ERL放射光源計画の進捗状況

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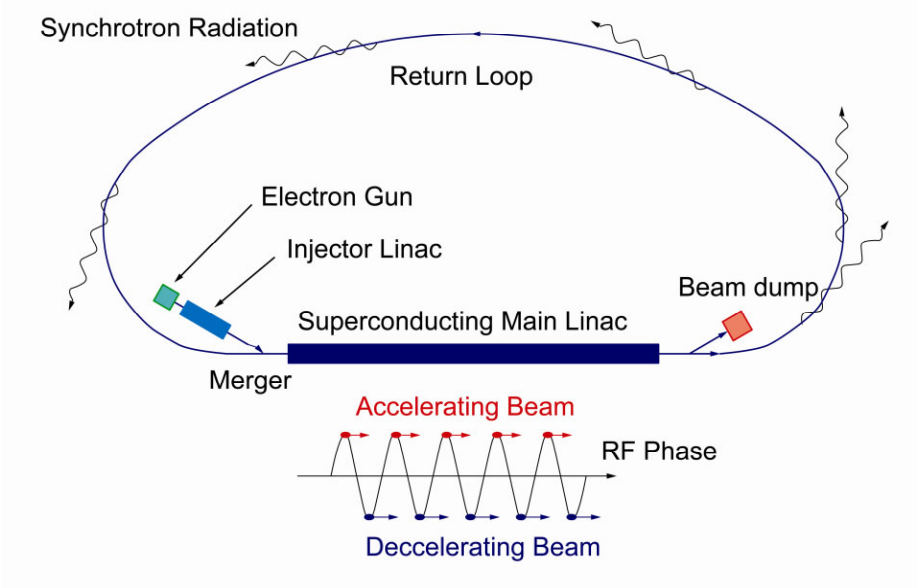
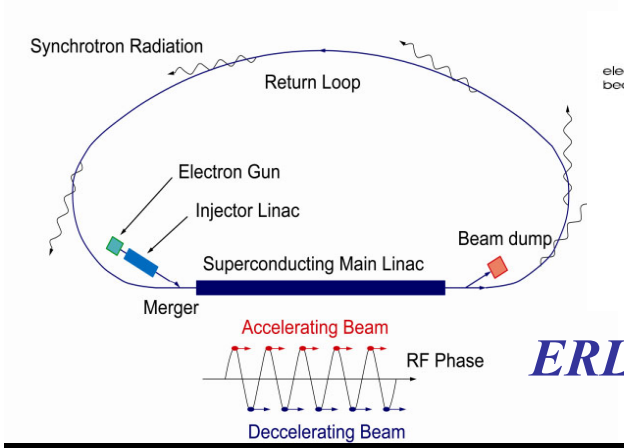
[3]東京大学物性研究所(ISSP)



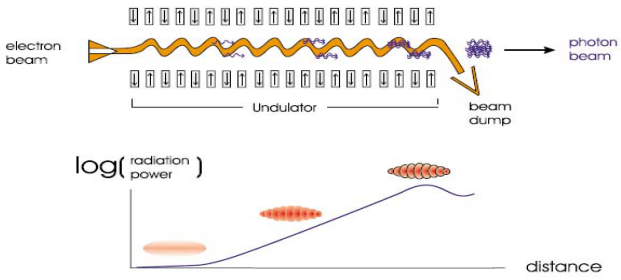
ERL関係発表

- 5-GeV ERLにおける共振器型X線自由電子レーザーの設計
  羽島良一（他）　　9P009
- ERL放射光源のための低エミッタンス大電流電子銃の開発
  羽島良一（他）　　9P010
- ERL電子銃励起用EO変調器型Ybファイバーレーザー発振機の開発
  伊藤功（他）　　9P011
- ERL主ライナック入力カプラー開発
  阪井寛志（他）　　9P012
- cERLのラティス設計
  島田美帆（他）　　9P013
- ERL主加速器のためのモジュール開発の現状
  梅森健成（他）　　9P014

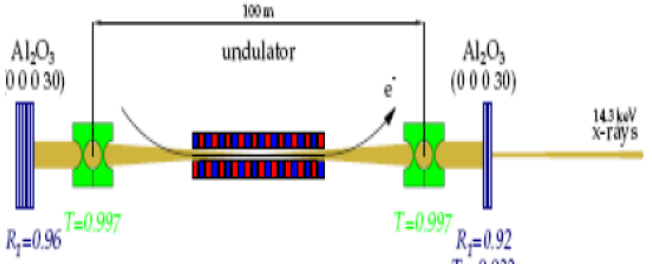
Comparison of ERL, SASE-FEL and XFEL-O



ERL



SASE-FEL



XFEL-O

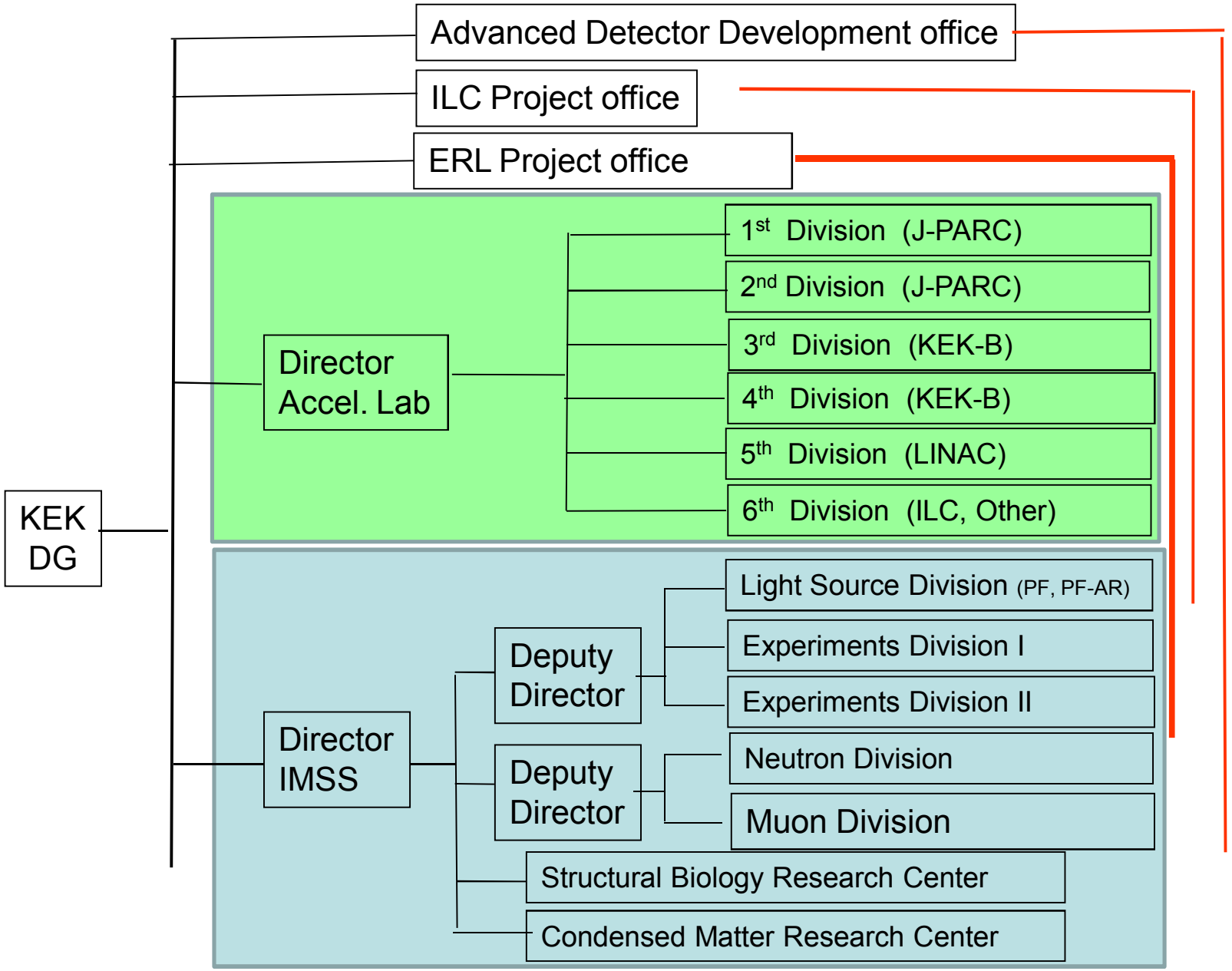
K.-J. Kim, Y. Shvyd'ko, S. Reiche, PRL. **100**, 244802 (2008).

