Construction of the second 500 kV Photocathode DC-gun at KEK

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Outline

- Introduction
- HV system setup & HV conditioning result
- Simultaneous triplet cathodes preparation system
- Summary

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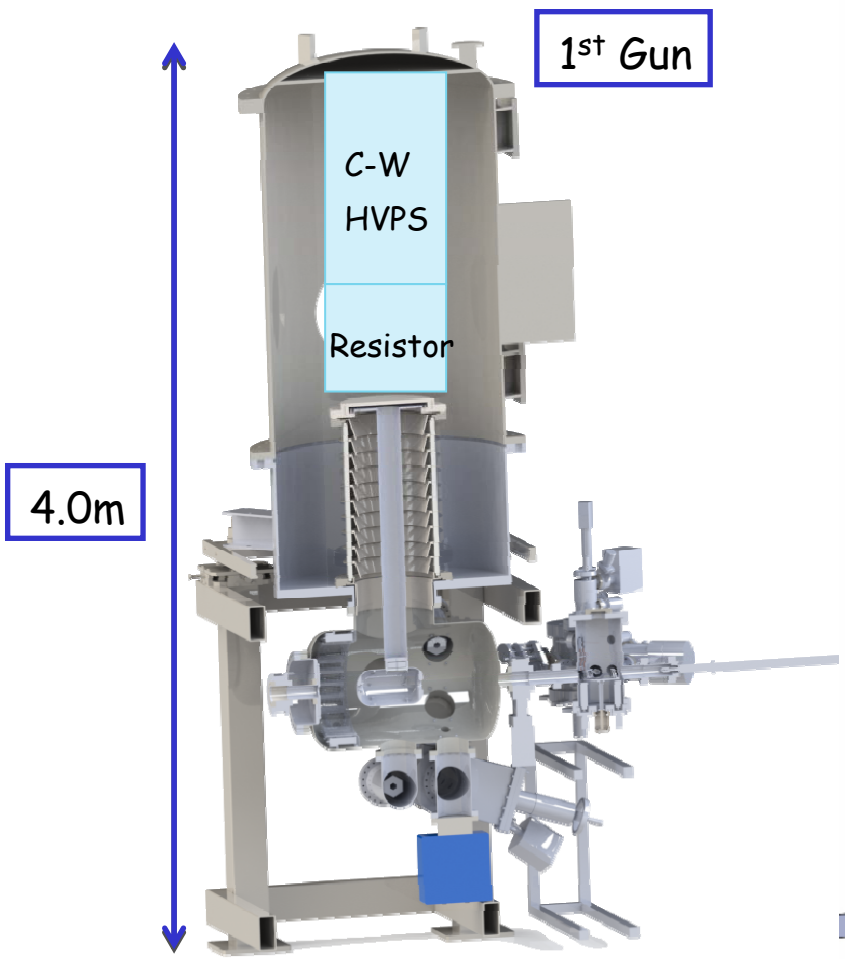
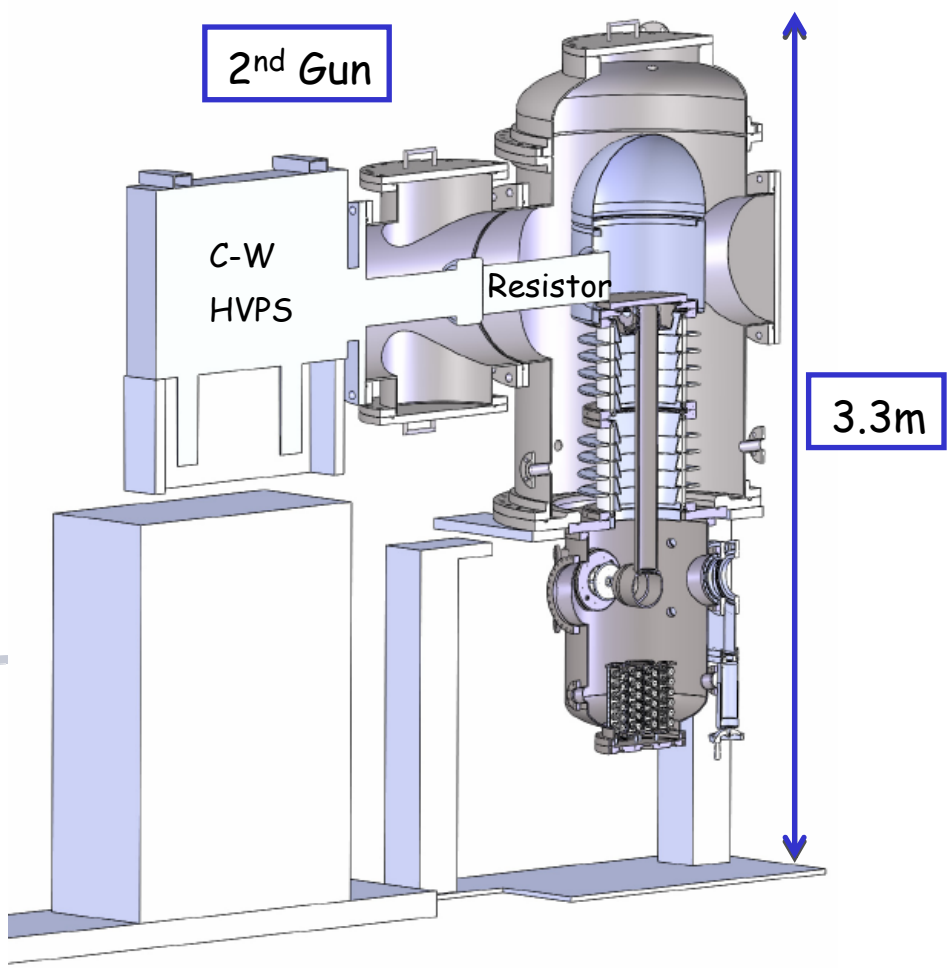
The 1st and 2nd 500kV DC Guns





Developed at JAEA from 2007 ~
Installed cERL at Oct. 2012.

