ISOLDE Workshop and Users meeting 2012

Monday, 17 December 2012 - Wednesday, 19 December 2012

CERN

Book of Abstracts

Contents

Welcome 67 1

Theoretical approaches to study reactions with light exotic nuclei 64 1

Study of deuteron emission in beta decay of 6He 31 1

12Be in the Maya active target 26 1

Proton resonance elastic scattering on 30Mg 22 3

The resonances of 30S and the 29P(p,gamma)30S reaction 7 3

COLLAPS 2012 - Status and Outlook 63 4

Recent Physics results of RIKEN RIBF and Future Prospects 59 4

Single-particle states in 79Zn studied via single-neutron transfer 14 5

Probing the semi-magicity of 68Ni via the 3H(66Ni,68Ni)p and 2H(66Ni,67Ni)p transfer reactions in inverse kinematics 11 6

MAGNETIC MOMENT MEASUREMENT IN 72ZN USING THE TRANSIENT FIELD TECHNIQUE AND COULOMB EXCITATON IN INVERSE KINEMATICS 21 7

First results from IS-510: Transfer reactions and Coulomb excitation with T-REX in the 68Ni region 34 7

Beta decay of 82Zn 44 8

Structure of 81Ga populated from the β- decay of 81Zn 3 8

HIE ISOLDE - Alignment and Monitoring System of the LINAC 86 9

SPINS, MOMENTS AND RADII OF 100-130Cd BY LASER SPECTROSCOPY 0 9

Simulations of the HIE-ISOLDE radio frequency quadrupole cooler and buncher vacuum using the Monte Carlo test particle code Molflow+ 66 10

Experimental results and numerical simulations of the HIE ISOLDE short Faraday Cup 35 11

Laser spectroscopy on neutron-rich 48-51K isotopes 24 11

The next generation of implantation chambers for GPS 82 11

Upgrade of the REX-ISOLDE charge breeder 51 12

HIE-ISOLDE cavity coating 85 13

Laser- and decay spectroscopy of neutron-deficient Tl isotopes 15 13

Dose estimations for target's storage and MEDICIS Lab. using Fluka 88 14

100 ns Bunch Spacing of Post-accelerated RIBs for the High Intensity and Energy ISOLDE Upgrade 81 14

Advanced SiC and Al2O3 as model targets for radioisotope beam production at HIE-ISOLDE 65 14

A feasible substitute of LaBr3 scintillator in the Ultra Fast Timing Technique for lifetime measurements of excited states. 43 15

Laser spectroscopy on the borders of the region of reflection asymmetry 30 16

Determination of the B(E2) value for the first 2+ state of 142Sm using Coulomb excitation at REX-ISOLDE 8 16

Quadrupole Collectivity in the Cd isotopic chain investigated with Coulomb Excitation 6 17

Radiation Protection Study for the HIE-ISOLDE project 25 18

Design Upgrade of the Mass Separator Magnets for HIE-ISOLDE 78 18

Online Operation of a Molten Salt Target at ISOLDE for the Beta Beams: Validation of Electro-Thermal Simulation with Experimental Data 50 18

Applications of solid-state RILIS lasers in experiments at ISOLDE 38 19

Precision mass spectrometry of short-lived nuclei with minute production rates 28 20

3D Integration models for the various installation stages of HIE-ISOLDE 84 20

Recent developments of the ISOLDE RILIS Remote Monitoring and Control System towards flexible collaborative data acquisition 27 21

Low level control upgrade to the ISOLDE High Resolution Separator magnet 80 21

Preliminary Study of the HIE-ISOLDE Beam Profile Monitor 36 22

Cooling and Ventilation Group Activities on ISOLDE Tunnel & Class A Lab during LS1 and for HIE-ISOLDE Intensity upgrade 79 22

Shape coexistence and charge radii in gold and astatine isotopes studied by in-source laser spectroscopy at RILIS-ISOLDE 5 23

Newly identified low-lying isomeric state in 80Ga from the beta- decay of 80Zn 20 23

HIE beam commissioning software application 83 24

Structure of the odd-odd 62,64Co nuclei: "is there evidence of the onset of particle-hole intruder states in these nuclei?"4 24

Design Upgrade of the ISOLDE Target Unit for HIE-ISOLDE 77 25

A Systematic Study of Nuclei in the A=60 -70 Mass Region 33 25

Upgrade of the Radio Frequency Quadrupole Cooler and Buncher for the HIE-ISOLDE Project 48 . . . 26

New quadrupole electromagnets with laminated steel yokes for the HIE-ISOLDE Beam Transfer Lines 87 . . . 27

Recent results and perspectives at the GANIL/SPIRAL2 facility 61 . . . 27

Recent Results on Spherical and Deformed Nuclei from NICOLE 52 . . . 27

Penning-trap mass spectrometry and search for long-lived isomers in neutron-deficient Au and At isotopes 40 . . . 28

Coulomb excitation of 196,198,200,202Po studied at REX-ISOLDE with the Miniball γ spectrometer 10 . . . 29

Beta-delayed fission of neutron-deficient Fr and At isotopes 17 . . . 30

Spectroscopic studies of the neutron-deficient francium isotopes at the CRIS beam line 9 31

CERN-MEDICIS: Recuperation of the dumped CERN protons for the production of medical isotopes in the ISOLDE Class A Laboratory 69 . . . 32

A Unique Matched Quadruplet of Terbium Radioisotopes for PET and SPECT and for alpha- and beta-Radionuclide Therapy: An in vivo Proof of Concept Study with a New Receptor-Targeted Folate Derivative 55 . . . 32

PAC Spectroscopy applied to biochemistry 54 . . . 33

First Application of β-NMR in Wet Chemistry 53 . . . 34

Recent results from the ISAC facility at TRIUMF 49 . . . 34

High power molten fluoride salt target for 18Ne production 39 . . . 35

Novel radioactive ion beams developed at ISOLDE 70 . . . 35

Operation and recent On-line Results of the Laser Ion Source and Trap Unit LIST 32 . . . 36

First spin-polarized nuclei at REX-ISOLDE 18 . . . 36

20 Years of Physics at the ISOLDE PSB Facility 62 . . . 37

Technical milestones in the development of ISOLDE 71 . . . 38

Future Developments at ISOLDE 72 . . . 38

Neutrino oscillations: progress and prospects 68 . . . 38

Ultra-high depth resolution MCsn+-SIMS for direct compositional analysis of low-dimensional structures of condensed matter systems 57 . . . 39

FLUENCE DEPENDENCE OF THE ATOMIC CONFIGURATION OF 57Fe IN ION-IMPLANTED ZnO 45 . . . 39

Lattice location of transition metals in dilute magnetic semiconductors using EC-SLI (IS453) 29 . . . 40

Manipulation of diffusion profiles in CdTe 2 41

INVESTIGATION OF 111mCd AND 117Cd IN Fe DOPED TiO2 AND SnO2 THIN FILMS BY MEANS OF PERTURBED ANGULAR CORRELATION SPECTROSCOPY 58 42

Nuclear structure of exotic neutron-rich nuclei with AGATA 16 42

Status of the WITCH experiment 23 43

Lifetime measurements using DSAM with the MINIBALL set-up 13 43

Resonance excitation in 7Be + d reaction to study 7Li abundance anomaly 19 44

Solenoidal spectrometer for HIE-ISOLDE 42 44

Radiative strength of neutron-rich nuclei and its astrophysical implications 37 45

Physics at HIE-ISOLDE 60 45

Status of the HIE ISOLDE cavity development 73 46

Installation and Integration of HIE ISOLDE 74 46

HIE beam commissioning planning and preparation work 75 46

Shape transition and coexistence in neutron-deficient rare earth nuclei: Coulomb excitation of 140Sm 46 47

Shape coexistence and shape evolution in neutron-rich A≃100 nuclei 1 47

Looking at the shape transition at N=60 by safe Coulex of Sr isotopes 12 48

Beta decay studies of the N=Z and waiting point nucleus 72Kr 41 48

An examination of the turbulent A = 100 region in light of (recent) experimental results (from ISOLDE) 76 49

67

Welcome

Corresponding Author: maria.garcia.borge@cern.ch

Light nuclei / 64

Theoretical approaches to study reactions with light exotic nuclei

Author: Antonio Moro[1]

[1] *University of Seville*

The discovery of halo nuclei in the middle eighties marked the beginning of a serial of nuclear and theoretical studies aimed at understanding their peculiar properties, the most remarkable being the presence of one or two weakly-bound nucleons with a high probability of exploring distances well beyond the range of the binding potentials. This gives rise to a dilute density distribution which extends much further than the radius expected for a stable nucleus of the same mass.
The loosely bound nature of these nuclei has also sizable effects in the scattering observables.
For example, the elastic scattering of halo nuclei on a heavy target at Coulomb barrier energies was long ago predicted [1] to depart significantly from the Rutherford formula, due to the polarization effect caused by the strong dipole Coulomb interaction. This effect is accompanied by a large breakup probability.
In this presentation, we discuss some recent experiments for several reactions induced by the halo nuclei 6He [2], 11Be [3] and 11Li measured at Louvain-la-Neuve, ISOLDE and TRIUMF, respectively, with emphasis on the theoretical approaches developed to interpret these results. In particular, we discuss recent advances in the Continuum-Discretized Coupled-Channels (CDCC) method required to describe the three-body structure of the 6He and 11Li nuclei and to include the effect of core excitation in the scattering of two-body halo nuclei with well deformed cores, such as 11Be.
We present also the data and theoretical analysis of several transfer reactions triggered by the collisions of 9Li [5] and 8Li [6] on a deuteron target, measured at ISOLDE.

Light nuclei / 31

Study of deuteron emission in beta decay of 6He

Author: Marek Pfutzner[1]

[1] *University of Warsaw (PL)*

Corresponding Author: marek.pfutzner@cern.ch

Recently, we have completed a measurement of beta-decay of 6He focusing on a very weak decay branch with emission of a deuteron. The bunches of 6He ions were delivered by the REX-Isolde and implanted into the Optical Time Projection Chamber, were their decays were recorded. Decay events of 6He into an alpha particle and a deuteron were clearly observed. Preliminary results of this experiment will be presented.

Light nuclei / 26

12Be in the Maya active target

Author: Sara Sambi[1]

Co-authors: Andreas Heinz [2]; Beatriz Fernandez Dominguez [3]; Bjorn Jonson [4]; Daisuke Suzuki [5]; Datta Usashi [6]; David Loureiro [7]; Giacomo Randisi [8]; Gibelin Julien [9]; Guillermo Ribeiro [10]; Hans FYNBO [11]; Manuel Caamano Fresco [12]; Maria Jose Garcia Borge [13]; Olof Tengblad [14]; Riccardo Orlandi [1]; Riccardo Raabe [15]; Ronja Thies [2]; Thomas Nilsson [16]; Thomas Roger [17]; freddy Flavigny [8]; geoff Grinyer [7]

[1] *Katholieke Universiteit Leuven (BE)*

[2] *Chalmers Univ. of Technology, Gothenburg, Sweden*

[3] *U*

[4] *Chalmers University of Technology (SE)*

[5] *Institut de Physique Nucléaire, Orsay, France*

[6] *Saha Institute Of Nuclear Physics, Kolkata, India*

[7] *GANIL, Caen, France*

[8] *Instituut voor Kern- en Stralingsfysica, KU Leuven, Belgium*

[9] *Laboratoire de Physique Corpusculaire, Caen, France*

[10] *Instituto de Estructura de la Materia, CSIC, Madrid, Spain*

[11] *Department of Physics and Astronomy, University of Aarhus*

[12] *Universidade de Santiago de Compostela, Spain*

[13] *CERN*

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

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

[16] *CTH Goteborg*

[17] *Katholieke Universiteit Leuven*

Corresponding Author: sara.sambi@cern.ch

Experiment IS520 aimed at studying the ground state of the unbound system 13Be.

The determination of the sequence of its low-lying states can shed light on the evolution of the N = 8 shell closure towards the dripline.
While a resonance in 13Be at about 2 MeV above the neutron emission threshold is confirmed and identified as a d5/2 state, the situation regarding other lower-lying states is more controversial and there are indications of a disappearance of the N=8 shell closure.

13Be also provides important information for the modeling of the two-neutron halo nucleus 14Be. According to theoretical works [1], the d5/2 resonance would have to be lower than the observed 2 MeV in order to reproduce the two-neutron separation energy in 14Be.
The discrepancy can be solved by an inversion of the 2s1/2 and 1p1/2 orbitals or including excitations or deformations of the 12Be core in the models.

To study the ground state of 13Be, we populate its isobaric analog resonance in 13B through the resonant scattering of 12Be nuclei on protons.
Once the IAS is populated, isospin conservation allows decay (to the entrance channel) via emission of a proton that will be detected in our setup.

The 12Be beam (post-accelerated for the first time in REX) was sent into Maya, an active target, in which the detection gas isobutane contained the protons that were the target of the reaction.
Maya is a gaseous detector [2], providing three-dimensional reconstruction of the tracks of the charged particles traversing the gas volume. Identification of the particles is achieved via the specific energy loss, the total energy deposited and the length of the paths.
An array of Si and CsI detectors covers the wall opposite to the beam entrance, to detect forward-emitted light ions which are not stopped in the gas volume. The detector has been successfully used in a number of reaction experiments [3-6].

The particular timing characteristics of REX beam, combined with those of the gas detector, made the experiment particularly challenging.
Furthermore, an important problem was represented by the contamination of 12C4+ ions in the 12Be

beam. Indeed, 12C was about 10ˆ4 times more intense than 12Be in our detector.
By modifying our detector we succeeded in eliminating the direct signals of the 12C beam, but 12C-induced events still represent the majority of events recorded in our data. 12Be-induced events will have to be carefully filtered out by applying coincidence conditions.

Preliminary results will be presented during the oral presentation.

References:
[1] I. J. Thompson and M. V. Zhukov, Phys. Rev. C 53, 708 (1996)
[2] Demonchy et al, NIMA 583 (2007) 341–349
[3] Caamano et al, PRL 99 (2007) 062502
[4] Monrozeau et al, PRL 100 (2008) 042501[5] Tanihata et al, PRL 100 (2008) 192502
[6] Roger et al, PRC 79 (2009) 031603

Light nuclei / **22**

Proton resonance elastic scattering on 30Mg

Author: Nobuaki Imai[1]

Co-authors: Daid Kahl [2]; Hakan Johansson [3]; Hossein Aghai Khozani [4]; Jan Pawel Kurcewicz ; Joakim Cederkall [5]; Momo Mukai [6]; Pavel Ivanovich Golubev [5]; Takashi Teranishi [7]; Yutaka Watanabe [6]

[1] *High Energy Accelerator Research Organization (KEK)*

[2] *Center for Nuclear Study, University of Tokyo*

[3] *Gesellschaft fuer Schwerionenforschung mbH (GSI)*

[4] *L*

[5] *Lund University (SE)*

[6] *High Energy Accelerator Research Organization (JP)*

[7] *Kyushu University (JP)*

We measured an excitation function of the proton resonance elastic scattering on 30Mg of 2.92 MeV/nucleon to study the isobaric analog resonances of the low-lying bound states in 31Mg. We successfully observed several resonances. In this paper, we'll present the angular momenta and spectroscopic factors of the parent bound states in 31Mg obtained by the R-matrix analysis on the excitation function.

Light nuclei / **7**

The resonances of 30S and the 29P(p,gamma)30S reaction

Author: Gunvor Thinggaard Koldste[1]

Co-author: IS476 IS476 [2]

[1] *Aarhus University (DK)*

[2] *ISOLDE*

Corresponding Author: gunvor.koldste.thinggaard@cern.ch

The nucleus 30S is situated at the proton drip line and thus plays an important role in the rp- and alpha-p-process via the 29P(p,gamma)30S reaction. The astrophysical relevant resonances are situated just above the proton threshold. We have studied the nucleus through beta-delayed proton decays of 31Ar in the IS476 experiment.

Knowledge of the resonances just above the proton threshold of 30S is limited. The energies of the two resonances predicted to dominate the 29P(p,gamma)30S reaction have recently been measured by Setoodehnia et al. Previously, no experiment has been able to measure the proton and gamma partial widths of these resonances. With our latest experiment made in 2009, which incorporated a segmented Si-particle array and two Miniball gamma detectors, it is possible to measure both protons and gammas from these resonances and thereby estimate the proton to gamma partial width ratio.
We have only been able to positively identify the gammas from the lowest of these two resonances at 4687(4) keV. Due to a substantial amount of electronic noise and beta background the protons from this resonance have not been identified. Instead, we have been able to put an upper limit on the ratio.
In November 2012 there will (hopefully) be a new experiment with an improved setup for detection of low-energy protons. The target group has made improvements to the target and ion-source so the hope is to get a substantially higher yield of 31Ar.
The latest results of the analysis of both experiments will be presented.

Light nuclei / 63

COLLAPS 2012 - Status and Outlook

Author: Mark Bissell[1]

[1] *Katholieke Universiteit Leuven (BE)*

Since the 1st April this year six experiments have been conducted by the COLLAPS collaboration using 76.5 shifts of ISOLDE online time. During the year experiments with Ca, neutron deficient Cd, neutron rich Cd, neutron rich K, biomedical-β-NMR with Mg, and finally Mn have been completed successfully. Preliminary results from these experiments will be presented covering aspects of physics ranging from the nature of the N=32 sub shell closure to the feasibility of online β-NMR in liquid samples. Future directions for these studies will be considered and the technical requirements reviewed.

Medium nuclei I / 59

Recent Physics results of RIKEN RIBF and Future Prospects

Author: Tohru Motobayashi[1]

[1] *RIKEN Nishina Center*

RIKEN has provided fast radioactive isotope (RI) beams since 1990. The new facility of RIKEN RIBF (RI Beam Factory) started operation in the end of 2006, and various experimental studies using its high-intensity RI beams with energies around 200 MeV/nucleon have been performed. They include production of many new neutron-rich isotopes, lifetime measurements for several r-process nuclei, and Q-moment measurements with a noble technique for creating spin-aligned RI beams. Direct reaction experiments of inelastic, nucleon removal, charge exchange reactions in inverse kinematics were also conducted for spectroscopy of nuclei very far from the stability valley which could not be accessed so far.
These studies were performed with the BigRIPS fragment separator for producing fast RI beams, the ZeroDegree spectrometer for analysis of reaction products, the high-resolution spectrograph SHARAQ, and the NaI(Tl) based high-efficiency gamma-ray detector array DALI2. RIBF now hosts the RISING Ge detector array from GSI. The collaboration program called EURICA (EUro ball RIken Cluster Array) has started. The spectrometer SAMURAI for particle-correlation measurements was constructed. Several neutron-ion coincidence experiments for studying unbound states in light neutron-rich nuclei were made. In addition, the facility SR2 for electron-RI scattering using the idea of SCRIT (Self Confining RI Target) and the "Rare RI-ring" for mass measurements for rarely produce, hence very exotic, isotopes are under construction.

In near-term future, to conduct various experimental studies with world-strongest RI-beams is a major focus of RIBF. Several options for long-term facility upgrade options are being discussed.

