Angle Resolved Photoemission Spectroscopy (3)

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ARPES plan- day 3

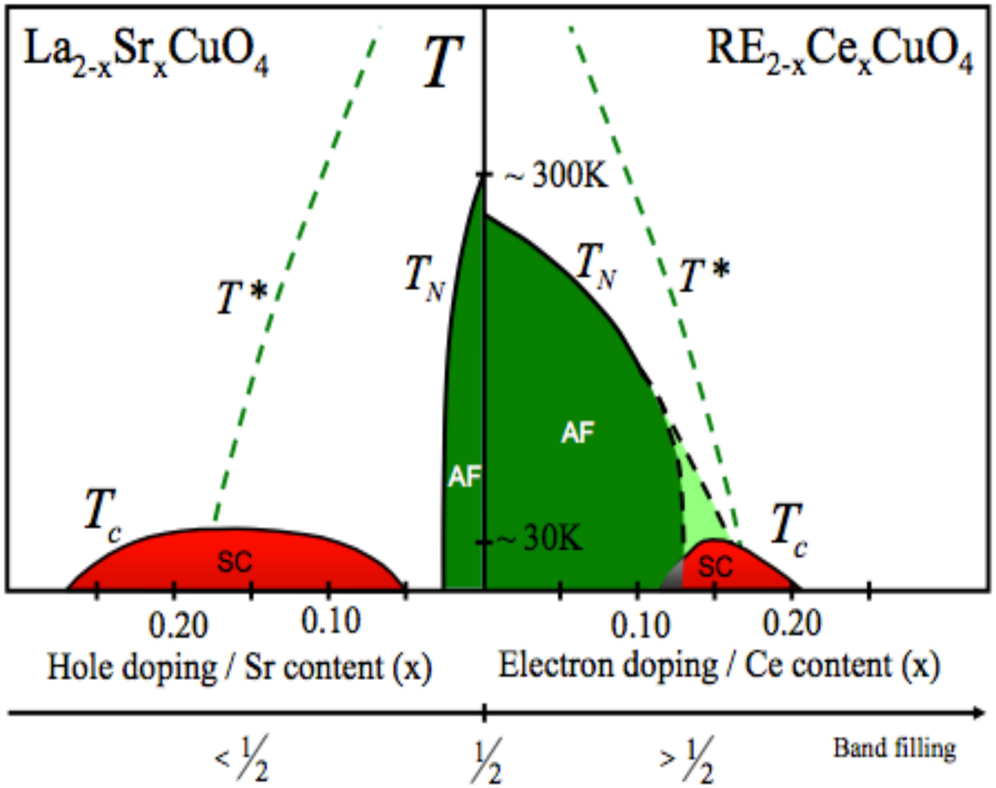
- ARPES on n-type cuprate superconductors. Focus on the “hot spots”.

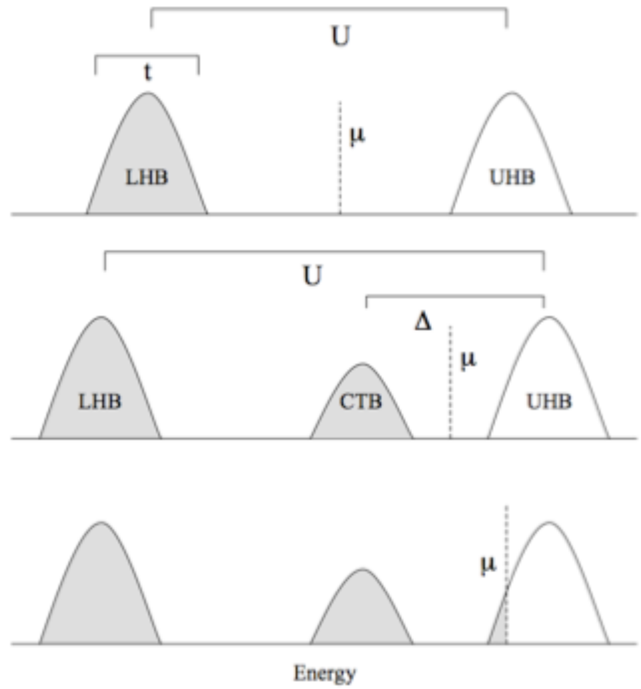
- Pseudogaps and SC gaps in p-type cuprates. Cooperation or competition (or both?) Different types of pgaps? How to separate out the different effects?

- Competition between pairing and pair-breaking (electron self energies).

- Linearity, deviations from linearity, ARPES scattering rates, and transport.

