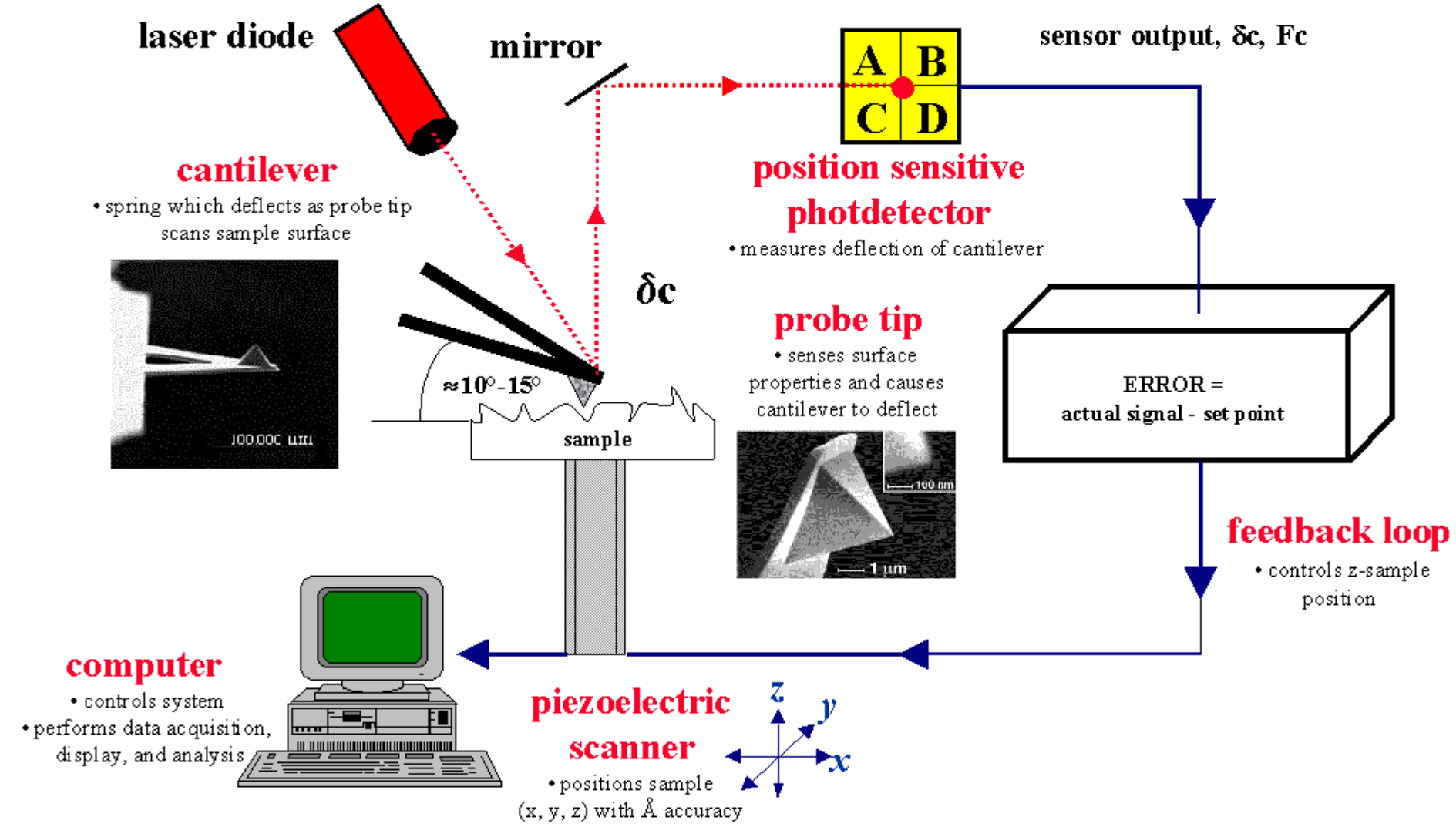
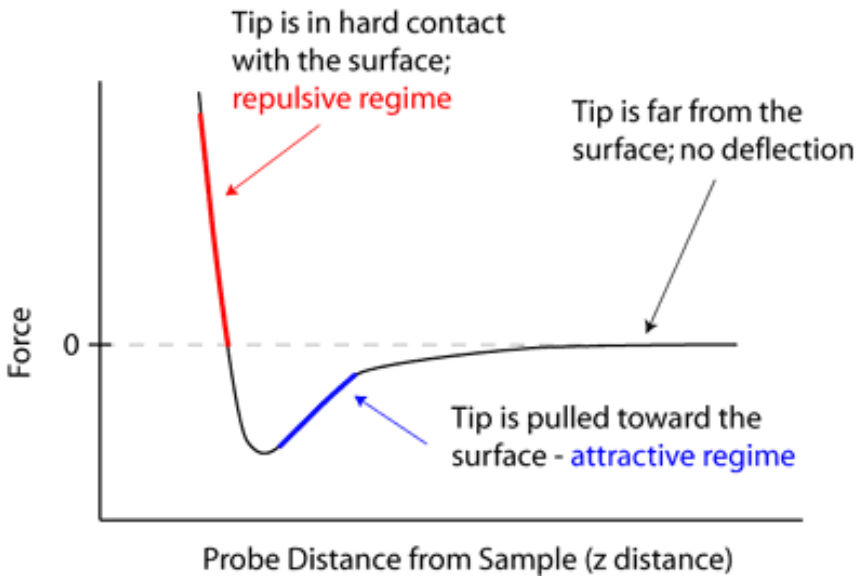
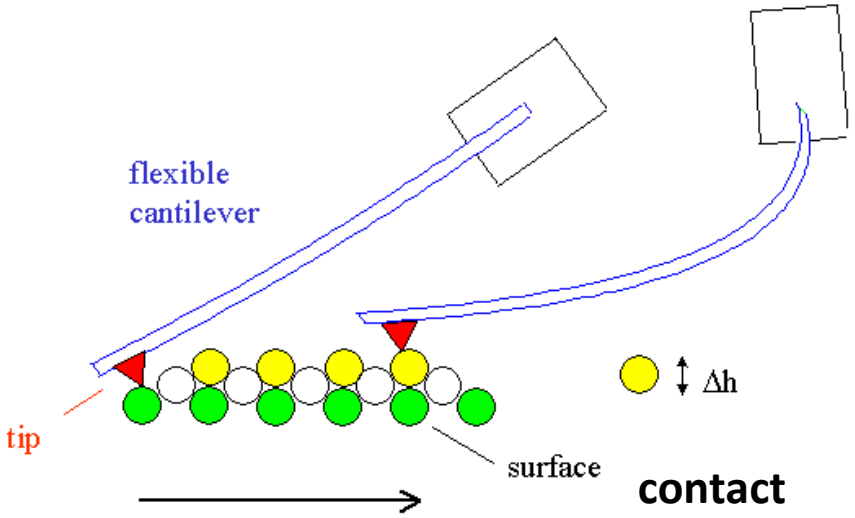
Atomic Force Microscopy (AFM) :

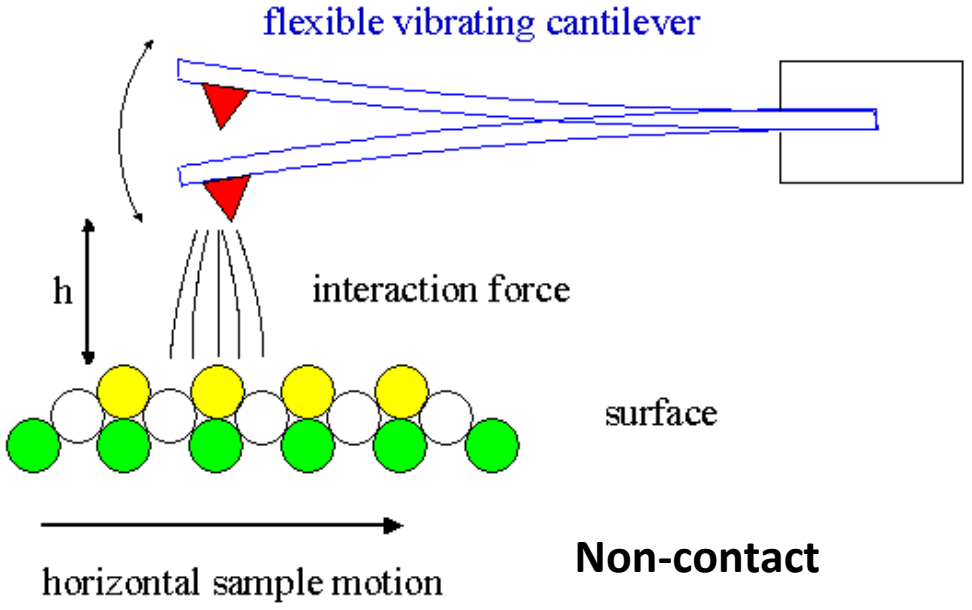
General Components and Their Functions



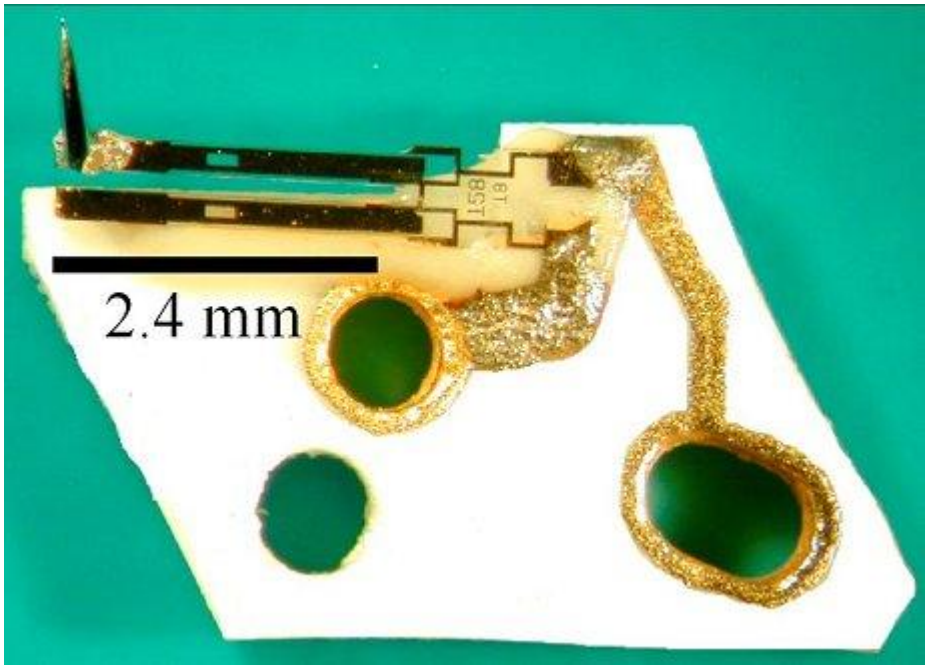
AFM: Force – distance curve, modes of operation

