Update on the status of the electron cloud studies at KEKB

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Contents

Brief review of our studies

Updates

- Clearing electrode
- Groove structure
- SEY measurement

Summaries and Future plans

EC Studies at KEK

- A pressing issue for the upgrade of KEKB (SKEKB): To establish effective and applicable EC mitigation techniques in a magnetic field
  - At drift space: “Solenoid field + Beam ducts with antechamber” is a basic and a very effective remedy.
  - In magnets, the antechamber-scheme and TiN coating is also effective. But more definitive techniques are required.

- Focused items in these years are;
  - Clearing electrode
  - Groove structure
  - Measurement of SEY
  - Coatings (TiN, DLC)

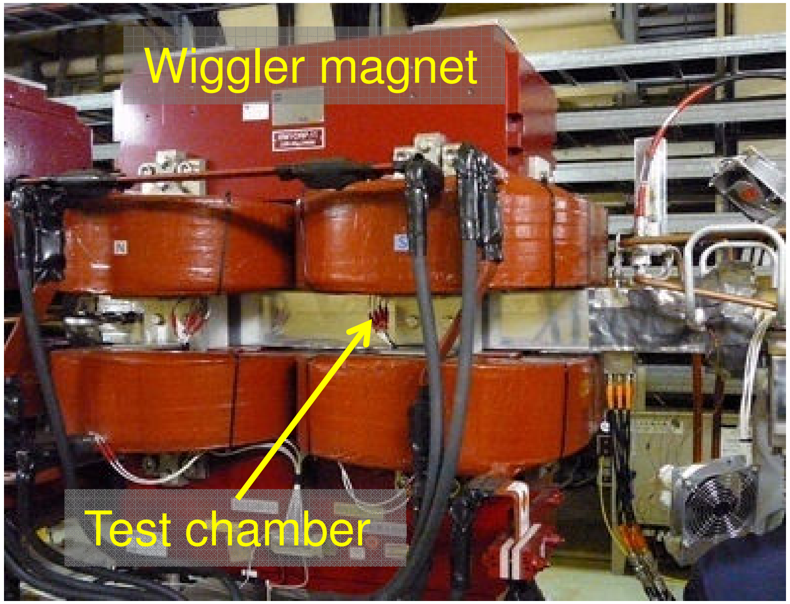
EC Studies at KEK

- Experiments of clearing electrodes and groove structures using the positron ring of KEKB
  - Energy = 3.5 GeV,
  - Current ~1600 mA (~ 6 ns spacings, 1585 bunches)
  - Bunch length ~ 6 mm
  - Measure the electron density around beam orbit by using electron monitors with RFA.
- Measurement of SEY at laboratory, in parallel.
  - Surface analysis
- Development of TiN coating apparatus

- Reported here are about the recent progress on the clearing electrode and the groove structure, and some results of SEY measurements.

Experimental setup at KEKB e^+ ring

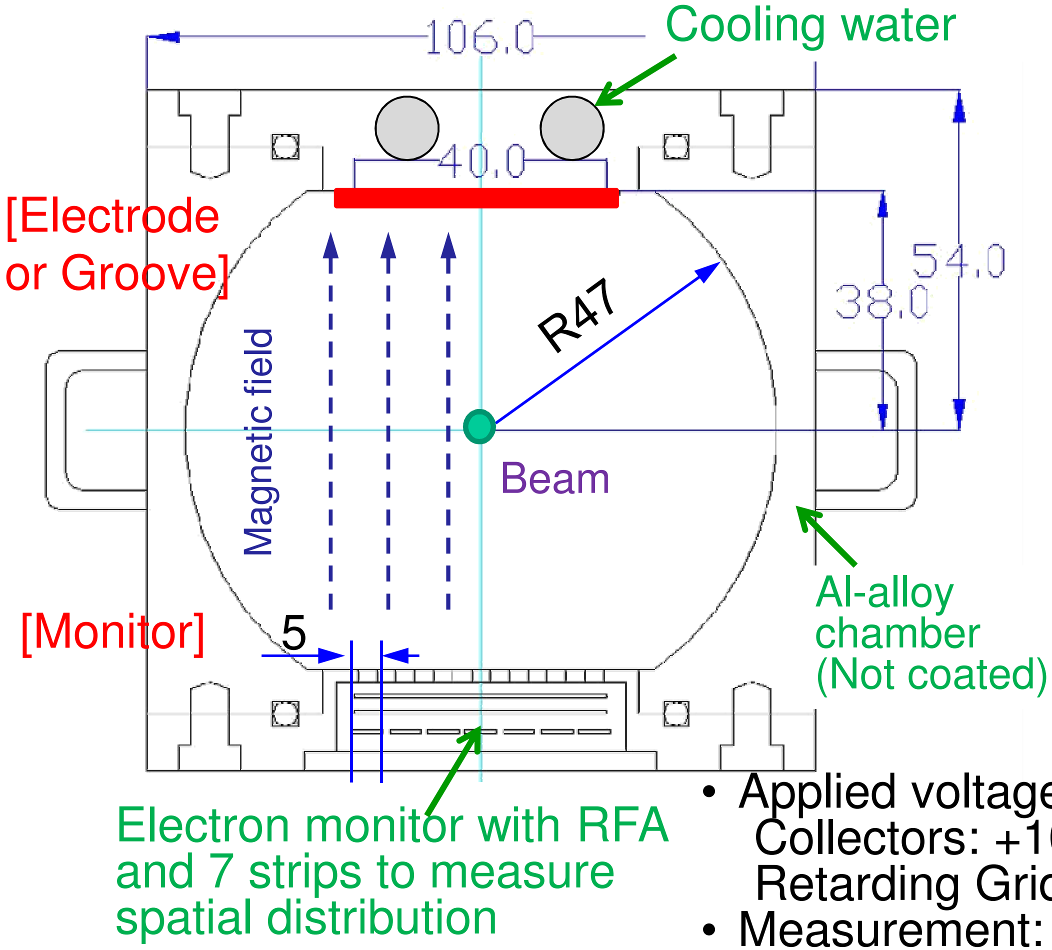
- A test chamber was installed in a wiggler magnet.
  - For tests of a clearing electrode or a groove structure
  - With a RFA, flange insertion

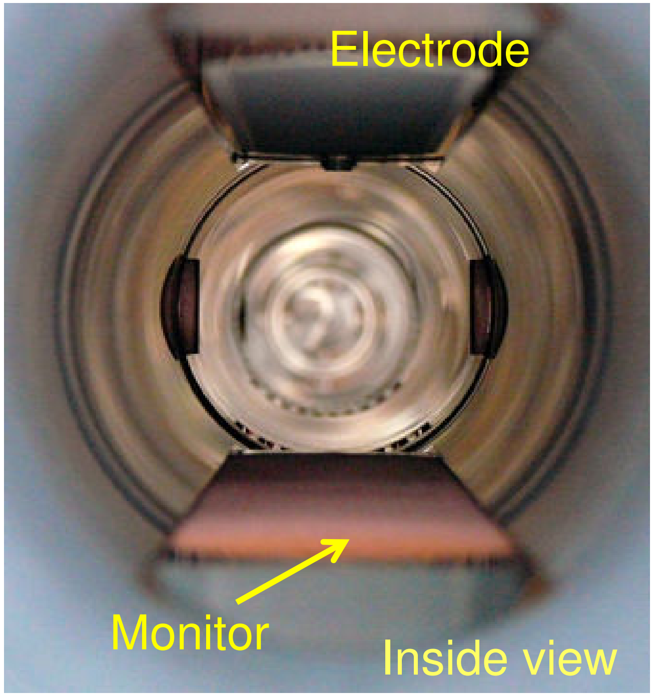


- Wiggler magnet:
  - Magnetic field: 0.78 T
  - Effective length: 346 mm
  - Aperture (height): 110 mm
  - The monitor and insertion are placed at the center of a pole.
- Irradiated photons: 2×10^{17} photons/s/m at 1600 mA

Experimental setup in KEKB e⁺ ring

- A test chamber with an electron monitor (with RFA) and a clearing electrode or a groove structure.





- Applied voltage
  Collectors: +100V
  Retarding Grid: 0 ~ -1 kV
- Measurement: DC mode

Clearing Electrode

- Very thin electrode structure was developed.
  - 0.2 mm alumina-ceramics and 0.1 mm tungsten electrode formed by a thermal spray method.
  - Good heat transfer
  - Low beam impedance

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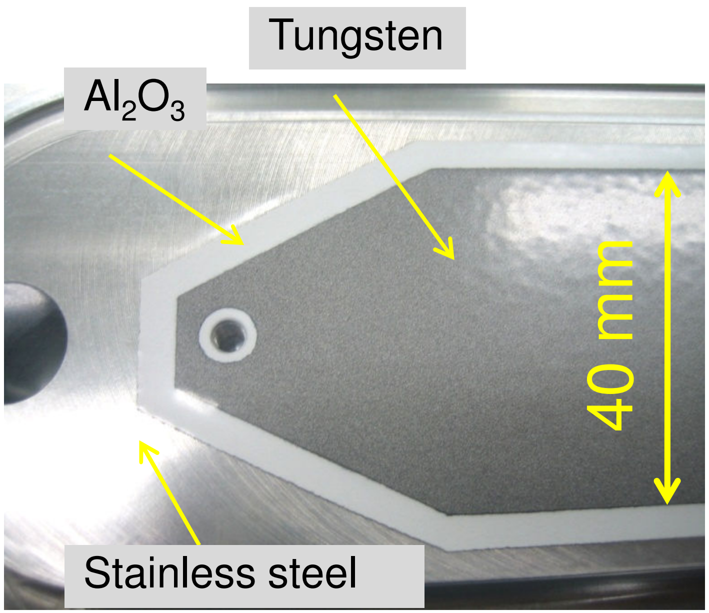
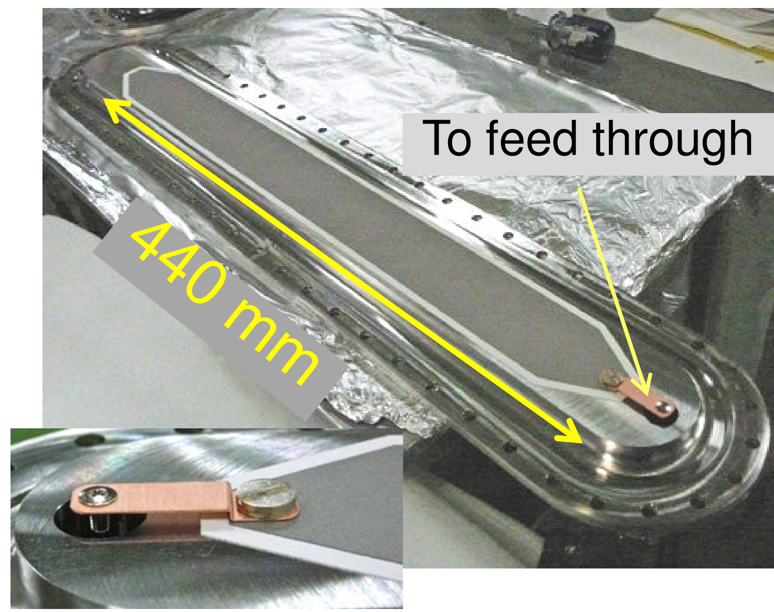


