Polarized electron update in Japan

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Outline

- 200kV electron source development
- 500kV electron source development
- Summary

The team of 200kV pol.e^- source development in Japan

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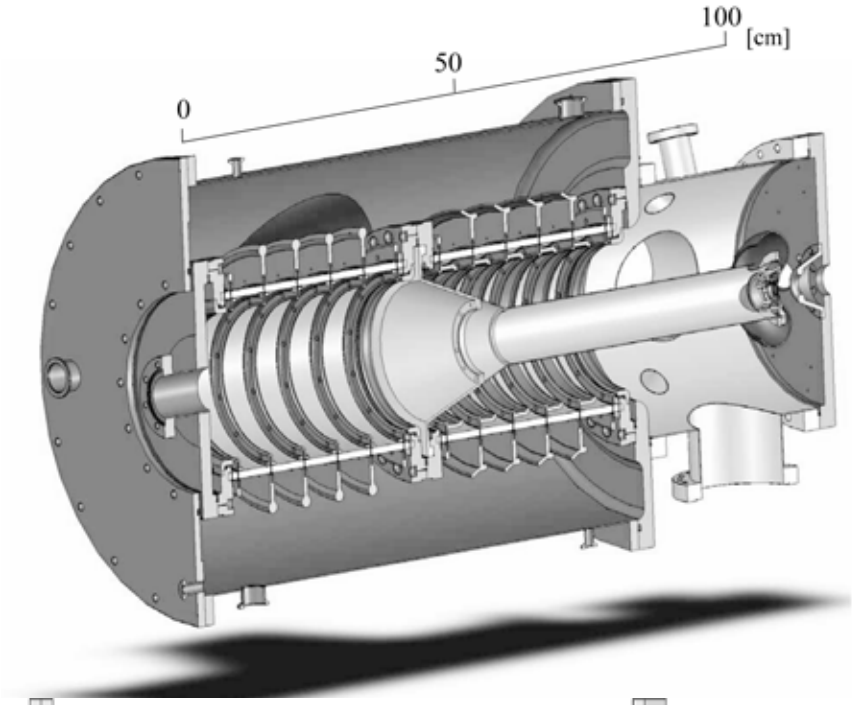
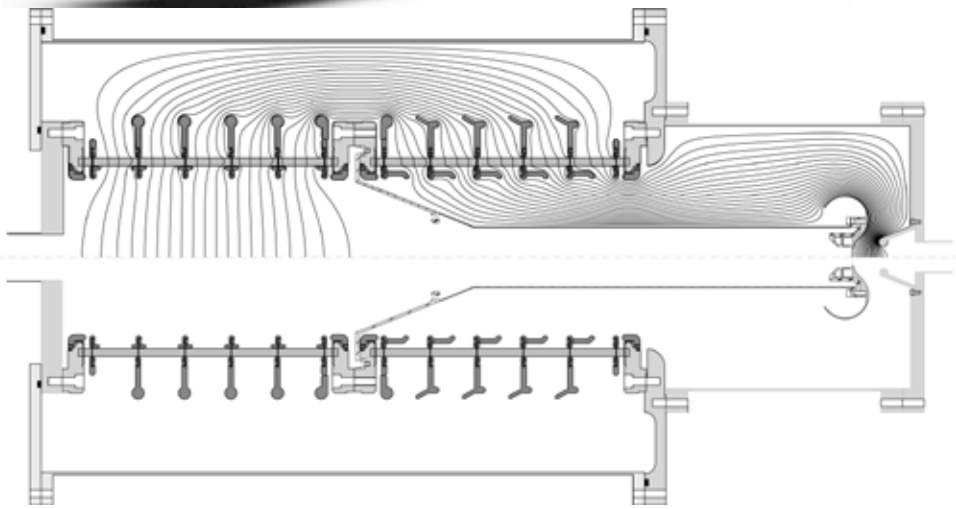
Daido Institute of Technology
T. Saka

Daido Steel Co. Ltd.
T. Kato

200kV gun basic performance



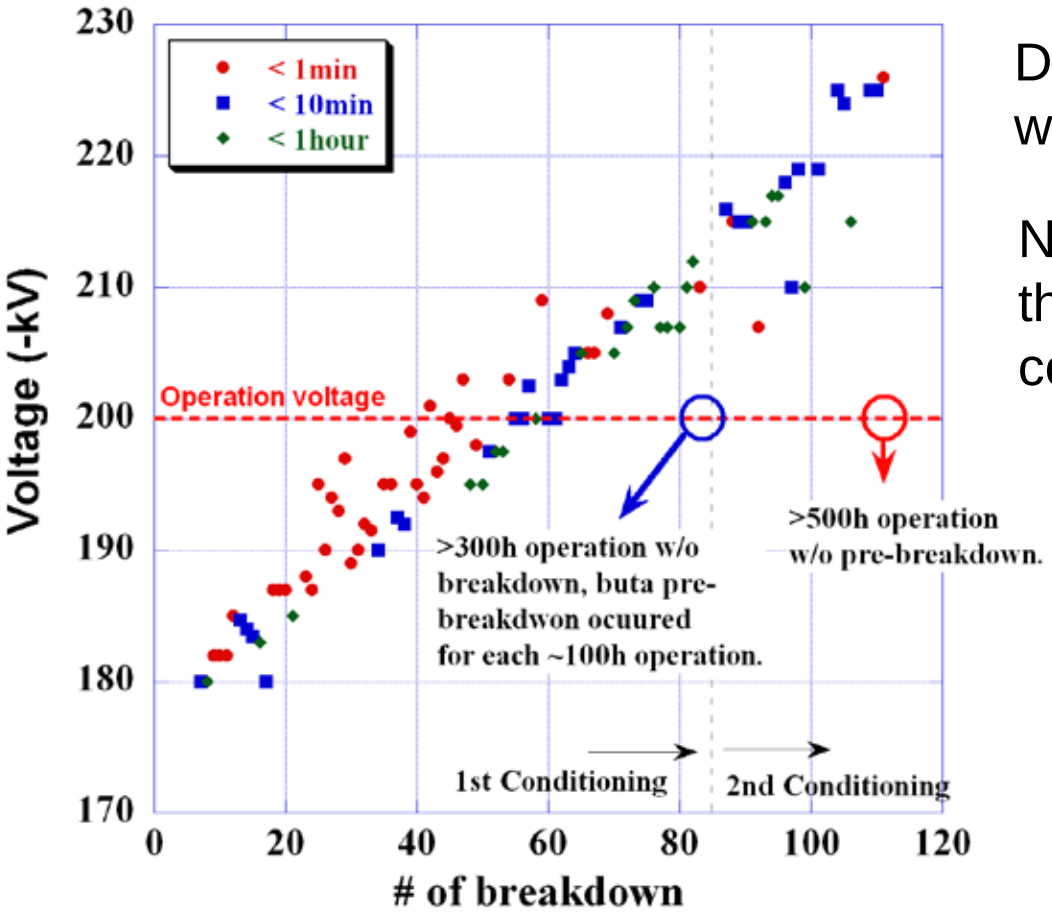


Base pressure: 2×10^{-9} Pa
200 baking for >100 hours
360 L/s IP, 850 L/s NEG
Maximum field gradient (200kV):
7.8MV/m (Cathode)
3.0MV/m (Photocathode)

<u>Electrode</u>
Cathode: Molybdenum (>99.6%)
Anode: Titanium (JIS-grad 2)
Finishing: electro-buff polishing

<u>Ceramic</u>
Dividing five segments w/ guard rings.
(to avoid field concentration)
500MΩ connection for each
<0.3MV/m for each segment at the junctions

