Thermal Triple Axis
BT-7 for Inelastic Scattering

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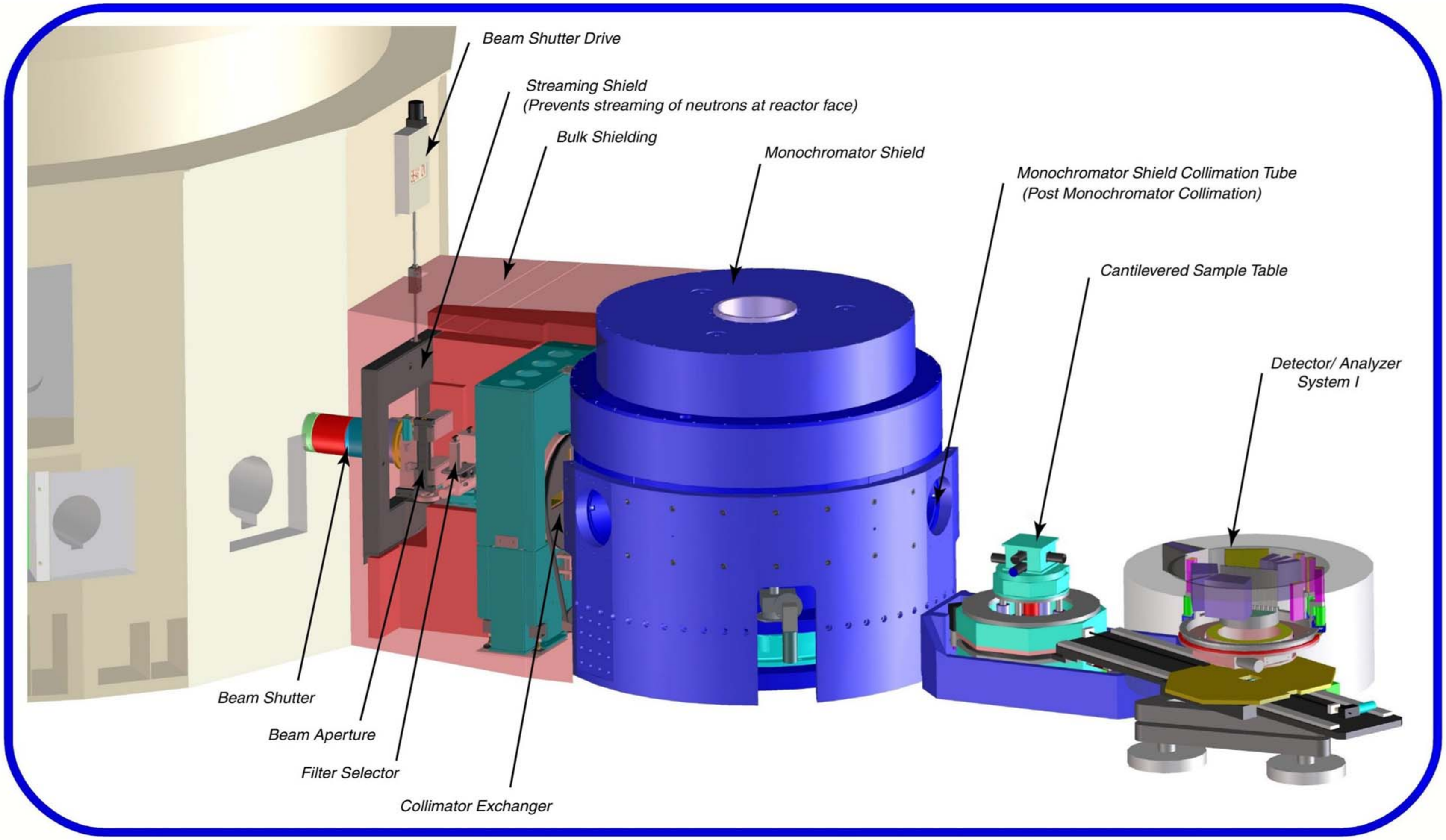
NCNR

BT-7 Features

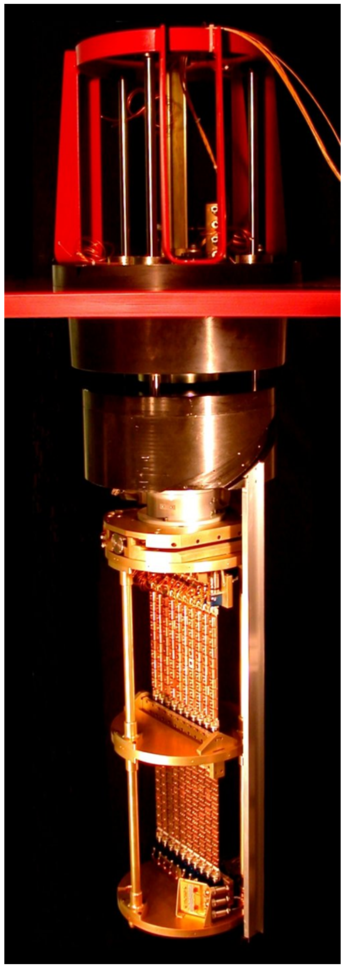
- Full use of large reactor beam (ID=15 cm)
- Choice of Double Focusing Monochromators
- Polarized Beam (Heusler→He^3)
- Elevator, magnet axis for sample (15 Tesla)
- Interchangeable Analyzer Systems
  - Conventional (with collimation)
  - Horizontal Focusing
  - Flat PG + PSD
  - Constant-E PSD scan
  - Diffraction with PSD
- Velocity Selector (future)

