DETECTORS, LASERS AND OPTICS CURRICULUM

COURSES for the PhD STUDENTS

DETECTORS, LASERS AND OPTICS CURRICULUM

Curriculum's main purpose is to train experts on:

- radiation detectors
- high-accuracy optical, mechanical and opto-mechanical systems
- laser devices

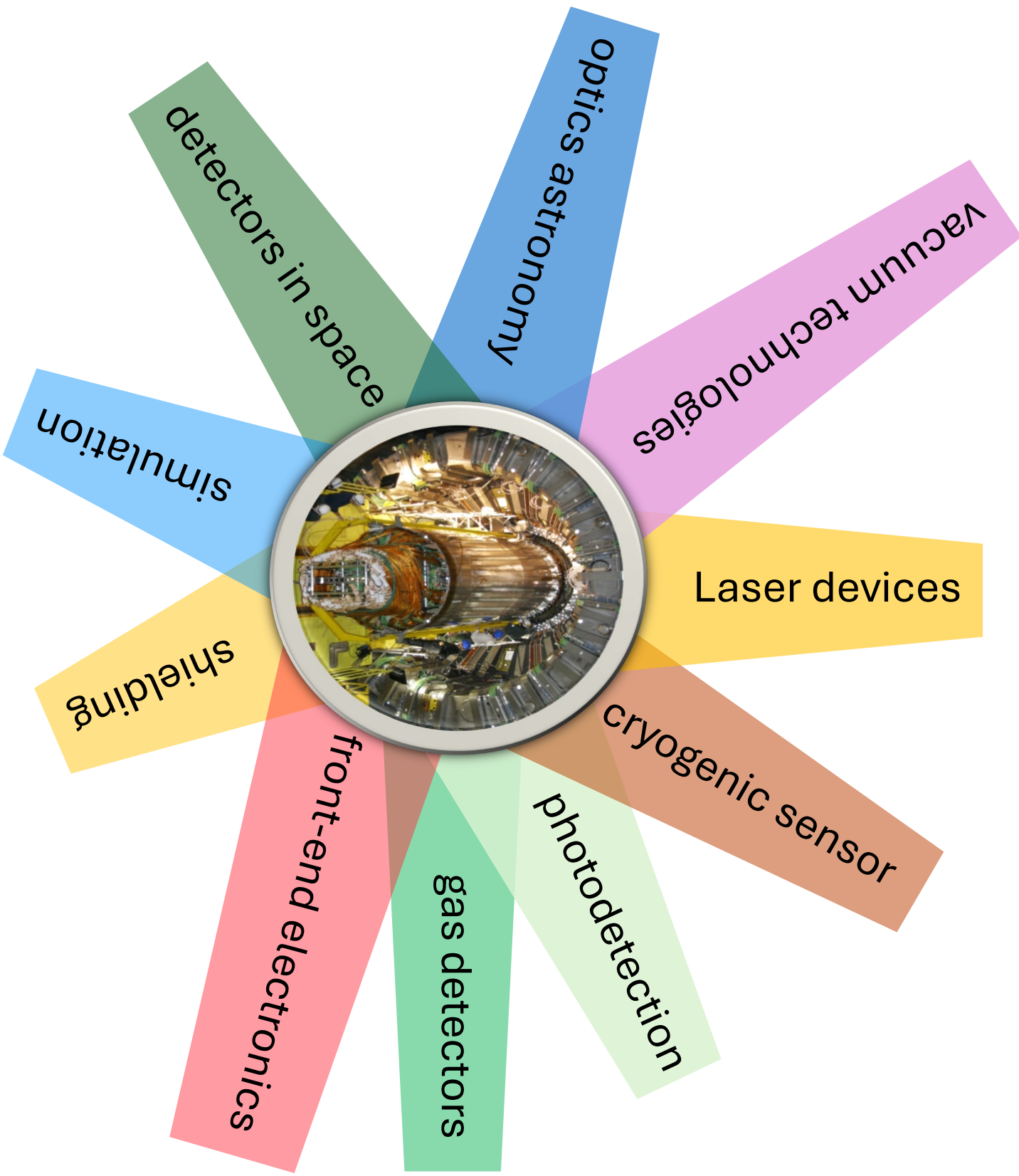
for fundamental research in physics and astronomy

