A Microresonator-Based Laser Doppler Velocity Sensor for Interplanetary Atmospheric Re-Entry

Ben Wise, Jaime DaSilva, and Elie Salameh
Adviser: Dr. Volkan Otugen

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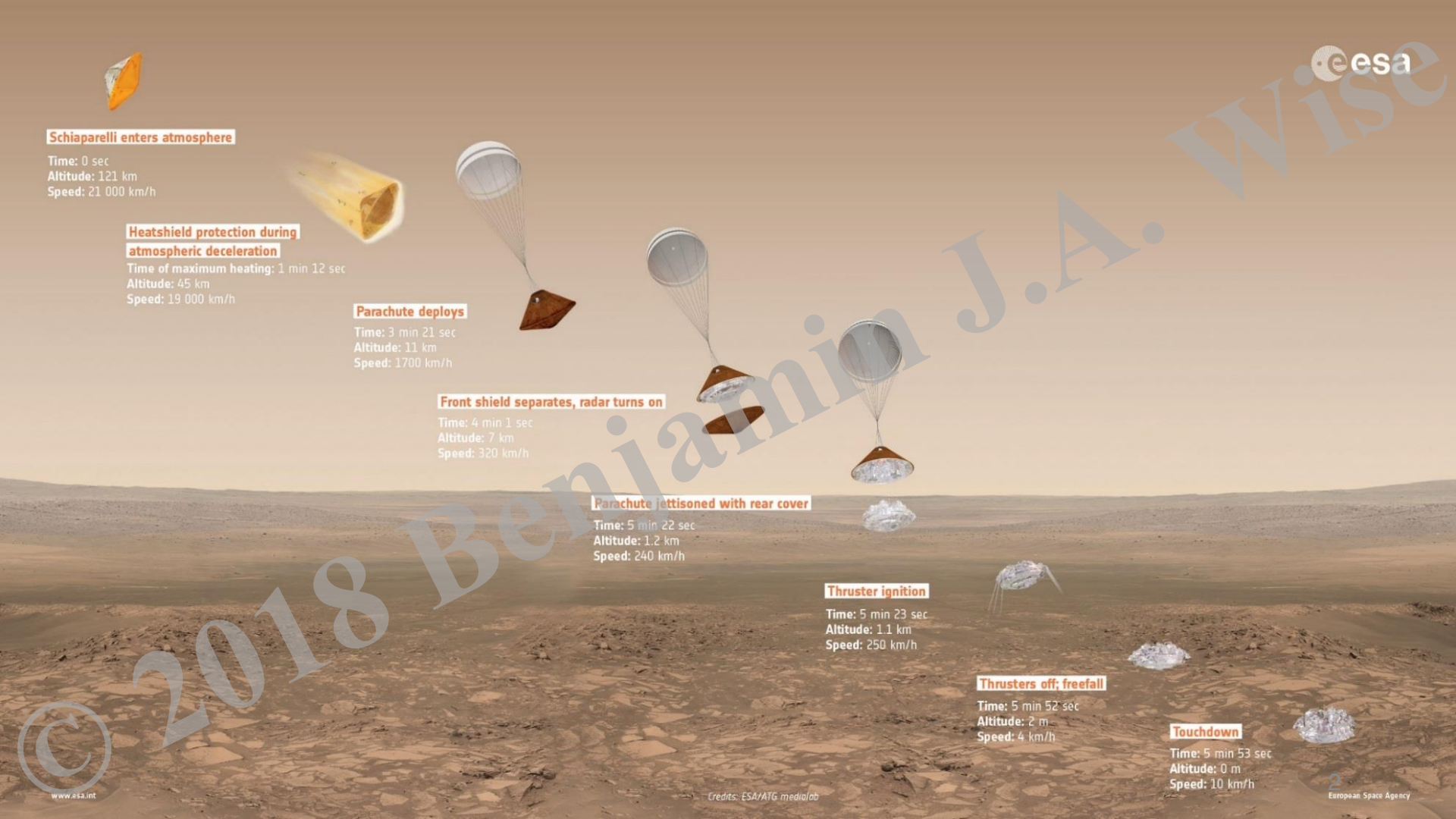
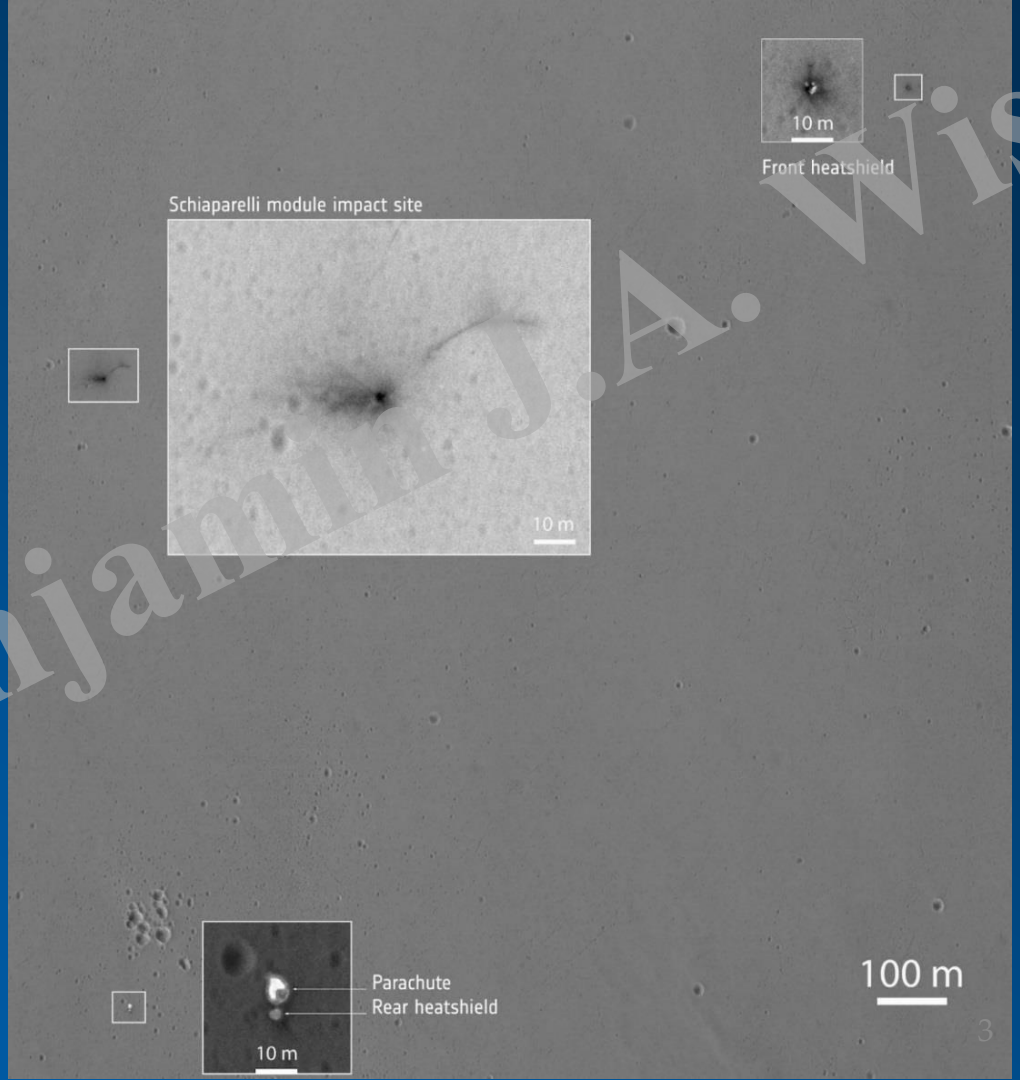
World Changers Shaped Here

