ISOLDE Workshop and Users meeting 2020

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Book of Abstracts

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Welcome

Corresponding Author: gerda.neyens@cern.ch

HIE-ISOLDE Session / 17

The SpecMAT active target

Authors: Oleksii Poleshchuk[1]; Riccardo Raabe[None]

[1] *KU Leuven, Institute for Nuclear and Radiation Physics*

Corresponding Author: oleksii.poleshchuk@kuleuven.be

The SpecMAT active target will be used to study isotopes in the exotic regions of the nuclide chart and investigate the fundamental questions related to the shell structure of nuclei far from stability via nucleon-transfer reactions in inverse kinematics. The active target will be placed in a strong and homogeneous magnetic field of the ISOLDE Solenoidal Spectrometer for reconstruction of the recoil particle energies based on the curvature of their trajectories in the magnetic field. To extract additional information about the populated low-lying states in the transfer reactions, SpecMAT is surrounded by an array of scintillation detectors for gamma-ray spectroscopy.

In this talk, will be highlighted the first characterisation of the SpecMAT Active Target. The characterisation measurement was aimed at correlation of reconstructed 3D charged particle tracks with gamma-rays, which will be discussed in details. Further installation plans of the detector at HIE-ISOLDE and a possible experimental campaign will be also presented in this talk.

HIE-ISOLDE Session / 23

Isovector valence-shell excitation of ^{140}Nd - (IS 546)

Author: Ralph Kern[1]

Co-authors: Georgi Rainovski [2]; Liam Gaffney [3]; Norbert Pietralla [1]; Radostina Zidarova [1]

[1] *TU Darmstadt*

[2] *Sofia University St. Kliment Ohridski*

[3] *University of Liverpool*

Corresponding Author: rkern@ikp.tu-darmstadt.de

The impact of the local shell structure on the proton-neutron mixing in low-energy quadrupole states is of particular interest in contemporary nuclear structure research. In vibrational nuclei, the two most generic quadrupole-collective excitations are a mixture of the collective 2^+ proton and 2^+ neutron excitations. The symmetric (isoscalar) coupling appears as the lowest-lying 2^+ state while the partly antisymmetric (isovector) one forms the so-called mixed-symmetry $2^+_{1,\mathrm{ms}}$ state. Due to the evolution of the $2^+_{1,\mathrm{ms}}$ states in the $N = 80$ isotonic chain, the properties of the mixed-symmetry states seem to be sensitive to the underlying sub-shell structure. In the $N = 80$ isotones ^{132}Te, ^{134}Xe, ^{136}Ba, isolated $2^+_{1,\mathrm{ms}}$ states have been identified by our group. In contrast, a sudden fragmentation of the $2^+_{1,\mathrm{ms}}$ state of ^{138}Ce has been observed due to the lack of a mechanism called valence-shell stabilization at the proton $g_{7/2}$ sub-shell closure at $Z = 58$ [1].
Results of the projectile Coulomb-excitation experiment (IS 546) at HIE-ISOLDE using Miniball will

be presented. The measured B($M1; 2_i^+ \rightarrow 2_1^+$) strengths distribution of the $N = 80$ isotone ^{140}Nd clarifies the properties of the $2^+_{1,\mathrm{ms}}$ state at $Z = 60$ [2].

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HIE-ISOLDE Session / 25

Collectivity in ^{142}Xe

Author: Corinna Henrich[1]

[1] *Technische Universitaet Darmstadt (DE)*

Corresponding Author: chenrich@ikp.tu-darmstadt.de

The neutron-rich ^{142}Xe lies north-east of the doubly-magic ^{132}Sn, in a region that is not only describable by nuclear theory with single-particle and mean-field approaches, but also became accessible in experiments in recent times.

Since the r-process is expected to pass through the region, knowledge on the nuclear structure of the nuclides therein may impact the theoretical description of the r-process as well as the observed peak at A $\approx$ 130 in the solar elemental abundances.

An interesting feature in the region are enhanced octupole correlations, e.g., reported for ^{132}Sn and peaking at ^{144}Ba. ^{142}Xe lies just two protons below ^{144}Ba, making it a perfect candidate for further investigation.

An excellent tool for the exploration of low-lying states in the nucleus is Coulomb excitation. The method gives direct access to reduced transition strengths and spectroscopic quadrupole moments, therefore probing the collectivity of nuclear excitations as well as nuclear shapes.

To gain understanding of the nuclear structure of ^{142}Xe, a Coulomb excitation experiment was carried out at HIE-ISOLDE. After undergoing "safe" Coulomb excitation, beam and target nuclei were detected with C-REX, an array of segmented Si detectors, which covers both forward and backward angles. The MINIBALL spectrometer was used to detect the emitted γ rays in coincidence.

Several reduced transition strengths of low-lying transitions along with the spectroscopic quadrupole moments of the respective states could be determined. Additionally, new low-spin low-energy states, interpreted as part of a γ band, demonstrated for the first time in this isotope, could be identified, and the location of the 3_1^- state supported.

The final results are presented and compared to SCCM and LSSM calculations.

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HIE-ISOLDE Session / 13

The single-neutron excitation of ^{207}Hg

Authors: Tsz Leung Tang[1]; Benjamin Peter Kay[1]; Calem R. Hoffman[1]; John Schiffer[2]; David Sharp[3]; Liam Gaffney[4]; Sean John Freeman[5]; Matthew Mumpower[None]; Alex Arokiaraj[6]; Edith Franziska Baader[None]; Peter Butler[4]; Wilton Catford[7]; Giacomo De Angelis[8]; Freddy Flavigny[9]; Matthew Gott[10]; Eleonora Teresia Gregor[8]; Joonas Konki[11]; Marc Labiche[12]; Ian Lazarus[13]; Patrick Thomas MacGregor[5]; Ismael Martel Bravo[14]; Robert Page[4]; Zsolt Podolyak[7]; Oleksii Poleshchuk[15]; Riccardo Raabe[16]; Francesco Recchia[17]; John Francis Smith[18]; Stuart Szwec[19]; Jiecheng Yang[6]

[1] *Argonne National Laboratory (US)*

[2] *ANL*

[3] *The University of Manchester*

[4] *University of Liverpool (GB)*

[5] *University of Manchester (GB)*

[6] *KU Leuven*

[7] *University of Surrey (GB)*

[8] *Universita e INFN, Legnaro (IT)*

[9] *IPN Orsay*

[10] *Argonne National Lab*

[11] *University of Jyvaskyla (FI)*

[12] *STFC Daresbury*

[13] *STFC Daresbury Laboratory (GB)*

[14] *University of Huelva (ES)*

[15] *KU Leuven, Institute for Nuclear and Radiation Physics*

[16] *Instituut voor Kern- en Stralingsfysica, K.U.Leuven*

[17] *Universita e INFN, Padova (IT)*

[18] *UWS - University of the West of Scotland (GB)*

[19] *University of Jyvaskyla*

Corresponding Author: ttang@anl.gov

The single-neutron excitation was studied for the first time via the ^{206}Hg(d,p) reaction in inverse kinematics using a ^{206}Hg beam. The beam was produced at the CERN's ISOLDE facility at an energy of 7.4 MeV/u. The energy and position of protons emitted at backwards angles were measured using the new ISOLDE Solenoidal Spectrometer (ISS) at a magnetic field strength of 2.5 T. The energy resolution is ~140 keV. Angular distributions suggest that the $0g_{9/2}$, $2d_{5/2}$, $3s${1/2}, $2d${3/2}$and0g$_{7/2} orbitals were observed in ^{207}Hg. The result improves the understanding of the r-process and the synthesis of heavy nuclei.

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HIE-ISOLDE Session / 5

Evolution of single-particle structure along $N = 17$: The $d(^{28}\mathrm{Mg},p)^{29}\mathrm{Mg}$ reaction measured with the ISOLDE Solenoidal Spectrometer

Author: Patrick Thomas MacGregor[1]

Co-authors: David Sharp [2]; Sean John Freeman [1]; Calem R. Hoffman [3]; Benjamin Peter Kay [3]; Liam Gaffney [4]; Edith Franziska Baader ; Maria Garcia Borge [5]; Peter Butler [4]; Wilton Catford [6]; Benjamin Cropper [2]; Giacomo De Angelis [7]; Marc Labiche [8]; Joonas Konki [9]; Thorsten Kröll [10]; Ismael Martel Bravo [11]; Daniel McNeel [12]; Robert Page [4]; Oleksii Poleshchuk [13]; Riccardo Raabe [14]; Francesco Recchia [15]; Tsz Leung Tang [3]; Jiecheng Yang [16]

[1] *University of Manchester (GB)*

[2] *The University of Manchester*

[3] *Argonne National Laboratory (US)*

[4] *University of Liverpool (GB)*

[5] *CSIC Madrid*

[6] *University of Surrey (GB)*

[7] *Universita e INFN, Legnaro (IT)*

[8] *STFC Daresbury*

[9] *University of Jyvaskyla (FI)*

[10] *TU Darmstadt*

[11] *University of Huelva (ES)*

[12] *University of Connecticut*

[13] *KU Leuven, Institute for Nuclear and Radiation Physics*

[14] *Instituut voor Kern- en Stralingsfysica, K.U.Leuven*

[15] *Universita e INFN, Padova (IT)*

[16] *KU Leuven*

Corresponding Author: patrick.thomas.macgregor@cern.ch

Single-particle structure has been observed to evolve away from stability. The ordering and separation between levels varies to the extent that the established magic numbers change. For example, in the neutron-rich region where Z = 8-20, the $N = 20$ shell closure weakens, with a new closure emerging at $N = 16$ in ^{24}O [1]. In order to understand the evolution of these shell closures, and provide robust data for the development of shell-model interactions, it is crucial to measure the single-particle properties of nuclei in this region. Of particular interest is the behaviour of the negative-parity intruder orbitals from above $N = 20$, the $f_{7/2}$ and p orbitals. The difference in energy between these and the positive-parity $d_{3/2}$ defines the $N = 20$ shell closure. Historically, shell-model calculations have failed to reproduce the energies of the observed negative-parity levels moving towards a region of the chart known as the "island of inversion" (IOI). Here cross-shell excitations become prevalent and these intruder configurations make up the ground-states. Data on negative-parity levels outside the IOI provide data for validating new interactions

Single-particle transfer reactions are an ideal probe of the single-particle properties of nuclei. Away from stability, it is necessary to perform them in inverse kinematics using radioactive ion beams. Here we present a measurement of the $d(^{28}\text{Mg},p)^{29}\text{Mg}$ reaction using the ISOLDE Solenoidal Spectrometer, probing the single-particle properties one neutron outside $N = 16$, in ^{29}Mg. Cross sections, excitation energies, and angular momenta for the observed nuclear states were extracted, and spectroscopic factors were deduced. These data can then be used to test new shell-model interactions developed to better describe cross-shell interactions in this region of the nuclear chart, including the EEdf1 [2] and FSU [3] interactions, and to explore the evolution of single-particle centroids along the $N = 17$ isotones.

