

Measurement of photoelectron yield

– Comparison between smooth and saw-tooth surfaces –

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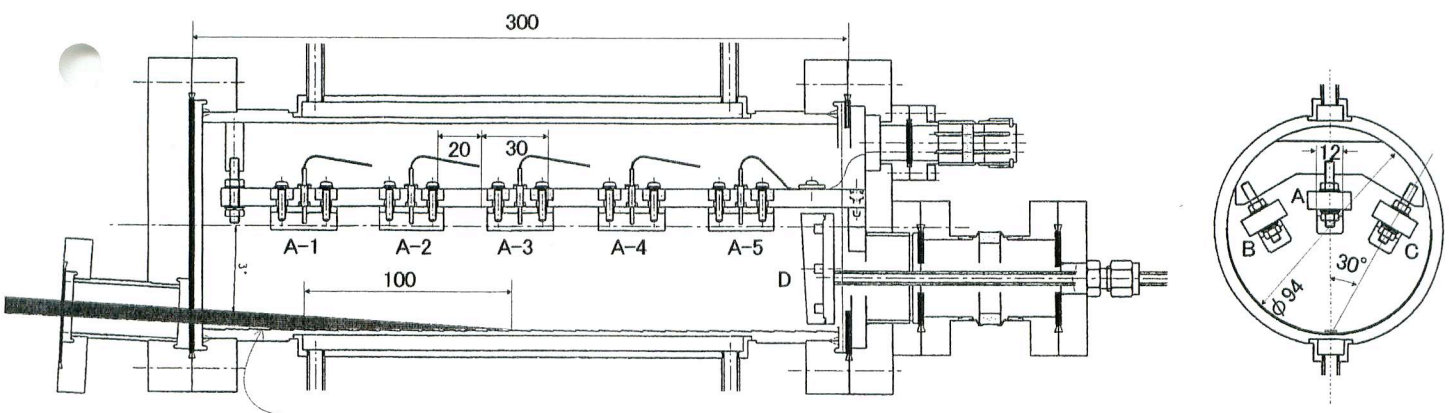
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Experimental set up

A test chamber is installed at the end of PF BL-21 line at KEK



SR from PF at KEK

Critical energy = 4.0 keV
(6 keV for KEKB LER)

