Simulating the Absorption and Emission Process in Ti:Sapphire

Ze Ouyang

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- pumping laser: ~5ns, 250mJ, 532nm
- gain material: ~1cm, light beam radius of 0.15cm

absorption cross section: 6.4e-20 cm^2

emission cross section: 4e-19 cm^2

Absorption process

given pumping laser: ~5ns, 250mJ, 532nm

$$\text{fluence} = \frac{250\text{mJ}}{\pi(0.15\text{cm})^2} = 3.54\text{e}3\text{mJ/cm}^2 = 3.54\text{J/cm}^2$$

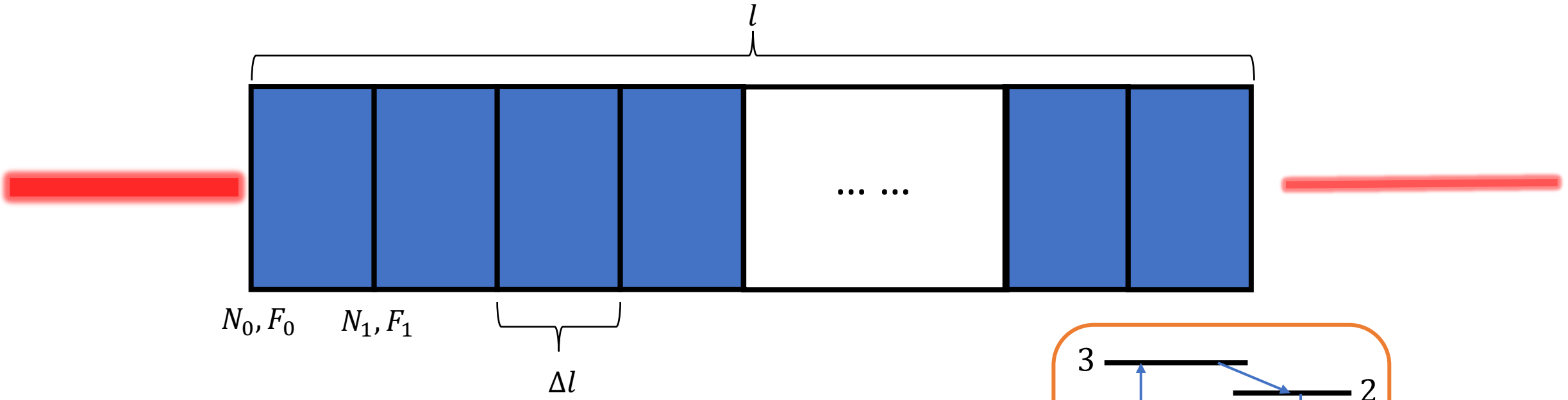
Intensity I : W/cm^2

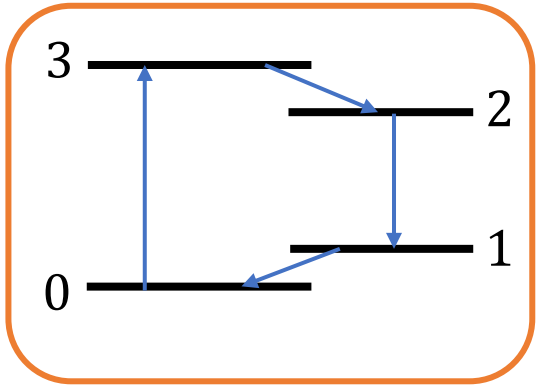
Fluence F : J/cm^2

$$g = \frac{1}{z}\frac{\mathrm{d}I}{\mathrm{d}z} \rightarrow g = \frac{1}{z}\frac{\mathrm{d}F}{\mathrm{d}z} \rightarrow F(z) = F(0)e^{gz}$$

