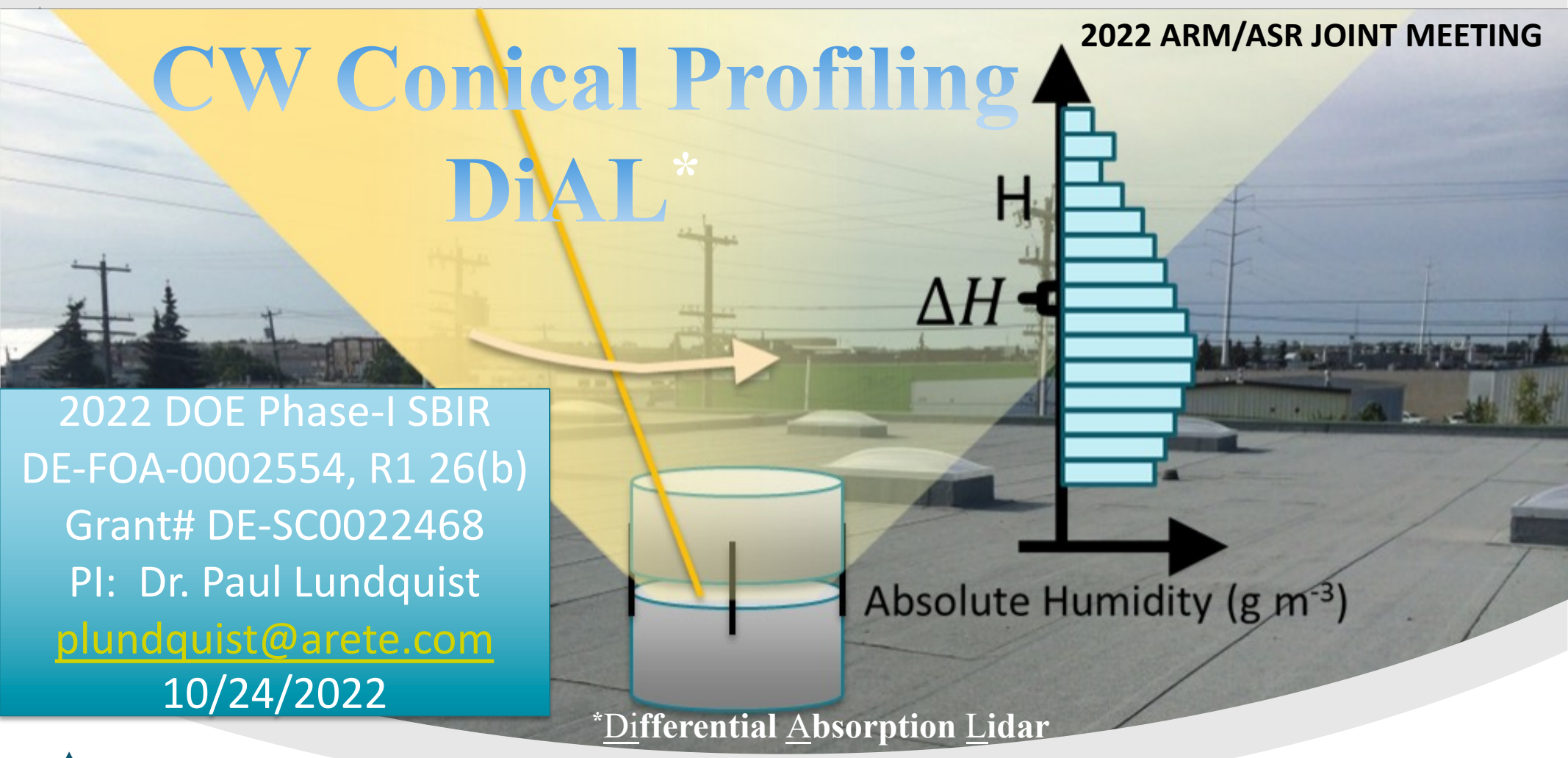
CW Conical Profiling DiAL*



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*Differential Absorption Lidar

