INTERNATIONAL ATOMIC ENERGY AGENCY
UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION
INTERNATIONAL CENTRE FOR THEORETICAL PHYSICS
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SMR. 767 - 7

MINIWORKSHOP ON STRONG CORRELATIONS
AND QUANTUM CRITICAL PHENOMENA
(4 - 22 July 1994)

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DOPED V_2O_3

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These are preliminary lecture notes, intended only for distribution to participants.

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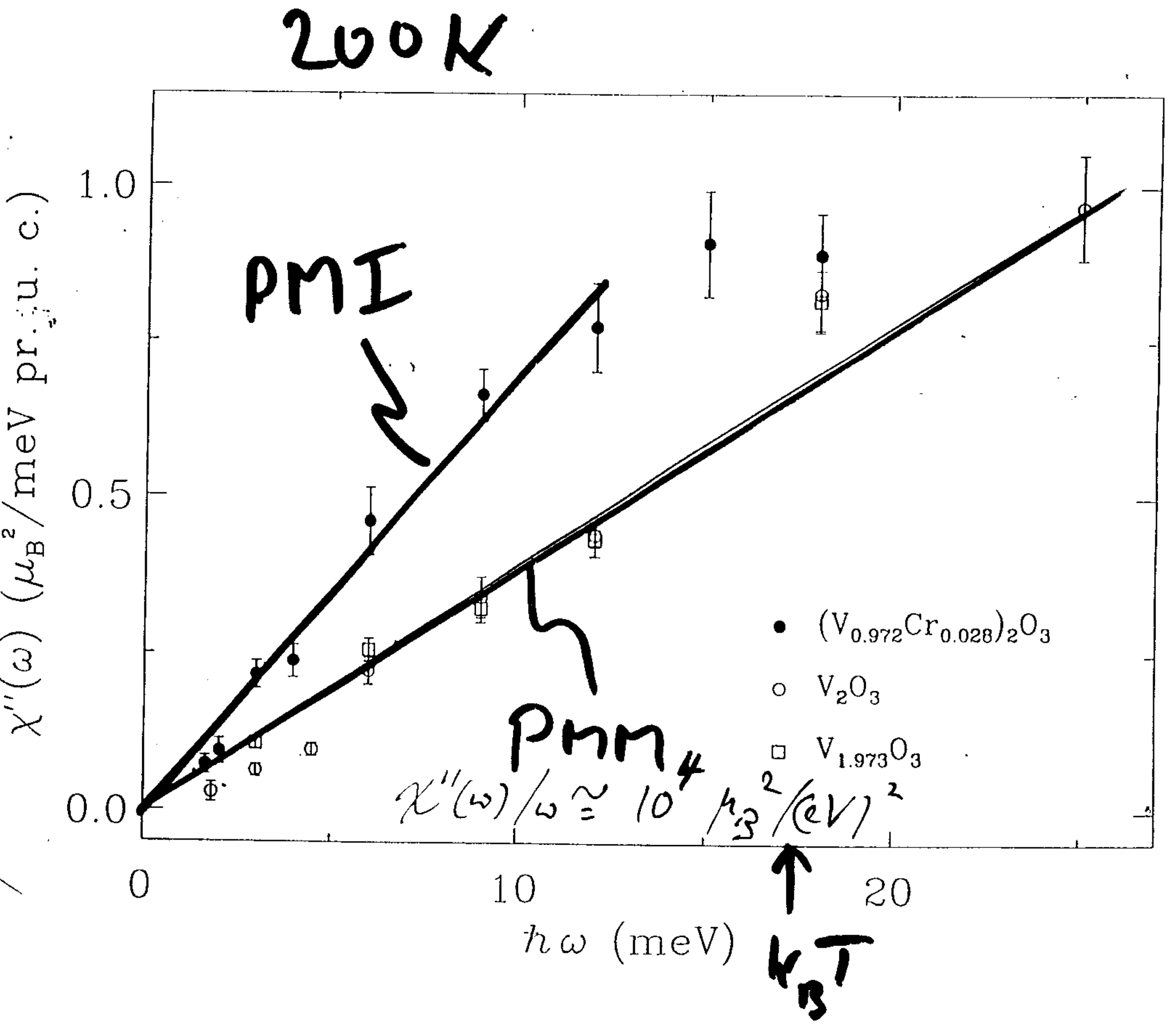
Doped V_2O_3

METAL - Classic Large Area
FS instability,
(spiral) spin density wave with
small moment, large fluctuations
AF Fermi liquid -
(i) large γ
(ii) $\rho = \rho_0 (1 + (T/T_F)^2)$
+ localization corrections
(iii) Moriya SCR theory
works (i.e. consistent
set of parameters)

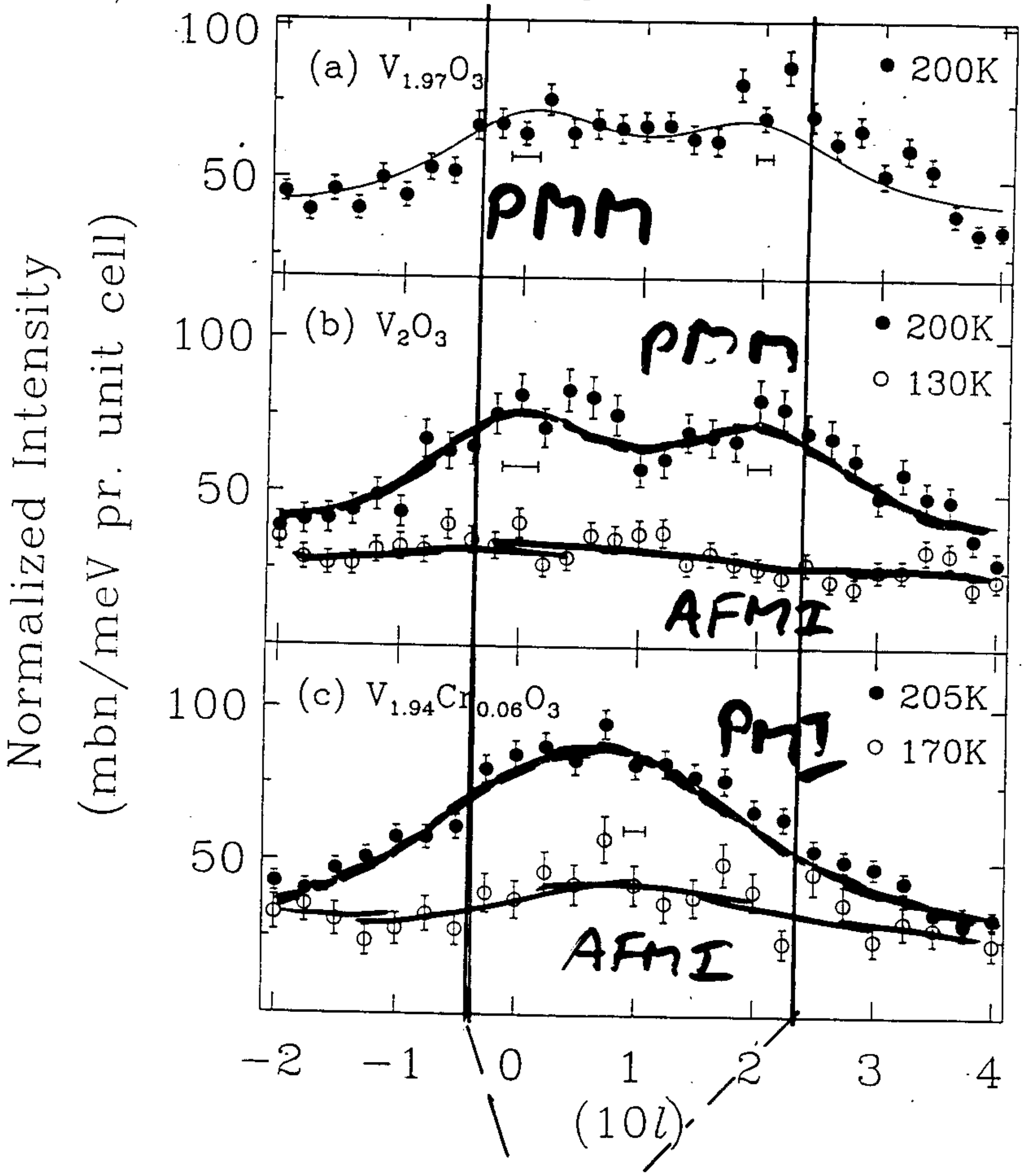
AFI - magnetically unrelated to
METAL

PMI - possibly related,
but lower kT ($\lesssim kT$?)