n-type cuprates

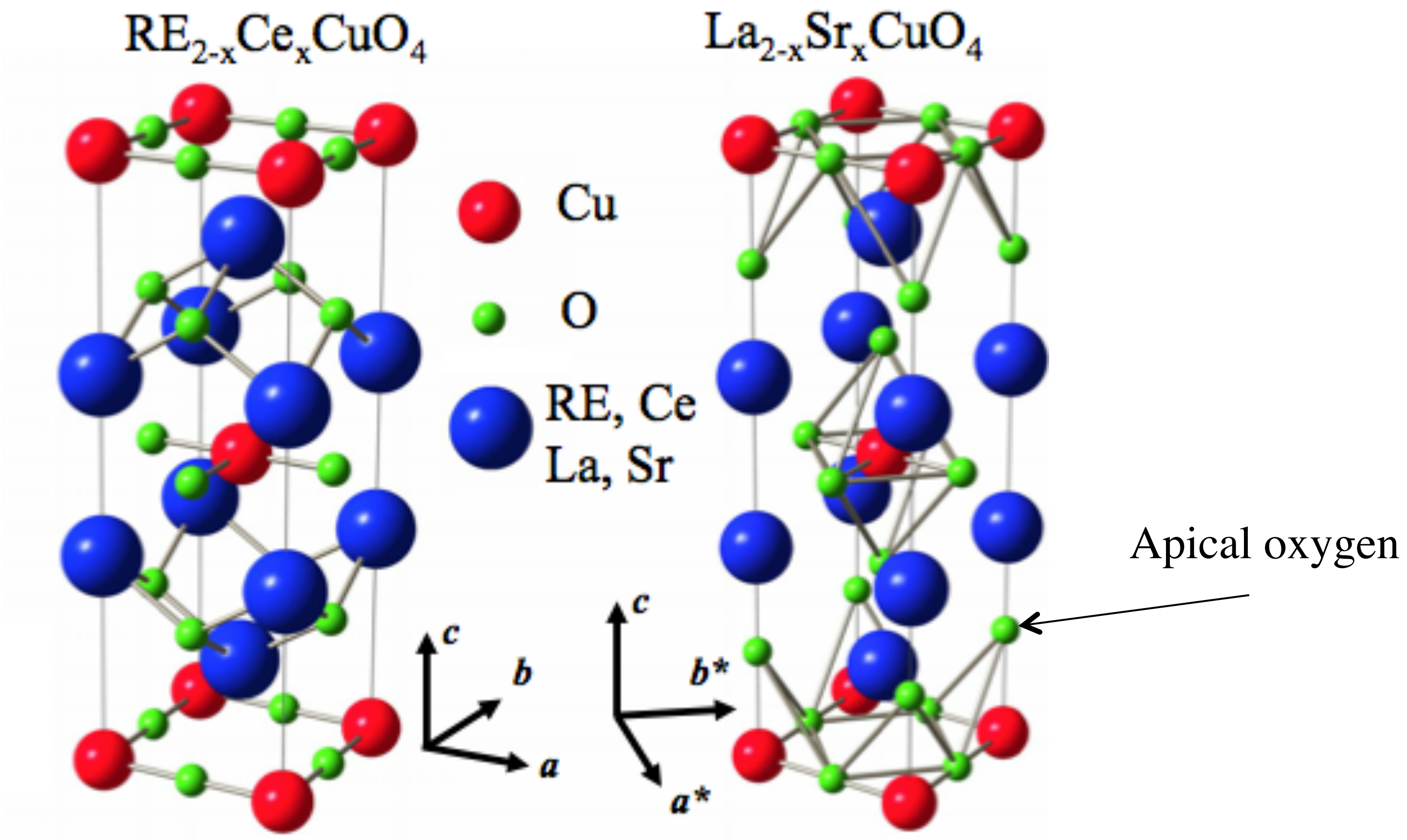




Armitage et al., Rev. Mod. Phys. 82, 2421-2487 (2010)

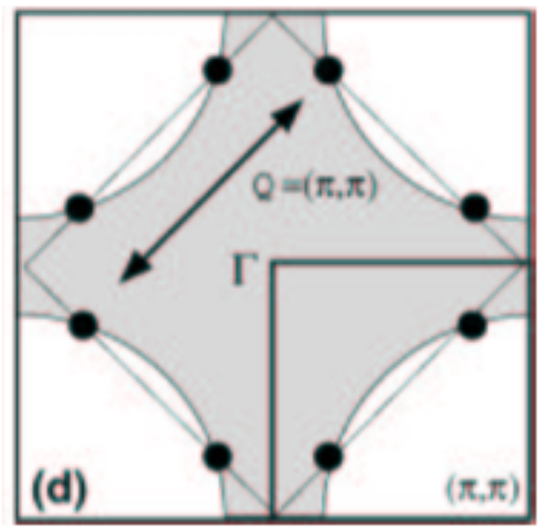
In the n-types:
- Long range AF order extends much farther, out to the SC doping levels.
- SC dome covers a smaller doping range.
- Possible coexistence of SC and AF order.
- Slightly different crystal struture (lack of apical oxygen atom).

Crystal structure of n-and p-type cuprates

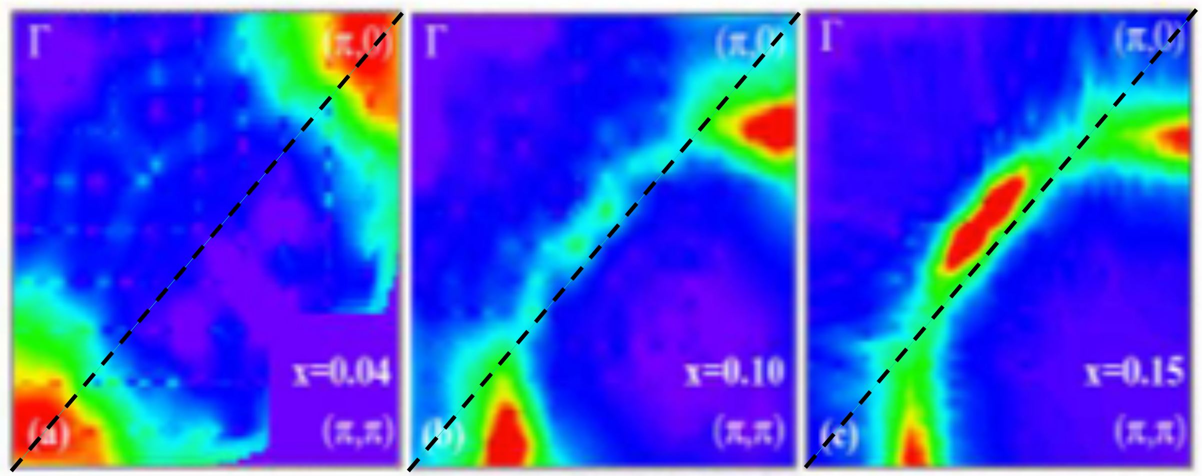


Armitage et al., Rev. Mod. Phys. 82, 2421-2487 (2010)

