Pseudogap effects on the ferromagnetic transition of $YBa_2Cu_3O_y$ and $SrRuO_3$ bilayers

or

Do pre-formed pairs exist above T_c?

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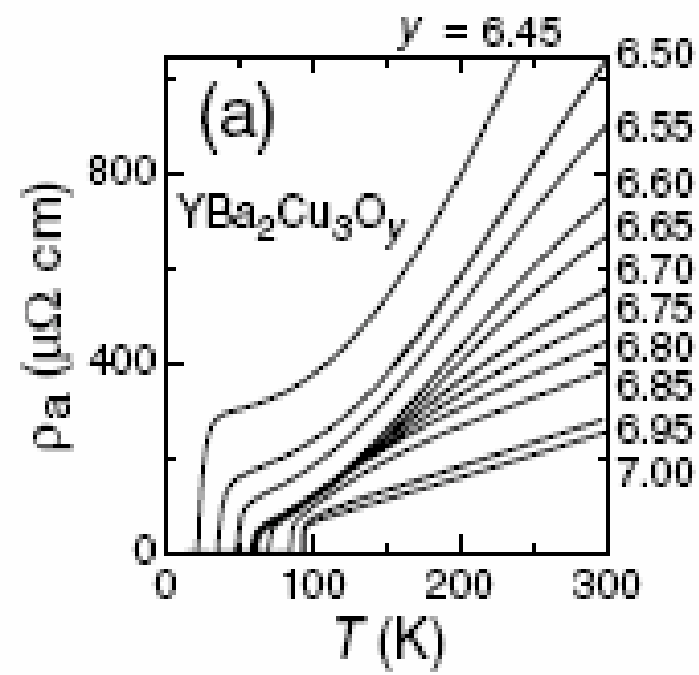
Outline

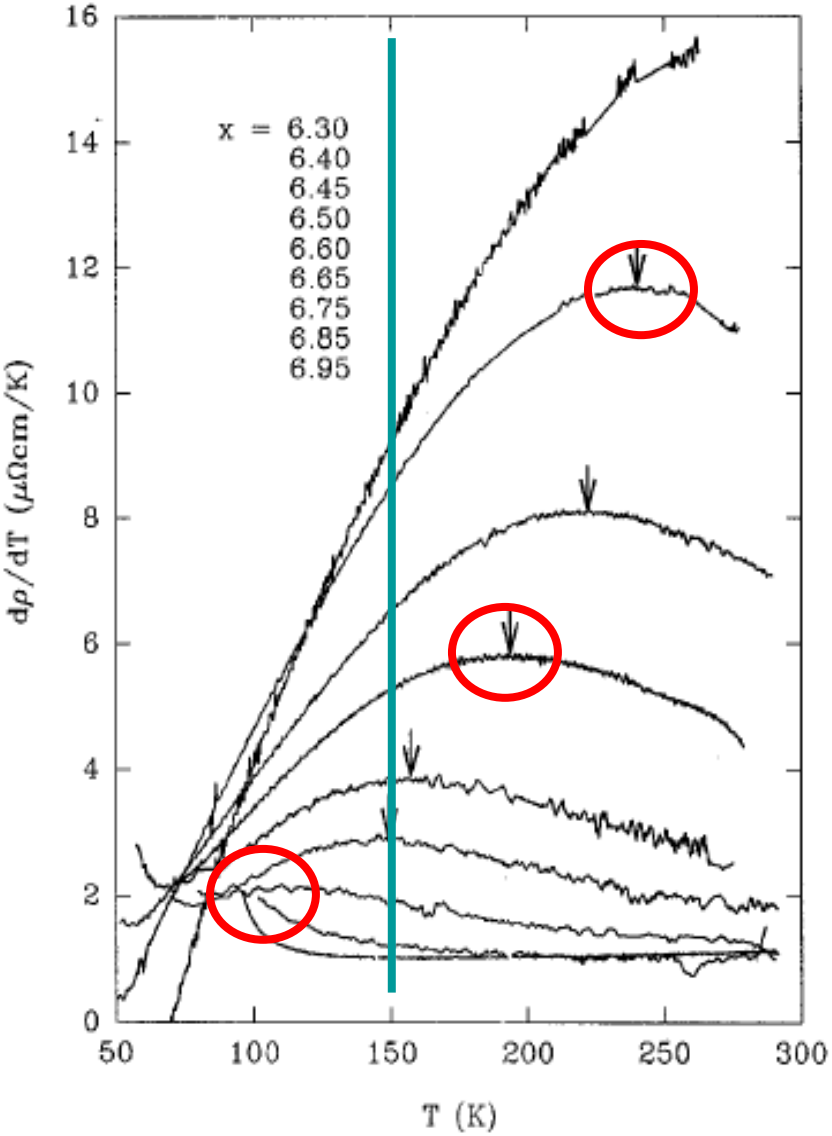
- Background -the pseudogap and the pre-formed pairs scenario
- Motivation & Methodology of how to design the experiment
- Results and discussion
- Conclusions

T* from R vs. T measurements

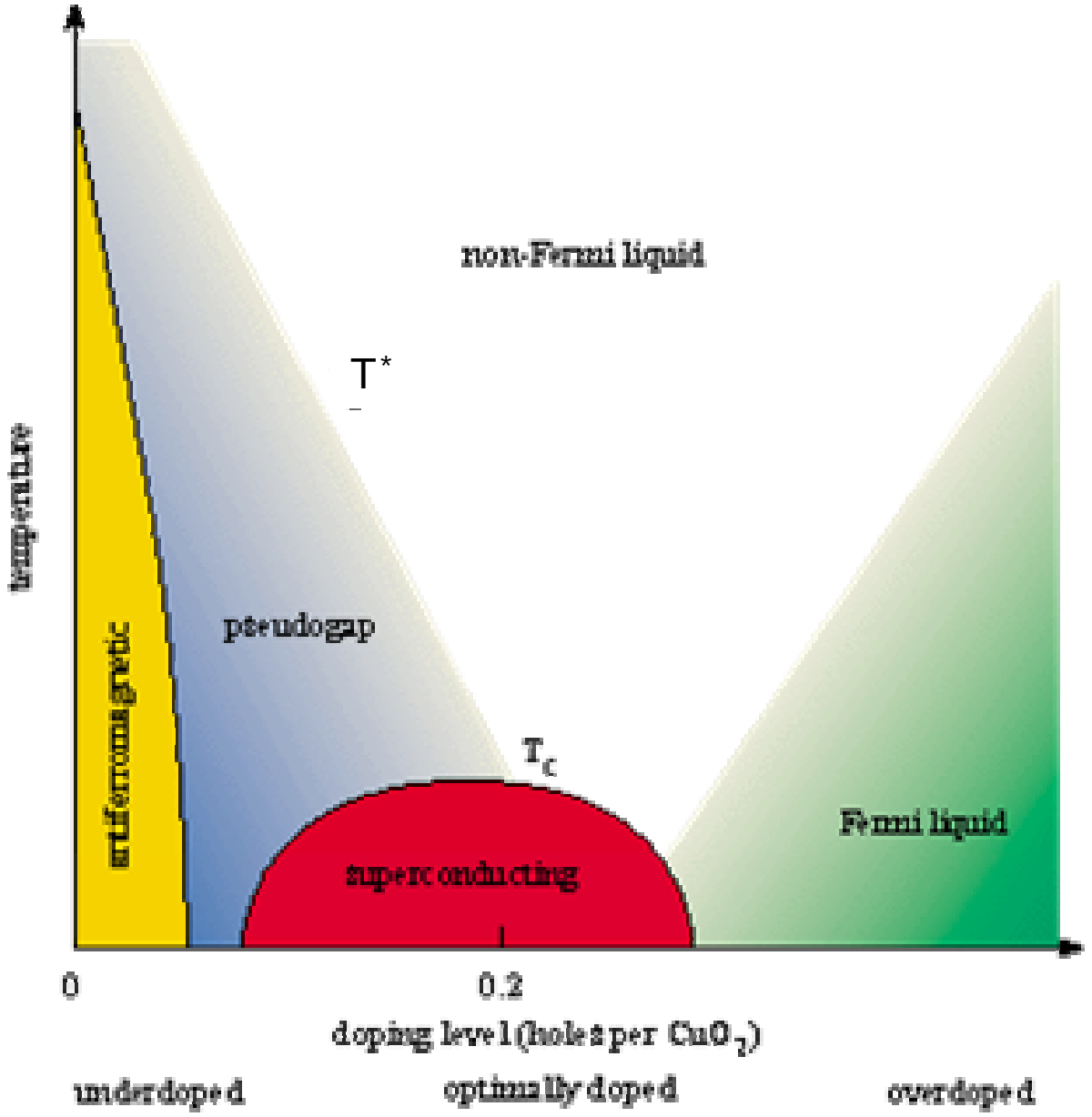
Ando & Segawa,
PRL, **88**, 167005 (2002)



