Gatchina, 17.12.2015: IV Polarized Neutron School

Spin-wave dynamics in FeGe in fully polarized state measured by means of small-angle neutron scattering

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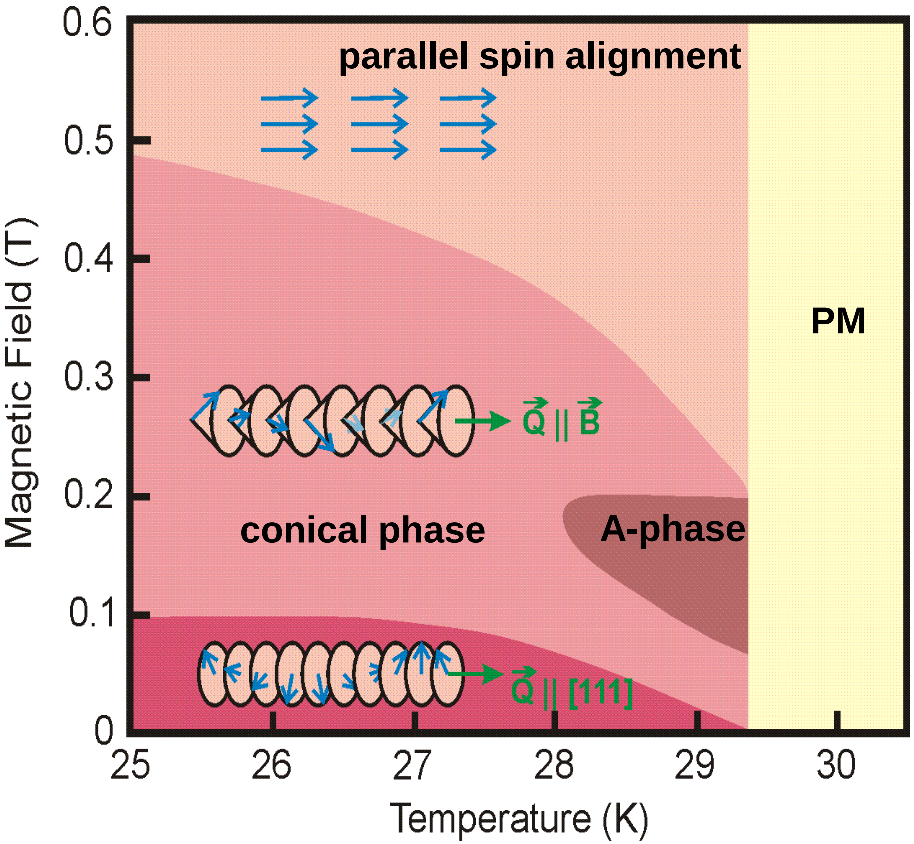
Magnetic phase diagram of MnSi [1]



[1] D. Menzel et al., ICM 2012.

- ferromagnetic exchange interaction J
- Dzyaloshinsky-Moriya interaction D
- anisotropic exchange interaction

Bak & Jensen (1980)

- cubic anisotropy

Nakanishi, et al. (1980)
Grigoriev, et al. (2015)

	MnSi	FeGe
T_{ord}	~29 K	~278 K
$\lambda_s = 2\pi/\lvert\mathbf{k}_s\rvert$	~18 nm	~70 nm
anisotropy →pinning	<111>	<100> 211/245 K<T< T_{ord} <111> T < 211/245 K
H_{c1}	~0.1 T	~0.1 T
H_{c2}	~0.6 T	~0.3 T
mag. mom	~0.4 μ_B	~1.0 μ_B

MnSi – SW in the FM state

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$$\theta_C^2(H) = \theta_0^2 - \frac{\theta_0}{E_i} H + \theta_B^2.$$

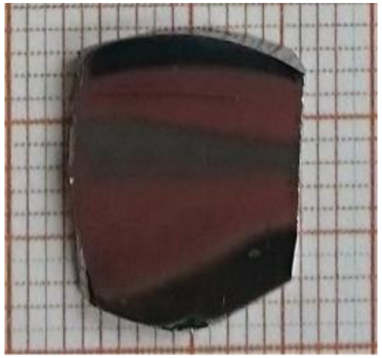
Θ_c – cut-off angle
$\Theta_0 = (2\ A\ m_n)^{-1}$, $m_n = 1.674\ldots\ 10^{-27}$ kg
Θ_B – Bragg angle
E_i – energy of the incident neutron
H – applied magnetic field

- chiral scattering from SW appears within the cirrcle with radius Θ_c, centered at Θ_B
- possibility to extract spinwave stiffness A from the measured cut-off angle

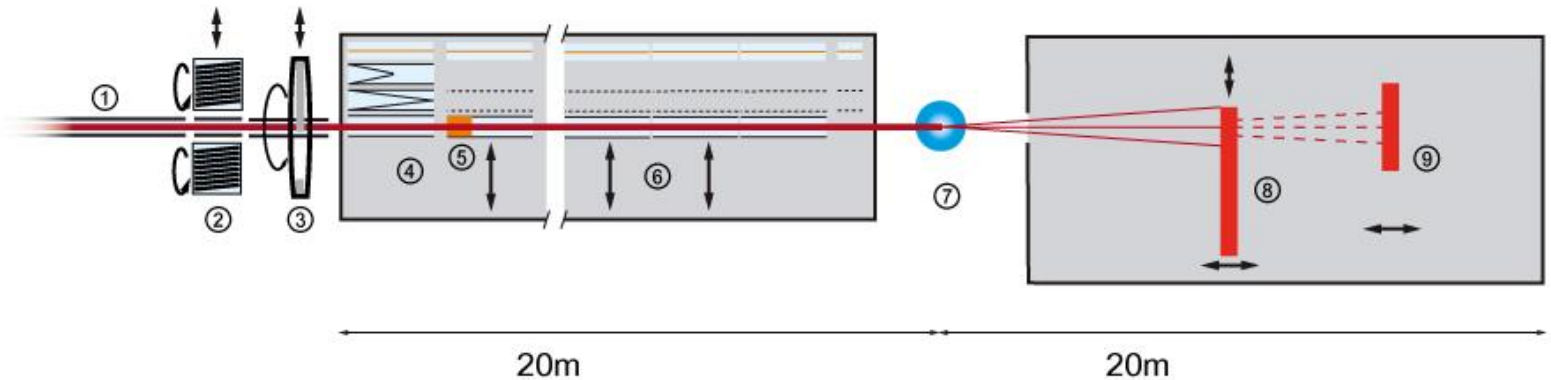
S. V. Grigoriev, et al., Phys. Rev. B(R), accepted.

