Electron Cloud Measurement and Vacuum Chamber Design

Presented by K. Kanazawa

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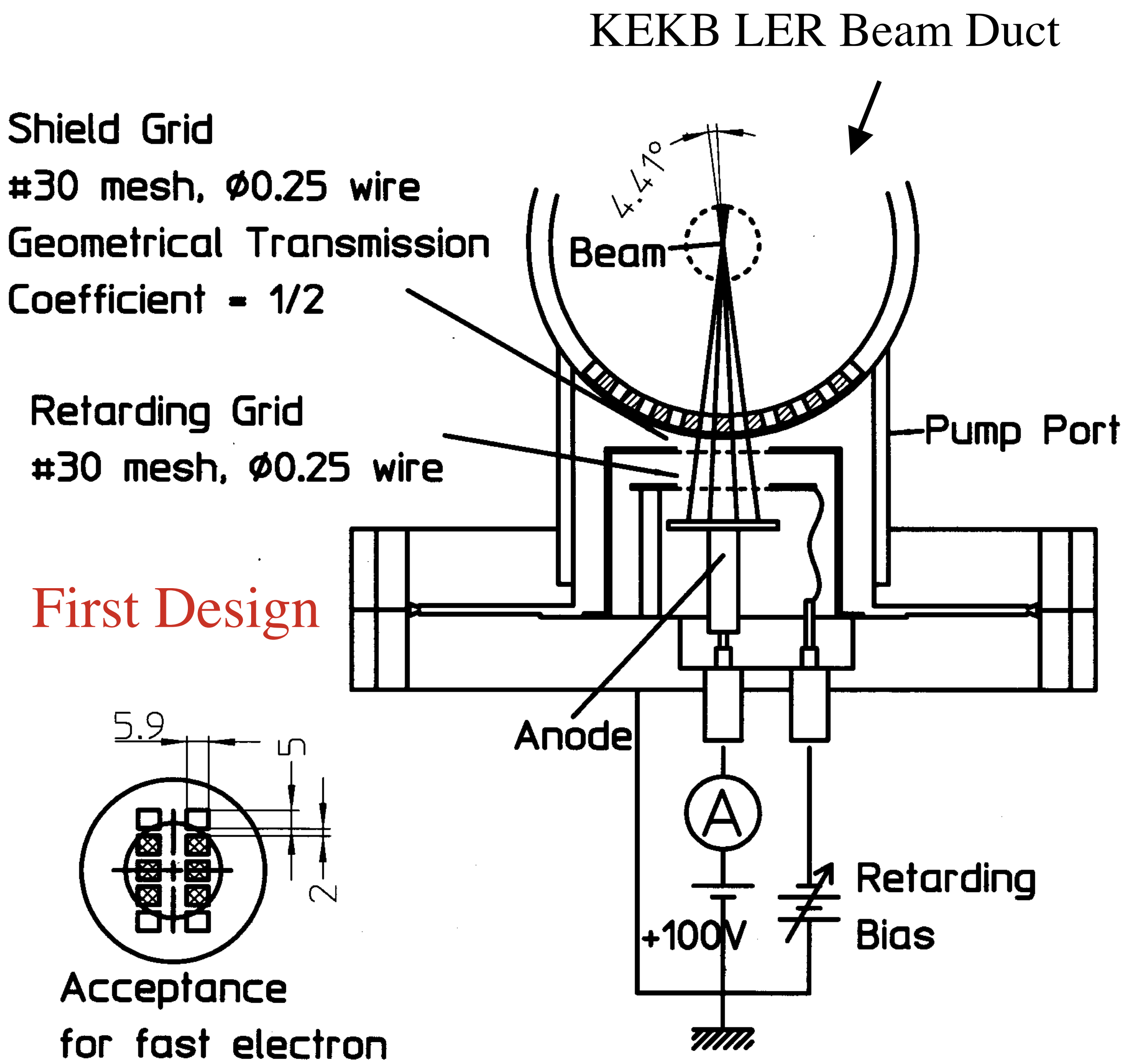
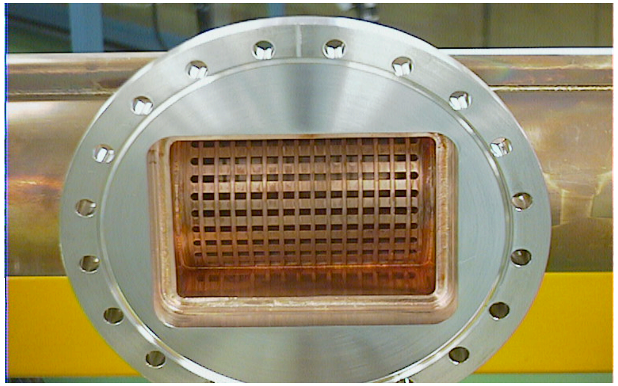
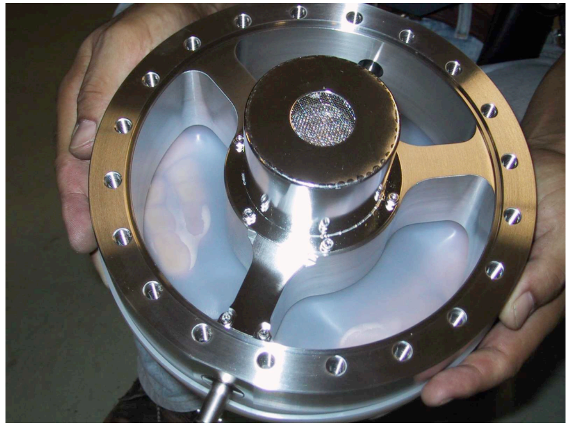
1. Electron Monitor (1)



