THE VARIATION OF THE SECONDARY ELECTRON EMISSION WITH SURFACE MODIFICATIONS

B. Henrist, N. Hilleret, M. Jimenez, C. Scheuerlein, M. Taborelli, G. Vorlaufer

CERN - LHC/VAC

EST-SM

TOPICS:

SECONDARY ELECTRON YIELD BEFORE AND AFTER ELECTRON BOMBARDMENT

THE "SIMULATOR" TOOL KIT

VARIATION OF GAS FLUX DURING CONDITIONING

CONDENSED GASES

SURFACE MODIFICATIONS DURING CONDITIONING

SIMULATOR TOOL KIT

MODEL FOR SECONDARY ELECTRON EMISSION

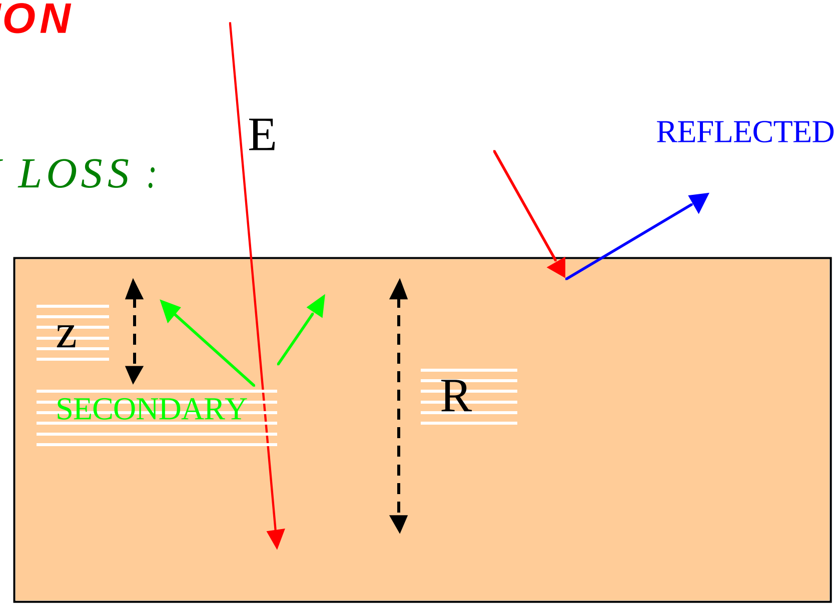
ASSUMPTIONS : FOR SECONDARIES

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

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

SIMULATOR TOOL KIT

MODEL FOR SECONDARY ELECTRON EMISSION

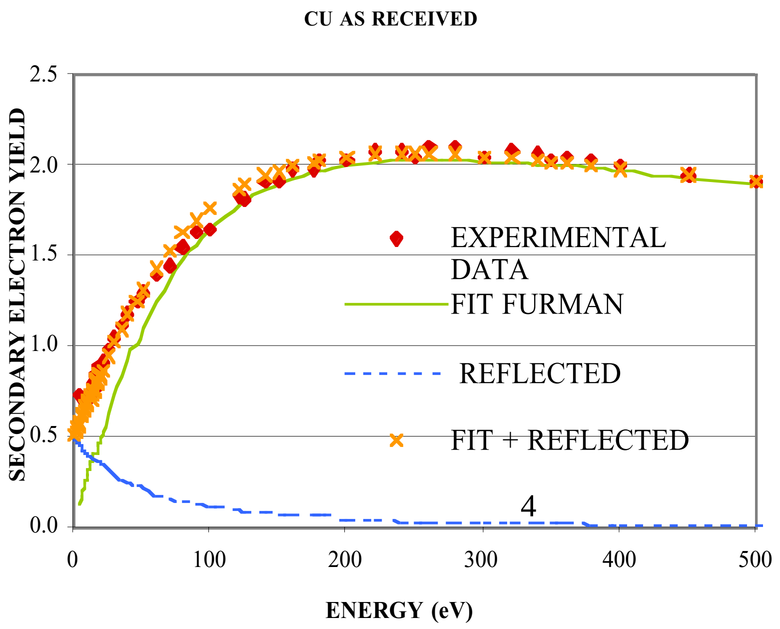
NUMERICAL VALUE TO FIT OUR EXPERIMENTAL DATA:

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

PRECEDING APPROXIMATION TO FIT HIGH ENERGY PART

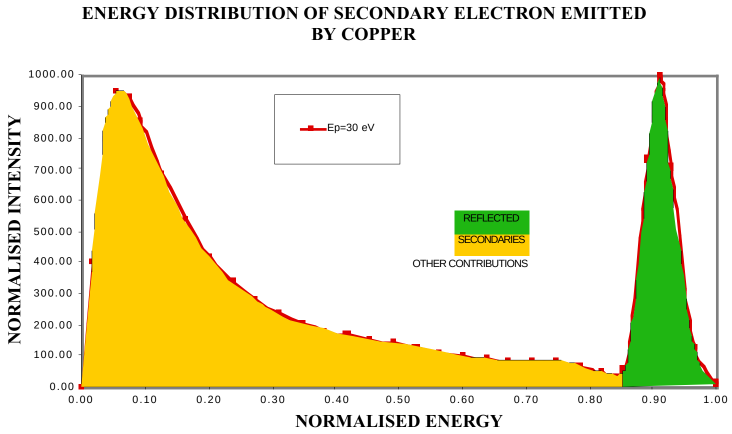
IF LOW ENERGY ELECTRONS HAVE TO BE CONSIDERED:

REFLECTED NOT NEGLIGIBLE :



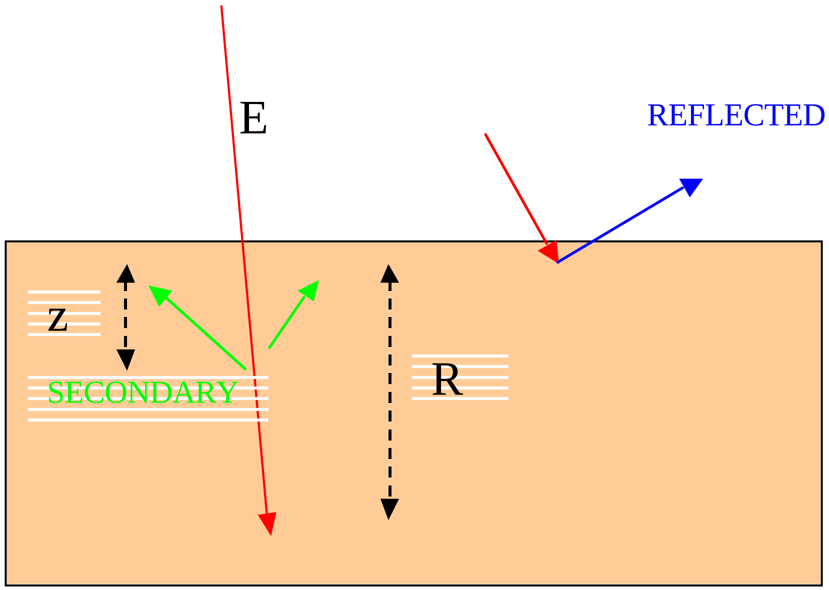
SIMULATOR TOOL KIT

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



FOR E_p> 300 eV
REFLECTED CONTRIBUTION NEGLIGIBLE

SECONDARY / REFLECTED PROCESSES COMPLETELY DIFFERENT



SIMULATOR TOOL KIT

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

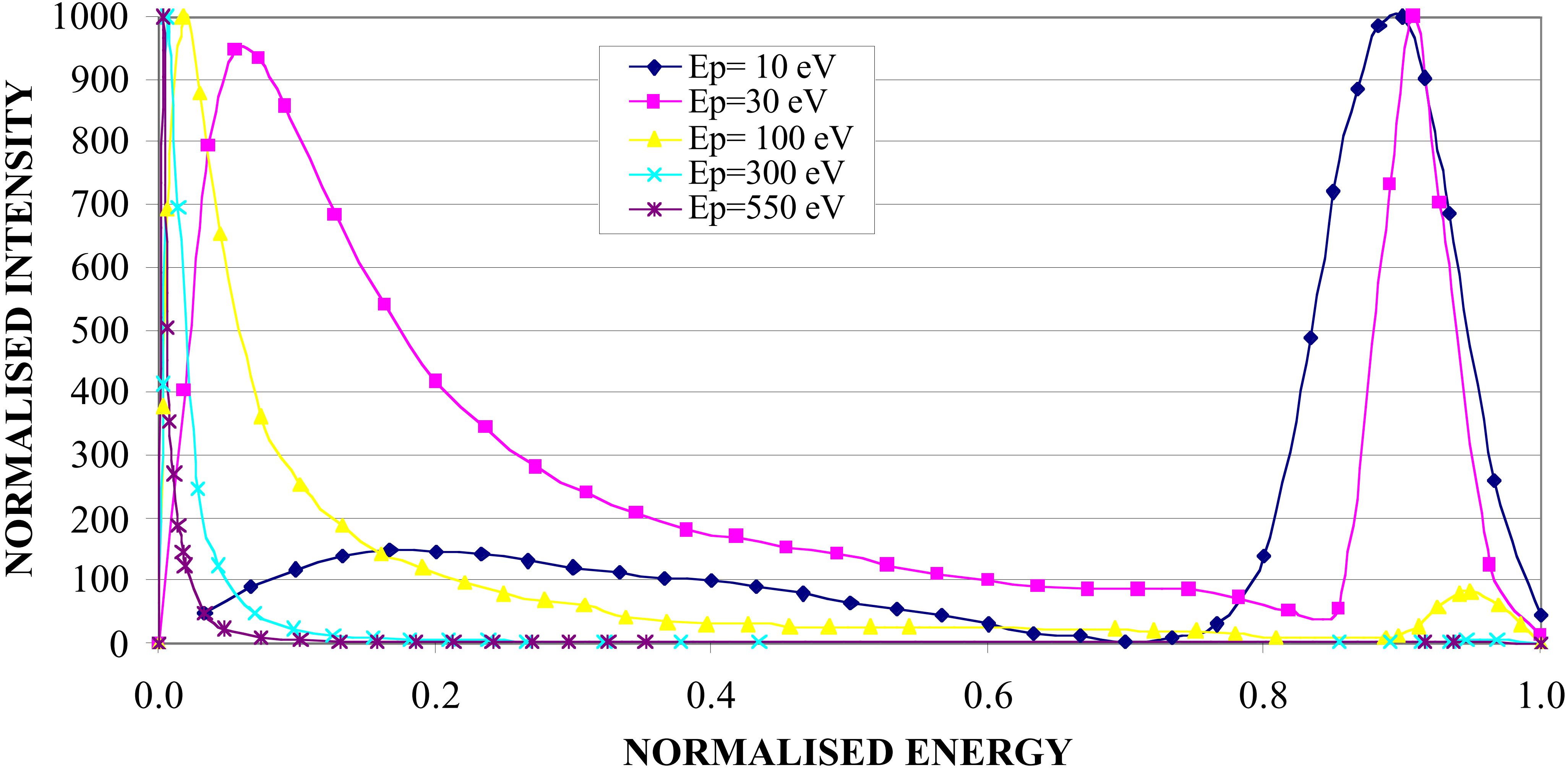
AND APPROXIMATED BY THE FOLLOWING RELATION:

