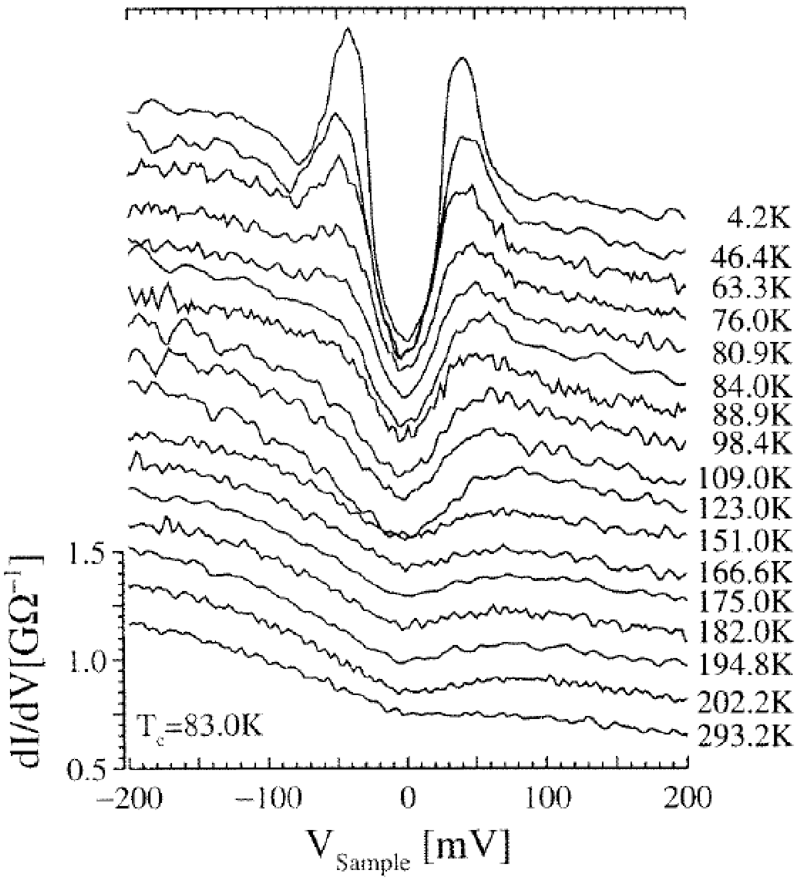
THERMODYNAMICAL APPROACH TO THE NORMAL PHASE

F. Chevy.

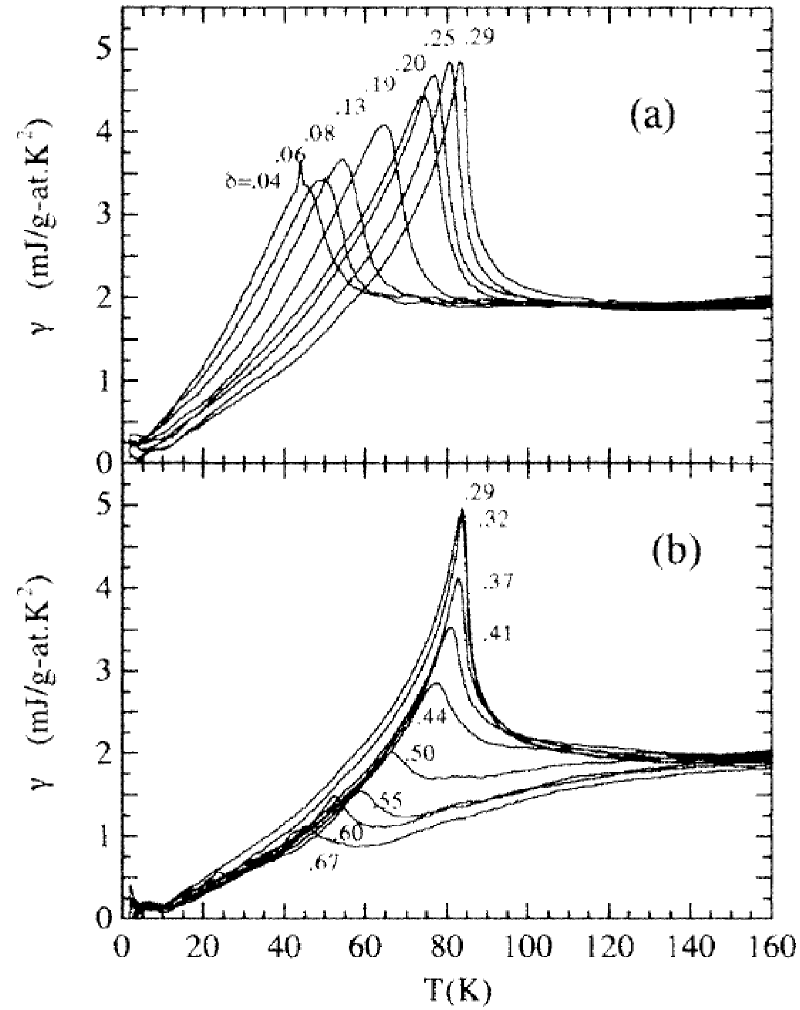
ECOLE NORMALE SUPERIEURE

Laboratoire Kastler Brossel
Physique quantique et applications

THE PSEUDOGAP PHASE IN HTC SUPERCONDUCTORS



SCANNING TUNNELING MICROSCOPE:
dI/dV ~density of states



SPECIFIC HEAT: $C_v = \gamma T$ (Fermi Liquid Theory); discontinuity at T_c

Thermodynamic Properties of the Fermi Liquid

FERMI LIQUID PARADIGM: the low temperature thermodynamics of a normal Fermi gas is dictated by the behaviour of long lived quasi-particles with renormalized parameters (*effective* mass…)

Thermodynamic consequences of the Fermi liquid hypothesis

- Finite compressibility at T=0
- Finite magnetic susceptibility at T=0
- Specific heat ~T

