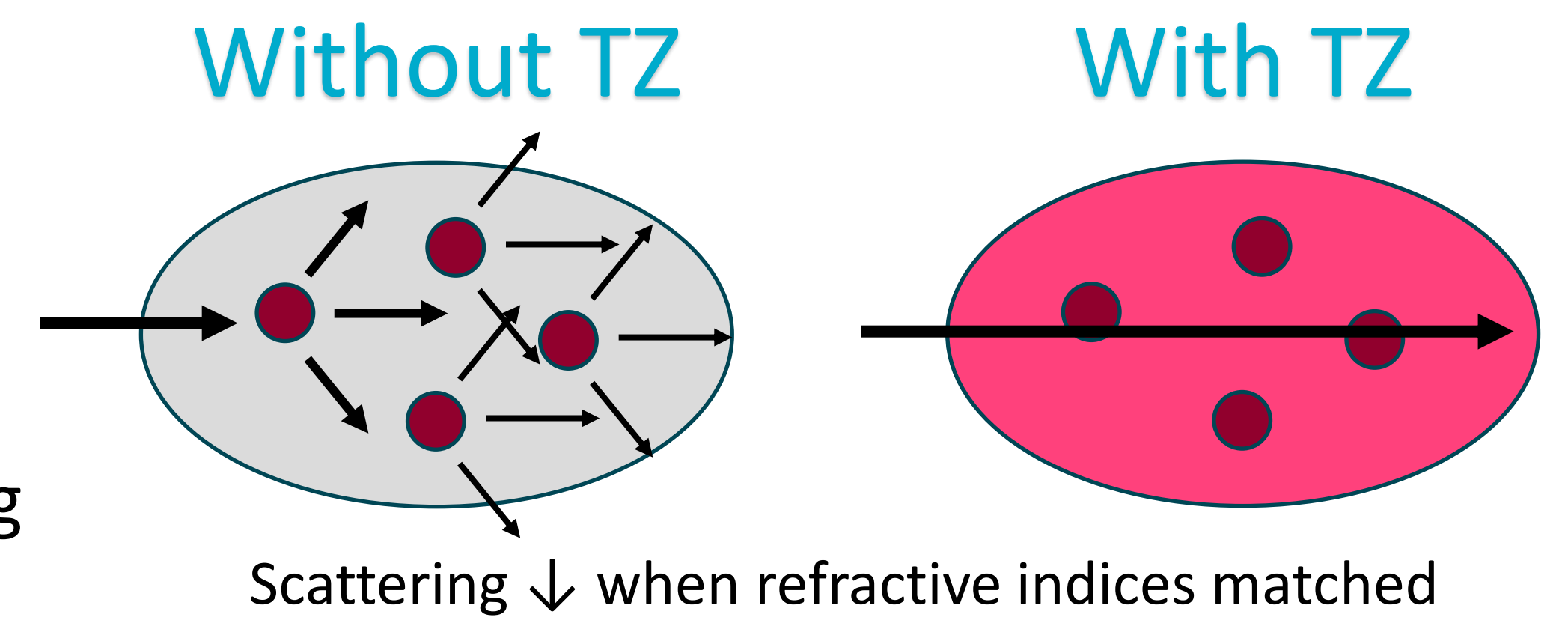


Abstract

Improving tissue transparency enhances light delivery in photothermal therapies (PTT). Inspired by recent experiments [1], we modeled how index-matching dyes, such as tartrazine (TZ), reduce scattering in tissue-like media. Our results support that matching the refractive index of the interstitial fluid to that of cells enhances light penetration. Simulations were performed using *treams* [2].



