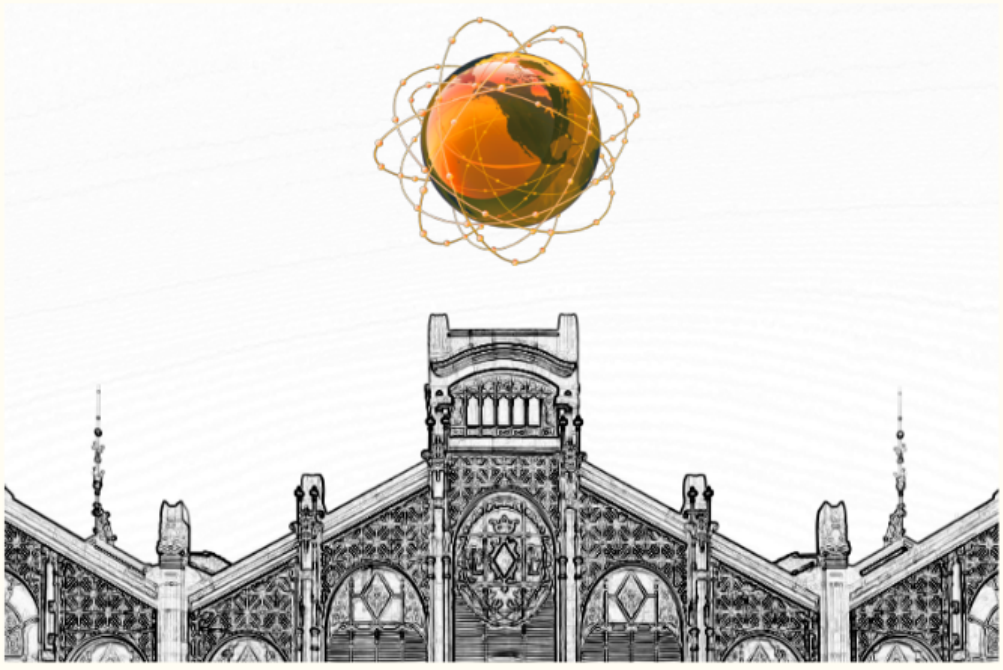
ANIMMA INTERNATIONAL SUMMER SCHOOL 2025




IFIC
INSTITUT DE FÍSICA CORPUSCULAR
CSIC
CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS
VNIVERSITAT DE VALÈNCIA
EXCELENCIA SEVERO OCHOA
AGENCIA ESTATAL DE INVESTIGACIÓN
MINISTERIO DE CIENCIA, INNOVACIÓN Y UNIVERSIDADES
sck cen
Belgian Nuclear Research Centre
cea
amU
Aix Marseille Université
FILIÈRE INSTRUMENTATION
Faculté des Sciences
INSTITUTE OF EXPERIMENTAL AND APPLIED PHYSICS CTU IN PRAGUE
GENERALITAT VALENCIANA
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VNIVERSITAT DE VALÈNCIA
VNIVERSITAT DE VALÈNCIA
Facultat de Física

Contents

AISS overview

AISS 2025 is possible thanks to the collaboration of IFIC; Parc Científic; the Department of Atomic, Molecular and Nuclear Physics; and the ANIMMA conference organisation.

Schedule example for group one: Students will be split into groups of four, each with a different schedule. All students will attend all theory and hands-on sessions.