MnSi – SW in the FM state

- large single crystals available

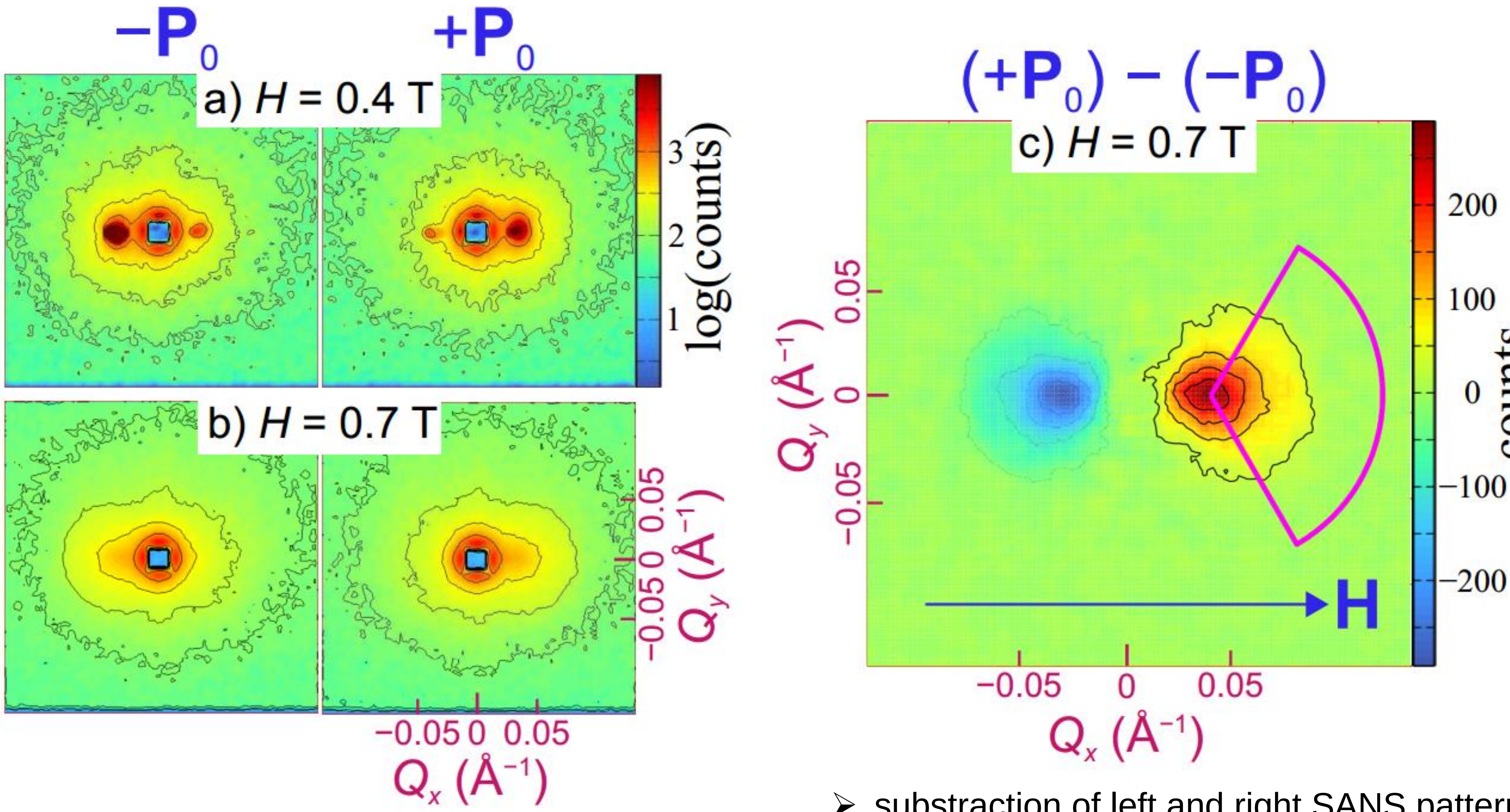


- SANS-1 at the MLZ Garching, Germany



① Neutron guide NL4a
② Velocity selector 1+2
③ TISANE Chopper
④ Changeable polarisers
⑤ Spin flipper
⑥ 4 collimation sections 19 m
(neutron guide, collimation slits)
⑦ Sample position
⑧ Position sensitive area detector, 1 x 1 m²
⑨ High resolution position-sensitive
area detector, 0.5 x 0.5 m²
(installation 2016)

