NEUTRON REFLECTIVITY AND MAGNETIZATION REVERSAL IN HEUSLER ALLOY SPIN VALVES

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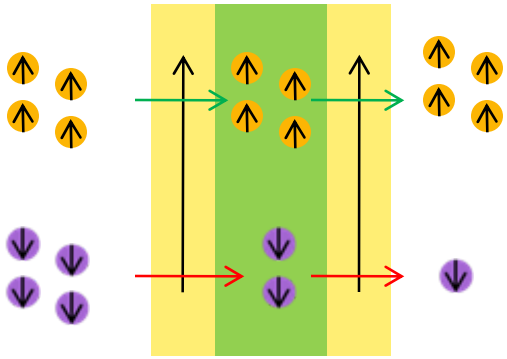
PRESENTATION OVERVIEW

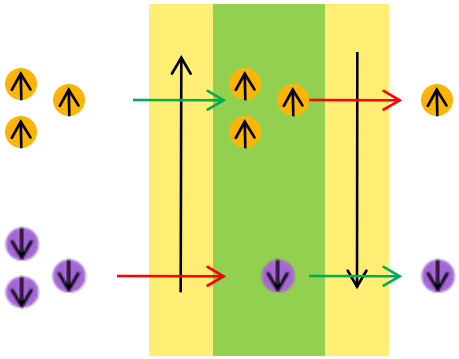
- Introduce Background Concepts
  - Giant Magnetoresistance
  - Spintronics and Spin Valves
  - Heusler Alloys
- Introduce Samples
- Discuss Problem
- Explain Polarized Neutron Reflectivity
- Present and Interpret Data

GIANT MAGNETORESISTANCE

- Resistance caused by two antiparallel ferromagnetic layers.



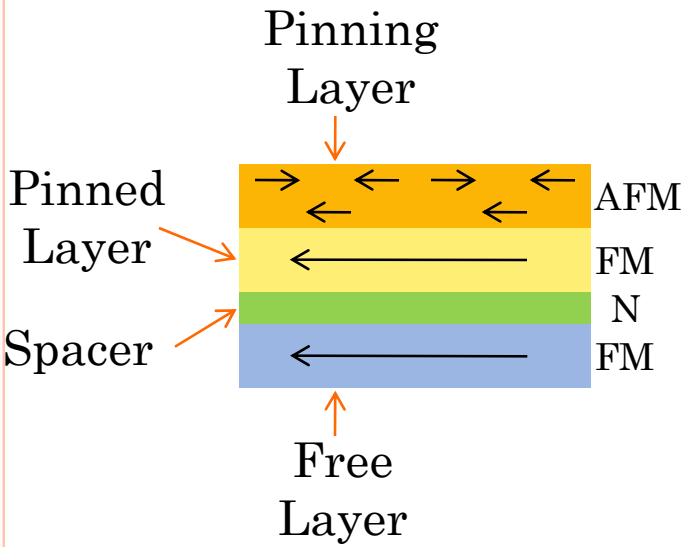
Electrons aligned parallel to layers can pass through.

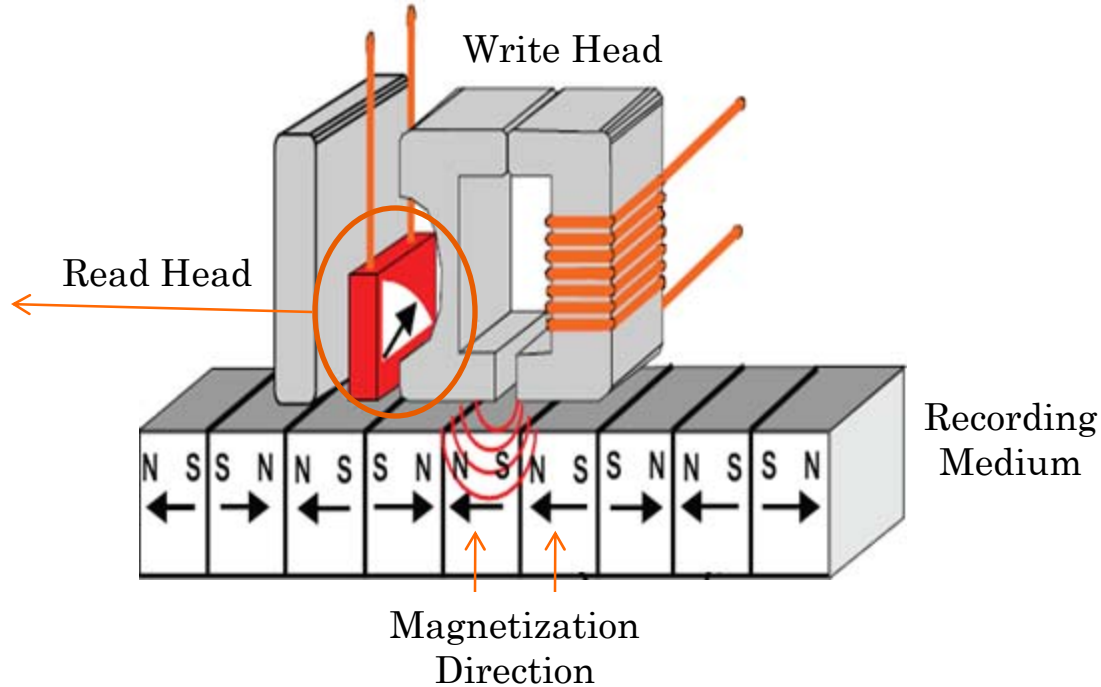


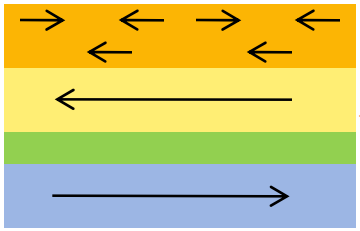
Electrons are filtered, a reduced current is measured.

- Alignment can be controlled by an external magnetic field.

SPINTRONICS AND SPIN VALVES



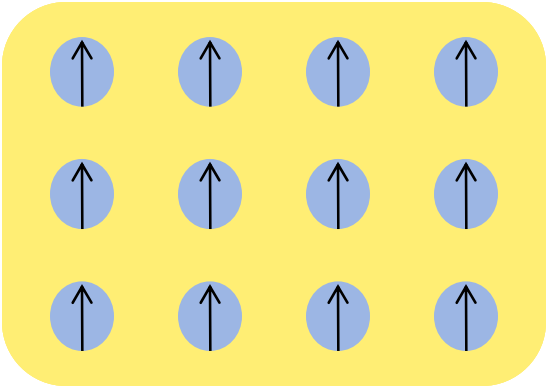




When pinned and free layers are antiparallel the read head measures a spike in resistance.