Areté

Federally Required Acknowledgement and Disclaimer

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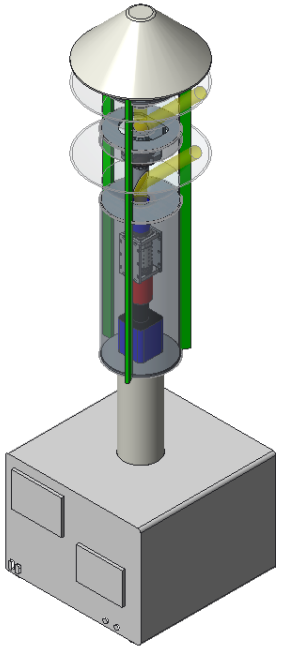
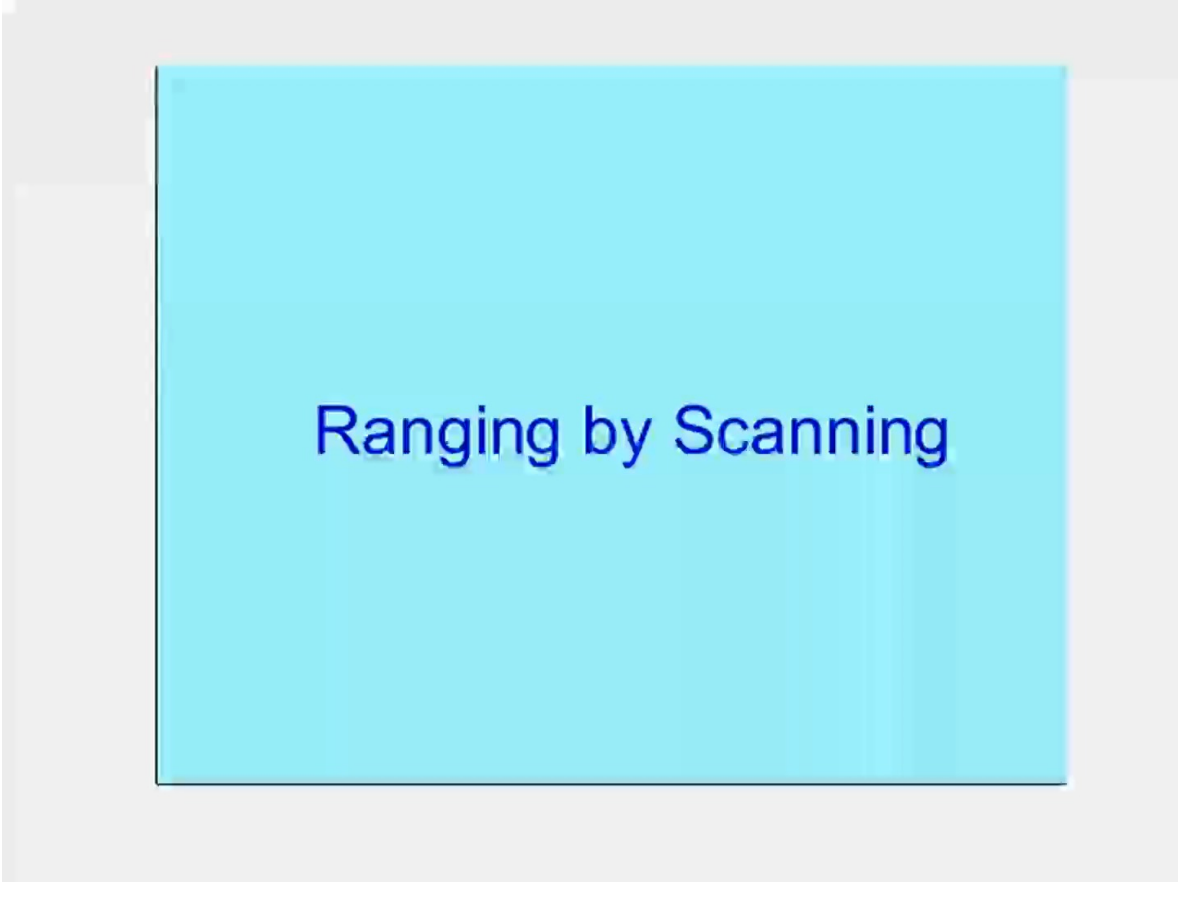
Top Level Summary

