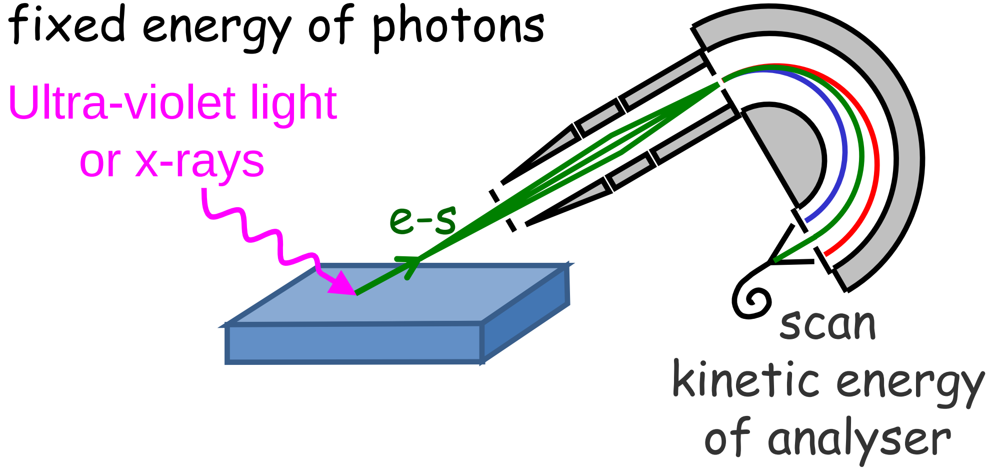
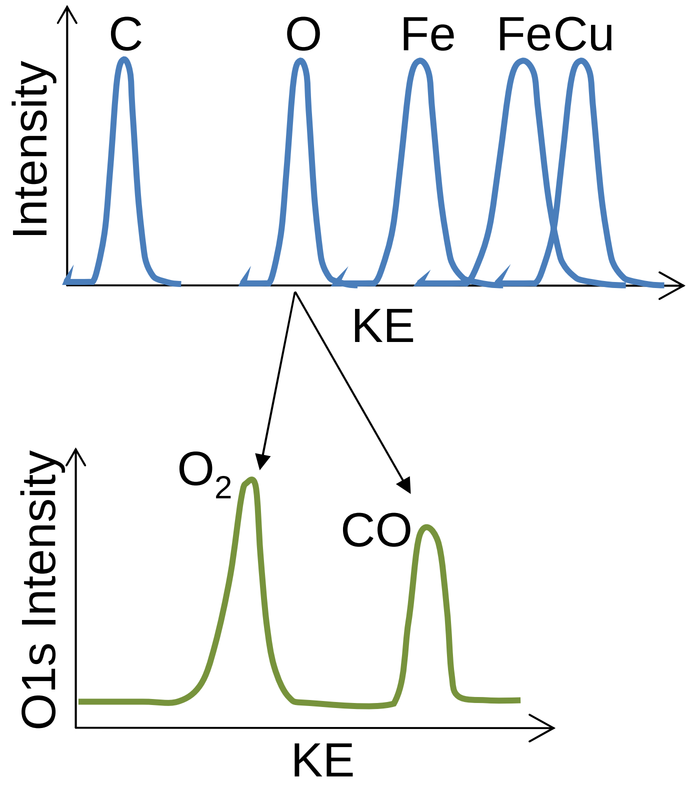
Penetrating-Field Threshold PhotoElectron Spectroscopy