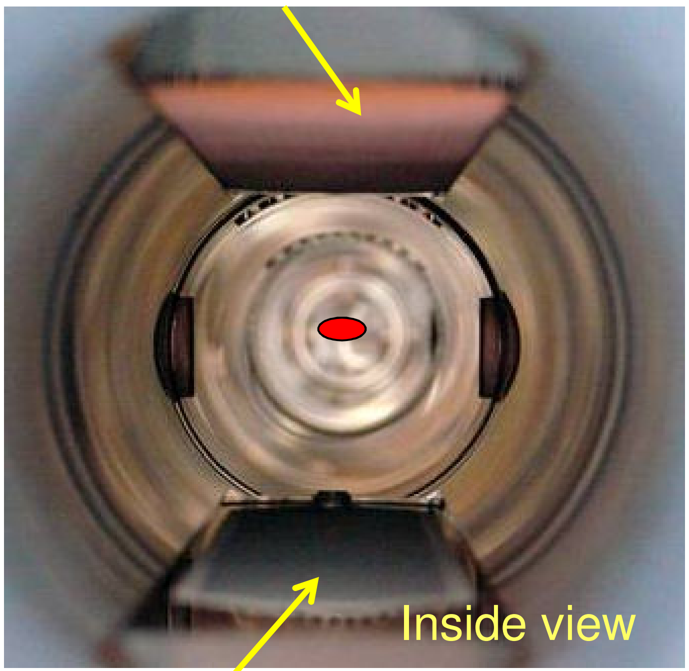
First model



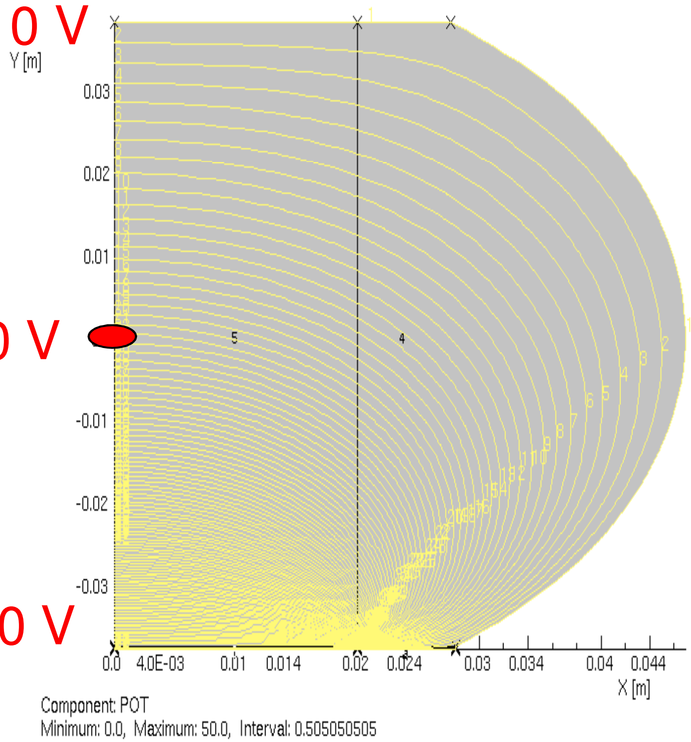
Clearing Electrode

- Electric potential in the chamber
  - ~6 kV/m at the beam orbit, if 500 V is applied to the electrode.

Electron monitor

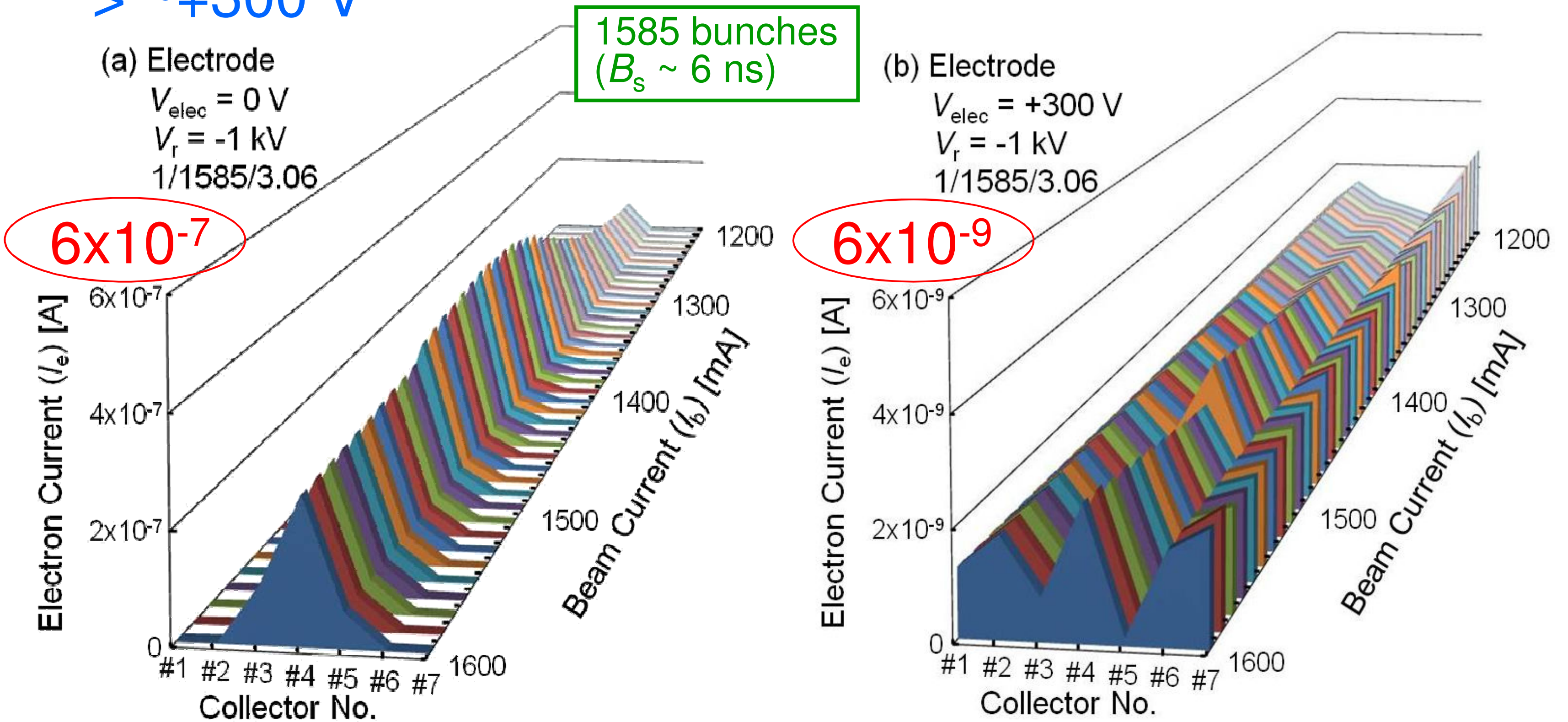


Electrode



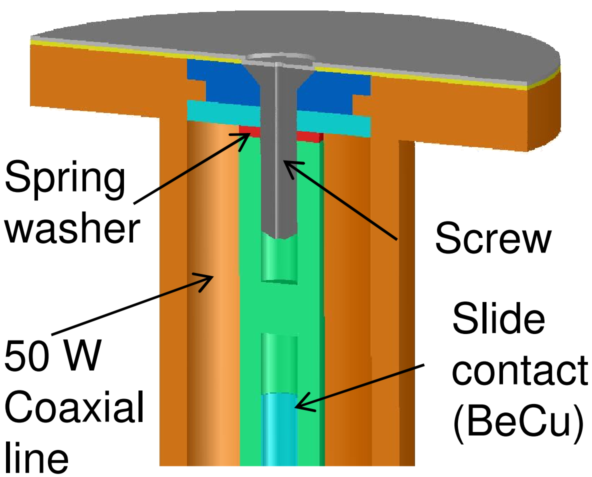
Clearing Electrode

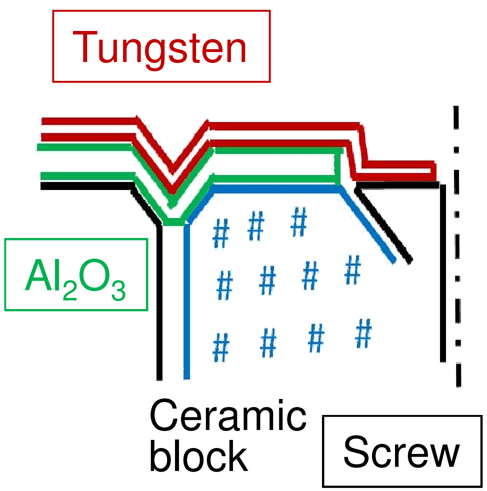
- Results
  - Drastic decrease in the electron density by applying V_{elec} was observed.
  - The electron density decreased to less than 1/100 at V_{elec} > ~+300 V

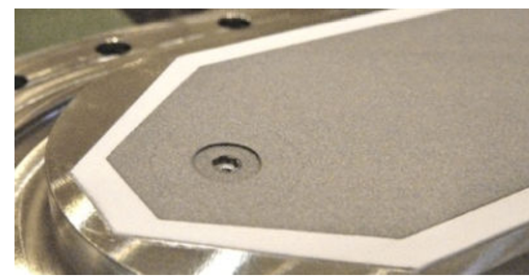


Clearing Electrode

- New connection was tested in the last run
  - No extra connection parts.
  - Very smooth surface.
- No increase in the leak current, no discharging
  - Leak current ≤1 μA at ±1 kV after ~ 2 months operation.
- But, poor electric contact to electrode (line contact) can be a problem in some cases.

