

# Streamer inception imaged at 80 million frames per second

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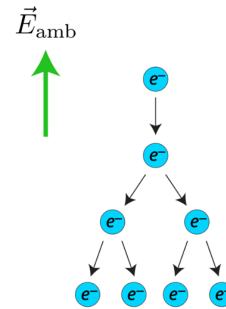
New Mexico Institute of Mining and Technology



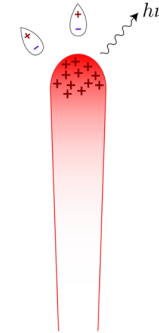
# The lightning initiation problem



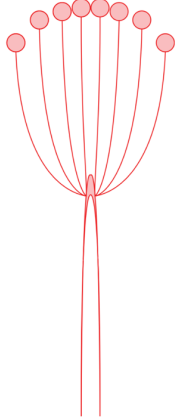
**Avalanches**



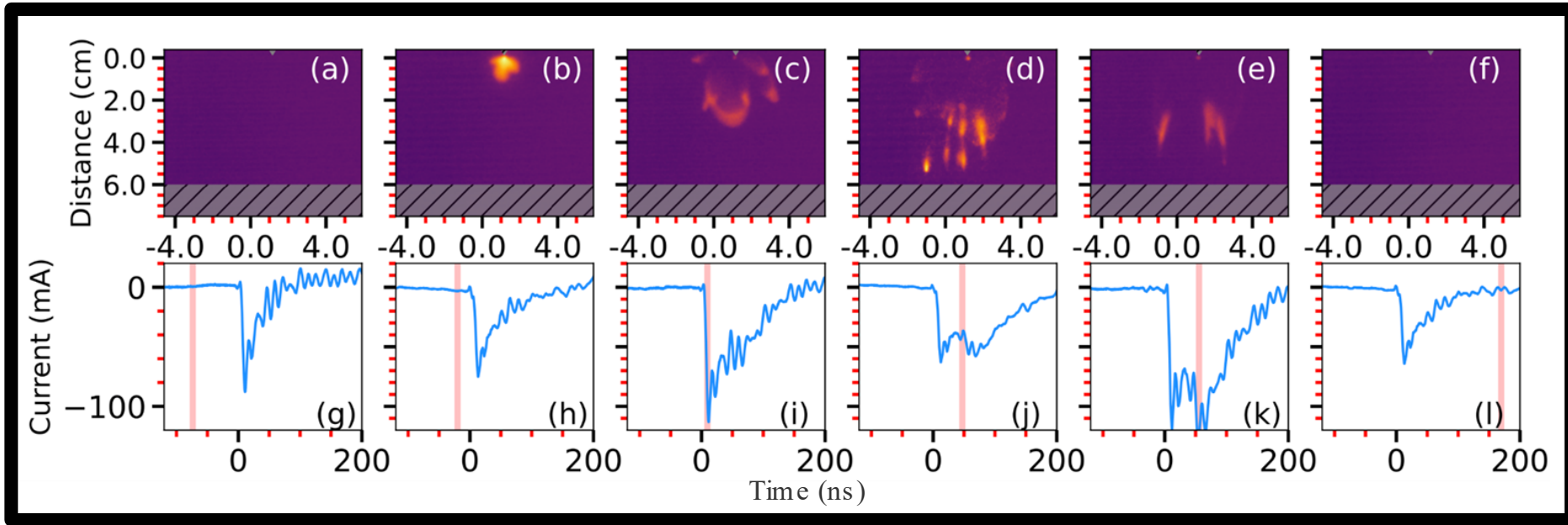
**Streamers**



**Leaders**



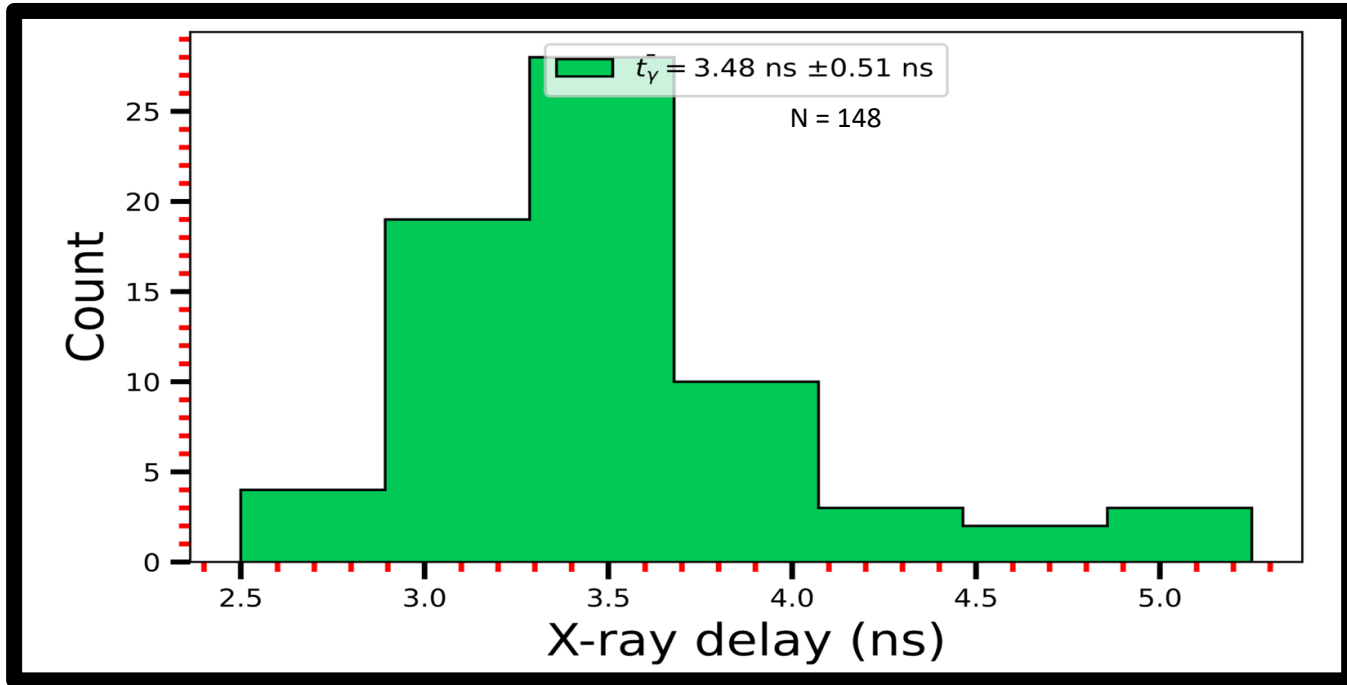
# Production of runaway electrons during the streamer inception phase



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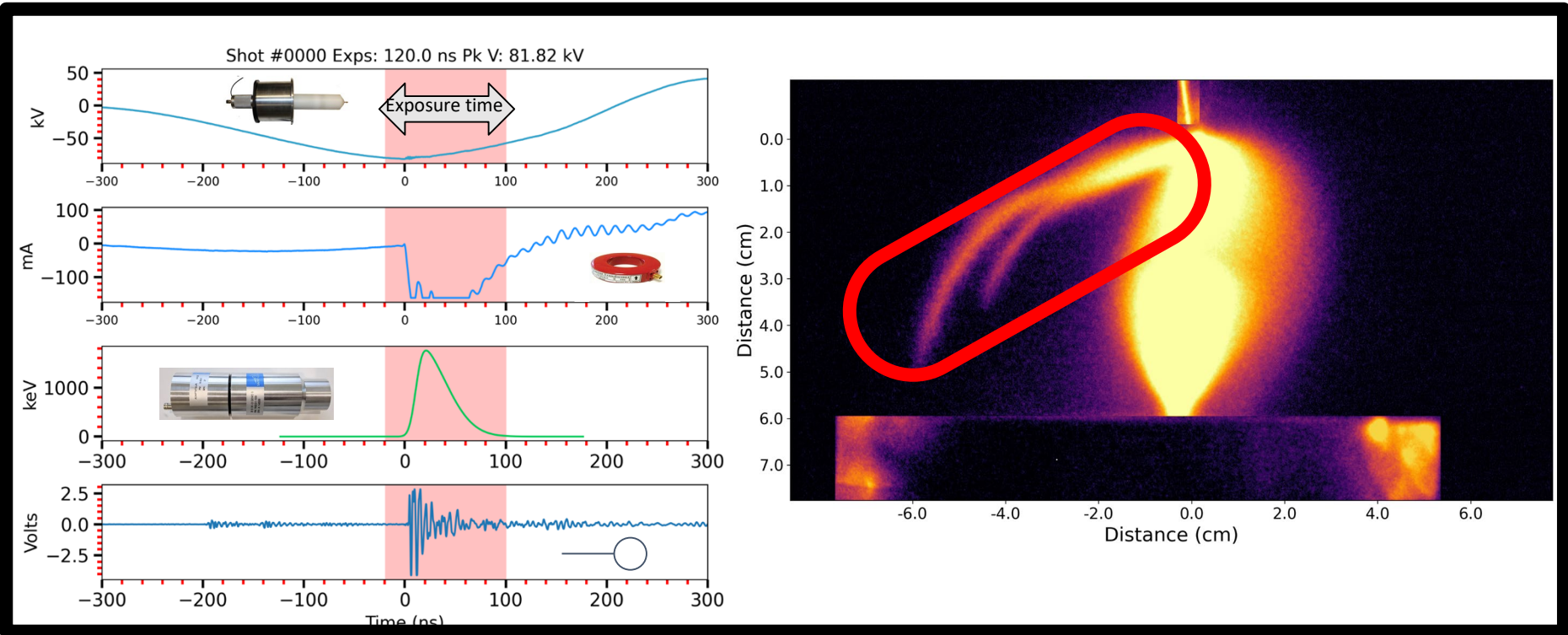


