Present status of Energy Recovery Linac (ERL) project

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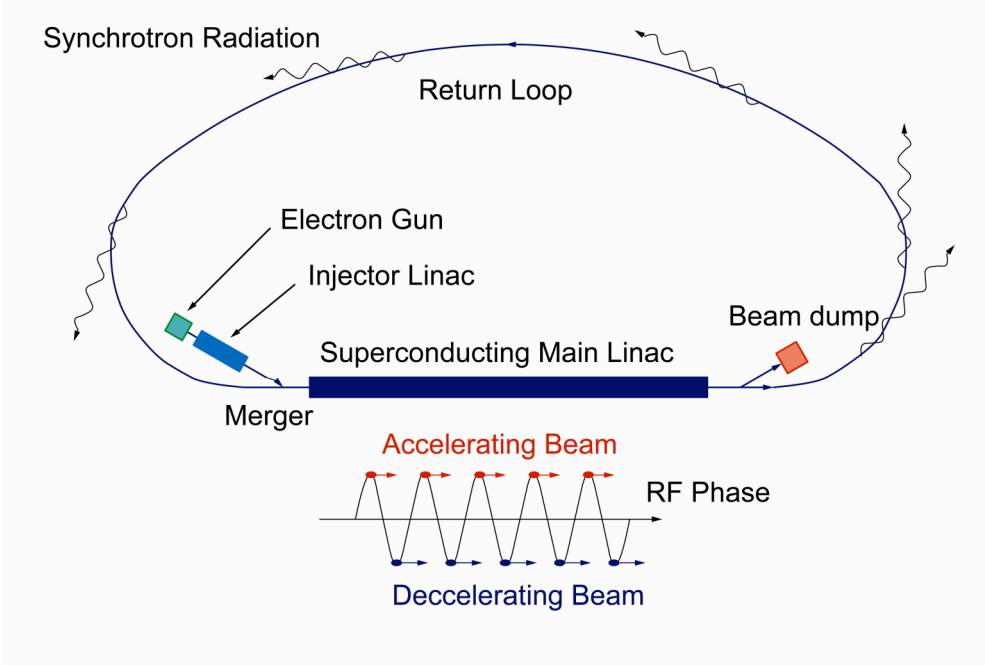
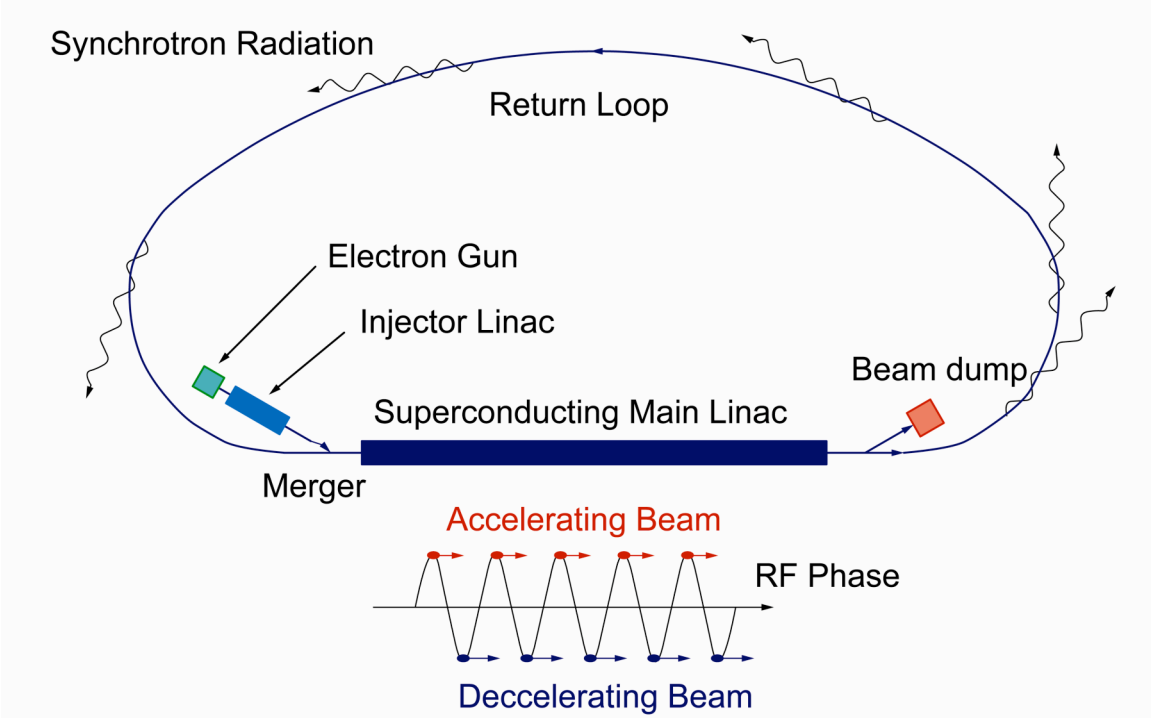