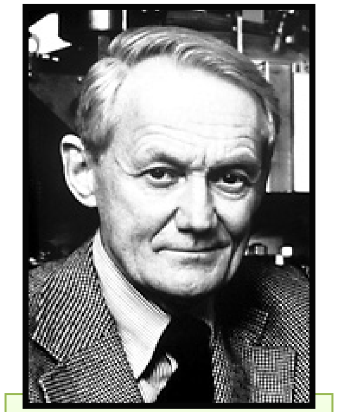
Michele Siggel-King

Electron Spectroscopy

fixed energy of photons



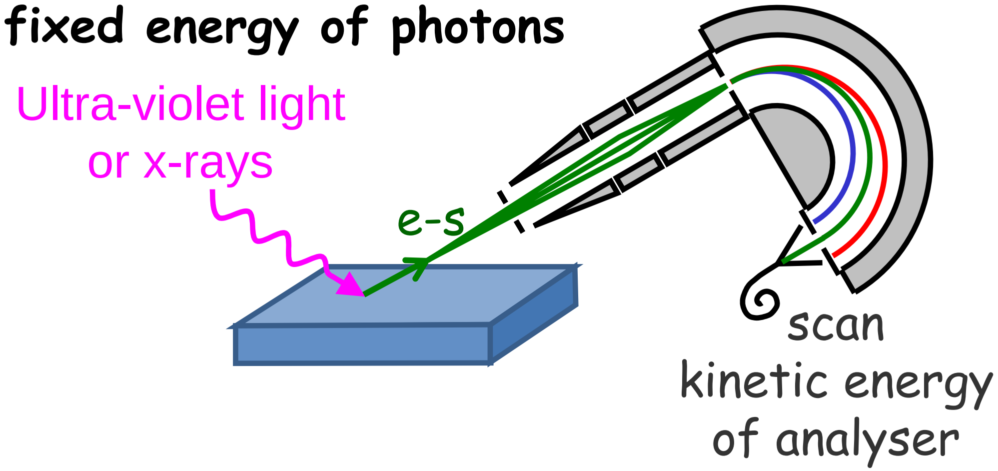


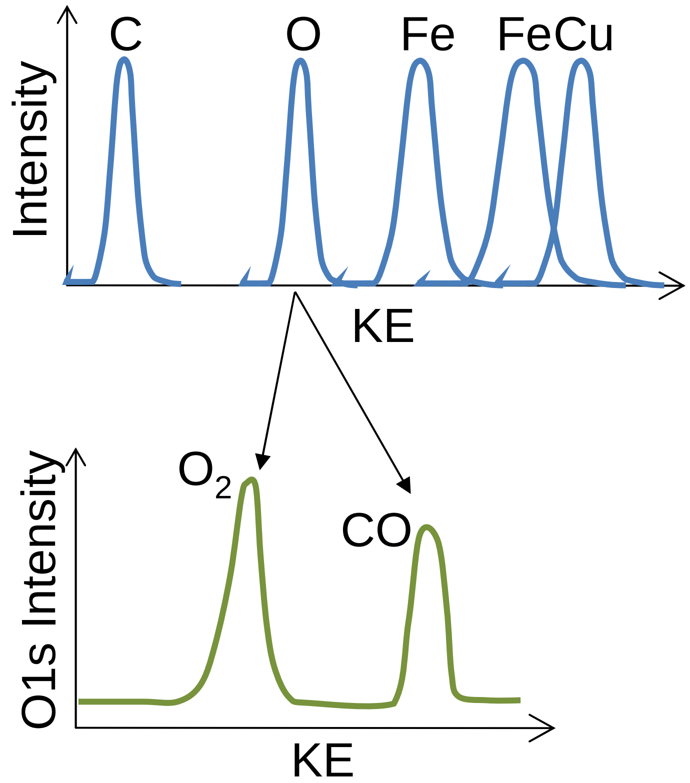


Kai Siegbahn
Nobel Prize
1981

Electron Spectroscopy

fixed energy of photons





Peak Intensities ⇒

- relative ionisation cross sections
- quantative – how much is present

Intensity (angle) ⇒

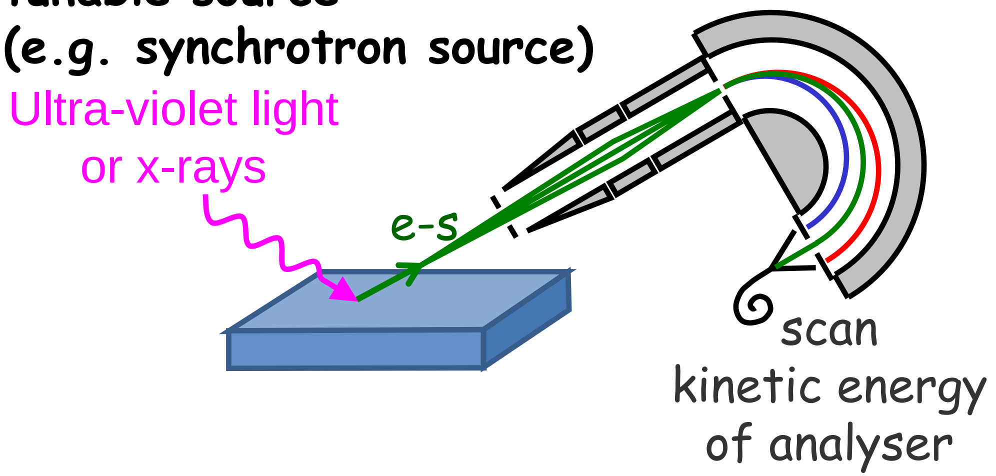
- symmetry of orbitals
- adsorbate orientation

Resolution:

- photon bandwidth
- spectrometer
- target (gas – Doppler)

Electron Spectroscopy

tunable source
(e.g. synchrotron source)



$A + h\nu \longrightarrow A^{**} \xrightarrow{\text{Autoionisation}} A^{+} + e^{-}$

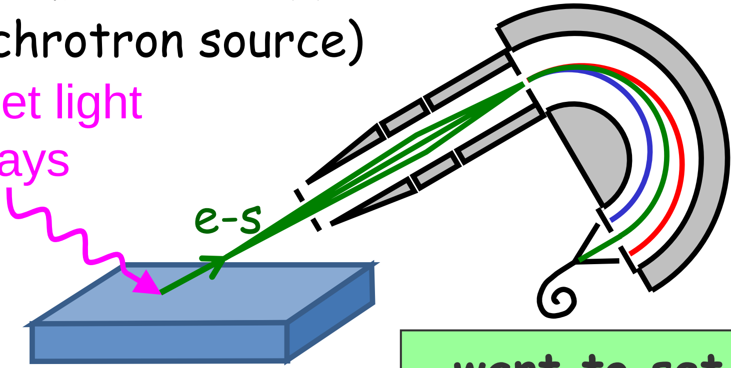
tune hv to energy of highly excited state

information about indirect photoionisation paths

Threshold PhotoElectron Spectroscopy

tunable source is scanned
(e.g. synchrotron source)

