# "Doctoral Day" Programme–03 June 2022

**Date and time:** Friday 03 June, 08:50
**Venue: Aula 7, Physics Building**

**08:50-09:00.- Welcome**
Joaquín Gómez Camacho, Programme Coordinator, Universidad de Sevilla,
Antonio Prados Montaño, Academic Commmittee Member, Universidad de Sevilla

## 09:00-10:00 Opening Talk

## Semiconductor radiation Detectors in High Energy Physics experiments

### Prof. Giulio Pellegrini, Instituto de Microelectrónica de Barcelona (IMB-CNM), Barcelona, Spain


I will give a short introduction on the semiconductor radiation detectors used in High Energy Physics experiments at CERN. I will also try to explain their special characteristics and the limitation for the future experiments. The requirements at the Large Hadron Collider (LHC) at CERN have pushed today's silicon tracking detectors to the very edge of the current technology. Future very high luminosity colliders or a possible upgrade of the LHC will require semiconductor detectors with substantially improved properties.

Finally, I will try to show the other use of semiconductor detectors with some special emphasis on medical and dosimetry applications. I will focus on the problematic that we are facing in a new cancer treatment based on ultra-high dose-rate ($\geq$40 Gy/s) called FLASH therapy.

**Giulio Pellegrini's Short CV:**

I graduated in physics at the University of Naples in Italy and obtained my PhD at the University of Glasgow in 2003. My activity is concentrating in innovative research and enjoys international acknowledgement. Several results of my research have been implemented in some of the most important high-energy physics experiments, confirming the world-class quality of the work we perform at IMB-CNM-CSIC where I can claim to give a crucial contribution. I am considered a worldwide expert in the field of advanced radiation hard silicon detectors and I am the head of the Radiation Detector Group at IMB-CNM-CSIC.

Since May 2012, I am the worldwide coordinator of the research line: "New Detector Structures", within the RD50 collaboration,[1] of the European Organization for Nuclear Research (CERN), whose mission is to develop radiation hard semiconductor devices for the Large Hadron Collider (LHC) experiments. It includes more than 50 institutes and 270 partners in Europe, Asia and the USA.

Since 2020, I am convenor of the Detector Roadmap panel in solid state detectors to assist the ECFA (The European Committee for Future Accelerators) to organize the detector R&D efforts in Europe , taking into account progress with emerging technologies in adjacent fields. This community roadmap will help to identify the grand challenges that will guide the R&D process on the medium and long term timescales, and define technology nodes broad enough to be used as the basis for creating R&D platforms.

[1] http://rd50.web.cern.ch/rd50/

# Morning Session

**Date and time:** Monday 03 June, 10:00
**Venue: Aula 7, Physics Building**

## Students' presentations

**10:00-10:20.- Juan Manuel Franco Patiño: "Modelling semi-inclusive neutrino-nucleus scattering"**

**Abstract:** Nuclear effects in neutrino-nucleus scattering are one of the main sources of uncertainty in the analysis of neutrino oscillation experiments. Due to the extended neutrino energy distribution, very different reaction mechanisms contribute to the cross section at the same time. Measurements of muon momentum are very important for experiments like T2K, where most of the information about the oscillation signal comes from detection of the final-state muons only. However, those inclusive measurements make difficult to distinguish the contributions of nuclear effects. For instance, they do not allow to separate between different nuclear models and are not sufficient to put constraints on the amount of two-body current contributions. This is why there is a growing interest in measurements of more exclusive processes, for instance the detection in coincidence of a muon and an ejected proton in the final state. Interpretation of such reactions, usually called semi-inclusive reactions, is challenging as it requires realistic models of the initial nuclear state and an appropriate description of proton final-state interactions. In this talk I'm going to present the theoretical predictions of semi-inclusive $\nu_\mu$-$^{12}$C obtained within an unfactorized approach based on the relativistic distorted wave impulse approximation (RDWIA) and compare them with latest T2K and MINER$\nu$A measurements.

