The Effect of Magnetic Shielding on Hall Thruster Performance and Internal Erosion

TOC

The 6kW Laboratory Hall Thruster

- Xe+ propellant
- BN, BNSiO2
- State of the Art (800V)
  - 3000s
  - 60% net efficiency

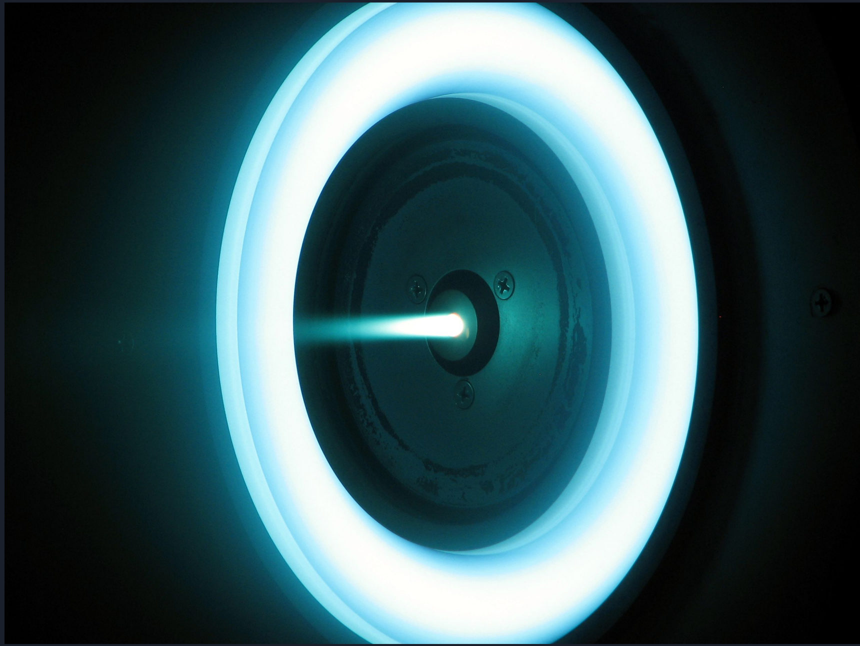

Figure 1. An H6 Operating at JPL

(Dotson et al, 2013)
(Goebel & Katz, 2008)
(Cusson et al, 2017)

