Possible Remedies to Suppress electron cloud in ILC damping ring

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Objective

- **Completely clear the E-cloud along the whole ring, include drift region and various magnets (dipole, quadrupole, wiggler….) so that we can release the limitation of Ecloud on the design of damping ring, such as, circumference, beam pattern, the aperture of beam pipe, SEY.**

Cures of e-cloud

- **Weak Solenoid (work well in drift region, but not in magnets)**
- **Chamber surface preparation (Vacuum chamber coatings, ribbed structures, Beam scrubbing)**
- **Electron Clearing devices**

Robert E. Kirby, etc,

Remained Problem for ILC:

How about electron cloud inside magnet (dipole, wiggler …)if we want to save one RING?

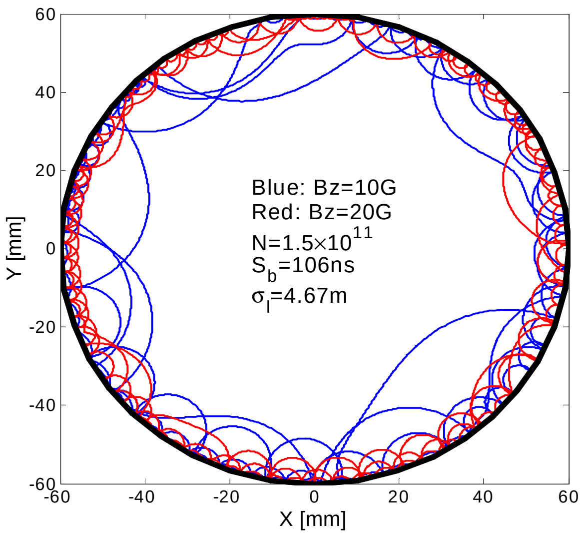
More creative and permanent solutions are needed!

- Solenoid ----drift region
- Electrode -----magnet
- Grooved surface-----magnet

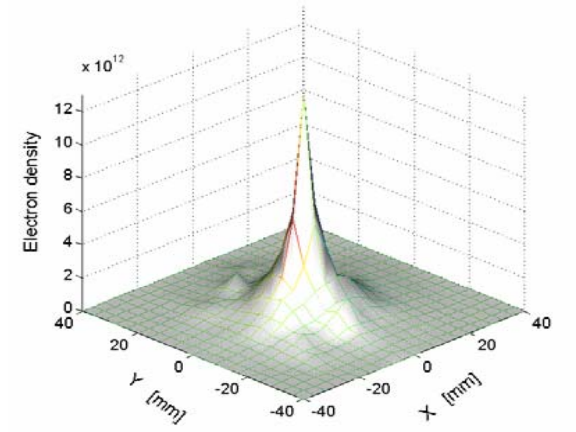
use CLOUDLAND program (PIC and Monte Carlo method)

Drift Region-----Solenoid

Orbit

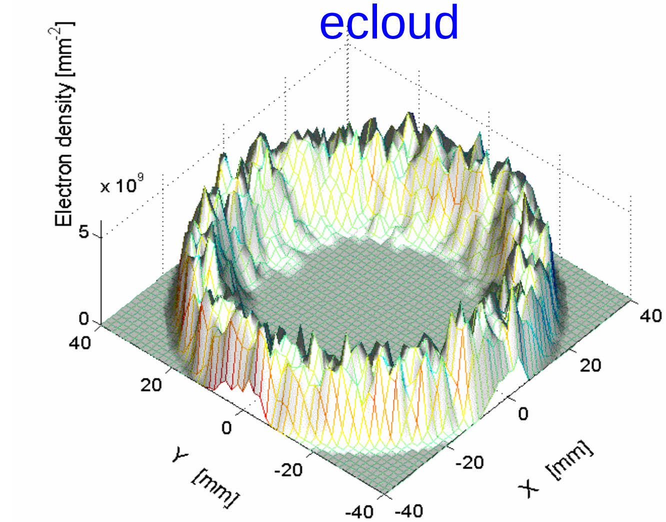


ecloud



Bz=0 Gauss

ecloud

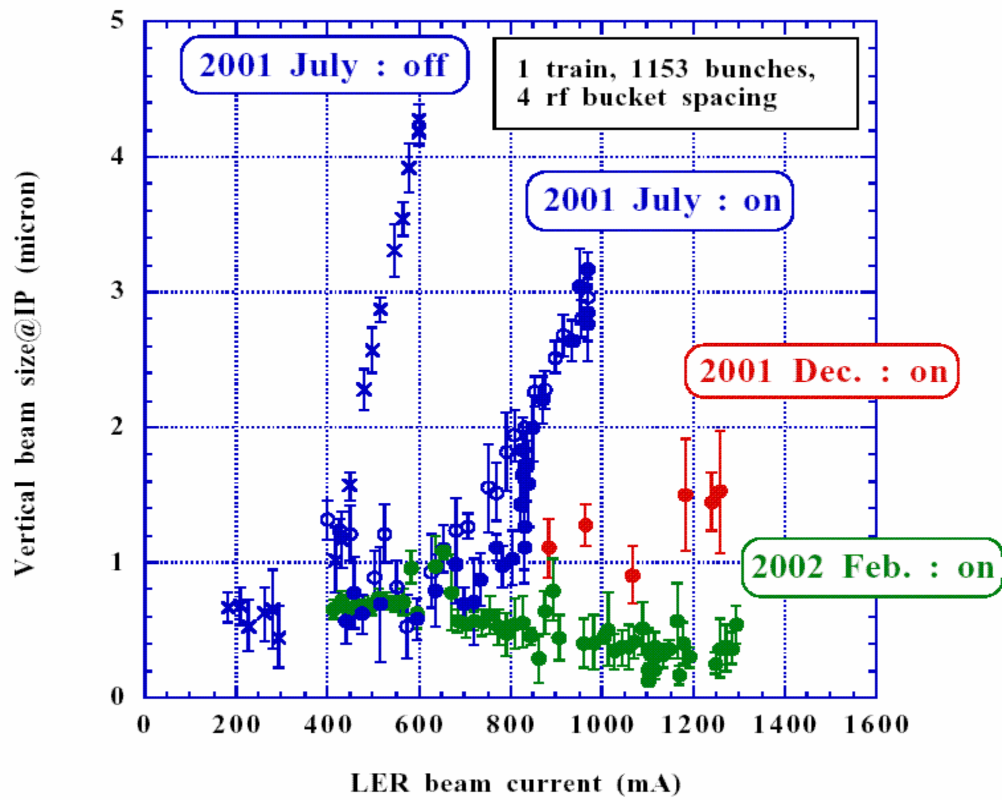


Bz=20 Gauss

A weak solenoid can suppress the electron multipacting by confining the electrons beam the pipe surface

Solenoid effect in KEKB LER

H. FUKUMA



After last installation of solenoid, blowup was disappea
up to 1300mA.

