Slicing beamtime at BESSY

W/Gd(5)/Fe(2)/Y(2) all optical switching and temperature-dependent magnetization dynamics

March 2021 – Covid time

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Wibke
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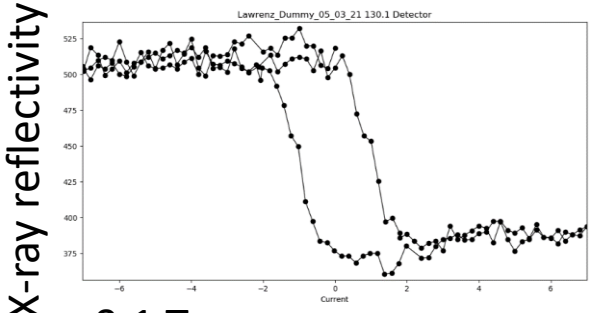
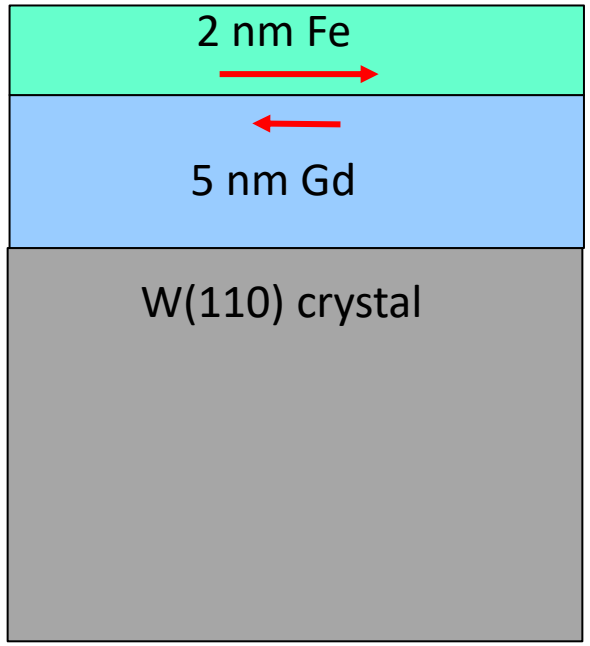
Characterization

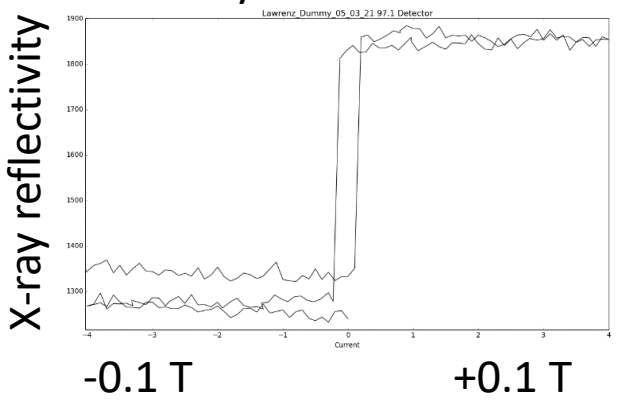
X-ray magnetic circular dichroism of Gd M_5

Gd hysteresis at 100 K

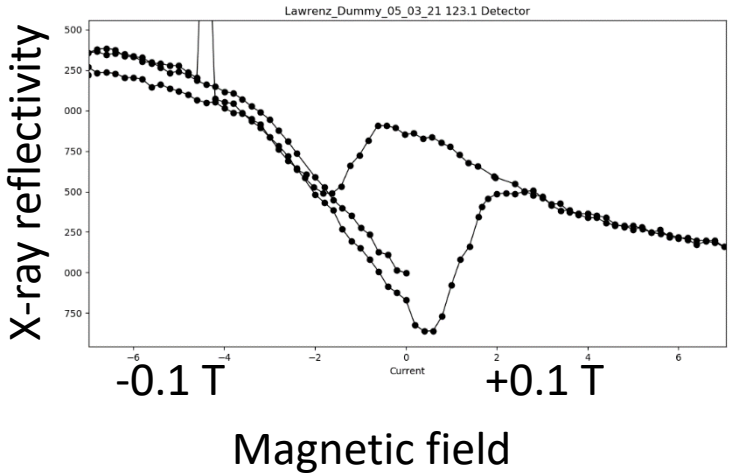




Gd hysteresis at 300 K

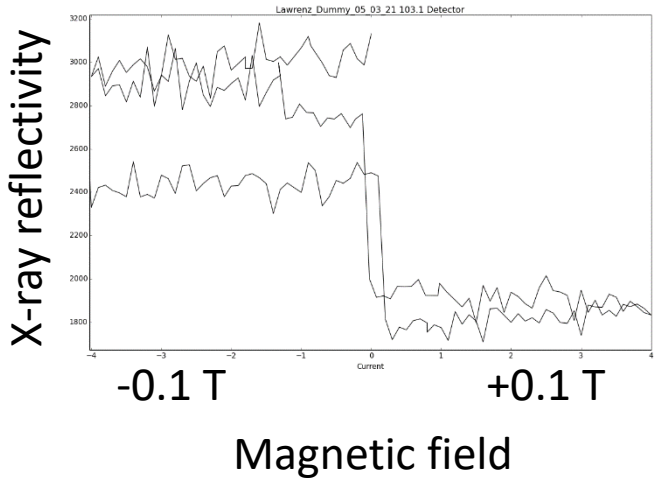


Fe hysteresis at 100 K

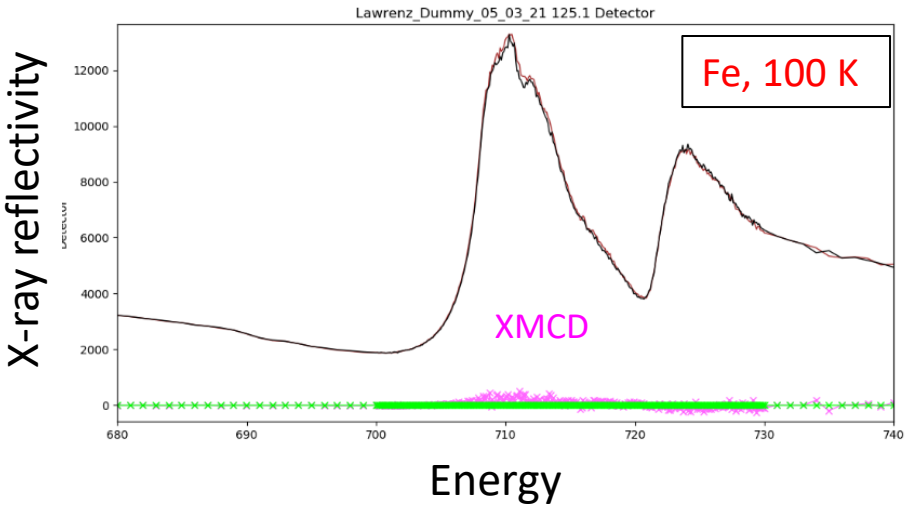


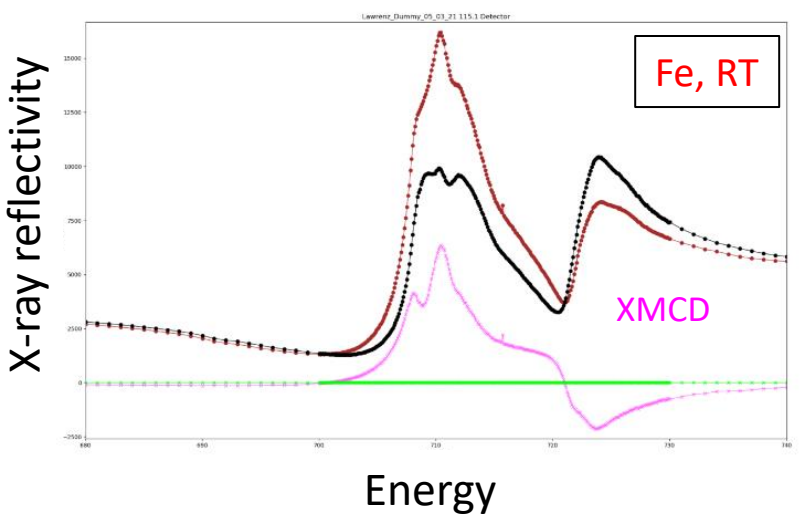
At 0.1 T Fe magnetization dragged along field

