EURO-LABS Newsletter

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Second Annual Meeting of EURO-LABS at Krakow, Poland, from October 9Th-11Th, 2023

Participants of BTS23 (IFIN-HH, Bucharest-Măgurele, Romania) in the salt mine used for low-background work

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101057511.

EDITORIAL

M.J.G. Borge
For the EURO-LABS Steering Committee

Fig. 1 Kick-off Meeting of EURO-LABS, at Bologna, Italy from October 3-5, 2022

Dear colleagues,

It is our pleasure to bring to you the inaugural issue of EURO-LABS Newsletter.

The four-year long ambitious EURO-LABS project is funded by the Horizon Europe program of the European commission. EURO-LABS is a strong collaboration of thirty-three partners from eighteen countries providing services for advancing frontier knowledge. This initiative represents a pioneering step in bringing together, at the European level, the Nuclear Physics and the High-Energy Physics (HEP) accelerator and detector communities to form a European super scientific community. The project recently celebrated its first birthday!

Thanks to the members of this community, who have worked very hard and in a timely fashion, all programmed deliverables (4) and milestones (19) have been achieved on time and the project is running successfully. The first report of EURO-LABS was submitted and has been accepted by the EU Project of 45 facilities at Officer.

A major goal of EURO-LABS is to foster the usage of various research infrastructures.

A large number of service improvements at various facilities are fully on schedule, that will further optimize the use of the beam time. Among these improvements one should mention the use of Machine Learning (ML) for beam monitoring. A shared platform has been created for the use of ML in several facilities.

We are proud to highlight that more than 1000 users have already benefited from the use of transnational access and state of the art experiments/developments have been conducted.

A salient transversal feature is providing basic and advanced hands-on schools to train the next generation of technical personnel and researchers. These complements the programme of existing schools at the European level. In order to promote FAIR (Findable, Accessible, Interoperable and Reusable) data principles towards more effective Open Science, a programme to encourage the research infrastructures and researchers mainly in the nuclear physics community to centralize the metadata of their datasets is underway.

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EDITORIAL

Detectors to serve in the next generations of experiments are being irradiated to target fluences and their performance evaluated and scrutinized in test beams. Experiments using high-energy electron or hadron beams, and tests of R&D prototypes of accelerator components have been conducted using EURO-LABS funds. A virtual facility providing theoretical tools has been created (Theo4exp), that will increase the impact of the science done at many of the labs associated with EURO-LABS as well as, for the wider experimental nuclear physics community.

This first newsletter highlights some of our recent activities, including a summary of the recent second EURO-LABS meeting (SAM EURO-LABS) as well as a report on the first basic training school.

Additionally, we provide a few scientific highlights done at the RIs of EURO-LABS, from detector development to nuclear clocks. Upcoming events like the next (advanced and basic) training schools, and the next annual meeting to be held at CERN are announced. Our intention is to have an issue of the newsletter every six months.

We are counting on your active collaboration in providing material in the form of news or highlights to make this possible. Please keep tuned to our emails or consult our website (https://web.infn.it/EURO-LABS/) for continuous updates.
We take this opportunity to wish you and your dears a year ahead filled with love, laughter and success.

Organigram of the EURO-LABS project

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NEWS ON COMING HANDS-ON SCHOOLS

EURO-LABS is committed to improve the efficiency of use of RIs and to increase its human and institutional capacity development. To this aim, EURO-LABS organizes a system of training activities, at various levels, starting with annual Basic Training schools and Advanced Training schools.

Last year we had a basic school organized in IFIN-HH, Romania and an article about the school is included in this newsletter. This year we have two schools that I shortly described in the following:

The Advanced training school of 2024 dedicated to Operation of Accelerators, June 3rd – 7th, 2024 to be organized at CERN, Geneva, Switzerland. It will involve hands-on activities in three facilities: CLEAR, ISOLDE and PSBooster. The training will cover an introduction to accelerators, control systems, beam characterization, steering algorithms, phasing SC cavities and other advanced topics.

