ISOLDE Workshop and Users meeting 2015

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Book of Abstracts

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Shape Coexistence Far From Stability

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I shall discuss the meaning of the "nuclear shape" in the laboratory frame
proper to the Spherical Shell Model.
Shape coexistence, shape mixing and shape entanglement will
be described in relevant physics cases, either
neutron rich at the N=20-28 and 40-50 Islands of Inversion,
or neutron deficient in the N=Z=40 region.

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Beta decay through broad resonances

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In many beta-delayed particle decays in light nuclei one observes broad features in the particle spectra that typically are interpreted as decays through broad resonances. I shall discuss this interpretation along with the alternative interpretation of the decay as proceeding directly to the continuum. Guidelines for when a decay belongs in one or the other category will be given, but there is an unavoidable overlap region. The discussion will be illustrated with examples from recent studies, e.g. in the decays of ^{8}B and ^{11}Be.
The discussion has implications for how beta strength is defined in such decays, as well as for how results of (R-matrix) fits to the spectra may be compared to reaction data.

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The science program at ISAC and ARIEL at TRIUMF

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The science program at TRIUMF for ISAC and ARIEL will be presented, including science highlights and status and plans for the upcoming ARIEL facility. Once ARIEL is operational, three parallel radioactive beams will be available for users, coming from both electron and proton induced reactions.

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Nuclear Polarizability: The Sleeping Beauty Of Nuclear Physics

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New polarization potentials will be presented based on: 1) the latest photo-neutron cross section evaluation and a missing factor of two in previous work, and 2) the mass dependency of the symmetry energy, $a_{sym}(A)$. The magnitude of the first one is 35% stronger than the currently accepted polarization potential. The second one opens up the possibility for a parameter-free polarization potential. Both polarization potentials are essentially the same for heavy nuclei. The polarization effect on quadrupole collectivity is more substantial than previously assumed for light nuclei. Particular cases will be discussed where long-standing discrepancies between high-precision Coulomb-excitation and lifetime measurements (e.g., tin and nickel isotopes) still remain. A solution to the long-standing discrepancy between B(E2) values determined in ^{18}O by several Coulomb-excitation studies and a high-precision lifetime measurement is provided in favor of the latter. Polarization effects in light nuclei also influence the determination of spectroscopic quadrupole moments in Coulomb-excitation measurements. The hindrance of polarizability observed in the photo-neutron cross section for single-closed shell nuclei is calculated to have a negligible effect on quadrupole collectivity, within the existing experimental uncertainties. This work provides a deeper insight into nuclear collectivity and presents a new field of exploration that may lead us to the elusive equation of state, tests of 3N forces and descriptions of neutron skins, neutron stars and supernova cores. This work is relevant to the Coulomb-excitation program at ISOLDE.

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Decay spectroscopy at RIBF: The EURICA project and its impact on nuclear structure and astrophysics

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Isomer- and β-decay spectroscopy are very effective approaches to study nuclear structure far from the β stability, where the production rates are extremely low. Thus they are capable to address many open questions in nuclear physics such as persistence of shell gaps, evolution of nuclear structure, shape coexistance and deformation in exotic nuclei with unbalanced neutron to proton ratio. Furthermore, β-decay studies on exotic nuclei provide important inputs for astrophysics such as β-decay half lives and β-delayed neutron- and proton-emission probabilities. This information are of great importance to model the astrophysical r- and rp-process and to understand the nucleosynthesis in the universe.

In order to take advantage of the high intensity primary beams at the RIBF facility, the EURICA project has been launched at RIKEN in 2012 with the goal of performing spectroscopic studies of very exotic nuclei. Many experimental campaigns have been completed successfully using fragmentation of ^{124}Xe beam and in-flight fission of ^{238}U beam. Many key nuclei and their neighboring isotopes have been produced and studied in details, such as ^{78}Ni, ^{110}Zr, ^{128}Pd, ^{100}Sn, ^{138}Sn, and ^{170}Dy. This contribution highlights the EURICA experiments performed at RIKEN and results obtained so far, covering isotopes from $Z = 26$ to $Z = 66$ with a large variety of physics case.

Nuclear Structure: Gamma Spectroscopy / 0

Overview of the AGATA campaigns

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The European germanium array AGATA has been transferred from the GSI facility to GANIL mid 2014. The GANIL experimental campaign was started beginning of 2015 and will be followed by different sub-campaigns until 2018. The presentation will mainly present the 2015 data taken at GANIL and some recent results obtained in the previous campaign in LNL and GSI. Perspectives on the 2016-2018 campaign will be shown.

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Photofission experiments and the IGISOL facility at ELI-NP*

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The possibilities for photofission experiments at the new ELI-NP facility will be discussed. At ELI-NP, high power laser systems together with a very brilliant gamma beam are the main research tools [1-3]. The status of the project will be reported. The γ-beam system and the expected performance of the electron accelerator and the production lasers will be discussed. The targeted operational parameters of the γ beam will be described.

At ELI-NP, next to research on fission barriers through measurements of transmission resonances [4,5] and investigation of rare fission events, such as ternary photofission [6], the possibilities for studies of the structure of neutron-rich exotic nuclei are considered. Two types of experiments related to the structure of fission fragments will be discussed, in-beam spectroscopy of fission fragments and separation of the isotopes of interest with the IGISOL technique, and experiments with them, such as β-decay or mass measurements.

Four basic set-ups are under consideration for these studies, namely a double Bragg TPC, a general purpose charge-particle detector array, based on THGEM technology for fragment identification, an IGISOL beam line and the ELIADE Ge detector array, coupled to different ancillary detectors for in-beam spectroscopy will be discussed, taking into consideration the optimal use of the γ beam.

The expected production yields in photofission will be discussed and the performance of the IGISOL beam line, which is under consideration within the ELI-NP project, will be discussed.

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Nuclear Structure: Gamma Spectroscopy / 21

Shape coexistence in 96,98Sr

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Neutron rich 96,98Sr isotopes were investigated by safe Coulomb excitation of radioactive beams at the REX-ISOLDE facility. Reduced transition probabilities and spectroscopic quadrupole moments have been extracted from the differential Coulomb excitation cross
sections. These results allow for the first time to draw definite conclusions about the shape coexistence of highly deformed prolate and spherical configurations. In particular, a very small mixing between the coexisting states is observed, contrary to other mass regions where strong mixing is the rule. Experimental results will be compared to beyond-mean-field calculations using the Gogny D1S interaction in a five-dimensional collective Hamiltonian (5DCH) formalism, which reproduce the shape change at N=60.

Facilities / **52**

Extreme Light Infrastructure - Nuclear Physics (ELI-NP)

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The new Research Center ELI-NP is under construction in Bucharest-Magurele, Romania. It is meant as a unique research facility to investigate the impact of very intense electromagnetic radiation (Extreme Light) on matter with specific focus on nuclear phenomena and their applications. The extreme light is realized at ELI-NP in two ways: by very high optical laser intensities up to 1023 W/cm2 and by the very short wavelength beams on γ-ray domain. The Gamma Beam System, based on Compton backscattering of a laser beam on electron beam accelerated by a warm LINAC, will produce variable energy gamma beam (Eγ = 0.2 − 19.5 MeV) with a very good bandwidth (in the 10-3 domain) and with very high brilliance (peak brilliance higher than 1021 photons/mm2/mrad2/s/(0.1% BW). This combination allows for stand-alone experiments with a state-of-art high-intensity laser, standalone high resolution γ-beam experiments or combined experiments of both photon sources. The description of the future ELI-NP facility and of the planned experiments will be presented.

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The SPES Radioactive Ion Beam Project at INFN: Status and perspectives

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Magic numbers are a key feature in finite systems of Fermions since they are strongly related to the underlying mean field. The evolution of the shells far from stability can be linked to the shape and symmetry of the nuclear mean field. The study of nuclei with large neutron/proton ratio allow to probe the density dependence of the effective interaction. Changes of the nuclear density and size in nuclei with increasing N/Z ratios are expected to lead to different nuclear symmetries and excitations. Recently it has been shown that the tensor force play an important role in breaking and creating magic numbers, being a key element of the shell evolution along the nuclear chart.
These studies are among the objectives of the SPES radioactive ion beam project of INFN. The SPES Radioactive Ion Beam (RIB) facility at INFN-LNL is presently in the construction phase.
The aim of the project is to provide high intensity and high-quality beams of neutron-rich nuclei to perform forefront research in nuclear structure, reaction dynamics and interdisciplinary fields like medical, biological and material sciences. SPES is a second generation ISOL radioactive ion beam

facility. It represents an intermediate step toward the future generation European ISOL facility EURISOL. The SPES project is part of the INFN Road Map for the Nuclear Physics; it is supported by the Italian national laboratories LNL (Legnaro) and LNS (Catania). It is based on the ISOL method with an UCx Direct Target able to sustain a power of 10 kW. The primary proton beam is delivered by a Cyclotron accelerator with an energy of more then 40 MeV and a beam current of 200 microA. Neutron-rich radioactive ions will be produced by Uranium fission at an expected fission rate in the target of the order of 10^13 fissions per second. The exotic isotopes will be re-accelerated by the ALPI superconducting LINAC at energies of 10A MeV and higher, for masses in the region of A=130 amu, with an expected rate on the secondary target of 10^7-10^9 pps. The present status and the perspectives of the project will be presented together with the related detector developments.