suppose the pumping laser of a δ-function

Absorption process





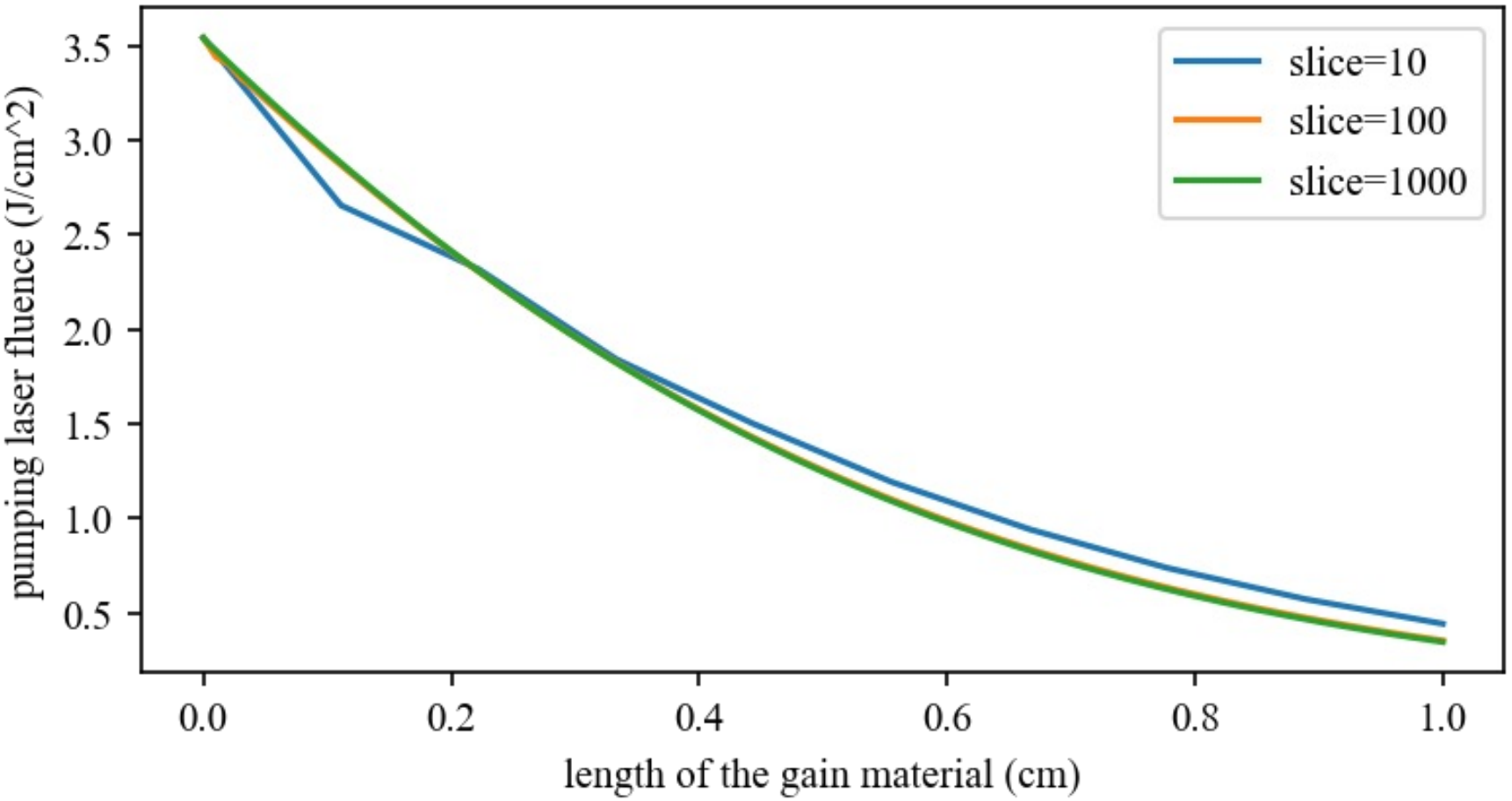
define $N = n_0 - n_3$ in each section

$$\begin{cases} F_{i+1} = F_i e^{-\sigma_{\text{abs}} N_i \Delta l} \\ N_{i+1} = \dfrac{F_i - F_{i+1}}{h\upsilon \Delta l} \end{cases}$$