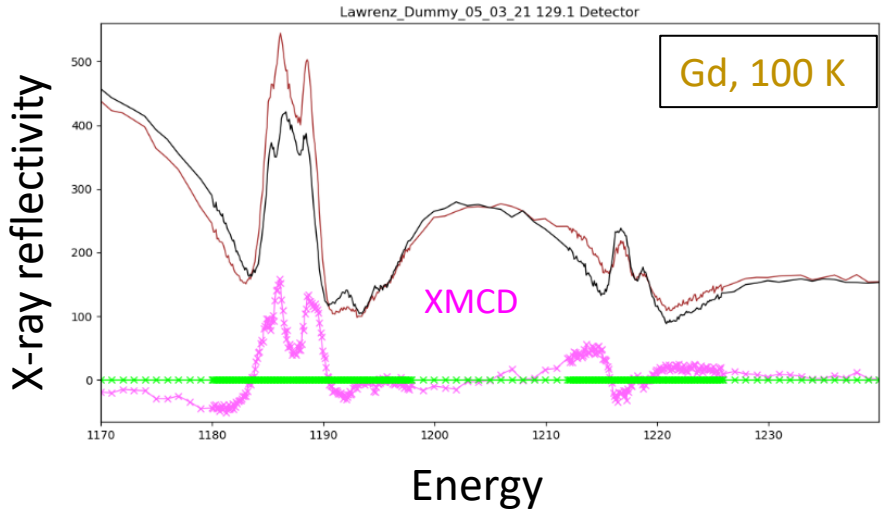
Fe hysteresis at 300 K

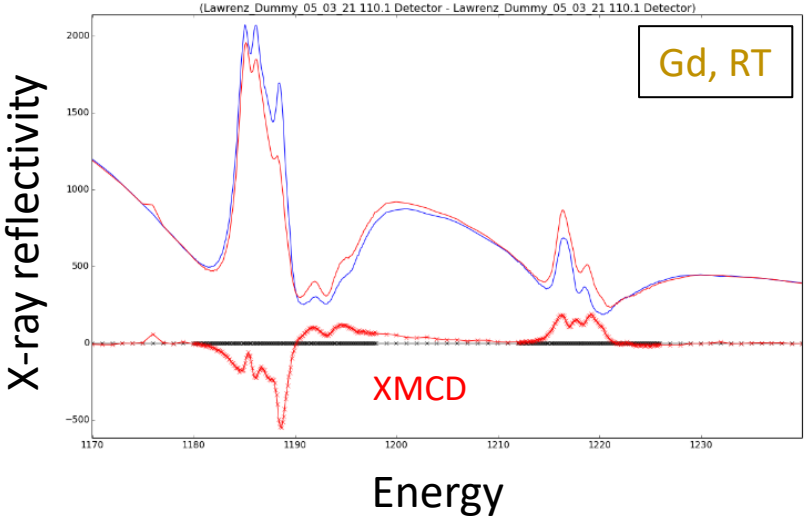


Static XMCD

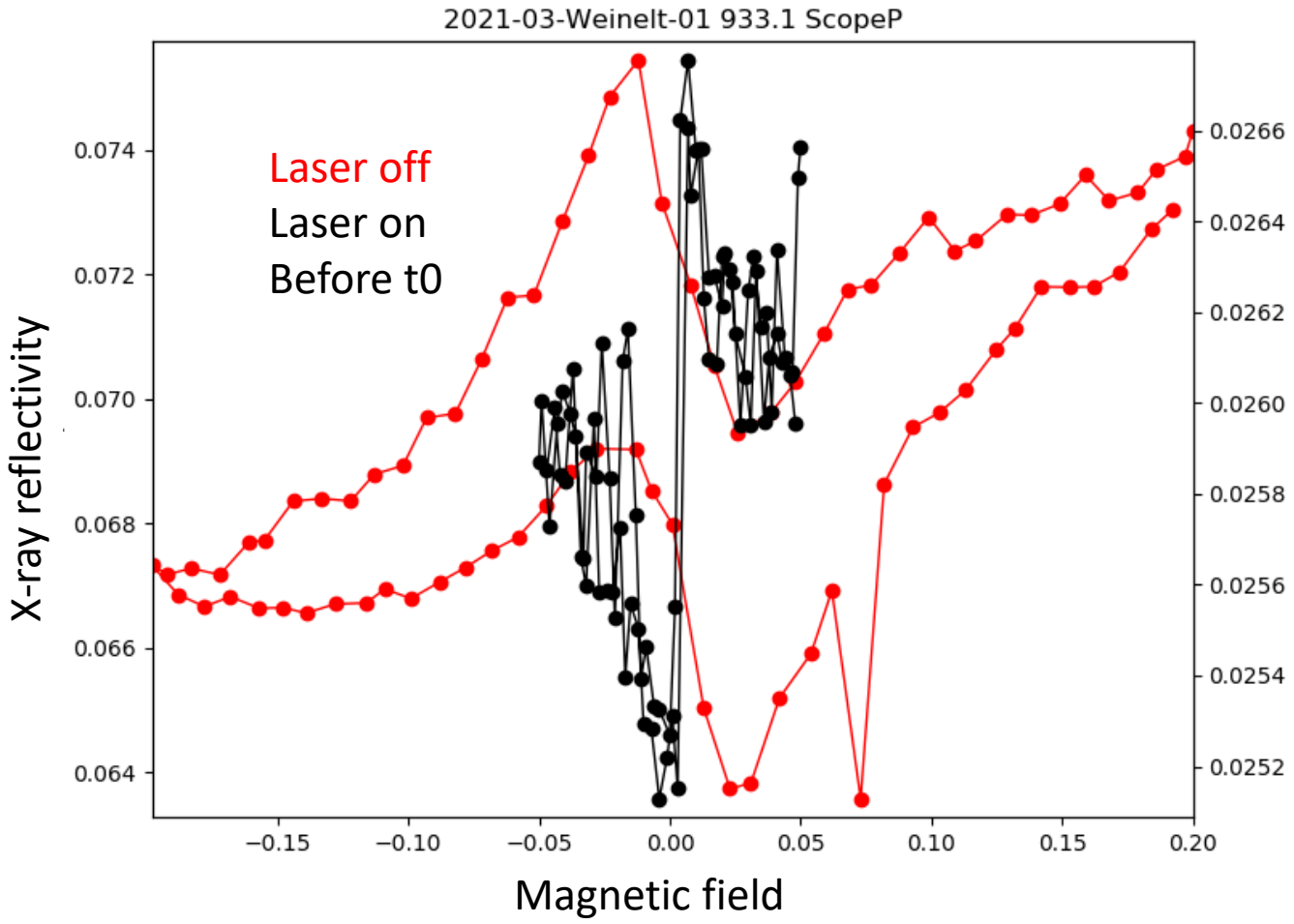

Lawrenz_Dummy_05_03_21 125.1 Detector
Fe, 100 K
XMCD
X-ray reflectivity
Energy


Fe, RT
XMCD
X-ray reflectivity
Energy

