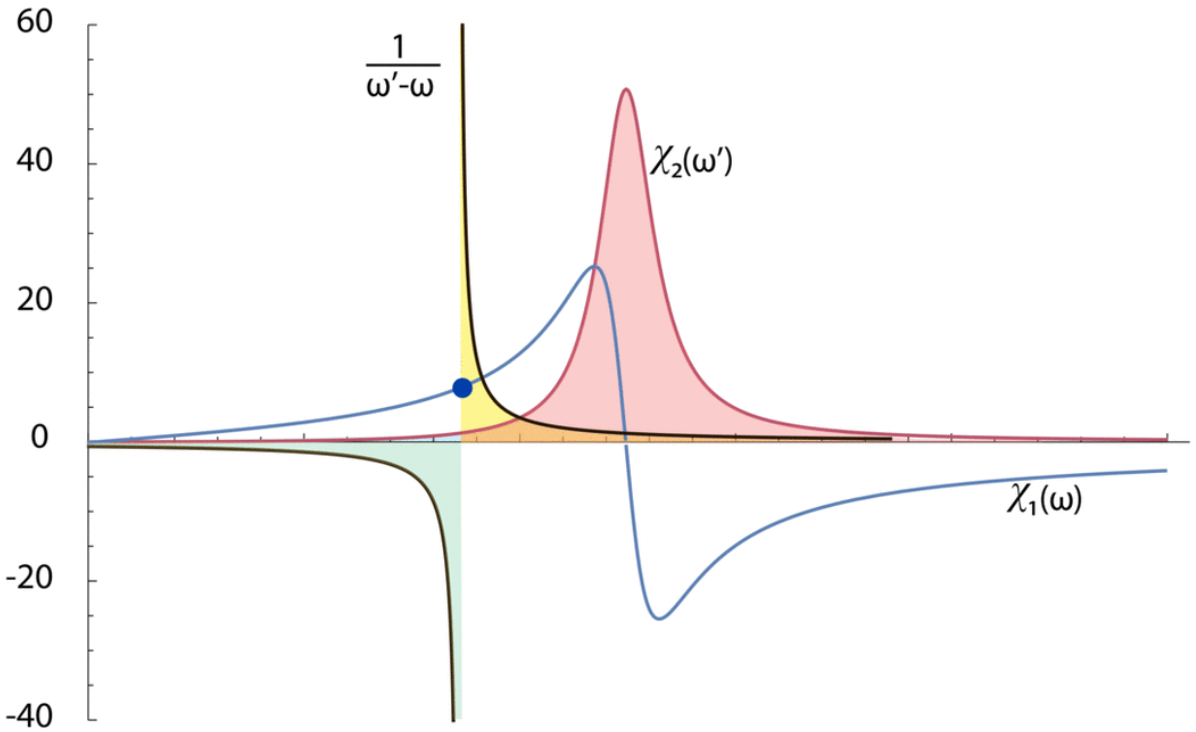
Kramers–Kronig relations

Kramers–Kronig relations

$$\chi(\omega) = \chi_1(\omega) + i\chi_2(\omega)$$

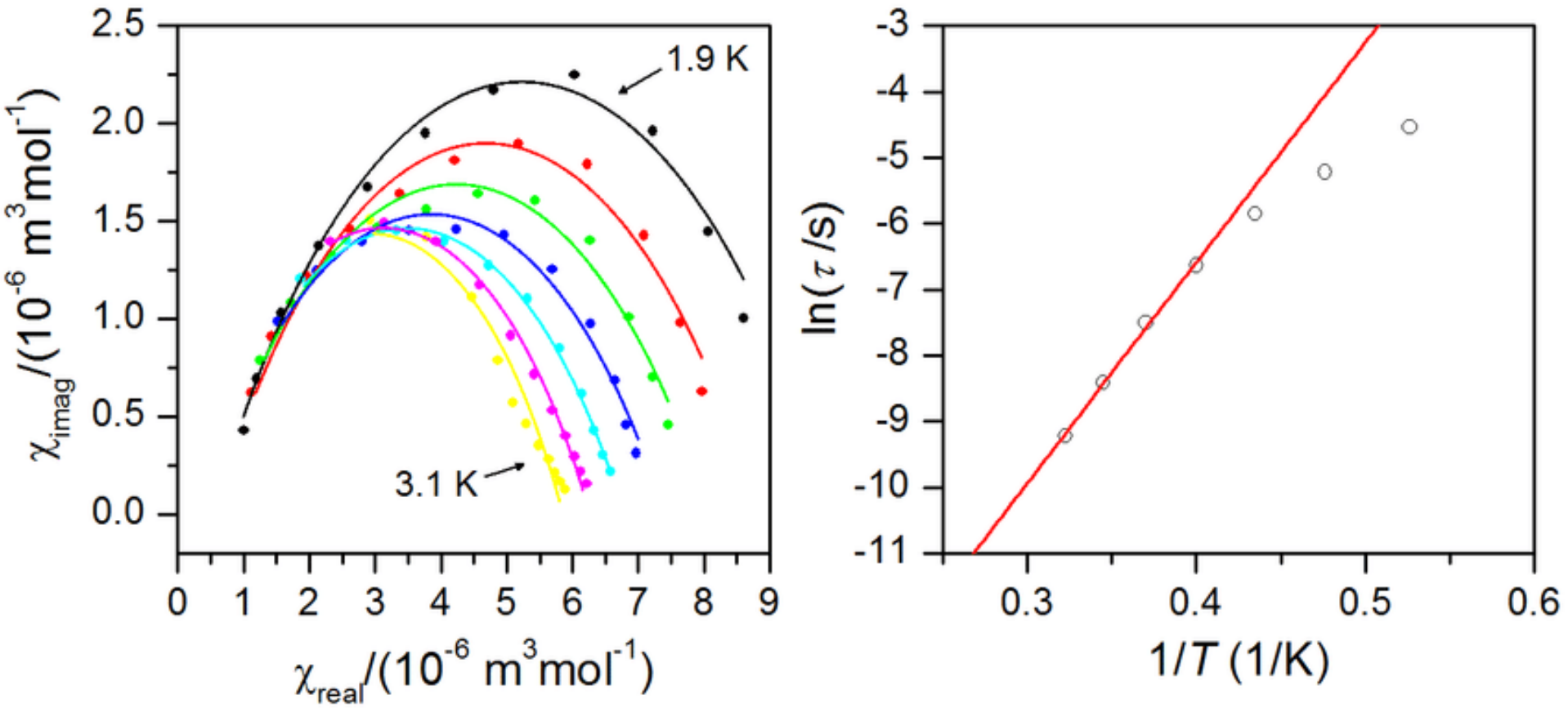
$$\chi_1(\omega) = \frac{1}{\pi}\mathcal{P}\int_{-\infty}^{\infty} \frac{\chi_2(\omega')}{\omega' - \omega}\, d\omega'$$

$$\chi_2(\omega) = -\frac{1}{\pi}\mathcal{P}\int_{-\infty}^{\infty} \frac{\chi_1(\omega')}{\omega' - \omega}\, d\omega'$$



https://en.wikipedia.org/wiki/Kramers%E2%80%93Kronig_relations

Kramers–Kronig relations: Cole-Cole plot



Kramers–Kronig relations in IR spectroscopy

complex reflectivity

$$\hat{r}(\omega) = \frac{n_0 - \hat{n}(\omega)}{n_0 + \hat{n}(\omega)} = r(\omega)e^{i\theta(\omega)}$$

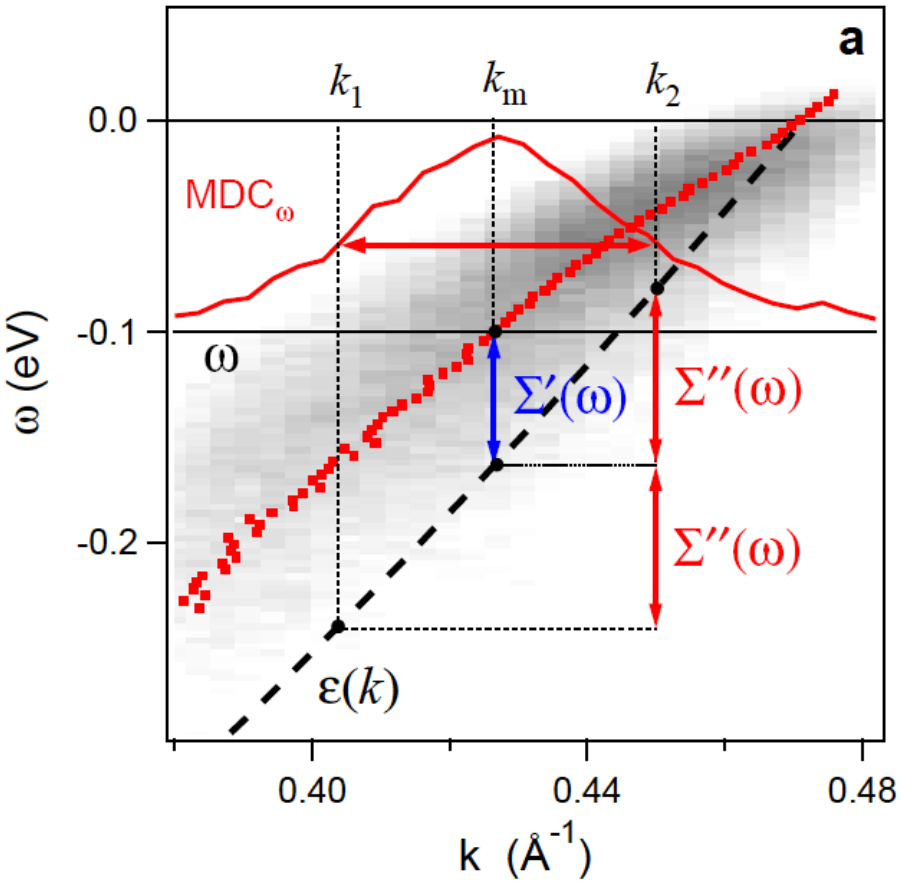
$\hat{n} = n + ik$ is the complex refractive index

$$\theta(\omega) = -\frac{2\omega}{\pi} P \int_0^\infty \frac{\ln r(\omega')}{\omega'^2 - \omega^2} d\omega'$$

https://iopscience.iop.org/article/10.1088/1742-6596/359/1/012013/pdf

Spectral function and Self-energy

$$A(\omega, \mathbf{k}) = -\frac{1}{\pi} \frac{\Sigma''(\omega)}{(\omega - \varepsilon(\mathbf{k}) - \Sigma'(\omega))^2 + \Sigma''(\omega)^2}$$



