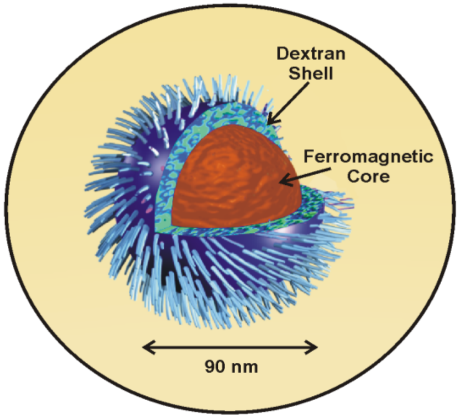
Magnetic Structure of Iron Oxide Nanoparticles Using PSANS



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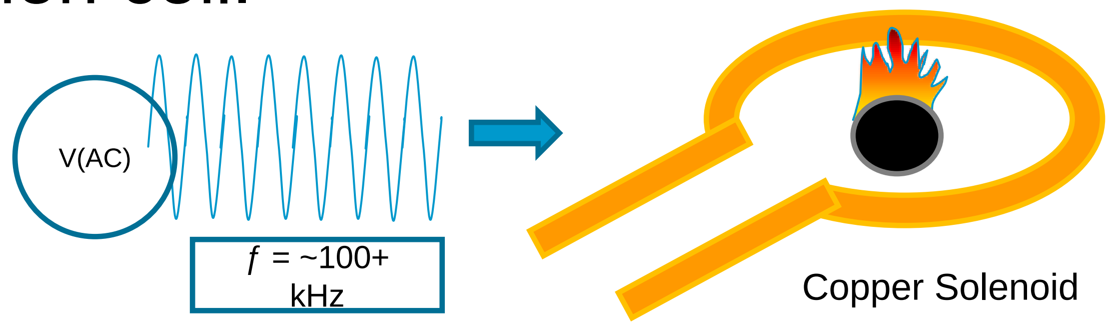
Background

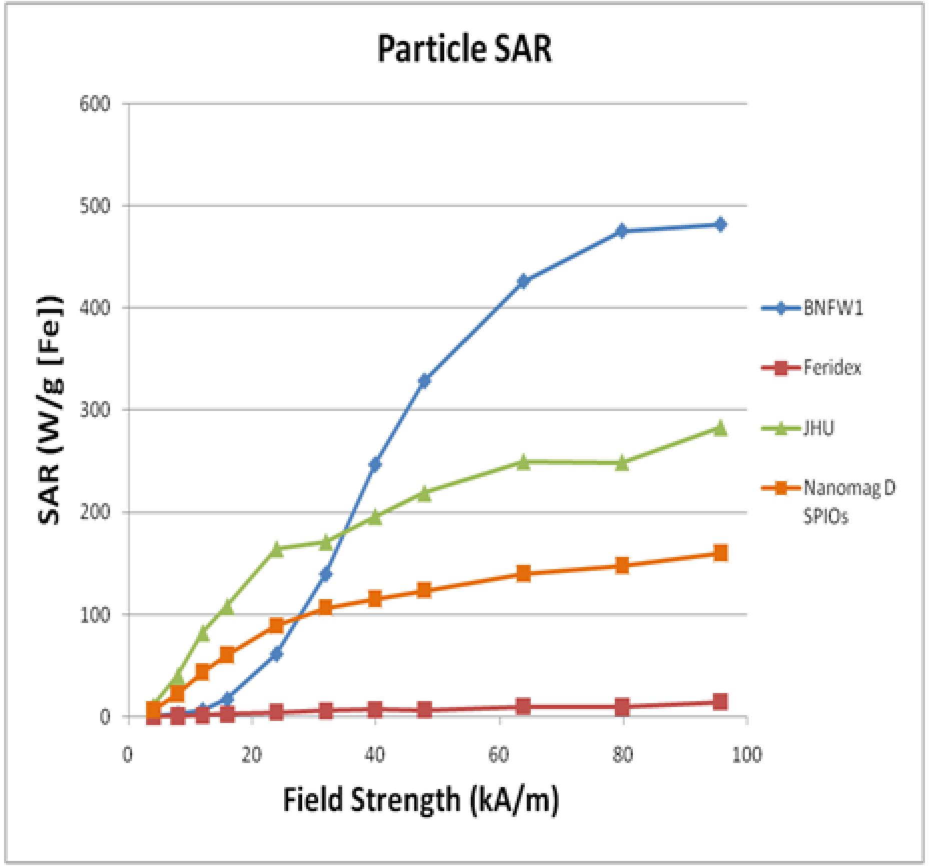
- Iron Oxide Magnetic Nanoparticles (IOMNPs) can be heated via alternating magnetic field in an induction coil.



