A new plan for the Tohoku synchrotron radiation facility: white paper

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Tohoku synchrotron radiation facility committee (tentative name)
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This white paper discusses five aspects related to the new plan for a futuristic medium size (3-GeV) synchrotron radiation facility with high brilliance in the north eastern provinces (Tohoku) of Japan, hereafter referred to as "Tohoku synchrotron radiation facility": 1) social demand, 2) relation to reconstruction in Tohoku district from great earthquake disaster, 3) technological validity and usefulness, 4) management for construction and operation of the facility and 5) synergetic effect on the Japanese society.

1) Social Demand

The Great East Japan Earthquake and Tsunami which occurred on 11 March 2011 was the greatest disaster in Japan which brouhgt more than 20,000 earthquake victims and about 340,000 disaster evacuees in the large area of east Japan centering on Miyagi, Iwate and Fukushima prefectures. It was really shattering. This catastrophe surpassed the Great Hanshin-Awaji earthquake on 17 January 1995 in the number of earthquake victims and extent of damage. This earthquake also gave an opportunity to reconsider the reliability and responsibility of science and technology for earthquake prediction, disaster prevention following tsunami, safety measures at nuclear power plants, maintenance of the national energy infrastructure and environmental measures against radioactive contamination.

Since the research and educational institutions such as universities, public organizations for research and development of different subjects and industrial technical development centers of various companies located in the Tohoku district suffered from the earthquake calamity, operations for the recovery and maintenance of those infrastructures were undertaken with great urgency at various levels of government and private organizations. In the meantime, various research and development infrastructures in west Japan are playing an important role in supporting recovery from disaster in east Japan including the Tohoku district. In particular, SPring-8 in the western part of Japan which is the advanced synchrotron radiation facility catering to a wide range of sciences and industries has been used and is emerging as an engine of recovery of east Japan by preventing major delay in research and development of new magnetic materials and green materials in the Tohoku district. However, the signal light has already begun to change from yellow to red. The number of requests is greater than the capacity of Spring-8 . If left in the present state, delays in development of new materials and technologies will pile up since no synchrotron radiation facility is available in Tohoku region. It is clear that the capacity and performance of synchrotron radiation facilities available in west Japan are not enough not only for promoting

reconstruction from disaster, but also for maintaining the technological leadership of our country.

For these reasons, it is strongly desired to construct a futuristic medium size (3-GeV) synchrotron radiation facility with high brilliance, as soon as possible in the north eastern provinces of Japan (Tohoku area). This is believed one of the better solutions to overcome the present and futuristic bottlenecks to technological progress of our country by fully maintaining leadership in research and development of materials characterization with resolution at the atomic level.

2) Relation to Reconstruction in Tohoku District from the Great Earthquake Disaster

Many core subjects of research and development carried out by various institutions located in Tohoku district are related to key technologies. Fundamental understanding of crucial issues is extremely important for the survival of industries in our country, staying ahead of competition from newly emerging countries. It is important from the point of technological strategy of our country.

Since many researchers in universities and public research institutions of the Tohoku region function as international leaders in their respective fields, they are expected to contribute to reconstruction and innovation of science and technology. This is particularly true when considering the recovery from the last great earthquake disaster. In addition, such issues include an emergency subject – decontamination of the environment around the Fukushima Daiichi Nuclear Power Plant.

In recent years, in order to keep the leading position of our country in the world as a science- and technology-intensive nation, it is indispensable from a nationwide perspective to fully consolidate the infrastructures for solving and controlling the materials behavior at the atomic level as a function of reaction time and then to continuously innovate advantages in fields of the valuable high-tech products and advanced materials. For this purpose, the synchrotron radiation facilities producing X-rays with short wavelength and high permeability are well recognized as one of the best tools. There have recently been growing demands from many technological institutions to use the synchrotron radiation facilities.

When a futuristic medium size (3-GeV) ring-type synchrotron radiation facility with high brilliance is constructed in the Tohoku region, a wide range of research subjects can be definitely covered by using various advanced tools for analyzing samples in the variety of states. It can also be anticipated that there will be an economic impact from rise in local production and local consumption. This also contributes to disaster risk diversification of the research infrastructure in our country, which is a lesson learned from the great earthquake of 11 March 2011. Fundamental and important research infrastructures should be disbursed in both east and west regions of our country.