MnSi – SW in the FM state

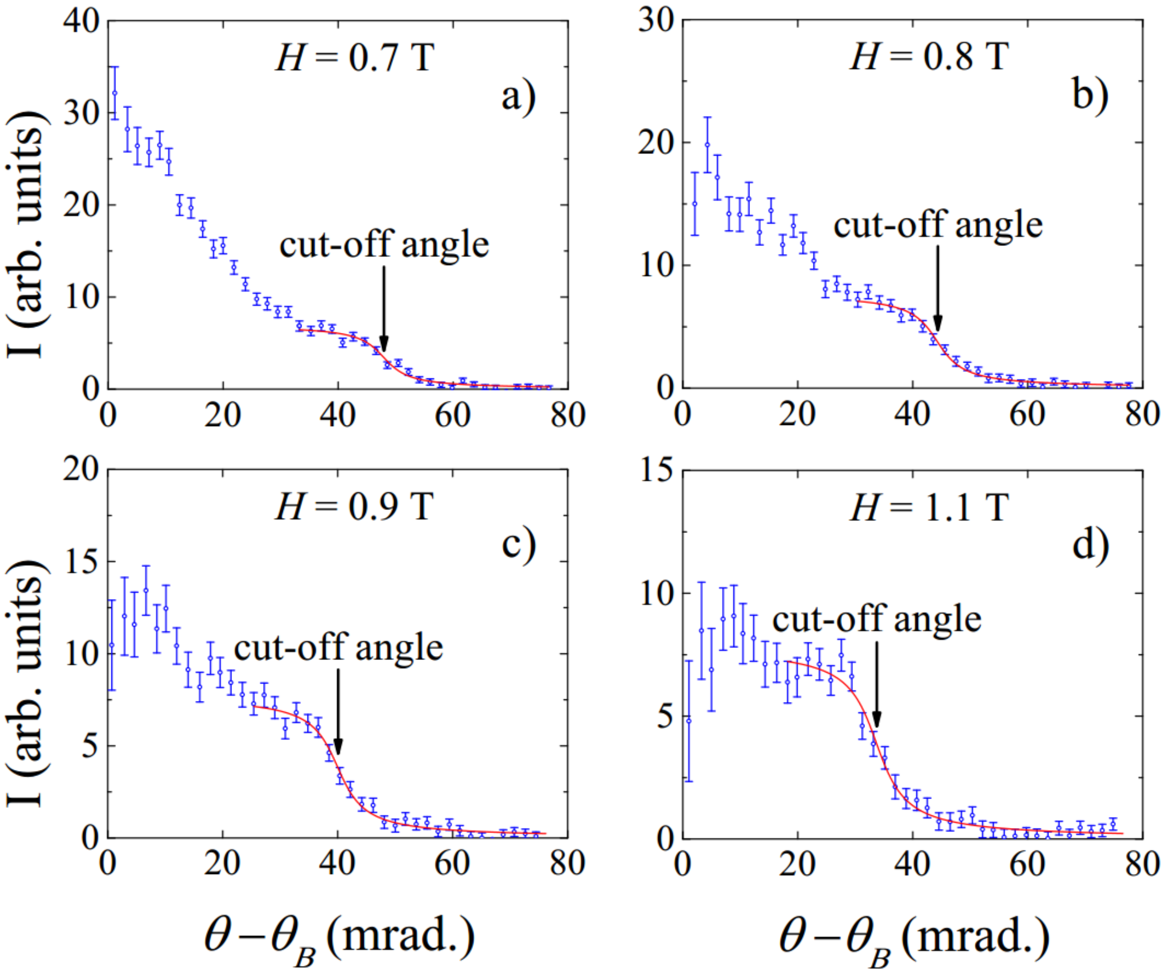


- substraction of left and right SANS patterns
- radial average over 120° to improve statistic

- 15K

S. V. Grigoriev, et al., Phys. Rev. B(R), accepted.

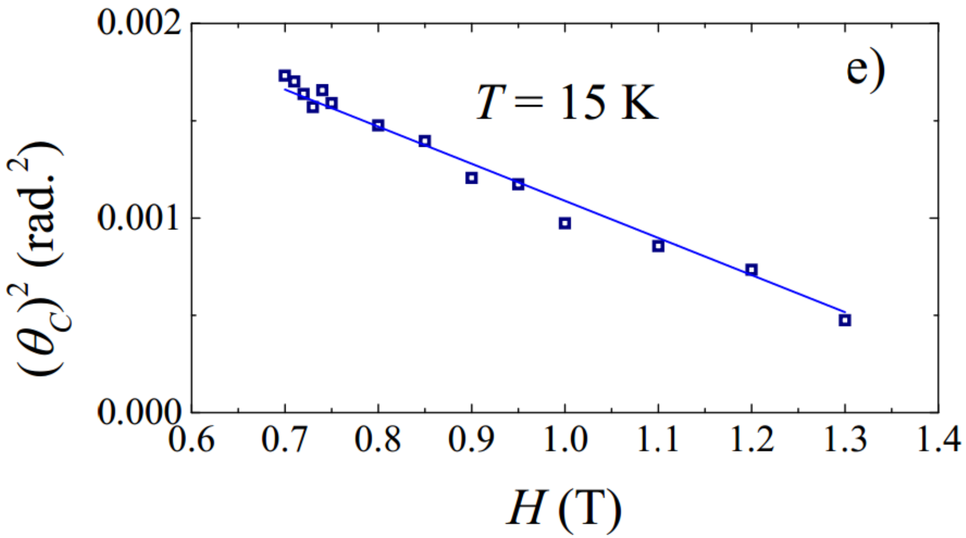
MnSi – SW in the FM state



$$1/2 - (1/\pi)\arctan(2(\theta - \theta_c)/\delta)$$

δ - sw damping

Θ_c – center of arctan-function



S. V. Grigoriev, et al., Phys. Rev. B(R), accepted.

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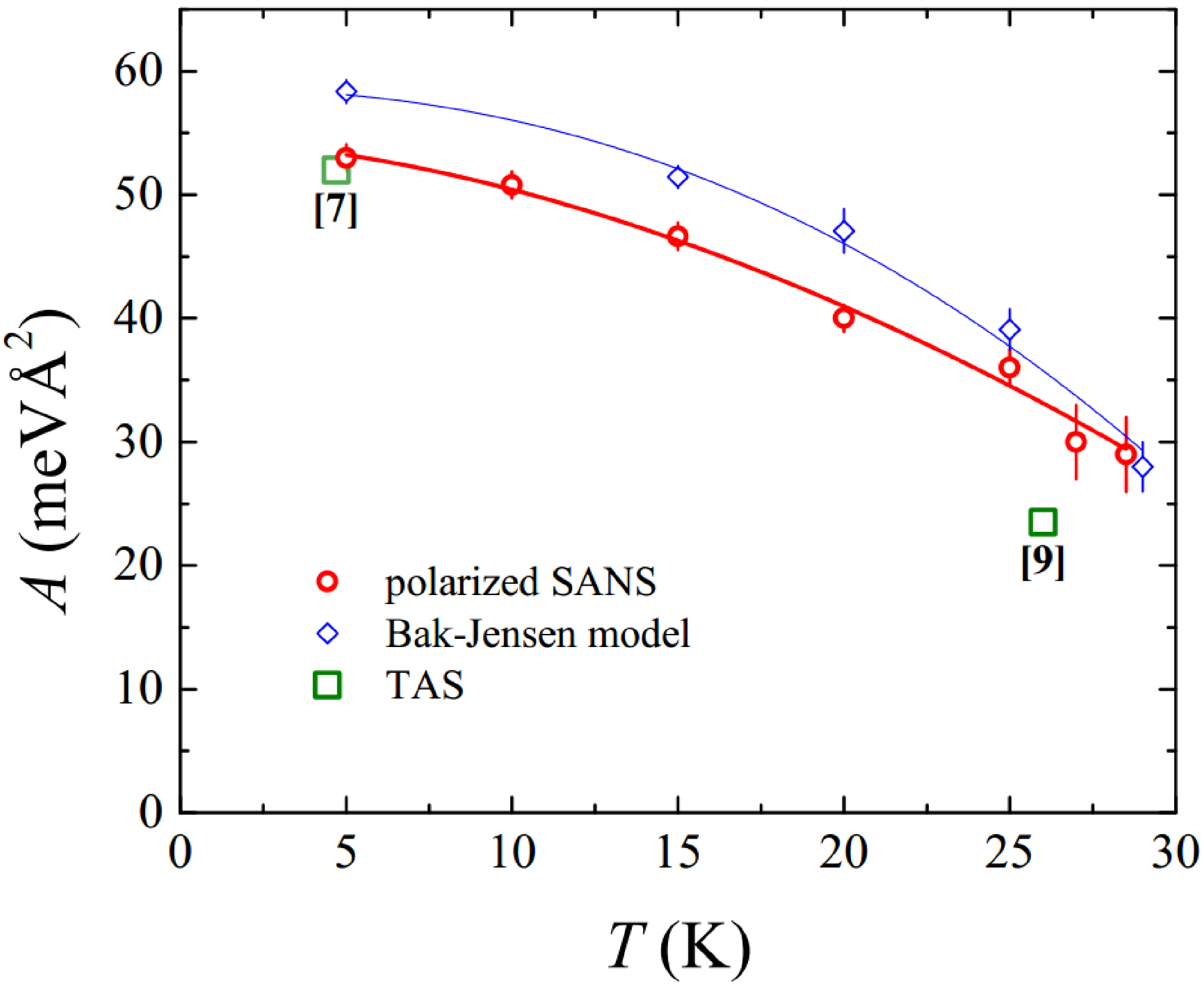
MnSi – SW in the FM state