	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**
XFEL-O (Option)	**~10^{27}**	**~10^{33}**	**~1M**	**100%**	**1**	**few**	**Single mode FEL**
SASE-FEL	**~$10^{22\sim24}$**	**~10^{33}**	**100~10K**	**100%**	**0.1**	**~1**	**One-shot measurement**
3rd-SR	**~$10^{20\sim21}$**	**~10^{22}**	**~500M**	**0.1%**	**10~100**	**~30**	**Non-perturbed measurement**

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

Merger of Accelerator Laboratory and PF Light Source Division

(Before 1st of April / 2009)



Merger of Accelerator Laboratory and PF Light Source Division

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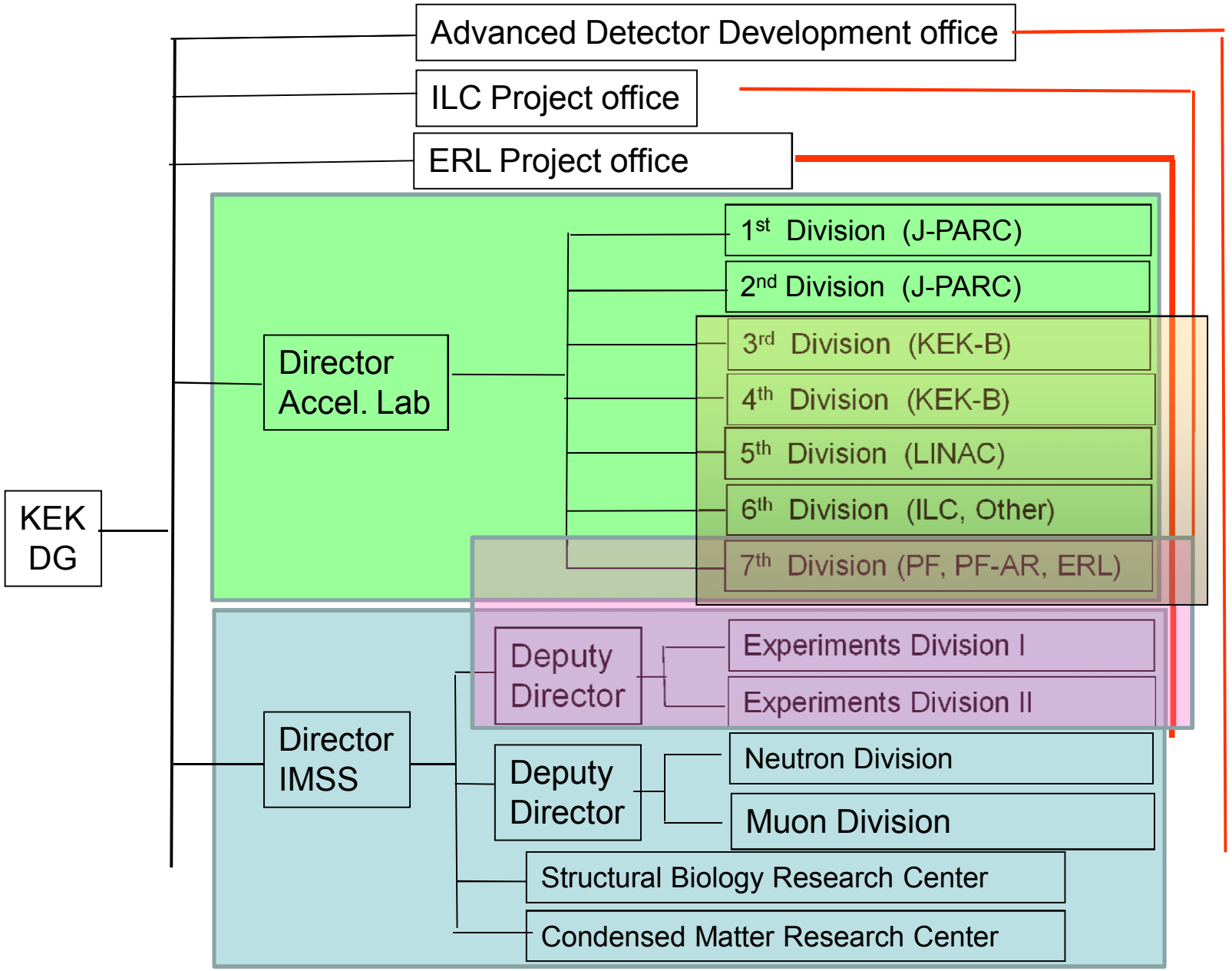


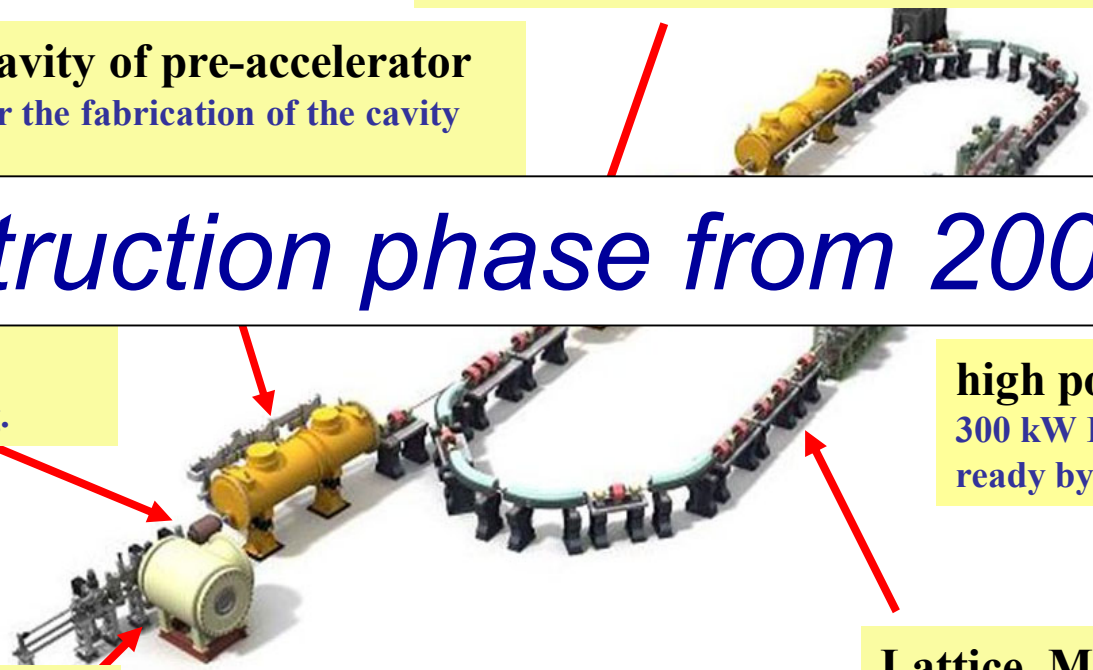
Development of ERL until 2008

CDR of Compact ERL has been published

Super conducting cavity for main accelerator
Single cell model ⇒ 9 cell model ⇒ Ready for the fabrication of the cavity for Compact ERL

super conducting cavity of pre-accelerator
2 cell model ⇒ Ready for the fabrication of the cavity for Compact ERL

Construction phase from 2009!