Plan for Future Light Source

Scientific requirement

Continuation (precise analysis)	**Jump** (cutting-edge science)
1) nano-structure beam size : mm → nm 2) electronic states ΔE : 1meV → 0.1meV	3) non-crystalline materials coherency 4) non-equilibrium states sub-pico second pulse
High brilliant light source	**Coherence and short pulse**

Energy Recovery Linac(ERL) is the most promising for future light source



◎ *Linac based light source:* **2~3 orders of magnitude!**

1) Emittance : 10pmrad (3rd generation source : ~10nmrad)

2) Short pulse : 0.1~1 pico-second (3rd generation source : ~0.1nano-second)

◎ *A large numbers of ID-beamlines*

Why 5GeV ERL for Future Light Source?

- **Performances**

  The brilliance and pulse width are 2 orders of magnitude brighter and shorter than those of 3rd generation synchrotron radiation facilities.

  (Option): XFEL-O: K.-J. Kim, Y. Shvyd'ko, S. Reiche, PRL. **100**, 244802 (2008).

- **Scientific Cases**

  Coherency

  Atomic and nanoscale imaging (Cells and Viruses, Nano-materials etc.)

  Femto-second science

  Real-time reaction which requires high repetition rate.

  (Chemical reaction, Photo-inused phase transition etc.)

  Nano beam

  Condensed matter physics under extreme conditions.

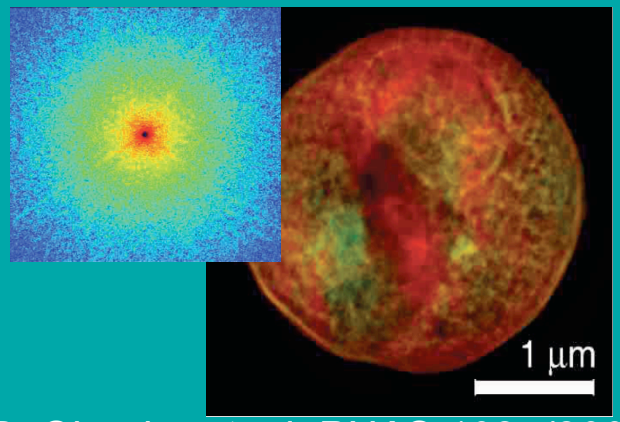
- A challenging machine
- A great potential of KEK to develop the ERL accelerator

  (superconducting technology, nano-beam technology)

Grand challenges for basic sciences

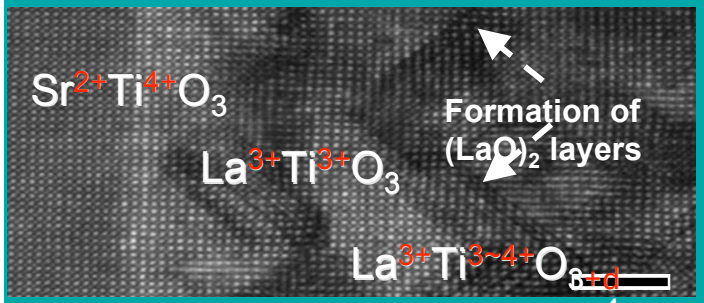
~ Non-crystalline materials and nano-science ~