$A(T) = A_0 (1 - c (T/T_c)^z$

$z = 1.8 \pm 0.3$

$A_0 = 0.054$ meVÅ^2

$c = 0.47$

Bak-Jensen-model:

$g\mu_B H_{c2} = A k_s^2$

→ cubic anisotropy

S. V. Grigoriev, et al., Phys. Rev. B(R), accepted.
[7] Y. Ishikwa ,et al., Phys. Rev. B. **16** 4956 (1977).
[9] F. Semadeni, et al., Physica B **267-268** 248-251 (1999).

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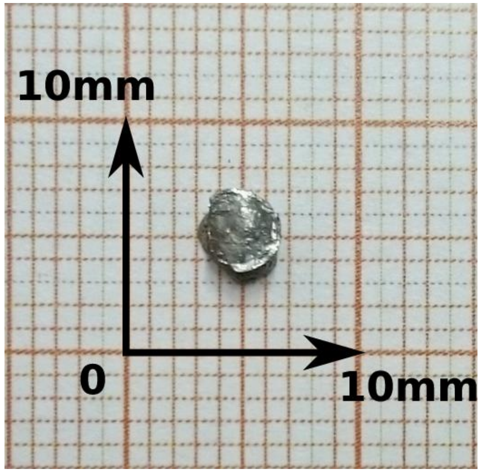
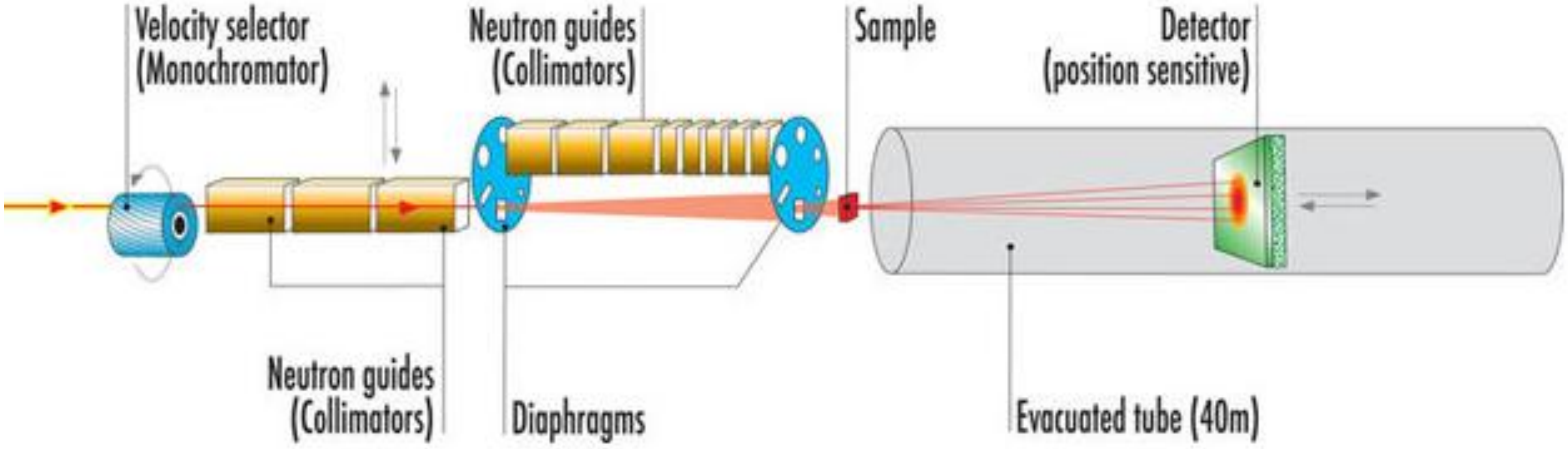
FeGe – SW in the FM state