Wuyts, Moshchalkov, and
Bruynseraede PRB, **53** 9418 (1996)



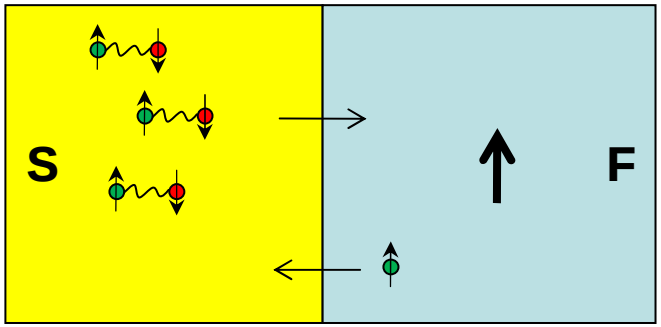
T* on the phase diagram



Motivation

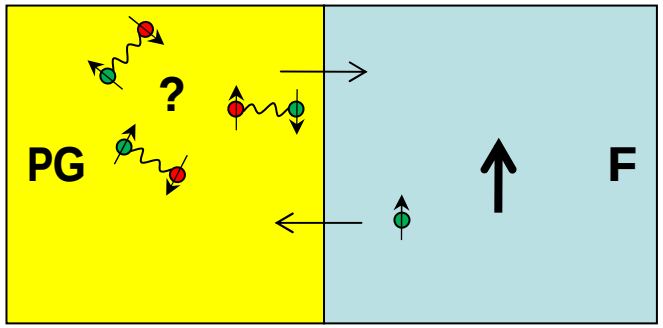
To look for a signature of pre-formed pairs
via a proximity effect in
S/F bilayers of $YBa_2Cu_3O_y/SrRuO_3$
where the YBCO is in the pseudogap regime