First Design



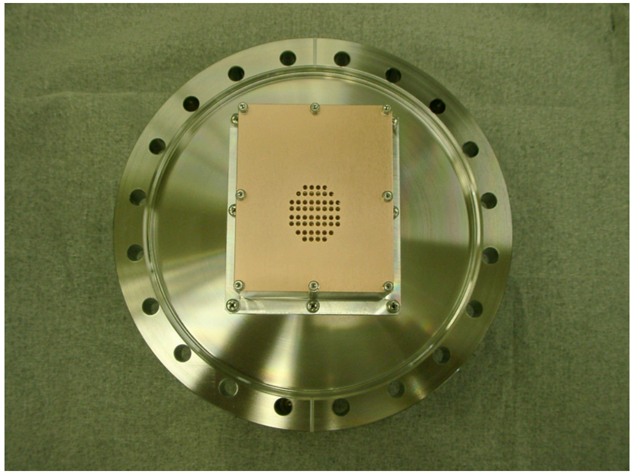
Pump port of KEKB LER



Electron Monitor
(Modified Type)

1. Electron Monitor (2)

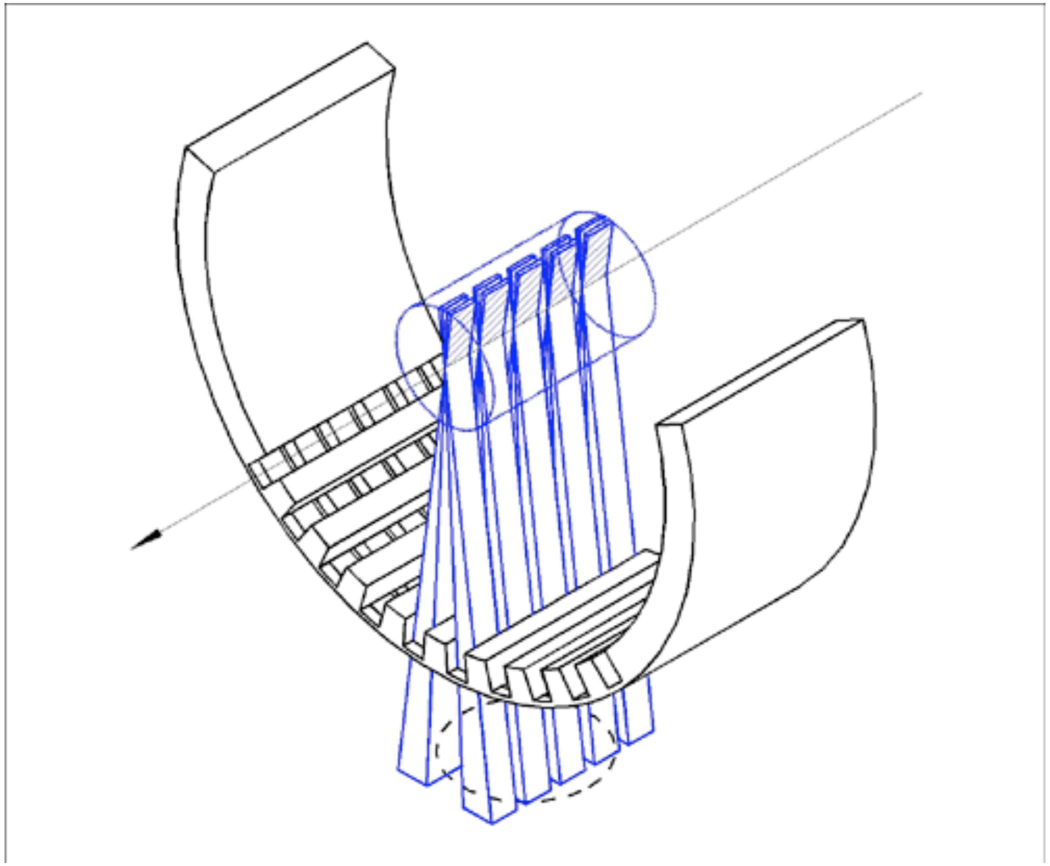
Recent Electron Monitor



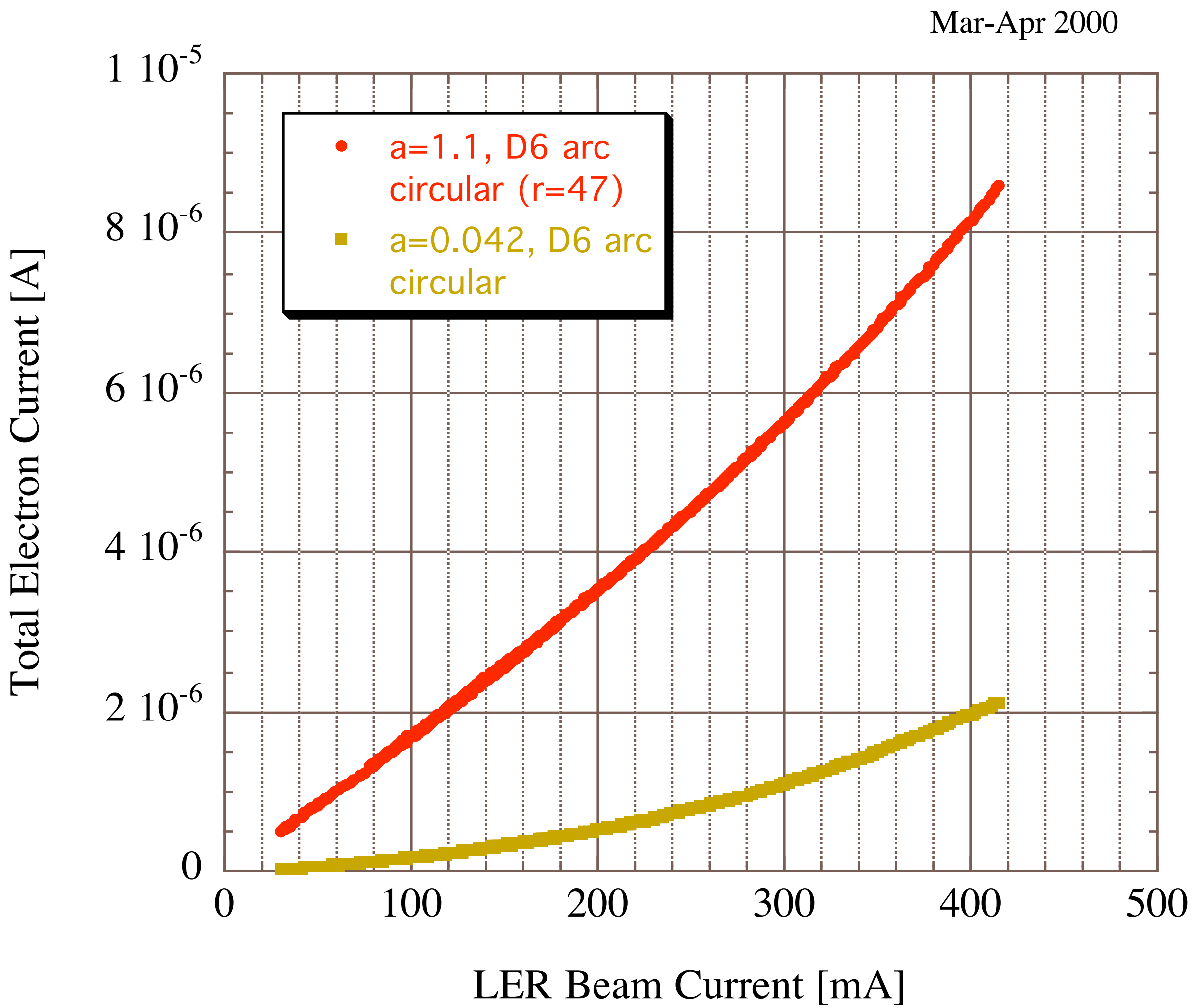
• Estimation of the electron cloud density

By selecting high energy electrons, the density near the bunch can be estimated. (K. Kanazawa et al, PAC05)
(In the following the density is estimated using a geometrical aperture of the detector.)

Conceptual drawing of the density measurement.