A Typical Hall Effect Thruster

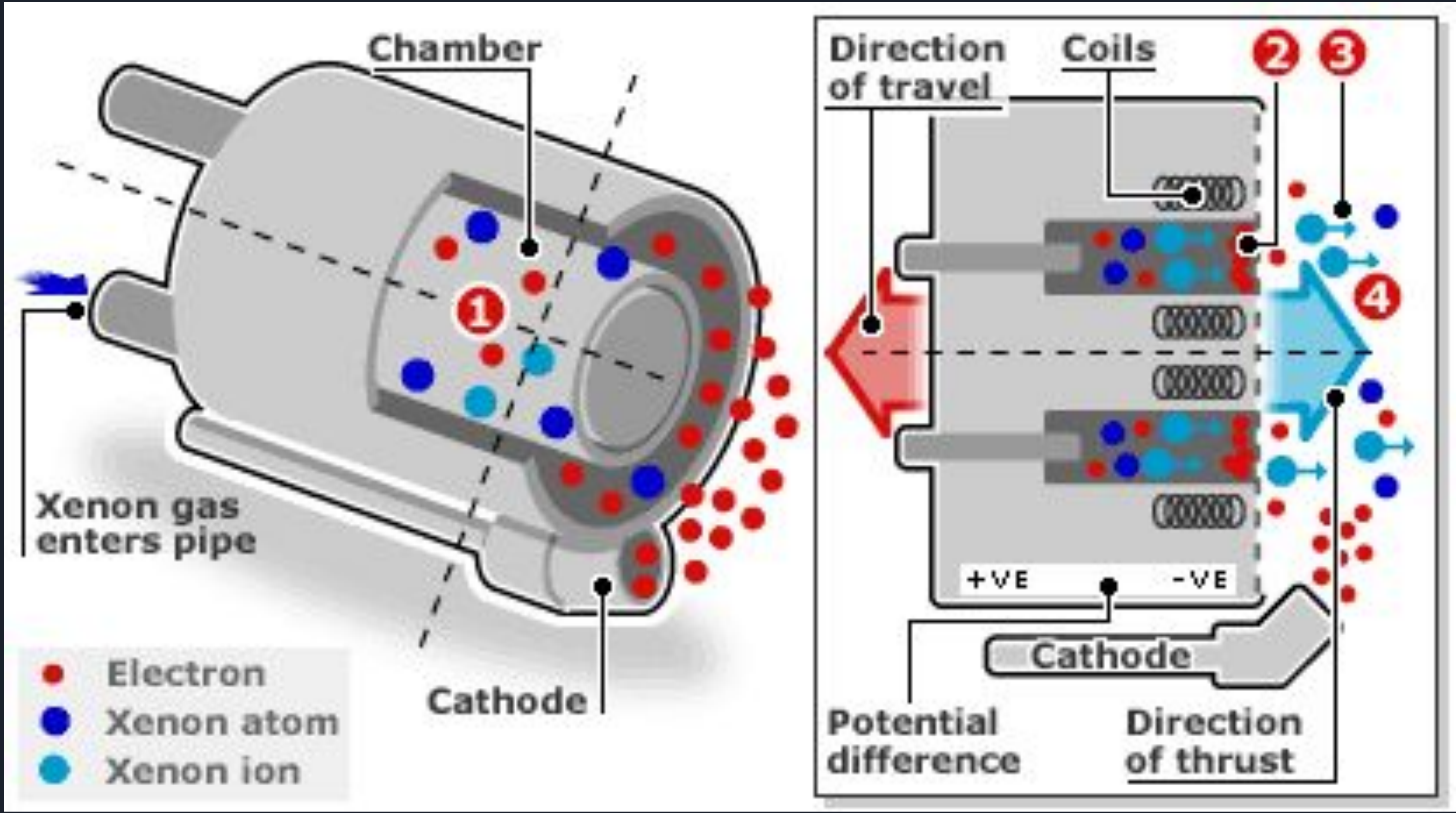

Figure 2. Workings of a Hall Effect Thruster

Figure 3. Before and After of MaSMi Operation Testing <20 hours

(Conversano et al, 2014)

Magnetic Shielding

- 2010's BPT-4000
- 5.6kh/10.4kh erosion less
  a. Anode deep electric fields
  b. Revert ions away from walls
  c. Reduce ion discrepancies

(Haag et al, 2010)
(Hofer et al, et al, 2014)