Medium nuclei I / 14

Single-particle states in 79Zn studied via single-neutron transfer

Author: Riccardo Orlandi[1]

Co-authors: Andrea Gottardo [2]; Andrea Jungclaus [3]; Andrei Andreyev [4]; Dennis Muecher [5]; Eda SAHIN [2]; Elisa Rapisarda [6]; Francesco Recchia [2]; Giacomo DE ANGELIS [7]; Jacob Johansen [8]; Jan Diriken [9]; Janne Pakarinen [6]; John F. Smith [4]; Jose Javier Valiente Dobon [2]; Joseph LANE [4]; Jytte Elseviers [9]; Katharina NOWAK [10]; Kathrin Wimmer [5]; Kieran Flanagan [11]; Mark L Huyse [12]; Mirko VON SCHMID [13]; Nigel WARR [14]; Peter Reiter [15]; Piet Van Duppen [12]; Reiner Krücken [16]; Riccardo Raabe [17]; Robert Chapman [4]; Roman August Gernhaeuser [16]; Steven Pain [18]; Thomas Elias Cocolios [6]; Thomas ROGER [19]; Thorsten Kroell [20]; Valentina Liberati [4]; Vinzenz Bildstein [21]

[1] *Katholieke Universiteit Leuven (BE)*

[2] *Laboratori Nazionali di Legnaro, IT*

[3] *IEM - CSIC, Madrid, Spain*

[4] *University of the West of Scotland, UK*

[5] *Technische Universitaet Muenchen, DE*

[6] *CERN*

[7] *Laboratori Nazionali di Legnaro, Italy*

[8] *University of Aarhus, Denmark*

[9] *Katholieke Universiteit Leuven, Belgium*

[10] *Techinschen Universitaet Muenchen DE*

[11] *University of Manchester, UK*

[12] *Katholieke Universiteit Leuven, BE*

[13] *Technische Universitaet Darmstadt DE*

[14] *University Cologne, Nuclear Physics Institut, DE*

[15] *University Cologne, Nuclear Physics Institut*

[16] *Technische Universität München, DE*

[17] *Katholieke Universiteit Leuven BE*

[18] *Oak Ridge National Laboratory, TN, USA*

[19] *KU Leuven*

[20] *Technische Universitaet Darmstadt (DE)*

[21] *University of Guelph, Canada*

Corresponding Author: riccardo.orlandi@cern.ch

Neutron-rich nuclei with magic numbers of neutrons and protons are reference points to map and understand the reorganization of the shell structure away from the line of beta stability. The region of nuclei near ^{78}Ni, the doubly-magic nucleus with the largest N/Z ratio, is the focus of considerable experimental and theoretical interest. The extent of the magicity of ^{78}Ni is still debated [1,2], since it is linked to the balance between the size of the Z=28 and N=50 shell gaps and the deformation-driving correlations produced by the promotion of nucleons across these gaps. Experiment IS491 aimed at the study of single-particle properties of ^{79}Zn, the even-Z N=49 isotone closest to ^{78}Ni. Low-lying states in ^{79}Zn were populated at Rex-Isolde via the ^{78}Zn(d,p) transfer reaction, in inverse kinematics. Transfer reactions are an ideal tool to determine effective single particle energies, linked to the size of the shell gap. The coincident detection of charged particles and gamma rays, permitted by the coupling of the T-REX and Miniball arrays, was of paramount importance for the understanding of the observed states, most of them populated for the first time. Results on ^{79}Zn level scheme and proton angular distributions will be shown. [1] M.-G. Porquet and O. Sorlin, Phys. Rev. C 85 (2012) 014307. [2] K. Sieja and F. Nowacki, Phys. Rev. C 85 (2012) 051310(R). *** This work was supported

by the European Union Seventh Framework Programme through ENSAR, contract no. 262010, and by the project MEC Consolider - Ingenio 2010; CDS2007-00042.

Medium nuclei I / 11

Probing the semi-magicity of 68Ni via the 3H(66Ni,68Ni)p and 2H(66Ni,67Ni)p transfer reactions in inverse kinematics

Author: Jytte Elseviers[1]

Co-authors: Andrei Andreyev [2]; Anna Katharina Nowak [3]; Dennis Muecher [4]; Francesco Recchia [5]; Jan Diriken [6]; Kathrin Wimmer [7]; Mirko Von Schmid [8]; Nikolaos Patronis [9]; Riccardo Raabe [10]; S. Ilieva [11]; Sara Sambi [1]; Stefanie Klupp [12]; Thomas ROGER [13]; Thorsten Kröll ; Vinzenz Bildstein [14]

[1] *K*

[2] *IKS*

[3] *Physik-Department E12-Technische Universitaet Muenchen*

[4] *Technische Universitaet Muenchen (DE)*

[5] *INFN - LNL*

[6] *Katholieke Universiteit Leuven*

[7] *Abteilung Physik-Technische Universitaet Muenchen-Unknown*

[8] *tu-darmstadt*

[9] *Department of Physics-University of Ioannina*

[10] *Katholieke Universiteit Leuven (BE)*

[11] *Tu-darmstadt*

[12] *TU Munchen*

[13] *KU Leuven*

[14] *Physik-Department E12, TU München*

Corresponding Author: jytte.elseviers@cern.ch

The region around the nucleus 68Ni, with a shell closure at Z = 28 and a sub-shell closure at N = 40, has drawn considerable interest over the past decades. 68Ni has properties that are typical of a doubly-magic nucleus, such as a high excitation energy and low B(E2:2+-0+) transition probability for the first excited 2+ level [1-3] and a 0+ level as the first excited state [4]. However, it has been suggested that the magic properties of 68Ni arise due to the fact that the N = 40 separates the negative parity pf shell from the positive parity 1g9/2 orbital [5,6], and indeed, recent mass measurements [7,8] have not revealed a clear N = 40 shell gap. Despite all additional information that was acquired over the last decade the specific role of the N = 40 is not yet understood.

Transfer reactions are a powerful tool to constrain spin and parities of excited states and to determine (relative) spectroscopic factors. In a first experimental campaign in 2009, the excitation spectrum of 67Ni was studied by performing a (d,p)-reaction on 66Ni in inverse kinematics using the MINIBALL setup in combination with the T-REX particle detection array. The excitation spectrum of odd mass nuclei, e.g. 67Ni, in the direct neighborhood of closed shells, such as 68Ni, is usually governed by single particle excitations. By measuring effective single-particle energies the shell gaps can then be fixed in order to further update the existing nuclear models.
In a second experimental campaign in 2011, 68Ni was studied through a (t,p)-reaction on 66Ni, using the same set-up. In this experiment a radioactive beam in combination with a radioactive target was used. The aim of this campaign was to measure the cross section for the population of the 0+ ground state and characterize the 0+ and 2+ excited states in 68Ni.

The excitation spectrum and the angular distribution of the emitted protons can be used to determine the spin and parity of the states populated in 67,68Ni. Further, excited states can be identified by using proton-gamma correlations. Preliminary results of such coincidence analysis, revealing the most populated states in the reactions, will be presented.

References:
[1] R. Broda et al., Phys. Rev. Lett. 74, 868 (1995).
[2] O. Sorlin et al., Phys. Rev. Lett. 88, 092501 (2002).
[3] N. Bree et al., Phys. Rev. C 78, 047301 (2008).
[4] M. Bernas et al., Phys. Lett. B 113, 279 (1982).
[5] H. Grawe and M. Lewitowicz, Nucl. Phys. A 693, 116 (2001).
[6] K. Langanke et al., Phys. Rev. C 67, 044314 (2003).
[7] S. Rahaman et al., Eur. Phys. J. A 34, 5 (2007).
[8] C. Guénaut et al., Phys. Rev. C 75, 044303 (2007).

Medium nuclei I / 21

MAGNETIC MOMENT MEASUREMENT IN 72ZN USING THE TRANSIENT FIELD TECHNIQUE AND COULOMB EXCITATON IN INVERSE KINEMATICS

Author: Andres Illana Sison[1]

Co-author: Andrea Jungclaus [1]

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

Corresponding Author: andres.illana@cern.ch

Nuclear magnetic moments are sensitive probes of the single particle properties of the nuclear wave function. The magnetic moment operator, with its explicit dependence on protons or neutrons involved in the configuration of the state and on their angular momenta, serves as a stringent test of the proposed main configuration of the nuclear state, as well as of other admixtures. It is, therefore, necessary to study nuclear magnetic moments of nuclei that lie close to nuclear shell closures or, in general, to any place on the nuclear chart where the valence nucleons start filling a higher lying orbital in the next major shell. A good example is provided by the N = 40 region around 68Ni on the neutron-rich side of the nuclear chart, where the positive parity νg9/2 orbital dives into the negative parity fp shell. It is a long standing issue whether N = 40 has to be considered as a new (sub)shell closure or whether the peculiar effects observed in the region can be traced back to the parity change between νg9/2 and the fp shell which prevents 1p1h states from contributing to the wave functions of positive parity states.
In experiment IS483, performed at REX-ISOLDE in November 2011, the g factor of the first excited 2+ state in 72Zn, g(21+), was measured using the Transient Field (TF) technique in combination with Coulomb excitation in inverse kinematics on a thick multilayer target. This technique has been successfully employed in the past in a large number of stable ion beam experiments [1]. However, only recently it was applied for the first time using low-energy radioactive ion beams at Oak Ridge [2,3]. In this contribution we will present the newly constructed transient field reaction chamber used in IS483 in conjunction with four MINIBALL cluster detectors, discuss the status of the analysis and finally compare the experimental result to a number of different large-scale shell model calculations.
[1] K.-H. Speidel et al., Prog. Part. Nucl. Phys. 49 (2002) 91.
[2] N. Benczer-Koller et al., Phys. Lett. B 664 (2008) 241.
[3] G. Kumbartzki et al, Phys. Rev. C 86 (2012) 034319.

Medium nuclei I / 34

First results from IS-510: Transfer reactions and Coulomb excitation with T-REX in the 68Ni region

Authors: Dennis Muecher[1]; Stefanie Klupp[2]

[1] *Technische Universitaet Muenchen (DE)*

[2] *Technische Universitaet Muenchen*

The microscopic details concerning the assumed magicity of the 68Ni nucleus are not yet fully understood. Due to the parity change between fp orbitals and the g9/2 orbital, a small gap between these can lead to a high-lying first excited state in 68Ni. This underlying subshell structure seems also responsible for the unusual behavior of excited 0+ states in neighboring even-even nuclei.
Our experiment IS-510 uses two complementary methods to explore these questions in detail: Transfer reactions and Coulomb excitation.
In 2011, the 2n transfer towards 74Zn was used to search for the unknown excited 0+ states beyond N=40. The Si-array T-REX together with MINIBALL were used to study excited states up to 5 MeV in 74Zn. At the same time, first data on Coulomb excitation of 72Zn were detected in forward direction.
In 2012, a new Si setup was used. This setup was specially designed to study the multiple Coulomb excitation and includes a movable forward Si-detector as well as the detection of scattered beam-particles in backward direction. This increases the sensitivity for the determination of quadrupole moments and mixing ratios. A high intense 72Zn beam of 100 pA was delivered to the MINIBALL target, allowing to observe multiple-step (off-Yrast) coulomb excitation events in this shell-model driven system.
We present first results of the IS-510 data.

Medium nuclei I / **44**

Beta decay of 82Zn

Author: Ioana Gheorghe[1]

[1] *H. Hulubei National Institute for Physics and Nuclear Engineering*

The Beta decay of 82Zn has been studied at ISOLDE, CERN using a fast timing experimental setup, which included a thin NE111A plastic beta detector, two HPGe gamma detectors and two LaBr3(Ce) detectors all positioned in a close geometry. A new value for the lifetime of the beta decaying g.s. of 82Zn was obtained and the -n branching ratio was measured for the first time. Tentative level schemes were constructed for 82Ga and 81Ga populated in the Beta– and Beta–-n decay
of 82Zn, respectively, which include 13 gamma-rays in 82Ga and 5 in 81Ga.

Poster session / **3**

Structure of 81Ga populated from the β- decay of 81Zn

Author: Vadym Paziy[1]

Co-authors: Henryk MACH [2]; Luis Fraile Prieto [3]

[1] *Universidad Complutense de Madrid*

[2] *Department of Nuclear and Particle Physics, Uppsala University*

[3] *Universidad Complutense (ES)*

V. Paziy1, H. Mach1, L.M. Fraile1, A. Aprahamian3, C. Bernards4, J.A. Briz5, B. Bucher3, C. J. Chiara6, Z. Dlouhy7, D. Ghita2, I. Gheorghe2, P. Hoff8, U. Köster9, W. Kurcewicz10, R. Lica2, N. Marginean2, R. Marginean2, B. Olaizola1, J.M. Régis4, M. Rudigier4, J.M. Udías1, T. Sava2, G. Simpson9, M. Stanoiu2, L. Stroe2, W. Walters11
1 Grupo de Física Nuclear, Universidad Complutense, Madrid, Spain
2 National Institute for Physics and Nuclear Engineering, Magurele, Romania
3 Department of Physics, University of Notre Dame, USA
4 Institut für Kernphysik, Köln, Germany
5 Instituto de Estructura de la Materia, CSIC, Madrid, Spain.
6 Department of Chemistry and Biochemistry, University of Maryland,

College Park, Maryland 20742, USA and Physics Division, Argonne National Laboratory, Argonne, Illinois 60439, USA
7 Nuclear Physics Institute of the ASCR, Rez, Czech Republic
8 Department of Chemistry, University of Oslo, Oslo, Norway
9 Institut Laue-Langevin, Grenoble, France
10 Faculty of Physics, University of Warsaw, Warsaw, Poland
11 Department of Chemistry, University of Maryland, College Park, Maryland

We report on the results of the beta-decay of 81Zn. The experiment was performed at the CERN ISOLDE facility in October 2011, in the framework of a systematic ultra-fast timing [1] investigation of neutron rich nuclei populated in the decay of Zn. Almost pure beams of Zn ions were delivered to our fast-timing station thanks to the use of the ISOLDE RILIS and a cooled quartz transfer line. This allowed the study of beta decay of Zn isotopes ranging from A = 71 to A = 82. The analysis included beta-gated gamma ray singles and gamma-gamma coincidences from the decay of 81Zn. The new level scheme of 81Ga includes more than 50 new transitions and about 40 new levels in the energy range up to 6400 keV, which extends the previously known structure [2]. The intensities and spin-parity assignments will be discussed together with the preliminary analysis of the level lifetimes.

[1] H. Mach, R.L. Gill, M. Moszynski, Nuclear Instruments and Methods in Physics Research A 280, 49 (1989).
[2] S. Padgett, M. Madurga, R. Grzywacz, I. G. Darby, S. N. Liddick, S. V. Paulauskas, L. Cartegni, C. R. Bingham, C. J. Gross, K. Rykaczewski, D. Shapira, D. W. Stracener, A. J. Mendez, II, J. A. Winger, S. V. Ilyushkin, A. Korgul, W. Królas, E. Zganjar, C. Mazzocchi, S. Liu, J. H. Hamilton, J. C. Batchelder, and M. M. Rajabali, Phys. Rev. C 82, 064314 (2010).

Poster session / 86

HIE ISOLDE - Alignment and Monitoring System of the LINAC

Author: Guillaume Kautzmann[None]

The HIE-ISOLDE project is a major upgrade of the ISOLDE REX facility. To run the linac in the optimum conditions the superconducting RF cavities and solenoids placed in cryomodules have to be aligned on the REX Nominal Beam Line (NBL) within a precision of, respectively, 0.3 mm and 0.15 mm at one sigma level along directions perpendicular to the beam axis. An integrated permanent alignment system based on BCAM opto-electronic sensors, optics and precise mechanical elements, is being developed. Part of these elements, i.e. the targets, will be installed in various non-standard environmental conditions such as high vacuum, cryogenic temperatures and will be observed through precise viewports.

Poster session / 0

SPINS, MOMENTS AND RADII OF 100-130Cd BY LASER SPECTROSCOPY

Author: Deyan Yordanov[1]

Co-authors: Andreas Krieger [2]; Christopher Geppert [3]; Dimiter Balabanski [4]; Georgi Georgiev [5]; Gerda Neyens [6]; Ivan Budincevic [6]; Jasna Papuga [6]; Kim Kreim [1]; Klaus Blaum [1]; Magdalena Kowalska [7]; Mark Bissell [6]; Michael Hammen [3]; Nadja Frömmgen [3]; Rainer Neugart [8]; Rodolfo Sánchez [9]; Wilfried Nörtershäuser [2]

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

[2] *Institut fuer Kernchemie-Johannes-Gutenberg-Universitaet Mainz*

[3] *Institut für Kernchemie, Johannes Gutenberg-Universität Mainz*

[4] *INRNE, Bulgarian Academy of Sciences*

[5] *CSNSM Centre de Spectrometrie Nucle aire et de Spectrometrie de*

[6] *K.U. Leuven*

[7] *CERN*

[8] *Johannes-Gutenberg-Universitaet Mainz*

[9] *GSI Helmholtzzentrum für Schwerionenforschung GmbH*

Corresponding Author: deyan.yordanov@cern.ch

We report on the first study of cadmium by high-resolution laser spectroscopy. Nuclear spins, electromagnetic moments and root mean square charge radii of ground and isomeric states have been determined along the chain, ultimately reaching the neutron 50 and 82 shell closures. These experimental data provide a solid basis for improving the nuclear-structure understanding in the vicinities of the doubly magic 100Sn and 132Sn. Specific questions, for instance the deformation of the cadmium isotopes, can now be resolved.

The measurements were carried out with the collinear laser spectroscopy setup at ISOLDE-CERN. For increased sensitivity the exotic species towards 100Cd and 130Cd were measured as bunched beams in an exotic atomic transition at 214 nm. The latter was achieved by a laser system for frequency quadrupling. This development could potentially give access to isotopic chains thus far unstudied due to atomic transitions deep in the UV spectrum.

Long-lived b- isomers are discovered in 127Cd and 129Cd. Spins and configurations are assigned to all observed states. The data reveal the relative degree of collectivity between ground and isomeric states, not only from their quadrupole moments, but through their charge radii as well.

In this contribution the experimental results and their preliminary interpretation will be presented in the context of the shell structure in the vicinity of Z=50 and its evolution towards the neutron 50 and 82 shell closures.

Poster session / 66

Simulations of the HIE-ISOLDE radio frequency quadrupole cooler and buncher vacuum using the Monte Carlo test particle code Molflow+

Author: Mario Armin Hermann[1]

[1] *Hochschule Karlsruhe, Technik und Wirtschaft*

The High Intensity and Energy Isolde (HIE-ISOLDE) project aims at upgrading CERNs present ISOLDE and REX-ISOLDE facilities to increase the energy and intensity of the delivered radioactive ion beams. This is achieved by means of a new post-accelerating, superconducting linac, accompanied by a design study of the major subsystems and the target areas, linked with the increased intensity of the proton primary beam from the future, upgraded injector's chain of Linac4 and Booster.
ISOLDEs existing subsystem RFQCB (radio frequency quadrupole cooler and buncher) called ISCOOL will be upgraded in the framework of the HIE-ISOLDE design study.
This paper describes the vacuum modeling of the future RFQCB using the Monte Carlo test particle scheme Molflow+. Molflow+ is a powerful and user friendly code to model vacuum systems in the molecular flow regime and the code is currently further improved within the vacuum group of CERN. In order to validate the simulation results of Molflow+, real pressure profiles along ISCOOL are measured using variable helium gas injection fluxes and compared with obtained Molflow+ results. Subsequently and after concluding that the results are well in accordance with the measurements, improved designs of the future RFQCB are simulated.
The workflow is as follows: in a first step, the 3D model to be simulated is simplified and adapted to the needs of Molflow+. After importing the model into this code, the probabilistic movement of gas particles can be simulated and resulting pressure levels in the system can be derived.

Poster session / 35

Experimental results and numerical simulations of the HIE ISOLDE short Faraday Cup

Authors: Alex Garcia Sosa[1]; Davide Lanaia[None]; Didier Voulot[1]; Enrico Bravin[1]; Esteban Daniel Cantero[None]; Matthew Alexander Fraser[1]; William Andreazza[1]

[1] *CERN*

Corresponding Author: esteban.daniel.cantero@cern.ch

The space for beam diagnostics at the HIE-ISOLDE REX postaccelerator is limited in the longitudinal dimension due to the beam optics requirements. The diagnostic boxes that will be installed between the cryomodules contain among other instruments a short Faraday cup (FC), which is used for measuring the beam currents. The characterization of the performance for this FC is very critical due to its special geometry, as the cup aperture diameter is larger than its total length. A prototype FC has been installed in a diagnostic box of REX-ISOLDE, and tested with stable beam of several beam energies and intensities since last August. Different polarization schemes have been proposed and evaluated experimentally. In this work we will present some of the results obtained in these tests, complementing our analysis with numerical calculations of the electrostatic fields present in the cup.

