



AGH UNIVERSITY OF SCIENCE
AND TECHNOLOGY



Micromagnetic simulations of spin torque driven magnetisation oscillations in magnetic tunnel junctions

Maciej Czapkiewicz, Marek Frankowski, Witold Skowroński, Tomasz Stobiecki

Department of Electronics, AGH Kraków, Poland

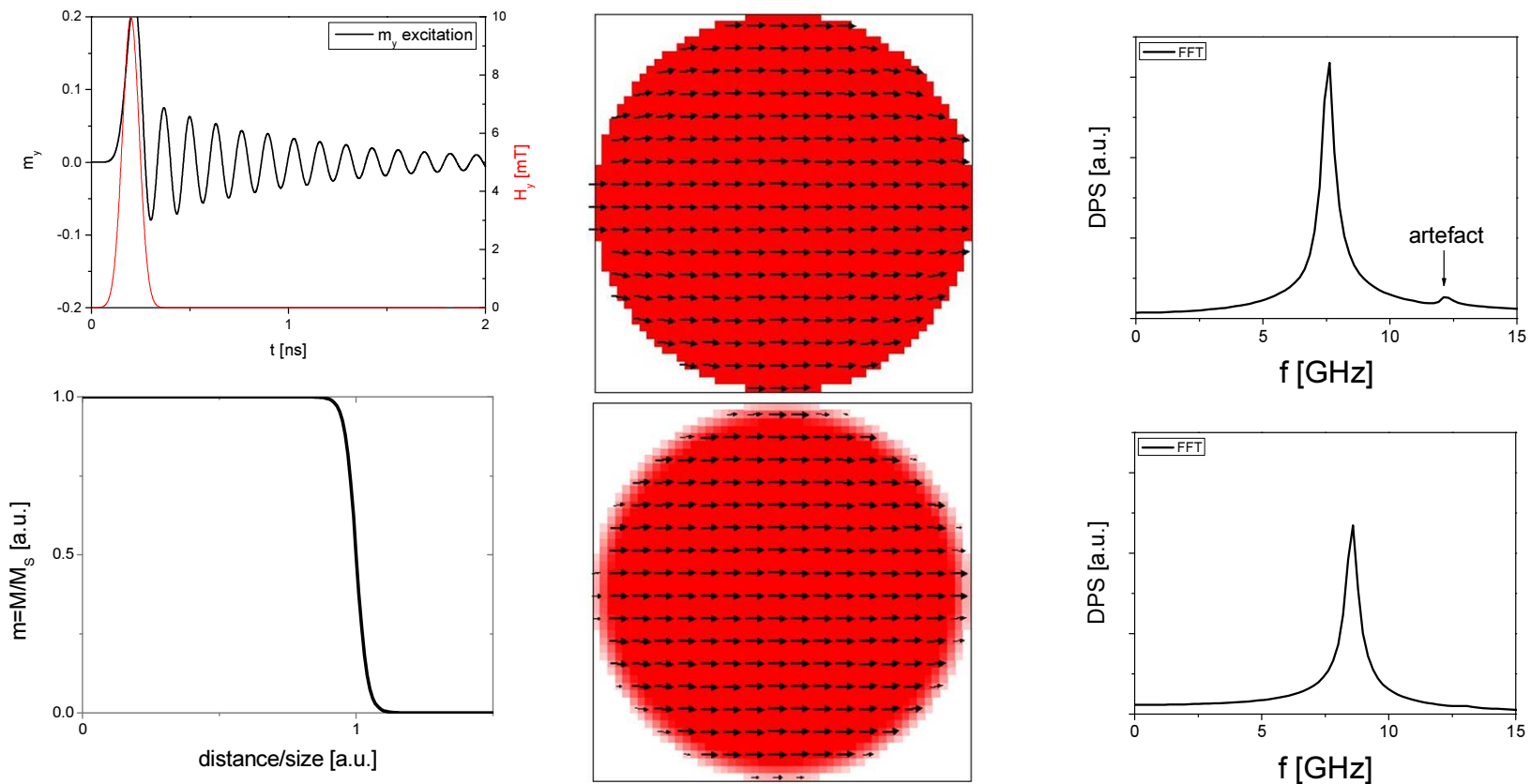


Schedule

- Nanodisc excitation – smoothed rim
- OOMMF extensions and simulation models
- Localised modes in two PSV states