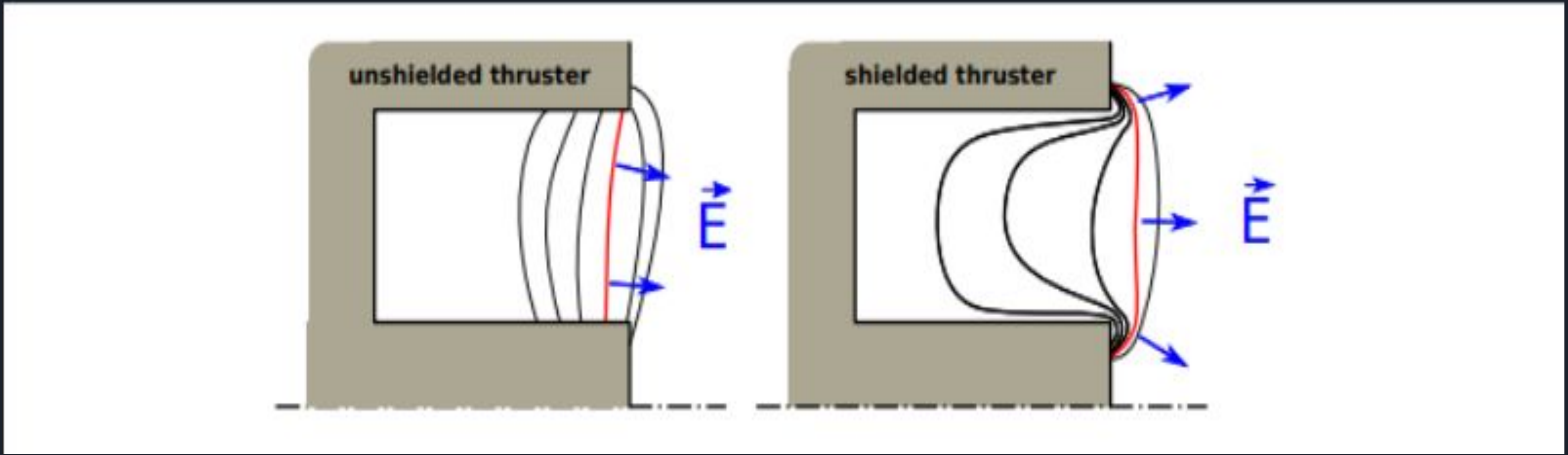

Figure 4. Magnetic field topology and of US (left) and MS (right). Red line shows the imposed magnetic field. Black lines show the extent of the electric fields.

(Grimaud & Mazouffre, 2017)

Purpose

- Increase viability for deep space purposes
  - Maintain specific impulses of US
    - 800V = 3000 s
  - Minimize erosion rate

Hypothesis

Alternate: Magnetic Shielding will reduce channel erosion while maintaining constant specific impulse values.

Null: Magnetic Shielding does not change or increase channel erosion while maintaining constant specific impulse values.

Methods

Data Search

- Google Scholar
    - Research Gate
    - Science Direct
    - International Electric Propulsion Conferences
- Dr. Dan Goebel & Ira Katz
- University of Michigan
    - UMich PEPL

