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^{41}Ca detection with Accelerator Mass Spectrometry at low energies: measurements on the 1 MV system at the Centro Nacional de Aceleradores

Carlos Vivo-Vilches[1,2,], José María López-Gutiérrez[1,2], Manuel García-León[1,3], Christof Vockenhuber[4], Thomas Walczyk[5]*

1Centro Nacional de Aceleradores (Universidad de Sevilla, Consejo Superior de Investigaciones Científicas, Junta de Andalucía), Thomas Alva Edison 7, 41092 Seville, Spain

2Dpto. de Física Aplicada I, Escuela Universitaria Politécnica, Universidad de Sevilla, Virgen de África 7, 41011 Seville, Spain

3Dpto. de Física Atómica Molecular y Nuclear, Universidad de Sevilla, Reina Mercedes s/n, 41012 Seville, Spain

4Laboratory of Ion Beam Physics, Paul Scherrer Institute and ETH-Zurich, 8093 Zurich, Switzerland

5Department of Chemistry (Faculty of Science), National University of Singapore, Science Drive 4, 117543 Singapore

During the last 2 years, the setup of the 1 MV Accelerator Mass Spectrometry system at the CNA for ^{41}Ca measurements has been established. The capacity of measuring this isotope with compact AMS systems for biomedical applications was already proven with the 0.6 MV AMS system at ETH Zurich, Tandy [1], improving the accuracy of this measurements by the detection of ^{39}K together with ^{41}Ca to correct the interference of its stable isobar ^{41}K [2]. These measurements have taken great advantage from the recent change of the stripping gas fron Ar to He [3], getting a much higher transmission. First measurements of blank samples (with natural Ca isotopic composition, ^{41}Ca/^{40}Ca < 10^{-15}) confirm the expected linear relation between measured (^{41}K+^{41}Ca) and ^{39}K, and a ^{41}Ca/^{40}Ca background of level 5×10^{-12}, equal to the one from Tandy; measurements of standard samples (with known ^{41}Ca/^{40}Ca ratio) show that ion losses in the High Energy section are only a 5%. Near future applications involve characterization of concrete samples from the primary shield from José Cabrera nuclear power plant for ENRESA and calcium metabolism studies with biomedical groups from the University of Sevilla, for which radiochemical procedures have been developed.

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Calibración absoluta de detectores de pérdidas de iones rápidos en dispositivos de fusión nuclear

M. Rodriguez-Ramos,[1,2], J. Garcia-Lopez,[1,2] , M. C. Jimenez-Ramos,[2], M. Garcia-Muñoz,[1,2,3], J. Galdon-Quiroga,[1], L. Sanchis-Sanchez,[1] and the ASDEX Upgrade Team[3]

[1] Dept. of Atomic, Molecular and Nuclear Physics. University of Sevilla, Sevilla, Spain,
[2] CNA (U. Sevilla, CSIC, J. de Andalucia), Sevilla, Spain
[3] Max-Planck-Institut für Plasmaphysik, Garching, Germany

**E-mail: mrodriguez67@us.es*

En los dispositivos de fusión nuclear por confinamiento magnético, la presencia de iones supratérmicos conocidos como iones rápidos (generados por los sistemas auxiliares de calentamiento y las reacciones de fusión) es esencial, ya que constituyen una fuente de energía y momento al depositar su energía en el volumen del plasma a través de colisiones coulombianas. Sin embargo, diferentes mecanismos de transporte pueden provocar las pérdidas de estos iones dando lugar a una degradación en la eficiencia de calentamiento del plasma y poniendo en peligro la integridad de la pared de la vasija de contención del plasma de fusión [1]. Con el fin de obtener una mejor comprensión de los mecanismos de transporte de manera experimental, detectores de pérdidas de iones rápidos basados en materiales centelleadores o FILD [2] (del inglés, Fast Ion Loss Detector) se encuentran instalados en prácticamente todos los dispositivos de fusión nuclear. Sin embargo, la cuantificación de las pérdidas absolutas no se había realizado hasta ahora debido a la compleja dependencia de la respuesta del material centelleador con la temperatura. Para este propósito, una nueva cámara de análisis con haces de iones (IBA) se ha instalado y equipado con un sistema de detección fotónica en el acelerador tandem 3MV del Centro Nacional de Aceleradores (CNA) [3]. En particular, la caracterización de la eficiencia absoluta, en términos del número de fotones emitidos por ion incidente, se ha llevado a cabo para los materiales centelleadores $SrGa_2S_4$:Eu^{2+} y el Y_2O_3:Eu^{3+} al bombardearlas con un haz de iones. Los fósforos analizados se han irradiado con iones ligeros de diferentes masas (deuterones, protones y partículas alfa) de energías del orden del MeV y a temperaturas que van desde temperatura ambiente [4] hasta 500 º C. Las condiciones experimentales se han elegido para reproducir el comportamiento de estos materiales en un entorno lo más parecido posible al que hay en los reactores de fusión. El rendimiento absoluto de las pantallas centelleadoras, la cuantificación de la transmisión de luz del sistema óptico del detector, la eficiencia de los sistemas de adquisición y la geometría 3D del colimador del detector se han utilizado para construir una función instrumental que permita inferir las perdidas absolutas de iones rápidos a partir de las mediciones realizadas con FILD. Las primeras medidas absolutas del número de iones rápidos que se pierden en el plasma están siendo llevadas a cabo por nuestro grupo de investigación, combinando experimentos realizados en el Centro Nacional de Aceleradores y en el tokamak ASDEX Upgrade del Max Planck Institut fur plasmaphysik.