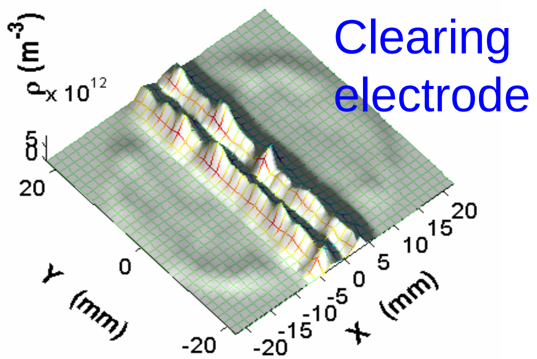
Electrode inside magnets--I

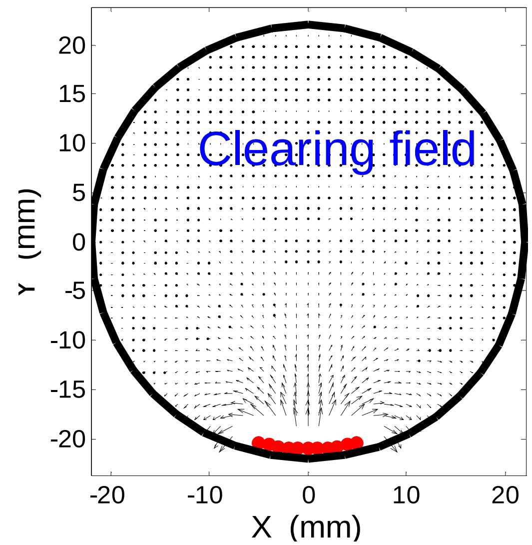
Stripline type in Dipole magnet (EPAC 2006, TUPLS003)

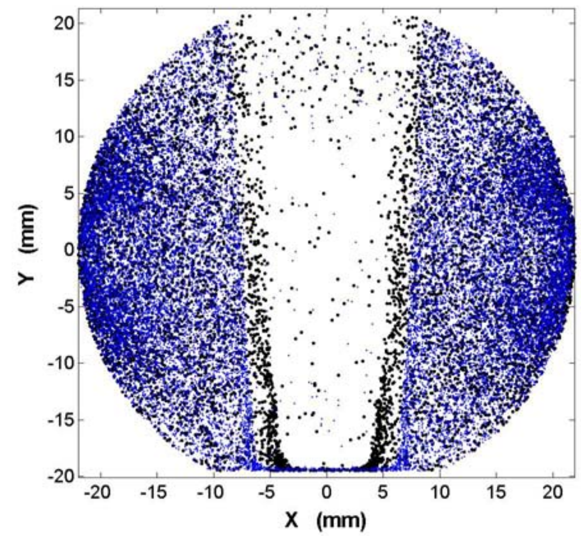
- The electrode is curved with the same shape of the chamber (round one here)
- The electrode is positively polarized in order to capture all the electrons to the electrode. It is electrically and thermally isolated to operate at a few hundreds voltage with respect to the beam pipe. There is a similar design for LHC dipole*
- The width of low electron density region increases with the size of the electrode