PROPOSED COURSES
FOR DETECTORS, LASERS AND OPTICS CURRICULUM

21 courses

- 8 courses specific for Detectors, Lasers and Optics curriculum
- 9 courses pertinent for both Detectors, Lasers and Optics and Electronics curricula
- 1 course pertinent for both Detectors, Electronics and Mechanics curricula
- 1 course pertinent for both Detectors and Computing curricula
- 1 course pertinent for Detectors, Electronics and Computing curricula
- 1 course pertinent for Detectors, Electronics, Electrotechnics and Computing curricula

WIDE CHOICE OF COURSES



Gaseous Detectors for Experimental Particle Physics

This course gives a comprehensive overview of the modern gaseous detectors, widely used in physics experiments. The basic working principles of radiation detection in gas medium will be provided. A special focus will be dedicated to the Micro Pattern Gas Detectors (MPGDs), representing the latest generation of position-sensitive gaseous detectors. The main applications in physics experiments will be reviewed. A description of the software tools for gaseous detector simulations will be provided together with an overview of the main techniques for performance measurements in lab.

Rosamaria Venditti (rosamaria.venditti@uniba.it) – Università degli Studi di Bari and INFN
Federica Maria Simone (federica.simone@poliba.it) – Politecnico di Bari and INFN

Electronic systems in high energy physics

Fundamentals on circuit theory and electronic devices. Noise theory in detector systems. Laboratory measurement on radiation detectors.

Adriano Lai (adriano.lai@ca.infn.it) – INFN Sezione di Cagliari

Photodetection: Scintillators and Silicon Photomultipliers

Advanced knowledge on radiation measurements and detection techniques, from classic scintillation detectors to Silicon Photomultiplier devices: Photon-matter interactions; Organic and Inorganic scintillators; Optical coupling; Solid-state photodetectors; SiPM technologies, properties and applications.
Prerequisites: It requires an elementary background in radiation measurements, radiation-matter interactions and basic electronics.

Elisabetta Bissaldi (elisabetta.bissaldi@poliba.it) – Politecnico di Bari and INFN

New Technologies for Cherenkov Telescopes

Advanced knowledge of Cherenkov telescopes technologies.
The lectures will foresee a detailed overview of technologies currently used in IACT facilities, focusing on the photodetectors and on the readout electronics, as well as on new technologies ready to be employed in Cherenkov telescopes of future generations.

Serena Loporchio (serena.loporchio@poliba.it) – Politecnico di Bari and INFN

Front-end electronics and DAQ systems for radiation detection (HE5)

	Waveforms and signal processing. Front End electronics. Review of electronics systems for signal conditioning. Signal charge collection in low power regimes. Data acquisition systems. Data processing and decoding. Radiation hardness. Specific examples on space-based detectors.

Felicia Barbato (felicia.barbato@gssi.it) – GSSI and INFN
Adriano Di Giovanni (adriano.digiovanni@gssi.it) – GSSI and INFN

High Energy Radiation Measurements (Laboratory course)

	Silicon-based light detectors. Readout and DAQ systems. Applications to space-based experiments. Tracking systems: measurement of observables and diagnostics.

Felicia Barbato (felicia.barbato@gssi.it) – GSSI and INFN
Adriano Di Giovanni (adriano.digiovanni@gssi.it) – GSSI and INFN

Radio and Optical Interferometry

One part of the course is dedicated to radio/mm interferometry and the other to optical/infrared interferometry.
The course covers the basics, a (non-detailed) description of how radio and optical interferometers work, the main instrumental and observational problems, illustrates some important results and makes an overview of the main observing facilities available.

