Status of 500-kV DC gun at JAEA

N. Nishimori, R. Nagai, R. Hajima

Japan Atomic Energy Agency (JAEA)

M. Yamamoto, T. Miyajima, Y. Honda

KEK

H. Iijima, M. Kuriki

Hiroshima University

M. Kuwahara, S. Okumi, T. Nakanishi

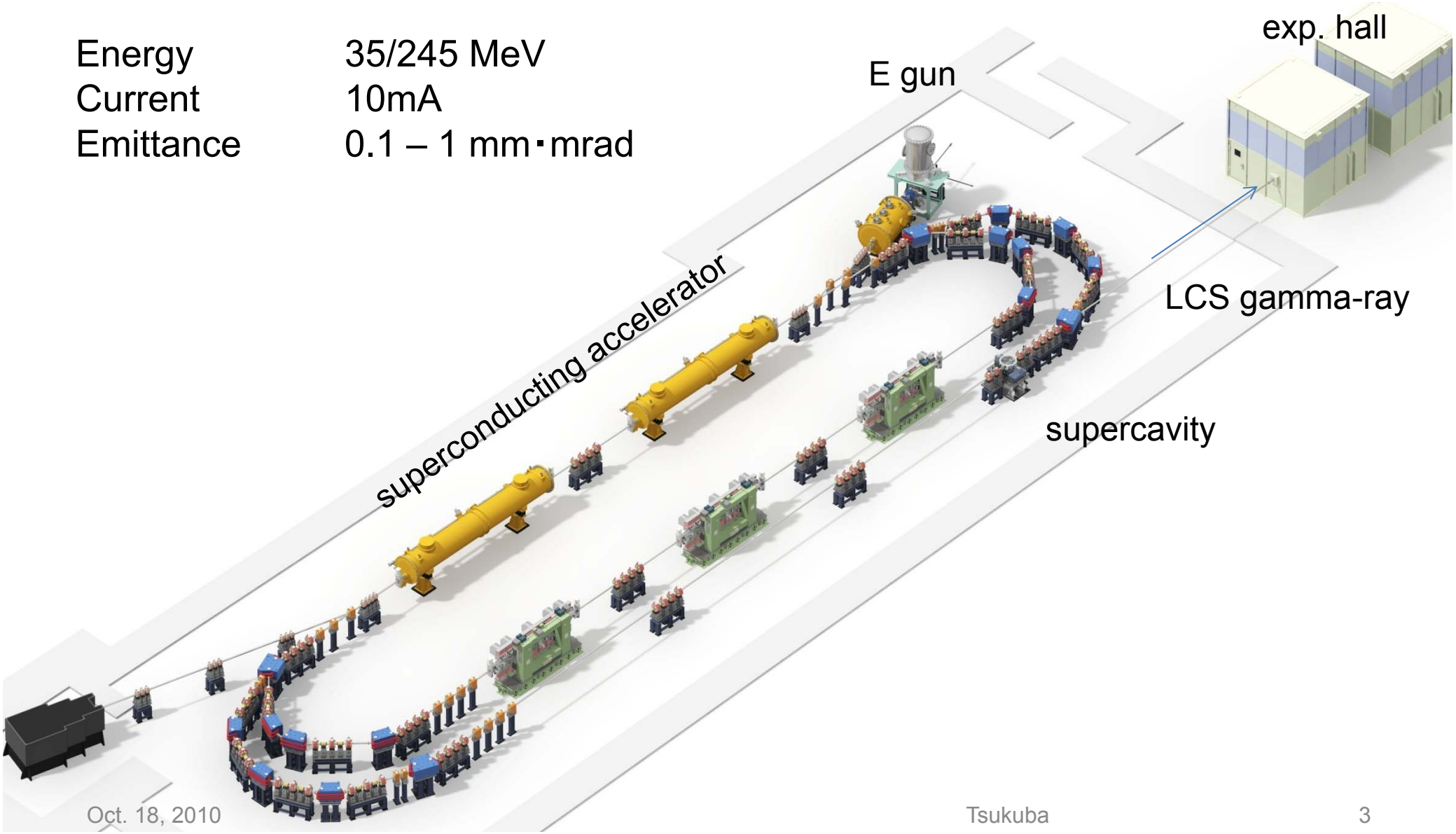
Nagoya Univiersity

Outline

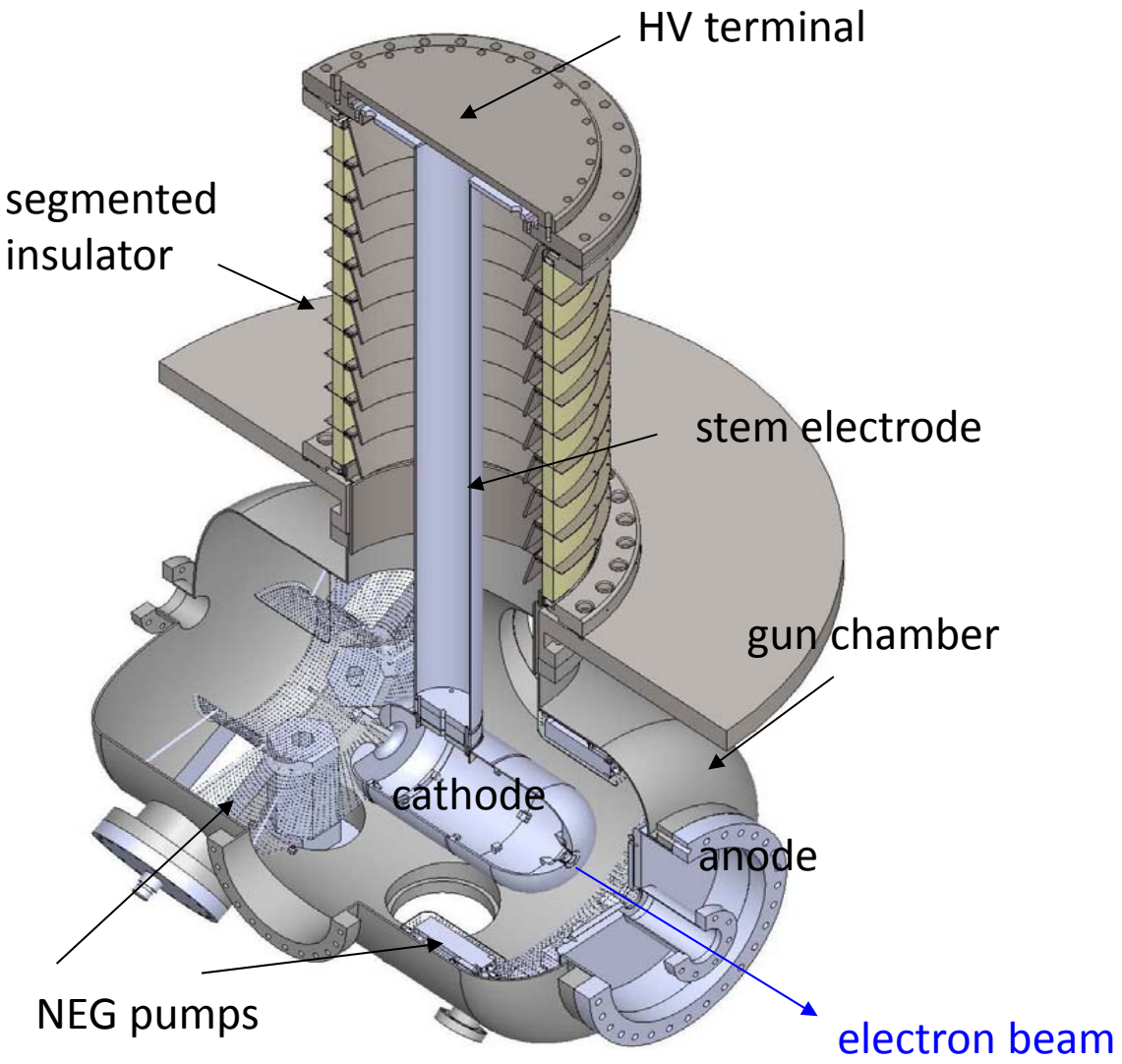
- Introduction (Compact ERL, a 500 kV DC gun)
- High voltage testing of segmented ceramics with a stem electrode
  - HV processing up to 550 kV
  - 500 kV for eight hours without any discharge
- High voltage processing with electrode in place
  - HV processing up to 526 kV
  - Local radiation problem
- Beam generation at 300 kV
- Summary and Outlook

Compact ERL (test facility)

