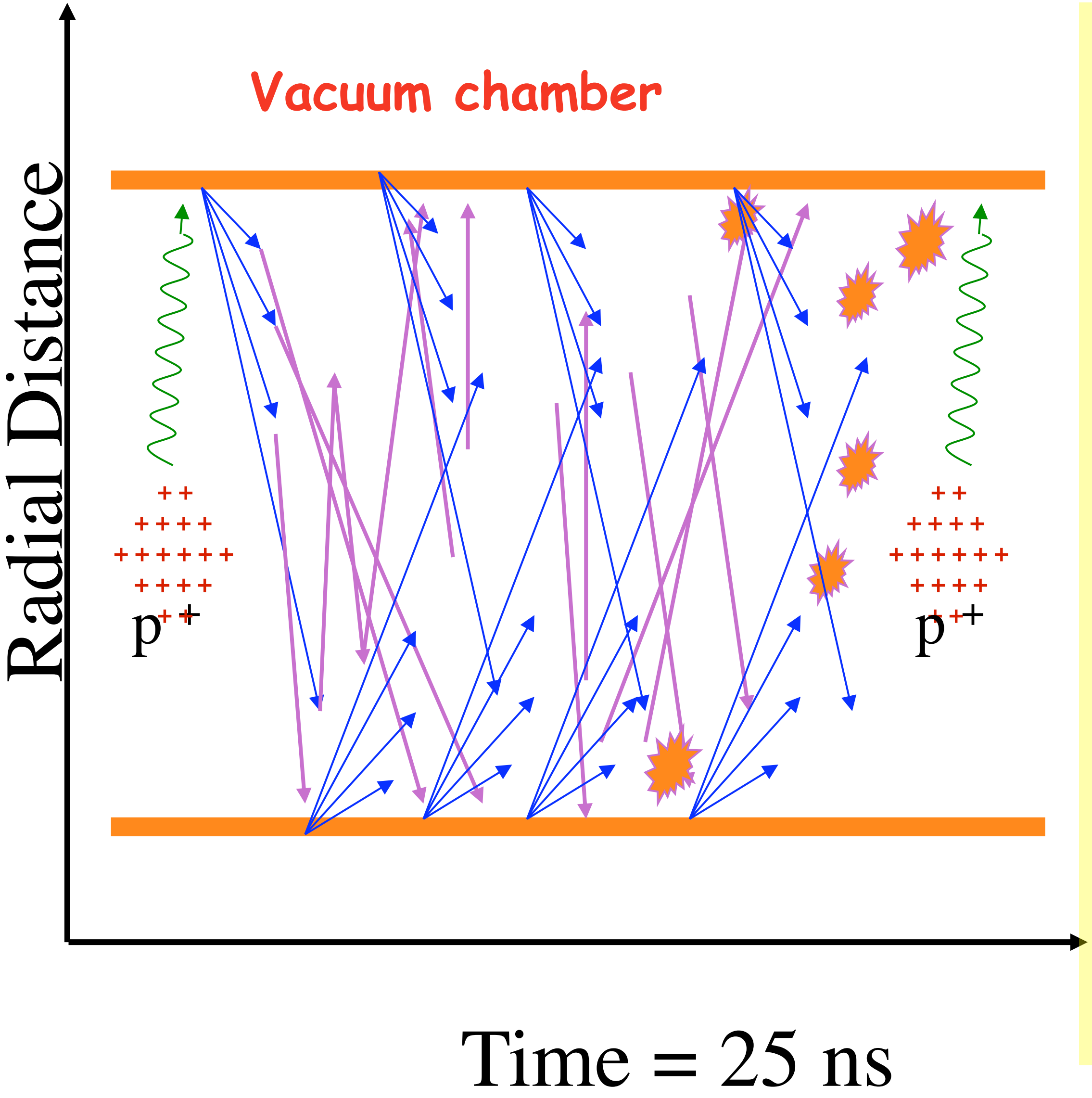
Realistic scrubbing scenario to reduce Secondary electron yield for LHC and new rings.

M. Commisso[1], V. Baglin[2], R. Cimino[1], T. Demma[1]

1)LNF-INFN Frascati (Roma) Italy. 2)CERN, Geneva, Switzerland

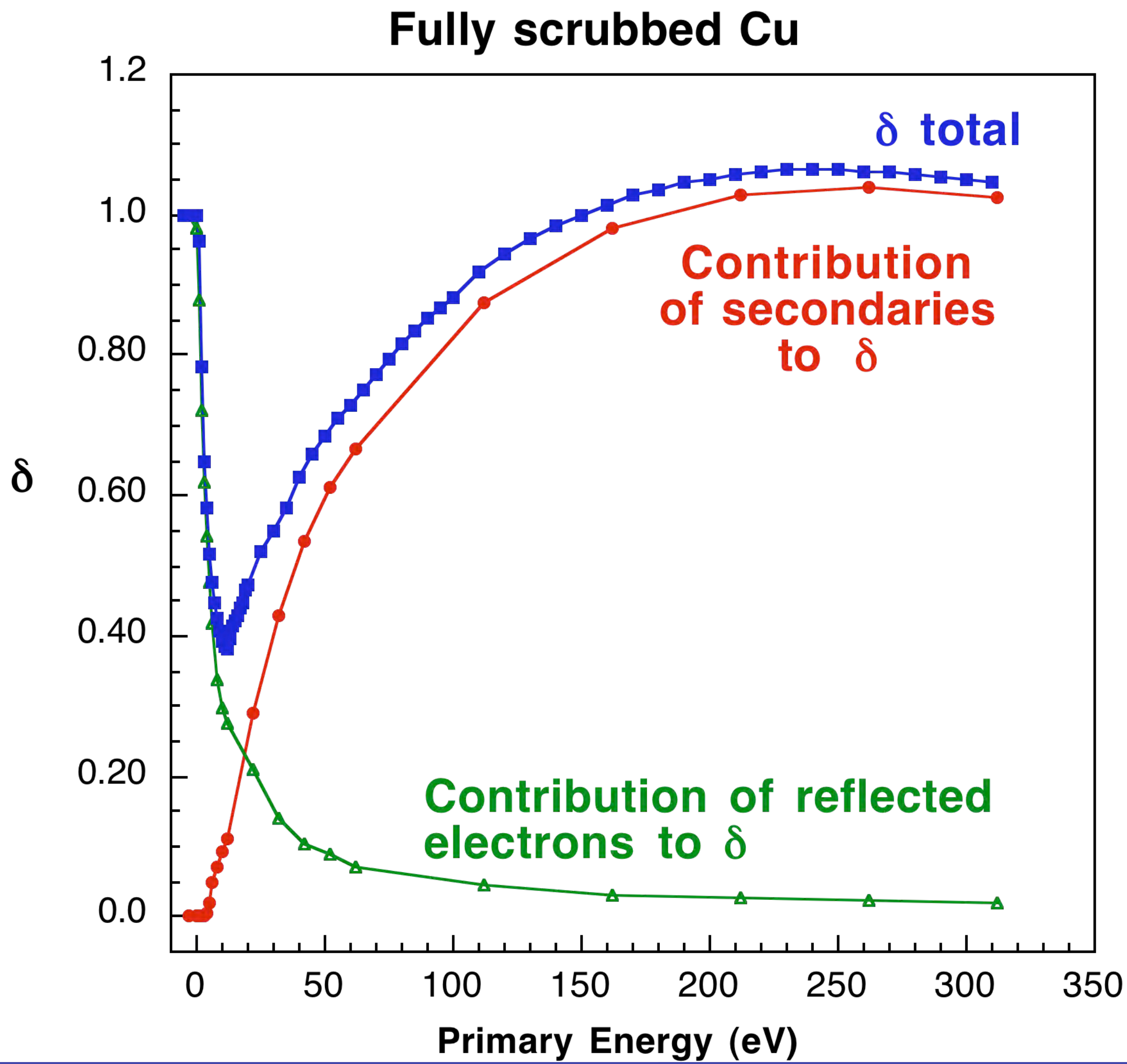
- The e- cloud problem and LHC.
- The "Scrubbing process"
- Observation of "energy dependent" Scrubbing efficiency and potential consequences
- Future work and implications for planned LERs.