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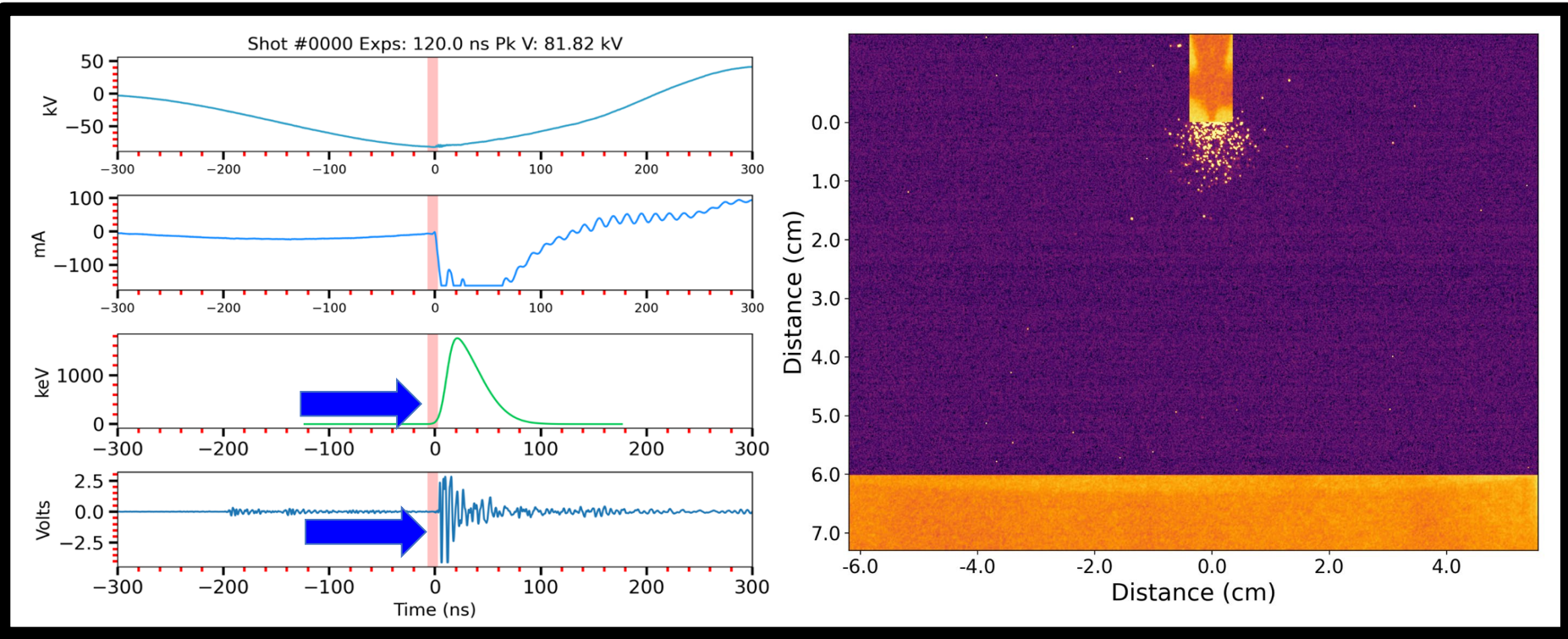
# Negative discharge dynamics : Long exposure