Energy	35/245 MeV
Current	10mA
Emittance	0.1 – 1 mm･mrad



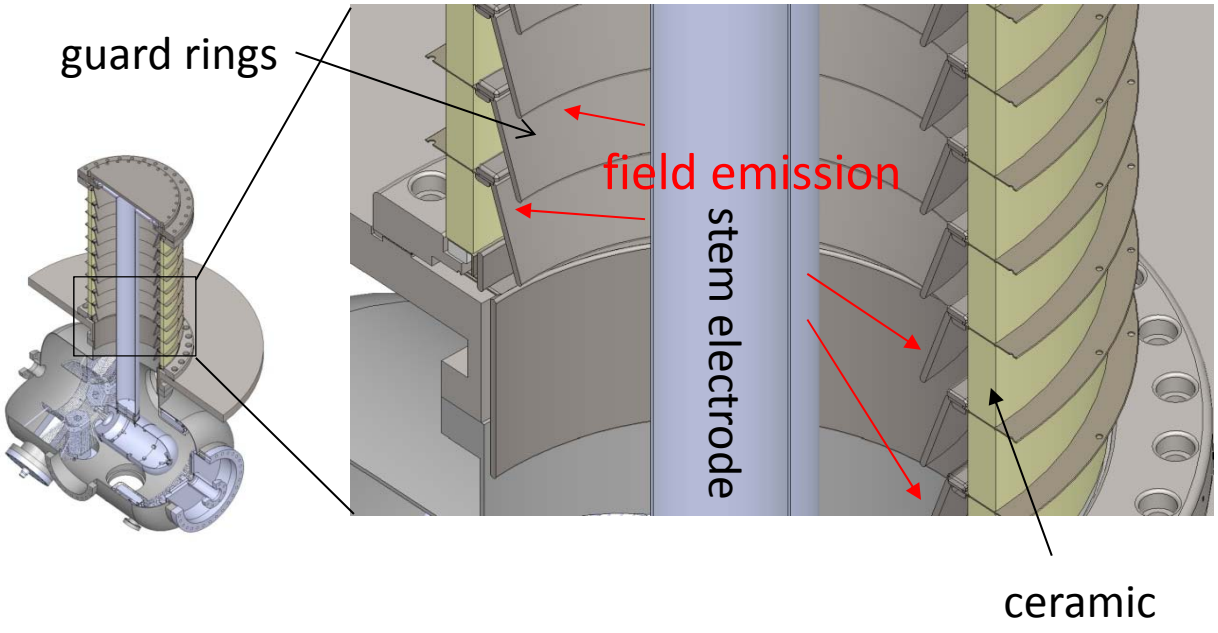
A 500 kV photocathode DC gun at JAEA

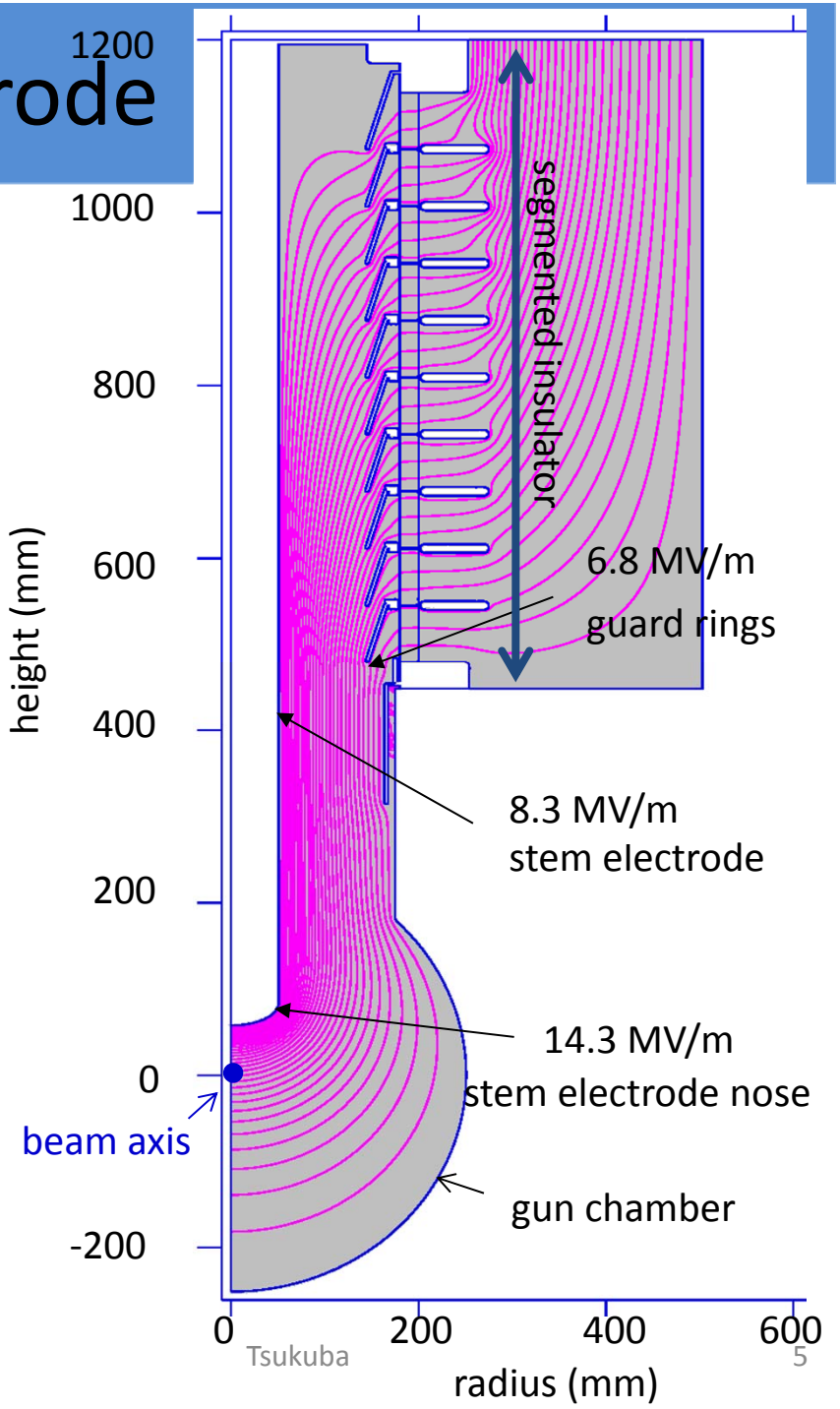


Field emission from stem electrode

Employed a segmented insulator to mitigate field emission problem.

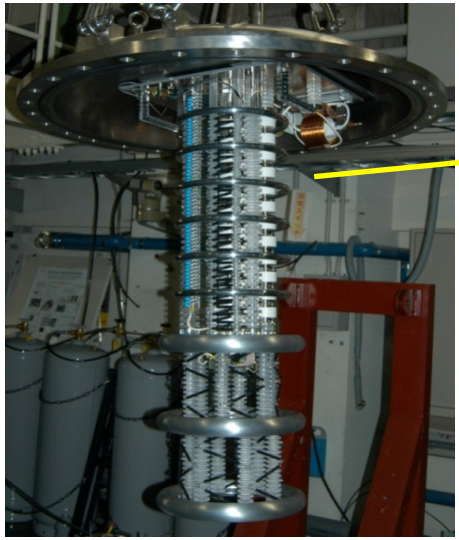
- uniform electric field
- means to attach rings which guard ceramics against field emission.

