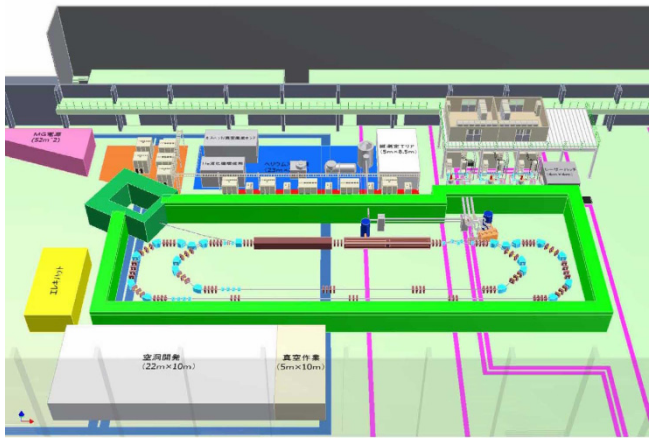
次世代放射光源
・ERLの概要とその光源特性

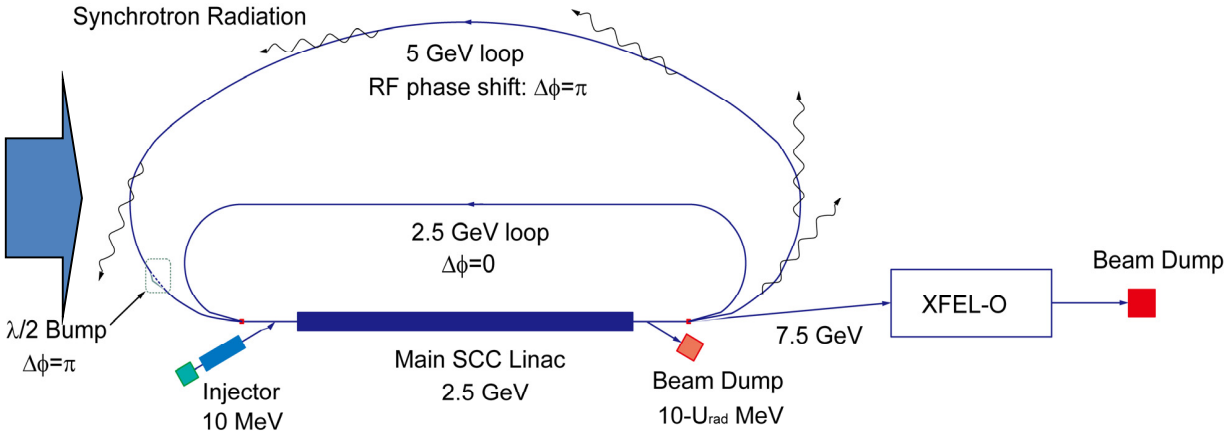
河田　洋

ERL Project Office, KEK

Photon Factory, IMSS, KEK

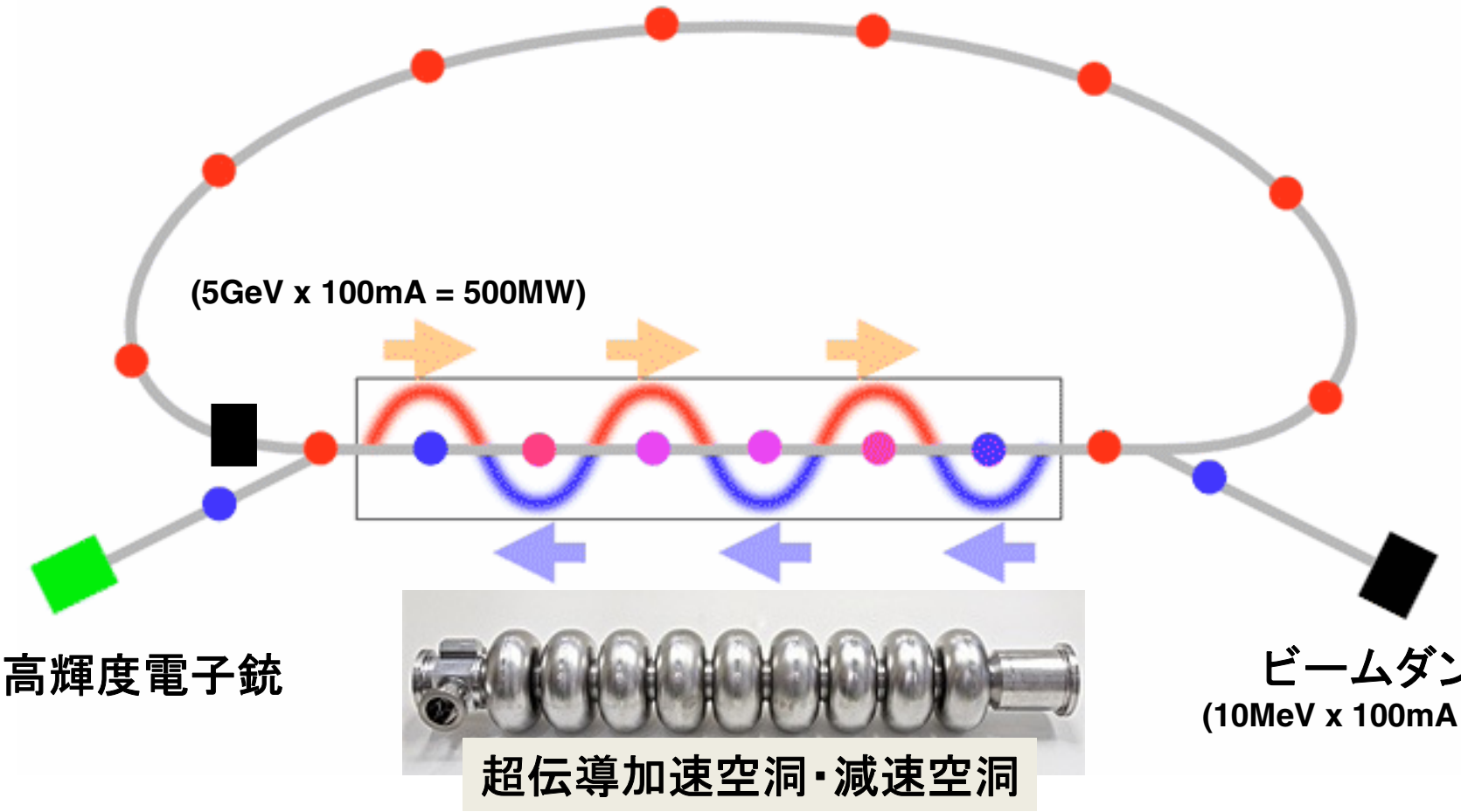


cERL

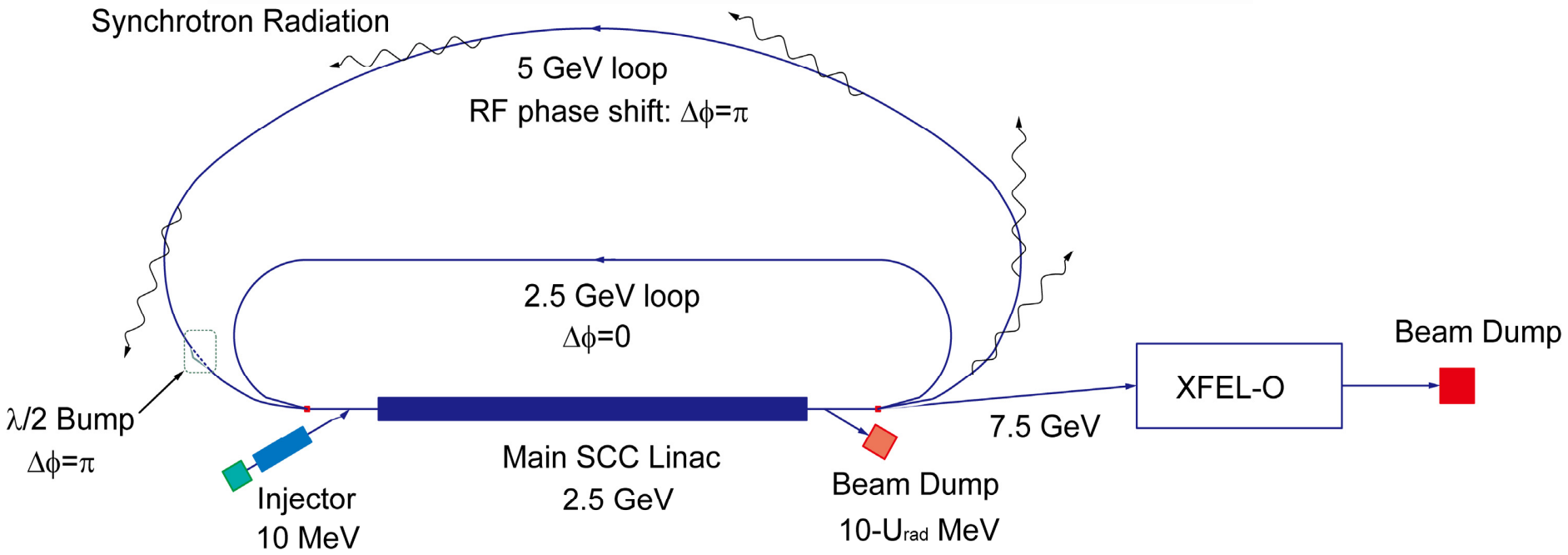


5GeV-ERL + XFEL-O

ERLの概念図


(5GeV x 100mA = 500MW)
高輝度電子銃
ビームダンプ
(10MeV x 100mA = 1MW)
超伝導加速空洞・減速空洞

ERL?



#) Linac based light source:

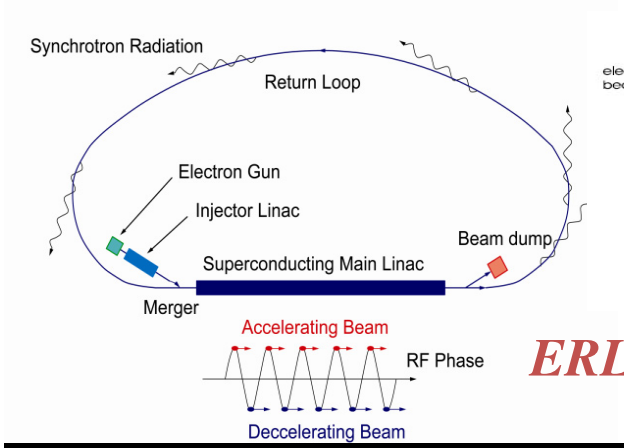
1) Emittance $\propto$ 1/γ ~10pmrad ~λ/4π

