The Absolute Value & Temperature Dependence of λ in $Ba(Co_{0.074}Fe_{0.928})_2As_2$

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TRIUMF
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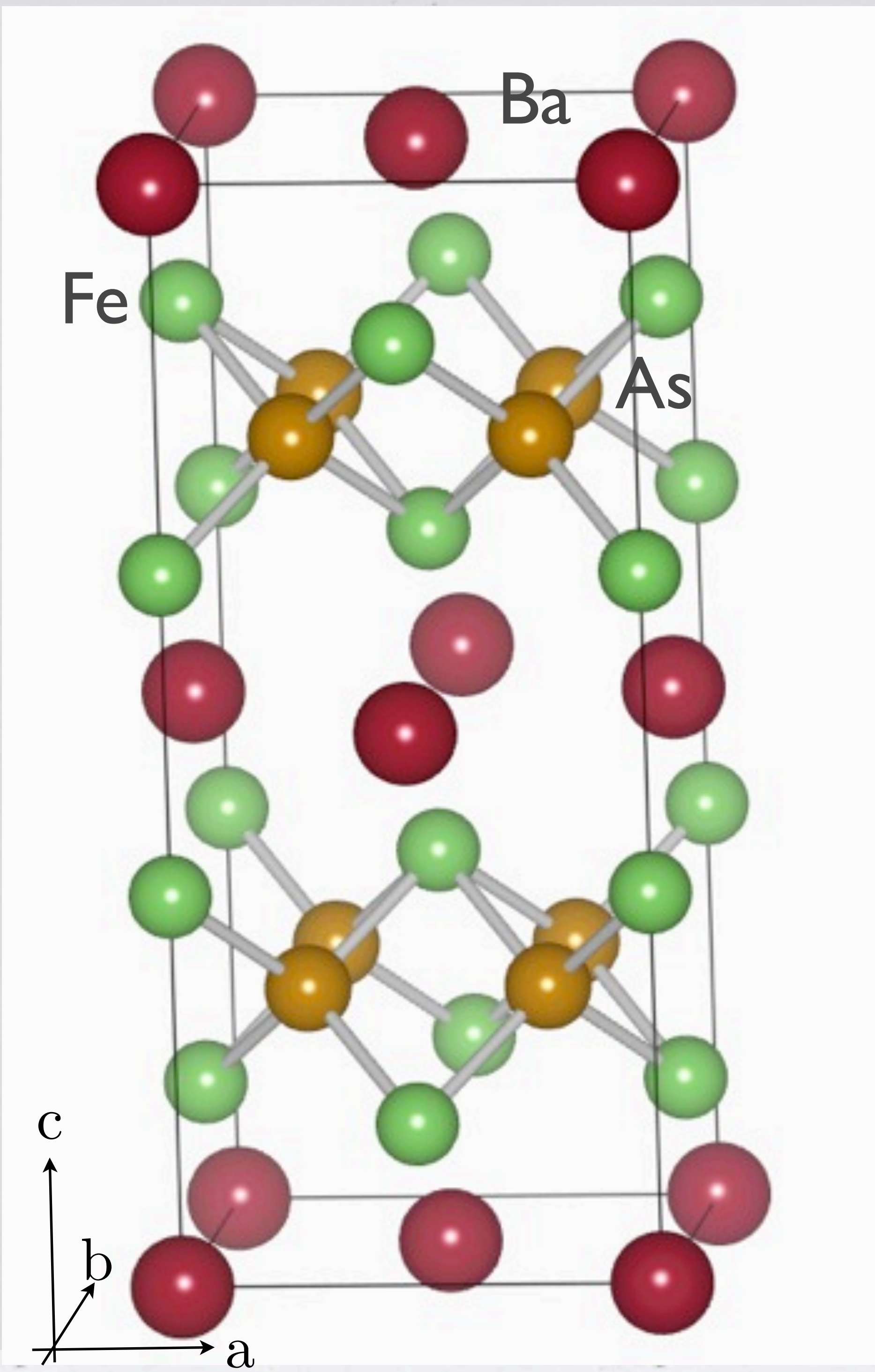
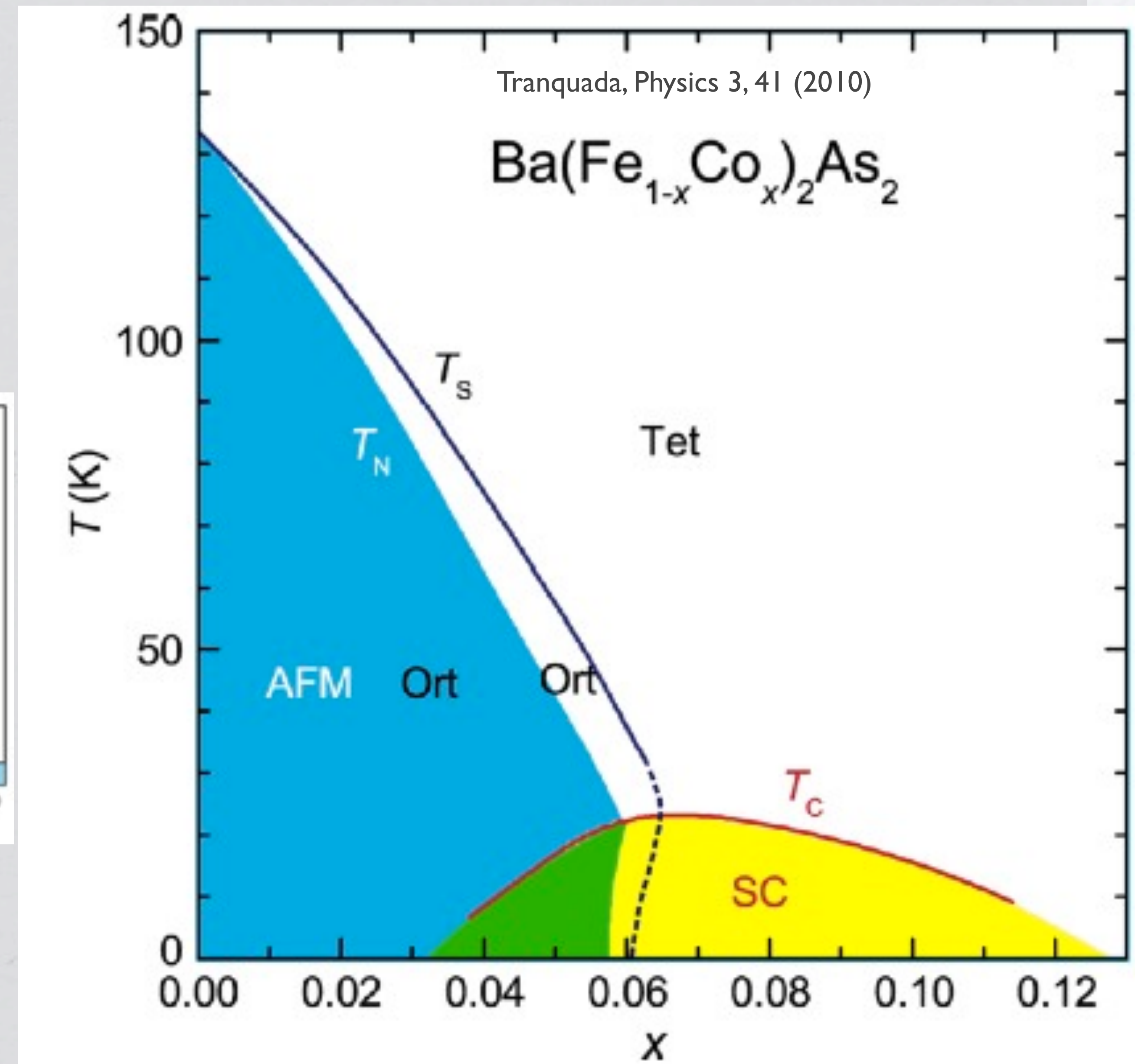
$BaFe_2As_2$

