# Performance at High Current Densities of a Magnetically-Shielded Hall Thruster

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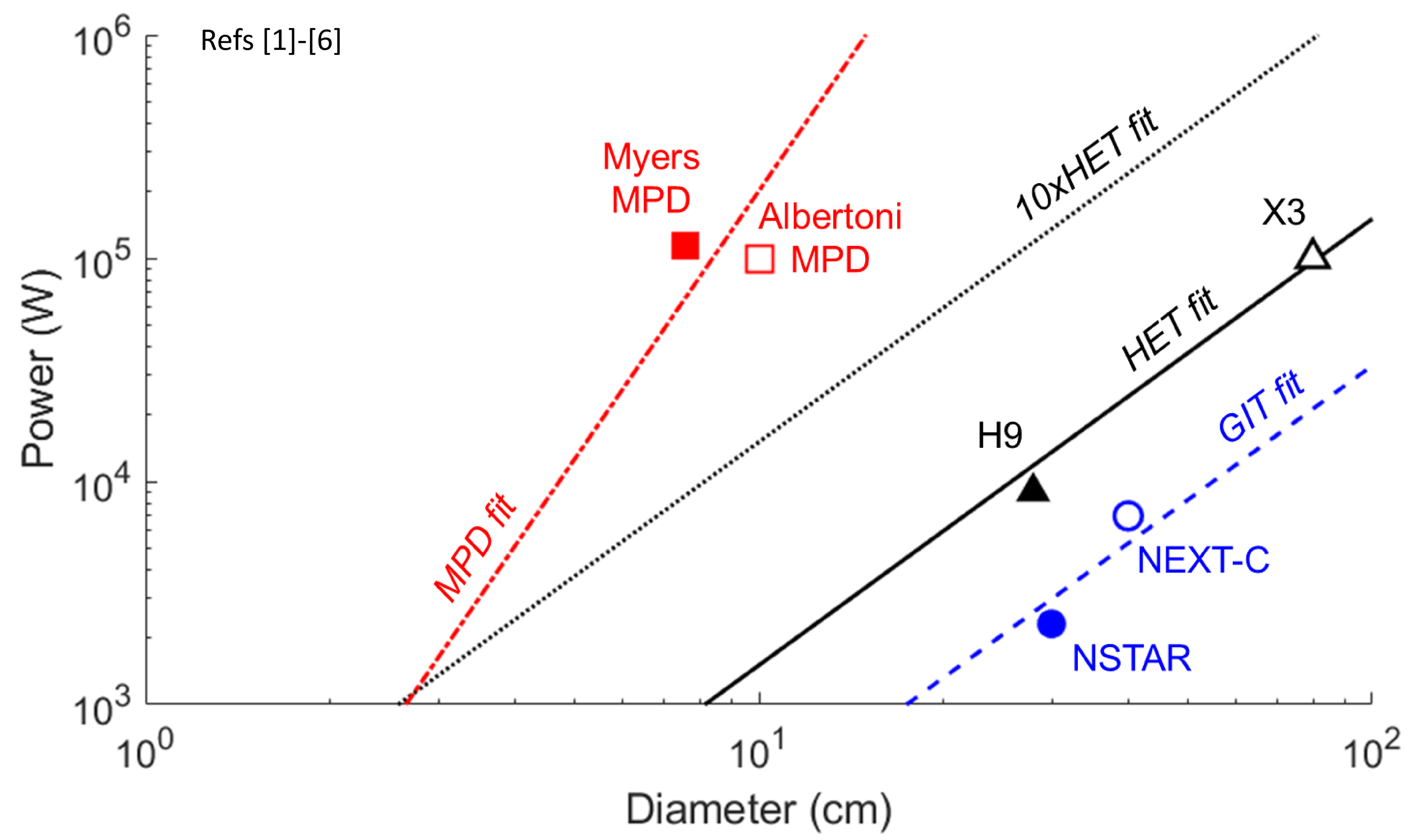
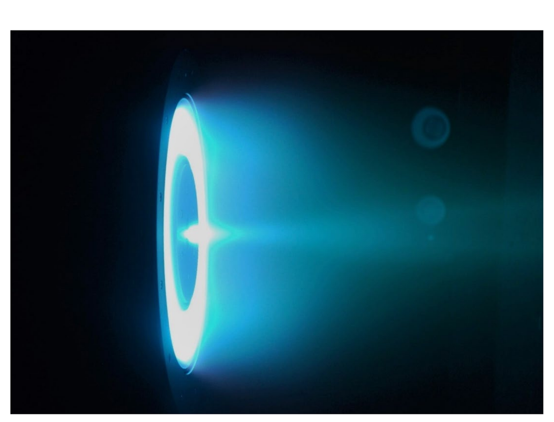
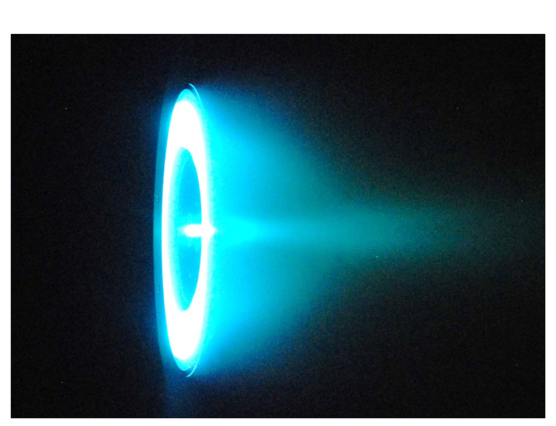
## Motivation




