Status of ERL Projects at KEK and JAEA

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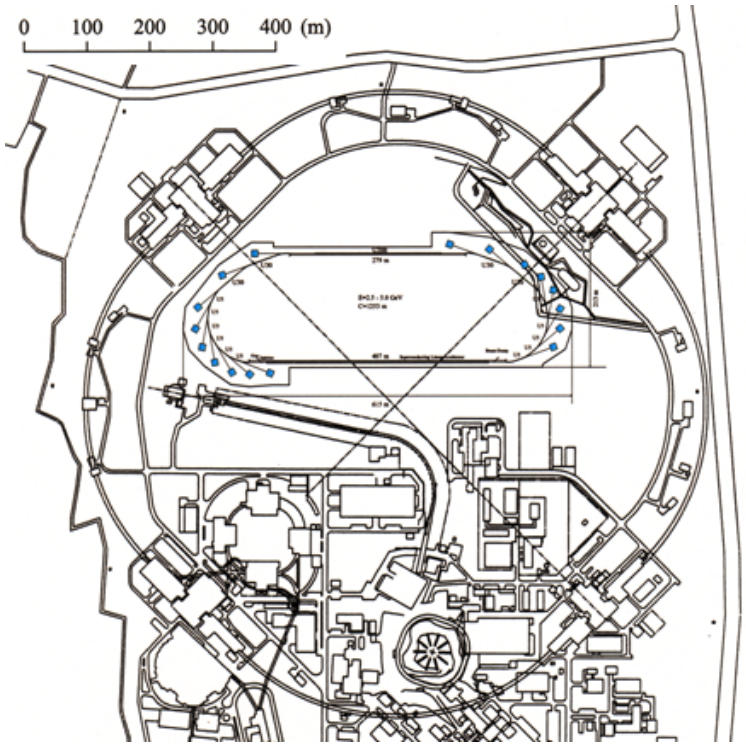
KEK : High Energy Accelerator Research Organization
JAEA: Japan Atomic Energy Agency (formerly, JAERI and JNC)

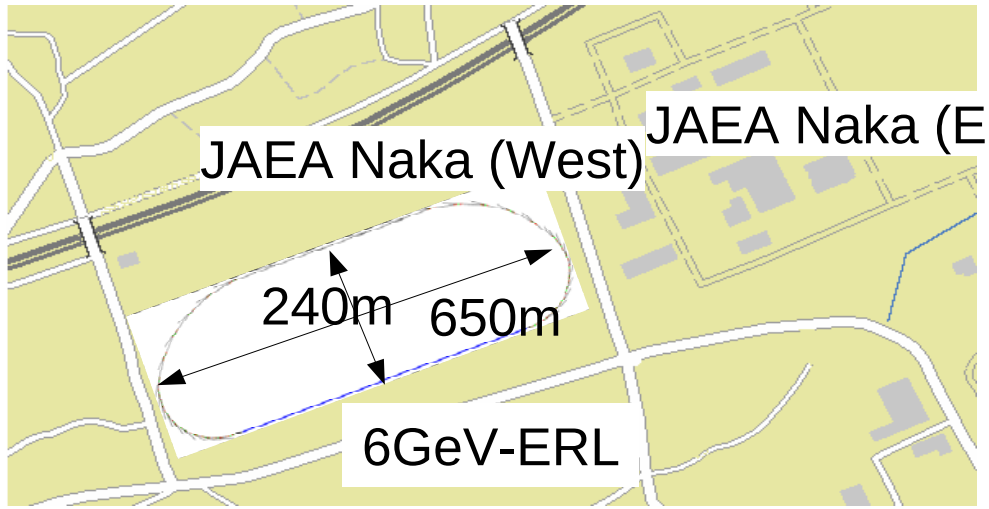
ERL Proposals in Japan

Two Japanese institutes, KEK and JAEA, proposed each own ERL-based synchrotron light source.

