Novel Spin Reorientation and Weak Ferromagnetism in $K_2V_3O_8$

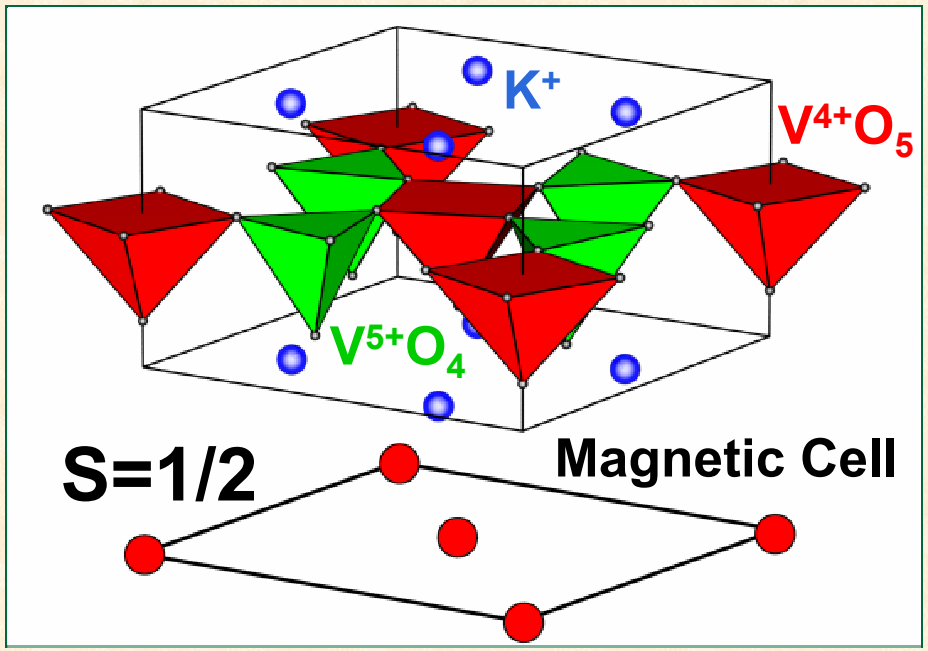
M.D. Lumsden, B.C. Sales, D. Mandrus,
J.R. Thompson and S.E. Nagler
Oak Ridge National Laboratory

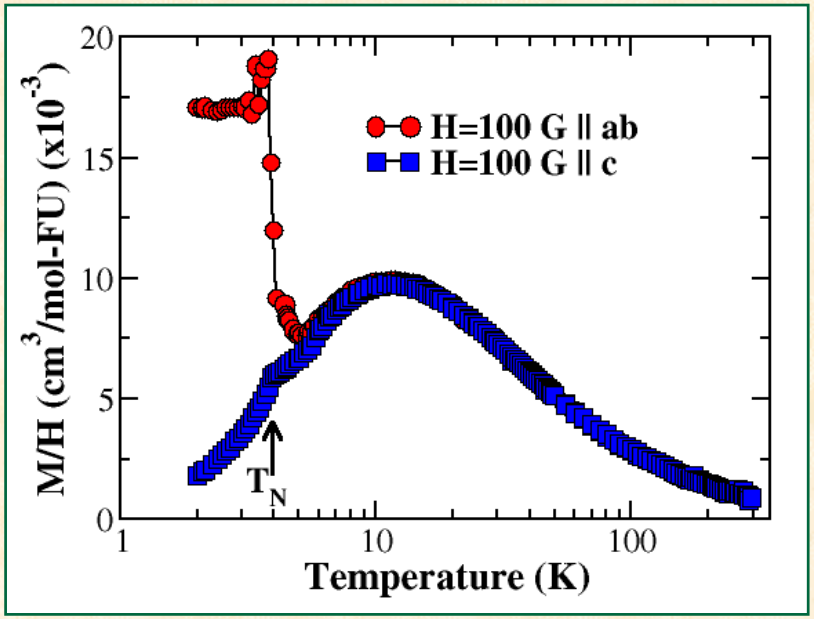
D.A. Tennant, Oxford University / ISIS
D.F. McMorrow, Risoe National Laboratory / PSI

Outline

- Structure/Magnetization
- Neutron diffraction
- Model and comparison with experiment
- Magnetic excitations