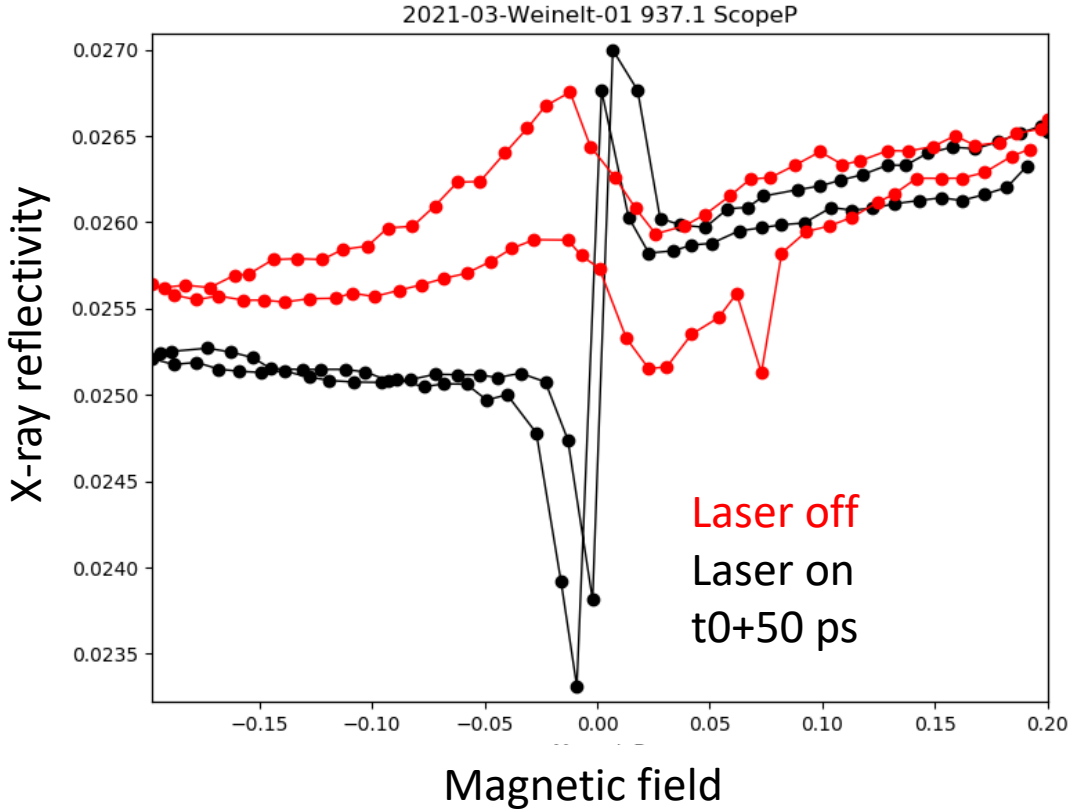

Lawrenz_Dummy_05_03_21 129.1 Detector
Gd, 100 K
XMCD
X-ray reflectivity
Energy

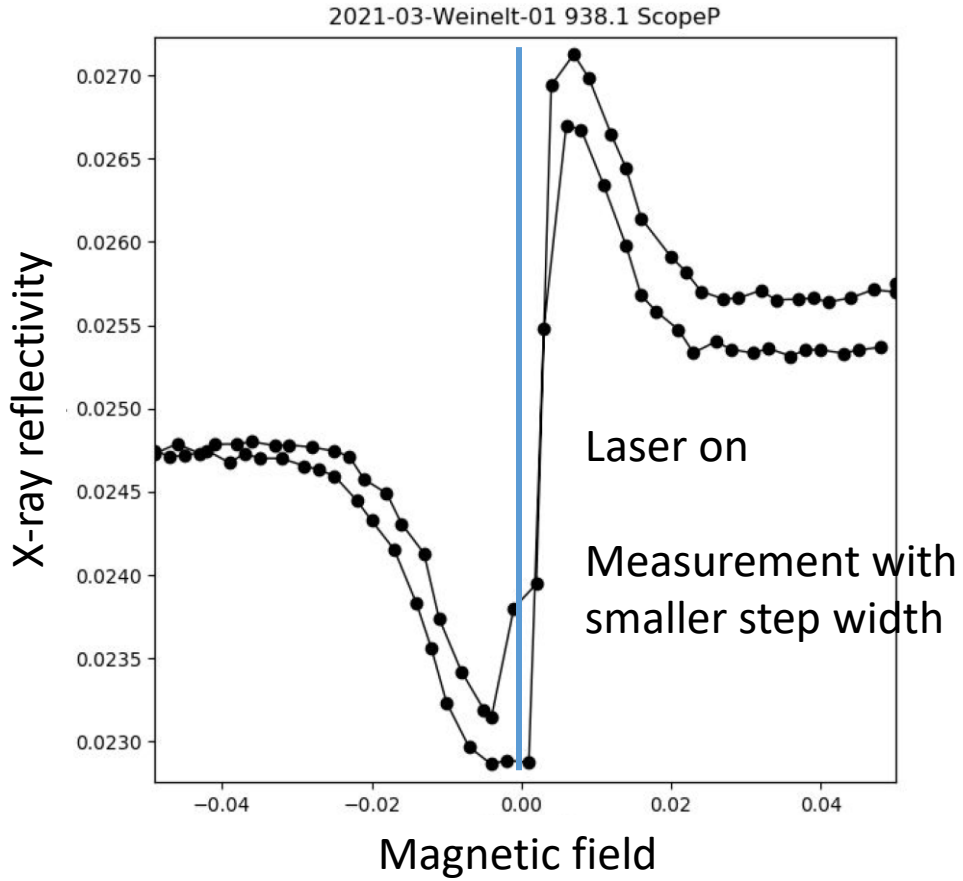

(Lawrenz_Dummy_05_03_21 110.1 Detector - Lawrenz_Dummy_05_03_21 110.1 Detector)
Gd, RT
XMCD
X-ray reflectivity
Energy