Injector
Started the designing.

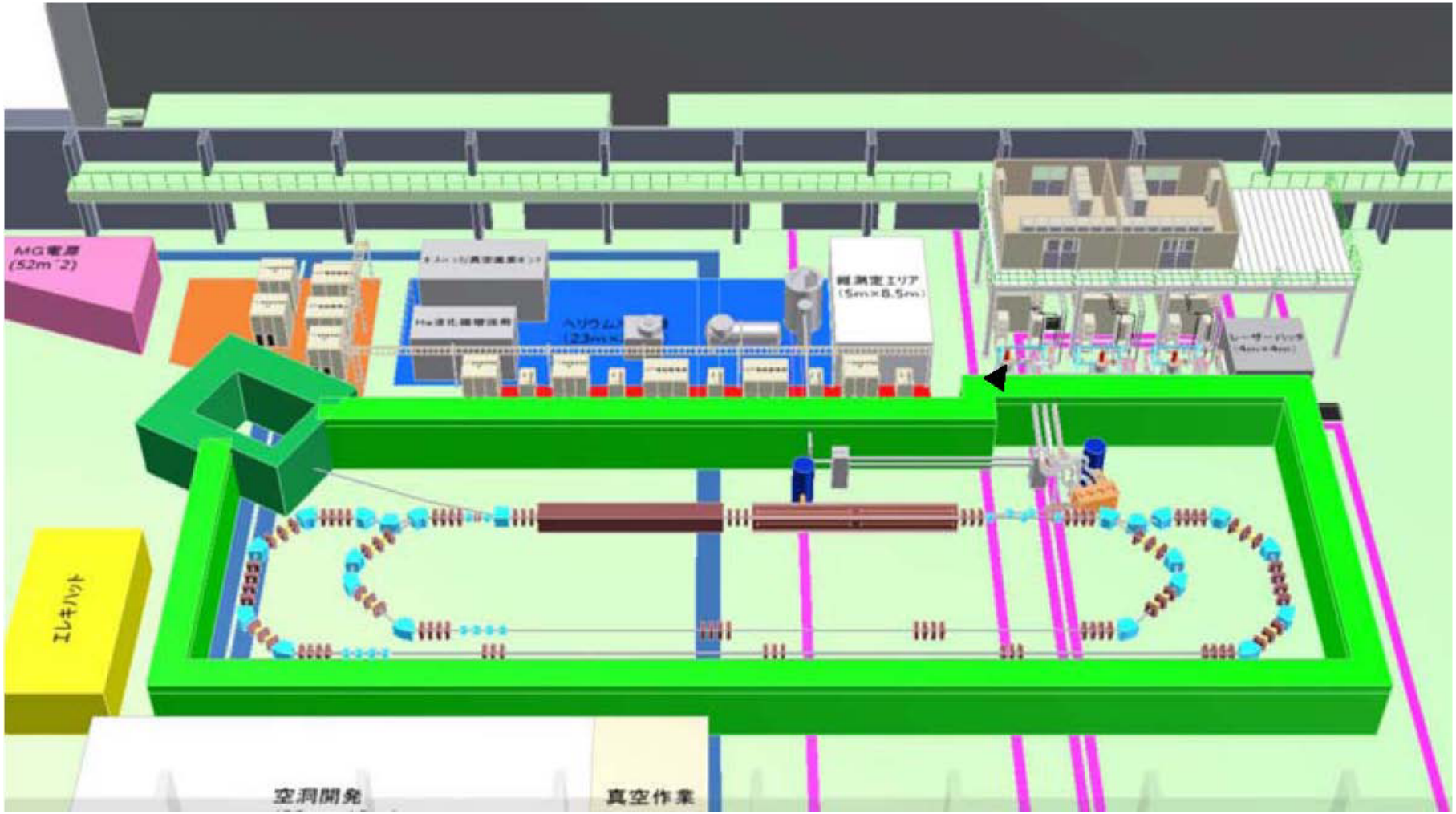
high power RF source
300 kW Klystron will be ready by October 2009

500kV・DC electron gun
The fabrication has started under the collaboration with JAEA, ISSP, Hiroshima Univ., Nagoya Univ. and KEK.

Laser system for electron gun
Development of Yb fiber-laser system in collaboration with AIST, ISSP and KEK.
⇒ Ready for the system of 10 mA electron beam current.

Lattice, Magnet, Vacuum
Designing stage

Compact ERL in East Counter Hall



Reconstruction of East Counter Hall

Feb.2009

02/Dec.2009

Development of DC Photocathode Gun

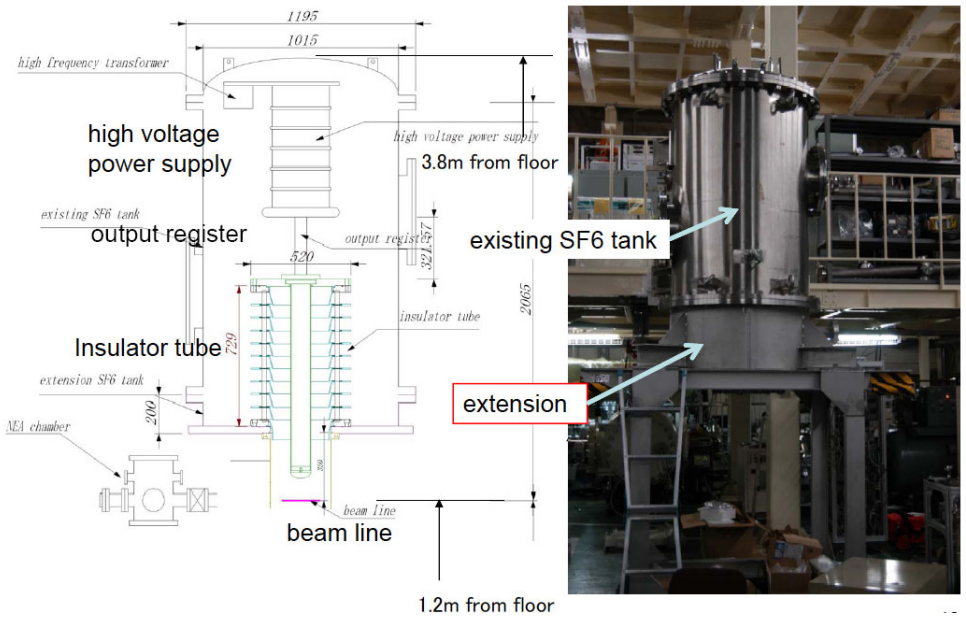
Goals:

- High voltage: 500 kV
- High average current: 10 - 100 mA
- Low emittance: 0.1 - 1 mm·mrad
- Long cathode lifetime (> hours)
- GaAs NEA cathode

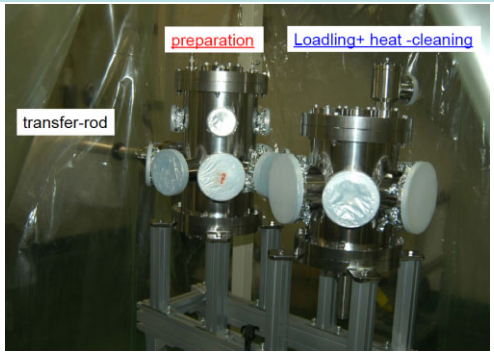
Collaboration with JAEA, Hiroshima Univ. and Nagoya Univ.