Structure

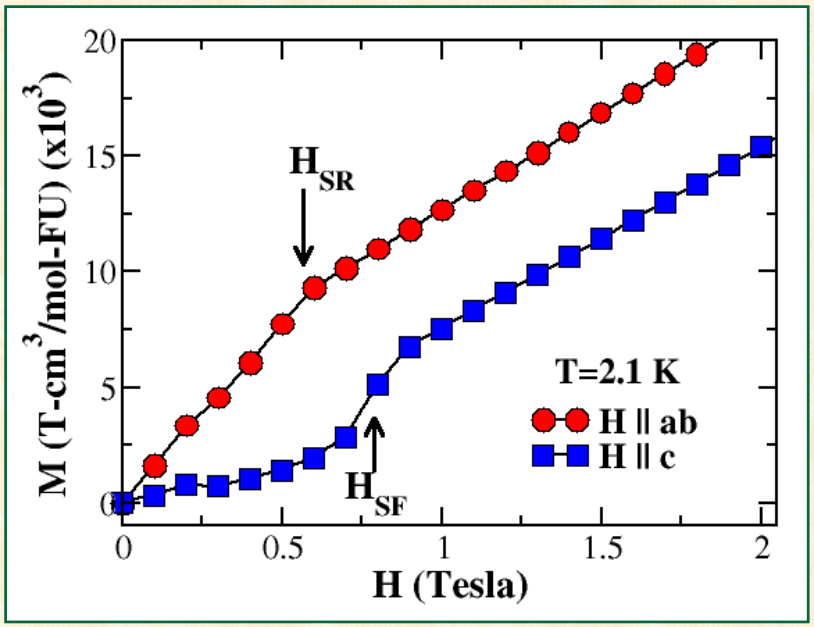




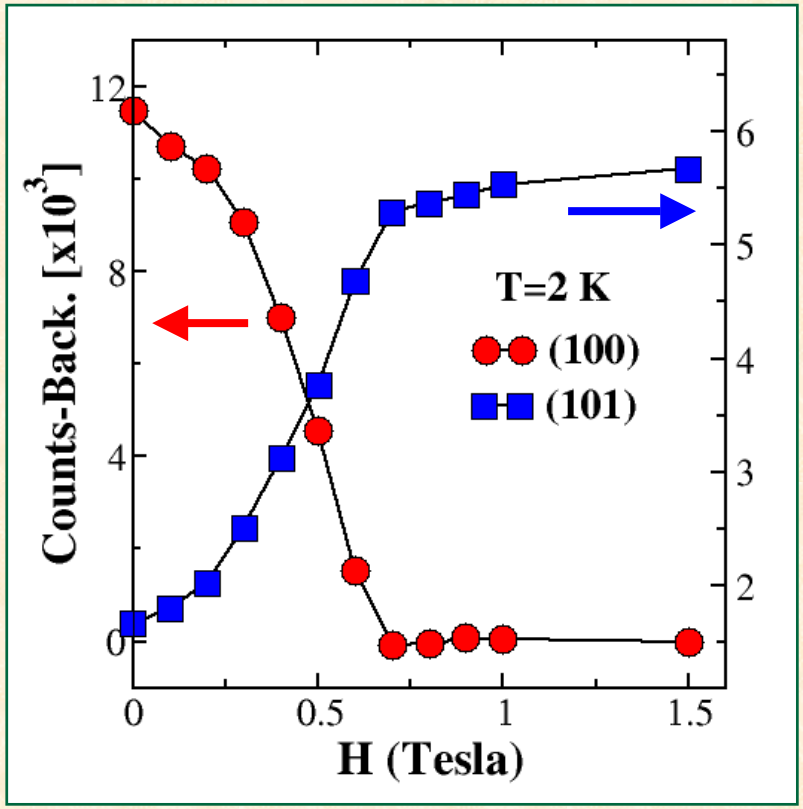
Magnetization

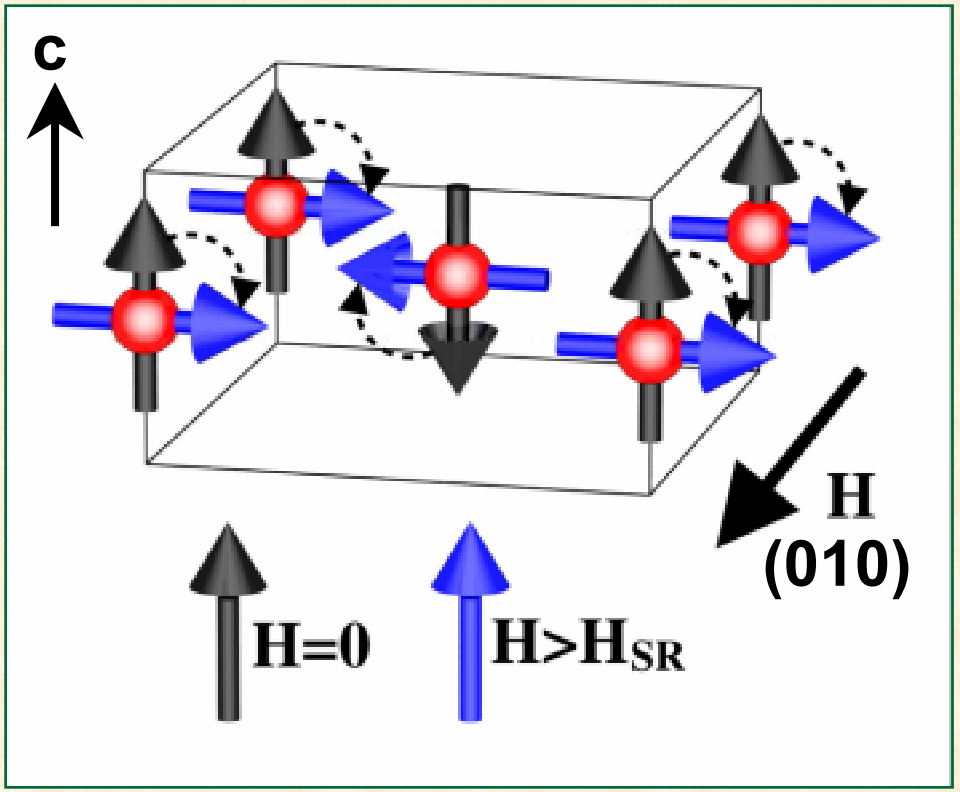
Spin-flop transition with **H** || *c* axis

Unexpected transition with **H** in basal plane



Unique Spin-Reorientation Transition





Spins along c - axis