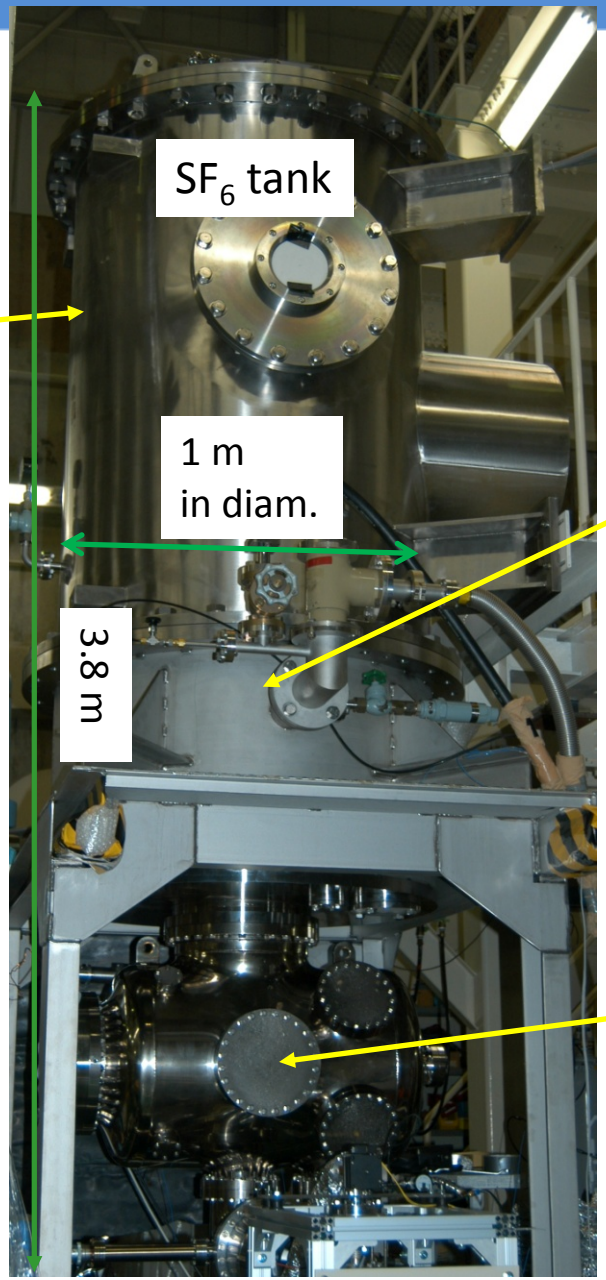




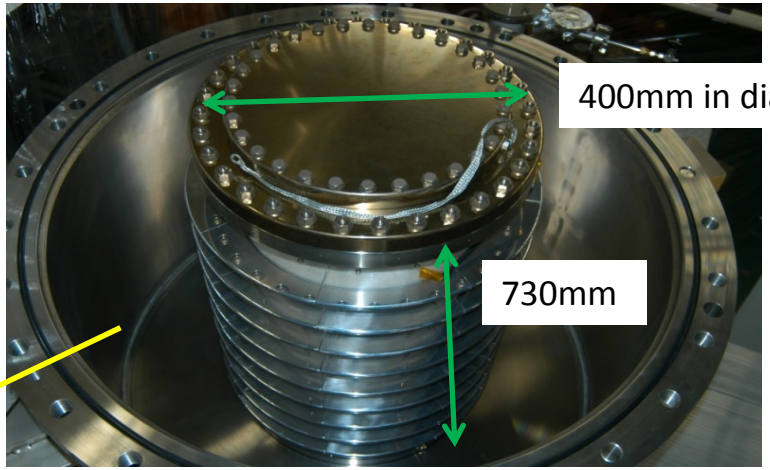
500kV DC gun at JAEA

550kV Cockcroft Walton power supply

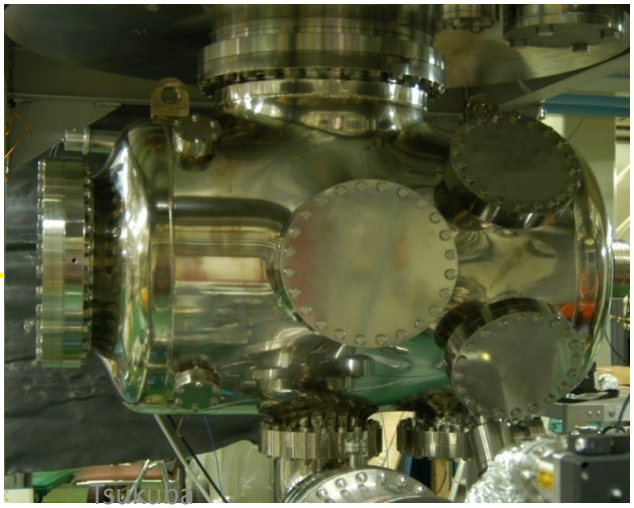




segmented insulator

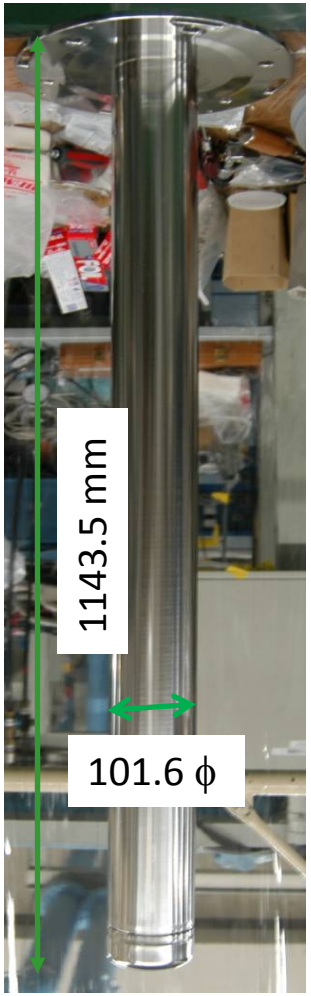


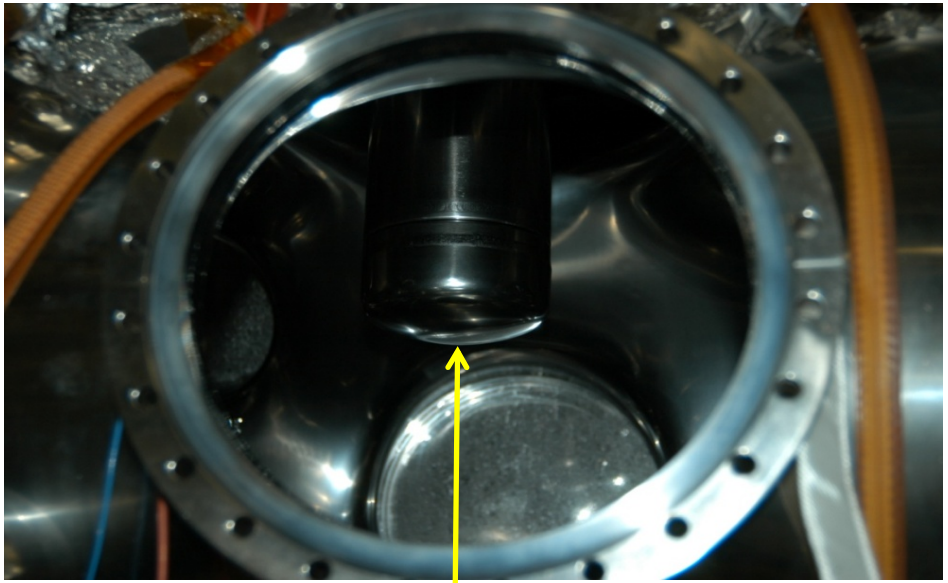
gun chamber made of titanium



High voltage testing with a stem electrode

stem electrode

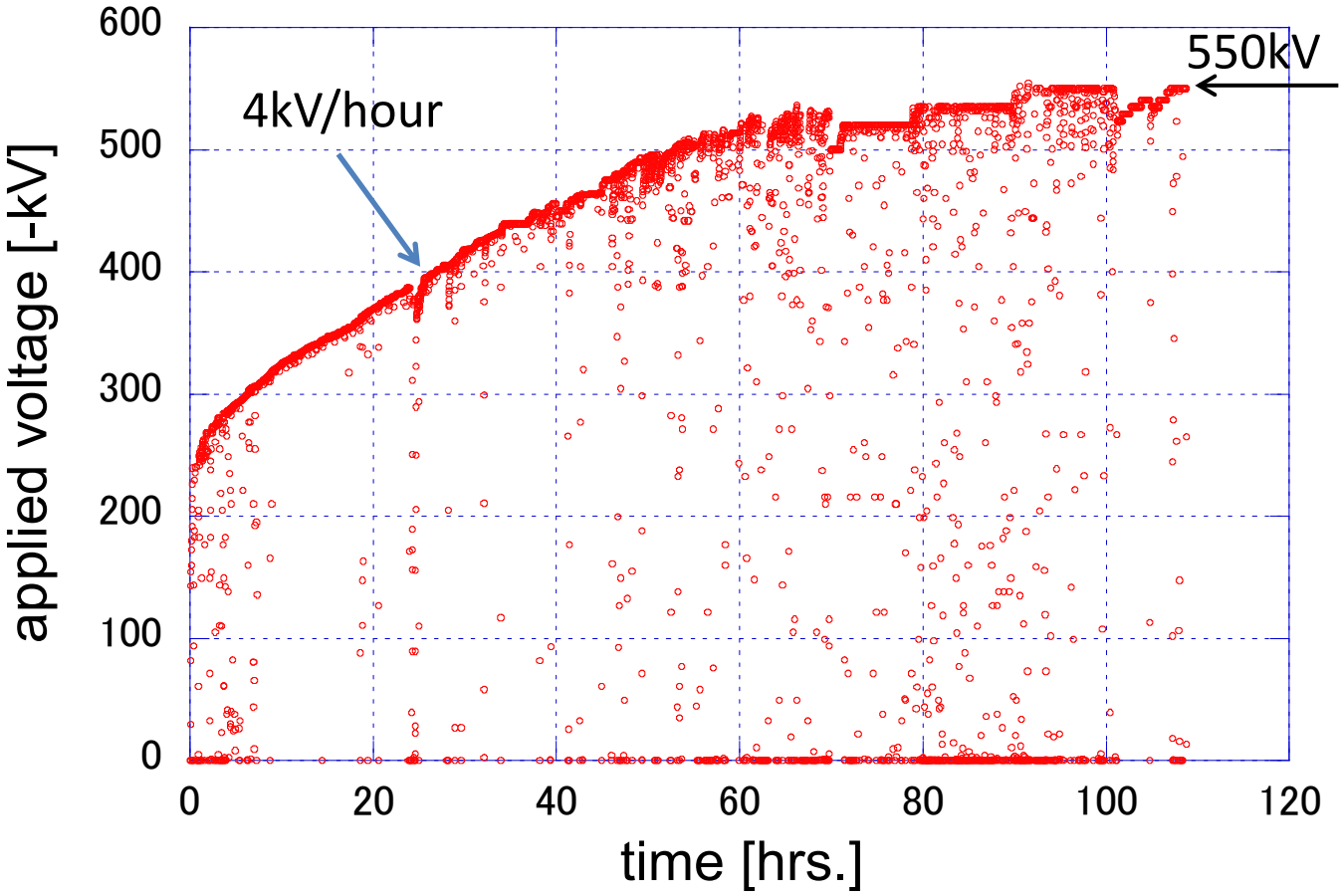




dummy cup instead of cathode electrode

HV processing

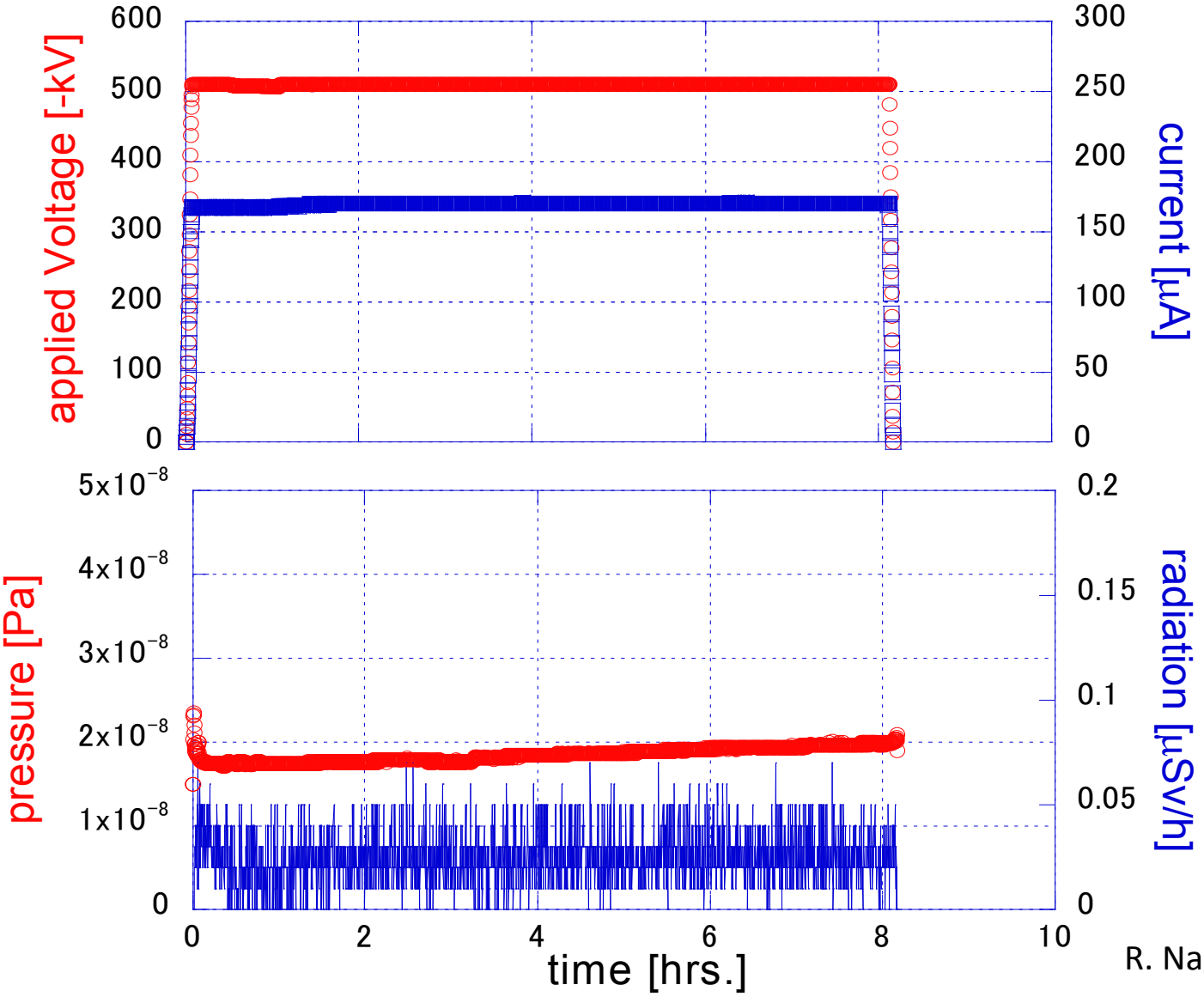
- 190℃ baking for 8 hours
- start processing at 3×10^{-8}[Pa]
- Vacuum pump: 1000L/s-TMP