2) Short purse of photon pulses~ 0.1~1 pico-second

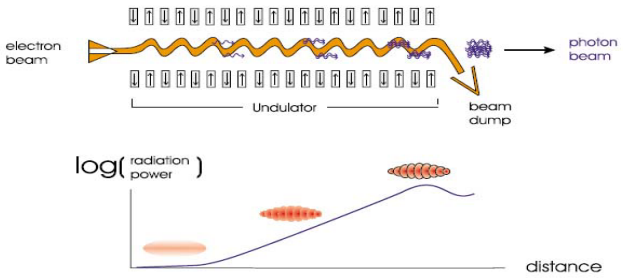
#) A great numbers of ID-beamlines

#) Possibility to realize the XFEL-O

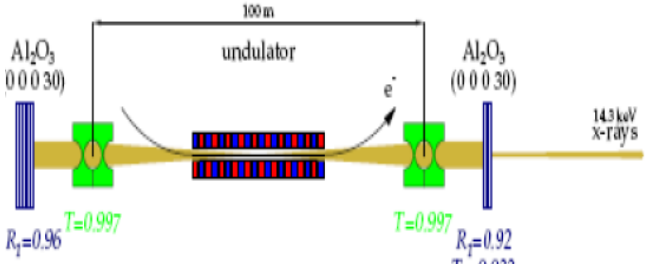
ERL, SASE-FEL そしてXFEL-Oの光の性質は？



ERL



SASE-FEL



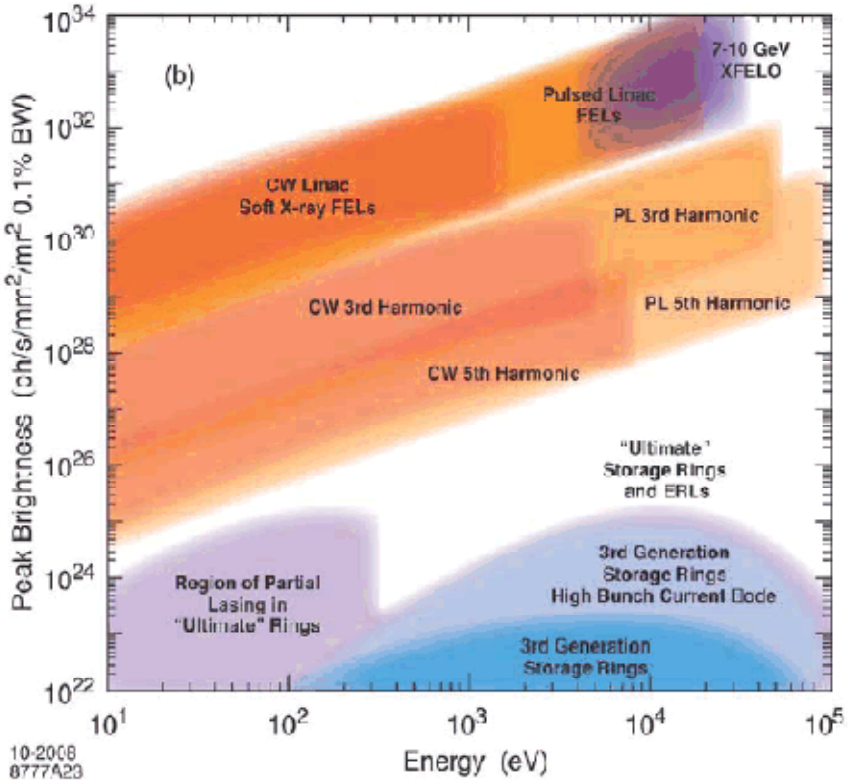
XFEL-O

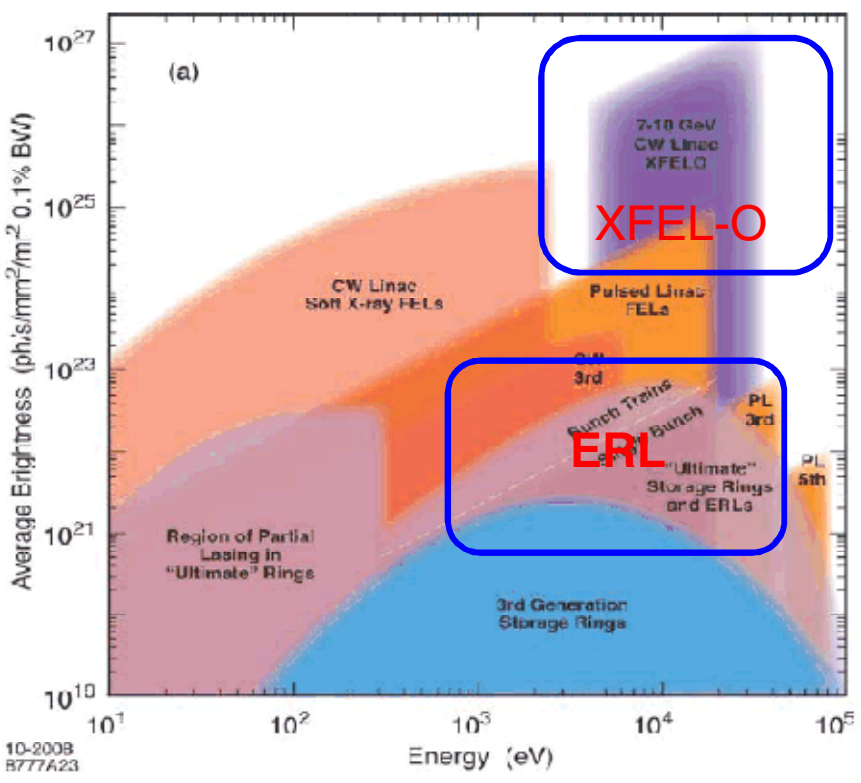
K.-J. Kim, Y. Shvyd'ko, S. Reiche, PRL. **100**, 244802 (2008).

	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	~10^{27}	~10^{33}	~1M	100%	1	few	Single mode FEL (few meV)
SASE-FEL	~$10^{22\sim24}$	~10^{33}	100~10K	100%	0.05	~1	One-shot measurement
3^{rd}-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)

