Mini Project

Phelopater Ramsis 202001171

University of Science and Technology at Zewail City

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Supervised by:

Dr. Salem Farag Hegazy

TA. Awad Khaled Mohamed

TA.. Mohammed Mansour
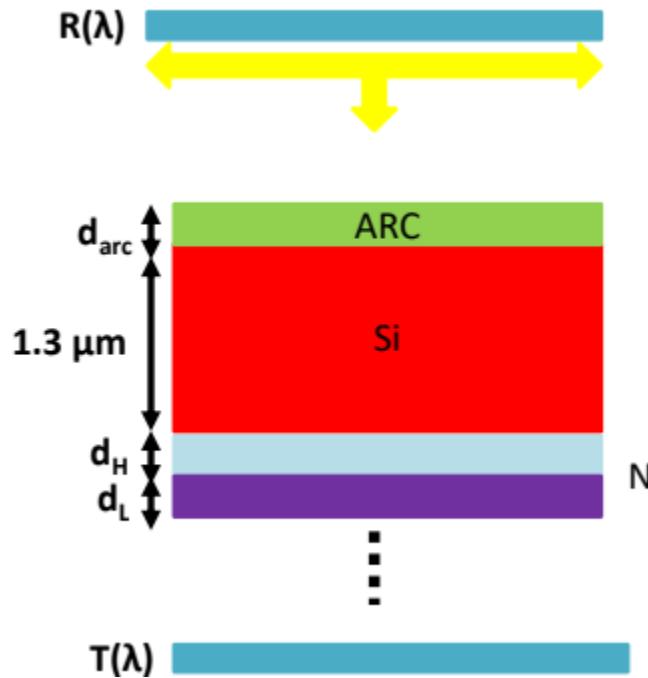
Table of Contents
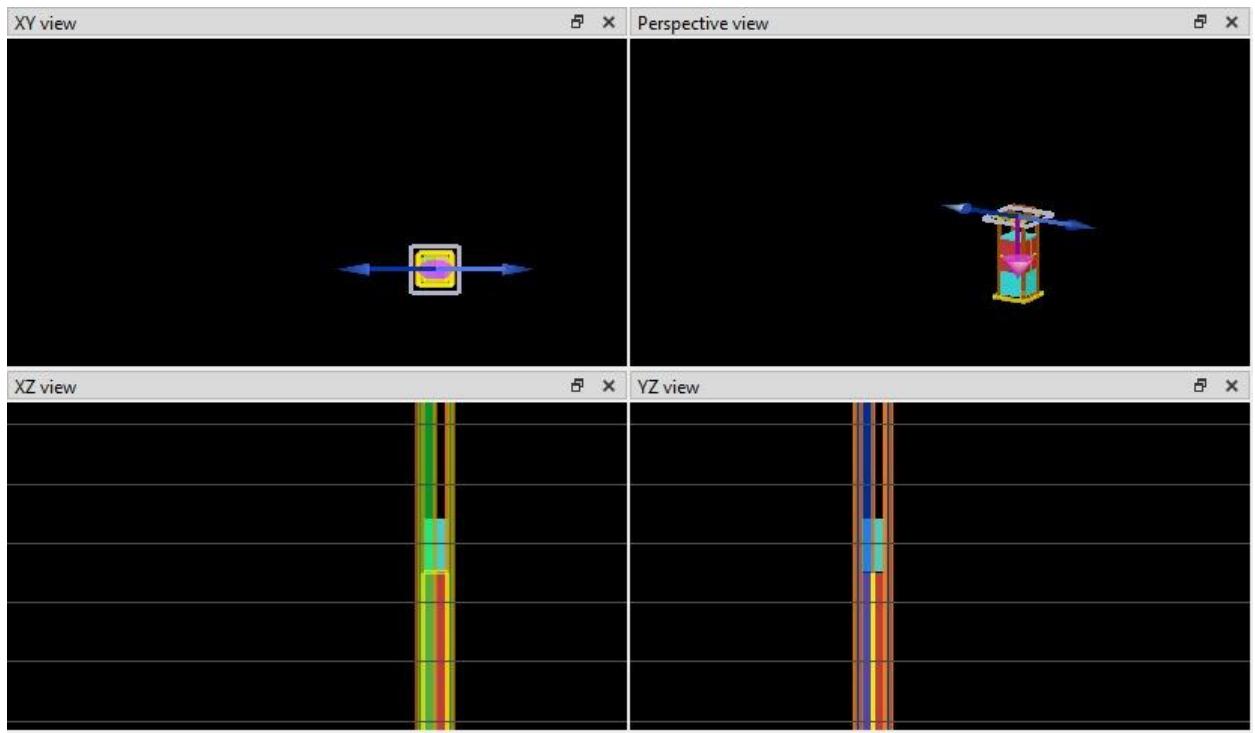
Problem:

The required problem is to consider a planar silicon solar cell structure that is coated with an antireflection (ARC) layer with a refractive index n2=1.9n_2 = 1.9n2=1.9 and has a dielectric mirror at the bottom composed of alternating layers with refractive indices nH=2.35n_H = 2.35nH=2.35 and nL=1.46n_L = 1.46nL=1.46, where the number of double layers NNN is 5. The dimensions of the simulation region are 500 nm in the x and y directions. The z-direction uses a Perfectly Matched Layer (PML) boundary condition, while anti-symmetric and symmetric boundary conditions are applied in the x and y directions, respectively. The wavelength range is from 300 to 1100 nm, with 201 frequency points.

1. Design the thickness ddd of the ARC layer and the dielectric mirror.
2. Calculate the reflectance, transmittance, and absorption for the solar cell with and without the ARC and dielectric mirror.
3. Plot the electric field distribution in the x-z and x-y planes at wavelengths of 800 nm and 1000 nm for the three cases.
4. Comment on the results.

Design:

Calculations:

Designing the thickness for ARC layer and Dielectric mirror:

For the ARC layer:

$$d_{ARC} = \frac{\lambda_{opt}}{4n_{ARC}}$$

d_{ARC} is the thickness of the ARC layer,

λ_{opt} is the optimal wavelength which is **675 nm** in this case,

n_{ARC} is the refractive index of the ARC layer which is **1.9**

$$d_{ARC} = \frac{675 * 10^{-9}}{4 * 1.9} = 88.81578947 \; nm$$

2. For the dielectric mirror:

$$d_H = \frac{\lambda_{opt}}{4n_L}$$

$$d_L = \frac{\lambda_{opt}}{4n_L}$$

where:

- refractive index layers of the dielectric mirror, respectively, which are **2.35** and **1.46**.
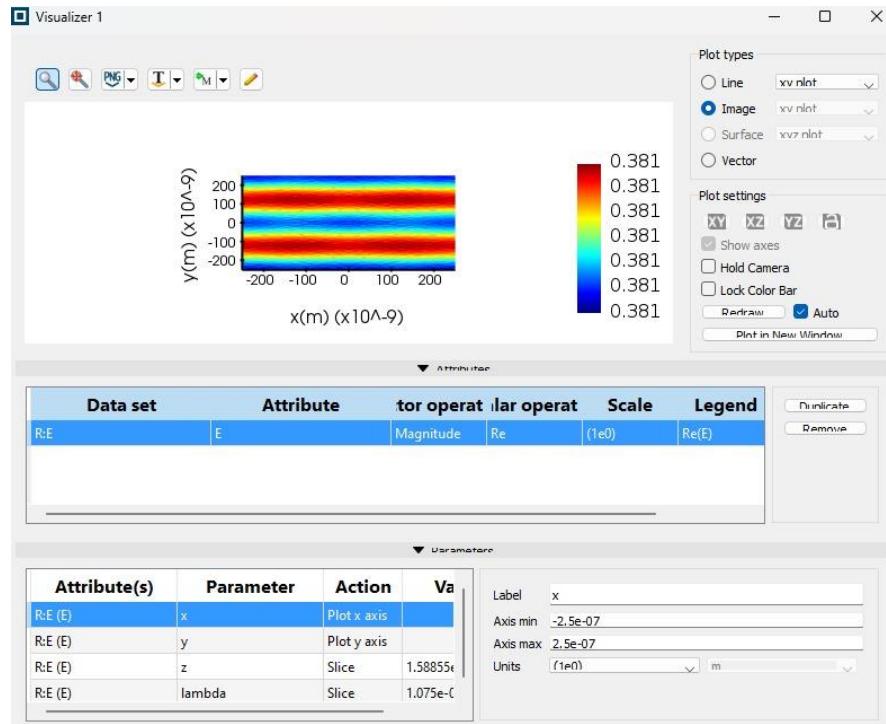
$$d_H = \frac{675 * 10^{-9}}{4 * 2.35} = 71.80851064 \; nm$$

$$d_L = \frac{675 * 10^{-9}}{4 * 1.46} = 115.5821918 \; nm$$
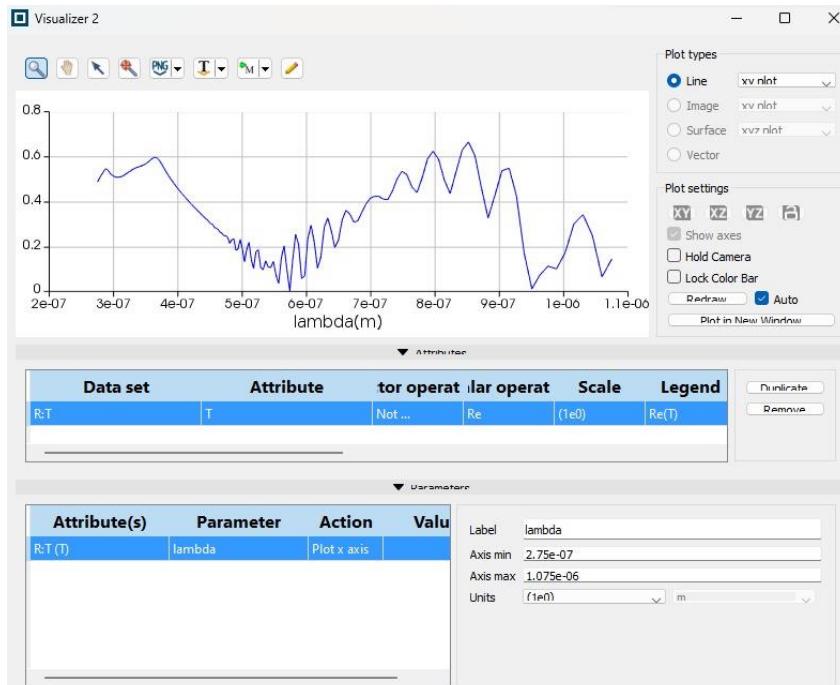
First the result with ARC and Dielectric mirrors:

1- At my Wavelength (675 nm):
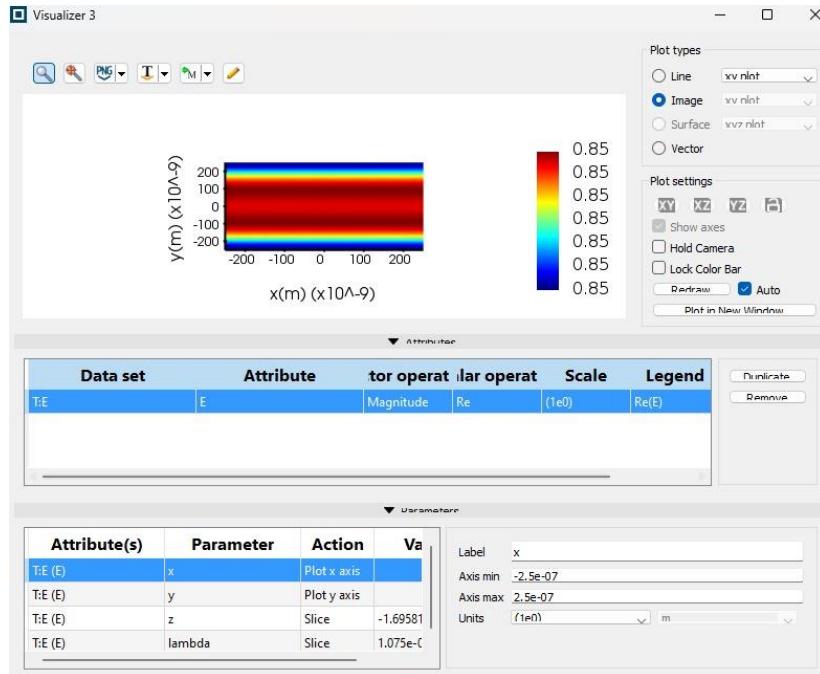
Reflectance: E
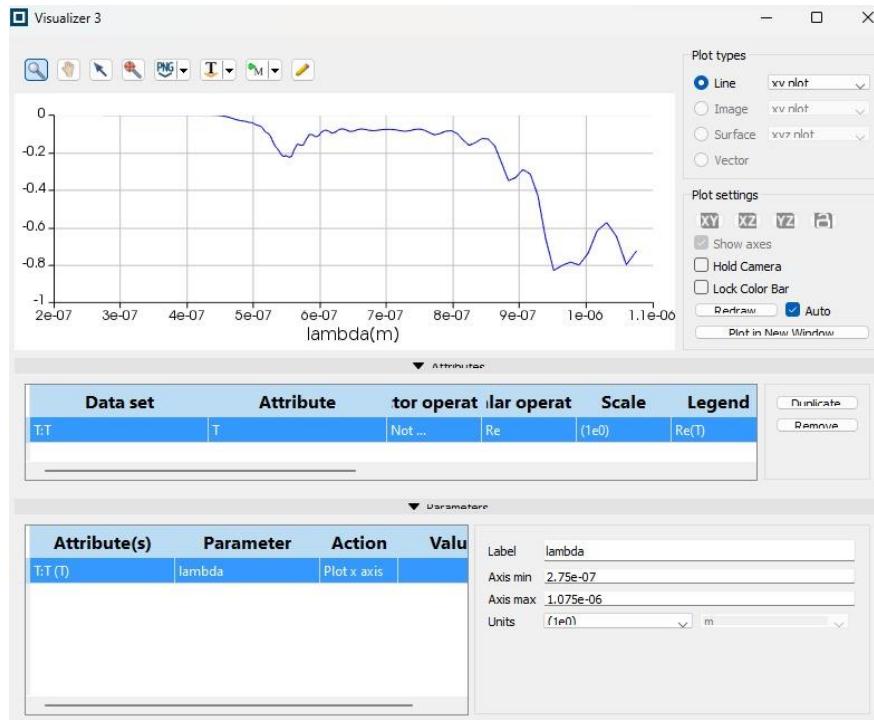
Reflectance: T

Transmittance: E
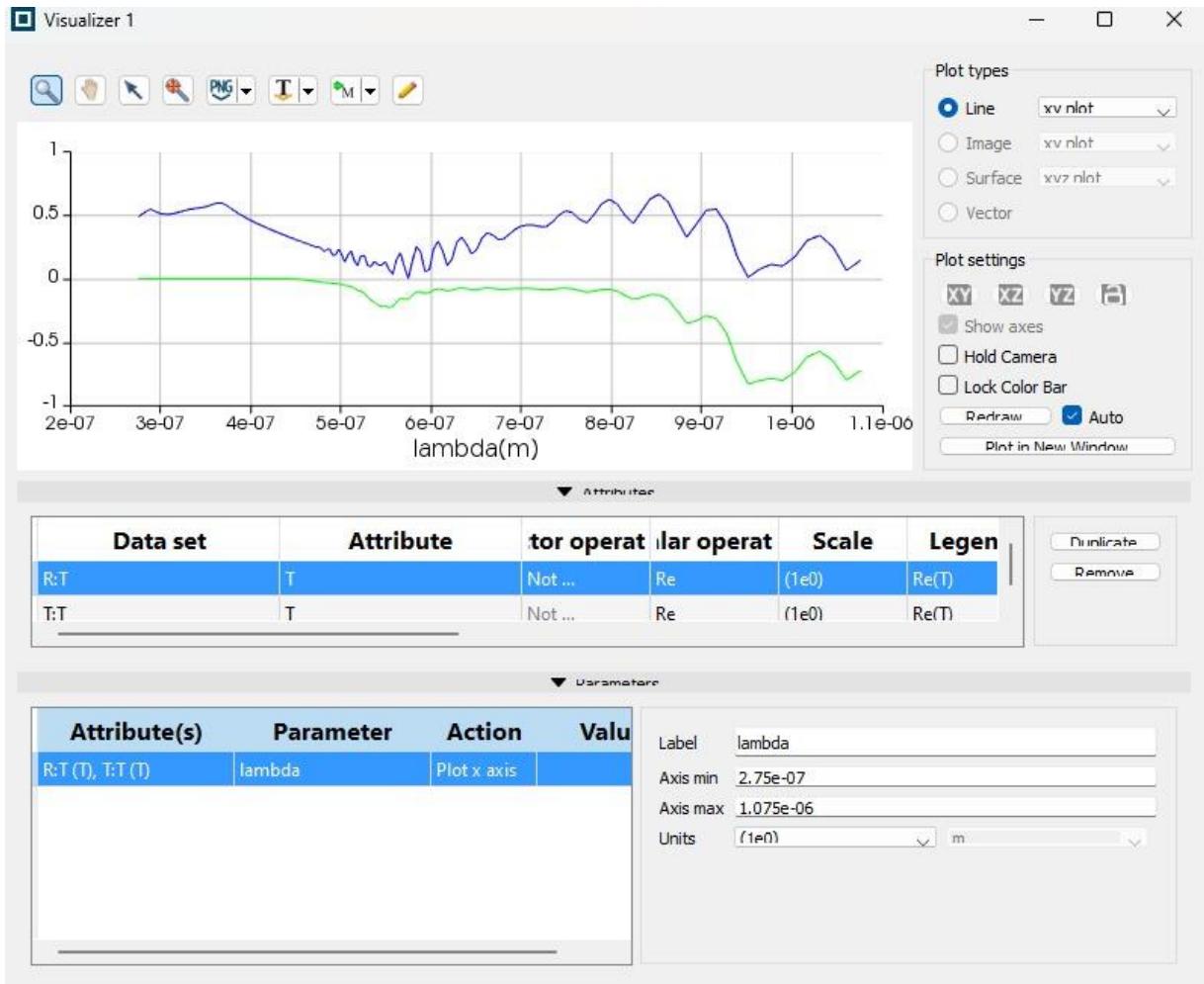
Transmittance: T
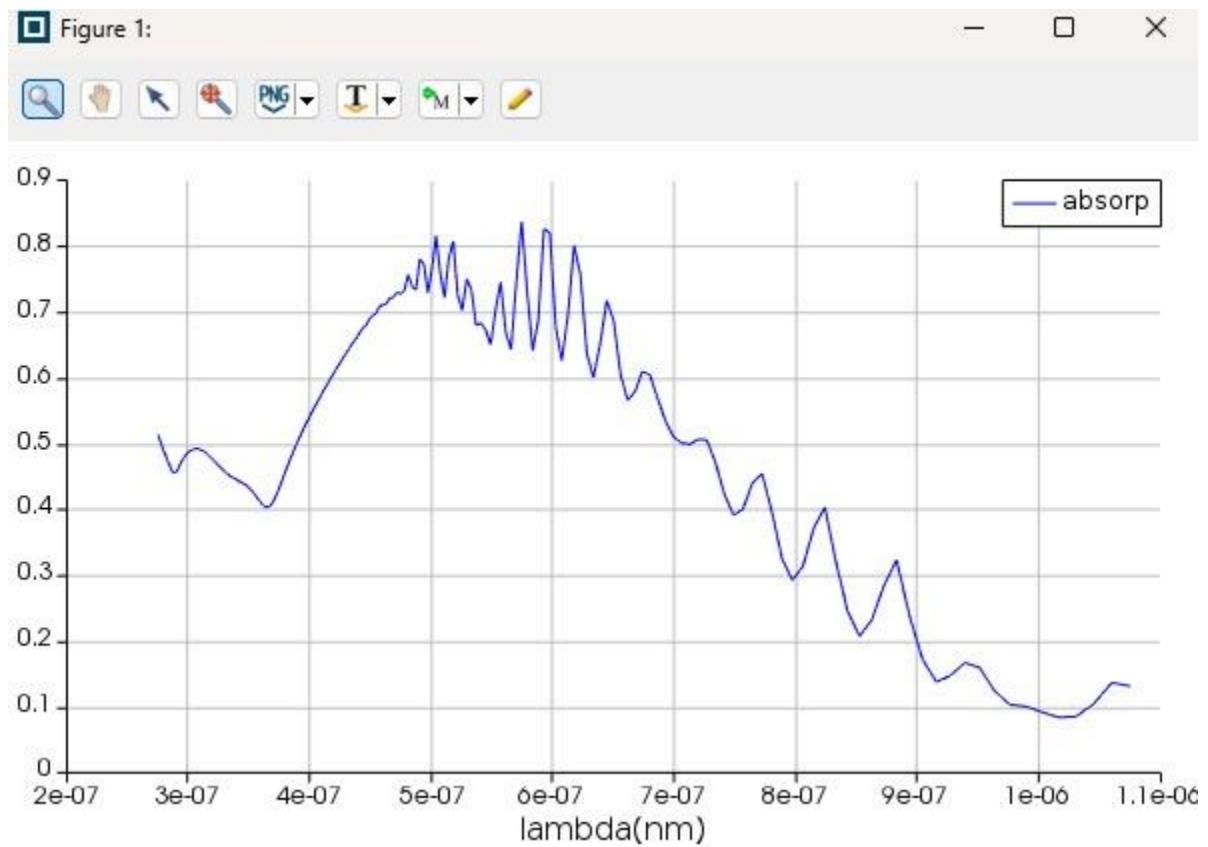
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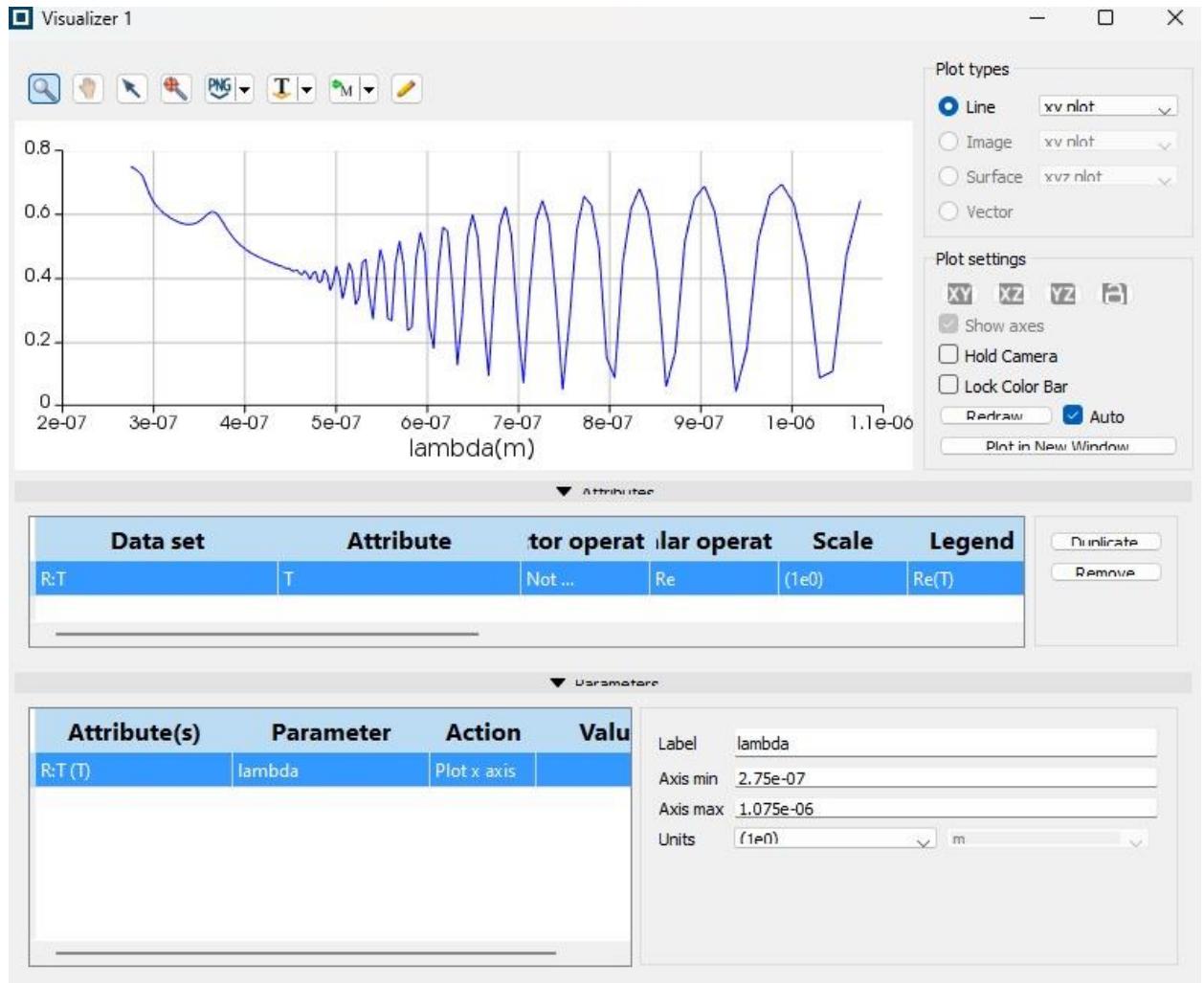
R and T: T