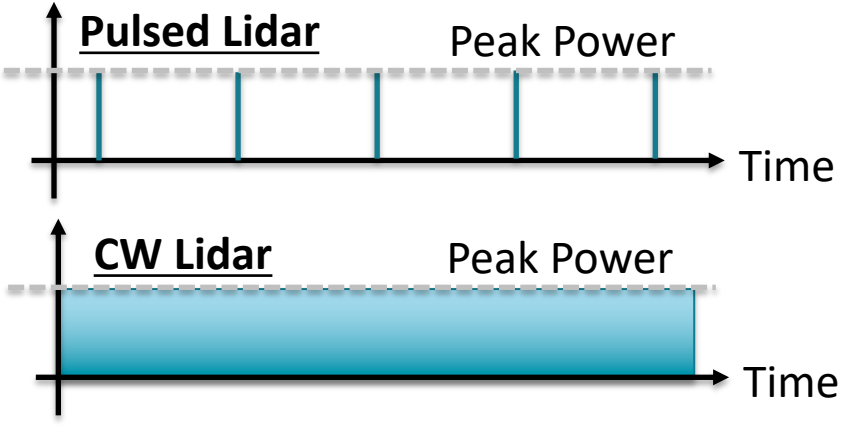
- **Sensor Objectives**
  - Measure water vapor vertical profiles up to 10's of meters to ranges of 2km-4km
  - Range Resolution for 5-minute collects (20m to 600m, 50m to 1.3km, 100m for longer ranges) with ~ 0.1 g/m^3 precision.
  - System Volume Objectives : ~ 12 cu. ft.
  - System Production Unit Cost Objectives: ~200k$ (lower with quantities)
  - Eye safe above 100ft.
- **Primary Operation Advancement**
  - Enable a much lower SWaP sensor (relatively small volume/weight)
  - Suitable for roof top deployment or mobile deployment
  - Sensor intrinsically scans, so some horizontal gradients may be measurable
- **Sensor Type**
  - Narrow Linewidth Differential Absorption Lidar DiAL (828 nm)
  - Uses CW semiconductor lasers (~ 2 Watts)
  - **"Ranging through Scanning" technique with rapid conical scan (patented & patent pending technology)**
- **Enabling Technologies**
  - **Ranges through rapid conical scanning of CW (100% duty cycle laser)**
  - Photon Sensitive CMOS cameras recently available on the market
  - Tapered Semiconductor Amplifiers
  - High spectral resolution dispersion with virtual imaging array
- **Technical Readiness**
  - TRL 3-4, some critical components are mature but overall initial demonstration for this application is planned for Phase II
  - We have demonstrated ranging through scanning technique on more mature prototypes for other applications



Ranging by Scanning



Semiconductor lasers are approximately peak power limited



CW Operation of semiconductor laser provides orders of magnitude greater average power, allowing **reduction of the receiver aperture and overall system volume**.