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Recent developments in the simulation of organic scintillation detectors with GEANT4

A.R. Garcia, D. Cano-Ott, T. Martinez, E. Mendoza (Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas (CIEMAT), Avenida Complutense 40, 28040, Madrid, Spain)
R. Nolte (Physikalisch-Technische Bundesanstalt (PTB), Bundesallee 100, 38116 Braunschweig, Germany)

The accurate determination of the response function of organic scintillation neutron detectors complements their experimental characterization. Monte Carlo simulations can reduce the effort and cost implied, in particular, for complex detection systems for which the characterization is more challenging.

GEANT4 is a Monte Carlo simulation toolkit that offers a great exibility in a wide range of applications. Previous studies have reported on its inaccuracy in the calculation of the neutron response of organic scintillation detectors above 6 MeV, due to an incomplete description of the neutron induced alpha production reactions on carbon. We have improved GEANT4 in this direction by incorporating models and data from NRESP. The latter is an excellent Monte Carlo simulation tool developed at the Physikalisch-Technische Bundesanstalt (PTB), Germany, for the specific purpose of calculating the neutron response function of organic scintillation detectors, that stands out among other codes in its application field for its high accuracy, specially, in the description of the neutron induced alpha production reactions on carbon. The results have been verified against simulations with NRESP and validated against Time-Of-Flight measurements with an NE213 detector at PTB.

The potential applications of this work extend to other types of detectors for which fast neutron induced reactions on carbon require an accurate description.

Ultra-fast PET rebining data and image reconstruction based on pseudoinversion

Alejandro López Montes, Joaquín López Herraiz, José Manuel Udías Moinelo

The problem of the reconstruction of images from nuclear medicine has been estudied and developed for many years. There have been used several methods with diferent results in resolution and computing time from analitical methos as FBP to iterative solutions where the variety of algorithms is enormous. Further, data acquired in 3D are often rebined into 2D data sets in order to speed-up reconstruction. Thus the reconstruction of 3D data can be cast into two steps, first a rebinning of data into 2D sets, followed by reconstruction of the 2D slices. For many practical purposes, it is accurate enough to aproximate both the rebining and the 2D-reconstruction problems as a set of linear equations, that can be solved by means of the pseudo-inverse matrix. We show that with the pseudo-inverse rebinning, we can get results much better than with the usual SSRB recovering more information than with the most sophisitcated FORE rebinning algorithm, and further the rebinning as well as the 2D reconstruction algorithms based on the pseudoinverse can be done in extremely short times.

Depth of Interaction correction strategies in high sensitivity PET scanners

Pablo Galve Lahoz, José Manuel Udías Moinelo, Joaquín López Herraiz

Actualmente, los precios de los escáneres PET vienen determinados por el número de detectores y la instrumentación utilizada en cada uno. A su vez, las dimensiones de cualquier escáner definen el número y tamaño de estos elementos, cerrando así su relación con los costes.

Centrándonos en esto, se ha dedicado este trabajo a la optimización del campo de visión (FOV), desarrollada a través de distintos métodos de recolocación de los LOR correspondientes a cada par de cristales. Basándonos en los resultados del simulador peneloPET, se ha estudiado la profundidad de interacción (DOI) en los detectores con la distancia axial de cada LOR. Se ha calculado el punto de interacción más probable para mejorar el posicionamiento de los LOR, y se ha ido un paso más allá utilizando la información sobre la DOI para dividir cada cristal en varios subconjuntos, repartiendo entre ellos las cuentas según la distribución obtenida. Otro enfoque, más intuitivo, consiste en encontrar la relación lineal entre las posiciones reales de fuentes puntuales y las reconstruidas, para aplicarlo directamente sobre los radios de cada LOR mientras se construye el sinograma.

Todos los resultados se han comparado con los métodos previos para distintos escáneres (Super Argus, Super Argus sin phoswich, y otras variaciones) obteniendo el mejor resultado para los escáneres sin phoswich mientras que la información del phoswich da ya buenos resultados sin aplicar las mejoras.

Symmetry energy and the neutron star core-crust transition in Gogny forces

C. Gonzalez-Boquera[1], M. Centelles[1], X. Viñas[1], A. Rios[2]

1 Departament de Física Quàntica i Astrofísica and Institut de Ciencies del Cosmos, Facultat de F´ısica, Universitat de Barcelona, Diagonal 645, E-08028 Barcelona, Spain
2 Department of Physics, Faculty of Engineering and Physical Sciences, University of Surrey, Guildford, Surrey GU2 7XH, United Kingdom

The second, fourth and sixth-order symmetry energies in nuclear matter ($E_{sym,2}$, $E_{sym,4}$ and $E_{sym,6}$, respectively) have been studied for several Gogny interactions. We have also calculated the second-order symmetry energy using the popular parabolic approximation, E^{PA}_{sym}. We find that the density dependence of $E_{sym,2}$ and E^{PA}_{sym} calculated with the different Gogny functionals shows relatively similar general tendencies, while the $E_{sym,4}$ and $E_{sym,6}$ corrections present a strong model dependence.