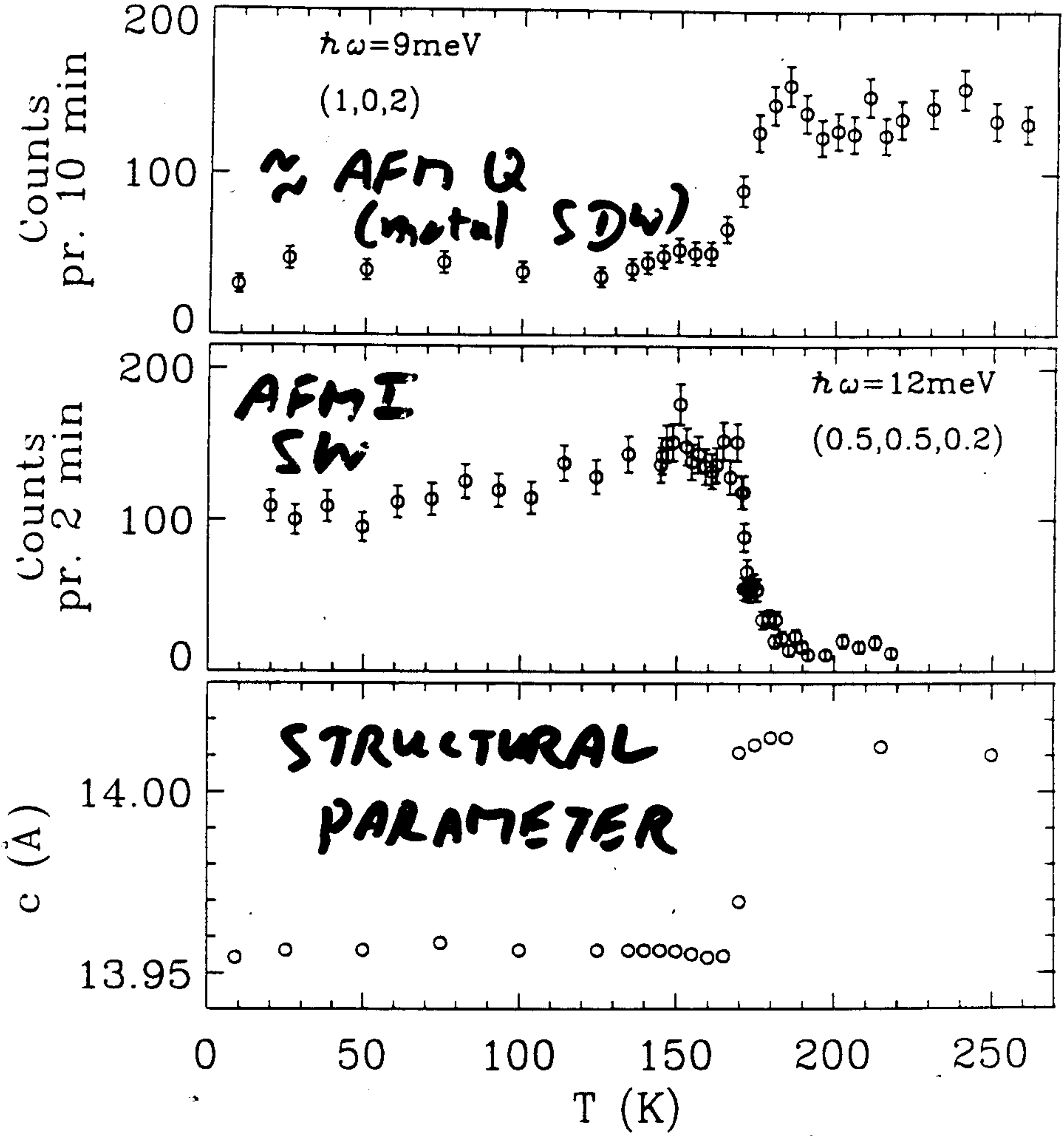
200K
PMI
PMM
$\chi''(\omega)$ (μ_B^2/meV pr. u. c.)
1.0
0.5
0.0
0
10
20
$\hbar\omega$ (meV)
$(V_{0.972}Cr_{0.028})_2O_3$
V_2O_3
$V_{1.973}O_3$
$\chi''(\omega)/\omega \simeq 10^4\ \mu_B^2/(eV)^2$
k_BT