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Recent results from the CARIBU facility

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CARIBU (CAlifornium Rare Ion Breeder Upgrade) is a new source for neutron-rich short-lived isotopes that can be used for experiments directly with low energy beams or at Coulomb barrier energy after post-acceleration through the ATLAS superconducting linac located at Argonne National Laboratory. CARIBU uses a novel gas catcher based system to make available isotopes of all species produced by 252Cf fission, independently of their chemical properties. It has now produced over 100 beams for experiments and these have been used successfully in campaigns of mass measurements at the CPT mass spectrometer and decay spectroscopy with the X-array, as well as a campaign of Coulomb excitation measurements with GRETINA and CHICO2. The CARIBU/ATLAS facility will be briefly described and recent results presented, together with ongoing upgrades to further improve its capabilities.

This work was carried out under the auspices of the US Department of Energy under Contract No. DE-AC02-06CH11357.

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ALTO - status, recent results and near-future plans

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ALTO is an international facility that provides in parallel stable and radioactive beams. The stable beam experiments are based on the operation of a 15 MV Tandem that can accelerate species from hydrogen up to iodine as well as clusters (C, Au …). The low-energy radioactive beams are produced using the photo-fission of UCx target. The experiments performed cover a large physics case from nuclear structure and astrophysics, atomic and cluster physics, biology and nano-technology.
A brief description of the facility will be given, illustrated with a few examples of recent results. The ongoing research program and the near-future projects and developments will be presented as well.

Fundamental Interactions & Beta Decay / 1

High-precision beta-decay studies to test the weak-interaction standard model

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Nuclear beta decay transforms up quarks in down quarks and vice versa. Therefore, high-precision measurements of beta decay allows under certain conditions to test the standard model of weak interaction. In particular, the conserved vector current (CVC) hypothesis can be tested and the Vud element of the CKM quark mixing matrix can be determined. For this purpose, high-precision data for 0+ - 0+ and mirror beta decays on the half-life, the branching ratios and the beta-decay Q value are required. These allow to determine the ft values for each decay which, corrected for electromagnetic and strong interaction contributions, yield universal Ft values independent of the particular transition. These Ft values are used to test CVC and the average <Ft> value allows to determine the weak vector coupling constant and the Vud matrix element.

After an introduction, the present status of these measurements is laid out and current experiments, in particular for new isotopes not yet included in the systematic will be described. For this purpose we will in particular present the efficiency calibration of a HP germanium detector which will serve to determine the branching ratios in beta decay. Finally, an outlook will close the presentation.

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β-delayed neutron spectroscopy at the ISOLDE Decay Station

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The investigation of isotopes far from stability provides a substantial test of our understanding of the forces involved in organizing nuclear matter. Ground state properties, such as its mass or spin

parity, and beta-decay properties, like the half-life or the neutron branching ratio are the typical observables that must be correctly reproduced to trust a nuclear theory calculation. In particular, trustworthy calculations of beta-decay half-lives and neutron branching ratios of exotic nuclei are invaluable inputs for models of stellar nucleosynthesis.

The recent availability of exotic nuclei beyond the N=(50,82) magic numbers has spurred a rush of experimental measurements that aim to disentangle their decay properties. These two regions are of special interest for beta-decay measurements as the decay is complicated by the fact that valence neutrons and protons occupy different major harmonic shells. Under these conditions the normally inert nucleons in the core are allowed to play a role due to the small overlap of the valence neutrons with low energy states in the daughter. Raising the difficulty for its experimental investigation, the large energy gap at N=50 implies the allowed decay of core neutrons occurs to neutron unbound states.

A systematic investigation of this so-called core decay in N>50,82 nuclei have been performed at ORNL and ISOLDE using different experimental setups including the neutron Time-of-Flight array VANDLE (Versatile Array for Neutron Detection at Low Energies). From the observed decay strength distribution we identified the large neutron branching ratios observed in Ga isotopes as arising from the decay strength associated to 0f5/2 neutrons. However the valence space in ^{84}Ga (Z_v=3,N_v=3) resulted in a very fragmented decay strength.

Here we present the results of the 2015 VANDLE campaign at ISOLDE. We measured the beta delayed neutron emission of ^{132}Cd. Thanks to the small valence space in ^{132}In, (Z_v=-1,N_v=-1), beta decay is expected to populate quasi-single particle states, and be dominated by the beta transition of the $g_{7/2}$—>$g_{9/2}$. This allowed us to have a unique insight to the nuclear structure of states making ^{132}Sn.

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Beta-delayed neutron spectroscopy in 51-54K

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In neutron-rich nuclei, especially near shell-closures, the increasing Q-value of beta decays and the lowering of the neutron-separation threshold, lead to the dominance of beta-delayed neutron emission as decay mode. At the same time, Q-values well above 10 MeV provide the possibility to study highly-excited particle-hole states populated by the GT decay.
A measurement was performed to study the beta-delayed neutron mission from the decay of neutron-rich potassium isotopes. Low-energy beams of 51,52,53,54K were produced by the reaction on UCx target from the PSB proton beam. The surface-ionized ions were delivered to the experimental setup, which combined the ISOLDE Decay (tape) Station with the VANDLE array for neutron spectroscopy. The IDS was equipped with a high-efficiency beta detector and four Ge clovers. The VANDLE array was made of 26 bars of plastic scintillators arranged in cylindrical configuration at 1 m distance around the implantation point, giving an overall efficiency of 10% for 1 MeV neutrons.
Beta-delayed gamma rays and neutrons from 51,52.53K were measured with sufficient statistics to reconstruct the excited levels below and above the neutron-separation threshold in 51,52,53K.
At the first place, this will allow one to identify particle-hole excited states which will help to track the monopole evolution in this exotic region by measuring

excitations across the N=28 and N=32 shell and sub-shell closures. At the second place, the GT strength distribution will be reconstructed up to high-energy states (10 MeV and above). The production of 54K was also demonstrated via the identification of its beta-n daughter 53Ca. Preliminary results will be shown, with a discussion for future perspectives at ISOLDE.

Fundamental Interactions & Beta Decay / 20

Recent results from the neutrino mass experiment ECHo using the new detectors with Ho-163 implanted at ISOLDE

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The Electron Capture in Ho-163 experiment, ECHo is designed to investigate the electron neutrino mass in the sub-eV region using high-precision measurements of the Ho-163 electron capture spectrum. The very good results obtained from the first prototypes of metallic magnetic calorimeters with ion-implanted Ho-163, among which the calorimetric measurement of the Ho-163 spectrum with the best energy resolution to date, have renewed the interest in Ho-163 based experiments. The production of the Ho-163 atoms as well as its implantation was carried out at the ISOLDE facility, CERN.
During the spectrum measurements in Heidelberg, we have identified several aspects of the detectors that could be significantly improved. In particular we aimed at developing a new detector design for which the probability to lose energy to the substrate is reduced and at increasing the purity of the implanted Ho-163 beam.
In December 2014 an off-line ion implantation was performed onto detectors with an optimized design. The Ho-163 source used in the experiment was produced by neutron activation of an enriched Er-162 target at ILL and chemically purified at PSI and at the Institute for Nuclear Chemistry at Mainz University.
We present the preliminary results obtained with the implanted detectors and a first characterization of the purity of the implanted beam.
The achieved results demonstrate that we succeeded in improving the detector response and the purity of the implanted beam with respect to the first experiment.

Poster Session / 35

HYPERFINE TECHNIQUES STUDIES OF GRAPHENE USING ISOLATED AD-ATOM PROBES

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The one-atom-thick crystal - graphene, uniquely combines extreme mechanical strength, exceptionally high electronic and thermal conductivities, as well as many other exotic properties, all of which make it highly interesting for fundamental physics and numerous applications. Its properties strongly depend on surface and interface nanoscale interactions, where new physical models should apply aiming their understanding and control.
In the present work we aim investigating the mechanisms of adhesion of ad-atoms on the surface, their capture processes, adsorption and migration of atoms, alone or intermediated by water and defects. The later aim is to investigate electronic, magnetic and catalytic properties resulting from such "dopant" like interactions. Experimental works are accompanied by theory and computational models generally based on density functional theory and/or molecular dynamics calculations, providing an important support for studying the electronic properties. In this context, our experimental observables are the hyperfine parameters of add-atoms on graphene, measured with the nuclear spectroscopy PAC (Perturbed Angular Correlations) technique. PAC allows to probe at the atomic scale the add-atoms interactions without interfering with the graphene electronic structure, thereby providing unique information, which is impossible to obtain by electron spectroscopy and electron microscopy techniques such as, AFM or STM, not exempted from interactions between the tip and the surface test or ad-atoms therein. By PAC measurements it can be determined the electric field gradient (EFG) and magnetic hyperfine field (MHF) at atomic scale, electronic structure and magnetic environment of ad-atoms. The EFG provides structural information, location of the probe, stability, and bond (ionic, covalent bonding, van der Waals). The MHF translates properties correlated with the electronic spin configuration.
In this presentation we will present first results of the PAC hyperfine parameters obtained in graphene grown at different substrates as a function of different temperatures and different probing elements, 111mCd and 199mHg. To complement the experimental studies, ab initio simulations, using the software Wien2k, with the self-consistent LAPW+lo method to solve the Kohn-Sham equations and GGA/LDA approximations, have been implemented to simulate the charge density distribution of ad-atoms on graphene for different probe isotopes. This is the first step to attain the next objective that is to understand the Cd, and Hg (our PAC probes) interactions at the graphene layer. Minima of energy for the ideal bond-length, the hyperfine parameters and the charge distributions in the unit cells will be presented.

Poster Session / 37

The Cu-68m isotope: A new PAC probe for hyperfine studies at CERN-ISOLDE

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A series of Perturbed Angular Correlation of γ-rays (PAC) experiments with Cu-68m as probe nuclei implanted in several solid-state samples were performed in November 2015 at VITO-ISOLDE at CERN. The decay scheme of Cu-68m/Cu-68 was selected in order to test the feasibility of studying the hyperfine interactions of the Cu isotope with the electromagnetic fields of the host material. Due

to the relatively short half-life of the 6- isomeric state (T1/2= 3.75 min) the PAC measurements were performed online in the middle end station of the VITO beamline, dedicated for traveling setups. The experimental setup was consisted of four LaBr3 scintillator detectors in perpendicular plane with respect to the ion beam and consequently to the implantation point, with a geometry of ±90° and ±180° between each other. The measurements were performed at room temperature.