Cross section = 5mm x 5mm

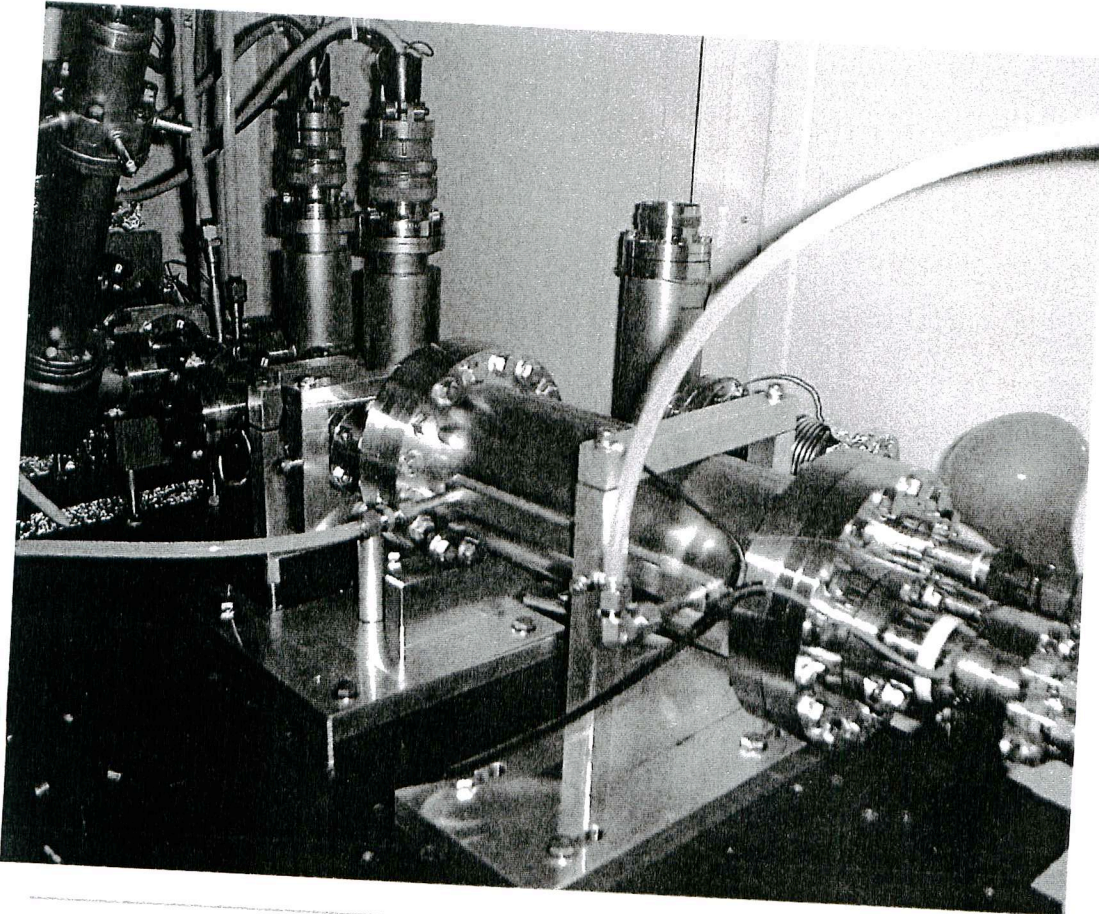
Incident angle = 3°

Incident photon = 5.87×10^{13} photons/s/mA
(per unit beam current)

Electrodes

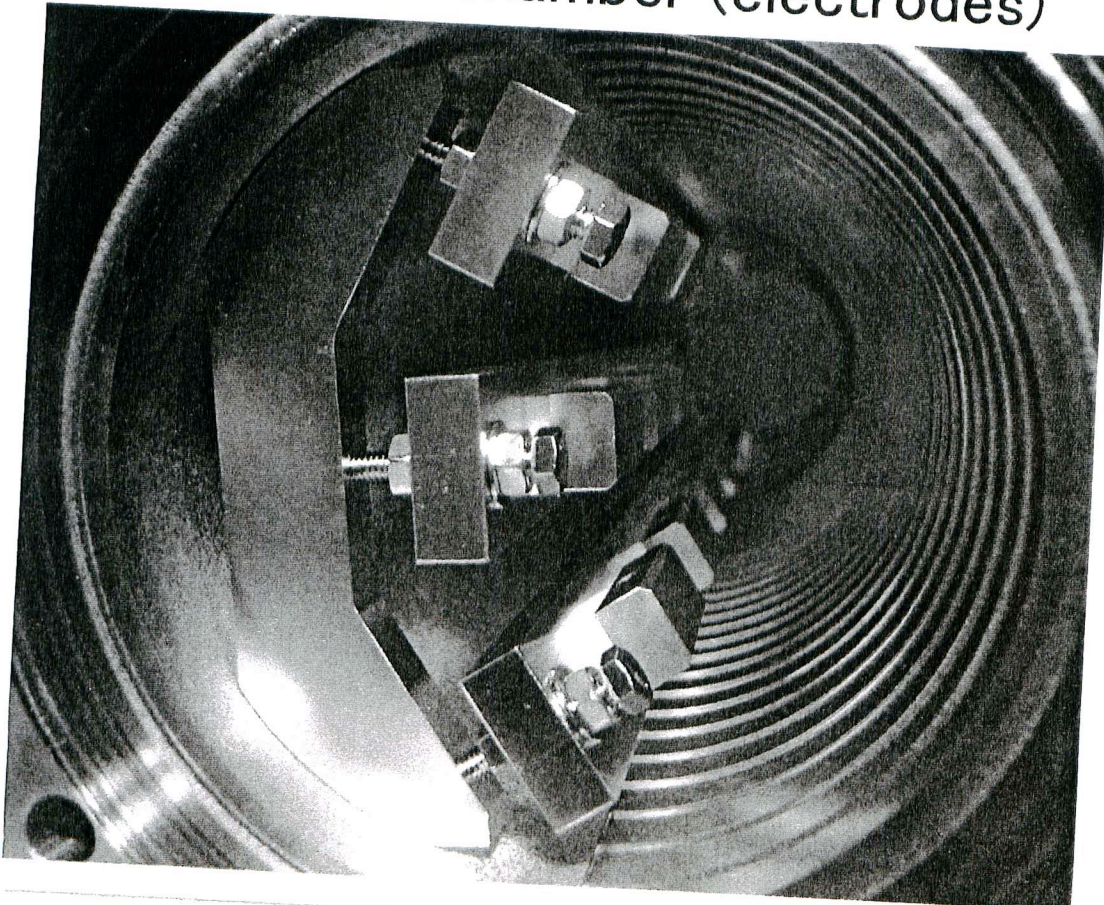
Five electrode axially, three lines azimuthally
One electrode at the end
The bias voltage can be applied independently.