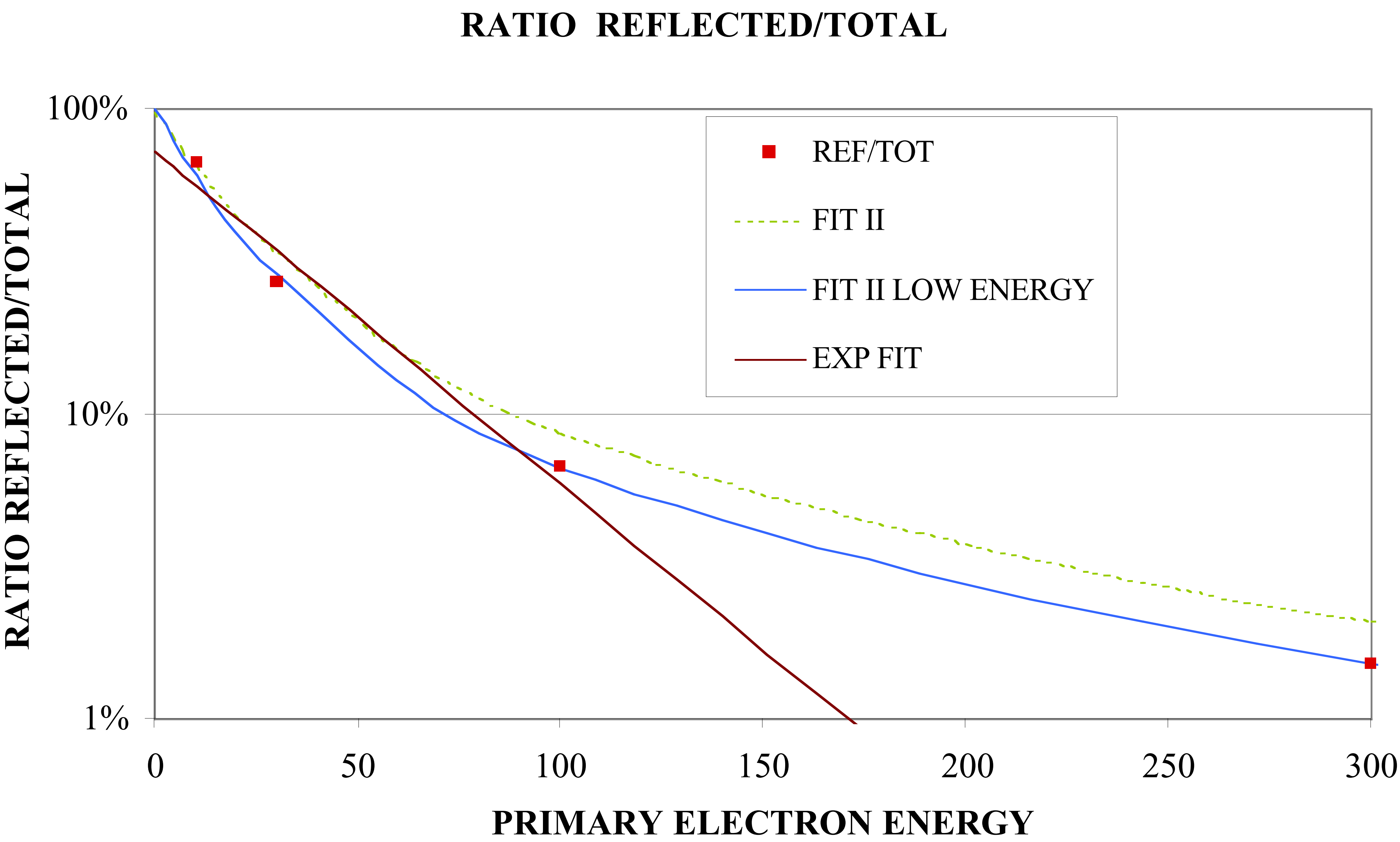
$$\ln(f) = A_0 + A_1 \times (\ln(E_p + E_0)) + A_2 \times (\ln(E_p + E_0))^2 + A_3 \times (\ln(E_p + E_0))^3$$

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

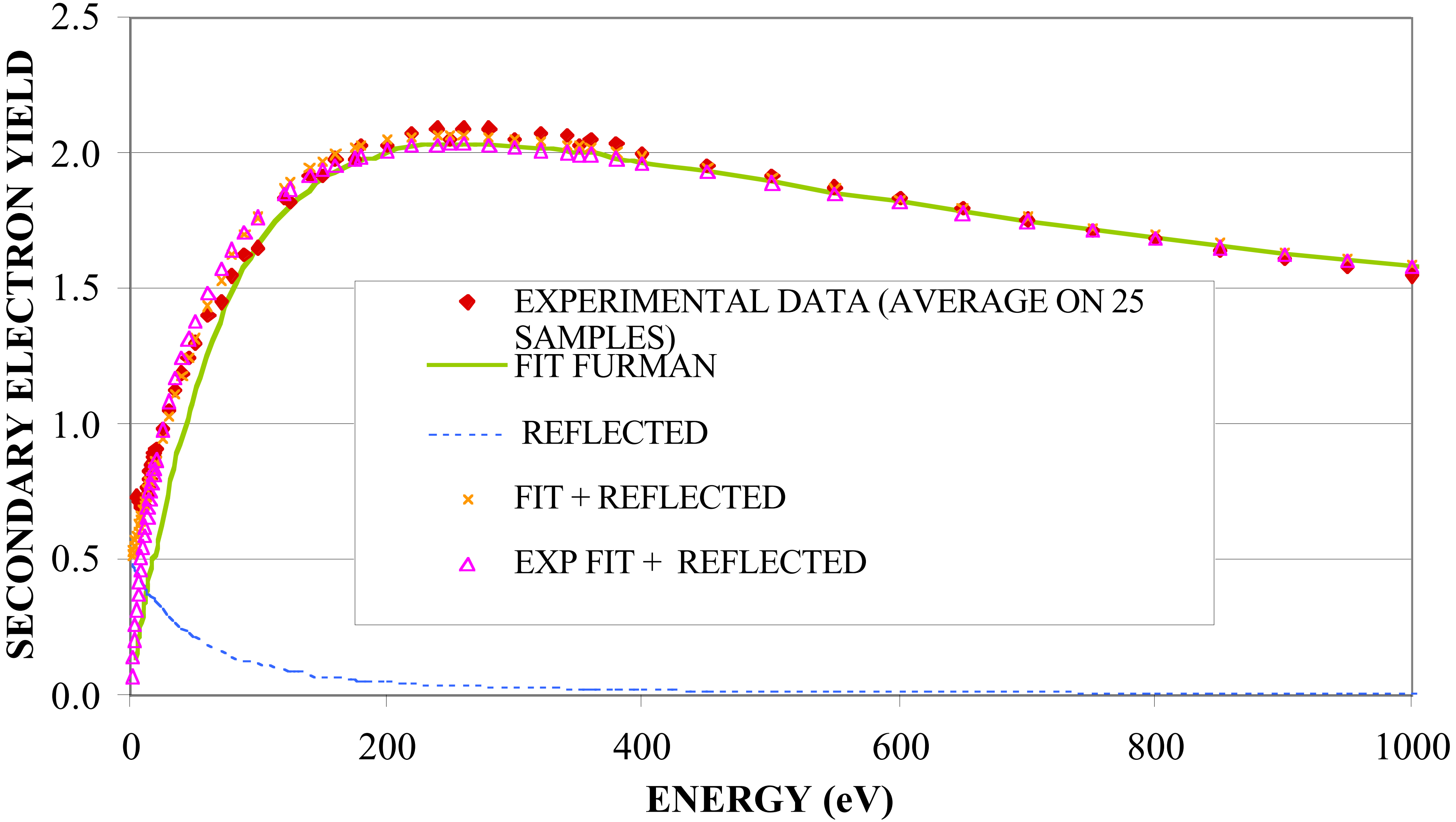
USING: A0 = 20.699890, A1= -7.07605, A2= 0.483547, A3= 0, E0=56.914686

