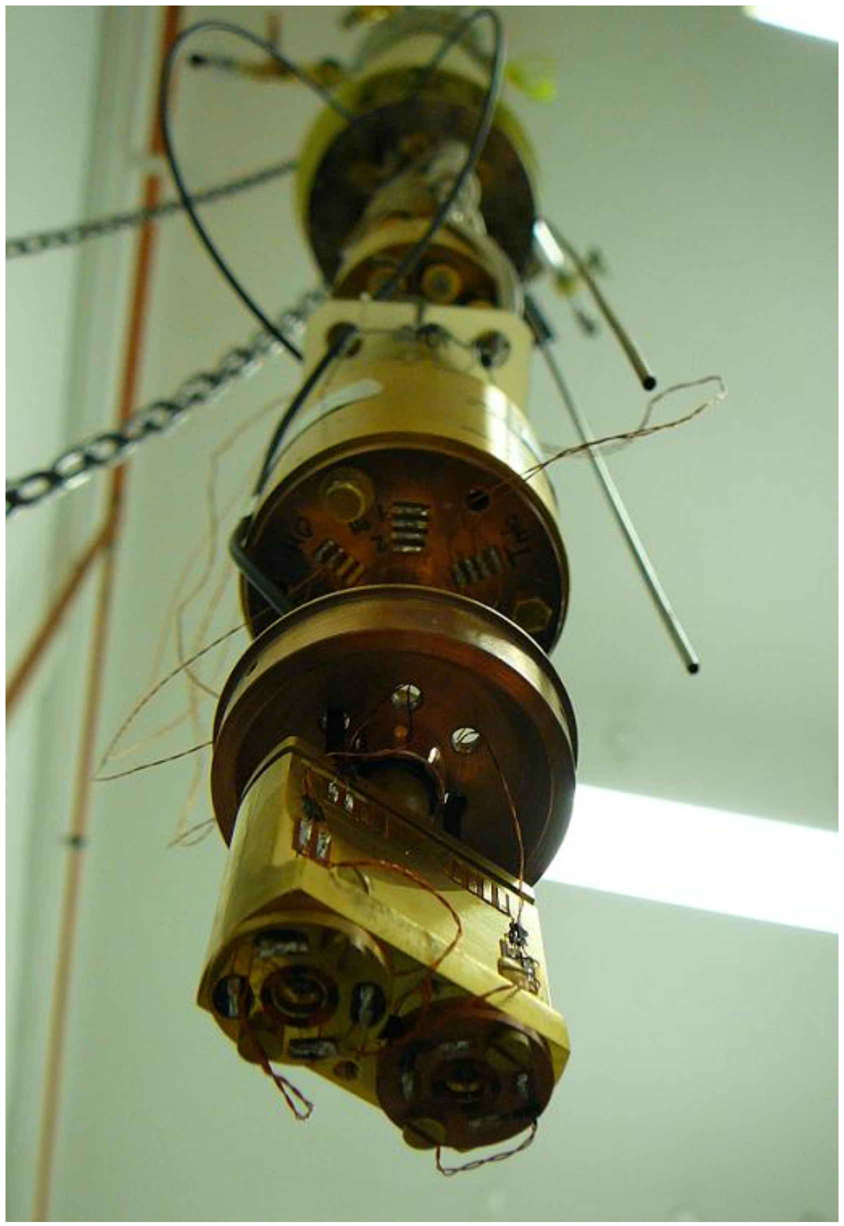
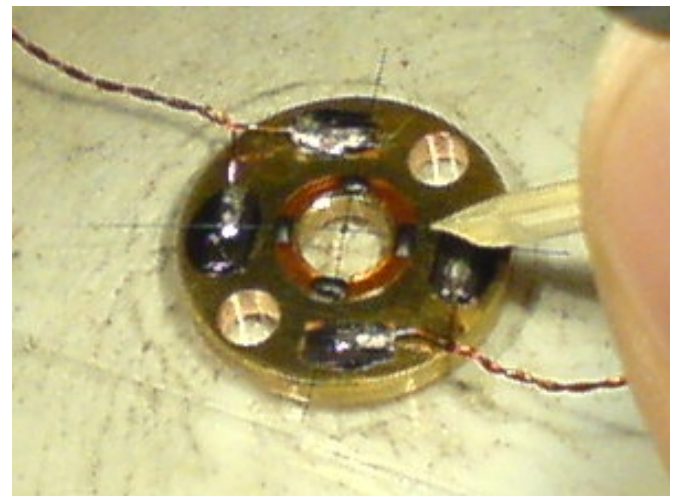
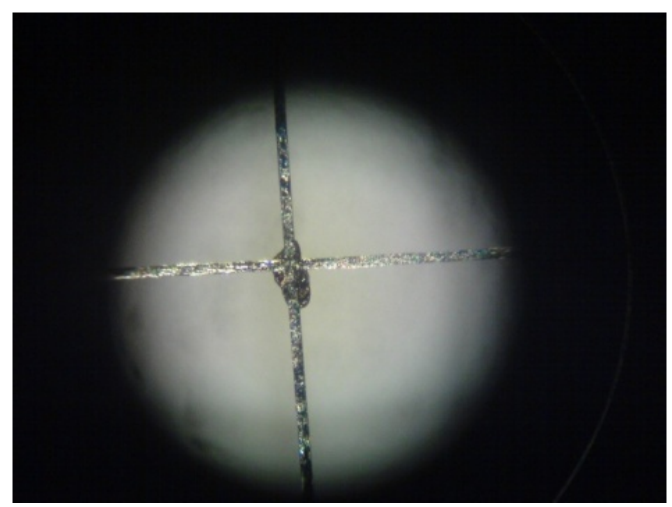
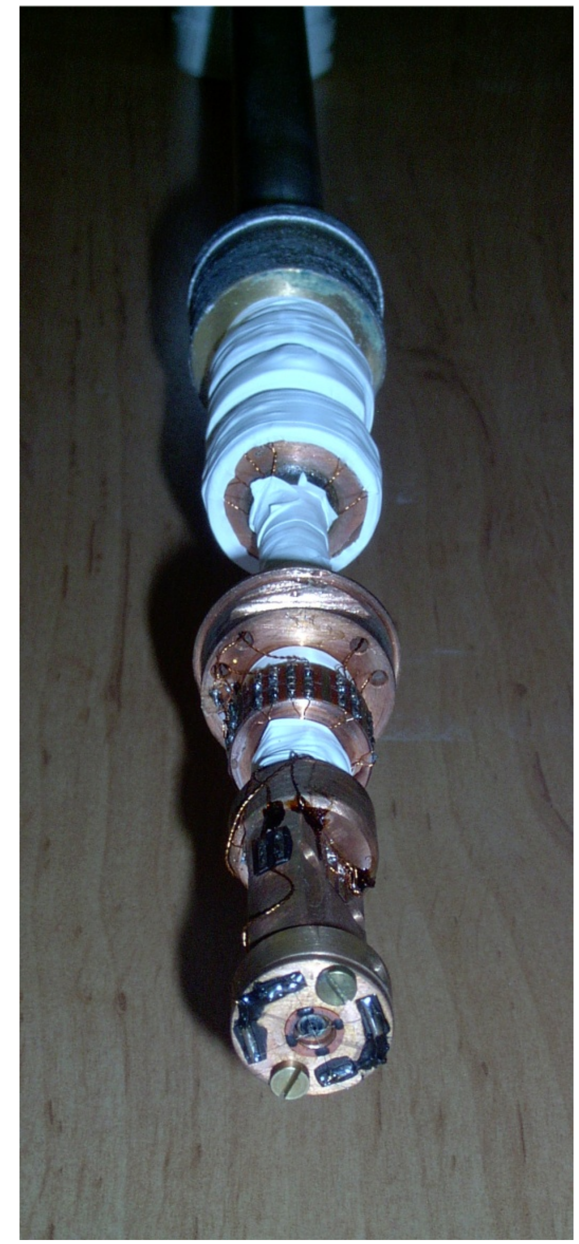
Experimental set-ups in ^{3}He and ^{4}He probes

J. Kacmarcik, Z. Pribulova, et al. , SAS, Kosice

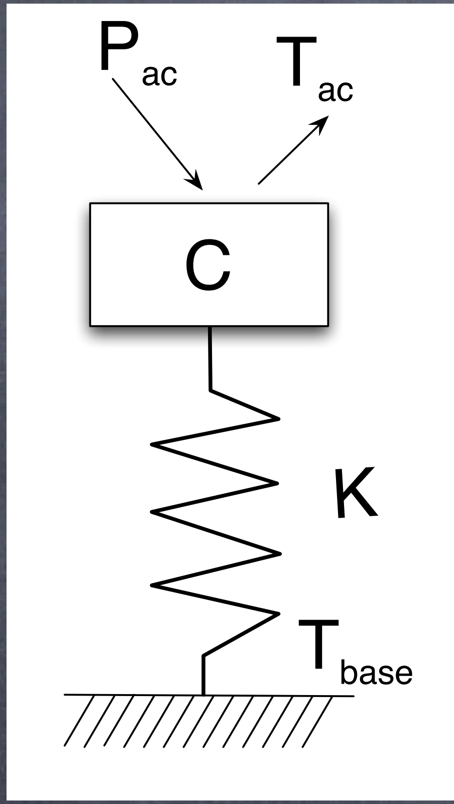








a little math



$$C\ dT/dt + K\ (T\text{-}Tb) = P$$

$$(\text{or } C\ dT/dt + K\ (T\text{-}Tb(\omega))=0)$$

Steady-state solution:

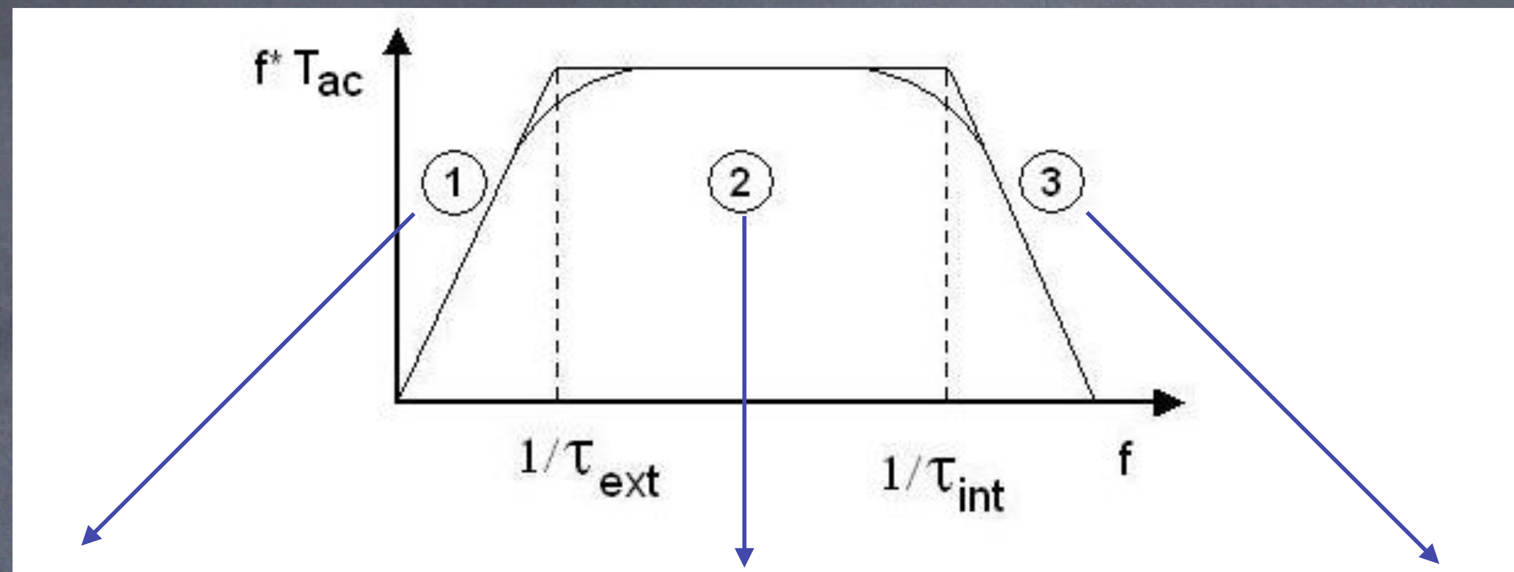
$T=T_b+T_{dc}+T_{ac}\exp(j\omega t)$

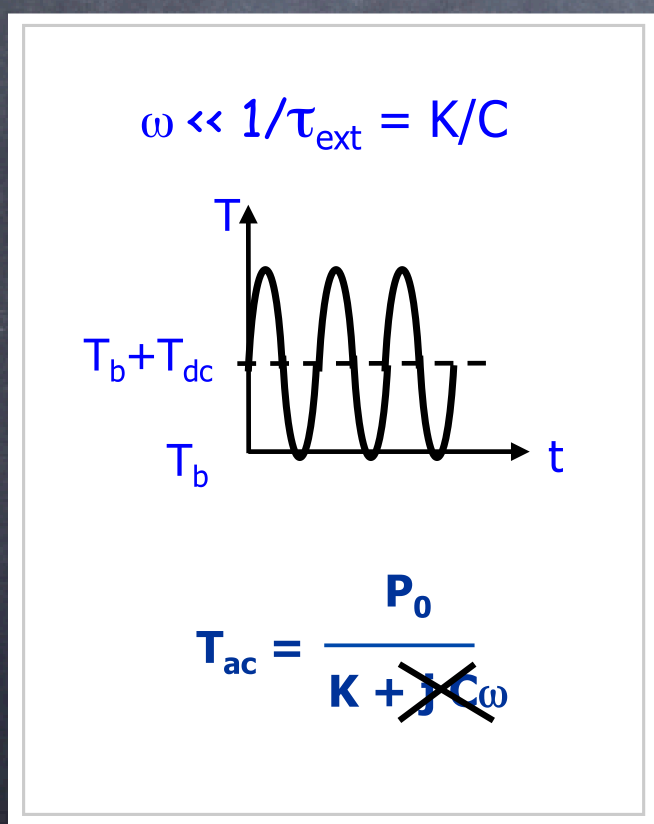
$$T_{dc} = P_0/K$$

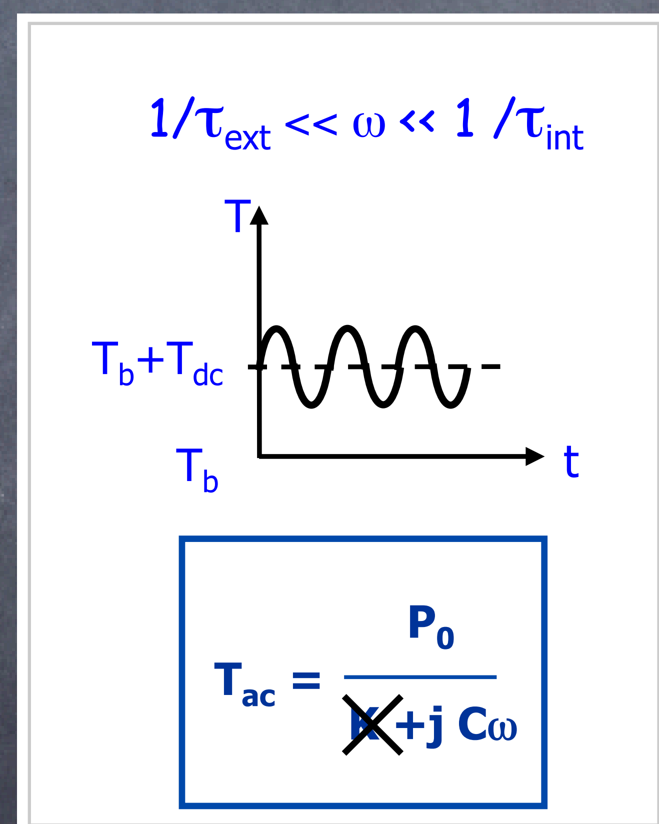
$$T_{ac}=P_1/(K+jC\omega)$$

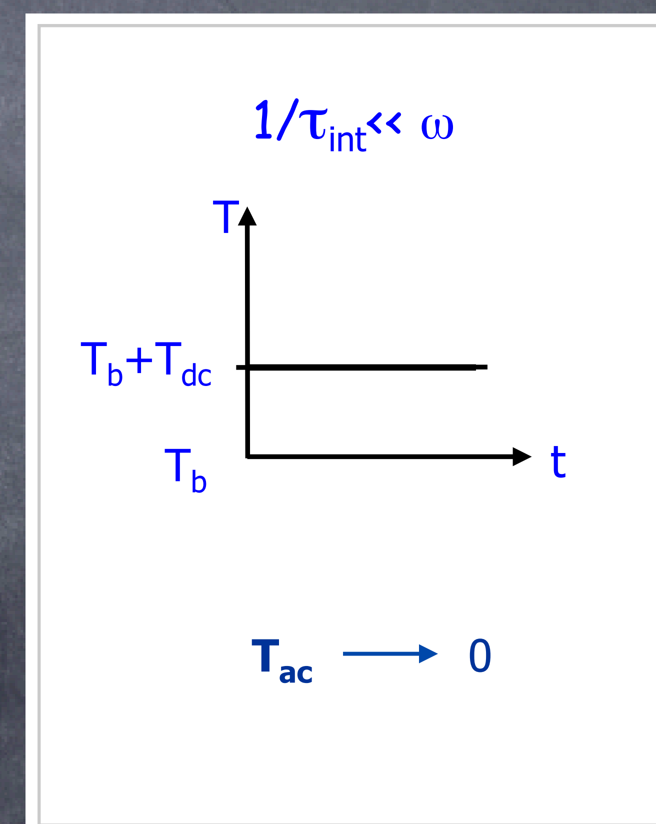
discussion of limitations later ...

different regimes









ac-calorimetry: Higher sensitivity

- Hc1 in MgB2
- iradiated KKBO
- pulsed magnetic field 62T, 100ms
- high pressure, diamond anvil pressure cell 15GPa
- thin films
- quantization of phonons (O. Bourgeois, CNRS-grenoble)

Phase : qualitative test for hysteresis !!!