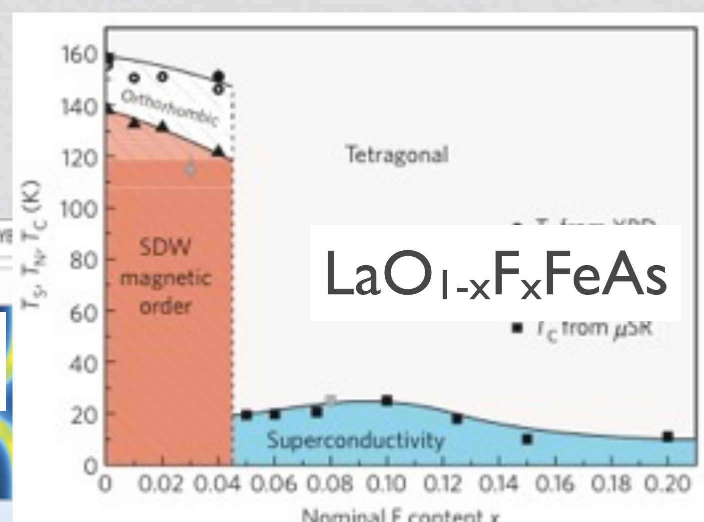
- The 122 family.
- Hole-doped [$(K_xBa_{1-x})Fe_2As_2$].
- Electron-doped [$Ba(Co_xFe_{1-x})_2As_2$].



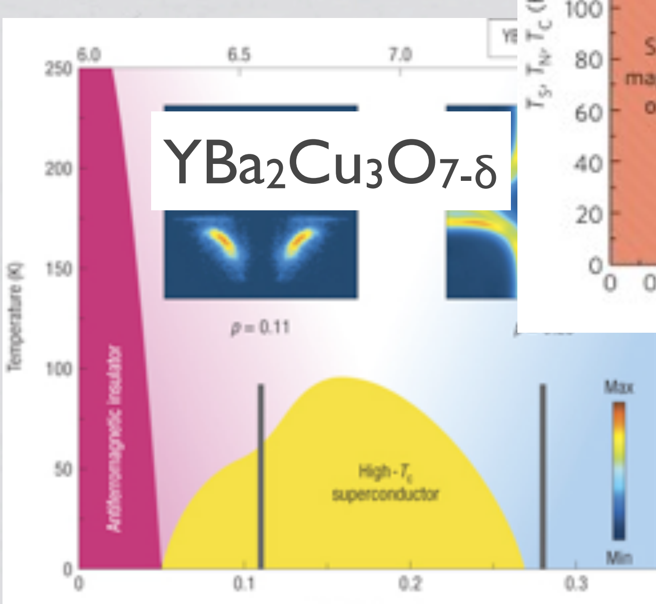
$Ba(Co_xFe_{1-x})_2As_2$

- Electron Doped 122.
- Similar to cuprates.





Luetkens, Nat Mater 8, 305 (2009)



Hossain, Nat Phys 4, 527 (2008)