Data Collection

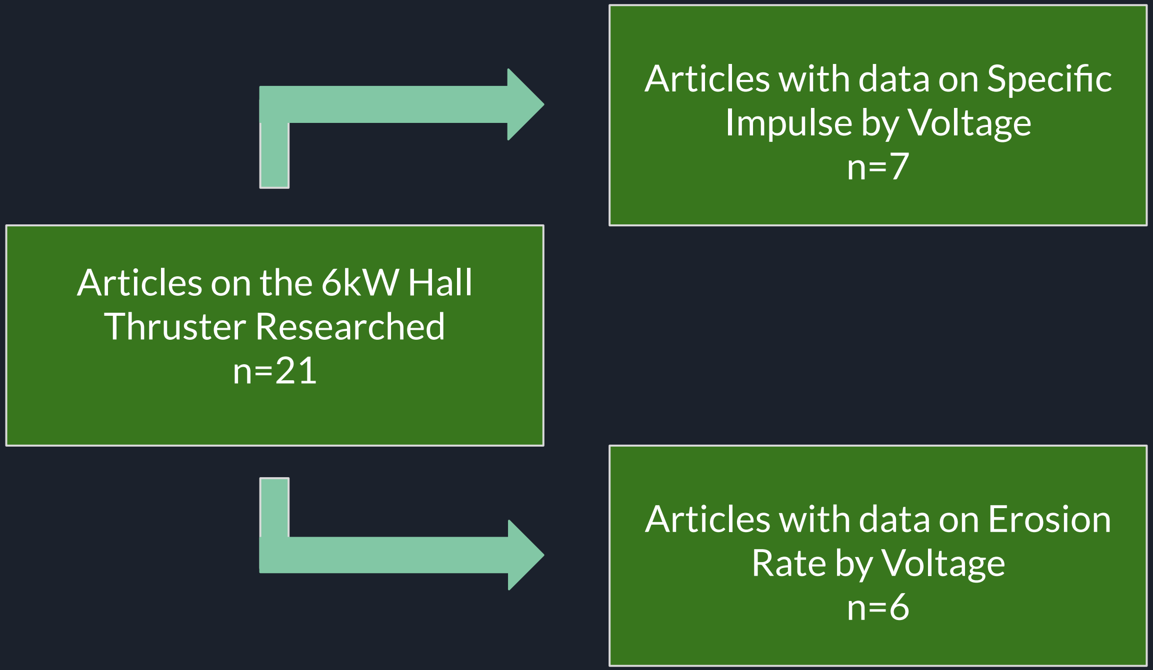

Figure 5. Article Collection Diagram

Data Analysis

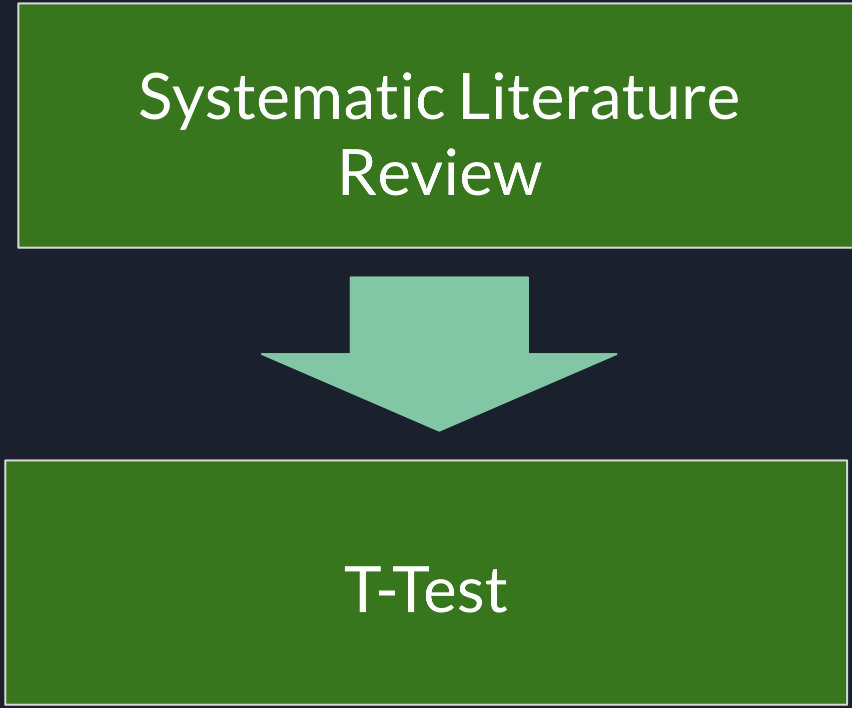

Figure 6. Data Analysis Diagram

Results

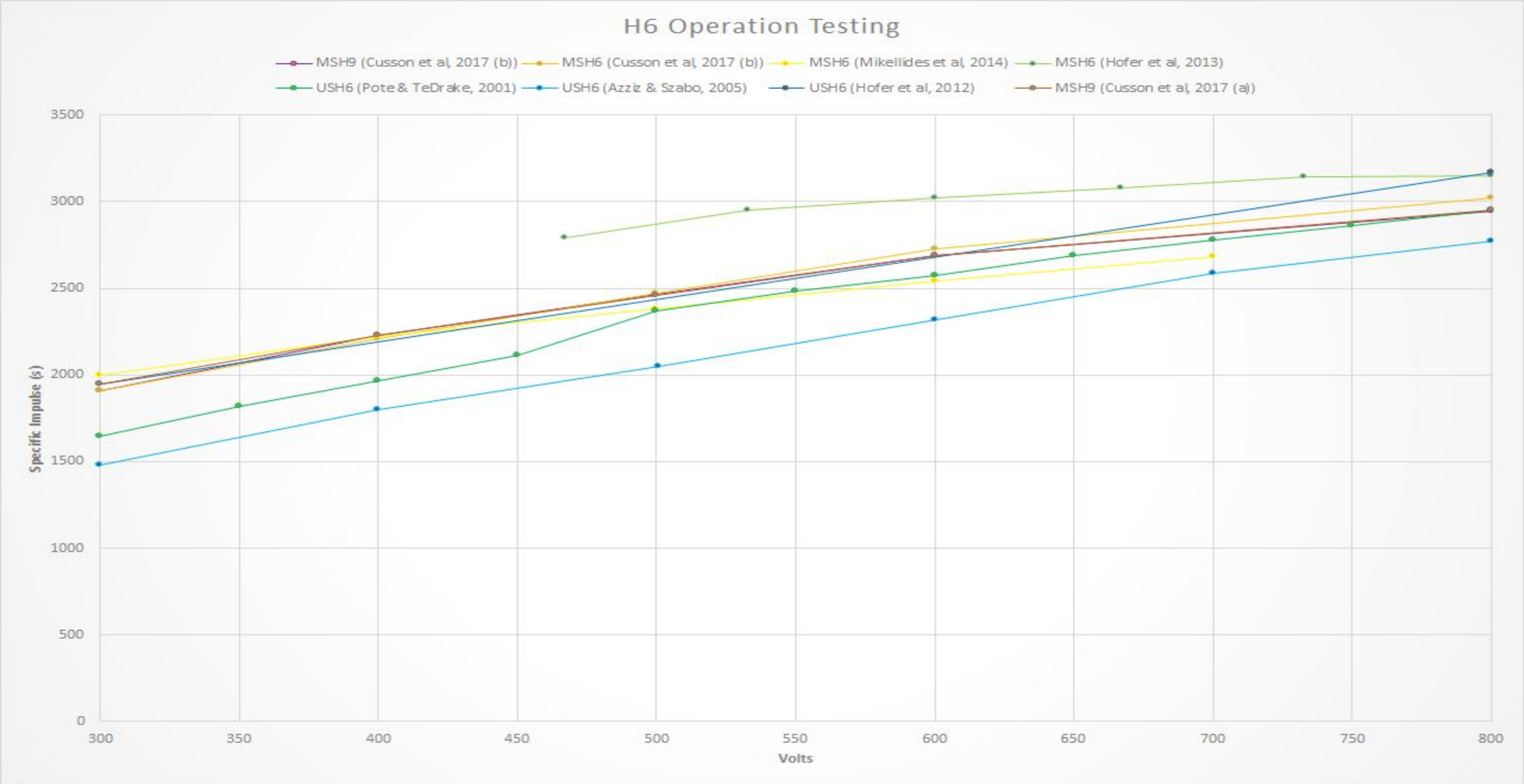

Figure 7. Specific Impulses of the H6 from 300V to 800V

Source	Magnetically Shielded?	Erosion (mm/kh)
(Goebel et al, 2012)	No	10
	Yes	6.8x10^-2
(Goebel et al, 2014)	No	9
(Hofer et al, 2012)	No	4.19
	No	4.75
	Yes	0
	Yes	2.4x10^-2
(Hofer et al, 2014)	No	6.37
	No	9.52
	Yes	0
	Yes	2.4x10^-2
(Mikellides et al, 2013)	No	8.7
	Yes	5.6x10^-1
(Jorns et al, 2015)	No	10
	Yes	7.78x10^-2

Figure 8. Erosion Rate of US and MS (300V)

T Values

- Specific Impulse: .012713208
- Erosion Rate: 9.16789877

Discussion

- Performance
  - 300V=2000Isp
  - 800V=3000Isp
- Erosion
  - >.56 mm/kh
  - MS Outer Wall erosion less<300V
- MS vs US
- Erosion rate: 73x less

Conclusion

- Alternate hypothesis
  - Specific Impulse: .01271320<1.943
  - Erosion: 9.16789877>2.015
- MS>US
- Increase candidacy for future deep space missions

Limitations

- Operation conditions
  - Efficiency (60~64%)
  - Operation times (>100h)
  - Thrust = mass x acceleration

Further Work

- Lifetime (hours)
- Nested Channel Hall Thruster
- BN, BNSiO2
  - Metallic Walls

Figure 9. A 100kW Nested Channel Hall Thruster

Acknowledgements

- Dr. Malhotra
- Professor Gallimore
- Dr. Dan Goebel
- Professor Jorns

References

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