Analysis of electron stimulated electron emission spectra from LHC beam screen material

Ian R. Collins
LHC/CERN

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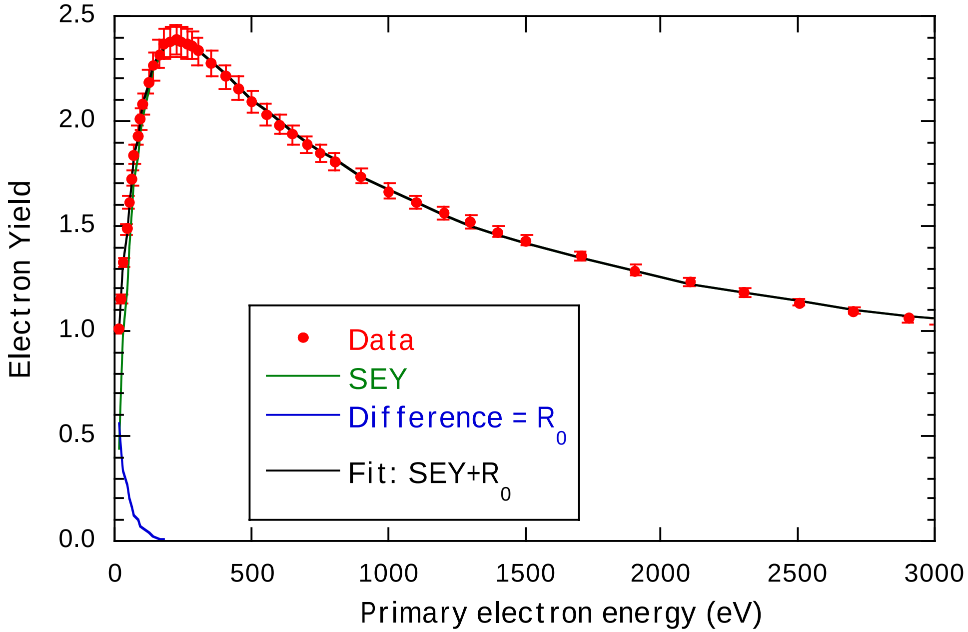
1. Introduction

- ➢ Miguel Furman first identified that reflected electrons could increase (x2.5) final LHC heat loads on the beam screen cryogenic circuit [1].

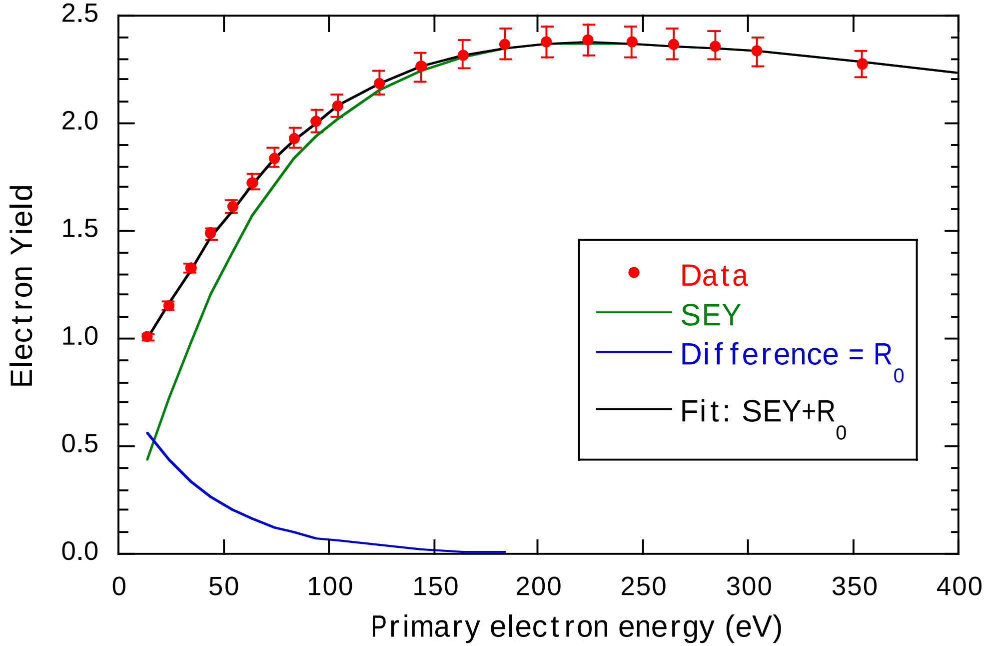
- ➢ More recent [2,3] simulations have shown a significant contribution to the LHC beam screen heat load due to reflected electrons and that they affect the electron-cloud rise and decay times