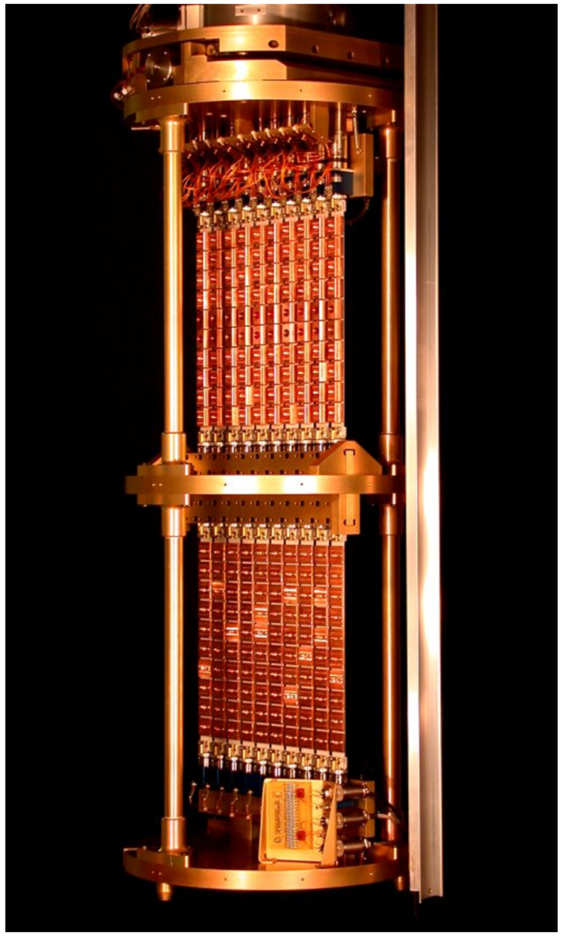
BT-7 New Thermal TAS

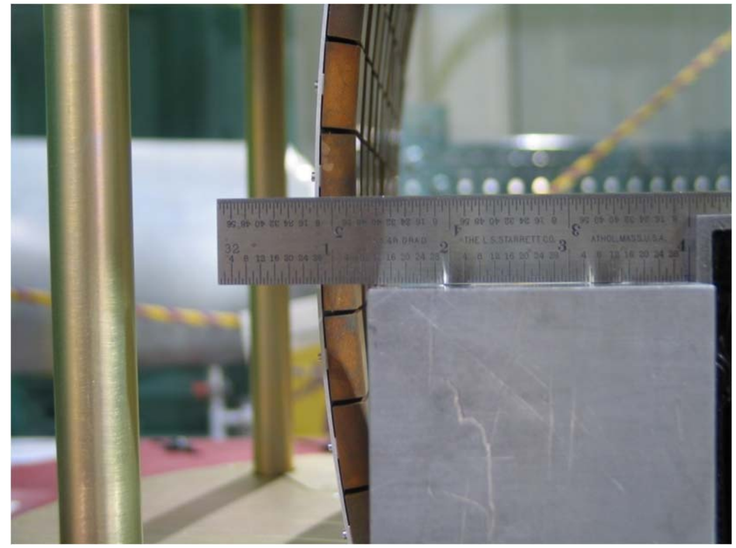
Overview



Double focusing monochromators



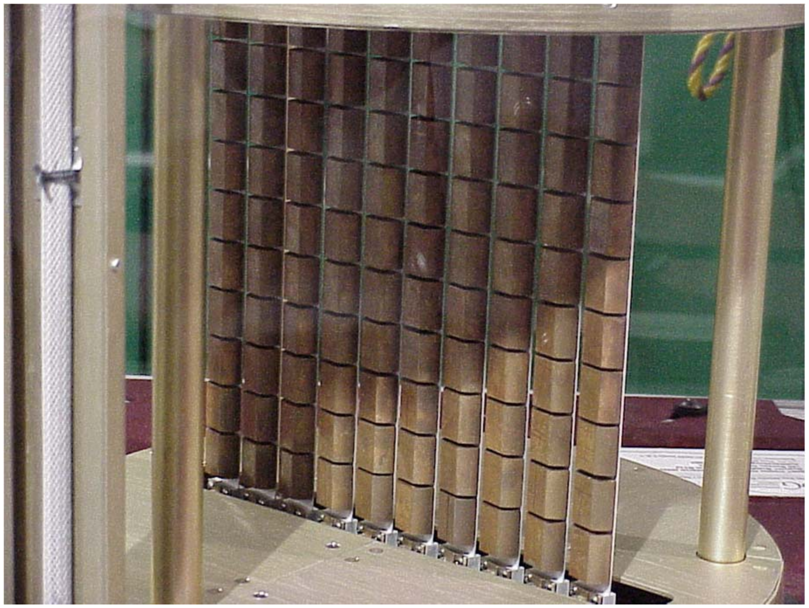




PG(002) d = 3.35 Å

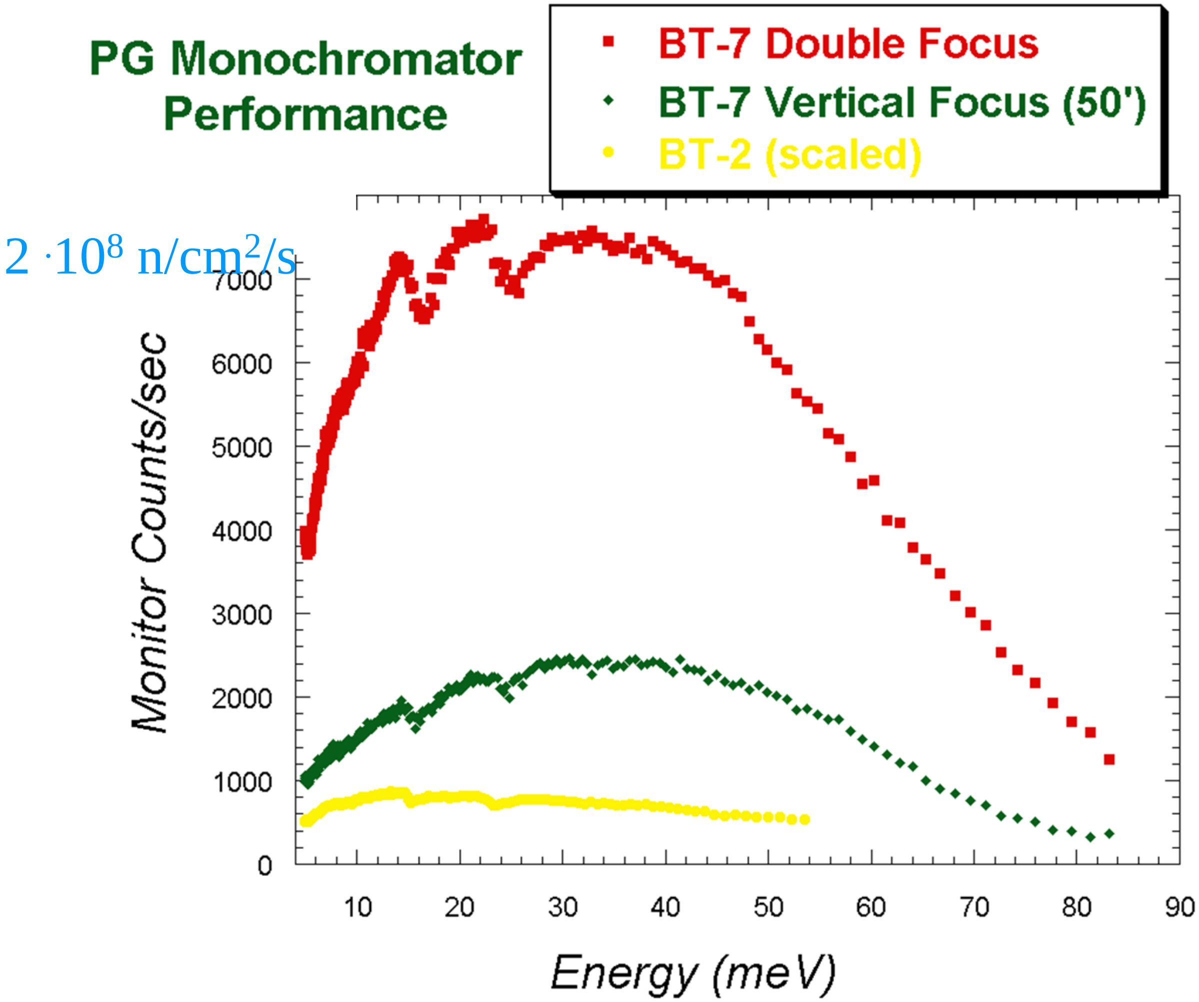
Cu(220) d = 1.27 Å

Monochromator Arrays



Cu(220) d = 1.27 Å   PG(002) d = 3.35 Å

Monochromator Improvements

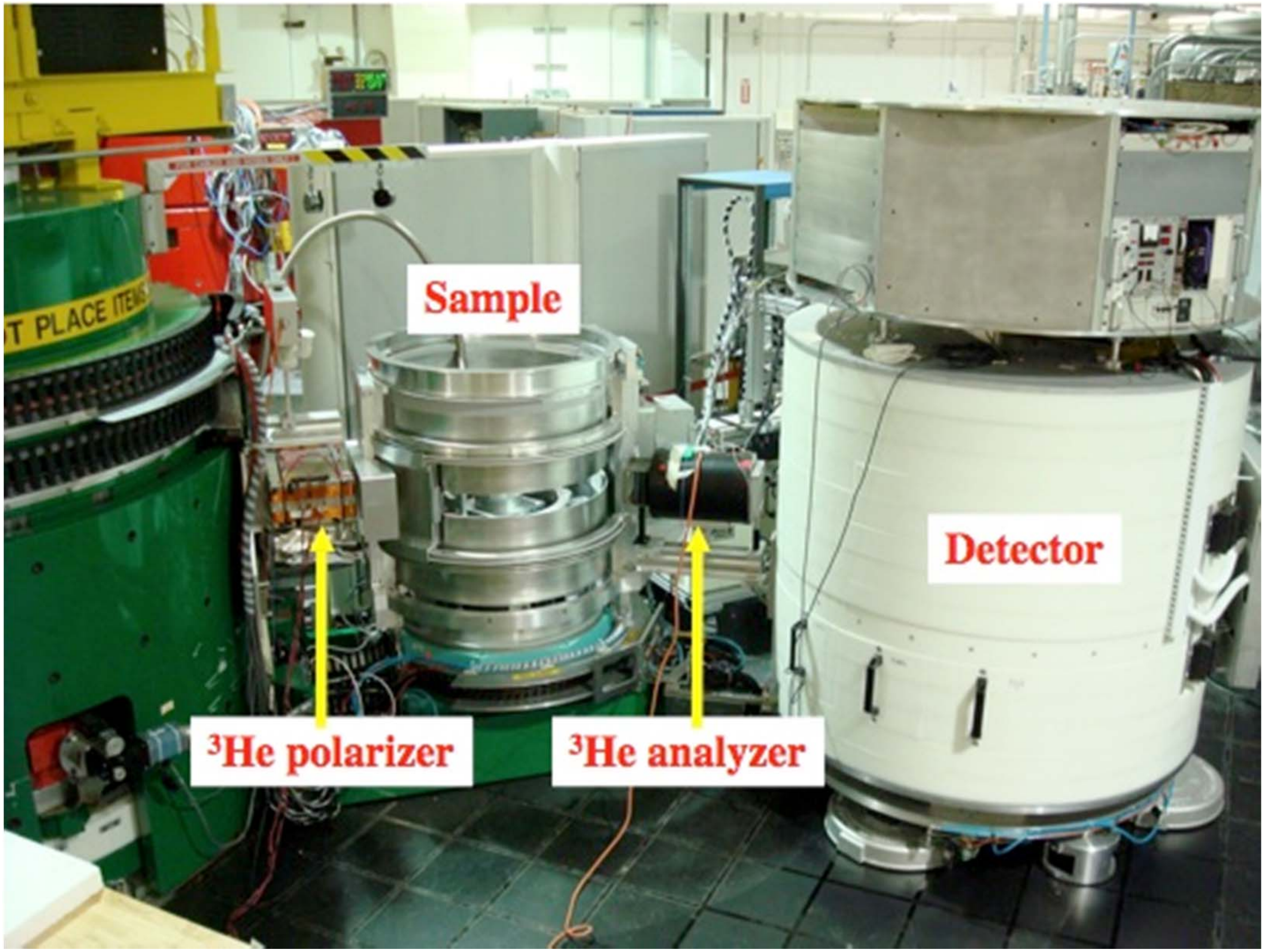


With vertical focusing, gain of 2.3 over BT-2/9 at 14.7 meV; gain of 3.5 at 40 meV.

