

## Final Report for NM EPSCoR Infrastructure Seed Award Track 1 – Research University

Project title: Towards Quantitative Understanding of Lightning Disruptive Effects for Protection of SMART Grids

PI: Dr. Caitano L. da Silva, Sub-awarded to: New Mexico Tech (NMT)

### I. Activities

The main objective of this project is to further advance the understanding of lightning physics to better devise protection mechanisms for power distribution SMART grids. The EPSCoR funds have supported the theoretical modeling research of undergraduate students Michael C. Taylor and John G. Pantuso, and the experimental research of graduate student Luis Contreras-Vidal, including the development of the Langmuir Spark Lab, pictured in Figure 1. The Langmuir Spark Lab is a new facility located on the NMT campus (in Workman Center) dedicated to the study of electrical discharges. The facility enables us to investigate fundamental process that take place in lightning discharges, but are difficult to probe in nature. The lab can also be used to test the effects of electrical discharges on SMART grid components.

(a) Spark Lab: Faraday cage



(b) 1st experiment: ns spark resistance measurements

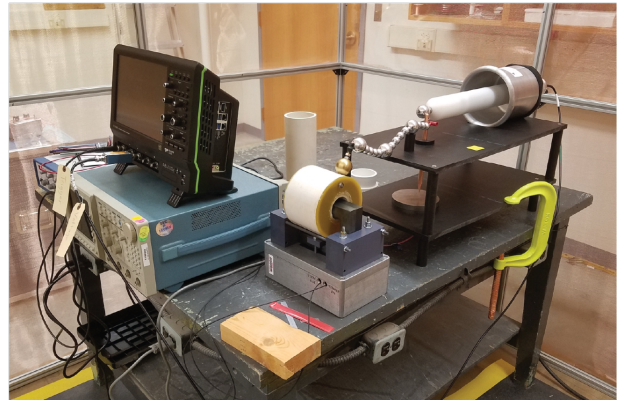


Figure 1 - The newly developed Langmuir Spark Lab. (a) Faraday cage. (b) First experiment.

### II. Equipment Purchased

No major equipment has been purchased with EPSCoR funds — the grant mostly covered salaries. Specifically, we have used project funds to purchase miscellaneous supplies to support the development of the Spark Lab, and to support the experimental research done by graduate student Luis Contreras-Vidal. A desktop computer to support the student's data analysis has also been purchased.

### III. Publications

In Sections III and IV below, the PI's name is marked in **bold**, while students supported by this grant are highlighted in **blue**. Two peer-reviewed journal publications have resulted from this grant. The research done by undergraduate student Michael C. Taylor is expected to result in a third paper to be submitted to *IEEE Trans. Electromag. Compat.* later this year.

**Contreras-Vidal, L.**, R. G. Sonnenfeld, **C. L. da Silva**, M. McHarg, D. Jensen, J. Harley, L. Taylor, R. Haaland, and H. Stenbaek-Nielsen (2021), Relationship between sprite current and morphology, *J. Geophys. Res. Space Phys.*, 126, e2020JA028930, doi: 10.1029/2020JA028930.

Jensen, D. P., R. G. Sonnenfeld, M. A. Stanley, H. E. Edens, **C. L. da Silva**, and P. R. Krehbiel (2021), Dart-leader and K-leader velocity from initiation site to termination time-resolved with 3D interferometry, *J. Geophys. Res. Atmos.*, Under Review, doi: 10.1029/2020JD034309.

### IV. Conference Presentations

This project results in nine conference presentations. In the list below, the first author is the presenter. Please note the contributions of the students funded by this project (highlighted in **blue**) eight of the nine presentations listed below.

**Contreras-Vidal, L.**, **C. L. da Silva**, R. G. Sonnenfeld, J. N. Tilles, and P. G. Clem (2020), Initial results from precision spark resistance measurements, Student poster presentation at the *2020 Virtual AGU Fall Meeting*, Abstract AE008-0001.

**da Silva, C. L.**, **M. C. Taylor**, T. D. Walker, and H. J. Christian (2020), Data-constrained simulations of the return stroke plasma properties, Poster presentation at the *2020 Virtual AGU Fall Meeting*, Abstract AE001-0015.

**Pantuso, J. G.**, and **C. L. da Silva** (2020), Algebraic electron beam operations for reconstructing runaway electron energy spectrum, Student poster presentation at the *2020 Virtual AGU Fall Meeting*, Abstract AE005-02.

**Pantuso, J. G.**, and **C. L. da Silva** (2020), Geant4 monoenergetic electron beam simulations of runaway electrons in streamer discharges, Student online poster presentation at the *9th New Mexico Tech Student Research Symposium*, Poster SRS2020-198, Socorro, NM.

**Taylor, M. C.**, and **C. L. da Silva** (2020), Data-constrained simulations of the temperature inside a lightning channel, Student online poster presentation at the *9th New Mexico Tech Student Research Symposium*, Poster SRS2020-180, Socorro, NM.

**Contreras-Vidal, L.**, R. G. Sonnenfeld, **C. L. da Silva**, D. Jensen, J. Harley, M. G. McHarg, L. M. Taylor, R. K. Haaland, and H. C. Stenbaek-Nielsen (2019), Comparing sprite currents with high-speed video measurements, Student poster presentation at the *2019 AGU Fall Meeting*, Abstract AE31B-3110, San Francisco, CA.

**Pantuso, J. G.**, and **C. L. da Silva** (2019), Geant4 monoenergetic electron beam simulations of runaway electrons in streamer discharges, Student poster presentation at the *2019 AGU Fall Meeting*, Abstract AE41B-3153, San Francisco, CA.

**da Silva, C. L.**, W. P. Winn, K. B. Eack, H. E. Edens, G. D. Aulich, S. J. Hunyady, R. G. Sonnenfeld, and P. R. Krehbiel (2019), The contrasting behavior of positive and negative upward lightning leaders evidenced by simultaneous current and VHF location measurements, Oral presentation at the *2019 AGU Fall Meeting*, Abstract AE12A-04, San Francisco, CA.

McHarg, M. G., J. Harley, C. Maldonado, C. T. Lane, L. M. Taylor, R. G. Sonnenfeld, **C. L. da Silva**, D. Jensen, **L. Contreras-Vidal**, R. K. Haaland, and H. Stenbaek-Nielsen (2019), Sprite streamer interactions at 100,000 frames per second, Contributed presentation at the *2019 AGU Fall Meeting*, Abstract AE23A-08, San Francisco, CA.

## V. Grant Applications

The support of the NM ESPCoR office was crucial in the development of the NSF CAREER proposal listed below. This is one of two proposals funded at NMT in over 20 years. See the press release linked here: [https://www.nmt.edu/news/2021/nsf\\_career\\_awards\\_2021.php](https://www.nmt.edu/news/2021/nsf_career_awards_2021.php)

Title: CAREER: Self-consistent and data-constrained simulations of the leader and return stroke processes in lightning discharges  
Submitted to: National Science Foundation PDM/GEO/NSF  
Role: Single PI  
Period: 08/01/2021 – 07/31/2026, Amount: \$523,159  
Status: **Funded**

Title: 2021 Sloan Fellowship – Polarity asymmetry in lightning physics  
Submitted to: Alfred P. Sloan Foundation  
Role: Single PI  
Period: 08/01/2021 – 07/31/2023, Amount: \$75,000  
Status: Rejected

Title: Lightning hazards to weapon systems in flight  
Submitted to: USAF Kirtland AFB/AFMC/AFNWC  
Role: Single PI  
Period: 06/01/2021 – 05/31/2022, Amount: \$68,000  
Status: Pending