination pathway and the possible radiological impact in the occupational workers and the environment. Here we present the first large scale survey undertaken at the Oil and the Aluminum industries. Regarding the oil industry, we report on 2 storage sites of used oil production tubes, where it was observed few cases with highly radioactive scales formed inside used oil production pipes, with radioactivity levels up to 2 kBq/g of 228Ra + 226Ra (IAEA recommended limit is 1 Bq/g, or 10 Bq/g if there is no contamination pathways). These values are amongst the highest worldwide. Also, crude fluid processing stations (oil/water/gas separation) were investigated, leading to valuable results on the geochemistry and isotopic ratios of produced waters, which can be of use in the NORM Management Program. On the other hand, also the first large scale survey performed in the Red Mud accumulation site in Venezuela is depicted. This large deposit (25 million m3 of red mud) exhibits TENORM, mainly as Th accumulation rising up to 3 Bq/g, which is the highest reported value worldwide (up to our knowledge). The U levels exhibits maximum values up to 0.56 Bq/g which are also among the highest levels globally. A complete analysis was undertaken showing the industrial enrichment factors (a 4 fold for Th and U), while isotope ratios track well the geological origin of this TENORM. As a result to highlight, in both study cases the use of a novel way to analyze the High Resolution Gamma Spectrometric results, together with other conventional analysis, allows to better understand the geochemical process originating this two TENORM as well as to improve the associated particulate matter dispersion and contamination, which in turns can be used for a better radiological risk assessment.

ID: 40

Topic: Nuclear Analytical Techniques and Applications

Datation of 210-lead review and generalization of radiochronological models

José Carlos Castillo Fallas
Tecnológico de Costa Rica

Abstract: The present investigation work on a review of the different datation models and their connection with the sedimentation process of 210-lead in soils. With that information, the objective is to create a generalizable model capable to add different initial conditions of the formation of the soils. Using Least Square Fitting Method to predict a radiochronological scale profile, obtain with gamma spectroscopy. With soils samples of Reserva Alberto Manuel Brenes, we obtain the chronostratigraphic profile with the highest 137Cs peak at 53 +/- 9 years with a coincidence of 1963 atmosphere nuclear weapon test, and the formation model fit with Constant Initial Concentration model.

ID: 41

Topic: Nuclear Analytical Techniques and Applications

210 lead dating in a water reservoir with rising sedimentation rates

Johnny Salas
Universidad Simón Bolivara - Venezuela

Abstract: In the frame of the Technical Cooperation Project IAEA/VEN7/004, it was set up the first Well Type HPGe gamma spectrometer in Venezuela, in order to evaluate the recent sedimentation by 210 lead. It allows the sediments dating of the last 150 years, in reservoirs and lacustrine systems.The 210 lead dating have been performed measuring the concerned radioactive elements from the natural decay chain of 238U, additionally were measured the radioactive elements from 232Th decay chain and 40K for each layer of the core. In this work it is shown the experimental efficiency calibration for a matrix of sediments and we recreate this source-detector enclosure set-up (HPGe well type detector) and the sediment matrix with the software Geant4 developed at CERN to simulate propagation and interaction of particles within detectors for high energy physics applications. Finally, the geo-chronological study for Maticora's reservoirs is presented using the CRS (Constant Rate of Supply) model which is applicable only in the nucleus D which present concentrations of 210Pbex substantively and systematically higher than 226Ra. From core C it follows that the sedimentation process happened so violent, making it impossible to incorporate 210 Pbex and depositing old soil, due to that this does not present appreciable amounts of 210 Pbex.

ID: 42

Topic: Nuclear Analytical Techniques and Applications

Proving the interface between history, art and science at the National Theater of Costa Rica via spectroscopic tools

Oscar A. Herrera
University of Costa Rica

Abstract: Paintings are one of the most striking means that human beings have used to share our history, learning, personal beliefs and thoughts. Paintings reflect the connection between the artist and its time, not only in the thematic and stylistic aspects, but in the availability of art materials such as pigments, vehicles and varnishes. Establishing and understanding these relations are key to provide accurate information about the artist's palette and developing conservation strategies. The ceiling of the Foyer of the National Theater of Costa Rica is decorated with three large format paintings from the 19th century made by the Italian painter Vespasiano Bignami. The paintings are known as La Poesía, La Música and La Danza (The Poetry, the Music and The Dance) and have undergone restorations in the past. However, their state of conservation is unknown and thus demand accurate scientific examination in order to document their status and the extent of undocumented previous restoration work. To overcome those issues, we propose the application of a combination of non-invasive and in-situ techniques to obtain information about the red pigment composition and actual state of conservation. We employed multispectral digital imaging in the Visible (Vis) and Near Infrared (IR) regions, using panoramic stitching techniques in order to obtain high resolution images of the very large artworks. Furthermore, fragments were taken from the 120-year-old main curtain from the National Theater of Costa Rica in order to understand information about the artist's palette. Results from scanning electron microscopy (SEM) shed light on the textiles used, evidencing the presence of cotton in the reinforcement fabric and linen in the curtain itself. The infrared spectroscopy technique (FTIR) conveys information on the binders used, egg yolk in this case. The elemental composition of the studied pieces was identified using X-ray fluorescence (XRF) spectroscopy technique.