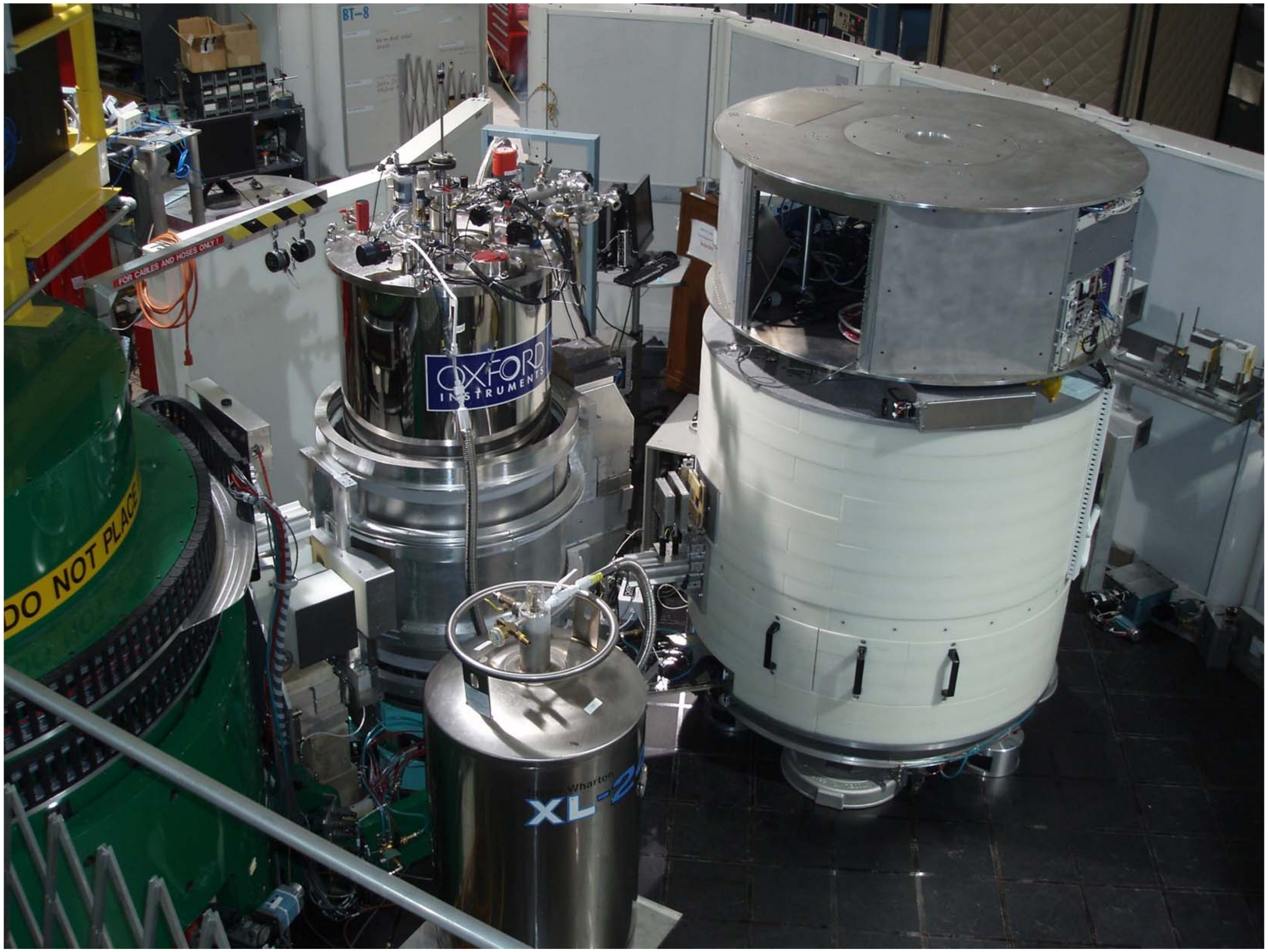
Double focusing, gain of 8.7 at 14.7 meV; gain of 10.8 at 40 meV

