Letters of intent for the DESIR facility - March 18 - 20, 2026

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GANIL Guest House

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Penning-trap mass measurements of 100-102Sn

Auteurs: PIPERADE Collaboration[None]; Pauline Ascher[1]

[1] *LP2iB*

The mass of the heaviest $N=Z$ doubly-magic nuclide, 100Sn, has never been directly measured so far. This iconic nucleus, along with its neighbouring nuclei, presents an enormous challenge for nuclear models, particularly in understanding shell closure evolution, isospin symmetry breaking and proton- neutron pairing. Additionally, $N=Z$ nuclides manifest an enhanced binding energy (known as the Wigner energy), due to the equal occupation of identical proton and neutron orbitals, making precise masses in the region crucial to deepen our understanding of this Wigner energy.
Recent beta-decay experiments as well as mass measurements gave contradictory results on the Gamow-Teller strength of the 100Sn beta decay. A precise mass measurement of 100Sn would help to solve this controversy.
Despite numerous mass measurements in this region over the last years, large uncertainties remain for some isotopes, while others have yet to be measured. In this LOI, we propose to focus on the neutron-deficient 100-102Sn isotopes. By performing the first direct mass measurements of 100Sn and 102Sn, we aim to reduce their binding energy uncertainties by more than two orders of magnitude.

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Penning-trap mass measurements of 45-47Cl

Auteurs: PIPERADE Collaboration[None]; Pauline Ascher[1]

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Studying the evolution of shell closures approaching the drip-lines is a powerful way to probe nuclear forces and refine the theoretical description of nuclear structure. The particular case of the spin-orbit $N=28$ magic number has been intensively investigated in various types of experiments. It has been suggested that the loss of magicity below 48Ca arises from a subtle interplay between proton- and neutron- induced collectivity. Indeed, at $N=28$, the proton d3/2 and s1/2 orbitals become degenerate, enabling quadrupole excitations for nuclei with $Z<20$. Moreover, when removing protons from the d3/2 orbital, the attractive residual interaction $\pi d_{3/2}-\nu f_{7/2}$ being stronger than $\pi d_{3/2}-\nu p_{3/2}$ leads to a weakening of the $N=28$ shell gap, again favouring quadrupole excitations. However, other effects such as three-body forces or the coupling to the continuum have also been suggested to play a role. Nuclear structure changes in this region remain not fully understood.
Mass spectrometry offers an alternative way to probe shell closures, by examining trends in one- and two-neutron separation energies (S_n and S_{2n}) along isotopic chains. In particular, the strength of a closure is directly related to a sudden drop in S_n and S_{2n} values, when crossing a magic number, making the masses at $N=29$ and $N=30$ especially critical. Along these isotonic chains, only the masses of K ($Z=19$) and Ar ($Z=18$) have been measured. Neutron-rich Cl have recently been measured at the LEBIT Penning Trap at MSU, but only up to $N=28$. The mass of 46Cl ($N=29$) has been measured, but the uncertainty remains large, whereas the 47Cl mass remains unmeasured.
Therefore, we propose to measure the masses of 45-47Cl, and thus probe the $N=28$ shell gap for $Z<18$ through binding energy trends, providing critical insights into the evolution of shell structure far from stability.

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Measurement of statistical properties of interest for the nucleosynthesis of p-nuclei by νp-process

Auteur: Camille Ducoin[None]

Nuclei beyond iron are mostly produced by neutron-capture processes (s-process and r-process). However, around 35 rare but stable nuclei, from 74Se to 196Hg, need another production mechanism, since they are situated on the neutron-deficient side of the stability valley. These are called p-nuclei. The main scenario for their production is photodisintegration of heavy, neutron-rich seed nuclei, in supernova environment with temperature reaching a few GK. However, this mechanism fails to explain the high abundance of some of the lightest p-nuclei, so other nucleosynthetic contributions are needed. One of the most promising scenarios is called νp-process: it consists of building the p-nuclei starting from the iron region in a proton-rich supernova environment, by proton captures helped by a neutrino flux. This flux indeed allows the late formation of neutrons and the occurrence of (n,p) reactions, by-passing the waiting points that would stop the building up of nuclei by proton capture alone.

Such process involves a large reaction network with exotic nuclei, and theory is needed to determine the corresponding reaction rates and extract the produced abundances. Theoretical calculations are usually based on the Hauser-Feshbach statistical model, where the cross sections depend on several nuclear properties such as optical potentials, level density and gamma strength.

We propose to determine the level density and gamma strength of some of the most crucial nuclei for the νp-process by applying the beta-Oslo method, where the nucleus of interest is produced by beta decay, and the consecutive gamma cascade is analyzed by TAS to extract the quantities of interest. For this purpose, we plan to use DESIR high-purity beams of radioactive nuclei and the new (NA)2STARS detection system, which couples existing arrays of scintillators already used for TAGS measurements (Rocinante, DTAS) with new LaBr3 modules that will increase the spectroscopic capacity of the device.

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Colinear LRC

Auteur: Mustapha Laatiaoui[1]

Co-auteur: Louis Lalanne [2]

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[2] *IJCLab*

The ground-state properties of atomic nuclei reflect the delicate balance between the repulsive force of the Coulomb interaction and the stabilizing force of nuclear interactions, including shell and pairing effects. Some of these properties, such as nuclear spin and electromagnetic moments, are accessible for optical spectroscopy in high-resolution mode. However, many exotic radionuclides of transition metals remain largely uncharted due to their vanishingly low production yields and the inability of conventional ISOL-type facilities to deliver samples rapidly enough for optical spectroscopy. To address these limitations in such studies, we propose combining colinear laser spectroscopy with laser resonance chromatography (LRC), a high-sensitivity technique originally developed for studying superheavy elements. At the DESIR facility, we will implement this approach and integrate it with the LASAGN beamline. The approach will exploit rare isotope beams from SPIRAL1/2 at kinetic energies of at least 30 keV to extract nuclear spins and moments at production rates that are orders of magnitude below conventional thresholds. This will enable the first-time measurement of extremely neutron-deficient, short-lived isotopes, such as ^{41}Ti and ^{47}Mn, establishing a new pathway to better understand nuclear structure in the vicinity of the proton drip line.

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Precision mass measurements of nuclei in the superheavy region

Auteur: Enrique Minaya Ramirez[1]

[1] *IJCLab*

Letters of intent submitted for the MLLTRAP collaboration

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High-precision mass measurements and high-resolution decay spectroscopy of neutron-deficient isotopes above Pb

Auteur: Enrique Minaya Ramirez[1]

[1] *IJCLab*

Letter of intent submitted from the MLLTRAP collaboration.

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Trap assisted laser resonance ionization spectroscopy for nuclear structure

Auteurs: Enrique Minaya Ramirez[1]; Louis Lalanne[2]

[1] *IJCLab*
[2] *IJCLAB*

Letter of intent submitted from the LASAGN and MLLTRAP collaborations.

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In-trap laser spectroscopy of laser cooled neutron deficient barium isotopes

Auteur: Simon LECHNER[None]

see attached

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High-precision mass measurements of laser cooled barium isotopes

Auteur: Simon LECHNER[None]

see attached

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LOIs for LASAGN

Auteur: Louis-Alexandre LALANNE[1]

Co-auteur: Ági Koszorús [2]

[1] *IPHC*

[2] *KU Leuven*

Attached are 6 LOIs for LASAGN at DESIR. Among those, 3 are for "day one" experiments targeting available SPIRAL1 beams to be studied with LASAGN phase 1 : O, F and Cl. The 3 other (P, B and Br/Kr) would be requiering beam devellopments from SPIRAL1, S3 and TULIP and LASAGN phase 2 for some of the measurments.

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Investigating shape coexistence in neutron deficient Cd isotopes

Auteur: Guillem TOCABENS[1]

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The study of shell evolution far from stability is a major focus of modern nuclear physics, such evolution is the cause of several interesting phenomena, one of which is shape coexistence. Shape coexistence can be characterized by the presence, in a narrow energy range, of several deformed nuclear configurations in the same nucleus. It is nowadays accepted that this phenomenon occurs almost in every isotope across the nuclear chart [1], but its study far from stability is fundamental in order to constrain nuclear models which aim at describing it in a microscopic approach. Recently, multiple shape coexistence was suggested to appear in ^{110}Cd and ^{112}Cd, following an extensive β-decay study performed at the TRIUMF facility using the GRIFFIN spectrometer [2]. The low-energy part of the level scheme of both isotopes was compared to beyond-mean-field calculations, and was interpreted as four rotational bands built on the first four 0^+ states, all corresponding to different shapes. In a more recent study aiming at the low-lying states in ^{106}Cd, a number of half-lives were determined using the AGATA array and the recoil distance Doppler-shift method [3]. Again, beyond-mean-field calculations predicted multiple different shapes for excited states in ^{106}Cd. Following these studies, an experiment was conducted at TRIUMF to reach more neutron-deficient Cd isotopes, namely ^{104,106}Cd. This LOI aims to extend the study of shape coexistence in Cd isotopes towards the N = Z line, closing in on region of the doubly-magic nucleus ^{100}Sn.