Developed at KEK from 2009 ~

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Special items of the 2nd DC-Gun

High voltage insulator

- 2 pairs of 5 segmented insulator
- Special Al_2O_3 based material (TA010, Kyocera)

Low outgassing vacuum system

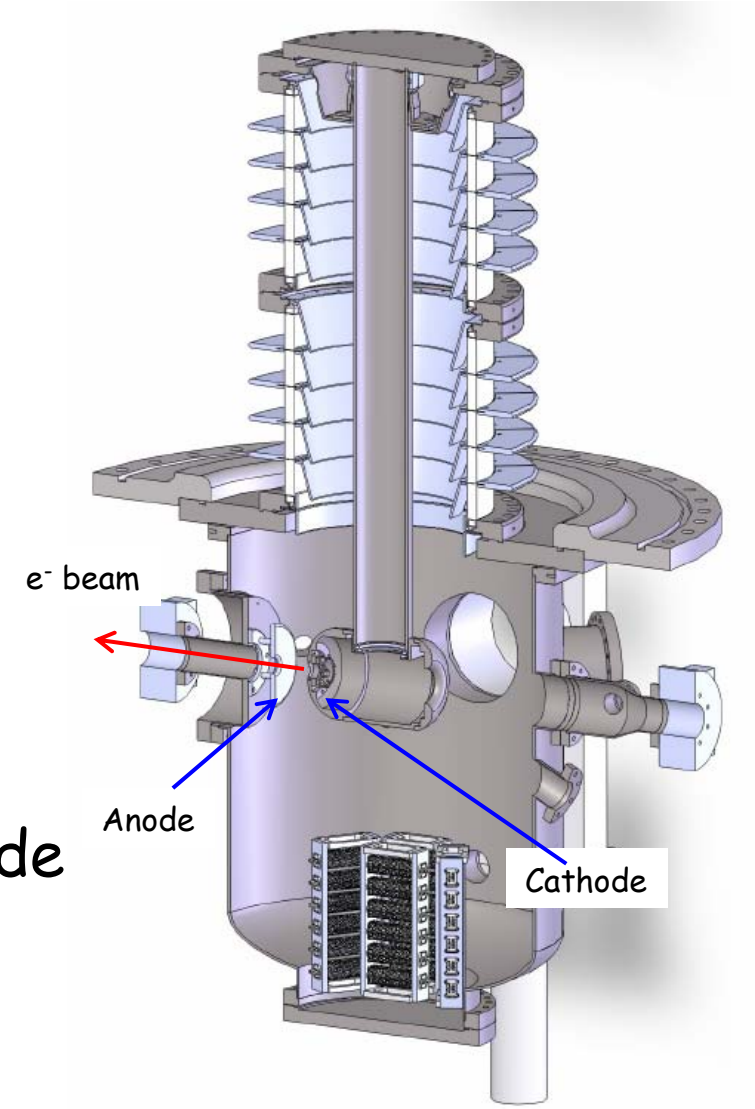
- Titanium chamber
- Titanium electrodes & guard rings
  - Non welding parts for in-vacuum components

High performance pumps for XHV

- 4K Bakeable cryopump & NEG pumps

Isolated anode & Repeller electrode

- Dark current monitor
- Reducing low energy backward ions



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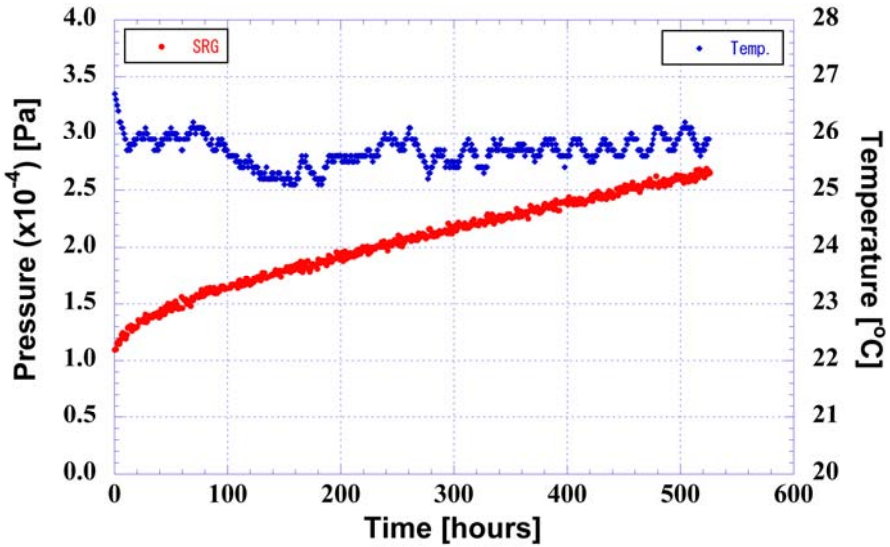
Vacuum performance

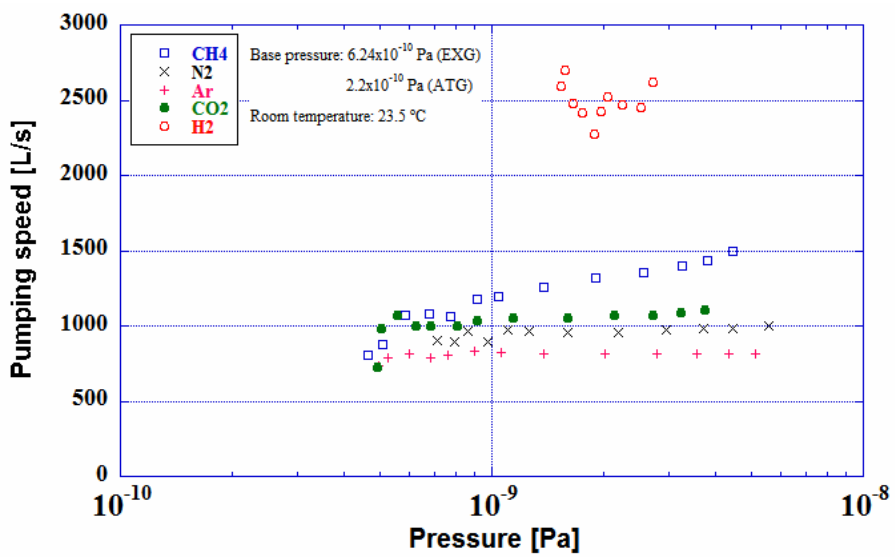
Outgassing rate



✓All components except main pumps (cryopump & NEGs) were installed.

✓ Very low total out gassing rate of 8.1x10^{-11} [Pa m^3/s] (H_2 equivalent) was achieved.

Pumping speed of Bakeable cryopump



✓ Cryo-panel temperature: 4K

✓ High pumping speed was obtained for CH_4, N_2, Ar, CO_2 under XHV condition.

✓ Ultimate pressure was limited by adsorption equilibrium of adsorbent for hydrogen.