Fabrizio Massi (fabrizio.massi@inaf.it) – INAF Arcetri

Laser Physics and Applications

This course begins with an overview of the fundamental physics of optical cavities and the process of spontaneous and stimulated emission, which leads to the development of laser amplifiers and oscillators. Various types of lasers are presented, including those designed for continuous wave and pulsed beam operation. The final component of this course provides a brief review of laser applications, with a specific emphasis on ultrashort laser applications.

Annalisa Volpe (annalisa.volpe@uniba.it) – Università degli Studi di Bari

High Energy Particle Physics Detectors in Space

Basic elements of particle physics. Interaction of charged particles and photons with matter. Generalities on astroparticle physics. Detectors for space applications: scintillators, photon detectors, silicon detectors.
Environmental verification strategy for space detectors: qualification and acceptance. Structural and mechanical verification requirements. Sinusoidal sweep vibration test, random vibration test, acoustic tests, mechanical shock tests. Electromagnetic compatibility requirements. Vacuum, thermal and humidity verification requirements. Thermal balance, thermal vacuum, temperature and humidity verification.

Nicola Giglietto (nicola.giglietto@poliba.it) – Politecnico di Bari and INFN
Serena Loporchio (serenza.loporchio@poliba.it) – Politecnico di Bari and INFN

Rare event search with Time Projection Chamber

Working principles of single and double phase experiments for dark matter searches and neutrino physics:

1. Physics of signals formation and detection, focus on recent developments of the scintillation light detection technology
2. Challenges to calibrate detectors, identify and suppress backgrounds
3. Review of the rich physics program.

Paolo Agnes (paolo.agnes@gssi.it) – GSSI AND INFN

Cryogenics sensors for astroparticle physics

Matter at low temperature, heat capacity, thermal conductivity. Thermal sensors: semiconductor thermistors, transition edge sensors, metallic magnetic calorimeters, kinetic inductance detectors. Applications in Astroparticle Physics.

Andrei Puiu (andrei.puiu@lngs.infn.it) – INFN Laboratori del Gran Sasso
Ivan Colantoni (Ivan.Colantoni@roma1.infn.it) – Sapienza Università di Roma and INFN

Vacuum technologies

The basics for the production and measurement of vacuum and analysis of the components of vacuum systems. In particular: Gas flow through ducts, flow regimes; Conductance and impedance; Gas flow in viscous state; Gas flow in the molecular regime; Conductance of a small opening; Conductance of short, long and elbow pipes; Vacuum materials: Desorption Permeability, Solubility, diffusion and degassing; The baking of a vacuum system; Vacuum welding and brazing; Vacuum materials and components; Electrical feedthroughs, rotators and translators; Vacuum production: Rotary pumps, Zeolites and traps; Piston pumps, Diaphragm pumps, Trochoidal pumps, Scroll pumps, Roots pumps, Claw pumps, Turbomolecular pumps, Diffusion pumps, Cryogenic pumps; Sizing of a vacuum chamber in low vacuum and UHV; Design Elements.

Oscar Azzolini (oscar.azzolini@lnl.infn.it) – INFN Laboratori Nazionali di Frascati

Advanced electronic sensing devices

The course focuses on advanced sensors and transducers for electronic applications. The working principle of several different types of electronic sensors and their integration strategies with electronic systems will be discussed. At the end of the course, students will gain advanced knowledges about the working principles of several different classes of sensors with a strong focus on innovative devices and applications.

Enrico Silva (enrico.silva@uniroma3.it) – Università degli Studi Roma Tre and INFN

Cabling and Shielding for low noise applications

The course illustrates and discusses the main characteristics of active and passive shielding and guarding systems in low-noise data acquisition applications. The main configurations based on coaxial and twisted-pair cables, shielded and unshielded, are covered, studying the impact of ground loops. The analysis of some case studies is carried out with the use of an analog simulator.