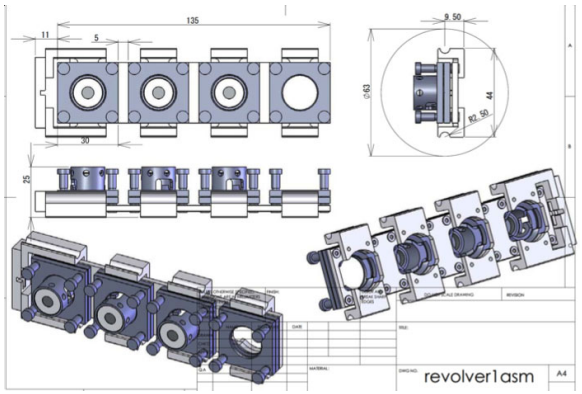
HV insulation tank

Designed and under construction.



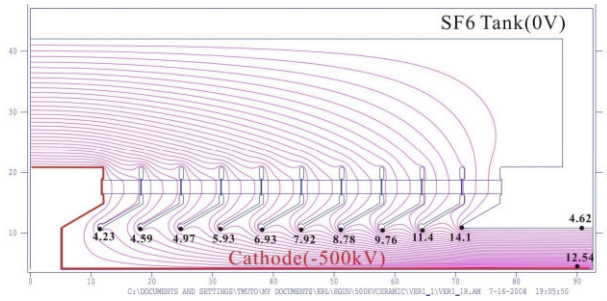
Photocathode preparetion chamber





Segmented ceramic insulator

- Guarding ceramic insulator from impinging field-emitted electrons
- Expect to prevent damage due to field emissions



Development of Superconducting Cavities

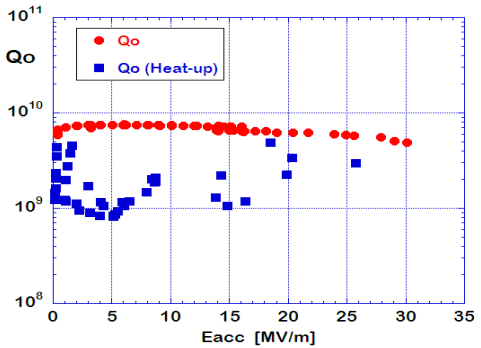
Injector Cavities

- 2-cell cavity design
- Medium gradient: 15 MV/m
- High input power: 85-170 kW/coupler
- Improved HOM coupler design

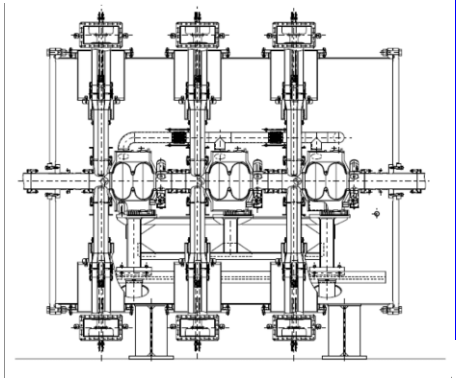
Status

- First prototype cavity was fabricated and tested.
- Achieved field gradient of 30 MV/m for a short time.

Prototype cavity.



Result of the first vertical test.

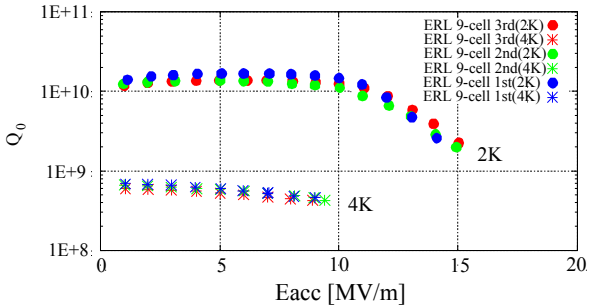


Main-Linac Cavities

- 9-cell cavity design
- HOM damping with large beam pipes/absorbers
- High beam current: 200 mA
- CW operation with 15 - 20 MV/m

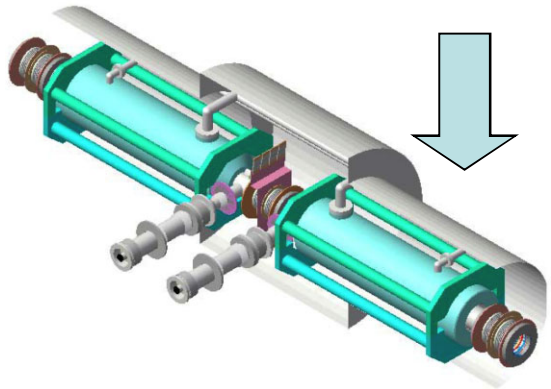
Status

- First prototype cavity was fabricated and tested.
- Achieved field gradient of 15 MV/m.

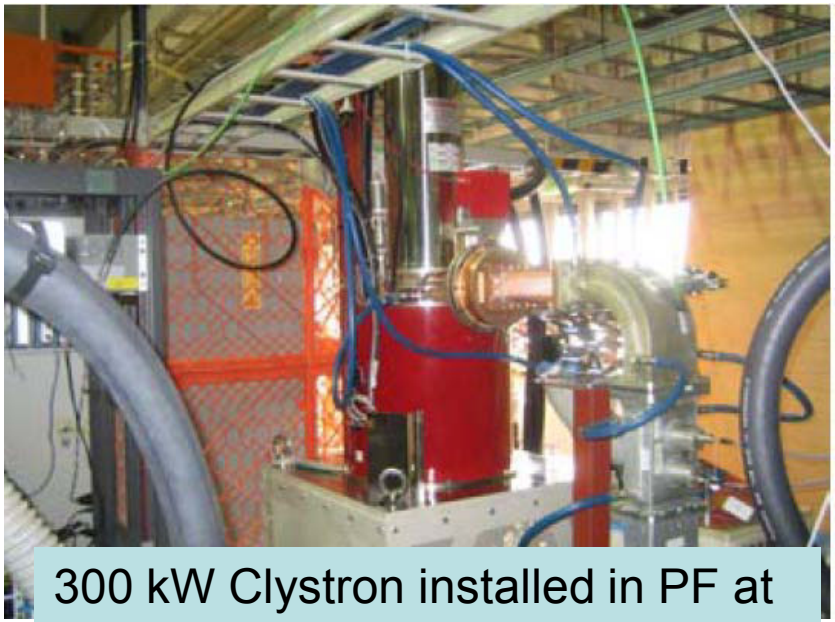


Result of the first vertical test.

Prototype cavity.



Development on RF source



300 kW Clystron installed in PF at the middle of Oct. 2009.

Prof. Fukuda and his coworkers; commissioning members of the Clystron.

The commissioning has been finished at the beginning of Dec. of 2009 and the test for an input coupler will start from the middle of Jan. of 2010.

