Simulating controllable acoustic waves via photoacoustic generator

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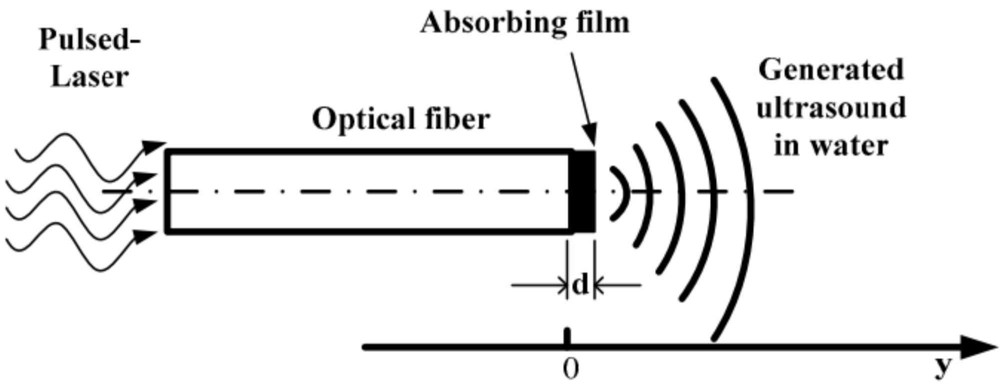
Ultrasound modulation is an emerging treatment approach for neurological disorders

- We want to illustrate the relationship between the geometry of the photoacoustic generator and the generated ultrasound.
- **Objective:** Repeat the simulation results in the paper *"Finite element modeling of an optical fiber photoacoustic generator performance"*

Optical fiber-based ultrasound generator being simulated

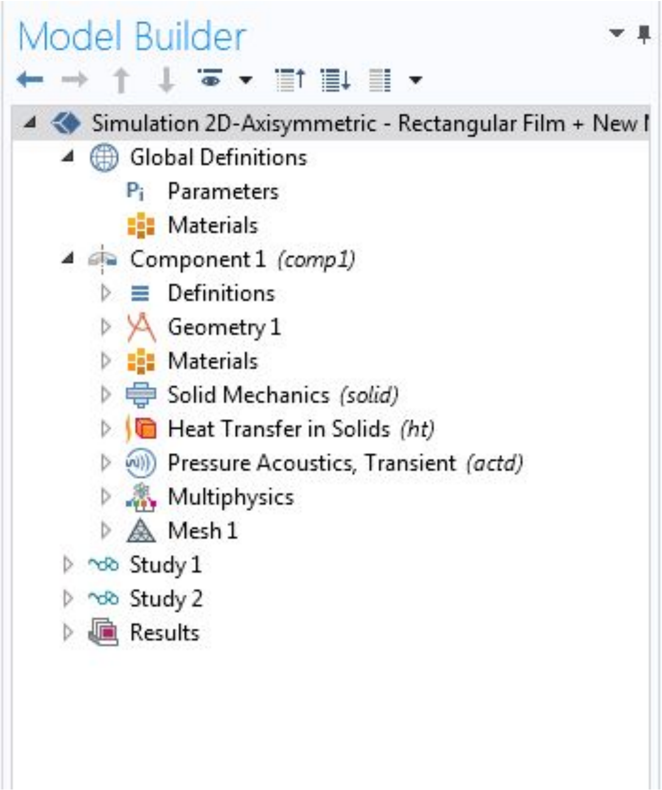


Work Summary

- Creating the simulation model based off of specifications given in the paper
- Defining an observation point “P” to monitor acoustic pressure
- Creating an appropriate heat source expression
- Matching simulation results with those given in the paper
- Creating a simulation model with both a rectangular absorption film and a spherical one.