“hot spots” and FS arcs

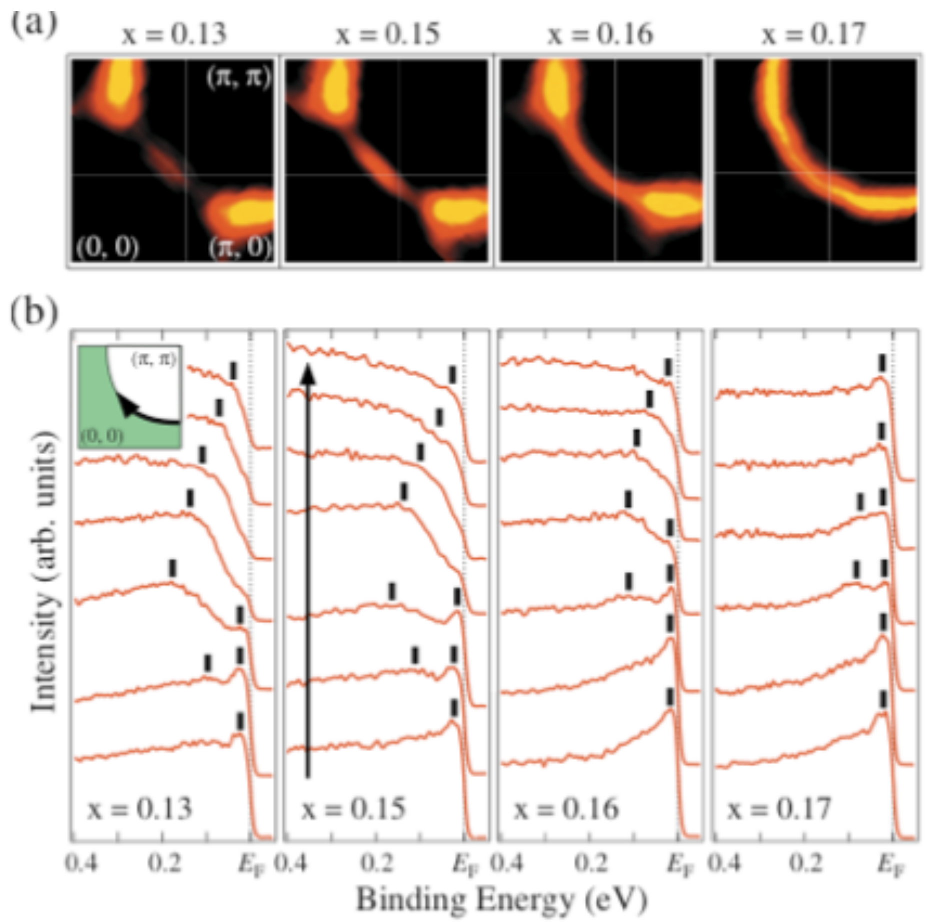


x=.04 x=.10 x=.15



Armitage et al., 2002

$Nd_{2-x}Ce_xCuO_4$

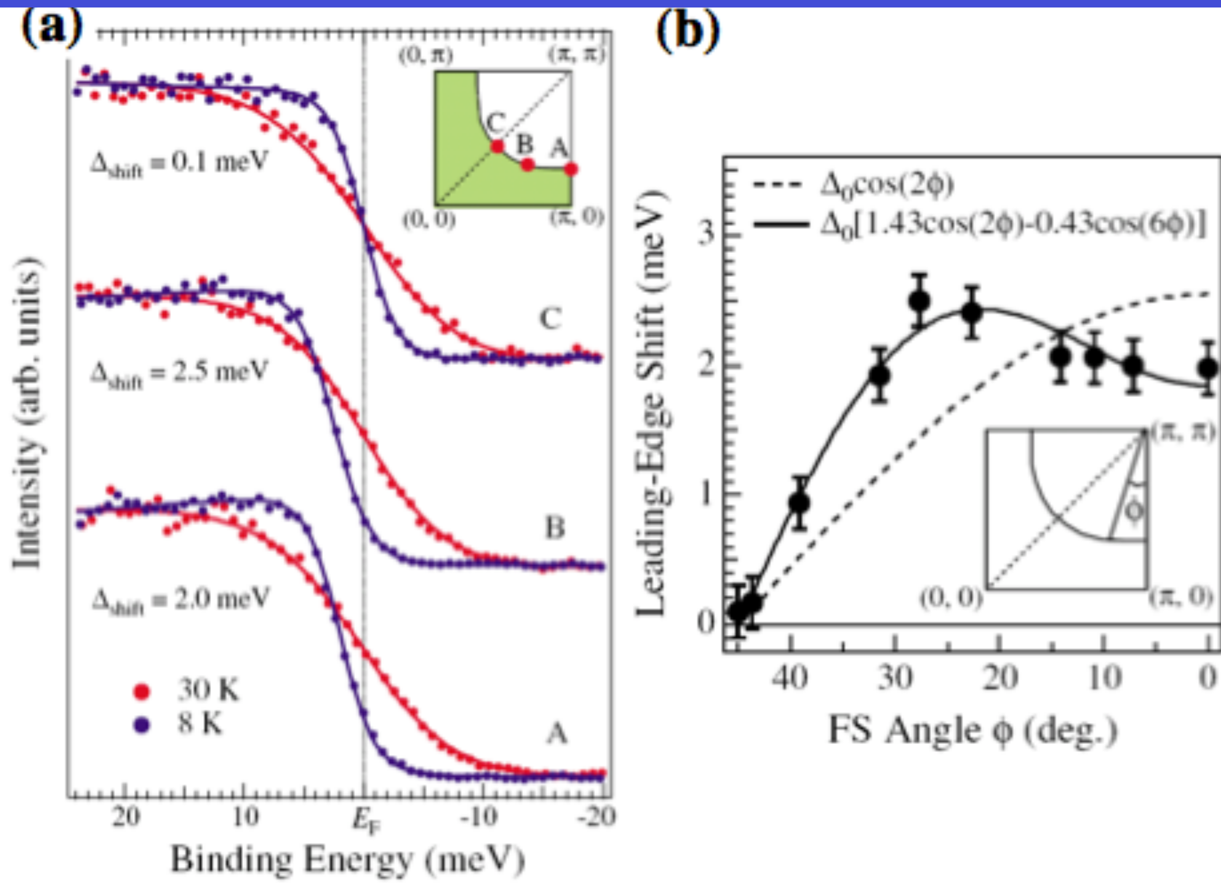


Hot spots go away at large doping levels.

