Photoelectron Spectroscopy

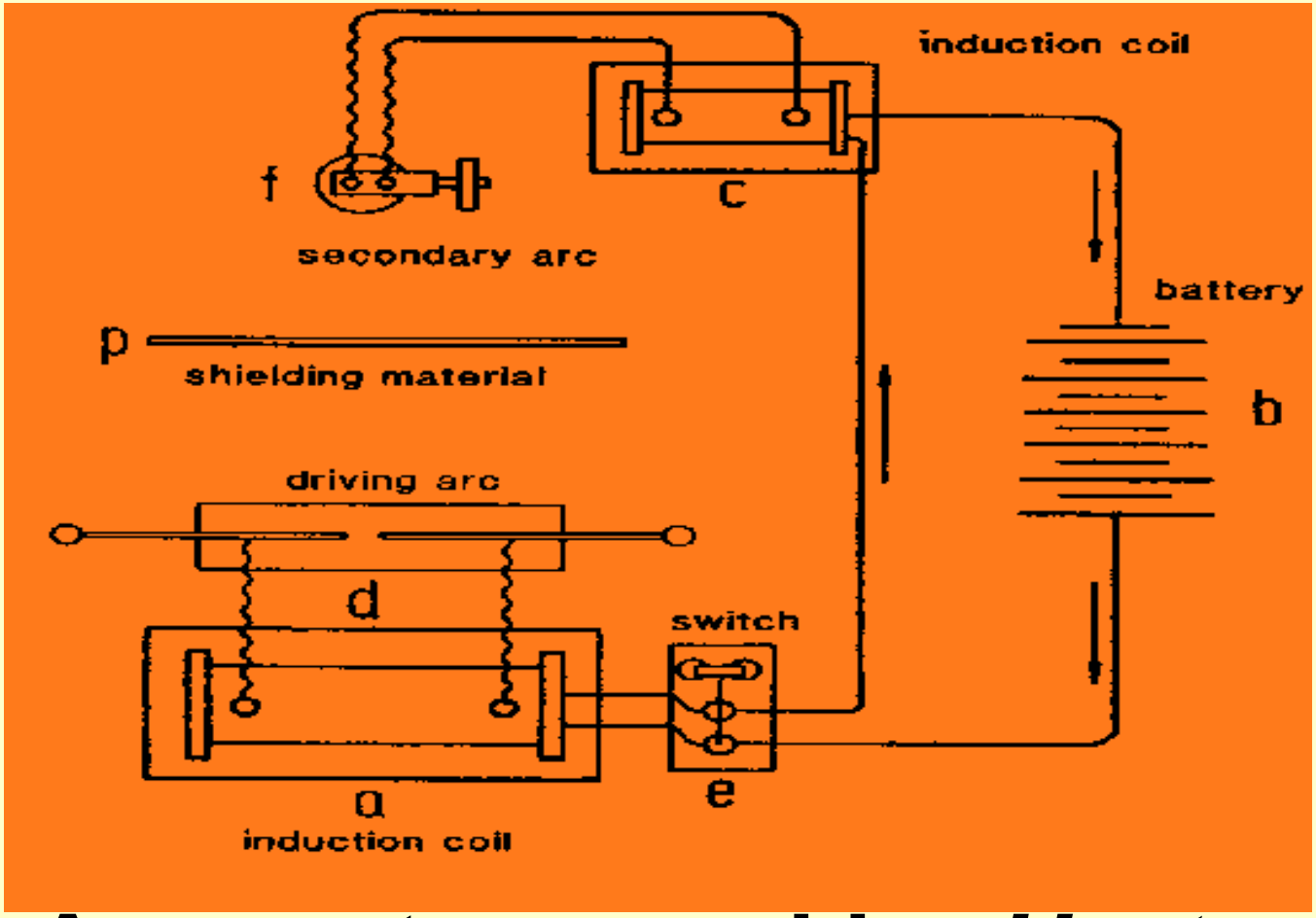
History

Instrumentation

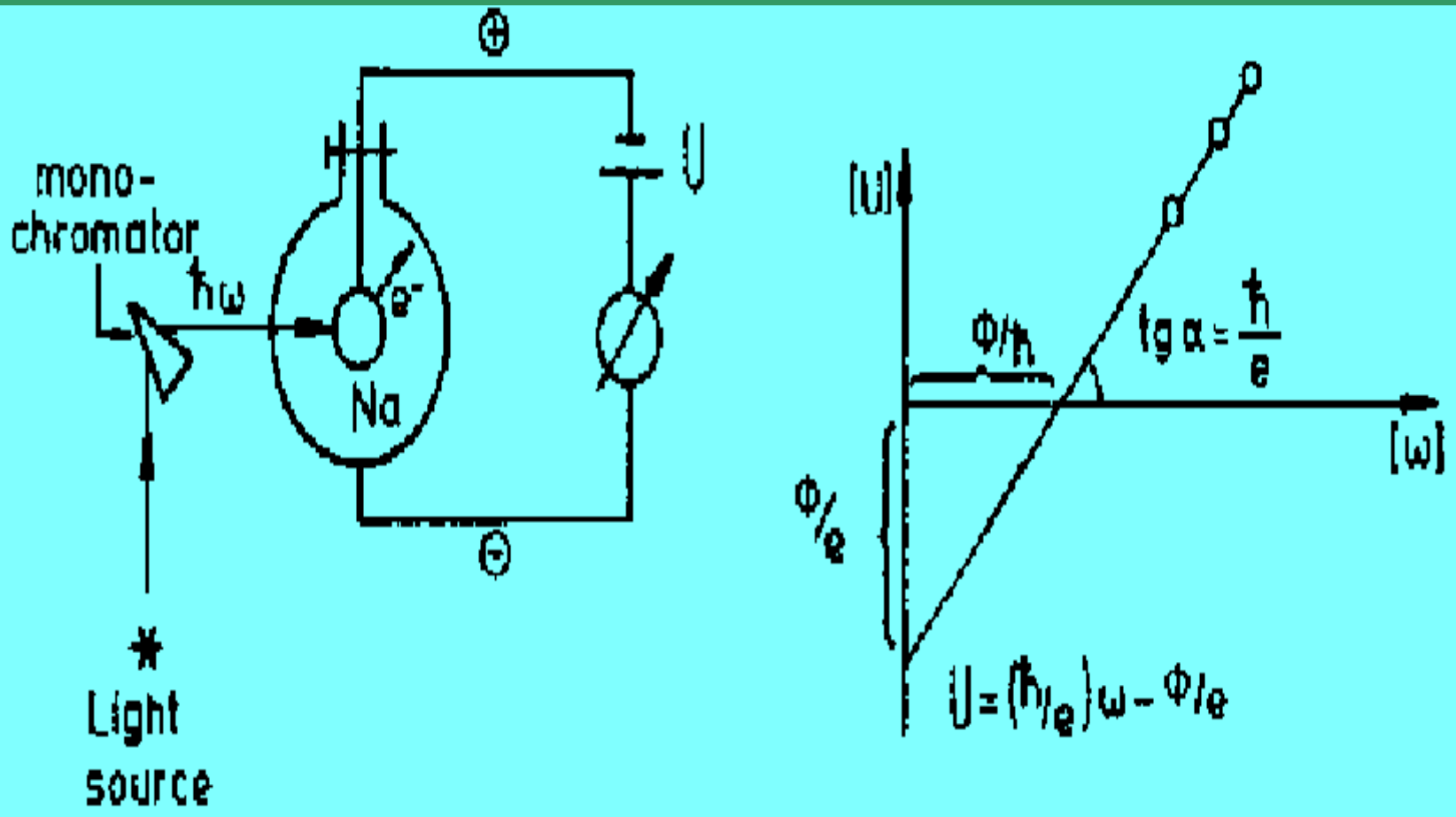
Data Analysis

Measurement Details

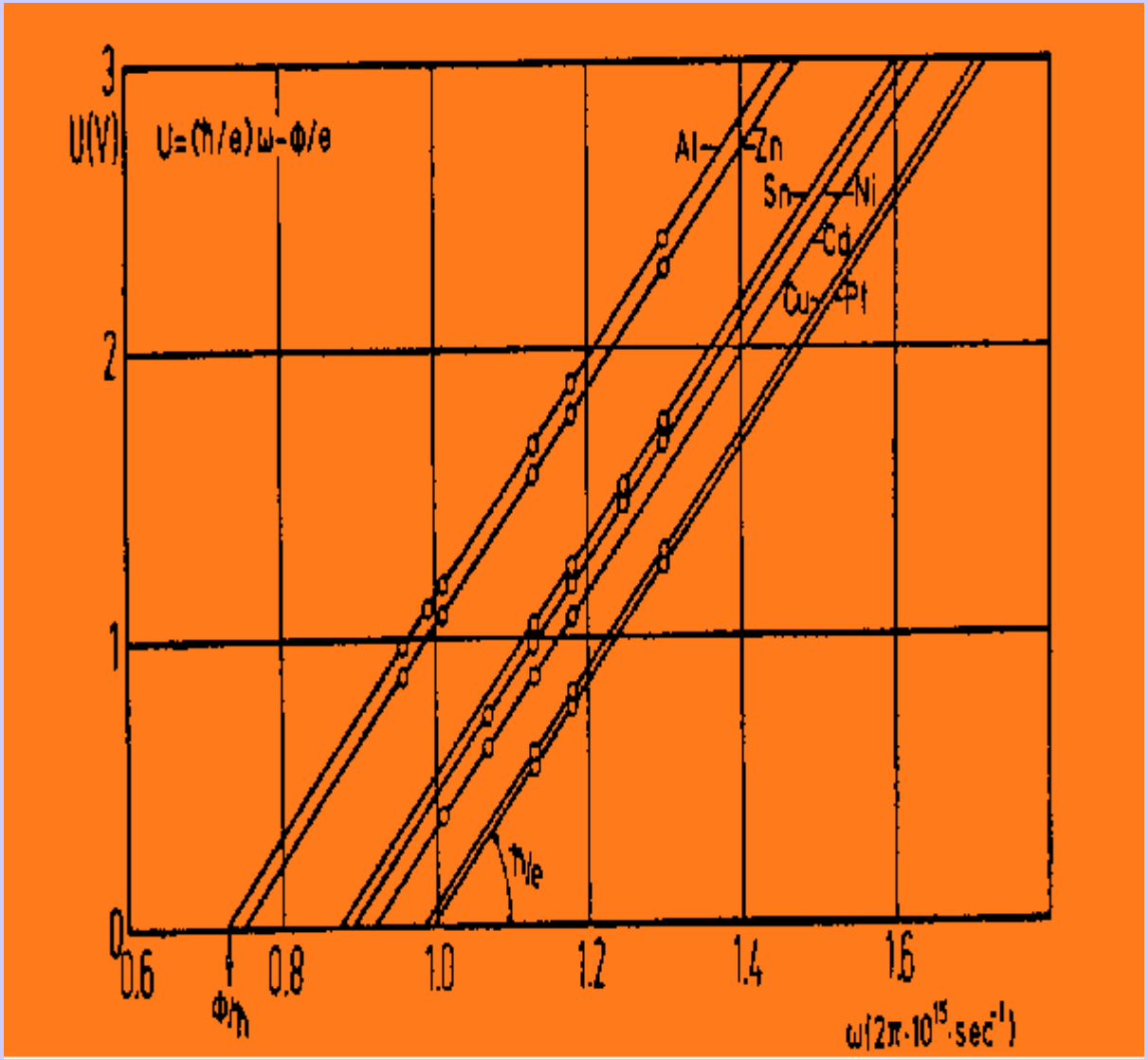
History



Apparatus used by *Hertz* for his "discovery" of the photoelectric effect (from S. Hüfner).



Plot of the retarding voltage, U needed
o make the current disappear with ω is
a straight line (from S. Hüfner).

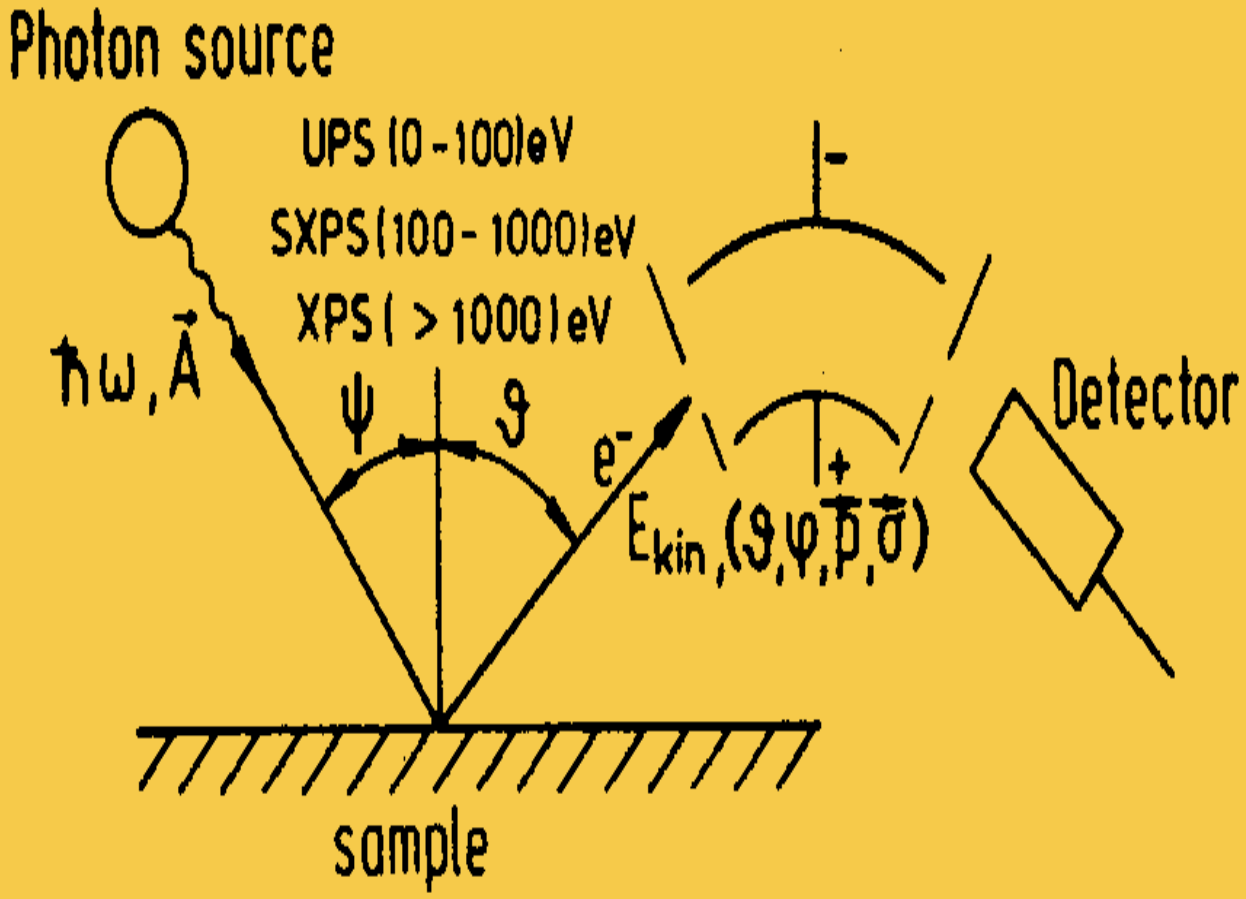


U vs. ω for a number of metals (from S. Hüfner).