SMU

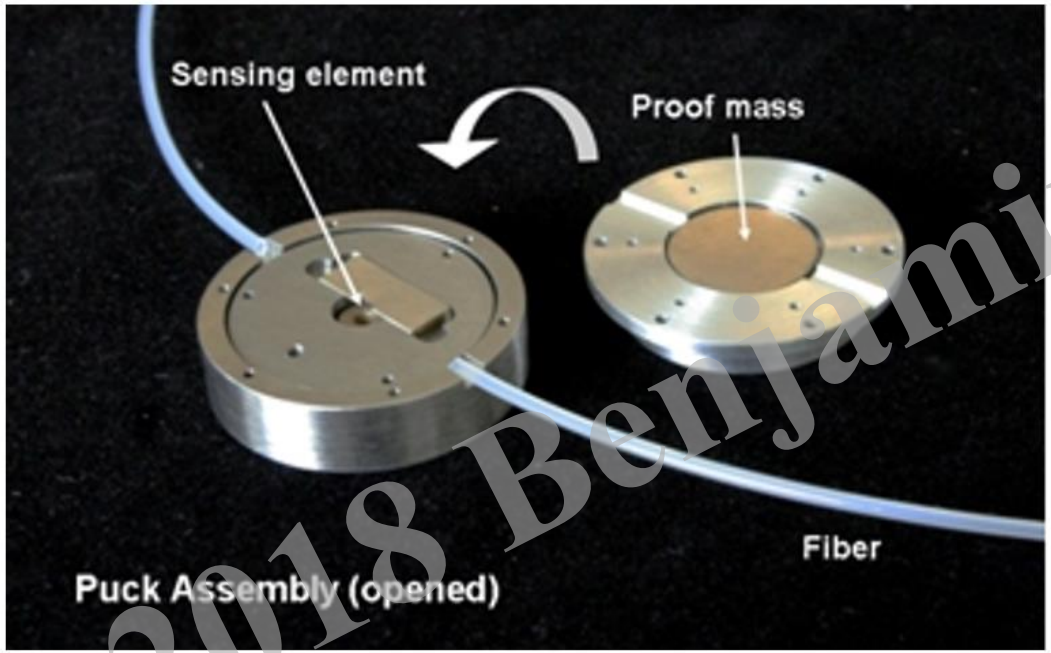


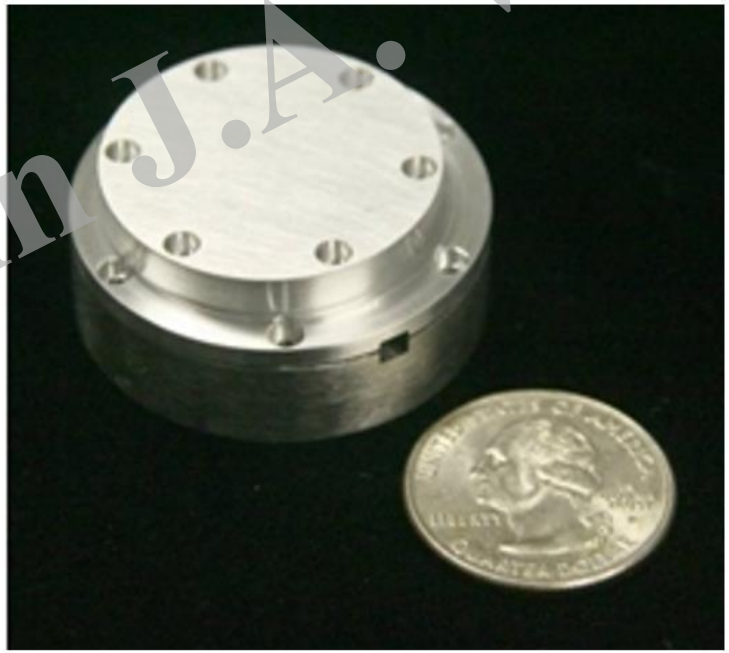
Crash Site

- Thrusters Off State
  - Burn Time: 3s (of >30s)
  - Altitude: 3.7 km
  - Velocity: 250 km/h
- Impact
  - Terminal Velocity
  - Estimated: 300-540 km/h

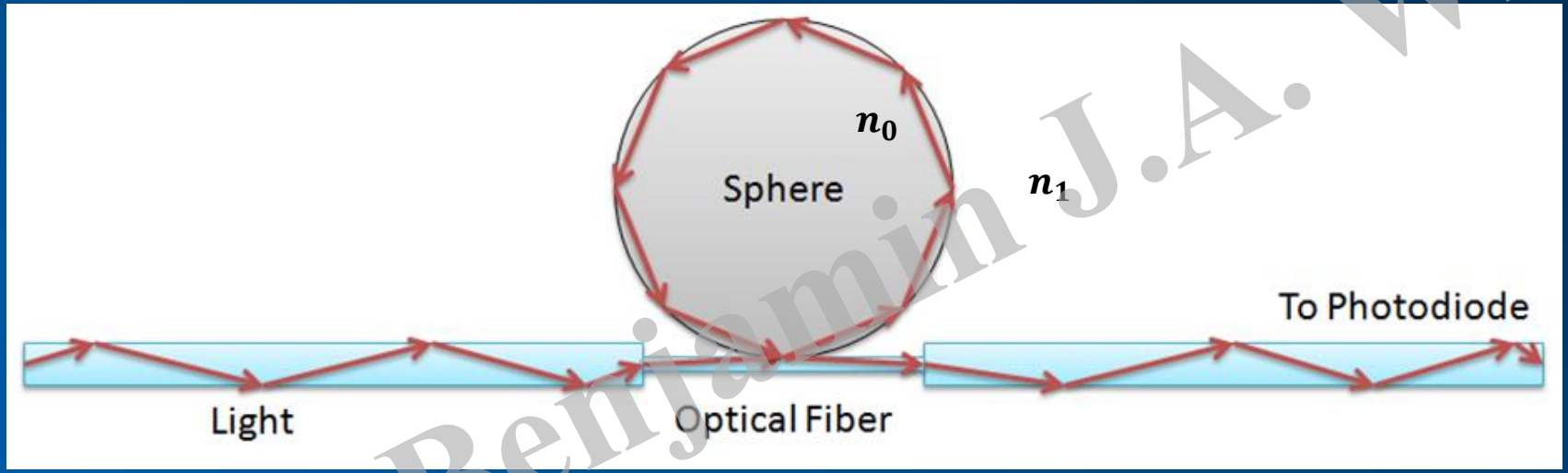


Why Whispering Gallery Mode Sensors?