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HIE-ISOLDE Session / 4

High-lying resonances in the ^{7}Be + d reaction

Authors: Sk Mustak Ali[1]; Dhruba Gupta[1]; Kabita Kundalia[1]; Swapan Kumar Saha[1]; Olof Tengblad[2]; Javier Diaz Ovejas[2]; Angel Perea Martinez[2]; Ismael Martel Bravo[3]; Joakim Cederkall[4]; Joochun Park[4]; Stuart Szwec[5]

[1] *Bose Institute (IN)*

[2] *Consejo Superior de Investigaciones Cientificas (CSIC) (ES)*

[3] *University of Huelva (ES)*

[4] *Lund University (SE)*

[5] *University of Jyvaskyla (FI)*

Corresponding Author: dhruba.gupta@cern.ch

The experiment IS 554 was carried out at HIE-ISOLDE to study high-lying resonances in the ^{7}Be + d reaction, in the context of the unsolved cosmological lithium problem. We utilized the scattering chamber at HIE-ISOLDE, with sets of DSSD covering an angular range of 8^o - 170^o. Resonance enhancement is one way to study the lithium abundance anomaly. The 16.63 MeV and other nearby resonance states in the ^{7}Be(d,p)^{8}Be* reaction have been identified and their decays are studied. I would discuss the results from the experiment.

Technical & Applications Session / 3

Multiferroic Bismuth Ferrite: First PAC and XRD studies on its ferroic alpha-beta phase transition

Authors: Georg Marschick[1]; Juliana Schell[1]

[1] *Institut Fur Materialwissenschaft Universität Duisburg-Essen (D*

Corresponding Author: georg.marschick@cern.ch

Work of numerous research groups has shown different outcomes of studies of the transition from the ferroelectric α-phase to the high temperature β-phase of the multiferroic, magnetoelectric perovskite Bismuth Ferrite (BiFeO$_3$ or BFO). Using the perturbed angular correlation (PAC) method with ^{111m}Cd as the probe nucleus, the α to β phase transition was characterized. These are the first data on ^{111m}Cd in BFO so far. The phase transition temperature, the change of the crystal structure and its parameters were supervised with measurements at different temperatures using a six detector PAC setup to observe the γ-γ decay of the ^{111m}Cd probe nucleus. The temperature dependence of the hyperfine parameters shows a change in coordination of the probe ion, which is substituting the bismuth site, forecasting the phase transition. A visible drop of the quadrupole frequency ω_0 at a temperature of about $T_c \approx 820°$C is indicating the α-β phase transition. Matching results with Density Functional Theory (DFT) simulations suggest orthorhombic $Pbnm$ crystal symmetry for the high temperature β-phase. This structure is proven from a nuclear point of view. Combined with high temperature x-ray diffraction (XRD) measurements also showing the beta phase appearing in $Pbnm$ setting, a general description of the β-phase could be made.

Technical & Applications Session / 33

Long Shutdown 2 developments at REX/HIE-ISOLDE for improved ion beam characterization and manipulation

Author: Niels Killian Noal Bidault[1]

Co-author: Jose Alberto Rodriguez [2]

[1] *CERN, INFN & Sapienza University of Rome*

[2] *CERN*

Corresponding Author: alberto.rodriguez@cern.ch

The complete characterization of high-energy Radioactive Ion Beams delivered to experimental stations is essential to the analysis of the phenomenology studied. This includes insights at the purity of the beam as well as its geometrical properties in the transverse and longitudinal phase spaces. The difficulty resides in adapting experimental techniques to very low-intensity ion beams typically encountered (below 10E6 pps).

As a new electron gun was recently installed at REX-Electron Beam Ion Source, the general performances of the charge-breeder were re-evaluated and an attempt is being made to correlate experimentally probed mechanisms with simulations. Besides, a new method is presented for measuring spectra of contaminants produced by REXEBIS with single-ion detection capability. After post-acceleration, we demonstrate the aptitude to measure the transverse and longitudinal beam properties, still in the sub-femto ampere range, and to manipulate the density distributions in the trace space.

Technical & Applications Session / 31

Gamma-MRI: towards high-resolution single photon imaging using highly-aligned gamma-emitting nuclei

Author: Karolina Kulesz[1]

Co-authors: Alexandre Dorsival [2]; Anna Zhuravlova [3]; Bernard Crepieux [2]; Charlotte Duchemin [4]; Emma Linnea Wistrom [5]; Ermanno Barbero [2]; Jaime Benito Garcia [6]; James Matthew Cruikshank ; Jared Croese [1]; Jean-Noel Hyacinthe [7]; Joao Pedro Ramos [2]; Jose Manuel Udias Moinelo ; Laura Dupont [1]; Lina Pallada [7]; Luis M Fraile [6]; Magdalena Kowalska [2]; Mark Bissell [8]; Miguel Garcia Diez [9]; Renaud Blaise Jolivet [10]; Stuart Warren [1]; Tassos Kanellakopoulos [11]; Thanh Phong Kevin Le [7]; Ulli Koester [12]; Victor Sanchez Tembleque [6]

[1] *Universite de Geneve (CH)*

[2] *CERN*

[3] *National Taras Shevchenko Univ. of Kyiv (UA)*

[4] *CERN EN/STI/RBS*

[5] *University of Oslo (NO)*

[6] *Universidad Complutense (ES)*

[7] *HEDS - Haute Ecole de Sante Geneve (CH)*

[8] *University of Manchester (GB)*

[9] *Universidad Complutense de Madrid*

[10] *CERN and University of Geneva*

[11] *KU Leuven (BE)*

[12] *Institut Laue-Langevin (FR)*

Corresponding Author: karolina.kulesz@cern.ch

The gamma-MRI approach proposes to use spin-aligned long-lived nuclear states and to combine the detection of their asymmetric gamma-ray emission with spin manipulation as in Magnetic Resonance Imaging (MRI). It aims to pave the way to a new medical imaging modality capable of overcoming some of the limitations of existing imaging modalities (PET, SPECT, MRI): the low spatial resolution of the nuclear medicine imaging techniques and the low sensitivity of the MRI.

Gamma-MRI is an ambitious and multidisciplinary endeavor requiring a multistep approach. Here, we report about its first milestone and proof-of-concept experiments, namely the production and detection of spin-aligned long-lived nuclear states.

The necessary experimental setup was assembled, commissioned, and tested with radioactive metastable Xe (mXe) isotopes in the summer of 2019 in the chemistry laboratories at ISOLDE.
The selected radioactive isotopes - ^{129m}Xe ($t_{1/2} = 9$ days, $E = 197$ keV, $I = 11/2^-$) and ^{131m}Xe ($t_{1/2} = 12$ days, $E = 164$ keV, $I = 11/2^-$) - were produced at the nuclear reactor in Grenoble (ILL), transferred to MEDICIS, where the samples were decontaminated in order to reassure the chemical cleanliness of the Xe samples, and then used experimentally for performing the proof-of-principle experiments. The feasibility of radioactive Xe isotopes production was also tested at ISOLDE at the GLM beamline (^{133m}Xe; $t_{1/2} = 2.19$ days, $E = 233$ keV, $I = 11/2^-$) in the summer of 2018.

Preliminary data analysis hints at modest, but clear, gamma-emission asymmetry, which proves the build-up of nuclear-spin alignment of metastable Xe. Further analysis and in-depth interpretation of the results is ongoing, taking into account different scenarios of nuclear-sublevel occupations, and supported by computational simulations.

This talk aims to cover the progress that has been made so far in the project.

