

# Statistical Error

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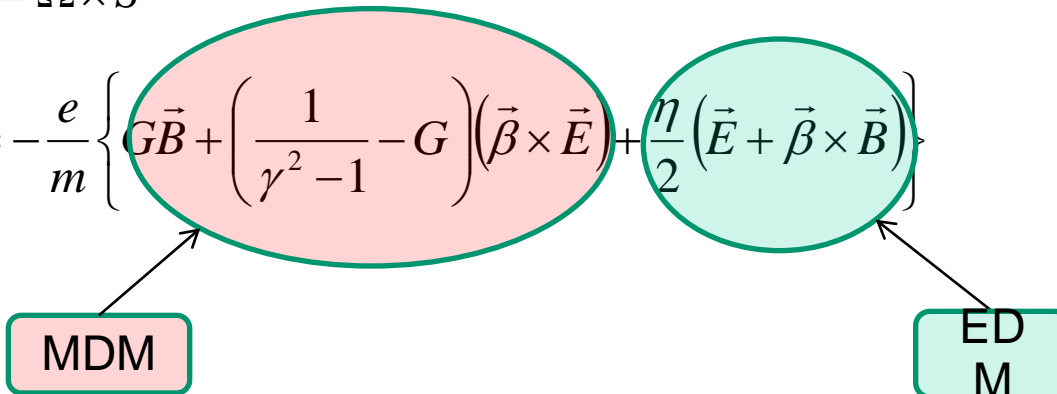
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# Methodology

When put into an electromagnetic field, the particle spin begins to precess according to the T-BMT equation:

$$\frac{d\vec{S}}{dt} = \vec{\Omega} \times \vec{S}$$

$$\vec{\Omega} = -\frac{e}{m} \left\{ \underbrace{G\vec{B} + \left( \frac{1}{\gamma^2 - 1} - G \right) (\vec{\beta} \times \vec{E})}_{\text{MDM}} + \underbrace{\frac{\eta}{2} (\vec{E} + \vec{\beta} \times \vec{B})}_{\text{EDM}} \right\}$$