Function in a cell



D. Shapiro et. al. PNAS,102, (2005)

Nano-materials at interface

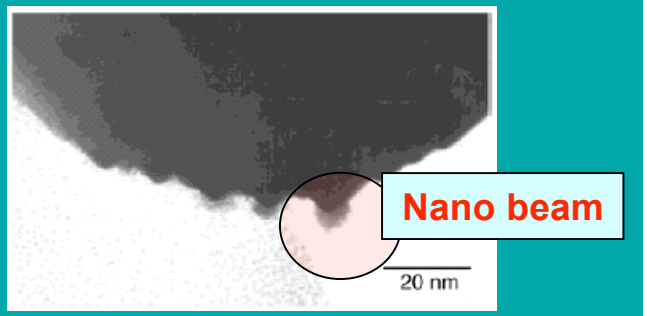


A. Ohtomo *et al.*
Appl. Phys. Lett. **80**, 3922 (2002)

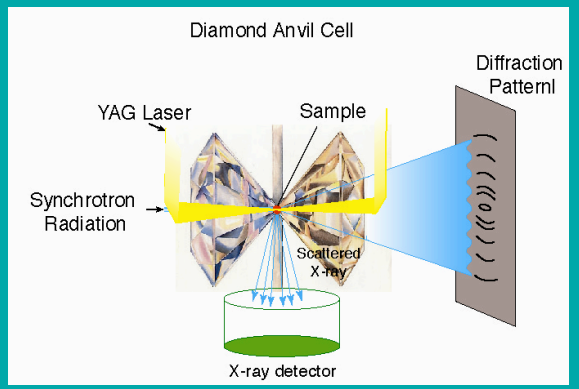
biology and chemistry

materials, energy and environment

Catalysis chemistry



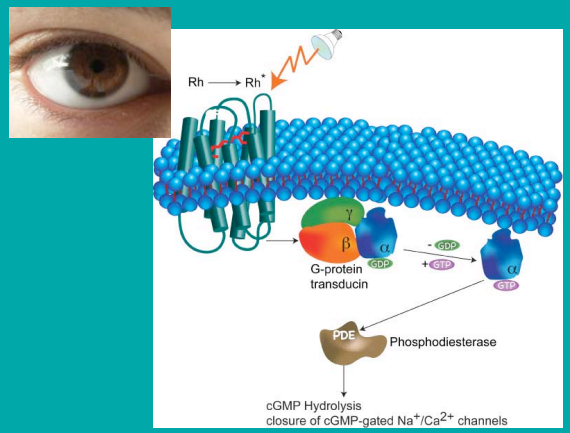
Extreme condition



Grand challenges for basic sciences

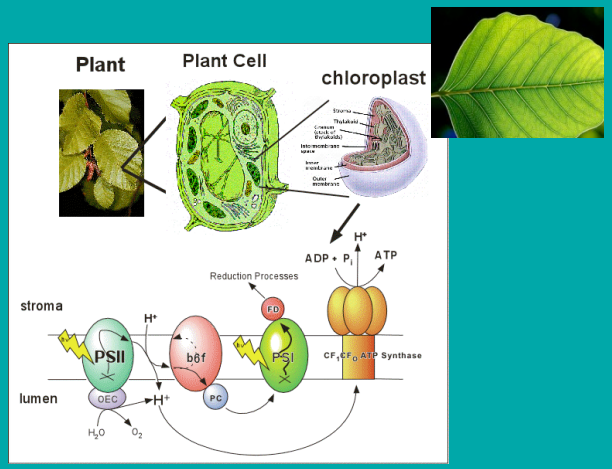
~ Non-equilibrium states generated by photons ~