Installation action

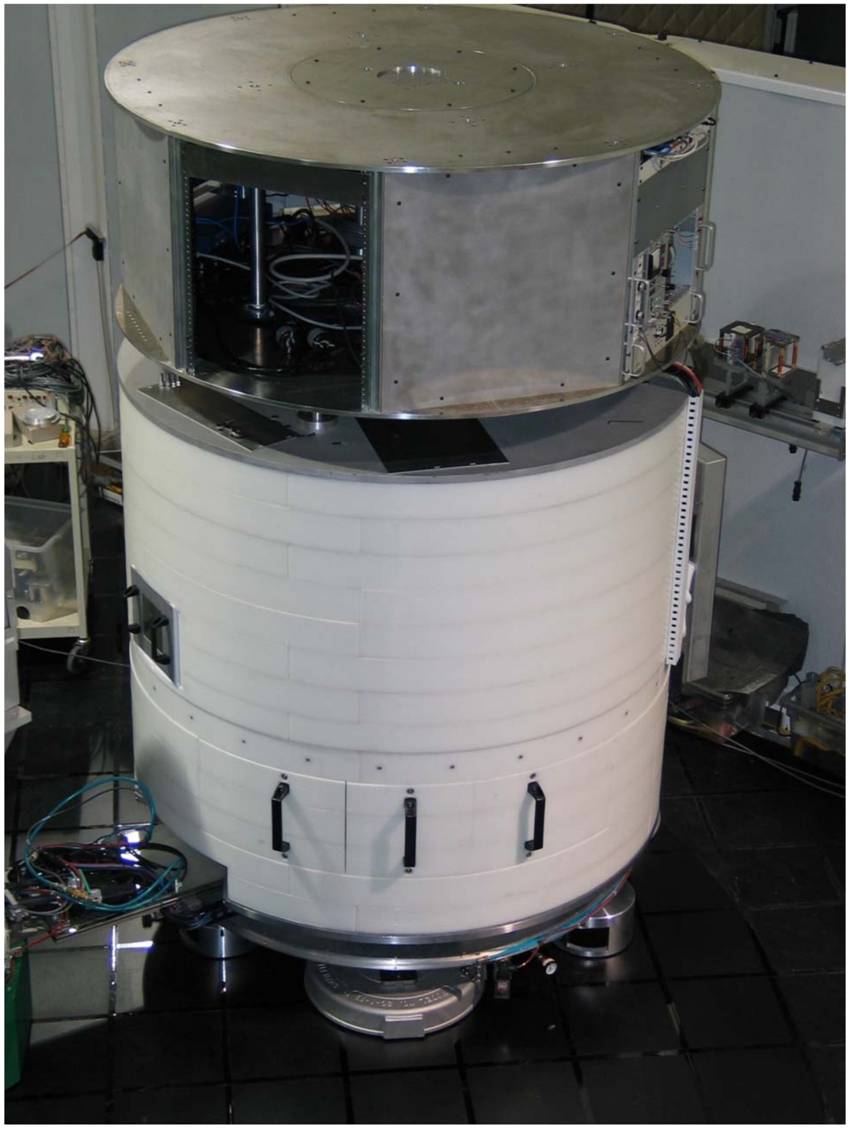
Polarized Beam



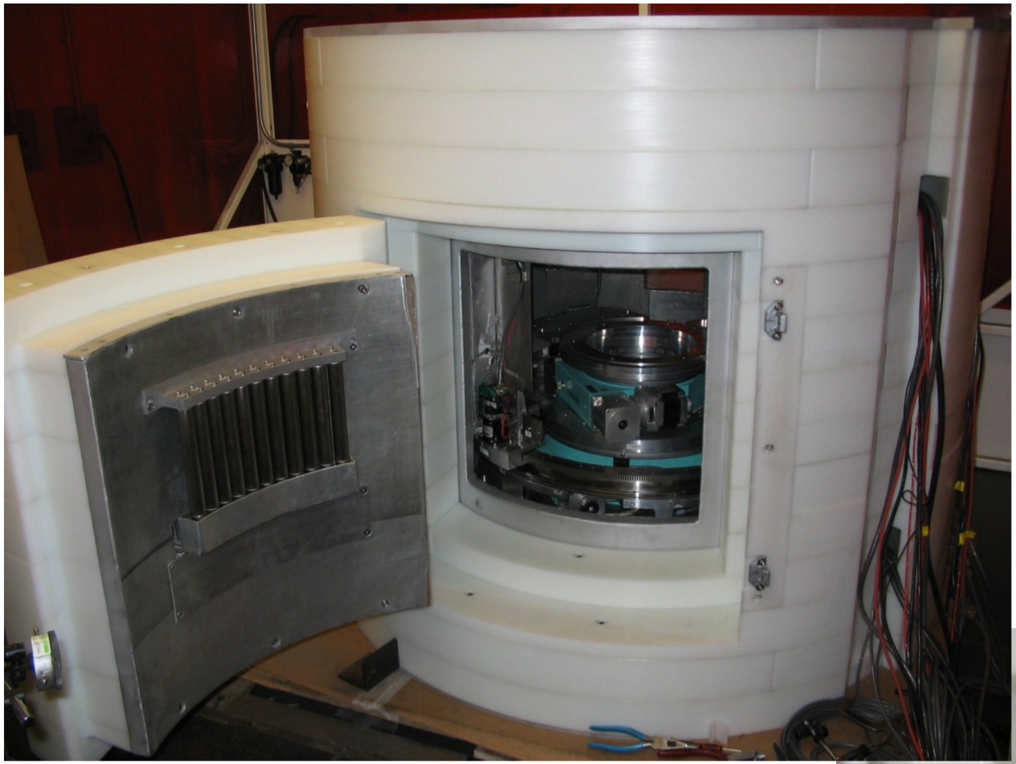
15 T magnet

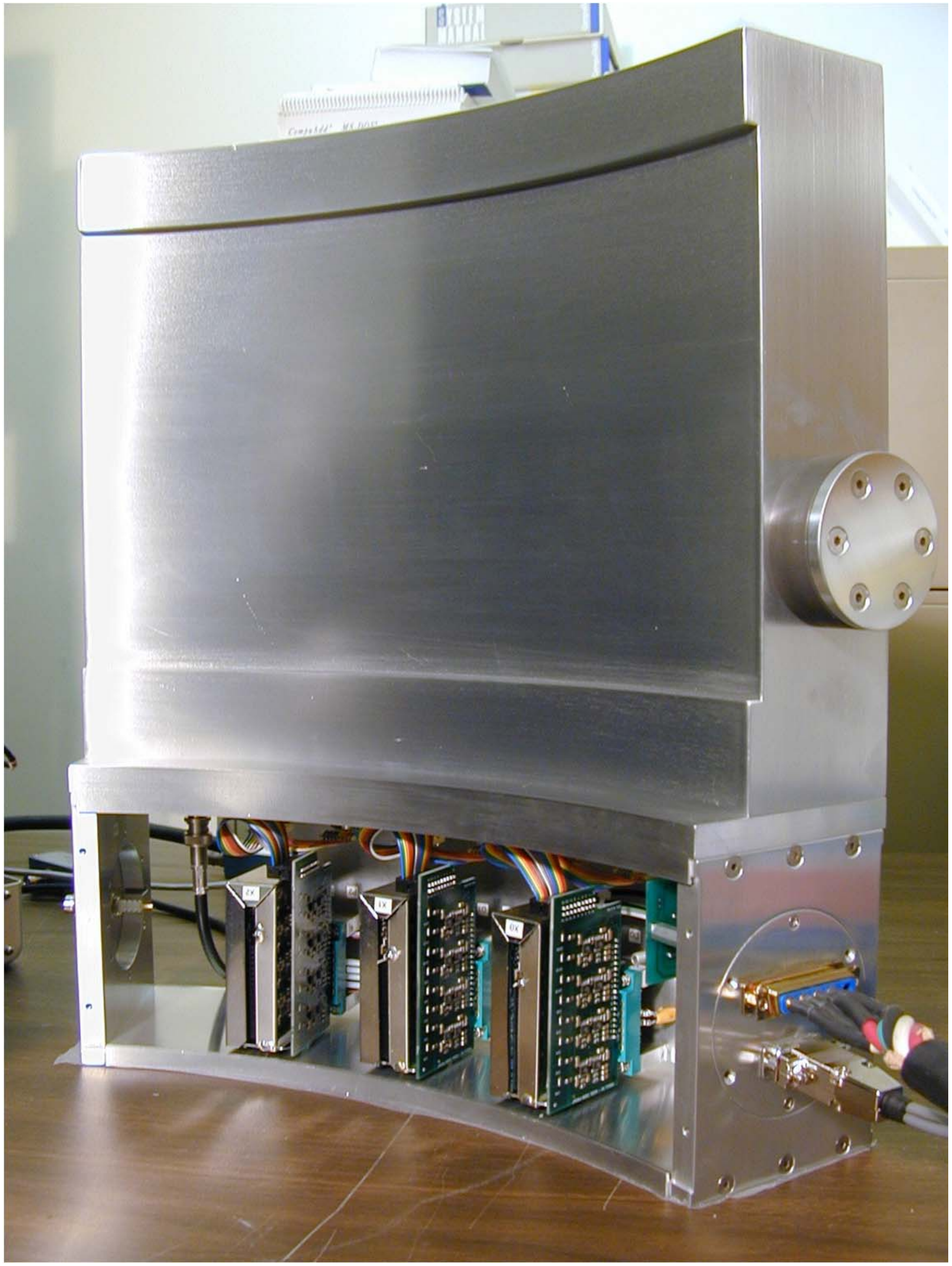

BT-8
OXFORD
INSTRUMENTS
FOR CABLES AND HOSES ONLY!
DO NOT PLACE
Wharton
XL-2

Analyzer System



Analyzer System



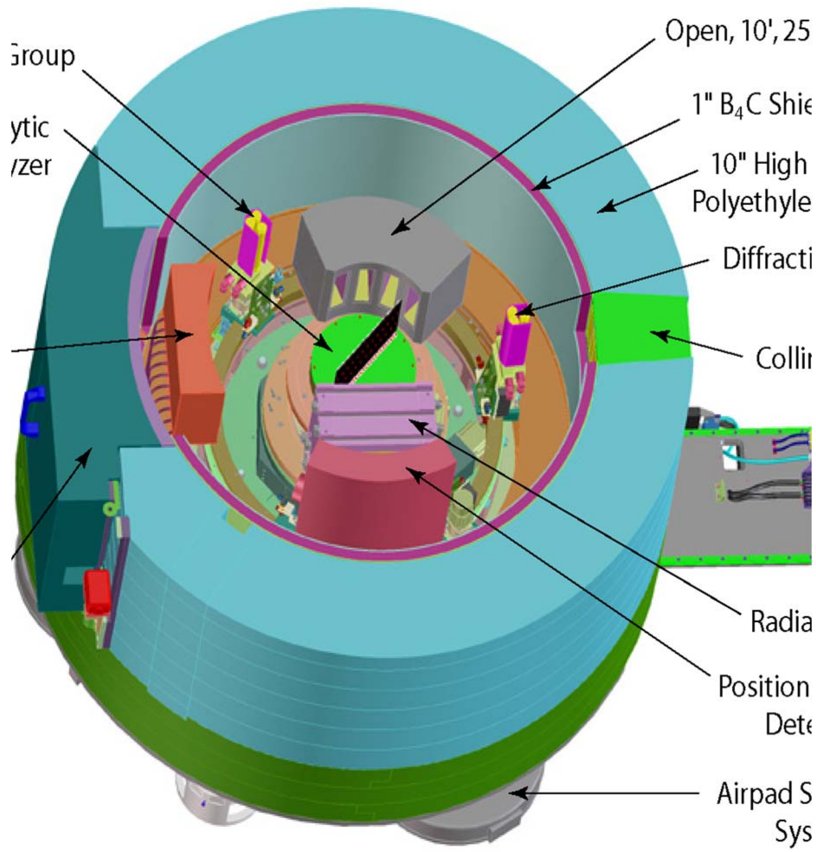


Position Sensitive Detector

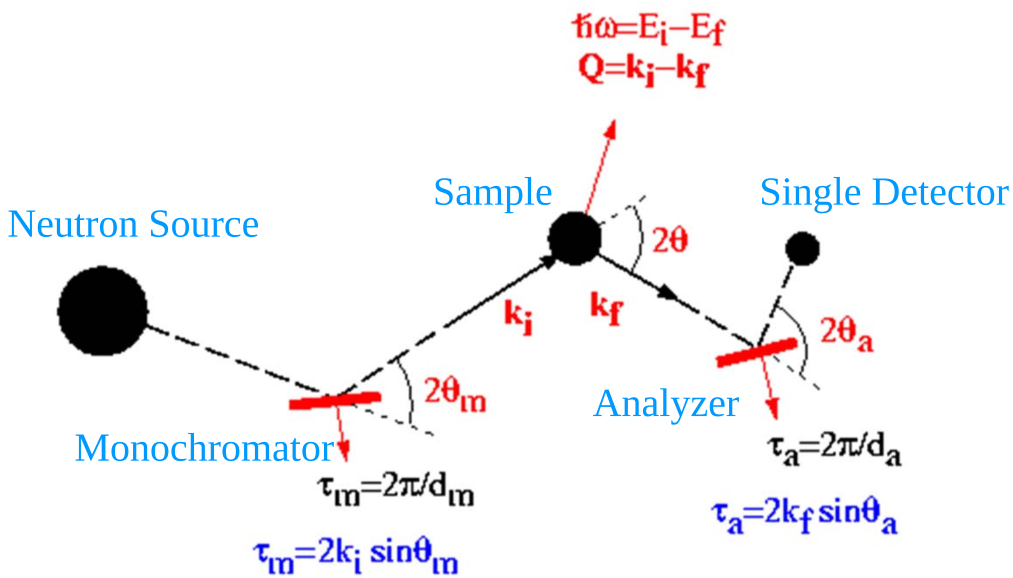
ORDELA 1348N

Analyzer Modes

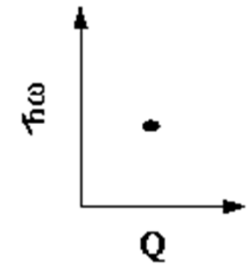
- Diffraction detector (single detector)
- Diffraction mode (radial collimator +PSD)
  - (door detector; poor man's PSD)
- Flat PG analyzer + collimation + SD
- Flat PG analyzer + PSD (range of **Q**, E or range of diffuse scatt.)
- Horizontal focusing (radial collimator + single detector)
- Horizontal energy focusing + PSD



Conventional Triple-Axis Spectroscopy (TAS)



A single point at a time



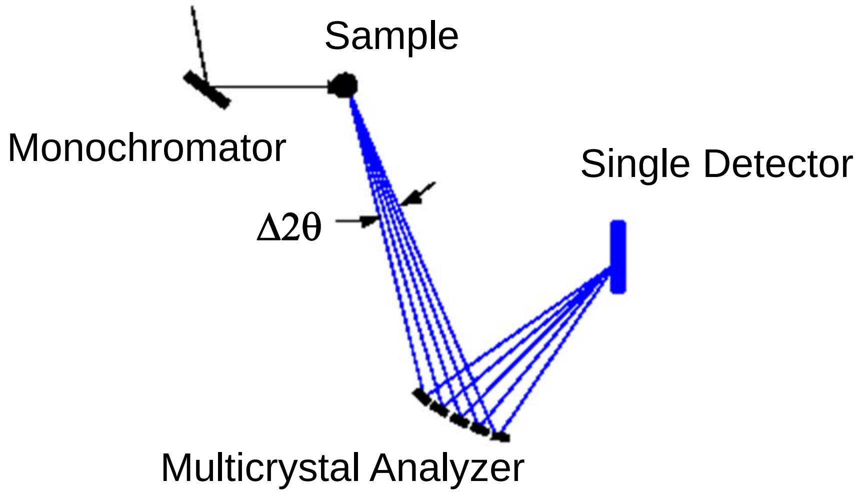
TAS is ideally suited for probing small regions of phase space