Using the exact expression of the equation of state (EOS) of asymmetric nuclear matter and its expansion at the different orders, we have studied the transition between the core and the crust of neutron stars in the thermodynamical method. We observe that small variations between the results for the transition asymmetry δ_t calculated with the exact EOS and the values calculated with the expansions of the EOS may imply larger variations in the transition density ρ_t and transition pressure P_t. Although the addition of higher order terms to the expansion of the EOS may give results closer to the ones calculated using the exact EOS, the gap between them may still be quite large. For the transition density, we obtain that the Gogny forces predict a decreasing, quasi-linear tendency with the slope of the symmetry energy L, whereas we do not observe any correlation with L for the transition asymmetry and pressure.

Digital Strategies for Time and Energy Measurement for Ultra-Fast Scitillators

V. Sanchez-Tembleque, V. Vedia, M. Carmona, L. M. Fraile, S. Ritt, J. M. Udías

Ultra-fast inorganic scintillators, like $LaBr_3$(Ce) are key detectors in Nuclear Physics and medical applications. On the other hand, fully digital acquisition systems, for which the pulses from the detectors are sampled at high rates, are being increasingly used. We present new digital pulse processing algorithms to extract time and energy signals from nuclear pulses produced by ultrafast detectors. We compare the results of the fully digital acquisition chain (DDAQ) to state-of-the-art results obtained with traditional electronics, based upon constant fraction discriminators (CFD), time to digital converters and multichannel analyzers. For this purpose, we have performed coincidence measurements using relatively large (1"x1.5"x1") truncated cone and cylindrical LaBr3(Ce) and CeBr3 crystals coupled to ultra fastphotomultipliers (PMTs). Coincidence measurements with Co-60 and Na-22 sources are acquired. The main advantage of fully digital processing is that many different algorithms may be applied to the same raw data set. Pulses from PMTs optimized for timing measurements were digitized to a switched capacitor array with a speed sampling of 5 Gs/s and a resolution of 16 bits, and to a fast digital oscilloscope able of 4 Gs/s and 8 bits resolution. With an in silico version of the analog CFD we obtain coincidence resolving times below 150 ps for Co-60, outperforming the standard acquisition system.

Single-particle structure of ^{17}C

X. Pereira-Lopez [a, b], B. Fernández-Domínguez [b], F. Delaunay [a]
a LPC Caen, France
b Universidade de Santiago de Compostela, Spain

On behalf of the E628 collaboration Universidade de Santiago de Compostela, LPC Caen, University of Surrey, IPN Orsay, University of Birmingham, GANIL, CEA/IRFU

The shell structure of stable and near-stable nuclei and the associated magic numbers are key elements in nuclear structure. It has been demonstrated, however, over recent years that the traditional magic numbers evolve when nuclei far from stability are explored. For example, recent experiments [1,2,3], including transfer studies by the TIARA collaboration at GANIL [4,5,6], have provided evidence to support the existence of a shell closure at N=16 in neutron-rich neon and oxygen isotopes associated with the vanishing of the N=20 shell gap. This has been understood as arising from the effects of the monopole part of the nucleon-nucleon interaction [7,8]. However, in the neutron-rich carbon isotopes, the extent to which the gap persists at N=16 is unclear. In an effort to answer this question we have attempted to probe the low-lying level structure of ^{17}C using the $^{16}C(d,p)^{17}C$ transfer reaction in inverse kinematics to locate the neutron single-particle orbitals involved in the formation of the N=16 shell gap. Of particular interest is the neutron 0d3/2 orbital, which spectroscopic strength is expected to be concentrated in the unbound states.

The experiment was carried out at the GANIL facility. A pure secondary beam of ^{16}C at 17.2 AMeV produced by fragmentation in the LISE3 spectrometer was used to bombard a CD_2 target. The light ejectiles were detected using the TIARA and MUST2 silicon (Si) strip arrays while a Si-Si-CsI telescope was placed at zero degrees to identify beamlike residues. In addition, four HPGe-EXOGAM clover detectors were used to measure the gamma-rays arising from ^{17}C bound excited states.

The detailed goals of the experiment, the setup, and the elastic and oneneutron transfer angular distributions will be shown in this presentation together with a preliminary interpretation of the experimental results.

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Caracterización y optimización de parámetros de adquisición en CT de mama para reducción de dosis

Amaia Villa Abaunza, José Manuel Udías Moinelo, Joaquín López Herraiz

La finalidad de este trabajo es optimizar y personalizar para cada paciente los parámetros en la adquisición de imagen de CT de mama de forma que se deposite una menor dosis sin reducción en la calidad de la imagen.

Se ha usado el método Monte Carlo PenEasy (versión simplificada de PENELOPE) para la simulación del transporte de fotones en las distintas geometrías y materiales considerados, y también el código de simulación “hybrid Ultra MC”, desarrollado en el grupo, debido a que es aproximadamente 50 veces más rápido. Para la reconstrucción de la imagen se han usado el método analítico FDK y el iterativo MLEM. Por otra parte, la evaluación de la calidad de imagen se ha basado en el estudio de la detectabilidad en las proyecciones, obteniendo así una pre-estimación sin necesidad de reconstruir la imagen.