Technical & Applications Session / 18

ISOLDE's high purity ion source LIST: Prospects for Run 3

Authors: Reinhard Heinke[1]; Mark Bissell[2]; Katerina Chrysalidis[3]; Thomas Elias Cocolios[4]; Valentine Fedosseev[3]; Jake Johnson[5]; Bruce Marsh[3]; Sebastian Raeder[6]; Bianca Bettina Reich[3]; Sebastian Rothe[3]; Felix Weber[7]; Klaus Wendt[7]

[1] *KU Leuven*

[2] *University of Manchester (GB)*

[3] *CERN*

[4] *KU Leuven - IKS*

[5] *IKS - KU Leuven*

[6] *GSI*

[7] *Johannes Gutenberg Universitaet Mainz (DE)*

Corresponding Author: reinhard.heinke@cern.ch

The Resonance Ionization Laser Ion Source (RILIS) today is a well-established technique for highly efficient and chemically selective radioactive ion beam production at the worldwide leading radioactive ion beam facilities such as CERN-ISOLDE [[1]]. Additionally, these laser ion sources allow for direct optical spectroscopy of exotic nuclei with sub ion-per-second production yields. Nevertheless, in experiments demanding high isotopic beam purity, active suppression of contamination arising from competing ionization processes is often essential. ISOLDE's Laser Ion Source and Trap (LIST) achieves this by spatial separation of the high temperature vapor transfer line from the cold and clean laser ionization volume of an RFQ ion guide structure positioned immediately downstream.
The LIST has been successfully applied for laser spectroscopy on polonium [[2]] and delivery of a clean magnesium ion beam for decay studies [[3]]. These experiments were previously inhibited by strong francium and sodium fractions, respectively. In the latter experiment in 2018, a contamination suppression factor of 10^6 was demonstrated, in contrast to the RILIS/LIST efficiency loss factor

of only 25.
During the long shutdown both ISOLDE frontends have been upgraded to support the LIST, also featuring two independent RF supply lines each. This refined infrastructure grants possibilities for RFQ operation alternatives, being tested at the ISOLDE off-line 2 separator: A dedicated transformer circuit at each target unit might be omitted for one fixed unit in the high voltage rack, leading to decreased complexity. Additionally, a square wave-type fast DC voltage switching approach similar to TRIUMF's IG-LIS [[4]] is explored.
Moreover, following successful off-line campaigns at Mainz University on technetium [[5], [6]], and promethium [[7]], a high-resolution operation mode for the LIST is being implemented at ISOLDE. Based on perpendicular laser –atom beam interaction, the experimental spectral linewidth can be reduced by an order of magnitude to the 100 MHz regime. Hyperfine structure investigation experiments to reveal nuclear structure information e.g. on neutron-rich actinium [[8]], exploiting this new technique in upcoming Run 3, will be presented.

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Technical & Applications Session / 9

Radio-Frequency waveform investigation for ion transport within the RFQcb at Offline 2

Authors: Stuart Warren[1]; Tim Giles[2]

[1] *Universite de Geneve (CH)*

[2] *CERN*

Corresponding Author: stuart.warren@cern.ch

A theoretical and practical investigation into the relation of the applied waveform and frequency with beam transmission of the general purpose Radio-Frequency Quadrupole cooler and buncher (RFQcb) commonly used at ISOLDE and the Offline 2 facility. Beams of ions were transported through the RFQcb with frequencies ranging from 100 kHz to 1 MHz in 250 Hz steps to determine the stability of transport for the applied waveform and frequency by measuring the beam current pre and post transport through the RFQcb using several in beam devices. Maximum beam transport was directly compared to the theoretical model of ion stability via the matrix solutions to the Hill's equation for each waveform type within the RQFcb over several masses ^{20}Ne,^{40}Ar,^{84}Kr and ^{131}Xe.

Beta-decay Session / 28

New β-decaying state in ^{214}Bi

Author: Boris Andel[1]

Co-author: IS650/IDS Collaboration

[1] *KU Leuven (BE)*

Corresponding Author: boris.andel@cern.ch

The structure of the odd-odd, neutron-rich bismuth isotopes provides an excellent testing ground for shell-model calculations. While the low-lying structure in ^{210}Bi ($Z = 83$, $N = 127$) is expected to be dominated by $(\pi h_{9/2})(\nu g_{9/2})$ configurations, the gradual filling of the $\nu g_{9/2}$ and higher-lying shells will alter this situation. For ^{210,212,214}Bi, $I^{\pi} = 1^{-}$ ground states were suggested 1, while in contrast to this, high-spin $[I^{\pi} = (6-8^{-})]$ ground states were proposed for ^{216,218}Bi [2,3]. Low-lying high-spin $[I^{\pi} = (8,9^{-})]$ isomers were observed in ^{210,212}Bi [1,4,5] and low-spin $[I^{\pi} = (3^{-})]$ isomer was suggested in ^{216}Bi 1. Moreover, β decays of these isotopes allow for investigation of excited levels in polonium isotopes [1-4] and for testing seniority scheme in these nuclei.
In this contribution, an identification of a new β-decaying state in ^{214}Bi is discussed. The experiment was carried out at ISOLDE Decay Station (IDS) as a part of a campaign dedicated to decay- and laser-spectroscopy studies of bismuth isotopes performed by our collaboration at ISOLDE-CERN. We investigated β decays of ^{214}Bi and observed strong feeding to high-spin levels in ^{214}Po, more particularly, to the 8_1^+ level 6 and states above, which unambiguously proves the existence of a high-spin β-decaying state in ^{214}Bi. Half-life of this new state was determined and by using γ-γ coincidences the level scheme of ^{214}Po was extended. Based on the β-decay feeding pattern a spin and parity assignment of $I^{\pi} = (8,9^{-})$ is preferred for the new β-decaying state in ^{214}Bi.
The existence of two β-decaying states in ^{214}Bi completes the chain of low-lying isomers present in odd-odd bismuth isotopes from ^{210}Bi to ^{216}Bi. The results will be discussed in connection to systematics in neighboring nuclei and compared with shell-model calculations.

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Beta-decay Session / 6

Shape coexistence in neutron-deficient mercury isotopes studied through β decay

Authors: Marek Stryjczyk[1]; IS641/IDS collaboration[None]

[1] *KU Leuven (BE)*

Corresponding Author: marek.stryjczyk@cern.ch

The neutron-deficient mercury isotopes ($Z = 80$) around $N = 104$ represent one of the most prominent examples of shape coexistence 1. This region has been extensively studied using various experimental techniques, such as laser spectroscopy [2,3], decay spectroscopy studies [4-6] and Coulomb excitation [7,8]. These studies point to the coexistence of two classes of states with strong mixing between the low-lying members in ^{182,184}Hg [1,6-8]. In particular, the presence of $E0$ components in the $I^{\pi} \rightarrow I^{\pi}$ ($I \neq 0$) transitions has been interpreted as a fingerprint for mixing 1.

In order to study the properties of the low-lying states in mercury isotopes around $N = 104$, the β decay of ^{182,184,186}Tl to excited states in ^{182,184,186}Hg has been measured at the ISOLDE Decay Station (IDS) at ISOLDE. The conversion electrons have been measured for the first time at IDS by employing the newly developed SPEDE spectrometer [9], which provided an energy resolution of 7 keV for an electron energy around 250 keV.

Compared to the previous study 6, an order of magnitude higher statistics was collected, which resulted in an expansion of the decay schemes. In particular, six transitions with strong $E0$ components and the third 0^{+} state have been identified in ^{184}Hg. Improved statistics gives more precise values for branching ratios and conversion coefficients, which are relevant for the Coulomb excitation experiments [10]. The experimental results will be discussed in the framework of shape coexistence in the mid-shell region.

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Beta-decay Session / 14

Physics beyond the Standard Model and the beta decay of 10C

Authors: Bertram Andreas Blank[1]; Mehdi Aouadi[2]; Pauline Ascher[3]; Mathias Gerbaux[None]; Jerome Giovinazzo[1]; Stéphane Grévy[4]; Teresa Kurtukian Nieto[4]; Michelle Dunlop[5]; Ryan Dunlop[None]; Alex Laffoley[6]; Gwen Grinyer[7]; Paul Finlay[8]

[1] *Centre National de la Recherche Scientifique (FR)*

[2] *CERN*

[3] *CENBG*

[4] *CEN Bordeaux-Gradignan*

[5] *University of Guelph*

[6] *University of Guelph (CA)*

[7] *University of Regina*

[8] *Katholieke Universiteit Leuven (BE)*

Corresponding Author: bertram.andreas.blank@cern.ch

One possible extention of the standard model of particle physics is the addition of left-handed scalar and tensor currents to the well-established V-A model of the weak interaction. These contributions can be tested by nuclear beta decay. The 0+ - 0+ decay of 10C and other light even-even nuclei can in particular determine limits on scalar currents.
In an experiment at ISOLDE, we have determined the branching ratio of the 0+ - 0+ branch of 10C decay with high precision. The results of this experiment will be presented and its limitations will be discussed. An outlook to a possible future experiment at ISOLDE under improved conditions will also be discussed.

Beta-decay Session / 16

Structure of 208Po populated through competing allowed and first-forbidden beta decays of 208At

Author: Matt Brunet[None]

Co-author: Zsolt Podolyak [1]

[1] *University of Surrey*

Corresponding Author: mattbrunet1@hotmail.com

The two prevailing models for nuclear structure are the shell model and the collective model, which characterise predominantly separate regions of the nuclide chart. Nuclei at the edges of, and/or between these regions are essential for broadening our understanding of both the models themselves and nuclear structure more generally. The proton-pair, neutron-hole-pair nucleus of ^{208}Po exhibits both shell and octupole collective behaviour, and therefore its structure is of particular interest for experimental research, particularly as theoretical models are limited in this region. ^{208}At decays from a 6^+ (Q_{EC} = 5000(9)~keV\cite{QBeta_208At}) state and thus the populated states of the daughter nucleus are limited in both energy and spin-parity by beta decay selection rules. As such, $\beta - \gamma$ decay spectroscopy is ideal for isolating and studying the low-lying, low-spin states of ^{208}Po. The large HPGe clusters at the IDS are superior to the smaller detectors used in prior experiments\cite{1981Exp,1983Exp,1985Exp}. This facilitated the placement of a number of gamma rays which were previously attributed to ^{208}Po but were not placed into the level scheme due to low statistics.