2. Synchrotron Light and Antechamber (1)

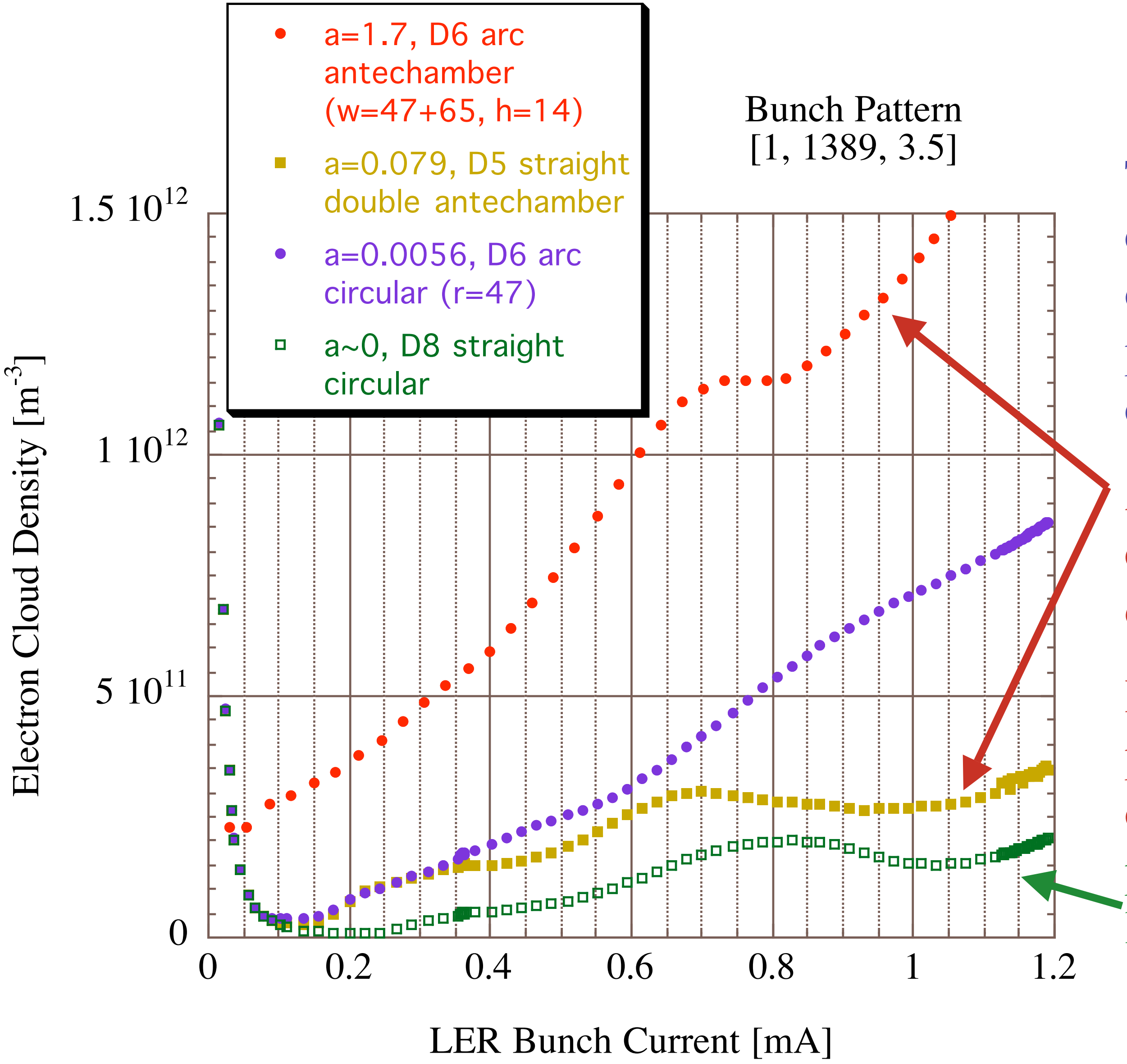


The electron current has a correlation with the direct intensity of synchrotron radiation.

This is confirmed also by the measurement using BPM. (M. Tejima)

‘a’ represents the photon intensity of direct synchrotron radiation.
(Linear photon density per meter) = (a/360)•(Total photon number)