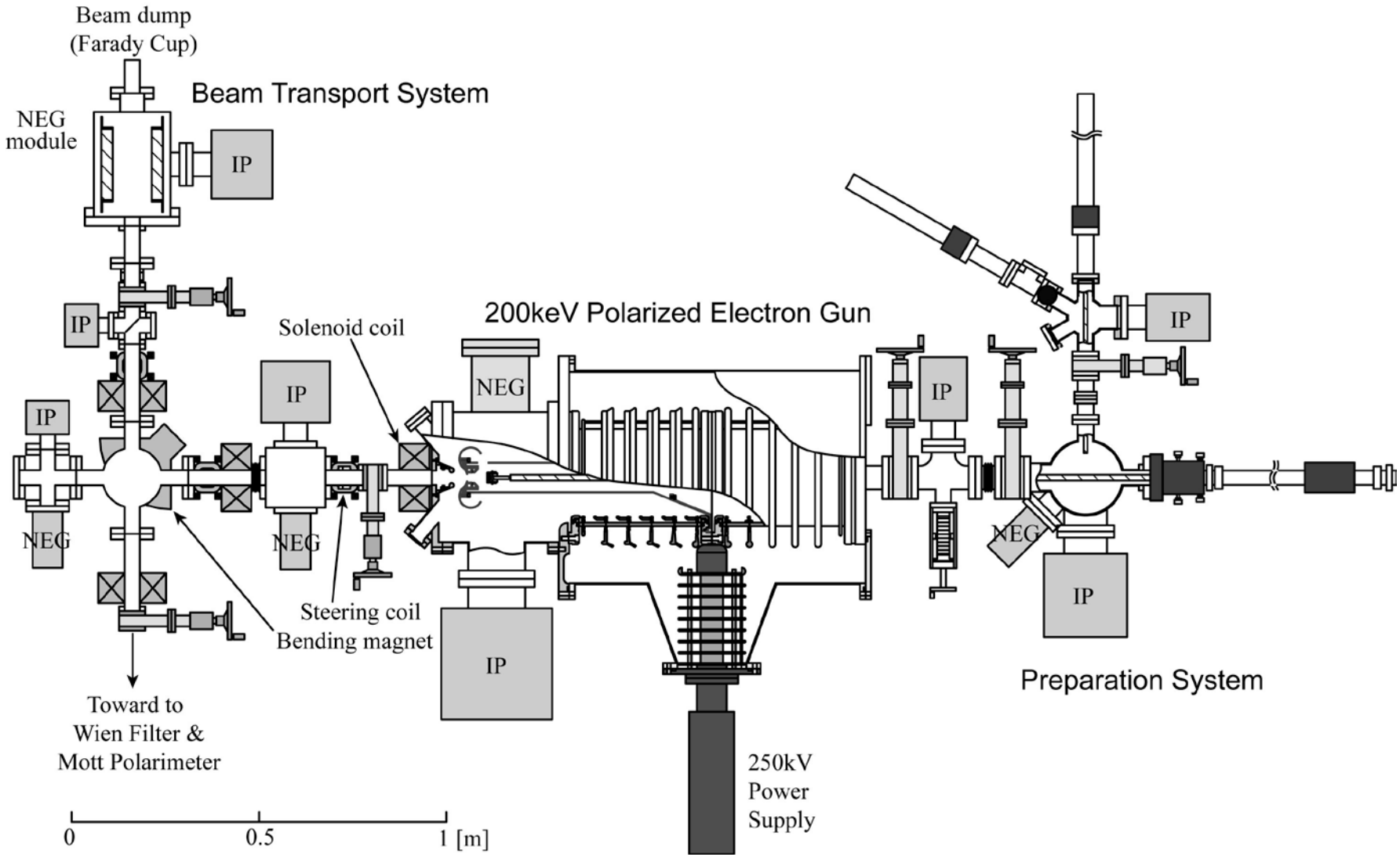
Mo(cathode)-Ti(anode) Electrode Conditioning History



Discharging electrode conditioning was done in UHV condition.

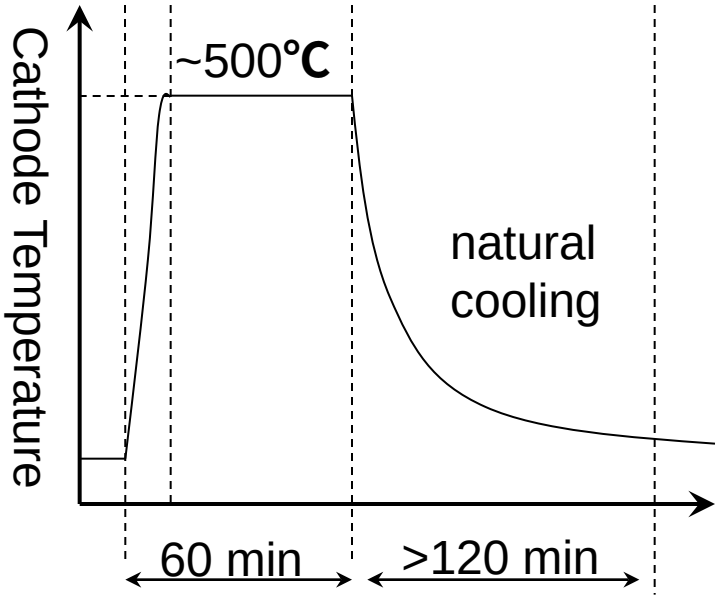
No pre-breakdown occurred more than 500 hours after 225kV conditioning

200kV polarized electron source

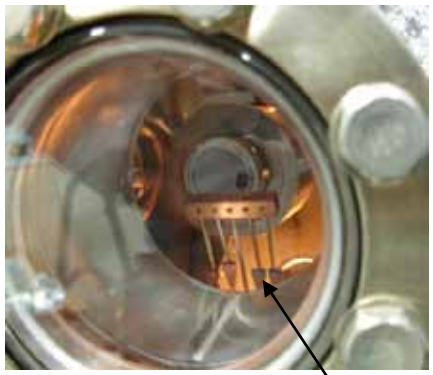


Cathode activation

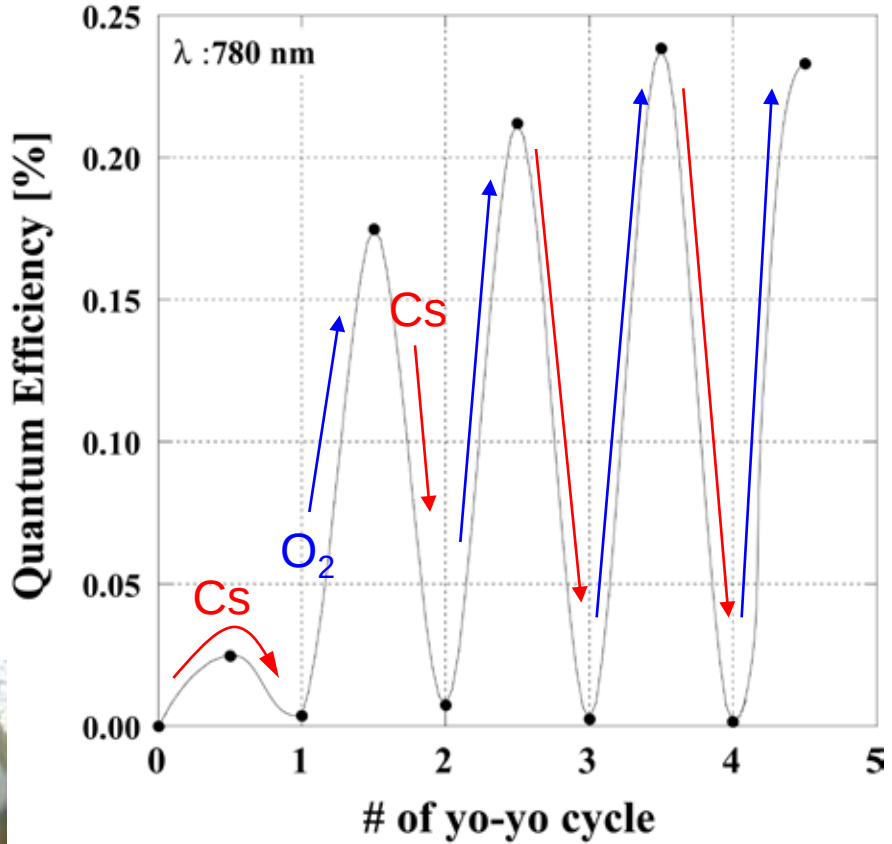
Heat cleaning process



heat cleaning ~500C 1h.