High-power electric propulsion devices in the 1-MW range are necessary to enable crewed missions to Mars and beyond [7]. While magnetically-shielded Hall thrusters are state-of-the art in the kW-range, its scaling to higher current densities has been limited compared to other devices (above) due to insufficiently high magnetic fields and high thermal loads. Our work characterizes performance at this upper limit and explores its physical causes.

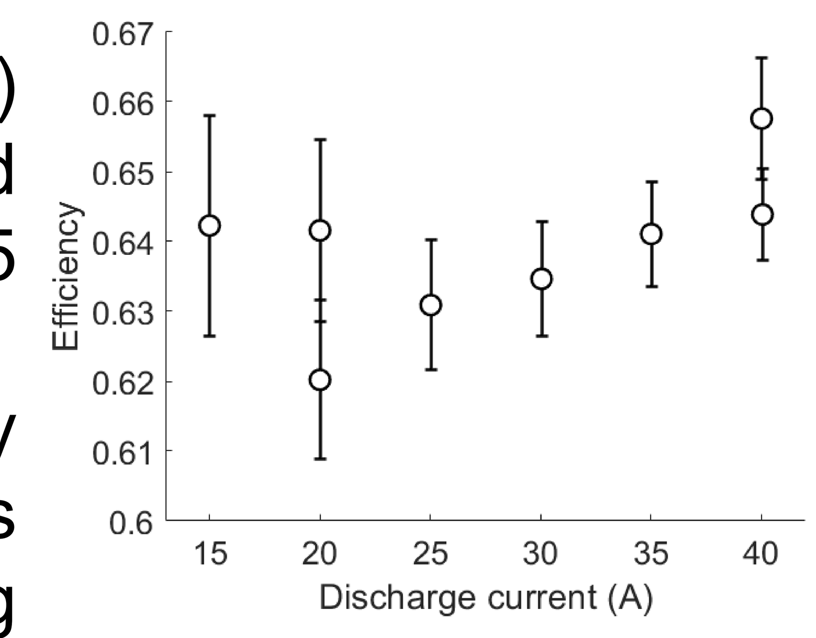
## Experimental Methods



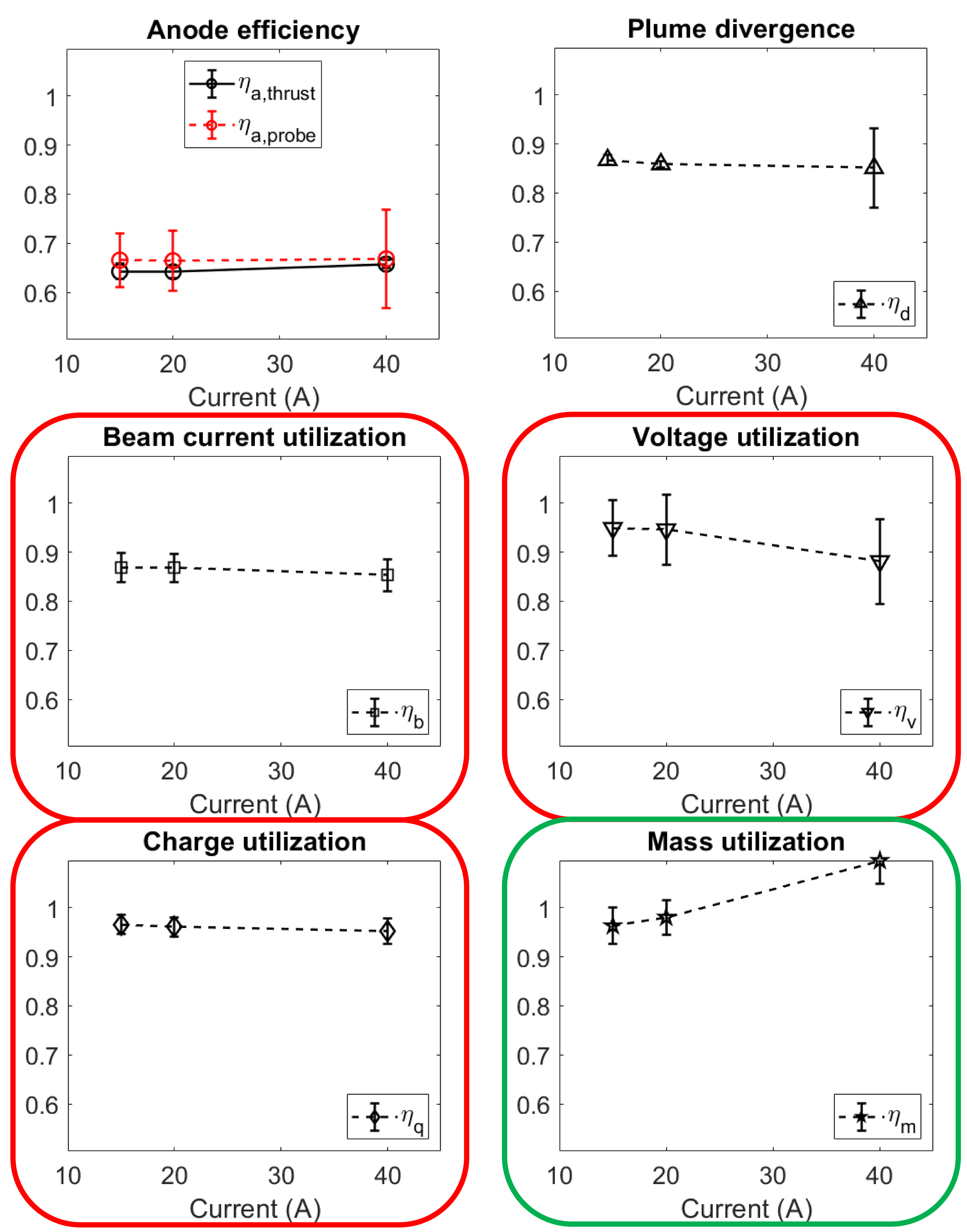


We ran the H9, a 9-kW magnetically-shielded Hall thruster, on xenon at 300 V and currents from 15 (top) to 40 A (bottom). The test was conducted in the Large Vacuum Test Facility at the University of Michigan. A thrust stand and probe suite were used to measure contributions to anode efficiency: voltage utilization $\eta_v$, current utilization $\eta_b$, charge utilization $\eta_q$, mass utilization $\eta_m$, and plume divergence $\eta_d$.

## Results




- Anode efficiency (right) increases slightly and plateaus between 15 and 40 A.
- Trend explained by increase in mass utilization balancing out decrease in current, voltage, and charge utilization (below).