Theoretical aspects

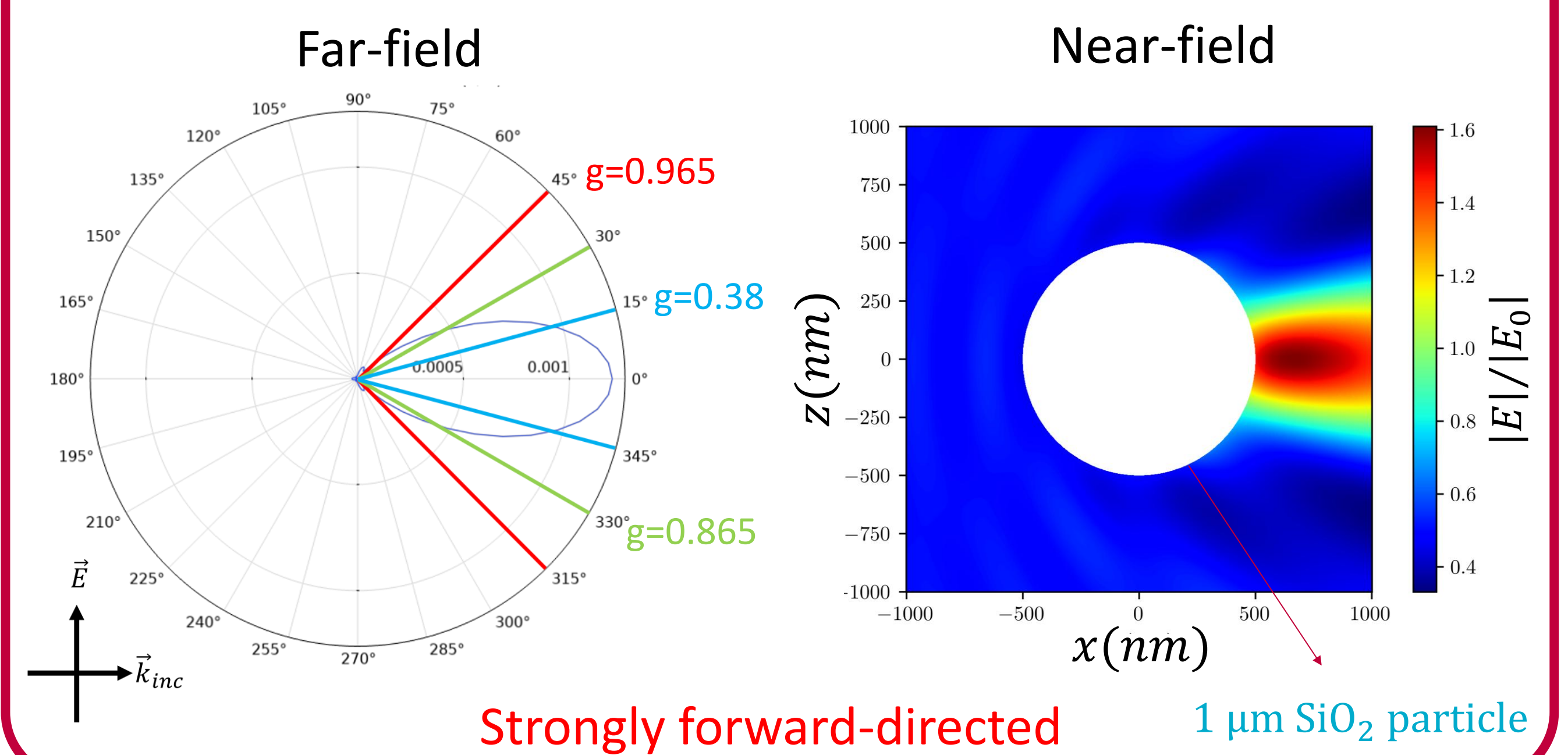
- Voigt model :
$$\epsilon(\omega) = \epsilon_{\infty} + \frac{1}{\sigma(\omega)\sqrt{\pi}} \int_{-\infty}^{+\infty} \exp\left[-\left(\frac{x - \omega_0}{\sigma(\omega)}\right)^2\right] \cdot \frac{\omega_p^2}{x^2 - \omega^2 - i\Gamma(\omega)\omega} dx$$

Central frequency of the absorption peak, Plasma frequency, Gaussian's standard deviation, Homogeneous damping
- Scattering coefficient [3] : $\mu_s(\lambda) = \frac{\ln(k(\lambda))}{d}$ with $k = \frac{TT}{T_0}$

