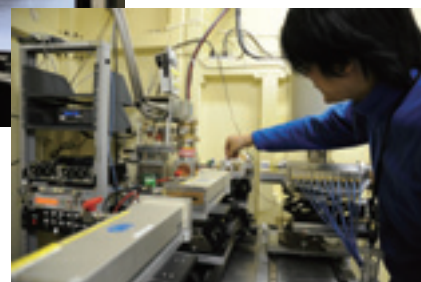
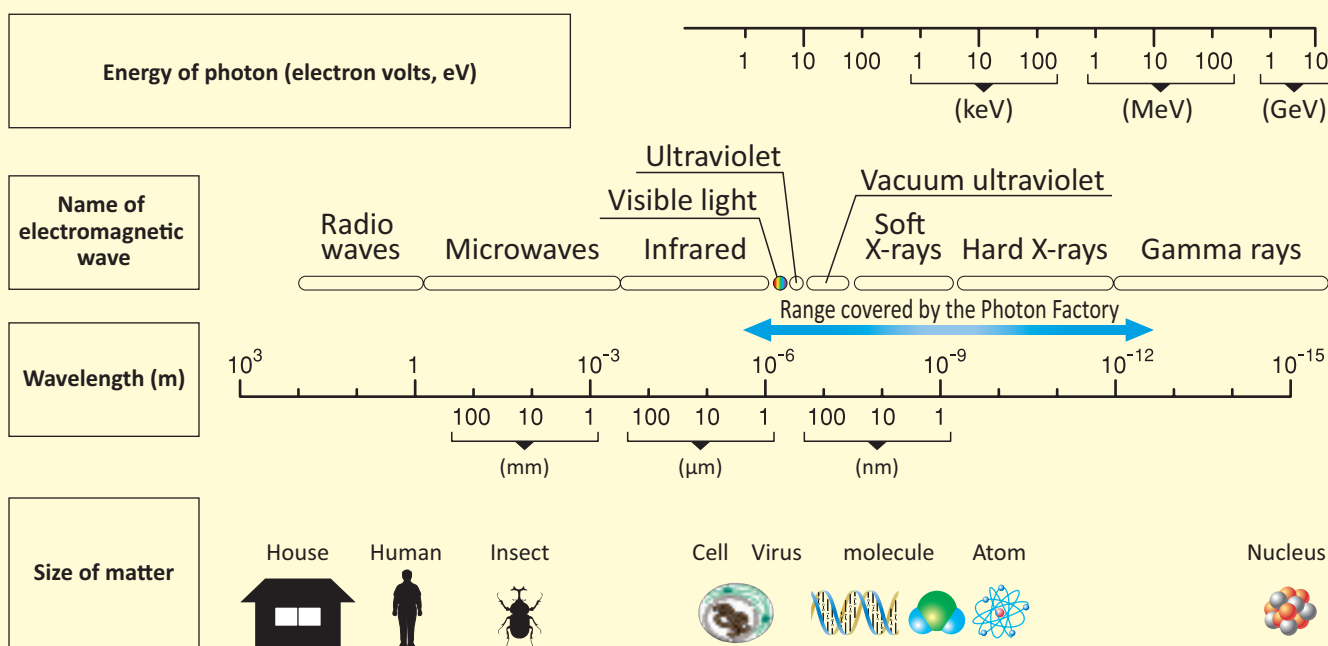


# Photon Factory, a light source for material and life sciences

The Photon Factory is an accelerator-based light source facility, as a part of the High Energy Accelerator Research Organization (KEK), Japan. The Photon Factory operates two storage rings, the 2.5-GeV PF ring and the 6.5-GeV PF Advanced Ring (PF-AR). The Photon Factory supplies brilliant X-rays and VUV light, which provide the means to understand the function of materials and life.



