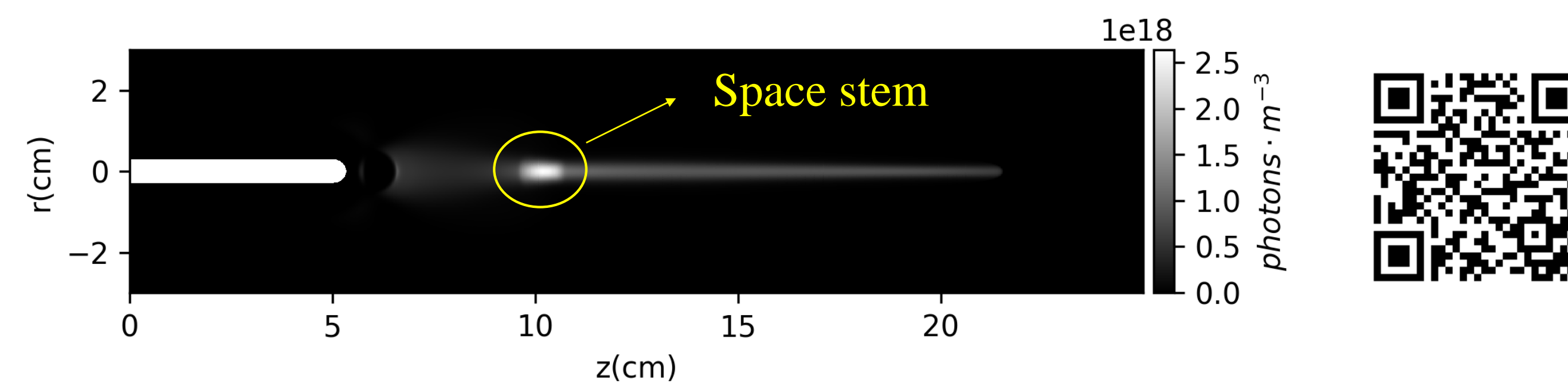
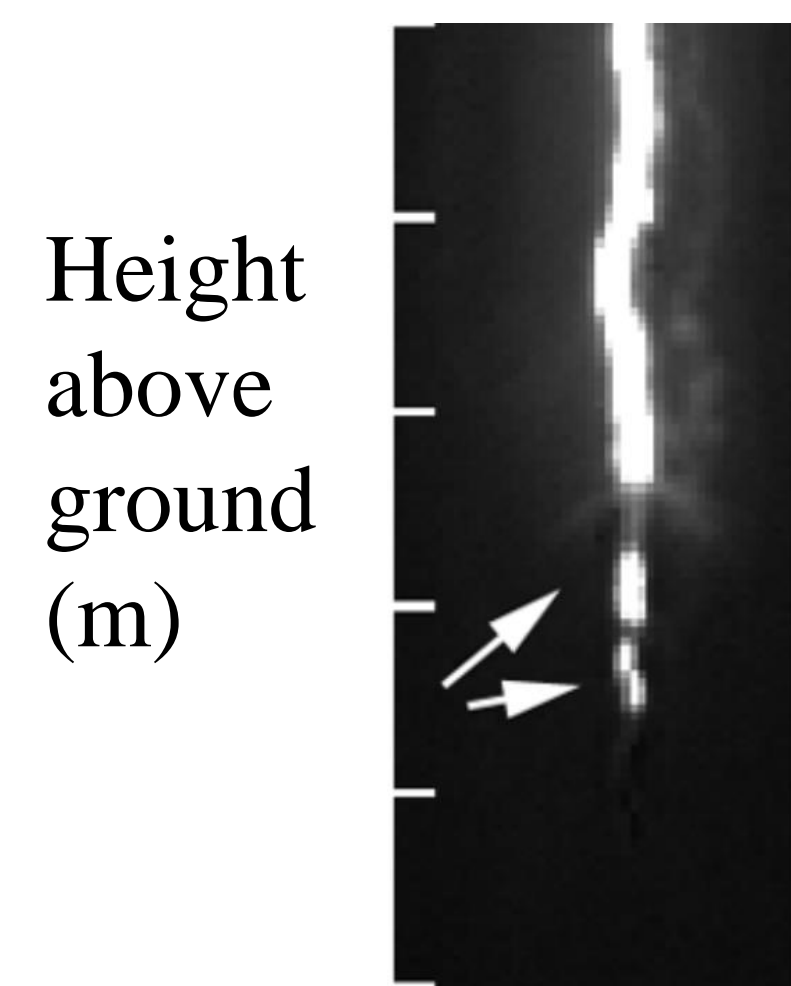