[1] P. E. Garrett, M. Zielińska, and E. Clément, An experimental view on shape coexistence in nuclei, Progress in Particle and Nuclear Physics 124, 103931 (2022)
[2] P.E. Garrett et al., Multiple shape coexistence in ^{110,112}Cd, Phys. Rev. Lett. 123, 142502 (2019)
[3] M. Siciliano et al., Lifetime measurements in the even-even $^{102-108}$Cd isotopes, Phys. Rev. C 104, 034320 (2021)

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Investigating shape coexistence close to ^{80}Zr

Auteur: Guillem TOCABENS[1]

[1] *IJCLab*

Nuclei in the region of ^{80}Zr have long been thought to exhibit strong nuclear deformation, and rapid changes in nuclear shape happen in this region of the nuclear chart. From spherical at N = 50, nuclei become strongly deformed in the N ≤ 40 region. Until now, studies focus on Yrast states and the observation of deformed bands in neutron-deficient Sr nuclei. Another way of studying these phenomena is through conversion electron spectroscopy, by which E0 transitions between two 0+ states can be measured. Low-lying 0^+ states and large E0 strengths are usually a hint of coexisting shapes becoming mixed [1] and their measure could very much help our understanding of the southern border of this region of deformation. Such low-lying 0^+ states have already been observed in neutron-deficient Kr and Se nuclei [2, 3] but a systematic study is still missing in Sr isotopes, approaching N = Z and the ^{80}Zr nucleus, where multiple shape coexistence is expected [4]. One low-lying 0^+ state has been observed in ^{80}Sr via ^{78}Kr(^{3}He, n) reaction at 1 MeV, but its decay to the ground-state was not [5] and could be related to a coexisting structure for which E0 information is missing. This LOI proposes to study 0^+ states in ^{82}Sr and ^{80}Sr, where E0 information is missing, down to ^{78}Sr where no such states have been observed yet and everything is to be done.

[1] P. E. Garrett, M. Zielińska, and E. Clément, An experimental view on shape coexistence in nuclei, Progress in Particle and Nuclear Physics 124, 103931 (2022)
[2] E. Clément et al., Shape coexistence in neutron deficient krypton isotopes, Phys. Rev. C 75 054313 (2007)
[3] A. Ahmed et al., Level structure of ^{70}Se, Phys. Rev. C 24 1486 (1981)
[4] T. R. Rodriguez, J. Luis Egido, Multiple shape coexistence in the nucleus ^{80}Zr, Phys. Lett. B 705 255 (2011)
[5] W. P. Alford et al., A study of the (3He, n) reaction on isotopes of krypton, Nucl. Phys. A 330-1 77 (1979)

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Trap-assisted decay spectroscopy of N = 49 isotopes

Auteur: Guillem TOCABENS[1]

[1] *IJCLab*

The ^{78}Ni region is of particular interest to better understand shell-evolution far from stability and shape coexistence phenomena occurring in the N = 40 region appear to extend to the N = 50 region [1]. Even though the N = 50 shell-closure seems to be rather robust far from stability, several observations of intruder configurations at low energy seem to indicate otherwise. First hints of shape coexistence in this region came from laser spectroscopy as a large mean-square charge radius of an isomer in ^{79}Zn was measured [2] and soon after β-decay revealed intruder states at low-energy in both ^{81}Ge and ^{82}As [3, 4]. Several low-lying isomers originating from intruder configurations are known in the region and hinder spin attribution from decay spectroscopy. This is especially true for N = 49 isotones, for which exists both a low and high-spin isomer. In this context, trap-assisted β-decay could significantly improve our understanding of the region, by providing selective decay of either the isomer or the ground state, and completing the decay schemes along N = 49 by assigning spins of low-lying states in search for intruder states.

[1] F. Nowacki, A. Poves, E. Caurier, B. Bounthong, Shape coexistence in 78Ni as the portal to the fifth island of inversion. Phys. Rev. Lett. 117, 272501 (2016)
[2] X. F. Yang, C. Wraith, L. Xie, et al., Isomer shift and magnetic moment of the long-lived 1/2+ isomer in ^{79}Zn : signature of shape-coexistence near ^{78}Ni. Phys. Rev. Lett. 116, 182502 (2016)
[3] C. Delafosse, et al., First trap-assisted decay spectroscopy of the ^{81}Ge ground state., Eur. Phys. J. A, 58(3), 51 (2022)
[4] A. Etilé, D. Verney, et al., Low-lying intruder and tensor driven structures in ^{82}As revealed by β-decay at a new movable-tape-based experimental setup., Physical Review C 91, 064317, 06 (2015)

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Searching for β-decaying isomers in neutron-deficient Pd isotopes

Auteur: Guillem TOCABENS[1]

[1] *IJCLab*

The region of neutron-deficient isotopes around the N = 50 shell-closure is a region where several very interesting nuclear structure phenomena occur. For example, a large number of high-spin, β-decaying isomers develop at high energy in the region south-west of ^{100}Sn, due to the large overlap between protons and neutron holes in the $g_{9/2}$ orbital. A summary of already observed spin-gap isomers can be found in [1], and shows the last known β-decaying isomer in Pd isotopes is in ^{95}Pd, with some high-spins isomers also observed in ^{94}Pd, but no β-branch observed. Such isomers offer a highly sensitive means of probing p-n interaction in the region. Once found using β-decay studies (either at DESIR using TULIP/S3 beams or as a first step directly at S3-LEB using IDEAS3), one can use the information to help further β-decay studies of Pd isotopes. Indeed, one of the capabilities DESIR will offer is the use of a Penning-trap before the decay station in order to separate isomers and study their decay. This LOI serves as a first step to trigger a trap-assisted β-decay program at DESIR to study the region south-west of ^{100}Sn. Pd isotopes are very interesting in that regard as high-spin β-decaying isomers are still to be observed reaching the N = Z line but are predicted and observed down to ^{95}Pd, and trap-assisted decay spectroscopy is not widely used in general, and in this region *a fortiori*.

[1] T. Faestermann, M. Górska, H. Grawe, The structure of ^{100}Sn and neighbouring nuclei, Progress in Particle and Nuclear Physics 69 85 (2013)

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Precision measurement of superallowed 0+⟶0+ beta decay observables in 70Br and 74Rb to constrain isospin symmetry breaking corrections relevant for precision tests of the Standard Model

Auteur: Bernadette Rebeiro[1]

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In attached document

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Total absorption gamma spectroscopy and beta energy spectrum shape measurement of PET-relevant medical radioisotopes

Auteur: Bernadette Rebeiro[1]

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Details in attached document

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Commissioning of the HINA Setup for In-Trap Decay Spectroscopy with 19Ne

Auteur: Sarah NAIMI[1]

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The HINA project (Highly Charged Ions for Nuclear Physics and Astrophysics) aims to develop in-trap decay spectroscopy of highly charged radioactive ions as a new experimental approach for nuclear physics and astrophysics studies. The method relies on storing HCIs in an electron-beam ion trap (EBIT) and observing their decay under well-defined atomic conditions, enabling studies of nuclear decay properties and atomic-nuclear effects.
We propose a Day-1 experiment at the DESIR facility using a 19Ne beam to validate the in-trap decay method with the HINA-EBIT setup. In addition, stable Ne ions will be used as reference species. The experimental approach is based on measuring ion storage lifetimes, which are determined by the competition between nuclear decay and charge-exchange processes with the residual gas. The measurements will rely on X-ray detection following dielectronic recombination induced by the EBIT electron beam.
19Ne is a suitable benchmark nucleus due to its well-known β+ decay properties, appropriate half-life, and expected availability at DESIR from SPIRAL1. This first experiment is primarily methodological and will demonstrate charge breeding, trapping, storage, X-ray-based lifetime measurements, and background conditions.
The results will validate the experimental concept of the HINA setup and establish the technical basis for future decay studies with exotic highly charged ions at DESIR.

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Penning trap measurement of the mass of 32Ar

Auteur: Mathias GERBAUX[1]

[1] *LP2iB - Université de Bordeaux*

Considering that isospin is a good symmetry, broken mainly by electromagnetic effects, E. P. Wigner introduced the isobaric mass multiplet equation (IMME) to describe how the masses of isobaric analog states (IAS) of a given multiplet vary with isospin projection (i.e. difference between proton and neutron numbers). For a set of IAS with the same mass number A, total isospin T, but different Tz, the IMME simply states that $M(A,T,Tz)=a+bTz+cTz^2$ where Tz=A/2-Z. This remarkably simple formula holds very well throughout the nuclear chart but however fails in a few specific cases including the A=32, T=2 quintet. This has been extensively studied both experimentally and theoretically and it is commonly accepted that the breakdown of the IMME comes from isospin mixing of the T=2 states with nearby T=1 states. Some discrepancies nonetheless remain between different calculations and better experimental inputs are thus still useful. The ground state of 32Ar being the less precisely known member of the quintet with a 1.8 keV uncertainty is the primary objective of this LoI. We aim at reducing that uncertainty by a factor 5 to 10. The second lesser-known member of the quintet is 32Cl which is also abundantly produced at SPIRAL1. Even though the precision on its mass is already quite good (600 eV), it could still be improved with the PI-ICR technique available at PIPERADE. The same applies to the third lesser-known member, 32Si that will be accessible through in-trap decay if beams of 32Al or 32Mg are available by the time when the experiment is performed.