⇨ Re-study low energy component of SEY spectra

[1] Miguel Furman, “ The electron-cloud effect in the arcs of the LHC” LHC Project Report 180 (1998)
[2] Mauro Pivi and Miguel Furman, PAC 2001
[3] Frank Zimmermann, Chamonix XI workshop 2001



Data
SEY
Difference = R0
Fit: SEY+R0
Electron Yield
Primary electron energy (eV)



Data
SEY
Difference = R0
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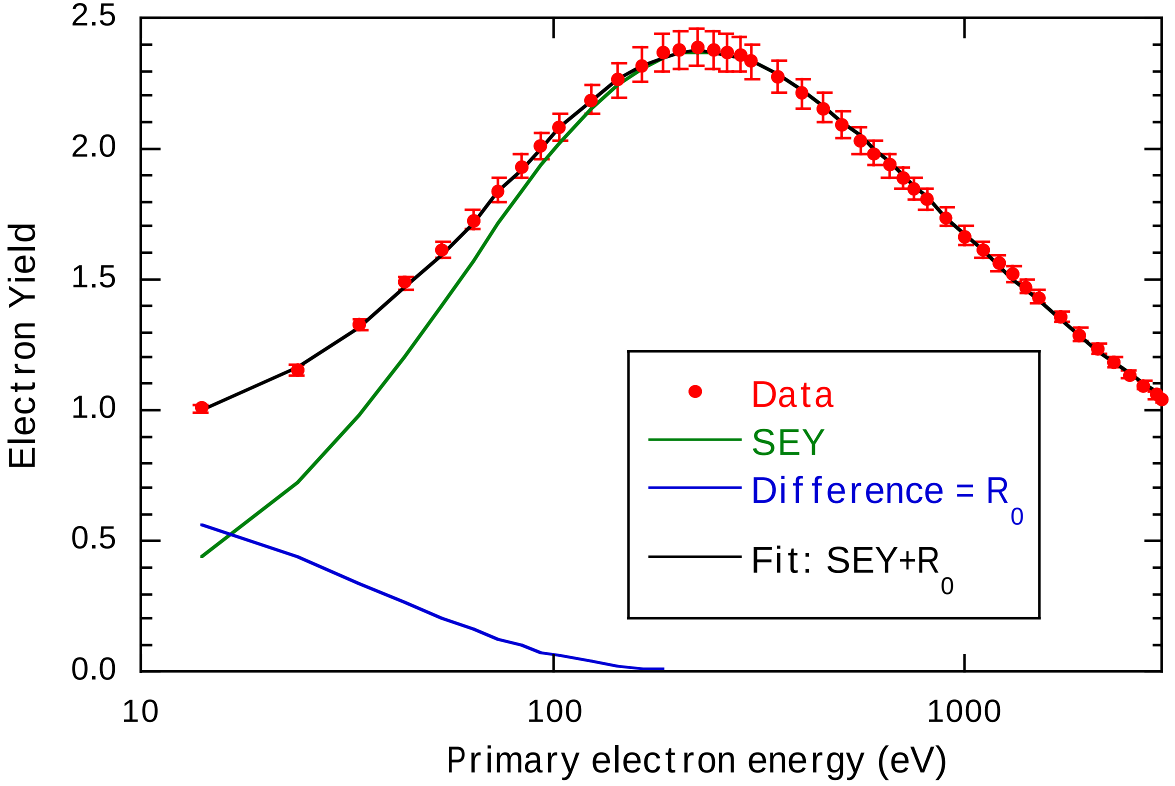
Electron Yield
Primary electron energy (eV)


