

High Magnetic Field Investigation of a Low-Dimensional Organic Conductor

$\text{Per}_2[\text{Pt}(\text{mnt})_2]$

Elizabeth L. Green

NHMFL: J.S. Brooks, P.L. Kuhns, A.P. Reyes, E.S. Choi

Portugal: M. Almeida, M.J. Matos, R.T. Henriques

UCLA: S. Brown, J. Wright



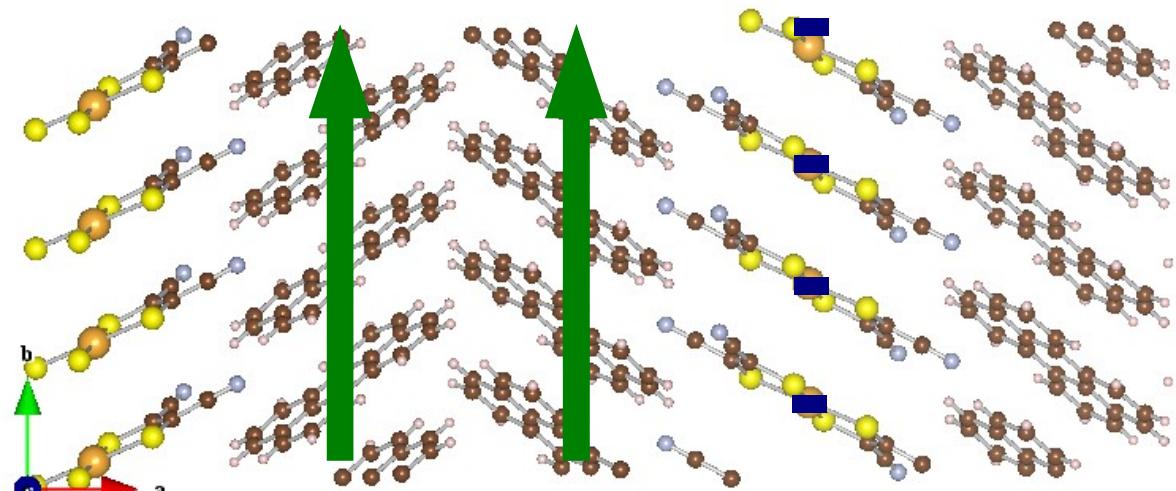
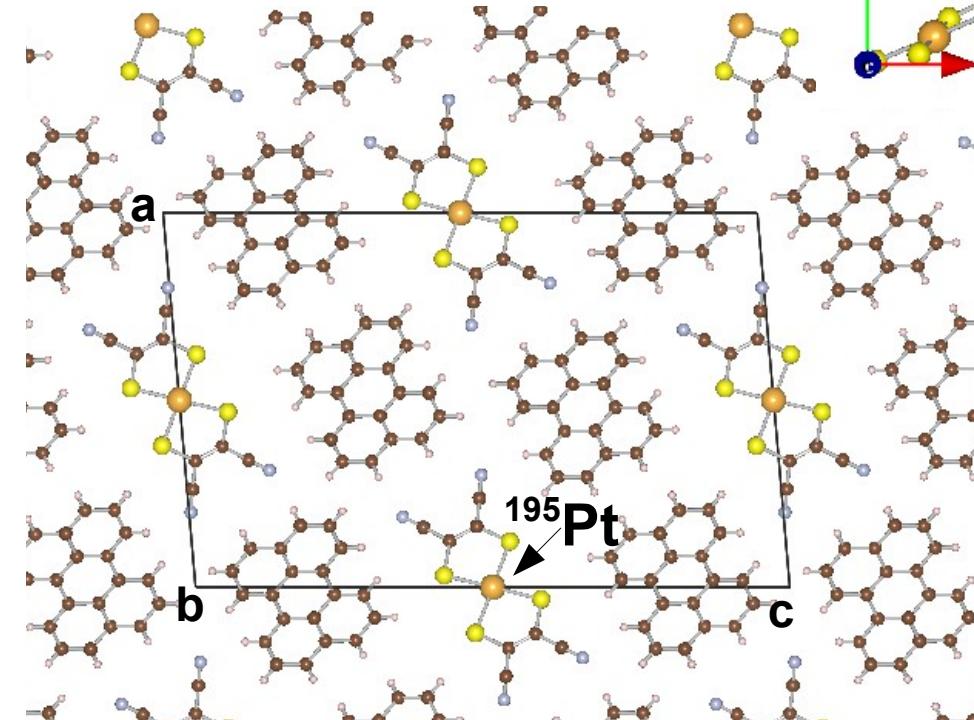
Conference attendance sponsored by ICAM (NSF DMR-0844115)



Crystal Structure

- Localized e^- on Pt chain
- $\frac{1}{4}$ filled conduction bands

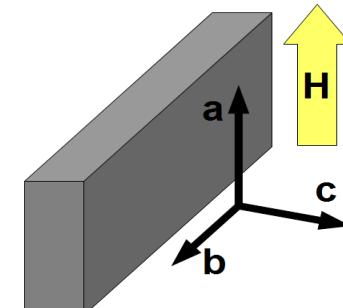
(mnt = maleonitriledithiolate)

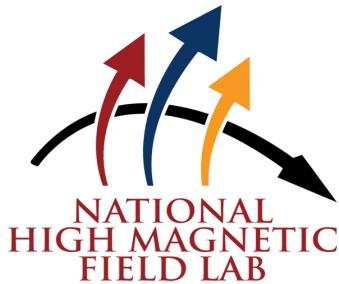


Per
Conduction
electrons

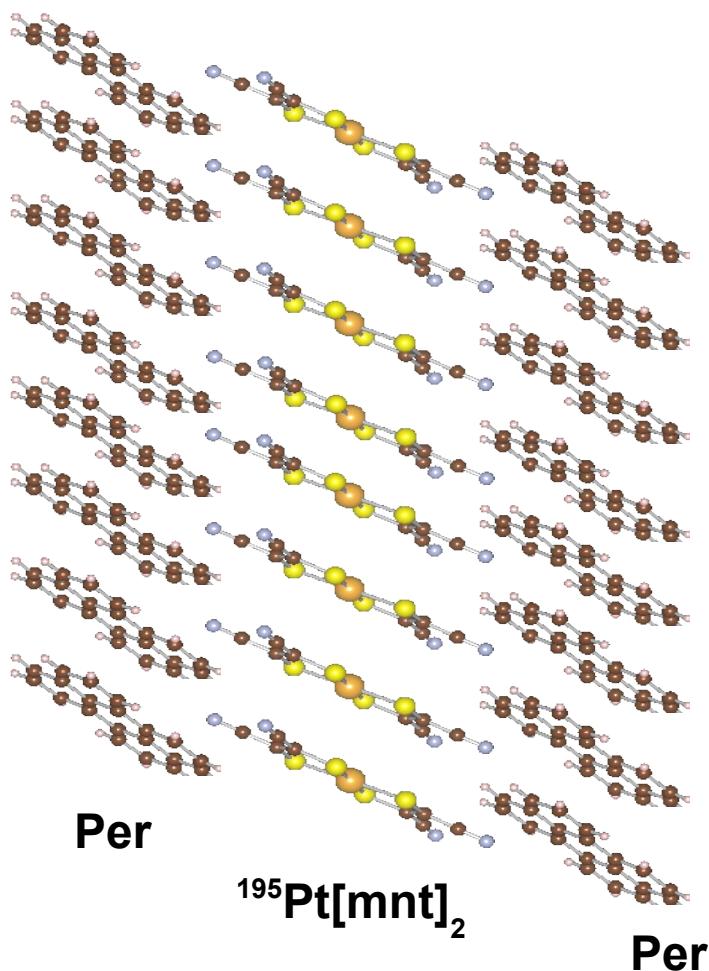
$^{195}\text{Pt}[\text{mnt}]_2$
Localized
electrons