Spectral Brightness

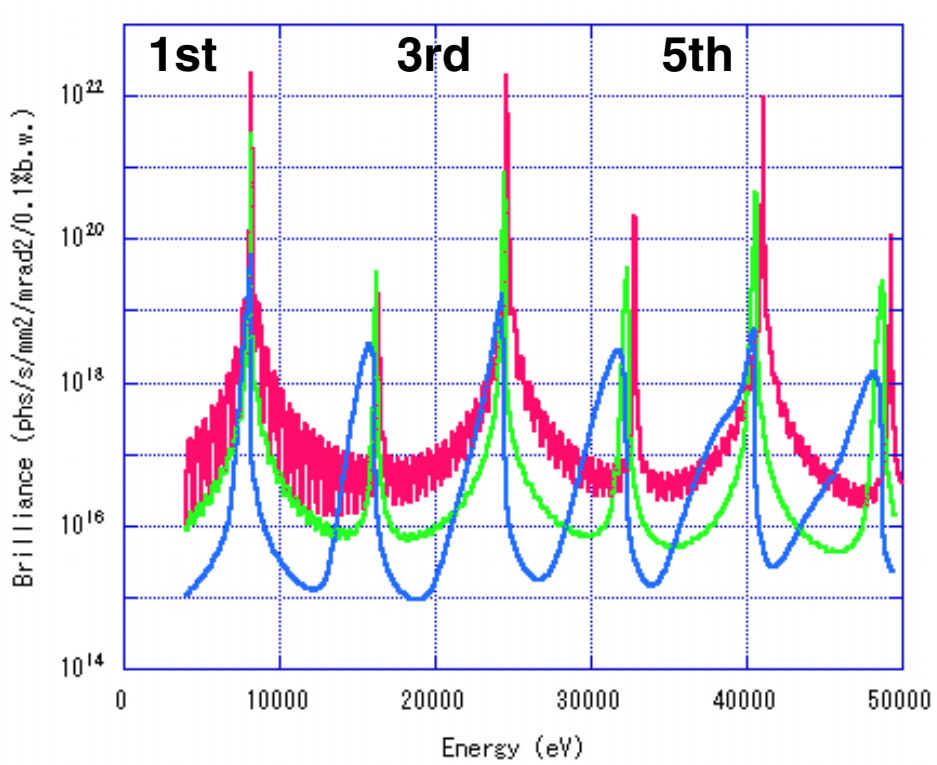


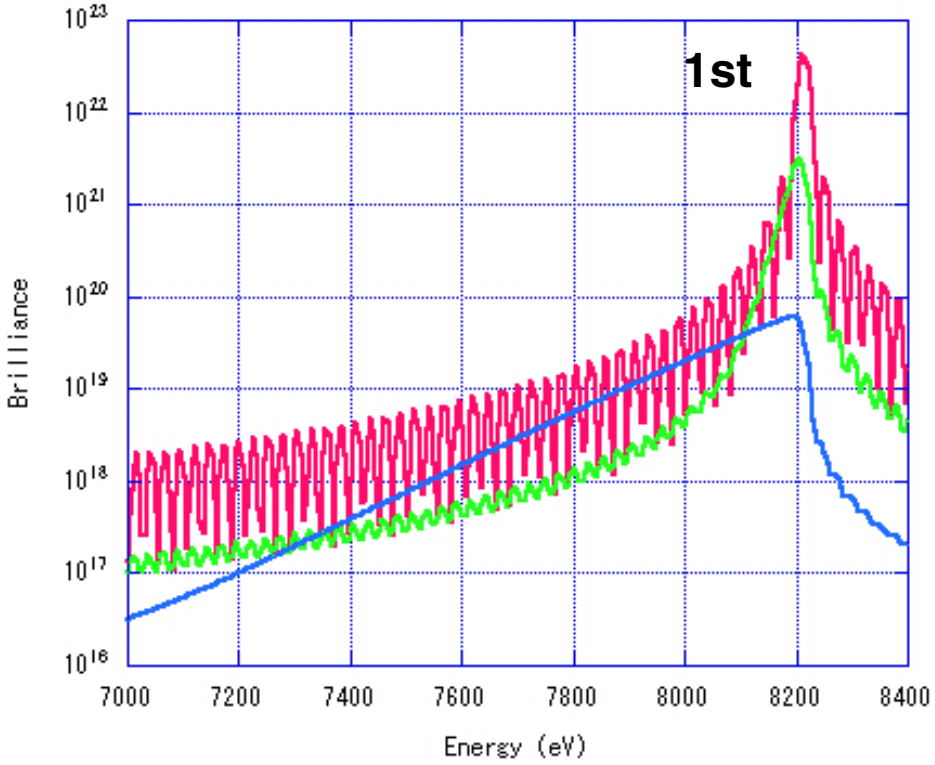


原図は次の資料より引用：R. Hettel, “Performance Metrics of Future Light 13 Sources”, FLS2010, SLAC, March 1, 2010.

SLAC NATIONAL ACCELERATOR LABORATORY

光源サイズと発散角による
アンジュレータスペクトルの違い





E=5GeV
I=100mA
βx=βy=5m
K=1.0
σ_E/E=4e-5
L=5m
λu=16mm

ε=10 pmrad

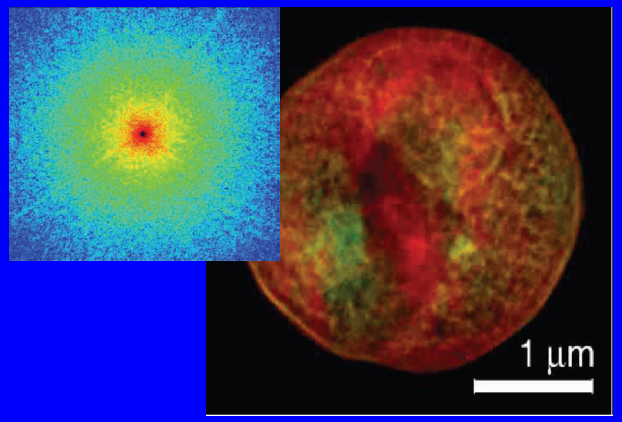
ε=100 pmrad

ε=1 nmrad

Grand challenges for basic sciences

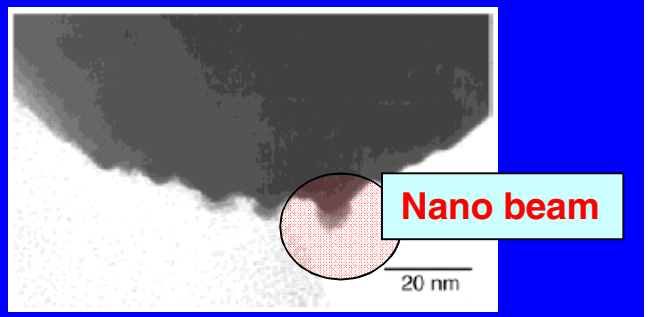
~ Non-crystalline materials and nano-science ~