## Negative Leader Stepping



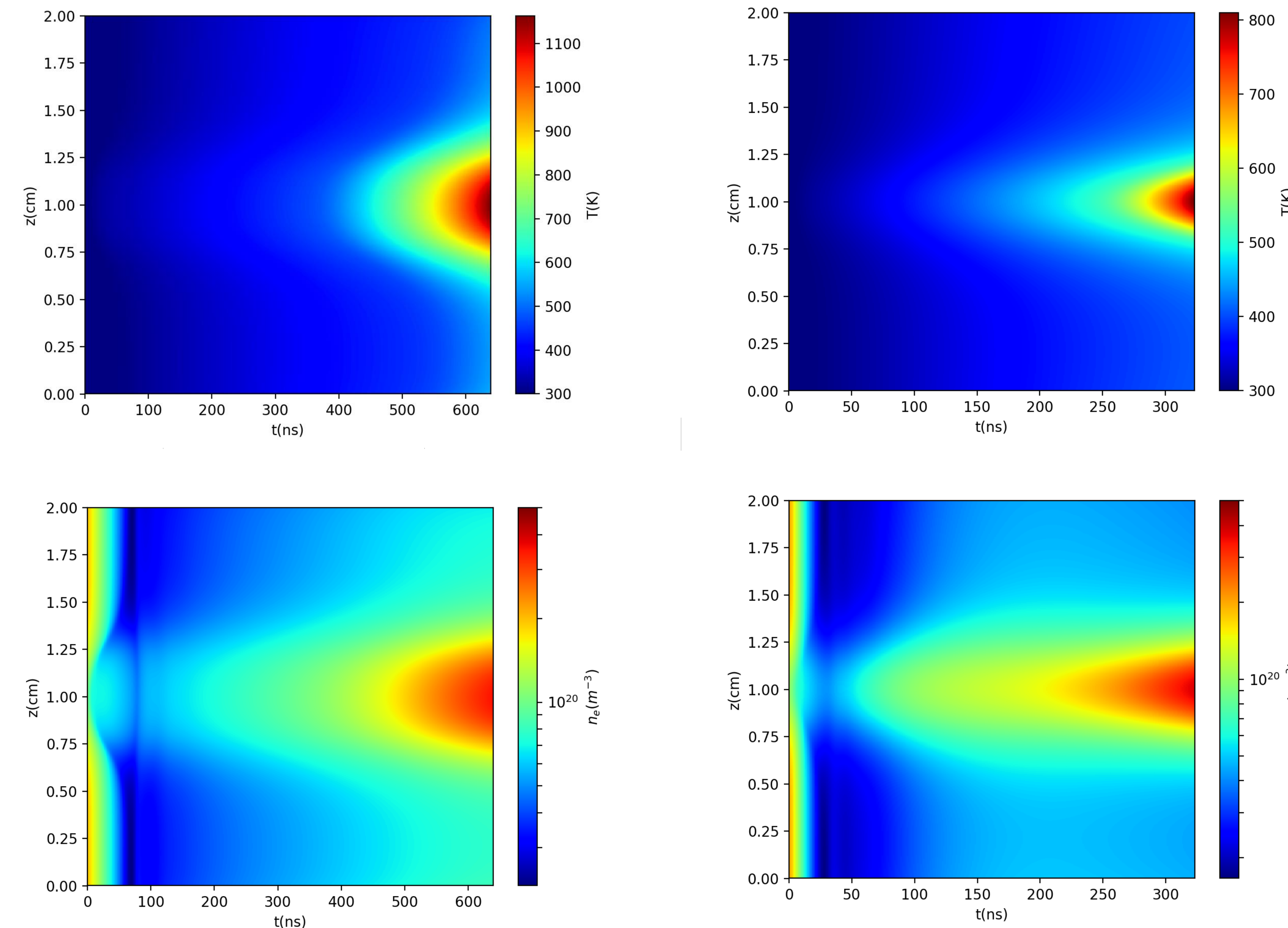
Second positive emissions of the molecular nitrogen

Malagón-Romero, A., & Luque, A. (2019). Spontaneous emergence of space stems ahead of negative leaders in lightning and long sparks. *Geophysical Research Letters*, 46, 4029–4038. <https://doi.org/10.1029/2019GL082063>



Biagi, C. J., Uman, M. A., Hill, J. D., Jordan, D. M., Rakov, V. A., and Dwyer, J. (2010), Observations of stepping mechanisms in a rocket-and-wire triggered lightning flash, *J. Geophys. Res.*, 115, D23215, doi:[10.1029/2010JD014616](https://doi.org/10.1029/2010JD014616).

