

# Investigating Magnetic Dead Layers in Rhombohedral Perovskites

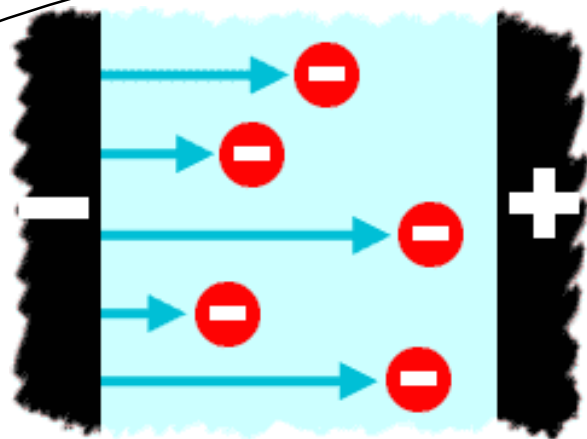
Jeremy Ashe

Mentored by: Ryan Need

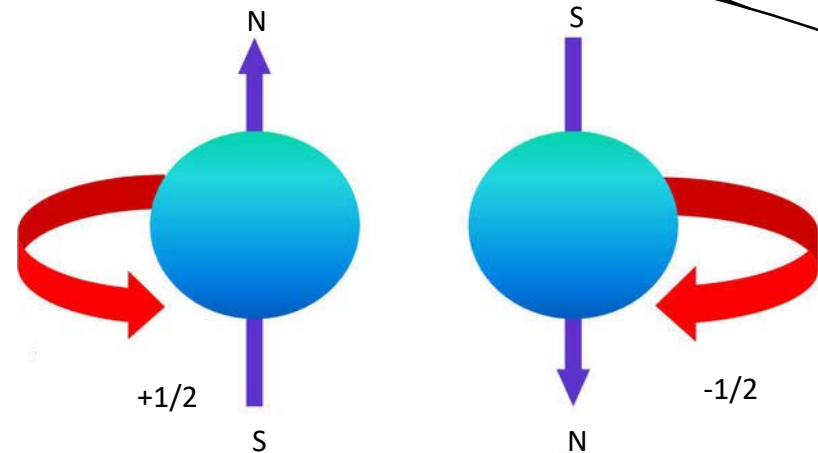


# Purpose

Technological Applications – better data storage & energy efficient



Electronics (magnitude)



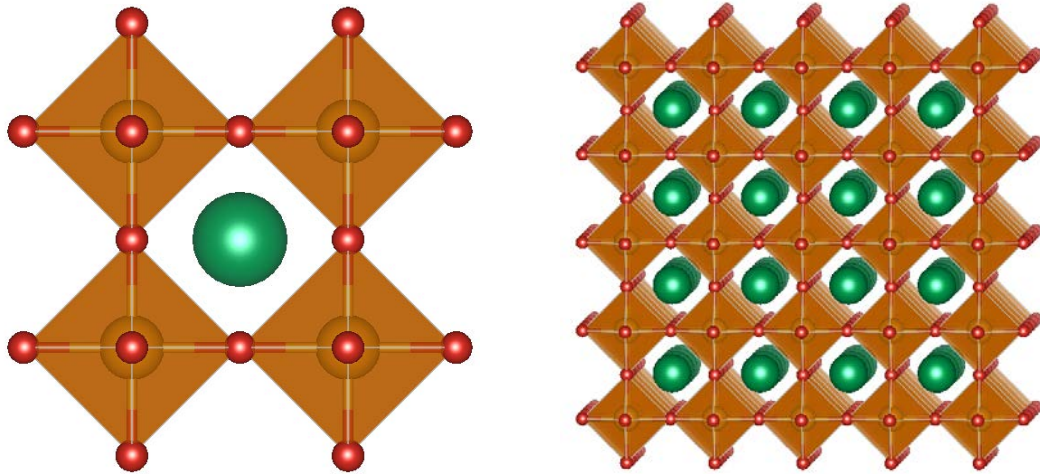
Spintronics (magnitude & direction)