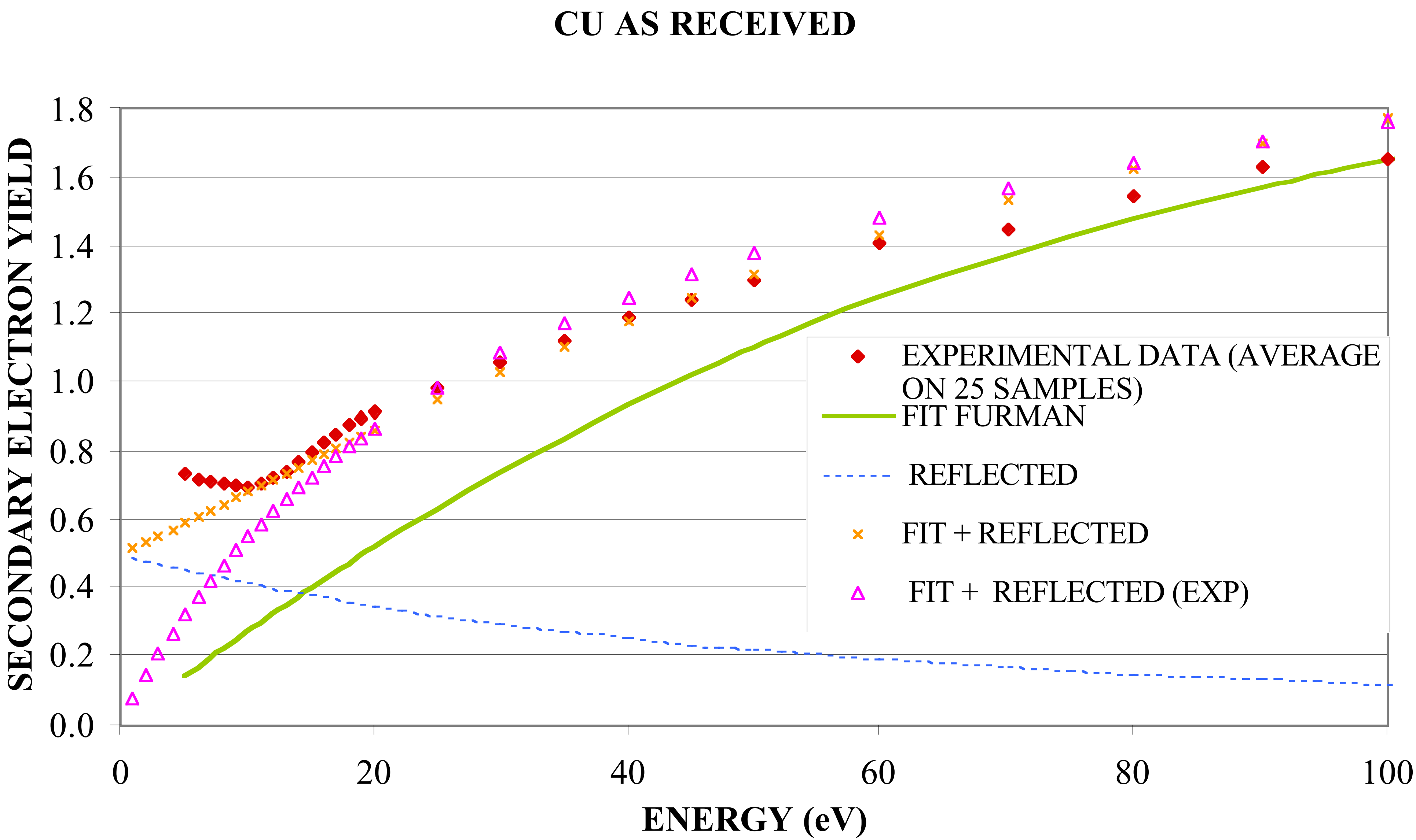
ENERGY DISTRIBUTION OF SECONDARY ELECTRON EMITTED BY COPPER



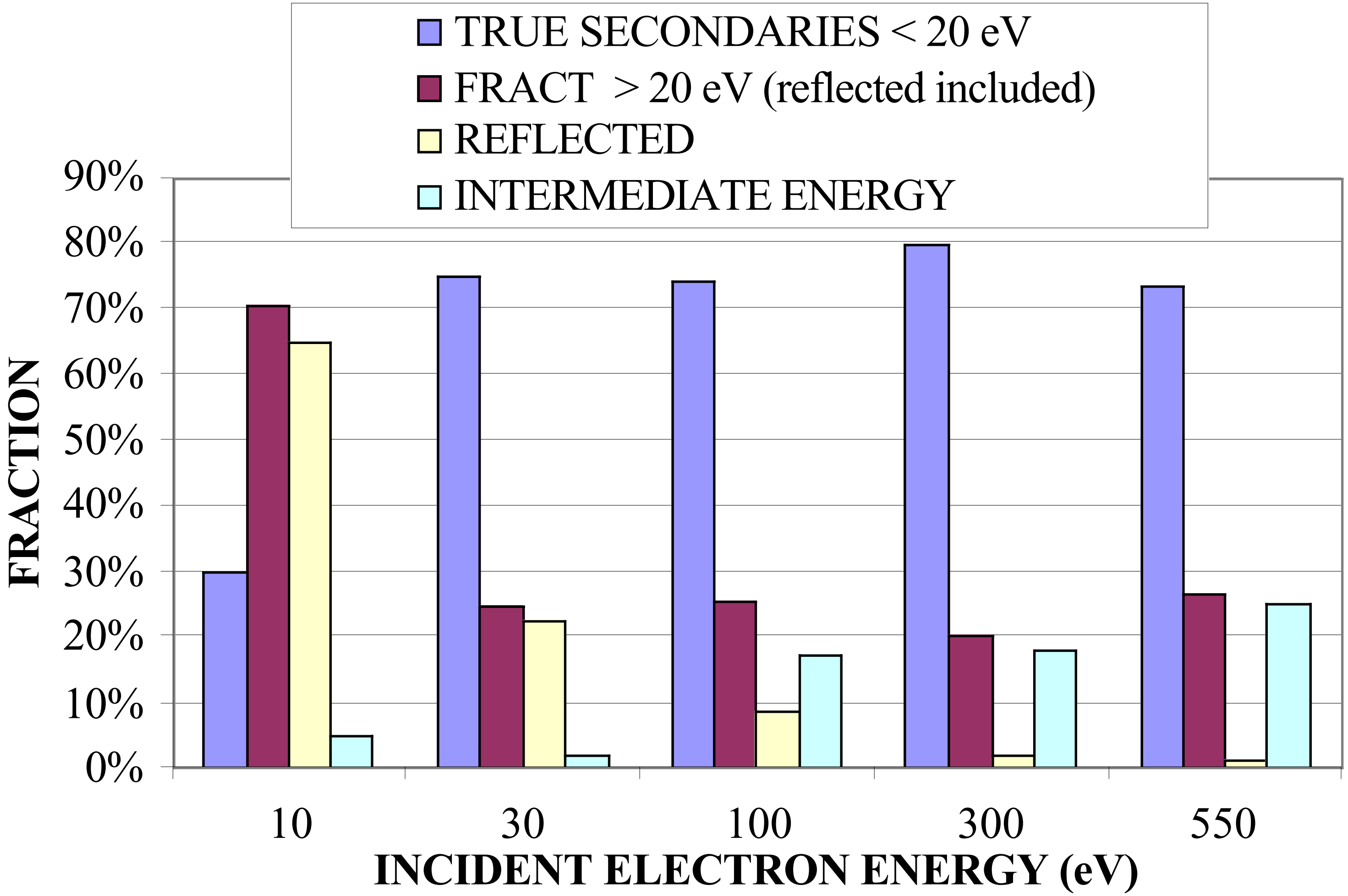

RATIO REFLECTED/TOTAL
100%
10%
1%
RATIO REFLECTED/TOTAL
REF/TOT
FIT II
FIT II LOW ENERGY
EXP FIT
0
50
100
150
200
250
300
PRIMARY ELECTRON ENERGY

CU AS RECEIVED




CU AS RECEIVED
SECONDARY ELECTRON YIELD
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
0
20
40
60
80
100
ENERGY (eV)
EXPERIMENTAL DATA (AVERAGE ON 25 SAMPLES)
FIT FURMAN
REFLECTED
FIT + REFLECTED
FIT + REFLECTED (EXP)

RELATIVE CONTRIBUTIONS IN THE SECONDARY ELECTRON ENERGY DISTRIBUTIONS



SIMULATOR TOOL KIT

TRUE SECONDARY ENERGY DISTRIBUTION

ENERGY DISTRIBUTION FITTED USING THE EXPRESSION:

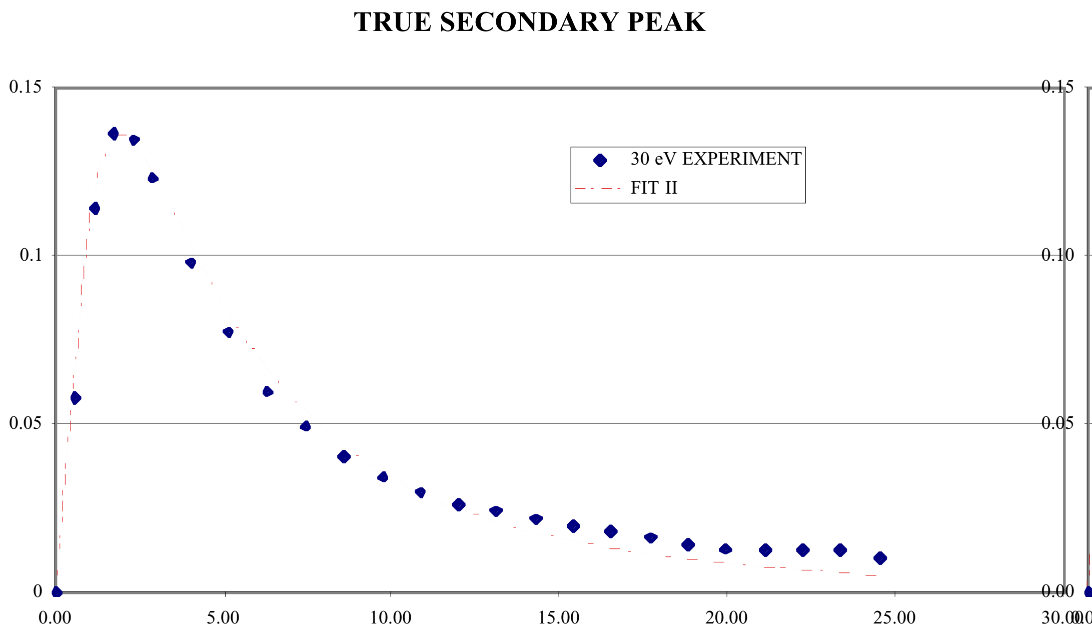
$$D(E_s) = C \times \exp\left\{ -\frac{\left[\ln \frac{E_s}{E_0} \right]^2}{2\tau^2} \right\}$$

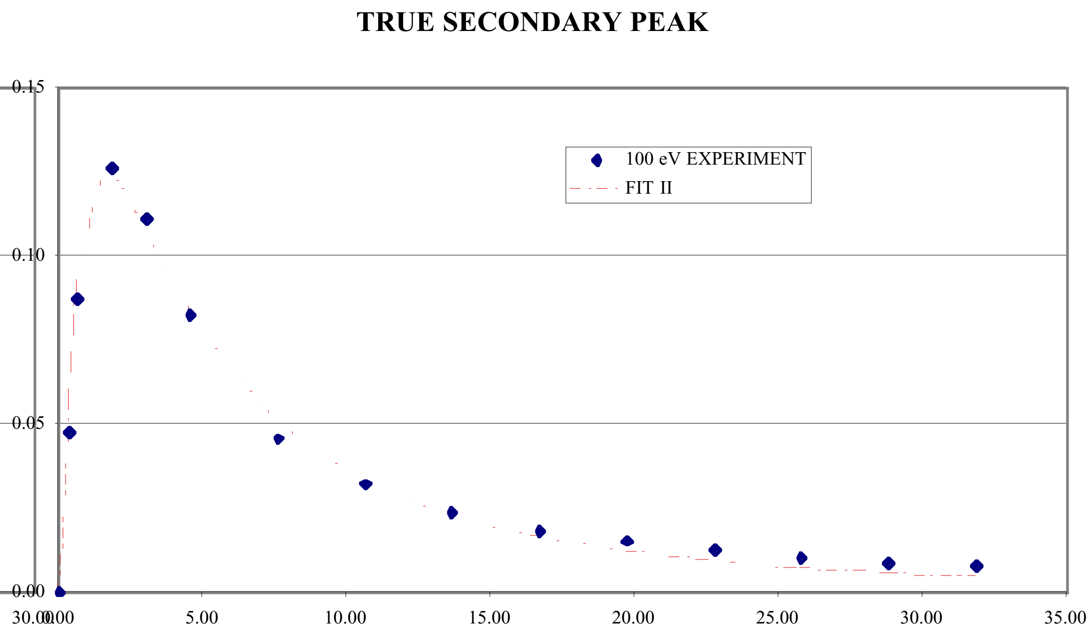
(J.J. Scholtz, D. Dijkkamp, R.W.A. Schmitz, Philips J. Res. 50, 375-389, 1996).