$X_{100} = 1 - \cos^2(90^\circ) = 1; \quad X_{101} = 1 - \cos^2(30.3^\circ) = 0.25$

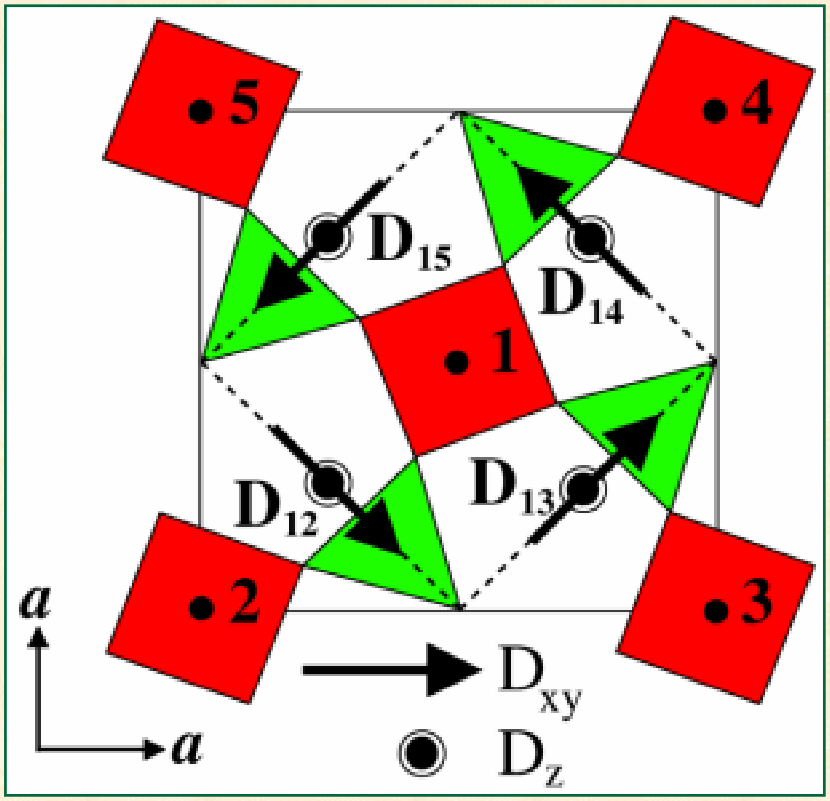
Spins along (100)

$X_{100} = 1 - \cos^2(0) = 0; \quad X_{101} = 1 - \cos^2(59.7^\circ) = 0.75$

$$\left(\frac{d\sigma}{d\Omega}\right) \propto 1 - (\hat{\tau}\cdot\hat{\eta})^2 = 1 - \cos^2\alpha \equiv X$$

where α is angle between $\vec{Q}$ and $\vec{S}$.