# Perovskite Oxides and Their Structures

Perovskites – chemical formula  $ABO_3$

**Cubic perovskite**

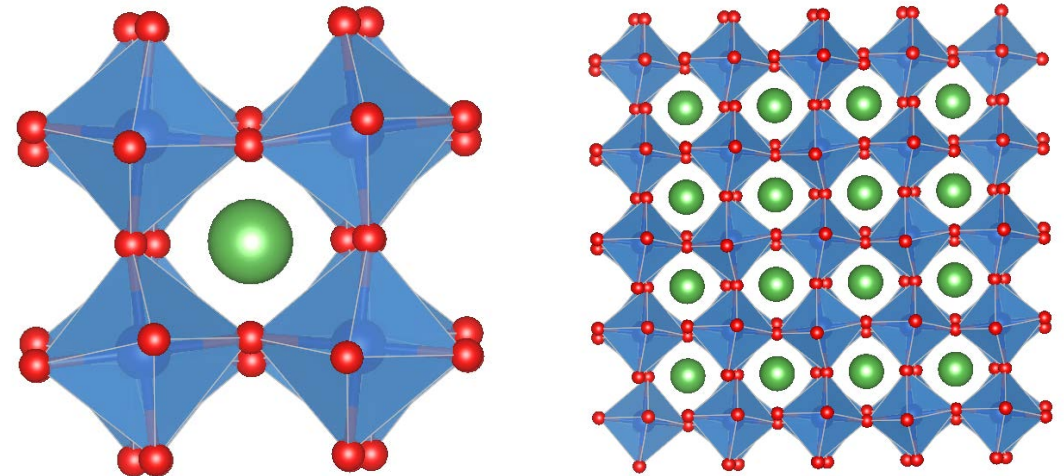
e.g.  $SrTiO_3$



*untitled octahedra, nonmagnetic*

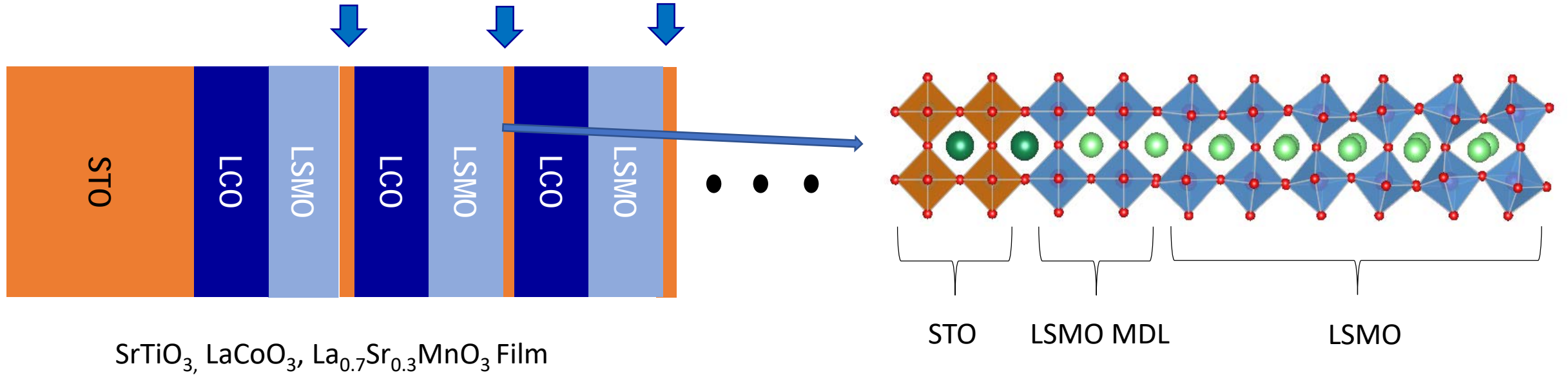
**Rhombohedral perovskite**

e.g.  $La_{0.7}Sr_{0.3}MnO_3$ ,  $LaCoO_3$



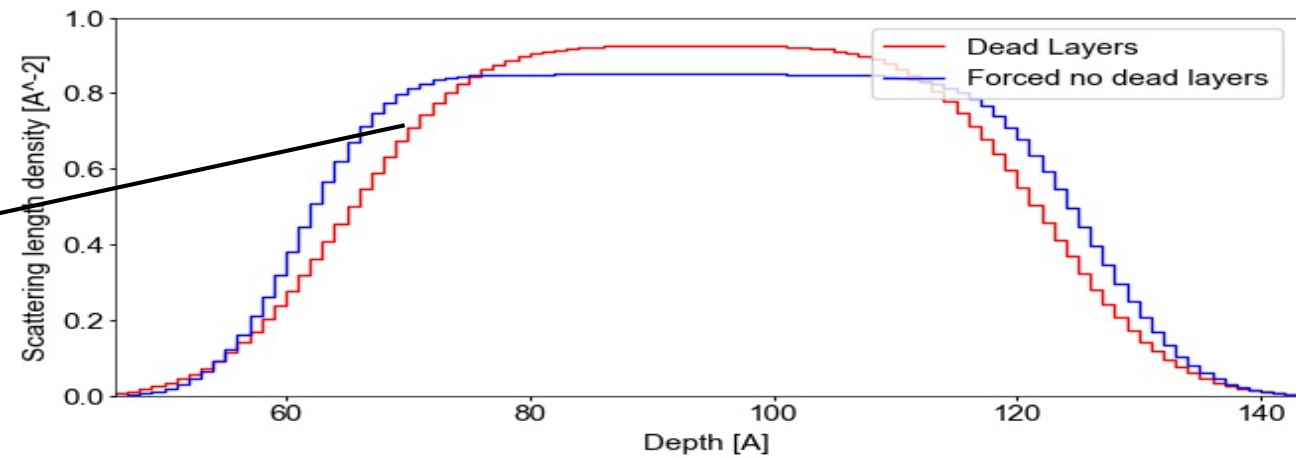
*tilted octahedra, magnetic*

# LCO/LSMO/STO Film & Magnetic Dead Layers (MDLs)

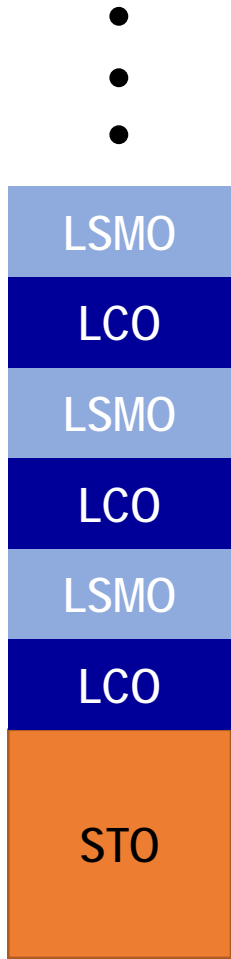