Absorption:
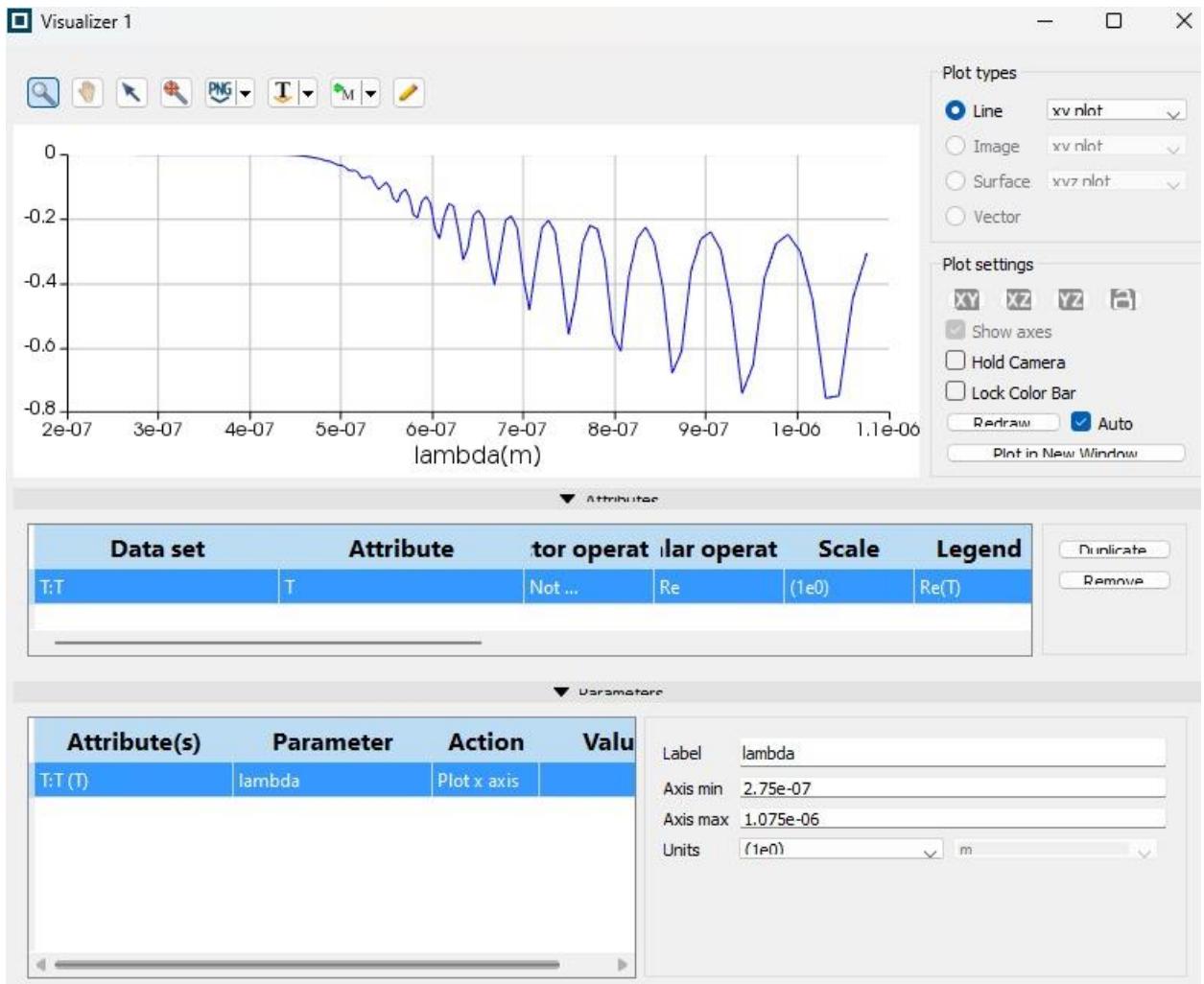
Wavelength 675 nm (without Arc & Dielectric mirrors):

Reflectance: T
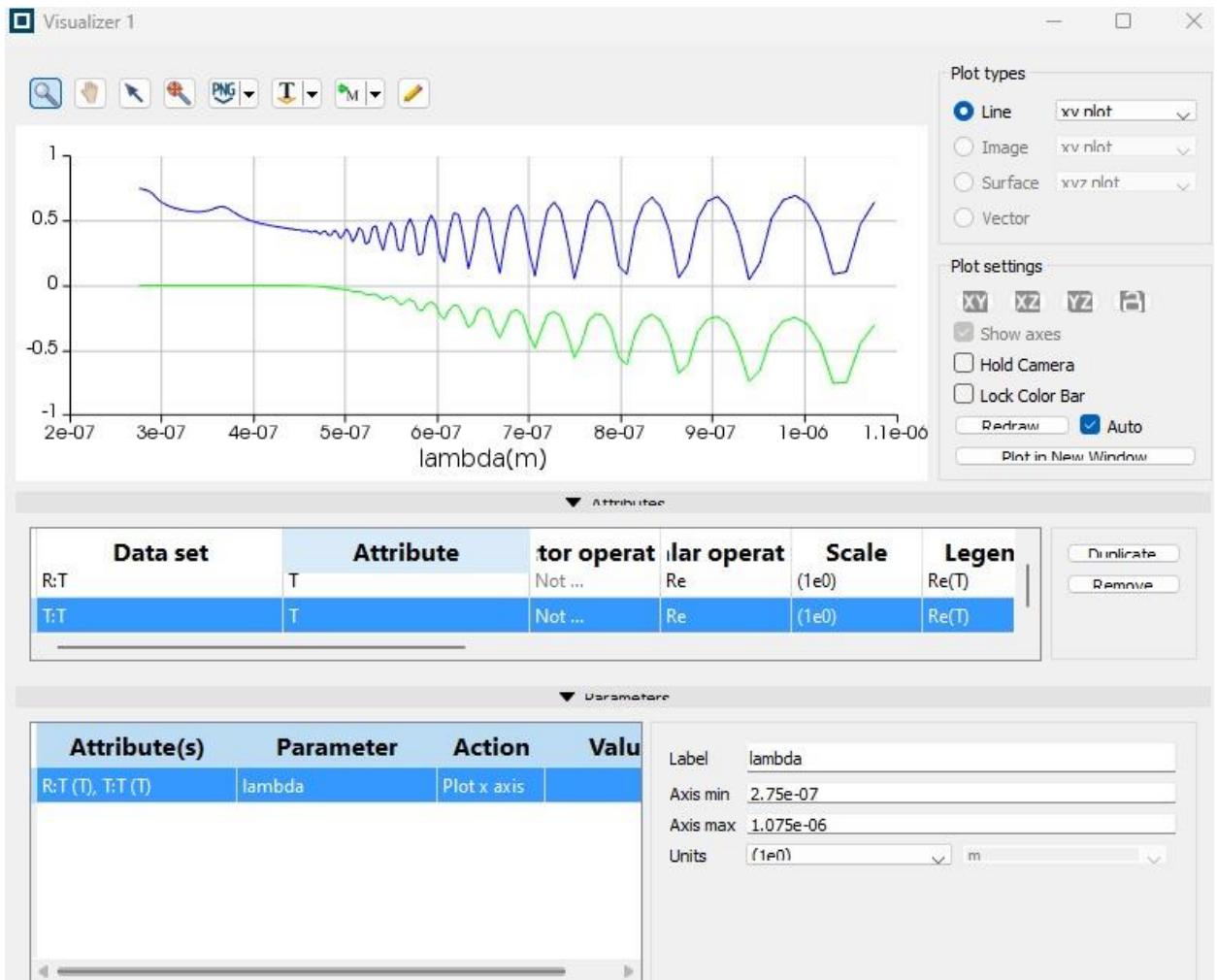
Transmittance: T
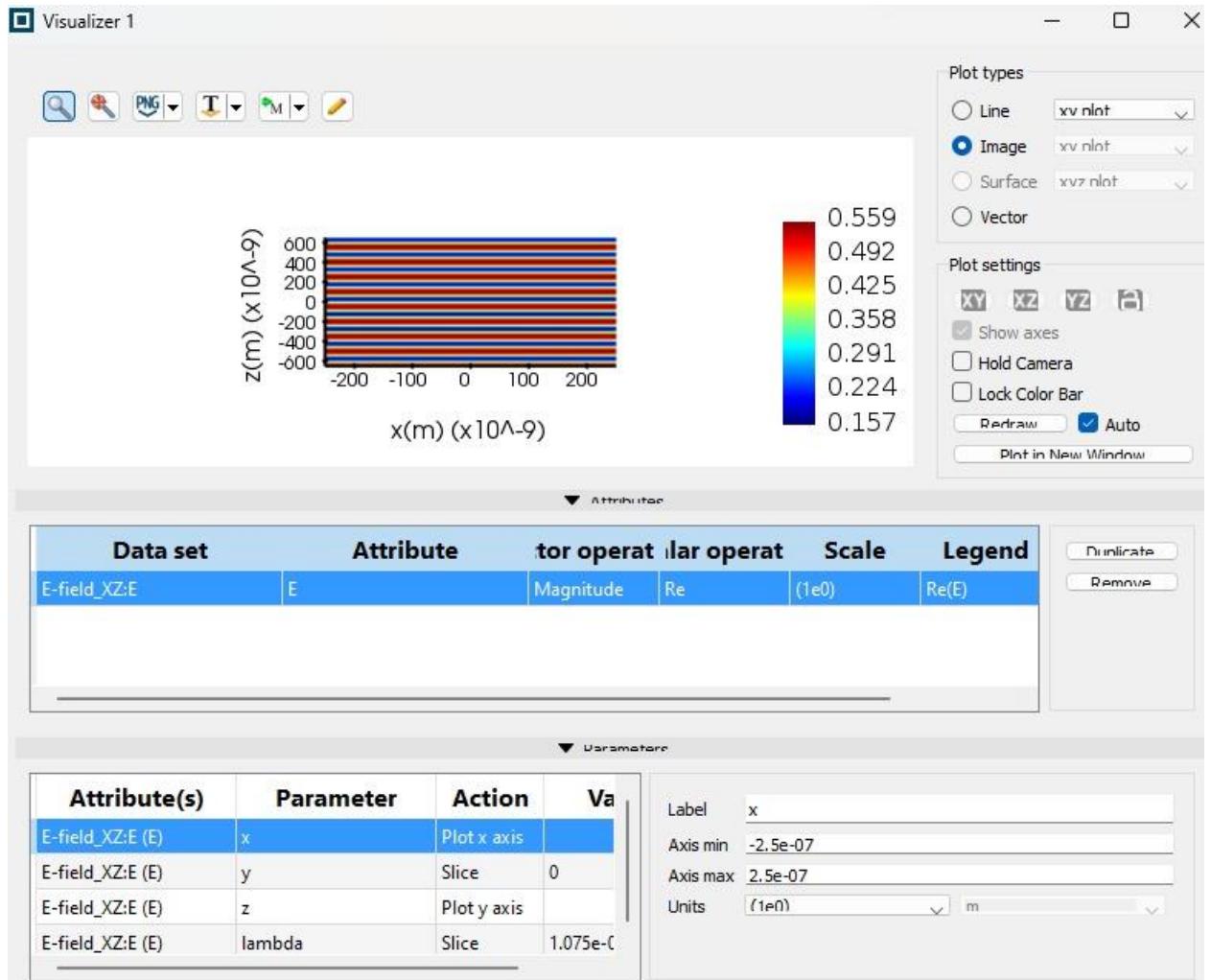
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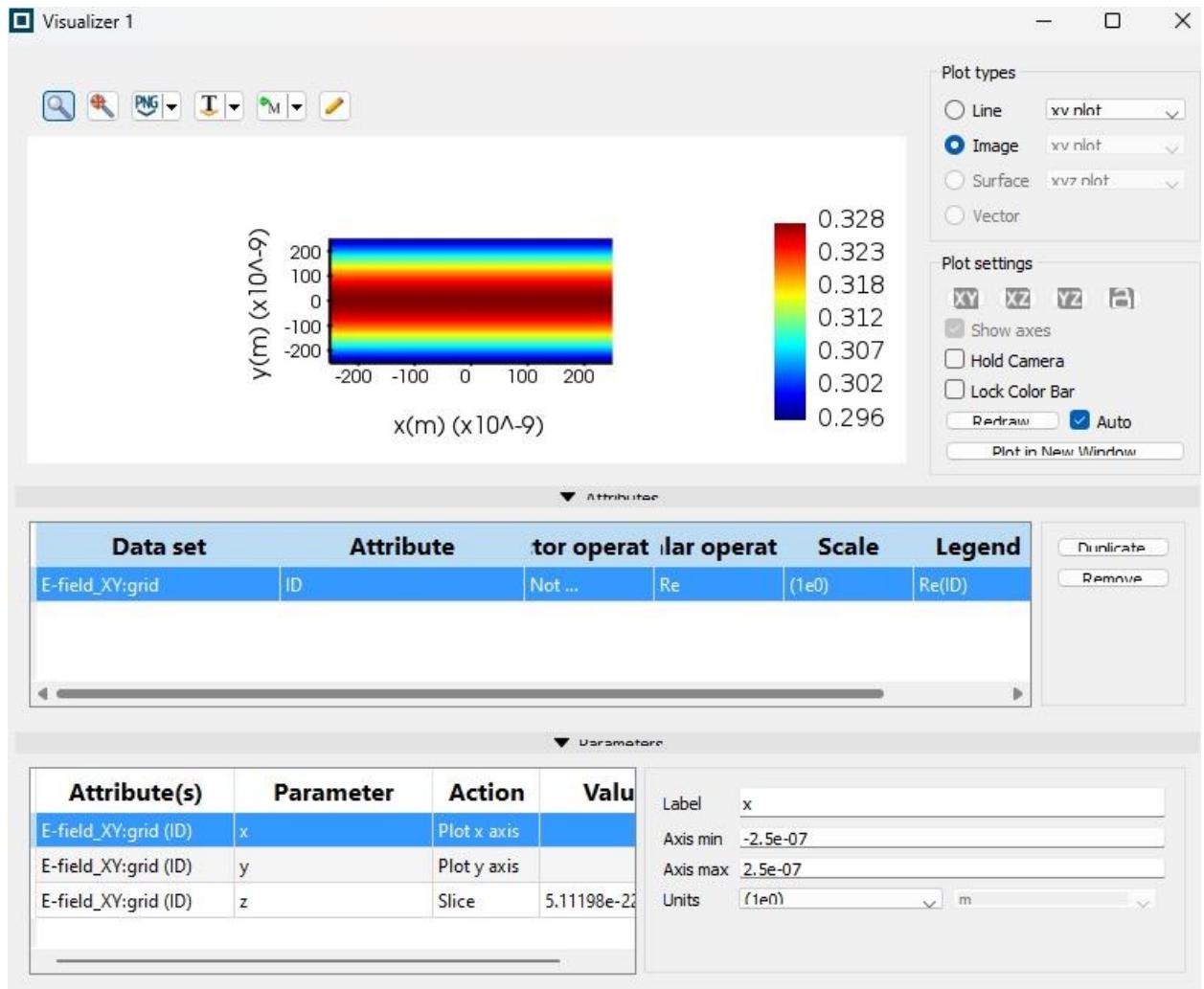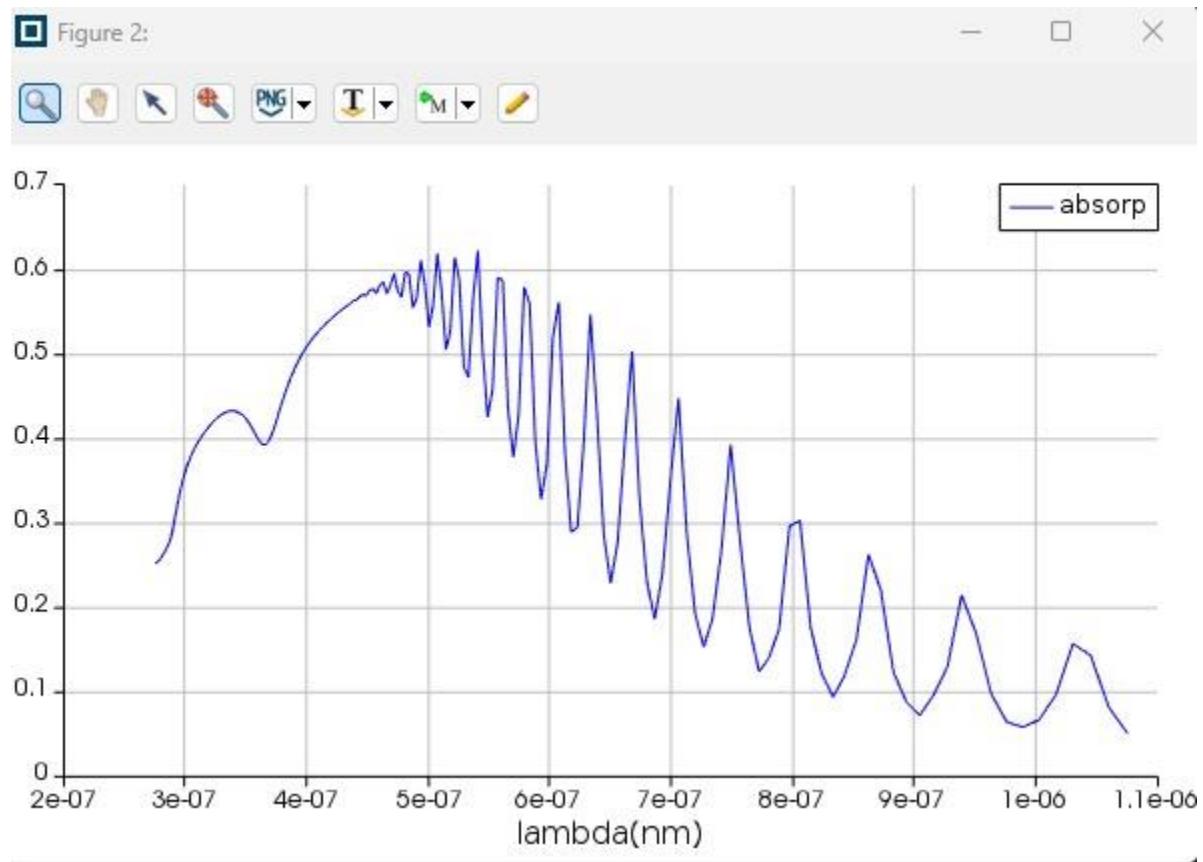
R and T: T