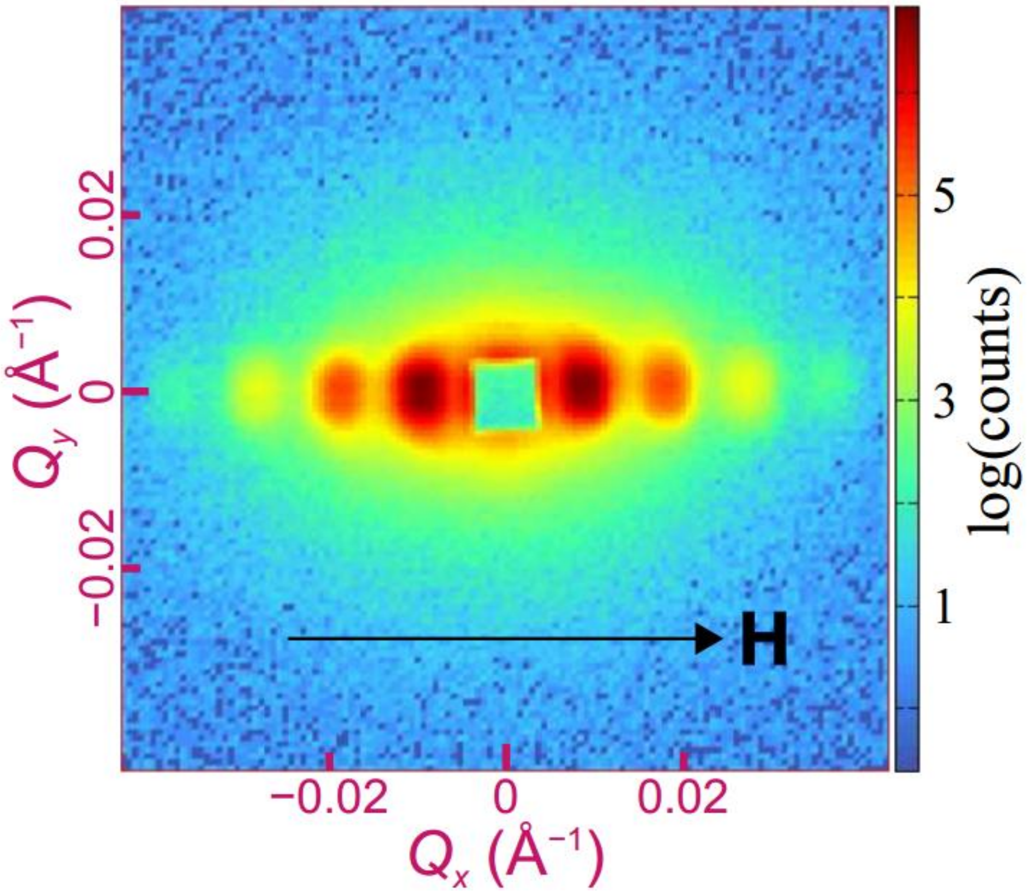


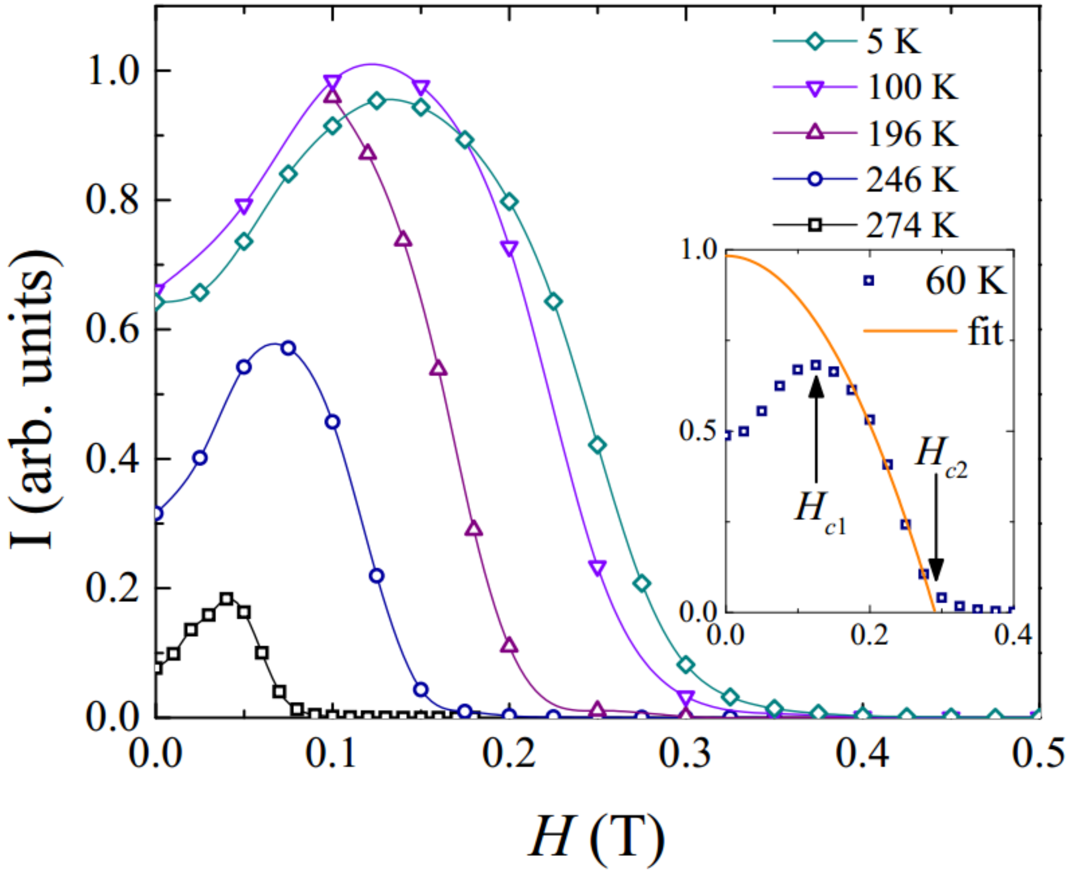
- no large single crystals available
- just powder samples

