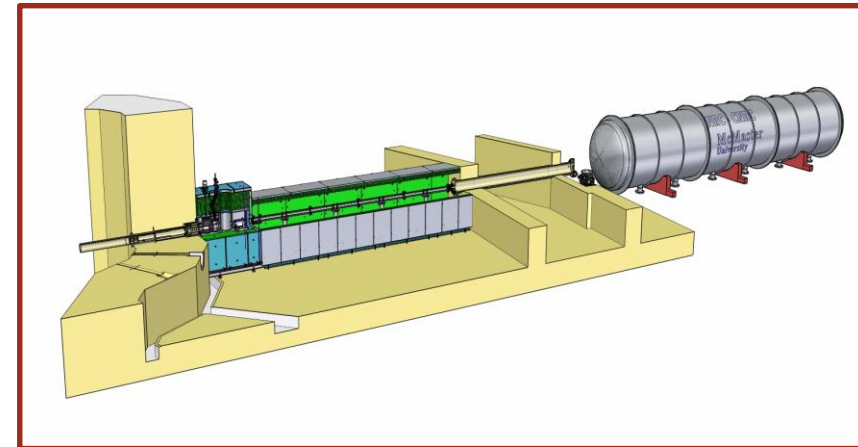




# MacSANS: A new Small Angle Neutron Scattering facility at McMaster University



Pat Clancy<sup>1</sup>, Zin Tun<sup>2</sup>, Maikel Rheinstadter<sup>1</sup>, Chris Heysel<sup>3</sup>, Bruce Gaulin<sup>1</sup>  
<sup>1</sup>McMaster University, <sup>2</sup>Canadian Neutron Beam Centre, <sup>3</sup>McMaster Nuclear Reactor

# Take-Home Message:

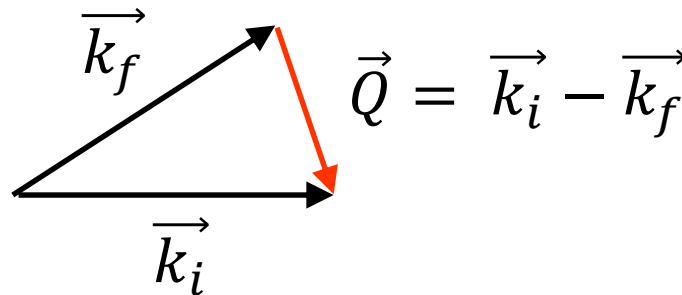
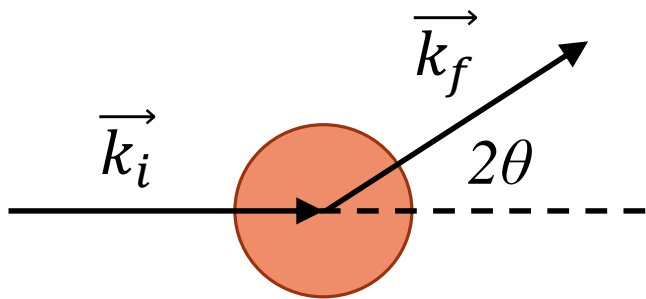
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- As of April 1<sup>st</sup>, the **McMaster Nuclear Reactor** is Canada's only source of neutron beams for materials research
- MNR currently has 2 beamlines devoted to neutron scattering:
- **McMaster Alignment Diffractometer (MAD)** - general purpose triple-axis spectrometer, open for proposals
- **McMaster Small Angle Neutron Scattering beamline (MacSANS)** - under construction, commissioning experiments to begin in Spring 2019
- We are looking for new users and new experiments
- Let us know: what do you need to do your science here?
- Contact us: [clancyp@mcmaster.ca](mailto:clancyp@mcmaster.ca) or [macneutrons@gmail.com](mailto:macneutrons@gmail.com)



# Why Neutron Scattering?

- Neutrons are an ideal tool for investigating the structural and magnetic properties of materials
- Electrically neutral: **non-destructive and very penetrating**
- Magnetic dipole moment: **sensitivity to magnetism**
- Scattering length depends on properties of nucleus: **elemental/isotopic contrast and sensitivity to light atoms (e.g. H and Li)**