Poster session / 24

Laser spectroscopy on neutron-rich 48-51K isotopes

Author: Jasna Papuga[1]

Co-authors: Deyan T. Yordanov [2]; Gerda Neyens [1]; Hanne Heylen [1]; Kim Kreim [2]; Klaus Blaum [2]; Magdalena Kowalska [3]; Marieke De Rydt [1]; Mark L. Bissell [1]; Mustafa M. Rajabali [1]; Rainer Neugart [4]; Rodolfo Sanchez [5]; Ronald F. Garcia Ruiz [1]; Wilfried Nörtershäuser [6]

[1] *Instituut voor Kern- en Stralingsfysica, KU Leuven, B-3001 Leuven, Belgium*

[2] *Max-Planck-Institute für Kernphysik, D-69117 Heidelberg, Germany*

[3] *Physics Department, CERN, CH-1211 Geneva 23, Switzerland*

[4] *Institut für Kernchemie, Universität Mainz, D-55128 Mainz, Germany*

[5] *GSI Helmholtzzentrum für Schwerionenforschung, D-64291 Darmstadt, Germany*

[6] *Institut für Kernchemie, Universität Mainz, D-55128 Mainz, Germany; Institut für Kernphysik, TU Darmstadt, D-64289 Darmstadt, Germany*

Laser spectroscopy was performed on bunched beams of K (Z = 19) isotopes at the COLLAPS beamline at ISOLDE-CERN. Nuclear spins, magnetic moments and mean square charge radii were deduced for 48,49,50,51K providing information about the nuclear structure beyond N = 28. In order to be able to measure the most exotic isotope (N = 32), a highly-efficient light collection region was developed and installed on the beam line.
The ground state spin and magnetic moments are sensitive to the configuration of the wave function, thus being a good probe to study the evolution of the proton single-particle configuration as neutrons are filling the ⊠p3/2 orbit. The results will be compared to Shell Model calculations using different effective interactions. The evolution of the 1/2 and 3/2 energy levels from N = 16 up to N = 32 will be discussed as well.
The change in the mean square charge radii along an isotopic chain is a good observable to probe the presence of a closed shell. Charge radii between N = 18 and N = 32 will be presented, covering two major shell closures and one subshell closure.

Poster session / 82

The next generation of implantation chambers for GPS

Author: Matthias Nagl[1]

[1] *Uni-Göttingen*

In order to optimize beam-time usage and sample handling as well as radio protection a new GPS implantation chamber with advanced load-lock-system is currently being built. In addition to this implantation chamber a second chamber containing facilities for beam deceleration/acceleration with the sample held at a potential of up to ± 60 kV will be mounted right behind the first chamber. In this chamber implantations with an extended ion energy range in between ˜0 keV and 120 keV will be possible.
Both chambers are designed to enable shoot through operation and thus allow the usage of a third chamber (for bio-physics implantations, tracer diffusion etc.) without the need to remove them. The ion optics contained in the deceleration chamber can be used for improved focusing during shoot-through operation. Due to the load-lock-system in the implantation chamber samples can be interchanged in one chamber with implantations taking place simultaneously in the other chamber. The load-lock-system will also allow for implantations into tilted samples in order to avoid unwanted ion channeling.
We will discuss the chamber concept in detail and show the current state of construction.

Poster session / 51

Upgrade of the REX-ISOLDE charge breeder

Author: Andrey Shornikov[None]

Co-author: Fredrik John Carl Wenander [1]

[1] *CERN*

Corresponding Author: andrey.shornikov@cern.ch

In order to comply with the extended requirements of the experimental program at ISOLDE after the upgrade to HIE-ISOLDE and with the prospective of the TSR@ISOLDE an upgrade of the existing REXEBIS charge breeder is being investigated. The new breeder is aiming to provide ions for reacceleration with A/q< 4.5 required by the linac and with a repetition rate of 100 Hz (linac limit). To reach these values the new breeder needs an electron beam of current density je exceeding the parameters of REXEBIS by a factor of 20.

The TSR@ISOLDE project sets even more challenging requirements, such as an increase of the electron energy up to 150 keV in order to ionize inner shell electrons for production of bare ions up to Z=60 and Na-like configurations of heavier ions up to Th and U. For breeding to such configurations one needs high ionization factors, and even at injection rate of ˜1 Hz the required current density in the breeder is in the range of je ˜10E+4 A/cm. sq. The breeding efficiency of ˜10 % for such charge states is possible only with a combination of vacuum enhancement by an order of magnitude to ˜10E-12 mbar and ion-ion cooling to suppress ion losses during the breeding process.

Altogether it sums up into a design concept which requires a complete replacement of the REXEBIS rather than partial upgrade of its subsystems. In the new breeder the immersed gun electron optics will be replaced with a high compression electron beam providing necessary current density. A new 6 T magnet is planned to be used to confine and compress the electron beam. A new three-stage vacuum system with distributed pumping is being designed to improve the vacuum and assure serviceability of the system.

In the presented poster we would like to introduce the early design concept of the new EBIS for High Energy, Compression and Current electron beam –HEC2EBIS, including the report on our first steps

towards the construction of the advanced electron gun for it. We also would like to show to the future HIE-ISOLDE/TSR@ISOLDE users the fundamental limits of the charge breeding system.

Poster session / 85

HIE-ISOLDE cavity coating

Author: Noemie Marie Jecklin[1]

[1] *CERN*

The HIE-ISOLDE project is the upgrade of the existing facility ISOLDE, which is dedicated to the production of a large variety of radioactive ion beams for many different experiments.

Among other things, HIE-ISOLDE project requires the production of many accelerating superconducting cavities in order to increase the speed and the energy of the beam. These superconducting cavities are made of a Copper substrate, in top of which is deposited a thin micrometric layer of a superconducting material, in our case Niobium.

In a first phase, the goals are to obtain good-quality Nb/Cu films - which is already a challenging task in such a complex geometry - and also to ensure reproducibility. This requires an in depth knowledge of thin film and ultra-high vacuum (UHV) technology. This activity is still ongoing.
In a second phase, the aim will consist of the "industrialization"of the HIE-ISOLDE cavities, meaning to carry out the production of the required number of cavities guaranteeing their quality and functionality.

Poster session / 15

Laser- and decay spectroscopy of neutron-deficient Tl isotopes

Author: Celine Van Beveren[1]

Co-author: Elisa Rapisarda [2]

[1] *K*

[2] *CERN*

Corresponding Author: celine.van.beveren@cern.ch

One of the regions of the nuclear chart that has drawn considerable interest is that of the neutron-deficient Pb isotopes with Z ˜ 82 and N ˜ 104. This region exhibits a dramatic manifestation of shape coexistence.

The occurrence of competing proton intruder states in the odd-Z Tl isotopes opens the ground for complex structures at low energy leading to isomerism. However, the spectroscopic elucidation of such structures has proven to be highly demanding. The decay schemes are extremely complex and low-energy, highly converted transitions must be reliably identified and located in the odd-mass decay schemes. This knowledge is crucial for the measurement of charge-state distributions (δ<r2>) through the resonant laser ionization technique..

Combining the high-sensitivity of the in-source laser spectroscopy technique and characteristic decay spectroscopy, exotic Tl isotopes (Z = 81) down to N = 98 have been studied in July 2011. The goal of these studies is to deduce mean-square charge radii of the ground-state and isomeric-states of the most neutron-deficient Tl isotopes. Complementary decay data on isomerically purified sources were additionally collected. In this contribution, we shall report on the present status of the decay- and laser spectroscopy analysis of these isotopes.

Poster session / 88

Dose estimations for target's storage and MEDICIS Lab. using Fluka

Author: Leonel Morejon Hernandez[None]

Using Fluka simulation code for particle transport by Monte-Carlo methods, and Flair software, the radiation levels' assessment has been done for different stages of engineering design. Dose levels for both prompt radiation (due to targets' irradiation in the esperimental hall) and non-prompt radiation (due to the hot targets stored) have been calculated. The several contributions to dose have been taken into account and calculated by various methods in order to speed up the simulations without compromising the accuracy of the results, permiting the evaluation of many different options for the storage (and features) relatively fast.

Poster session / 81

100 ns Bunch Spacing of Post-accelerated RIBs for the High Intensity and Energy ISOLDE Upgrade

Author: Matthew Alexander Fraser[1]

[1] *CERN*

The feasibility of pre-bunching at a sub-harmonic frequency into the REX-ISOLDE RFQ was investigated to respond to a request for a 100 ns bunch spacing from several new experiments striving to operate at the HIE-ISOLDE facility, see e.g. [1]. The HIE-ISOLDE project [2] represents a major upgrade of the ISOLDE nuclear facility with a mandate to increase the energy and intensity, as well as improve the quality, of post-accelerated radioactive ion beams produced at CERN. The focus of the upgrade is a new superconducting linac providing 40 MV of accelerating potential capable of delivering to experiments all the radioisotopes available at ISOLDE at energies of over 10 MeV/u. The 100 ns bunch spacing would facilitate the identification of reaction products by time-of-flight techniques, which is not currently possible with the bunch spacing determined by the RFQ frequency of 101.28 MHz. A scheme involving a 10.1 MHz multi-harmonic buncher delivering bunches separated by 98.7 ns was studied. The RFQ beam dynamics was modeled using the PARMTEQM program [3] and single-particle simulations were carried out with a batch routine such that the acceptance, transmission and emittance could be characterized systematically as a function of the pre-buncher design variables: voltage, distance before RFQ, number of harmonics and relative amplitude of each harmonic component. The single-particle routine was important for characterizing the acceptance and for understanding how the satellite bunches are populated with the PARMTEQM model of the RFQ. Transmissions of well over 70% could be achieved in the main bunch; a chopper will be needed to remove the populated satellite bunches and to attain the <1% background specified by the experiments. The results of a comprehensive beam dynamics study will be presented in this contribution. The opportunity of using the pre-buncher to reduce the longitudinal emittance formed in the RFQ was also investigated.

References

[1] S.J. Freeman et al., Letter of Intent for Physics at HIE-ISOLDE: HELIOS, CERN-INTC-2010-031, CERN, 2010.
[2] M. Lindroos et al., Nucl. Instrum. Meth. B 266, pp. 4687–4691 (2008).
[3] K.R. Crandall et. al., RFQ Design Codes, LANL report, LA-UR-96-1836, revised 2005.

Poster session / 65

Advanced SiC and Al2O3 as model targets for radioisotope beam production at HIE-ISOLDE

Author: Michal Adam Czapski[1]

[1] *CERN*

A search of new target materials showing better mechanical characteristics and release properties of radioisotopes is one of the aims of the HIE-ISOLDE project.
It has been already proven that by controlling the microstructure of a target material in terms of grain size down to 50 nm, and porosity its release properties can be altered. On the other hand such changes also influence its mechanical properties which in turn can change their aging behavior. This investigation needs to be described more thoroughly before any modification is introduced in the design of HIE-ISOLDE targets.
The first goal of this study is the synthesis of two model materials from the groups of carbides and oxides (i.e. silicon carbide and alumina) with the ice-templating technique which permits controlling pore formation conditions within the material. So-prepared silicon carbide and alumina present well-defined open uniaxial porosity of defined pore size and fraction.
The second goal of this study is the preparation of the irradiation of produced targets at two CERN facilities, at ISOLDE and at HiRadMat, which use proton beams of two different energies, 1.4 GeV and 450 GeV respectively. This study comprises calculations of isotope production and energy deposition using Fluka and Abrabla codes, as well as thermo-mechanical using simulations ANSYS workbench v. 14 to verify the mechanical integrity of the material under irradiation.

Poster session / 43

A feasible substitute of LaBr3 scintillator in the Ultra Fast Timing Technique for lifetime measurements of excited states.

Author: Victoria Vedia[1]

Co-authors: Bruno Olaizola [2]; Esteban Picado [2]; Henryk MACH [3]; Luis Fraile Prieto [4]; Vadym Paziy [2]; jose udias [2]

[1] *Universidad Complutense de Madrid (UCM)*

[2] *Universidad Complutense de Madrid*

[3] *Department of Nuclear and Particle Physics, Uppsala University*

[4] *Universidad Complutense (ES)*

Corresponding Author: victoriavedia@gmail.com

V. Vedia1, L.M. Fraile1, H. Mach1, B. Olaizola1, V. Paziy1, E. Picado1, J.M. Udías1

1 Grupo de Física Nuclear, Universidad Complutense, Madrid, Spain

The measurement of absolute nuclear transition probabilities is a very sensitive tool to study the structure of atomic nuclei. Direct access to transition rates can be achieved via the lifetimes of the nuclear levels de-excited in radioactive decay. The Advanced Time-Delayed (ATD) method, or Fast Timing [1], is a well-established technique to measure lifetimes ranging from 5 ps to 50 ns. The development of the technique was originally based on the use of BaF2 inorganic crystals with excellent time response, and on the combination of these fast BaF2 scintillators with high-resolution HPGe detectors to provide a good energy selection [2]. Recently, a major breakthrough occurred with the introduction of the LaBr3(Ce) scintillator [3], which unites very good time response with energy resolution of the order of 3% at 662 keV, much better than 9% for BaF2 crystals.

A viable alternative to LaBr3 requires excellent time resolution and good energy resolution. The recently developed CeBr3 scintillator is a very promising candidate due to its fast rise time, high photon yield and his lower price [4, 5]. It is considered a feasible substitute of LaBr3 especially for large arrays of fast detectors for timing applications. The shape optimization of some of the fast

detectors for the Fast Timing Technique has been performed at ISOLDE. In this work we report on the time response of a CeBr3 cylindrical crystal of 1-inch in height and 1-inch in diameter at 22Na and 60Co photon energies. The time response was measured against a fast reference BaF2 detector. Hamamatsu R9779 and Photonis XP20D0 fast photomultipliers were used. The full width at half maximum (FWHM) time resolution for an individual CeBr3 crystal coupled to Hamamatsu PMT is reported to be as low as 119 ps at 60Co energies, which is comparable to the resolution of 107 ps reported for LaBr3.

[1] H. Mach, R.L. Gill, M. Moszynski, Nuclear Instruments and Methods in Physics Research A 280, 49 (1989)
[2] H. Mach, F. Wohn, G. Molnár, K. Sistemich, J.C. Hill, M. Moszyn´ski, R. Gill, W. Krips, D. Brenner, Nuclear Physics A 523, 197 (1991)
[3] E.V. van Loef, P. Dorenbos, C.W.E. van Ejik, K. Kr¨amer, H.U. Gu¨del, Nuclear Instruments and Methods in Physics Research A 486, 254 (2002)
[4] K.S. Shah, J. Glodo, W. Higgins, E.V.D.V. Loef, W.W. Moses, S. Member, S.E. Derenzo, S. Member, M.J. Weber, IEEE Transactions on Nu- clear Science 52(6), 3157 (2005)
[5] P. Guss, M. Reed, D. Yuan, A. Reed, S. Mukhopadhyay, Nuclear Inst. and Methods in Physics Research, A 608(2), 297 (2009)

Poster session / 30

Laser spectroscopy on the borders of the region of reflection asymmetry

Authors: Ivan Budincevic[1]; Kieran Flanagan[2]

[1] *IKS, KU Leuven*

[2] *University of Manchester (GB)*

Corresponding Author: kieran.flanagan@cern.ch

Two successful experimental campaigns have been carried out in 2012 on the new Collinear Resonant Ionization Spectroscopy (CRIS) experimental beam line. During these campaigns a sensitivity to 1 atom in 60 was demonstrated using the measured yield of 202Fr as a reference. This work has also demonstrated a suppression of isobaric contamination by a factor of 105.
These experiments have measured the hyperfine structures of 218Fr and 219Fr bordering the region of the shape transition of the nucleus from spherical to octupole-quadrupole deformed. This region of reflection symmetry breaking is centred at the N=137 isotone chain. This region is characterized by almost degenerate doublets of the same spin but different parities in the odd-even nuclei and an alternating spin and parity band sequence (0+ 1- 2+ 3-$\cdots$) that are connected by enhanced E1 matrix elements in the even-even nuclei . This has been attributed to either the presence of an octupole deformation or alpha clustering. The presence of octupole deformation is alluded to by the dramatic reversal in the odd-even staggering of the isotope shifts and a vanishing magnetic moment in the laboratory frame. This talk will present the latest measurements on 218Fr and 219Fr as well as the neutron rich isotope 229Fr and 231Fr and discuss the future prospects of measuring out to 233Fr at ISOLDE.

Poster session / 8

Determination of the B(E2) value for the first 2+ state of 142Sm using Coulomb excitation at REX-ISOLDE

Authors: Christopher Bauer[1]; Robert Stegmann[1]

Co-authors: Antoaneta Damyanova [2]; Burkhard Siebeck [3]; Desiree Radeck [4]; Esther Sabine Bönig ; Georgi Ivanov Rainovski [5]; Kalin Gladnishki [5]; Marcus Scheck [6]; Michael Thurauf [1]; Miroslav Danchev [5]; Norbert Pietralla [7]; Pierre Thoele [4]; Tim Thomas [3]

[1] *Technische Universitaet Darmstadt (DE)*

[2] *Universite de Geneve (CH)*

[3] *Universitaet zu Koeln (DE)*

[4] *Universitaet zu Koeln*

[5] *University of Sofia (BG)*

[6] *TU Darmstadt*

[7] *IKP, Technische Universität Darmstadt*

Corresponding Author: robert.stegmann@cern.ch

In order to investigate the effect of shell stabilization of mixed-symmetry states [1] it is intended to identify and study the mixed symmetry states in the N = 80 isotones. A necessary prerequisite for such an endeavor is the measurement of the E2 transition strength of the first 2+ state. A beam of radioactive 142Sm ions with an energy of 2.85 MeV/u was impinging on a 1.4 mg/cm2 48Ti as well as on a 2 mg/cm2 94Mo target. Gamma rays from the decay of Coulomb excited states were measured by the MINIBALL array while the nuclei were identified by a DSSSD. The transition strength of the first 2+ to the 0+ ground state in unstable, neutron deficient 142Sm could preliminarily be determined to 29(3) W.u. The result for the B(E2) value deviates from recent QPM calculations [2, 3] while it is in agreement with state-of-the-art large-scale shell model calculations [4, 5]. This finding provides a benchmark for the foreseen investigation of the effect of shell stabilization of the quadrupole isovector valence shell excitations.

[1] G. Rainovski et al., Phys. Rev. Lett. 96, 122501 (2006)
[2] Ch. Stoyanov, private communication (2012)
[3] N. Lo Iudice, Ch. Stoyanov, D. Tarpanov, Phys. Rev. C 77, 044310 (2008)
[4] D. Bianco et al., Phys. Rev. C 85, 034332 (2012)
[5] N. Lo Iudice, private communication (2012)

Poster session / 6

Quadrupole Collectivity in the Cd isotopic chain investigated with Coulomb Excitation

Author: Sabine Bönig[1]

Co-authors: Anna-Lena Hartig [1]; Christopher Bauer [2]; Marcus Scheck [3]; Michael Thürauf [1]; Stoyanka Ilieva [1]; Thorsten Kroell [2]

[1] *Technische Universität Darmstadt*

[2] *Technische Universitaet Darmstadt (DE)*

[3] *TU Darmstadt*

The cadmium isotopic chain with a proton number of Z=48 is one of the most interesting in nuclear structure physics due to the proximity to the proton shell closure at Z=50. Performed Coulomb excitation experiments on 122-126Cd exhibit high excitation strengths for the 0_gsˆ+⟶2_1ˆ+ transition. Shell model calculations are not able to reproduce the experimentally found values although the shell closure is near. However, Beyond-Mean-Field calculations agree with the experimental results, taking a prolate deformation into account. In this contribution, the latest results on the investigation of the B(E2,0ˆ+⟶2_1ˆ+) value of 128Cd via Coulomb excitation with MINIBALL at REX-ISOLDE will be presented. We will discuss the experimentally found transition strength considering a non-vanishing quadrupole moment and place it in the overall picture of the behaviour of the B(E2,0ˆ+⟶2_1ˆ+) values of this isotopic chain. Additionally the status of the analysis on the recently performed Coulomb excitation experiment of 123Cd will be presented. These results will give an insight into the onset of collectivity in neutron-rich Cadmium isotopes.