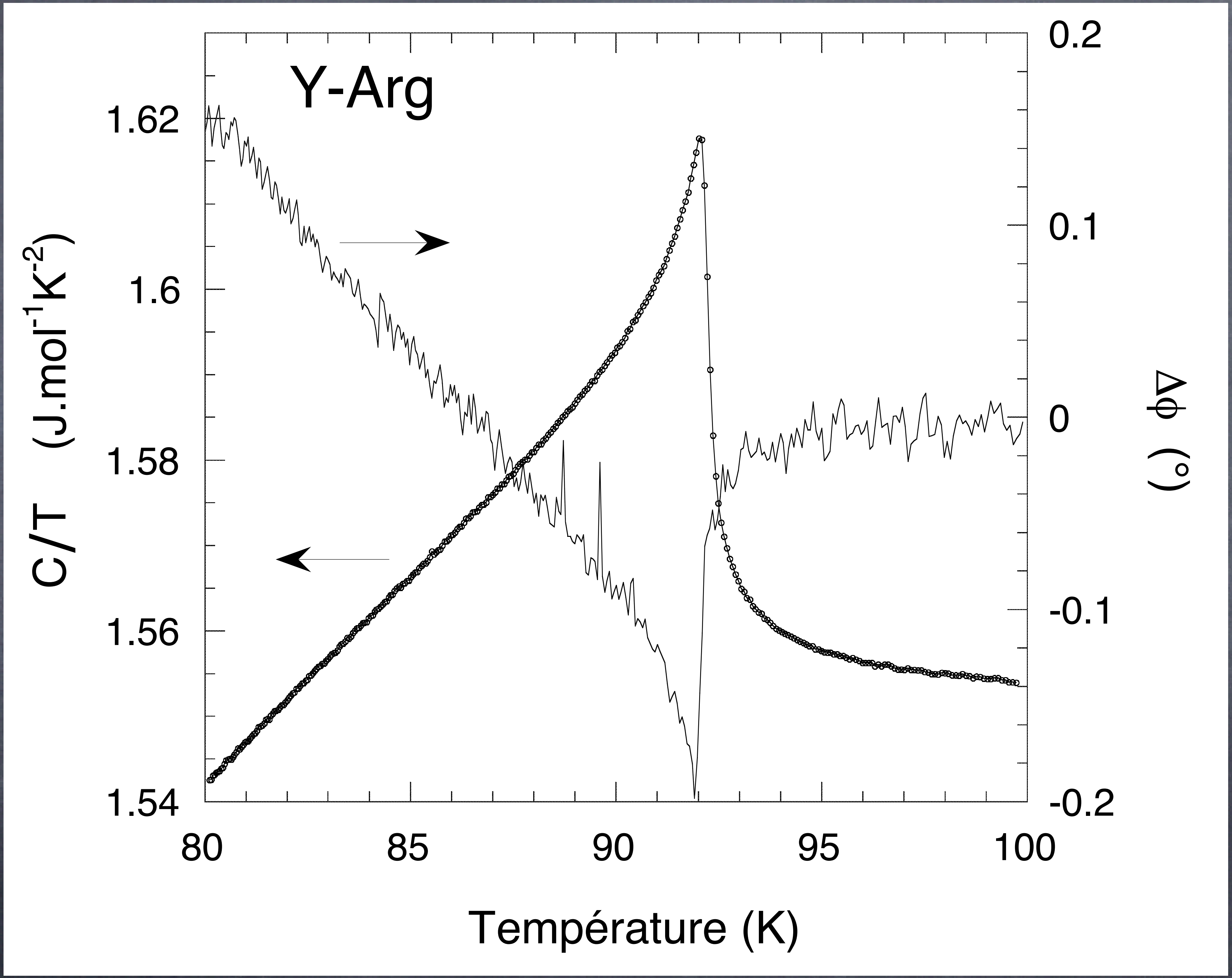
- $\tan(\phi) = -C\omega/K$ and $\Delta C > 0$ implies < 0
- in liquid crystals (many phases nematic, smectic,...)

obervation in ac-calorimetry :

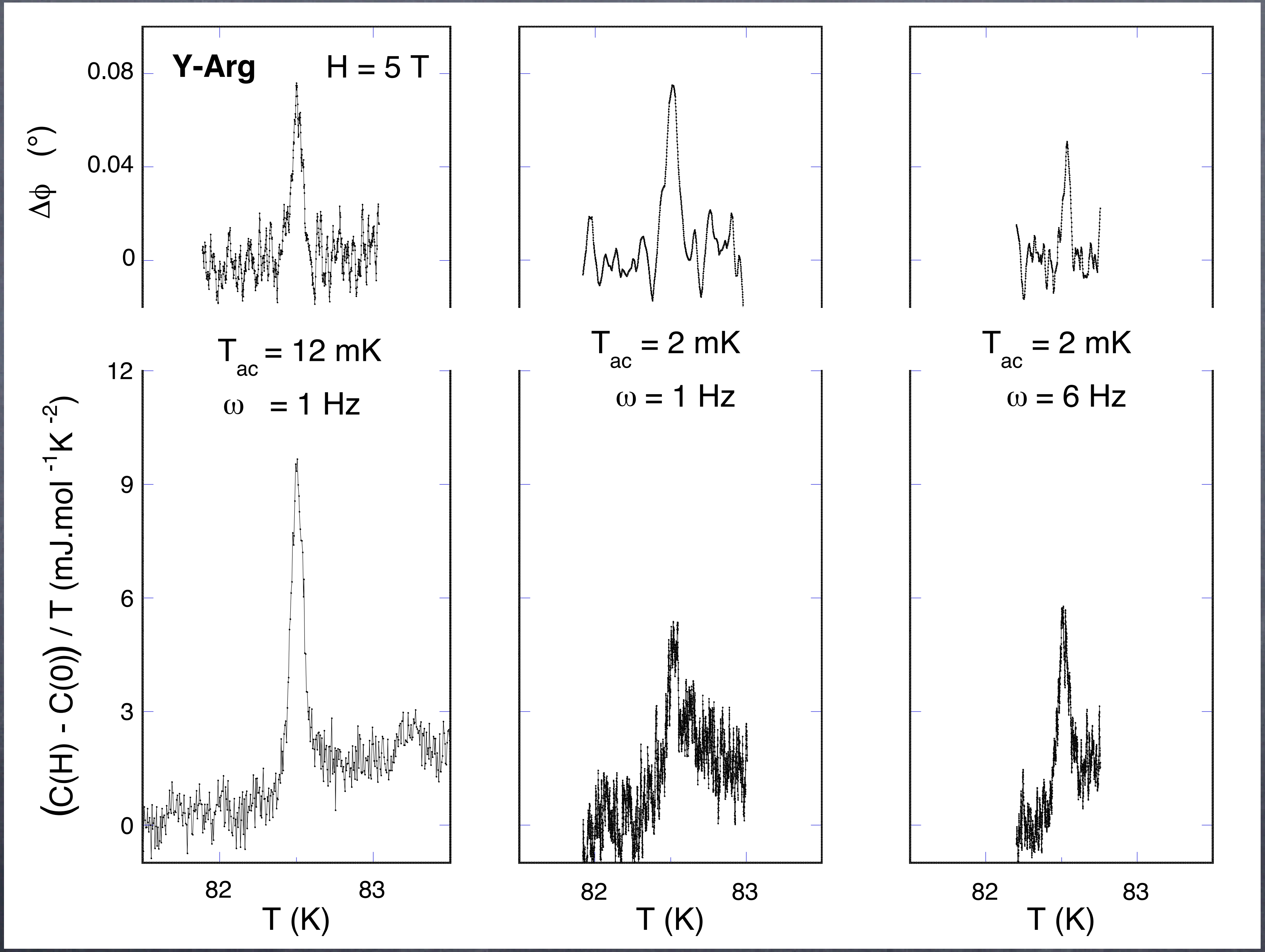
2nd order transition: $\Delta\phi < 0$

1st order transition: $\Delta\phi > 0$ in FACT hysteresis

anomaly in the phase at T_c is NEGATIVE

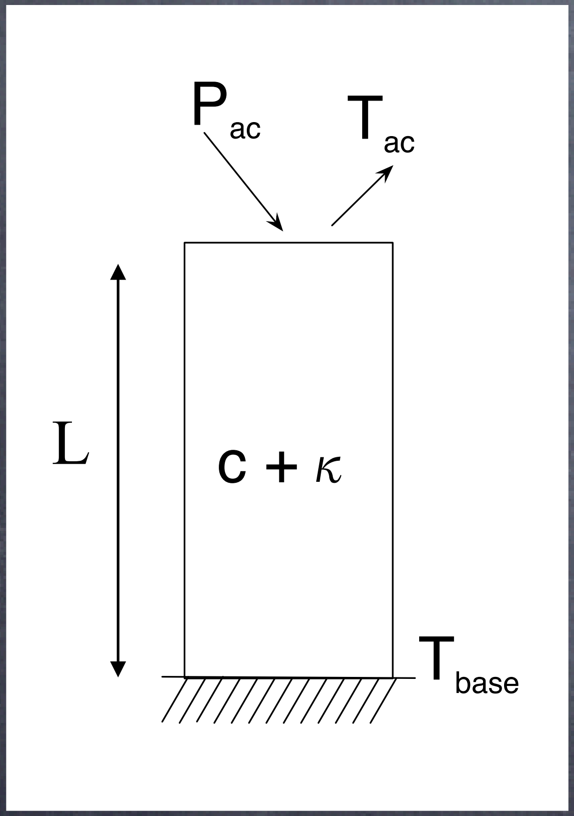


anomalous behavior of phase at vortex melting due probably to hysteresis



You measure X and Y (K and C) !!

