



Christopher Roper

Ph.D. Student, Aerospace Engineering
Second Year ARCS Scholar
Dodson/Plummer Award



Understanding Wave Generation and Energetic Electron Beam Propagation Using a Space-Based Accelerator System

Georgia Tech Ph.D. Research: Project Beam-PIE **HPEPL**

Beam Plasma Interaction Experiment (Beam -PIE): A Sub-Orbital Active Experiment Using Pulsed Electron Beams

Beam PIE is a sounding rocket experiment that will use an electron beam to quantitatively understand and characterize how energetic electron beams in space couple to plasmas to stimulate whistler -mode and R-X-mode radiation.

UNCLASSIFIED Slide 1
LA-UR-22-25656 Los Alamos NATIONAL LABORATORY

Georgia Tech Motivation **HPEPL**

Problem: Satellites in Low Earth Orbit (LEO) Are Vulnerable To Enhanced Electron Flux In The Inner Radiation Belt.

(a) 10-KT predicted impact of High -Altitude Nuclear Detonation (HAND) (150km) on Satellite lifetimes⁵
(b) Dose accumulation Rates, Baseline model⁵

UNCLASSIFIED Slide 2
LA-UR-22-25656 Los Alamos NATIONAL LABORATORY

Georgia Tech Motivation: Continued **HPEPL**

Overall Goal: Quantitatively test wave generation by pulsed electron beams (both Whistler mode and X-mode).

Figure 3 : Particle scattering and measuring changes in the mirror altitude near the loss cone
Solution: Launch Mother-Daughter Sounding Rocket for project Beam -PIE

Figure 4: Schematic of the Beam PIE payload and instrument locations

UNCLASSIFIED Slide 3
LA-UR-22-25656 Los Alamos NATIONAL LABORATORY

Georgia Tech Experimental Set-up **HPEPL**

(a) (b)

Beam-PIE: Laboratory Progress Phase 2

UNCLASSIFIED Slide 4
LA-UR-22-25656 Los Alamos NATIONAL LABORATORY

Georgia Tech Data Analysis & Results **HPEPL**

Figure 6: Electron beam capture on YAG(Ce) Yttrium Aluminum Garnet Screen (a) Front (b) Rear

Figure 7: CST Microwave Studio Particle Current Density Modeling (a) Meshing (b) Simulation

UNCLASSIFIED Slide 5
LA-UR-22-25656 Los Alamos NATIONAL LABORATORY

Georgia Tech Conclusion and Future Work **HPEPL**

Beam-PIE
The Beam-Plasma Interactions Experiment

(a) Beam PIE visual concept (b) Electric field probes as deployed in sounding rocket¹

UNCLASSIFIED Slide 6
LA-UR-22-25656 Los Alamos NATIONAL LABORATORY

[1] Reeves, Geoffrey D., et al. "The beam plasma interactions experiment: An active experiment using pulsed electron beams." *Frontiers in Astronomy and Space Sciences* 7 (2020): 23. [2] Reeves, Geoffrey D. "Wave Generation and Wave-Particle Interaction Using Space-Based, RF, Linear Electron Accelerators." 2021 USNC-URSI Radio Science Meeting (USNC-URSI RSM). IEEE, 2021. [3] Duffy, Leanne Delma, et al. "Beam dynamics modeling of the Beam Plasma Interaction Experiment." *AGU Fall Meeting Abstracts*. Vol. 2020. 2020. [4] Reeves, Geoffrey D., et al. "The Beam Plasma Interactions Experiment (Beam PIE): A sub-orbital active experiment." *AGU Fall Meeting* 2019. Agu, 2019. [5] Carlsten, Bruce E., et al. "Response to comment on "radiation-belt remediation using space-based antennas and electron beams" by G. Ganguli and C. Crabtree." *IEEE Transactions on Plasma Science* 48.2 (2020): 604-607. [6] Carlsten, Bruce. "Applications of Compact Accelerators in Space for National Security." (2018).