ERL09（Energy Recovery Linac **45th ICFA Beam Dynamics**

Workshop June 8-12, 2009, Ithaca, USA)

- KEK and JAEA will organize the next workshop of ERL2011

http://www.lepp.cornell.edu/Events/ERL09/

ERL Science Workshop

http://pfwww.kek.jp/pf-seminar/ERL/workshop/index.html

ERL Science Workshop
(domestic workshop)

Date : 9-11 July 2009
Site: KEK

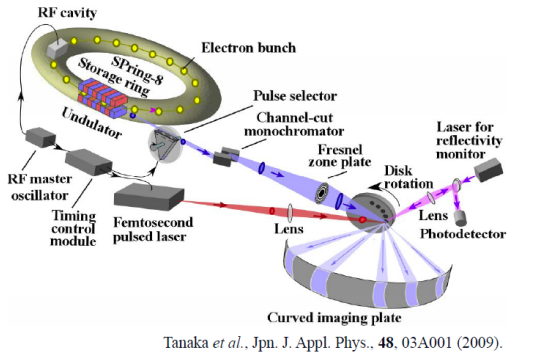
#) Outline of ERL project
#) Femto-second science
#) Local structures in disordered materials
#) Hierarchical structure in materials at a space and a time domains
#) Sophisticated Instrumentation
#) Discussion

Numbers of participants: 85

KEK Proceedings 2009-4
http://ccdb4fs.kek.jp/tiff/2009/0925/0925004.pdf

Femto-second science

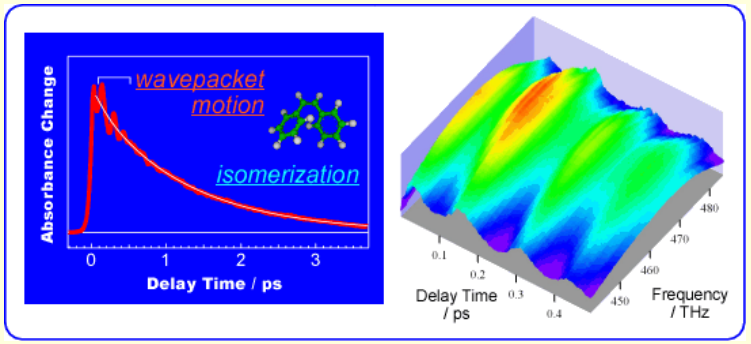
“Time-resolved techniques with next generation femtosecond pulsed synchrotron radiation sources” By Y. Tanaka, RIKEN



Tanaka *et al.*, Jpn. J. Appl. Phys., **48**, 03A001 (2009).

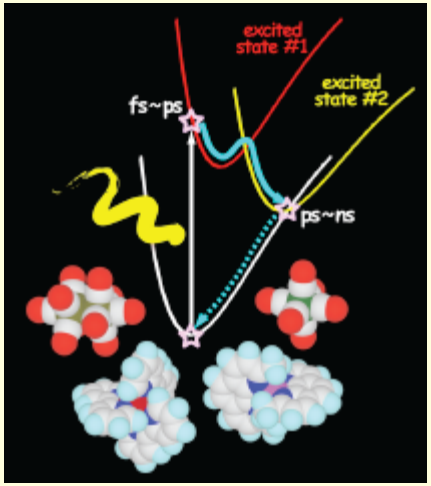
- ERL promises the dynamics measurements with the wide time range (m-sec to femto-sec).
- Development of femto-sec timing technologies.

“Ultrafast structural tracking of reacting molecules and expectation for synchrotron radiation of the next generation” By T. Tahara, RIKEN



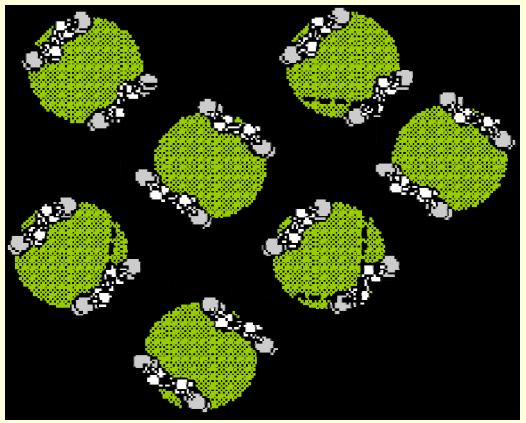
- Direct observation of the structural change (fluctuation) in bio-molecules (X-FELO)

“Time resolved XAFS research of materials chemistry” By Y. Inada, Ritsumeikan Univ.



- To understand the chemical function of catalysis, dynamics measurements with the wide time range (msec to femto-sec) is essentially important.

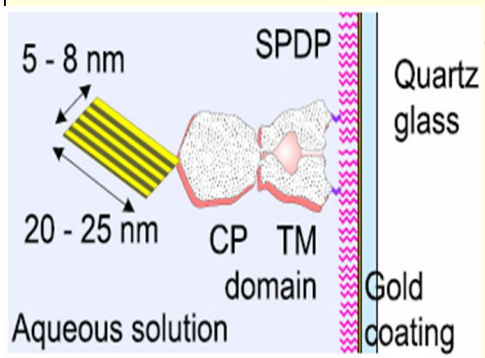
“Ultrafast spectroscopy of photo-induced phase trensition in organic salts” By S. Iwai, Tohoku Univ.



- Dynamics of domain (cluster) formation and domain boundaries

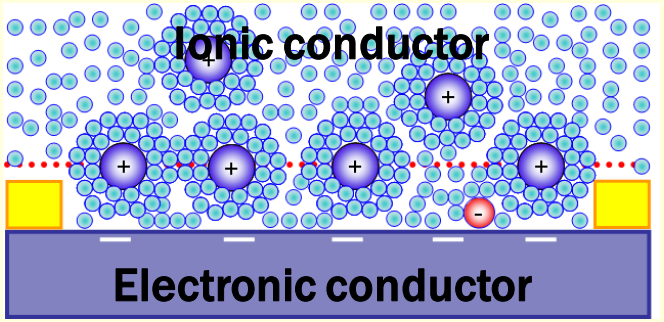
Local structures in disordered materials

"Advanced single molecule observations and the task of the next X-ray light sources" By Y. C. Sasaki, The Univ. of Tokyo



- Structural determination from single molecules
- High speed (ps-fs) and high accuracy (pm)
- Single molecule calorimeter
- Control of functional dynamical behaviors

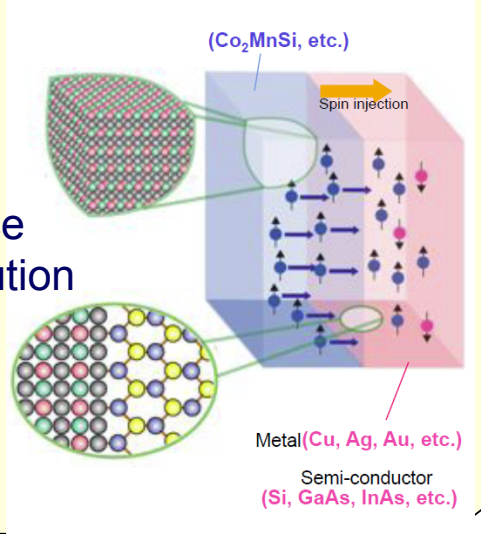
"Electronic function at the non-equilibrium solid/liquid interfaces" By Y. Iwasa, Tohoku Univ.



