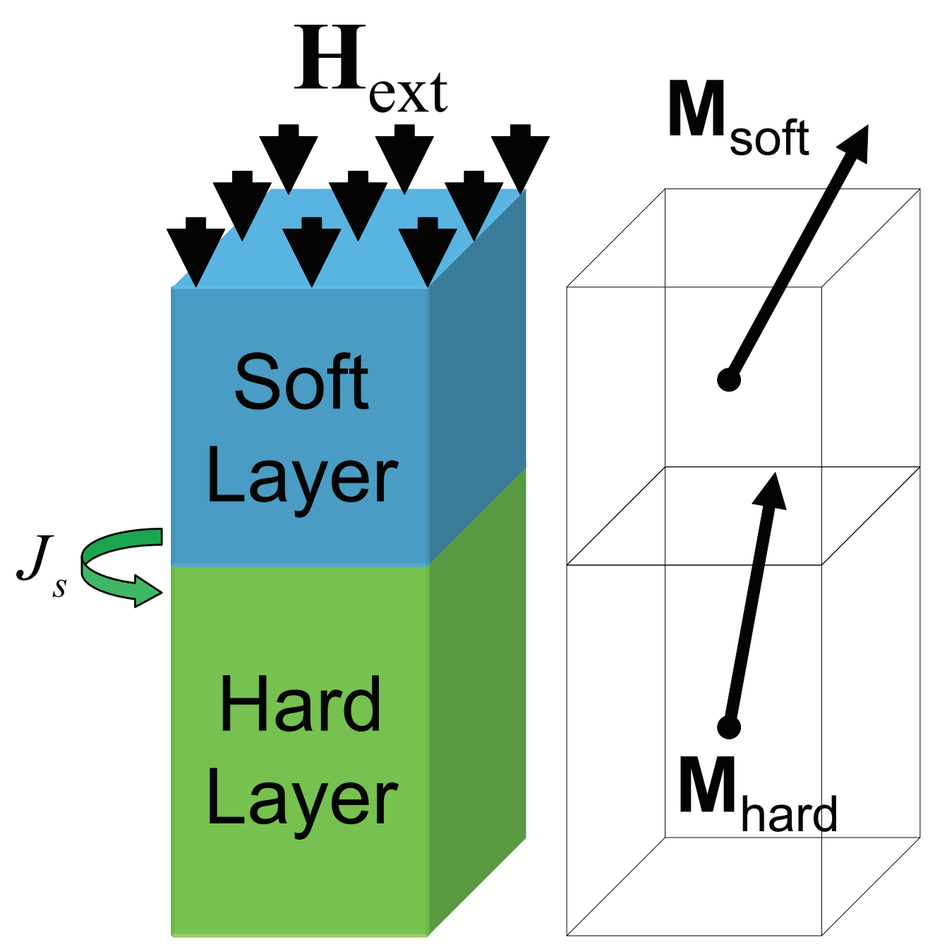
Magnetic Reversal in Composite Patterned Media

Richard Choi

Background

- Landau Lifshitz Equation:



$$\frac{d\mathbf{m}}{dt} = -\gamma H_K\left(\mathbf{m}\times\mathbf{h}_{eff}\right) - \gamma H_K\alpha\left(\mathbf{m}\times\left(\mathbf{m}\times\mathbf{h}_{eff}\right)\right)$$

$$\mathbf{H}_{eff} = \underbrace{(\mathbf{k}_l\cdot\mathbf{m})\mathbf{k}_l}_{\text{anisotropy}} + \frac{\mathbf{H}_{ext}}{\underbrace{H_k}_{\text{external}}} \underbrace{+2\frac{M_s}{H_k}l_{ex}^2\nabla^2\mathbf{m}}_{\text{exchange}} + \underbrace{\frac{M_s}{H_k}\nabla\int\frac{\nabla\cdot\mathbf{m}}{|\mathbf{r}-\mathbf{r}'|}d\mathbf{r}'}_{\text{demagnetization }(H_{magn})}$$