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The MORA Experiment: Measuring the Time-Reversal Odd D Correlation in Nuclear Beta Decay

Auteur: Pierre DELAHAYE[1]

[1] *GANIL*

Why are we living in a world made of matter? The "Matter's Origin from RadioActivity"(MORA) experiment [1] is looking for answers. CP violation is one of the three famous Sakharov conditions needed for explaining the matter –antimatter imbalance observed in the Universe [2]. The measurement of the CP violating D correlation in the beta decay of trapped and laser polarized 23Mg+ and 39Ca+ ions, as proposed in the framework of MORA, complements the search for Electric Dipole Moments to look for new interactions, that would explain this imbalance [3].
MORA employs an innovative polarization technique, combining the high efficiency of ion trapping with that of laser orientation. The experiment is currently taking data using 23Mg+ beams from the IGISOL facility, at the University of Jyväskylä, Finland, where the proof-of-principle for the laser polarization technique has recently been achieved [4]. This validation, along with recent advancements in beam purity, will enable MORA to measure the D correlation to a precision of 5·10-4 in the coming years - rivaling the best current limits from neutron decay [5].
The potential of 39Ca+ to further enhance these measurements is being explored through the ANR-funded ACCLAIM MORA project. By utilizing both isotopes at DESIR - delivered as high intensity beams (> 107 pps) from the GANIL/SPIRAL 1 facility and purified by the HRS - MORA aims to push sensitivities for D to ~10-5, venturing into uncharted territory. At this level, MORA will not only by probe CP-violating effects via the D correlation but also investigate CP –conserving new physics through Final State Interactions [6].
The MORA project is supported by ANR under contract number ANR-25-CE31-4222.
[1] P. Delahaye, E. Liénard, I. Moore et al., "The MORA project," Hyp. Int. 240(2019)63. *
[2] A. D. Sakharov, "Violation of CP invariance, C asymmetry, and baryon asymetry of the universe," JETP Letters, 5(1967)24.
[3] A. Falkowski and A. Rodriguez-Sanchez, "On the sensitivity of the D parameter to new physics", (2022)," Eur. Phys. J. C 82(2022)1134. *
[4] N. Goyal et al. , "Performance of the MORA apparatus for testing time-reversal invariance in nuclear beta decay", Eur. Phys. J. A 61(2025)221*[5] H. P. Mumm et al., "New Limit on Time-Reversal Violation in Beta Decay," PRL107(2011)102301.*
[6] E. Alviani and A. Falkowski, "On the Coulomb corrections in nuclear beta decay", arXiv:2412.17702 [hep-ph]
Articles marked with an asterik are articles from the MORA collaboration.

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P,T violation in actinide molecules

Auteur: Afonso SIMOES DOS SANTOS VICENTE[1]

Co-auteurs: Antoine De Roubin [2]; Daniel Comparat [3]; Hans Lignier [3]; Louis-Alexandre Lalanne [1]; Pierre Delahaye [4]; Rafael Ferrer [5]; Serge Franchoo [1]; Vladimir Manea [1]

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[3] *Laboratoire Aimé Cotton-CNRS*
[4] *Ganil*
[5] *KU Leuven*

Radioactive molecules have emerged as precision probes for the violation of fundamental symmetries. Those containing actinides produced at S3 possibly offer an unprecedented sensitivity to parity and time-reversal violation. The ambient temperature of molecules interacting with a laser beam, however, masks any sensitivity to fundamental symmetries. Making use of the Reglis gas cell at the S3 Low Energy Branch, we are now able to produce cold molecules below 20 kelvin within a supersonic gas jet. This approach provides an essential intermediate step toward the millikelvin regime achievable through laser cooling. We are now working on the controlled production of these radioactive molecules by means of improved gas purification and implementation of electrical fields in the gas cell.

Before a high-precision experiment can take place neutralization of the molecules and further cooling through subsequent implantation in a cryogenic solid matrix and/or collection in a magneto-optical trap will be needed. Such an experiment would necessarily take place at Desir, where the particles can be collected under well-understood conditions of background, whilst assuring the coherence of the sample and ultimately reaching the sensitivity that would allow to improve the present limits on symmetry violations.

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EC on H-,He and Li-like 37Ar, 64Cu and 68Ga

Auteur: Michele SGUAZZIN[1]

[1] *IJCLab - CNRS*

In-trap decay spectroscopy of highly charged ions (HCIs) is the main objective of the HINA (Highly Charged Ions for Nuclear Physics and Astrophysics) project, which aims to exploit a dedicated setup combining an Electron Beam Ion Trap (EBIT) and an electrostatic trap to produce, confine, and study the decay of HCIs. In such systems, where only a few bound electrons remain, electron-capture (EC) decay rates can differ from those of neutral atoms due to the hyperfine interaction providing unique insights into nuclear structure and decay processes relevant to nuclear astrophysics.
Following the day-1 experiment of the HINA experiment, we propose the first investigation of the EC decay rate of H-, He- and Li-like in ^{37}Ar, ^{64}Cu and ^{68}Ga using in-trap decay spectroscopy. The first objective is to confirm the theoretical prediction of decay rate in such a system [1,2].
If a sufficient amount of H-like ions can be produced and good vacuum conditions allow it, we aim to measure the half-life of H-like ^{37}Ar, which will have direct implications in the modelling of Galactic Cosmic Rays (GCR) propagation in our Galaxy.
The second candidate, ^{64}Cu, represents an interesting case of hyperfine-controlled electron-capture decay in hydrogen-like ions, where the EC decay can be almost completely suppressed, leading to lifetimes of order magnitude longer than in the neutral atom, having a half-life of 12.7 h. Although the EBIT electron beam cannot coherently drive hyperfine transitions, it can induce collisional hyperfine mixing, effectively quenching long-lived hyperfine states and enabling the observation of electron-capture decay. Since the branching ratio for EC is 43%, the challenge would be to distinguish this latter from β+ (17%) and β- (40%) decays. Since Q β- is very low, we expect to trap the daughter nucleus ^{64}Zn and therefore be able to distinguish this decay rate. Since β+ decay rate should not change, we should be able to deduce indirectly EC decay rate.
The third candidate ^{68}Ga having a branching ratio for EC of 10% might be the most challenging.
The measurements will rely on X-ray detection following dielectronic recombination induced in the EBIT by the electron beam or, in the electrostatic trap of the set-up employing the signal induced on a pick-up electrode by the confined ions.

[1] Z. Patyk et al, Orbital electron capture decay of hydrogen- and helium-like ions, PRC77 (2008)
[2] K. Siegień-Iwaniuk and Z. Patyk, Nuclear electron capture in Li-like ions, Phys. Rev. C 84 (2011)

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Commissioning Highly Charged Ions Collinear Laser Spectroscopy on 36,38,40Ar^{5+,6+}

Auteur: Michele SGUAZZIN[1]

[1] *IJCLab - CNRS*

The installation of the HINA (Highly Charged Ions for Nuclear Physics and Astrophysics) project and the related Electron Beam Ion Trap (EBIT) will represent a unique opportunity to access spectroscopy studies on highly charged ions. Our aim at the DESIR facility is to combine the availability of highly charged ions (HCIs) with the existing collinear laser spectroscopy (CLS) setup, LUMIERE/LASAGN, to perform high-precision nuclear measurements of isotope shifts and extract observables such as nuclear charge radii.

To study the feasibility of this method at DESIR, we propose a first laser spectroscopy measurement on highly charged stable argon isotopes $^{36,38,40}Ar^{5+,6+}$. These nuclei can be easily produced at SPIRAL1, while the 5^+ and 6^+ charge states can be rapidly populated by the EBIT developed within the HINA framework. The experimental procedure will rely on three main phases: injection of singly charged ions into the trap, the charge breeding process, extraction (pulsed or continuous) from the EBIT, and final transmission to LUMIERE/LASAGN.

Stable argon nuclei in the 5^+ and 6^+ charge states represent an ideal commissioning case. They combine accessible optical transitions with moderate electronic complexity, and their high production intensities provide reliable beams suitable for investigating HCIs production and transmission efficiencies to LUMIERE/LASAGN. Comparing different charge states enhances sensitivity to nuclear and isotope shifts, and the availability of extensive benchmark data will allow direct comparison with the obtained results.
The results will validate the experimental concept and the synergy between HCI production and collinear laser spectroscopy at DESIR, opening future opportunities for studies of HCI laser spectroscopy on short-lived nuclei.