$\hbar\omega = 9$ meV

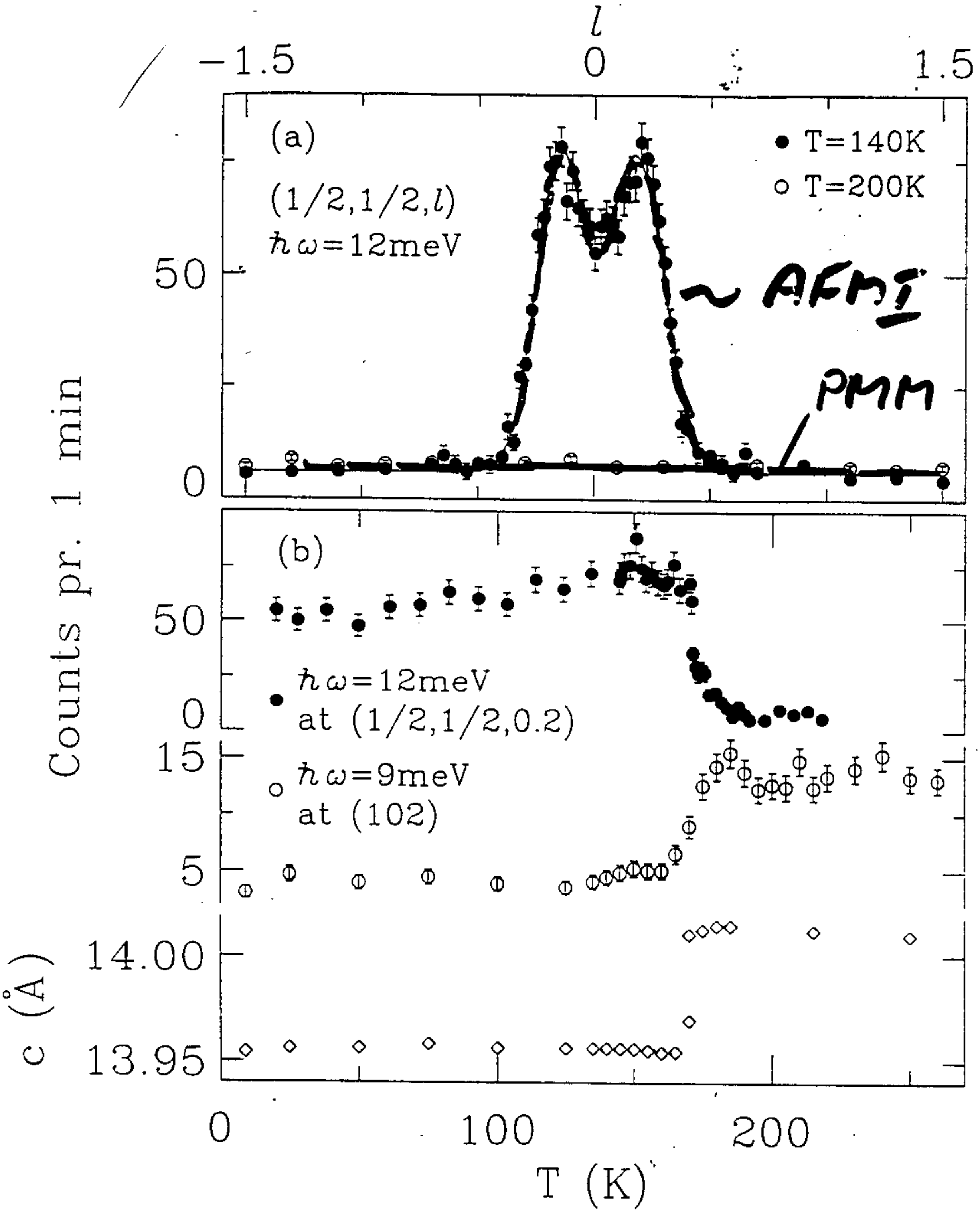


$q_0^{\pm}$ for SDW in $V_{1.94}Cr_{0.06}O_3$

pure V_2O_3

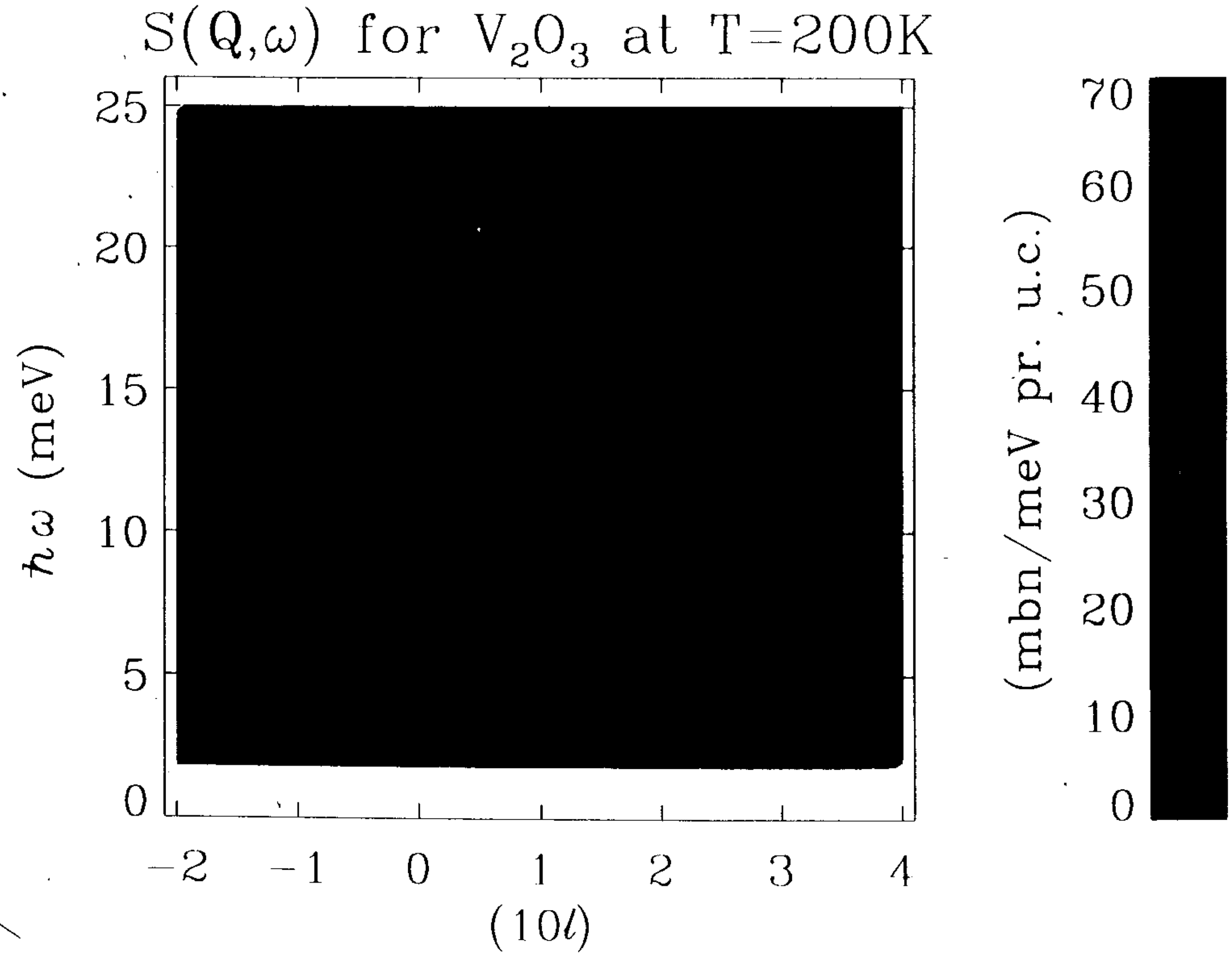


ALL RATHER HOPELESS,
BUT . . .



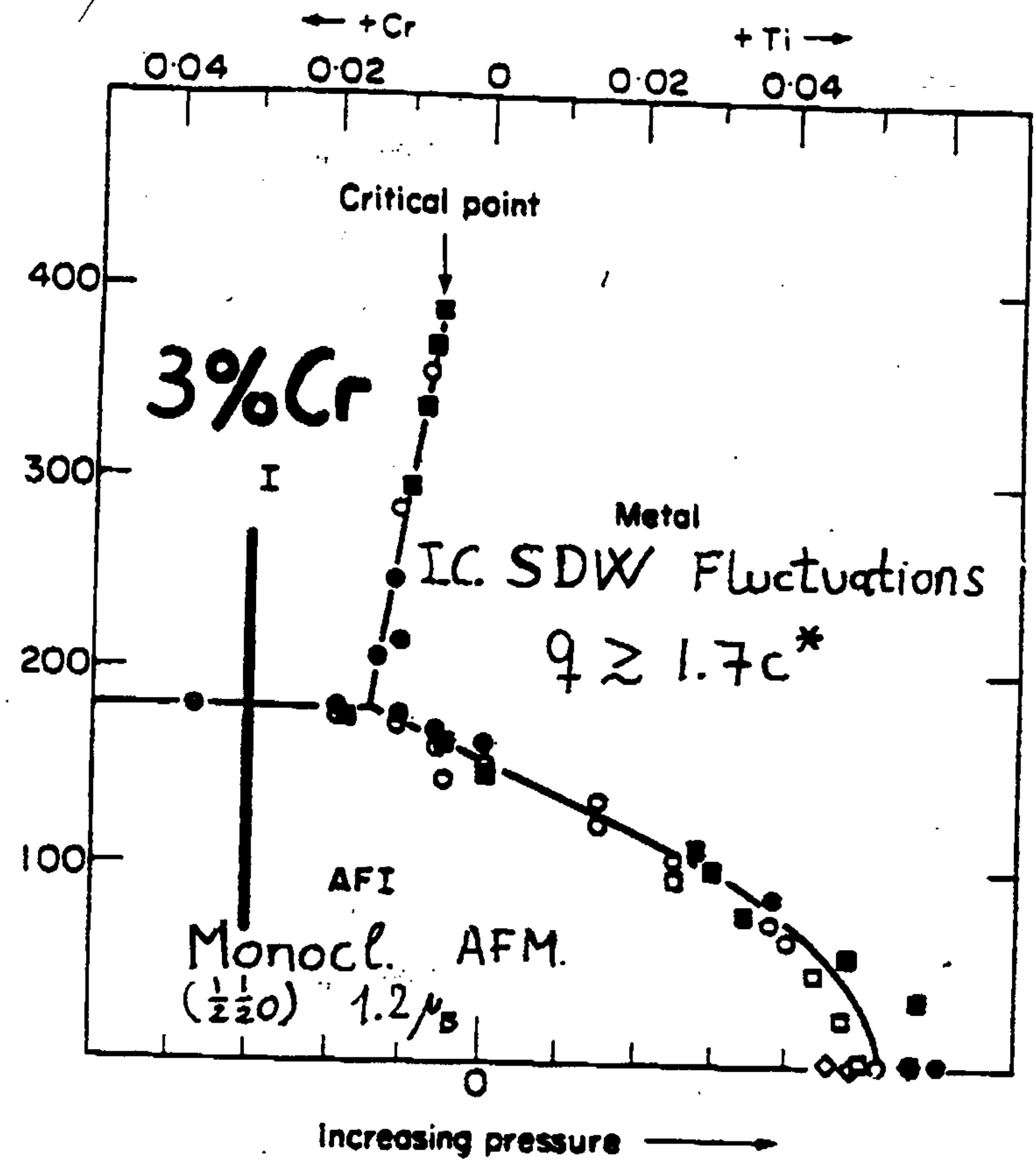
l
−1.5
0
1.5
(a)
(1/2,1/2,l)
ħω=12meV
T=140K
T=200K
~ AFMI
PMM
Counts pr. 1 min
50
0
(b)
ħω=12meV at (1/2,1/2,0.2)
ħω=9meV at (102)
15
5
c (Å)
14.00
13.95
0
100
200
T (K)

(V)



S(Q,ω) for V_2O_3 at T=200K
ħω (meV)
0
5
10
15
20
25
−2
−1
0
1
2
3
4
(10ℓ)
(mbn/meV pr. u.c.)
0
10
20
30
40
50
60
70