The "e-cloud" phenomenon (in pills)



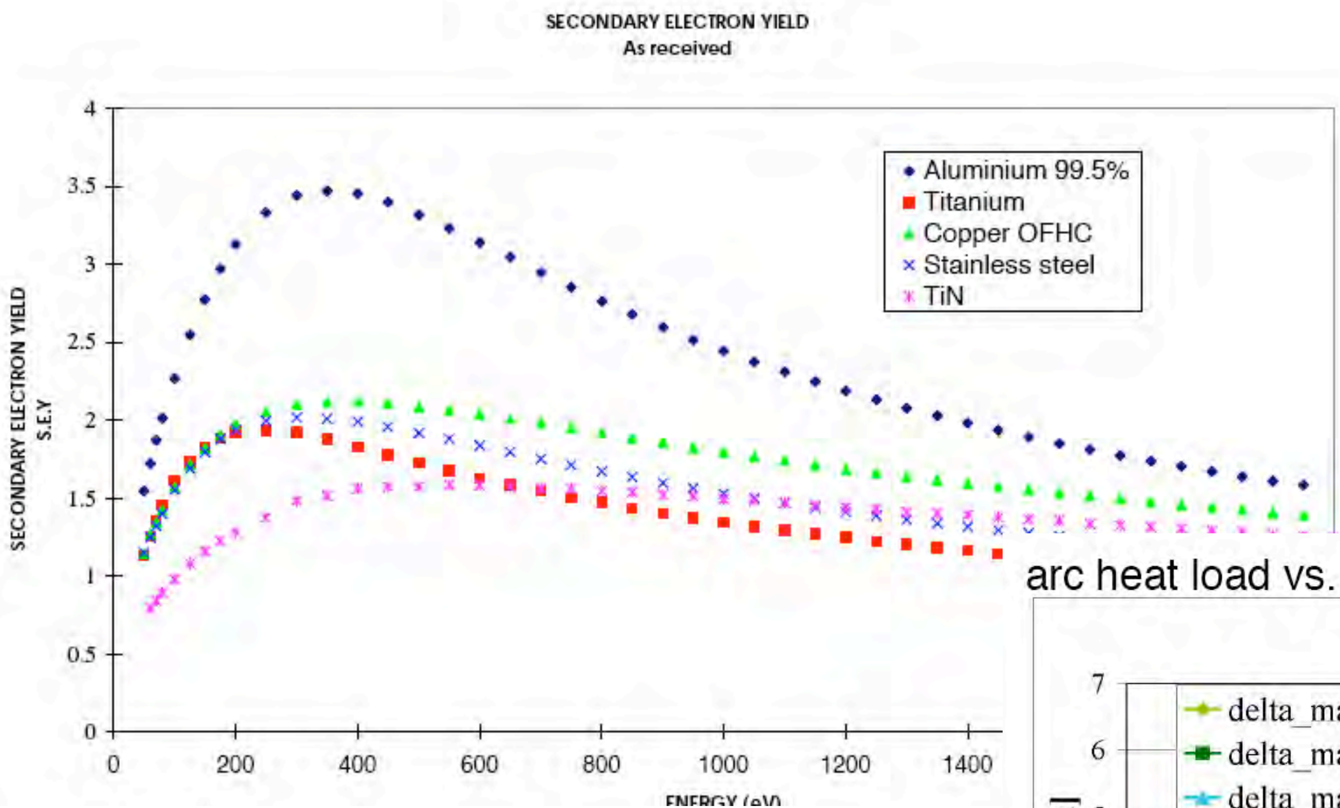
The accelerated particle beam produces SR and/or e^- that, by hitting the accelerator's walls generate photo-e^- or secondary-e^-. Such e^- can interact with the beam (most efficiently for positive beams) and multiply, inducing additional heat load on the walls, gas desorption and may cause severe detrimental effects on machine performance.

One of the most relevant parameter for e-cloud studies is: S.E.Y. (or δ)



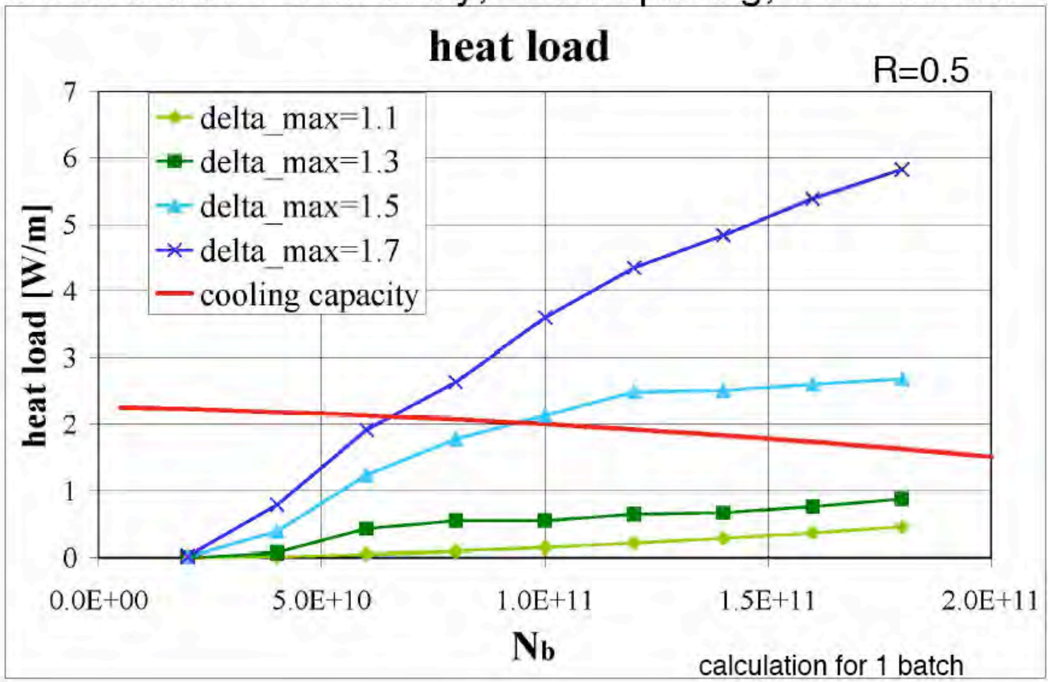
I.e.: the number of electrons created after bombardment of a single electron.

Measure of Secondary e^- YIELD



.... And its impact to simulations.

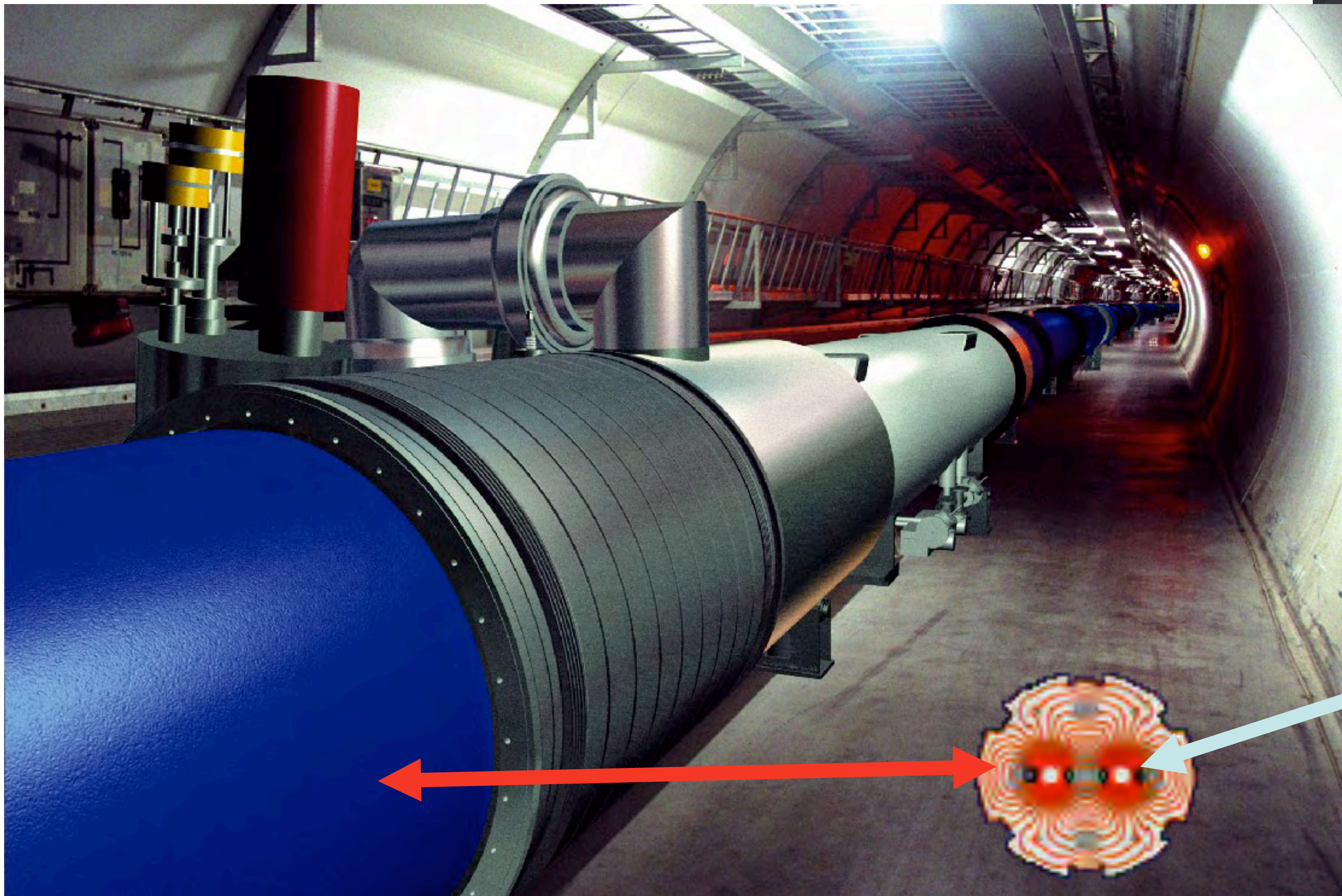
arc heat load vs. intensity, 25 ns spacing, 'best' model