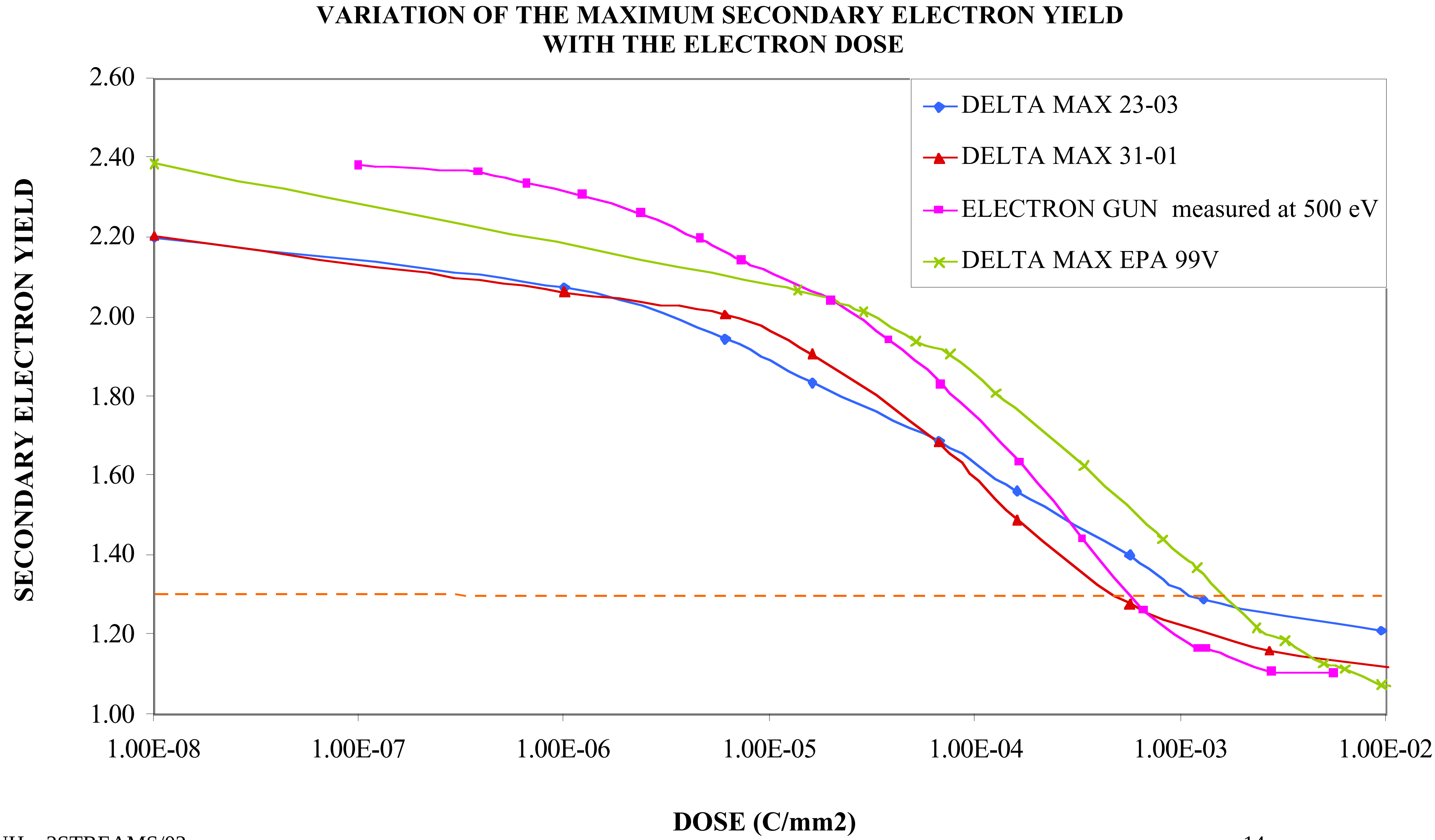
PRIMARY ENERGY (eV)	C	E_0	τ	UPPER ENERGY BOUND (eV)
10	0.277	1.57	0.985	5
30	0.136	1.9	0.99	22
100	.126	1.58	1.16	22
300	.155	2.1	0.85	21
550	0.2	1.48	0.909	26