Instrumentation

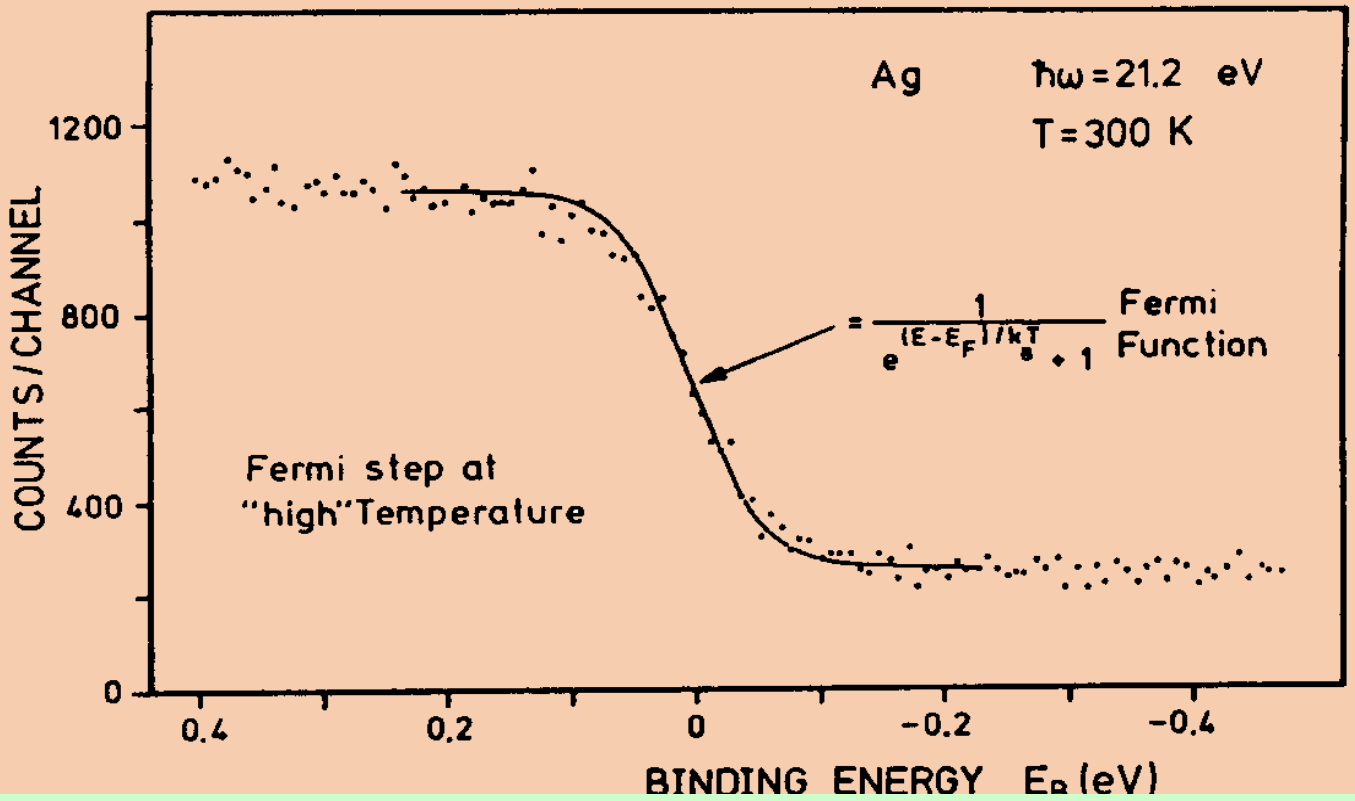
Components of a Spectrometer

- **Ultrahigh vacuum (UHV)**
- **Photon source**
- **Sample**
- **Electron energy analyser**
- **Electron detector**
- **Data recording, processing and output system**

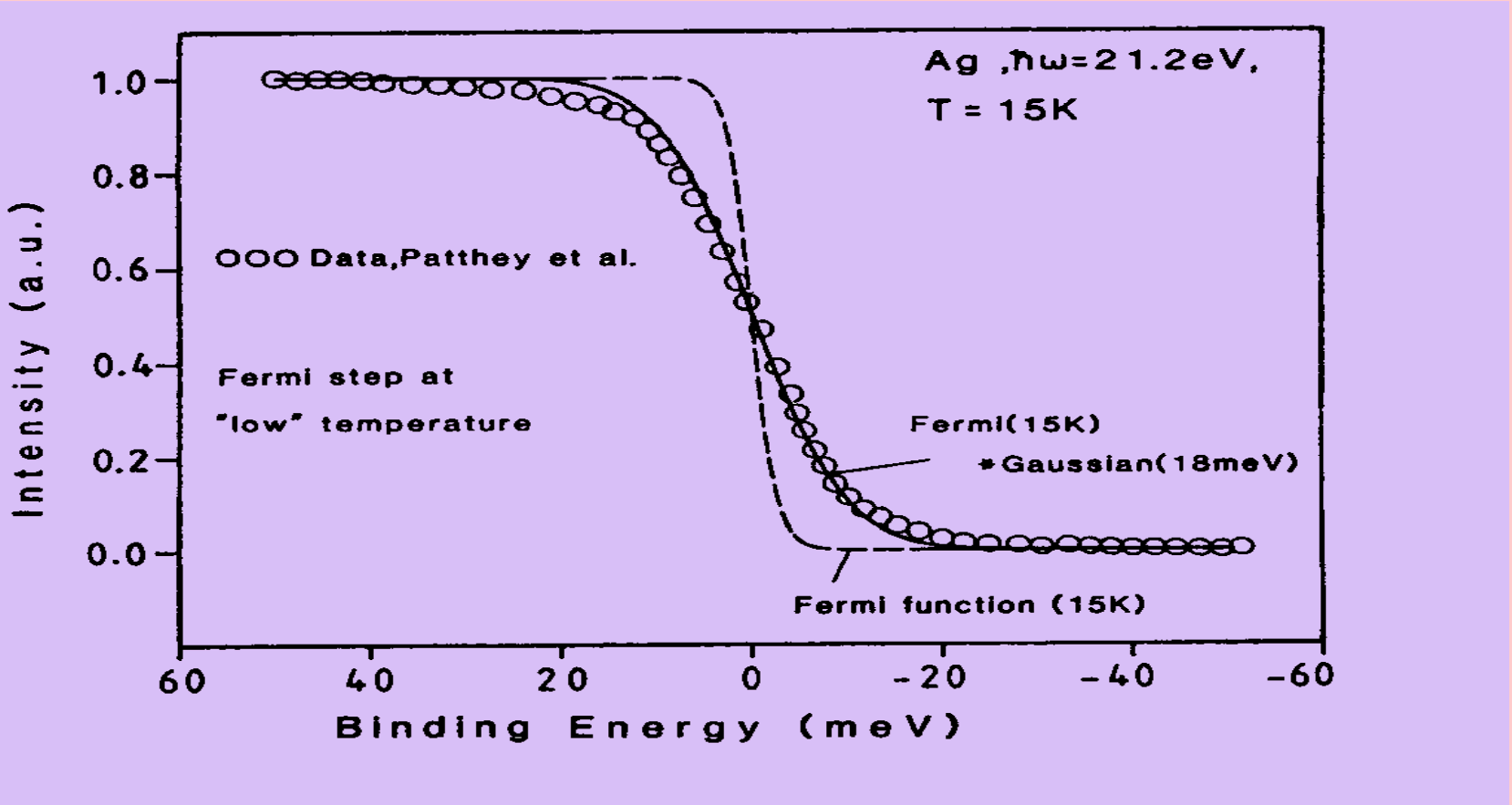


A modern PES instrument

(from S. Hüfner).

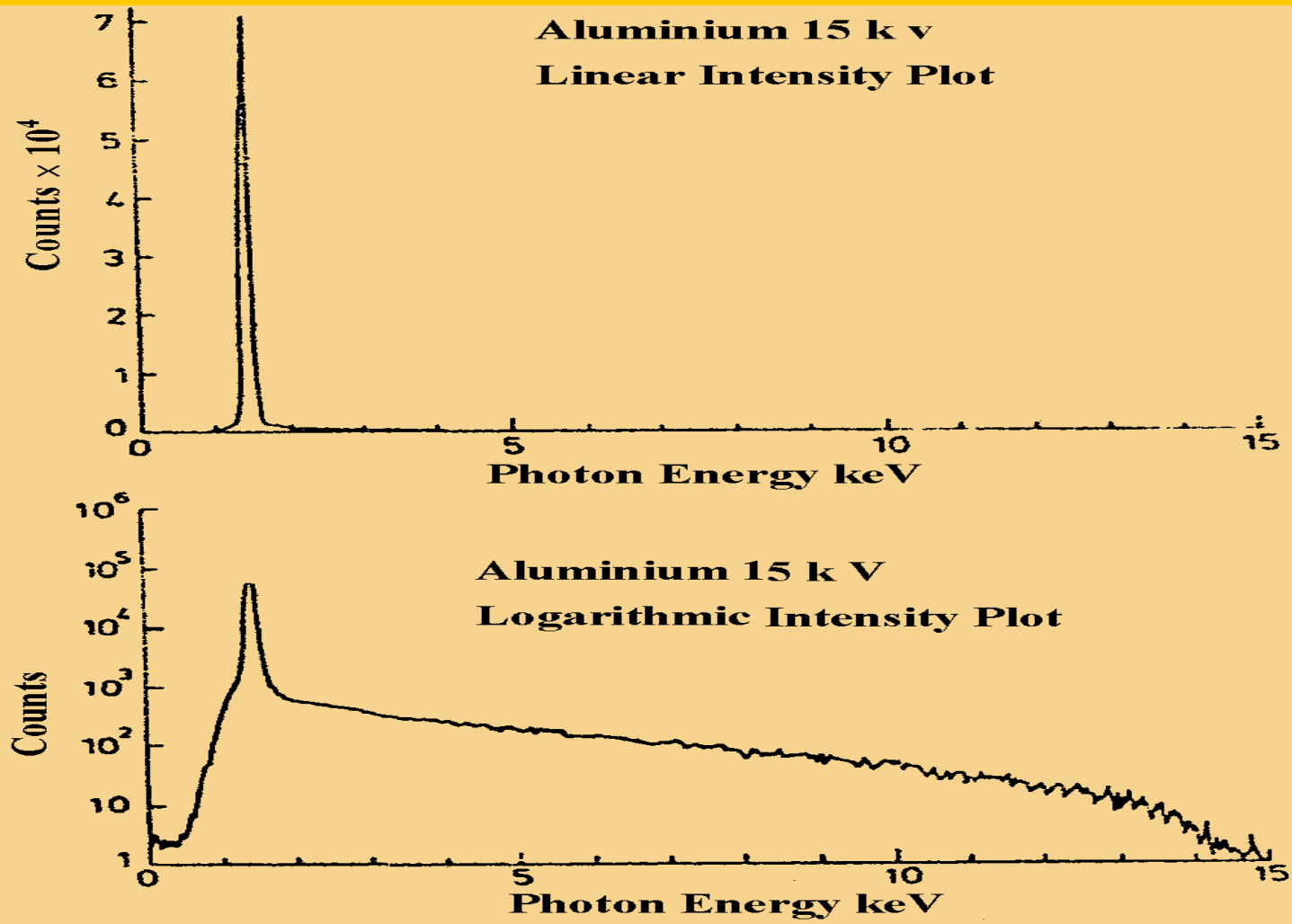


EDC around E_F in an UPS spectrum of Ag. Solid line is the Fermi function at RT (from S. Hüfner).

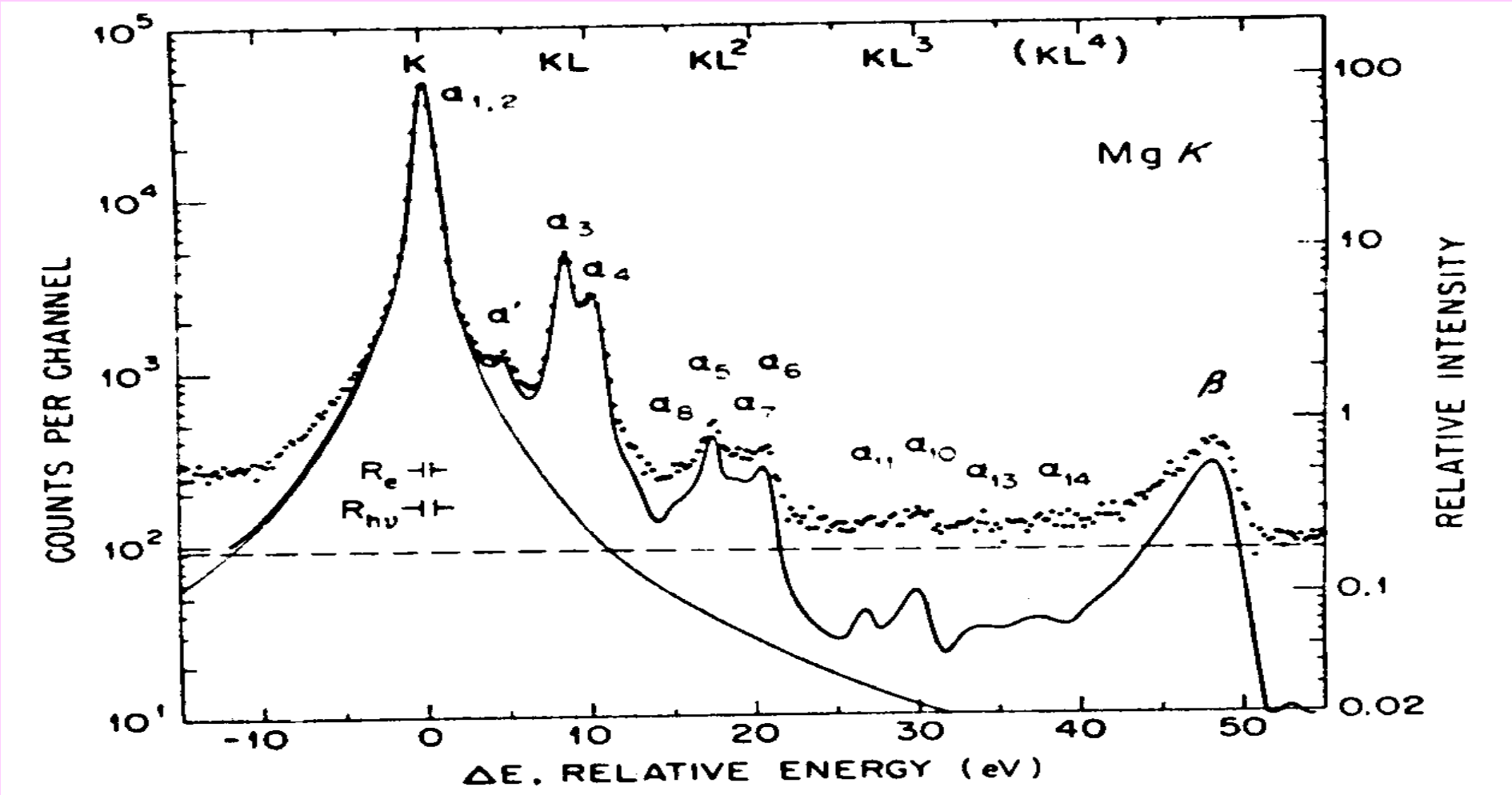


UPS EDC at E_F of Ag (15 K). Resolution, ΔE
s obtained by convoluting a Fermi function
with a Gaussian function (from S. Hüfner).