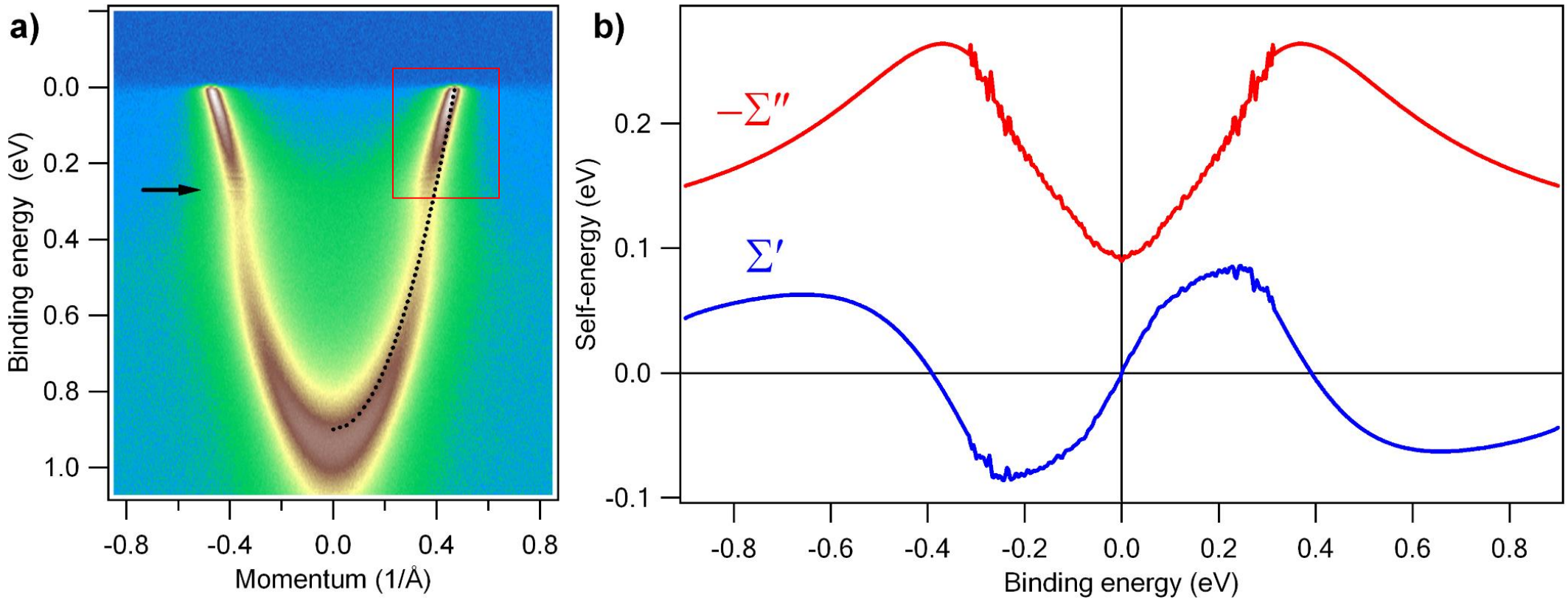
$$\mathrm{EDC}(\omega) = A(\omega)_k$$

$$\mathrm{MDC}(k) = A(k)_\omega$$

$$\Sigma'(\omega) = \omega - \varepsilon(k_m)$$

$$\Sigma''(\omega) = -v_F W(\omega)$$

Kramers–Kronig relations

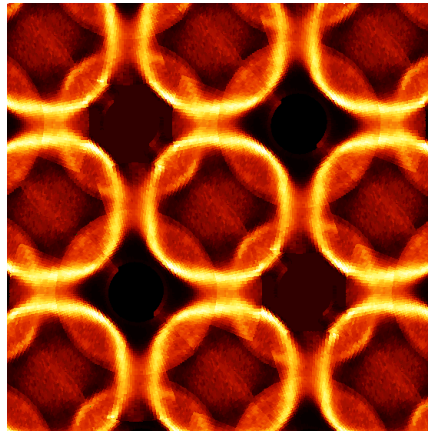


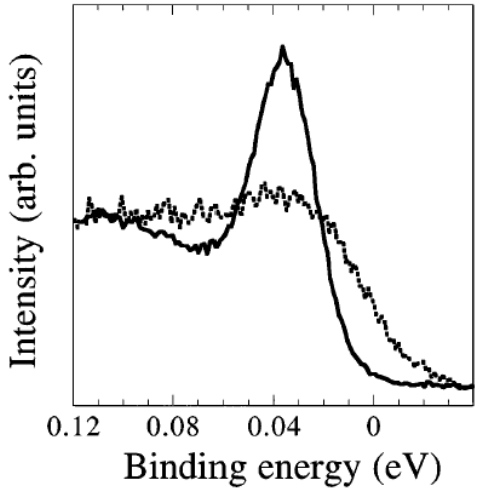
Kordyuk *PRB* 2005

Масивні дані

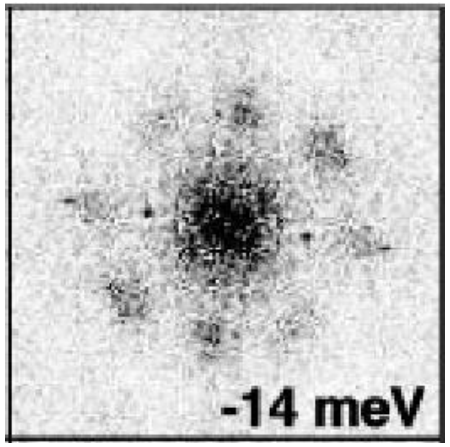