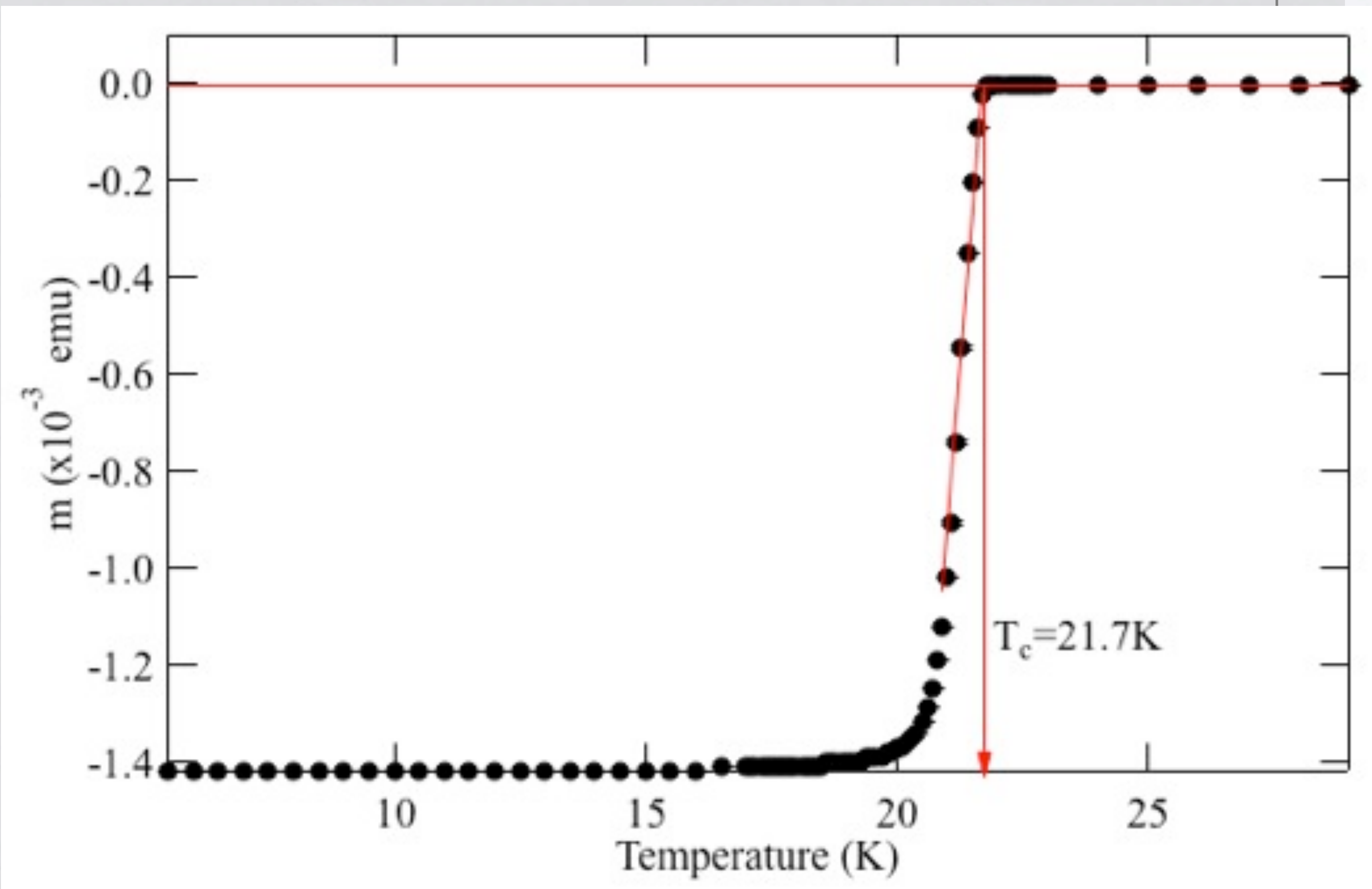
$Ba(Co_{0.074}Fe_{0.926})_2As_2$

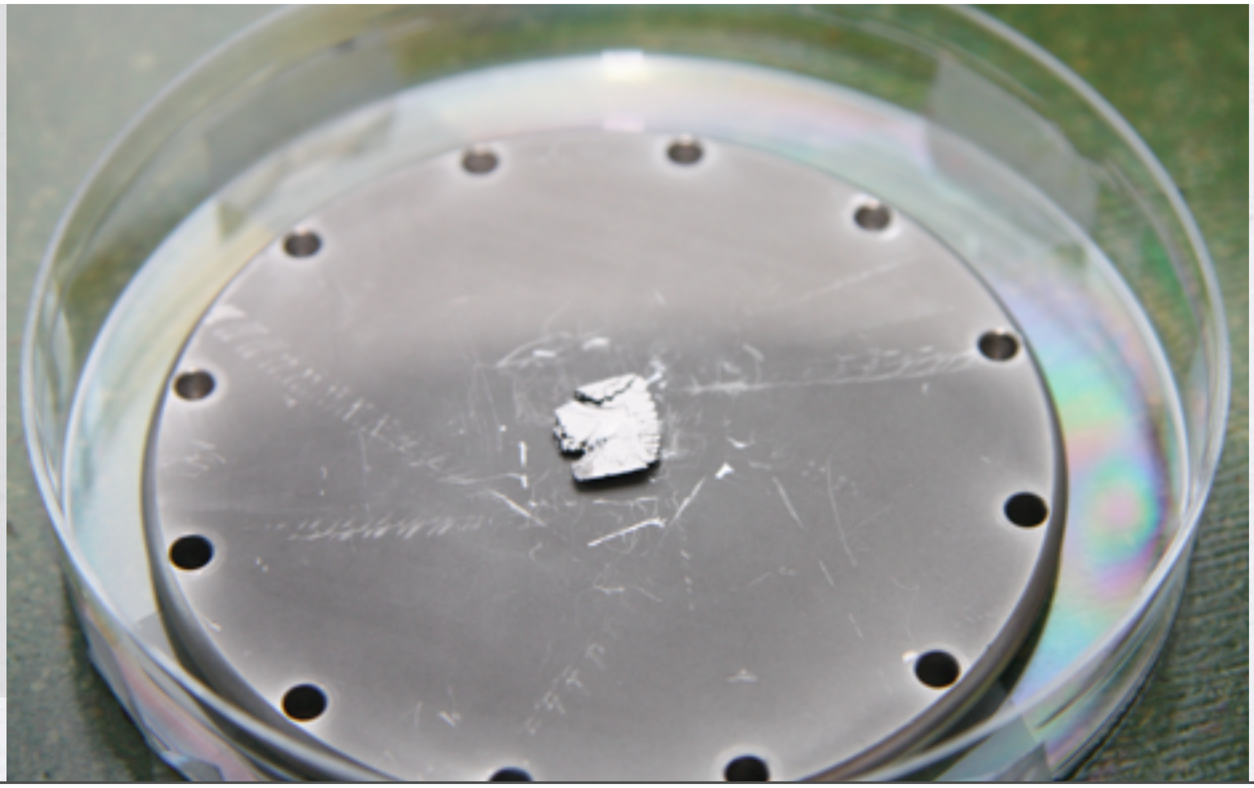
* $H_{c1} \approx 100G$[1] at 2K, $H_{c2} \approx 30T$ at 15K.

	λ_0	T_c
MFM/SSS[2]	250±25nm	22.4K
TDR[3,4]	270±100nm, 208nm	22.8K, 22K
TF-μSR[5]	216±0.7nm (B=0)	22.1K

1Sefat et al., PRL 101, 117004 (2008).
2Luan et al., PRL 106, 067001 (2011).
3Gordon et al., PRB 82, 054507 (2010).
4Gordon et al., PRL 102, 127004 (2009).
5Williams et al., PRB 82, 054507 (2010).