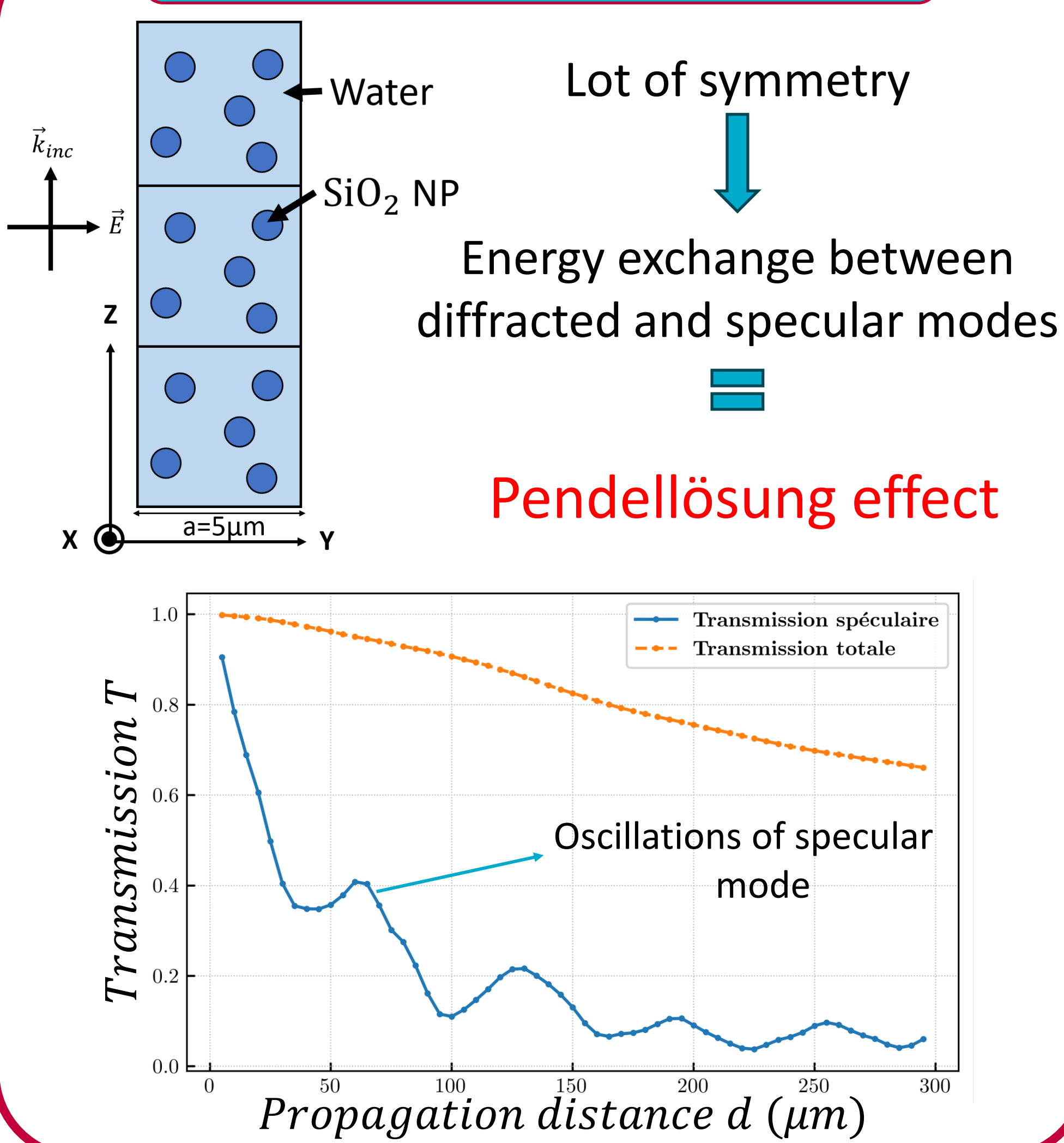
Propagation distance in cm, Total transmission, Specular transmission
In biological tissues : $\mu_s = [150 \text{ cm}^{-1}, 300 \text{ cm}^{-1}]$
- Anisotropy factor g [3] : $g = \int_0^{\pi} p(\theta) \cos \theta \cdot 2\pi \sin \theta d\theta$