- one hundred hours to reach 550 kV
- quarter hour for each 1kV step from 250 kV to 500 kV
- slower processing above 500 kV

R. Nagai et al., “High-voltage testing of a 500-kV dc photocathode electron gun”, RSI. 81 033304 (2010).

Stable operation at 500 kV for 8 hours



C.W.:510kV

R_{div} : 5GΩ

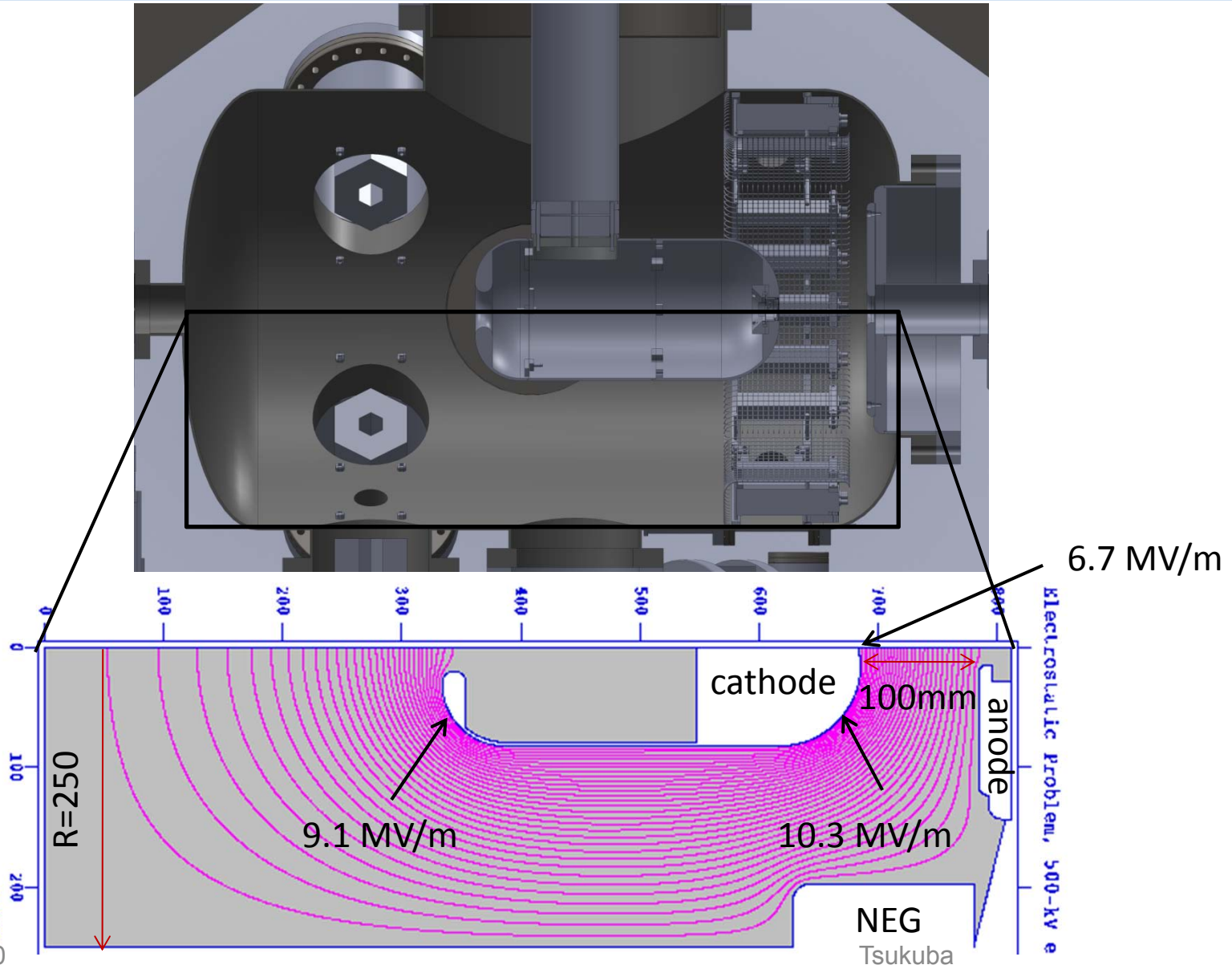
R_{out} : 0.1GΩ

→500kV@insulator

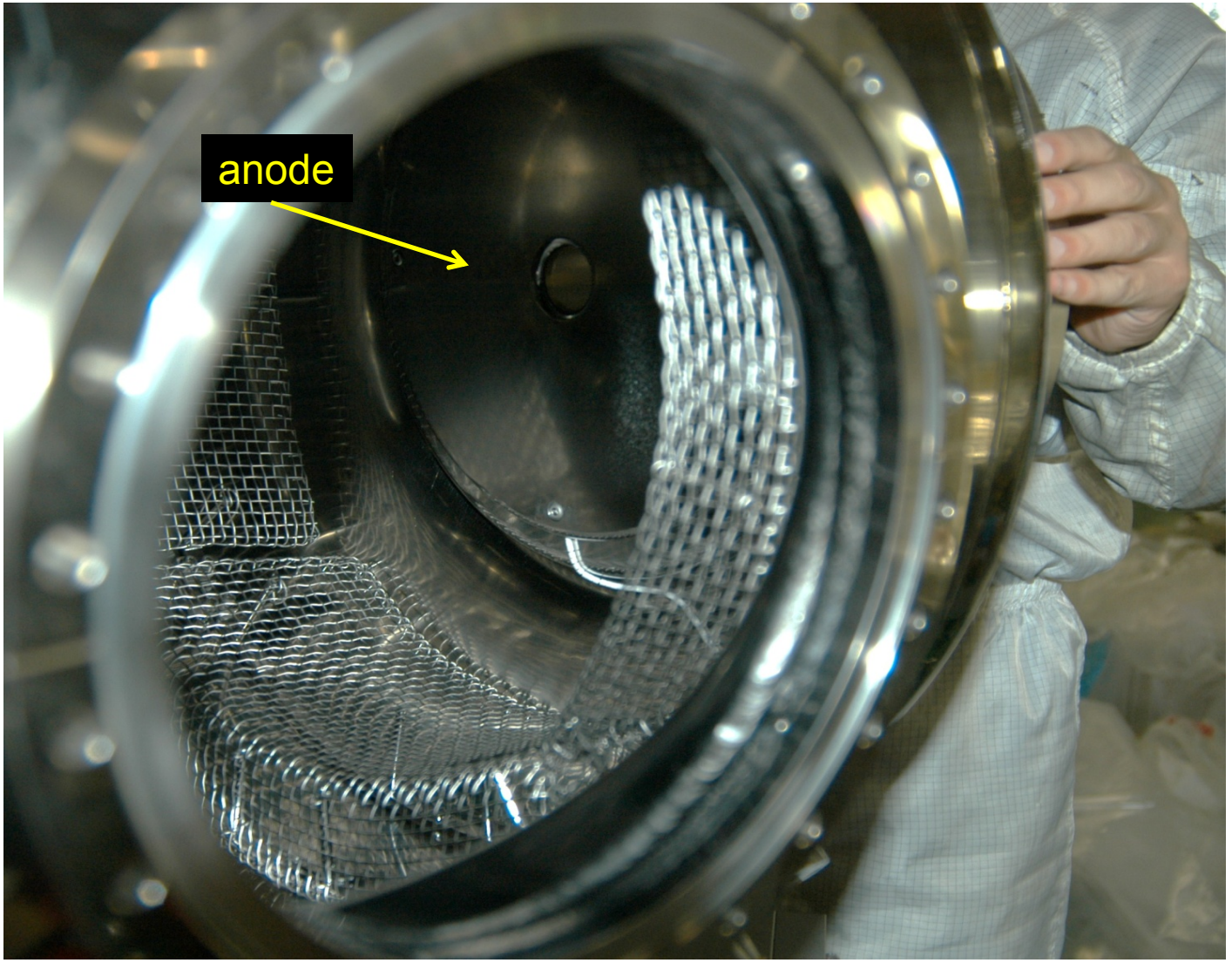
No indication of discharge, local heating due to dark current