Приклади «масивних» даних

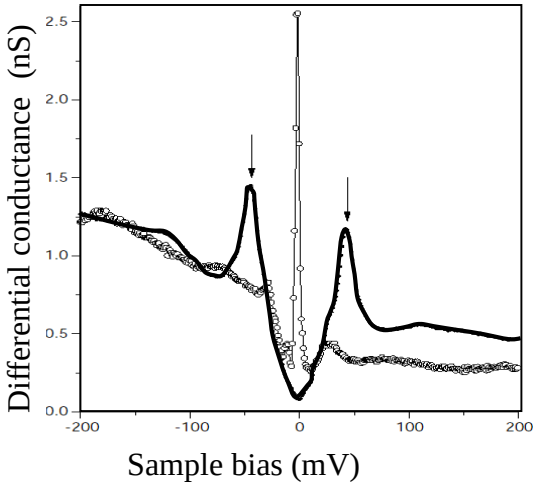
ARPES



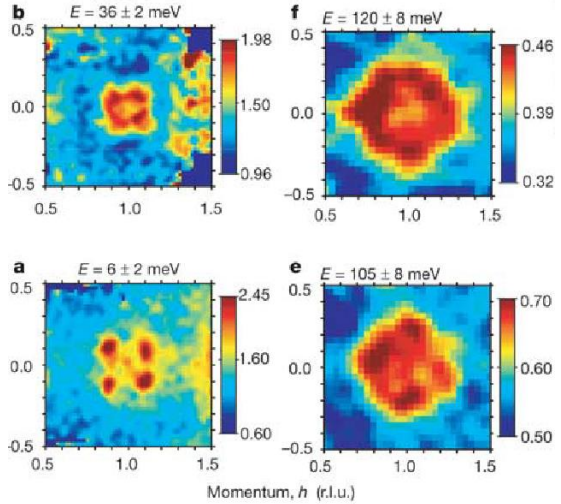


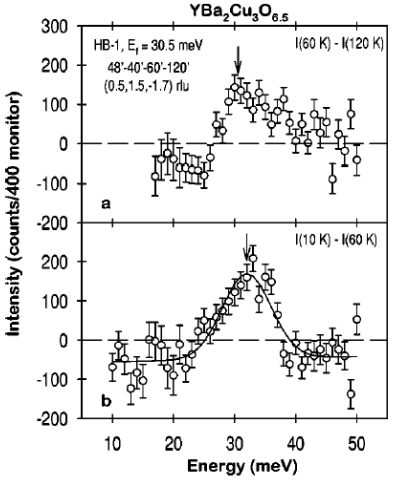
STS



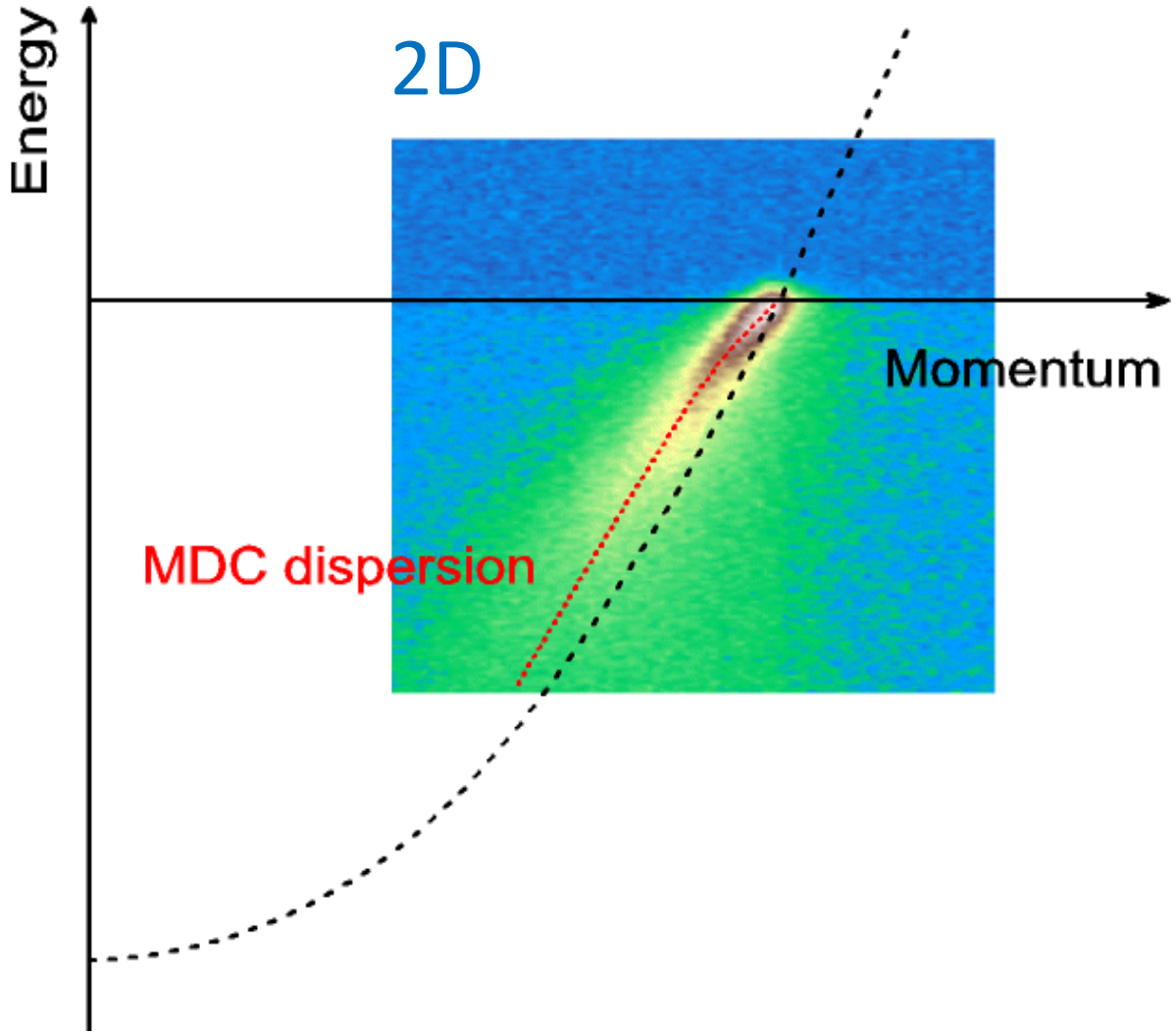


INS

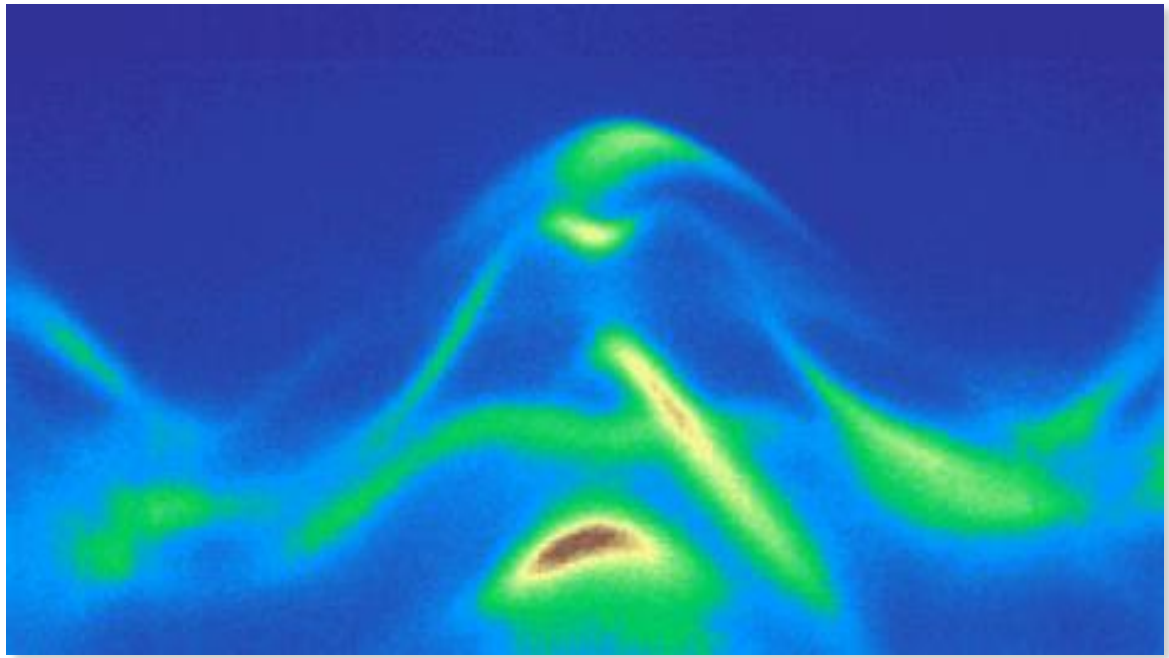




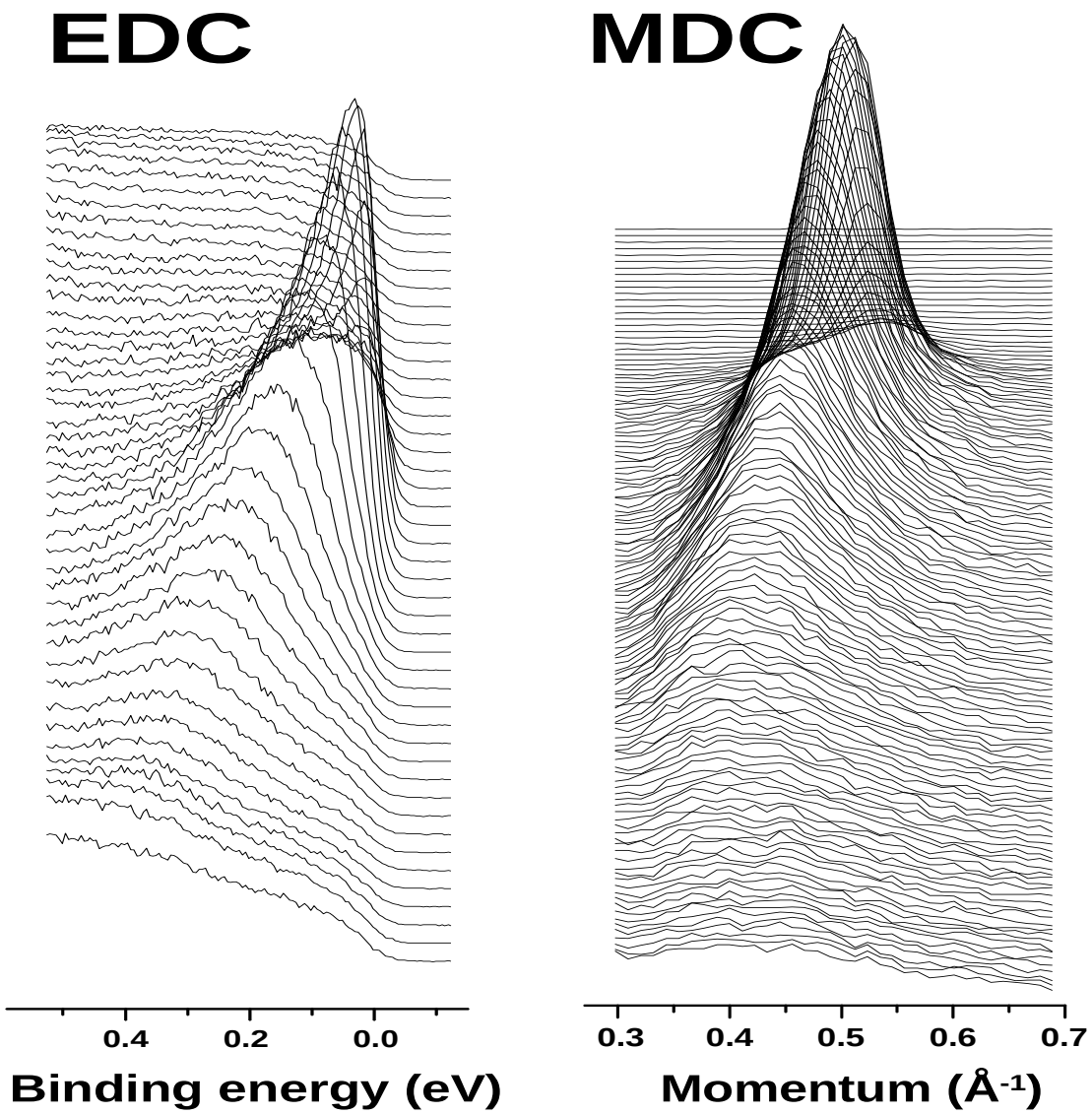
ARPES data



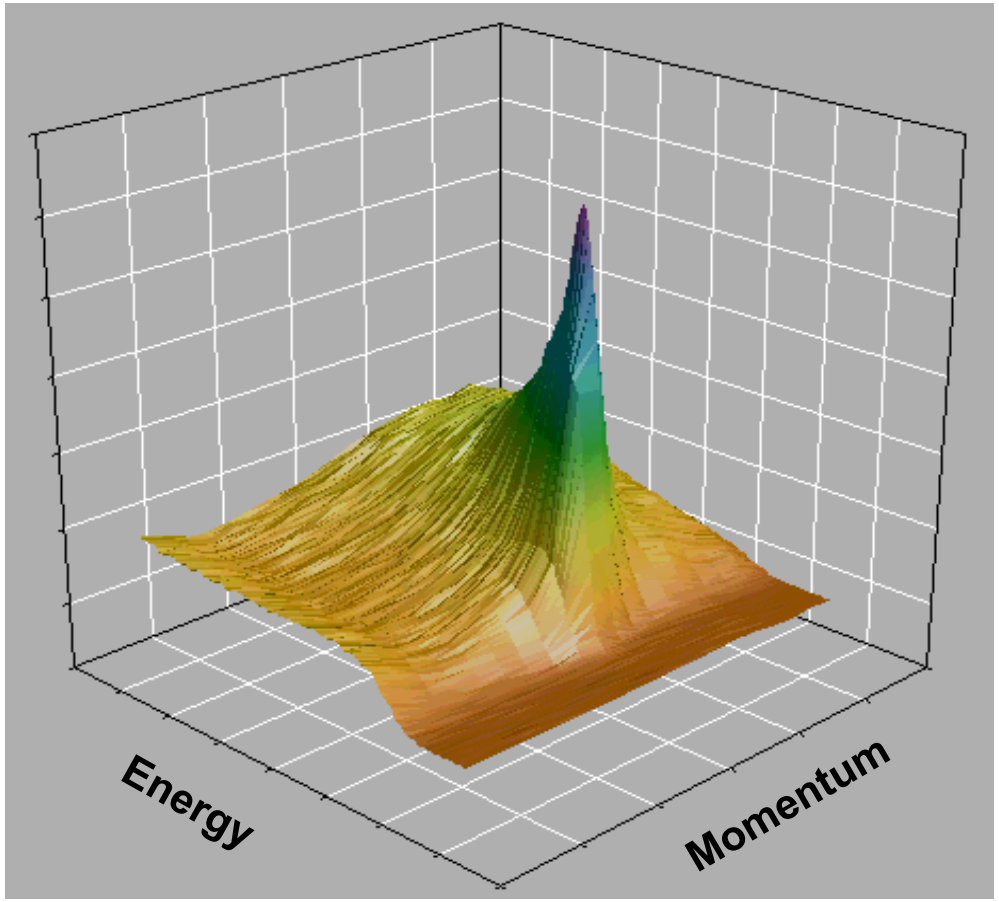
3D



ARPES data

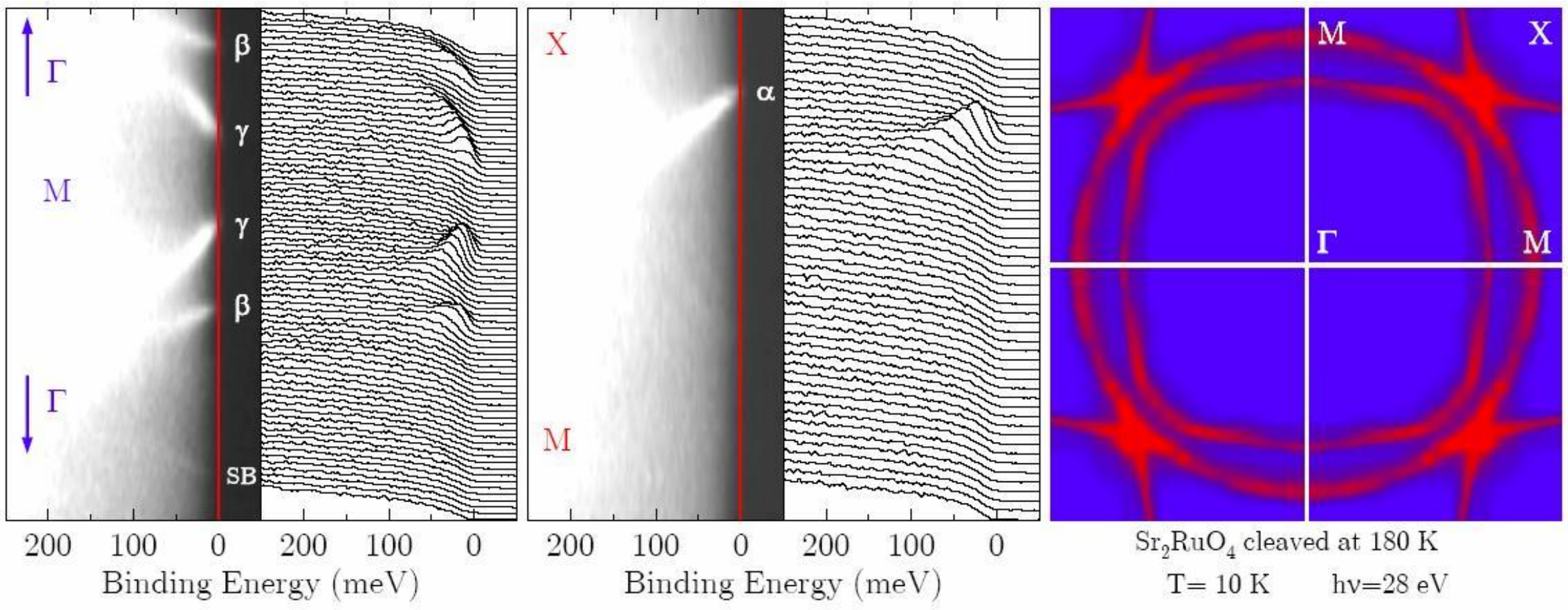