Gd hysteresis at 235 K



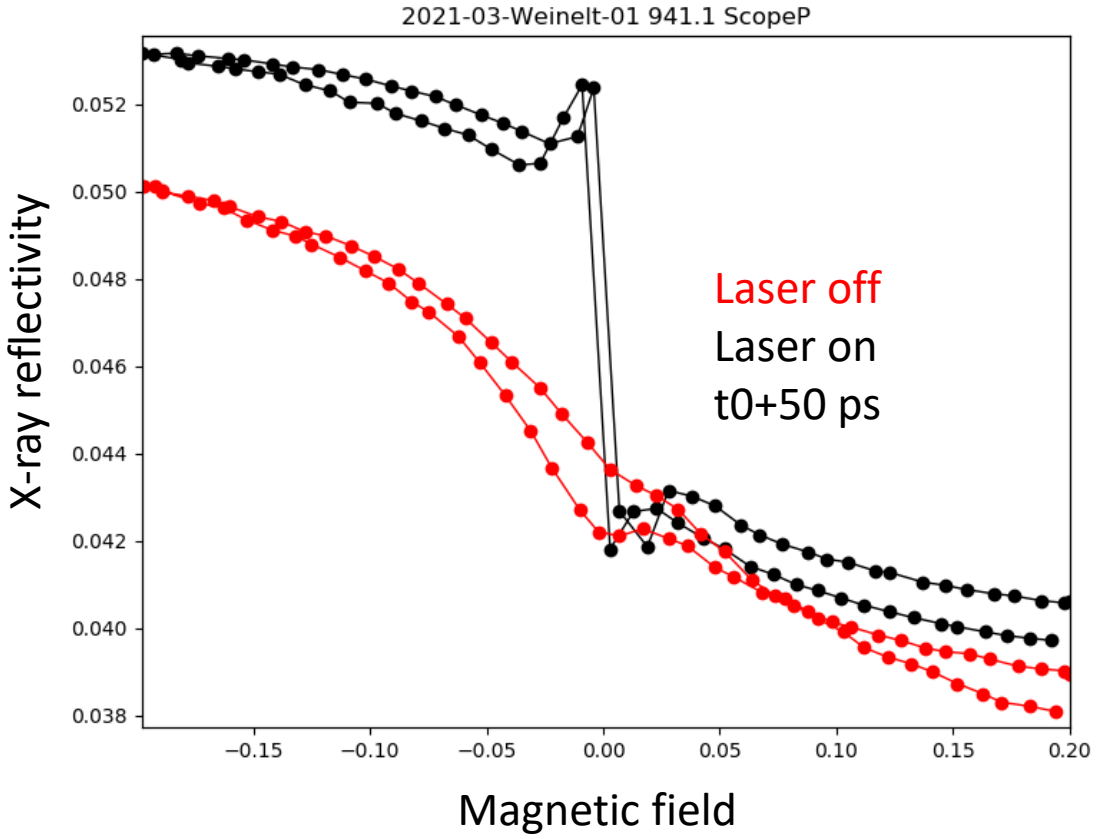
Gd hysteresis at 235 K

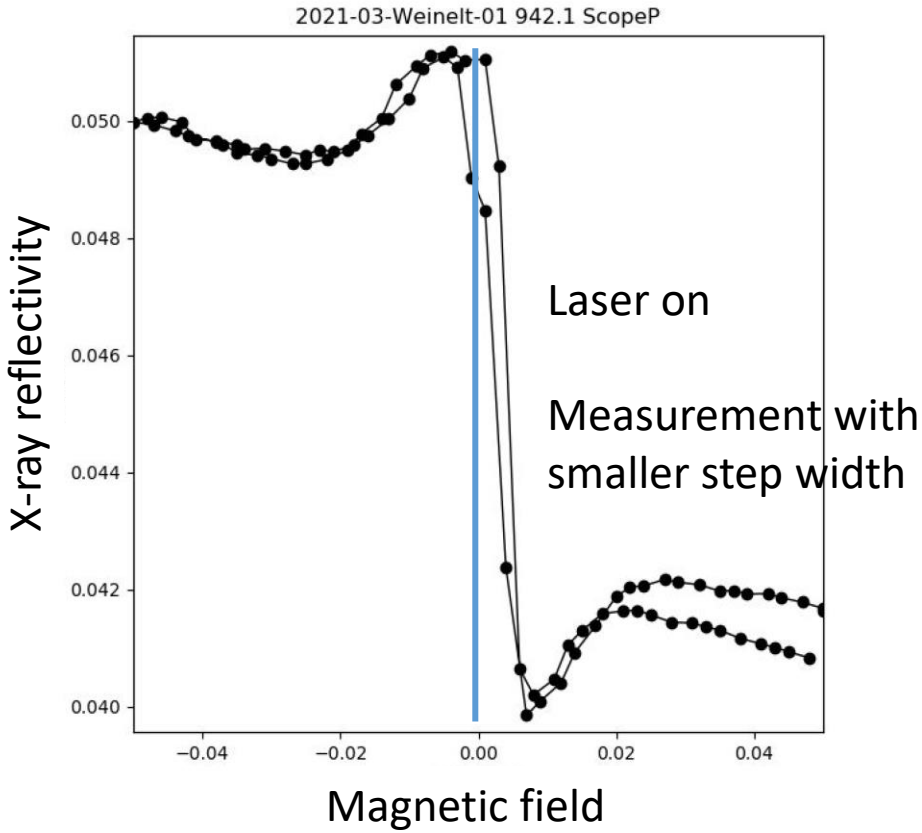




Looks like small *exchange* bias

Fe hysteresis at 235 K

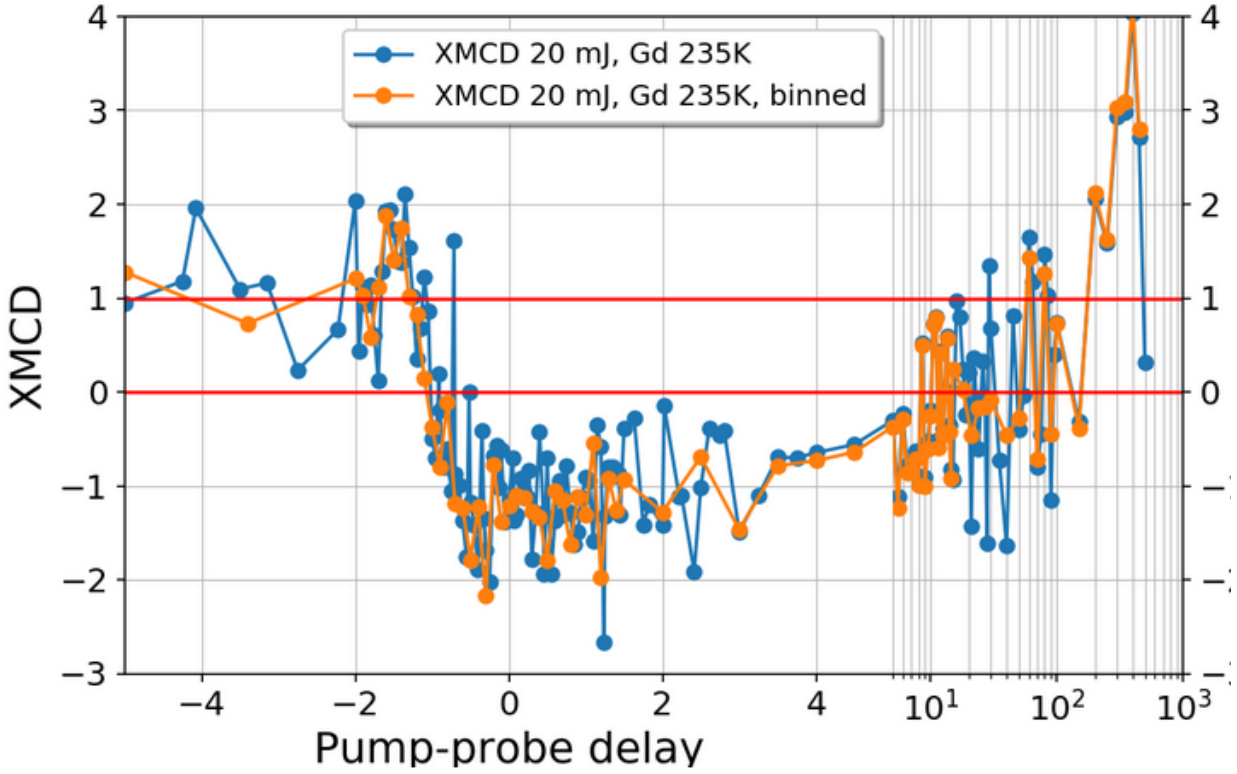




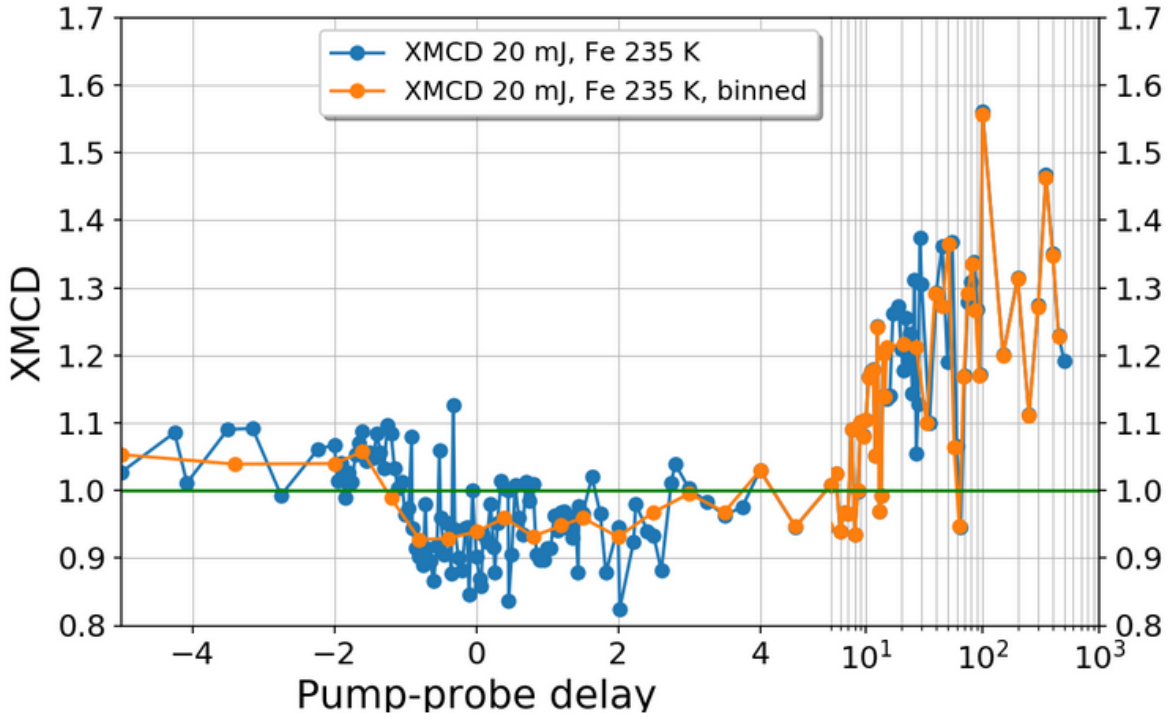
Looks like small *exchange* bias

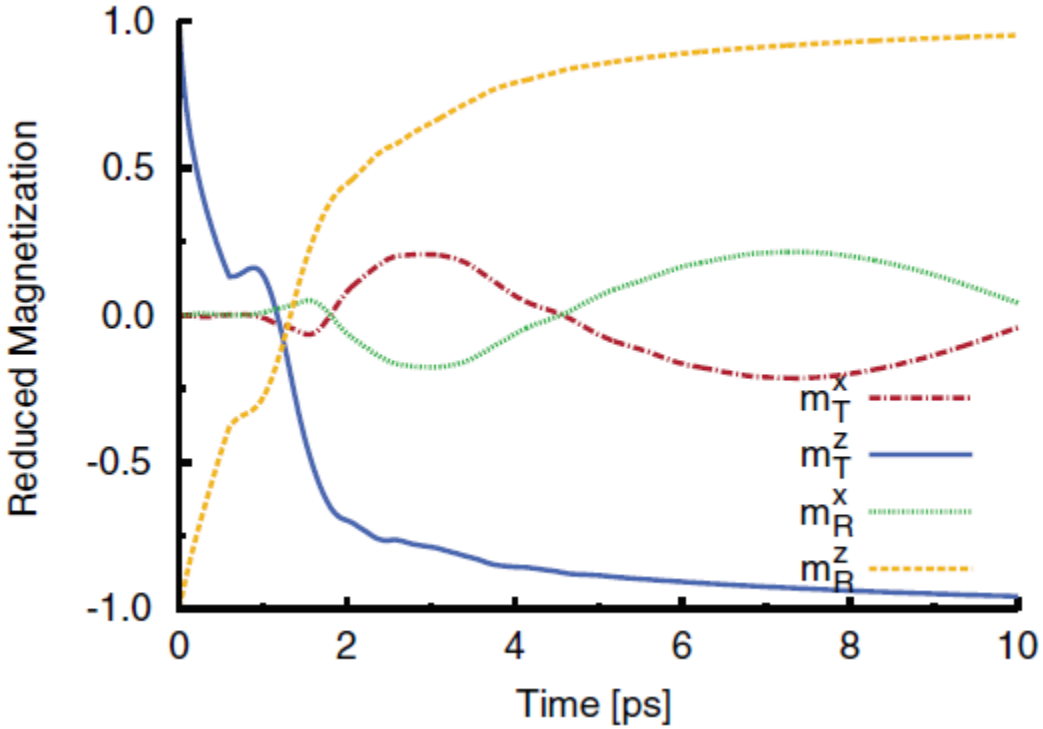
AOS of W/Gd/Fe – long timescale !

Gd

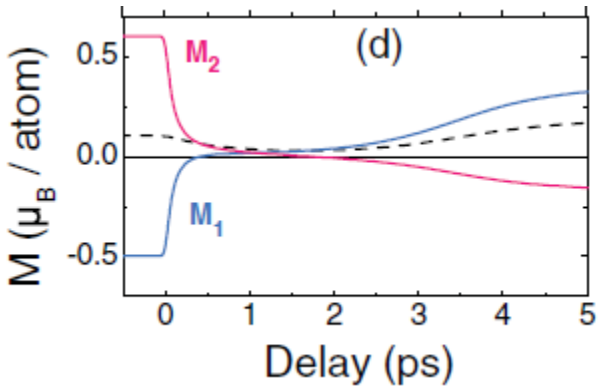


Fe

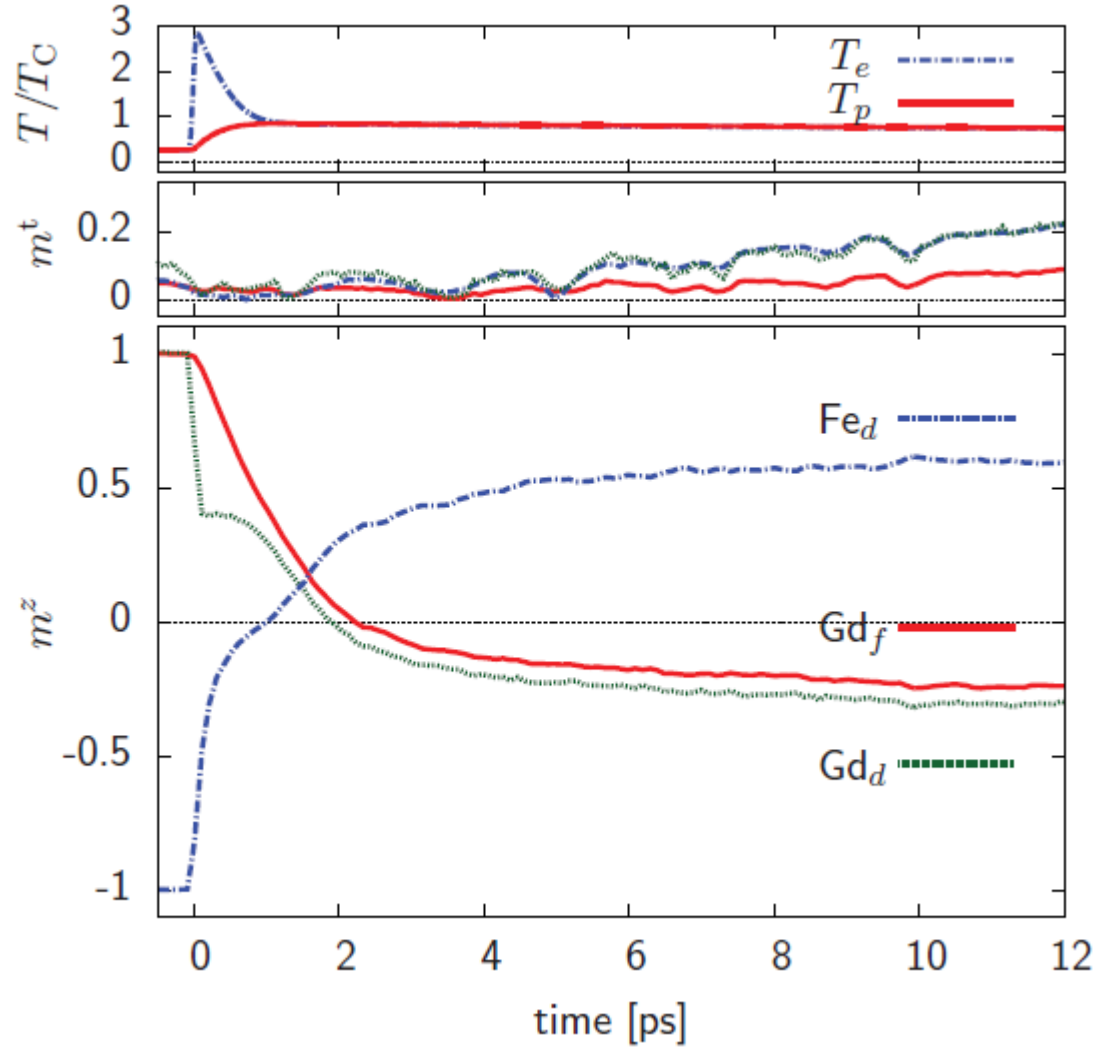