2. Synchrotron Light and Antechamber (2)

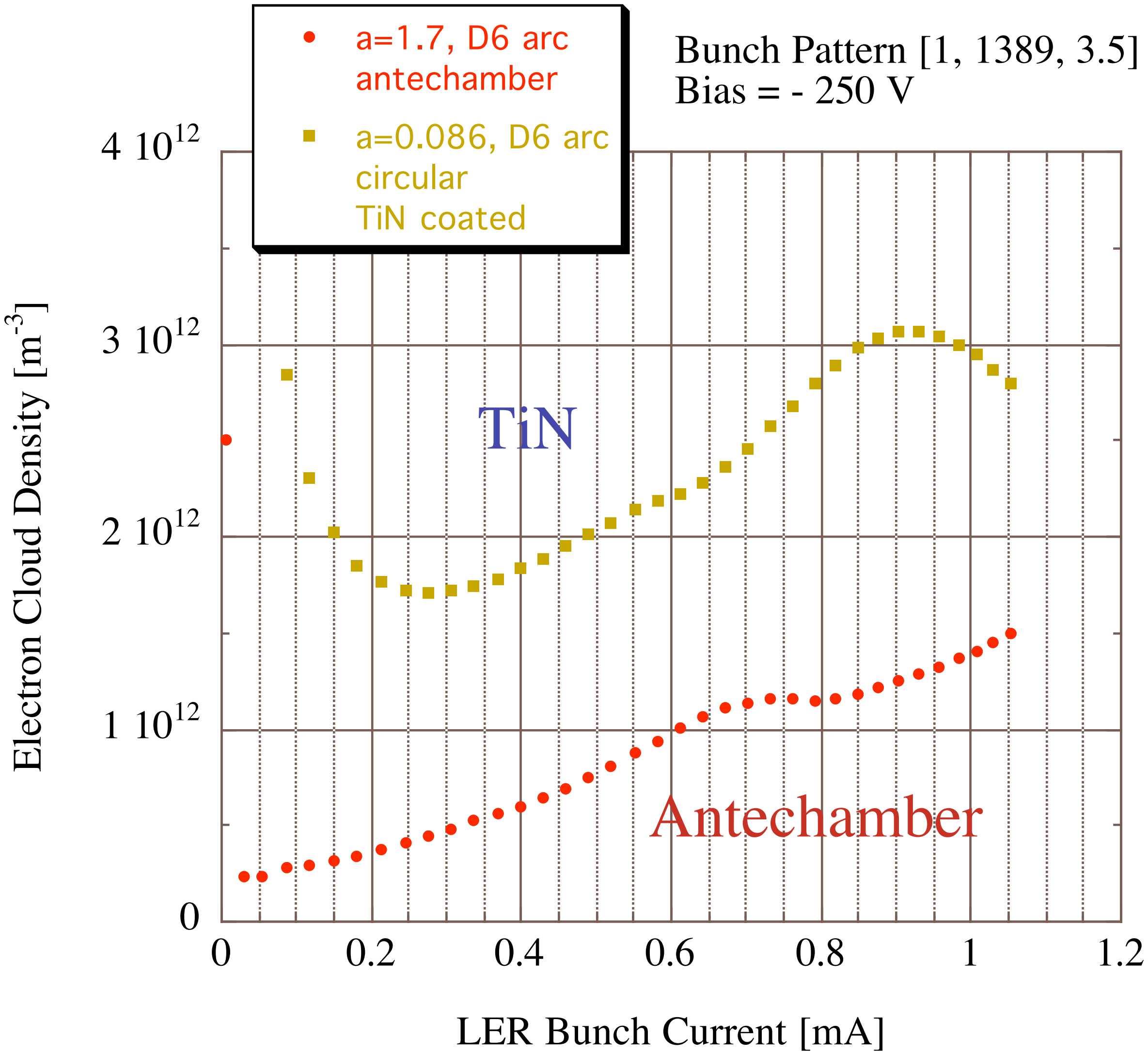


The antechamber is effective to reduce the contribution of photoelectrons to the electron cloud.

Antechamber reduces the electron cloud density drastically.

However the removal of photoelectrons is not complete compared to the place where synchrotron light is negligible.

