OAK RIDGE National Laboratory

FY20 Thermal Neutron Scattering Measurements at the ORNL Spallation Neutron Source

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U.S. DEPARTMENT OF ENERGY

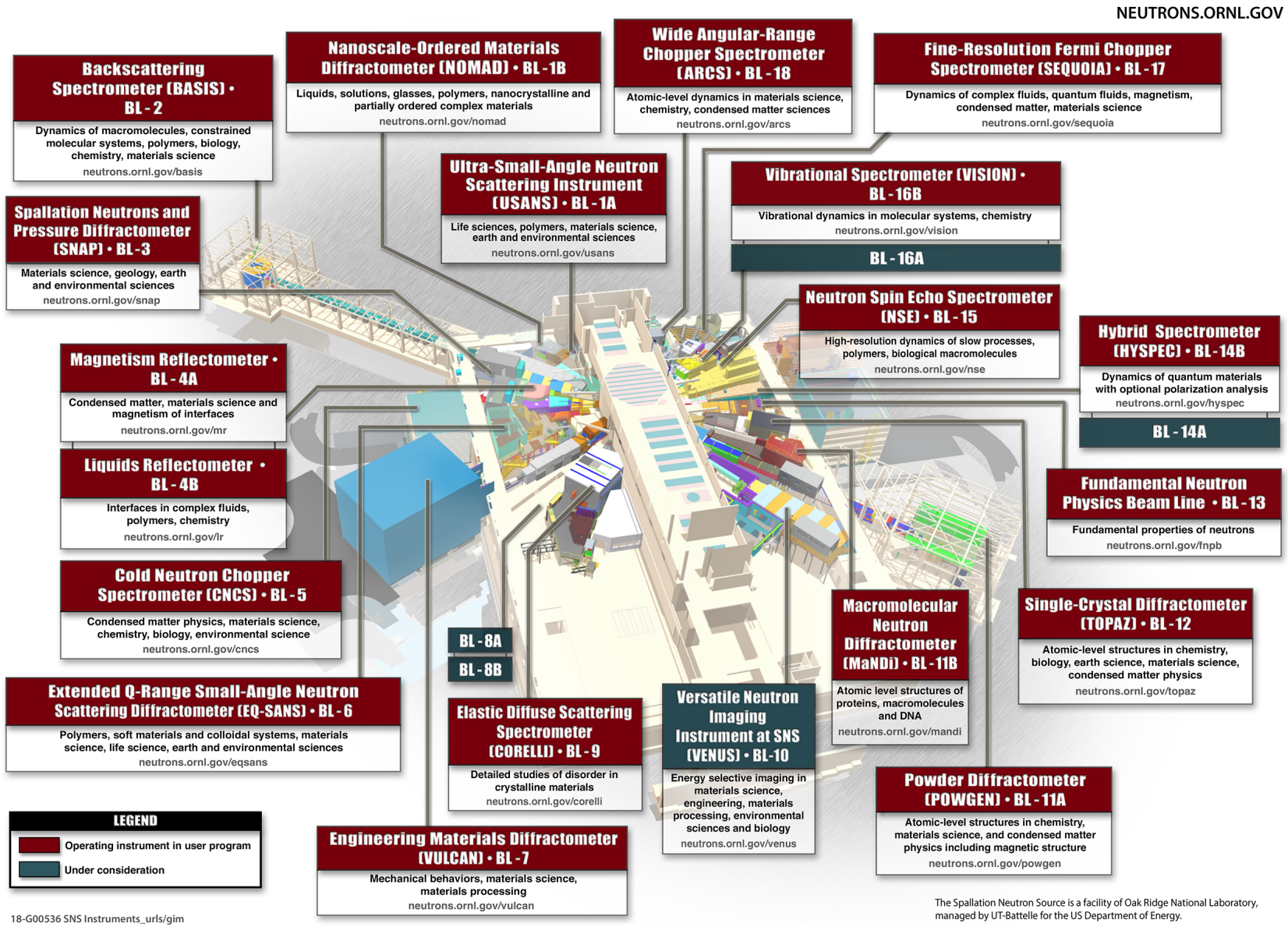
Overview

- Spallation Neutron Source (SNS)
  - Facility layout
  - Instruments used
- Measured materials
  - Yttrium hydride
  - Polystyrene
- Conclusions

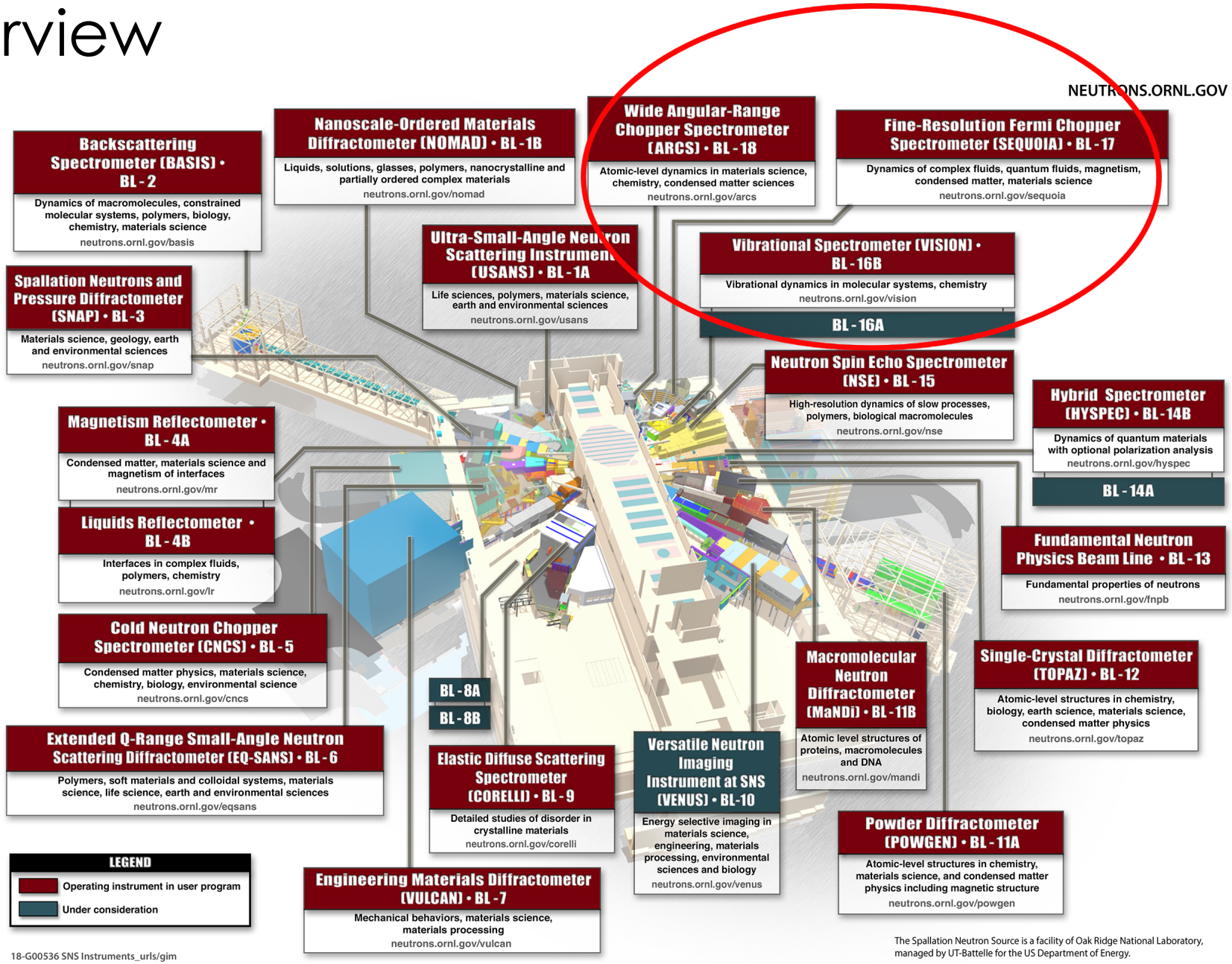
SNS Overview

- High-energy protons accelerated to 1 GeV
  - 1.4 MW LINAC
- Neutron produced by spallation with mercury target
  - Pulsed neutrons produced at 60 Hz
- Neutrons thermalized by passing through water moderator
- Peak brightness: ~1 × 10^{13} n/cm^2/sr/Å/s