R. Nagai et al., RSI 81 033304 (2010).

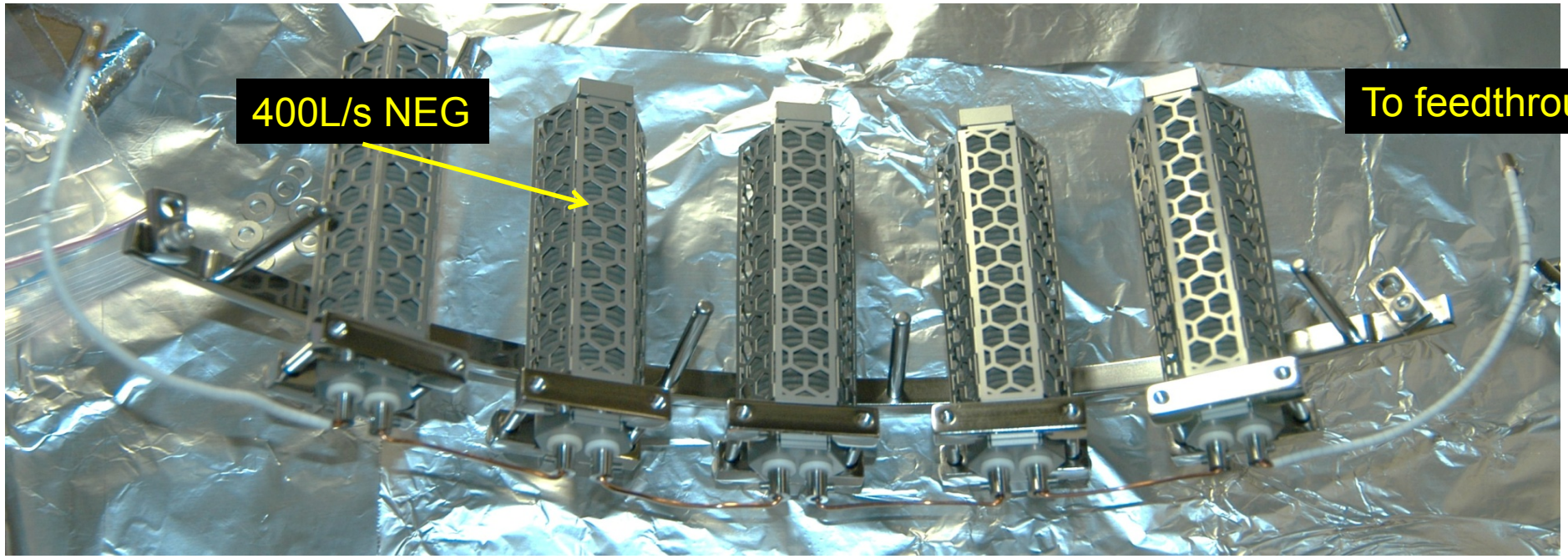
Cathode electrode: POISSON calculation

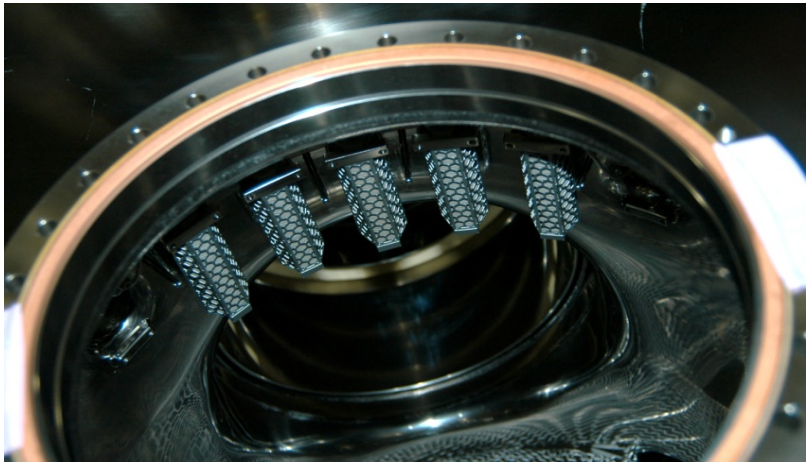


Installation of electrodes



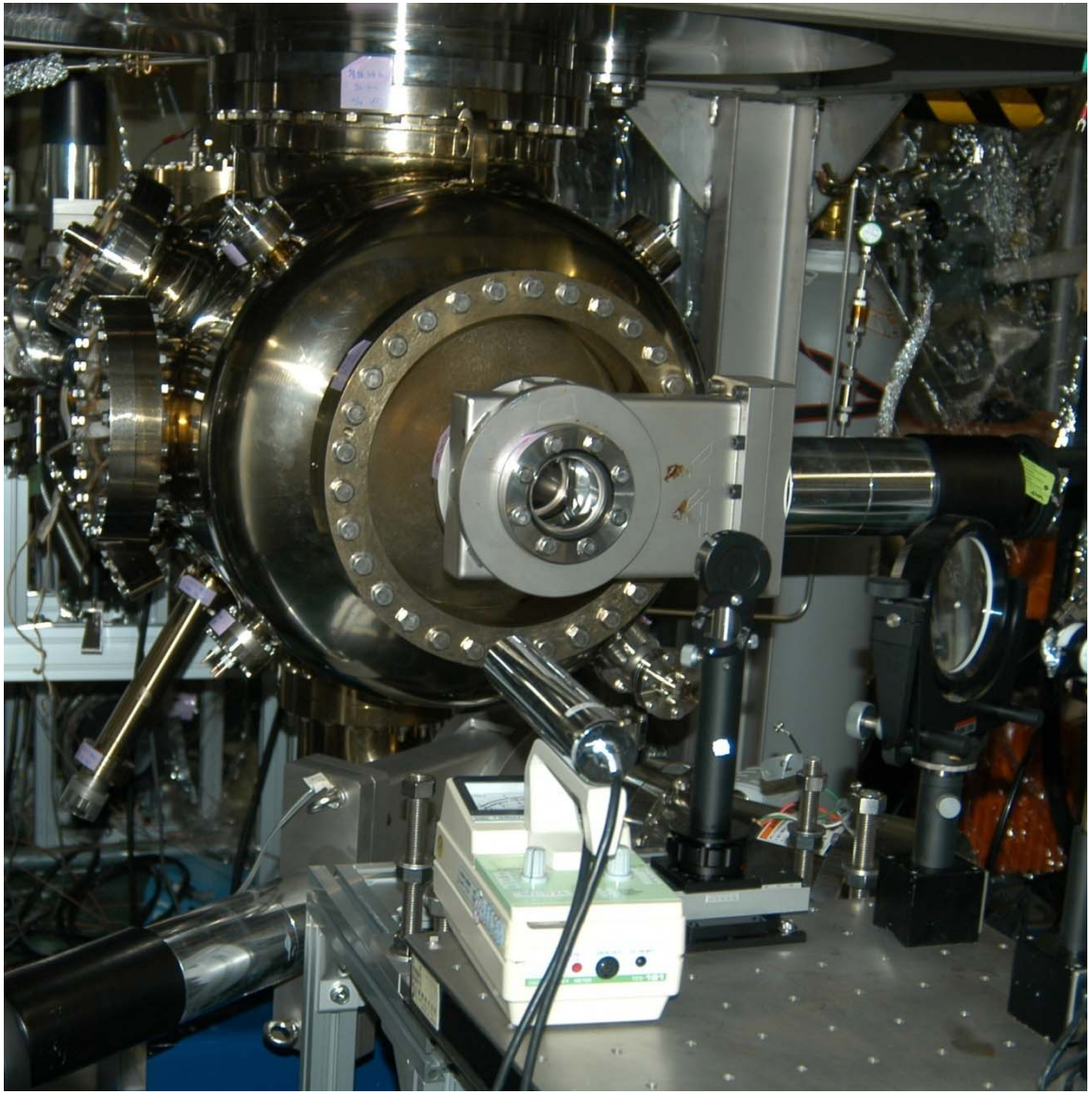
Installation of NEG pumps





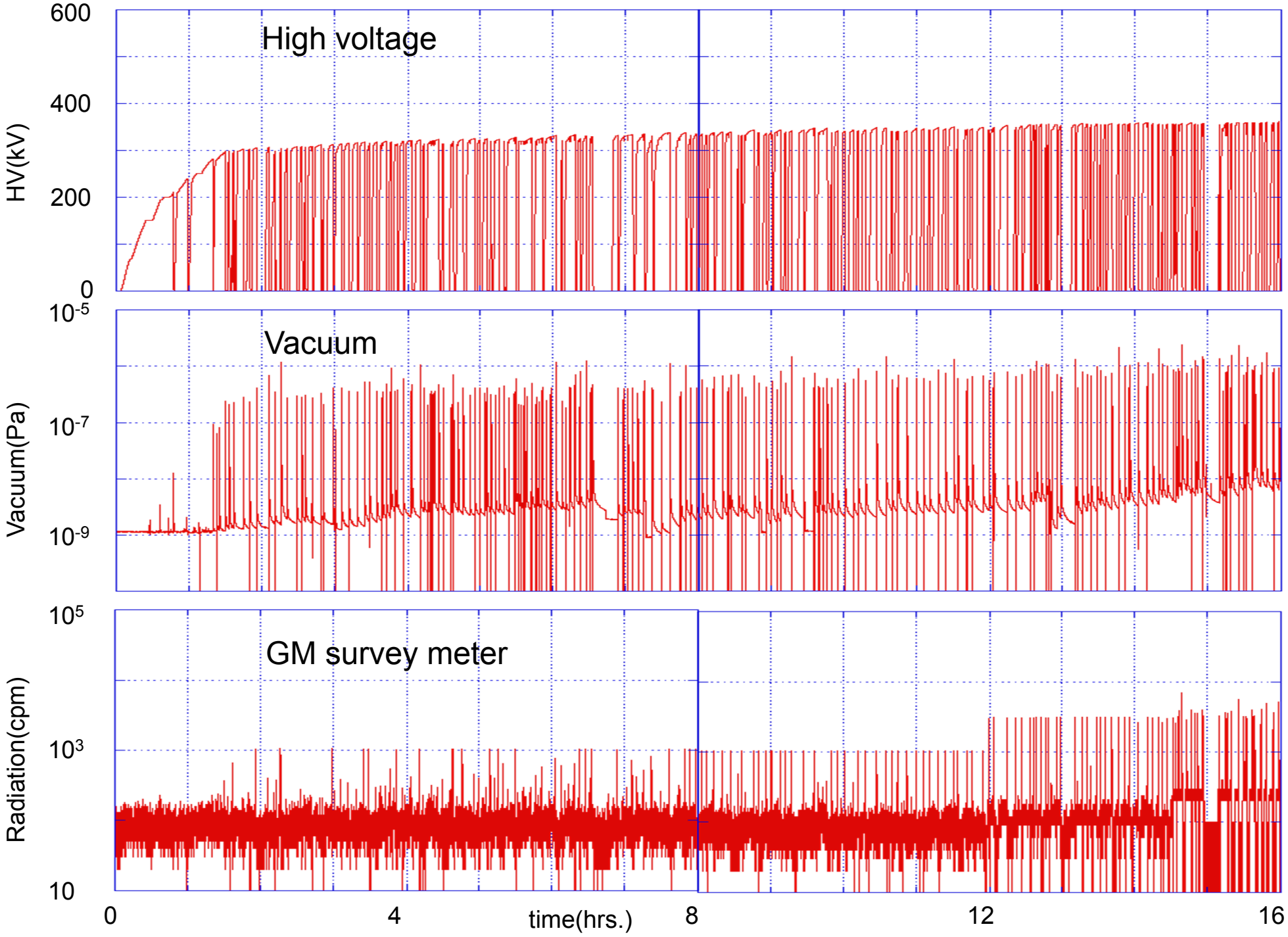
8,000 l/s around electrodes
10,000 l/s downstream of cathode