15-18 students (Trainees) will be selected for this Hands-on course of Acceleration Operation of 5 days. To apply please visit the indico page https://indico.cern.ch/event/1357293/

The deadline for application is January 31st.

The Basic Training School on Accelerators 2024, BTS24, organized at HIL and INCT, will take place in June 18-27 in Warsaw, Poland. The Heavy Ion Laboratory (HIL) with the U200-P cyclotron provides a heavy ion beam and the Institute of Nuclear Chemistry and Technology (INCT) has electron accelerators. 5 - 20 students will be selected and will perform experiments with heavy ion and electron beams as well as with radioactive sources to get a basic knowledge and develop skills on use of detectors, electron beam control and dosimetry. The announcement for this school will be released in February. Details will be published in February on the HIL website (https://www.slcj.uw.edu.pl/en).

Participants of both schools will be financed by EURO-LABS(Grant Agreement No: 101057511): travel with economy class within Europe, accommodation, and subsistence support. Trainers will be local and international experts.

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EURO-LABS ANNUAL MEETING

Maria Colonna (INFN, Catania, Italy)

Fig. 3 Meeting of the Governing Board of EURO-LABS

The 2nd Annual Meeting of EURO-LABS (SAM EURO-LABS) was held in Krakow from the 9th to 11th October 2023, hosted by IFJ PAN. The meeting was a unique opportunity to present the activities carried out during the first year of the project and to outline strategies and goals for the coming years. The event featured a lively exchange of ideas aimed at further improving cross-fertilization and establishing future collaborations between the communities involved in EURO-LABS. These exchanges were triggered by a detailed discussion of activities and first results achieved following the Transnational Access (TA) offered at a large variety of accelerators, from Nuclear Physics infrastructures to Research Infra-structures (RIs) for Accelerator and Detector R&D.

The talks given at the meeting highlighted the broad range of science and technology, with interesting intersections across different Work Packages (WP): from creating intergalactic conditions for the first time in laboratory, to characterizing the ^{229}Th isomer and its potential use as a nuclear clock. Tests of innovative equipment for FLASH radiation therapy pursued at more than one RI, along with very sensitive measurements for tracing radioactive elements in the North Sea, were among the highlights relating to interdisciplinary research. Impressing developments in accelerator and detector R&D for High Energy Physics were presented, paving the way for significant innovations.

Figs 1 & 2: Visit to the CCB at Krakow

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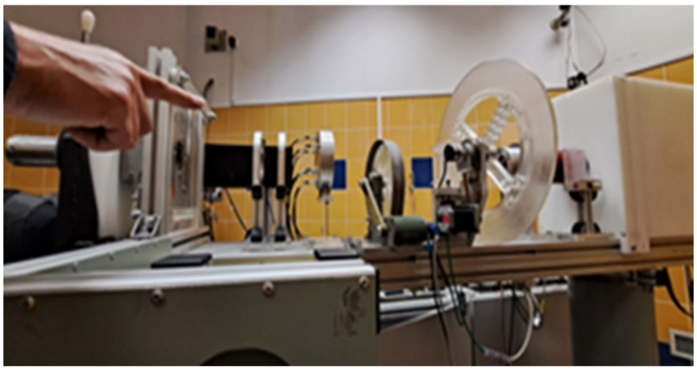
EURO-LABS ANNUAL MEETING

Highly relevant progress is presented for transverse activities, concerning dissemination, Open Science, modern technologies of wide interest, and hands-on training. Actions towards the establishment of a Data Management Plan based on FAIR principles at all EURO-LABS RIs were largely discussed. The delivery of an optimizer toolkit prototype for accelerator control (based on ML techniques), to be deployed at several RIs, was discussed. The plan of the coming EURO-LABS joint training events was presented. The dissemination tools put in place during the first year, including the project website and several informative videos of the RIs, were described.

