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REPORT ON AN INTERNATIONAL ACCELERATOR SCHOOL - ISBA23

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Abstract

The sixth International School on Beam dynamics and Accelerator technology (ISBA23) was held for 10 days from August 3rd to 12th, 2023 at Pohang Accelerator Laboratory (PAL) in Korea. ISBA23 was jointly hosted by Korea Atomic Energy Research Institute (KAERI) and Korea Accelerator and Plasma Research Association (KAPRA). After screening 83 registrant's resumes and letters of recommendation, 70 students from Korea, Japan, China, Taiwan, India, and Thailand were finally admitted to the school. For 10 days, 20 professional scientists from Korea, Japan, China, Taiwan, Thailand, Germany, and the USA gave 30 valuable lectures and 14 hands-on training sessions with ASTRA and ELEGANT accelerator codes. Thanks to the generous financial support from 14 sponsors, the school was successfully completed. We report on ISBA23, which is the biggest international accelerator school in Asia.

INTRODUCTION

The aim of ISBA is to provide young researchers and graduate students in Asia with an opportunity to learn about beam dynamics and accelerator technologies such as superconducting linac and magnet systems, and to serve as a gateway to full scale accelerator research. In addition, ISBA also aims at the development of accelerator science and international human networks in the Asian region.

From 2018, ISBA series was started as an international accelerator school supported by the previous IINAS program of Japanese government (MEXT), and it has been operated by researchers in Japan, Korea, China, Taiwan, and India [1]. From 2023, researchers from Thailand also joined the operation [2]. ISBA is important because it can also provide graduate students and young researchers with opportunities to study intensively in an international environment, not only to acquire knowledge and skills, but also to create opportunities for accelerator research and to lay the groundwork for their future activities as researchers.

Figure 1 shows a group photo taken at the opening ceremony of ISBA23. The fourth person from right in the front row is Prof. Won Namkung, who is a pioneer of accelerator science in Korea. He gave an excellent address at the ceremony introducing the history of accelerator science in Korea.

SCHOOL OUTLINE AND STRUCTURE

The co-chairs of the organizing committee of ISBA23 are Yujong Kim (KAERI & UST, Korea) and Masao Kuriki (Hiroshima U., Japan). The full list of the organizing committee members can be found from the ISBA23 website [2]. The local logistics were managed by Yujong Kim and Yong Woon Park, and the webpage was managed by M. Kuriki with help of Hitomi Kusama (KEK, Japan) [2].

Table 1: Affiliation Region of Students and Lecturers

Region	No. of Student	No. of Lecturer
Korea	33	9
Japan	13	4
China	11	1
Taiwan	5	1
India	4	1
Thailand	4	1
Germany	·	1
USA	·	2
Total	70	20

70 attending students and 20 lecturers from each region are summarized in Table 1. Please note that the summary is based on affiliation instead of nationality.

The structure of ISBA23 is as follows [2]. There were four days of basic lectures to cover beam dynamics, magnets, and so on. On the fifth day, as shown in Fig. 2, there was an excursion to Gyeongju city, which is the famous ancient capital of the Silla dynasty. From the sixth day, special lectures were given to cover colliders, the medical accelerators for heavy ion, electron, proton, and BNCT based cancer therapies, Artificial Intelligence (AI) and EPICS DAQ for the machine learning based advanced research in accelerators, and the 3rd and 4th generation synchrotron light sources. On the 9th day, as shown in Fig. 2, there were the accelerator facility tours at the Korea Multi-purpose Accelerator Complex (KOMAC), a 100 MeV proton accelerator facility of KAERI in Gyeongju and PLS-II and PAL-XFEL, two light source facilities at PAL in Pohang. In addition, the school banquet was held on the evening of the 9th day [2]. Two social events, the excursion and the banquet were helpful for all attendees to make meaningful interactions and human networks. Two accelerator facility tours were also helpful for students to understand accelerators more deeply by looking into accelerator hardware directly.