From the experimental PAC spectra of the perturbation function R(t) and the respective Fourier Transforms (FFT) of Cobalt and Nickel single crystals the magnetic dipole moment (μ) of Cu was extracted. Furthermore, from the spectrum of a host Cu2O crystal, the electrical quadrupole moment (Q) of the probe nuclei was clearly identified. As a result, a good characterization of the Cu isotope was succeeded and Cu can now be considered as the new probe nuclei for PAC experiments in Solid State Physics (SSP) and chemistry.

Poster Session / 13

Mass measurements of isomeric states in neutron-deficient 195,197Po isotopes at ISOLTRAP

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In this work neutron-deficient isotopes 195(g,m)Po and 197(g,m)Po have been investigated by using high-precision Penning-trap mass spectrometry at ISOLTRAP [1]. In addition, decay measurements on these isotopes were performed with the assistance of ISOLTRAP's multi-reflection time-of-flight mass spectrometer (MR-TOF MS) [2], which successfully enabled us to deliver an isobarically pure beam [2] to the decay point, while the resonant ionization laser ion source (RILIS) of ISOLDE was used to selectively enhance the isomer or the ground state [3] of the investigated isotopes. The mass values of (195,197)m,gPo were measured with high-precision Penning-trap mass spectrometry using the well-established TOF-ICR technique [4], from which we determined the excitation energy of the 13/2+ state in 195,197Po for the first time, completing the knowledge of the energy systematics in the region. With this new information, the masses of the isomeric states of lead, radon, and radium in this region can be obtained from α-decay chains. The relevance to shape coexistence in the neutron-deficient lead region will be discussed.

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Poster Session / 18

Mass measurements of neutron-rich copper isotopes and technical developments at ISOLTRAP

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We present very recent ISOLTRAP [1, 2] measurements of neutron rich copper isotopes, where – with the help of the multi-reflection time-of-flight mass spectrometer – ^{79}Cu was reached for the first time. Having only one proton above the $Z = 28$ core, the binding energies of the copper isotopes are sensitive to the evolution of nuclear shell structure close to the doubly-magic ^{78}Ni isotope. The measurements belong to an extended ISOLTRAP campaign on very neutron-rich nuclides for nuclear-structure and astrophysical cases To reach out to even further exotic nuclides at very high precision, a position-sensitive ion detector was installed behind the precision Penning trap. It will allow the application of the Phase-Imaging Ion-Cyclotron-Resonance (PI-ICR) [3] method, which was developed at SHIPTRAP/GSI. This new technique offers higher precision in less measurement time as well as a much higher resolving power, and thus ability to resolve low-lying isomers, compared to the present Time-of-Flight Ion-Cyclotron-Resonance technique [4]. The current status and an outlook on the implementation of the PI-ICR technique at ISOLTRAP will be presented

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Poster Session / 29

Study of molybdenum oxide by means of perturbed angular correlation spectroscopy

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MoO3 is a promising material for applications in sensors and future electrochromic imaging devices. Since the phenomenology at the origin of the macroscopic properties occurs at the atomic scale, we used the nuclear technique of Perturbed Angular Correlation (PAC), after implantation of 111mCd or 176Lu at ISOLDE, on MoO3 samples to investigate the defect structure and recovery upon ion implantation and subsequent annealing, as well as the site occupancy of the implanted impurity. Cd in MoO3 is intended to be an electrical dopant and may improve the transport properties of this material, while rare earth doping is investigated for their light emission characteristics. The samples studied were α-MoO3 single crystals grown by a sublimation method. The PAC measurements were carried out as a function of temperature in air after annealing at 450° C also under air for 20 min. Raman measurements were carried out at room temperature by using a 633 nm He–Ne laser as the excitation source, and reveal a high crystalline quality that is not affected by annealing treatments in air up to 450 0C. After annealing, two Electric Field Gradients distributions are observed, which for 37 % of the 111mCd atoms are characterized by a fundamental frequency ω01 = 247 Mrad/s with an asymmetry parameter of 0.484 and negligible frequency distribution. The remaining fraction is characterized by ω02 = 212.98 (4.69) Mrad/s and a wide frequency distribution that we assume to be due to a fraction of probes incorporated in damaged – non-annealed sites in the crystal. The well-defined quadrupole frequencies observed are the evidence for Cd and Lu occupying a limited number of lattice sites in the host. Also, it was found that a low temperature is required to anneal defects and place an important fraction of the impurity atoms in relatively regular sites, with no defects in their neighborhood. Actually, it is not clear if the wide distribution of EFGs found for the biggest fraction of probing atoms is due to intrinsic defects on the crystals or from a not-optimized annealing procedure. PAC has shown to be a powerful technique to probe the incorporation of potential impurity dopants upon temperature measurements and systematic studies are envisaged.

Poster Session / 56

Subsystems of the new GLM implantation chambers

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For the GLM branch of ISOLDE an ensemble of new collection chambers is currently being finished. One chamber allows rapid sample
changing by means of a load-lock system as well as tilted implantations. The second chamber will provide the possibility to
implant decelerated or post-accelerated ion beams and thus to control implantation depth. Finally, a third chamber will be
optimized for online PAC measurements featuring low gamma absorption and mounting positions for scintillation detectors very
close to the sample position which can be heated up to 1000°C while simultaneously implanting and measuring.
For improved radio protection and better usability this chamber ensemble will be remotely controllable to a large extent. To

achieve this goal several specialized electronic subsystems were developed. Our poster will present features and advantages of
these newly developed systems and devices as well as the automation concept of the chamber ensemble.

Poster Session / 39

Results on francium isotopes at the collinear resonance ionisation spectroscopy (CRIS) setup

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ISOLDE Workshop 2015

G. J. Farooq-Smith on behalf of the CRIS collaboration

Exotic isotopes of francium with yields as low as 100 ions/second have been examined with high efficiency and low background at the CRIS experiment, by the coupling of collinear laser and resonance ionisation spectroscopy techniques [1]. In addition, pure state beams have been examined even in the midst of isobaric contamination: previous highlights include the separation of overlapping ground and isomeric states in 202Fr and 204Fr with complementary decay spectroscopy techniques [2, 3], and reaching the very neutron-rich isotopes of francium, up to 231Fr [4].

Recently, the use of high-resolution laser techniques has allowed the quadrupole moment of 219Fr to be determined for the first time [5]. In addition, the ability to run at an improved duty cycle has resulted in the first measurements of 214Fr, which with a half-life of 5 ms represents the shortest-lived isotope to be measured online with laser spectroscopy [6]. Laser-assisted nuclear decay spectroscopy of 206Fr has also been performed at the decay spectroscopy station [7]. All of these results will be presented, in light of the improvements made at the CRIS setup.

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Poster Session / 66

Emission Mössbauer study of 57Fe in InN following 57Mn* implantation

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The lattice sites and valence states of Fe ions in InN were investigated by emission Mössbauer spectroscopy following the implantation of radioactive 57Mn+ ions at ISOLDE/CERN, stimulated by reports of ferromagnetic effects observed in virgin InN [1] and also when doped with 3d transition metals [2]. Angle dependent measurements performed at room temperature on the 14.4 keV γ-rays from the 57Fe Mössbauer state (populated from the 57Mn β− decay) reveal that the majority of the Fe ions are nearly substituting the In cations, and/or associated with N vacancy type defects. Emission Mössbauer spectroscopy measurements conducted over a temperature range of 105–723 K did not show the presence of magnetically split sextets in the "wings" of the spectra as observed in GaN and AlN [3] suggesting the absence of Fe3+ in the material.

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Hyperfine Interactions in Pd foils during D/H electrochemical loading

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The study of the Fleischmann and Pons Effect (FPE) i.e. the excess power production during electrochemical loading of deuterium in palladium has a multidisciplinary character. Correlations between

the material status and the occurrence of the effect as well as some changing of the electrochemical interface status have been observed. During the last two decades the phenomenon was observed, well above the measurement uncertainties, in several calorimetric experiments. The lack of reproducibility has been so far responsible for the absence of a clear explanation of the phenomenon but measurement chains have been conceived to enhance the spectrum of information required to define the effect. Recently a specific study was carried out that discovered Radio Frequency emission during the occurrence of excess power. Such observations and interrogations are motivating studies of working cells, but atomic scale probes are desirable. In this work we used the local probe nuclear technique of Perturbed Angular Correlations (PAC). The probe nucleus 181Hf(181Ta) was implanted into four Pd samples at 80 keV. After recovery of implantation defects by vacuum annealing at 550 ℃, the PAC measurements were carried out during loading of D (D2O) or H (H2O) as a function of applied current and voltage. The spectra clearly evidenced the diffusion and distribution of foreign (H, D) atoms, during loading expressed by the observation of three different EFG distributions – a static like distribution of EFG probably due to an equilibrium concentration of D atoms, - a dynamic distribution probably due to out-of equilibrium diffusion of D atoms, and a specific EFG that is due to the occurrence of a regular charge distribution in the surroundings of the probing Ta atom. This might be due to a temporary coherent distribution of D atoms inside the Pd lattice, that makes a regular charge distribution in the neighbourhood of about 10% - 15% of the Hf/Ta probe atoms. This last EFG is only observed on some spectra during some loading periods. Contrarily, only the static and dynamic "states" were observed during the H loading.