Application of DM interaction to $K_2V_3O_8$



As spins 2 - 5 are identical,

$$\vec{D}_{total} = \sum_{j=2}^{5} \vec{D}_{1j} = 4D_z\hat{z}$$

$$DM\ term = 4D_z\left(\vec{S}_1 \times \vec{S}_2\right)_z$$

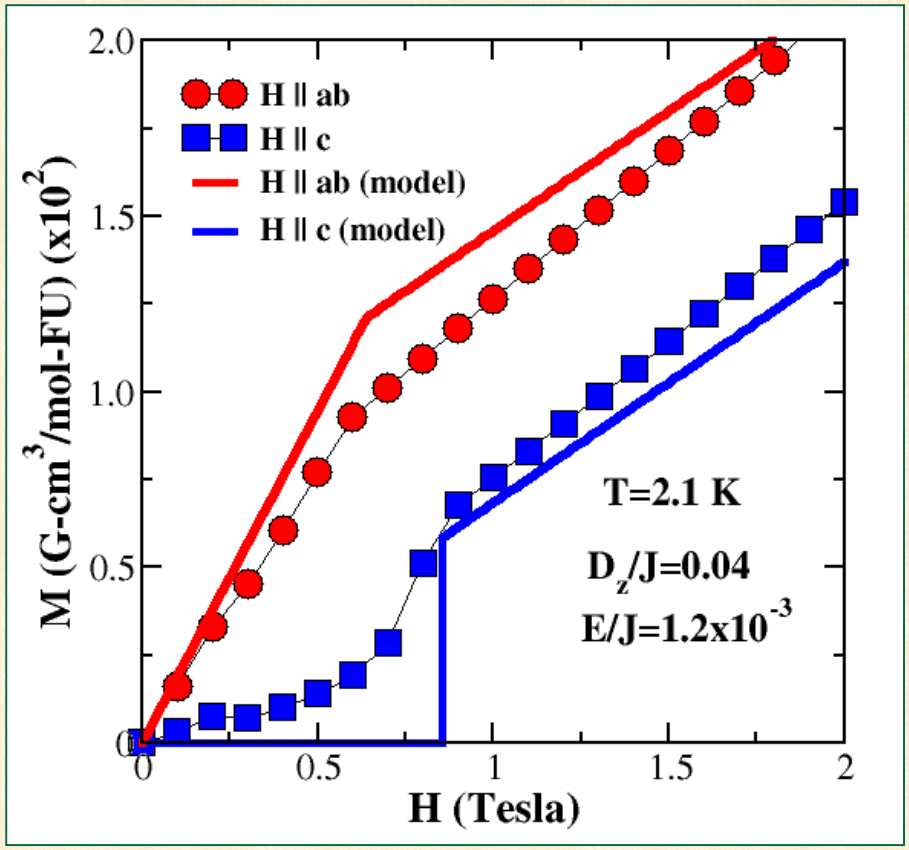
- **Hamiltonian** (T=0):
  2 sublattice, mean-field model:

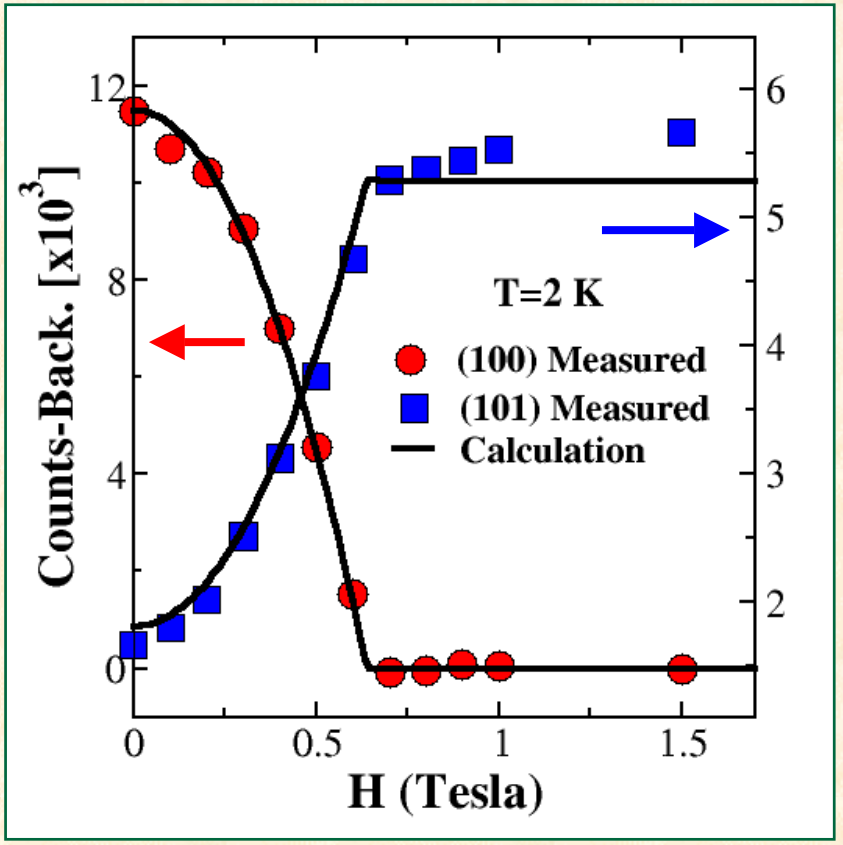
$$H = 8J\vec{S}_1 \cdot \vec{S}_2 + 8D_z\left(\vec{S}_1 \times \vec{S}_2\right)_z$$

- Add **c-axis anisotropy**. Hamiltonian:

$$H = 8J\vec{S}_1 \cdot \vec{S}_2 + 8D_z\left(\vec{S}_1 \times \vec{S}_2\right)_z + 8ES_{1z}S_{2z}$$