Matsui 2007

Non-monotonic gap as a function of k

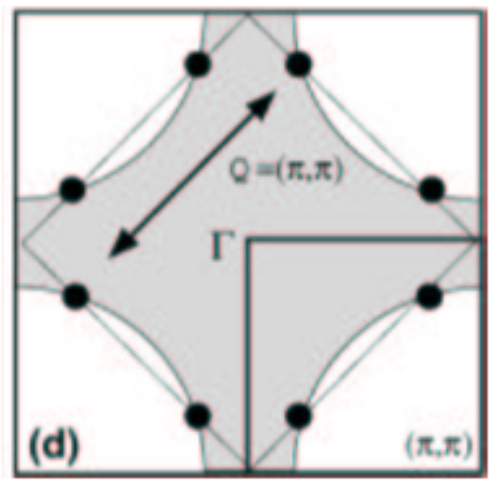
$Pr_{0.89}LaCe_{0.11}CuO_4$



Matsui 2005

Effect originally seen in polarized Raman spectroscopy (Blumberg 2002).
Maximum gap appears roughly at the locations of the hot spots.
→ (π,π) AF fluctuations driving the d-wave superconductivity

“hot spots” in p-type cuprates



Many aspects of the data in p-type cuprates are consistent with hot spot physics, but it is not as incontrovertible as in the n-type cuprates.

N-state scattering rates (peak broadening) are stronger as one goes from the node to the antinode. In p-types there is no evidence that the scattering gets “colder” past the hot spots.

This is not inconsistent with broadly peaked AF scattering due to very short-ranged AF fluctuations. But then these would be hot regions and not hot spots.

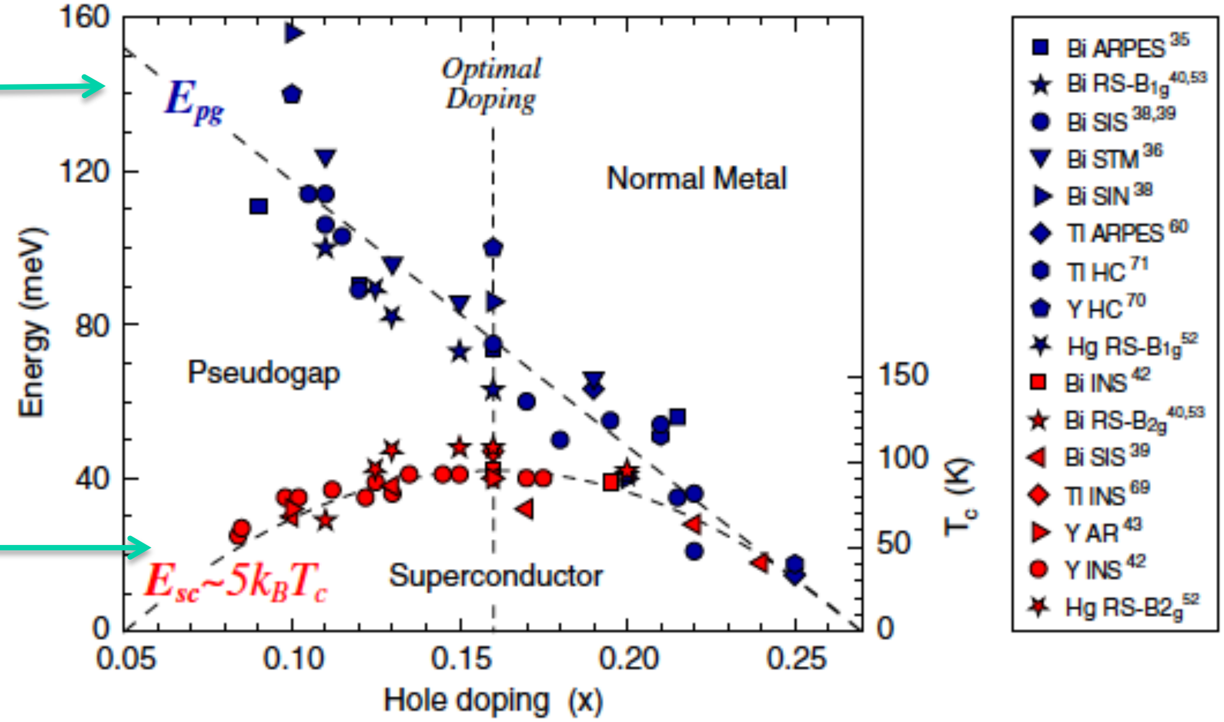
Edges of the Fermi arcs (which are also not at all sharp in k-space) sometimes associated with the hot spots.

IOP Publishing — Reports on Progress in Physics
Rep. Prog. Phys. 71 (2008) 062501 (9pp) doi:10.1088/0034-4885/71/6/062501

Two gaps make a high-temperature superconductor?