COMSOL Modeling Setup

1. Geometry
2. Materials
3. Physics
4. Results



Geometry/Materials

Original

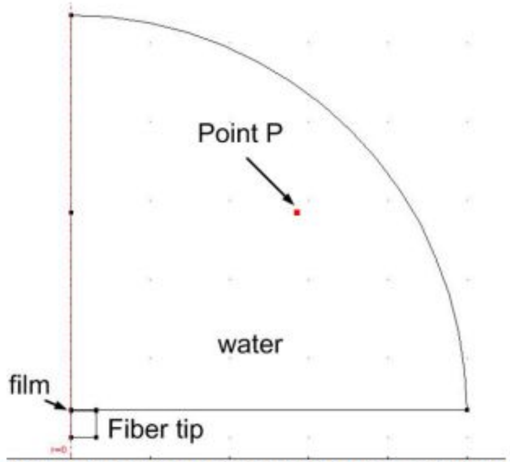
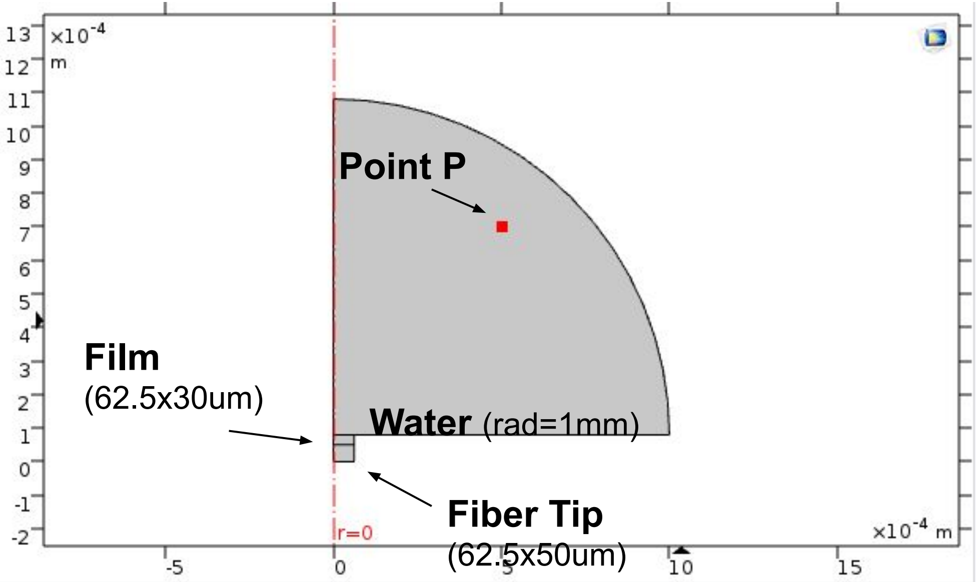


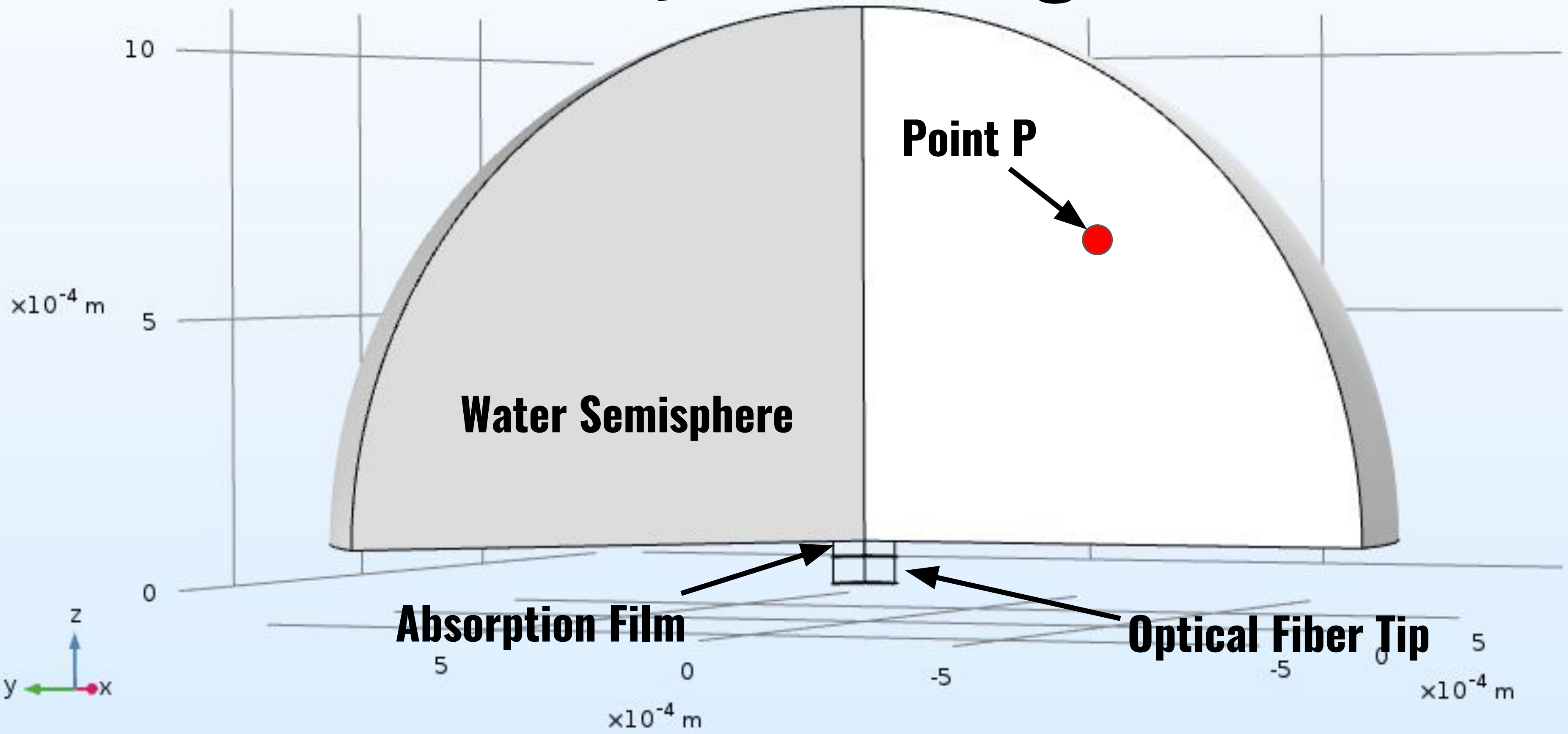
Figure 6. Point P is chosen to monitor ultrasound pressure inside the water.