MDLs are regions of depleted ferromagnetism

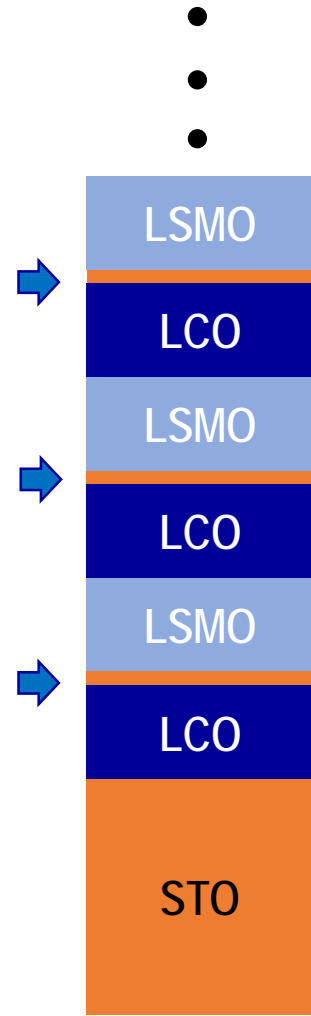
Different curves caused by MDLs



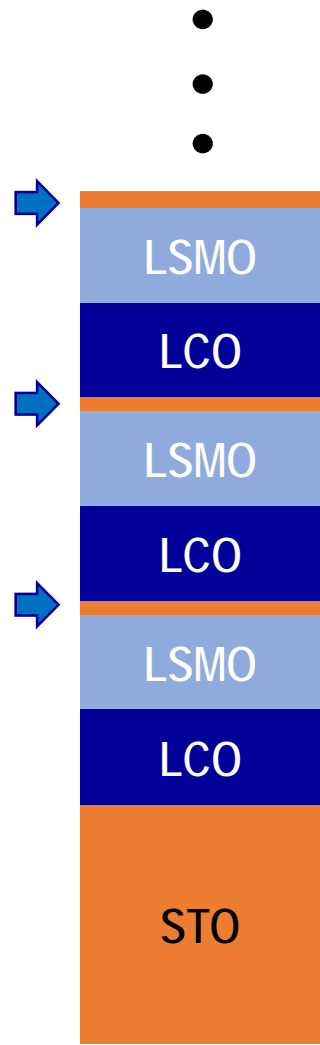
# Sample Structures



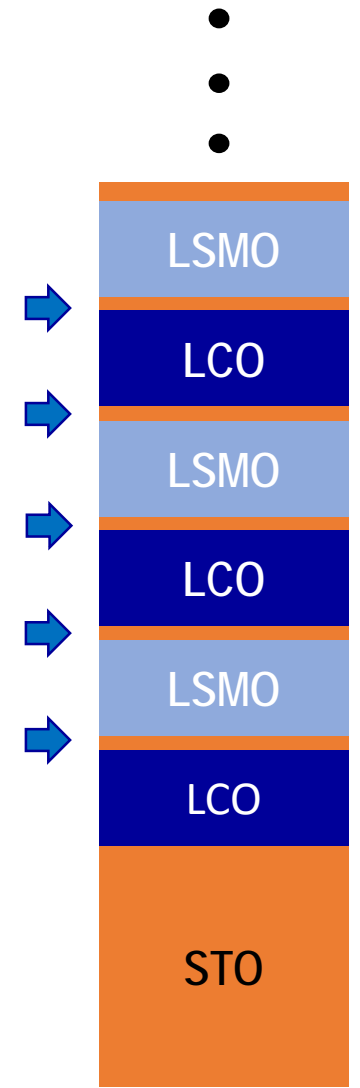
LCO/LSMO Superlattice



LCO/STO/LSMO Superlattice



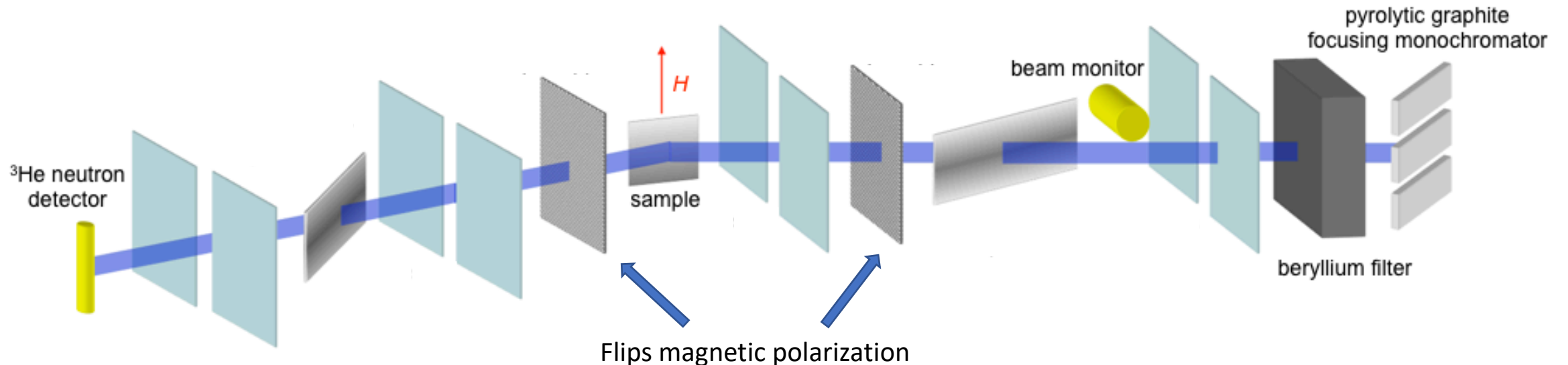
LCO/LSMO/STO Superlattice



LCO/STO/LSMO/STO Superlattice

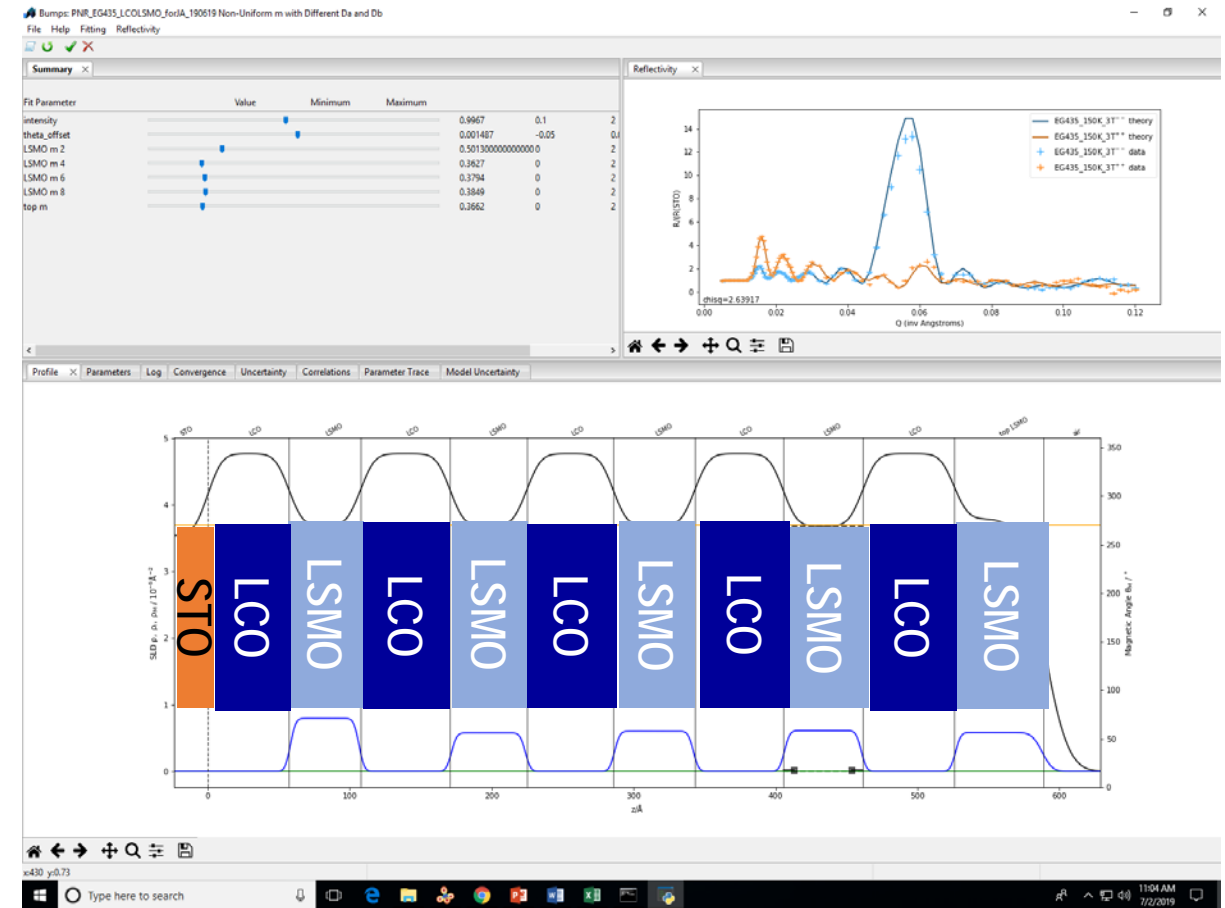
# Polarized Neutron Reflectometry (PNR)