Function in a cell

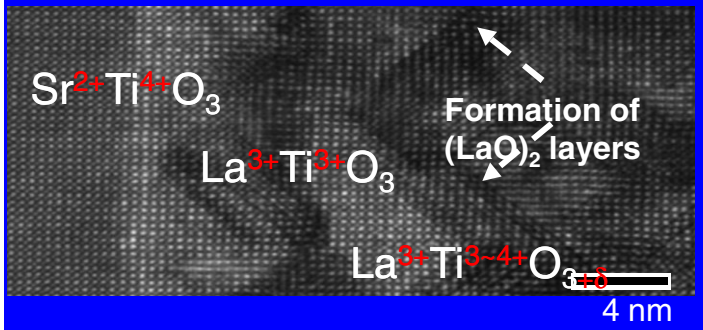


biology and chemistry

Catalysis chemistry

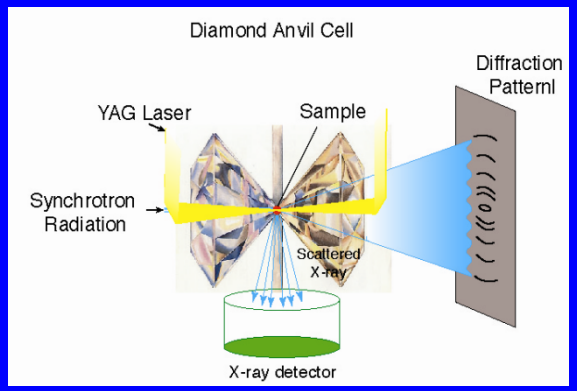


Nano-materials at interface



materials, energy and environment

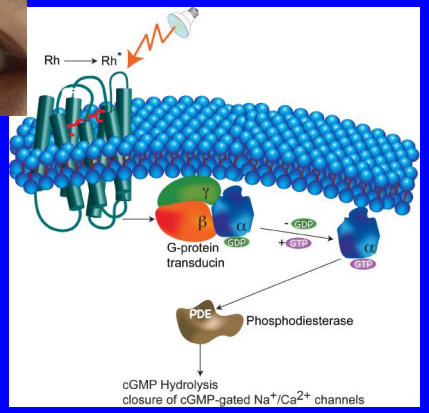
Extreme condition



rand challenges for basic sciences

~ on-equilibrium states generated by photons ~

visual sensing

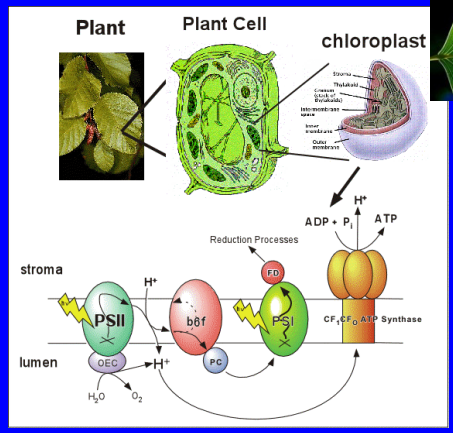


biology

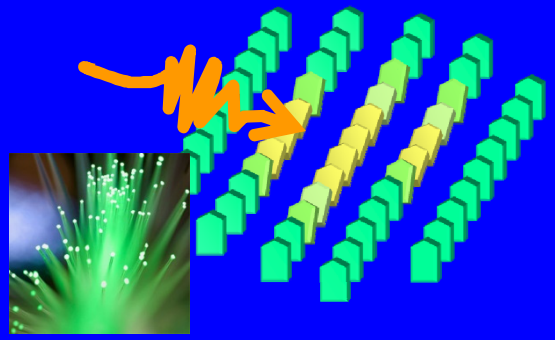
and

chemistry

photosynthesis



ultrafast photo-switching



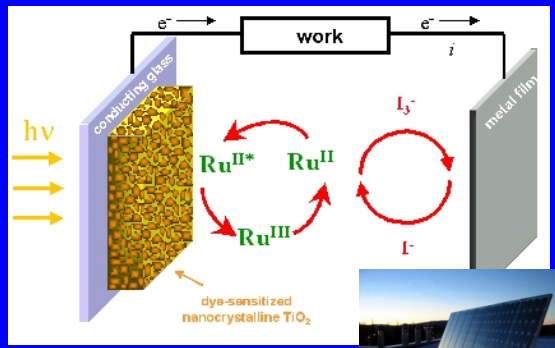
materials,

energy