3. Surface Coating (1)



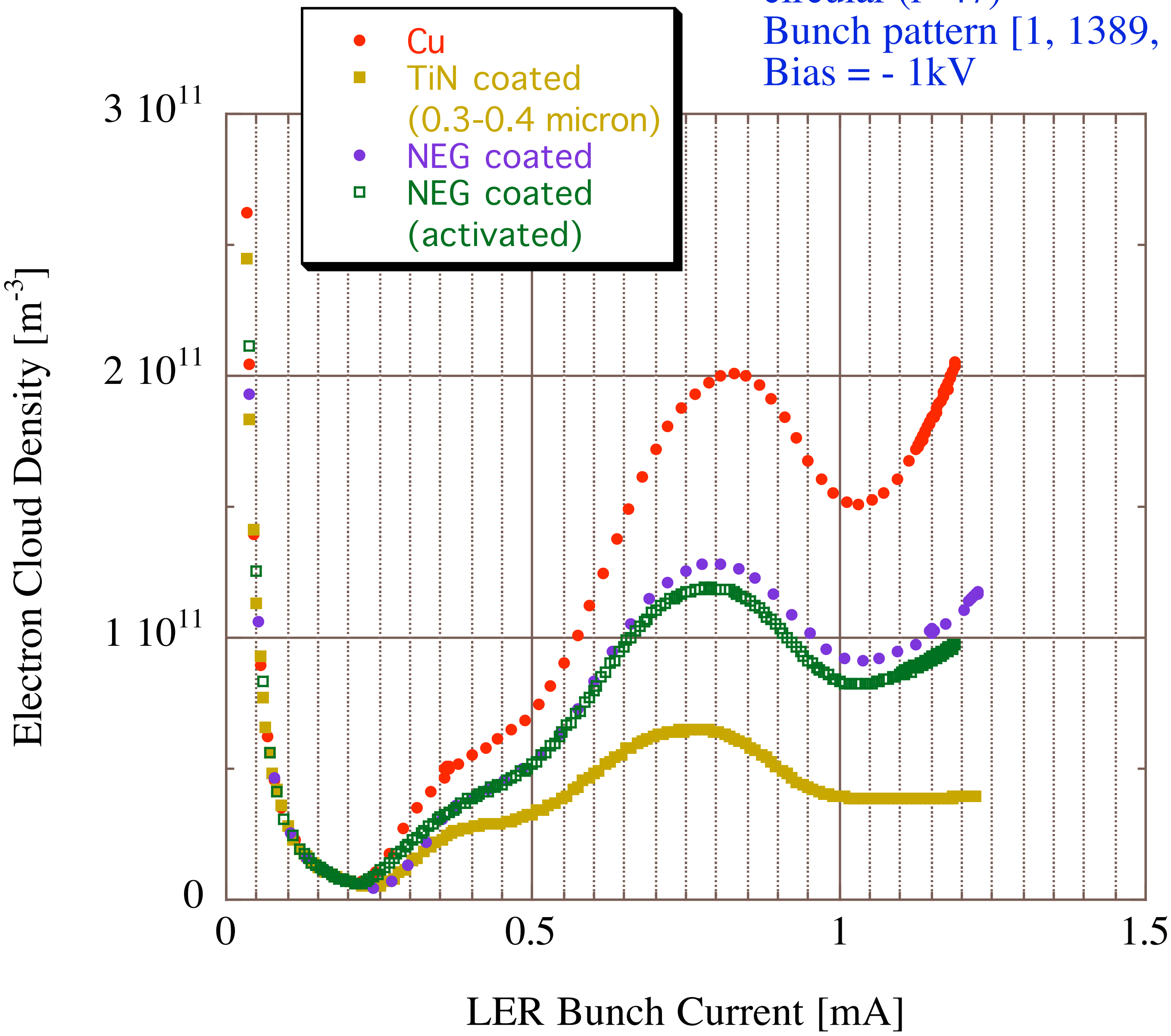
Under synchrotron radiation, TiN coating is not effective compared to the antechamber structure.

The effect of coating on the multipacting process is studied at the place where direct synchrotron radiation is negligible. (next slide)

TiN coating is done by R. J. Todd and H. C. Hseuh (BNL)

3. Surface Coating (2)

a ~ 0, D8 straight
circular (r=47)
Bunch pattern [1, 1389, 3.5]
Bias = - 1kV



TiN coating:
BNL

NEG coating:
SAES Getters

3. Surface Coating (3)

Fitting the curves in the previous figure by simulation, Y. Suetsugu derived the photoelectron yield (η_e, in this case for stray photons) and the maximum (δ_{max}) of the secondary electron yield (SEY) for each coating.

His procedure and result are summarized as follows.

η_e : photoelectron yield, δ_{max} } fitting parameter

Furman's (old) formula (normal incidence) :

$$\delta(E) = 1.11 \times \delta_{max} \left(\frac{E}{E_{max}} \right)^{-0.35} \times \left(1 - e^{-2.3\left(\frac{E}{E_{max}} \right)^{1.35}} \right)$$

$E_{max} = 300$ [eV]

→

	η_e	δ_{max}
Cu	0.28 - 0.31	1.1 - 1.3
NEG	0.22 - 0.27	0.9 - 1.1
TiN	0.13 - 0.15	0.8 - 1.0

