Fast timing for nuclear structure and applications - FAST'25

Report of Contributions

Contribution ID: **1** Type: **Oral presentation**

Unlocking the Nuclear Matrix Elements of Neutrinoless Double-Beta Decay: A Novel Experimental Approach

The search for the detection of neutrinoless double-beta ($0\nu\beta\beta$) decay is one of the main experimental challenges in particle and nuclear physics. Its measurement has the potential to demonstrate that neutrinos are their own antiparticles, reveal matter-antimatter asymmetry, and provide insights into absolute neutrino mass. Despite extensive experimental efforts using various isotopes, $0\nu\beta\beta$ decay remains unobserved, with significant uncertainty in the theoretical Nuclear Matrix Elements (NME) that are essential for interpreting potential signals. In this presentation, I will outline a promising experimental approach to address this challenge by leveraging electromagnetic transitions—specifically, double-magnetic dipole (gamma-gamma-M1M1) decays from double isobaric analog states (DIAS).). In order to effectively detect these transitions, we propose to employ LaBr3 detectors. Indeed, their excellent time resolution is crucial to discriminate the gamma-gamma decays from competing processes. This innovative method offers a pathway to constrain NMEs, advancing our understanding of $0\nu\beta\beta$ decay mechanisms and its implications for fundamental physics [1,2]

1. B. Romeo et al., Phys. Lett. B 827, 136965 (2022).
2. B. Romeo et al., Phys. Lett. B 860, 139186 (2025).

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Session Classification: Event

Contribution ID: **2** Type: **Oral presentation**

Portable African Neutron-Gamma Laboratory for Innovative Nuclear Science

Thursday 13 March 2025 10:30 (30 minutes)

iThemba LABS has pioneered a mobile gamma-ray detection unit[1] which allows a user to operate in the field and chart the location, strength \ and energy of gamma radiation. The system incorporates a sensitive \ scintillation detector[2] typically used for accelerator-based \ spectroscopy at the SSC laboratory and was integrated into a backpack \ incorporating a fast 125 MHz digitiser for readout and a GPS enabled \ Raspberry Pi microprocessor system, allowing in situ measurements of \ radiation around the Cape Town site, with collected data streamed to the cloud and analysed offline. After conducting a series of rollout \ radiation measurement tests at Faure site, iThemba LABS has successfully used the gamma-ray detection system in collaboration with local and regional institutions to take radiation monitoring measurements from calibrated sources in the field, including radiation measurements tests conducted at Kruger National Park and at mining areas both in South Africa and in Botswana. It has also been used in the commissioning of the SAIF facility monitoring the performance of the water-cooling circuits.

The Portable African Neutron-Gamma Laboratory for Innovative Nuclear Science (PANGoLINS) project aims to investigate measurements of both gamma rays and neutrons which forms an important component part on site or in transit and the detection of both fissile material for the use in decarbonised energy sources or disposal thereof. A core component of the project is be to miniaturize the weight of the gamma ray detection device and associated infrastructure so that it can be loaded on an unmanned aerial vehicle to enable access to, and enhance performance of radiation monitoring measurements at remote sites leading to autonomous operations.

PANGoLINS incorporates commercial detector assemblies of LaBr3(Ce), SrI2(Eu) and/or CLYC(Ce) for spectroscopy. In addition, the project encompasses the instrumentation of other scintillation detectors with silicon photomultiplier technologies. The coupling of these to readout devices such as high density ADC readout are planned for applications for nuclear science, medical imaging or astronomy.

An overview of the project, its progress and potential outcomes will be presented.

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[2] Msebi, L. et al., NIM-A. 1026 (2022) 166195, doi: 10.1016/j.nima.2021.166195

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Session Classification: Day 2

Track Classification: Facilities and arrays: Large scintillator and hybrid arrays

Contribution ID: **3** Type: **Oral presentation**

Building a Hybrid Compton Camera System for Improving Medical Imaging Applications

Thursday 13 March 2025 12:30 (30 minutes)

This work investigates building a two-stage Compton camera in terms of energy resolution, efficiency, fast timing, and geometrical configuration for beam range monitoring in hadron therapy. While development of a clinical imaging device has made tremendous strides, there are challenges to be addressed.
A Compton camera prototype is investigated, assessing the optimal geometrical configuration of compact, low-voltage 14 x 14 x 25.4 mm $LaBr_3$:Ce and SrI_2:Eu SiPM-readout scintillation detectors to maximise on the strengths of the cutting-edge SiPM technology. These detectors, manufactured by CapeScint (MA, USA), have demonstrated excellent energy resolution ($\approx 3.4\%$ at 662 keV), and are known for their fast-timing capabilities. The tracking of scatter events was modelled using the TOPAS Monte Carlo toolkit to assess the best measurement configuration and timing attributes, followed by measurements with standard gamma-ray sources. Further, two CLYC-6 SiPM-readout detectors have been commissioned to maximise on their neutron detection capability using pulse shape discrimination to distinguish between neutron and gamma events for in-situ neutron dose measurements during hadron therapy.
The development of this device would assist in the improvement of hadron therapy safety margins to optimise the dose to cancer cells while reducing the effect to the surrounding healthy tissues and organs at risk. This will improve treatment effectiveness and helping strengthen the application of hadron therapy in the fight against cancer. An overview of preliminary results will be presented.