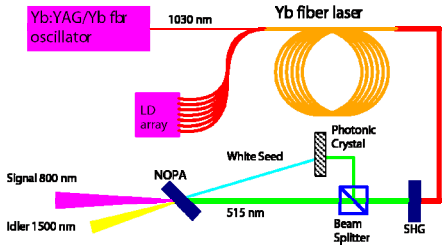
and

environment

solar cell



R&D Efforts for Key Accelerator Components

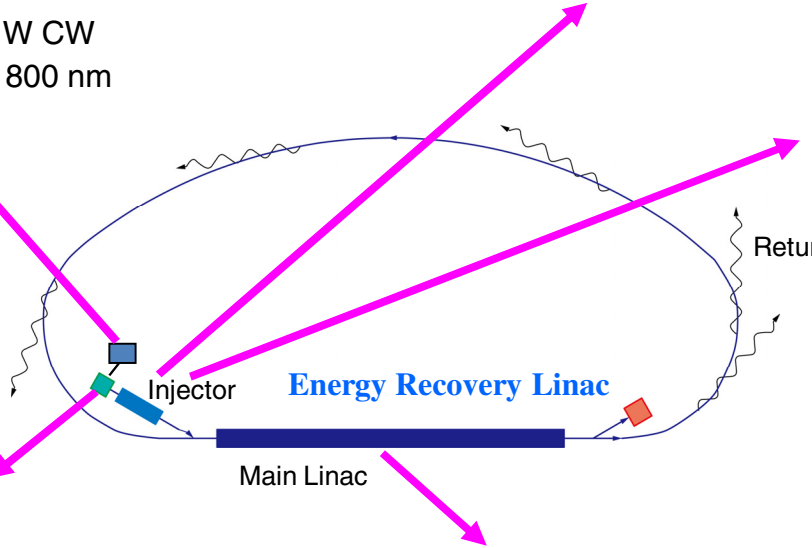


Gun drive laser:

- High average power: 15 W CW
- Repetition: 1.3 GHz, λ ~ 800 nm

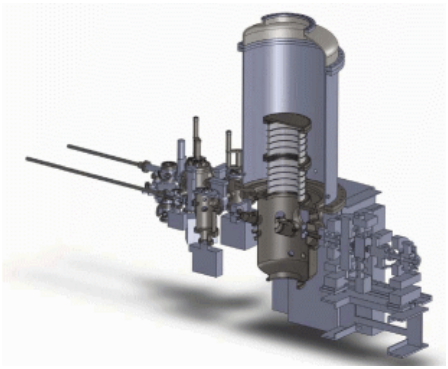
SC cavities for injector

- High input power: 170 kW/coupler
- Medium gradient: 15 MV/m
- High beam currents: 100 mA (CW)



High-power RF source

- 1.3 GHz, 300 kW (CW) for injector



High-brightness photocathode DC gun:

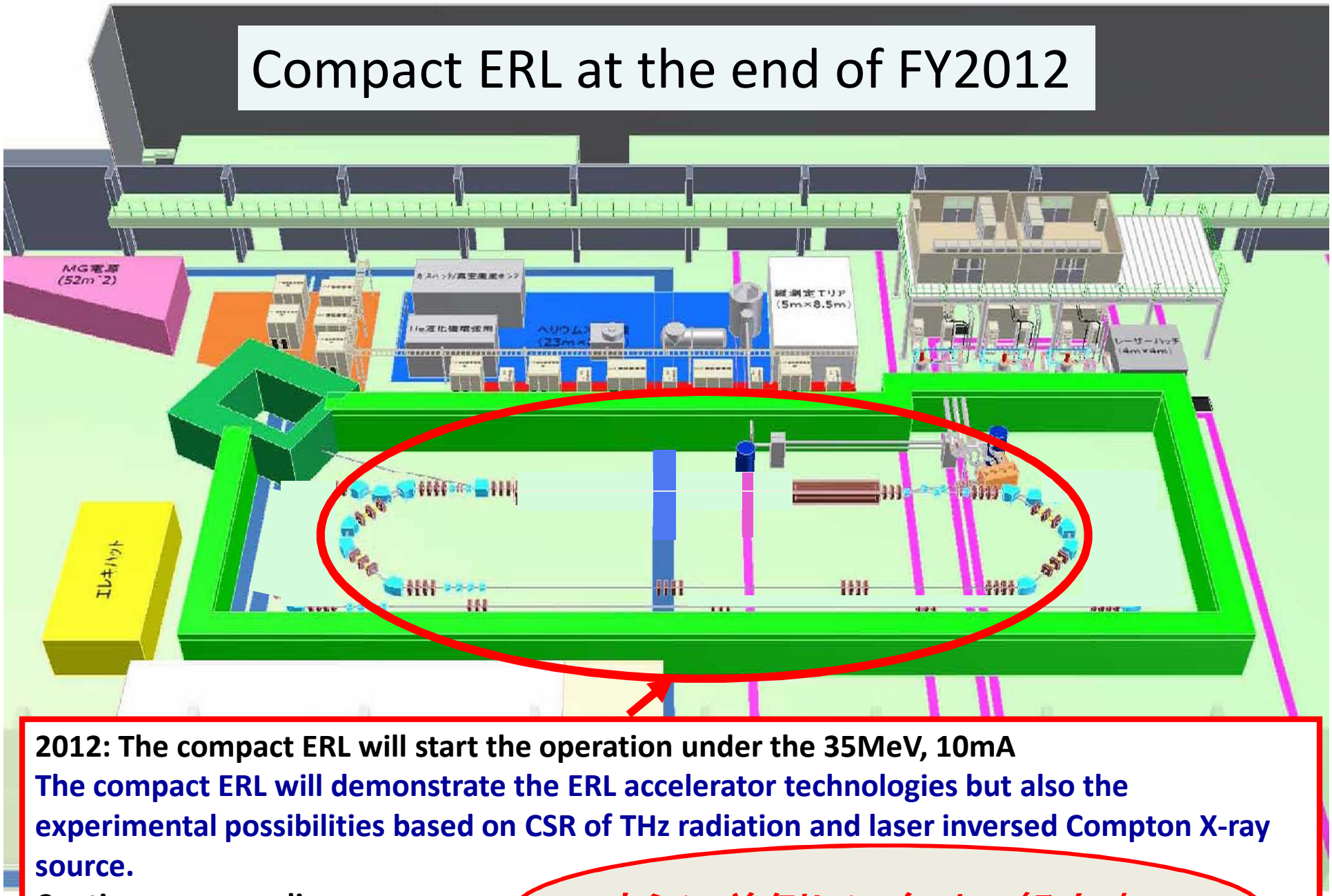
- 500 kV, 10-100 mA
- Normalized emittance: 0.1 - 1 mm·mrad