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Trap-assisted laser spectroscopy and mass spectrometry of neutron-deficient platinum and iridium isotopes

Auteur: Vladimir MANEA[1]

[1] *IJCLab-IN2P3-CNRS*

In the last two decades, there have been significant advances in the laser spectroscopy of neutron-deficient nuclides around the lead isotopic chain (a recent view of the extent of the gathered data can be found in [1]). These measurements have revealed a rich and quickly shifting landscape, with the charge radii exhibiting sudden jumps and oscillations with the variation of neutron number as in the gold (Z = 79) and mercury (Z = 80) isotopic chains, signaling a competition between markedly different nuclear structures which are quasi-degenerate in energy. The first extension of the data below the neutron midshell in the two chains suggests a lifting of this quasi-degeneracy and a return to a droplet-type trend of charge radii ([1], [2]). The refractory character of elements with lower proton number (Z < 79) has however prevented an expansion of the studies towards the proton midshell, with the only successful measurements following a collection-decay-desorption method from a mercury primary beam (the COMPLIS experiment [3]). It remains unclear how this picture evolves toward the proton dripline, where the droplet-like trends still need confirmation. It is also unclear what happens closer to the proton midshell, where full nuclear collectivity is expected to emerge.

With its intense primary beams and gas-cell method, the S3 spectrometer offers a promising alternative for the study of refractory elements, using fusion-evaporation reactions that favor the production of very neutron-deficient isotopes and gas-flow-based extraction which is not affected by the elements'refractory character. The very good spectral resolution of the gas-jet laser ionization and spectroscopy technique [4] offers an additional strength to study odd isotopes with complicated hyperfine structures, without sacrificing the simplicity of the in-source laser-spectroscopy technique.

In this Letter of Intent, we propose a program to study the refractory elements platinum and iridium combining the strengths of the S3-LEB and DESIR facilities. The isotopes of interest can be produced by a range of reactions, including 58,60Ni on an enriched or natural Sn target, both components of which will be available in the first years of the S3 operation. Isotopes having no long-lived isomeric states can be studied directly with S3-LEB and the PILGRIM mass spectrometer or the SEASON decay station. Isotopes with very low-lying isomers, such as 168-176Ir would be detected using the PI-ICR technique at the DESIR Penning-trap installations, which would allow both an individual determination of their hyperfine structure and first-time mass measurements. In addition, high-resolution alpha spectroscopy can be performed on the isotopes of Ir using the in-trap development of a DESIR Penning-trap mass spectrometer. As shown in [5], the combination of high-resolution mass spectrometry and laser spectroscopy can be crucial for the correct assignment of the ground-state charge radius. The sensitivity of the PI-ICR technique would be key if the high-spin and low-spin states of the Ir isotopes are populated very asymmetrically in the reaction. DESIR could also benefit the program by opting for a broadband production method (with a natural Sn target) and exploiting the powerful separation capability of the HRS. Although clearly stepwise and long-term, this program can help develop through the beams of refractory elements a unique niche of production and research for the broader S3-LEB/DESIR programs.

[1] J. Cubiss et al., Phys. Rev. Lett. 131, 202501 (2023).
[2] B. Marsh et al., Nature Physics 14, 1163{1167 (2018)
[3] J. Sauvage et al., Hyperfine Interactions 129, 303–317 (2000)
[4] R. Ferrer et al., Nat. Comm. 8, 14520 (2017)
[5] J. Cubiss et al., Phys. Rev. C 102, 044332 (2020)

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Probing octupole deformation limits in neutron-deficient actinides at DESIR

Auteur: Emmanuel Rey-herme[1]

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The study of octupole deformation in atomic nuclei provides crucial insight into nuclear structure at the limits of stability. While the octupole deformation region centered at Z~88, N~136 has been well established experimentally, the question of its extent remains open, especially at higher Z. Experimental measurements in this region would help establish the boundaries of octupole collectivity as proton number increases.
The DESIR facility, coupled with the opportunities offered by S3 beams, offers a unique opportunity to investigate neutron-deficient actinides through complementary measurement techniques. The combination of high-precision mass measurements (PIPERADE), laser spectroscopy (S3-LEB or LASAGN), and decay spectroscopy (SEASON) will provide a comprehensive characterization of nuclear structure in this unexplored region.
For californium isotopes, fusion-evaporation reactions using ^{36}S beams on natural lead targets can access $^{239-243}$Cf, with production rates of several ions per second expected after S3-LEB. These isotopes lie in the predicted octupole-deformed region (N=136-140), where theory suggests significant gains in binding energy (~1-1.5 MeV) due to octupole correlations. Signatures of octupole deformation have already been found in neutron-deficient actinides through charge radii measurements compared with theoretical predictions. Similarly, alpha-decay spectroscopy has been used to study fine structure transitions populating low-lying octupole states, providing signatures of reflection-asymmetric shapes. The combination of those three techniques can thus provide key information to theoretical models and help pinpoint the precise extent of the region of deformation.
This experimental program will map the extent of octupole deformation in the neutron-deficient actinides, testing theoretical predictions and advancing our understanding of exotic nuclear shapes far from stability.

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Moments of excited states with DESIR

Auteur: Radomira Lozeva[1]

[1] *IJCLab, CNRS*

Online text: Nuclear moments of excited states are proposed to be measured with the DESIR facility, on light to heavy neutron-deficient isotopes with SPIRAL1 and S3-LEB beams. Experiments may be performed after beam bunching using e.g. GPIB, purification and/or e.g. MR-TOF-MS device and employment of both IPAC and TDPAC techniques using an adapted gSPEC device in standalone mode, or in combination with existing/foreseen devices. Specific isotopes of interest span from Nb-Mo nuclei up to Sb nuclei in the vicinity of 100Sn. The newly-developed beams, including Te, would further enlarge the scope of such measurements.

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Gamma and particle measurement of the beta decay of 20-Mg

Auteur: Iolanda MATEA MACOVEI[1]

[1] *IJCLab*

Two reactions important for the CNO cycle break-out to rapid proton capture process in type I x-ray can profit from the
measurement of beta-delayed particle emission from GS of 20-Mg : 15-O(a,g)19-Ne and 19-Ne(p, g)20-Na.
19-Ne(p, g)20-Na : the resonance at Er = 457keV (E* = 2647keV in 20Na) in the Gamow window is populated by beta decay of 20-
Mg. From previous measurements, upper limits for the population of the state were reported and a lower limit for logft suggests that
the spin of the state has a value higher than 1.
15-O(a,g)19-Ne : following beta-proton decay, an excited state at 4.033 MeV in 19-Ne is populated. The astrophysical reaction is
dominated by a resonance at 4.03 MeV in 19-Ne at the temperatures of CNO-cycle break-out in type I x-ray bursts. The resonance
energy is known , but the strength is not measured. The observation in decay spectroscopy of an alpha branch from this state along
with the its known lifetime would allow to determine the resonance strength.
The most recent measurements of the beta decay of 20-Mg were done using a cocktail of fragmented 24Mg beam at NSCL and the
decaying nuclei were implated in a thick plastic detector. The production rate of 20-Mg was about 5kHz, and 20-Mg was about 35 %
out of the implanted cocktail-beam. Only beta and gamma emissions were measured.

Using SPIRAL1 20-Mg beam, DESIR purification facilities and DESIR Spectroscopy Decay station (with beta, gamma and charged
particle detection), one can provide a cleaner and more complete spectroscopy of 20-Mg decay.