ID: 43

Topic: Nuclear Instrumentation and Facilities.

Performance of 5-µm PIN Diamond Diodes as Thermal Neutron Detectors

Ricardo Alarcon
Arizona State University

Abstract: The properties of diamond that contribute to its value in radiation detection include large bandgap, high electron and hole mobilities, high breakdown field, and high displacement damage threshold. These properties combine to enable radiation hard, low background, and efficient particle detectors. Research at Arizona State University has developed and demonstrated diamond p-i-n particle detectors based on epitaxial growth of n-type, phosphorus doped diamond, p-type, boron doped diamond, and high purity undoped (intrinsic) diamond. The detector i-layer thickness has been adjusted to match the penetration depth of designated alpha particles, which minimizes background due to gamma radiation and high energy particles. Moreover, the detectors operate in pulse mode with a bias of only a few volts. The unique properties of the p-i-n diode led to the development of a new method to mitigate the effects due to the accumulation of trapped charge in the diamond. Recognizing these advantages led us to propose the development of an efficient thermal neutron detector through the integration of a boron nitride neutron absorption layer and an optimized diamond p-i-n detector. Like diamond, boron nitride is a hard, high temperature material that is expected to survive in extreme environments. A number of BN/diamond pin neutron detectors have been fabricated at Arizona State University and tested at the Ohio State University Nuclear Reactor Laboratory. The tests include pulse counting measurements at a thermal neutron beamline with a flux of 4x10^6 n/cm^2/s, and irradiation of the detectors in the core of the reactor for a fluence of 10^15 n/cm^2. The thermal beam results show performance as expected with no significant background above threshold and with a reasonable expectation of pulse counting capability at fluxes up to 10^10 n/cm^2/s. The irradiation results indicate the onset of a new capability in advanced sensor instrumentation based on diamond diodes.

ID: 44

Topic: Nuclear Instrumentation and Facilities.

The LARAMED project at INFN-LNL

Gaia Pupillo
INFN-LNL

Abstract: Advancements in nuclear medicine are based on the development of new and more effective radiopharmaceuticals, the biomolecular probes that helps physicians in the diagnosis and treatment of several diseases, especially cancers. The use and availability of a variety of radionuclides, with different physicochemical properties, is the ground of such advancements. In particular, theranostic radionuclides represent a step towards the personalization of medicine, giving the opportunity to select the patient with a high change to positively respond to the specific treatment, by using the same radiopharmaceutical for a low-dose imaging session (SPECT or PET) prior therapy. Among the emerging theranostic radioisotopes, the LARAMED project focused on the production of 67Cu and 47Sc, since they are attracting the attention of the international scientific community, as underlined by the IAEA CRP focused on "Therapeutic Radiopharmaceuticals Labelled with New Emerging Radionuclides (67Cu, 186Re, 47Sc)". In fact, at INFN-LNL a high performance cyclotron (70 MeV maximum proton energy) was installed in 2015, to be dedicated not only to the new frontiers of nuclear physics studies (SPES project), but also to the interdisciplinary and medical physics investigations, through the LARAMED project, acronym for LAboratory of RADionuclides for MEDicine. Albeit the facility is currently under development (installation of beam-lines, laboratories etc.), the young researchers team started working on the proton-based production of conventional and emerging radionuclides, ranging from nuclear physics to radiochemistry. The LARAMED program is a box full of dedicated projects, aimed at the investigation of alternative methods for target realization (E_PLATE, 2018-2019) and at the production of specific radionuclides by using proton beams: 99mTc (TECHN-OSP and APOTEMA, 2012-2017); 52Mn (METRICS, 2018-2020) and the theranostic 67Cu (COME, 2016) and 47Sc (PASTA, 2017-2018). An overview of the current status of the facility and of the main results on the alternative production routes of 67Cu and 47Sc is the purpose of this presentation.