- ST-FMR measurements of real MTJ pillar
- Simulations of MTJ pillar eigenmodes
- Simulation of MTJ pillar STI oscillations
- Summary

Nanodisc excitation

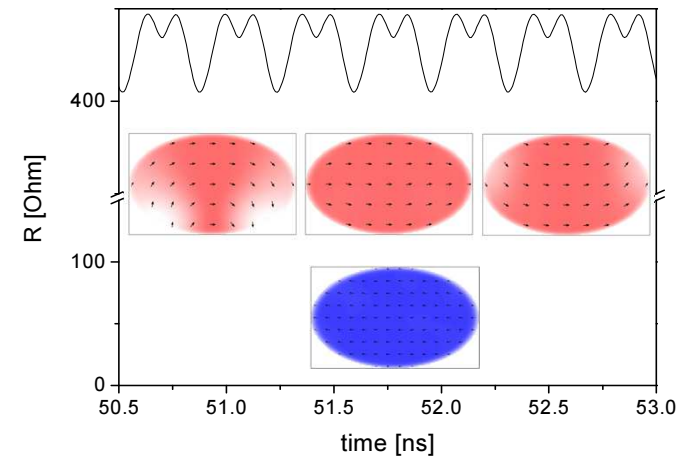
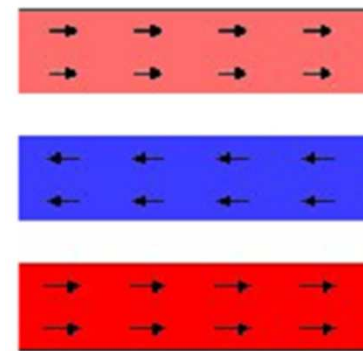
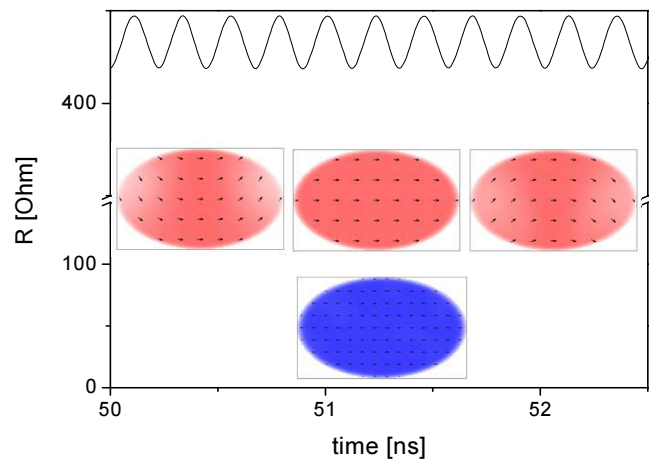
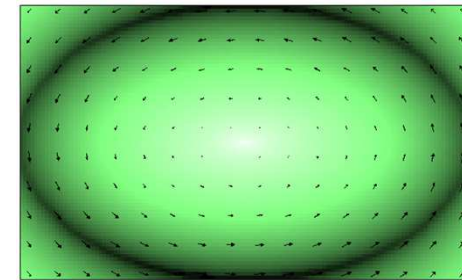
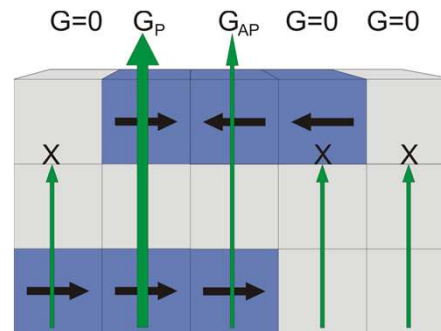
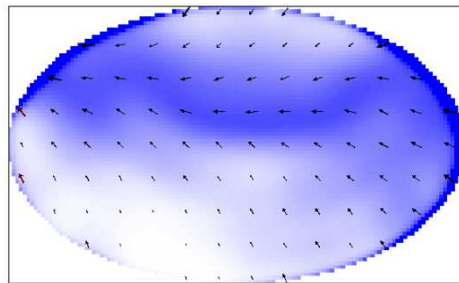
- Excitation of 300x300x2 nm disc by pulse field