Ultra-violet light
or x-rays

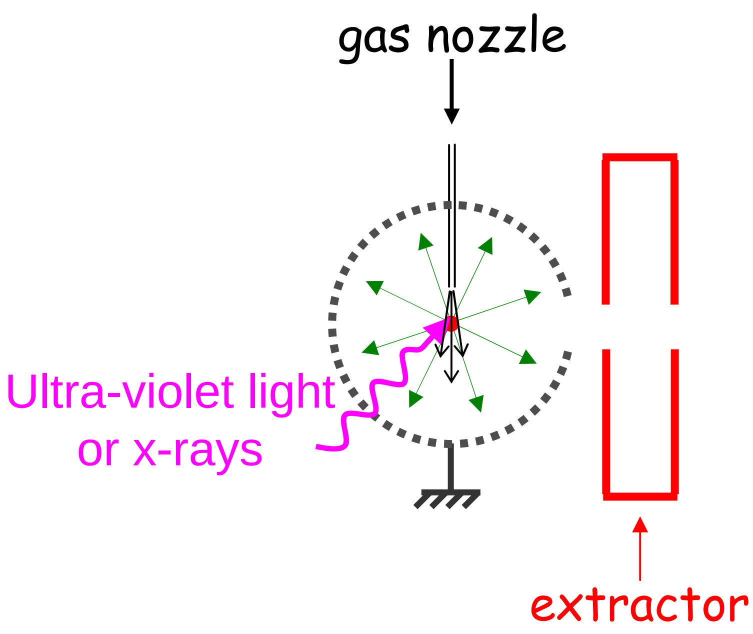


want to set spectrometer to accept e-s of “0” KE (~<1 meV)

optimise spectrometer

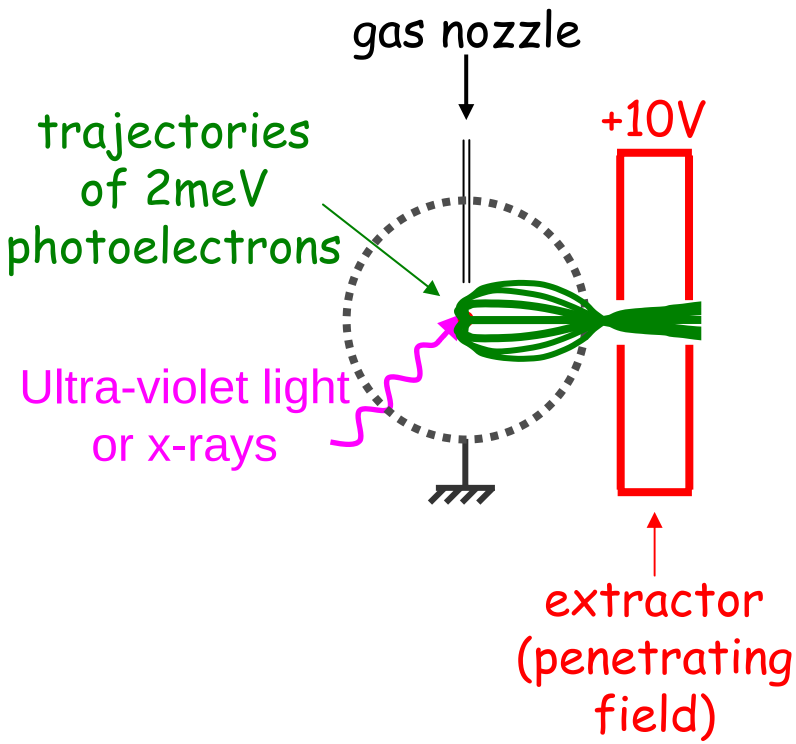
Penetrating Field Threshold Spectrometer