- D11 at the ILL Grenoble, France



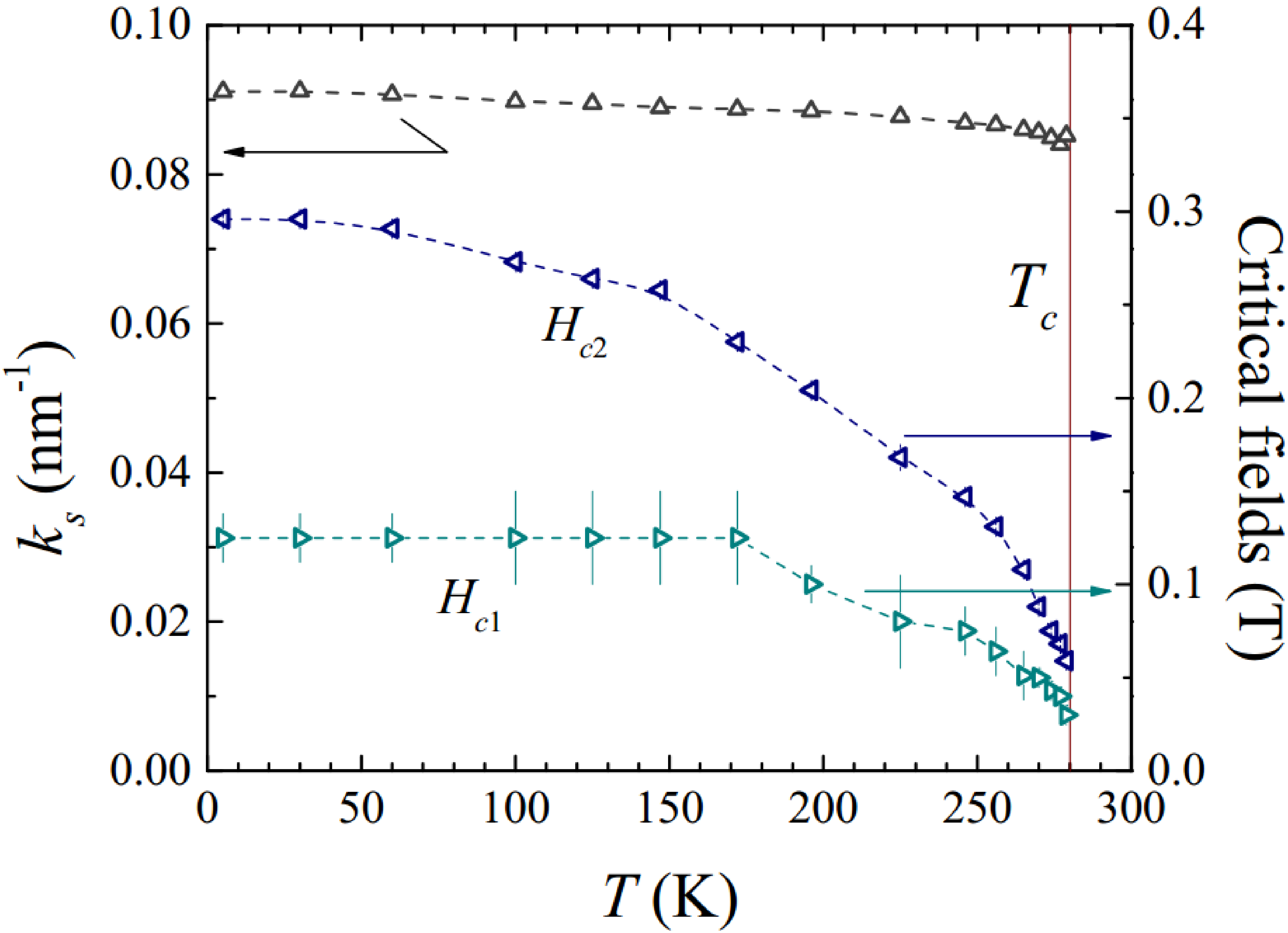
FeGe – SW in the FM state



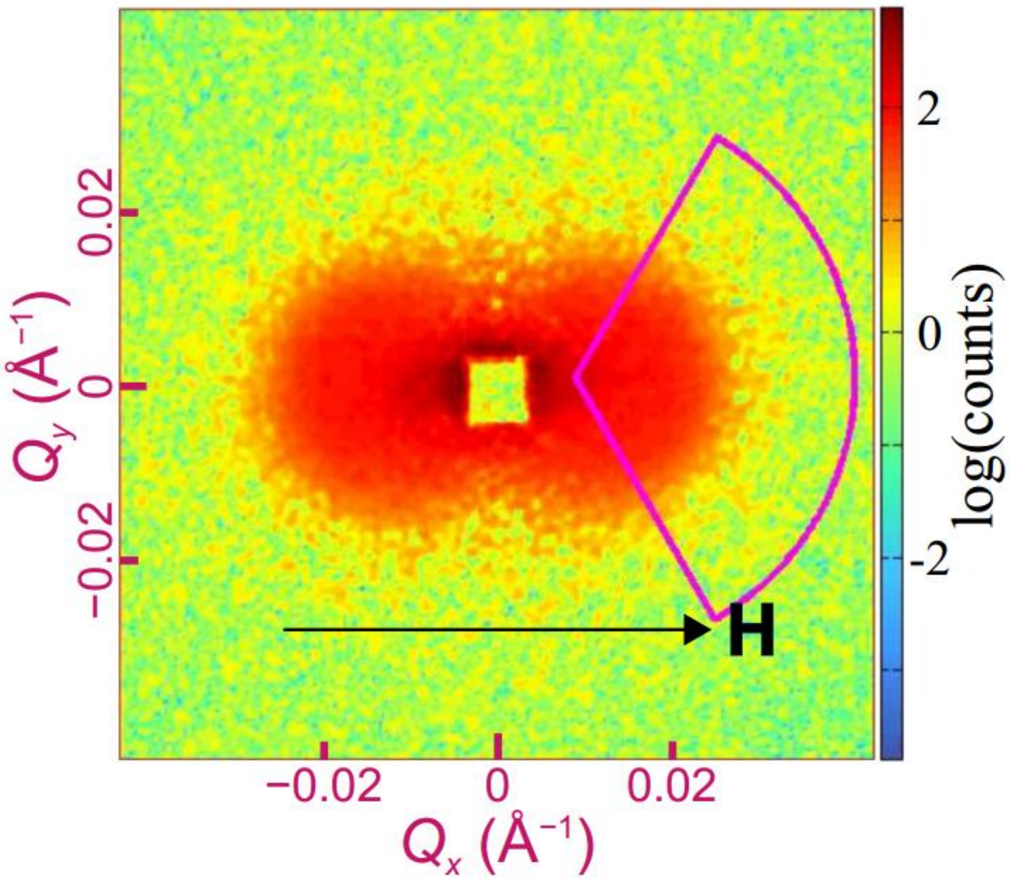


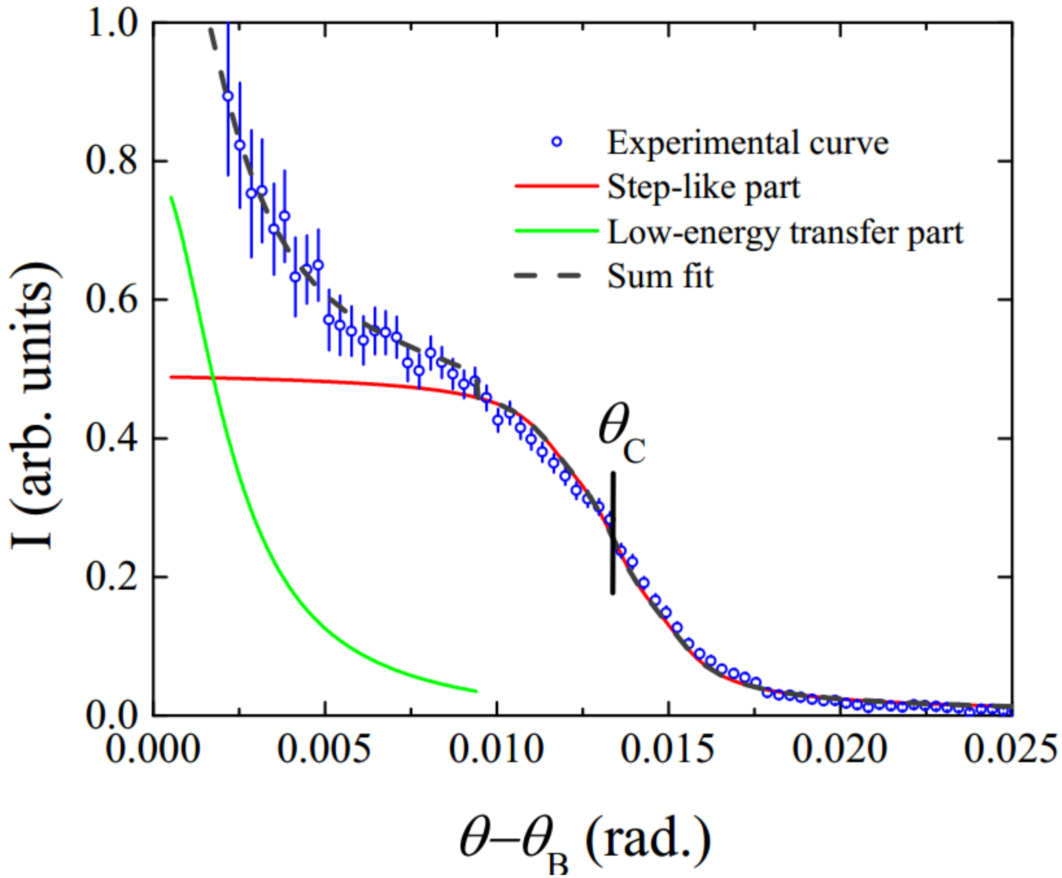
- T = 250 K