Shortcoming: Low data collection rate

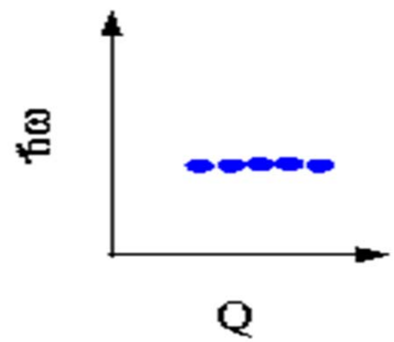
↓ ***Improvement***

Multicrystal analyzer and position-sensitive detector

Horizontally Focusing (HF) Analyzer Mode
13 blades on BT-7

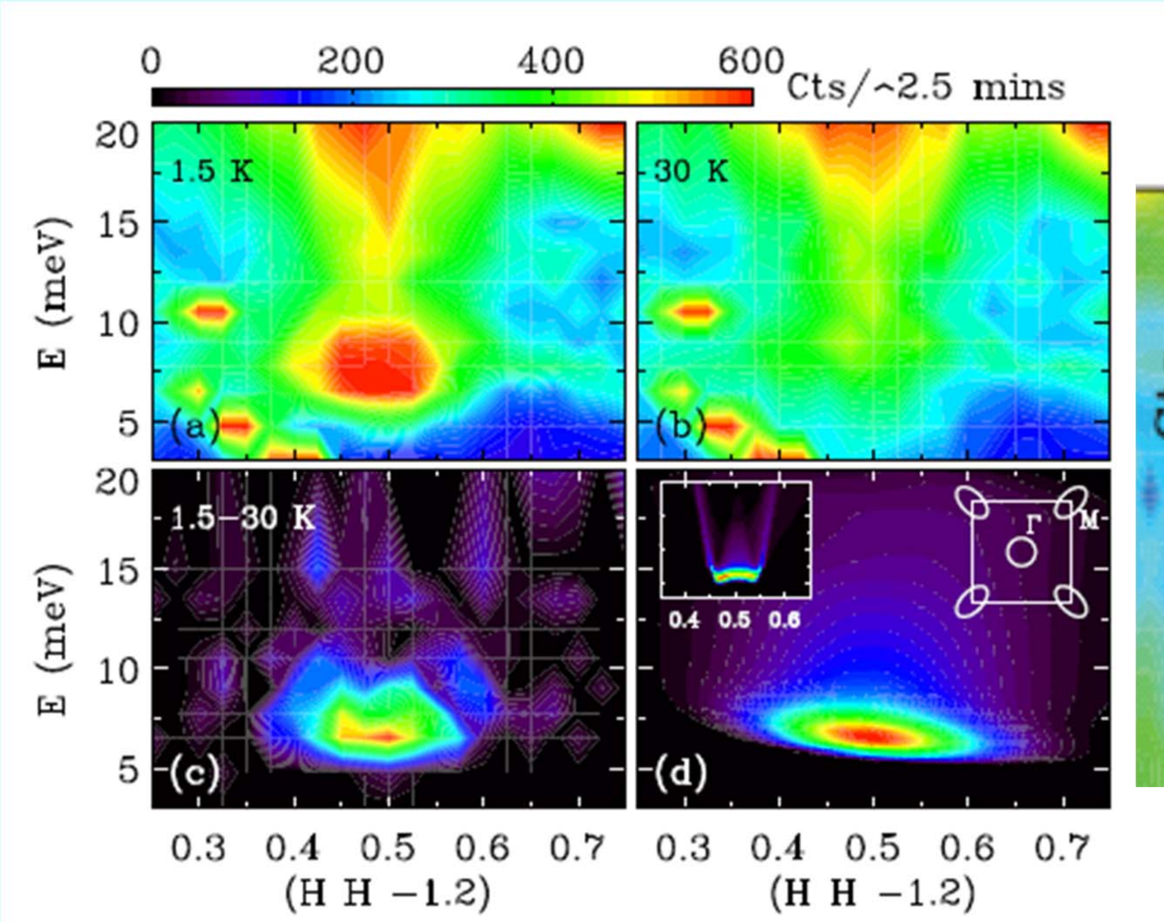


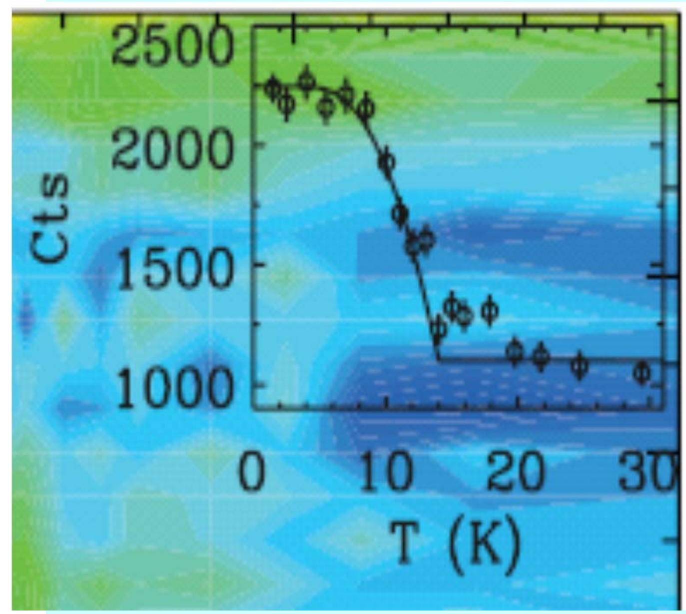
Relaxed Q-resolution



Useful for studying systems with short-range correlations

Spin Resonance in $Fe(Se_{0.4}Te_{0.6})$

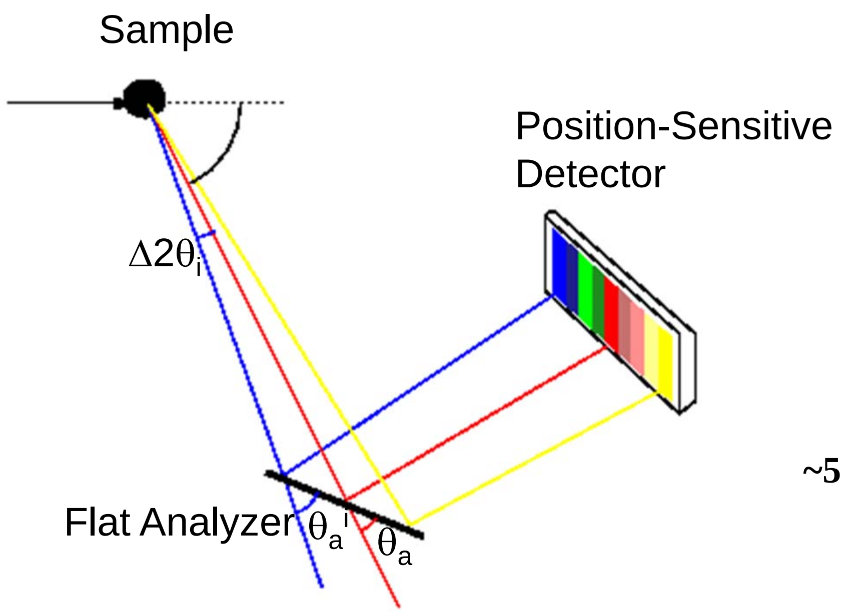


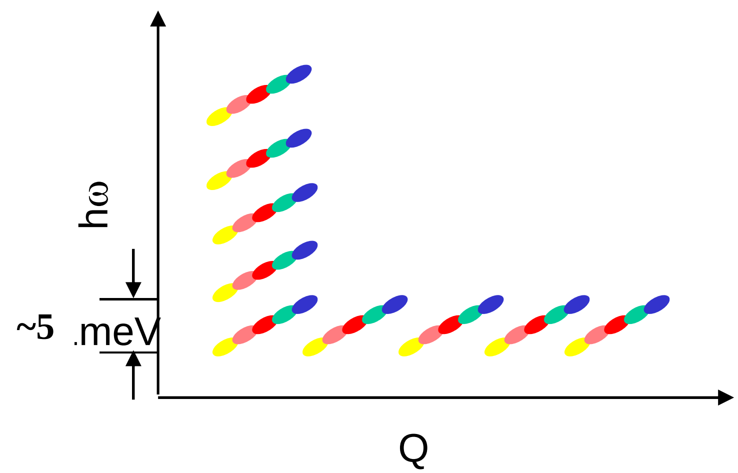


Y. Qiu, W. Bao, Y. Zhao, C. Broholm, V. Stanev, Z. Tesanovic, Y.C. Gasparovic, S. Chang, J. Hu, B. Q., M. Fang, and Z. Mao, Phys. Rev. Lett. **103**, 067008 (2009).

Position-Sensitive Detector Mode

with Flat Analyzer (not focusing)



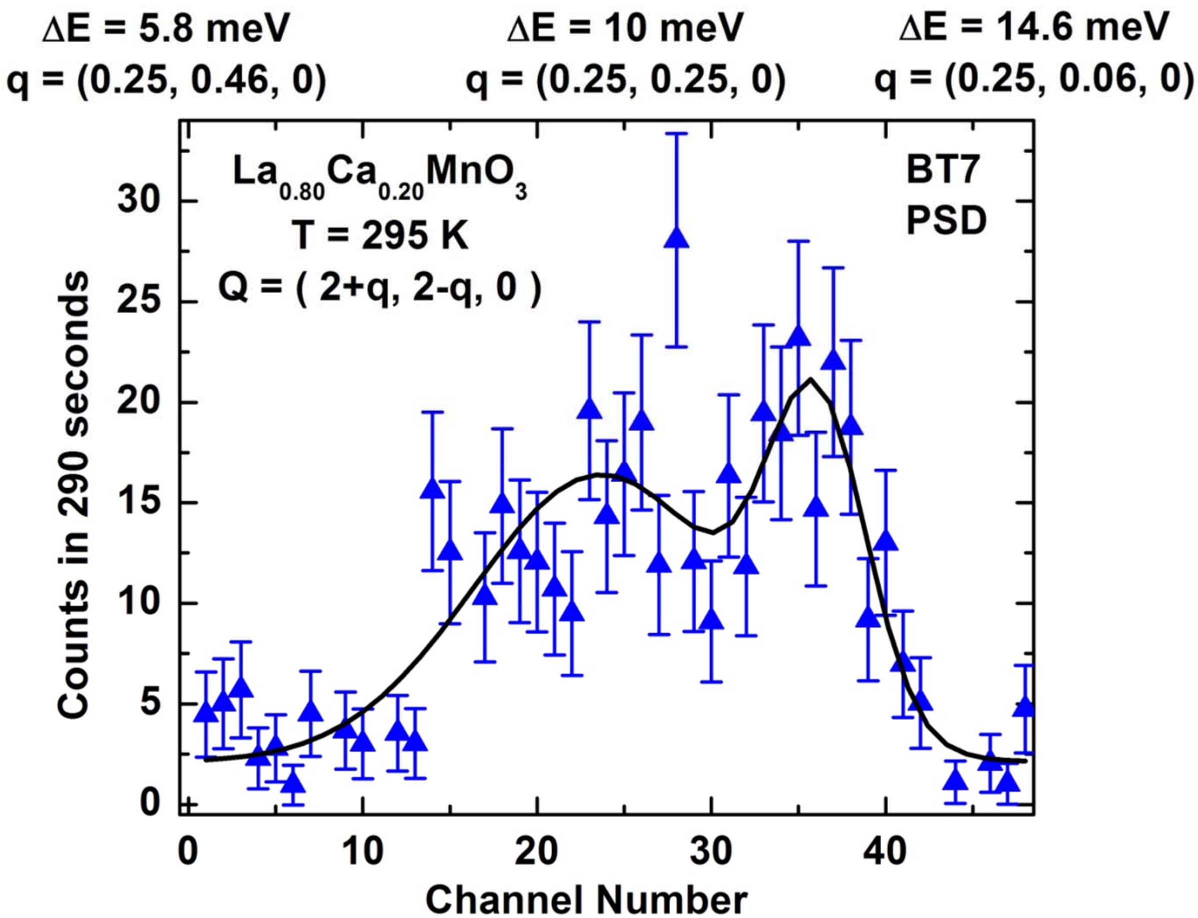


Probes scattering events at different energy and momentum transfers simultaneously