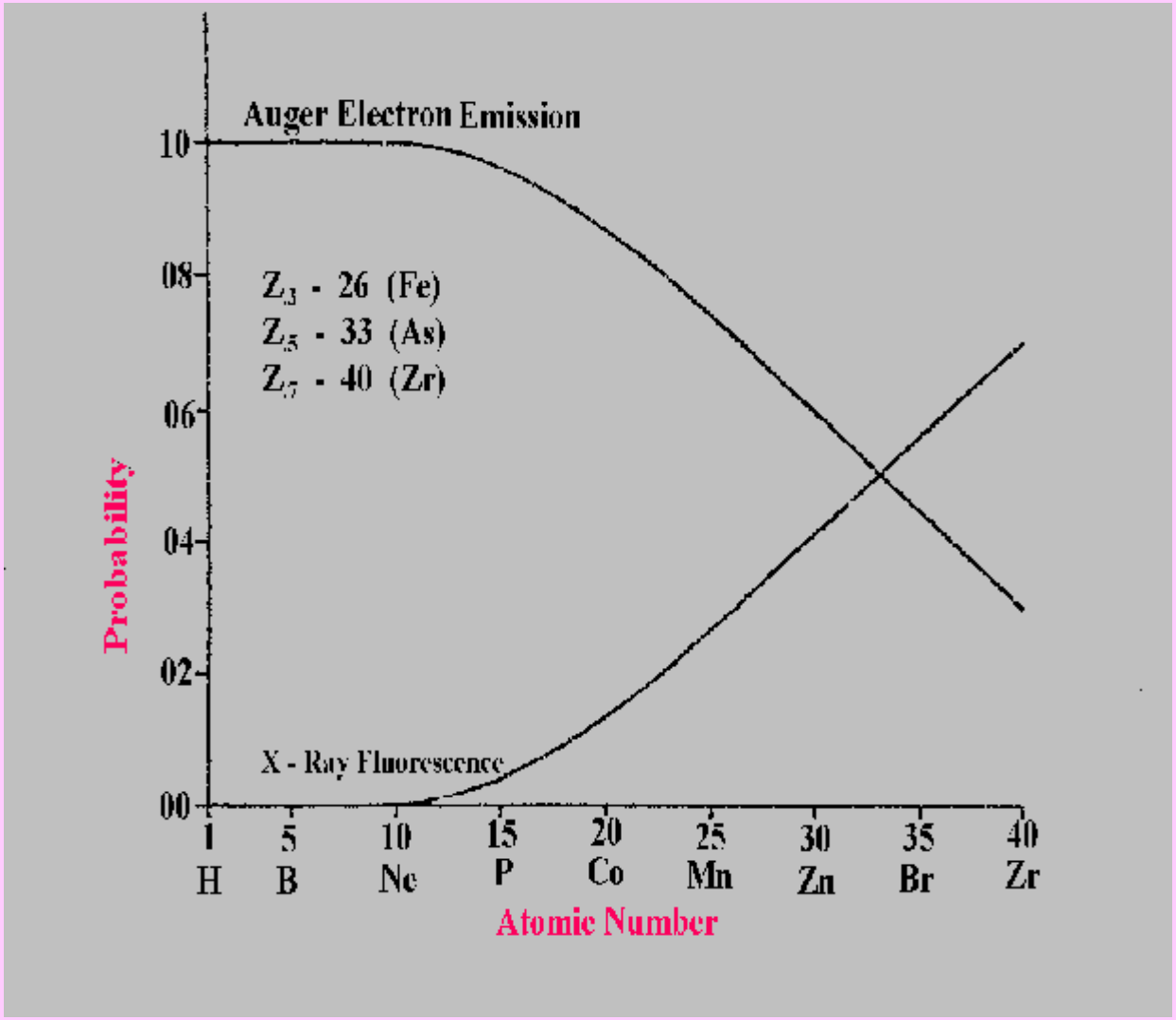
Photon sources



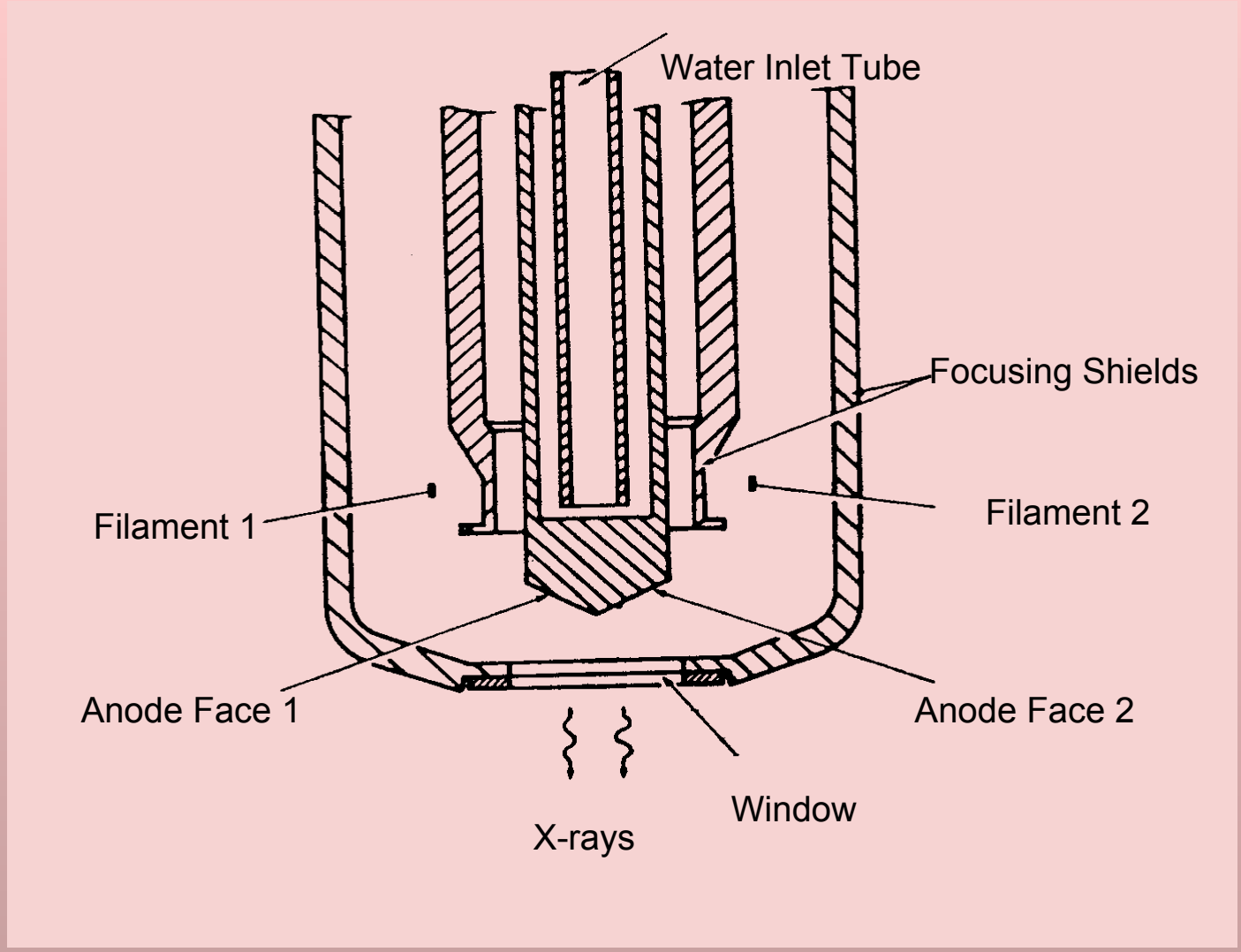
X-ray emission spectrum of an Al target induced by 15 kV electrons.



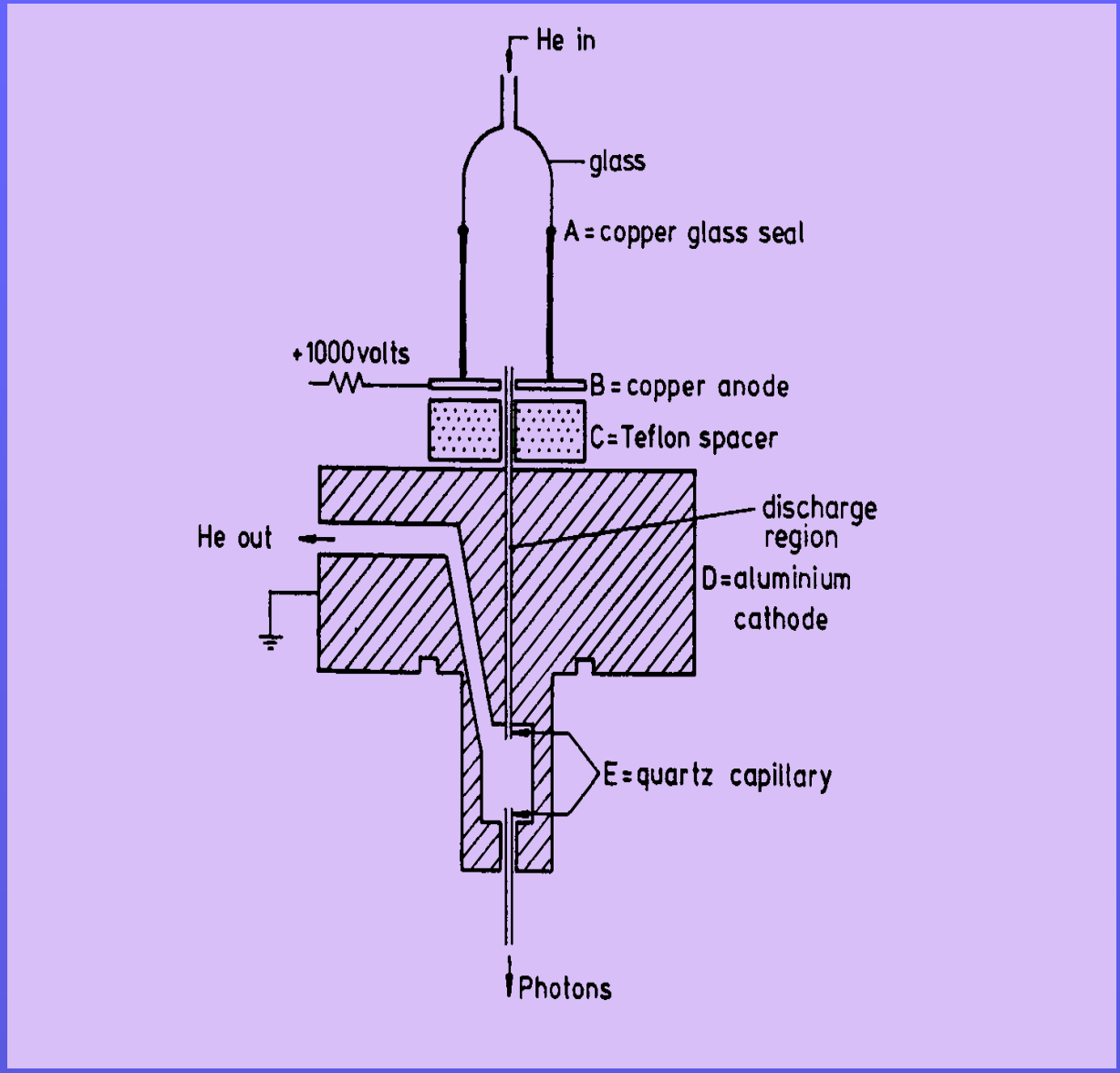
The K emission spectrum of Mg.



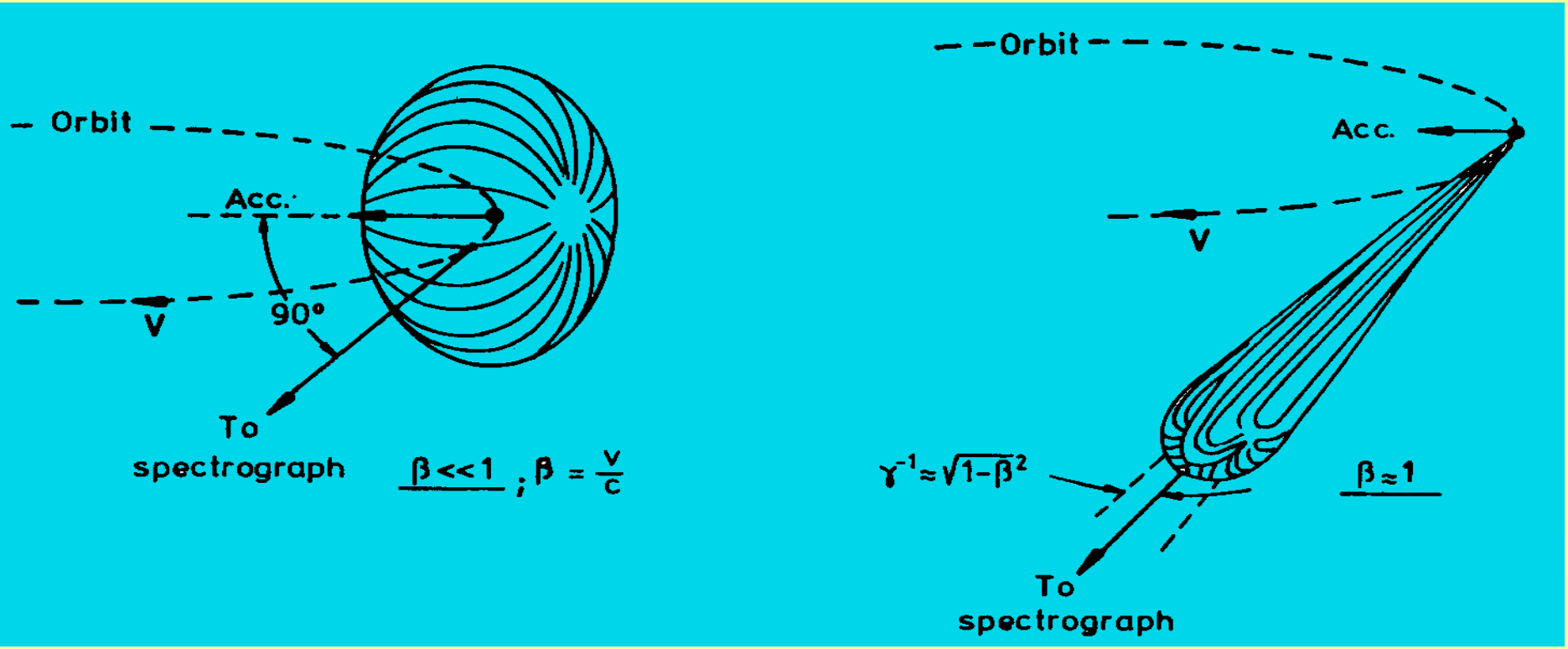
Comparison of X-ray fluorescence and Auger emission probabilities.