SC cavities for main linac

- Medium gradient: 15-20 MV/m (CW)
- High average current: 200 mA
- Higher-order-mode damping

Presented by Dr. S. Sakanaka at Light source subcommittee

Compact ERL at the end of FY2012



2012: The compact ERL will start the operation under the 35MeV, 10mA

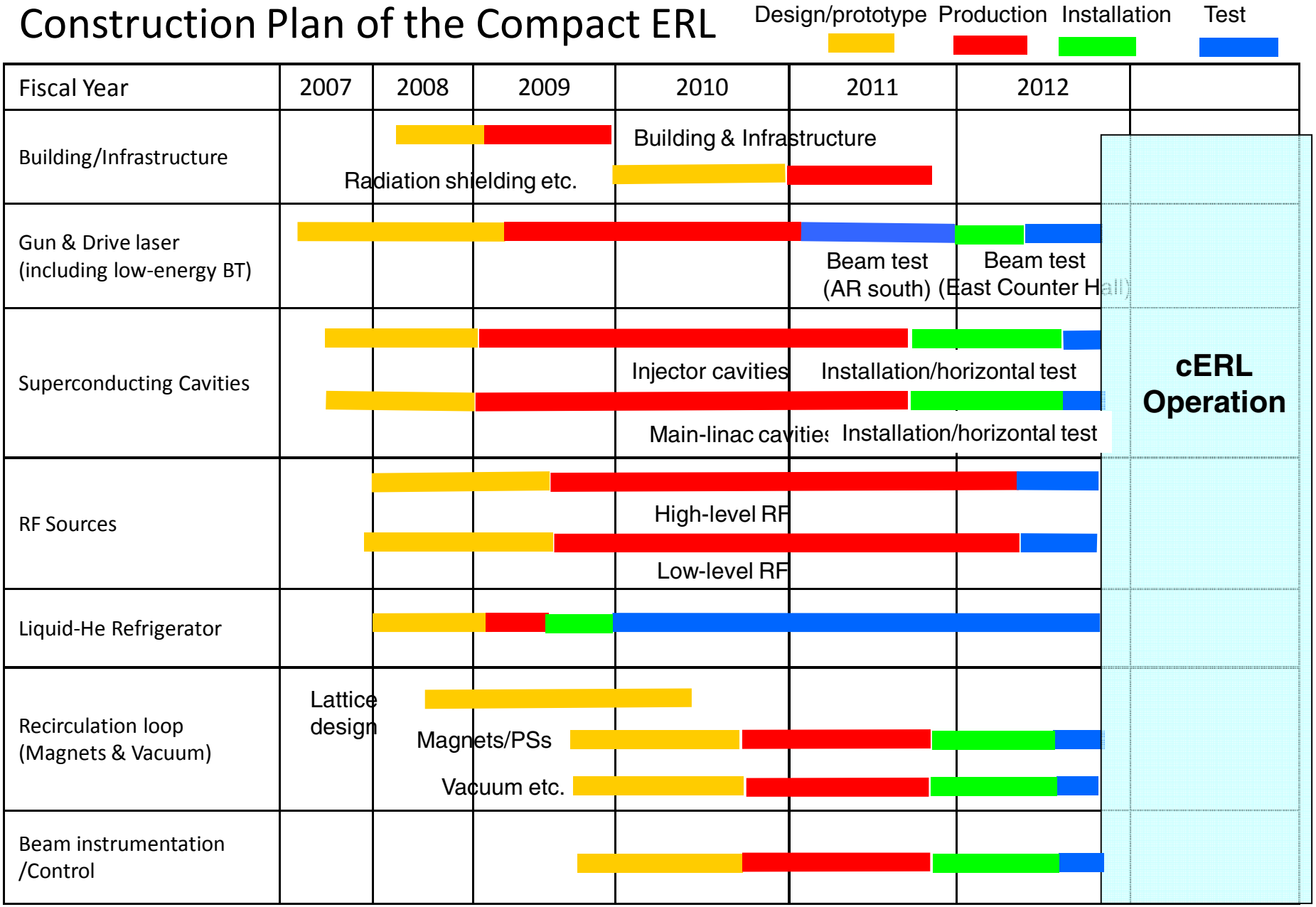
The compact ERL will demonstrate the ERL accelerator technologies but also the experimental possibilities based on CSR of THz radiation and laser inversed Compton X-ray source.

Continuous upgrading:

さらに前倒しに向けて努力中！

Recent View in the East Counter Hall

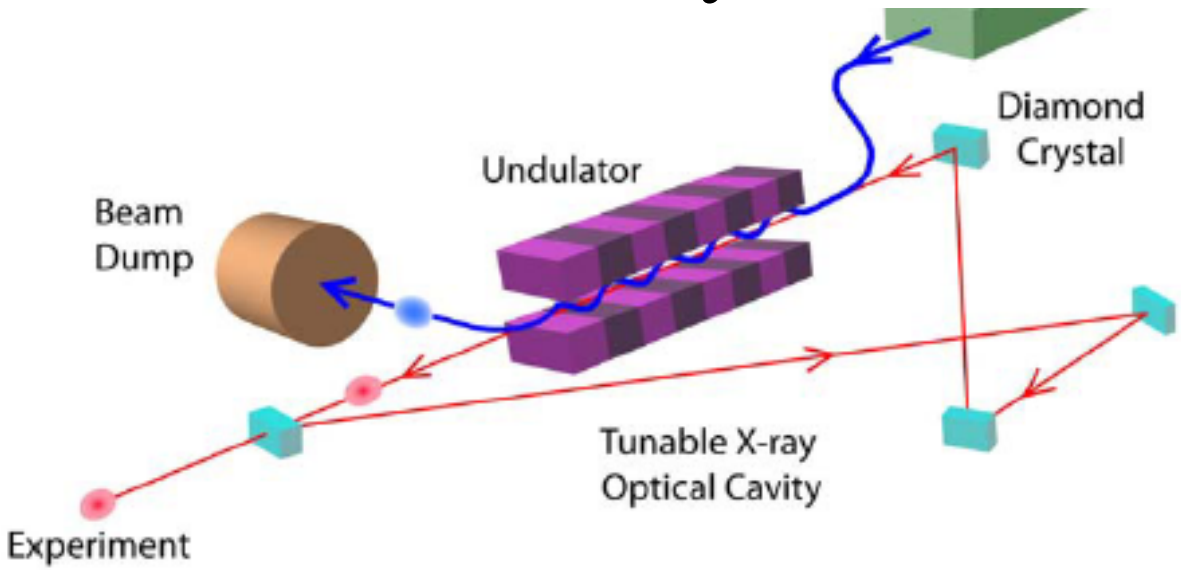
Construction Plan of the Compact ERL



Presented by Dr. S. Sakanaka at Light source subcommittee

Hard X-Ray FEL Oscillator

By Kwang-Je Kim



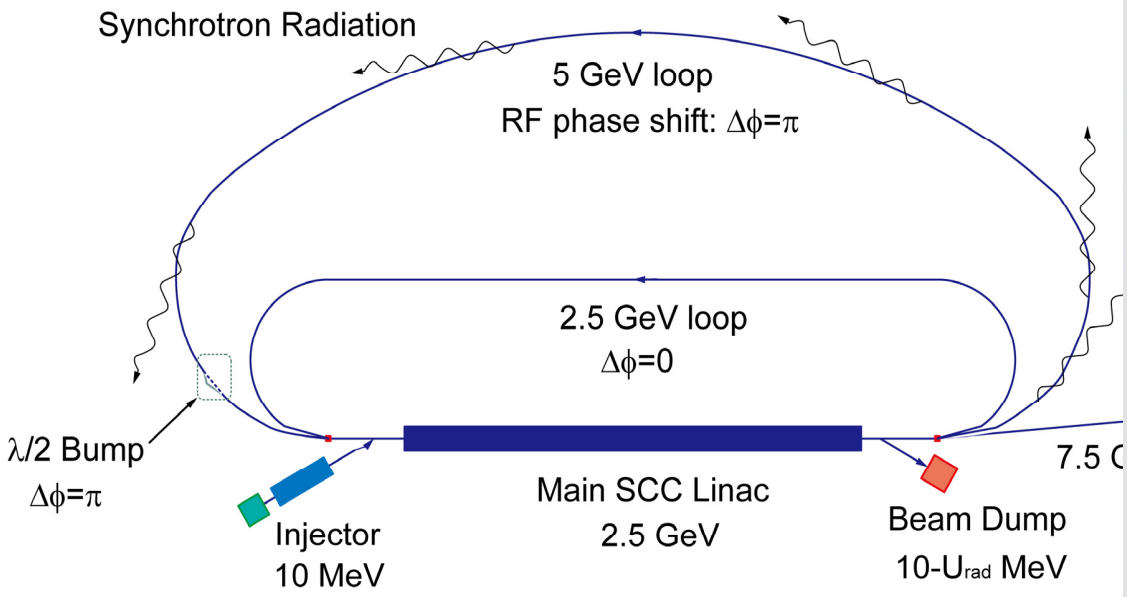
- Store an X-ray pulse in a Bragg cavity→ multi-pass gain & spectral cleaning
- Provide meV bandwidth
- MHz pulse repetition rate→ high average brightness

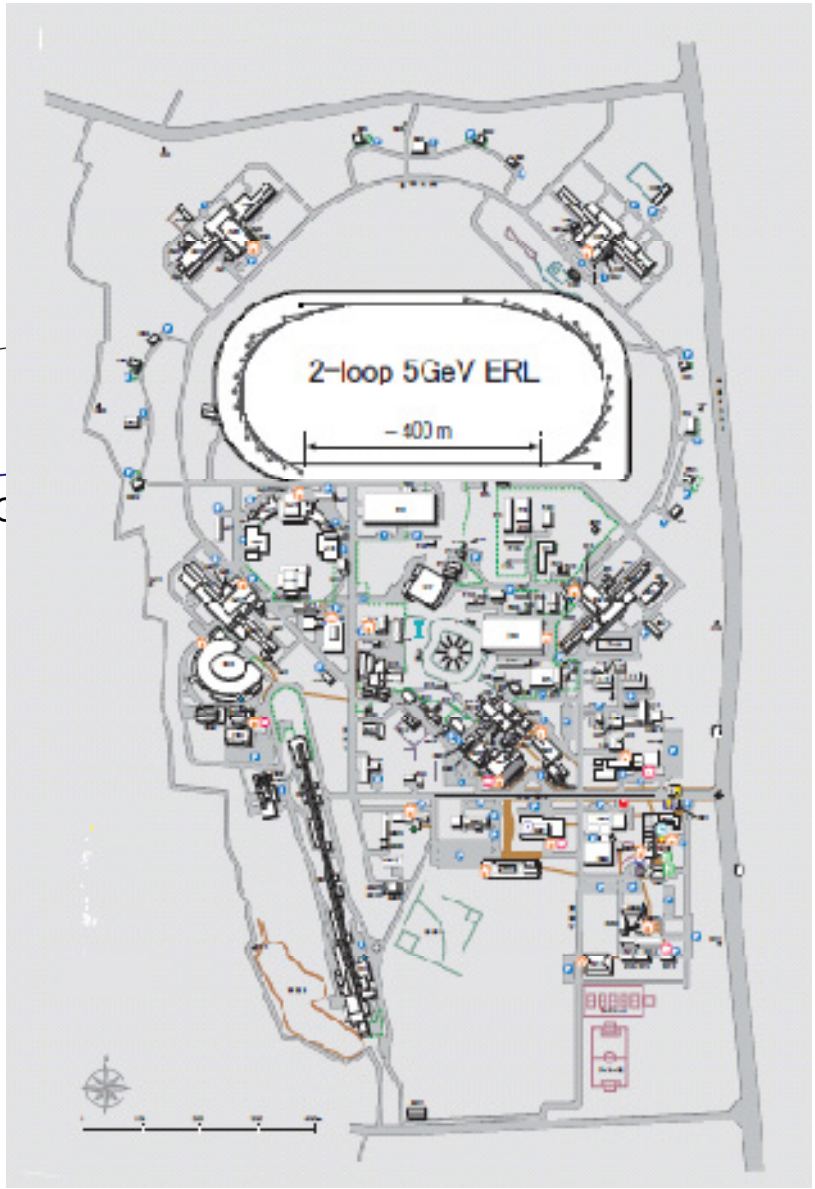
(10^{15} Photons/sec, 10^{9} photons/pulse @ ~10keV with a few meV b.w.)