Survey (hω-Q) space by changing the incident energy and scattering angle

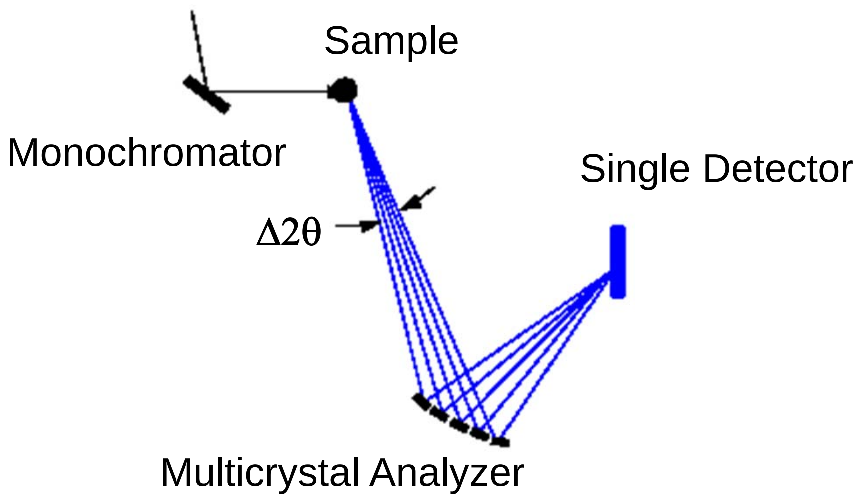
La-CaMnO$_3$ Polarons

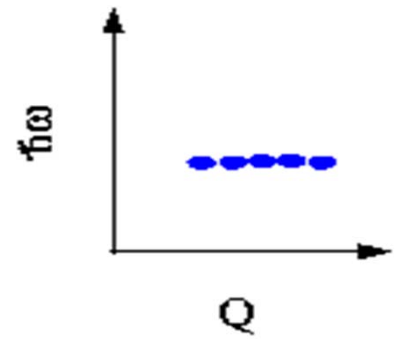
PSD mode



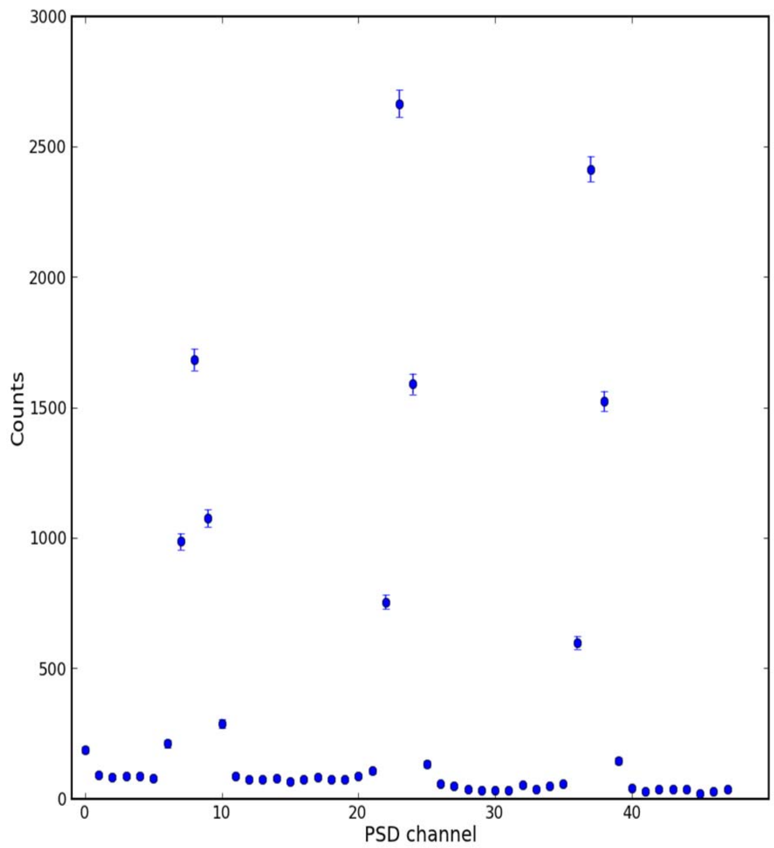
Rotate array so that each blade falls on a different position of the PSD