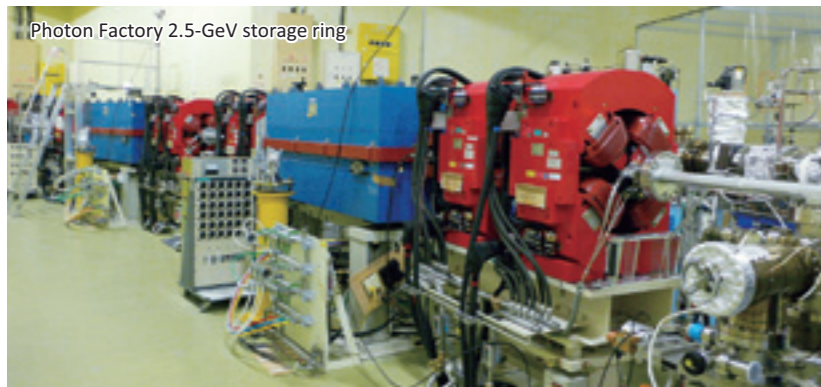
## Electromagnetic Spectrum



## What are the properties of light from the Photon Factory?

When charged particles move in a circular orbit at speeds close to the speed of light, photons are emitted in the forward direction. This radiation is called as synchrotron radiation (SR). The properties of the synchrotron radiation are;

- a continuous spectrum from ultraviolet to X-rays, allowing an energy-tunable light source
- highly collimated light
- highly polarized light
- pulsed light with the pulse widths about 100 picoseconds



Photon Factory 2.5-GeV storage ring

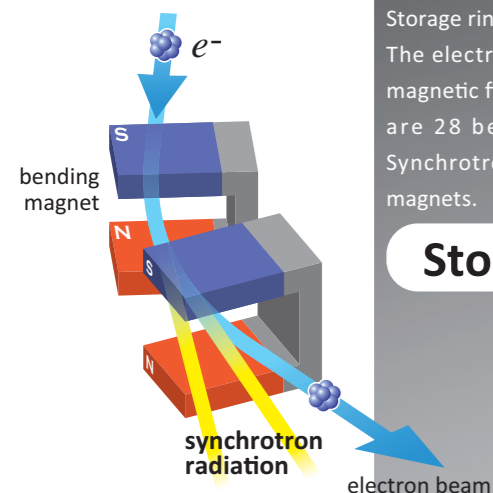
The experimental hall spread outward the storage ring is a venue for research of materials and life sciences.

## Experimental Hall



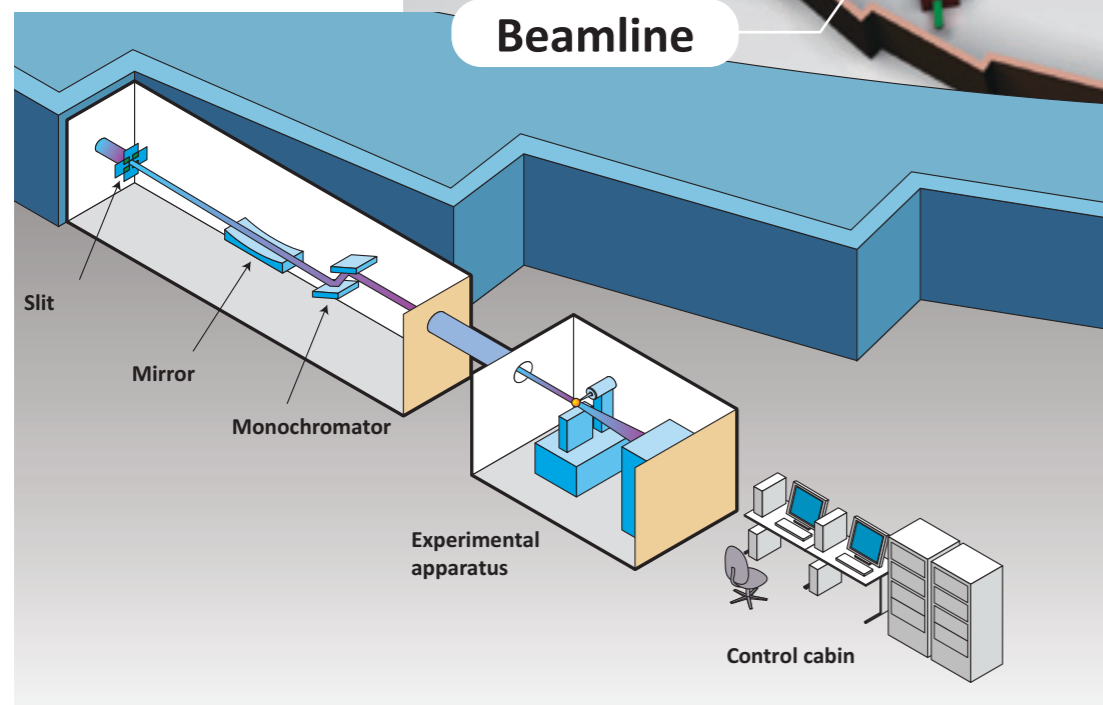
Storage ring is a light source accelerator of ring shape. The electron beam is bent into a circular path by a magnetic field produced by a bending magnet. There are 28 bending magnets in 2.5-GeV PF ring. Synchrotron radiation is emitted from all of these magnets.