Grand canonical equation of state

Effective mass

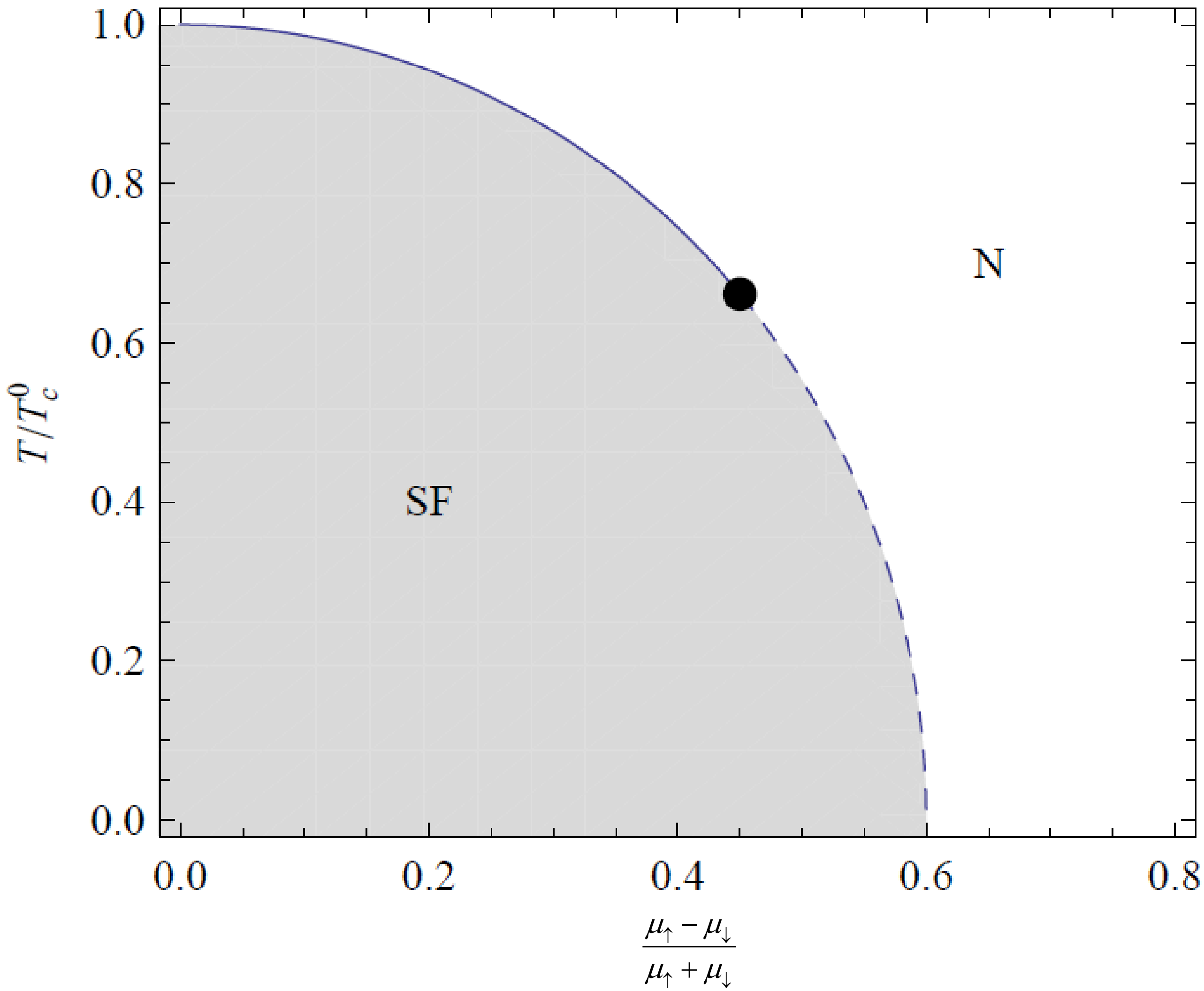
$$\frac{P(\mu,T)}{P_0(\mu,0)} = \xi_n^{-3/2}\left(1 + \frac{5\pi^2}{8}\xi_n \frac{m^*}{m}\left(\frac{k_B T}{\mu}\right)^2 + \frac{15}{8}\chi b^2 + \dots\right)$$