. SIMULATOR TOOL KIT

TRUE SECONDARY ENERGY DISTRIBUTION

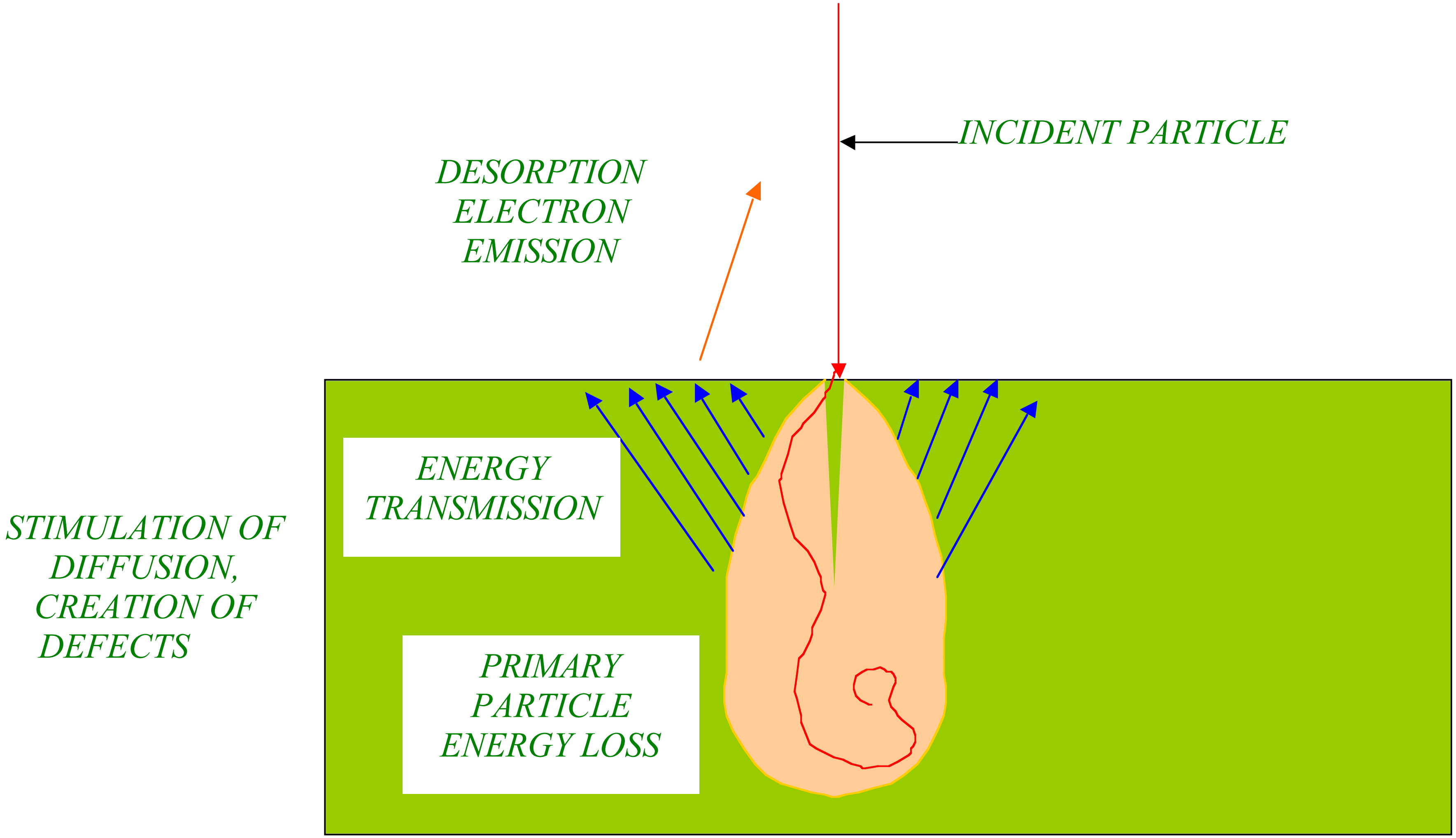




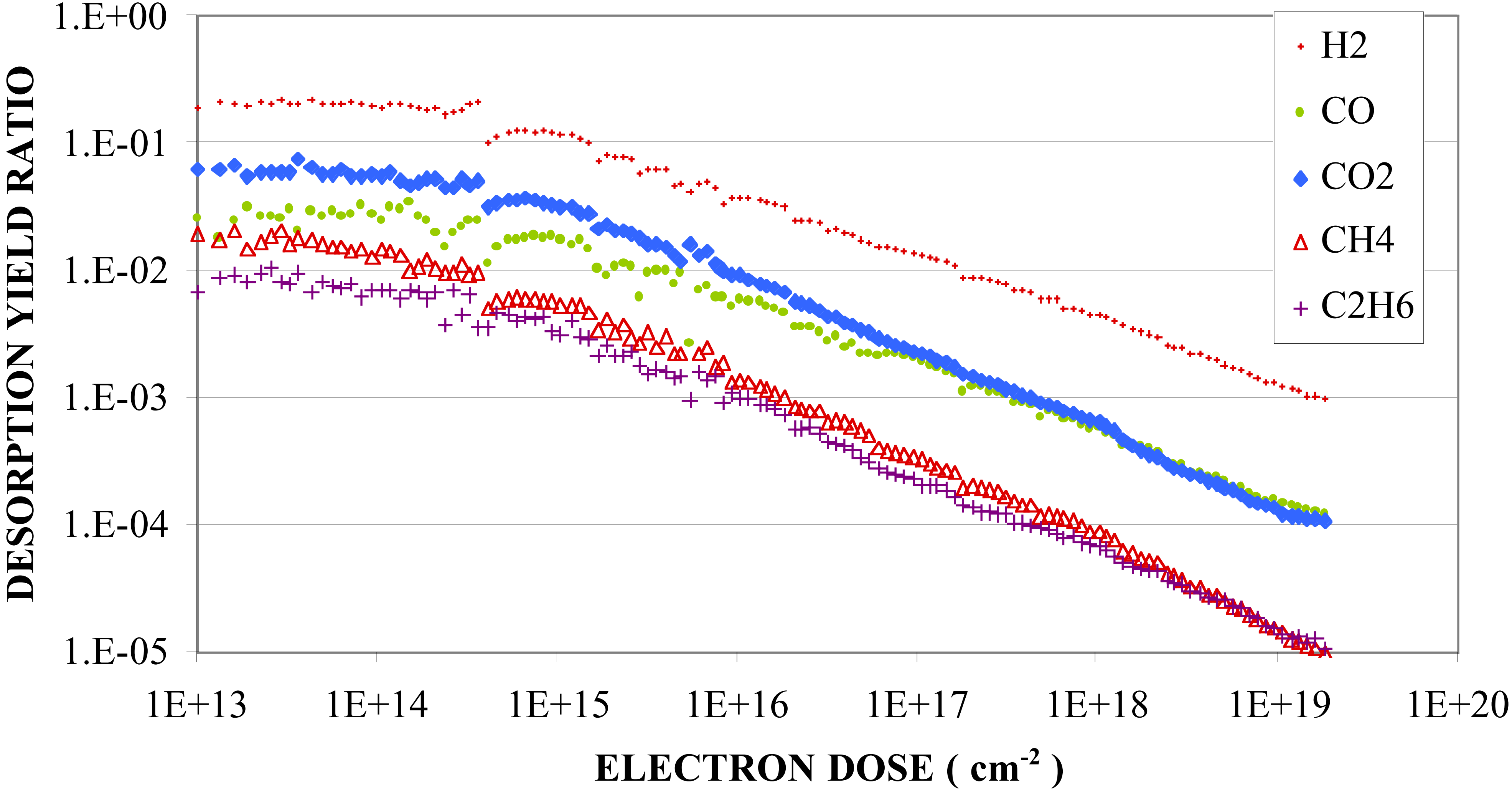

VARIATION OF THE MAXIMUM SECONDARY ELECTRON YIELD
WITH THE ELECTRON DOSE
SECONDARY ELECTRON YIELD
DOSE (C/mm2)
2.60
2.40
2.20
2.00
1.80
1.60
1.40
1.20
1.00
1.00E-08
1.00E-07
1.00E-06
1.00E-05
1.00E-04
1.00E-03
1.00E-02
DELTA MAX 23-03
DELTA MAX 31-01
ELECTRON GUN measured at 500 eV
DELTA MAX EPA 99V

CONDITIONING

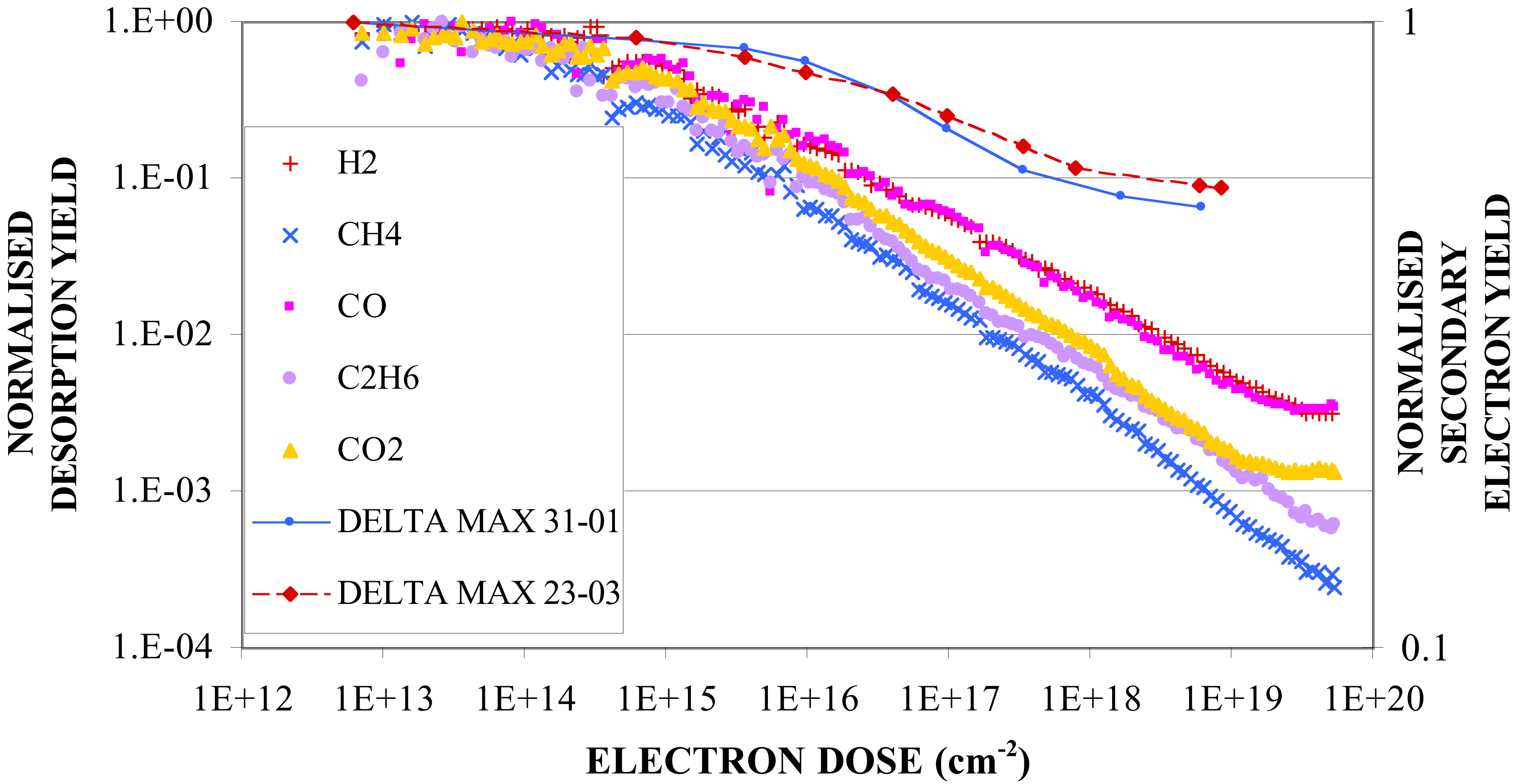
DESORPTION AND SECONDARY ELECTRON EMISSION



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)



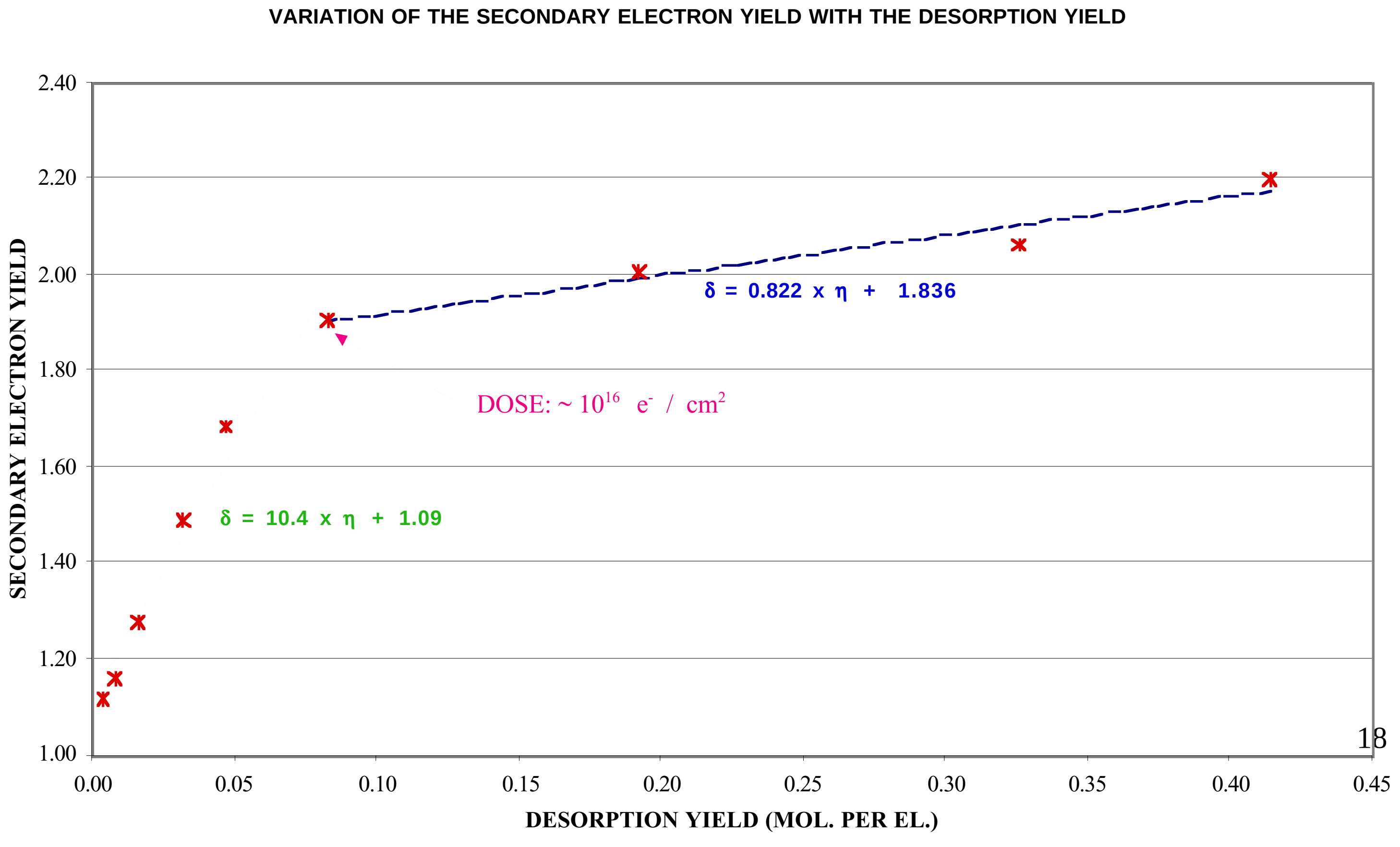
CONDITIONING

DESORPTION AND SECONDARY ELECTRON EMISSION

RELATIONS BETWEEN DESORPTION AND CONDITIONING

EASY OBSERVABLE IN ACCELERATOR : GAS FLUX (I.E. PRESSURE)

RELATION BETWEEN CONDITIONING AND GAS FLUX??



