Additively Manufactured Plastic Plasma Spectrometer (AMPPS)

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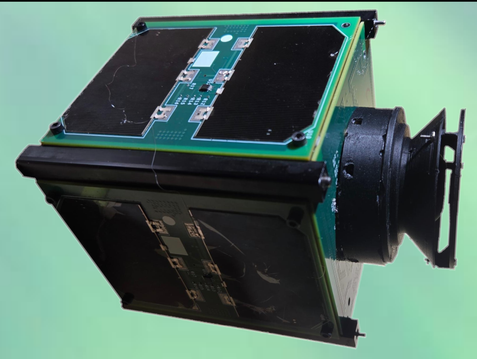
Plasma spectrometers detect charged particles, such as electrons in the Aurora. This is a top hat style plasma spectrometer manufactured through the process of 3D printing with a low outgassing plastic: PVDF (Polyvinylidene fluoride). By interlacing carbon-doped plastic with the PVDF, we printed all the electrodes, insulators, and shielding.

AMPPS can work on spacecraft as small as a 1-U CubeSat, or a sounding rocket ejectable subpayload.

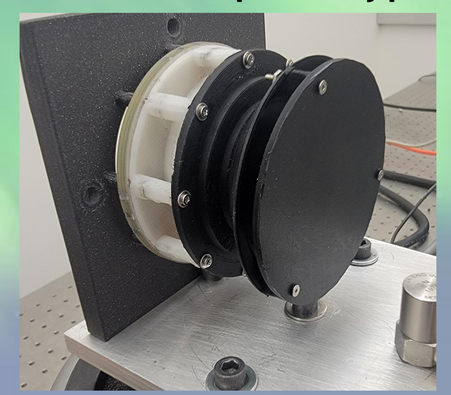


AMPPS survived vibration tests at the NASA GEVS 14.1g standard in all axes, despite being roughly half the weight of a more traditional prototype.

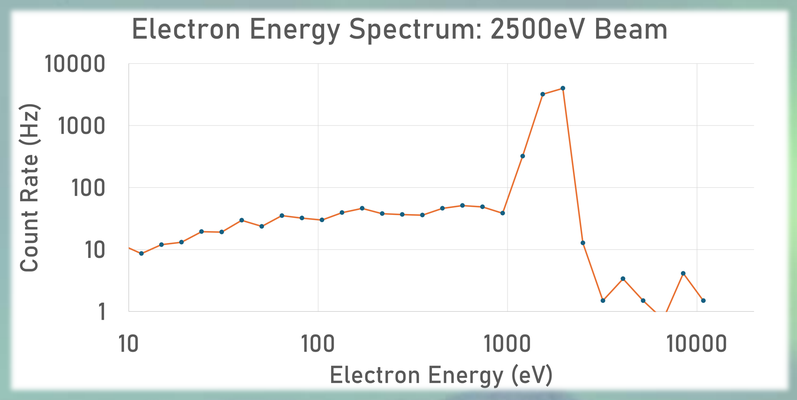
3D printing pushes space plasma instruments further due to lightweight, cheap, and easy to manufacture parts. We are using “monolithic” multi-material prints to achieve electrode geometries which are not possible with traditional subtractive manufacturing methods.

AMPPS Prototype Specs

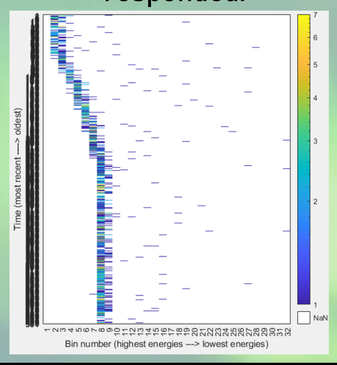
Mass	< 137g
Shape	63mm diam. 61 mm long
Field of View	2 x 180° x 10°
Energy Range	~ 25 eV – 25 keV
Electrical Cable	3.3V, GND, UART RX/TX Single 10-pin DF-52
Power Use	< 0.6 Watts
Memory	64 MB or 40 minutes



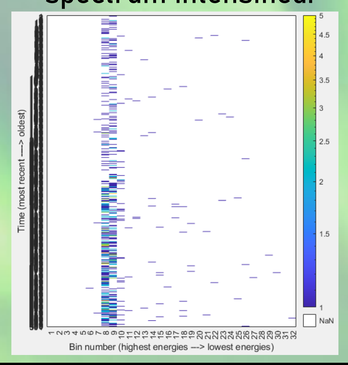
AMPPS vibration table setup



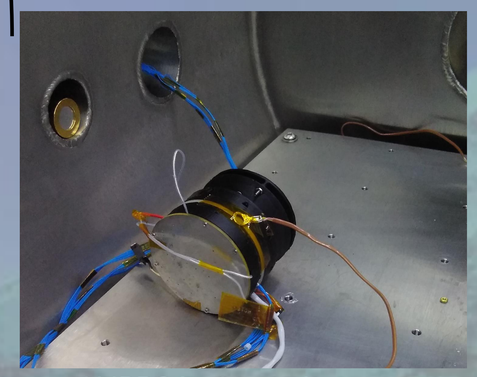
When the beam energy was changed, the spectrum responded:



When the electron beam flux increased, the spectrum intensified:



AMPPS was tested in an electron beam at various fluxes and energies, at various temperatures.

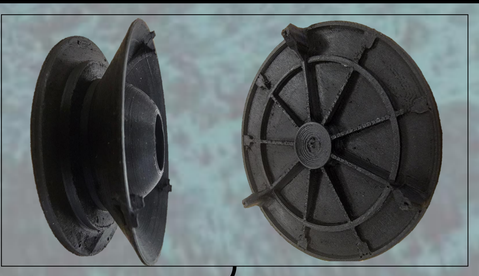


AMPPS in thermal vacuum during electron beam testing

The High Voltage Power Supply (HVPS) generates up to 4200V. This requires a spacer to prevent arcing to the motherboard. It supplies exponential voltage sweeps 100 times per second.

The Motherboard collects and amplifies electron pulses using a PADI preamplifier-discriminator ASIC. It stores electron spectra in flash memory. It manages power distribution and protection, while communicating with the HVPS and the rest of the spacecraft.

The detector stack uses two MicroChannel Plates (MCPs) to amplify the charge of each individual electron. The MCPs are sandwiched by insulators with embedded conductive plastic rings to provide high voltage power. The output electrons land on the anode surfaces of the motherboard. The outer surfaces of the detector stack are conductive to prevent charge build-up on surfaces. The curved spiral arms provide a vibration-tolerant mounting platform for the MCPs, which are fragile glass.



The Electro-Static Analyzer (ESA) filters electrons through a narrow curved channel. The channel’s electric field is rapidly changed by the high voltage supply, to collect a complete energy spectrum. Electrons which pass through the ESA impact the detector MCP stack.