## Storage Ring



Light produced by a storage ring is introduced to experimental apparatuses by "beamlines". There are many common components called "optics" in beamline for arranging the light, such as "slit" to cut it, "mirror" to focus it and "monochromator" to get only specific wavelength of it.

## Beamline



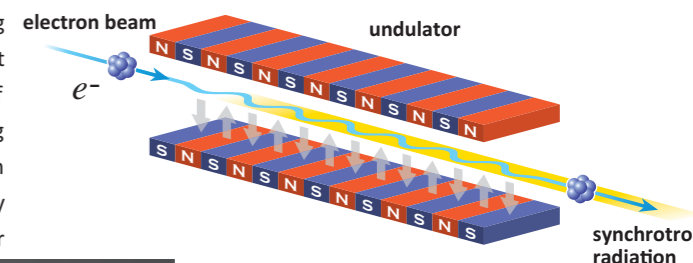
# Looking into the Photon Factory

Undulator is an equipment for increasing brightness of synchrotron radiation. It consists a succession of magnets of alternating polarity and is used as being inserted at the straight section between bending magnets. The light produced by each magnetic pair interferes each other

and gets incredible brightness. In-vacuum undulator developed at the Photon Factory enables us to get highly brilliant X-ray beam by strong magnetic field. Now this type of undulator has become a worldwide standard.

The Photon Factory had upgraded to increase the number of straight sections available for undulators in 2005 and new beamlines with brighter light have been constructed every year since then.

## Undulator



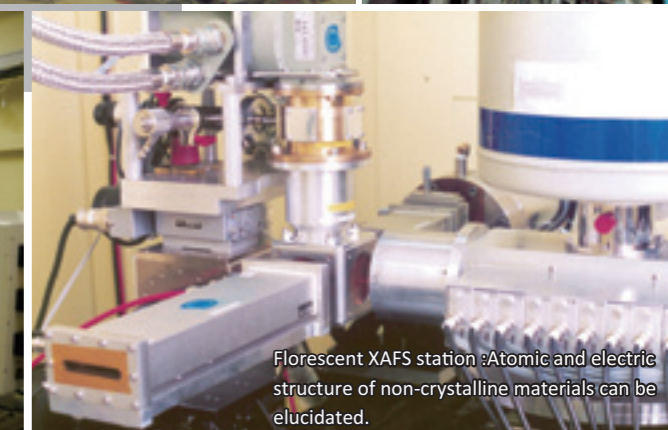
Alignment of an in-vacuum undulator

## Experimental stations

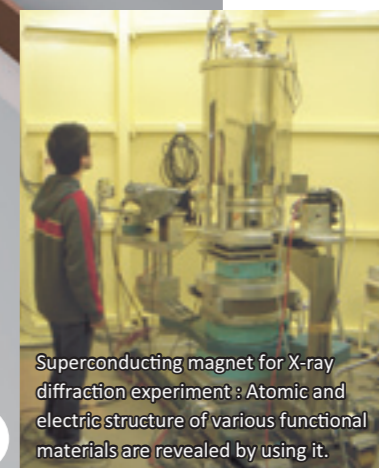
Materials interact with light by many ways. The light diffracted or transmitted, fluorescent X-rays or emitted electrons are detected by "detectors" to know how and what interaction takes place between photons and materials. There are various types of experimental apparatuses in the Photon Factory.