Present in the structure of ^{208}Po are two notable features. The first is a relatively long-lived ($T_{1/2}$ = 350(20)~ns\cite{Po208NNDC}) isomeric state, the half life of which was measured in this analysis using $\gamma - \gamma - \delta t$ coincidence matrices to be 377(9)~ns~\cite{MyConfProc}. The second is a 1995~keV 3^- state identified by this analysis, which can provide insight into the octupole collectivity prevalent in this mass region.

The ^{208}Po level scheme has been significantly extended. 46 newly observed transitions and 26 new levels have been placed in an expanded level scheme alongside pre-existing and (re)assigned transitions and levels. Spin-parity assignments are based on decay patterns, previously measured conversion electron coefficients and logft values. Comparison with shell model calculations showed a good agreement for non-core-excited states.

Investigation into beta decay branching also yielded interesting conclusions. First-forbidden decays populate predominantly states at high excitation energies, which can be qualitatively explained by shell model considerations. First-forbidden and allowed β decay have similar yields, a feature which is consistent with other nuclei in the region. The observation of many of the first-forbidden β decay branches relied on the high detection efficiency for high-energy γ rays which had not been observed in prior experiments. Observations of the β-decay properties of nuclei in the N<126, Z>82 region suggests that ^{208}Po and its neighbouring nuclei provide a good testing ground for first-forbidden β-decay calculations, the understanding of which is important for the r-process nucleosynthesis.

In the presentation the details of the IDS experimental setup will be outlined and a general overview of the analysis and the new level scheme will be given. The implications of the new level scheme will be discussed further with regard to collective behaviour, comparison to shell model calculations, and beta decay branching. The analysis for which was recently submitted to Phys. Rev. C.

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Beta-decay Session / 12

Competition between allowed and first-forbidden beta decay: 208Hg->208Tl

Author: Zsolt Podolyak[1]

[1] *University of Surrey (GB)*

Corresponding Author: zsolt.podolyak@cern.ch

The β decay of ^{208}Hg into the one-proton hole, one neutron-particle $^{208}_{81}$Tl$_{127}$ nucleus was investigated at the ISOLDE Decay Station. Shell-model calculations describe well the level scheme deduced, validating the proton-neutron interactions used, with implications for the whole of the N>126, Z<82 quadrant of neutron-rich nuclei. While both negative and positive parity states with spin 0 and 1 are expected within the Q_β window, only three negative parity states are populated directly in the β decay. The data provide a unique test of the competition between allowed Gamow-Teller and Fermi, and first-forbidden β decays, essential for the understanding of the nucleosynthesis of heavy nuclei in the rapid neutron capture process. Furthermore, the observation of the parity changing $0^+ \rightarrow 0^-$ β decay where the daughter state is core excited is unique, and can provide information on mesonic corrections of effective operators.
The work was recently accepted for publication in Physical Review Letters.

Posters Presentations / 22

Investigation of the radiative decay of ^{229m}Th using the beta decay of ^{229}Ac

Author: Sandro Fabian Kraemer[1]

Co-authors: Kjeld Beeks [2]; Michael Block [3]; Thomas Cocolios [1]; Jao Martins Correia [4]; Stefaan Cottenier [5]; Hilde De Witte [1]; Kristof Dockx [1]; Rafael Ferrer [1]; Sarina Geldhof [1]; Ulli Köster [6]; Mustapha Laatiaoui [7]; Razvan Lica [4]; Pin-Cheng Lin [1]; Vladimir Manea [8]; Janni Moens [1]; Iain Moore [9]; Lino Pereira [1]; Sebastian Reader [10]; Mikael Reponen [9]; Sebastian Rothe [4]; Thorsten Schumm [2]; Benedict Seiferle [11]; Simon Sels [1]; Peter Thirolf [11]; Paul Van den Bergh [1]; Piet Van Duppen [1]; André Vantomme [1]; Matthias Verlinde [1]; Elise Verstraelen [1]; Ulrich Wahl [12]

[1] *Institute for Nuclear and Radiation Physics, KU Leuven, Belgium*

[2] *Institute of Atomic and Subatomic Physics, Vienna University of Technology, Austria*

[3] *GSI Helmholtzzentrum für Schwerionenforschung, Germany*

[4] *ISOLDE-CERN, Switzerland*

[5] *Center for Molecular Modelling, Ghent University, Belgium*

[6] *Institut Laue-Langevin Grenoble, France*

[7] *Helmholtz-Institut Mainz, Germany*

[8] *Institut de physique nucleaire d'Orsay, France*

[9] *Department of Physics, University of Jyväskylä, Finland*

[10] *GSI Helmholtzzentrum f'ur Schwerionenforschung, Germany*

[11] *Ludwig-Maximilians-Universität München, Germany*

[12] *Centro de Ciencias e Tecnologias Nucleares, Universidade de Lisboa, Portugal*

Corresponding Author: sandro.fabian.kraemer@cern.ch

A unique feature of thorium-229 is its isomer with an exceptionally low excitation energy, proposed as a candidate for future optical clocks 1. The small decay width is expected to outperform the accuracy of current state-of-the-art atomic clocks by an order of magnitude 2. The current best measurement of the excitation energy results in a value of 8.28(17)eV 3, whereby the isomer is populated in the alpha decay of uranium-233. The development of an optical clock requires however an improved precision of the excitation energy by at least an order of magnitude. Spectroscopic experiments searching for a direct signature of the radiative decay have to-date been unsuccessful, partially due to the background induced during the population of the isomer.

A new approach using the beta decay of actinium-229 is studied as a novel method to populate the isomer with high efficiency and in low background conditions 4. Produced online at the ISOLDE facility, actinium is laser-ionized and implanted into a high-bandgap crystal in specific lattice positions, inhibiting the electron conversion decay of the isomer. A favourable feeding pattern significantly increasing the population of the isomer compared to uranium-233 and the higher degree of control over the lattice position due to the low recoil energy of the beta decay of actinium-229 are expected to increase the signal-to-noise ratio of vacuum-ultraviolet (VUV) spectroscopic measurements of the radiative decay.

A setup for VUV spectroscopy to study photons from the radiative decay of the isomer is presented. It includes implantation into thin-film CaF2 crystals and a highly efficient grating spectrometer coupled to a cooled photomultiplier detector, allowing to search for a weak signal with an energy resolution down to 6 meV. Based on a feasibility experiment performed in 2018 4, different background contributions are studied and compared to the expected signal in order to evaluate the feasibility. The setup will be used in an experimental campaign at ISOLDE planned for the period 2021-2022 5.

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Posters Presentations / **26**

Characterisation of Highly UV Absorbing Coatings at MIRACLS

Author: Peter Plattner[1]

Co-authors: Paul Fischer [2]; Hanne Heylen [3]; Carina Kanitz [4]; Varvara Lagaki [5]; Simon Lechner [6]; Franziska Maria Maier [7]; Bernhard Maaß [8]; Wilfried Noertershaeuser [8]; Lutz Christian Schweikhard [9]; Markus Kristian Vilen [3]; Frank Wienholtz [3]; Stephan Malbrunot [3]

[1] *University of Innsbruck (AT)*

[2] *University Greifswald*

[3] *CERN*

[4] *Friedrich-Alexander-Universität Erlangen-Nürnberg*

[5] *Ernst Moritz Arndt Universitaet (DE)*

[6] *CERN, TU Wien*

[7] *Universität Greifswald*

[8] *Technische Universitaet Darmstadt (DE)*

[9] *University of Greifswald (DE)*

Corresponding Author: peter.plattner@cern.ch

Collinear Laser Spectroscopy (CLS) plays an important role in the study of short-lived radionuclides as it reveals nuclear ground state properties such as spin, electro-magnetic moments and mean-square nuclear charge radii[1, 2]. To access exotic radionuclides with very low production yields, the Multi Ion-Reflection Apparatus for Collinear Laser Spectroscopy (MIRACLS) is currently being developed at ISOLDE [3–5].This novel approach significantly improves the experimental sensitivity of CLS by confining an ion bunch of rare isotopes in a Multi-Reflection Time-of-Flight (MR-ToF) device. While the ions are bouncing back and forth between the electrostatic mirrors of the MR-ToF apparatus, the same ion bunch can be probed by the spectroscopy laser during each revolution. This increased observation time boosts the sensitivity by a factor of 30-600 compared to conventional CLS.
A leading contribution to background in fluorescence-based CLS is found in laser-induced stray light which is scattered into the photon detectors in the optical detection region. For this reason, the inner components of a conventional CLS beamline are typically painted in light-absorbing colours to minimise this source of background. These coatings must exhibit good electric conductivity to establish well-defined electric fields and, hence, well-controlled ion trajectories and energies. At MIRACLS, the requirement of excellent vacuum conditions in the MR-ToF device poses additional constraints on the outgassing rates of these coatings, which are generally not well known. In order to identify materials suitable for MIRACLS, we have been characterising coatings with optimal light absorption in the UV range. In particular, their photon reflectance, vacuum performance, and electric properties are studied. Vantablack is an example for an 'ultra-black'coating based on carbon nanotubes produced by Surrey NanoSystems Ltd.6. At 280 nm, its total hemispheric reflectance is approximately one order of magnitude smaller than Graphite which is often used for CLS at ISOLDE. Exceeding our expectations, we have demonstrated that these new, highly UV-light absorbing coatings are also compatible with ultra-high-vacuum pressures of $<5 \cdot 10^{-11}$ mbar.
This poster will show recent results of the characterisation of highly UV absorbent coatings in comparison to conventionally used coatings. Moreover, it will be discussed in which way the best performing coatings are employed within the MIRACLS apparatus.
This work is part of the ATTRACT project funded by the EC under Grant Agreement 777222.
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Posters Presentations / 19

Determination of the experimental upper limit of the rare β-proton branch of 8B

Author: Silvia Vinals Onses[1]

Co-authors: Olof Tengblad [1]; Enrique Nacher Gonzalez [2]

[1] *Consejo Superior de Investigaciones Cientificas (CSIC) (ES)*

[2] *Univ. of Valencia and CSIC (ES)*

Corresponding Author: silvia.vinals.onses@cern.ch

In this workshop, we present the latest results coming out of the data analysis of the IS633 experiment carried out at the IDS on 2017, related with the rare β-delayed proton branch present in the decay of 8B. This branch is supposed to be enhanced by the proton-halo configuration of the 8B, however, there is a lack of experimental results.

