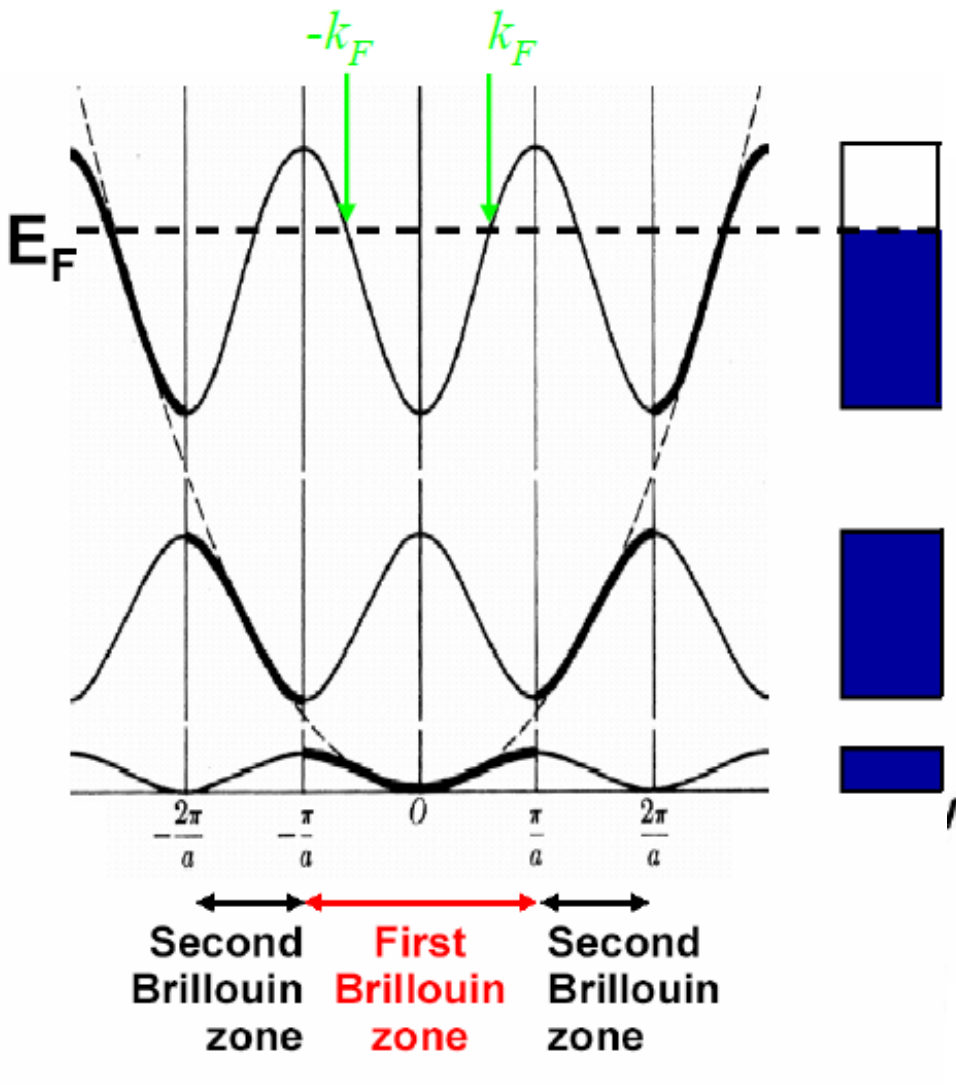
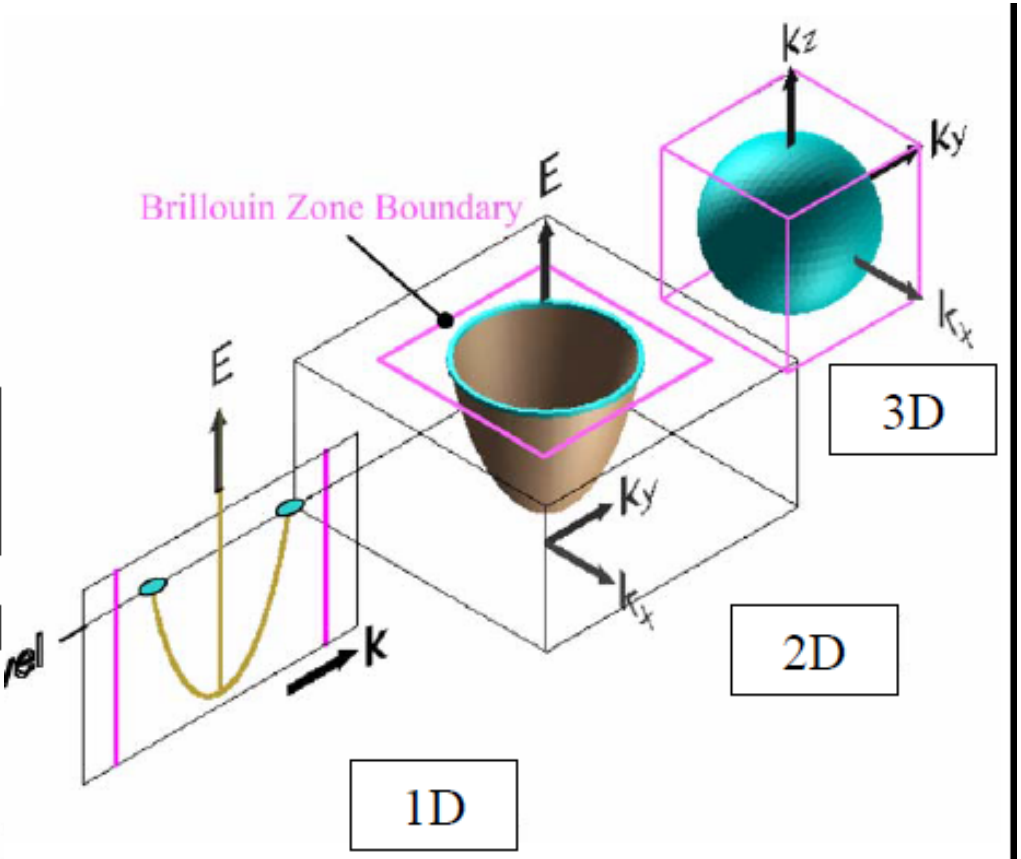
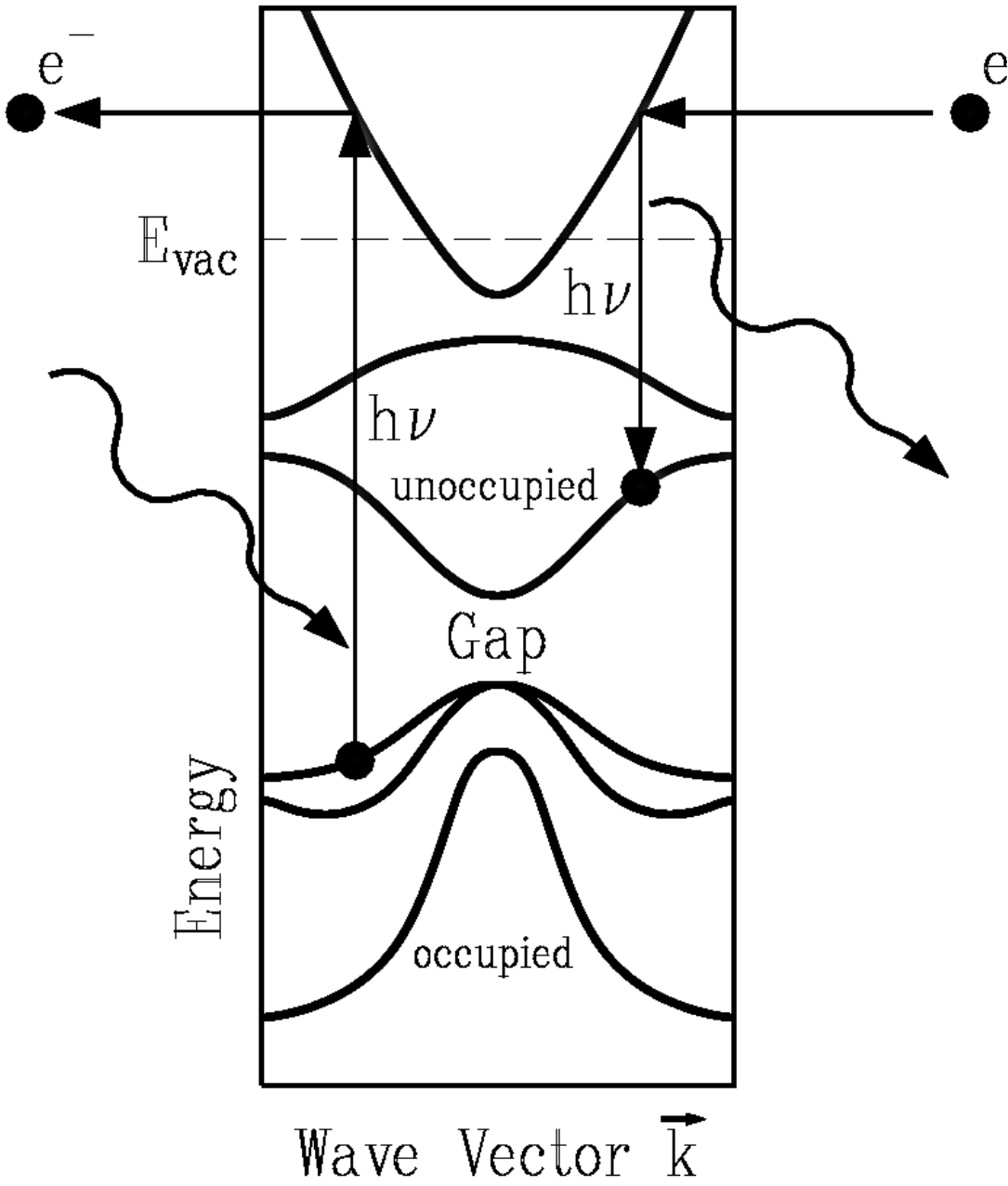