Mediante las simulaciones se ha podido determinar cuáles son las configuraciones óptimas que minimizan el ruido en las proyecciones sin superar un máximo límite de dosis (12 mGy). Por tanto, es posible la definición de una óptima configuración de adquisición en los parámetros de CT para cada paciente (teniendo en cuenta el tamaño y la densidad de la mama).

Análisis de detectores de diamante monocristalinos con protones de baja energía

M.C. Jiménez Ramos[1,2], J. Garcia Lopez[1,2], M. Rebai[3], C. Cazzaniga[4]
[1]Dpto. Física Atómica, Molecular y Nuclear, Universidad de Sevilla. 41080 Sevilla, Spain
[2]CNA (U. Sevilla, J. Andalucia, CSIC), Av. Thomas A. Edison 7, Isla de la Cartuja 41092 Seville, Spain,
[3]University of Milano Bicocca, Piazza della Scienza 3, 20126 Milano, Italy
[4]STFC, Rutherford Appleton Laboratory, Didcot, OX11 0QX, United Kingdom.

Los monocristales de diamante presentan buenas propiedades de transporte de carga, bajas corrientes de fuga y también buena resolución en energía por lo que se plantean como candidatos para muchas aplicaciones, por ejemplo, para las medidas de neutrones rápidos en las fuentes pulsadas de espalación y para experimentos dentro del área de los plasmas para fusión. Sin embargo, se han encontrado efectos transitorios en su respuesta durante las irradiaciones con iones, como las partículas alfa de las fuentes de calibración. La existencia de trampas en el detector hace que se retengan portadores y que se modifique el campo eléctrico de deriva teniendo como consecuencia la disminución de la altura de pulsos durante las irradiaciones. Este suceso se conoce como "efecto de polarización" y sus características dependen de que el detector se polarice positiva o negativamente. En este trabajo se presentan las respuestas de dos detectores de diamante de distintos tamaños al irradiarlos con protones de 1 y 3 MeV.

Keywords: Detectores de diamante, efecto de polarización, aceleradores de baja energía.

Gamma and fast-timing spectroscopy of the ^{30}Mg and ^{29}Mg nuclei

J. Benito: Grupo de Física Nuclear, Facultad de Físicas, Universidad Complutense, Madrid, Spain; L.M. Fraile: Grupo de Física Nuclear, Facultad de Físicas, Universidad Complutense, Madrid, Spain; H. Mach: Grupo de Física Nuclear, Facultad de Físicas, Universidad Complutense, Madrid, Spain; B.Olaizola: Grupo de Física Nuclear, Facultad de Físicas, Universidad Complutense, Madrid, Spain; O. Tengblad: Instituto de Estructura de la Materia, CSIC, Madrid, Spain; R. Boutami: Instituto de Estructura de la Materia, CSIC, Madrid, Spain; C. Jollet: Institut de Recherches Subatomiques, IN2P3-CNRS, F-67037 Strasbourg, Cedex 2, France; W.A. Plóciennik: The Andrzej Soltan Institute for Nuclear Studies, 05-400 Swierk, Poland; D.T. Yordanov: K.U. Leuven, IKS, Celestijnenlaan 200 D, 3001 Leuven, Belgium; M. Stanoiu: IPN, IN2P3-CNRS and Université Paris-Sud, F-91406 Orsay Cedex, France; M.J.G. Borge: Instituto de Estructura de la Materia, CSIC, E-28006 Madrid, Spain; P.A. Butler: ISOLDE, PH Department, CERN, CH-1211 Geneva 23, Switzerland; Oliver Lodge: Laboratory, University of Liverpool, Liverpool, L69 3BX, United Kingdom; J. Cederkäll: ISOLDE, PH Department, CERN, CH-1211 Geneva 23, Switzerland; Ph. Dessagne: Institut de Recherches Subatomiques, IN2P3-CNRS, F-67037 Strasbourg, Cedex 2, France; B. Fogelberg: Department of Nuclear and Particle Physics, Uppsala University, P.O. Box 535, S-75121 Uppsala, Sweden; H.O.U. Fynbo: Institut for Fysik og Astronomi, Aarhus Universitet, DK-8000 Aarhus C, Denmark; P. Hoff: Department of Chemistry, University of Oslo, P.O. Box 1033 Blindern, N-0315 Oslo, Norway; A. Jokinen: University of Jyväskylä, Department of Physics, P.O.Box 35 (YFL), FIN-40014 Jyväskylä, Finland,Helsinki; Institute of Physics, P.O.Box 64, FIN-00014 Helsinki, Finland; A. Korgul: Institute of Experimental Physics, Warsaw University, Ho_za 69, PL 00-681 Warsaw, Poland; U. Köster: ISOLDE, PH Department, CERN, CH-1211 Geneva 23, Switzerland; Institut Laue-Langevin, B.P. 156, F-38042 Grenoble Cedex, France; W. Kurcewicz: Institute of Experimental Physics, Warsaw University, Ho_za 69, PL 00-681 Warsaw, Poland; F. Marechal: Institut de Recherches Subatomiques, IN2P3-CNRS, F-67037 Strasbourg, Cedex 2, France; T. Motobayashi: RIKEN, Hirosawa 2-1, Wako, Saitama 351-0198, Japan; J. Mrazek: Nuclear Physics Institute, AS CR, CZ 25068, Rez, Czech Republic; G. Neyens: K.U. Leuven, IKS, Celestijnenlaan 200 D, 3001 Leuven, Belgium; T. Nilsson: ISOLDE, PH Department, CERN, CH-1211 Geneva 23, Switzerland; J. Nyberg: Department of Nuclear and Particle Physics, Uppsala University, P.O. Box 535, S-75121 Uppsala, Sweden; S. Pedersen: Institut for Fysik og Astronomi, Aarhus Universitet, DK-8000 Aarhus C, Denmark; A. Poves: Departamento de Física Teórica C-XI, Universidad Autónoma de Madrid, E-28049, Spain; B. Rubio,22: Instituto de Física Corpuscular, CSIC University of Valencia, E-46071 Valencia, Spain; E. Ruchowska: The Andrzej Soltan Institute for Nuclear Studies, 05-400 Swierk, Poland; The ISOLDE collaboration