- Heat applied to cancer cells can have a substantial therapeutic effect.
- Heat may sensitize cancer to radiation therapy and/or chemotherapeutic agents.

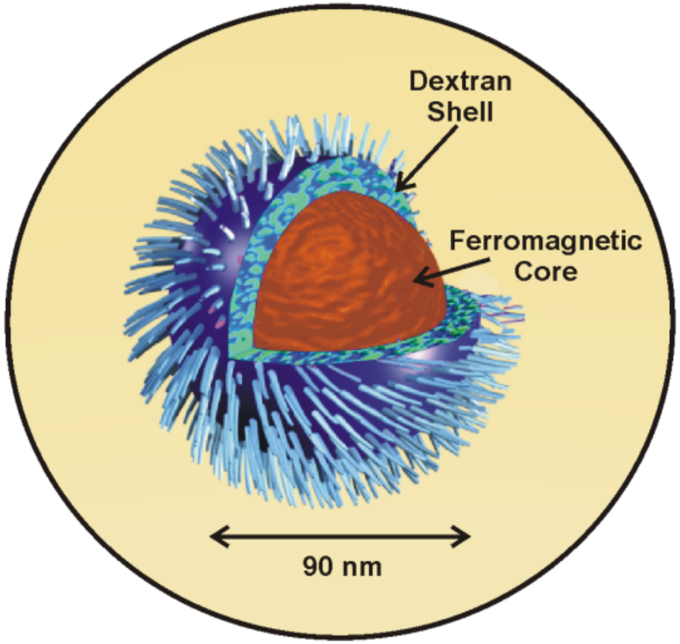
Background

- Heat Generation is measured for various nanoparticles as the SAR (specific absorption rate) measured in W/g(Fe).
- For clinical application high heat output is desirable.
- Particle heat output curves vary depending on the particle properties and magnetic field strength.



What particle properties influence the heat generation?

