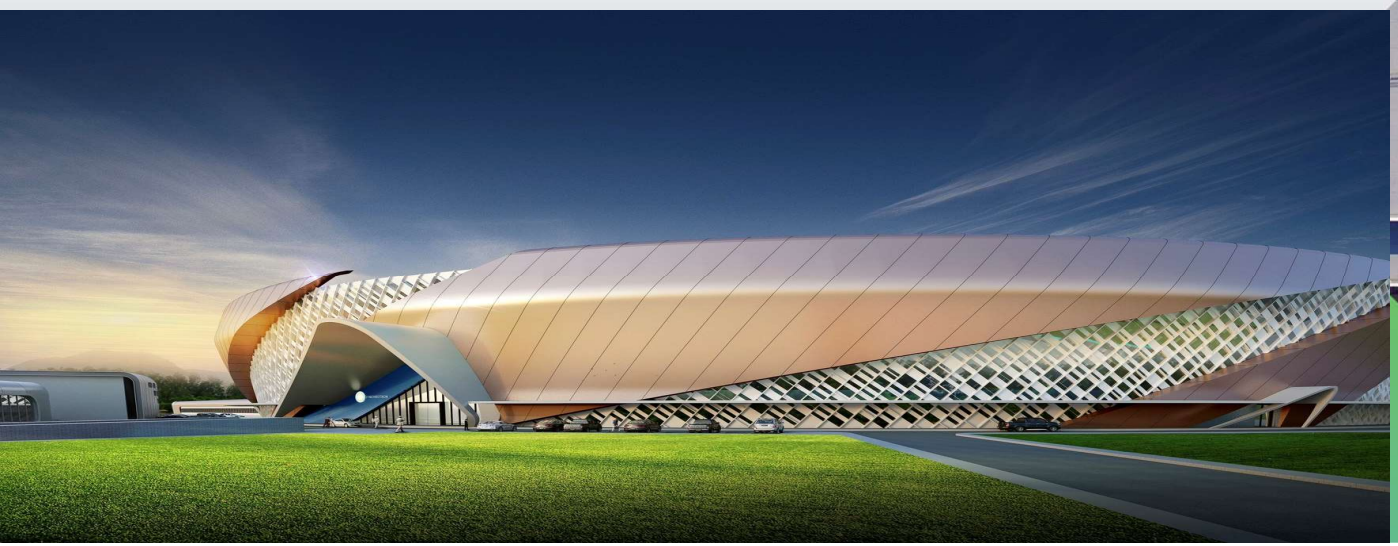
Synchrotron Facilities

Applications in Medical, Pharmaceutical and Public Health Research

Supagorn Rugmai

Synchrotron Light Research Institute (Public Organization)



The Synchrotron Light Research Institute (Public Organization)

- Public Organization: A (non-profit) national facilities
- Autonomous government institution with Executive Board as a policy maker
- Under supervision of Ministry of Higher Education, Science, Research and Innovation (MHESI)
- 212 staff (60 Researchers, 80 Engineers & Technicians)
- Operating 1.2 GeV Siam Photon Laboratory + Facilities
- Developing synchrotron-related technologies
- 3.0 GeV SPS-II design and construction