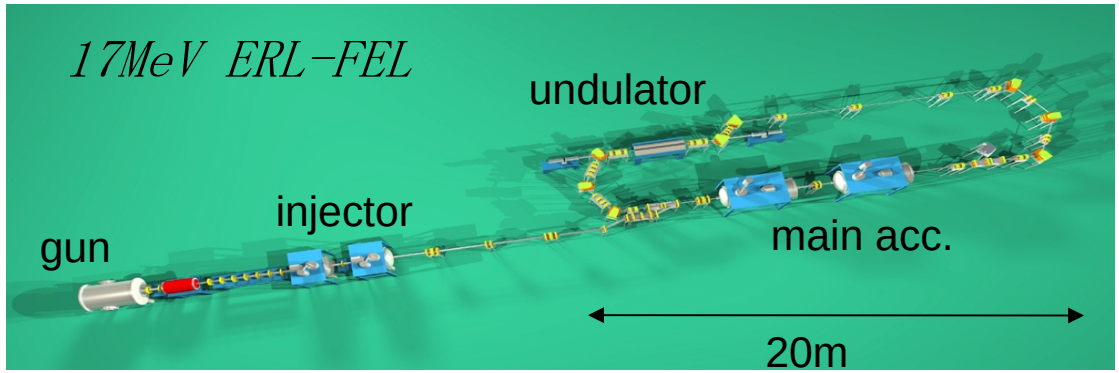
KEK 5GeV ERL at Tsukuba site

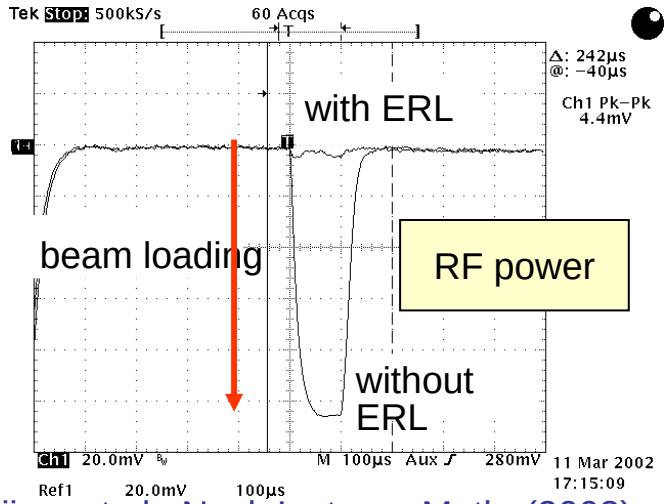


JAEA 6GeV ERL at Naka site

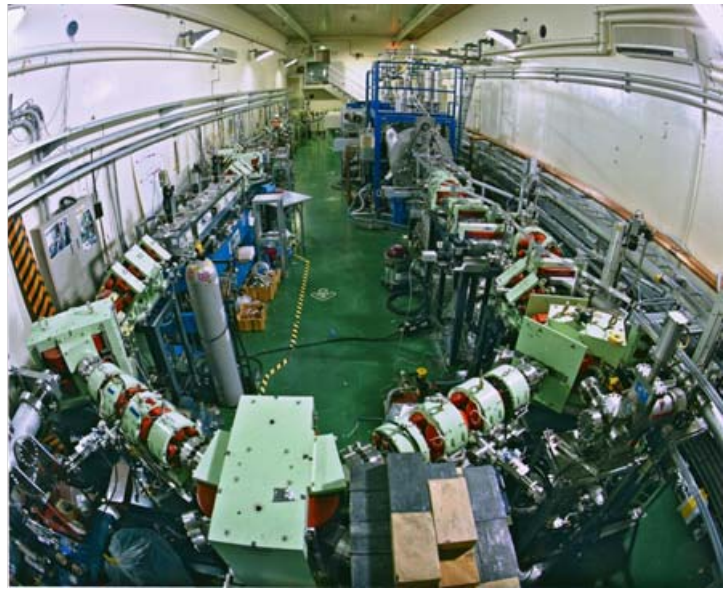


17MeV ERL at JAEA





R. Hajima et al., Nucl. Instrum. Meth. (2003)

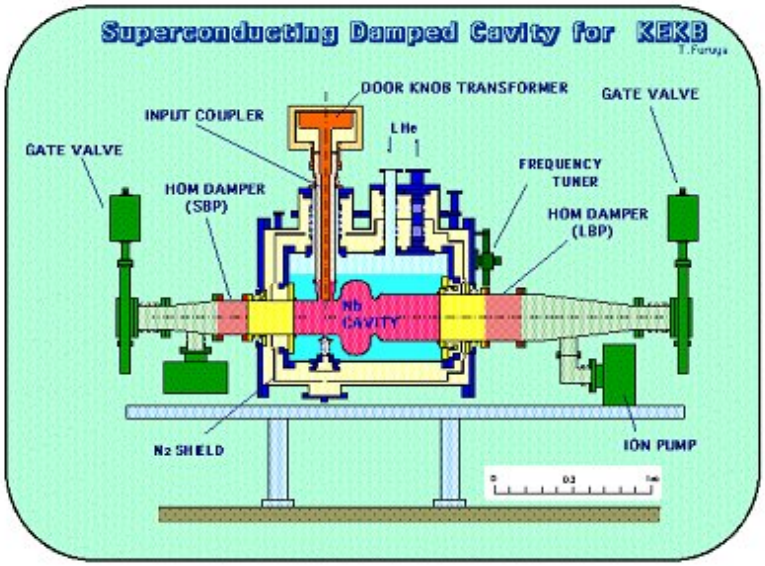


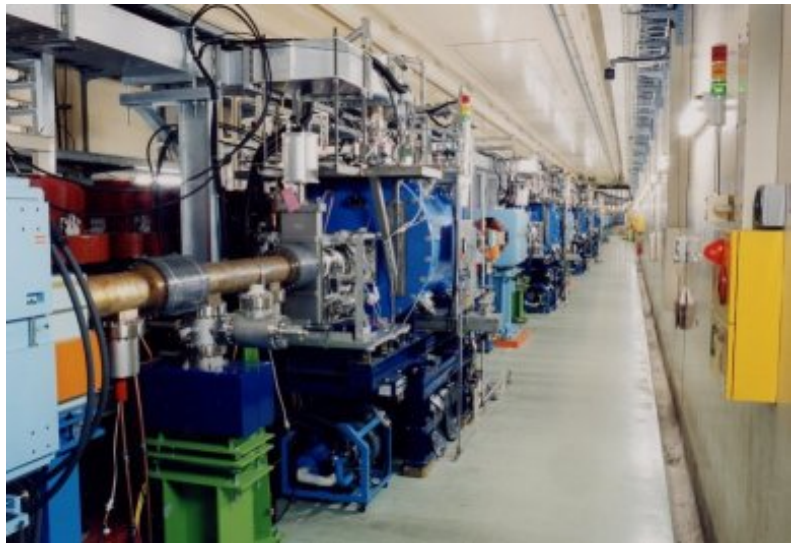
Design, Construction and Operation of the ERL (1999-)

SC-cavity technologies at KEK

Technical Base for the Superconducting (SC) cavities at KEK

- **Fundamental R&D (1973 – 1980)**
- **TRISTAN 509 MHz 5-cell cavities (1980 – 1995)**
- **KEKB 509MHz single-cell HOM free cavity (1991- ; operation 1998 -)**
  Eight single-cell cavities can produce 11 MV under beam currents of 1.35 A.
- **KEKB 509MHz crab cavities (under development)**
- **R&D for L-band structures for the linear collider (ILC)**





Superconducting Damped Cavities for the KEKB (Courtesy: T. Furuya).

Collaboration between KEK and JAEA

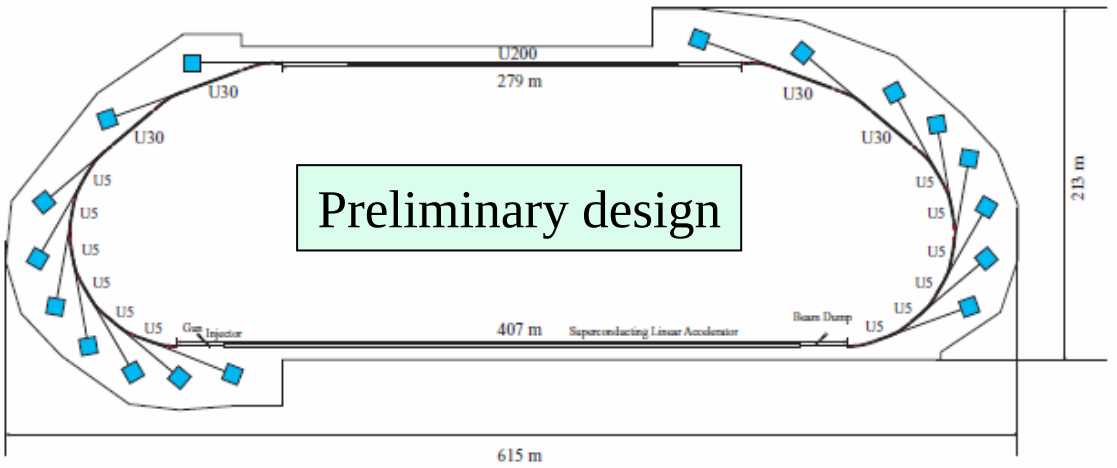
KEK and JAEA agreed to promote an ERL-based next-generation light source in Japan based on their stimulated technologies (March, 2006).