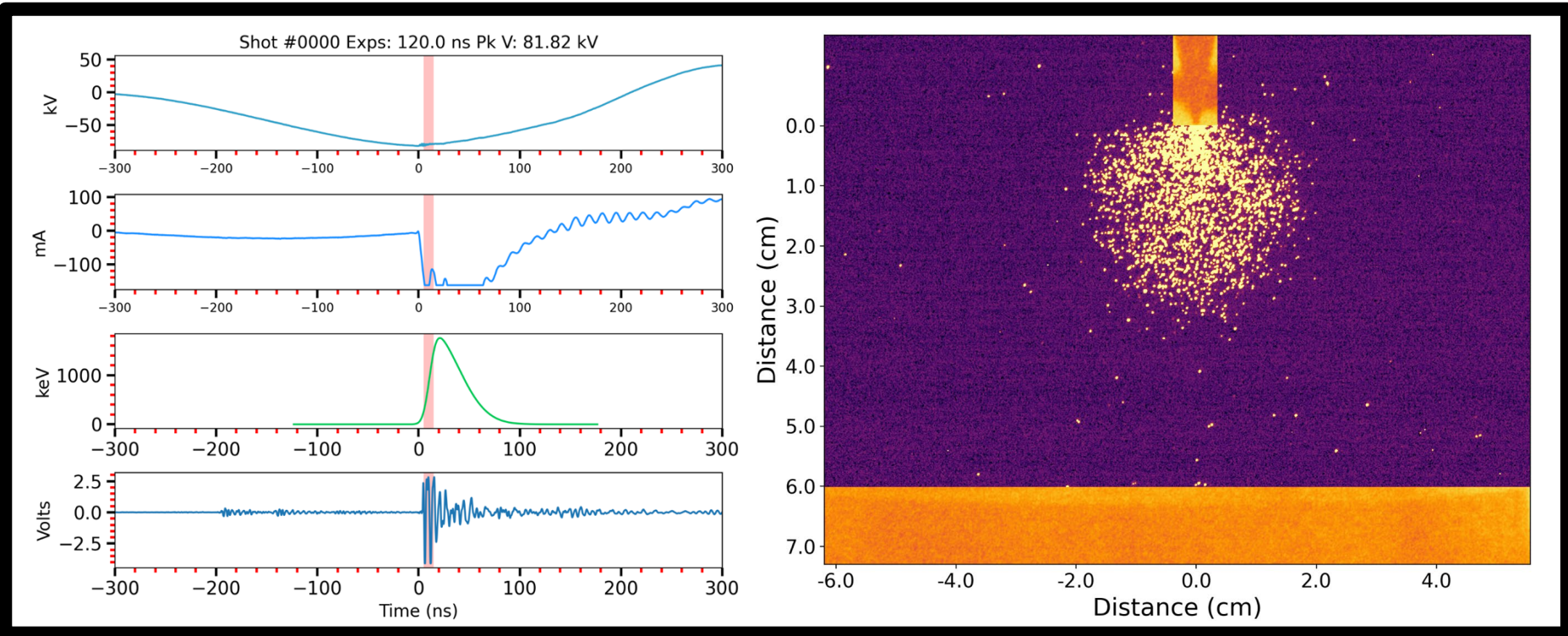




# Negative discharge dynamics : Timelapse