$Ba(Co_{0.074}Fe_{0.926})_2As_2$

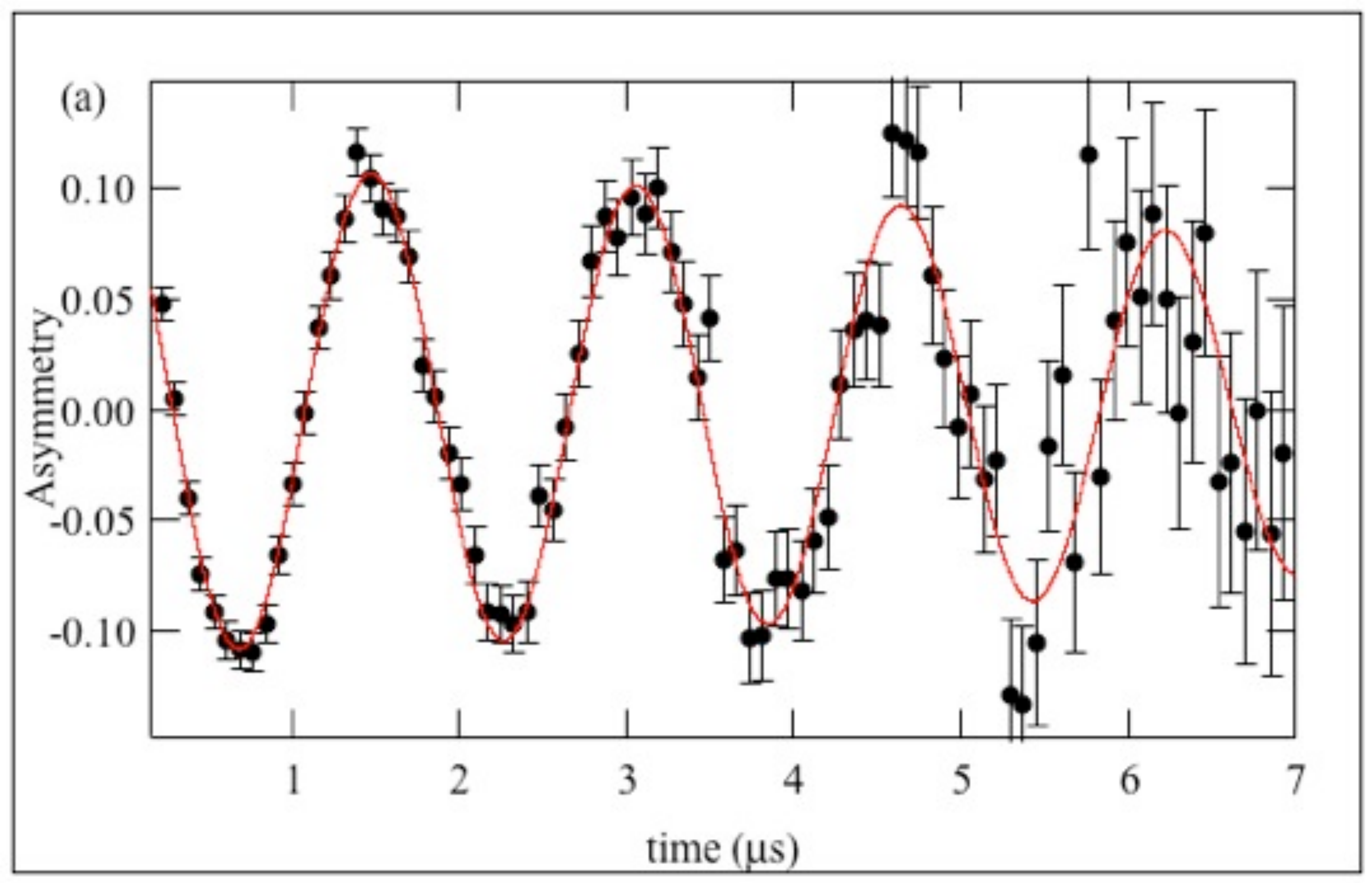


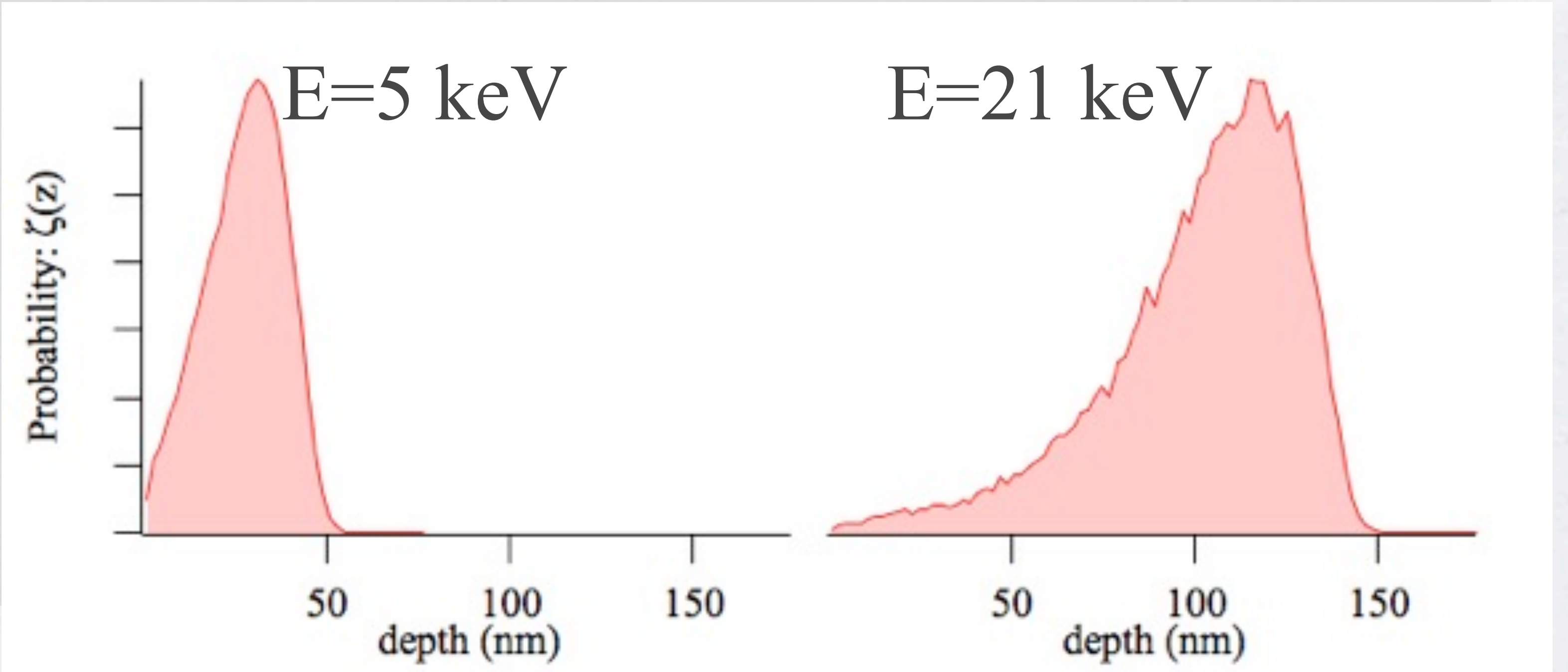


- x=0.074 - Optimally doped.
- T_c=21.7 K .
- what is λ_0, $\lambda(T)$? the symmetry?