Compressibility

Susceptibility

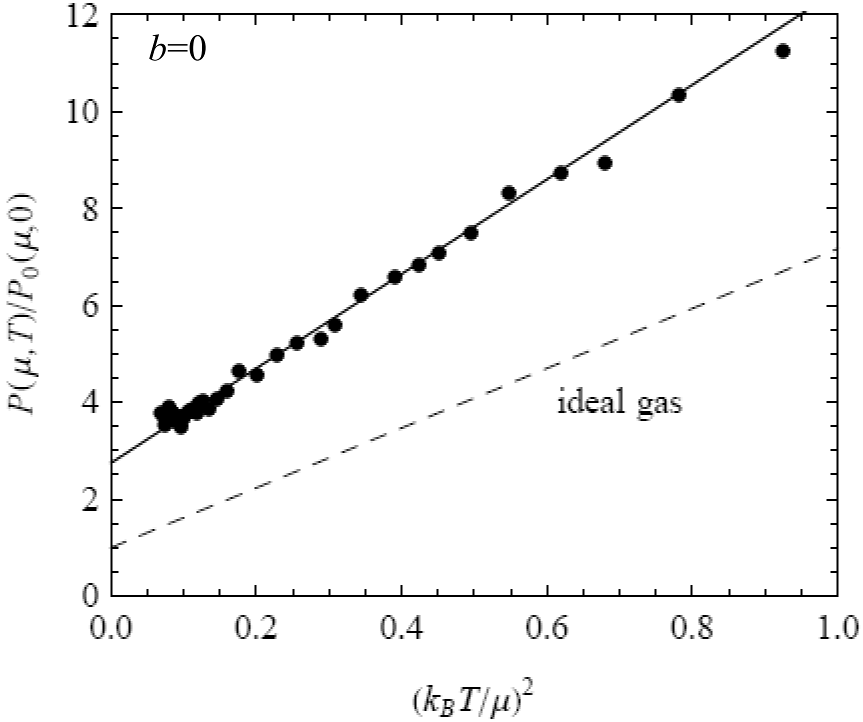
$$\mu = \frac{\mu_\uparrow + \mu_\downarrow}{2} \qquad b = \frac{\mu_\uparrow - \mu_\downarrow}{\mu_\uparrow + \mu_\downarrow}$$ (effective magnetic field)