Our Simulation



- Geometry is built on a 2D-axisymmetric plane
- Material for fiber tip is glass fiber
- Material for absorption film is graphite foil

3D-Geometry - Rectangular Film



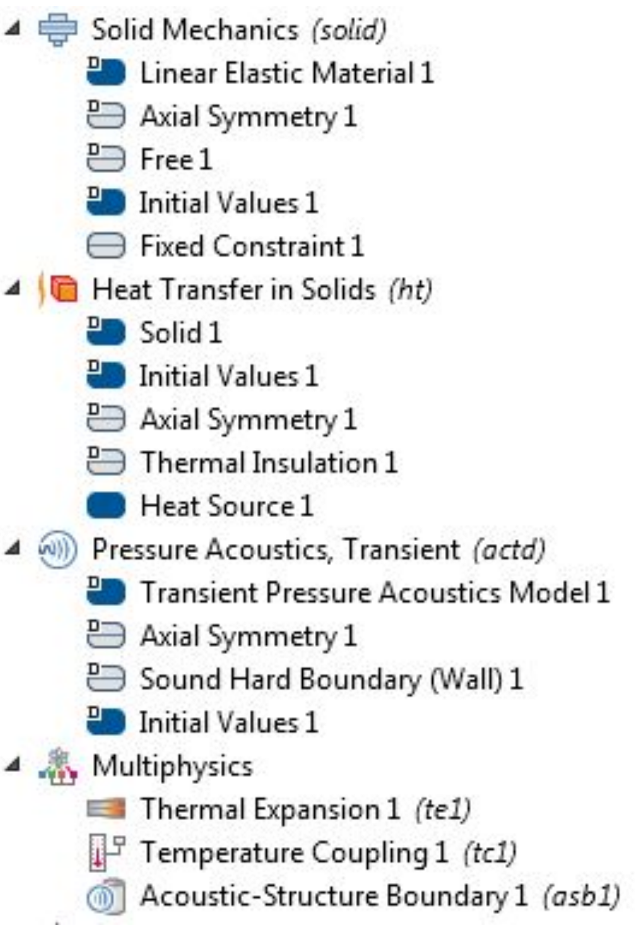
Physics/Multiphysics

"In COMSOL, three application modes ("Heat transfer by conduction" mode, "solid stress and strain" mode, and "pressure acoustic" mode) are employed to calculate the photoacoustic process simultaneously."

1.

2.

3.