Synchrotron facilities around the world

SPRING 8-II, Japan (1996)
8 GeV

SLS, Switzerland (2001)
2.4 GeV

SSRF, China (2009)
3.5 GeV

NSLS II, USA (2014)
3 GeV

MAX-IV, Sweden (2016) 3 GeV

APS, USA (1995)
7 GeV

Australian Synchrotron (2007)
3 GeV

ALBA, Spain (2010)
3 GeV

TPS, Taiwan (2014)
3 GeV

SLIT-J, Japan (2023) 3 GeV

SPS, Thailand (2001)
1.2 GeV

ESRF, France (1994)
6 GeV

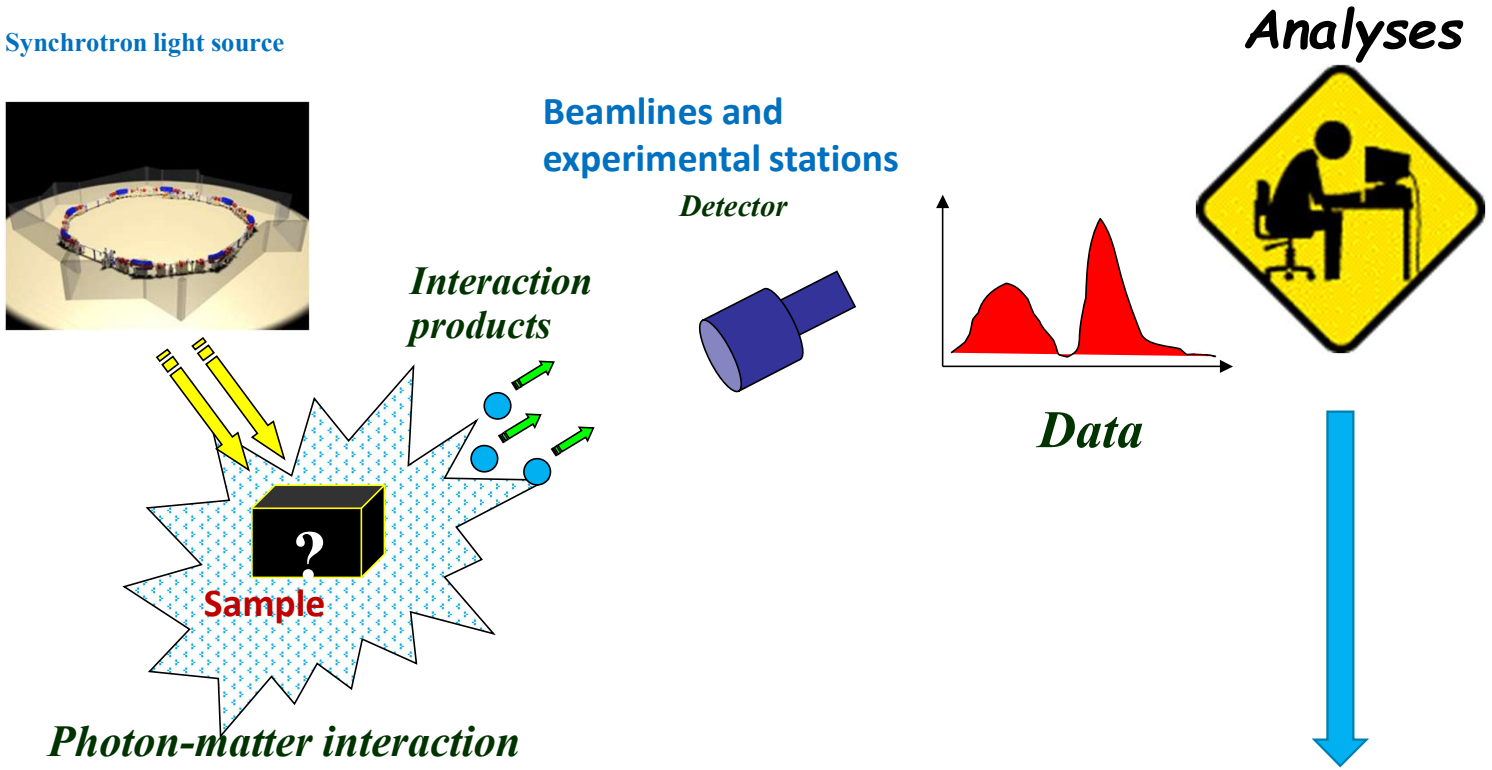
Elettra, Italy (2009)
2 GeV

PLS II, South Korea (2011)
3 GeV

Sirius, Brazil (2020)
3 GeV

SPS II, Thailand (2029)
3 GeV

User facility: Servicing synchrotron light and measurement systems



- User
- SLRI-User collaboration

Provided by SLRI

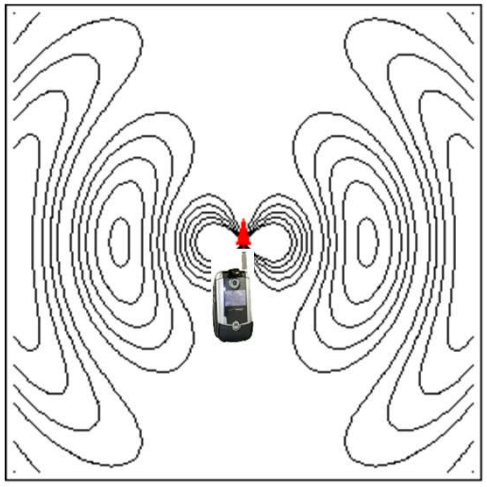
Provided by SLRI, Institutes, Companies or Consortium