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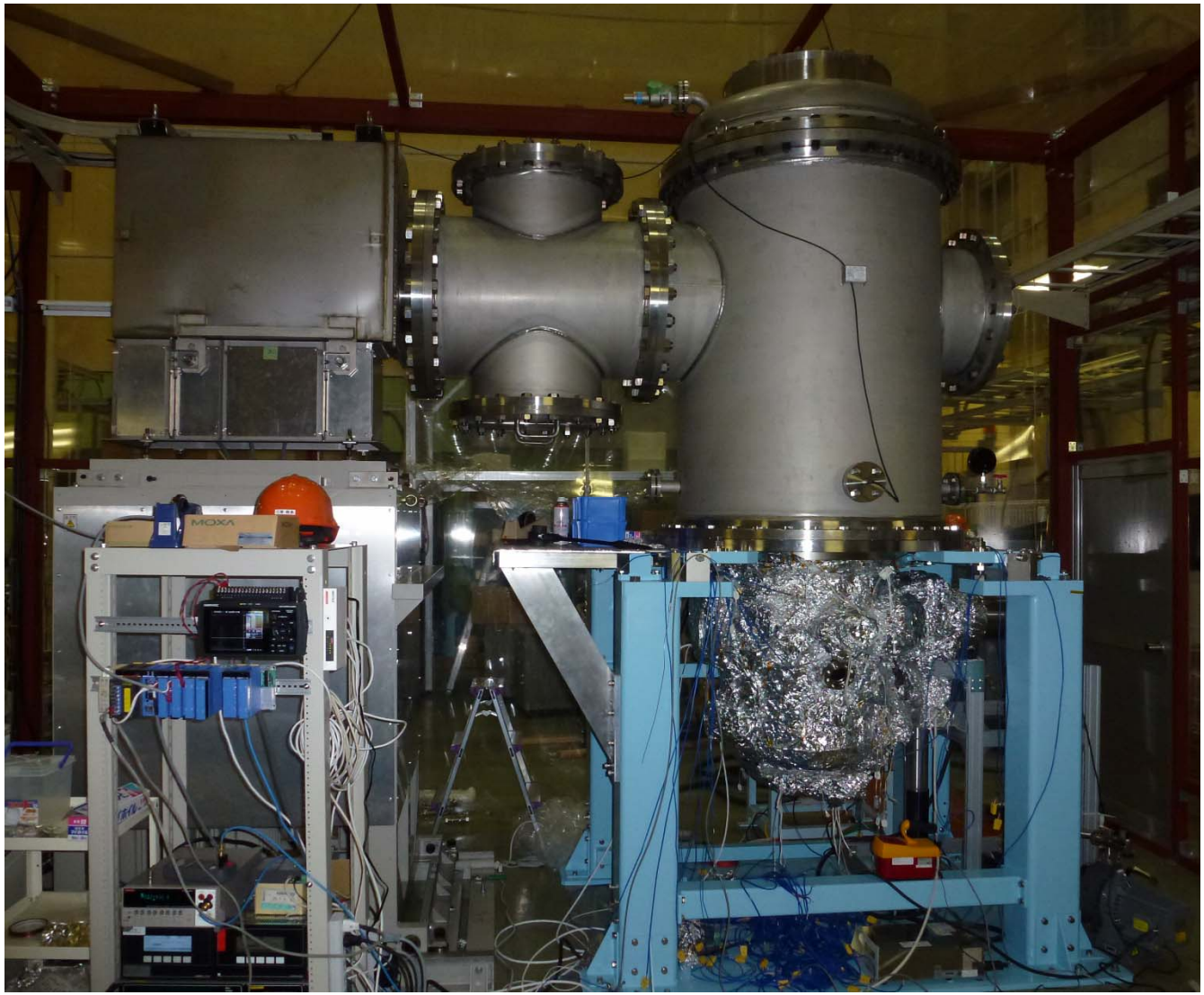
The 2nd 500kV DC-Gun @KEK



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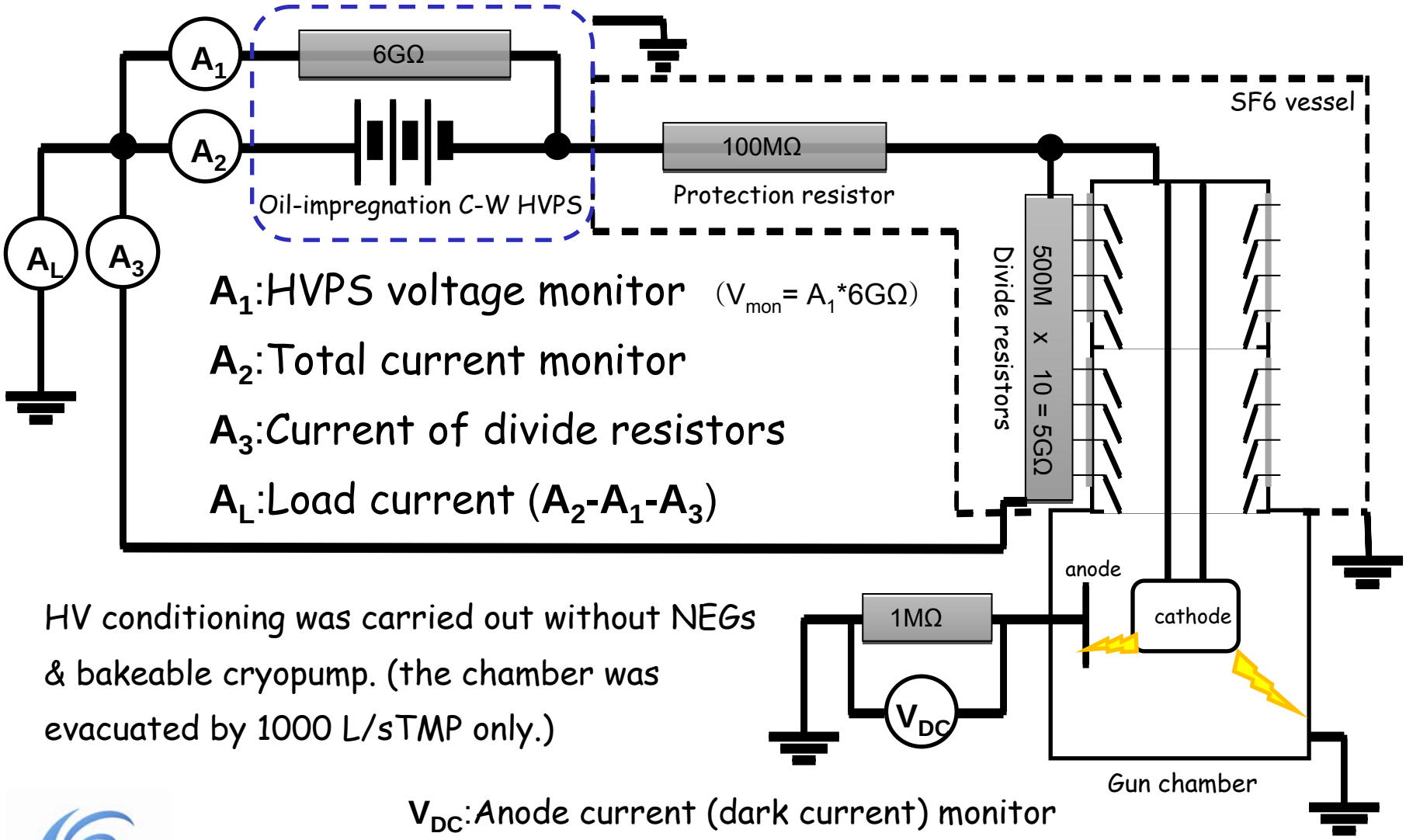
Outline of HVPS Connection



HV conditioning was carried out without NEGs & bakeable cryopump. (the chamber was evacuated by 1000 L/sTMP only.)