S Hüfner[1,2], M A Hossain[1,2], A Damascelli[1,2] and G A Sawatzky[1,2]

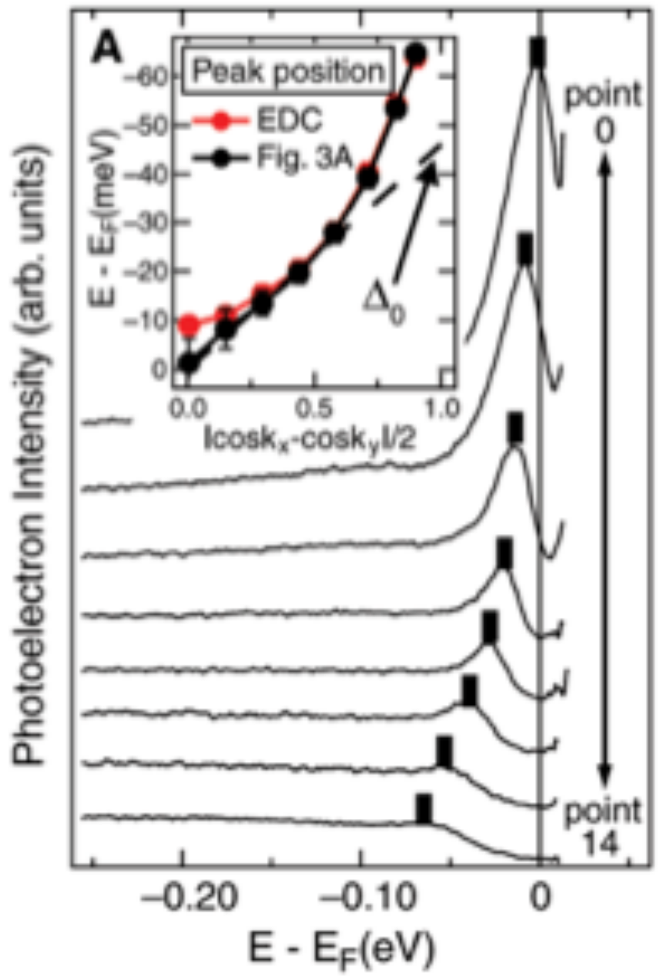
Almost exclusively antinodal measurements.



Nodal gap behavior?

- When measuring at the antinode are you measuring the max of the SC gap or something completely different (e.g. a gap from a competing order?)
- Is antinodal pseudogap a precursor to the SC gap, or is it a separate competing gap.
- Are there multiple types of pseudogaps (a competing order gap plus a prepairing gap)?

“Hockey stick” in the gap function
T_c=50K underdoped Bi2212

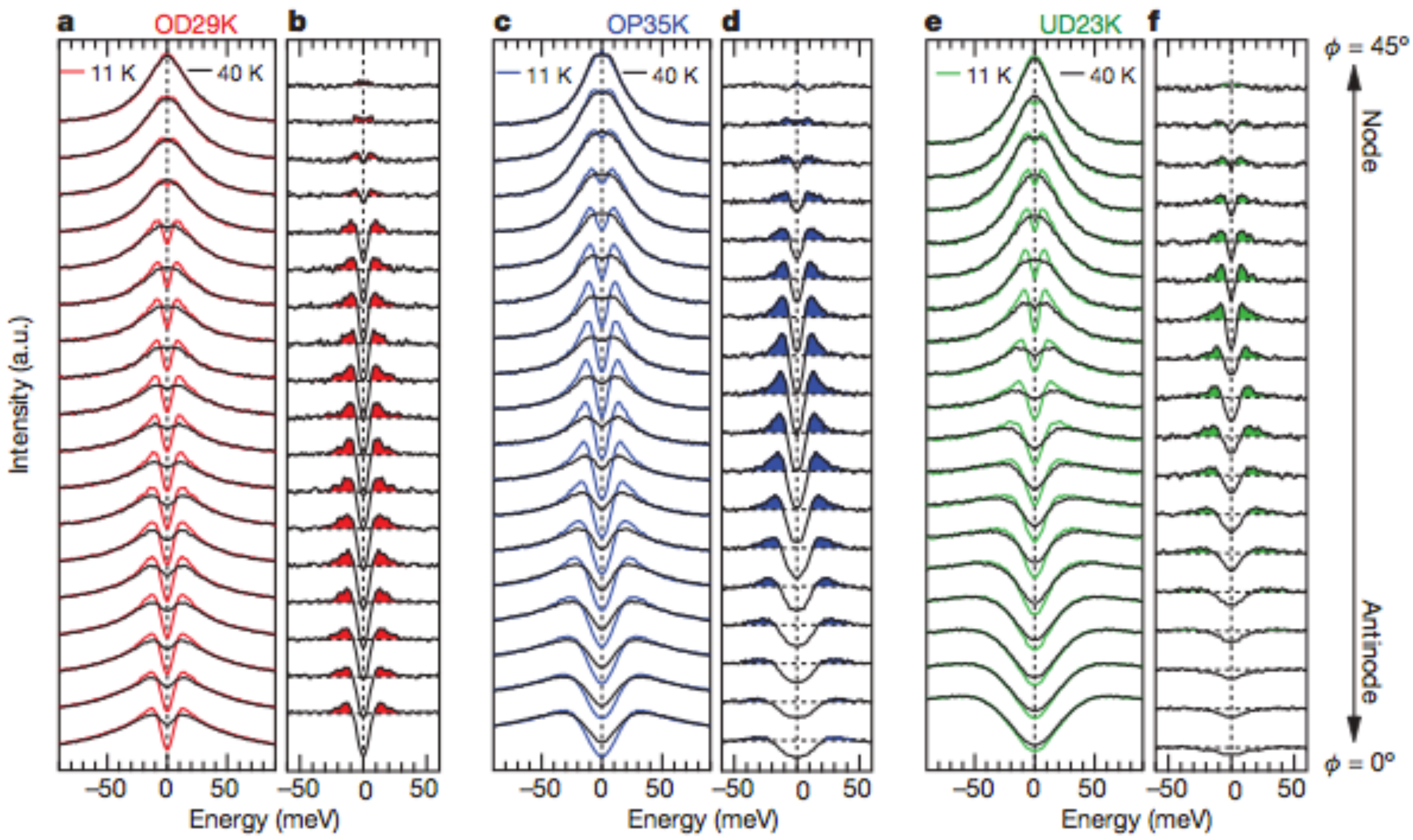


- Simplistic peak-position analysis.