- Neutrons have unique properties
  - Electrically neutral
  - Magnetic
  - Behave like waves
- PNR data shows film's magnetic and nuclear depth
- PNR data was collected for the modeling of the thin films



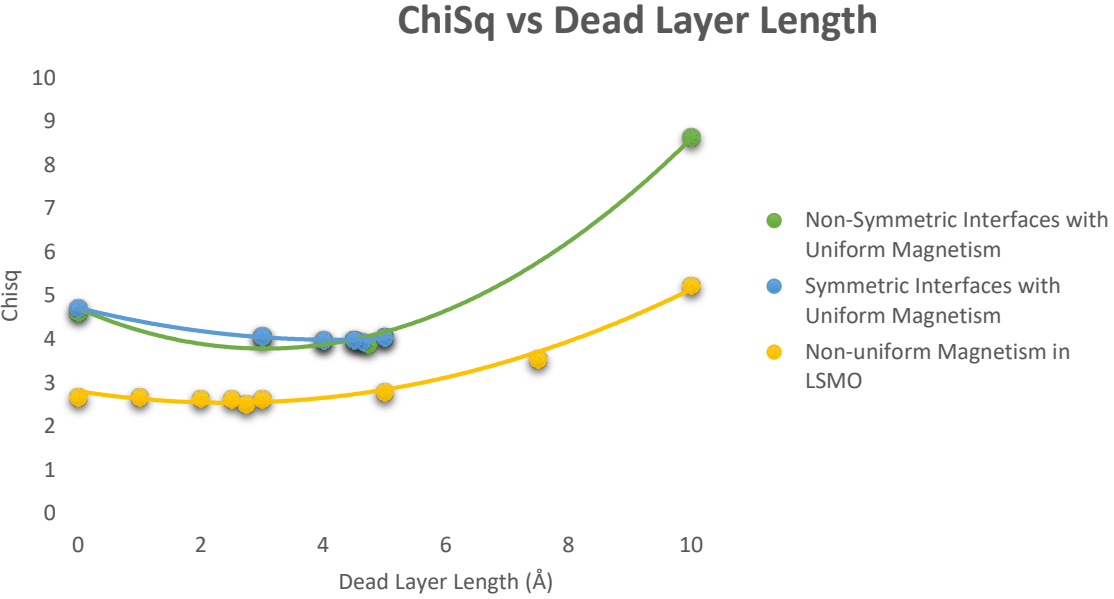
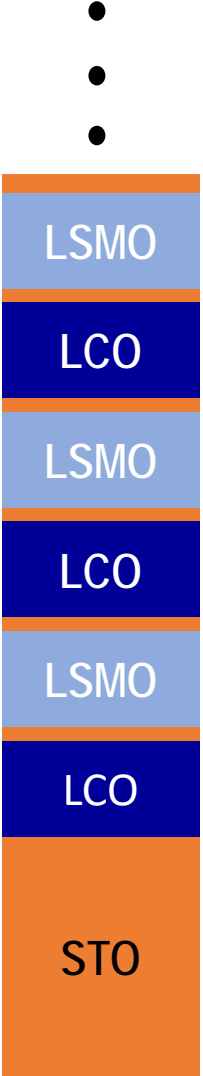
# Modeling Methods

- Used python scripts in refl1d software to find models of the films
  - Models fit inputted PNR data
  - Python scripts have different film parameters
  - Lower the  $\chi^2$  /Chisq value (statistical value), the better the fit
- MDL parameter includes:
  - Dead layer presence
  - Dead layer length
  - Dead layer roughness
- The MDL parameters were systematically changed in order to find how  $\chi^2$  changed with different MDL values