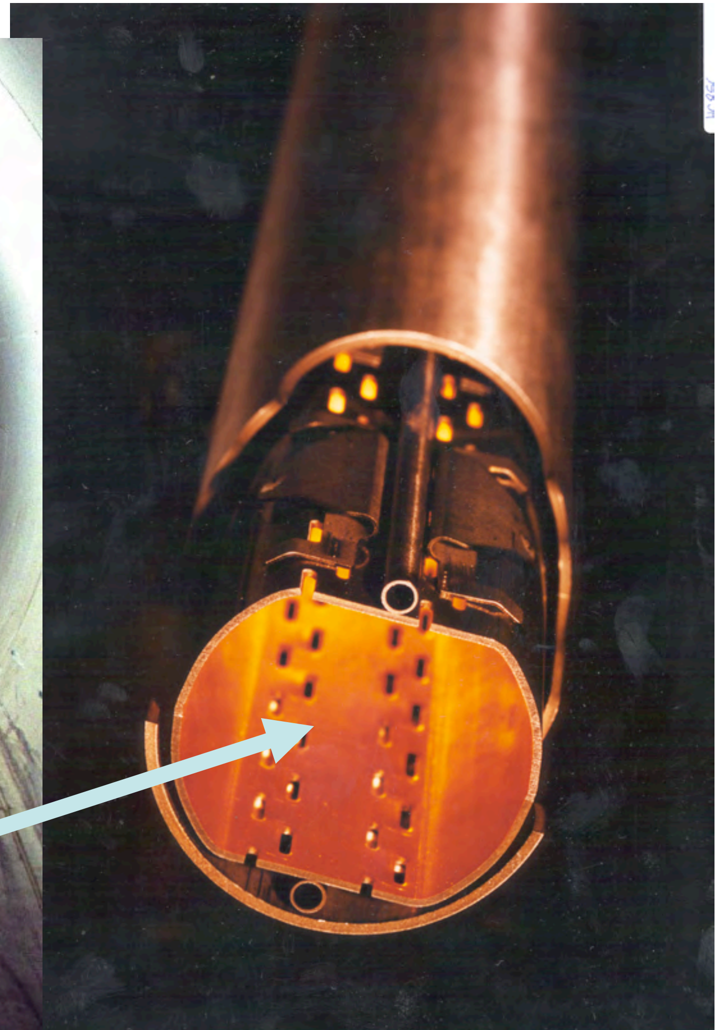


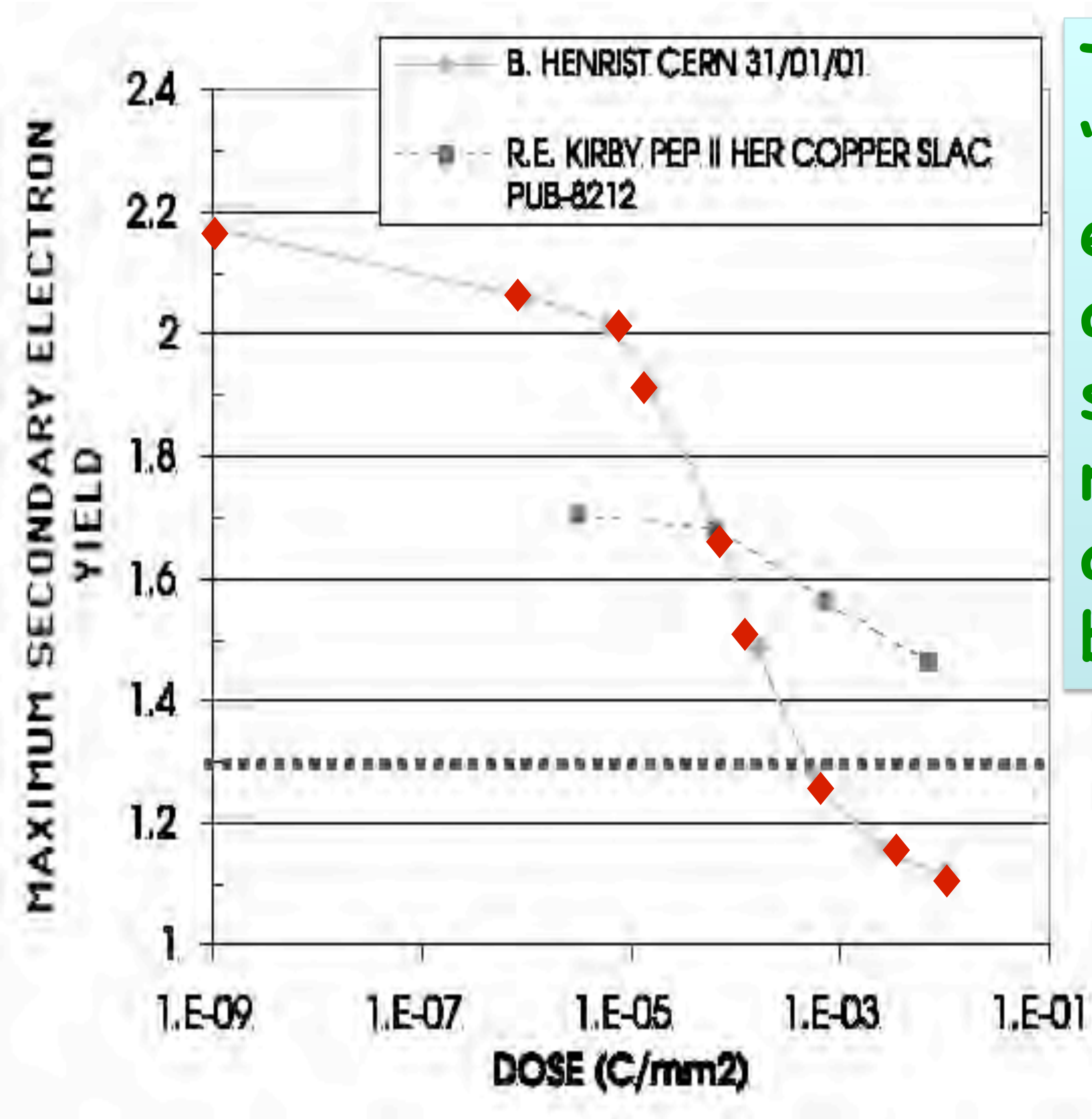
heat load for quadrupoles higher in 2nd batch; still to be clarified

Frank Zimmermann, LTC 06.04.05

For LHC: Cupper surfaces and "scrubbing" in the LT dipole regions.







The Beam "scrubbing" effect is the ability of a surface to reduce its SEY after e$^-$ bombardment.