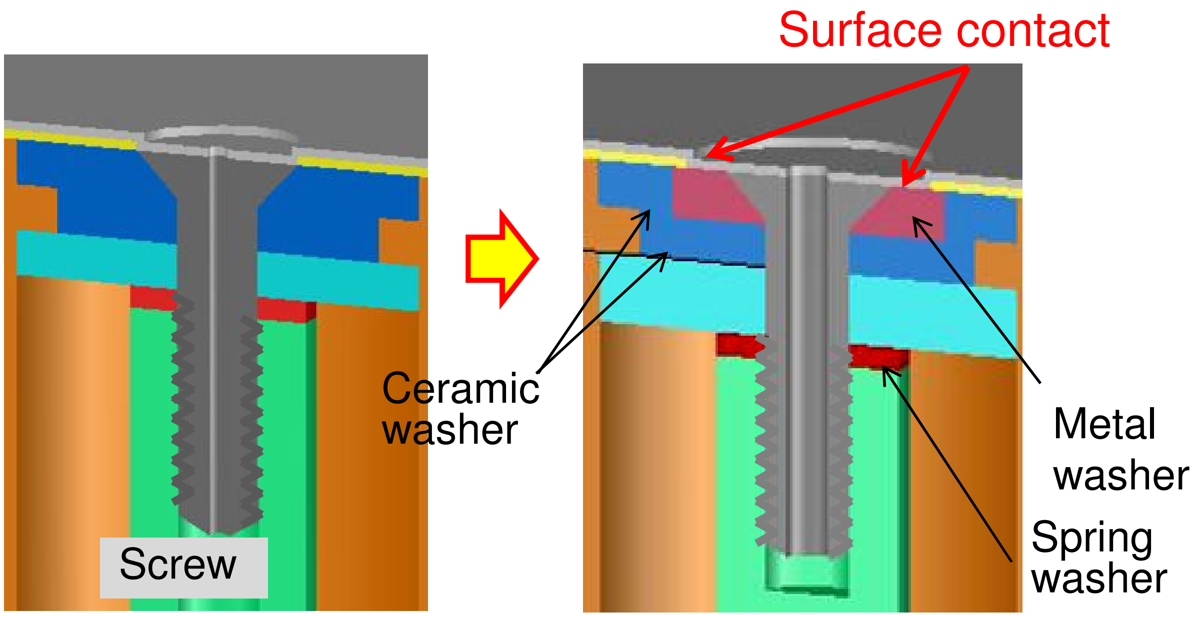


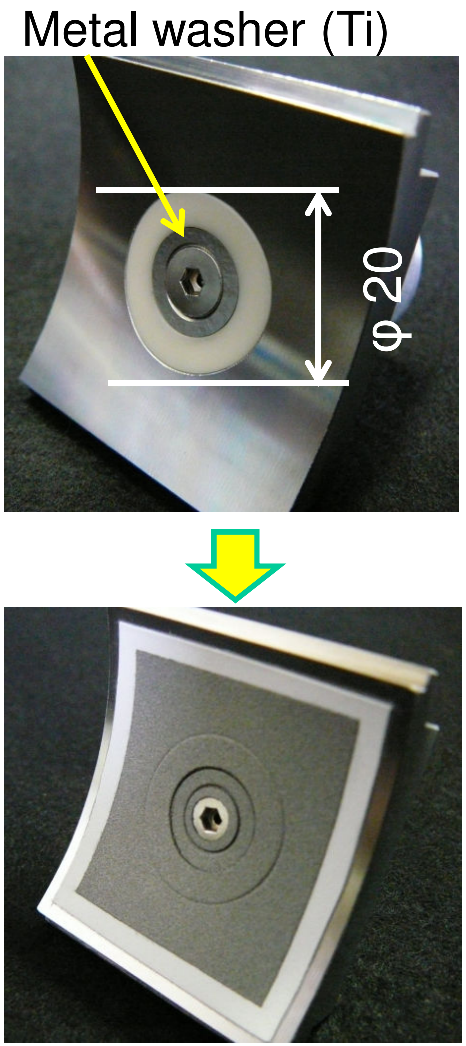




Clearing Electrode

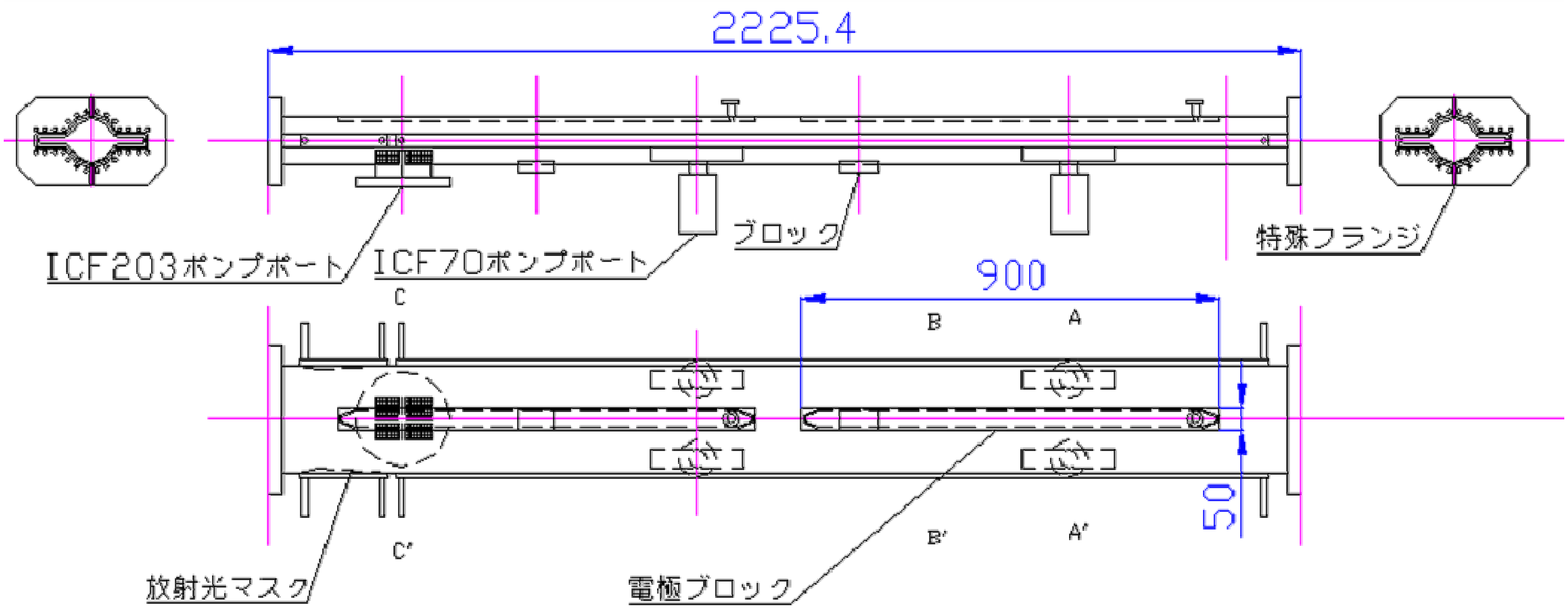
- A revised connection structure will be tested in the next run.
  - Minor change
  - Line electric contact → surface contact
- Thermal spray test using a test sample is now undergoing.





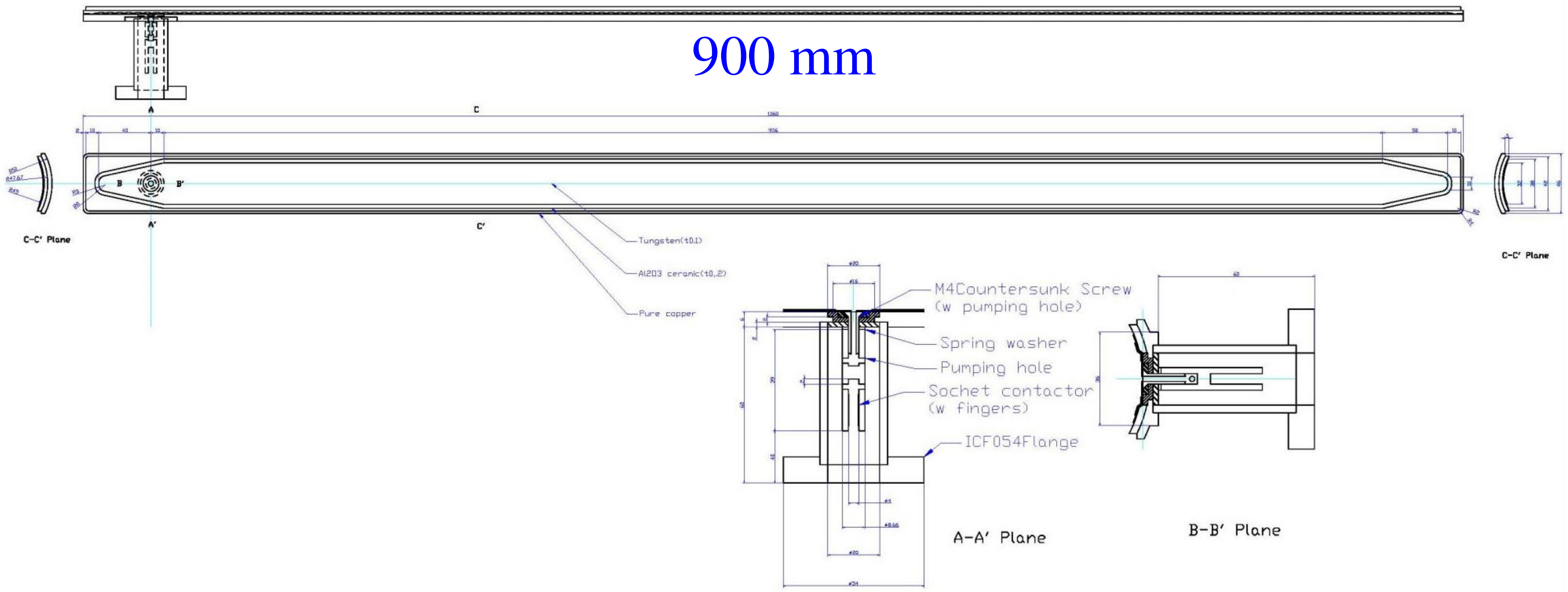
Clearing Electrode: Next plan

- It is a promising method for a wiggler section.
  - That is, a straight chamber
- A test beam duct (copper) with two clearing electrodes is under manufacturing and will be installed to LER in November.
  - The electrodes have a revised connection structure.