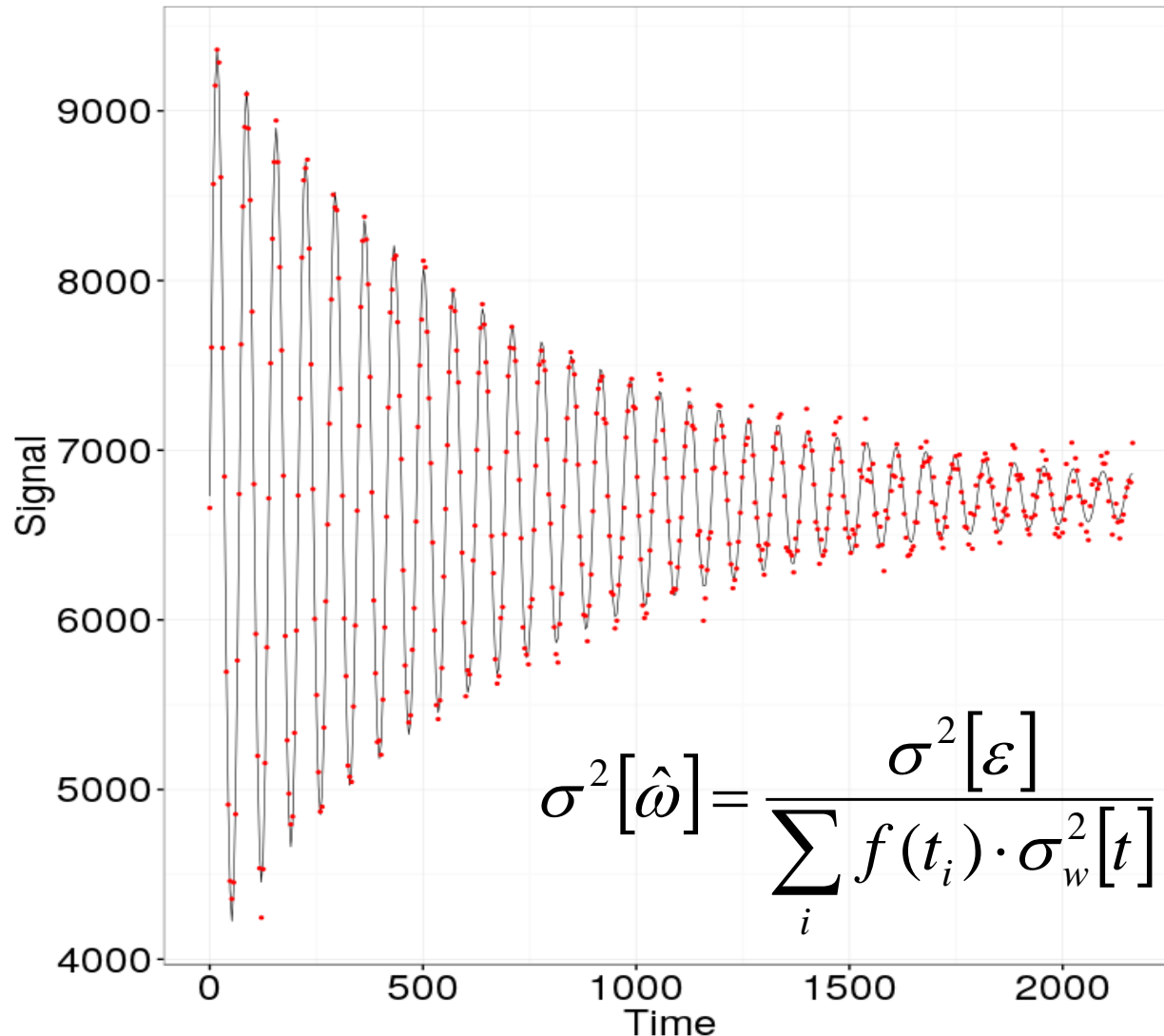
By measuring the beam's polarization, we can determine the frequency