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Session Classification: Day 2

Track Classification: Medical applications: Fast scintillators for time-of-flight PET and other imaging modalities

Contribution ID: **4** Type: **Oral presentation**

Upgrade of the fast-timing capabilities of the FATIMA array

Wednesday 12 March 2025 15:05 (30 minutes)

The FAst TIMing Array (FATIMA) detector system is a key component of the DEcay SPECtroscopy (DESPEC) experiment at the Facility for Antiproton and Ion Research (FAIR). FATIMA currently comprises 36 cylindrical 1.5×2" LaBr3(Ce) detectors, designed for precise measurements of mean lifetimes in the picosecond-to-nanosecond range [1]. These sensitive measurements use the exceptional timing properties of LaBr3(Ce) crystals in combination with fast R9779 Hamamatsu photomultiplier tubes (PMTs).
However, in recent years, several limitations of PMTs have been identified, prompting the exploration of alternative technologies. One promising approach involves the use of Silicon Photomultiplier (SiPM) technology [2]. In this work, we present a novel readout system that integrates large-area SiPM arrays with FATIMA-type LaBr3(Ce) crystals. This new system preserves the fast-timing capabilities typically achieved with conventional PMTs [3].
Energy calibration was conducted using 137Cs and 152Eu radioactive sources, while timing performance was assessed with a 60Co source. The results were benchmarked against those obtained with the R9779 PMTs, highlighting the feasibility of achieving comparable energy and timing resolutions, which are crucial for nuclear structure studies.
To further enhance the system's performance, a temperature compensation circuit was developed to maintain gain stability during long-duration experiments, such as those conducted in in-beam and off-beam nuclear physics experiments.

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[1] M. Rudigier, Z. Podolyák, P. Regan, A. Bruce, S. Lalkovski, R. Canavan, E. Gamba, O. Roberts, I. Burrows, D. Cullen et al., Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment 969, 163967 (2020)
[2] M. Grodzicka-Kobylka, M. Moszynski, T. Szczesniak, Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment 926, 129 (2019), silicon Photomultipliers: Technology, Characterisation and Applications
[3] S. Pascu, A. Stoica, C. Neacsu, A. Bruce, C. Costache, B. Das, M. Górska, C. Mihai, M. Mikolajczuk, Z. Podolyák et al., Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment 1070, 170001 (2025)

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Session Classification: Day 1

Track Classification: Facilities and arrays: Large scintillator and hybrid arrays

Contribution ID: **5** Type: **Oral presentation**

The Fast-Timing Array for DESPEC at GSI

Wednesday 12 March 2025 14:35 (30 minutes)

FATIMA (FAst TIMing Array) [1] is the fast-timing detector system for measurements of nuclear lifetimes at the DESPEC (DEcay SPECtroscopy) station [2] of the radioactive beam facility GSI. The array is composed of 36 $LaBr_3$(Ce) scintillator detectors coupled to photomultiplier tubes and the GSI-developed fast-timing data acquisition system TAMEX, making possible lifetime measurements on the order of several picoseconds with the $\gamma - \gamma$ fast-timing method. At DESPEC, FATIMA is employed in conjunction with a suite of ancillary detectors; the fast-timing array surrounds a stack of highly pixelated implantation detectors and plastic scintillators, which allow for $\beta - \gamma$ coincidence measurements, while a series of high-purity germanium detectors provide excellent energy resolution. \\

Since its manufacture FATIMA has been involved in numerous DESPEC experimental campaigns, allowing for precision measurements of excited state lifetimes in a range of exotic nuclei produced by the fragment separator of GSI. These include a range of isotopes in the mass$\sim$100 and mass$\sim$190 regions for fundamental investigations of seniority structure, shape coexistence and transition. In upcoming years, FATIMA will be used as part of the IDATEN array at the Radioactive Isotope Beam Facility (RIBF) at RIKEN, in addition to taking part in further experimental campaigns as part of the DESPEC setup. \\

In this talk an introduction to both DESPEC and FATIMA will be given, highlighting recent developments with the array, followed by a summary of several key results that have been published in recent years. \\

[1] Rudigier, M. \textit{et al.}, "\textit{FATIMA —FAst TIMing Array for DESPEC at FAIR}" (2018), NIM A \textbf{969} (163967). \newline
[2] Mistry, A. \textit{et al.}, "\textit{The DESPEC setup for GSI and FAIR}" (2022), NIM A \textbf{1033} (166662).

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Session Classification: Day 1

Track Classification: Facilities and arrays: Large scintillator and hybrid arrays

Contribution ID: **6** Type: **Oral presentation**

Fast Timing capabilities of CeBrA and Auxiliary Detectors

The fast and high efficiency $CeBr_3$ scintillators detectors of the $CeBr_3$ Array (CeBrA) located at the John D. Fox Superconducting Linear Accelerator Laboratory at Florida State University (FSU) are designed for fast-timing spectroscopy in nuclear structure studies. This work presents the fast-timing capabilities of CeBrA in three key experimental configurations: γ-γ coincidences within CeBrA, particle-γ coincidences in nuclear reactions using CeBrA and the Super-Enge Split-Pole Spectrograph (SE-SPS), and γ-conversion electron coincidences with CeBrA and Passivated Implanted Planar Silicon detectors (PIPS).

Each of these configurations provides a unique window into nuclear-structure phenomena. As shown by the CeBrA Demonstrator [1], γ-γ coincidences within CeBrA enable lifetime determination of nuclear levels in the sub-nanosecond regime using the slope and convolution method. Meanwhile, the excellent particle energy resolution of the SE-SPS allows for narrow excitation energy gates, enabling the selective study of the γ decay of excited states populated through light-ion induced nuclear reactions with CeBrA. These particle-γ coincidences enable the determination of γ-decay intensities, particle-γ angular correlations for assigning spin-parity quantum numbers, and nuclear level lifetimes. Additionally, the combination of CeBrA with PIPS detectors has allowed for γ-conversion electron coincidences. This configuration allows for the extraction of conversion coefficients and nuclear level lifetimes, thanks to the fast timing capabilities of $CeBr_3$ scintillators.

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[1] A. L. Conley et al. "The CeBrA demonstrator for particle-γ coincidence experiments at the FSU Super-Enge Split-Pole Spectrograph". In: Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment 1058 (Jan. 1, 2024), p. 168827. issn: 0168-9002. doi: 10.1016/j.nima.2023.168827. url: https://www.sciencedirect.com/science/article/pii/S0168900223008185 (visited on 01/02/2024).