OOMMF extensions

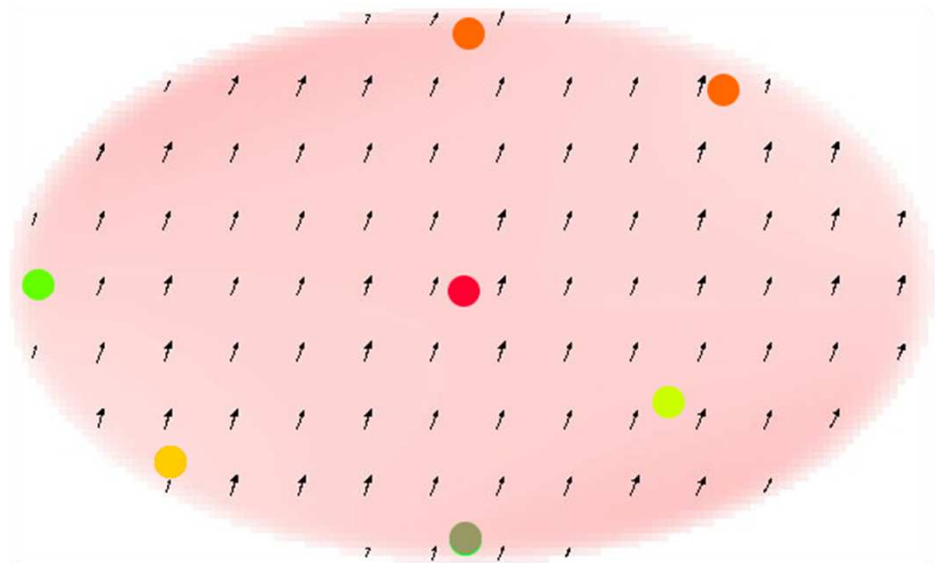
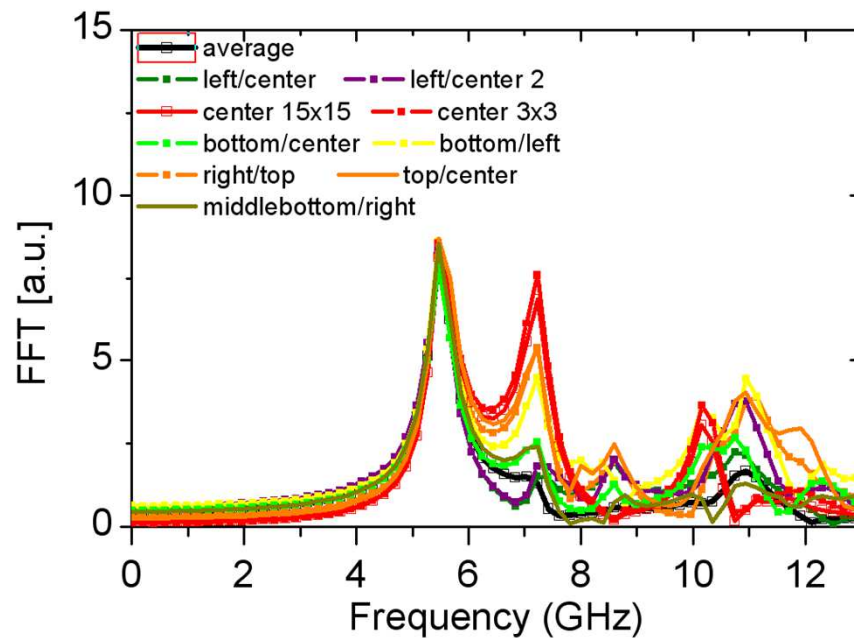
- MF_CurrentFlowEvolver