The meeting was also the occasion to discuss and finalize the first periodic report of the project. This was also addressed in more specific separate Work Package meetings. In the coming year, actions will be taken to address small fluctuations emerged in the offered TA and make its distribution more uniform.

Figs 4 & 5: Photos taken during the visit to CCB



Efforts will also be dedicated to further promoting diversity of potential TA users, engaging people of different nationality, gender, age and level of professional expertise.
The event ended with the meeting of the EURO-LABS Governing Board.

Fig. 6: Group photo of the attendees at the SAM Meeting

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FIRST EURO-LABS BASIC TRAINING SCHOOL BTS23 AT IFIN-HH

Livius Trache (IFIN-HH, Bucharest-Măgurele, Romania)

Fig. 1: Participants of BTS23 (IFIN-HH, Bucharest-Măgurele, Romania) in the salt mine used for low-background work.

The Training Science Board (TSB) decided in February to grant the organization of the first basic training school to IFIN-HH. The local organizers proposed to host it on September 13-23, 2023. It was a wholly hands-on event, based on experiments carried out at two of IFIN-HH's tandem accelerators in Bucharest-Magurele. To ensure maximum student experience in performing beam experiments, we applied in advance to the institute's Program Advisory Committee (PAC), for 3 days of beamtime at each of the 3 and 9 MV machines.

These turned out to be ideas much appreciated by the students not only from Europe, but from 5 continents. While we started with plans to host about 15 students, the demand was so high that we had to accept double that number.

The initial call was in June and in the end we accepted 20 candidates from Europe with full support for travel, accommodation and subsistence and 5 from outside Europe who accepted that travel will be supported by their institutions - we covered their accommodation and subsistence. Plus 4 local students, from 2 Bucharest universities. Note the students from S. Africa, Brazil, Mexico ... In the end we had 27 students, from bachelor degrees (2) to master students, PhD students and postdocs (2). The time spent on lectures was reduced to the minimum required.

Basically we planned for a 3 days experiment at the small 3 MV tandetron accelerator. A visit to an ultra-low background laboratory of the institute in a salt mine close to the Carpathian mountains, clubbed with an excursion was made for one day. This was followed by three days of experiments at the larger 9 MV tandem accelerator.

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FIRST EURO-LABS BASIC TRAINING SCHOOL BTS23 AT IFIN-HH

From the beginning the students were separated in 3 working groups and each went through most of the basics of experimental nuclear physics: accelerators, detectors, electronics, targets and target making, data acquisition from single channel to multi-parameter acquisition and analysis. In-beam data taking, de-activation measurements on-site and in the salt mine, with more complex setup at the ROSPHERE array with ancillary neutron and particle detectors, was made.

The Friday of first week was dedicated data analysis of first experiment and to visits in several large infrastructures IFIN-HH has on the same campus, but not involved directly in the program: Department of Hadron Physics, the gamma-ray irradiator IRASM, Extreme LIght Source-Nuclear Physics (ELI-NP), Romanian Accelerator Mass Spectrometry (RoAMNS), etc. These was done in separate groups.

The second Friday, Sep 22nd, a joint wrap-up session was scheduled where each group presented its results, discussed their impressions and gave their feedback.

The dedication and inspirations put in reports were remarkable.

Diversity, while not sought by organizers came naturally and can be illustrated by one group reporting: “we are 9 people from 8 countries and 5 continents”. One can see that in the photo below, taken in the impressive salt mine.
It should be noted that the whole event was essentially conducted by a team of young people from IFIN-HH, led by Dr. Razvan Lica, Dr. Alexandra Spiridon and Dr. Constantin Mihai.

The program is detailed on event's website: https://indico.nipne.ro/event/246/ under "timetable".

Given the rich infrastructure of IFIN-HH (including for accommodation and food) and the help of the Management, we believe that it went well till the end and stayed on the budget.