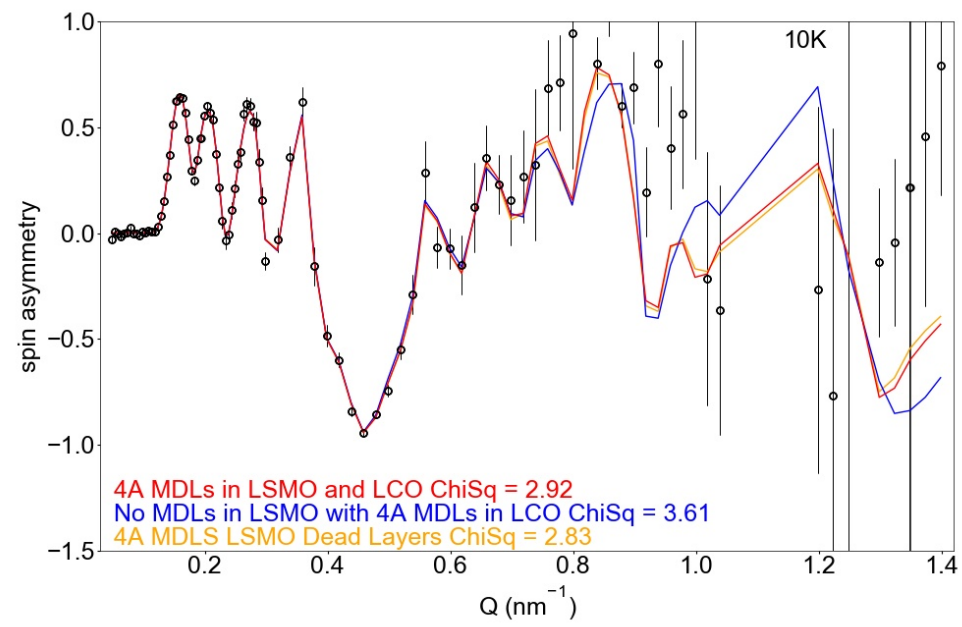
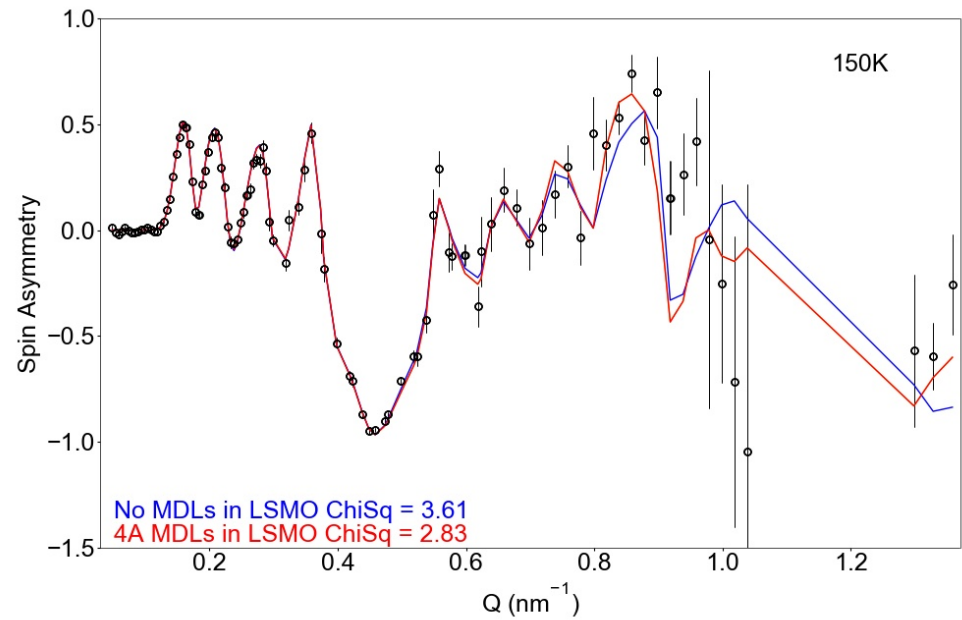


Refl1d finding best fit for LCO/LSMO repeated film

# LCO/STO/LSMO/STO Superlattice

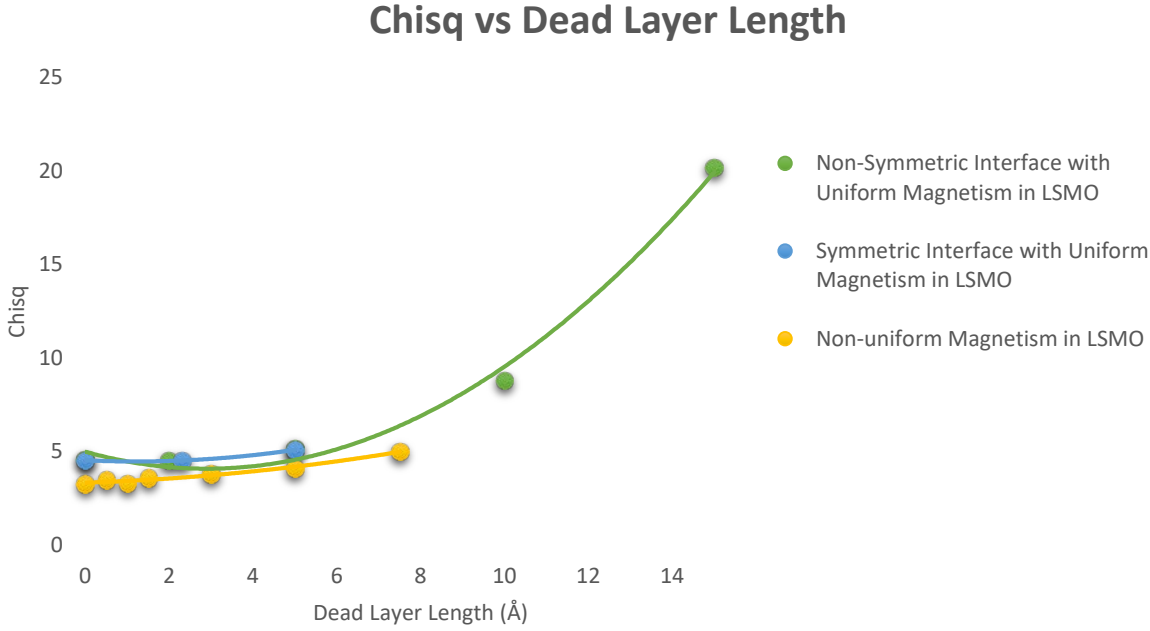
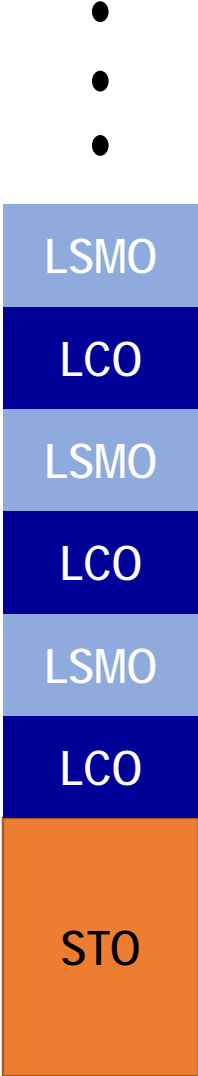