Alberto Aloisio (alberto.aloisio@unina.it) – Università Federico II di Napoli and INFN

Programmable System on Chip (SoC) for data acquisition and processing

The course provides an overview of today's programmable devices such as the latest generation FPGAs which are now System on Chips which combine the registers, look-up tables and logic gates typical of FPGAs with one or more ARM processors, dedicated blocks such as DSP and PLL, tens of Gb/s transceivers, integrated memories and processors dedicated to the implementation of neural networks. The course will provide the basis for using the Vitis AI development environment by proposing a workflow that starts from writing simple VHDL codes that will be implemented in a more complex system that includes processors, memories and embedded transceivers.

Domizia Orestano (domizia.orestano@uniroma3.it) – Università degli Studi Roma Tre and INFN

Adaptive Optics for Astronomy

This course will introduce students to the principles of Adaptive Optics and its applications in astronomy. Students will learn about the different types of AO systems, how they work, and how they are used to make astronomical observations.
The course will cover the following topics:
- The physics of the Earth's atmosphere and its effects on astronomical observations
- The principles of adaptive optics
- Different types of AO systems
- The design and implementation of AO systems
- Applications of AO in astronomy

This course is suitable for students with a background in physics or astronomy. No prior knowledge of AO is required.

Carmelo Arcidiacono (carmelo.arcidiacono@inaf.it) – INAF Padova

Numerical Simulation of Electronic Devices with TCAD Tools for high energy physics applications

The course aims to provide students with the methods and tools to perform numerical simulations of electronic devices using Technology CAD (TCAD) tools. In particular, the simulation of the integrated circuits fabrication process and the simulation of their operation at the device/circuit level will be discussed. The Synopsys Sentaurus software, currently at the state-of-the-art for process and device simulation, will be used.
Lectures will be alternated with hands-on sessions.

Arianna Morozzi (arianna.morozzi@pg.infn.it) – INFN Sezione di Perugia
Daniele Passeri (daniele.passeri@unipg.it) – Università degli studi di Perugia and INFN

Simulation of optical photon propagation for generic scintillator-based detectors

This course aims to provide the student with knowledge of radiation measurements and detection techniques. It will also provide the student the capability to implement a dedicated MC simulation of the performances of a generic scintillator-based detector using the GEANT 4 toolkit with hands-on sessions.

Serena Loporchio (serena.loporchio@poliba.it) – Politecnico di Bari and INFN
Davide Serini (davide.serini@ba.infn.it) – INFN Sezione di Bari

MORE DETAILS ON COURSES

Gaseous Detectors for Experimental Particle Physics

Course Objective	These lectures give a comprehensive overview of the modern gaseous detectors, widely used in physics experiments. The basic working principles of radiation detection in gas medium will be provided. A special focus will be dedicated to the Micro Pattern Gas Detectors (MPGDs), representing the latest generation of position-sensitive gaseous detectors. The main applications in physics experiments will be reviewed. A description of the software tools for gaseous detector simulations will be provided together with an overview of the main techniques for performance measurements in lab.
Course Teacher	Rosamaria Venditti (rosamaria.venditti@uniba.it) – Università degli Studi di Bari and INFN Federica Maria Simone (federica.simone@poliba.it) – Politecnico di Bari and INFN
PhD Year	First
Duration	16h lectures in 4 weeks
Starting period	September
Mode of attendance	dual mode
Final Evaluation	Presentation on topics covered in the course
Proposed for	Detectors, Lasers and Optics

Electronic systems in high energy physics

Course Objective	Fundamentals on circuit theory and electronis devices. Noise theory in detector systems. Laboratory measurement on radiation detectors.
Course Teacher	Adriano Lai (adriano.lai@ca.infn.it) – INFN Sezione di Cagliari
PhD Year	First
Duration	48h in 12 weeks (includes laboratory and hands-on sessions)
Starting period	September
Mode of attendance	
Final Evaluation	
Proposed for	Electronics – Detectors, Lasers and Optics