## Dry Air VS Humid Air Simulations

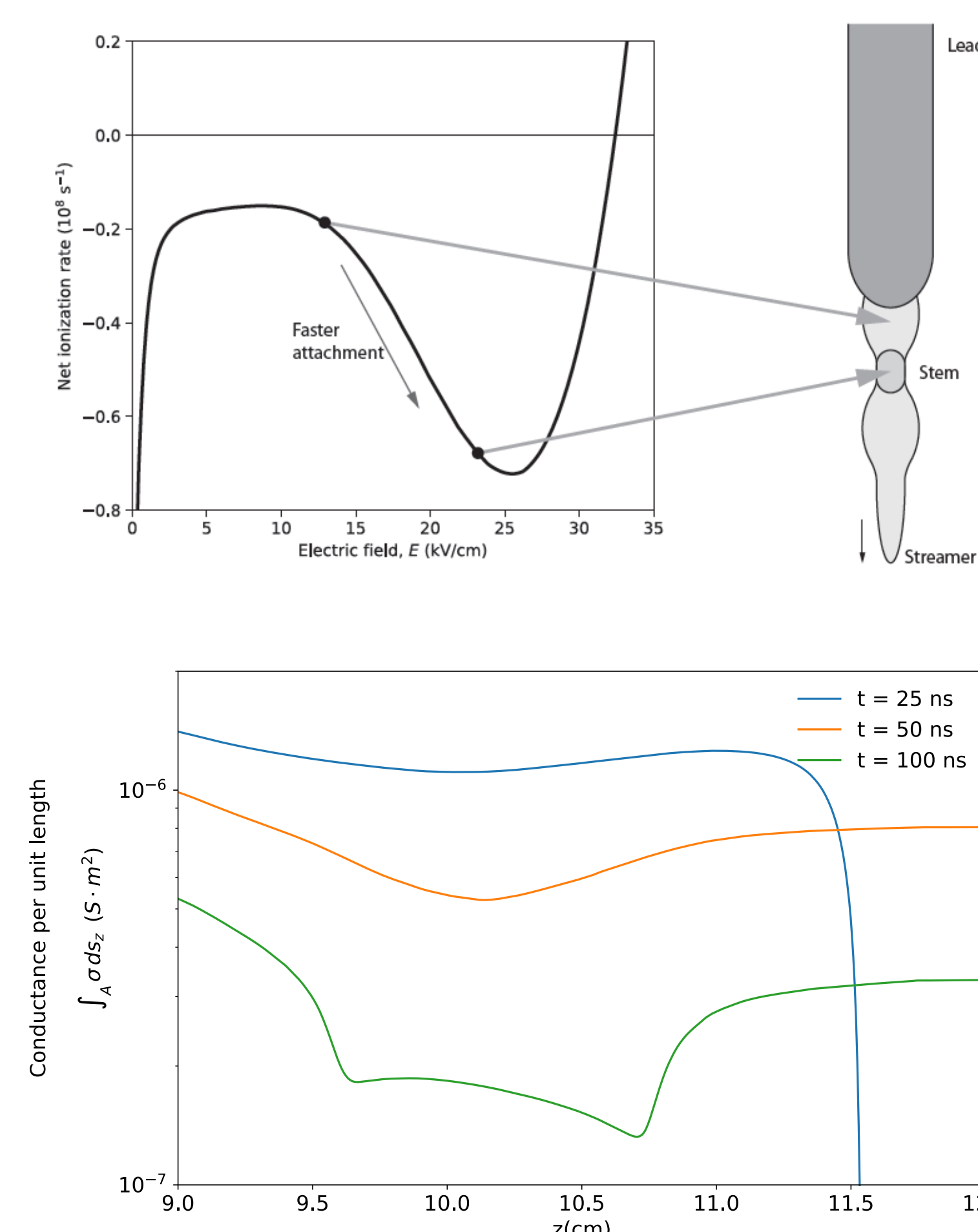


**Sequence of events:**

**Conditions: Constant current set to 0.25 A, dry air (left) and humid air 1.5% (right)**

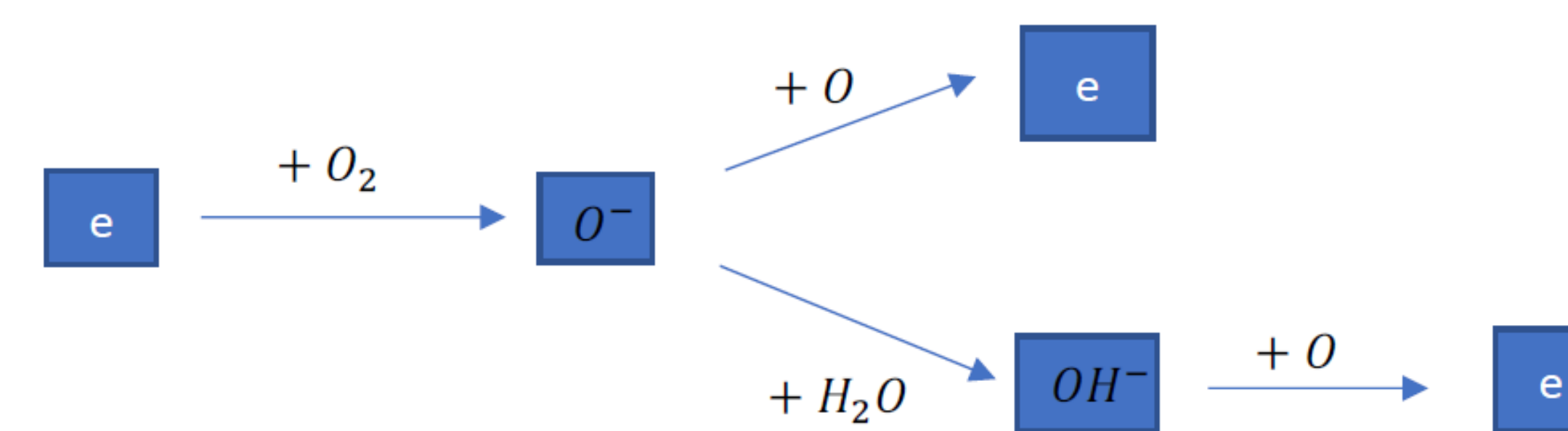
**Humid air:** Electric field enhancement in the space stem leading to a sharp increase of temperature and electron density.