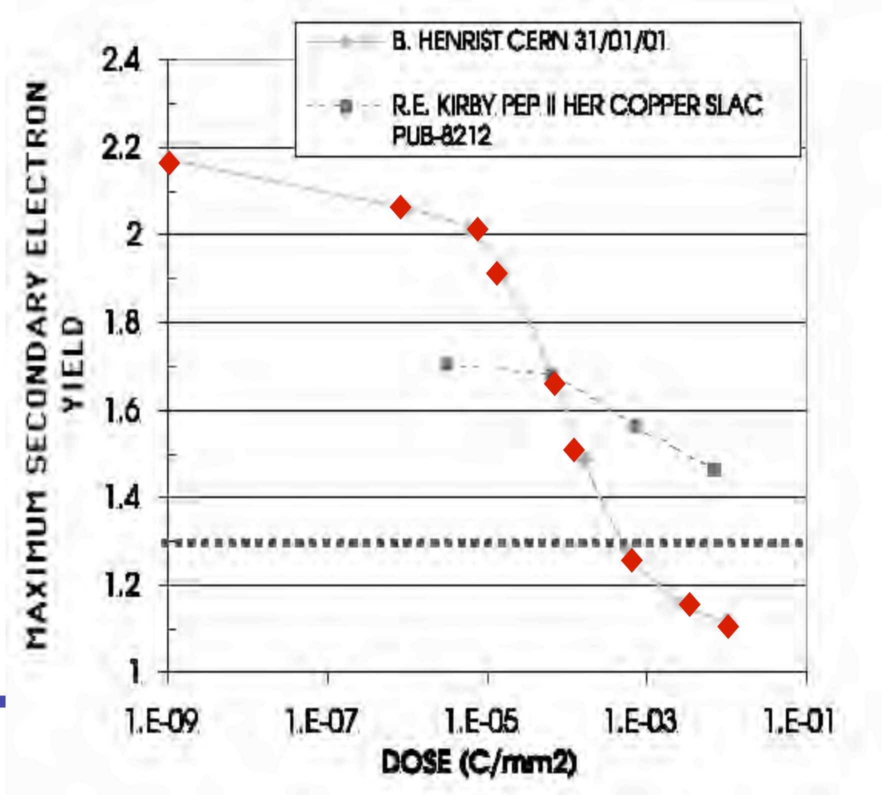
The nominal LHC operation relies on ***SCRUBBING***

… On the beam scrubbing effect:

from LHC PR 472 (Aug. 2001):

"…Although the phenomenon of conditioning has been obtained reproducibly on many samples, the exact mechanism leading to this effect is not properly understood. This is of course not a comfortable situation as the LHC operation at nominal intensities relies on this effect…"

The detailed study of the observed SEY reduction with dose, can give a deeper understanding on the processes occurring at surfaces and on the real Scrubbing efficiency.

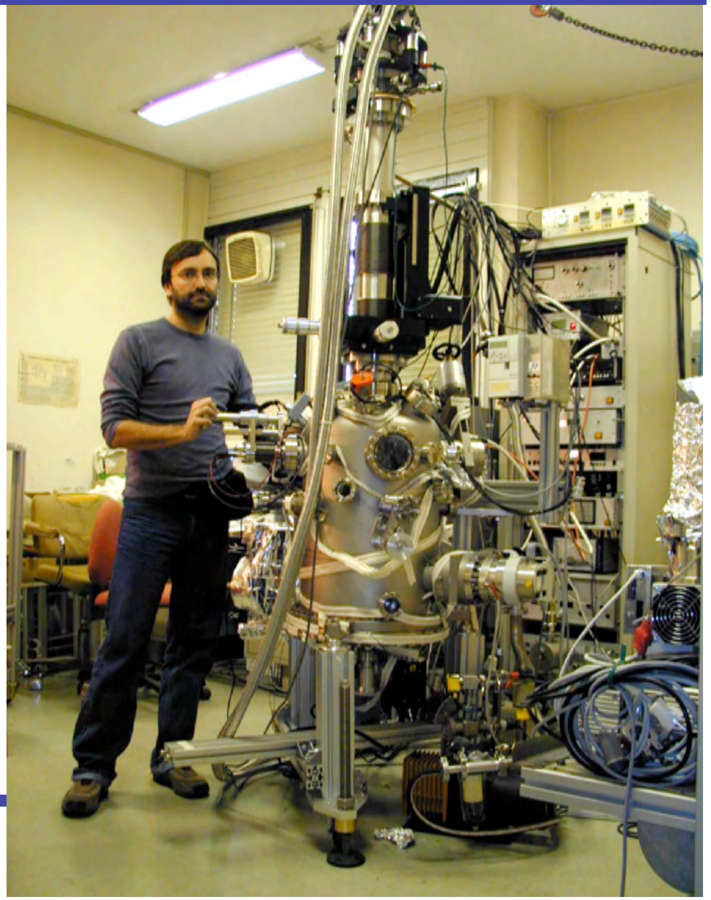


ALL THE DATA ON "SCRUBBING" HAVE BEEN OBTAINED IN THE LABORATORY BY BOMBARDING WITH 500 eV e^- FOR INCREASING TIME (DOSE)

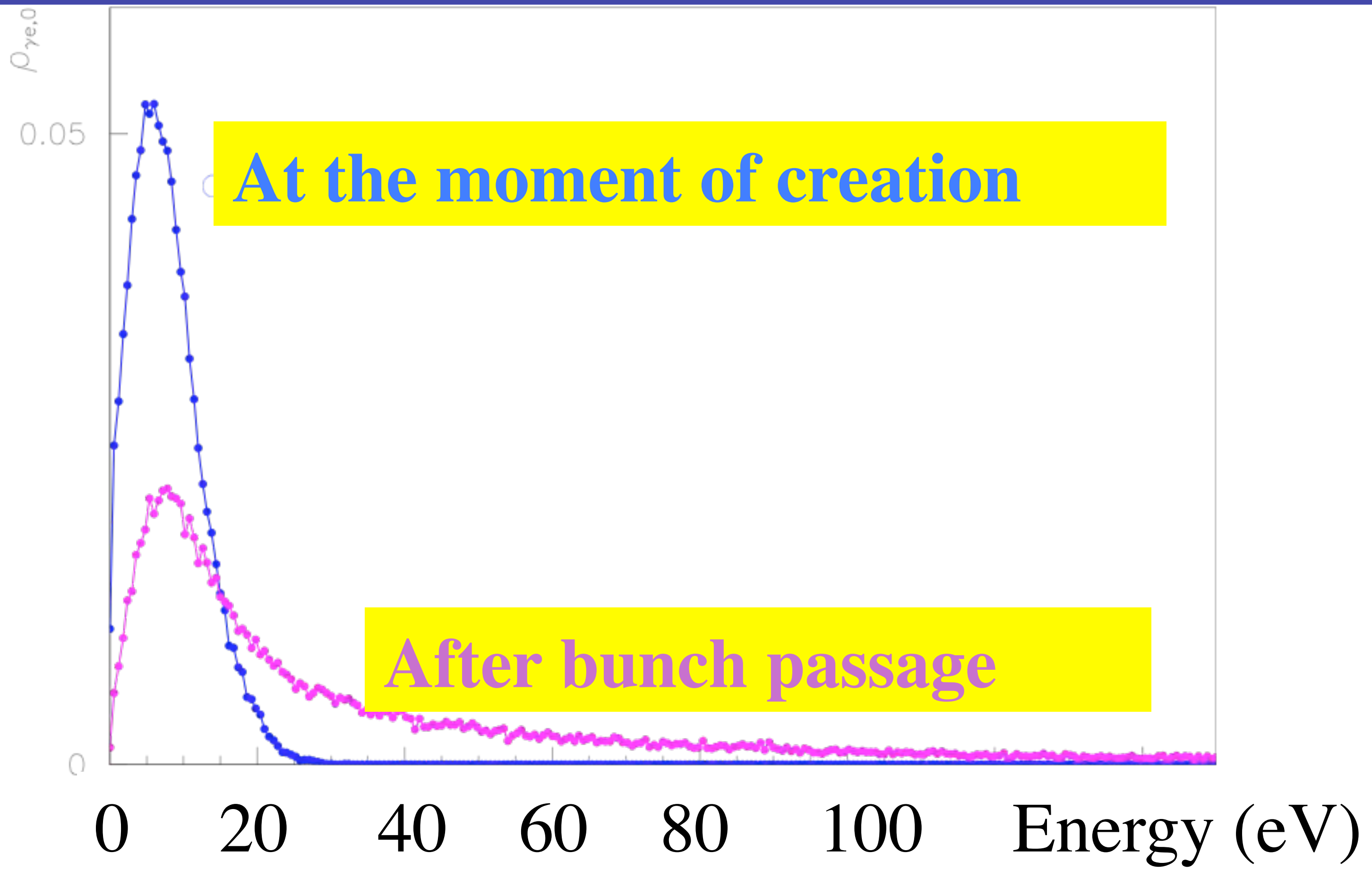
Dose= N° e^- x t(s) xA (mm^2)