Nuclei far from stability are an excellent target for both advanced experimental techniques and nuclear models. In areas of the nuclide chart far from the valley of stability new phenomena appear such as the so-called islands of inversion. These are regions where the ordering of the single particle energy levels is not the usual one, but it appear inverted. The existence of these areas makes it very interesting identify their boundaries and to understand the underlying physical phenomena that drive the inversion.

In this paper, the β γ γ (t) together with γ-ray spectroscopy were applied to investigate the levels and level lifetimes in ^{29,30}Mg. The excited structure in Mg has been populated in the β-decay and β-delayed neutron emission of Na isotopes produced at the ISOLDE facility. Two new levels along with eight new transitions were identified in ^{30}Mg, together with two new transitions in ^{29}Mg. Several half-lives in the nanosecond range were measured for the 1789 keV state in ^{30}Mg, and for the 54 keV and 1430 keV levels in ^{29}Mg. Reduced transition probabilities were determined based on the lifetime measurements and the decay schemes. They were compared to existing complementary data and to neighboring nuclei in the region.

^{236}U at the Centro Nacional de Aceleradores: first environmental studies

Mercedes López-Lora[1,2,], Elena Chamizo[1], Isabelle Levy[3], M.K. Pham[3], Martina Rožmarić[3], Deon C. Louw[4], Oxana Blinova[3], Matthieu Bressac[3,5], Manuel García-León[1,6]*
[1]Centro Nacional de Aceleradores (Universidad de Sevilla, Consejo Superior de Investigaciones Científicas, Junta de Andalucía), Thomas Alva Edison 7, 41092 Seville, Spain
[2]Dpto. de Física Aplicada I, Escuela Universitaria Politécnica, Universidad de Sevilla, Virgen de África 7, 41011 Seville, Spain
[3]International Atomic Energy Agency, Environment Laboratories, MC 98000 Monaco
[4]National Marine Information and Research Centre, PO Box 912, Swakopmund, Namibia
[5]Institute for Marine and Antarctic Studies, University of Tasmania, Hobart, TAS, Australia
[6]Dpto. De Física Atómica Molecular y Nuclear, Universidad de Sevilla, Reina Mercedes s/n, 41012 Seville, Spain

Recently, several studies have been focused on the determination of ^{236}U ($T_{1/2}$ =2.342·10^7 y) in seawater due to its potential in oceanography. This radionuclide is considered an ideal oceanographic tracer because of its conservative behavior, long half-life and mainly anthropogenic origin. However, ^{236}U concentrations in the general environment, and specifically in the oceans, are extremely low. The study of ^{236}U in environmental samples has recently become possible as a result of the high sensitivity reached by modern Mass Spectrometry systems, especially, by Accelerator Mass Spectrometry (AMS), which features with the lowest $^{236}U/^{238}U$ background atomic ratios mainly by means of the destruction of the molecular isobars in the terminal of an electrostatic tandem accelerator in the so-called stripping process. However, the measurement of this radionuclide is not a fully consolidated technique for the AMS community. There are still several experimental and technical issues to be solved and it is still necessary to have well-established radiochemical methods to address very low-level environmental studies accurately.

In this context, at the Centro Nacional de Aceleradores (CNA) in Seville (Spain), it has been recently demonstrated that ^{236}U can be determined at environmental levels by the 1MV AMS system [1,2]. Besides, a radiochemical method for small-volume seawater samples (up to 10 L) has been optimized. The first ^{236}U studies in seawater were carried out in the frame of the existing collaboration between the IAEA Environment Laboratories in Monaco, the National Marine Information and Research Centre (NatMIRC) in Namibia and the CNA. These first ^{236}U results were obtained from a seawater column in the northwestern Mediterranean Sea [3] and from a set of samples collected in the northern Benguela upwelling system, in the South-Atlantic Ocean.

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Multi-particle emission from ^{31}Ar at IDS

*I. Marroquín[1], O.Tengblad[1], E. Nácher[1], A.Perea[1] for the MAGISOL** collaboration*
[1]Instituto de Estructura de la Materia, CSIC, Madrid, Spain
***Madrid-Aarhus-Göteborg collaboration*

In the beta decay of exotic nuclei, far from stability, the daughter nuclei might be formed in an excited state, which is unstable against particle emission. This phenomenon is called β-delayed particle emission and is due to a high Q-value and low separation energy for particle emission. The decay of the proton drip-line nucleus ^{31}Ar is one of the most exotic β-delayed multi-particle decays. It has a large Q_β -window and as a consequence many different β-delayed decay channels are open: βγ, βp, βpγ, β2p, β2pγ, β3p and perhaps also β3pγ [1].