High-throughput protein crystallography station : It is constructed with many sophisticated techniques such as X-ray detector with large-area and high-resolution, highly-precise rotation axis and robotics.



Florescent XAFS station :Atomic and electric structure of non-crystalline materials can be elucidated.



Superconducting magnet for X-ray diffraction experiment : Atomic and electric structure of various functional materials are revealed by using it.



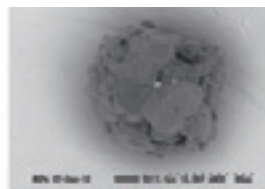
Angle-resolved photoelectron spectrometer with large hemispherical electron analyzer.

# Research Highlights

The Photon Factory supplies highly-brilliant X-rays and VUV light, which provide the means to understand the basic structure and function of materials including condensed matter, biological systems, environmental and chemical materials and many others.

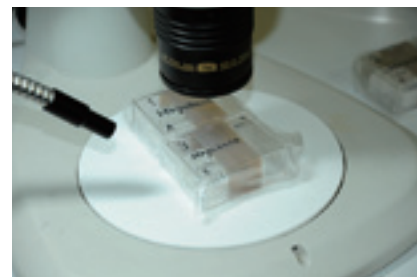
## Analysis of asteroid Itokawa particles brought by Hayabusa

The early history of the small asteroid “Itokawa” has tiny granular samples brought back to the Earth by Itokawa is similar in mineral composition to chondrite primitive material in the solar system.

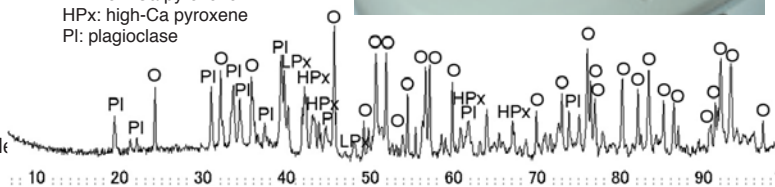


**Itokawa RA-QD02-0013**

O: olivine  
LPx: low-Ca pyroxene  
HPx: high-Ca pyroxene  
Pl: plagioclase

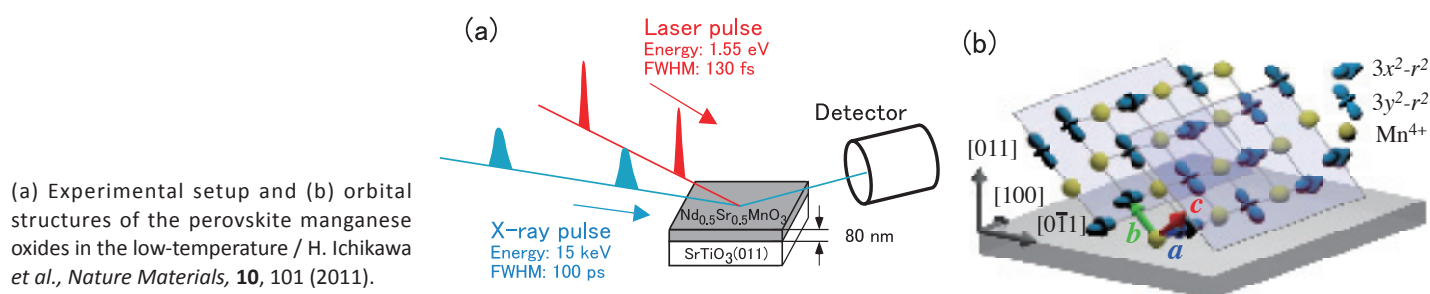


Microscopic view (upper left) and X-ray diffraction pattern (lower) of dust particle from asteroid Itokawa / T. Nakamura *et al.*, *Science*, **333**, 1113 (2011).



