SECONDARY ELECTRON EMISSION :

EXPERIMENTAL RESULTS AND THEIR IMPLICATIONS

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CERN - LHC/VAC

TOPICS:

SECONDARY ELECTRON YIELD BEFORE AND AFTER ELECTRON BOMBARDMENT

THE IMPORTANCE OF LOW ENERGY SECONDARY ELECTRONS

SECONDARY ELECTRON ENERGY DISTRIBUTION

REFLECTED ELECTRONS AT LOW ENERGY AND FITS FORMULAE

TOPICS:

- ***MORE ABOUT CONDITIONING***

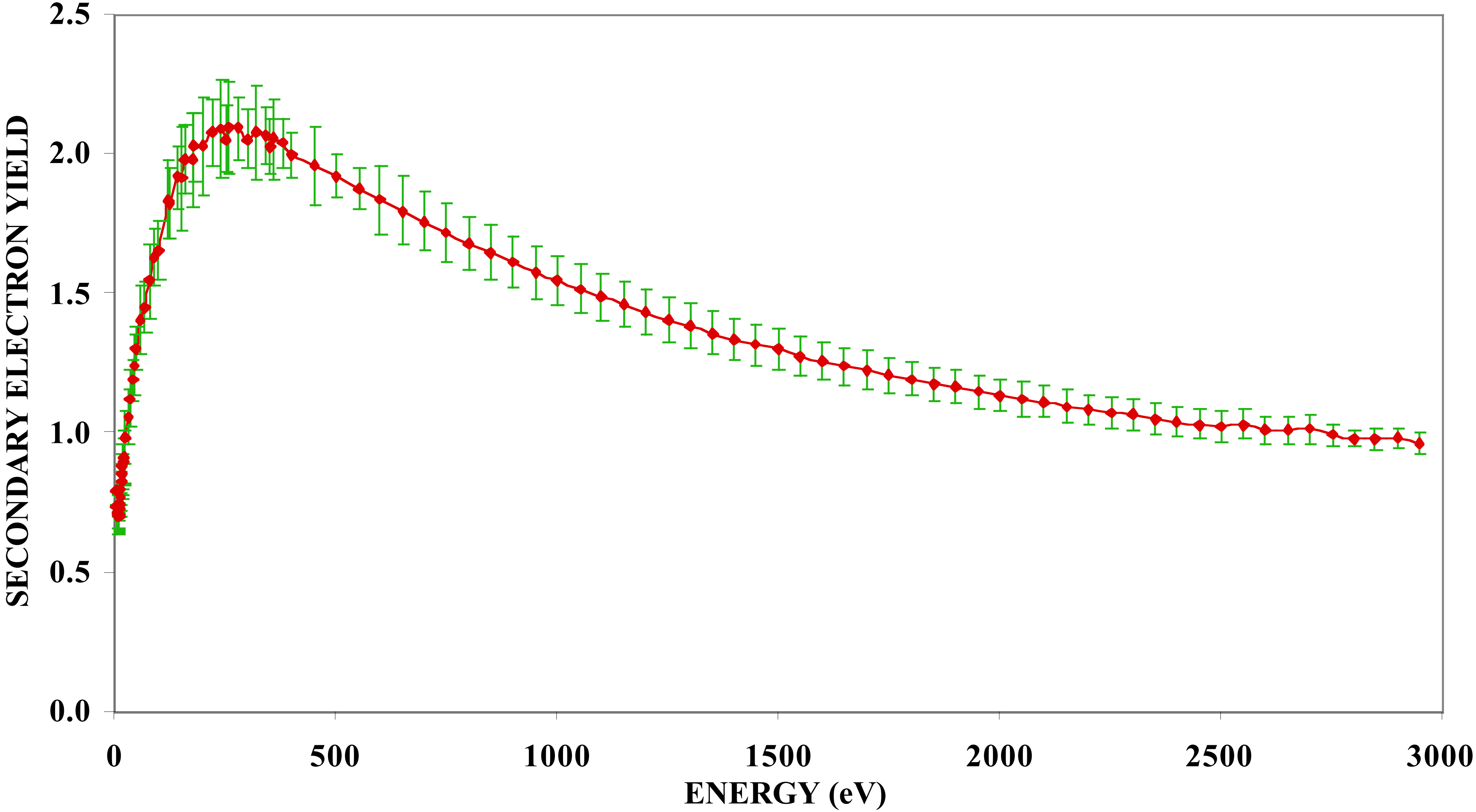
THE INFLUENCE OF AIR EXPOSURE ON CONDITIONING

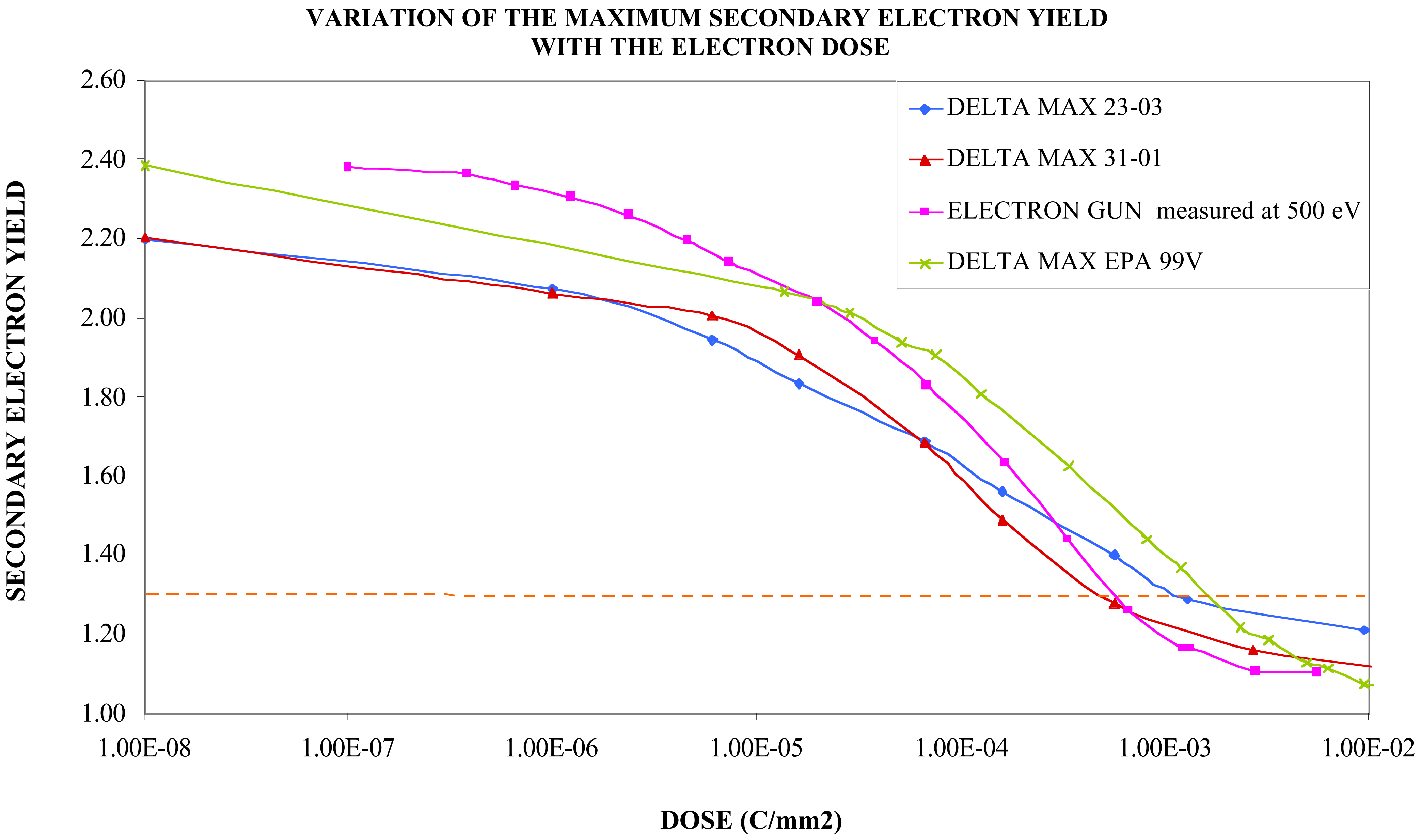
ELECTRON INDUCED DESORPTION η

RELATION BETWEEN η, δ, ***DESORBED GAS QUANTITY***

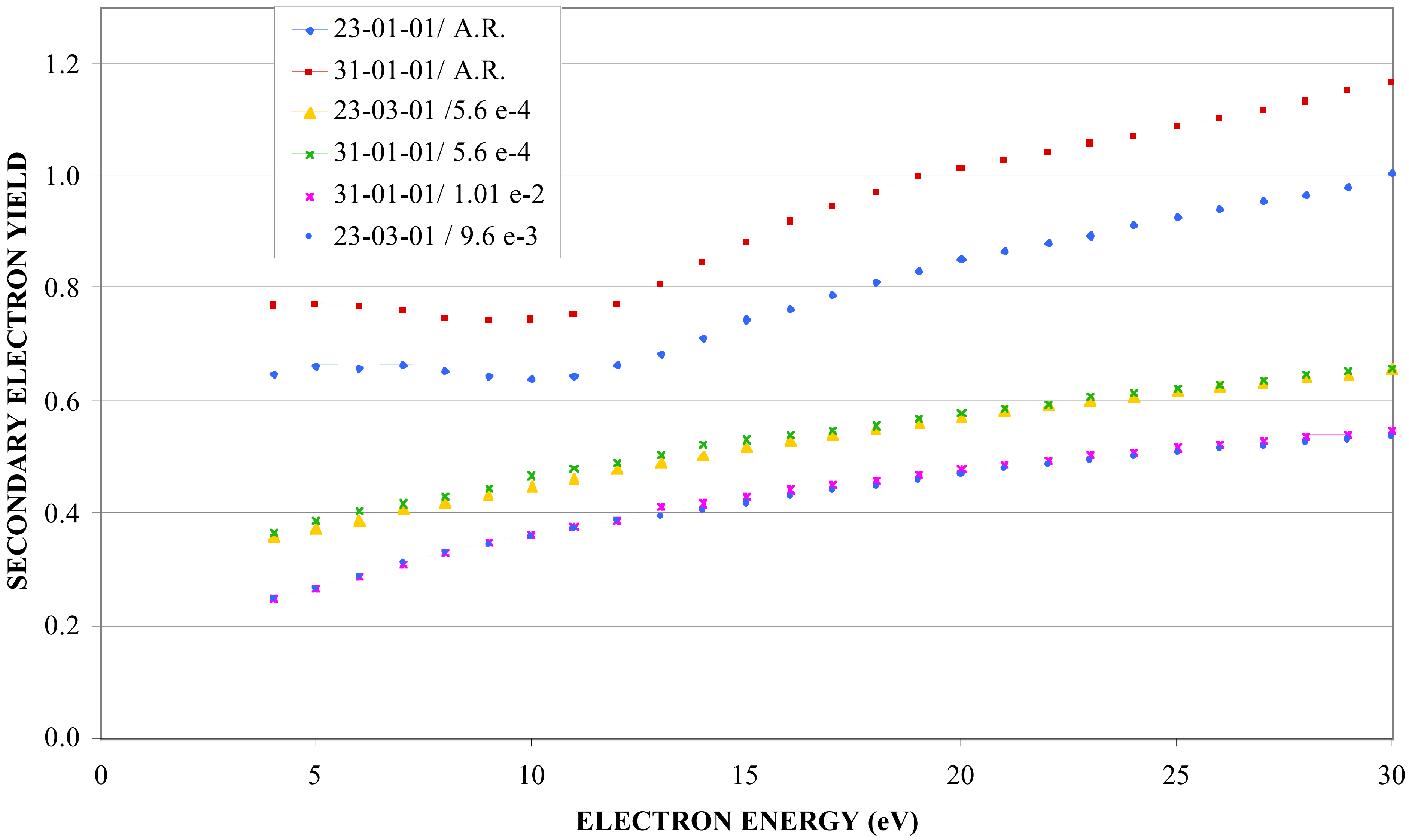
RELATION BETWEEN CLEANING AND CONDITIONING

AVERAGE SECONDARY ELECTRON YIELD OF 25 AS RECEIVED COPPER SAMPLE

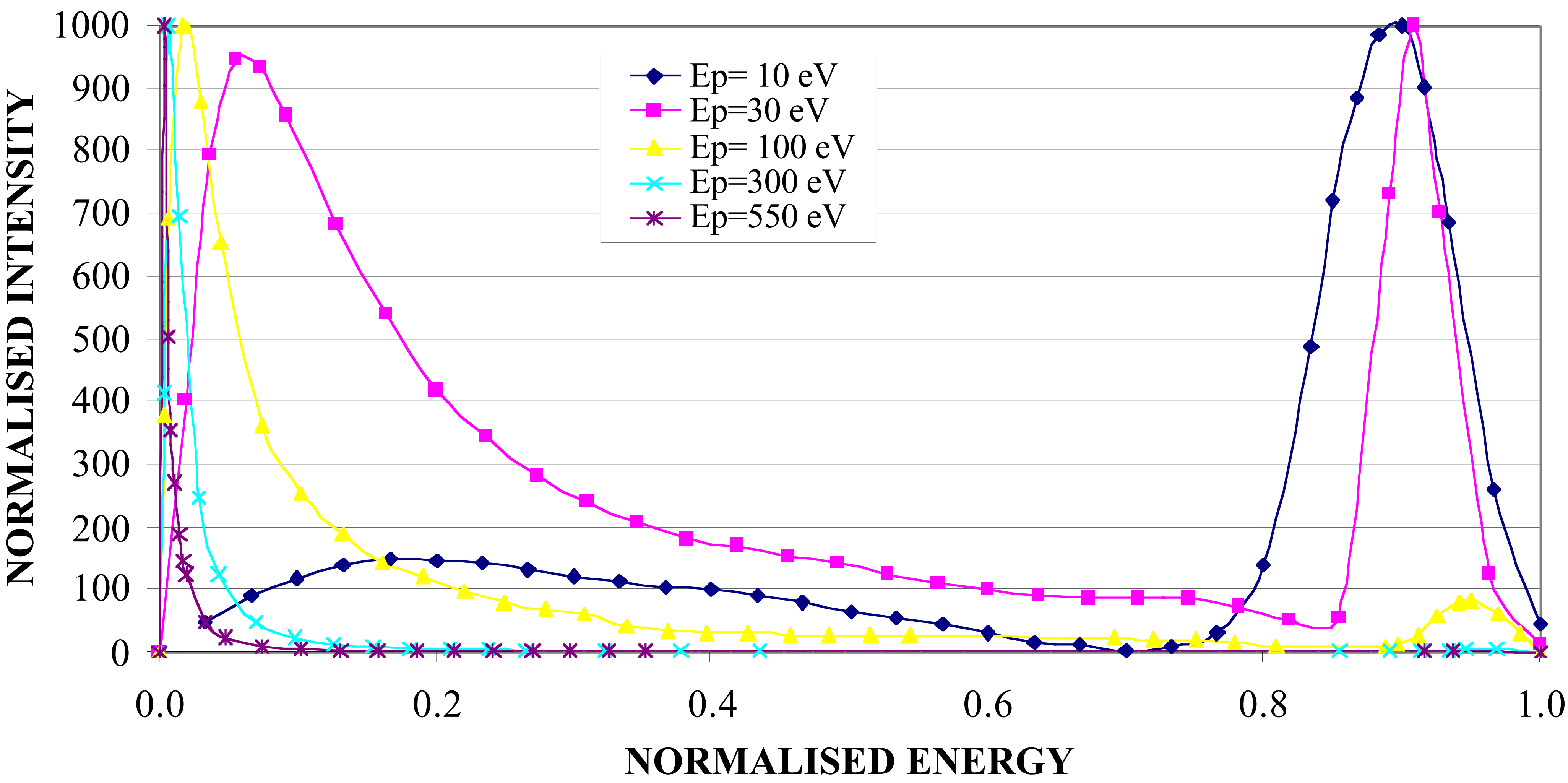