At KEK Photon Factory, extensive discussions on their future project were made with SR users and accelerator physicists in Japan. They came to the conclusion that a 5GeV-class ERL should be the most suitable for their future project.

The promotion of ring-type next-generation light sources (including ERL) is strongly supported by the Japanese Society for Synchrotron Radiation Research (JSSRR).

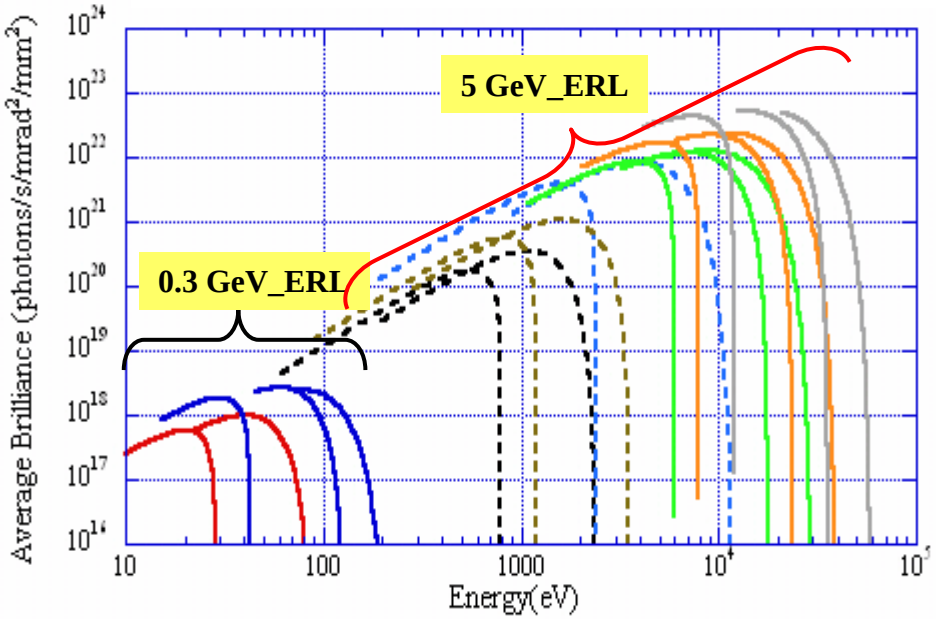
-- Not only FELs, but also cutting-edge ring-type SR sources are essential and urgent (in the report from the special committee of JSSRR).

Target specifications of ERL

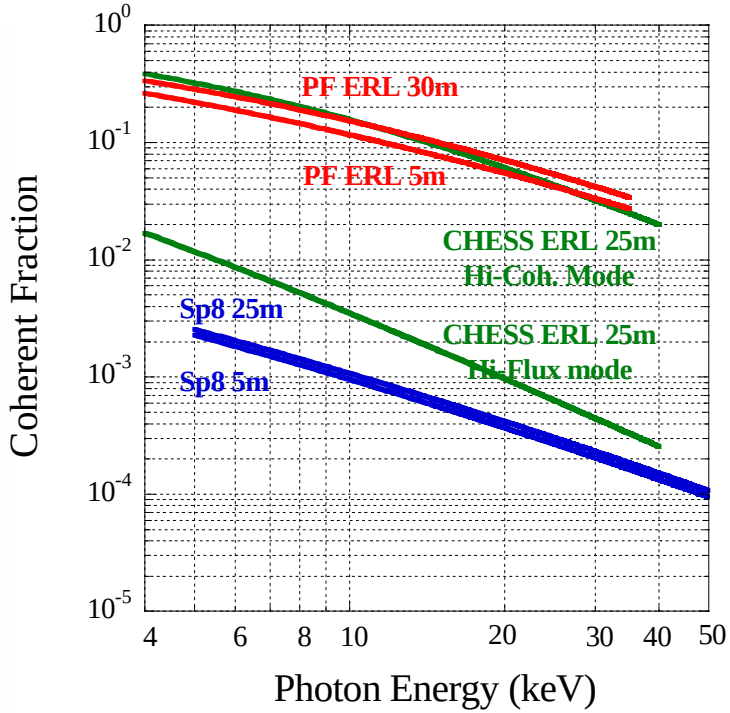


Beam energy	5 GeV
Average current	100 mA
Normalized emittance	0.1 – 1 mm·mrad
Average brilliance (@ 0.1 nm) from ID's	10^{21} – 10^{23} ph/s/0.1%/mm^2/mrad^2
Average flux	> 10^{16} ph/s/0.1%
Spectral range	30 eV – 30 keV
Minimum bunch length	< 100 fs
Number of ID's	20 - 30

Target specifications (cont.)



Average brilliance.



Expected coherent fraction.