$I(k,\omega)$ 2D



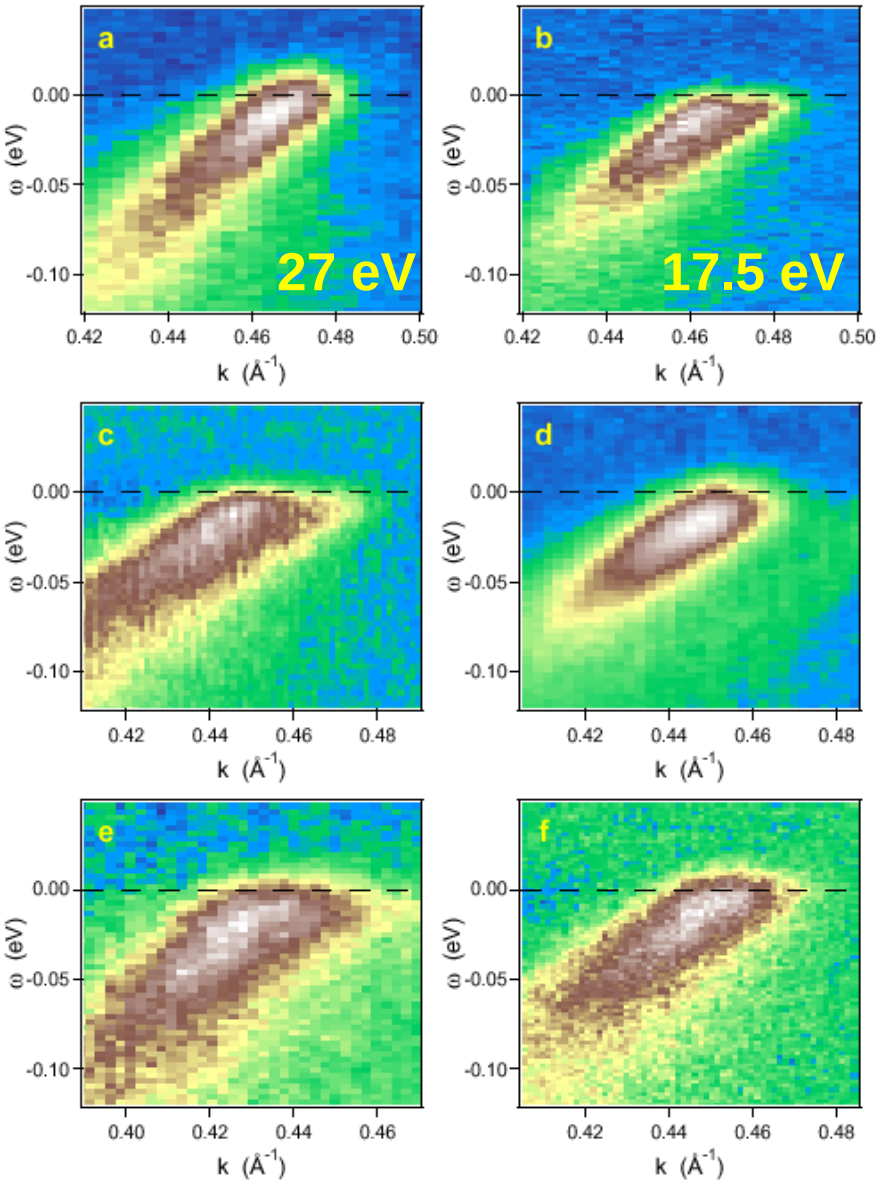
Borisenko *PRB* 2001

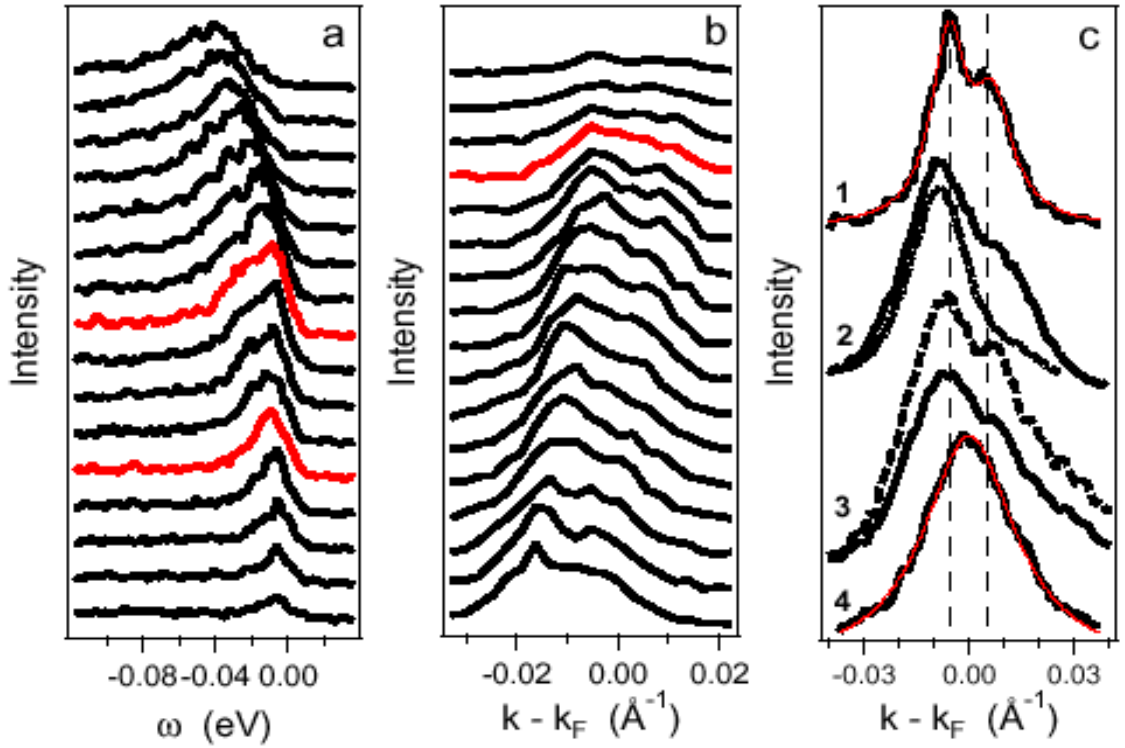
ARPES data

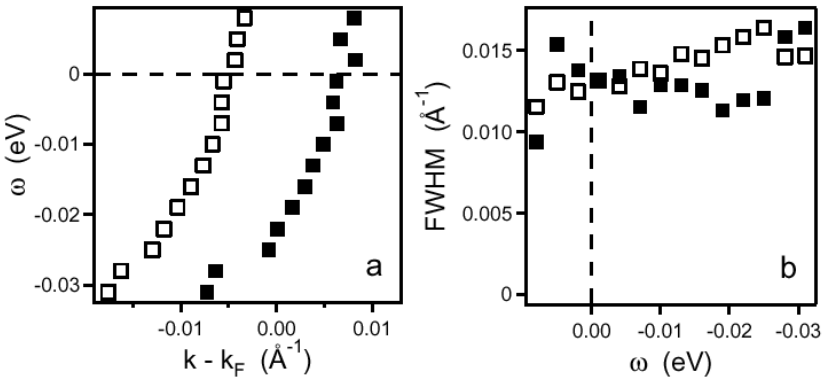


A. Damascelli et al., PRL 85, 5194 (2000)

Nodal splitting





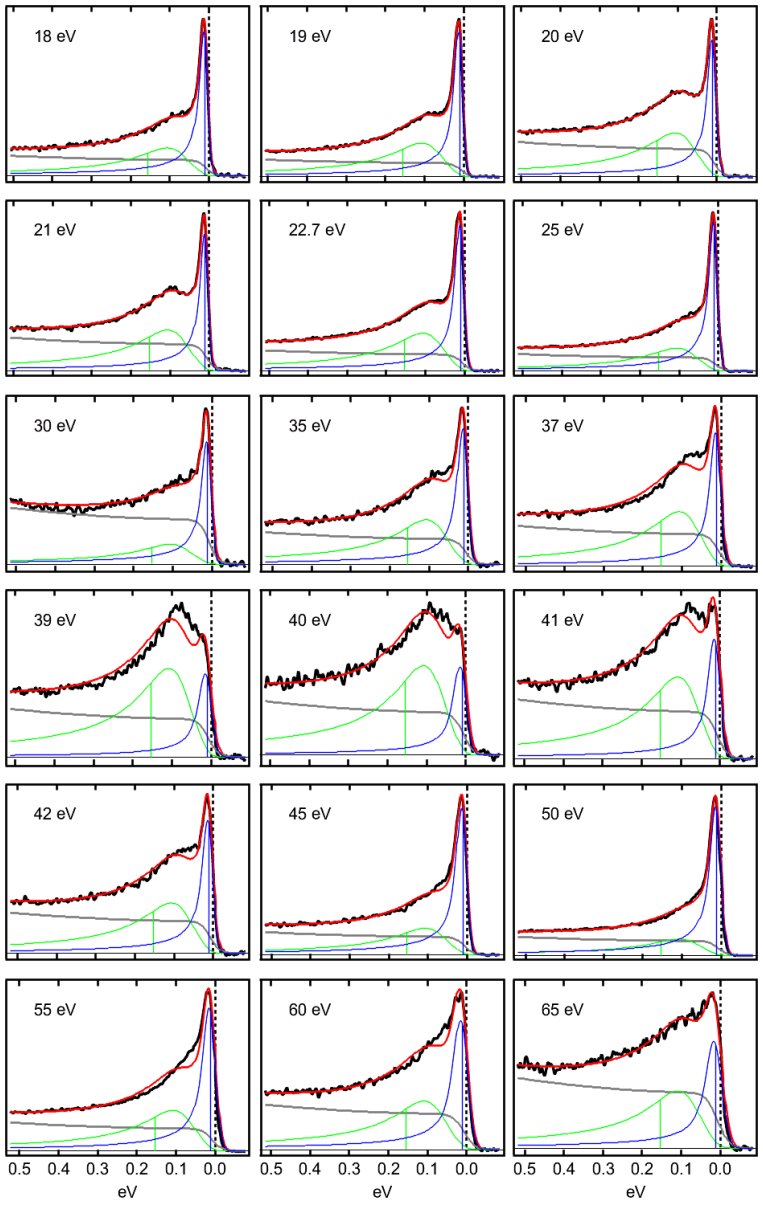


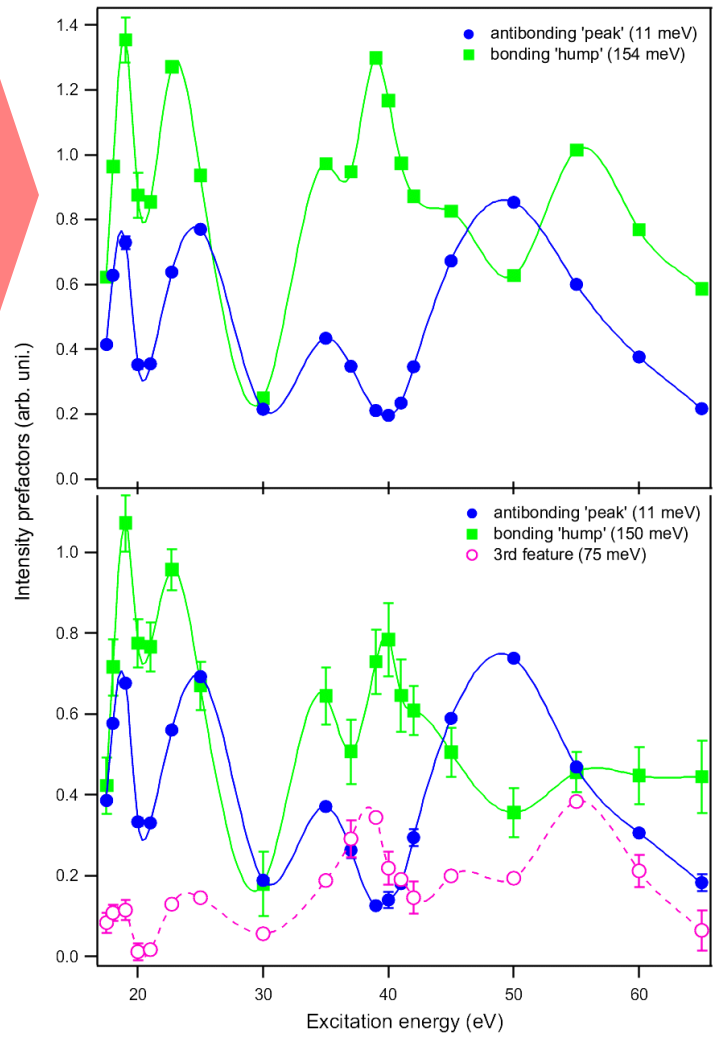
$\Delta k = 0.012$ 1/Å

$\Delta \varepsilon = 50$ meV (bare!)