Test chamber



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Inside of the test chamber (electrodes)



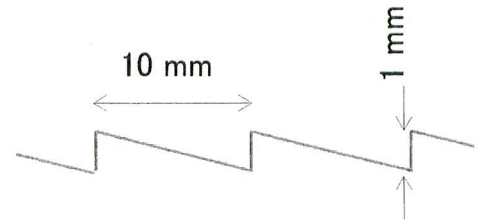
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Test chamber

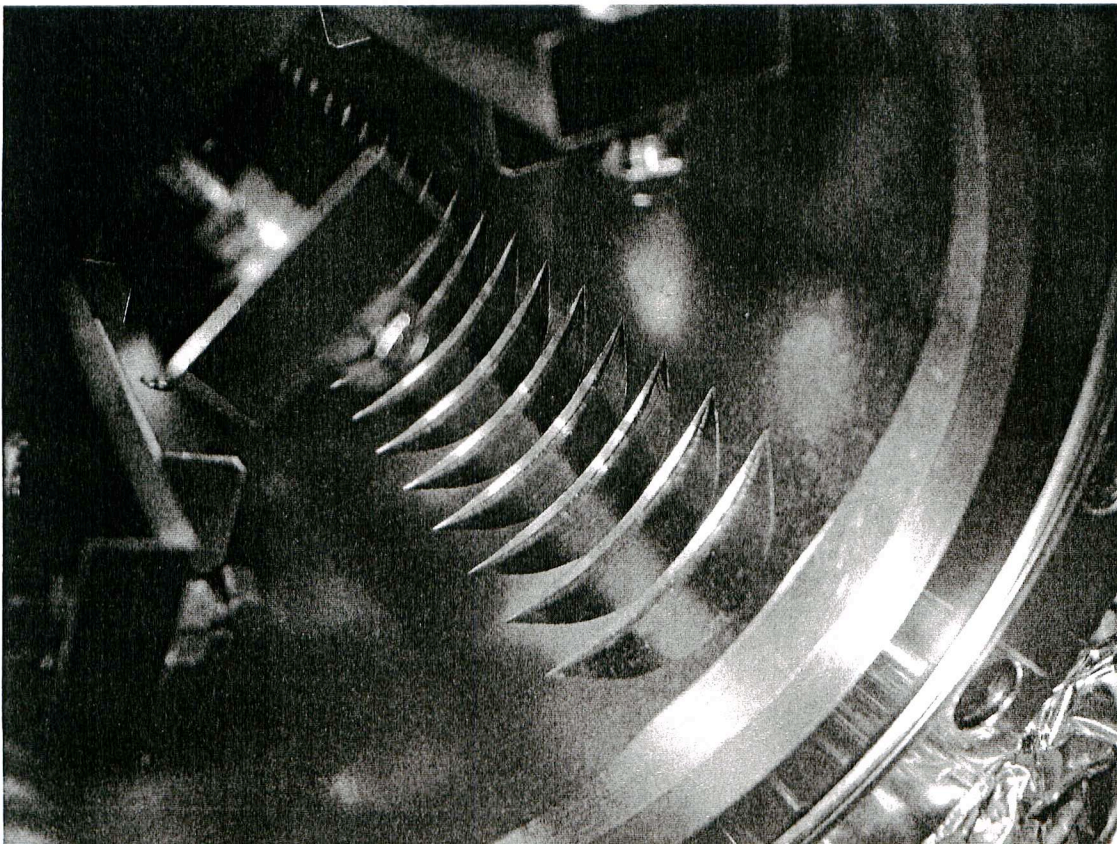
- Material: OFC
- Inner diameter = 94 mm
- Length = 300 mm

Surface

- (1) Sawtooth-1
Depth = 1mm, Pitch = 10mm,
Half of chamber surface
- (2) Sawtooth-2
Depth = 1mm, Pitch = 10mm,
Only near the irradiated section
- (3) Machining ($R_a = \sim 7$)
Lathed azimuthally
- (4) Smooth ($R_a = 0.02$)
Cold drawn chamber used for KEKB LER