(elastic scattering)

$$n\lambda = 2d \sin \theta$$

$$Q = \frac{4\pi}{\lambda} \sin \theta = \frac{2\pi}{d}$$

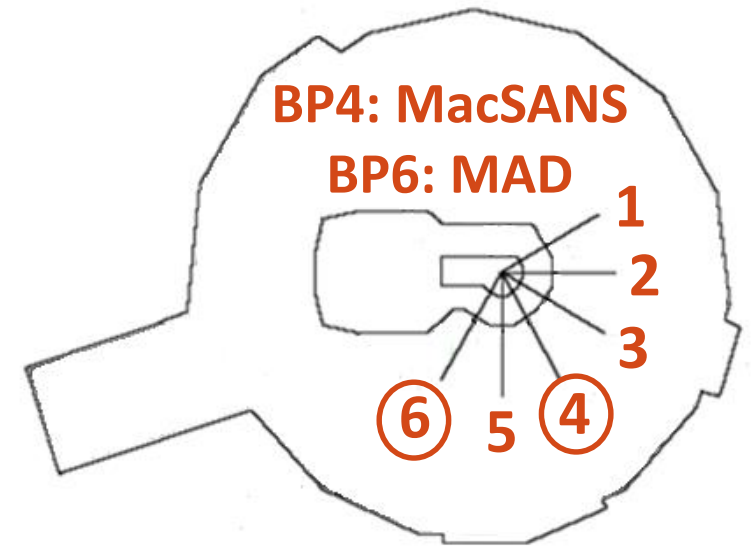
- Neutron diffraction (elastic scattering): measures structure and static properties
- Neutron spectroscopy (inelastic scattering): measures characteristic excitations and dynamics

# The McMaster Nuclear Reactor

- 5 MW open-pool reactor  
(operates 3 MW, ~ 80 hours/week)
- In operation since 1959
- Multi-purpose research reactor:
  - **Neutron scattering**
  - Production of medical isotopes
  - Neutron irradiation/activation analysis
  - Neutron radiography
  - Intense positron beam facility

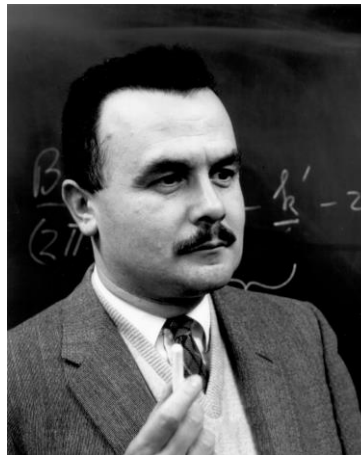
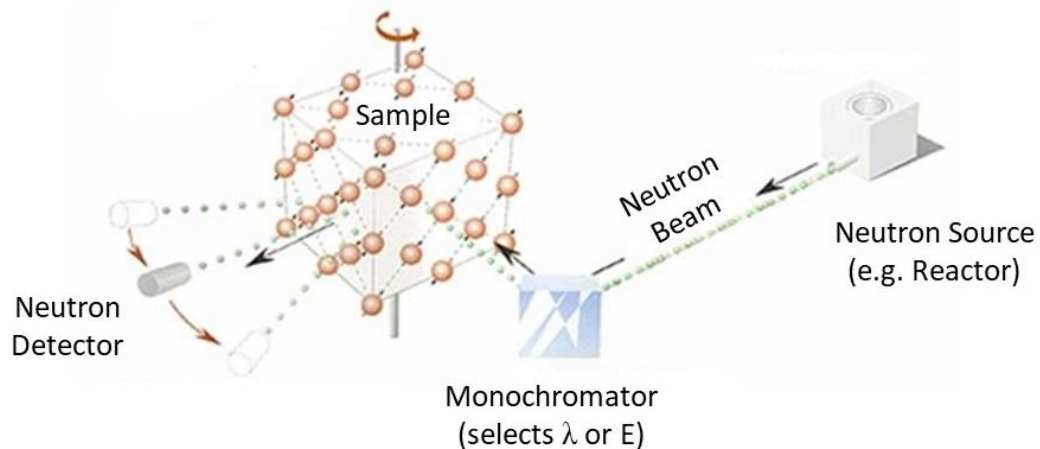