$-k_F$
k_F
E_F
$\frac{2\pi}{a}$
$\frac{\pi}{a}$
0
$\frac{\pi}{a}$
$\frac{2\pi}{a}$
Second Brillouin zone
First Brillouin zone
Second Brillouin zone


Brillouin Zone Boundary
E
k
kz
ky
kx
3D
2D
1D

Angle Resolved PES/IPES

(ARUPS, KRIPES)

vertical transitions



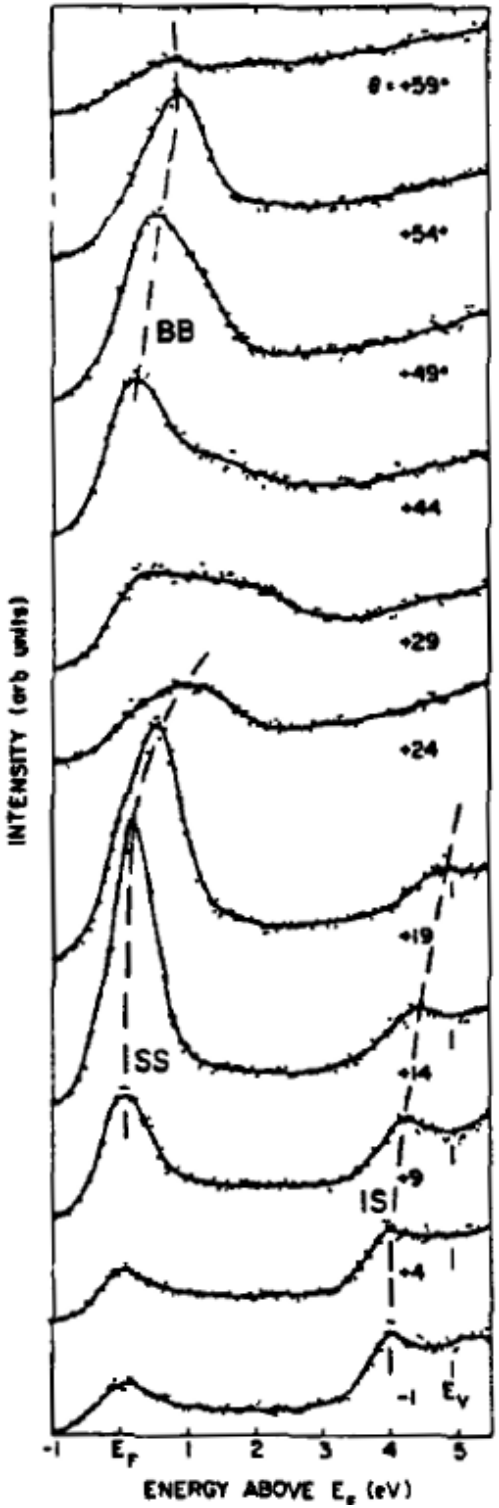
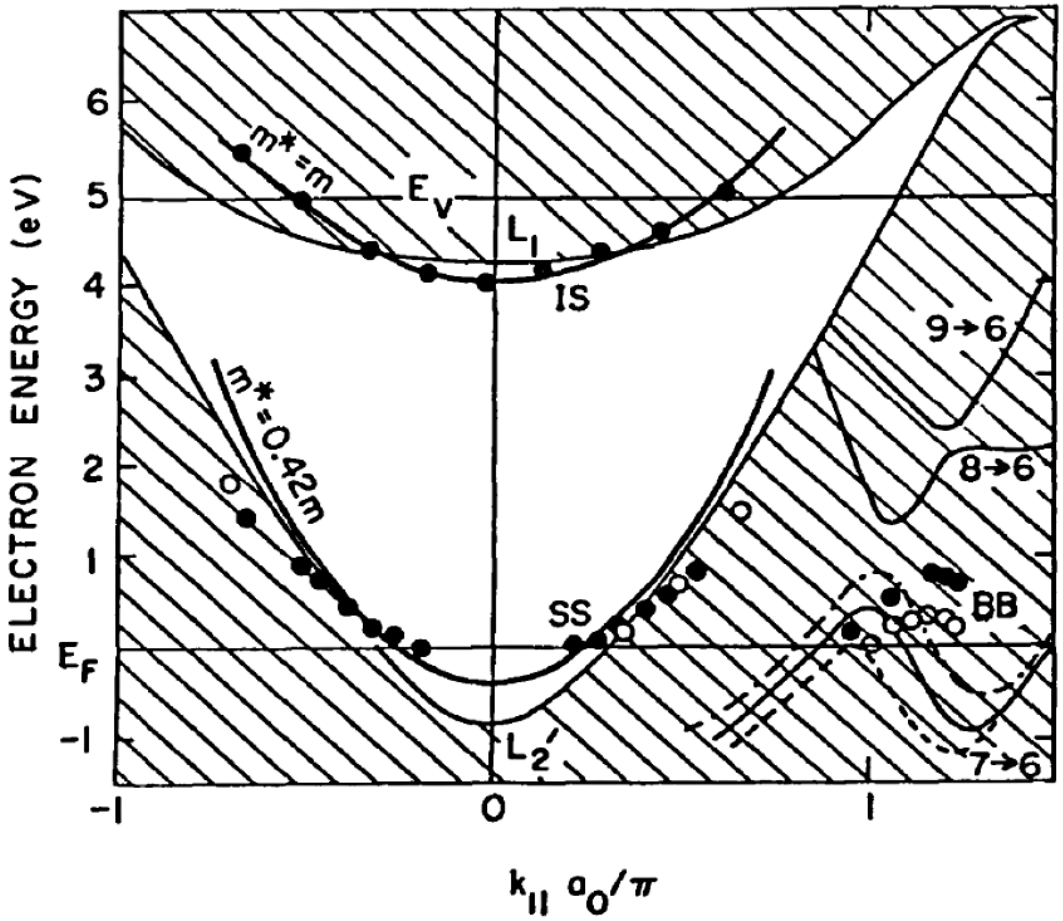
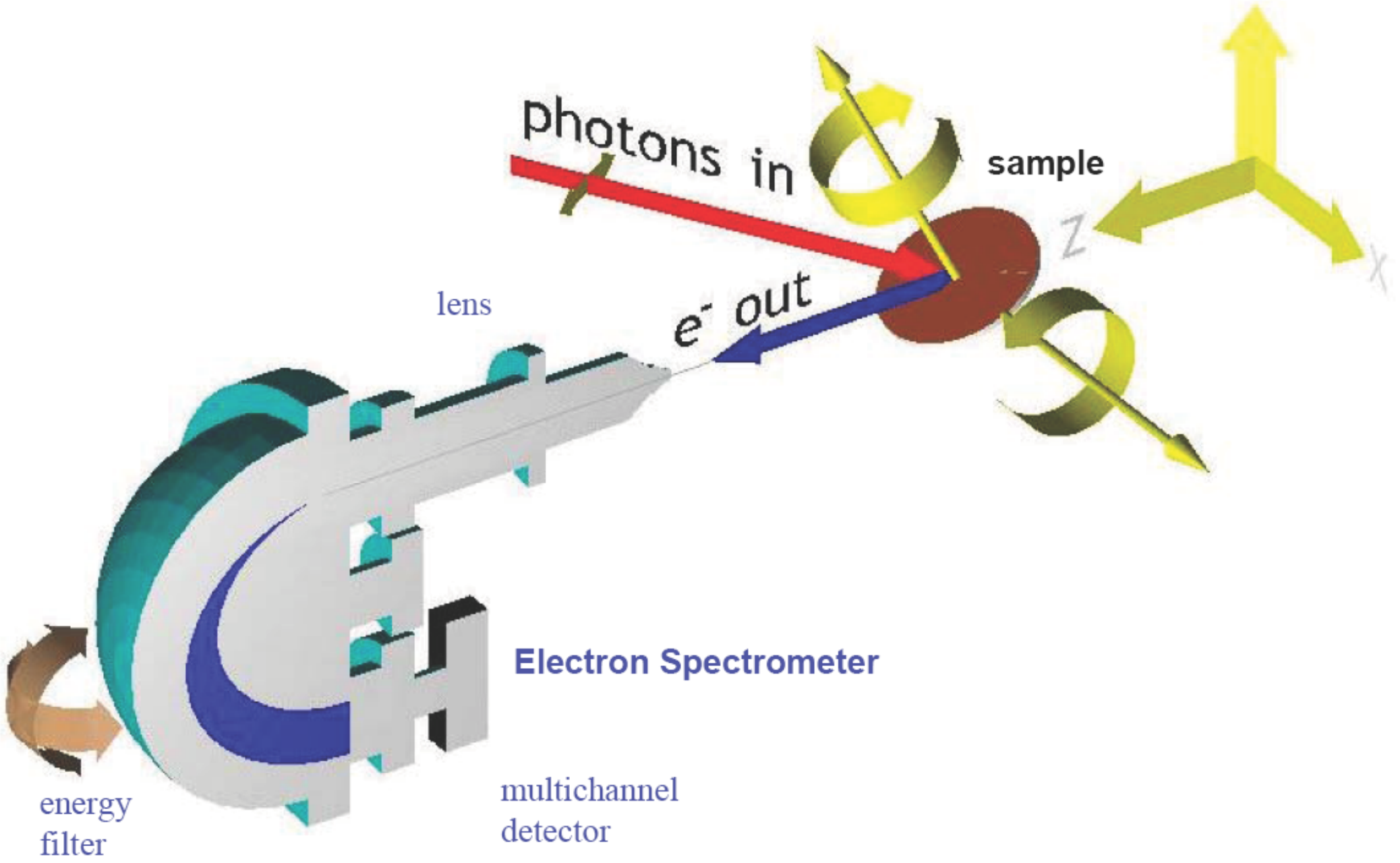