This rare decay proceeds through electron capture (EC) to the 17.6 MeV state of 8Be which, instead of breaking up into two α-particles, emits a low-energy proton of 337 keV, known from reaction studies 1. Assuming a proton-halo configuration of 8B, an extremely low branching ratio has been estimated considering it as a 7Be core plus an orbiting proton 2. The EC would occur on the 7Be-core and therefore the transition matrix element can be estimated to be the same as for the decay of 7Be g.s. to 7Li g.s. Scaling by the half-live, an upper limit of the branching ratio is set to 2.3·10-8 3.

This very low branching ratio in combination with the low energy of the proton oblige us to realize a specific and compact set-up in order to enhance the sensitivity to the proton branch. The main decay of 8B is always accompanied by an α-α coincidence in two opposite detectors, we thus aim for an improved anticoincidence efficiency to exclude all events accompanied by a β- or an α-particle.

To determine the experimental upper limit, an accurate knowledge of the set-up and the electronics used in the experiment has been crucial. By comparing the experimental results with accurate Geant4 simulations of the set-up has allowed us to determine the upper limit of the branching ratio to the 17.6 MeV state, reducing by two orders of magnitude the previous experimental estimation 3 with a confidence level of 99.99% (3).

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Lise Meitner Prize Ceremony / 38

Welcome words, Chair of the Division of Nuclear Physics, European Physical Society

Corresponding Author: reifarth@physik.uni-frankfurt.de

Lise Meitner Prize Ceremony / 39

Welcome words, Director of Research and Computing, CERN

Corresponding Author: eckhard.elsen@cern.ch

Lise Meitner Prize Ceremony / 40

Welcome words, ISOLDE Collaboration Spokesperson

Corresponding Author: gerda.neyens@cern.ch

Lise Meitner Prize Ceremony / 41

Virtual donation of certificate and medal

Corresponding Author: reifarth@physik.uni-frankfurt.de

Lise Meitner Prize Ceremony / 42

Laudatio for Piet Van Duppen

Corresponding Author: klaus.blaum@mpi-hd.mpg.de

Lise Meitner Prize Ceremony / 43

Laudatiio for Bjorn Jonson

Corresponding Author: piet.vanduppen@fys.kuleuven.be

Lise Meitner Prize Ceremony / 44

Laudatio for Klaus Blaum

Corresponding Author: bjn@fy.chalmers.se

Lise Meitner Prize Ceremony / 45

Concluding remarks

Corresponding Author: reifarth@physik.uni-frankfurt.de

Ground State Properties Session / 15

Laser photodetachment spectroscopy in an MR-ToF device: towards the isotope shift measurements in short-lived radioinuclides

Authors: David Leimbach[1]; Varvara Lagaki[2]

[1] *Johannes Gutenberg Universitaet Mainz (DE)*

[2] *Ernst Moritz Arndt Universitaet (DE)*

Corresponding Author: david.leimbach@cern.ch

The electron affinity (EA) is the energy released when an additional electron is bound to a neutral atom, thereby creating a negative ion. Due to the lack of a long-range Coulomb attraction, the EA is dominated by electron-correlation effects resulting in binding energies in the order of only a few electronvolts. Hence, negative ions represent intriguing probes for theoretical atomic models which consider physics beyond the independent particle approximation. A prime example for the importance of the accurate description of the electron correlation is the theoretical calculation of the specific mass shift. The latter is required when extracting nuclear charge radii from laser-spectroscopy work. Measurements of the EA hence represent an additional, new benchmark to validate and improve computational models.
Berzinsh et al. determined the isotope shift in the electron affinity of the two stable chlorine isotopes, 35Cl and 37Cl both experimentally and theoretically1, but they only agreed to the order of magnitude. Later, Carette and Godefroid 2 improved the theoretical precision and received a value that agreed with the experiment, even improving the precision of the calculation beyond the accuracy of the measurement of Berzinsh et al.

Therefore, we have launched an experimental campaign to determine the isotope shifts in the EA between 35Cl and 37Cl isotopes with high precision. To this end, we have coupled a negative ion source to the multi-reflection time-of-flight (MR-ToF) device of the MIRACLS proof-of-principle setup [3,4,5], in which we aim to perform laser-photodetachment-threshold spectroscopy. By ” reusing”the negative ion beam during each revolution inside the MR-ToF device, the efficiency in the photodetachment and, thus, detection method is largely increased. This will allow us to employ continuous wave lasers, which leads to an improved precision in comparison to the previously used high power and broadband pulsed lasers. Moreover, we intend to measure the isotope shift of 36Cl (versus 35Cl) which will extend this type of studies for the first time to long-lived radionuclides.
Later on, this novel approach could be applied to EA isotope shift measurements of short-lived isotopes that require on-line production as well as EA determination of sparsely produced radioelements such as polonium and eventually superheavy elements.
Here, we will present the technique, developments, and the first results of the ongoing experimental campaign.

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Ground State Properties Session / 30

Laser spectroscopy of neutron-rich 207;208Hg isotopes: Illuminating the kink and odd-even staggering in charge radii across the N = 126 shell closure

Authors: Thomas Day Goodacre[1]; Anatoli Afanasjev[2]; Anatoly Barzakh[3]; Bruce Marsh[4]; Simon Sels[5]; Peter Ring[6]; Nakada Hitoshi[None]; Andrei Andreyev[7]; Piet Van Duppen[5]; Numa Al Thubiti[8]; Boris Andel[9]; Dinko Atanasov[4]; Jonathan Billowes[10]; Klaus Blaum[11]; Thomas Cocolios[5]; James Cubiss[12]; Gregory James Farooq-Smith[9]; Dmitry Fedorov[13]; Valentine Fedosseev[4]; Kieran Flanagan[10]; Liam Gaffney[14]; Lars Herman L Ghys[9]; Mark L Huyse[9]; Susanne Kreim[4]; David Lunney[15]; Kara Marie Lynch[4]; Vladimir Manea[15]; Yisel Martinez Palenzuela[None]; Pavel Molkanov[13]; Marco Rosenbusch[16]; Ralf Erik Rossel[17]; Sebastian Rothe[4]; Lutz Christian Schweikhard[18]; Maxim Seliverstov[19]; Pietro Spagnoletti[20]; Celine Van Beveren[21]; Matthieu Veinhard[4]; Elise Verstraelen[5]; Andree Welker[22]; Klaus Wendt[17]; Frank Wienholtz[4]; Robert Wolf[11]; Alexandra Zadvornaya[None]; Kai Zuber[23]

[1] *TRIUMF (CA)*

[2] *Mississippi State University*

[3] *Petersburg Nuclear Physics Institute*

[4] *CERN*

[5] *Institute for Nuclear and Radiation Physics, KU Leuven, Belgium*

[6] *Technical University Munich*

[7] *IKS*

[8] *Umm Al-Qura University-Unknown-Unknown*

[9] *KU Leuven (BE)*

[10] *University of Manchester (GB)*

[11] *Max-Planck-Gesellschaft (DE)*

[12] *University of York (GB)*

[13] *NRC Kurchatov Institute PNPI (RU)*

[14] *University of Liverpool*

[15] *Université Paris-Saclay (FR)*

[16] *RIKEN*

[17] *Johannes Gutenberg Universitaet Mainz (DE)*

[18] *University of Greifswald (DE)*

[19] *Petersburg Nuclear Physics Institut (RU)*

[20] *UWS*

[21] *Katholieke Universiteit Leuven (BE)*

[22] *CERN Fellow*

[23] *Technische Universitaet Dresden (DE)*

Corresponding Author: thomas.day.goodacre@cern.ch

The mean-square charge radii of ^{207,208}Hg have been studied by the application of in-source resonance ionization laser spectroscopy, employing the ISOLDE-RILIS together with the Windmill detector and the ISOLTRAP MR-ToF MS. The characteristic kink in the charge radii at the N = 126 neutron shell closure has been revealed, providing the first information on its behavior below Z = 82. This work was conducted as part of an experimental campaign which also investigated the neutron deficient end of the mercury isotope chain.

A theoretical analysis has been performed within relativistic Hartree-Bogoliubov and non-relativistic Hartree-Fock-Bogoliubov approaches, considering both the new mercury results and existing lead data. Contrary to previous interpretations, it is demonstrated that both the kink at N = 126 and the odd-even staggering (OES) in its vicinity can be defined predominately at the mean-field level.