α – damping constant; γ – gyromagnetic ratio

H_K – coercivity field; $\mathbf{H}_{eff}$ – effective field

$\mathbf{M}$ – magnetization; M_s – saturation magnetization

$$\mathbf{m} = \frac{\mathbf{M}}{H_K};\quad \mathbf{h}_{eff} = \frac{\mathbf{H}_{eff}}{H_K}$$

- *The Landau-Lifshitz equation is the standard dynamic model used for the motion of magnetization. We used a normalized form of the equation since it is considerably simpler.*

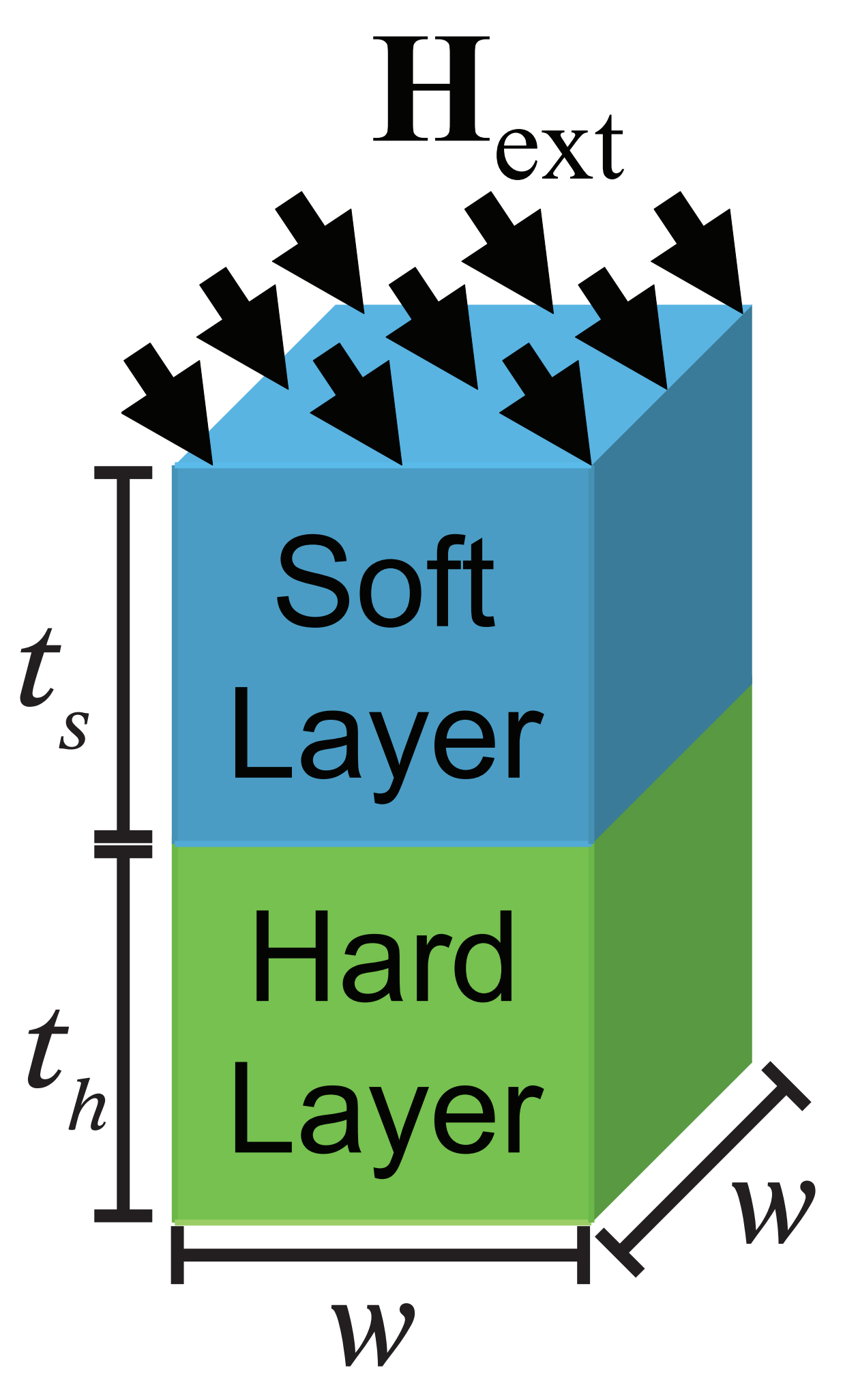
Two important goals in magnetic recording: Stability and Speed.