Synchrotron light from relativistic electrons bent in magnetic field

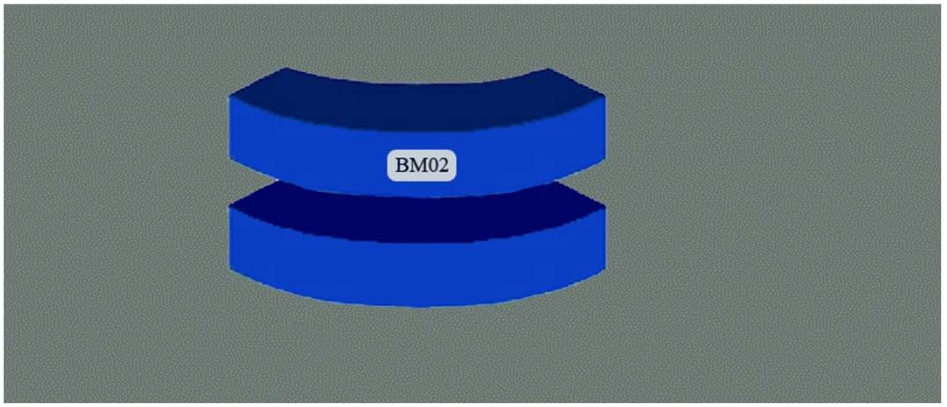
$$\nabla \cdot \vec{E} = 4\pi\rho$$
$$\nabla \cdot \vec{B} = 0$$
$$\nabla \times \vec{E} = -\frac{1}{c}\frac{\partial \vec{B}}{\partial t}$$
$$\nabla \times \vec{B} = 4\pi\,\rho\vec{\beta} + \frac{1}{c}\frac{\partial \vec{E}}{\partial t}$$

ประจุที่เคลื่อนที่ด้วยความเร่ง ปล่อยแสง

อิเล็คตรอนในเสาอากาศ
ปล่อยคลื่นวิทยุ



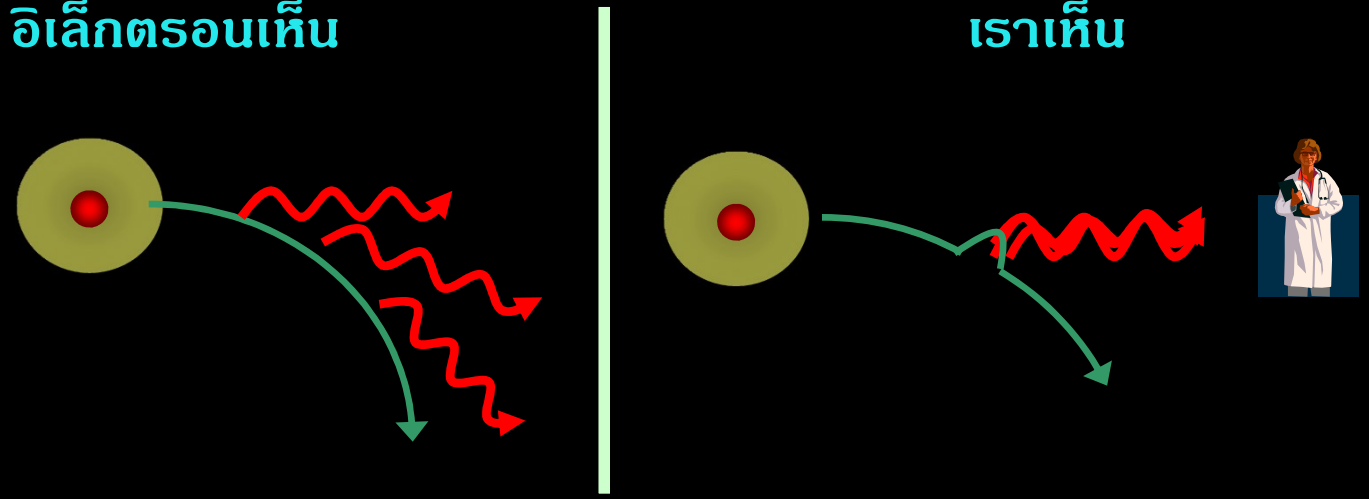
แสงซินโครตรอน ผลิตจากอิเล็กตรอน ที่เลี้ยวโค้งด้วยความเร็วแสง