**6 neutron beamports at MNR**



# MAD: McMaster Alignment Diffractometer

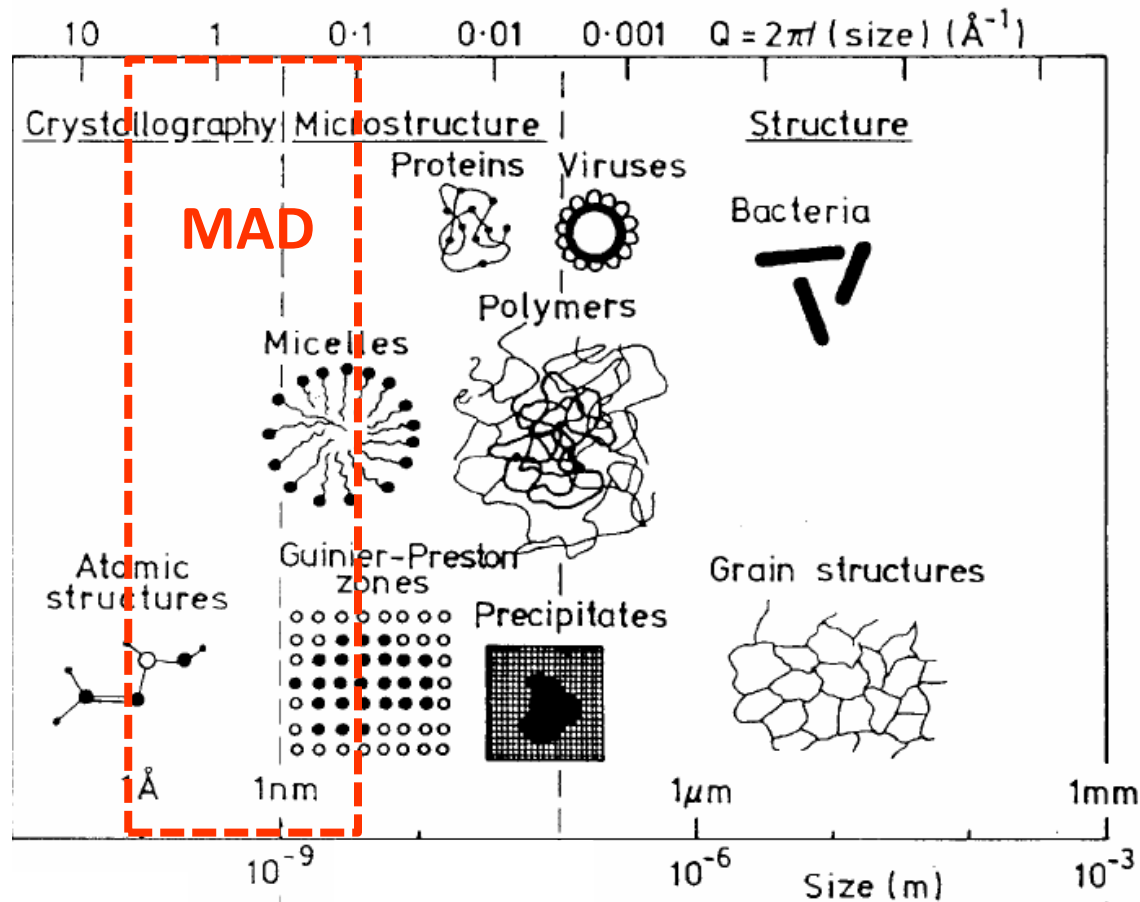
- Triple-axis neutron spectrometer located on Beamport 6
- Built on site of Brockhouse's original McMaster triple-axis
- Primarily used for elastic scattering (alignment, crystal quality)
- Operating since 2010, upgraded in 2017