KEK-JAEA ERL Test Facility

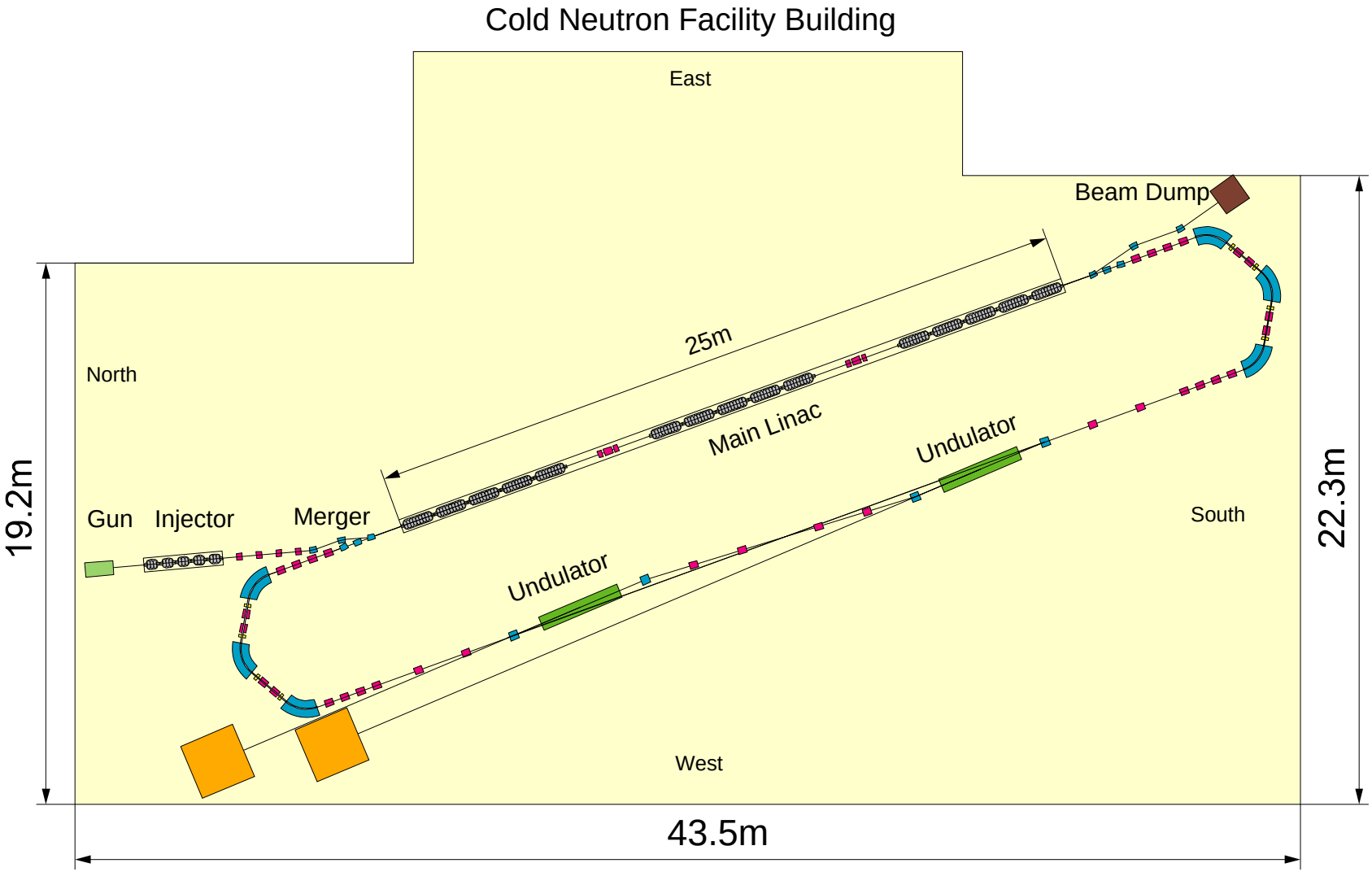
As a first step of their collaboration, KEK and JAEA started to develop key technologies for the ERL, and are planning to construct together an ERL test facility at KEK site.

We are also promoting cooperation with the other Japanese SR facilities, SPring-8, UVSOR, and ISSP (U. Tokyo), to organize an R&D team.

Tentative parameters of the ERL test facility

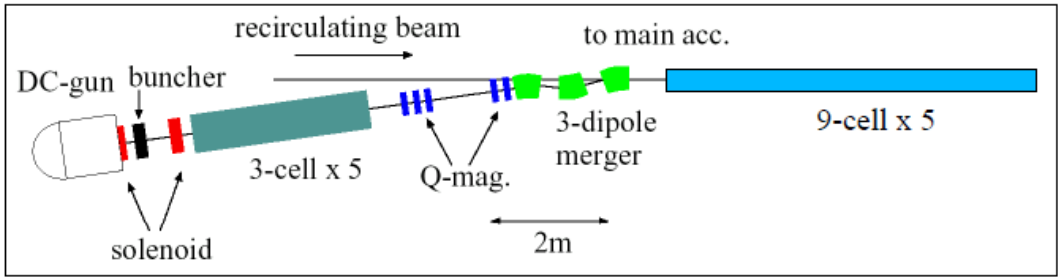
Beam current	100 mA
Injection energy	5 MeV (up to 15 MeV at lower currents)
Beam power at injector	500 kW
Normalized emittance	1 – 0.1 mm·mrad (initially, larger)
Beam energy at main linac	60 – 200 MeV (increase step by step)
Bunch length (rms)	~ 100 fs (short bunch mode)

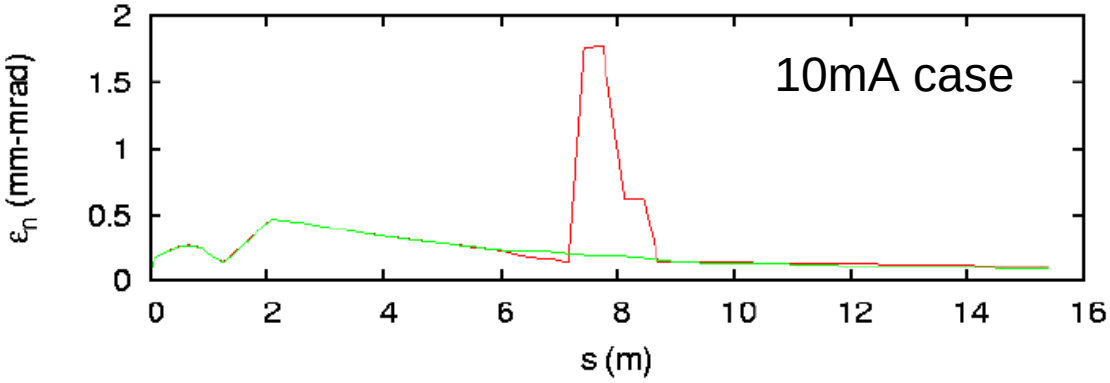
KEK-JAEA ERL Test Facility (cont.)



Preliminary plan of ERL test facility at KEK.

Design of Injector (tentative)





500kV gun, 5MeV injection

normalized emittance
1mm-mrad for 100mA
0.1mm-mrad for 10mA

R. Hajima et al., NIM-A557, 103-105 (2006)

We are optimizing our design further.