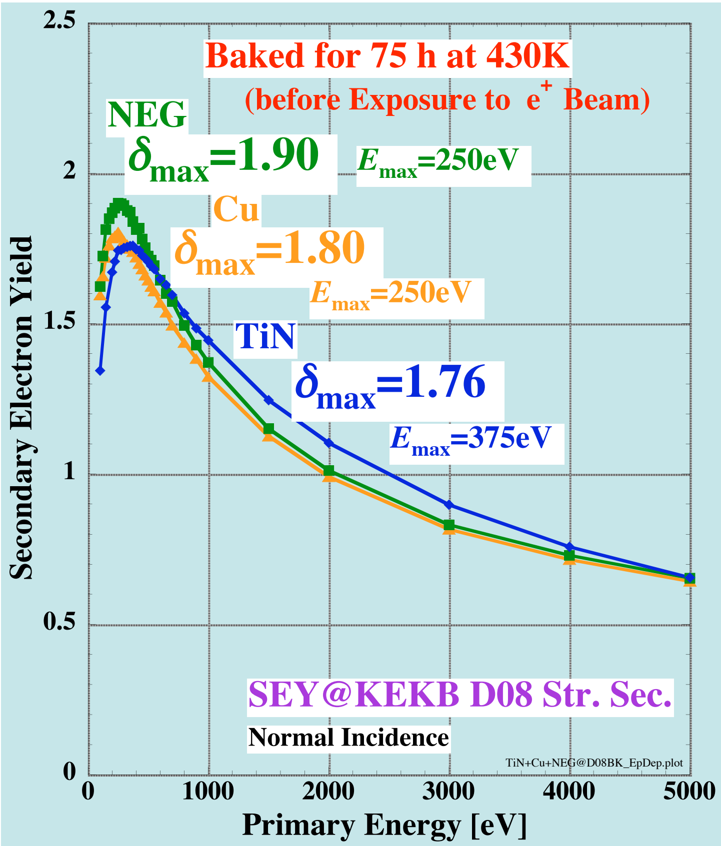
However, S. Kato showed by setting corresponding samples in a vacuum chamber of LER, that after exposure to a certain amount of electron irradiation from electron cloud, the δ_{max} of each sample decreased to 0.96 ~ 1.08 (in situ measurement) .

The difference of δ_{max} between samples is small compared to the above simulation. Especially Cu showed the lowest value of 0.96.

3. Surface Coating (4)

S. Kato's result can be summarized as follows,

If we use the Furman's expression for SEY, $\delta(E) = \delta_{max}(\theta)\dfrac{s(E/E_{max})}{s-1+(E/E_{max})^s}$

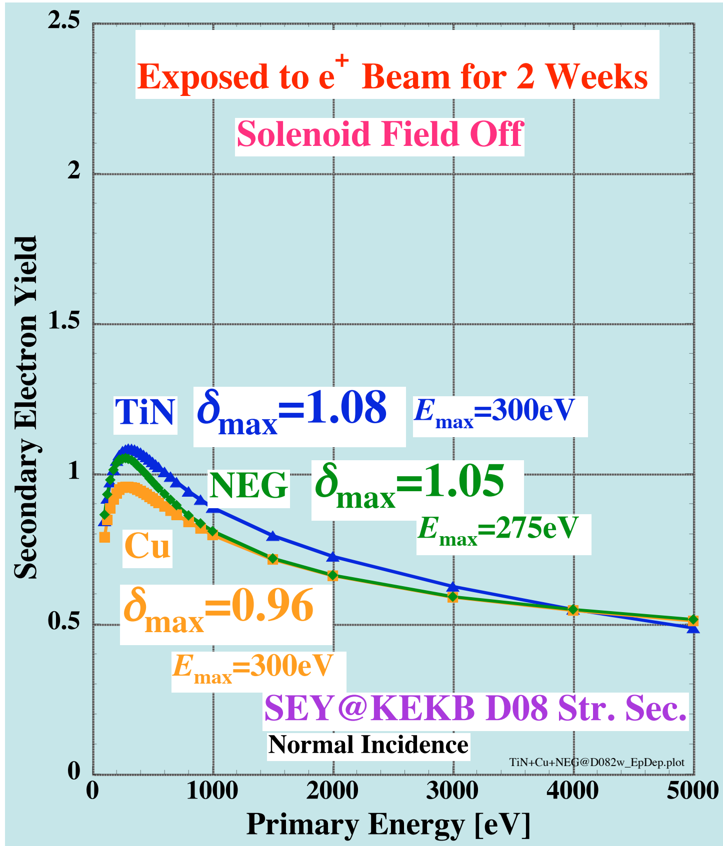


observed result, for example, for Cu is,

$\delta_{max}(0)$: 1.8 → 0.96

E_{max} : 250 eV → 300 eV

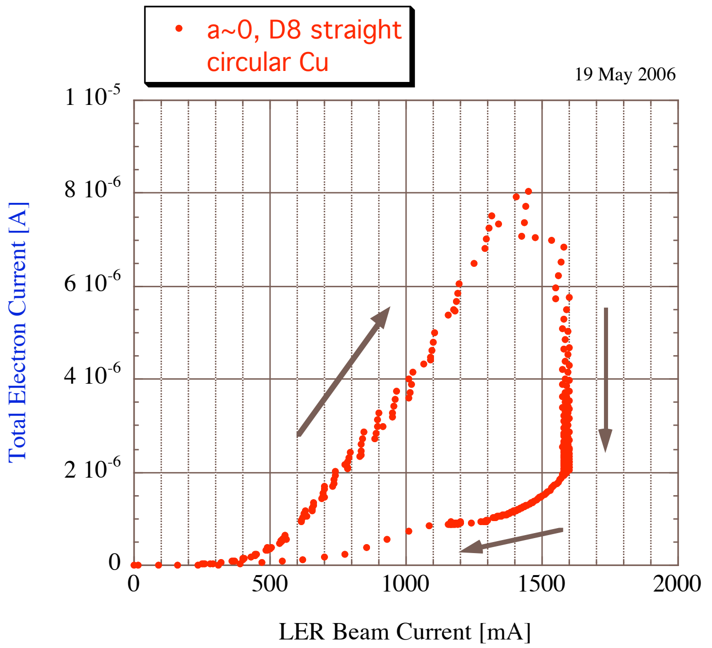
s : 1.44 → 1.33



3. Surface Coating (5)

The surface of vacuum chambers with different coatings are exposed to electron irradiation of more than 10^{23} electrons per cm^2 ($E > 1keV$) before measurement. SEY is well reduced.