LLG+STT+magnetoresistance+Oersted Field



- MF_MagCut

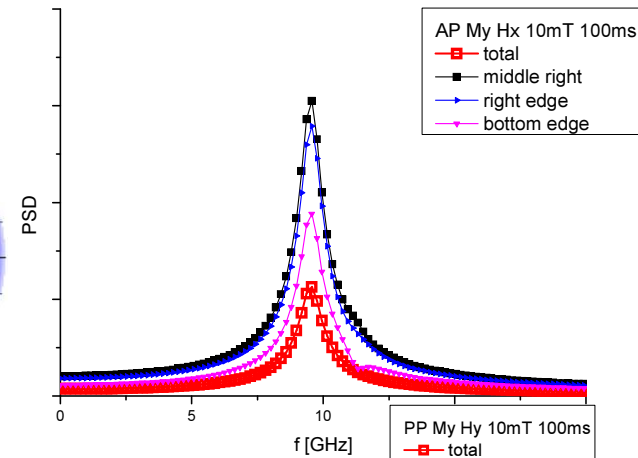
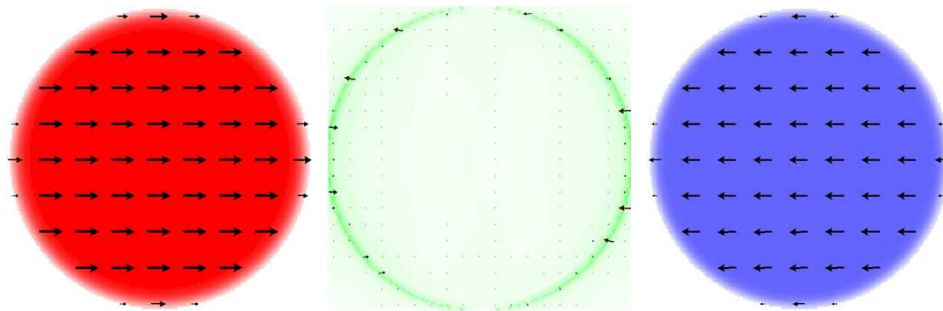
Localised m_x , m_y , m_z or magnetoresistance output



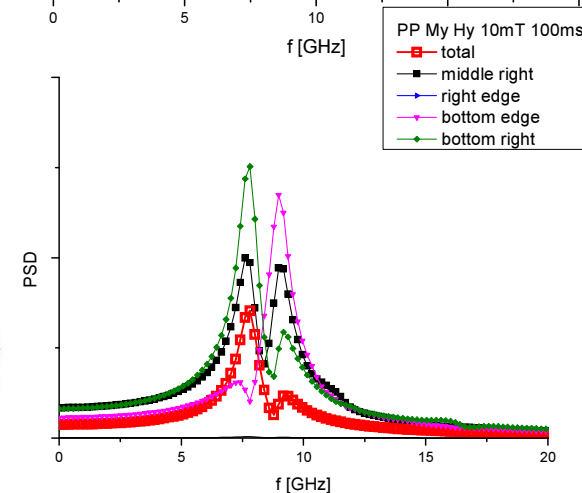
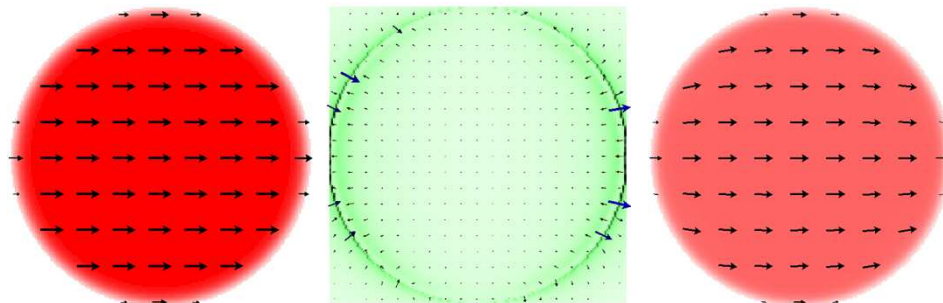
Localised modes in PSV