13 different Q values at the same energy transfer

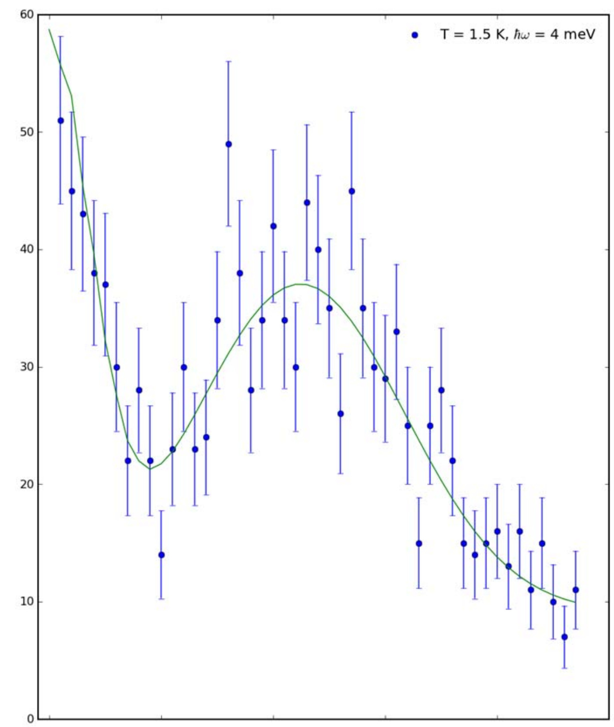




Inelastic Scattering with PSD



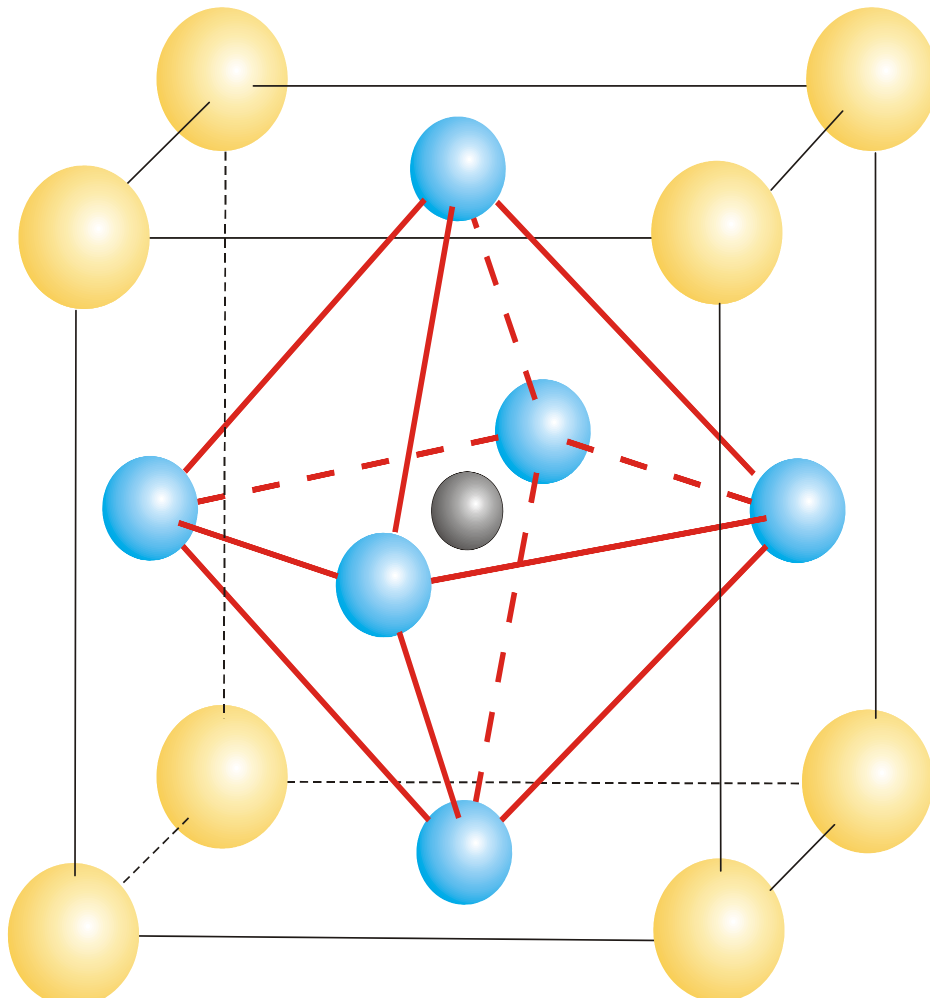
T=2 K, 4 meV



0.47 0.50 0.57

H →

CMR basics

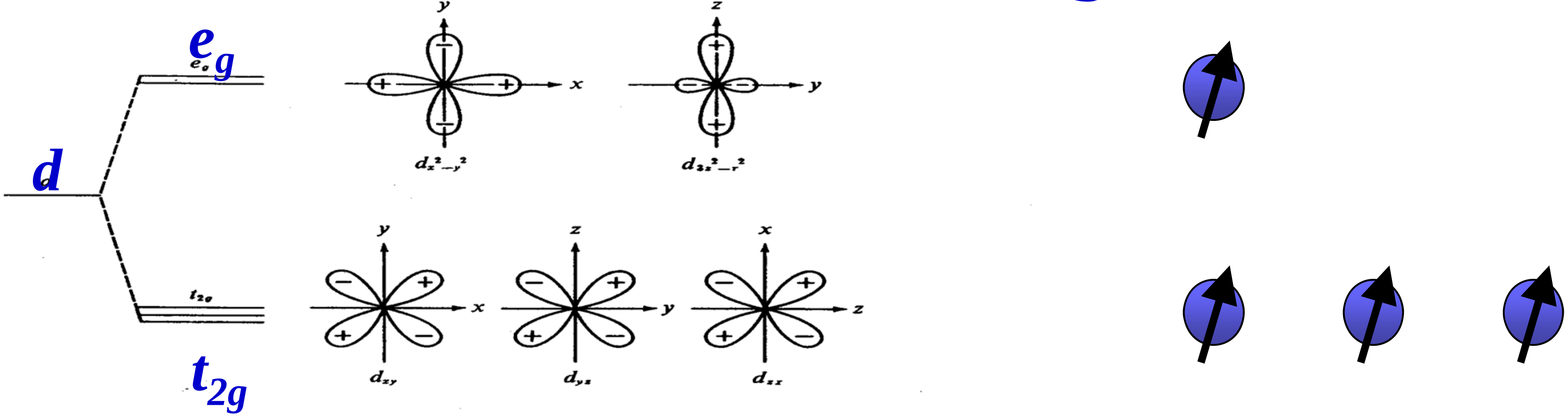


Ideal Perovskite Structure
(Cubic)

$LaMnO_3$

Basic Interactions

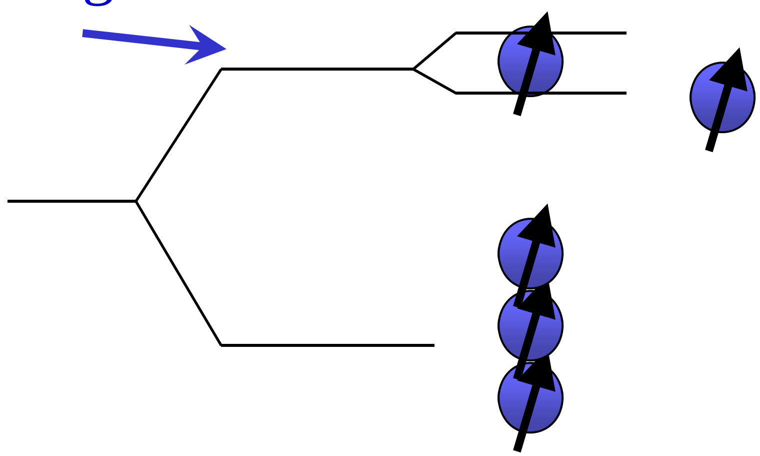
Mn^{3+} in LaMnO$_3$



Strong Hund’s Rule Coupling
(on-site electrons must be parallel)
Jahn-Teller Distortion

Basic Interactions in $LaMnO_3$

Doubly degenerate



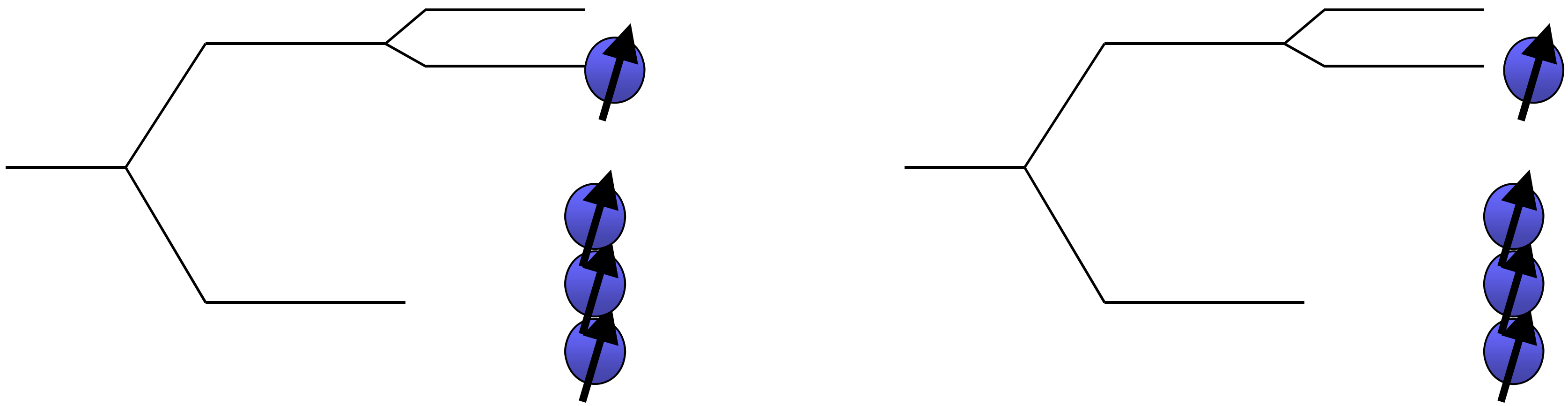
Strong Hund's Rule Coupling

(on-site electrons must be parallel)

Jahn-Teller Distortion couples spins with lattice

Basic Interactions

$LaMnO_3$

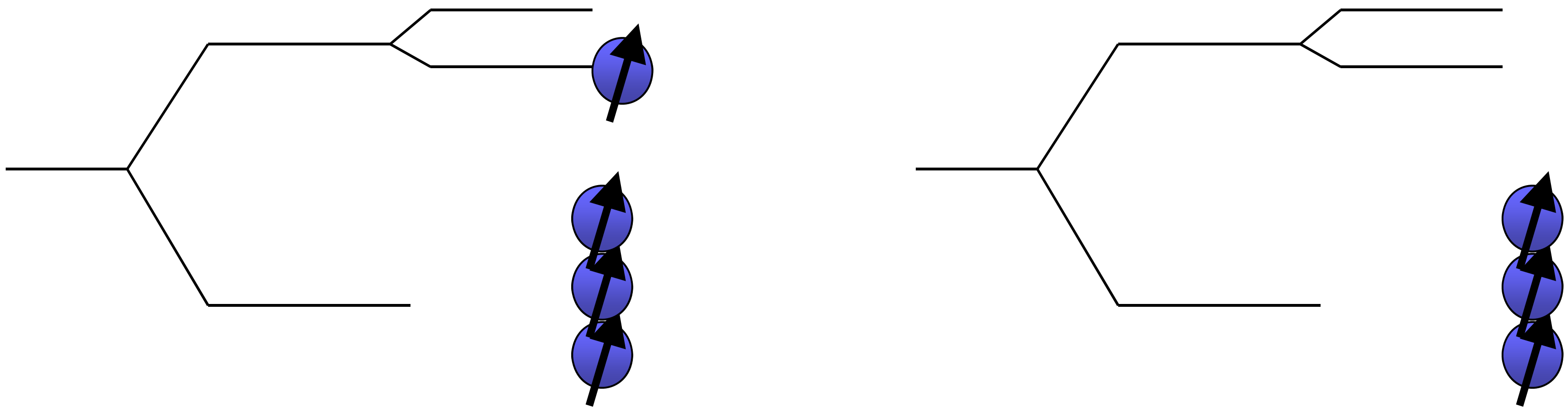


e_g electron can only hop if core spins are parallel (& an empty site)

