

I.FAST

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General workshop on Task 7.2 activity summary

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ABSTRACT

I.FAST Task 7.2, Enabling Technologies for Ultra Low Emittance Rings, focuses on the networking in the field of low emittance rings, which is dominated by the recent upgrades of the X-ray storage rings and the exploitation of synergies with existing and future e+/e- colliders. Strengthening the networking activities in the key technologies of low-emitting rings leads to R&D paths that are closely linked to project partners, other facilities and scientific fields. To promote networking, Task 7.2 has so far organized five international workshops and one joint experiment. New networks have been established through workshops and scientific events, and synergies with other research and industrial areas have been realized through the organization of workshops with diversity and inclusion.

I.FAST Consortium, 2024

For more information on IFAST, its partners and contributors please see <https://ifast-project.eu/>

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Executive summary

There are many key technologies and in-depth knowledge required to realize ultra-low emittance rings, which provide high quality beams for synchrotron light sources, damping rings and e^+/e^- circular colliders. Networking activities to share knowledge and information on the key technologies strongly promote new projects for ultra-low emittance rings, and also stimulate innovation and synergies that occur through networking with other scientific research and industrial areas.

I.FAST Task 7.2 aims at networking in the field of ultra-low emittance rings by organizing general and thematic workshops where participants can communicate with each other and share the latest information and knowledge in order to strongly promote new projects on ultra-low emittance rings.

The partners of I.FAST Task 7.2 are fully motivated to organize the workshops and other scientific events such as joint experiments, and have successfully organised five international workshops and one joint experimental campaign so far. It can be said that the objectives of I.FAST Task 7.2, namely networking, have been achieved to the extent that new networking has taken place in the field of ultra-low emittance rings.

1 Introduction

In the scientific areas based on synchrotron radiation and e^+/e^- colliders, the demand for high-quality electron/positron beams with ultra-low emittances is now becoming much higher. However, the realization of such high-quality beams necessitates scientific and technological breakthroughs in several accelerator physics and technology issues. To realize ultra-low emittance beams and utilize them for cutting-edge experiments, extensive research and development based on profound understanding and knowledge of accelerator physics and technology are necessary. Given the complexity of an accelerator system, which consists of a large number of hardware devices, and networking activities that enable the exchange and sharing of information and knowledge accompanied by technology transfer, are in a high demand for projects on ultra-low emittance rings.

In response to these demands, the partners in I.FAST Task 7.2 are engaged on enabling technologies up to innovations for ultra-low emittance rings and on strengthening of networking activities in these areas. This is being achieved through the organization of scientific events such as international workshops, which provide opportunities for the exchange of information and knowledge. Based on the objectives, I.FAST Task 7.2 has so far organized five international workshops regarding ultra-low emittance rings. In addition, the working group Task 7.2 organized joint experiments on accelerator physics and technology, which allow participants to work on the same experimental topics together and to discuss them with each other. These activities are based on monthly meetings where the partners of I.FAST Task 7.2 prepare the workshops, the experiments and exchange information on the latest topics, research results and innovations related to ultra-low emittance rings.

2 Workshop Organization

2.1 WORKSHOP ON BEAM DIAGNOSTICS AND DYNAMICS IN ULTRA-LOW EMITTANCE RINGS (ONLINE)

Synchrotron radiation sources and e^+/e^- colliders require high-quality beams with ultra-low emittance. To assess the beam quality and stability, technological breakthrough in beam diagnostics are necessary to evaluate the beam quality achieved at a level that previous accelerators have never reached. To direct the development of the beam diagnostic system in the optimal direction for ultra-low emittance beams, it is essential to enhance the understanding of beam dynamics and to facilitate the exchange of information and knowledge between diagnostics side and the beam dynamics side. Based on these ideas, the workshop on beam diagnostics and dynamics in ultra-low emittance rings was organized [1]. The workshop period was from April 25 to 29, 2022, during the international pandemic, and it was challenging to proceed with workshop activities. However, the workshop was conducted online by the Karlsruhe Institute of Technology (KIT) with participants from around the world. The workshop included sessions on beam diagnostics and beam dynamics, with the objective of exchanging information and knowledge between the two sides of beam diagnostics and beam dynamics. The workshop's contents have been summarized briefly and published as the IFAST project report [2].