Standard PE: *For T<Tc*

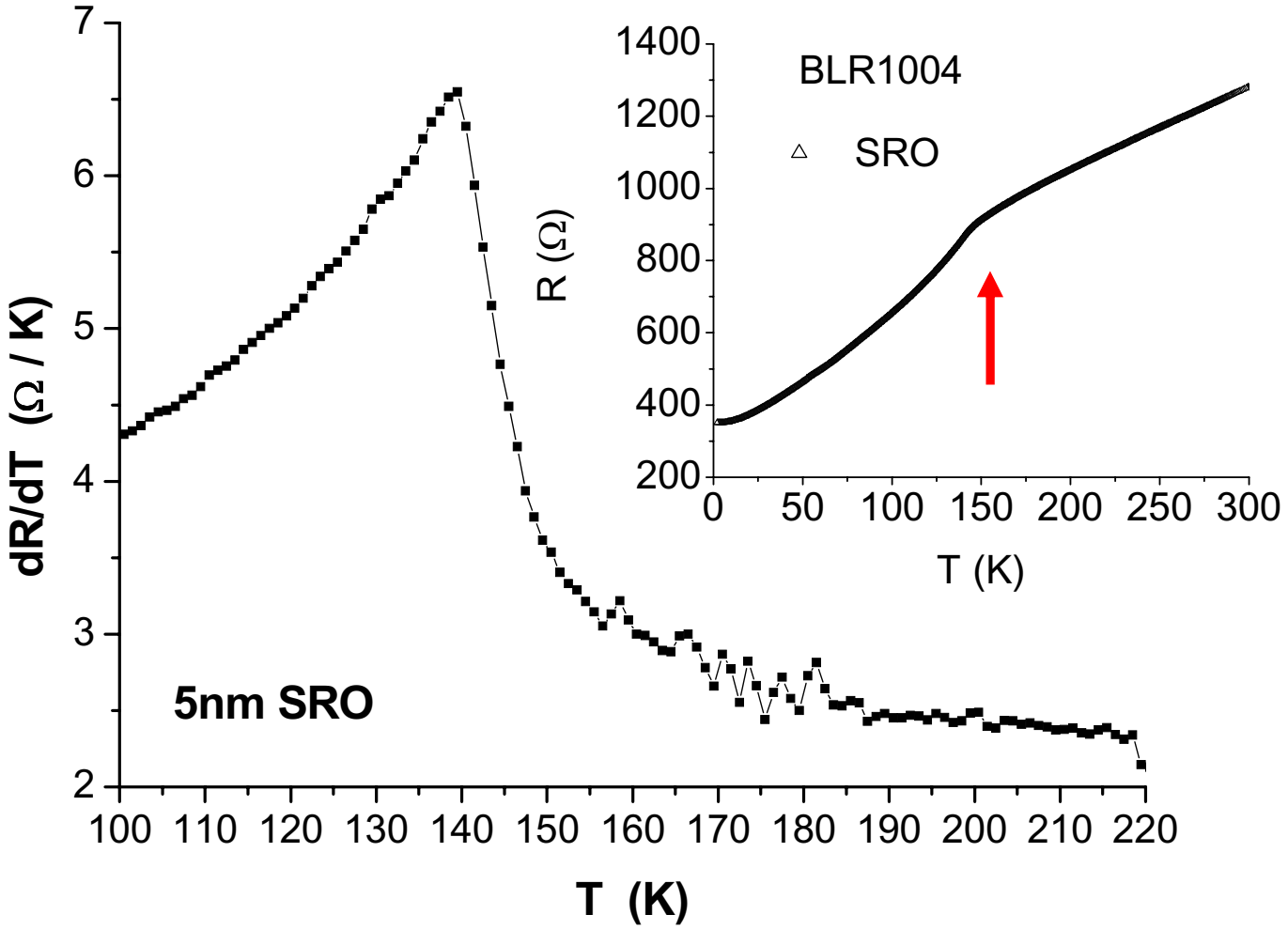


PG/F PE:
Where
F is the probe

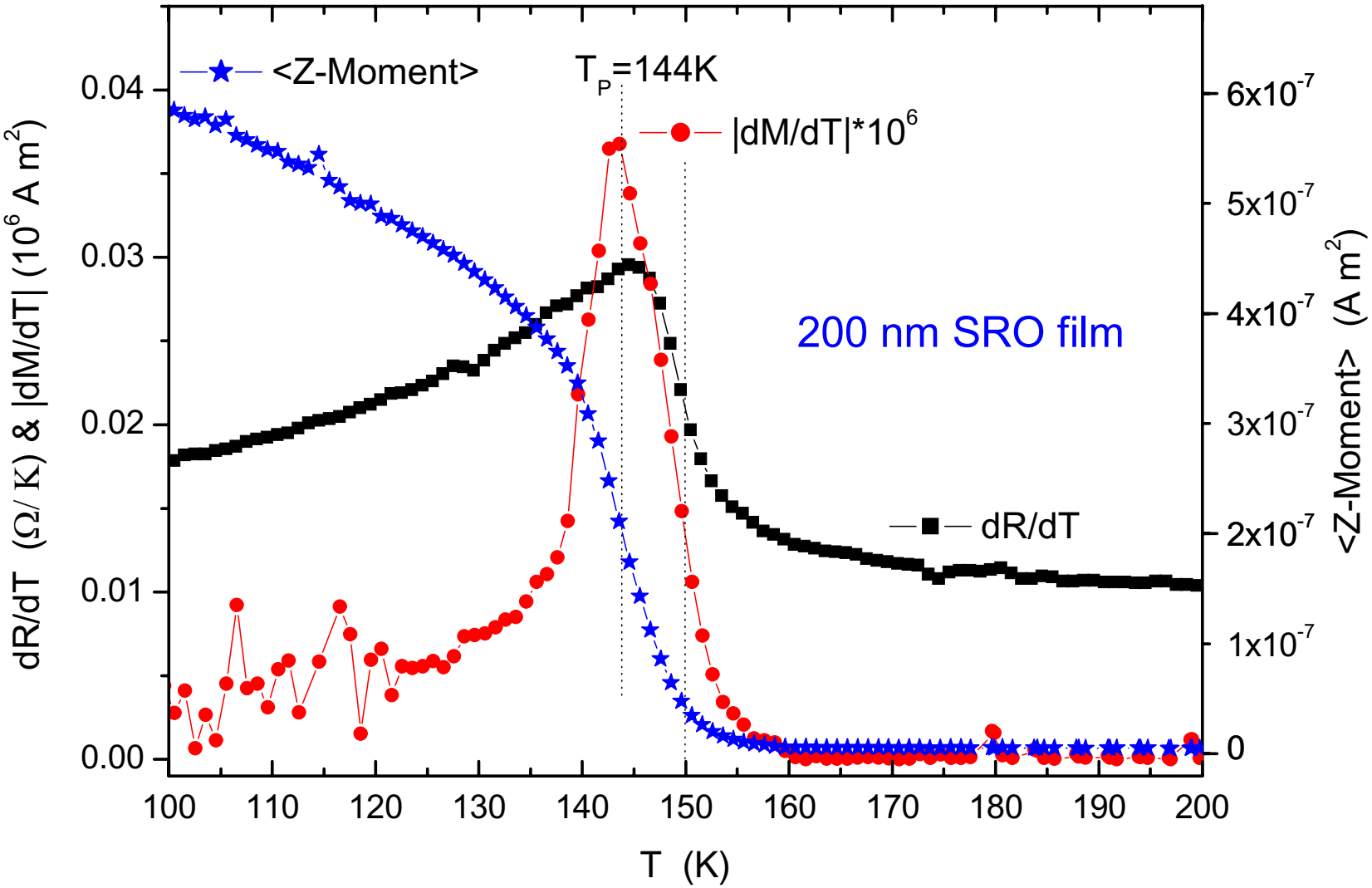
*For Tc<T<T**



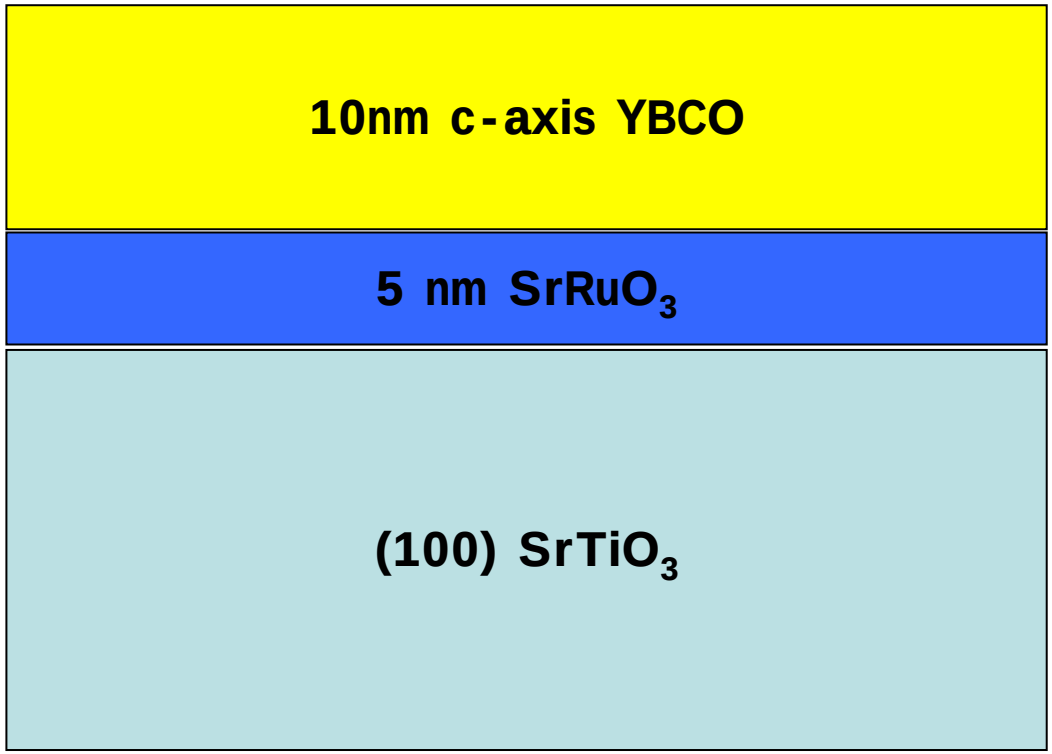
As the ferromagnetic layer (F) we chose $SrRuO_3$ (the "probe")



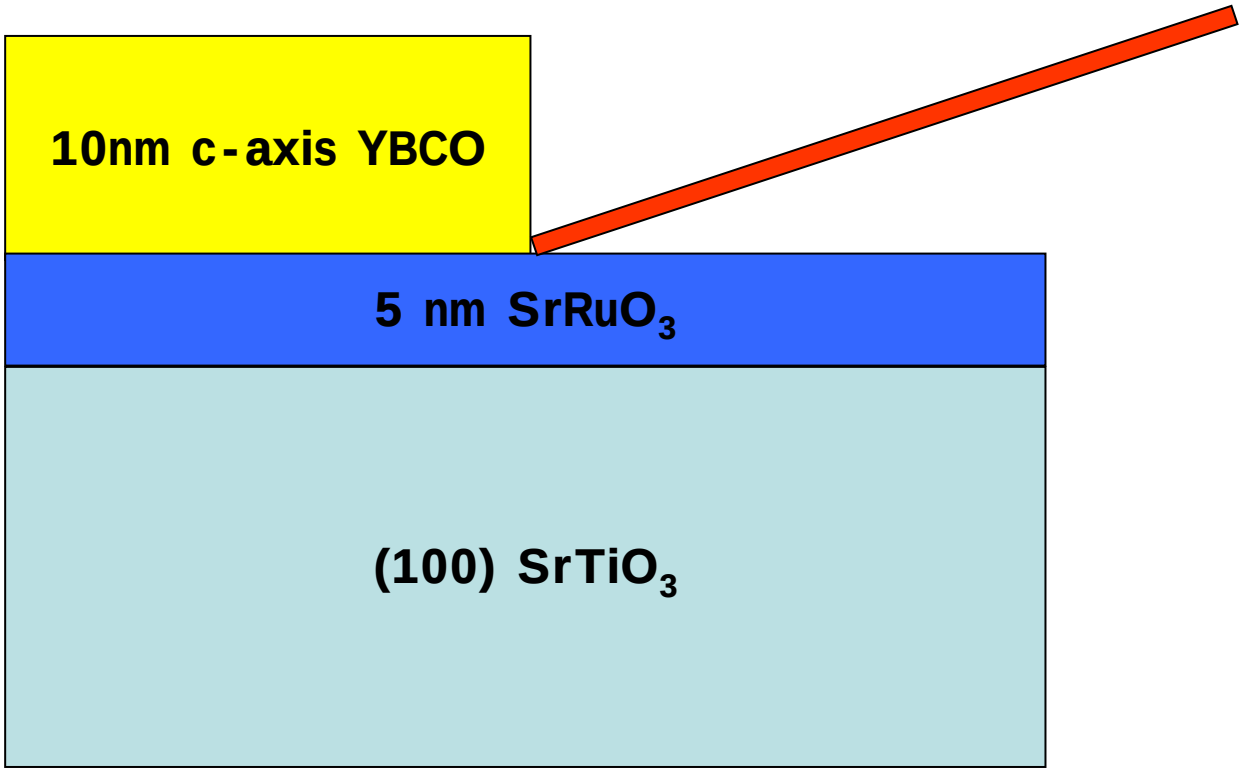
Show the dR/dT relation to dM/dT & sensitivity issues