Synchrotron light from relativistic electrons bent in magnetic field

แสงความเข้มสูง จากอิเล็กตรอนที่เลี้ยวโค้งด้วยความเร็วสูง

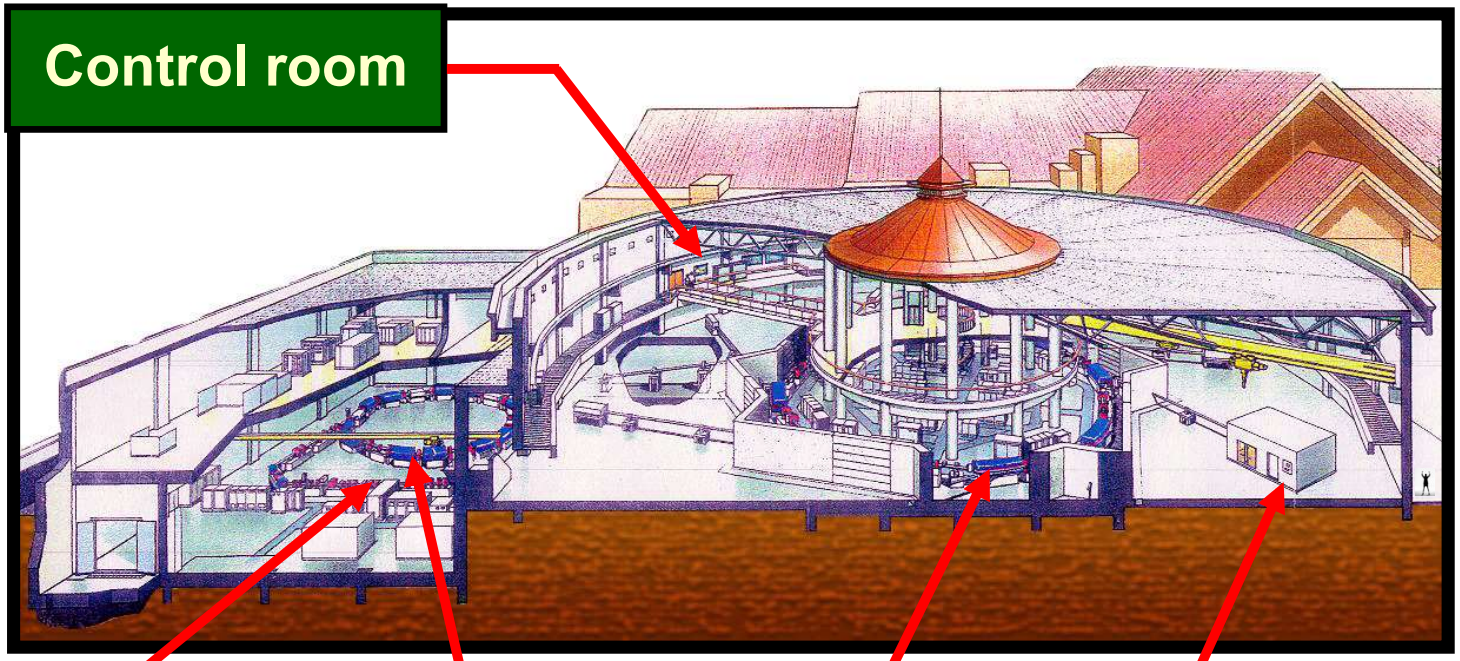
ผลของทฤษฎีสัมพัทธภาพ : เวลาของอิเล็กตรอน ยาวกว่าเวลาของเรา



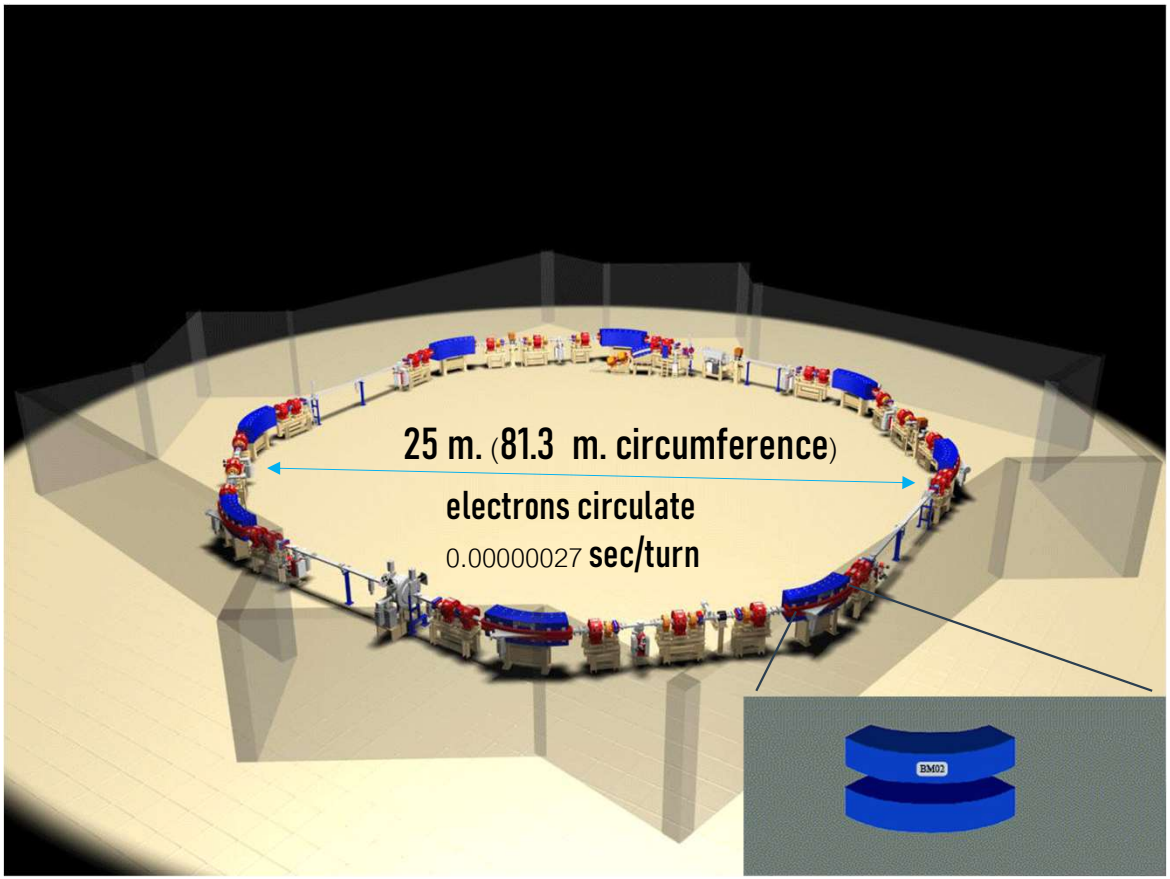
ที่โคราช เวลาของอิเล็กตรอนช้ากว่าเวลาของเรา 11 ล้านเท่า