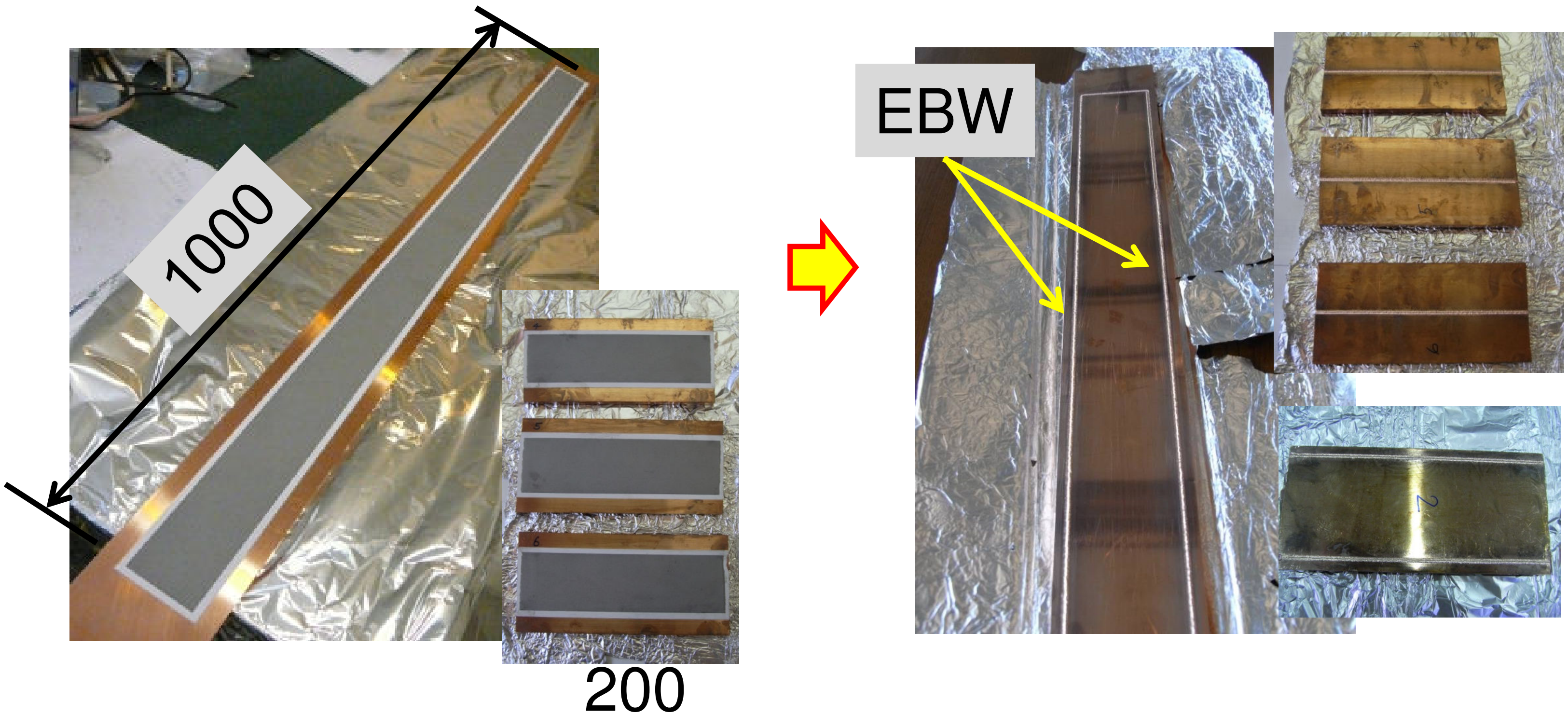
Clearing Electrode : Next plan

- Electrode
  - 900 mm long
  - Welded to copper beam duct by EBW
  - Have a curvature radius of 45 mm
  - Have a revised connection structure



Clearing Electrode : Next plan

- Heat load test during EBW
  - Insulated resistance did not change after EBW at back side of samples (1 m and 200 mm)
  - Penetration thickness = 2~3 mm
- No degradation of insulated resistance was found.



Groove structure

- Groove geometrically reduces the effective SEY.
  - The effect was demonstrated in a magnetic field.
- The latest model has a shallow groove structure.
  - Shallow groove has a low impedance.

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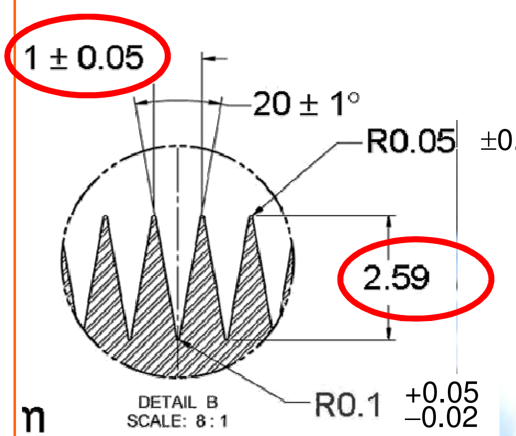
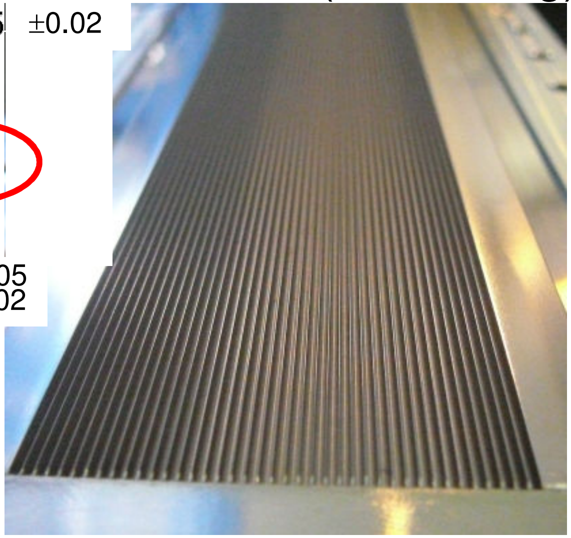
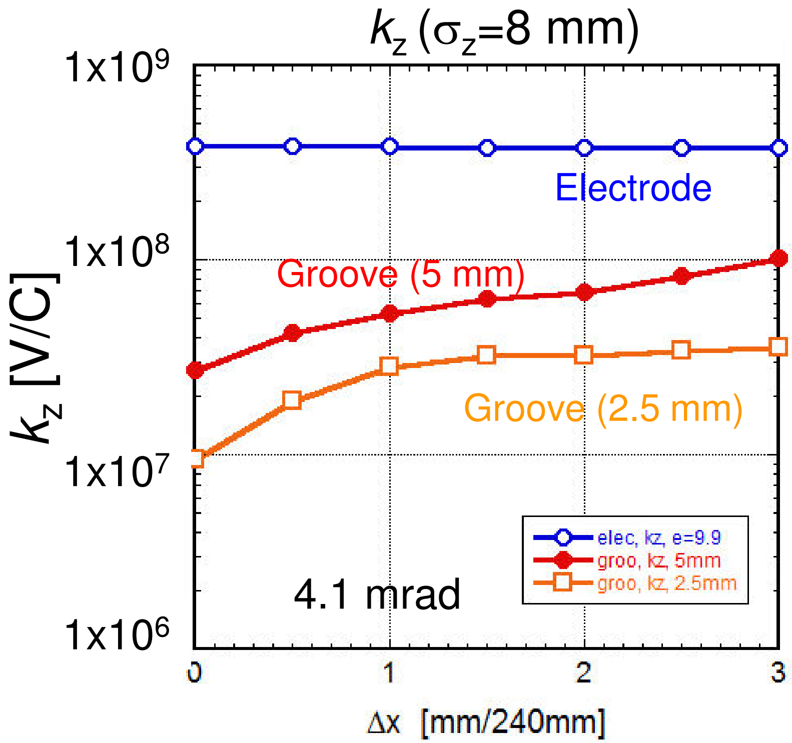