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Decay of states near particle emission threshold in even 38,40-S isotopes populated by beta decay (+structure studies in the odd Sulfur isotopes 37,39 from beta decay of Phosphore)

Auteur: Iolanda MATEA MACOVEI[1]

[1] *IJCLab*

GT beta-decay to 1- states in 38- and 40-S can take place if the GS spin of the parent nuclei is 2-. This is why

the present proposal should be considered with the one concerning the measurements of GS spins with LASAGNE.
The Q-beta window for the decay of 38- and 40-P is 12.2 and 14.7 MeV, respectively, well above the neutron emission
threshold (Q-beta-n of 4.2 and 7 MeV, respectively). The beta-spectroscopy of 38P is quite poorly known. For 40-S, the
spectroscopy is reacher, but spin and parities are uncertain. No gamma transition from states with possible 1- spin and
parity to GS are measured.
This experiment is intented to complete the spectroscopy of beta decay with a particular attention eventual population of
high lying states decaying by dipole radiation to the GS or low excited 2+ states.
(considering also structure studies in the sulfur isotopes from beta decay of odd A Phosphore)

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Destruction of 26Al studies by beta decay of 27P->27Si

Auteur: Iolanda MATEA MACOVEI[1]

[1] *IJCLab*

Improved beta-proton spectroscopy of 27P. Application to the Al26(p,g)Si27 reaction (astrophysical motivation)

Beam intensity > 10 pps
Tape station + charged particle detection
gamma detection

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Elucidating the transition in shell structure and deformation from the doubly-magic 100Sn to the Isospin-Symmetric Island of Inversion around 80Zr with laser spectroscopy of neutron-deficient Pd

Auteur: Sarina Geldhof[1]

[1] *GANIL*

The neutron-deficient region below the heaviest doubly-magic N=Z nucleus 100Sn provides a rich and important testing ground for nuclear structure effects, from shell closures and the evolution of deformation and single-particle behaviour moving away from them, to neutron-proton pairing around the N=Z line. It has thus attracted significant interest in recent years, with measurements of several ground- and isomeric-state properties performed at various facilities worldwide [1-3,5]. Mass measurements have crossed the N=50 shell closure in some chains in the region [2], certain up to the N=Z line. Laser spectroscopy studies beyond N=50 in this region are however currently limited to the silver chain, where a surprisingly large kink in the charge radii was observed when crossing the shell closure [3]. This is in contrast to the behaviour across N=50 in lighter nuclei such as Mo, located closer to the so-called "Isospin-Symmetric Island of Inversion"around 80Zr [4]. The palladium chain is located right in the middle between the two N=Z nuclei 100Sn and 80Zr.
As the S3 spectrometer will be well suited for the production of RIBs in this region, several LOIs have already been proposed for laser spectroscopy measurements in the gas jet environment of the S3-Low Energy Branch. The Pd chain poses a particular challenge, as no resonant laser ionisation scheme with sensitivity to the nuclear parameters has been found so far. Due to the electronic structure, any transition from the atomic ground state will display none or barely any isotope shifts, making charge radii measurements in the gas jet (near) impossible.

In a collinear beamline, however, such as the LASAGN setup foreseen in the DESIR facility, this limitation can be overcome by populating metastable states in a charge-exchange cell and performing spectroscopy from these states. This strategy has enabled isotope shift and hyperfine structure measurements in the Pd chain at the IGISOL facility over the past years, down to 98Pd [5]. Taking advantage of the higher production rates at S3, we propose to extend these measurements across the N=50 shell closure, possibly down to the N=Z 92Pd nucleus. This would permit studying the evolution of the kink in the charge radii across N=50 when moving away from Z=50, and add clarity on the transition from the region around the doubly magic 100Sn nucleus towards the "Isospin-Symmetric Island of Inversion"around 80Zr.

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ARGOS –a nuclear spin orientation setup for electromagnetic moment- and nuclear spin studies

Auteur: Georgi Georgiev[1]

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Nuclear electromagnetic moments provide key information for a deeper understanding of nuclear structure. Magnetic dipole moments are highly sensitive to the single-particle configurations of nuclei, while electric quadrupole moments are fingerprints of the nuclear deformation. Furthermore, reliable determination of spin and parity assignments is essential for interpreting nuclear structure. All these studies rely on obtaining information about nuclear spin orientation. This can be achieved either by orienting the entire nuclear ensemble through polarization or alignment, or by exploiting angular correlations such as β–γ or γ–γ correlations for the nuclear states of interest.
The experimental requirements for nuclear moment and spin determination studies can be combined within a single setup. The ARGOS (Array for β and γ Radiation Geometry and Spin studies) system is foreseen to integrate an array of $LaBr_3$ detectors, a permanent magnet providing a homogeneous magnetic field of up to 0.4 T, and a host ladder enabling rapid exchange of implantation media. The design concept of the setup will be presented together with its expected performance. Requirements on beam characteristics and the first envisaged physics cases will be discussed as well.

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Mass evolution at the extreme neutron deficient-side of the N=82 shell in the Lu, Yb and Tm isotopic chains

Auteur: Antoine de Roubin[1]

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Abstract:
Since the beginning of this decade, investigation near the proton dripline has regained interest thanks to the recent advancements in terms of neutron deficient radioactive ion beam production and continuous development of low energy apparatus dedicated to high-precision measurements. Among them, Penning-trap mass spectrometers offer a way to experimentally determine the exact localization of the proton dripline by extracting proton separation energies. Such measurements are crucial for testing predictive capabilities of nuclear theories. They have also proven to be useful in studying changes in the nuclear structure shell closure towards driplines, where shells can weaken or disappear giving rise to new magic numbers [1,2].

Recently, significant efforts have been put at TRIUMF using TITAN's multi-reflection time-of-flight mass spectrometer to perform high-precision mass measurements in the N = 82 vicinity in the ytterbium [2] and thulium [3] isotopic chains. However, this region of the nuclear chart is known to be the host of several low-lying isomeric states. The presence of such isomers can somewhat limit the precision of mass measurements due to contamination issues, preventing a complete interpretation of the experimental results.
We propose here to investigate the mass evolution in the neutron deficient lutetium, ytterbium and thulium isotopic chains combining the strengths of the S3LEB and PIPERADE/MLLTRAP apparatus, located in the S3 and DESIR experimental areas, respectively. The isotopes of interest can be produced at S3 using, for instance, a nickel primary beam on various targets, like Mo or Ru. The future mass measurements discussed here will require the use of the PI-ICR technique [4] at the DESIR Penning-trap installations which will allow enough resolving power to separate ground-states from the low-lying isomeric states. Additionally, the laser spectroscopy capabilities of S3LEB, when coupled with the PI-ICR technique, will enable unambiguous identification of ground and isomeric states, ensuring robust and interpretable results.

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Total Absorption Gamma-ray Spectroscopy of waiting points of the rp-process of nucleosynthesis with the new STARS array

Auteur: Muriel Fallot[1]

Co-auteurs: Alejandro Algora [2]; Jean-Charles Thomas [3]

[1] *Subatech*

[2] *IFIC*

[3] *GANIL*

Total Absorption Gamma-ray Spectroscopy of waiting points of the rp-process of nucleosynthesis with the new STARS array

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Beta-delayed (multi-)proton emission at DESIR

Auteur: Jérôme Giovinazzo[1]

Co-auteur: Emmanuel Rey-Herme [2]

[1] *LP2IB (CENBG) CNRS / Univ. Bordeaux*

[2] *CEA Saclay*

The study of the beta-delayed two-proton (β–2p) emission is an important tool to obtain direct information about the structure of proton-rich nuclei. This exotic decay can be either a sequential emission via an intermediate state or a simultaneous emission of the two protons. Up to now, the 2p direct branch has never been evidenced. Recently, a silicon cube, a high-efficiency charged-particle detector, has been developed to search for such correlated 2p emission.
With a detection set-up such as SEASON or the Silicon Cube previously developed, the study of several or other β–2p candidates like ^{22}Al, ^{23}Si, ^{26}P, ^{27}S, ^{31}Ar, ^{35}Ca, ^{43}Cr, $\cdots$will be possible at the DESIR facility with beams from SPIRAL1 or S3-LEB.

The one-proton emission also allows to address many questions for nuclei close to the drip-line: first estimates of atomic masses and Coulomb displacement energy, structure and deformation from the B(GT) distribution over a large Q_{EC} window, etc. In addition, with gamma detection (such as foreseen for BESTIOL or EXOGAM), the competition between gamma and proton de-excitation can be addressed for astrophysical interests (resonances close to emission threshold) and to test the isospin mixing in populated states.
The achievable topics and precisions highly depend on the production rate (at detection point). Typically, a minimum of the order of 1 Hz is expected. From the isotopes mentioned above, most will not be available when the DESIR facility will start receiving beams. Only ^{22}Al, ^{31}Ar and possibly ^{26}P may be accessible. ^{31}Ar has already been studied in detail in previous works, and could be considered for testing the detection setup and related analysis. For ^{22}Al and ^{26}P, no detailed decay scheme is known and they are good candidates for the proposed measurements.