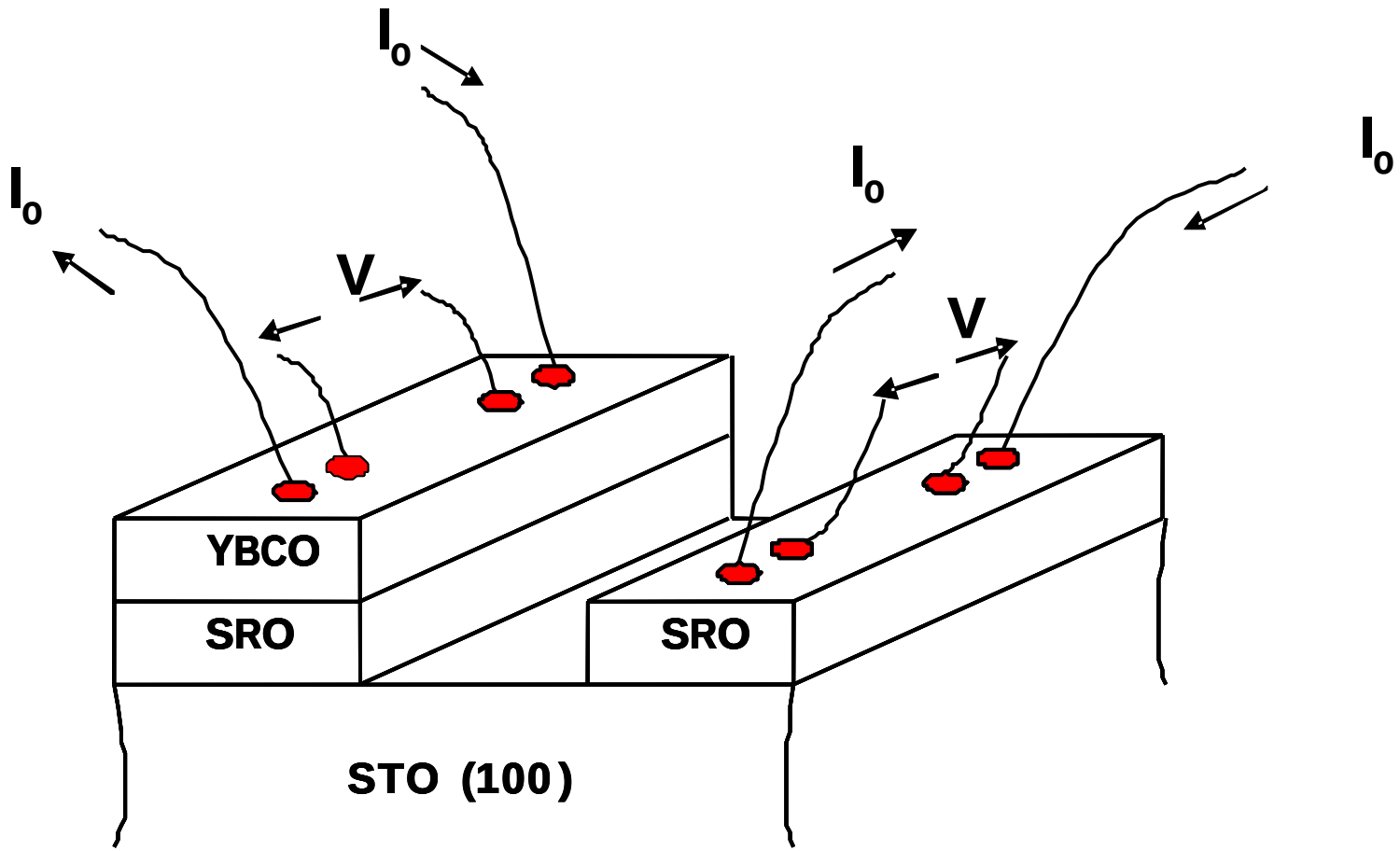
Preparation of the bilayers and reference films



Preparation of a bilayer and its reference film on the same wafer by the use of a shadow mask



Simple patterning & contacts config.



Where did we work on the P.D. and why?

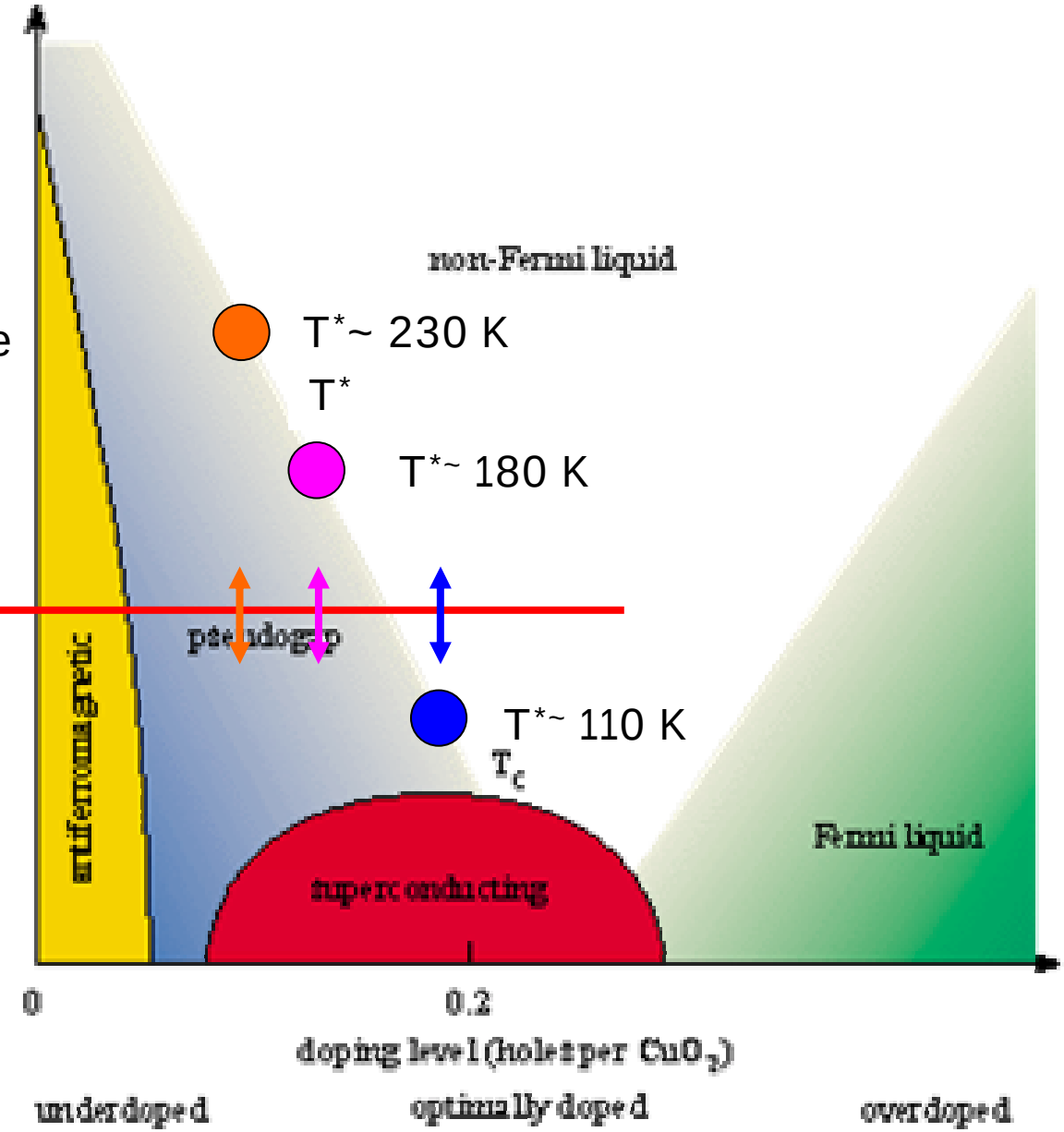
For $YBa_2Cu_3O_y$:

For the T_C= 30 K phase

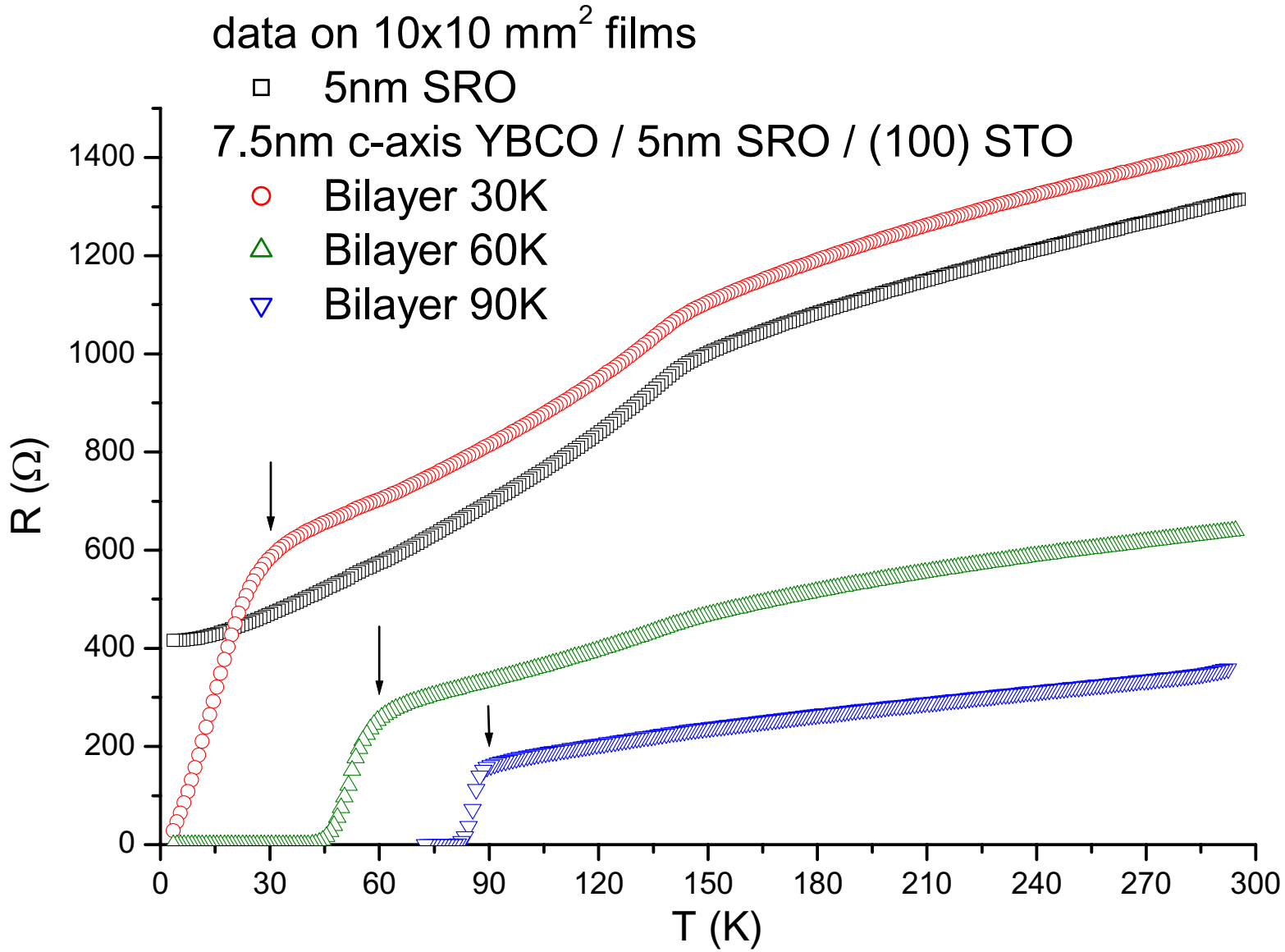
For the T_C =60 K phase

T_{Curie} of $SrRuO_3$ is 150 K

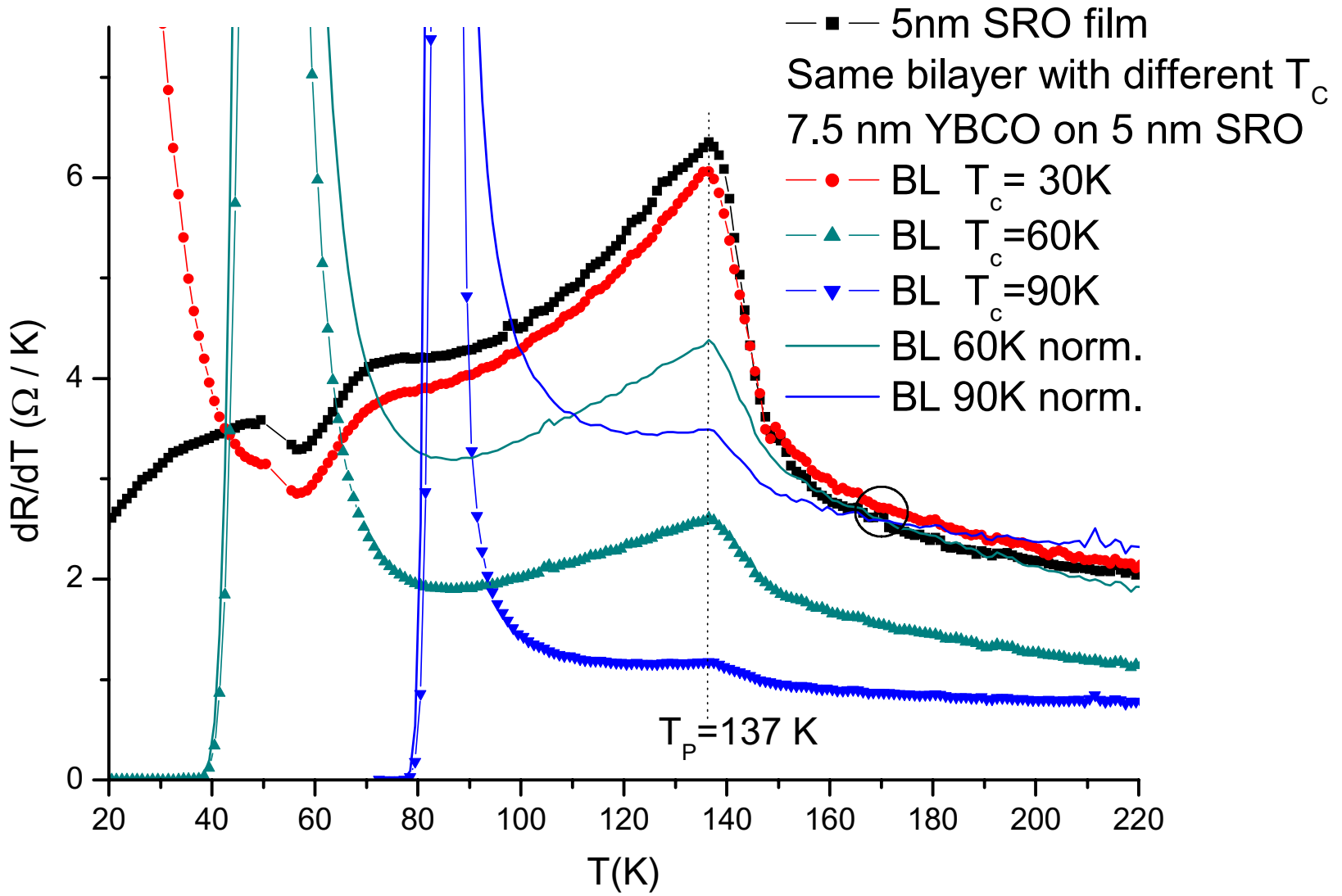
For the T_C=90 K phase



Results at different doping levels



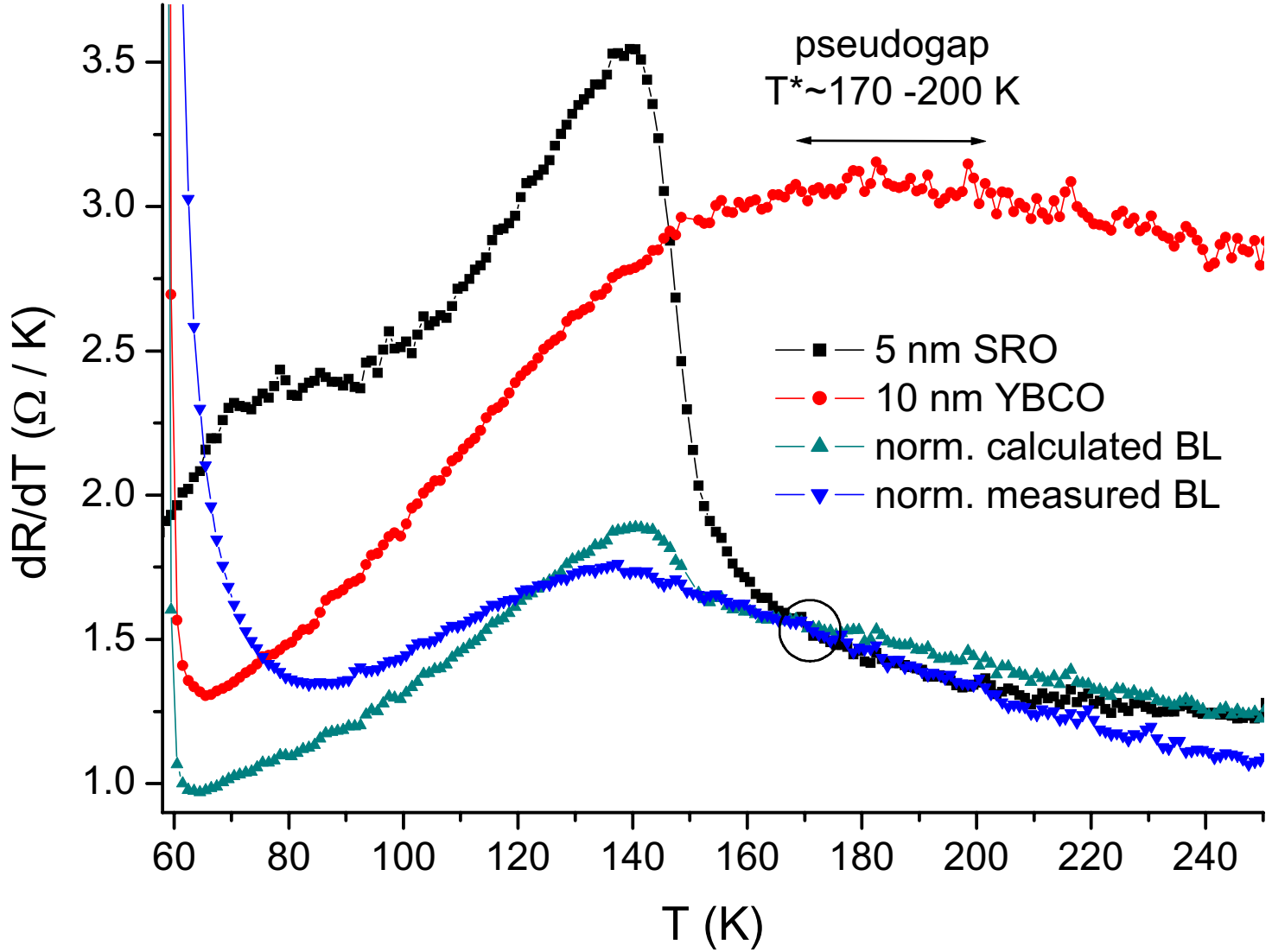