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Session Classification: Event

Contribution ID: **7** Type: **Oral presentation**

Revealing the nature of yrast states in neutron-rich polonium isotopes

Thursday 13 March 2025 15:30 (30 minutes)

Polonium isotopes having two protons above the shell closure at $Z = 82$ demonstrate a wide variety of high-spin isomeric states across the whole chain.
The structure of neutron-deficient isotopes up to ^{210}Po ($N = 126$) is well established thanks to being easily produced through different methods, as opposed to their neutron-rich counterparts for which not much information is currently available and only selective techniques can be used for production.
The presentation will focus on first fast-timing measurements of yrast states up to 8^+ in ^{214,216,218}Po isotopes produced in the β-decay of ^{214,216,218}Bi at the ISOLDE Decay Station of ISOLDE-CERN.
The only half-life value previously available in literature corresponding to the 8^+ state in ^{214}Po was 20 times larger than the presently reported one. The extracted transition probabilities $B(E2)$ values provide a crucial test of the different theoretical approaches describing the underlying configurations of the yrast band.
The new experimental results are described by shell-model calculations using the KHPE and H208 effective interactions and their pairing modified versions. These results contradict the previous expectations of isomerism for the 8^+ yrast states in neutron-rich polonium isotopes, showing an increase in configuration mixing as opposed to the simple seniority scheme applicable in the neutron-deficient cases.

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Session Classification: Day 2

Track Classification: Nuclear structure: Nuclear structure from fast-timing measurements

Contribution ID: **8** Type: **Oral presentation**

Time response evaluation of fast photomultiplier tubes for LaBr3(Ce) crystal readout

Friday 14 March 2025 09:30 (30 minutes)

In the framework of the HISTARS (HIE-ISOLDE Timing Array for Reaction Studies) project at ISOLDE/CERN, it is planned to install a gamma-ray array specifically designed for fast-timing measurements of nuclear states populated in reactions. State-of-the-art inorganic scintillators, such as $LaBr_3$(Ce) [Vedia2015,Vedia2017,Fraile2020] or $CeBr_3$ [Picado2017], are commonly used due to their excellent properties for both time and energy resolution. These scintillators are typically coupled to fast photomultiplier tubes (PMTs) or silicon photomultipliers (SiPMs), which ensure high count rate capabilities and fast response, while maintaining good energy resolution, making them ideal for the challenging conditions of such experiments.
In this work, we have characterized four different head-on PMTs with bialkali photocathode by Hamamatsu in combination with a $LaBr_3$(Ce) crystal with the shape of a truncated cone 1.5" in height and with bases of 1.5" and 1" in diameter. Among the chosen PMTs a customized version of the 2-inch 8-stage bialkali photocathode R9779 in the assembly H10570 is used as a reference. The other three, newer PMTs, are a 1.5-inch 8-stage R13408, and a 2-inch 8-stage R13089 model, in two different assemblies, H13719-Y006 and H13719-Y007.
We report on the time response at 511 keV and Co-60 photon energies using a fast digitizer module. Digital processing data techniques and a genetic algorithm [Sanchez-Tembleque2019] were employed for time pick-up. Results on energy resolution, linearity, and time walk will also be presented.

References

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Session Classification: Day 3

Track Classification: Instrumentation: Fast front-end and readout electronics

Contribution ID: **9** Type: **Oral presentation**

Fast-Timing analysis of 212Po and 214Rn following nuclear reactions

Thursday 13 March 2025 14:30 (30 minutes)

Fast-Timing measurements in isotopes produced by transfer or fusion-evaporation reactions is challenging due to the appearance of several interfering γ-rays from different reaction channels. It is therefore necessary to clean up the reaction channel, or rather the γ-ray spectra, of the isotope of interest from contaminations. Usually the use of HPGe gates can be applied to clean up the spectra which corresponds to a high loss of statistics due to the efficiency of the HPGe detectors. More convenient is the use of particle detectors with a gate on the ejectile of the reaction or in the case that the isotope of interest decays via α-decay, the α-ray. Furthermore, it is possible to use physical properties of the isotope of interest, such as isomeric states or the lifetime of the α-decaying ground state.
As an example of the use of gates on particles or "physical properties", I will present the recent results of the ^{212}Po transfer reaction and, in particular, the ^{214}Rn fusion-evaporation experiment at the ROSPHERE γ-ray detector array at IFIN-HH in Magurele, Romania. The particle detector used was the SORCERER array consisting by solar cells.

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Session Classification: Day 2

Track Classification: Nuclear structure: Nuclear structure from fast-timing measurements

Contribution ID: **10** Type: **Oral presentation**

Lifetime measurements of low-energy octupole states in radium-224

Thursday 13 March 2025 15:00 (30 minutes)

For certain nuclei long-range octupole-octupole residual interactions can cause a reflection-asymmetric (pear) shape to occur. This octupole deformation, combined with quadrupole deformation, causes a separation between the centre of mass and centre of charge in the nucleus, resulting in a significant electric dipole (E1) moment. This effect enhances the strength of the E1 and electric octupole (E3) transitions, characteristic features of such nuclei.

The presence of these low lying J= $1^-$and 3^- is indicative of octupole deformation. An example of one of these nuclei is radium-224 which is octupole deformed in the ground state as evidenced by the observation of enhanced E3 transitions[1]. Their work measured a large E3 strength but could only give an upper limit on the reduced transition probability of the E1 transition (B(E1)).

The aim of this experiment was to measure the lifetimes of the low-lying J= $1^-$and 3^- states in radium-224 and, therefore, measure the E1 strength. This was done by observing the beta decay of francium-224 ions which were produced at the ISAC facility in TRIUMF. The lifetime of these states was measured by using the $LaBr_3$(Ce) detectors of the GRIFFIN array and the generalised centroid difference method. Measuring the lifetime of these states makes it possible to perform a direct measurement of the low-energy dipole response in radium-224 for the first time.

References

[1] L. P. Gaffney et al., "Studies of pear-shaped nuclei using accelerated radioactive beams,"Nature, vol. 497, pp. 199–204, May 2013.