- LSMO has MDLs around 4Å at STO interface
- Magnetism in LSMO and LCO is non-uniform
- Magnetic dead layers occur at some rhombohedral-to-cubic material interfaces

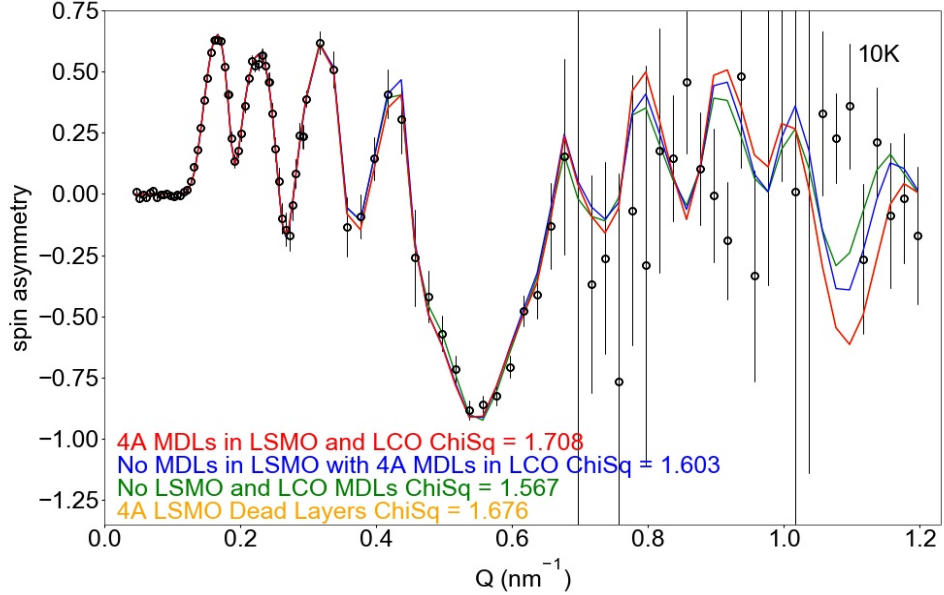
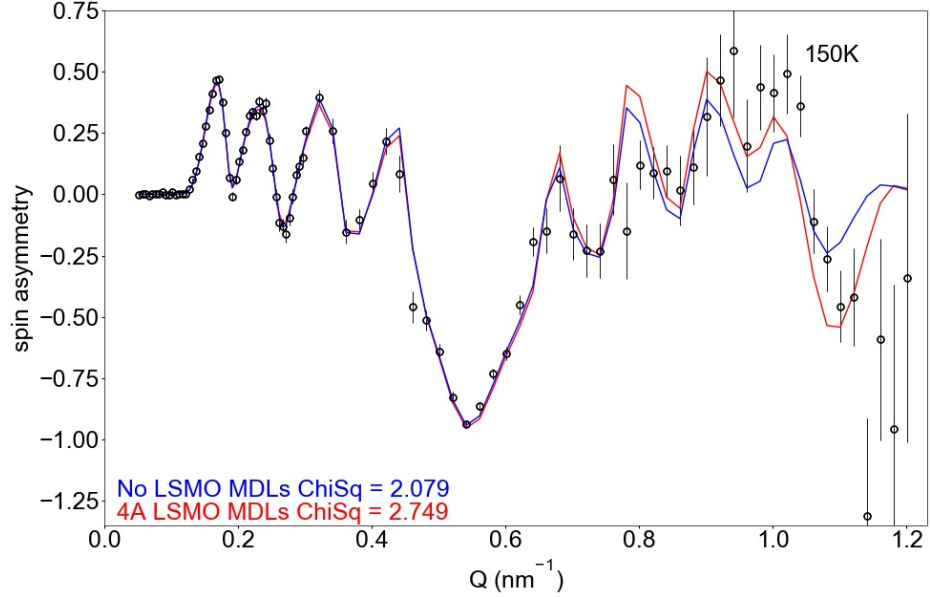