X-ray source with dual filament and anode faces.

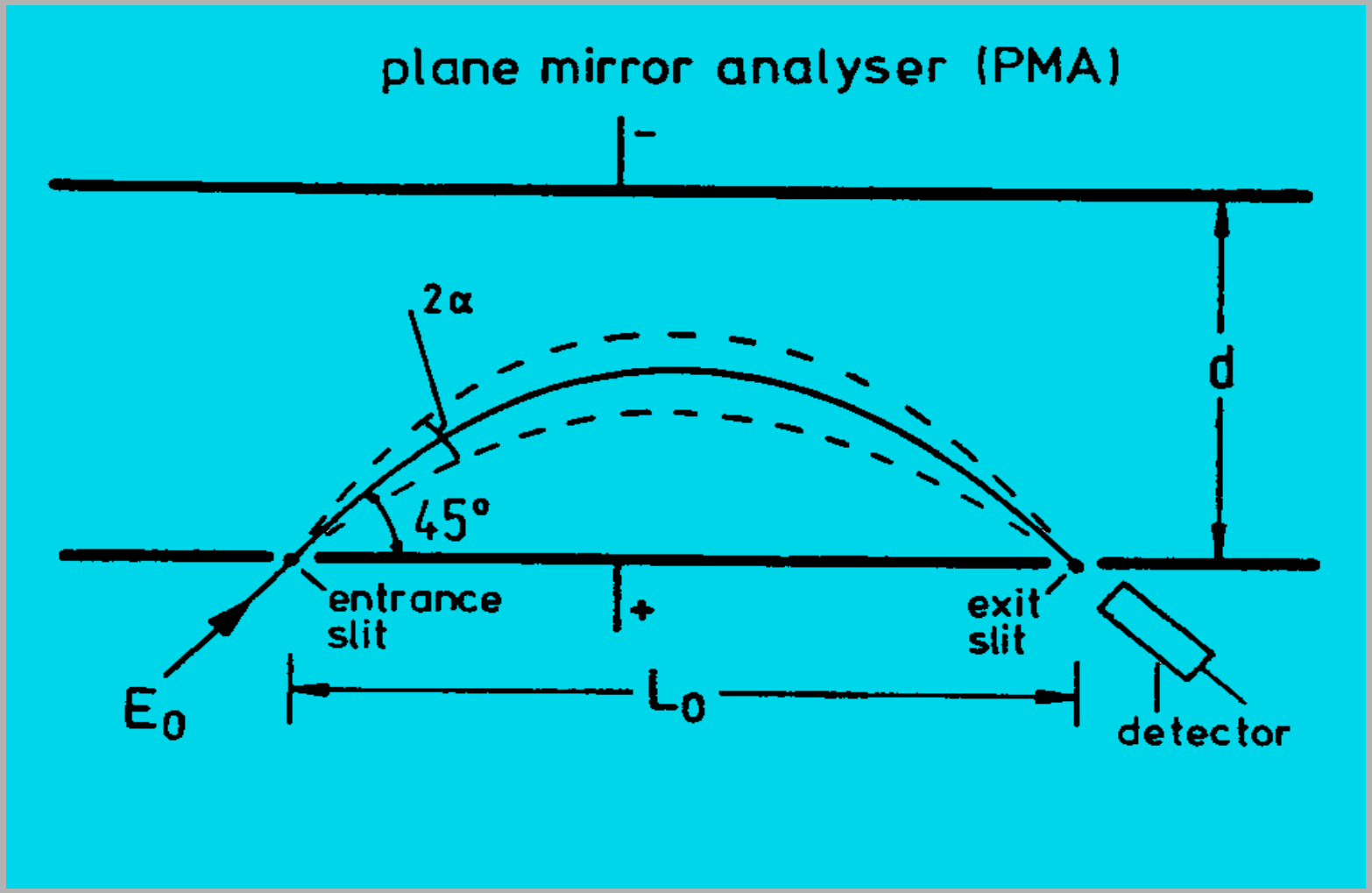


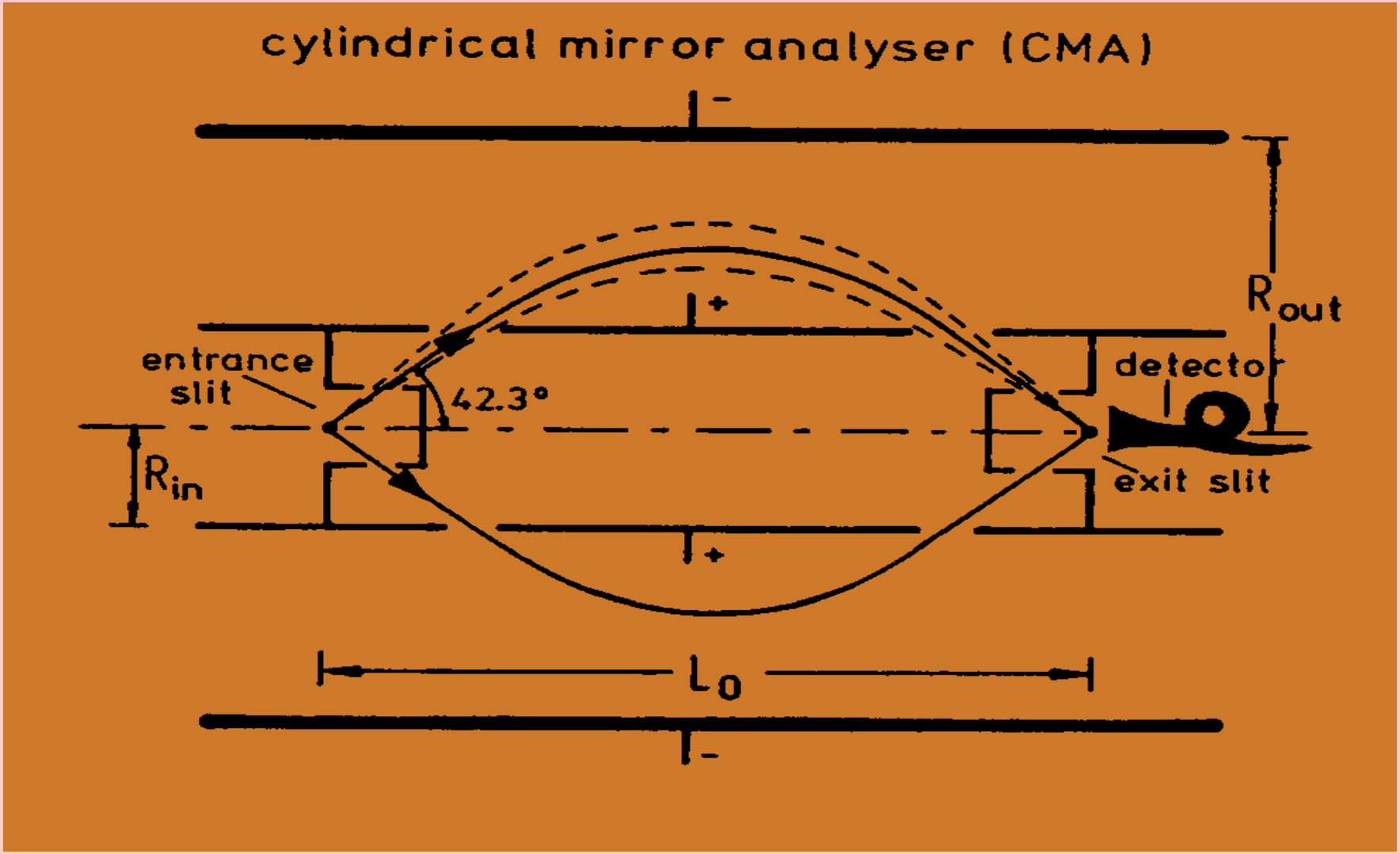
Gas discharge lamp (from S. Hüfner).



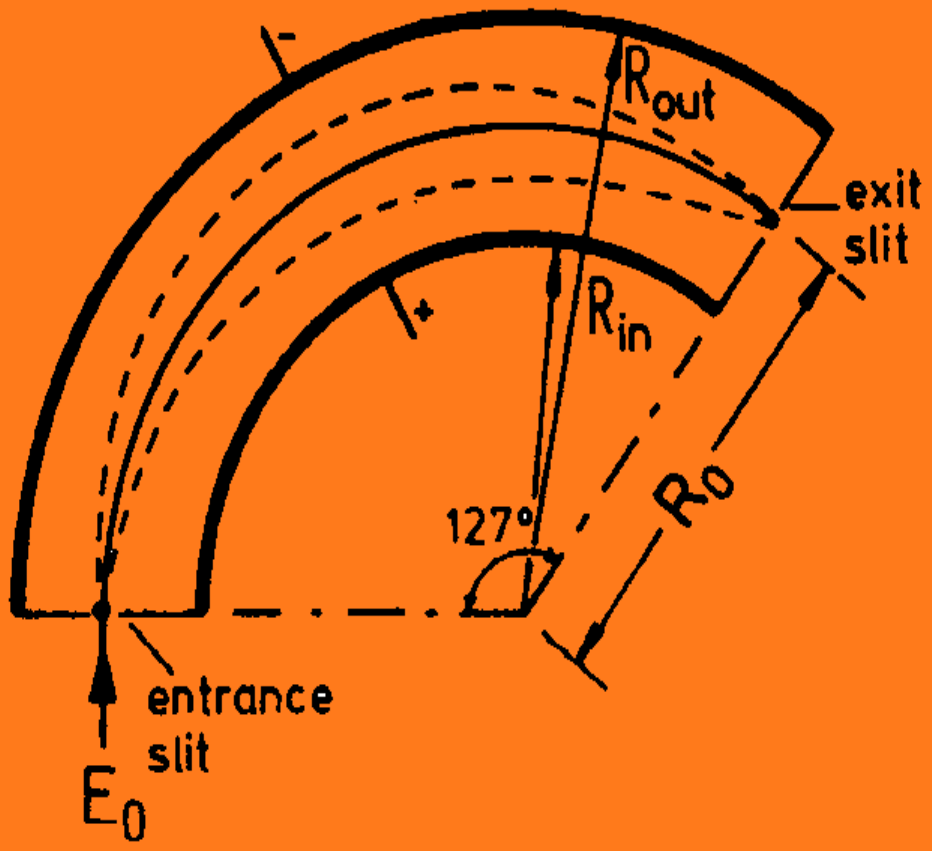
Radiation characteristic of an electron moving in a circular orbit at v/c = β << 1 and $\beta \cong$ I (from S. Hüfner).