The aim of the IS577 experiment performed at the ISOLDE Decay Station (IDS) was the identification of the β3p and β3pγ-decays in ^{31}Ar as well as to provide important information on the resonances of ^{30}S and ^{29}P, relevant for the astrophysical rp-process [2].

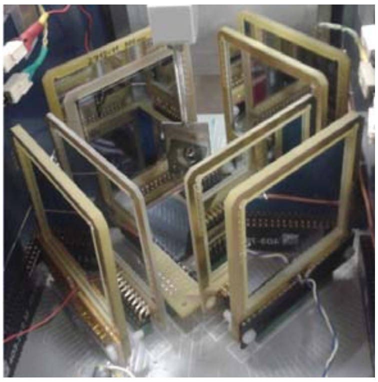

Figure 3. Charged particle detector setup. The beam was collected in a carbon foil located at the middle of the detector setup

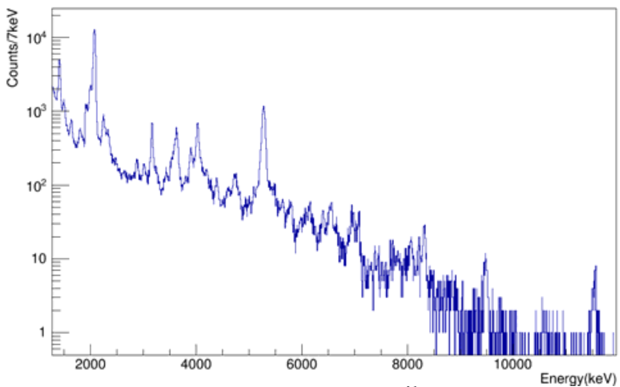

Figure 5. β-delayed proton spectrum from ^{31}Ar (all statistics are included). Several proton lines from the decay are observed.

The IDS is a new installation at ISOLDE devoted to β-decay measurements. This is the first time that one of these kind of experiments based on decay studies is carried out taking advantage of this permanent station. Our collaboration installed a new implantation chamber; the *MAGISOL Si-Plugin Chamber,* consisting in 5 Double Sided Si Strip Detectors (DSSSD) backed by un-segmented Si-pad detectors in ΔE-E telescope configuration. In addition, there are 4 HPGe clover-detectors surrounding the chamber for gamma detection. This setup is compact with high efficiency for both multi-particle emission and gamma ray detection with low cutoff energy as well.

The Si-array (Fig. 1) detects multi proton emission over a wide energy range with the good energy (25 KeV) and angular (3^{O}) resolution that are needed to characterize the different p-channels of ^{31}Ar. A proton spectrum from all the telescopes is shown below. Further, with this setup it is possible to measure proton-gamma and proton-proton coincidences, therefore, we can see gamma transitions from levels of ^{30}S and ^{29}P and determine the spin of levels of ^{30}S and ^{31}Cl, respectively. I will present here preliminary results, as one-proton-gated gamma spectrum and proton-proton angular correlations.

[1] Proposal to the ISOLDE and Neutron ToF Committee, INTC-P-386, September 2013
[2] G.T. Koldste et al. Phys. Letters B 737 (2014) 383-387

Systematic Measurements of Knockout Reacction Cross Sections in Medium Mass Nuclei

Javier Díaz Cortes for the FRS Collaboration

New measurements of the knockout reaction cross sections of tin isotopes with N = 63-82 were obtained. The isotopic distributions of the cross sections were measured by using inverse kinematics at relativistic energies. Using this technique, fragments are emitted in forward direction and this allows us to analyze them with an in-flight magnetic spectrometer. The experiment took place at the GSI facility and the forward emitted reaction products are identified with the Fragment Separator (FRS) magnetic spectrometer. We present here the first systematic measurement of one-nucleon removal cross section for Z=50 isotopes. A very interesting behavior is observed from the differences between the cross sections measured for the removal of neutrons from neutron-rich isotopes and from neutron-deficient isotopes, and exactly the opposite behavior for the proton removal channel.

Detection of gamma rays in the reaction $^{14}B(p,2p)^{13}Be$ and its importance to interpret the structure of ^{13}Be

G. Ribeiro, E. Nacher, O. Tengblad, B. Jonson for the R3B Collab

The R3B instrumentation constitutes a universal fixed-target set-up with the detection and identification of incoming beam as well as of all outgoing charged particles, neutrons, and gamma rays, thus making possible complete inverse-kinematics reaction-experiments using relativistic RIBs (300–1500 AMeV). Experiments with the most exotic and short-lived nuclei produced in the reaction-target and analysed in the super-FRS before reaching the set-up allows for the exploration of the isospin frontier at and beyond the drip-lines.

In this contribution we report on the structure of the unbound nucleus ^{13}Be measured in complete kinematics using an incoming ^{14}B beam at 490 MeV/u. Resonant states have been populated in ^{13}Be using the selective (p,2p) channel under quasifree scattering conditions for the first time. Furthermore, prompt gamma rays emitted in the reaction in coincidence with the fragments of interest were detected and used to interpret the structure of ^{13}Be.