VARIATION OF THE MAXIMUM SECONDARY ELECTRON YIELD
WITH THE ELECTRON DOSE
SECONDARY ELECTRON YIELD
2.60
2.40
2.20
2.00
1.80
1.60
1.40
1.20
1.00
1.00E-08
1.00E-07
1.00E-06
1.00E-05
1.00E-04
1.00E-03
1.00E-02
DOSE (C/mm2)
DELTA MAX 23-03
DELTA MAX 31-01
ELECTRON GUN measured at 500 eV
DELTA MAX EPA 99V

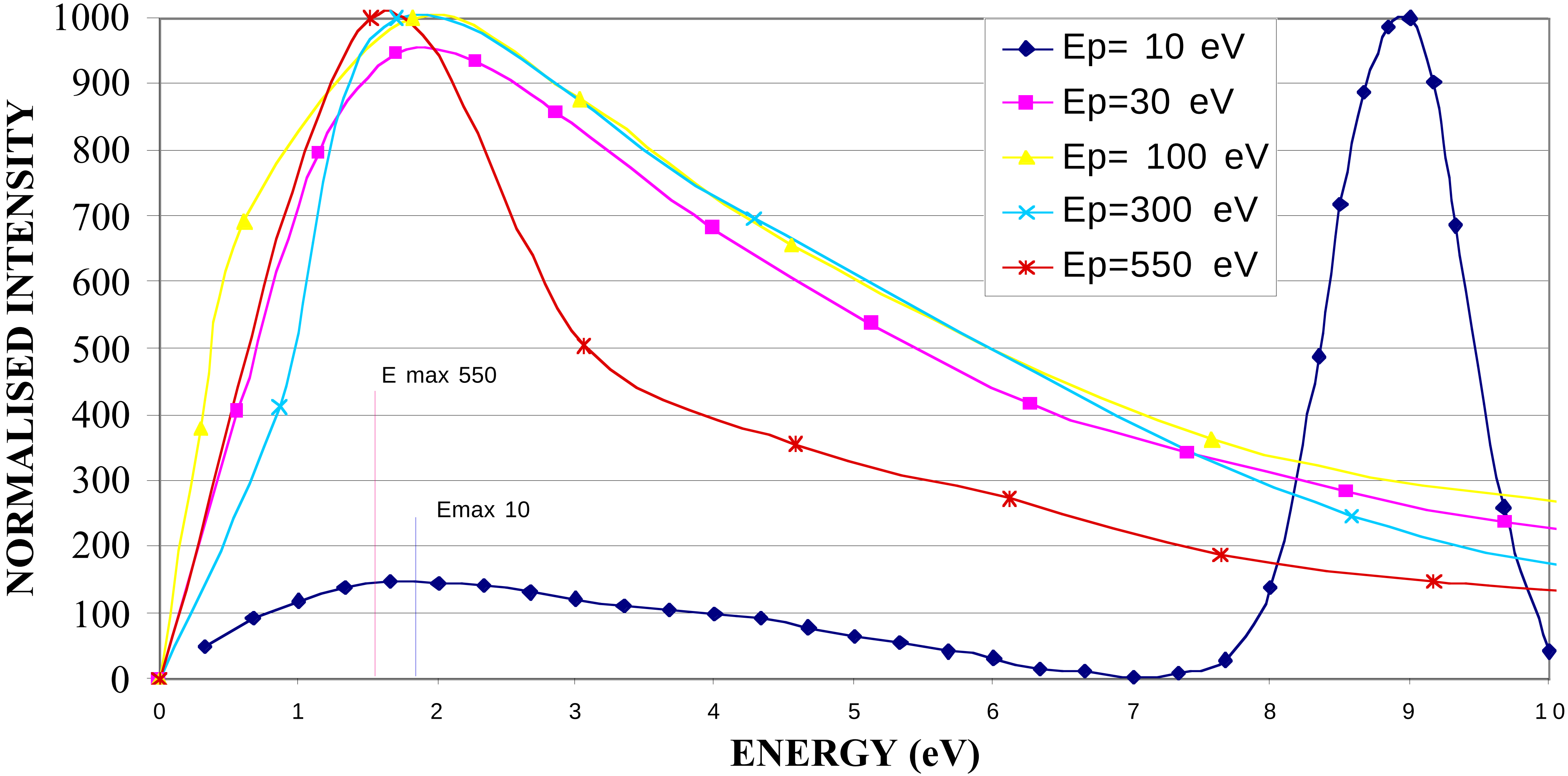
SECONDARY ELECTRON YIELD VERSUS ELECTRON ENERGY ION BOMBARDED COPPER

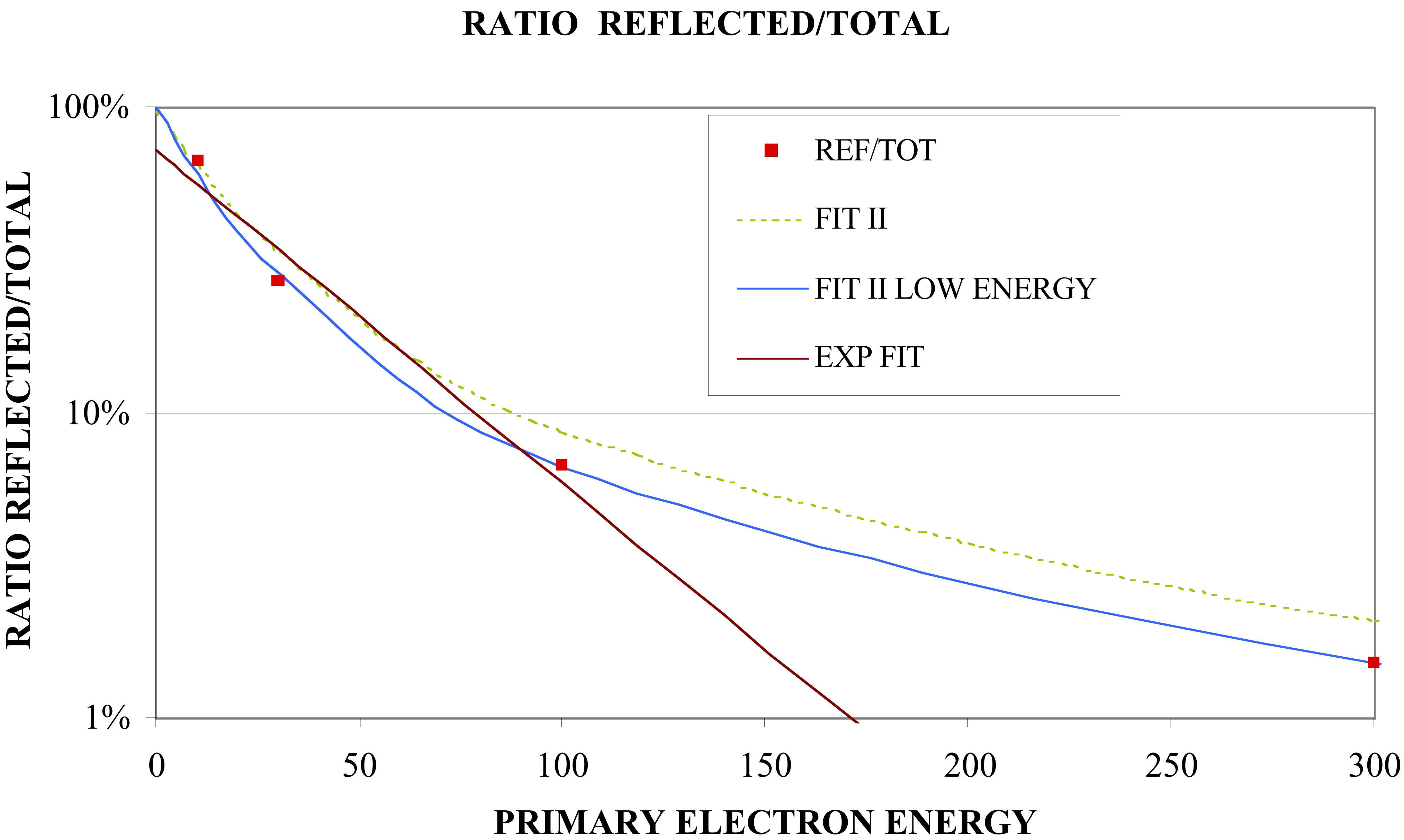


ENERGY DISTRIBUTION OF SECONDARY ELECTRON EMITTED BY COPPER



ENERGY DISTRIBUTION OF SECONDARY ELECTRON EMITTED BY COPPER

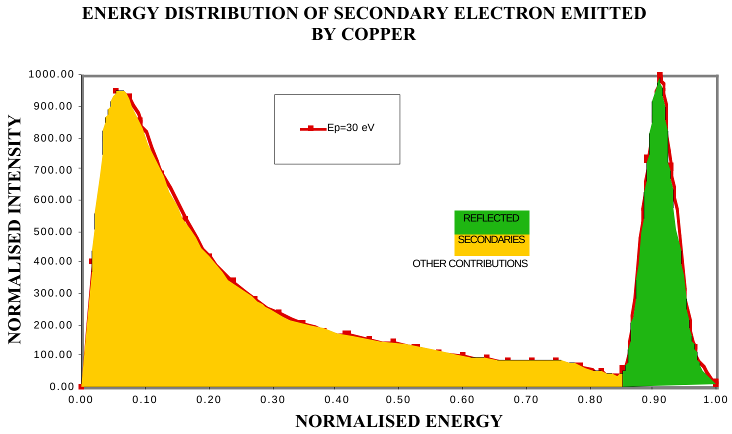




RATIO REFLECTED/TOTAL
100%
10%
1%
RATIO REFLECTED/TOTAL
0
50
100
150
200
250
300
PRIMARY ELECTRON ENERGY
REF/TOT
FIT II
FIT II LOW ENERGY
EXP FIT