Pt
H
C
S
N

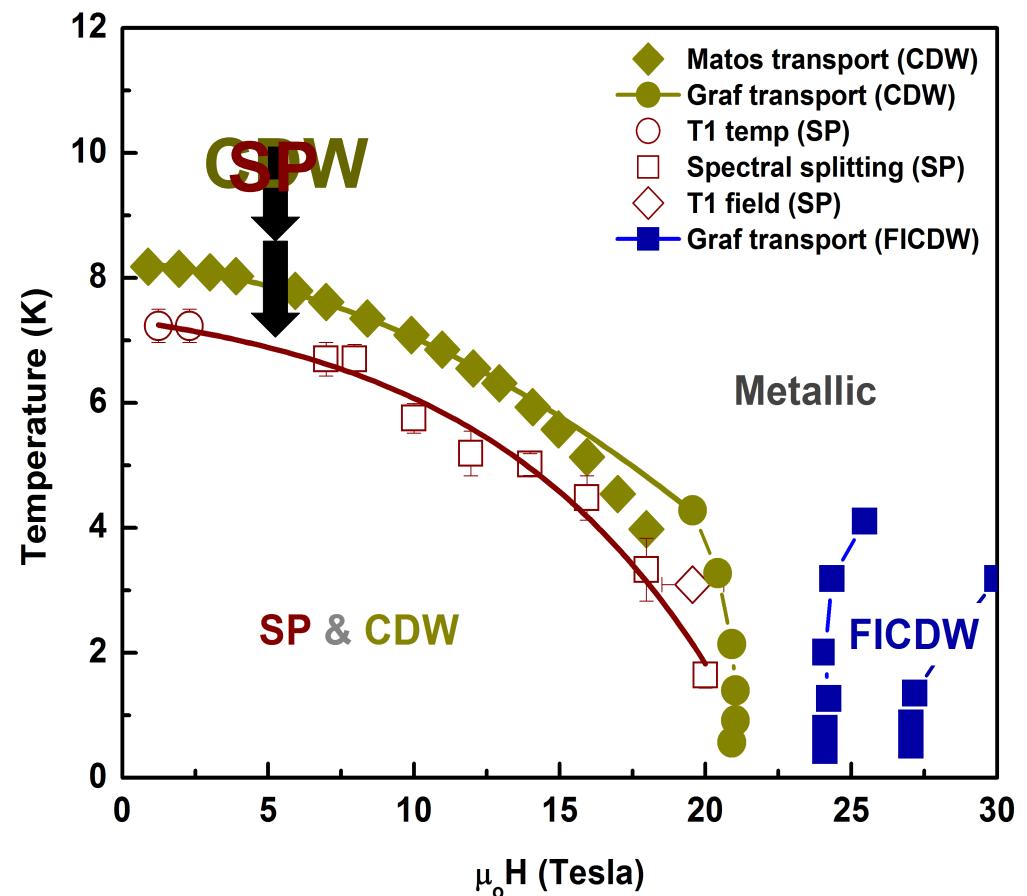




Crystal Structure

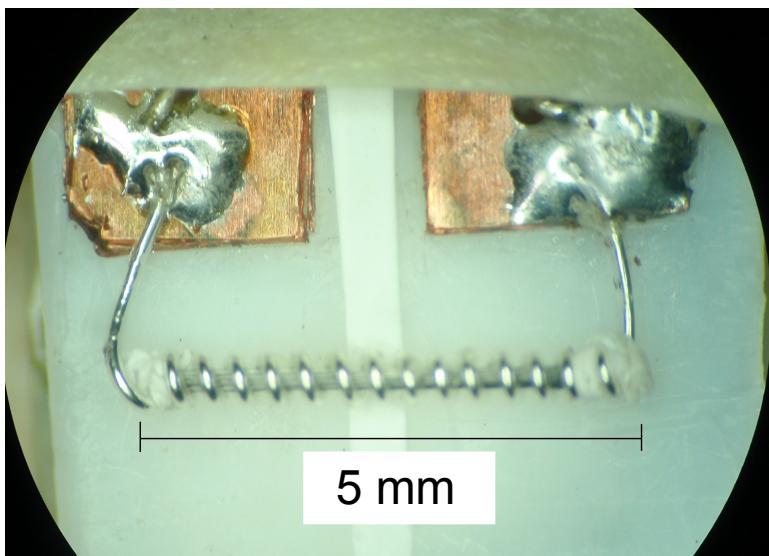


Note: Lattice distortion is very small!!

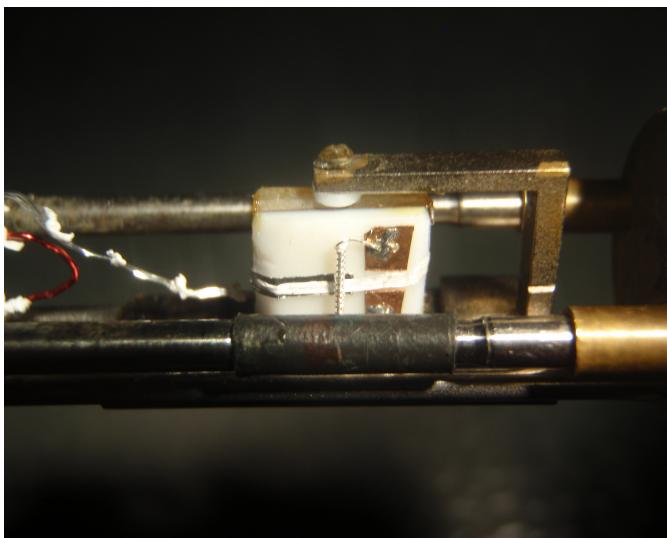


- Green, Brooks, et al *PRB*, **84**, 121101(R) (2011)
- Matos, M., et al., *Phys Rev B*, **54**, 15307 (1996)
- Graf, D., et al., *Phys Rev Letters*, **93**, 076406 (2004)

Experimental Set-up

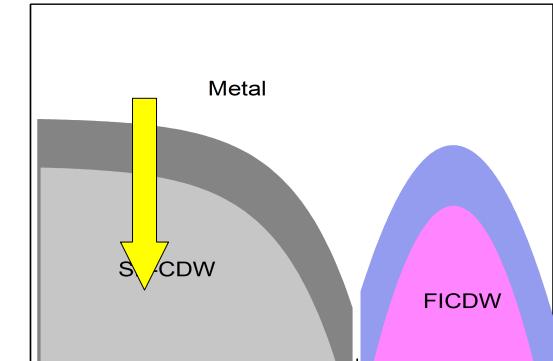
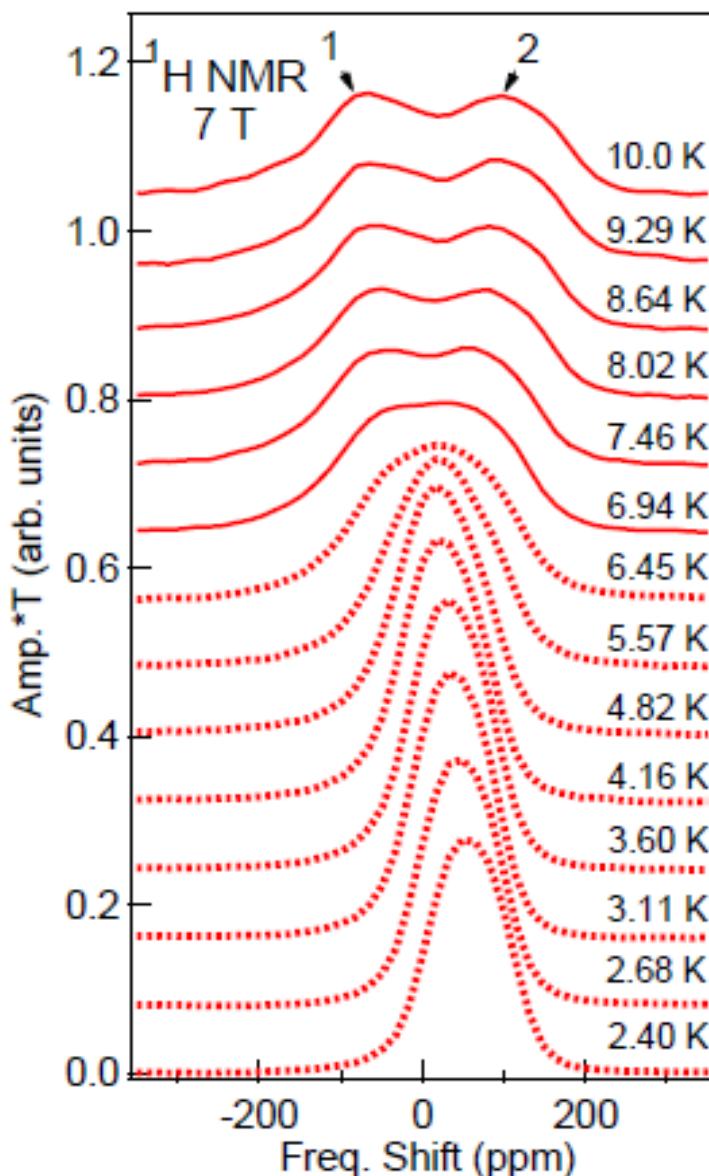


- **^1H NMR / Low proton background**
 - Ag wire / PTFE insulation
 - Low ^1H background probe
- **Small single crystal**
 - 5mm x 0.18 mm x 50 μm
 - Few spins
 - $^1\text{H} \rightarrow \sim 10^{18}$
 - $^{195}\text{Pt} \rightarrow \sim 10^{17}$
- **High Frequencies**
 - $\gamma = 42.5774 \text{ MHz/T}$ (for protons)