Temperature derivatives of the Resistance



- A 7.5 nm thick YBCO layer is too thin to shift the T_p of SRO

10nm YBCO on 5nm SRO

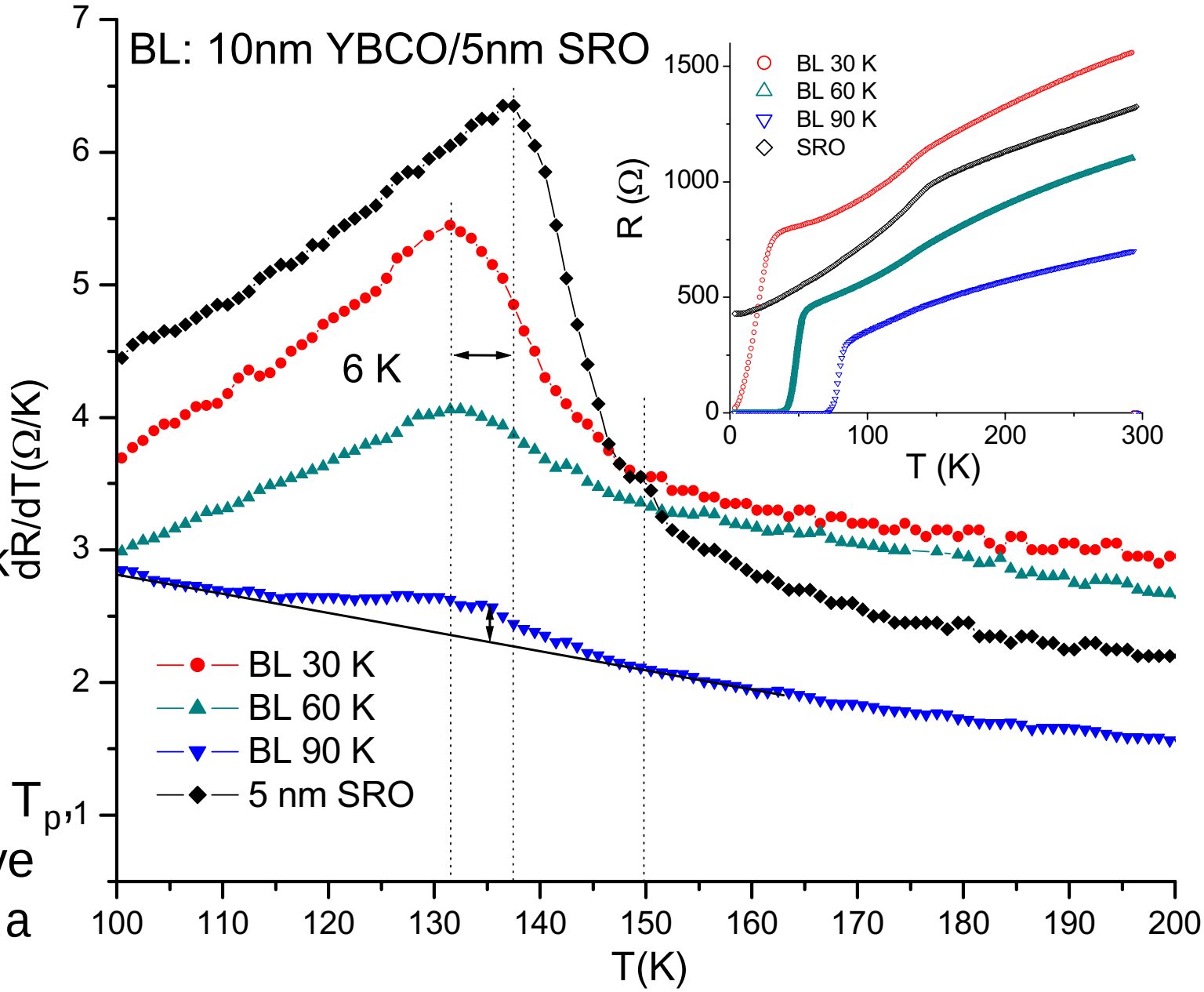
Test the contributions of the separate layers
And the interaction between them