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Lattice site and excited electronic states of implanted rare earth 172Lu ions in Ga2O3

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Gallium oxide (Ga2O3) belongs to the family of transparent conductive oxides, electrically conductive materials that are optically transparent. These materials have been widely studied due to their technological applicability, and Ga2O3, having the widest band-gap among them (4.8 eV), is a very interesting material for photonic applications working in the visible and UV wavelength region.
These functionalities might be enhanced by doping Ga2O3 with optically active rare earth (RE) ions due to their sharp and mostly temperature stable RE emission lines, whose spectral range spans from the infrared to the ultraviolet.
In this context, Perturbed Angular Correlation (PAC) measurements were performed after implantation of RE 172Lu probes into Ga2O3 polycrystalline samples in order to study the lattice site of the implanted RE ions. Moreover, because 172Lu decays by electron capture, it was possible to study the recombination of ionized and excited electronic states of the impurity/dopant as a function of temperature.
These results were later compared to Density Functional Theory (DFT) simulations via the implementation of different atomic local models, where the electric field gradient of each configuration was calculated.

Poster Session / 6

Coulomb breakup of ^{7}Be

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Radiative capture cross sections at astrophysical energies are difficult to measure directly. The time reversed Coulomb breakup reaction may be used in such cases. Thus the Coulomb breakup of ^{7}Be, preferably in the presence of heavy targets can be used to measure the production cross section of ^{7}Be by ^{3}He + ^{4}He $\longrightarrow$ ^{7}Be + γ. This would enable measurements at low relative breakup energies (astrophysical energies) between the breakup fragments, thereby extracting information about the required radiative capture reaction. This avoids required extrapolation in the direct method from measurements performed at higher energies. We plan to measure the ^{7}Be breakup on ^{12}C and ^{208}Pb targets at HIE-ISOLDE to determine the astrophysical S factor $S_{34}(0)$. Preliminary calculations will be presented.

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VITO (Versatile Ion-polarized Techniques Online)

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On behalf of the VITO Collaboration, T. E. Mølholt.

The VITO (Versatile Ion-polarized Techniques Online) medium scale experiment is a modification of the existing UHV line at ISOLDE. The VITO beamline has been under construction since 2014 and is installed permanently in the low-energy part of the ISOLDE hall. When fully commissioned, the unique experimental setup will open up numerous possibilities for carrying out multidisciplinary studies in the areas of biophysics, nuclear and solid state physics, and fundamental interaction physics [1,2,3].

The VITO beam line will deliver ISOLDE beams in two different modes providing either spin-polarized atoms or ions [4], or non-polarised ions to three fully independent experimental end stations, spanning in vacuum from atmospheric pressure down to UHV (below 10⁻¹⁰ mbar).

The first end station is dedicated to UHV collections and measurements performed in the ASPIC chamber [5] mainly utilized for solid state physics and material science applications. The middle end station is reserved for travelling experiments and/or the testing of the beam polarisation. The third end station is for β-NMR spectroscopy or β-γ asymmetry mainly for biophysics and is the major addition/upgrade to the VITO beamline together with the spin polarization setup. This upgrade will make it possible to implant and study liquid bio-samples [6,7].

An overview will be given of the current status and for future perspectives.

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Poster Session / 51

Integration of the compact Photoionization Spectroscopy Apparatus (PISA) to ISOLDE-RILIS

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The Resonance Ionization Laser Ion Source (RILIS) is the principle ionization technique for radioactive beam production at ISOLDE. It is based on multi-step laser resonance excitation and ionization of atomic species and is typically applied inside the hot cavity of the ISOLDE target and ion source assembly. To enable efficient laser ionization for additional elements, optimal ionization schemes have to be developed and tested. With six tunable lasers at hand, the ISOLDE RILIS is well equipped for extensive scheme development.

Here we introduce the photoionization spectroscopy apparatus (PISA), a compact atomic beam unit for RILIS scheme development, independent from the availability of target stations. Samples of the element to be investigated can be evaporated from an oven and ionized using the RILIS lasers. New RILIS schemes can now be initially investigated without the need for an ISOLDE target unit or dedicated use of the ISOLDE target and separator, speeding up the process later on. Several additional applications of PISA are foreseen during RILIS operation: During RILIS setup it provides the means to optimize some laser parameters prior to the availability of an ion beam from the target; During operation the ion current generated using the RILIS reference beams inside the reference cell could serve as an additional observable for the RILIS performance monitoring; PISA can be used as a reference while performing in-source laser spectroscopy. This method, which is unobtrusive and easily adjustable for different elements, would save beam time while increasing the accuracy of the measurements. We will discuss the parameters of PISA and its integration into RILIS alongside an overview of future developments towards mass selectivity and improved sample switching and heating.

Poster Session / 36

Lattice location of implanted 111Ag in 3C-SiC

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SiC is a wide band gap semiconductor with an increasing number of applications in high-temperature electronics. Similar to Si, transition metals (TMs) in SiC are the source of deep levels in the band

gap, however, the knowledge on structural properties of TMs in SiC, such as possible lattice sites, is much less advanced.
In this work we report first results on the lattice site location of implanted 111Ag (7.45 d) in single-crystalline cubic (3C)-SiC, evaluated by means of the emission channelling effect. Following 30 keV low-fluence (3×1012 cm−2) ion implantation, the β− emission patterns from 111Ag implanted samples were measured with a position-sensitive electron detector around the <100>, <111>, <110> and <211> crystallographic directions. All measurements were performed at room temperature, starting with the as-implanted state and following 10 minute isochronal annealing steps up to 1075 °C in vacuum. While the data analysis is still in progress, so far we clearly identify 111Ag atoms located on two different lattice sites. In the as-implanted state, a fraction of 111Ag sits on ideal substitutional silicon sites (SSi), whereas the second fraction is located near substitutional C sites (SC) roughly 0.20 Å away from the ideal site.
Upon annealing up to 1075℃ we observe a continuous increase of 111Ag atoms fractions, sitting in both near-SSi and near-SC sites, accompanied with a progressive displacement towards their respective antibonding ABSi and ABC sites.
Although the analysis of the experimental data is ongoing, it is already clear that Ag on tetrahedral interstitial (T) sites does not play a relevant role in this system. The absence of interstitial Ag is therefore a key feature of this transition metal, not only in SiC but as well in Si [1] and Ge [2].
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Poster Session / 7

The cosmological lithium problem in the context of resonant enhancement

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The destruction of the ^{7}Be nucleus is immensely important in studying the ^{7}Li abundance anomaly. The relevant reaction rates, particularly the destruction of ^{7}Be through resonance excitation in the transfer reaction ^{7}Be (d,p) ^{8}Be *, need to be measured with better accuracy before one can invoke solutions beyond nuclear physics. The T-REX detector array is suitable for such measurements. An experiment to that effect, IS 554 at HIE-ISOLDE, would be carried out. Preparation including simulation of that upcoming experiment will be presented.

Poster Session / 11

Study at the corner stone of the region of deformation around A∼100

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Exhibiting one of the most sudden onset of deformation, the neutron-rich A=100 mass region has recently attracted a vast interest from the nuclear structure community.

The influence of the neutron contribution to the deformation has been already well investigated in the Sr and Zr isotopes; however, a better understanding of the role played by the proton orbitals was needed to draw a complete picture of the mechanisms involved in the sudden onset of deformation. A smooth development of collectivity has been recently observed in ^{96}Kr via mass measurements and Coulomb excitation. The Rb isotopes exhibit a step increase of the quadrupole moment at N=60, indicating deep structural changes by just adding one proton compared to the Kr case.

In the present study, excited states of neutron-rich ^{97,99}Rb were populated for the first time via Coulomb excitation using the REX-ISOLDE facility and the MINIBALL spectrometer. Complementary to the previous magnetic moment measurement, comparisons of the results with particle-rotor model calculations allowed for unambiguous assignment of the $\pi g_{9/2}[431]3/2^+$ Nilsson-model orbital as the configuration of the ground state of ^{97}Rb on top of which the rotational band is built. The degree of deformation in the band is essentially similar to what has been observed well inside the deformation region around A$\sim$100, such as in the Sr and Zr cases.

Moreover, this study highlights the potential of the Coulomb excitation technique to obtain further spectroscopy information far from stability.

Revealing a similar structure, the ^{99}Rb case constituted a challenge, pushing the limits of studying very short lived post-accelerated radioactive beams.

Poster Session / 38

Radioactive probe studies of coordination modes of heavy metal ions from natural waters to functionalized magnetic nanoparticles

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Perturbed angular correlation (PAC) spectroscopy experiments were used to study the adhesion of toxic heavy metal ions in aqueous solution to magnetic nanoparticles, to understand the structures and optimum trapping conditions in solutions (water and nitrate). In this work we analyze the results of the radioactive mercury and cadmium isotopes available for PAC, which were implanted in ice. The ice was then used to make solutions with the magnetic nanoparticles. Nanoparticles with different shapes (cubes and spheres) and different coatings were synthesized for study: magnetite (Fe3O4), magnetite coated with silica (SiO2), and also functionalized with dithiocarbamate (DTC) groups, which are expected to provide a stronger mercury uptake. A systematic study of the different conditions finds mainly three different EFG environments for all the different samples. The results are found to be independent of the shape of the particles. To complement the experiments, we performed first-principles density functional calculations are performed for the DTC functional groups in different configurations, to compare electric field gradients with PAC measurements with reference DTC samples. The relaxed theoretical structure is obtained and the binding to Hg is identified in this case. We used the PAW method with the local-density approximation, but the study with more sophisticated approximations (such as B3LIP) is in progress.