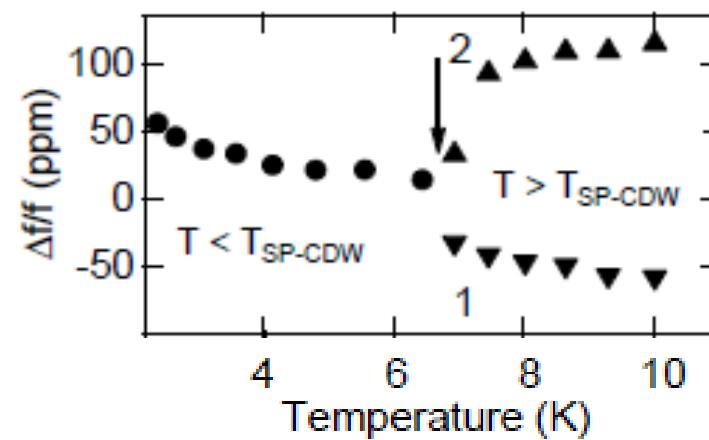




Temp Dep Spectra

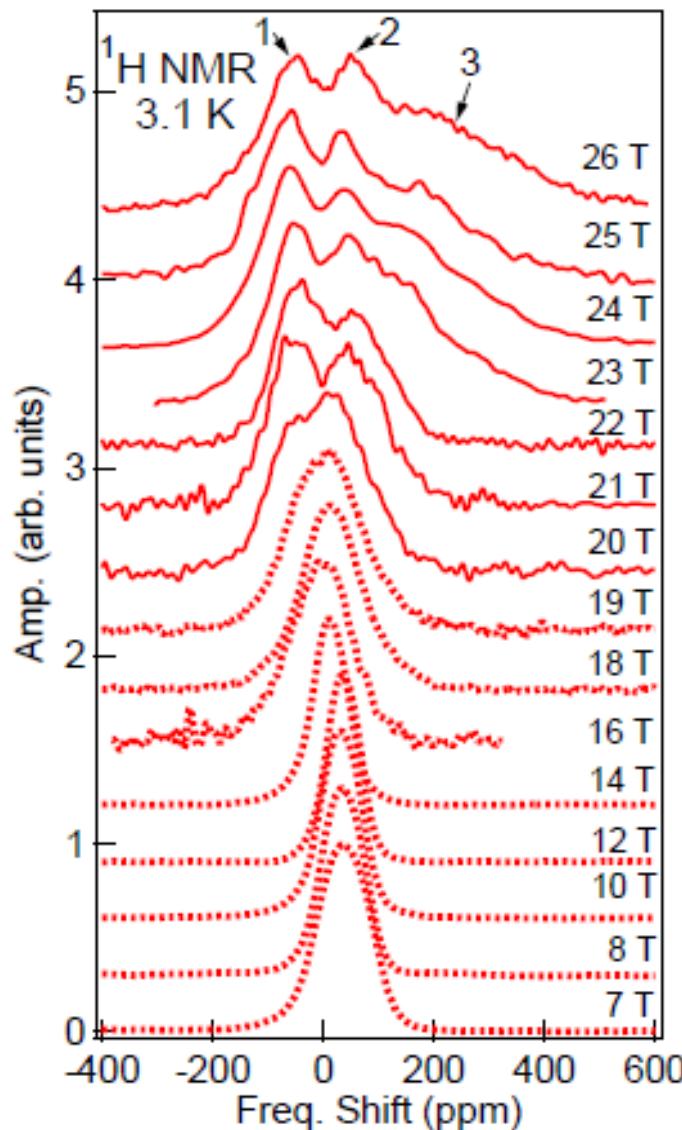
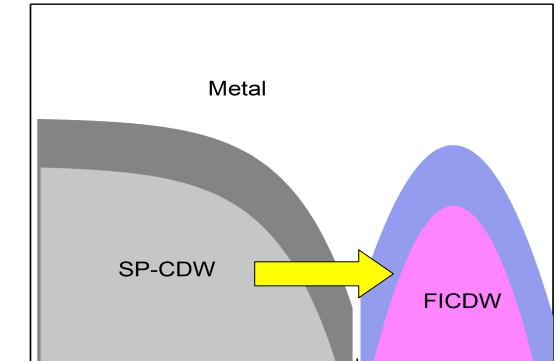


- Peak splitting indicates SP-transition
- Distribution of local field

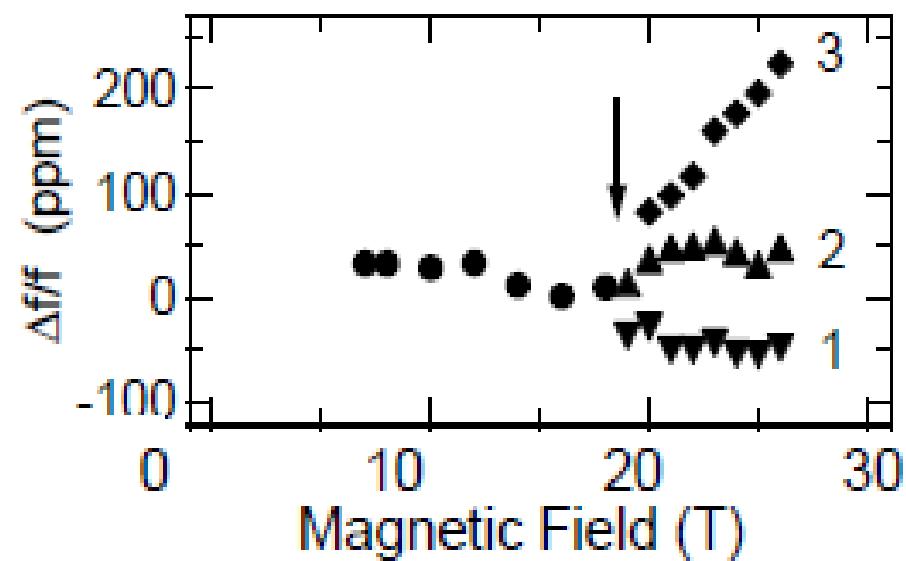




High Field Spectra

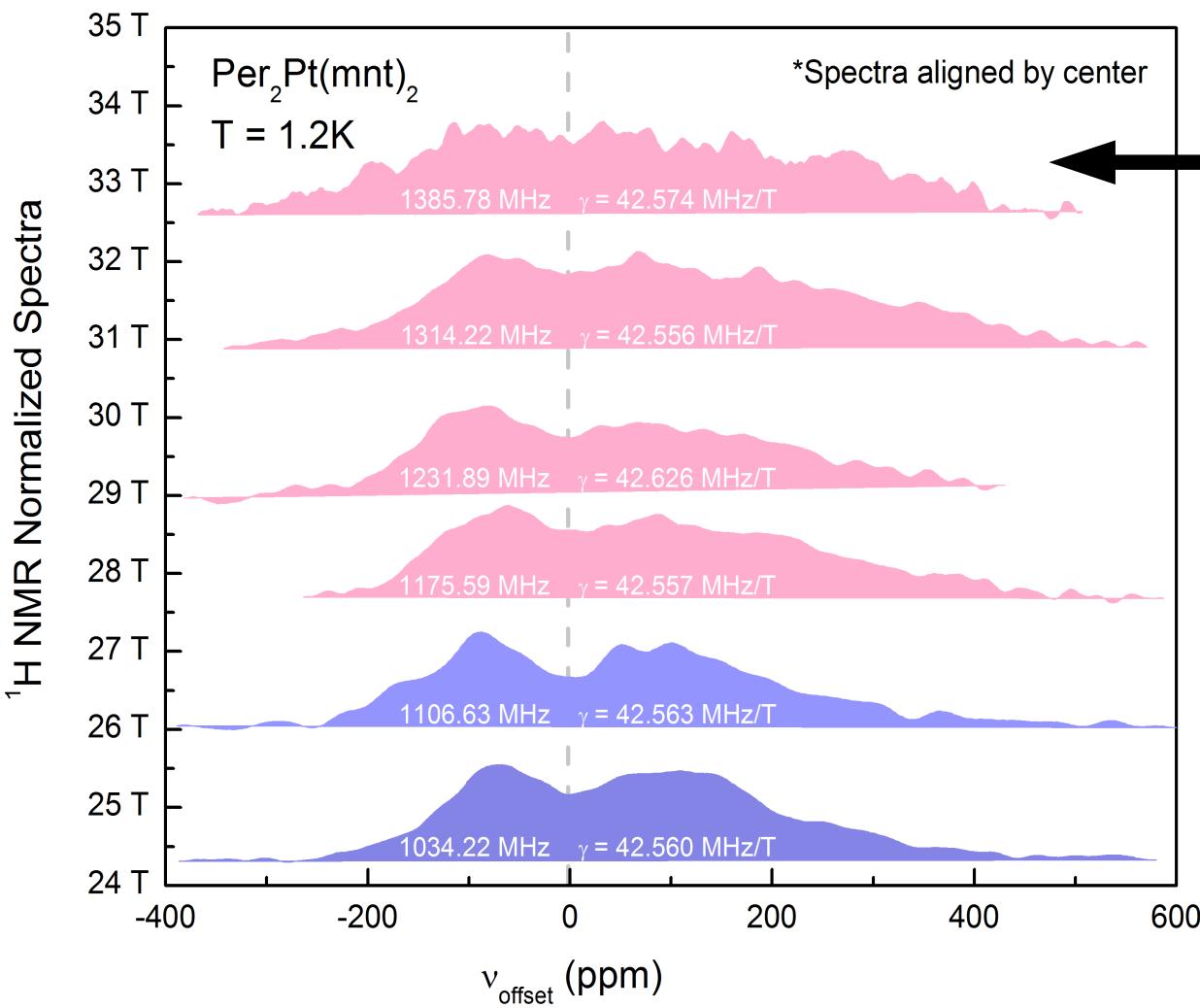
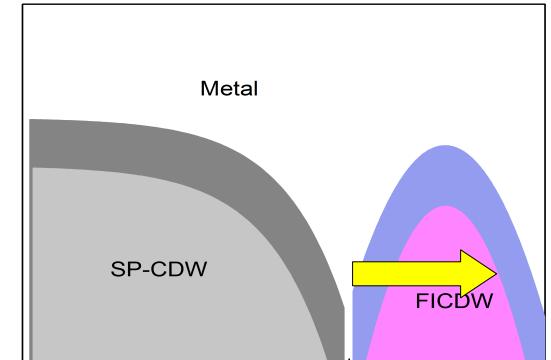