- Pinned Layer/thick spacer/Free Layer excitation

- AP state

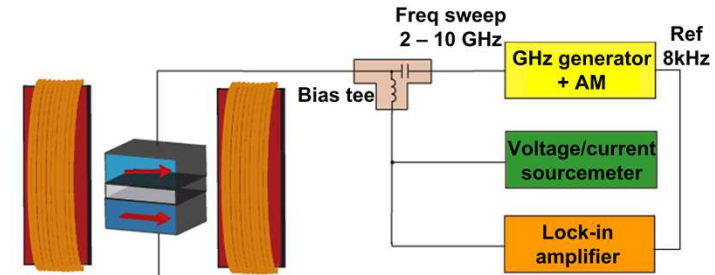
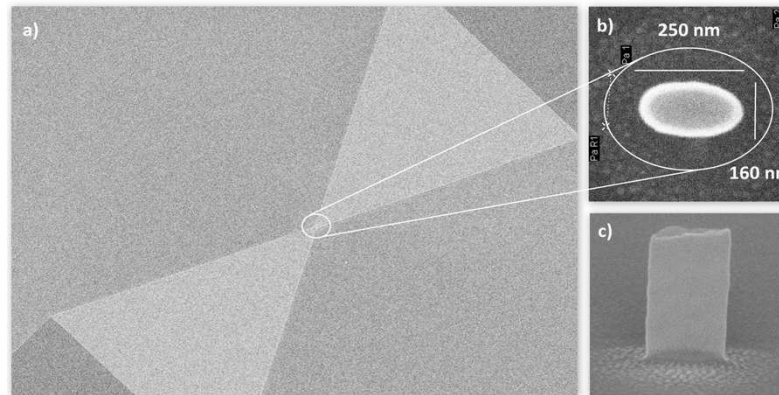


- P state



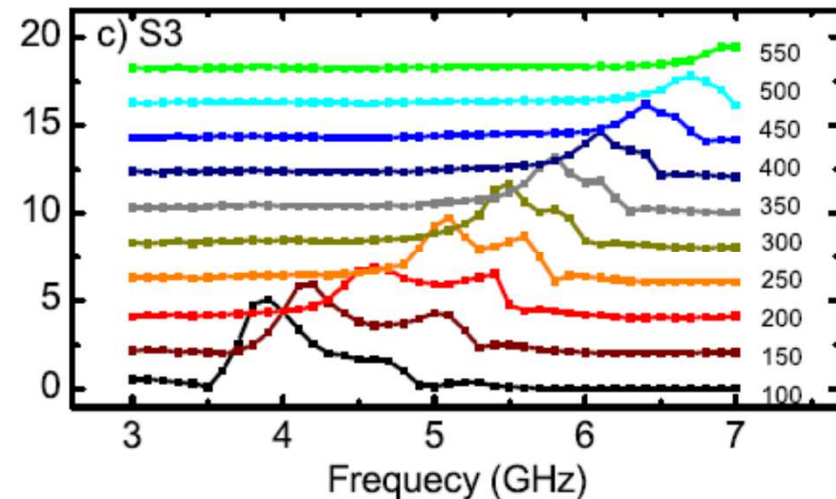
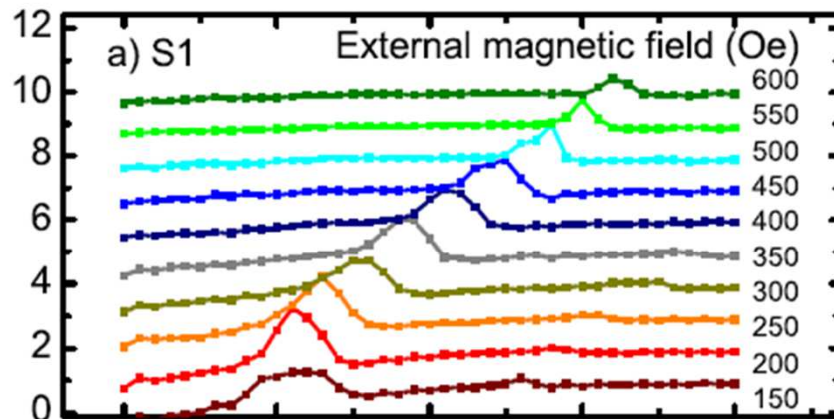
ST-FRM of real MTJ