Ecloud

Without Clearing electrode







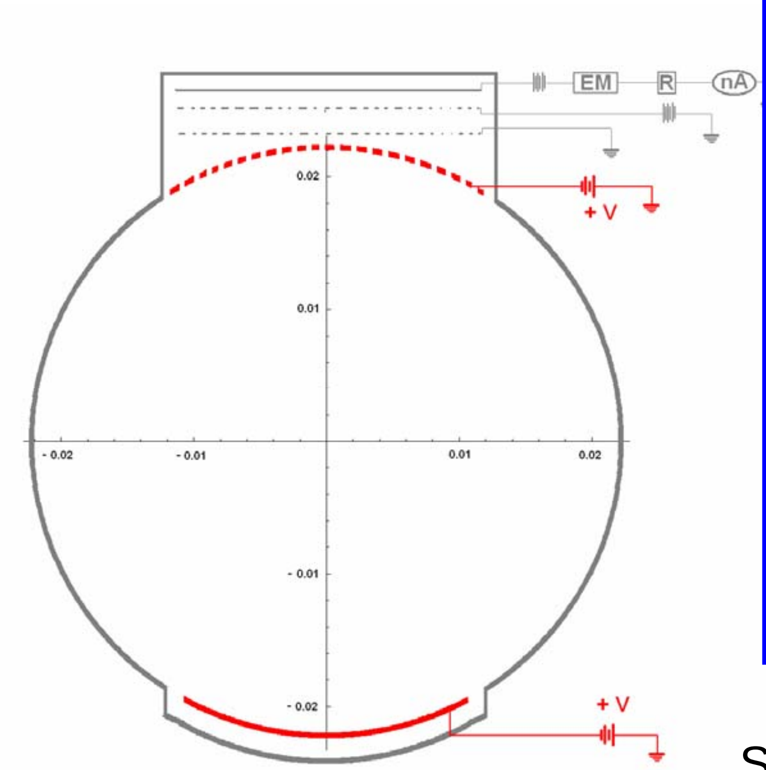
Ecloud

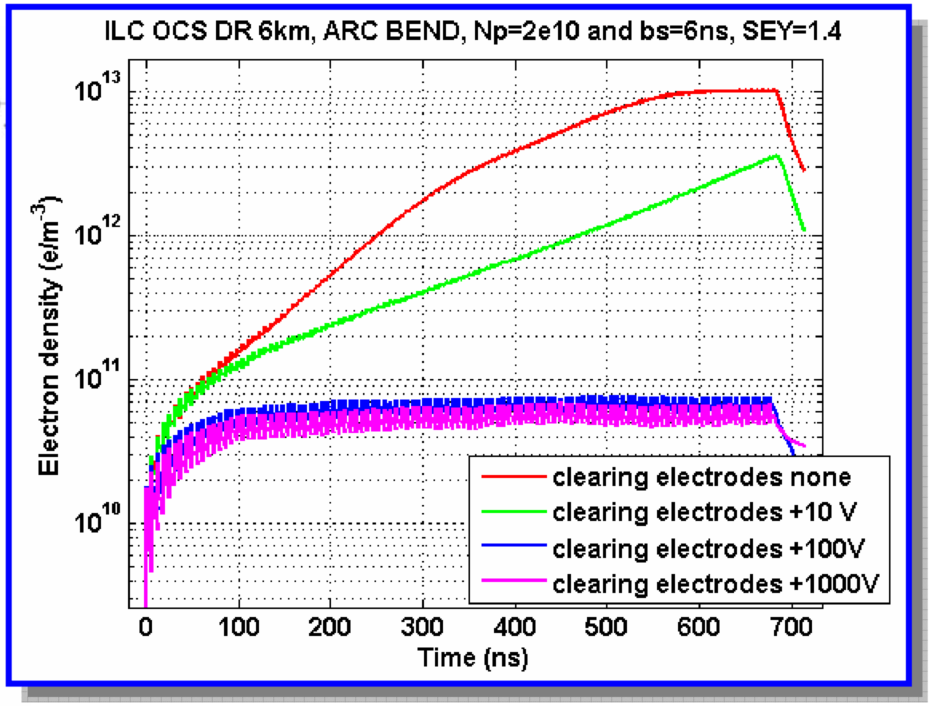
with Clearing electrode

* P. McIntyre and A. Sattarov, Proceedings of PAC2005, TPAP047, 2005

Electrode inside magnets--II

Curved coradial type in dipole magnet (M. Pivi)





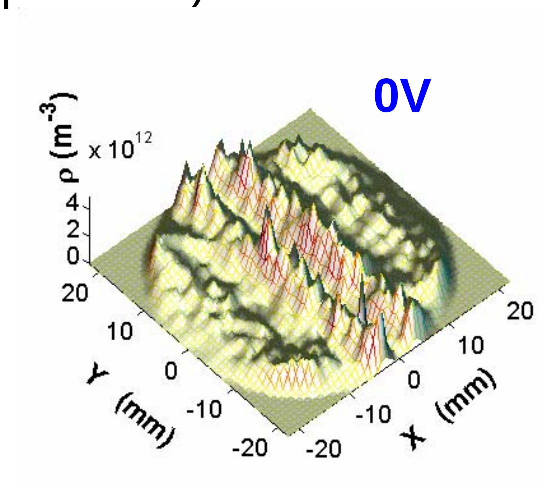
BEND chamber with curved clearing electrodes

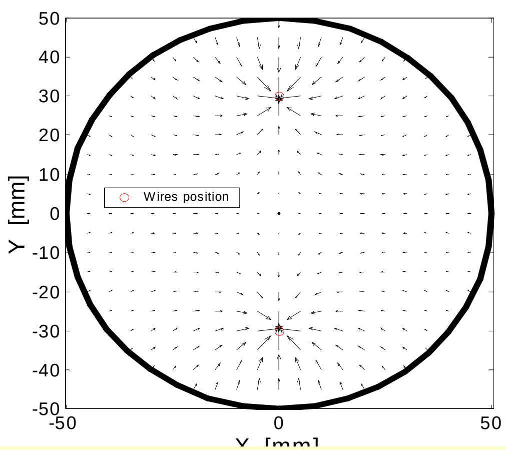
Simulation using POSINST code of electron cloud build-up and suppression with clearing electrodes. ILC DR positron: assuming one single 6 km ring.

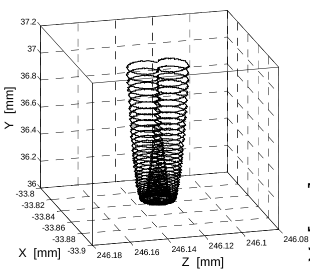
Electrode inside magnets--III

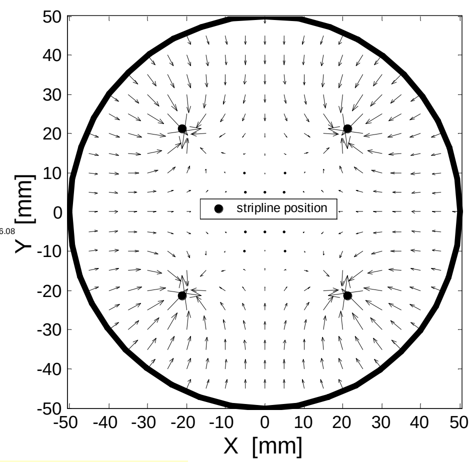
Wire type for various magnets (KEK Preprint-137)

- *The electric field must be along the magnetic field line in order to effectively repel the electron.*
- ***The wire electrodes must have** negative potential **relative to the grounded chamber!!!***
- *The field is perfect!!! (very weak field at chamber center, strong vertical field around both the top and bottom of the chamber, where multipacting could happen.*

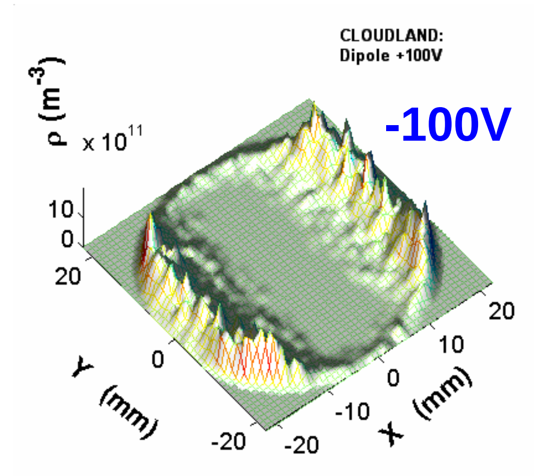








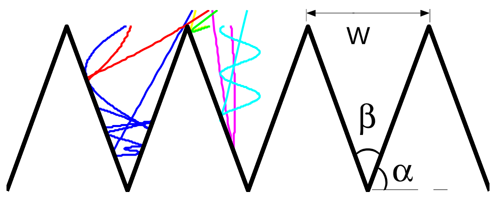
Configuration of electrodes and clearing field in a dipole/quadrupole magnet