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Constraining key reaction rates for Supernovae and Neutron Stars with Total Absorption Gamma-ray Spectroscopy with the new STARS array

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Co-auteur: Jean-Charles Thomas [2]

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Constraining key reaction rates for Supernovae and Neutron Stars with Total Absorption Gamma-ray Spectroscopy with the new STARS array

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Constraining key reaction rates of the rp-process with Total Absorption Gamma-ray Spectroscopy with the new STARS array

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Constraining key reaction rates of the rp-process with Total Absorption Gamma-ray Spectroscopy with the new STARS array

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Search for cluster radioactivity from barium isotopes

Auteur: Bertram Blank[1]

[1] *LP2i Bordeaux*

Cluster radioactivity can be understood as a phenomenon between alpha decay and fission, a kind of very asymmetric fission. This radioactivity has been observed for the first time in the 1980s in the decay of 223Ra [1]. Since then cluster emission in more than 20 heavy nuclei has been experimentally evidenced [2]. However, all these cases have daughter nuclei in the close vicinity of doubly-magic 208Pb. With a daughter nucleus in the direct vicinity of a doubly-magic nucleus, the Q value for cluster emission is increased and the cluster decay probability increases compared to alpha decay.
A new region of cluster radioactivity was proposed above doubly-magic 100Sn. The isotopes 112Ba and 114Ba are, according to theoretical predictions, the best candidates to search for cluster radioactivity in this new region of the chart of nuclei by the emission of 12C clusters. However, even in this favourable case, the branching ratio of cluster radioactivity is as small as 10-4 to 10-7 per decay. Therefore, the first step in the search for cluster radioactivity in the 100Sn region is to measure precisely the triple alpha decay energies. For the decay of 114Ba, these alpha energies have already been measured with precisions between 10 and 40 keV. However, more precision is needed to improve the predicting power of models. For 112Ba, no experimental information exists. After the successful measurement of these alpha decay energies, searches for cluster radioactivity can be sought of. During these experiments, the masses of 112Ba and 114Ba will be measured.
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Spectroscopy of state-selected 94Ag isotopes

Auteur: Bertram Blank[1]

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The isotope 94Ag has three long-lived states [1,2,3,4]: the ground state (T1/2 = 26 ms), a first long-lived (7+) isomer (T1/2 = 550 ms, E*= 1350(400) keV), and second long-lived (21+) isomer (T1/2 = 400 ms, E* = 7-8 MeV). The (21+) isomer is of particular interest, because it is said to decay by (i) beta-decay and a long gamma-ray cascade [1], (ii) beta-p decay (BR ≈ 20%) [2], (iii) direct one-proton emission (BR ≈ 2-4 %) [3], and (iv) direct two-proton emission (BR = 0.5(3)%) [4]. However, one of the two direct one-proton decay channels could not been observed in a subsequent experiment [5]. In addition and more important, the 2p decay channel was not observed at all in this second experiment [5]. Mass measurements also pointed to inconsistencies in the proposed decay scheme [6,7].
The aim of the present Letter of intent is to produce 94Ag by a fusion-evaporation reaction (40Ca (4.8 MeV/u) on a 58Ni target) and select the 21+ isomeric state with PIPERADE. The isomerically pure 94Ag(m) will be implanted in the catcher foil of the Silicon cube detector, where the decay protons will be detected with 6 DSSSDs and the gamma rays with four high-efficiency germanium detectors. The experiment will allow the first time to perform decay spectroscopy with ultra clean samples, unlike previous spectroscopy experiments, and clarify the existence or not of the above mentioned decay channel.
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Beyond-neutron-threshold structure investigations in the N=20 & 28 regions via beta-delayed spectroscopy techniques

Auteur: David Verney[1]

[1] *IJCLab*

Abstract:
The discovery of β-delayed neutron emission is almost as old as that of nuclear fission itself. In 1939, Roberts et al. [1] reported neutron emission persisting for more than a minute after the end of irradiation of a bottle containing roughly 100 g of uranium nitride. It was later recognized that this process plays a pivotal role both in nucleosynthesis, in particular the r-process, and in reactor kinetics, where controllability relies crucially on the presence of a delayed neutron population [2]. Yet, nearly nine decades after its discovery, no fully microscopic theory exists that can describe this key phenomenon end-to-end, from the β decay of the precursor to the complete energy spectra of all emitted products. Indeed, β-delayed neutron emission was incorporated almost immediately by Bohr and Wheeler into their liquid-drop description, and since that early era the process has remained, to a large extent, walled within the same paradigm. It is commonly framed as a two-step mechanism: first, β decay populates a "compound-nucleus"configuration in the Bohr sense; second, the subsequent de-excitation is governed by purely statistical laws [3]. Within this viewpoint, it is widely assumed that the system rapidly loses the structural memory of the β-decaying state, so that the final emissions do not depend on it.
Over the past few years, however, a growing body of observations has revealed strongly non-statistical behavior in radioactive decay, placing this picture under severe strain. Several of these findings were initiated at ALTO in the N=50 region, through (i) the pronounced oscillations of Pn values along the gallium chain for N>50 [4], (ii) γ/neutron competition persisting at spectacular "altitudes", far more than 1 MeV above the neutron separation threshold [5], and more recently (iii) in the N=82 region, through the wholly unexpected observation of delayed-neutron emission within one of the narrowest Qβn windows in the nuclear chart (the decay of 126Cd, with Qβn=85±3 keV) [6]. These breakthroughs were achieved in an ISOL-production mode context, using sources collected on a movable tape and specialized instrumentation such as the TETRA 3He neutron counter, essentially free of an intrinsic detection-energy threshold, and the PARIS γ-ray spectrometer for very-high-energy γ radiation.
Through this LoI, we express our interest in extending these studies to the A=40–50 region, close to the magic numbers N=20 and N=28, by exploiting the beams of 36,37,38,39,40P, 42,43,44,45Cl, and 48,49,50K that are indicated as potentially available from SPIRAL1 via fragmentation of a 48Ca primary beam. These beams have already been used at ISOLDE, with pioneering work by a Strasbourg group on Cl and K beams in the early 1980s [7], and by a GANIL/Dubna collaboration at LISE for P isotopes in the late 1980s [8]. It is precisely in the potassium chain beyond N=28 that the striking oscillatory behavior of Pn values was first noted ; this observation directly inspired the subsequent work in the N=50 region reported in Ref. [4]. However, most of these early studies were not conceived with the search for non-statistical decay phenomena in mind, and they did not have access to the dedicated tools required to reveal them, such as TETRA or PARIS. Moreover, and rather surprisingly, a recent re-investigation of the decay of 51,52,53K at ISOLDE [9] did not report any non-statistical signatures. The authors themselves underline the unexpected nature of this outcome, but it is plausible that an energy-threshold effect in their neutron detector, underestimated in their analysis, may have masked the relevant features. This tends to demonstrate that a dedicated revisit of this case is worthwhile.
The forthcoming development of a sufficiently versatile and modular decay station at DESIR, able, like the BEDO station at ALTO, to host multiple detector types, including bulky devices, in a compact geometry, is essential to carry out this program successfully.
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DESIR Needs Fission: A quantitative reassessment under today's GANIL constraints

Auteur: Fadi Ibrahim[1]

Co-auteur: David Verney [1]

[1] *IJCLab*

The commissioning of the DESIR hall, equipped at its entrance with world-class beam purification and radioactive-ion preparation devices, opens outstanding opportunities for low-energy, trap-based, laser-based, and β-delayed studies. However, the full scientific potential of DESIR, commensurate with the efforts invested in its realization, will remain constrained over the coming decade by an overly narrow portfolio of beams and by the limited diversity of driver sources able to feed the hall in the short to medium term.
DESIR was originally conceived in the framework of a SPIRAL2 program that included an ISOL fission-fragment capability, a component that was de-scoped long ago. The scientific consequence is well identified: without intense beams of neutron-rich intermediate-mass nuclei, which fission uniquely provides with competitive yields, the DESIR physics case risks remaining artificially restricted. It is therefore timely to formulate concrete, technically realistic options that can be implemented within the present GANIL/SPIRAL2 accelerator and operational constraints.
Paradoxically, the time elapsed since the original SPIRAL2 fission concept has also been an opportunity. Over the past two decades, substantial experimental benchmarks and modeling efforts have clarified achievable fission rates, spatial production profiles, and release characteristics associated with different actinide excitation regimes, benefiting from the long operational feedback of major ISOL facilities such as ISOLDE and TRIUMF, as well as from more recent, smaller-scale implementations such as ALTO. In this context, the start of DESIR provides a natural occasion for a comprehensive reassessment of fission-based production schemes optimized for ISOL performance rather than for raw fission yield alone.
Within the scope of this LoI, and with the aim of strengthening the DESIR scientific program, we examine three distinct approaches to inducing fission in uranium-carbide targets from a unified perspective. The comparison is framed using the figure of merit that matters for very neutron-rich ISOL beams: fission selectivity against parasitic reaction channels, spatial localization of fragment creation, excitation-energy regime, power density, and the resulting impact on release efficiency and effective delivered beam intensity. The objective is not to advocate a single, one-size-fits-all solution, but to establish, on the basis of experimental reference points and quantitative estimates, the respective strengths and limitations of each approach in the specific context of existing GANIL/SPIRAL2 capabilities. This comparative analysis is intended to support an original and competitive physics program at DESIR, enabled by the availability of fission-fragment beams produced in a moderate (few kW) power, operationally realistic ISOL mode.

