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Table of Contents

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1. Introduction and motivation for the school

In the framework of EURIZON Work Package 7, which focuses on the development of detector technologies, a two-week specialist school on particle detectors was organised.

Website of the school: https://indico.cern.ch/event/1224299/

The main purpose of the school was the training of young scientists on state-of-the-art particle detection technologies in the fields of particle physics, heavy-ion physics and neutron physics.

Organising the school was motivated by the following arguments:

- Continuous progress in particle detector technologies is fundamental for advancing our knowledge in the above-mentioned experimental physics domains.
- Detectors are becoming ever more accurate (space, time, energy, etc) and faster. Full detection systems often require millions/billions of readout cells to feed ever more powerful algorithms for reconstruction and interpretation. It is therefore important for young professionals to stay well informed about recent technology developments.
- A large diversity in detector technologies exists, while young professionals are normally exposed in their daily work to a limited range of technologies only.
- Particle detectors are important for societal applications (medical imaging, material science, space applications).
- An on-site specialist school brings important added value in the form of professional networking opportunities among peers.

Designing, building and operating particle detectors and the assessment and interpretation of their measurement data requires a broad skillset covering theoretical knowledge, hands-on skills and computing skills. These were all addressed in the scientific programme of the school.

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The targeted audience of the school were PhD students already working on particle detector technologies. Advanced master students and early postdocs were also invited to apply.

2. Venue, scientific and social programme of the school

The school was organised at the Bergische Universität of Wuppertal, Germany, from July 17th to July 28th 2023.

The scientific programme comprised:

- Lectures in the morning by world experts in particle detectors, 37 lectures in total.
- Hands-on exercises on detector hardware, detector simulation and data analysis. Each student participated in 7 or 8 exercises, which could be chosen individually among 12 options.
- An afternoon workshop on "Making engaging scientific presentations".
- A student session, where 12 students presented their work, taking directives from the communication workshop into account.

The social programme of the school comprised:

- Common lunches and coffee breaks at the University
- Two social dinners downtown in Wuppertal.
- A visit to the UNESCO site of the "Zeche Zollverein" old coal mine, and adjoining dinner.

The lecture topics included:

- Calorimetry
- Characterization of detectors
- Environmental sustainability of basic research
- Evolution of working detector systems from R&D to construction, operation and performance
- Gaseous detectors
- Neutron detectors
- Non-collider detectors
- Particle identification
- Photodetection
- Quantum sensing
- Readout- trigger - data acquisition
- Silicon detectors
- Tracking systems

The list of hands-on exercises:

- Drift tube characterisation
- Micro-pattern gas detector, measure mu-RWELL efficiency
- Cosmo boxes
- Microchannel plate photomultipliers (MCP-PMT) with delay-line anode

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- Silicon photomultiplier (SiPM)
- Silicon pixel detector
- Silicon strip detector, Landau distribution
- Do-it-yourself particle detector
- Root tutorial
- Geant4 tutorial
- Simulation of silicon pixel detector and spatial resolution
- Analysis of silicon pixel test beam data

The hands-on exercises were developed and made available by several EURIZON institutes and were shipped to Wuppertal for use at the school. These institutes also ensured the presence of expert tutors in Wuppertal for the exercises they supplied.

The lecture presentations as well as the tutorials of the hands-on exercises are publicly available on the web site of the school.

3. Organisational aspects

The international organising committee comprised several members of the EURIZON project. The full list of committee members is listed on the school Poster, see Appendix A. The international organising committee convened on a regular basis during the 12-month period preceding the school. It took full responsibility for organising the scientific contents of the school, as well as the accompanying financial planning.

The local organising committee took responsibility for all local aspects of the school and for the social programme. Its members are listed on the Poster (see Appendix A). Facilitating the hands-on exercises was an important challenge for the local organisation. It implied making approximately 12 additional rooms available to the school, as well as the supply and handling of e.g. high-purity gas for the gaseous detectors, radioactive sources, electronic instruments, as well as numerous computers for the software-related exercises. All related safety aspects were handled professionally by the local organisers. A special lecture on safety aspects for the hands-on exercises was given on the first day of the school. The University of Wuppertal also ensured the presence of student-helpers for various logistics aspects of the school.

FAIR GMBH in Darmstadt took responsibility for the overall financial administration, such as the handling of financial claims from the lecturers, the hands-on tutors, the student helpers and the 25 students that were selected for full or partial financial support from the school. Further, FAIR GMBH realized all procurement needed in preparation of the detector school, such as bulk orders for lodging, lunches at the university, transportation and other orders related to the social events. These orders were executed in accordance with German law on public spending.

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4. Student application and selection

The school was widely advertised via numerous mailing lists of institutes, physics experiment collaborations and overarching national and international organisations in the domains of particle physics, heavy-ion physics and neutron physics. The school was also advertised within the EURIZON project consortium. The registration opened early February 2023 and was closed on April 11th 2023. In addition to relevant personal data and a curriculum vitae, applicants were requested to provide a reference letter from a professor or supervisor. Altogether 143 fully validated/completed applications were received. The overall quality of the applications was good, with a majority of candidates fitting the target audience of the school.