$$\vec{\Omega}^{\pm} = \vec{\Omega}_{MDM} \pm \vec{\Omega}_{EDM}$$

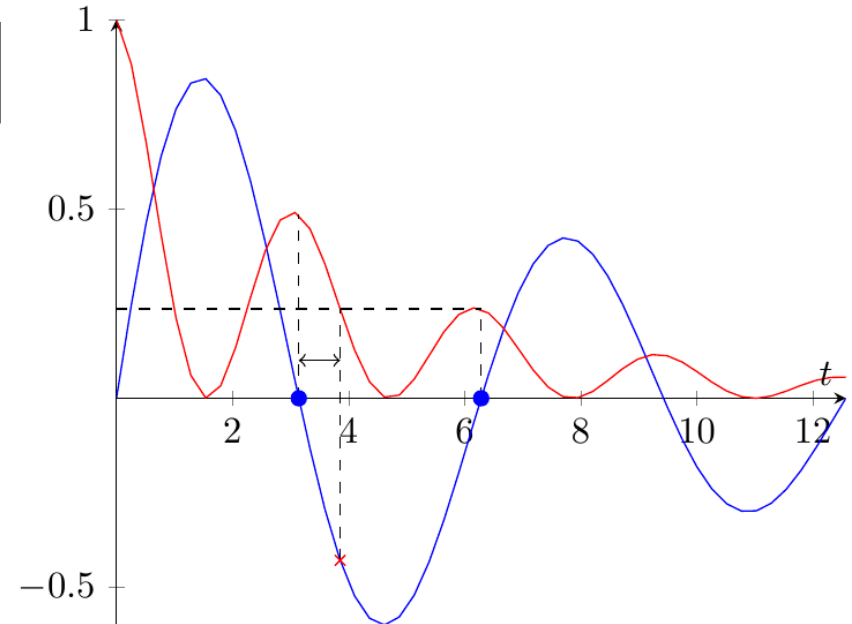
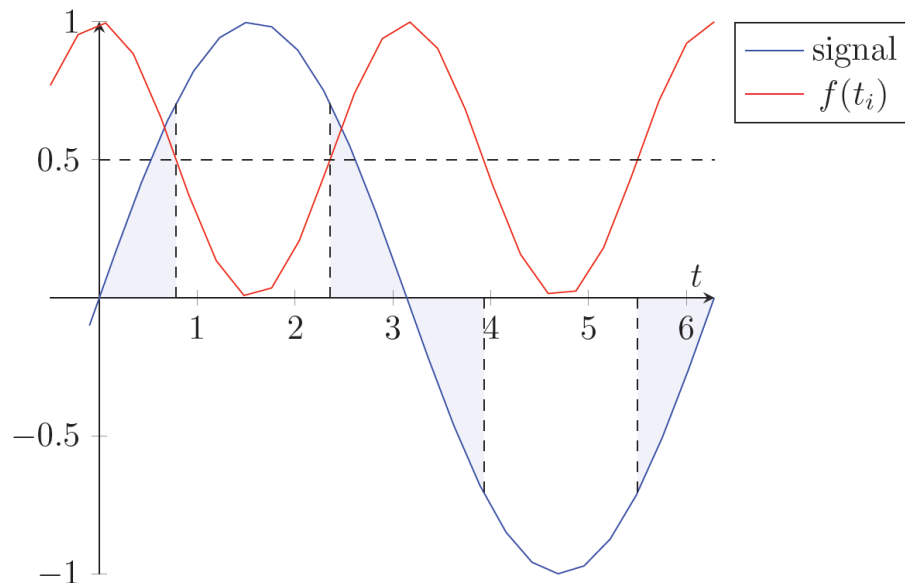
Comparing the CW vs CCW frequencies, determine  $\Omega_{EDM}$

# Problem statement

$$N(t) = N_0 \cdot \left(1 + P \cdot