DAY 1 (Saturday 7th of June)	DAY 2 (Sunday 8th of June)	DAY 3 (Monday 9th of June)
Welcome		
Theory 1 1h *Interaction of radiation with matter* Prof. Dr. Abdallah Lyoussi	**Theory 3** 1h *Nuclear heating rate measurements* Prof. Dr. Eng. Christelle Reynard-Carette	**Theory 5** 1h *High energy physics instrumentaion* Dr. Arantxa Ruiz Martínez
Computer Lab 1 2h *PET Imaging – GATE/GEANT4 simulations* Dr. Ana Ros García	**Computer Lab 2** 2h *Medical imaging, data manipulation, and AI* Dr. Francisco Albiol Colomer Dr. Salvador Tortajada Velert	**Experimental Lab 7** 1h15 *High frequency signal processing* Dr. Nuria Fuster-Martínez Dr. Daniel Esperante Pereira Juan Carlos Fernández Ortega
Coffee break	Coffee break	Coffee break
Theory 2 1h *Physical principles of radiation detectors* Prof. Dr. Abdallah Lyoussi	**Theory 4** 1h *Medical physics instrumentation* Dr. Gabriela Llosá Llácer	**Experimental Lab 8** 1h15 *Compton camera imaging* Dr. Luis Barrientos Mauriz Wilson Ramírez Tejerina
Lunch 1h	**Lunch** 1h	**Experimental Lab 9** 1h15 *Timepix detectors Basic* Dr. Michael Holik Dr. Vladimir Vicha
Experimental Lab 1 1h15 *Cloud chamber* Dr. Matthew Strugari Wilson Ramírez Tejerina Dr. Santiago González de la Hoz	**Experimental Lab 4** 1h15 *The DEMO++ detector in the NEXT experiment* Juan David Villamil Pokhee Saharia Dr. Joshua Edward Renner Fabian Kellerer Dr. Neus Lopez March Camilo Andrés Cortés	**Lunch** 1h
Experimental Lab 2 1h15 *Measuring Environmental Radioactivity with a Portable HPGe detector* Mireia Simeó Vinaixa Dr. Nadia Yahlali	**Experimental Lab 5** 1h15 *A DEMO to Measure an RC Circuit Time* constant with an Arduino Dr. Nadia Yahlali	**Experimental Lab 10** 1h15 *Timepix detectors Advanced* Dr. Michael Holik Dr. Vladimir Vicha
Coffee break	Coffee break	Coffee break
Experimental Lab 3 1h15 *White rabbit synchronization* Dr. Diego Real Máñez Dr. David Calvo Diaz-Aldagalán	**Experimental Lab 6** 1h15 *Multi-anode photomultiplier tubes* Dr. Fernando Hueso	**Examination** 1h45 *Multiple choice questions* 10 Theory questions 12 Lab questions 13 correct: minimum to pass

How to get to the AISS

The meeting point for the first day is at the main entrance of IFIC. The easiest way to get there is by tram, the nearest stop is "À punt". There is information about the metro and tram lines on the Metrovalencia website. Keep in mind that the frequency of trams decreases during weekends.

Theory

Session T1&T2. Radiation physical principles

Prof. Dr. Abdallah Lyoussi

Prof. Dr. Abdallah Lyoussi is physicist researcher in experimental physics and Research Director and Senior Fellow in Nuclear Instrumentation and measurement at French Atomic and Alternative Energies Commission CEA in Cadarache, France. He is also Professor at French Institute of Nuclear Sciences and Technologies and Aix Marseille University. He received his MSc in nuclear physics from Fes University (Morocco) in 1988 and MSc in Nuclear Engineering from French institute of nuclear sciences and technologies (INSTN) in 1990. In 1994, he received his PhD in nuclear physics and, in 2002; he received advanced graduation in Research and Development supervising activities on experimental physics (HDR). He was awarded French Nuclear Energy Society price for his works on photofission interrogation as nondestructive measurement by using a LINAC machine. He is the founder and the General Chairman of the international conference ANIMMA (Advancements in Nuclear Instrumentation Measurement Methods and their Applications) since 2009. Since 2010, as the main founder he is the CEA scientific coordinator of the LIMMEX join Lab between CEA, CNRS and Aix-Marseille University he is involved in instrumentation and measurements in extreme media. Since 2014, he is IEEE Distinguish Lecturer and IEEE Senior Member. Abdallah Lyoussi has worked on several nondestructive measurement methods such as photofission interrogation, neutron interrogation by using different kinds of detectors, electronics, data acquisition systems and advanced particle production machines like LINAC; neutron generators, X tubes. He developed, patented and published various works related to innovative and advanced nuclear measurement methodologies. Abdallah Lyoussi is now mainly involved in supervising R&D on nuclear instrumentation and measurement in severe media (nuclear reactors, nuclear fuel cycle, dismantling and decommissioning, radioactive wastes assays, severe accident monitoring, safeguards...).