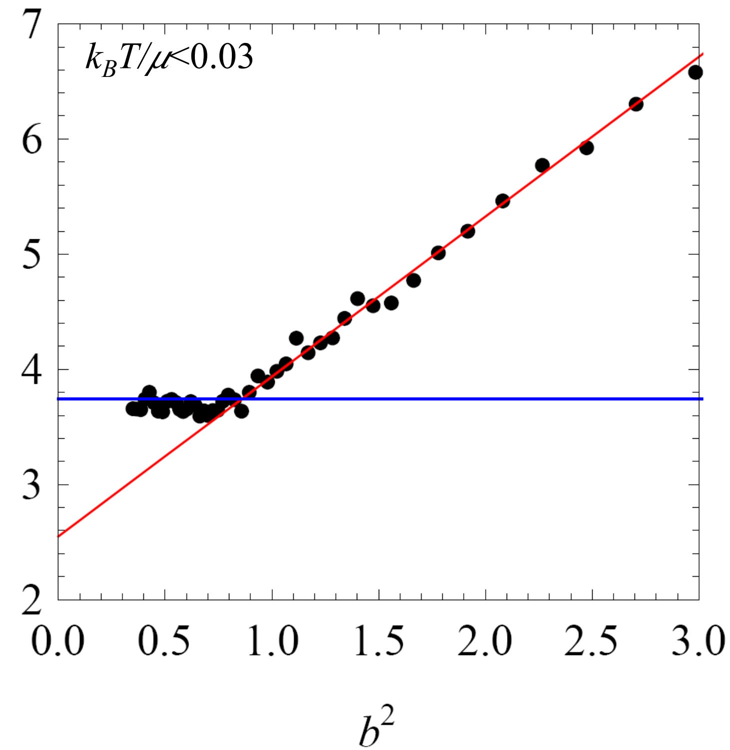
The phase diagram of the unitary Fermi gas



EQUATION OF STATE OF A UNITARY FERMI GAS

(S. Nascimbène *et al. Nature* **463**, 1057 (2010); S. Nascimbène et al. ArXiv:1012.4664, accepted in PRL)



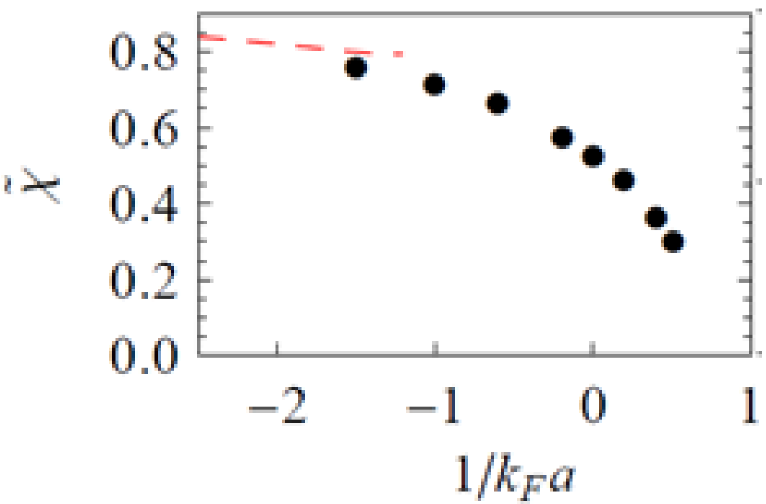


	Exp.	The*.
m^*/m	1.13	???
ξ_n	0.51(2)	0.56
χ	0.27(1)	0.27

* Fixed Node Monte Carlo (S. Girogini, Trento)