F_0 is given, N_0 will be guessed to meet the relationship: $F(l) = 10\% F(0)$

Absorption process

Fluence with the length of the material



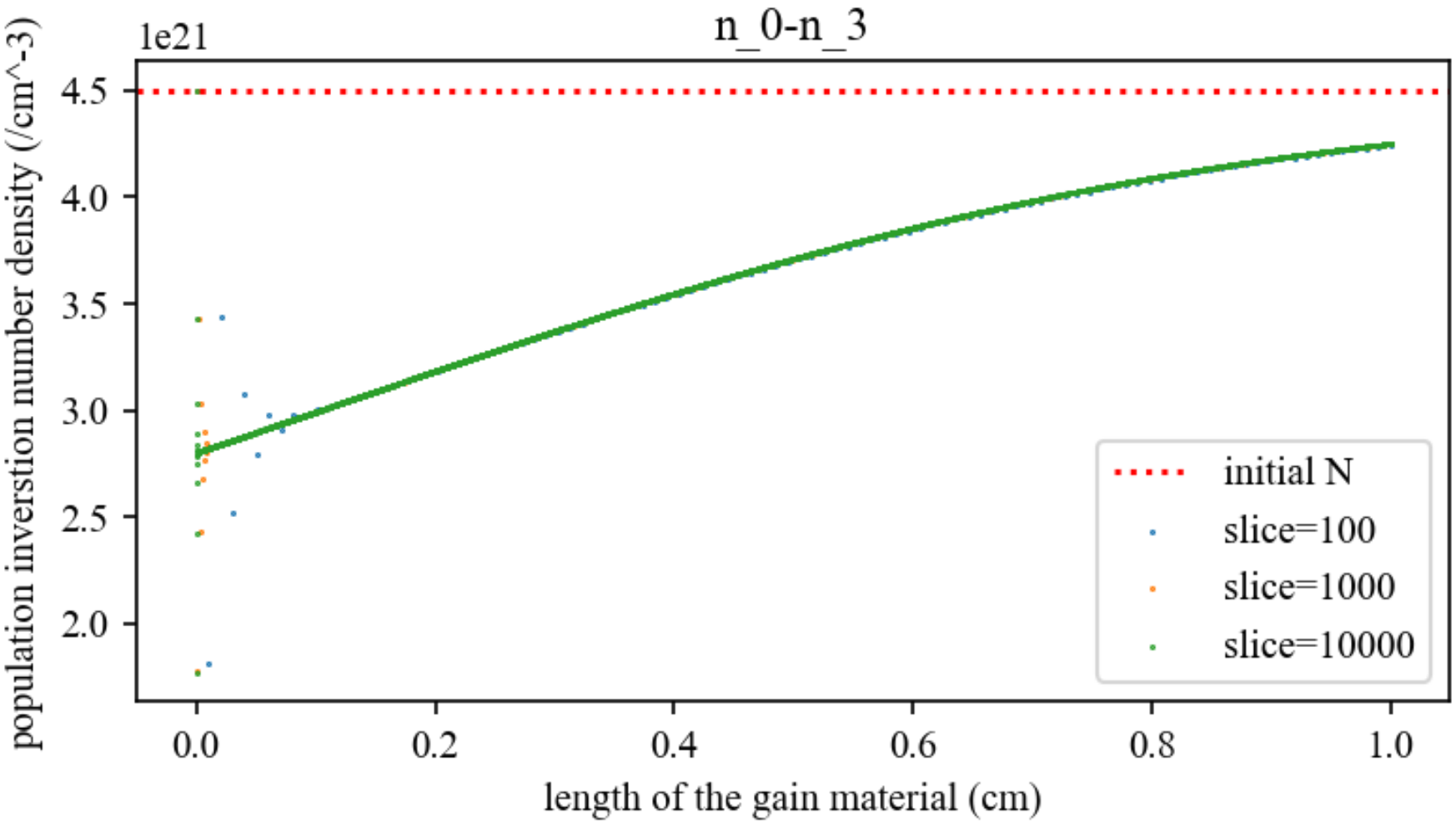
result:

N_0=4.5e21 cm^{-3}

slice=1000

absorption rate 90.27%

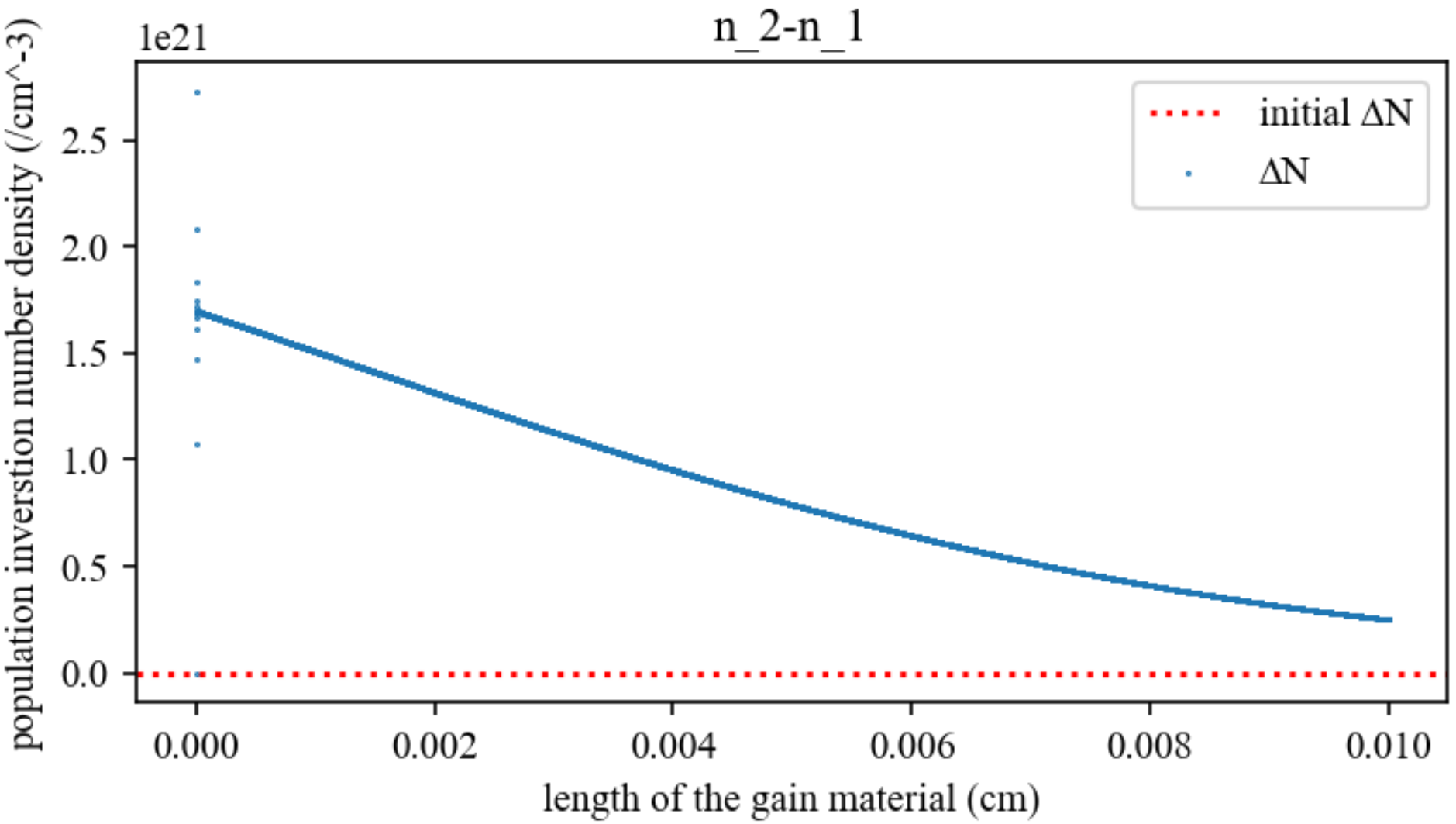
Absorption process



result:

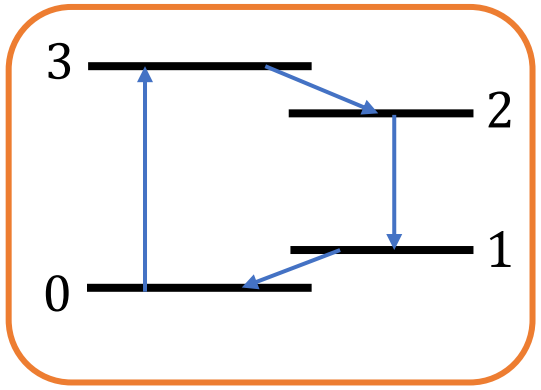
N has a giant drop at first due to the edge effect, then gets bigger due to the weakness of the pumping laser.

Emission process



Just a subtraction from Page 5. Thus, no need to test whether it is converged given different slice numbers.