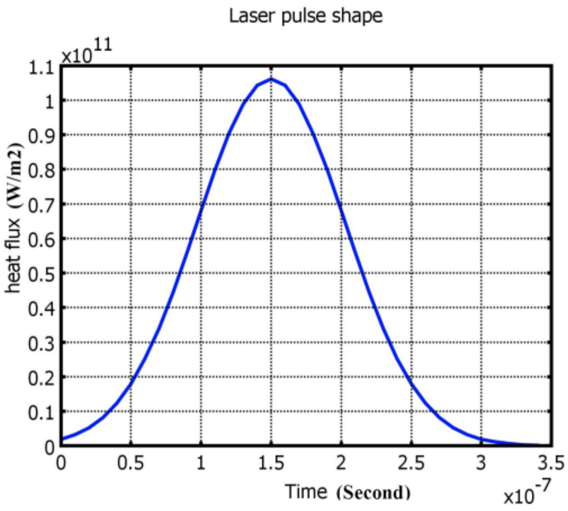


Modeling the Heat Source

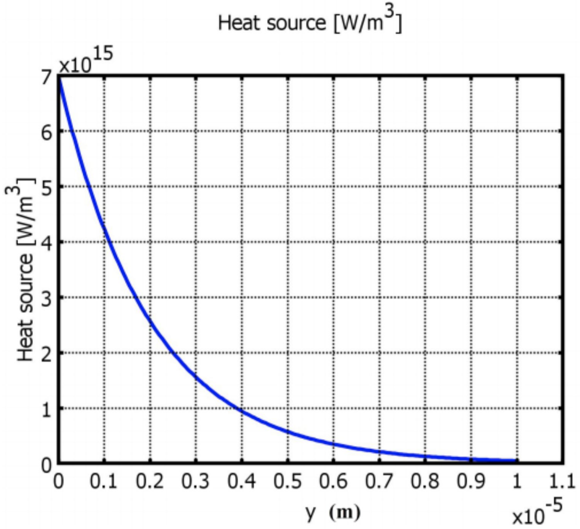
- Heat source is defined by G(y,t)
- Fig (a) shows G(y,t) vs Time
- Fig (b) shows G(y,t) vs Depth [y-direction]

$$G(y,t) = I(t)\frac{(1-R)}{\delta}\exp(-\frac{y}{\delta})$$

$$I(t) = \frac{E_p}{A \cdot \tau_p}\exp(-\frac{4 \cdot (t-\tau_p)^2}{\tau_p{}^2})$$



(a)

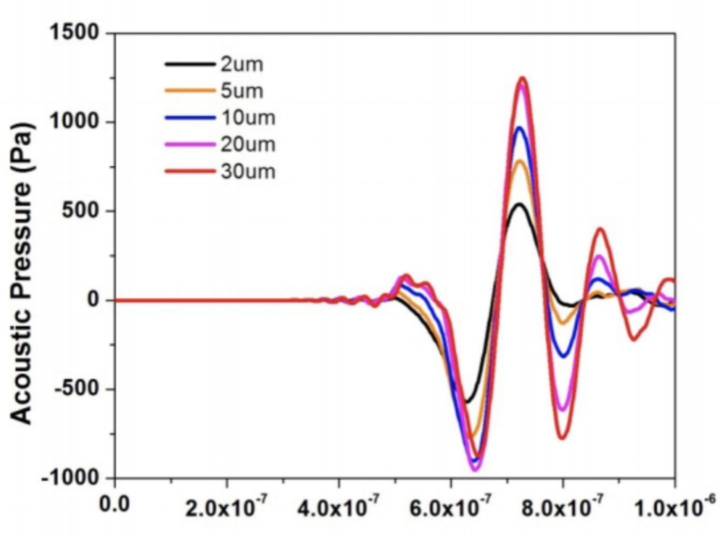


(b)