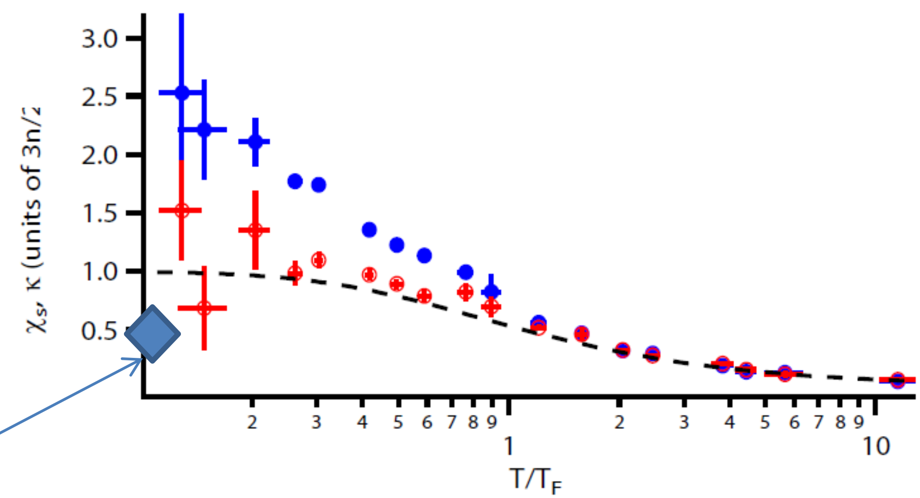
FOCUS ON SPIN SUSCEPTIBILITY FERMI GAS

(S. Nascimbène et al. ArXiv:1012.4664, accepted in PRL)



T=0 FIXED NODE MONTE-CARLO (S. GIORGINI) + EXPERIMENTAL EOS

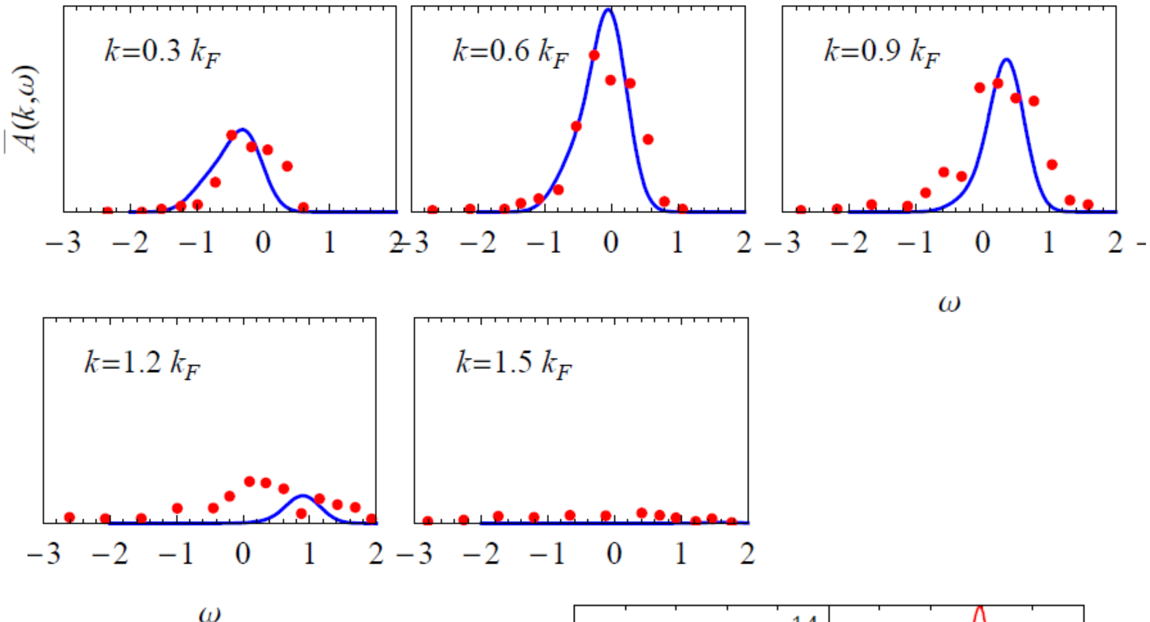
MIT EXPERIMENT (SEE A. SOMMER'S TALK)