Each day, generally, we had 5 lectures. Four lectures were ordinary lectures, but the last lecture was allocated for the hands-on training sessions with ASTRA and ELEGANT codes as shown in Fig. 2 [3, 4]. Since students had selected one of the codes in advance, everyday, students were trained at one of two parallel hands-on training sessions. Through those hands-on training sessions, students had the opportunity to develop their simulation skills by designing various

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Figure 1: The group photo at the ISBA23 opening (left) and closing (right) ceremonies. Students hold up their certificates with wonderful smiles on their faces at the closing ceremony.

accelerators with ASTRA and ELEGANT codes. As shown in Fig. 2, at a session on the last day, students presented their simulation results of accelerator designs [2].

After dinner on the first day, we held a communication and greeting session where all attendees introduced themselves. The purpose of that session was to encourage interaction among students and lecturers to make the human networks, which is one of the key objectives of the school [2, 5].

In the slots after dinner, we had four student sessions on August 4th, 5th, 6th, and 8th. In those sessions, students presented their accelerator related researches, which had been performed at their home institutes [2, 5].

Lastly, on the 10th day, there were the award ceremony as shown in Fig. 2 [5]. Based on the grading by the lecturers, the five top students got the best R&D presentation awards on their great researches at their home institutes, and four teams also got awards on their great accelerator design works done at the hands-on training sessions. In addition, 14 sponsors also provided the ISBA scholarship to cover all expenses for round-trip travel, meals, and accommodation to 25 students. As shown in Fig. 1, Yujong Kim, co-chair of ISBA23, handed out ISBA23 certificates to all students at the end of the ISBA23 closing ceremony. The certificate is just a piece of paper, but it will be more worthful than $10M to those who have completed the 10 day-long intensive lectures and the rigorous hands-on trainings. This is evident in their beaming and proudful smiles as shown in Fig. 1.

SCHOOL CURRICULUM

Theoretical Lectures

The detailed curriculum of ISBA23, including the lecture materials, can be found at the ISBA23 website [2]. The curriculum was kicked off by *Introduction to Accelerator Science* by M. Kuriki, followed by fundamental subjects: *Foundation of Beam Dynamics - I, II, and III* by Yujong Kim, *Magnet Theory* by Yong Woon Park, *Particle Generation* by Zachary J. Liptak, *RF Accelerators and Superconducting Accelerators* by Sang-hoon Kim, *Electron Injector and Linac* by M. Kuriki, *Synchrotron and Circular Accelerator* by Kaoru Yokoya, *Coupled Bunch Mode Beam Instabilities and Feedback Systems for Synchrotron Light Sources* by Yujong Kim, *RF System* by Sakhorn Rimjaem, *Beam Diagnostics* by Changbum Kim, *Collider* by Kaoru Yokoya, and *Proton and Heavy Ion Accelerators* by Dong-O Jeon.

The latest applications were also presented as *Industrial Accelerators and Applications* by M. Kuriki on behalf of A. Deshpande, *Proton Linac based BNCT Cancer Therapy* by Young-soon Bae, *Heavy Ion Cancer Therapy* by M. Kuriki on behalf of A. Deshpande, and *Electron Linac based Cancer Therapy* by Heuijin Lim.

Some advanced topics were also presented as *Advanced Beam Dynamics in Circular Accelerators* by Jie Gao, *Advanced Beam Dynamics in XFEL Driving Linac* by Yujong Kim, and *Analytic Treatment of Linac* by Jie Gao.

AI has had a big impact on accelerator science in recent years. On the topic, we had lectures such as *Foundation of AI* by Geunhyeong Lee, *ChaptGPT for Scientists* by Hyunkil Shin, *Machine Learning and AI-based Beam Diagnostics* by Hirokazu Maesaka, *De Novo Drug Design with AI* by Hyunkil Shin, and *EPICS Accelerator Control System and DAQ for AI* by Kukhee Kim.

One of the latest trends in light source accelerators is the storage ring based light sources. Wei-Keung Lau gave a good introduction of *The 3rd and 3.5th Generation Synchrotron Light Source Facilities* followed by *Advanced Beam Dynamics in the 4th Generation Synchrotron Light Source Projects* by Yong-Chul Chae.