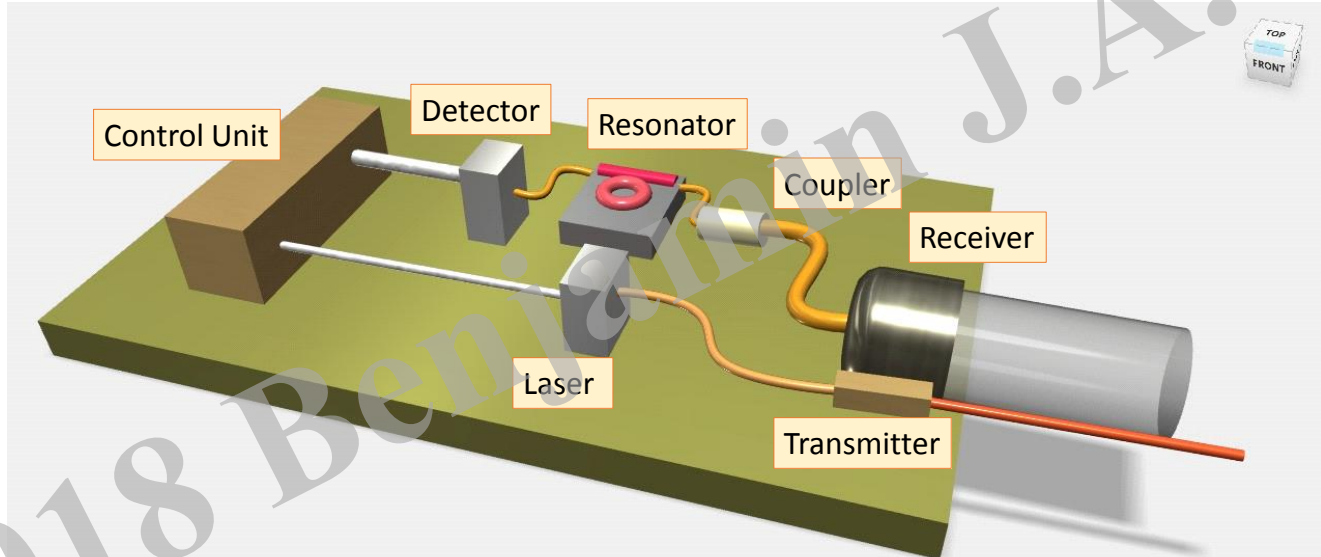


The Whispering Gallery Mode

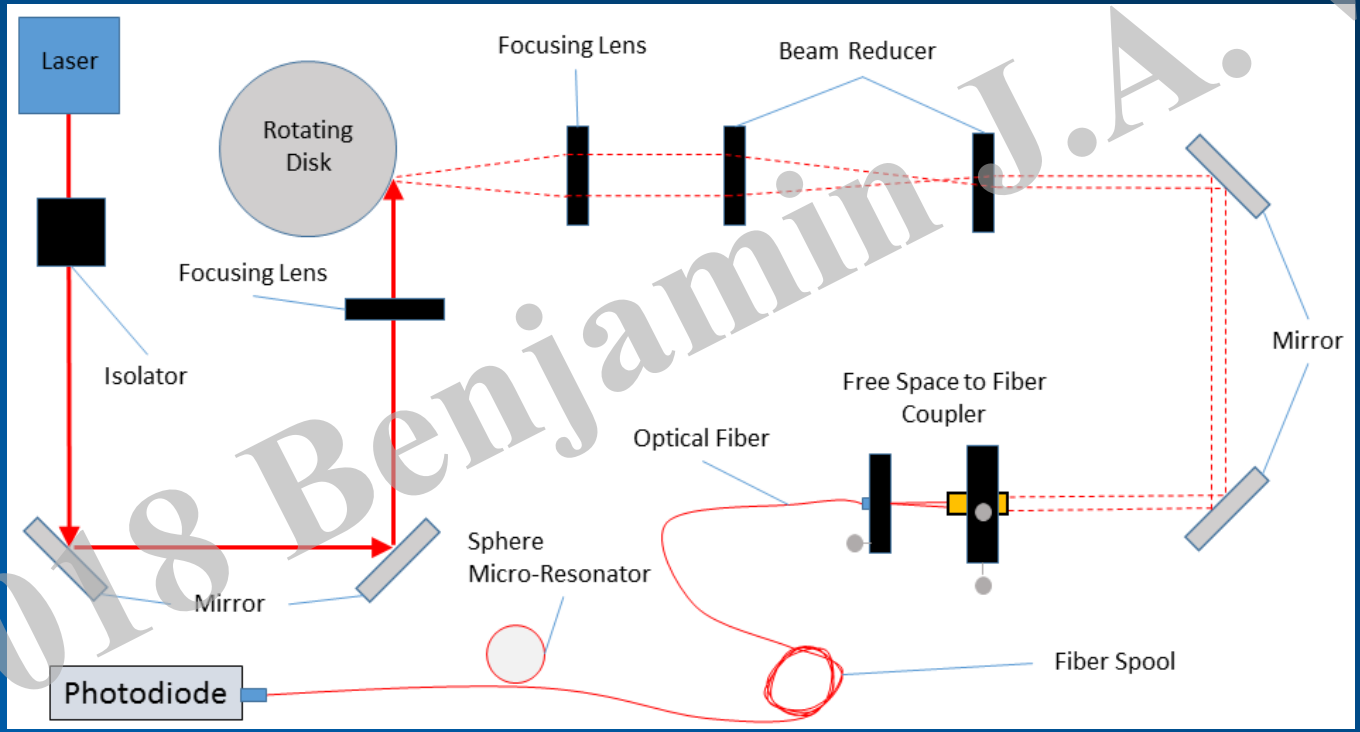


- Resonance Condition: $\boldsymbol{2\,\pi\,r\,n_0 = l\,\lambda}$ for $r \gg \lambda$
- Very High Q-Factor Sensing ($Q = \frac{\lambda}{\delta\lambda} > 10^7$)