SNS Overview



SNS Overview



SNS: ARCS & SEQUOIA

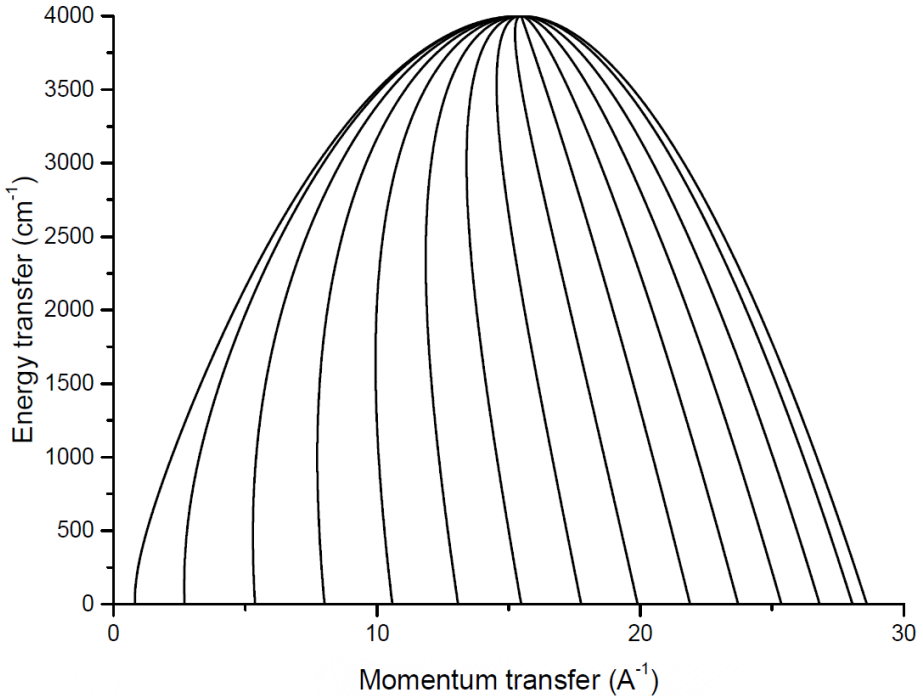
- Time-of-flight direct geometry spectrometer
- User chooses incident energy; Fermi choppers rotate to collimate white beam to selected energy
- Detector setup measures final energy and scattering angle
  - SEQUOIA: slightly better energy resolution
  - ARCS: larger angular range

SNS: VISION

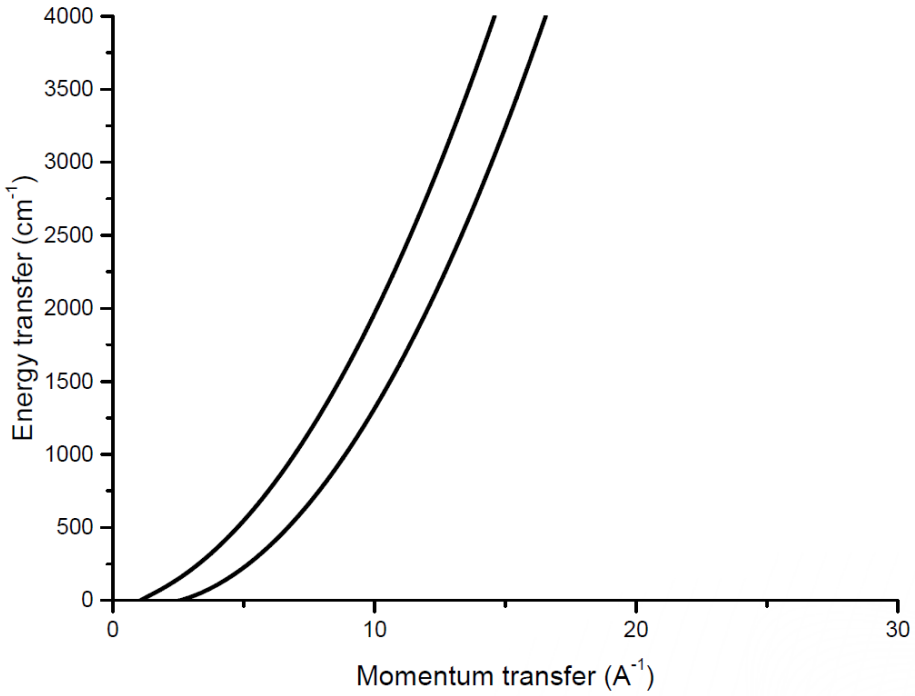
- Indirect geometry vibrational spectrometer
- White beam of neutrons hits target
- Scattered neutrons reflected off graphite blocks to two detectors for forward- and backward-scattering angles
- Graphite blocks configured to scatter neutrons at 4 meV
- Constant relative energy resolution

SNS: (Q,E) Grid of Direct and Indirect Spectrometers

Direct Geometry Spectrometer (ARCS)



Indirect Geometry Spectrometer (VISION)