This project is supported by BMBF (No. 06 DA 9036I and No. 06 DA 7040), HIC for FAIR and EU through ENSAR (No. 262010).

Poster session / 25

Radiation Protection Study for the HIE-ISOLDE project

Author: Sandra Giron[None]

Corresponding Author: sandra.giron@cern.ch

The HIE (High Intensity and Energy)-ISOLDE is a project for a major upgrade of the ISOLDE facility which consists in the design and the construction of a superconducting linear accelerator associated to a high-power target. It will allow to increase the energy of the accelerated radioactive ion beams up to 10 MeV/u for the heaviest ions (compared to 3 MeV/u today) with an intensity of 15 kW.

The replacement of the REX post-accelerator by a new superconducting linac leads to different safety aspects, including radiation protection. X-rays, neutron emission and radioactive isotopes are the main sources of radiation hazards expected. The X-rays emitted by RF cavities have been identified as the main hazard, driving the shielding requirements. As a consequence, X dose rates emitted by RF cavities have been measured on a test-bench and Monte Carlo simulations using FLUKA have been performed to define the required shielding. The HIE-ISOLDE project as well as the status of the radiation protection study of the new superconducting linac will be presented.

Poster session / 78

Design Upgrade of the Mass Separator Magnets for HIE-ISOLDE

Author: Mathieu Augustin[1]

[1] *CERN*

The High Intensity and Energy (HIE)-ISOLDE project at CERN, features major improvements of the High Resolution Separator (HRS).
In its current design, the performance of the HRS is constrained by ion source emittance and second-order distortions in the magnet dipoles. A new layout has been proposed to overcome these limitations. It firstly features the operation of the RFQ beam cooler in order to reach a beam emittance of 3π mm.mrad and its installation before the separation process. Additional ensuing constraints, such as available space in the separator room and positioning between upstream and downstream beamlines, would then not be solved with the 90° and 60° magnets operated in the current design.
The use of a 120° magnet and a 90° bend is consequently seen necessary for the new layout. Second-order aberrations intrinsic to magnetic dipoles and responsible for emittance increase have been compensated by pole shimming.
Firsts estimations shows that the current resolution of the HRS could be multiplied by a factor of 3 with the proposed layout, and rise up to 20 000 for a 3π mm.mrad cooled beam.
Results from numerical simulations and offline tests of the magnet stages of the HRS are presented and discussed together with the new design features.

Poster session / 50

Online Operation of a Molten Salt Target at ISOLDE for the Beta Beams: Validation of Electro-Thermal Simulation with Experimental Data

Author: Serena Cimmino[1]

Co-authors: Stefano Marzari [2]; Tania Manuela De Melo Mendonca [3]; Thierry Stora [2]

[1] *Universita e INFN (IT)*

[2] *CERN*

[3] *Univ. Federal do Rio Grande do Sul (BR)*

Corresponding Author: serena.cimmino@cern.ch

The main objectives of the BETA BEAMS project is to produce high energy beams of pure electron neutrinos and anti-neutrinos for oscillation experiments, by beta decay of 6He and 18Ne radioactive ion beams, studied in a decay ring at γ=100.
The production of 6He beam has already been accomplished using a thick beryllium oxide target; however, the production of the needed rate of 18Ne has proven to be more challenging. In order to achieve the requested yield for 18Ne a new high power target design based on a circulating molten salt loop has been proposed.
To verify some elements of the design, a static molten salt target prototype has been developed at ISOLDE and operated successfully.
This paper describes the electro-thermal study of the molten salt target taking into account the heat produced by Joule effect, radiative heat exchange, active water cooling due to forced convection and air passive cooling due to natural convection.
The numerical results were compared with the available experimental data in order to validate the model. This approach allows improving the reliability of the model, which will help to predict the thermo-mechanical impact of the required targets for the future facilities such as HIE-ISOLDE and the Beta-Beams.

Poster session / 38

Applications of solid-state RILIS lasers in experiments at ISOLDE

Author: Sebastian Rothe[1]

Co-authors: Anatolij Barzakh [2]; Bruce Marsh [1]; Daniel Fink [1]; Dmitri Fedorov [3]; Maxim Seliverstov [1]; Nobuaki Imai [4]; Ralf Erik Rossel [5]; Valentin Fedosseev [1]

[1] *CERN*

[2] *Petersburg Nuclear Physics Institute*

[3] *Petersburg Nuclear Physics Institute (PNPI)*

[4] *High Energy Accelerator Research Organization (JP)*

[5] *Johannes-Gutenberg-Universitaet Mainz (DE)*

Corresponding Author: sebastian.rothe@cern.ch

The resonance ionization laser ion source (RILIS) is the most widely used ion source at ISOLDE. Up to three beams of precisely tuned pulsed lasers ionize the element of interest with high selectivity and efficiency. To keep up with the increasing demand for RILIS use the fleet of lasers has been gradually upgraded in recent years. The system now comprises three tunable dye lasers and three complementary solid-state Titanium:Sapphire lasers (Ti:Sa), both pumped by frequency doubled Nd:YAG lasers. The operating time of the combined system reached an annual record value of >2700 hours during 2012.
The application of the RILIS for high resolution in-source laser spectroscopy and isomer separation requires a reduction of laser line-width to about 1 GHz, closely matching the Doppler-width of the atomic transitions of the heavy nuclei under investigation. This mode of operation, was a domain of the dye lasers and has now been achieved also for Ti:Sa lasers that were installed in 2011. The newly developed narrow-band Ti:Sa laser was applied for in-source laser spectroscopy of polonium, astatine and gold isotopes as well as for collinear resonance ionization spectroscopy of francium isotopes at the CRIS experiment.
The current status and on-line performance in 2012 of the RILIS laser ion source will be presented. Recent laser developments of the solid-state Ti:sapphire lasers and their application to laser spectroscopy will be described with an emphasis on the technical details. The planned improvements of RILIS infrastructure are subject to the outlook of the presentation.

Poster session / 28

Precision mass spectrometry of short-lived nuclei with minute production rates

Author: Susanne Kreim[1]

Co-authors: Alexander Josef Herlert [2]; Christine Böhm [3]; Christopher Borgmann [4]; David Lunney [5]; Dennis Neidherr [6]; Dietrich Beck [7]; Dinko Atanasov [3]; Enrique Minaya Ramirez [6]; Frank HERFURTH [8]; Frank Wienholtz [9]; Juliane Stanja [10]; Kai Zuber [11]; Klaus Blaum [4]; Lutz Schweikhard [12]; Magdalena Kowalska [1]; Marco Rosenbusch [13]; Martin Breitenfeldt [14]; Robert Wolf [12]; Sarah Naimi [15]; Sebastian George [16]; Sergey Eliseev [17]; Stefan Schwarz [18]; Vladimir Manea [5]; Yuri Litvinov [19]; burcu Cakirli [20]

[1] *CERN*

[2] *University of Manchester (GB)*

[3] *Max-Planck-Institut für Kernphysik, Heidelberg, Germany*

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

[5] *CSNSM Centre de Spectrometrie Nucle aire et de Spectrometrie de*

[6] *GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Germany*

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

[8] *GSI Darmstadt*

[9] *Ernst-Moritz-Arndt-Universitaet (DE)*

[10] *Technische Universitaet Dresden (DE)*

[11] *Technische Universitaet Dresden*

[12] *Ernst-Moritz-Arndt-Universität, Greifswald, Germany*

[13] *Ernst-Moritz-Arndt-Universitaet-Unknown-Unknown*

[14] *Katholieke Universiteit Leuven (BE)*

[15] *RIKEN Research Facility, Japan*

[16] *Institut fuer Kernphysik*

[17] *Max-Planck-Institute for Nuclear Physics*

[18] *NSCL, Michigan State University, East Lansing, USA*

[19] *GSI, Darmstadt*

[20] *Max-Planck-Institut fuer Kernphysik (MPI)-Max-Planck-Gesellscha*

Corresponding Author: susanne.waltraud.kreim@cern.ch

As matter becomes very neutron-rich, the proton-neutron imbalance changes the structure of nuclei with respect to the level ordering observed in stable nuclei. Since models used for predicting the structure of exotic nuclei are fitted to describe the shell gaps in stable nuclei, the question arises whether these models produce a correct description of the shell closures far from stability where nuclei typically have very short half-lives. The position and strength of these closures are critical for the successful modelling of astrophysical processes, where masses are needed as important input.
The mass spectrometer ISOLTRAP consists of four traps, a radio-frequency Paul trap for beam cooling and bunching, two Penning traps –the first for purifying the beam, the second for the actual mass measurement –and an electrostatic mirror trap acting as a multi-reflection time-of-flight mass separator (MR-TOF-MS). This device is especially suited for mass measurements on nuclides with ms half-life and production rates of only a few ions per second and still provides uncertainties sufficient to answer nuclear-structure and astrophysical questions.
The recent measurements on neutron-rich calcium and potassium isotopes up to 54Ca and 53K as well as a comparison to recent ab-initio calculations using three-nucleon forces will be presented.

Poster session / 84

3D Integration models for the various installation stages of HIE-ISOLDE

Author: Eleftherios Zografos[1]

[1] *CERN*

In this poster the 3D Integration models for the various installation stages of HIE-Isolde are presented. Those three in total stages vary from the 5.5 MeV Stage 1 to the 10 MeV Stages 2a and 2b. Additionally we focus on the two most demanding from the integration point of view areas i.e. the intercryomodule area and the quadrupole doublets. Finally the progress on the integration of the machine inside the facility is presented.

Poster session / 27

Recent developments of the ISOLDE RILIS Remote Monitoring and Control System towards flexible collaborative data acquisition

Author: Ralf Erik Rossel[1]

Co-authors: Bruce Marsh [2]; Detlef Richter [3]; Klaus Wendt [4]; Sebastian Rothe [1]; Valentine Fedosseev [2]

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

[2] *CERN*

[3] *Hochschule RheinMain*

[4] *Johannes Gutenberg-Universitaet Mainz*

Corresponding Author: ralf.erik.rossel@cern.ch

With a steadily increasing on-line operation time of a record 2500 hours in the year 2011, the Resonance Ionization Laser Ion Source (RILIS) is one of the key components of the ISOLDE on-line isotope production user facility at CERN, Geneva, Switzerland. It has played a major role in providing highly demanded radioactive ion beams of various elements with the highest efficiency and unmatched isobaric purity.
To achieve this reliable service, RILIS is currently operated in shift mode with operators continuously monitoring all crucial Laser parameters such as wavelengths, powers, beam positions and timing. With the upgrade to the "Dual RILIS"mode of operation in the year 2011/2012, a complementary, fully solid state Titanium:Sapphire laser system was added to the existing dye laser setup. This also demanded the setup of a network-extended, LabVIEW-based remote monitoring and control system to support operators as well as users in covering four key aspects in RILIS operation: machine protection, system monitoring, automated self-reliance and collaborative data acquisition with optimal performance.
The success of ISOLDE experiments relies on good knowledge of experimental conditions as well as excellent participant communication. This high demand for reliable, synchronized, and collaborative data exchange can now be met by the most recent developments in making RILIS'process values accessible from experimental setups, leading to more efficient utilization of beam time and successful measurement results.
The overall concept, technologies implemented and recent applications are presented in this talk.

Poster session / 80

Low level control upgrade to the ISOLDE High Resolution Separator magnet

Author: Martino Colciago[1]

[1] *CERN*

In the framework of the High Intensity and Energy (HIE)-ISOLDE project at CERN the working specifications of the High Resolution Separator will change.
The HRS dipole magnetic field has to be controlled with an accuracy of a few ppm and a much faster response than the current one. In order to achieve this strict requirement an accurate model of the magnet has to be determined and a new low level control system should be developed. This control system is based on a new feedback loop control structure and on an observer to compensate for the intermittency of the field measurements.
This should be able to predict the magnetic field value using knowledge of the supply current and the measurements of the magnetic field, when available. This latter is given by a punctual measurement performed with an NMR (Nuclear Magnetic Resonance) probe.
In this contribution, I will present the activity performed during 2012 in the contents of the Design Study Work Package (WP 6) connected to the new low level control of the HRS magnet.

Poster session / 36

Preliminary Study of the HIE-ISOLDE Beam Profile Monitor

Authors: Alex Garcia Sosa[1]; Davide Lanaia[None]; Didier Voulot[1]; Enrico Bravin[1]; Esteban Daniel Cantero[None]; Matthew Alexander Fraser[1]; William Andreazza[1]

[1] *CERN*

Corresponding Author: alejandro.garcia.sosa@cern.ch

In the context of the HIE-ISOLDE upgrade of the post-accelerator, a beam profile monitor is foreseen as an instrumentation device for the superconducting LINAC and beam transfer lines. It consists of a slit scanner and a redesigned Faraday cup. The effect of the different slit sizes on the current monitor has been studied in order to optimize the beam profile results. Numerical simulations have been made to study the performance of the profile monitor at different beam parameters. Electrostatic Fields and Particle Tracking results are presented.

Poster session / 79

Cooling and Ventilation Group Activities on ISOLDE Tunnel & Class A Lab during LS1 and for HIE-ISOLDE Intensity upgrade

Author: Andrea Polato[1]

[1] *CERN*

Cooling and Ventilation group's activity can be split into two main tasks:
1. Upgrade works during LS1:
a. Modification of the Cooling and Ventilation systems due to the new targets handling robots to be installed inside the Tunnel;
b. Cooling and Ventilation of the Class A Laboratory in prevision of the MEDICIS Laboratory extension;
2. Design Study activities related to the intensity upgrade of the proton beam:
a. Modification of the Tunnel HVAC System;
b. Modification of the HRS and GPS cooling system;

In this contribution, I will present the activity performed during 2012 in order to integrate the ventilation and cooling systems to the new equipment that will be installed in the Tunnel and in the Class A Laboratory. The approach to the design of new ventilation system that will supply the MEDICIS laboratory will be mentioned as well.
Finally, a dedicated section will describe the contents of the Design Study Work Package (WP 6.2) relative to the upgrade of the Cooling and Ventilation systems in prevision of the Intensity upgrade of the proton beam.

Poster session / 5

Shape coexistence and charge radii in gold and astatine isotopes studied by in-source laser spectroscopy at RILIS-ISOLDE

Author: Andrei Andreyev[1]

[1] *University of York*

On behalf of York-KU Leuven-Gatchina-Mainz-Bratislava-Liverpool-ISOLDE collaboration

The competition between spherical and deformed nuclear shapes at low energy gives rise to shape coexistence in the region of the neutron-deficient lead isotopes with Z˜82 and N˜104 [1]. In order to determine to which extend the ground and/or isomeric states of those and neighboring nuclides are affected by this phenomenon, an extended campaign of investigation of changes in the mean-square charge radii is on-going at ISOLDE. By combining the high sensitivity of the in-source laser spectroscopy technique, ISOLDE mass separation and Windmill alpha-decay spectroscopy setup [2], it has been possible to study long isotopic chains of lead [3] and polonium [4], down to N=100 and N=107 respectively, and, recently, thallium isotopic chain down to N=98 [5].

In this contribution, we will present the systematics of charge radii in thallium isotopes [5] together with the first preliminary results of the 2012 experimental campaign at ISOLDE (IS534 experiment) to study charge radii in the long chains of the astatine and lightest gold isotopes [6]. In the gold and astatine cases, next to Faraday cup and Windmill measurements, also the Multi-Reflection Time-of-Flight (MR-ToF) mass separation technique [7] involving the ISOLTRAP collaboration was used.

References
[1] K.Heyde and J. Wood. Rev. Mod. Physics 83, 1467 (2011)
[2] A.N. Andreyev et al„ Phys. Rev. Lett. 105, 252502,(2010)
[3] H. De Witte et al., Phys. Rev. Lett. 98, 112502 (2007)
[4] T.E. Cocolios et al., Phys. Rev. Lett. 106, 052503 (2011)
[5] A.N. Andreyev, A. Barzakh et al., IS511 experiment at ISOLDE (2012)
[6] A.N. Andreyev, V. Fedosseev, P. Van Duppen et al., IS534 experiment at ISOLDE (2012)
[7] R. N. Wolf et al., Nucl. Instr. and Meth. A 686, 82-90 (2012)

Poster session / 20

Newly identified low-lying isomeric state in 80Ga from the beta-decay of 80Zn

Authors: D.G. Ghita[1]; H Mach[2]; L.M. Fraile[2]; N Marginean[1]; Razvan Lica[1]

Co-author: APRAHAMIAN, A. (Department of Physics, University of Notre Dame, Notre Dame, Indiana, USA) BERNARDS, C. (Institut fur Kernphysik, Koln, Germany) BRIZ, J.A. (Instituto de Estructura de la Materia, Madrid, Spain) BUCHER, B. (Department of Physics, University of Notre Dame, Notre Dame, Indiana, USA) CHIARA, C. (Argonne National Laboratory, Lemont, Illinois, USA) DLOUHY, Z. (Nuclear Physics Institute, AS CR, Rez, Czech Republic) GHEORGHE, I. (Horia Hulubei National Institute of Physics and Nuclear Engineering, Magurele, Romania) HOFF, P. (Department of Chemistry, University of Oslo, Oslo, Norway) JOLIE, J. (Institut fur Kernphysik, Koln, Germany) KOSTER, U. (Laboratoire de Physique Subatomique et de Cosmologie (LPSC) Grenoble, France)

KURCEWIC, W. (Institute of Experimental Physics, University of Warsaw, Warsaw, Poland) MARGINEAN, R. (Horia Hulubei National Institute of Physics and Nuclear Engineering, Magurele, Romania) OLAZIOLA, B. (Grupo de Fisica Nuclear, Facultad de CC Fisicas, Universidad Complutense, Madrid, Spain) PAZIY, V. (Grupo de Fisica Nuclear, Facultad de CC Fisicas, Universidad Complutense, Madrid, Spain) REGIS, J.M. (Institut fur Kernphysik, Koln, Germany) RUDIGIER, M. (Institut fur Kernphysik, Koln, Germany) SAVA, T. (Horia Hulubei National Institute of Physics and Nuclear Engineering, Magurele, Romania) SIMPSON, G. (Laboratoire de Physique Subatomique et de Cosmologie (LPSC) Grenoble, France) STANOIU, M. (Horia Hulubei National Institute of Physics and Nuclear Engineering, Magurele, Romania) STROE, L. (Horia Hulubei National Institute of Physics and Nuclear Engineering, Magurele, Romania) WALTERS, W. (Department of Chemistry, University of Maryland, College Park, Maryland, USA) . [3]

[1] *Horia Hulubei National Institute of Physics and Nuclear Engineering*

[2] *Grupo de Fisica Nuclear, Facultad de CC Fisicas, Universidad Complutense, Madrid, Spain*

[3] *IS441 collaboration*

The beta decay of 80Zn was part in systematic studies of neutron rich Zn nuclei. The measurements were performed at the ISOLDE facility at CERN. The beta gated gamma-gamma coincidences provided a significantly modified level scheme for 80Ga compared to the previously reported one. The main goal of our research was to identify excitation energies of two beta decaying states. The new level scheme includes a new low-lying state at 22.4 keV. Properties of the level scheme suggest that the ground state has spin J = 6 and the next excited state has spin J = 3 in agreement with shell model calculation and previous collinear laser spectroscopy measurements.