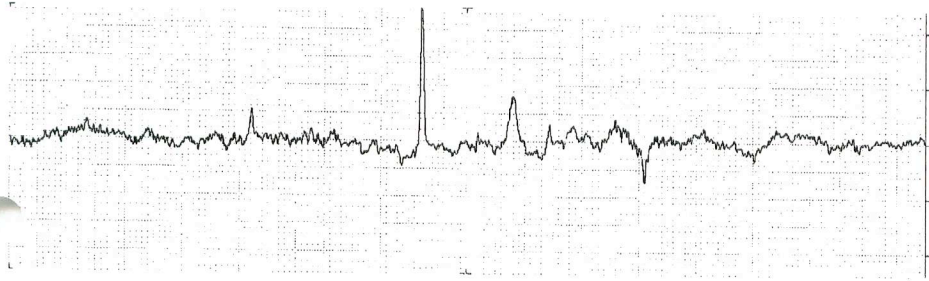
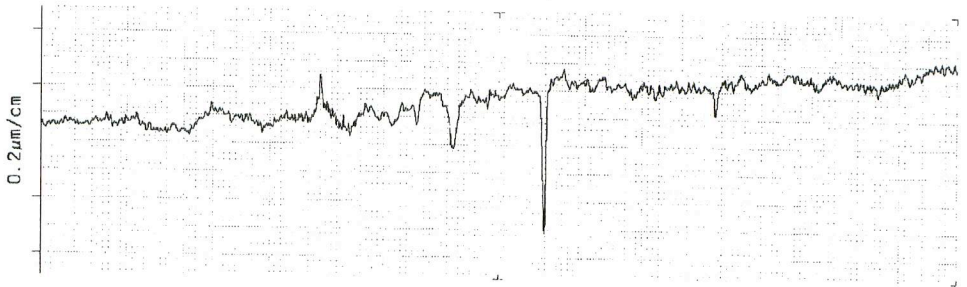
Saw-tooth surface



Axial roughness of smooth surface (cold drawing)