visual sensing

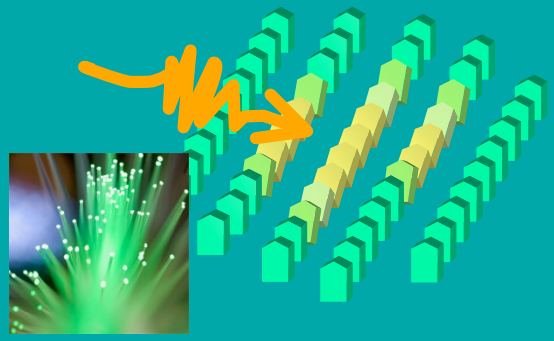


biology
and
chemistry

photosynthesis

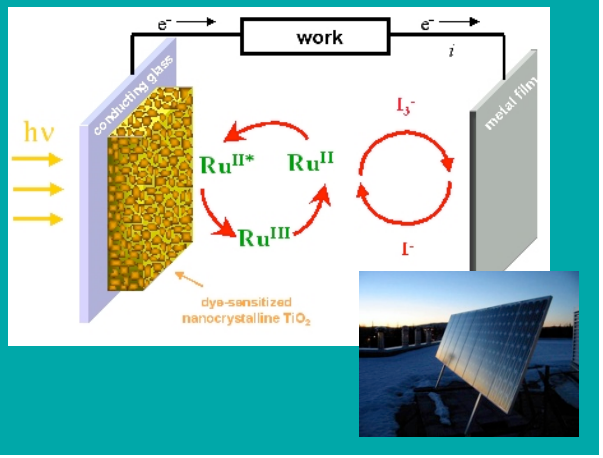


ultrafast photo-switching

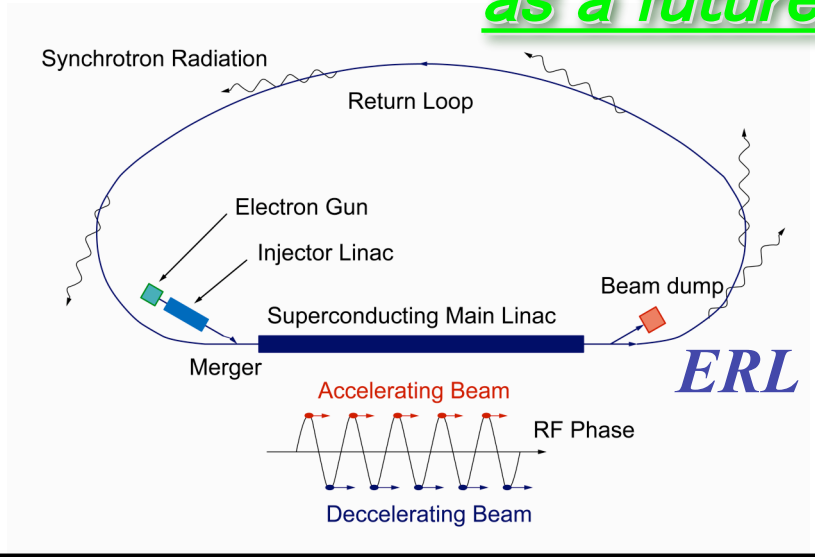


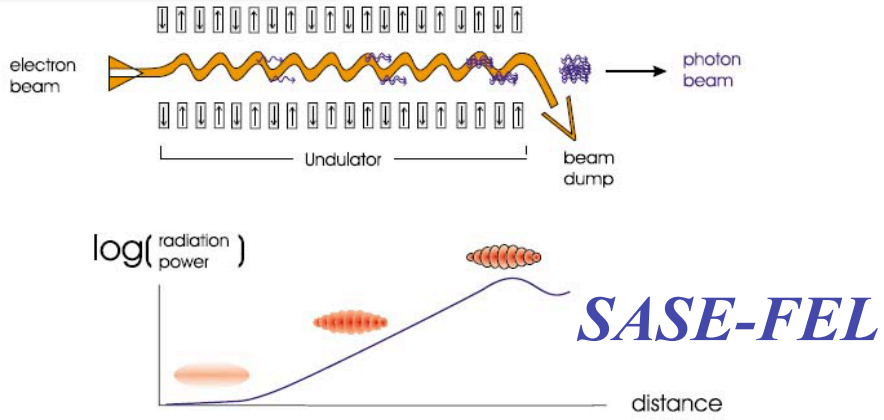
materials,
energy
and
environment

solar cell



Comparison between ERL and SASE-FEL as a future light source

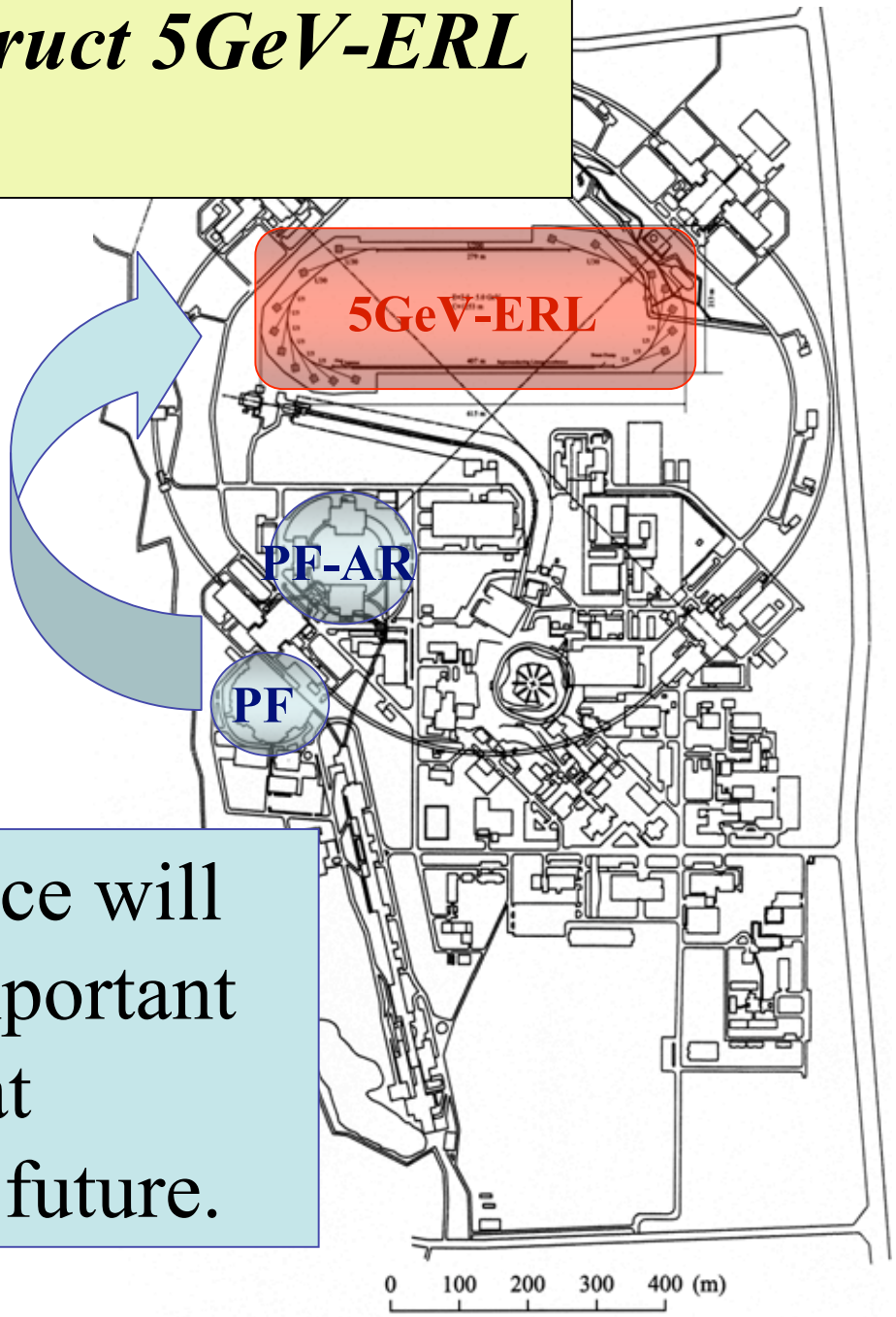