V_{DC}:Anode current (dark current) monitor

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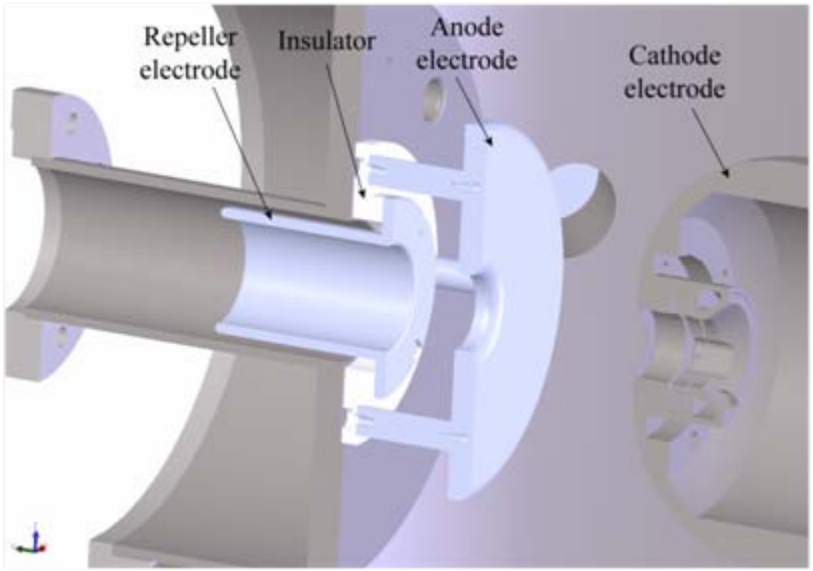
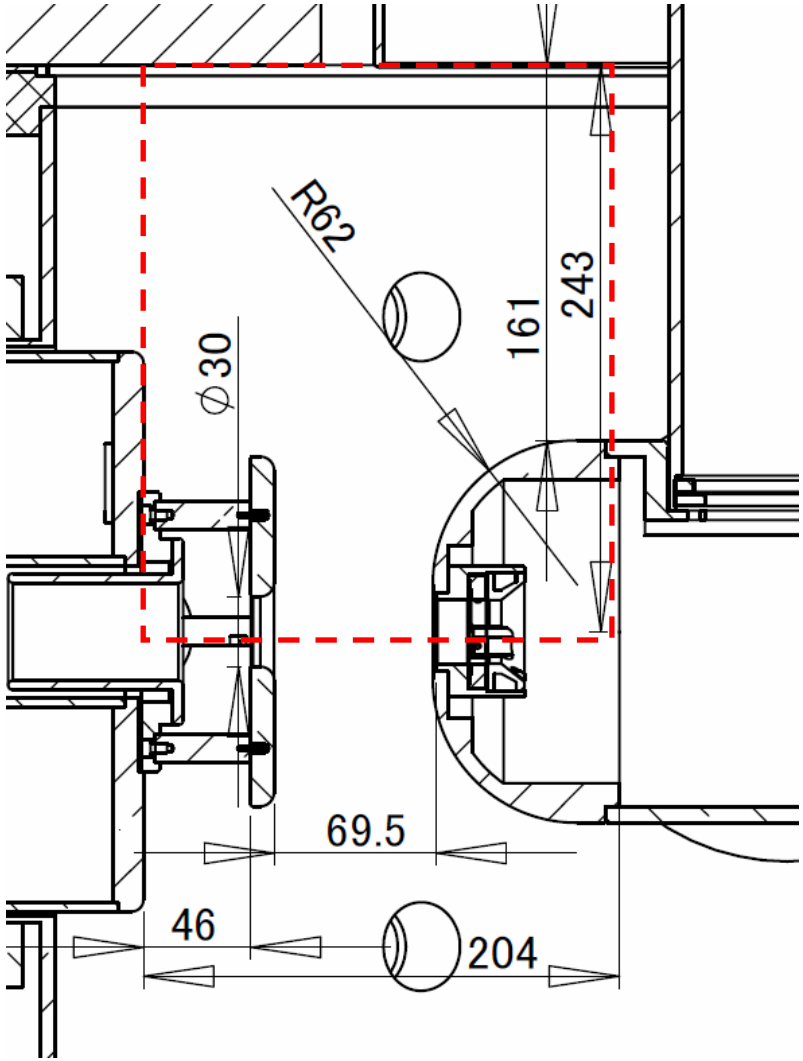
Electrodes Shape and Geometry





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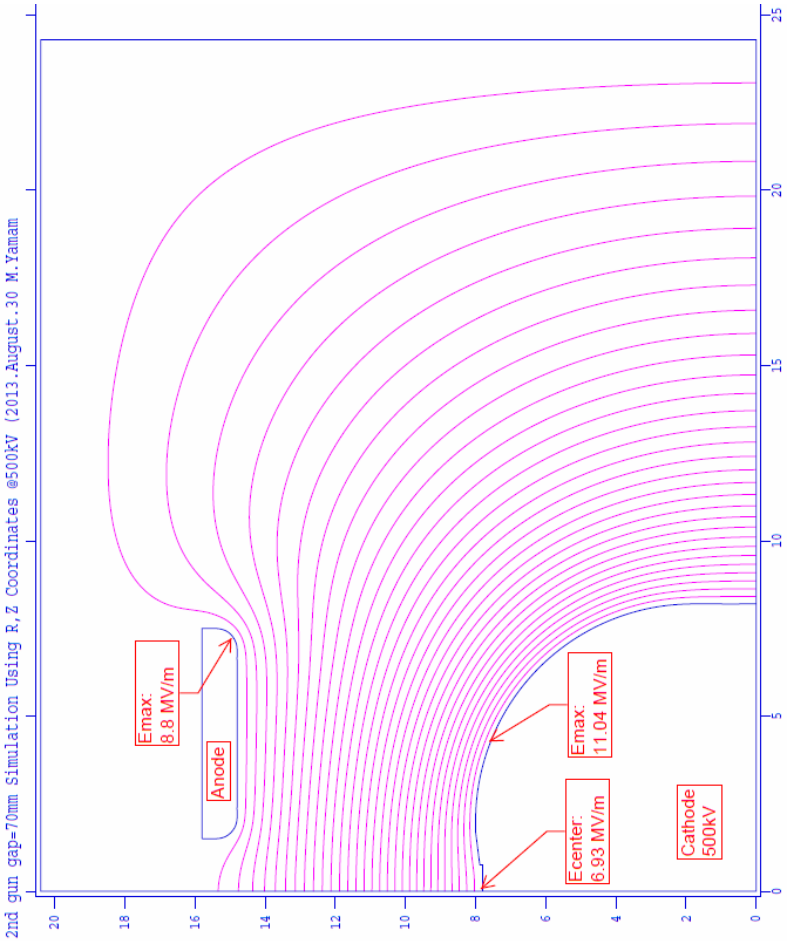
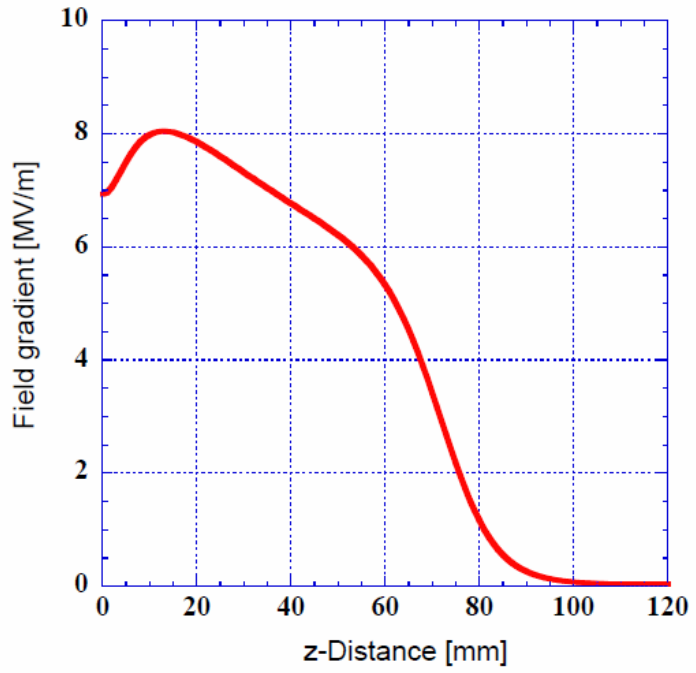
E-Field Map