2.5
2.0
1.5
1.0
0.5
0.0
10
100
1000
Electron Yield
Primary electron energy (eV)
Data
SEY
Difference = R0
Fit: SEY+R0

Objectives of analysis:

- Determine magnitude of the reflected component.
- Obtain an empirical fit to the experimental data and parameterise changes with electron conditioning that may be used in simulations.

2. Analysis

SEY data taken were from LHC beam screen material (Cu co-laminated stainless steel) at room temperature on a SR beamline (EPA at CERN) [4]. Generated photoelectrons were accelerating onto the sample to condition ('scrub') with electrons.

- Quantitative results from nine as-received samples and four electron dosed samples (10.4 mC/mm^2)

- Qualitative results by monitoring changes with electron dose from one sample (+44eV).

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[4] Vincent Baglin *et al*., Chamonix XI workshop 2001

Performed χ^2 fitting (assuming 1% error on the measured currents) using:

- simple description for SEY :

$$\delta_{max} \times \left[\frac{s \times \left(\frac{E}{E_{max}} \right)}{s - 1 + \left(\frac{E}{E_{max}} \right)^s} \right]$$

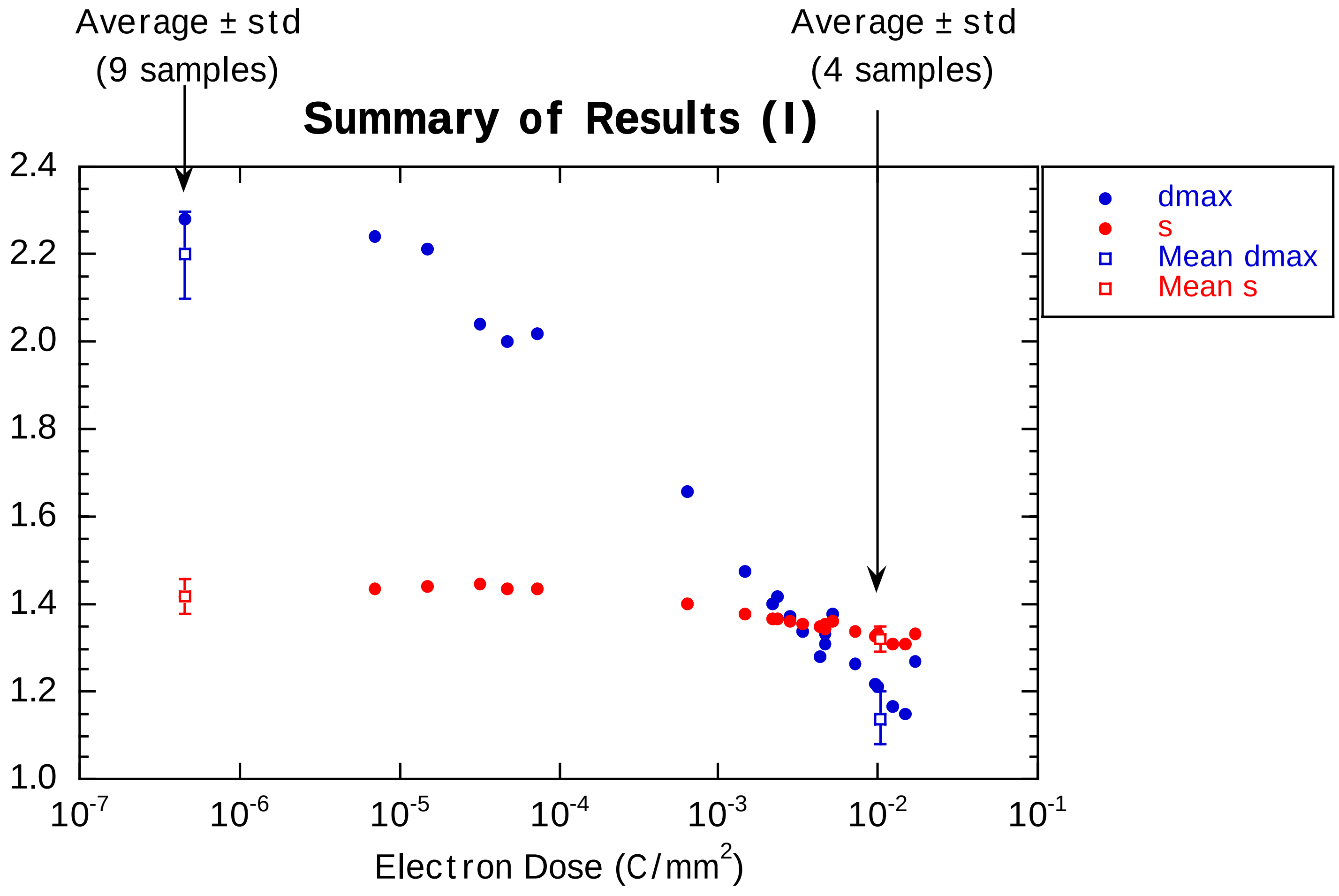
(d_{max}, s, E_{max}) – affects mainly high energy region of the spectrum