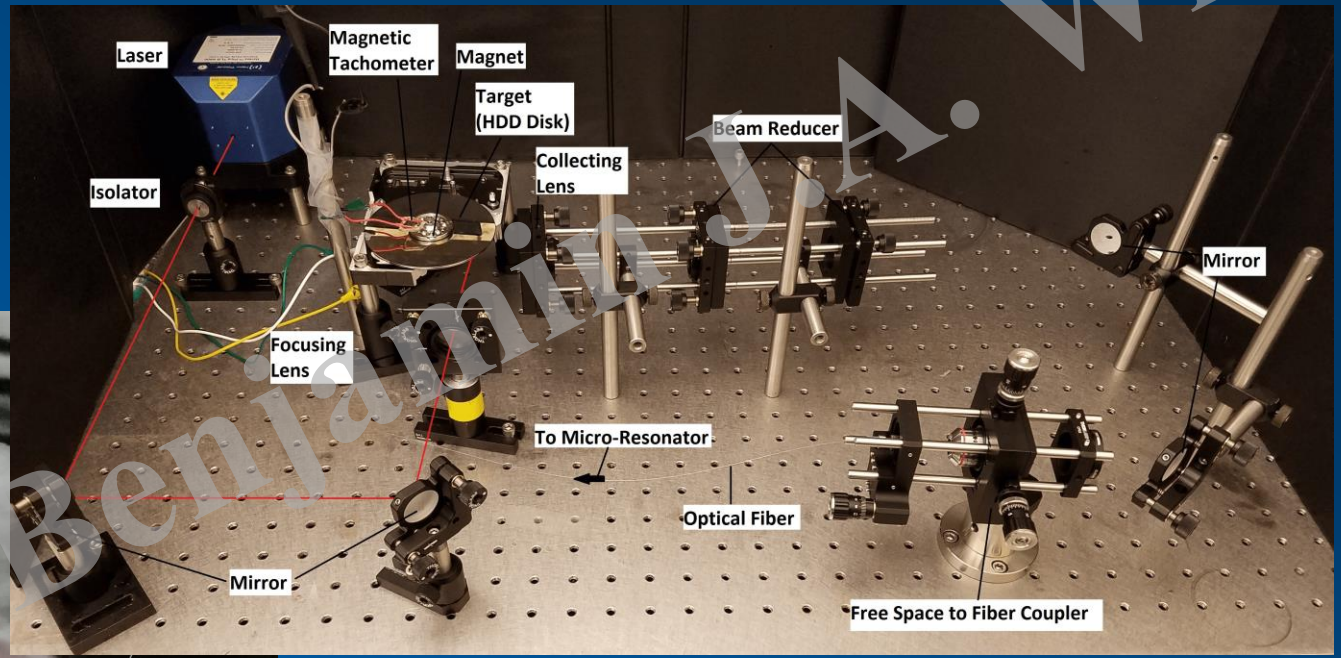
Overall System Schematic

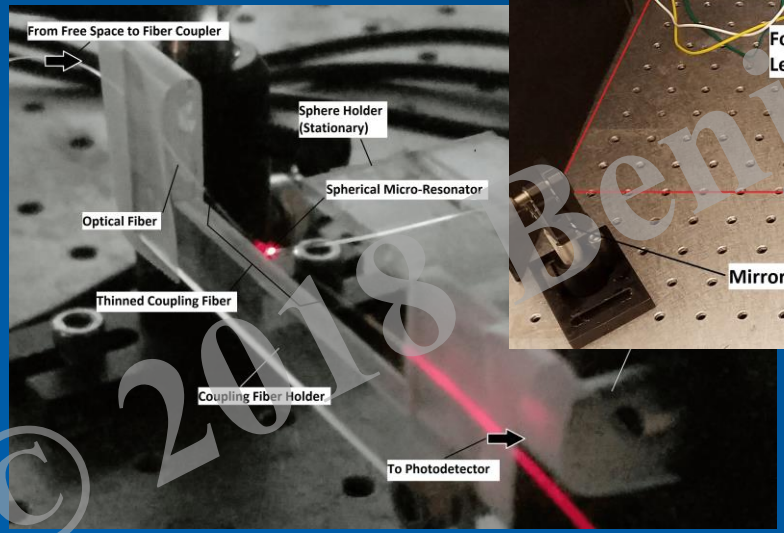


Laser-Modulated Resonance Excitation

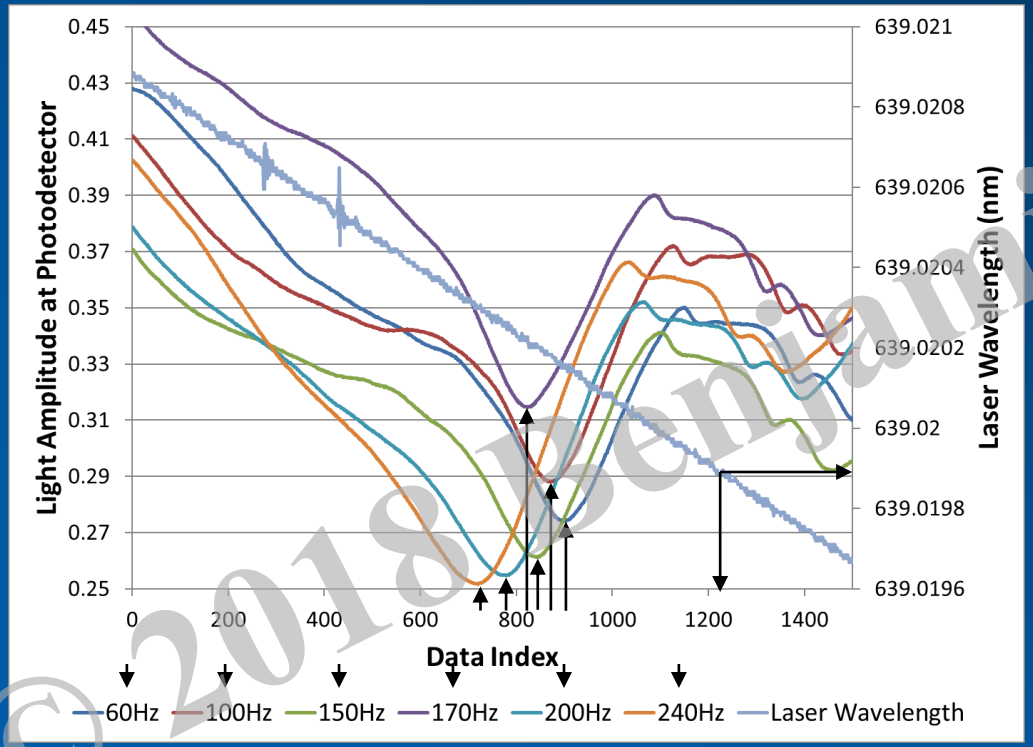


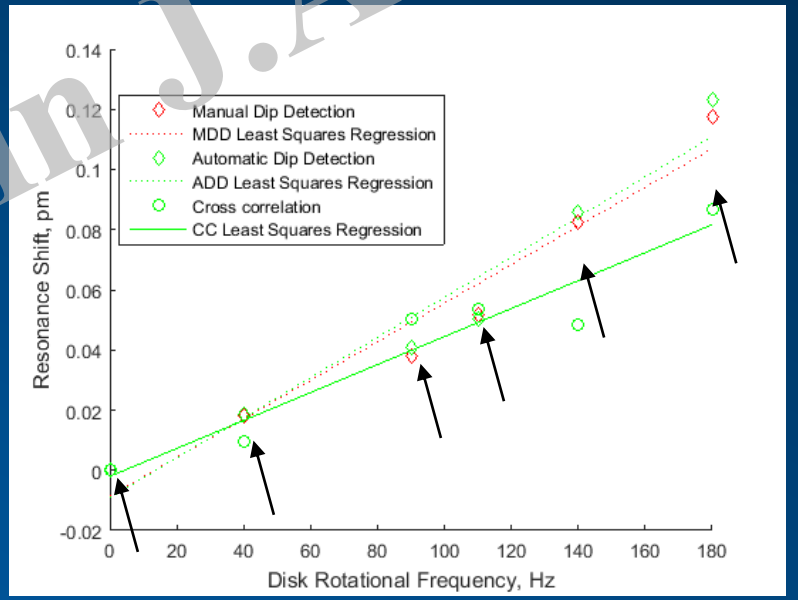
Laser-Modulated Resonance Excitation



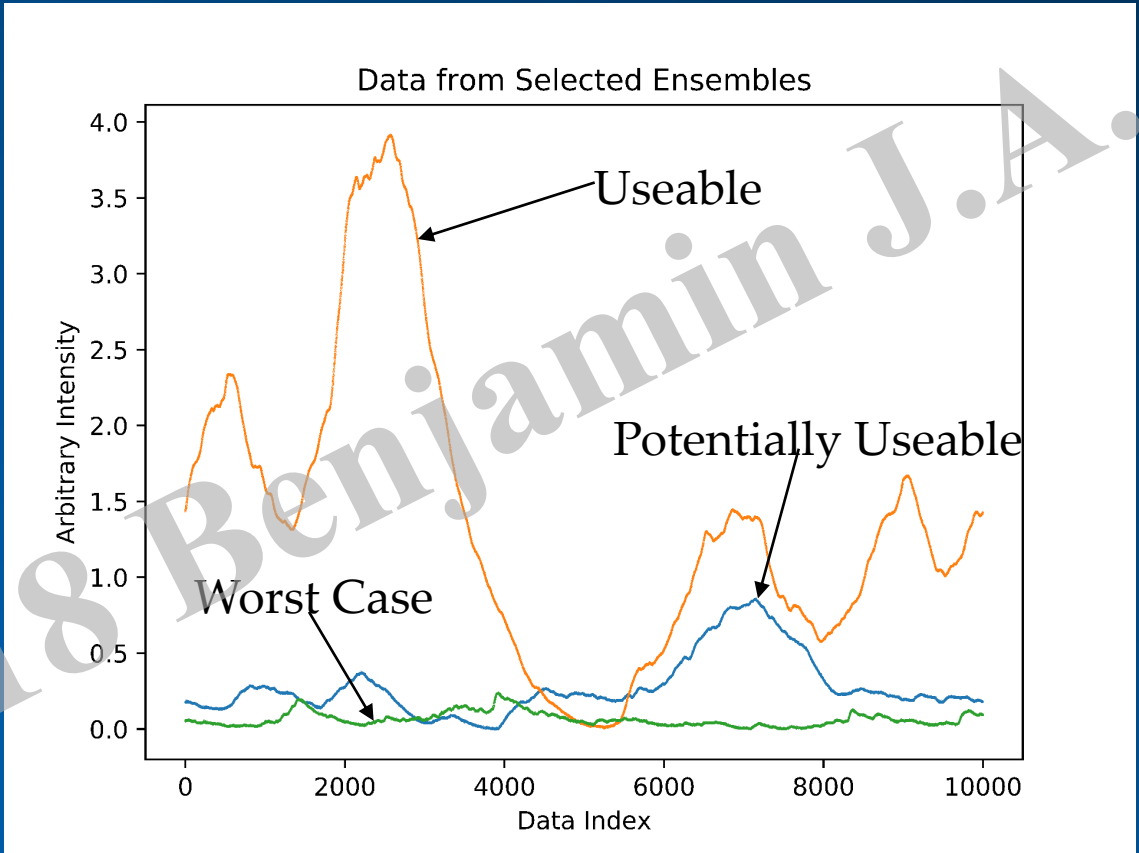


Laser-Modulated Resonance Excitation Results