**10:20-10:40.- Farnaz Faramarzi: "Electronically foveated Dynamic vision sensor"**

**Abstract:** Conventional vision sensors produce images of the entire field of view at a fixed frame rate, while biological vision systems do not have a notion of frame. Our eyes observe surroundings in an asynchronous and continuous way. Whenever the retina detects some relevant information to send, asynchronous electric nervous pulses or spikes are sent through the optical nerve. Inspired by the visual processing mechanisms in the retina, dynamic vision sensor (DVS) measures brightness in each pixel asynchronously and then outputs an asynchronous and discrete stream of spatiotemporal event information that encodes the time, location, and sign of brightness changes. DVSs feature unique characteristics such as contrast coding under wide illumination variation, microsecond latency response to fast stimuli, and low output data rates (which greatly improve the efficiency of post-processing stages). Although modern event cameras are trending toward higher sensor resolutions to have enabled new applications, they are increasingly placing a burden on the end-user in terms of both data bandwidth and computational requirements of downstream systems. In this work we presented an electrically foveated DVS to achieve high-resolution object recognition in the target visual field combined with a wide visual field able to detect objects of interest in the periphery with low computational load.

**10:40-11:00.- David Palomeque Mangut: "Study of a Wireless Power and Data Transfer System Over a Single Pair of Coils"**

**Abstract:** A system to transfer both mW-power and Mbps-data over an inductive link using a single pair of coils is proposed. The system is able to handle a wide range of loads by implementing a load adapter block that divides the operation into two phases: a Power Transfer Phase (PTP) and a Data Transfer Phase (DTP). On the one hand, during PTP, a constant amount of power is drawn from the inductive link, regardless of the current demanded by the load. On the other hand, during DTP, the load is powered with external capacitors, allowing the inductive link to be used for data transmission. With this architecture, intended to be used in a neural implant, power can be delivered to a wide range of loads without affecting the uplink/downlink data communication reliability and with no need of extra coils. Thus, the proposed solution permits minimizing the overall size of the neural implant. An electrical mixed-signal model of the system is described and implemented in MATLAB Simulink through Simscape Electrical and Stateflow toolboxes. Simulations performed on the electrical model of the system are shown and discussed.

**11:00-11:20.- Eusebio Rodríguez: "Nonmonotonic quantum phase gathering in curved spintronic circuits"**

**Abstract:** Spin carriers propagating along quantum circuits gather quantum spin phases depending on the circuit's size, shape, and spin-orbit coupling (SOC) strength. These phases typically grow mono-tonically with the SOC strength, as found in Rashba quantum wires and rings. In this work we show that the spin-phase gathering can be engineered by geometric means, viz. by the geometric curvature of the circuits, to be non-monotonic. We demonstrate this peculiar property by using one-dimensional polygonal models where flat segments alternate with highly curved vertices. The complex interplay between dynamic and geometric spin-phase components— triggered by a series of emergent spin degeneracy points— leads to bounded, global spin phases. Moreover, we show that the particulars of the spin-phase gathering have observable consequences in the Aharonov-Casher conductance of Rashba loops, a connection that passed unnoticed in previous works.

**11:20-11:50.- COFFEE BREAK**

**11:50-12:10 Javier Arcenegui: "SmartNFT, a new Ethereum Improvement Proposal for Non-Fungible Tokens tied to physical assets with user management"**

**Abstract:** Non-Fungible Tokens (NFTs) open a new point of interest in the circular economy model, which involves sharing and reusing materials and products as long as possible. NFT ownership is considered in the ERC (Ethereum Request for Comments)-721 standard. However, the ERC-721 standard does not define the possibility of tying an NTF to a physical asset (for example, an electronic device) that generates its own blockchain account. In addition, the management of the users of the assets is not included either. An extension of the ERC-721 standard, SmartNFT, has been submitted as Ethereum Improvement Proposal (EIP) so that a new standard includes the tie of the asset with the NFT through its blockchain account and the necessary logic to assign who uses it without losing the ownership of the NFT. This new EIP is very suitable for sharing assets, for example electronics and ICT, batteries and vehicles, constructions and buildings, which are sectors that use most resources and are the focus of the Circular Economy Action

Plan adopted by the European Commission. Several use cases of the EIP proposal are illustrated for shared assets.