Photodetection: Scintillators and Silicon Photomultipliers

Course Objective	Advanced knowledge on radiation measurements and detection techniques, from classic scintillation detectors to Silicon Photomultiplier devices: Photon-matter interactions; Organic and Inorganic scintillators; Optical coupling; Solid-state photodetectors; SiPM technologies, properties and applications. Prerequisites: It requires an elementary background in radiation measurements, radiation-matter interactions and basic electronics
Course Teacher	Elisabetta Bissaldi (elisabetta.bissaldi@poliba.it) – Politecnico di Bari and INFN
PhD Year	First or Second
Duration	10h lectures + 6h laboratory in 1,5 months
Starting period	May/June
Mode of attendance	lectures in dual mode
Final Evaluation	Report
Proposed for	Detectors, Lasers and Optics

New Technologies for Cherenkov Telescopes

Course Objective	Advanced knowledge of Cherenkov telescopes technologies. The lectures will foresee a detailed overview of technologies currently used in IACT facilities, focusing on the photodetectors and on the readout electronics, as well as on new technologies ready to be employed in Cherenkov telescopes of future generations.
Course Teacher	Serena Loporchio (serena.loporchio@poliba.it) – Politecnico di Bari and INFN
PhD Year	First
Duration	16h lectures in 2 months
Starting period	April
Mode of attendance	dual mode
Final Evaluation	Report
Proposed for	Detectors, Lasers and Optics

Front-end electronics and DAQ systems for radiation detection (HE5)

Course Objective	Waveforms and signal processing. Front End electronics. Review of electronics systems for signal conditioning. Signal charge collection in low power regimes. Data acquisition systems. Data processing and decoding. Radiation hardness. Specific examples on space-based detectors.
Course Teacher	Felicia Barbato (felicia.barbato@gssi.it) – GSSI Adriano Di Giovanni (adriano.digiovanni@gssi.it) - GSSI
PhD Year	First or Second or Third
Duration	15h lectures + hands-on sessions
Starting period	March/April
Mode of attendance	dual mode for lectures, in person for hands-on sessions
Final Evaluation	Discussion on exercises solved at home
Proposed for	Electronics – Detectors, Lasers and Optics

High Energy Radiation Measurements (Laboratory course)

Course Objective	Silicon-based light detectors. Readout and DAQ systems. Applications to space-based experiments. Tracking systems: measurement of observables and diagnostics. Prerequisites: have taken the HE5 course.
Course Teacher	Felicia Barbato (felicia.barbato@gssi.it) – GSSI Adriano Di Giovanni (adriano.digiovanni@gssi.it) – GSSI
PhD Year	First or Second or Third
Duration	20h laboratory sessions in one week
Starting period	March/May
Mode of attendance	in person
Final Evaluation	Report
Proposed for	Detectors, Lasers and Optics

Radio and Optical Interferometry

Course Objective	One part of the course is dedicated to radio/mm interferometry and the other to optical/infrared interferometry. The course covers the basics, a (non-detailed) description of how radio and optical interferometers work, the main instrumental and observational problems, illustrates some important results and makes an overview of the main observing facilities available.
Course Teacher	Fabrizio Massi (fabrizio.massi@inaf.it) – INAF Arcetri
PhD Year	First or Second
Duration	12h lectures
Starting period	April/June
Mode of attendance	online
Final Evaluation	
Proposed for	Detectors, Lasers and Optics

Laser Physics and Applications

Course Objective	This course begins with an overview of the fundamental physics of optical cavities and the process of spontaneous and stimulated emission, which leads to the development of laser amplifiers and oscillators. Various types of lasers are presented, including those designed for continuous wave and pulsed beam operation. The final component of this course provides a brief review of laser applications, with a specific emphasis on ultrashort laser applications.
Course Teacher	Annalisa Volpe (annalisa.volpe@uniba.it) – Università degli studi di Bari
PhD Year	First or Second
Duration	16h lectures
Starting period	June
Mode of attendance	dual mode
Final Evaluation	Presentation on a laser system chosen by the student
Proposed for	Detectors, Lasers and Optics