Atxitia *et al.;* PRB **87** (2013)



Schellekens, Koopmans*;*
PRB **87** (2013)



Wienholdt *et al.;* PRB **88** (2013)

T = 235 K + laser

Within 2 ps after laser excitation

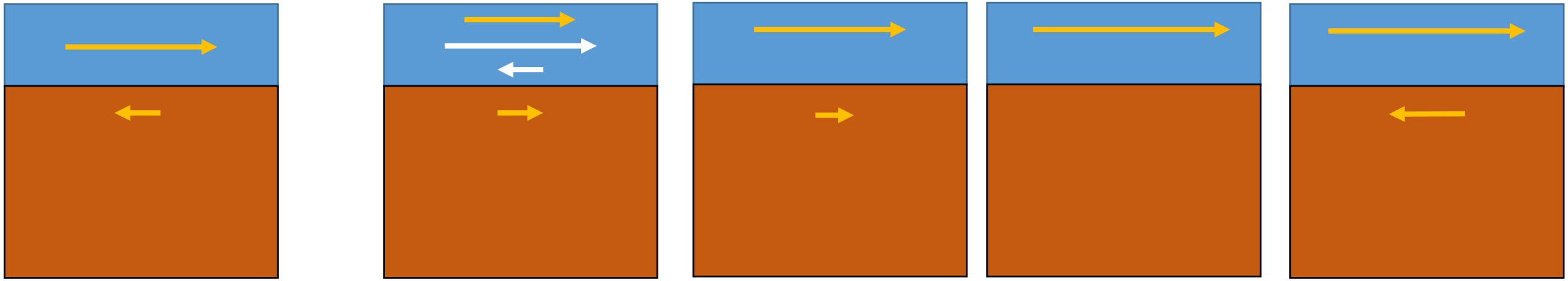
~ 7.5 ps after laser excitation

~ 10-100 ps after laser excitation

100 ps – 1ns recovery

Fe

Gd



H H H H H

above T_{comp}

Fe magnetization has the lead

all optical switching of Fe „against field“

M_{Gd} switches (at interface)