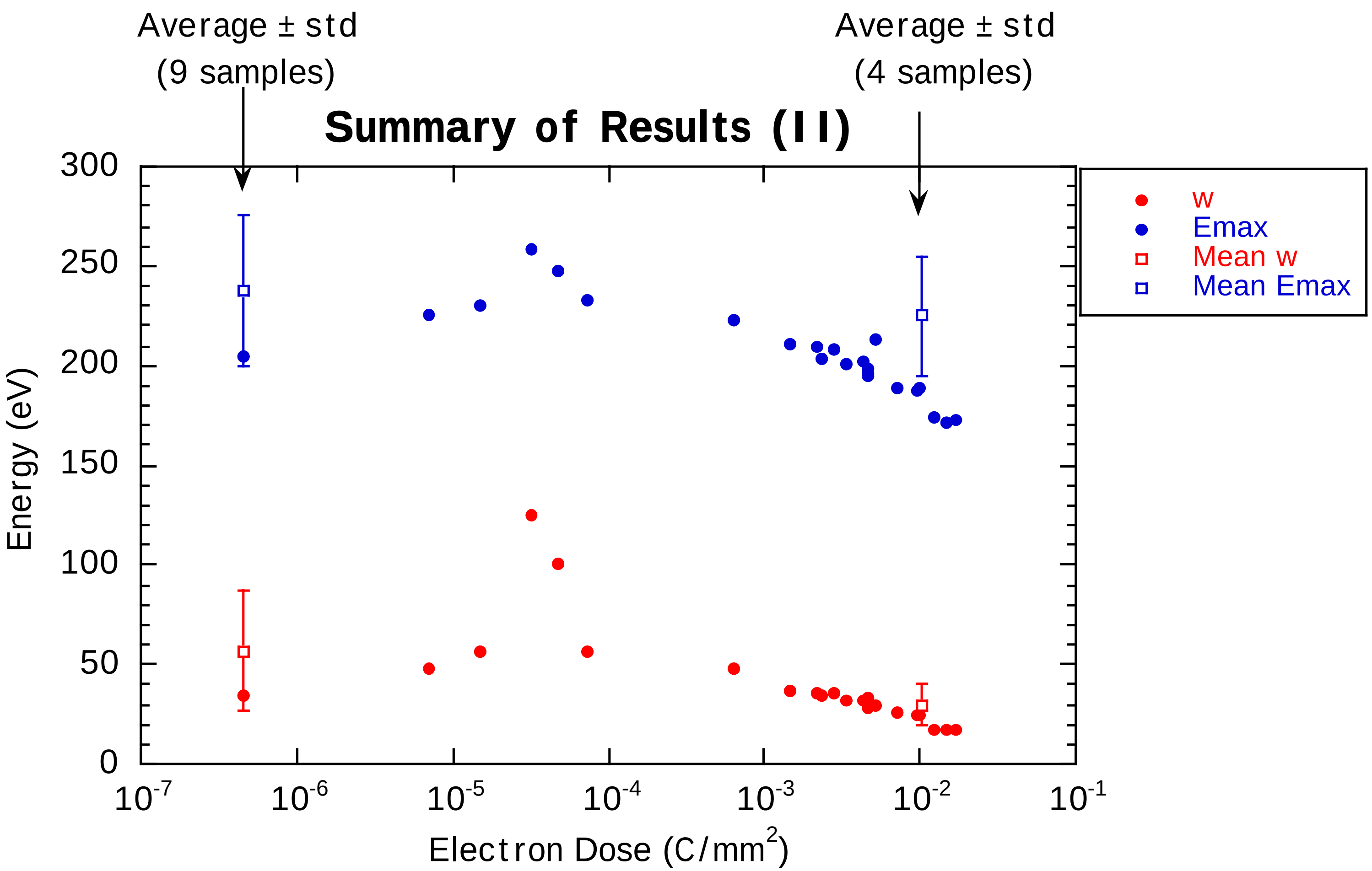
- and exponential for reflected component