Ground State Properties Session / 8

Collinear laser spectroscopy of exotic Pd isotopes at the IGISOL facility

Author: Sarina Geldhof[1]

Co-authors: Agota Koszorus [2]; Bradley Cheal [2]; Charlie Stuart Devlin [2]; Iain Moore [3]; Lucia Caceres [4]; Markus Kortelainen [3]; Mikael Reponen [3]; Paul Campbell [5]; Ruben Pieter De Groote [6]; Wouter Gins [6]

[1] *University of Jyvaskyla (FI), KU Leuven (BE)*

[2] *University of Liverpool (UK)*

[3] *University of Jyväskylä (FI)*

[4] *GANIL (FR)*

[5] *University of Manchester (UK)*

[6] *University of Jyvaskyla (FI)*

Corresponding Author: sarina.geldhof@kuleuven.be

High-resolution laser spectroscopy has been proven to be a powerful tool to extract nuclear structure data in an almost model-independent manner 1. The isotope shift which can be extracted from the hyperfine spectra of exotic nuclei gives direct access to their changes in mean-square charge radii. This provides information on e.g. deformation and shape coexistence, proton-neutron pairing correlations, and the presence of nuclear shell closures. In recent years, measurements of nuclear charge radii have also been proven exceptionally potent in testing state-of-the-art nuclear Density Functional Theory (DFT) and ab-initio approaches [2-4].

The Pd isotopes are located in a transitional area in between smooth parabolic trends observed in the changes in mean-square charge radii in the Sn, In, Cd and Ag chains, and a region below where the trend in changes in mean-square charge radii shows evidence of a dramatic shape change observed at N=60, maximized and centred around the yttrium system. In this area between both regions however, i.e. the Tc, Ru, Rh and Pd isotopes, no optical spectroscopic information has been available for radioactive nuclei so far. This is in part due to the refractory character of these nuclei, which makes their production challenging for many facilities, but also due to their complex atomic structure.

At the IGISOL facility, these difficulties were overcome thanks to the chemically insensitive production method, and the recent installation of a charge-exchange cell and a new cw Ti:sapphire laser. Collinear laser spectroscopy was performed on exotic Pd isotopes, which are known to be deformed from decay spectroscopy studies, although there is disagreement on the origin and character of the (possible) change in deformation. The measured nuclear charge radii will be presented in this contribution, and the implication on the deformation/shape of the isotopes will be discussed. In addition, the results will be compared to state-of-the-art DFT calculations using Fayans Energy Density Functionals [3,5]. Recent benchmarks of nuclear DFT were performed on spherical systems, close to (doubly-)magic systems [3,6,7], so this presents the first test of the performance of these functionals for well-deformed isotopes.

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Ground State Properties Session / 7

High-precision laser ionization spectroscopy towards 100Sn

Authors: Fredrik Olof Andre Parnefjord Gustafsson[1]; Shiwei Bai[2]; Jonathan Billowes[3]; Cory Binnersley[3]; Mark Bissell[3]; Thomas Elias Cocolios[4]; Gerda Neyens[5]; Christopher Malden Ricketts[3]; Kieran Flanagan[3]; Ruben Pieter De Groote[6]; Ben Cooper[7]; Gregory James Farooq-Smith[1]; Serge Franchoo[8]; Ronald Fernando Garcia Ruiz[9]; Agota Koszorus[10]; Elisa Romero Romero[11]; Adam Robert Vernon[1]; Shane Wilkins[5]; Xiaofei Yang[2]; Hanne Heylen[5]; Klaus Wendt[12]; Kristian König[13]; Wouter Gins[6]

[1] *KU Leuven (BE)*

[2] *Peking University (CN)*

[3] *University of Manchester (GB)*

[4] *KU Leuven - IKS*

[5] *CERN*

[6] *University of Jyvaskyla (FI)*

[7] *University of London (GB)*

[8] *Centre National de la Recherche Scientifique (FR)*

[9] *Massachusetts Inst. of Technology (US)*

[10] *University of Liverpool*

[11] *Oak Ridge National Laboratory - (US)*

[12] *Johannes Gutenberg Universitaet Mainz (DE)*

[13] *Michigan State University*

Corresponding Author: fredrik.parnefjord.gustafsson@cern.ch

Collinear resonance ionization spectroscopy is a powerful technique which can provide a unique insight in nuclear properties such as spins, electromagnetic moments and changes in mean-square charge radii from near doppler-free measurement of the hyperfine structure. This technique was used at the Collinear Resonance Ionization Spectroscopy (CRIS) beamline at ISOLDE-CERN, for studying nuclear structure in the proximity of the heaviest self-conjugate doubly magic nucleus 100Sn. Recently, state-of-the-art many-body methods including ab-initio calculations have been able to reach this important stepping-stone in the nuclear landscape. However, many questions remain unanswered regarding the nuclear structure of the lightest tin isotopes due to the lack of experimental data. The controversial robustness of the shell closure, insufficient understanding of the collective behaviour and the unknown level ordering of the neutron d5/2 and g7/2 shell-model orbits further motivate the curiosity.
In preparation for studying the exotic neutron-deficient cases extensive testing using a recently

commissioned ion source enabled spectroscopy of all stable tin isotopes. This work allowed for the development of several previously unexplored laser ionization schemes of tin. The insight of their sensitivity to nuclear observables and overall efficiency laid foundation for the study of the unstable tin nuclei and provide valuable insight for atomic physics calculations. Using two selected ionization schemes the hyperfine structure of ground and long-lived isomeric-states, extending from 124Sn down to 104Sn were investigated. These new measurements allow for the first determination of electromagnetic moments, changes in mean-square charge radii and ground-state spin assignments of 104-107Sn, shedding new light on the level ordering and collectivity approaching N=50.

Ground State Properties Session / 10

High-precision mass measurements of neutron-rich krypton isotopes

Authors: Ivan Kulikov[1]; Maxime Jean Albert Mougeot[2]; Jonas Karthein[3]; Lukas Nies[None]; Yuri Litvinov[4]; Klaus Blaum[2]; David Lunney[5]; Frank Wienholtz[6]; Vladimir Manea[5]; Dinko Atanasov[6]; Lutz Christian Schweikhard[7]

[1] *GSI - Helmholtzzentrum fur Schwerionenforschung GmbH (DE)*

[2] *Max-Planck-Gesellschaft (DE)*

[3] *Ruprecht Karls Universitaet Heidelberg (DE)*

[4] *GSI, Darmstadt*

[5] *Université Paris-Saclay (FR)*

[6] *CERN*

[7] *University of Greifswald (DE)*

Corresponding Author: ivan.kulikov@cern.ch

As small as it is, about 1% of the total mass of an atom, the binding energy carries precious information regarding all the forces at play within the system. Hence, studying the evolution of binding differences along isotopic and isotonic chains can reveal nuclear structure effect such as shell closures or region of increased collectivity. In particular, the neutron-rich region between molybdenum and krypton isotopic chains is known to show such a sudden onset of collectivity around A = 100. This deformation is experimentally observed through the evolution of the mean-square charge radii 1, the energy of the first 2+ excited state 2 and, finally, the ratios between first 4+ and first 2+ excited states 3. The A=100 region was extensively studied by many Penning trap mass spectrometers. The TOF-ICR measurement from ISOLTRAP mass spectrometer nailed the mass of 97Kr, and no irregularities in two-neutron separation energy were seen 4. It was established as a critical point boundary 5.

New mass measurements of 96Kr, 97Kr and 98Kr were carried out during the experimental campaigns at ISOLTRAP mass spectrometer located at CERN. The measurements were performed using the multi-reflection time-of-flight mass spectrometry and time-of-flight ion-cyclotron-resonance techniques. This contribution will present preliminary results of the aforementioned experiments.

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Ground State Properties Session / 20

MIRACLS: From Proof of Principle Towards First Online Operation

Author: Franziska Maria Maier[1]

Co-authors: Paul Fischer [2]; Hanne Heylen [3]; Carina Kanitz [4]; Varvara Lagaki [5]; Simon Lechner [6]; Peter Plattner [7]; Simon Mark C Sels [3]; Markus Kristian Vilen [3]; Frank Wienholtz [3]; Wilfried Noertershaeuser [8]; Lutz Christian Schweikhard [9]; Stephan Malbrunot [3]

[1] *Universität Greifswald*

[2] *University Greifswald*

[3] *CERN*

[4] *Friedrich-Alexander-Universität Erlangen-Nürnberg*

[5] *Ernst Moritz Arndt Universitaet (DE)*

[6] *CERN, TU Wien*

[7] *University of Innsbruck (AT)*

[8] *Technische Universitaet Darmstadt (DE)*

[9] *University of Greifswald (DE)*

Corresponding Author: franziska.maria.maier@cern.ch

The Multi Ion Reflection Apparatus for Collinear Laser Spectroscopy (MIRACLS) is a novel approach for Collinear Laser Spectroscopy (CLS) in order to probe the most 'exotic'nuclides with very low production yields 1. This is achieved by trapping an ion bunch in an electrostatic ion beam trap, also known as Multi-Reflection Time-of-Flight (MR-ToF) device in precision mass spectrometry 2, in which the ion bunch can interact with the laser beam during each revolution. Due to this extension of the observation time, the experimental sensitivity will be increased by a factor of 30-600 compared to traditional CLS.
During the last year, major efforts have been dedicated to a proof-of-principle experiment. We have successfully demonstrated the functionality of MIRACLS when performed in a low-energy (≈1.5 keV) MR-ToF device 3 adapted for CLS. The isotope shift in the D1 transitions of 24,26Mg+ has been carefully studied under varying operation modes to evaluate systematic CLS uncertainties in the MIRACLS approach. Moreover, the boost in experimental sensitivity has been estimated by comparing the signal strength in the MIRACLS data to conventional, single-pass CLS in the same device.
Building upon the experience gained in MIRACLS' proof-of-principle experiment, a new electrostatic ion beam trap is currently being developed. It will operate at a beam energy of 30 keV which minimises the Doppler broadening and, thus, enables high resolution CLS. In a first step, this 30-keV device will be coupled to the LA2 beamline at ISOLDE. There, we will address either neutron-rich magnesium isotopes in the island of inversion or cadmium isotopes at and beyond the N=50 and N=82 neutron shell closures as the first science cases.
In this talk, the results of the MIRACLS' proof-of-principle experiment will be presented along with the design, layout and expected performance of the new 30-keV apparatus currently in preparation for MIRACLS'first online operation at ISOLDE.