V_2O_3



← +Cr
+Ti →
0·04
0·02
0
0·02
0·04
Critical point
400
300
200
100
T
3%Cr
I
Metal
I.C. SDW Fluctuations
q ≳ 1.7c*
AFI
Monocl. AFM.
(½½0) 1.2μB
0
Increasing pressure →

$V_{2-y}O_3$

A CLASSIC SDW FROM FERMI SURFACE INSTABILITY

A_m / A

ρ $\quad \Delta\rho/\rho|_{T=0} = 0.02$

χ $\quad M/2\mu_B = 0.075$

C $\quad \Delta C/1.43\,C(T_N) = 0.08$

$\int \chi''(q,\omega) > 5 M_Q^2$

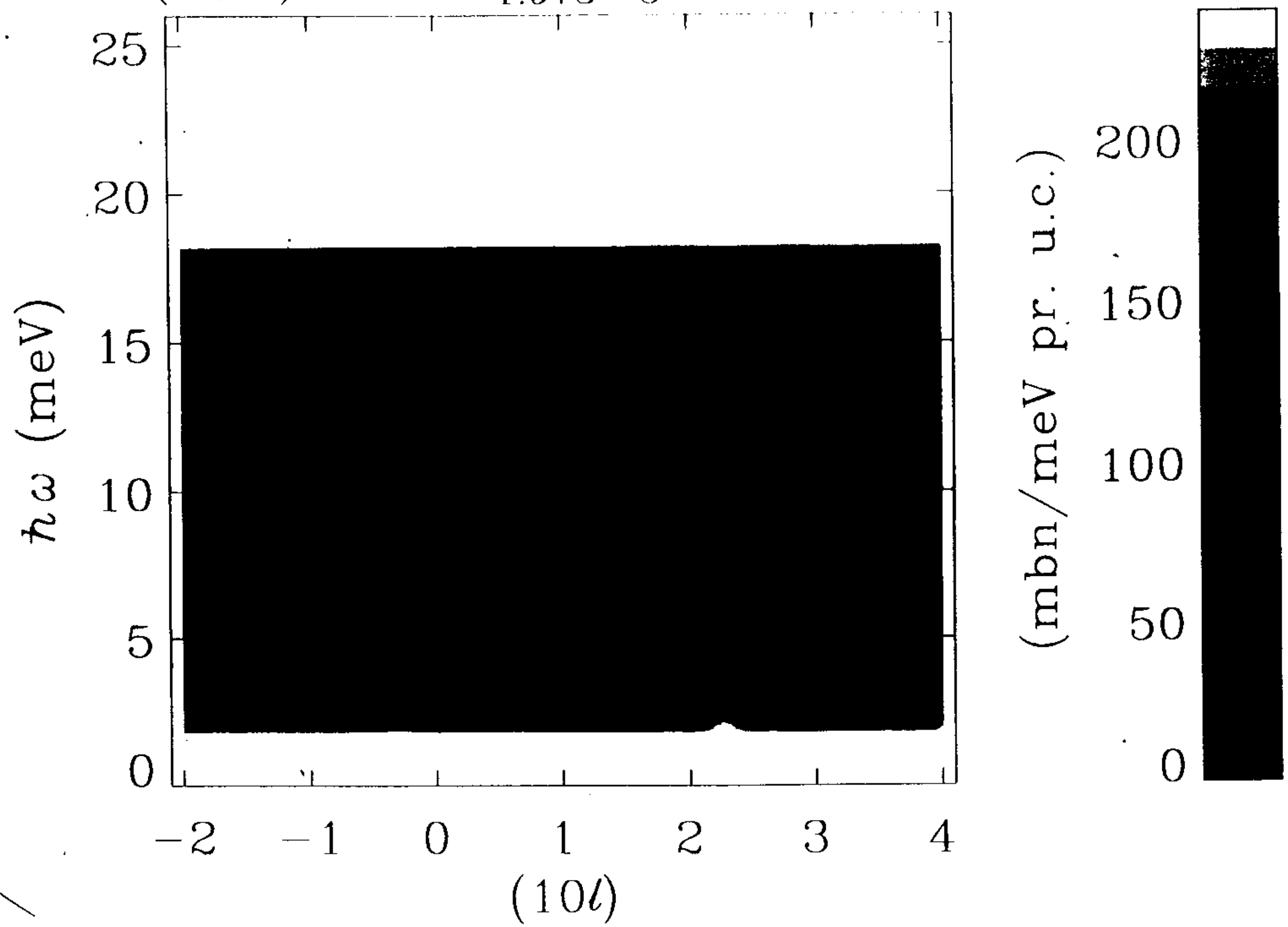
$\hbar\omega \lesssim 18\,\text{meV}$

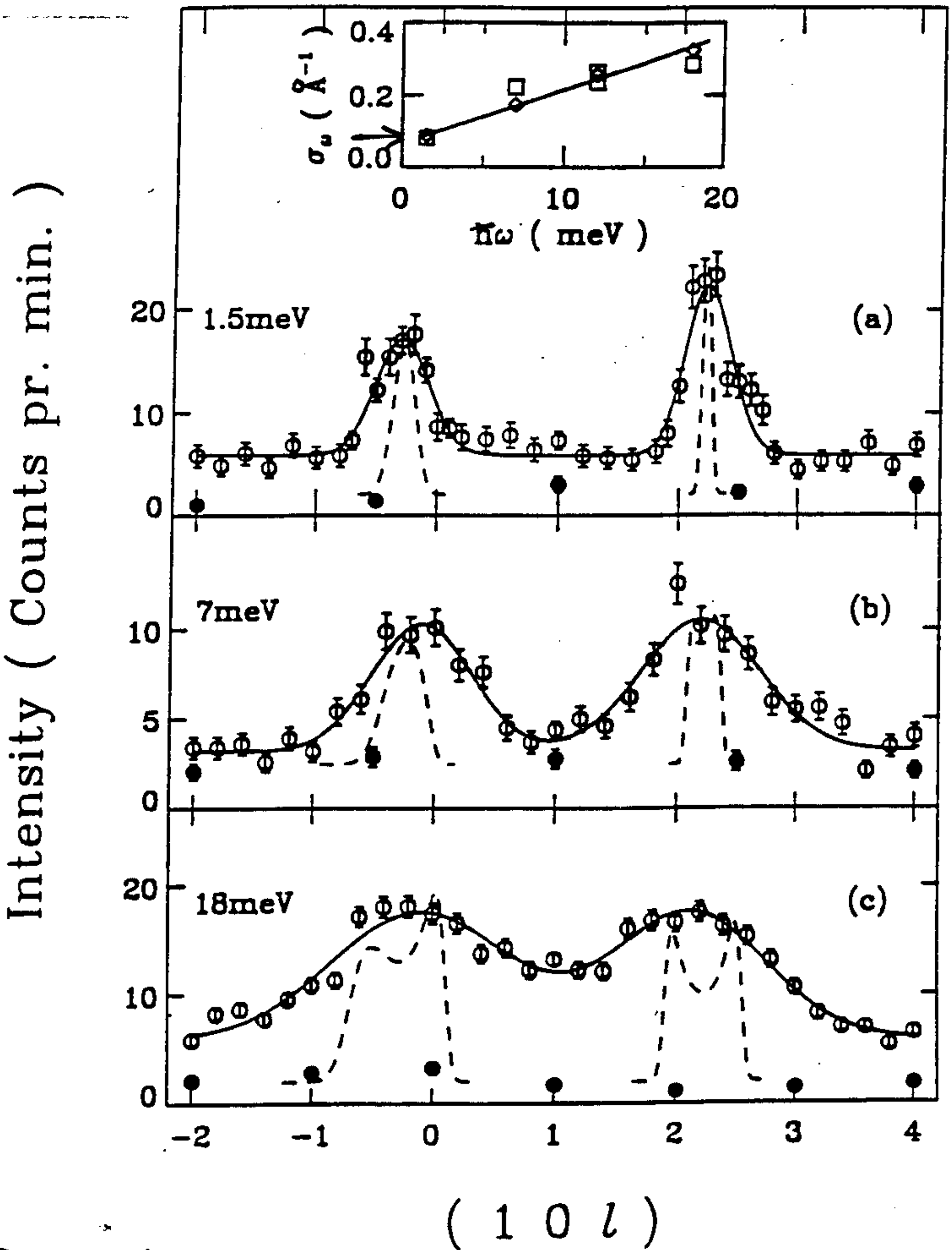
$\Delta q / \Delta q_y$ is small ($\lesssim 7\times10^{-3}\, c^*$)

BUT WHAT HAS THIS TO DO WITH IMT & PURE V2O3?