Analysers

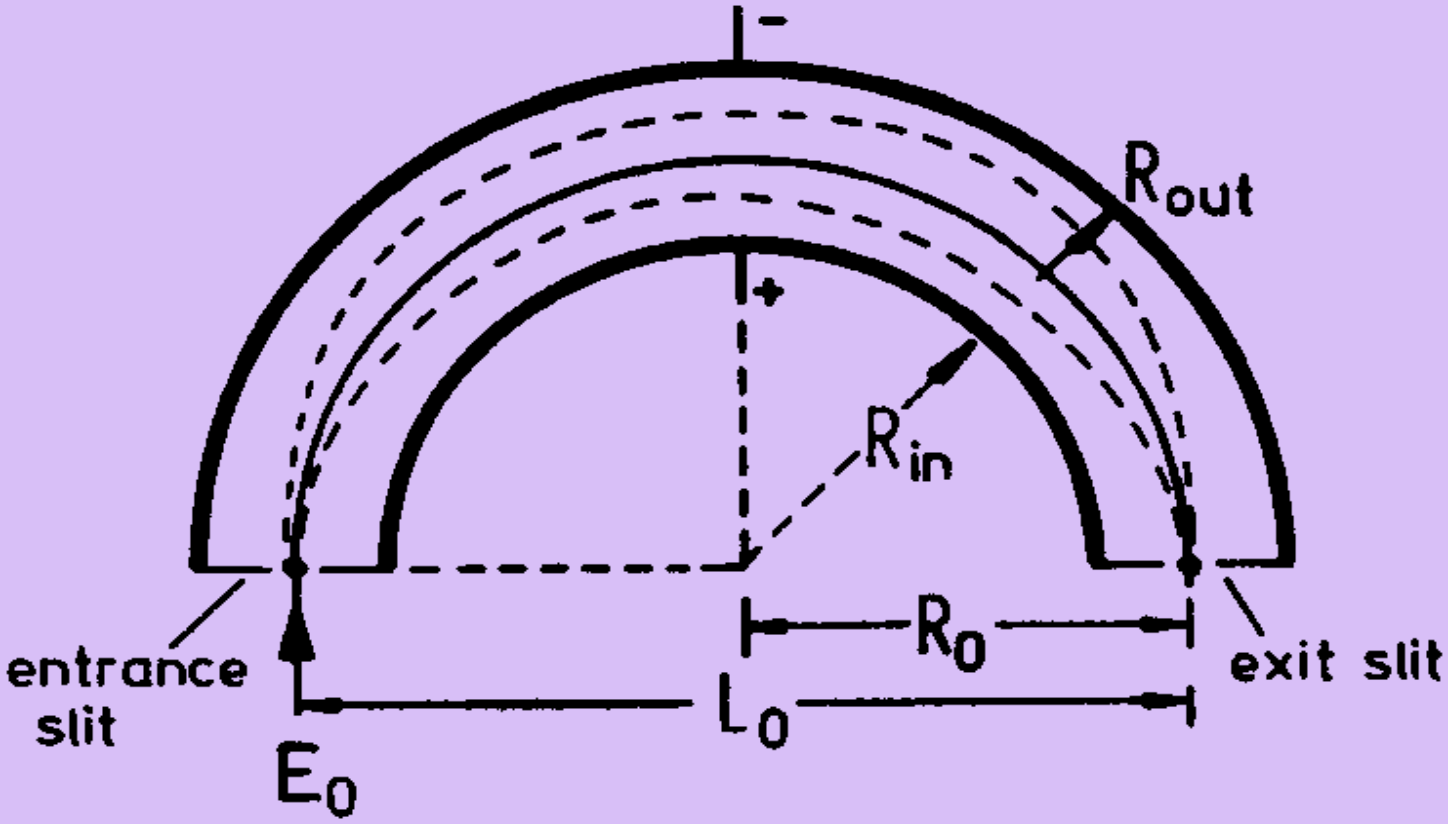

plane mirror analyser (PMA)
-
2α
d
45°
entrance
slit
+
exit
slit
E0
L0
detector

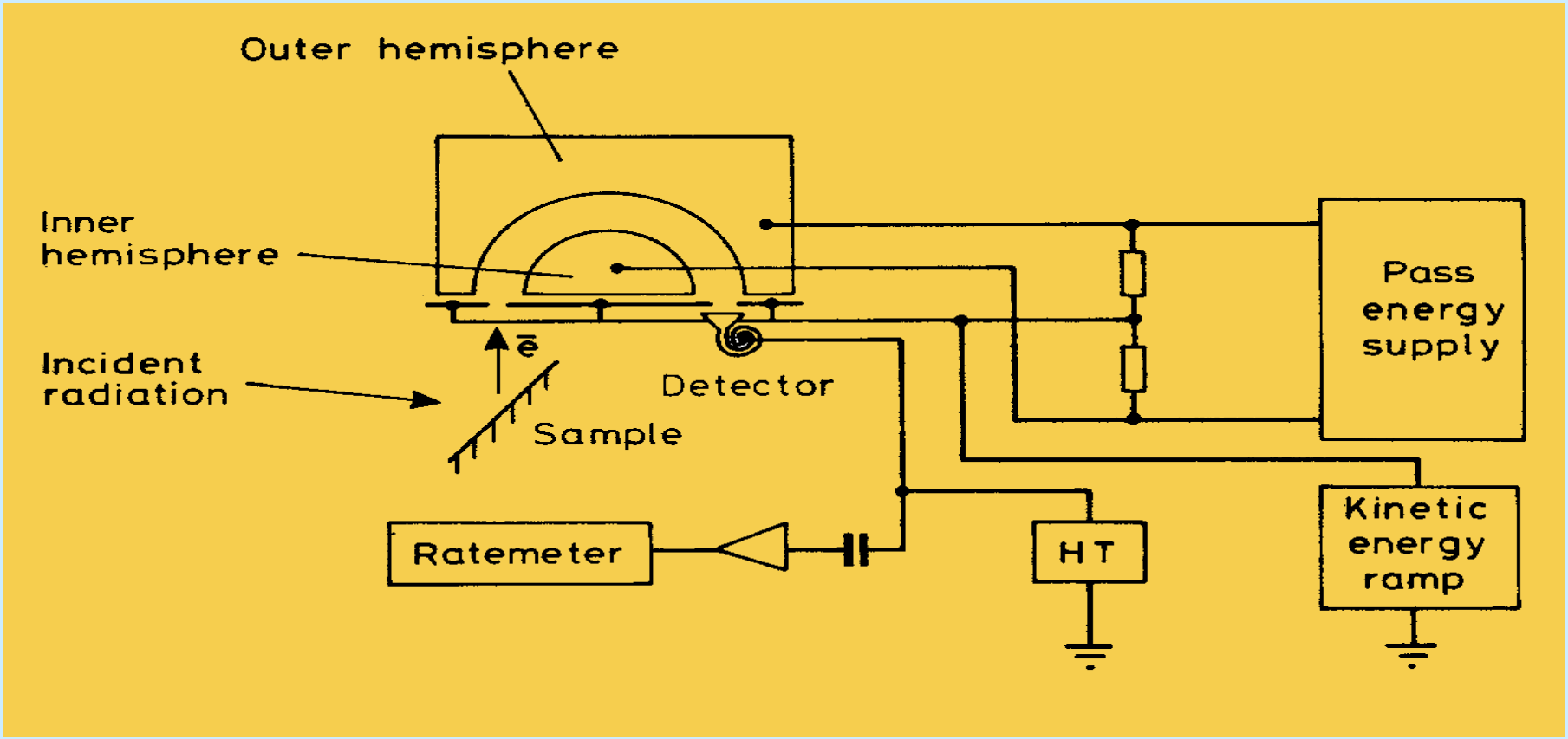

cylindrical mirror analyser (CMA)
-
+
+
-
entrance slit
42.3°
detector
exit slit
R_{out}
R_{in}
L_0

cylindrical deflection analyser (CDA)

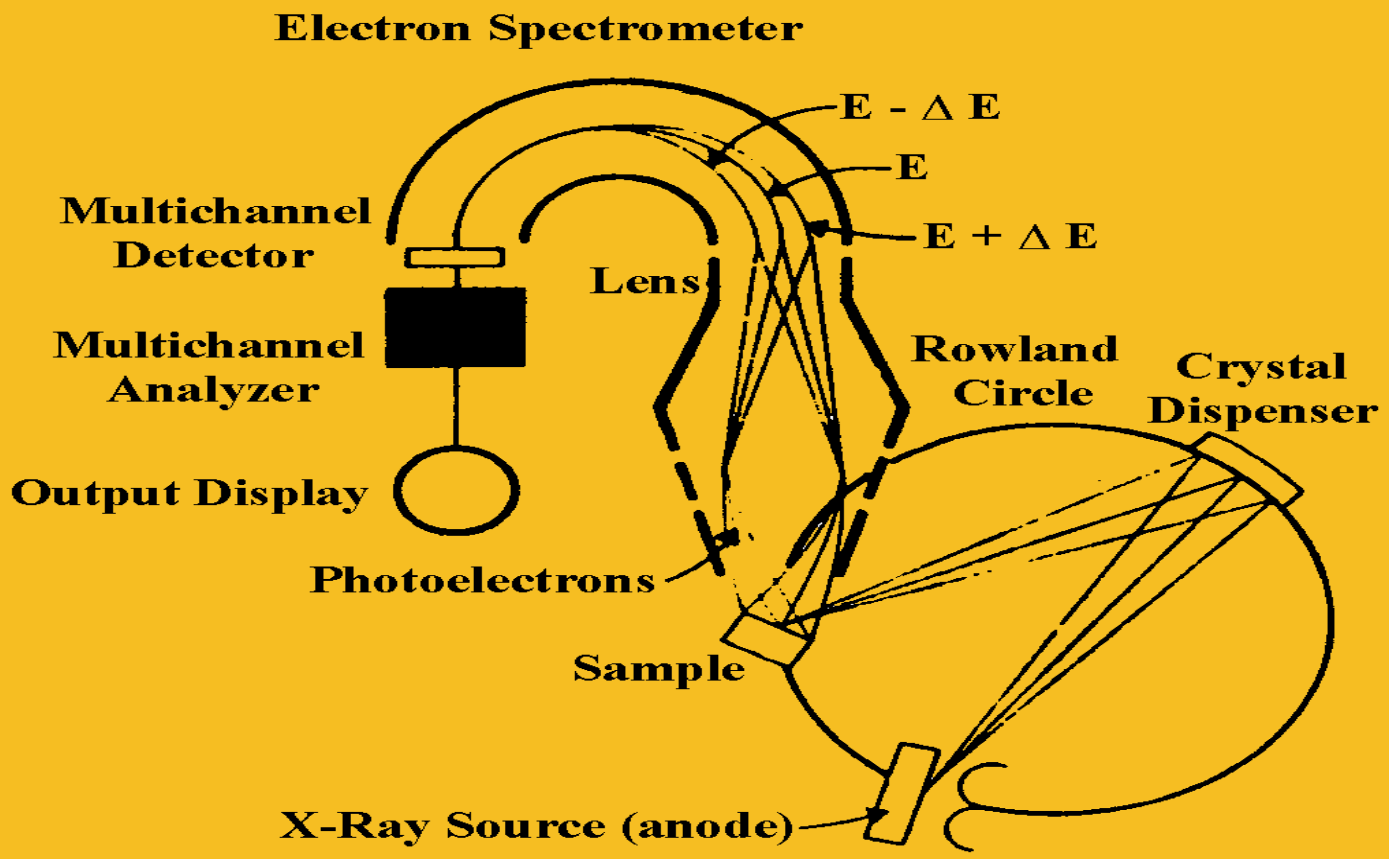


spherical deflection analyser (SDA)

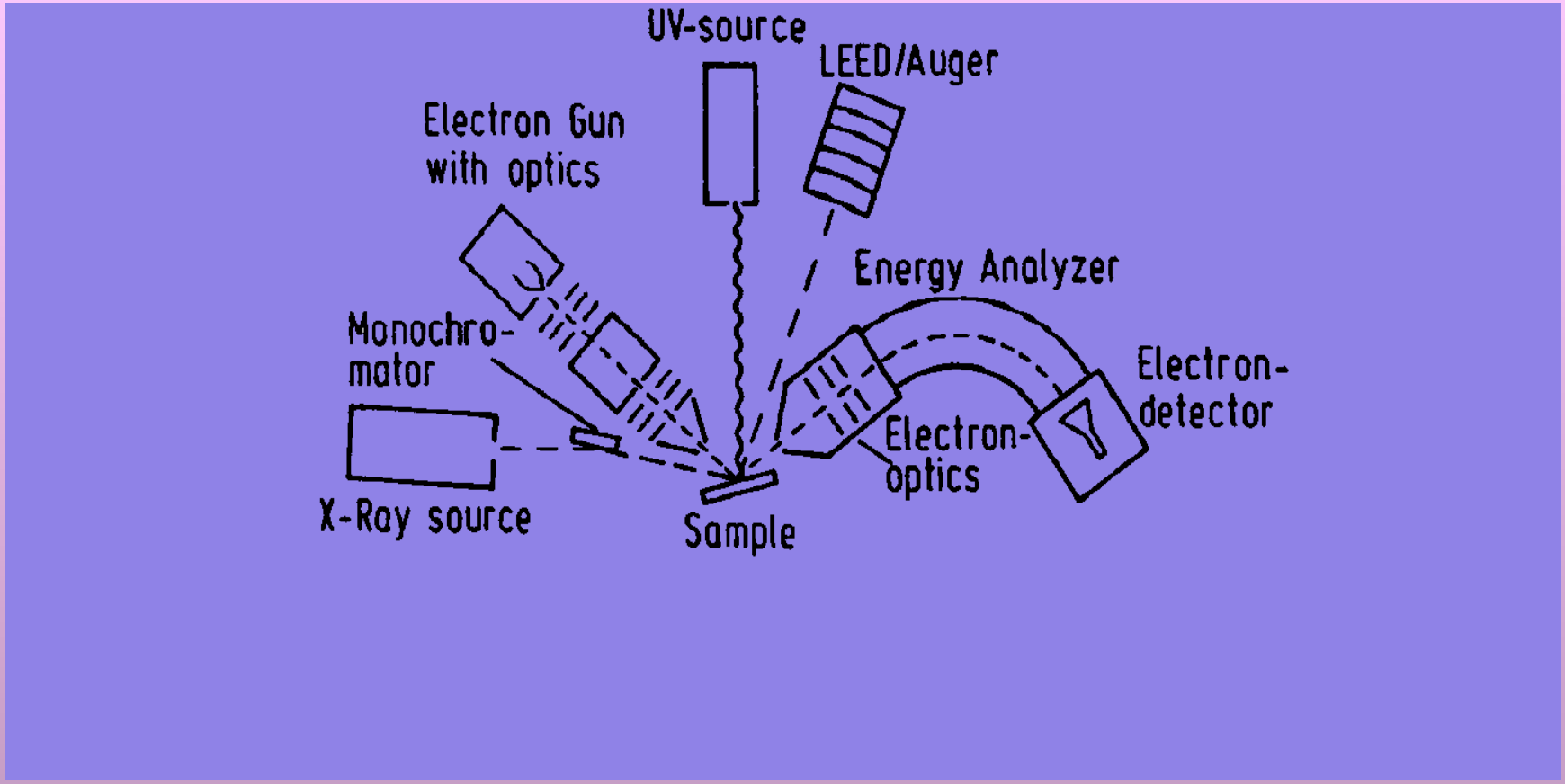




Hemispherical sector electron energy analyser and control electronics.

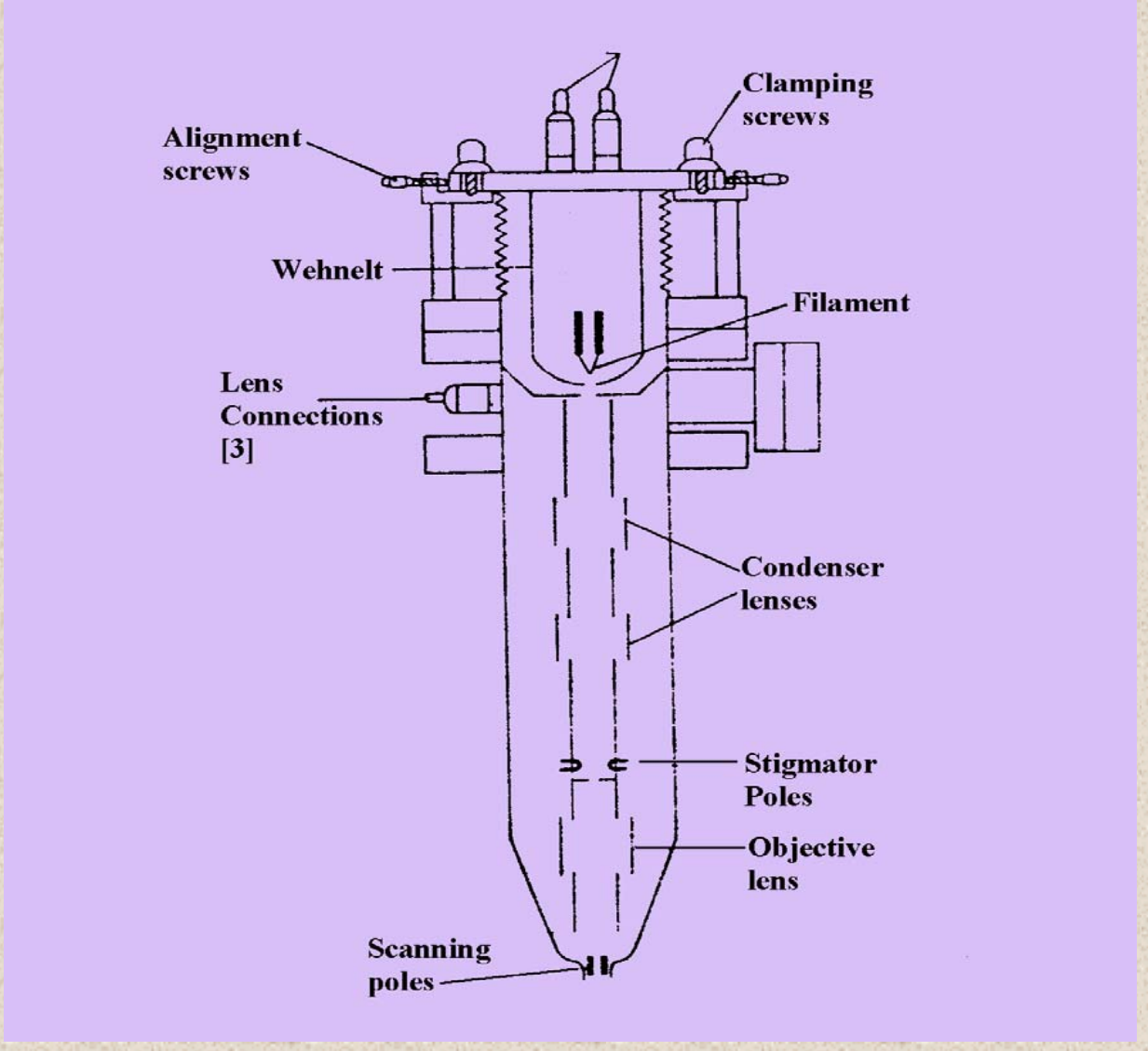


Spectrometer with X-ray monocromatisation (from Chapter 1 of H. Windawi, F. F. L. Ho).