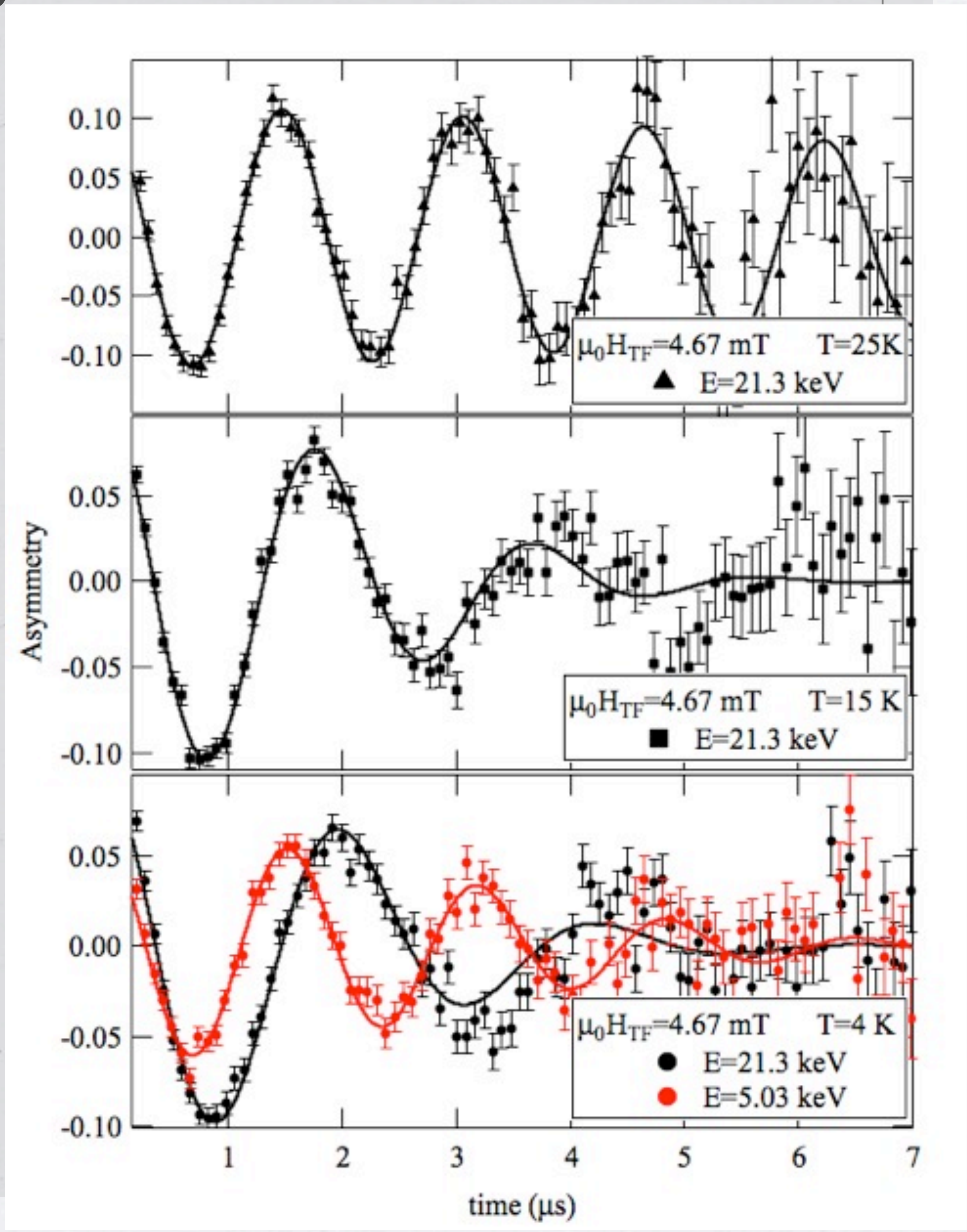
LE-μSR

- the normal state, $T=25$ K, H$=46.7$ G
- Measurements with different implantation energy ⟶ depth dependence of B.
- λ_0: T=lowest… ,Vary μ^+ energy
- λ(T): E=Const. , Vary T





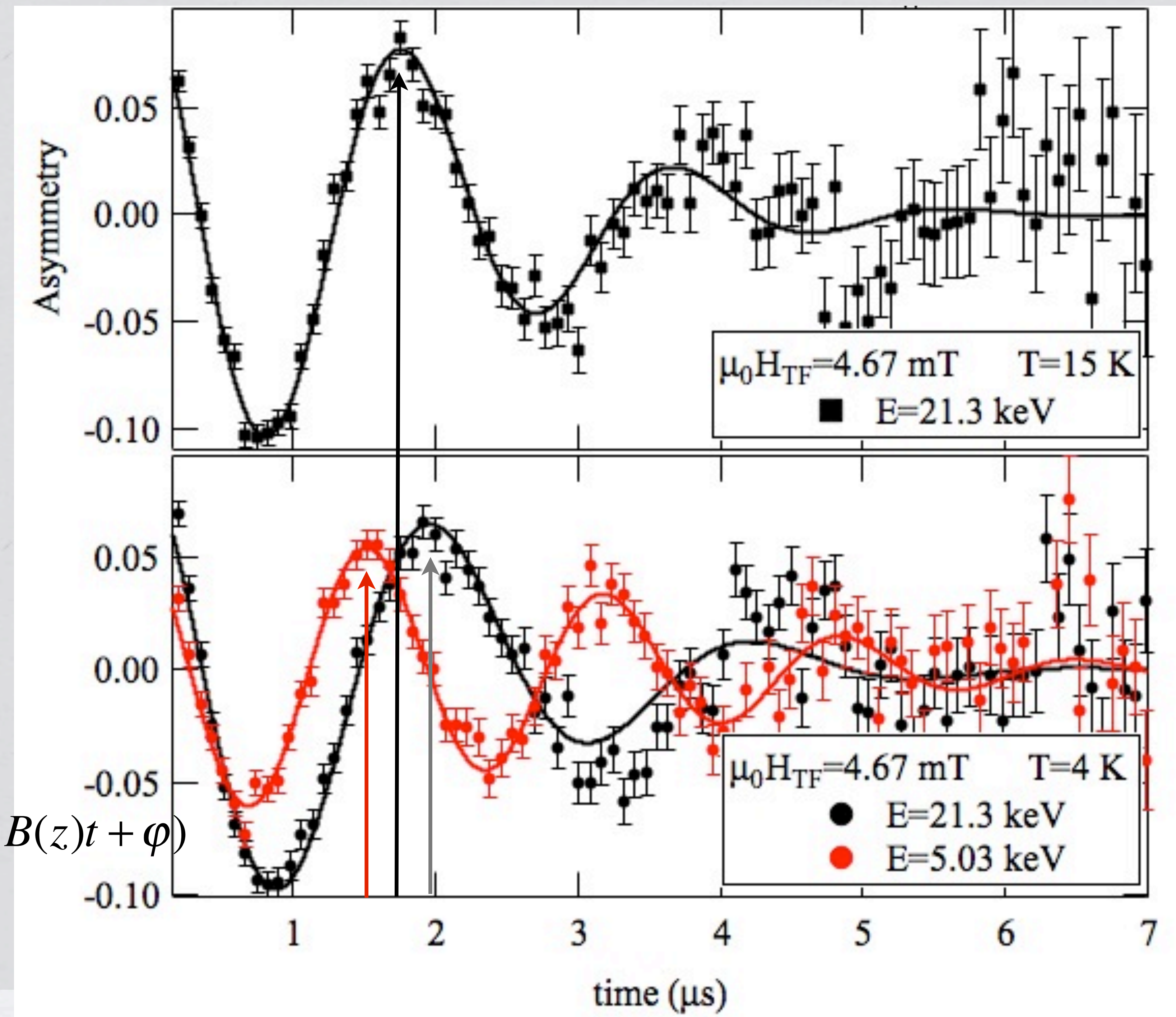
LE-μSR



$$B(z) = \begin{cases} B_0 \exp\left(-\dfrac{z-d}{\lambda}\right) & z \le d \\ B_0 & z > d \end{cases}$$

$$P(t) = P_0 \exp\left(-\frac{(\sigma t)^2}{2}\right) \int dz\ \zeta(z) \cos(\gamma_\mu B(z) t + \varphi)$$