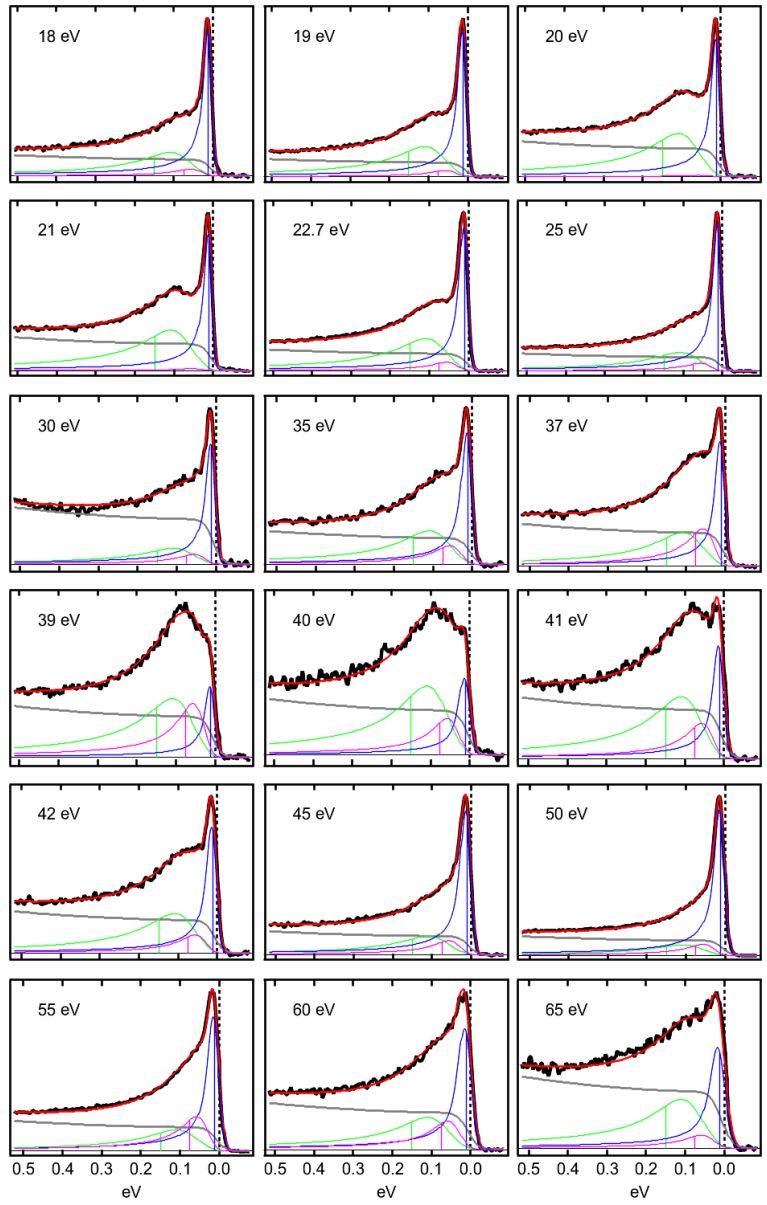
Kordyuk *PRB* 2004

Energy dependence of PDH for OD Bi(Pb)-2212

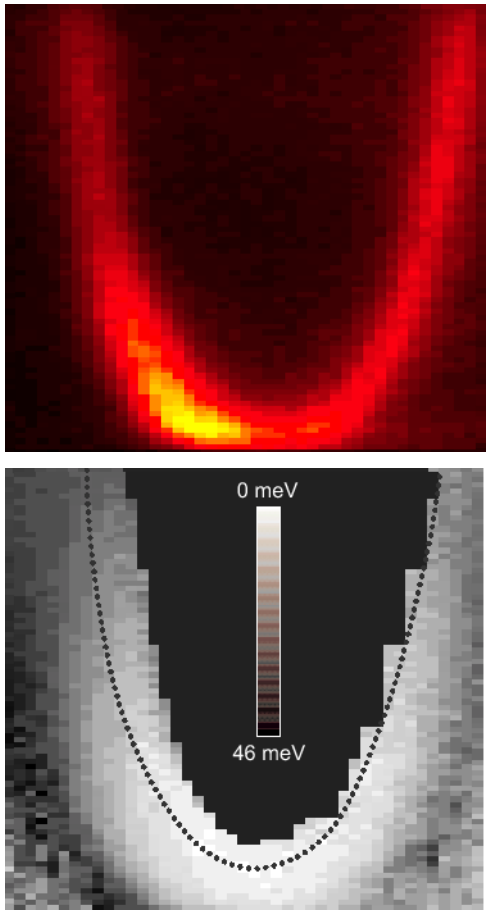


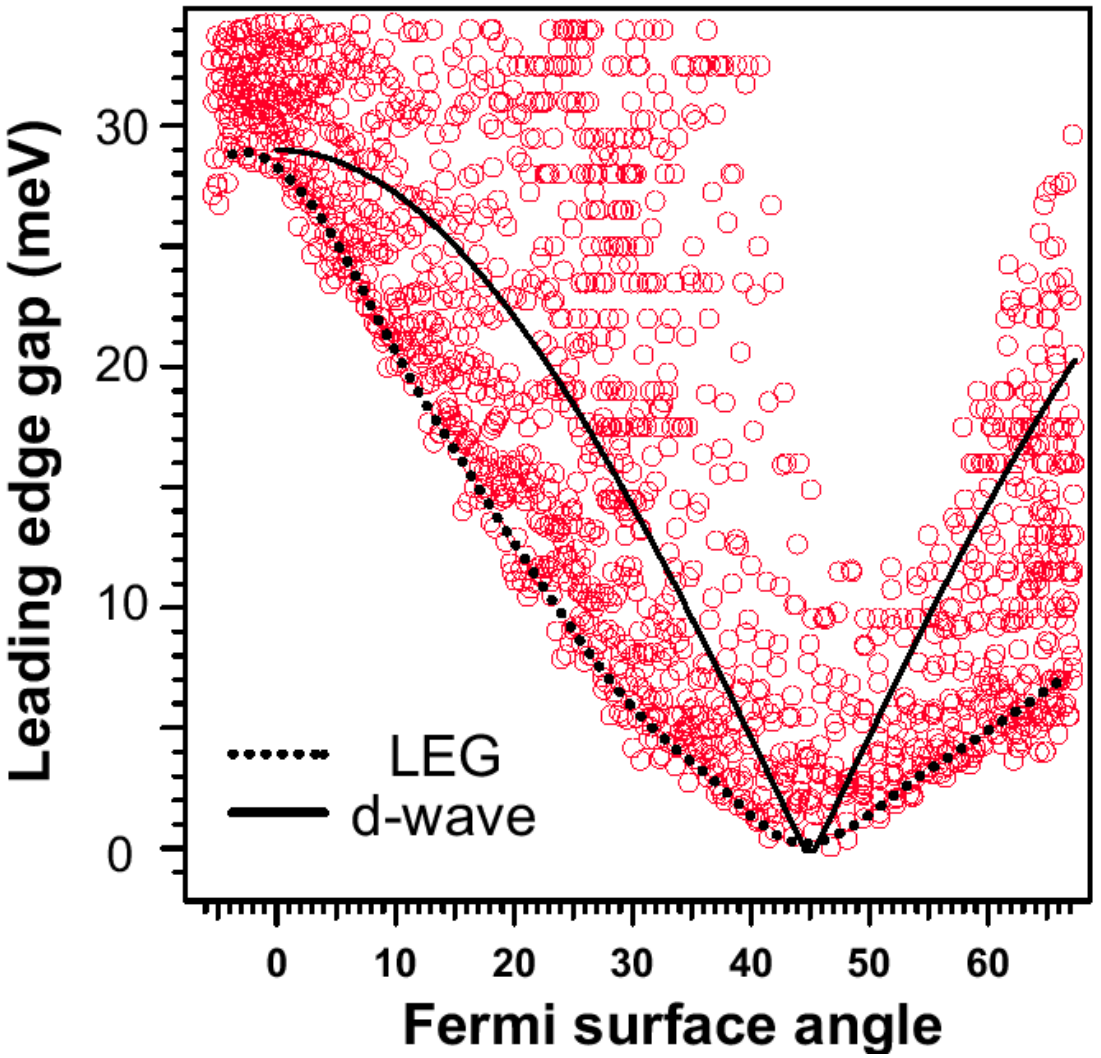


Kordyuk *PRL* 2002



Superconducting gap





Borisenko *PRB* 2002

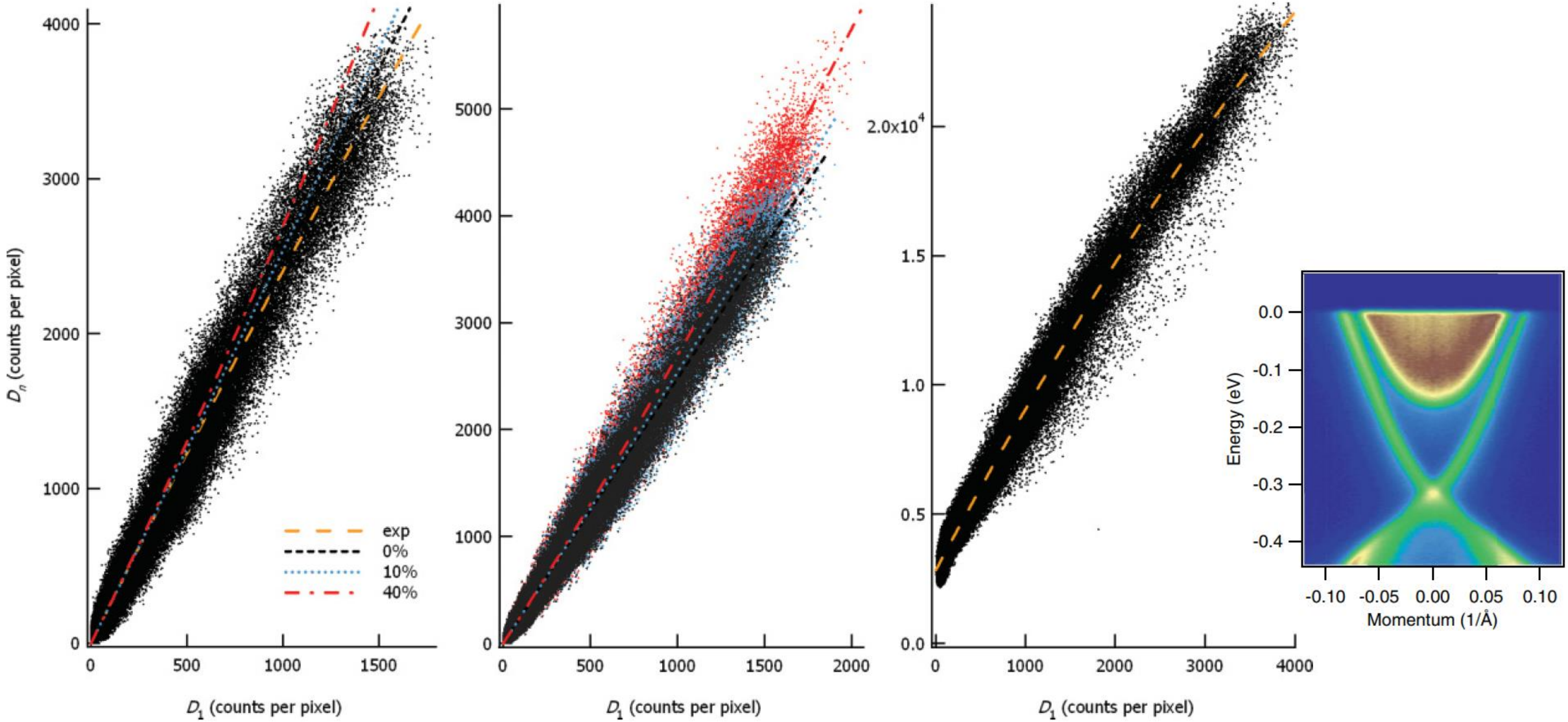
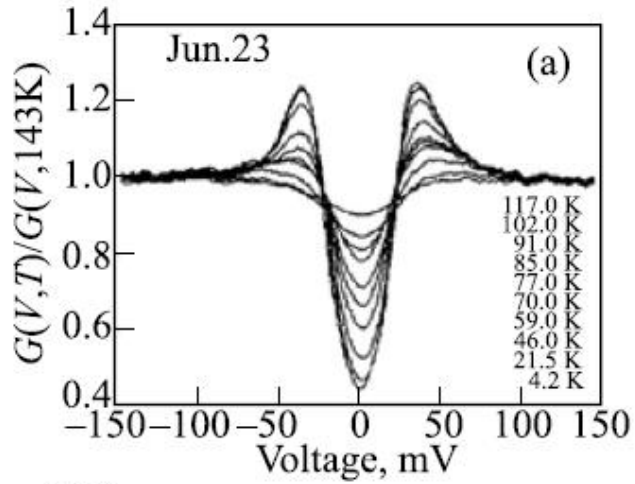
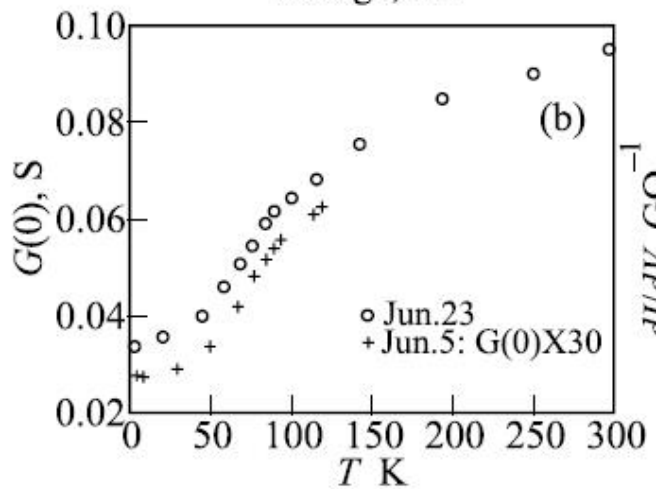
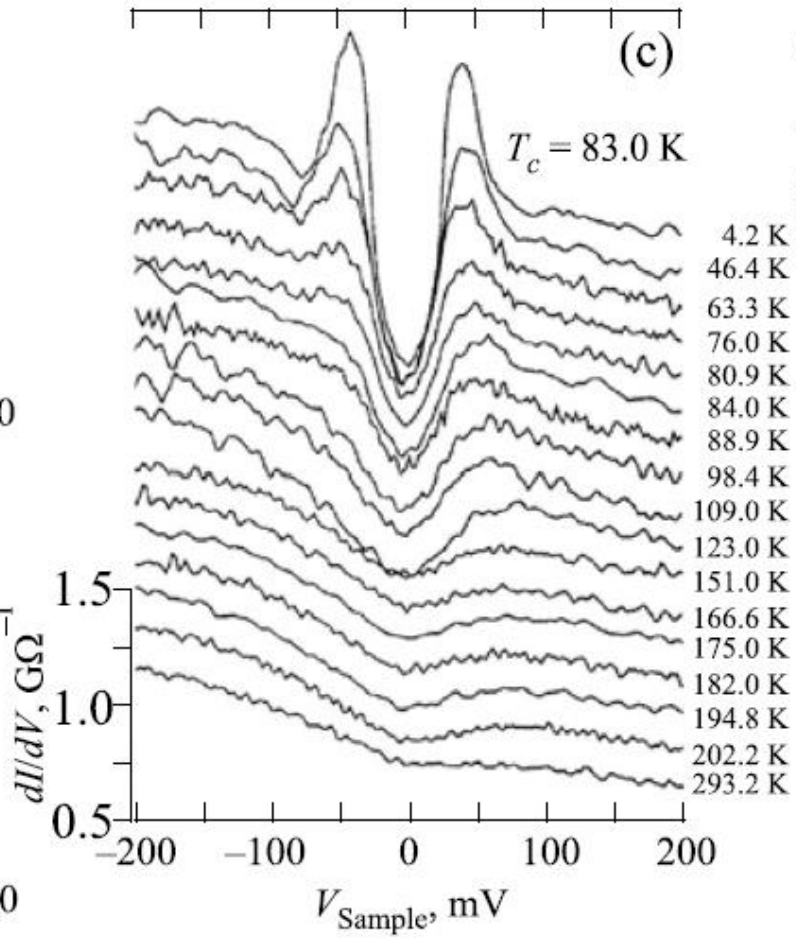


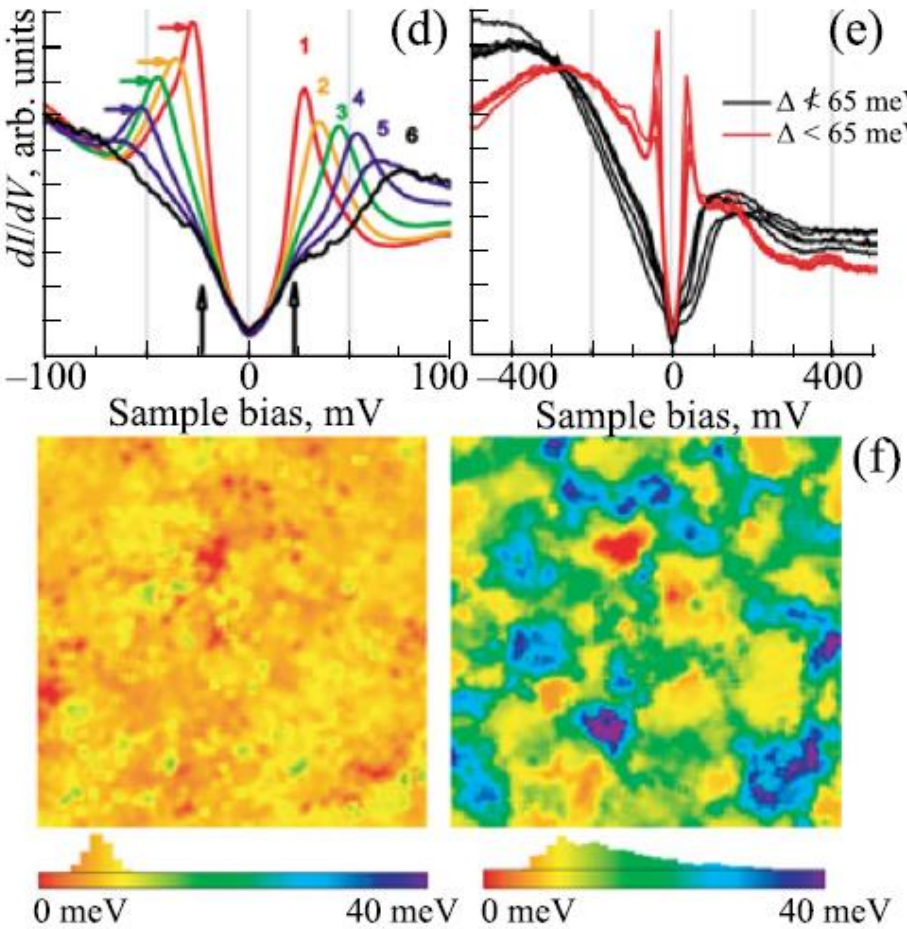
FIG. 8. (Color online) The intensity of each pixel of one ARPES spectrum, $D_n(\omega_i, k_j)$, vs the intensity of the corresponding pixel of another, D_1, spectrum: spectra #2 vs #1 (left); #3 vs #2 (right); and simulated based on spectrum #1 with $n = 2.5$ and $\alpha = 0$, 0.1, and 0.4 (center).