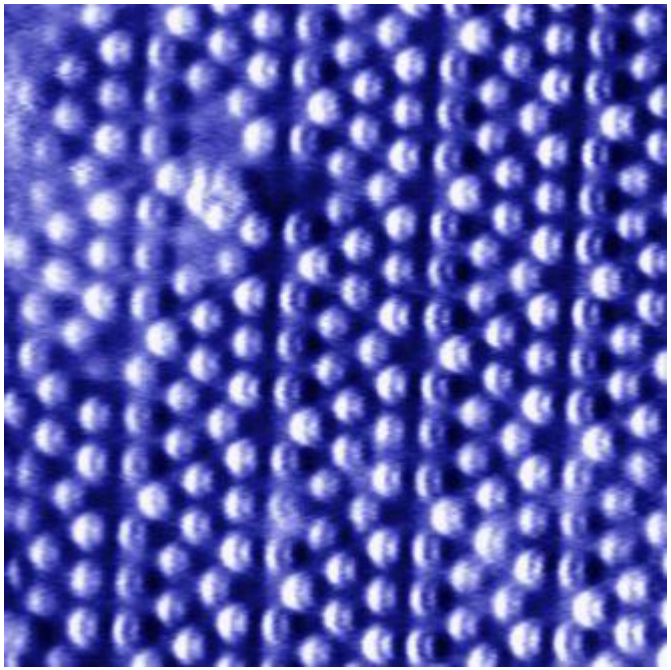






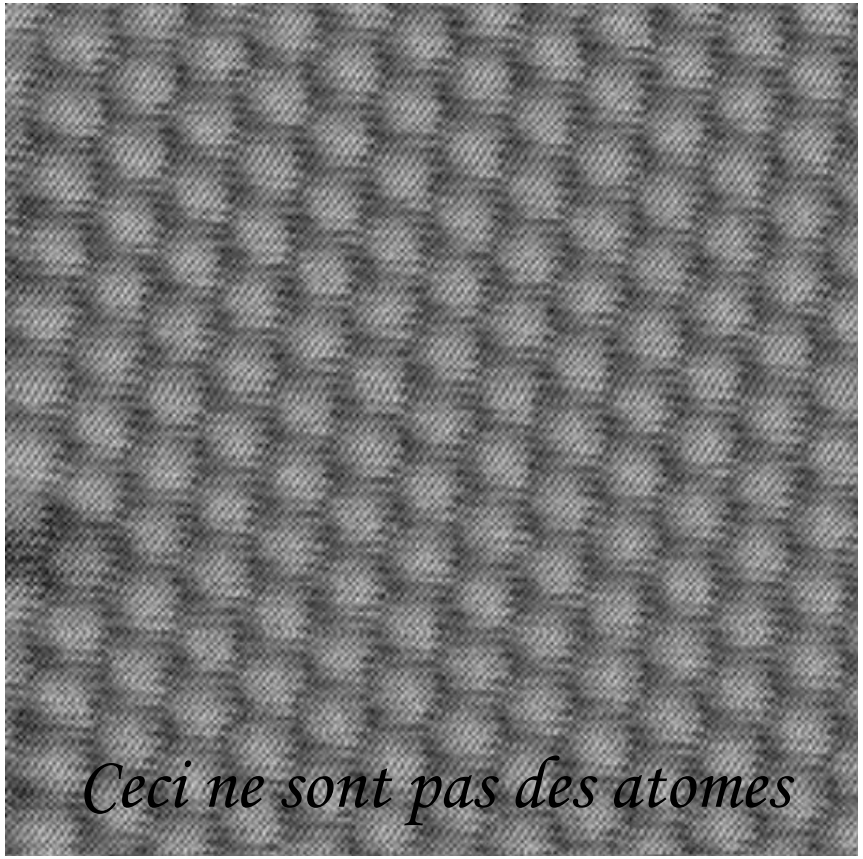
AFM: Q-Plus sensor





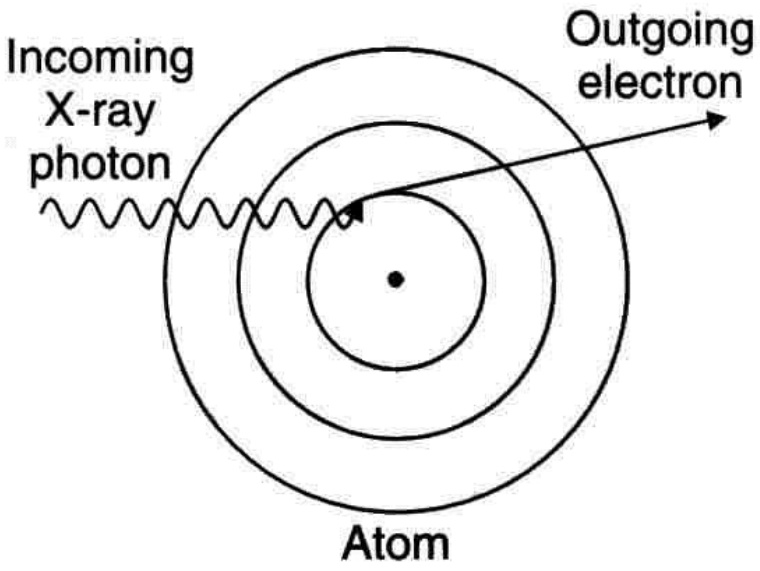
Si(111) -7x7

Can you really „see“ atoms?

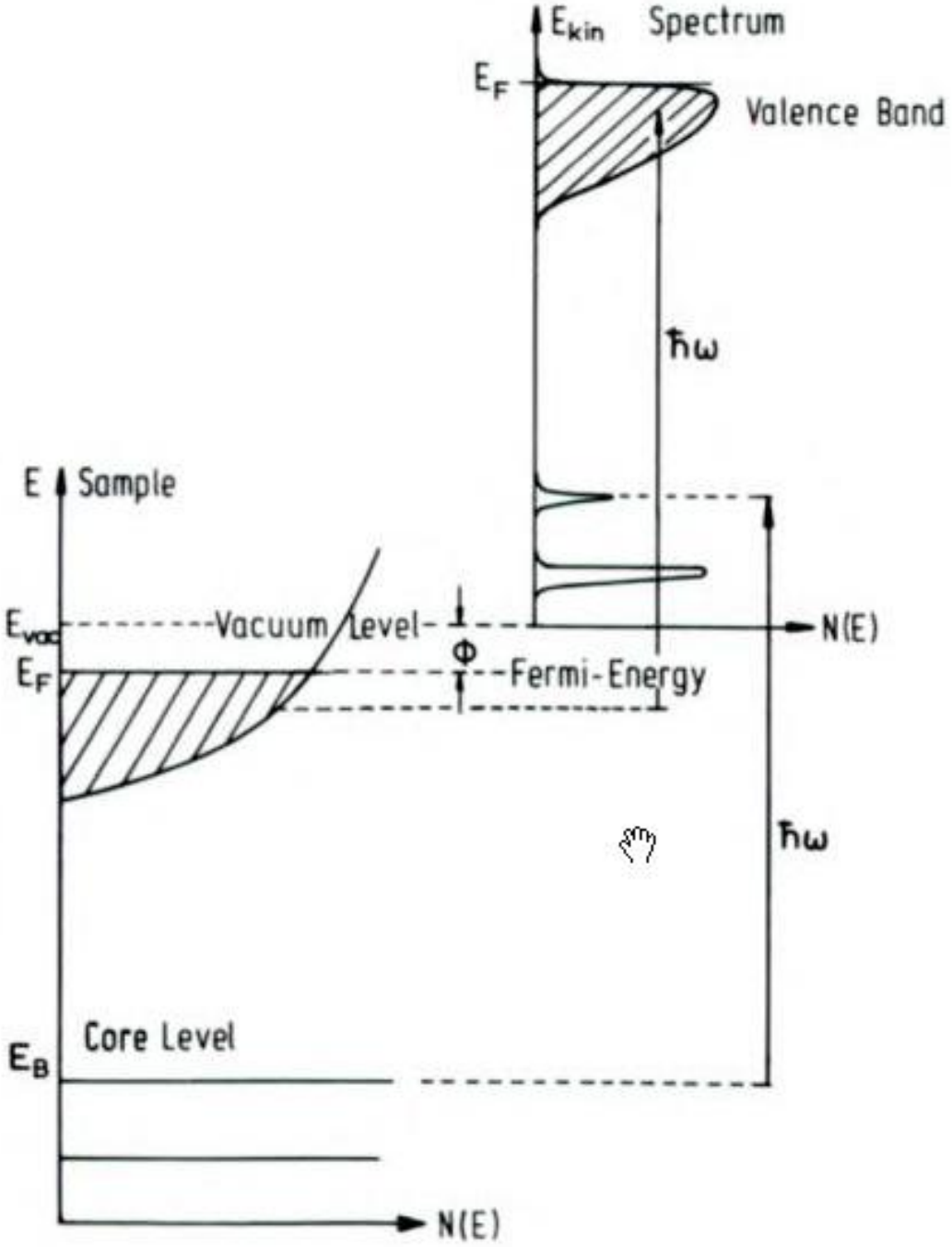


Carsten Busse, 1999 (Al(111))