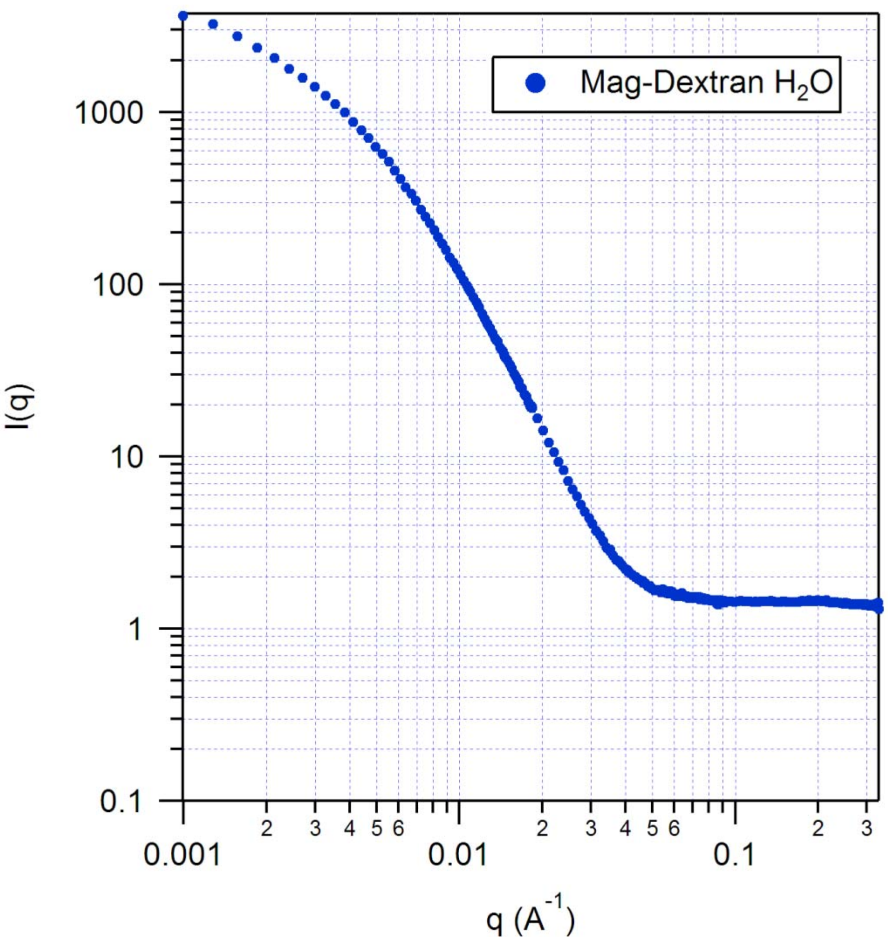
Iron Oxide Nanoparticle



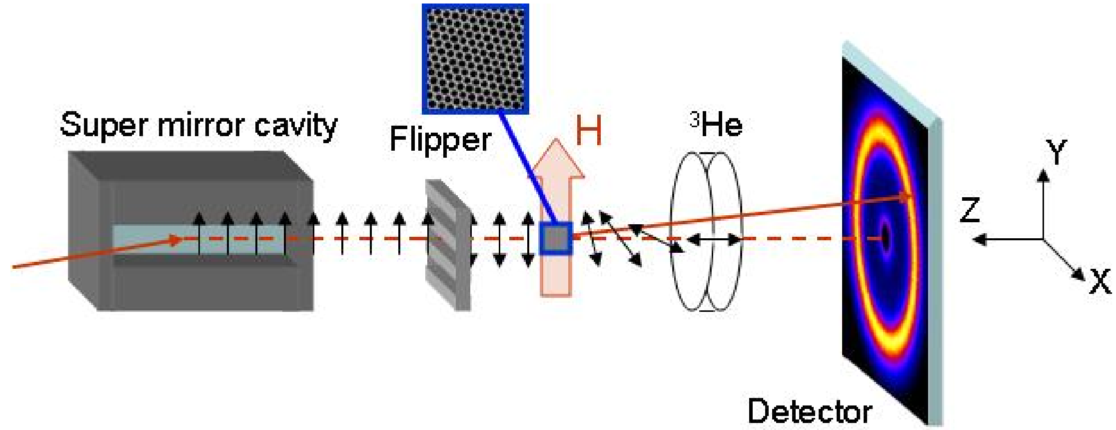
- Iron Oxide Core
- Physisorbed Dextran Shell,(MW = 40,000) shell, (branched polysaccharide)
- Aqueous solution
- Polydispersity (DLS) of ~30%

Motivation

- Use SANS to look at nm shell structures
- Good contrast between H_2O and Fe_3O_4 (-0.52e -6 vs.6.91e -6 A^{-2})
- D_2O is a good contrast match to core—lets us see the shell (6.32e -6 vs.6.91e -6 A^{-2})
- Contrast matching the core yielded a different structure at high Q.
- Nuclear scattering was reduced by contrast matching.
- To determine if the scattering is from the magnetic core or the dextran, PSANS measurements are necessary.