- Increase in the gap magnitude in antinodal regime beyond the expecations from the pure SC d-wave form.

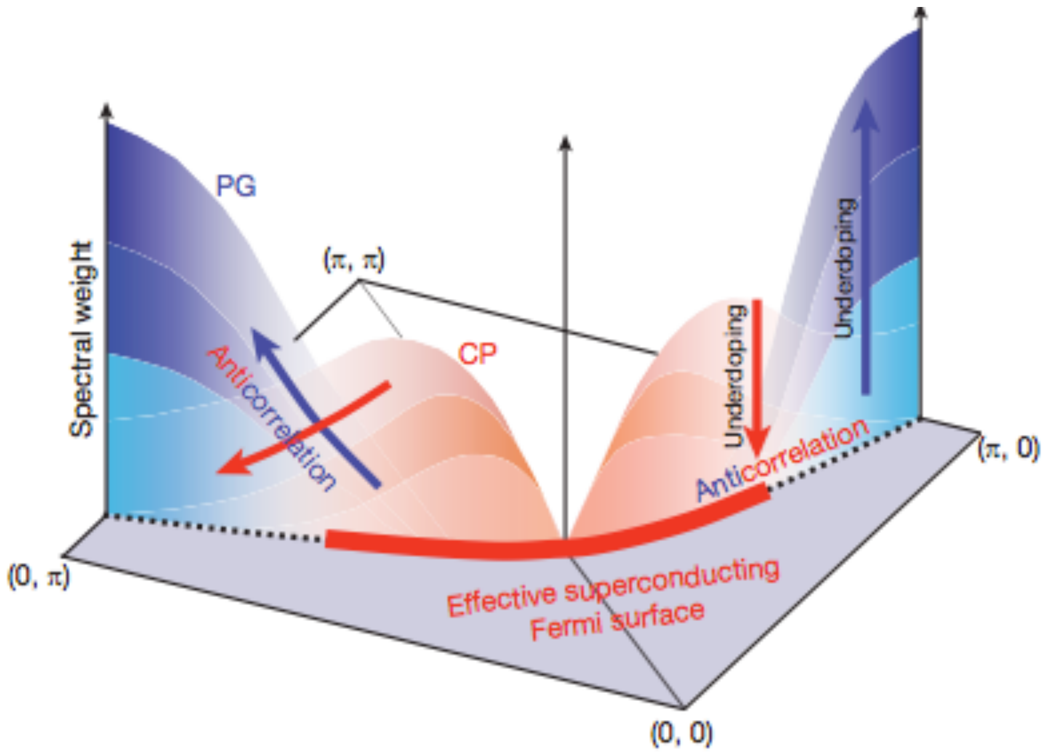
Tanaka et al. Science 2006

Competition between the antionodal pgap and the SC gap (Bi2201)



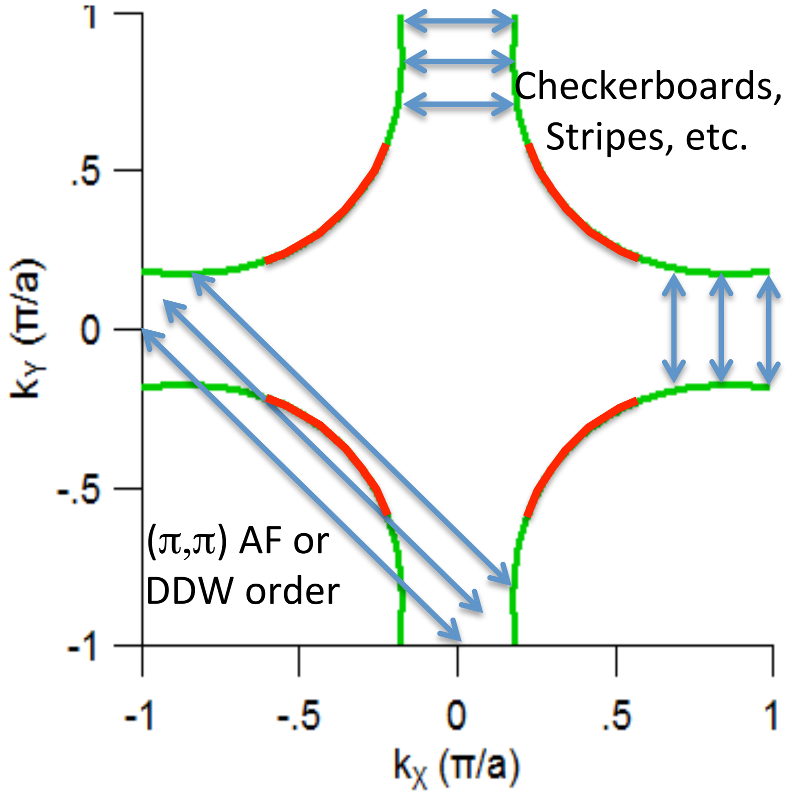
Kondo et al. Nature 2009

Competition between the antionodal pgap and the SC gap (Bi2201)

