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DELIVERABLE REPORT

ORGANISATION OF HANDS-ON WORKSHOPS & TRAINING SCHOOLS

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Abstract:

The INTRANS (INstrumentation and Training for Nuclear Spectroscopy and Reaction Dynamics) Service Improvement subtask of the EURO-LABS Horizon EU program, promotes the coordination between the research infrastructures and research groups involved in nuclear spectroscopy and reaction studies, to optimize the use of valuable resources and enhance synergies among researchers on a broad European scale for frontline research in these fields. The present document reports on the hands-on training schools organized by INTRANS.

EURO-LABS Consortium, 2025

For more information on EURO-LABS, its partners and contributors please see <https://web.infn.it/EURO-LABS/>

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Executive summary

INTRANS is dedicated to provide expertise on the optimal employment of experimental setups for nuclear spectroscopy and nuclear reaction in the research infrastructures of EURO-LABS. Training and sharing knowledge in experimental methods and techniques is a way to enhance the quality of the scientific output of the experimental programs carried out within the EURO-LABS infrastructures. INTRANS has organized or sponsored several hands-on training courses for new users as well for more experienced researchers, engineers and technicians. These courses are essential for training the next generation of physicists in state-of-the-art spectroscopic methods and techniques. They also enable technical staff to learn from experts and share their knowledge and experience in the field of detector technology and associated instrumentation.

1. AGATA DATA ANALYSIS WORKSHOPS

The **Advanced Gamma Tracking Array (AGATA)** is the largest European gamma-ray detector for nuclear physics related activities and its only equivalent is **Gamma-Ray Energy-Tracking Array (GRETA)** in the USA. AGATA is used in experiments with both intense stable and radioactive ion beams, to study the structure and reaction mechanisms of atomic nuclei as a function of angular momentum, isospin, and temperature at the limits of their stability. AGATA is based on the principle of gamma-ray tracking, which is made possible by the advent of segmented high-purity germanium crystals, advanced digital electronics, and pulse-shape analysis. By using these latest technologies, the precise energy and 3D position of each of the interaction points of the Compton scattered gamma rays can be determined and gamma-ray tracking algorithms can be used to reconstruct the full energy and the first interaction point of the gamma rays that hit the spectrometer. This allows to maximize the performance of the array. The AGATA Data Analysis workshops are dedicated to help young researchers and PhD students familiarize themselves with the complex AGATA data pipeline and process the data taken during the AGATA campaigns. These workshops focused on the analysis methods and tools that have been developed by the AGATA collaboration. The participants also have dedicated hands-on sessions to learn how to use the software for data replay, namely:

- Pre and post pulse-shape analysis signal processing
- Energy calibration and neutron-damage correction
- Ancillary-detector data treatment & selection
- Gamma-ray tracking
- Grid access and analysis tools

Two such workshops have been held in the present reporting period. The first one took place at the Laboratori Nazionali di Legnaro, Italy from 10-15/09/2023 (<https://agenda.infn.it/event/36303/>) and the second one was held from 13-17/02/2024 at IP2I, Lyon, France (<https://indico.in2p3.fr/event/34092/>).

In the first school, there were 54 participants, in the second, there were 24. The number of lecturers was 7 in both instances. The schools lasted a whole week, with lectures in the morning and hands on sessions in the afternoons with the first afternoon dedicated to the installation and compilation of all the required computer programs on the personal computers of all the participants. During the school in Lyon, the students also visited the IN2P3 Computing Center (CC-IN2P3) where a copy of all the very large AGATA data is stored.



Figure 1: Photograph of the participants and lecturers of the 2025 AGATA Data Analysis workshop in front of servers of the CC-IN2P3.

2. HANDS-ON TRAINING ON OPERATION, TEST AND REPAIR OF HYPER PURE GE DETECTORS

Because of their effective balance between high detection efficiency and high energy resolution, germanium detectors are the workhorse of nuclear spectroscopy for basic nuclear physics research but also for many applications (nuclear imaging, activation analysis, environmental monitoring, nuclear security,...). Germanium detectors are complex devices comprising one or more high-purity germanium (HPGe) crystals in a cryostat cooled at liquid nitrogen temperatures. They require high voltages of up to many kV to be applied to one or more electrodes as well as low-noise and fast amplification of the electric currents generated by the interaction of gamma rays. Germanium detectors are fragile and expensive and require specific handling, maintenance and trouble shooting diagnostics. The hands-on training school on operation, test and repair of HPGe detectors was addressed especially to physicists, engineers and technicians involved in HPGe detectors usage in Europe, from the simple tapered single crystal to the more complex AGATA clusters. The training course took place at the Laboratori Nazionali di Legnaro, Italy from 2-6/09/2024 (<https://agenda.infn.it/event/40689/>). The school was a continuation of similar schools organized in the framework of NUSPIN (ENSAR2) in 2018 at IKP-Cologne (organized by J. Eberth and D. Napoli) and in 2019 at the University of Liverpool (organized by A. Boston). The school attracted 22 trainees and included 9 lectures and 10 hands-on laboratories about the generalities of Ge detectors, their maintenance, operation and underlying concepts. Each laboratory was supervised by trainers and could accommodate a group of 3-4 trainees at a time.