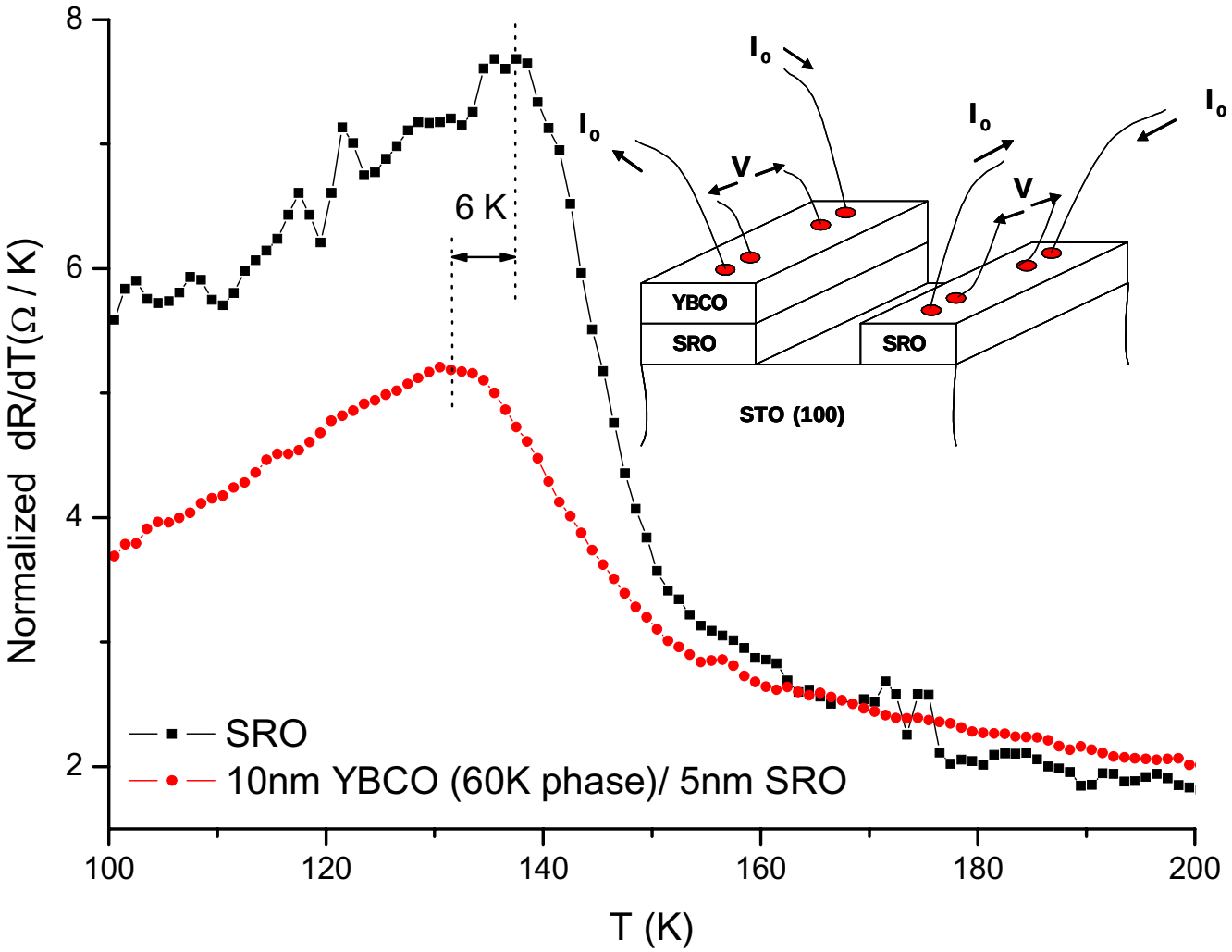
Bilayers with the 30, 60 and 90 K YBCO

A large T_p shift when the YBCO is at 30 & 60 K

The 90 K phase Peak is too broad and small to determine $T_{p,1}$ But we have better data



A BL & a reference layer on the same wafer



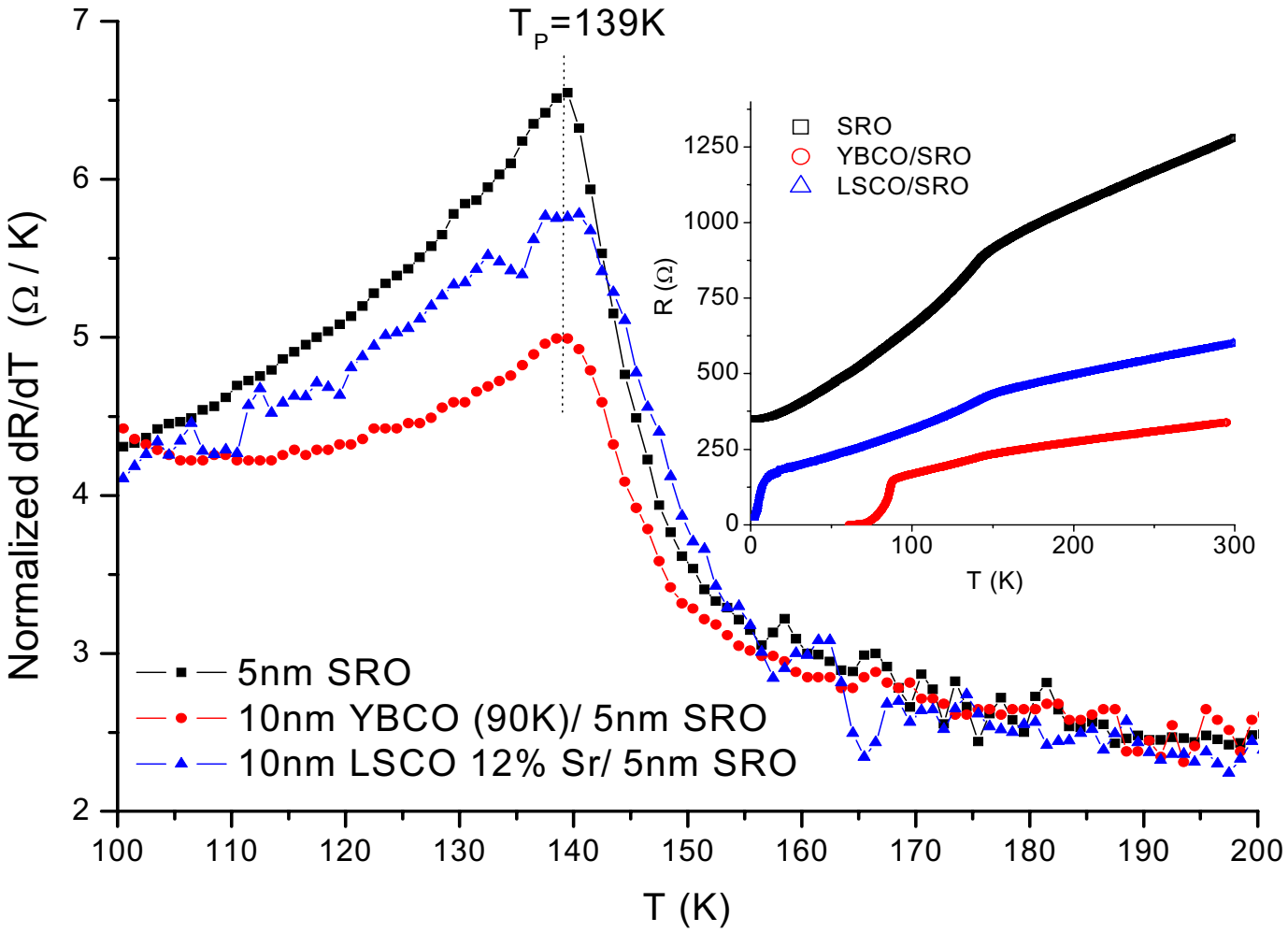
- Are the conjectured preformed pairs injected into the SRO layer lowering its T_p ??