Poster session / 83

HIE beam commissioning software application

Author: Davide Lanaia[None]

The HIE–ISOLDE superconducting (SC) linac will start operation in 2015 with a total of 32 SC cavities envisaged when the installation is completed. The high numbers of cavities that operators will have to tune requires new software applications in order to ensure a fast machine set up. This contribution will show some ideas, and preliminary results about the applications that will be developed for the SC accelerator.

Poster session / 4

Structure of the odd-odd 62,64Co nuclei: "is there evidence of the onset of particle-hole intruder states in these nuclei?"

Author: William Walters[1]

Co-authors: B Kay [2]; Bogdan Fornal [3]; Chris Chiara [4]; Deyan Radulov [5]; Dieter Pauwels [6]; Fedosseev Valentine [7]; Mark huyse [5]; Piet Van Duppen [5]; Rafal Broda [3]; Robert Janssens [8]; S. zhu [8]; Ulli Koester [9]

[1] *University of Maryland*

[2] *York*

[3] *Krakow*

[4] *Maryland*

[5] *Leuven*

[6] *Belgian Nuclear Research Center (BE)*

[7] *CERN*

[8] *ANL*

[9] *ILL*

Corresponding Author: wwalters@umd.edu

Following the identification of the deformed particle-hole intruder states in 67Co by Pauwels et al., and the subsequent identification of a second low-energy 1+ level in adjacent odd-odd 66Co, along with other isomeric levels, the question arose, "how can the structure of 66Co be compared with the evolution of the structure of the lighter odd-odd Co isotopes?"Stated another way, are there features of the lighter odd-odd Co isotopes that show evidence of the onset of the deformed intruder levels? In this presentation, data from β decay of neutron-rich 61-67Mn isotopes, selectively ionized at ISOLDE at CERN, are combined with data from deep inelastic reactions of a 64Ni beam with a 238U target at the ATLAS facility at Argonne National Laboratory to identify the 1+ levels and higher-spin levels in 62,64Co to which the "intruder" and "spherical structures"in 66Co can be compared.

Poster session / 77

Design Upgrade of the ISOLDE Target Unit for HIE-ISOLDE

Author: Jacobo Abraham Montano Carrizales[None]

Corresponding Author: jacobo.montano@cern.ch

The High Intensity and Energy (HIE)-ISOLDE project is a major upgrade of the existing ISOLDE and REX-ISOLDE facilities with the objective of increasing the energy and the intensity of the delivered radioactive ion beam (RIB) [1]. In order to accommodate the future increase of primary beam intensity delivered by the new LINAC4 H- driver, a major study is being carried out to upgrade the existing designs of the ISOLDE target and its supporting infrastructure.
In particular, the extraction optics plays an important role in the initial beam transport and the quality of the beam supplied to the mass separators. Important factors include the emittance of the beam and the beam profile to avoid beam losses.
A new double electrode extraction system has been developed for simplifying and improving the interface between the target unit and the "Front End"(target coupling table). Numerical and experimental studies have been performed in order to define the new extraction geometry, and the coupling table has been adapted to keep the compatibility. The results of the studies and the mechanical model developed are presented and discussed in this poster.

Poster session / 33

A Systematic Study of Nuclei in the A=60 -70 Mass Region

Authors: Nilberto H. Medina[1]; Paula R. P. Allegro[2]; Silvia M. Lenzi[3]

Co-authors: Dennis L. Toufen [4]; E. W. Cybulska [1]; Frederico A. Genezini [5]; Guilherme Z. Zahn [5]; José R. B. Oliveira [1]; Lagy T. Baby [6]; Marcilei A. G. Silveira [7]; Peter Bender [6]; Roberto V. Ribas [1]; Samuel L. Tabor [6]; Vandana Tripathi [6]; Vinicius A. B. Zagatto [1]; Wayne A. Seale [1]

[1] *Instituto de Física, Universidade de São Paulo, São Paulo, Brazil*

[2] *Instituto de Física, Universidade de São Paulo, São Paulo, Brazil and Dipartimento di Fisica e Astronomia dell' Università and INFN, Sezione di Padova, I-35131, Padova, Italy*

[3] *Dipartimento di Fisica e Astronomia dell' Università and INFN, Sezione di Padova, I-35131, Padova, Italy*

[4] *Instituto de Física, Universidade de São Paulo, São Paulo, Brazil and Instituto Federal de Educação, Ciência e Tecnologia, Guarulhos, Brazil*

[5] *Instituto de Pesquisas Energéticas e Nucleares, São Paulo, Brazil*

[6] *Florida State University, Tallahassee, USA*

[7] *Centro Universitário da FEI, São Bernardo do Campo, Brazil*

Corresponding Author: pallegro@pd.infn.it

One of the most reliable models to describe the nucleus is the Large Scale Shell Model, which has demonstrated to reproduce with very good accuracy detailed nuclear properties (see ref. [1] for a review). In the A=50-80 mass region, many studies have been published attempting to explain the role of the 0g9/2 orbital in the high spin states, especially in the neutron-rich nuclei like, for example, 59-66Fe [2], 65,67Cu [3], 70,80Ge [4,5] and the odd-mass isotopes of As, Ge and Ga [6]. Two different studies have investigated the role of the 0g9/2 orbital in neutron-rich odd-mass Ga isotopes. In ref. [7] band-like structures, where a proton is excited to the 0g9/2 shell are studied. In ref. [8] the importance of this orbital in describing the change in structure along the Ga isotopic chain is shown. More recently, the role of the 1d5/2 orbital has been discussed by Lenzi et al. [9].

Not that far for stability, the role of both 0g9/2 and 1d5/2 orbitals has still to be investigate. In particular, this is put in evidence in the odd and odd-odd-mass nuclei. Recently, the high spin excited states of odd-odd 64,66,68,70Ga have been studied with in-beam gamma-ray spectroscopy experiments performed at University of São Paulo using the SACI-PERERE [10] spectrometer and at Florida State University using the Clover Array System [11]. In this work, we investigate the role of the 0g9/2 and 1d5/2 orbitals in these Ga isotopes by means of Large Scale Shell Model calculations using the Antoine code [12] and three different residual interactions: FPG [13], JUN45 [14] and LNPS [9]. This has been done in the framework of a systematic study of odd-mass Zn, Ga and Ge nuclei in the mass A= 60-70 region.

[1] E. Caurier et al., Rev. of Mod. Phys. 77, 427 (2005).
[2] S. Lunardi. et al., Phys. Rev. C 76, 034303 (2007).
[3] C. J. Chiara et al., Phys. Rev. C 85, 024309 (2012).
[4] M. Sugawara et al., Phys. Rev. C 81, 024309 (2010).
[5] H. Iwasaki.et al., Phys. Rev. C 78, 021304(R) (2008).
[6] N. Yoshinaga et al. Phys. Rev. C 78, 044320 (2008).
[7] I. Stefanescu et al., Phys. Rev. C 79, 064302 (2009).
[8] B. Cheal et al. Phys. Rev. Lett. 104, 252502 (2010).
[9] S. M. Lenzi et al., Phys. Rev. C 82, 054301 (2010).
[10] J.A. Alcántara-Núñez, Nucl. Instr. and Meth. A 497, 429 (2003).
[11] Web site: http://www.physics.fsu.edu/nuclear/foxlab/nuclear-foxlab.html (2012).
[12] E. Caurier and F. Nowacki, Acta Phys. Polonica B 30, 705 (1999).
[13] O. Sorlin et al., Phys. Rev. Lett. 88, 092501 (2002).
[14] M. Honma et al., Phys. Rev. C 80, 064323 (2009).

Poster session / 48

Upgrade of the Radio Frequency Quadrupole Cooler and Buncher for the HIE-ISOLDE Project

Author: Carla Babcock[None]

Co-author: Tim Giles [1]

[1] *CERN*

Corresponding Author: carla.babcock@cern.ch

The ISCOOL RFQCB (radio frequency quadrupole cooler and buncher) at the
CERN facility ISOLDE is used to reduce the emittance and energy spread of the beam, and to give it a time structure before it is sent to the experiments [1]. The upgrade to ISOLDE, HIE-ISOLDE, will encompass many aspects, including an upgrade to the high resolution separator area that will see the ISCOOL design improved and the machine moved to a position between the ion source and the separator magnets. This will
improve beam quality by increasing the resolving power of the HRS magnets.
The focus of the ISCOOL upgrade will be on fixing the problems of alignment with the current machine, improving the integrity of the vacuum just outside the ISCOOL chamber, stabilizing the gas pressure inside the chamber, modifications to the extraction and injection electrodes to facilitate direct matching to the other beamline
components, and the changes associated with the new position. To accomplish these goals, a test

stand will be created, which will be used to test various components of the design study, including the ISCOOL currently in use at ISOLDE.
Preparation for the construction of the test stand will involve the physical construction of the new RFQCB, which should be finished by January 2013, simulation to determine the exact optical properties and tolerances of the current design and consideration of all the changes required when moving ISCOOL to a new location; this step is necessary because of possible space restrictions, the higher beam intensities, the
compatibility with other beamline components, and a much more radioactive environment. This study will result in a more reliable, more efficient RFQCB. Its better optical properties will lead to an increase in the quality of the ISOLDE beam.

[1] A. Jokinen et al., Nucl. Instr. and Meth. in Phys. Res. B 204 (2003) 86-89

(This research project has been supported by a Marie Curie Early Initial Training Network Fellowship of the European Community's FP7 Programme under contract number (PITN-GA-2010-264330-CATHI))

Poster session / 87

New quadrupole electromagnets with laminated steel yokes for the HIE-ISOLDE Beam Transfer Lines

Author: Panagiotis Farantatos[None]

The aim of the HIE-ISOLDE project is to greatly expand the physics program compared to that of REX-ISOLDE, containing three major elements: higher energies, improvements in beam quality and flexibility, and higher beam intensities. In the framework of this project, a new beam focusing quadrupole electromagnet is designed, which shall be followed by its series production in industry. Extensive magnetic simulations have been performed in order to evaluate and optimize the new quadrupole's electromagnetic design and harmonic content. The performance requirements and main parameters of the magnet, along with its basic design methodology and simulation results of the latest quadrupole's electromagnetic configuration are presented.

Heavy nuclei / 61

Recent results and perspectives at the GANIL/SPIRAL2 facility

Author: Marek Lewitowicz[1]

[1] *GANIL*

Recent results related to study of nuclei far from stability obtained at the GANIL facility [1] will be presented. Developments of high intensity stable and radioactive ion beams at GANIL cyclotrons and SPIRAL1 facility as well as important upgrade of existing detection systems will open new opportunities in experimental nuclear physics. Future operation modes of the GANIL/SPIRAL2 complex as a multi-user facility will be discussed. Options for long-term developments of GANIL will be shortly presented.

Heavy nuclei / 52

Recent Results on Spherical and Deformed Nuclei from NICOLE

Author: Gary Simpson[1]

Co-authors: Carole Valerie Gaulard [2]; Frederik Wauters [3]; Jovana Nikolov [4]; Miroslav Veskovic [5]; Nicholas Stone [6]; Philip Malzard Walker [7]; Suguru Muto [8]; Takashi Ohtsubo [9]; Ulli Koester [10]; William Walters [11]

[1] *LPSC*

[2] *Centre de Spectrometrie Nucleaire et de Spectrometrie de Masse (CSNSM)*

[3] *katholieke universiteit leuven*

[4] *University of Novi Sad*

[5] *University of Novi Sad (RS)*

[6] *Oxford University*

[7] *University of Surrey (GB)*

[8] *KEK*

[9] *Niigata University*

[10] *Institut Max von Laue-Paul Langevin (FR)*

[11] *University of Maryland (US)*

The NICOLE dilution refrigerator is an on-line Low-Temperature Nuclear Orientation facility installed at ISOLDE, principally used to measure the magnetic moments of atomic nuclei.
The ground-state of the nucleus 49Sc has only one f7/2 proton outside a doubly magic 48Ca core. This makes this nucleus one of the few available for testing the fundamental theory of nuclear magnetism. The magnetic moment has been measured by online nuclear magnetic resonance (NMR) of nuclei oriented at milli-Kelvin temperatures to be (+)5.616(25) mN [1]. The result is discussed in terms of a detailed theory of the structure of the magnetic-moment operator, showing excellent agreement with calculated departure from the f7/2 Schmidt extreme single-particle limit value. The measurement completes the sequence of magnetic moments of the Sc isotopes with even numbers of f7/2 neutrons; the first such isotopic chain between two major shells for which a full set of moment measurements exists. The result further completes the isotonic sequence of ground-state moments of nuclei with an odd number of f7/2 protons coupled to a closed sub-shell of f7/2 neutrons. A comparison with recent shell-model calculations of the latter sequence is made.
On-line nuclear orientation has been used to measure the gamma-ray angular distributions and magnetic moment of the 37/2- high-K isomer of 177Hf. The magnetic moment of the isomer is found to be 7.33(9) μN and high precision E2/M1 multipole mixing ratios are extracted for transitions in bands built on the 23/2+, 1.1 s, isomer at 1315.4 keV and on the 9/2+, 0.663 ns, isomer at 321.3 keV. These new results and magnetic moment and in-band spectroscopic data on other nearby isotopes are examined to test the degree to which the assumption of additivity can be seen as a reliable predictor of the moments of high-K isomers in this region.

[1] T. Ohtsubo et al. Phys. Rev. Lett. 109, 032504 (2012).
[2] N. Stone et al. in preparation.

Heavy nuclei / 40

Penning-trap mass spectrometry and search for long-lived isomers in neutron-deficient Au and At isotopes

Author: Vladimir Manea[1]

Co-authors: Alexander Josef Herlert [2]; Christine Boehm [3]; Christopher Borgmann [3]; David Lunney [1]; Dennis Neidherr [4]; Dietrich Beck [4]; Dinko Atanasov [3]; Enrique Minaya Ramirez [4]; Frank HERFURTH [4]; Frank Wienholtz [5]; Juliane Stanja [6]; Kai Zuber [6]; Klaus Blaum [3]; Lutz Schweikhard [5]; Magdalena Kowalska [7]; Marco Rosenbusch [5]; Martin Breitenfeldt [8]; R.Burcu Cakirli [9]; Robert Wolf [5]; Sarah Naimi [10]; Sebastian George [5]; Sergey Eliseev [3]; Stefan Schwarz [11]; Susanne Kreim [12]; Thomas Elias Cocolios [7]; Yuri Litvinov [4]

[1] *CSNSM Centre de Spectrometrie Nucleaire et Spectrometrie de Masse*

[2] *FAIR GmbH, Darmstadt, Germany*

[3] *Max-Planck-Institut fur Kernphysik, Heidelberg, Germany*

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

[5] *Ernst-Moritz-Arndt-Universitaet, Greifswald, Germany*

[6] *Technische Universitaet Dresden (DE)*

[7] *CERN*

[8] *Instituut voor Kern- en Stralingsfysica, Leuven, Belgium*

[9] *Max-Planck-Institut fur Kernphysik, Heidelberg, Germany, University of Istanbul, Department of Physics, Istanbul, Turkey*

[10] *RIKEN Research Facility, Japan*

[11] *NSCL, Michigan State University, East Leasing, USA*

[12] *CERN, Max-Planck-Institut fur Kernphysik, Heidelberg, Germany*

Corresponding Author: vladimir.manea@cern.ch

Various experiments on neutron-deficient isotopes around the magic proton number Z = 82 suggest a complex behavior in the proton-neutron valence space. The occupation of intruder proton orbitals leads to shape coexistence, or sudden transitions from spherical or slightly-deformed to deformed shape. One important example is the shape transition which occurs in the Au isotopic chain at mass number A = 186 and persists as neutrons are further removed from the nucleus.

We present here recent ISOLTRAP measurements of the ground-state and isomer masses of neutron-deficient Au (Z = 79) and At (Z = 85) isotopes, below and around the neutron subshell N = 112. These measurements address the onset of collectivity observed in this region of the nuclear chart.

Isomers have already been studied with ISOLTRAP's Penning traps, using their high resolution to determine the ordering of the nuclear states, as well as the corresponding excitation energies. The results presented here were completed by an investigation of the hyperfine structure of the measured isotopes. This was achieved, in collaboration with RILIS, by using the new ISOLTRAP multi-reflection time-of-flight mass separator (MR-TOF MS). The high separation power of the MR-TOF MS offers the possibility of in-source laser spectroscopy with reduced or, in many cases, no background from contaminating ions. Together with the advantages of using direct ion detection, the MR-TOF MS offers a complementary approach to conventional decay-based detection methods.

Heavy nuclei / 10

Coulomb excitation of 196,198,200,202Po studied at REX-ISOLDE with the Miniball γ spectrometer

Author: Nele Kesteloot[1]

Co-authors: Beyhan Bastin [2]; Didier Voulot [3]; Elisa Rapisarda [3]; Fredrik John Carl Wenander [3]; Jan Diriken [4]; Katarzyna Wrzosek-Lipska [1]; Liam Gaffney [5]; Magdalena Zielinska [6]; Marcus Scheck [7]; Mark L Huyse [1]; Nick Bree [8]; Nigel Warr [9]; Peter Butler [5]; Piet Van Duppen [1]; Tuomas Grahn

[1] *Katholieke Universiteit Leuven (BE)*

[2] *Katholieke Universiteit Leuven-Unknown-Unknown*

[3] *CERN*

[4] *Katholieke Universiteit Leuven*

[5] *University of Liverpool (GB)*

[6] *CEA Saclay*

[7] *TU Darmstadt*

[8] *K.U.Leuven*

[9] *Institut für Kernphysik Köln*

Corresponding Author: nele.johanna.k.kesteloot@cern.ch

The neutron-deficient polonium isotopes with two protons outside the closed Z = 82 shell represent an interesting region of the nuclear chart to study shape coexistence in nuclei [1]. When going from the closed neutron shell at N=126 towards the most neutron deficient nuclei around N=104 the nuclear structure of the polonium isotopes changes from a general-seniority-type regime, towards a structure that is dominated by shape coexistence. The 200Po isotope manifests itself as a transitional nucleus between these two extremes [2,3]. However, questions remain concerning this transition; the sign of deformation and the magnitude of mixing between the different configurations are still unclear. Coulomb excitation at safe energies serves as an ideal technique to investigate the magnitude of transitions between low-lying states, revealing information on the deformation of these states and on the mixing of the different bands.

In the September 2009 test phase of the IS479 experimental campaign [4] 200Po beams were produced and post accelerated to an energy of 2.85 MeV/u at the REX-ISOLDE facility in CERN. The radioactive ion beam was delivered to a stable 104Pd target placed in the middle of the Miniball γ spectrometer to induce Coulomb excitation. There was little or no contamination with a beam purity of 98.8(9)% and the count rate of ˜106 pps at Miniball with a proton beam intensity of 1.1μA confirmed the predicted count rates.

The test phase was followed by a successful continuation of the experimental campaign in September 2012. During the remaining beam time, beams of 196,198,202Po were produced and post accelerated at REX-ISOLDE and Coulomb excitation was observed at the Miniball detection setup for all the isotopes. Furthermore parasitic data on the Coulomb excitation of 196Tl, which was the 50% contaminant in the 196Po beam, was gathered.

Using the Coulomb excitation analysis code Gosia [5] and the experimental information it will be possible to determine the B(E2) values coupling the low-lying excited states for the whole transitional range (196-202Po). In 196Po it will be especially interesting to compare the B(E2) value from the Coulomb excitation experiment to the value determined from the lifetime experiment [6]. The amount of statistics should also allow us to fix the sign of the quadrupole moments of the first excited 2+ states. Finally these results will be discussed within the framework of shape coexistence and configuration mixing and will be compared with recent results from beyond mean-field calculations [7].

In the presentation the first results from the 2012 experimental campaign will be shown together with the results from 2009.