René Magritte, 1923

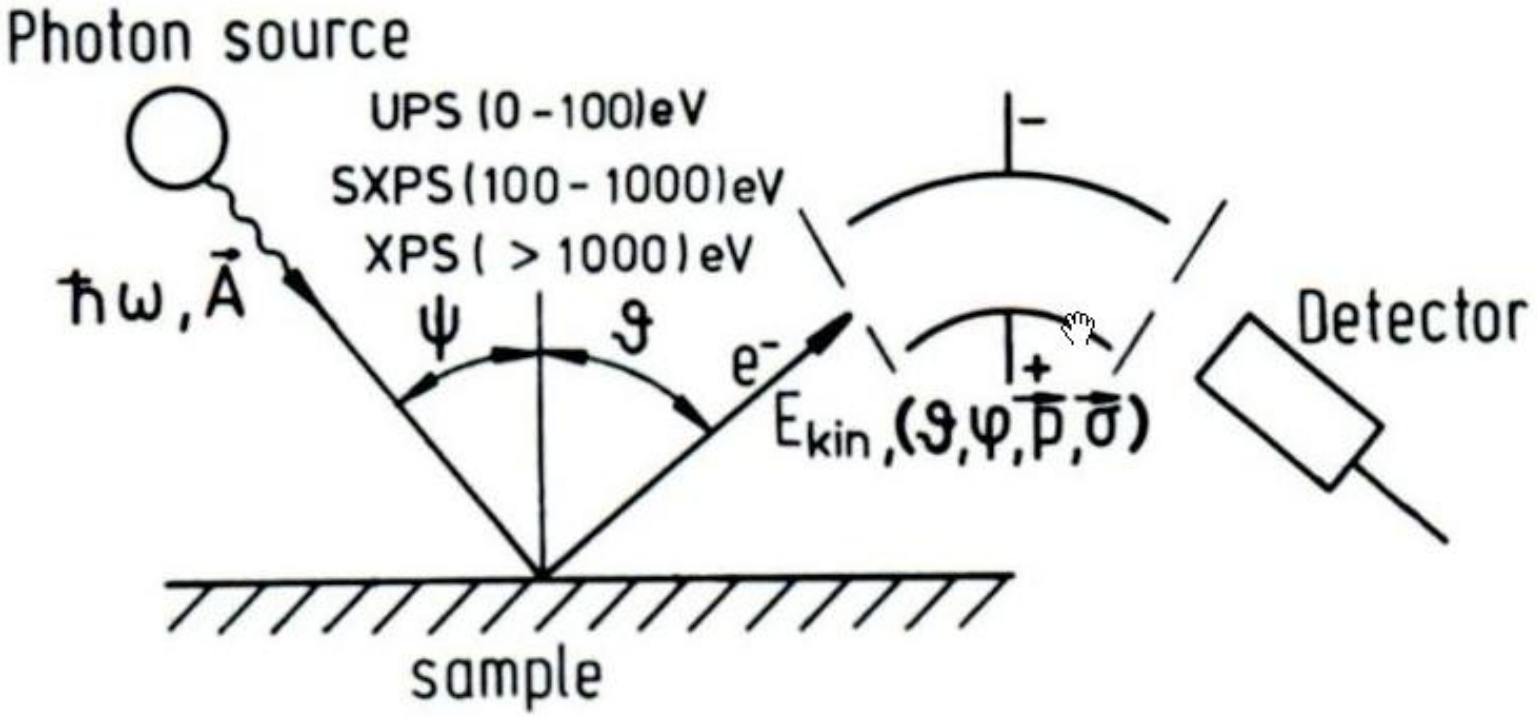


$$E_{\mathrm{kin}} = \hbar\omega - \phi - E_{\mathrm{b}}$$



K. M. Siegbahn

Nobel price in physics 1981 for Siegbahn (shared with Bloembergen and Schawlow)
"for his contribution to the development of high-resolution electron spectroscopy".



$\vec{A}$: vector potential of incident light

ψ : incident angle

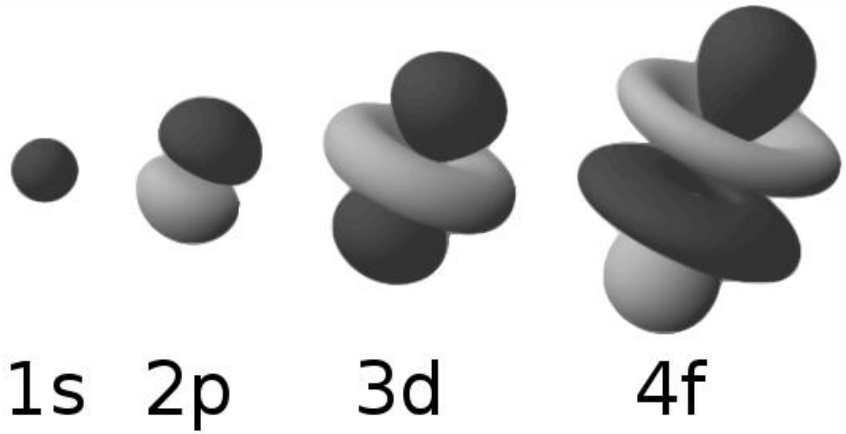
ϑ : polar angle of emission

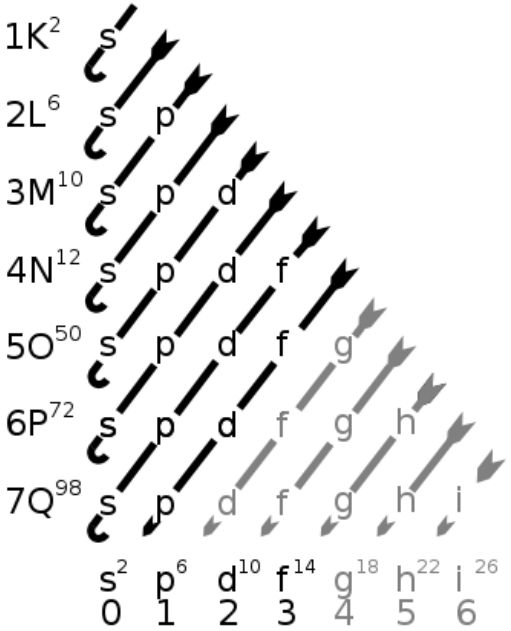
φ : azimuthal angle of emission

E_{kin} : kinetic energy of emitted electron

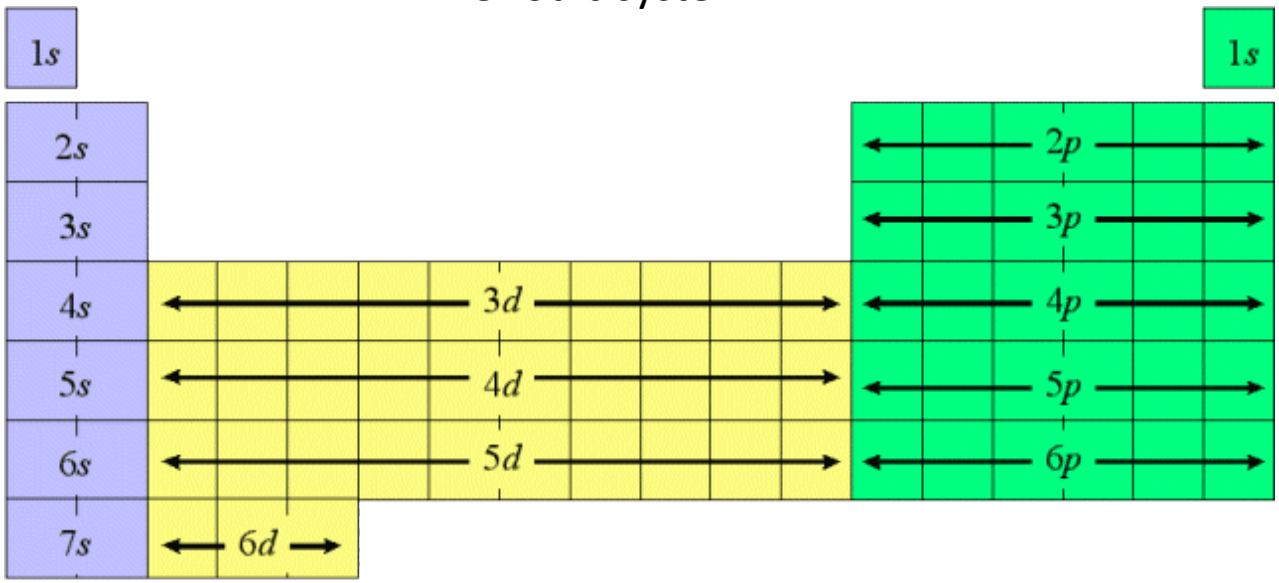
$\vec{p} = \hbar\vec{k} = \hbar\dfrac{2\pi}{\lambda}\vec{e}_k$: momentum of emitted electron