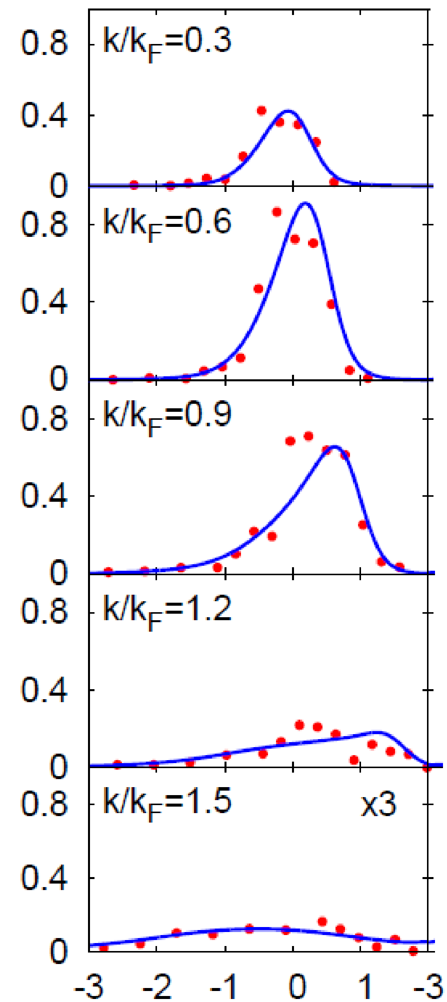
Our value

Spectral Functions

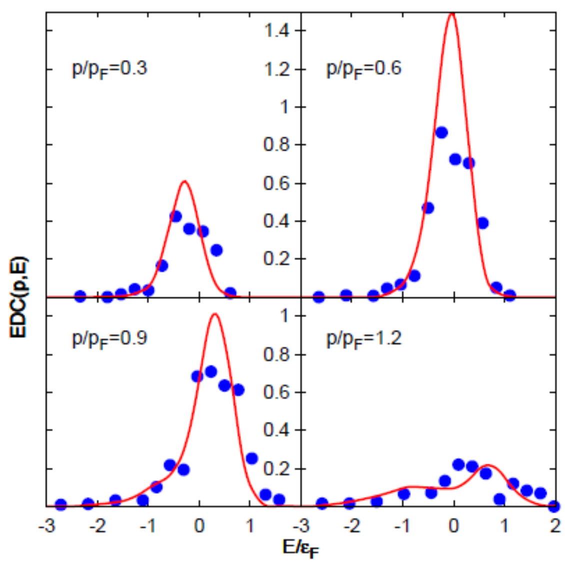
Fermi Liquid Model: $A(k,\omega)=\delta(\hbar\omega- \hbar^2k^2/2m^*+\mu)$