The Siam Photon Source

The Siam Photon Laboratory



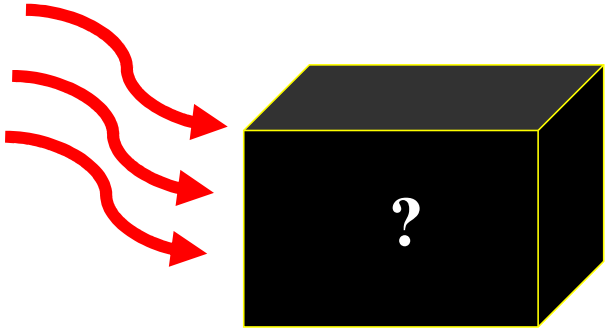
Electron storage ring



THAI SYNCHROTRON NATIONAL LAB

The Siam Photon Laboratory

The Siam Photon Laboratory



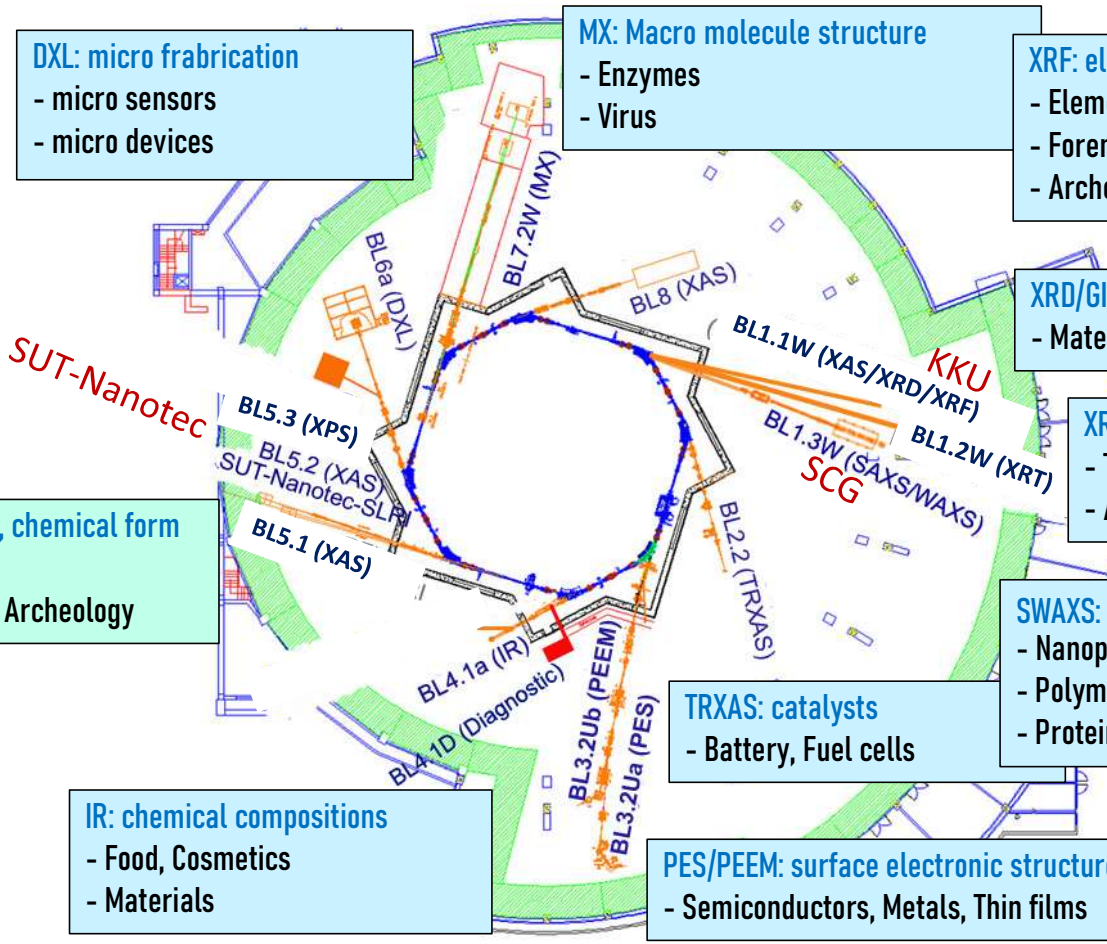
Photon energy used is related to binding energy of the structures

