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# 3D Simulation of the Laser Interstitial Thermal Therapy in Treatment (LITT) of Brain Tumors

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# Agenda

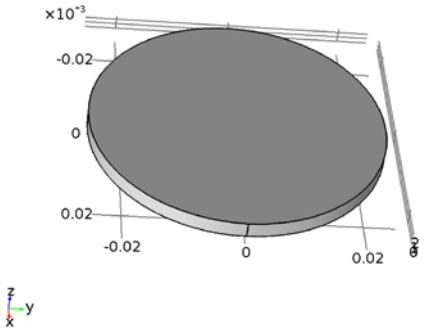
- **Simulating with COMSOL Multiphysics®**
- **LITT: Laser Interstitial Thermal in Treatment with a heat transfer :**
  - **Geometrical description of the model.**
  - **Heat distribution.**
  - **Mesh.**
  - **Thermal damage.**
- **Live Demo: LITT, Apps.**
- **Q&A Session .**

# Introduction

- restriction of the number of probes that a patient can tolerate.
- mathematical model simulation is more effective to help doctors in planning their thermal treatment doses.
- maximize therapeutic effects while minimizing side effects.

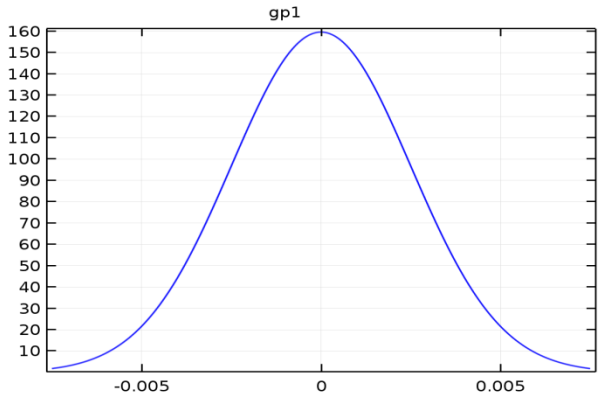
# Material and methods

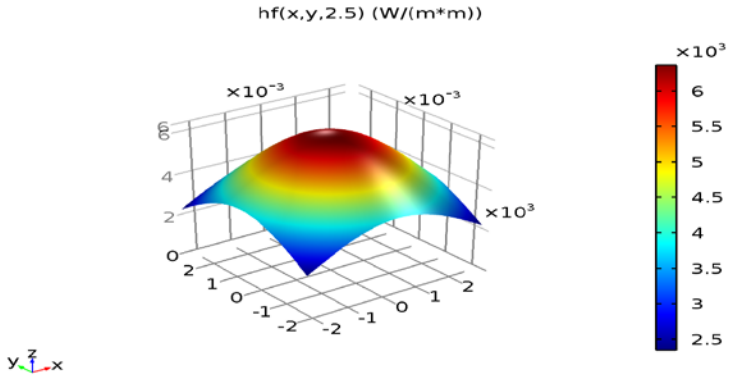
- The Brain  tissue is modeled as a Cylinder of radius r_mat-inner and height thickness_inner, 3D,  Bioheat Transfer (ht), Time dependent of  range (0,0.1,10) seconds, heated by a 0.25 W laser.



# Laser procedure

- The laser beam  is modeled as a heat source in the plane with Gaussian profile gp1
- The waveform function wv1 is a Triangle with Angular frequency and Phase equal 0 and the Amplitude equal 1.



# Modeling in COMSOL Multiphysics

- **Heat distribution**

$$\rho C_p \frac{\partial T}{\partial t} + \rho C_p \mathbf{u} \cdot \nabla T + \nabla \cdot \mathbf{q} = Q + Q_{bio}$$

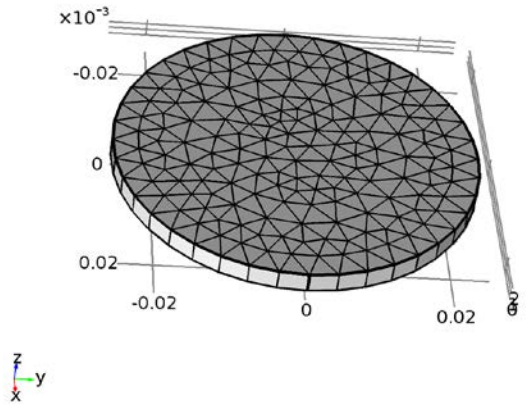
$$Q_{bio} = \rho_b C_b \omega_b (T_b - T) + Q_{met}$$

# Material properties needed for analysis, and definition

| Name | Expression | Value | Description |
|---|---|---|---|
| r_mat_inner | 1[in] | 0.0254 m | material inner radius |
| thickness_inner | 2750[um] | 0.00275 m | mat inner tickness |
| r_spot | 2.5[mm] | 0.0025 m | Radius of laser spot size |
| p_laser | 0.25[W] | 0.25 W | Laser power |
| period | 10[s] | 10 s | Time of laser to move back and forth |
| emissivity | 0.8 | 0.8 | surface emissivity of mat1 |
| Temp | 293.15[K] | 293.15 K | Initial Temperature |
| rho_blood | 1035[kg/(m*m*m)] | 1035 kg/m³ | Density Blood |
| omega_blood | 0.866[l/s] | 8.66E−4 m³/s | Blood Perfusion Rate |
| cp_blood | 3650[J/(kg*K)] | 3650 J/(kg·K) | Specific Heat Blood |
| A | 7.39e39[1/s] | 7.39e39 | Frequency factor |
| dE | 2.577e5[J/mol] | 2.577e5 | Activation energy |

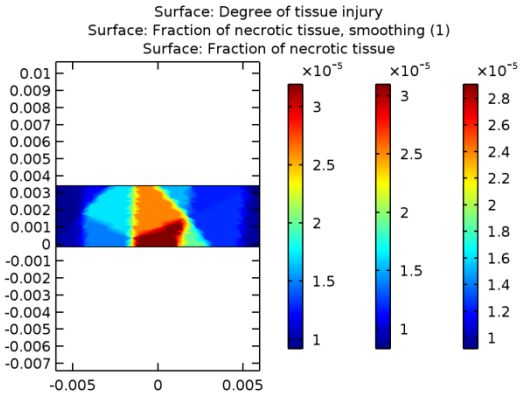
# Mesh

- The brain tissue is meshed using a triangle swept mesh.