Ru 7
CuN 30
Ta 10
Co ₄₀ Fe ₄₀ B ₂₀ 2.3
MgO wedge
Co ₄₀ Fe ₄₀ B ₂₀ 2.3
Ru 0.9
Co ₇₀ Fe ₃₀ 2
PtMn 16
Ta 3
CuN 50
Ta 3
CuN 50
Ta 5
Si/SiO ₂



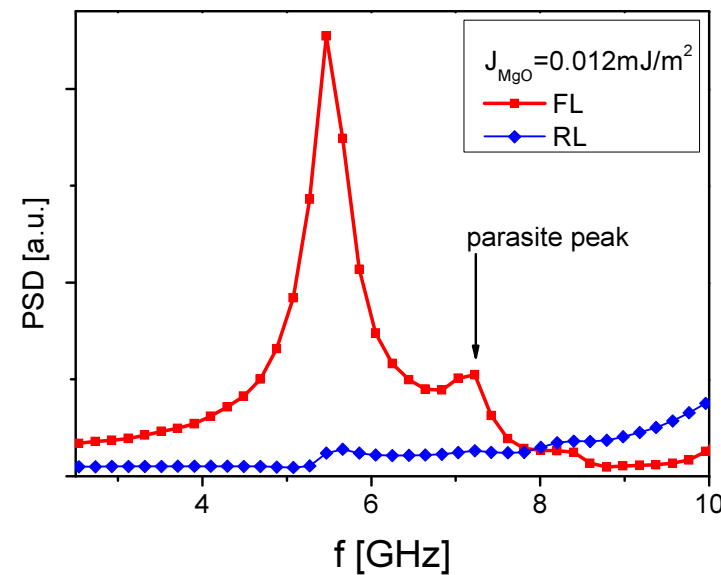
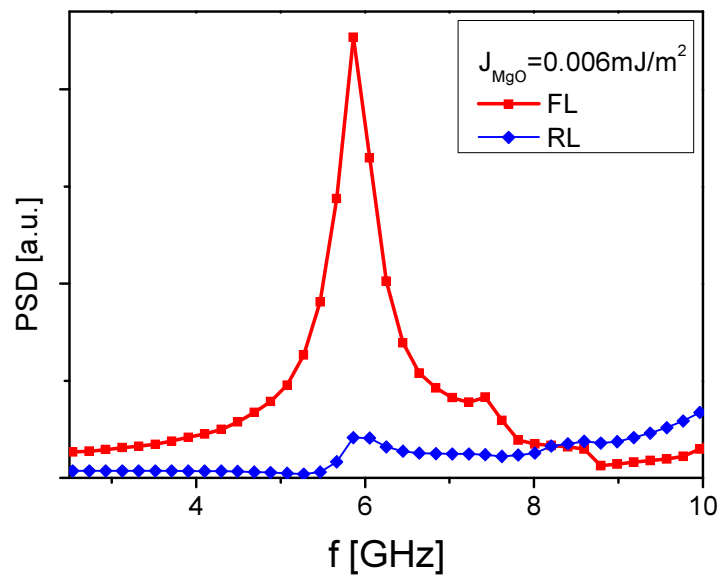
Setup for spin diode effect measurements