## Space Stem Precursor: Low Conductivity Region



Attachment Instability

Low conductivity region



## Observations

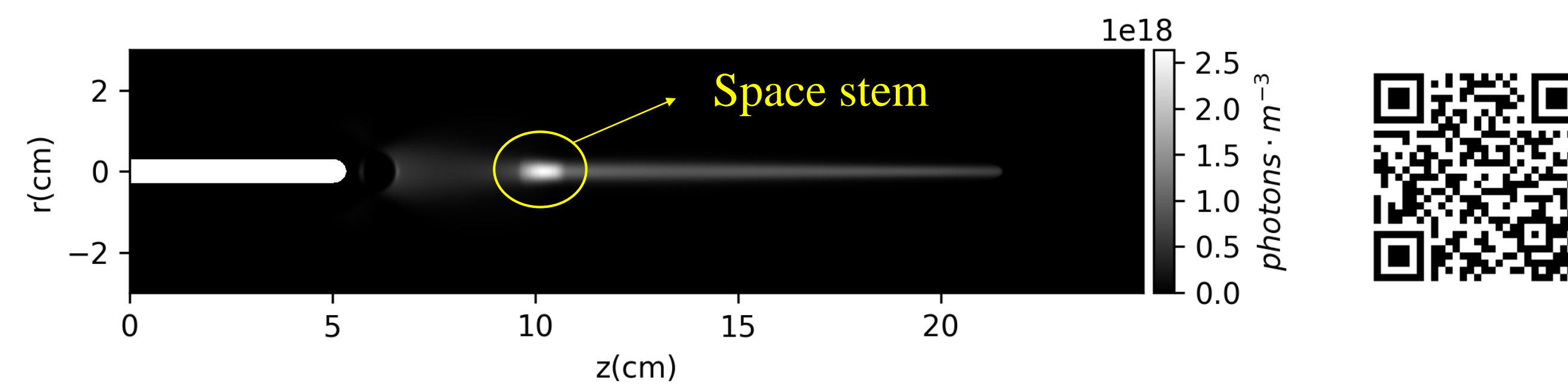
In humid air, under relatively high electric fields (approx. 90 Td),  $OH^-$  is the most abundant negative ion. This high abundance leads to fast detachment as water concentration increases.