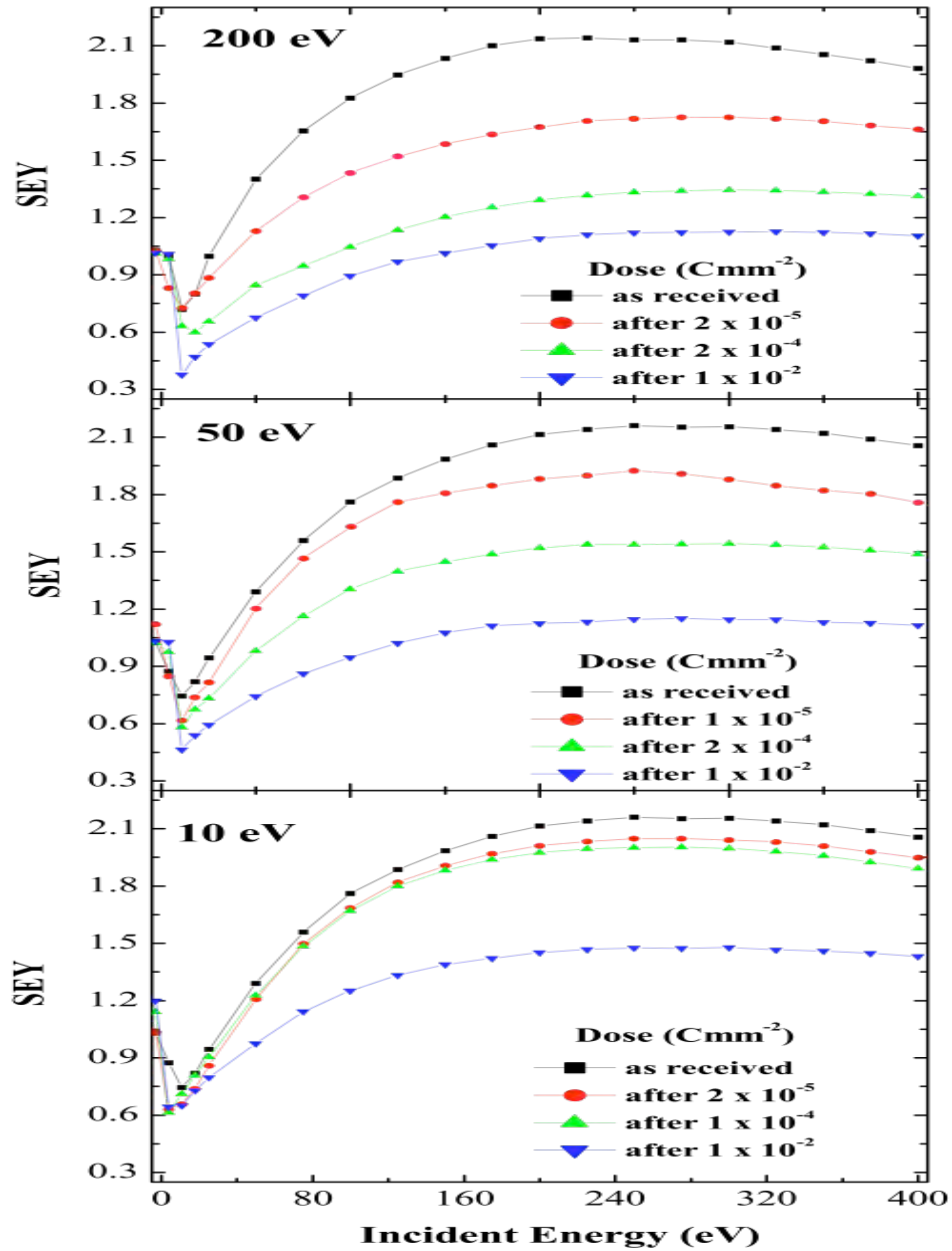
- **What energy do the e^- participating in the cloud have in the accelerator?**

- **do 10 e^- @ 500 eV scrub as 10 e^- @ 20 eV?**

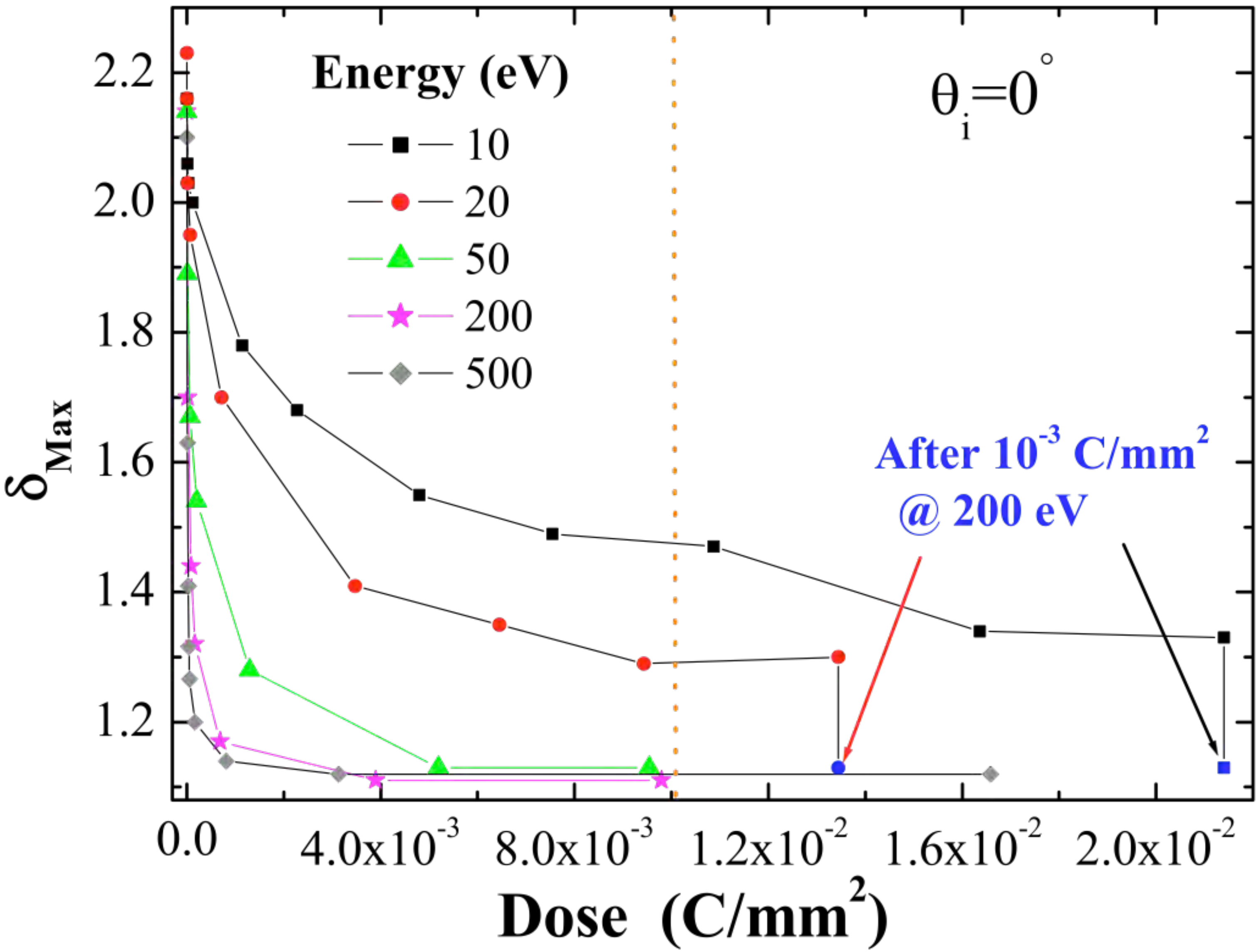


Preliminary simulation by F. Zimmermann (2001) shows that the main contribution lies at low energy!