Ra 0.023 μm
 Rv 0.45 μm

断面曲線
 L=0.8mm
 x2

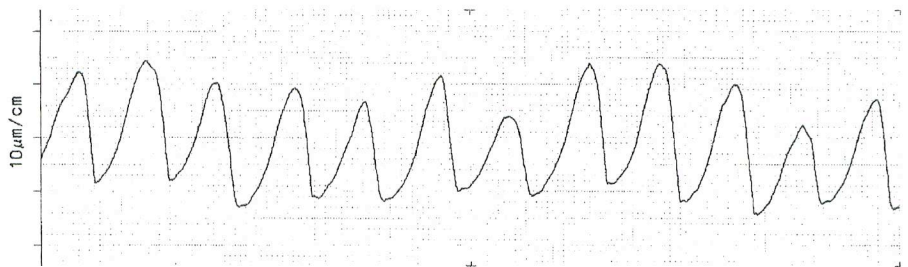


粗さ曲線
 λc=0.8mm
 L=0.8mm
 x2

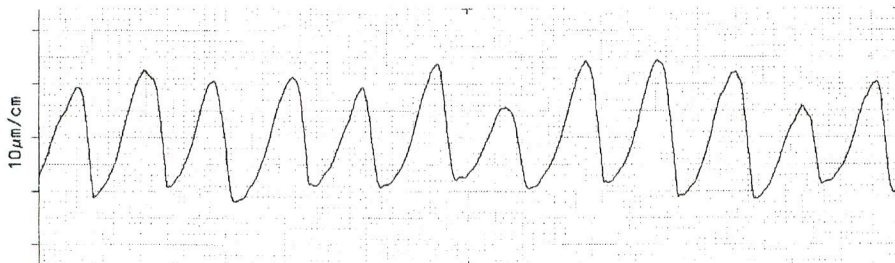
Axial roughness of machining surface

Ra 6.594 μm
 Rv 25.79 μm

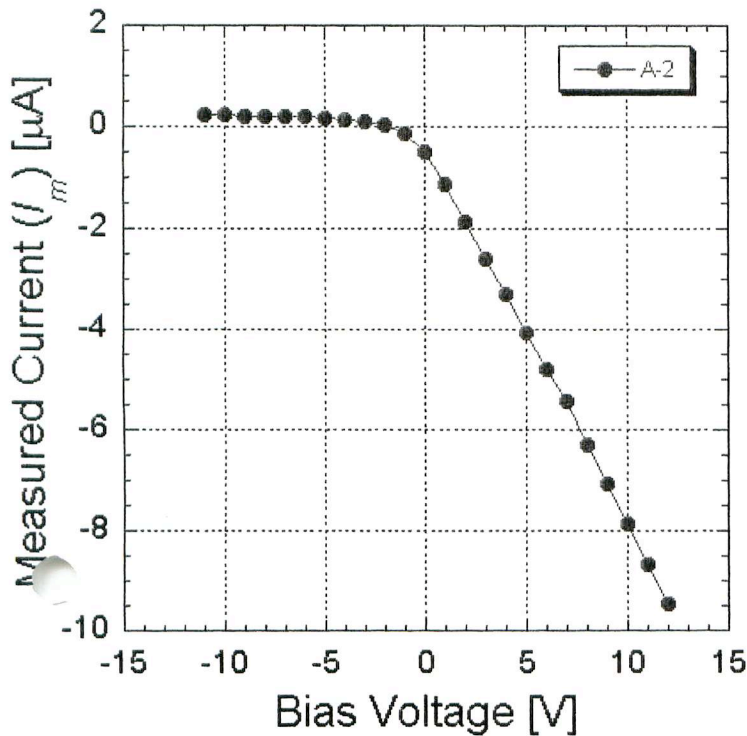
断面曲線
 L=0.8mm
 x2



粗さ曲線
 λc=0.8mm
 L=0.8mm
 x2



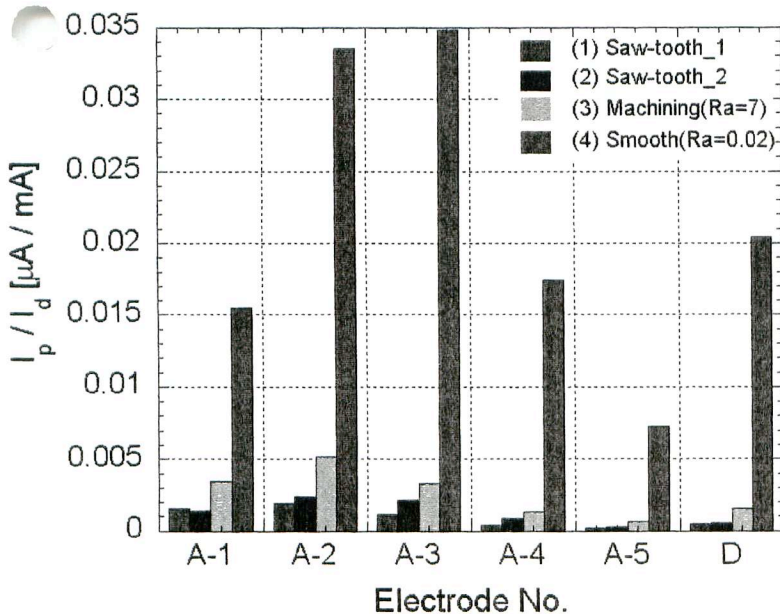
(1) Energy of photoelectrons



- The currents (I_m) are measured changing the bias voltage (-11V - +11V) at A-2 electrode.
- I_m decreases monotonously for positive voltage.
 - > Photoelectrons near the electrode are attracted.
- I_m saturates at about -5 V for negative voltage.
 - > Photoelectrons from chamber surface is reflected.
 - > Only the current of electrons emitted from the electrode.
 - > The energy of photoelectrons is 5 eV at most.
- Definition of photoelectron current: $I_p = I_m(0V) - I_m(-11V)$