HEUSLER ALLOYS

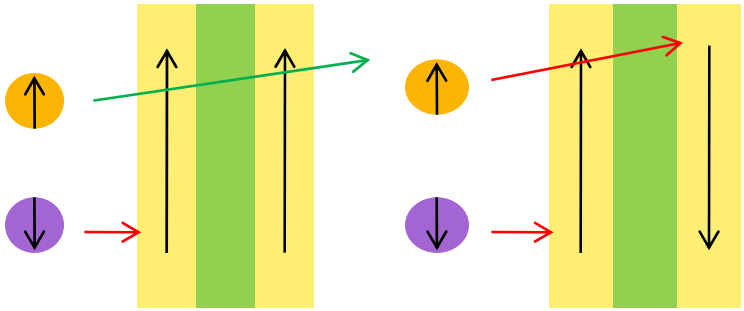
- Half metals



Half metals have 100% spin polarization.

Cobalt)
ation.

- 100% polarization stops leakage and increases GMR

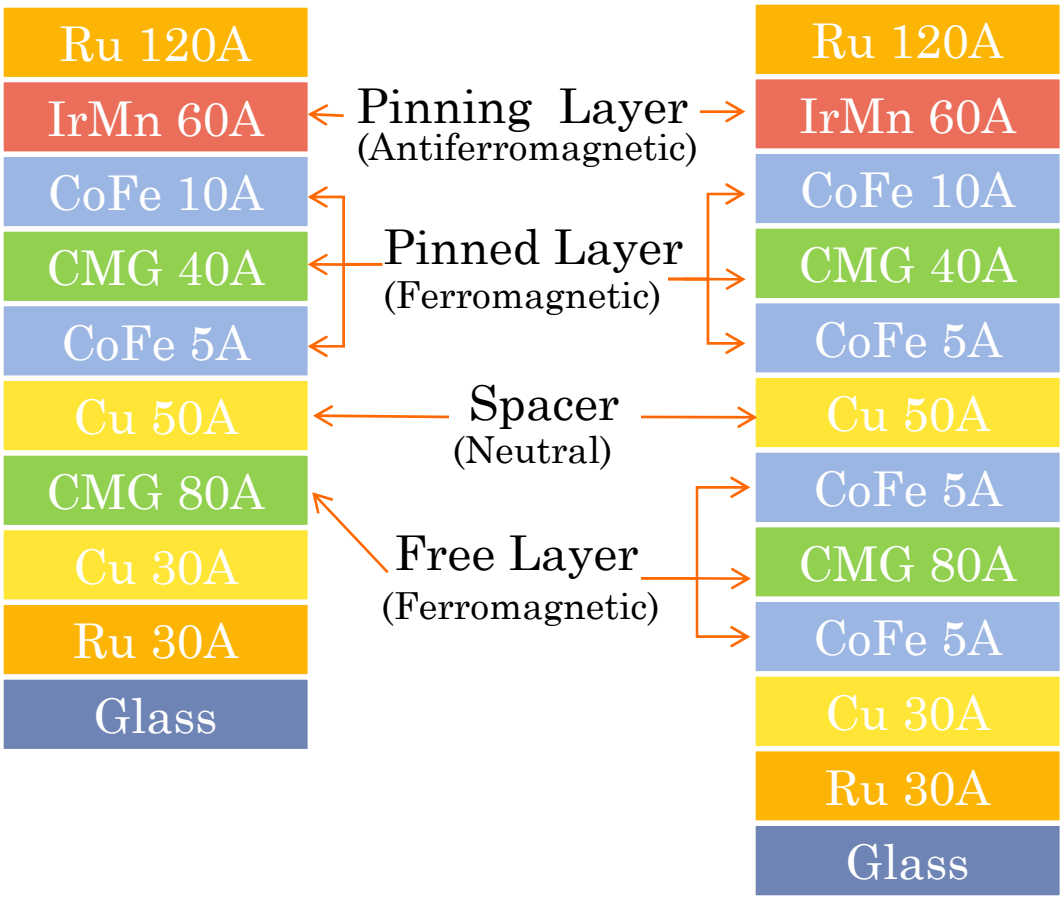


- Heusler alloys have a high curie temperature (aligns ferromagetically at high temperatures)