Pseudogap in Tunneling

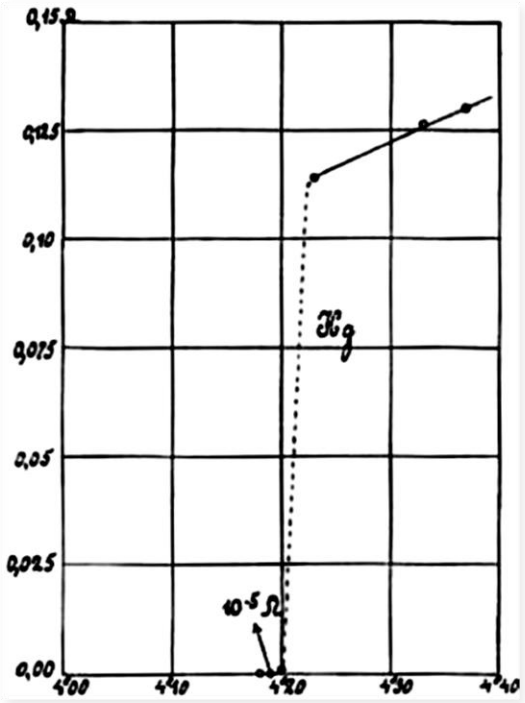


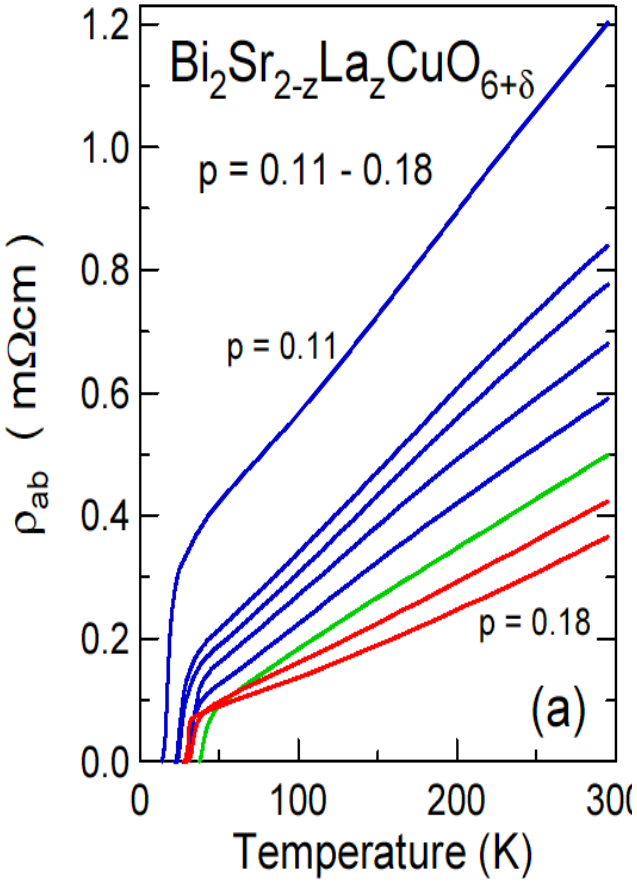


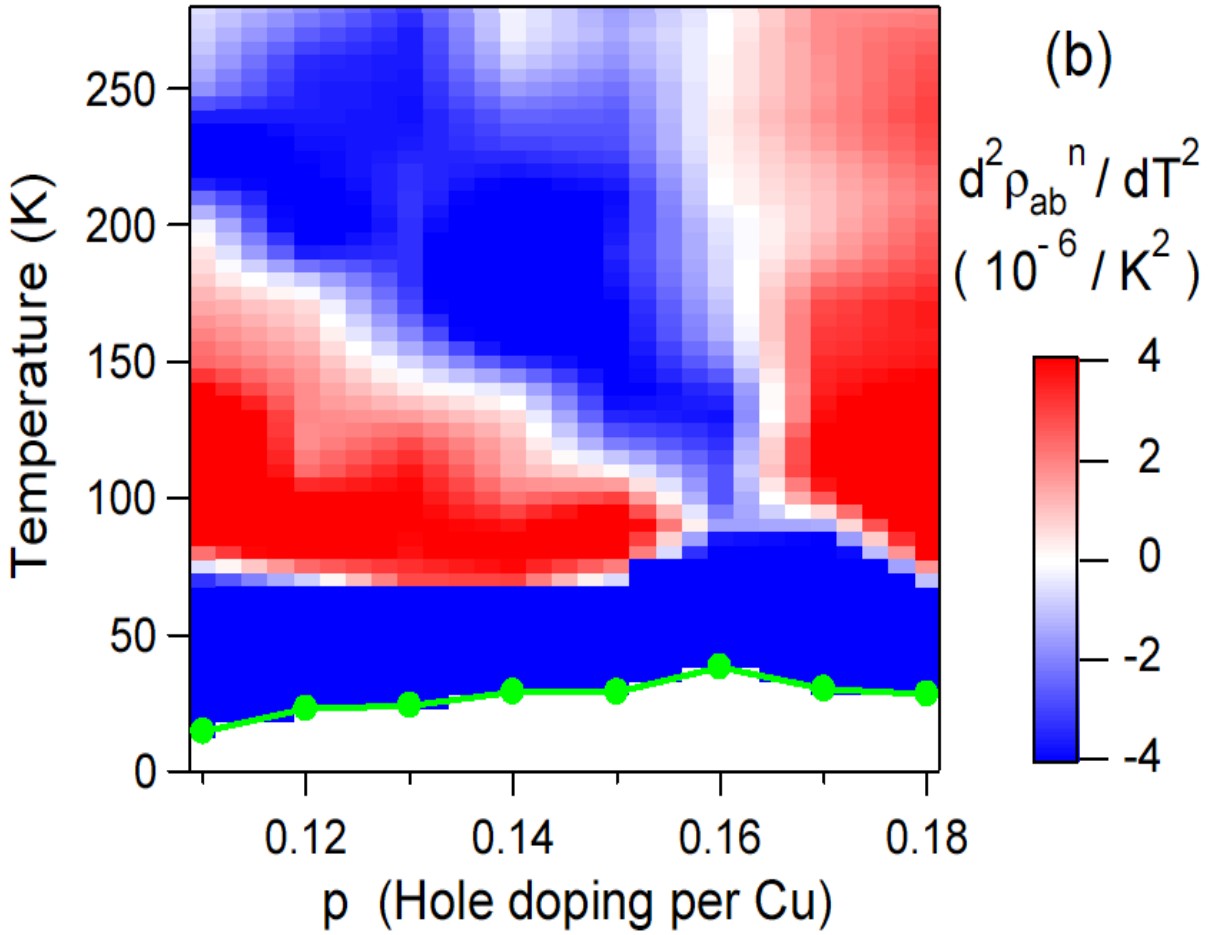




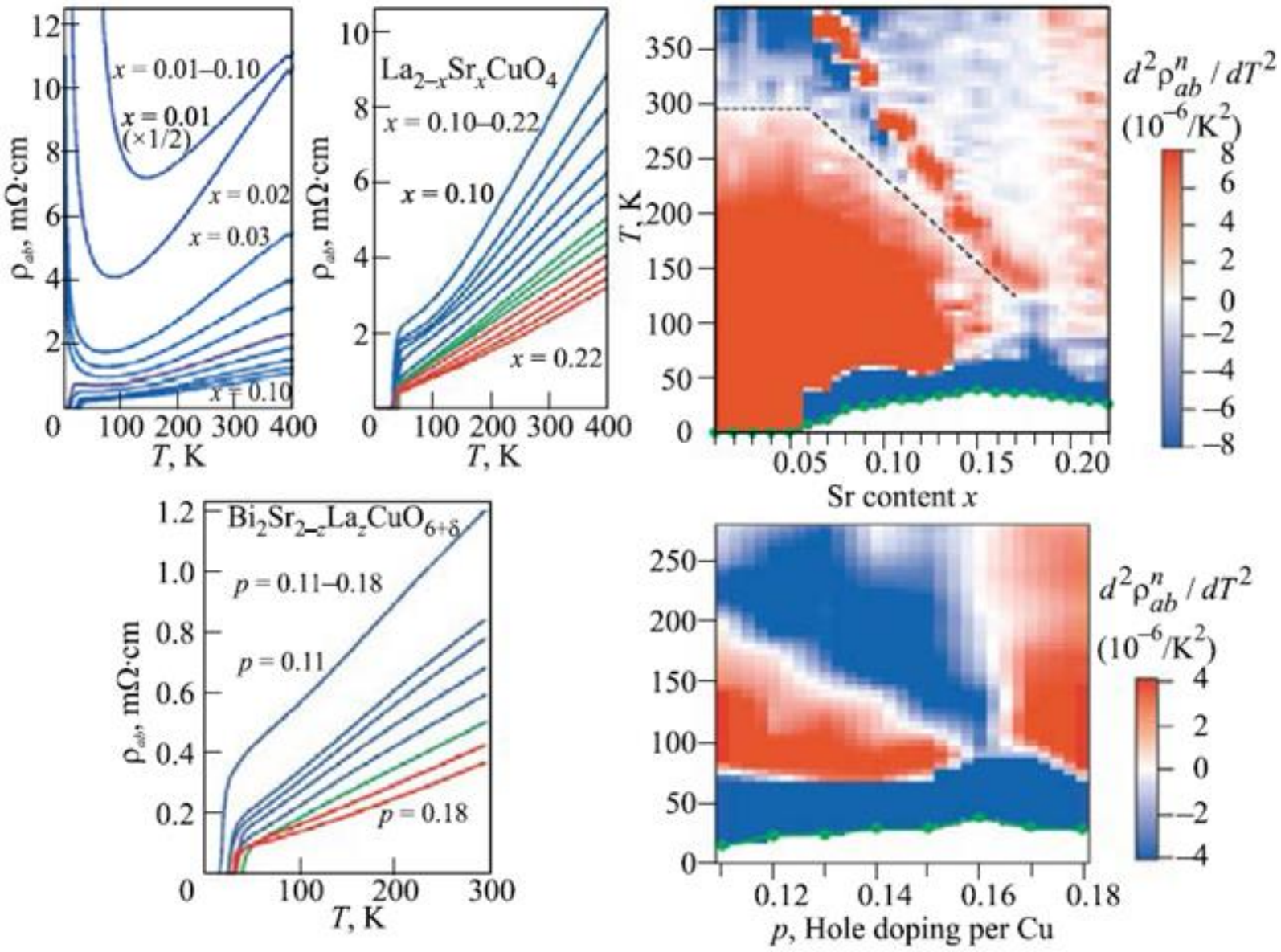
Phase diagram from a Mapping of the In-Plane Resistivity Curvature

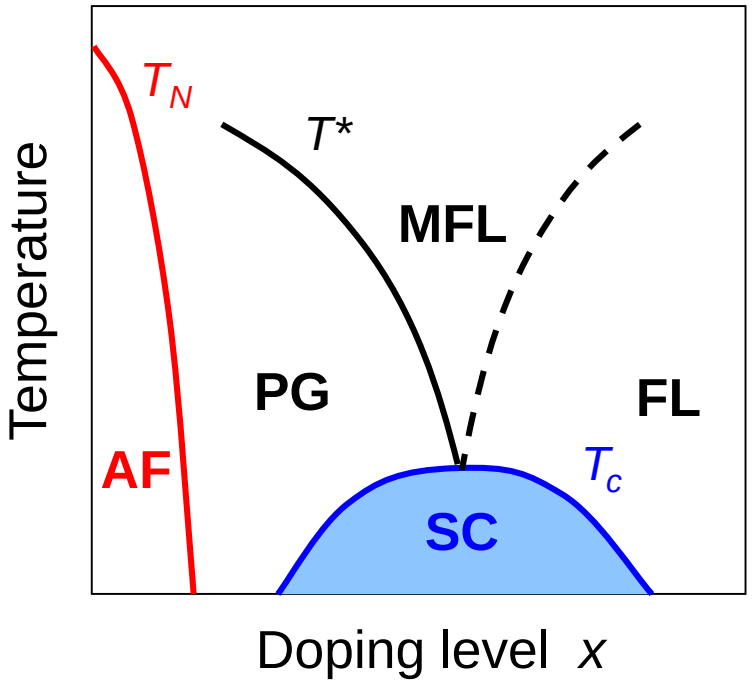






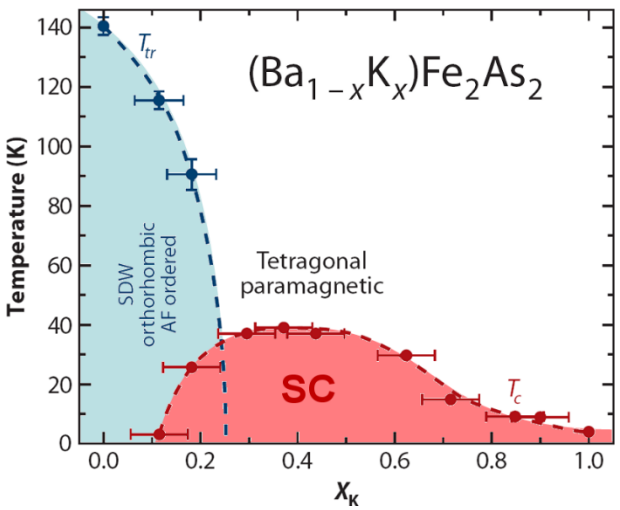
Ando *PRL* 2004



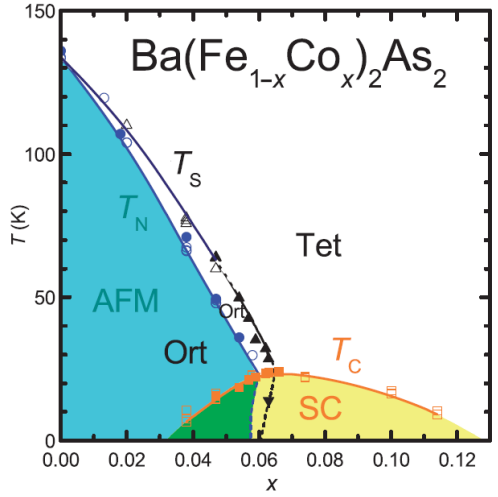


Ando *PRL* 2004

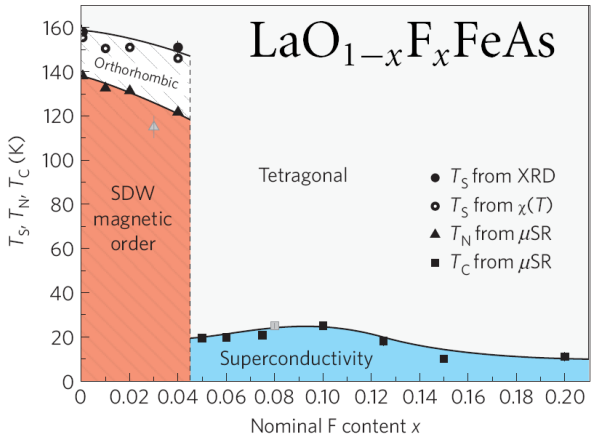
Phase diagrams



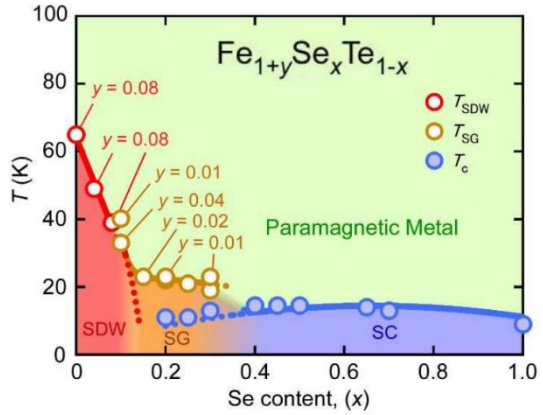
H.-H.Wen & S.Li Annu. Rev. Cond. Mat. Phys. 2011