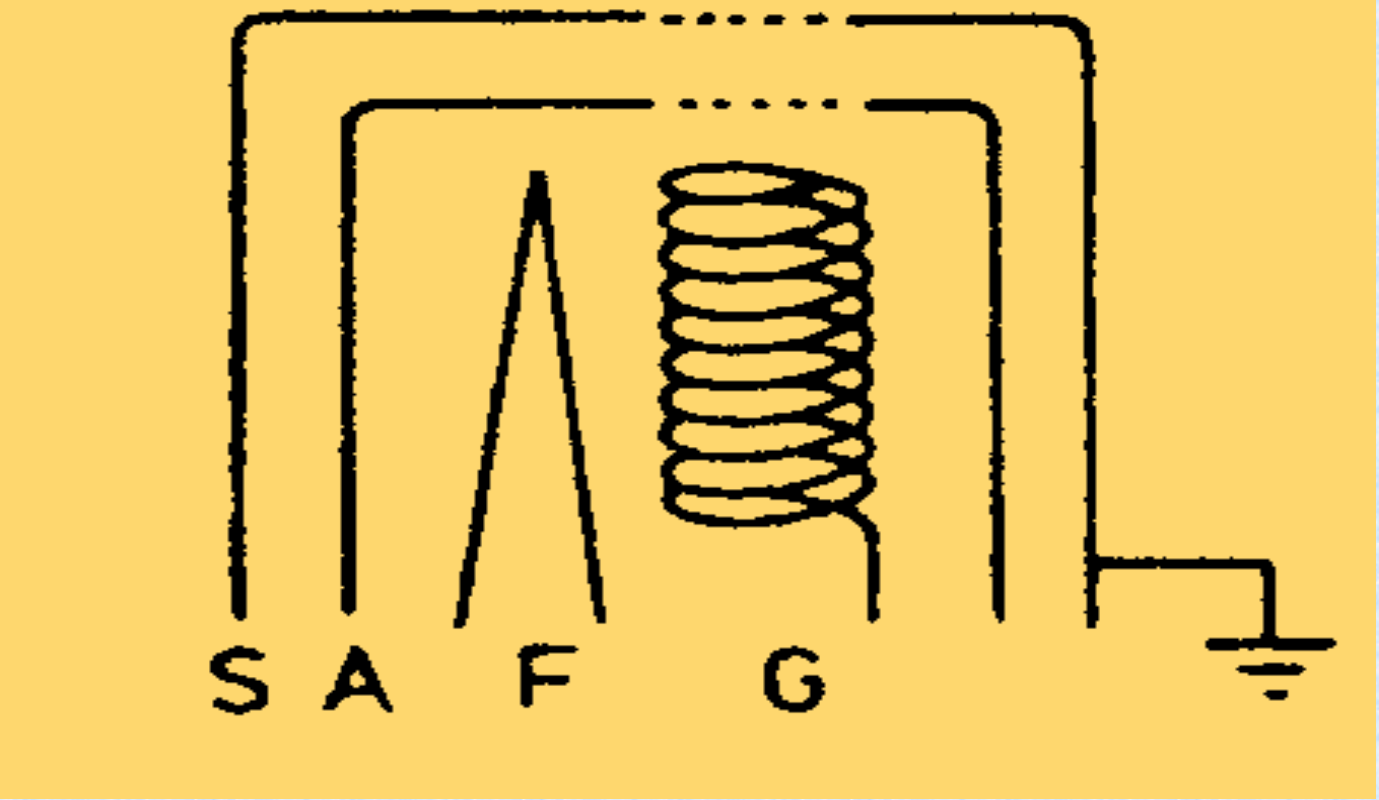
Modern instrument for UPS, XPS, AES and EELS (from S. Hüfner).

Electron Gun

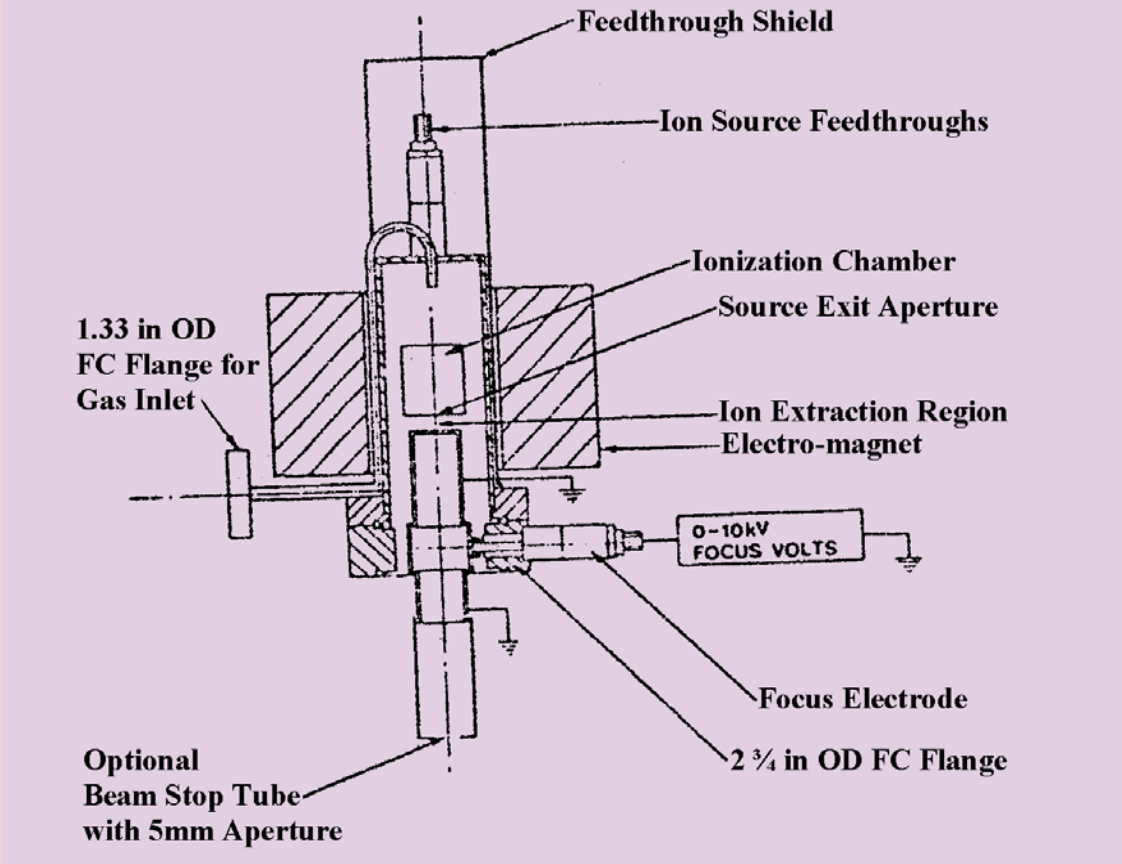


An electron gun for beams up to 10 ke V (from Chapter 2 of D. Briggs and M. P. Seah).

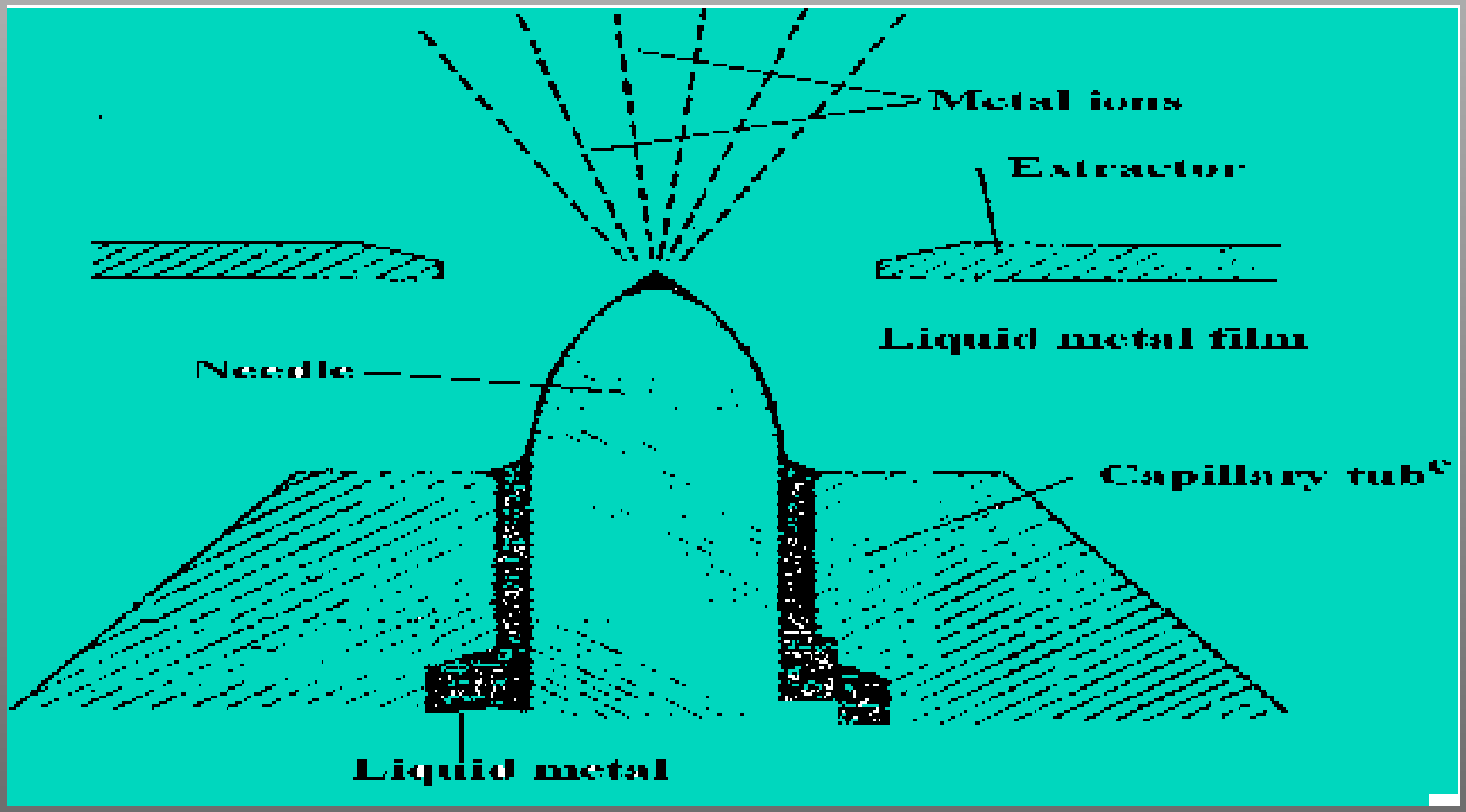
Surface Sensitivity and Etching



Ion gun based on an ionization gauge geometry.

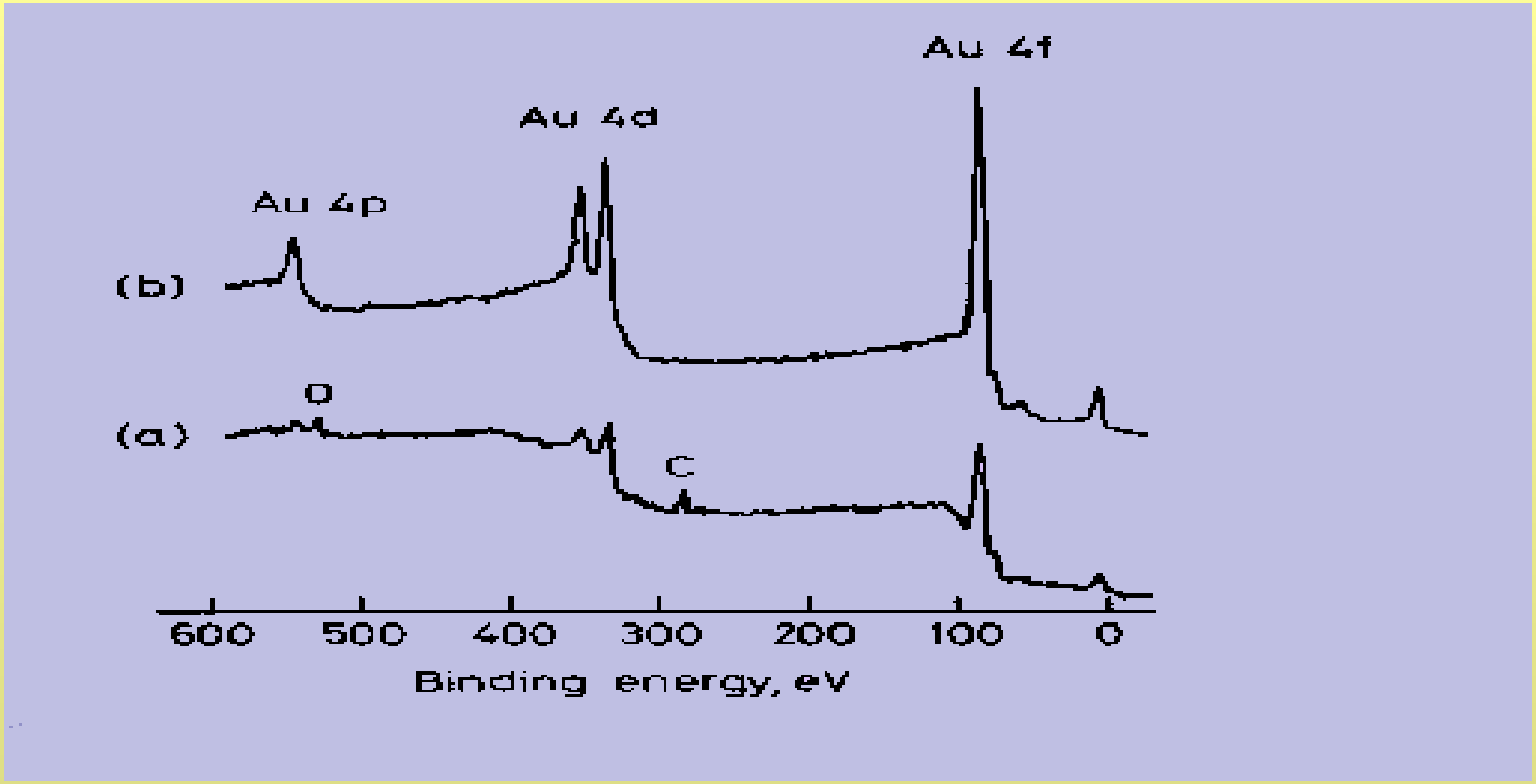


Ion gun using a Penning discharge. Ions of 500 eV - 10 keV can be produced (from Chapter 2 of D. Briggs and M. P. Seah).