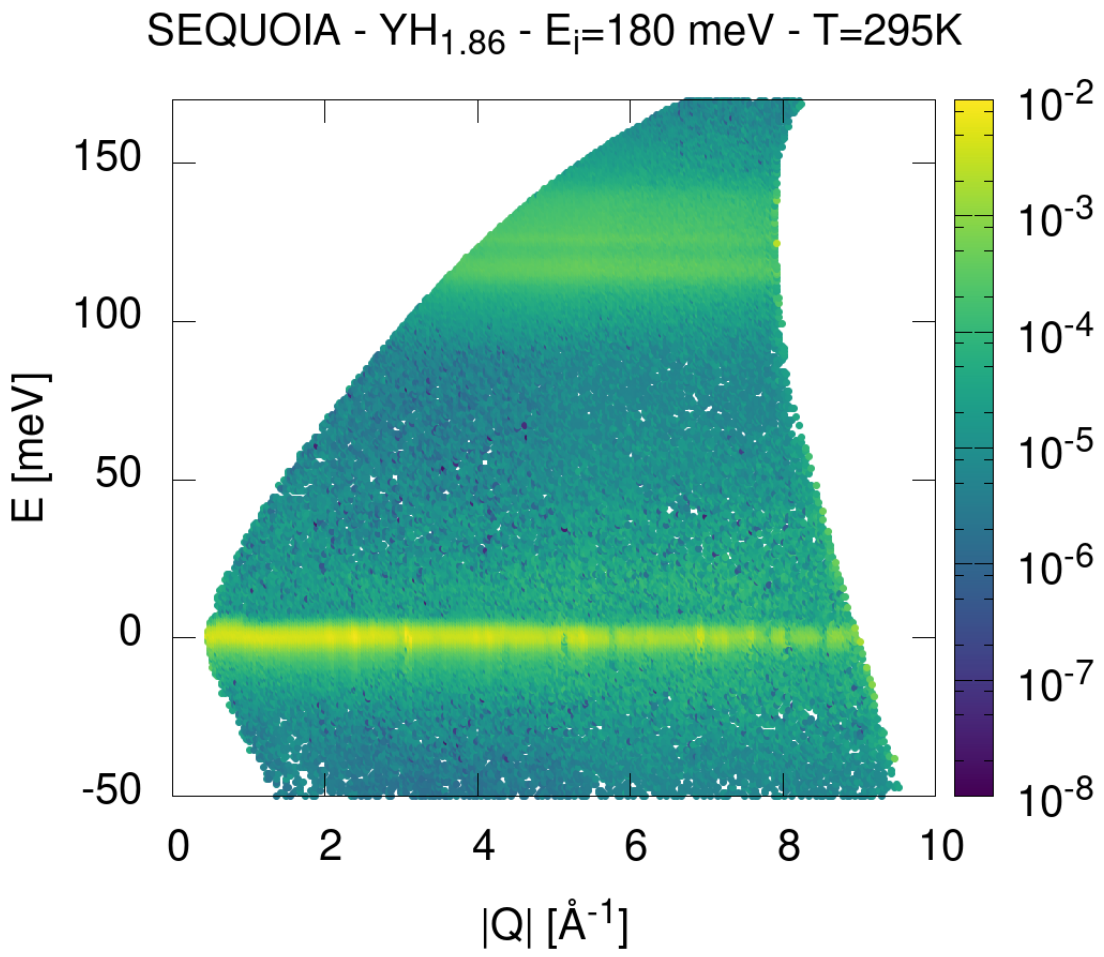
YH_x Overview

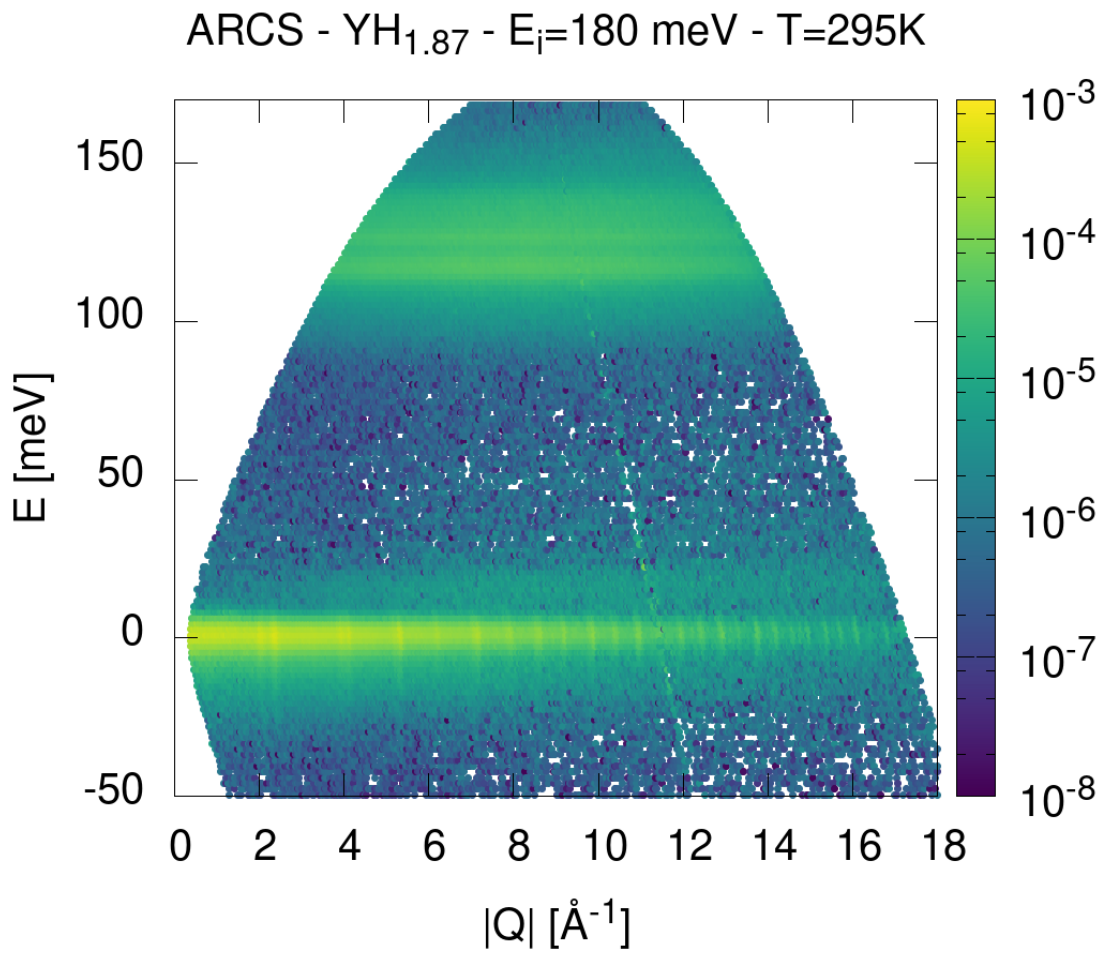
- Moderator of choice for Oak Ridge National Laboratory (ORNL) Transformational Challenge Reactor (TCR)
- Measurement is two-fold:
  - Hydrogen concentration
  - Anharmonicities at high temperatures
- Modeling efforts in corresponding talk
  - "Modeling of Anharmonic Effects and Temperature Depencency of the YH_2 Phonon Spectrum," by Kemal Ramić

YH_x Overview

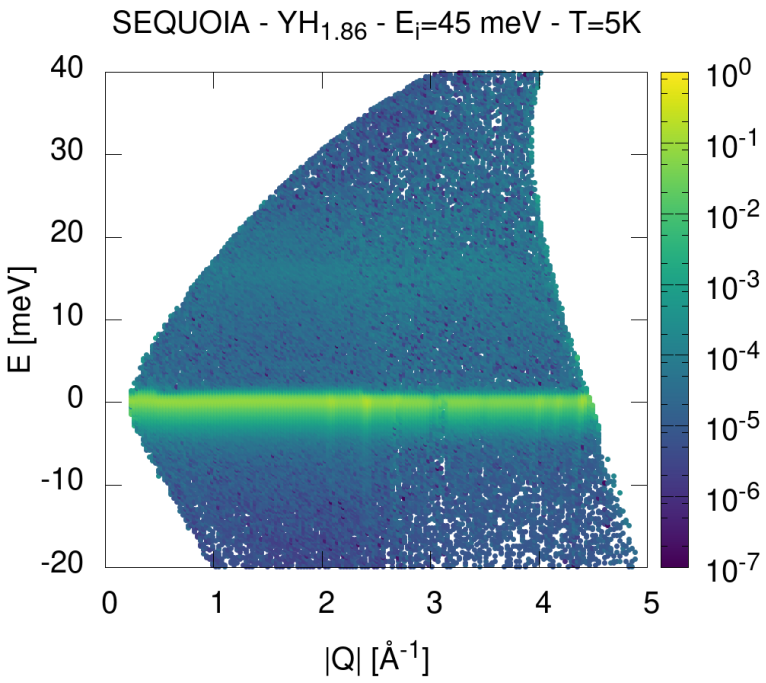
SNS instrument	Samples	Sample form	Sample fixture	Mass (g)	Incident neutron energy (meV)	Temperature (K)
SEQUOIA	$YH_{1.62}$	Powder	Aluminum plate and cover	0.6966	45, 180, 600	5
	$YH_{1.86}$			0.702		5, 295, 550, 800
VISION	$YH_{1.62}$			0.6966	N/A	5, 293
	$YH_{1.74}$			0.6684		
	$YH_{1.86}$			0.702		
	$YH_{1.90}$			0.7696		
ARCS	$YH_{1.68}$	0.1 mm hydride foil	Thin-wall quartz tube	1.6681	45, 180, 600	295, 550, 800, 900, 1,000, 1,100, 1,200
	$YH_{1.87}$			1.8937		