- Cobalt Manganese Germanium (CMG)
  - Co_2MnGe

OUR SAMPLE PROFILES

Spin Valves



Free Layers

THE PROBLEM

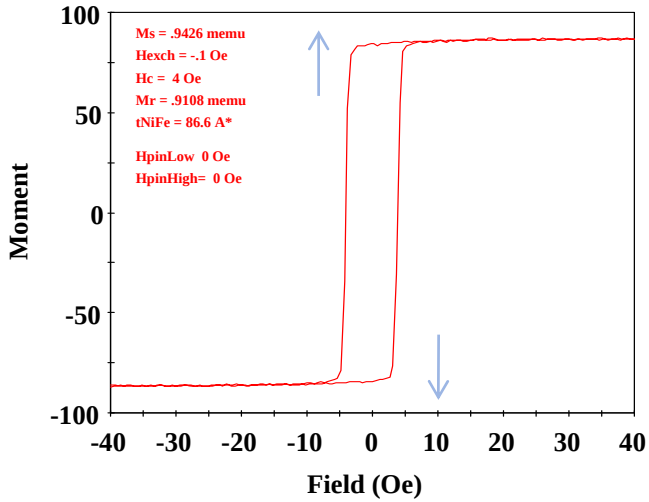
CoFe
CMG
CoFe

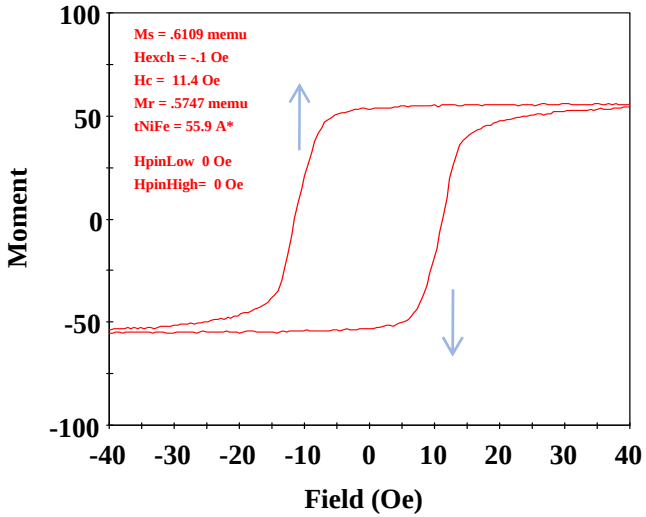
With CoFe

Without CoFe

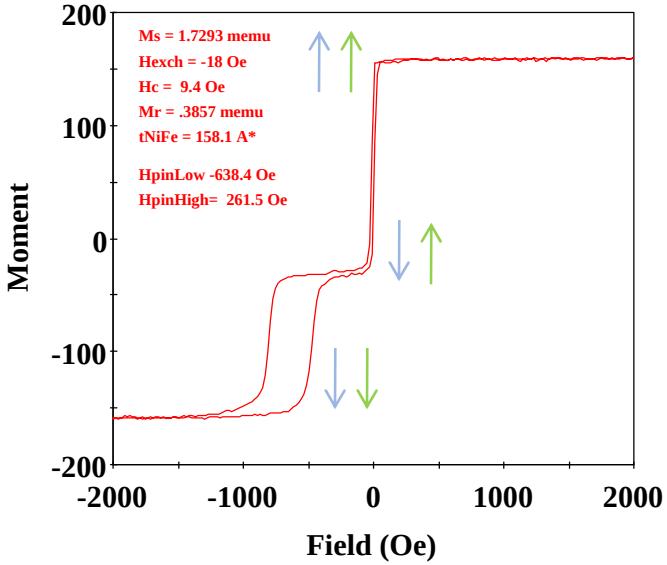
CMG

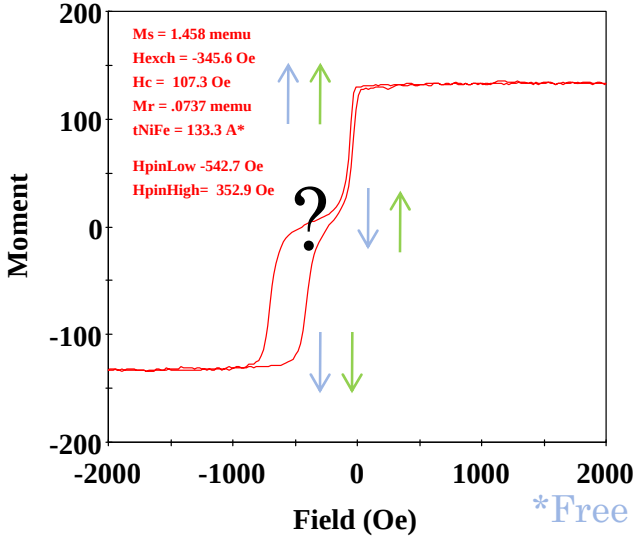
Free Layers





Spin Valves

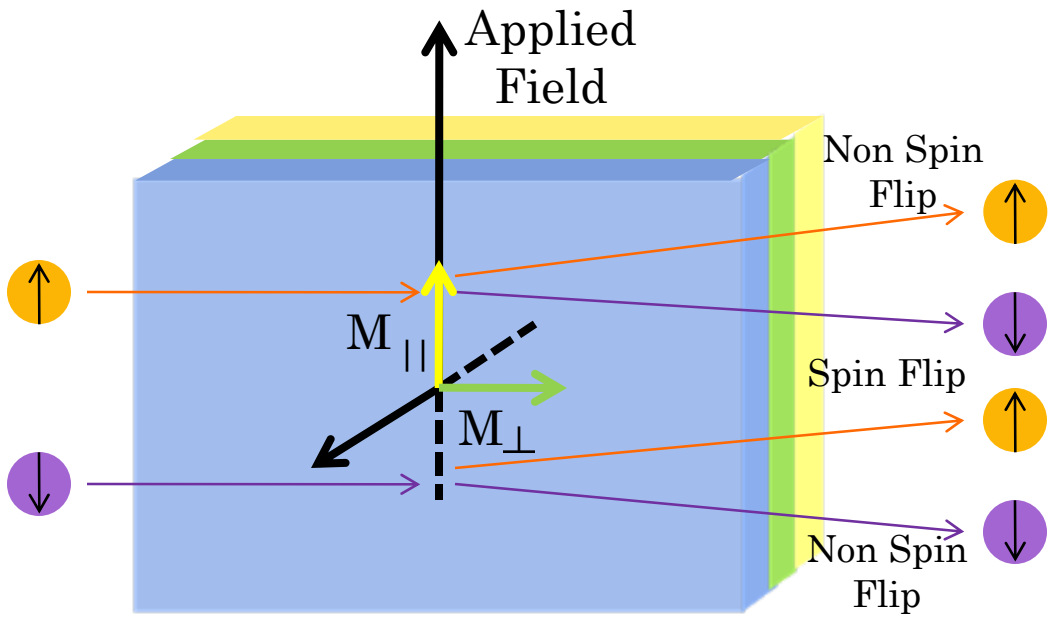


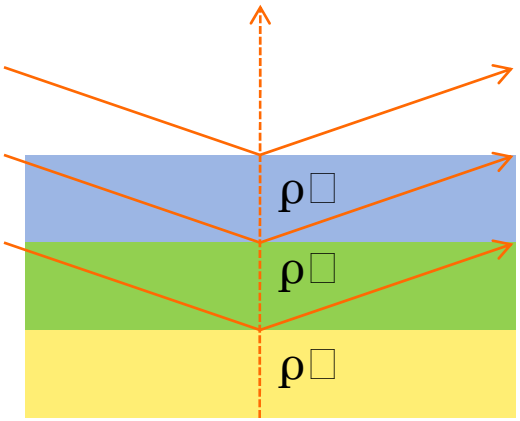


*Free Layer
*Pinned Layer

POLARIZED NEUTRON REFLECTIVITY (PNR)

- Sensitive to nuclear and magnetic structure vs. depth.
- NSF is sensitive to $M_{||}$ and to structure
- SF is sensitive to $M_{\perp}$





- Neutrons reflect at interfaces between layers.
- Each layer has a Scattering Length Density and Magnetic Density