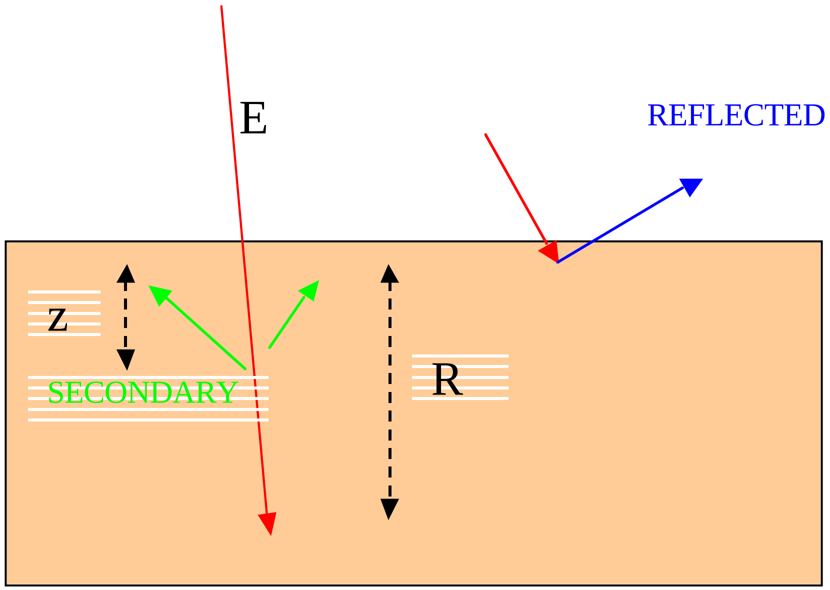
NUMERICAL EXPRESSIONS FOR SIMULATION

$$\delta_t = \delta_S + \delta_R$$



FOR E_p> 300 eV
REFLECTED CONTRIBUTION NEGLIGIBLE

SECONDARY / REFLECTED PROCESSES COMPLETELY DIFFERENT



NUMERICAL EXPRESSIONS FOR SIMULATION

MODEL FOR SECONDARY ELECTRON EMISSION

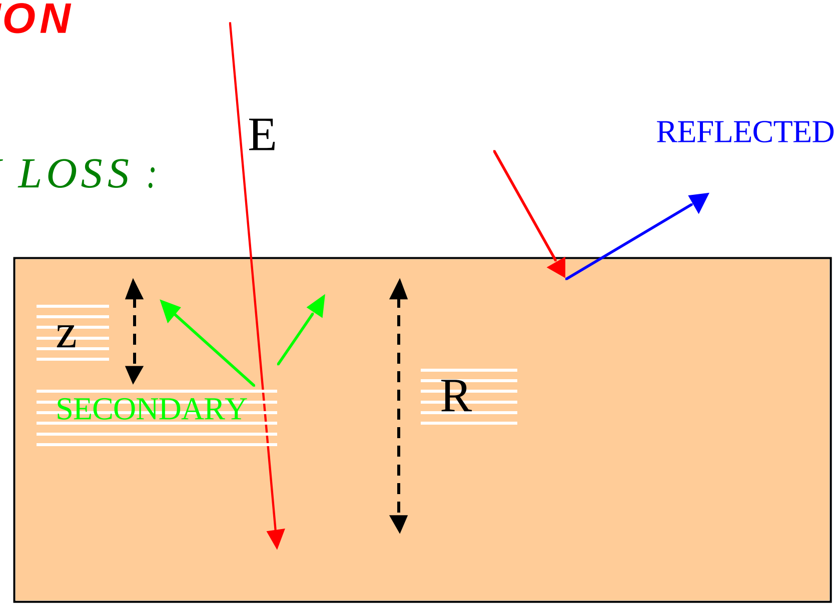
ASSUMPTIONS : FOR SECONDARIES

PRIMARY ELECTRON: CONSTANT ENERGY LOSS :

$$\frac{\partial E}{\partial z} = \frac{E}{R}$$

ESCAPE PROBABILITY

$$P = A \times \exp(-z/\lambda)$$



NORMALISATION TO δ_m, E_m TO ELIMINATE PHYSICAL CONSTANTS (e.g. λ)

(D.C. Joy Journal of microscopy 147,1,51-64, 1987)

SIMPLIFIED BY M. FURMAN

$$\delta_s = \delta_{MAX} \frac{s \times (\frac{E_p}{E_{MAX}})}{s - 1 + \left(\frac{E_p}{E_{MAX}}\right)^s}$$

NUMERICAL EXPRESSIONS FOR SIMULATION

MODEL FOR SECONDARY ELECTRON EMISSION

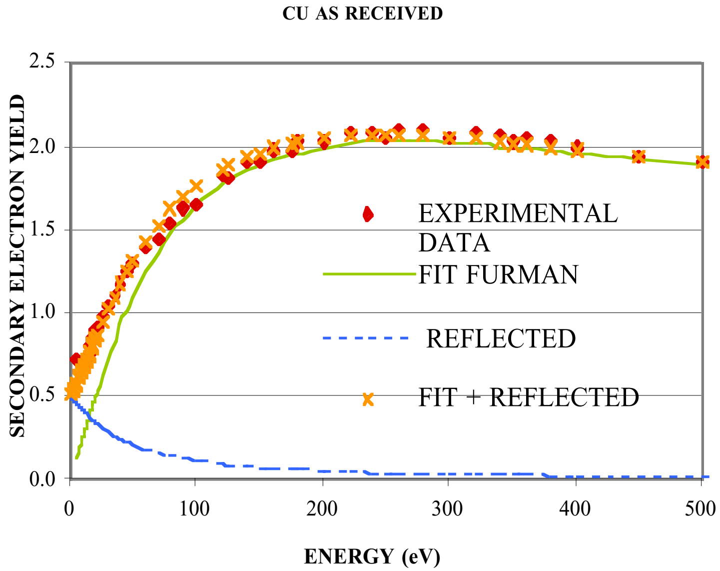
NUMERICAL VALUE TO FIT OUR EXPERIMENTAL DATA:

SAMPLE STATE	*AS RECEIVED*	*FULLY CONDITIONED*
d_{MAX}	*2.03*	*1.13*
E_{MAX}	*262*	*318*
s	*1.39*	*1.35*

IF LOW ENERGY ELECTRONS HAVE TO BE CONSIDERED:

REFLECTED NOT NEGLIGIBLE :

=> PRECEDING APPROXIMATION TO FIT HIGH ENERGY PART



NUMERICAL EXPRESSIONS FOR SIMULATION

REFLECTED CONTRIBUTION

$$\delta_t = \delta_S + \delta_R \quad => \quad \delta_R = f \times \delta_t \Rightarrow \delta_t = \delta_S + f \times \delta_t$$

$$\delta_t = \delta_s \times \frac{1}{(1-f)}$$

FRACTION OF REFLECTED ELECTRONS (f) : N_R / N_{TOT}

CAN BE MEASURED FROM PRECEDING CURVES

AND APPROXIMATED BY THE FOLLOWING RELATION:

$$\ln(f) = A_0 + A_1 \times (\ln(E_p + E_0)) + A_2 \times (\ln(E_p + E_0))^2 + A_3 \times (\ln(E_p + E_0))^3$$

[1](J.J. Scholtz, D. Dijkkamp, R.W.A. Schmitz, Philips J. Res. 50, 375-389, 1996).

USING: A0 = 20.699890, A1= -7.07605, A2= 0.483547, A3= 0, E0=56.914686
(Curve labelled FIT II low energy).