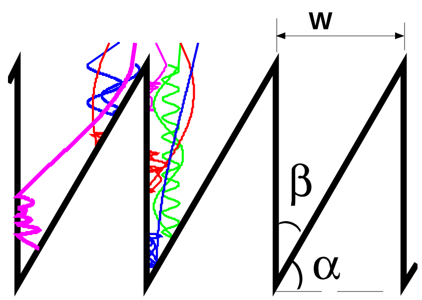
Ecloud in ILC Dipole

Grooved surface in a magnet

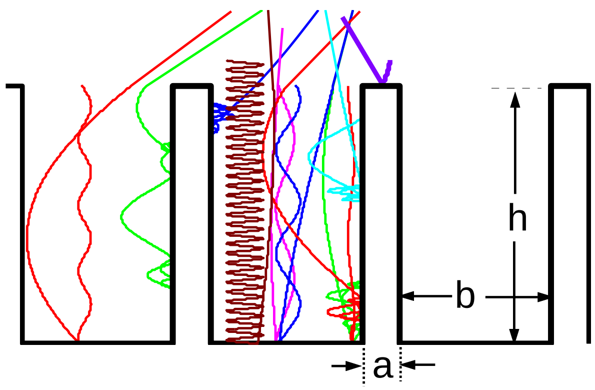
(L. Wang, T. Raubenheimer , Submitted to NIMA)



(a) Isosceles triangular surface

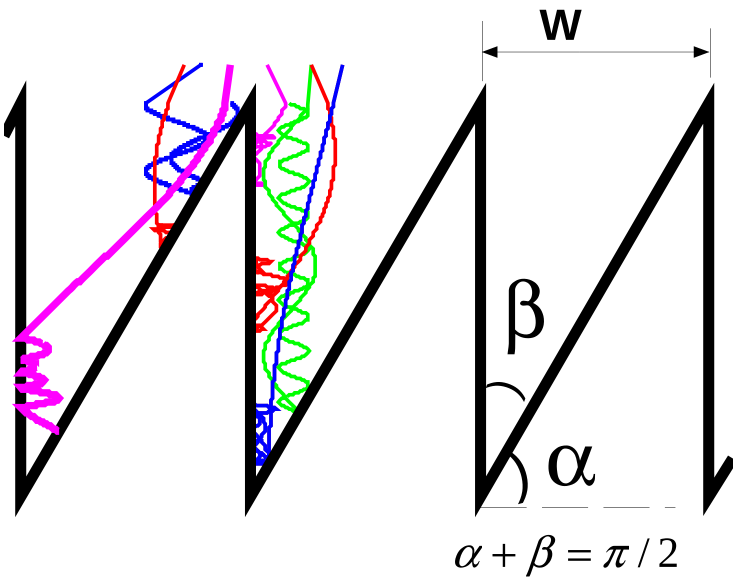


(b) Sawtooth surface



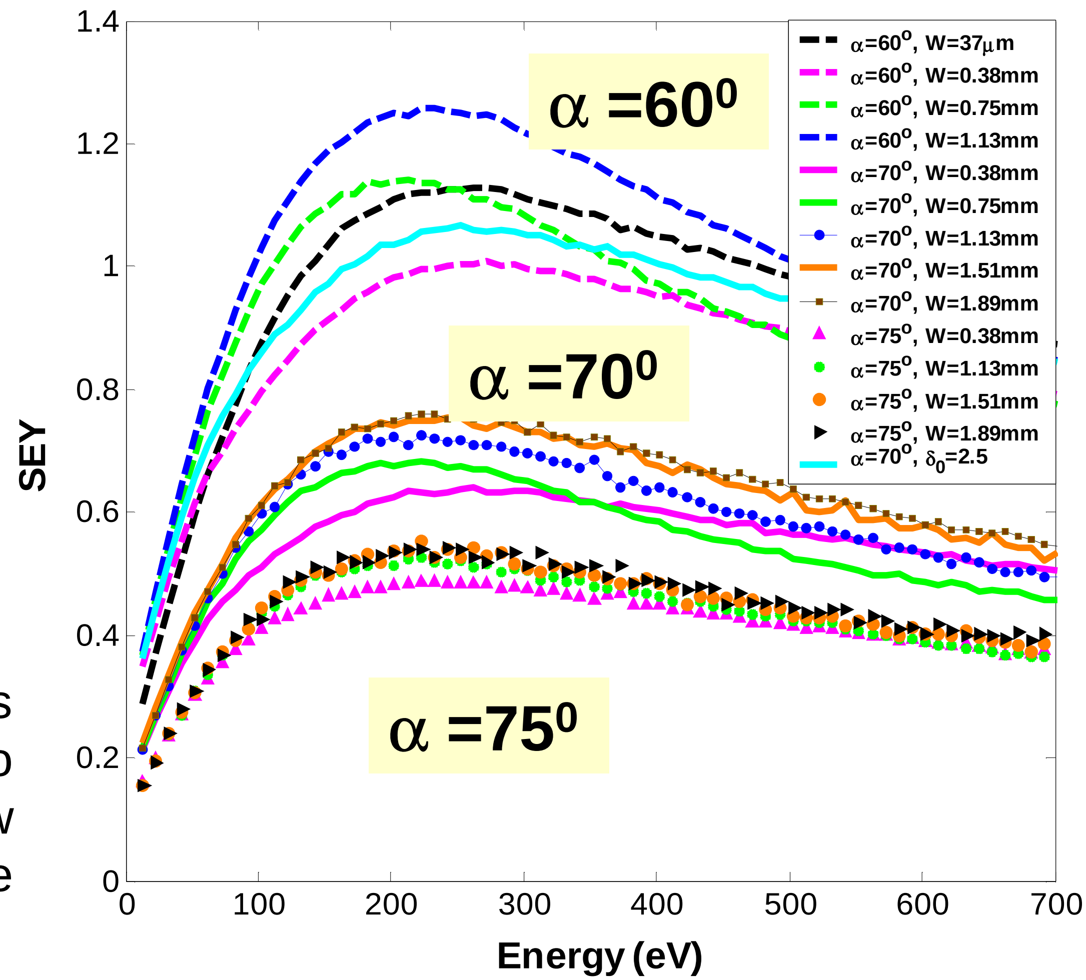
(c) Rectangular

Sawtooth Surface



Mechanism

Some of the secondary electrons emitted from the surface return to the surface within their first few gyrations, resulting in a low effective secondary electron yield.