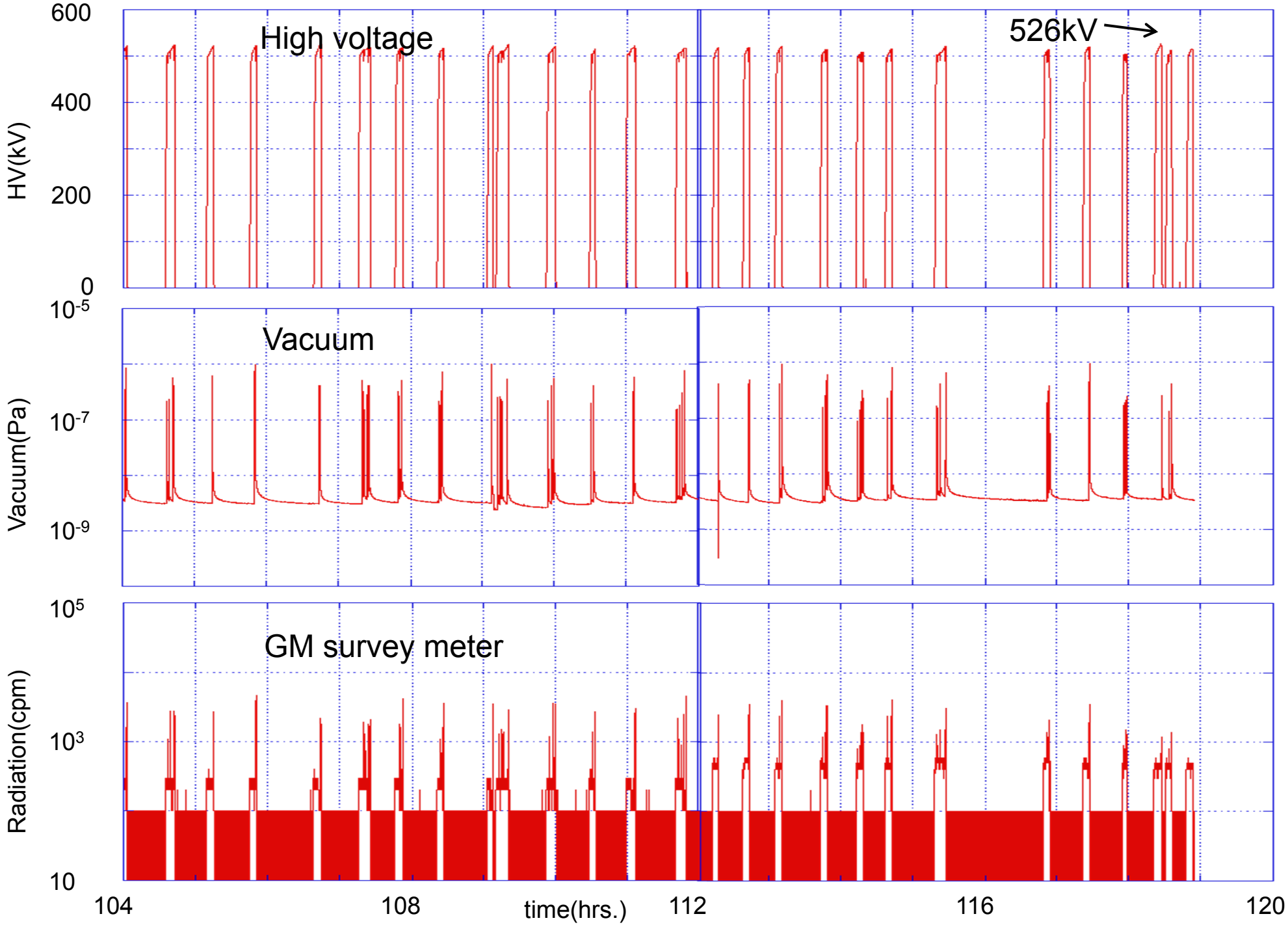
Processing setup



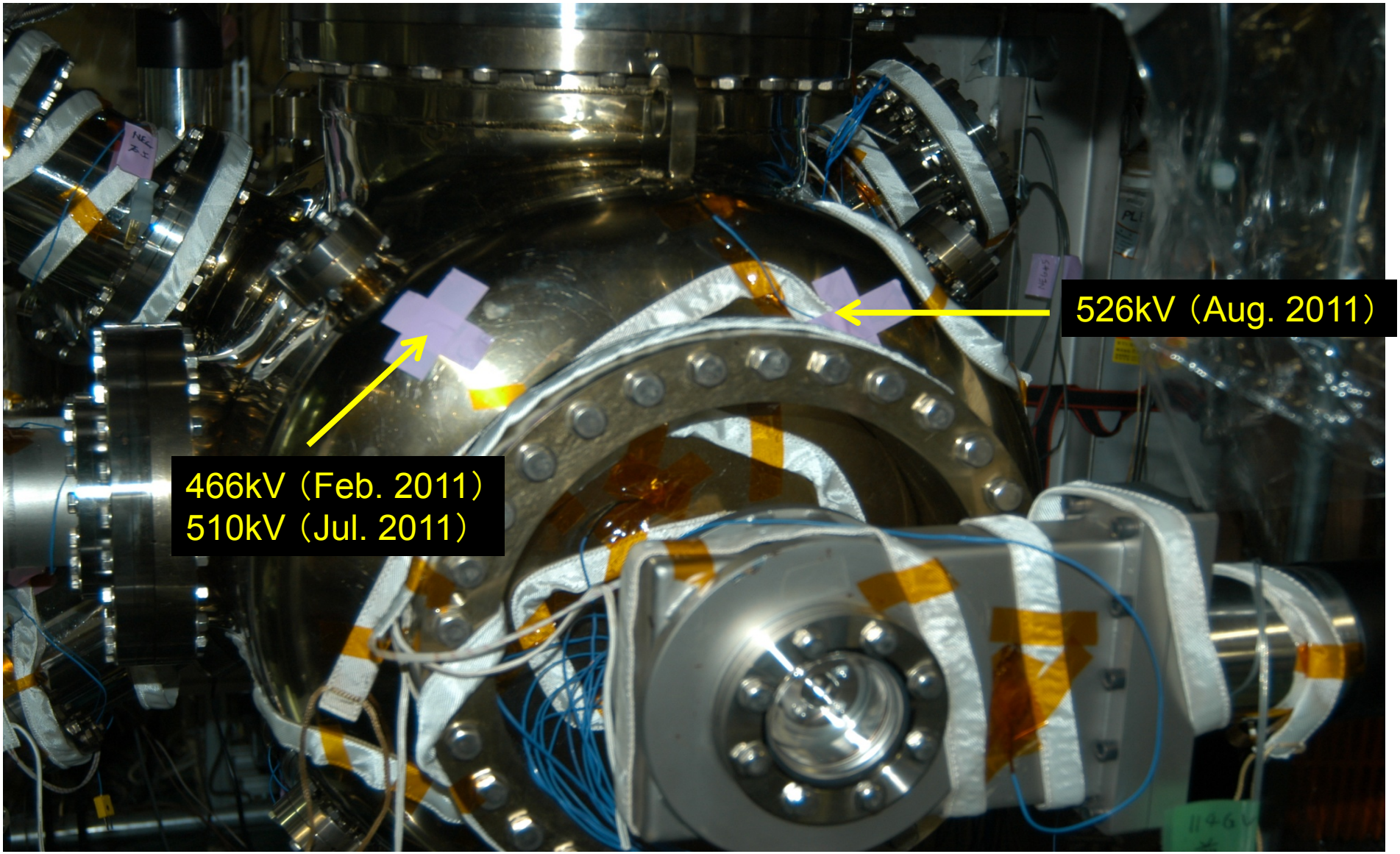
Interlock system:
>1x10^{-6}Pa
>3μSv/h

NaI/GM detector:
0.2m downstream of anode
Time constant 3s

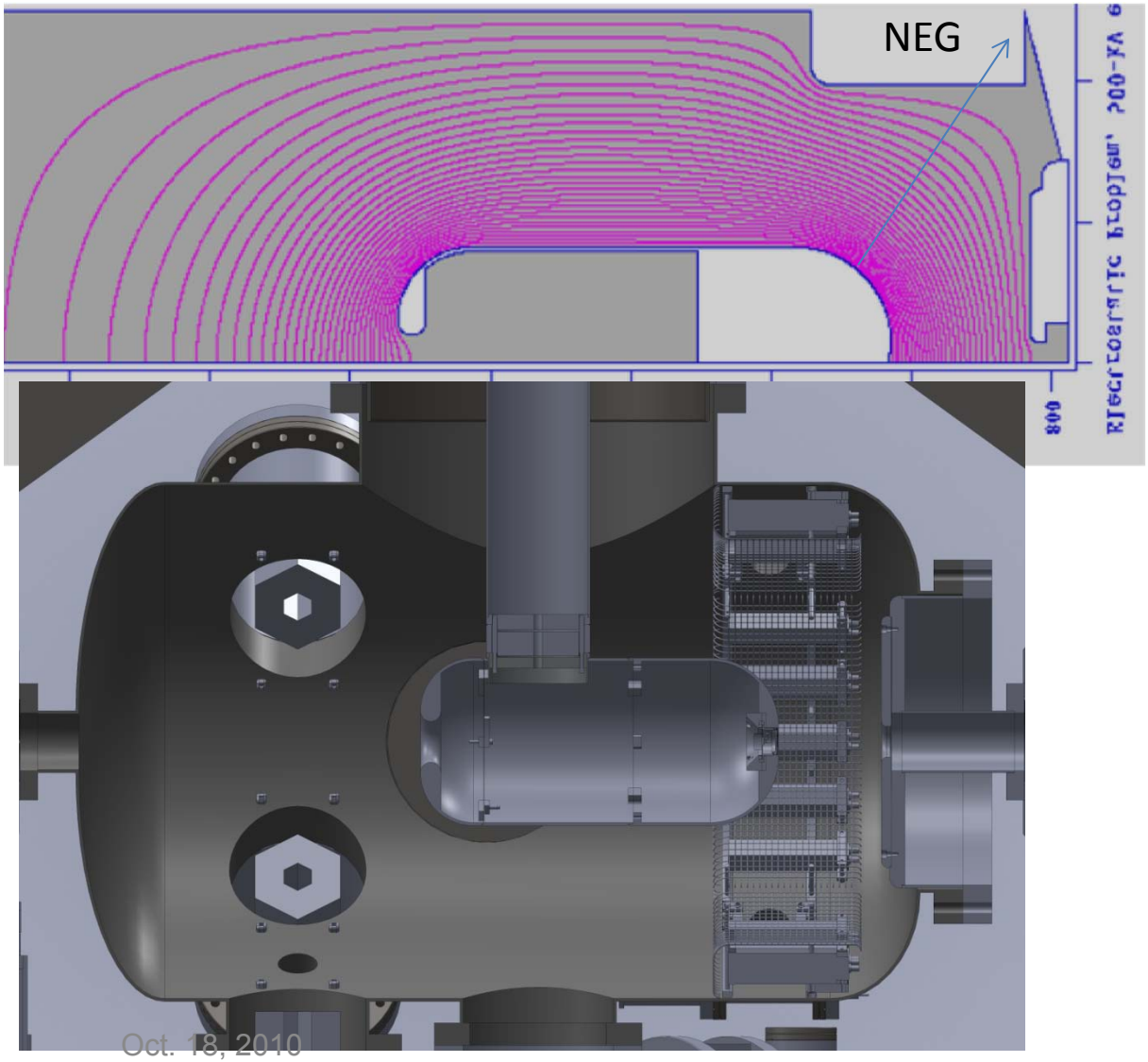

High voltage
HV(kV)
600
400
200
0
Vacuum
Vacuum(Pa)
10-5
10-7
10-9
GM survey meter
Radiation(cpm)
105
103
10
0
4
8
12
16
time(hrs.)


High voltage
526kV
HV(kV)
600
400
200
0
Vacuum
Vacuum(Pa)
10^{-5}
10^{-7}
10^{-9}