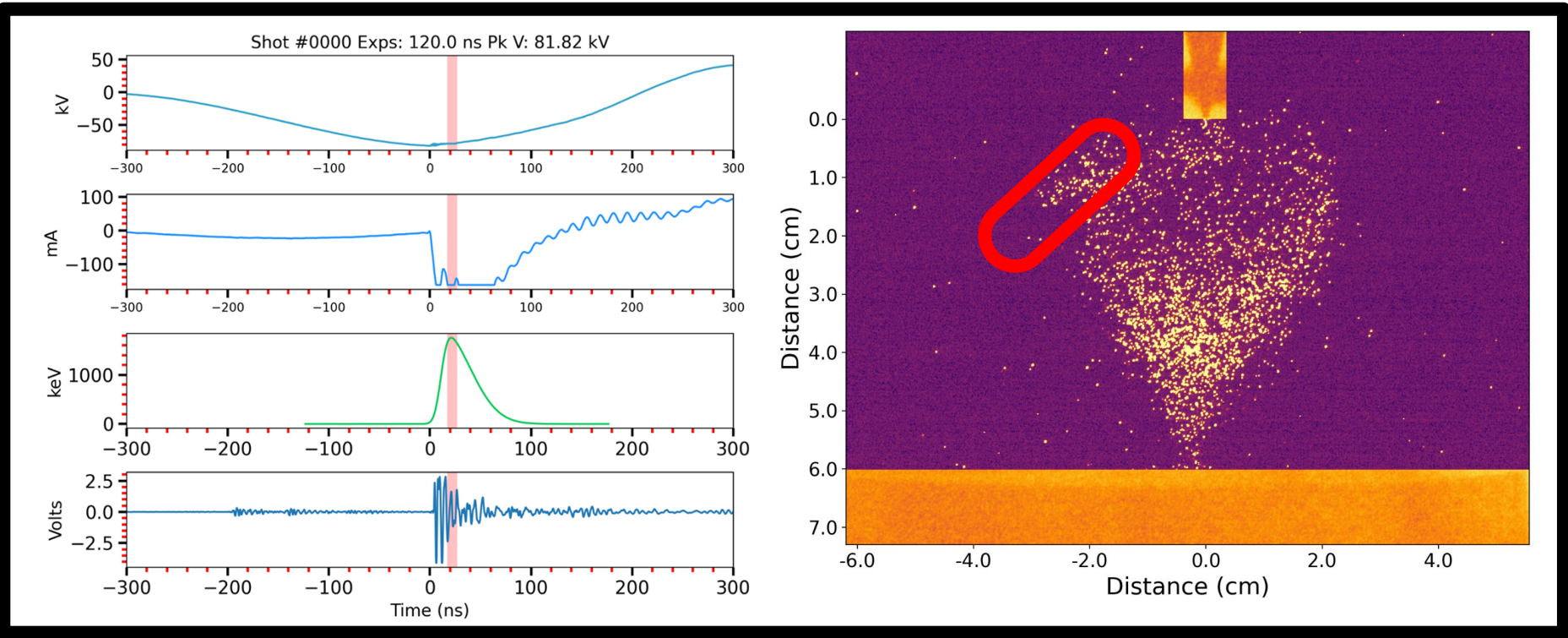


# Negative discharge dynamics : Timelapse

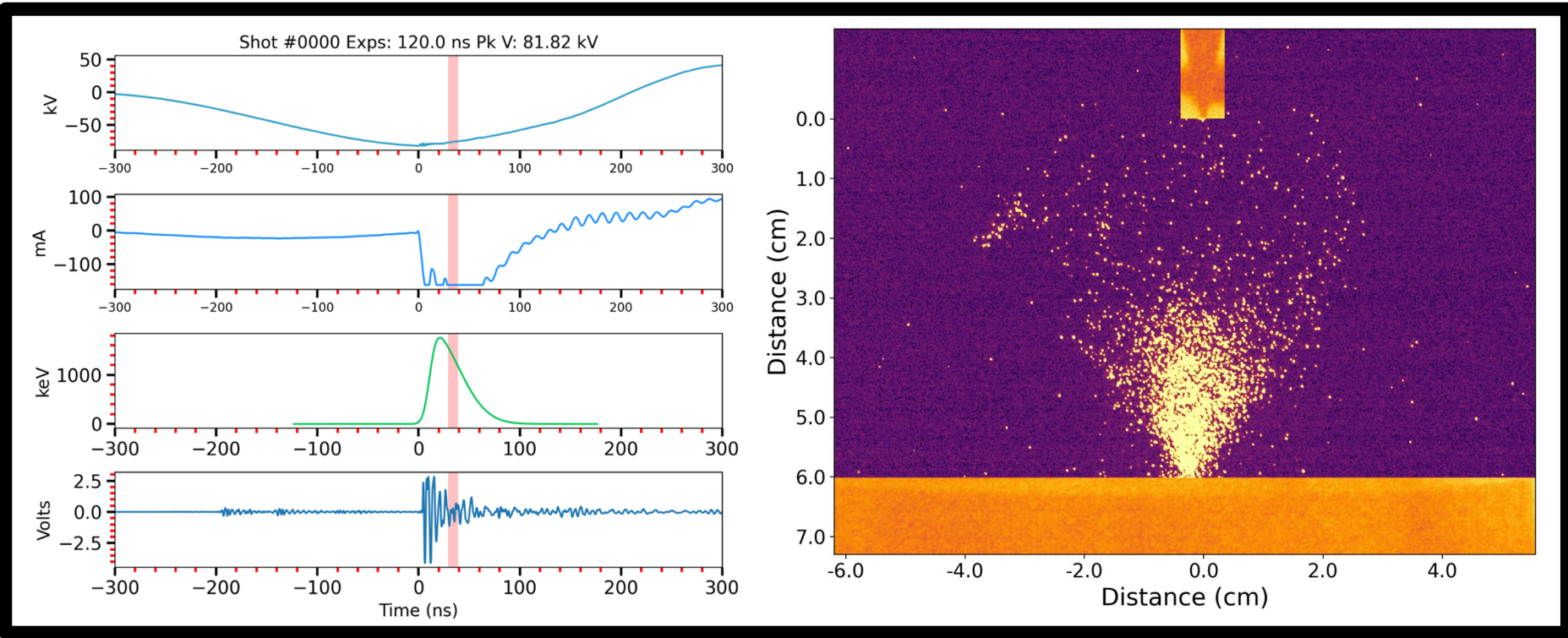