- Broadens and third peak emerges
- Displays Zeeman-like behaviour

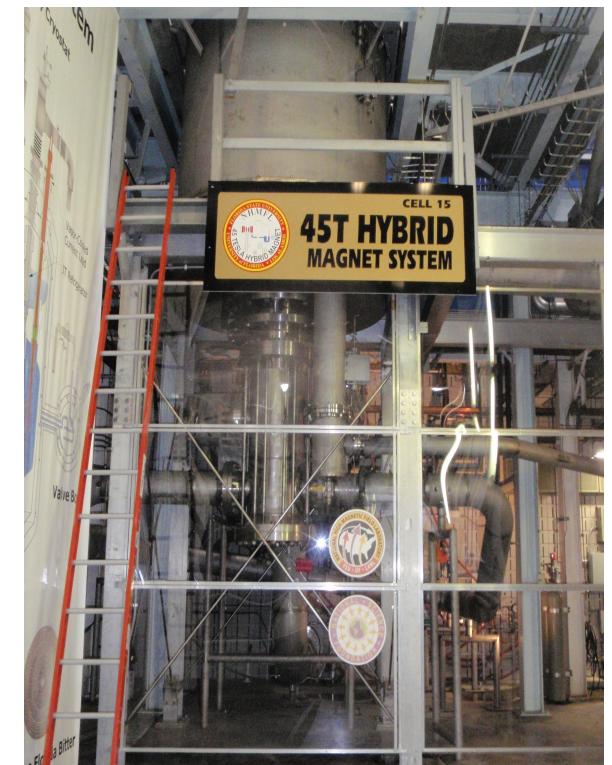




High(er) Field Spectra

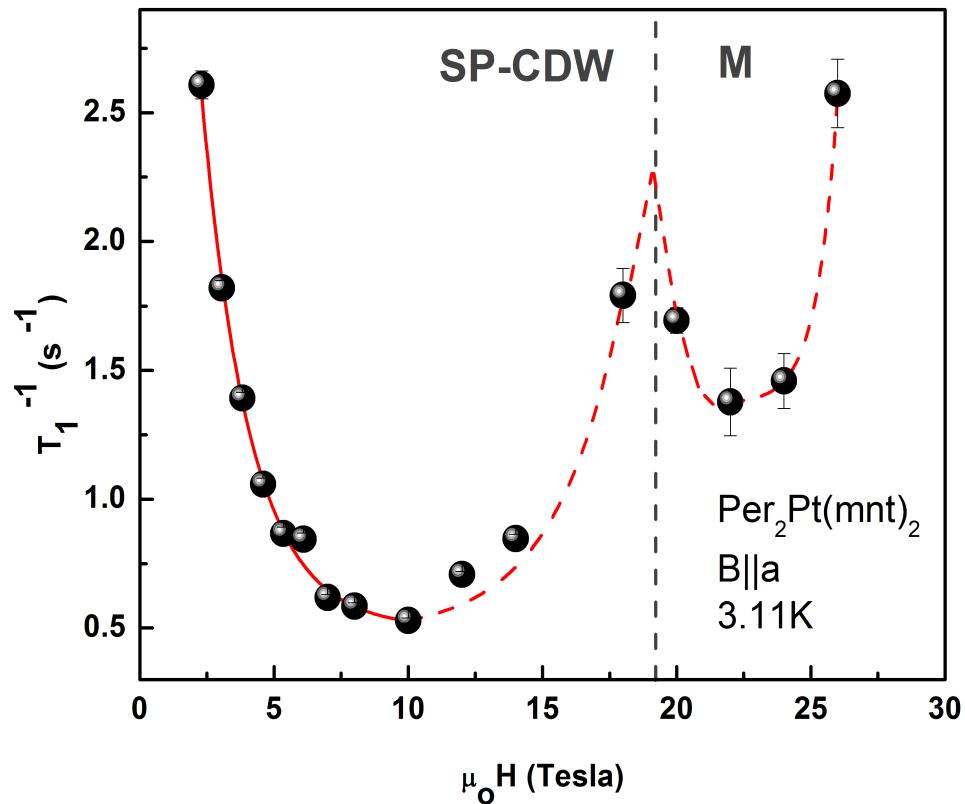


Broadening due to
localized moment

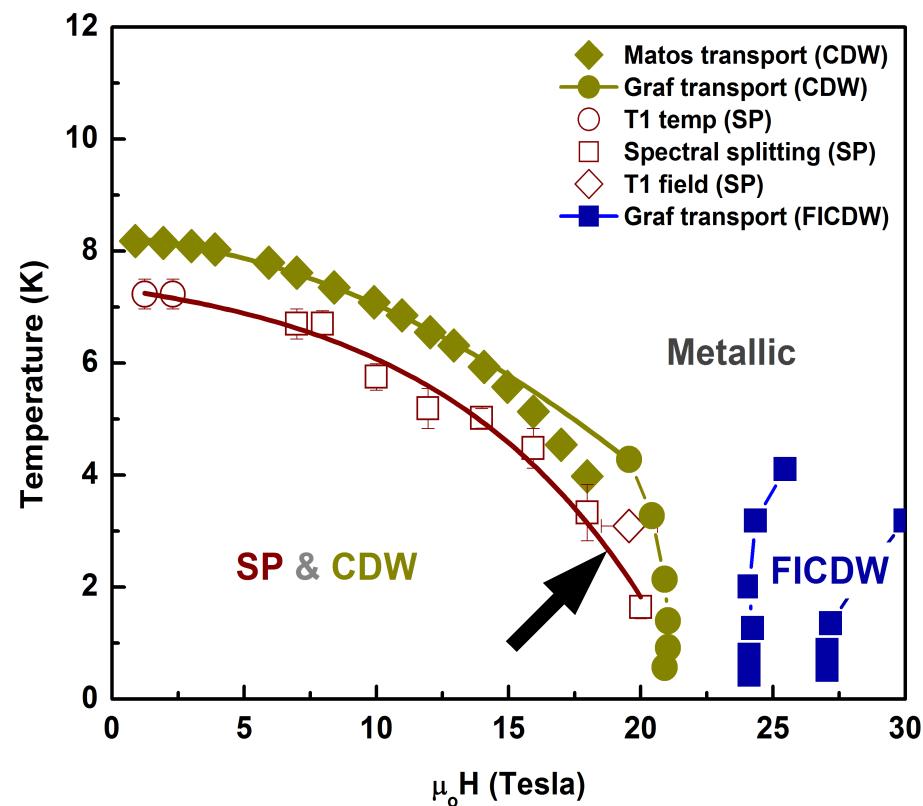