Fig 2: Participants during one of the hands-on sessions of the BTS23 school

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RADIATIVE DECAY OF THE ^{229}Th CLOCK ISOMER

Sean Freeman (ISOLDE - CERN, Geneva, Switzerland)

The nucleus ^{229}Th has an isomeric state at an unusually low excitation energy of around 8.3 eV. This nuclear state might therefore be manipulated directly by lasers, and it was identified many years ago as a possible basis for a nuclear clock. Such devices would outclass the most precise atomic clocks that are available today and might serve as sensitive research tools facilitating new research, such as searches for minute variations with time of the values of fundamental "constants" of Nature or to look for ultra-light dark matter.

During 2021, experiments were performed at CERN's radioactive ion beam facility, ISOLDE, that took a key step forward towards characterising this isomer. To realise a nuclear clock, the isomer must be placed in an environment that suppresses non-radiative decay paths, such as electron conversion. Placing the Th isomer in a large-bandgap crystal is one way to do this. These experiments embedded ^{229}Ac, which subsequently β decays to Th populating the isomer, into different solid-state hosts. Vacuum-ultraviolet spectroscopy was used to observe the radiative decay of the isomer for the first time. The energy of the isomer was determined more precisely than previous studies and the half-life of the isomer embedded in a MgF2 crystal was measured [1].

Further improvements in the uncertainties are very important to ease future searches for direct laser excitation of ^{229}Th populating the isomer.

Laser bandwidths are narrow compared with the current uncertainties on the isomer energy. So, reducing the many months it would currently take to scan the laser frequency to match the isomer energy is a vital step. Moreover, measuring the efficiency of the radiative decay process and the isomer's half-life in different large-bandgap crystals unravels information about its disintegration modes. During 2022, further experiments, supported by EURO-LABS, were undertaken at ISOLDE to increase the precision on the isomer energy, as well as to determine the half-life in other types of crystals. The experiments ran well, and the results of the data analysis are eagerly awaited.

Fig. 1: Artistic View of the use of a nuclear physics clock

[1] Sandro Kraemer *et al.*, Nature 617, 706 (2023).

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AGATA - Our jewel of nuclear structure

JJ Valiente-Dobon (INFN, Padova, Italy)

Fig. 1: Photo of the AGATA device as it is already in operation at LNL, Italy

Advanced GAmma Tracking Array (AGATA) is an array of high-purity segmented germanium detectors, which represents the state of the art for gamma-ray detection worldwide. It has been designed and constructed within a collaboration of many European countries and institutions. Thanks to its segmentation, digital data acquisition electronics and pulse-shape analysis techniques, AGATA can track the path of a gamma-ray in the spectrometer to reconstruct its emission angle as well its energy. This ensures to achieve unprecedented Doppler correction resolving power.

In the first After the first successful campaign with the AGATA demonstrator at LNL (2009-2012), AGATA moved to GSI (2012-2013) and later to GANIL (2014-2021). Since April 2022, the AGATA array returned to LNL for a physics campaign using stable beams ranging from hydrogen to lead (and uranium in a near future), delivered by the Tandem-ALPI-PIAVE accelerator complex at energies from 20-25 MeV/u (lightest ions) to about 7-8 MeV/u (heaviest ions). In the first phase of the ongoing LNL campaign, AGATA has been coupled to the PRISMA mass spectrometer to study gamma-ray emission from exotic nuclei produced in the multi-nucleon transfer and fusion-fission reactions and then identified in PRISMA.

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AGATA

Complementary detectors, like the SPIDER, EUCLIDES, OSCAR and SAURON silicon arrays for charged particles and ions are also used in this campaign. The physics cases under study involved shell evolution and configuration mixing in key regions of the nuclear chart, such as the vicinity of the N=20 island of inversion or the ^{78}Ni doubly-magic nucleus, quadrupole and octupole shapes and collectivity across a wide range of nuclear masses, as well as measurements of astrophysical interest. Several Coulomb-excitation experiments investigated shape coexistence along Z=40 and Z=50, while fusion-evaporation reactions were used to study properties of rotational bands in heavy neutron-deficient nuclei. Nuclear reaction studies were also performed, aiming to investigate the gamma-ray emission from the quantum tunneling of neutrons between the reacting beam and target nuclei. Another measurement used a novel approach to increase the sensitivity to very small fusion cross sections by combining gamma-ray and particle spectroscopy.