e^{-t/\tau_d} \cdot \sin(\omega \cdot t + \phi)\right) + \varepsilon_t$$



# Two aspects



# Goals

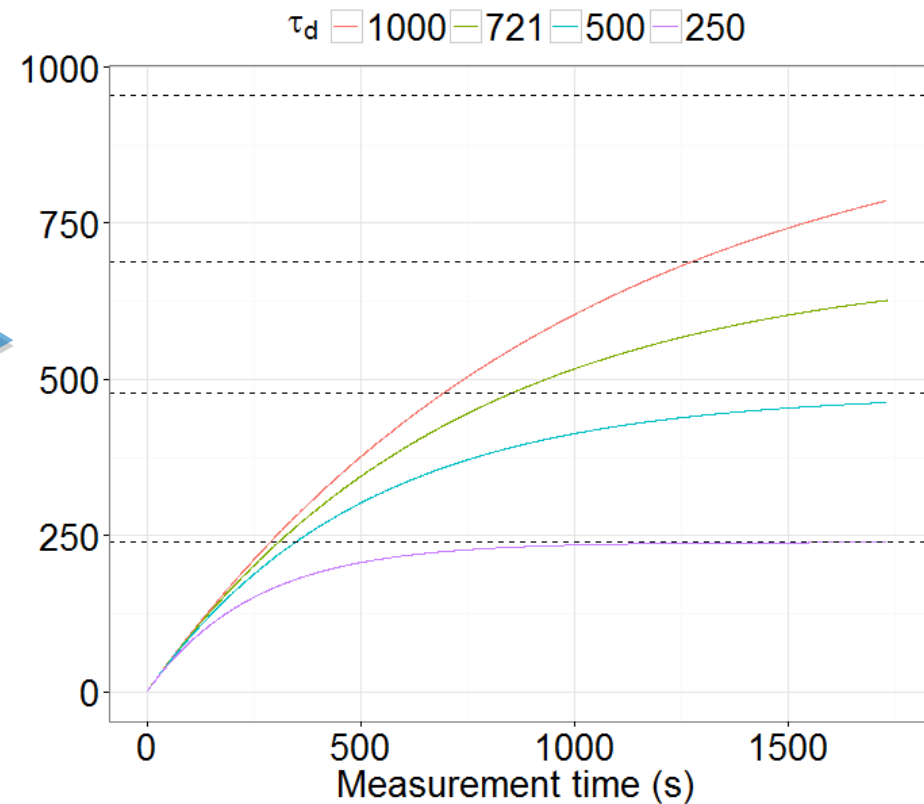
- Under what conditions sampling modulation is beneficial
- How much modulation is appropriate
- At what point measurement is no longer informative