	average brilliance	peak brilliance	repetition rate (Hz)	coherent fraction	bunch width(ps)	# of BLs	Remark
ERL	~10^{23}	~10^{26}	1.3G	~20%	0.1~1	~30	Non-perturbed measurement
SASEFEL	~$10^{22\sim23}$	~10^{33}	100~1K	100%	0.1	~1	One-shot measurement
XFEL-O (Option)	~10^{27}	~10^{33}	~1M	100%	1	few	Single mode FEL

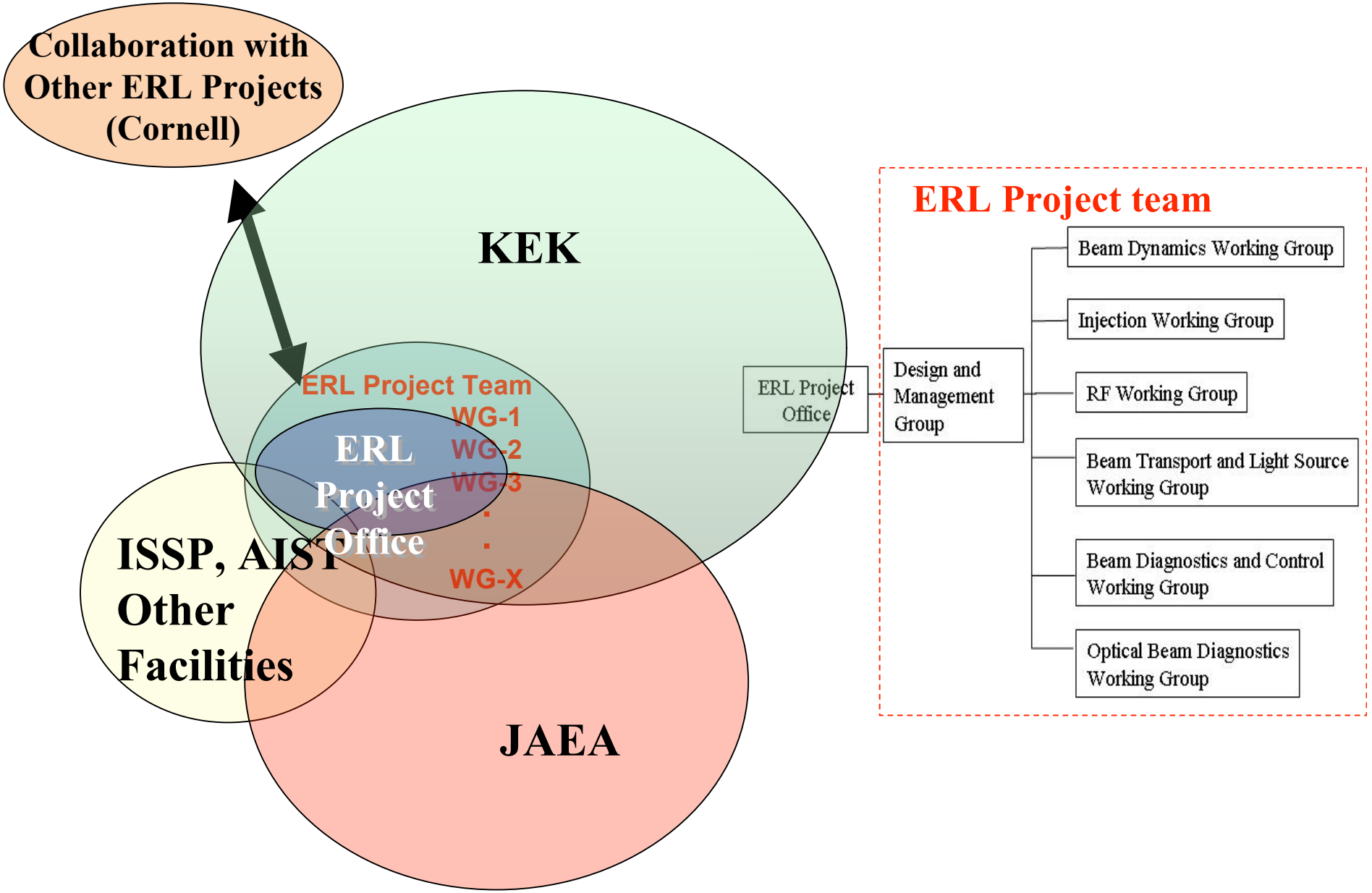
(brilliance : photons/mm^2/mrad^2/0.1%/s @ 10 keV)