NUMERICAL EXPRESSIONS FOR SIMULATION

REFLECTED CONTRIBUTION

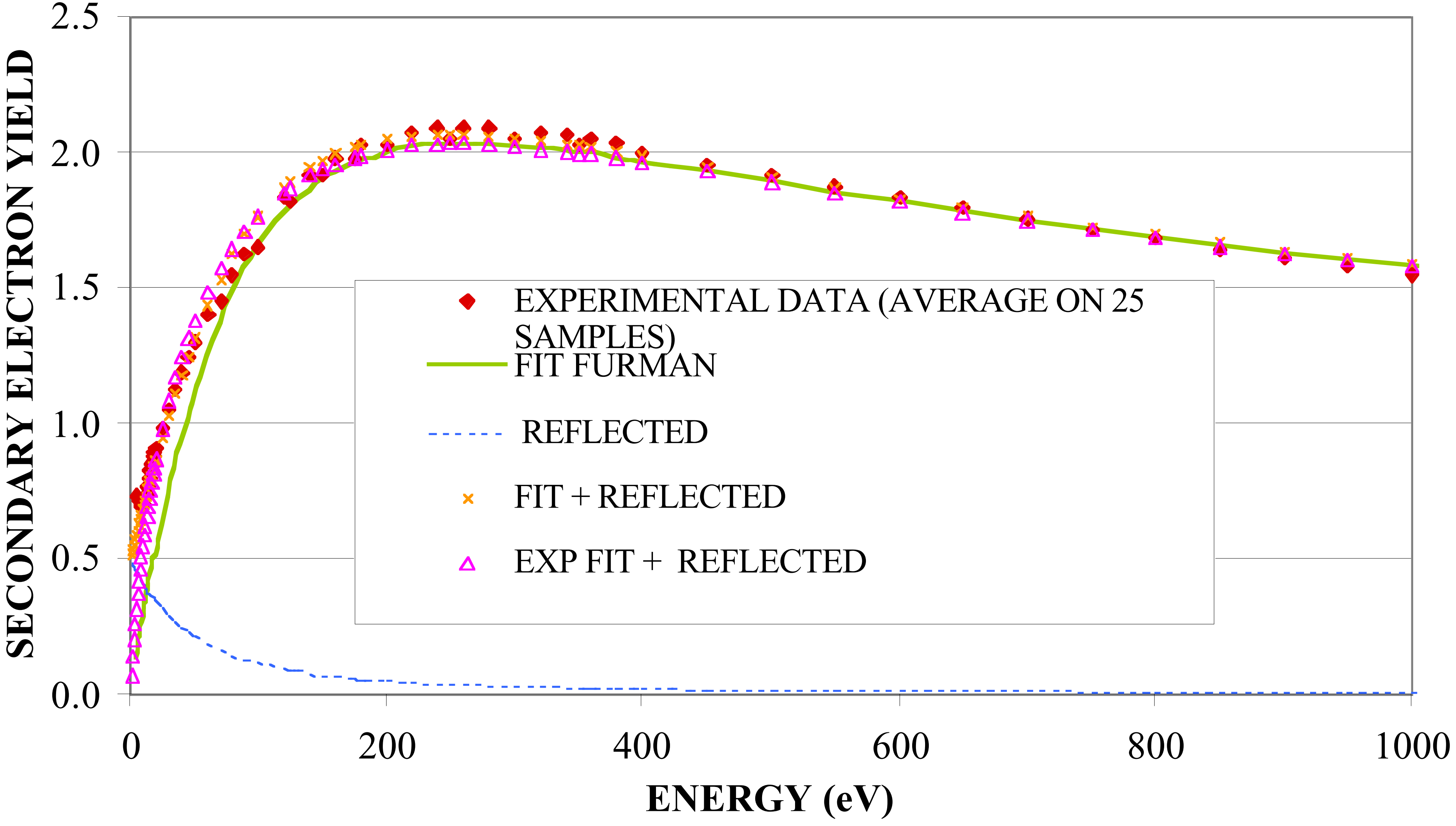
AN EXPONENTIAL LAW COULD ALSO BE USED BELOW 100 EV

$$f = R_0 \times \exp(-E_p / w)$$

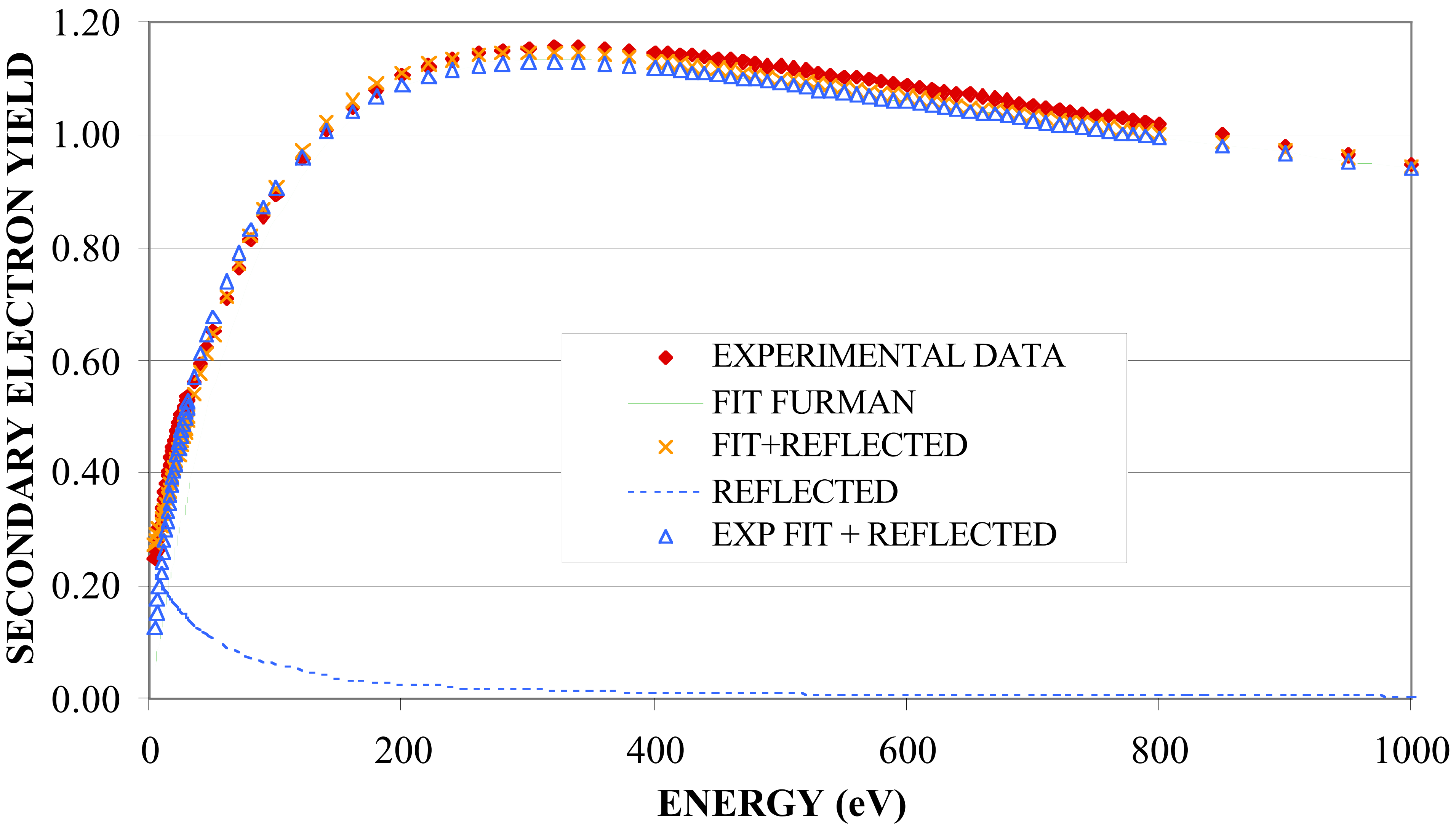
USING: R_0= .64438713, w=43.2268304. (Curve labelled EXP FIT)

RANGE LIMITED 30 -> 100 eV (cf. Following curves)