We performed careful "scrubbing" experiments as a function of the electron primary energy


Energy (eV)
10
20
50
200
500
$\theta_i = 0^\circ$
After 10^{-3} C/mm^2
@ 200 eV
δ_{Max}
2.2
2.0
1.8
1.6
1.4
1.2
0.0
4.0x10^{-3}
8.0x10^{-3}
1.2x10^{-2}
1.6x10^{-2}
2.0x10^{-2}
Dose (C/mm^2)

We show that the actual energy of the e^- responsible for the scrubbing does affect its scrubbing efficiency.

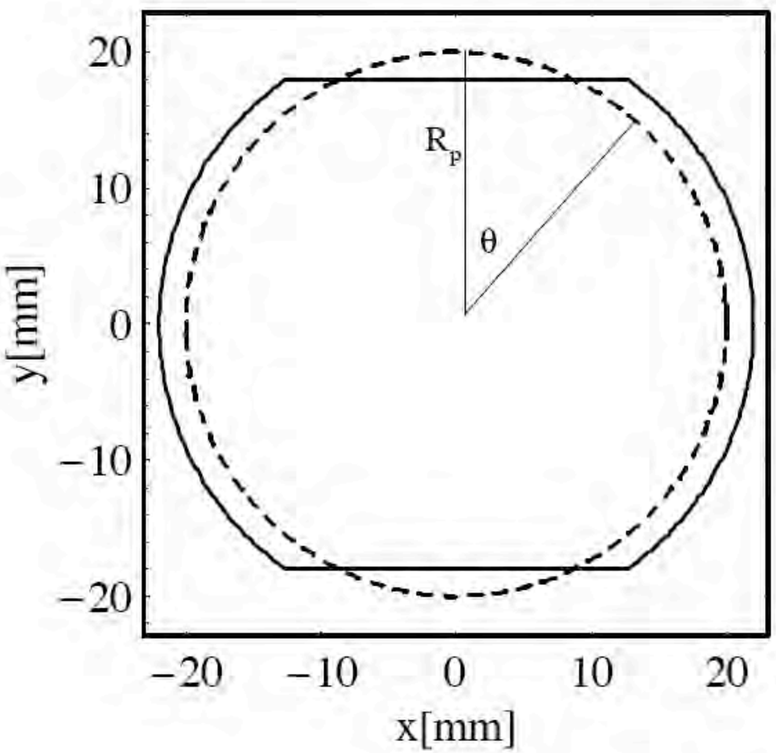
Simulation shows that most of the e^- in the cloud do have energies less than 20 eV, so that our data could have significant implications to optimize machine commissioning operation.

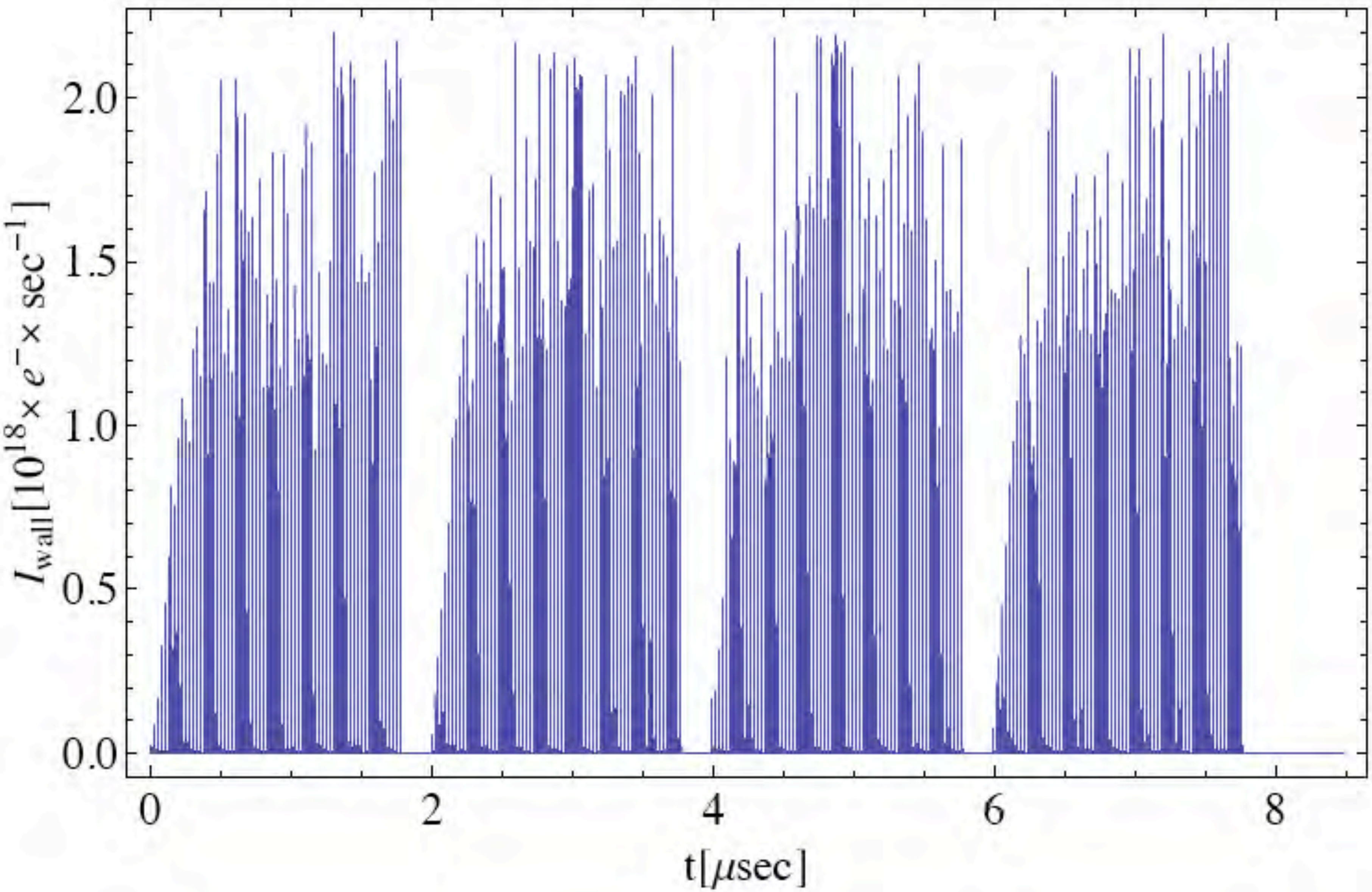
In simulations each electron must be "dressed" with his scrubbing efficiency associated to its energy.

Theo DEMMA performed some preliminary simulation to see if one can optimize the "scrubbing" process @ LHC