ID: 45

Topic: Nuclear Instrumentation and Facilities.

Effects of temperature on light output and pulse shape discrimination capability of siloxane-based scintillators

Felix Pino
University of Padova and INFN Laboratori Nazionali di Legnaro

Abstract: In this work, we report a detailed study of the effects on the neutron/γ discrimination (PSD) capability and the light yield of siloxane-based scintillator after being heated at different temperatures, in the range 60 °C - 150 °C, during 24h. The solid scintillator is composed of phenyl containing polysiloxane (PSS100), as base polymer, loaded with moderate amounts (6 wt%) of 2,5-diphenyloxazole (PPO) as primary dye and Lumogen Violet (LV) as wavelength shifter. Light yield was evaluated by measuring the position of the Compton edges on the γ-ray spectra acquired using 137Cs and 22Na calibration sources. For the PSD capability investigation a 252Cf source was used. Photomultiplier signals were acquired using a fast digitizer (CAEN DT5725) and analysed on-line by implementing digital pulse processing methods. We observed that light yields of scintillators heated at 60 °C and 100 °C were very similar to the room-temperature detected value, whereas, when heated at 150 °C, the light yield decreased to around 40% with respect to pristine value. In the same way, the figure of merit for n/γ discrimination of the scintillator heated at 100 °C displayed negligible changes with respect to the not-annealed scintillator, while annealing at 150 °C leads to almost complete loss of the n/γ discrimination capability. Similar tests were performed using the commercial plastic scintillator EJ-299 (currently named EJ-276). When this scintillator was heated at temperatures as high as 80 °C during 24h, the light yield and the n/γ discrimination parameter are deteriorated to around 80 % of the pristine values. Furthermore, it is worth to mention that for temperatures higher than 70 °C the mechanical and optical features of the plastic EJ-299 are remarkably degraded with visible deterioration of stiffness and transparency. In particular, the variation in absorption/emission characteristics have been analyzed by UV-vis spectrophotometry and excitation/fluorescence spectroscopy, in order to correlate the annealing treatment with the formation of aggregates and/or the degradation of the scintillator components, both in the synthesized siloxane scintillator and in the commercial standard EJ-299.
The demonstrated feasibility of the discrimination between fast neutrons and γ-rays at temperatures as high as 100 °C for prolonged times using siloxane-based scintillators clearly widens the range of application of organic-based scintillators to particular fields of usage, where high temperature also induced by high irradiation fluxes can be reached

ID: 46

Topic: Nuclear Instrumentation and Facilities.

Compact, low-power and low-weight gamma-ray spectroscopic system for mobile radiation monitoring and mapping

Samira Sánchez
Nuclear Physics Laboratory – Simon Bolivar University

Abstract: This work consists on the design, assemble, optimization and test of a compact, low-power, and low-weight gamma-ray spectroscopic system for mobile radiation monitoring and mapping using a scintillation-based radiation detector. The scintillation crystal used is a Thallium doped Sodium Iodide (NaI(Tl)) of about 1" x 1" x 2" volume, coupled to a Silicon Photomultiplier (SiPM). The SiPM measures the light intensity produced by the scintillator and generates a current pulse whose amplitude is proportional to the energy deposited within the crystal by each gamma photon. Such pulses have a short time duration (fast rise and falling edge, about 2 micro seconds) which categorizes them as high frequency signals. The developed gamma-spectrometric system performs the analogue treatment of the pulses (amplification and filtering) without the need of the charge sensitive pre-amplifier stage, as well as it digitizes and registers the maximum amplitude of each pulse to finally deliver the energy spectrum (standard Pulse High Analysis). The system development includes a micro-controller programming to carry out the Multichannel Analyser tasks. The new system's performance is comparable to that of the laboratory instruments in terms of energy resolution and linearity. The best resolution reachable with both systems is 8 % and both of them are linear at least up to 2500 keV, no matter the shaping time or SiPM bias voltage. The system works with +3.7 V/ 2000 mAh Li-polymer battery and its weight is 230 g (NaI) + 105 g (all the electronic system, including batteries). It was designed so that different modules like GPS, Bluetooth, flash memory, etc. could be added giving to the system updating flexibility. The devised system portability, power consumption, upgrade possibility and low cost, make it a good choice to perform in-situ gamma ray spectrometric measurements.

ID: 47

Topic: Nuclear Instrumentation and Facilities.