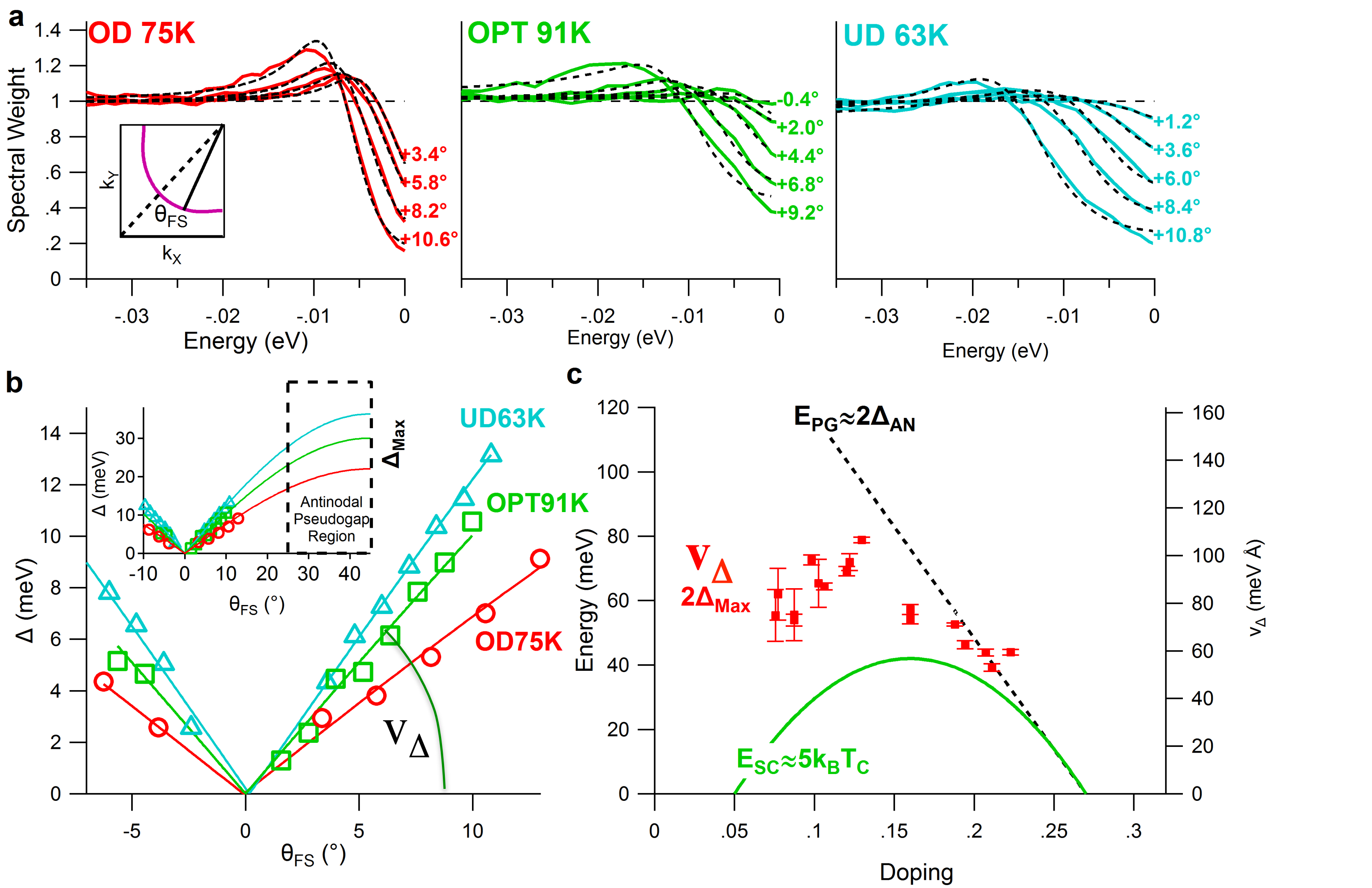


Kondo et al. Nature 2009

Near-node (or Fermi arc region) is the cleanest place to study the superconductivity