- H = 0.075 T (~H_{c1})

FeGe – SW in the FM state



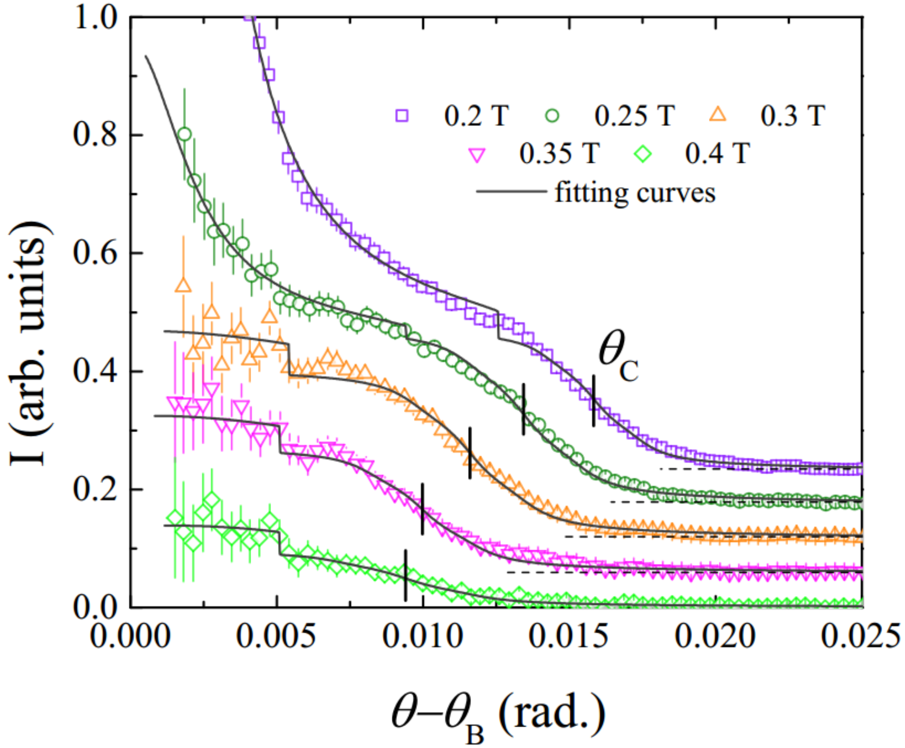
FeGe – SW in the FM state

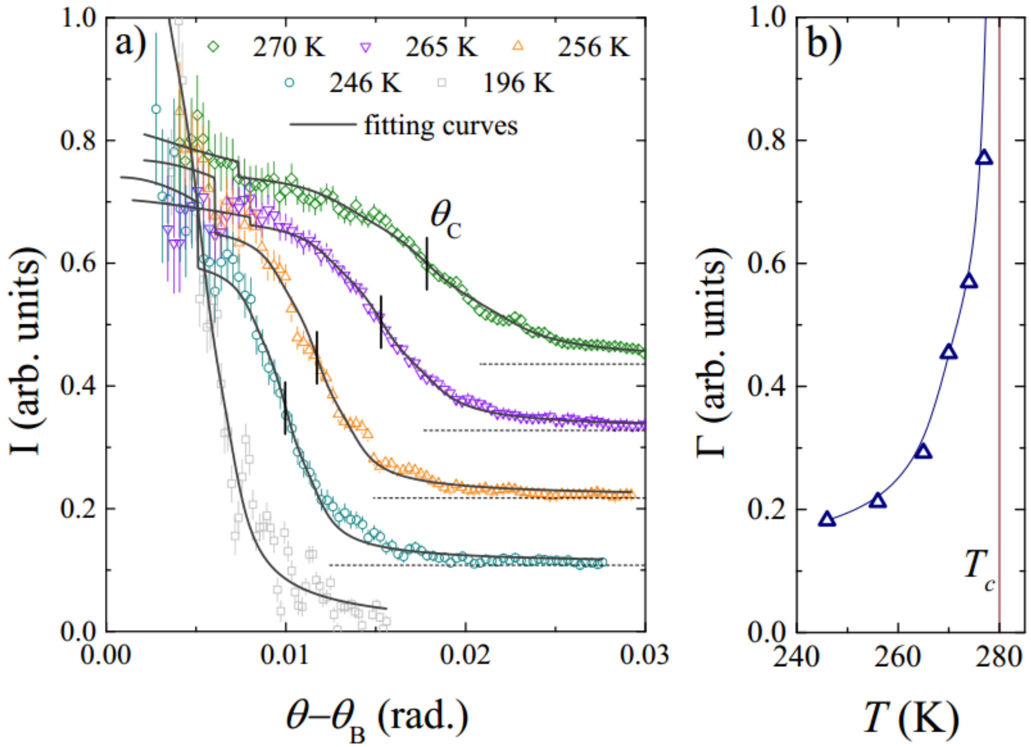




- T = 246 K
- H = 0.25 T (>H_{c2})