E field XZ:
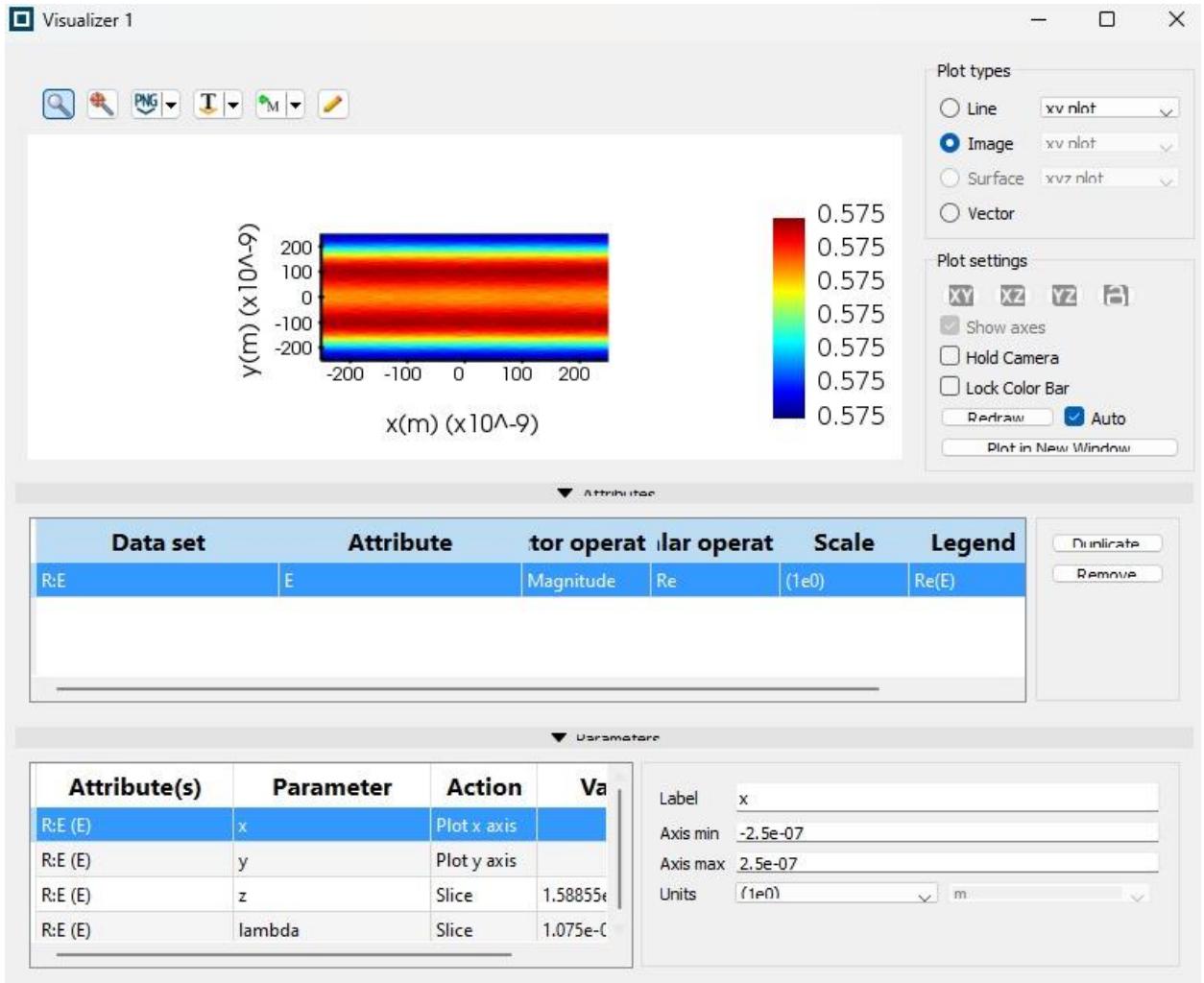
E field XY:
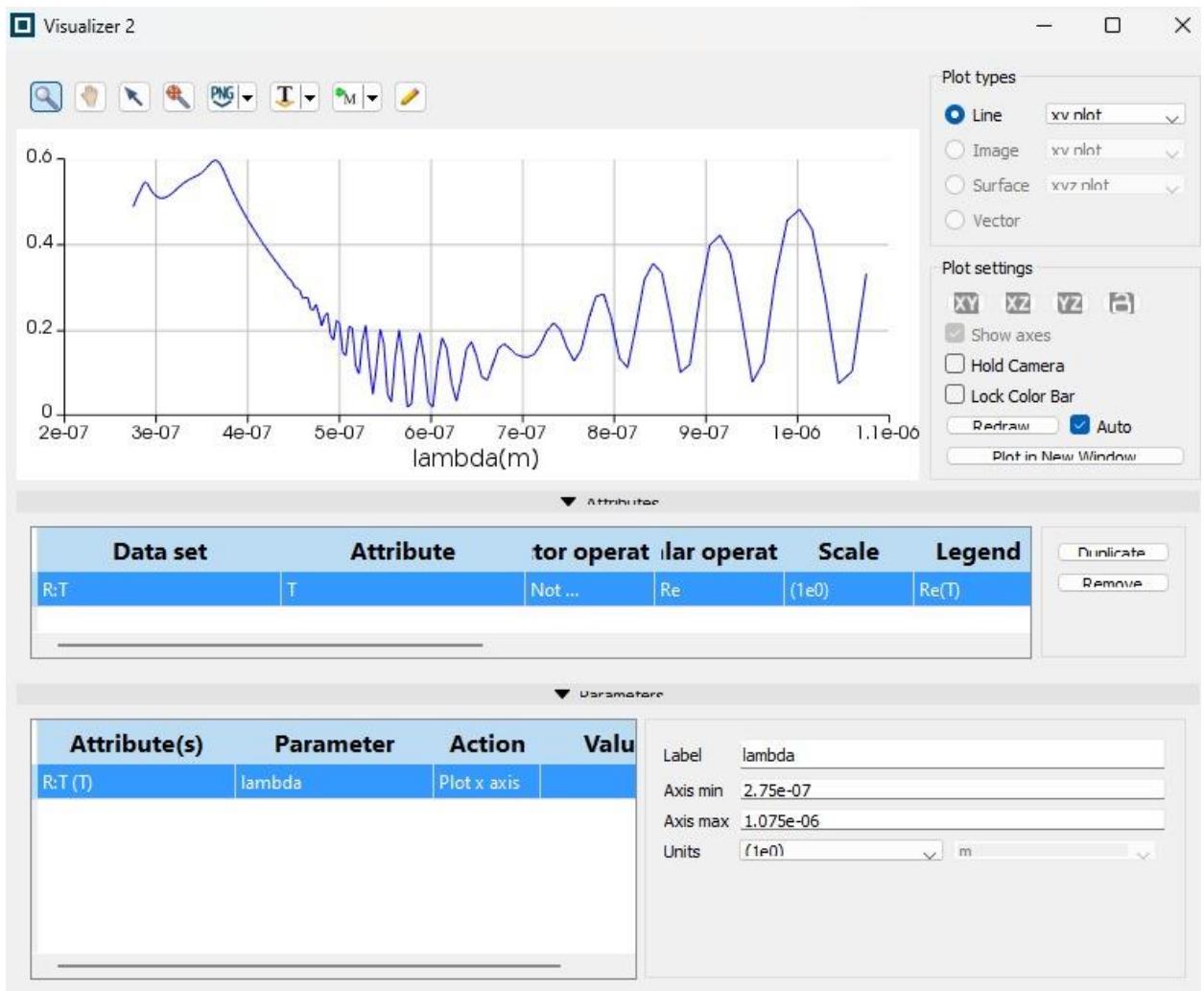
Absorption:

Wavelength of 675 nm (with ARC only):