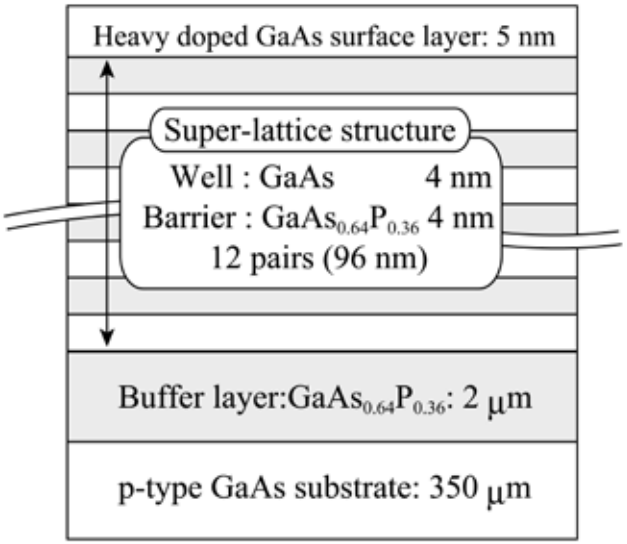
NEA activation process

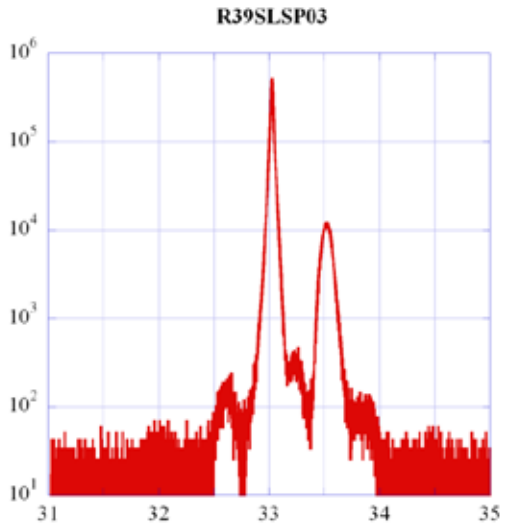


GaAs-GaAsP superlattice photocathode
(f 23mm special shaped substrate)

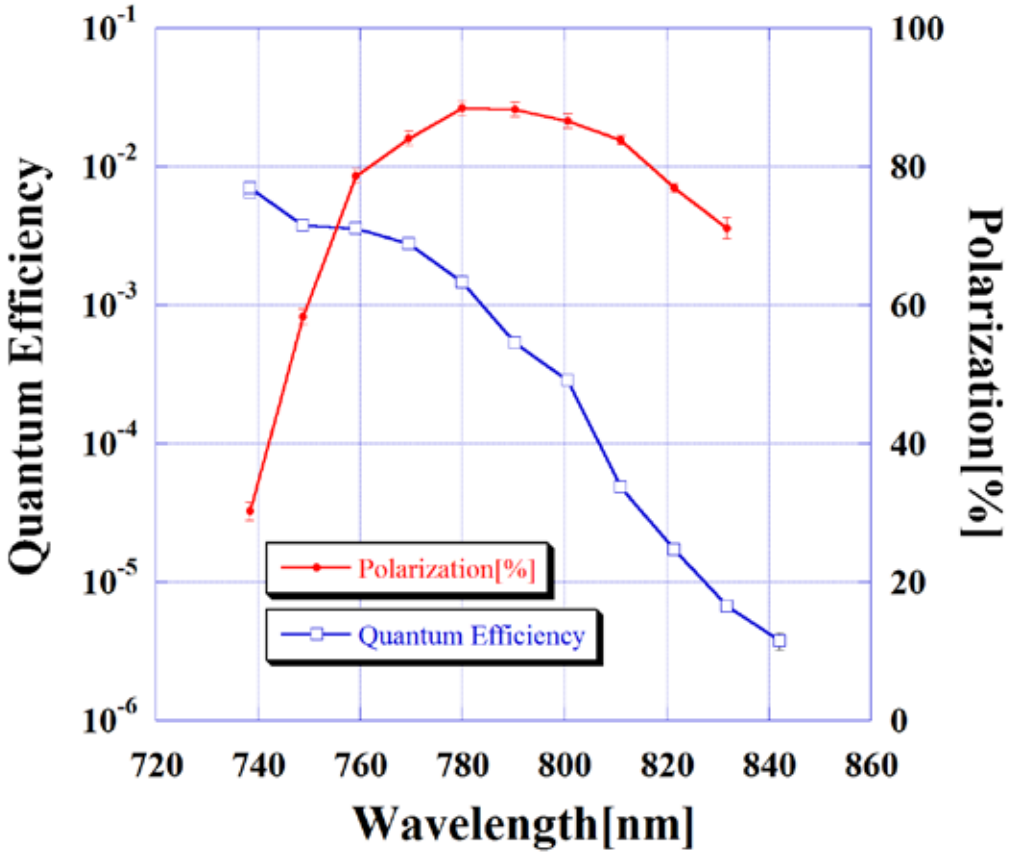
QE~0.23% (l =780nm)

e-beam polarization



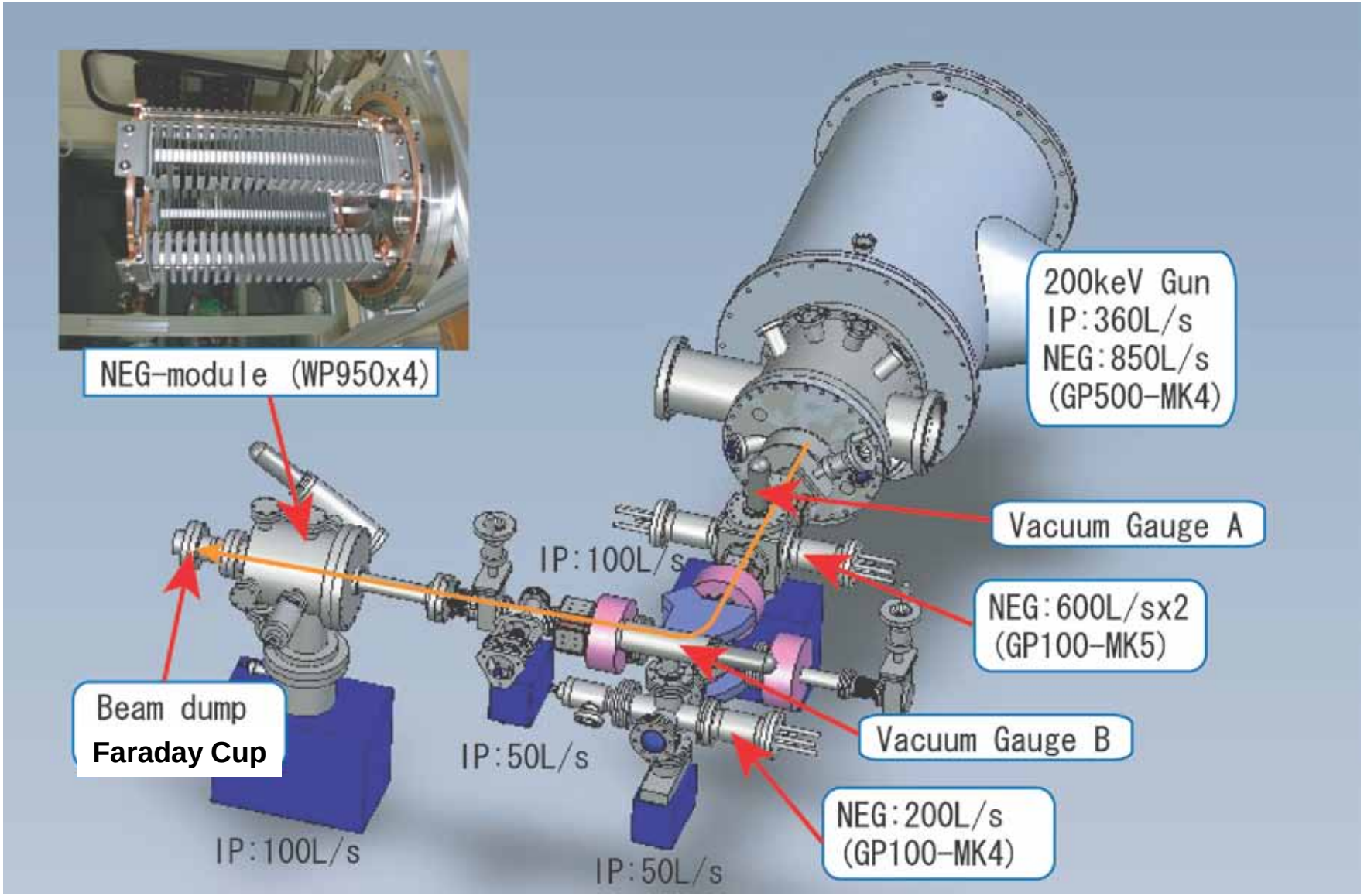


XRD measurement (measured by X.Jin)