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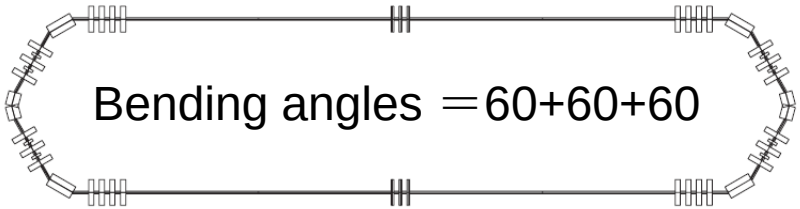
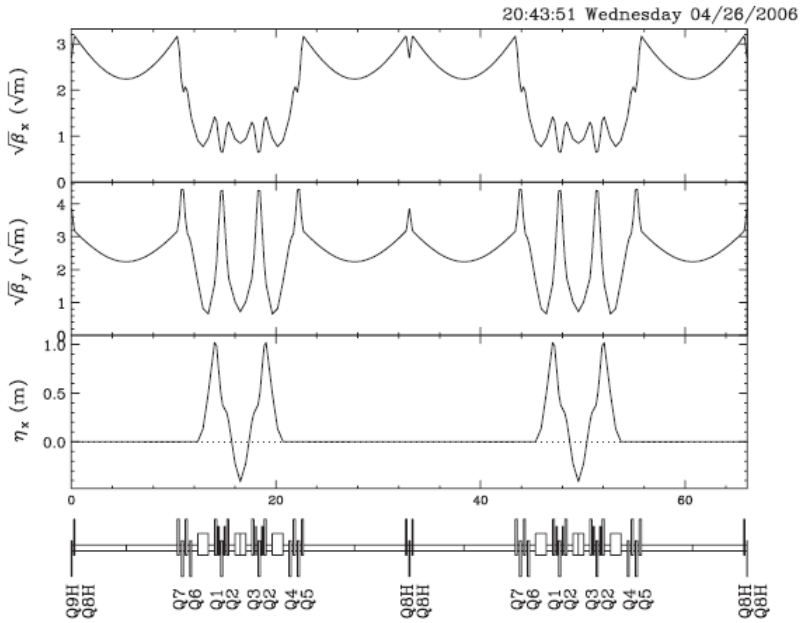
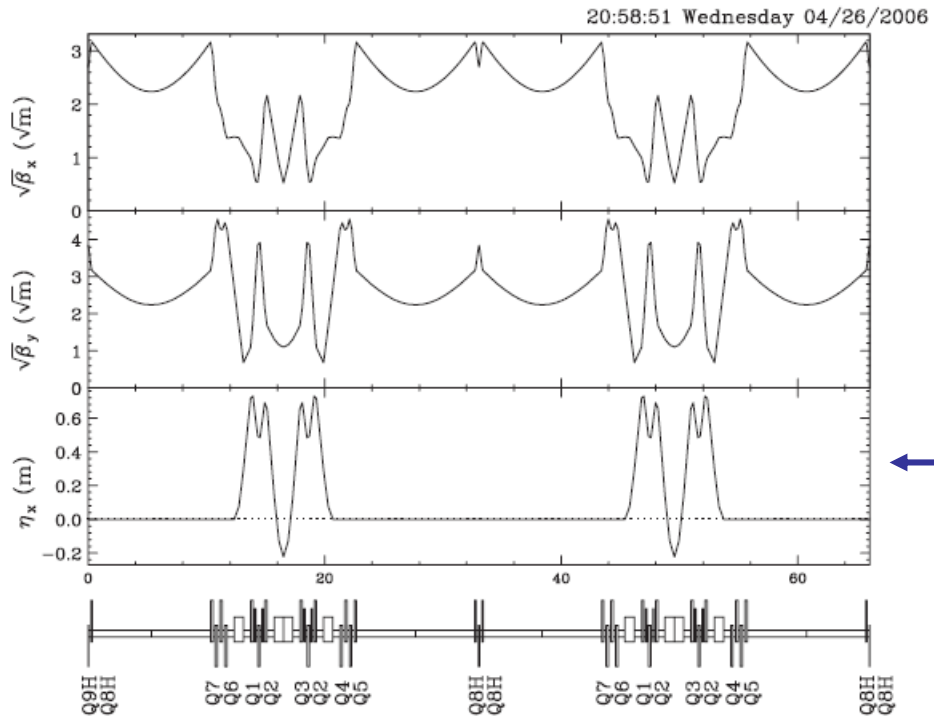
250 kV gun + 240 kW injector:

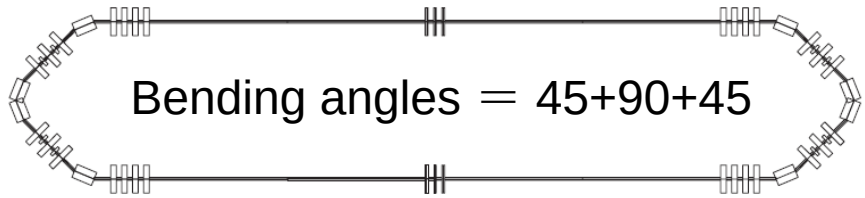
250kV gun, 12MeV injection → 10mA, 0.2mm-mrad
250kV gun, 4.5MeV injection → 50mA, 1.3mm-mrad

Preliminary Design of Return Loop









Principal R&D Issues at the Test Facility

- Establish key technologies.
  - Low-emittance electron gun and cryomodules.
- ERL operations at high currents of 100 mA.
  - Test of cryomodules, BBU, beam losses, etc.
- Production of ultra-low emittance beams.
  - Space charge effect, wakefields, ions, CSR, etc.
- Production of ultra-short bunches of ~100 fs.
- Beam stability (energy, position) required for the light sources.

R&D Status: Low-emittance Gun (JAEA)

average current > 100mA

normalized emittance < 0.1mm-mard

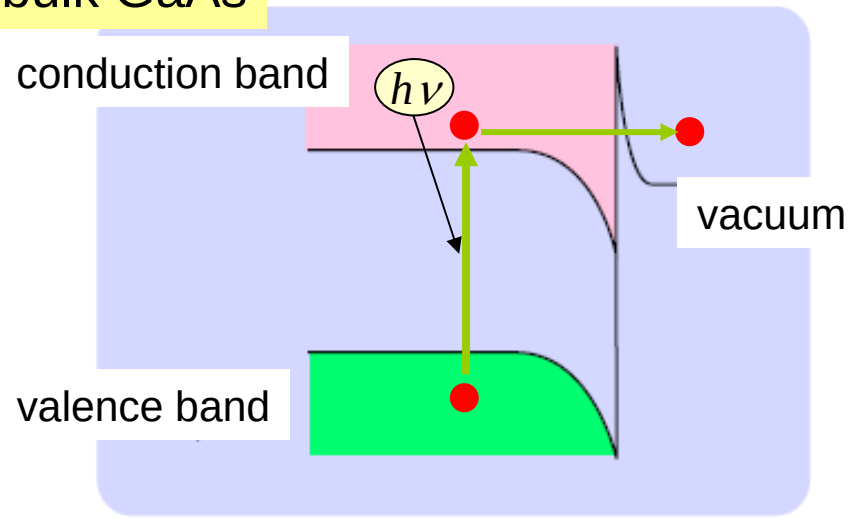
DC gun with NEA-GaAs cathode (most promising)