Workshop statistics:

20 presentations in 2.5 days, 81 participants from research areas

2.2 LOW EMITTANCE RING – PERMANENT MAGNET WORKSHOP

Nowadays, permanent magnet technology has been strongly focused on, accompanied by technological progress and the demand to reduce energy consumption for accelerator operation. Motivated by these backgrounds, the workshop on permanent magnet was organized jointly by LEAPS-PerMaLIC [3] and IFAST from November 14 to 15, 2023 in Trieste with the local support of Elettra Sincrotrone Trieste. In the workshop, the state-of-the-art topics regarding the permanent magnet systems were discussed widely with the participants worldwide, not only from accelerator institutes but also from industrial areas. The workshop comprehensively covered scientific and technological topics related to permanent magnets and also focused on innovations with a wide range of discussions, including the production and industrialization of permanent magnets. The workshop was a great success and the contents of the workshop, including the presentation slides, have been published on the Indico workshop website [4].

Workshop statistics:

19 presentations in 1.5 days, 42 participants from research and industrial areas

2.3 LOW EMITTANCE RINGS WORKSHOP

The concept of ultra-low emittance rings is based on a variety of key technologies and beam dynamics knowledge relevant for achieving high quality beams. In order to share the latest information and knowledge covering a wide range of accelerator physics and technology, the partners of Task 7.2 organized an international workshop, the Low Emittance Rings Workshop 2024 at CERN from February 13 to 16, 2024. The aim of the workshop was to share knowledge and information on ultra-low emittance rings across a wide range of design approaches and performance goals that drive key technologies, including lattice design, optics measurement and correction, nonlinear dynamics, magnet design, beam stability, feedback and diagnostics, ring design challenges, collective effects, harmonic cavity design and experiments, energy calibration, machine learning and artificial intelligence. In particular, a full session organized in collaboration with I.FAST WP 11 (Sustainable Concepts and Technologies) [5] was dedicated to power consumption, energy efficiency and sustainability. All the presentations discussed were state-of-the-art topics worldwide, and the participants were able to strengthen the network in the field of ultra-low emittance rings, including light source storage rings, damping rings, and e^+/e^- circular colliders, by sharing knowledge and the latest advances in the field. The total number of registered participants reached almost one hundred, and the participants came from various fields of accelerator physics and technology, including institutes and industrial areas worldwide, with diversity. The workshop reached many relevant conclusions and the contents of the workshop have been summarized and published on the Indico workshop website [6].

Workshop statistics:

60 presentations in 4 days, 99 participants from research and industrial areas

2.4 WORKSHOP ON BUNCH-BY-BUNCH FEEDBACK SYSTEMS AND RELATED BEAM DYNAMICS

In ultra-low emittance rings, due to the high quality of the beams, collective beam instabilities can be stimulated by interactions between the beams and the environment, such as RF cavities and vacuum chamber walls, leading to a degradation of the beam quality. Bunch-by-bunch feedback systems are becoming one of the indispensable devices to ensure beam quality in ultra-low emittance rings. The bunch-by-bunch feedback systems have been installed in several ring-based synchrotron light sources, damping rings and e^+/e^- circular colliders. The aim of the bunch-by-bunch feedback systems workshop was to strengthen the networking in the field of feedback systems in order to exchange the latest information and experiences that feedback system specialists have established so far. Based on the objectives, the workshop was organized at KIT from March 3 to 6, 2024. It should be emphasized that people involved in the development of bunch-by-bunch feedback systems worldwide attended the workshop together and shared their knowledge and experiences, which was one of the results of the networking activities. The workshop was jointly organized by SOLEIL and KIT, both of which were the I.FAST Task 7.2 partners and resulted in relevant and sufficient scientific and technological conclusions. The contents of the workshop has been published on the Indico workshop website [7].

Workshop statistics:

18 presentations in 3 days, 43 participants from research and industrial areas

2.5 WORKSHOP ON INJECTORS FOR STORAGE RING BASED LIGHT SOURCES

Directly after the workshop on bunch-by-bunch feedback systems and related beam dynamics, the workshop on injectors for storage ring based light sources was held at KIT from March 6 to 8, 2024. The organization of these two workshops aimed at synergies between two different scientific fields. In ultra-low emittance rings, injectors such as booster synchrotrons supply beams to main storage rings that function as light sources. To ensure stable beam operation of the main storage rings, the injectors must be operated to deliver high quality beams to the main rings while maintaining high stability. The injector workshop also aimed to share the latest information and experience on the operation and upgrading of injectors in operation and under consideration, accompanied by new projects for the main storage ring light sources. Since the injector workshop was held immediately after the bunch-by-bunch feedback workshop, several participants from the feedback workshop also attended the injector workshop, and several discussions were held using technical terms from the bunch-by-bunch feedback systems. This showed that the two workshops achieved synergies and could contribute to networking between two different scientific fields. The workshop was jointly organized by Paul Scherrer Institute (PSI), SOLEIL and KIT, which are the I.FAST Task 7.2 partners. As same as the workshop on bunch-by-bunch feedback systems, the injector workshop reached relevant and sufficient scientific and technological conclusions with strengthened networking activities. The contents of the workshop have been published on the Indico workshop website [8].

Workshop statistics:

21 presentations in 1.5 days, 41 participants from research areas

3 Other Networking Activities

3.1 JOINT EXPERIMENTAL CAMPAIGN ON BUNCH-BY-BUNCH FEEDBACK SYSTEMS

Between the workshops on bunch-by-bunch feedback systems and the workshop on injectors, a joint experimental campaign [9] took place at the Karlsruhe Institute of Technology (KIT) in collaboration with partners of I.FAST Task 7.2 and the EU project EURO-LABS [10], where the workshop participants conducted experiments with the Karlsruhe Research Accelerator (KARA), a 2.5 GeV electron storage ring, and its bunch-by-bunch feedback system as well as in the 500 MeV Booster. Beyond the preparation of the experimental campaign, the team Task 7.2 has organized online meetings called Feedback Meeting to exchange information and knowledge about bunch-by-bunch feedback systems as a networking activity with specialists of feedback systems. Experimental topics and contents for the joint experimental campaign were discussed there and during the feedback system workshop to ensure the networking activity and search for relevant topics concerning the feedback system with the workshop participants. Three experimental topics were selected and conducted in a 1.5-day experimental period. The data and results have been shared with all interested participants, and the data analysis and subsequent discussions are ongoing.

3.2 POSTER PRESENTATION AT IPAC'24

In order to disseminate our networking activities worldwide, I.FAST Task 7.2 gave a poster presentation at IPAC'24 entitled "Networking Activities of the I.FAST Project on High Brightness Accelerator for Light Sources", where the objectives and networking activities of I.FAST Task 7.2 were presented. The presentation also aimed at networking not only in the field of low emittance rings, but also in other fields of accelerator physics and technology, such as hadron and linear accelerators. Several fruitful discussions took place during the poster session by inviting people from research and industry interested in networking activities. During the discussion, several people commented positively on the networking activities organised by I.FAST Task 7.2 and even asked about the next workshop plans. This clearly shows that our networking activities have a broad impact and contribute to the networking in the field of accelerator physics and technology, which are the objectives of I.FAST Task 7.2. The poster presentation was a success and its contents have been published in the conference proceedings [11].

3.3 INVITED TALK AT IBIC'24

International Beam Instrumentation Conference (IBIC) 2024 [12], held in Beijing, suggested the participants of the bunch-by-bunch feedback workshop to give an invited review talk on bunch-by-bunch feedback systems by summarizing the feedback workshop held at KIT in March 2024. Upon receiving the suggestion, Dr. Takeshi Nakamura of KEK, one of the bunch-by-bunch system developers and workshop participants, presented his review talk entitled "Bunch-by-bunch feedback systems review" in which he summarized and presented the contents of the feedback workshop. The presentation showed many valuable discussions and conclusions we reached at the workshop and our networking activities. In particular, international conferences, in this case IBIC, noticed our networking activities and nominated us as candidates for invited speakers. This means that our Task

7.2 activities have been widely recognized as worthy of attention. The presentation was a success and the content of the presentation will soon be published as a conference proceedings [13].

4 Conclusion

The objective of I.FAST Task 7.2 is to strengthen the networking in the field of ultra-low emittance rings. The partners of Task 7.2, even during the challenging period due to the global pandemic, have actively organised workshops and joint experimental campaigns focusing on key technologies such as magnet design, vacuum, beam instrumentation, RF, injection and feedback systems. It can be said that the objectives of Task 7.2, namely networking, have been achieved to the extent that new networking has taken place with information exchange and synergy. Further networking activities will be intensified in the I.FAST project and also after the current project in order to establish technologies in the field of high-brightness synchrotron light sources.

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