High Energy Particle Physics Detectors in Space

Course Objective	Basic elements of particle physics. Interaction of charged particles and photons with matter. Generalities on astroparticle physics. Detectors for space applications: scintillators, photon detectors, silicon detectors. Environmental verification strategy for space detectors: qualification and acceptance. Structural and mechanical verification requirements. Sinusoidal sweep vibration test, random vibration test, acoustic tests, mechanical shock tests. Electromagnetic compatibility requirements. Vacuum, thermal and humidity verification requirements. Thermal balance, thermal vacuum, temperature and humidity verification.
Course Teacher	Nicola Giglietto (nicola.giglietto@poliba.it) – Politecnico di Bari and INFN Serena Loporchio (serenza.loporchio@poliba.it) – Politecnico di Bari and INFN
PhD Year	First or Second
Duration	16h lectures in 2 months
Starting period	February/March
Mode of attendance	dual mode
Final Evaluation	Report
Proposed for	Mechanics – Electronics – Detectors, Lasers and Optics

Rare event search with Time Projection Chamber

Course Objective	Working principles of single and double phase experiments for dark matter searches and neutrino physics: 1. Physics of signals formation and detection, focus on recent developments of the scintillation light detection technology 2. Challenges to calibrate detectors, identify and suppress backgrounds 3. Review of the rich physics program.
Course Teacher	Paolo Agnes (paolo.agnes@gssi.it) – GSSI
PhD Year	First or Second or Third
Duration	12h lectures
Starting period	March/May
Mode of attendance	dual mode
Final Evaluation	Oral Exam
Proposed for	Electronics – Detectors, Lasers and Optics

Cryogenics sensors for astroparticle physics

Course Objective	Matter at low temperature, heat capacity, thermal conductivity. Thermal sensors: semiconductor thermistors, transition edge sensors, metallic magnetic calorimeters, kinetic inductance detectors. Applications in Astroparticle Physics.
Course Teacher	Andrei Puiu (andrei.puiu@lngs.infn.it) – INFN Laboratori del Gran Sasso Ivan Colantoni () –
PhD Year	First or Second or Third
Duration	12h lectures
Starting period	March/May
Mode of attendance	dual mode
Final Evaluation	Oral Exam
Proposed for	Electronics – Detectors, Lasers and Optics

Vacuum technologies

Course Objective	The basics for the production and measurement of vacuum and analysis of the components of vacuum systems. In particular: Gas flow through ducts, flow regimes; Conductance and impedance; Gas flow in viscous state; Gas flow in the molecular regime; Conductance of a small opening; Conductance of short, long and elbow pipes; Vacuum materials: Desorption Permeability, Solubility, diffusion and degassing; The baking of a vacuum system; Vacuum welding and brazing; Vacuum materials and components; Electrical feedthroughs, rotators and translators; Vacuum production: Rotary pumps, Zeolites and traps; Piston pumps, Diaphragm pumps, Trochoidal pumps, Scroll pumps, Roots pumps, Claw pumps, Turbomolecular pumps, Diffusion pumps, Cryogenic pumps; Sizing of a vacuum chamber in low vacuum and UHV; Design Elements.
Course Teacher	Oscar Azzolini (oscar.azzolini@lnl.infn.it) – INFN Laboratori Nazionali di Frascati
PhD Year	First or Second
Duration	14h lectures + 6h laboratory sessions (+ visit to vacuum infrastructure) in one month
Starting period	April
Mode of attendance	dual mode
Final Evaluation	presentation
Proposed for	Detectors, Lasers and Optics

Advanced electronic sensing devices

Course Objective	The course focuses on advanced sensors and transducers for electronic applications. The working principle of several different types of electronic sensors and their integration strategies with electronic systems will be discussed. At the end of the course, students will gain advanced knowledges about the working principles of several different classes of sensors with a strong focus on innovative devices and applications.
Course Teacher	Enrico Silva (enrico.silva@uniroma3.it) – Università degli Studi Roma Tre
PhD Year	First or Second
Duration	15h
Starting period	
Mode of attendance	dual mode
Final Evaluation	
Proposed for	Electronics – Detectors, Lasers and Optics