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Session Classification: Day 2

Track Classification: Nuclear structure: Nuclear structure from fast-timing measurements

Contribution ID: **11** Type: **Oral presentation**

L-forbidden M1 transitions in N=50 isotones

Wednesday 12 March 2025 16:30 (30 minutes)

Regions near closed shells in areas of the nuclear chart far from stability are very interesting from the point of view of nuclear structure, since they provide an ideal testing ground to investigate the competition between single particle degrees of freedom and collective effects from many nucleons. This is the case for nuclei near the doubly-magic ^{78}Ni nucleus, with Z = 28 and N = 50 [1]. The systematics of transitions from the first-excited states of the even-A N = 50 isotones [2, 3] is very enlightening, since M1 transitions are expected to be l forbidden, resulting in long half-lives with small transition probabilities [4-6].

A more complete understanding of these l forbidden M1 transitions could be achieved by extending the systematics. To this end, two complementary experiments were performed at two different facilities: ISOLDE (CERN) and ILL (Grenoble, France).

The first experiment aimed to study the half-life of the first excited state of the ^{83}As via a β-decay experiment of ^{83}Ga at the ISOLDE Decay Station during a recent beam test. These nuclei were produced via fission induced by fast neutrons in a UC$_x$ target.

In the second experiment, the half-lives of the first excited states in ^{85}Br and ^{87}Rb [7] were investigated at the LOHENGRIN spectrometer at ILL. Here, the nuclei of interest were produced by a fission experiment at ILL, where the parent nuclei, ^{85}Se and ^{87}Kr, were transported and mass-separated by the LOHENGRIN spectrometer.

In the following, I will present a preliminary analysis of both experiments, discussing the methodologies used and the initial results obtained. Additionally, I will draw some conclusions regarding the systematics of the l-forbidden M1 transitions, highlighting their implications for nuclear structure

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Session Classification: Day 1

Track Classification: Nuclear structure: Nuclear structure from fast-timing measurements

Contribution ID: **12** Type: **Oral presentation**

Fast-timing and high-resolution spectroscopy investigation of the 128Cd -> 128In -> 128Sn beta-decay chain

Friday 14 March 2025 11:55 (30 minutes)

The isotopic chains close to the magic proton number $Z = 50$ have motivated an extensive experimental and theoretical effort during the last decades. Their simple structure provides an excellent ground to study shell-evolution along the chain, as well as to understand the interplay between single particles and collective degrees of freedom. The systematic study of their excited structure, and in particular, the measurement of lifetimes, provides key observables to get a deeper insight into the structure of these nuclei. Through lifetime measurements, it is possible to extract the electromagnetic strengths, $B(XL)$, providing valuable information that can be used to test the validity of shell-model calculations.

The result obtained during the experimental campaign was performed at the ISOLDE Decay Station (IDS). High purity Cd ($Z = 48$) beams were produced after the fission of a thick UC_x target, selectively ionized by the ISOLDE Resonance Ionization Laser Ion Source (RILIS) and separated in mass using the General Purpose Separator (GPS) ISOLDE mass separator.

High-resolution gamma spectroscopy using six highly efficient clover-type HPGe detectors was used to build a new level scheme. The Advanced Time-Delayed $\beta\gamma\gamma$(t) [1,2] method is employed in order to access lifetimes down to the 10 ps range. This technique makes use of a compact fast-timing setup with two γ-$LaBr_3$(Ce) detectors and three fast \(\beta \)-detectors. This method is the most suited to measure lifetimes in the sub-nanosecond range and dealing with the large amount of low-lying isomers that are common in this region.

In this work, we have revisited the excited structure of the β-decay chain ^{128}Cd→^{128}In→^{128}Sn [3,4,5]. This analysis has allowed us to expand the known level schemes, and moreover, lifetimes in the sub-nanosecond range have been directly measured for the first time in ^{128}In and ^{128}Sn. We will report on the experimental results derived from this analysis and provide a discussion of the deduced $B(XL)$ in comparison with theoretical calculations.

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Presenter: LLANOS EXPOSITO, Marcos (Universidad Complutense (ES))

Session Classification: Day 3

Track Classification: Nuclear structure: Nuclear structure from fast-timing measurements

Contribution ID: **13** Type: **Oral presentation**

Revisiting the octupole collectivity in 96Zr

Wednesday 12 March 2025 17:30 (30 minutes)

Since N=56 is one of the so-called "octupole magic numbers", ^{96}Zr is expected to show a strong octupole collectivity. According to several experiments carried out about 30 years ago to determine the $B(E3; 0^+_1 \rightarrow 3^-_1)$ value, it is one of the largest in the entire nuclear chart. However, the results differ by 30%. We therefore carried out an experiment at ILL in April 2024 to determine the observables required to conclude on the octupole collectivity: the lifetime of the first 3^- state and the branching ratio in its decay. For this purpose, ^{96}Y was produced in a $^{235}\mathrm{U}(\mathrm{n}_{th}, \mathrm{f})$ fission reaction and subsequently selected by LOHENGRIN. The decay product ^{96}Zr was analysed with a HPGe CLOVER detector, four $LaBr_3$(Ce) scintillation detectors and a plastic β-detector in close geometry. The status of the analysis will be presented.
This work was supported by EURO-LABS.

Author: HARTIG, Anna-Lena (Technische Universitaet Darmstadt (DE))

Presenter: HARTIG, Anna-Lena (Technische Universitaet Darmstadt (DE))

Session Classification: Day 1

Track Classification: Nuclear structure: Nuclear structure from fast-timing measurements

Contribution ID: **14** Type: **Oral presentation**

Fast timing opportunities at ILL Grenoble

Wednesday 12 March 2025 15:35 (30 minutes)

ILL operates two user instruments that enable fast timing measurements with nuclides that are either neutron-rich or close to stability.
The LOHENGRIN fission fragment recoil separator provides mass- and energy separated beams of fission products. In particular short-lived (microsecond) isomers or beams of refractory elements that are less suited for ISOL facilities are of interest for decay spectroscopy at LOHENGRIN. Combined setups enable either microsecond-isomer-tagged or beta-gamma-gamma fast timing experiments.
Complementary to LOHENGRIN, the FIPPS instrument uses an intense pencil beam of thermal neutrons incident on stable or radioactive targets. Gamma rays emitted after neutron capture or neutron-induced fission respectively are detected by an array of 8 HPGe clover detectors with anti-Compton shield. This basic array is complemented with additional Ge detectors and/or LaBr3 detectors for fast timing.
A review of typical past and possible future fast timing experiments will be given.