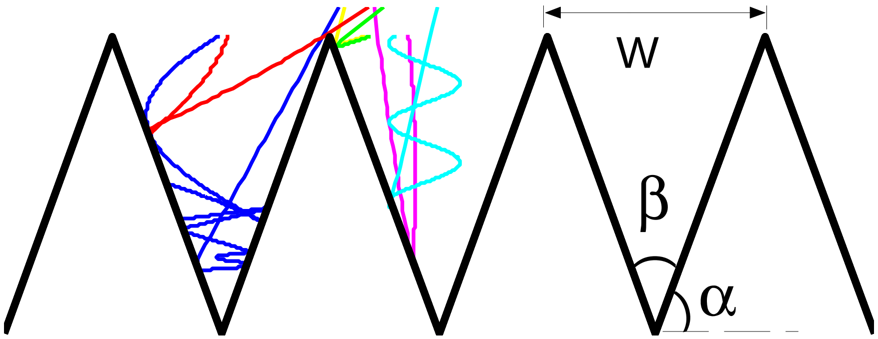


Requirement:

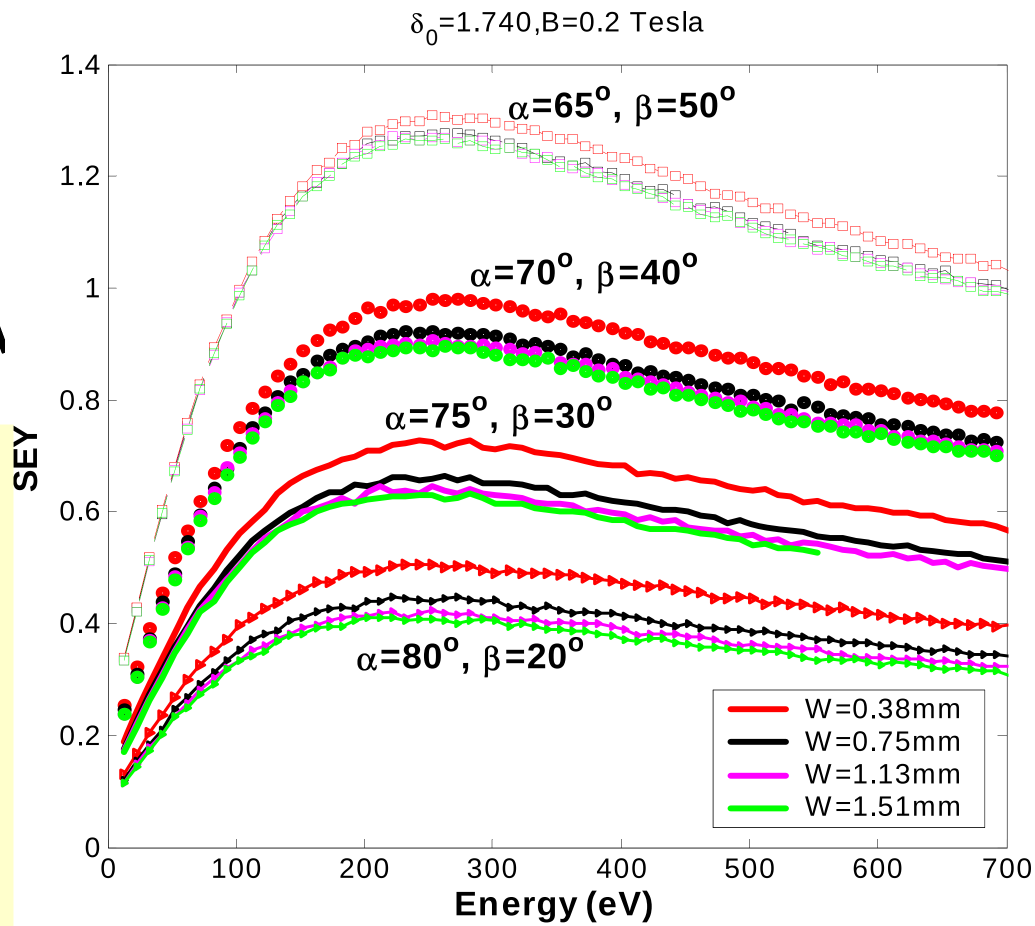
$\alpha > 70^0$, W> 0.38mm

Effective SEY from sawtooth surface in a dipole magnetic field. δmax=1.74, $Emax$=330eV, B_0=0.2Tesla.

Isosceles triangular surface I



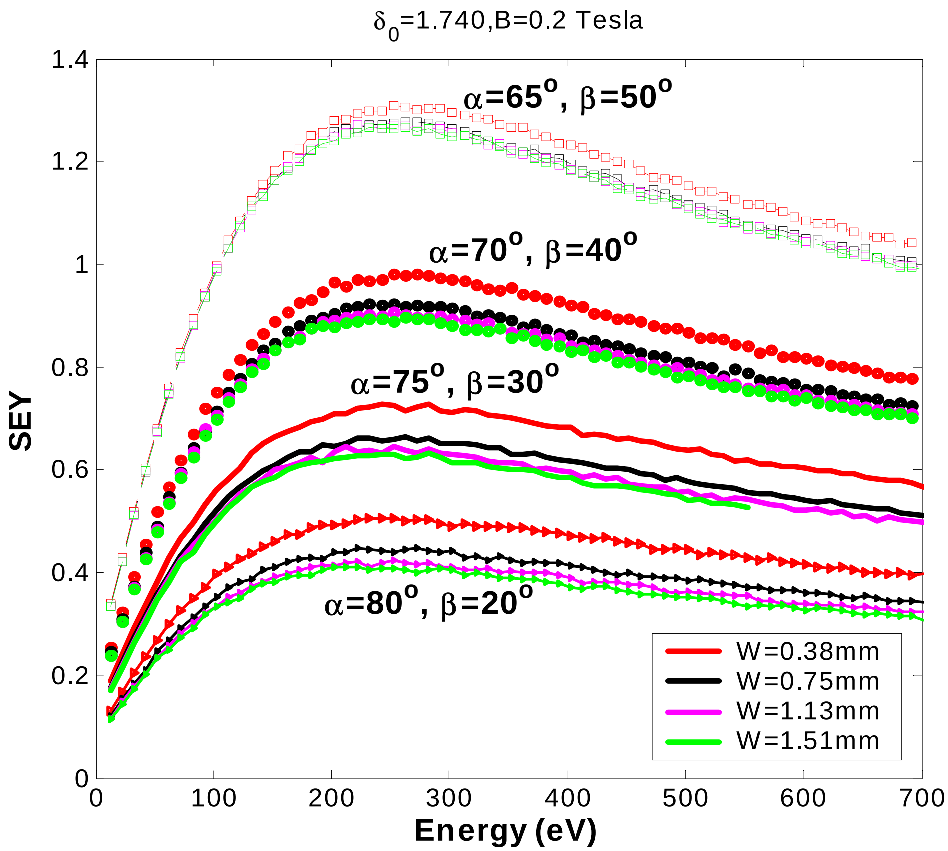
- **Sensitive to slope angle α**
- **Weak dependence on W. (saturated at larger W~2.0mm, no upper limitation on W!!!)**
- **Very weak dependence on B.**
- **Requirement:** α **>70⁰, W> 0.38mm**