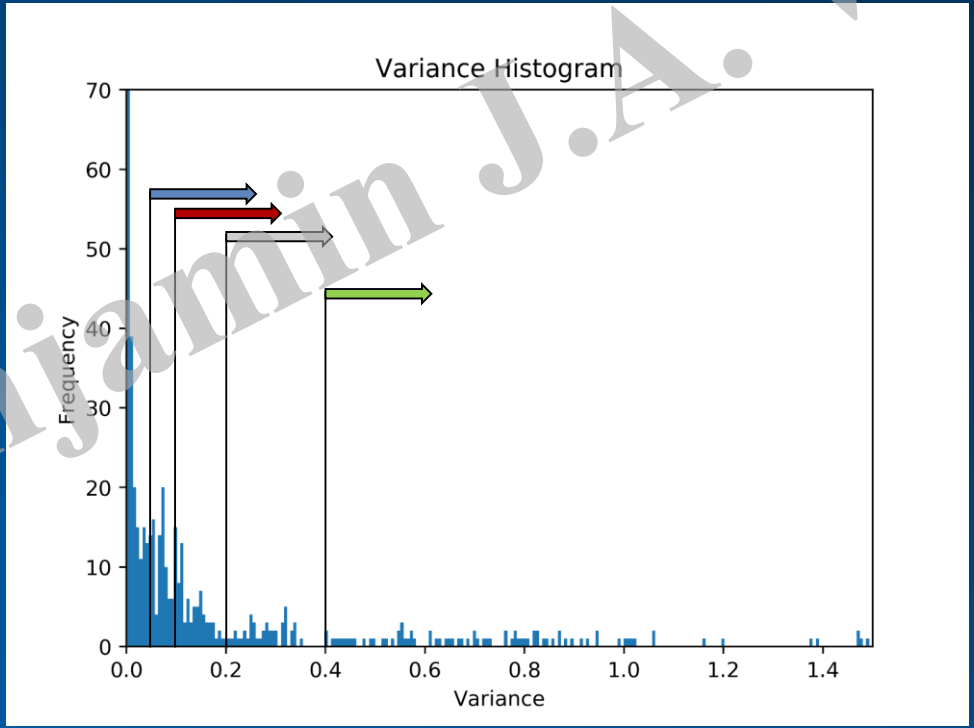


Signal Processing Motivation

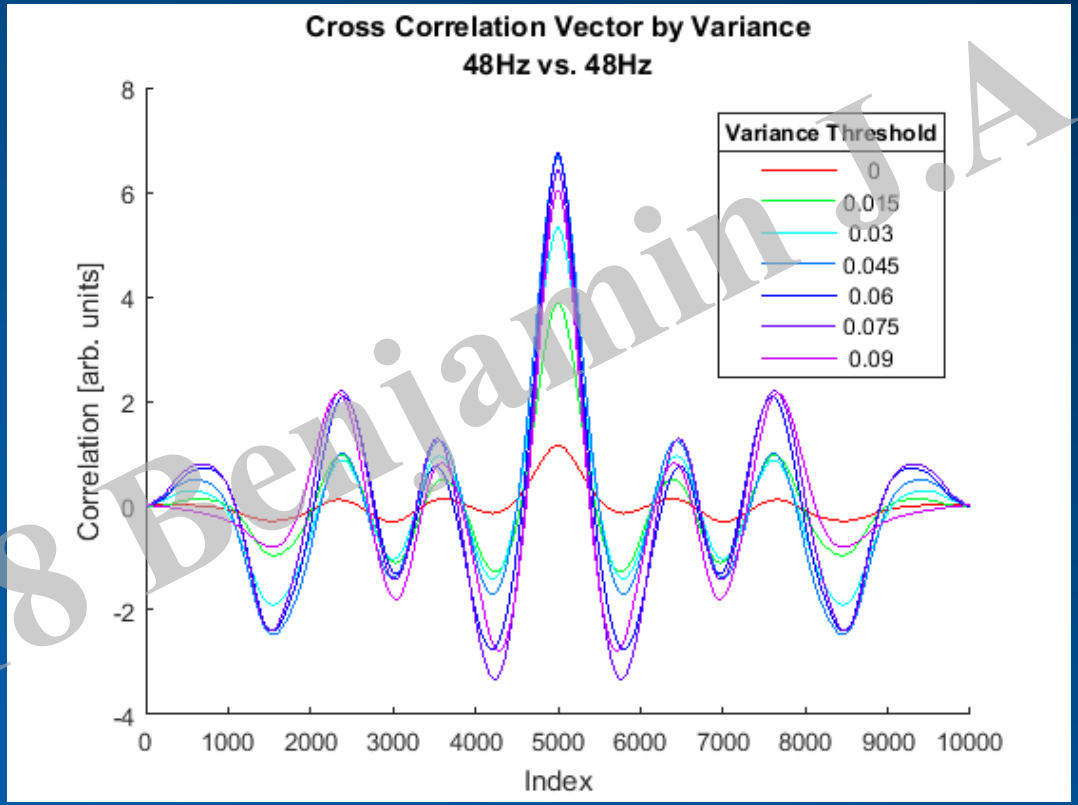


Variance Filtering

$$\sigma^2 = \frac{1}{N}\sum_{i=1}^{N}(x_i - \mu)^2$$

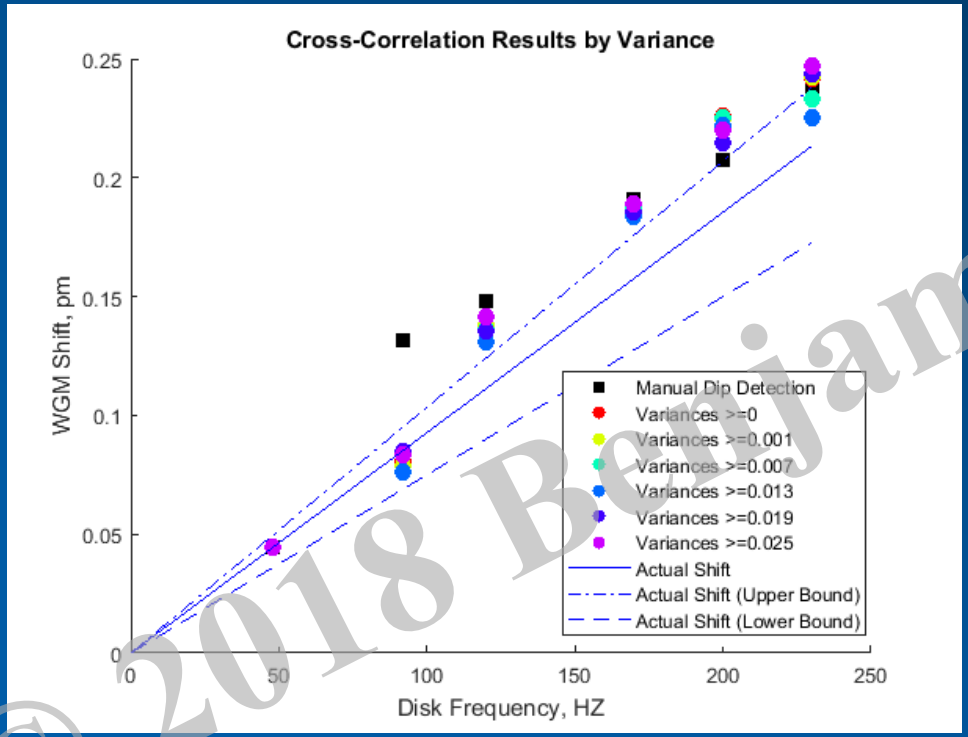


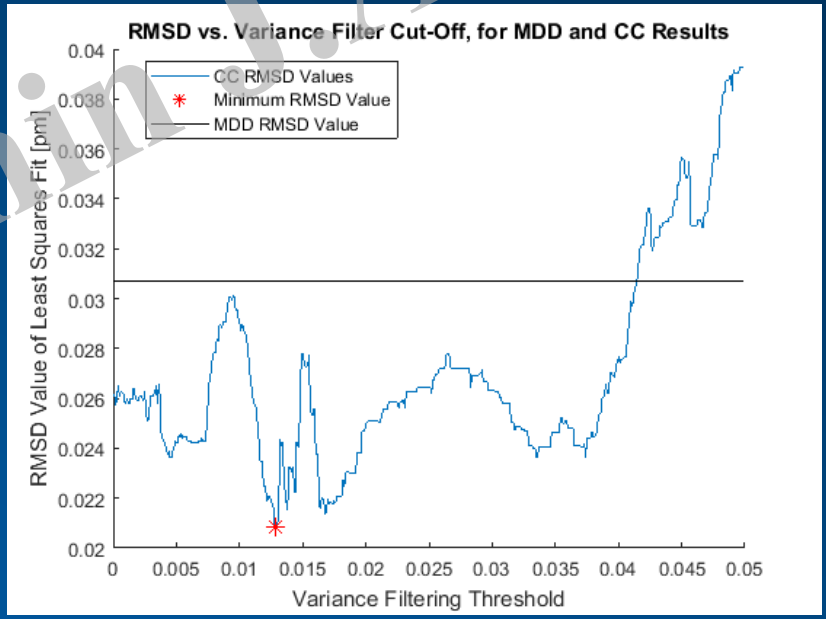
Variance Filtering Results



Variance Filtering Results

$$RMSD = \sqrt{\frac{\sum_{i=1}^{n}(\hat{y}_i - y_i)^2}{n}}$$





Conclusion

- Showed the Need for Accurate, High Resolution, Physically Small Velocity Sensors
- Showed How the WGM Phenomenon Occurs and a Design for a Velocity Sensor
- Demonstrated Doppler Shift Detection from a Solid Moving Target is Possible
- Demonstrated the Need for and Tested a New Signal Processing Approach to Mitigate Intermittent Signals
- Results Were Very Encouraging
  - At the Proof-of-Concept level, we were able to measure Doppler shift due to relative motion, with a miniaturized single-beam LIDAR device.
  - We were able to overcome or mitigate some of the major challenges of this method.
  - Moving toward direct measurement of a particle laden jet.

Acknowledgements

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