Summary

The course will be focus on the physical principles of radiation and is divided in two sessions:

- Interaction of radiation with matter.
- Physical principles of radiation detector:
  - Gas-filled detectors
  - Scintillation detectors
  - Solid-state detectors (semiconductor, diamond, TLD)
  - Activation detectors

Session T3. Nuclear heating rate measurements

Prof. Dr. Eng. Christelle Reynard-Carette

Prof. Dr. Eng. Christelle Reynard-Carette (1974) graduated in Thermal Sciences at Aix Marseille University in 1998 and obtained her PhD on heat/mass transfer in microgravity (boiling, thermocapillary convection, parabolic flights) at the same university in 2001. She is professor at Aix Marseille University (laboratory IM2NP UMR7334, DETECT department, team Microsensors-Instrumentation). She is deputy director for research of ISFIN institute (Institute of Fusion Sciences and Instrumentation in Nuclear Environments). She conducts research on the design, development, miniaturization and characterization of sensors for the on-line measurement of key quantities within nuclear reactors (absorbed dose rate/nuclear heating rate, calorimetry, irradiation campaigns). She led/leads several joint research programs with the CEA (IRESNE, Jules Horowitz Reactor) within the framework of the AMU-CEA-CNRS joint laboratory LIMMEX (Instrumentation and Measurement in EXtreme Environments) created in 2010 and for which she is responsible for AMU and CNRS. She collaborates with various partners and international nuclear centers. As an example, she is in charge of two A*Midex projects involving the MIT's Nuclear Reactor Laboratory (CALOR-I project for research area, MOBIL-APP project for education area). She is also involved in the ANIMMA conference and the Franco-Moroccan school EFMMIN since their creation (member of the scientific and steering committees, organization chair workshops). She is also responsible of two master's tracks in instrumentation, measurement and metrology (in particular a new international track dedicated to Instrumentation and Measurement Science for Major Nuclear Research Facilities which started in 2022).

Summary

The nuclear heating rate, corresponding to an intense absorbed dose rate induced by the various interactions between radiation and matter and leading to an increase in temper-

ature in the matter, represents a key nuclear quantity for research reactors and their associated irradiation experiments in terms of thermal, thermal-hydraulic and mechanical design and data interpretation. The nuclear heating rate is measured on-line by means of specific calorimetric sensors called calorimeters. There are two types of calorimeters: the single cell calorimeter and the differential calorimeter. The short course will present:

- these different types of calorimeters,
- their design, materials, instrumentation and assembly,
- their thermal principle,
- their calibration under laboratory conditions without nuclear radiation,
- their measurement methods under real conditions (irradiation campaign),
- their main characteristics (sensitivity, measurement range, response time...),
- their advantages and drawbacks,
- the associated challenges.

The short course will be illustrated by the comprehensive approach conducted at Aix-Marseille University to innovate in calorimetry by coupling experimental work with simulations from laboratory conditions to real conditions and illustrated by focusing on the CALORRE differential calorimeter used in the MITR reactor in October 2024.

Session T4. Medical physics instrumentation

Gabriela Llosá

Dr. Gabriela Llosá has been the coordinator of the IRIS group at IFIC (Valencia) since 2014. She received her MSc in Physics in 1998 and her PhD in physics in 2005, both from the University of Valencia. In 2011 she was awarded with the IDEA award of the 'Fundación de las Artes y las Ciencias'. She has more than twenty years experience in detector development, mainly for medical applications. She started working in the construction of detectors for different particle physics experiments at PSI and CERN and later on she specialized in detectors for medical imaging. She has always worked in the development of novel technologies and techniques at the frontiers of the state of the art and within international projects and collaborations. She has collaborated with numerous research groups, mainly from Switzerland, Italy, Germany, Slovenia, USA and Canada. Her current interests focus principally on the development of Compton cameras for hadron therapy treatment monitoring and for visualization and dosimetry of the distribution of radionuclides in the patient's body in Targeted Radionuclide Therapy. Overall, she has participated in more than 25 funded research projects (mostly Spanish, Italian and European) and been the P.I. of more than 10, some of