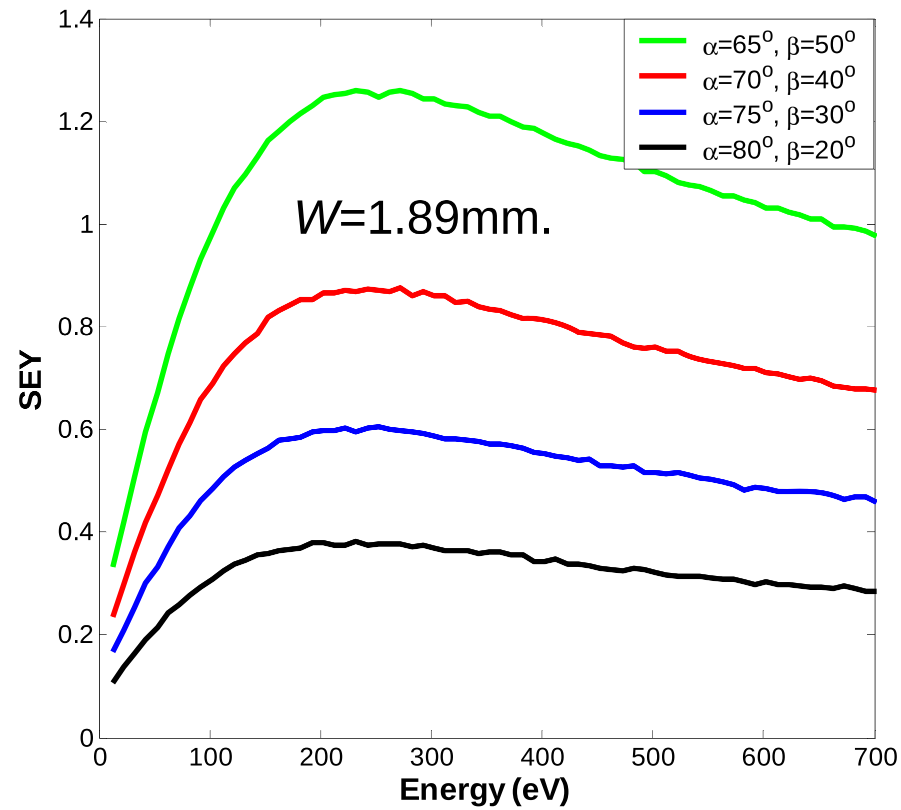


B=0.2 Tesla (dipole magnet of ILC)

Isosceles triangular surface II

Effect of B

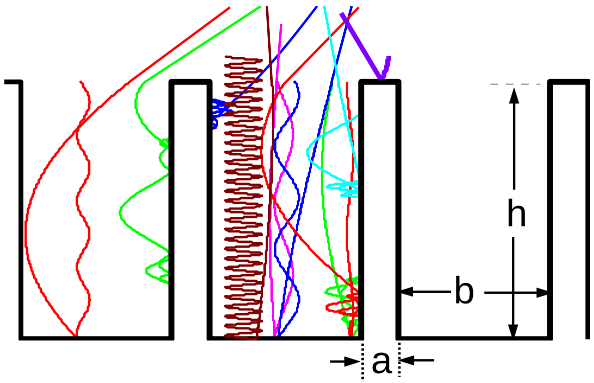




B=0.2 Tesla (dipole magnet of ILC)

B=1.6 Tesla (Wiggler magnet of ILC)