can be used to measure thermal conductivity at the same time



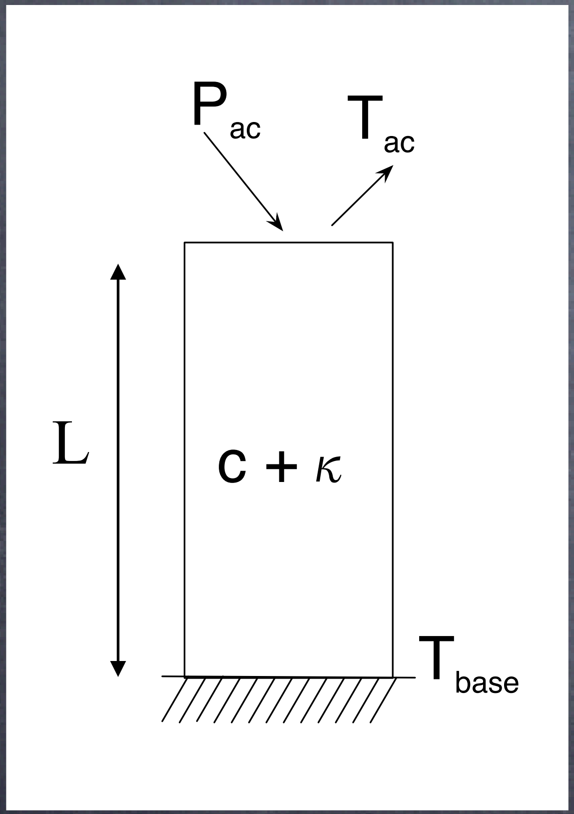
$$c\frac{\partial T}{\partial t} = \kappa\frac{\partial^2 T}{\partial x^2}$$ with boundary conditions

$$l^2 = \frac{\kappa}{jc\omega} = L^2\frac{K}{jC\omega}$$ thermal length

$$\boxed{T_{ac} = \frac{P}{Ktanh(L/l)}}$$

You measure X and Y (K and C) !!

can be used to measure thermal conductivity at the same time

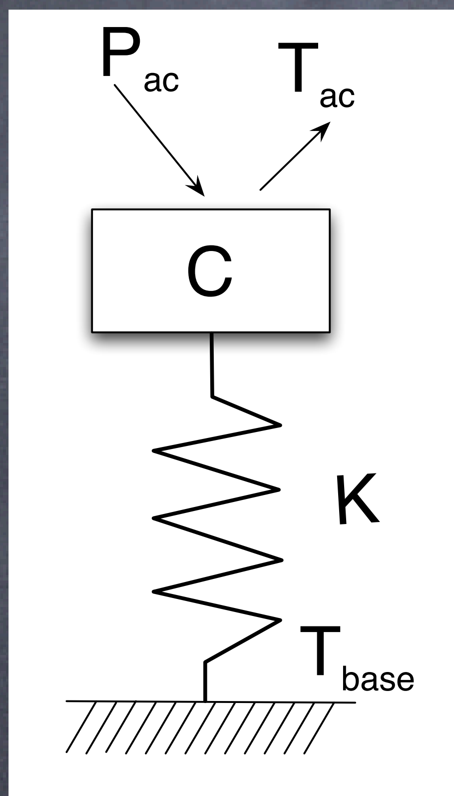


$$\boxed{T_{ac} = \frac{P}{K tanh(L/l)}}$$

- at low f, $C\omega/K<<1$: $Tac = P/K$
- at intermediate f, both K and $C\omega/K$
- at high f: thermal effusivity

$$\mathrm{mod}\, T_{ac} = \frac{P}{\sqrt{KC\omega}}$$

addenda contribution



+ c_{add}

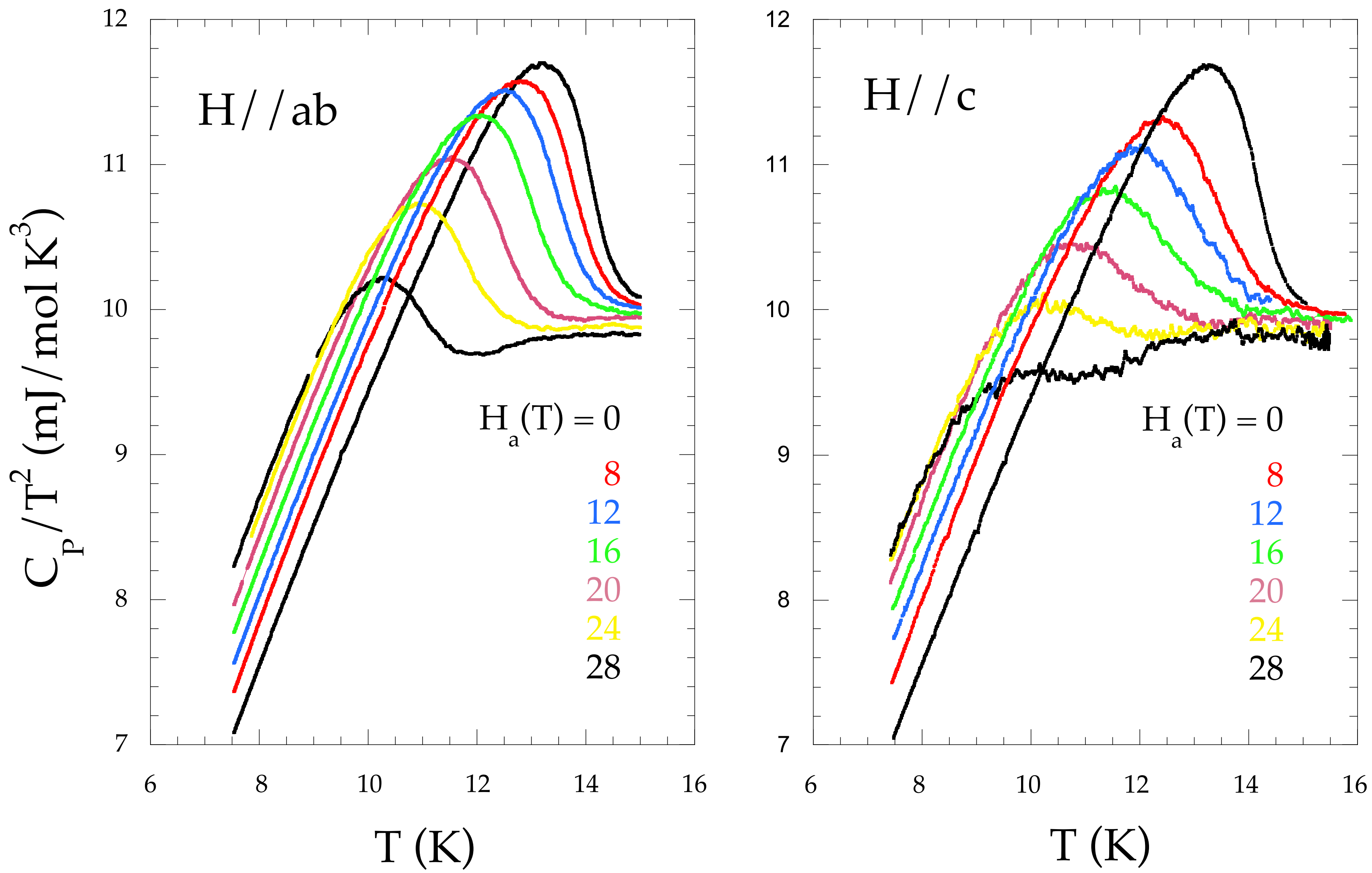
$$\boxed{T_{ac} = \frac{P}{Ktanh(L/l) + \underbrace{jC\omega}_{\text{addenda}}}}$$