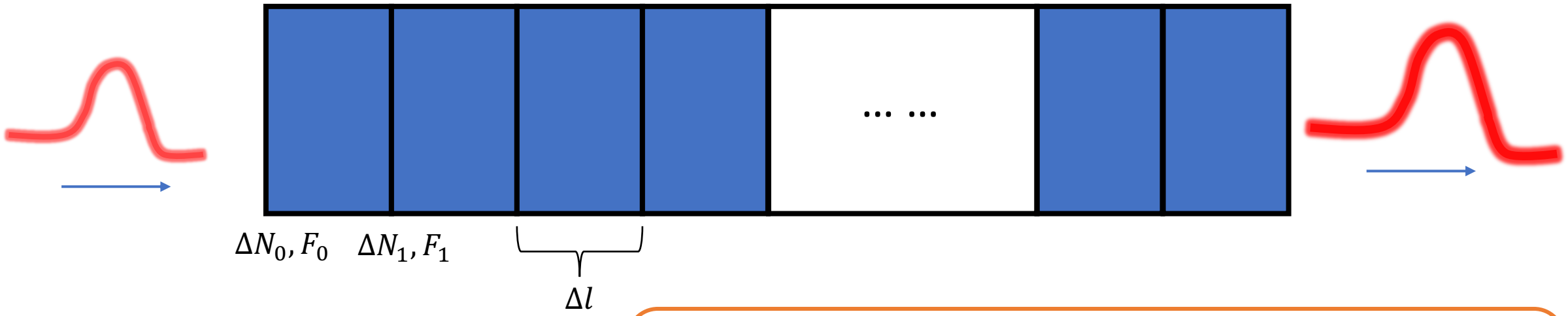
Emission process



define $\Delta N = n_2 - n_1$ in each section

so $\Delta N = N_0 - N$

certainly the ΔN_0=0

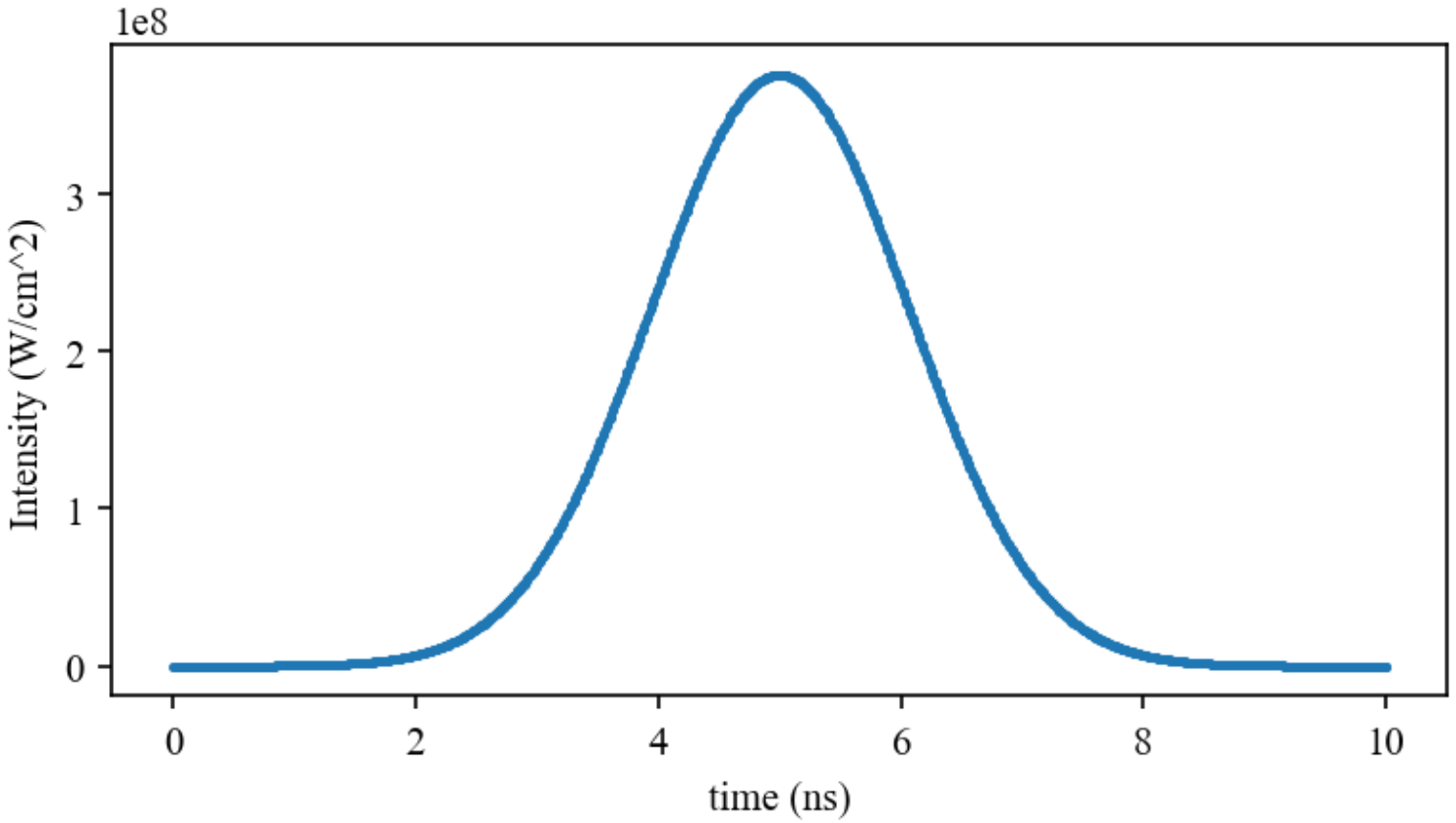


$$\begin{cases} F_{i+1} = F_i e^{\sigma_{\mathrm{emi}} \Delta N_i \Delta l} \\ \Delta N_i = \Delta N_i - \dfrac{F_{i+1} - F_i}{h\upsilon \Delta l} \end{cases}$$