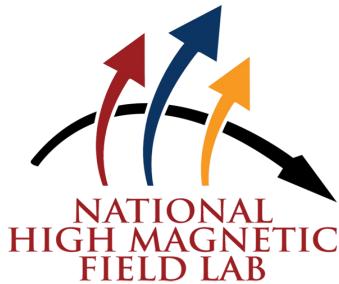


High Field T_1

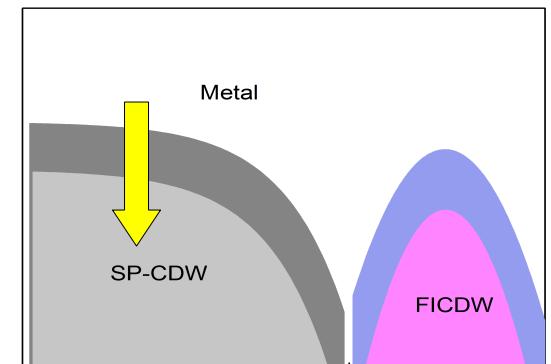
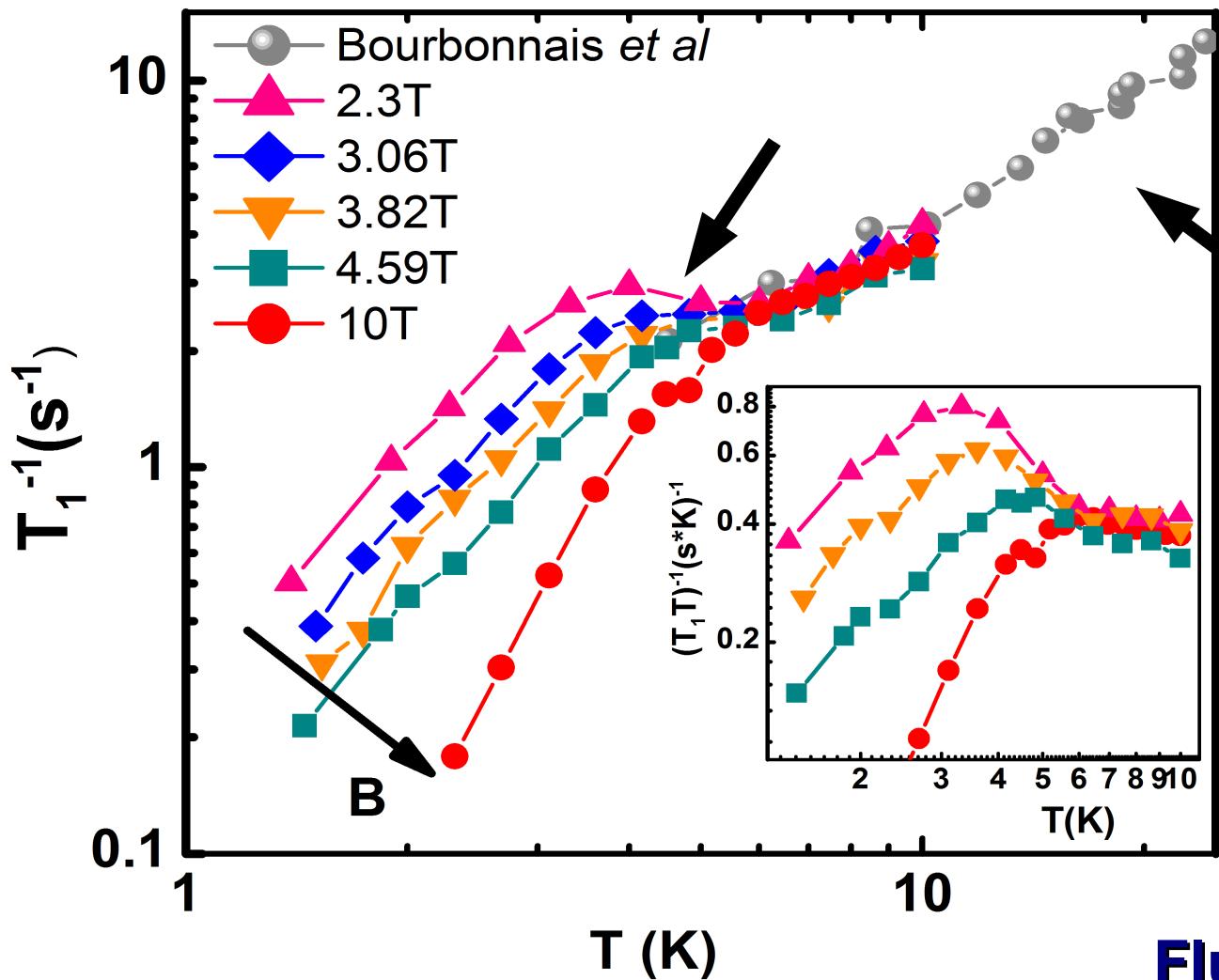


- T_1 fast at low fields





T_1 measurements



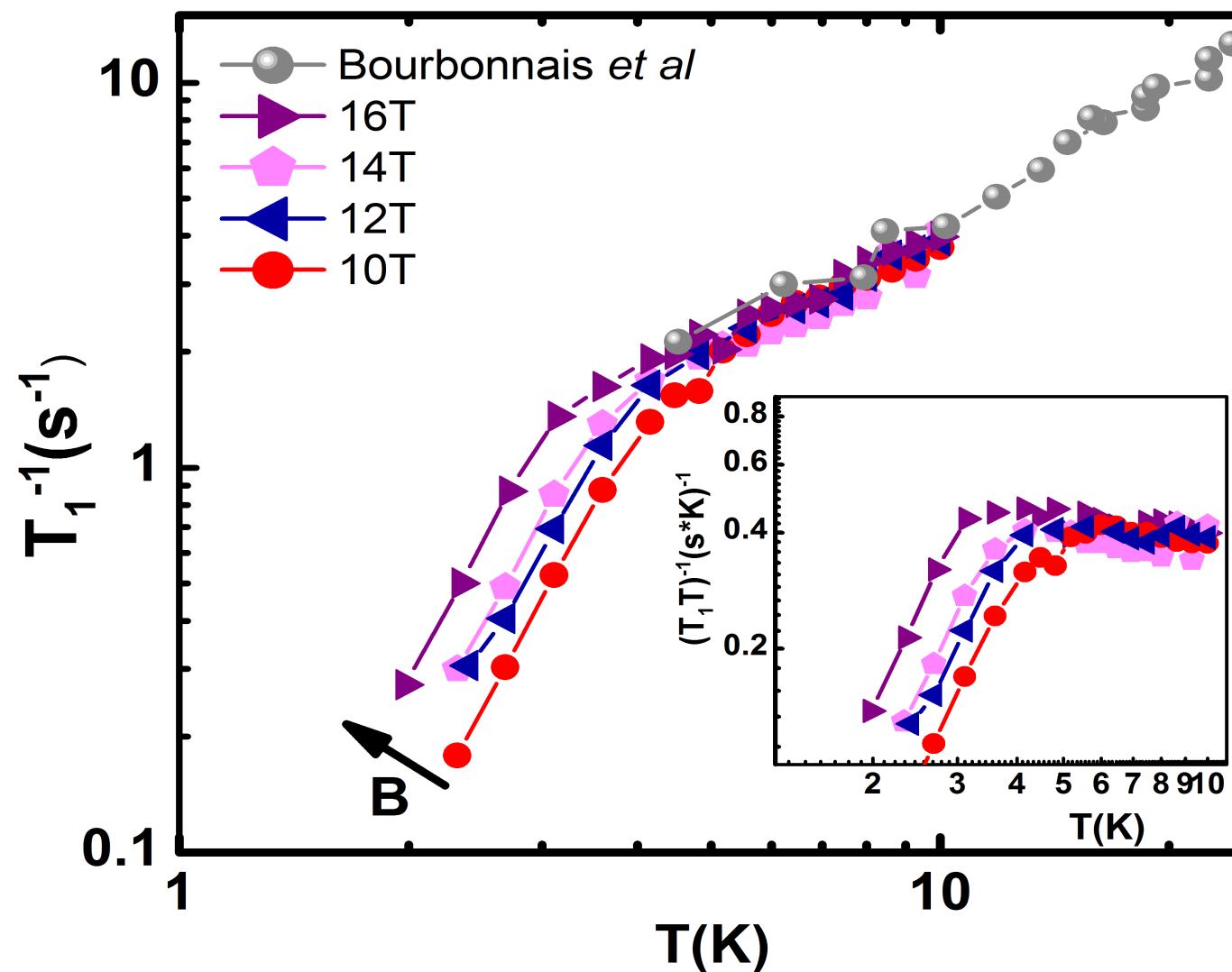
- Agreement
- Linear temperature dependence
- Field-dependent