Chemical bonds → **Infrared (FTIR)**

Surface electrons (semi-conductor, metal) → **Ultra Violet (PES)**

Atoms and molecules → **X-rays (XRD, SAXS, XTM, XPS, XAS, …)**

The Siam Photon Laboratory



DXL: micro frabrication
- micro sensors
- micro devices

MX: Macro molecule structure
- Enzymes
- Virus

XRF: elemental analyses
- Elemental composition
- Forensic science
- Archeology

XRD/GIXRD: Crystal structures,
- Materials, Thin films

XRT: 3D x-ray imaging
- Tissues, Bones, Fibers
- Archeology, Medicine

XAS: atomic arrangement, chemical form
- Atomic structures
- Environment, Materials, Archeology

SWAXS: nano structures
- Nanoparticles, micelles
- Polymers, Bio materials
- Protein, Starch

TRXAS: catalysts
- Battery, Fuel cells

IR: chemical compositions
- Food, Cosmetics
- Materials

PES/PEEM: surface electronic structures, microspectroscopy
- Semiconductors, Metals, Thin films

Synchrotron-related technology development

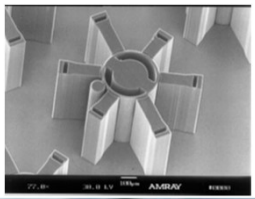
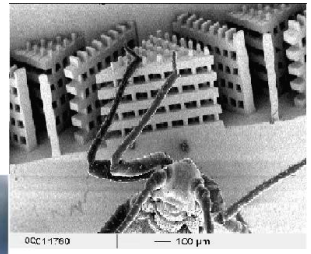
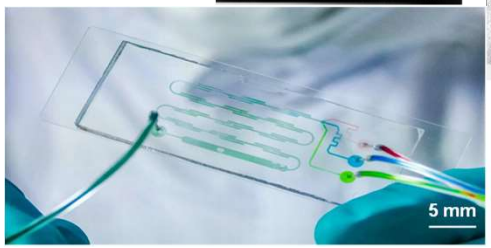
Development of accelerator and synchrotron-related technologies

- Vacuum system
- UHV welding, brazing
- Component fabrication
- Control system
- …