especially important in pressure cell where C_{add} is large

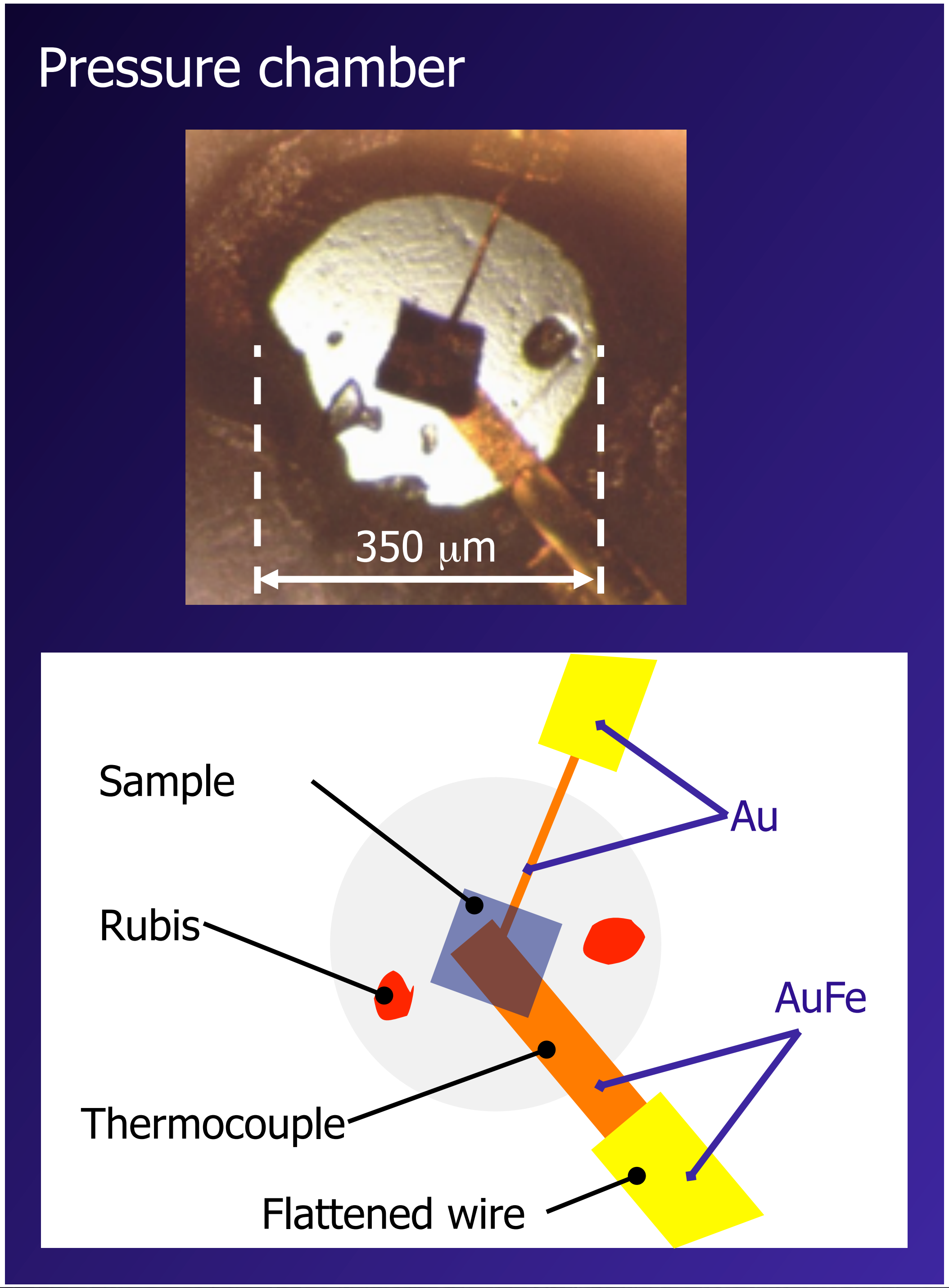
Extreme conditions: resistive 30Tesla

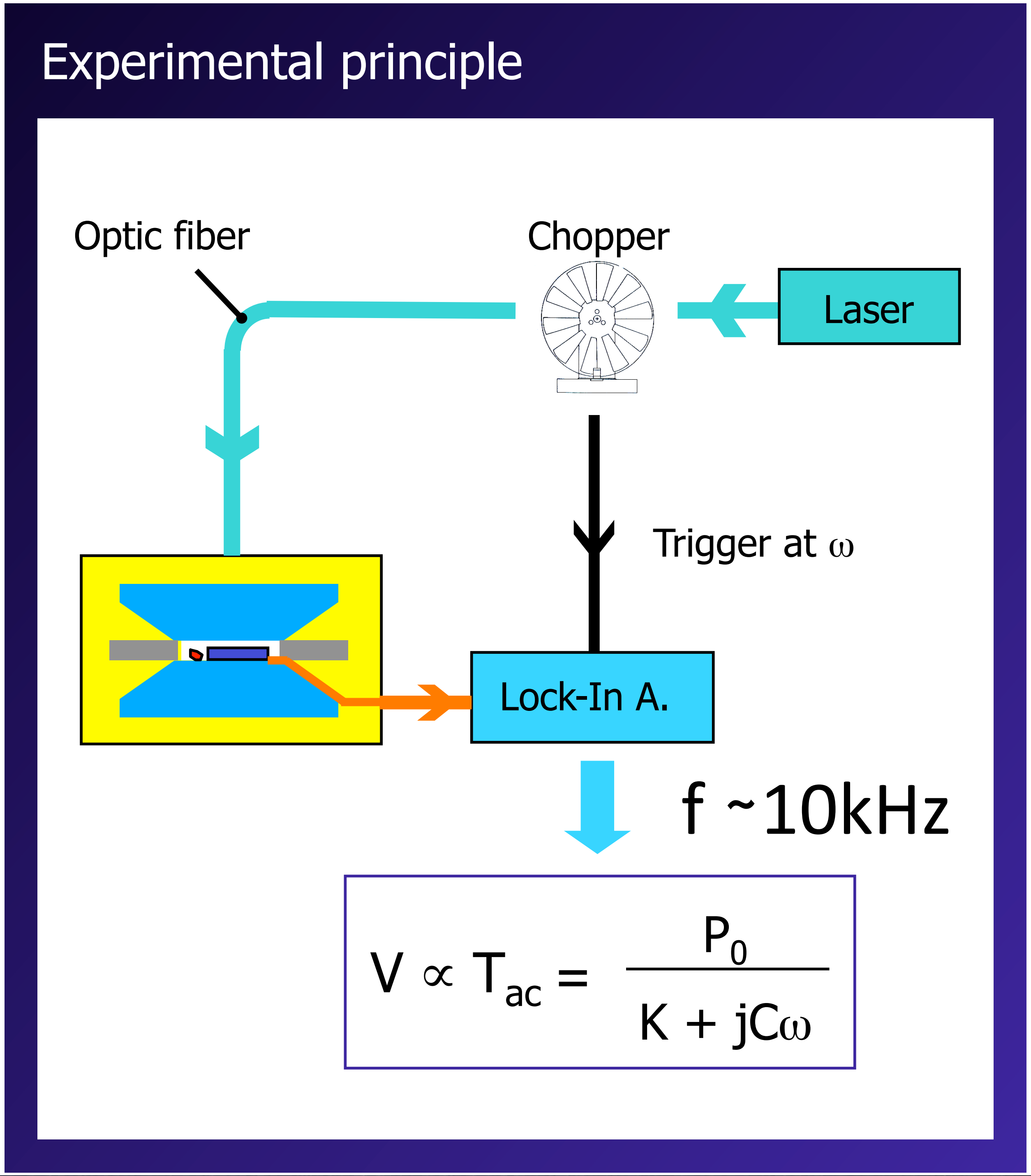
Some recent results in pnictide superconductor:
$Fe(Se_x,Te_{1-x})$ up to 28 Tesla (M10 in LNCMI)