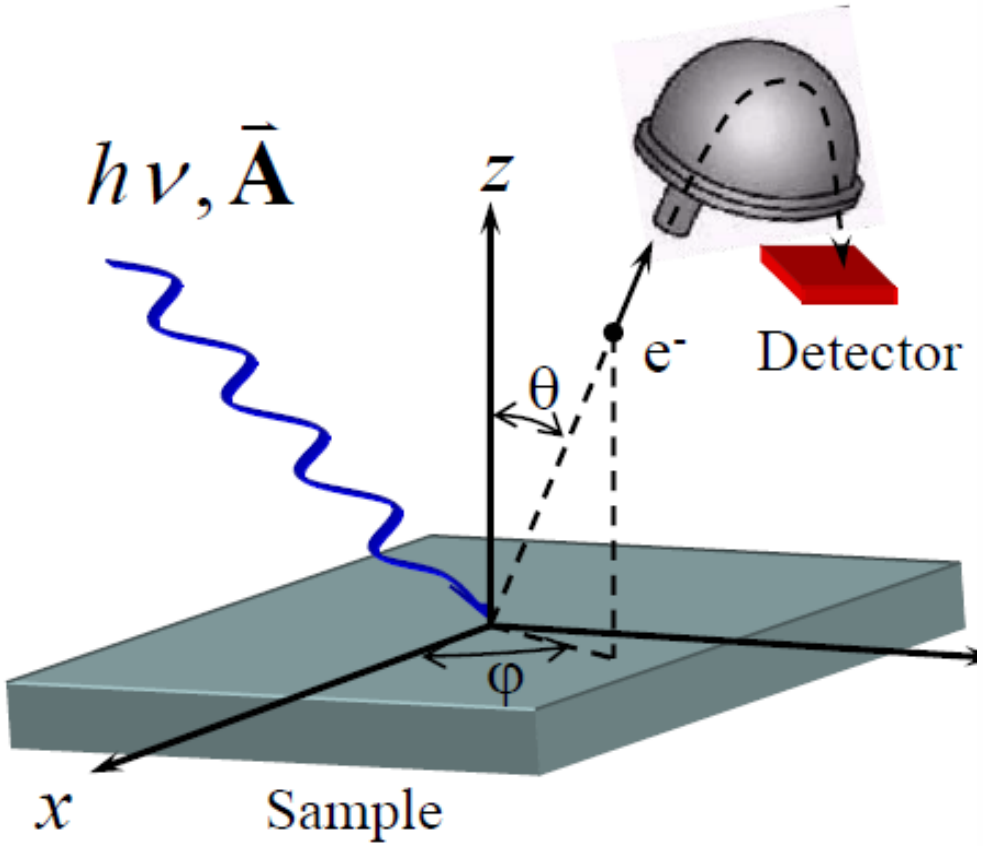
Fig. 3. KRIPES data taken on Cu(111) at $\hbar\omega = 11.0$ eV as a function of angle θ of electron incidence. Three features are indicated: (BB) a bulk band structure peak, (SS) a Shockley surface state, and (IS) an image state.

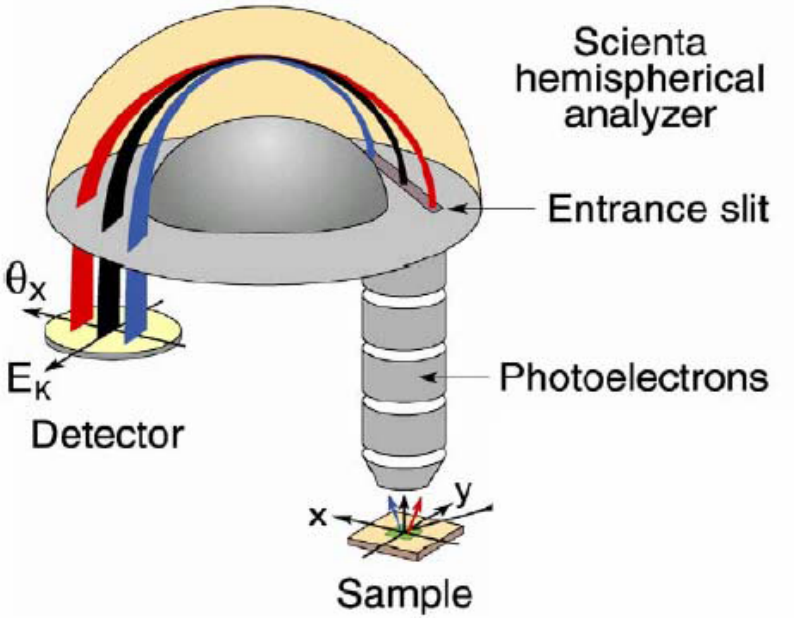


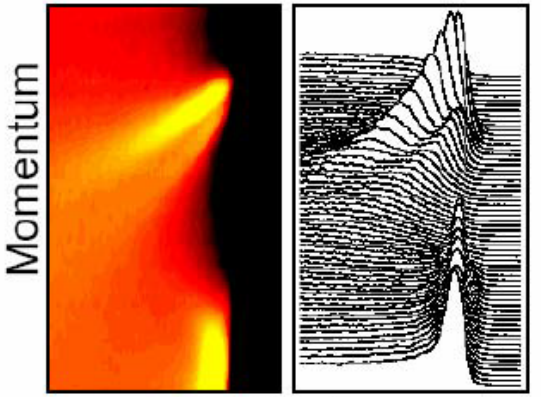
N.V. Smith, D.P. Woodruff, Progr. Surf. Sci. 21 (1986) 295