Experimental Design



Things to consider

- Decay of ^3He
- Polarization corrections

Measurements

Background corrections

- •Open Beam
- •Empty Sample Holder
- •Blocked beam

Polarization Efficiencies

- •Open beam with/without ^3He
- •Polarized beam, no sample, ⇑⇑,⇓⇓, ⇑⇓, ⇓⇑
- •Polarized beam with beam block

Scattering of Sample

- •⇑⇑,⇓⇓, ⇑⇓, ⇓⇑

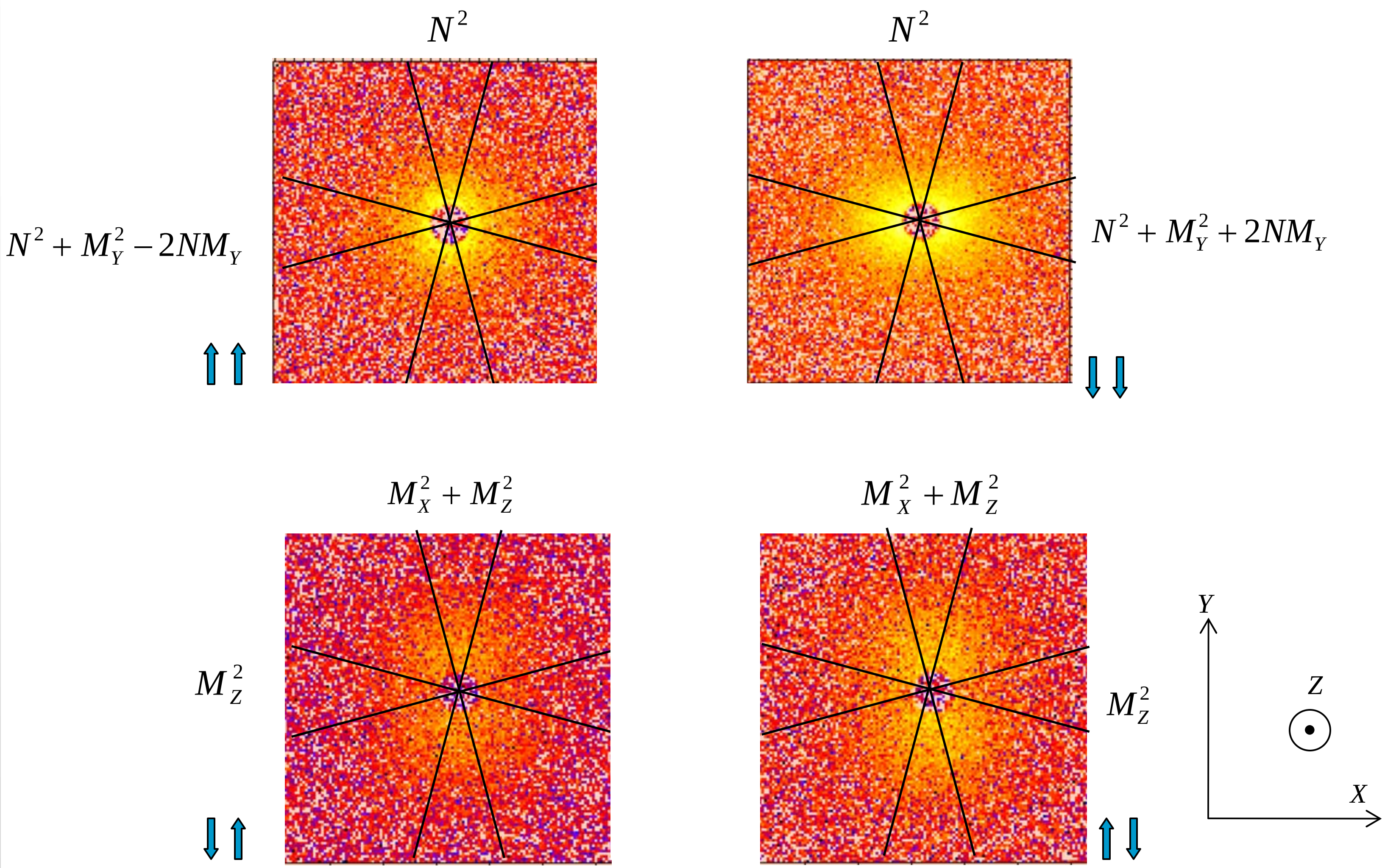
Polarization Efficiencies

P_{3He}=0.974, at start time

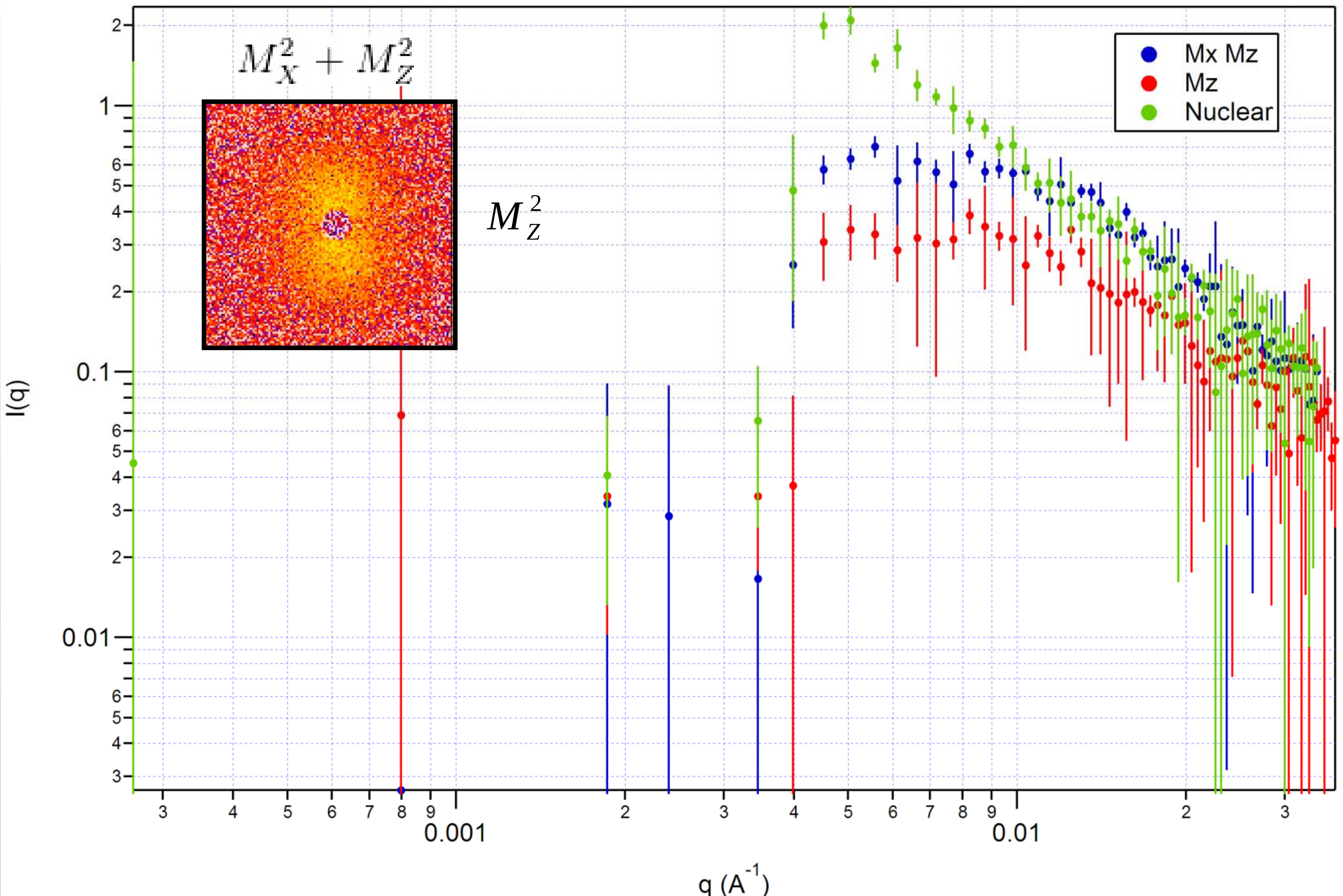
P_{SM}=0.865

P_F=0.910