monocrystal : m~ 50 µg and f = 16Hz



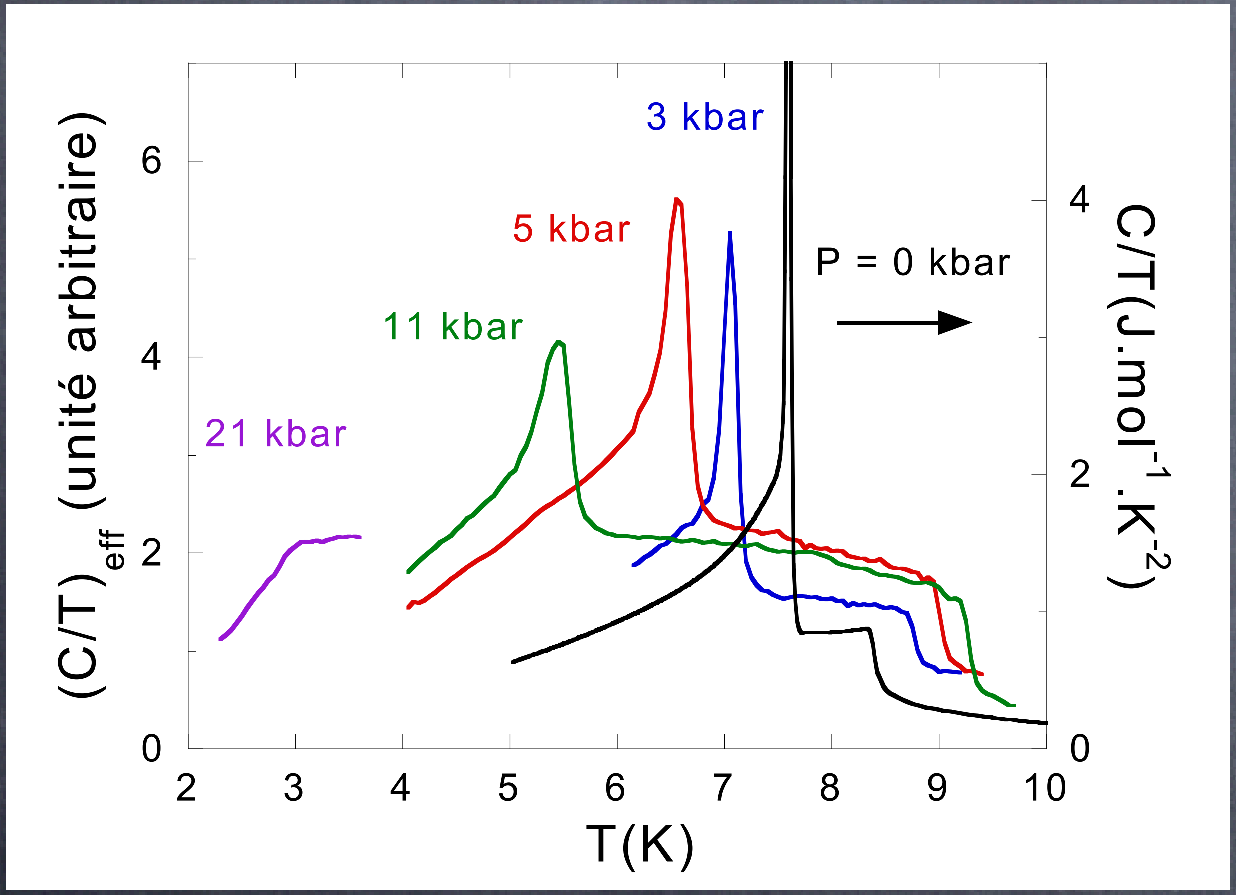
Extreme conditions: pressure 15Gpa

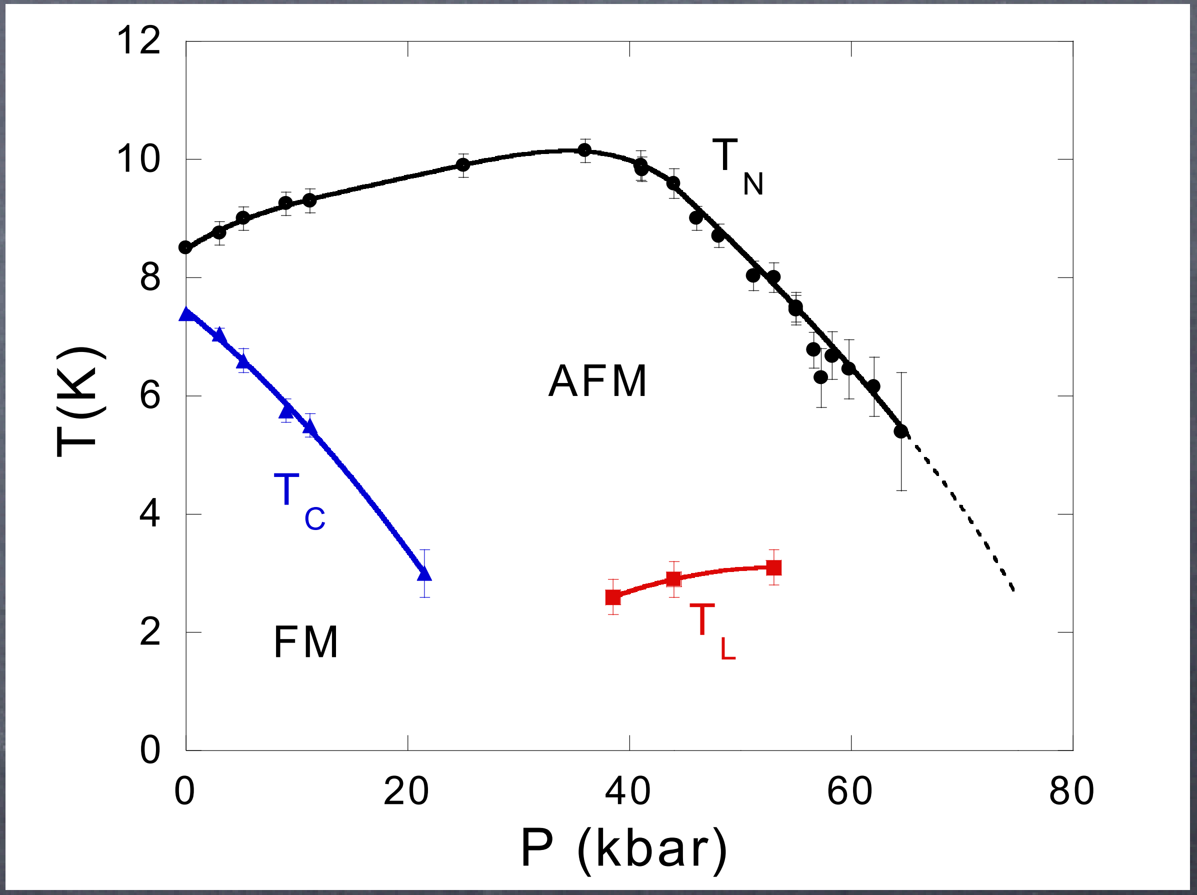




ideal tool to draw a phase diagram under pressure

$CeRu_2Ge_2$

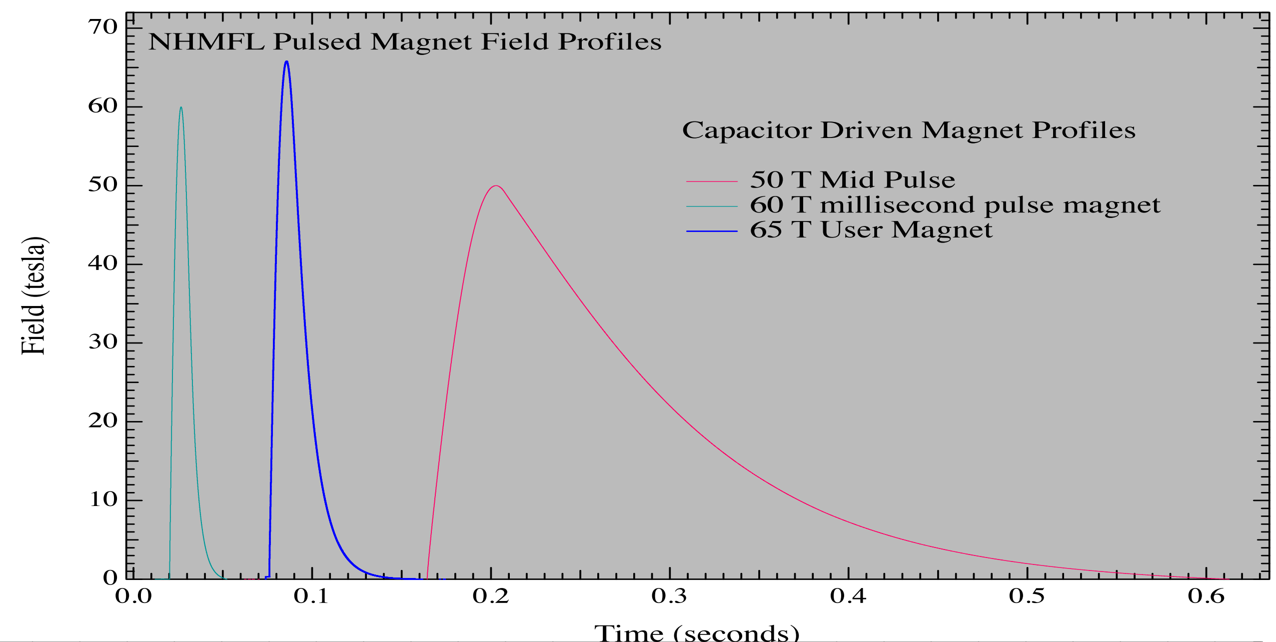




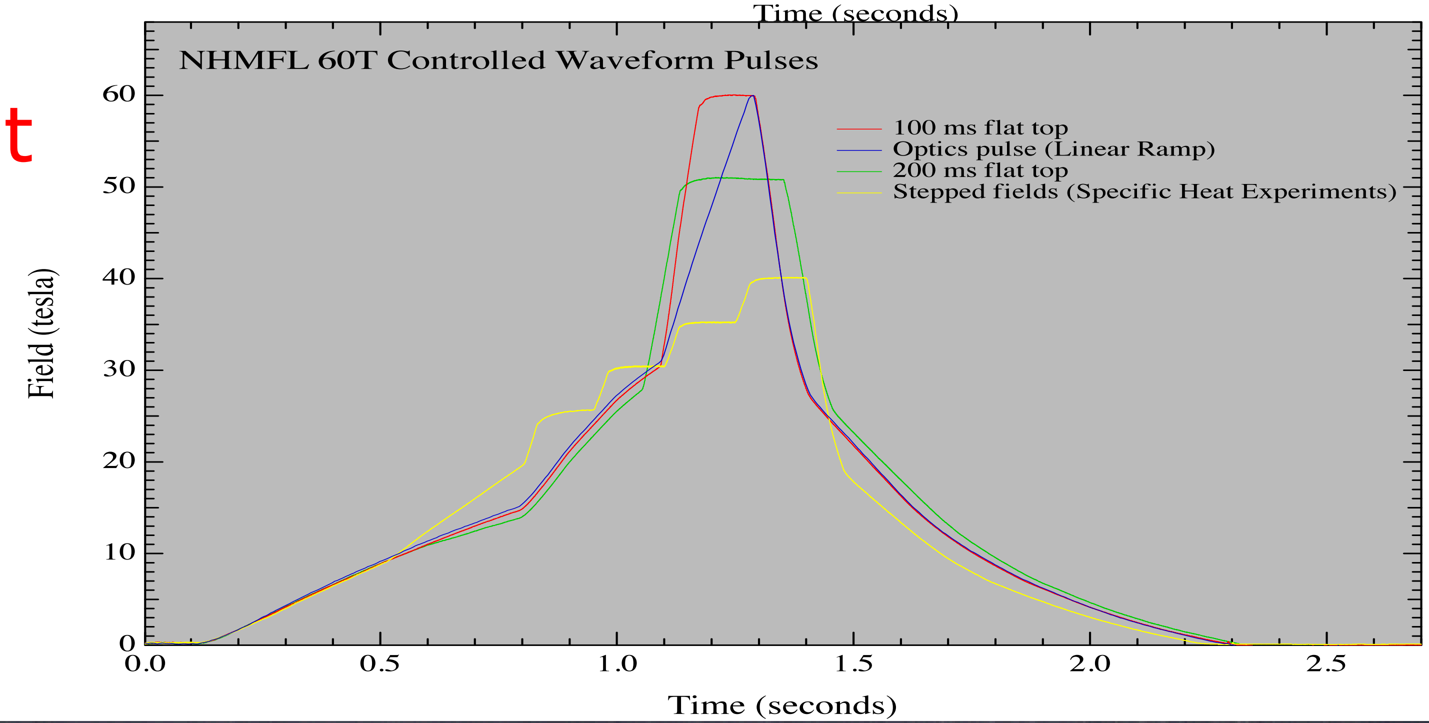
AC-Calorimetry in Capacitor-Bank-Driven Pulsed Fields