Low reversal fields are possible using different structures and parameters (damping constant, applied angle, etc). The point being that using the same high coercivity field, you can decrease the reversal field for the structure. This leads to increased stability, an issue that becomes more important as hard disk areal density increase and bit sizes decrease.

Simulation Parameters:

$w = l_{ex} = 10\text{nm}$; $t_h = 5\text{nm}$; $H_K = 15{,}000$ Oe; $M_s = 500\ ^{emu}/_{cc}$; J_s (interlayer exchange coupling) $= 0.3\ (2K_h t_h)$

Reversal vs Applied Angle



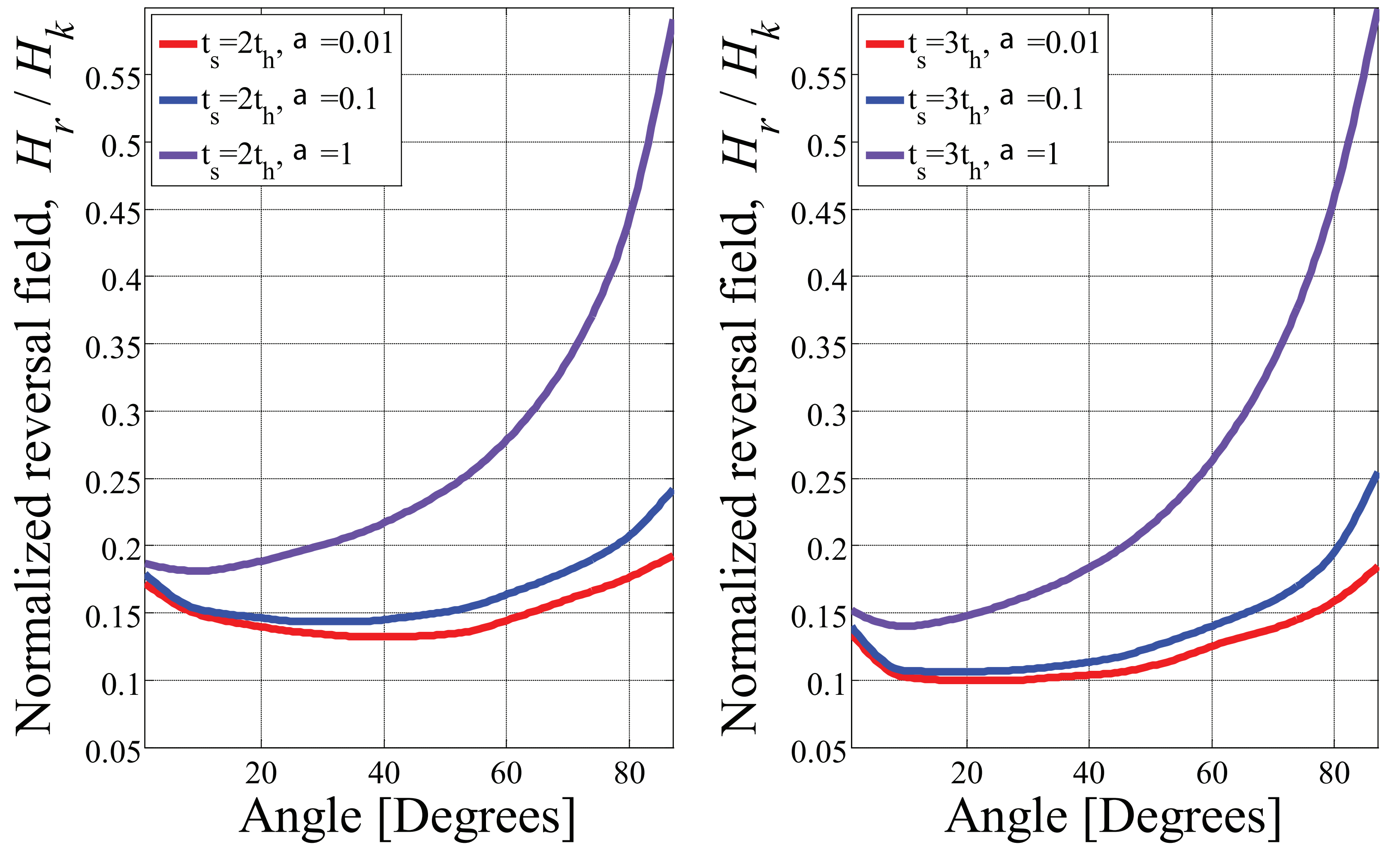
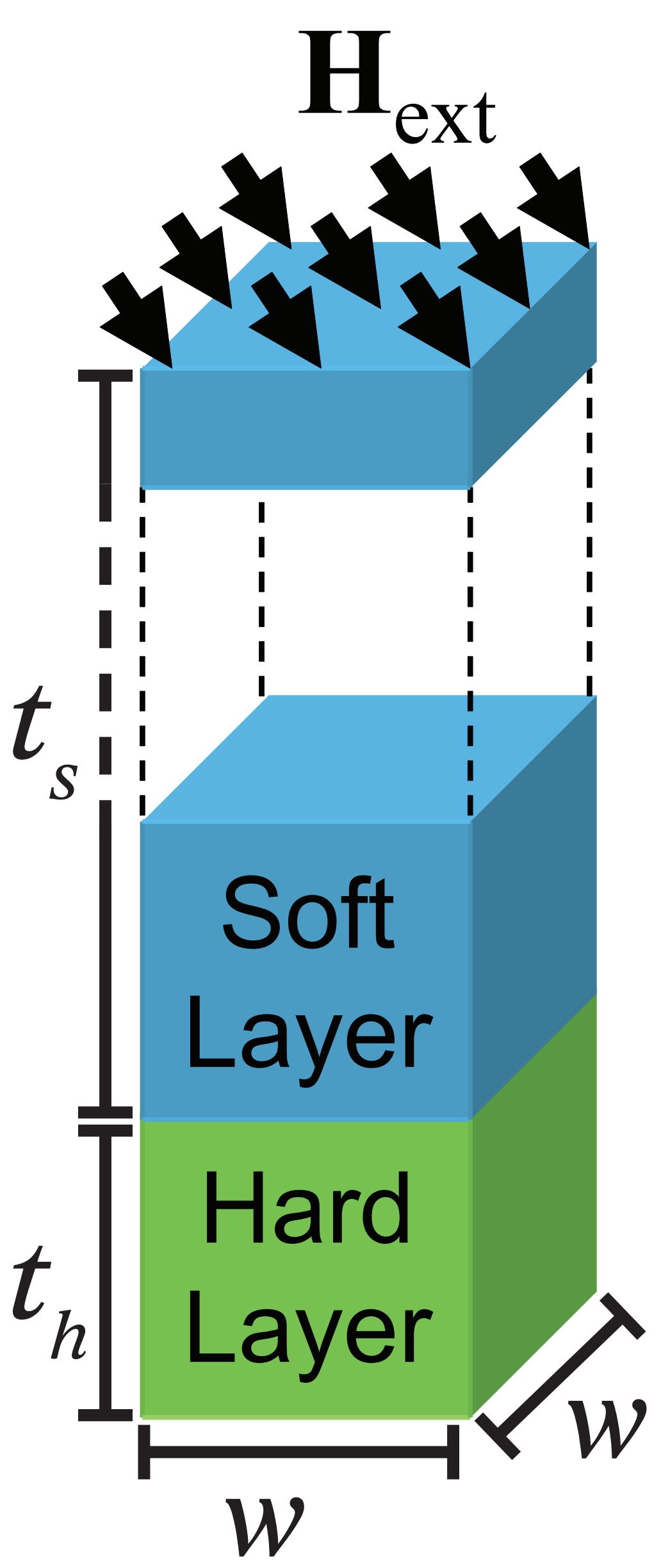


Figure 1. By sweeping the angle at which we apply the field we see that we can obtain a lower reversal field for incident angles other than 0° to the top surface of the structure.