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Posters Presentations / 24

β-NMR studies of Ionic Liquids

Authors: Katarzyna Maria Dziubinska-Kuhn[None]; Beatrice Karg[1]; Nikolay Azaryan[2]; Jared Croese[1]; Karolina Kulesz[1]; Stuart Warren[1]; Mikolaj Hubert Baranowski[3]; Mark Bissell[4]; Luca Cerato[1]; Robert Dale Harding[5]; Renaud Blaise Jolivet[6]; Tassos Kanellakopoulos[7]; Maciej Kozak[8]; Miguel Madurga Flores[9]; Jörg Matysik[10]; Gerda Neyens[11]; Lina Pallada[12]; Andrzej Skrzypczak[13]; Joanna Wolak[8]; Dalibor Zakoucky[14]; Swantje Mohr[15]; Marion PUPIER[16]; Jasmine Viger-Gravel[16]; Magdalena Kowalska[11]

[1] *Universite de Geneve (CH)*

[2] *Adam Mickiewicz University (PL)*

[3] *University Adam Mickiewicz (PL)*

[4] *University of Manchester (GB)*

[5] *University of York (GB)*

[6] *CERN and University of Geneva*

[7] *KU Leuven (BE)*

[8] *Adam Mickiewicz University, Poznan, Poland*

[9] *University of Tennessee (US)*

[10] *Leipzig University, Leipzig, Germany*

[11] *CERN*

[12] *HEDS - Haute Ecole de Sante Geneve (CH)*

[13] *Poznan University of Technology, Poznan, Poland*

[14] *Czech Academy of Sciences (CZ)*

[15] *University of Greifswald, Greifswald, Germany*

[16] *University of Geneva, Geneva, Switzerland*

Corresponding Author: kasia.d@cern.ch

Nuclear Magnetic Resonance (NMR) analysis of vacuum-compatible solvents, such as Ionic Liquids (ILs) is crucial to understand their inter- and intramolecular arrangement in the pure liquid environment. This knowledge is useful to increase the electrochemical properties of ILs, resulting directly from their structure. Recent studies revealed that small aggregations of water molecules can become well isolated and vacuum-stable in specific types of ILs. One of the most studied examples are imidazolium salts able to form networks based on the cation-anion interactions and trap water molecules in between. This behaviour of ILs is especially important for their electrochemical properties, such as conductivity which can be significantly increased by the presence of the defined number of water molecules with a special arrangement in the solvent.
Due to the high hygroscopicity of Ionic Liquids, precise analysis of water –Ils interaction is often not possible. In comparison to conventional NMR, liquid-state β-NMR spectroscopy can provide a qualitative knowledge about such interactons, because it allows to implant short-lived isotopes of alkali metals directly into a liquid host in high vacuum environment. The change in the detected beta-decay asymmetry represents the on- and off-resonance response of the implanted atoms to an applied rf field and can be used to obtain detailed information about the chemical environment of the implanted short-lived isotope.
This contribution will present the results of β-NMR measurements performed with the short-lived 26Na in imidazolium-based Ionic Liquids with short side alkyl chains, such as BMIM-HCOO and EMIM-DCA, together with complementary 1D and 2D NMR measurements and Molecular Dynamics simulations.

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High-Voltage Stabilization of MIRACLS' Proof-of-Principle Experiment

Author: Carina Kanitz[1]

Co-authors: Paul Fischer [2]; Varvara Lagaki [3]; Simon Lechner [4]; Franziska Maria Maier [5]; Peter Plattner [6]; Simon Mark C Sels [7]; Markus Kristian Vilen [7]; Frank Wienholtz [7]; Lutz Christian Schweikhard [8]; Stephan Malbrunot [7]

[1] *Friedrich Alexander Univ. Erlangen (DE)*

[2] *University Greifswald*

[3] *Ernst Moritz Arndt Universitaet (DE)*

[4] *CERN, TU Wien*

[5] *Universität Greifswald*

[6] *University of Innsbruck (AT)*

[7] *CERN*

[8] *University of Greifswald (DE)*

Corresponding Author: carina.kanitz@cern.ch

The proof-of-principle (PoP) experiment of the Multi-Ion Reflection Apparatus for Collinear Laser Spectroscopy (MIRACLS) has demonstrated novel experimental techniques for laser spectroscopy and Multi-Reflection Time-of-Flight (MR-ToF) mass spectrometry 1. Certain developments in this low energy MR-ToF device (≈1.5 keV), however, were limited by instabilities of high-voltage sources. In particular, even small fluctuations in the high voltages applied to the electrodes of the sensitive electrostatic mirrors result in a degraded resolving power of the mass spectrometer. Also the resolution of collinear laser spectroscopy can be limited by power-supply instabilities, which can change the energy of the trapped ions resulting in a broadening of the laser-spectroscopic line shape. Therefore, we have now implemented passive as well as active voltage-stabilization features in the MIRACLS PoP setup, following the recent implementations at ISOLTRAP 2 and at Greifswald 3.

This poster will introduce our approaches for voltage stabilization and report on the improved performance in the test measurements with MIRACLS' PoP setup. An outlook on the voltage stabilization for MIRACLS' upcoming 30-keV device will be given, which also represents the prototype of the future ISOLDE general-purpose MR-ToF mass separator.

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Posters Presentations / **11**

A new Laser Ablation Ion Source for reference masses at ISOLTRAP

Author: Lukas Nies[1]

[1] *CERN / University of Greifswald*

Corresponding Author: lukas.nies@cern.ch

The ISOLTRAP mass spectrometer at ISOLDE/CERN comprises various ion traps for precision mass spectrometry on short-lived radioactive isotopes produced by the ISOLDE facility 1. Systematic studies of the uncertainties associated with the different measurement techniques are essential to further increase and achieve the setup's highest reachable precision. Previously, a Laser Ablation Ion Source (LAS) injecting carbon clusters into the Penning trap system was used to study the systematics of the Time-of-Flight Ion Cyclotron Resonance technique (ToF-ICR) 2. However, the remodeling of ISOLTRAP's vertical beamline section and the implementation of a Multi-Reflection Time-of-Flight Mass Spectrometer / Mass-Separator (MR-ToF MS) 3 has necessitated a relocation and redesign of the LAS. Located on a high-voltage platform in front of ISOLTRAP's RFQ buncher, cooled laser-ablated ions will then be available for each of ISOLTRAP's mass-measurements components. Using a nano-second pulsed laser to ablate ions from targets such as carbon and other elements, a large variety of reference masses will be available for the study of mass-dependent uncertainties of the MR-ToF MS, ToF-ICR, and the recently implemented Phase-Imaging Ion-Cyclotron-Resonance (PI-ICR) techniques [4,5]. The LAS will likewise provide offline mass calibrants during mass measurement campaigns. In this contribution, the status of the new LAS for ISOLTRAP will be presented.

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Phase transition pathway of Sr3Hf2O7

Authors: Estelina Lora da Silva[1]; Adeleh Mokhles Gerami[2]

Co-authors: Neenu Lekshmi [1]; Jao Martins Correia [3]; Araujo Joao Pedro Esteves De Araujo [4]; Armandina Maria Lima Lopes [4]

[1] *IFIMUP, Department of Physics and Astronomy, Faculty of Science, University of Porto*

[2] *Institute for Research in Fundamental Sciences (IR)*

[3] *ISOLDE-CERN, Switzerland*

[4] *Universidade do Porto (PT)*

Corresponding Author: estelina.silva@fc.up.pt

We present an ab-initio study performed by means of Density Functional Theory (DFT), group-subgroup symmetry analysis and lattice dynamics to direct the design of Ruddelstein-Popper (RP) perovskite systems with novel properties and therefore aid experimental synthesis. From this study it is possible to obtain information regarding the structural properties and local landscapes, such as octahedra rotations, tilts and distortions which occur during a structural phase transition, and that will aid and complement the interpretation of analysis performed through Perturbed Angular Correlation (PAC) radioactive nuclear techniques.

More specifically we focus our study on the Sr3Hf2O7 system characterized by a high-temperature I4/mmm (S.G. 139) centrosymmetric structure and a ground-state Cmc21 (S. G. 36) ferroelectric system. We have probed potential candidates that may form the pathway transition through the I4/mmm ⟹ Cmc21 the structural phase transitions, and which were obtained through group-theoretical analysis, namely Fmm2 (S.G. 42), Cmca (S.G. 64) and Cmcm (S.G. 63). These phases were then analyzed to probe the electronic properties (band gap widths and partial density of states; PDoS), electric field gradients and dynamical stabilities through lattice dynamics. We found that the band gaps increase has the symmetry of the systems decrease, with the ground-state structure presenting the largest gap width (˜5.95 eV). By probing the PDoS we observe a direct relation regarding the tilts and rotations of the O perovskite cages as the transition occurs; these show large variations mostly for the O p-states which contribute mostly to the valence band maximum and consistent with the distortions from the high-symmetry to the low-symmetry phases. Moreover we also show that the asymmetry parameter, η, of the electric field gradients tend to vary as the transition occurs, namely these increase through the transition pathway, with Cmc21 evidencing largest values of the order of 0.704, 0.704 and 0.944 for the Hf, Sr1 and Sr2 sites, respectively.