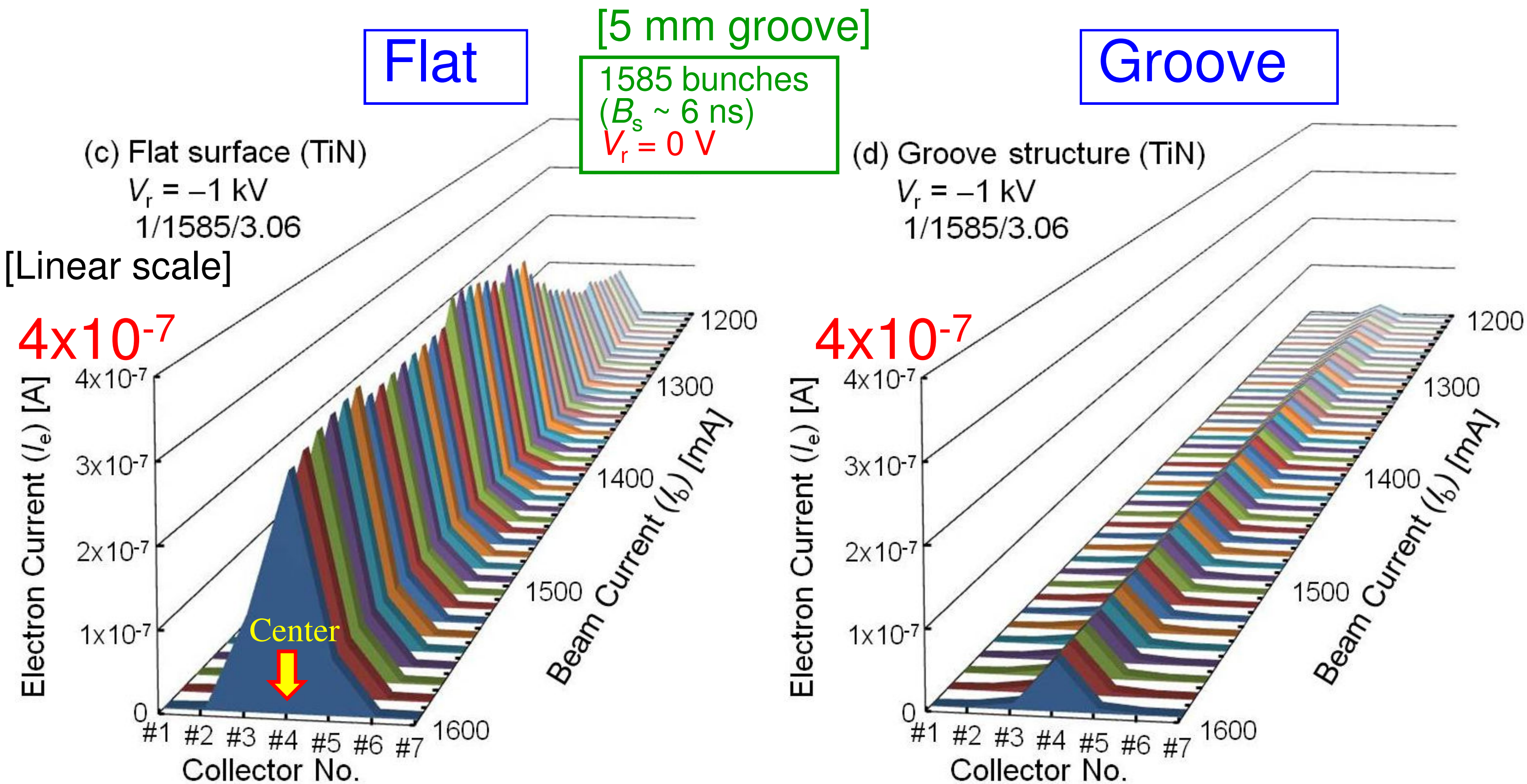
SS model(No coating)





Groove structure

- Result
  - The electron density decreased to 1/6~1/10 compared to the case of a flat surface.



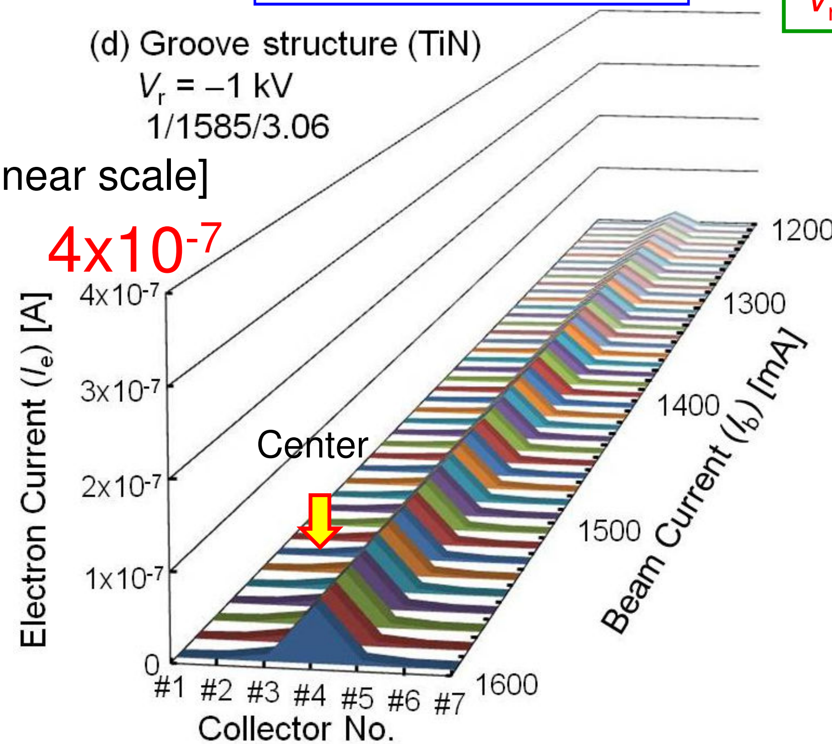
Groove structure

- Result
  - The shallow groove showed the comparable reduction of electron density to that of the previous one (5 mm), although no TiN coating (after sufficient conditioning).

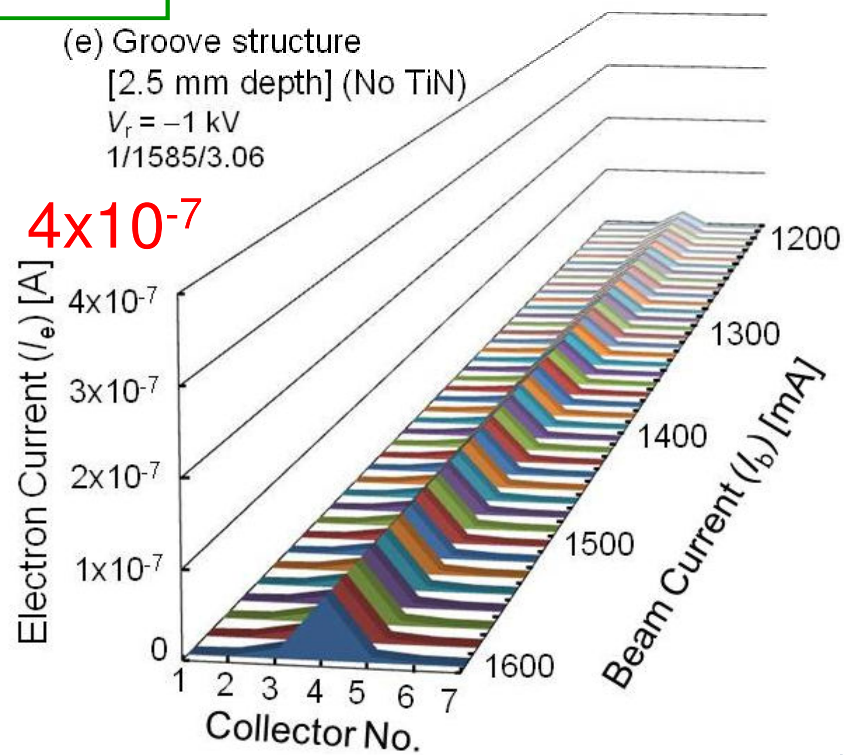
1585 bunches
(B_s ~ 6 ns)
V_r = -1 kV

5 mm groove

[Linear scale]