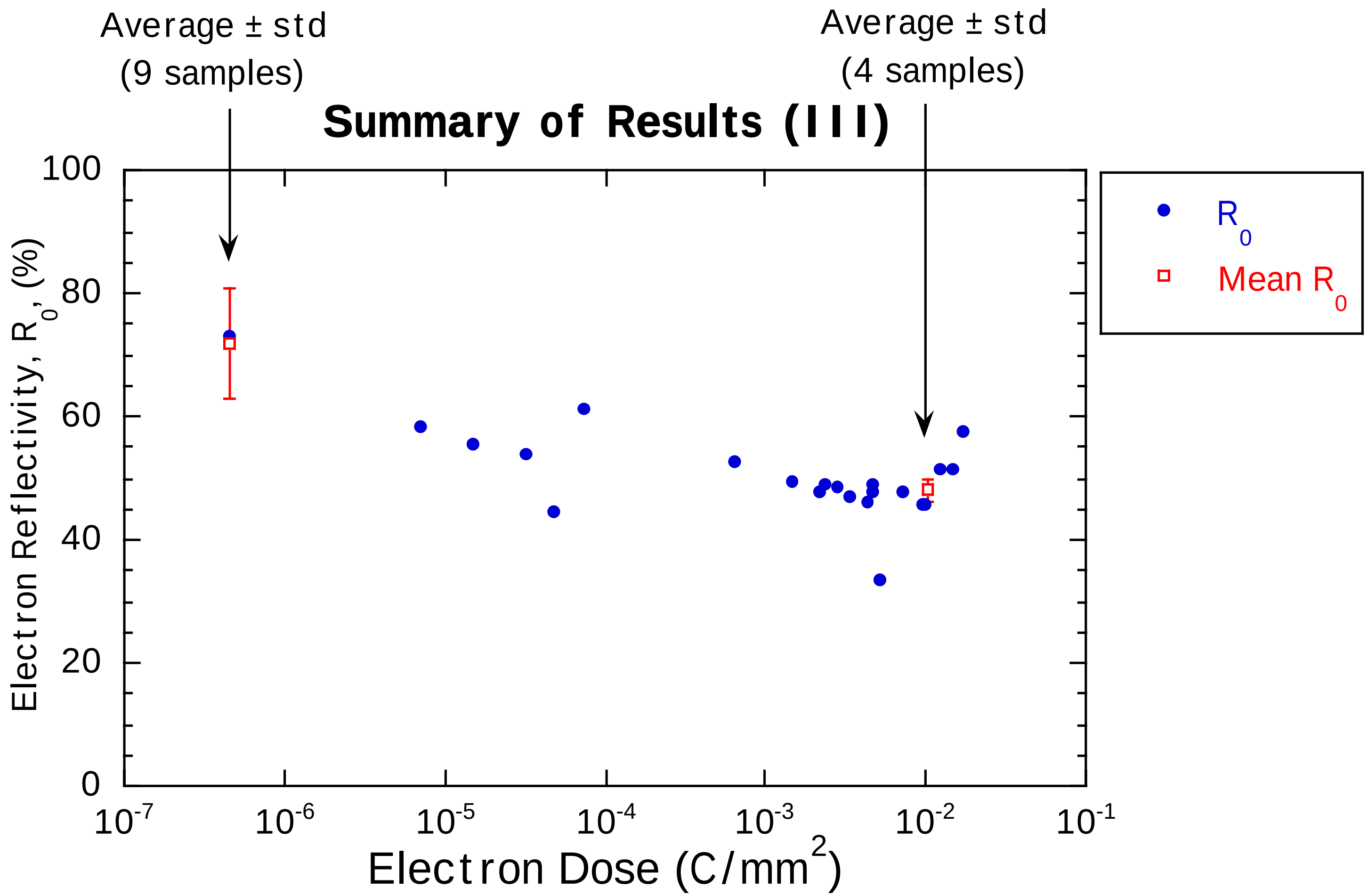
$$R_0 \times \exp\left(-\frac{E}{w} \right)$$