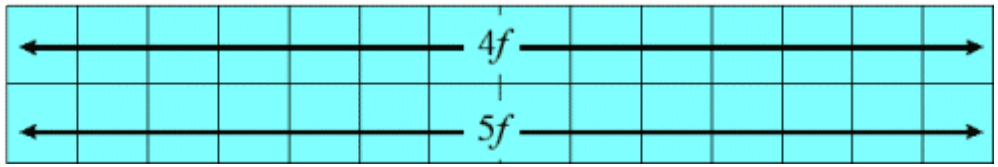
$\vec{\sigma}$: spin of emitted electron



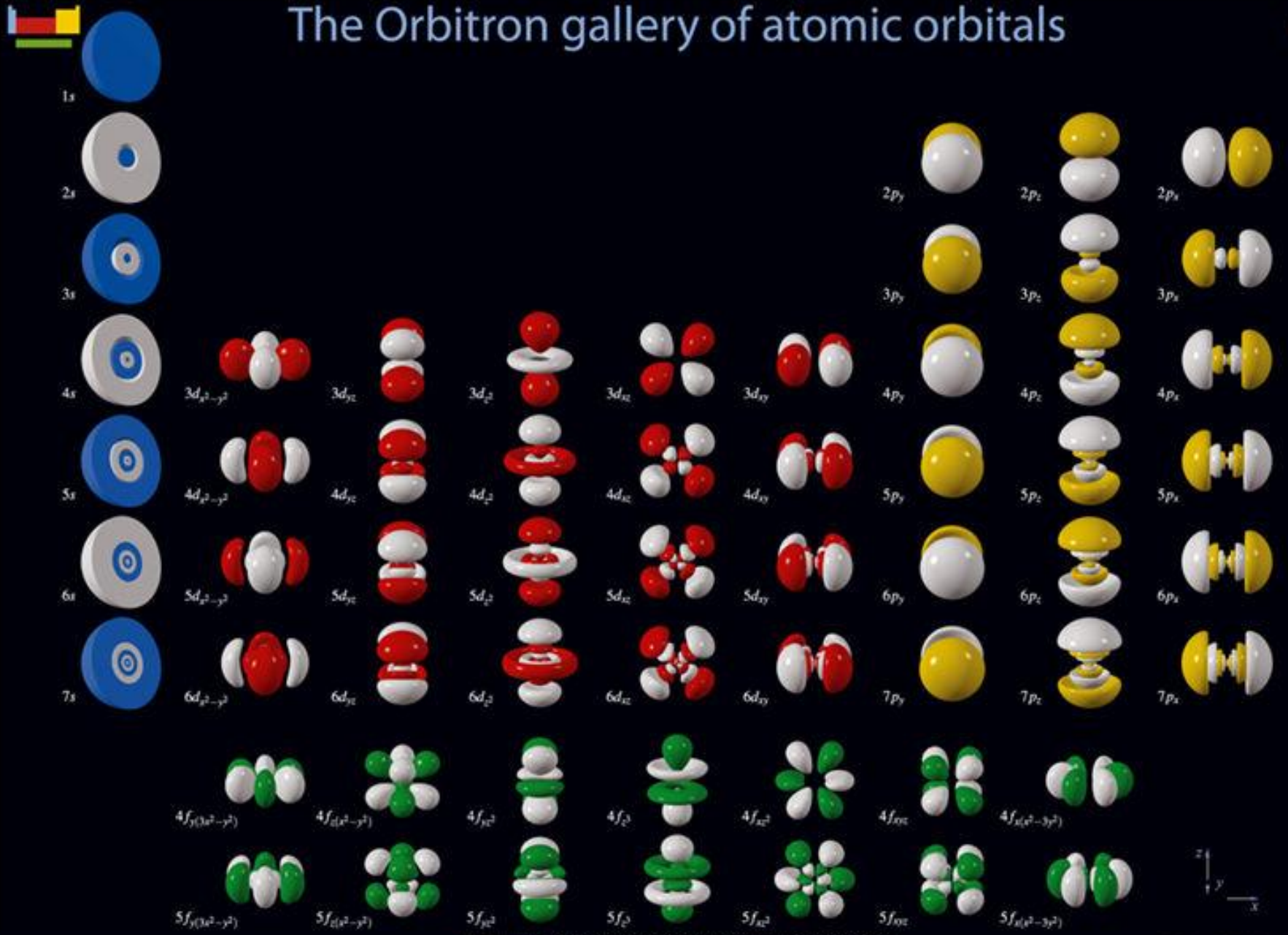


Periodic system

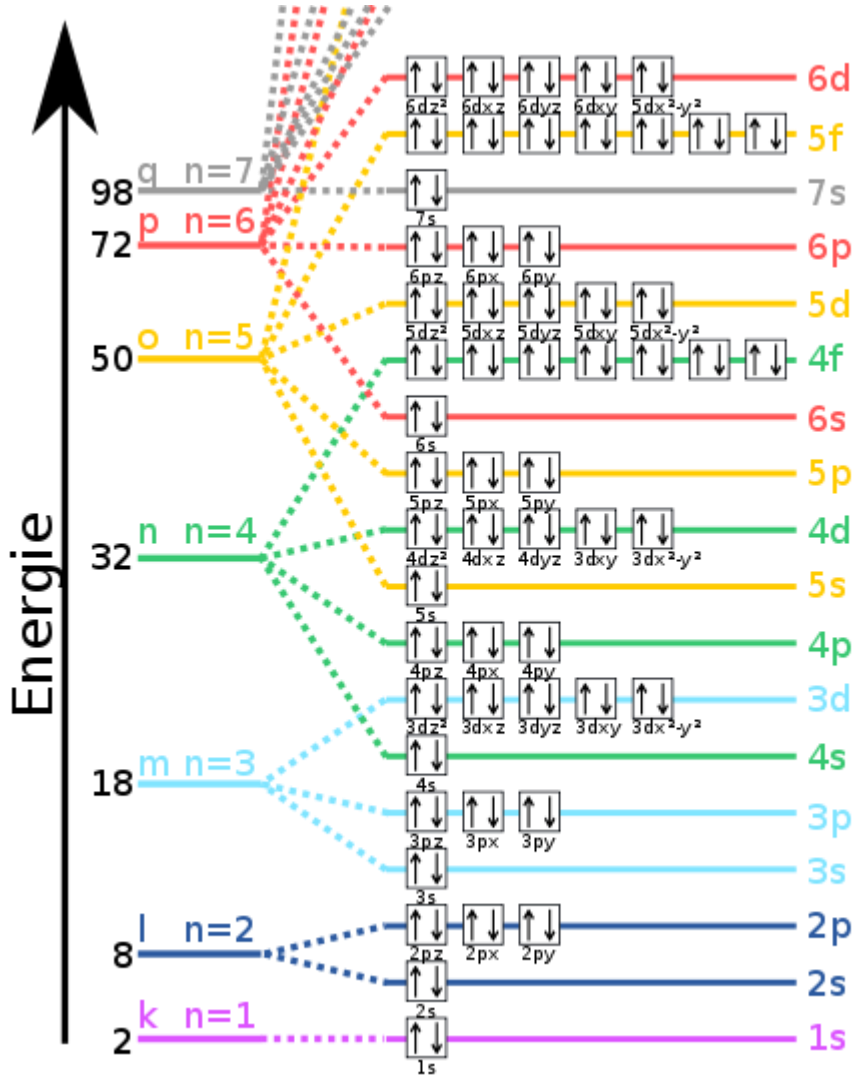


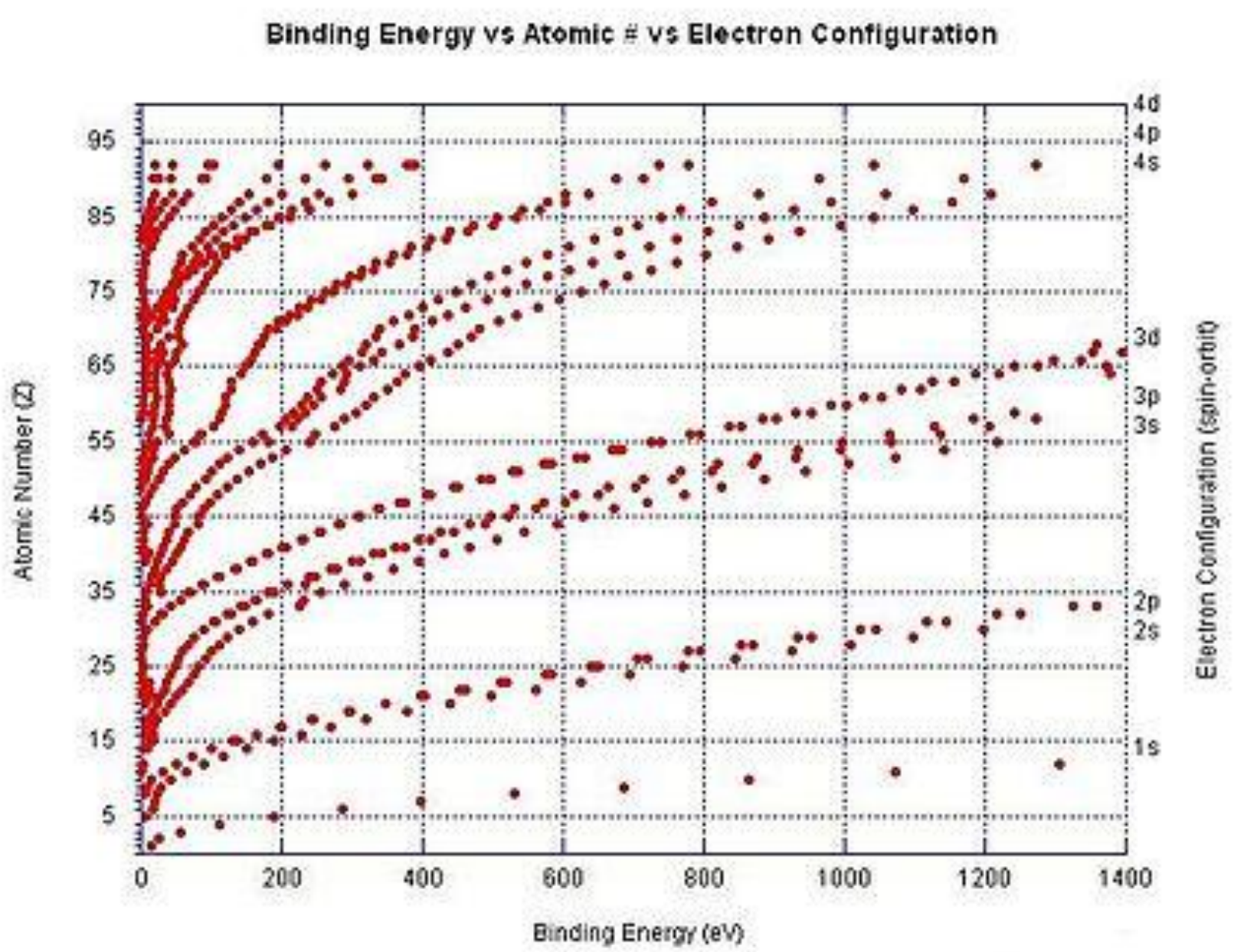


The Orbitron gallery of atomic orbitals

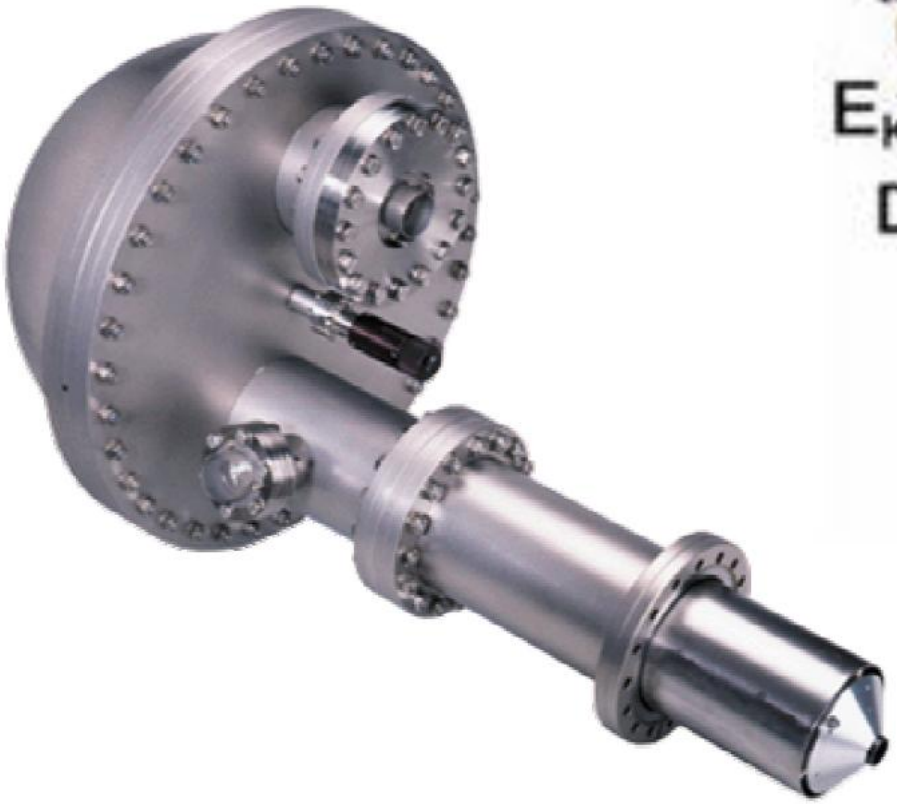


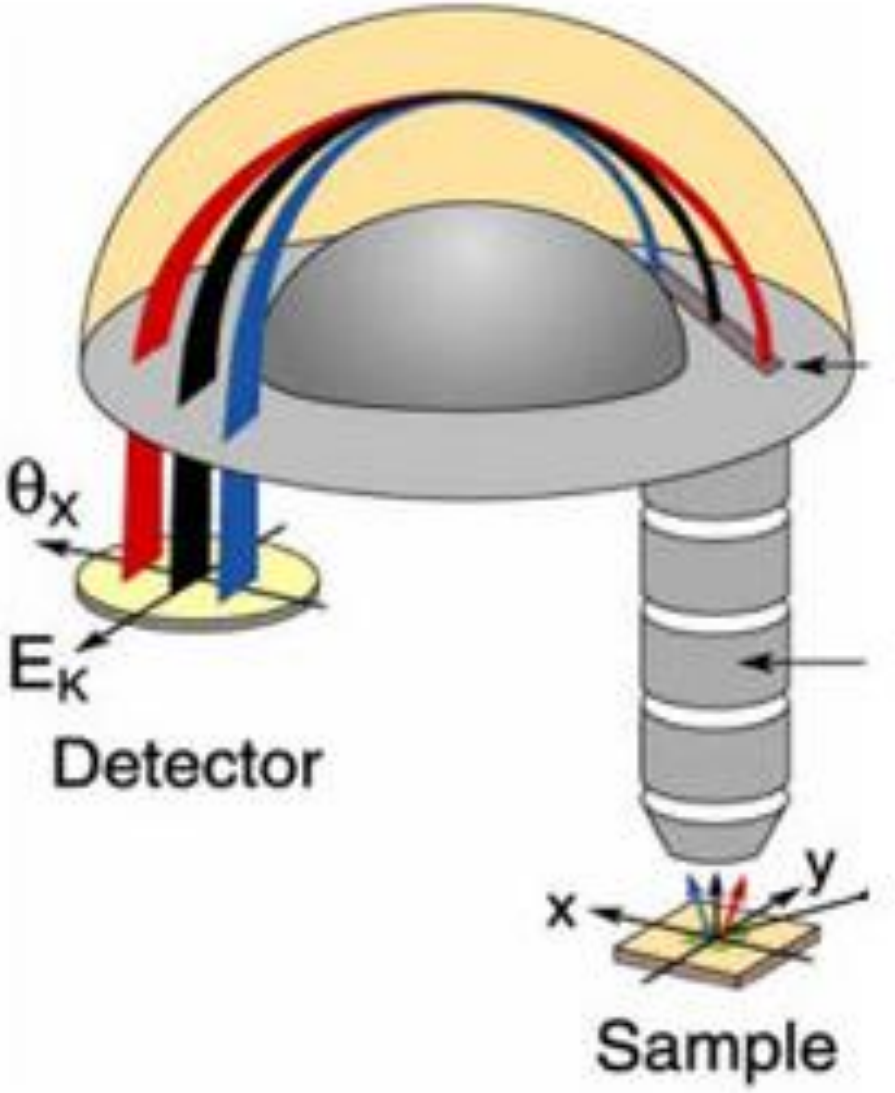
WebElements - the periodic table on the web: www.webelements.com


Energie
98
72
50
32
18
8
2
q n=7
p n=6
o n=5
n n=4
m n=3
l n=2
k n=1
6d
5f
7s
6p
5d
4f
6s
5p
4d
5s
4p
3d
4s
3p
3s
2p
2s
1s
6dz²
6dxz
6dyz
6dxy
5dx²-y²
7s
6pz
6px
6py
5dz²
5dxz
5dyz
5dxy
5dx²-y²
6s
5pz
5px
5py
4dz²
4dxz
4dyz
3dxy
3dx²-y²
5s
4pz
4px
4py
3dz²
3dxz
3dyz
3dxy
3dx²-y²
4s
3pz
3px
3py
3s
2pz
2px
2py
2s
1s