# LCO/LSMO Superlattice

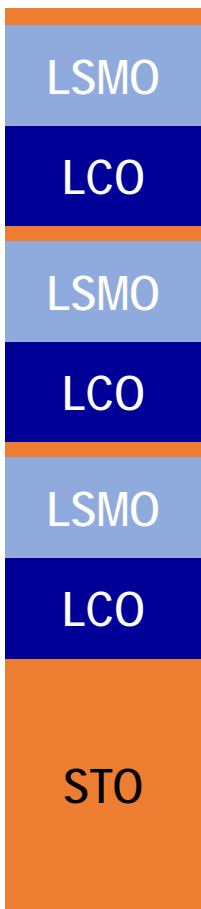
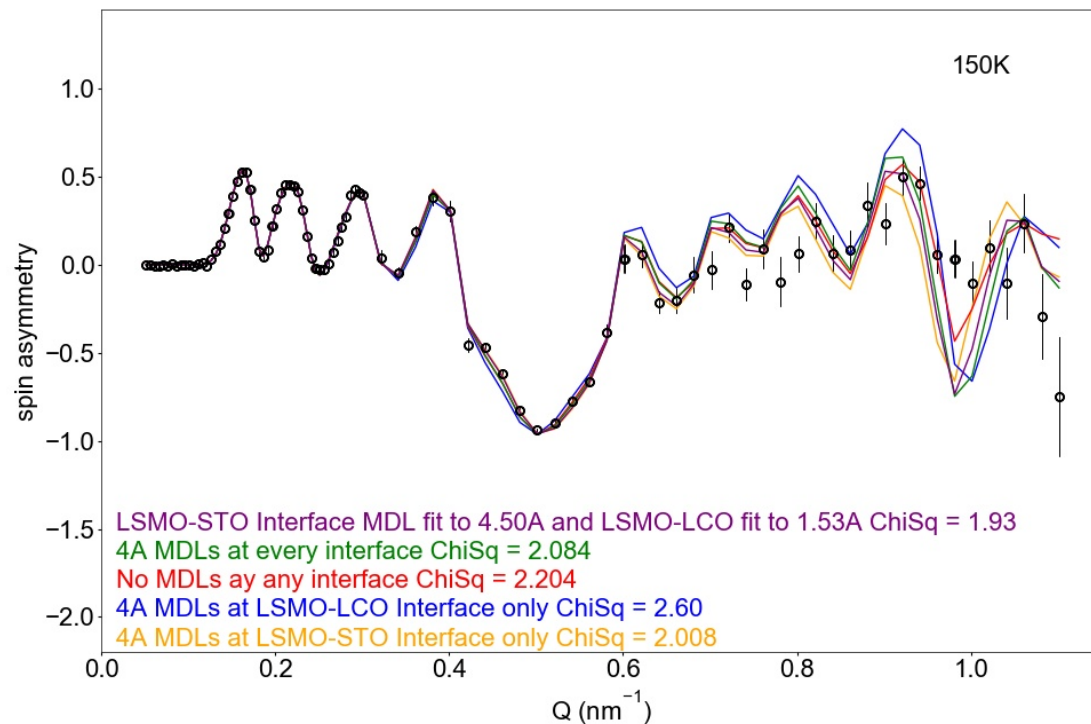
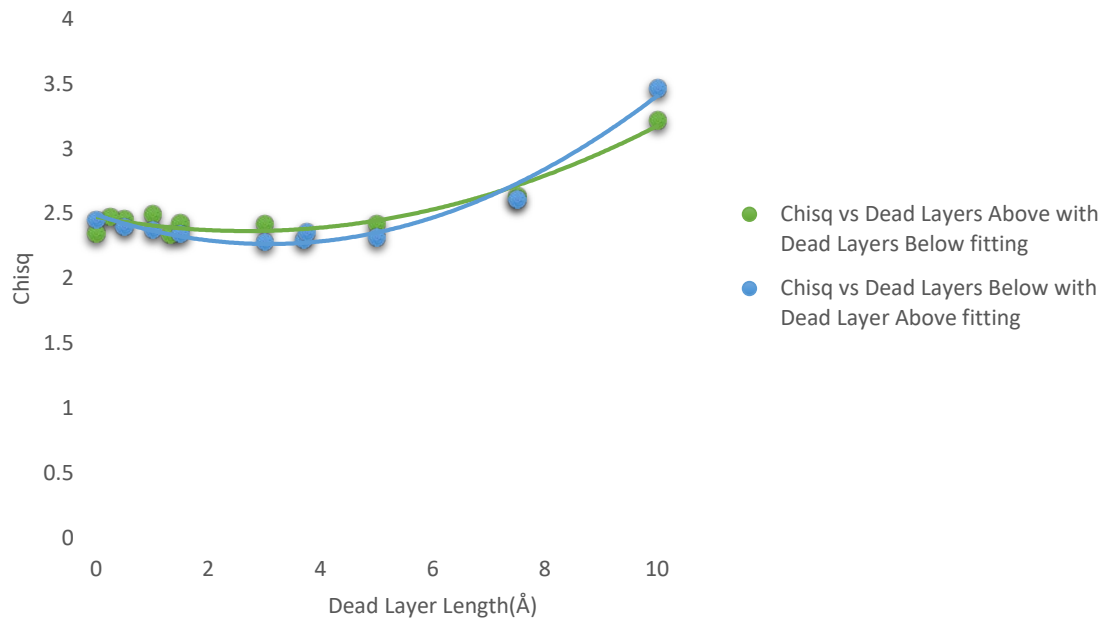


- LSMO has no MDLs at LCO interface
- Magnetism in LSMO and LCO is non-uniform
- Magnetic dead layers do not occur at some rhombohedral-to-rhombohedral material interfaces



# LCO/LSMO/STO Superlattice

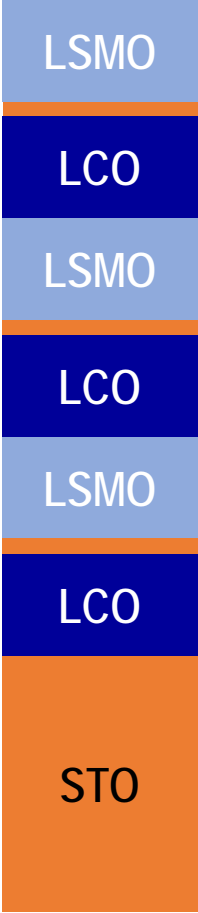
Chisq vs Dead Layer Length



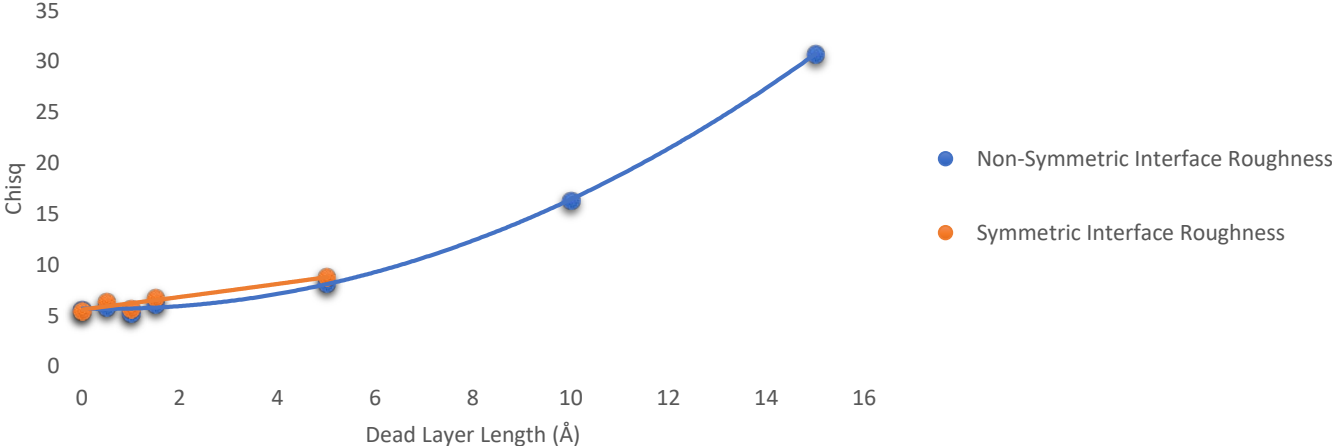
- Reinforces 4Å MDLs in LSMO at STO interface
- Reinforces no MDLs in LSMO at LCO interface
- Reinforces that the magnetism in LSMO and LCO is non-uniform
- Proves findings in LCO/STO/LSMO/STO superlattice sample and LCO/LSMO superlattice sample