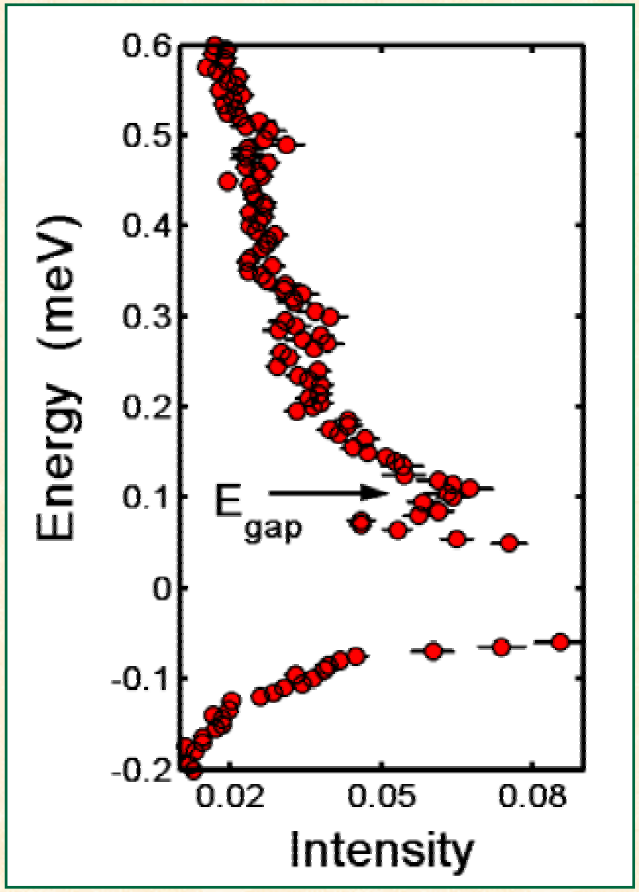
Comparison with Experiment

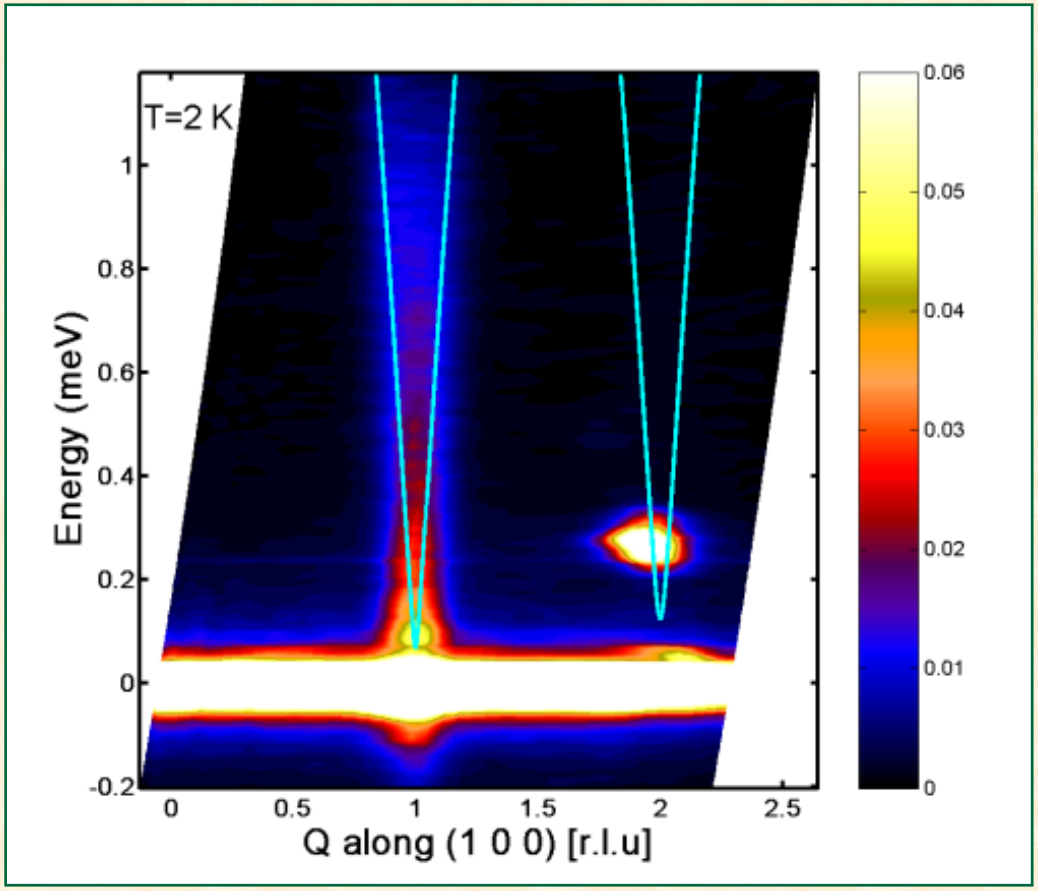




Excellent agreement between model and experiment (both magnetization and diffraction)