Is it possible to construct 5GeV-ERL in Tsukuba campus?

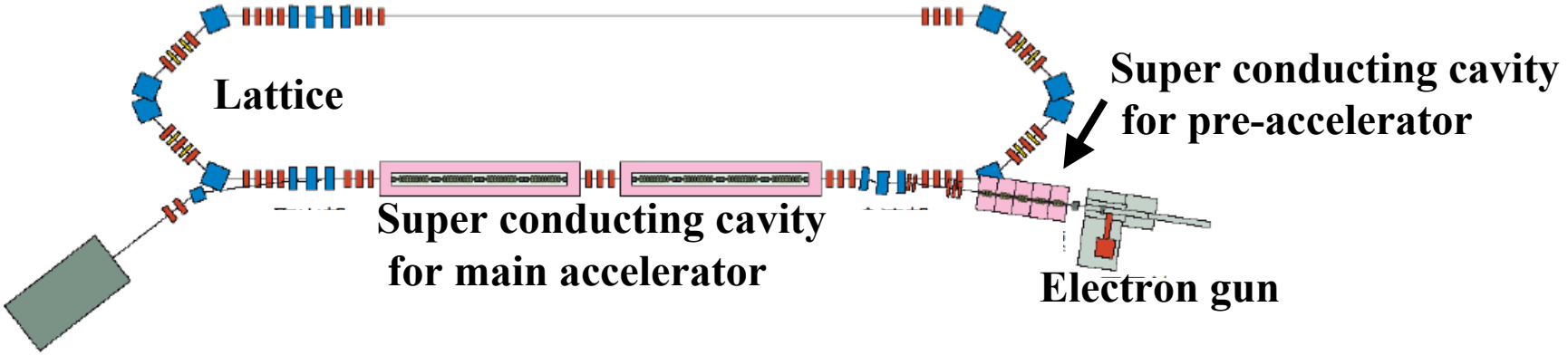


5GeV-ERL light source will be one of the most important accelerator facilities at Tsukuba campus in a future.