LE-μSR

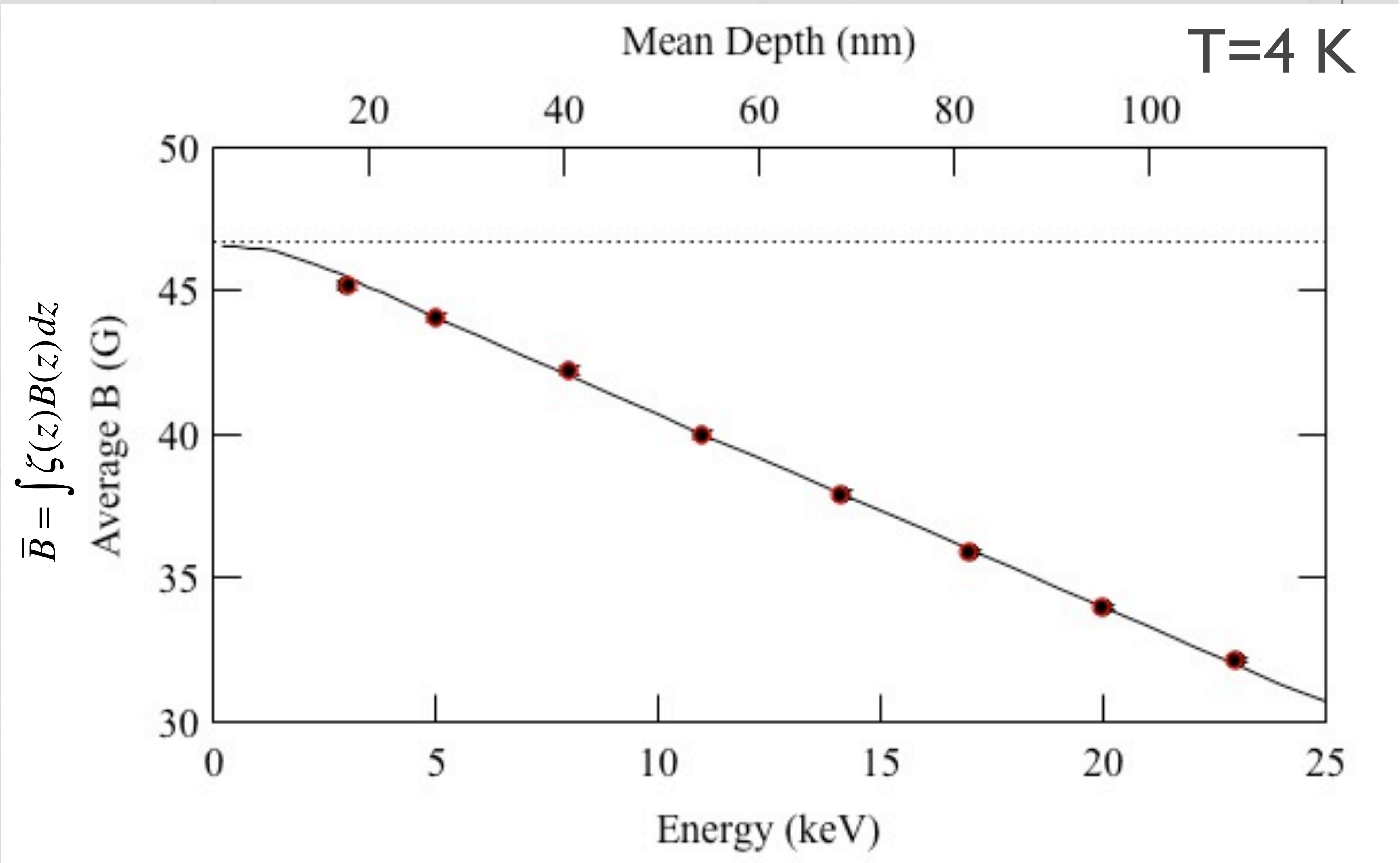


$$B(z)=\begin{cases} B_0 \exp\left(-\frac{z-d}{\lambda}\right) & z \le d \\ B_0 & z > d \end{cases}$$

$$P(t)=P_0 \exp\left(-\frac{(\sigma t)^2}{2}\right)\int dz\ \zeta(z)\cos(\gamma_\mu B(z)t+\varphi)$$

LE-μSR

- λ_0=252.7±2.7nm
- d=14.5(9)nm.



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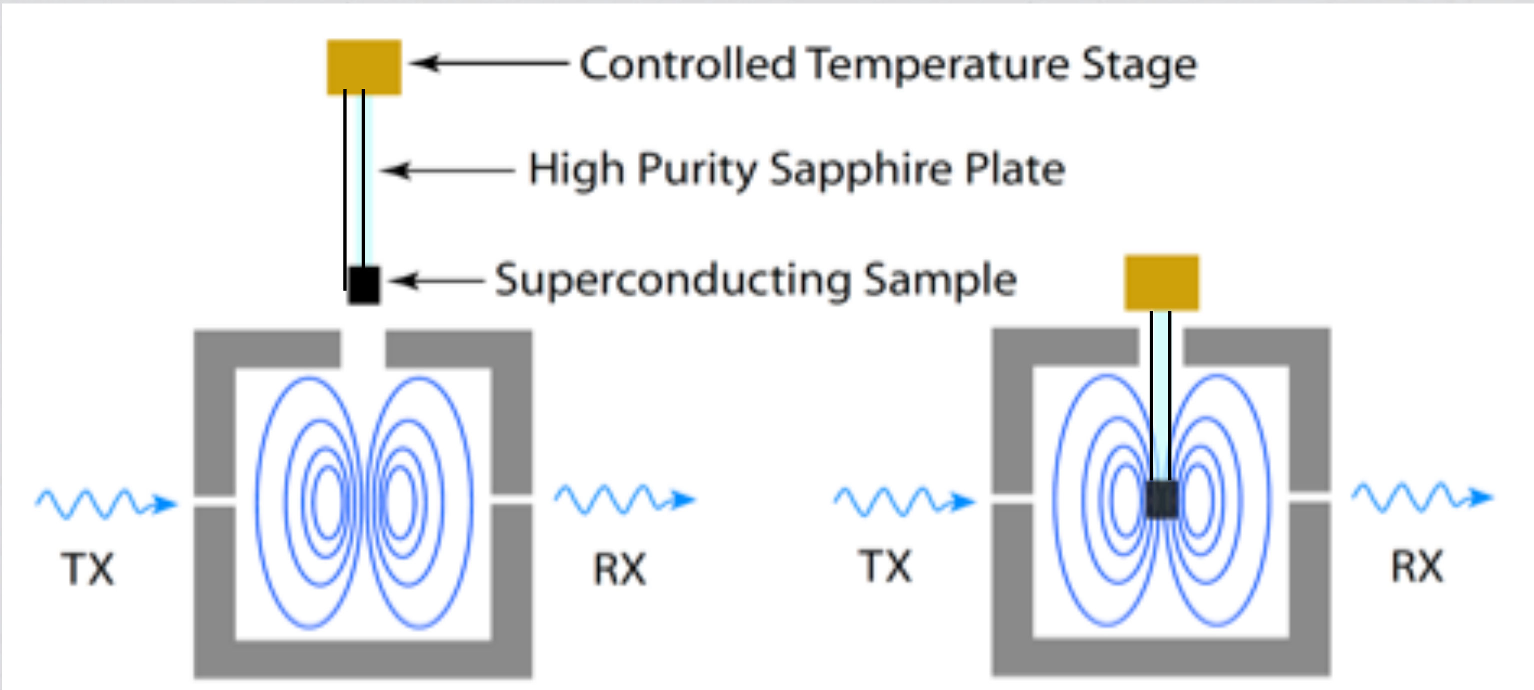
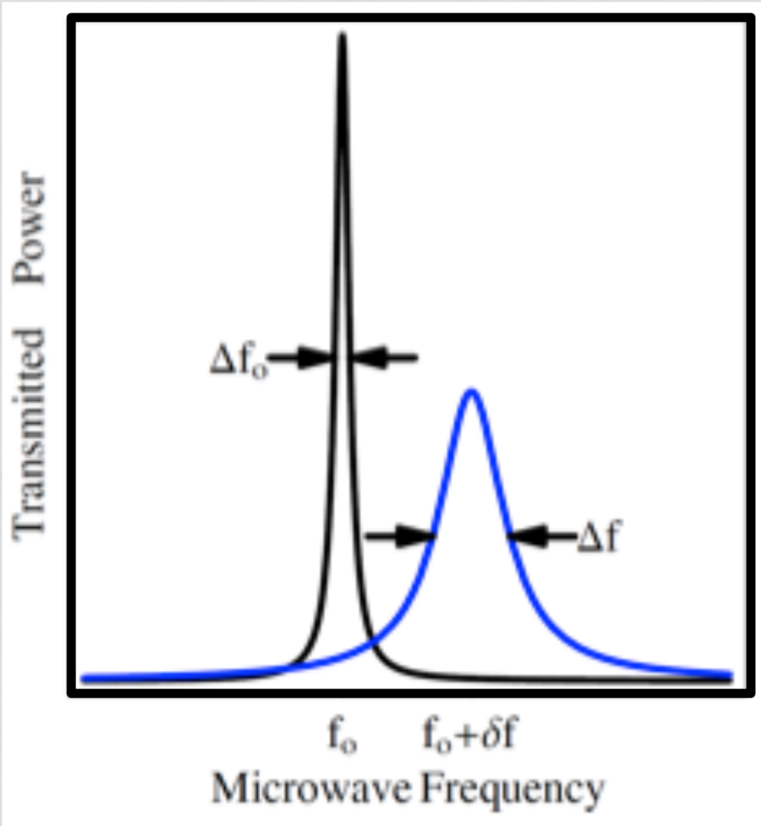
μW