Penetrating Field Threshold Spectrometer

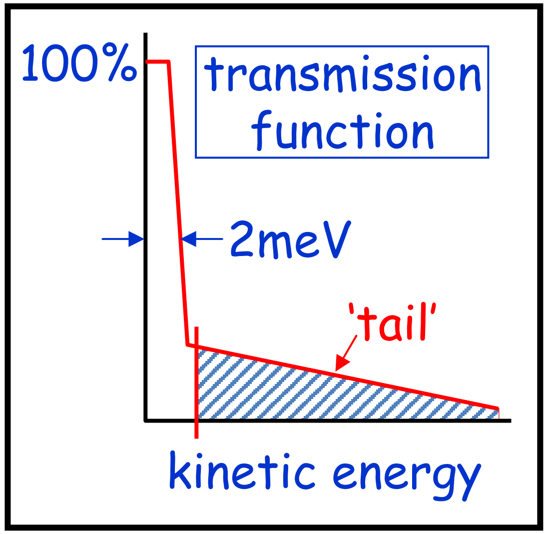


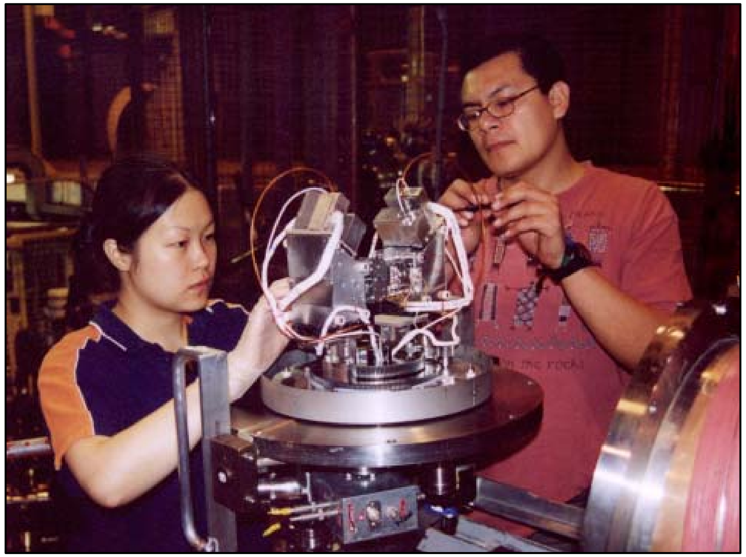
e- s

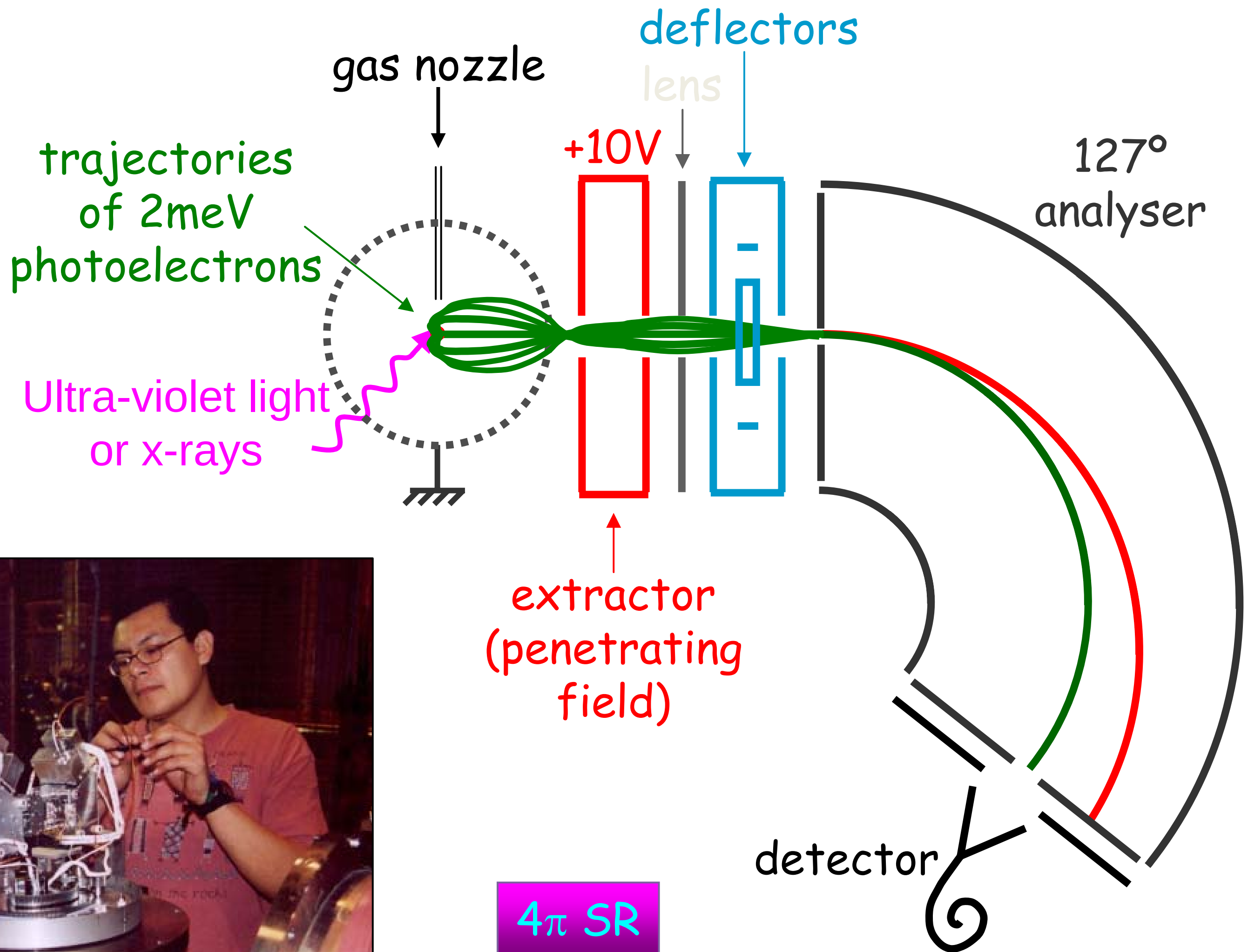
Penetrating Field Threshold Spectrometer