R:E

R:T

T:E

T:T
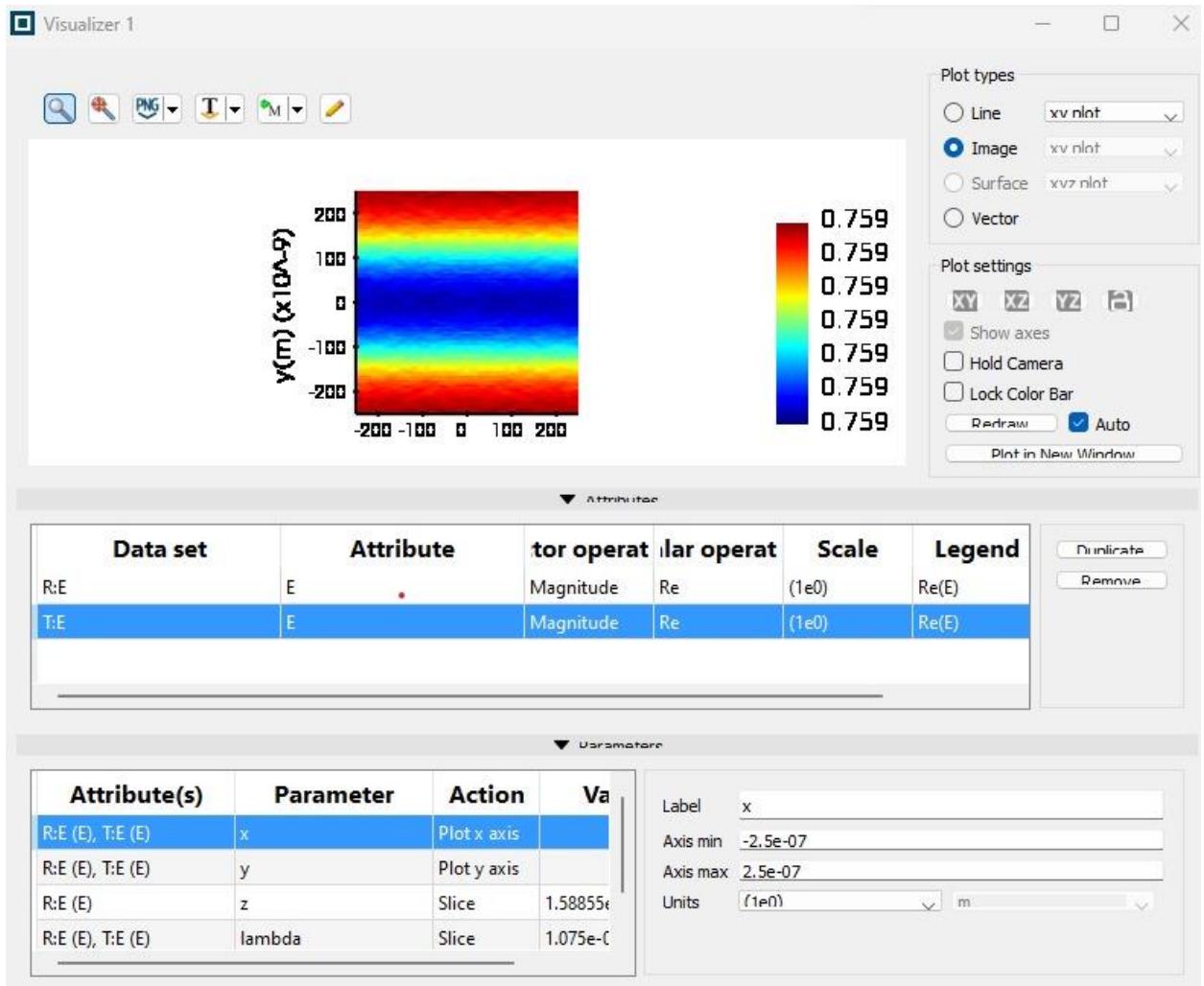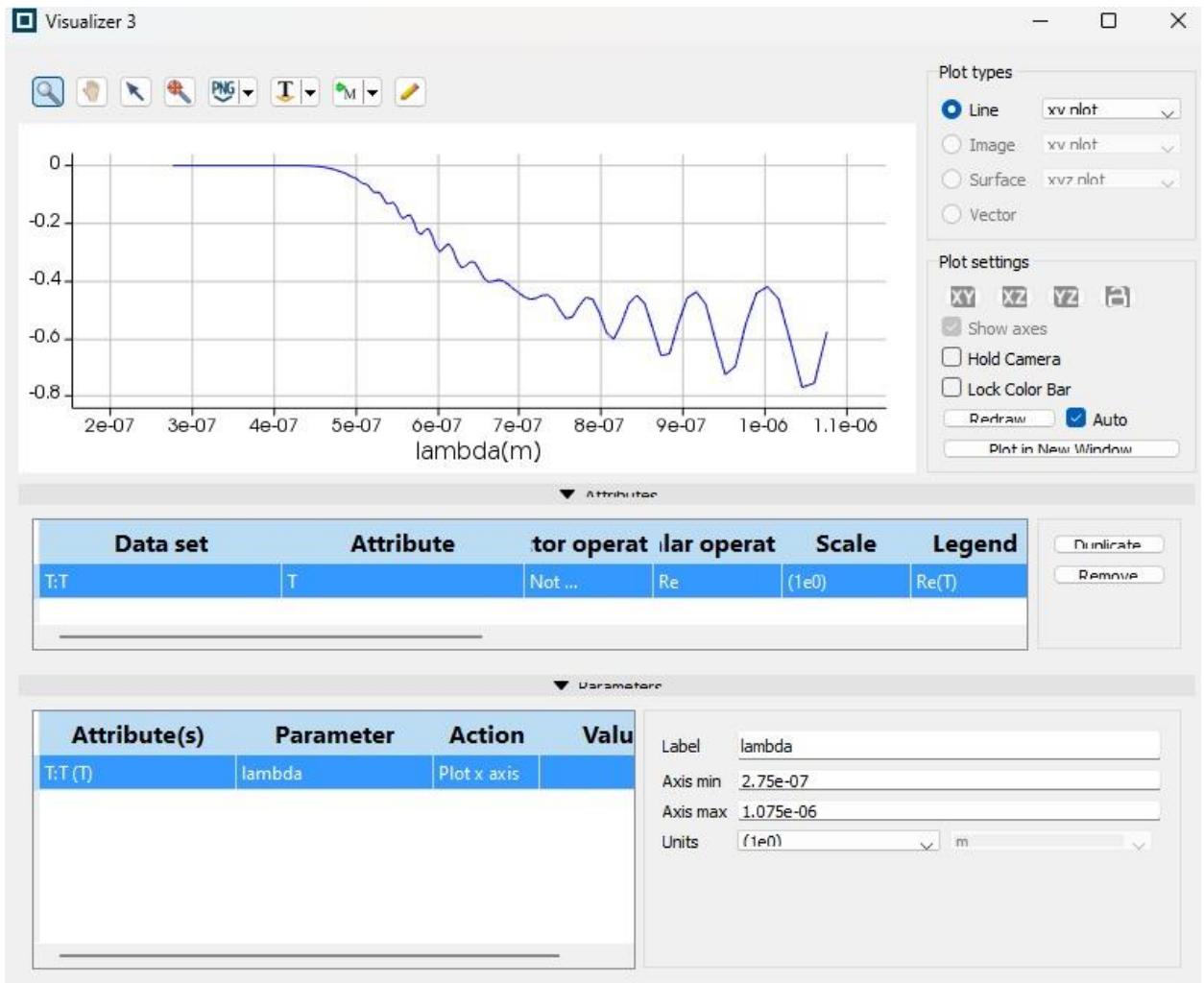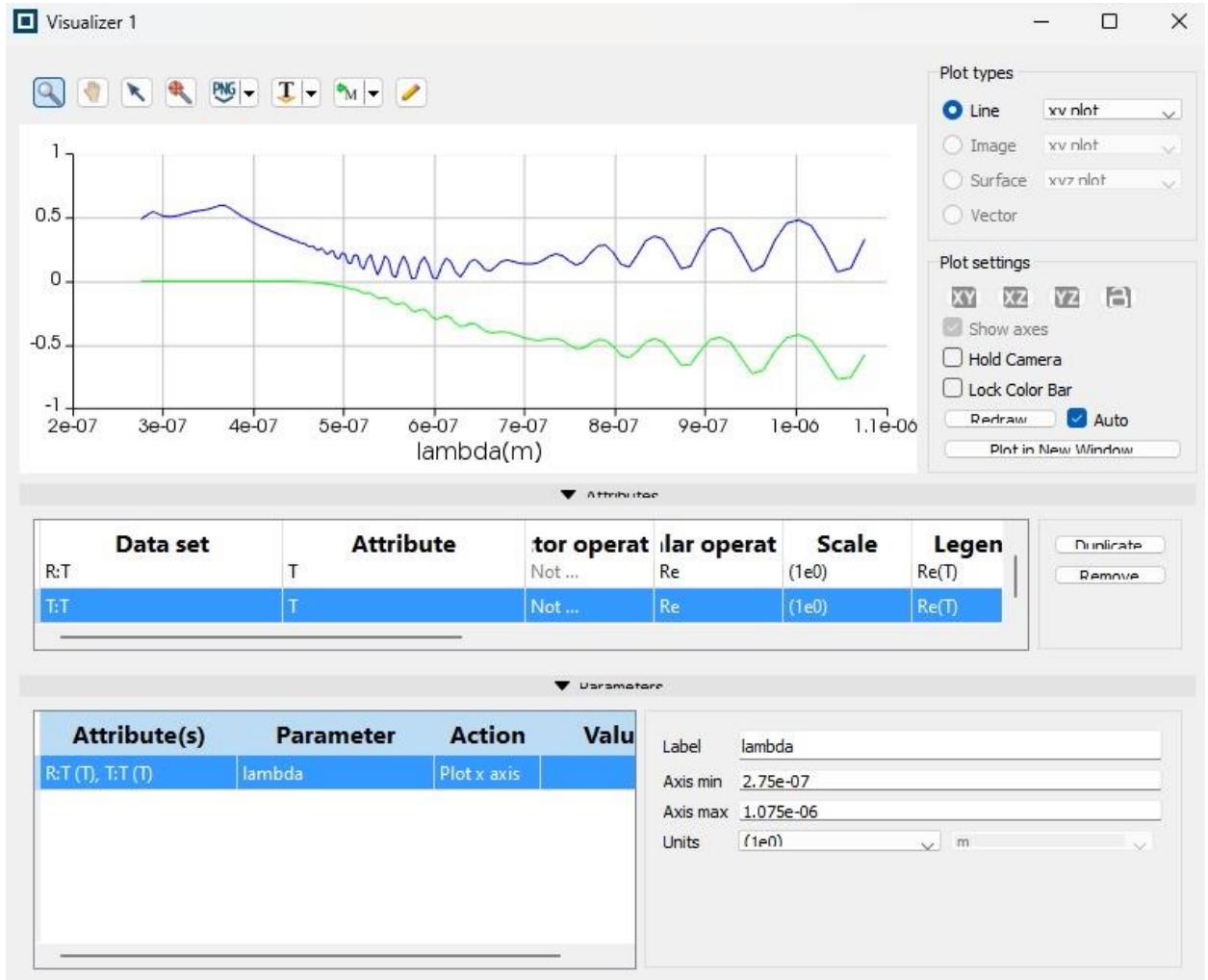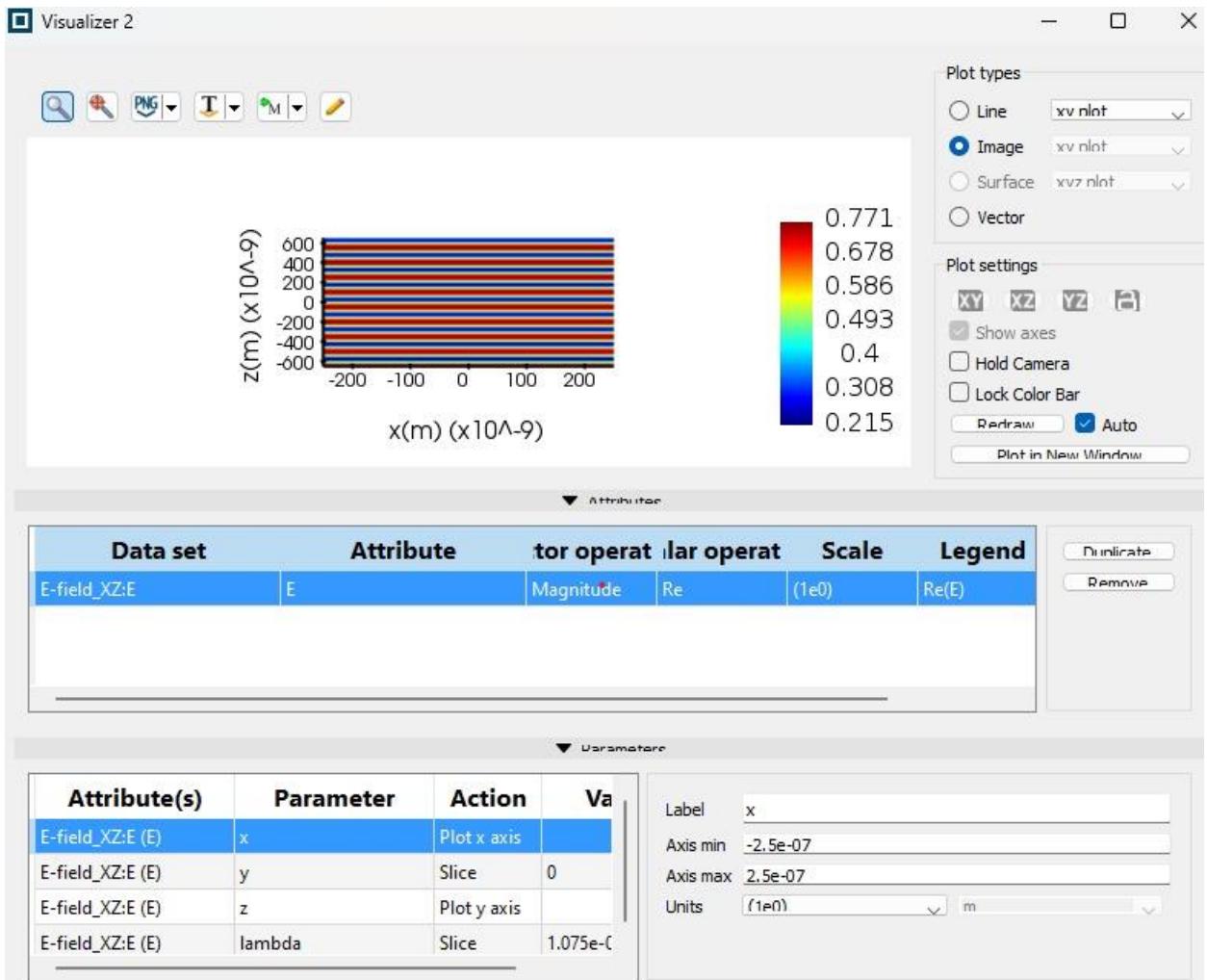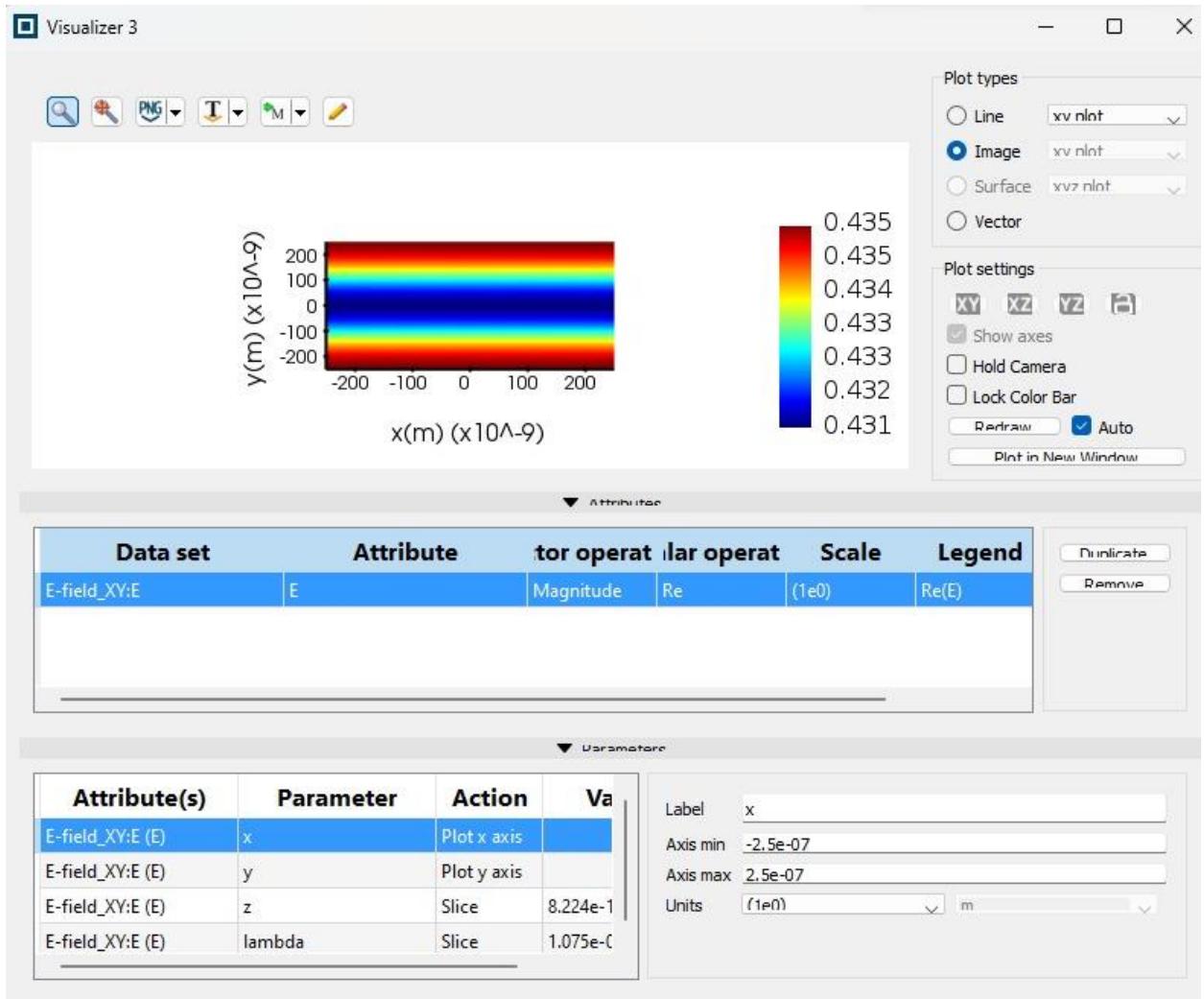
Compare between R & T Graphs:
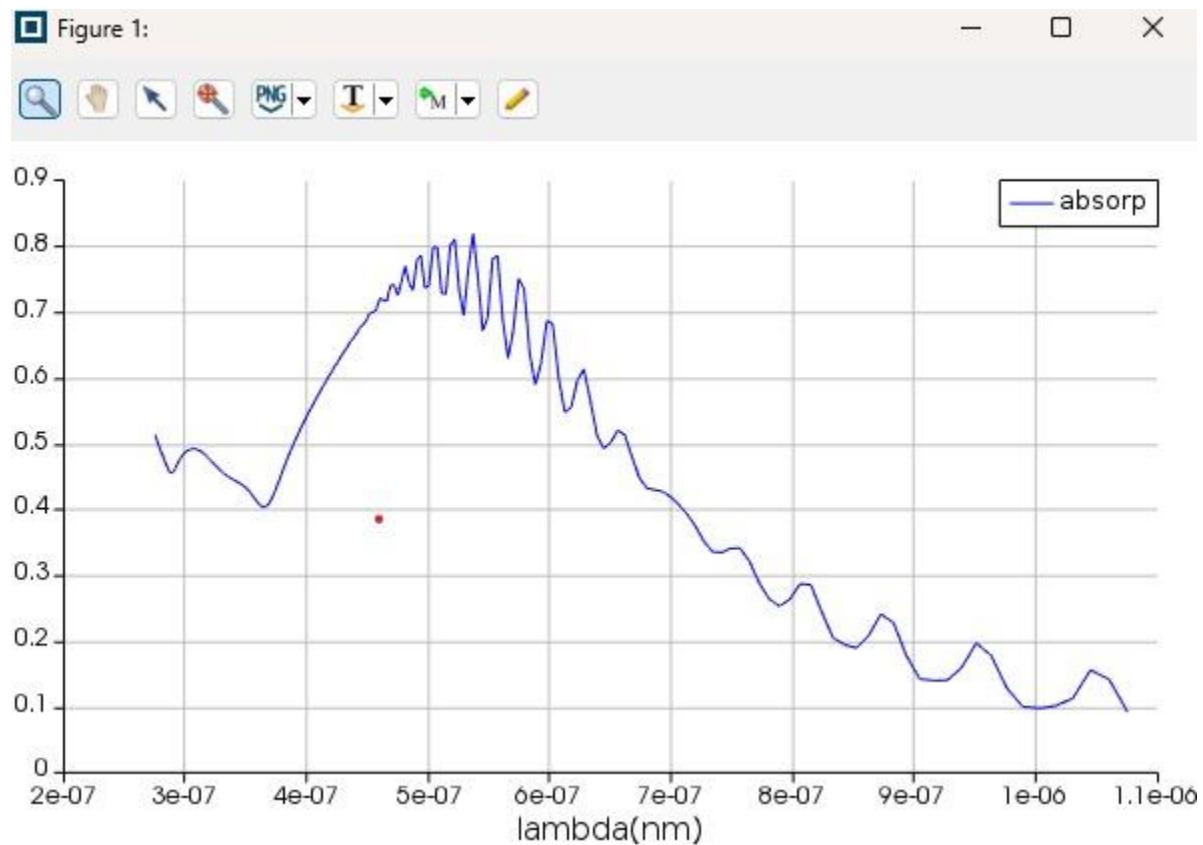
E Field XZ:
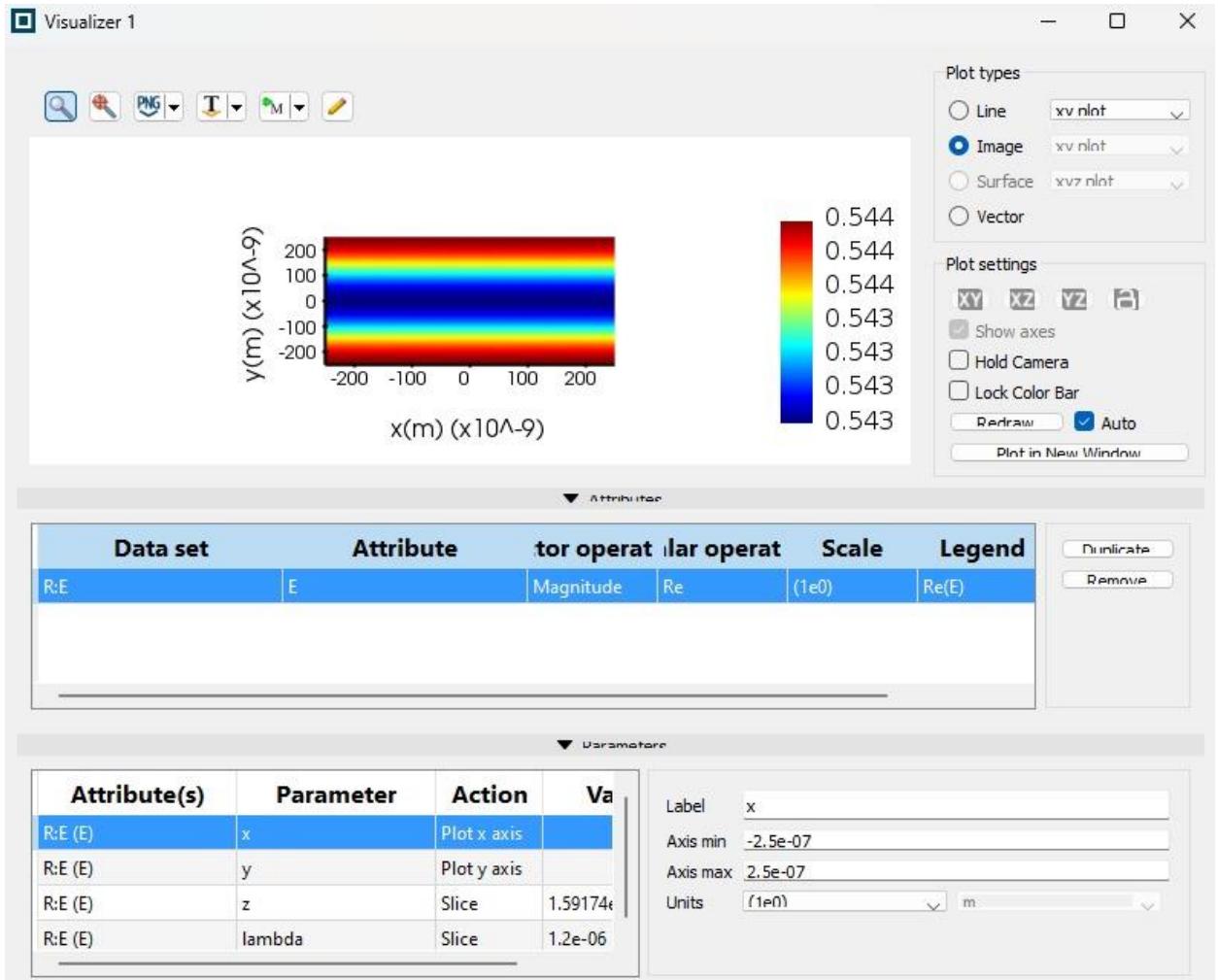
E-field XY:
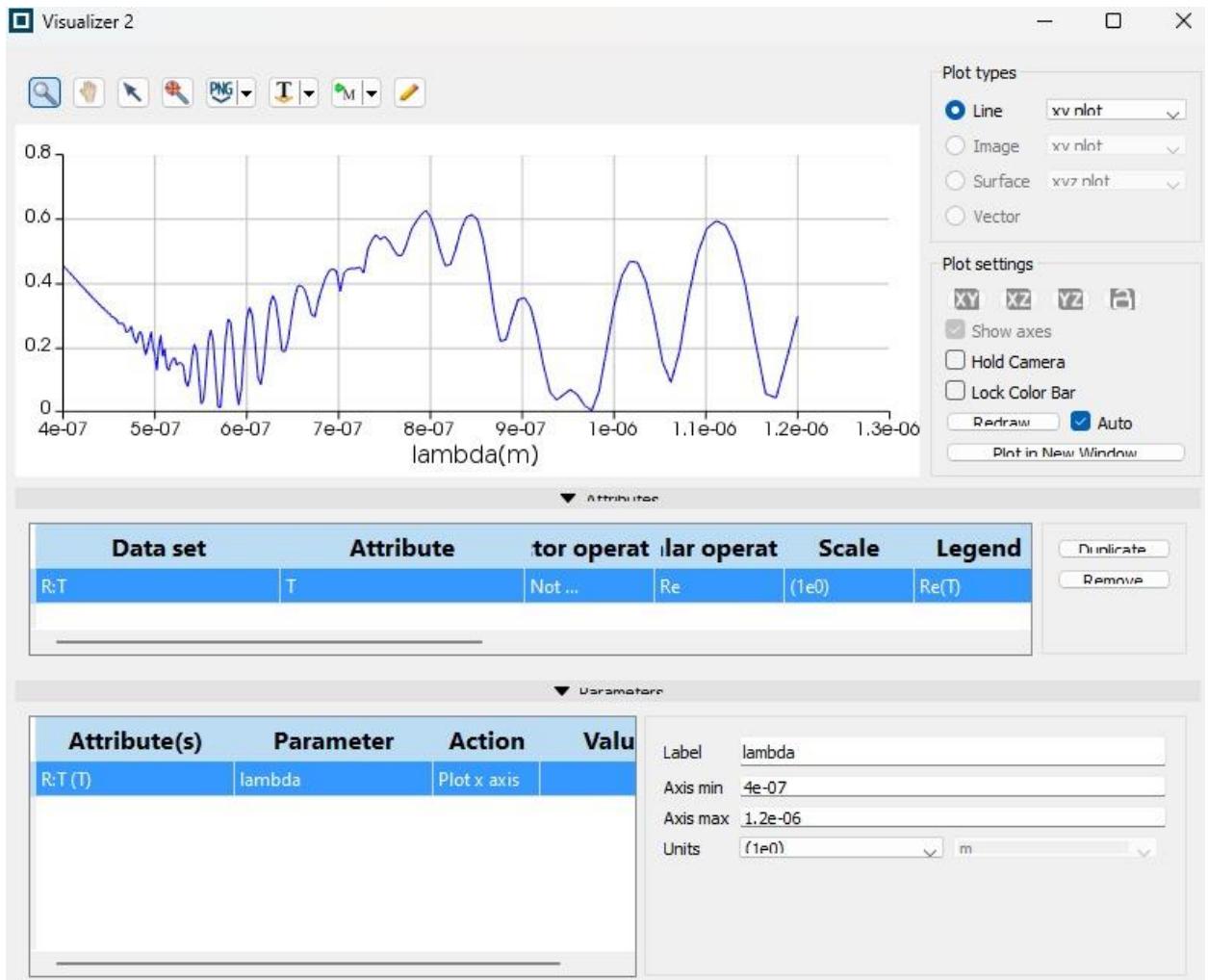
Absorption:

Wavelength of 800 nm (with ARC and Dielectric Mirrors):
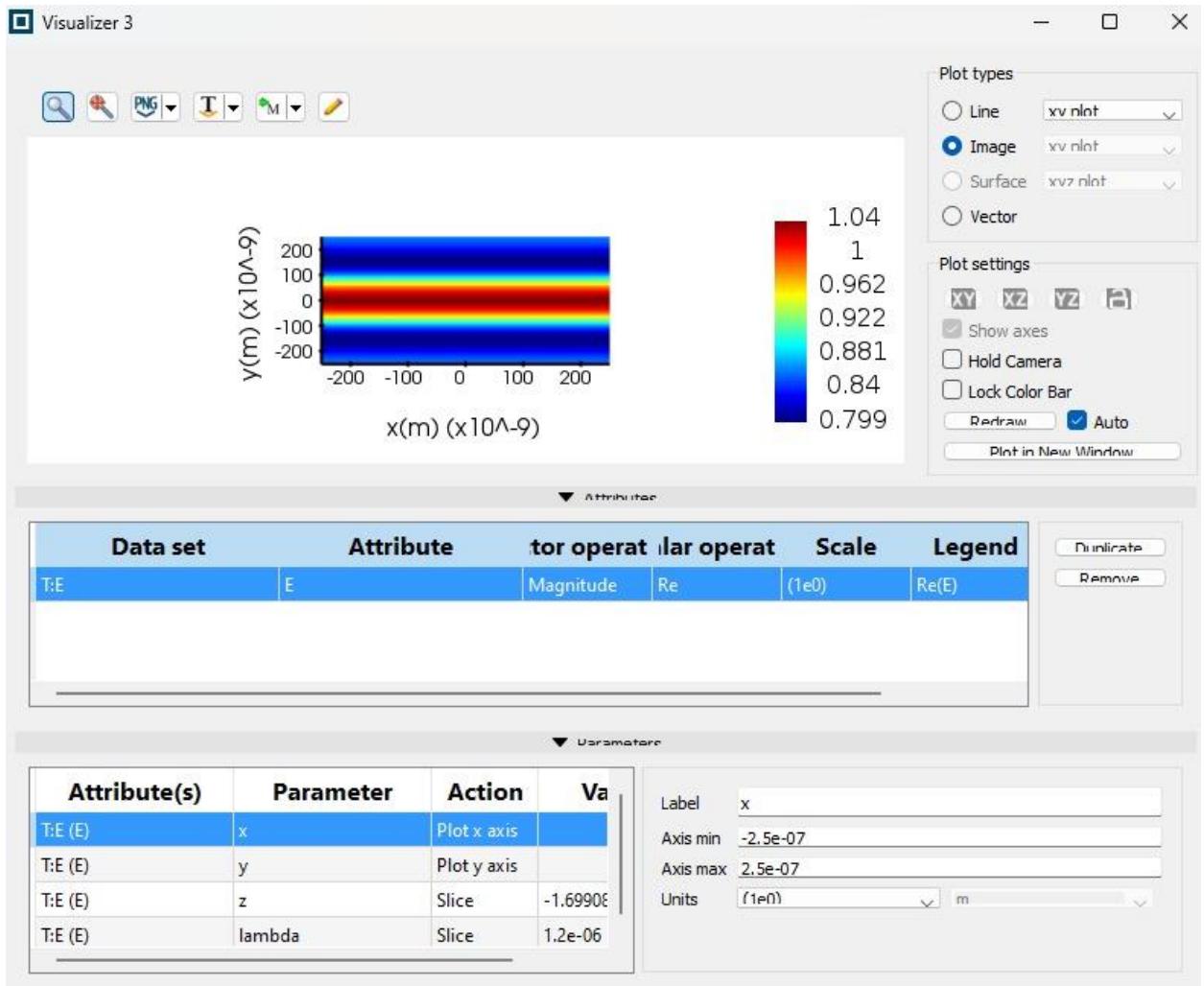
R:E
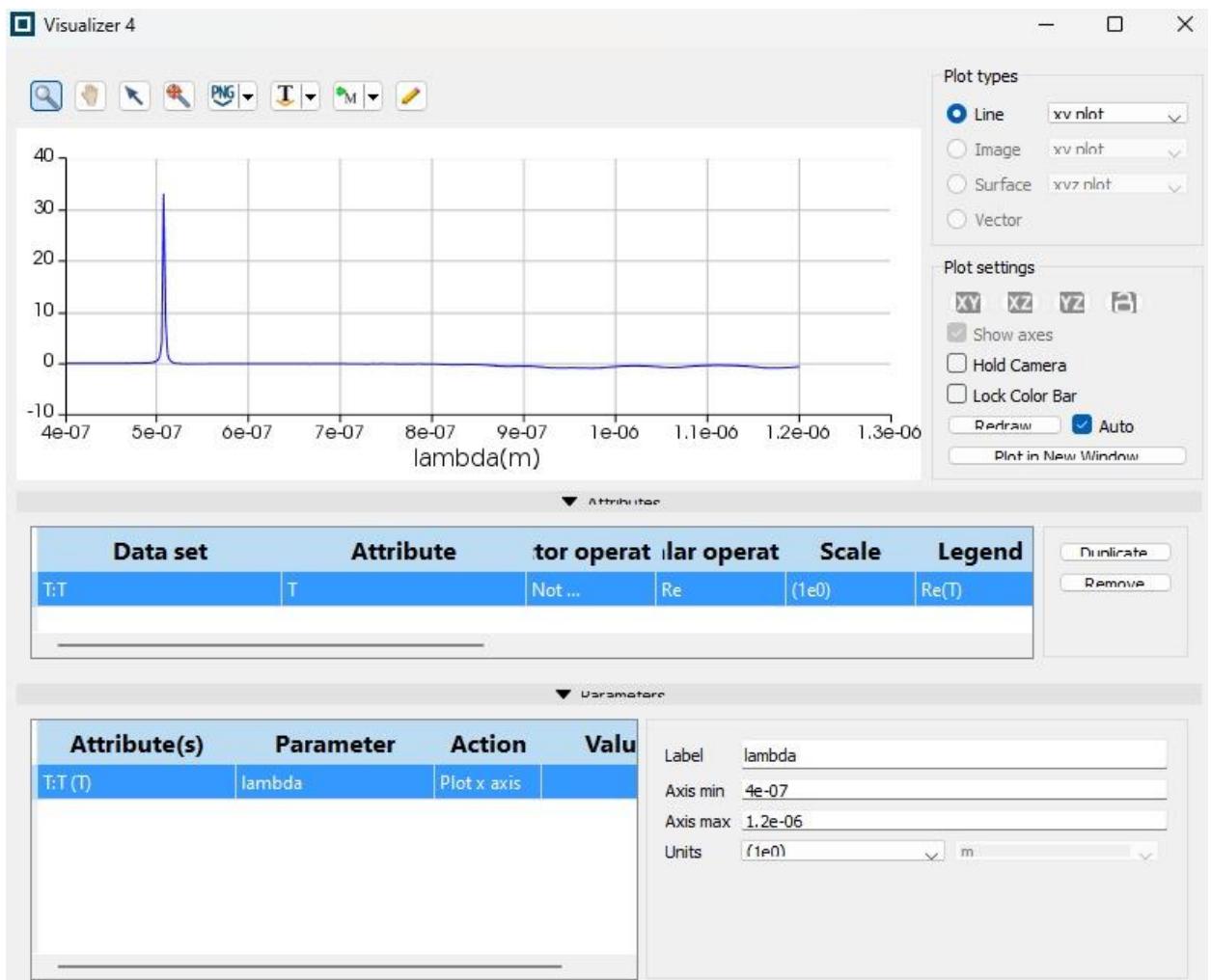
R:T
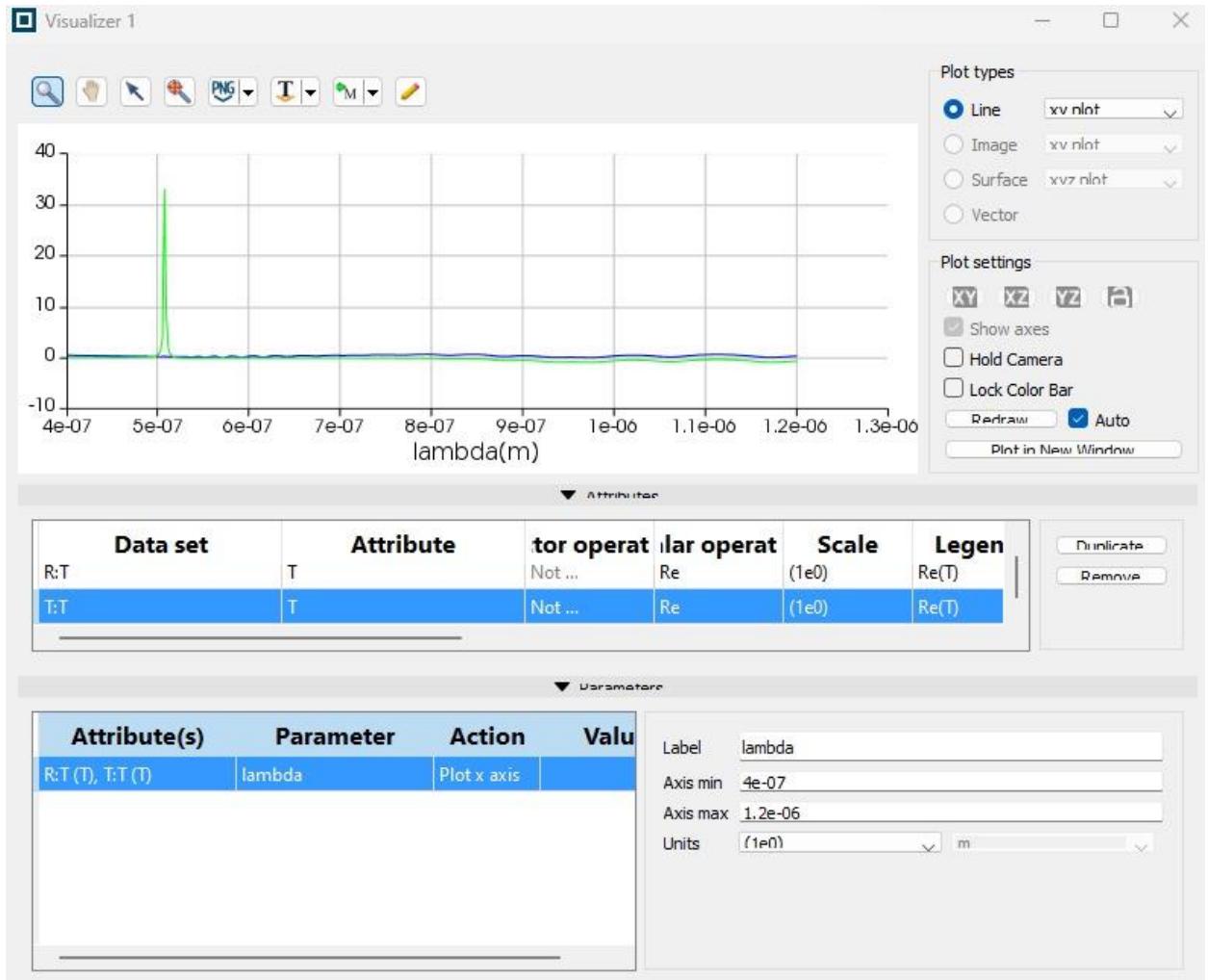
T:E
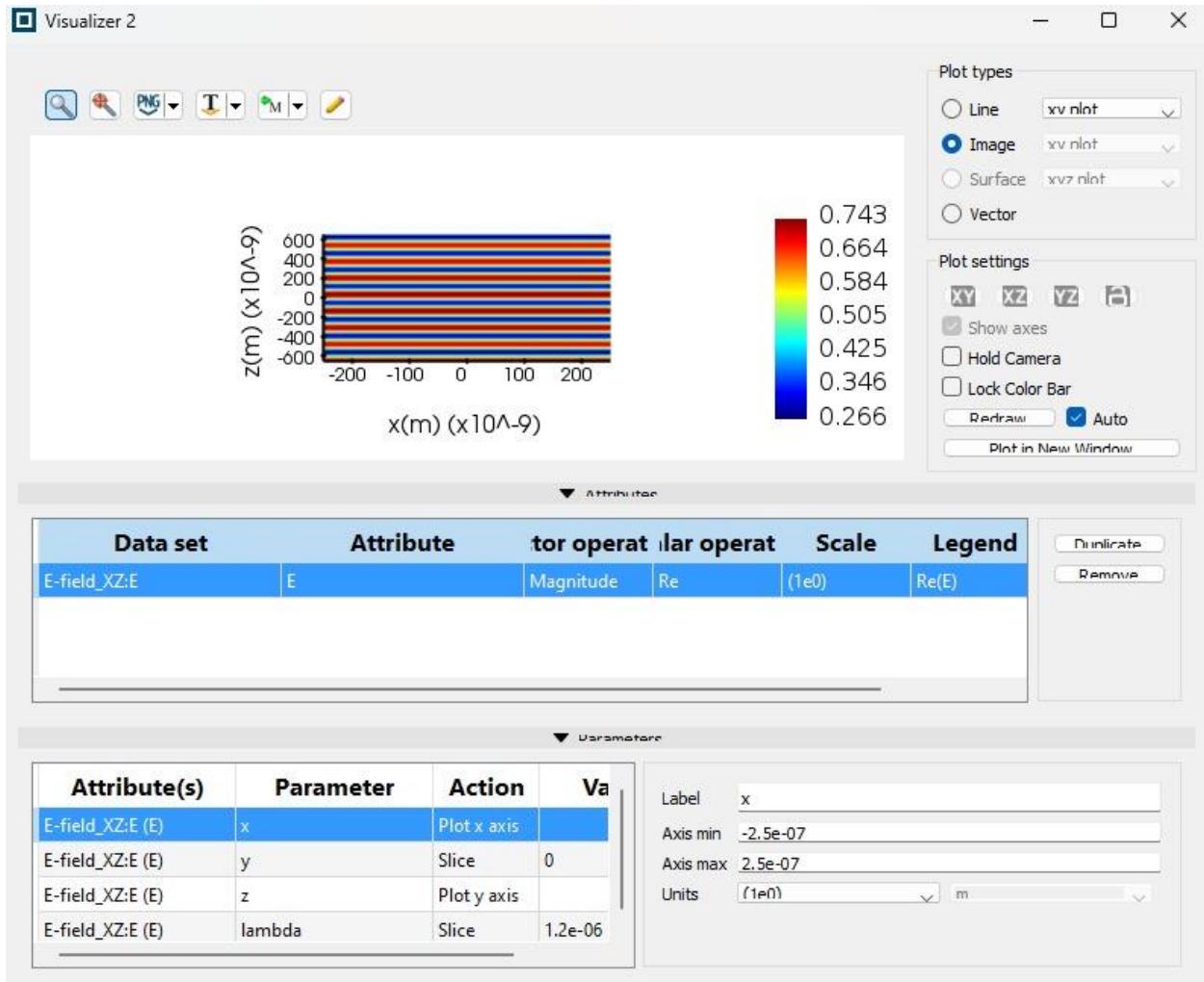
T:T
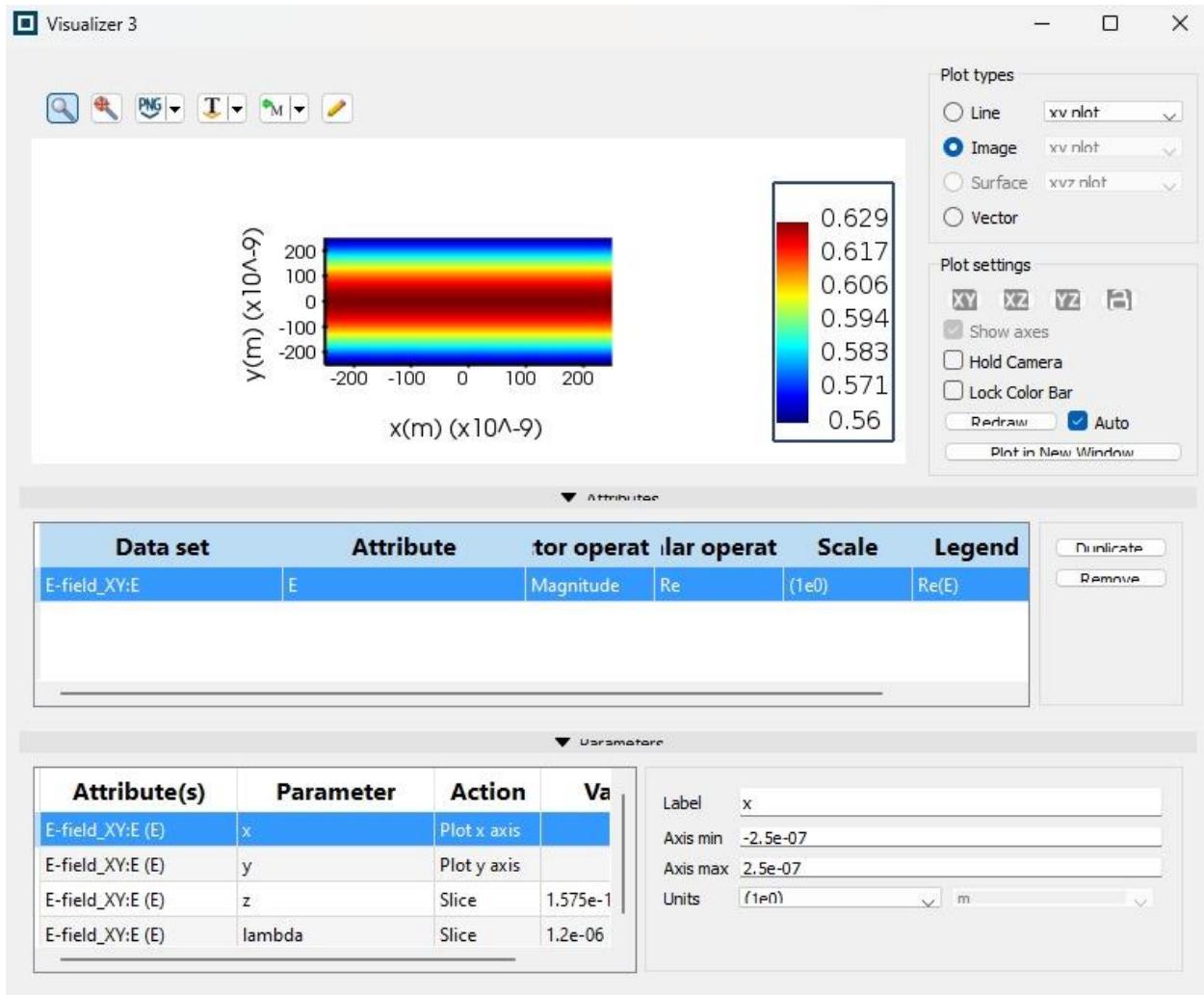
Compare R and T:
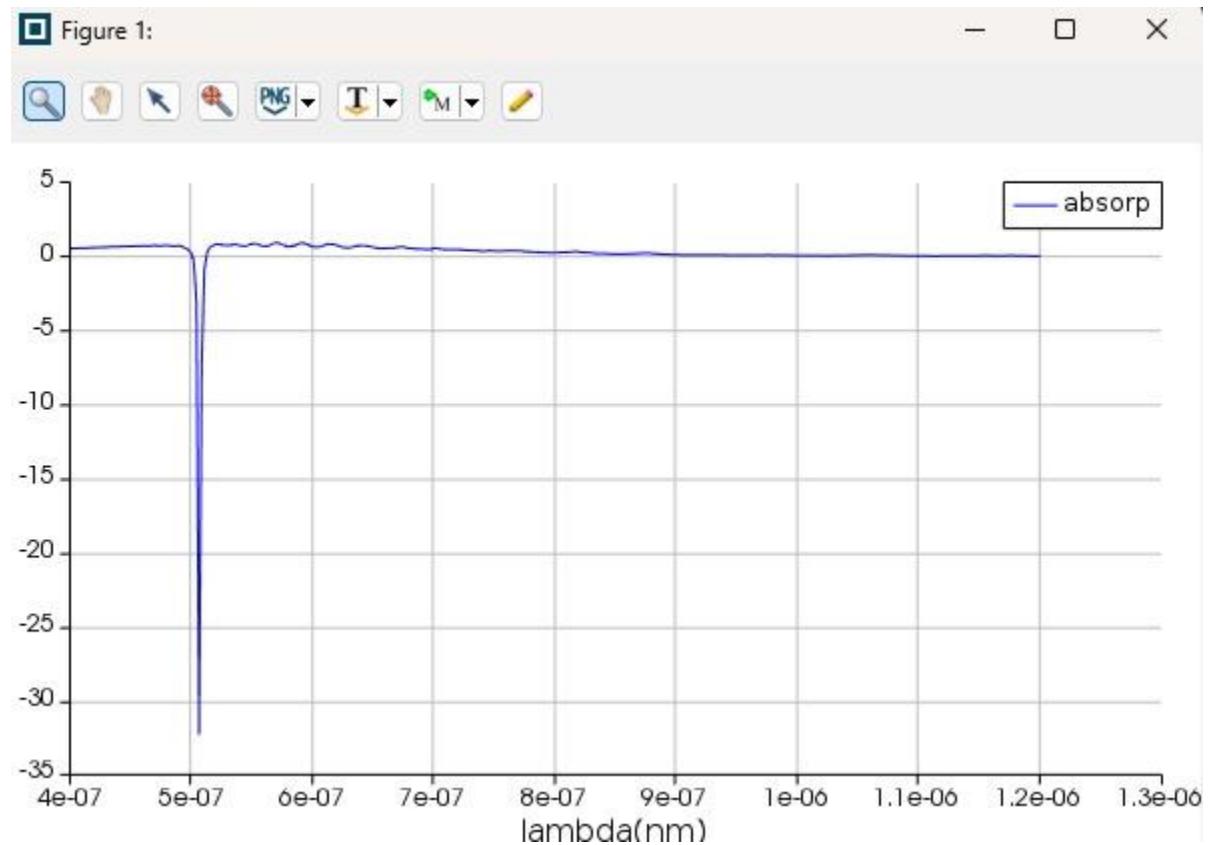
E-Field XZ:

E-Field XY:
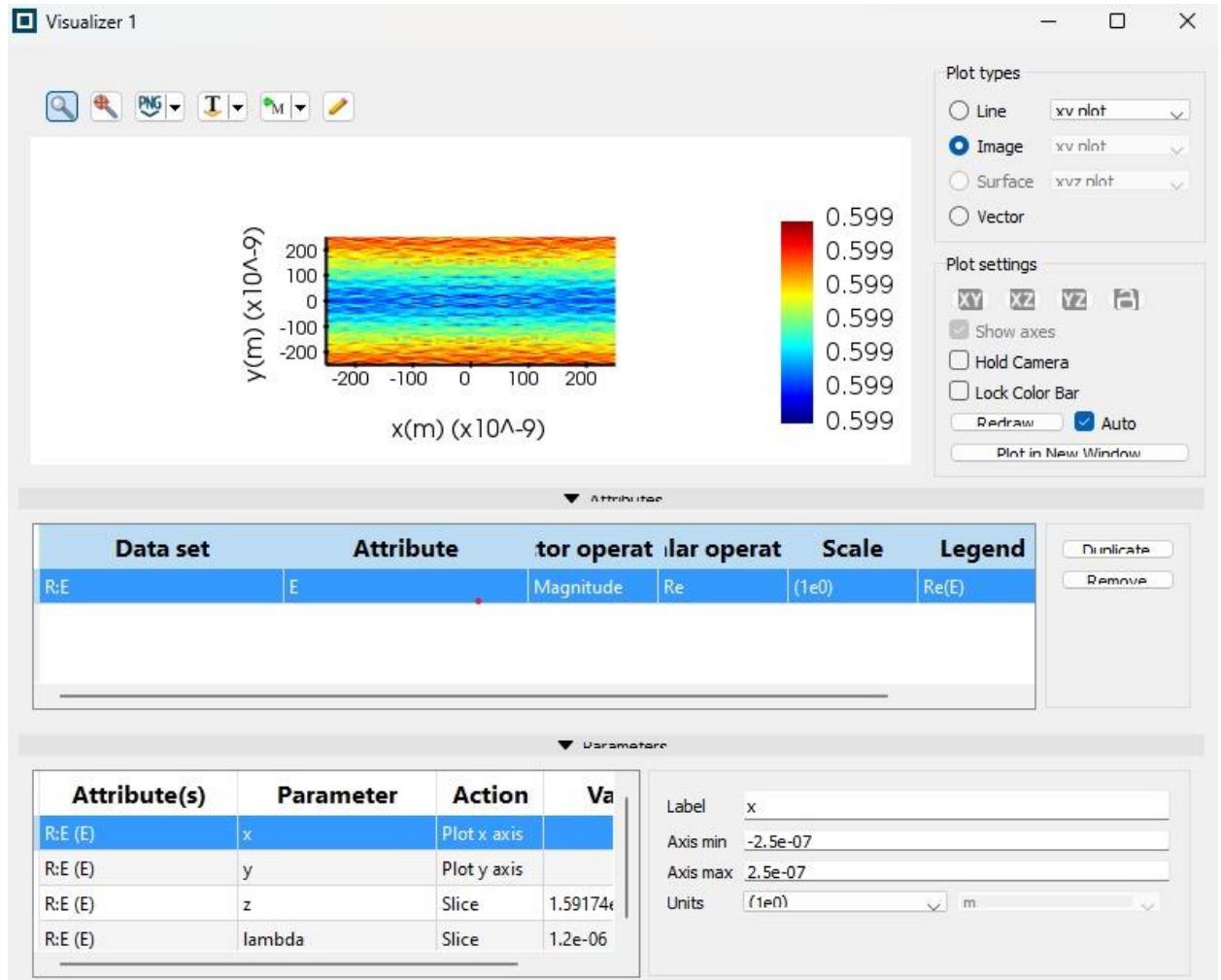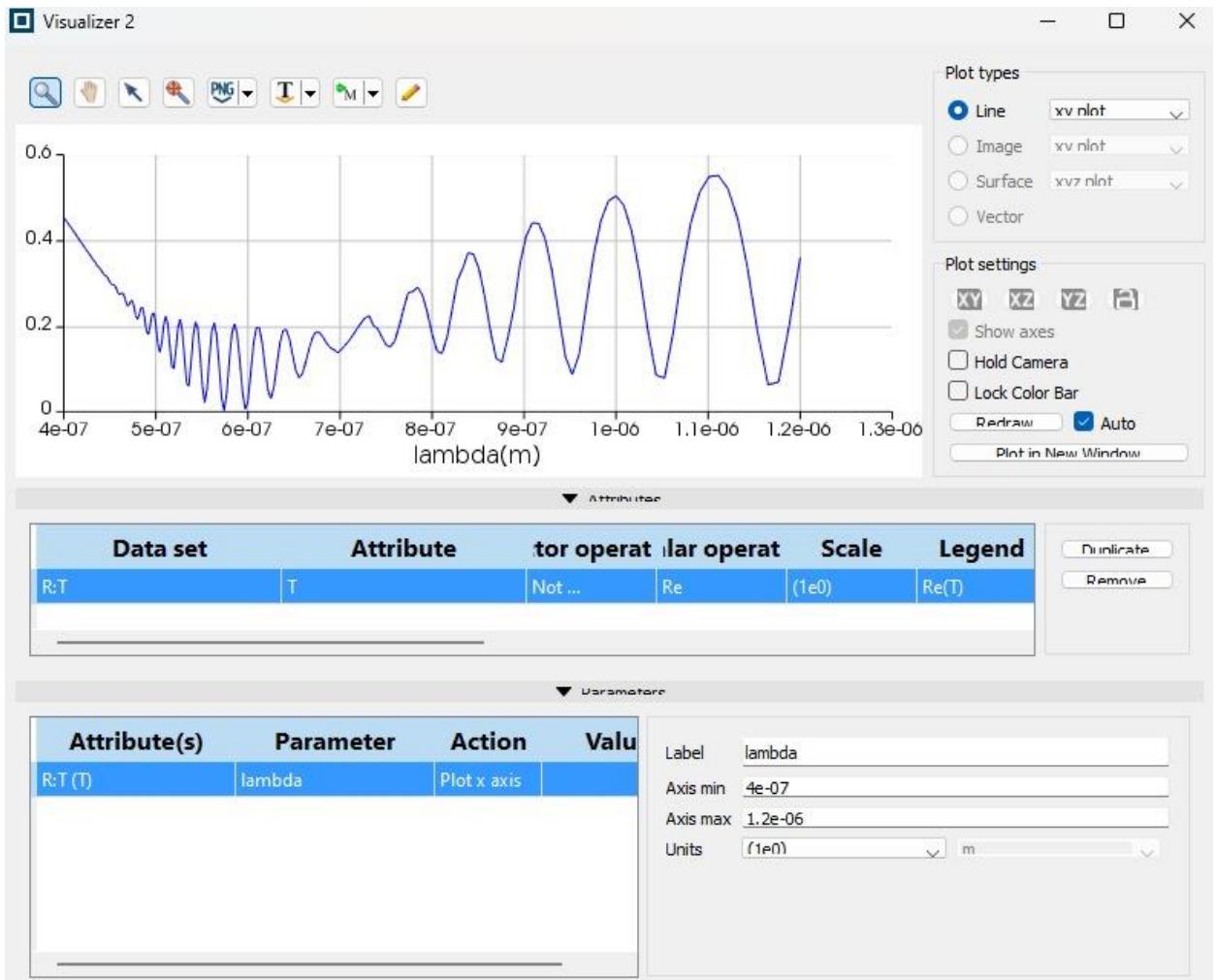
Absorption:

Wavelength of 800 nm (with ARC only):

R:E

R:T

T:E

T:T
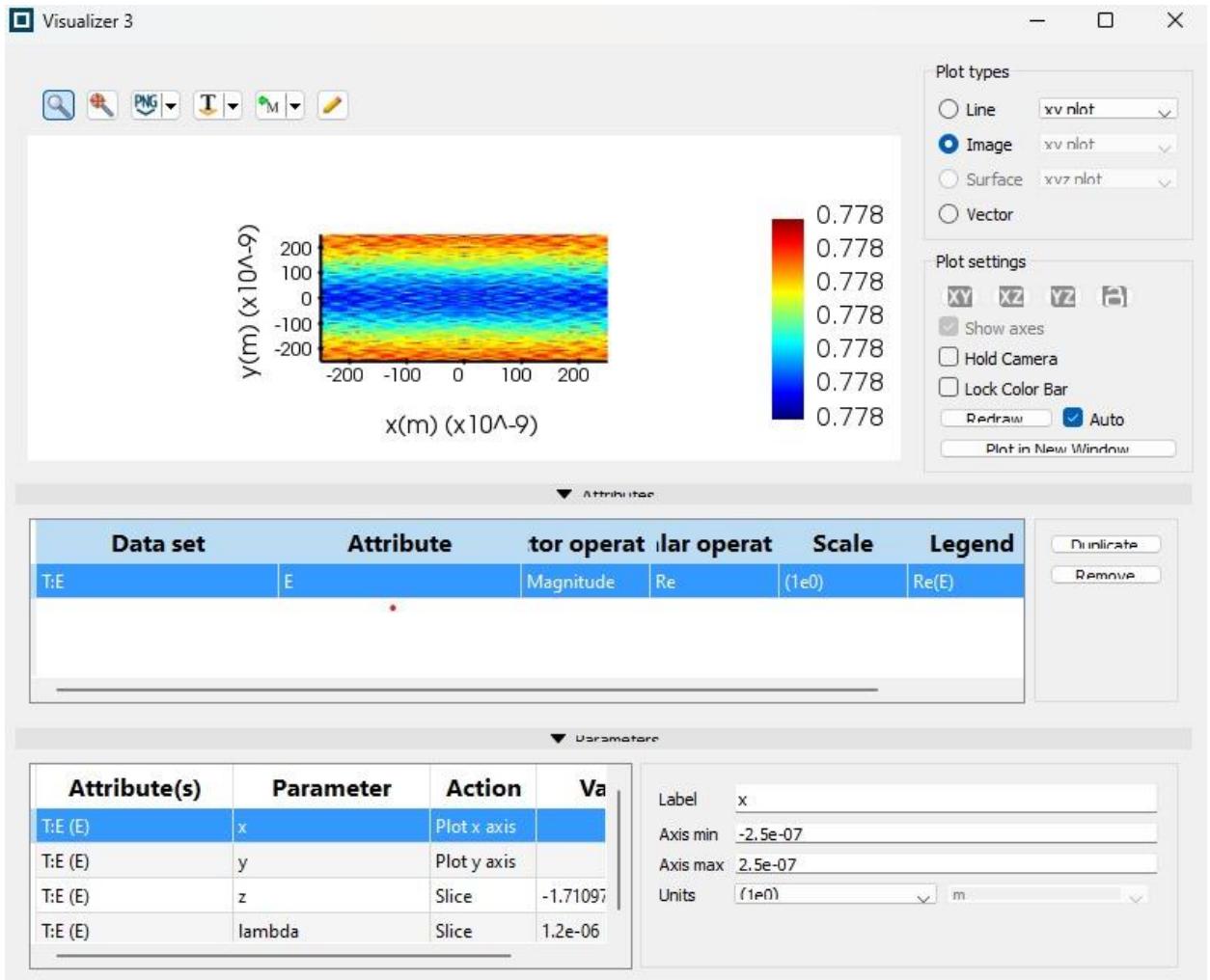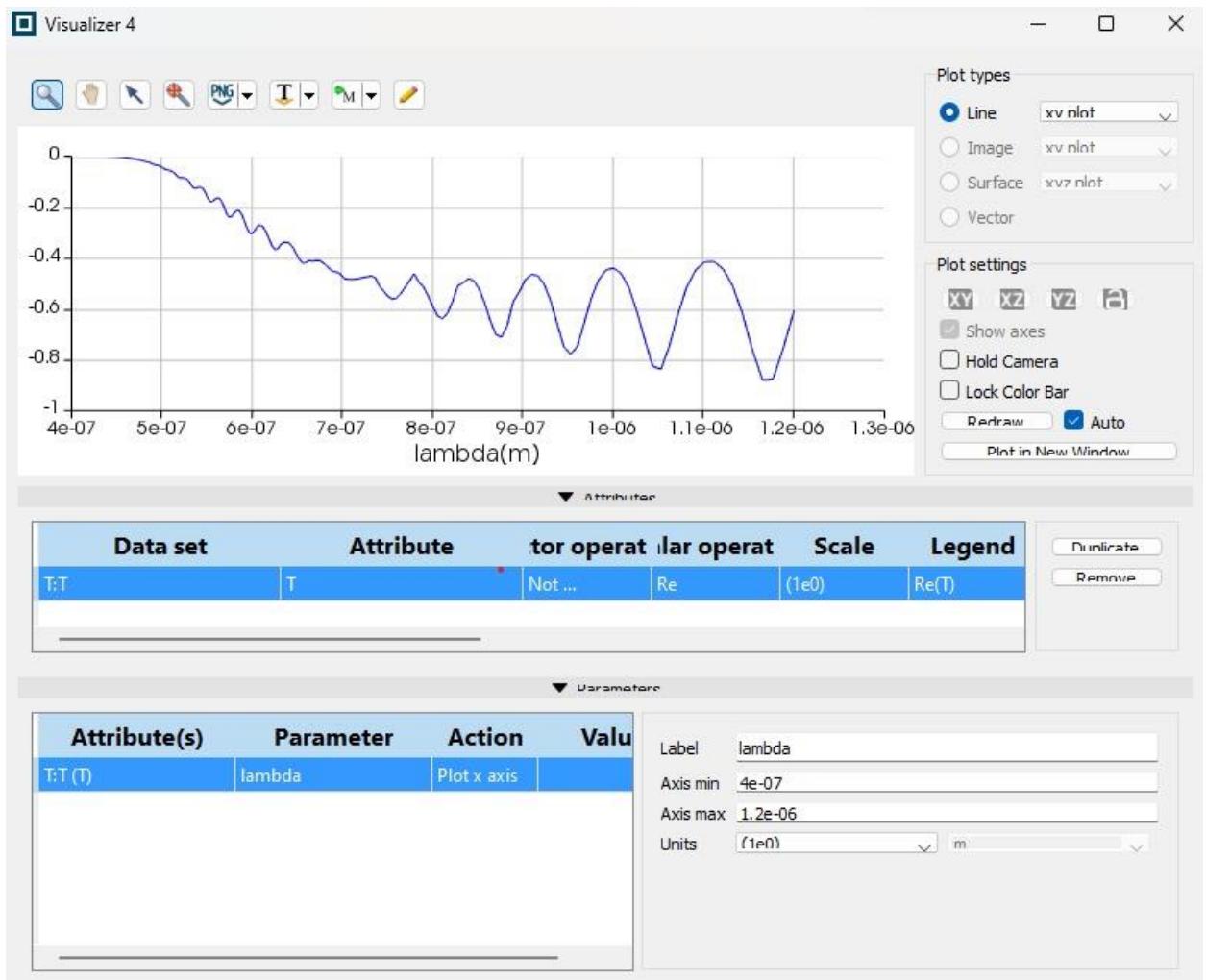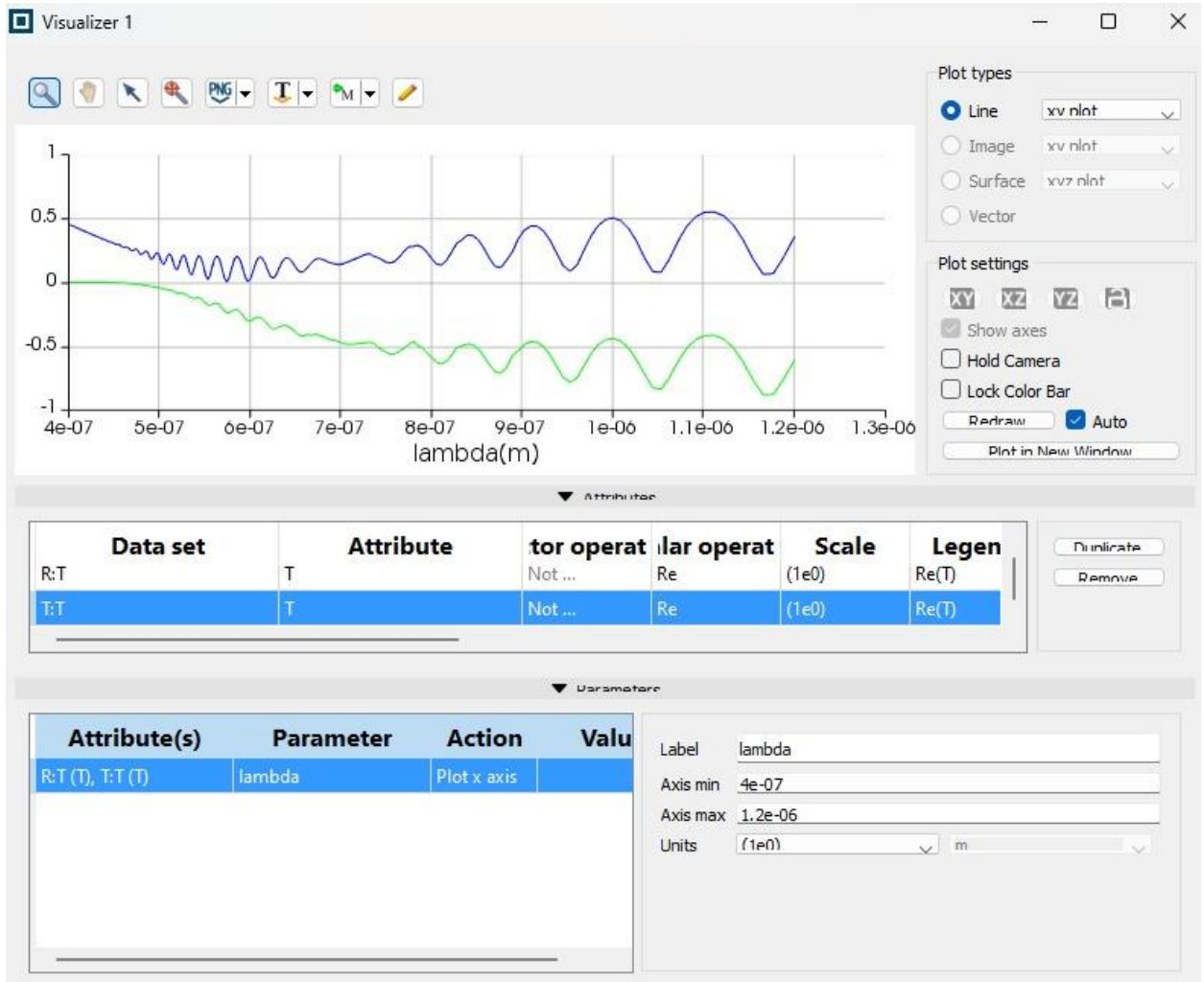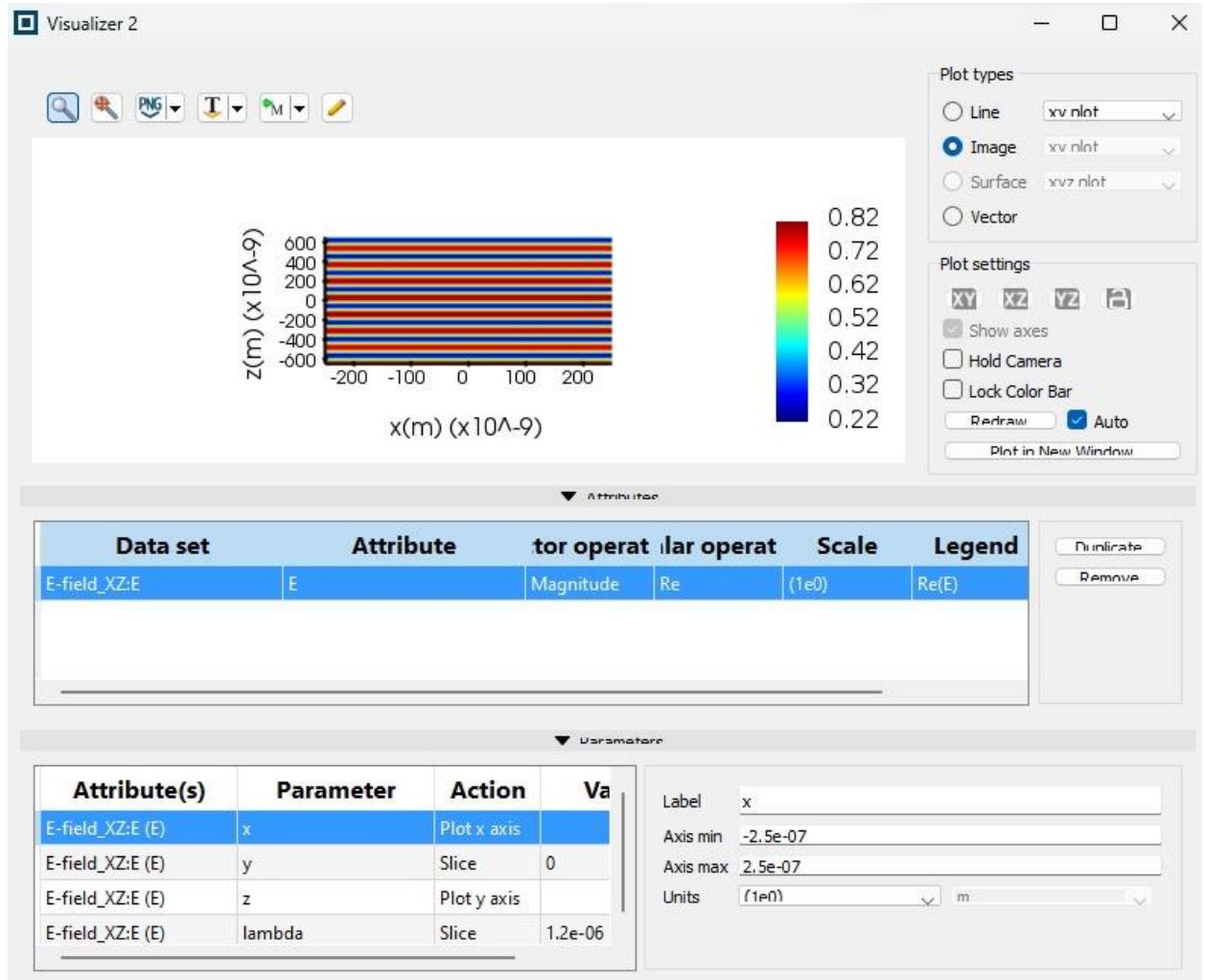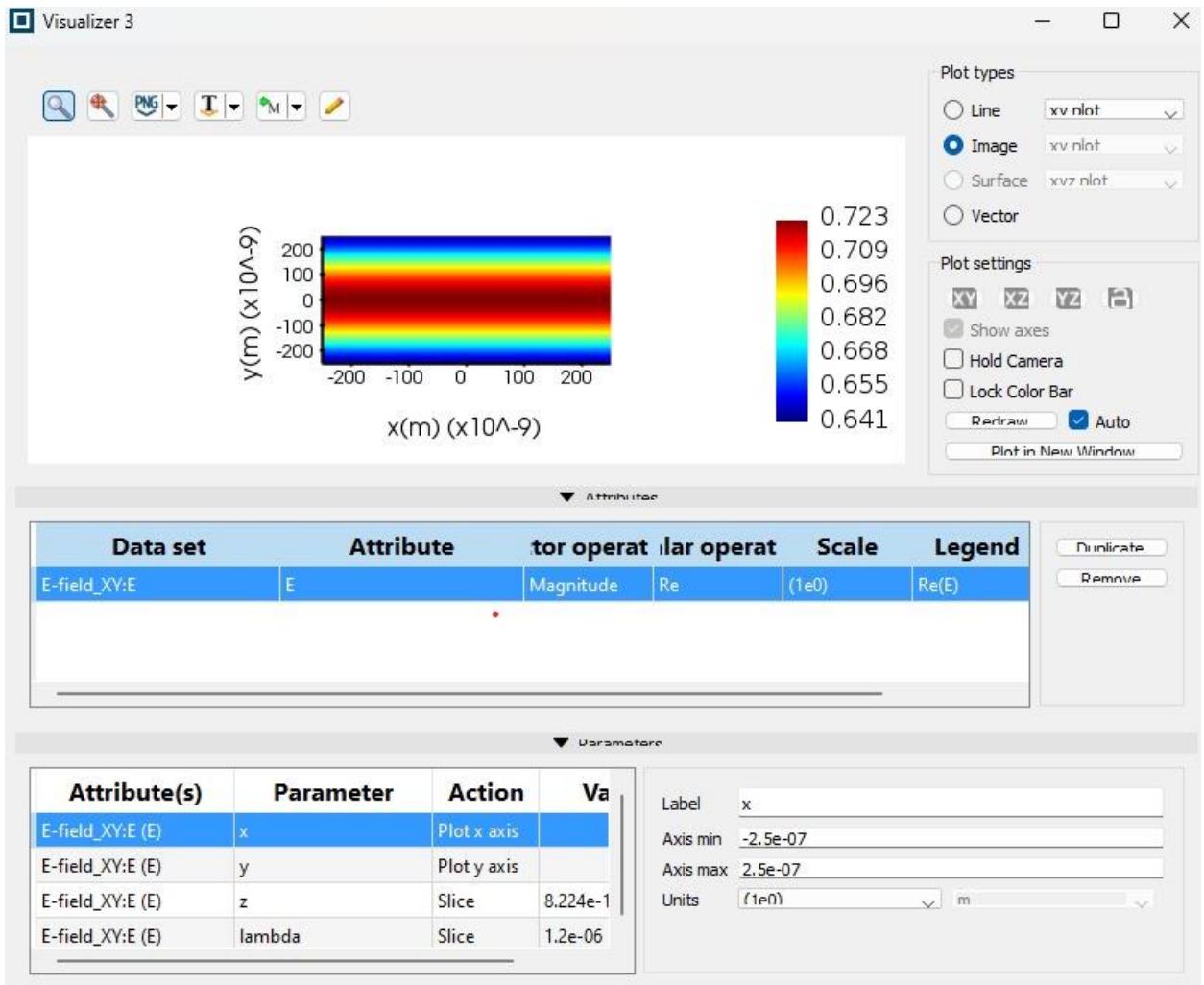
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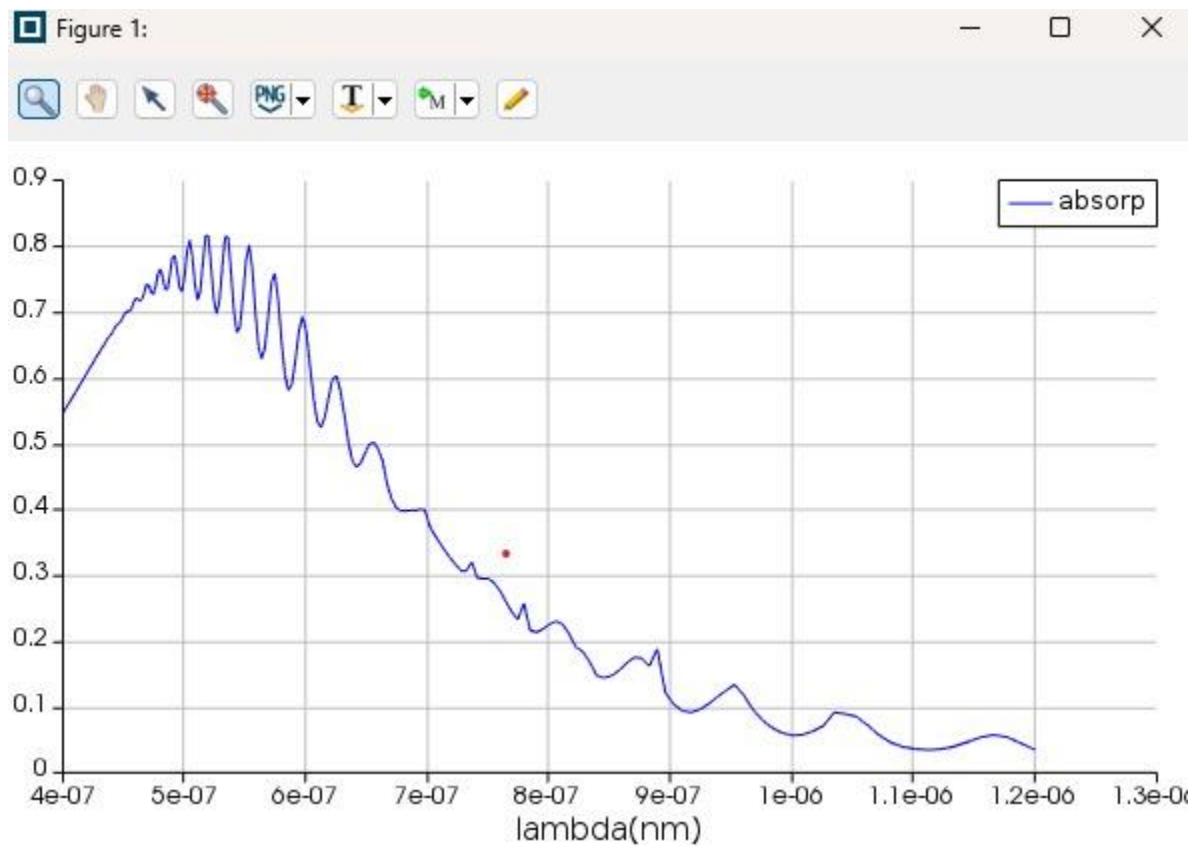
E-Field XZ