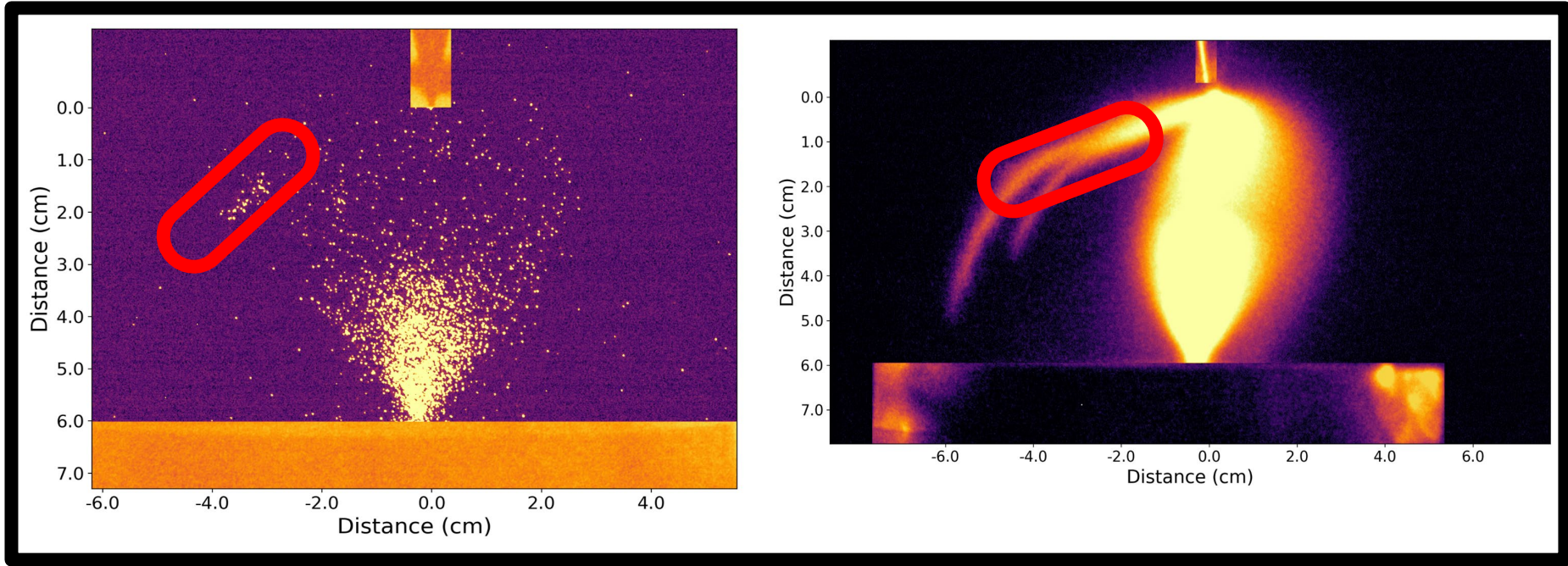
# Negative discharge dynamics : Timelapse