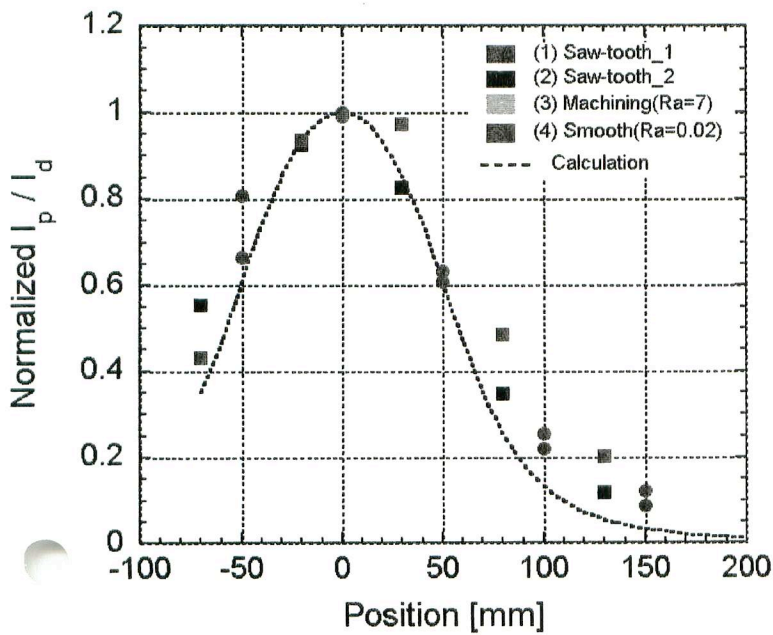


(2) Axial distribution of photoelectron currents



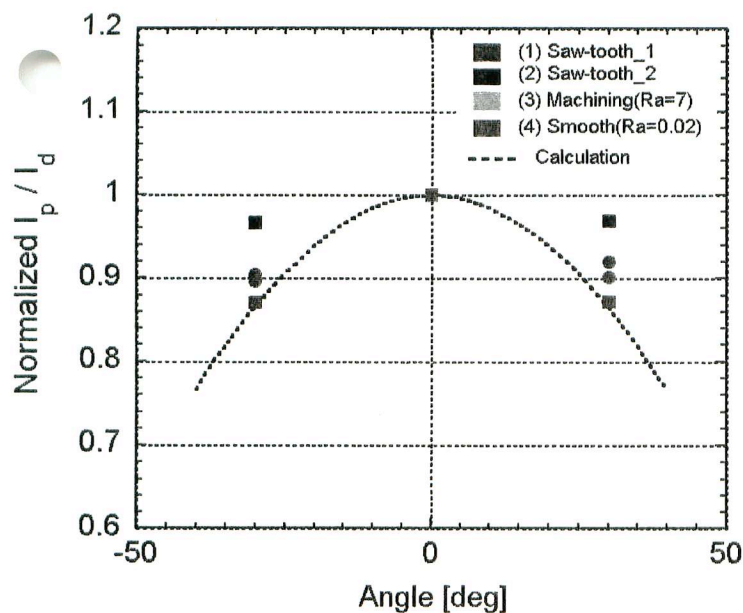
- Photoelectron currents per unit beam currents at [A] and [D] electrodes.
- The peak is at the center of irradiated section.
- The peak photoelectron currents for saw-tooth surface is 1/17 of that for smooth surface.
- Even for the machining surface, the peak photoelectron currents is 1/7 of that for smooth surface.

(3) Axial distribution of photoelectron currents



- Photoelectron currents at [A] electrodes were normalized by that at the center of irradiated section.
- The dotted line is calculated distribution assuming the emission following cosine law.
- Photoelectron currents almost follows the calculation.
- The values at forward direction are larger than the calculation.
- The values at backward direction for saw-tooth are also larger than the calculation.

(4) Azimuthal distribution of photoelectron current



- Photoelectron currents at A-2, B-2 and C-2 were normalized by that at A-2 electrode.
- The dotted line is calculated distribution assuming the emission following cosine law.
- Photoelectron currents almost follows the calculation.
- The distribution for saw-tooth, however, is flatter than the calculation.

(5) Results

Photoelectron yields are calculated assuming that the photoelectrons are emitted following the cosine law.

Critical energy	45 eV[CERN]			194 eV[CERN]			4.0 keV		
Incident angle	11 mrad			11 mrad			52 mrad		
	R[%]	y	y*	R[%]	y	y*	R[%]	y	y*
Saw-tooth	1.8	0.053	0.053	1.2	0.052	0.052	0.18	0.016	0.016
Machining							1.1	0.04	0.04
Smooth	80.9	0.022	0.114	77.0	0.073	0.318	33.2	0.29	0.434