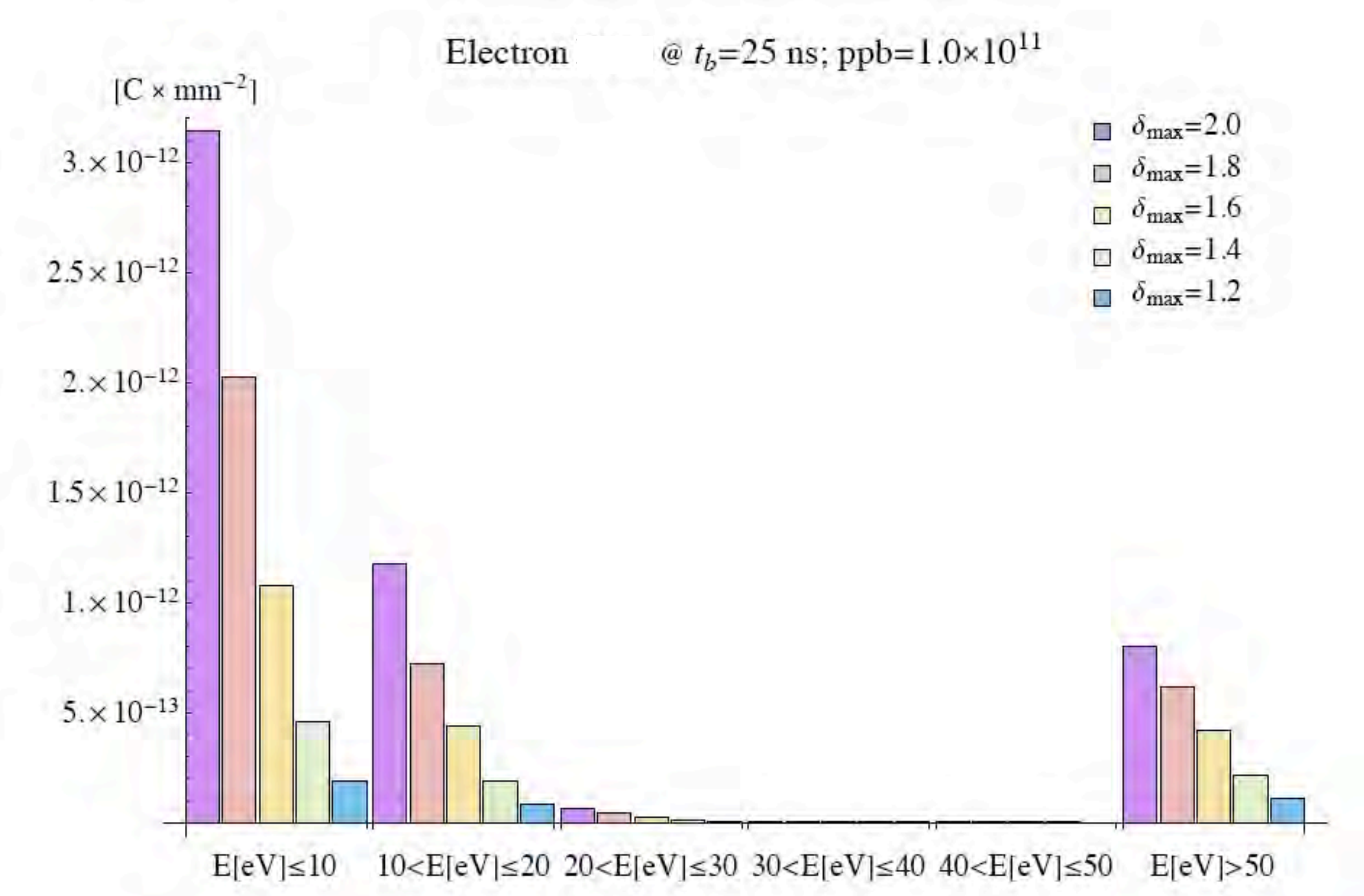
Table 1: Parameters used for ECLOUD simulations.

parameter	units	value
beam particle energy	GeV	7000
bunch spacing t_b	ns	25; 50; 75
bunch length	m	0.075
number of trains N_t	-	4
number of bunches per train N_b	-	72; 36; 24
bunch gap N_g	-	8
no. of particles per bunch	10^{10}	10; 3.0
length of chamber section	m	1
chamber radius	m	0.02
circumference	m	27000
primary photo-emission yield	-	$7.98 \cdot 10^{-}$
maximum SEY δ_{max}	-	1.2(0.2)2.0
energy for max. SEY E_{max}	eV	237