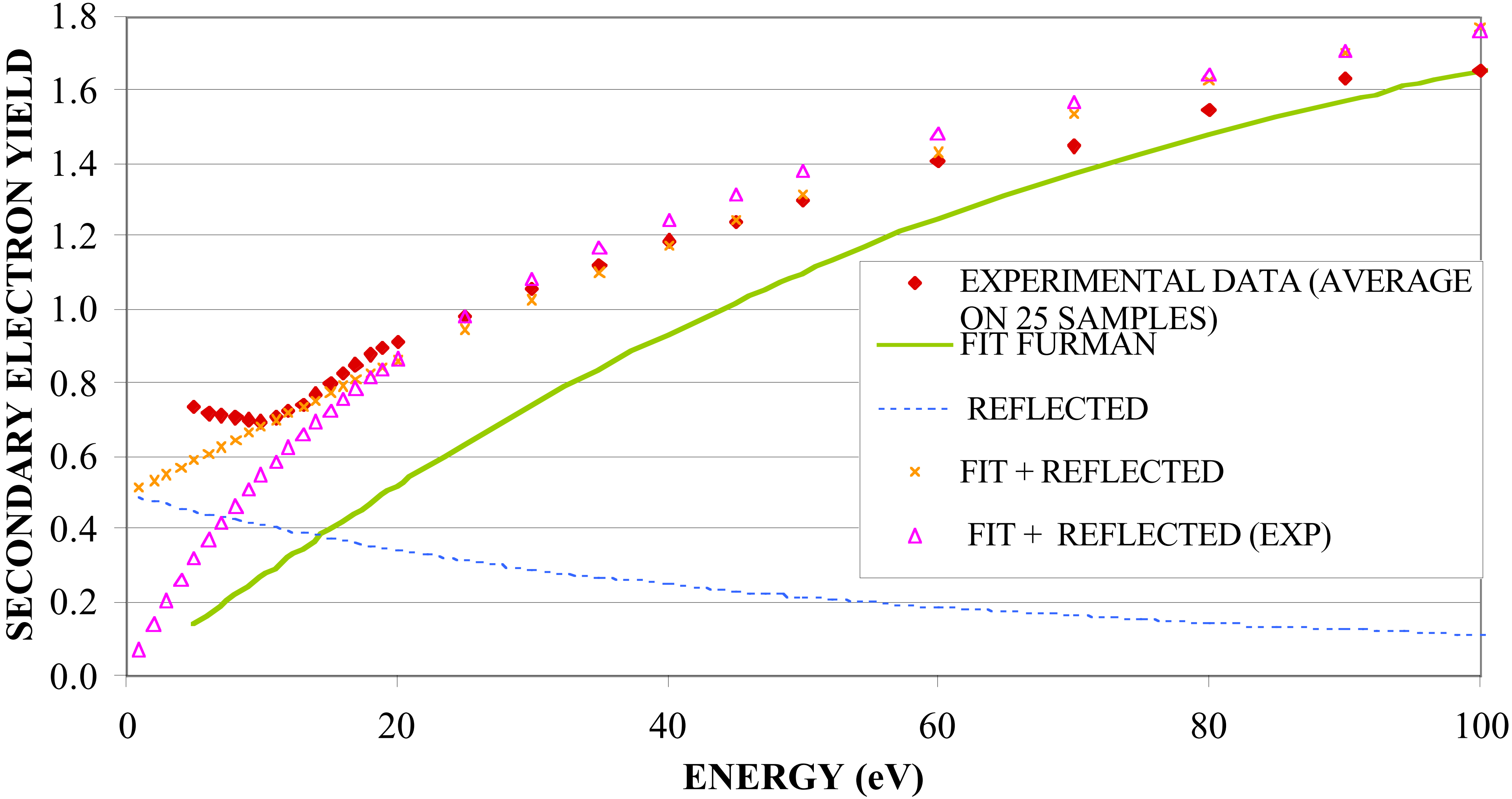
CU AS RECEIVED



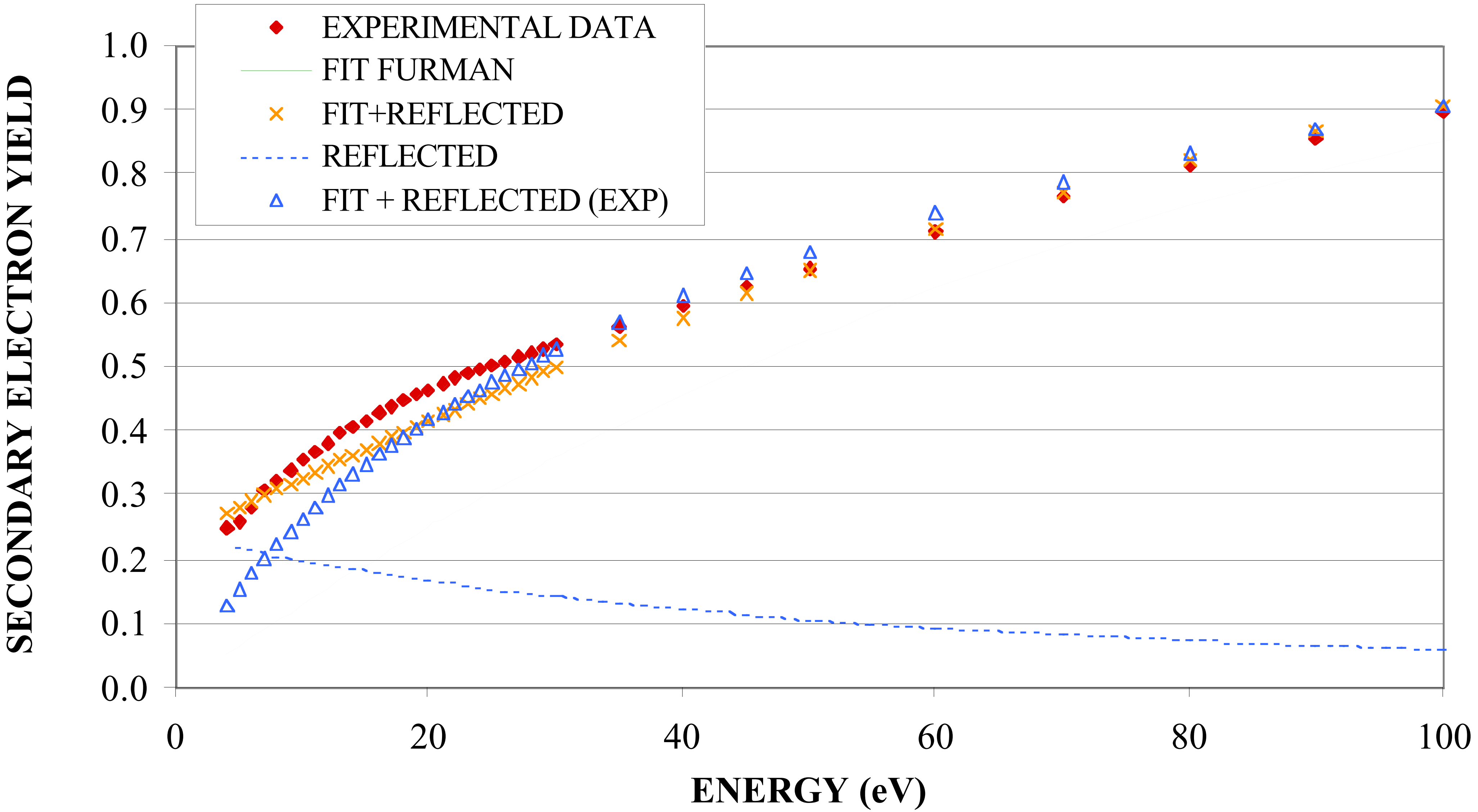
CU EXPOSED TO 0.01 C/mm2



CU AS RECEIVED



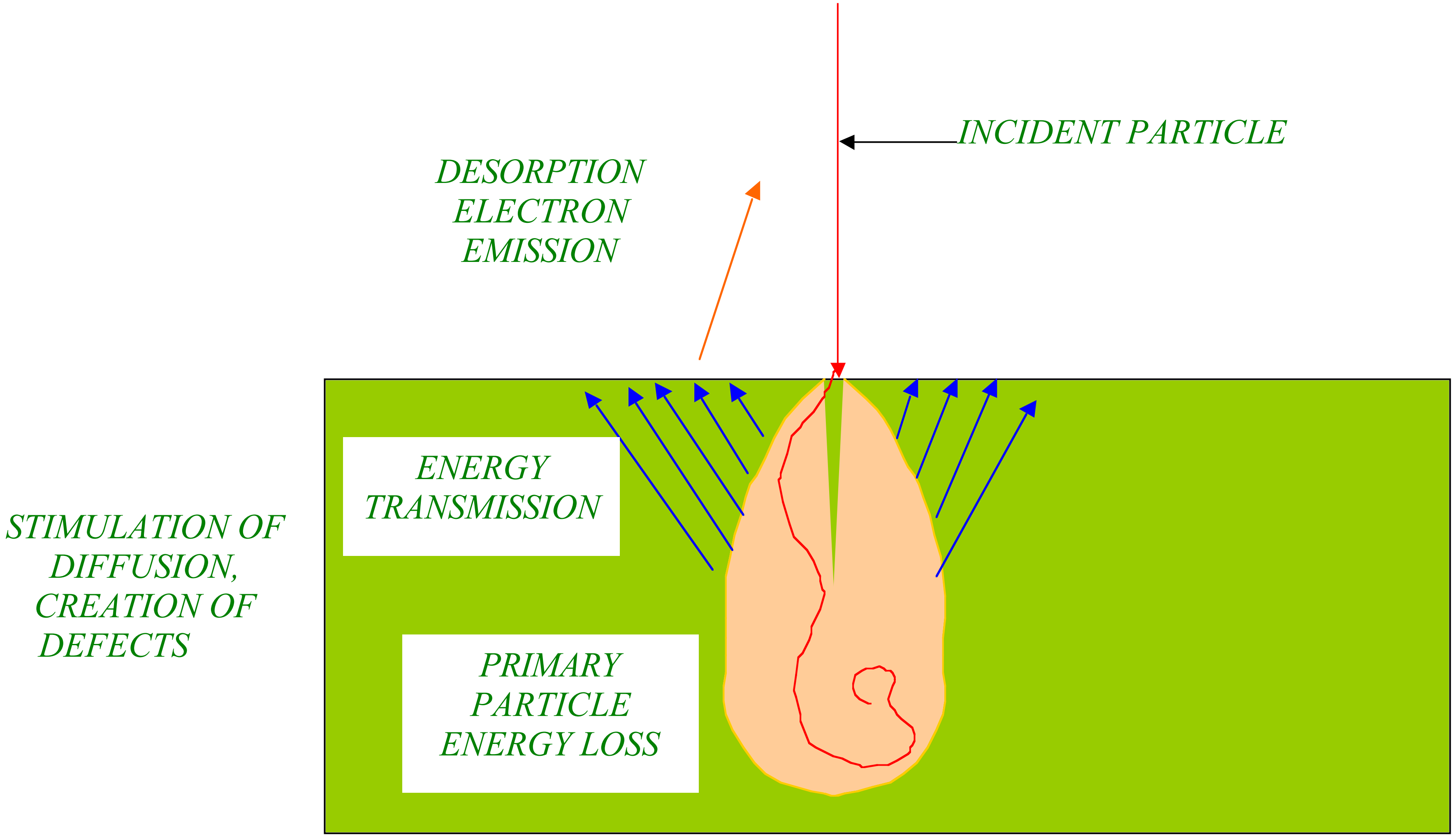
CU EXPOSED TO 0.01 C/mm2



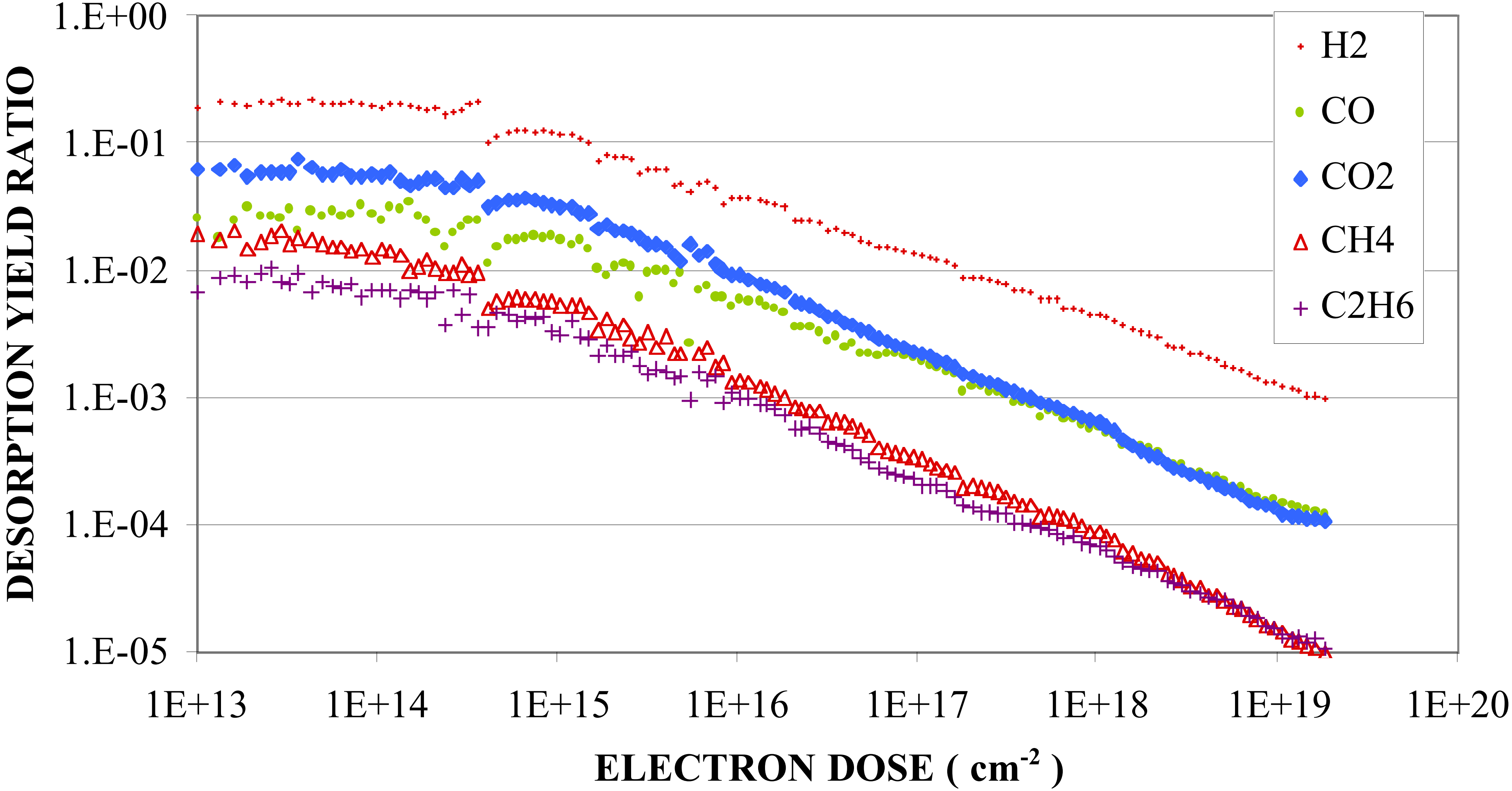
ELECTRON BOMBARDMENT

DESORPTION AND SECONDARY ELECTRON EMISSION

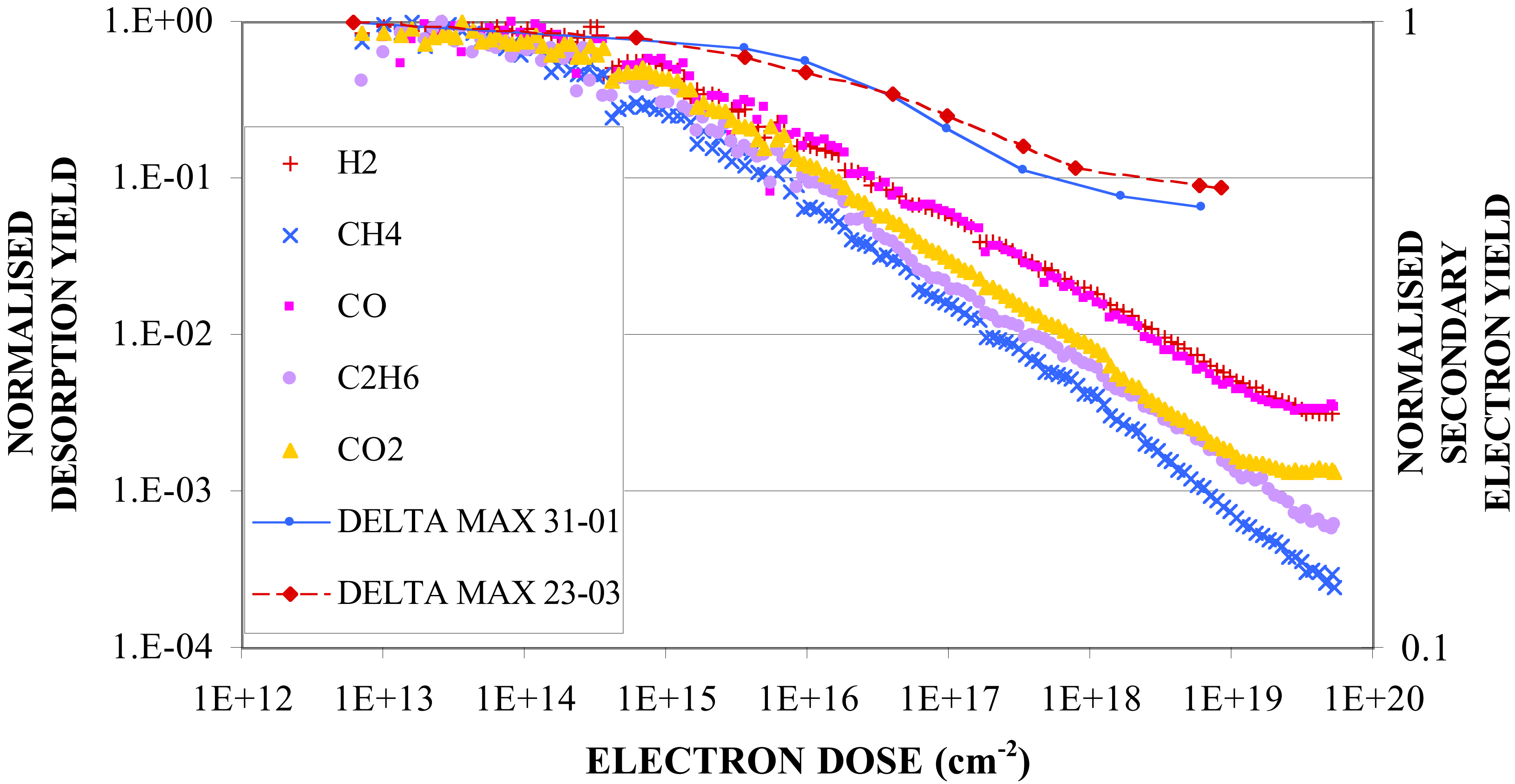
RELATIONS BETWEEN DESORPTION AND CONDITIONING



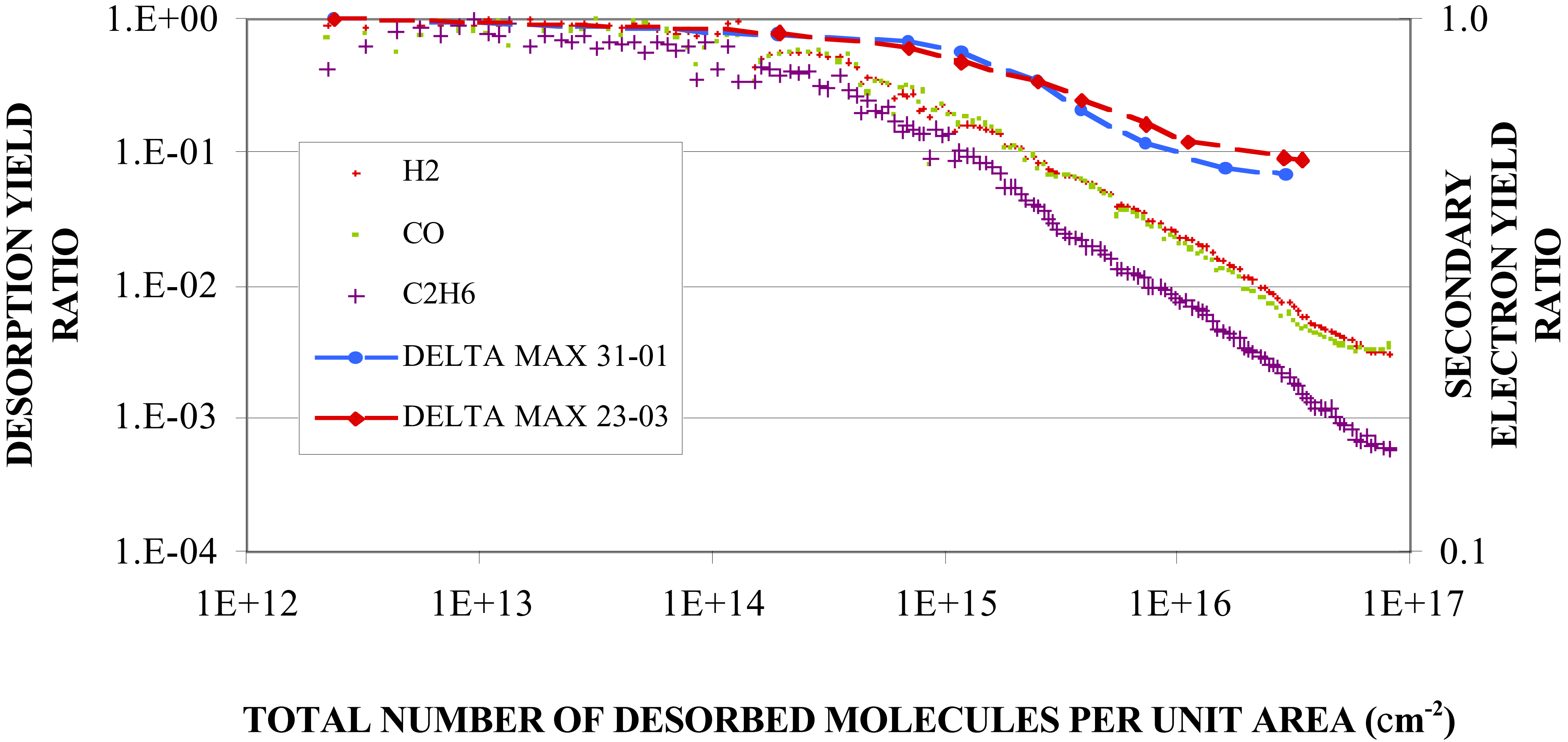
VARIATION OF THE ELECTRON INDUCED DESORPTION WITH THE ELECTRON DOSE (AS RECEIVED COPPER)