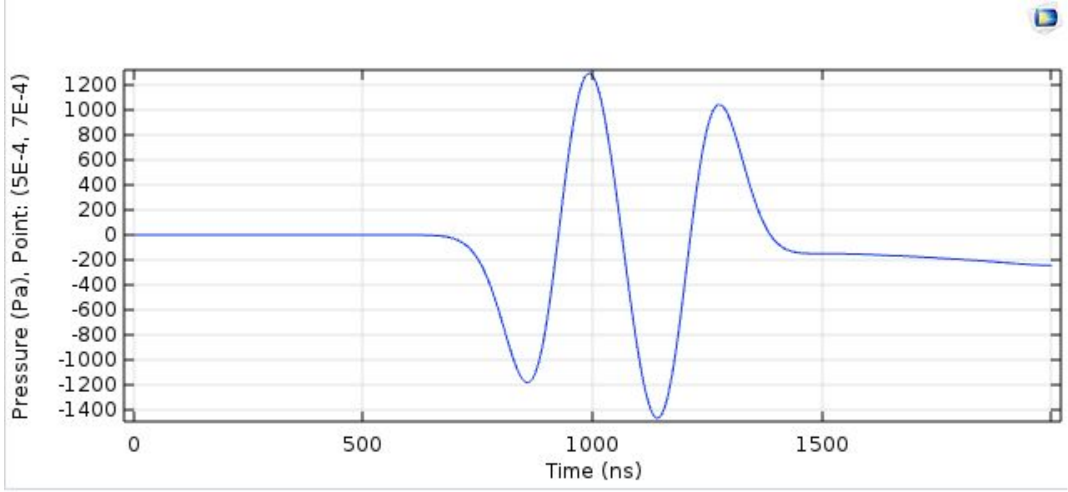
Results: Rectangular Absorbing Film

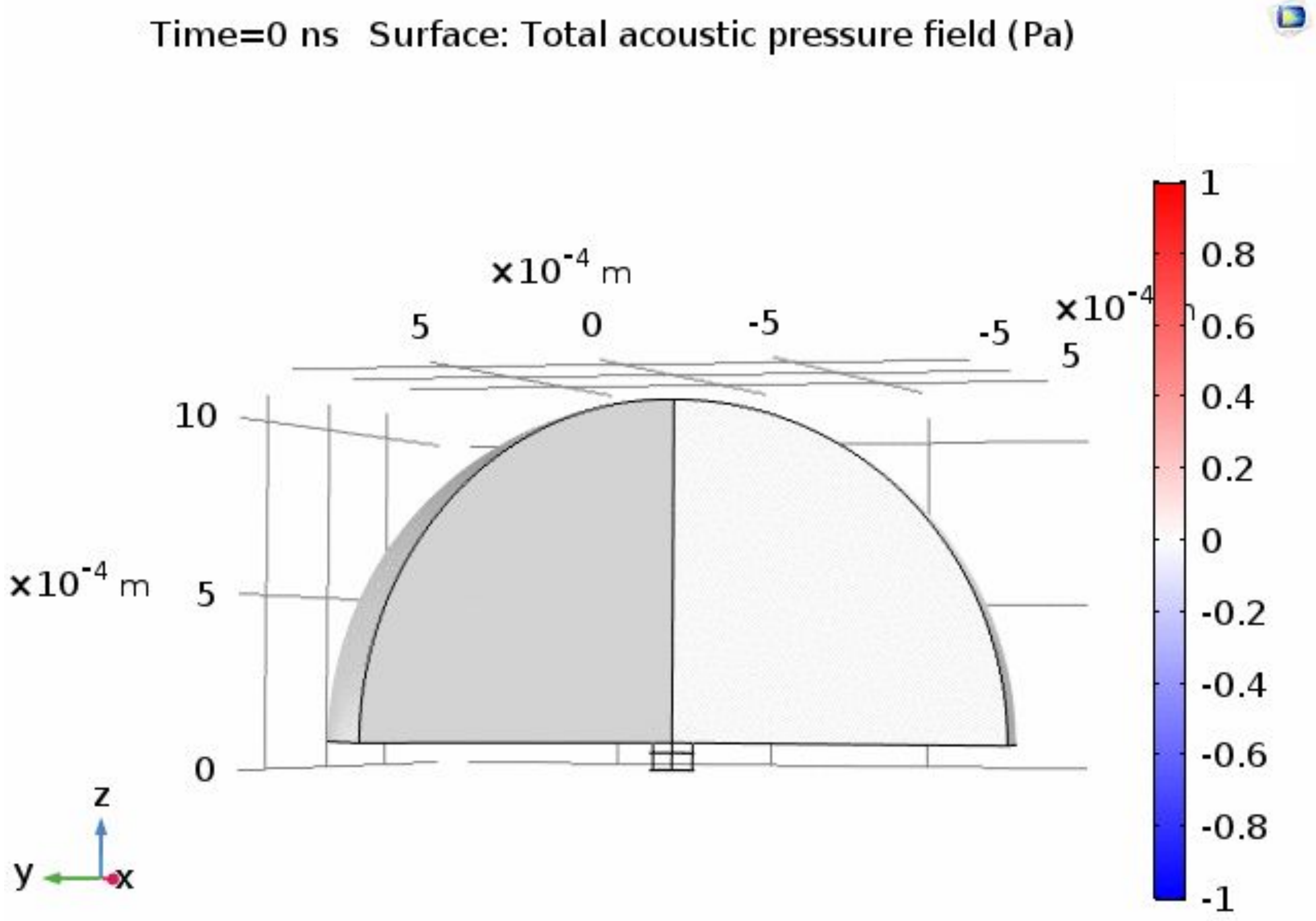
- We were able to match:
  - The general trend of the produced ultrasound pressure.
  - The general maximum and minimum of acoustic pressure