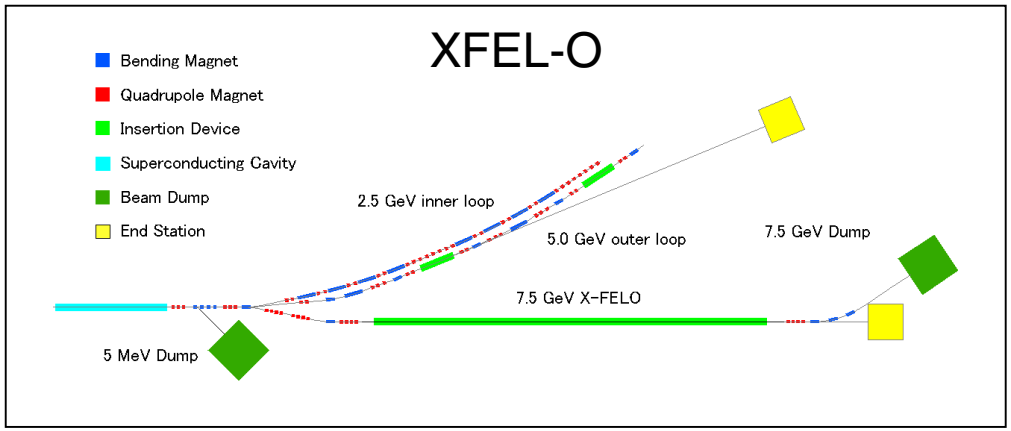
- Zig-zag path cavity for wavelength tuning
- Single mode X-ray laser (time and space domains)

Originally proposed in 1984 by Collela and Luccio and resurrected in 2008 (KJK, S. Reiche, Y. Shvyd'ko, PRL 100, 244802 (2008)

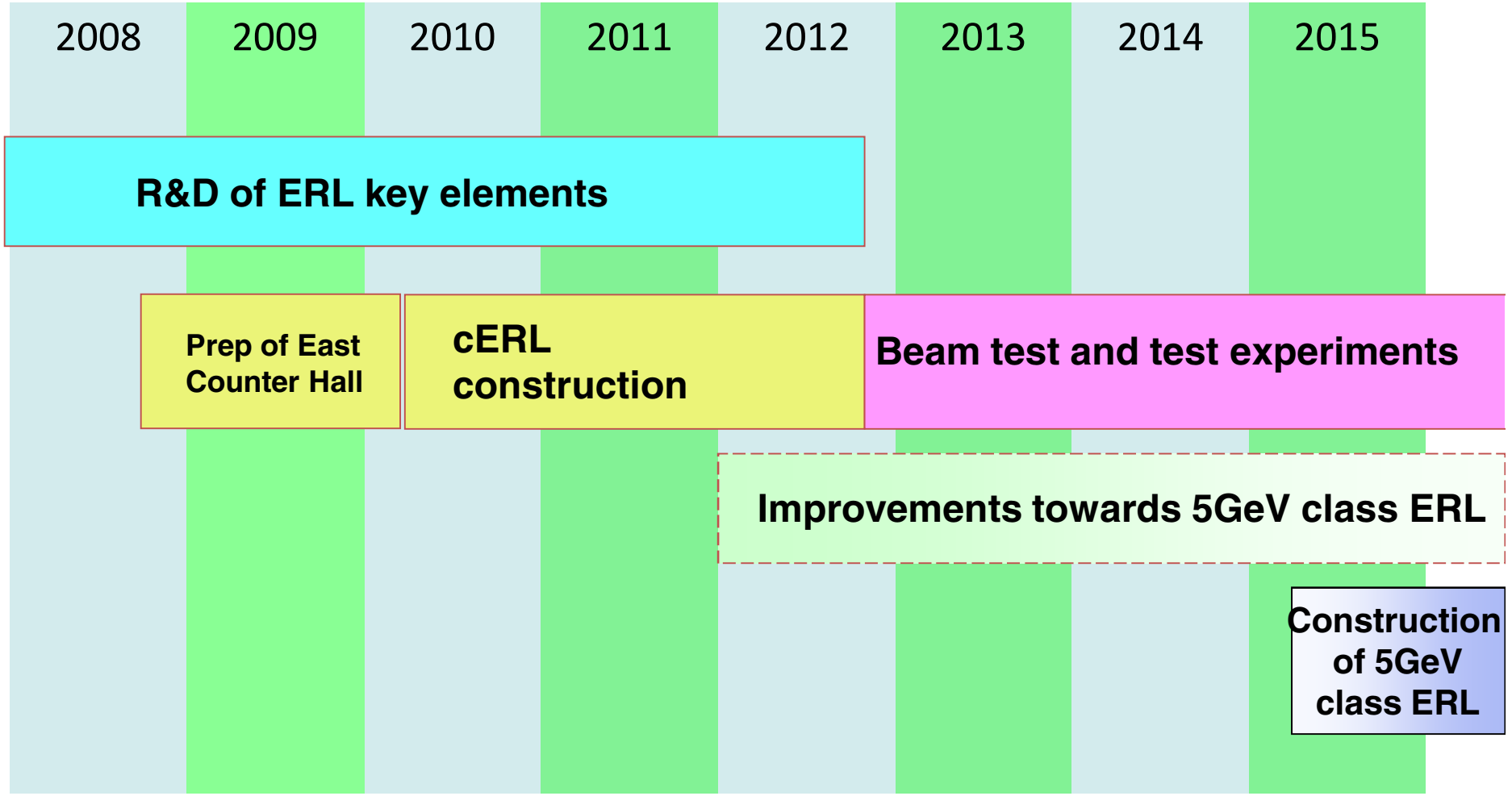
Preliminary Design of 5GeV ERL







cERL, ERL: target timelines



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

まとめ

- 次期放射光源実現に向けてcERLの建設を2009年度から開始。
- 東カウンターホールの整備、インフラ整備（ヘリウム冷凍機、冷却水、電源、一部のRF源整備）は終了。
- 高輝度電子銃、超伝導空洞はR&Dフェーズからの導入機製作フェーズに。
- 2012年度末にcERLの運転を開始し、技術開発を進め、できるだけ早くに5GeVクラスのERL 、XFEL-Oの建設を開始。
- ERLおよびXFEL-Oサイエンスワークショップ（研究会）を積み上げて開催する予定。
- 12月7-8日の物構研シンポジウム（IMSS Symposium)を開催し、XFEL-O の技術開発に関してAPSからYuri Shvyd'koが講演。
- 「あなたの実験はERLでどうなる？（仮題）」の趣旨のPF研究会を現在企画中。

ユーザーの皆様の声をこのプロジェクトの力としていきたいと思っています。