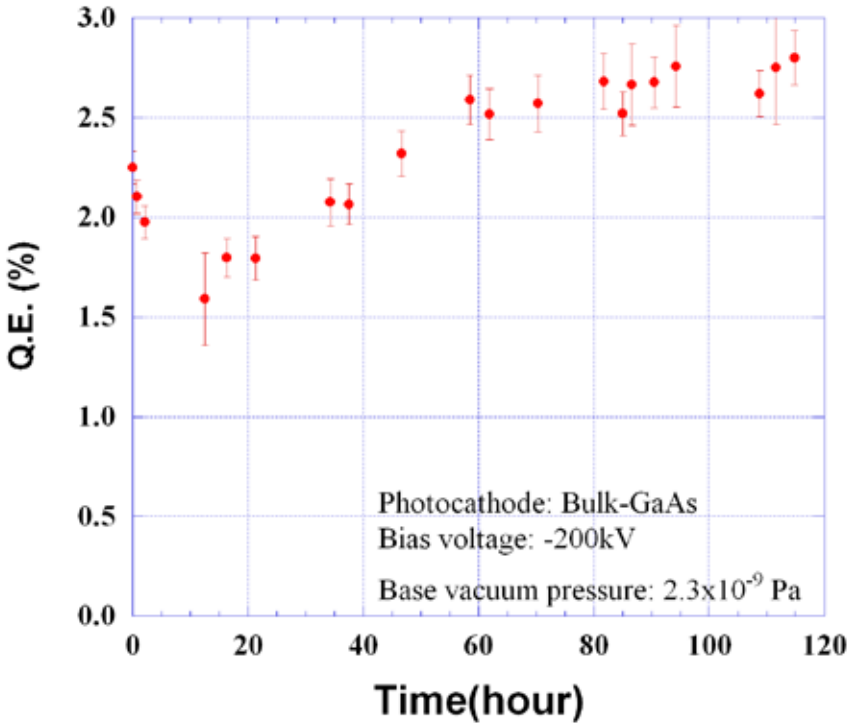


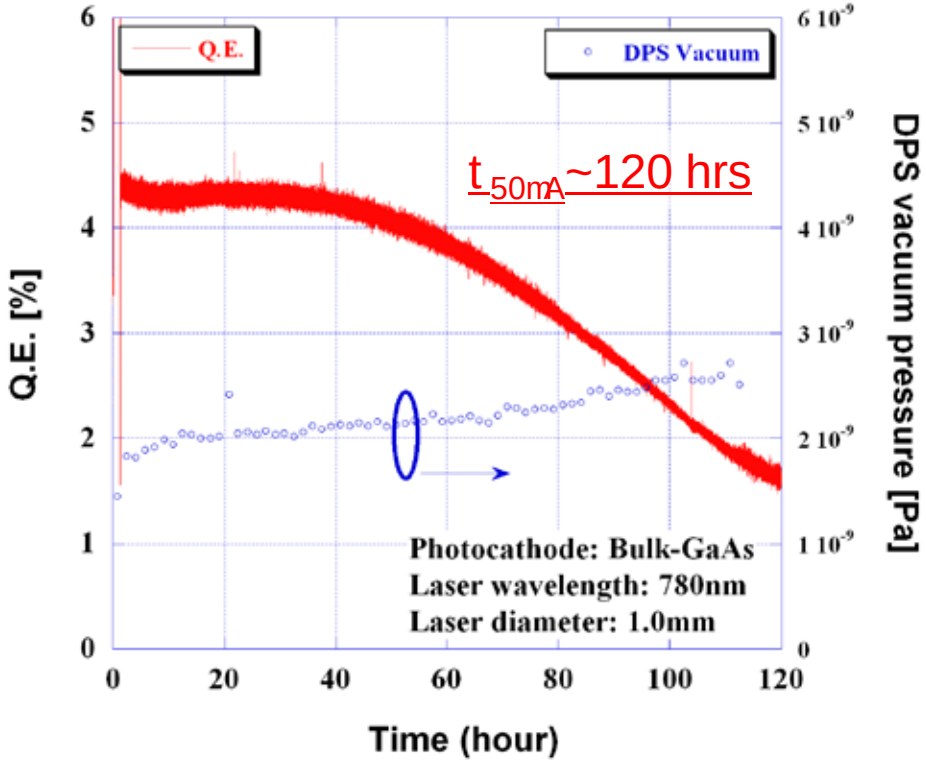
Photocathode: GaAs-GaAsP superlattice
(using a φ23mm substrate)
l =780nm
Polarization 88%±1%(stat.) ±5%(sys.)

Beam transport & Vacuum system



Dark & Operational Lifetime Measurement





Experimental conditions;

Photocathode: Bulk-GaAs (w/o anodization, w/o Cs masking during activation)