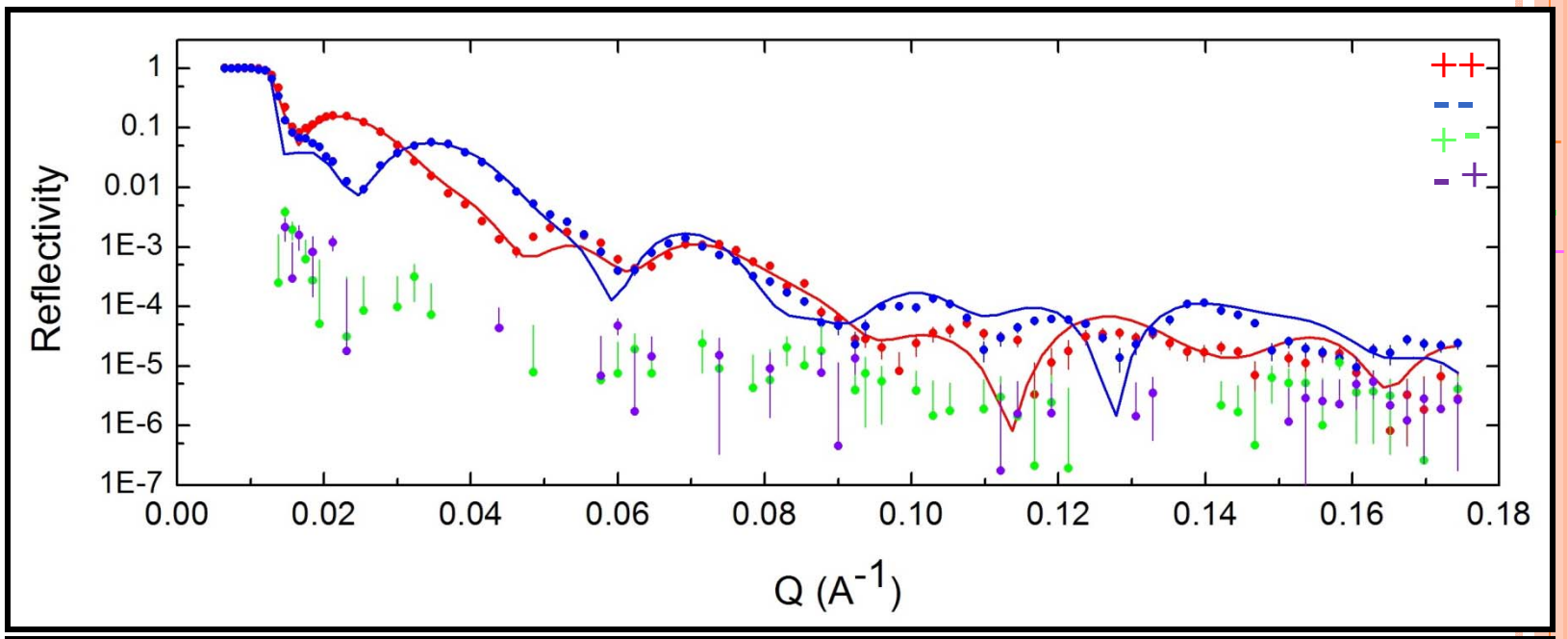
NEUTRON DATA

SPIN VALVE WITH COFE AT 250 OE

CoFe

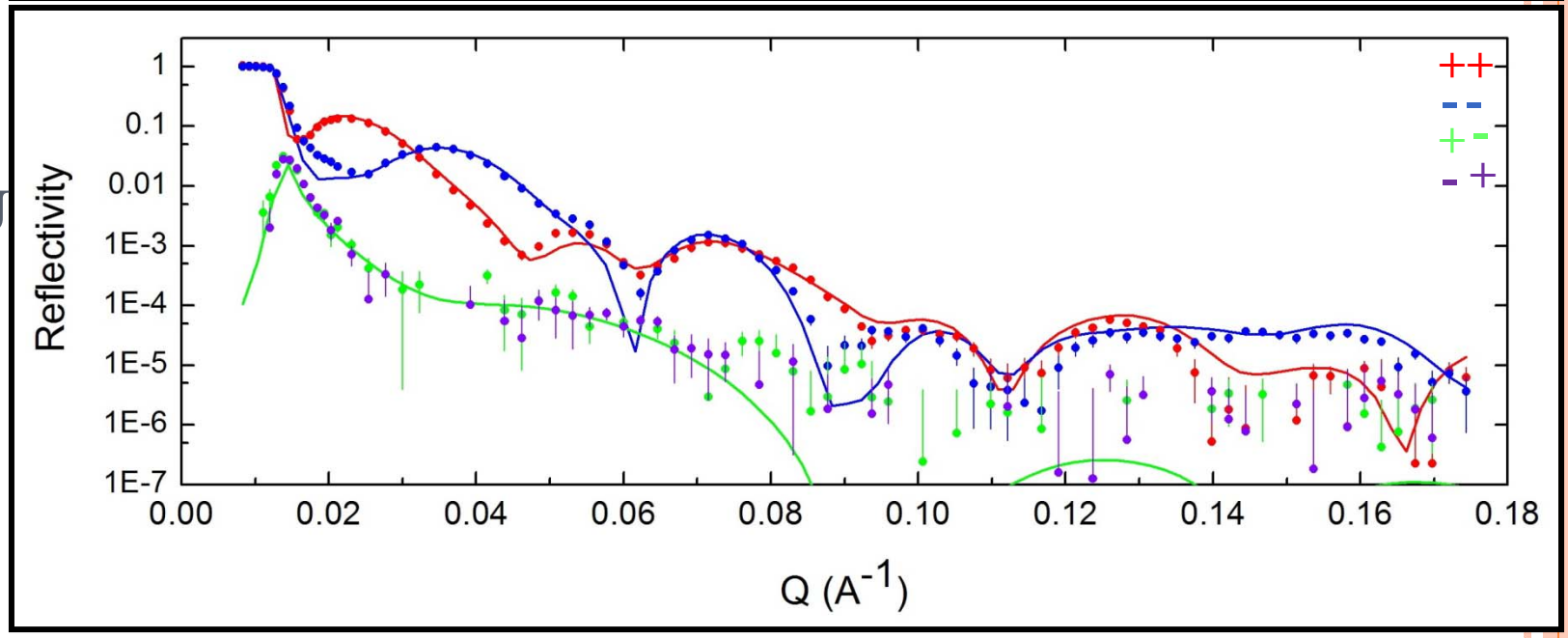
CMG

CoFe



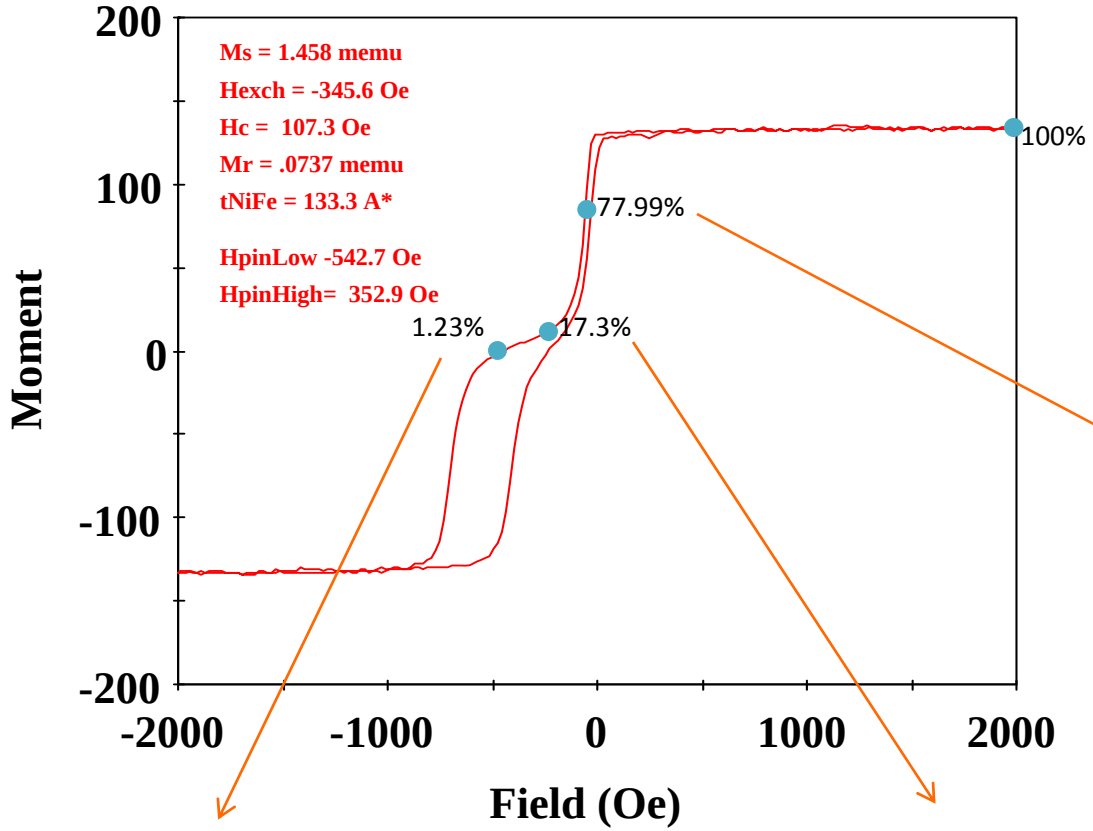
SPIN VALVE WITHOUT COFE AT 250 OE

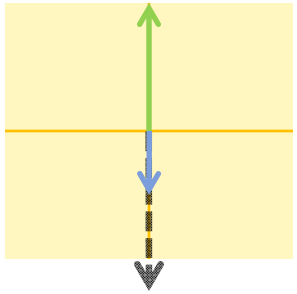
CMG



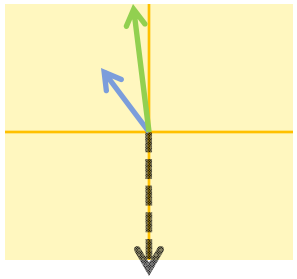
MAGNETIC MOMENT OF SPIN VALVE WITHOUT CMG COFE

↑ Pinned
↑ Free
↑ Field

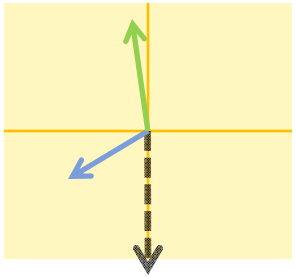




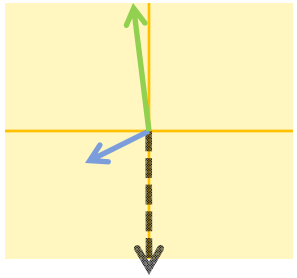
Expected
Net Magnetization: Decreased
Free Layer Angle: 270°



