Why Do We Need Synchrotron Radiation Facilities?

Spring-8
SACLAC
We use light, when we observe something. Long distance stars are observed with telescopes, while the tiny objects with microscopes, both using visible light. The light for observing much smaller "nano-world" consists of X-rays. Since their discovery, we have searched for the more intense X-ray sources for 150 years. It turned out the synchrotron radiation from the electrons in accelerators became intense X-rays when the electron energy is high. This synchrotron radiation (SR) has been gradually utilized since 1960’s. While the nano-science and technology prosper in 1990’s, utilizing the information of nano-scale structure and function of a substance and controlling it, SR became an indispensable probe to the nano-world. SPring-8 had developed many new technologies which tow the SR science in the world. Synthesizing some of them has led to a completely new X-ray free-electron laser, SACLAL. Many SR facilities around the world are using the technology that SPring-8 has developed, SPring-8 and SACLAL, illuminating the nano world, are now beyond the mere light source for observation, but have given the "solution" which clarifies the cause of the novel functions which nano-world has created.

Synchrotron Facilities in the World

How become synchrotron facilities are

Synchrotron Facilities in Japan

Synchrotron radiation (SR) facilities generate intense X-rays resulting from high-energy electrons charging their orbit. The X-rays are utilized to observe the atomic/molecular world. Among the many SR facilities in Japan and around the world, SPring-8 and SACLAL provide the highest level of capabilities.
What are X-rays?

X-rays are a type of electromagnetic wave discovered by Dr. Wilhelm Conrad Rontgen. In 1895, Rontgen discovered a type of light able to penetrate materials. The X-rays were named after the X used in mathematics to denote an unknown variable. The first X-ray image was the hand of his wife. Now X-rays are widely used in hospitals.

How can X-rays portray small objects?

Because X-rays have a very short wavelength.

Although light with a longer wavelength cannot image small objects, light with a shorter wavelength can.

What can SPring-8 do?

SPring-8 can image small objects that have never been observed before by using very strong X-rays from a large accelerator.

How to generate strong X-rays?

Strong X-rays are generated by bending electron beams moving at nearly the speed of light. To create stronger X-rays, periodic arrays of magnets called undulators multiply bend electron beams.
Q5
What is the most important technology invented at SPring-8?

A5
Two inventions at SPring-8 are particularly noteworthy.

In-vacuum Undulator
Stronger X-rays are generated by arranging magnets close together.

Osaka MIRROR
A focusing mirror with extremely high precision achieves a high quality of focusing due to its small surface error of a nano-meter.

Q6
What kind of research conducted at SPring-8?

A6
SPring-8 has 57 beamlines serving numerous research fields, ranging from advanced science to everyday life.

Results of our research improve our daily life!
What is SACLA?

SACLA is an X-ray free electron laser facility that enables us to visualize ultrafast phenomena such as the motion of atoms and molecules during their chemical reaction.

SACLA is the offspring of Japanese technology born and nurtured at SPring-8.

How was SACLA built?

SACLA was built by leveraging the Japanese technology born and nurtured at SPring-8.

How is SACLA different from other XFEL facilities?

SACLA, at one-fifth the size of European and American facilities, can provide the comparable performance.

<table>
<thead>
<tr>
<th>Facility</th>
<th>Length (m)</th>
<th>Energy (GeV)</th>
<th>Beamtime (s)</th>
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<tbody>
<tr>
<td>European XFEL</td>
<td>3.4 km</td>
<td></td>
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<tr>
<td>LCLS</td>
<td>4 km</td>
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<tr>
<td>SACLA</td>
<td>700 m</td>
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</tbody>
</table>
**Q10**

**A10**

How do you make the X-ray laser at SACLA?

Electrons are accelerated with linearly aligned C-band accelerators and transported to the long in-vacuum undulator, in which the X-ray laser is generated.

![Diagram of the SACLA facility](image)

**Q11**

**A11**

How can SACLA improve our lives?

SACLA has revealed the mechanisms of photosynthesis in plants. This can potentially lead to artificial photosynthesis, which would help us generate environmentally friendly energy. SACLA has visualized living biological cells, which may contribute to advances in medical research.

![Diagram showing SACLA's impact on photosynthesis](image)

Photosynthesis is a familiar phenomenon, but its detailed mechanism has been unknown. SACLA has revealed a part of the mystery.