To study an apparent discrepancy between the simulation and the in-situ SEY measurement, the following simulation can be suggested.



Reduction of electron current after exposure to the stored beam.

η_e : photoelectron yield : fitting parameter

Furman's (new) formula (normal incidence) :

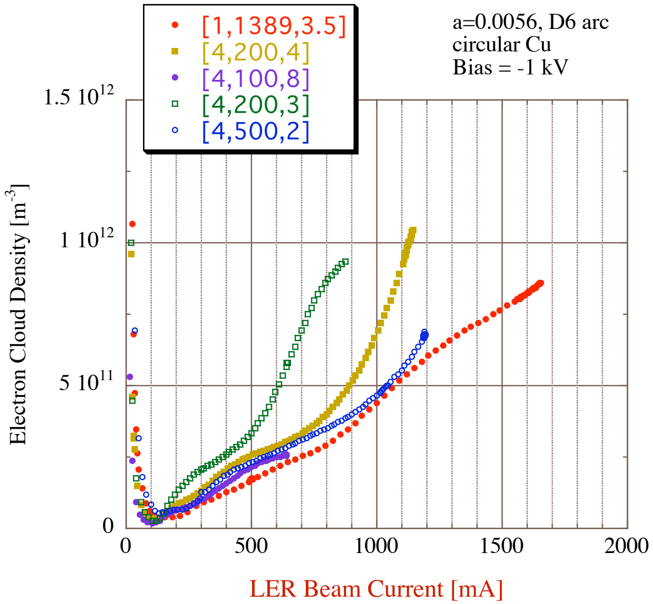
$$\delta(E) = \delta_{max} \frac{s(E/E_{max})}{s-1+(E/E_{max})^s}$$

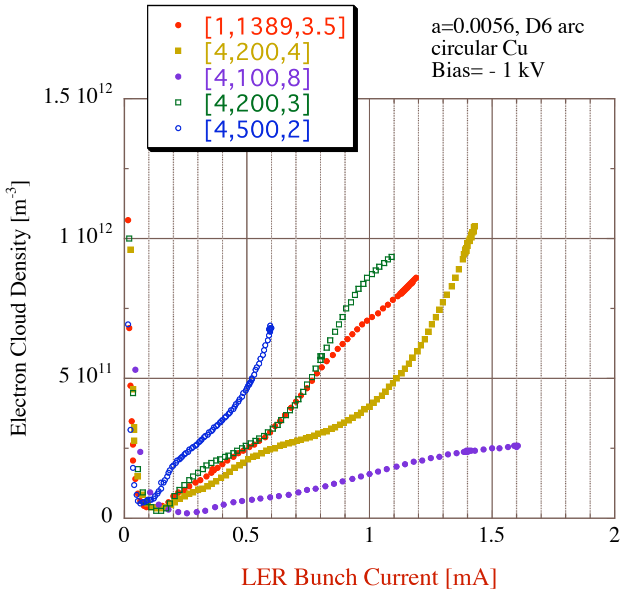
With measured δ_{max}, E_{max}, and s

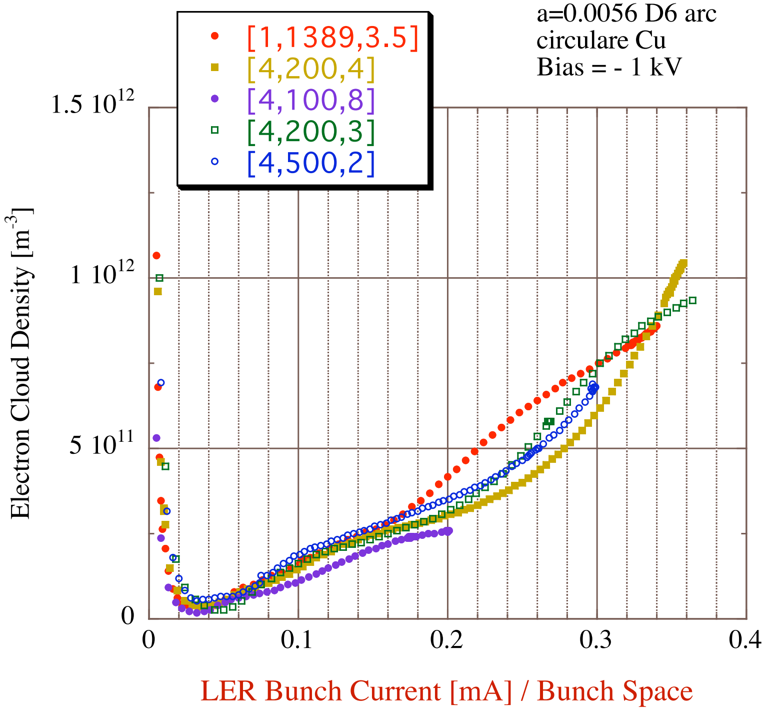
$\rightarrow$

	η_e
Cu	?
NEG	?
TiN	?