In total 65 students were selected and attended for the full duration of the school. The individualised participation of students in hands-on exercises was the main reason for limiting the number of participants to 65. The table below summarises a few statistical facts about the pool of applicants and the pool of selected students.

Applicant pool:

Number of fully completed applications	136
Number of countries of applicant institute	31
Male / female / other ratio	67 / 28 / 5 %

Selected students:

Number of selected students	65
Number of student institute countries	18
Number of student nationalities	27
Male / female / other (%)	68 / 29 / 3 %
Master student / PhD student / postdoc (%)	14 / 80 / 6 %
Nb. selected for funding for travel and/or lodging	25

In addition to the students, 21 lecturers, 23 hands-on tutors and a further 13 organisers and helpers attended the school (part time or full time).

In view of their visa application for entry to Germany, FAIR GMBH prepared invitation letters for 7 students. Several students reported that delays for visa appointments at German consulates were long. Finally, only one student did not succeed to obtain the visa in time for the school.

5. Financial aspects

FAIR administration realized a total of 21 orders for bulk restaurant contracts, bulk hotel accommodation contracts, group transportation, transport of detector gases and diverse electronics parts for hands-on experiments. Further, FAIR administration reimbursed a total of 56 individual participants, that is lecturers as well as funded students, for travel expenses that had occurred with the aim to realize the school. Two FAIR employees were reimbursed

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for the business trips and three new temporary student contracts were realized by FAIR with students in Wuppertal so that they could help with the realization on site.

For these actions a total of 104 kEuro were spent whereas the available budget foreseen by EURIZON for the school amounted to 150 kEuro. A detailed financial statement on these activities and expenditures will be provided. It was fortunate for the school to be equipped with abundant budget as the real expenses were very difficult to estimate and many individuals realized expenditures (e.g.travel, lodging) on their own behalf, which later needed to be reimbursed. Out of the perspective of the organizers all students that were in need of financial support have been funded for their participation. Many other students received their travel expenses covered by their home institutions. Such co-funding by the sending institutes is in general a healthy measure to guarantee seriousness on the participant´s side.

Travel expenses of all the lecturers have been reimbursed, however, no honorary was individually paid for any lectures or engagements. All participants delivered their contributions out of personal interest and love for the subject.

6. Overall observations, student feedback and outlook

The school took place in a smooth and relaxed atmosphere without incidents. Students generally showed pronounced interest, asking numerous questions at the end of each lecture. According to the general feedback received from the students, the school was considered a big success. It was said to correspond to a real need, not easily available elsewhere in Europe. The lecture programme was considered of high quality and well-fitting the expectations of the students. Praise was expressed in particular for the hands-on exercises carried out in small groups. Students lined up each morning to inscribe for the afternoon exercise of their choice.

The local team of the Bergische Universität Wuppertal succeeded in providing a perfect environment for the school and for the comfort and safety of the participants. This deserves extra mention in view of the organisational challenges posed by the hands-on exercises.

Given the large pool of applicants, compared to the capacity of the school, and given the general highly positive feedback received, the wish was expressed broadly to seek for opportunities to organise such a school every year or every second year in the future.

The organisers and the students are very thankful to the EURIZON project for the opportunity provided for the 2023 detector school.

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Appendix A, School Poster

eurizon
European network
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Detector School — July, 17–28, 2023

for training young scientists on state-of-the-art particle detection technologies in the fields of particle-, heavy-ion- and neutron-physics

Lectures and hands-on exercises:

- Tracking & Calorimetry
- Particle Identification
- Gaseous & Silicon detectors
- Neutron & Photon detection
- Detector readout & Data acquisition
- Quantum sensing
- Communication in science
- Sustainability of Research Facilities

Website:
https://indi.to/EURIZONdetschool

E-mail:
EURIZON.detschool@cern.ch

New Venue: BERGISCHE UNIVERSITÄT WUPPERTAL
Wuppertal, Germany

International Organizing Committee:

Lucie Linssen, Eva Sicking (CERN); Simon Spannagel (DESY); Francesco Piscitelli (ESS); Jürgen Eschke, Irakli Keshelashvili, Christian J. Schmidt (GSI); Marcello Abbrescia, Nicola De Filippis (INFN-Bari), Gianluigi Cibinetto (INFN-Ferrara), Gianni Bencivenni (INFN-Frascati), Margherita Primavera (INFN-Lecce); Michael Düren, Marc Strickert (JLU Giessen); Mustafa Schmidt, Christian Zeitnitz (Univ. Wuppertal)

Local Organizing Committee:

Mustafa Schmidt, Christian Zeitnitz, Wolfgang Wagner, Christian Pauly, Katerina Lipka (DESY/Wuppertal), Tobias Flick
Secretary: Daniela Schulz

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Design: M. Düren, Photos: CERN

CERN · DESY. · ESS EUROPEAN SPALLATION SOURCE · FAIR · INFN · JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN · BERGISCHE UNIVERSITÄT WUPPERTAL

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