[1] K. Heyde and J.L. Wood, Rev. Mod. Phys 83 (2011) 1467.
[2] R. Julin et al., J. Phys. G 27 (2001) R109.
[3] A.M. Oros et al., Nucl. Phys. A 645 (1999) 107.
[4] B. Bastin et al., INTC-P-247 (2008).
[5] T. Czosnkyka, D. Cline, C.Y. Wu Bull. Amer. Phys. Soc. 28 (1983) 745.
[6] T. Grahn et al., PRC 80 (2009) 014323.
[7] P.-H. Heenen, private communication (2012)

Heavy nuclei / 17

Beta-delayed fission of neutron-deficient Fr and At isotopes

Author: Lars Herman L Ghys[1]

[1] *Katholieke Universiteit Leuven (BE)*

Corresponding Author: lars.ghys@cern.ch

Beta-delayed fission (bdf) happens when a precursor nucleus first undergoes beta-decay to a high-lying excited state above or around the fission barrier in the daughter nucleus that subsequently fissions. Although bdf is a rare event, its study allows us to probe the nuclear fission process of excited nuclei with low excitation energies and known ranges of spins and parities as shown from

our previous work on the bdf of 180Tl where an unexpected asymmetric mass distribution in the fission fragment distribution was observed [1].
Since 2009, a number of experiments on bdf in the neutron-deficient lead region have been carried out at ISOLDE. In this contribution we report on the latest results of this experimental campaign whereby the bdf of 200,202Fr (IS466, May 2011) and of 194,196At (IS534, May 2012) was studied.
For all mentioned nuclei, bdf has been firmly identified and for 194,196At and 202Fr, enough statistics were collected to construct energy and mass spectra of the fission products. Although the data analysis is still ongoing, compared to the 180Hg case a different fission fragment mass distribution is observed. This indicates that these nuclei represent a transition region between asymmetric and symmetric fission as observed in the heavier Rn and Ra isotopes studied via Coulomb excitation induced fission [2]. The results will be discussed in a more global framework of fission studies in this mass region and also data from beta- and alpha decay studies obtained as a by product, will be presented.

[1] : A.N. Andreyev et al., PRL 105, 252502 (2010)
[2]: K.-H Schmidt et al., Nucl. Phys. A 665, 221 (2000)

*This work was performed by RILIS-ISOLDE(CERN) –UWS,Paisley (UK) - IKS,KU Leuven (Belgium)-Comenius University, Bratislava (Slovakia)-OLL, University of Liverpool (UK)-JAEA, Tokai (Japan) –SCK•CEN, Mol (Belgium) collaboration.

Heavy nuclei / 9

Spectroscopic studies of the neutron-deficient francium isotopes at the CRIS beam line

Author: Kara Marie Lynch[1]

Co-authors: Andrew Smith [1]; Bruce Marsh [2]; Gerda Neyens [3]; Hanne Heylen [4]; Hinko Henry Stroke [5]; Ivan Budincevic [4]; Jonathan Billowes [1]; Kieran Flanagan [1]; Mustafa Rajabali [6]; Ronald Fernando Garcia Ruiz [4]; Ruben Pieter De Groote [4]; Sebastian Rothe [7]; Stijn De Schepper [4]; Thomas Elias Cocolios [2]; Thomas Procter [1]

[1] *University of Manchester (GB)*

[2] *CERN*

[3] *K.U. Leuven*

[4] *Katholieke Universiteit Leuven (BE)*

[5] *New York University (US)*

[6] *Katholieke Universiteit Leuven*

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

Corresponding Author: kara.marie.lynch@cern.ch

The Collinear Resonant Ionization Spectroscopy (CRIS) experiment at ISOLDE, CERN uses laser radiation to stepwise excite and ionize an atomic beam for the purpose of ultra-sensitive detection of rare isotopes, and hyperfine structure measurements. The technique also offers the ability to purify an ion beam that is heavily contaminated with isobars, including the ground state of an isotope from its isomer, allowing sensitive secondary experiments to be performed.

A new program using the CRIS technique to select only nuclear isomeric states for decay spectroscopy commenced last year. The isomeric ion beam is selected using a resonance of its hyperfine structure, where it is deflected to a decay spectroscopy station (DSS). This consists of a rotating wheel implantation system for alpha and beta decay spectroscopy, and up to three germanium detectors around the implantation site for gamma-ray detection.

Laser spectroscopy provides a measurement of the spin, moments and charge radii of the ground and isomeric states in the parent nucleus, while the level structure of the daughter nucleus comes from the complementary decay spectroscopy, thus providing a wealth of information on the isotope under investigation.

Resonant ionization laser spectroscopy and the new technique of laser assisted decay spectroscopy have recently been performed at the CRIS beam line on the neutron-deficient francium isotopes. Here the latest results from our experimental campaign will be presented, alongside an overview of the CRIS beam line and the DSS.

Biophysics and Medical / 69

CERN-MEDICIS: Recuperation of the dumped CERN protons for the production of medical isotopes in the ISOLDE Class A Laboratory

Corresponding Author: thierry.stora@cern.ch

The ISOLDE facility at CERN is in operation for more than forty years, and has successfully extended various technological aspects of the so-called ISOL beam production, extracting high-purity grade exotic radioisotope beam "online", while irradiating 20cm thick targets with about 50% of the available CERN 1.4 GeV protons. In its present location since 1991, the ISOLDE facility has delivered various beams to 300 different approved experiments, for fundamental research in nuclear and astrophysics, solid state physics, and biological and medical research. Our facility is also best known for its contribution to the field of medical imaging and treatment, applying radio-lanthanides such as 149Tb for PET imaging and Targeted ⍺-therapy (G.J. Beyer et al., Eur. J. Nucl. Med. Mol. Imaging (2004) 31, 547).
Here we report on the project to implement a laboratory for the production of isotopes of medical interest in the ISOLDE Class A work sector, where the target stations and related infrastructures are located. Its main characteristics will be the installation of a transport system capable of activating appropriate materials with the proton beam downstream, behind the ISOLDE production targets, before the beam is lost in the beam dumps. Indeed CERN high energy protons loose only 10% of their energy past the ISOLDE production targets, and are thus still capable of producing isotopes in an additional target irradiation stand for the present purposes. The clear advantage is that this program can be carried out without the need to fit in the streamline of the ISOLDE approved and scheduled experimental program. The infrastructure, for its optimal performance, needs in addition a radiochemical laboratory equipped with appropriate hot-cells and an isotope mass spectrometer; this type of infrastructures has shown to provide batches of carrier-free medical isotopes. The present development of the project, external collaborations and future required steps will be outlined.

Biophysics and Medical / 55

A Unique Matched Quadruplet of Terbium Radioisotopes for PET and SPECT and for alpha- and beta-Radionuclide Therapy: An in vivo Proof of Concept Study with a New Receptor-Targeted Folate Derivative

Author: Cristina Müller[1]

Co-authors: Holger Dorrer [2]; Karl Johnston [3]; Konstantin Zhernosekov [4]; Roger Schibli [5]; Ulli Köster [6]

[1] *Center for Radiopharmaceutical Sciences ETH-PSI-USZ, Paul Scherrer Institute, Villigen-PSI, Switzerland*

[2] *Laboratory of Radiochemistry and Environmental Chemistry, Paul Scherrer Institute, Villigen-PSI, Switzerland and Department of Chemistry and Biochemistry, Laboratory of Radiochemistry and Environmental Chemistry, University of Bern, Berne, Switzerland*

[3] *ISOLDE-CERN*

[4] *Center for Radiopharmaceutical Sciences ETH-PSI-USZ and Laboratory of Radiochemistry and Environmental Chemistry, Paul Scherrer Institute, Villigen-PSI, Switzerland*

[5] *Center for Radiopharmaceutical Sciences ETH-PSI-USZ, Paul Scherrer Institute, Villigen-PSI, Switzerland and Department of Chemistry and Applied Biosciences, ETH Zurich, Zurich, Switzerland*

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

Background: Compared to other lanthanides, terbium (Tb) comprises clinically attractive radionuclides such as 152Tb and 155Tb with suitable decay properties for PET and SPECT imaging and 149Tb and 161Tb suitable for targeted alpha- and beta-radionuclide therapy. To evaluate these 4 radioisotopes we employed the folic acid/folate receptor (FR)-targeting strategy which has been thoroughly investigated over years by our group. Thus, the goal of this proof-of-concept study was to produce all 4 Tb-radioisotopes and assess their diagnostic and therapeutic features in vivo when labeled with a folate-based targeting agent.
Methods: 161Tb was produced by irradiation of 160Gd targets with neutrons at Paul Scherrer Institute or Institut Laue-Langevin. After neutron capture, the short-lived 161Gd decays to 161Tb. 149Tb, 152Tb, and 155Tb were produced by proton-induced spallation of tantalum targets, followed by an online isotope separation process at ISOLDE/CERN. The isotopes were purified by means of cation exchange chromatography at PSI. A long-circulating DOTA-folate conjugate (cm09) was radiolabeled with all four Tb-radioisotopes under standard labeling conditions. Biodistribution studies were performed over seven days using 161Tb-cm09. Diagnostic PET/CT (152Tb-cm09) and SPECT/CT (155Tb-cm09 and 161Tb-cm09) and therapy experiments with 149Tb-cm09 and 161Tb-cm09 were performed in KB tumor bearing mice.
Results: Carrier-free Tb-radioisotopes were obtained after purification, with activities ranging from approximately 6 MBq (for 149Tb) to approximately 15 GBq (for 161Tb). The radiolabeling of cm09 was achieved in >96% radiochemical yield for all 4 Tb-radioisotopes. The tissue distribution of 161Tb-cm09 resulted in a high tumor uptake (˜20% ID/g, 24 h p.i.) which was retained over several days. PET/CT and SPECT/CT studies allowed excellent tumor visualization in mice even 24 h after injection of the 152Tb-cm09 and 155Tb-cm09. Targeted radionuclide therapy studies performed with 149Tb-cm09 and 161Tb-cm09 revealed a significant inhibition of tumor growth and a prolonged survival (>1.7-fold and >2-fold) of treated mice compared to untreated controls.
Conclusions: This is the first comprehensive study with all 4 Tb-radioisotopes using one and the same targeting agent (Müller et al. J Nucl Med 2012, in press). Excellent in vivo tumor visualization was enabled with 152Tb-cm09 and 155Tb-cm09 using PET/CT and SPECT/CT. Thus, 152Tb and 155Tb could become ideal diagnostic matches for their therapeutic counterparts 149Tb and 161Tb providing identical chemical properties. Regarding the therapeutic approach, promising results were obtained after application of 149Tb-cm09 and 161Tb-cm09 with respect to a prolonged overall survival of the mice and an effective tumor growth inhibition.
Acknowledgements: This study was financially supported by the Swiss National Science Foundation (Ambizione Grant), the South Africa/Switzerland Joint Research Program (SSAJRP) and by the European Union via the ENSAR Project (contract 262010).

Biophysics and Medical / 54

PAC Spectroscopy applied to biochemistry

Authors: Lars Hemmingsen[1]; Monika Stachura[2]

Co-author: Attila Jancso [3]

[1] *Dept. of Natural Sciences, The Royal Veterinary and Agricultural University*

[2] *University of Copenhagen (DK)*

[3] *University of Szeged*

Corresponding Author: lhe@kvl.dk

Due to the complexity of systems in living matter nuclear techniques are not commonly used in biology and biochemistry. The ISOLDE facility is, however, a perfect place for carrying out experiments with Perturbed Angular Correlation of γ-rays (PAC) spectroscopy. This well established technique is suitable for addressing different biological topics, such as metalloprotein structure, dynamics of protein folding or protein –protein interaction, providing information on the molecular and electronic structure at the PAC probe site. By approaching from simple inorganic complexes we aim to elucidate the fundamental chemistry of heavy metal ion interaction with proteins. This involves

studies on de novo designed peptides, naturally occurring proteins, plants and recently also bacteria. In the present work we have selected some of the biological applications that we find particularly interesting. We will show how, with the use of PAC and NMR spectroscopy, we can monitor the time scale of dynamics at the metal ion binding site. Furthermore, we will present data on heavy metal ions binding to proteins and finally, we will illustrate some interesting examples of in vivo studies.

Biophysics and Medical / 53

First Application of β-NMR in Wet Chemistry

Authors: Alexander Gottberg[1]; Lars Hemmingsen[2]; Magdalena Kowalska[3]; Monika Stachura[4]

[1] *CERN / CENBG / CSIC*

[2] *Dept. of Natural Sciences, The Royal Veterinary and Agricultural University*

[3] *CERN*

[4] *University of Copenhagen (DK)*

Corresponding Author: alexander.gottberg@cern.ch

In August 2012 β-NMR spectroscopy was successfully applied for the world's first experiments on liquid samples - an achievement which opens new avenues of research in the fields of wet chemistry and biochemistry. This project was motivated by the need for finding a new experimental approach to directly study biologically highly relevant metal ions, such as: Mg(II), Cu(I), Ca(II), and Zn(II).
The resonance spectrum recorded for Mg-31 implanted into a liquid sample shows two clear peaks, which originate from Mg ions occupying two different coordination geometries, illustrating that this technique can in fact discriminate between different structures - the first and the most important step towards the application of β-NMR spectroscopy in chemistry.
A prototype bio-β-NMR spectrometer, designed and constructed explicitly for this purpose using polarized ions at the COLLAPS setup, allowed for testing different aspects, such as: different liquids, vacua and rest gases, showing that even aqueous solutions are within reach.
In a future biochemical perspective, this proof-of-principle allows the application of β-NMR for studying metal ions, which are silent in most other spectroscopic techniques in their body-like environments.

Technical news / 49

Recent results from the ISAC facility at TRIUMF

Author: Friedhelm Ames[1]

[1] *T*

Corresponding Author: ames@triumf.ca

At the ISAC facility at TRIUMF radioactive ions are produced by bombarding solid targets with 500 MeV protons from a cyclotron. With a proton beam current up to 100 micro Amps it is the ISOL facility with the highest beam power of the primary beam so far. The facility is operational for more than 10 years and a wide range of different target materials have been used combined with surface, FEBIAD or resonant laser ion sources. Since about 3 years this was extended to actinide targets. Presently the license limit for those is at 10 micro Amps. Ions extracted from the target ion source systems can be either used for low energy experiments directly or they can be post accelerated up to an energy of about 10 MeV/u. The original design of the post accelerator only allowed the acceleration of ions lighter than 30 amu. During the last years charge breeding for heavier ions with an ECR ion source has been installed and a first experiment with accelerated Rb isotopes has been performed this year. The presented will give an overview of the facility and concentrate on recent results.

Technical news / 39

High power molten fluoride salt target for 18Ne production

Author: Tania Mendonca[1]

Co-authors: Daniel Heuer [2]; Etam Noah [3]; Michel Allibert [2]; Rastilav Hodak [4]; Thierry Stora [1]; Veronique Ghetta [2]

[1] *CERN, EN-STI-RBS Div. 1211 Geneva 23, Switzerland*

[2] *Laboratoire de Physique Subatomique et de Cosmologie, Université Joseph Fourier, CNRS/IN2P3, 53 rue des Martyrs, 38026 Grenoble, France*

[3] *University of Geneva, Section de Physique, DPNC –CH-1211 Geneva 4, Switzerland*

[4] *Department of Nuclear Physics and Biophysics, Comenius University, Mlynská dolina F1, SK-842 15 Bratislava, Slovakia*

The isotope pair 6He/18Ne has been suggested as the baseline isotopes for the Beta beams project [1]. The production of these isotopes has been studied within the EURISOL-DS project, where a top-down approach provided the need for the production of about 6x10ˆ13 6He and 1x10ˆ13 18Ne per second which would lead to rates of 2.9x10ˆ19 anti-νe and 1.1x10ˆ19 νe over a running period of 2 and 8 years, respectively [2]. The production of 6He at the required rates was successfully validated using the isotope separation online (ISOL) method exploiting a solid neutron converter at 100-200 kW level [3]. On the other hand, the production of 18Ne using oxide targets was found to be more problematic.
A target unit designed for the production of the required rates of 18Ne for the Beta Beams project is presented. The target material consisted of a binary fluoride system, NaF:LiF (molar ratio 39:61), with melting point at 649ºC. The principle was tested online at CERN/ISOLDE using a static target unit. The production of ISOL beams of Ne were monitored as a function of the target temperature and proton beam intensity. Moreover, other low Z isotopes have been measured and an increase of two orders of magnitude on carbon isotopes has been observed.
The production of 18Ne from the NaF:LiF molten salt target contributes to the validation of a high power molten salt circulating loop, which will allow reaching the required high rates of this isotope for the beta beams. Rates of 10ˆ13 18Ne/s are predicted, exploiting 1 MW, 160 MeV proton beam produced from an upgraded Linac4 at CERN, an useful rate for the foreseen beta beam facility [4]. Moreover, the influence of alternative proton drivers, such as a 250 MeV deuteron beam proposed during EURISOL-DS project [2], in the present design concept is discussed.

References
[1] P. Zuchelli, Phys. Lett. B 532, 166 (2002)
[2] Final Report of the EURISOL Design Study, J. Cornell Ed., GANIL (2009)
[3] T. Stora et al., Eur. Phys. Lett. 98, 32001 (2012)
[4] T. Stora, Proceedings of the Workshop "European Strategy for Future Neutrino Physics", CERN Yellow Report 2012, CERN-2010-003, 110 (2010)

Technical news / 70

Novel radioactive ion beams developed at ISOLDE

Corresponding Author: matthias.kronberger@cern.ch

The Target & Ion Source Development program (TISD) at CERN-ISOLDE aims at developing novel target materials and ion source concepts in order to provide beams that were not accessible previously in sufficient intensities at ISOLDE. During this running period, tests of a novel neutron converter design, nanocrystalline UCx and CaO targets, a liquid salt target, and a Helicon-type rf powered ion source were realized. This presentation reviews the latest results of the program and provides an outlook on future developments relevant for HIE-ISOLDE.

Technical news / 32

Operation and recent On-line Results of the Laser Ion Source and Trap Unit LIST

Author: Sven Richter[1]

Co-authors: Alexander Gottberg [2]; Anatoly Barzakh [3]; Andrei Andreyev [4]; Bernard Crepieux [5]; Bruce Marsh [5]; Celine Van Beveren [6]; Daniel Fink [5]; Dieter Pauwels [7]; Dmitri Fedorov [8]; Elisa Rapisarda [5]; H.-Juergen Kluge [9]; Kara Marie Lynch [10]; Kieran Flanagan [10]; Klaus Blaum [11]; Klaus Wendt [1]; Lars Herman L Ghys [12]; Mark L Huyse [12]; Maxim Seliverstov [13]; Nobuaki Imai [14]; Piet Van Duppen [12]; Ralf Erik Rossel [1]; Richard Catherall [5]; Sebastian Raeder [1]; Sebastian Rothe [1]; Thierry Stora [5]; Thomas Elias Cocolios [5]; Valentine Fedosseev [5]

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

[2] *CERN / CENBG / CSIC*

[3] *B.P. Konstantinov Petersburg Nuclear Physics Institute - PNPI (*

[4] *IKS*

[5] *CERN*

[6] *K*

[7] *Belgian Nuclear Research Center (BE)*

[8] *Petersburg Nuclear Physics Institute (PNPI)*

[9] *GSI*

[10] *University of Manchester (GB)*

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

[12] *Katholieke Universiteit Leuven (BE)*

[13] *Johannes Gutenberg-Universitat*

[14] *High Energy Accelerator Research Organization (JP)*

Today the Resonant Ionization Laser Ion Source (RILIS) has developed to become the preeminent technique for production of rare isotopes, being interfaced to different kind of ISOLDE targets. Striking advantages are its universality, high ionization efficiency and unsurpassed elemental selectivity. Unavoidable surface ionization processes on the hot cavity surfaces of the ion source produce some remaining isobaric contaminations in the radioactive ion beam, predominantly arising from alkaline and alkaline earth elements. The Laser Ion Source and Trap device (LIST) strongly suppresses these beam contaminations by a repeller electrode positioned at the ion source exit. In this way emerging of any ions from the hot area is prevented. Neutral atoms pass the electrode and are ionized by the laser radiation inside the volume of the LIST, which is defined by a guiding field radiofrequency quadrupole structure. In this way total elemental selectivity is achieved at the expense of a reduced efficiency due to geometrical constraints. This latter drawback is somewhat balanced by the possibility to rapidly switch the source from highest purity LIST-mode to high efficiency Ion-Guide-mode.