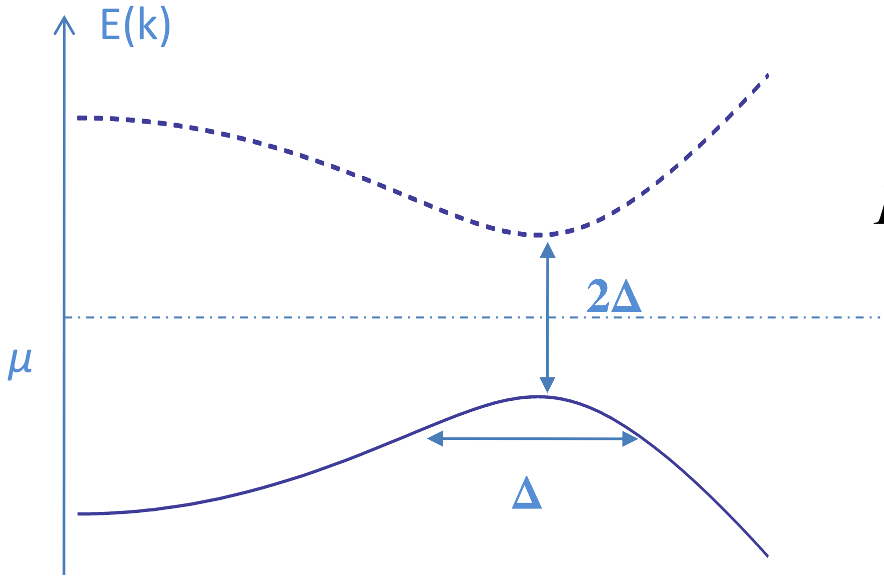
Diagrammatic
(*Strinati*)



Quantum Monte-Carlo
(*Magierski et al.*)

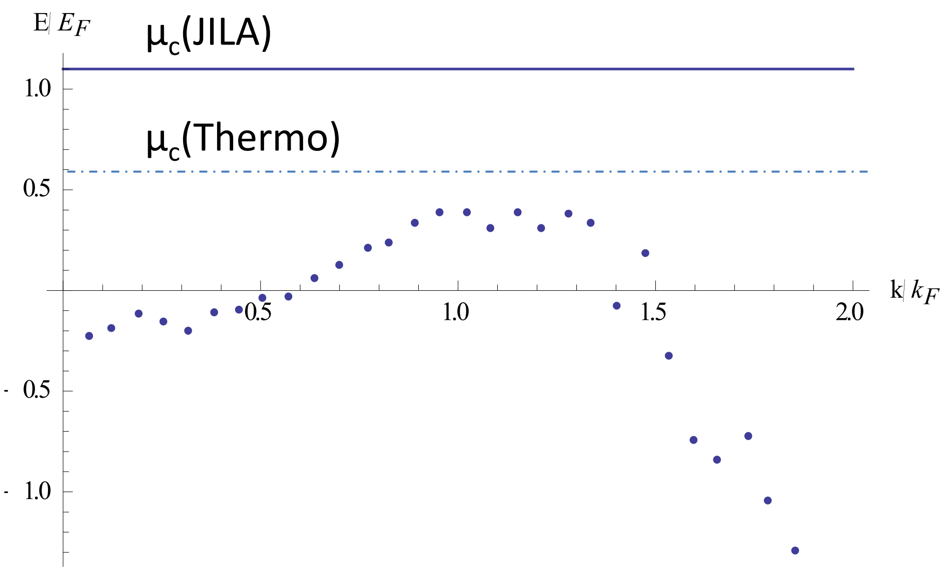


What is Δ*? How to quantify it?



$$E_{BCS}(k) = \mu \pm \sqrt{(p^2/2m - p_F^2/2m)^2 + \Delta^2}$$

BCS Theory identifies the band gap and the width of the back-bending



From JILA's data, at $T \sim T_c, \mu \sim 1.1\ E_F$

Thermodynamics experiments, Monte-carlo : at $T \sim T_c$, $\mu \sim 0.6\ E_F \Longrightarrow \Delta < 0.2 E_F$ (line broadening $0.25 E_F$)