**Bertram Brockhouse (1918-2003)**  
**1994 Nobel Prize in Physics**  
**McMaster Professor 1962-1984**



# For larger length scales, need smaller angles...

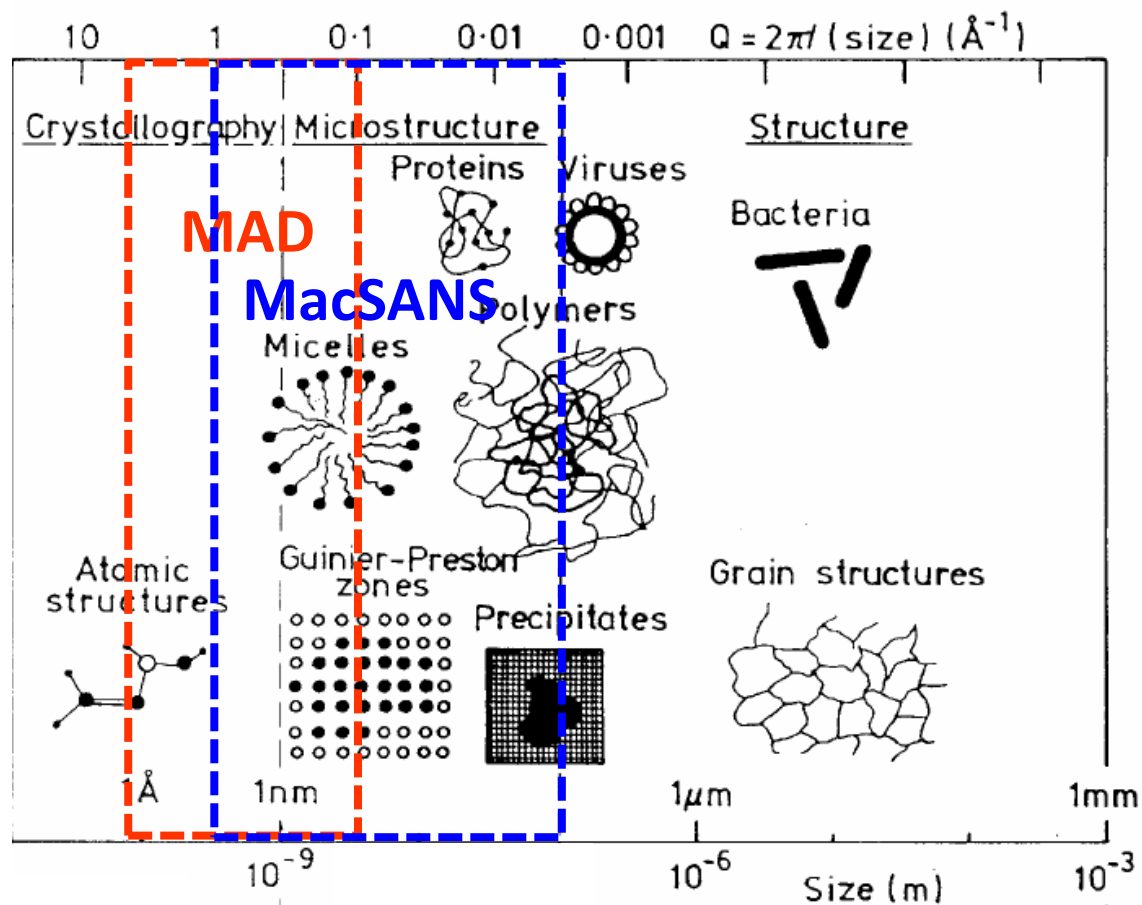


$$Q = \frac{4\pi}{\lambda} \sin \theta = \frac{2\pi}{d}$$

- **MAD**: wide angle neutron scattering ( $Q_{\min} \sim 0.1 \text{ \AA}^{-1}$ , length scales  $< 70 \text{ \AA}$ )