Bourbonnais, C., *et al.*, *Phy Rev B*, 44, 641-651 (1991)
 Green, Brooks, *et al*, unpublished data

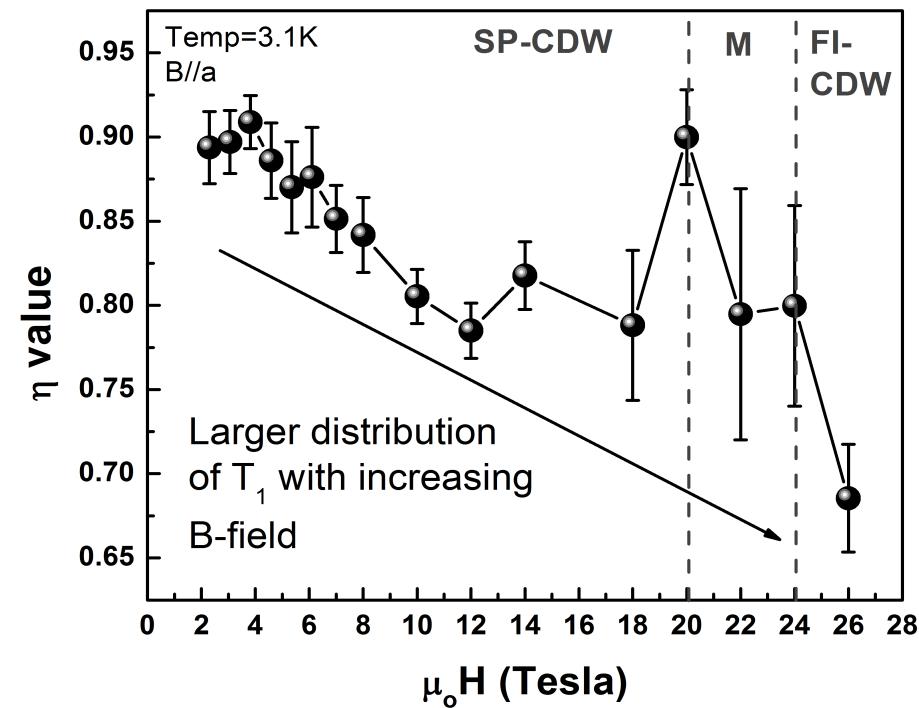
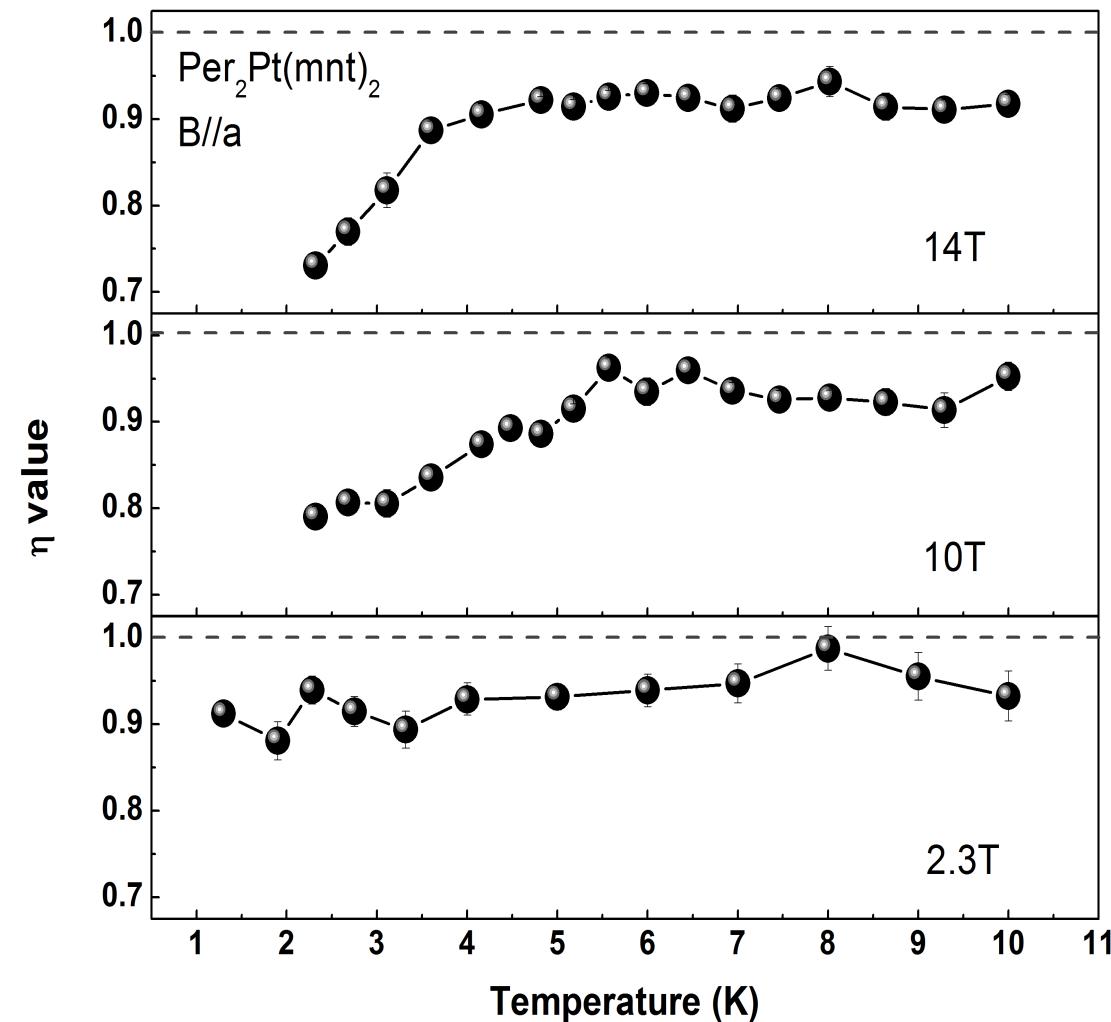
**Fluctuations on Pt site
dominate T_1 mechanism**