the light cannot be always amplified, should satisfy the new $\Delta N_i > 0$

Emission process

given incident laser



peak intensity: 3.5e8 W/cm^2

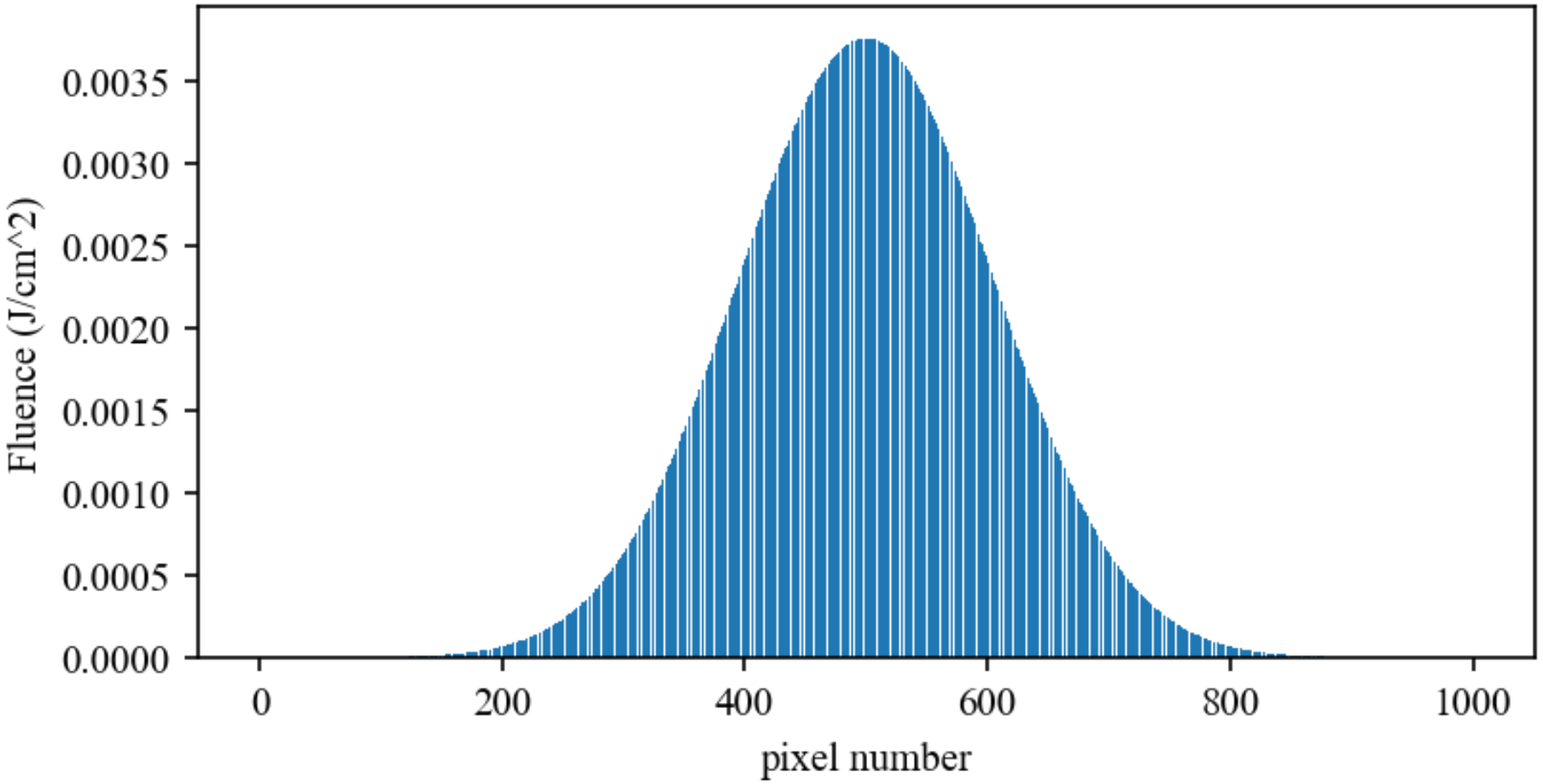