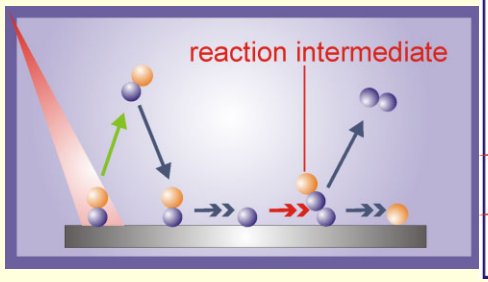
- Challenge: Discover new superconductors
- Multidisciplinary materials science in non-equilibrium states at solid-liquid interfaces

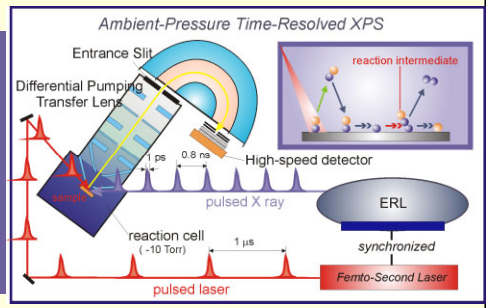
"Present status and perspective of materials research on spintronics " By K.Takanashi, Tohoku Univ.

- Challenge of the observation of spin current at the interface with the spatial resolution of atomic level.



"Study on chemical reaction at surfaces/interfaces and future prospects" By H.Kondoh, Keio Univ.

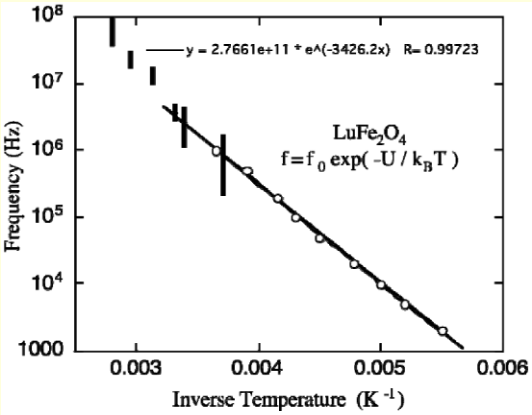




- Chemical reaction at the surface/interfaces
- To clarify the intermediate states with nm spatial resolution

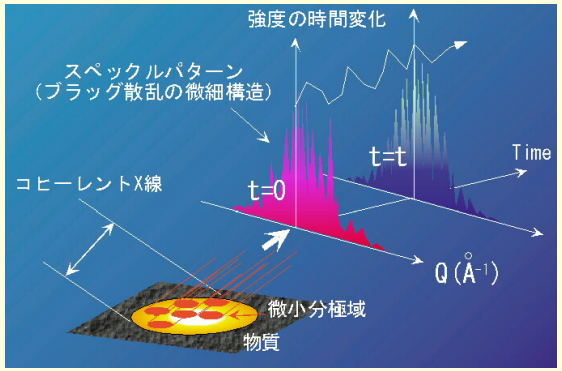
Hierarchical structure in materials at a space and a time domains

"Slow electronic fluctuation in electronic ferroelectric $LuFe_2O_4$" By N. Ikeda, Okayama Univ.



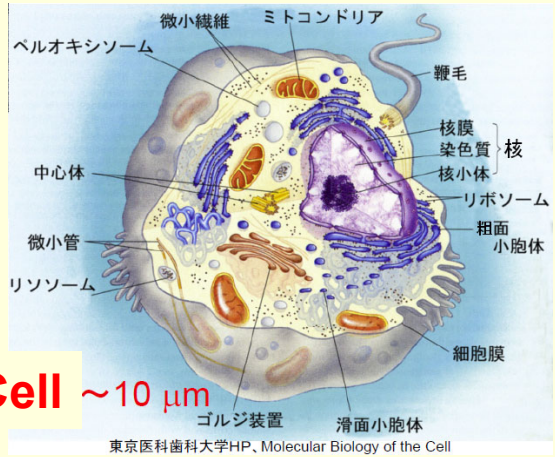
- Frustration system of the charge and orbital ordering of Fe^{2+} and Fe^{3+}.
- Investigate the domain formation to clarify the magneto-dielectric response!

"Current situation and future prospects of an application of x-ray photo correlation spectroscopy to the solid state physics" By K. Ohwada, JAEA



- We need 2-3 order higher coherent flux to investigate the super-lattice diffractions

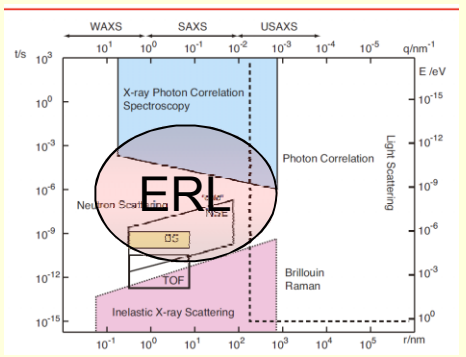
"Imaging of hierarchical structures of the cell using coherent X-ray" By M. Nakasako, Keio Univ.

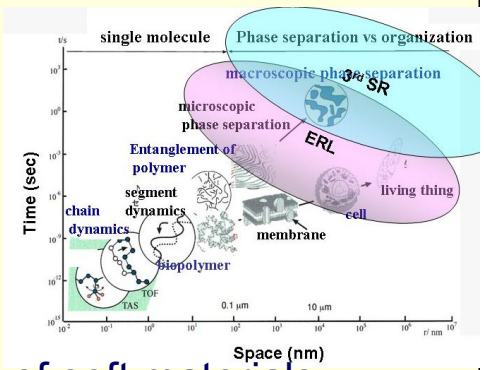


Cell ~10 μm

- Investigate the bio-molecules in a cell to clarify the function

"Hierarchical structure of soft matter and expectations for ERL" By Y. Shinohara, the UNiv. of Tokyo

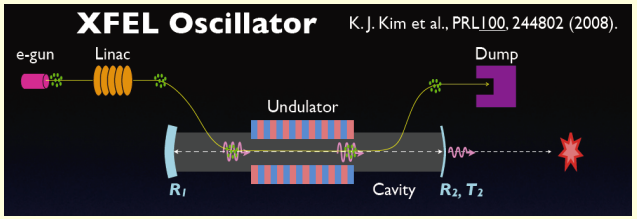


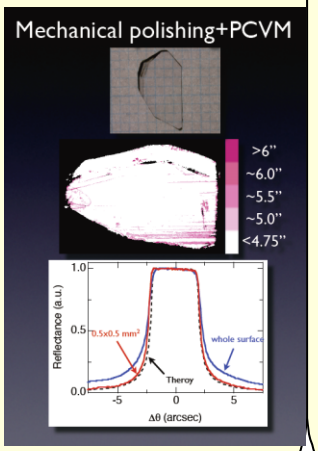


Hierarchical structure of soft materials (Non-crystalline, disordered material ,and fluctuation)

Sophisticated Instrumentation

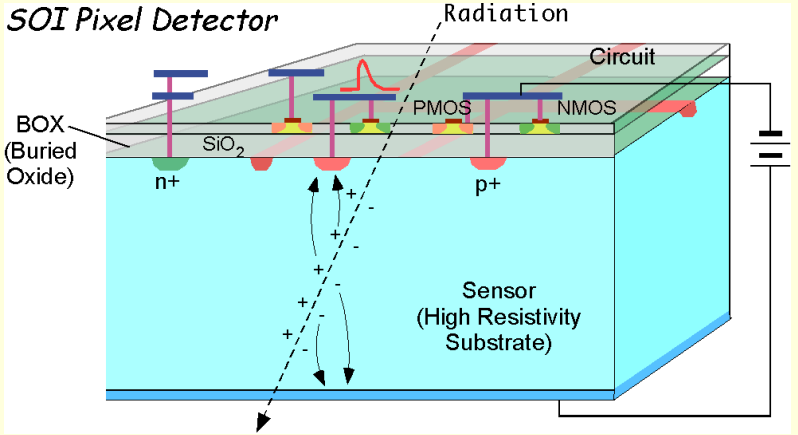
"Present status and perspective of diamonds as x-ray optical element" By K. Tamasaku, RIKEN