3) Technological Validity and Usefulness

In the 2000s many medium size (3-GeV) synchrotron radiation facilities, especially the ring-type light source, were set up throughout the world. They include SLS of Switzerland, SOLEIL of France, DIAMOND of UK, AS (referred to also as VICTORIA) of Australia, SSRF of Shanghai, China, and ALBA of Spain, most of which are now functional. Furthermore, medium size ring-type synchrotron radiation sources with high brilliance, such as TPS of Taiwan, NSLS-II of USA, and MAX-IV of Sweden,

have been planned one after another and construction has started. Such international activities clearly indicate the importance and the necessity of "medium size (3-GeV) synchrotron radiation facility" as an advanced fundamental tool. Such facility can only provide the nano-meter sized beam with high brilliance, so that one can realize innovation in a wide range of areas, such as biotechnology, materials, electronics, energy and security/safety. The synchrotron radiation facility is no longer accepted only for scientific use. In our country, some successful results have been obtained in science and technology of synchrotron radiation. In 2011, SACLA of SPring-8 (SACLA: SPring-8 Angstrom Compact free electron LAser) started the use of the X-ray free electron laser (XFEL), although it is a "linear-type light source" and mainly used for pioneering work in optical science.

The "ring-type light source" proposed in this plan can find solutions to challenging problems of research and development for various purposes by supplying opportunities to address many fundamental and essential requirements at once. Such "diversity and simultaneity" of utilization and application of synchrotron radiation facility is considered an essential feature of the advanced light source presently proposed. The ring-type advanced light source is certainly suitable for recovery from the earthquake disaster in the Tohoku region, as well as for supporting innovation in various industries in the whole of Japan within a reasonable time.

This proposal for "ring-type synchrotron radiation facility" in Japan may be viewed in the light of the fact that even SPring-8 will give up its position of highest brilliance in Asia to TPS of Taiwan, when the new light source is completed in 2014. Of course, there is a possibility of recovery in part from such a situation by upgrading SPring-8 or following the ERL plan of Photon Factory, High Energy Accelerator Research Organization at Tsukuba. However, at least in the next 5 to 10 years, it is likely to play second fiddle to the ring-type synchrotron radiation facilities in the world. For this reason, there is urgent need to promote the present plan as soon as possible. It is particularly true from a viewpoint of international competition in science and technology of the ring-type synchrotron radiation facility.

From a technological viewpoint, the present plan will certainly catch up with the light source performance of the medium size ring-type synchrotron radiation facilities available in the world, within the short construction period of about two years by effectively using the latest technologies such as a C band accelerator and a vacuum sealing undulator originally developed by SPring-8/SACLA. The usefulness and validity of such original technologies developed in our country have been fully confirmed by the recent excellent results of SPring-8 and SACLA in relation to accelerator science and X-ray optics, and their application to new research subjects in various fields.

Since extensive discussion about the construction and utilization of "a medium size (3-GeV) synchrotron radiation facility with high brilliance" has not been held in our country for many years, our competence in this area may be falling behind international standards. This plan certainly offers a means to sidestep this limitation in one stroke.

4) Management for Construction and Operation of Facility

The construction cost in this plan is expected to be 20 billion yen. This will make available 20 to 30 beam lines, thus, 20 or more research and development domains can be covered. Assuming 5000-hours of operation in a year, a total of 2000 to 3000 research projects can possibly be carried out and it is expected to contribute to research and development not only of Tohoku district, but also of the whole country. So

this plan may be considered a very efficient investment. Only the advanced synchrotron radiation facility herein proposed can provide the nano-meter sized beam with high brilliance, so that one can realize innovation in a wide range of areas, such as materials production technology, biotechnology, and energy and environmental technology. It is thought that the actual working group for construction should be formed by specialists from entire Japan, using human resources in north-eastern provinces of Japan.

The proposed facilities with low operation cost will be planned following a rigorous energy-saving design. It is thought that about 1 to 1.5 billion yen per year for operational expenses will be further needed for maintenance and subsequent upgradation. Although there are several ways of meeting the operational expenses after construction, the minimum cost should be continuously provided. Such resources will be ensured before starting construction of the proposed advanced light source. Since this plan basically supports science and technology in our country, such support is of strategic importance.

For the management system, various possibilities can be examined besides the public-use promoting method presently used. For example, the management can be entrusted to a technical research association composed of representatives from industrial, administrative and academic sectors. The investment responsibility, the results and intellectual property obtained are defined by legal contract. With respect to the governmental contribution, it is desirable that both Ministry of Education, Culture, Sports, Science and Technology and Ministry of Economy, Trade and Industry take part in the management to build a smart system for strongly supporting the cooperation between industrial side and the academic side, for example through the organizations such as NEDO (New Energy and Industrial Technology Development Organization) and JST (Japan Science and Technology Agency). Such involvement is based on the notion that the nation has properties and operational expenses, users take part in management and utilization, and the application of advanced synchrotron radiation facility to various industrial subjects result in solutions that will benefit the economy. This is one of the main targets of the present plan. Such arrangement is believed to be effective for promoting innovation in industries by making it possible to put forward new applications of advanced synchrotron radiation facility to various industrial subjects through good industry-university cooperation. This concept differs somewhat from the management system of PF and SPring-8, where the viewpoint of academic side is preferentially taken into account.