Technical Session 1 / 62

ISOLDE-RILIS: new features - more possibilities

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The Resonance Ionization Laser Ion Source (RILIS) is the most frequently applied ion source type at ISOLDE. The RILIS method of step-wise resonance laser excitation and ionization of the nuclear reaction products, makes it both highly selective and efficient. A continuous program of technical upgrades of the laser installation, as well as research and development of the RILIS technique, is necessary to fulfil the ever-increasing demand for new, more intense, or higher purity ion beams. The laser launch system for the GPS front-end was redesigned and the laser beam reference area was rebuilt and upgraded with a refined beam stabilization and monitoring system. This, in conjunction with the implementation of an autonomous machine protection system, enabled "on-call" RILIS operation, successfully tested for the first time during the 2014 ISOLDE on-line period, to become the standard mode of operation in 2015. The RILIS DAQ system has been upgraded and streamlined, managing the links between the RILIS, the Windmill detector system and the ISOLTRAP MRToF-MS for in-source laser spectroscopy experiments. Ongoing developments envisage further exploitation of the bunched time structure of the RILIS laser ions. A new fast beam switching option has been tested, showing promising results and plenty of applications for ISOLDE users.
We present the status of the RILIS system, a summary of the operation in 2015, recent upgrades and new capabilities. Concluding with an outlook considering the promising future areas of development.

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The New Isolde Tapestation

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The Isolde tapestation lies at the very heart of the facility, and is an essential instrument for both operation and development of radioactive beams. It provides a real-time determination of the radioactive beam yield via a measurement of the time profile with which isotopes are released from the target unit. This information may be correlated with the anticipated isotope production of the target and its diffusion and effusion characteristics, and used to determine target and ion-source performance. Such information is vital to the development of new and improved target types. It is also essential for the routine operation of the Isolde facility, providing assurance that the radioactive beams meet the quality requirements requested by the experiments. In the event of low counting rates, unexpected background, or other breakdown, the tapestation is the first diagnostic tool to be used in determining the source of the problem.

The existing Isolde tapestation has, after more than forty years of service, reached the end of its life and is in need of replacement. I shall present the design of the new high-performance tapestation for Isolde, outline the new features, and give the status of its construction.

The new tapestation will be installed in spring 2016 and will run for one year in parallel with the old tapestation, during which time it will be tested, calibrated and validated. Once this process is complete the old tapestation will be retired and the new tapestation will take its place.

I shall also outline some new proposals, including continuous monitoring of target performance and measurement of integrated target yields.

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Radioactive beams at ISOLDE: Status and Developments

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The mission of the Target and Ion Source Development Team (TISD) at CERN-ISOLDE is to develop beams of new elements or shorter-lived isotopes. It is also to make sure that the current targets and ion sources operate with optimized settings and deliver high, pure and stable beams over time to the physics community. In this contribution, a report on the isotope yields of the uranium carbide targets produced from a new uranium oxide batch, will be given. In general, good and stable beam intensities that match and even surpass ISOLDE database values were obtained. A special focus will be given to online target nanomaterial prototypes tested over 2015 and 2014, namely a room temperature calcium oxide and various carbide-carbon nanocomposites. Furthermore, a short overview of the negative ion beams tests at ISOLDE will be given and also an update on the on-going beam development projects.

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Development of Radioactive Boron Beams for ISOLDE

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Even though ISOLDE can provide a wide range of isotopes from many different elements, extraction of some elements still proves to be difficult. This is especially true for refractory and chemically reactive elements like carbon, boron and refractory metals. Although extraction of these elements as more volatile molecules was suggested many decades ago, extraction has only been successful for some of these elements up to now. In particular beams of 8B are requested for a long time by a variety of experiments. However, until recently extraction of sufficient yields was not achieved at any ISOL facility.
This talk will present important considerations for the development of new ISOL beams and will give detailed information on investigations performed for the development of boron beams.
These considerations include calculations of production cross sections, the chemical equilibrium between boron and materials present in the target container as well as diffusion and ionization characteristics.
The results obtained from these studies were exploited in two prototype targets and tested at ISOLDE during the online period 2015, leading to the first ever ISOL beam extraction of 8B as 8BF_2^+.

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CERN-MEDICIS : An update

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CERN-MEDICIS aims at producing radioisotope batches by collection from mass separated radioactive beams for medical applications. To fulfil its goal, a new dedicated target irradiation station has been designed and tested in the HRS beam dump. A Radiation Hard Rail Conveyor System, developed within a technology transfer project, transports the targets for irradiation and back for isotope extraction. Several aspects of the facility have been designed and are under construction, such as the personnal and material access system and the target storage. The LISOL dipole magnet is being delivered to CERN for refurbishement before installation. In parallel with the construction of the

facility, the CERN-MEDICIS collaboration is active and expands further, highly benefiting from the MEDICIS-PROMED Marie Curie network that started this year. In a final part of the presentation, we will show how CERN-MEDICIS fits within the existing network of facilities producing medical isotopes.

Technical Session 2: HIE-ISOLDE / 64

Machine Commissioning

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The HIE ISOLDE project reached a major milestone in October 2015, when radioactive beams were delivered to the users for the first time. This important achievement was the culminating point of an intense year during which the first cryomodule of the HIE ISOLDE superconducting Linac and its high-energy beam transfer lines were installed and subsequently brought into operation. An essential phase of this process is the so-called hardware commissioning, whereby all the technical systems are thoroughly tested in the final configuration in order to define the envelope of parameters within which the machine could be operated, to test and validate software and controls, and to investigate the limitations preventing the systems to reach their design performance. Methods and main results of the first hardware commissioning campaign of the HIE ISOLDE post accelerator will be reviewed in this contribution.

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Beam Instrumentation

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The requirements and constraints imposed by the superconducting HIE-ISOLDE REX led to the development of a new type of beam diagnostics boxes. These devices are designed around the stringent geometrical constraints of the inter-cryo-module regions. Compromises and optimisations had to be done in order to fit precise and reliable current, profiles and position measurements inside a few centimetres of longitudinal space.
The various types of diagnostic boxes of HIE-ISOLDE REX will be presented, along with the status of the devices and the results obtained during the first months of operation. The present consolidation and improvement plans will also be described.

Technical Session 2: HIE-ISOLDE / 61

Beam Commissioning and First Operation

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This has been an important year for the ISOLDE facility. A lot of new equipment has been installed on the HIE-ISOLDE side including the first cryomodule and several High Energy Beam Transfer lines (HEBT). In addition, many of the subsystems in the REX normal conducting linac have been renewed or refurbished. Following the hardware commissioning of the different systems and in preparation for the start of the physics program, many tests and measurements were conducted as part of the beam commissioning program. The results of some of these tests will be included in the presentation. In addition, a summary of the first operational experience will also be presented and discussed.

Technical Session 2: HIE-ISOLDE / 60

The Next Steps

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After 20 years of successful ISOLDE operation at the PS-Booster [1], The first cryomodule of the new superconducting linear accelerator HIE-ISOLDE (High Intensity and Energy ISOLDE), installed downstream of the REX-ISOLDE accelerator, was commissioned. It supplies the Miniball array, where an experiment using radioactive zinc ions (see box) began at the end of October. This is the first stage in the upgrade of the REX post-accelerator where the energy of the radioactive ion beams was increased from 3 to 4.3 MeV per nucleon. The facility will ultimately be equipped with four high-beta cryomodules that will accelerate the beams to 10 MeV per nucleon. This presentation aims to provide an overview of the upcoming shut-down activities and plans for the second phase of the project.

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Testing classical concepts with the help of modern techniques at ISOLTRAP

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The evolution of nuclear binding energies with proton and neutron number is one of the key experimental inputs for the study of nuclear structure. It contributed significantly to the consolidation of the traditional concepts of nuclear shells and nuclear deformation, still largely present in phenomenological theoretical approaches. We will present recent ISOLTRAP measurements of binding energies of exotic nuclides in the vicinity of proton and neutron shell closures and across regions of nuclear deformation. The masses of cadmium isotopes 129-131Cd bring new information concerning the strength of the N = 82 shell closure below the magic proton number Z = 50 where 130Cd is considered a classical waiting-point nucleus for the r-process of nucleosynthesis. We will illustrate that the measured masses have a significant impact on the prediction of the abundance of r-process nuclides around mass A = 130. In addition, recent ISOLTRAP mass values of neutron-rich nuclides 101,102Sr, 100-102Rb, 97, 98Kr close to the border of the A = 100 shape-transition region will be discussed in the framework of self-consistent mean-field theory. The masses of the most exotic of these nuclides were determined using ISOLTRAP's multi-reflection time-of-flight mass spectrometer. Furthermore, this device was used as beam-detection system for a number of in-source laser-spectroscopy studies in the neutron-deficient lead region, exhibiting very interesting phenomena of shape transition and shape coexistence. Results from the most recent campaigns on mercury and gold isotopes will be presented.

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How to handle a radioactive nucleus: a LEGO Robot for ISOLDE

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An outreach programme has been developed at The University of Manchester to introduce Year 10/11 students (14-16 year old) to nuclear physics research and, hopefully, excite them about the cool things that can be achieved with a Physics degree. This project was initiated in conjunction with ISOLDE 50th anniversary, which was celebrated last year, and towards the 50th anniversary of ISOLDE's first radioactive ion beam. This programme is funded by the STFC Public Engagement Small Award.

The outreach programme combines lectures about radioactivity, with a focus on understanding basic concepts such as radioactivity and radioprotection, and the manipulation of LEGO Mindstorm kits to think about the difficulty of remote handling of very radioactive material. In this presentation, we shall report on the activity and the workshops we have carried out, as well as introducing **LEMITH** (LEGO Mindstorm ISOLDE Target Handler), a new robot to be added to the ISOLDE family, but dedicated to the ISOLDE Visitors Space.