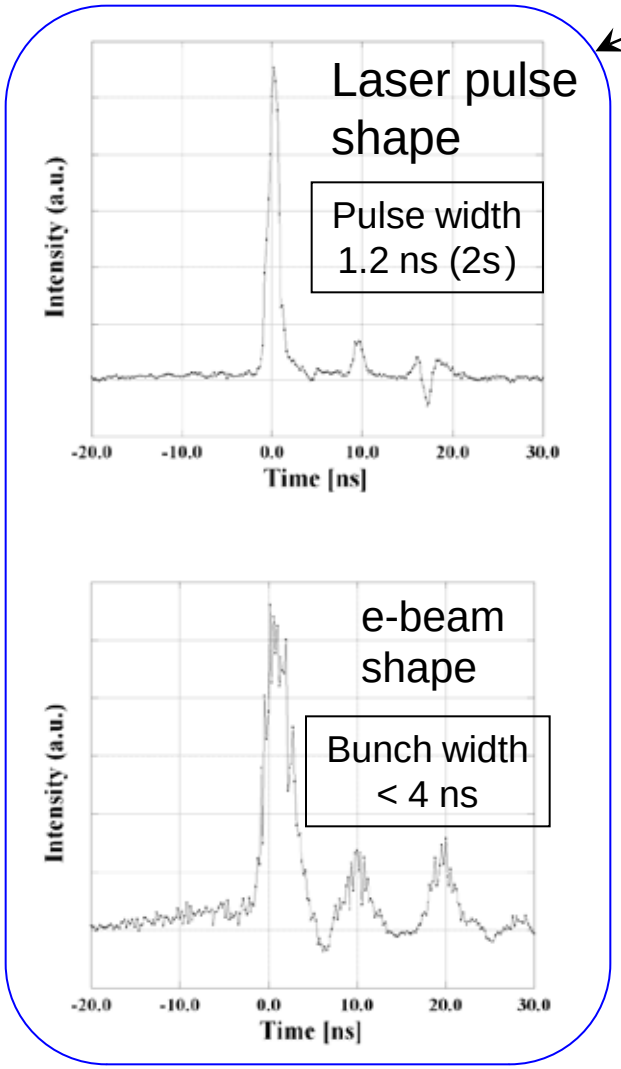
Dark-Lifetime measurement

Base pressure: 2.3×10^{-9}Pa, Bias voltage: -200kV, Dark current: <1nA

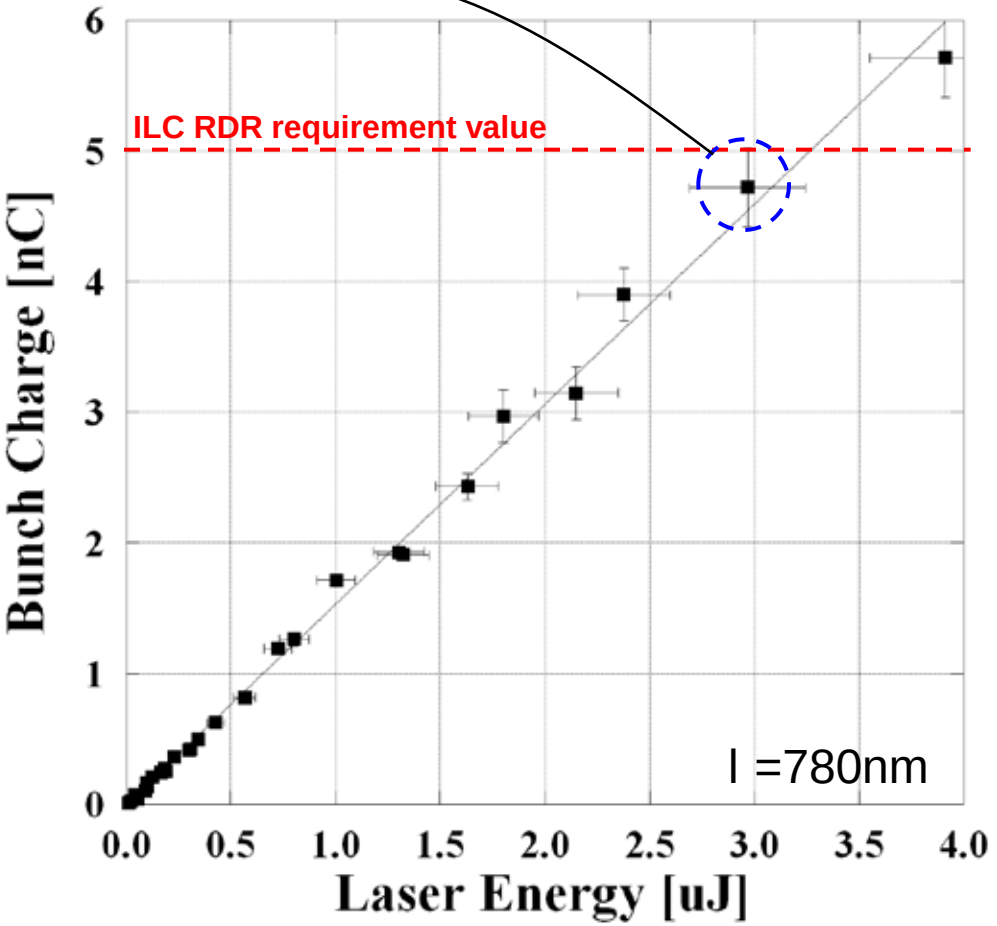
Operational-Lifetime measurement

Laser dia. f 1mm, 50mA constant output, Beam transport efficiency >96%

Single bunch generation



Time resolution of our faraday cup system might be limited several ns.



Photocathode: GaAs-GaAsP SL.
Laser spot diameter: f 17mm

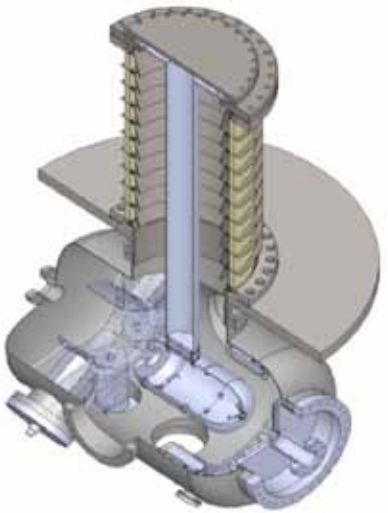
No charge limitation was detected up to 5.7nC/bunch.

Summary of the 200kV pol-e gun

	requirement	achievement	note
polarization	> **80%**	**88%** (l =780nm)	GaAs-GaAsP supperlattice PC using a φ23mm special substrate
Q.E.	≥ **0.5%**	**0.23%**(l =780nm)	bunch charge of 4.8nC was generated by a laser pulse energy of 3mJ
Cathode lifetime	> **100 hrs**	**~120 hrs** (50mA operation)	Beam loss at transfer line is a main issue
Bunch charge	≥ **4.8nC**	**5.7 nC**	No charge limit was detected up to 5.7nC
Bunch width	≤ **2ns**	< **4ns** (~1.2 ns)	Time resolution of our FC system was limited.
Multi-bunch generation	2625 bunches /macro-pulse, 5 Hz	single bunch, 10 Hz	Laser system development is needed.

500kV electron gun system

Two 500kV electron gun systems based on using an NEA-GaAs photocathode are developed at JAEA and KEK for a future ERL light source.



JAEA 1st Gun

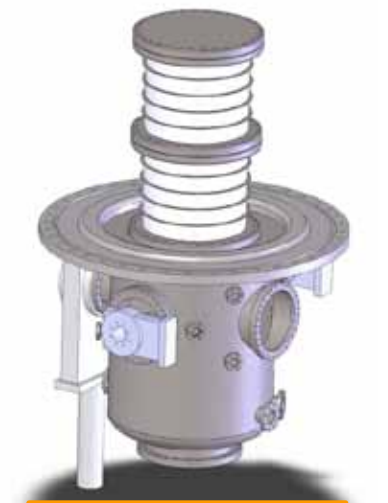
Avarage beam current

ILC: 50~100 mA, ERL: 10~100mA

cathode lifetime problem will be seriously.
1E-10 Pa vacuum indispensable for ERL gun.

Advantages of 500kV ERL gun

- Simplify buncher systems by a short bunch generation.
- Improve the beam transport efficiency due to low emittance beam generation.
- Improve the cathode lifetime due to vacuum improvement.