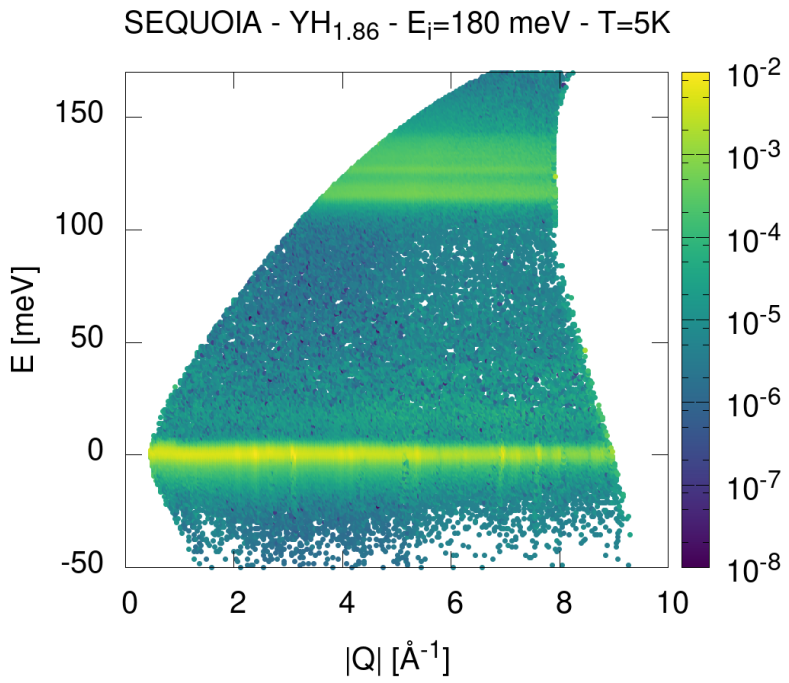
YH_x: ARCS/SEQUOIA Comparison

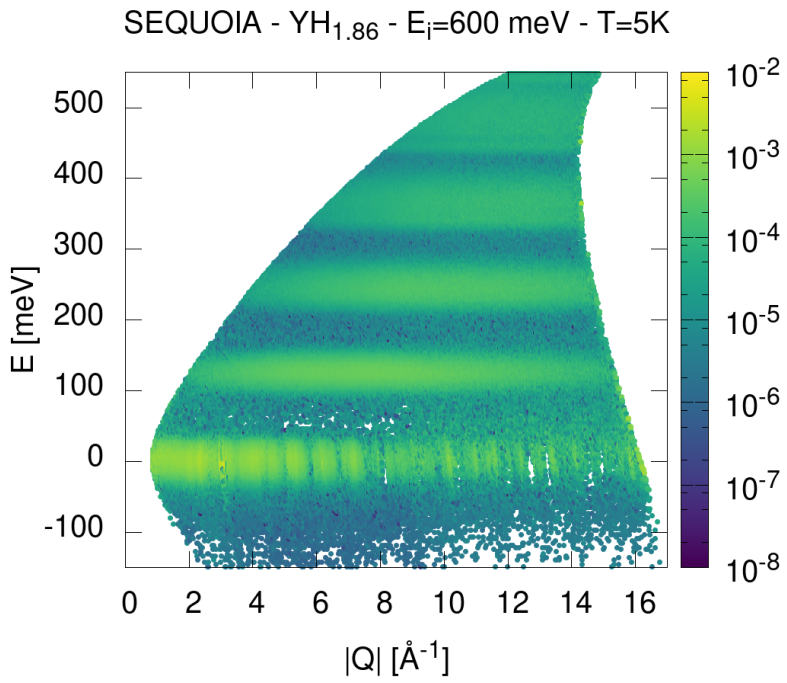




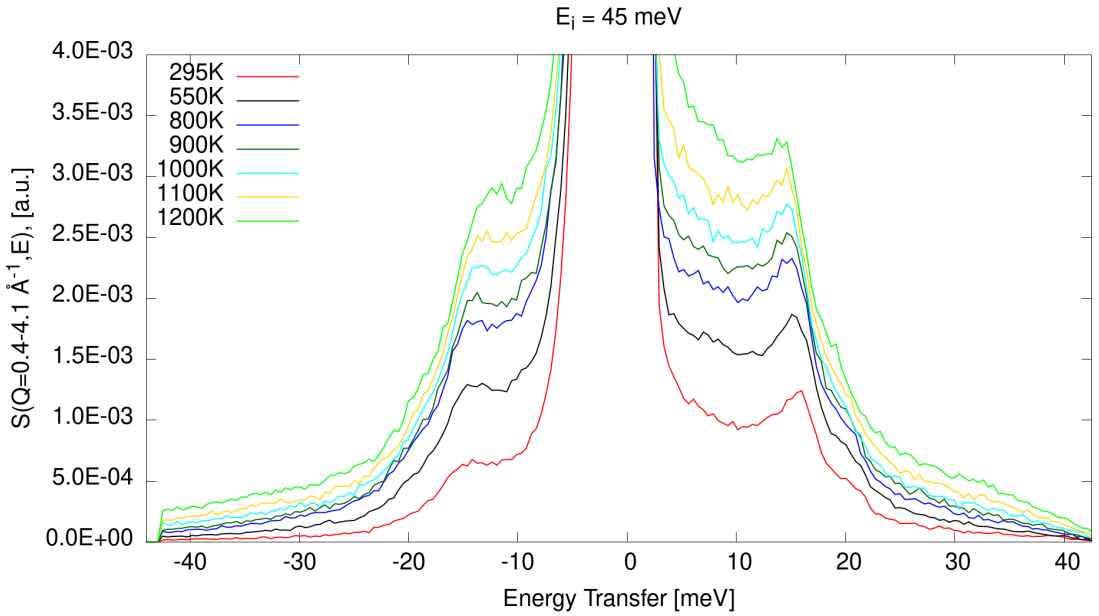
YH_x: SEQUOIA measurements