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Laser spectroscopy on Zn isotopes and isomers

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Laser spectroscopy measurements were performed on bunched beams of Zn (Z = 30) isotopes at ISOLDE-CERN using the ion cooler-buncher ISCOOL and the high-resolution collinear laser spectroscopy setup COLLAPS. The experimental measurements allowed to deduce the nuclear spins, magnetic moments and quadruple moments of odd-Zn isotopes and isomers up to ^{79}Zn, as well as the mean square charge radii of $^{62-80}$Zn. These new results provide nuclear structure information on the Zn isotopic chain across the N = 40 sub-shell and up to the N = 50 shell closure.

As the nuclear moments are a sensitive probe of the configuration of the wave function, the experimental results are compared to large scale shell model calculations using jj44b/JUN45 (^{56}Ni core and pfg shell) [1,2] effective interactions and state-of-the-art shell-model calculations in a large model space (pf for proton and sdg for neutron) [3]. Shell evolution of $^{69-79}$Zn isotopes with increasing neutron occupation of the $\nu g_{9/2}$ orbit will be discussed based on the experimental measurements and the shell model calculations.

The measured changes in mean-square charge radii along the Zn chain cover the N = 40 sub-shell and reached the N = 50 shell. This result will be presented to discuss the proposed sub-shell/shell closure at N = 40/N = 50 in the Ni region together with earlier measurements of Cu and Ga [4,5].

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Interesting moments at CRIS this year

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The Collinear Resonance Ionization Spectroscopy (CRIS) experiment combines laser spectroscopy and nuclear-decay spectroscopy to provide nuclear-structure measurements of exotic isotopes. At CRIS, the high resolution innate to collinear laser spectroscopy is combined with the high efficiency of ion detection to provide a sensitive technique to probe an isotope's hyperfine structure. In addition to hyperfine-structure studies, ionization of the isotope of interest allows the (ground state or isomeric) ion beam to be deflected to a decay-spectroscopy station for radioactive -decay studies in clean conditions.

The first measurements performed at the CRIS experiment achieved a linewidth of 1.5 GHz, allowing the magnetic moments and charge radii of isotopes down to ²⁰²Fr to be studied [1,2]. More recently, high-resolution laser spectroscopy was achieved, allowing measurements of the quadrupole moments of francium isotopes [3-5] with linewidths of ~20 MHz.

This past year has seen the commissioning of the new CRIS laser laboratory in Building 508, in addition to the installation of a new narrow-linewidth Ti:Sa laser system with high output powers and a broad tuning range. Integration of the new method for chopping CW laser light, used in last year's francium campaign, for two additional laser systems has allowed high-resolution studies of copper and gallium isotopes to be achieved.

Here we report on the interesting moments from the past year: the events that have improved the experimental setup and the electromagnetic-moment measurements that have resulted from such improvements.

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Shedding a light on the nuclear structure of Mn isotopes towards $N = 40$

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The region south of $^{68}_{28}\mathrm{Ni}_{40}$ has attracted much interest due to the sudden onset of deformation observed near $N = 40$. For a better understanding of the dynamics responsible for this change in nuclear structure, it is desirable to expand the experimental knowledge on how the interplay between single-particle and collective nature evolves as a function of proton and/or neutron number. In this light, the ground state properties of Mn ($Z = 25$) isotopes from $N = 28$ up to $N = 39$ were studied in two collinear laser spectroscopy experiments at ISOLDE. In combination with large-scale shell model calculations, these results illustrate the importance of particle-hole excitations across $N = 40$ and $Z = 28$ for Mn isotopes approaching $N = 40$. In particular, the strong influence of the neutron $\nu d_{5/2}$ orbital on the observed deformation is demonstrated.

In a first campaign, the hyperfine spectra of $^{51,53-64}$Mn were measured using standard bunched-beam collinear laser spectroscopy on atomic manganese. Although the magnetic moments and isotope shifts were extracted with high precision, the quadrupole moment sensitivity was low. Hence, in a follow-up experiment, laser spectroscopy was performed on a more sensitive ionic transition starting from a metastable state. To efficiently enhance the population of this metastable state, optical pumping in the cooler-buncher was successfully applied for the first time at ISOLDE.
Apart from the high-precision quadrupole moments, this second experiment also yielded isotope shifts providing a critical test of the electronic factor calculations which are needed for reliable mean-square charge radii extraction. The measured quadrupole moments and mean-square charge radii give complementary information on the development of deformation and will be the main topic of the talk.

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Photo detachment of negative ions at ISOLDE: Towards measurement of the Electron Affinities of Radioactive Elements

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Negatively charged ions are mainly stabilized through the electron correlation effect. A measure for their stability is the binding energy which is termed electron affinity (EA). The energy required

to form a positively charged ion by releasing an electron from the neutral atom is referred to as ionization potential (IP). These two energies are fundamental characteristics, defining the chemical properties of the atom in compounds.
In previous campaigns at ISOLDE we have performed precision measurements of the IP of astatine and polonium by observing series of Rydberg resonances using laser spectroscopy. The logical next step is to also measure the electron affinity of these elements. The method of measuring the photo detachment threshold is widely used for precisely determining this quantity.
We will present results from our first experimental campaign at ISOLDE, based on an approved Letter-of-intent. We will explain the method and the experimental setup, introducing the newly commissioned Gothenburg ANion Detector for Affinity measurements by Laser PHotodetachment (GANDALPH) and show the first data obtained using negative iodine beams extracted from ISOLDE. We will conclude with an outlook and also present a concept that could be applied for purification of negative ion beams extracted from ISOLDE.

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Conventional and Synchrotron-based Mössbauer Spectroscopy of Iron Proteins and Spin Crossover Materials

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Mössbauer spectroscopy and synchrotron based nuclear resonance scattering techniques are ideal tools to study electronic and dynamic properties of iron centers in chemical and biological systems. During the last years Nuclear Inelastic Scattering (NIS) has been used by us to detect iron based vibrational modes in powders of iron(II) based spin crossover (SCO) compounds 1. In order to carry out orientation dependent nuclear resonance scattering experiments on small single crystals of e.g. iron proteins and/or chemical complexes a 2-circle goniometer including sample positioning optics has been installed at beamline P01, PETRA III, DESY, Hamburg. This sample environment has been tested with single crystals of SCO complexes and with hydrogen peroxide treated myoglobin single crystals [2] and is now available for all users of this beamline. Nuclear Forward Scattering (NFS) of SCO microstructures [3] has been applied to monitor the spin switch between the S=0 and S=2 state and quantum chemical calculations based on density functional theory (DFT) have been used to identify spin molecular modes which are responsible for spin marker bands [4]. In order to investigate the dynamic properties of large biomolecules like proteins, DFT methods and molecular mechanics can be coupled for the calculation of the proteins vibrational density of states. Based on our experience with NO transporter proteins [5] we are now studying substrate and inhibitor interactions of Fe-S proteins like the LytB protein [6] which is a potential target enzyme for new antibiotic drugs.

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Nuclear Applications / **32**

The isotopes Tb-149 and Tb-152 in preclinical investigations: Report on the successes and challenges of the 2015 Medical Isotope Campaign for IS528.

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During the 2015 Ta target run, PSI concentrated on the collection and purification of ^{149}Tb and ^{152}Tb. Both isotopes could be harvested in sufficient quantities to allow transport to PSI, purification and significant imaging and therapy investigations. We report some of the successes and preliminary results of this campaign.

As in our previous ISOLDE campaigns the cumulative Tb yields were significantly boosted by use of resonant laser ionization of the respective Dy precursors. The new Dy laser ionization scheme using Ti-sapphire lasers instead of dye lasers provided excellent Dy yields and a very stable laser ionization. The ion beam composition was measured on-line with the ISOLTRAP MR-TOF mass spectrometer to validate the laser tuning and to quantify the contribution of Dy, Tb, Gd, Eu and the dominant oxide sidebands PrO, CeO, LaO. This enabled optimized collections in particular for ^{149}Tb. With 1.5 hours of collection and 2 hours decay before shipping, up to 200 MBq could be shipped to PSI.

Complementing our previous therapy studies with ^{149}Tb-cm09 and ^{161}Tb-cm09 that demonstrated therapeutic efficacy of these radiopharmaceuticals [1,2], we were now focusing on possible side effects of such a treatment. For this purpose healthy mice without tumors are injected at increasing activity levels for the purpose of investigating kidney damage after alpha therapy with ^{149}Tb-folate and compare it with the damage caused by ^{161}Tb-folate based beta therapy. These mice are currently being monitored regarding body weight and potential changes of blood plasma parameters. Raising levels of blood urea nitrogen and creatinine would be an indication for loss of kidney function. The plan is to follow the development over a period of about 8 months.
In 2014 we could inject 3 mice with 2 MBq/mouse and study their evolution, in 2015 we continued this ^{149}Tb-cm09 dose escalation study with 6 mice injected with 5 MBq/mouse.

For the ^{149}Tb pilot study with peptides we managed to label DOTANOC and DOTA-RGD at high specific activity of up to 10 MBq/nmol. This will allow the performance of a relevant therapy study in the next production run.

We also managed to label both peptides with the imaging isotope ^{152}Tb. They have been injected into AR42J and U87MG tumor-bearing mice which were imaged using a benchtop small animal PET/CT scanner (Genisys8, Sofie Biosciences). Tumor visualization was readily achieved with both targeting agents and, due to the high sensitivity of this scanner, it was possible to image tumors also at late time points after injection of the mice.

In order to facilitate an experiment at CHUV, we separated ^{152}Tb and sent 150 MBq to Lausanne where it was possible to label a neurotensin derivative (NT-20.3-Ile) and inject 4 tumor-bearing mice

which were with 8 MBq each for scanning 1.5-2 h after injection using a small-animal PET scanner.