4. Under Various Bunch Patterns (1)







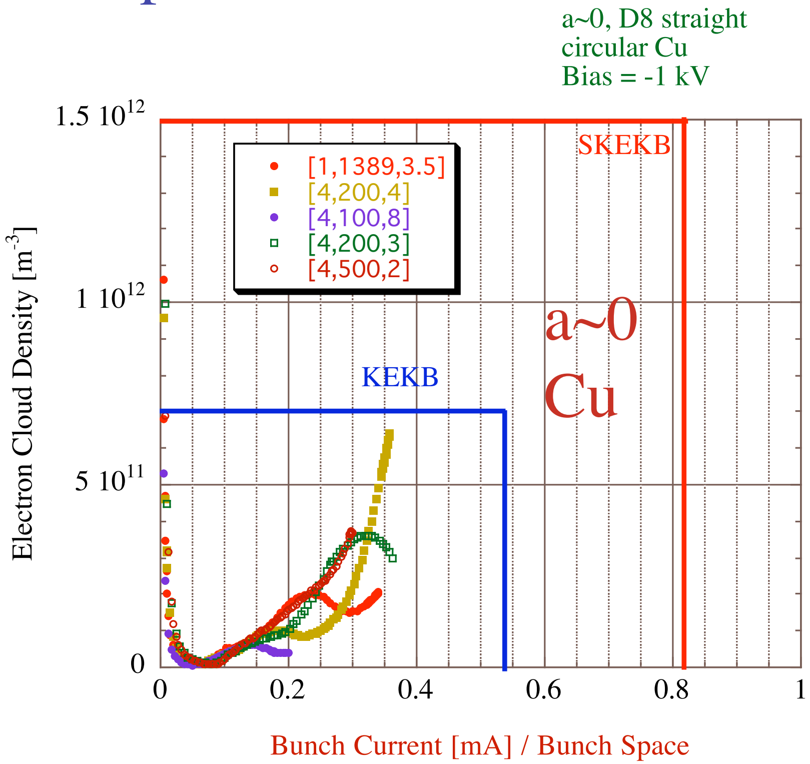
Electron cloud density for various bunch patterns is measured.

The dependence on bunch pattern is almost in good agreement with the simulation by Suetsugu.

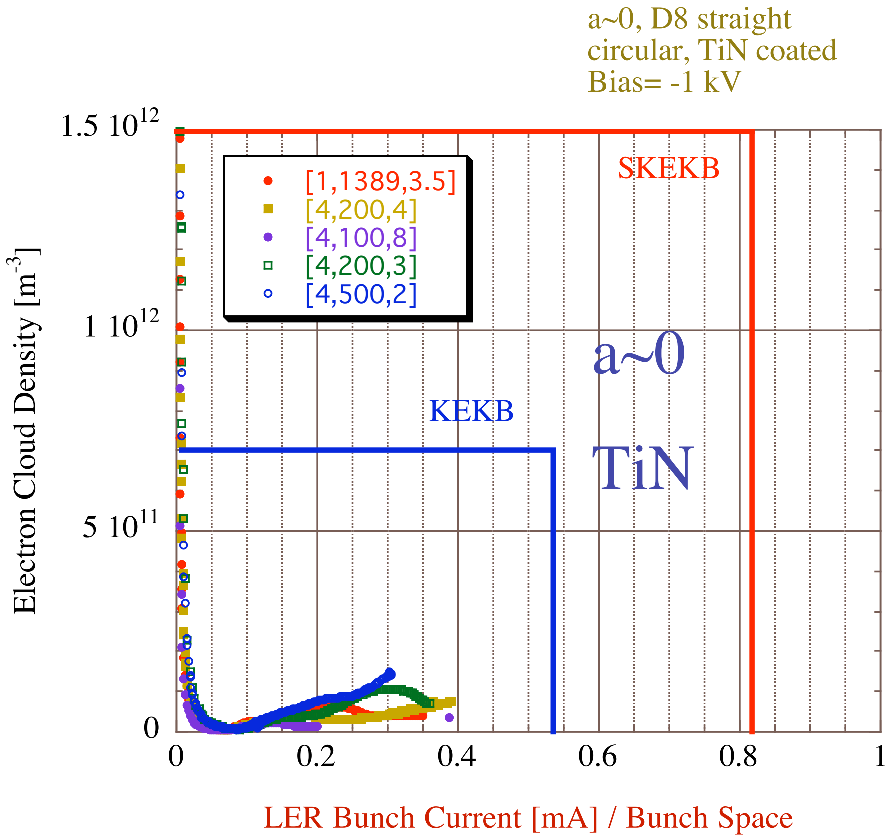
The variety of curve converges if the density is plotted against the linear density of the stored current.

4. Under Various Bunch Patterns (2)

Comparison with the critical density of the head-tail instability



TiN coated duct under negligible SR seems to satisfy the criterion of the head tail instability.



The critical density for KEKB is from Ohmi and Zimmermann PRL **85**, 3821(2000).

For SKEKB, from LoI.

5. Summary

- The electron cloud density depends on the intensity of synchrotron radiation.
- Antechamber reduces the contribution of photoelectrons but not complete.
- Probable inconsistency between the in situ SEY measurement and the cloud measurement need further study including simulation.
- If direct synchrotron radiation is negligible, the density of electron cloud in a TiN coated chamber seems to be lower than the critical density for the head-tail instability.

Planed measurements:

The cloud density for antechamber+TiN coating.

Effect of clearing electrodes.

Density in a solenoid field.