Field: 50 Oe
Net Moment: 745.16emu/cm³
Free Layer Angle: 134°



Field: 520 Oe
Net Magnetization:
11.75 emu/cm³
Free Layer Angle: 243°



Field: 250 Oe
Net Magnetization:
165.62 emu/cm³
Free Layer Angle: 243°

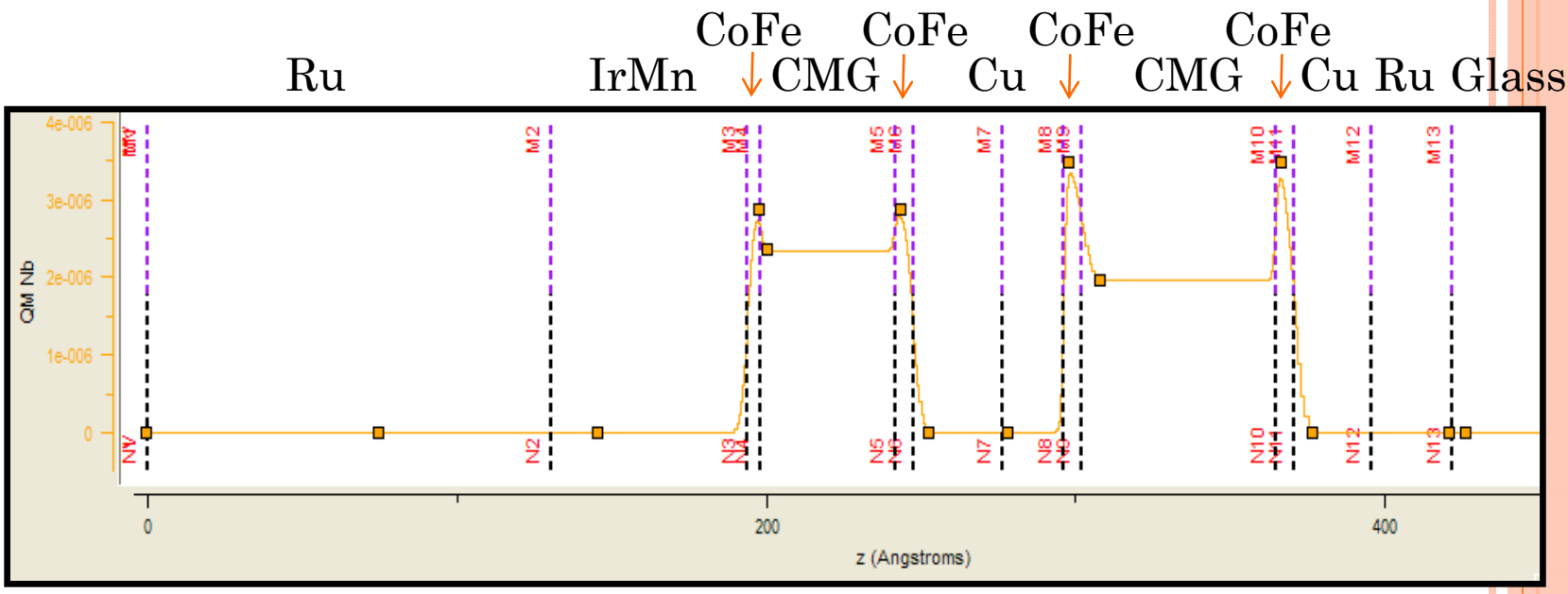