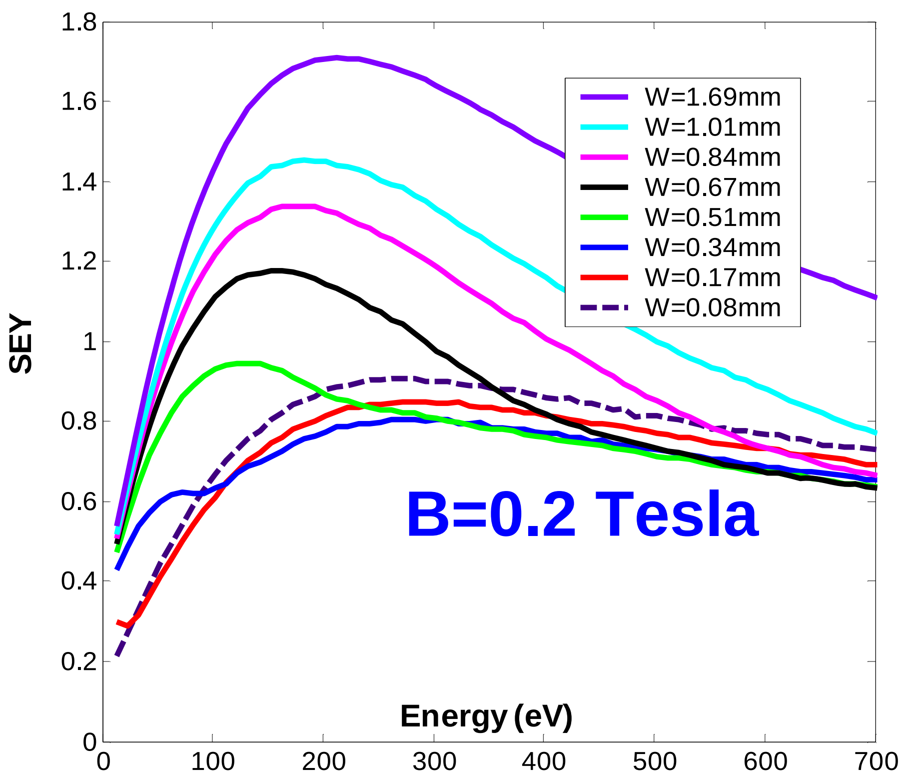
Rectangular Surface

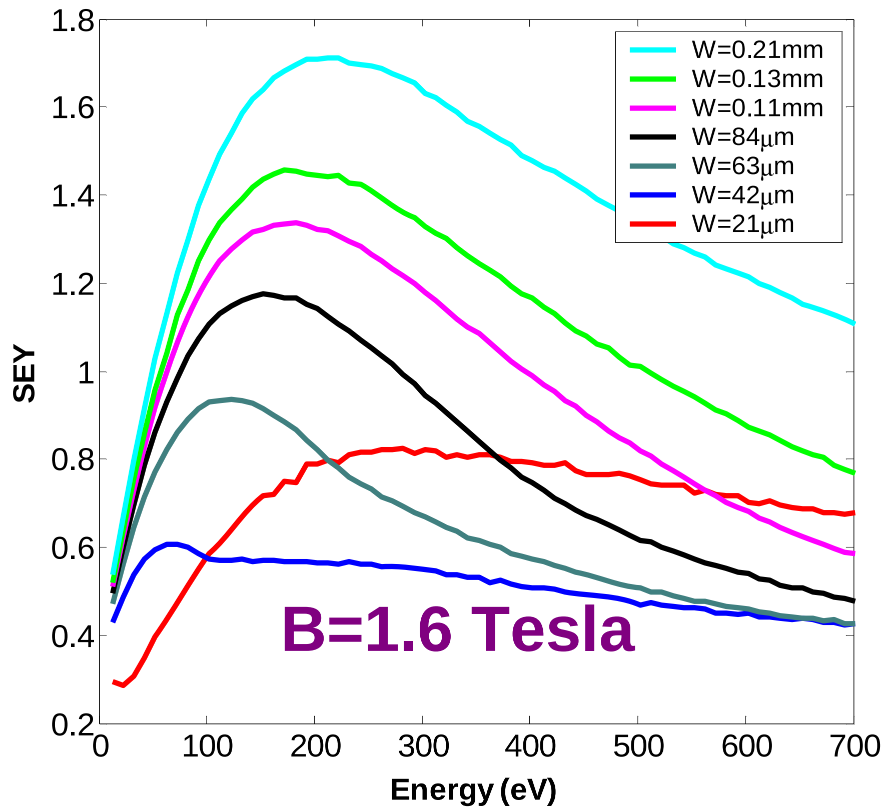


- **Sensitive to size and magnetic field**
- **Requirement: (a <<b)**

0.08mm <W< 0.51mm in 0.2 Tesla field

21μm < W <63 μm in 1.6 Tesla field



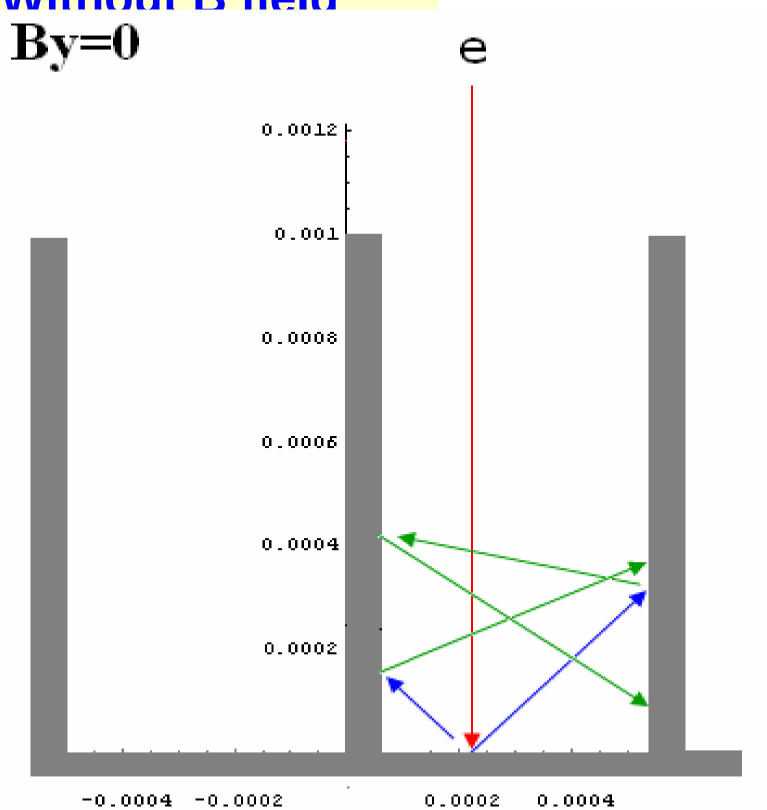


Rectangular Grooves to Reduce SEY (M. Pivi)

Rectangular grooves can reduce the SEY without generating geometric wakefields.