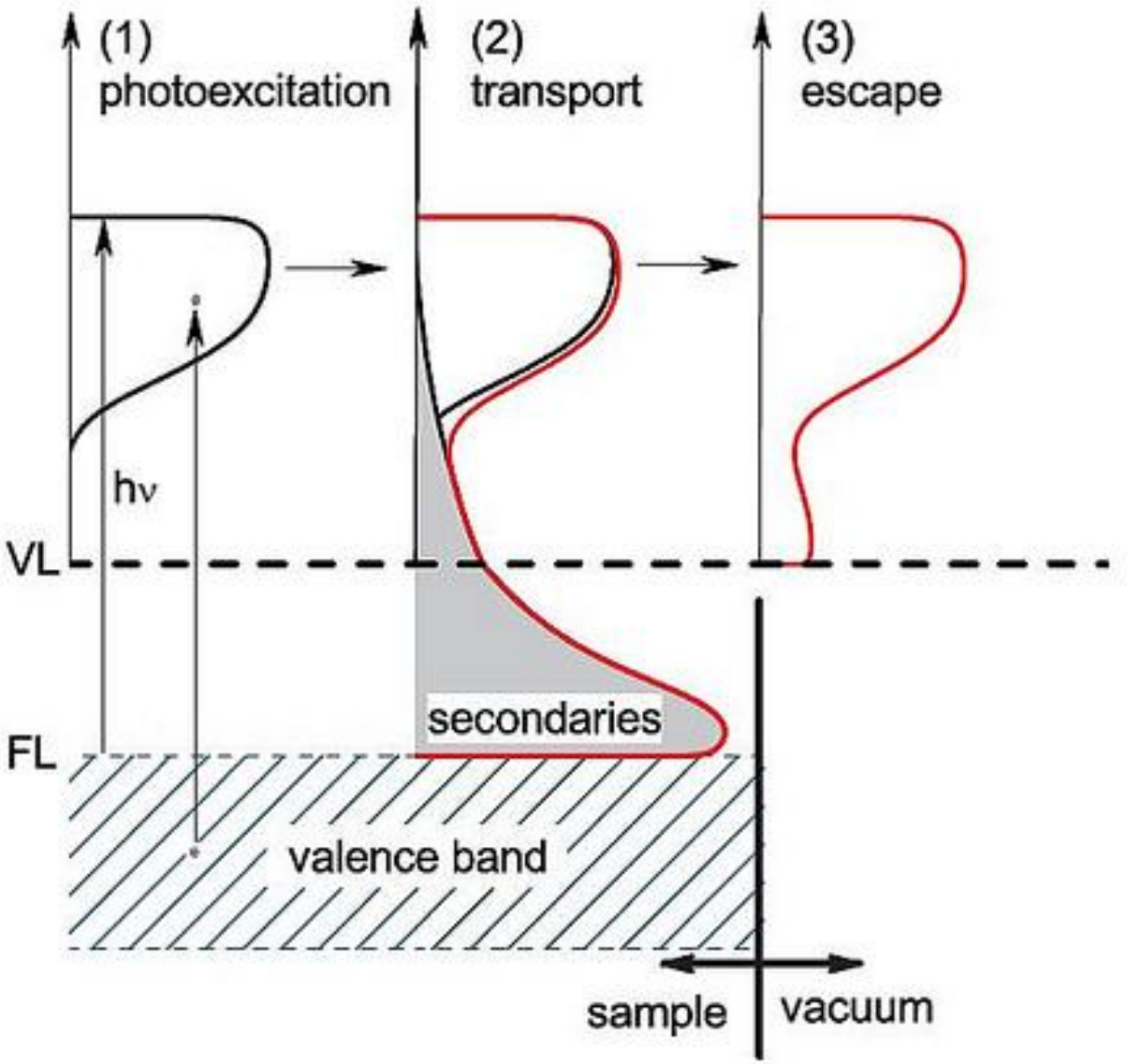

Binding Energy vs Atomic # vs Electron Configuration
Atomic Number (Z)
95
85
75
65
55
45
35
25
15
5
0
200
400
600
800
1000
1200
1400
Binding Energy (eV)
Electron Configuration (spin-orbit)
4d
4p
4s
3d
3p
3s
2p
2s
1s