- E-Field Map @ 500 kV





- Cathode center: 6.9 MV/m
- Cathode electrode:
  - Outer surface: 11.0 MV/m (max.)
  - Edge of wehnelt: 11.9 MV/m (max.)
- Anode electrode: 8.8 MV/m (max.)

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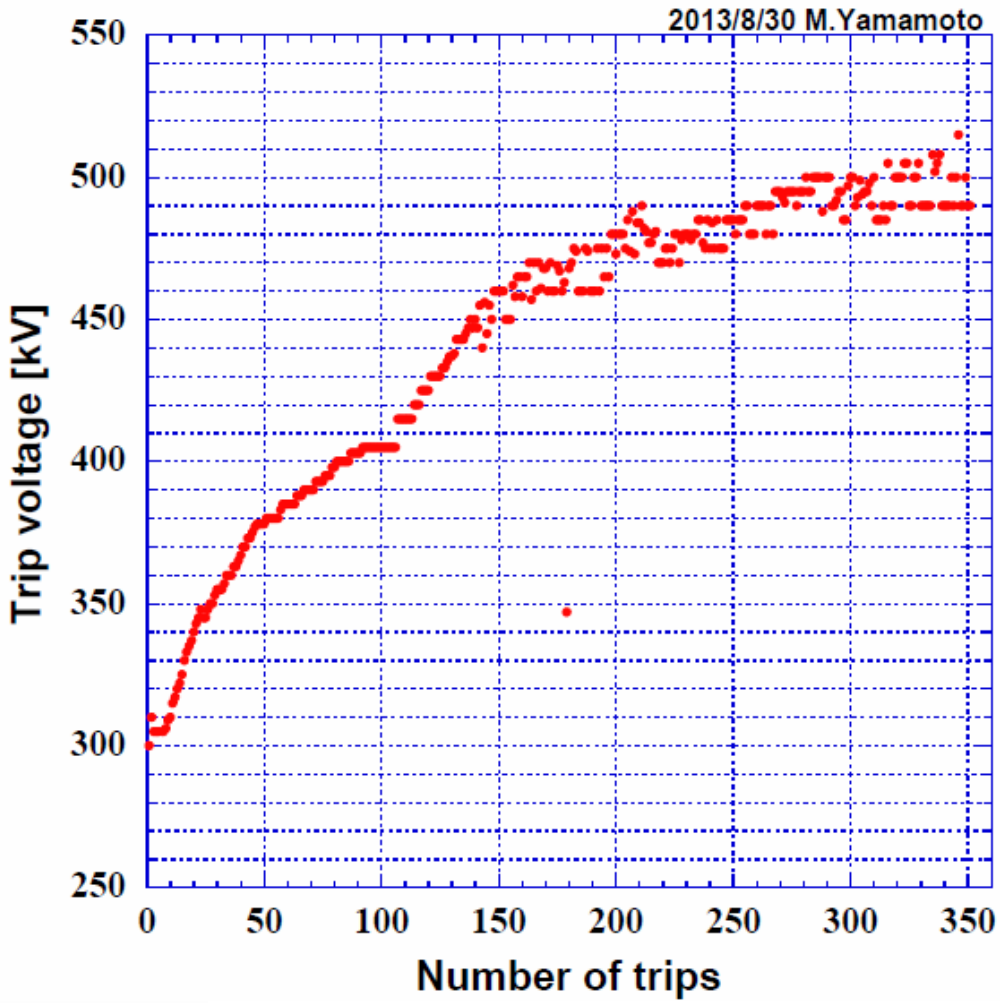
HV Conditioning History



- ✓ Base pressure: 1.0×10^{-8} Pa.
- ✓ SF_6 pressure: +0.2 MPa.
- ✓ Only 5 days conditioning.
  (Just start from Aug.26th)
- ✓ The first trip happened at 300 kV.
- ✓ All trips involved vacuum trip and almost detected radiation.
- ✓ Trip voltage slope to be gentle around 500 kV.