Phase function for scattering angle θ

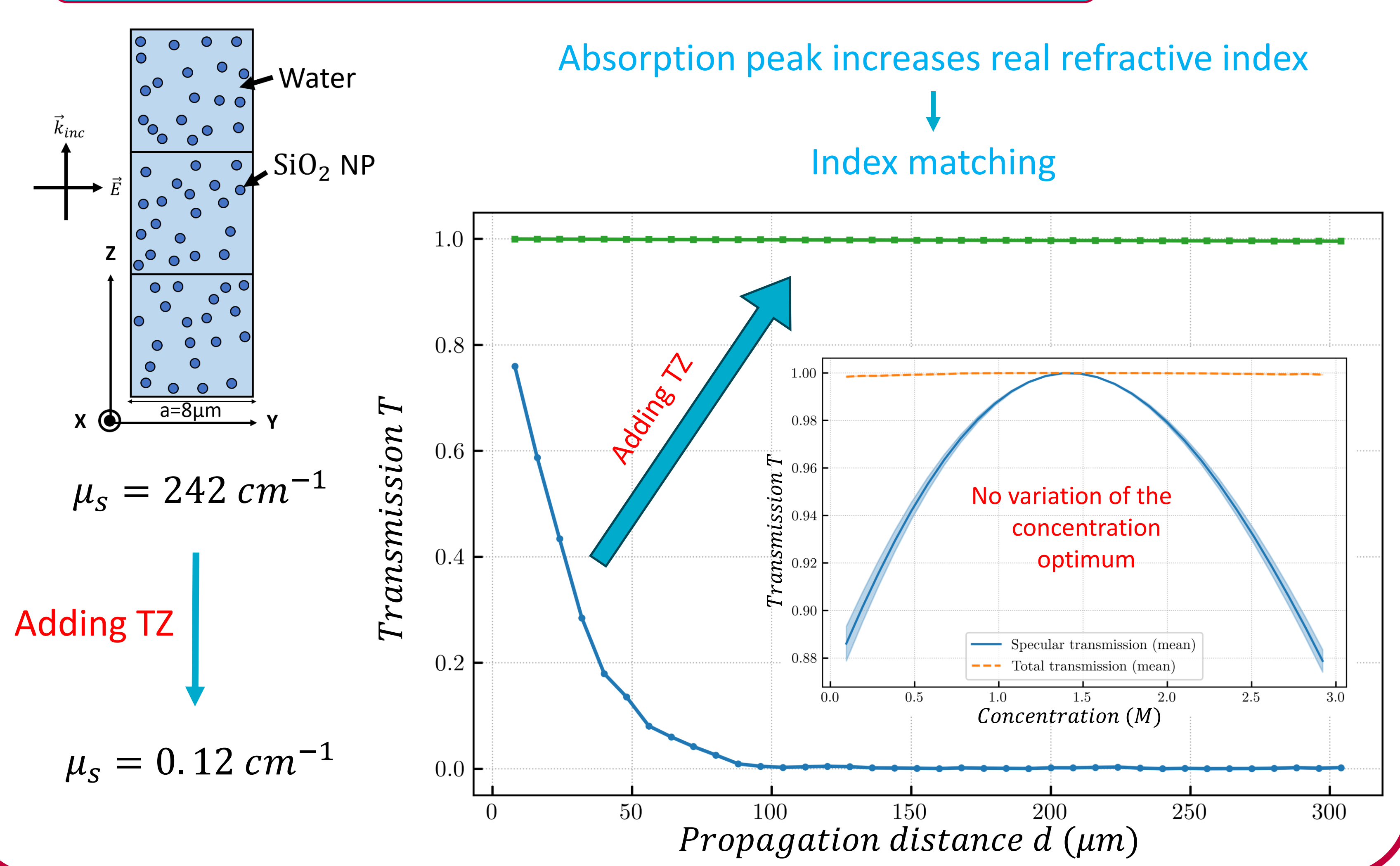
Silica particle



Pendellösung effect



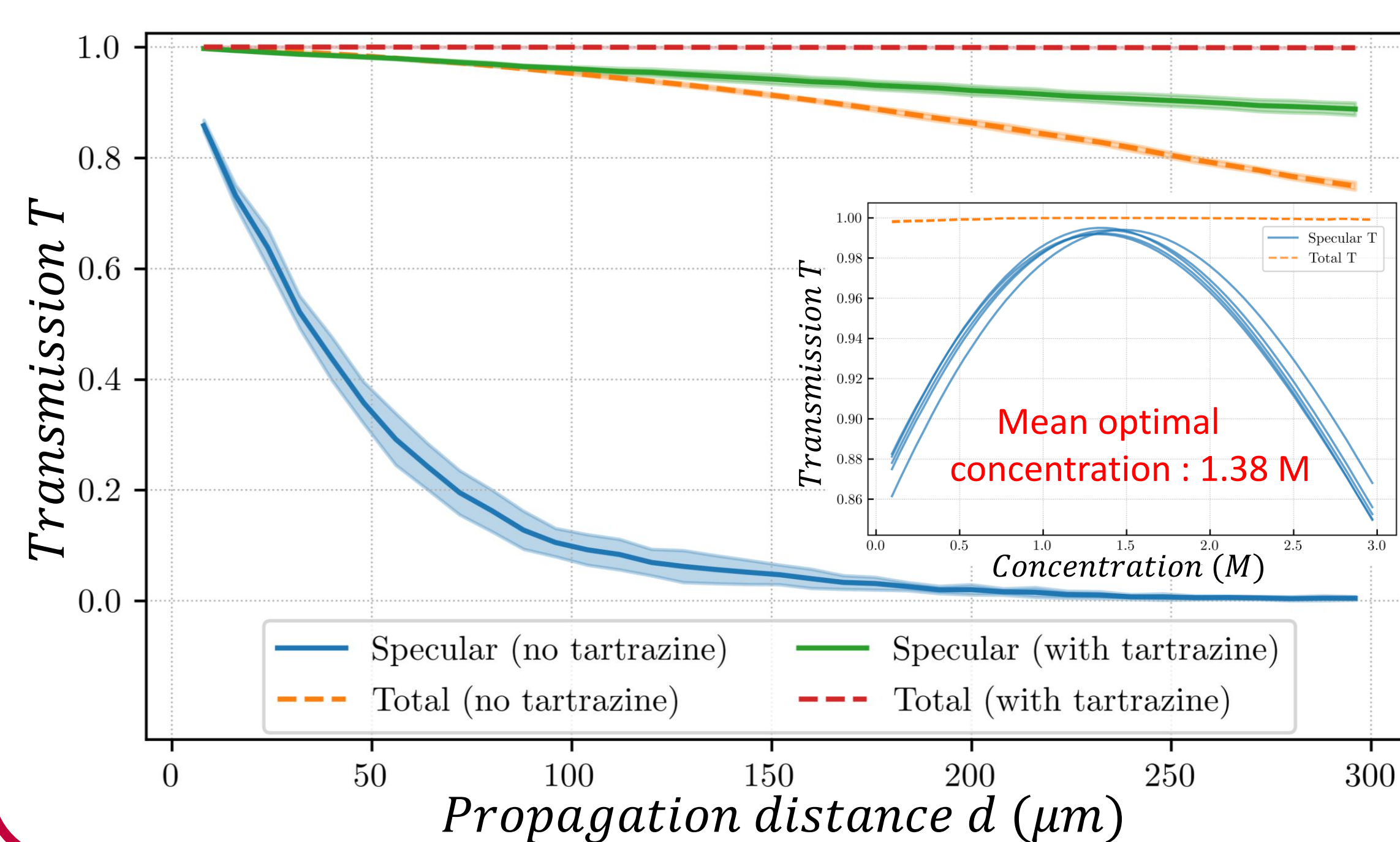
Increasing transmission with tartrazine



Tartrazine vs Gold

Absorption peak provided by gold nanoparticles ?
VS
Gold Nps concentration in PTT : $10^{14} - 10^{16} \text{ m}^{-3}$
Maxwell Garnett + Kramers-Kronig Calculations
Gold Nps concentration needed for index matching = $1.34 \times 10^{19} \text{ m}^{-3}$
Biological constraints limit applicability

Index variation per silica particle



$TT \neq T_0$
Redistribution of light between direct and diffracted channel
 $\mu_s = 181 \text{ cm}^{-1}$
Adding TZ
 $\mu_s = 4 \text{ cm}^{-1}$

Conclusion

- It is possible to mimic the scattering of human tissues with semi-periodic simulations.
- Index matching remains effective even with a variation of the refractive index of 10 %.

Outlook

Test other absorbers
Effect works as long as absorption matches target range
Add unit cell disorder
To mimic biological complexity