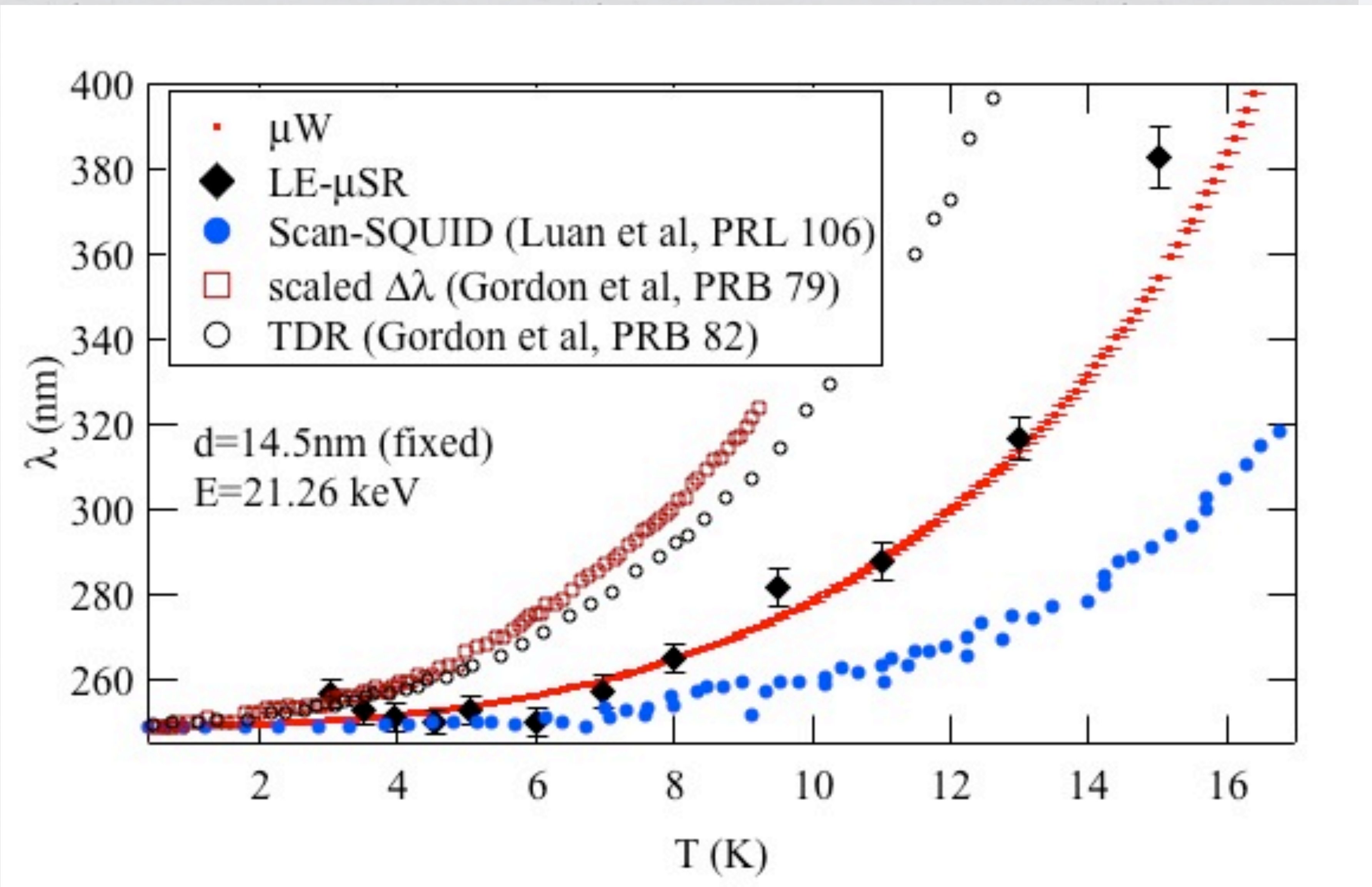


- Cavity perturbation : a precise determination of Δλ.

Monday, May 23, 2011

µW

* Microwaves: A precise determination of Δλ.