(9)

S(Q,ω) for $V_{1.973}O_3$ at T=1.4K





NOT CONVENTIONAL
SW, BUT LONGITUDONAL FLUCTUATIONS

Figure 5

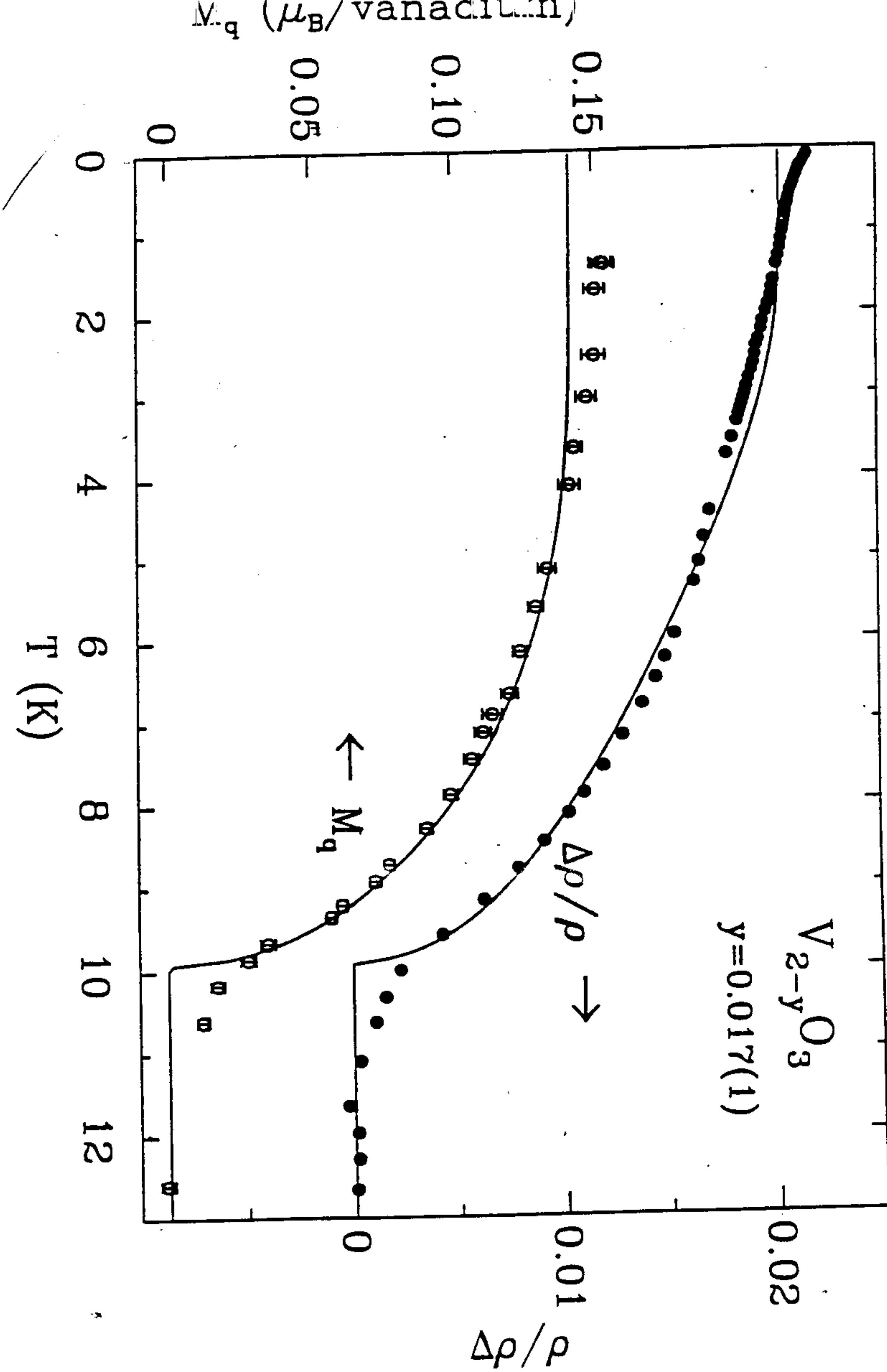
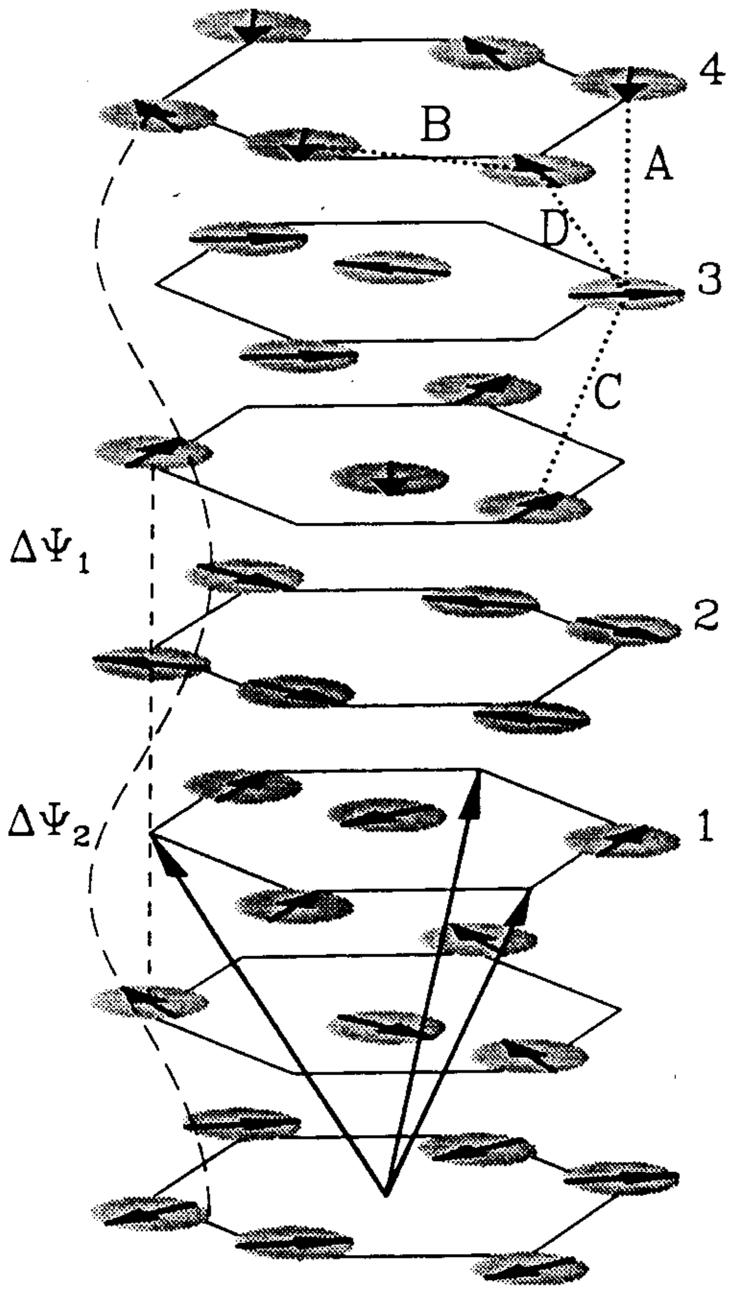
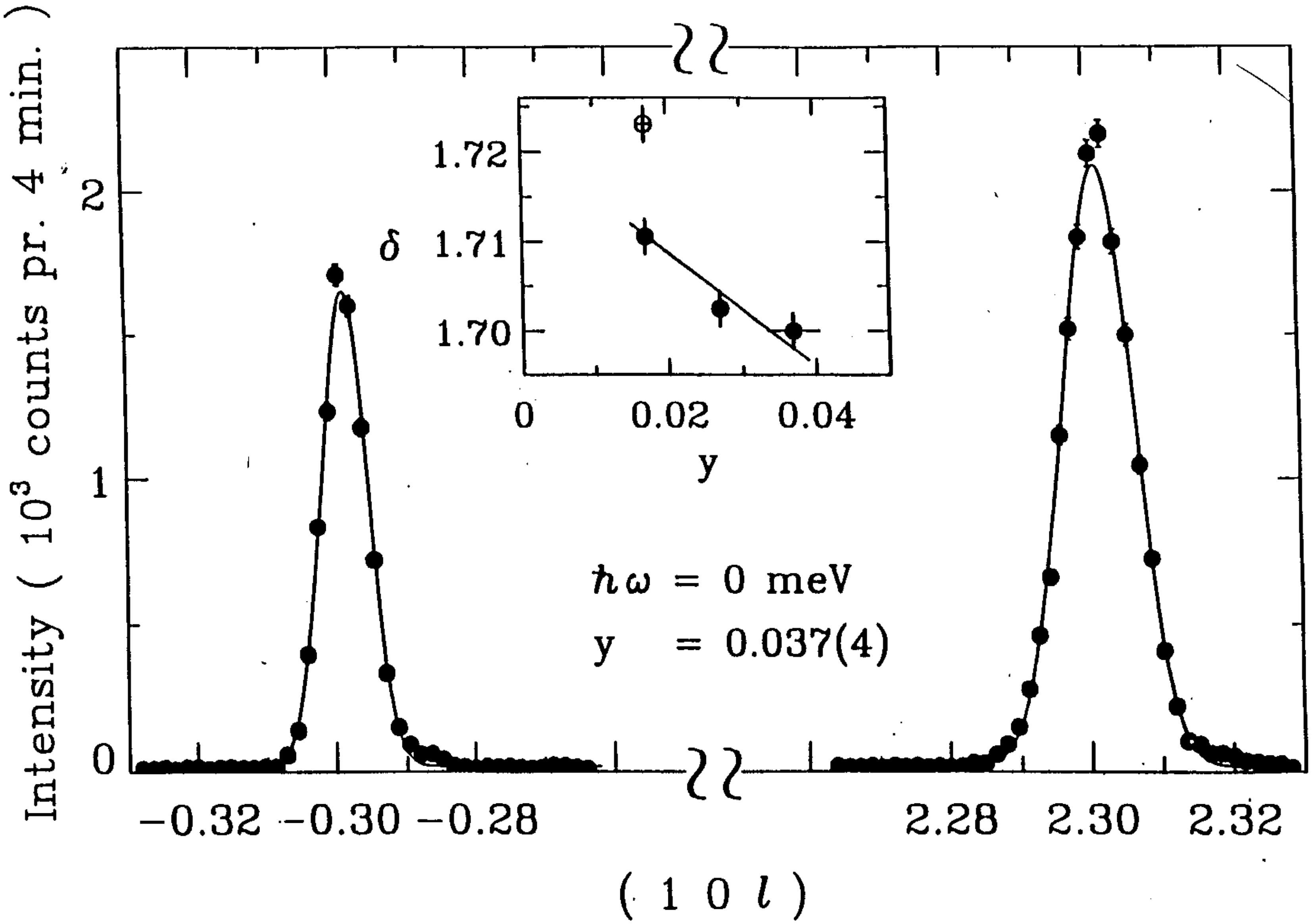