- Thin MgO (high J) vs. thick MgO (low J)



MTJ eigenmodes

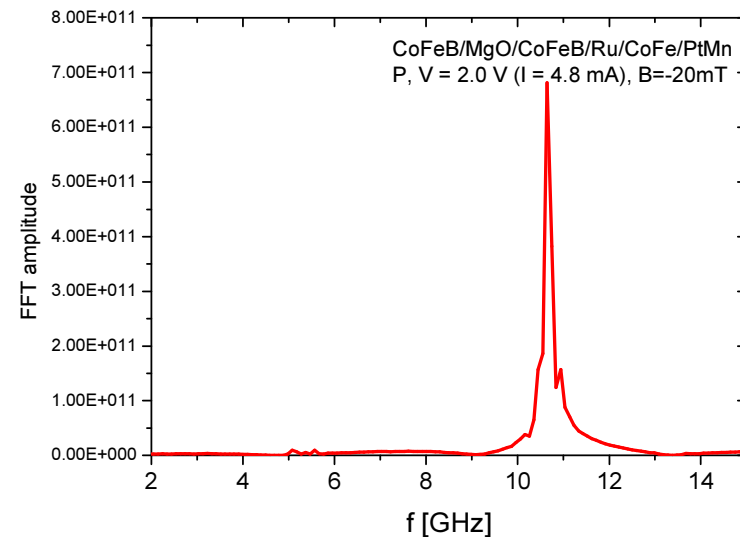
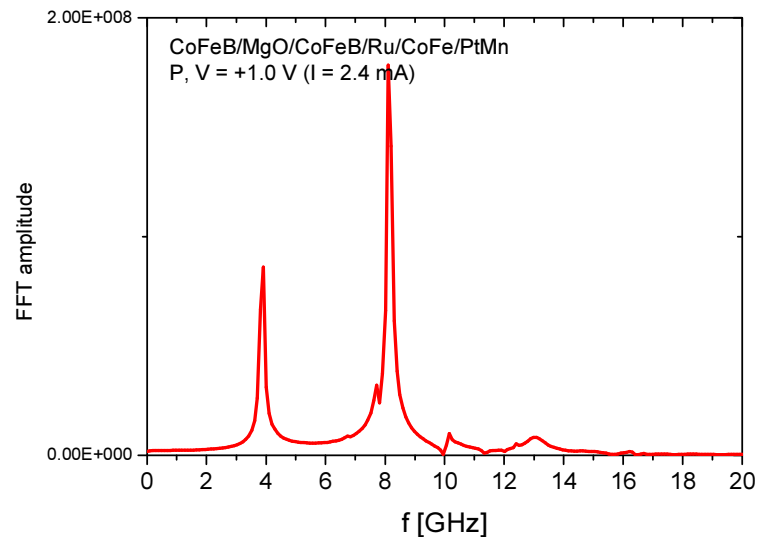
- Micromagnetic simulation, current pulse exc.



Additional peak arise from the localised mode of FL due to effective field inhomogeneities as a resultant of high J energy

STI oscillation

- Frequency and oscillation mode depend on spin polarised current flow



Summary

- Spectral purity strongly depend on effective field homogeneity
- Effective field homogeneity can be disturbed by demagnetising field or interlayer coupling energy
- Micromagnetic models must take into account all side effects, including Oersted field, STT-magnetoresistance feedback etc, especially for high current excitations