MAGNETIZATION PROFILE

SPIN VALVE WITH COFE AT 250 OE

CoFe

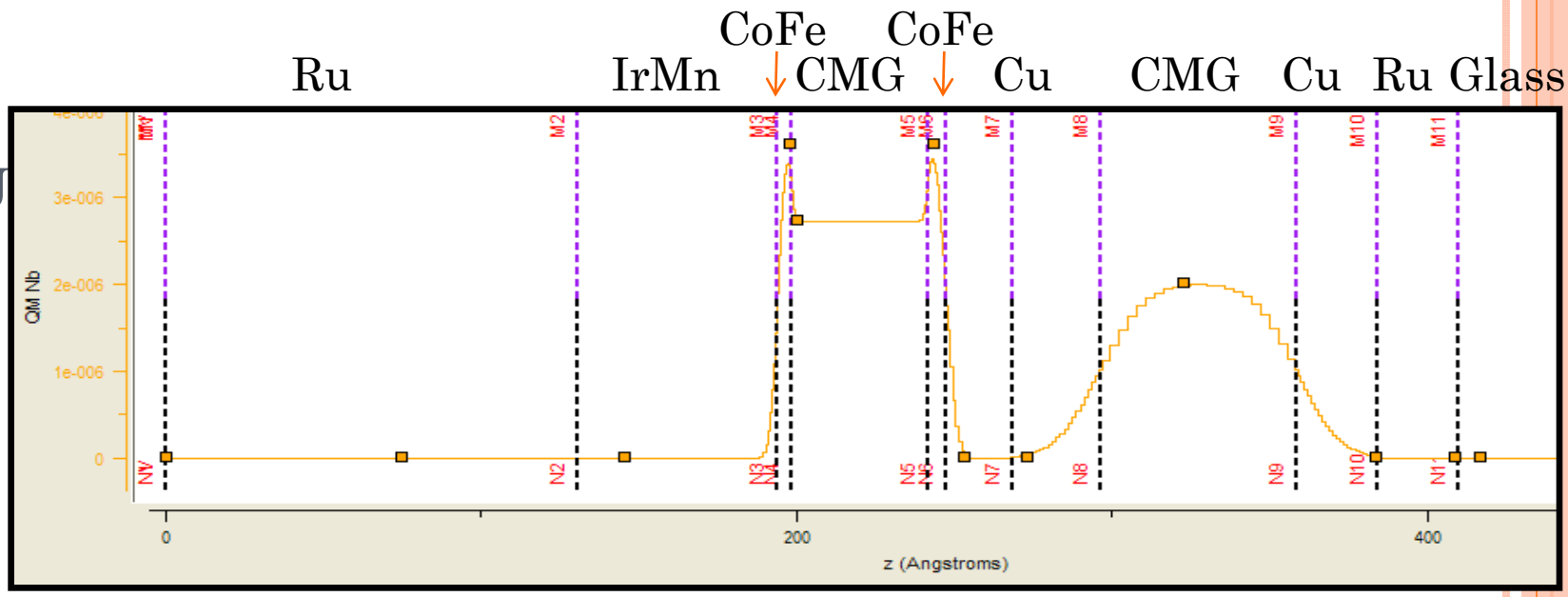
CMG

CoFe



SPIN VALVE WITHOUT COFE AT 250 OE

CMG



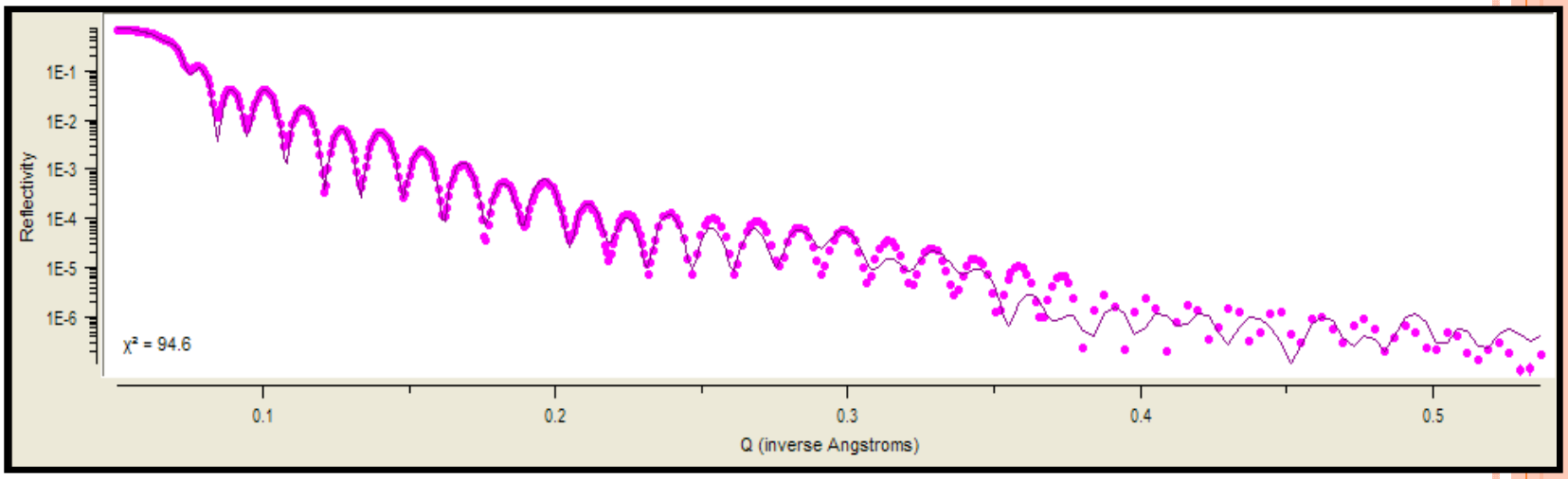
X-RAY DATA

SPIN VALVE WITH COFE

CoFe