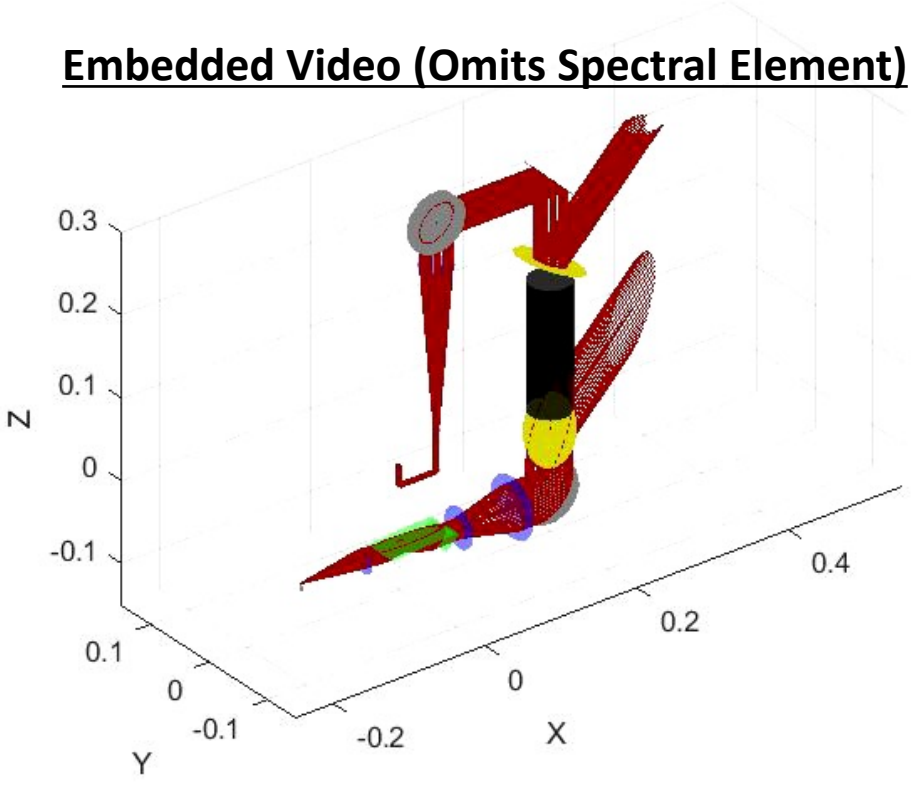
Rapid scanning distributes optical power through larger solid angle, reducing intensities **below eye safety** thresholds

Video to show core concept (with sparse scatterers for simplicity)

Optical Design Simulation

- Design uses mirrors on both sides of mirror axial for separate transmitter and receiver
- Dove prism rotates the images at half the rate of the scanner
- Each range is mapped to a static position on a camera image plane

Embedded Video (Omits Spectral Element)



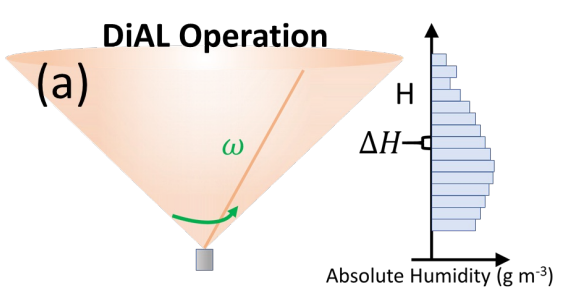
Arete's Scanning Lidar Technology

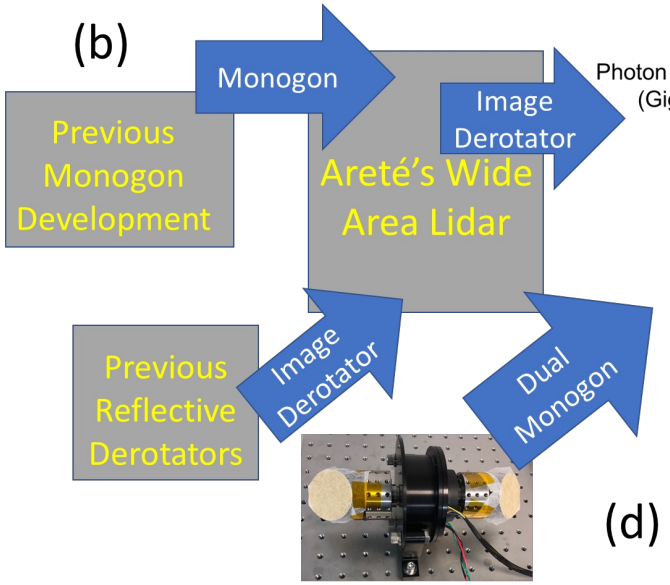
a) System works by sweeping a CW laser over a conical pattern, integrating signals over the sweep to obtain a vertical water vapor profile