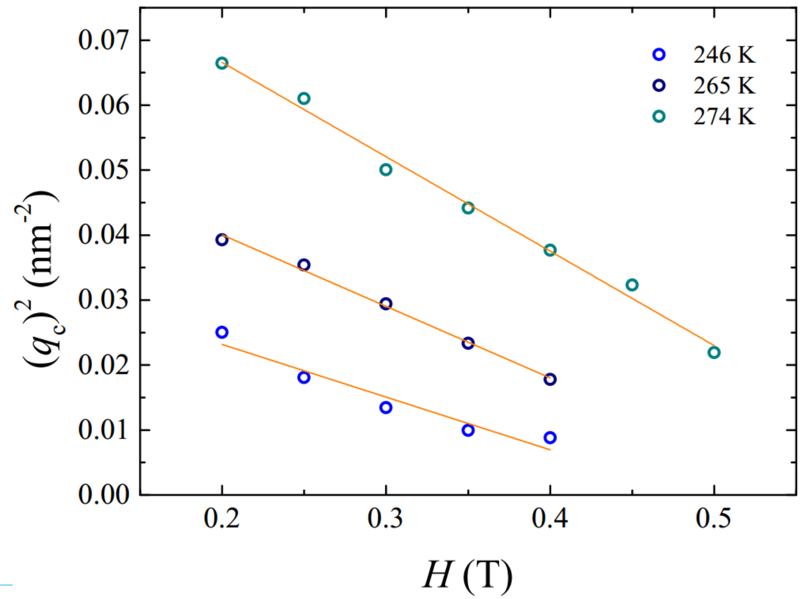
FeGe – SW in the FM state



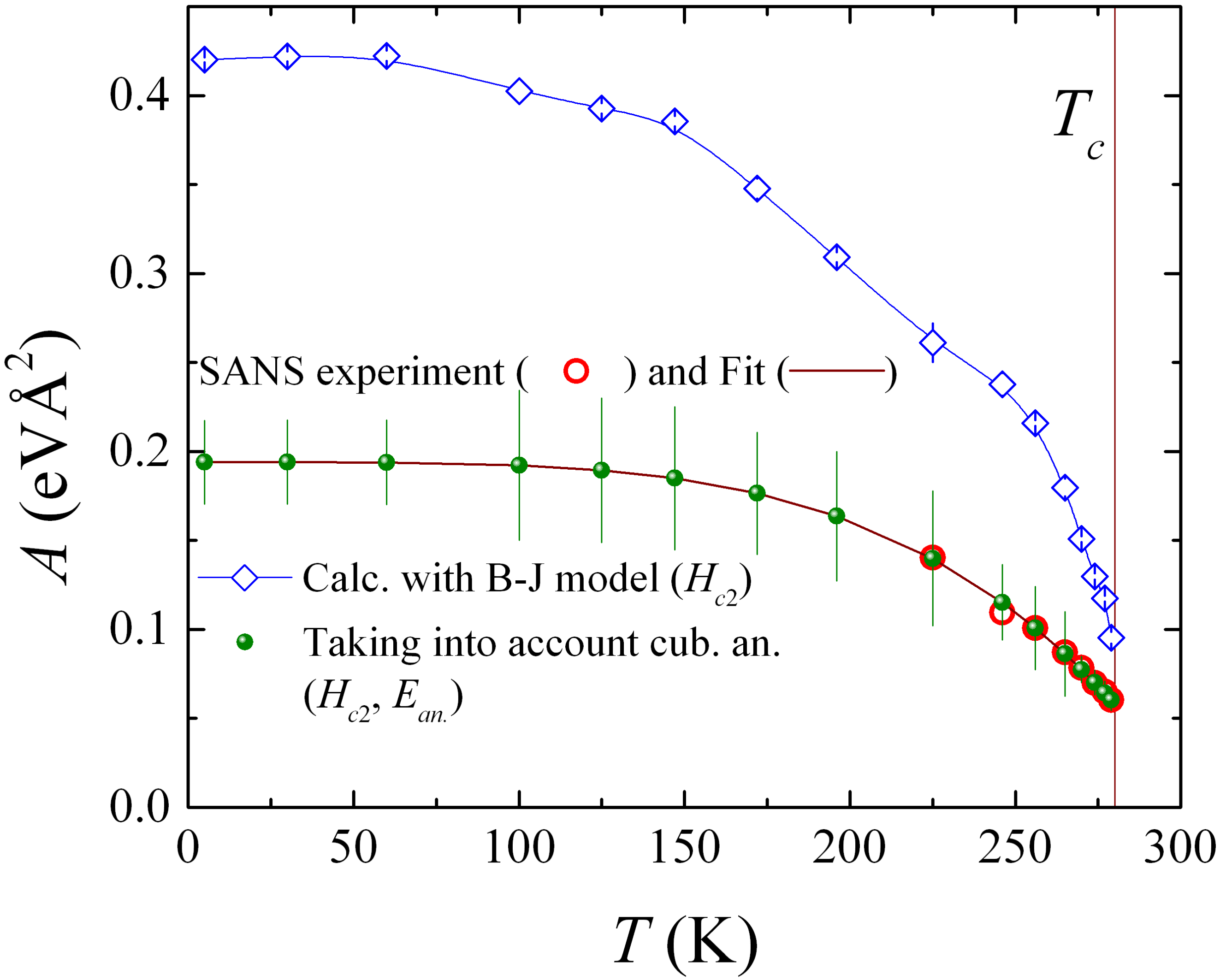


- T = 246 K

- H = 0.35 T (>H_{c2})



FeGe – SW in the FM state



$$H_{c2} = Ak_s^2 + \beta \left(\frac{Ak_s^2}{10KS_\xi^3} \right) H_{c1}$$

Similar correction of ~5% for MnSi

Conclusion

- summary:
  - exp. proof of the dispersion relation for helimagnets with DM interaction
  - chirality of DM helimagnets one handed excitations in FP state above H_{c2}
  - pointed out role of the cubic anisotropy
  - polarization ‘not always necessary’ ☺

- outlook:
  - many more DM helimagnets to measure…

Thank you for your attention