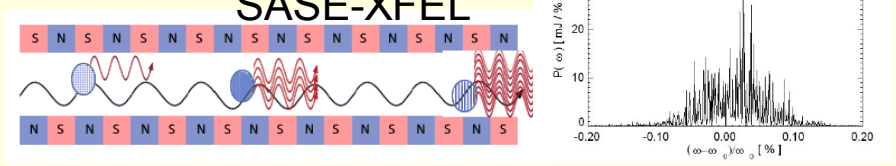
- Still there are many things to improve the performance (Imaging applications, thinning and polishing diamond crystal plates)

"Development of next generation high-speed 2D X-ray detector with SOI technology" By Y. Arai, KEK

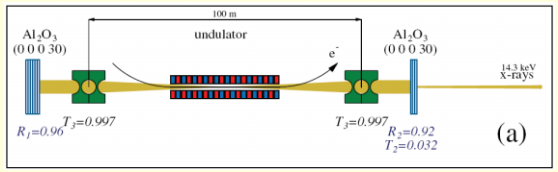


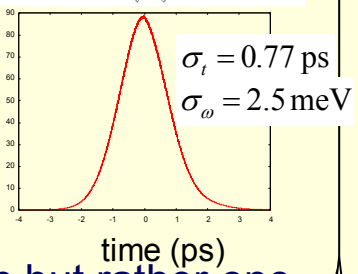
"Light source performance of X-FELO" By R. Hajima, JAEA

SASE-XFEL



X-FELO





"X-FELO is not just an option but rather one of the targets of the KEK-ERL project!"

"Development of hard x-ray optical systems/devices" By A. Takeuchi, JASRI/Spring-8

Focused beam of 1 nm will be possible by using several techniques.

It is necessary to recognize the following issues.

1. Vibration: optics, light source, ground, and building
2. Temperature stability
3. Radiation damage of the optical components
4. Measurement systems for nm order
5. Speckles from optics

Summary of the ERL scientific workshop 1

- Femto-second science
  - ERL promises the dynamics measurements with the wide time range (msec~fsec) based on pump-prove experiment.
  - X-FELO would be a wonderful light source (1MHz, 10^9 photons/pulse with the energy resolution of several meV).
- Local structures in disordered materials
  - 10 nm spatial resolution gives us functional information in disordered materials and surface/interface, electric double layers, and spintronics.
  - A number of experimental techniques to be developed such as fast-detectors, combination with other imaging techniques, triggering system for chemical reactions, and so on.
- Hierarchical structure in materials in a wide range of spatial and time domains
  - High brilliance coherent X-rays with high repetition rate (1.3 GHz) will give us a new scientific activities on hierarchical structure in materials at a space and a time domains. (form slow dynamics to 10^8Hz and sub nm to mm)
  - Development of detectors for XPCS is essentially needed.

Summary of the ERL scientific workshop 2

- Sophisticated Instrumentation
  - "X-FELO is not just a option but rather one of the targets of the KEK-ERL!"
  - There are a number of things to develop optics, detectors, and facilities.

- Future workshops
  - Separate workshops corresponding to each scientific sessions featured in July workshop will be organized by the leadership of the ERL project office.
  - Scientific sessions on the applications of X-FELO should be included.

21st/ Dec./ 2009 Seminar for XFEL-O (KEK)

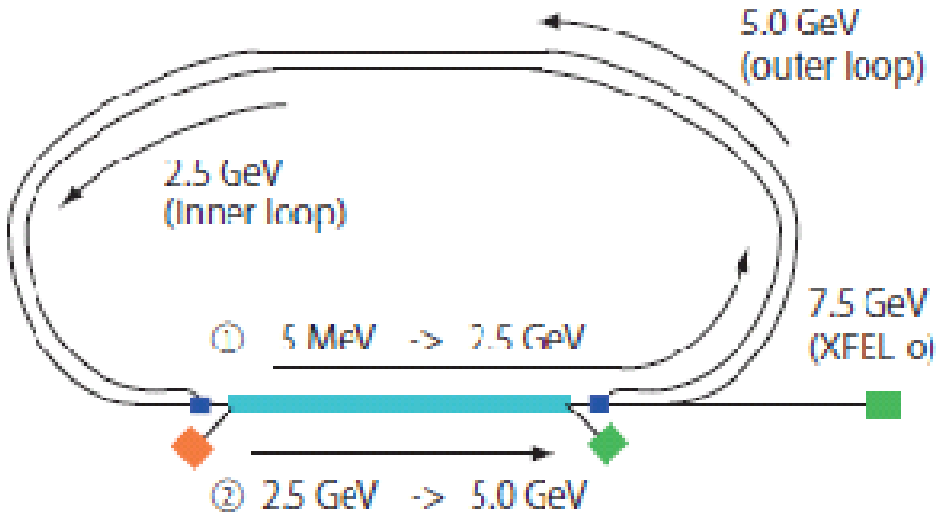
"Welcome & Opening address"
Osamu Shimomura (IMSS/ KEK)

"An X-ray Free Electron Laser Oscillator: Promises and Challenges"
Kwang-Je Kim (APS/ ANL)

"A simulation work of a velocity-bunching XFEL-O "
Nobuyuki Nishimori (JAEA)

"The idea how to measure dynamical charge susceptibility combined with X-ray and Neutron inelastic scattering"
Jun-ichiro Mizuki (JAEA)