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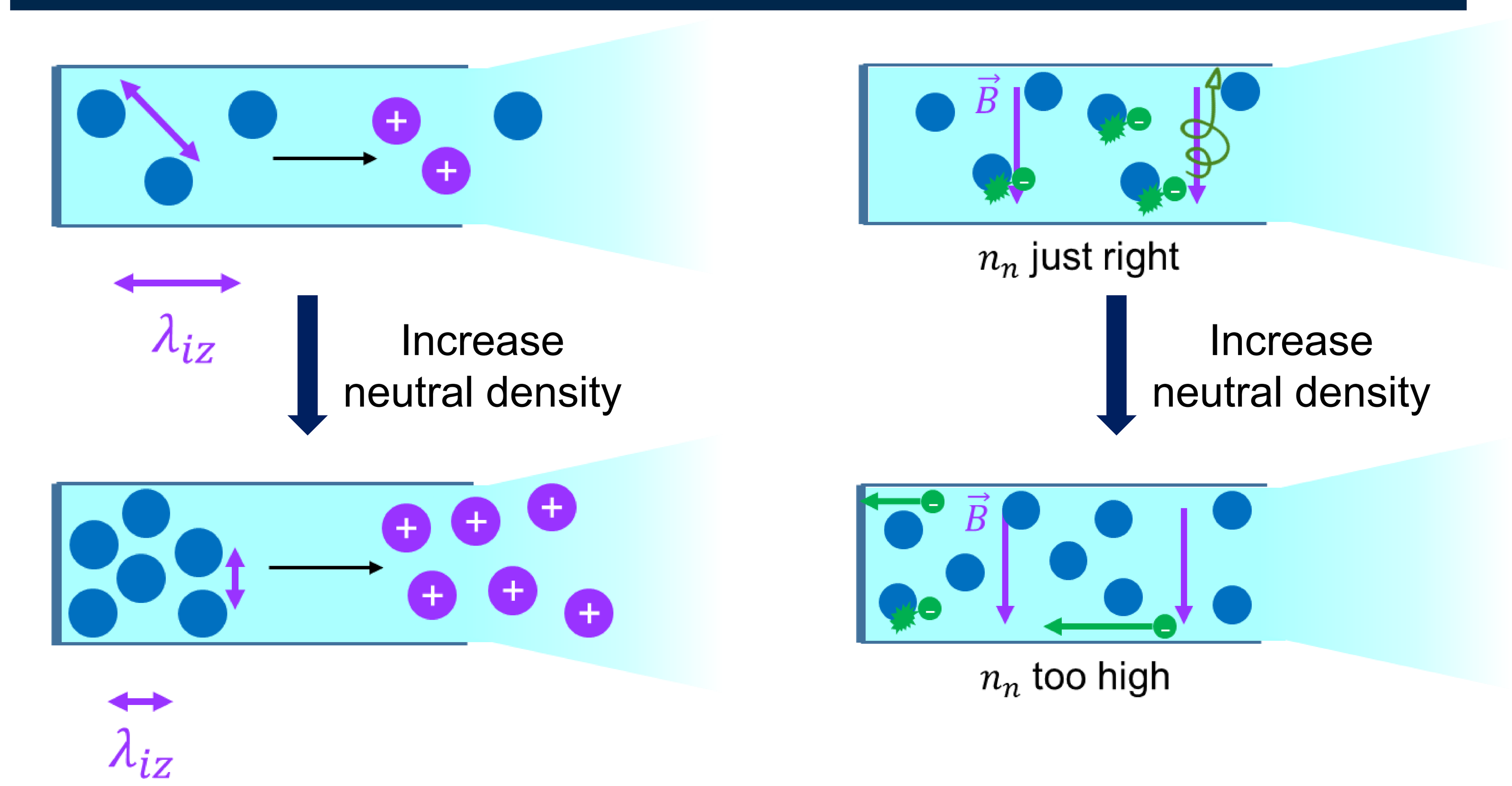
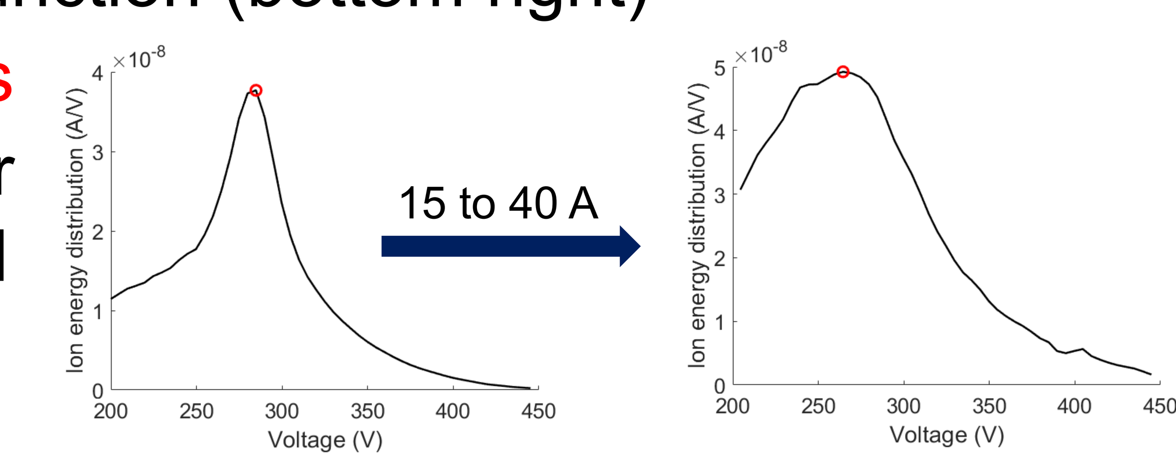
## Discussion




- $\eta_m$ increases due to high neutral density → shorter ionization mean free path (top left)
- $\eta_b$ decreases due to high neutral density → higher electron mobility (top right)
- $\eta_v$ decreases due to broader ion velocity distribution function (bottom right)
- $\eta_q$ decreases due to higher ion-to-neutral density




## Conclusions

1. The efficiency of a shielded Hall thruster stays relatively constant at higher currents.
2. The mass utilization increases while the current, voltage, and charge utilizations decrease.
3. The efficiency may decrease at higher currents.

## References

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