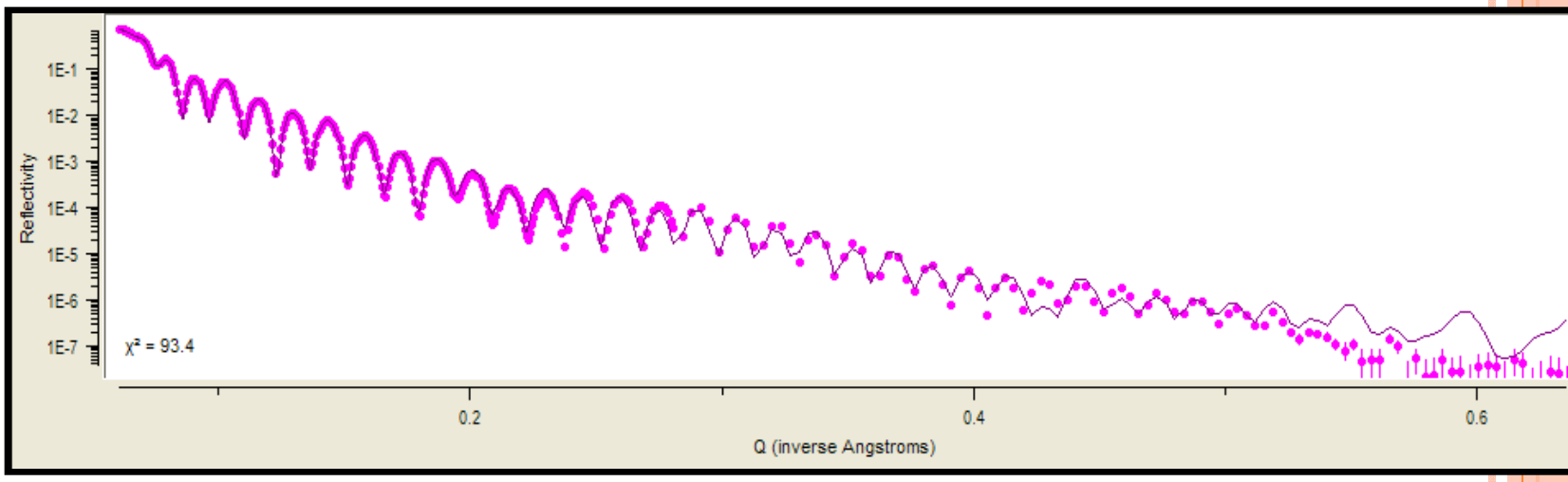
CMG

CoFe



SPIN VALVE WITHOUT COFE

CMG



X-RAY PROFILE

SPIN VALVE WITH COFE

CoFe

CMG

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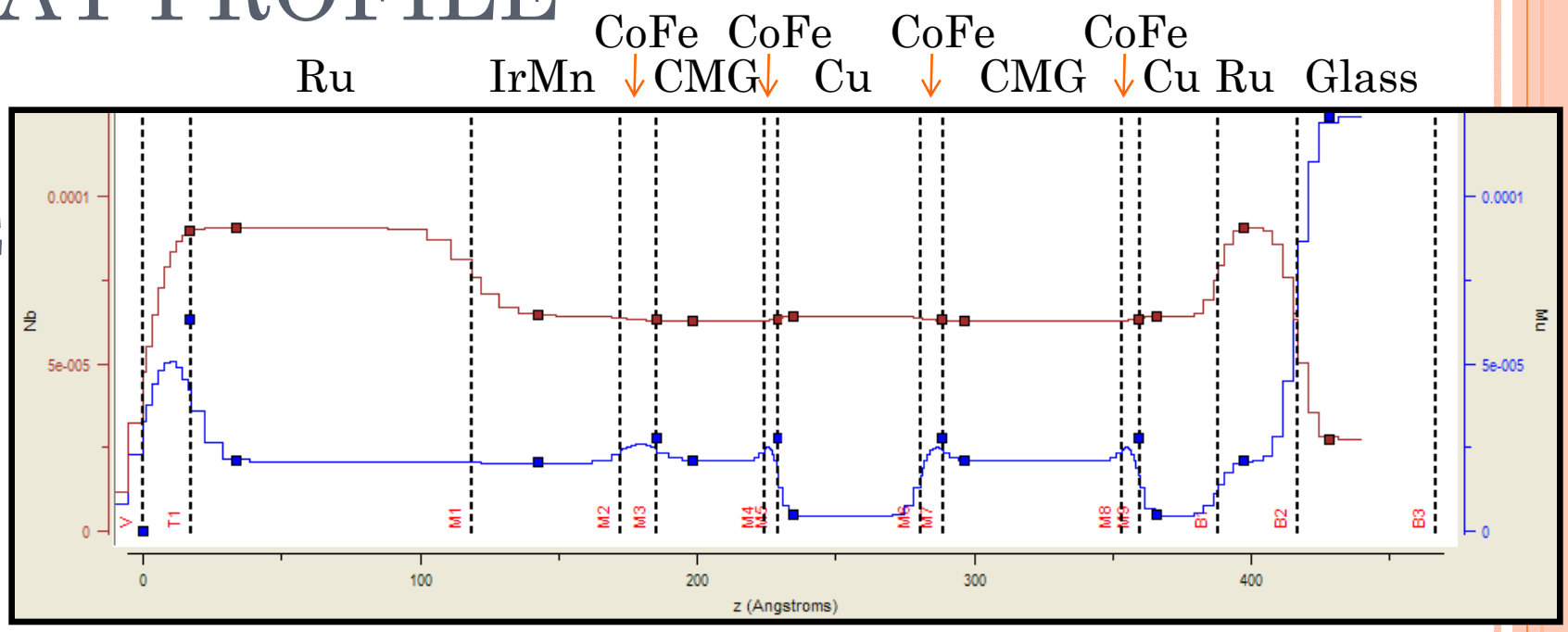
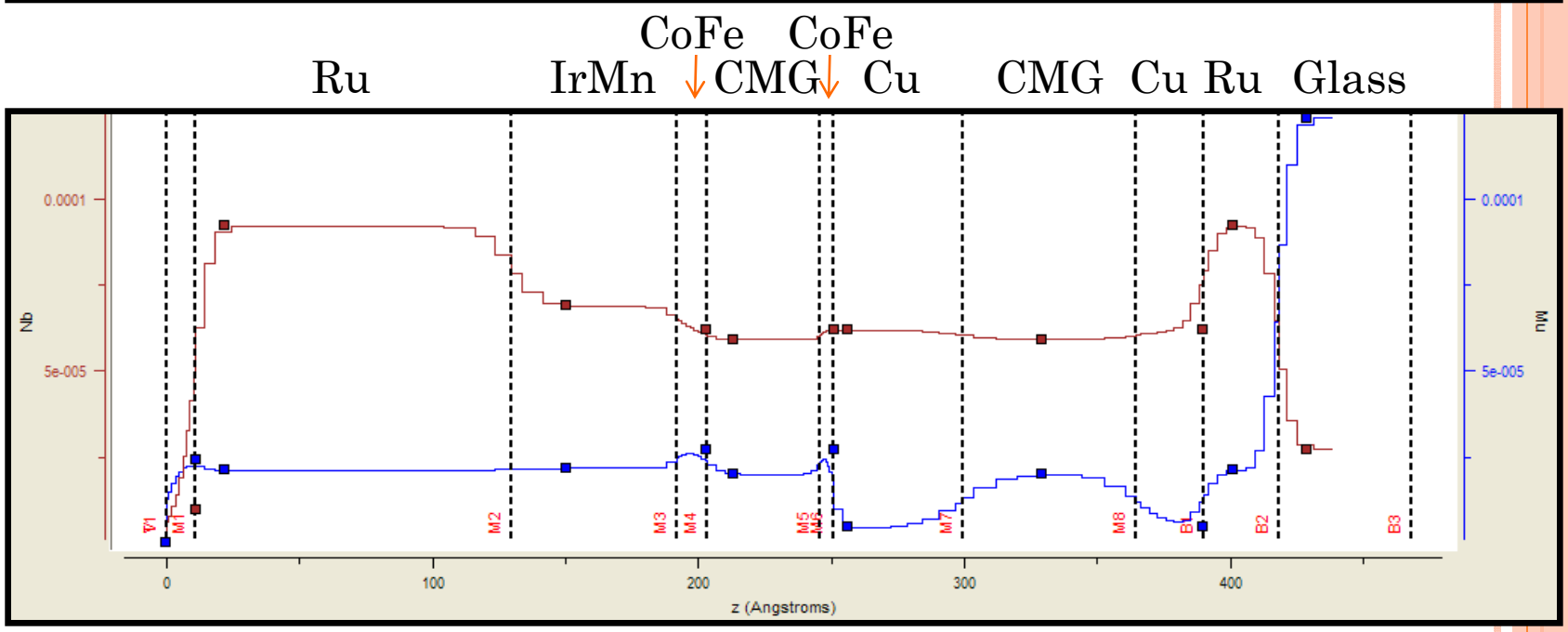