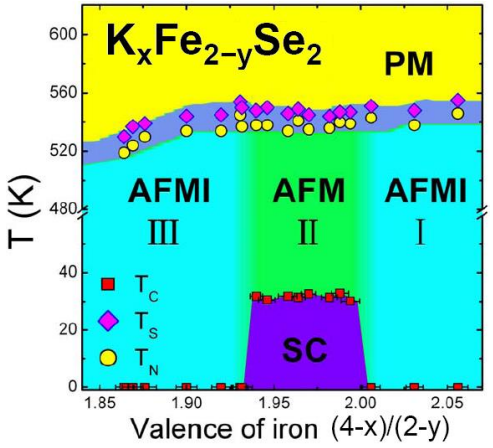
S.Nandi *et al.* PRL 2010



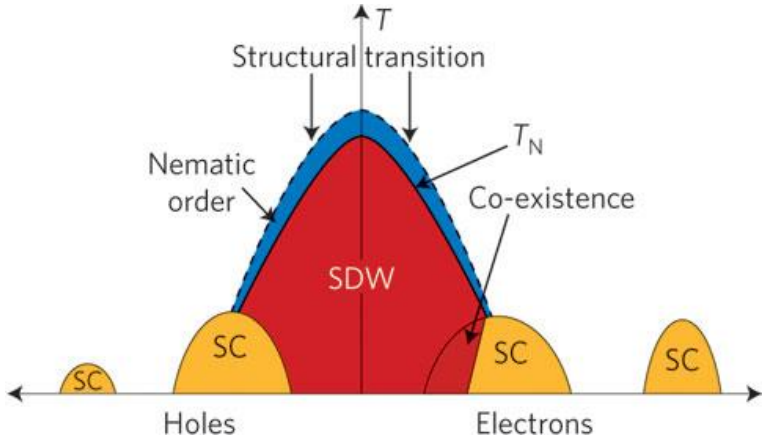
H.Luetkens *et al.* Nature Mat. 2009



N.Katayama *et al.* arXiv:1003.4525

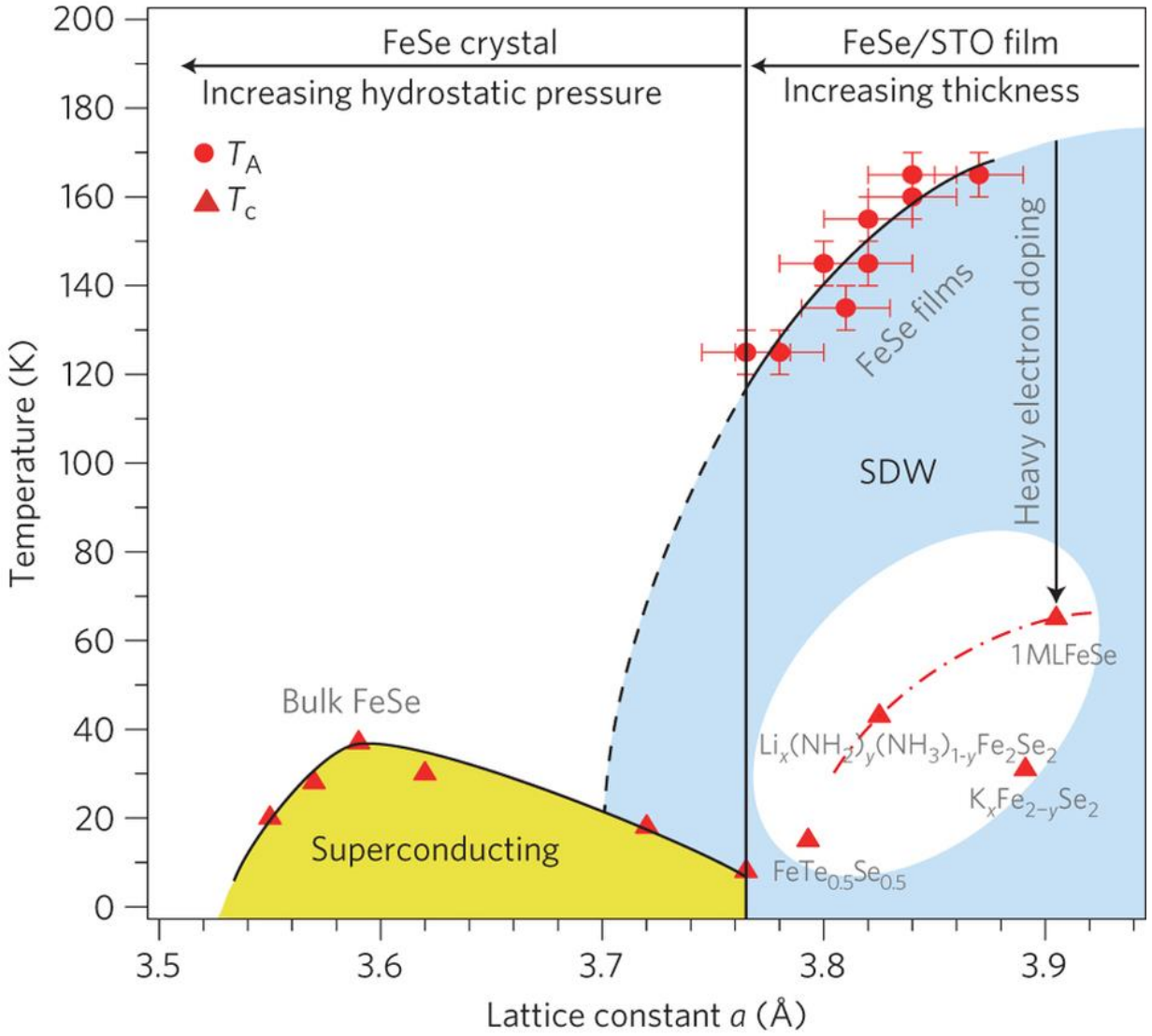


Y.J.Yan *et al.* arXiv:1104.4941



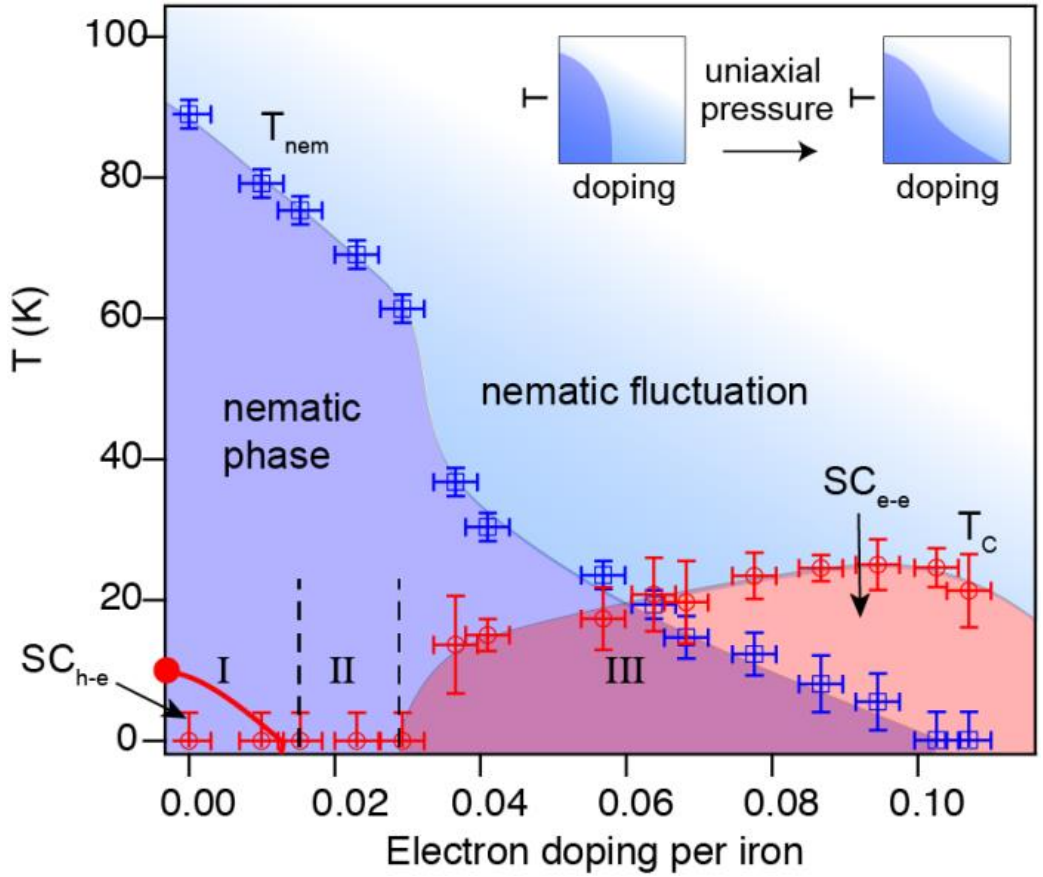
Basov & Chubukov *Nature Phys.* 2011

FeSe single crystal / STO film



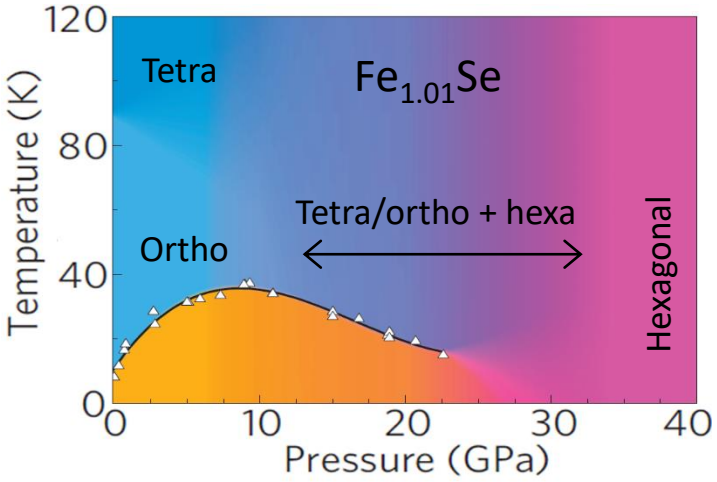
S. Tan, *Nature Materials* 2013

K-coated FeSe single crystal

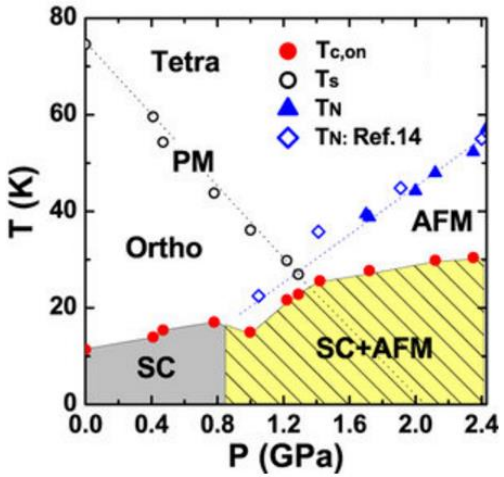


Ye 2015

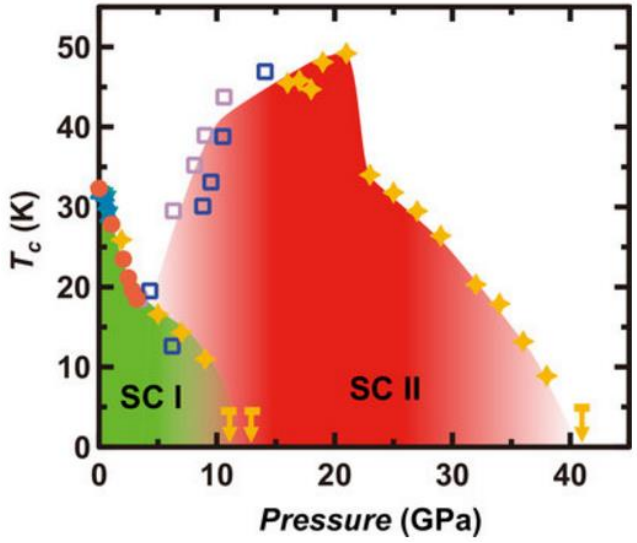
FeSe under pressure



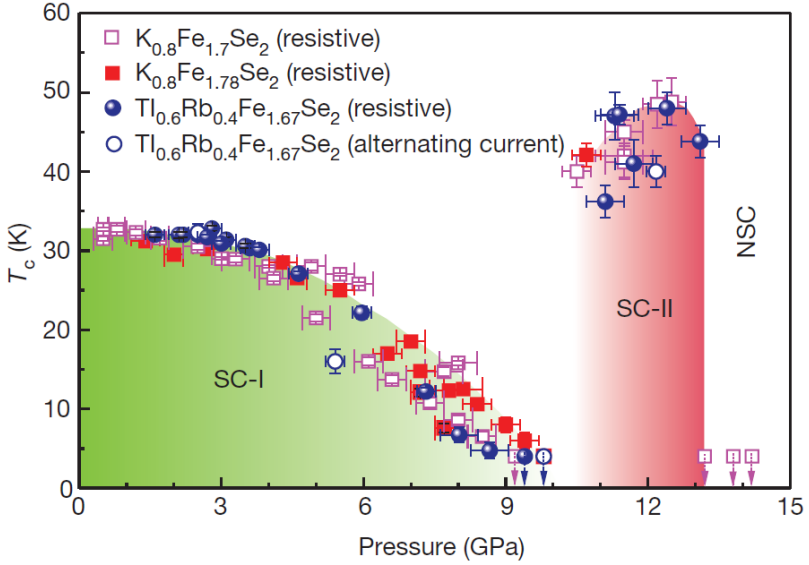