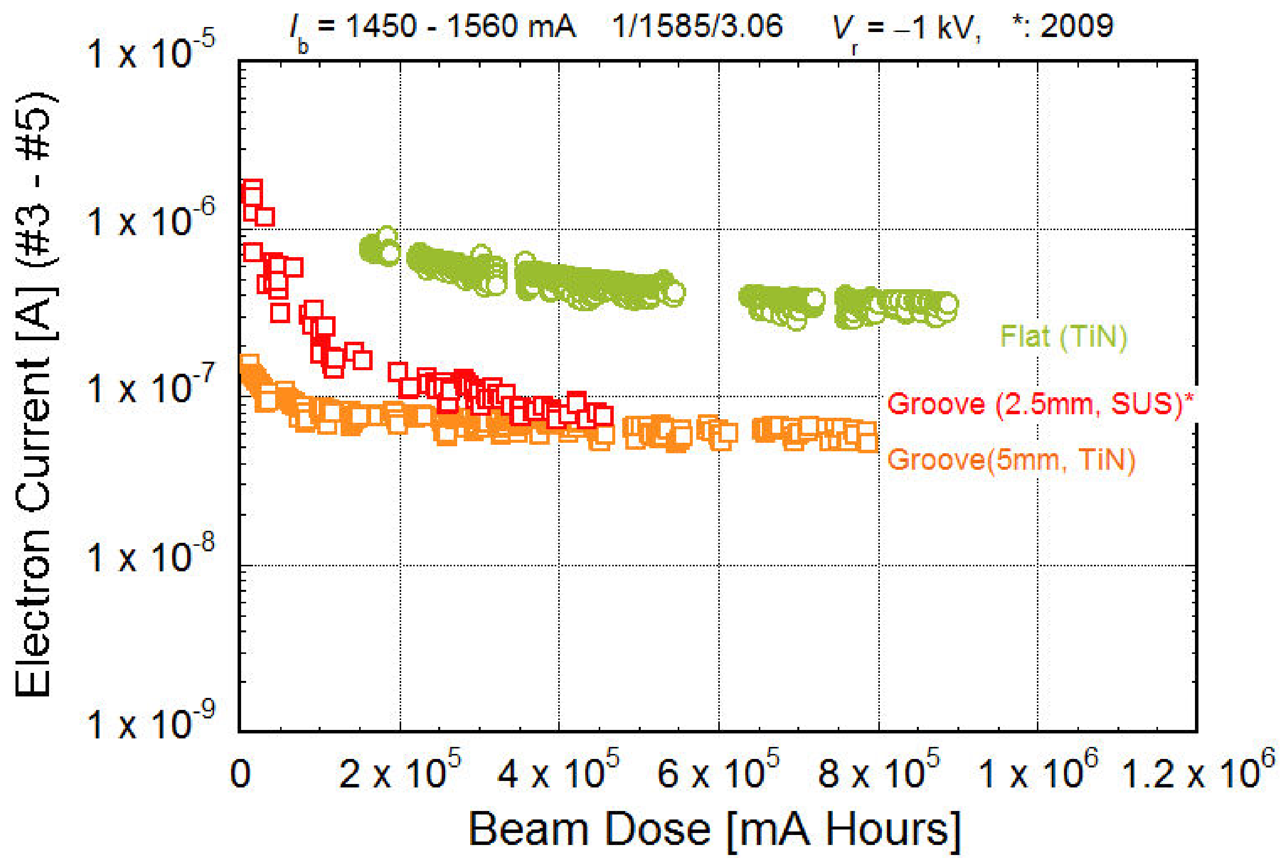


2.5 mm groove



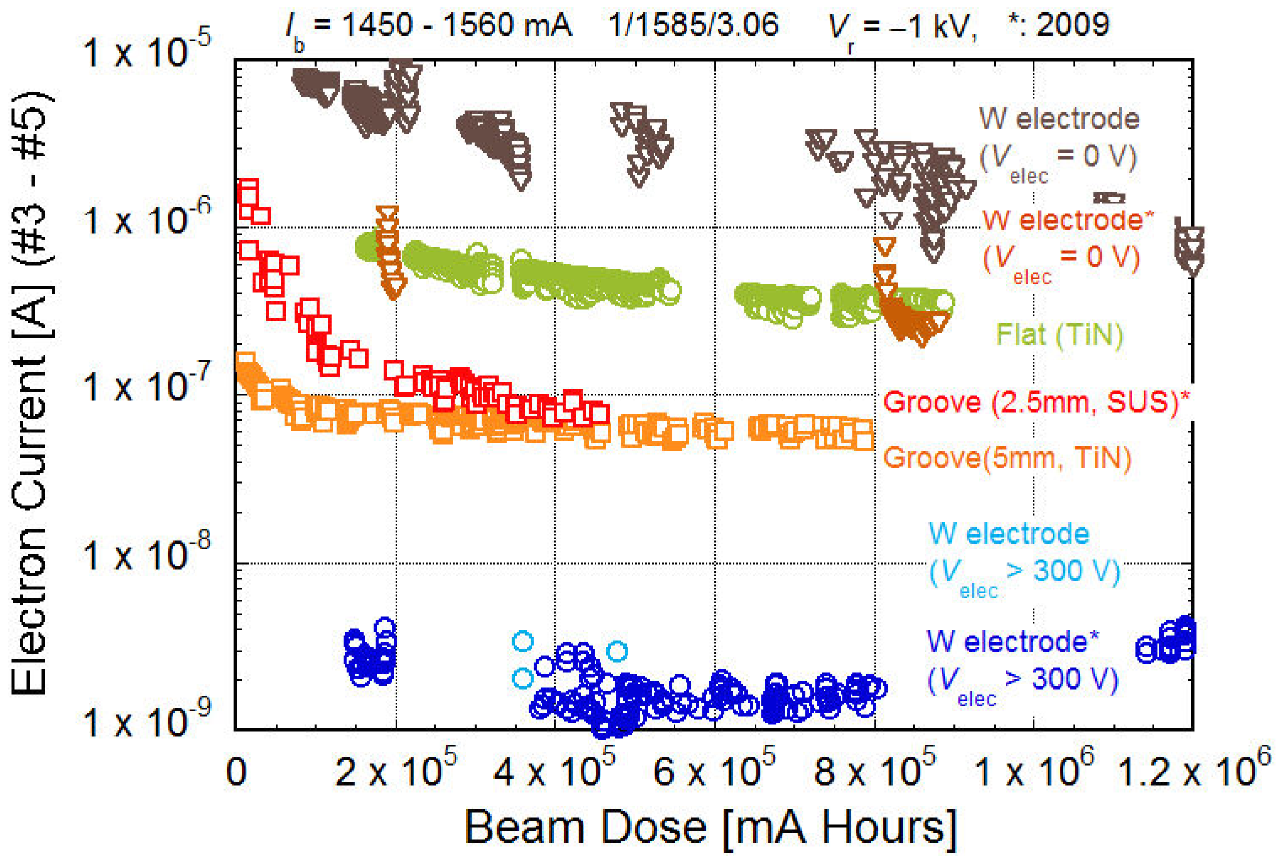
Groove structure

- Compared to the case of TiN-coated flat surface;
  - Groove structure: 1/6~1/10
    - Effect of structure is larger than that of TiN?
    - Further investigation is required (→Next plan).



Groove and Clearing electrode

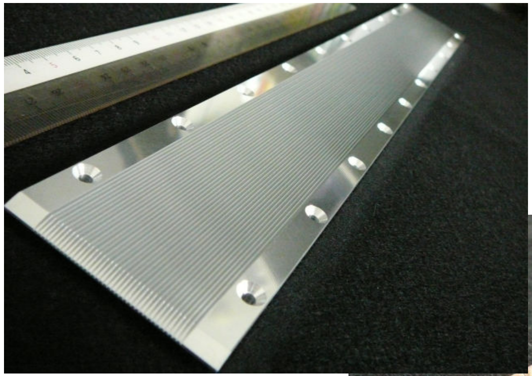
- Compared to the case of TiN-coated flat surface;
  - Clearing electrode (> +300 V): 1/100~1/500
    - ~1/50 of groove structure



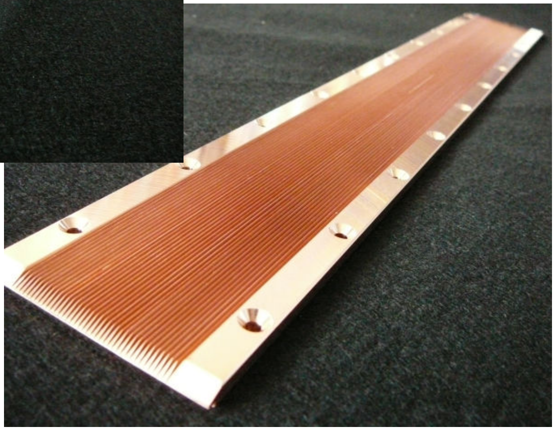
Groove structure: Next Plan

- Test of aluminum and copper groove structure (2.5 mm depth) with/without TiN coating in the next run
- Install a new second test chamber
  - An electron monitor with RFA and 14 strips collectors

Al-alloy



Cu

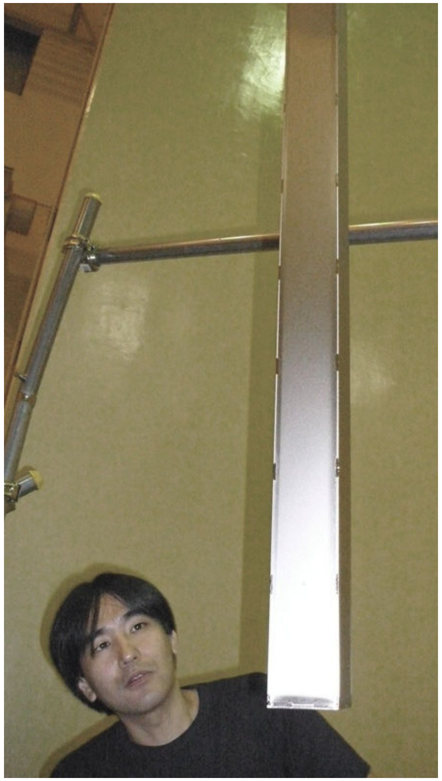


Second test chamber

First test chamber

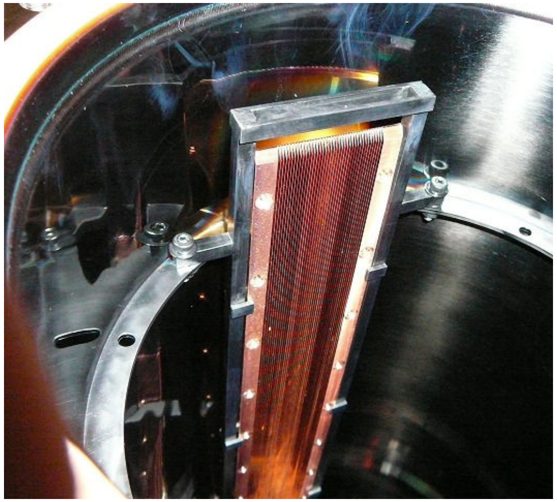
Groove structure: Next Plan

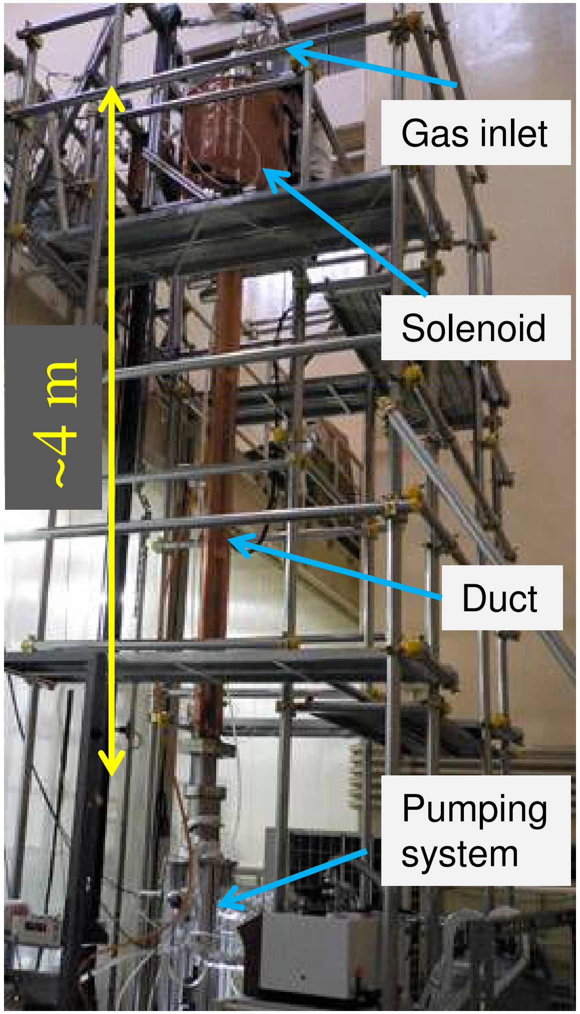
- T i N coating system for grooved block are under development.
  - A square Ti target is used to uniformly coat the grooved surface.