# LCO/STO/LSMO Superlattice

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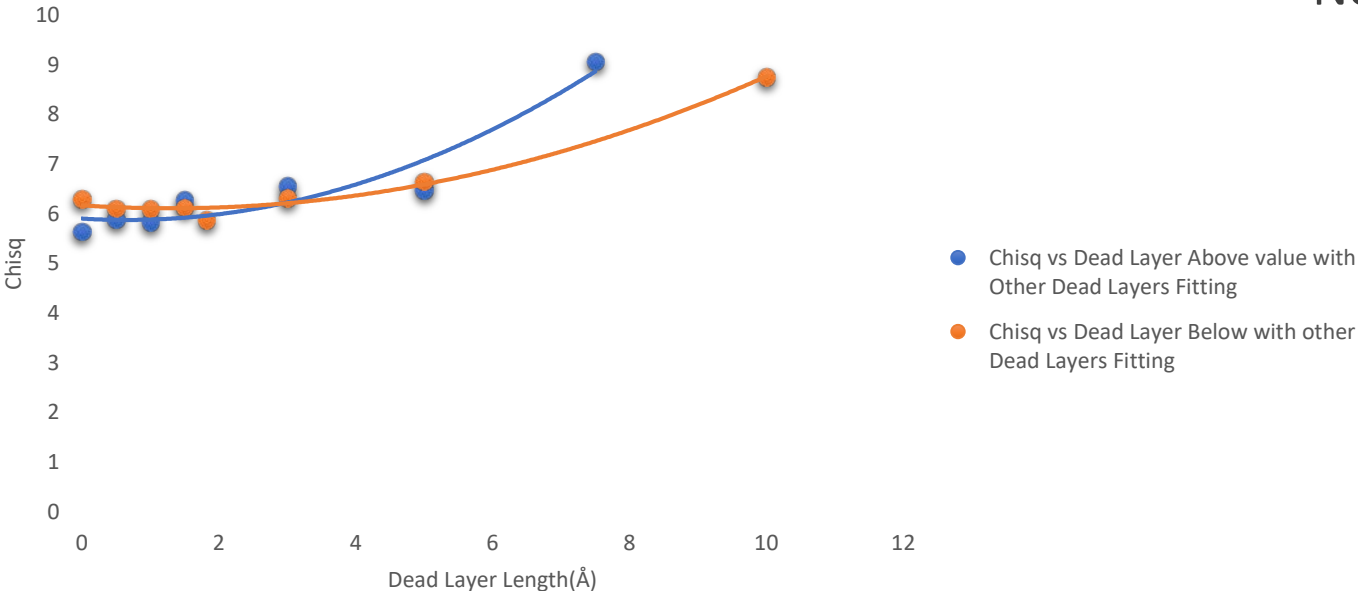


Chisq vs Dead Layer Length with Non-Uniform Magnetism



This sample had very bad fits

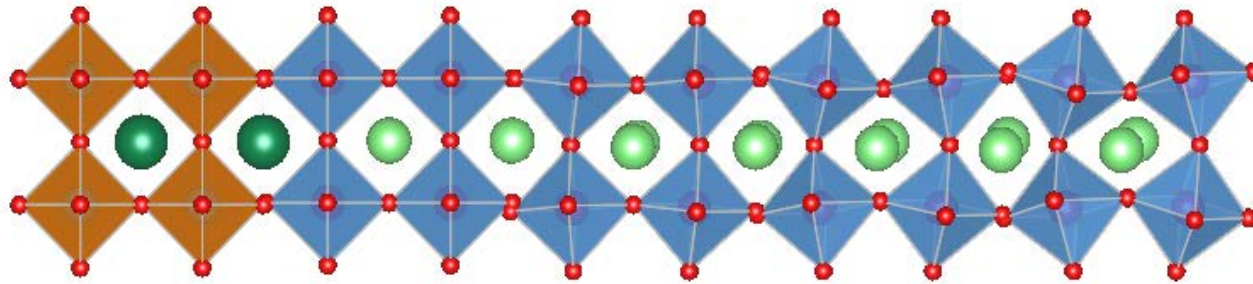
Chisq vs Dead Layer Length with Non-Uniform Magnetism



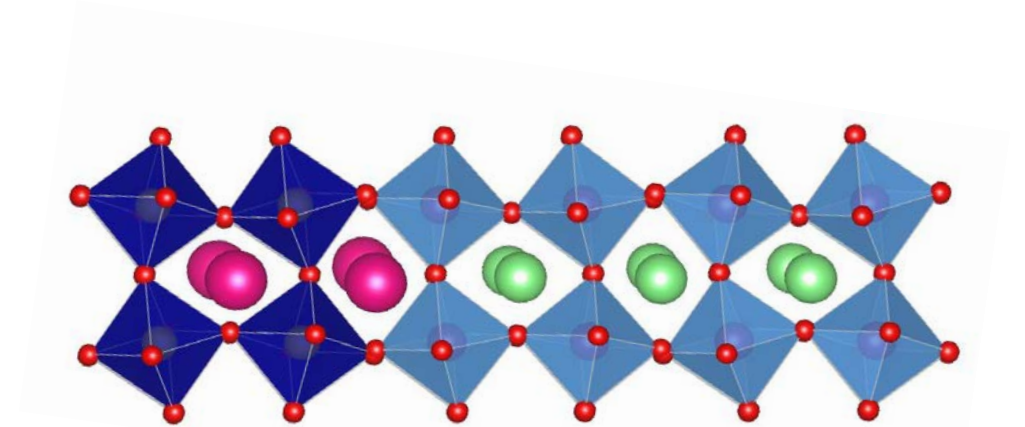
Non-conclusive information could be determined

# Conclusions

- MDLs occur in LSMO at interface with STO
- MDLs occur at some rhombohedral-to-cubic material interfaces
  - Sharp change in crystalline structure



- MDLs do not occur in LSMO at interface with LCO
- MDLs do not occur at some rhombohedral-to-rhombohedral material interfaces
  - Lacks sharp change in crystalline structure



# Acknowledgements

## Special Thanks:

- Ryan Need, mentor
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