Structure of the ERL Project Office



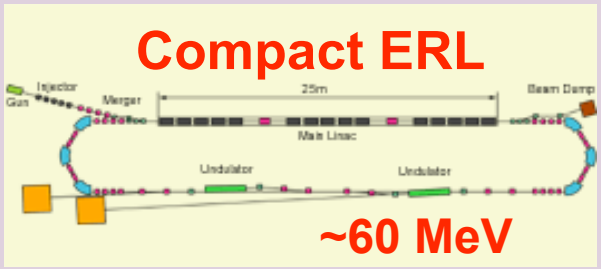
Development of the accelerator components



- **Super conduction cavity for main accelerator (KEK, ISSP, JAEA)**
  (37MV/m`Single cell model ⇒ 9 cell model ⇒ Cryo-module will be designed from the next fiscal year)
- **Electron gun (JAEA, Hiroshima Univ., KEK, and Nagoya Univ.)** (construction of electron gun of 250 kV and we start the designing of the electron gun of 500kV)
- **Development of the laser system for electron gun (AIST, ISSP, KEK)**
  (Yb fiber laser of ~100MHz oscillator ⇒ 1.3GHz oscillator)
- **Development for the super conducting cavity of pre-accelerator (KEK)**
  (Test cavities have been completed.)
- **Start the development of high power RF source**
  (300 kW Klystron will be ready until the next summer)
- **Designing of the cryogenic systems (KEK)**
- **Designing of the lattice (KEK, ISSP, UV-SOR, JAEA)**
- **CDR of Compact ERL has been published at March 2008**