Square Ti target

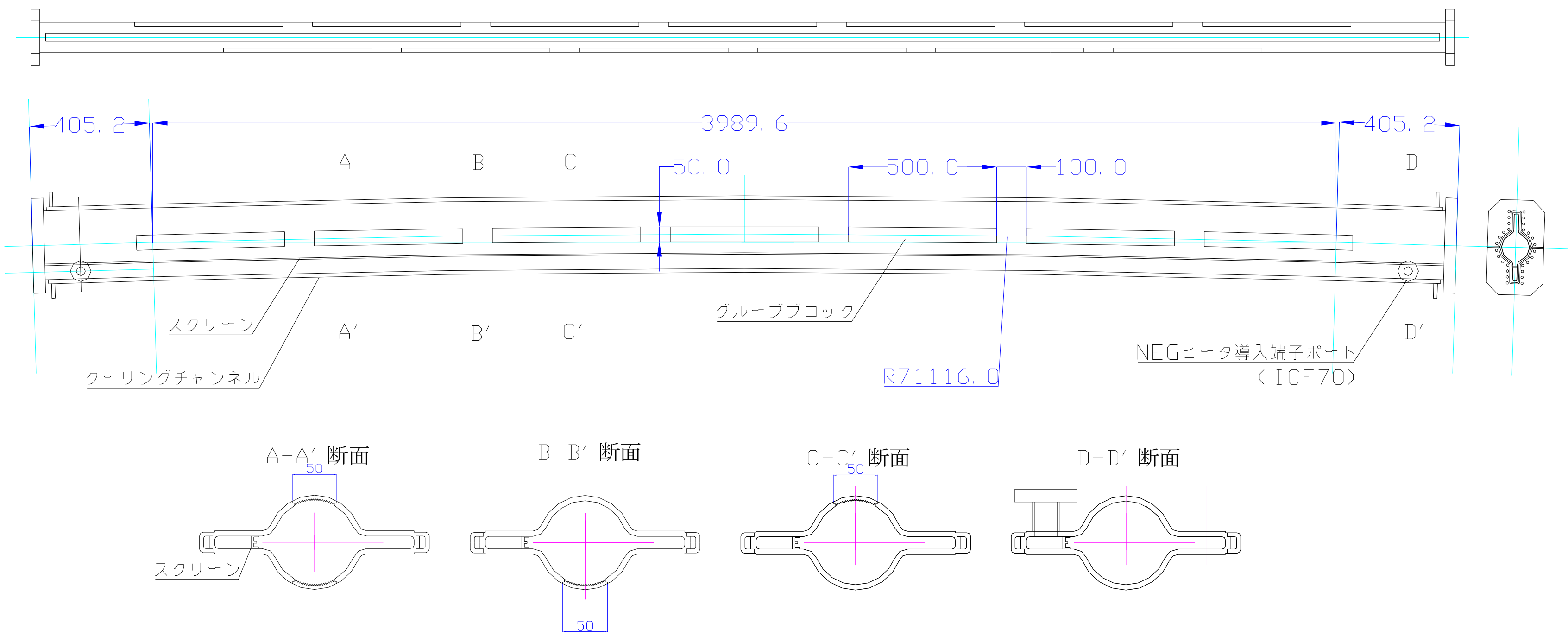
Grooved block (sample) set in the chamber





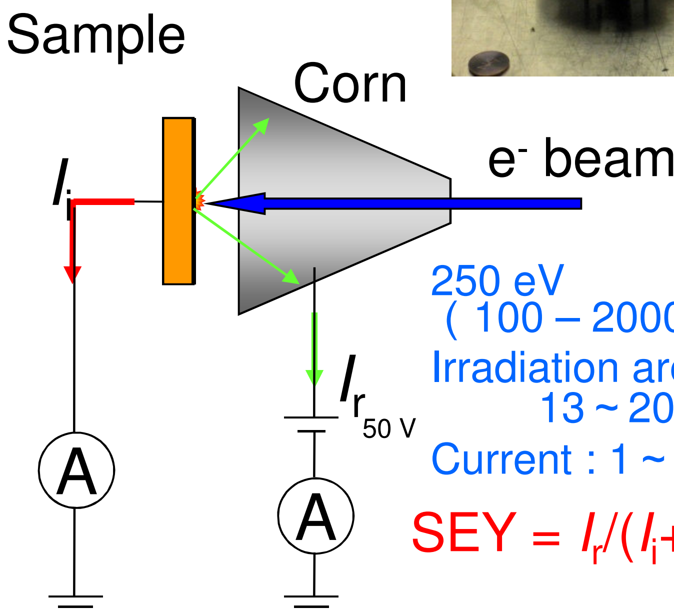
Groove structure: Next Plan

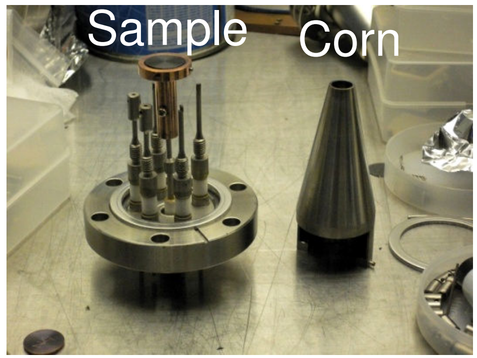
- Aluminum-alloy beam pipe for a bending magnet
  - Under manufacturing
  - Several groove blocks are welded at the top and bottom of beam channel.
    - Extrusion with groove is impossible.



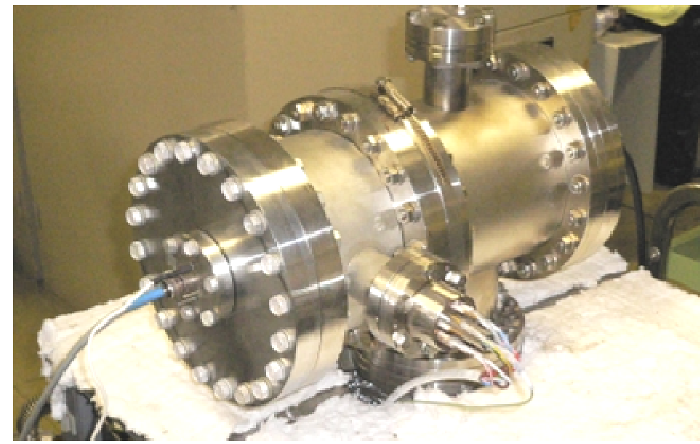
SEY Measurement at Laboratory

- SEY of sample pieces (without magnetic field)





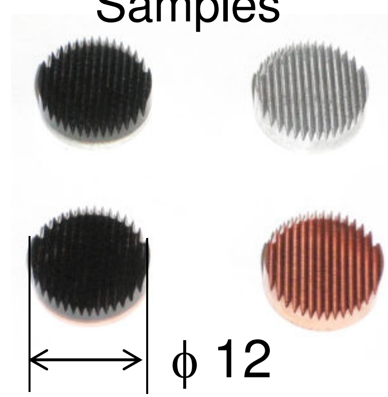
Test chamber



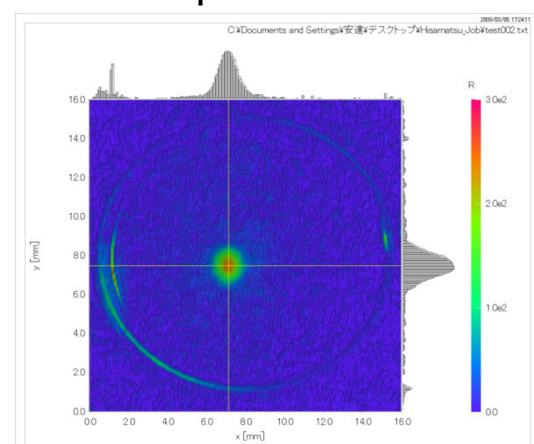
250 eV
(100 – 2000 eV)
Irradiation area :
13 ~ 20 mm²
Current : 1 ~ 2 μA