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High-Precision Mass Measurements near the N = 50 shell closure

Auteur: Laetitia Canete[None]

The vicinity of ^{100}Sn is a rich landscape for studying nuclear isomers and exotic decay modes, including super-allowed α, βp, β2p, βα, and βpα emissions. This region is further characterized by enhanced neutron-proton pairing arising from its proximity to shell closure, making it an ideal testing ground for the nuclear shell model. In nuclear astrophysics, the rapid proton capture process (rp-process) follows a path close to the proton-drip line passing through the neighbourhood of 100Sn. Despite considerable interest and significant recent experimental progress [1-4], data on ground and isomeric states of nuclei near the proton-drip line remains missing or partially known. For example, in the silver isotopic chain, the mass of 95Ag was recently measured at the IGISOL facility but the predicted two long-lived isomers were somehow not observed [3]. Additionally, nuclei such as ^{94}Ag, ^{96}Cd, and ^{98}In exhibit N=Z spin-gap isomers, with ^{94}Ag standing out due to its multiple decay channels and two long-lived isomeric states—one of which features a uniquely high spin (21+) for a β-decaying isomer. Precise mass measurements of these isotopes are therefore essential to clarify and constrain theoretical predictions of nuclear structure in this region.
Penning trap spectroscopy, combined with the Phase-Imaging Ion-Cyclotron-Resonance (PI-ICR) technique, offers unparalleled resolving power and sensitivity allowing to distinguish states with

very low energy differences and measure mass with high precision [5]. In this Letter of Intent, we propose to take advantage of the strengths of the S3LEB and the forthcoming PIPERADE double Penning traps at the DESIR facility to perform high-precision mass measurements of neutron-deficient nuclei near the proton-drip line. In parallel, the production of these nuclei could be carried out using SPIRAL1 via fusion-evaporation reactions in an optimized Target Ion Source System (TISS) coupled to a FEBIAD ion source, within the framework of the TULIP project [6]. The use of the PI-ICR technique in combination with PIPERADE should enable the resolution of states with minimal energy differences and mass measurements at a precision level of up to $\delta M/M \sim 10^{-10}$. Additionally, isomers in the vicinity of ^{100}Sn could be further investigated through post-trap decay spectroscopy. Together, these measurements will not only benchmark theoretical nuclear structure models but also provide critical constraints for rp-process network calculations, thereby advancing our understanding of nucleosynthesis and refining predictions for the N=Z=50 region and beyond.

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[3] Z. Ge et al., Phys. Rev. Lett. 133, 132503 (2024)
[4] G. Kripkó-Koncz et al., Phys. Rev. Res. 7, L042022 (2025)
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Study of the β decay of Tz=-1 nuclei for nuclear structure and astrophysics and to test the CVC hypothesis

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Study of the β-decay of $T_z = -1$ nuclei for nuclear structure and astrophysics and to test the CVC hypothesis

We propose to measure the β-decay of the $T_z = -1$ member of the $T = 1$ triplets, in particular the $T_z = -1$ nuclei ^{42}Ti, ^{46}Cr, ^{50}Fe and ^{54}Ni, using the Total Absorption Gamma-ray Spectroscopy (TAGS) technique. These measurements are of profound interest for both nuclear structure and nuclear astrophysics.

These nuclei play a critical role in nucleosynthesis pathways in stellar environments, particularly the rp-process (rapid proton-capture process) occurring in supernova explosions and Type-I X-ray bursts [Bla08,Par09]. The β-decay rates of these isotopes, such as ^{42}Ti, influence the flow of nucleosynthesis and determine how matter is transformed into heavier isotopes. Small changes in these rates can significantly alter the final abundance patterns and the rise time of X-ray bursts [Hou23]. These measurements are critical to allow tests of theories that will be used to calculate nuclear properties in stellar explosive conditions.

The decay of these nuclei probes Gamow–Teller (GT) strength distributions. This provides critical data to constrain GT quenching and improve shell-model weak-rate extrapolations used in astrophysical networks. On the other hand, the comparison of these β decays with charge-exchange (CE) reactions carried on the mirror stable nuclei can be used to investigate isospin-symmetry-breaking effects.

Furthermore, the superallowed $0^+ \rightarrow 0^+$ Fermi transitions in these nuclei provide stringent tests of the Conserved Vector Current (CVC) hypothesis, contributing to the high-precision determination of the V_{ud} element of the Cabibbo–Kobayashi–Maskawa (CKM) matrix which is a fundamental requirement for testing the Standard Model.

Hardy and Towner presented a comprehensive review of superallowed β decays of 23 nuclei, including ^{42}Ti, ^{46}Cr, ^{50}Fe and ^{54}Ni, using the experimental results of refs [Mol15,Kur09]. Currently, while ^{46}Cr, ^{50}Fe, and ^{54}Ni have been added to survey tables, their results are not yet precise enough for V_{ud} extraction, and ^{42}Ti still requires more precise half-life and branching-ratio data [Har15,Har20].

Both Hardy and Towner, and Hou et al [Hou23], who have recently measured the Q values of these decays with greater precision, believe that improved measurements of the half-lives and $B(\mathrm{GT})$ distributions should allow them to be included in the determination of V_{ud} and thus contribute to precision tests of the CKM matrix.
The β-decay properties of the nuclei we propose to measure are summarized below.
Parent nucleus ^{42}Ti ($T_{1/2}$ (ms)= 208.34 ± 0.57, Q_β (keV)= 7016.48 ± 0.22)
Daughter nucleus ^{42}Sc ($T_{1/2}$ (ms) = 680.79 ± 0.28, Q_β (keV) = 3751.22)
Parent nucleus ^{46}Cr ($T_{1/2}$ (ms) = 244.3 ± 1.3, Q_β (keV) = 7603 ± 20)
Daughter nucleus ^{46}V ($T_{1/2}$ (ms)= 422.62 ± 0.05, Q_β (keV) = 4882 ± 22)
Parent nucleus ^{50}Fe ($T_{1/2}$ (ms) = 152 ± 6, Q_β (keV) = 8151 ± 8)
Daughter nucleus ^{50}Mn ($T_{1/2}$ = 283.19 ± 0.08, Q_β (keV) = 4583.5 ± 2.2)
Parent nucleus ^{54}Ni ($T_{1/2}$ (ms) = 114.2 ± 0.3, Q_β (keV) = 8790 ± 5)
Daughter nucleus ^{54}Co ($T_{1/2}$ = 193.27 ± 0.04, Q_β (keV) =4351.6 ± 1.6)

We intend to use the TAGS technique to investigate these decays. As indicated above, the primary objective is to measure the β-intensity distribution (I_β) and the β-decay strength $B(\mathrm{GT})$ free from the "Pandemonium" systematic error [Har77], ensuring that high-energy, low-intensity γ-ray cascades are not missed, which is essential for accurate I_β and $B(\mathrm{GT})$ determinations. We also aim to provide additional validation to the technique in the high-energy range through comparisons with CE reaction data in mirror nuclei, and to supply high-precision data on branching-ratios, which currently dominate the experimental uncertainties for these $T_z = -1$ parent decays.
The measurements will be made with the upgraded hybrid Total Absorption Spectrometer (TAS) array which has been developed in the framework of the (NA)^{2}STARS project and will be installed at DESIR. This new hybrid TAS spectrometer will be composed of either DTAS [Tai15,Gua18] or Rocinante [Val17], which was refurbished recently [Orr25], and new $LaBr_3$(Ce) modules arranged in a star configuration.

The proposed beams (^{42}Ti, ^{46}Cr, ^{50}Fe and ^{54}Ni) will require beam development. The number of UTs is based on the number of implantations of the parent nucleus required to obtain 10^6 counts in the β-gated TAS spectrum, which represents the optimal goal. A minimum of 10^5 counts in the β-gated TAS spectrum could also be considered for cases where production is more difficult. To estimate counting rates, we assume a 40% detection efficiency for β particles, a total efficiency of 70% for single-γ detection in TAS, and approximately 100% efficiency for γ cascades. Provided that 10 pps are available, 20 UTs should be considered for each nucleus under study. If the beam intensities are higher, the corresponding number of UTs will be scaled down accordingly.

As the daughter nuclei (^{42}Sc, ^{46}V, ^{50}Mn and ^{54}Co, respectively) subsequently decay via superallowed Fermi transitions, with half-lives comparable to those of the parent nuclei, the tape cycle cannot be used either to purify the nucleus of interest or to collect the daughter under sufficiently clean conditions. Therefore, to subtract the background arising from the decay of the daughter nuclei, beam time to measure the daughter nuclei, has to be included in the total number of requested UTs and is not yet accounted for.

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Exotic superallowed (and mirror) beta-decay studies with the TAS technique

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Abstract:
Nuclear physics provides one of the most precise probes to test the electroweak interaction [Har20]. The procedure is based on the study of super-allowed Fermi beta decays, and requires high-precision determination of the half-life of the decay, the Q value and the branching ratio of the 0+ to 0+ transition (in the case of T=1 analog decays). The method relays on the validity of the Conserved Vector Current (CVC) hypothesis, and actually it provides a way to test it. If the hypothesis holds, it is expected that the corrected Ft values of the super-allowed transitions do not depend on the decay and can be directly related to the fundamental vector coupling constant (Gv).
From the mean value of the corrected Ft values, it is possible to determine Gv, and from the ratio of Gv/GF the Vud matrix element can be determined. In the equation, ft stands for the conventional ft value definition, δ_(R)^',δ_NS,δ_C,Δ_R^V are small corrections, and GF is the weak interaction constant of the muon decay. Vud is the largest matrix element of the upper row of the Cabibbo-Kobayashi-Maskawa (CKM) matrix. This provides a way to test the unitarity of the CKM matrix, which is a fundamental requirement for the validity of the Electroweak Standard Model.