Author: KOESTER, Ulli (Institut Laue-Langevin (FR))

Presenter: KOESTER, Ulli (Institut Laue-Langevin (FR))

Session Classification: Day 1

Track Classification: Facilities and arrays: Large scintillator and hybrid arrays

Contribution ID: **15** Type: **Oral presentation**

Development of a Clover-Like LaBr3(Ce) detector module

Friday 14 March 2025 10:00 (30 minutes)

Development of a clover-like LaBr3(Ce) detector module
S. Dutta, C. Cassells, B.S. Nara Singh, M. Bowry, D. O'Donnell, M. Scheck, J.F. Smith
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This work explores the application of clover-like LaBr3(Ce) detector modules to gamma-ray spectroscopy. The crystals are directly coupled to Silicon Photomultipliers (SiPMs), therefore, they are compact, more portable and usable in environments of high magnetic fields [1]. For the first time, the SiPMs are directly coupled to the bare crystals without any other intermediate layer. This new type of construction improves the resolution by more than 0.5% compared to devices such as those used in Ref. [1] where commercially available canned crystals are coupled to SiPMs. In addition, the clover geometry allows for the add-back method to improve spectral quality [2]. This approach applied to germanium detectors was known to minimise Compton background, although the Full Width at Half Maximum (FWHM) of observed gamma-ray peaks show some increase [3-5]. However, such a detriment has not been observed for the clover-like LaBr3(Ce) detector module and FWHM stayed unaltered in any significant manner. On the other hand, the peak-to-total (P/T) ratio is greatly improved (for example, 33% for Cs-137) due to the application of the add-back technique. During the workshop, some results using the standard gamma-ray sources will be presented. Furthermore, the use of this module, with higher efficiency than that of germanium detectors, in nuclear astrophysical setups will be mentioned.
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"etc···see https://web-docs.gsi.de/~wolle/INDIA/IUAC-2007/PAPERS/NIMA432_90.pdf)
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[5] B.S. Nara Singh et al. "Characteristics of a two-fold Segmented clover detector", Nuclear Inst. and Methods in Physics Research, A 506 (2003) 238249.

Author: Ms DUTTA, Sulagna (University of the West of Scotland)

Co-authors: Dr SINGH, B.S. Nara; Mr CASSELLS, Cameron (University of the West of Scotland); Dr ODONNELL, David; Prof. JENKINS, David.G; Prof. SMITH, John F.; Dr BRIZ, Jose Antonio; Prof. SCHECK, Marcus; Dr BORGE, Mariano.J.G; Dr BOWRY, Michael; Prof. TENGBLAD, Olof; Dr JOSHI, Pankaj

Presenter: Ms DUTTA, Sulagna (University of the West of Scotland)

Session Classification: Day 3

Track Classification: Facilities and arrays: Large scintillator and hybrid arrays

Contribution ID: **16** Type: **Oral presentation**

Redshifted Cherenkov radiation for fast-timing detectors

Friday 14 March 2025 10:30 (30 minutes)

The enhancement of time response in scintillator-based gamma-ray detectors is crucial for applications such as Time-of-Flight Positron Emission Tomography (TOF-PET) and experimental nuclear and particle physics. One promising approach to achieve this improvement is by utilizing Cherenkov radiation, which is emitted nearly instantaneously compared to traditional scintillation light. However, a major limitation of Cherenkov-based detection is the low yield of detectable photons, as most are emitted in the ultraviolet (UV) range, where many materials exhibit high absorption and reduced transparency.
To overcome this limitation, we propose the use of Redshifted Cherenkov Radiators (RCR). By introducing fluorescent dopants into liquid solvents, Cherenkov photons are shifted from the UV to the visible spectrum, where materials are more transparent and conventional photodetectors exhibit higher efficiency. This technique aims to increase the number of detected Cherenkov photons, ultimately leading to improved timing resolution in radiation detectors.
To evaluate the feasibility of this approach, we tested different liquid solvents, including octadecene (ODE), chloroform ($CHCl_3$), and dimethyl sulfoxide (DMSO), with POPOP as a wavelength-shifting dopant. UV absorption analysis confirmed that ODE exhibits the highest transparency in the UV range and the incorporation of POPOP led to an increase between 17% to 56% in detected Cherenkov photons, as shown in Figure 1 left, which compares the relative detection yield for different solvents with and without the wavelength shifter.

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Time-correlated single photon counting (TCSPC) measurements indicated a slight degradation (˜15%) in time response due to the re-emission process. However, coincidence time resolution (CTR) measurements with LYSO detectors, using the setup illustrated in Figure 1 right2, showed that the increase in detected photons compensates for this degradation. Consequently, further improvements in detector design to enhance Cherenkov photon detection could simultaneously improve light yield and time resolution, reinforcing the potential of RCR detectors for applications requiring maximized light collection.
The redshifting of Cherenkov photons using fluorescent dopants significantly enhances detection efficiency while maintaining competitive time resolution. The increased photon yield offsets the minor time degradation, making RCR technology a promising solution for high-performance TOF-PET detectors. These results indicate that further refinements in redshifting materials and detection optimization could push the limits of molecular imaging and precision timing applications.

Authors: FERNÁNDEZ BORREGUERO, Claudia; UDIAS MOINELO, Jose Manuel; Prof. FRAILE, Luis M (Universidad Complutense (ES)); ESPAÑA PALOMARES, Samuel (CSIC)

Presenter: FERNÁNDEZ BORREGUERO, Claudia

Session Classification: Day 3

Track Classification: Instrumentation: New detector technologies

Contribution ID: **17** Type: **Oral presentation**

Fast Timing Experiments with Hamamatsu SiPMs and Scintillators

Thursday 13 March 2025 17:30 (30 minutes)

We study the temporal response of different arrays of Hamamatsu SiPMs coupled to fast scintillators. The detectors used include for instance a 36 Hamamatsu SiPM matrix (3x3mm), and a 4 Hamamatsu SiPM matrix (6x6mm), each with electronic readouts boards aiming to simplify the design. These arrays were coupled to fast scintillators, such as a LaBr3(Ce) truncated cone (1.5" high, with bases of 1" and 1.5" diameter), a cylindrical LaBr3(Ce) crystal (1" high, 1" diameter) and a 3x3x5mm cubic Lyso crystal.