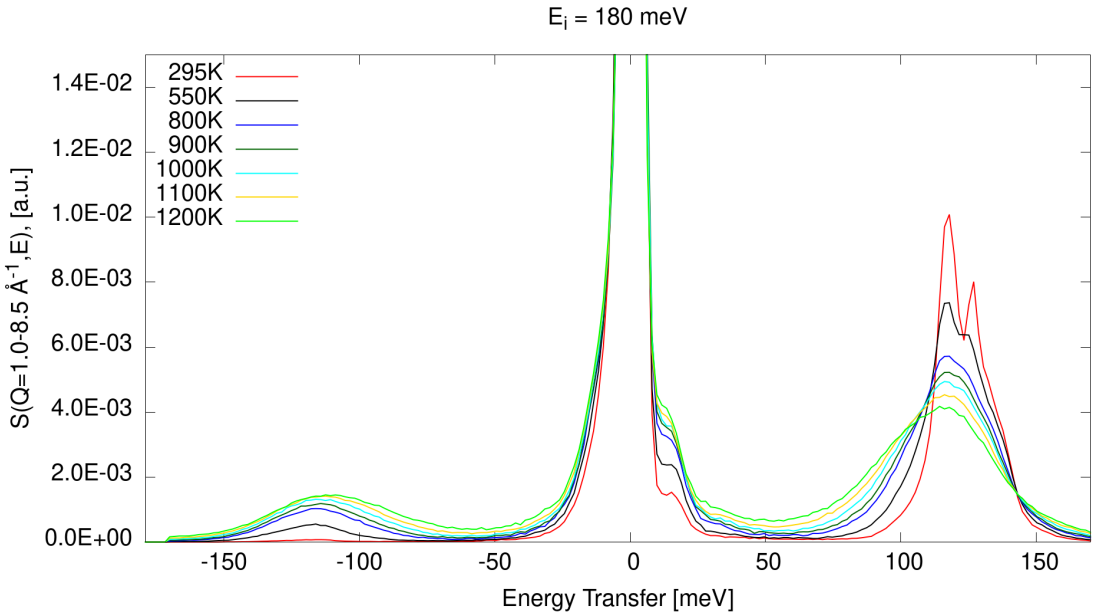


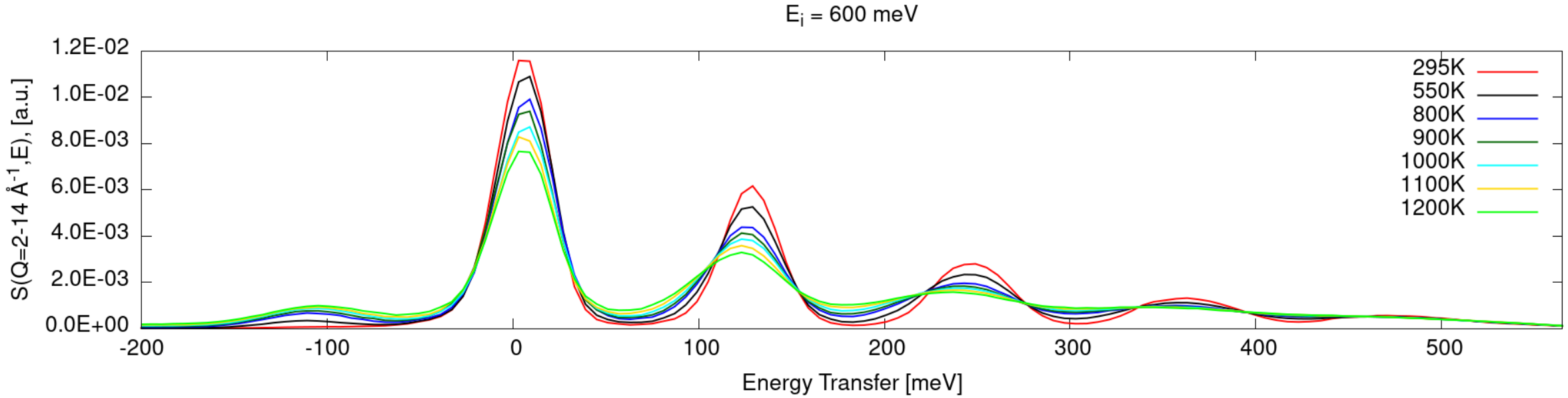




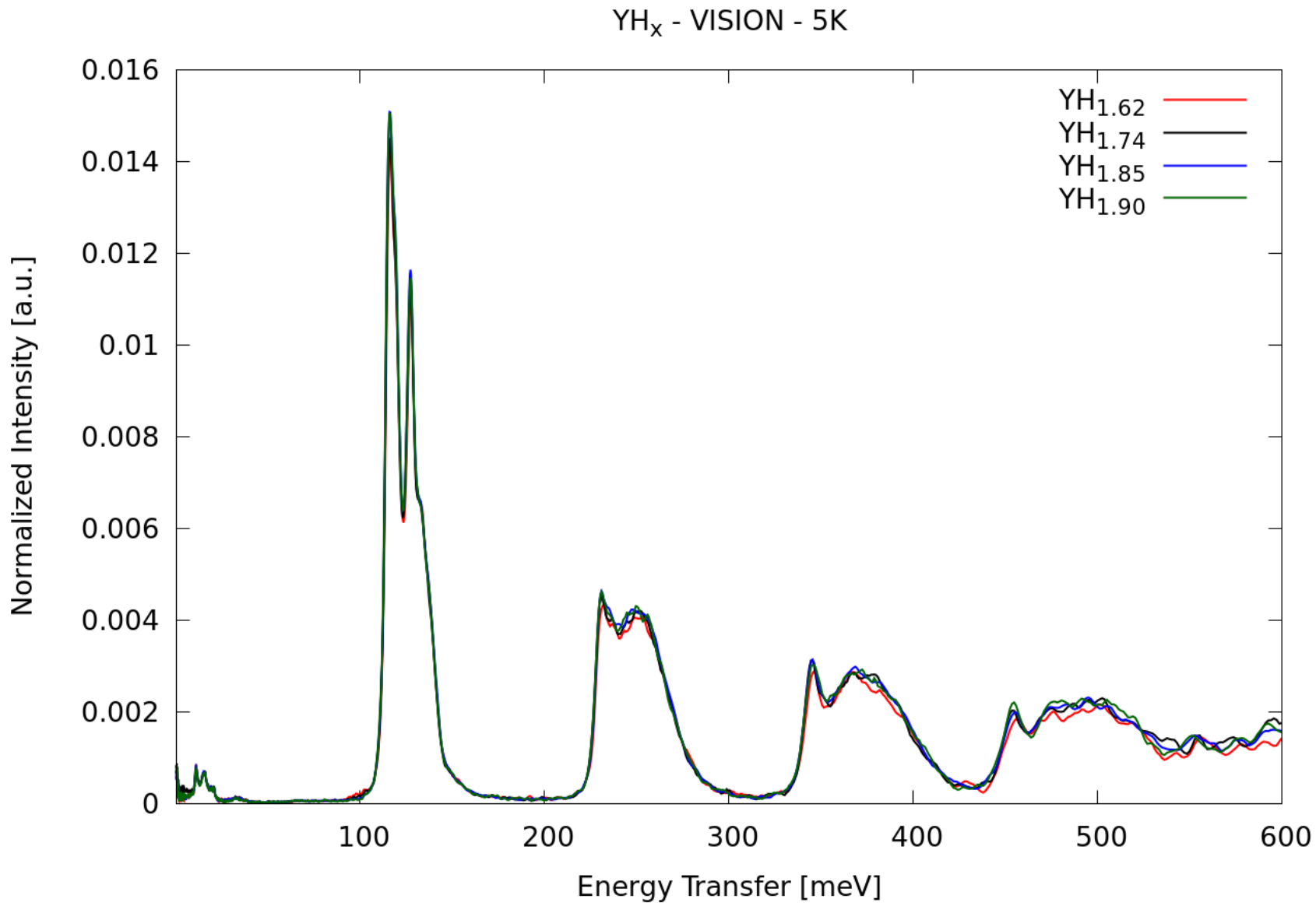
YH_x: ARCS Measurements—Temperature Comparison