## Conclusions

In this work we have presented the results of our simulations for the evolution of a space stem precursor under dry and humid air conditions. These results show that the presence of water molecules enhances the electric field and the heating rate of the space stem, reaching 2000 K considerably faster than in dry air. This could make feasible the stepping of positive leader discharges under high humidity conditions.

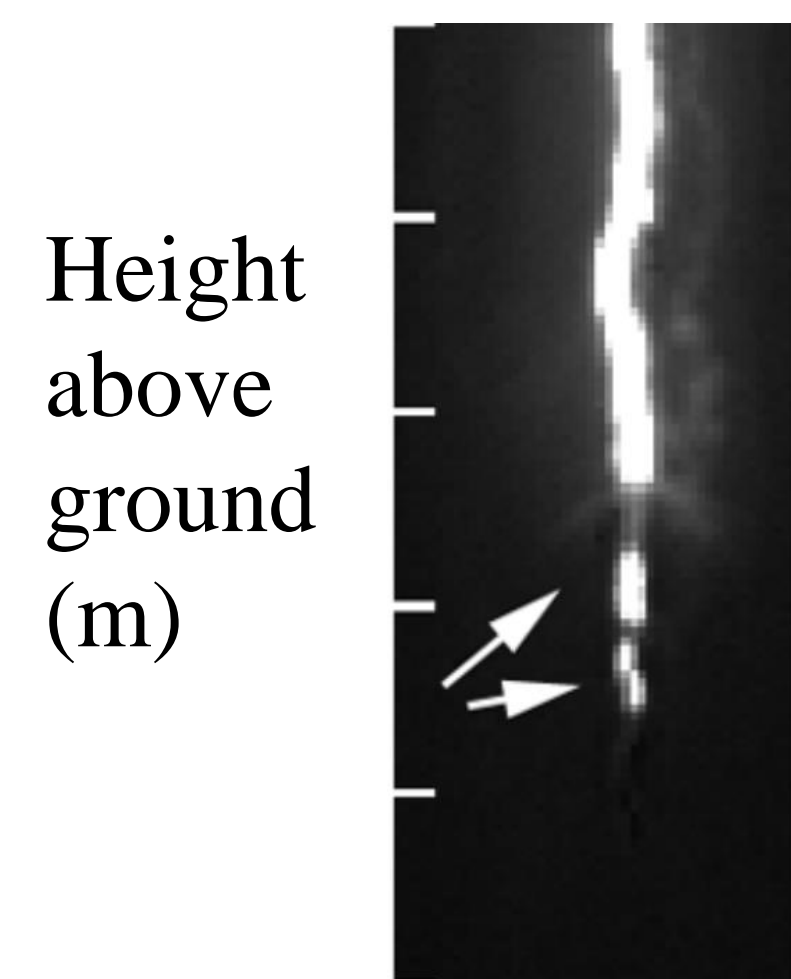


## Negative Leader Stepping



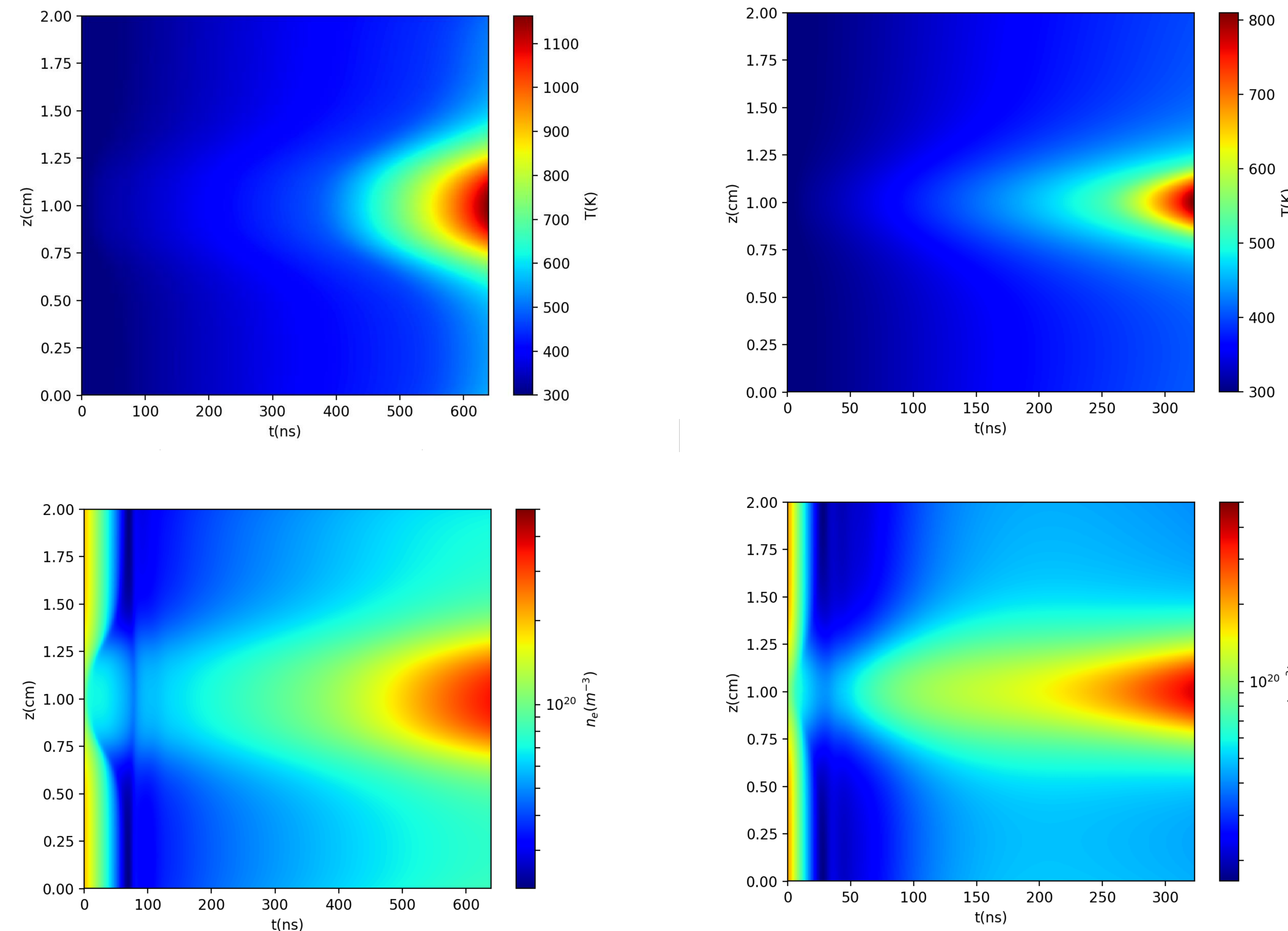
Second positive emissions of the molecular nitrogen

Malagón-Romero, A., & Luque, A. (2019). Spontaneous emergence of space stems ahead of negative leaders in lightning and long sparks. *Geophysical Research Letters*, 46, 4029–4038. <https://doi.org/10.1029/2019GL082063>



Biagi, C. J., Uman, M. A., Hill, J. D., Jordan, D. M., Rakov, V. A., and Dwyer, J. (2010), Observations of stepping mechanisms in a rocket-and-wire triggered lightning flash, *J. Geophys. Res.*, 115, D23215, doi:[10.1029/2010JD014616](https://doi.org/10.1029/2010JD014616).