Cabling and Shielding for low noise applications

Course Objective	The course illustrates and discusses the main characteristics of active and passive shielding and guarding systems in low-noise data acquisition applications. The main configurations based on coaxial and twisted-pair cables, shielded and unshielded, are covered, studying the impact of ground loops. The analysis of some case studies is carried out with the use of an analog simulator.
Course Teacher	Alberto Aloisio (alberto.aloisio@unina.it) – Università di Napoli
PhD Year	First or Second or Third
Duration	10h lectures
Starting period	March
Mode of attendance	dual
Final Evaluation	
Proposed for	Electronics – Detectors, Lasers and Optics

Numerical Simulation of Electronic Devices with TCAD Tools for high energy physics applications

Course Objective	The course aims to provide students with the methods and tools to perform numerical simulations of electronic devices using Technology CAD (TCAD) tools. In particular, the simulation of the integrated circuits fabrication process and the simulation of their operation at the device/circuit level will be discussed. The Synopsys Sentaurus software, currently at the state-of-the-art for process and device simulation, will be used. Lectures will be alternated with hands-on sessions.
Course Teacher	Arianna Morozzi (arianna.morozzi@pg.infn.it) – INFN Sezione di Perugia Daniele Passeri (daniele.passeri@unipg.it) – Università degli studi di Perugia and INFN
PhD Year	First or Second or Third
Duration	20h in one week
Starting period	February/June
Mode of attendance	dual
Final Evaluation	Report
Proposed for	Electronics – Detectors, Lasers and Optics

Simulation of optical photon propagation for generic scintillator-based detectors

Course Objective	This course aims to provide the student with knowledge of radiation measurements and detection techniques. It will also provide the student the capability to implement a dedicated MC simulation of the performances of a generic scintillator-based detector using the GEANT 4 toolkit with hands-on sessions.
Course Teacher	Serena Loporchio (serena.loporchio@poliba.it) – Politecnico di Bari and INFN Davide Serini (davide.serini@ba.infn.it) – INFN Sezione di Bari
PhD Year	First
Duration	20h in 2 weeks
Starting period	May
Mode of attendance	dual mode
Final Evaluation	project discussion
Proposed for	Electronics – Detectors, Lasers and Optics – Computing

Programmable System on Chip (SoC) for data acquisition and processing

Course Objective	The course provides an overview of today's programmable devices such as the latest generation FPGAs which are now System on Chips which combine the registers, look-up tables and logic gates typical of FPGAs with one or more ARM processors, dedicated blocks such as DSP and PLL, tens of Gb/s transceivers, integrated memories and processors dedicated to the implementation of neural networks. The course will provide the basis for using the Vitis AI development environment by proposing a workflow that starts from writing simple VHDL codes that will be implemented in a more complex system that includes processors, memories and embedded transceivers.
Course Teacher	Domizia Orestano (domizia.orestano@uniroma3.it) – Università degli Studi Roma Tre and INFN
PhD Year	First or Second
Duration	20h
Starting period	
Mode of attendance	
Final Evaluation	
Proposed for	Electronics – Electrotchnics and Electrotechniques for Accelerators – Detectors, Laser and Optics – Computing

Adaptive Optics for Astronomy

Course Objective	This course will introduce students to the principles of Adaptive Optics and its applications in astronomy. Students will learn about the different types of AO systems, how they work, and how they are used to make astronomical observations. The course will cover the following topics: - The physics of the Earth's atmosphere and its effects on astronomical observations - The principles of adaptive optics - Different types of AO systems - The design and implementation of AO systems - Applications of AO in astronomy This course is suitable for students with a background in physics or astronomy. No prior knowledge of AO is required.
Course Teacher	Carmelo Arcidiacono (carmelo.arcidiacono@inaf.it) – INAF Padova
PhD Year	First or Second
Duration	12h
Starting period	
Mode of attendance	
Final Evaluation	
Proposed for	Detectors, lasers and Optics – Computing