The training school has also led to the idea of the creation of a “HPGe Experts Community”. For this purpose, a survey was proposed to the participants of the school and also to many research institutes and infrastructures of EURO-LABS. The survey aims at establishing the interest of the expert's in creating this community and to assess the present situation of HPGe detector laboratories ten years after the EGAN (EU Seventh Framework Programme - FP7) Survey on Detector Maintenance and Repair Capabilities, 2012. The survey is closed and the answers are currently being processed.



Figure 2: Photograph of the participants and lecturers of the 2024 Hands-on training on Operation, Test and Repairs of Hyper Pure Ge Detectors.

3. FLORENCE TRAINING SCHOOL ON COULOMB EXCITATION

Low-energy Coulomb excitation is capable of providing unique information on static electromagnetic moments of short-lived excited nuclear states. In the scattering of two nuclei, the electromagnetic field that acts between them causes their excitation. The process selectively populates low-lying collective states and is ideally suited to study phenomena such as shape coexistence and the development of exotic deformations (triaxial or octupole shapes). Historically, these experiments were restricted to stable isotopes. However, the advent of new facilities providing intense beams of short-lived radioactive species has opened the possibility of applying this powerful technique to a much wider range of nuclei. A training course dedicated to the Coulomb excitation technique, which is used in state-of-the-art experimental setups in Europe and the rest of the world, took place at the Università degli Studi di Firenze, Italy from 2-6/09/2024 (<https://agenda.infn.it/event/40689/>). The school comprised lectures in which the observables that can be measured in Coulomb excitation were introduced and recent examples of complex Coulomb-excitation studies were presented. In the practical sessions, the participants learnt how to use the GOSIA and FRESKO codes in order to estimate counting rates expected in an experiment and to extract electromagnetic matrix elements from experimental data.

A total of 40 participants registered to the school.



Figure 3: Photograph of participants and lecturers at the Florence training school on Coulomb excitation.

4. OTHER ACTIONS

In the spirit of the NUSPIN workshops (which were held under the auspices of the European integrated activity ENSAR2), INTRANS organized a workshop at IJCLab, Orsay, France from 22-25/01/2024 (<https://indico.ijclab.in2p3.fr/event/9682/>). The aim was to present the status of nuclear research using gamma-ray detectors in Europe and in the world and to discuss its perspectives. Sessions were dedicated to the presentation of the latest results obtained at gamma-ray facilities, of recent theoretical studies and to the discussion on the challenges of future research, experimental campaigns and technical developments, in particular artificial intelligence and novel germanium detector technologies. Review talks were followed by shorter contributions on physics highlights selected from submitted abstracts and there was a very animated poster session. The workshop was a great success and many participants asked that a second workshop be organized before the end of the EURO-LABS project.

5. FUTURE PLANS

INTRANS also plans to organize at least two more training schools. A Germanium Detector School is already scheduled and will be hosted at the University of Liverpool from 7th – 11th April 2025. The school is aimed at postgraduate students, postdoctoral researchers and electronics engineers who are not experts in germanium detector systems. The school is a complementary activity to the recent Hands-on Workshop on Test, Operation and Repair of detectors held at Laboratori Nazionali di Legnaro (LNL) in September 2024. The school will give an introduction to germanium detector systems and provide training in essential measurement techniques. The other hands-on training course yet to be scheduled is a third AGATA Data Analysis workshop.

INTRANS is also sponsoring a meeting to discuss and develop physics cases for possible future stopped beam campaigns at the RIKEN Nishina Centre for Accelerator based Science Japan using WAS3ABI as implantation detector in combination with a new gamma-ray spectrometer composed of 8 Clover detectors from CENS and IMP Lanzhou, along with 16 **DESPEC Germanium Array Spectrometer** detectors (DEGAS) from the **H**igh-resolution in-flight **SPEC**troscopy/ **DE**cay **SPEC**troscopy (HISPEC/DESPEC) project of FAIR including GAMMAPOOL germanium capsules. The meeting will be held in Valencia at the end of march 2025 (<https://indico.ific.uv.es/event/7909/>).