Penetrating Field Threshold Spectrometer





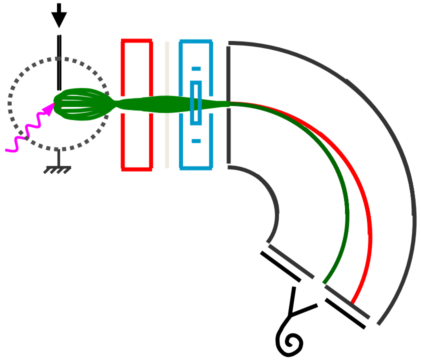


4π SR

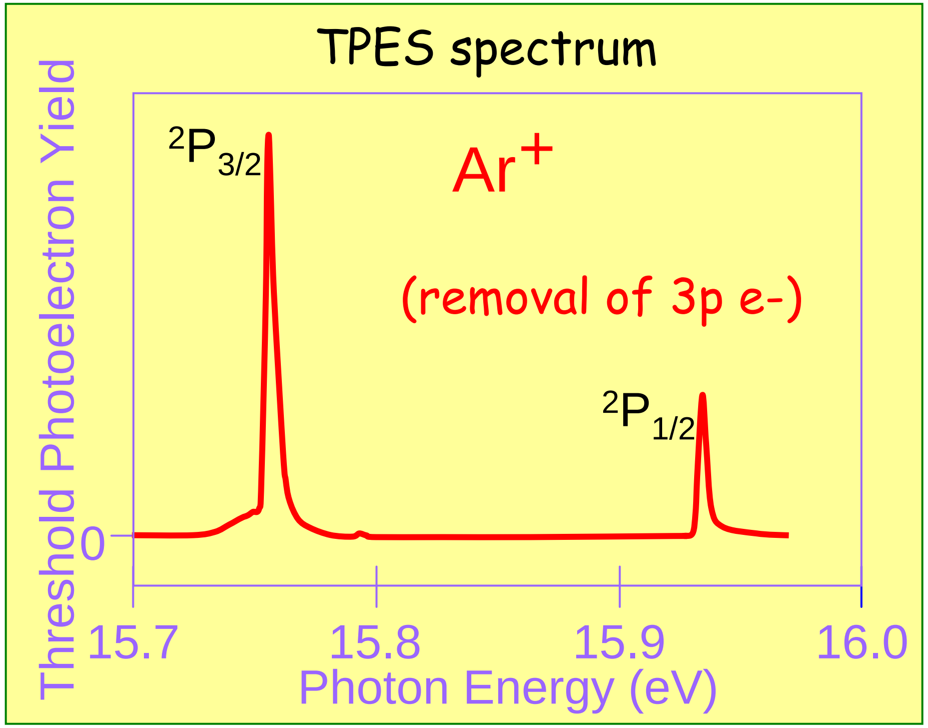
e- s

Threshold PhotoElectron Spectroscopy

tunable source is scanned
(e.g. synchrotron source)



spectrometer is tuned to accept e-s of "0" KE (~<1 meV)

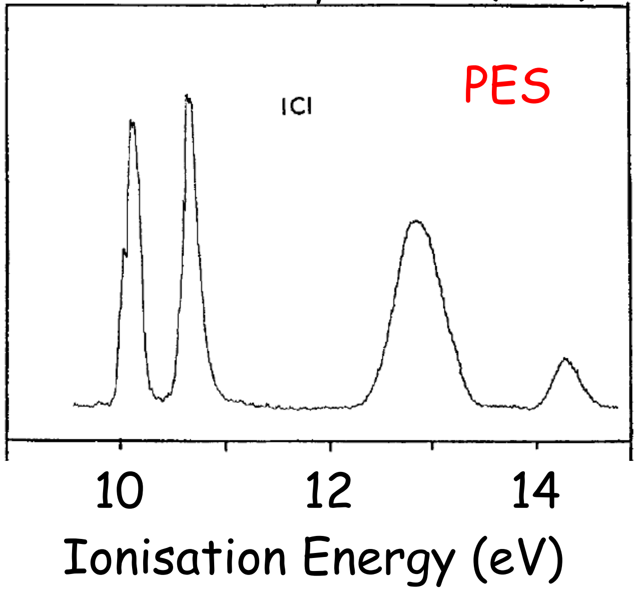


Advantages:

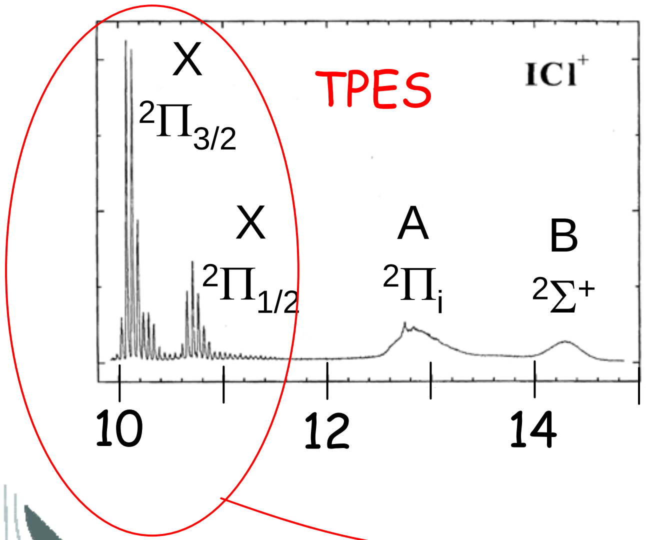
- very high energy resolution
- very high collection efficiency (4π SR)
- no Doppler broadening of spectra
- non-Franck-Condon behaviour

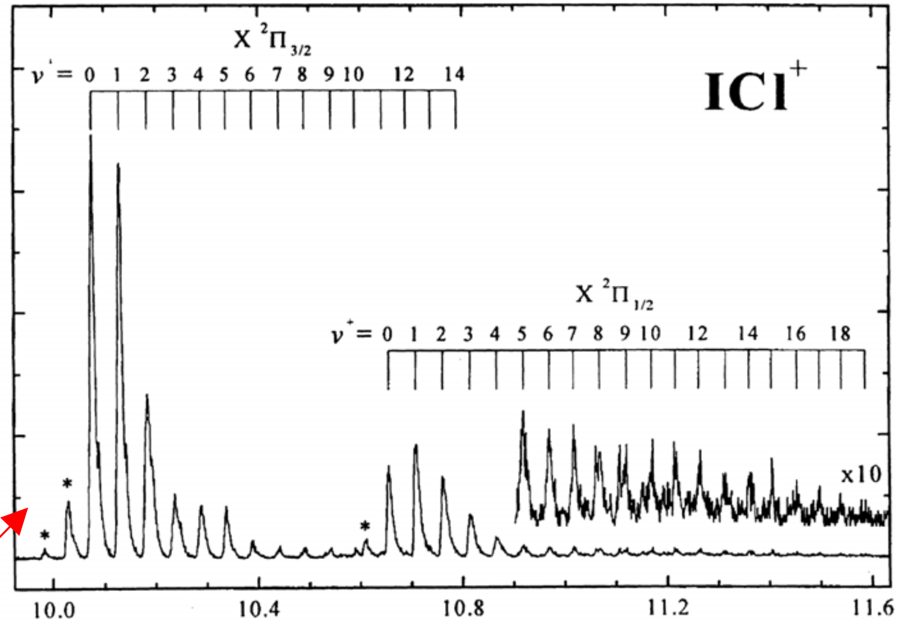
Threshold Spectroscopy of ICl

Potts ... Trans. Faraday Soc. 67 (1971) 1242



Resolution of TPES ⇒ hν bandwidth;
(spectrometer contribution negligible)





Yencha ... Chem Phys Letts. 325 (2000) 559

Threshold Photoelectron Spectroscopy

- has enabled a wealth of new information to be obtained about atomic and molecular targets
- generally complementary to conventional PES
- mainly spectroscopic (e.g. vib const & internuclr sepn of ion)
- may also contain dynamical information
  (mechanisms of single and double ioniztn)

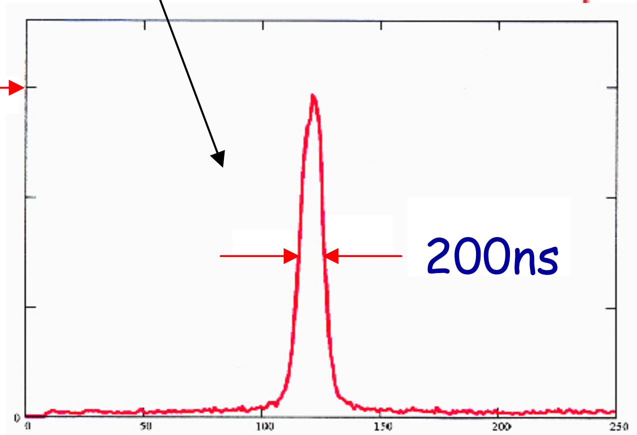
Coincidence Spectroscopy

coincidence techniques can be used for any two or more species (e.g. charged particles or photons)