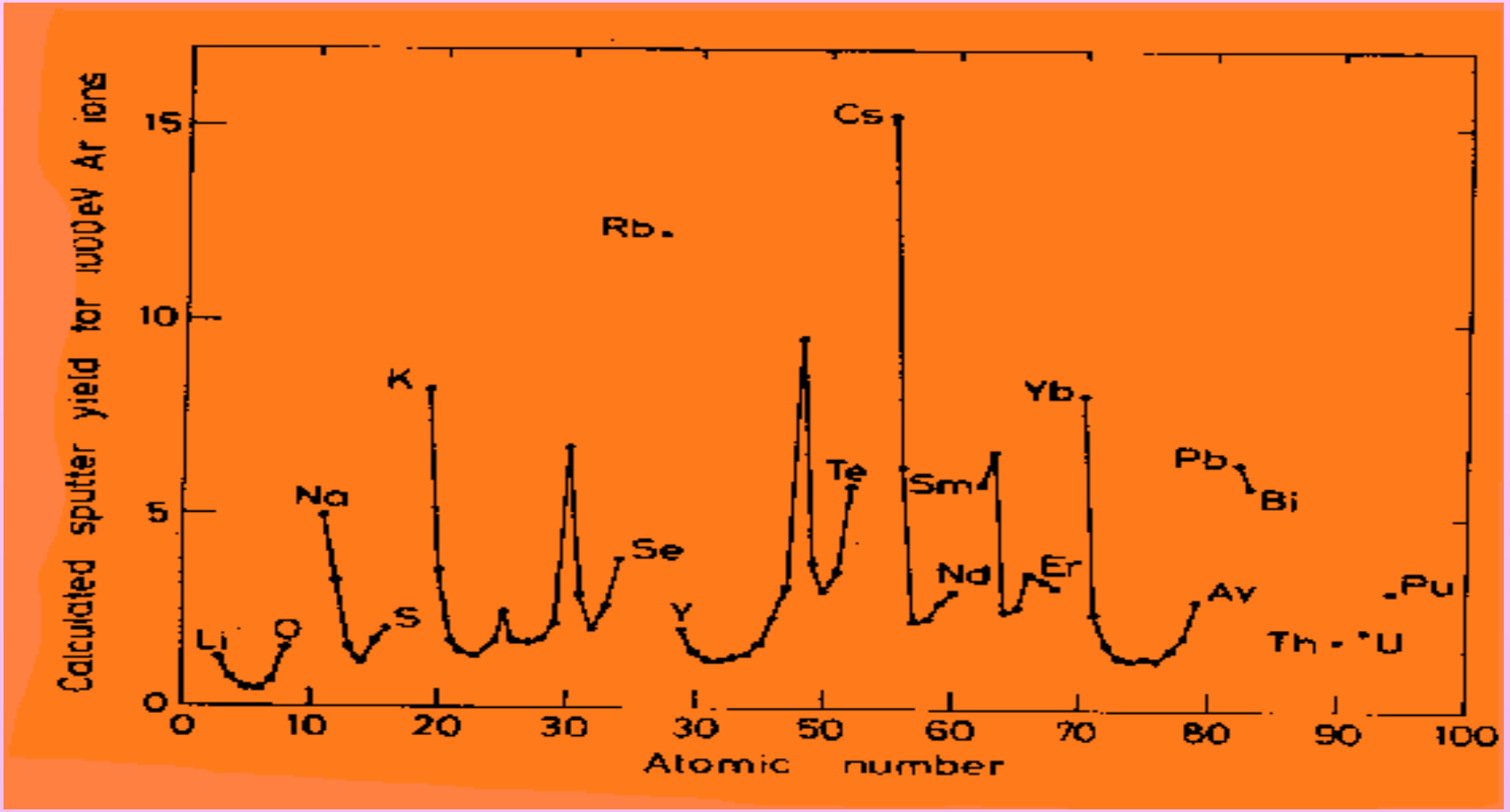
A liquid-metal field emission ion source

(from Chapter 2 of D. Briggs and M. P. Seah).



The low binding energy regions of spectra from a gold surface (a) before and (b) after ion bombardment

(from Chapter 6 of G. C. Smith).



A compilation of predicted sputter yields for elements, for argon ions of 1 keV (from Chapter 6 of G. C. Smith).

Schematic illustration of ion induced processes during sputtering (from chapter 6 of G. C. Smith).

Detectors

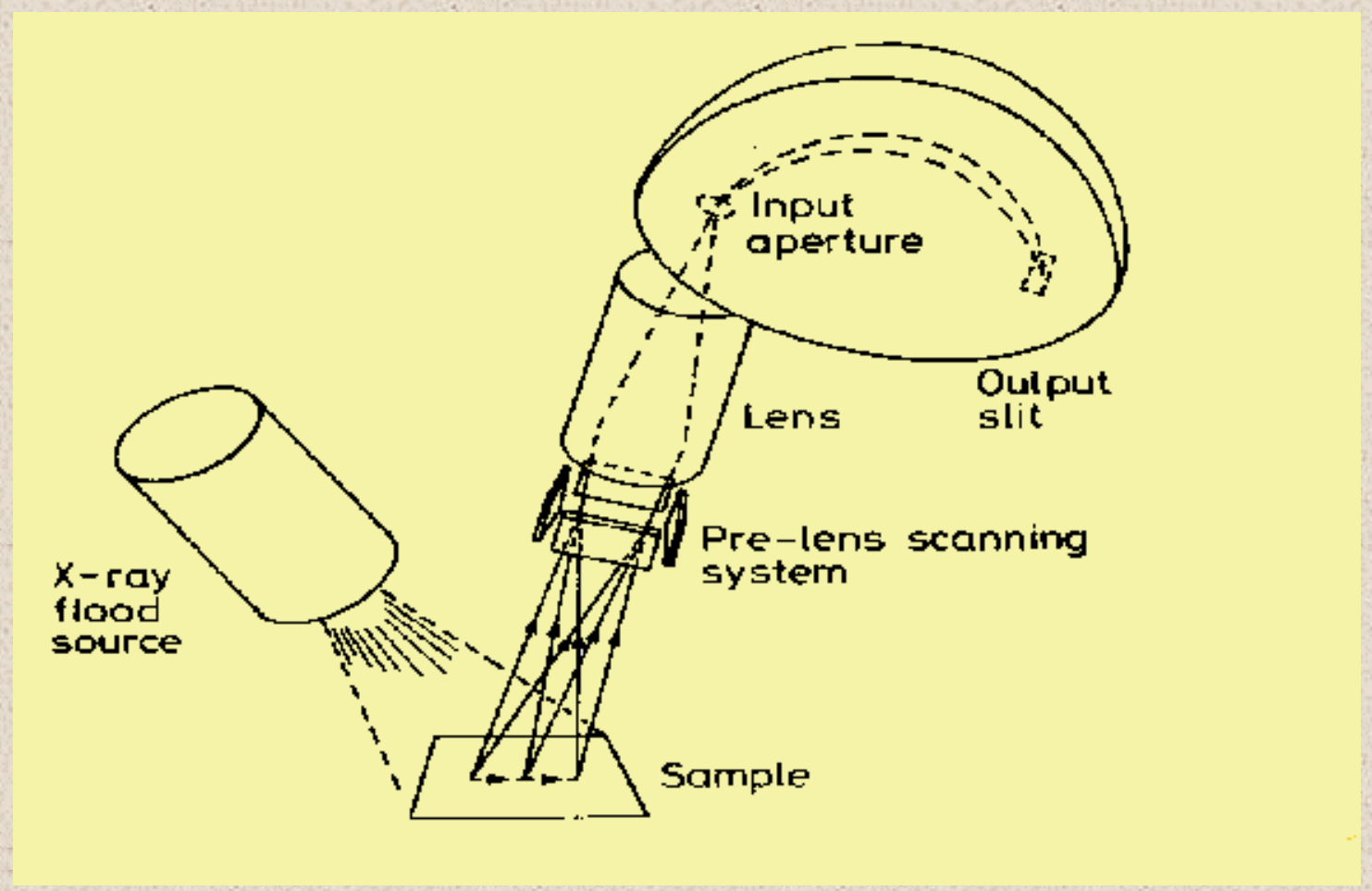
1. Single-Channel Detector

Channel electron multiplier:A continuous dynode surface. High count rate of 10^6 counts per second.

2. Multi-Channel Detector

A set of parallel detector chains or position sensitive detectors kept at the analyser exit slit plain.

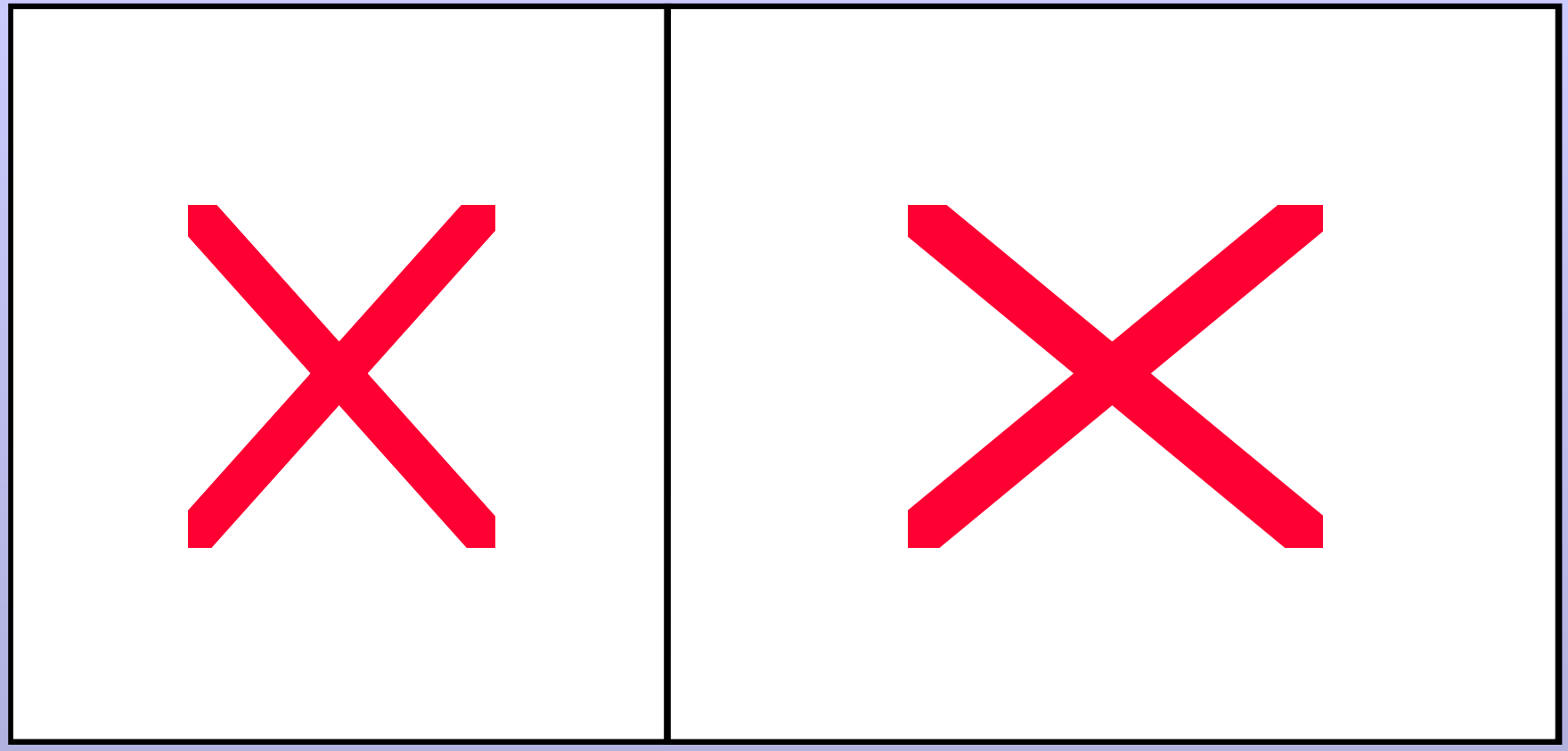
Scanning XPS



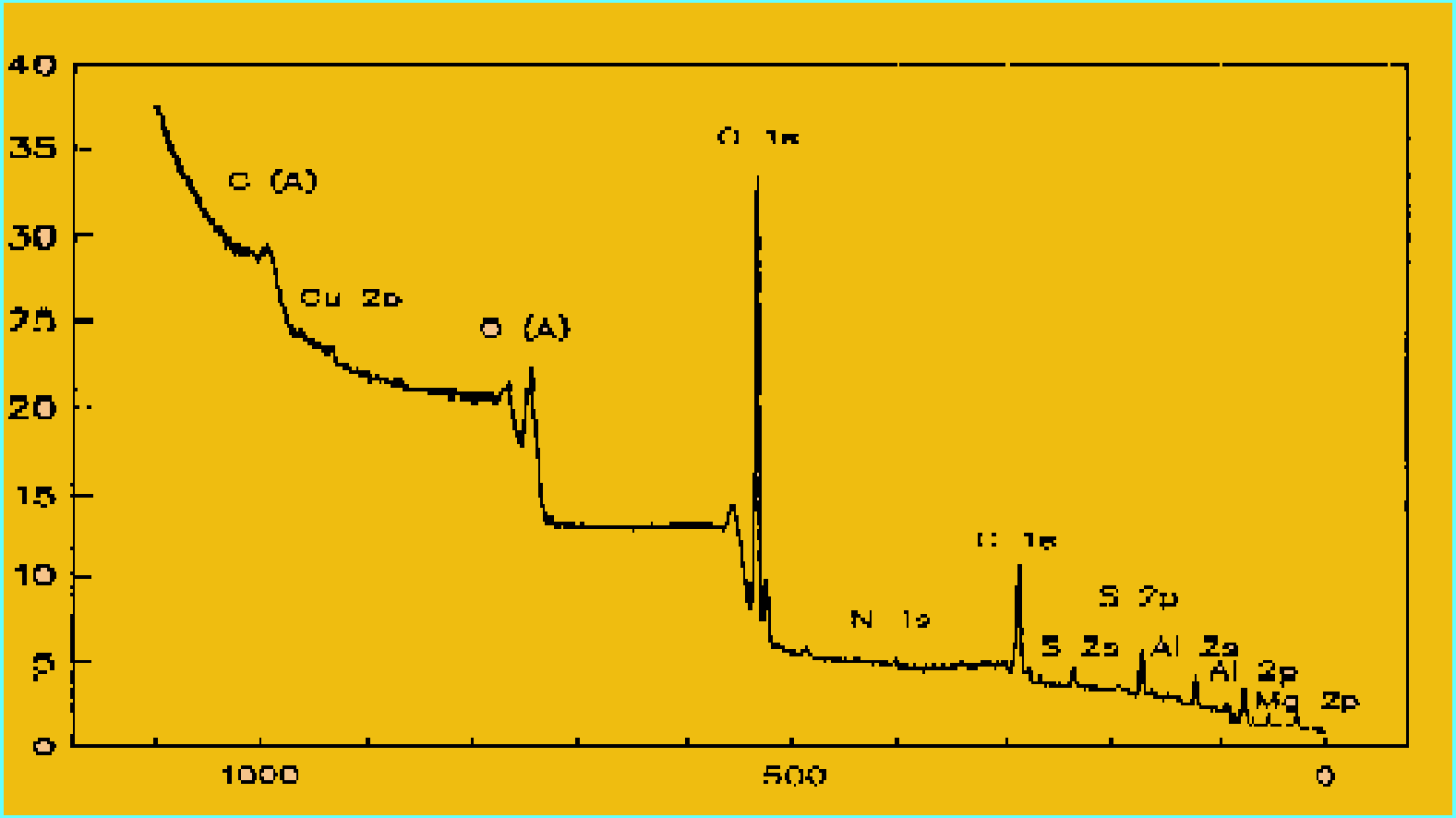
A simple method of XPS imaging using a conventional HAS instrument (from Chapter 3 of G. C. Smith).