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Safety Interlock

Monitors for Safty

* Vacuum (EXG, 3BG)
  (trigger level: >5x10^{-7} Pa)
* Radiation (Ionization chamber)
  (trigger level: >20 uSv/h)
* Anode current
  (trigger level: >500 nA)

HVPS Controller

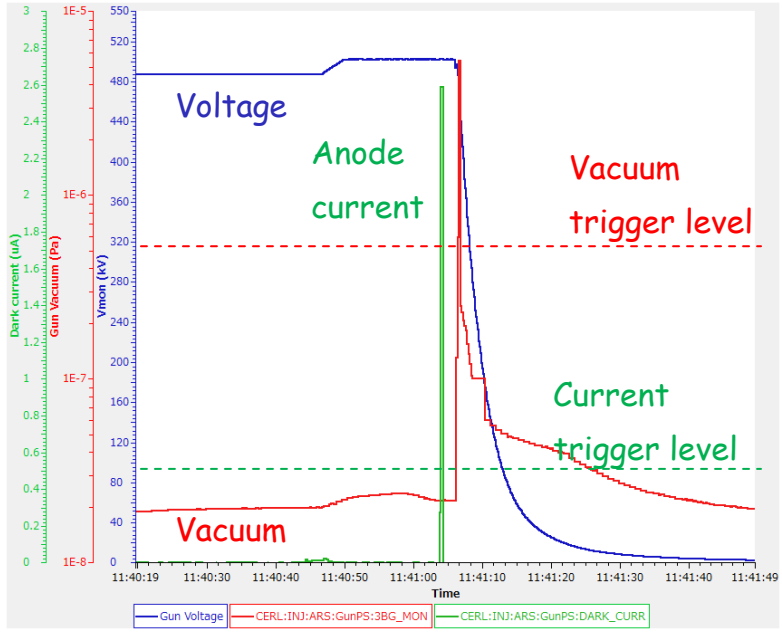
* Over Current
  (Total Current max.: 300uA)
* Current Continuous mode > 1s
  (Load Current setting: 20uA)
* Other troubles

Total Trips

351 times

314 times

37 times



- ✓ ~90% trips happened between anode-cathode gap.
- ✓ Anode current monitor was helpful to reduce X-ray dose because of its quick response.

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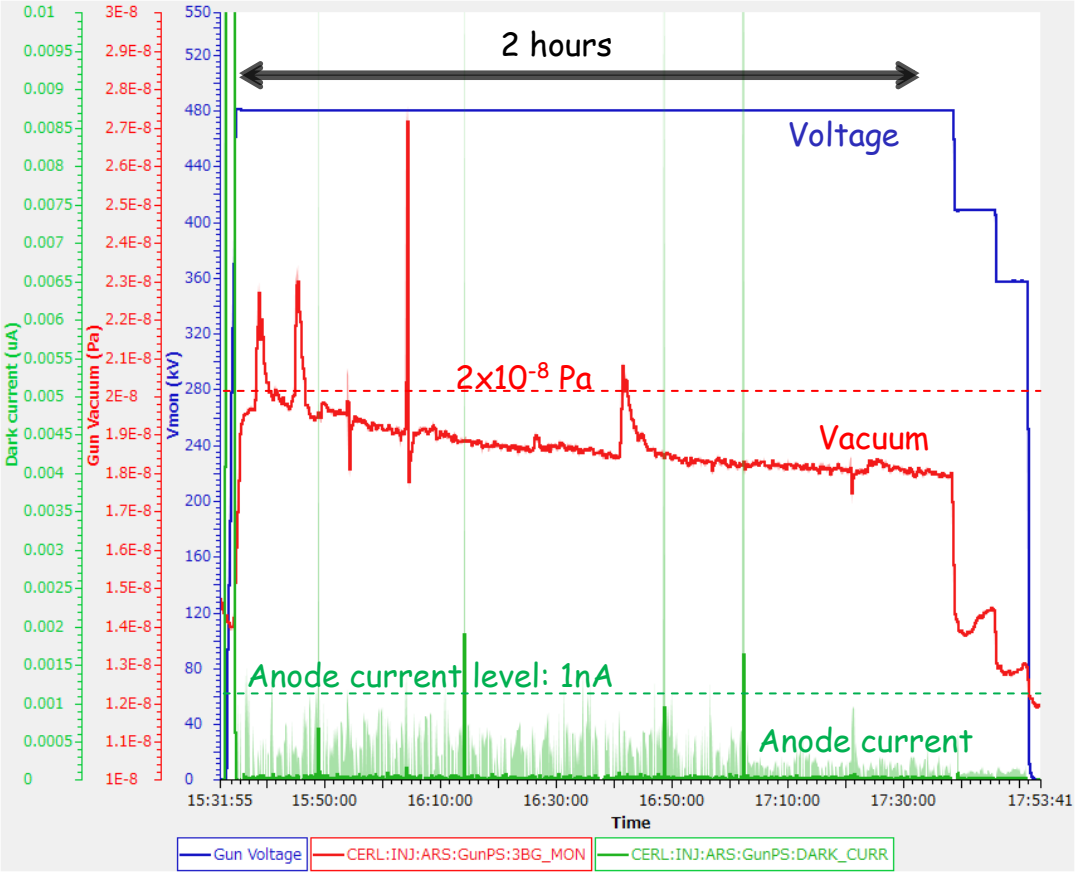
480 kV Test



- ✓ The test was carried out after HV conditioning of 350 trips.
- ✓ HV down didn't happen during 2 hours operation.
- ✓ Some small vacuum trips still remained.
- ✓ Anode current was lower than 1nA normally.
- ✓ Dependence of base pressure on applied voltage was observed.

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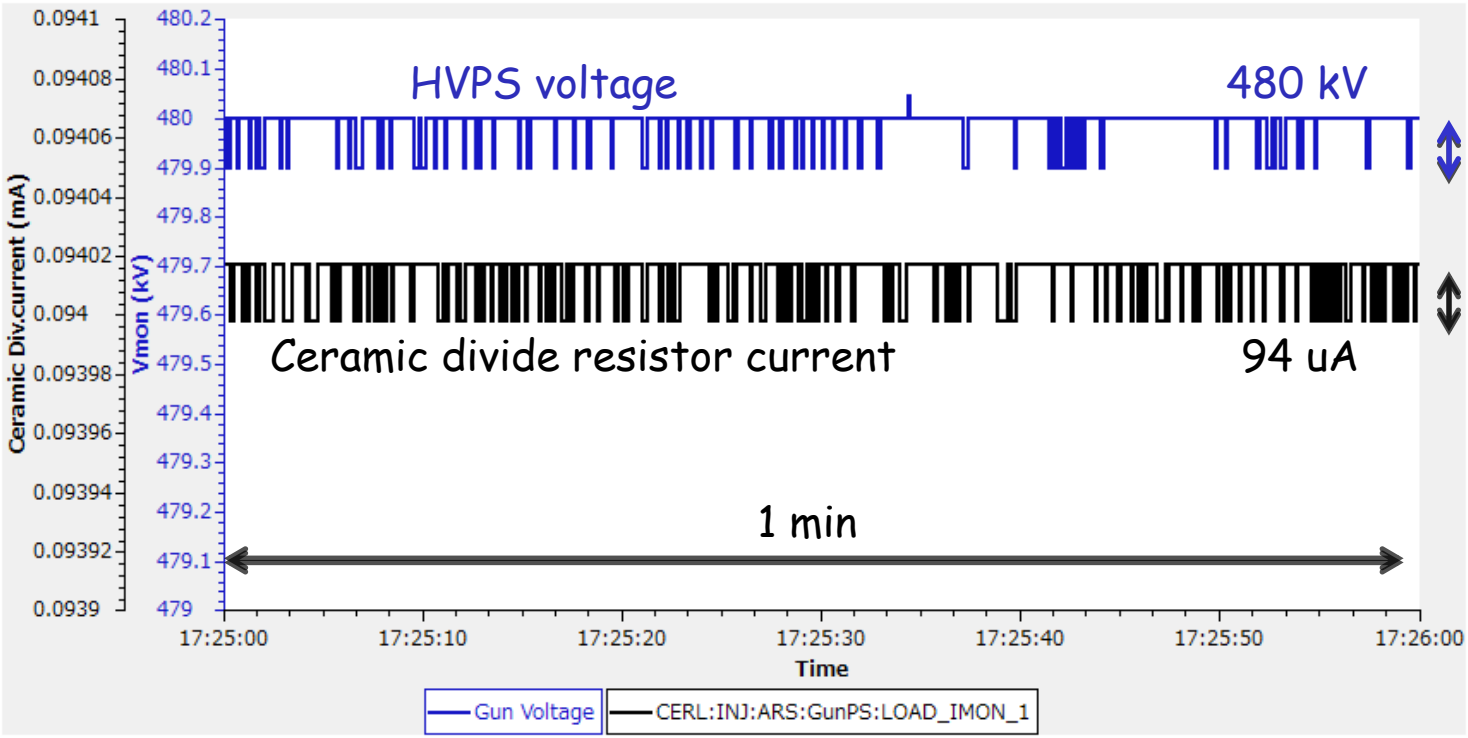
HVPS Stability (without beam loading)