A Hamamatsu PMT (model R9779, assembly: H10570, MOD 3), featuring an 8-stage photomultiplier with a bialkali photocathode and a quartz window coupled to a cylindrical LaBr3(Ce) crystal (1" high, 1" diameter) was used as a reference. The temporal response of the detectors was evaluated using Na-22 (511keV) and Co-60 radioactive sources, and the signals were digitized using a DRS4 system for more precise time-of-arrival analysis. We will continue this study in order to achieve a more complete analysis.

Author: GAITAN DOMÍNGUEZ, Sara

Co-authors: CABALLERO RODRIGUEZ, Miriam (Universidad Complutense (ES)); Prof. FRAILE, Luis M (Universidad Complutense (ES)); MARTINEZ NOUVILAS, Victor (Universidad Complutense (ES)); SANCHEZ TEMBLEQUE, Victor (Universidad Complutense (ES)); UDIAS MOINELO, Jose Manuel

Presenter: GAITAN DOMÍNGUEZ, Sara

Session Classification: Day 2

Track Classification: Instrumentation: Fast front-end and readout electronics

Contribution ID: **18** Type: **Oral presentation**

Probing the coexistence of nuclear shapes through the first lifetime measurement of the 0^+_3 state in ^{120}Sn

Friday 14 March 2025 12:25 (30 minutes)

The semi-magic $^{120}_{50}Sn_{70}$ lies in the neutron mid-shell among the other stable Sn isotopes, where shape coexistence was observed with the signature of deformed bands built on excited 0^+ states intruding into the yrast band that is built on the spherical ground state. However, the lifetime of the excited 0^+_3 state only has a lower limit of 6 ps in the literature, which prevents the study of transition strengths, and as a result, its structure is obscured.

The 0^+_3 lifetime was measured in the first thermal neutron capture experiment, ^{119}Sn(n,γ^{many})^{120}Sn, at the Institut Laue-Langevin, where the world's highest-flux thermal neutron beam was delivered at 10^8 n/cm^2/s at the target position on an isotopically enriched ^{119}Sn target. Low-spin states in ^{120}Sn were populated up to the neutron separation energy $S_n = 9.1$ MeV, and the decaying gamma-ray cascades were detected with the Fission Product Prompt Gamma-ray Spectrometer (FIPPS) comprised of eight Compton-suppressed HPGe clovers coupled to an array of 15 $LaBr_3$ scintillation detectors. The $LaBr_3$ scintillators, which were used for gamma-ray detection and lifetime measurement using the Generalized Centroid Difference (GCD) method, have fast timing responses and are ideal for extracting lifetimes between 10 and a few hundred ps.

In total, there are 4×10^9 counts in the $\gamma\gamma\gamma$ cube where two $LaBr_3$ events were in coincidence with one HPGe.

Lifetime measurement for the 0^+_3 state in ^{120}Sn using the GCD technique will be presented with nuclear structure interpretations from realistic shell-model calculations. Additional lifetimes will also be measured where the $\gamma\gamma\gamma$ cascade's statistics permit. Analysis is also underway for a similar neutron-capture experiment populating low-spin excited states in ^{118}Sn.

Authors: GARGANO, Angela; MICHELAGNOLI, Caterina (Institut Laue-Langevin); Prof. ANDREOIU, Corina (Simon Fraser University); PETRACHE, Costel (Université Paris-Saclay CNRS/IN2P3); WU, Frank (Simon Fraser University); RÉGIS, Jean-Marc (IKP); SPAGNOLETTI, Pietro Nicola (University of Liverpool (GB)); KARAYONCHEV, Vasil (ANL)

Presenter: WU, Frank (Simon Fraser University)

Session Classification: Day 3

Track Classification: Nuclear structure: Nuclear structure from fast-timing measurements

Contribution ID: **19** Type: **Oral presentation**

MLTiming: Pairwise Learning for Improving Timing Resolution in TOF-PET

Thursday 13 March 2025 12:00 (30 minutes)

Accurate timing characterization of detected radiation events in Positron Emission Tomography (PET) provides Time-of-flight (TOF) information for detected coincidences, which improves the signal-to-noise ratio of the reconstructed images. In this work, we propose a method to train machine learning (ML) models to assign accurate timestamps to events measured in radiation detectors making use of just the signals detected by individual detectors, without the need of resorting to other detector signals. We performed a proof-of-concept study using four different neural network (NN) architectures, trained with event pairs constructed with the measured signal and a delayed version of it. The delay is used as a label in the training process. The proposed trained model was evaluated with data acquired with a ^{22}Na point source using a pair of $LaBr_3$(Ce) crystals in the shape of truncated cones coupled to fast photomultiplier tubes (PMTs). The detected γ-ray pulses were sampled at 5 Gsamples/s. A decrease of 15% in Mean Absolute Error (MAE) and of 16% in Coincidence Time Resolution (CTR) compared to the analog constant fraction discrimination (A-CFD) -from 284 ± 3 ps to 238 ± 1 ps- method was achieved. The proposed ML methods requiere moderate computing power and are fast enough (>250kcps) for its practical implementation in PET scanners with many detectores modules.

