

Workshops on Acceleration and Applications of Heavy Ions at the Heavy Ion Laboratory, University of Warsaw



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Nuclear physics students, especially in countries where no accelerator facilities are present, have often quite limited possibilities of getting acquainted with modern scientific apparatus. Existing faculty physics laboratories offer usually only basic equipment and propose standard experimental tasks which do not stimulate independent thinking and creativity. As a response to these needs, Workshops on Acceleration and Applications of Heavy Ions are organised every year at the Heavy Ion Laboratory of the University in Warsaw, giving students a unique opportunity to gain experience in methods of data acquisition and analysis, in operating the cyclotron including beam diagnostics measurements and in charged particle and gamma-ray detection techniques.



Participants work in small teams (2-4 people) to prepare and perform nuclear physics measurements using dedicated apparatus available in the Heavy Ion Laboratory. For this purpose, a week of cyclotron beamtime is allocated. These tasks provide them with a hands-on experience with modern scientific equipment (detectors and related electronics, vacuum systems) and offer a possibility to get acquainted with good practice rules of laboratory work (e.g. sources and target handling). The workshop is concluded by a session of student presentations in a form of 20 minutes talks on measurements and results of each team.

Examples of experimental tasks include:

- Beam focusing in heavy ion acceleration,
- Beam energy measurements based on the Rutherford scattering,
- Identification of excited bands in gamma-gamma coincidences,
- Gamma-ray measurements using scintillation detectors,
- Experimental study of nuclear reactions,
- Identification of reaction products based on pulse shape analysis,
- Elemental analysis using X-ray fluorescence,
- Measurements of natural activity in environmental samples.



The experimental part of the workshop is accompanied by a series of lectures on subjects related to heavy ion physics. The lectures take place every day in the morning and offer introductions to subjects such as target preparation, ion optics, presentation of various experimental techniques as well as applications of nuclear methods in other fields, such as medicine and nuclear energy.

Polish edition of the workshop is organised every year since 2005 and is currently intended for students starting their third year of studies. As the Bologna process has been implemented in most of Polish universities, this is the moment when students start thinking about their future specialisation area and possible BSc projects. We hope that participation in the workshop will encourage them to choose a subject of their thesis in the domain of nuclear physics.

The number of participants has been increasing every year, reaching nineteen (which is the maximum we are able to accept) in 2008. After success of the first editions, we usually receive over two times more applications than the number of places available. It should be also noted that almost every year new institutions join the list of universities interested in sending their students to the Workshop. The participants are often willing to continue the collaboration with HIL in a form of a summer internship or at the MSc stage. Three MSc theses prepared at HIL by former Workshop participants have been defended: one in 2008 at the Adam Mickiewicz University in Poznań and two in 2009 at the University of Silesia in Katowice.



The first **international edition** of the Workshop on Acceleration and Applications of Heavy Ions took place at HIL in March 2011. A two weeks course for 19 participants was organised jointly by HIL, University of Huelva (Spain) and University of Sofia (Bulgaria) as an Erasmus Intensive Programme (IP).



The workshop was initially intended for students of the 2nd cycle of studies, but finally also several young PhD students profited from it. Thanks to the received EU funding from the LLP Erasmus programme, it was possible to extend the workshop to full two weeks. The first week was used for setting up of the experimental apparatus and in-beam measurements. During the second week of the workshop, participants analysed the collected data, performed additional off-beam measurements (if needed) and prepared final presentations. Thanks to complementarity of partner institutions' areas of competence, the offer of lectures was also much broadened as compared to the one-week Polish edition.



Student questionnaires show that the workshop was generally very well received (it was graded on average at 4.5/5). The support from the home institution (4.3/5) and the host institution (4.8/5) was also appreciated. Students judge highly the learning outcomes (4.5/5) and personal outcomes (4.4/5) of the workshop. Expertise of the teachers (4.7/5) and the overall quality of teaching (4.6/5) are reported as the strongest points of proposed academic activities. Students judge that this is quite likely that participation in the workshop will help them in their future studies (4.3/5), but it is less clear when it comes to finding a job (3.4/5). Other comments from participants include suggestion of work in smaller teams, necessity of more stress put on the safety rules of laboratory work, and complaints on low English skills of some students. While we have no plans to reduce the number of students in a team (it would require participation of more teachers, which is hardly possible - in the last edition the number of teachers involved was even higher than the number of students!), other comments will be taken into account in future editions.

The second international edition of the workshop is planned for March 2012 and this time the Akdeniz University from Antalya, Turkey, will join the list of co-organisers. More foreign universities express their interest in joining in the project.

According to our knowledge, apart from the Workshops on Acceleration and Applications of Heavy Ions at HIL Warsaw, there is no other training of this kind offered by European accelerator centers. Existing training programmes and summer schools do not provide accelerator beam time and sophisticated equipment for teaching purposes only: common practice is incorporating students in research groups and assigning them routine and sometimes deskilled tasks. In this aspect, our project is unique and innovative: offered a real hands-on experience with modern equipment and an opportunity to work in an international group on an open problem.



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