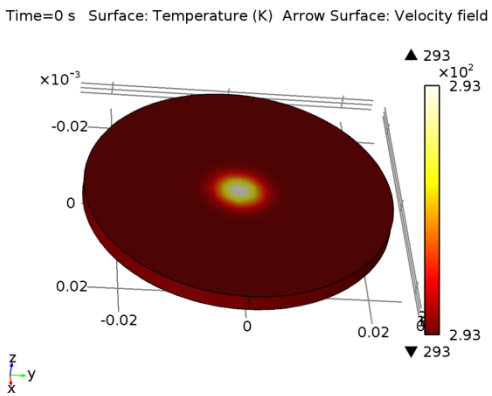
# Tissue Damage

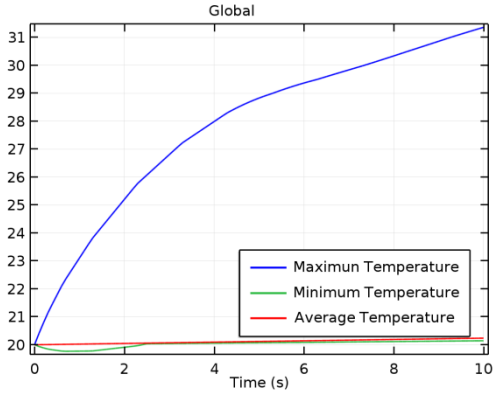
- **The Damage is calculated from the Arrhenius law:**



# Simulation Results

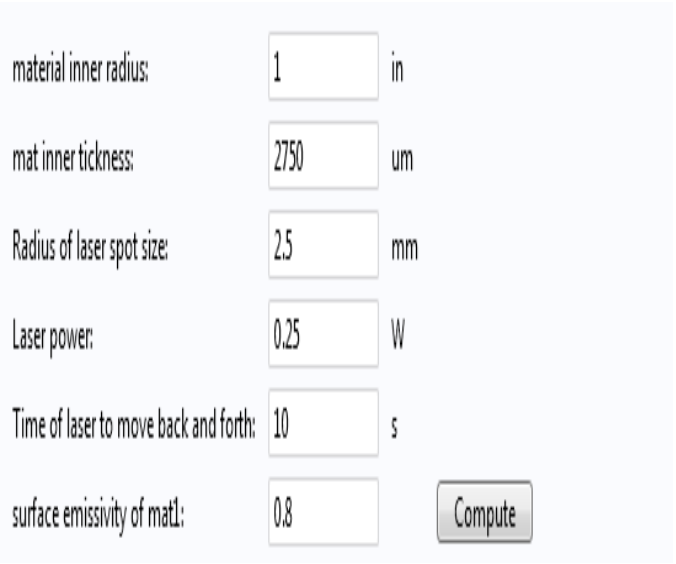
- During the simulation, the physician can play with the input values to Control the thermal ablation during a laser surgery/cancer treatment.
- The heat distribution during the simulation which will help physicians to predict and organize the treatment.
- Such model shows also the impact of the thermal damaged tissues during the simulation.

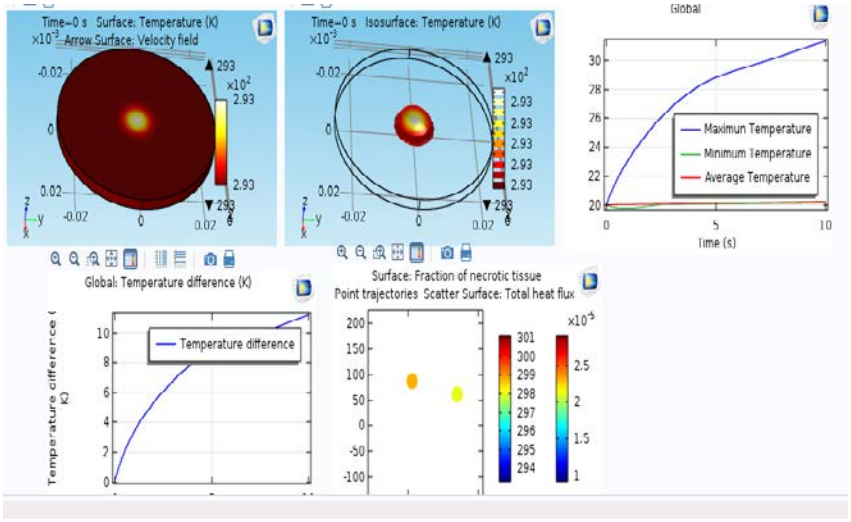


# Apps for physician' use

- Physicians will use their laptops or smart phones to access and run the application remotely.



# Conclusion

- Controlled thermal ablation is a big challenge during a laser surgery/cancer treatment. A tool to help physicians predict and organize the treatment will be helpful.
- In this paper, we proposed a simulation model of the LITT with physicians' interaction via Comsol Apps. Such model shows the impact of the heat distribution and thermal damage of the tissue during the simulation.