M_q (μ_B/vanadium)
0.15
0.10
0.05
0
T (K)
0
2
4
6
8
10
12
$\Delta\rho/\rho$
0.02
0.01
0
$V_{2-y}O_3$
y=0.017(1)
← M_q
$\Delta\rho/\rho$ →

Figure 3



$T_N = 10K$

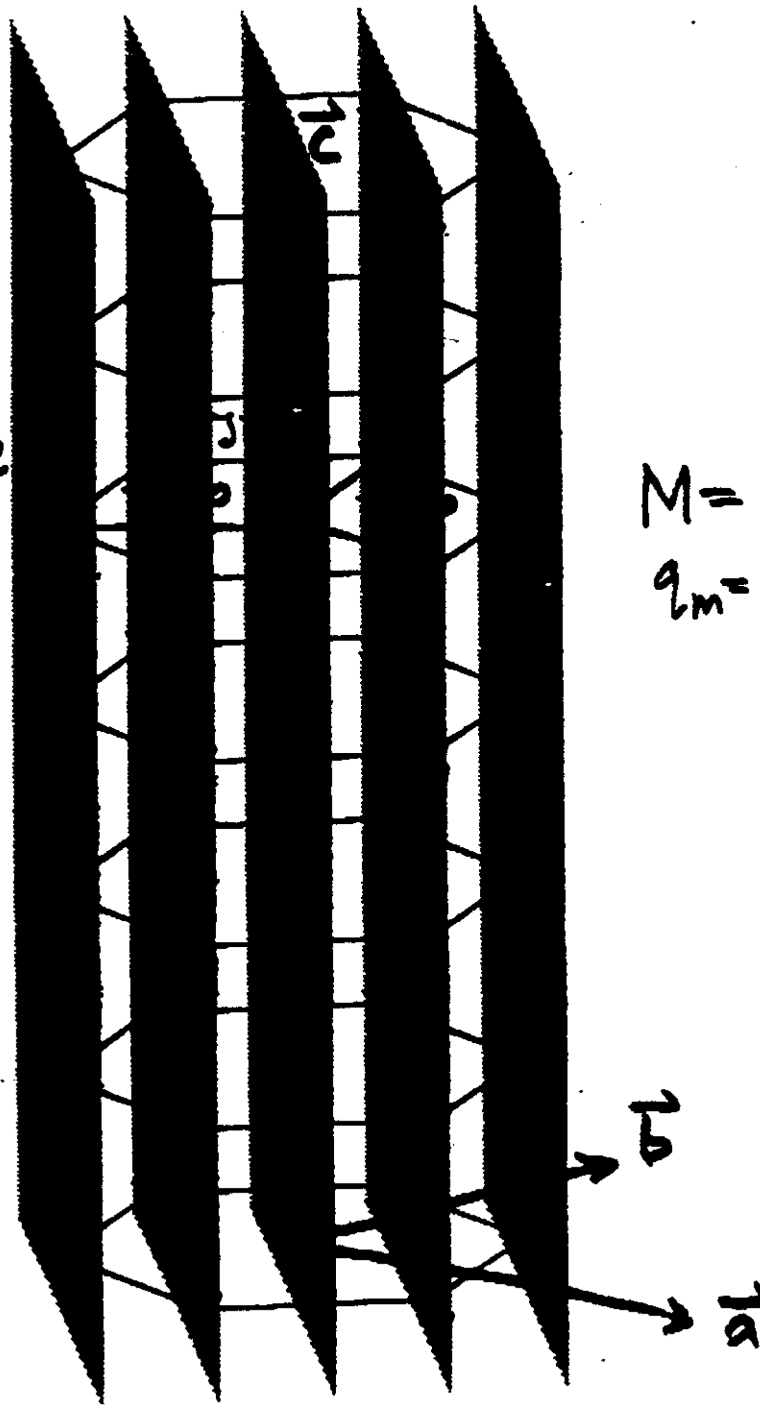


Intensity (10^3 counts pr. 4 min.)
0
1
2
−0.32
−0.30
−0.28
2.28
2.30
2.32
(1 0 l)
$\hbar\omega$ = 0 meV
y = 0.037(4)
δ
1.70
1.71
1.72
0
0.02
0.04
y

