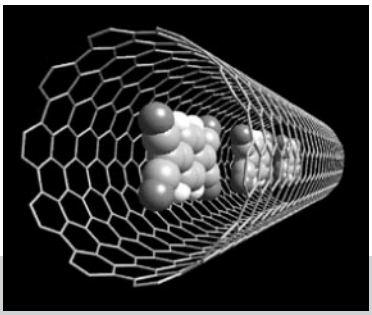
business or teaching and a leading authorities in their fields. All of their consultations are free of charge, and they will help with all aspects, up to and including the writing of the application.

Recently the needs of medium sized companies are also increasing, but it is difficult because of the scale of these companies for them to come and perform experiments themselves. In an attempt to resolve this problem, a system has been planned to help those with no experience with synchrotron radiation.

One such measure is the offering of analysis services. From last year, a mail in service was implemented, whereby a sample was sent in the mail for a structural analysis of a protein, which was completed at SPring-8. Planning is underway to make this service generally available.

**Possibilities for Industry/University Cooperation**

One of the issues being considered for the future is cooperation with small and medium sized high technology companies that need synchrotron radiation technology. SPring-8 serves as a point of contact for research organizations, including universities, and industry, both of which have an interest in research. The 'knowledge' existing in the research institutions, and the 'technology' held by companies, if it is combined in its use of the SPring-8 synchrotron radiation, may lead to solutions to problems that were previously inaccessible, and may lead to the creation of new industries. This kind of collaborative relationship is already underway, with successes such as in the analysis of rust mechanisms by a university professor working together with companies.



Discovery of organic molecules in carbon nanotubes

## SPring-8

**Developer:** Japanese Atomic Research Development Institute (Independent Administrative Agency), Institute of Physical and Chemical Research (Independent Administrative Agency)
**Address:** 1-1-1 Koichi, Sayo-gun, Sayo-cho, Hyogo-ken (Inside the Harima Science Garden City)
**URL:** http://www.spring8.or.jp/
**Electrical Energy:** 8 billion eV(8GeV)Accumulation Rings/Beamlines: 62 (48 in operation, 1 under construction)
Accumulation ring Circumference: 1,436m
Commenced Operation: October 1997
**Examples of Major Industrial Uses:** Development of Automatic Regeneration for Automobile Exhaust Gas Catalysts, Testing of Fiber Combinations for Studless Tires, Predicting life of Solders before Cracking from Fatigue, Structural Analysis of Hair Cuticles, etc.

# Arrival of the "New Light" XFEL

**RIKEN Harima Institute**
(Independent Administrative Agency)
**Tetsuya Ishikawa**
Head of the RIKEN SPring-8 Center
Project Leader of SPring-8 Joint-Project for XFEL
PhD Engineering

**What is the X-ray Free Electron Laser (XFEL)?**

Synchrotron radiation is a type of light that enables scientists to see materials in great detail. The light from a laser is characterized by its well-defined wavelength and phase. The XFEL is called "the dream light" because it derives from wavelengths in the X-ray region. Synchrotron radiation is emitted from an electron traveling near the speed of light when its path is bent by a magnetic field or undulator. An undulator is a device consisting of 2 rows (up and down) of magnetic poles with alternative N and S polarity. An electron moving between the rows will "zigzag" with a small periodicity and emit a bright light at a specific wavelength. The XFEL generated by the phase of synchrotron radiation is arranged by the magnetic fields of an undulator.

An XFEL has three main features. First, the light can be seen finely, as if observing an ant on earth from the moon-the resolution is 0.1nm or less. Next, it allows observation of fast moving phenomena, in the time light moves 0.01nm. Further, it has a brightness of more than 100 million times that of the SPring-8. Thus it is more detailed, faster, and brighter.

**Construction Underway for 2010 Start of Operations.**

In 2000, we first proposed building an XFEL. At the end of 2003, we completed development of the critical technologies for XFEL such as linear accelerators, short period undulators, and the electronic guns required to create high quality electron beams. In 2004, this device was recognized as a candidate for the Key Technology of National Importance, and a 1/32 sized prototype was completed in 2005. In June of last year, lasing was observed with the prototype. Construction of the XFEL is now underway, with a planned commencement of operations in 2010.

**Most Compact and Highest Quality in the World**

Currently three projects in the world, including Japan, are going forward with development of XFEL facilities. DESY (Deutsches Elektronen-Synchrotron), in the EU, plans to build a 3.3 kilometer long XFEL to be operational in 2013. And in the USA, SLAC (the Stanford Linear Accelerator Center) plans to use its 3 km linear accelerator (which has been used in high energy physics) for developing a Free Electron Lasers, and they are anticipating beginning operations in 2008 or 2009.

The main objective of our plan is to produce a light of the similar properties to that of the EU and USA, with a size of about 700m. Not only that, but we will also produce light with a short wavelength at the very low electron energy; 8GeV compared to more than 10GeV for their facilities. In other words, we are planning to build a facility with the same capabilities as that of the EU and USA, at about the same time and at a significantly lower cost.

**Pharmaceuticals, Environment, Energy, and the Future...**

The XFEL will be used for the analysis of membrane proteins, which facilitate communication between the interior and exterior of cells. The SPring-8 Synchrotron Radiation makes it possible to see the atomic arrangement, but since the light waves are incoherent, it is necessary to crystallize the protein . Some proteins can never be crystallized, but as much as 60% or more are believed not to be crystallizable using existing technology. However, the XFEL makes it possible to see a protein's structure even without crystallization. This can shorten the period required for analysis, greatly contributing to progress in the pharmaceutical industry by saving substantial time in the development of new drugs.

Also, SPring-8 research has demonstrated that some nano-structures are capable of holding materials of high density. In addition, XFEL is expected to allow the development of materials which can remove toxins from contaminated buildings and environmental pollutants, and increase the efficiency of fuel cells.

Overview of the accelerator storage area of the X-ray free electron laser

Further, some dreamlike innovations such as the creation of rare elements from other elements or enabling the removal of toxic materials from nuclear waste may become possible.

**Industrial Application still a Future Issue**

SPring-8 is not far away from the goal of the Synchrotron Radiation X-ray source. Although many applications for SPring-8 have been well established so that it can meet specific industrial needs, XFEL is still undergoing development and testing. The applications of XFEL are still premature for the industrial sectors to utilize them. However, once they are established by sophisticated researchers, the XFEL will find many applications for industries.

## XFEL Development Plan

**Developer:** RIKEN (Independent Administrative Agency)
**Address:**1-1-1 Koto, Sayo-gun, Sayo-cho, Hyogo-ken
(inside Harima Science Garden City)
**Length:** Approximately 700m
**Energy:** 8 billion eV (8GeV)
Oscillation Wavelength: 0.06nm
**Total Cost:** 37 billion yen
**Commence Operation:** 2010
**URL:** http://www.harima.riken.jp/xfel/