- ✓ About 1.5 hours need to stabilize HVPS output.
- ✓ Less than 2×10^{-4} stability was obtained by HVPS voltmeter and ceramic divide resistor current independently.

(Resolution was limited by 12-bit ADC of HVPS control PLC)

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Cathode Preparation System (1)

- ✓ NEA cathode is good for generate beam with low MTE. 
- ✓ NEA surface is easily damaged. 
  - Weak for ion back-bombardment.
  - Quite sensitive for vacuum. (It is difficult to treat by vacuum suit case)
- ✓ Spend much time to cathode preparation. 
  - Need several hours to finish preparation processes.
- ➢ Steps of NEA cathode use for actual operation in ERL

  1. Generate good gun vacuum, reduce backward ions…
  2. Establish efficient cathode change & preparation system.
     - Simultaneous several cathodes cleaning & activation.
     - Storage many activated cathodes in good vacuum.

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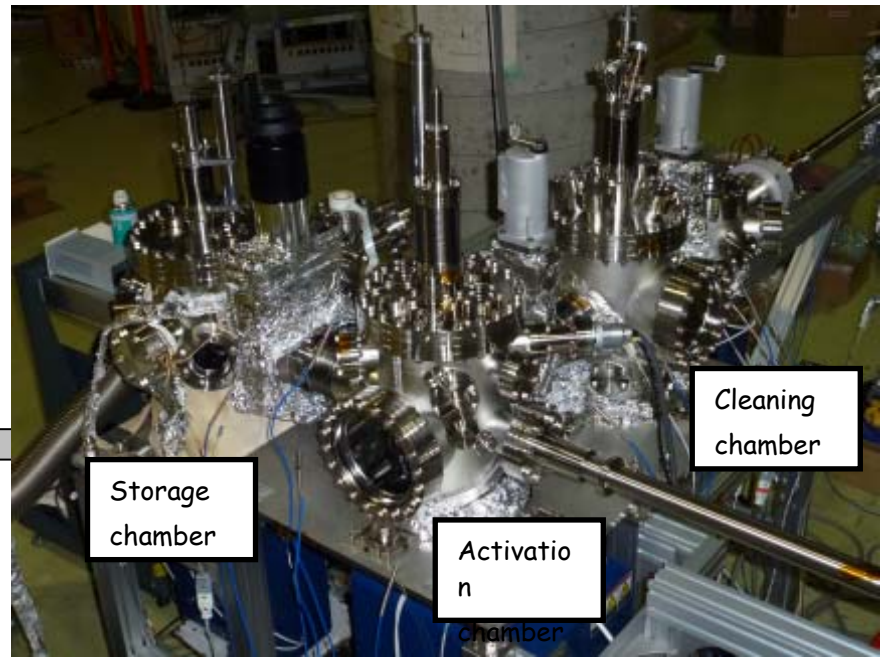
Cathode Preparation System (2)

Short dead time for exchange cathode during gun operation.



Activate & storage 6~9 cathodes per day.