CONDITIONING

DESORPTION AND SECONDARY ELECTRON EMISSION

RELATIONS BETWEEN SecElectronEmission, FLUX AND CONDITIONING

Q gas flux:

$$Q = \eta \times I, \quad I \approx k \times \delta \Rightarrow Q \approx k \times \eta \times \delta$$

DOSE VARIATION VERSUS TIME:

$$D = I \times t \quad I \approx k \times \delta(D) \quad \Rightarrow D = k \times \delta(D) \times t$$

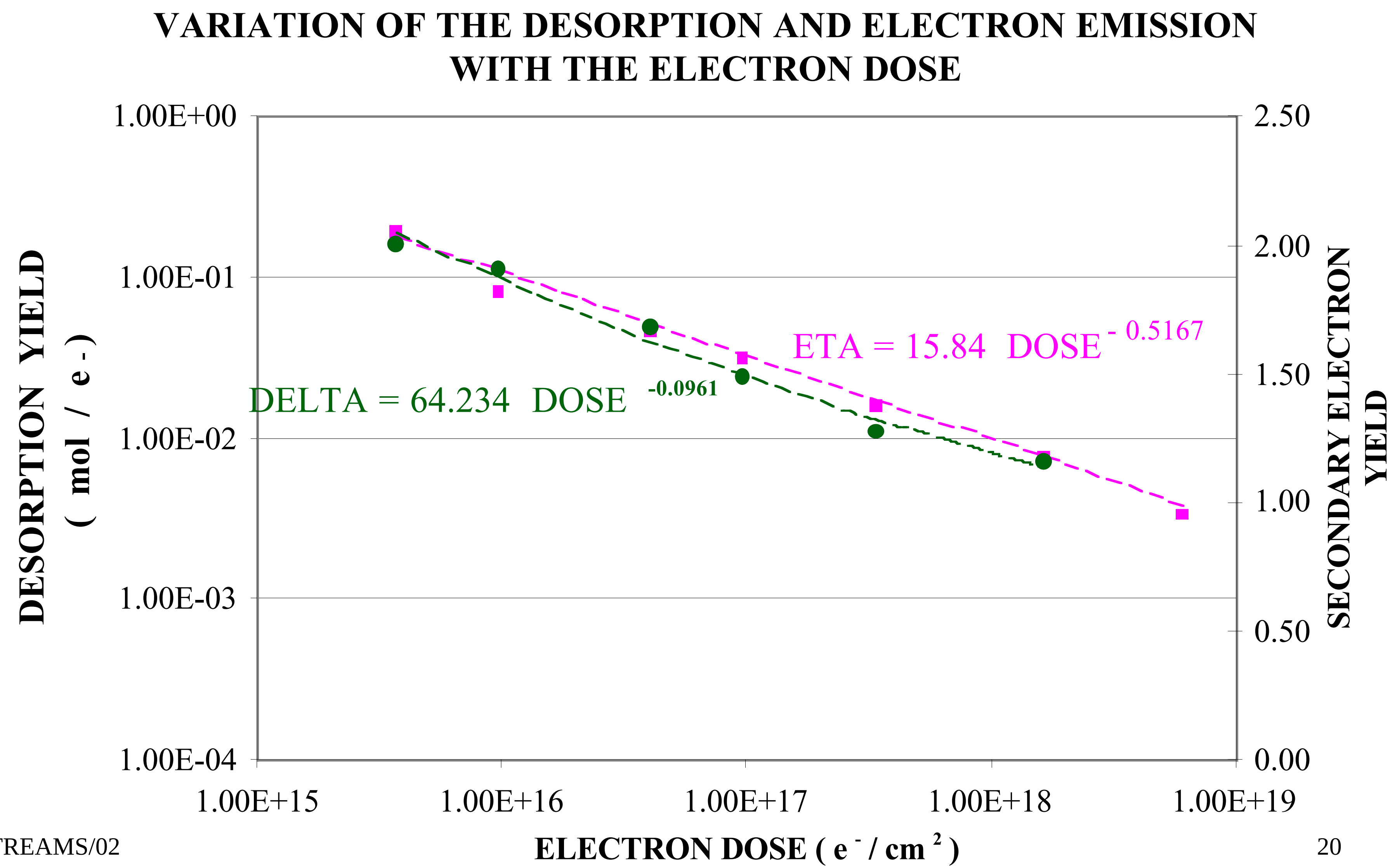
OVERSIMPLIFIED TO START,

POSSIBLE INFLUENCE OF PRESSURE ON e CLOUD CURRENT

*=>**FASTER** PROCESSING AS DESORPTION DECREASES ALSO WITH THE DOSE*

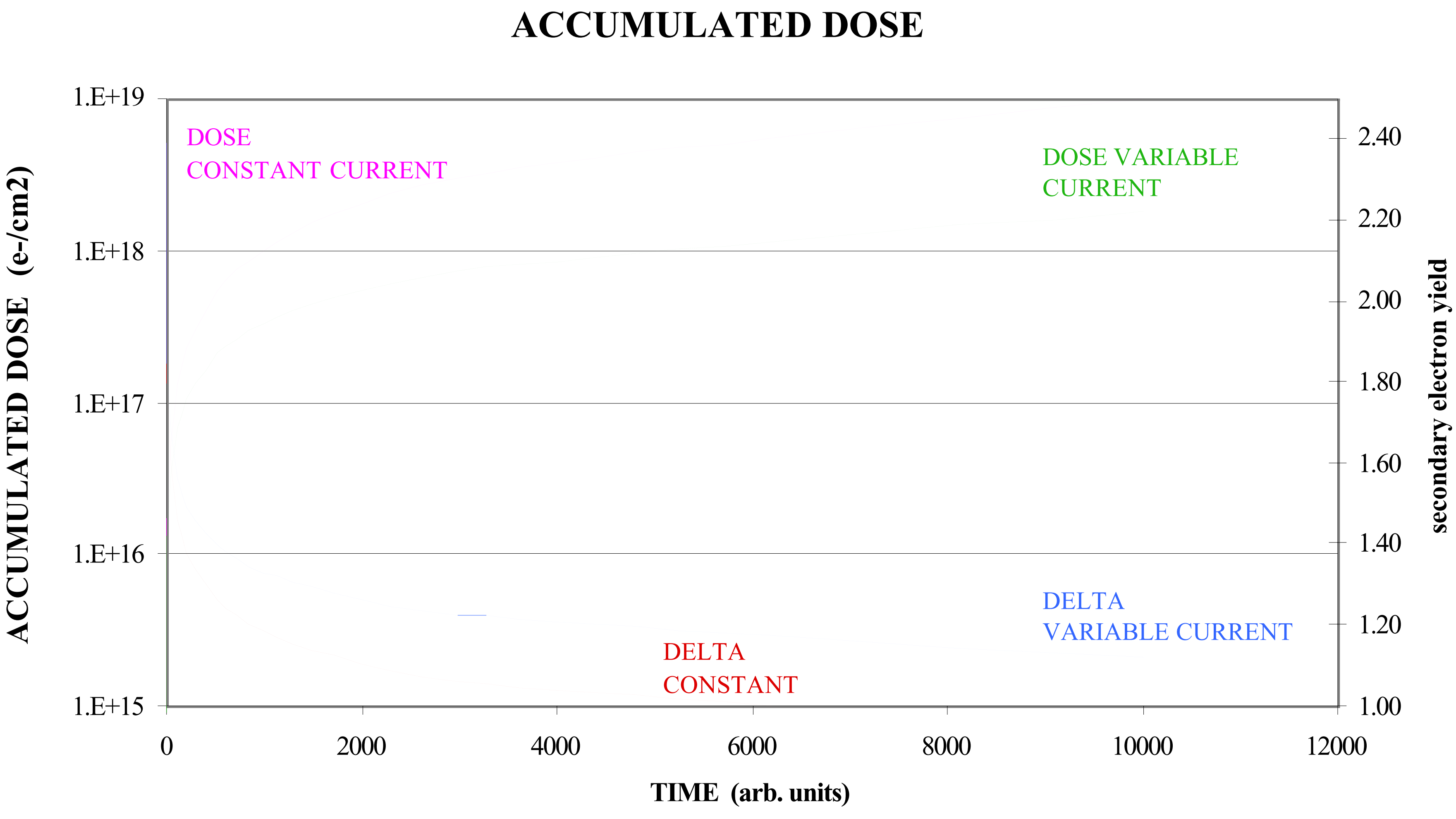
CONDITIONING

DESORPTION AND SECONDARY ELECTRON EMISSION



CONDITIONING

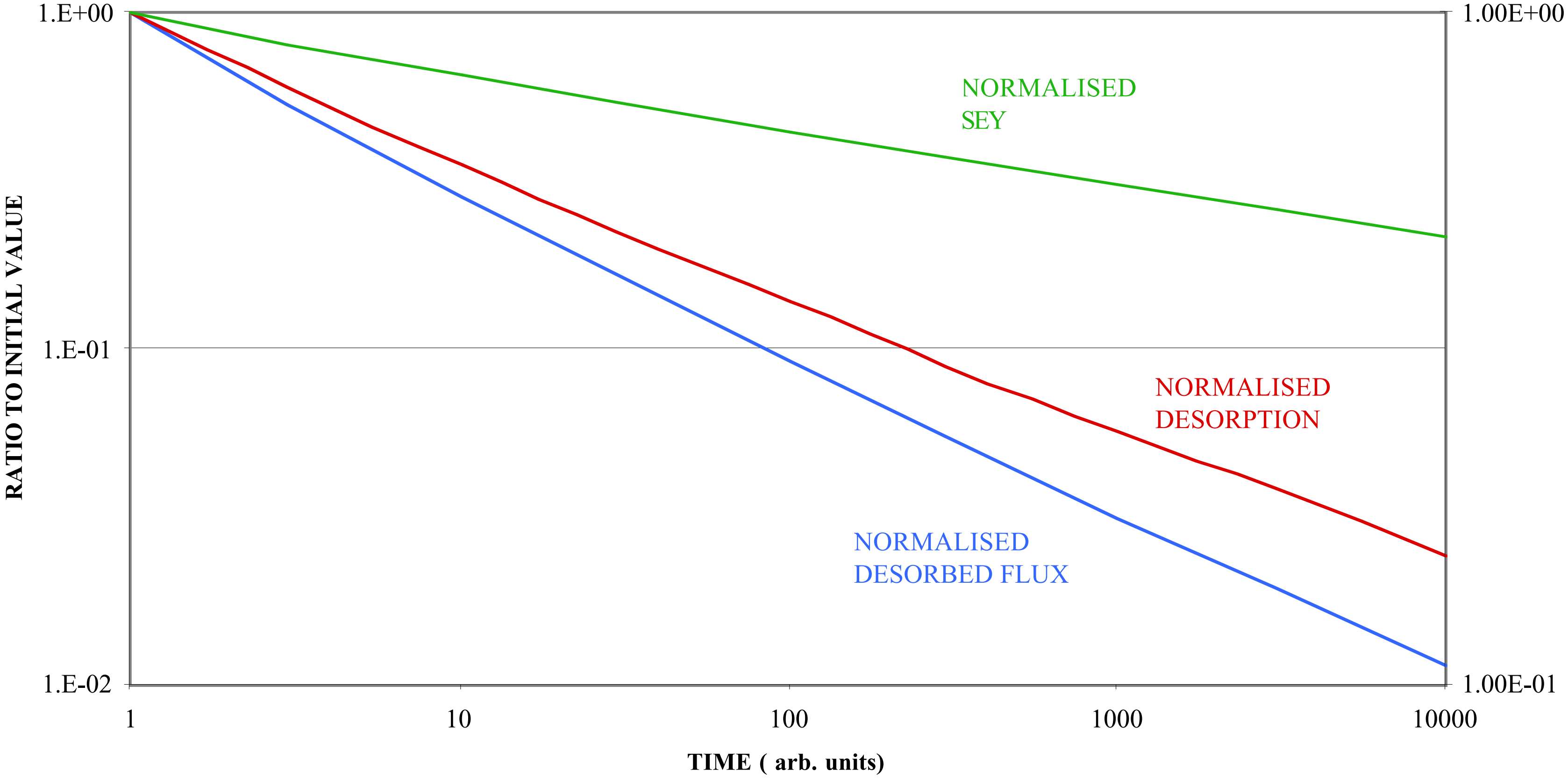
DESORPTION AND SECONDARY ELECTRON EMISSION



CONDITIONING

DESORPTION AND SECONDARY ELECTRON EMISSION

VARIATION OF SURFACES PROPERTIES WITH CONDITIONNING



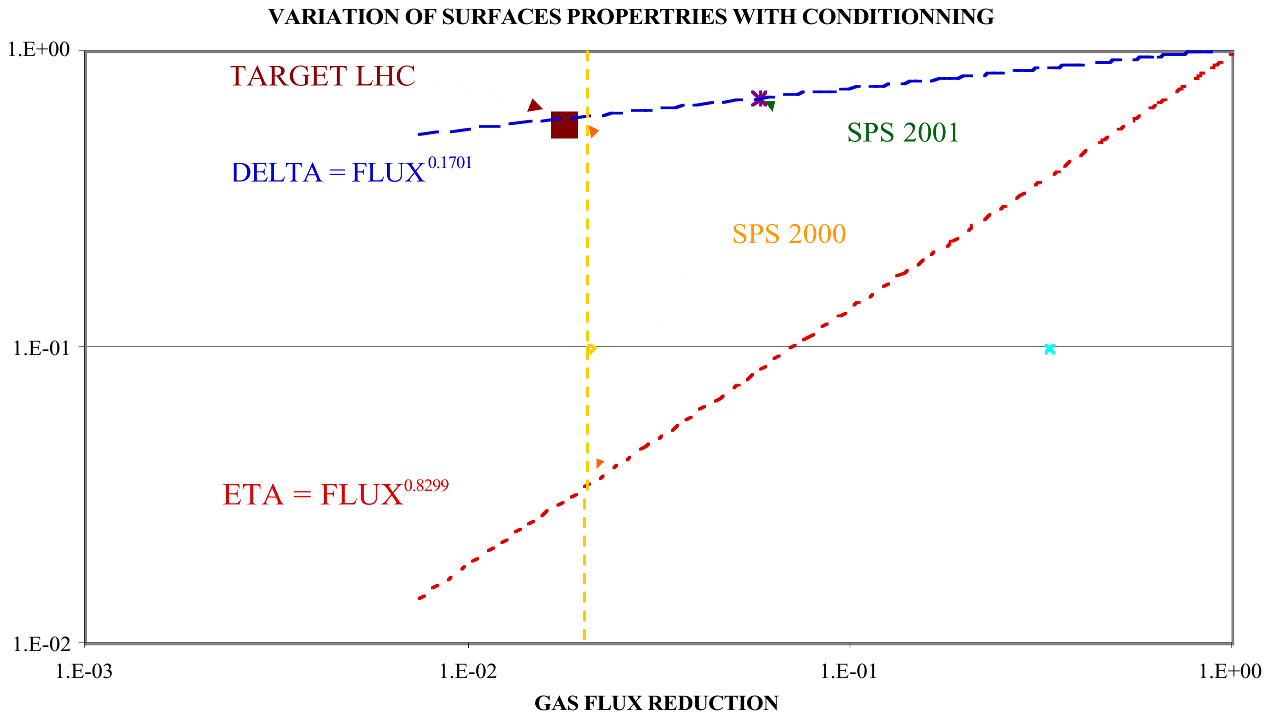
CONDITINNING