We would like to thank the RILIS team for excellent Dy ionization and the ISOLTRAP-MR-TOF-MS team for the on-line measurement of the beam composition as essential information to optimize the collection conditions. We are particularly grateful to CERN's and PSI's radioactive shipping services which did their best to cope with the constraints of the EDH system to minimize delays in shipping. In the longer run we aim at installing a setup for chemical separation of Tb from its unwanted pseudo-isobars (CeO sidebands) at MEDICIS. Thus the activity and dose rate of the shipped parcels could be reduced considerably.

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Nuclear Applications / 22

Decay induced de-chelation of positron-emitting electron-capture daughters and its use in preclinical PET.

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The purpose of this study was to assess the value of ¹⁴⁰Nd/¹⁴⁰Pr and ¹³⁴Ce/¹³⁴La as *in vivo* PET generators through kinetic evaluation of the pairs with somatostatin analogues in the neuroendocrine tumor-based somatostatin receptor 2 (sst2) system. By employing a known sst2 internalizing vector, DOTATATE, and a known non-internalizing vector, DOTALM3, we attempted to determine *in vivo* diffusion kinetics of a freed positron-emitting daughter ¹⁴⁰Pr³⁺ in tumor-bearing mice.

Methods: ¹⁴⁰Nd and ¹³⁴Ce were produced by proton-induced spallation of a tantalum target at ISOLDE, electromagnetically separated, and implanted in a thin zinc layer on gold foils. After dissolving the zinc, the products were chemically separated, reacted with sst2 targeting vectors DOTATATE or DOTALM3, and the ¹⁴⁰Nd labeled vectors were i.v. injected into dual-flank H727 xenograft bearing mice (n = 8 for each tracer). PET scans were taken at 1, 3, and 16 hours post injection. Following the last image, the animals were euthanized, and then imaged intact at 30 min post-mortem. The differences between the 16 h PET scan and the post-mortem scan were used to study the diffusion behavior of ¹⁴⁰Pr³⁺ following the parent ¹⁴⁰Nd EC decay. Three additional mice were scanned under the same protocol after injection of ¹⁴⁰Nd³⁺ in HEPES-buffered isotonic saline to investigate the free ion distributions in the tumor model.

Results: In total 950 MBq of ¹⁴⁰Nd and 140 MBq of ¹³⁴Ce were collected at ISOLDE and shipped to Hevesy Lab. ¹⁴⁰Nd reactions with DOTATATE and DOTALM3 were efficient at 5 MBq/nmol (n = 2 each). ¹³⁴Ce labeling was inefficient, and could only be achieved with receptor-saturating levels of the vectors, thereby precluding their use *in vivo*. The *in vivo* scans showed only a small difference in the tumor PET signal between pre- and post-mortem scans, with a slight increase in tumor signal post-mortem when DOTALM3 was used. Non-targeted organs, however, showed interesting source and sink behaviors illuminating some properties of the renal and hepatic interaction with neodymium and praseodymium.

Conclusion: Based upon the results of this study we conclude that ¹⁴⁰Nd imaging in preclinical models might be possible without designing an electron-capture-dislocation resistant chelate. In such cases, the imaging protocol established here is a useful test to determine how ¹⁴⁰Nd PET is altered by diffusion. Further, with careful experimental design it may be possible to exploit the diffusion effects to observe biological phenomena such as vector internalization.

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Study of orbital melting and Jahn-Teller distortions in La(Nd, Sm, Pr)MnO3 Manganites by means of perturbed angular correlations

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In the last years, a deep focus has been devoted to manganites and their exquisite properties triggered by the interplay of spin, orbital, charge and structural degrees of freedom, driven by both fundamental interest and possible applications on colossal magnetoresistance, magnetocaloric and multiferroic properties [1,2]. Additionally, low-cost AMnO3, as well as its doped counterparts, have shown promising results for catalyst solutions [3]. In these systems orbital occupancy of the metal ion, orbital order and the Jahn-Teller effect play a critical role on the material's macroscopic properties.
In this work, a Perturbed Angular Correlation (PAC) study on the RMnO3 (R=Sm, Nd, Pr, La) system is presented, showing a linear increase of the main component (Vzz) of the Electric Field Gradient (EFG) with the rare-earth ionic radius. These results are compared with ab initio density functional theory calculations, carried out also in the framework of this study. Different values of the on-site Coulomb parameters were used in the calculations in order to better reproduce the experimental results.
Additionally, the EFG temperature evolution was studied at the La site for the prototype LaMnO3 system across the Jahn-Teller and concomitant orbital order/disorder transition. Unexpectedly, a drastic change in the EFG parameters was observed at temperatures much below the Jahn-Teller transition, pointing to a new characteristic temperature in this system. This result gives further proof of the recently reported [4,5] partial melting of the system's orbital order occurring in this system at temperatures much below the order/disorder transition.

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Nuclear Applications / 27

Emission Channeling with Timepix position sensitive dectectors

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With the availability of new high resolution position sensitive detectors the oportunity to measure emission channeling patterns with a small angular sampling step arrises. The detector used, Timepix, is a cern developed position senstive detector with a 55um side pixel and a matrix of 512*512. Here will be present the necessary sistems for running the detector, measurement, data transfer and data analysis. In addition to the measurement of 24Na and 42K implanted GaN, by both the previous detector with 1.4mm pixel and Timepix.

Special Topic / 48

Neutrino physics: today, tomorrow and later.

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Now that the Higgs boson is found, the physics of massive neutrinos become the frontier of knowledge and mystery in particle physics. The present status will be reviewed, as well as the almost foreseeable future. On a longer time scale, solving the question of neutrino masses might help to solve several pending issues in our understanding of the Universe, such as dark matter and the baryon asymmetry of the Universe.

Hyperfine Interactions & Beta Decay Studies / 55

Resonance photoionization spectroscopy of short-lived isotopes in the lead region (Z=82) using the ISOLDE RILIS

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Over 30 years ago isotope shifts and hyperfine structures of mercury and gold isotopes were measured by laser spectroscopy at ISOLDE [1,2,3]. Nuclear charge radii, spins, and magnetic and quadrupole moments were determined, revealing the sudden and unforeseen onset of shape staggering and deformation for the neutron-deficient isotopes, and sparking a great interest in this region of the nuclear chart. These experiments were performed by either collinear florescence spectroscopy (Hg) or resonance ionization in an atomic beam after isotope collection (Au). As such, the respective sensitivity and lifetime constraints imposed by the experimental conditions limited their reach towards more exotic isotopes. Today, the Resonance Ionization Laser Ion Source (RILIS) [4], which the most commonly used ion source at ISOLDE, can also be operated in an enhanced resolution, wavelength-scanning mode. In this case the ionization efficiency is sensitive to the isotope shift or hyperfine structure during a laser scan. This represents the most sensitive laser spectroscopy method at ISOLDE. Although the spectral resolution is limited by the Doppler broadening of atomic transitions inside the ionization region, for the heavier elements this is not prohibitive to the extraction of nuclear structure information. By exploiting the array of ion beam detections setups that are available at ISOLDE: (α/β/γ) detection with the Leuven Windmill system; direct ion counting with the ISOLTRAP MR-TOF MS; and ion beam current measurements using the ISOLDE Faraday cups, our collaboration has performed extensive laser and nuclear-spectroscopic studies of isotopes in the lead region [5,6,7]. During 2015, two further studies were highly successful: Experiment IS534 [8] measured isotopes and isomers of 176-182Au for the first time, revealing that the Au ground states, which become prolate-deformed at N=108 [3], re-join the near-spherical trend below N=101, with a pronounced shape-staggering in the transition region; Experiment IS598 [9] measured 15 mercury isotopes, extending the charge radii systematics below N=101 down to 177Hg, and above N=126 up to 208Hg. The results delineate the region of pronounced shape-staggering, and thereby provide a long-awaited conclusion to one of the earliest and most renowned measurements in this field. Our recent results will be summarized and an outlook towards future studies and developments of the technique will be presented.

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Hyperfine Interactions & Beta Decay Studies / 45

New emission Mössbauer spectroscopy studies at ISOLDE in 2015

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In 2015, several beams were for the "first" time utilized for emission Mössbauer spectroscopy (eMS) studies at ISOLDE with applications in solid state physics and biophysics.

These include laser ionized ^{119}In (2.1 min.) and ^{119}Ag (2.1 s) for ^{119}Sn eMS, ^{151}Dy → ^{151}Gd (120 d) for ^{151}Eu eMS and ^{197}Hg (62 h) for ^{197}Au eMS.

I will present the newly utilized beams and the new type of physics that can be explored with them. Some highlights will be presented.

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PAC spectroscopy applied in metallobiochemistry

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Metal ions are essential to all living systems, and are for example involved in catalysis, regulation of gene expression, controlling and maintaining structure and folding of biomolecules, and electron transport. Inside cells the concentration of both essential and toxic metal ions is tightly controlled, and one facet of metallobiochemistry is the structure and function of various metallobiosensors, which selectively bind and respond to the presence of either Cu(I), Zn(II), Ag(I), Cd(II), Hg(II), or other metal ions. We will present recent examples of applications of PAC spectroscopy, elucidating the structure and function of metallobiosensors [1,2].