Reversal vs Soft Layer Thickness



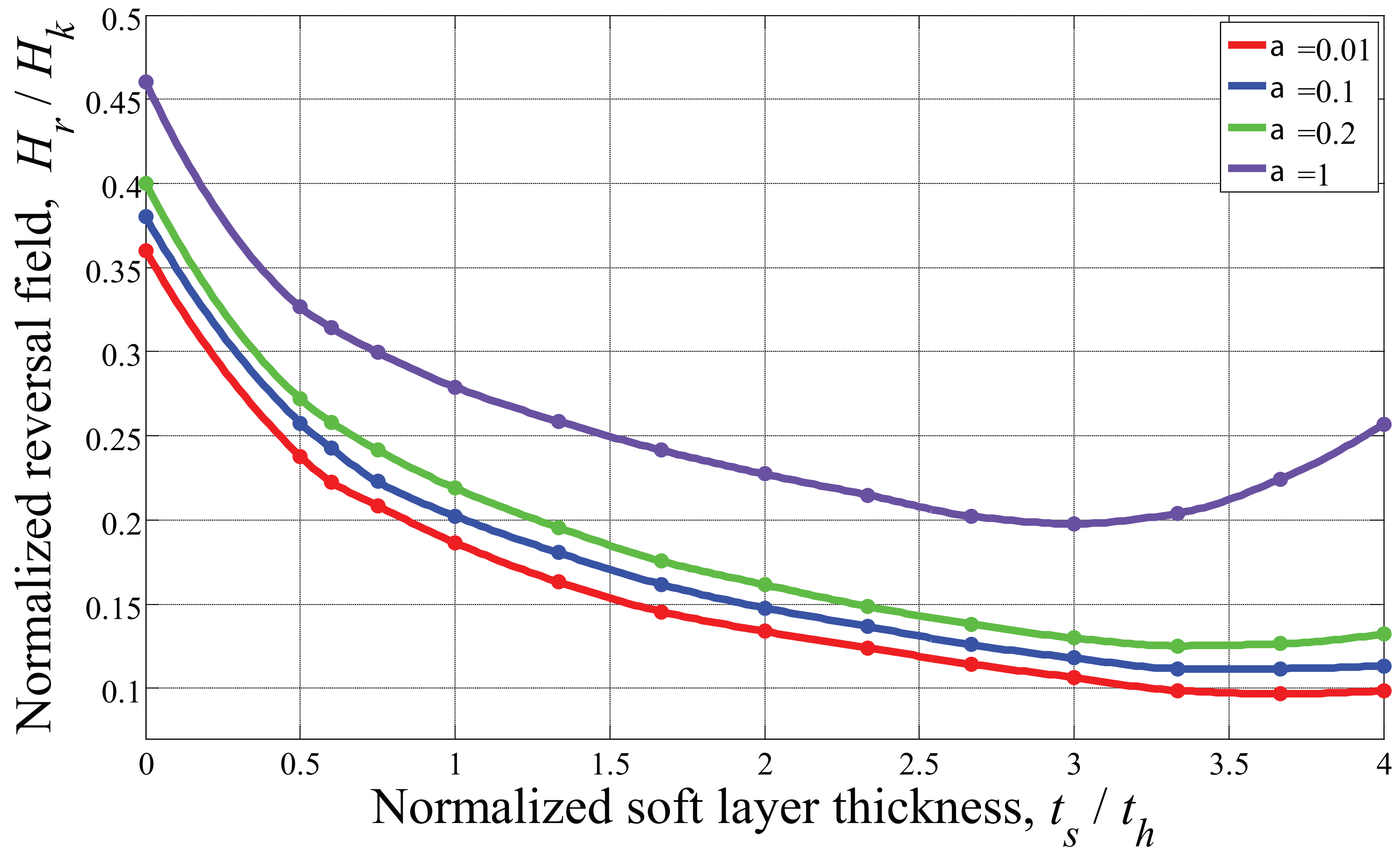