Adapted from C. Glinka, NCNR

# For larger length scales, need smaller angles...



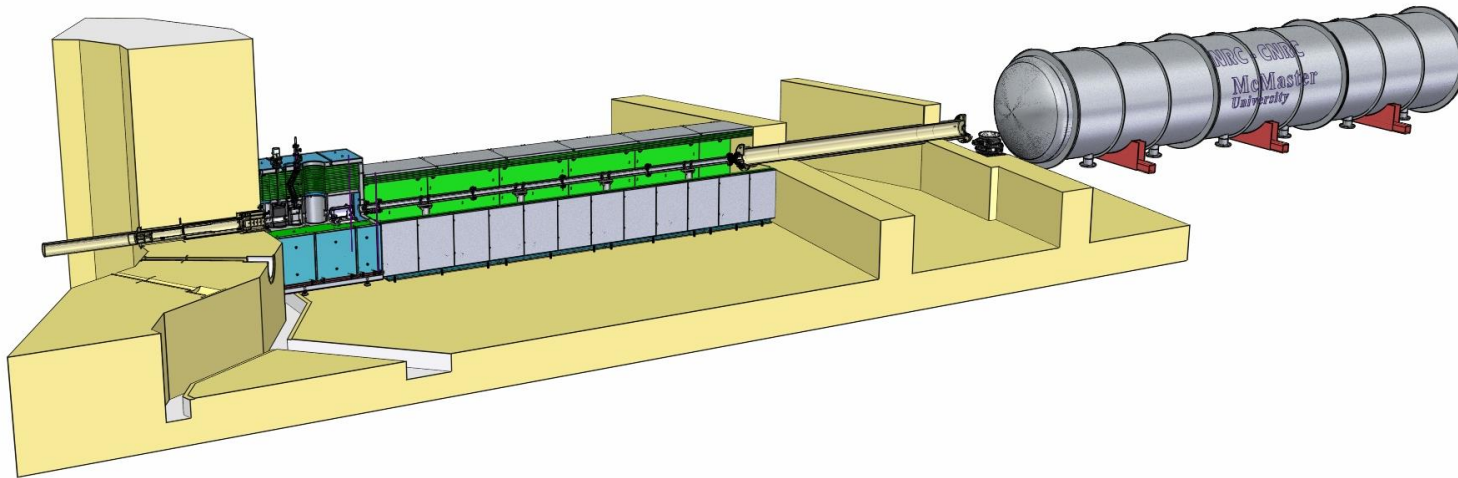
$$Q = \frac{4\pi}{\lambda} \sin \theta = \frac{2\pi}{d}$$

- **MAD**: wide angle neutron scattering ( $Q_{\min} \sim 0.1 \text{ \AA}^{-1}$ , length scales  $< 70 \text{ \AA}$ )
- **MacSANS**: small angle neutron scattering ( $Q_{\min} \sim 0.005 \text{ \AA}^{-1}$ , length scales  $< 1300 \text{ \AA}$ )
- Opens up many more opportunities for soft matter science...

Adapted from C. Glinka, NCNR

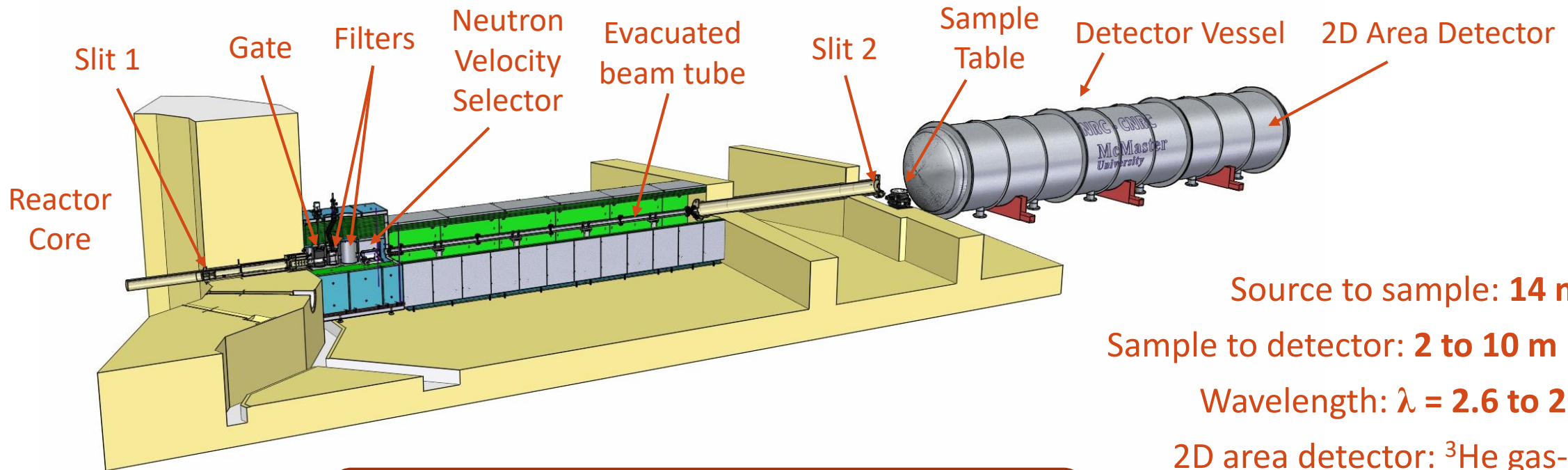
# MacSANS: Small Angle Neutron Scattering