Through careful filtering, several decays are accepted as known with sufficient precision to be included in the calculation (see Hardy et al. [Har20]), but there is limited knowledge of several heavier decays that could also be considered. The interest in these studies arises mainly because adding heavier systems to the compilation can provide a more stringent test of the theoretical corrections employed in the calculations of the Ft values. With this letter of intent, we propose to study some cases with A ≥ 70, that can be of interest in this realm.

The study will profit from the use of the total absorption spectroscopy technique (TAS), that can provide gamma-cascade efficiencies of almost 100%, of interest for detecting weak gamma decay branches. These decay branches de-excite populated 1+ and non-analog 0+ states in the daughter nucleus that compete with the ground state (gs) to ground state transition. The technique will allow us to determine more precise branching ratios in combination with the high-resolution technique. In our measurements, it is also foreseen to apply a new method to determine the gs to gs feedings [Gua20], which is based on a revised method introduced originally by Greenwood et al. [Gre96]. The procedure (see Guadilla et al. [Gua20]) has been already successfully applied to the 100Tc decay study [Gua17,Gua20], which is a decay that has a similar beta decay pattern (large gs to gs branch), providing a precision of the order of 0.5%.

The study we propose represents a first effort to obtain information on heavier systems, which could allow for more rigorous evaluation of the theory used to determine the corrections needed to achieve the corrected Ft values. Similar studies can also be performed in mirror T=1/2 nuclei [Nav09].
The measurement will be carried out using the upgraded hybrid TAS array, which has been developed within the [(NA)2STARS] project and will be installed at DESIR. This new hybrid TAS will consist of either DTAS [Tai15,Gua18] or Rocinante [Val17], which was refurbished recently [Orr25], together with new LaBr3(Ce) modules arranged in a star-shaped configuration.

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Total absorption gamma spectroscopy study of the beta decay of 100Sn

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The study of the beta decay of 100Sn can be considered a flagship experiment of fragmentation facilities of new generation. The reasons are clear. The production of this isotope is very challenging, requiring very high primary beam intensities and the related physics is very interesting. On one hand, 100Sn is the last accessible N=Z double magic nucleus that is stable from the perspective of particle emission. On the other hand, its decay is considered of great relevance from the perspective of nuclear structure [Fae13]. Due to the double magic character, shell model calculations are possible, and predict that most of the BGT is concentrated in one 1+ level in 100In, and a very limited population to additional states in 100In is expected. This has important consequences, because this decay is also expected to be the one of the smallest Log ft of all the beta transitions in the nuclide chart, and if the BGT is properly determined experimentally, it can provide means to study the quenching of the gA constant in the nuclear medium (quenching of the Gamow Teller strength, see for example [Gys19] and references therein).
Previous beta decay studies of 100Sn have suffered from limited statistics. The first spectroscopic study employing the RISING Ge array was performed at GSI [Hin12] and the decay level scheme was deduced by placing the identified gamma rays in a pattern similar to a level scheme deduced from theory. The study was revisited at RIKEN (see [Lub19], and even though limited coincidence relations were found, it was not possible to unambiguously place the 1+ state in their work. In the study they keep the same level scheme proposed by Hinke et al. [Hin12]. The problem arises because there are three possible level scheme arrangements depending on which theory is assumed.
If one considers the nearly 100 % efficiency of the TAS technique for detecting gamma cascades, a total absorption spectrometer measurement should be sufficient (if enough statistics is collected) to unambiguously place the 1+ state in 100In. In addition, a high statistics study could also make possible the identification of additional 1+ states populated in the decay, making possible a better estimation of the Gamow-Teller quenching for this relevant decay.
The measurement will be carried out using the upgraded hybrid TAS array, which has been developed within the (NA)2STARS project and will be installed at DESIR. The new hybrid TAS will consist of either DTAS [Tai15, Gua18] or Rocinante [Val17], which was refurbished recently [Orr25], together with new LaBr3(Ce) modules arranged in a star-shaped configuration. Please also note that total absorption measurements also require additional measurements of the daughter activity.

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Study of ⍰-decay and ⍰-delayed proton emission in neutron deficient isotopes of Cd and In (Z = 48, 49)

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Abstract: In this Letter of Intent we would like to study the beta-decay and beta-delayed proton emission in Cd(Z = 48, N = 49,50,51) and In(Z = 49, N = 52,53) isotopes. The measurements include the decay gamma rays by both high resolution spectroscopy (HRS) and total absorption spectroscopy (TAS). With these measurements, the properties of the excited states in the daughter and the beta-feeding intensities will be established. We will also determine the branching ratio of the beta-delayed proton emission, whereever applicable. In the long run, the halflife measurement of the excited daughter states will also be attempted by fast timing technique by taking advantage of the use of LaBr3:Ce detectors. These measurements will provide crucial information on the shell structure for the neutron-deficient nuclei around the doubly magic 100Sn and will provide useful inputs to the astrophysical process for the production and abundance of proton-rich nuclei, in particular above the 96Cd waiting point nucleus. This proposed study encompasses both sides of the N = 50 shell closure to get a comprehensive picture of the decay modes around neutron shell closure close to 100 Sn. The produced nuclei (using, parimarily, heavy-ion induced fusion evaporation reaction), following Z and A separation, will be implanted on a magnetic tape and transported to the decay station composed of a powerful spectrometer developed by (NA) 2 STARS collaboration. This detection system include a combined TAS array consisting of LaBr3(Ce), NaI(Tl) and BaF2 detectors. This will also include a few HPGe detectors and beta detector to facilitate the HRS measurement, X-ray measurement and charged particle detection.

The goal of the experiment will be fully achieved through a series of measurements with increasing complexity in terms of nucleus being studied and the detection system being used.

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ASGARD

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The Aluminium Superconducting Grid Array for Radiation Detection (ASGARD) anticipates to perform world-first precision spectroscopy of recoiling nuclei following short-lived beta decays. It will do this using novel superconducting tunnel junction detectors operated inside a windowless dilution refrigerator that can be coupled to a room temperature beam line. As part of the first measurements, we envision stable beam commissioning and first physics measurements to constrain the top-row unitarity of the quark mixing matrix, and the presence of exotic scalar and tensor currents with the isotopes requested.

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Beta-decay study of neutron-deficient transitional Pt and Ir isotopes using (NA)2STARS

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β-decay study of neutron deficient transitional Pt and Ir isotopes using (NA)2STARS

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Search for Weak Exotic Currents with Nuclear Beta Decay

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Abstract:
Beta decay correlation coefficients and the beta spectrum shape are 2 powerful observables to constrain the existence of Physics beyond the Standard Model of particles in the weak sector.
New constraints on deviations from the standard expected value of the angular correlation coefficient are currently being set at WISArD, ISOLDE, with a precision of 0.1-0.2% that will allow us to bring constraints on exotic scalar currents competitive with the expected next generation constraints from LHC. The WISArD experiment relies on the measurement of the kinematic shift of the beta-delayed proton group of the IAS of 32Ar. The kinematic shift is proportional to the angular correlation coefficient of interest. This shift is increased in lighter nuclei and 20Mg has been identified as the best candidate to perform such a measurement with increased sensitivity to scalar currents by a factor 10-20%. Such a measurement requires the development of a new setup at DESIR, which includes a superconducting magnet reaching 4 to 5T, and must rely on the purification set-ups of the beam (HRS, PIPERADE), to suppress 20Na contamination.

Beta shape measurements are used to set new constraints on exotic tensor currents by extracting the Fierz interference term from a direct comparison of the expected shape (simulations) to the data. This extraction is possible to the required level of precision when the standard recoil order corrections, namely weak magnetism, are unambiguously known and sufficiently high statistics can be reached. These conditions are met in mirror nuclei and decays with ΔT3=±1, pointing to a few short-lived candidates: 6He, 17F, 20F etc. Beta shape measurements are currently being performed in the WISArD magnet with long-lived isotopes using Si(Li) detectors. Feasibility studies will be carried out to assess the possibility to reach high level of precision with stacked Si(Li) detectors, in preparation of beta-shape measurements with short-lived isotopes for which the Q values are higher than 2 MeV at DESIR, i.e 6He or 20F. Such measurements also require the installation of a superconducting magnet at DESIR, with a large enough bore to fit Si(Li) and gamma detectors for beta and Bremsstrahlung escape detection. Beam purity is essential to avoid superposition of beta spectra in the detectors hence the need for the purification set-ups of DESIR.