T_1 measurements



Distribution of T_1



- Distribution of relaxation rates increases with increasing field

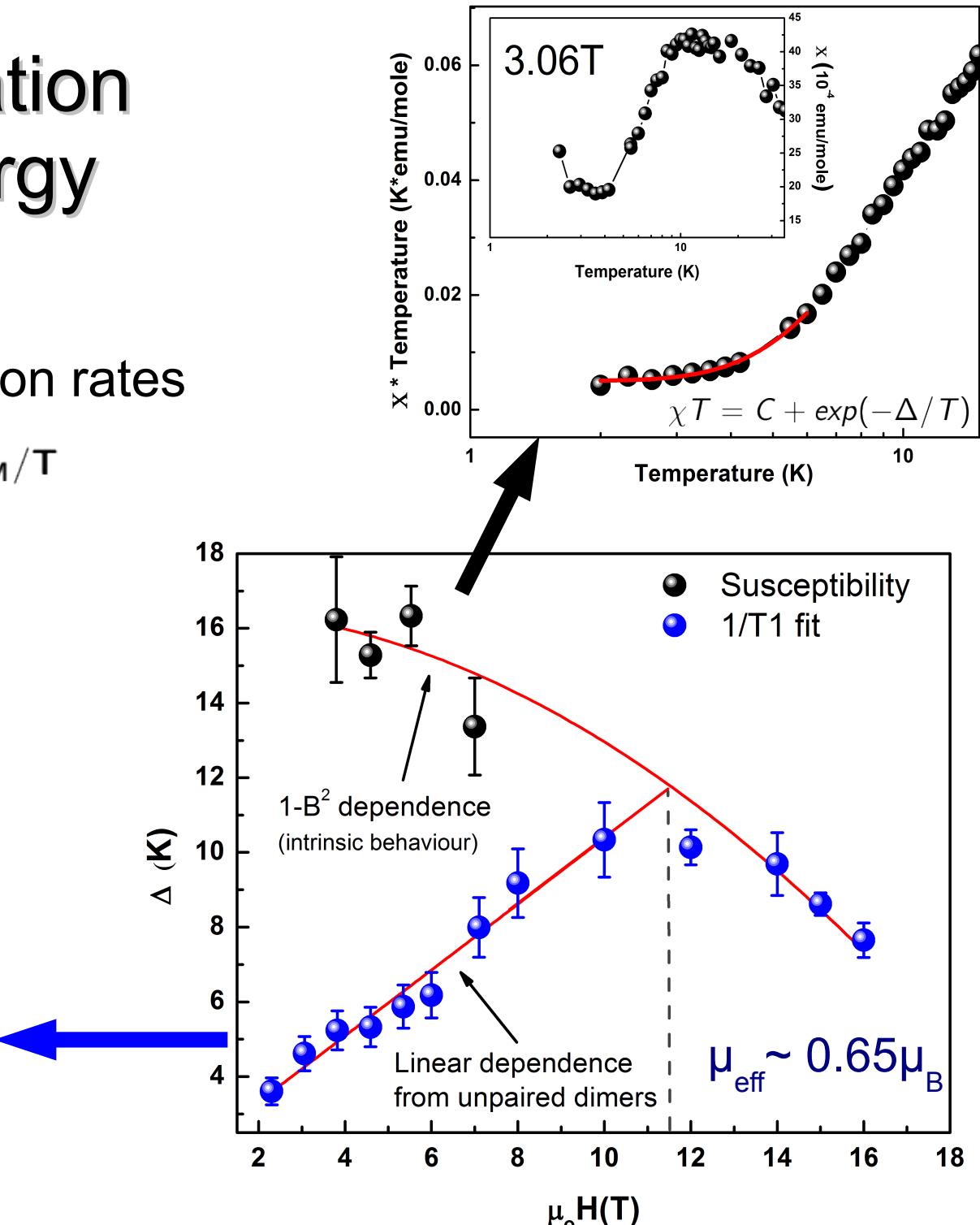
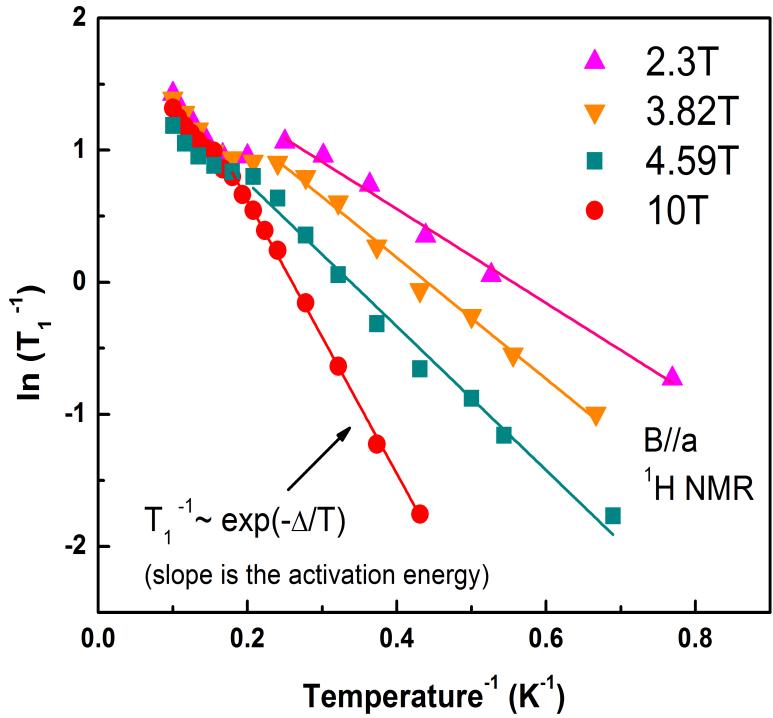
$$M = M_o(1 - \exp(-t/T_1)^\eta)$$



Activation Energy

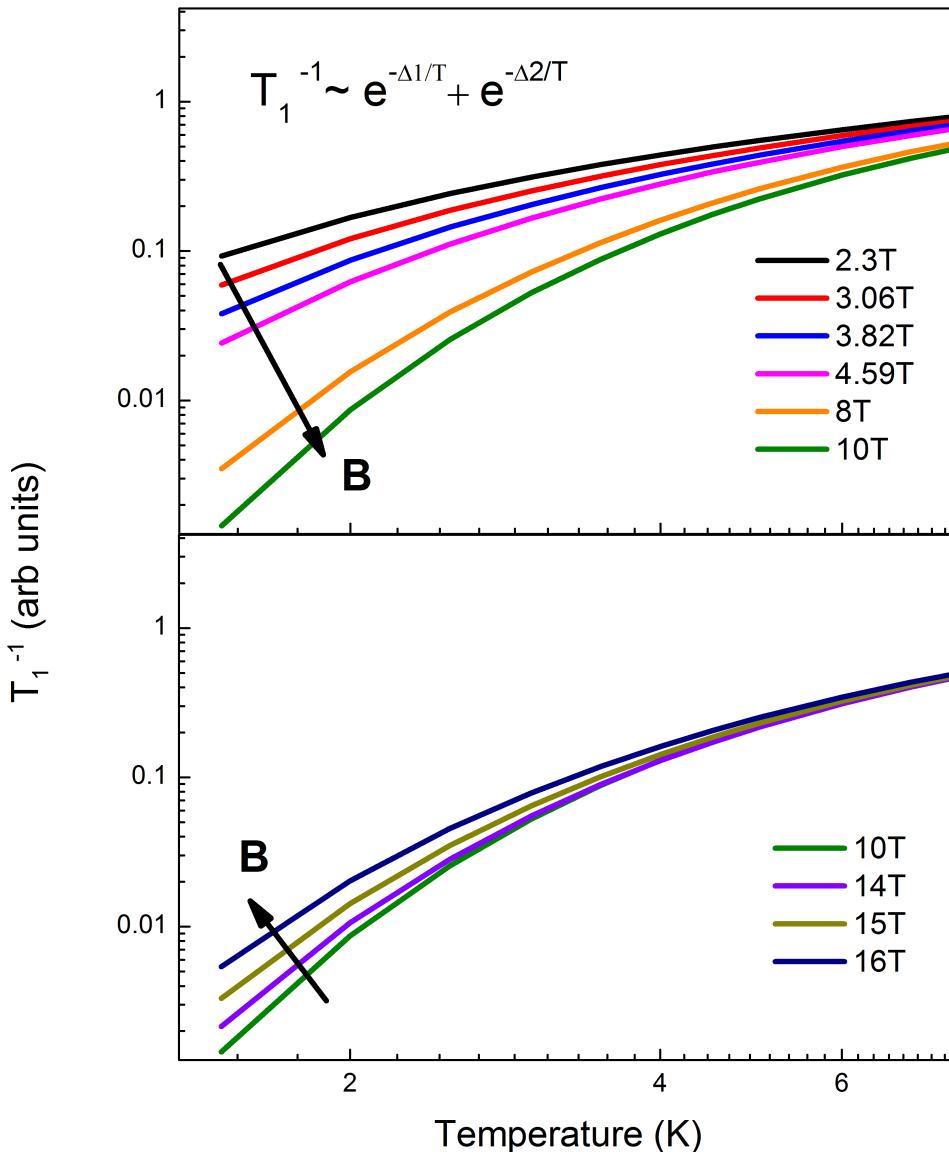
- Two contributions to relaxation rates

$$T_1^{-1} \sim e^{-\Delta_{SP}/T} + e^{-\Delta_{PM}/T}$$





Two Spin System Model



- Two system model replicates the field dependent T_1 data

$$T_1^{-1} \sim \underbrace{e^{-\Delta_{SP}/T}}_{\text{SP}} + \underbrace{e^{-\Delta_{PM}/T}}_{\text{PM}}$$

- Intrinsic behaviour of SP-chain

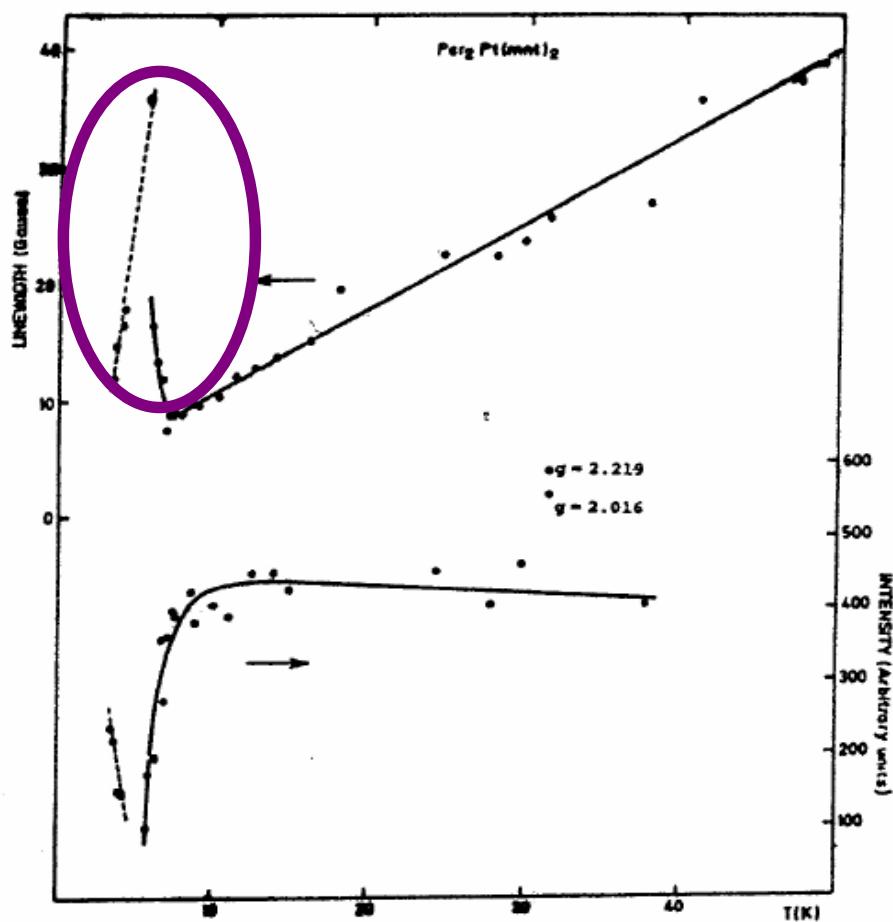
$$\Delta_{SP} \sim \Delta_o (1 - B^2)$$

- Residual PM contribution (unpaired dimers)