# Spread

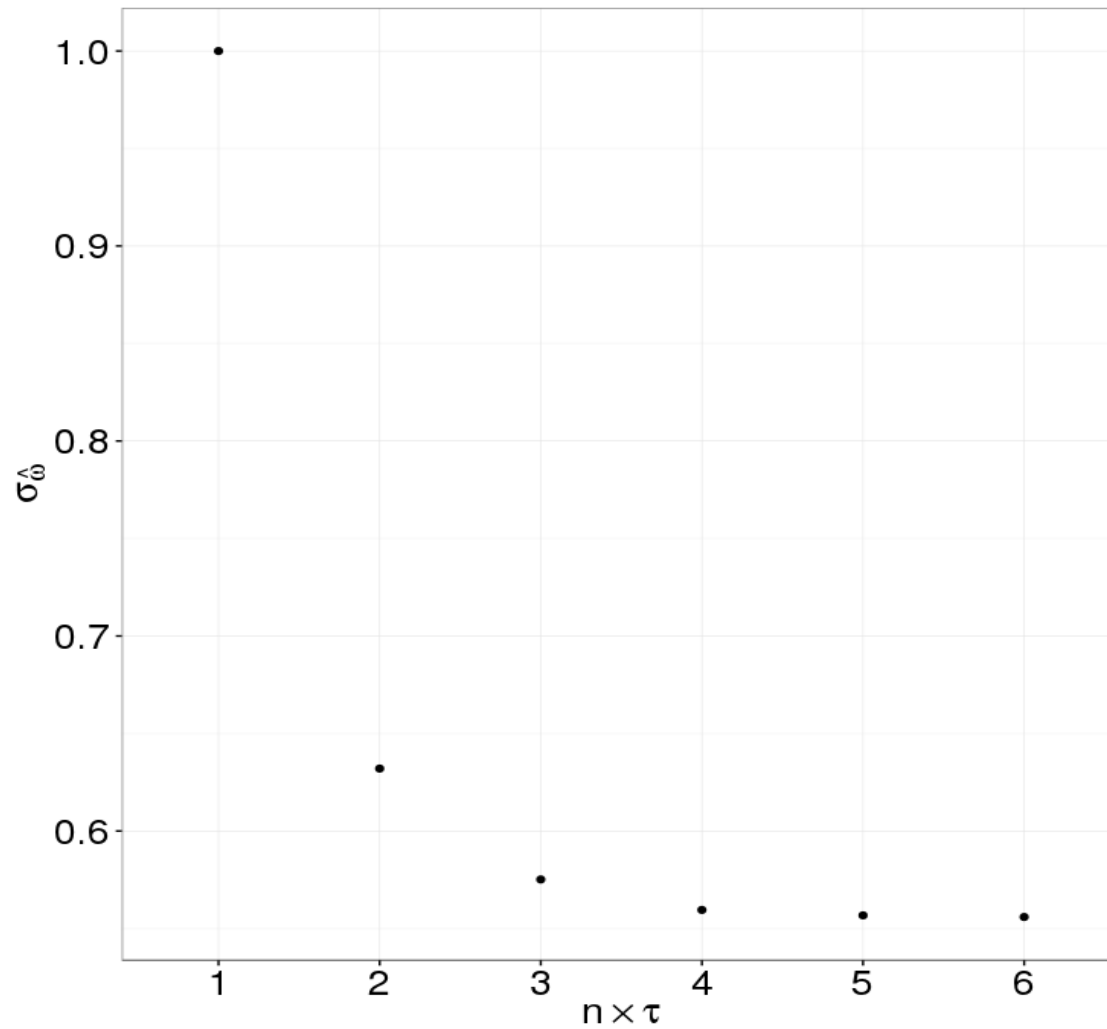
$$\sum f(t_i) = n_{\varepsilon/zc} \cdot x_{01} \cdot \frac{\exp\left(-\frac{\pi}{\omega\tau_d} n_{zc}\right) - 1}{\exp\left(-\frac{\pi}{\omega\tau_d}\right) - 1}$$