duration: 10ns

FWHM: 2.5ns

total energy: 0.0706J

Emission process

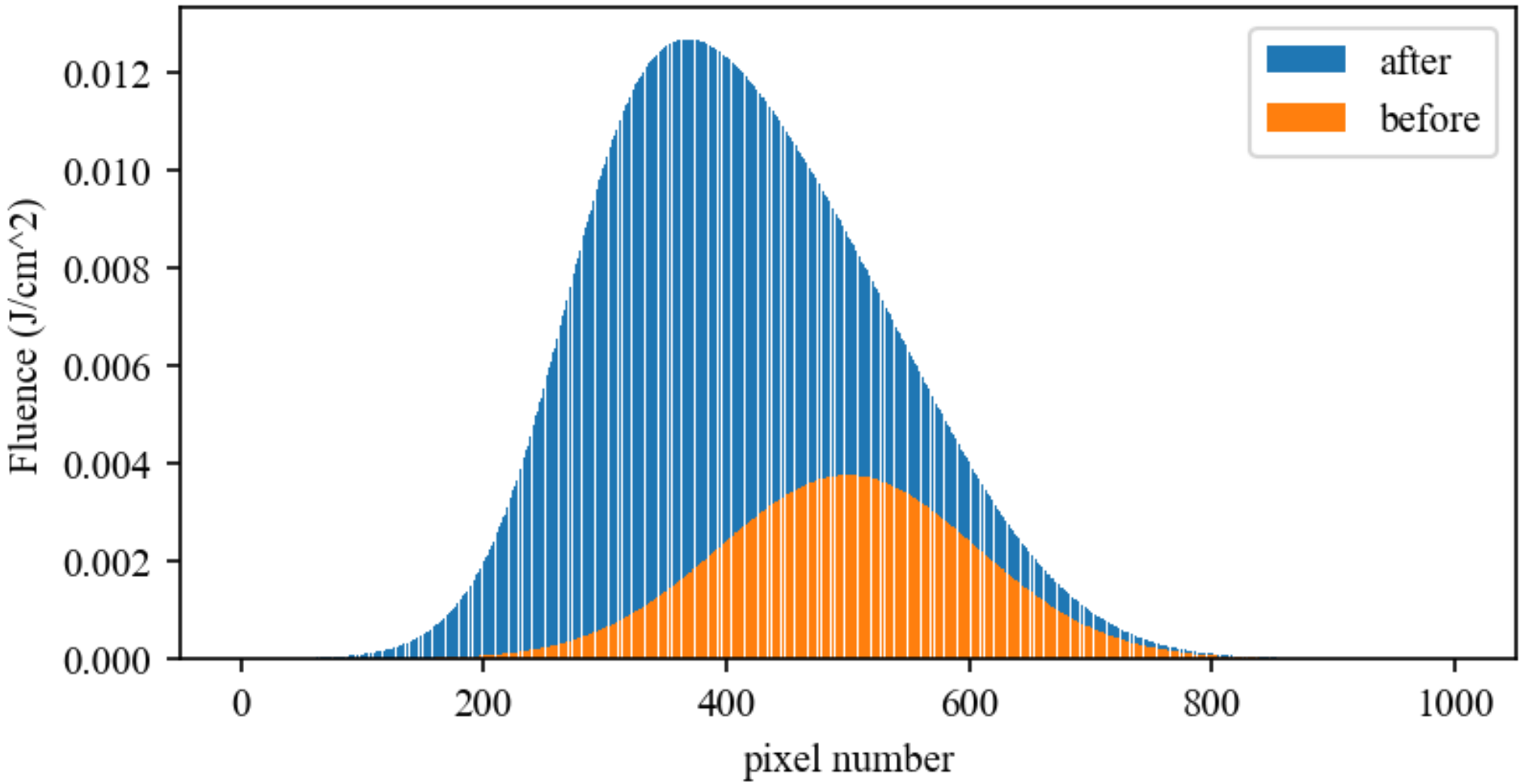
method: To make it independent with time, cut it into pieces of fluence slices