DESORPTION AND SECONDARY ELECTRON EMISSION

GAS FLUX PRESSURE IN ACCLERATORS

VARIATION OF FLUX ALLOW TO DEDUCE VARIATION OF ETA AND DELTA

ALLOW TO EXTRAPOLATE FROM SPS TOWARDS LHC



RELATION BETWEEN EL. CLOUD INTENSITY AND DELTA/ETA TO BE REFINED

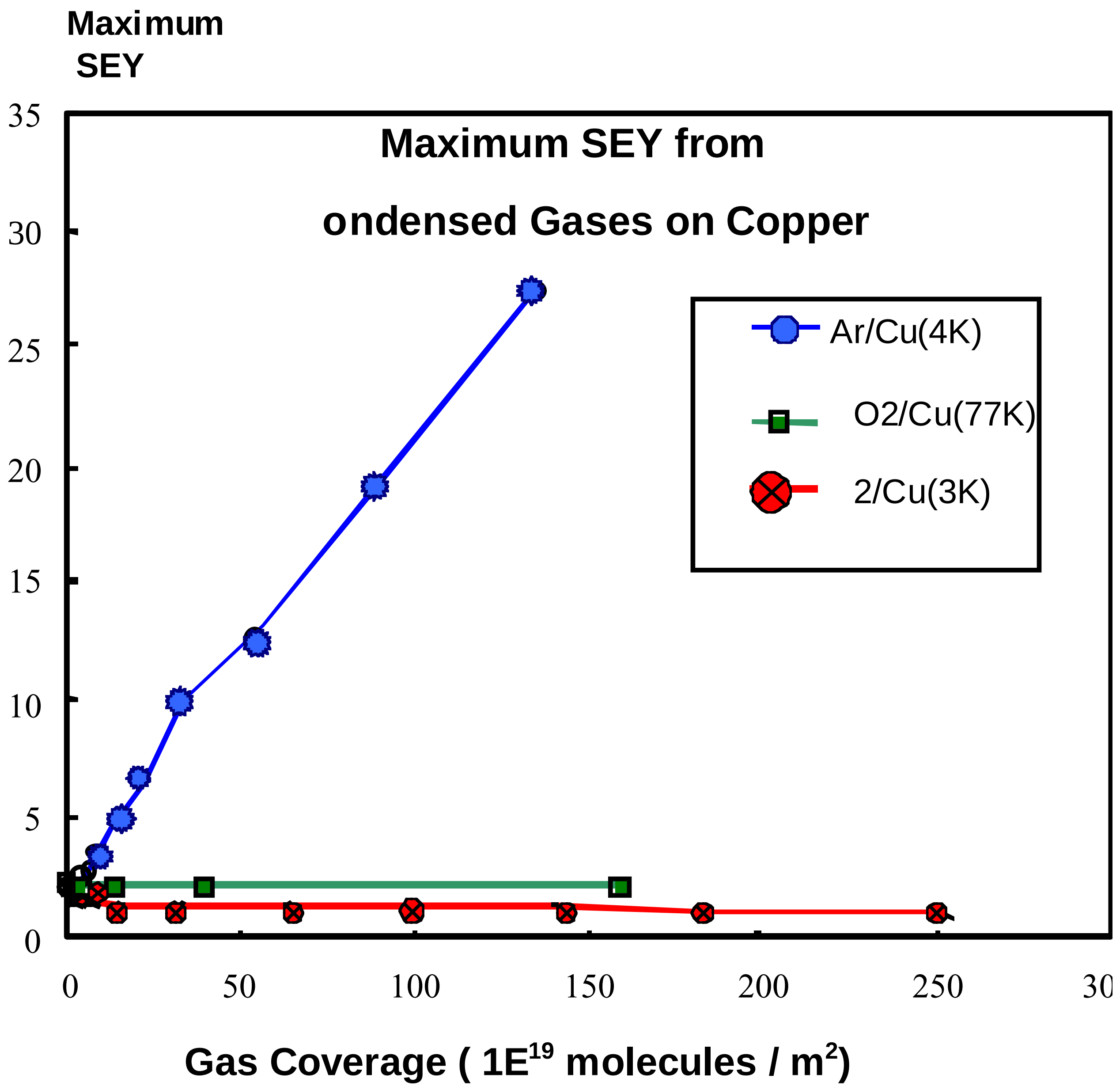
CONDENSED GASES

NO INFLUENCE FOR PRACTICAL COVERAGES

FOR NOBLE GASES

INSULATING

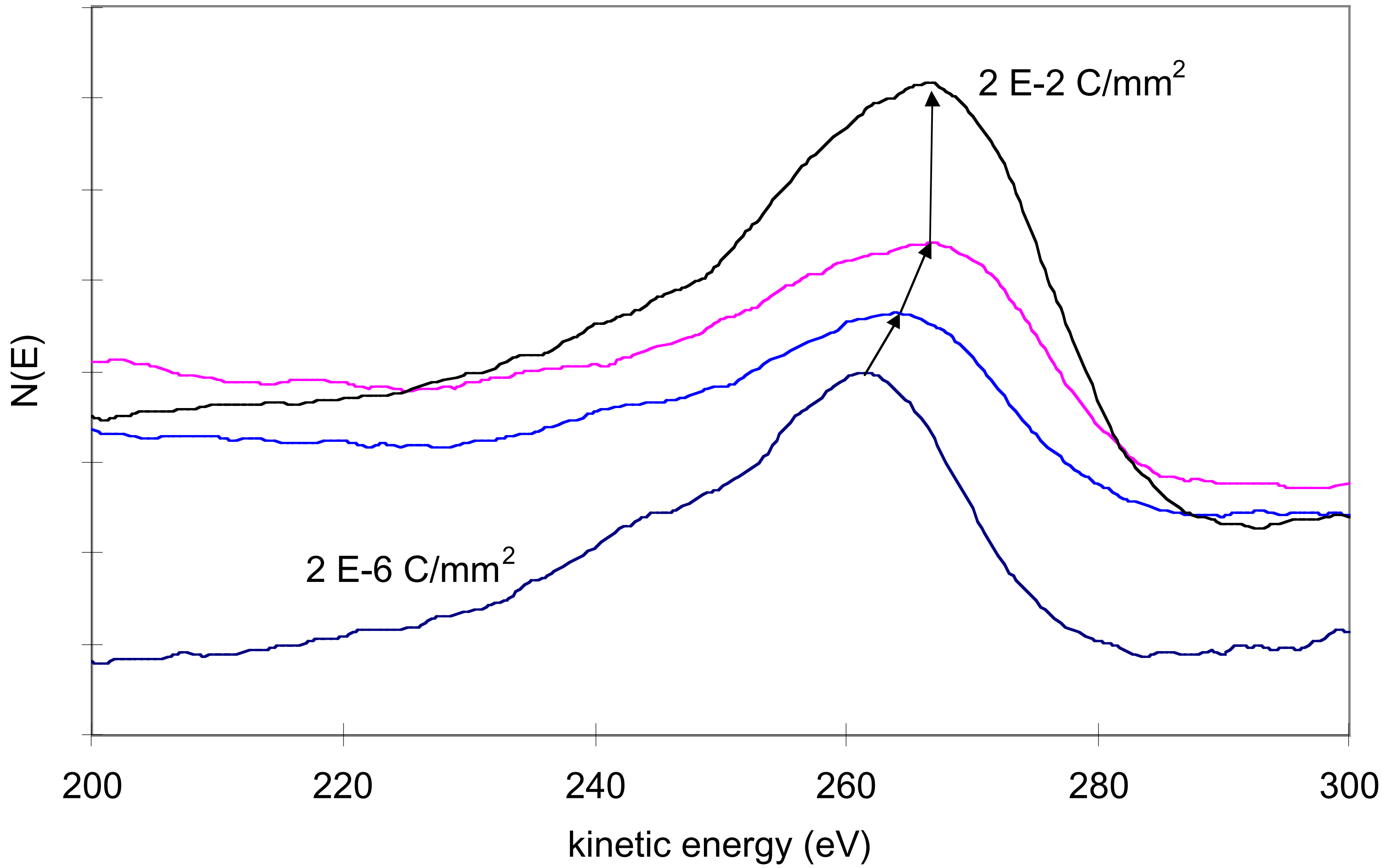
LARGE INCREASE



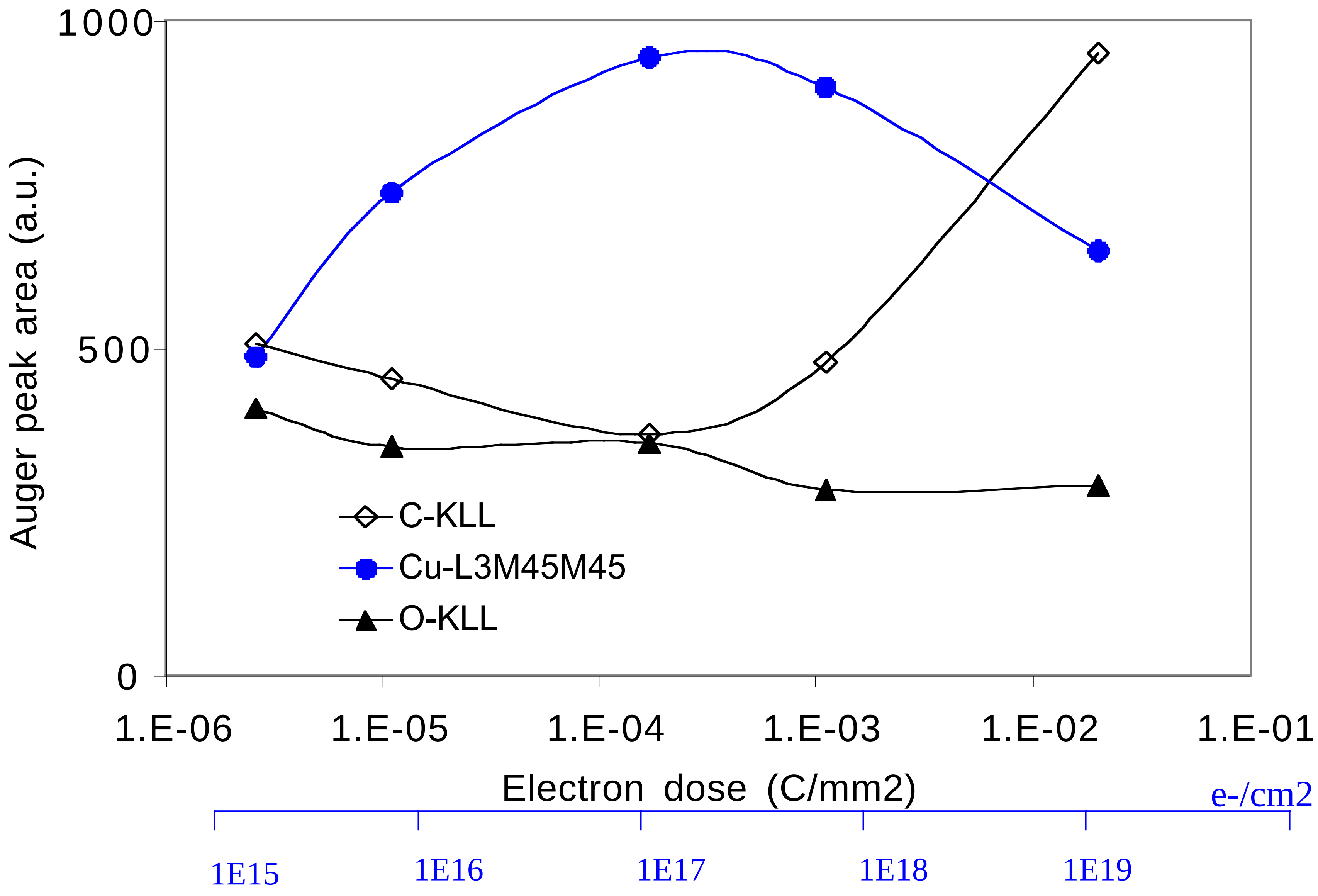
SURFACE MODIFICATIONS DURING CONDITIONING

SHIFT IN THE POSITION OF C-KLL PEAK =>

MODIFICATION OF THE CARBON CHEMICAL BOND NO SHIFT FOR OXYGEN



SURFACE MODIFICATIONS DURING CONDITIONING



SURFACE MODIFICATIONS DURING CONDITIONING

INITIAL DECREASE OF OXYGEN AND CARBON ON THE SURFACE (10^{17} e^-/cm^2)

SMALLER DECREASE FOR OXYGEN:

DESORPTION COMPENSATED BY MORE SIGNAL FROM OXIDE

MAXIMUM COPPER PEAK FOR A DOSE ~ 10^{17} e^-/cm^2