Original



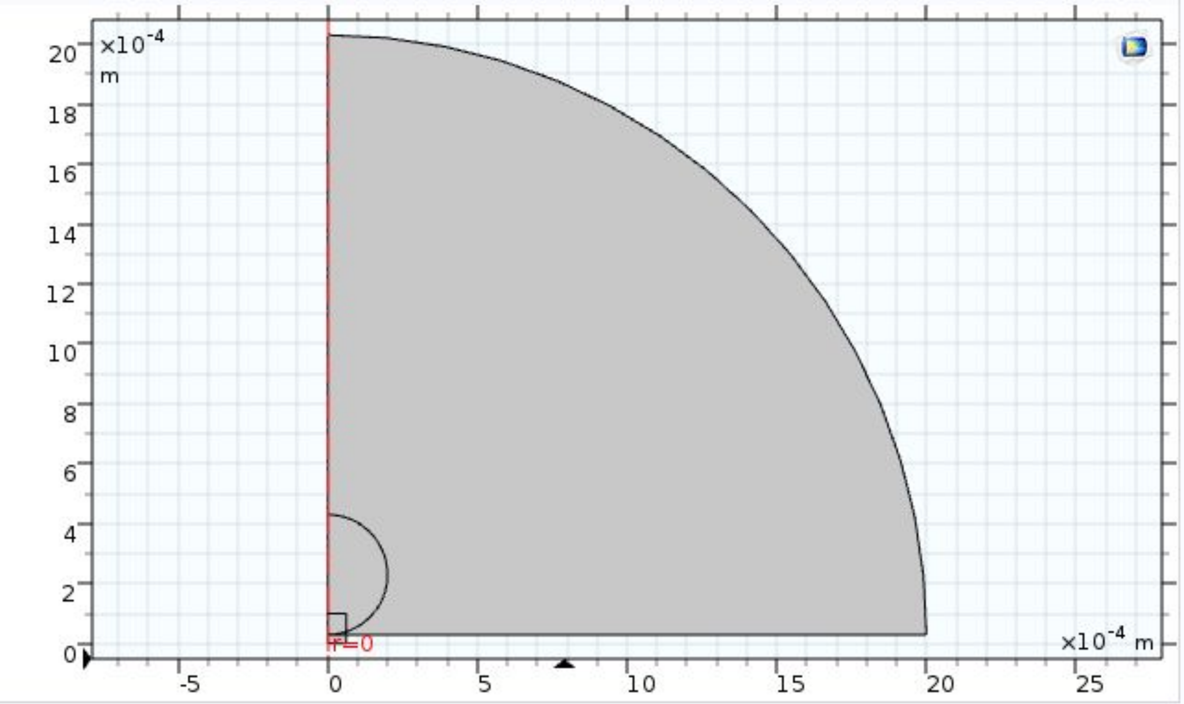
Our Simulation



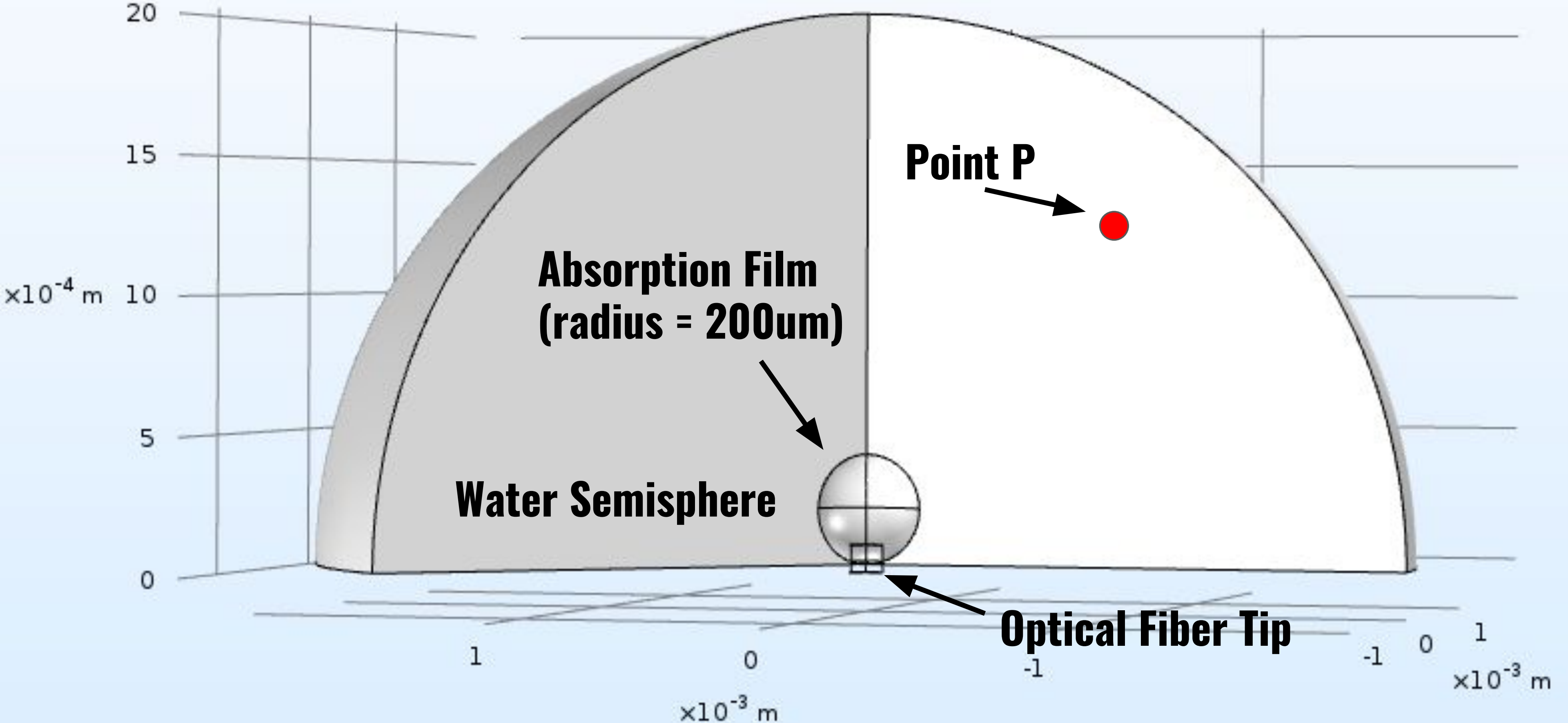

Time=0 ns Surface: Total acoustic pressure field (Pa)
×10^-4 m
5
0
-5
-5
×10^-4 m
5
10
5
0
×10^-4 m
z
y
x
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1

Model #2: Spherical Absorption Film

- In order to create a simulation that is more representative of experimental conditions, we created a separate simulation with a spherical absorption film
- All physics, materials, studies, and parameters were left the same
- Geometry and meshing were adjusted appropriately