**12:10-12:30.- Daniel López Aires: "Behaviour of natural/synthetic clays exposed to nuclear waste corrosion products in the near-field of a geologic repository for nuclear waste disposal"**

**Abstract:** Nuclear energy stands out as a promising energy source to reduce greenhouse gases emission reducing the use of fossil energy sources. However, it produces long-lived and highly radioactive waste, so-called High-level Radioactive Waste (HLW). Up to present there is no global and definite disposal strategy for the HLW, while tons of radioactive wastes are being generated yearly. An urgent solution for this problem is needed. Deep Geological Disposal stands out as the most promising and globally accepted solution. The nuclear waste would be stored and sealed underground with a multibarrier system so that the nuclides can disintegrate without harming the biosphere. Bentonite, a type of swelling clay, is proposed as the last engineered barrier of the disposal due to its ability to limit water inflow to the waste container, to self-seal and to filter radionuclides, among others. This last property is crutial for the long-term safety and hence for the validation of this disposal strategy. This PhD will explore radionuclides filtration using real spent fuel leachates and a choice of bentonites proposed as candidate materials. We aim to explore realistic and useful solutions to underpin the safety of Deep Geological Repositories.

**12:30-12:50.- Andrea Ferrario: "Depth Scanning Image Sensor: a smart CMOS Image Sensor for 3D sensing"**

**Abstract:**Depth sensing assumed an increasing role in the last decades and it is now a common feature in most of the devices that are used in everyday life. Starting from smartphones, smart home robots, AR/VR headset 3D sensing has spread in diverse fields such as automotive, medical, industrial, security, etc. Among different depth sensing technologies, single photon counting devices, such as SPADs, have emerged as a powerful solution for this kind of problem with direct time of flight (dToF) being the technique adopted for depth detection. However, several drawbacks such as need of quenching circuits, accurate time to digital converters, low quantum efficiency, low fill factor, high IO bandwidth and special fabrication process, led to the idea of this Depth Scanning Image Sensor solution (DSIS). DSIS uses standard image fabrication process eliminating the issue of special fabrication techniques. Moreover, standard pixels are used with the advantage of better quantum efficiency, fill factor, simpler readout and possibility to switch between 2D and depth sensing imaging styles. A first 576x504 pixels prototype with multiple subarrays to test different pixel architectures was fabricated in an advanced 110nm CMOS image sensor technology. First stage testing results on pixels characteristics are available.

**12:50-13:10.- Manuel Jiménez Través: "Oscillatory Neural Networks for Neuromorphic Computing"**

**Abstract:** Oscillatory Neural Networks (ONN) are a brain-inspired alternative non-von Neumann architecture, based on oscillatory-based computing that encodes information in the phase differences between neurons. This way, massively parallel and energy-efficient computation can be performed resorting to the synchronization phenomena of a fully-

connected network. ONN exhibits affinity in its operation with Hopfield Neural Network (HNN), which is a special kind of fully-connected recurrent neural network with one single layer, as well as they share training methods such as the well-known Hebbian learning rule. Typical application for ONN and HNN is pattern recognition as associative memory in such a way they can be trained to set different target patterns as fixed points of the network state-space. To do so, high capacity and retrieval, given degenerated input patterns, capabilities are desired. In this talk, a digital implementation developed as a paradigm concept demonstrator is presented along with exploration on different learning methods.

**13:10-13:30.- Juan de Dios del Pino Corredera: "Modeling of drought in Andalusia through integration of conventional and remote sensing data"**

**Abstract:** Drought is a natural risk present in Andalusia, accentuated because future climate scenarios predict an increase in its frequency and intensity. Edaphic drought is one of the least studied despite its impact on vegetation, agriculture, livestock and other sectors dependent on soil water. The Palmer index is widely used in the United States for its study. In the Mediterranean area, the results can be improved, due to the complex topography compared to the simplicity of the great American plains. The objective is to find an adaptation of the Palmer index for the study and monitoring of edaphic drought in Andalusia. The study is carried out for several meteorological observatories representative of the most frequent climates in Andalusia.

## Flash Talks

**13:30-13:35.- María Teresa Rodríguez González: "Proton-induced cross sections of $\beta^+$ emitters for PET range verification"**

**Abstract:** In proton therapy, several studies confirm the need for more accurate cross section data up to 200 MeV of the reaction channels of interest in both online and offline PET range verification. In order to measure the reaction cross sections of these isotopes, a comprehensive study has been performed at three different irradiation faccilities. The experimental approach, analysis and preliminary results will be discussed.

**13:35-13:40.- Pedro Martín Holgado: "The role of the CNA in the first Interlaboratory Comparison in Dosimetry between four ISO/IEC 17025 Accredited European Irradiation Facilities"**

**Abstract:** Interlaboratory comparisons are strongly recommended for accredited entities IEC/ISO 17025. Four accredited European laboratories have successfully compared their dosimetry procedures and practices. RadLab, one of the participants, is the gamma radiation laboratory located at the Spanish National Accelerators Center (CNA) which was commissioned in 2013 by the consortium formed by the CNA and the company ALTER Technology. Since then, both entities have had a close collaboration on different research projects.