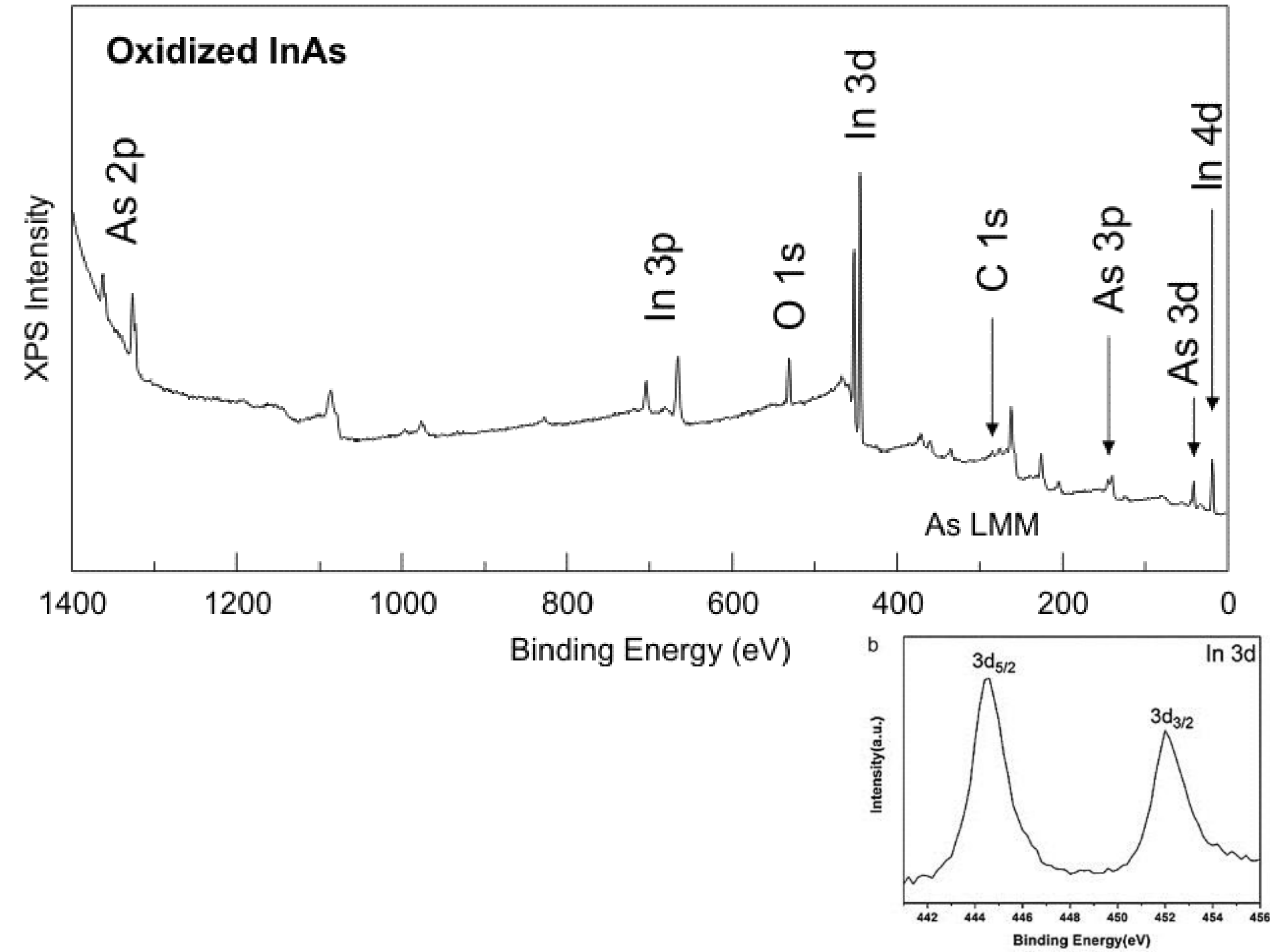
hemispherical energy analyzer



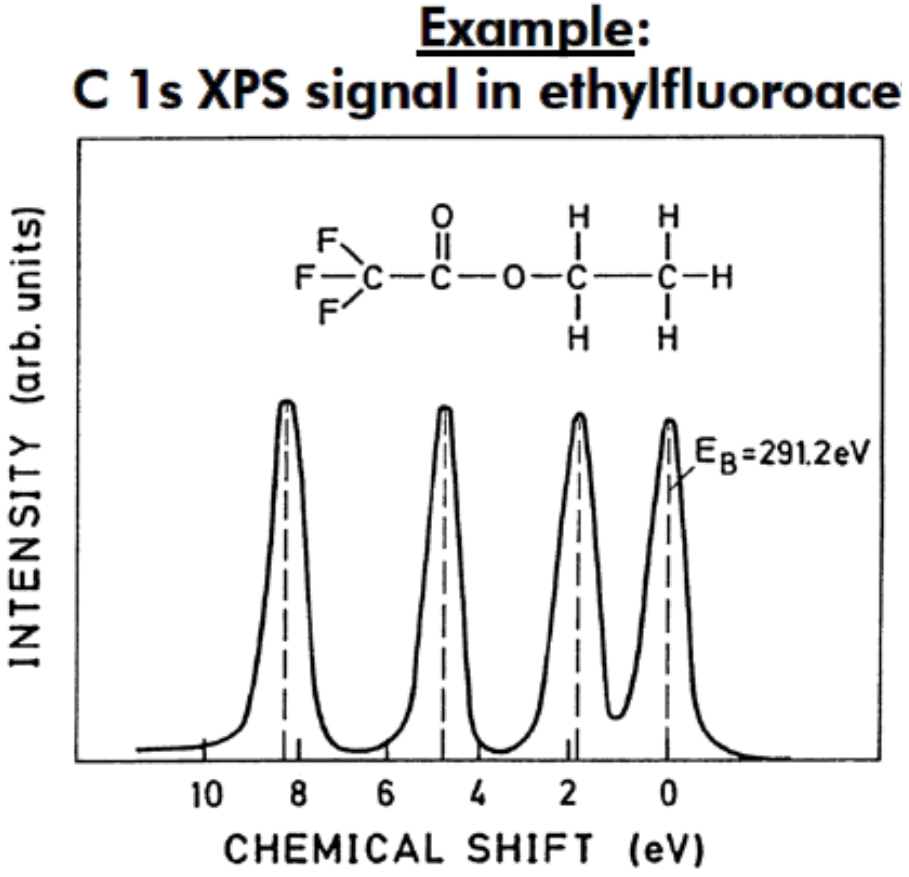


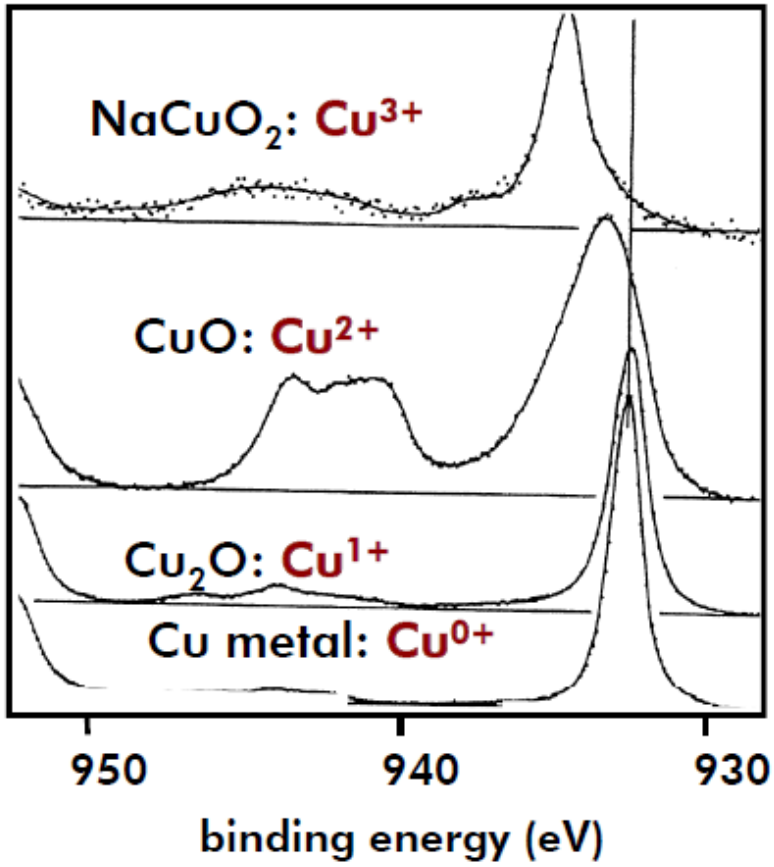
Three-step model



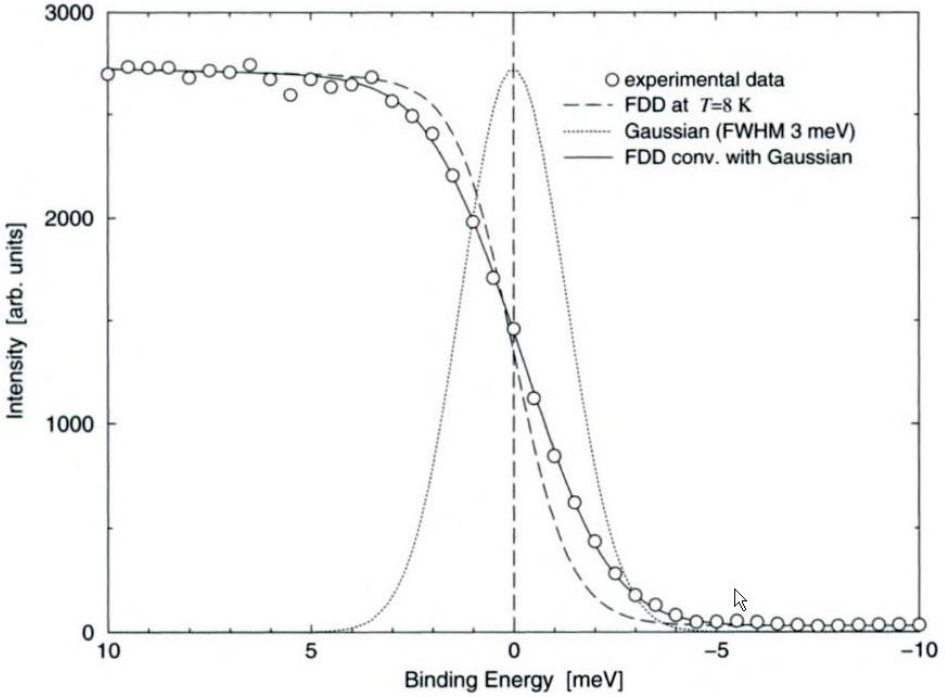

Oxidized InAs
As 2p
In 3p
O 1s
In 3d
C 1s
As 3p
As 3d
In 4d
As LMM
XPS Intensity
1400
1200
1000
800
600
400
200
0
Binding Energy (eV)
b
In 3d
3d5/2
3d3/2
Intensity(a.u.)
442
444
446
448
450
452
454
456
Binding Energy(eV)