Medvedev 2009



Jung 2015



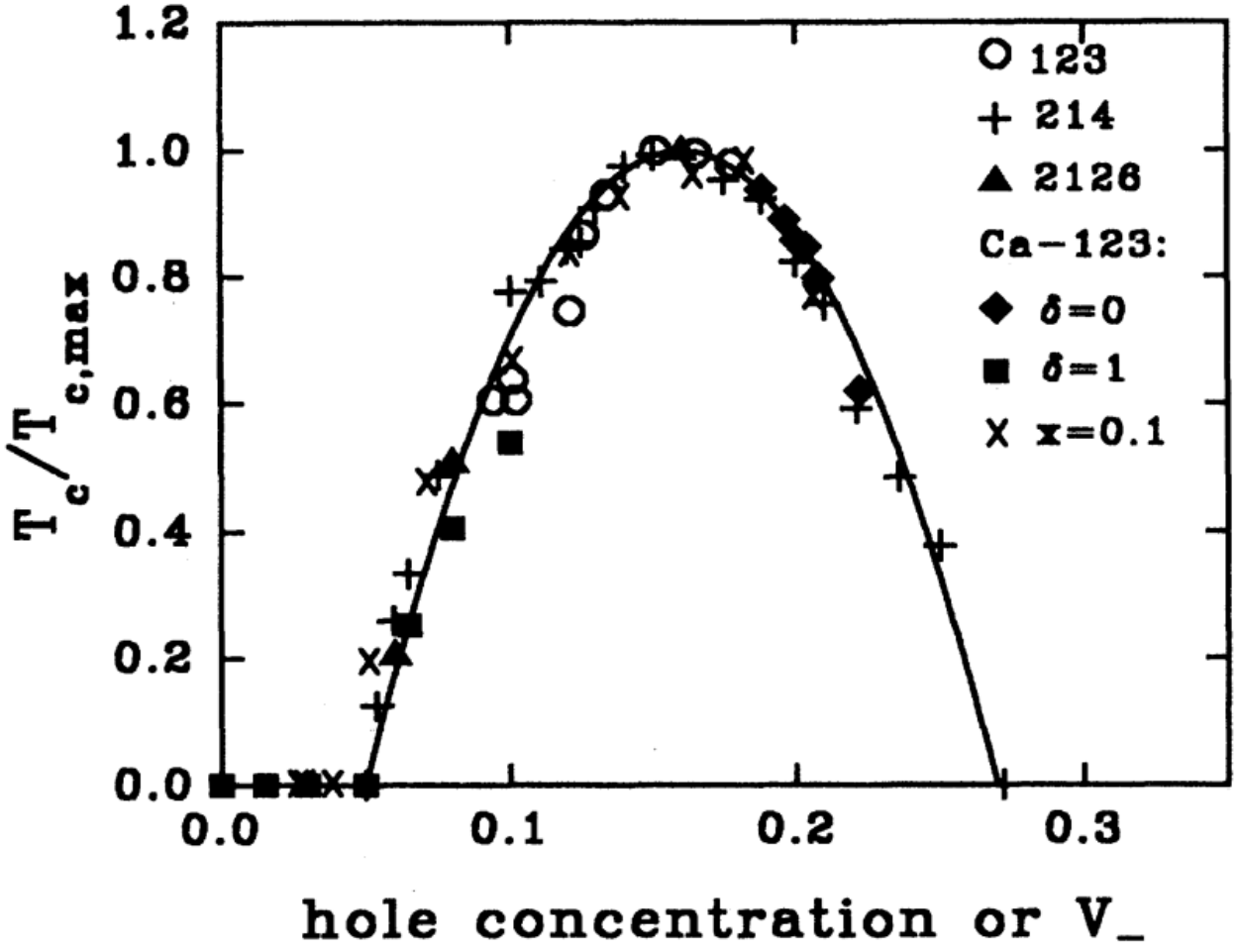
Izumi 2015

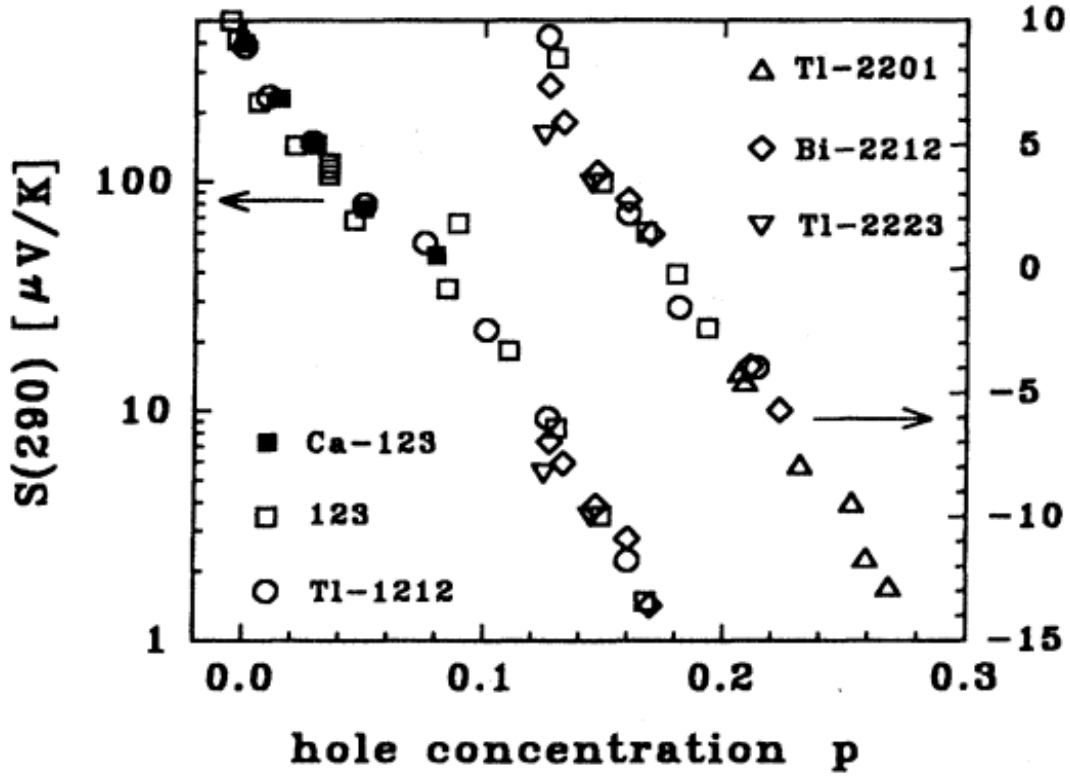


Sun 2012

Емпіричні кореляції

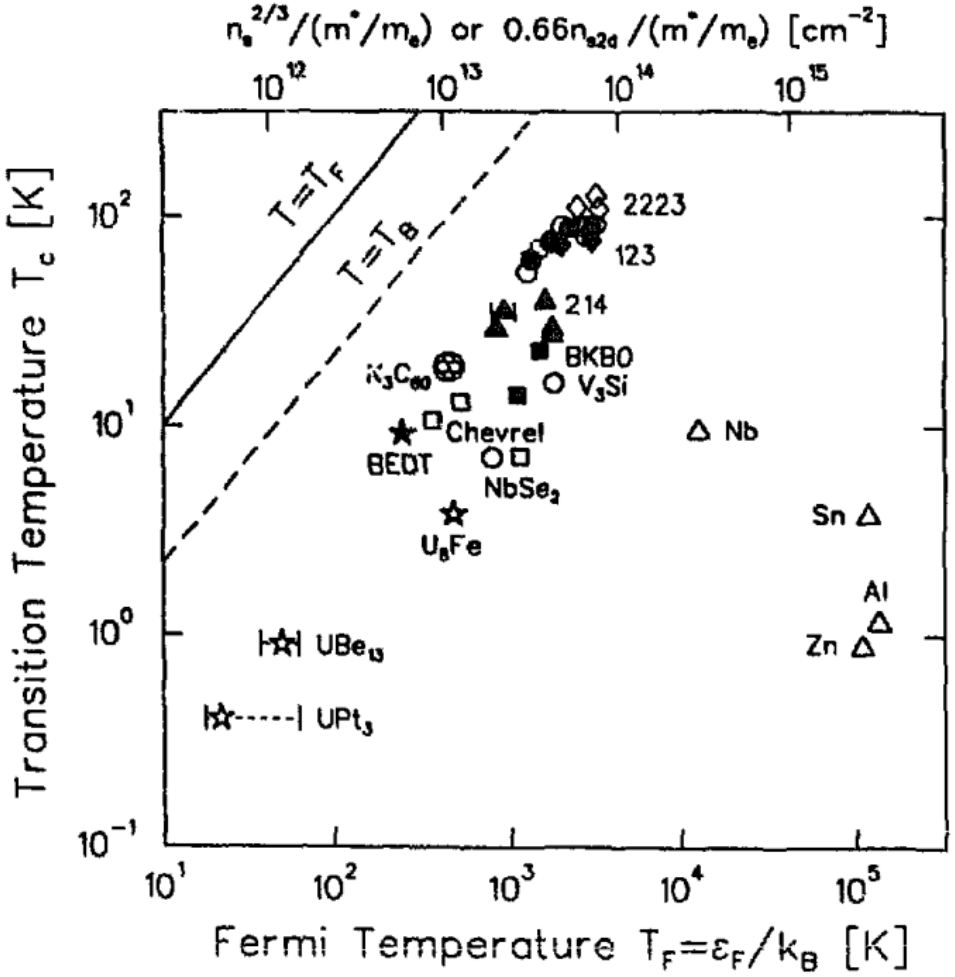
Tallon's "universal" dopping parabola





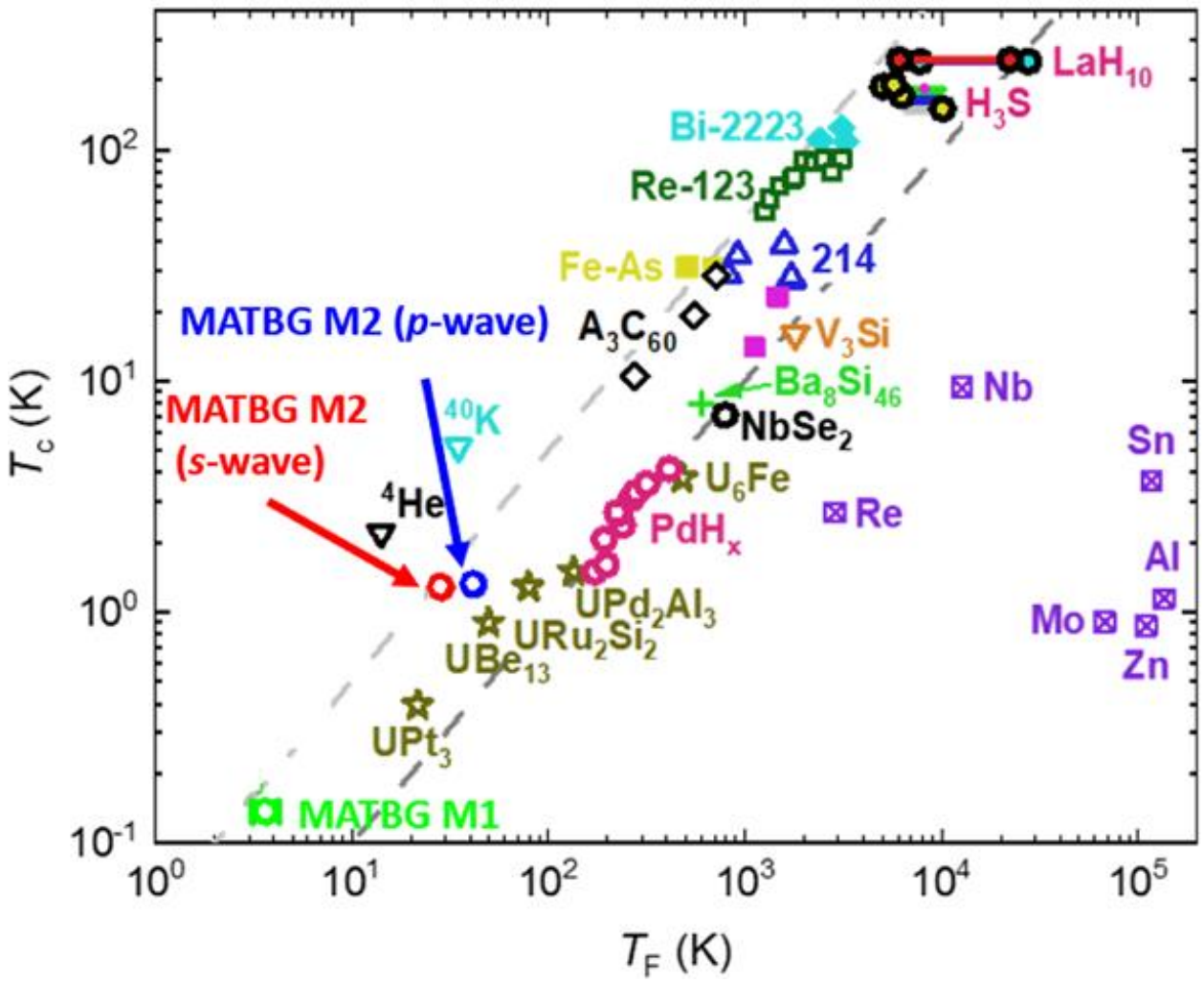
J. L. Tallon et al. *Phys. Rev. B* **51**, 12911(R) (1995)

Uemura plot



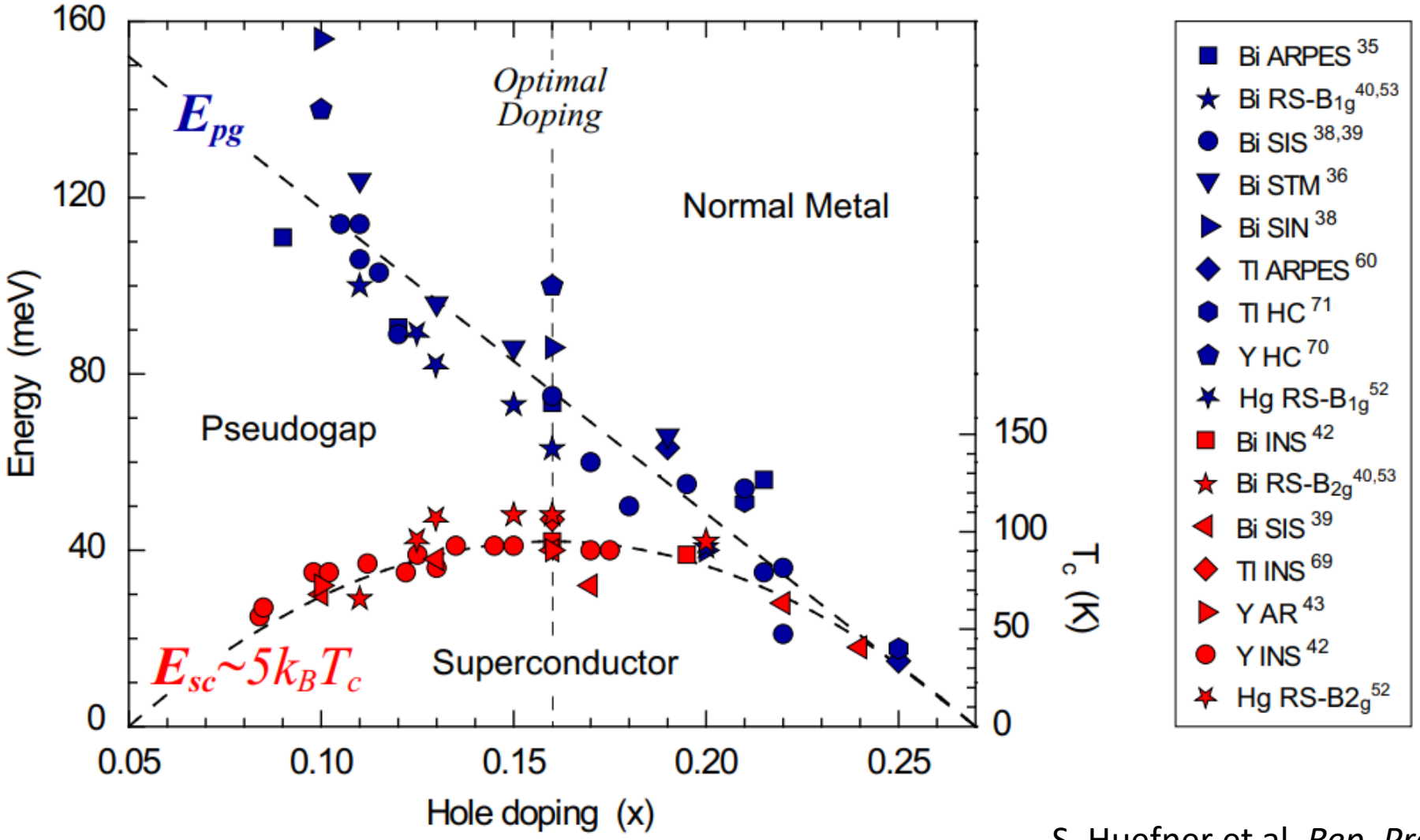
… from λ from muSR

Y.J. Uemura *Physica C* **185–189,** 733 (1991)



E. F. Talantsev et al. *Scientific Reports* **10**, 212 (2020)

Two Gaps Make a High-Temperature Superconductor?



S. Huefner et al. *Rep. Prog. Phys.* **71**, 062501 (2008)