



Contribution ID: 1684 Contribution code: THPR81

Type: **Poster Presentation**

The design of a rocket based RF electron accelerator for space applications

Thursday, 23 May 2024 16:00 (2 hours)

Beam Plasma Interactions Experiment (Beam-PIE) is a NASA sounding rocket experiment that successfully ran in November 2023. Beam-PIE used space as a laboratory to explore wave generation from a modulated electron beam in the ionosphere. Beam-PIE electron accelerator used a 10keV electron gun and a 5-GHz RF cavity, enabling the acceleration of the electron beam to a total energy of ~25–60 keV. The experiment was pulsed at VLF frequencies ranging from 5 to 500 kHz. The third parameter was duty cycle which ranged from 2.5% to 10%. In total, 32 different combinations of beam parameters were used and repeated every 32 seconds through the flight at various altitudes and background plasma conditions. Each of these different beam parameters ran for a $\frac{1}{2}$ -second beam pulse, separated by $\frac{1}{2}$ -second intervals when the beam was off. Beam-PIE was successful at generating plasma waves. We present an outline of the accelerator design, theoretical predictions, and experimental results of generated plasma waves. Results will be used to quantitatively test our understanding of beam-plasma-wave interactions in the space environment with applications to space communication and radiation belt remediation.

Footnotes

- [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] Marksteiner, Quinn, et al. "Beam dynamics and radiation modeling for the Beam Plasma Interaction Experiment." *AGU Fall Meeting Abstracts*. Vol. 2021. 2021.
- [3] Yakymenko, Kateryna, et al. "Beam physics in support of active experiments in space." *APS Division of Plasma Physics Meeting Abstracts*. Vol. 2019. 2019.

Funding Agency

This research was funded by the U.S. Department of Energy through the Laboratory Directed Research and Development program of the Los Alamos National Laboratory, under project number 20230461ER.

Paper preparation format

Word

Region represented

North America

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Session Classification: Thursday Poster Session

Track Classification: MC8: Application of Accelerators, Technology Transfer, Industrial Relations, and Outreach: MC8.U09 Other Applications