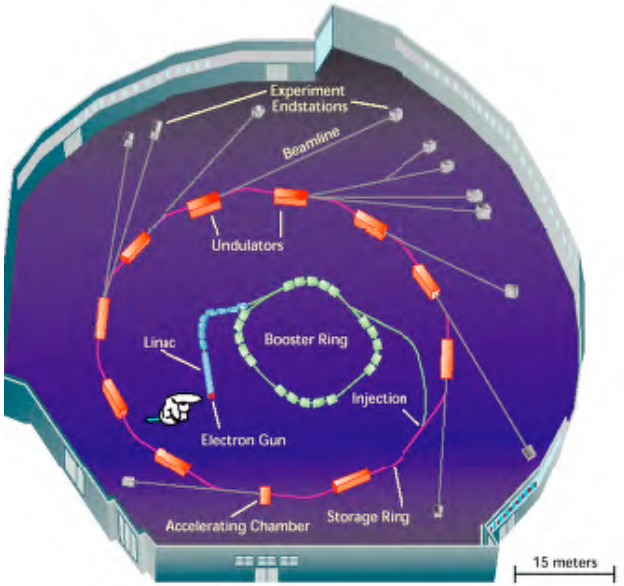
Experimental Geometry

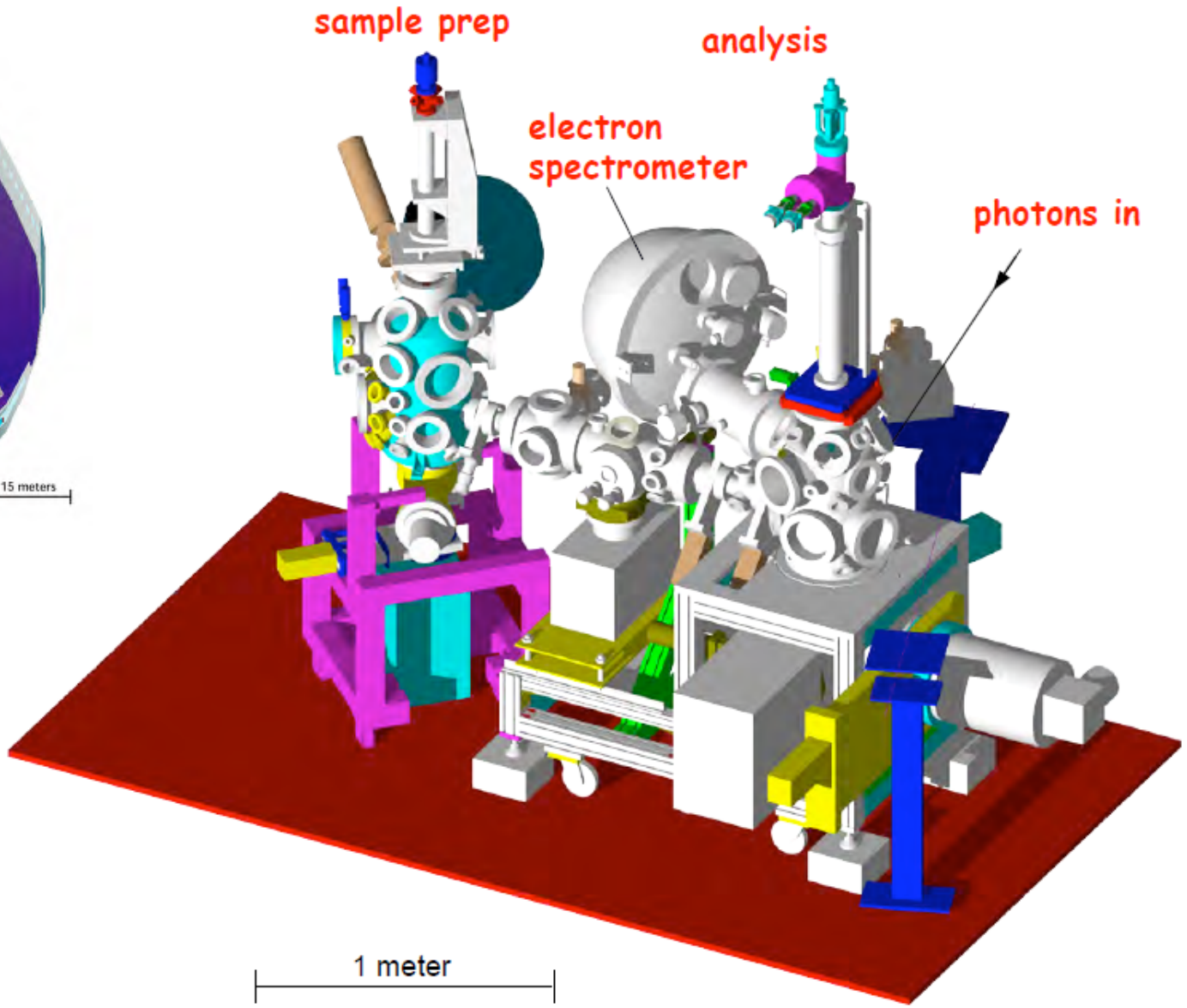



$h\nu, \vec{\mathbf{A}}$
z
e⁻
Detector
θ
φ
x
Sample

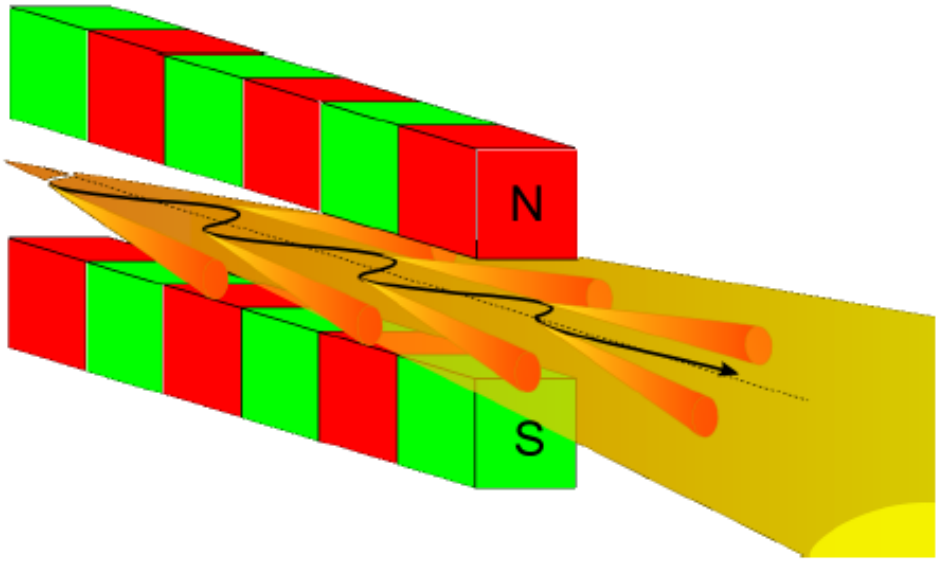

Scienta
hemispherical
analyzer
Entrance slit
θx
Eκ
Detector
Photoelectrons
x
y
Sample


Momentum
Binding Energy

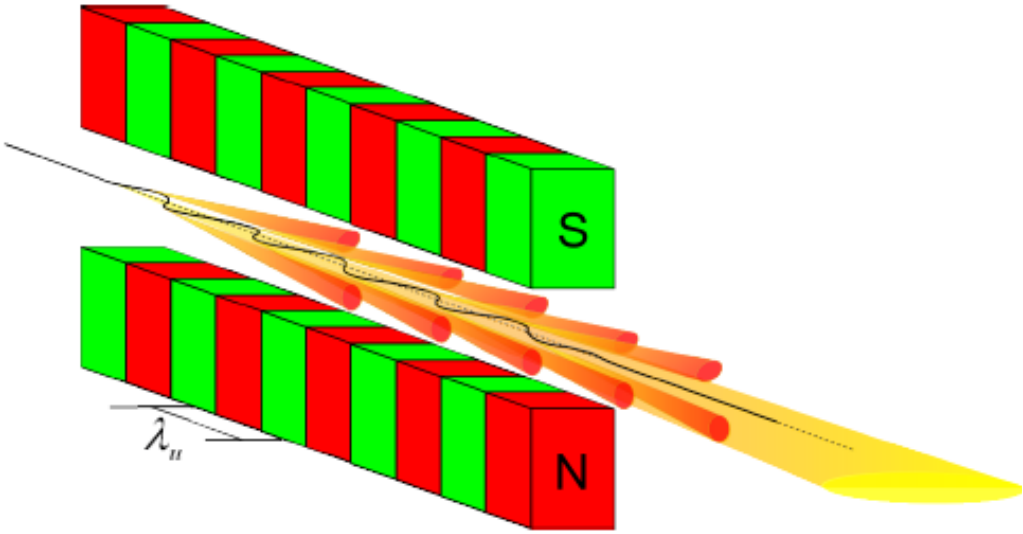

Experiment Endstations
Beamline
Undulators
Linac
Booster Ring
Injection
Electron Gun
Accelerating Chamber
Storage Ring
15 meters


