

# Variable Temperature Bolometer for Sensing Neutral Atomic and Molecular Beams

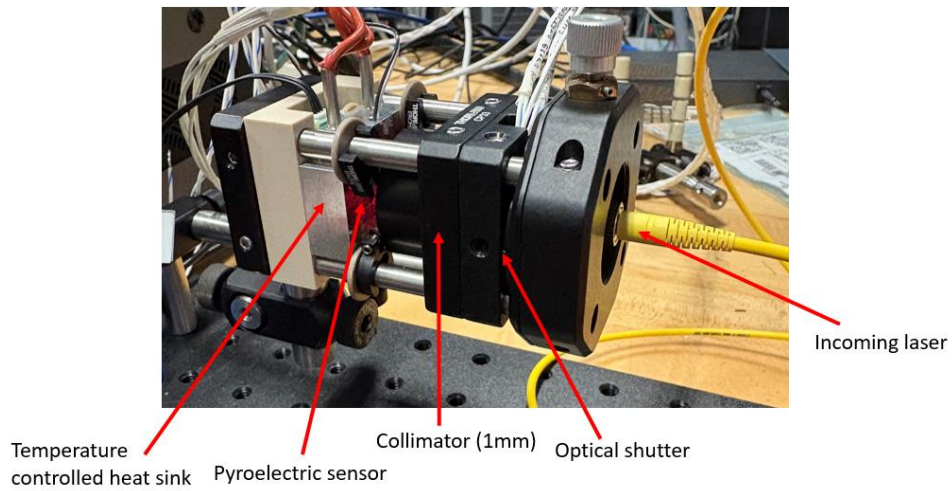
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Quantitative measurement of the energy and momentum flux delivered by particle beams is central to nanoscale fabrication, film deposition, propulsion system characterization, and space environment simulation. While established techniques exist for characterizing photon, electron, and ion beams, accurate metrology of neutral and partially ionized plumes remains limited, particularly in low-energy, low-current sources such as electrospray ionization (ESI) used for molecular deposition and hybrid beam processing. Traditional detectors (Faraday cups, microchannel plates, mass spectrometers) are blind or only weakly sensitive to neutrals.

Here we report the development of a variable-temperature pyroelectric bolometer (Figure 1) that enables quantitative measurement of energy flux from photons, neutral gas flows, and mixed ion-neutral plumes in vacuum. The detector measures the net energy exchange between the incident flux and the surface: photon absorption and energetic particles produce heating, while low-energy neutrals can yield an apparent cooling signal when they extract energy via accommodation and re-emission<sup>[1]</sup>. Target applications include quantitative analysis of polydisperse electrospray plumes, neutral characterization of plasma propulsion systems, and hyperthermal beam flux measurements.

The bolometer is mounted on a motorized linear stage within a micro-torr vacuum chamber, with the active surface held a few kelvin above room temperature. Three stimuli are applied: (i) a modulated continuous-wave laser to determine detector responsivity; (ii) a choked argon jet introduced through an approximately 0.75 mm orifice from a sub-torr upstream reservoir, which expands into the high-vacuum region and produces a negative-going signal when the jet static temperature is below the surface temperature; and (iii) a multi-emitter ESI source operated under vacuum with an ionic liquid, generating a mixed plume of molecular ions, clusters, droplets, and neutrals characterized by time-of-flight mass spectrometry for the charge-to-mass ratios of the charged species.

[1] M. Faubel and R. Schlemmer, *J. Phys. E: Sci. Instrum.* 21, 75 (1988).



*Figure 1:* Pyroelectric bolometer is tested and calibrated with a 1-2.5 mW laser. Total power reaching the sensor past the collimator is 4-7.5  $\mu$ W.