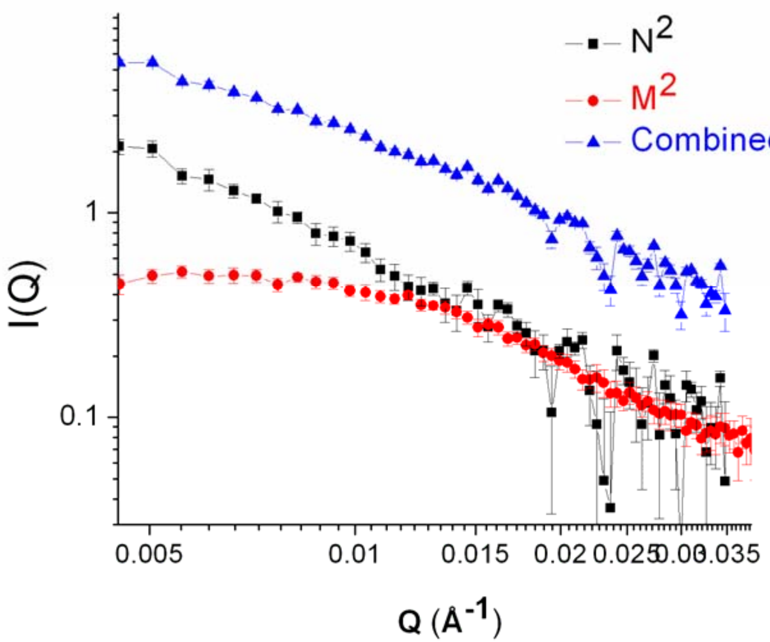
PSANS 2D Intensity Data

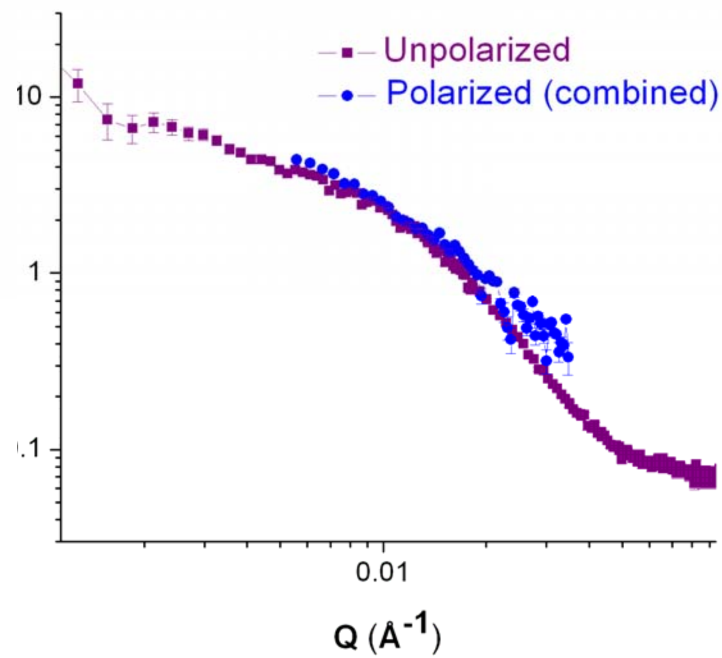


Isotropic Magnetic Scattering

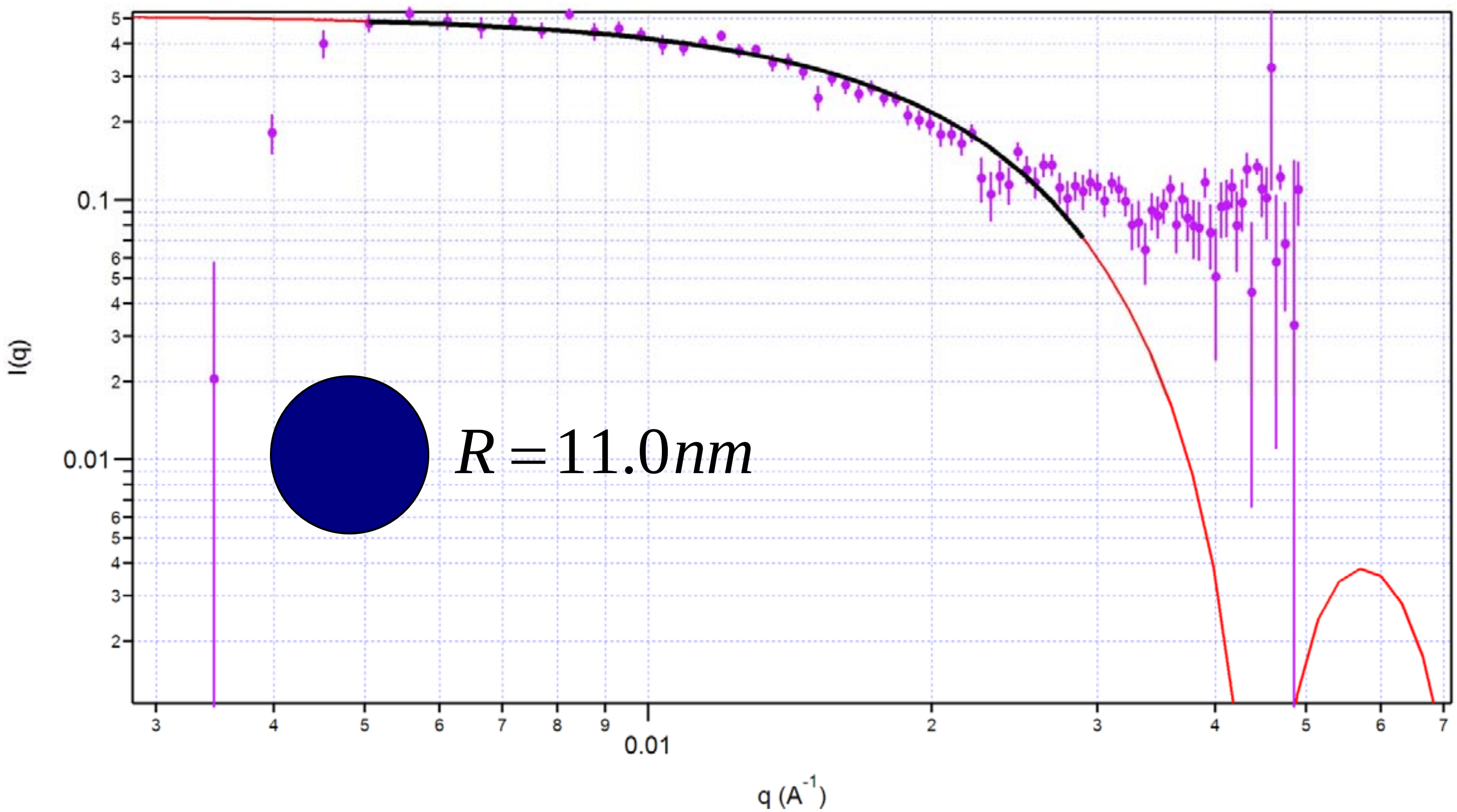


Comparison of Polarized and Unpolarized Beams



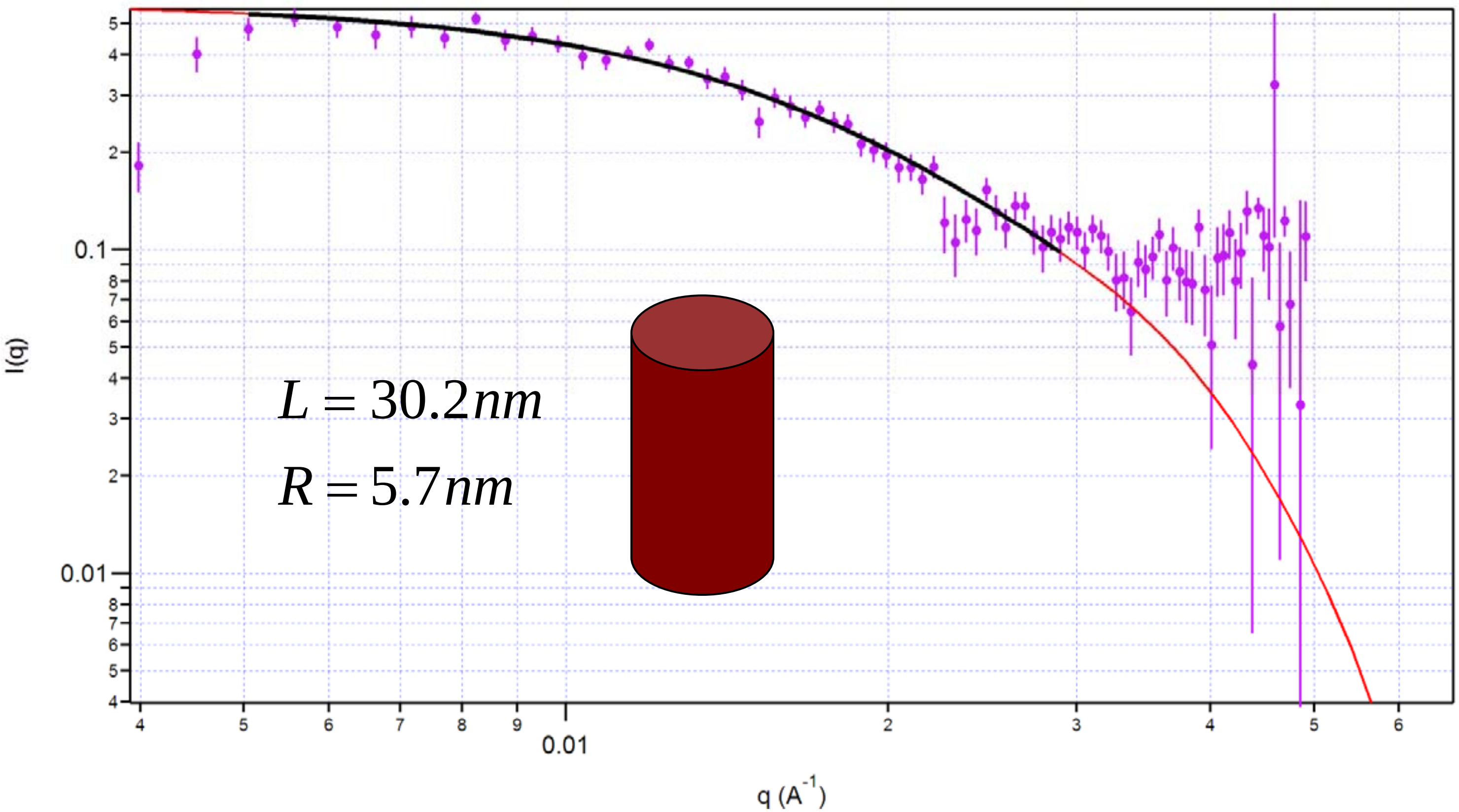


Sphere Fit



$$R_G = \sqrt{\frac{3}{5}} R = 8.5nm$$

Cylinder Fit



$$R_G = \sqrt{\frac{R^2}{2} + \frac{L^2}{12}} = 9.6nm$$

Conclusions

- There is magnetic scattering from the core
- PSANS allows us to separate the nuclear scattering from the magnetic scattering
- The magnetization is isotropic
- There is some magnetic structure (~10 nm) smaller than the core (~50 nm)

Group F

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Special Thanks

Andrew Jackson, Kathryn Krycka,
Cindi Dennis, Cedric Gagnon, David Mildner,
and Paul Butler