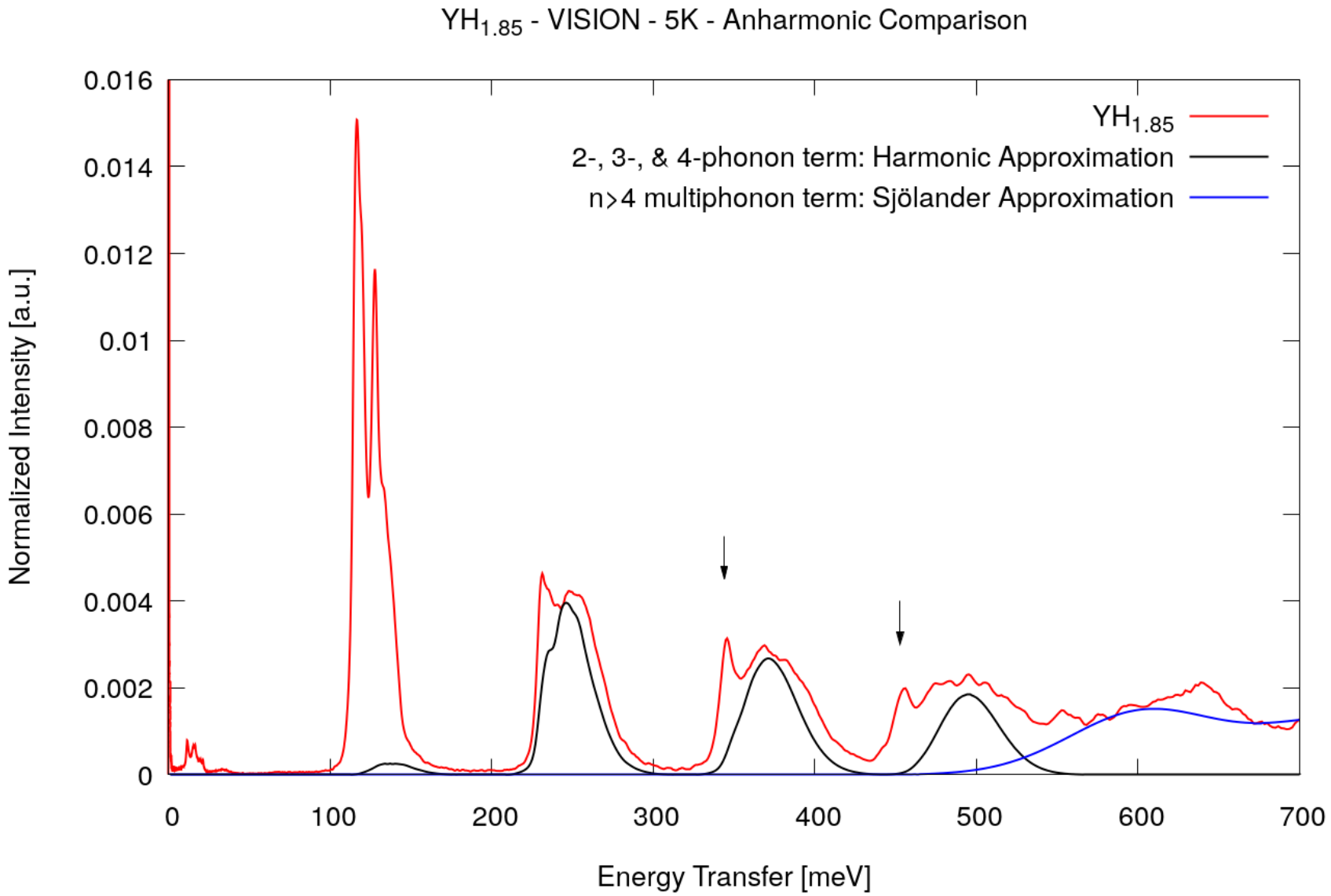




YH_x: VISION Measurements



YH_x: VISION Measurements



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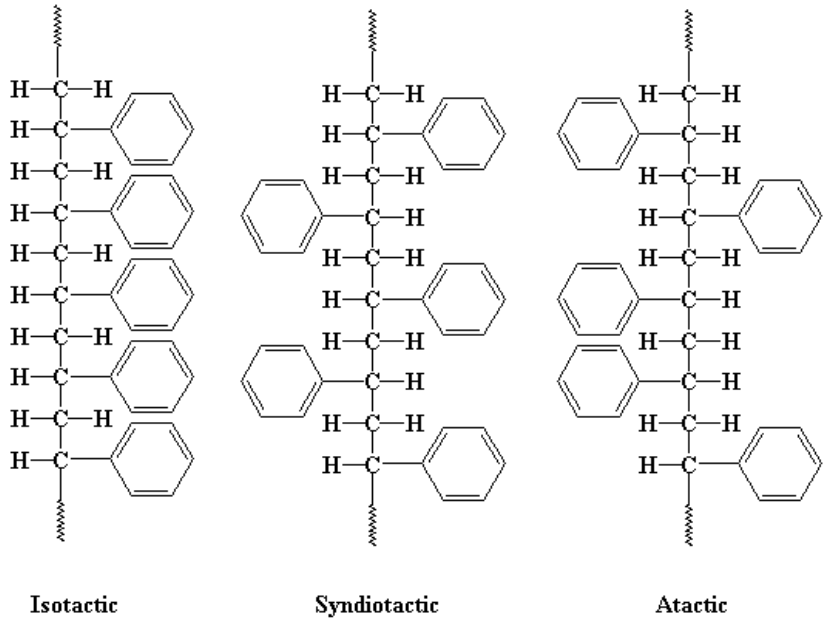
Polystyrene Overview

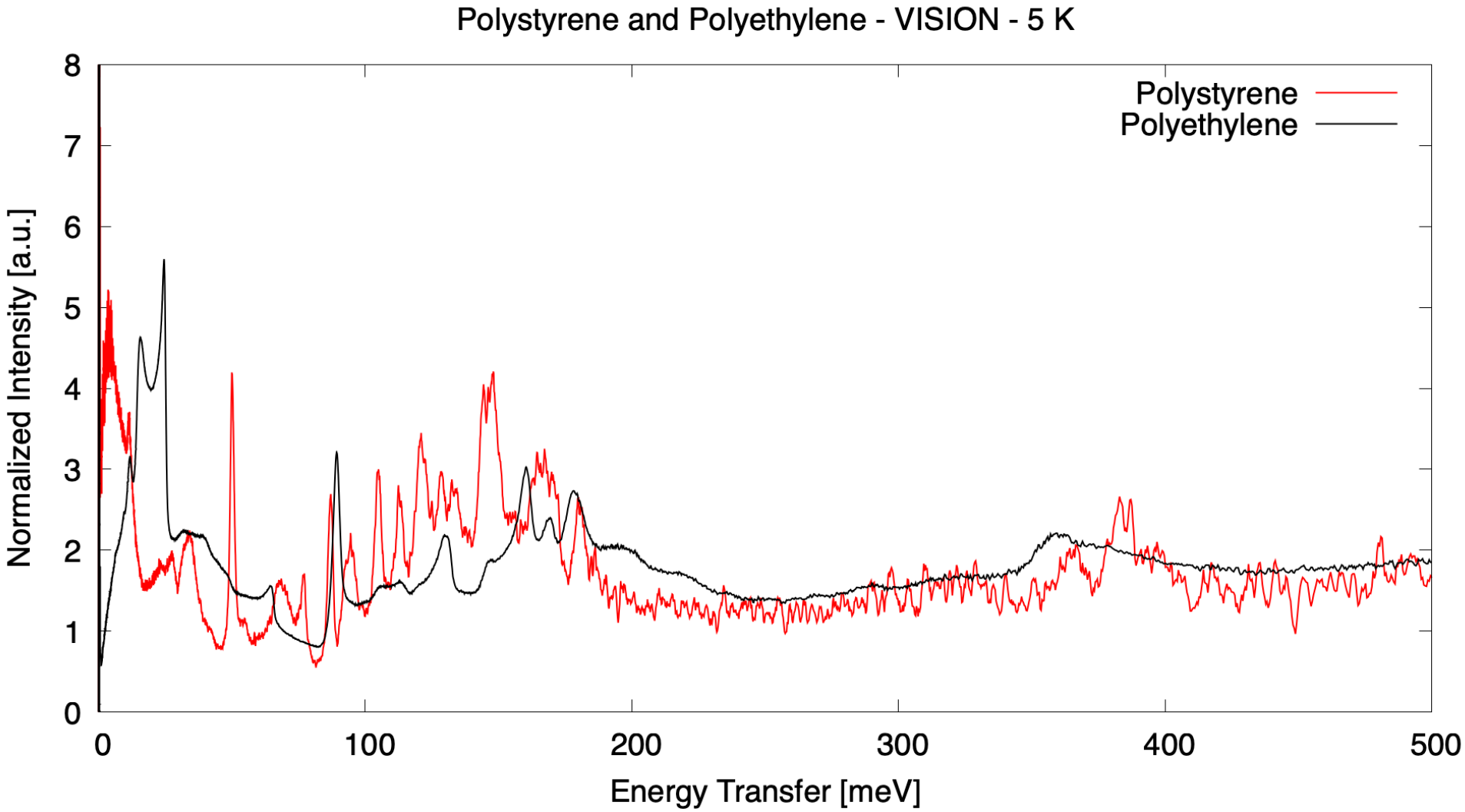
- Nuclear Criticality Safety Program material of interest; used in several International Criticality Safety Benchmark Evaluation Project benchmarks
- Previously used polyethylene as a surrogate
- Scientific merit:
  - Molecular weight
  - Tacticity
  - Crystal vs. amorphous