(R_0, w) – affects mainly low energy part of the spectrum

3. Results


Average ± std
(9 samples)
Average ± std
(4 samples)
Summary of Results (I)
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
10-7
10-6
10-5
10-4
10-3
10-2
10-1
Electron Dose (C/mm2)
dmax
s
Mean dmax
Mean s


Average ± std
(9 samples)
Average ± std
(4 samples)
Summary of Results (II)
300
250
200
150
100
50
0
Energy (eV)
10-7
10-6
10-5
10-4
10-3
10-2
10-1
Electron Dose (C/mm2)
w
Emax
Mean w
Mean Emax



Average ± std
(9 samples)
Average ± std
(4 samples)
Summary of Results (III)
100
80
60
40
20
0
Electron Reflectivity, R0, (%)
10-7
10-6
10-5
10-4
10-3
10-2
10-1
Electron Dose (C/mm2)
R0
Mean R0

Summary

	Mean ± standard deviation				
Parameter	s	R_0 (%)	w (eV)	d_{max}	E_{max} (eV)
Initial	1.42 ± 0.04	72 ± 9	57 ± 30	2.2 ± 0.1	238 ± 38
Conditioned	1.32 ± 0.03	48 ± 2	30 ± 10	1.14 ± 0.06	225 ± 30

☺ This analysis is consistent with preliminary Energy Distribution Curves (EDC) [5]

☺ Such a parameterisation has been used in simulations for the SPS where improved agreement with observation has been obtained.

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[5] R.E.Kirby, private communication

4. Future directions

- Measure EDC of electron emission at between 5 and 20K (the beam screen operating temperature) to:
  - i) determine directly the relate contributions to the electron emission spectrum (including diffuse electrons),
  - ii) quantify electron conditioning

- Identify *ex-situ* treatments (pre-cleaning, air baking *etc.*) that may improve *in–situ* conditioning.

5. Conclusions

- ☺ Electron conditioning only affects the maximum of the SEY (2.2 ± 0.1 to 1.14 ± 0.06) and the reflection probability of the primary electrons, (72 ± 9) % to (48 ± 2) %. The other fitting parameters (curve shape, energy at the SEY maximum, and width of reflected component) remain essentially unchanged.

- ☺ EDC are required to quantify directly the contributions to the electron emission spectra.

6. Acknowledgements

Vincent Baglin is thanked for providing the raw data for analysis.