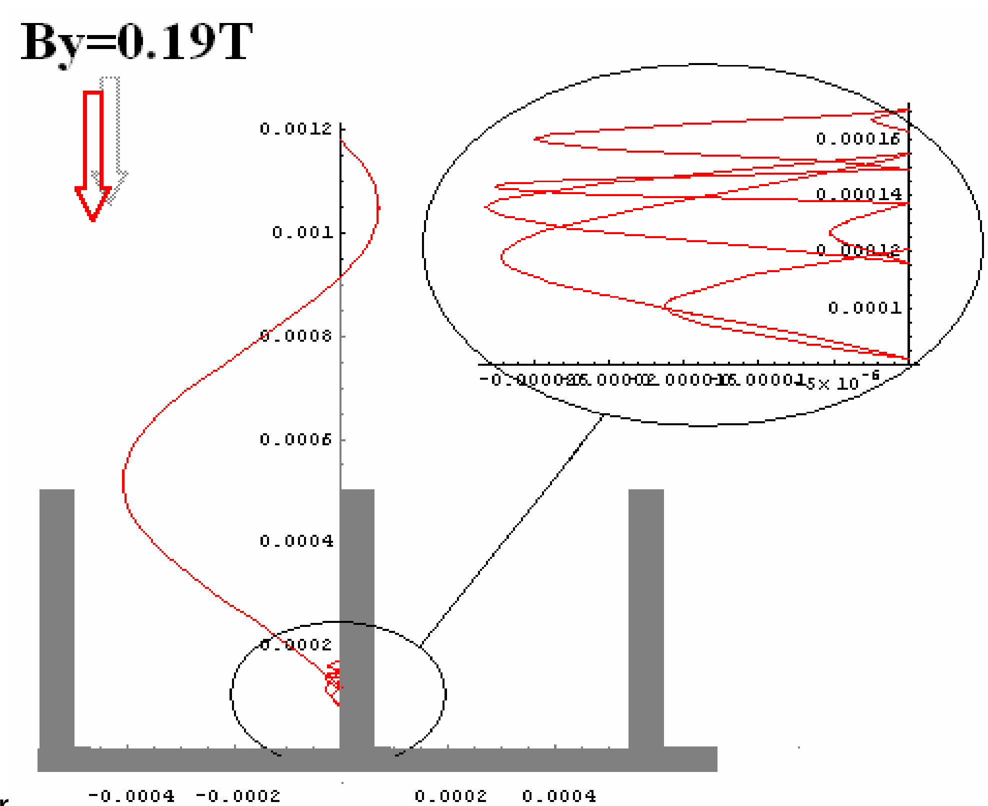
Macro fins (mm scale)

USE IN STRAIGHT
Without B field



Micro fins (µm scale)

USE IN **BEND, WIGG, QUAD?**
With B field

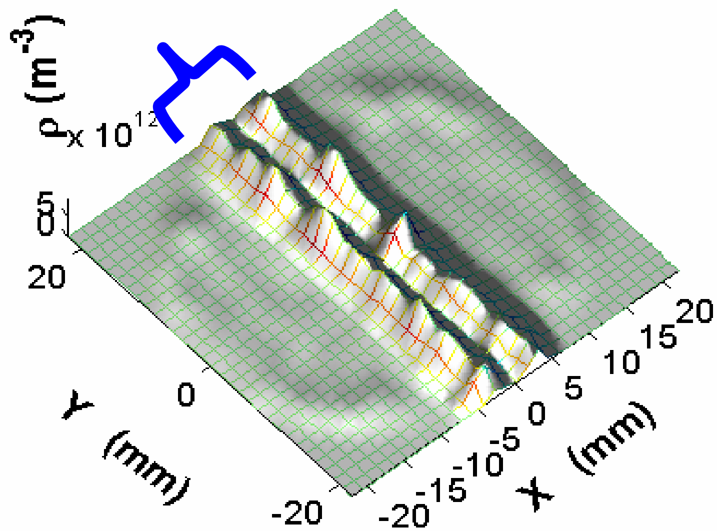


Application and impedance

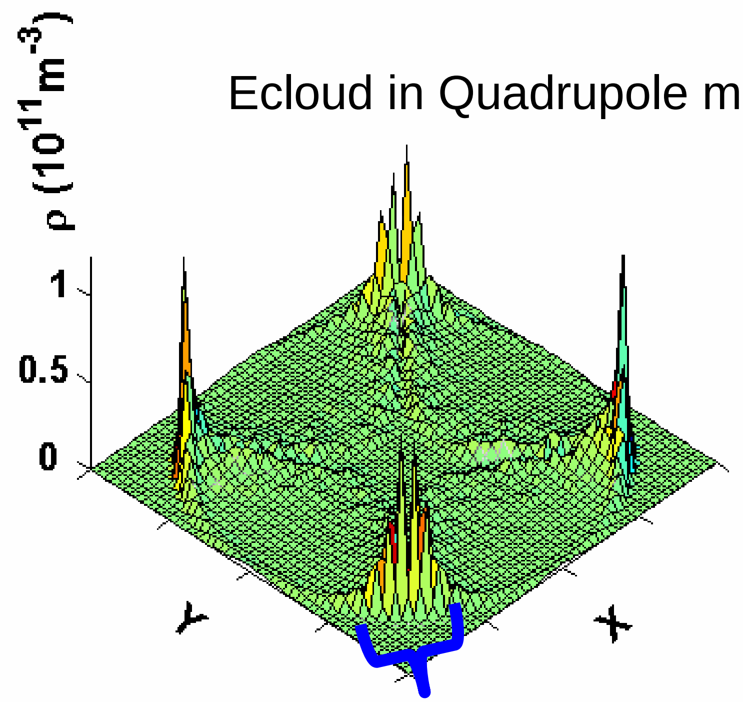
A rectangular grooved vacuum chamber cover the whole chamber surface increases the impedance by a factor of 48% [1]

The impedance enhancement due to the sawtooth and isosceles triangular surface is small due to the small percentage (for example 7.2% in dipole) of the coverage of the grooved surface.

Ecloud in Dipole magnet



Ecloud in Quadrupole magnet



[1] K. Bane and G. Stupakov, SLAC-PUB-11677.

Summary

Besides Solenoid, Coating and **Beam scrubbing, we also consider the following two approaches to clear electrons in magnet**

- **Clearing electrode in magnet** Electrode in wiggler ?
  - Traditional Stripline Type located at the bottom of chamber. (EASY to be to be manufactured)
  - **Coradial stripleline type with gaps between electrode and beam pipe (impedance…)**
  - **Wire type (work in various magnets, Support, impedance…?)**
- **Grooved surface in magnet**
  - Both **sawtooth** and **isosceles triangle** surface can significantly reduce the effective SEY with a weak dependence on the size of surface and magnetic field. **They work at dipole, quadrupole and wiggler (1.6 Tesla), No limitation on magnetic field! No upper limitation on size.**

    Requirement: α **>70^0, W> 0.38mm**
  - **The effect of rectangular surface is sensitive to size and magnetic field.**

    Requirement: **0.08mm <W< 0.51mm in 0.2 Tesla field**

    21μm < W <63 μm in 1.6 Tesla field