KEK 2nd Gun

The team of 500kV Gun development in Japan

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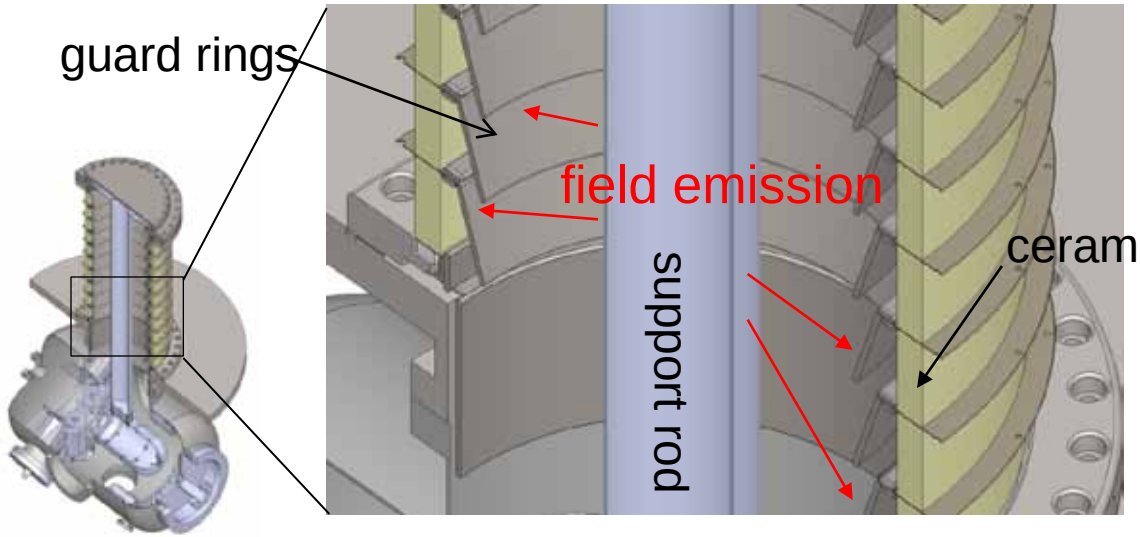
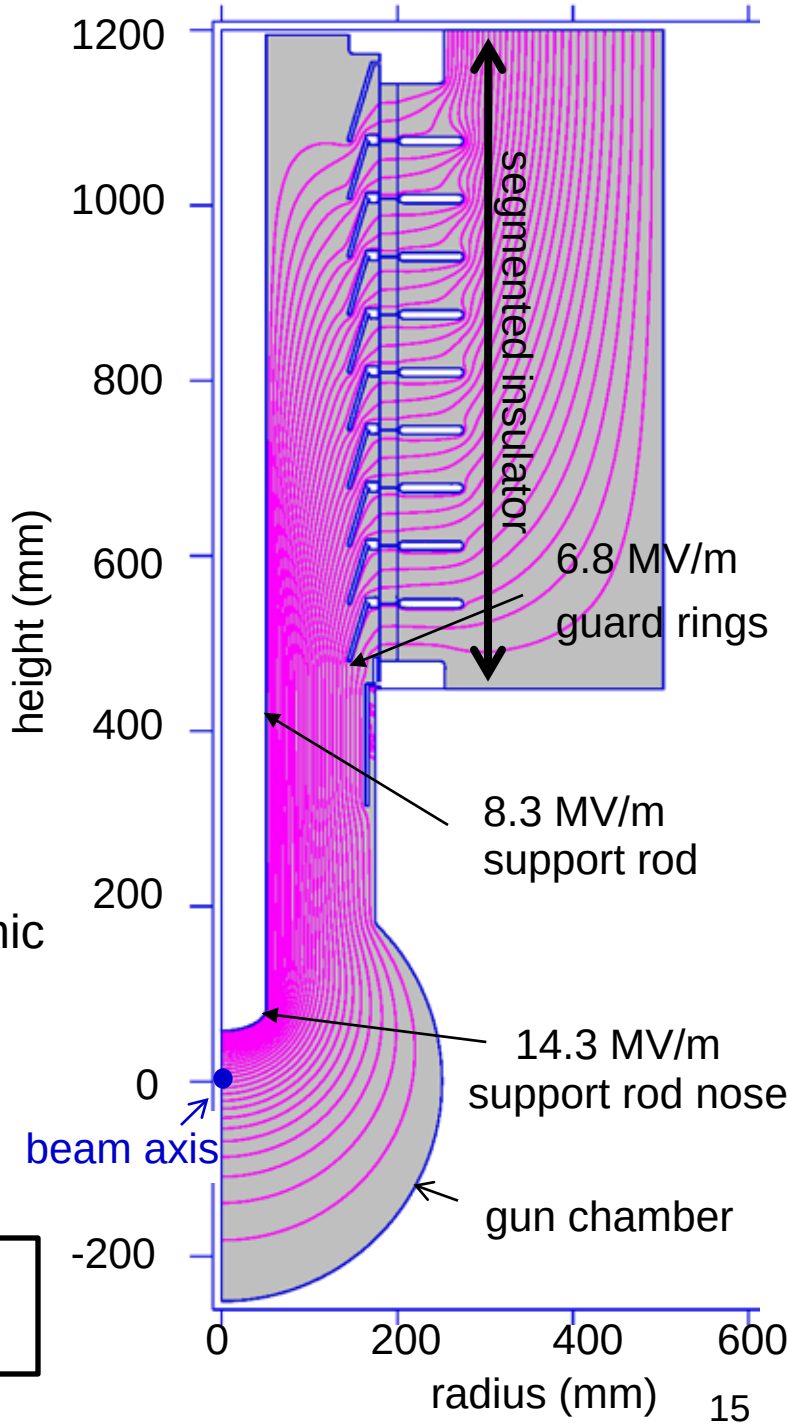
500kV DC gun at JAEA

Employed a segmented insulator to mitigate field emission problem.

Øuniform electric field
Ømeans to attach rings which guard ceramics against field emission.

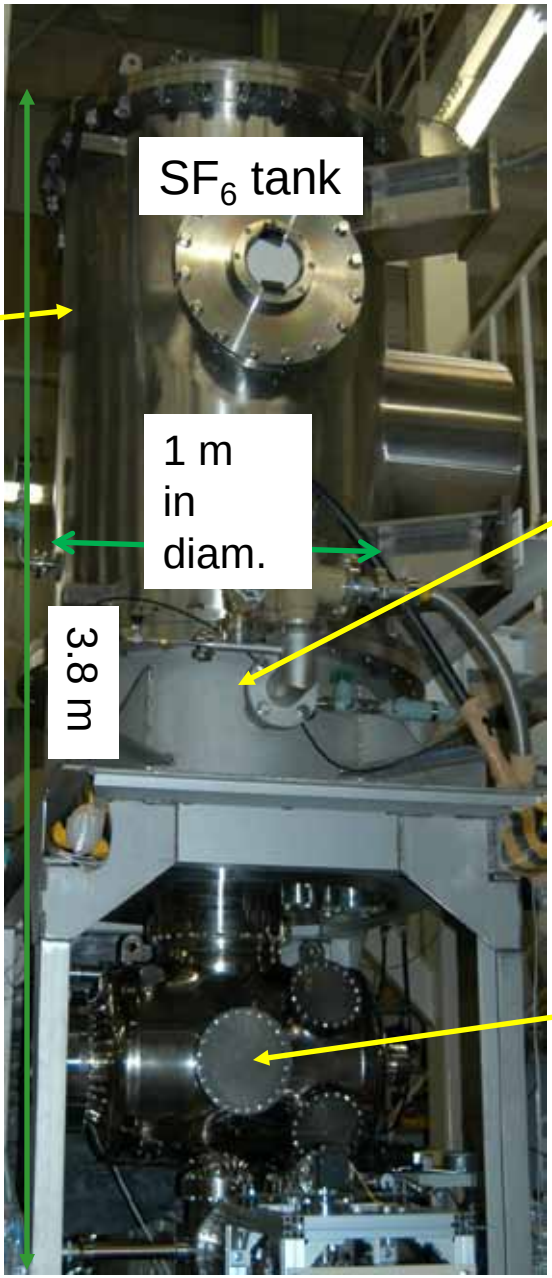




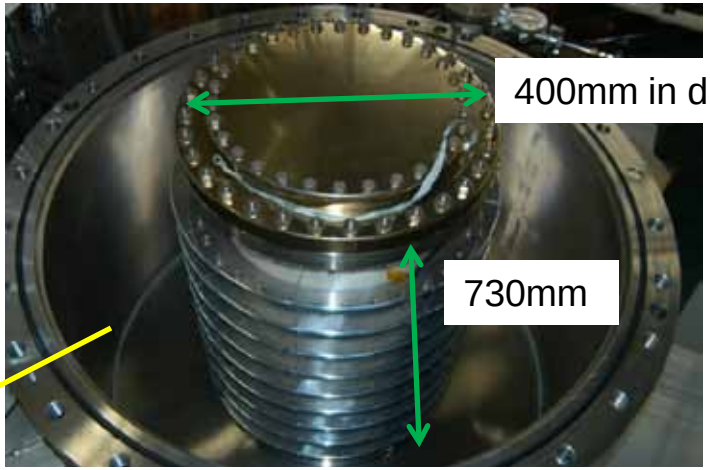
Details are published on R. Nagai et al., Rev. Sci. Instr. 81 (2010), 033304