Strategy for gun development

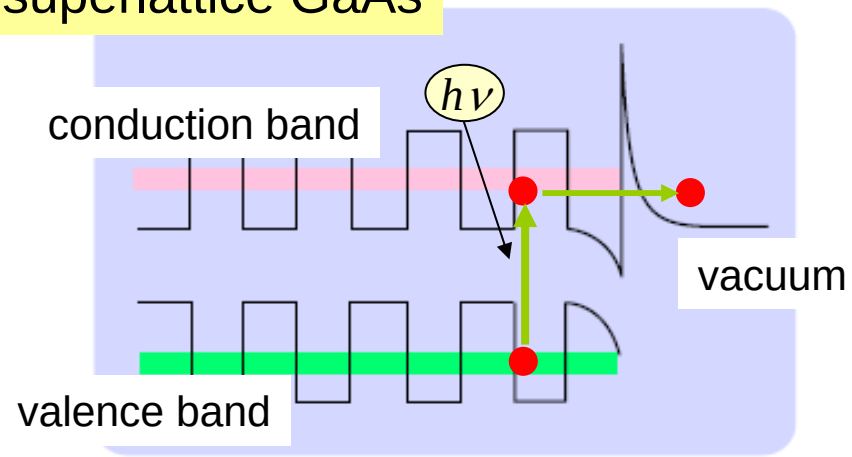
- Superlattice GaAs photocathode (Dr. Nishitani, JAEA)
  - quantum confinement effects
  - high-average current and small emittance
  - collaboration with Nagoya Univ.
- DC gun
  - 250-kV, 50mA gun (making full use of property of JAEA-FEL)
  - ultra-high vacuum for a long-life cathode
  - load-locked cathode preparation

Superlattice GaAs

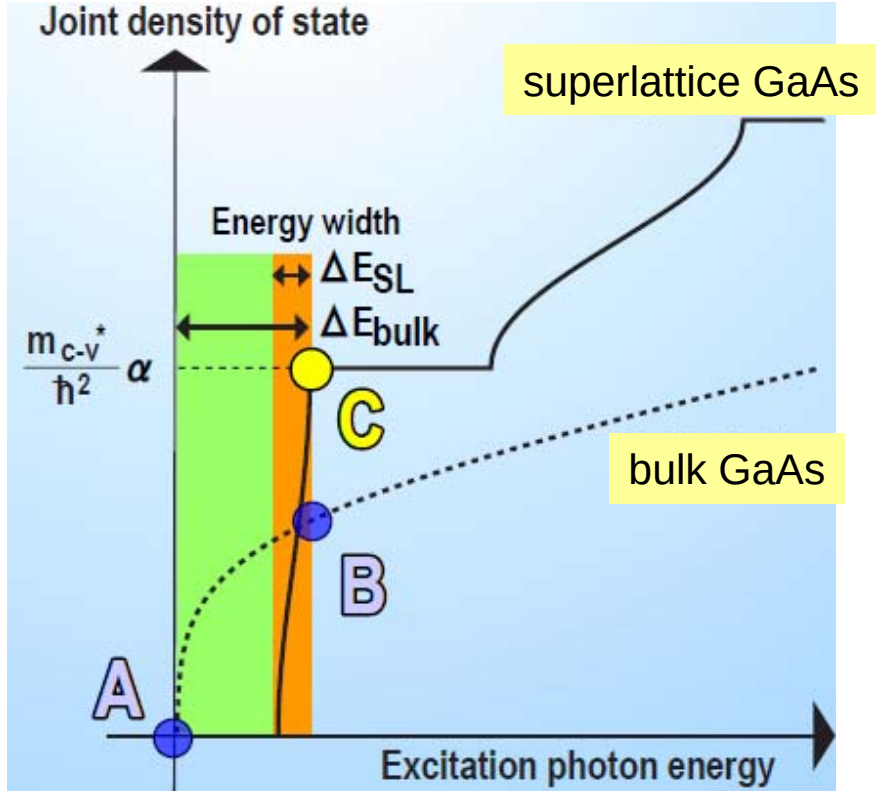
bulk GaAs



superlattice GaAs



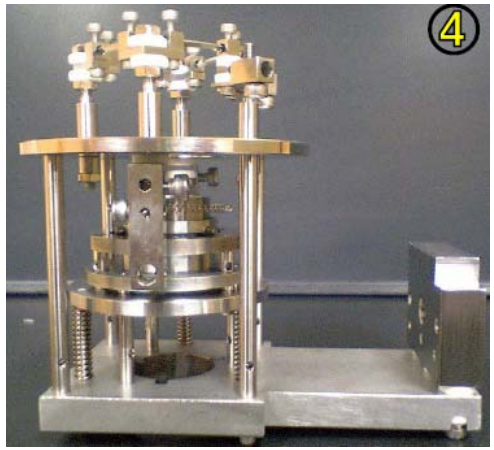
T.Rao et al., NIM-A 557 (2006) 124–130



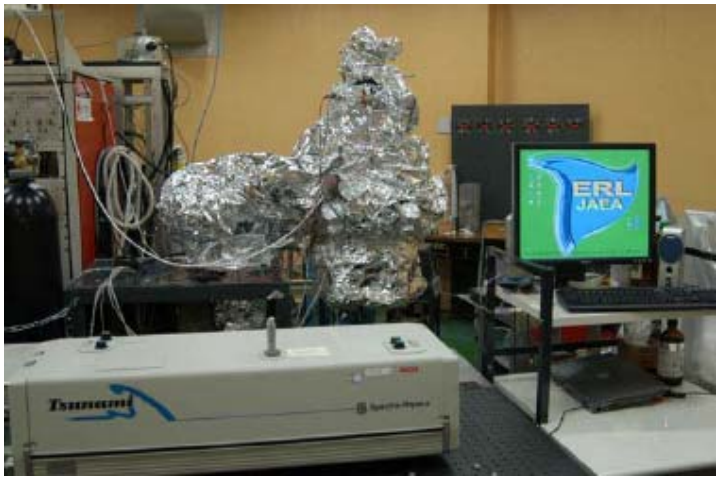
	Q.E.	emittance
A	low	small
B	high	large
C	high	small