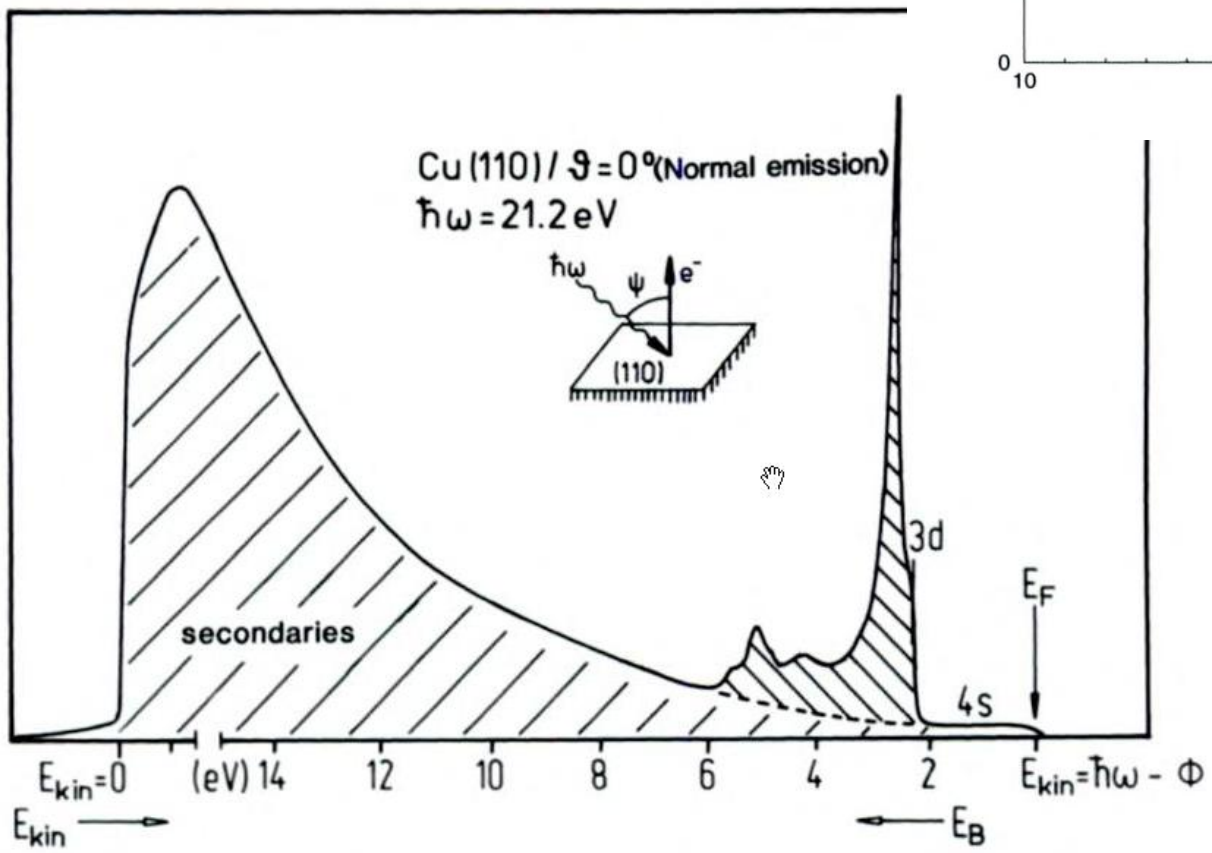
Chemical shift in XPS



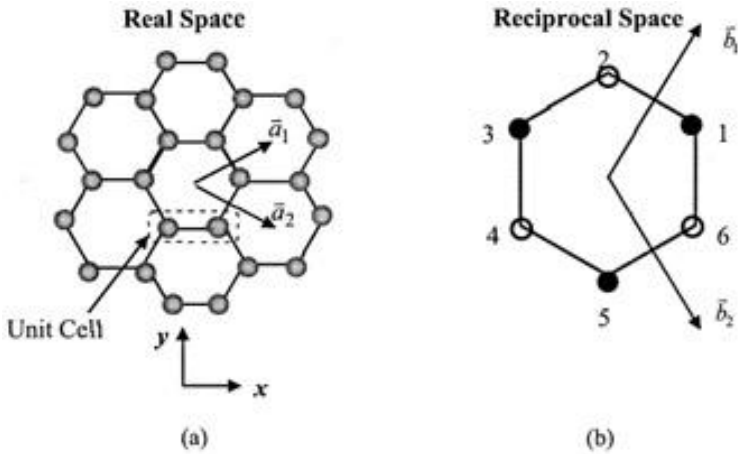


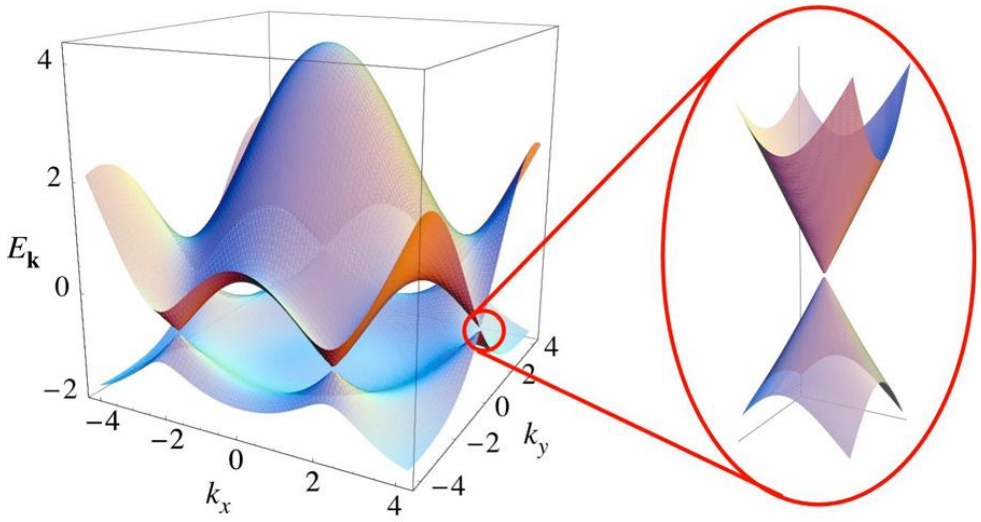
UPS

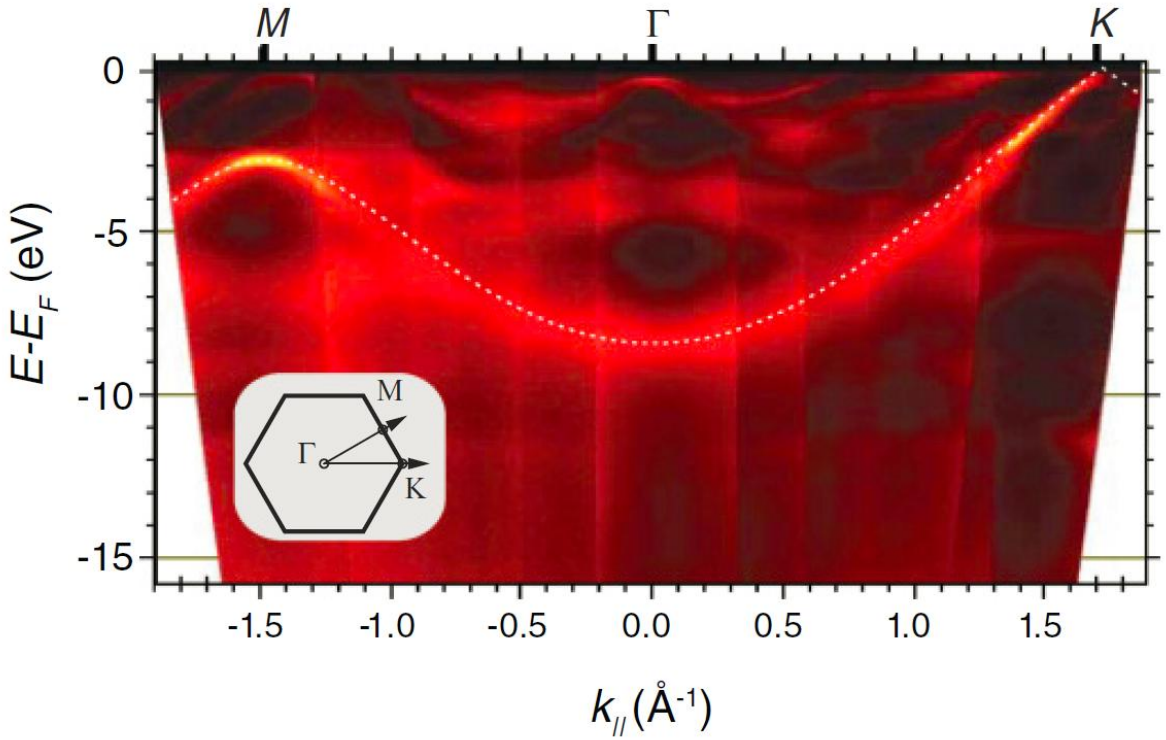

3000
2000
1000
0
Intensity [arb. units]
10
5
0
−5
−10
Binding Energy [meV]
experimental data
FDD at T=8 K
Gaussian (FWHM 3 meV)
FDD conv. with Gaussian

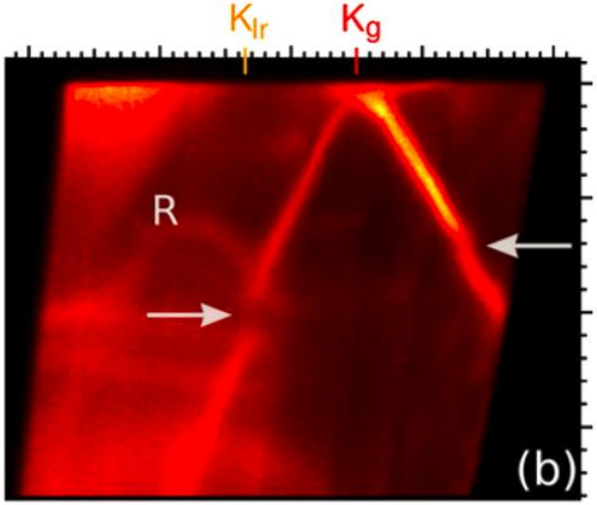

Cu (110) / ϑ = 0° (Normal emission)
ħω = 21.2 eV
ħω
ψ
e⁻
(110)
secondaries
3d
4s
E_F
E_kin=0
(eV) 14
12
10
8
6
4
2
E_kin=ħω - Φ
E_kin
E_B

ARPES on graphene

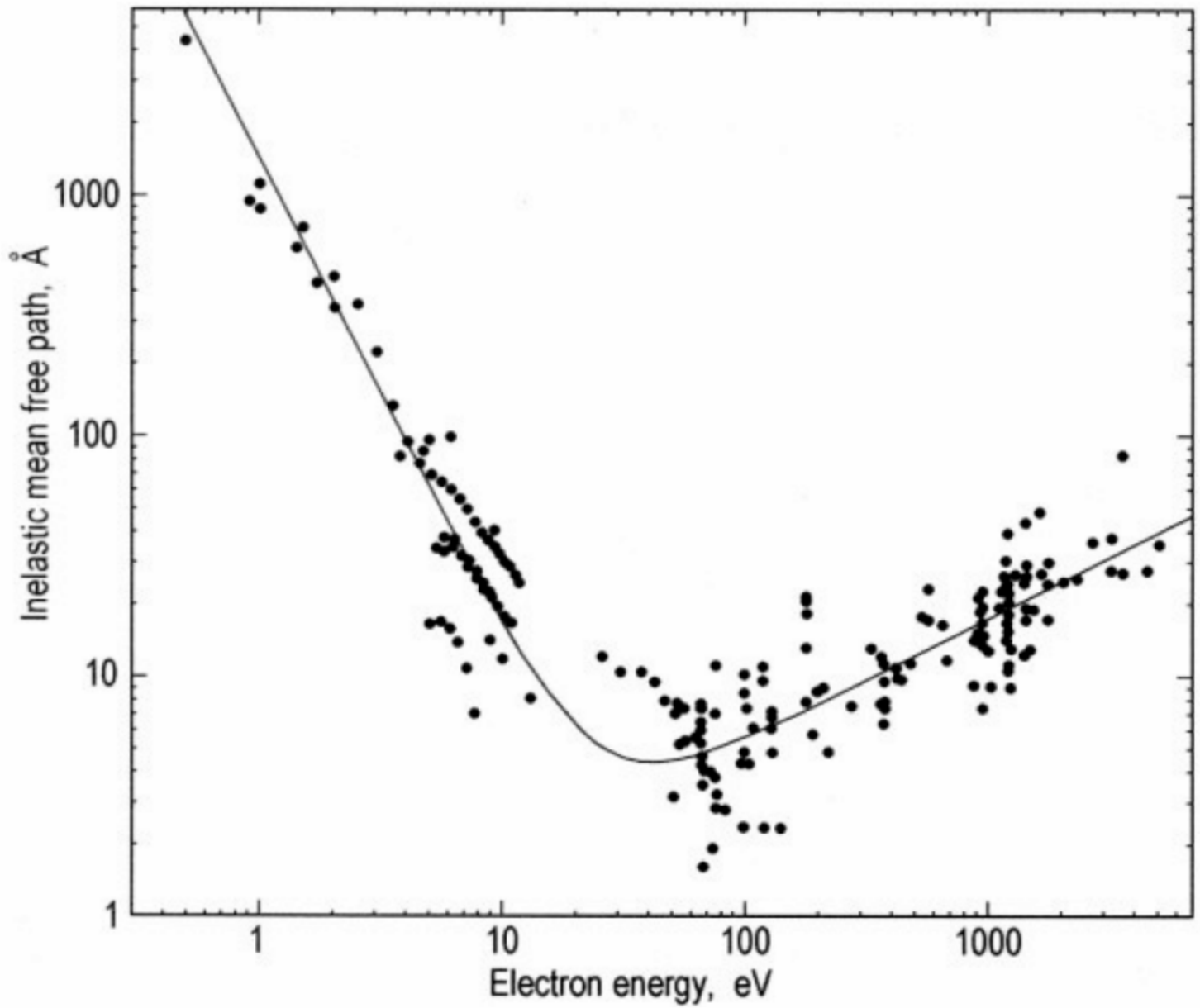








The Universal Curve for the Electron Mean Free Path



New analyzer generation with parallel multi-angle and energy recording

- Improved **energy resolution**
- Improved **momentum resolution**
- Improved **data-acquisition efficiency**

	ΔE (meV)	$\Delta\theta$
past	*20-40*	*2°*
now	*2-10*	*0.2°*