each pixel goes through the amplified process successively

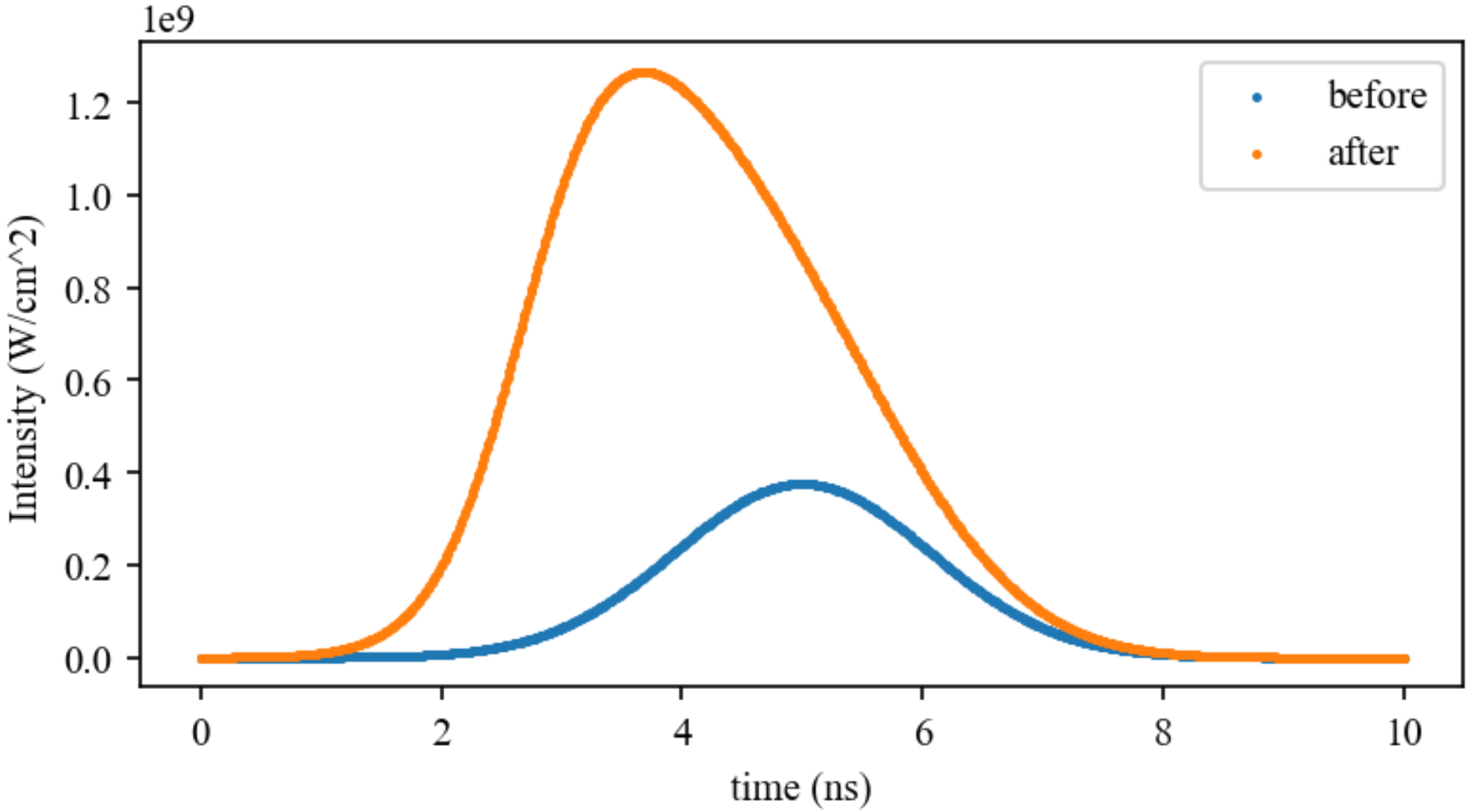
Emission process

after amplification

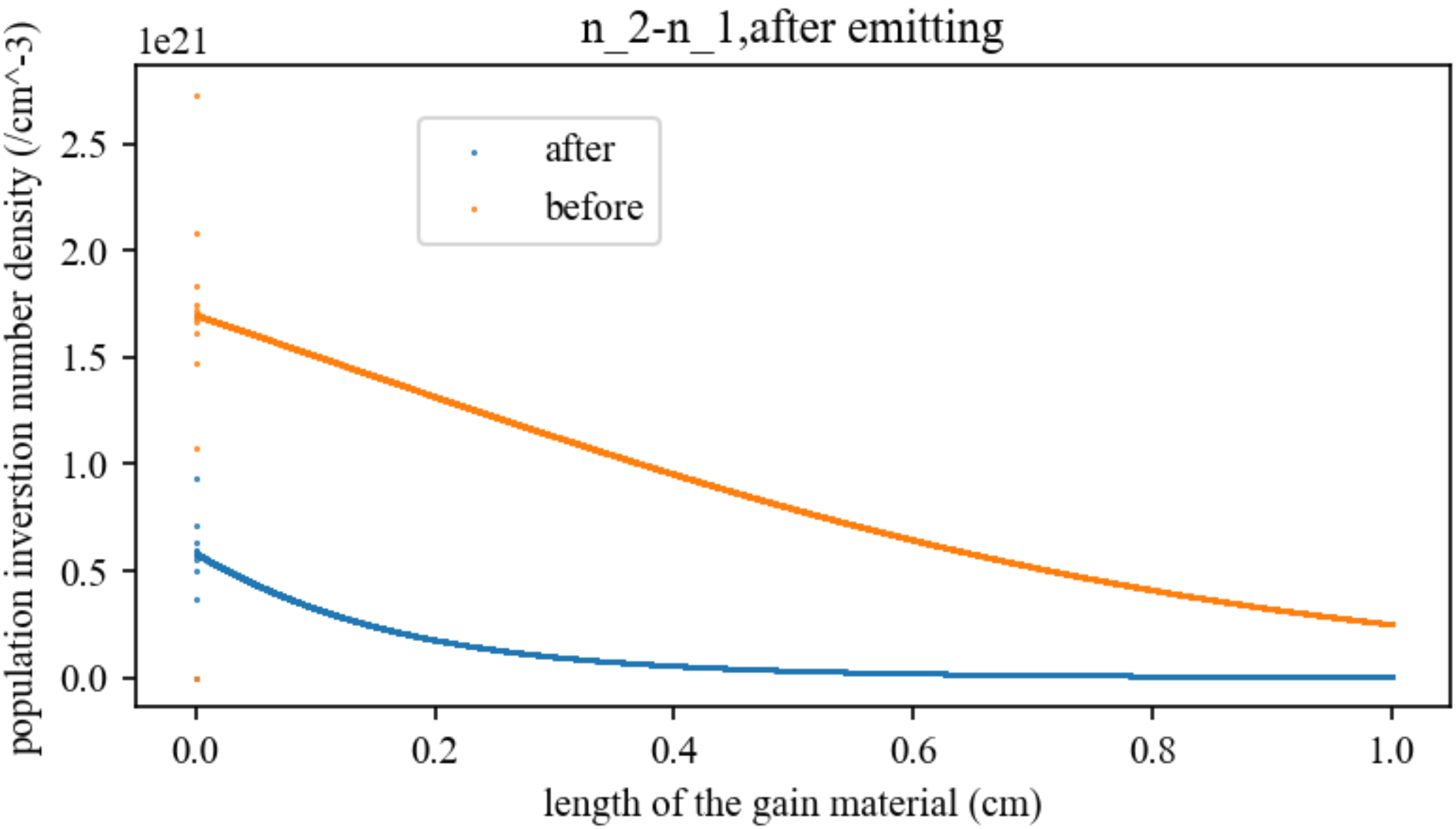


Emission process

convert to intensity



Emission process



Summary

leave out the refraction index of the gain material?

reference

the cross section is given in page 20 in the article