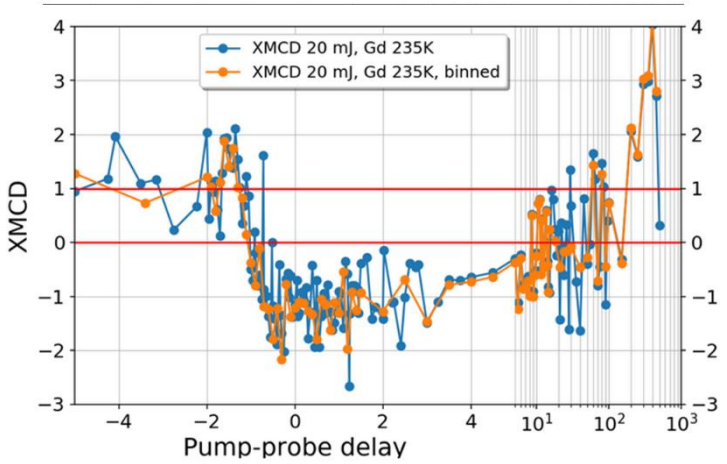
M_{Fe} drops by 10 %

M_{Fe} back

M_{Gd} starts to decrease

M_{Gd} = 0

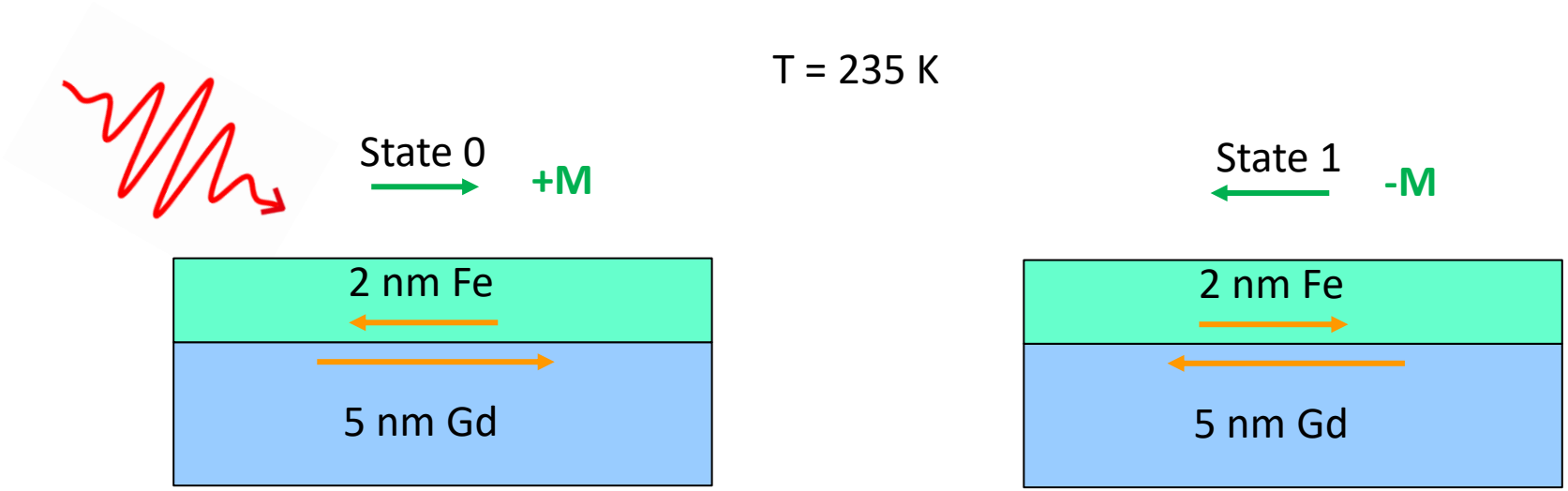
M_{Gd} recovers



I would assume without external field H to see also switching of Fe – this may take some time evolving from the interface

All optical toggle switching

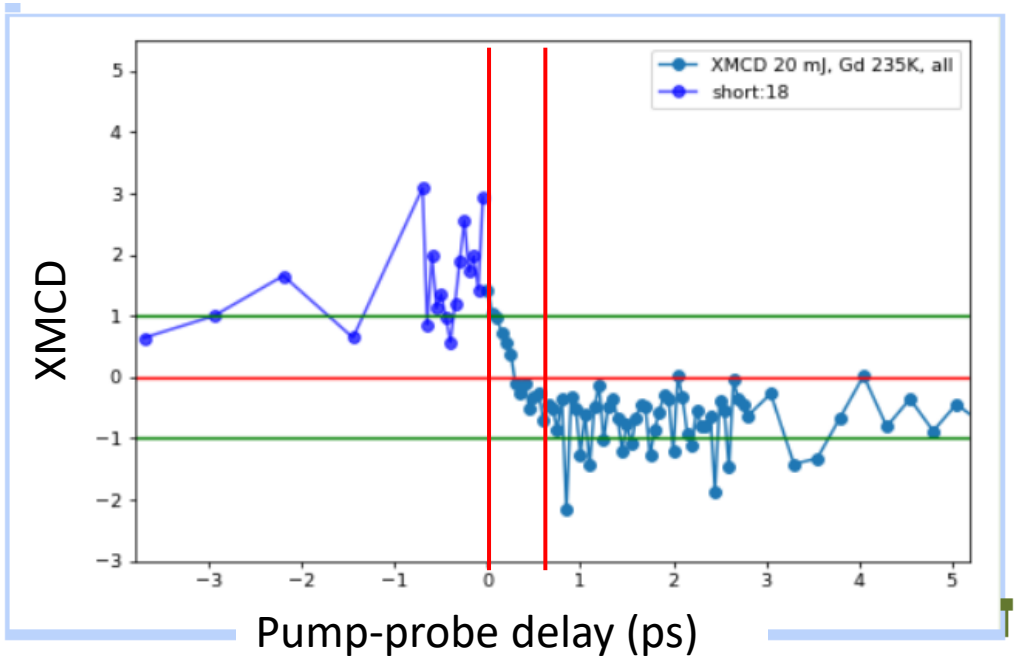
T = 235 K



What happens to

Exchange Splitting ?

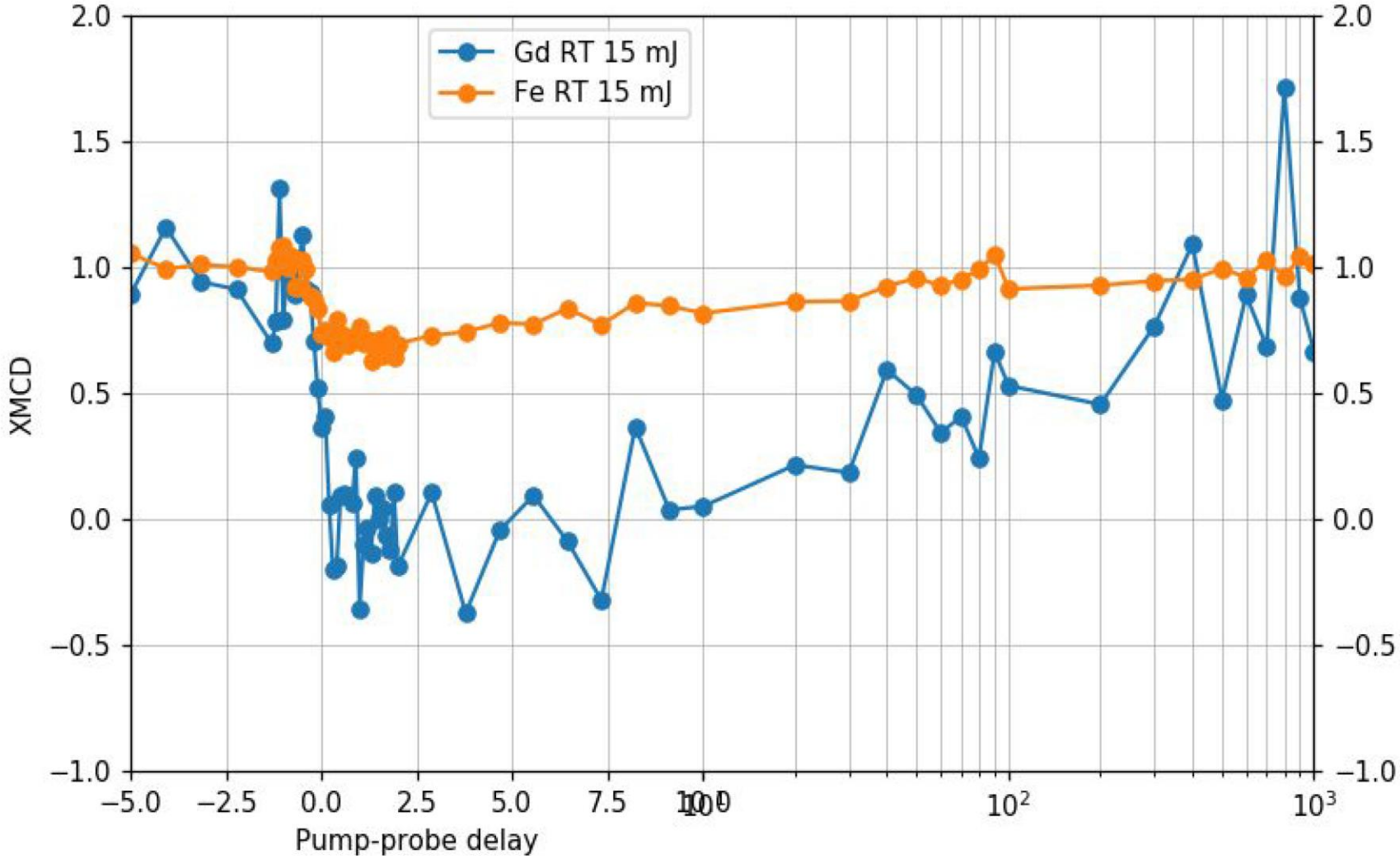
Spin polarization ?