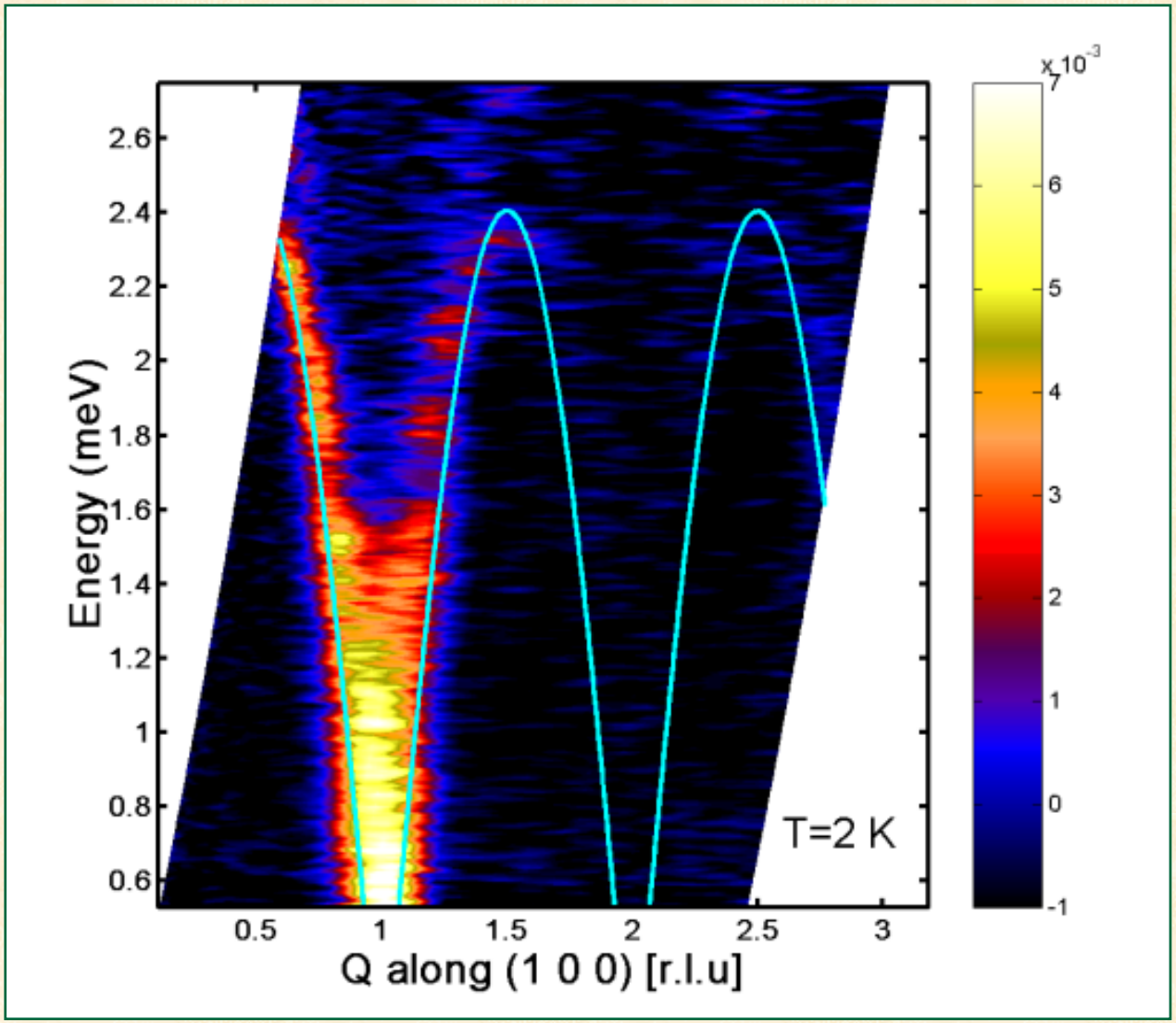
Low energy excitations (IRIS):





$$\Delta_{predicted} = 2\left\{(J+E)^2 - (J^2+D^2)\right\}^{\frac{1}{2}} \approx 70\ \mu\text{eV}.$$