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SiPM-based beta detectors at ISOLDE

Authors: Catalin Neacsu[1]; Constantin Mihai[2]; George Pascovici[1]

[1] *IFIN-HH*

[2] *H*

Corresponding Author: catalineacsu@gmail.com

The Silicon Photomultipliers (SiPMs) are among the most recent solid-state developments in radiation detection. Having the timing performance close to classical Photomultiplier Tubes (PMTs), superior mechanical robustness, reduced dimension and weight, immunity to magnetic field and operating at low voltages, with a cost slightly higher than a classical PMTs, they often replace classical PMTs whenever there is an advantage in doing so. IFIN-HH is developing SiPM detectors for both γ and β radiation, using scintillators such as LaBr3(Ce) and plastic scintillators respectively. As part of the collaboration between ISOLDE and IFIN-HH, we developed a miniaturized plastic scintillator readout for the ISOLDE Tape Station, offering a compact, robust and versatile β detector. Furthermore, a recent development for the ISOLDE Decay Station is represented by a set of plastic scintillating pads read via SiPMs acting as VETO detectors that will discriminate the background events originating from high-energy β particles depositing their energy into the HPGe crystals.

Posters Presentations / **2**

Non-Statistical Effects in Beta & Gamma Decays and Beta-Delayed Fission Analysis

Author: Igor Izosimov[1]

[1] *Joint Institute for Nuclear Research*

Corresponding Author: izosimov@jinr.ru

The β-transition probability is proportional to the product of the lepton part described by the Fermi function $f(Q_\beta - E)$ and the nucleon part described by the β-decay strength function $S_\beta(E)$, where E is the excitation energy in daughter nuclei and Q_β is the total energy of β-decay.
The previously dominant statistical model assumed that there were no resonances in $S_\beta(E)$ in Q_β-window and the relations $S_\beta(E) = Const$ or $S_\beta(E) \sim \rho(E)$, where $\rho(E)$ is the level density of the daughter nucleus, were considered to be a good approximations for medium and heavy nuclei

for excitation energies $E > 2 \div 3 MeV$. The effect of the non-statistical resonance structure of the $S_\beta(E)$ on the probability of delayed fission was first investigated in 1. Then the method developed in 1 for the description of delayed processes by considering the $S_\beta(E)$ structure was used to analyze delayed fission of a wide range of nuclei [2–6]. Ideas about the non-statistical structure of the strength functions $S_\beta(E)$ have turned out to be important for widely differing areas of nuclear physics 4.
When studying delayed fission, (i.e., fission of nuclei after the β-decay) one can obtain information on fission barriers for nuclei rather far from the stability line [1-3]. The delayed fission probability substantially depends on the resonance structure of the $S_\beta(E)$ both for β^- and β^+/EC-decays [1-6]. It can therefore be concluded from this analysis of the experimental data on delayed fission [1-6] that delayed fission can be correctly described only by using the non-statistical β-transition strength function reflecting nuclear-structure effects.
In β-decay the simple (non-statistical) configurations are populated and as a consequence the non-statistical effects may be observed in γ-decay of such configurations. In delayed fission analysis the γ-decay widths Γ_γ calculated using the statistical model, which, in general, can only be an approximation. Non-statistical effects in (p, γ) nuclear reactions in the excitation and decay of the non-analog resonances, for which simple configurations play an important role, were analyzed in 5. The strong non-statistical effects were observed both for $M1$ and $E2$ γ-transitions. Because the information about γ-decay is very important for delayed fission analysis, it is necessary to consider the influence of non-statistical effects on delayed fission probability not only for β-decay, but also for γ-decay.
In this report some features of β-delayed fission probability analysis are considered. It is shown that only after proper consideration of non-statistical effects both for β-decay and γ-decay it is possible to make a quantitative conclusion about fission barriers.

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High intensity ISOL ion source for long-term irradiation

Author: Sophie Hurier[1]

Co-authors: Thomas Elias Cocolios [2]; Kim Rijpstra [3]

[1] *KU Leuven, SCK-CEN*

[2] *KU Leuven - IKS*

[3] *SCK-CEN*

Corresponding Author: sophie.hurier@sckcen.be

The **MYRRHA** project (Multi-purpose hYbrid Research Reactor for High-tech Applications) is the first prototype of a subcritical lead-bismuth cooled reactors driven by a particle accelerator (˜ 100-600 MeV proton). In parallel to the reactor, **ISOL@MYRRHA** will extract part of the proton beam coming from the accelerator and use it to produce Radioactive Ion Beams (RIBs) with the Isotope Separation On-Line (ISOL) technique for experiments which require long beam times without interruption, high-precision measurements or to perform experiments which hunt very rare phenomena. Those experiments have different needs from already existing ISOL: an **isotope production increase** by using **higher intensity** primary beams on a **longer period of time without losing** the radioisotope **beam quality**.

One part of this ISOL system, which will be affected by this higher input, will be the ion source, and we will need to **create an ion source adapted to this new input before the start of the**

new accelerator at SCK-CEN. We choose to work on Surface Ion Source [SIS] because they are reliable and usually of a simple design. Only a few attempts to modify these sources have been made on materials and cavity sizes, by Kirchner 2 for example. But there are other parameters to explore. There is also a lack of research on the physical processes inside the ionisation cavity and their impact on the performance of the source. To identify the relevant parameters which will affect our ion source at higher intensity, we need to understand through theoretical studies and numerical simulation analysis how those parameters affect the output parameters, like the total efficiency. First using Thermal-Electric simulations with ANSYS 1 then with Plasma simulations with Starfish 4. To start our simulation, we need first to validate our model and simulation conditions with already existing experimental results. That is why we tried, as a starting point, to reproduce the results coming of a heating system of an ion source & its transfer-line from a study 3 from the Selective Production of Exotic Species (SPES) project. Then with this simulation model, which was validated by experimental results, we can start modifying this ion source and see what the thermal-electric response: Insulate electrically (& Thermally) or Add a second feed through for a better control on the electrical flow and so of the heating of the ionizer tube. Those new ion source heating systems need to be tested, improved and validated through numerical simulations and in the future with experimental results for the creation of the best ion source for the day-1 operation at **ISOL@MYRRHA**. A heating test stand has thus been designed and commissioned at **SCK-CEN** to test the prototype ion sources.

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Novel acquisition systems and smart FPGA programmability

Author: Ferdinando Giordano[None]

Corresponding Author: ferdinando.giordano@cern.ch

New solutions in the field of detector acquisition systems are presented: starting from the first ADC to bring an easy FPGA programmability, the R5560, then the first model the new generation of CAEN digitizers, the V2740, will be presented along with the Open FPGA it features.
The main technical specifications will be illustrated along with some specific use case: the LoKI experiment at ESS, that it was the first to adopt the R5560 with a customized firmware to read out its boron coated straw tubes.
Finally, an overview of the software tools available to the users will be presented, the recently developed *SciCompiler* and *COMPASS*: the first makes FPGA programming simpler thanks to a graphic interface where different logic block can be combined to create a simple firmware, the second is a readout software designed to control all CAEN digitizers taking data with DPP firmwares.

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Prize announcement for CAEN Best Poster and Best Young Speakers

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Hyperfine and Density Functional Theory Studies of SrMnGe2O6, SrCoGe2O6 and CaMnGe2O6

Author: Ricardo Manuel Alves Pacheco Moreira[1]

Co-authors: Joao Pedro Esteves De Araujo [1]; Armandina Maria Lima Lopes [1]; Céline Darie [2]; Céline Goujon [2]; Lei Ding [3]; Claire Colin [2]; Goncalo De Pinho Oliveira [1]; Pedro Miguel Da Rocha Rodrigues [1]; Joao Martins Correia [4]; Murielle Legendre [2]

[1] *Universidade do Porto (PT)*

[2] *CNRS, Inst NEEL, Grenoble*

[3] *ISIS Pulsed Neutron Facility, Rutherford Appleton Laboratory, Harwell Oxford*

[4] *Instituto Superior Tecnico (PT)*

Corresponding Author: ricardo.manuel.alves.pacheco.moreira@cern.ch

Multifunctional materials have been under the spotlight due to their fundamental scientific interest and for potential applications in technology. In particular, the Pyroxene family of materials, with general chemical formula AM(Si,Ge)2O6, has been the subject of of some recent interest due to the discovery of multiferroic and magnetoelectric properties among these materials. More specifically, SrMnGe2O6, SrCoGe2O6 and CaMnGe2O6 are isostructural, crystallizing with monoclinic C2/c symmetry and are characterized by zigzag chains of MnO6 octahedra linked by edgesharing, separated by GeO4 tetrahedra chains along the same axis, linked by corner-sharing. Due to this arrangement these systems present a rich diversity of low-dimensional magnetic properties. The existence and possible interplay of low dimensionality and magnetic frustration results in multiferroic and/or magnetoelectric properties.

Since these properties might arise from local structural features that are not well described by methods based on long-range average structural models, the use of local probe studies is essential. In this context, hyperfine methods, such as perturbed angular correlation (PAC) spectroscopy where the study of the electric field gradient (EFG) in the vicinity of a probe atom, allows reconstructing of the atomic and electronic environment of the probe in the material, helps to clarify the origin of the properties exhibited in these systems. In this work a temperature dependent EFG study will be presented and discussed, guided by Density Functional Theory EFG simulation results, exploring in particular the effect of the U correction from the Hubbard Model in an attempt to better explain the experimental results.

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