- State-of-the-art small angle neutron scattering (SANS) beamline for study of nanostructured materials (biological membranes, polymers, high temperature superconductors, novel magnets, metals and alloys)
- Currently under construction on Beamport 4
- Scheduled to begin commissioning experiments in **Spring 2019**





# MacSANS Instrument Design



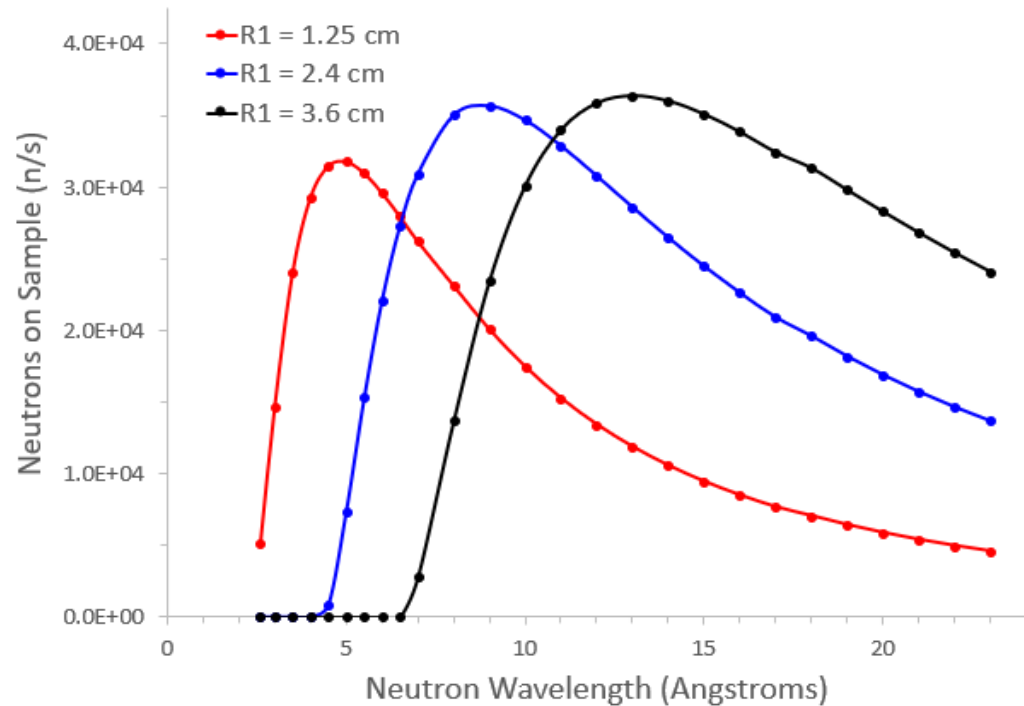
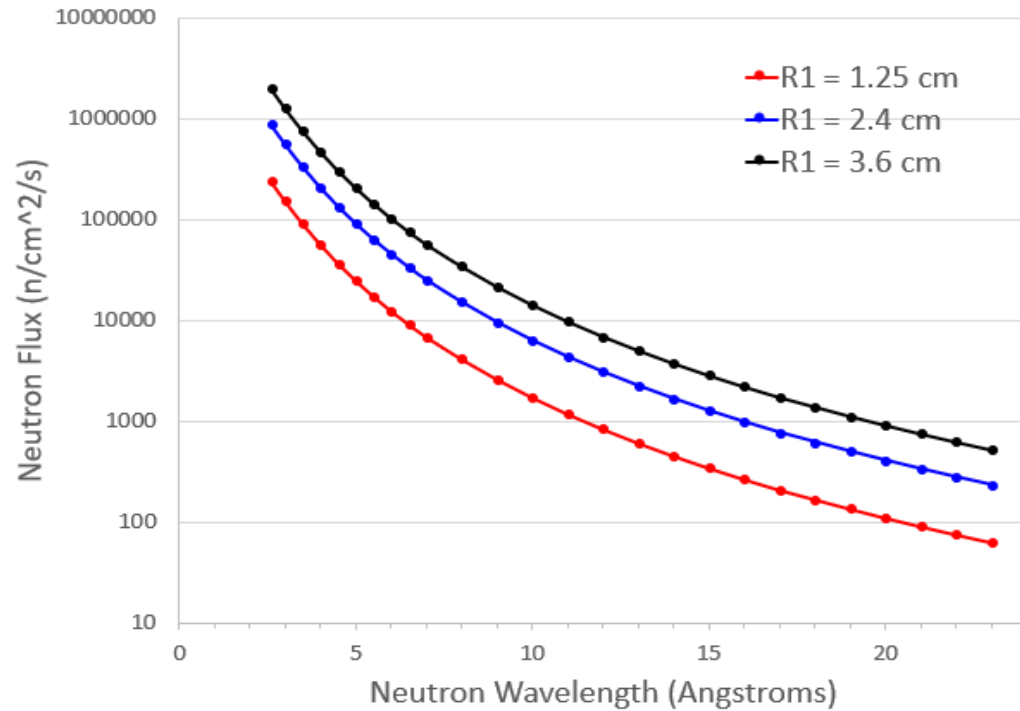
MacSANS probes structure and magnetism on length scales ranging from **0.5 nm** to **125 nm**