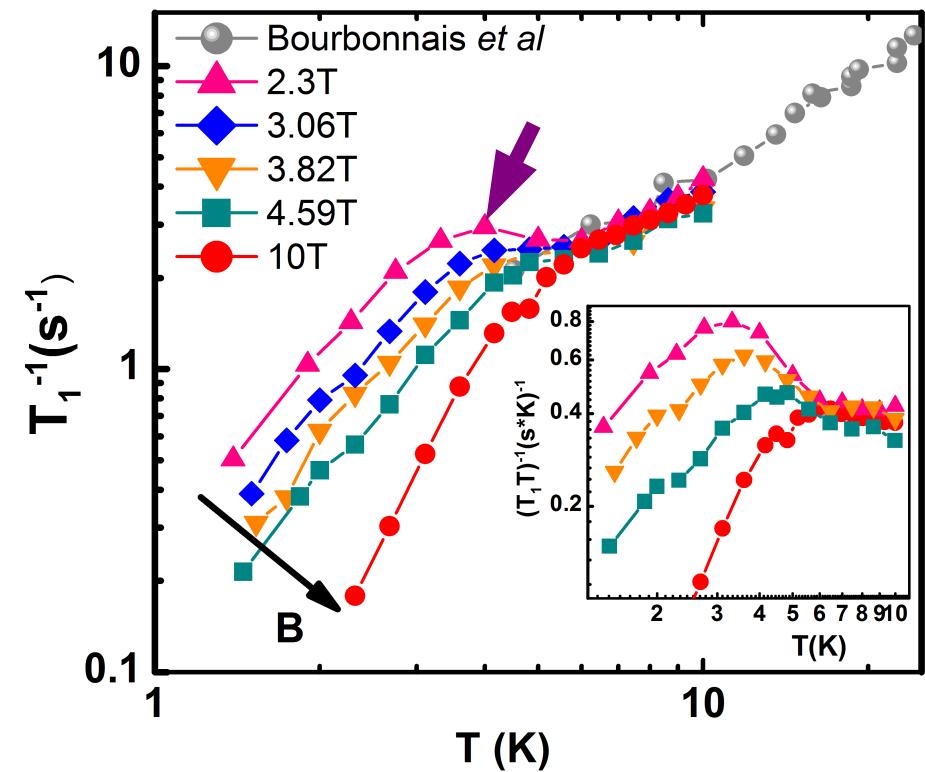
$$\Delta = \frac{\mu_{eff} g}{k_b} B$$



EPR



R. T. Henriques, L. Alcácer, M. Almeida, S. Tomic
Molecular Crystals and Liquid Crystals, **120**, 237-241 (1985)



$$T_1^{-1} \sim e^{-\Delta_{SP}/T} + T_{1epr}^{-1} e^{-\Delta_{PM}/T}$$

J.S. Waugh, C.P. Slichter, Phy Rev B, **37**, 4337(R) (1988)

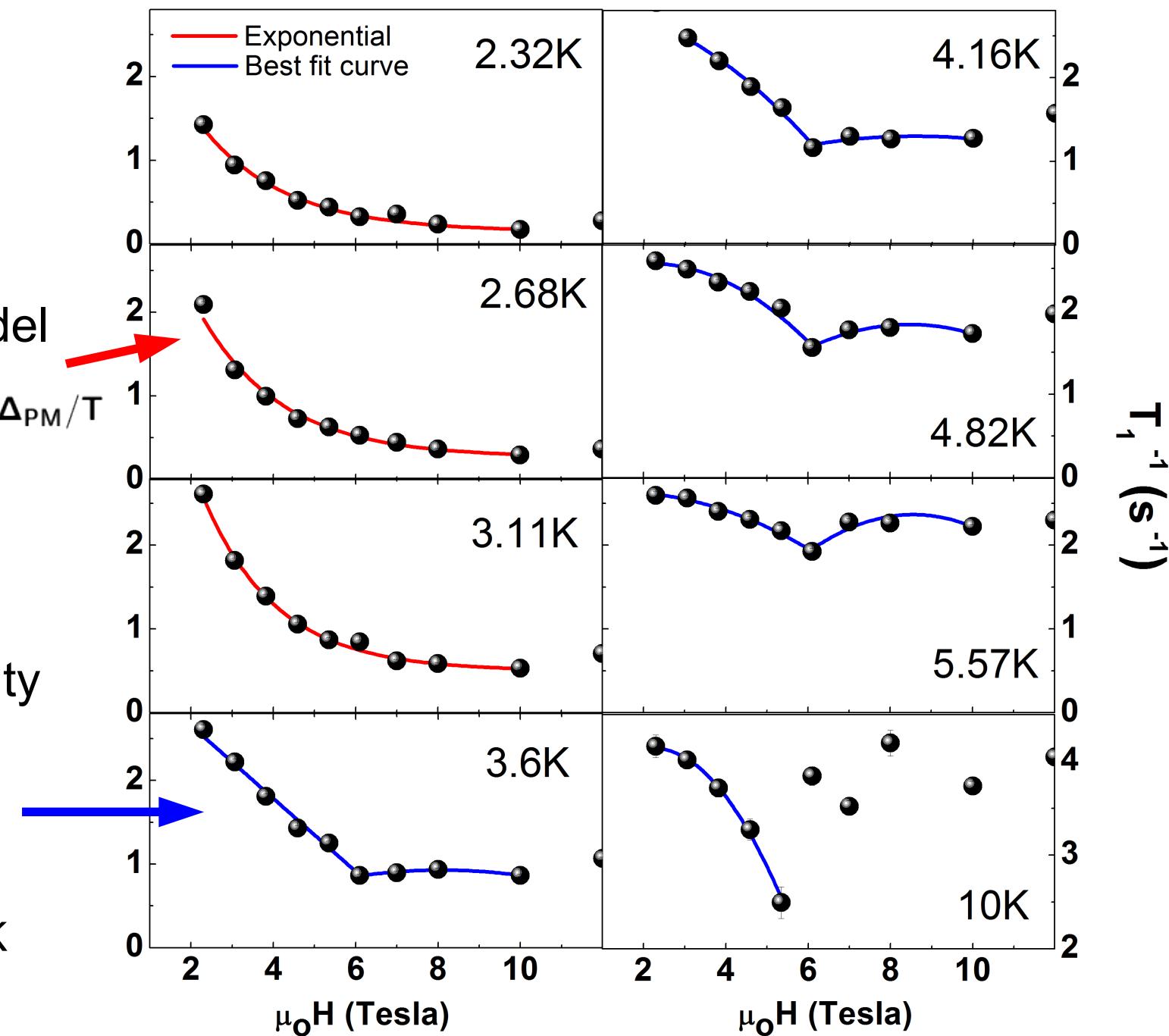


Fits with our model

$$T_1^{-1} \sim e^{-\Delta_{SP}/T} + e^{-\Delta_{PM}/T}$$

Note the concavity reversal

Trend line
(No physical model to explain data 3.6K and above)





Conclusions

- Field and temperature dependent nuclear relaxation rates
- Mapped out the SP-phase boundary
- Explained by two spin systems on SP-chain
 - For low temperatures (below 3.5K)

$$T_1^{-1} \sim e^{-\Delta_{SP}/T} + T_{1_{epr}}^{-1} e^{-\Delta_{PM}/T}$$

↑
1-B² ↑
 B

- High temperatures become more complicated
- Distribution of relaxation rates increases with magnetic field

Dziękuję za uwagę