# Negative discharge dynamics : Timelapse

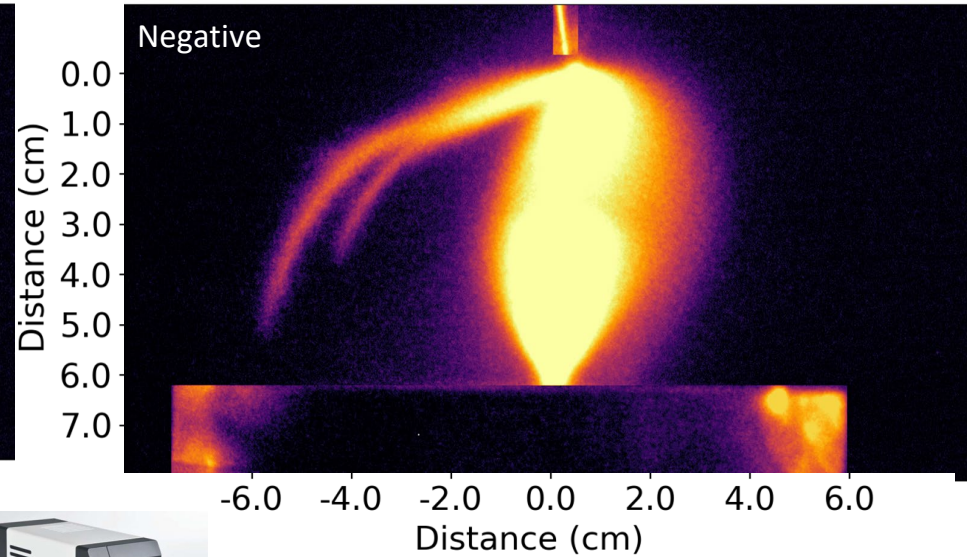
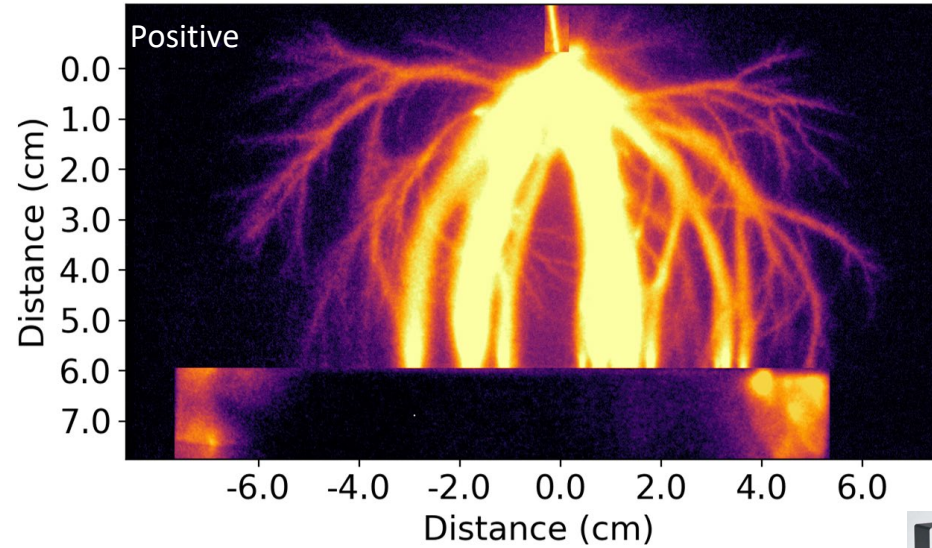


# Negative discharge dynamics : Long vs short exposure





# Positive vs negative discharge dynamics :



# Summary and conclusions

- ❖ Runaway electrons are produced early on during the streamer inception phase. Therefore:
  - Runaway electrons may influence the discharge development; &
  - No complex mechanisms are necessary to explain their production.
  
- ❖ Positive discharges do not produce X-rays and have different morphological features.



# References

- Cooray, *et al.* (2009). On the possible origin of X-rays in long laboratory sparks. *Journal of Atmospheric and Solar-Terrestrial Physics*
- Ihaddadene, *et al.* (2019). Modeling of a new electron acceleration mechanism ahead of streamers. *Journal of Geophysical Research: Space Physics*
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- Sander Nijdam *et al.* (2020) The physics of streamer discharge phenomena. *Plasma Sources Sci. Technol*29 103001