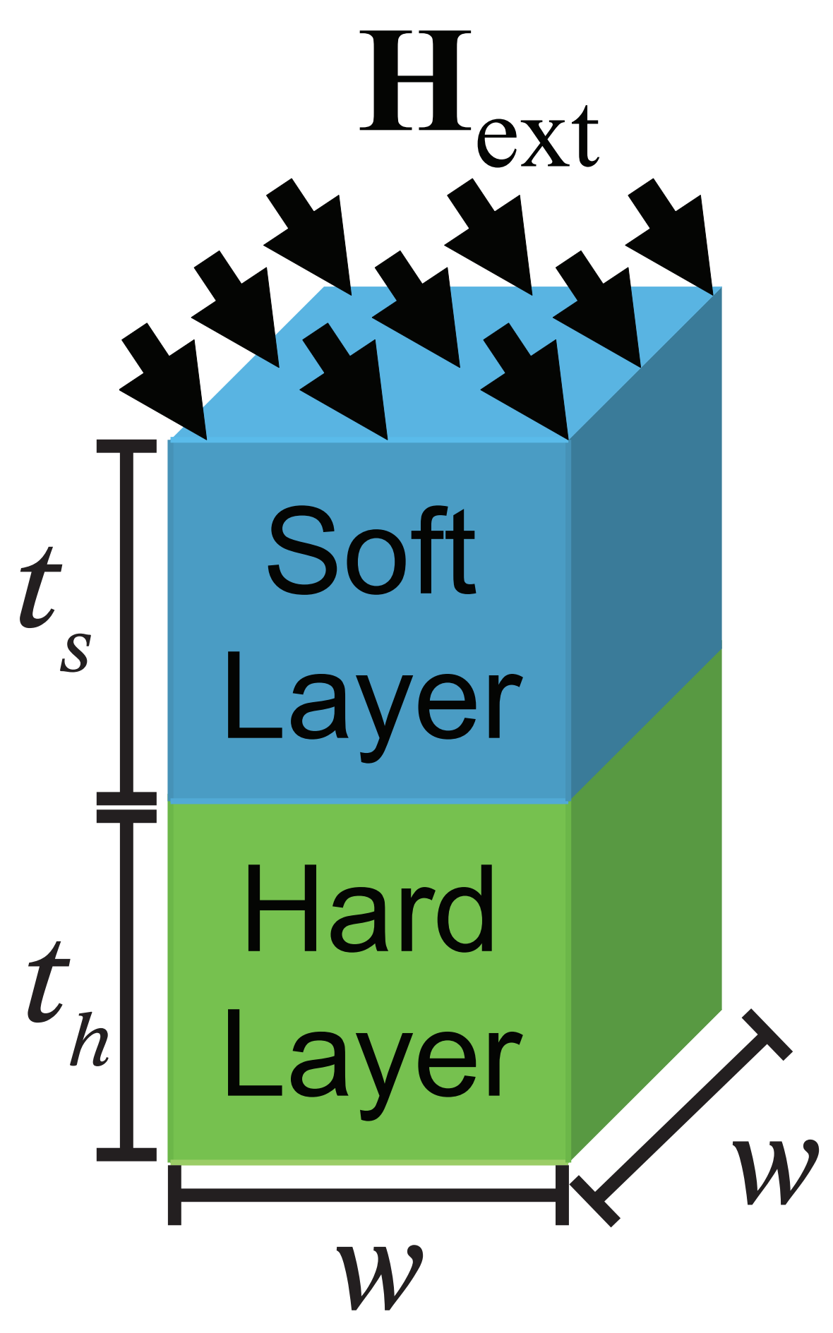