Author: AVELLANEDA GONZÁLEZ, José Andrés

Co-authors: LOPEZ HERRAIZ, JOAQUIN (Complutense University of Madrid); UDIAS MOINELO, Jose Manuel; Prof. FRAILE, Luis M (Universidad Complutense (ES)); Dr SÁNCHEZ-TEMBLEQUE, Victor (Universidad Complutense de Madrid)

Presenter: AVELLANEDA GONZÁLEZ, José Andrés

Session Classification: Day 2

Track Classification: Medical applications: Fast scintillators for time-of-flight PET and other imaging modalities

Contribution ID: **20** Type: **Oral presentation**

Timing Resolution of a Single Electron Detector with SiPM Light Readout

Thursday 13 March 2025 17:00 (30 minutes)

In some applications the transmission detectors are required to follow the path of radiation or to confirm that a particle entered a given volume. Moreover, such detectors should provide as much as possible information about the interacting radiation (energy deposited, time of interaction) and at the same time, change the particle state (direction, energy) as little as possible. We proposed a transmission detector based on thin plastic for detection of single electrons. The developed detector consists of thin (1mm) square (30x30mm) plastic scintillator (Nuvia SP32) read by SiPM arrays produced by FBK. These are linear arrays (1x36mm) coupled to one or two opposite faces (1x30mm) of the scintillator. Here, the initial measurements of timing resolution of this detector are presented. The reported data cover the coincidence measurements (versus fast, inorganic scintillator) with 511keV annihilation quanta from Na-22 gamma source as well as the timing resolution of 1MeV electrons (from Bi-207 internal conversion) passing through the detector. The recorded light yield is also presented.

Authors: Dr SZCZESNIAK, Tomasz (National Centre for Nuclear Research); Dr GRODZICKA-KOBYŁKA, Martyna (National Centre for Nuclear Research); KOSINSKI, Tymoteusz (National Centre for Nuclear Research); Dr MATUSIAK, Michal (National Center for Nuclear Research); MAZUREK, Krzysztof (National Centre for Nuclear Research); KLIMASZEWSKI, Jan (National Centre for Nuclear Research); Prof. WRONKA, Slawomir (National Centre for Nuclear Research); Dr ACERBI, Fabio (Fondazione Bruno Kessler (FBK)); Dr GOLA, Alberto (Fondazione Bruno Kessler (FBK))

Presenter: Dr SZCZESNIAK, Tomasz (National Centre for Nuclear Research)

Session Classification: Day 2

Track Classification: Instrumentation: Fast front-end and readout electronics

Contribution ID: **21** Type: **Oral presentation**

New lifetime measurements in neutron-rich even-even Zn nuclei via the decay of Cu isotopes

Friday 14 March 2025 12:55 (30 minutes)

Shell evolution around magic and double-magic numbers, such as ^{68}Ni ($N = 40$) and ^{78}Ni ($N = 50$), has always attracted many theoretical and experimental investigations. For this purpose, the experimentalists have been studying a set of observables, as i.e. the first excited 2^+ state energy and the transition probability between the first 2^+ states and the ground state, $B(E2; 2_1^+ \rightarrow 0_1^+)$. Moreover, adding valence nucleons to N = 40 open shell leads to a rapid increase of collectivity, with an interplay of both collective and single-particle degrees of freedom. Such rapid changes indicate underlying complex effects and make this region ideal for testing theoretical calculations. However, conducting this research towards the most exotic nuclei, around N = 50, was impossible up until recently due to the difficulty of producing these neutron-rich Ni beams. In this region, zinc isotopes, which are two protons above the Z magic number 28, between N = 40 to N = 50, are ideal for investigating the evolution of the nuclear structure. Up-to-date, all the known transition probabilities have been depicted via in-beam experiments [1-10], and in some cases the results are controversial.

Recent studies indicated the presence of a ns isomeric state at high excitation energies in ^{76}Zn [11]. The isomeric state was interpreted as a negative-parity level arising from neutron excitation of the pf shell to the $g_{9/2}$ orbital [11]. Its isomeric character was explained as a result of a very small E1 transition rate, with a value of 10^{-8} e^{2}fm^2. This transition is much more hindered than any other E1 transition measured in this region. Hence, this value might indicate the influence of some structure effects that cannot be reproduced by any shell-model calculation so far.

With the main goal to verify and expand the in-beam results, a new beta-decay study of Cu isotopes was carried out at the ISOLDE facility, to investigate the excited states of zinc isotopes between N = 40 and N = 50. This measurement took place at the new ISOLDE Decay Station (IDS), equipped with four highly efficient clover-type Ge detectors, along with a compact fast-timing setup consisting of two LaBr$_3$(Ce) detectors and a fast β-plastic detector. The employment of this setup allows us to extract lifetimes down to the ps range. This contribution will be focused on the lifetimes measured in ^{74,76,78}Zn, in particular, we will present the comparison with the previous in-beam experiments and new isomer states, including the new observed by Chester *et al.*[11]. As a conclusion, we will discuss the new results and their influence on the understanding of the systematic of the excited states in the even-even Zn isotopes.

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Authors: (IS622 COLLABORATION); Dr ILLANA SISON, Andres (Universidad Complutense (ES)); Dr

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Presenter: BENITO GARCIA, Jaime (INFN-LNL)

Session Classification: Day 3

Track Classification: Nuclear structure: Nuclear structure from fast-timing measurements

Contribution ID: **22** Type: **Oral presentation**

Expanding the EAGLE Array at HIL: The FLASH Campaign for Fast-Timing Spectroscopy

Thursday 13 March 2025 10:00 (30 minutes)

The EAGLE array (European Array for Gamma Levels Evaluations) 1 is a multi-configuration detector set-up for in-beam nuclear spectroscopy studies at the Heavy Ion Laboratory (HIL) of the University of Warsaw. It can accommodate up to 30 Compton-suppressed HPGe detectors.

Building on this foundation, a new campaign, FLASH (Fast-Timing $LaBr_3$ Array for Spectroscopy at HIL), is planned to expand the experimental capabilities of the EAGLE array. By incorporating up to 15 $LaBr_3$(Ce) detectors, the setup will enable advanced fast-timing measurements, opening a possibility for precise lifetime measurements of excited nuclear states.
The current status of the setup will be presented as well as information on the expected performance. The goals of the commissioning experiment, planned after the workshop, will also be outlined. In addition, several physics ideas intended with the FLASH setup will be discussed.

This presentation aims to highlight the potential of the FLASH campaign and inspire collaboration and innovative research ideas within the community.