## Dry Air VS Humid Air Simulations

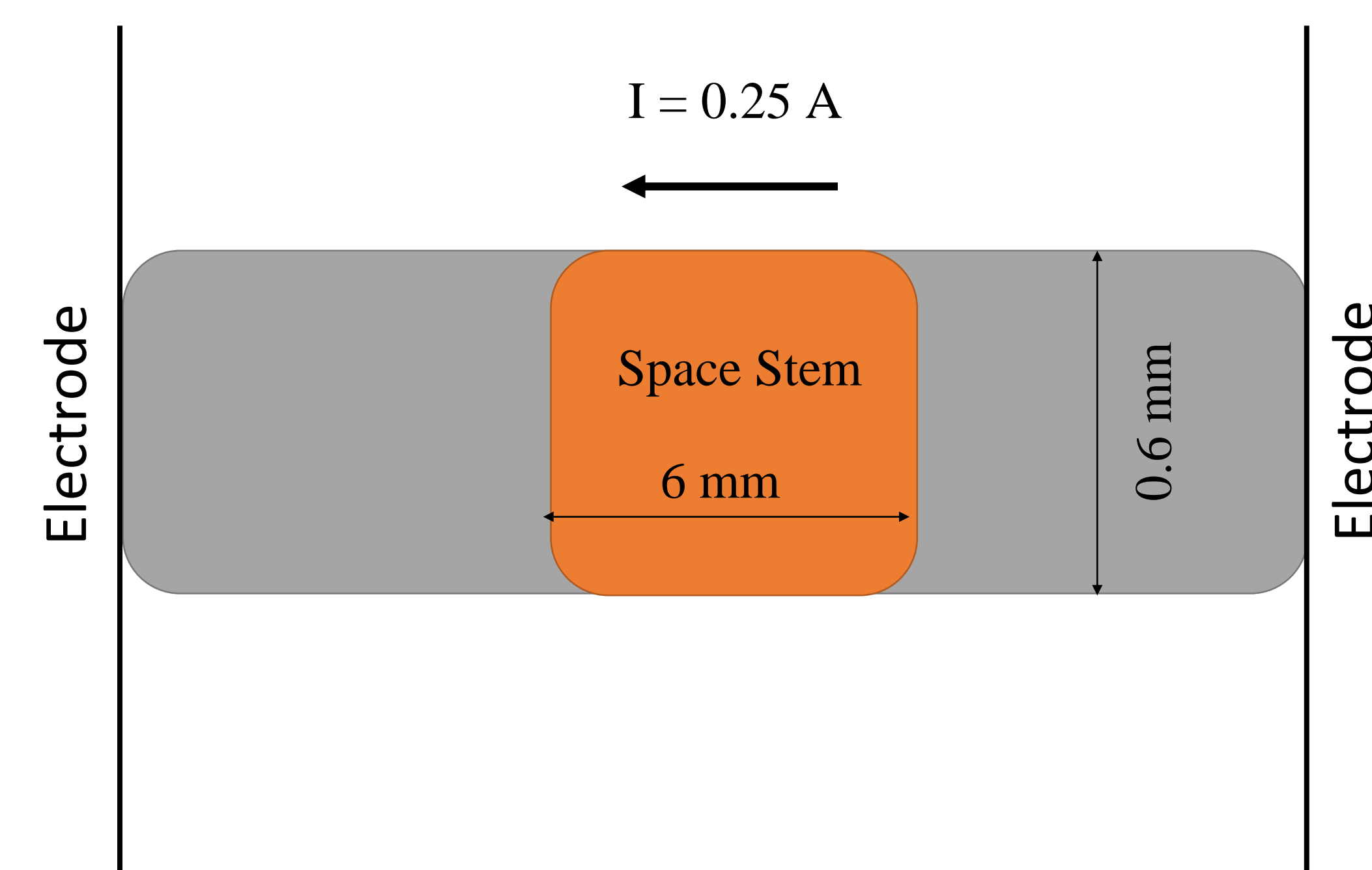


**Sequence of events:**

**Conditions: Constant current set to 0.25 A, dry air (left) and humid air 1.5% (right)**

**Humid air:** Electric field enhancement in the space stem leading to a sharp increase of temperature and electron density.

## Simulation settings



## Observations

In humid air, under relatively high electric fields (approx. 90 Td),  $OH^-$  is the most abundant negative ion. This high abundance leads to fast detachment as water concentration increases.

## Conclusions

In this work we have presented the results of our simulations for the evolution of a space stem precursor under dry and humid air conditions. These results show that the presence of water molecules enhances the electric field and the heating rate of the space stem, reaching 2000 K considerably faster than in dry air. This could make feasible the stepping of positive leader discharges under high humidity conditions.