Deep X-ray Lithography and microelectronic systems

- Micro sensors
- Microfluidics
- …

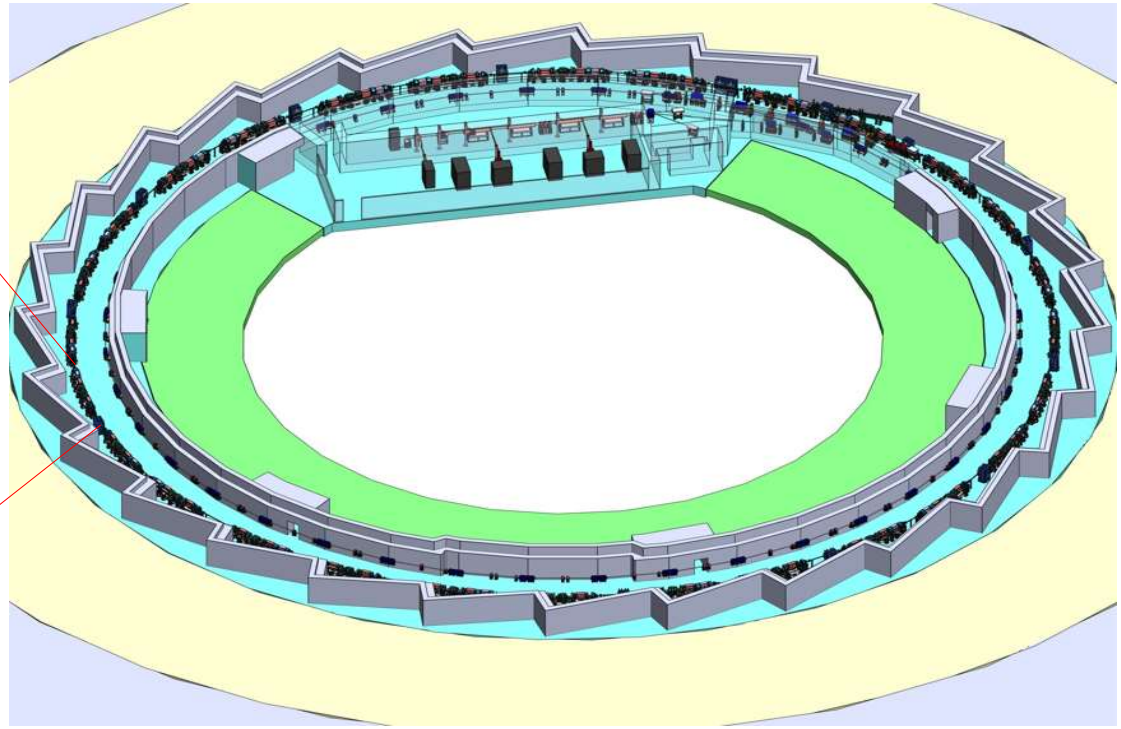
The future: The Siam Photon Source II

- Located in the Eastern Economic Corridor area in Rayong

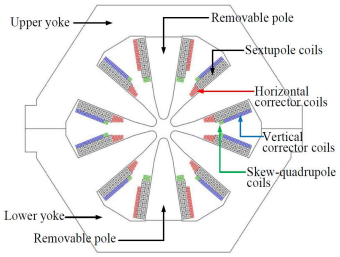
3 GeV 4th generation synchrotron light source

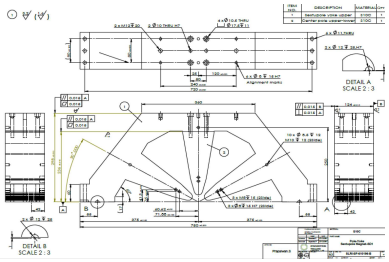
THAI SYNCHROTRON NATIONAL LAB

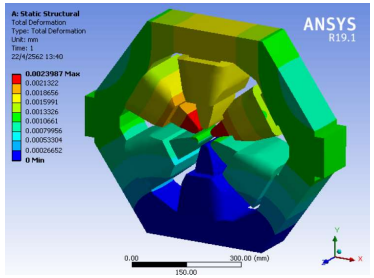
320 meter circumference 3 GeV storage ring

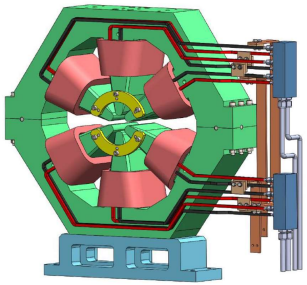


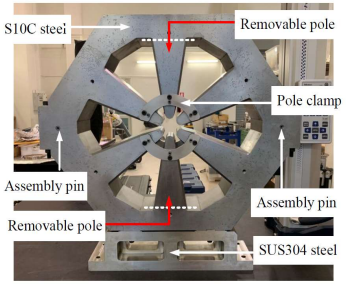
50% of components are fabricated in Thailand