Figure 2. The field is applied instantaneously at a 45° angle. We see that generally there is a lower reversal field for greater thicknesses, reducing the reversal field by over a factor of two.

Fast Precessional Reversal

Fast Precessional Reversal (FPR):

The modern trend of ultra-high density leads to requirements of using elements of small size with high ultra stability and ultra fast switching time. Previous research shows fast write head switching leads to decreased reversal fields when compared to slow switching. We can qualitatively examine switching times for fast precessional reversal.



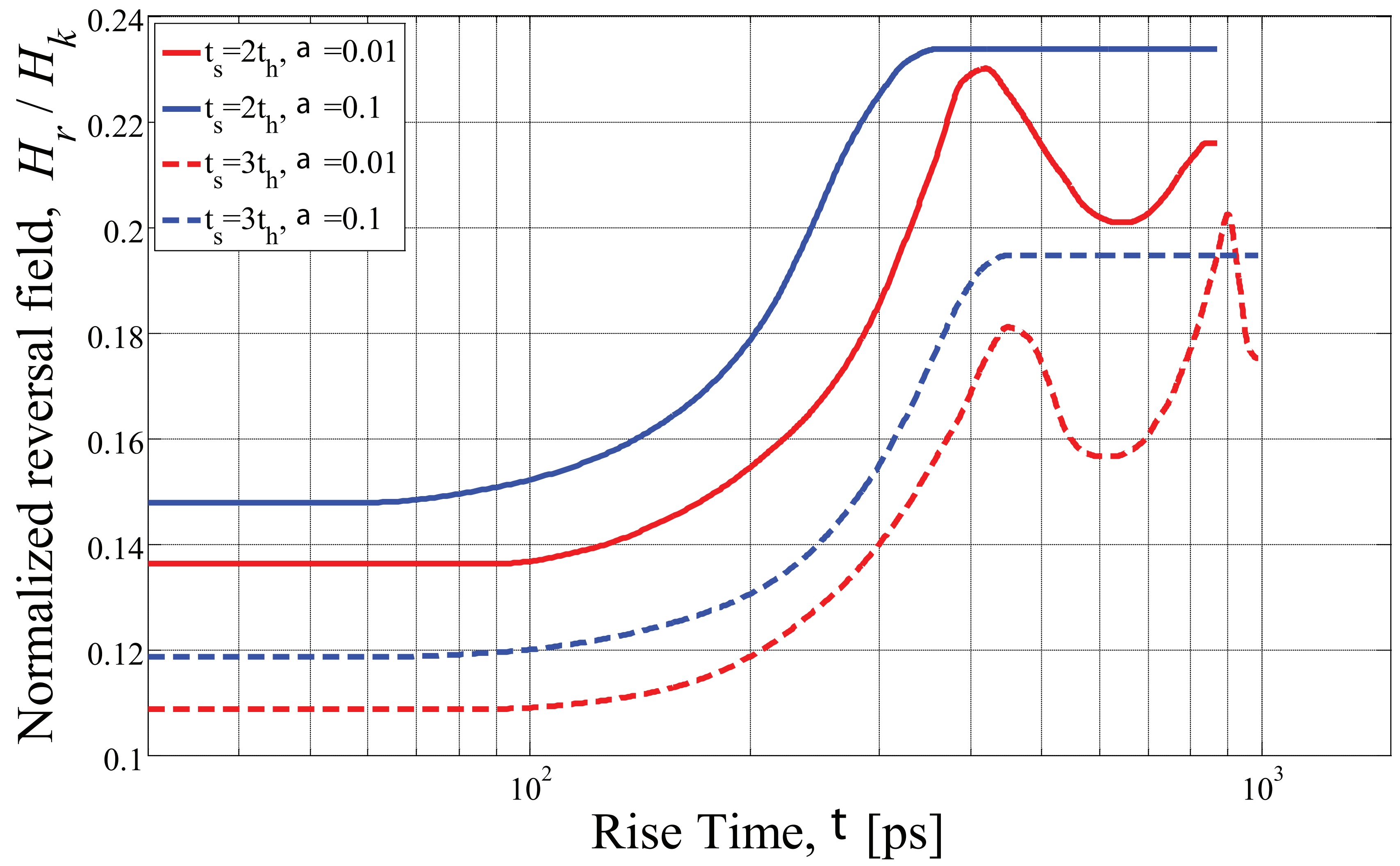


Figure 3. The field is applied at a 45° angle. We see a large and realistic rise time margin (100ps -200ps). Rise time margins for a single hard layer dot were approximately 10ps.

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