3D Geometry - Spherical Film

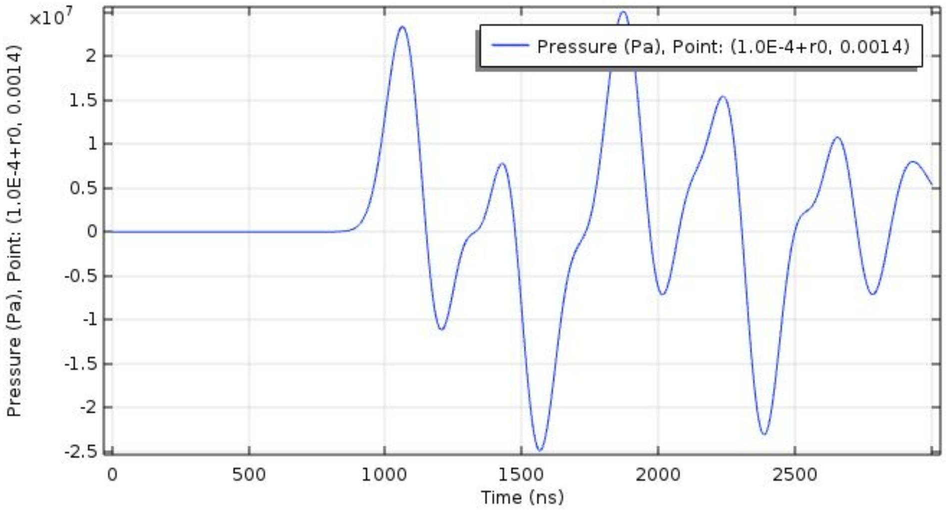


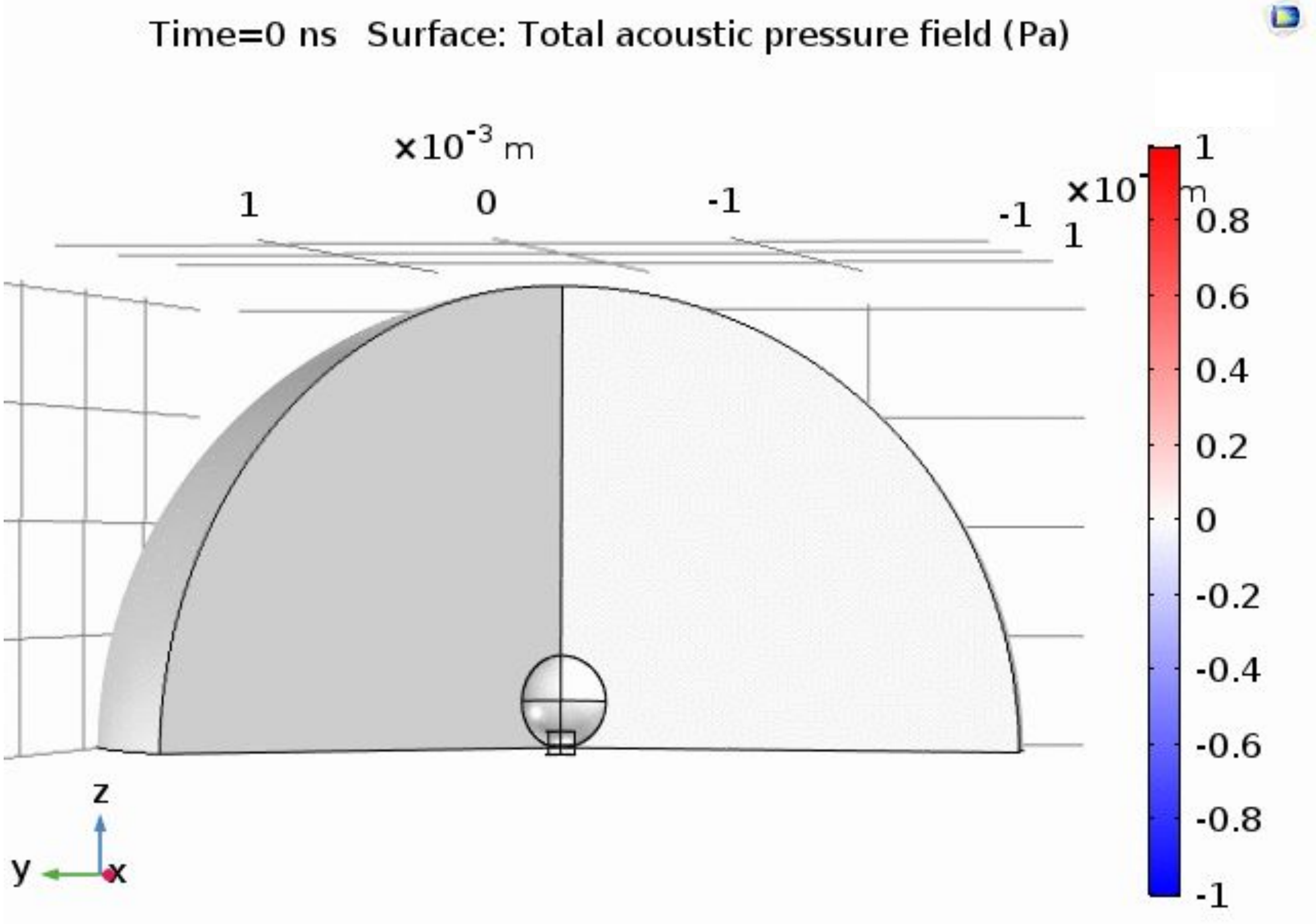
Results: Circular Absorbing Film

- We were unable to match the simulation results with the experimental results
- Further adjusting of the heat source/materials is required

Experimental

Simulation




Time=0 ns Surface: Total acoustic pressure field (Pa)
×10^-3 m
1
0
-1
-1
1
×10
m
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
z
y
x

Future Directions

- Adjusting the spherical absorption film simulation to match experimental results
- Investigate how the frequency of ultrasound changes when the radius of a circular absorption film is changed
- Perform the simulation with a concave absorption film that focuses the pulsed laser