Generación de isótopos emisores de positrones y rayos gamma para imagen médica

Joaquin L. Herraiz, Luis Mario Fraile, Jose Manuel Udias
Grupo de Física Nuclear. Universidad Complutense de Madrid

La gran mayoría de isótopos usados en imagen medica se pueden clasificar en emisores de rayos gamma (para equipos de gamma-cámaras y SPECT), y en emisores de positrones (para PET). En este trabajo analizamos la disponibilidad y producción de isótopos que emiten positrones y rayos gamma de manera prácticamente simultánea (<50 ps). Las emisiones de estos isótopos se pueden distinguir de las de emisores puros de positrones, permitiendo hacer imagen simultánea de dos trazadores marcados con ellos, tal como hemos demostrado en estudios recientes con la técnica multiplexed PET (mPET). Sin embargo la limitada disponibilidad actual de estos emisores de positrones+rayos gamma es una de las principales barreras para esta nueva técnica de imagen. En este trabajo, mostraremos cuales de estos isótopos (como el ^{124}I o el 76Br) se están produciendo en laboratorios y empresas, y pueden ser distribuidos a todo el mundo debido a su larga vida media. También mostraremos resultados de la producción de algunos otros con vida media más corta como el ^{60}Cu (T1/2 = 23 min), ^{52m}Mn (T1/2 = 21 min) y ^{94m}Tc (T1/2 = 53 min), obtenidos experimentalmente con un acelerador linear de protones de 10 MeV. Los resultados obtenidos muestran la posibilidad de generar estos isótopos con haces de protones de energía moderada.

Transfer to the continuum calculations for (p,pN) and transfer reactions on Borromean nuclei

M. Gómez-Ramos[1], J. Casal[1;2], A.M. Moro[1]
1 Departamento de FAMN, Facultad de Física, Universidad de Sevilla, Apdo. 1065, E-41080 Sevilla, Spain
2 European Centre for Theoretical Studies in Nuclear Physics and Related Areas (ECT)*

Nucleon removal (p; pn) and (p; 2p) reactions at intermediate energies have gained renewed attention in recent years as a tool to extract information from exotic nuclei, thanks to the availability of exotic beams with which to perform these reactions in inverse kinematics. The information obtained from these experiments is complementary to that obtained from nucleon removal experiments with heavier targets (knockout), but is expected to be sensitive to deeper portions of the wave function of the removed nucleon. Recently, some nucleon removal (p; pN) reactions have been applied to Borromean nuclei, i.e., three-body systems with no bound binary sub-systems. In this case the residual ejectile is unbound and will subsequently decay into its components. By measuring the momenta of the decay fragments, it is possible to reconstruct the relative energy spectrum for the two-body ejectile, which is expected to provide information on the structure of the initial three-body nucleus.

In this work we present an extension of the Transfer to the Continuum [3] formalism with the aim of applying it to (p; pN) reactions involving Borromean nuclei. The main features of the method are the inclusion of the reaction dynamics and the use of a microscopic description of the three-body system. The method is applied to the reaction ^{11}Li(p; pn)^{10}Li*[1]. ^{10}Li energy distributions are obtained and compared to experimental data.

Using an analogous treatment of the overlaps between ^{11}Li and ^{10}Li a DWBA approach is used to study the recently measured ^{11}Li(p; d)^{10}Li* reaction [4]. Good agreement between experimental and theoretical calculations is found both in transfer and (p; pn) reactions and it is found that the same ^{11}Li model gives a good reproduction of both reactions. We find that the results are very sensitive to the underlying three-body structure model and, in particular, to the inclusion of the ^{9}Li spin and the content of s and p congurations in ^{11}Li ground state.

[1] Y. Aksyutina et al, Phys. Lett. B, 430 (2008)
[2] Y. Aksyutina et al, Phys. Lett. B, 718 (2013)
[3] A.M. Moro, Phys. Rev. C 92, 044605 (2015)
[4] A. Sanetullaev et al, Phys. Lett. B, 481 (2016)

On the use of complementary neutron beam facilities and techniques for capture cross section measurements

J. Lerendegui-Marco[1,] C. Guerrero[1], M.A. Cortes-Giraldo[1], J.M. Quesada[1], M.I. Gallardo[1]
1, Universidad de Sevilla, 41012 Sevilla, Spain

Neutron capture cross sections are crucial for a wide variety of applications, such as innovative nuclear technologies, stellar nucleosynthesis, basic and medical physics. The neutron energy range of interest (thermal, epithermal and/or fast) in each application is sometimes quite different. These can be accessed in specific facilities (nuclear reactors or particle accelerators inducing different nuclear reactions) where the capture cross section are measured using different experimental methods (total or partial absorption, Time-Of-Flight, Activation, Prompt Gamma Analysis, etc...). In general, complementary results obtained from different beams and techniques help reducing systematic deviations and provide a comprehensive cross section over a wide energy region. This will be illustrated through the discussion of the neutron capture experiments of ^{171}Tm, of interest for the sprocess nucleosynthesis, carried out by the University of Sevilla at CERN/n_TOF, the TRIGA Reactor at Mainz, the LiLiT 30 keV neutron beam in Israel, and the Budapest Research Reactor.

Medida de la sección eficaz de captura neutrónica del Tl-204 en el experimento n_TOF del CERN y resultados preliminares

Adrià Casanovas Hoste
Universitat Politècnica de Catalunya

La mitad de las abundancias de los elementos entre el hierro y el bismuto se producen en el proceso s (slow) de captura de neutrones.