sample prep
analysis
electron spectrometer
photons in
1 meter

Wiggler



Undulator



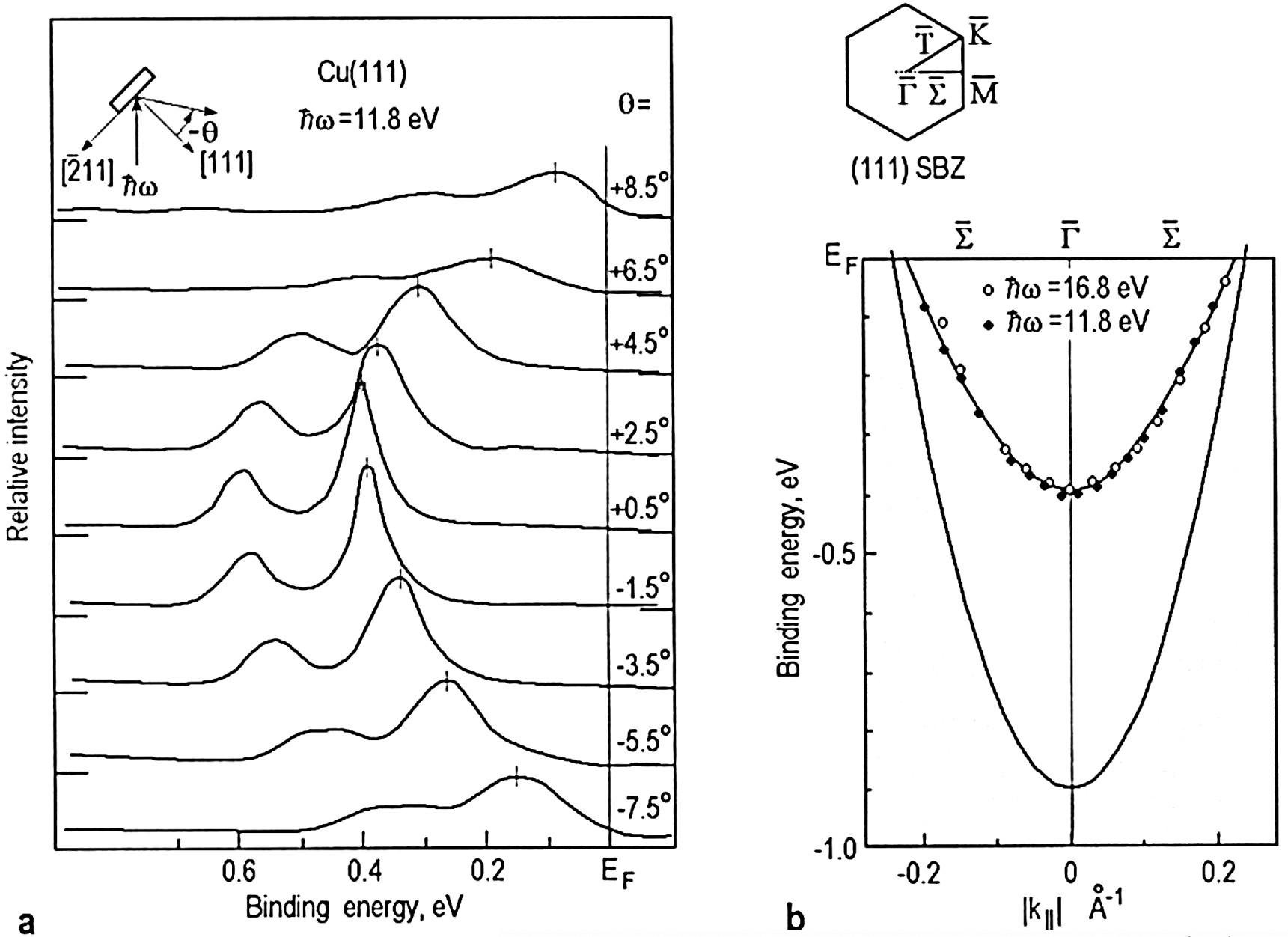
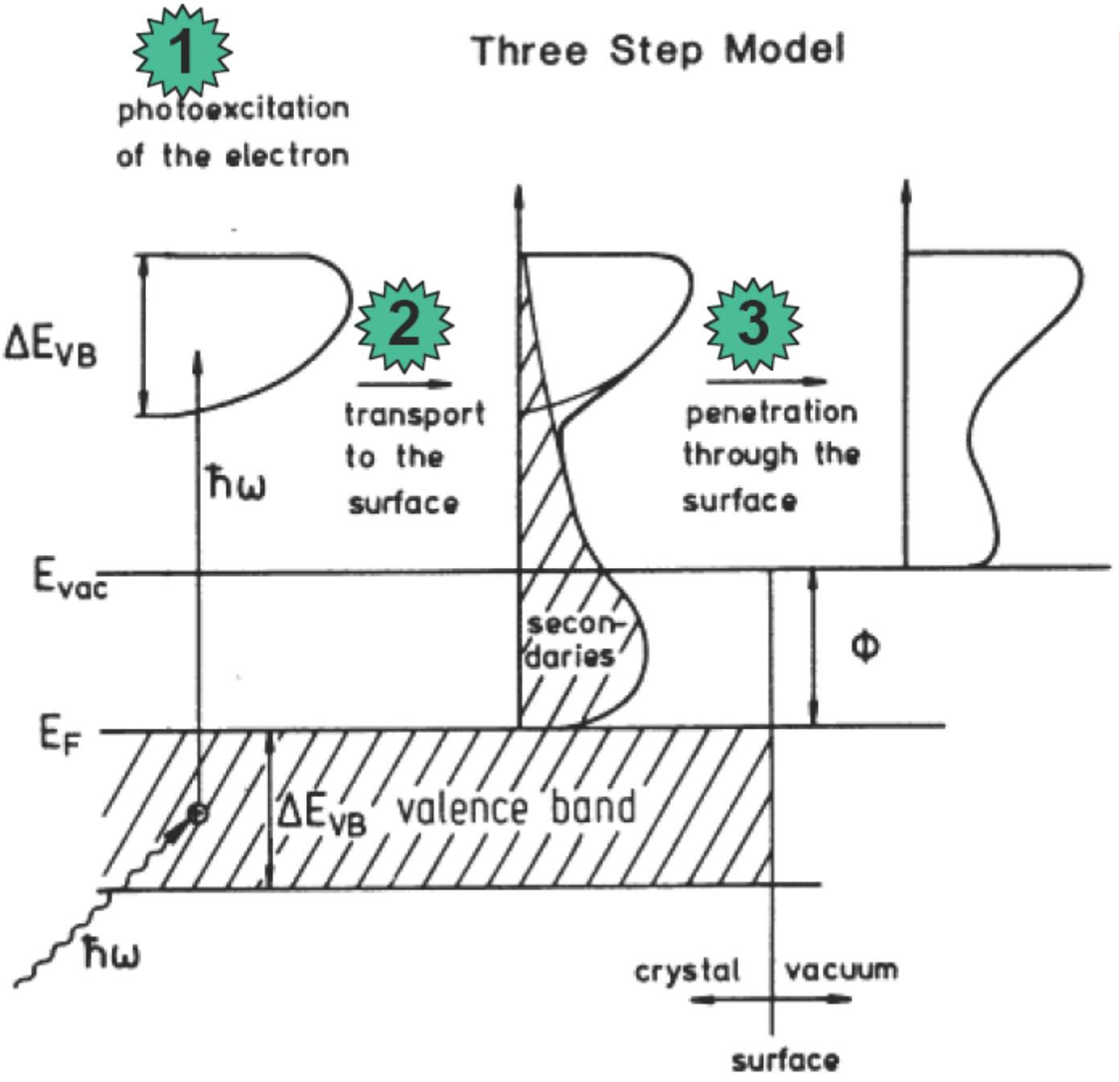
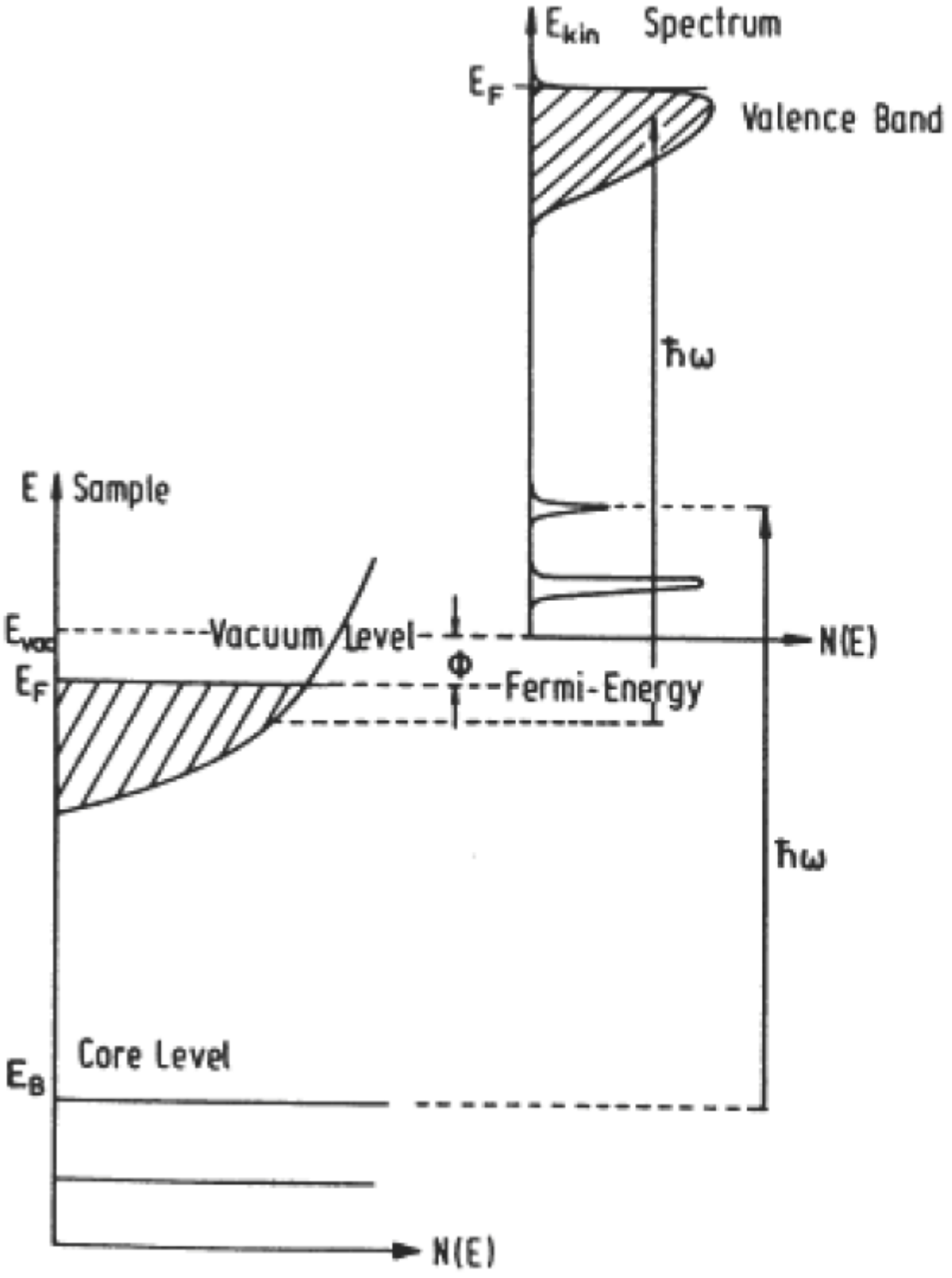