E-Field XY:
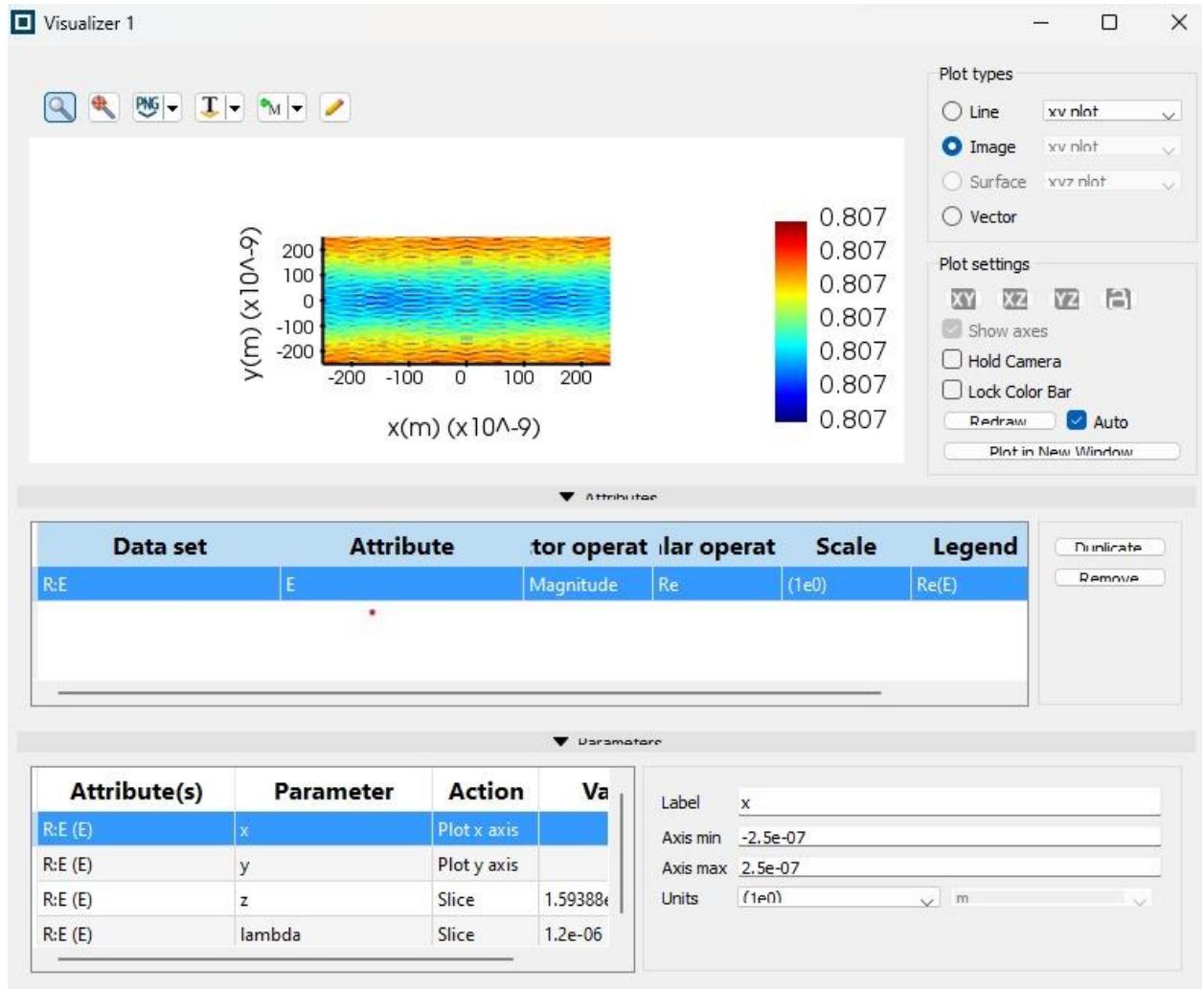
Absorption:
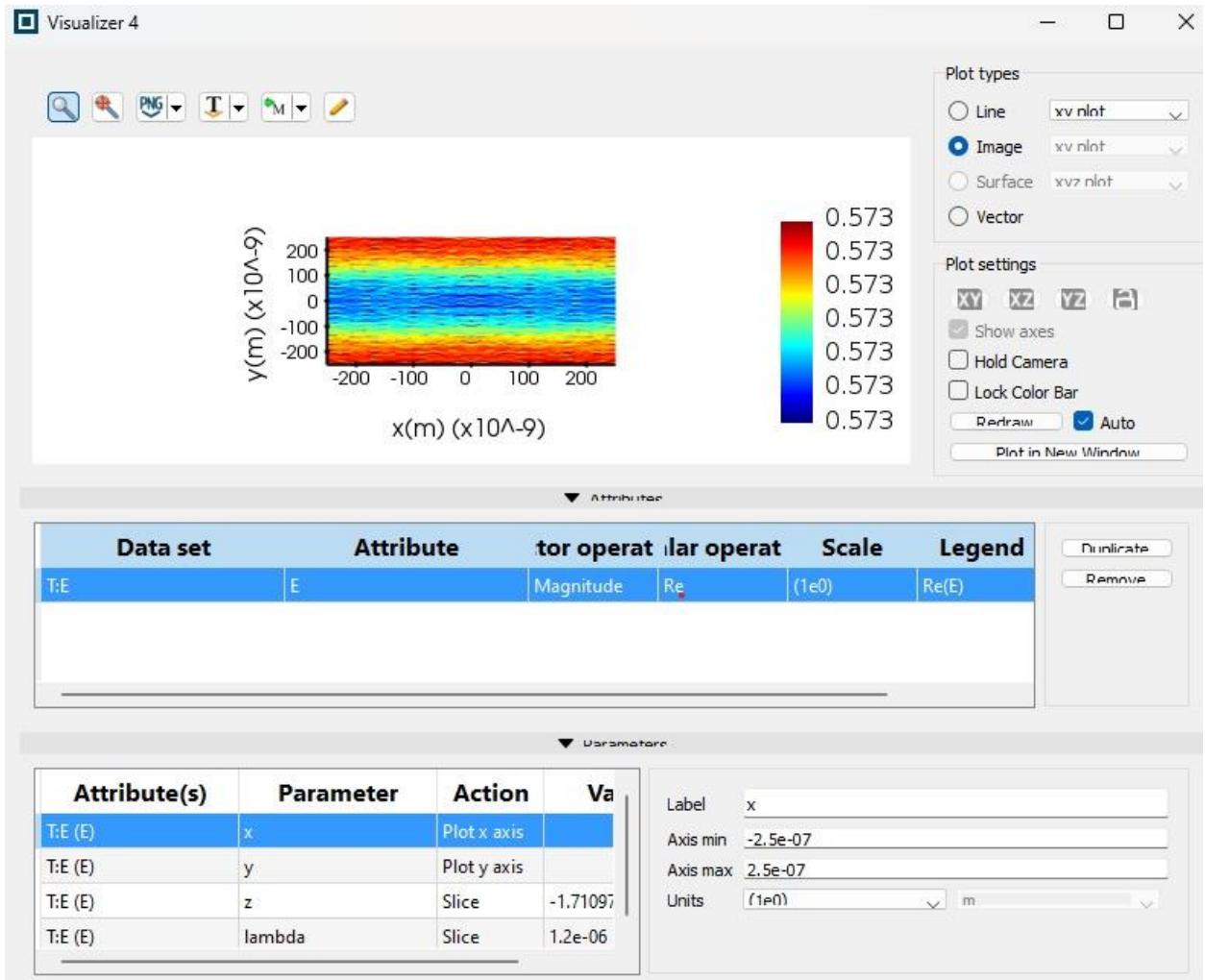
Wavelength of 800 nm (without ARC and Dielectric Mirrors):
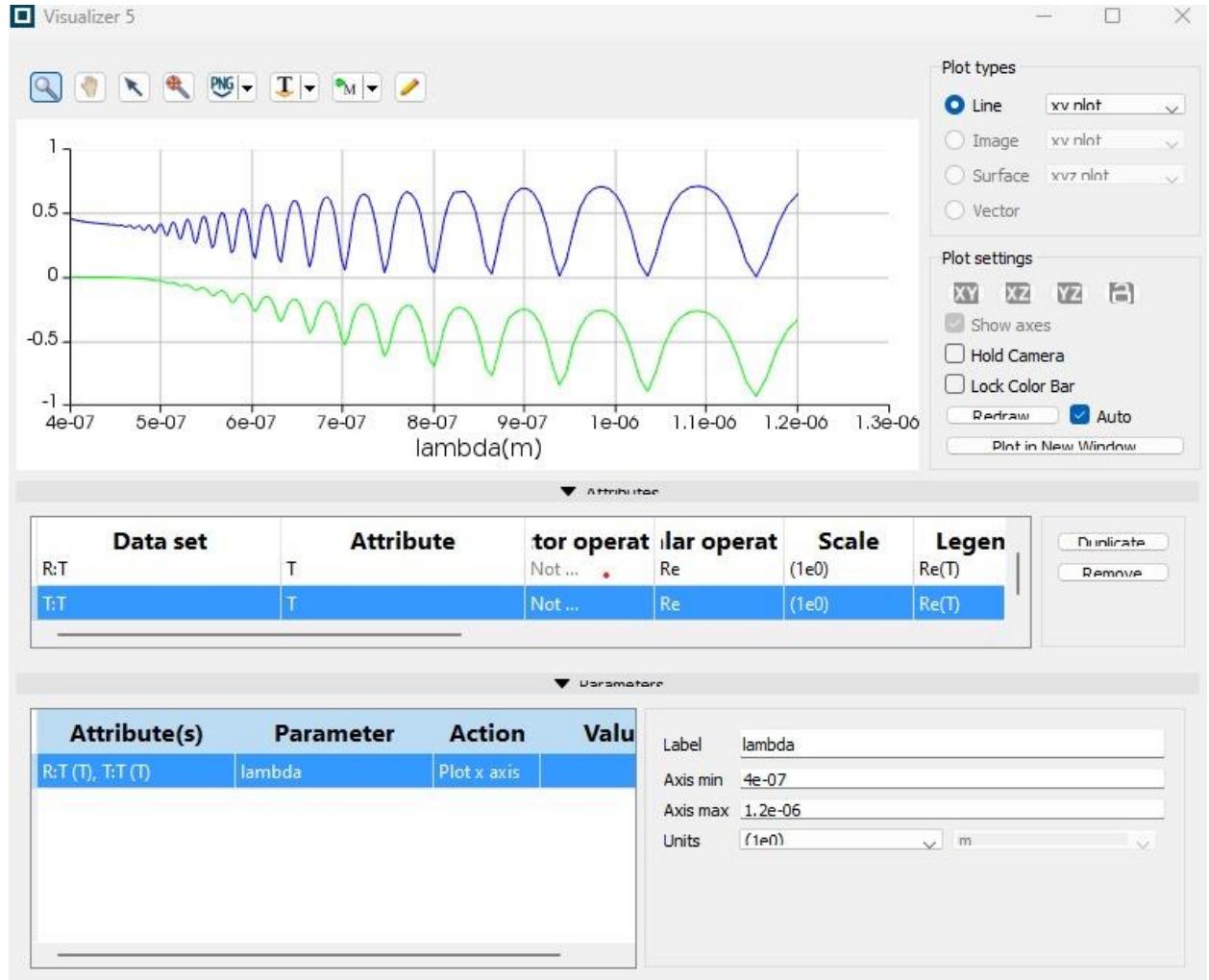
R:E
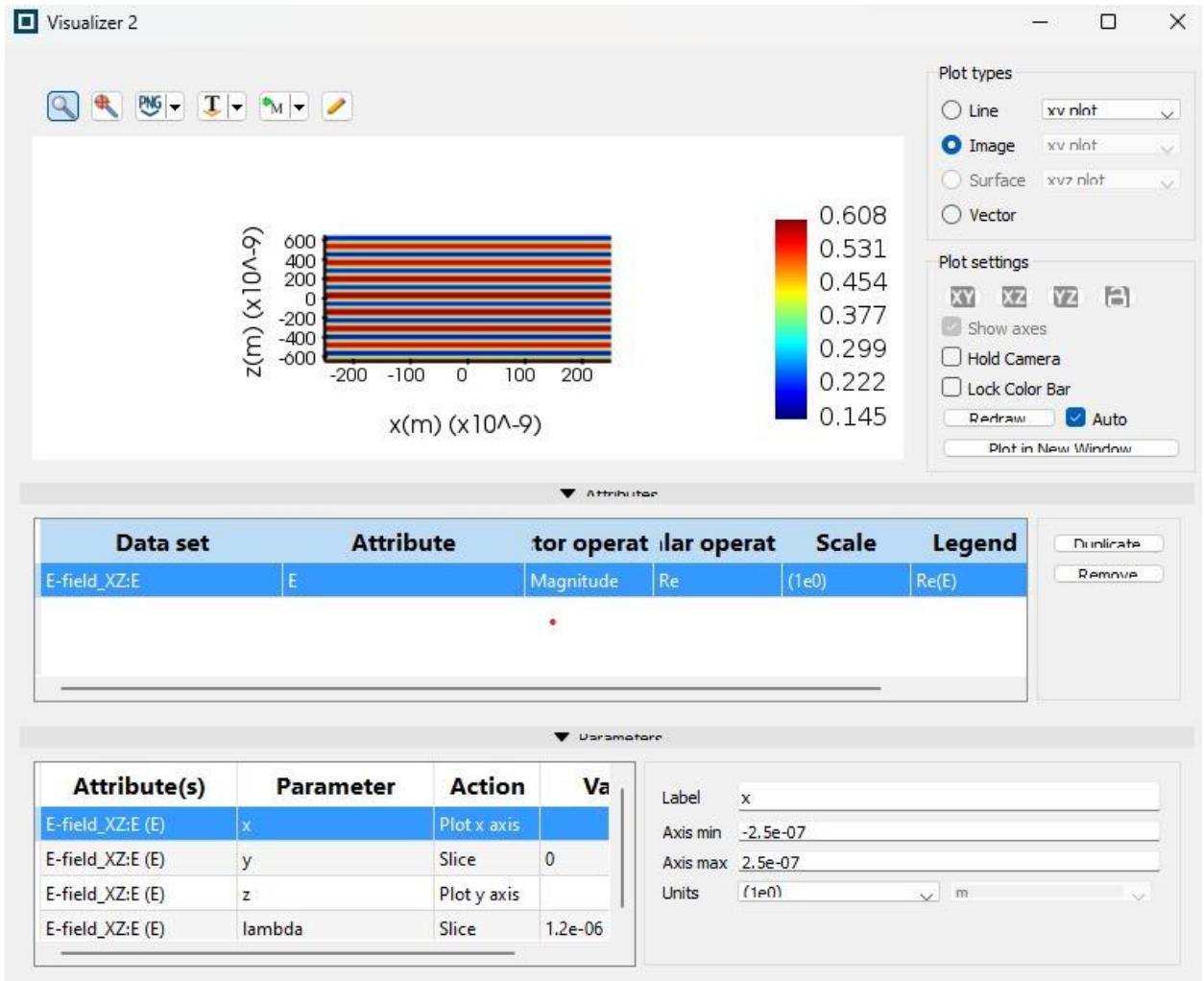
T:E
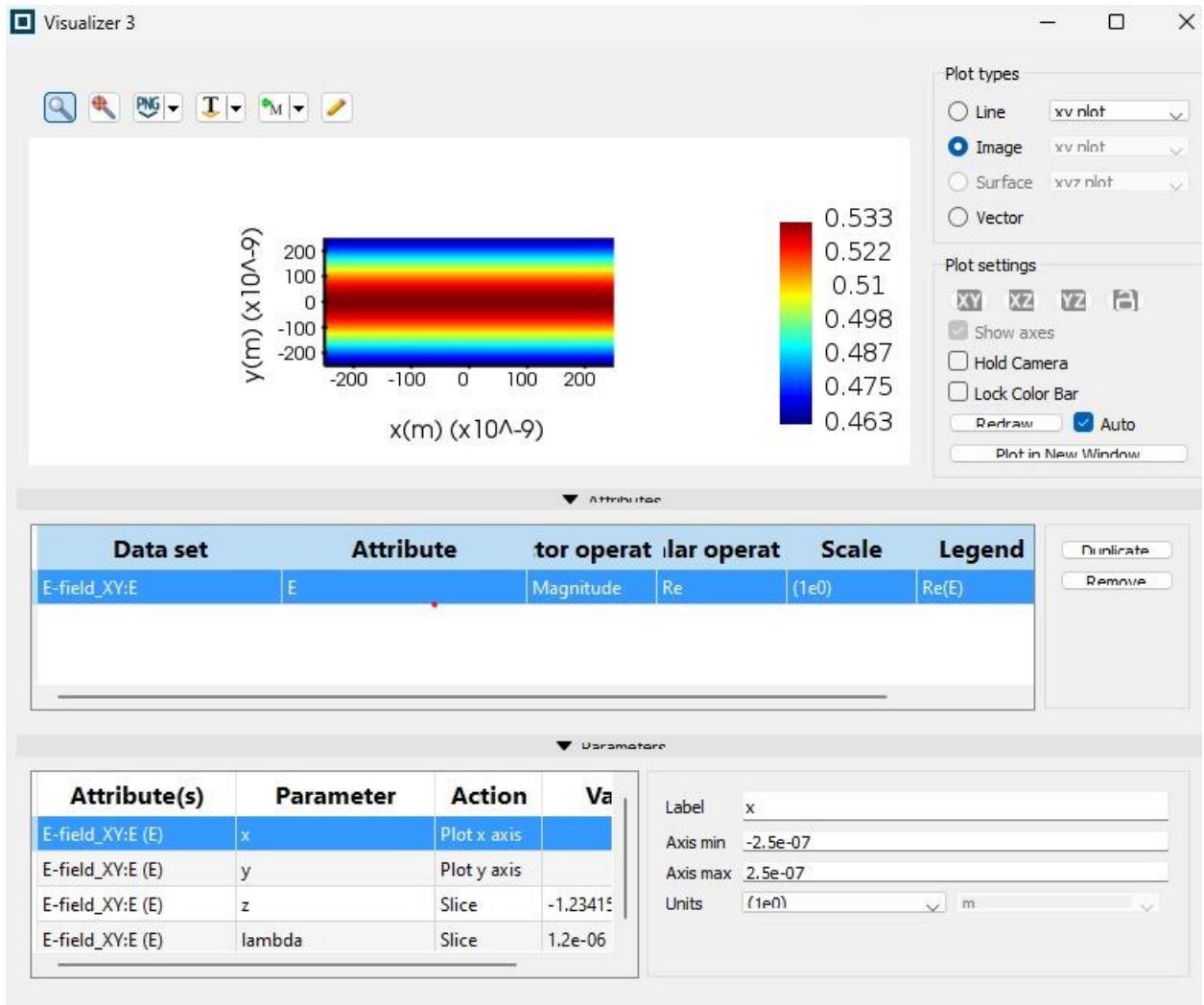
Compare between R and T:T