$$\Delta_{measured} \approx 100\ \mu\text{eV}.$$

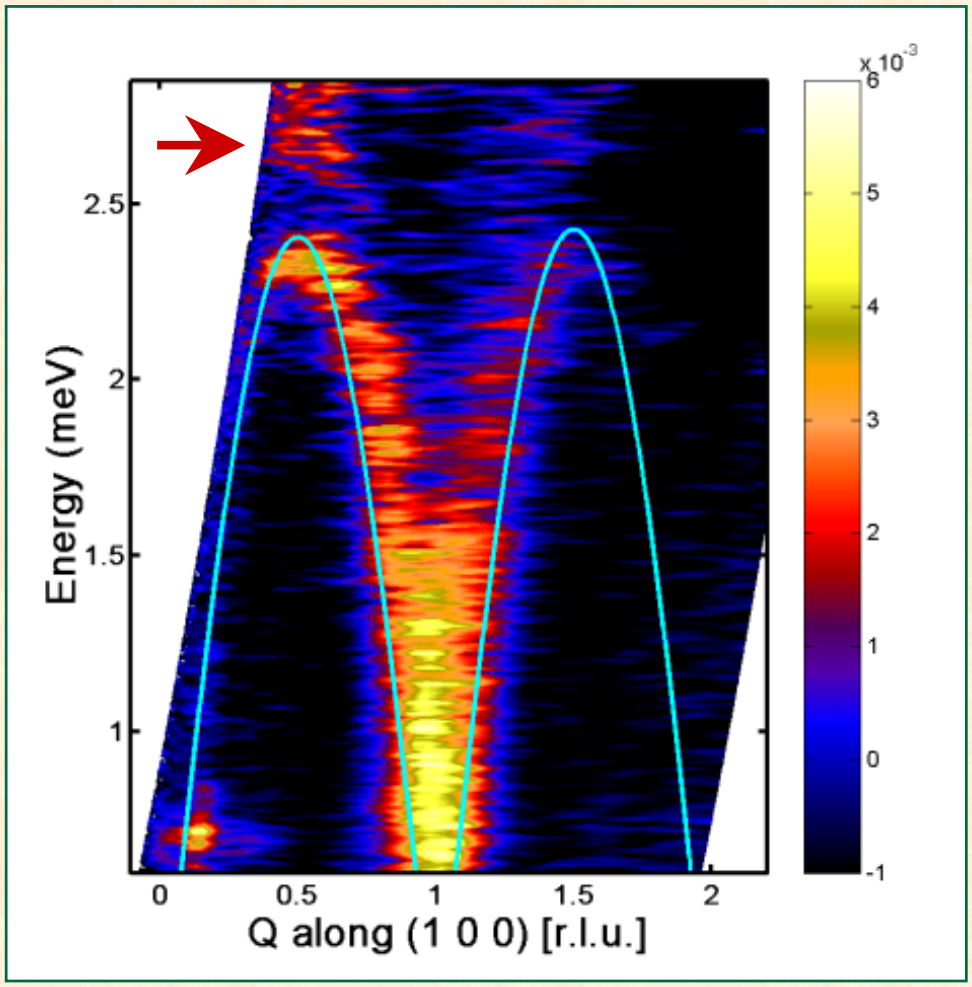


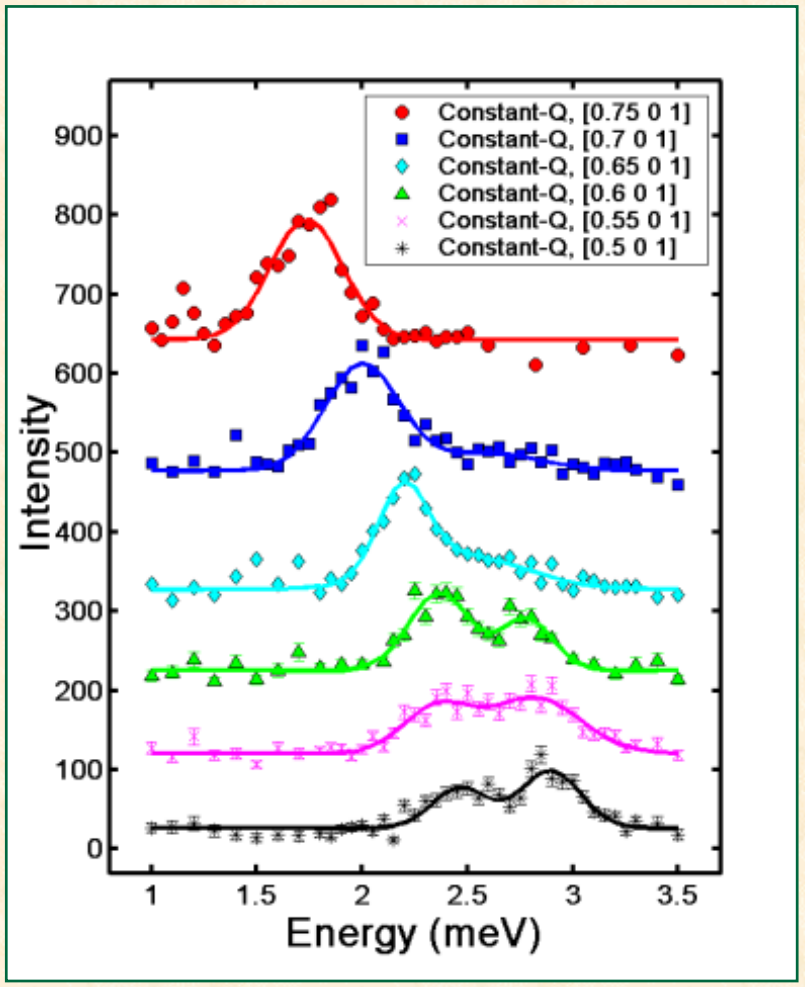
IRIS data (ISIS)

$J \approx 1.2$ meV

Consistent with peak in magnetic susceptibility.

Additional scattering?? Near ZB only





Summary

- Novel spin reorientation in presence of a basal plane magnetic field.
- Model based on DM interactions and additional c-axis anisotropy is consistent with experimental observations.
- Unexplained additional scattering in magnetic excitation spectrum.