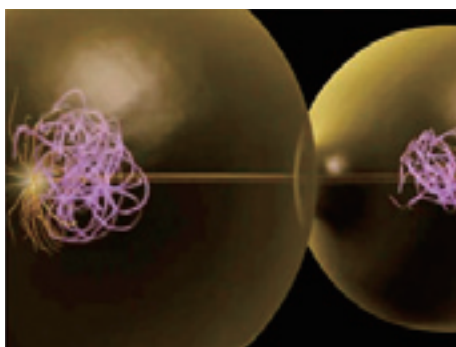
## Hidden state revealed by time-resolved X-ray diffraction

Perovskite manganese oxides show thermally induced structural phase transitions coupled with an insulator-to-metal transition. Picosecond time-resolved X-ray diffraction technique revealed that a charge and orbitally ordered “hidden state” which cannot be reached under thermal equilibrium conditions.

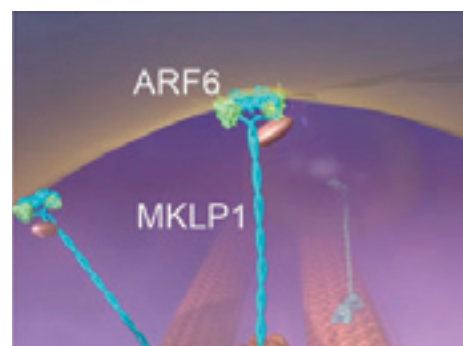


## Structural basis of a protein complex responsible for cytokinesis

Cytokinesis is the final stage of cell division, during which cells exhibit drastic morphological changes. Structure of Arf6-MKLP1 complex was determined and revealed that the complex plays a crucial role in cytokinesis by connecting the microtubule bundle and membrane at the cleavage plane.



Cytokinesis and Arf6-MKLP1 complex connecting the microtubule bundle and membrane at the cleavage site / H. Makyio *et al.*, *EMBO J.*, **31**, 2590 (2012).



## Users

KEK, one of the Inter-University Research Institute Corporation, provides large-scale experimental facilities such as the Photon Factory, to researchers in Japan and abroad to encourage effective and advanced research. The Photon Factory accepts around 3,500 users per year who work in a wide variety of fields.

## Education

The Photon Factory carries out graduate education in the School of High Energy Accelerator Science of the Graduate University for Advanced Studies (Sokendai). The Photon Factory also accepts graduate students from universities all over the Japan and the world to train them for the next generation.



## International collaboration

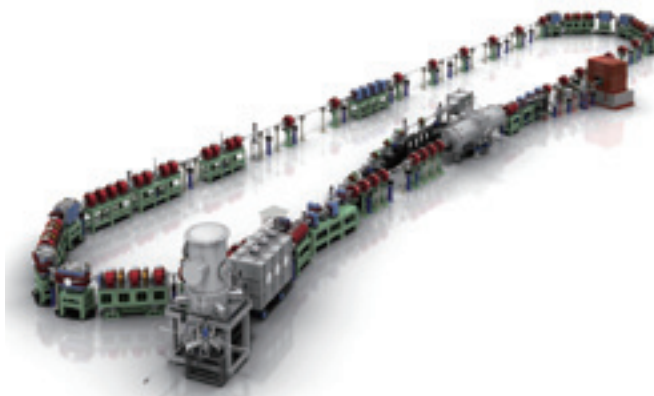
The Photon Factory has been working on international research collaboration, especially in the Asia-Oceania region. The Australian Beamline at the Photon Factory was operated from 1992 to 2013. It contributed to cutting-edge research conducted by Australian researchers and to the establishment of the Australian Synchrotron. The Indian Beamline was built in 2009, which allows fundamental research by Indian researchers. We have been contributing to the construction of the SESAME accelerator in the Middle East.



# ERL (Energy Recovery Linac) for the next generation light source

The Energy Recovery Linac (ERL), a linac-based light source in future, can produce extremely low emittance beams and very-short X-ray pulses. The ERL will enable scientists to conduct nondestructive measurements on rapidly evolving dynamical materials with nanometer spatial resolution. This would benefit

research in materials, life, chemical, and environmental sciences. The compact ERL (cERL) has been constructed for the development of the accelerator components of ERL. The beam commissioning of cERL has started in 2013.



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Photon Factory



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