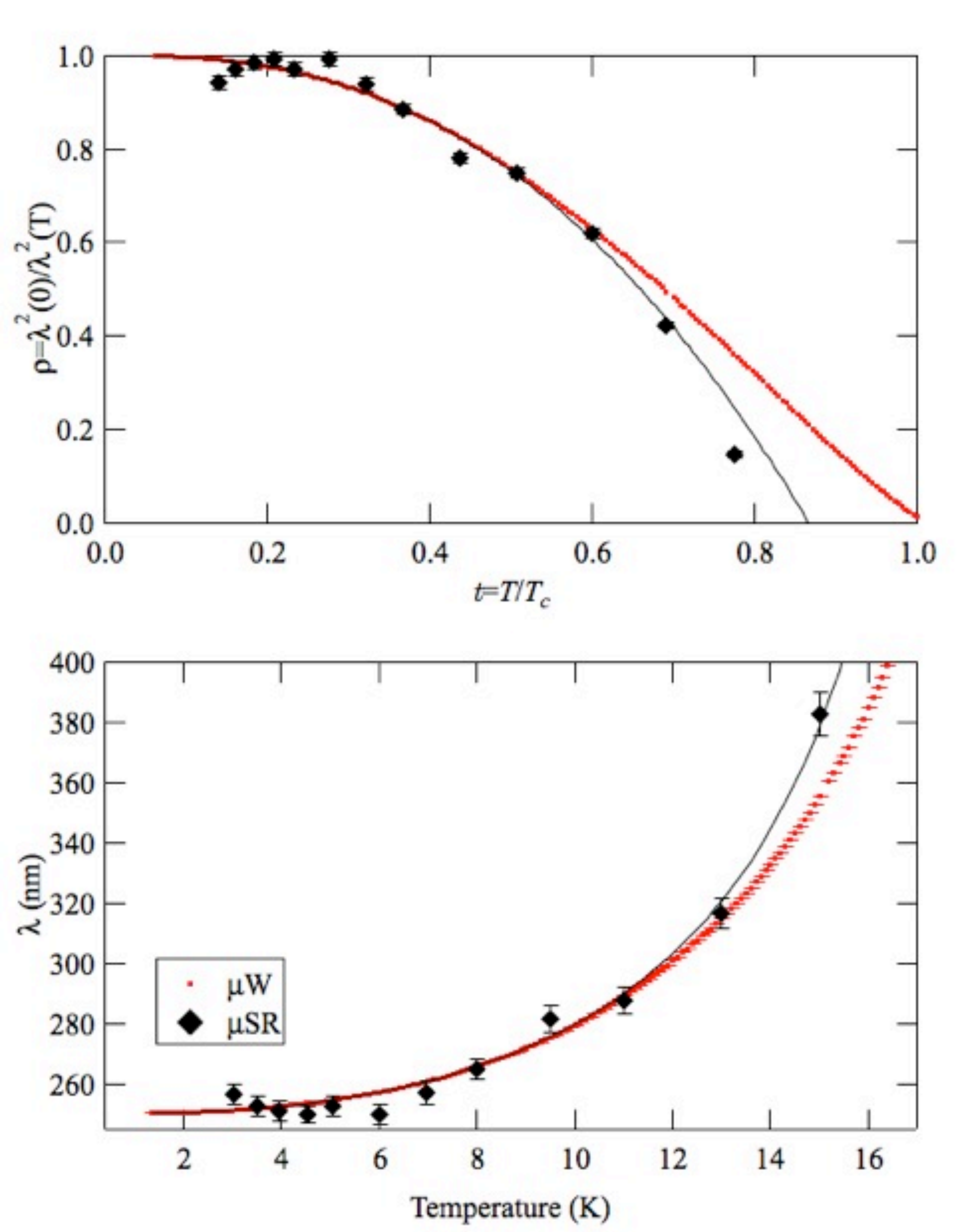
superfluid density

- power law model.
- T cut-off dependent.

$$\rho = \frac{\lambda^2(0)}{\lambda^2(T)} \approx 1 - \left(\frac{T}{T^*}\right)^n$$

$$n = 2.537(8)$$

$$T^* = 18.81(8)\text{K}$$



superfluid density

* 2-gap model.
* Fits the whole T range.

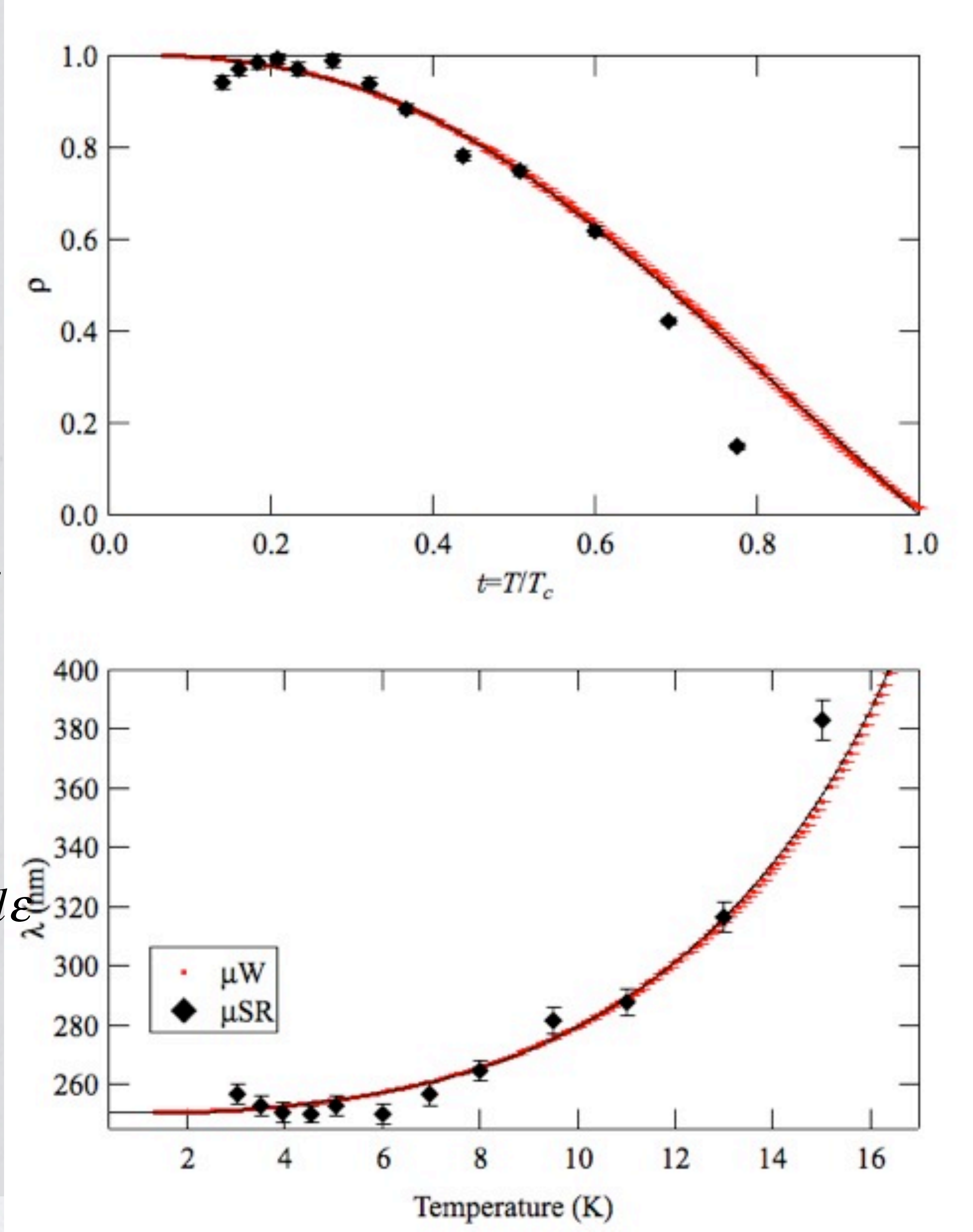
$$\rho = 1 - x\frac{\delta n_s(\Delta_s(T),T)}{n_s(0)} - (1-x)\frac{\delta n_L(\Delta_L(T),T)}{n_s(0)}$$

$$\Delta_{s,L}(T) = \Delta_{s,L}(0)\tanh\left[\frac{\pi k_B T_c}{\Delta_{s,L}(0)}\sqrt{a\left(\frac{T_c}{T}-1\right)}\right]$$

$$\frac{\delta n_s}{n_s(0)} = \frac{2}{k_B T}\int_0^\infty f(\varepsilon,\Delta(T),T)[1-f(\varepsilon,\Delta(T),T)]\,d\varepsilon$$

$$2\Delta_{0,L} = 3.46(10)k_B T_c$$

$$2\Delta_{0,S} = 1.20(7)k_B T_c$$



Summary

- λ_0=252.7±2.7nm was determined using LE-μSR.
- a dead-layer of d=14.5(9)nm.
- λ(T) was measured using microwaves and LE-μSR.
- a two-gap model indicates $$2\Delta_{0,L} = 3.46(10)k_B T_c$$ $$2\Delta_{0,S} = 1.20(7)k_B T_c$$
- a power-law shows $$n = 2.537(8)$$ $$T^* = 18.81(8)\ \mathrm{K}$$