1 J. Mierzejewski *et al.*, Nucl. Inst. & Meth. Phys. Res. Sec. A **659**, 84 (2011).

Authors: ŠPAČEK, Andrej (Heavy Ion Laboratory at the University of Warsaw); NAPIORKOWSKI, Pawel (Institute of Experimental Physics); Prof. KRÖLL, Thorsten (Technische Universitat Darmstadt, Germany)

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Presenter: ŠPAČEK, Andrej (Heavy Ion Laboratory at the University of Warsaw)

Session Classification: Day 2

Track Classification: Facilities and arrays: Large scintillator and hybrid arrays

Contribution ID: **23** Type: **Oral presentation**

Fast-Timing Study of Nuclear Shape Deformation in ^{100}Sr across N=60

Wednesday 12 March 2025 17:00 (30 minutes)

The region around N≈60 with Z≤40 has generated considerable interest as it features the most abrupt shape transition known to date in the nuclear chart, when crossing from N=58 to N=60 1. This transition is closely linked to shape coexistence [2], a phenomenon where two or more states with different intrinsic shapes coexist within the same nucleus at low excitation energy and within a narrow energy range. Specifically, the abrupt change arises from the inversion of two distinct quantum configurations of nucleons, each corresponding to different nuclear shapes. These shifts are interpreted as quantum phase transitions [3], indicating a fundamental transformation in nuclear properties. This phase transition emphasizes the importance of nuclear deformations and the variety of shapes present in neutron-rich nuclei such as strontium and zirconium.
To investigate shape transitions and nuclear structure in Sr isotopes across N=60, an experiment was conducted at the ISOLDE Decay Station (IDS) [4], populating their excited states via the beta decay of ^{100}Rb, ^{101}Rb and ^{102}Rb. The fast-timing method [5], particularly through the use of γ-γ coincidences, enables the measurement of half-lives of excited states on the order of tens of picoseconds. A versatile detector system was employed, consisting of high-purity germanium (Clover-type) detectors for precise gamma-ray identification, plastic scintillators for beta particle detection, and $LaBr_3$(Ce) crystals, valued for their superior time resolution in measuring excited-state lifetimes.
In the case of ^{100}Sr (N=62), once shape inversion occurs at N=60, intruder states play a crucial role in understanding the structural evolution of the nucleus. These states refer to configurations where nucleons follow an orbital occupancy order that does not align with the predictions of the spherical shell model, underscoring the importance of deformation and collective effects.
This contribution presents new half-life measurements that resolve discrepancies from previous values and provide new insights into the nuclear structure of neutron-rich nuclei in the N≈60 region, furthering the understanding of the shape deformation phenomenon.
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Authors: Dr OLAIZOLA, Bruno (Consejo Superior de Investigaciones Cientificas (CSIC) (ES)); SÁNCHEZ PRIETO, Jesús (Consejo Superior de Investigaciones Cientificas (CSIC) (ES))

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Presenter: SÁNCHEZ PRIETO, Jesús (Consejo Superior de Investigaciones Cientificas (CSIC) (ES))

Session Classification: Day 1

Track Classification: Nuclear structure: Nuclear structure from fast-timing measurements

Contribution ID: **25** Type: **Oral presentation**

HISTARS: a proposal for fast-timing measurements at HIE-ISOLDE

Thursday 13 March 2025 09:30 (30 minutes)

Presenter: BERNIER, Nikita (Universidad Complutense (ES))

Session Classification: Day 2

Track Classification: Facilities and arrays: Large scintillator and hybrid arrays

Contribution ID: **27** Type: **Oral presentation**

Advances and Challenges in TOF-PET: From Technology to Applications

Thursday 13 March 2025 11:30 (30 minutes)

Positron Emission Tomography (PET) is a powerful imaging technique that enables the study of physiological and molecular processes in vivo. The introduction of Time-of-Flight PET (TOF-PET) has driven significant improvement on image quality by enhancing signal-to-noise ratio and enabling potential dose reduction. This talk will explore the latest developments in detector technology, signal processing, and system integration that are shaping the next generation of TOF-PET. Additionally, key challenges and future research directions will be discussed.

Presenter: ESPAÑA, Samuel (Consejo Superior de Investigaciones Científicas (CSIC))

Session Classification: Day 2

Track Classification: Medical applications: Fast scintillators for time-of-flight PET and other imaging modalities

Contribution ID: **45** Type: **Oral presentation**

Remembering Henryk Mach

Friday 14 March 2025 11:25 (15 minutes)

Authors: KORGUL, Agnieszka Barbara (University of Warsaw (PL)); Prof. FRAILE, Luis M (Universidad Complutense (ES))

Presenters: KORGUL, Agnieszka Barbara (University of Warsaw (PL)); Prof. FRAILE, Luis M (Universidad Complutense (ES))

Session Classification: Day 3

Track Classification: History of fast timing: History of fast timing

Contribution ID: **46** Type: **Oral presentation**

Remembering Prof. Marek Moszyński

Friday 14 March 2025 11:40 (15 minutes)

Presenter: Dr SYNTFELD-KAŻUCH, Agnieszka (National Centre for Nuclear Research)

Session Classification: Day 3

Track Classification: History of fast timing: History of fast timing

Contribution ID: **50** Type: **Oral presentation**

Concluding remarks

Friday 14 March 2025 13:25 (5 minutes)

Author: Prof. FRAILE, Luis M (Universidad Complutense (ES))

Presenter: Prof. FRAILE, Luis M (Universidad Complutense (ES))

Session Classification: Day 3

Contribution ID: **51** Type: **Oral presentation**

Welcome session

Wednesday 12 March 2025 14:30 (5 minutes)

Presenter: Prof. FRAILE, Luis M (Universidad Complutense (ES))

Session Classification: Welcome session

Contribution ID: **52** Type: **Oral presentation**

Yield measurements with the GARY scintillator array

Thursday 13 March 2025 16:30 (30 minutes)

T.B.F

Author: ALONSO-SANUDO ALVAREZ, Odette (Universidad Complutense (ES))

Presenter: ALONSO-SANUDO ALVAREZ, Odette (Universidad Complutense (ES))

Session Classification: Day 2

Track Classification: Facilities and arrays: Large scintillator and hybrid arrays