$$t(z) = \tau_d \cdot \ln\left(\frac{1}{1-z}\right)$$

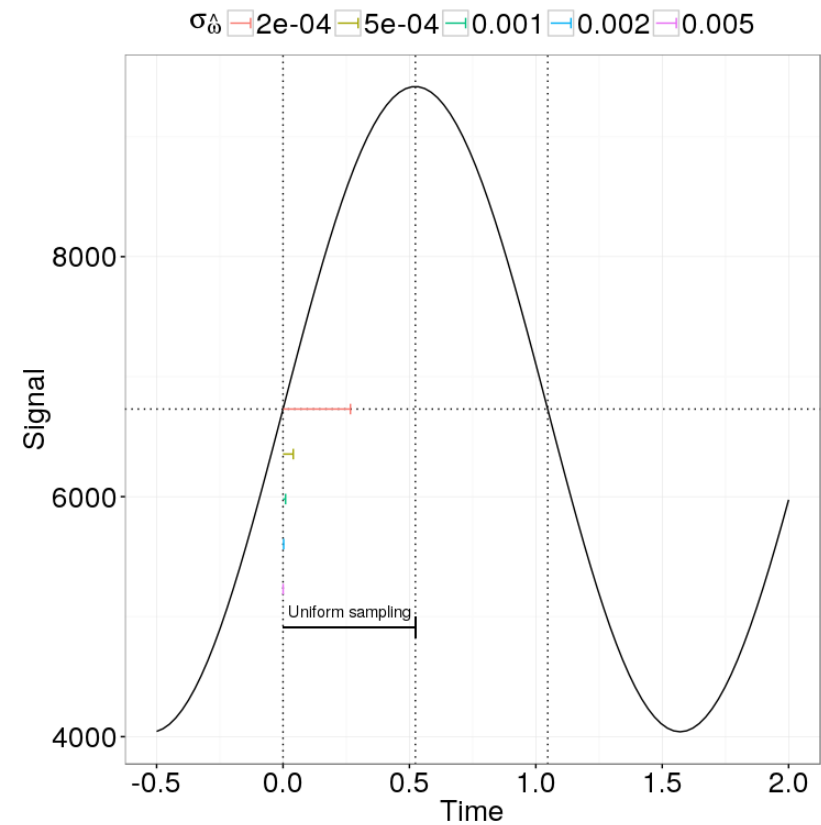
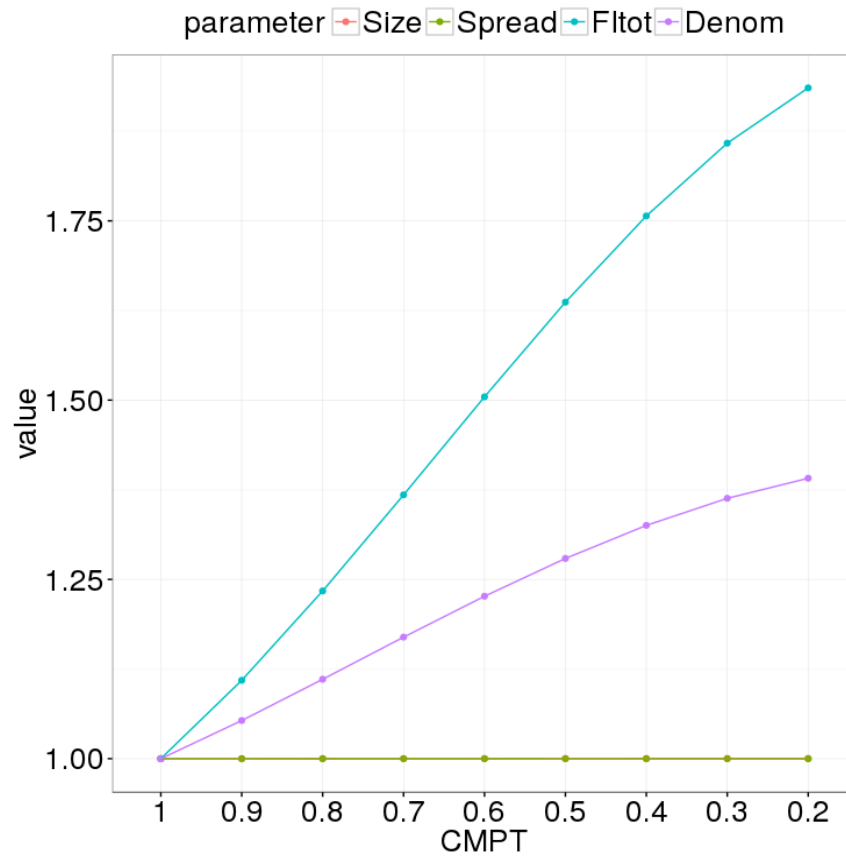
FI limit (%)	Reached ( $\times \tau_d$ )	SNR@3% error
95	3.0	1.7
90	2.3	3.3
70	1.2	10.0
50	0.7	16.5