500kV DC gun at JAEA

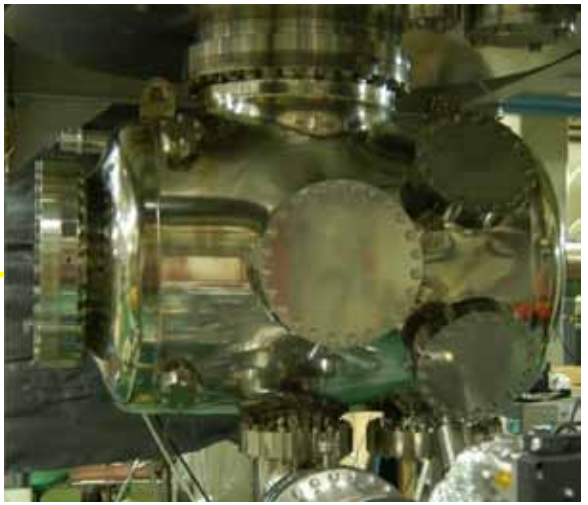
550kV Cockcroft Walton power supply



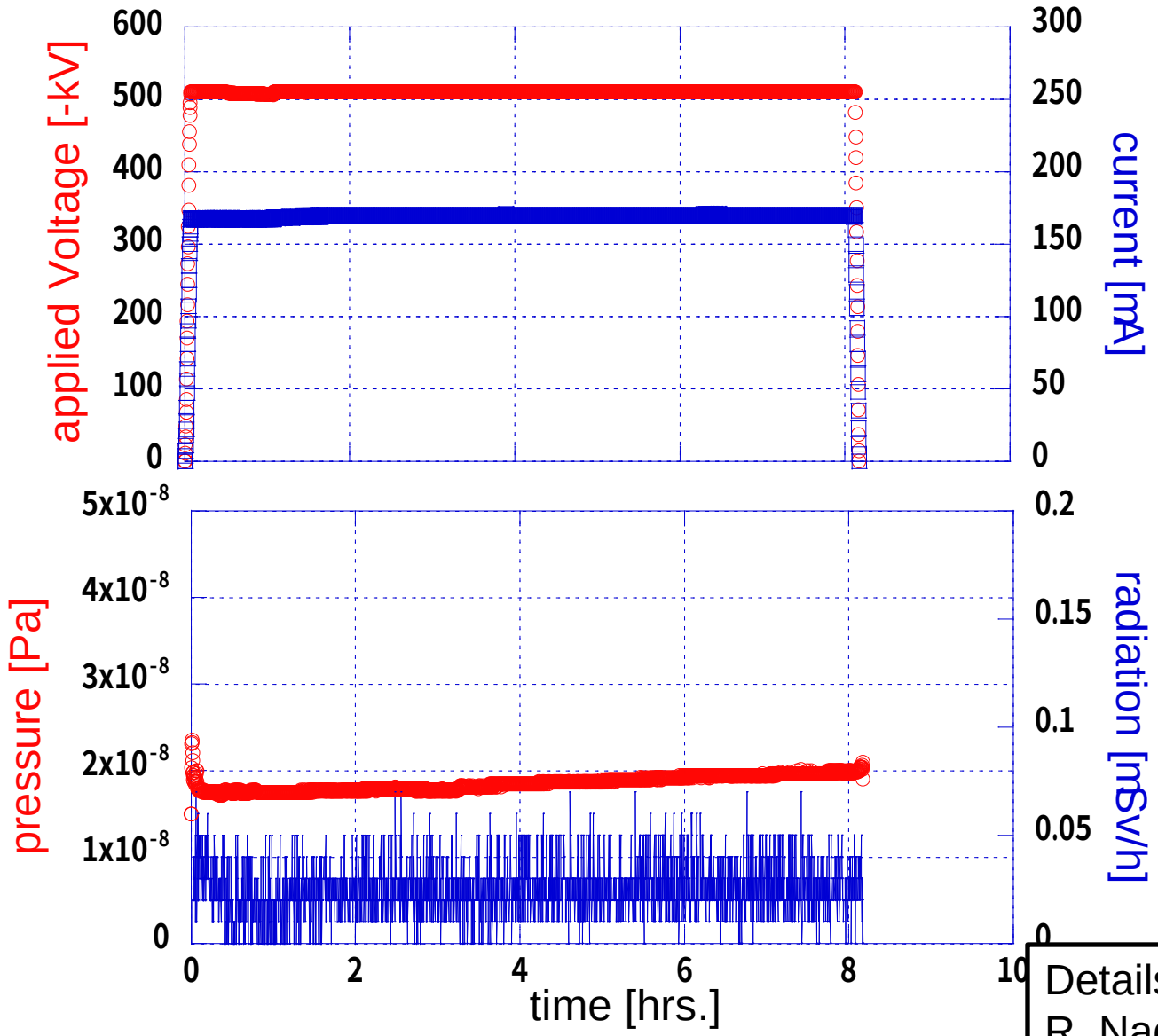
segmented insulator



gun chamber made of titanium



Stable operation at 500 kV for 8 hours

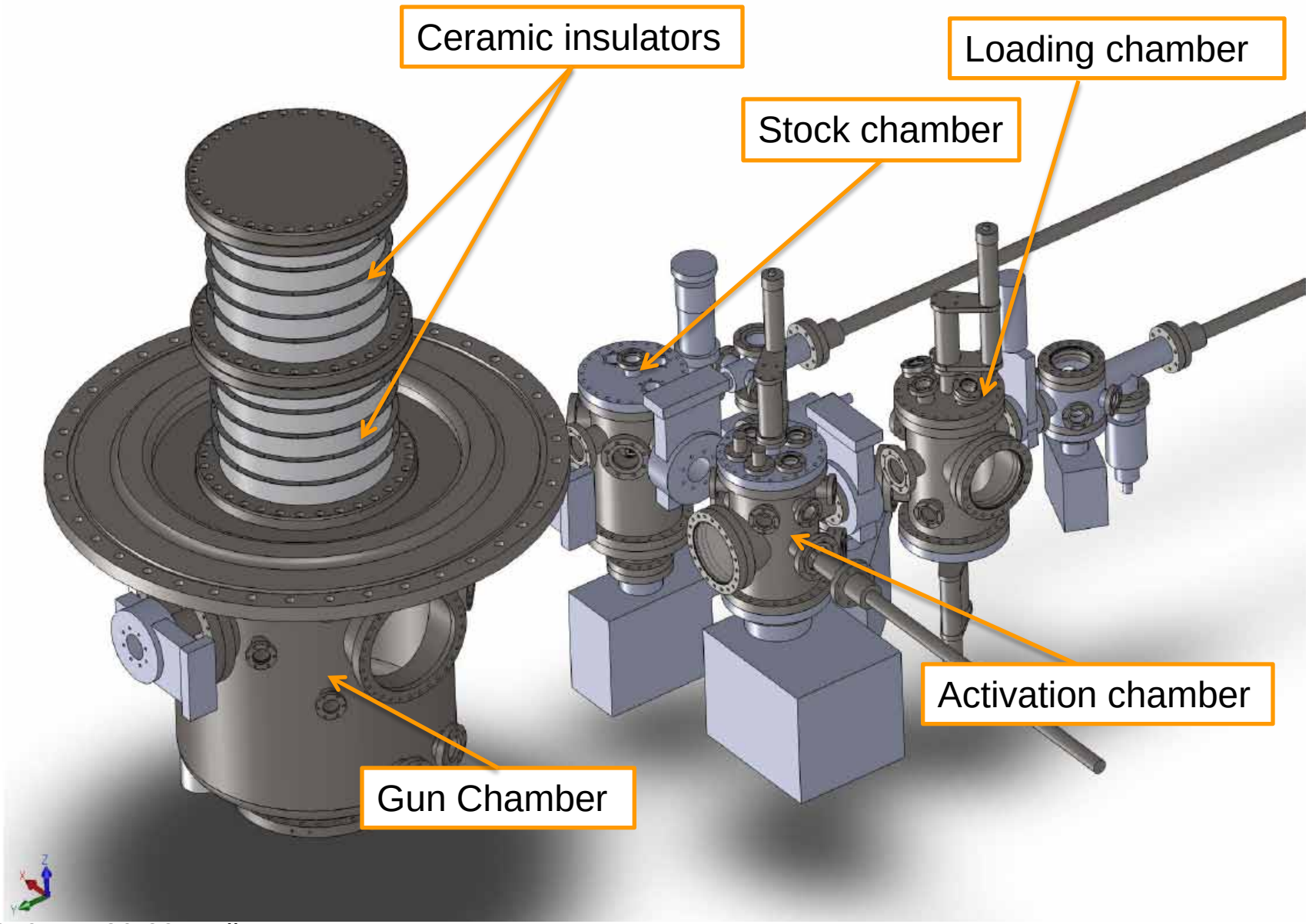


C.W.:510kV
R_{div}:5GΩ
R_{out}:0.1GΩ
→500kV@insulator

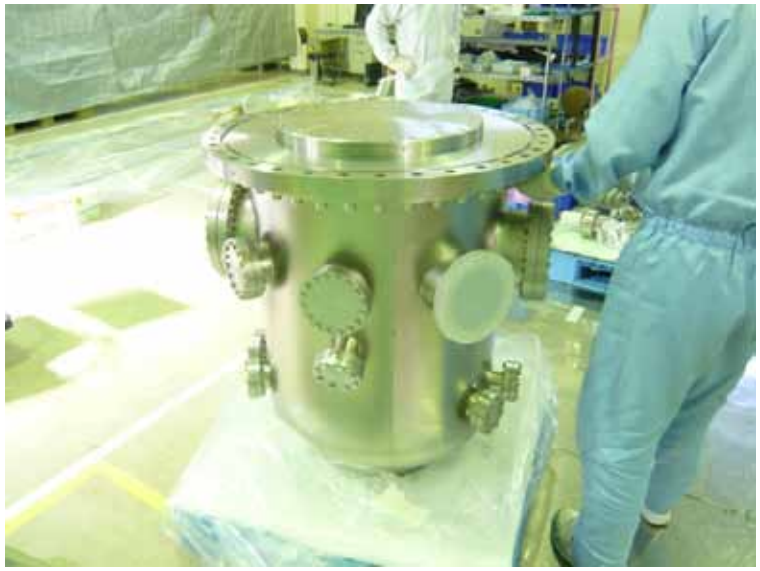
No indication of discharge, local heating due to dark current

Details are published on
R. Nagai et al., Rev. Sci. Instr. 81 (2010), 033304

500kV DC Gun at KEK



gun chamber fabrication

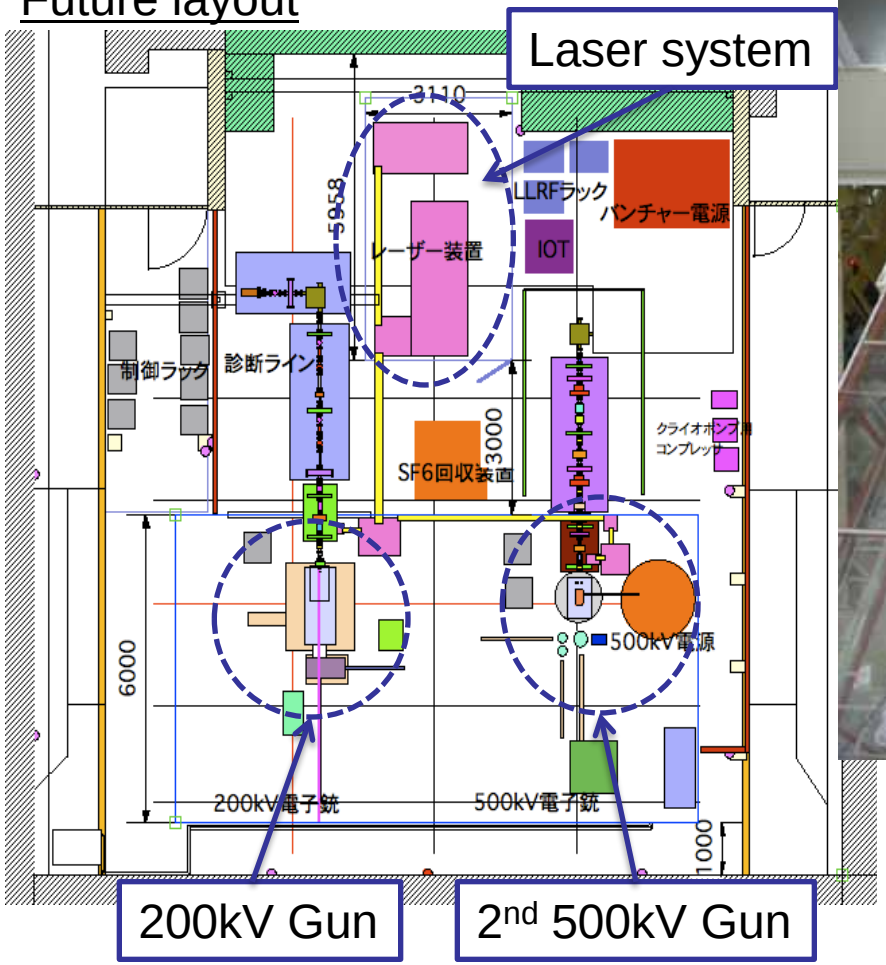


Chamber and flanges are made of titanium and titanium alloy.

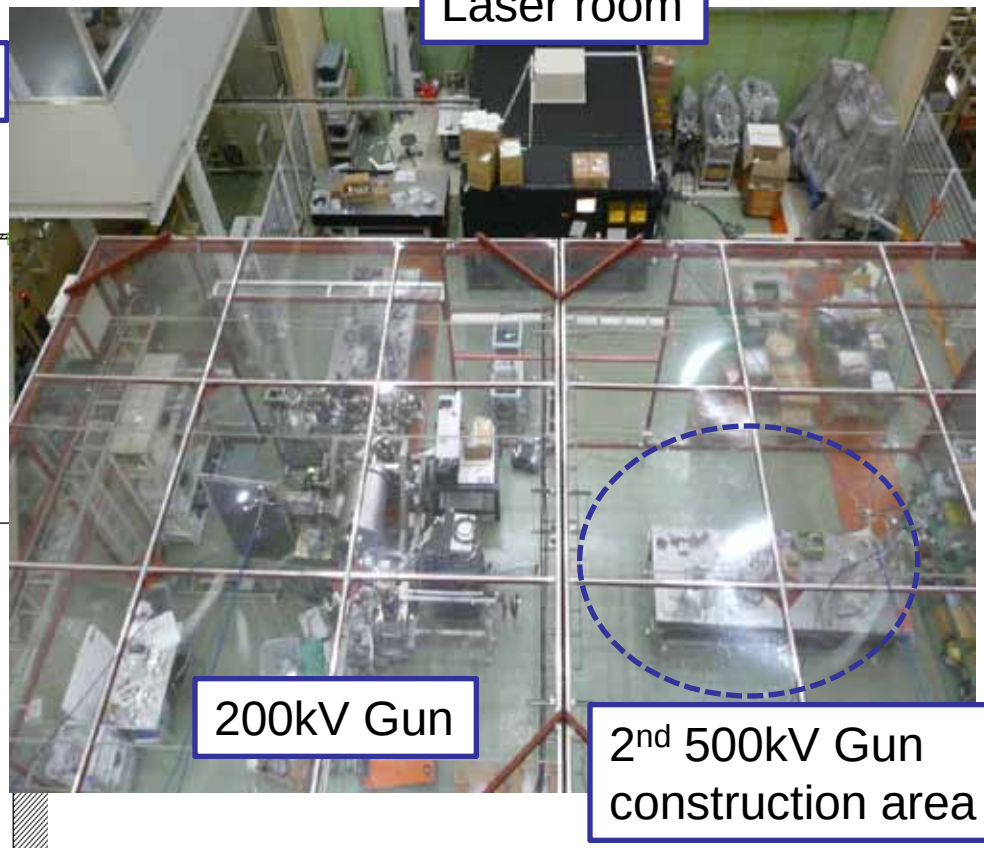
Photocathode DC Gun Test Facility at KEK

PF-AR south experiment area

Future layout



Present layout



Evaluation of cathode, beam control and monitor system will be done using the 200kV gun system.

Summary

Ø 200kV electron source

- High voltage conditioning was succeeded using the Mo-Ti electrode.
  - Long 200kV operation (>500 hrs) with dark current of <1nA is assured by the discharge conditioning up to 225kV.
- Dark- and 50mA operational Lifetime measurement
  - Dark-lifetime >200hrs, 50mA operational-lifetime~120hrs were observed.
- GaAs-GaAsP superlattice photocathode
  - QE 0.23%, pol. 88% was observed using special shape substrate for the 200kV gun.
- Nano-second bunch generation
  - No charge limitation was detected up to 5.7nC/bunch using GaAs-GaAsP PC.

Ø 500kV electron source

- Two gun systems are developed at JAEA and KEK.
- Applied voltage of 500kV was succeeded for 8 hours at JAEA using a segumented ceramics with titanium guard rings and support rod.
  - High voltage conditioning was succeeded up to 550kV.
- Photocathode DC gun test facility was build at KEK PF-AR south area.