One of the strengths of the AGATA array is the capability to measure lifetimes of excited nuclear states for the most exotic, weakly-produced, nuclei, in order to obtain crucial information on the nuclear wave functions that provide the most stringent tests of existing nuclear models.
At LNL, this capability is being fully exploited by developing new techniques for such lifetime measurements.

A new deuterated target, evaporated on a gold foil to enable stretching it on a plunger device, was developed, as well the use of a plunger device in an inverse configuration to determine the lifetimes of the excited states of the heavy partner (for example, platinum and osmium) in a binary reaction. Silicon detectors for light ejectiles have also been employed in combination with AGATA to measure lifetimes of excited levels in nuclei populated by one and two-nucleon transfer, where the direct population of the state of interest can be ensured by gating on the excitation energy deduced from the measured energies of light particles. This eliminates the problem of feeding from higher-lying states, making it possible to measure very short lifetimes in complex level schemes.
To date, 26 experiments have been performed, including three that were commissioning experiments. About 1700 hours of beam on target were delivered to AGATA at LNL in the period May-December 2022, and the total number of beam-on-target hours in 2023 will reach about 3000 by the end of December. In the first semester of 2024, AGATA will remain in the its present configuration, and several experiments are already planned with many more new projects discussed at the last collaboration workshop in view of proposing them to the LNL Program Advisory Committee.
Since 2022, numerous users of the AGATA array benefitted from transnational access to LNL under the EURO-LABS grant agreement, and a workshop on AGATA data analysis has been organized at LNL within the INTRANS subtask of EURO-LABS.

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D-MAPS in EURO-LABS

Marko Mikuž (JSI, Ljubljana, Slovenia)

MAPS – Monolithic Active Pixel Sensors – are in essence a well-established imaging sensor technology used, for example, as "electronic film" in digital cameras. In the realm of the CMOS (Complementary Metal-Oxide Semiconductor) visible light imagers, MAPS around 1995 took over from the CCD (Charge Coupled Device) imagers, which are still preferred for imagers in astronomy, like the 3.2 Giga-pixel optical camera of the Vera Rubin Observatory. The term Monolithic denotes the presence of the sensor and read-out electronics on the same silicon wafer, and Active refers to the integration of the signal encoding circuitry into each of the pixels.

In particle physics, early attempts on MAPS implementation were made in the 1990's at the US West Coast. The first widely used MAPS sensor family was the MIMOSA (Minimum Ionizing MOS Active pixel sensor) family designed by the Strasbourg group at the turn of the millennium. Sensors from the MIMOSA family are still operational in many test-beam tracking telescopes, also in the EURO-LABS facilities at CERN and DESY.

The advantages of monolithic over the hybrid pixel sensor technology are very attractive: absence of interconnection between the sensor and the read-out ASIC by costly bump bonding, ultra-low sensor capacitance, thin, almost zero-mass devices, and access to commercial foundries with huge production capability. They are indeed a physicist's dream.

The ultimate showcase of the MAPS development is the planned ITS3 upgrade of the ALICE vertex detector. It features monolithic, 50 μm thick detectors, which by connecting reticules by stitching result in wafer size devices that can be bent into cylinders encircling the beam pipe. Because of the small sensor capacitance, the integrated read-out, designed in 65 nm technology of TSMC (Taiwan Semi-conductor Manufacturing Company), is sufficiently low power to be air-cooled, resulting in an extremely low mass budget.

The drawback of MAPS is that the charge collection to the electrode is accomplished mostly by diffusion, resulting in a rather slow device, which is highly susceptible to radiation damage. The proposal to overcome this limitation is due to Ivan Perić in 2007, who suggested to use large deep wells as collection electrodes and burry the readout in the electrode itself (Figure 1).