Jahn-Teller Distortion couples spins with lattice

Basic Interactions

$LaMnO_3$



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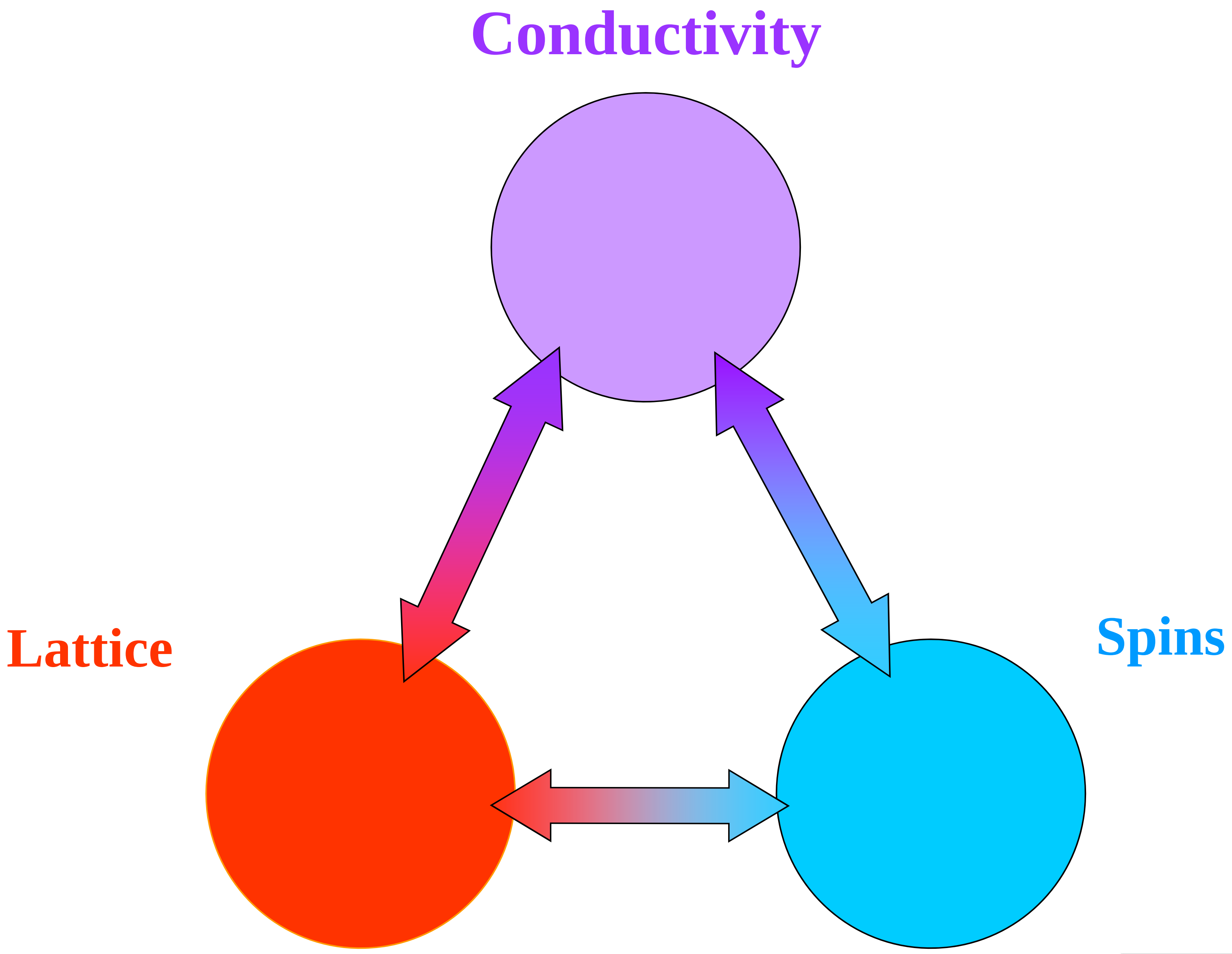
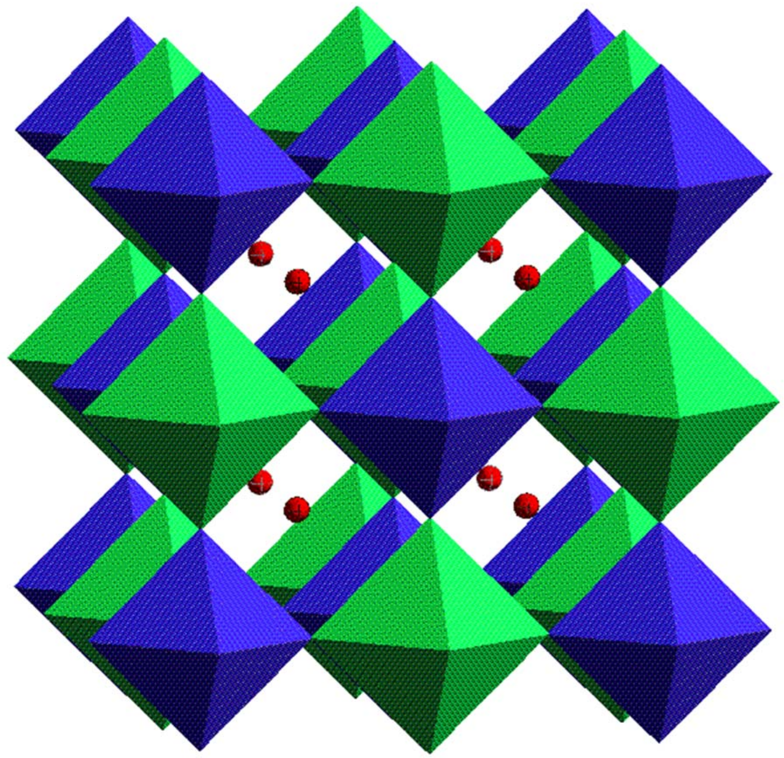

Conductivity
Lattice
Spins

Doping of Structure

$(La-Ca)MnO_3$

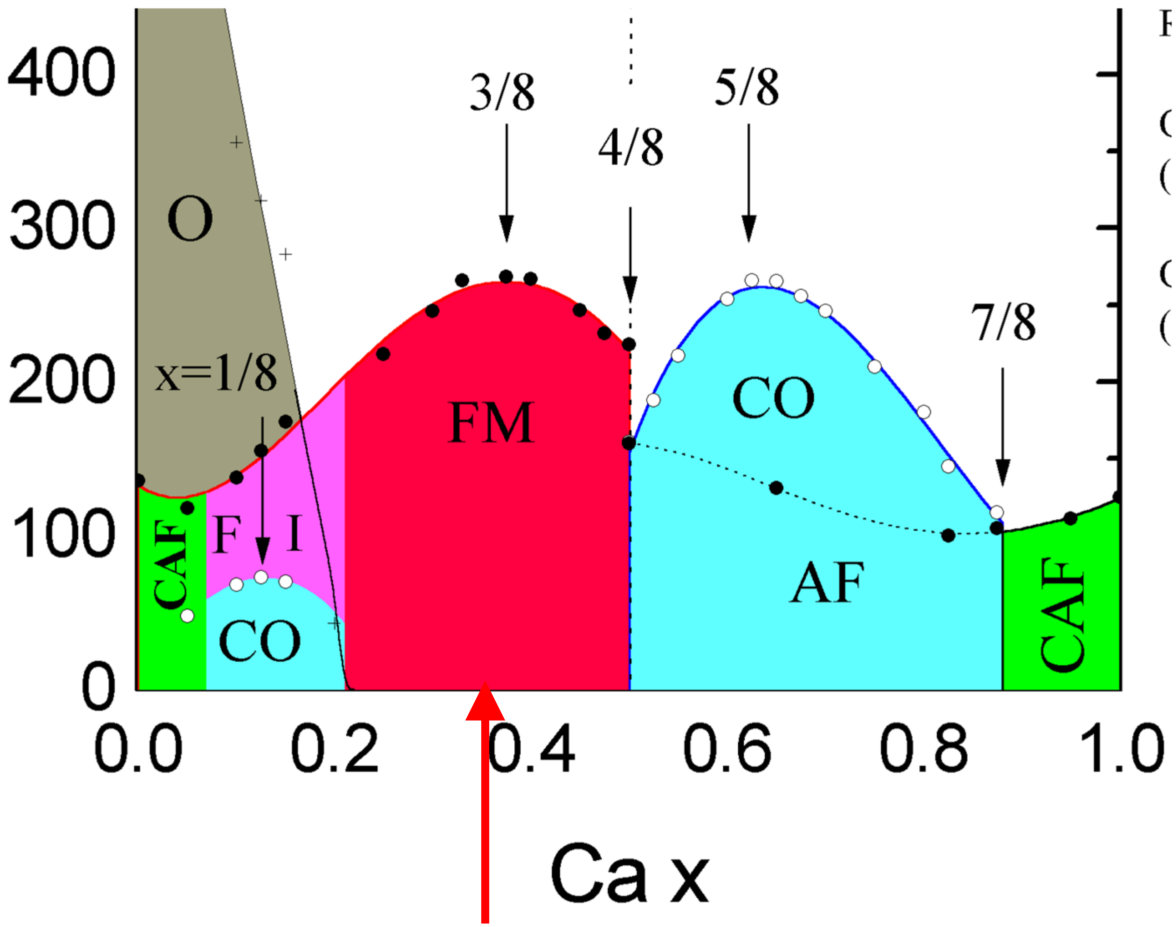
$LaMnO_3$

$Ca^{2+} \rightarrow La^{3+}$ $Mn^{3+} \rightarrow Mn^{+4}$



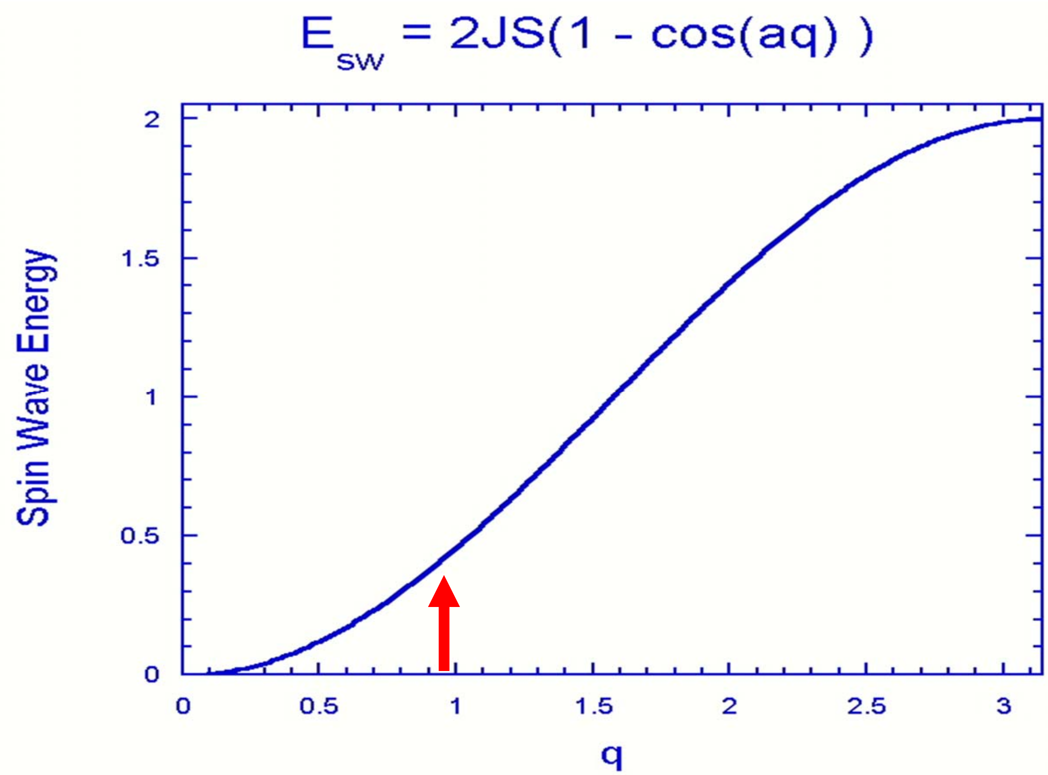
$La_{1-x}Ca_xMnO_3$

Phase Diagram



S-W. Cheong and C. H. Chen
Colossal Magnetoresistance, Charge Ordering, and Related Properties of Manganese Oxides (World Scientific, 1998), p. 241 (Ed. by Raveau and Rao)

Excitations



$$E_{sw} = 2JS(1 - \cos(aq)) \approx \Delta + D(T)q^2$$

$$D(T) \sim M(T)$$

$$\Gamma \sim T^2 q^4$$