After off-line development at the Mainz University RISIKO separator, the LIST has successfully undergone its initial on-line tests installed at a titanium-target of the ISOLDE GPS in May 2011. Isobarically pure beams of ^{21, 22, 27}Mg isotopes were produced, suppressing contaminations by up to 1600 with an efficiency loss of around a factor of 50. Recently, LIST operation in connection with an uranium carbide target has been demonstrated and enabled determination of isotope shifts and hyperfine structures for the two missing short-lived isotopes ^{217,219}Po in the long sequence of Po isotopes as studied by the collaboration of IS 456. In addition decay spectroscopy on ²¹⁹Po could be performed for the first time using the IKS windmill detector set-up. No negative side effects on the LIST operation were encountered during this run from the strong outgassing of this target material.

Technical news / 18

First spin-polarized nuclei at REX-ISOLDE

Authors: Christophe Sotty[1]; Hans Toshihide Tornqvist[2]

Co-authors: Andreas Heinz [3]; Andrew Stuchbery [4]; Anukul Dhal [5]; Asli Kusoglu [6]; Deyan Yordanov [7]; Dimiter Balabanski [8]; Fredrik John Carl Wenander [2]; Georgi Georgiev [1]; Håkan Johansson [9]; Magdalena Kowalska [2]; Michael Hass [10]; Miguel Luis Lozano Benito [2]; Nobuaki Imai [11]; Thomas Nilsson [12]; Yoshikazu Hirayama [13]

[1] *CSNSM Centre de Spectrometrie Nucle aire et de Spectrometrie de*

[2] *CERN*

[3] *Chalmers, SE*

[4] *ANU, Canberra*

[5] *Weizmann Institute, IL*

[6] *CSNSM*

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

[8] *INRNE, Bulgarian Academy of Sciences*

[9] *Chalmers*

[10] *Weizmann Institute of Science (IL)*

[11] *High Energy Accelerator Research Organization (JP)*

[12] *CTH Goteborg*

[13] *KEK, JP*

Corresponding Author: hans.toshihide.tornqvist@cern.ch

Spin-polarized nuclei are of great interest in many fields of physics, for example in nuclear structure, solid state and bio-physics. To reach this wide range of applications, an in-flight polarization technique based on the passage of ions through thin tilted foils has been investigated. This technique allows a beam of any non-zero spin nucleus to be polarized and post-accelerated. An experimental setup based on this technique has been installed at the REX-ISOLDE post-accelerator at CERN. To measure the degree of polarization, a β-NMR setup has been constructed after the polarizing foils. Recently we have concluded a successful commissioning run at REX-ISOLDE using a beam of ^{8}Li that passed through tilted carbon foils and was implanted into a target crystal for observation of the angular distribution of
beta particles. RF was applied in order to observe the NMR spectrum, with the unambiguous signal of the destruction of β asymmetry. Nuclear polarization in the percent region has been measured.

This contribution will present the experimental setup, including the tilted-foil and β-NMR systems. Next the ^{8}Li experiment will be described, followed by results and their interpretation. The setup presented here constitutes a major improvement over past tilted-foil experiments at ISOLDE which used a high voltage platform and much lower energy ions. An outlook and future plans for the setup will be given.

Celebrating 20 years of ISOLDE at the PSBooster / 62

20 Years of Physics at the ISOLDE PSB Facility

Author: Bjorn Jonson[1]

[1] *Institute of Theoretical Physics*

The ISOLDE Facility at the CERN SC was closed in connection with the shut-down of the CERN SC on December 19, 1990 after about 23 years of operation. ISOLDE was given the opportunity to continue its activity in an external beam from the PS Booster. The new ISOLDE PSB Facility was inaugurated in the end of May 1992 after less than 18 months of construction. Very fast the scientific programme was also launched and already on at the end of June, 1992, the first successful experiment finished data taking. In this talk I shall give some examples on highlights in experiments and experimental techniques during the past 20 years that has brought ISOLDE to the world-leading facility we have today.

Celebrating 20 years of ISOLDE at the PSBooster / 71

Technical milestones in the development of ISOLDE

I have had the privilege to follow ISOLDE since 1965 where I as CERN fellow studied nuclear reaction cross-sections of astrophysical interest. I was the last one to use the of-line mass separator of the CERN Nuclear Chemistry Group for this purpose. Hereafter it was devoted to the target and ion-source development for the now planned Isotope Separator On-Line (ISOLDE) to become on line to the CERN 600MeV proton synchro cyclotron. Based on my further involvement I will draw your attention to a number of technical milestones which I find of importance in the successfully development of ISOLDE into the first radioactive ion-beam accelerator on-line to the PS Booster.

Celebrating 20 years of ISOLDE at the PSBooster / 72

Future Developments at ISOLDE

Corresponding Author: richard.catherall@cern.ch

The ISOLDE Facility is going through a substantial change, both in terms of infrastructure and new developments for the improvement of radioisotope production. The target area upgrade project includes the replacement of the target handling robots and the installation of the alpha gamma hot cell required for the waste treatment of irradiated target units. As part of the HIE-ISOLDE project, the Design Study is addressing issues associated with the increase in proton-beam intensity from the commissioning of Linac 4 and the improvement of beam quality delivered to the user community. The Test Storage Ring (TSR) project is also advancing, to the extent that it could be operational by 2016. Another exciting prospect is the Booster upgrade from 1.4 GeV to 2 GeV and the impact that this will have on isotope production if made available to the ISOLDE facility.
This presentation will give an overview of the above and other future developments and give an insight to the future of ISOLDE operation.

68

Neutrino oscillations: progress and prospects

Author: Vittorio Palladino[1]

[1] *Universita e INFN (IT)*

Corresponding Author: vittorio.palladino@cern.ch

The talk will provide a snapshot today, after 14 years of
discoveries:

a) The evidence, from 1998 on, of a first “atmospheric” transition
wavelenght with essentially maximal mixing, dominated by muon to tau neutrino transitions.
b) The evidence, soon after, of a second larger “solar” wavelenght again with large, thou not maximal, mixing.
c) The rapid progress of accurate measurements of both wavelenghts (mass splittings) and mixings.
d) The recent detection in 2011-2 of the subdominant atmospheric muon to electron neutrino transition, supporting the 3*3 nature of the
phenomenon.

including reach and implications for particle physics (new energy scales and Higgs, leptonic CP violation, sterile neutrinos) and the prospects of on going and future experiments in Europe and in

the
world.

Solid State Physics / 57

Ultra-high depth resolution MCsn+-SIMS for direct compositional analysis of low-dimensional structures of condensed matter systems

Author: Purushottam Chakraborty[1]

[1] *Saha Institute of Nuclear Physics*

Excellent detection sensitivity, high dynamic range and good depth resolution make the secondary ion mass spectrometry (SIMS) extremely powerful for the analysis of surfaces and interfaces of materials. However, a serious problem in SIMS analysis is its "matrix effect"that hinders the materials quantification. Realistic SIMS quantification having analytical accuracy better than ±20% requires the analysis of standard samples of the impurity species in the chemical matrix of interest. These standards are necessary because secondary ion yields depend on both the impurity species and its chemical environment. Different chemical matrices have different sputter ion yields and thus, the ion yields for a given element or molecule may vary significantly depending on the chemical matrix. This ion yield variation, known as "SIMS matrix effect", is a function of the electronic (and vibrational) states of both the sputtered species and the surface as well as the chemical bonding of the species to the surface. Ion yields in SIMS can vary by several orders of magnitude, thus effectively preventing quantitative SIMS analysis.

Corrective measures are therefore needed to calibrate the secondary ion currents into respective concentrations for accurate compositional analysis. Working in the MCs+-SIMS mode (M –element to be analyzed, Cs+ –bombarding ions) can circumvent the matrix effect. The emission process for the species M0 is decoupled from the MCs+ ion formation process, in analogy with the ion formation in secondary neutral mass spectrometry (SNMS), resulting in a drastic decrease in matrix effect in the MCs+-SIMS mode. Although this technique has found its applicability in direct quantification, it generally suffers from a low useful yield. In such cases, detection of MCsn+ (n = 2,3,. . .) molecular ions offers a better sensitivity (even by several orders of magnitude) as the yields of such molecular ion complexes have often been found to be higher than that of MCs+ ions. Several works have been reported on the emission of MCsn+ molecular ions, but a complete understanding on the formation mechanisms of these ion complexes is still lacking. The MCsn+-SIMS technique in all its complexities has great relevance in the analysis of materials. The talk will address on the possible formation mechanisms of MCsn+ molecular ion complexes and their applications in interfacial analysis of ultra-thin films, metallic multilayers, semiconductor superlattices, quantum wells and compositional analysis of MBE - grown Si1-xGex alloy structures. Our division has made significant contributions in ion-solid interactions in general and ion microbeam analysis of surfaces and interfaces of a wide variety of condensed matter systems in particular. Our focus is the controlled growth, characterizations and modifications of low-dimensional structures with tunable morphology and properties. The talk will also touch upon the glimpses of some of our important activities.

Solid State Physics / 45

FLUENCE DEPENDENCE OF THE ATOMIC CONFIGURATION OF 57Fe IN ION-IMPLANTED ZnO

Author: Karl Johnston[1]

[1] *Universitaet des Saarlandes (DE)*

ZnO doped with 3d-metal impurities has been of scientific interest since the suggestion that it could be a magnetic semiconductor with applications in spintronics [1]. Since then, inconsistent reports on the presence of dilute magnetism have been published, with only few reports using local atomic probe methods such as Mössbauer spectroscopy. In our previous work utilizing emission Mössbauer spectroscopy (MS) following 57Mn (T½ = 1.5 min.) implantation we have demonstrated that in the dilute case (< 10-3 at. %) we observe Fe3+ atoms in a paramagnetic state [2] exhibiting slow (˜105 Hz) spin-lattice relaxation at room temperature [3]. At higher concentrations (˜1 at. %), implanted Fe is known to form precipitates [4]. Little is known about what happens on the atomic scale within the concentration range between the above extremes, and whether within this range carrier mediated magnetism as described by Dietl et al. [1], bound polarons as suggested by Coey et al. [5], or spin polarized defects could form a long-range ferromagnetic coupling.
In this contribution we present emission MS results obtained on 57Mn implanted into 56Fe pre-implanted ZnO and on 57Co/57Fe implanted ZnO.
At the lowest fluence (<3×10-5 at.%) the spectra are dominated by a fairly narrow single line due to Fe2+ on substitutional Zn sites. For medium fluences (2×10-4 at.% to 0.3 at.%) the spectra show evidence of paramagnetic side wings attributed to Fe3+ showing slow paramagnetic relaxation. At the highest fluences (>0.1 at.%) the paramagnetic side wings broaden due to increasing spin-spin relaxation and the spectra are finally (>1 at.%) dominated by Fe2+ on distorted substitutional sites and on damage sites [6].
The fluence dependence and in particular the concentration dependence of the spin-spin relaxation rate will be discussed. This work supports the suggestions given in recent papers that the observed magnetism in many cases is an artifact caused by unintentional precipitation or misinterpretation of the experimental data (see e.g. discussions in [7]).

Solid State Physics / 29

Lattice location of transition metals in dilute magnetic semiconductors using EC-SLI (IS453)

Author: Lino M. C. Pereira[1]

Co-authors: André Vantomme [1]; Joao P. E. Araújo [2]; João Guilherme M. Correia [3]; Kristiaan Temst [1]; Ligia P. A. Amorim [1]; Stefan Decoster [1]; Ulrich Wahl [3]

[1] *Instituut voor Kern- en Stralingsfysica, KU Leuven, B-3001 Leuven, Belgium.*

[2] *IFIMUP and IN–Institute of Nanoscience and Nanotechnology, Universidade do Porto, 4169-007 Porto, Portugal.*

[3] *Instituto Tecnológico e Nuclear, Instituto Superior Técnico, Universidade Técnica de Lisboa, 2686-953 Sacavém, Portugal.*

The coexistence of semiconducting behavior and ferromagnetic order in dilute magnetic semiconductors (DMS) continue to challenge our understanding of condensed matter [1,2]. For a given impurity-host combination, the electrical and magnetic properties are largely determined by the lattice sites occupied by the dopant atoms. The canonical example is Mn-doped GaAs (narrow-gap), where Ga-substitutional Mn orders ferromagnetically and interstitial Mn acts as a compensating defect which reduces the Curie (ordering) temperature. The situation is somewhat different in wide-gap DMS materials such as ZnO and GaN doped Mn, Co and Ni, for which it is generally accepted that the transition metals occupy only cation substitutional sites.

In this talk, we will review recent emission channeling experiments on the lattice location of 56Mn, 61Co and 65Ni in GaAs, ZnO and GaN [3-6], carried out at the on-line EC-SLI (Emission Channeling of Short-lived Isotopes) setup at ISOLDE. In Mn-implanted GaAs, we have shown that, while the majority of the implanted Mn impurities occupy substitutional Ga sites, up to ˜30% occupy tetrahedral interstitial sites with As nearest neighbors [3,5]. Contrary to the general belief that interstitial Mn is removed by thermal annealing at ˜200°C [5,6], we have shown that the interstitial fraction persists above 400°C [3,5]. In Co- and Mn-implanted ZnO and GaN, in addition to the expected majority in cation sites, we have shown that significant fractions (˜20%) of the implanted Co and Mn impurities substitute the anion (O in ZnO and N in GaN) [4,6], a behavior which had never been observed or even considered theoretically before.

These results have profound implications on the current understanding of DMS materials, in terms of self-compensation mechanisms and the prospects to achieve room temperature ferromagnetism. As an outlook, we will outline how the new opportunities created by these findings will be explored at the Nuclear Solid State Physics group at IKS (KU Leuven), not only at ISOLDE but also at neutron (at ILL-Grenoble and HZB-Berlin) and synchrotron (ESRF-Grenoble and the Australian Synchrotron) facilities.

[1] T. Dietl, Nature Materials 9 (2010) 965.
[2] M. Dobrowolska, K. Tivakornsasithorn, X. Liu, J. K. Furdyna, M. Berciu, K. M. Yu, and W. Walukiewicz, Nature Materials 11 (2012) 444.
[3] L. M. C. Pereira, U. Wahl, S. Decoster, J. G. Correia, M. R. da Silva, A. Vantomme, and J. P. Araújo, Appl. Phys. Lett. 98 (2011) 201905.
[4] L. M. C. Pereira, U. Wahl, S. Decoster, J. G. Correia, L. M. Amorim, M. R. da Silva, J. P. Araújo, and A. Vantomme, Phys. Rev. B 84 (2011) 125204.
[5] L. M. C. Pereira, U. Wahl, S. Decoster, J. G. Correia, L. M. Amorim, M. R. da Silva, J. P. Araújo, and A. Vantomme, Phys. Rev. B 86 (2012) 125206.
[6] L. M. C. Pereira, U. Wahl, S. Decoster, J. G. Correia, L. M. Amorim, M. R. da Silva, J. P. Araújo, and A. Vantomme, accepted for publication in Physical Review B.

Solid State Physics / 2

Manipulation of diffusion profiles in CdTe

Author: Johannes Lehnert[1]

Co-authors: Herbert Wolf [1]; Karl Johnston [1]; Manfred Deicher [1]; Thomas Wichert [1]

[1] *Experimentalphysik, Universität des Saarlandes, 66123 Saarbrücken, Germany*

Corresponding Author: manfred.deicher@tech-phys.uni-sb.de

Radiotracer experiments are the most sensitive tool for the study of diffusion phenomena in solids. At ISOLDE/CERN diffusion experiments have been performed using the unique diversity of radiotracers delivered for implantation by ISOLDE.
It has been shown that in CdTe the group I elements Cu, Ag, Au, and Na can exhibit the phenomenon of uphill diffusion, which under suitable conditions results in the formation of symmetric concentration-depth profiles that are strongly peaked about the center of a typically several 100 µm thick crystal [1,2,3]. The phenomenon of uphill diffusion is quantitatively understood and successfully described by a theoretical model [4,5] leading to the conclusion that the dopant profile essentially images the profile of the deviation of stoichiometry generated by the diffusion of Cd-interstitials into the initially Te-rich CdTe crystal.
Uphill diffusion can be observed also at significantly lower sample temperatures down to 450 K, if metal layers are evaporated onto the implanted surface of an initially Te-rich CdTe crystal [6]. The effect is mostly pronounced in case of the Ag dopant and Cu as covering metal layer. We will present first results demonstrating that this effect can be applied to manipulate doping profiles of Ag in CdTe by diffusion resulting in 3-dimensionally structured dopant distributions embedded deeply inside the CdTe crystal.
The range of radiotracers suited for diffusion experiments has been significantly enlarged by setting up an online-diffusion chamber at ISOLDE. This chamber enables the use of isotopes having half-lives of less than 1 h and is equipped for measuring concentration profiles extending on a depth scale of up to 10 µm.
This work has been funded by the BMBF under contract 05KK7TS2.

[1] H. Wolf, F. Wagner, Th. Wichert and ISOLDE Collaboration, Phys. Rev. Lett. 94 (2005) 125901
[2] H. Wolf, F. Wagner, T Wichert, Defect and Diffusion Forum 237-240 (2005) 491.
[3] H. Wolf, F. Wagner, J. Kronenberg, Th. Wichert, and ISOLDE collaboration, Defect and Diffusion Forum 289-292 (2009) 587.
[4] H. Wolf, F. Wagner, Th. Wichert, R. Grill and E. Belas, J. Electr. Mat. 35 (2006) 1350
[5] H. Wolf, F. Wagner, J. Kronenberg, Th. Wichert, R. Grill, E. Belas, and The ISOLDE collaboration, Diffusion Fundamentals 8 (2008) 3.1-3.8.

[6] H. Wolf, J. Kronenberg, F. Wagner, M. Deicher, Th. Wichert, and ISOLDE Collabora-tion, Appl. Phys. Lett. 100, (2012) 171915.

Solid State Physics / 58

INVESTIGATION OF 111mCd AND 117Cd IN Fe DOPED TiO2 AND SnO2 THIN FILMS BY MEANS OF PERTURBED ANGULAR CORRELATION SPECTROSCOPY

Author: Juliana Marques Ramos[1]

[1] *University of São Paulo*

Fe-doped thin films of the semiconductors SnO2 and TiO2 have been measured by means of the perturbed ⊠⊠ angular correlation spectroscopy (PAC) in order to investigate the ferromagnetism and to study the electric quadrupole interactions. Important technological applications of these oxides [1,2], especially as candidates for diluted magnetic semiconductor [3] in the emerging area of spintronics, have been the chief motivation for this study. The films were deposited by sputtering process on the Si (100) substrate from a target with a purity of 99.999% and with an applied magnetic field of 500 G at the University of São Paulo and 2% of Fe were ion implanted using the ion implanter, Bonn Isotope Separator (BONIS) at the University of Bonn. The thickness of these films were 100 nm and the implantation of 111mCd or 117Cd was made at ISOLDE. The thermal treatment for the samples using 111mCd as probe nuclei was done in vacuum for 10 minutes at 873 K. The samples with 117Cd implanted underwent thermal annealing in air for 10 minutes. The hyperfine parameters were systematically studied as a function of measurement temperature. The thin films were characterized by energy dispersive spectroscopy (EDS) and scanning electron microscopy (SEM) and the results indicates that the samples were homogeneous and without impurities. The PAC results show the presence of electric quadrupole interactions for both the oxides. One of the interactions corresponds to the value of rutile for both the oxides.