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D-MAPS in EURO-LABS

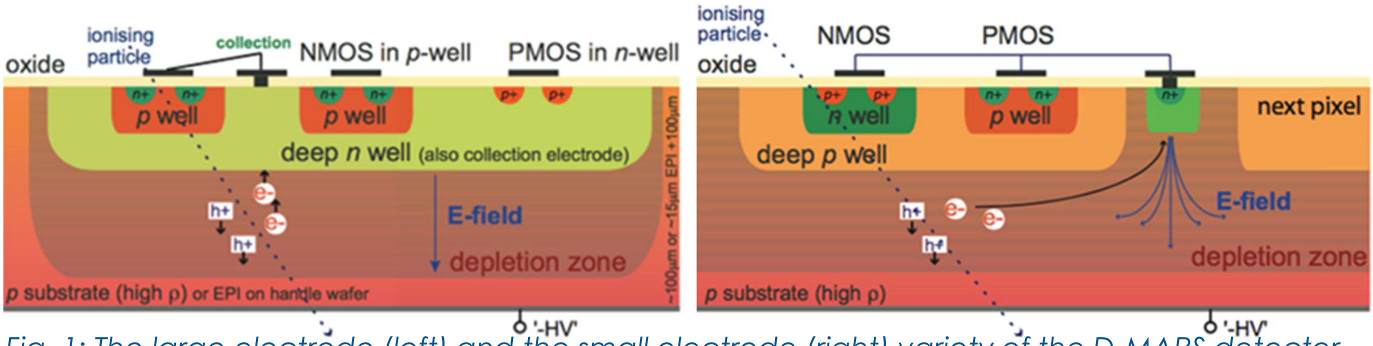

Fig. 1: The large electrode (left) and the small electrode (right) variety of the D-MAPS detector. The electric field of the large electrode is more uniform and the drift vertical, while for the small electrode lateral drift is needed to collect the charge.

Nested p and n-wells are needed to provide complete CMOS design functionality. Although electrode capacitance is significantly increased, larger bias voltages between the electrode well and the backplane, possible in the HV-CMOS technology, allow for creation of a substantial depletion layer under the electrode. Charge collection is now predominantly by drift in the electric field in the depletion zone, enhancing and speeding up the signal and improving radiation hardness. Hence the name of the device – D-MAPS for Depleted-MAPS.

The current development of D-MAPS can be grouped into two branches: the large electrode concept follows up on the original idea, while the small electrode variety reverted largely to the MAPS concept. A design upgrade exploiting the available larger bias, however, enables drift-based charge collection from the depleted region extending out from the small electrode (Figure 1).

D-MAPS sensor developments were targeted for outer regions of the pixel tracker upgrades for HL-LHC and the produced prototypes met specifications. The collaborations decided, however, to keep uniform (hybrid) technology throughout the tracker.

A future upgrade challenge for D-MAPS is the planned exchange of the innermost pixel layers of ATLAS and CMS at about one half of HL-LHC luminosity, and the steady LHC-B vertex detector upgrades.

Vigorous detector R&D is pushed by proponents of both options. EURO-LABS research infrastructures play a paramount role in enabling these developments.

Prototype detectors are being irradiated with protons and neutrons, so far at Birmingham and Ljubljana, irradiations at other EURO-LABS facilities are also planned. The devices are tested in the high-energy test-beams at CERN and DESY, supplying decisive results on detector performance both before and after various levels of radiation damage.

The development of D-MAPS is expected to gain additional momentum with the formation of the DRD3(Detector R&D) collaboration at CERN, dealing with strategic R&D of solid-state detectors in line with the implementation of the ECFA Detector R&D Roadmap. In the DRD3 structure, one of the four work packages (WP1) is entirely dedicated to development of monolithic CMOS detectors. An additional boost in usage of EURO-LABS facilities will also arise from DRD7, dealing with R&D on electronics, which forms an integral part of the D-MAPS detector.

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