Status:
14:57
17.03.2021

Switching time: 600 fs

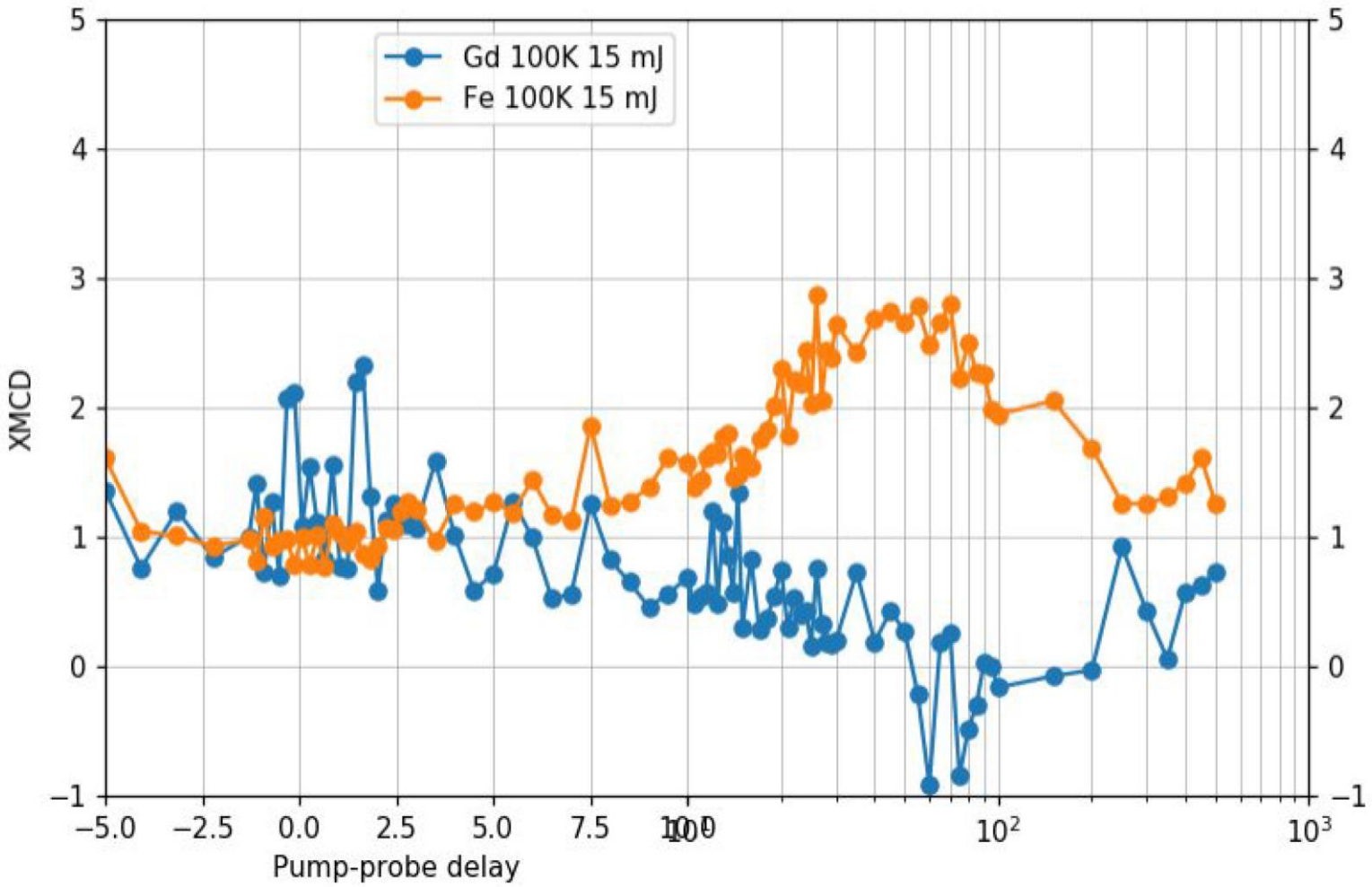
Ultrafast demagnetization at 300 K, above T_{comp}

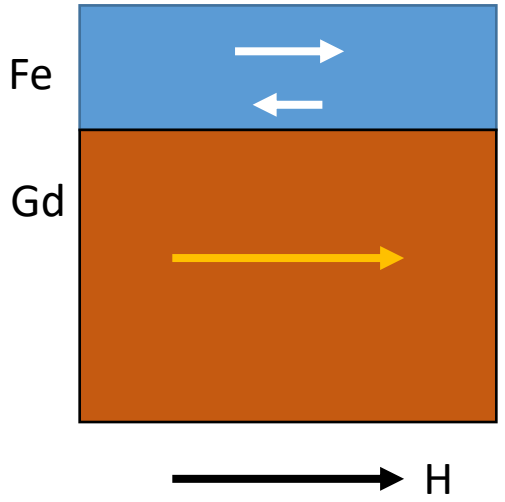


High T – Fe has the lead.

Weak AFM coupling destroyed by Fe demagnetization, both films demagnetize on ultrafast sub-ps timescale

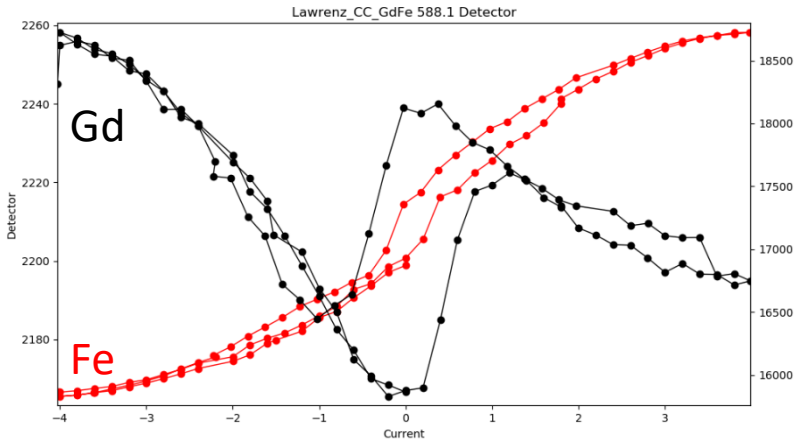
Ultrafast demagnetization at 100 K, below T_{comp}