DESORPTION MEASUREMENTS =>$6x10^{15}$ mol/cm^2 RELEASED FOR THIS DOSE

FOR HIGHER DOSES CARBON PEAK INCREASES

EXPERIMENTS AT VARIABLE PARTIAL PRESSURES OF CO, CH_4

=> NO INFLUENCE ON THE DOSE DEPENDENCE

ORIGIN OF THE CARBON??? STILL A QUESTION

CONDITIONING:=> INITIAL CLEANING FOLLOWED BY CARBON LAYER BUILD UP

CONCLUSIONS

*IMPORTANCE OF THE **CORRECTION FOR REFLECTED ELECTRONS** WHEN **VERY LOW INCIDENT ENERGY** IMPORTANT IN SIMULATIONS*

FORMULAE GIVEN FOR : YIELD AND ENERGY DISTRIBUTION

*USUAL **CONDENSED GASES** HAVE **LITTLE EFFECT** ON THE SECONDARY ELECTRON YIELD EXCEPTION : NOBLE GASES AT THICK COVERAGES*

DESORPTION AND CONDITIONING PARALLEL PHENOMENA:

***GAS FLUX VARIATION** IS A **GOOD INDICATOR** OF THE CONDITIONING PROCESS*

*SUBTLE **CHANGES** IN THE **SURFACE COMPOSITION** PARALLEL (AT THE ORIGIN OF} **CONDITIONING***

FORMULA AVAILABLE FOR SIMULATIONS :

RECONDITIONING *AFTER AIR EXPOSURE IS*