GM survey meter
Radiation(cpm)
10^{5}
10^{3}
10
104
108
time(hrs.)
112
116
120

Local radiation



What causes local radiation? dust ?



Local radiation

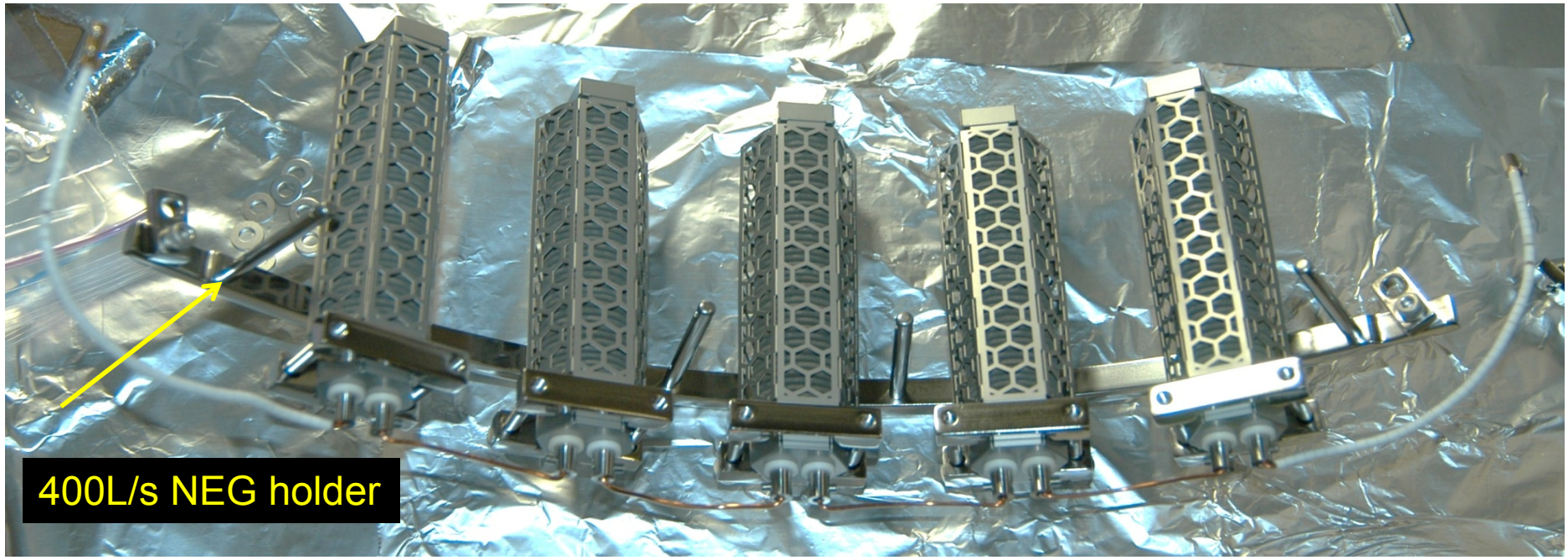
Does not exist at fist
Appears suddenly after a discharge
Disappears by hand wiping

→ dust inside HV chamber

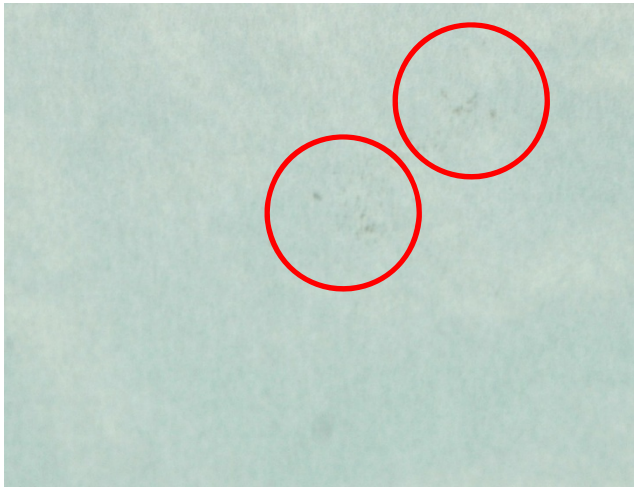
Generated from max. E field
Levitation of dust ?

Observed upward radiation only
Fall from NEG, mesh or holder ?