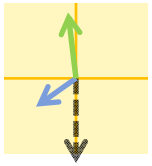
SPIN VALVE WITHOUT COFE

CMG

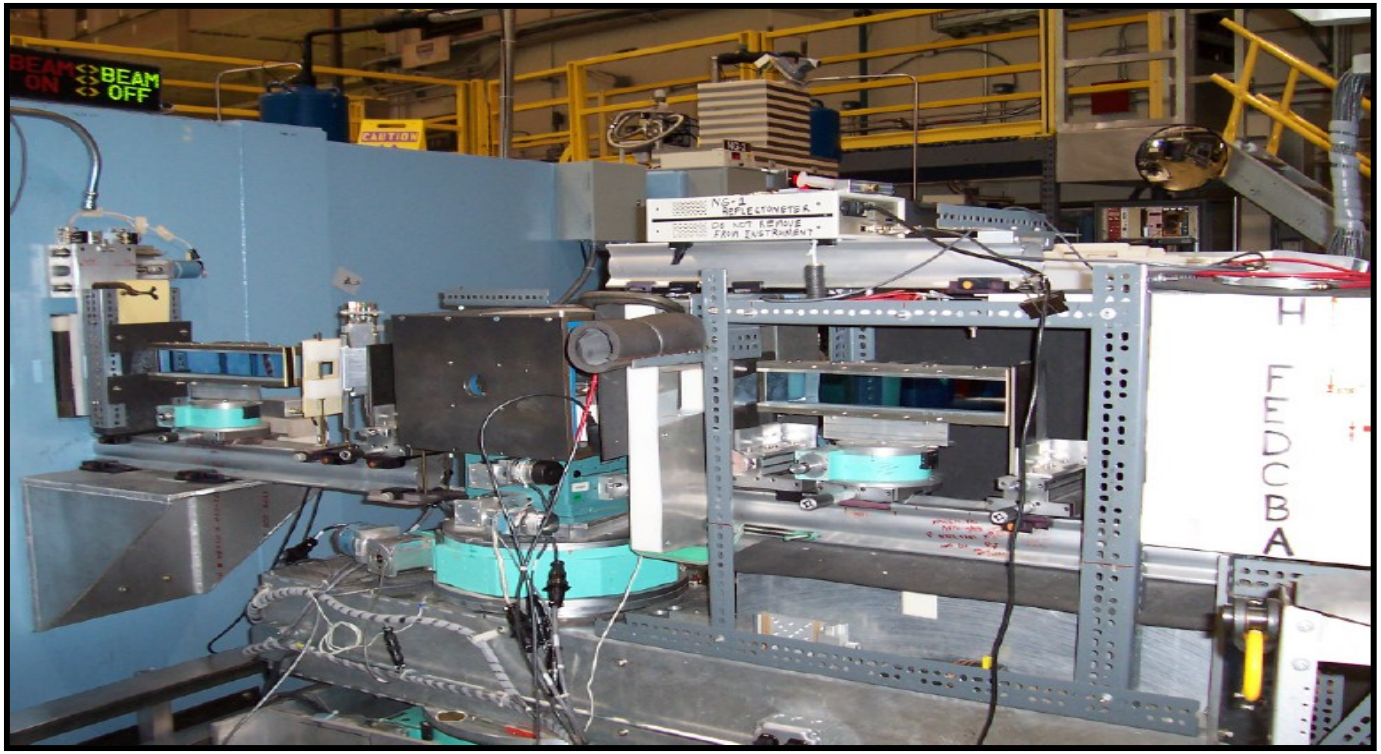


CONCLUSIONS

- CMG spin valves exhibit strong GMR
  - CoFe layers increase GMR
- CMG spin valves without CoFe show evidence of canting during reversal
  - Coherent rotation



- Canting could be explained by increased roughness around CMG layer
  - Pin holes
  - Complex coupling
- CMG spin valves without CoFe are rougher
- Further Studies:
  - Roughness
  - Different locations of CoFe layers
  - Other explanations?



NG1 – Polarized Neutron Reflectometer

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