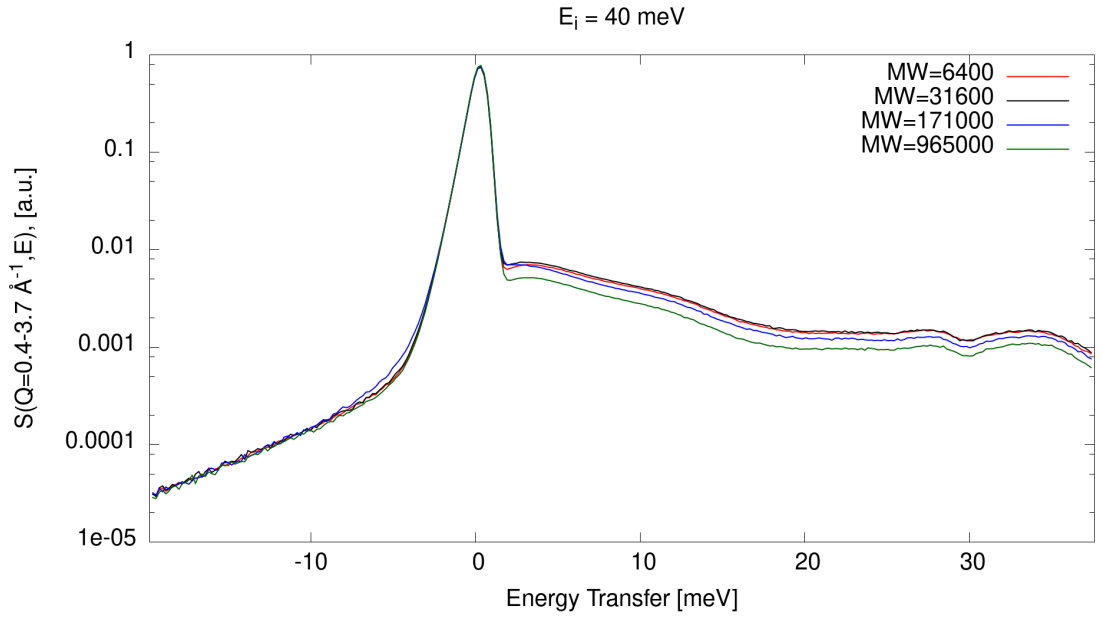
Polystyrene Overview

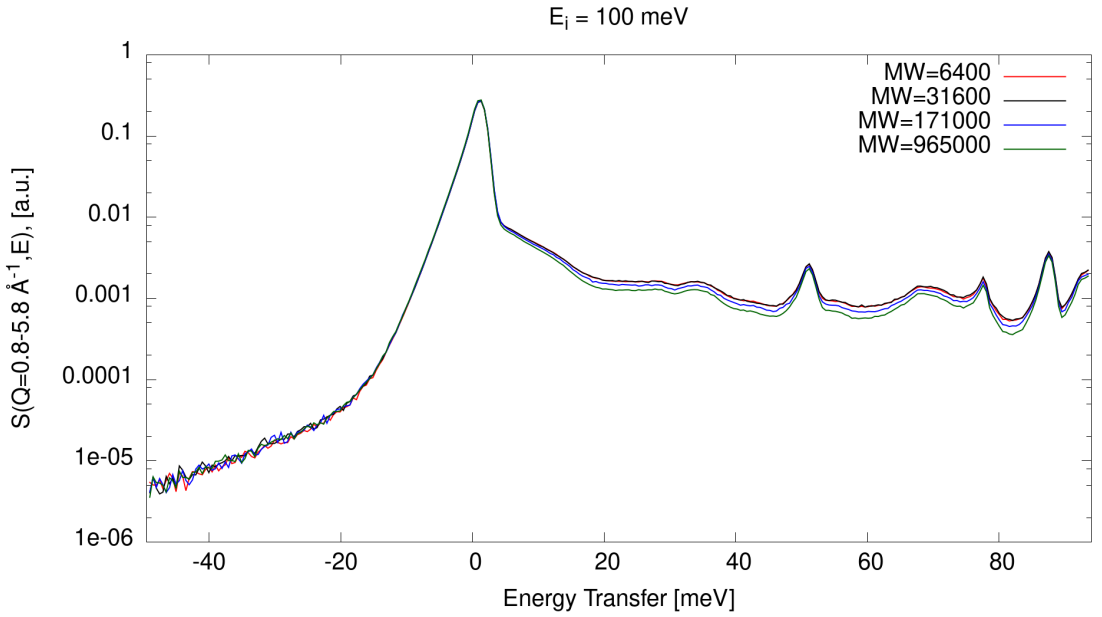
Material	MW	Incident neutron energy (meV)	Temperature (K)
Syndiotactic Polystyrene (sPS)	6,400	40, 100, 225, 500	5, 293
	31,600	40, 100, 225	5
	171,000		
	965,000	40, 100, 225, 500	5, 293
Atactic Polystyrene (aPS)	5,800	40, 100, 225, 500	5
	25,000		
	170,000		
	650,000		

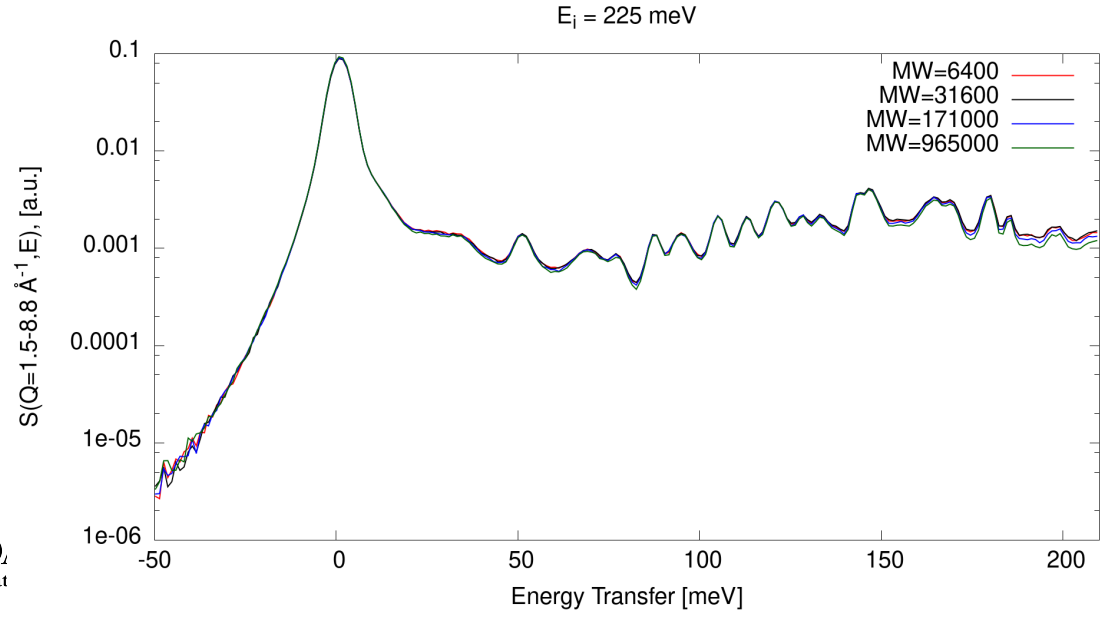
Polystyrene: Comparison with Polyethylene