coll: Y. Kohama and M. Jaime, Los Alamos National Laboratory

Short & Mid pulsed magnet



Long pulsed magnet



AC microcalorimetry
in pulsed field :

<u>Challenges to build a calorimeter :</u>

- An external time constant 1ms :
  - adaptation of thermal link K
- An internal time constant 100 µs :
  - choice of fast enough thermometer
  - sample mounting (glue)
  - heater in good thermal contact
- Keeping a good signal/noise ratio with such a bandwidth !!!!

Some thermodynamics : magneto-caloric effect and Cp (H)

$$dq = TdS = T\left(\frac{\partial S}{\partial H}\right)_T dT + T\left(\frac{\partial S}{\partial T}\right)_H dH$$

$$P = C\frac{dT}{dt} + T\left(\frac{\partial S}{\partial H}\right)_T \frac{dH}{dt}$$

no heating

$P = k\ (T_b - T)$

MCE

$$\frac{\Delta T}{T} \propto \left(\frac{\partial S}{\partial H}\right)_T \frac{\frac{dH}{dt}}{k}$$

ac heating

$P = k\ (T_b - T) + P_{ac}$

Cp (H)

$$T_{ac} = \frac{P_{ac}}{k + \left(\frac{\partial S}{\partial H}\right)_T \frac{dH}{dt} + jC\omega}$$

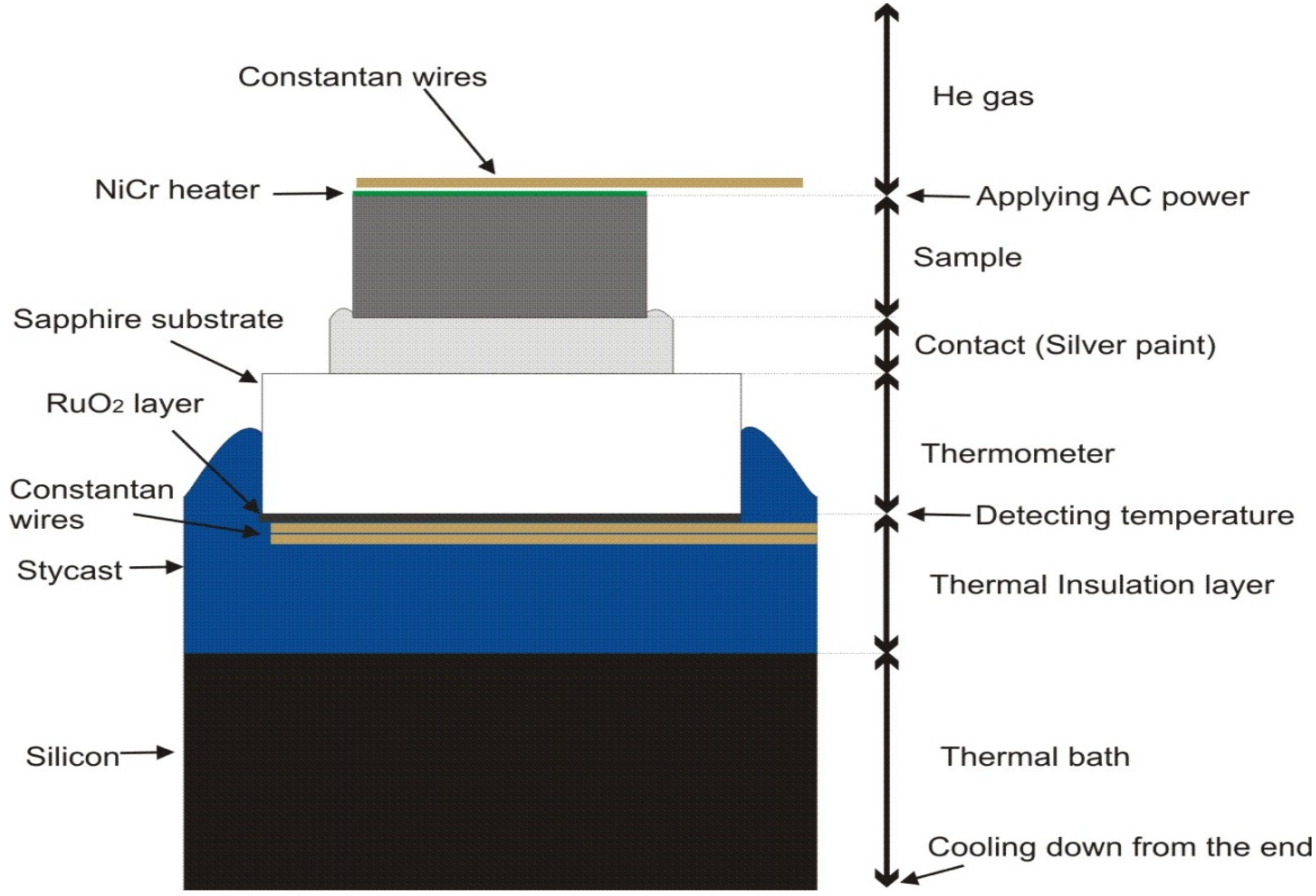
Sample holder

Heater (P)

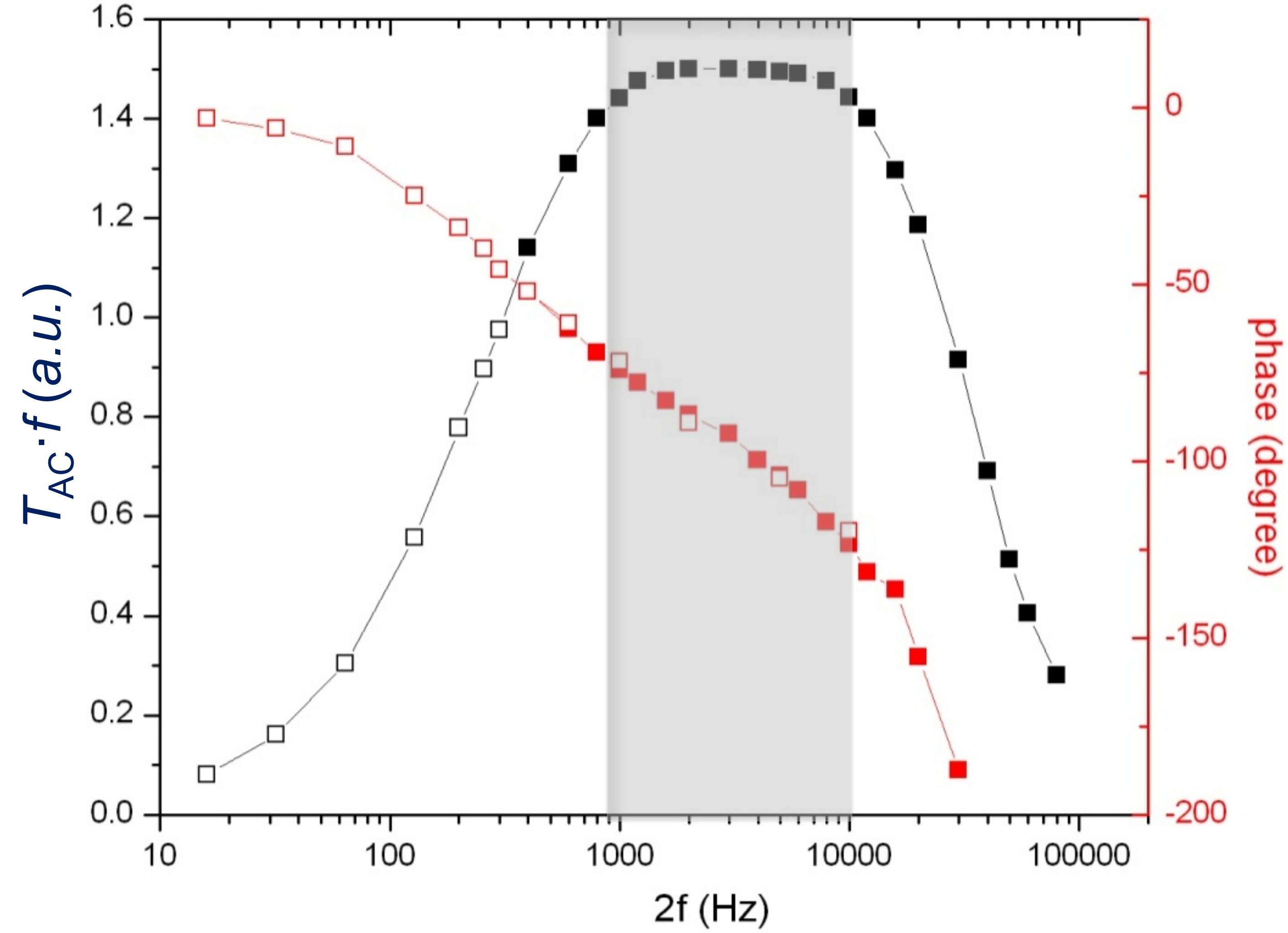
T (Kelvin)