Source to sample: **14 m**  
Sample to detector: **2 to 10 m** (variable)  
Wavelength:  $\lambda = 2.6$  to **23 Å**  
2D area detector:  $^3\text{He}$  gas-filled  
**1m × 1m** area, **7 mm** resolution  
Q-range: **0.005 to 1.25 Å<sup>-1</sup>**



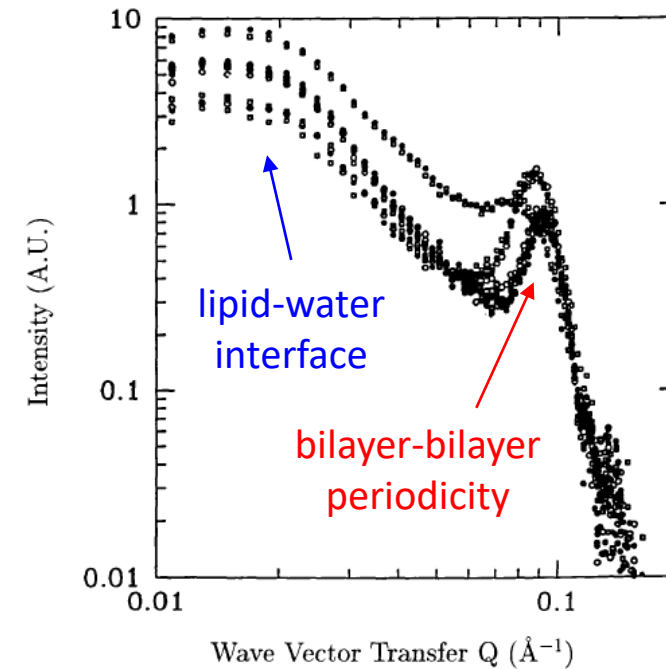
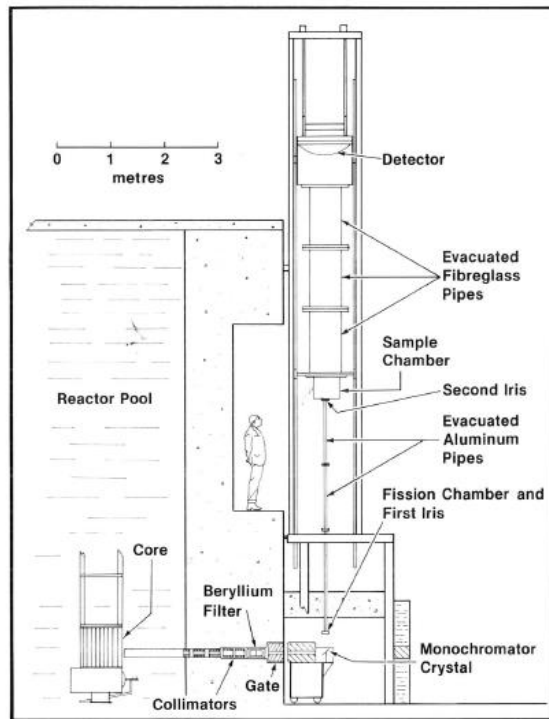
# MacSANS Instrument Performance

- Predicted instrument performance for high resolution setting ( $Q_{\min} = 0.005 \text{ \AA}^{-1}$ ):