them in collaboration with hospitals and protontherapy centres. She has also led several innovation and valorization projects and R&D contracts with companies. Concernig training of young researchers, she is a lecturer in the Masters of Medical Physics and of Advanced physics of the University of Valencia since 2009 and 2014 respectively. She has supervised eight PhD theses and over 30 research works from Bachelor, Master and Erasmus+ students. She is the president of the medical physics group of the Spanish Royal Physics Society (RSEF) since 2019. She is founder and main organizer of the RSEF/IFIMED medical physics conference (four editions since 2016) and co-organizer of the RSEF Biennial Symposium and CPAN days.

Summary

This lecture will revise in a descriptive way the origins of medical imaging, the evolution and the latest advances and current research of the detectors employed in diagnostic (SPECT, PET and CT) and therapy (radiotherapy, particle therapy). It will cover the following topics:

- Gamma cameras, SPECT and Compton cameras.
- PET: from block detectors to time-of-flight PET.
- CT scanner generations.
- Therapy with photons and protons.

Session T5. High energy physics instrumentation

Dr. Arantxa Ruiz Martínez

Dr. Arantxa Ruiz Martínez is an experimental physicist at the Institute of Corpuscular Physics (IFIC), joint center of the Spanish National Research Council (CSIC) and the University of Valencia. She has conducted her research in the ATLAS experiment of the LHC accelerator at CERN since 2004. She received her PhD in 2009 with Cum Laude honors. She joined IFIC with a Ramón y Cajal grant in 2018 and is a tenured scientist (científica titular) since 2023. She has made important contributions to several areas of the ATLAS trigger system (online event selection for permanent storage), being its maximum responsible as ATLAS trigger coordinator during the LHC Run 3 data taking start. She is currently the Institute Representative at IFIC of the ATLAS Trigger and Data Acquisition (TDAQ) project as well as principal investigator of different national and regional research projects focused on the Phase-II Upgrade of the ATLAS detector.

Summary

This is an introductory course on particle detection and triggering in High Energy Physics. Strategies for event selection in real time in modern particle physics experiments will be presented. Basic concepts such as data size, rate, bandwidth, dead time, busy, efficiency, etc. will be presented. The course will be structured as follows:

- Trigger and Data Acquisition (DAQ) system concepts
- From signal to physics
- Event building
- Online data processing

Hands-on sessions

Session CL1. PET Imaging - GEANT4/GATE simulations

Dr. Ana Ros García

Instituto de Física Corpuscular (IFIC), CSIC-UV, Valencia, Spain

Summary

This hands-on exercise is focused on the simulations of PET scanners with Geant4 and GATE. The course will include a short theoretical introduction to PET and its data acquisition formats in order to fully understand the output of the simulations that will be run. In the hands-on section, there will be practical exercises to visualise and manipulate data using ROOT and the command line, as well as Geant4 and GATE simulations for PET.

Session CL2. Medical imaging, data manipulation, and AI

Dr. Francisco Albiol and Dr. Salvador Tortajada Velert

Instituto de Física Corpuscular (IFIC), CSIC-UV, Valencia, Spain

Summary

The course is an introductory lecture about how medical imaging is handled in medical environments. This will be focused to help to provide what are the most common techniques for understanding and minipulating several groups of medical images, including xray, CT MRI and US.