Algunos nucleidos producidos a lo largo de la cadena del proceso, al ser radiactivos, son de especial importancia: en ellos los procesos de decaimiento compiten con los de captura, por lo que si se conoce la sección eficaz de esta reacción pueden proporcionar información muy útil del entorno donde se producen. Uno de estos nucleidos es el Tl-204. La sección eficaz de captura de este isótopo del talio, además, afecta significativamente a las abundancias primordiales de Pb-205, que es radiactivo (T1/2 = 15 millones de años) y de Tl-205. La proporción entre estas dos abundancias se puede emplear para obtener información cronométrica sobre los últimos eventos de tipo s-process ocurridos en el sistema solar.

Partiendo de esta base, la sección eficaz de captura del Tl-204 fue medida el verano del año pasado en el experimento n_TOF del CERN. En esta charla se tratarán primero los preparativos previos a la medida y las condiciones del experimento, para mostrar finalmente los primeros resultados (preliminares) del análisis de los datos recogidos.

New results from β-decay spectroscopy of proton-rich nuclei

S. E. A. Orrigo[1], B. Rubio[1], Y. Fujita[2,3], W. Gelletly[4], B. Blank[5]
1 Instituto de Física Corpuscular, CSIC-Universidad de Valencia, E-46071 Valencia, Spain
2 Department of Physics, Osaka University, Toyonaka, Osaka 560-0043, Japan
3 Research Center for Nuclear Physics, Osaka University, Ibaraki, Osaka 567-0047, Japan
4 Department of Physics, University of Surrey, Guildford GU2 7XH, Surrey, UK
5 Centre d'Etudes Nucl. de Bordeaux Gradignan, CNRS/IN2P3 Univ. Bordeaux, Cedex, France

Beta-decay spectroscopy is a powerful tool to investigate the structure of exotic nuclei. The β decay of the proton-rich, T_z = -2 nuclei ^{56}Zn [1], ^{48}Fe and ^{52}Ni [2], and of the odd-odd, T_z = -1 nucleus ^{52}Co [3] has been studied in an experiment performed at GANIL. New interesting results will be presented, going from the first observation of the exotic β-delayed ɣ-proton decay in ^{56}Zn [1] to the first observation of the 2^+ isomer in ^{52}Co [3]. In all cases partial decay schemes have been determined, with absolute Fermi and Gamow-Teller transition strengths.

In the T_z = -2 nuclei the de-excitation of the Isobaric Analogue State (IAS) via β-delayed proton emission is isospin-forbidden, however it is observed in all three cases and it competes with the β-delayed ɣ rays [2]. The case of ^{56}Zn is peculiar for various reasons [1]. Only for this nucleus there is another 0^+, T = 1 state which mixes with the IAS, making the proton decay allowed. Then, the proton decay should be four orders-of-magnitude faster than the ɣ de-excitation. Nevertheless, the latter is still observed, indicating some hindrance of the proton decay. Another interesting feature is that the states populated in the ^{56}Cu daughter by β-delayed ɣ rays are also proton-unbound and thereafter decay by proton emission. This is the first experimental evidence of a new decay mode in the fp-shell, the β-delayed ɣ-proton decay [1].

Finally, we have also observed for the first time the 2+ isomer in ^{52}Co and determined its half-life [3]. The odd-odd nuclei are particularly difficult to study because there are often two long-lived states, one of which is the ground state, with similar half-lives. By looking at both the ^{52}Co and ^{52}Ni implants, we were able to disentangle the β decays of the 2^+ isomer and the 6^+ ground state in ^{52}Co.

[1] S.E.A Orrigo et al., Phys. Rev. Lett. 112, 222501 (2014).
[2] S.E.A Orrigo et al., Phys. Rev. C 93, 044336 (2016).
[3] S.E.A Orrigo et al., Phys. Rev. C, in press (2016); arXiv:1605.08769 [nucl-ex]

Detección Directa de Partículas de Materia Oscura Mediante Dispersión Elástica con Núcleos

Miguel Molero González, Elvira Moya Valgañón y Óscar Moreno Díaz
Grupo de Física Nuclear, Universidad Complutense de Madrid

El trabajo realizado presenta un modelo teórico para la detección de partículas de materia oscura mediante su dispersión elástica con núcleos. Se considera la interacción a través de corrientes vectoriales y axiales en el vértice del proyectil (partículas de tipo débil) y únicamente vectoriales en el vértice del blanco (mayoritariamente independiente del espín nuclear). Para los cálculos se utiliza tanto la parte coherente como algunas contribuciones incoherentes. Los resultados proporcionan las secciones eficaces diferenciales e integradas para un amplio rango de masas y velocidades de las partículas incidentes, y para cada uno de los núcleos blanco. También se obtiene una cota mínima al número de eventos esperados en un detector, correspondiente principalmente a las dispersiones coherentes que se detectan por retroceso del núcleo blanco. Finalmente, se muestran ejemplos del número de eventos detectados con blancos que se usan actualmente en instalaciones experimentales de detección directa mediante dispersión elástica (Xenón y Argón), de tal modo, que en futuras investigaciones la comparación de resultados ya obtenidos con el presente modelo puede permitir un mejor entendimiento sobre la naturaleza de la materia oscura. Además, los resultados mostrados pueden ayudar al diseño de nuevos detectores basados en otros elementos.