Status and Perspectives of a US-based Electron-Ion Collider (EIC)

Bernd Surrow
Temple Univeristy

Abstract: Understanding the properties of nuclear matter and its emergence through the underlying partonic structure and dynamics of quarks and gluons requires a new experimental facility in hadronic physics known as the Electron-Ion Collider (EIC). A US-based facility capable of colliding high-energy polarized electron and ion beams at high luminosity has been envisaged for a long time and articulated as the highest priority for new construction following the completion of the Facility for Rare Isotope Beams (FRIB) at Michigan State University, most recently in the last 2015 long-range plan by the US nuclear science community.

The EIC will address some of the most profound questions concerning the emergence of nuclear properties by precisely imaging gluons and quarks inside protons and nuclei such as the distribution of gluons and quarks in space and momentum, their role in building the nucleon spin and the properties of gluons in nuclei at high energies. Two facility concepts have been presented to address these conditions, at Brookhaven National Laboratory and Jefferson Laboratory taking advantage of existing accelerator infrastructure and accelerator expertise. In addition, detector concepts have been presented to provide the necessary experimental tools. The realization of the full EIC physics program requires, in addition, a theory program to predict and interpret future experimental results at an EIC facility.

The US Department of Energy requested following the release of the last long-range plan in 2015 the review of the science case of a future EIC program by the US National Academy of Sciences (NAS). This review process started in January 2017 and concluded with the release of a report which was publicly presented on July 24, 2018, stating that `the committee unanimously finds that the science that can be addressed by an EIC is compelling, fundamental and timely'.

The status and perspectives of a US-based EIC facility will be discussed in this presentation.

ID: 48

Topic: Nuclear Instrumentation and Facilities.

Exotic nuclei at SPES, the forthcoming research infratructure for fundamental nuclear physics studies and for applications at the Legnaro National Laborarory

Daniela Fabris
Legnaro National Laborarory

Abstract: The SPES facility, which is currently in the installation phase at the Laboratori di Legnaro of INFN (Italy), consists of a new cyclotron accelerator delivering a high intensity, up to 70 MeV proton beam. Two beams can be delivered at the same time. The three main uses of the high power beams are: production of radioactive beams (RIBs) by ISOL technique fror fundamental nuclear physics studies, radioisotopes production for both research and production purposes and high intensity neutron beam generation.

Fundamental nuclear physics studies will be performed through the ISOL facility, in which the beam impinges on a direct sliced target for the production of a variety of radioactive nuclei for nuclear physics experiment. The target-ion source complex represents the core of the ISOL facility, where the choice of the target material is vital to ensure excellent performances in terms of quantity and regularity of the isotopic yields over the duration of beam delivery. The main target material for nuclear physics applications will be fissile. Such configuration will provide intense neutron-rich radioactive ion beams obtained by proton-induced fission of a uranium carbide (UCx). Moreover other targets will be used, like silicon carbide (SiC) to produce p-rich beams. The exotic isotopes generated in the target will be ionized and mass separated: a beam line dedicated to experimental measurements at low energy is provided, together with the transport line, which, through the ADIGE facility based on a Charge Breader, a Medium Resolution Mass Spectrometer and a normal conductive Radiofrequency Quadrupole injector, will be coupled to the post accelerator ALPI to provide exotic beams up to 10 MeV/A for A=130.

The status of the project will be presented.

ID: 49

Topic: Education on Nuclear Physics and Applications.

Women in Science

Marcelei Guazzelli
Centro Universitário FEI

Abstract: Women in Science

ID: 50

Topic: Education on Nuclear Physics and Applications.

Tools to Help Students Maximize Their Learning

Mariela Porras
University of Cost Rica

Abstract: "The goal of this session is to discuss present-day andragogy techniques that can be applied to medical physics education. There is burgeoning research on the mind's natural processes for understanding and assimilating information. These findings have led to teaching tools that tap into the student's innate learning abilities to better comprehend and retain concepts. This session aims to present these techniques and how they can be incorporated in existing curricula without necessitating a complete re-design of the course's structure. Whether one chooses to have a flipped classroom or a more traditional approach, these methods will provide instructors with the tools necessary to help their students achieve a deeper understanding of the field. Optimizing the educational learning environment ultimately leads to more productive learning, more efficient preparation for certification examinations, and overall better-prepared professional life-long learners."(1) This presentation focuses on tools that can be incorporated by the instructors in the design of their classes and shared with students to optimize their learning. - - - (1) This presentation is based on a previously presented work at AAPM Annual Meeting 2017, as part of Adult Learning (Andragogy) Techniques for Medical Physics, a joint-panel discussion. The abstract of the original session has been included for completeness and transparency.