Figure 1

commensurate AF order in Insulator

need structure distortion to stabalize AF order

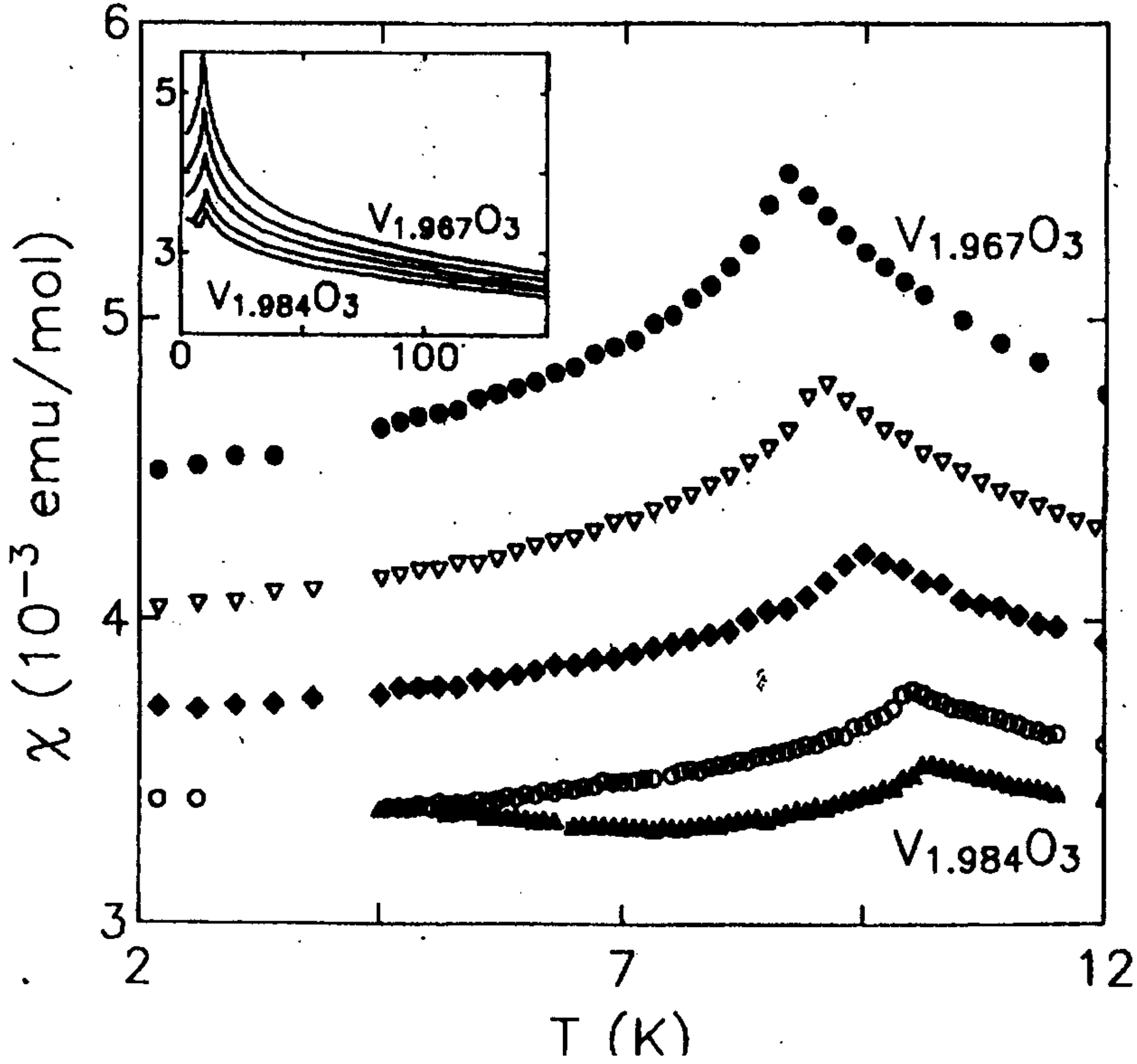


$M = 1.2 \mu_B / V$

$q_m = (\frac{1}{2}\ \frac{1}{2}\ 0)$ Hex.

R.M. Moon, PRL 25 527 (1970)

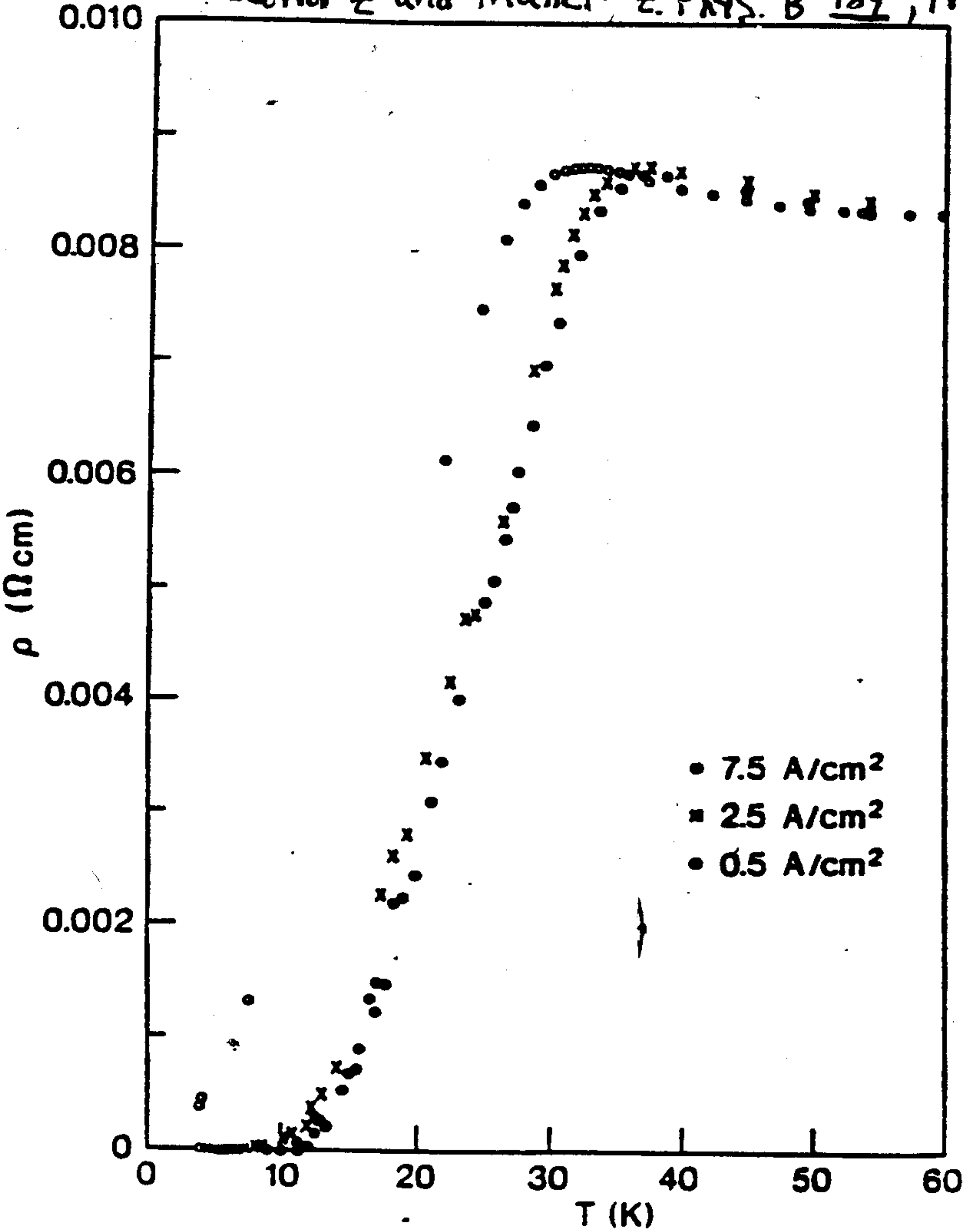
S.A. Carter et al. PRL 67, 3440 (1991).



2D / Doped Mott-Hubbard Systems:

AFMI → Superconductor

Bednorz and Müller Z. Phys. B 189, 189 (1986)



Neutron Scattering

$$\frac{\partial^2 \sigma}{\partial \Omega \partial \omega} = \frac{k_f}{k_i} S(\vec{Q}, \omega) \qquad \hbar\omega = E_i - E_f$$