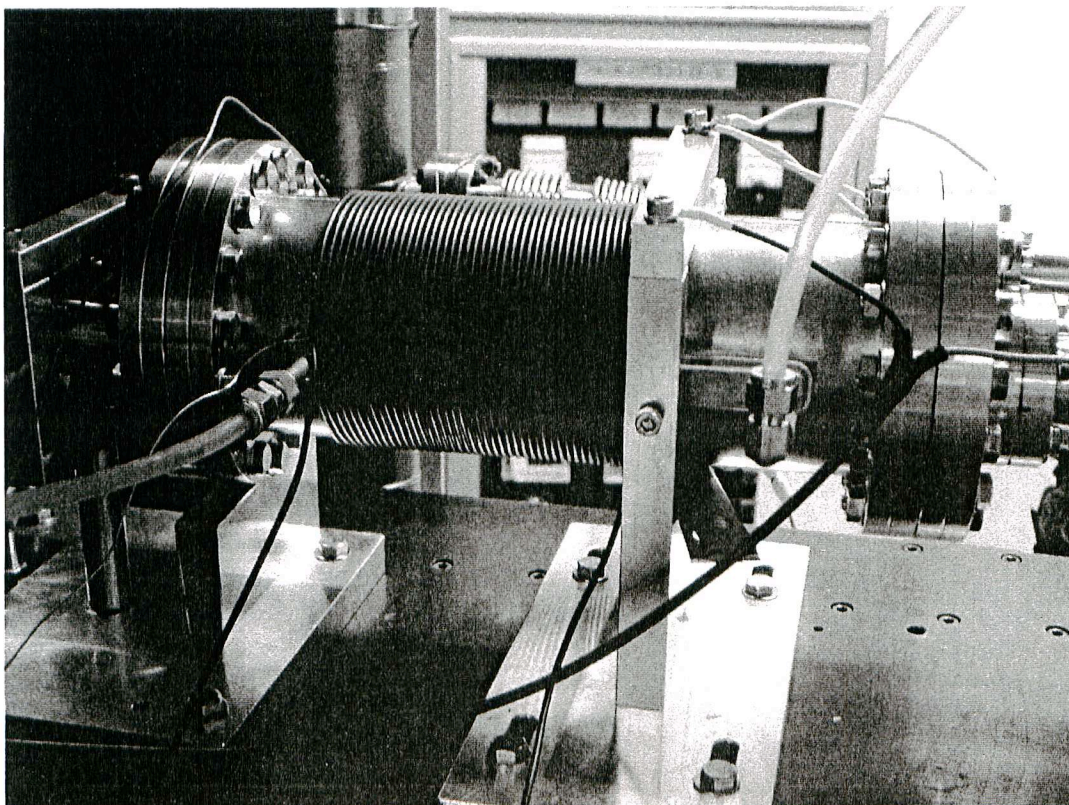
R[%]:
Reflectivity

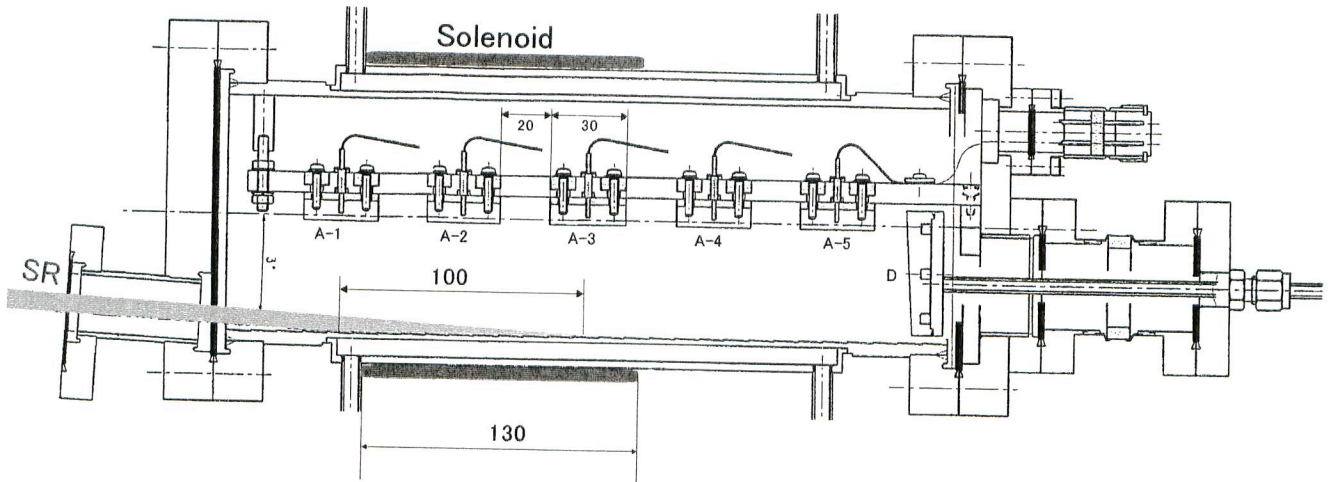
$$y^* = y / (1 - R)$$

[CERN]
(Collins, et al.)
Saw-tooth:
Height: 30 μ m,
Pitch: 500 μ m
Smooth:
Ra=0.2
Incident angle:
11 mrad

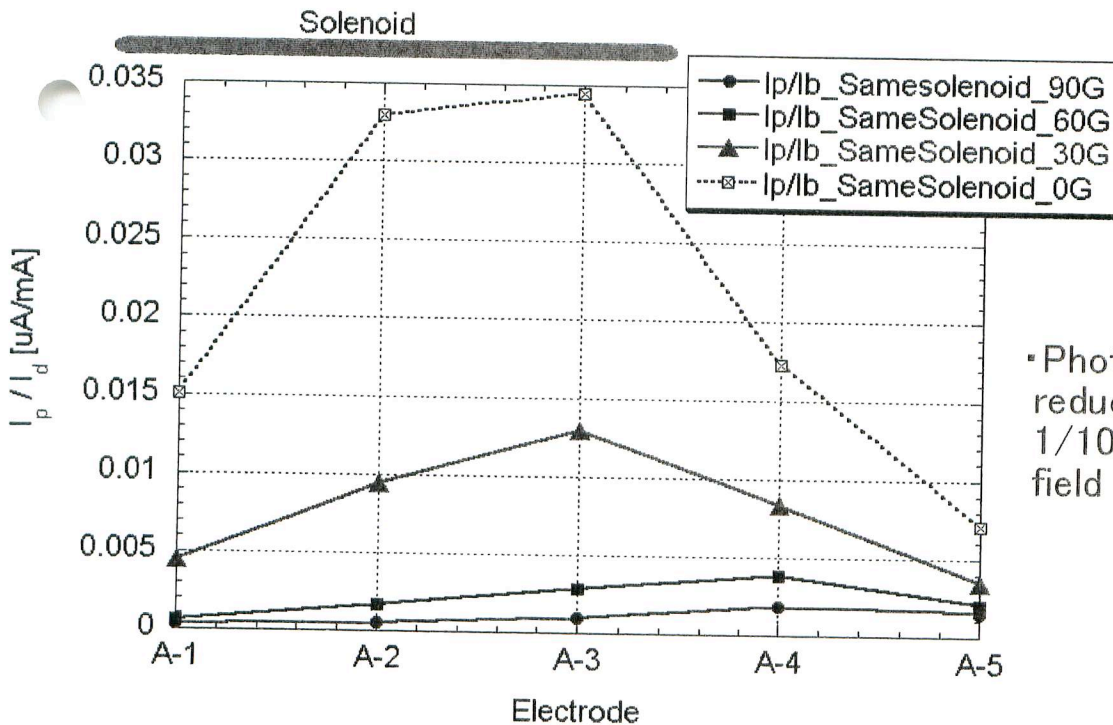
- Photoelectron yield for saw-tooth reduced 1/18, Effective photoelectron yield reduced to about 1/27
- Values for smooth surface are almost same as those at CERN.
- Values for saw-tooth seems smaller than those at CERN.