ID: 51

Topic: Education on Nuclear Physics and Applications.

Attention as a predictor of academic performance of university students and its relationship with reading and writing frequency

Josiane Pawlowski
Universidad de Iberoamérica

Abstract: Introduction: Attention is an essential aspect of the learning process. Psychological measurements instruments of attention are considered, traditionally, a good scholar achievement predictor. That students with higher grades also have higher selective and divided attention skills and make fewer mistakes, in comparison with more distracted or restless students who usually have lower grades and worst performance in attention test. Besides, attentional complaints are usually manifested by the students. The d2 test is a psychological measurement that evaluates sustained and selective attention, giving also scores of processing speed, number of correct and incorrect answers, omissions and fluctuation or variation in the performance, that indicate concentration and stability during task execution.
Objectives: This research aimed: 1) to investigate if the results of a sustained attention test can predict academic performance of university students, comparing physics and psychology students, and 2) to evaluate the relationship between attention and reading and writing frequency, both from electronic and traditional sources. Method: A sample of 155 university students, 80 males and 75 females, from 18 to 35 years old (M = 22; SD = 3.42), 77 physics students and 78 psychology students, answered a sociodemographic questionnaire, a reading and writing short scale, and the d2 Attention Test. Also, the grades of the participant students were obtained at the end of course. Data were analyzed with Pearson correlations, repeated measures ANOVA and regression analysis. Results: The attention test scores were associated with higher grades in physics students, but not in psychology students. Therefore, sustained attention can predict better academic performance of physics students but not for psychology students. Sustained attention was associated with printed newspapers or scientific printed papers and digital books reading frequency, also with electronic writing frequency, but not with traditional handed writing. Differences were found in attention scores between males and females, having that males had higher scores in processing speed, concentration index and stability during task execution, while scores on omissions and errors were similar for both groups.
Conclusion: The Sustained and Selective Attention d2 Test can be used as a predictor for academic performance in physics students and, therefore, can be used as a selection test on the admission process for this career, for example, but is not suitable for psychology.

ID: 52

Topic: Education on Nuclear Physics and Applications.

Can we start with the training?

Pilar Liliana Mabel Marinelli
Facultad Regional Delta/ I.S.F.T N°195

Abstract: Students of ¨today¨ and the current teaching, diversify at the wrong time with the speed of progress scientific and technological, and space and tools are not always available to accompany these changes with aulic and planned tasks according to the circumstances. Argentine academic programs are determined to follow obsolete and increasingly lethargic models, while some sectors of the world are advancing in strategic planning in Energy, industrial and development matter. The teaching of basic Nuclear Physics and the study of its technological applications as a resource and alternative energy, is not a notion that pproaches students in the early years of the careers of engineering (with the exception of Nuclear Engineering) and it is, an imperative need in the times we run. We are doing a survey on the knowledge that students of First year Chemical, Electrical, Mechanical and Information Systems Engineering bring from their high school training With this information, we are trying to reorder the curriculum so we can introduce elementary notions of this branch of Physics without neglecting the contents defined for each career insertion but, at the same time, incorporating conceptual elements necessary for the current times and design methodologies to ease the way in which they should be approached to students. The above taking into account that the Delta Regional Faculty is 39 km away from the Nuclear Power Plant Atucha I and Atucha II and it can be strategic student training for job placement in current Centrals and the future Site Central.

ID: 53

Topic: Hadron Structure, Phases of Nuclear Matter, QCDHadron Structure, Phases of Nuclear Matter, QCD

Isospin-dependent phase diagram of nuclear matter

Jorge López-Gallardo
University of Texas

Abstract: We study the phase diagram of nuclear matter extending it from the traditional two-dimensional density-temperature plane to three-dimensional space of density, temperature, and isospin asymmetry. We identify the liquid-gas coexistence region by means of Maxwell constructions over pressure-volume isotherms. Such pressure-density equations of state were constructed from data obtained from interpolating results from molecular dynamics simulations of infinite nuclear systems in the liquid phase those of Fermi gases at low (sub-saturation) densities. The molecular dynamics results were used to obtain the energy per nucleon and pressure for systems with densities and temperatures in the ranges ρ=0.01 to 0.2 fm−3, T between 1 and 15MeV, and with isospin content of x = Z/A = 0.3, 0.35, 0.4, 0.45 and 0.5. The results indicate that symmetric and asymmetric matter are self-bound and show a coexistence region that extends, approximately, to densities of up to ρ0/2, temperatures of up to 16MeV, and down to proton fractions of 13%.