$$\vec{Q} = \vec{k}_i - \vec{k}_f$$

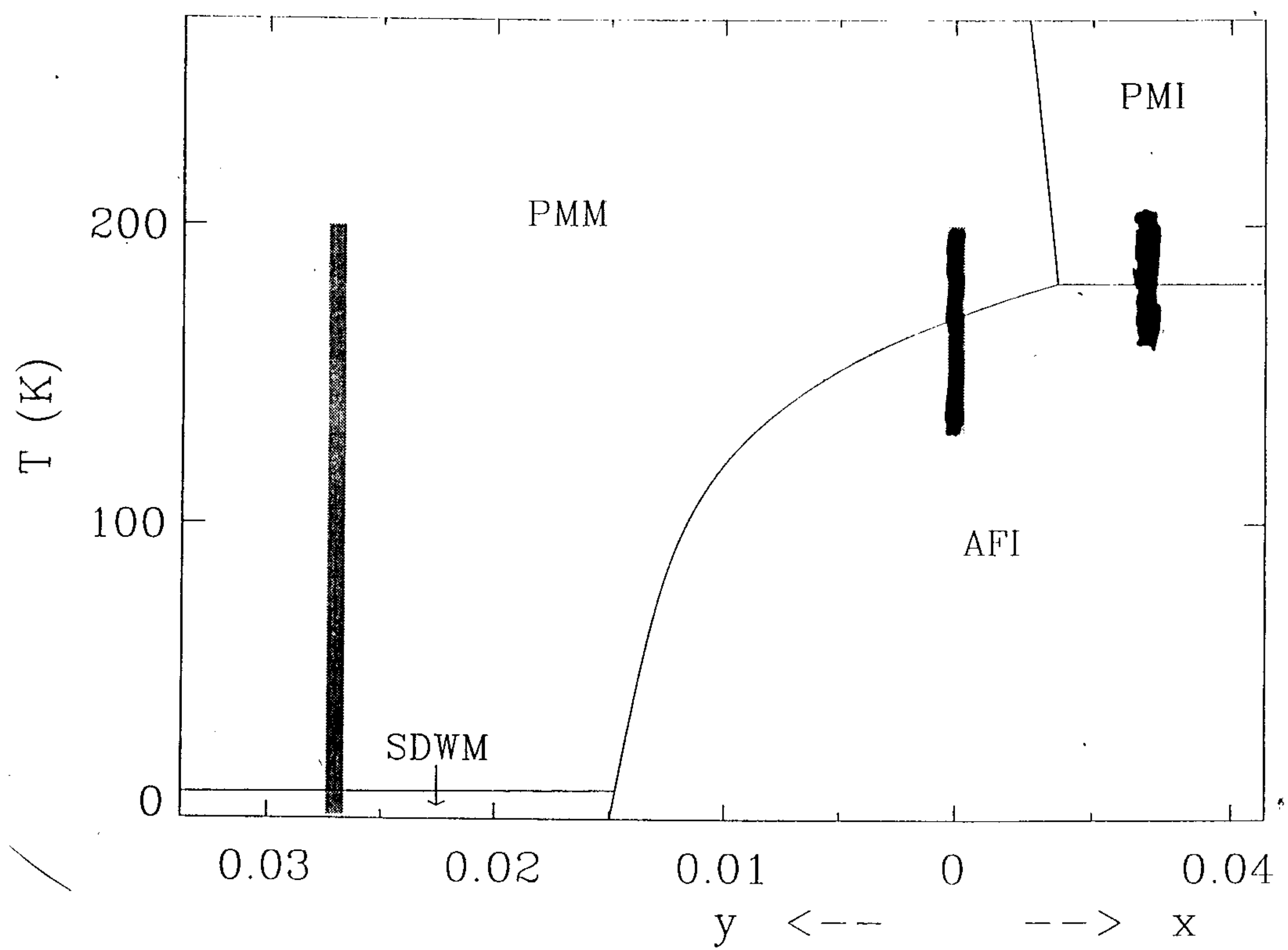
At T=0

$$S(Q,\omega) = \sum_f \left| \langle f | s_Q^+ | 0 \rangle \right|^2 \delta(\hbar\omega - (E_f - E_i)) = \chi''(Q,\omega)$$

Fermi's Golden Rule is all that is needed

Neutrons are an ideal probe because

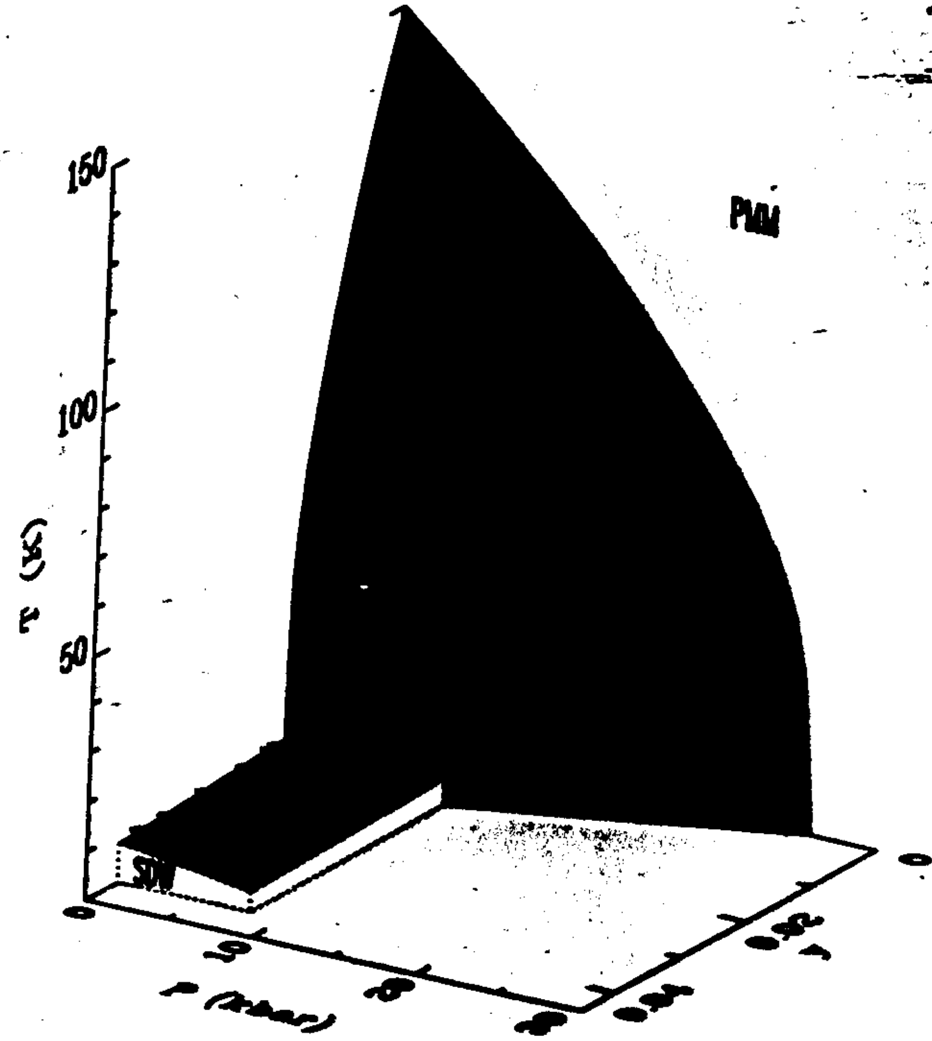
- $\lambda = \frac{0.286}{\sqrt{E}} \mathring{A} \approx$ Interatomic spacing
- with $1 meV \leq E \leq 1 eV$
- Neutrons carry a magnetic moment and no charge
- ⇒ couple to lattice and spins - not charge
- No surface effects

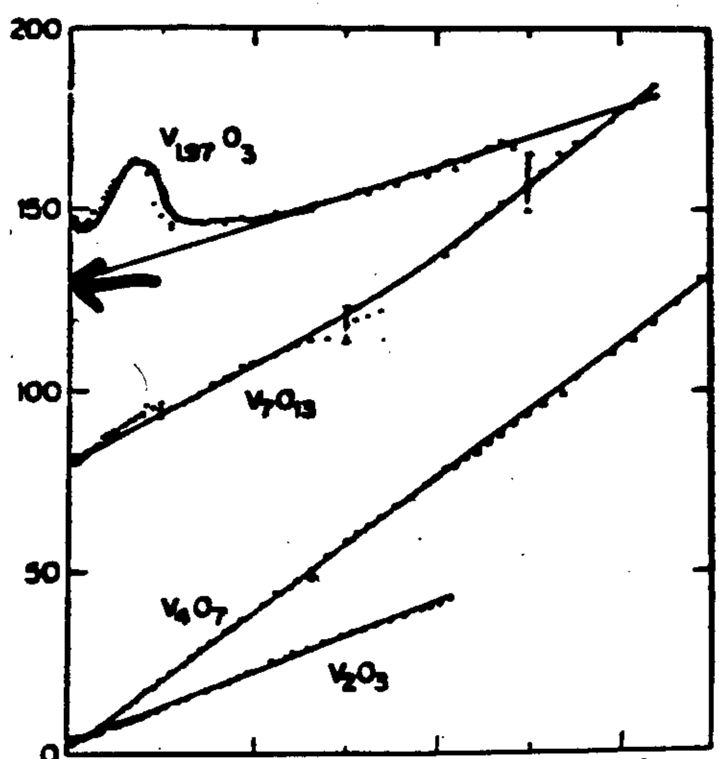


← V deficiency Cr doping

$/_{2-y}O_3$

...ao et al.,
...ys. Rev. Lett.
...1, 766 (1993)





D.B. McWhan et al.,
Phys. Rev. B 7,
326 (1973)

Figure 4

Doped Mott-Hubbard
System:

3D AFMI → SDW

$\gamma_0 = 54 \frac{mJ}{mole\text{-}K^2}$

Collaborators

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Rosenbaum - Chicago

Honig - Perdue

Mason - Toronto

Hayden - Bristol

Taylor
Perring
} ISIS