For this purpose, the supporting system should be designed for non-academic personnel, in order to facilitate the use of this cutting-edge tool called synchrotron radiation for various industrial applications. For example, the "synchrotron radiation user bank (tentative name)” can be organized with the help of professors and researchers of the seven National University Corporations, public research institutes and research centers located in the Tohoku district. The plan will catalyze cooperation between industry and academia. The joint use of the synchrotron radiation facility makes "close cooperation of basic science and industrial application" possible. It will also contribute to "the expansion and development of the synchrotron radiation community" nationwide. Professional persons also want to help and support non-specialists who wish to use synchrotron radiation for the first time in their own field. The plan will include a positive introduction as well as standardization of nano-applications of the proposed advanced light source to various subjects, starting from the time of construction.

In conclusion, it is very important to make the Tohoku advanced synchrotron radiation facility user-friendly and more accountable to the related community, by using management know-how available in the different synchrotron radiation facilities currently operated around the world.

5) Synergistic Effects on the Whole Society

One of the main aims of this plan is to strongly promote wide range of innovative ideas on the use of "high-intensity nano beam" or "short pulse duration" to industrial applications. This is realized with the help of professors and researchers of seven National University Corporations and public research organizations, located in the north eastern provinces of Japan. A new "Tohoku STIR base" (STIR: Science, Technology, Innovation and Reconstruction) will be established that will create a stream of good cooperation between industry, government and university.

As already mentioned, for keeping the leading position of our country in the world as a technology-intensive nation, it is indispensable from a nationwide perspective to fully consolidate the infrastructures for understanding and controlling materials behavior at the atomic level as a function of reaction time and then to continuously innovate and engineer valuable high-tech products and advanced materials. The advanced synchrotron radiation facility with high brilliance is well recognized as an excellent tool. Recently there has been a growing demand from many technological institutions to use the synchrotron radiation facilities. For this reason, the present plan can help and support such requirements in the whole country. This also efficiently contributes to the short-term plan for recovery from the Great East Japan Earthquake that took place on 11 March 2011.

The medium size (3-GeV) synchrotron radiation facility with high brilliance herein proposed certainly provides high productivity in the future, even if the international energy-resources situation changes, because the new facilities with low operation cost will be planned by adopting an integrated energy-saving design using regionally produced electricity from mega-solar photovoltaic generation system. The proposed plan is likely to become a model for STIR base organizations of the future.

The ripple effects of the plan are not limited to the Tohoku region. As already mentioned, public is aware that valuable high-tech products and many advanced materials are important for the survival of industries in our country, staying ahead of competition from other countries, such as South Korea, Taiwan and China. In recent years, one of the essential requirements to stay ahead is the ability to design and manufacture valuable high-tech products and advanced materials, leading the world by exact grasp and fine control based on knowledge about the behavior of substances at the atomic level. Thus, the joint use of the synchrotron radiation facility makes "close cooperation of basic science and industrial application" possible. In addition, such synergistic effects are not limited to substances/materials, but has the potential of producing new innovation in a wide range of fields, such as life science, biotechnology, and environmental science and engineering. In other words, the ring-type synchrotron radiation facility with high brilliance proposed here can provide many opportunities and meet many needs concurrently. "Diversity and simultaneity of utilization" will be the main characteristics, providing solutions to research and development, so that the ripple effects can engulf the entire society.

Finally, some thoughts on the construction-site are presented. Since the so-called nano applications developed by researchers in Japan is one of the main utilizations of advanced synchrotron radiation facility, the construction-site of Tohoku synchrotron radiation facility should certainly be suitable for such nano application development by providing very good vibration control. The Great East Japan Earthquake has revealed the strong solid rock regions as well as the weak ones. Using such information and considering the merits of proximate power supply and easy accessibility for traffic, a final decision on

the construction-site will be made. Combining with substantial transportation networks, such as the available Shinkansen and highways, distribution of manufacturing industry, and the issue of risk reduction, it can be concluded that the Tohoku region is certainly a proper area for the location of the new synchrotron radiation facility.

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