Thermal link

Bath



frequency tests



$Sr_3Cr_2O_8$

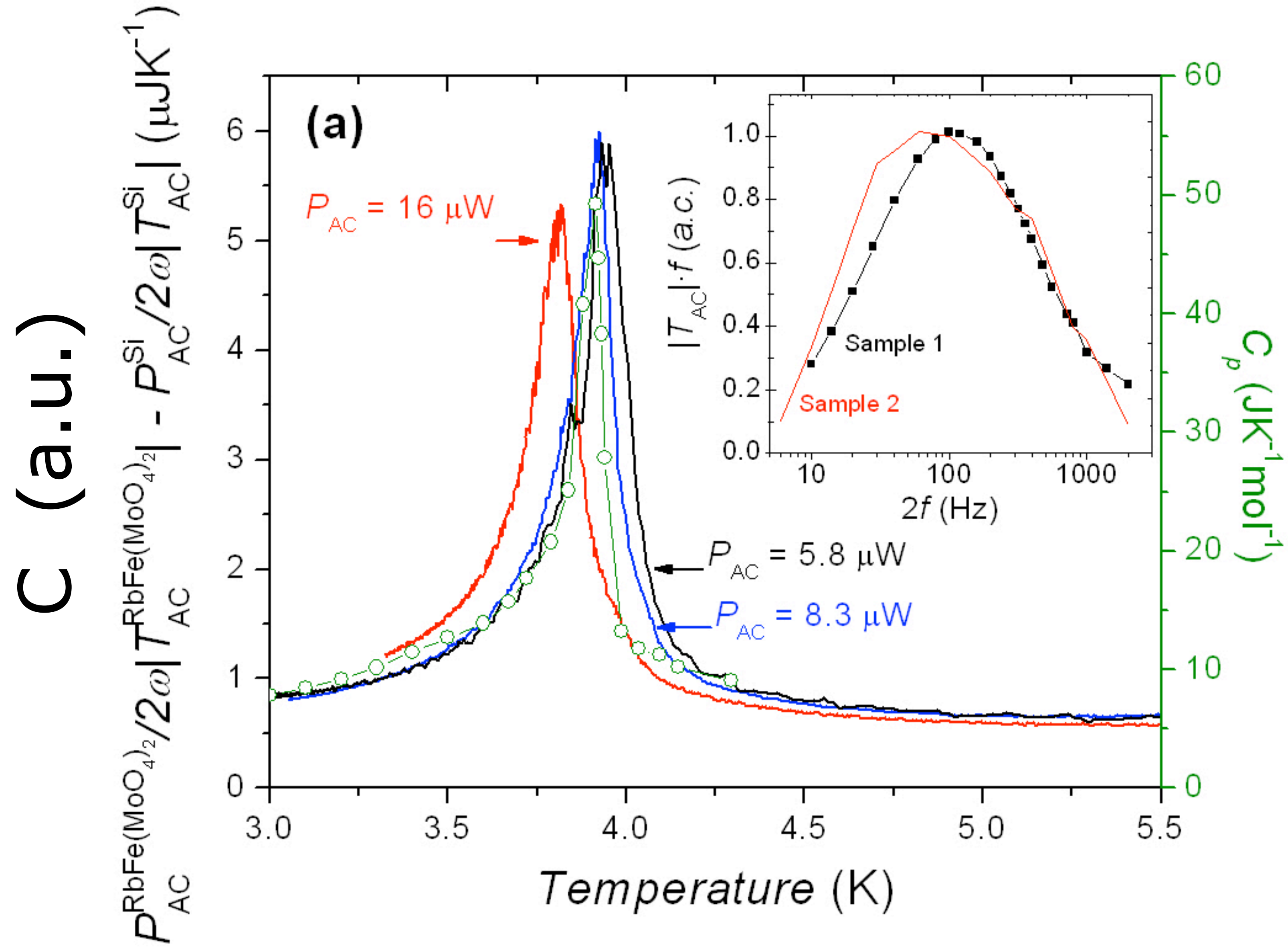
4K

C=1.1 10^{-8} J/K

1kHz < *f* < 10 kHz !!

tests in zero field

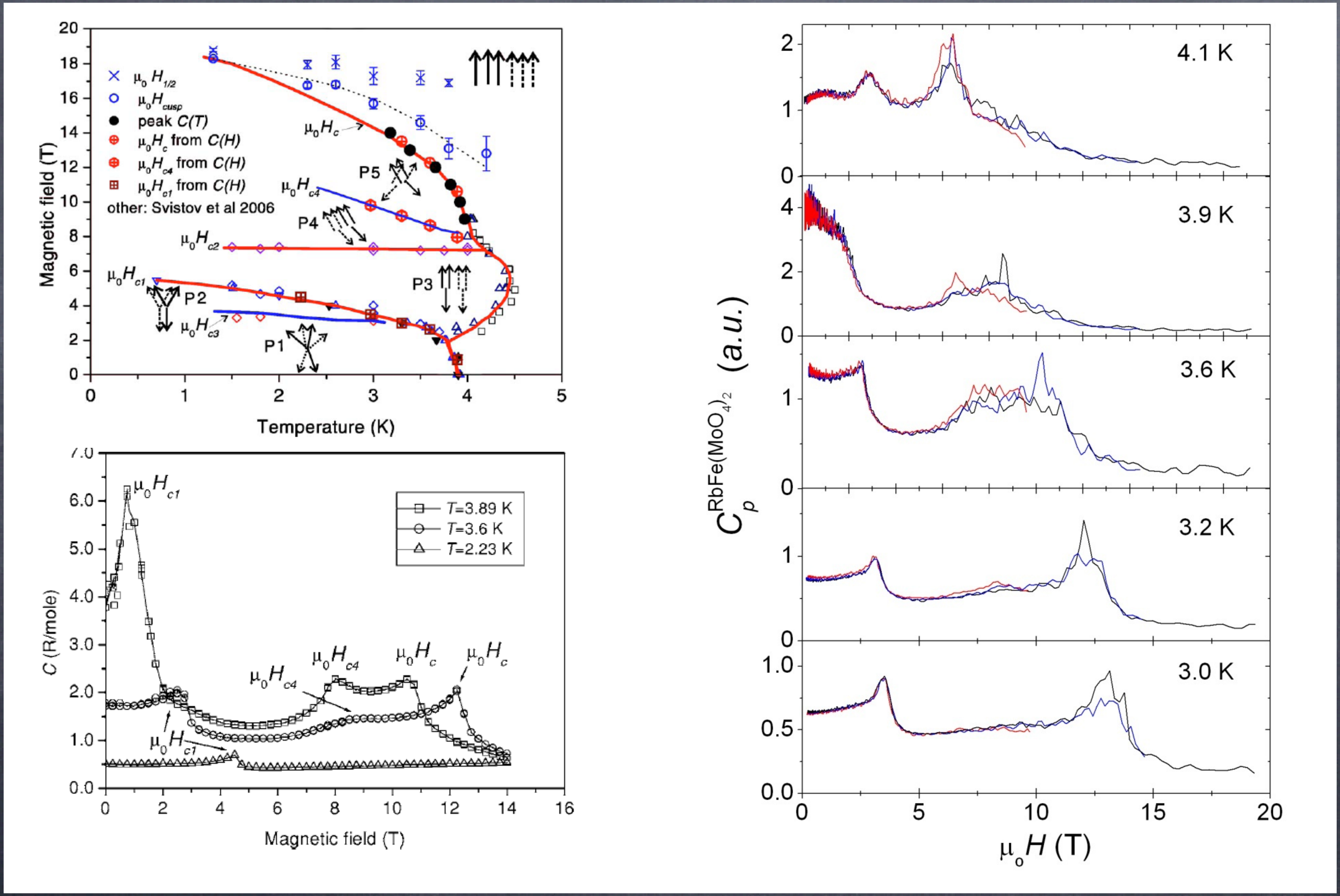
crystal of triangular antiferomagnet $RbFe(MoO_4)_2$



400 Hz

2.5 K/s !!!!

tests in moderate pulsed fields



Thank you

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