Fig. 5.24. ARUPS determination of the dispersion for the Cu(111) sp surface states. (a) Experimental photoemission energy distribution curves from Cu(111) for several angles near normal emission (the scattering geometry is shown in the inset). The location of the main maximum is of interest, the second peak being due to the Ar I doublet. (b) Evaluated dispersion of Cu(111) surface states plotted with a projection of bulk continuum of states (shaded region). Note that the dispersion curve is invariant with the change of the photon energy (open circles correspond to 16.8 eV, closed circles to 11.8 eV) (after Kevan [5.19])


Three Step Model
1
photoexcitation
of the electron
2
transport
to the
surface
3
penetration
through the
surface
ΔEVB
ħω
Evac
secon-
daries
Φ
EF
ΔEVB valence band
ħω
crystal
vacuum
surface



$$E_{kin} = \hbar\omega - \Phi - |E_B|$$

Measured Kinetic Energy

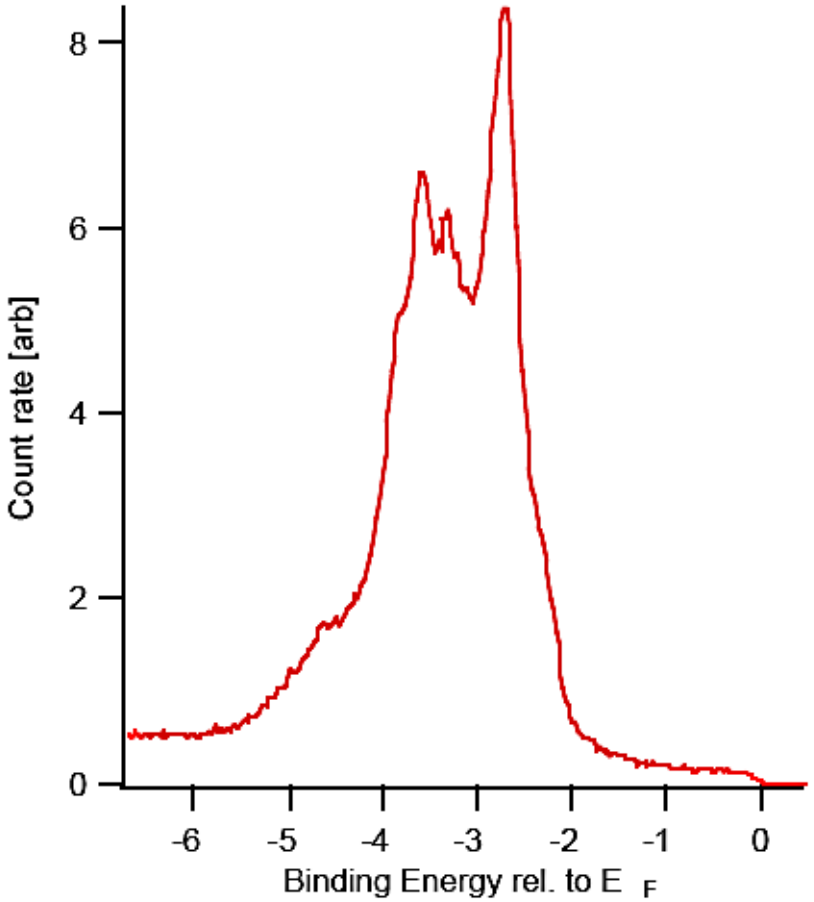
Measureed Photon Energy

Measured Work Function

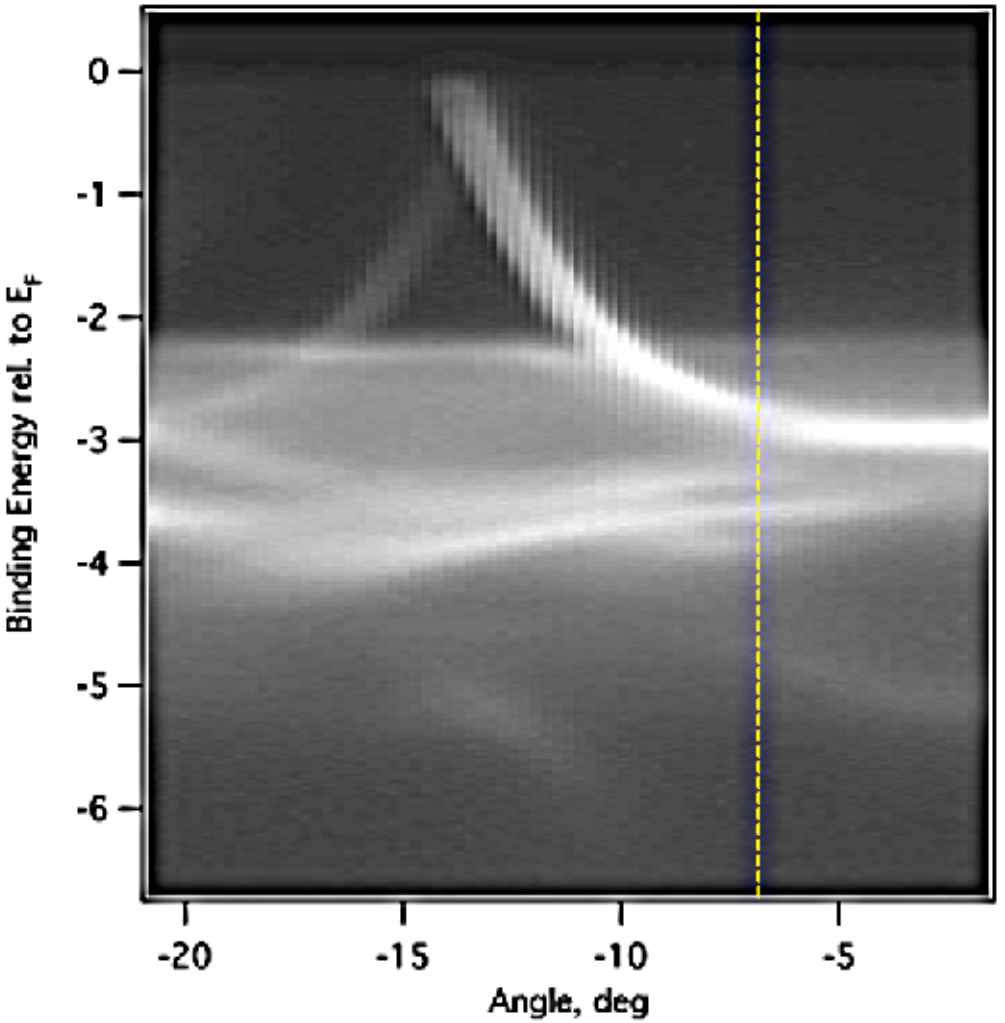
Electron Binding Energy

Typical Experimental Result

ALS



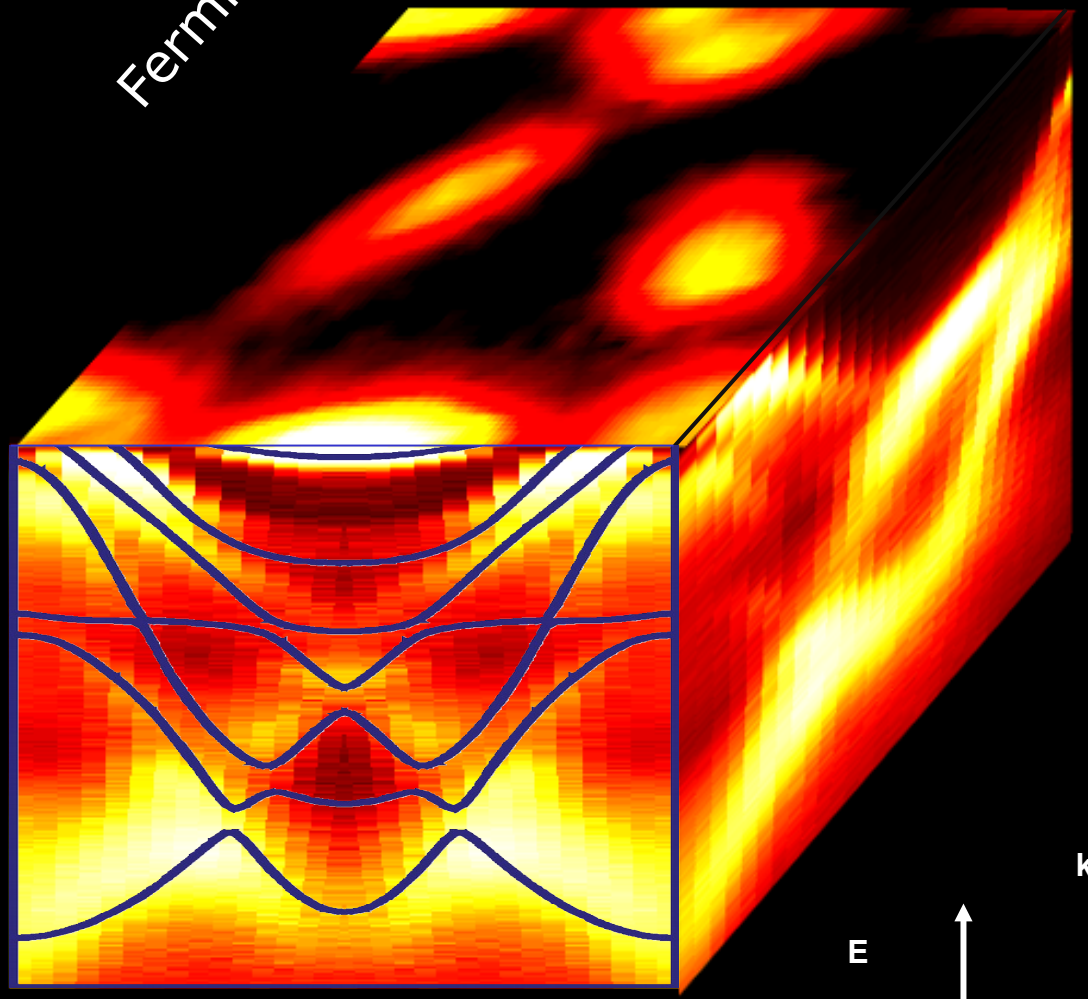
A spectrum at a single polar angle



Accumulate spectra as the angle is scanned

surface

Fermi-

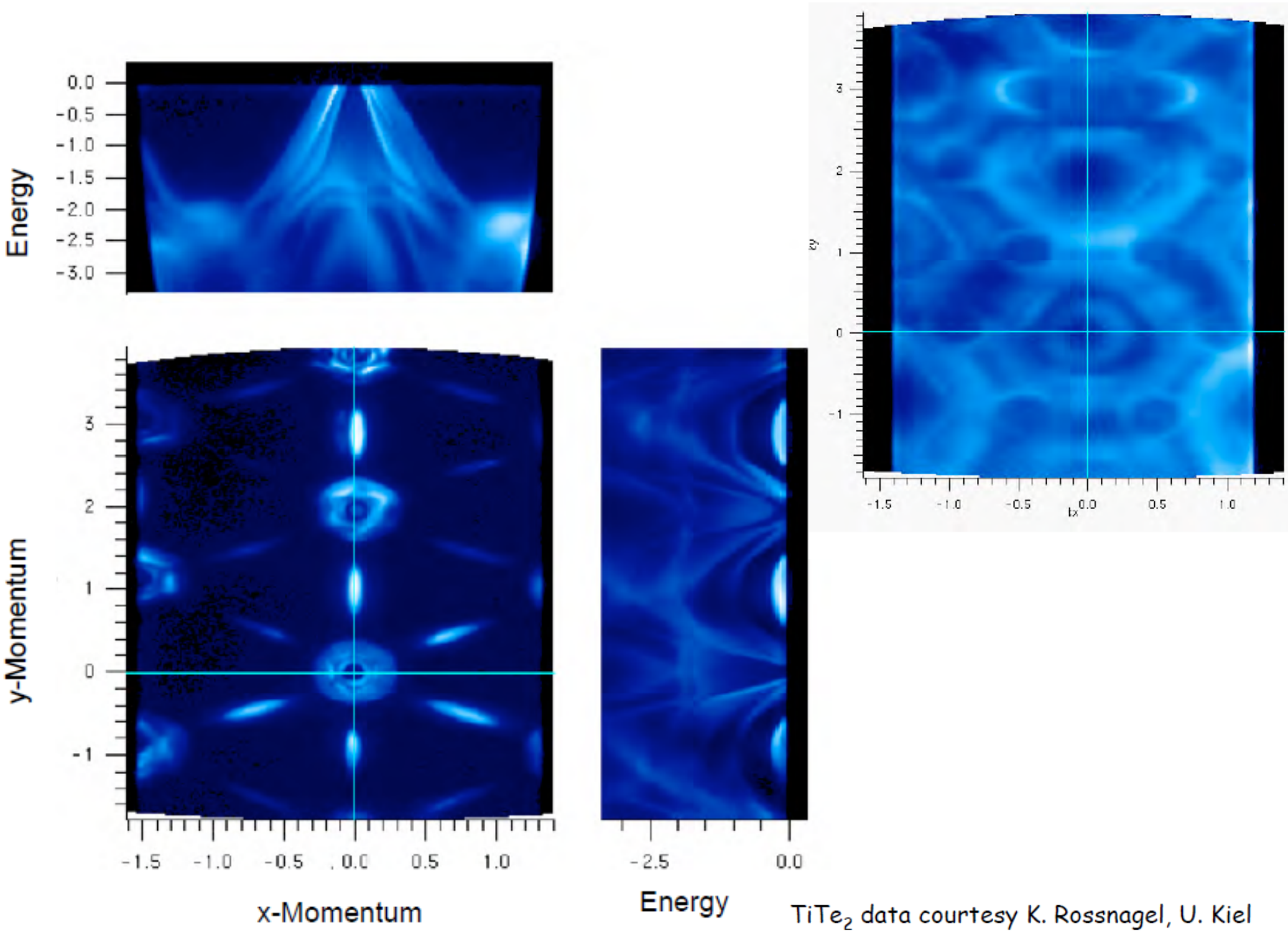


E

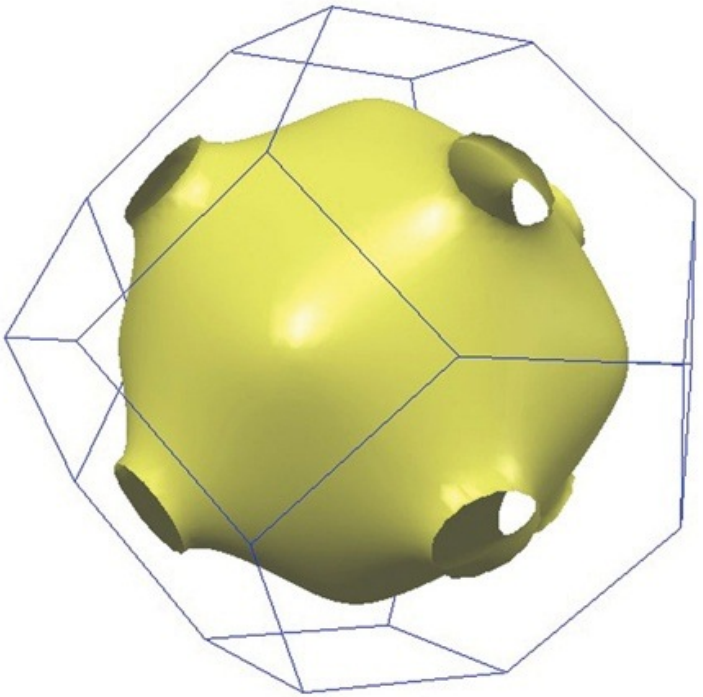
$k_{||y}$

$k_{||x}$

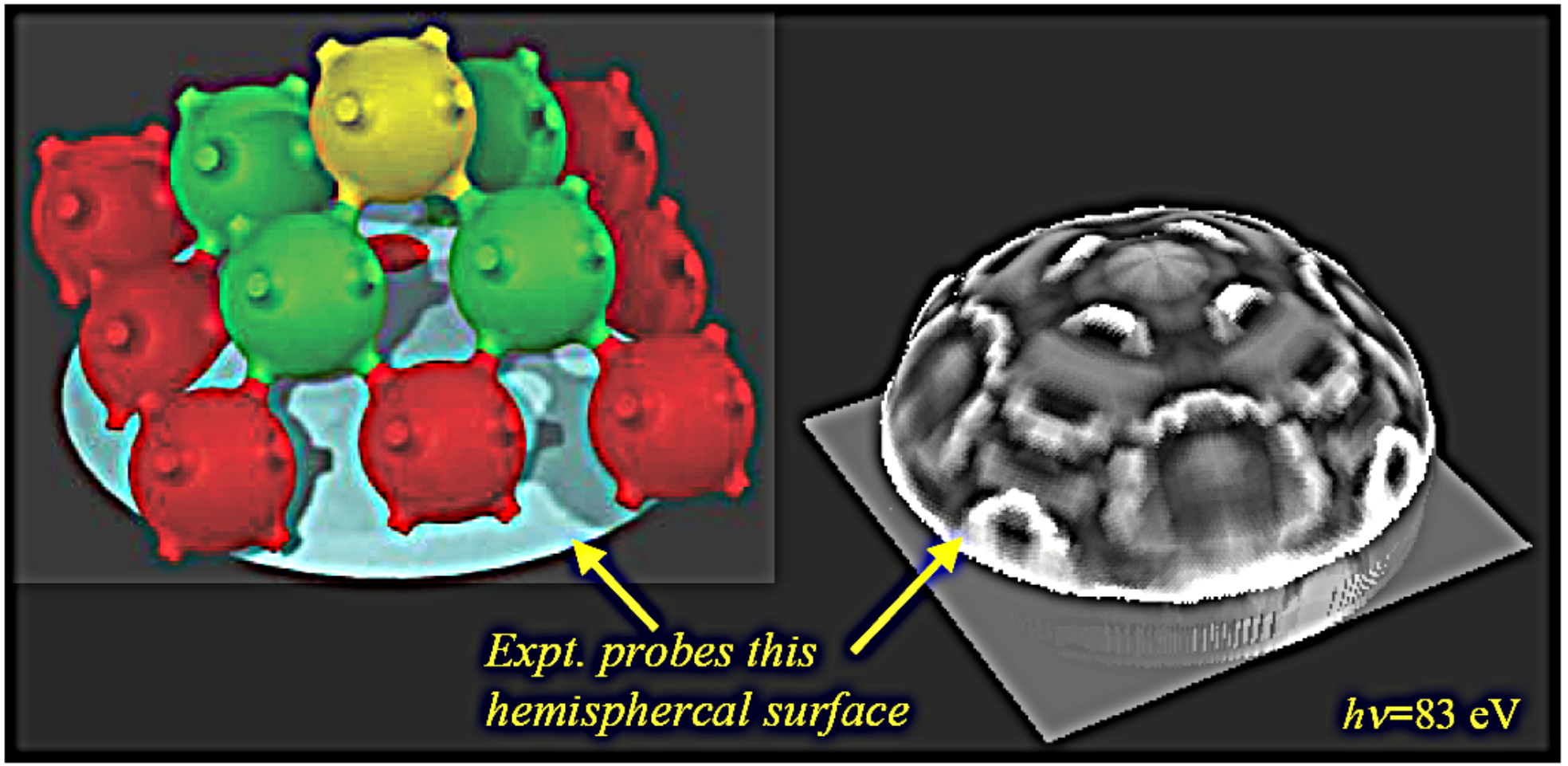