Session EL1. The cloud chamber

Dr. Matthew Strugari, Wilson Ramírez Tejerina and Dr. Santiago González de la Hoz

Instituto de Física Corpuscular (IFIC), CSIC-UV, Valencia, Spain

Dr. Santiago González de la Hoz

Director of the *Department of Atomic, Molecular and Nuclear Physics*[1], Faculty of Physics, University of Valencia

1. *The material used for this hands-on laboratory session was provided by the department.*

Summary

The session will consist of visualising the traces of the detected particles (alphas, electrons, positrons, muons and photons) in the cloud chamber coming from cosmic rays and natural radioactivity. The physics behind the interaction of the particles determines its trace making it possible to differentiate between particles. Furthermore, the cloud chamber will be used for the calculation of the activity of a Rn-222 radioactive source and the activity of its decay products.

Session EL2. Measuring Environmental Radioactivity with a Portable HPGe detector

Mireia Simeó Vinaixa and Dr. Nadia Yahlali

Instituto de Física Corpuscular (IFIC), CSIC-UV, Valencia, Spain

Summary

A portable NaI(Tl) detector and a portable High Purity Germanium (HPGe) detector, both mounted on a mobile platform that are used in the Laboratory of Environmental Radioactivity of the University of Valencia will be used in this session.

The students will perform a calibration exercise of the detector with a set of gamma radioactive sources followed by the measurement of the radioactive background in the detector location, and a swift analysis of the spectra to identify the main radioactive components of this background.

Session EL3. White rabbit synchronization

Dr. Diego Real Máñez and Dr. David Calvo Diaz-Aldagalán

Instituto de Física Corpuscular (IFIC), CSIC-UV, Valencia, Spain

Summary

The session will consist of a demonstration of the White Rabbit protocol, showcasing how to synchronize one of the KM3NeT nodes with a White Rabbit switch to the nanosecond level. The connection between the two devices will be established using a 50 km fiber optic spool, and the PPS (Pulse Per Second) signals of both devices will be monitored using an oscilloscope. Additionally, a brief introduction to the White Rabbit protocol will be provided, along with KM3NeT as a featured case study, highlighting its significance as a scientific facility utilizing this technology.

Session EL4. The DEMO++ detector in the NEXT experiment

Dr. Neus Lopez March, Dr. Joshua Edward Renner, Juan David Villamil, Pokhee Saharia, Fabian Kellerer and Camilo Andrés Cortés

Instituto de Física Corpuscular (IFIC), CSIC-UV, Valencia, Spain

Summary

The NEXT experiment (Neutrino Experiment with a Xenon TPC) is designed for the study of neutrinoless double-beta decay, a hypothetical process that, if detected, could provide crucial insights into the nature of the neutrino and the violation of lepton number conservation. The NEXT experiment employs a high pressure time projection chamber (TPC) technology filled with xenon gas to achieve high-precision detection of rare events. As part of this project, the student will conduct a detailed analysis of real data containing Krypton (Kr) events. These data will be obtained using the NEXT-DEMO++ detector, a demonstration version of the main experiment operating at the Instituto de Física Corpuscular (IFIC). The purpose of this analysis is to characterize the detected events and measure their energy resolution. To carry out this study, a Jupyter Notebook will be used, an interactive programming tool that will allow for efficient visualization, processing, and analysis of the data.

Session EL5. A DEMO to Measure an RC Circuit Time Contant with an Arduino

Dr. Nadia Yahlali Haddou

Instituto de Física Corpuscular (IFIC), CSIC-UV, Valencia, Spain

Summary

This DEMO allows to simply and quickly measure the discharge current of a capacitance of an RC circuit as a function of time, and determine from it the time constant of the circuit. The RC-DEMO is assembled using sets of capacitances and resistors (to vary the time constant values) connected in series to a project board. The capacitance is charged using a 9 or 12V battery and the circuit is connected to one of the 16 analog inputs of an Arduino Uno, which is programmed to record charge or current with a sampling rate of 16 MHz. The students

will use a combination of resistors and capacitors to set up an RC circuit using the RC-DEMO elements, and will measure its discharge current as a function of time to determine the time constant of the circuit.