Hands-on Training with ASTRA and ELEGANT

Zachary J. Liptak and Sakhorn Rimjaem taught seven *Hands-on Training Sessions with ASTRA code*, while Yujong Kim taught seven *Hands-on Training Sessions with ELEGANT code* [2, 5]. Since all students were intensively trained by attending seven hands-on training sessions, which are totally 630 minutes during the school period, they could get deep simulation and accelerator design skills with ASTRA and ELEGANT codes. The trainings were conducted in groups, with each group choosing one of several assigned tasks to design their own accelerators with ASTRA and ELEGANT codes. The objective of the training was achieved if the students could show that their designed accelerators can deliver the assigned beam parameters.

In case of the hands-on training with ASTRA code, students were asked to design linacs with the RF photoinjector

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Figure 2: From top left to bottom right: excursion at the Bulguksa temple, hands-on training with ASTRA, presentation on hands-on training with ELEGANT, awards on the hands-on training, lecture room, facility tour at PAL-XFEL, banquet, receiving the ISBA scholarship.

or the thermionic RF gun. In case of the hands-on training with ELEGANT code, students were asked to perform one of following three main tasks or one of slightly modified ones [2, 5]:

1. **Design of two 4 GeV MBA based storage rings with a circumference of about 800 m and a 7BA-MBA lattice and with a circumference of about 1600 m and a 9BA-MBA lattice.** RF frequency is 500 MHz. Dispersion should be closed at long drift sections. Chromaticity should be compensated to near zero. Tunes should be far away from the resonance lines. $\beta_{x,y}$ should be smaller than 20 m. Try to optimize lattices to achieve the lowest possible emittance and a wide dynamic aperture.
2. **Design of an S-band injector with a bunch compressor, 3 FODO cells for beam diagnostics.** The initial and final energies are about 150 MeV and 250 MeV. The single bunch charge is 200 pC. Longitudinal and transverse short-range wakefields should be considered in S-band and X-band linacs. Coherent Synchrotron Radiation (CSR) should be considered in the bunch compressor. After the bunch compressor, bunch length should be shorter than 50 µm. The normalized projected emittances after the bunch compressor should be smaller than 0.4 µm. The normalized core slice emittances after the bunch compressor should be smaller than 0.38 µm. $\beta_{x,y}$ should be smaller than 50 m. After the bunch compressor, the peak current should be higher than 380 A. The phase advance per the FODO cell of β_x is 50 degree, and the phase advance per the FODO cell of β_y is 25 degree. The length of the FODO cell is 3.2 m [6].
3. **Optimization of lattice for the superconducting linac of DESY FLASH facility with an initial energy of about 125 MeV and its final energy of 450 MeV.** The type of superconducting linac is DESY TESLA type. The number of bunch compressor system is 2. The initial bunch length is 1.812 mm, and the final bunch length is smaller than 475 µm. The 3.9 GHz 3rd harmonic cavity is not installed. The final horizontal normalized projected emittance should be about 15 µm. The final peak current should be higher than 2.5 kA. $\beta_{x,y}$ should be optimized along the whole FLASH linac to avoid the chromatic effects along the linac and to get a good emittance at the end of the linac.

SUMMARY AND ACKNOWLEDGMENTS

ISBA23, the first ISBA school in Korea was successfully completed. 70 students from Asian regions gathered and spent 10 days to study accelerator beam dynamics and technologies intensively. All students must have truly enjoyed the lectures and other social events. This is the first ISBA held outside of Japan, and this is a big step forward for ISBA to become a truly international school. In 2024, the ISBA school will be held at Chiang Mai in Thailand. Since 2018, Masao Kuriki and Yujong Kim have been working together for the ISBA school. Recently, they realized that the level and number of registered students were gradually improved every year, which is a good indication that the training program of the ISBA school is helpful to young accelerator students and scientists in the Asian region.

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