$$h\upsilon + A \rightarrow A^{++} + e^- + e^-$$

Time spectrum

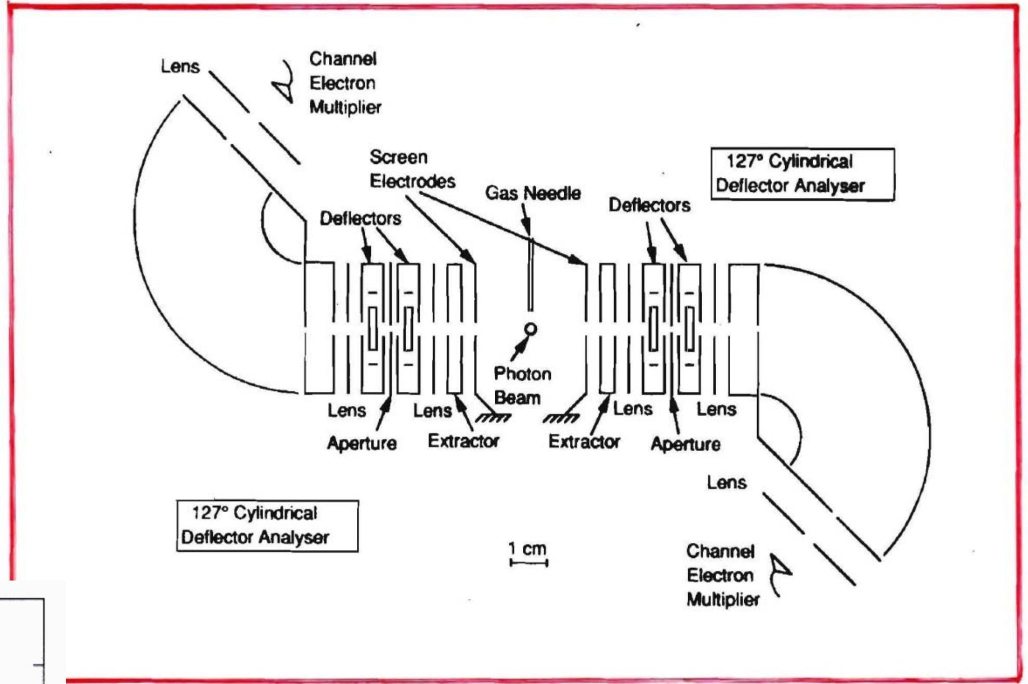
CR = 5 Hz

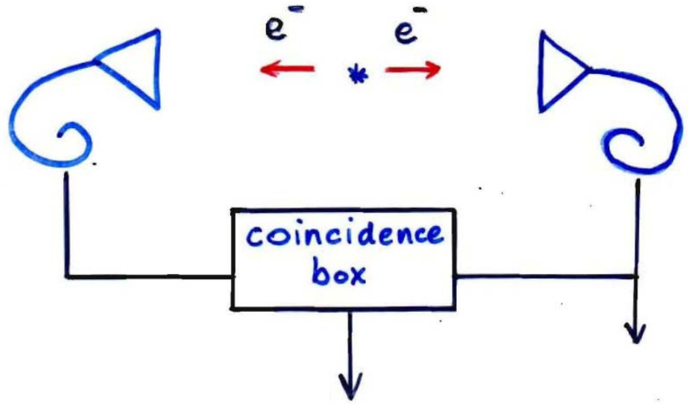


200ns

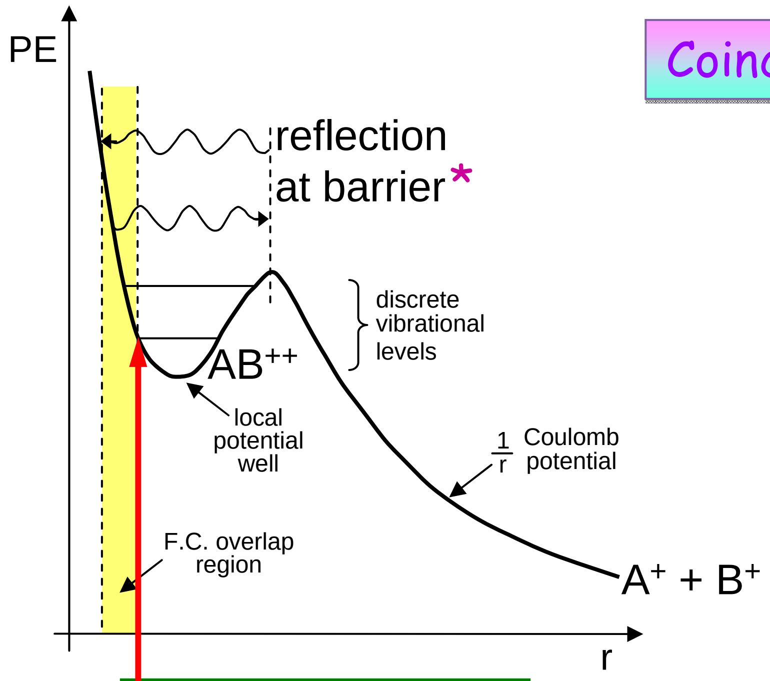
channel

Threshold PhotoElectron PhotoElectron Coincidence (TPEPECo) spectrometer





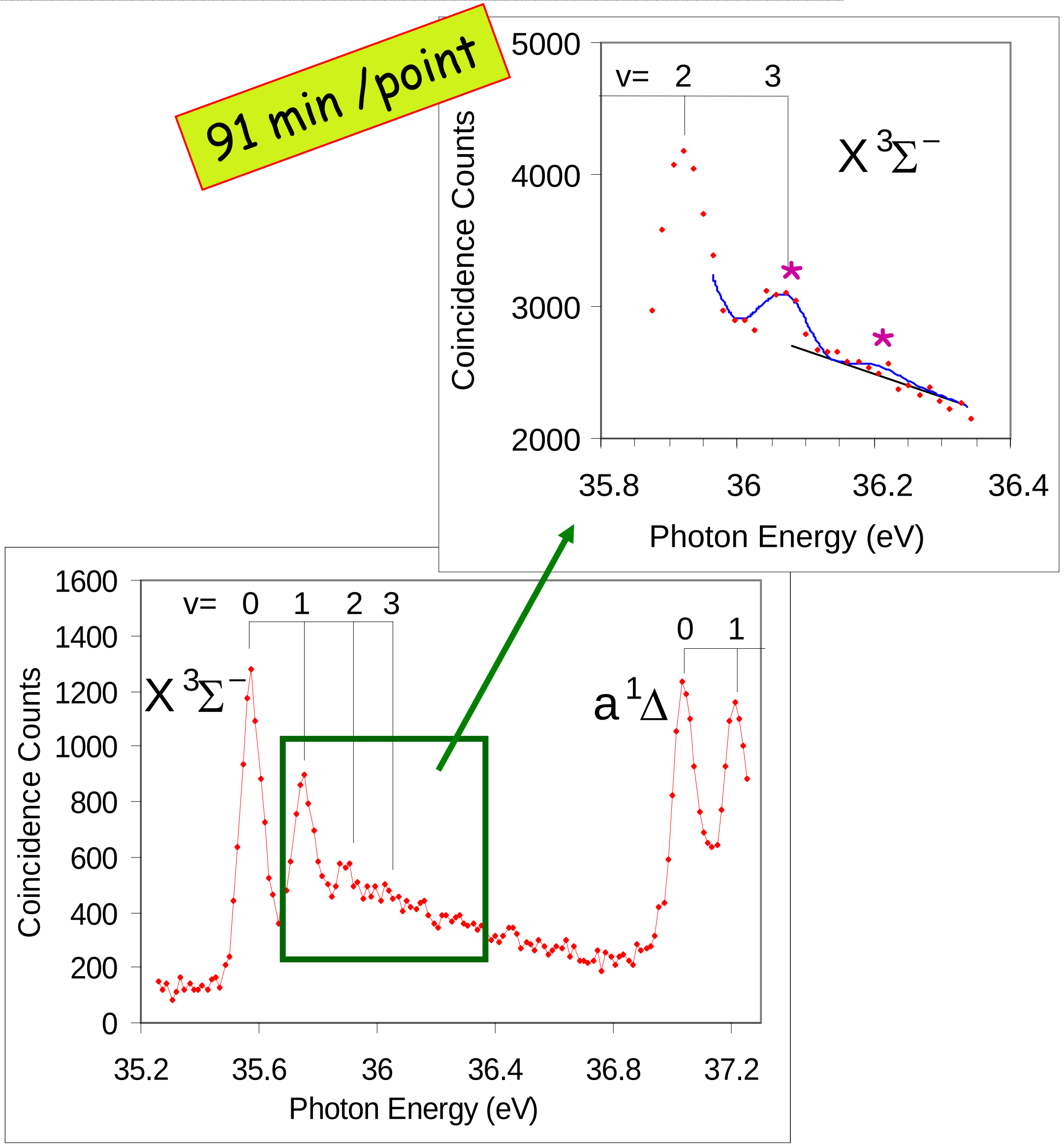
Coincidence Spectroscopy (TPEPECo) of HCl



select level w/
excitation source

Doubly charged ions (e.g. HCl^{++})
can have local minimum that
supports vibrational levels
(e.g. α-particle decay)

$HCl + h\nu \rightarrow HCl^{++} + e^- + e^-$



D. Brown, Ph. D Thesis and 2006-7 SRD Annual Report

Summary

Photo Electron Spectroscopy – a basic review

Penetrating-Field Threshold Photo Electron Technique

- basic concepts
- penetrating field threshold spectrometer
- TPES of ICl
- coincidence threshold spectroscopy (TPEPECo) of ICl

Applications and Uses of Penetrating Field Threshold Spectroscopy

Advantages of TPES:

- very high collection efficiency (4π SR)
- non-Franck-Condon behaviour
- very high energy resolution
- no Doppler broadening of spectra
- spectrometer independent of mass

TPES has been used extensively for the detection of **threshold electrons** generated by using **electrons or photons** as the excitation source.

but what about some other applications involving (e.g.)

positrons? antiprotons?

muons? ?????? neutrons?

medical? atmospheric? biological?

Acknowledgments

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by

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Frank Read, F.R.S.

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