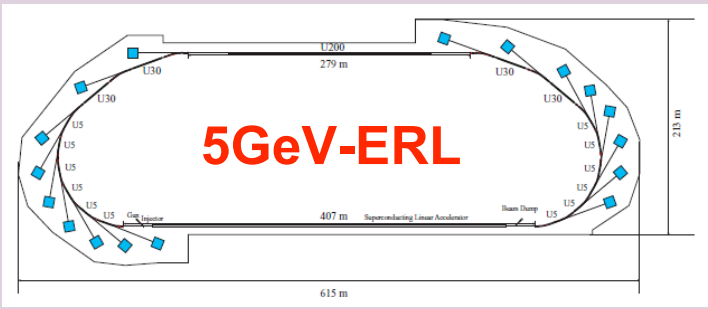
Evolution of ERL

Development of key components



~2013

Future light source



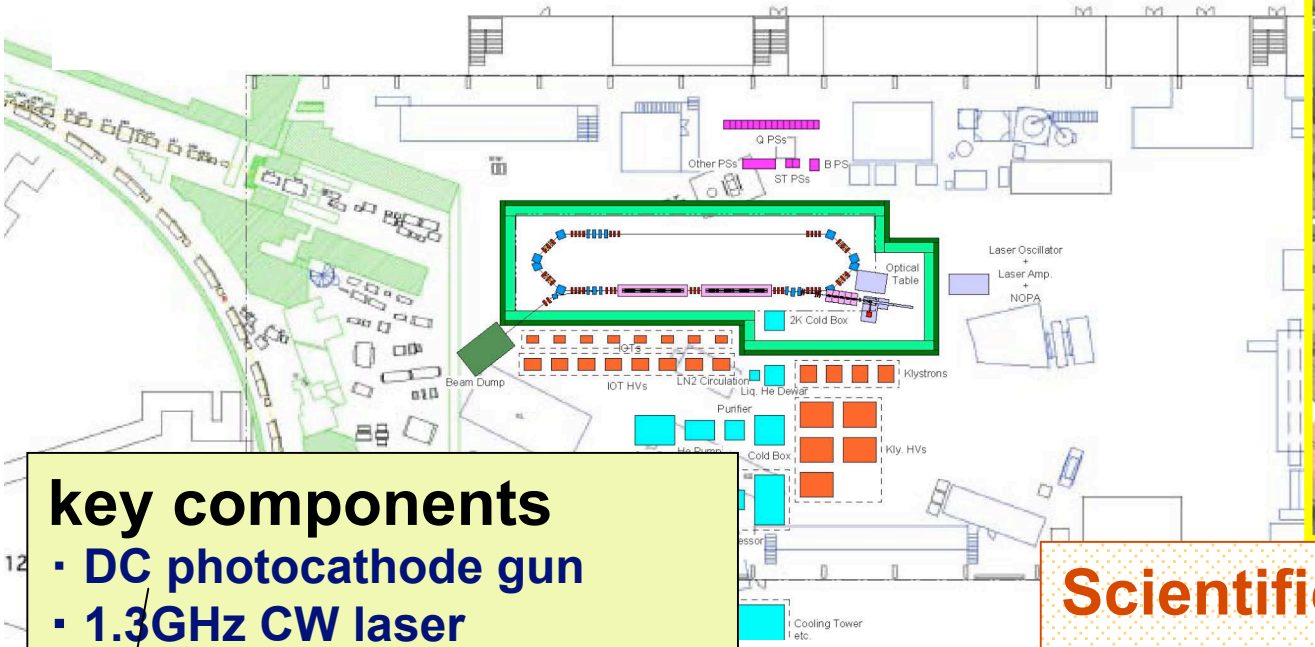
2013~

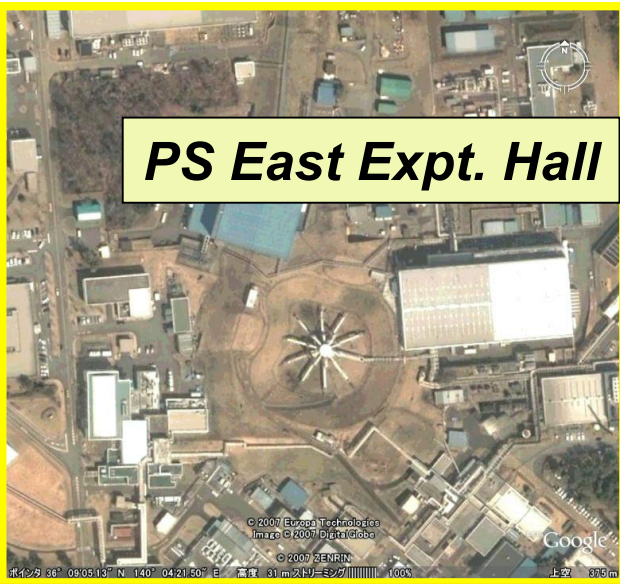
Coherent SR at THz region

Hard X-ray (-10keV) by laser inversed Compton scattering

Spread of the advanced compact X-ray imaging sources to hospitals

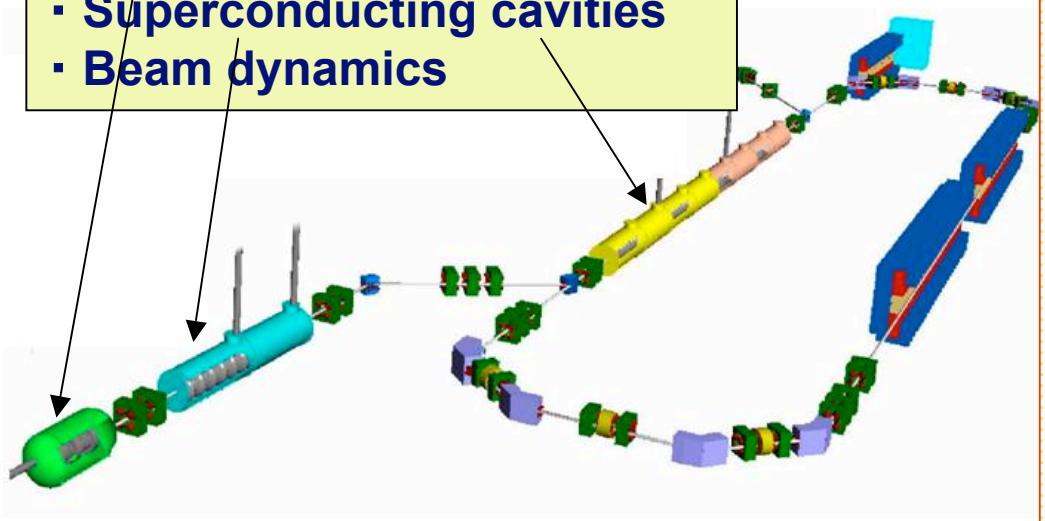
Compact ERL





key components

- DC photocathode gun
- 1.3GHz CW laser
- Superconducting cavities
- Beam dynamics



Scientific Case

CSR at THz region
high intensity by order of 6-7
compared with conventional source

Hard X-ray by laser inversed Compton scattering

- extremely small beam
  ⇒ e.g. medical imaging
- fs science

Time Schedule of the ERL Project

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Compact ERL Design										
Development of key components										
Construction										
Commissioning										
User operation										
5GeV ERL Design										
Construction										

1)Construction of a ~60 MeV class Compact ERL
2) Demonstration of the principle of the ERL until the end of 2012.
3) We hope to start construction of 5 GeV class ERL from ~2013.

Summary

- ERL project has been progressed under the collaboration with KEK, JAEA, ISSP, AIST, CHESS and other facilities.
- To resolve technical & physical challenges and demonstrate the characteristic scientific cases on ERL, the Compact ERL is under construction.
- The Compact ERL will consist of a 5-MeV injector, 1-2 cryomodules, a return loop and a beam dump. The energy will be 60-200 MeV.
- R&D for the DC photocathode gun and for the SC cavities have been progressed.
- CDR of Compact ERL has been published at March 2008
- Funding to develop the advanced accelerator technology (basic technology for ILC and ERL) from this fiscal year.