SEY = $I_r/(I_i+I_r)$

Samples

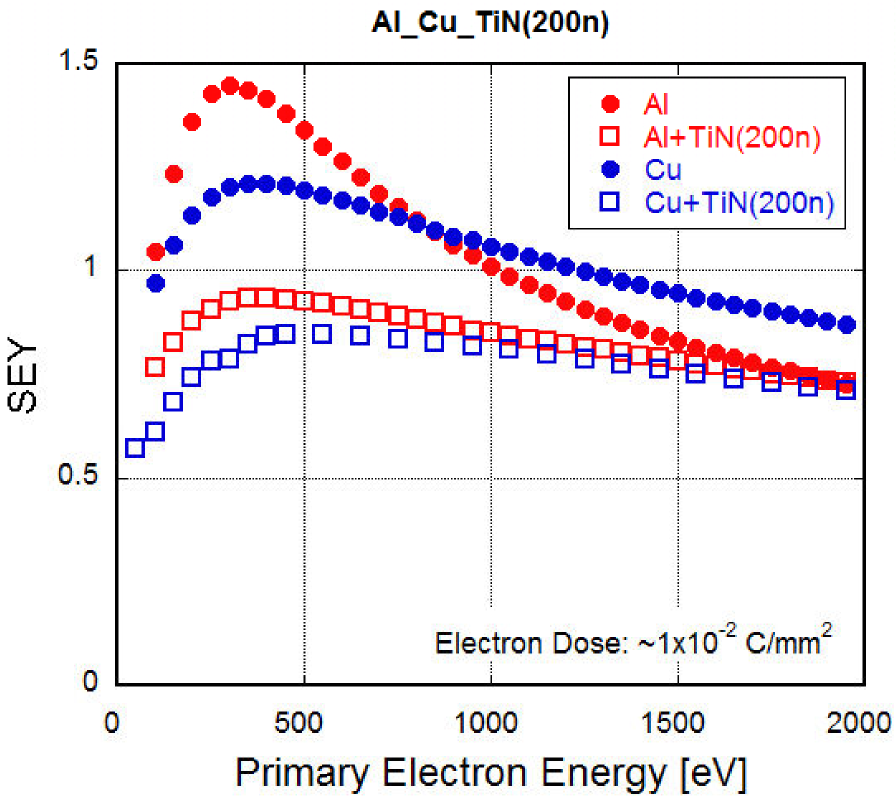


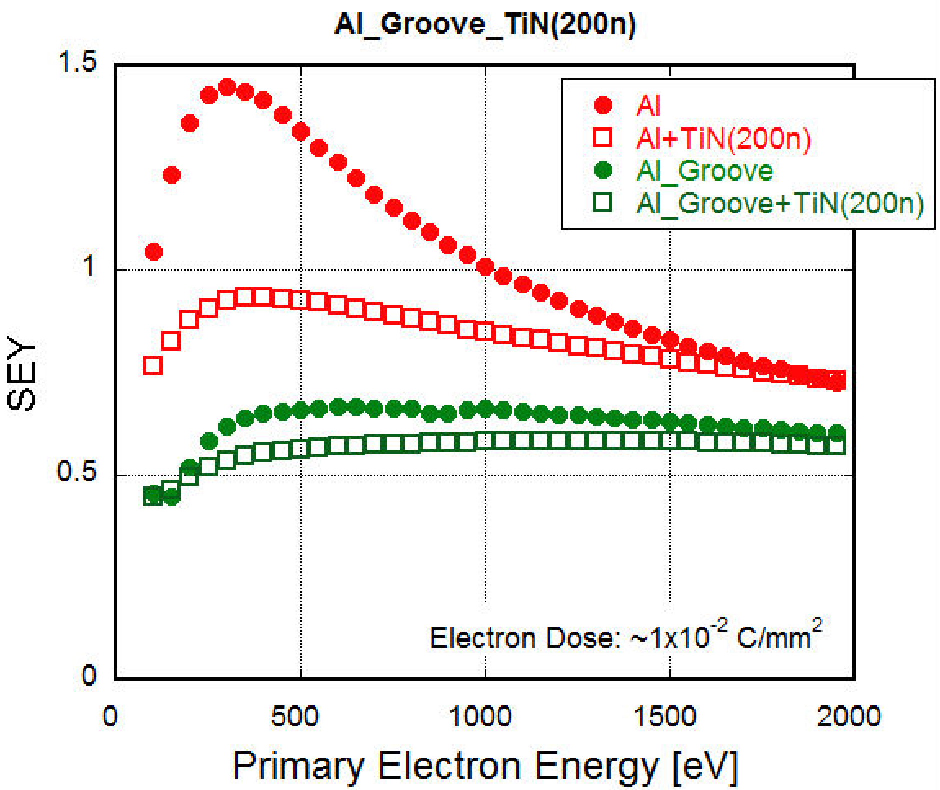
Spot size



SEY Measurement at Laboratory

- Typical results
  - TiN coating decrease Max. SEY to 0.9~0.8.(Al, Cu)
  - Groove structures decrease it to ~0.7 even without TiN (Al); the effect of groove structure seems larger

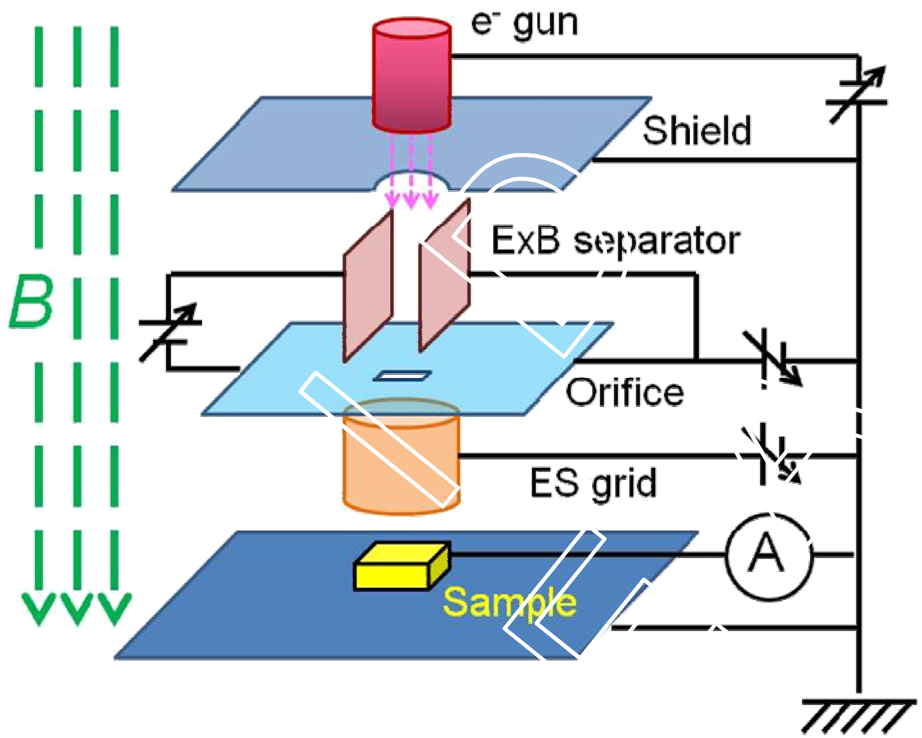




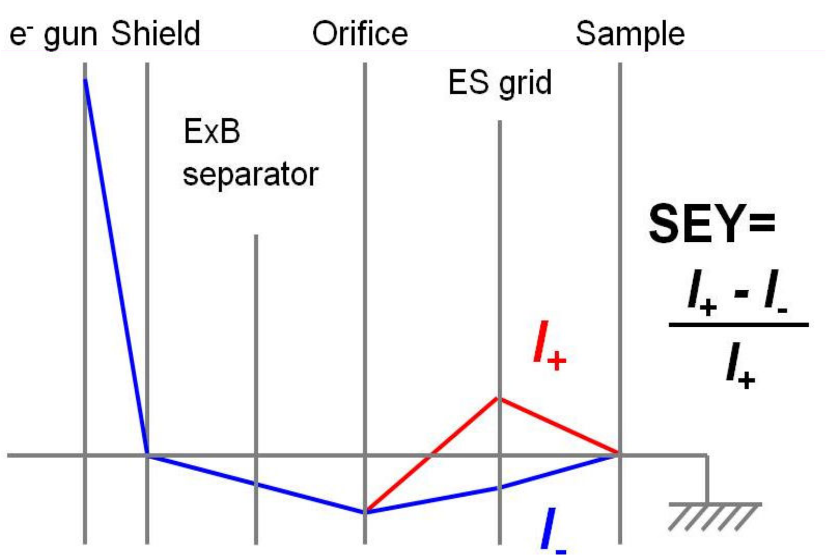
SEY Measurement at Laboratory

- A plan to measure SEY in a strong magnetic field is under consideration.
  - Still only idea: a big problem is how to separate and absorb secondary electrons…..

Configuration



Potential distribution

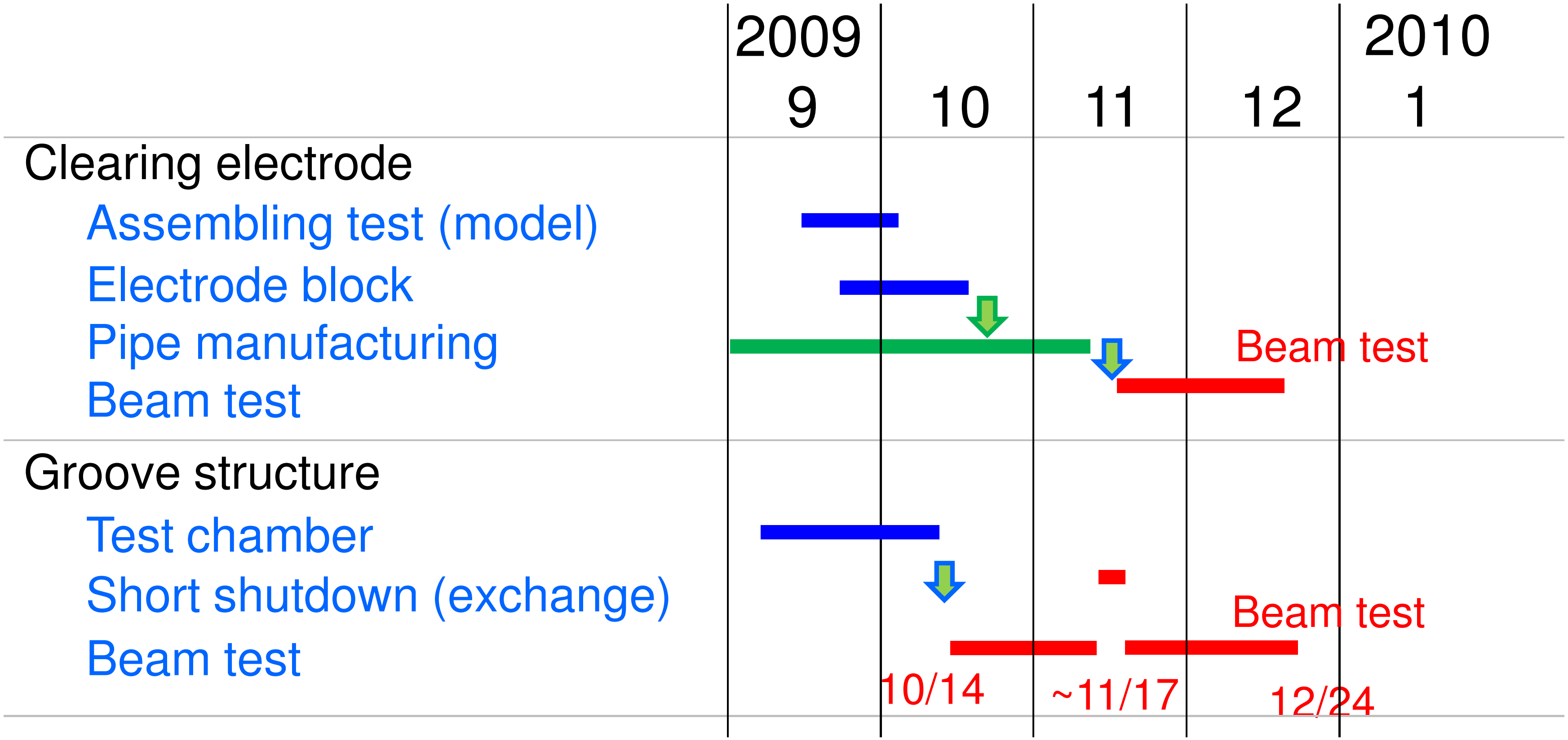


Summaries

- The improved clearing electrode and the shallow groove structure are being tested.
- Clearing electrode
  - The problems at connection to feed-through found before was much improved.
  - Quality of thermal spray?
- Groove structure:
  - A groove with a depth of ~2.5 mm is promising.
  - The coating system is now under development.
- SEY measurement continues in parallel with beam tests.
- Beam pipes with these countermeasures are under manufacturing.

Study schedule at KEKB

- Beam test of groove structure and clearing electrode in the final phase.
- Next year…..Unknown.



For SuperKEKB

- In the present design parameters (Low emittance option), the beam pipe of the positron ring will be made of aluminum alloy.
  - TiN coating should be indispensable.
  - We are requiring a dedicated facility for the coating.

- Present countermeasures against ECE:
  - Arc section: Beam pipe with antechambers
  - Drift space: Solenoid and TiN coating
  - In quadrupole magnets: TiN coating
  - In bending magnets: TiN coating and grooves
  - In wiggler magnets: Clearing electrodes (or grooves)