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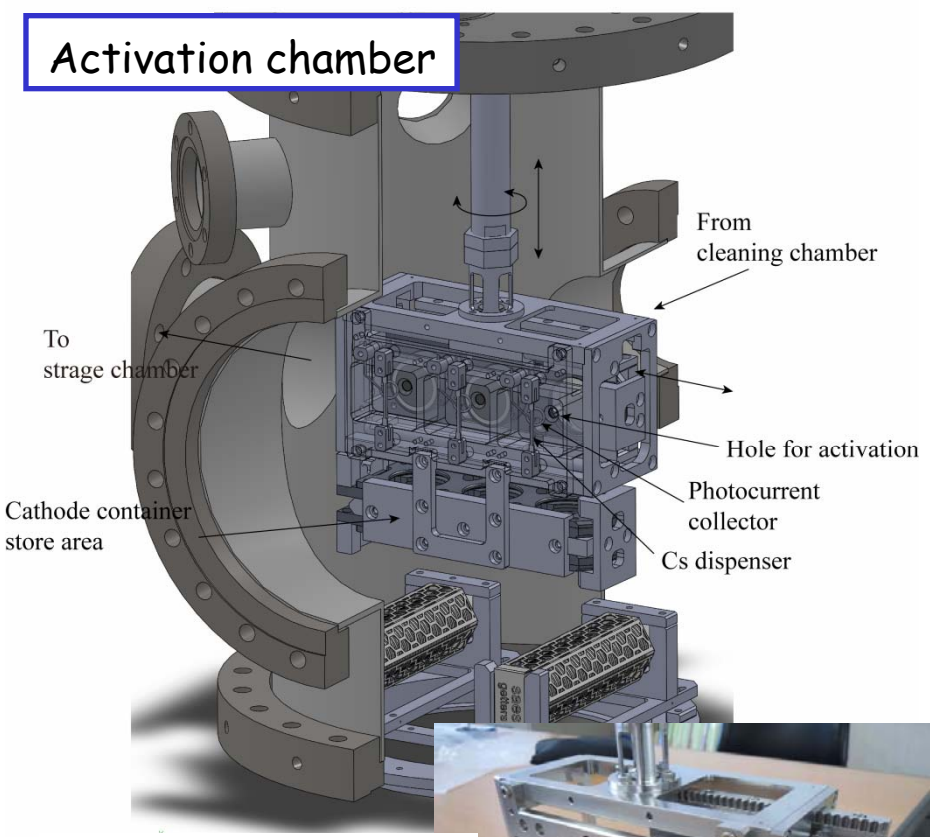
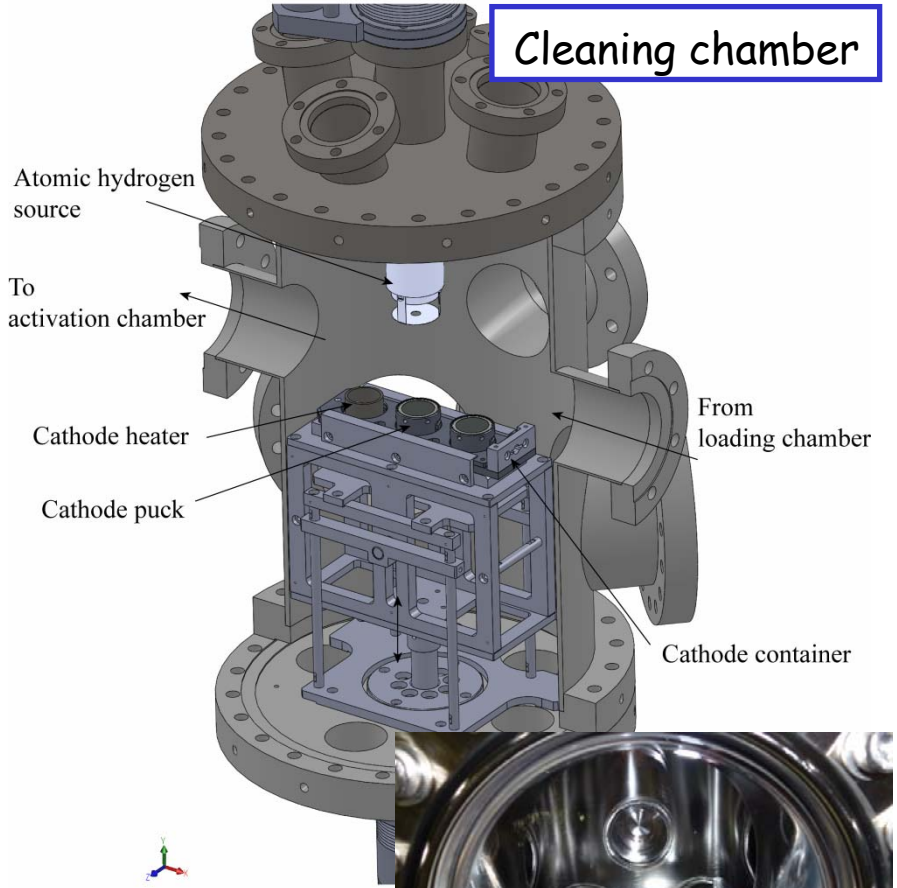
Cathode Cleaning & Activation System

Activation chamber



Three Cs sources & photo-electron collectors.
Two cathode-containers store area.

Cleaning chamber



Atomic hydrogen source(s) & three cathode heaters

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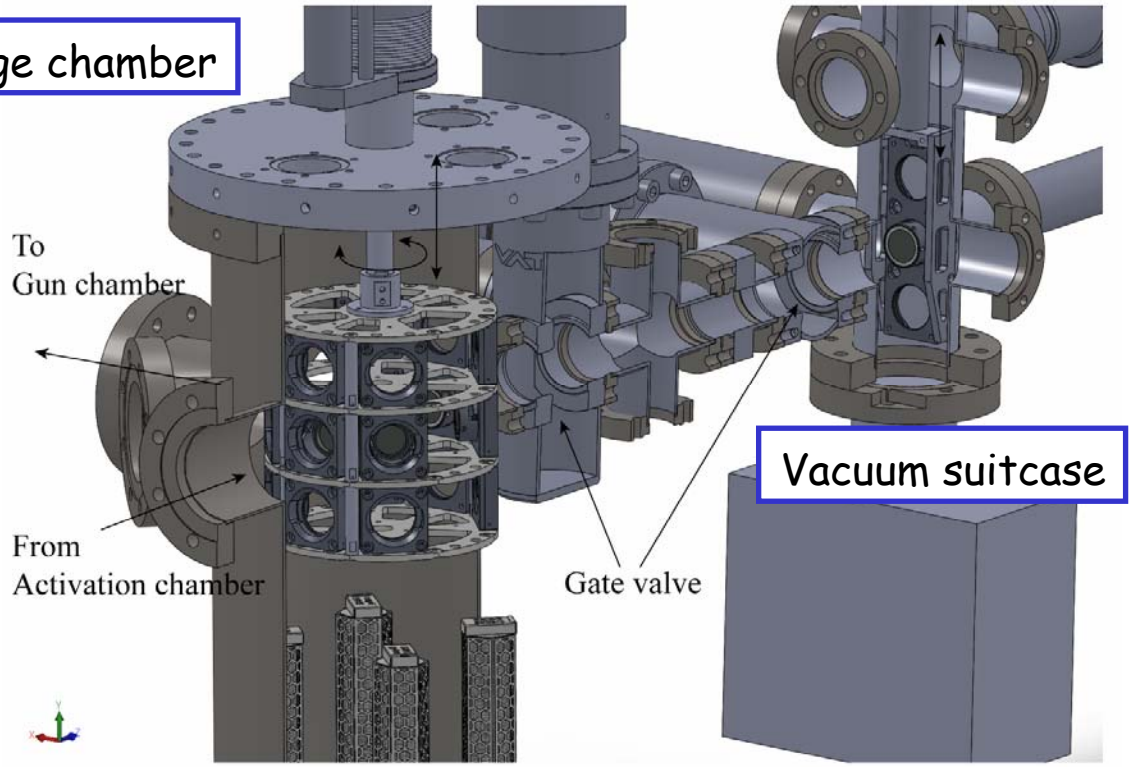
Cathode Storage & Vacuum Suitcase



- ✓ 18 cathodes (max.) can be stored under XHV condition.
- ✓ Other type of cathode can be installed directly by using vacuum suitcase optionally.
- ✓ The function of automatic QE map observation will be developed.

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Summary

✓ The 2nd DC-gun is almost constructed.

✓ The total out gassing rate of overall dc gun system was suppressed to Q ~8.1x10^{-11} [Pa m^3/s].

✓ The pumping speed of the 4K bakeable cryopump was measured.

- ~1000 L/s for CH_4, N_2, CO_2 @ 1x10^{-9} [Pa].

✓ HV conditioning was carried out and reached over 500 kV.

- About 90% trips happened between the anode-cathode gap.
- 480 kV, 2 hours test has been done without HV trip.

✓ The design of simultaneous triplet cathodes preparation and cathode storage system has been finished. The system is now under construction.

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Acknowledgement

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