- $\sim 3.5 \times 10^4$  neutrons/sec at the sample position

# Flashback: Canada's First SANS Beamline



- DPPC lipid membrane suspension in D<sub>2</sub>O
- 3 phases: gel, ripple, and liquid crystal
- Track temperature evolution with SANS

*J. Avelar et al, Mat. Res. Soc. Symp. Proc. (1995)*

- Beamport #3 at MNR: Vertical SANS (operational 1987 to 2003)
- Q-range: 0.012 to 0.3 Å<sup>-1</sup> (compare to 0.005 to 1.25 Å<sup>-1</sup> on MacSANS)

# MacSANS Timeline

April 2012:  
CFI proposal  
submitted

**INNOVATION.CA**  
CANADA FOUNDATION  
FOR INNOVATION | FONDATION CANADIENNE  
POUR L'INNOVATION

October 2016:  
Construction of SANS  
Experiment Hall begins

October 2017:  
SANS Experiment  
Hall complete



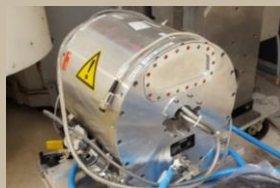
Summer 2018:  
Fabrication of primary  
components

March 2019:  
Area detector  
arrives

November 2012:  
CFI funding awarded



May 2017:  
Velocity selector arrives



June 10<sup>th</sup>, 2018:  
Soft Matter Canada



(YOU ARE HERE)

Fall 2018:  
Installation of  
primary components

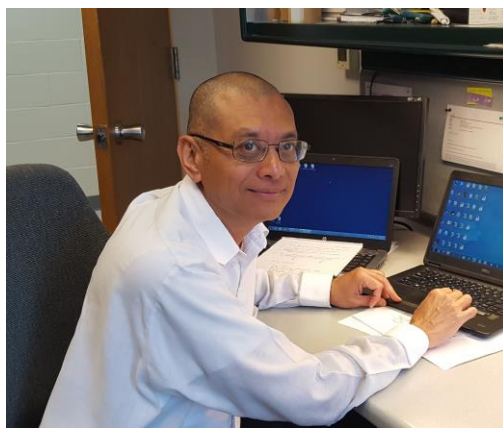
Spring 2019:  
**COMMISSIONING  
BEGINS**



# Acknowledgments



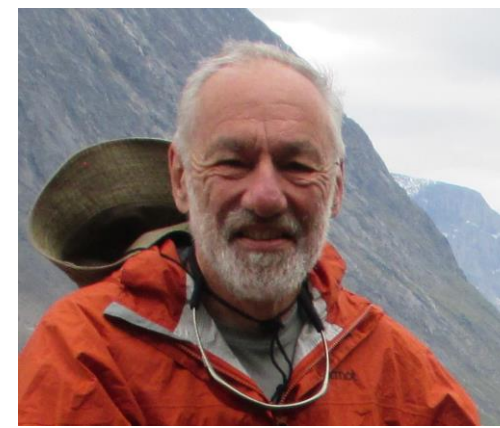
Bruce Gaulin & Chris Heysel



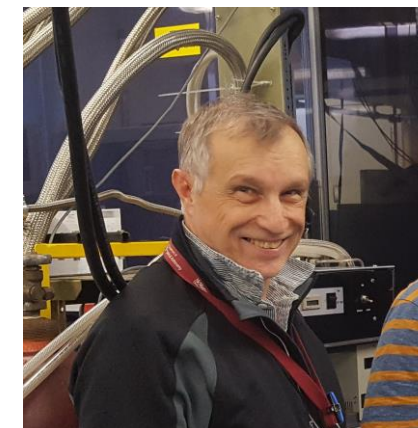
Zin Tun



Derrick West



Mark Vigder



Marek Kiela

The neutron scattering program at MNR is grateful for incredible support from the staff of the McMaster Nuclear Reactor and the Canadian Neutron Beam Centre at Chalk River



We would also like to thank the 10 “Principal Users” of MacSANS: Bruce Gaulin, **Maikel Rheinstadter**, **Kari Dalnoki-Veress**, **Cecile Fradin** (Physics & Astronomy), Yuriy Mozharivskyj and **Harald Stover** (Chemistry), **Emily Cranston**, **Todd Hoare**, and **Robert Pelton** (Chemical Engineering), **Richard Epand** (Biochemistry)



# Take-Home Message:

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