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Hyperfine Interactions & Beta Decay Studies / 8

Shape coexistence in odd-Au isotopes investigated with BEGe detectors

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The shape coexistence in ^{181,183,185,187,189}Au was investigated via β^+/EC decay of corresponding Hg isotopes. Samples of Hg isotopes were produced by deposition of low-energy beam from ISOLDE facility. For this purpose a new travelling setup, the TATRA tape transportation system was developed. It uses the metallic tape prepared by rapid quenching of alloy melt producing amorphous metal. Because of this material, the system has excellent vacuum properties.
Novel Broad Energy Germanium (BEGe) detector BE2020 was used to detect γ rays. Its excellent energy resolution makes it very promising type of detector for future decay studies. As it will be presented it allows to construct comprehensive level schemes based dominantly on spectra of γ ray singles. Preliminary results of the analysis of ^{183}Au data will presented. Moreover, technical issues of the TATRA system and fundamental characteristics of the the BEGe detector will be discussed in the presentation.

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Study of octupole deformation in n-rich Ba isotopes populated via β decay

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Barium isotopes are located in a region of the Segr\'e chart characterized by a variety of shape phenomena, including shape coexistence and presence of static octupole deformations.
In this isotopic chain alternating-parity bands, with large and constant B(E1) transition moments, have been found in $^{140-144}$Ba; the neighboring nucleus, ^{146}Ba, shows instead slower E1 transition rates than ^{144}Ba~\cite{Mac92}. The same effect is expected to be present in the heavier even-even isotopes~\cite{But91}, which are the object of this study.
In this contribution results from an experiment aiming at studying the β decay of Cs isotopes up to A=152 will be presented.
The measurement of gross quantities such as decay half-lives and β-delayed emission probabilities P$_n$, are of great relevance for the understanding of the rapid neutron-capture process (r-process) around the second abundance peak. Apparent beta-feedings and tentative logft values of yrast and

non-yrast low-energy levels populated in the daughter $^{148-152}$Ba can be measured, providing a first access to the nuclear structure of these very neutron-rich Ba isotopes. The measurement of the lifetime of specific states gives an additional in-sight in the structure of the populated nuclei.
The experiment was performed in Dec.~2014 at the ISOLDE Decay Station (IDS) set-up using the fast tape station of K.U.-Leuven, equipped with 4 Clover detectors, 3 fast plastic scintillators and 3 $LaBr_3$(Ce) detectors, for fast-timing measurements.
The radioactive beam species were produced in proton-induced fission reactions using a UCx target equipped with a standard surface ionizer.
Owing to rates lower than expected the decay of $^{148-150}$Cs could only be accessed.
First experimental information extracted from the data will be presented.

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Hyperfine Interactions & Beta Decay Studies / 9

MAGISOL decay-experiments 2015

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On behalf of the MAGISOL, the IS507 and the IS541 collaborations

I will present preliminary results from two decay-experiments, which were performed by the MAGISOL collaboration at ISOLDE in 2015.

The first experiment was a decay-study of ^{20,21}Mg performed at the ISOLDE decay station. The beta-decays of ^{20,21}Mg provide information about the beta-strength functions to states in ^{20}Na and ^{21}Na. Such information is important for comparison to the nuclear shell model, and to the strengths to similar transitions in the mirror nuclei. For ^{20}Mg there is an additional interest in determining the spin and parity of the 2.65 MeV proton unbound resonance in ^{20}Ne. This is important for the hot CNO breakout sequence ^{15}O$(\alpha,\gamma)^{19}$Ne(p,γ)^{20}Na towards the rp-process such as e.g. found in X-ray bursts. A part of the IS507 experiment was already performed in 2013 and the results were presented at the workshop last year. Analysis of the first set of data has revealed several new decay channels in ^{21}Mg. This includes both new beta-delayed proton branches and, for the first time, beta-delayed alpha emission branches [1,2]. Similar decays are expected in ^{20}Mg including βpα and $\beta\alpha$p decays to ^{15}O. I will present results from the first attempts to see these decays.

The aim of the second experiment was to determine the branching ratio for the beta-delayed proton emission in ^{11}Be. The experiment was performed at LA1 and was the second part of the IS541 experiment, the results from the first experiment can be found in [3]. Beta-delayed proton emissions are rarely observed in neutron-rich nuclei and ^{11}Be is expected to be one of the best candidates for such a decay because of the halo structure. The branching ratio in ^{11}Be is estimated to be in the order of 10^{-8}, much lower than the $(8.3 \pm 0.9) \cdot 10^{-6}$ measured in our first experiment [3]. The energy of the emitted proton is very small and instead of measuring the protons, the ^{11}Be nuclei are implemented in a copper-foil and the amount of ^{10}Be is then determined in an AMS measurement afterwards. The amount of implanted ^{11}Be and any contamination leading to additional ^{10}Be in the sample have to be determined to a high precision, due to the very small branching ratio. I will present the status of the determination of the implanted nuclei including a HRS scan from ^{10}Be to ^{11}Li. This is one of the first measurements of this profile at ISOLDE.

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Post-Accelerated Beams / 14

MINIBALL entering the HIE-ISOLDE era

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The MINIBALL spectrometer has been reinstalled for the HIE-ISOLDE experiments. MINIBALL will benefit from the energy upgrade enabling multistep Coulomb excitation experiments and few-nucleon transfer reactions studies of heavy nuclei. The first experiment was dedicated a study of the evolution of the nuclear structure along the zinc isotopic chain
close to the doubly magic nucleus ^{78}Ni. The preliminary data from that experiment will be presented.

Post-Accelerated Beams / 10

Spectrometer Systems for TSR@ISOLDE

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The advent of HIE-ISOLDE with high-intensity radioactive beams at energies of ~10 MeV per nucleon and the transfer of the Test Storage Ring (TSR) from Heidelberg to ISOLDE will open up new opportunities for precision studies of exotic nuclei 1. New spectrometer systems are being designed and developed to exploit these capabilities, including a silicon detector system to be used in-ring with gas-jet targets for lighter beam species and an external spectrometer for heavier beams that will be cooled and then extracted from the TSR. The external spectrometer, which will operate on the same principle as the HELIOS device at Argonne National Laboratory [2], is also intended for use with beams directly from HIE-ISOLDE before the TSR is installed. This presentation will provide an overview of these spectrometer systems and an update on their current status.

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Shape Evolution in the Refractory Isotopes 100Zr and 110Ru Studied by Low-energy Coulomb Excitation

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The N=60 region, for the Sr and Zr isotopic chains, is an interesting example of shape evolution.
On the neutron-rich side of these isotopic chains, N=56 is observed to become an effective sub-shell closure with ^{96}Zr (and ^{98}Sr) exhibiting the properties of a doubly-magic nucleus. However, with

the addition of only four neutrons, ^{100}Zr is observed to become strongly deformed. This sudden change from a spherical shape to one with large deformation has attracted numerous theoretical and experimental investigations and is probably the most sudden change from a spherical shape to one with large deformation of known nuclei.
The case of ^{110}Ru is also intriguing as the possible existence of triaxial shapes close to the ground state has been discussed for ruthenium isotopes lying close to the mid-shell between N=50 and N=82. It has been shown previously that empirical criteria for triaxiality, such as the relative positions of excited states, are satisfied for neutron-rich ruthenium isotopes.

In order to shed new light on these phenomena, Coulomb excitation experiments were performed with the aim of determining matrix elements between low-lying excited states. Radioactive ^{100}Zr and ^{110}Ru beams were provided by the CARIBU system at Argonne National Laboratory, the only facility able to deliver
intense beams of refractory elements. De-excitation
-rays were detected with GRETINA detector
array with the CHICO2 particle detector array employed for the detection of beam particles and recoiling target nuclei. In this presentation, an overview of the recently performed experiments will be given and initial results presented along with a comparison with state-of-the-art Beyond Mean Field theoretical calculations.

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Investigation of isovector valence-shell excitations in nuclei around the N=82 shell closure

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The two-fluid nature of nuclear matter leads to the existence of special excited states which are symmetric or partially anti-symmetric with respect to the relative contributions of the two components of the system, protons and neutrons. These latter states are called proton-neutron mixed-symmetry states (MSSs) [1,2]. The fundamental MSS of weakly collective vibrational nuclei is the one-quadrupole phonon $2^+_{1,ms}$ state 1. It is intended to identify these states in three related nuclei near the $N = 82$ shell closure. Due to their isovector character, MSSs decay rapidly by magnetic dipole transitions and are comparatively short lived. Investigating FSS and MSS of weakly collective nuclei provides insight in the effective proton-neutron interaction in the nuclear valence-shell.

It is proposed to perform Coulomb excitation experiments on beams of radioactive ions delivered by HIE-ISOLDE that differ by two neutrons from the $N = 82$ magic number: ^{136}Te, ^{140}Nd, ^{142}Sm. Scattered particles will be detected by a DSSSD detector and γ rays will be detected by the MINIBALL array. In ^{136}Te the proposed Configurational Isospin Polarization (CIP) [3] effect will be determined by measuring the E2 excitation yield distribution to the two lowest 2^+ states. The expected proton-dominated one-phonon character of the second excited 2^+ state of ^{136}Te will be tested on the basis of absolute electromagnetic matrix elements from the observed Coulomb excitation cross sections. Complementary lifetime information on this predominant $2^+_{1;ms}$ state will be extracted using the differential DSAM technique. The experiment will clarify to what extent CIP is responsible for the 2^+ anomaly in ^{136}Te [4].

We will further investigate the microscopic mechanism which leads to a concentration or a fragmentation of the quadrupole-collective isovector valence-shell excitations, an effect called \textit{shell stabilization} of MSSs [4]. This aim will be achieved by identification of MSSs of the unstable nuclei ^{140}Nd and ^{142}Sm. The first steps of this program have been undertaken in two runs of the experiment IS496 in which we have measured the $B(E2; 2^+_1 \rightarrow 0^+_1)$ transition strengths in these radioactive nuclei [6,7]. The program will be completed by finally identifying the MSSs of these nuclei from E2 and M1 strengths measured relative to the population of the first 2^+ states in Coulomb excitation (CE) reactions.

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Concluding Remarks

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