Session EL6. Multi-anode photomultiplier tubes

Dr. Fernando Hueso-González

Instituto de Física Corpuscular (IFIC), CSIC-UV, Valencia, Spain

Summary

Multi-anode PMTs are position-sensitive photomultiplier tubes (PS-PMTs), that are usually coupled to scintillation crystals and read out using the Anger logic with a resistance network. In this session, an 8x8 PS-PMT (H8500) coupled to a monolithic BGO scintillation crystal will be deployed to obtain the energy spectrum of diferent gamma-ray sources, as well as the sensitivity to spatial displacements of collimated sources. Thanks to the resistance network, only 4 channels out of the 64 anodes are extracted and digitized with an oscilloscope. The gamma-ray interaction position can then be reconstructed using a center-of-gravity equation.

Session EL7. High frequency signal processing

Dr. Nuria Fuster-Martínez, Dr. Daniel Esperante Pereira and Juan Carlos Fernández Ortega

Instituto de Física Corpuscular (IFIC), CSIC-UV, Valencia, Spain

Summary

Most accelerators deployed worldwide use radiofrequency technology (from 3 Hz until 3 GHz) to accelerate particles. To apply this technology, it is necessary to design complex data acquisition and processing systems able to deal with high frequency signals. In this session, we will analyze the behavior of several electronic components that compose the most critical system elements. To do so, we will deploy a vector network analyzer (VNA) that gives information regarding the amplitude and phase of the transmitted and reflected

signals within these elements. In addition, we will setup an RF circuit to decrease the frequency of an input signal and use a spectrum analyzer to understand it's behavior. Tasks: calibrate and measure the scattering parameters of RF components with a VNA; setup and analyze a mixing circuit to decrease the frequency of an input signal.

Session EL8. Compton camera imaging

Dr. Luis Barrientos Mauriz and Wilson Ramírez Tejerina

Instituto de Física Corpuscular (IFIC), CSIC-UV, Valencia, Spain

Summary

This lab session focuses on using the MACACO III Compton Camera to study gamma rays emitted by a Na-22 point source. The session begins with the setup of the system, concentrating on the two detector planes utilized for the measurements. A spectrum is measured in singles and another in coincidences, with comparisons and discussions on their differences. The coincidence spectrum is then calibrated to account for the detector's energy response. Finally, a reconstruction algorithm is applied to generate an image of the Na-22 source's position.

Session EL9. Timepix basics

Dr. Michael Holik (IEAP CTU & FEE UWB)

Institute of Experimental and Applied Physics, Czech Technical University in Prague Faculty of Electrical Engineering, University of West Bohemia in Pilsen

Dr. Vladimir Vicha (IEAP CTU)

Institute of Experimental and Applied Physics, Czech Technical University in Prague

Summary

Participants will get familiar with the sophisticated pixel detector Timepix through the session of practical hands-on exercises performed with SESTRA educational kit. Participants will learn how to build an experimental set-up, how to configure measurement parameters, how to run acquisition and how to evaluate measured data. The basic types of radiation

produced by several emitters, including natural radiation background, will be studied and distinguished according to recorded tracks via the pixel detector. Further, the properties of each kind of radiation will be examined.

Session EL10. Timepix detectors advanced

Dr. Michael Holik (IEAP CTU & FEE UWB)

Institute of Experimental and Applied Physics, Czech Technical University in Prague Faculty of Electrical Engineering, University of West Bohemia in Pilsen

Dr. Vladimir Vicha (IEAP CTU)

Institute of Experimental and Applied Physics, Czech Technical University in Prague

Summary

Participants will learn more about sophisticated Timepix detectors via demonstration of three advanced experiments: Application of Timepix in a delayed coincidence measurement exploiting time-of-arrival and spectroscopy information in order to identify (alpha-gamma or gamma-gamma) coincidence events observing a radiation source. Detection of neutrons via adapted pixel device using converter materials suitable for fast or thermal neutrons. Analysis of Timepix data recorded on the ground level, on-board of the airplane, on the satellite orbit focusing on identification of space radiation and its specifics.