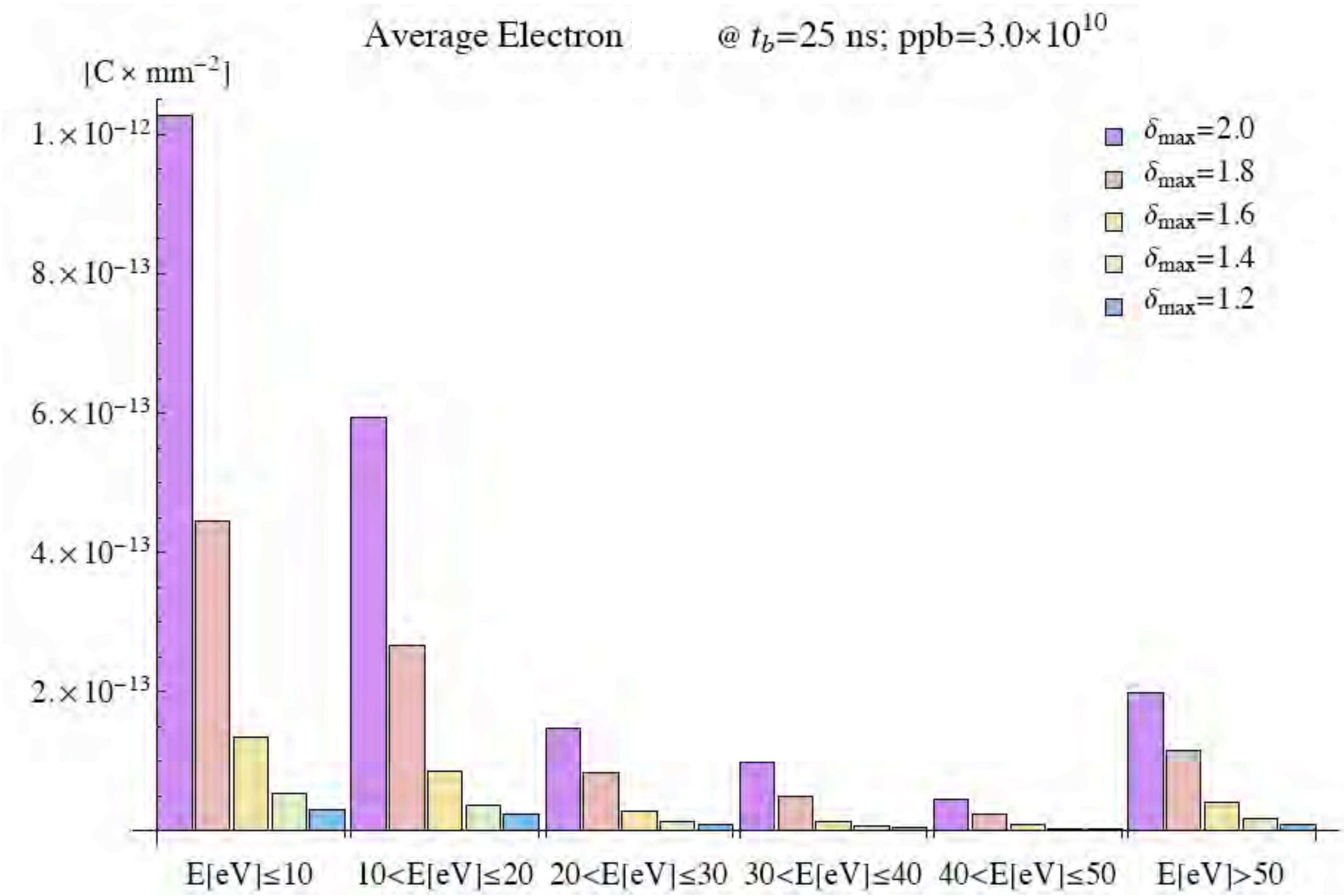




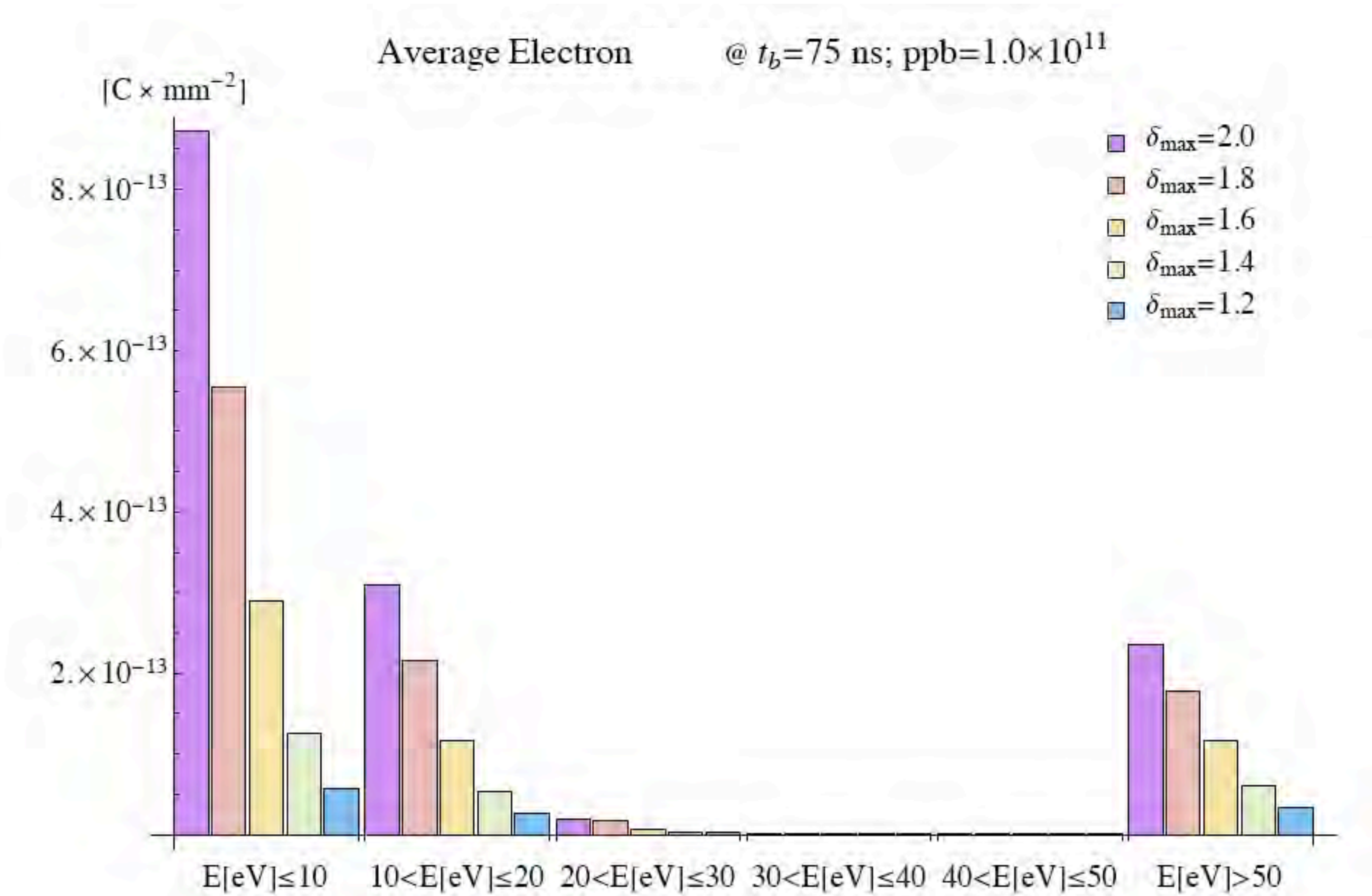
Instantaneous current I_{wall} of e^- bombarding the wall of an LHC-like vacuum chamber computed with ECLOUD. The bunch spacing is tb = 25nsec, and the δmax = 1.8.



Simulated energy components of the number of electron delivered to the chamber walls during the passage of an LHC-like bunch train (tb = 25ns, ppb = $1x10^{11}$) for different values of δ max.



Simulated energy components of the number of electron delivered to the chamber walls during the passage of an LHC-like bunch train (tb = 25ns, ppb = $3x10^{10}$) for different δ max.



Simulated energy components of the number of electron delivered to the chamber walls during the passage of an LHC-like bunch train (tb = 75ns, ppb = 1×10^{11}) for different δ max.

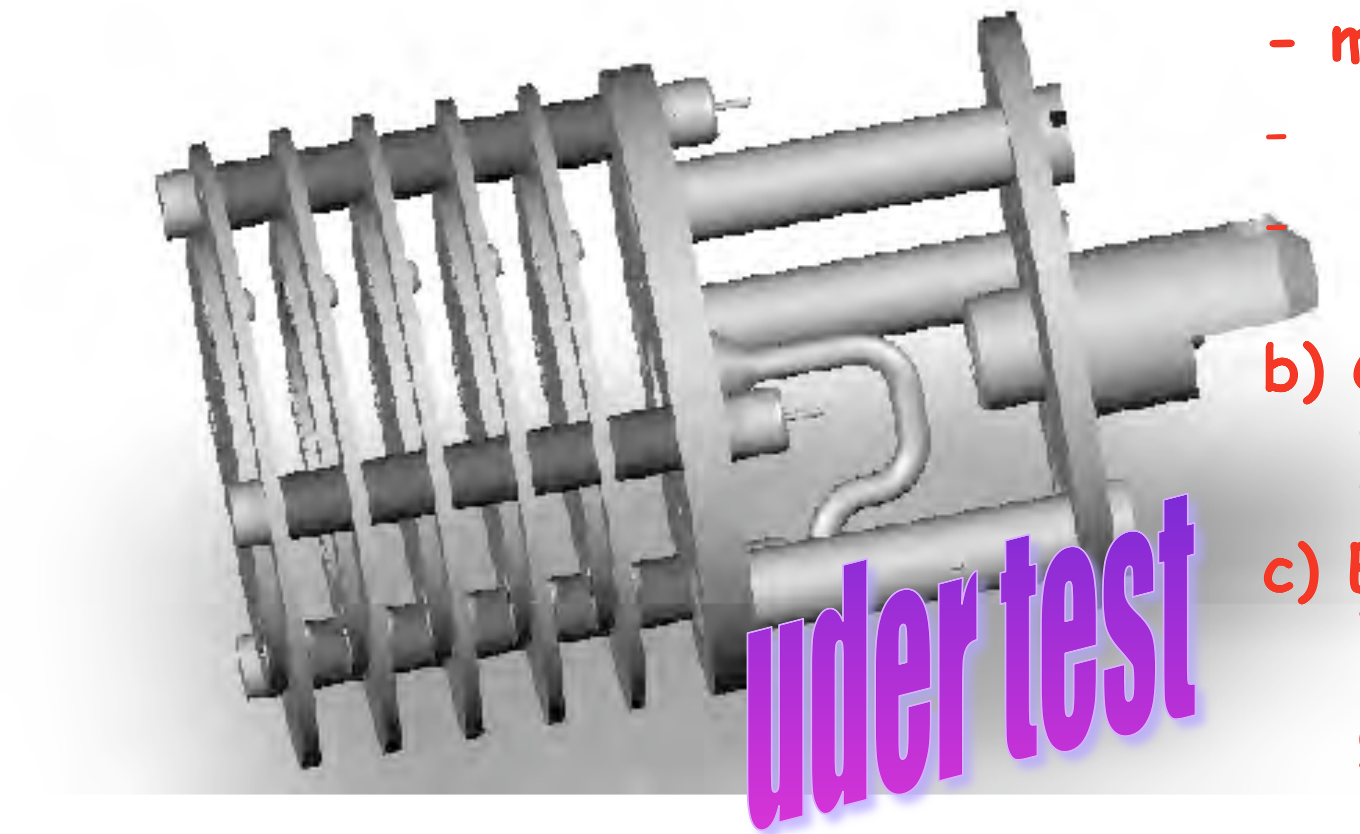
Open problem & DAΦNE (and Anka?) as a working test bench for e-cloud studies

Need to measure the “actual” energy of the electron hitting the walls to validate simulations vs “real machine” behaviour!

Can we directly measure such properties of the e-cloud in the DAΦNE (or Anka?) ring?

Careful Laboratory test shows that RFA are not able to measure accurately very low energy electrons if not carefully designed for this porpoise.

At DaΦne (maybe at Anka?) we plan to measure e⁻ energy by inserting in the machine Energy-resolved El. Detectors.



5 grids for:

- mass screening
- energy resolution
- Sensitivity to low energy electrons

b) Channeltron / channelplate for high counting rate

c) Etherodine counting thecnique to eliminate low energy e^- generated inside the detector (dominant)

CONCLUSION:

- This preliminary analysis shows that it is indeed possible to choose the LHC commissioning scenario to maximize the electrons hitting the walls with energy bigger than 50 eV. (need much more study!).
- A deeper understanding of the chemical process occurring during "scrubbing" may suggest additional specific surface treatment, lowering the yield without the need of a circulating beam. (difficult but worth trying)
- **For new Low Emittance Rings counting on "scrubbing" does not seem to be a valid solution pushing towards a serious effort to develop stable and reliable low yield coatings.**
- **To this aim the collaboration between different machines are more than welcome.**

Acknowledgments:

- C. Vaccarezza, M. Biagini,, P. Barone, A. Bonanno, S. Guiducci, M. Zobov, P. Raimondi, A. Drago, R. Larciprete and the LNF-INFN accelerator group

- V. Baglin, G. Bellodi, I.R Collins, M. Furman, O. Gröbner, A. G. Mattewson, M. Pivi, F. Ruggero, G. Rumolo, F. Zimmermann,

etc..