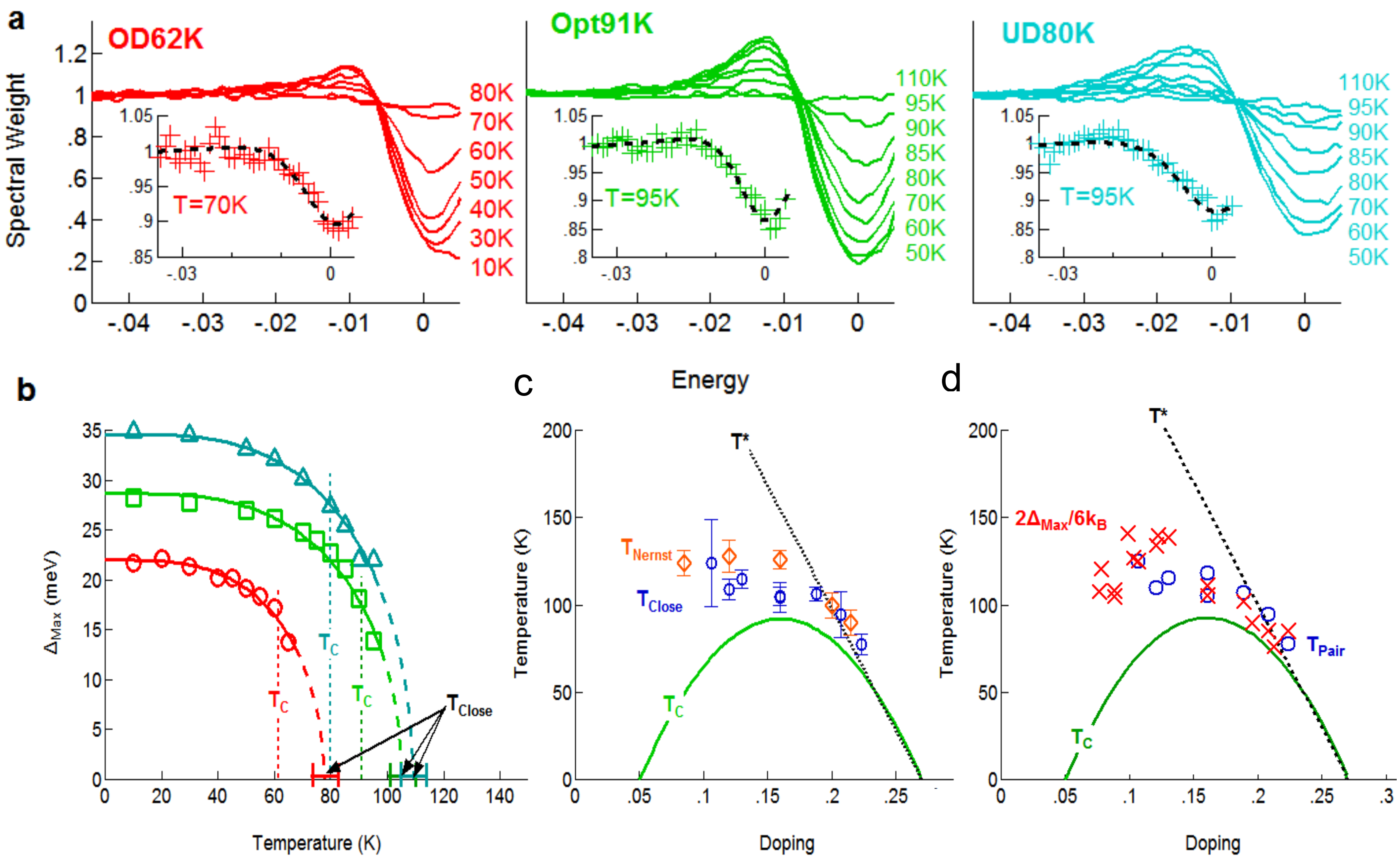
Doping Dependence of Δ_{SC}



Δ_{SC} follows neither the SC dome nor T*

T.J. Reber, D.S.D et al. (submitted)

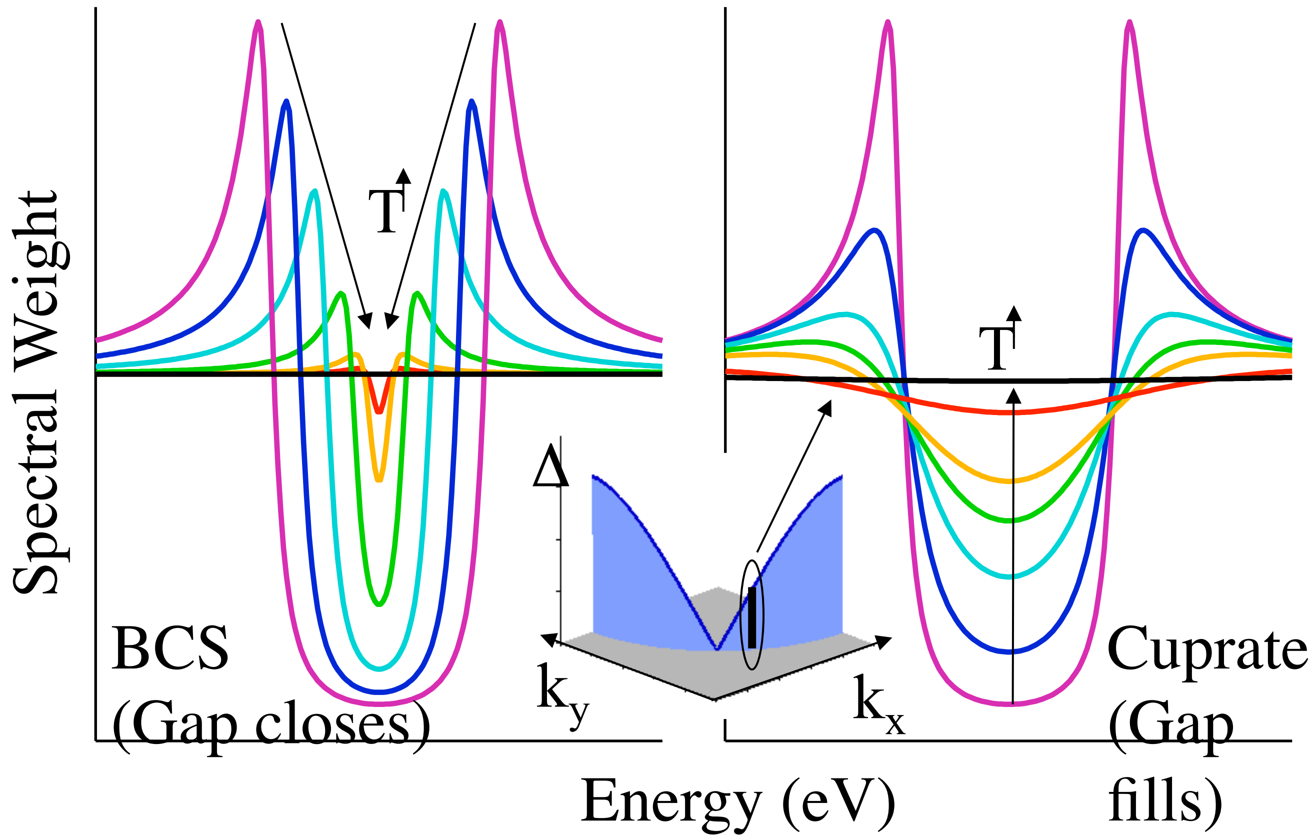
Doping Dependence of T_{Close}



Pre-pairing observed at all dopings studied.
T_{Close} matches T_{Onset} as found in Nernst expts.
Wang/Ong et al. *PRL* (2005)

Qualitative match to Josephson Plasma Resonance expts on UD YBCO.
Bubroka/Bernhard et al. PRL (2011)

Closing/Filling of the gaps with temperature



The filling of the gap in cuprates is due to the rapidly rising Γ (scattering rate) with temperature. This is a phenomenology observed in essentially all spectroscopies on cuprates, but has been difficult to quantify.

Reber et al.