An XPS image of the solder pads on a surface mounting electronic device (from Chapter 3 of G. C. Smith).

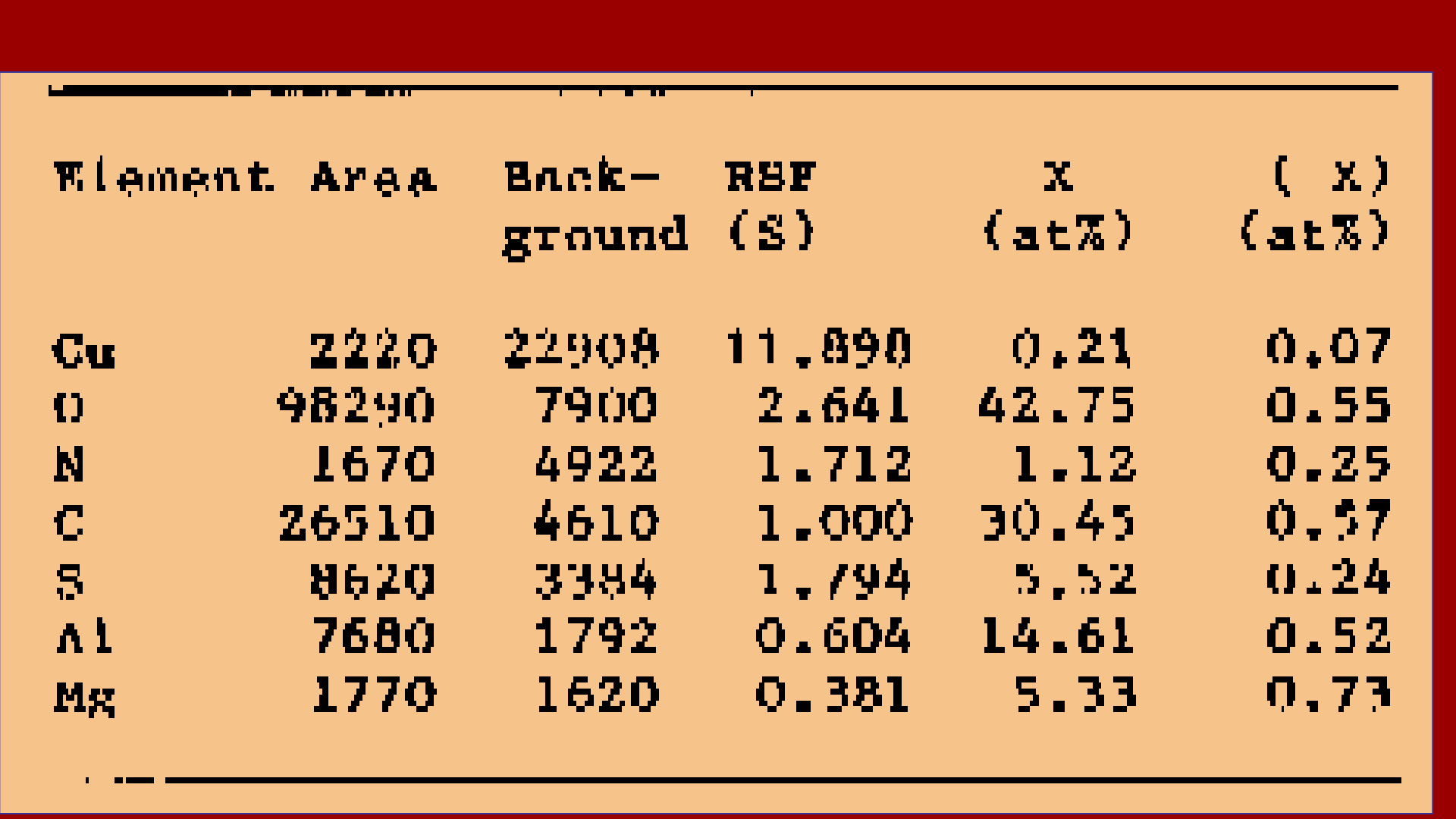
Data Analysis



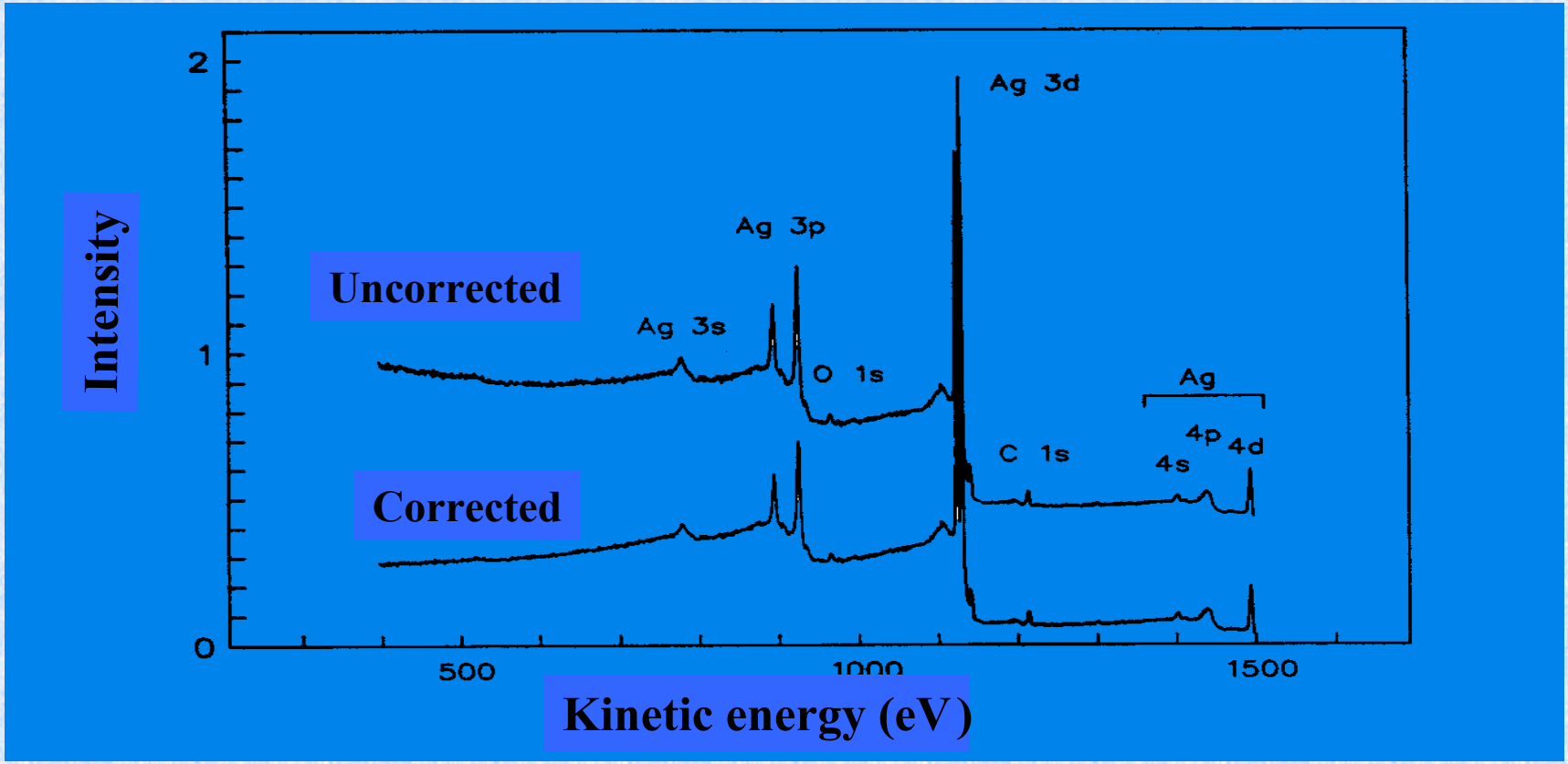
An idealized photoelectron peak showing, the application of a simple straight line background, and the Shirley background (from Chapter 4 of G. C. Smith).



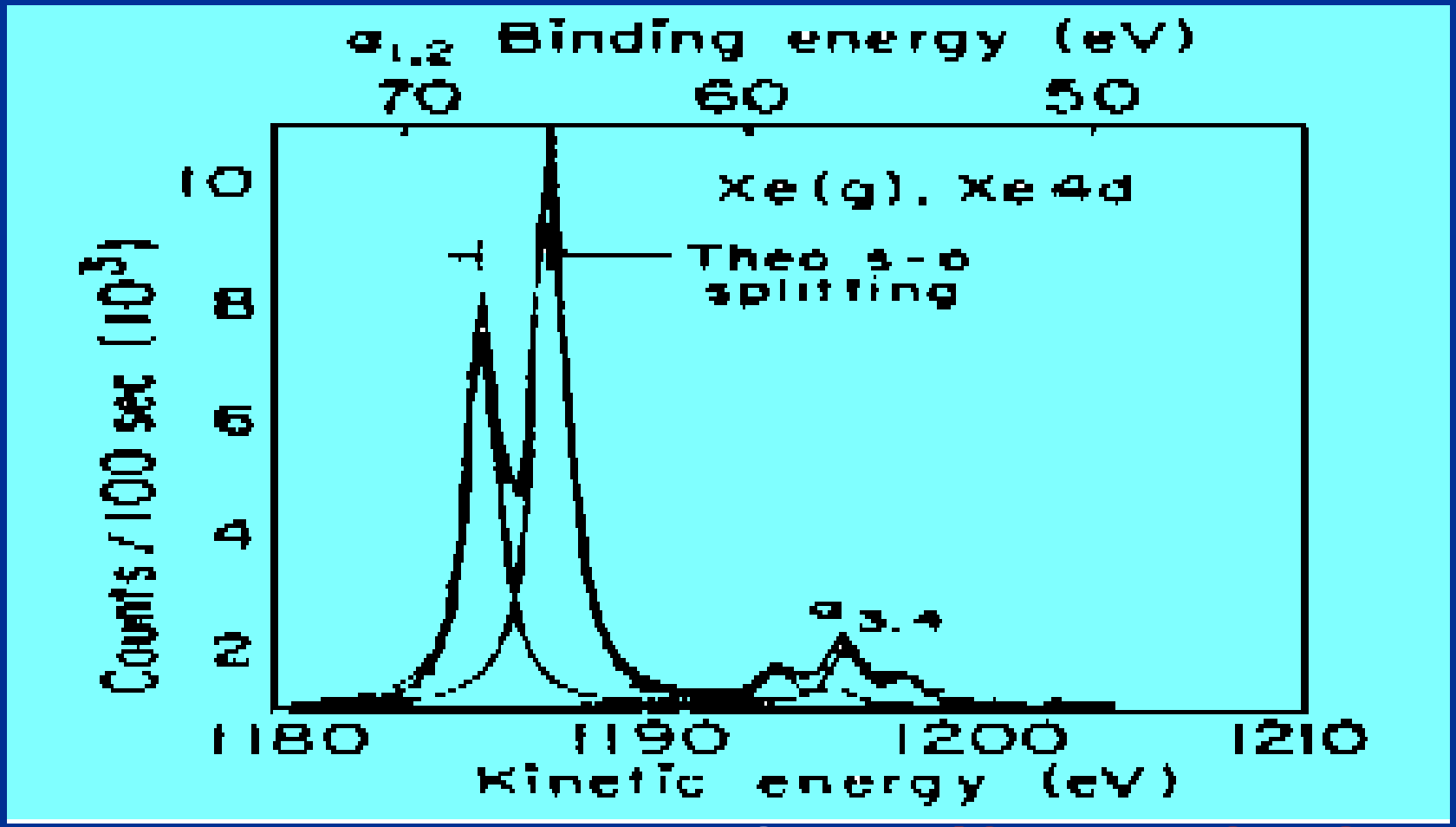
XPS spectrum of a multi-component sample for quantitative analysis (from G. C. Smith).



Element	Area	Back-ground	RSF (S)	X (at%)	(x) (at%)
Cu	2220	22908	11.890	0.21	0.07
O	98290	7900	2.641	42.75	0.55
N	1670	4922	1.712	1.12	0.25
C	26510	4610	1.000	30.45	0.57
S	8620	3384	1.794	5.52	0.24
Al	7680	1792	0.604	14.61	0.52
Mg	1770	1620	0.381	5.33	0.73



Contaminated silver surface, before and after correction for the energy dependence of transmission (from G. C. Smith).



4*d* spectrum of Xe (from C. S. Fadley and D. A. Shirley, Phys. Rev. A2, 1109, 1970).

Analytical requirements

Samples

State

Almost any solid can be analyzed

Amount

Micrograms

Preparation

Sample can be analyzed as received. Because the analysis is done in high vacuum, some samples require cleaning.

Analysis time

Survey spectrum: 1 to 5 min.
High resolution acquisition: 5 to 25 min per region

Limitations

General

- **Conducting and semiconducting samples.**
- **Nonconducting samples with additional facilities.**

- Samples to be vacuum compatiable.
- Samples should not degrade under x-ray.
- Quantification is difficult.

Accuracy

- Limited spatial resolution
- The sampling depth of three monolayers

Sensitivity and Detection Limits

- Around 0.3%.