Solenoid around the test chamber



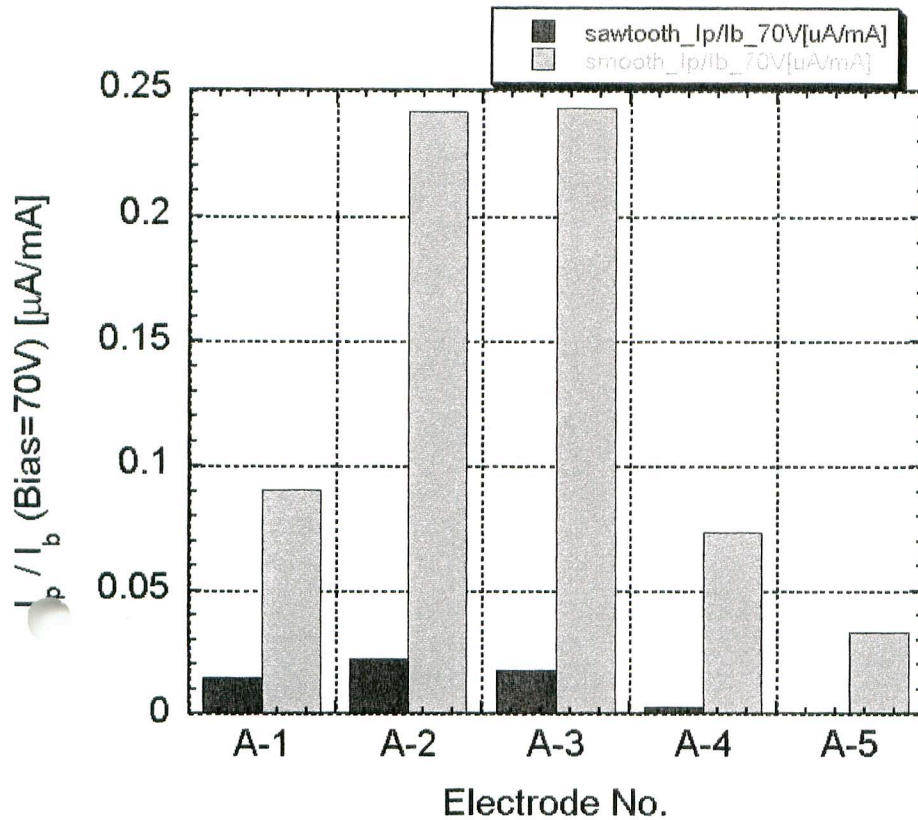


(6) Effect of solenoid field



• Photoelectron currents reduced to less than 1/10 for the magnetic field of 60 G.

(7) Effect of beam field



- + 70V is applied to all [A]–[C] electrodes to simulate the DC electric field assumed as a beam.

- Saw-tooth surface is also effective under the DC electric field.

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Summary

- (1) The energy of photoelectrons is 5 eV at most.
- (2) The peak photoelectron currents for saw-tooth surface is 1/17 of that for smooth surface.
Even for the machining surface, the peak photoelectron currents is 1/7 of that for smooth surface.
Effective photoelectron yield reduced to about 1/27
- (3) Photoelectron currents almost follows the cosin law emission.
- (4) Solenoid magnetic field of about 60 G reduces the yield to less than 1/10.
- (5) Saw-tooth surface is also effective under the DC electric field assumed as a beam.

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