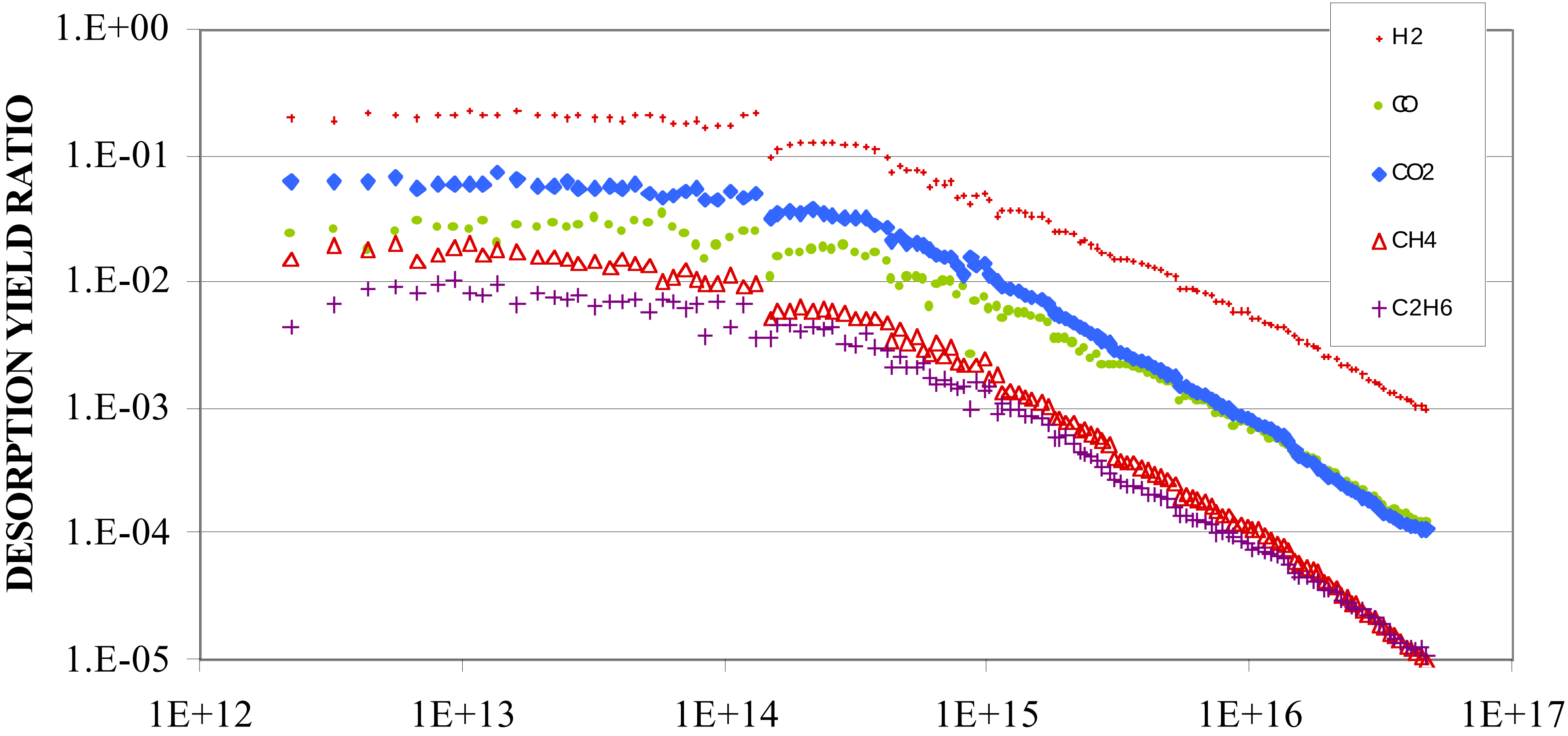
VARIATION OF THE ELECTRON INDUCED DESORPTION WITH THE BEAM DOSE(AS RECEIVED COPPER)



VARIATION OF THE ELECTRON INDUCED DESORPTION AND OF THE SECONDARY ELECTRON YIELD WITH THE NUMBER OF MOLECULES DESORBED (AS RECEIVED COPPER)

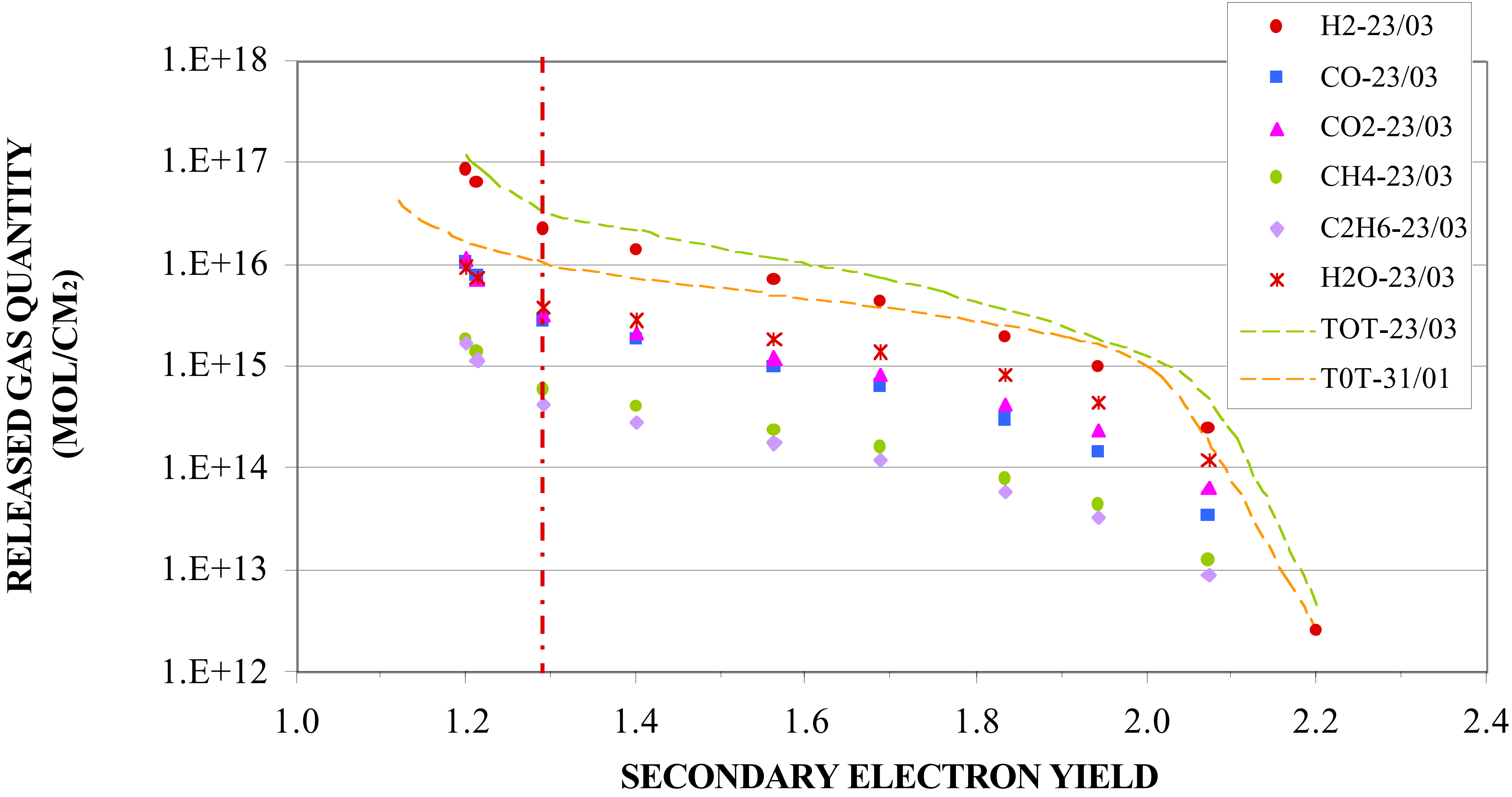


VARIATION OF THE ELECTRON INDUCED DESORPTION WITH THE NUMBER OF MOLECULES DESORBED(AS RECEIVED COPPER)



TOTAL NUMBER OF DESORBED MOLECULES PER UNIT AREA (Cm^{-2})