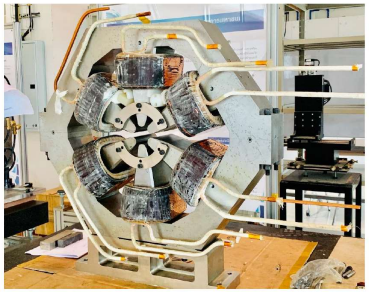








Machining tolerance < ±10 μm

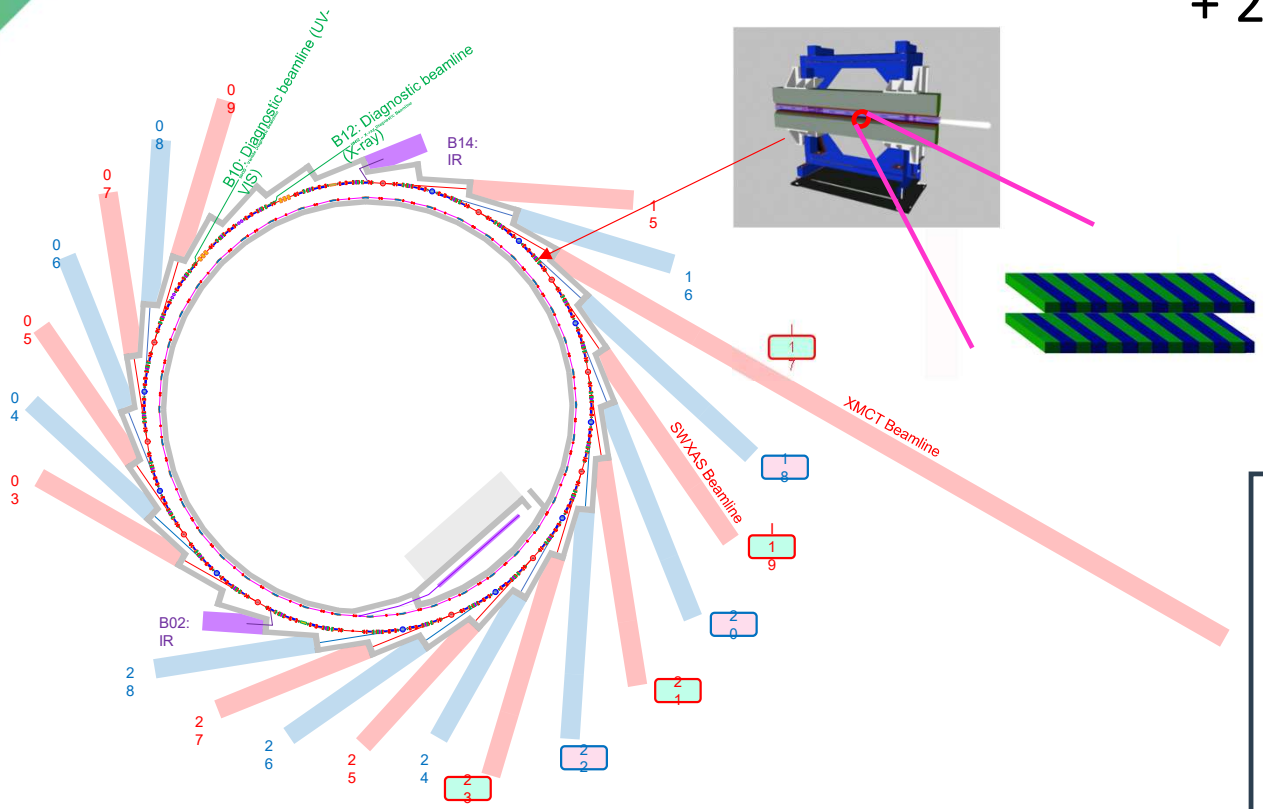


Magnetic field quality $\left(\frac{\Delta B}{B}\right) < 1\times10^{-3}$

Sextupole magnet with skew quad & STH & STV

Prototype development of Storage Ring Magnets

Beamlines



Can accommodate 22 insertion device beamlines + 2 IR beamlines

- ASEAN beamlines (tentative)
  - Singapore
  - Indonesia
- Companies
- Universities
- Research consortium

7 first phase public beamlines

1. High Resolution Soft X-ray Spectroscopy (HRSXS)
2. Tender X-ray Absorption Spectroscopy (TXAS)
3. Hard X-ray Absorption Spectroscopy (HXAS)
4. Small and Wide Angle X-ray Scattering (SWAXS)
5. High Resolution X-ray Diffraction (HRXRD) and Macromolecular X-ray Crystallography (MX)
6. X-ray Micro Computed Tomography (XMCT)
7. FTIR Spectro-imaging (IR)

4th generation 3 GeV synchrotron

ADVANTAGE

- > 10,000 times higher intensity
- Micro-Nano beam
- High energy x-rays
- Variable polarization

CAPABILITY

- Small samples (e.g. micro crystal)
- Very dilute sample
- ppb level detection
- High spatial resolution
- Sub-micron fabrication
- Sub-micron resolution imaging and tomography
- High density + large samples for imaging
- Probing fast reactions
- Dichroism studies

Medical, pharmaceutical and public health research with synchrotron

- X-ray Imaging and Tomography
  - High resolution 3D images (tissue, bone, brain, fiber)
- X-ray Scattering
  - Semi-ordered structural probe (collagens, micelles, drug delivery)
  - Solution scattering (shapes of macromolecules, cell organelle)
- X-ray Diffraction
  - Crystalline structures (minerals, bone, tooth)
  - Macromolecular Crystallography (enzymes, virus)
- X-ray Fluorescence
  - Trace element analyses (minerals, contamination, environment)
- X-ray Absorption Spectroscopy
  - Chemical speciation of elements (minerals, contamination, environment)
- FTIR micro-spectroscopy
  - Chemical composition (skin, cells)
- Deep X-ray Lithography
  - Micro devices
  - Microfluidic

Thank you