**13:40-13:45.- Carlos Domínguez Matas: "RAD-HARD design techniques for SAR-ADC"**

**Abstract:** This thesis focuses on the research and development of radiation hardening techniques for high performance mixed-signal ICs in aerospace application. As test vehicle, a 1.2V 65nm 13-bit 50Msps SAR-ADC has been integrated. The original contributions of this work can be summarized as: (i) proposal of a novel non-intrusive radiation SEE

detector, (ii) development of an adaptative technique for asynchronous timing, and (iii) simplification of the digital calibration hardware for capacitor mismatch and offset.

**13:45-13:40.- María de los Ángeles Millán Callado: "Characterization of neutron detectors for nuclear physics experiments in a laser-driven neutron source"**

**Abstract:** This work reports the preliminary results of an experimental campaign carried out in autumn 2021 at the DRACO laser facility of the HZDR in Dresden, Germany, with the objective of studying the feasibility of carrying out time-of-flight nuclear reaction measurements in the harsh environment of a laser-driven neutron source. The experiment consisted of characterizing and optimizing the response of different neutron detectors to these conditions under different ion acceleration and neutron production configurations.

**13:50-13:55.- Pedro Punta de la Herrán: "Structure of $^{17}$C in a deformed potential and its application to $^{16}$C(d,p)$^{17}$C"**

**Abstract:**The structure of $^{17}$C is studied in a two-body model: a weakly-bound neutron moving in a deformed potential generated by the core. Energies and associated wave functions are calculated diagonalizing the Hamiltonian in the Transformed Harmonic Oscillator basis. The wave functions obtained are used to calculate differential cross sections of the reaction $^{16}$C(d,p)$^{17}$C, comparing with the experimental data from Phys. Lett. B **811** (2020) 135939.

**13:55-14:00.- José Luis García León: "Detection and measurement of radionuclides. The case of 55Fe and 63Ni"**

**Abstract:** Liquid scintillation counting (LSC) is an alternative when determining the activity of an electron emitting radionuclide. This is the case of 63Ni and 55Fe, which decay by beta emission and electron capture respectively. In this work, two liquid scintillation spectrometers were studied and adapted for 63Ni and 55Fe measurements.

Determination of activity concentration of 55Fe and 63Ni is very important for decommissioning nuclear power plants due their presence in radioactive waste.

**14:00-14:05.- Antonio Jesús López Fuentes: "Characterization of natural ($^{210}$Pb and $^{238}$U) and anthropogenic ($^{236}$U) radioactivity in a sediment core from the Black Sea"**

**Abstract:**Very scarce literature has been published about radioactive contamination, both in seawater and sediments, at the Black Sea. In this work, we present the first $^{236}$U results in sediments from the western Black Sea. The 1 MV AMS facility at Centro Nacional de Aceleradores (CNA, Seville, Spain) has been used for the $^{236}$U/$^{238}$U ratio measurement. The $^{238}$U has been determined using gamma spectrometry and ICP-MS/MS technique at CITIUS. Also a $^{210}$Pb based dating method has been applied for the age characterization. The $^{236}$U results will be interpreted in the context of the contamination sources in the western Black Sea.

**14:05-14:10.- Álvaro Saiz Castillo: "A deep learning approach to QPT analysis of the Agassi model"**

**Abstract:** In this talk, we discuss and analyze an extended Agassi model, which describes a many-body system in Nuclear Physics. It presents a very rich quantum phase diagram that gives rise to several quantum phase transitions (QPTs) of different character, making it of great interest in the field of QPTs. We show how deep learning algorithms can help us effectively and efficiently classify the quantum phase of the system using only the time dynamics of a correlation function.

**Attendees (without talk):**

- Unai Abascal Ruiz
- Javad Ahmadi Farsani
- Iván Díez de los Ríos Luis
- Jesús José Domínguez-Palacios Durán
- Hamidreza Erfanijazi
- Gregorio García Valladares
- Amir Khan
- Hossein Khosravi
- Alessio Mancini
- Kiera McKay
- Roberto José Méndez Romero
- Kourosh Mokhtari
- Sergio Palomeque Mangut
- Andrés Santana Andreo
- Aamir Sohail Nagra
- Daniel Suárez García
- Virginia Zúñiga González

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