New techniques / 16

Nuclear structure of exotic neutron-rich nuclei with AGATA

Author: Jose Javier Valiente Dobon[1]

[1] *LNL (INFN)*

Corresponding Author: valiente@lnl.infn.it

The European project AGATA is the result of a combined effort of many different countries and institutions to serve the future needs of the challenging experiments at new radioactive ion beam facilities. The new concept of the gamma-ray tracking spectrometer AGATA bases its excellences in being capable of identifying the gamma interaction points (pulse shape analysis) and via software in reconstructing the trajectories of the individual photons (gamma-ray tracking). This leads to abandon the Compton suppression concept and to build therefore an array where the full 4π solid angle is covered by germanium detectors, thereby obtaining much larger photopeak efficiency and peak-to-total ratio.

AGATA in its first implementation (the AGATA Demonstrator) has been coupled to the large-acceptance magnetic spectrometer PRISMA from 2009 until the end of 2011 at the Laboratori Nazionali di Legnaro (LNL) in a experimental campaign aimed, mainly, at the study of the properties of neutron-rich nuclei populated via multinucleon transfer or deep inelastic reactions. The experiments spanned from the Si neutron-rich isotopes nearby the island of inversion up to the heavy shape-transitional neutron-rich osmium isotopes. For many exotic nuclei, lifetime measurements were possible by

using the differential Recoil Distance Doppler Shift method developed for multinucleon-transfer reactions in combination with the AGATA and PRISMA spectrometers. In this presentation, some selected results on neutron-rich nuclei studied with the AGATA Demostrator at LNL will be discussed.

New techniques / 23

Status of the WITCH experiment

Author: Tomica Porobic[1]

Co-authors: Andreas Knecht [2]; Christian Weinheimer [3]; Claire Couratin [4]; Dalibor Zakoucky [5]; Etienne Liénard [4]; Ferenc Glück [6]; Gergelj Soti [1]; Gilles Ban [4]; Marcus Beck [7]; Martin Breitenfeldt [1]; Michael Tandecki [8]; Nathal Severijns [1]; Paul Finlay [1]; Peter Friedag [3]; Simon Van Gorp [9]; Valentin Kozlov [10]; Xavier Fabian [4]; Xavier Fléchard [4]

[1] *Katholieke Universiteit Leuven (BE)*

[2] *CERN*

[3] *Westfaelische Wilhelms-Universitaet Muenster (DE)*

[4] *LPC Caen*

[5] *Acad. of Sciences of the Czech Rep. (CZ)*

[6] *KIT*

[7] *Universität Mainz*

[8] *Inst. voor Kern- en Stralingsfysica - Katholieke Universiteit Le*

[9] *Inst. of Physical and Chemical Res. (JP)*

[10] *KIT - Karlsruhe Institute of Technology (DE)*

Corresponding Author: tomica.porobic@cern.ch

One of the goals of precision measurements in nuclear beta-decay is searching for deviations from the Standard Model that could point to new physics. The primary aim of WITCH experiment [1] at the ISOLDE/CERN facility is the search for a scalar interaction in beta-decay by a precise (0.5%) determination of the beta-neutrino angular correlation coefficient, a, which would constrain a possible scalar contribution to less than 10%. For that purpose, a scattering-free source made of two Penning traps is combined with a MAC-E filter to probe the energy of recoiling daughter nuclei. First daughter recoil spectrum was obtained in June 2011 in the decay of 35Ar, allowing for a first albeit still crude determination of a. In this talk, subsequent upgrades of the system and the results of the latest online run (November 2012) will be presented.

[1] M. Beck et al., Eur. Phys. J. A47(2011) 15

New techniques / 13

Lifetime measurements using DSAM with the MINIBALL set-up

Author: Michael Thurauf[1]

Co-authors: Christian Stahl [1]; Christopher Bauer [1]; Esther Sabine Bonig [1]; Joerg Leske [2]; Marcus Scheck [2]; Norbert Pietralla [3]; Stoyanka Ilieva [4]; Thorsten Kroell [1]

[1] *Technische Universitaet Darmstadt (DE)*

[2] *TU Darmstadt*

[3] *IKP, Technische Universität Darmstadt*

[4] *Technische Universität Darmstadt (DE)*

Corresponding Author: michael.thurauf@cern.ch

The transistion strengths of excited low-lying states serve as a sensitive testcase for theoretical models, such as the nuclear shell model. In the region around the doubly magic nucleus 132Sn experimental data on transition strengths and, thereby, lifetimes of the excited states are scarce. To improve the experimental situation, we determined the lifetimes of the first 2+ states in 140Ba [1] and 126Cd [2] using the Doppler-shift attenuation method (DSAM) for the first time with the MINIBALL set-up at REX-ISOLDE. Within this contribution a summary of both experiments and the analysis performed with the newly implemented DSAM code APCAD [3] will be presented. In the future, HIE-ISOLDE will give new opportunities for experiments using DSAM technics due to higher recoil velocities.

Supported by BMBF (No. 06 DA 9036I, 06 DA 9041I, 06 DA 7040, 06 DA 7047I and 06 MT 238) and EU through ENSAR (No. 262010).

[1] C. Bauer et al. Phys. Rev. C 86, 034310 (2012).
[2] M. Thürauf, Master's thesis.
[3] C. Stahl, Master's thesis.

New techniques / 19

Resonance excitation in 7Be + d reaction to study 7Li abundance anomaly

Author: Dhruba Gupta[1]

Co-author: Swapan K Saha [1]

[1] *Bose Institute*

A nuclear physics solution is searched to resolve the 7Li abundance anomaly in the cosmos. The enhancement of nuclear reaction rates by nuclear resonances plays a vital role in nuclear astrophysics. The existing contradiction between theory and observation demands more study on the resonances in 7Be(d,d) and 7Be(d,p) reactions, before invoking physics beyond the standard Big Bang Nucleosynthesis.

New techniques / 42

Solenoidal spectrometer for HIE-ISOLDE

Author: David Gareth Jenkins[1]

[1] *University of York (GB)*

Corresponding Authors: rw10@york.ac.uk, david.gareth.jenkins@cern.ch

The study of transfer reactions in inverse kinematics with radioactive beams will be a centrepiece of the programme once HIE-ISOLDE commences operation in a few years' time. There are several different approaches to such studies including the use of silicon arrays like T-REX and SHARC. An alternative is to use a solenoidal spectrometer such as HELIOS at Argonne National Laboratory. In this approach, light ions perform helical trajectories in the field of a large solenoidal magnet and are detected on axis in a compact silicon array. This leads to certain advantages over competing techniques such as the removal of kinematic compression and performing particle identification from the cyclotron period.

A project to build such a solenoidal spectrometer for HIE-ISOLDE has got off the ground over the last twelve months, with two international workshops held, and a redundant solenoid acquired from the University of Nottingham which could form a testbed system. The present status of this project will be given and highlights of the workshops in terms of Physics ideas and technical discussions will be presented.

New techniques / 37

Radiative strength of neutron-rich nuclei and its astrophysical implications

Author: Francesca Giacoppo[1]

[1] *University of Oslo*

F. Giacoppo1, L. Bernstein2, D. Bleuel2, P.A.Butler3, T. K. Eriksen1, A. Görgen1, M. Guttormsen1, T. W. Hagen1, A.C. Larsen1, H. T. Nyhus1, T. Renstrøm1, S. Rose1, S. Siem1, G.M. Tveten1, A.Voinov4, M. Wiedeking5, and J. Wilson6

1Department of Physics, University of Oslo, N-0316 Oslo, Norway
2Lawrence Livermore National Laboratory, USA
3Oliver Lodge Laboratory, University of Liverpool, United Kingdom
4Department of Physics and Astronomy, Ohio University, USA
5 iThemba LABS, South Africa
6 IPN Orsay, CNRS-IN2P3, Orsay, France

The density and width of nuclear excited states increase with excitation energy towards the particle sepa
The NLD and the RSF are fundamental input parameters for calculating nuclear reaction cross-sections and
The Oslo nuclear physics group has developed a method to determine simultaneously the NLD and the RSF from
Recently an unexpected low-energy increase in the radiative strength function of light and medium-mass nu
An experimental program to study the gamma-ray strength function of neutron reach nuclei has been recentl

[1] A. Schiller et al., Nucl. Instrum. Methods Phys. A 447, 498 (2000).
[2] A. C. Larsen et al., Phys. Rev. C 83, 034 315 (2011).
[3] A.Voinov et al., Phys. Rev. Lett. 93, 142504 (2004).
[4] M. Guttormsen et al., Phys. Rev. C 71, 044307 (2005);
[5] M. Wiedeking et al., Phys. Rev. Lett. 108, 162503 (2012).
[6] A. C. Larsen and S. Goriely, Phys. Rev. C 82, 014318 (2010).
[7] S. Siem et al. "Statistical properties of warm nuclei: Investigating the low-energy enhancement in the gamma strength function of neutron rich nuclei". Submitted proposal to INTC –October 2012

HIE-ISOLDE / 60

Physics at HIE-ISOLDE

Author: Magdalena Kowalska[1]

[1] *CERN*

Corresponding Author: kowalska@cern.ch

The HIE-ISOLDE project has met with large enthusiasm from the physics community. This is because the higher energy will allow nuclear reactions such as transfer and fusion for the first time for many exotic nuclear species, while the quality and intensity upgrades will give access to beams which could not be studied before.

In June 2010 the INTC committee has received 34 HIE-ISOLDE Letters of Intent, while in November 2012 31 full Proposals for the first state of energy increase were submitted. The major physics topics to be studies are nuclear shapes, shell evolution, halo properties, nuclear astrophysics, and even questions relevant for superheavies. The main experimental techniques are Coulomb excitation, transfer reactions, and elastic scattering. These will make use of the existing ISOLDE setups, such as MINIBALL or REX scattering chamber, those used at or planned for other facilities (MAYA and ACTAR), but also new systems to be located at ISOLDE, such as the Helical-orbit spectrometer.

The talk will summarise the physics topics and experimental setups included in the recent HIE-ISOLDE proposals and will give more details based on a few selected examples.

HIE-ISOLDE / 73

Status of the HIE ISOLDE cavity development

Corresponding Author: walter.venturini@cern.ch

The high beta accelerating cavity for the HIE ISOLDE linac is based on the Nb sputtering on copper technology pioneered at CERN for LEP2 and which was further adapted to the QWR shape in INFN-LNL in Italy. The specifications for the cavity performance are challenging, calling for 6 MV/m accelerating field and Q0 of 4.7 108, i.e. at 10 W dissipated power. A development program was launched at CERN since 2008 in order to set up a production chain for the HIE ISOLDE linac. At the end of 2012 the cavity performance reached for the first time 5 MV/m at 10 W, approaching the specifications. Even though work will still be necessary to consolidate the result and to further improve it, the present performance would already allow reaching 5.3 MeV/u up to A/q= 4/5 in phase 1 of HIE ISOLDE. The way is thus paved for a physics run already making use the first two cryo modules installed in the linac. The presentation will focus on the cavity developments in 2012 and on the next planned steps.

HIE-ISOLDE / 74

Installation and Integration of HIE ISOLDE

Corresponding Author: erwin.siesling@cern.ch

Those of you familiar with the Isolde facility surely noticed the two new buildings that arose on the east side of the Isolde experimental hall. They will house the services and infrastructure necessary for the new superconductive HIE Linac such as cooling, ventilation and cryogenics as well as the RF and other subsystems. The HIE Linac itself and the High Energy Beam Transferline in the extension of the Isolde experimental hall will be build in different phases. With the goal of physics at 5.5MeV/u from the HIE Isolde Linac in 2015 in mind the installation will take place though the CERN Long Shutdown LS1 and continue in 2014 after the LS1 period with the low energy part of the Isolde facility running in parallel. This talk will give you an insight in the different steps of installation, the changes to the existing Isolde facility and the schedule of the HIE Isolde project.

HIE-ISOLDE / 75

HIE beam commissioning planning and preparation work

Corresponding Author: davide.lanaia@cern.ch

The HIE-ISOLDE linac will start operation in 2015 with the first physics runs. The beam commissioning of the first 10 cavities of the SC linac will take place over a period of 4 to 5 months at the end of 2014 beginning of 2015. A number of preparation test are ongoing with the present REX linac beam to validate the beam diagnostics and to characterize the beam at the input of the SC linac. This presentation will review the ongoing beam test, the tuning strategy and operational software development and the beam commissioning planning.

Medium nuclei II / 46

Shape transition and coexistence in neutron-deficient rare earth nuclei: Coulomb excitation of 140Sm

Author: Malin Klintefjord[1]

Co-authors: Andreas Goergen [1]; Ann-Cecilie Larsen [2]; Burkhard Siebeck [3]; Elisa Rapisarda [4]; Francesca Giacoppo [5]; Gry Merete Tveten [1]; Magdalena Zielinska [6]; Nigel Warr [3]; Per Hoff [1]; Peter Reiter [7]; Pierre Thoele [3]; Sunniva Siem [1]; Tamas Tornyi [8]; Therese Renstrøm [1]; Wolfram Korten [9]

[1] *University of Oslo*

[2] *EPF group-Department of Physics-University of Oslo*

[3] *University of Köln*

[4] *CERN*

[5] *University of Oslo (NO)*

[6] *CEA - Centre d'Etudes de Saclay (FR)*

[7] *University Cologne, Nuclear Physics Institut*

[8] *University of Debrecen*

[9] *CEA Saclay*

Corresponding Author: andreas.gorgen@fys.uio.no

The open-shell nuclei with Z>50 and N<82 are predicted to have the largest ground-state deformation in the entire nuclear chart. The shapes are predicted to be prolate except for a small region of nuclei with Z>60 and N≈78, which are predicted to be oblate. Similar to the situation in Hg and Pb isotopes at neutron mid-shell, prolate and oblate shapes can be expected to lie close in energy for N=78 isotones at proton mid-shell. Calculations beyond the mean-field approach with the generator coordinate method predict shape coexistence and a transition from prolate to oblate ground-state shapes between 140Sm and 142Gd. We have performed a Coulomb excitation measurement with a 140Sm beam scattered on a 94Mo target in order to measure spectroscopic quadrupole moments for excited states and transition strengths between them. The ISOLDE facility has provided a quasi-pure beam of 140Sm with an average intensity of 2e5 particles per second in June/July 2012. At least three excited states in 140Sm were populated during the experiment: the 2+ and 4+ states of the ground-state band and a state at an excitation energy of 990 keV which is tentatively assigned as a second 0+ state. Such a low-lying excited 0+ state would support the predicted scenario of shape coexistence. The statistics collected during the experiment will allow analyzing differential Coulomb excitation cross sections as a function of scattering angle. Experimental details and first results from the experiment will be discussed.

Medium nuclei II / 1

Shape coexistence and shape evolution in neutron-rich A≃100 nuclei

Author: Alexandrina Petrovici[1]

[1] *IFIN-HH*

The structure of neutron-rich nuclei in the A˜100 mass region
relevant for the astrophysical r-process manifests drastic changes in some isotopic chains and often sudden variations of particular
nuclear properties have been identified. For a realistic description of the evolution in structure with increasing spin, energy, and isospin determined by shape coexistence and mixing beyond-mean-field approaches are required.

Our recent studies represent an attempt to the self-consistent description of the shape coexistence phenomena in neutron-rich A˜100 nuclei (1,2,3) within the complex Excited Vampir variational model with symmetry projection before variation using a realistic effective interaction based on the Bonn A potential in a large model space. The triple shape coexistence and the shape evolution in the N=58 Sr and Zr isotopes, the shape evolution in a chain of Zr nuclei, as well as the Gamow-Teller beta-decay properties of neutron-rich Zr nuclei will be presented.

1. A. Petrovici, K.W. Schmid, A. Faessler, J.Phys. 312, 092051 (2011).
2. A. Petrovici, K.W. Schmid, A. Faessler, Prog. Part. Nucl. Phys. 66, 287 (2011).
3. A. Petrovici, Phys. Rev. C85, 034337 (2012).

Medium nuclei II / 12

Looking at the shape transition at N=60 by safe Coulex of Sr isotopes

Author: Emmanuel Clement[1]

[1] *GANIL*

The IS451 experiment aims to investigate the shape transition at N=60 in the n-rich Sr isotopes by safe Coulomb excitation at the Miniball setup using REX. In 2007, we have investigated the N=58 nearly spherical Sr96 using a molecular extraction within an UCx primary target. A second run in 2011 focussed on the highly deformed isotopes 98Sr using at that time in-trap and in-EBIS beta decay to produce an intense secondary beam. The results of both run will be presented. New B(E2), spectrocopic quadrupole moment and new level will be shown. The shape transition will be described using electromagnetic transition and theoretical model based on the mean-field formalism.

Medium nuclei II / 41

Beta decay studies of the N=Z and waiting point nucleus 72Kr

Author: Jose Antonio Briz Monago[1]

Co-authors: Enrique Nacher Gonzalez [2]; Maria Jose Garcia Borge [3]; Olof Tengblad [1]

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

[2] *Instituto de Fisica Corpuscular (IFIC) UV-CSIC*

[3] *CERN*

Corresponding Author: jose.antonio.briz.monago@cern.ch

The N=Z nucleus 72Kr is situated in the mass region A≈70-80, where phenomena such as shape coexistence [1,2] and possibly also np pairing effects can show up. From the astrophysical point of

view, 72Kr is involved in the rp-process of stellar nucleosynthesis being a waiting point nucleus as 73Rb, next step in the one proton capture, is unbound and there is a competition between the two proton capture, one proton capture, and beta decay of 72Kr. For this reason, a good knowledge on its beta decay properties such as B(GT) and level lifetimes are of vital importance for astrophysical calculations.
Total Absorption Spectroscopy (TAS) studies have previously shown successful results on information of the shapes of the ground state of nuclei as 76Sr and 74Kr [3,4].
Our method consists of the comparison between experimental B(GT) distributions, obtained by combining the TAS measurement with precise studies of the low spin structure, and calculations performed using the self-consistent HF plus RPA method with different types of Skyrme interactions [5] for the different deformations of the ground state of the parent nucleus in the beta decay.
The conversion coefficients of the de-excitation transitions were not available and the spin-parity of the low lying states in the daughter nucleus, 72Br, was not firmly established. All this information is crucial in order to face the analysis of the TAS data so we made an experimental campaign in two steps at ISOLDE: firstly, to study the low-spin structure of 72Br by means of the 72Kr beta decay and, secondly, the TAS measurement of this decay, with the "Lucrecia"spectrometer, to obtain the B(GT) distribution.
We here report on the results obtained through the TAS measurement including the information extracted on the deformation of the ground state of 72Kr by comparing the experimental B(GT) distribution with calculations, the measured conversion coefficients of the low-lying levels in 72Br and the information obtained on its level scheme (levels spin-parities, transition multipolarities, etc$\cdots$).

[1] J.H. Hamilton et al., Phys. Rev. Lett. 32, 239 (1974)
[2] C. Chandler et al., Phys. Rev. C 56, R2924 (1997)
[3] E. Nácher et al., Phys. Rev. Lett. 92, 232501 (2004)
[4] E. Poirier et al., Phys. Rev. C 69, 034307 (2004)
[5] P. Sarriguren et al., Nucl. Phys. A658, 13 (1999) and Nucl. Phys. A691, 631 (2001)

Medium nuclei II / 76

An examination of the turbulent A = 100 region in light of (recent) experimental results (from ISOLDE)

Corresponding Author: lunney@csnsm.in2p3.fr

It's not just a coincidence that dramatic changes in nuclear deformation occur over just a few nucleons in the middle of a region defined by proton and neutron shell closures. Some of the most sudden and intense shape transitions on the chart occur in the A = 100 region bounded by the Z = 28 and 50 proton closed shells and the N = 50 and
82 neutron closed shells. These rambunctious nuclides have been studied using various experimental and theoretical approaches. This talk will introduce the turbulent, A = 100 region, citing some of the historical literature. (Mostly) recent experimental results, principally - but not exclusively - from ISOLDE, will then be presented.
A special emphasis will be placed on ground-state properties and how they complement the more specific spectroscopic probes.