Control experiments in BL with cuprates out of the pseudogap regime (T*<120 K)

- No shift of T_p for both YBCO & LSCO in this case

↓

No effect by the injection of normal electrons from the SC above T* into the SRO

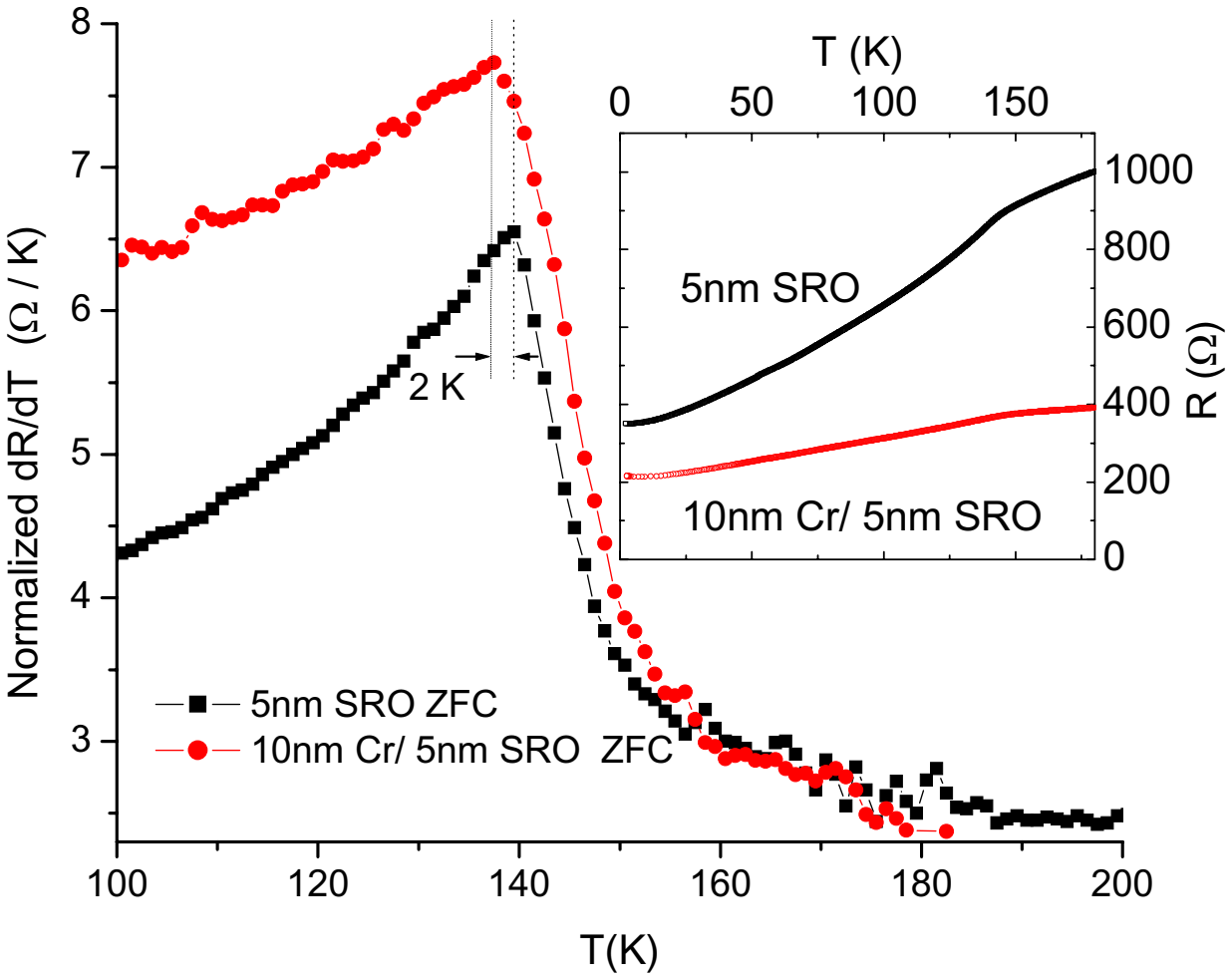


A control experiment in a bilayer with an antiferromagnet (Cr)

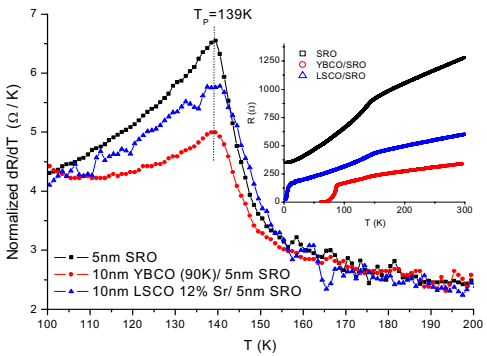
10 nm Cr / 5 nm SRO

1. Injection of electrons with opposite spins into the SRO leads to only a 2 K shift down of T_p

2. An inverse PE can lead to loss of itinerant electrons in the SRO, thus lowering its T_p

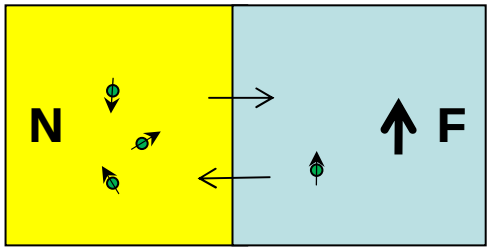


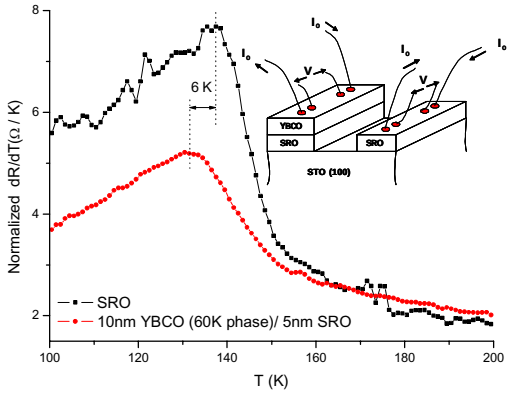
Comparison of the main results



$\Delta T_p \sim 0$

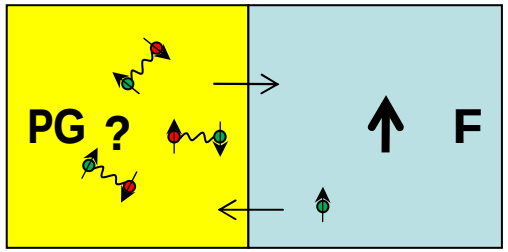
T*<120K

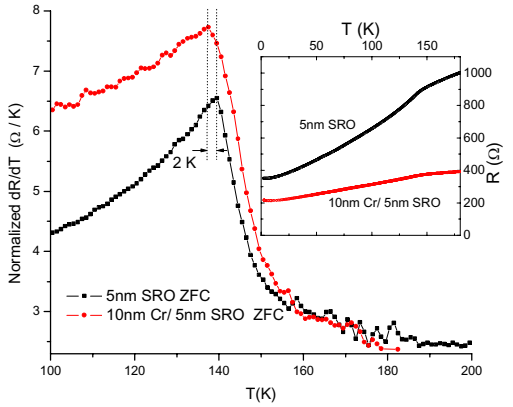




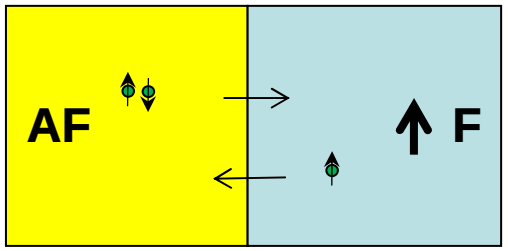
$\Delta T_p \sim 6$ K

T*>170





$\Delta T_p \sim 2$ K



- Large T_p shifts – only when the YBCO is in the PG regime!
- A small T_p shift – by injection of electrons with opposite spins
- Thus only the injection of correlated electrons with zero spin yields a large effect – these might be the preformed pairs

Conclusions

- Large Tp shifts –
  necessitates correlated electrons injection

- This is consistent with the preformed pairs scenario,
  but is not a definitive proof of their existence

- But…

- If it looks like a duck, sounds like a duck and walks like a duck, it is a duck!!