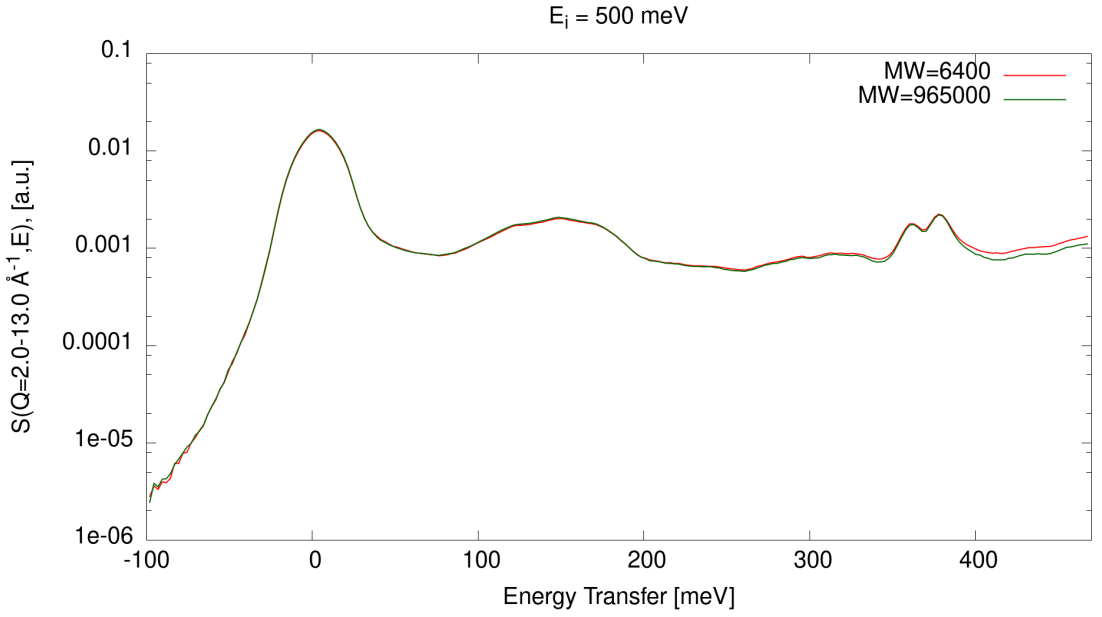


Polystyrene: sPS Molecular Weight Comparison

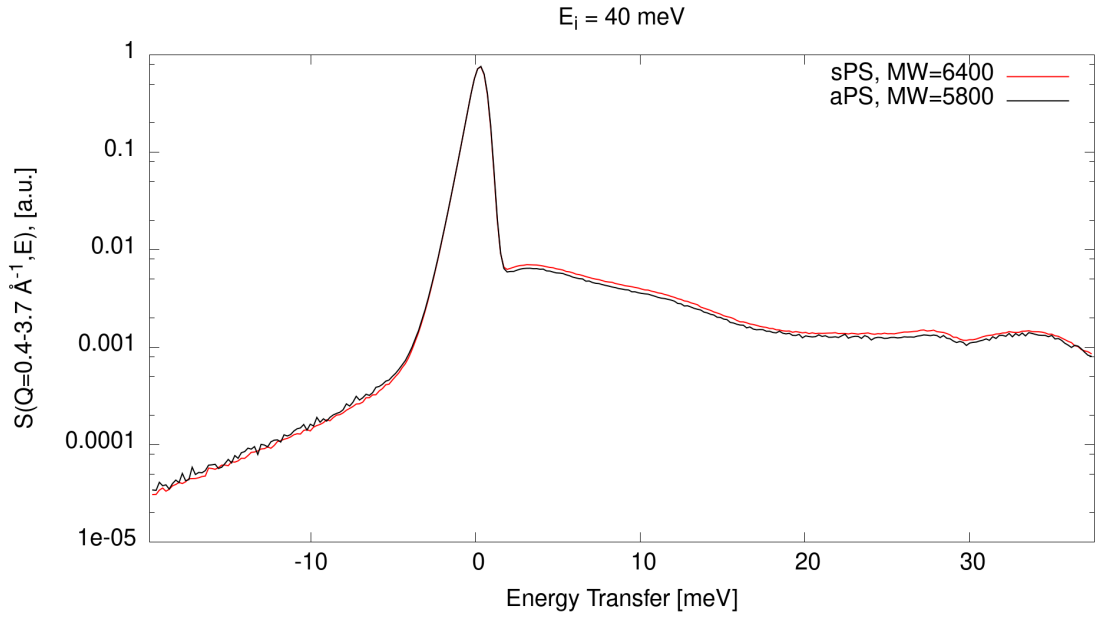


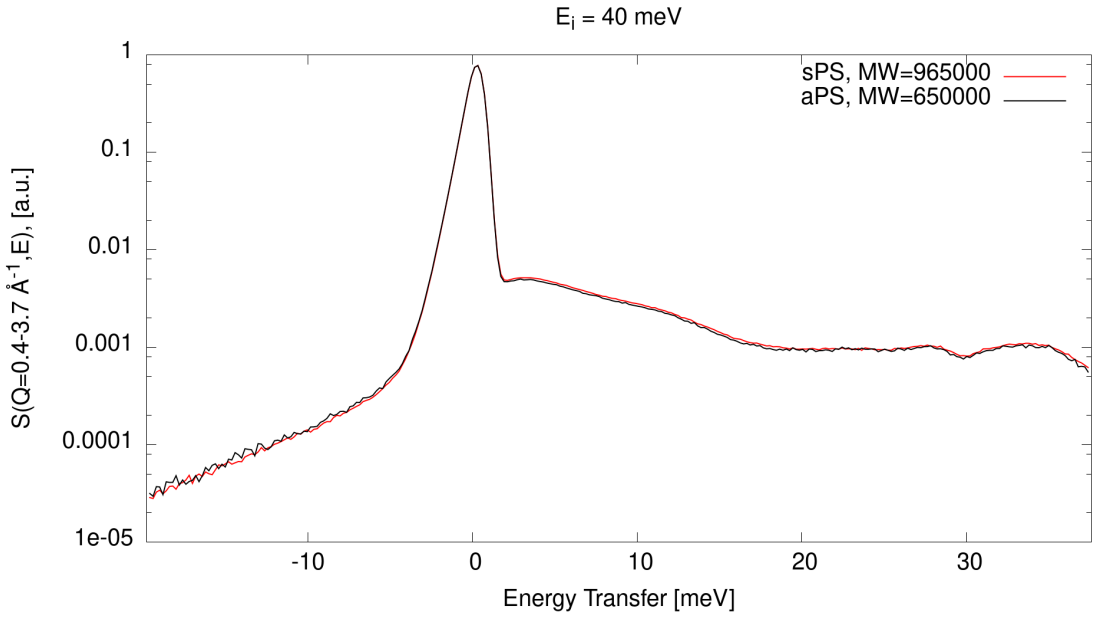


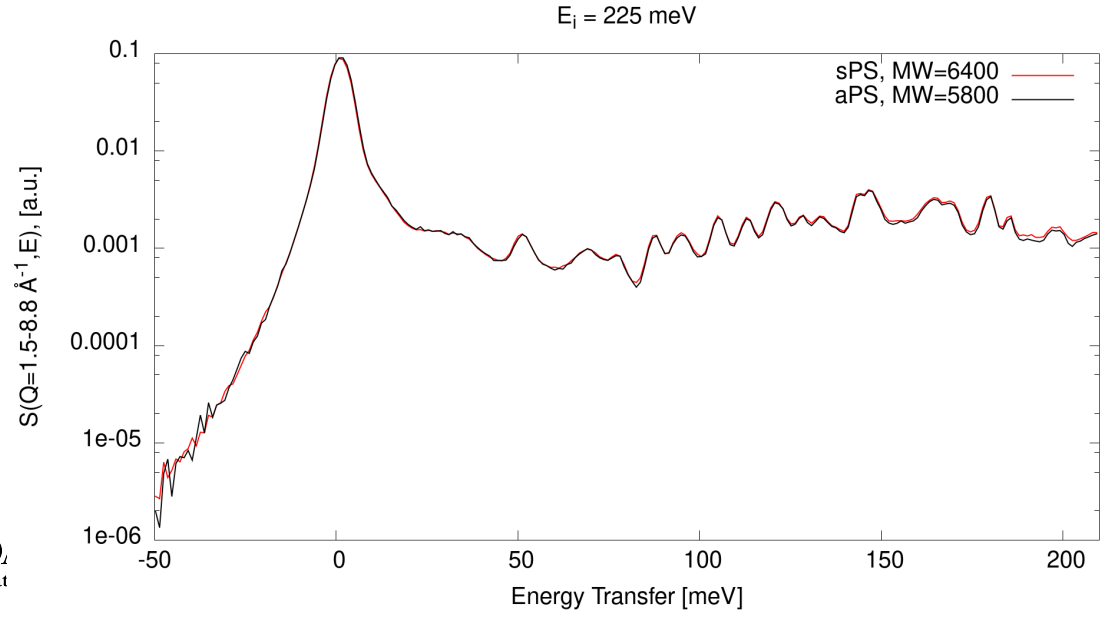


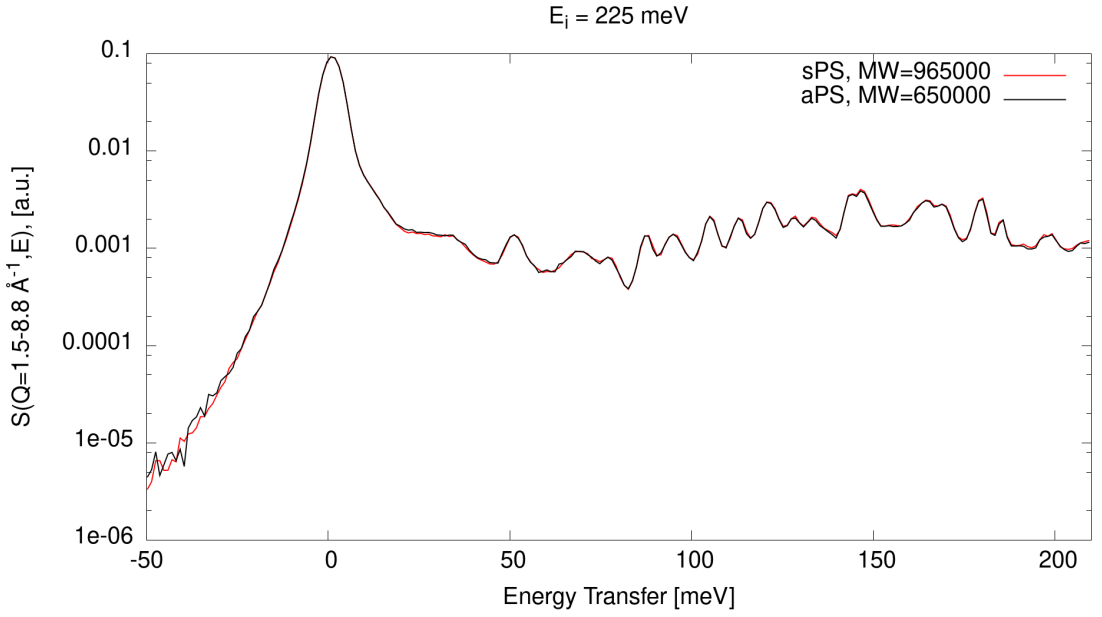


Polystyrene: Tacticity Comparison









Conclusions

- YH_x
  - Anharmonicities play significant role in inelastic spectra
- Polystyrene
  - Inelastic spectra different from polyethylene
  - No noticeable difference in inelastic scattering as a function of MW or tacticity for amorphous samples
  - Further measurements planned to determine effect of crystallinity

Acknowledgments

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Questions?