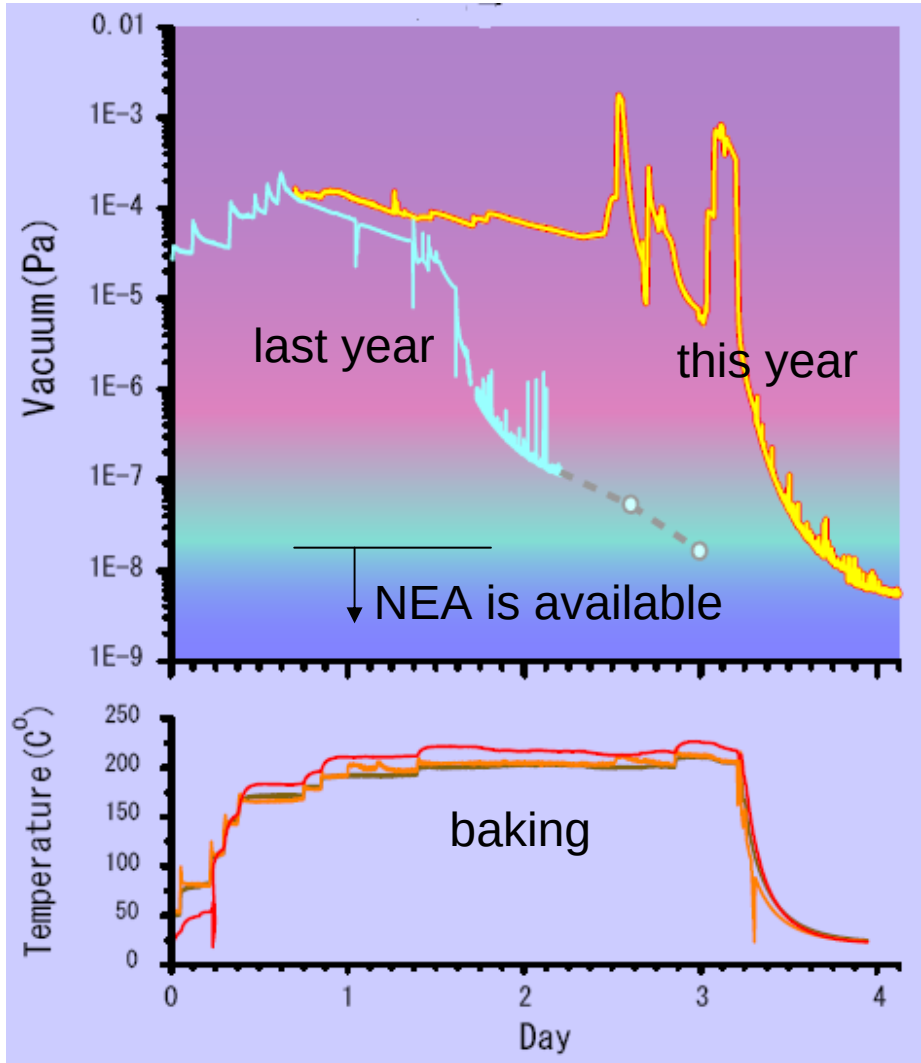
Photocathode Test Bench

cathode holder



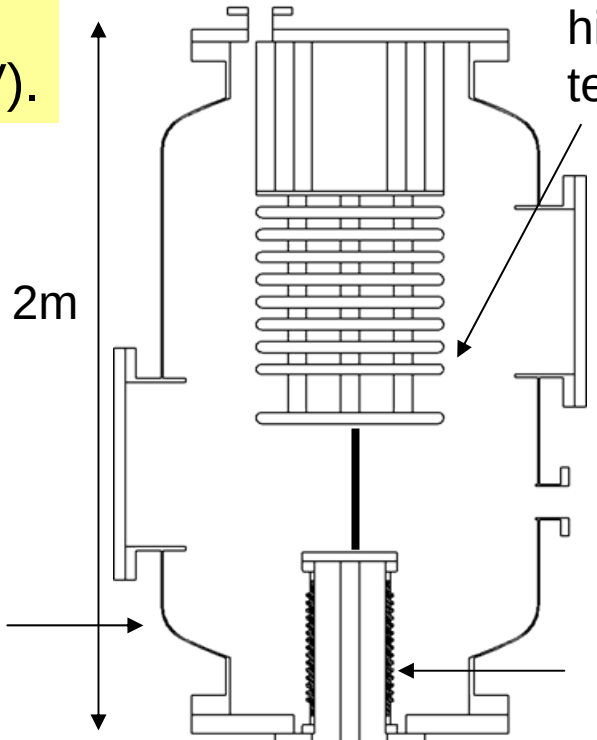
UHV chamber and laser

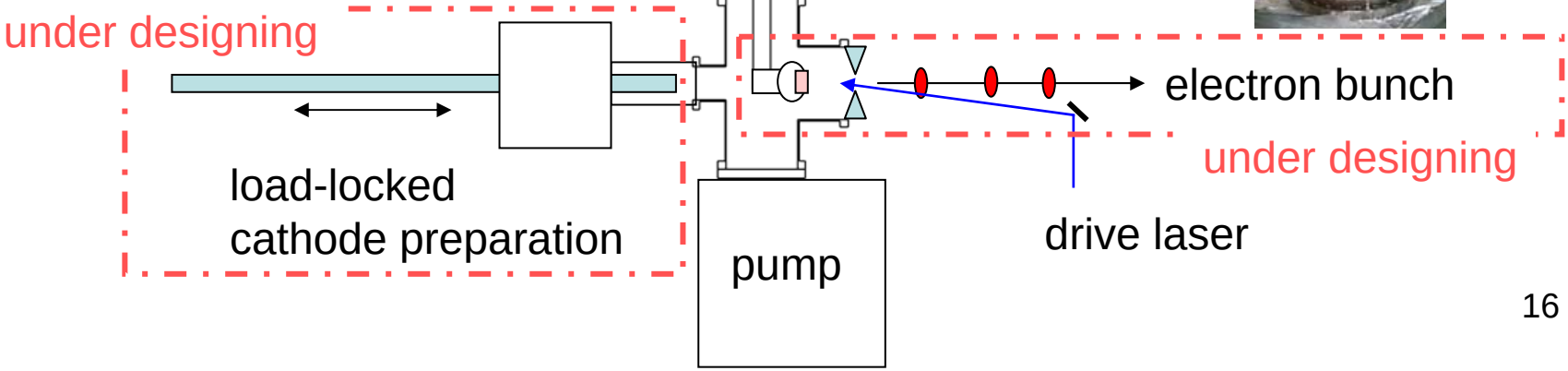




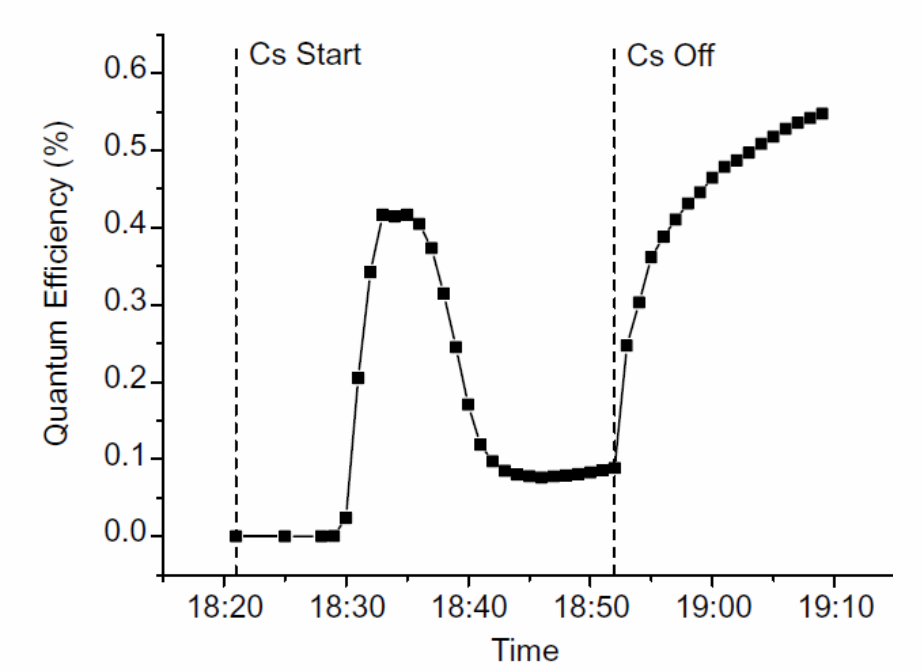
Development of a DC gun

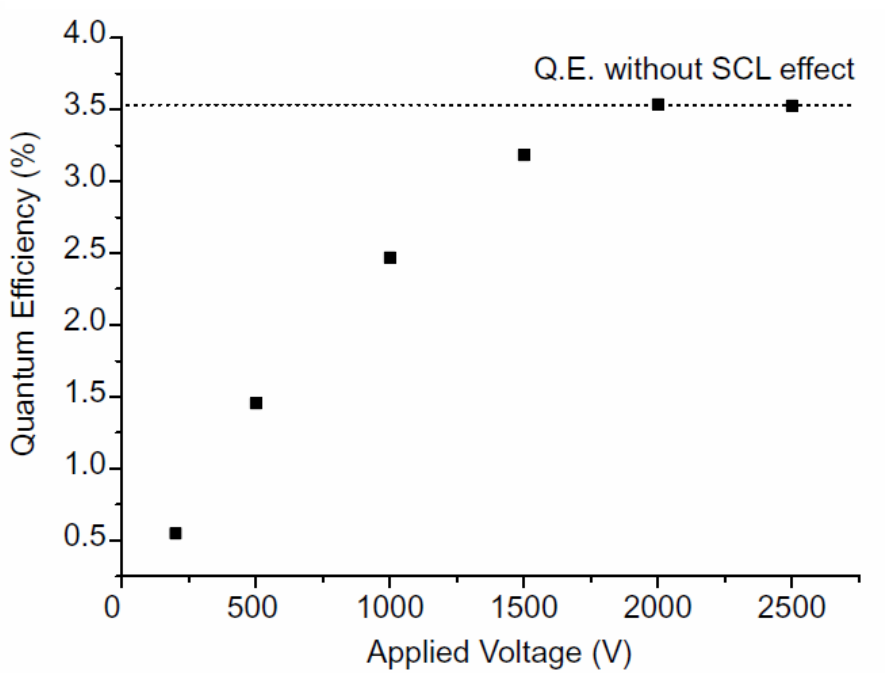
high-voltage test
was completed (245kV).





1st photo-electrons from a NEA-GaAs



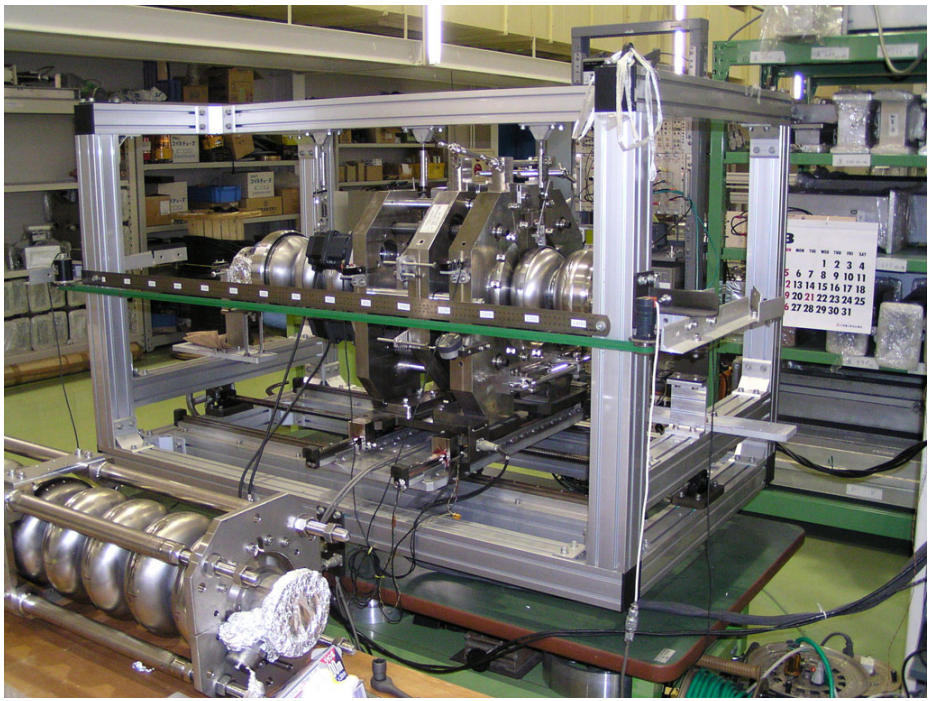


1st photo-electrons from a NEA-GaAs cathode (Feb.27, 2006).

bulk GaAs was used as a reference.

R&D Status: Superconducting Cavities (KEK)

- R&D team has just organized.
- Close collaboration with Superconducting Test Facility (STF) team at KEK.



Developing SC-cavities for the STF (courtesy, S. Noguchi).

Conclusions

The KEK Photon Factory has decided to promote a 5GeV-class ERL for their future project.

KEK and JAEA agreed to develop key technologies together for the ERL-based next-generation light sources.

These movements are welcomed by the user community including the JSSRR (Japanese Society for Synchrotron Radiation Research).

R&D efforts on the key technologies, as well as the design of ERL test facility, have started at KEK and JAEA under a collaboration with the other Japanese SR facilities.

We hope to promote collaborations with foreign institutes.