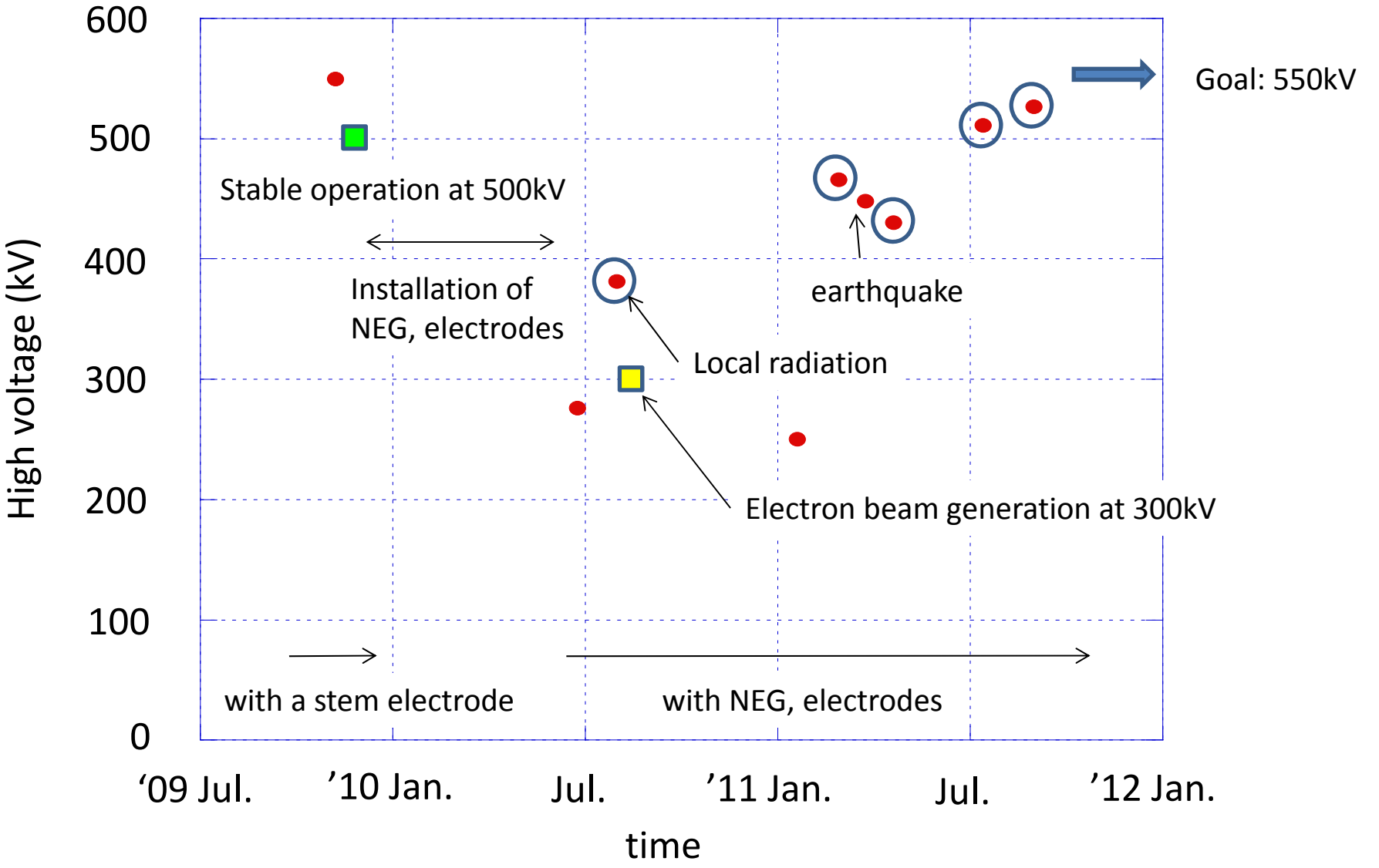
Possible source of dust



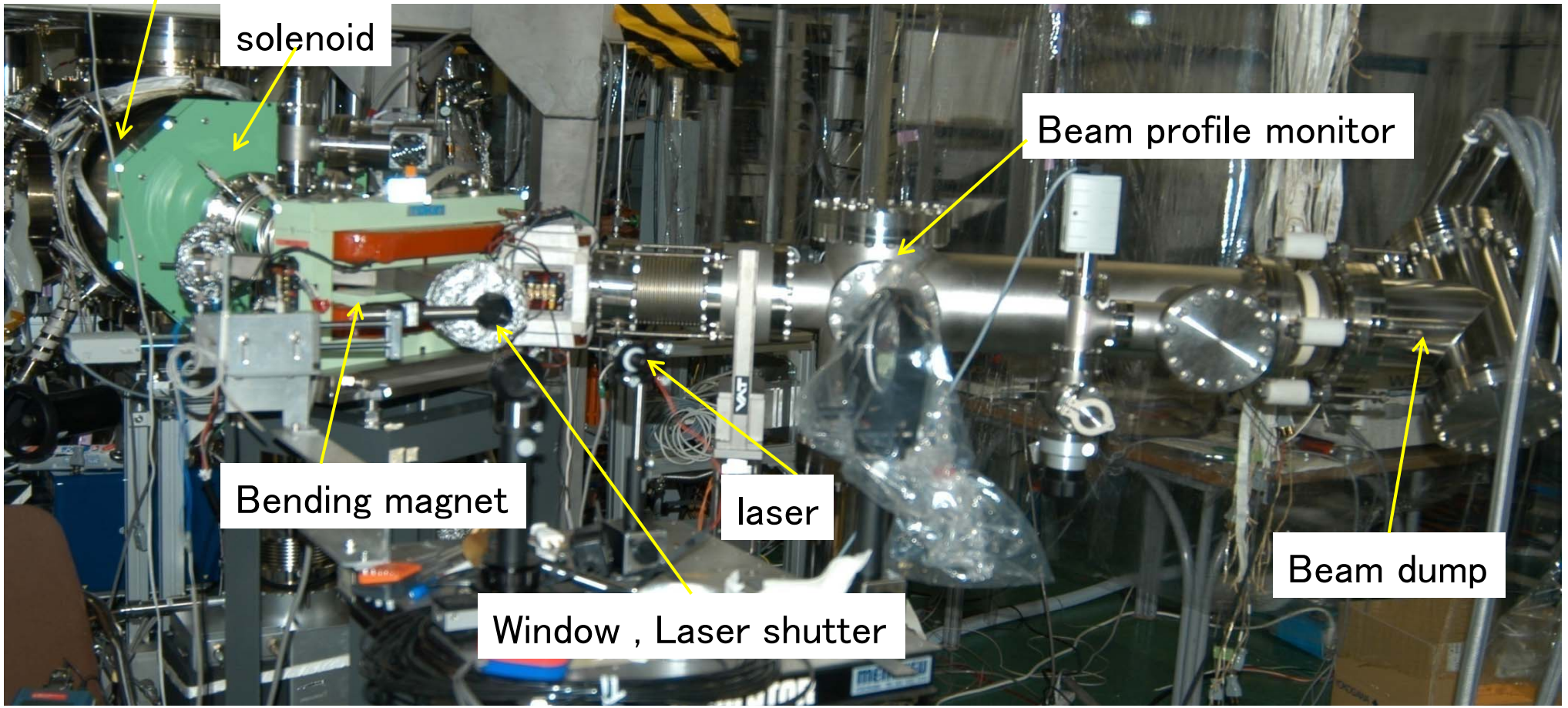
Polishing powder found in holes of NEG holder parts



History of HV processing



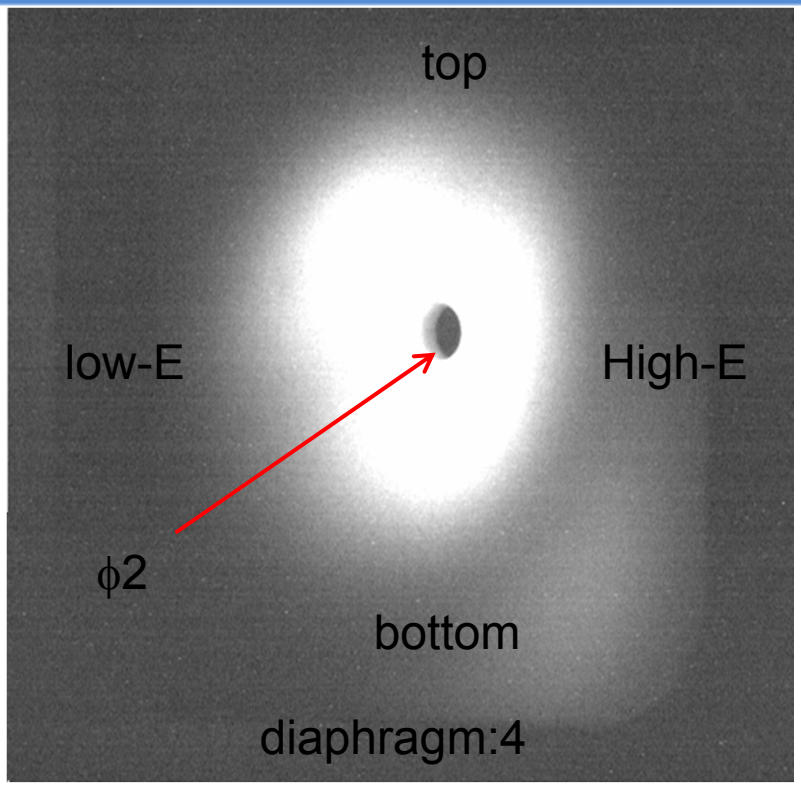
Downstream beam line

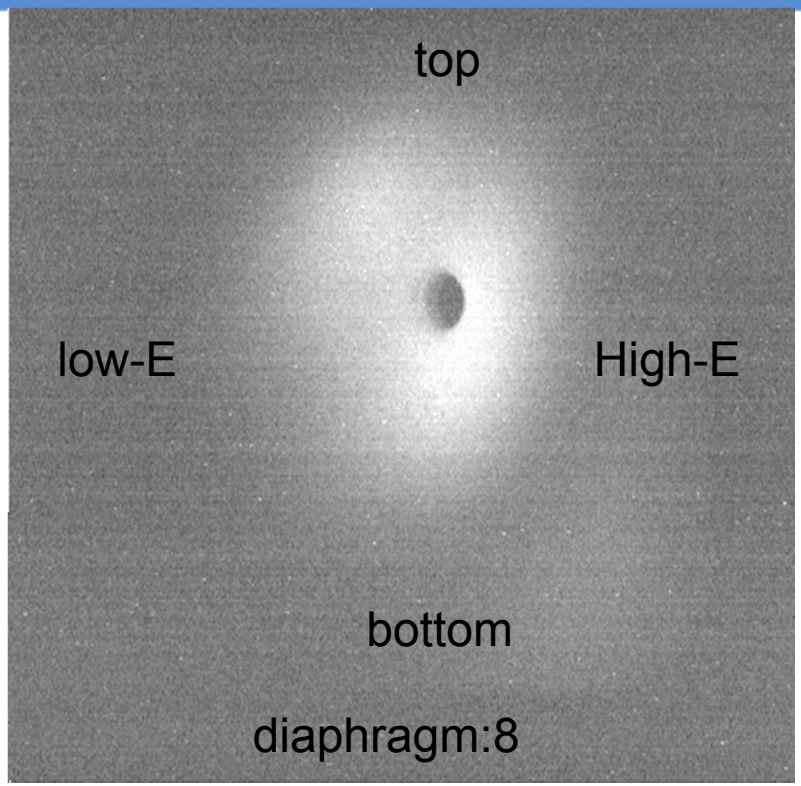


1.2 m from anode to bending magnet

0.7 m from bending magnet to beam profile monitor

300 keV beam generation





- Beam profile on screen placed 1.9m downstream from anode.
- 15nA@beam dump, laser power 1.4μW@532nm, QE=2.5%
- 5.7μA@beam dump at maximum due to radiation from beam dump

Summary and Outlook

- 500kV gun status
  - ✓ HV test with a stem electrode: 550kV processing, 500kV for 8 hours without any discharge
  - ✓ Electrodes: installed. Maximum field <10.3 MV/m, 6.7 MV/m on cathode
  - ✓ NEG pumps: Installed in gun chamber
  - ✓ Vacuum: $<1\times10^{-9}$ [Pa] in HV chamber
  - ✓ HV test with electrodes in place: 526kV processing
  - ✓ Beam generation at 300kV
- Outlook
  - HV processing up to 550kV by solving local radiation problem