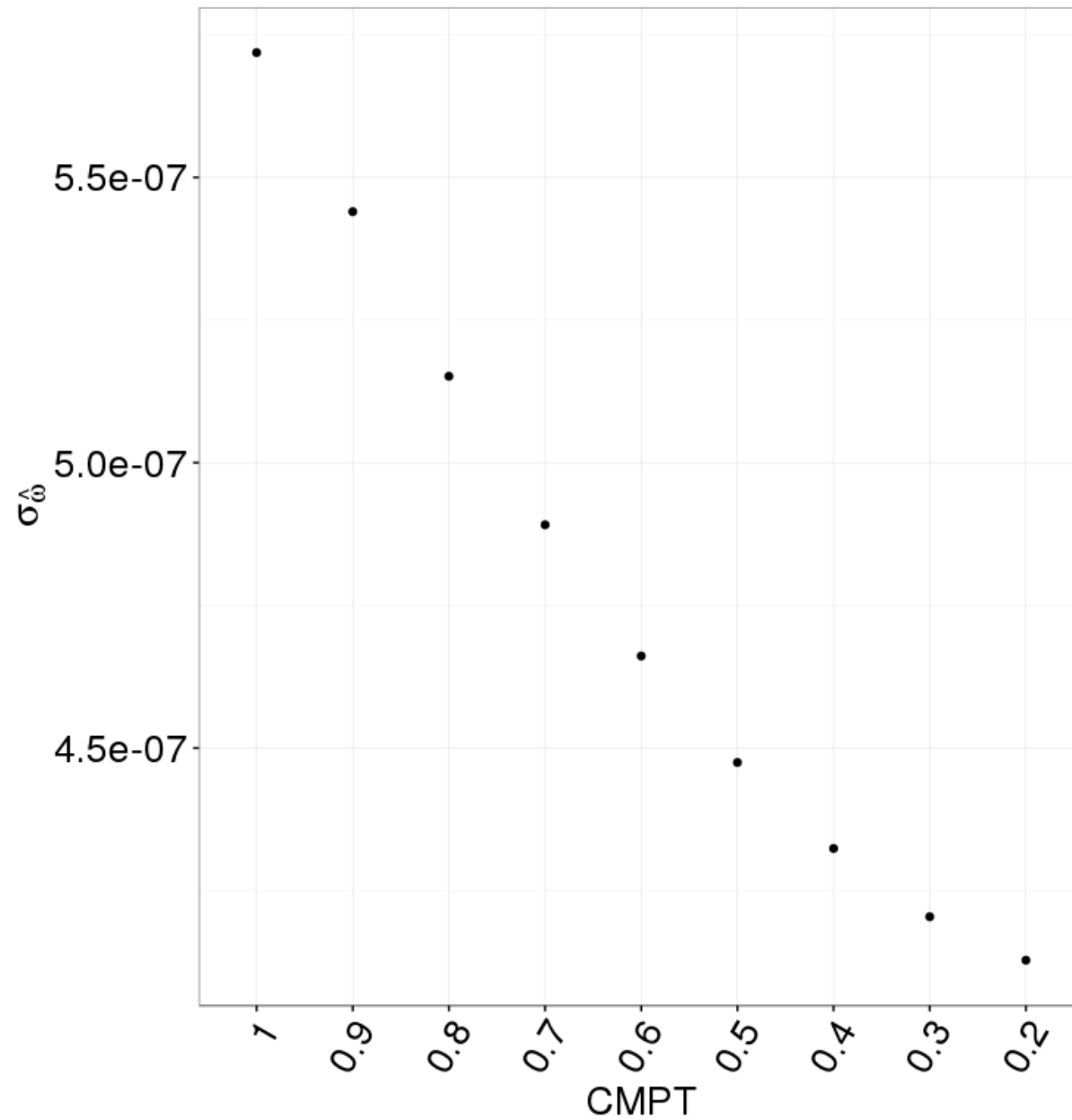
# Simulation



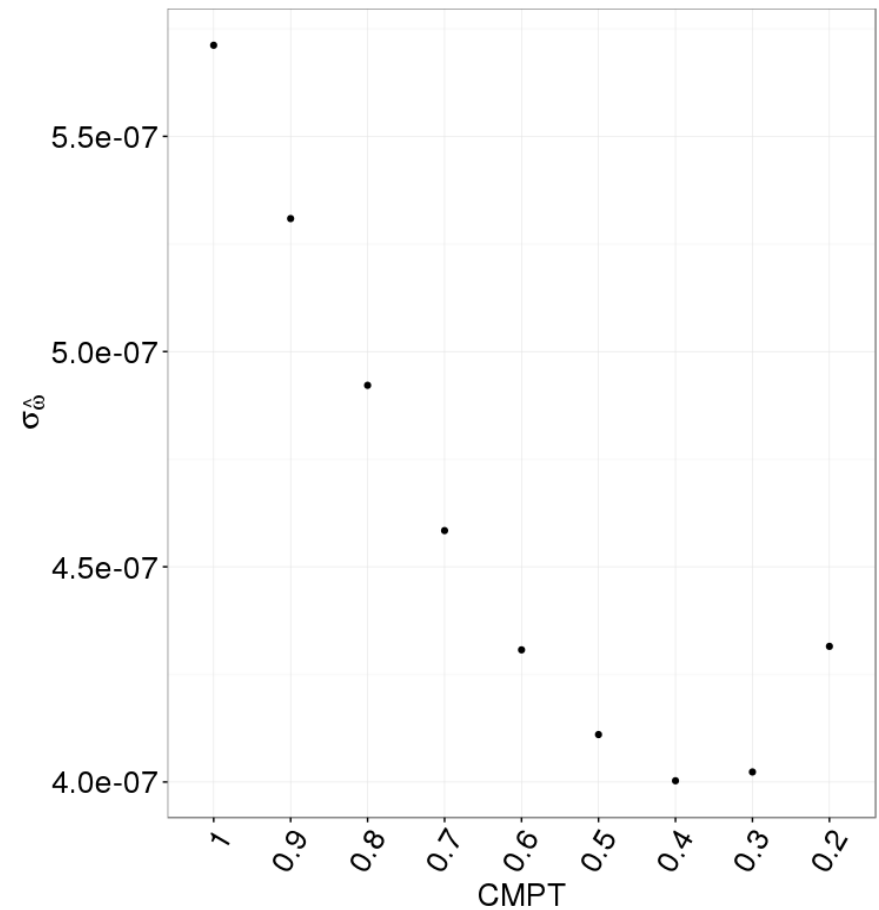
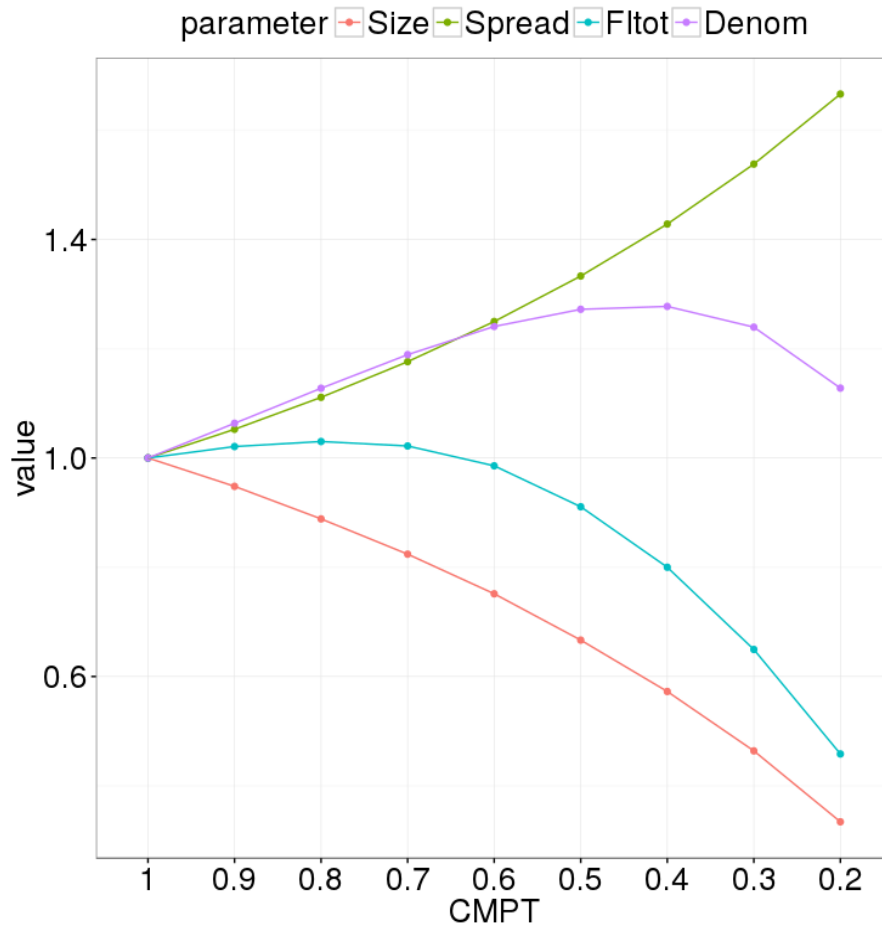
# Modulation: Beam lifetime doesn't matter







# Modulation: Beam lifetime does matter



# Decoherence

$$S(t) = \sum_i \sin(\omega_i \cdot t + \phi_i)$$