VARIATION OF THE DESORBED GAS QUANTITY AS A FUNCTION OF THE SECONDARY ELECTRON YIELD



ELECTRON BOMBARDMENT

DESORPTION AND SECONDARY ELECTRON EMISSION

RELATIONS BETWEEN DESORPTION AND CONDITIONING

INFLUENCE OF CLEANLINESS: IN SITU A.G.D. CLEANED SAMPLES

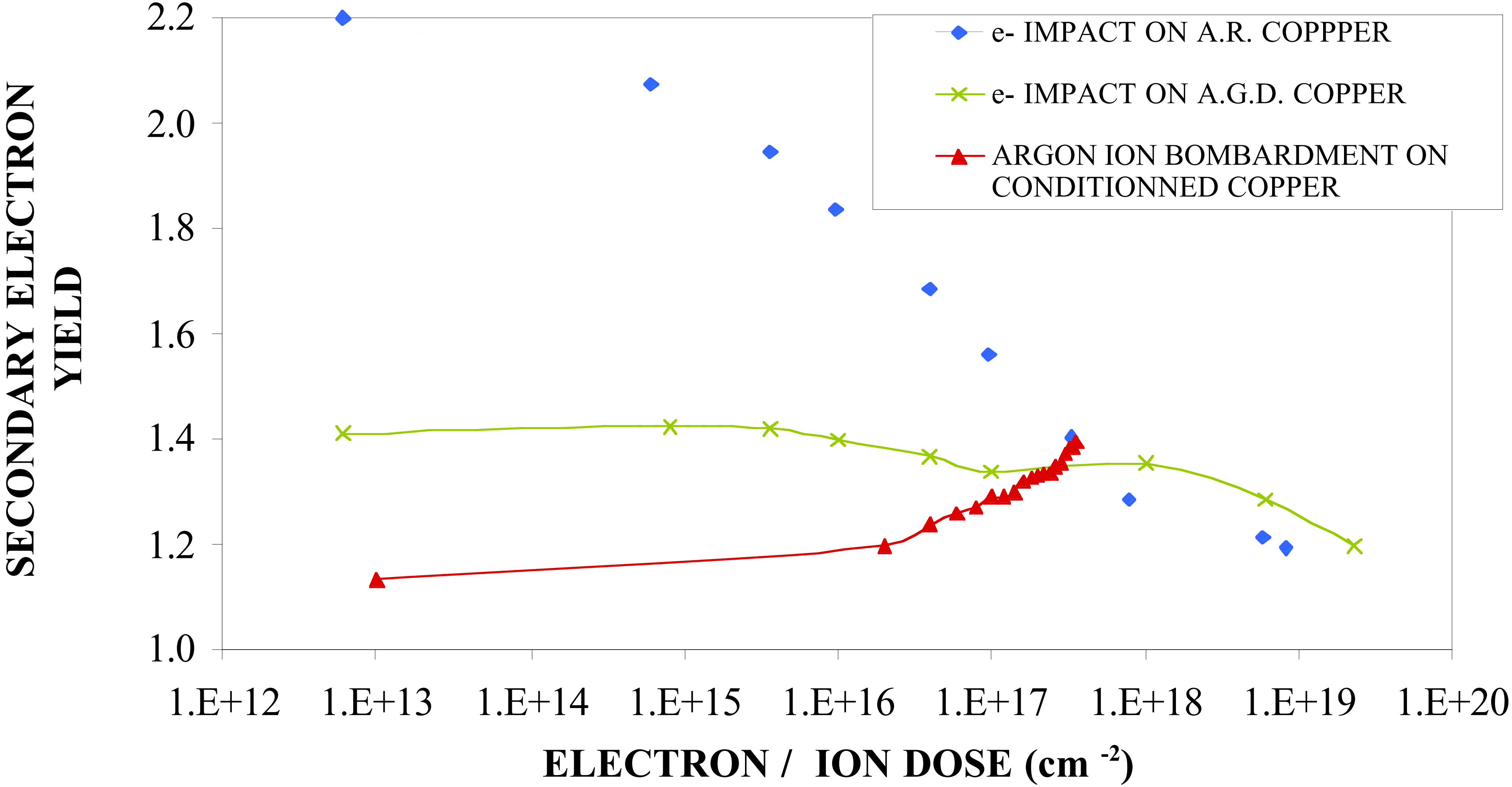
VERY LOW DESORPTION YIELD PRODUCED:

S.E.Y. DECREASES WHEN AN A.G.D COPPER SURFACE IS EL. BOMBARDED

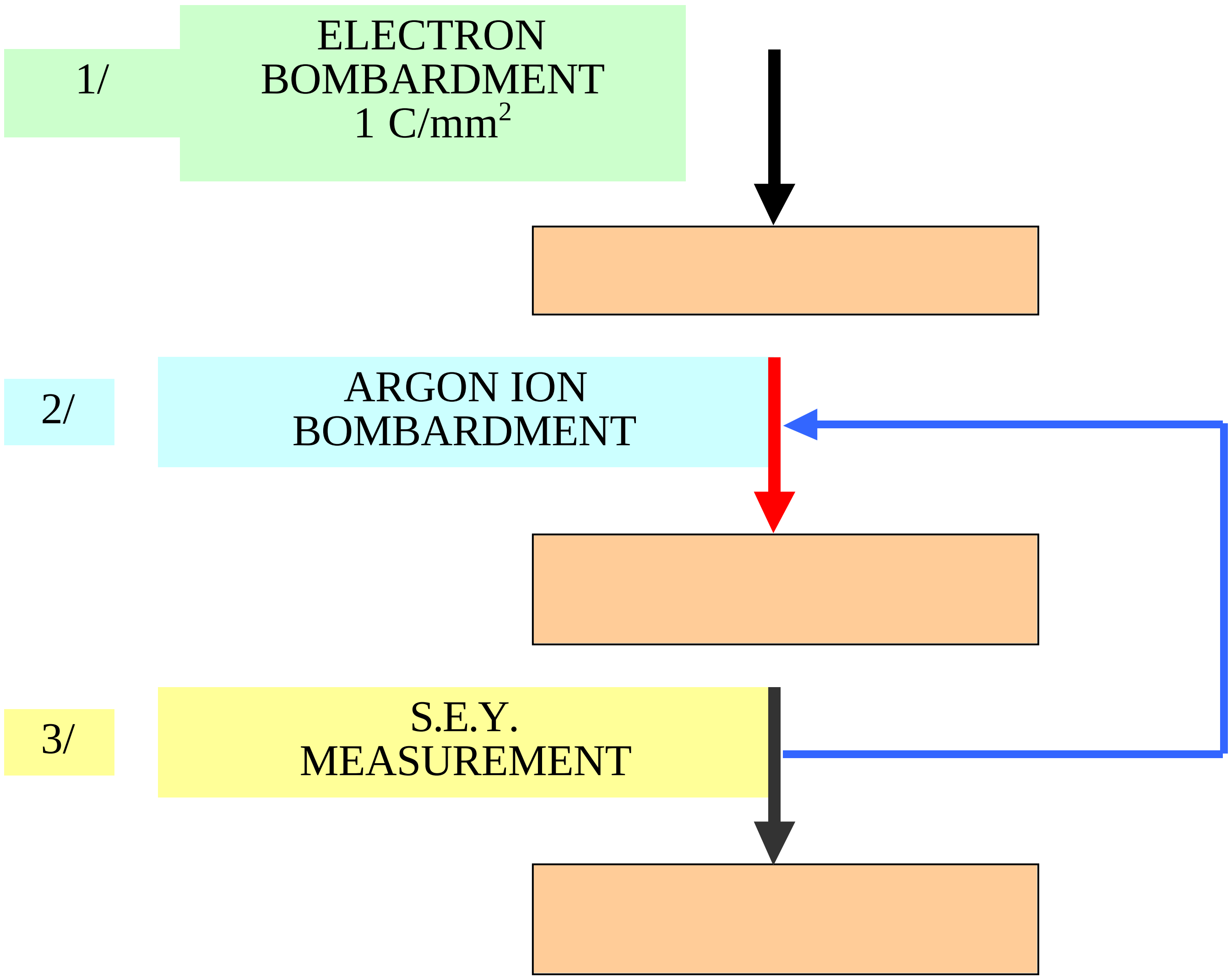
S.E.Y. INCREASES WHEN CONDITIONED CU IS A.G.D

THE CLEANEST SURFACE HAS NOT THE LOWEST SECONDARY ELECTRON YIELD

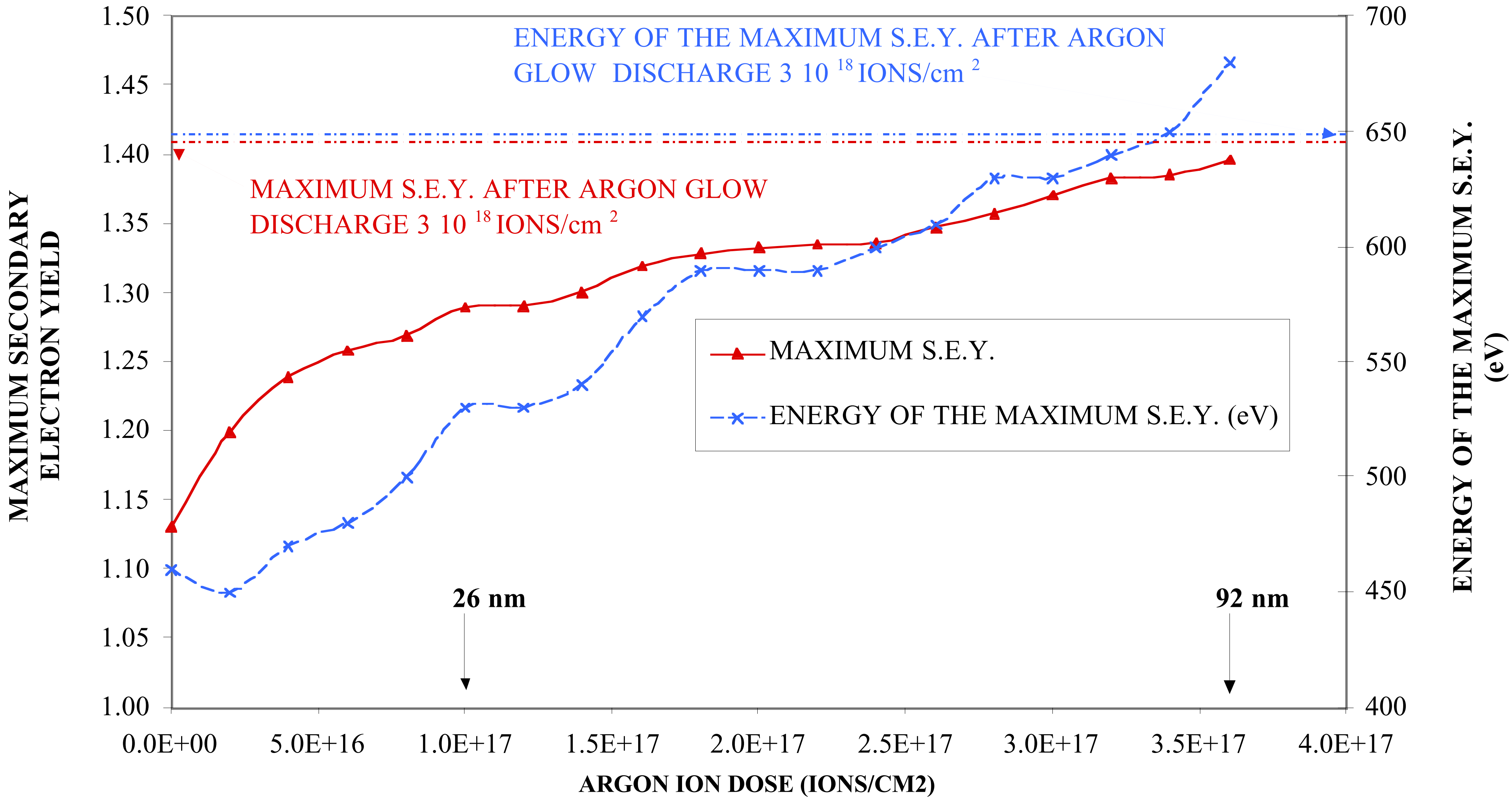
VARIATION OF THE SECONDARY ELECTRON DOSE WITH THE ELECTRON / ION DOSE



PROCEDURE FOR ION BOMBARDMENT



VARIATION OF THE S.E.Y. OF A CONDITIONNED COPPER SAMPLE DURING ARGON ION BOMBARDMENT



ELECTRON BOMBARDMENT

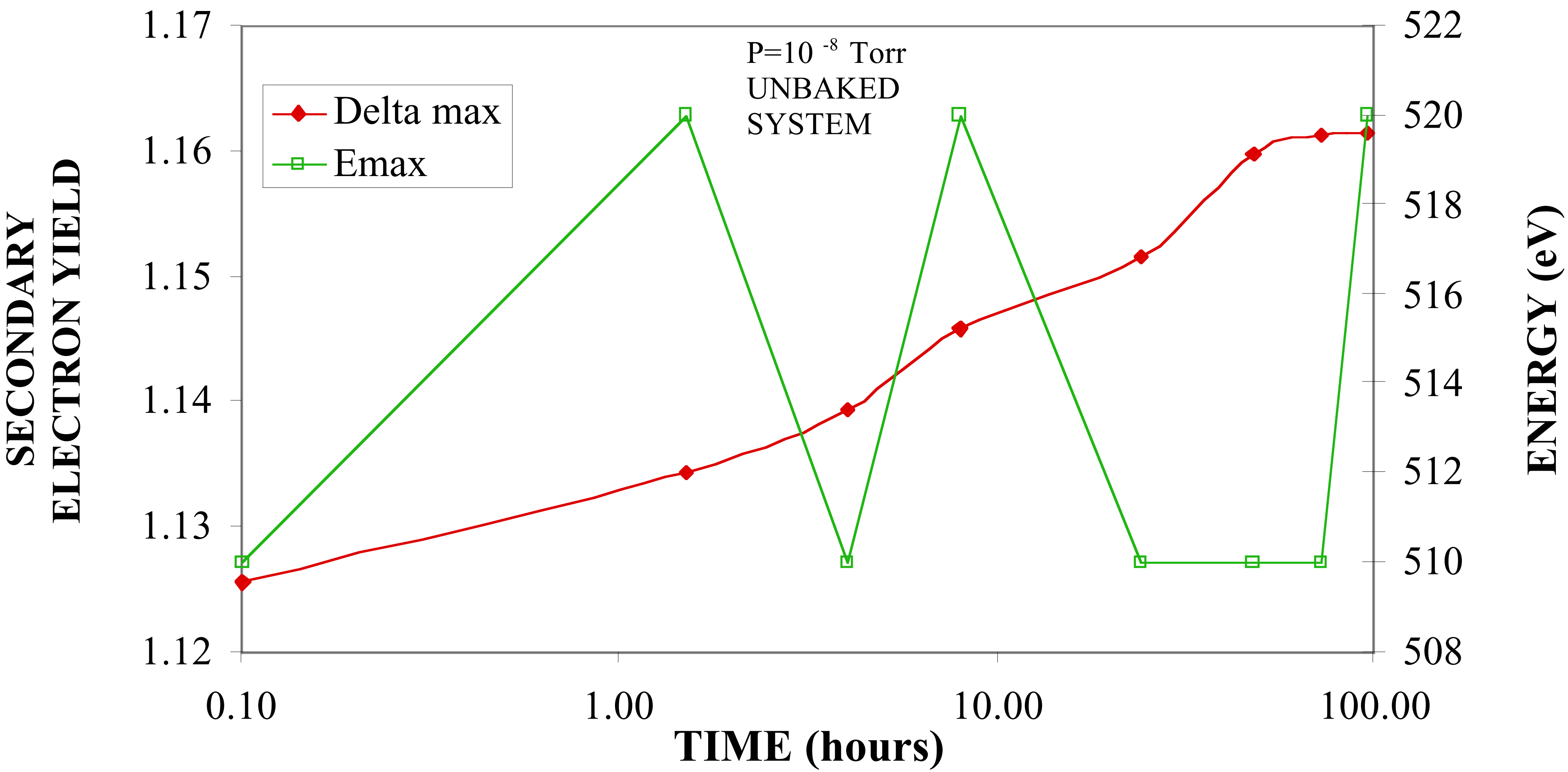
EFFECT OF VACUUM / AIR EXPOSURE

IMPORTANT DURING THE OPERATION OF AN ACCELERATOR

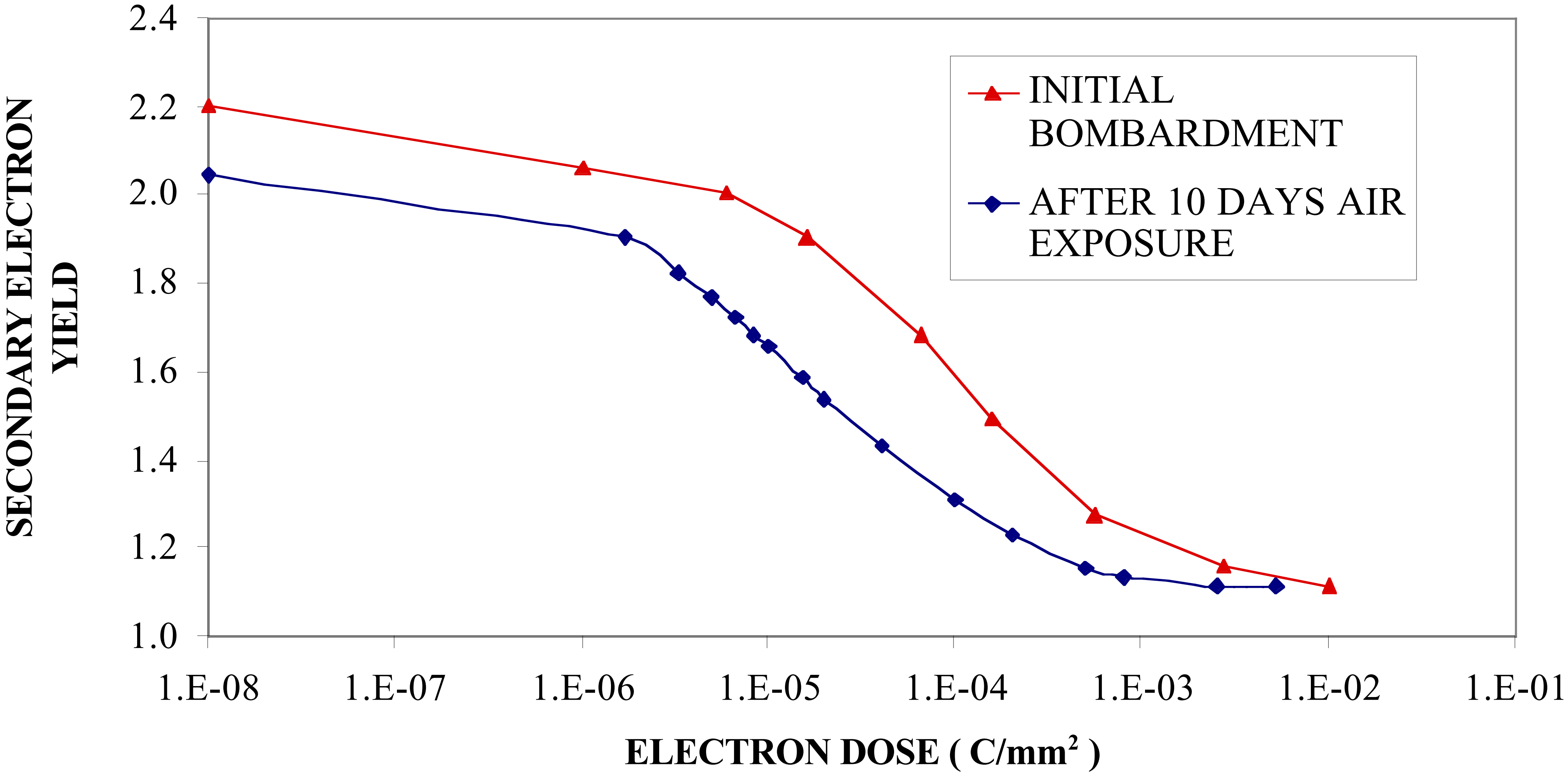
IS CONDITIONING LOST?

FOR HOW LONG??

VARIATION OF THE SECONDARY ELECTRON YIELD AFTER ELECTRON BOMBARDMENT



VARIATION OF THE SECONDARY ELECTRON YIELD WITH THE ELECTRON DOSE BEFORE AND AFTER AIR EXPOSURE



ELECTRON BOMBARDMENT

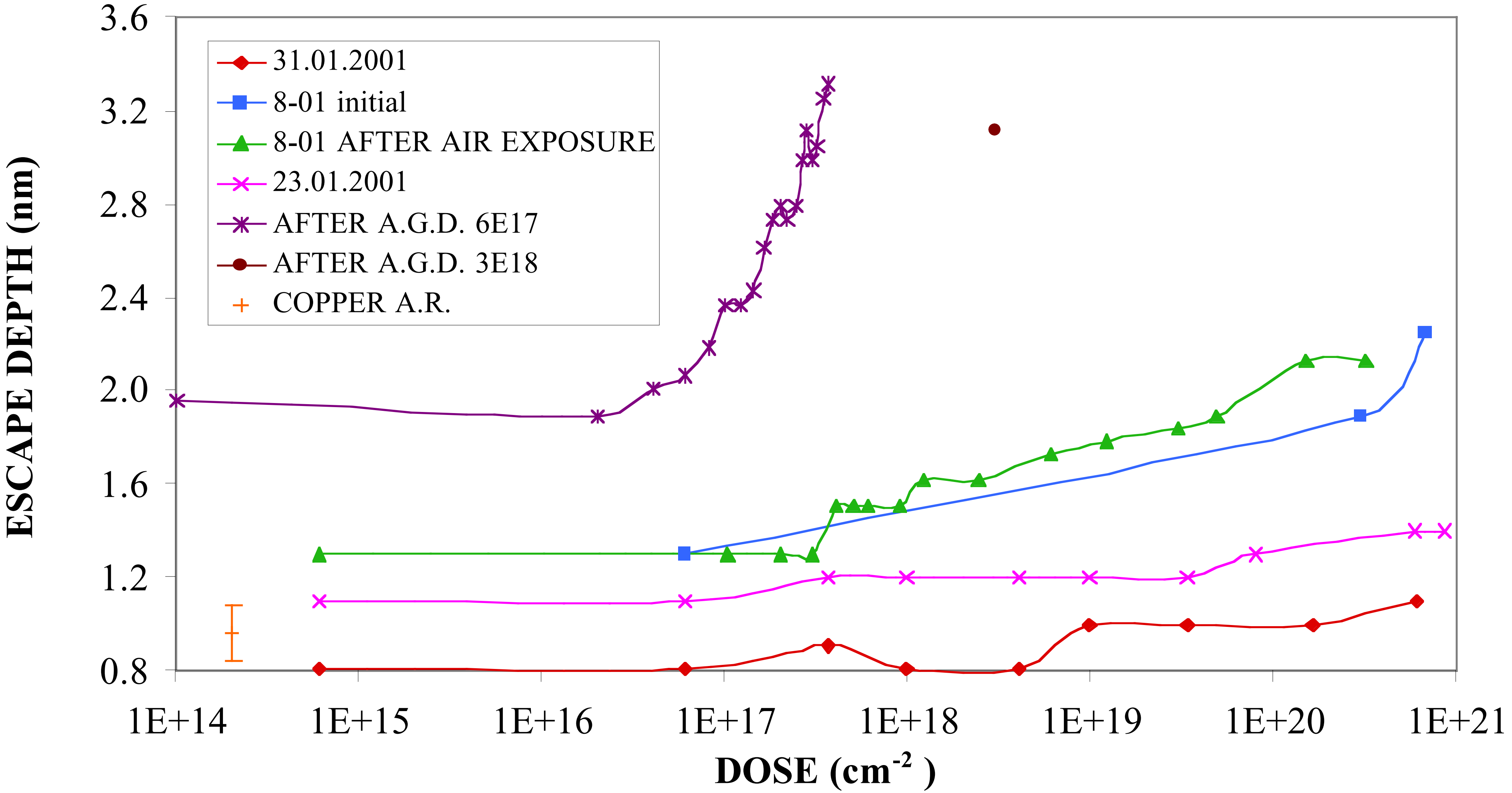
EFFECT OF VACUUM / AIR EXPOSURE

UNDER VACUUM A SLIGHT DECONDITIONING VISIBLE AFTER 100 HOURS

AFTER AIR EXPOSURE: BACK TO UNTREATED VALUE (10 DAYS)

BUT RECONDITIONING MUCH SHORTER (FACTOR 10 IN DOSE)

VARIATION OF THE ESCAPE DEPTH DURING ELECTRON / ION BOMBARDMENT



CONCLUSIONS

***WHEN LOW ENERGY ELECTRONS ARE OF IMPORTANCE** : REFLECTION MUST BE CONSIDERED*

BASED ON ENERGY DISTRIBUTION MEASUREMENTS A FIT ALLOWS TO CALCULATE THE RATIO REFLECTED/TOTAL

BETTER APPROXIMATION AT ELECTRON ENERGIES < 50 eV

*THE **SIMULTANEOUS** VARIATION OF **DESORPTION** AND ELECTRON **EMISSION** HAS BEEN STUDIED*

*PARALLEL REMOVAL OF ~ **10->100 MONOLAYERS** OF GAS (H_2, CO, CO_2)*

BUT** CLEANEST SURFACE HAS NOT THE LOWEST YIELD : **PARALLEL # CAUSALITY

RECONDITIONING** AFTER AIR EXPOSURE IS APPROXIMATELY **10 TIMES FASTER