Preliminary Design of 5GeV ERL



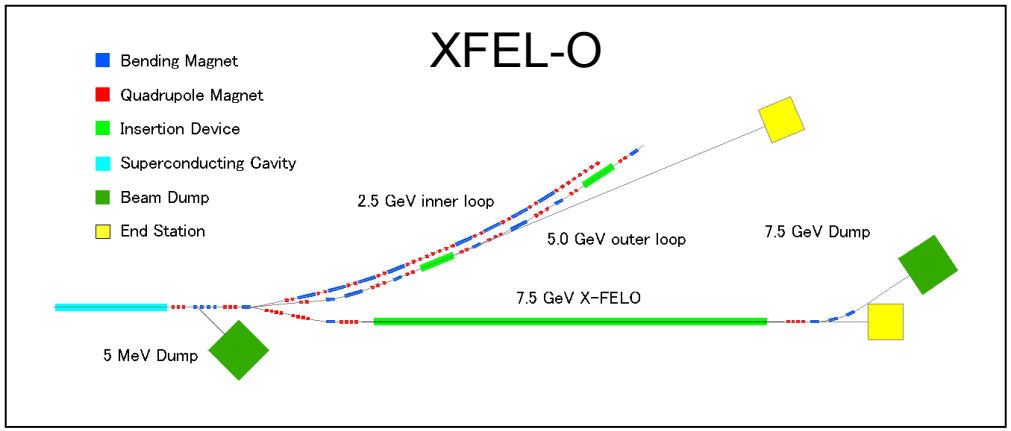
Energy Recovery Mode

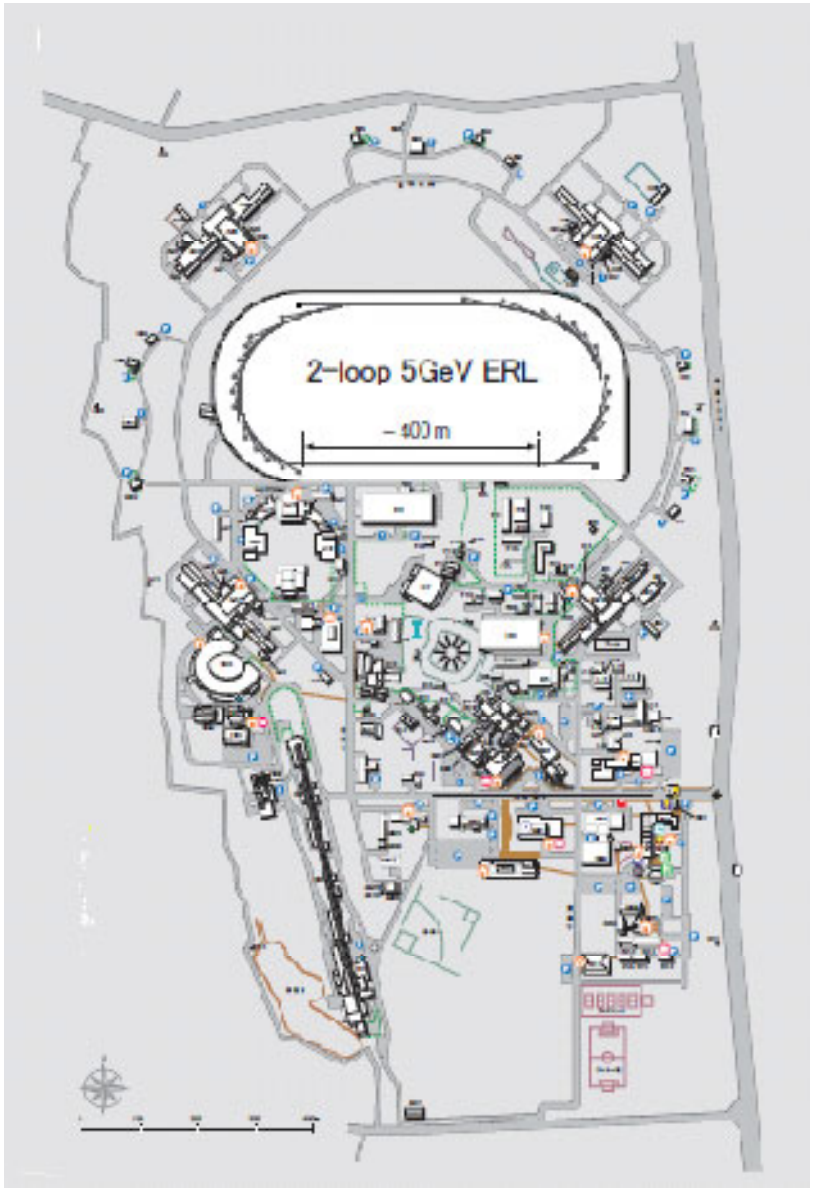
③ 5.0 GeV -> 2.5 GeV

④ 2.5 GeV -> 5 MeV

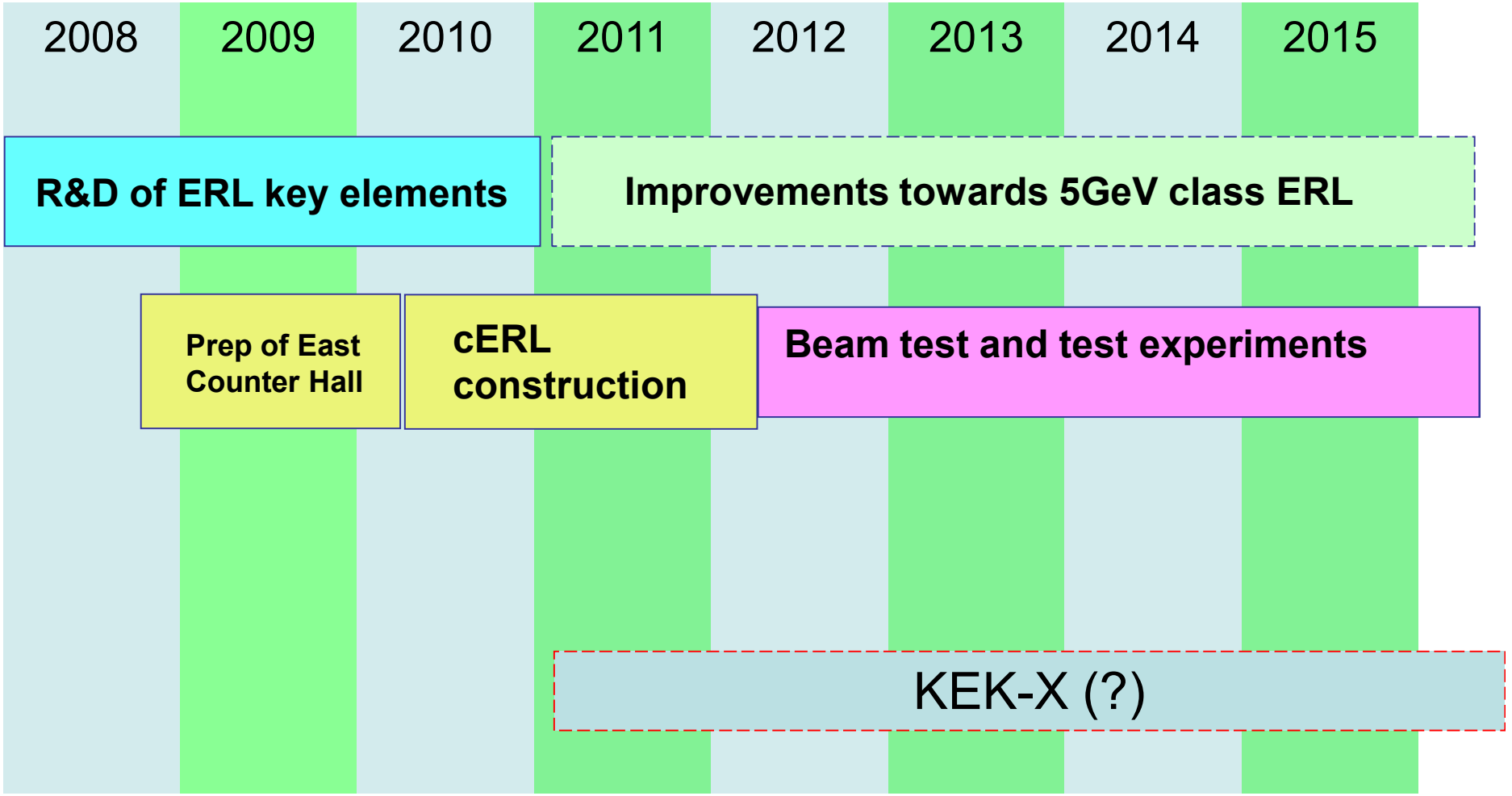
XFEL-o Mode

③ 5.0 GeV -> 7.5 GeV





cERL, KEK-X, ERL: target timelines



References:
KEK roadmap, March 2008
Design of compact ERL, Hajima et al., pp. 160-161.

∗ to be updated periodically

Summary

- We have started the construction of c-ERL in FY2009.
- The EAST counter hall will be ready to construct the accelerator components at the April of 2010
- ERL Science workshop has been organized successfully. Users are very much interested in the possibility of ERL and also XFEL-O.