electronic band structure E(k)



$TiTe_2$ data courtesy K. Rossnagel, U. Kiel



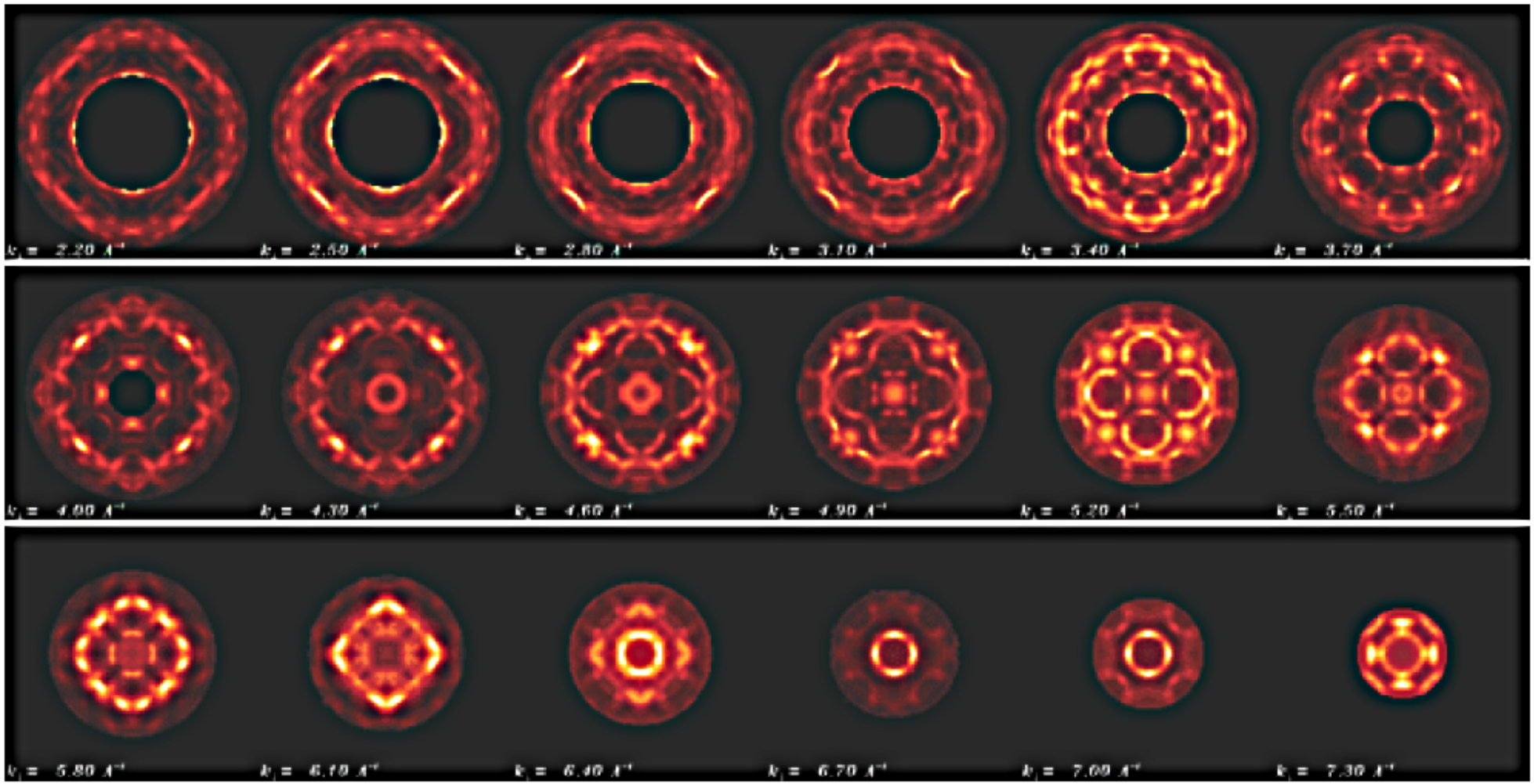
Constant-|k| cut through Fermi surface of Cu(100)



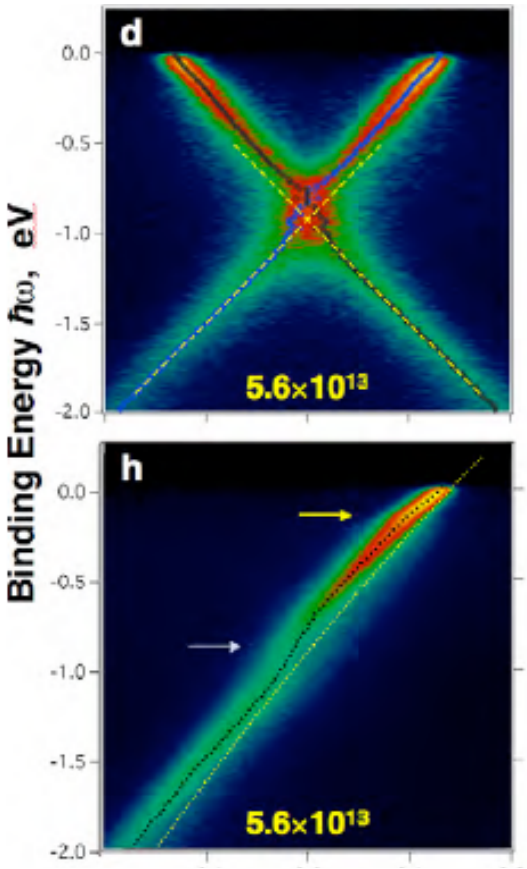
Copper (100) Fermi Surface Animation

ALS

Today Fermi surface mapping is a routine job



$k_z = 2.2$ to 7.0 Å^{-1}, $\Delta k_z = 0.3$ Å^{-1}



$$\overbrace{A(k,\omega)} = \frac{1}{\pi}\frac{\left|\mathrm{Im}\,\Sigma(k,\omega)\right|}{\left[\omega-\omega_k^0-\mathrm{Re}\,\Sigma(k,\omega)\right]^2+\left[\mathrm{Im}\,\Sigma(k,\omega)\right]^2}$$

$$\Sigma(k,\omega) = \underbrace{\mathrm{Re}\,\Sigma(k,\omega)} + i\underbrace{\mathrm{Im}\,\Sigma(k,\omega)}$$