E-field XZ:
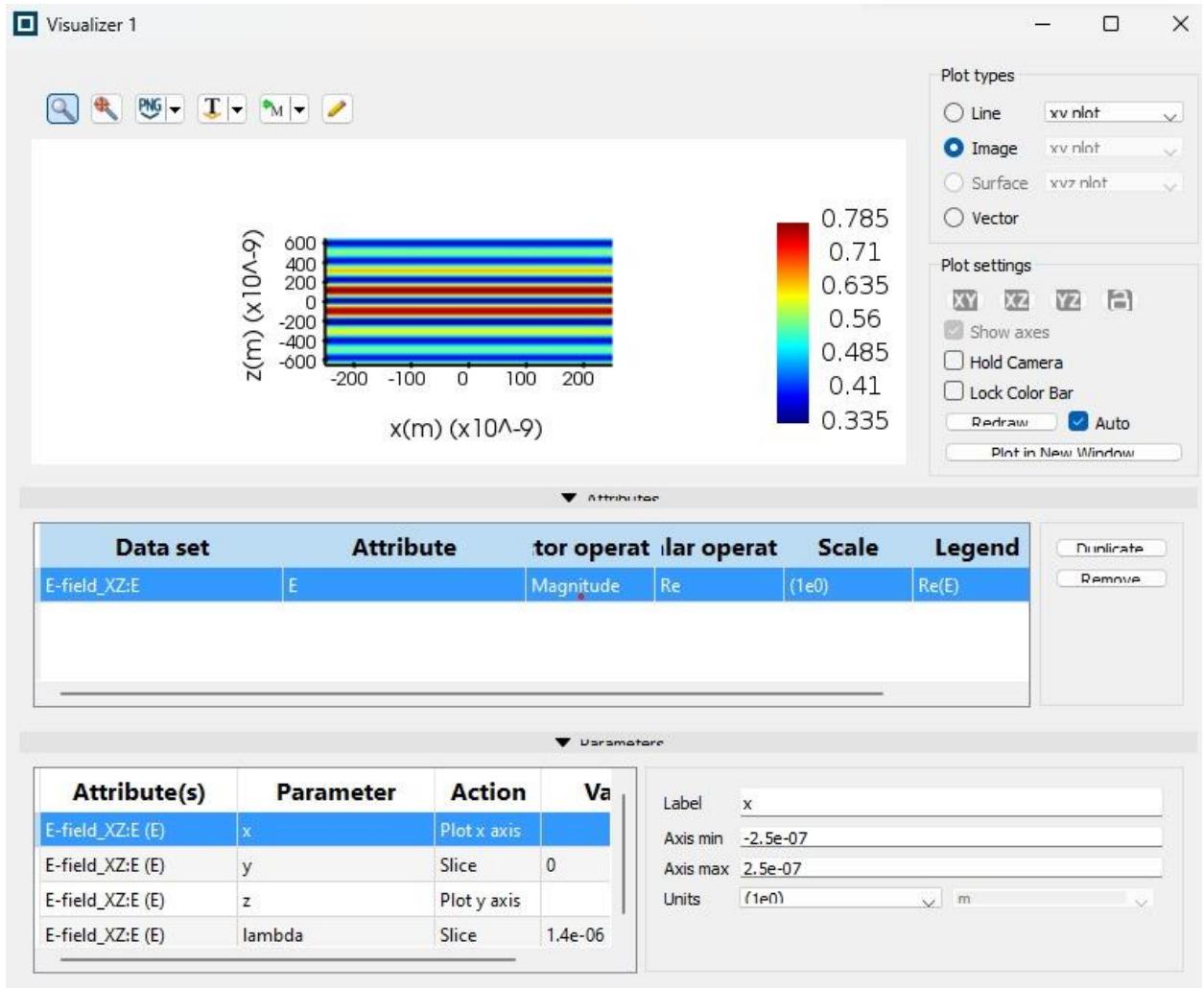
E-Field XY:
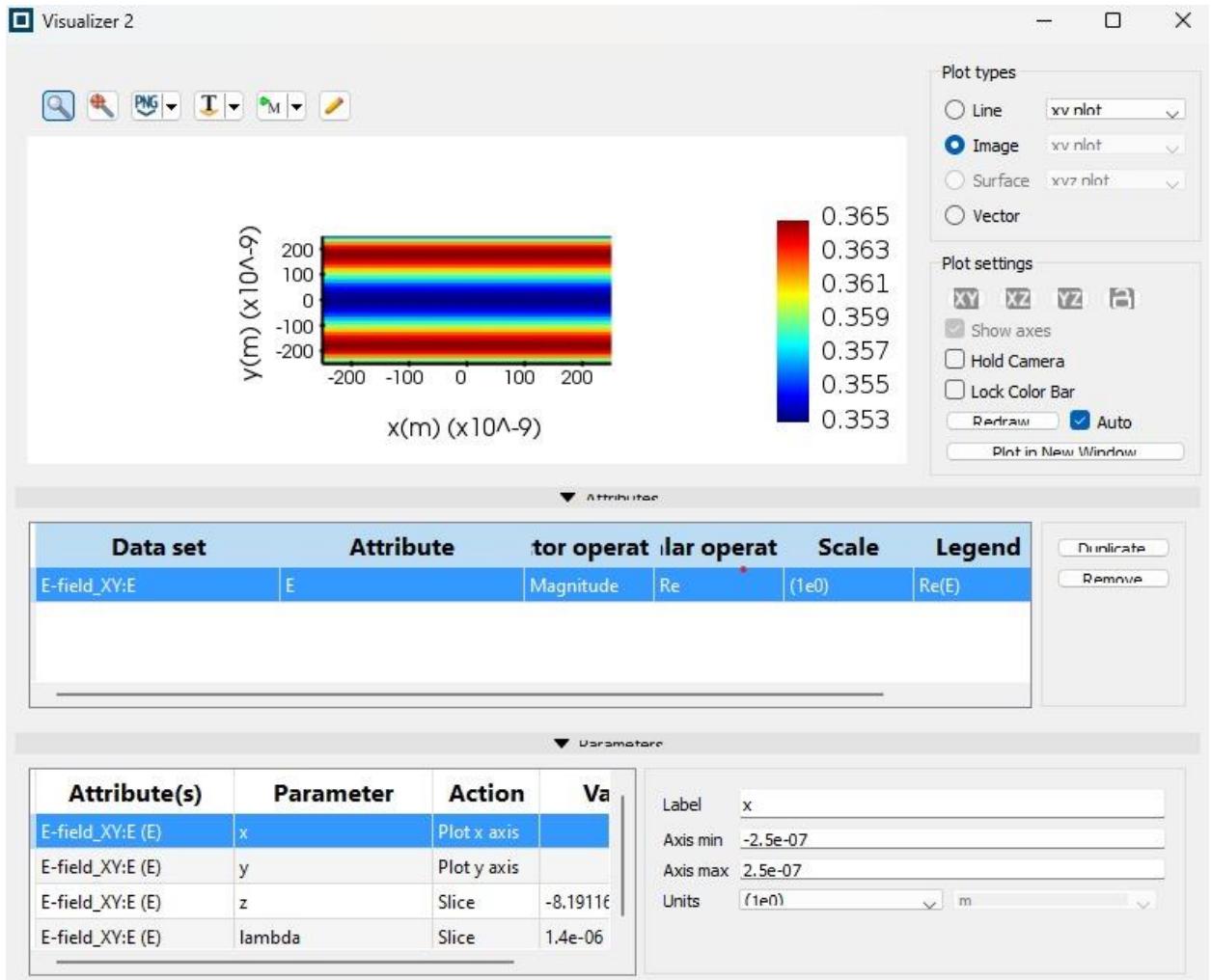
For wavelength 1000 nm (With ARC and Dielectric mirrors):
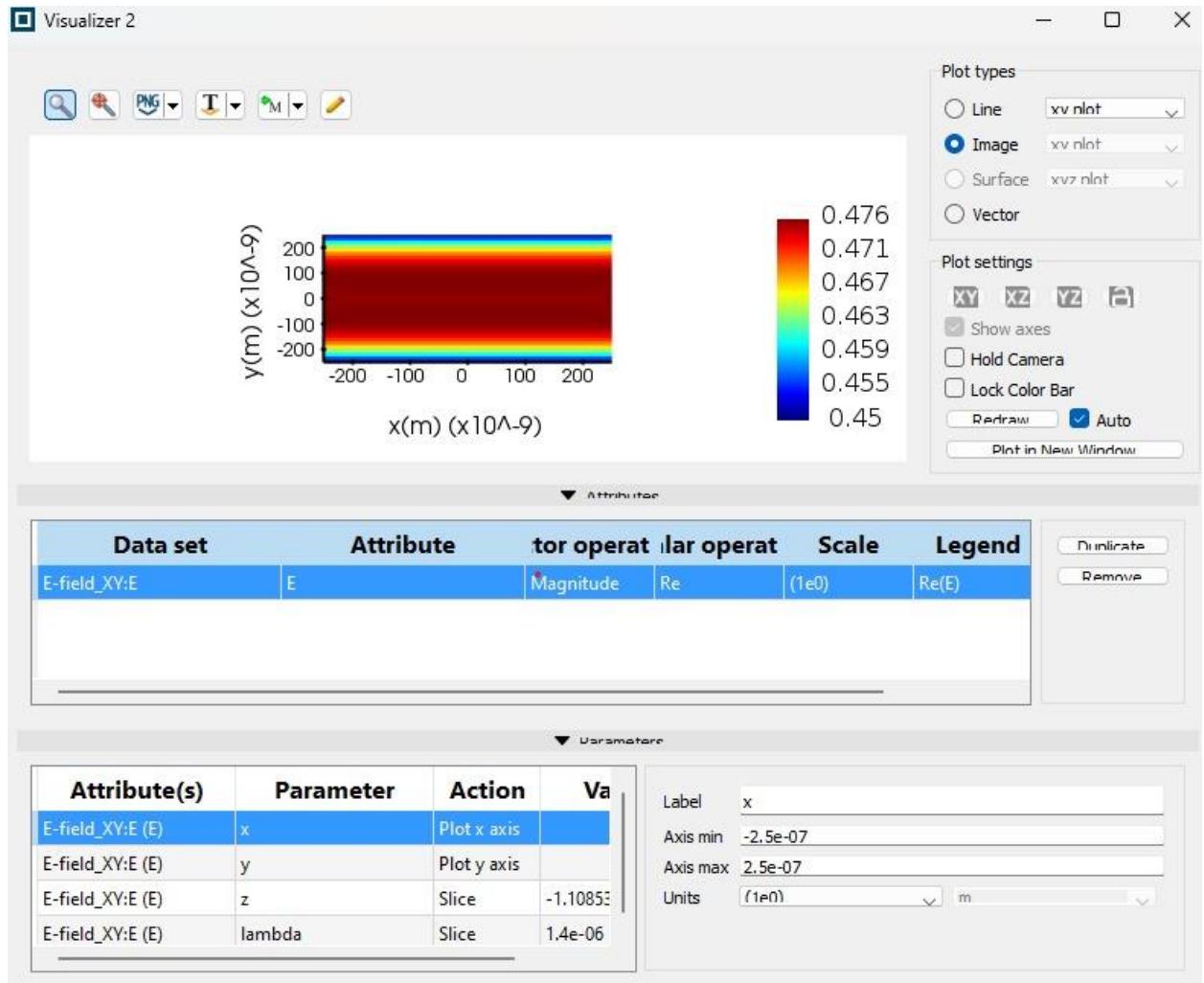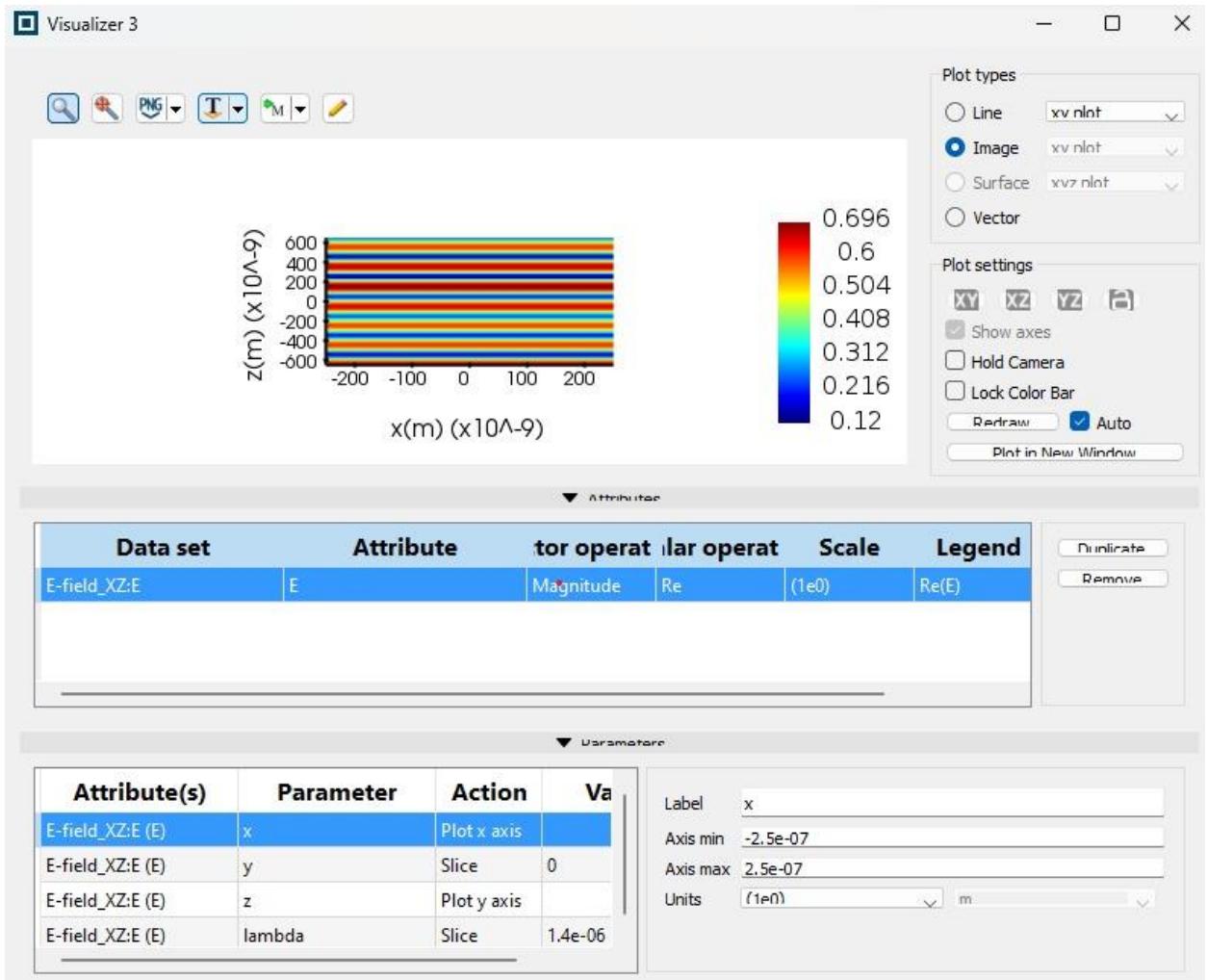
E-Field XZ:

E-field XY:

For wavelength 1000 nm (With ARC only):

E-field XY:
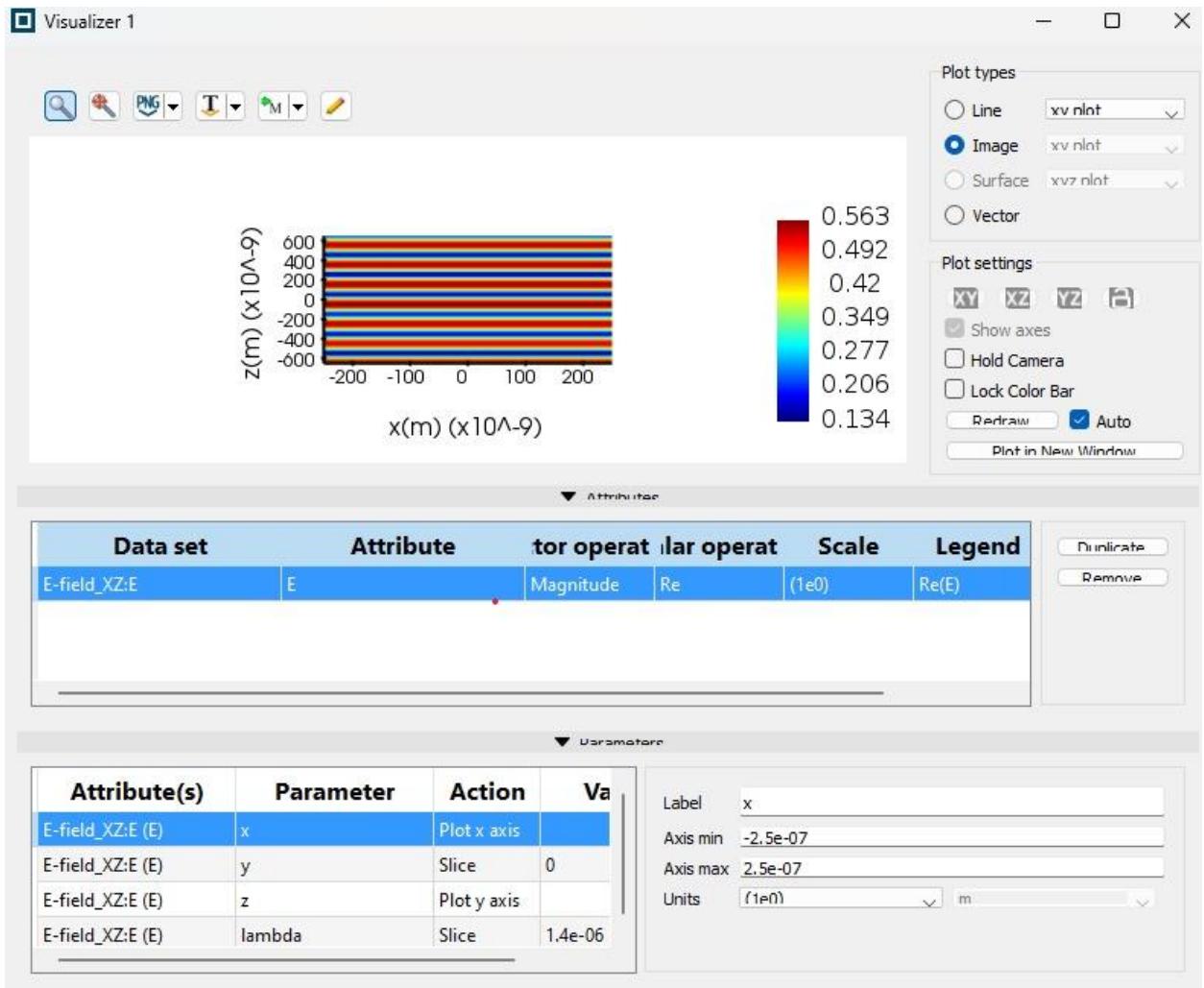
E-field XZ:
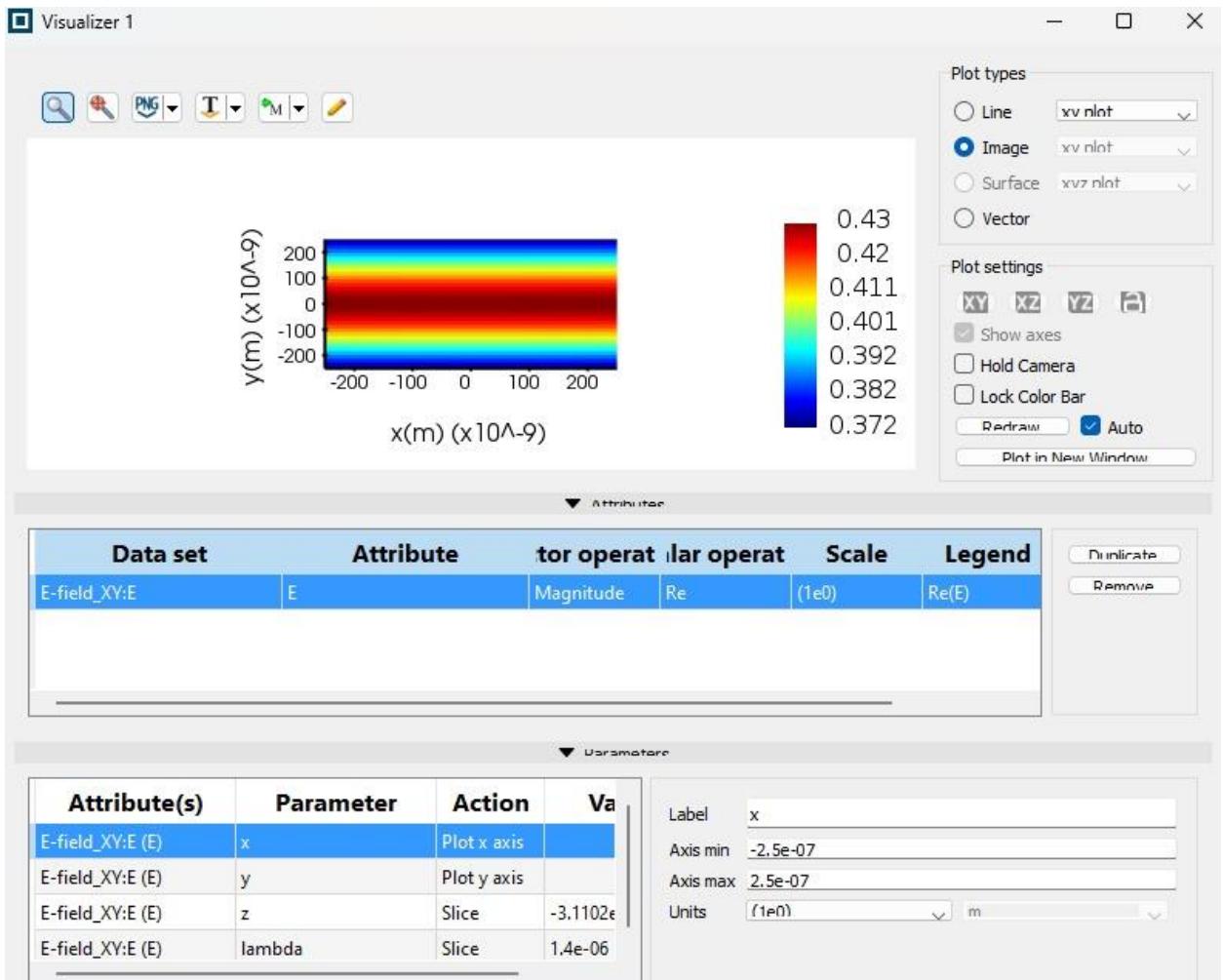
For wavelength 1000 nm (Without ARC and Dielectric mirrors):

E-field XZ:

E-field XY:

Comments:

When adding the Anti-Reflection Coating (ARC) layer and Dielectric Mirrors:

- The reflectance is reduced after applying the ARC layer to the silicon layer.
- The transmittance decreases after adding the mirror layers to the silicon layer, especially around the 675 nm wavelength, which is our target range.
- Absorption increases, as illustrated in the left figure, due to the combination of mirrors and the ARC layers, with a significant effect near the 675 nm wavelength.

For the Anti-Reflection Coating (ARC) only:

- Comparing scenarios with and without the ARC layer in terms of absorption and electric field, we observe an increase in absorption (power capture) because the ARC layer reduces reflectance, allowing more power to be captured.