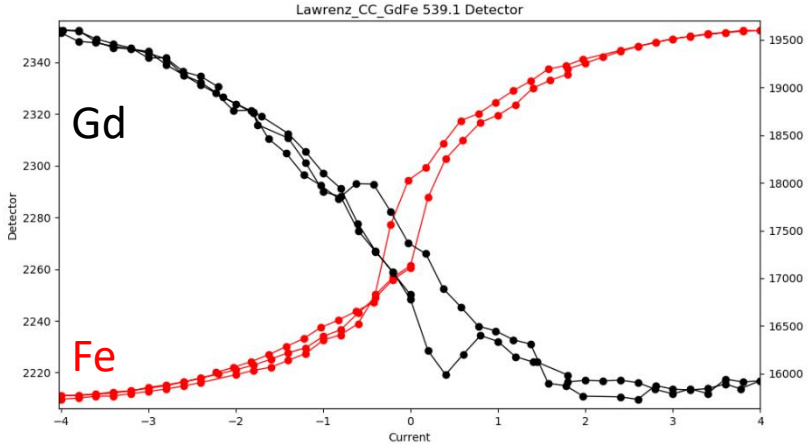


Low T - Gd magnetization has the lead:
Slow demagnetization of Gd via 4f-phonon (note no ultrafast component – stabilized by strong AFM !) leads to further magnetization of Fe in field direction (see tilted hysteresis)

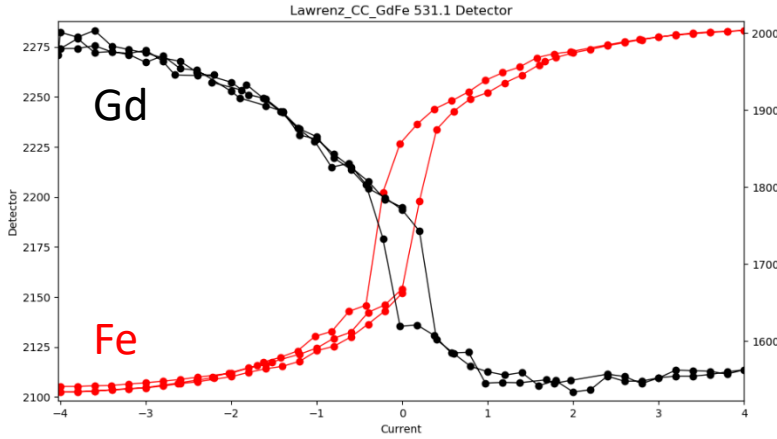
Temperature dependence from static measurements at PM3



T = 220 K

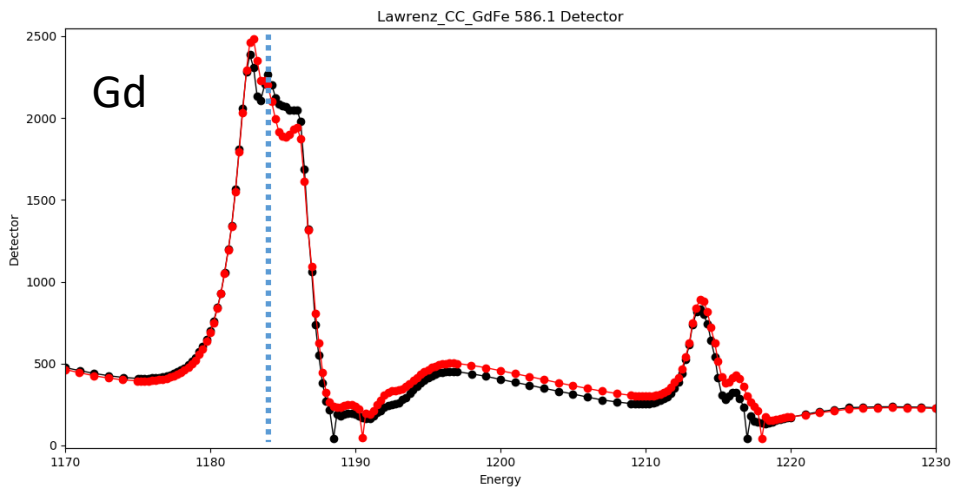


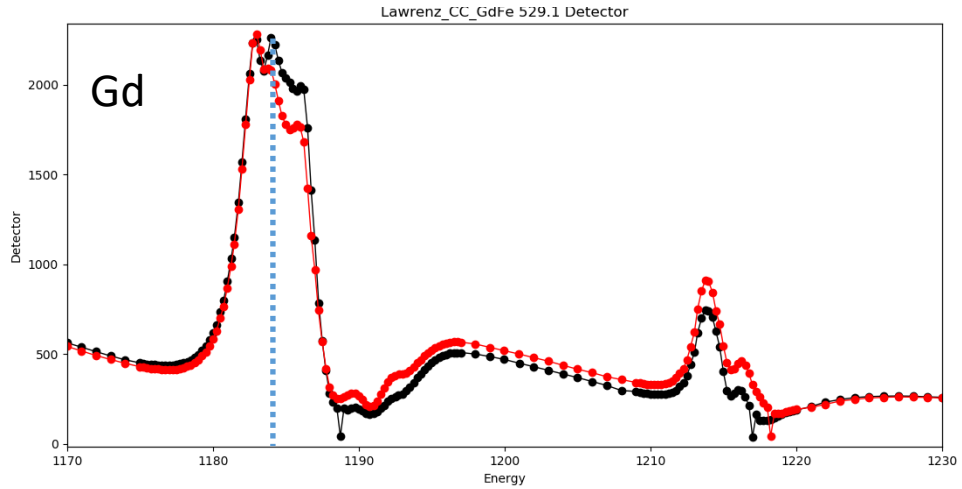
T = 258 K

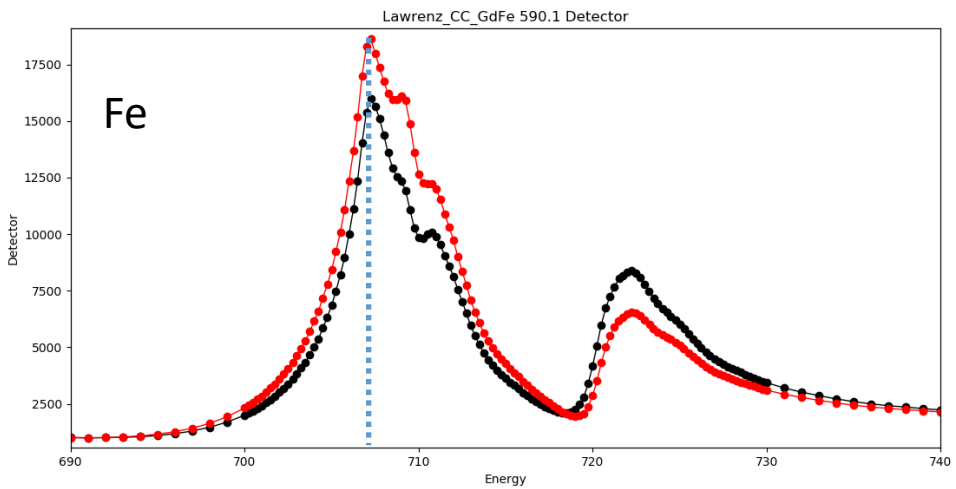


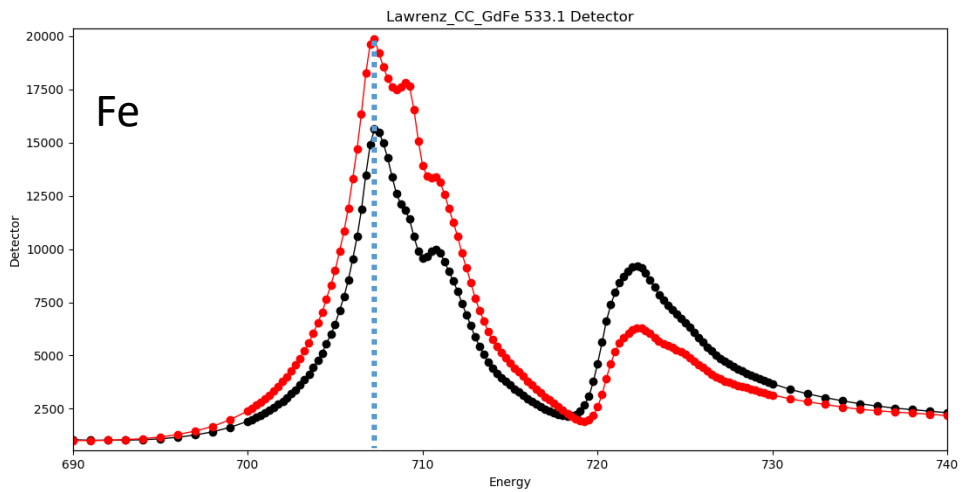
T = 270 K

Energy spectra show little difference due to competition between Zeeman and exchange (I = ± 3 A)









T = 220 K

T = 270 K