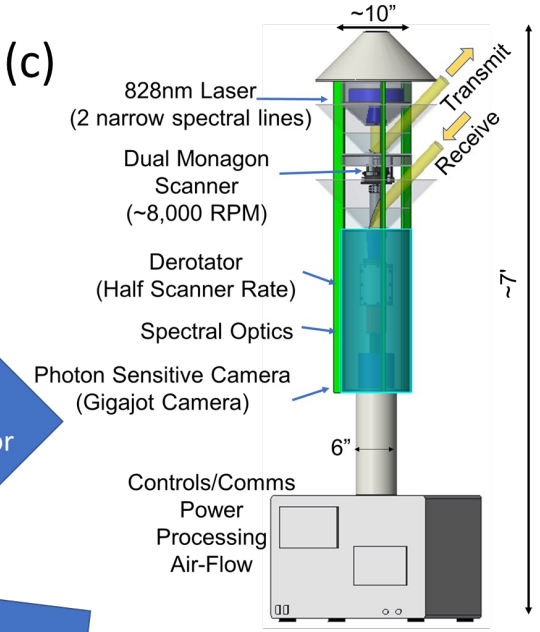
b) The approach leverages technologies Arete has previously demonstrated for "ranging through scanning".

c) This is a cartoon diagram of major components. A "dual monogon" simultaneously scans the transmitter and receiver; An image derotator maps the signal into a range dependent static image pattern; Spectral filtering removes solar background and permits image analysis of light from both a laser "on" the water vapor absorption line and "off".

d) We expect that the technology can be packaged into a small form factor to permit easy installation (e.g., on building roofs)





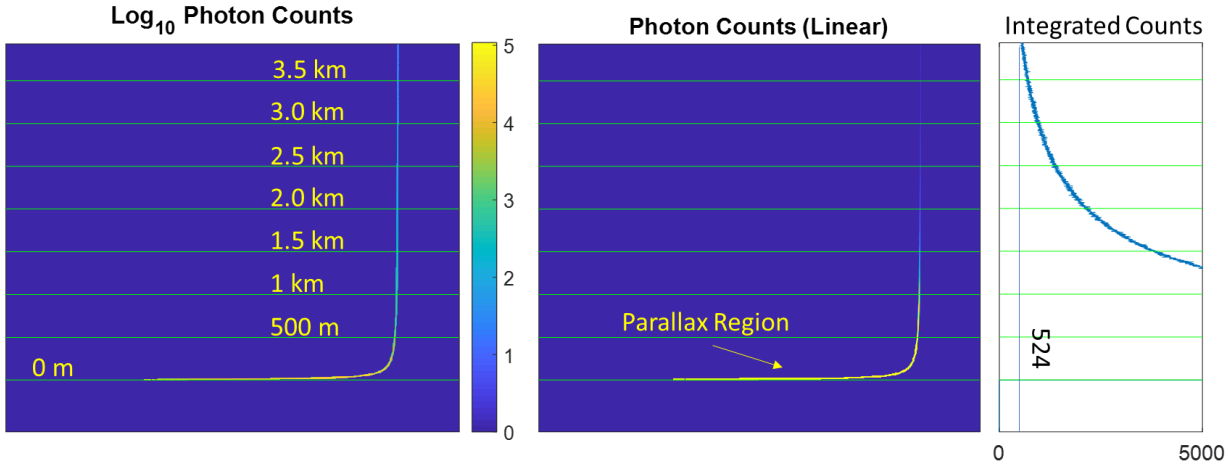


(d)

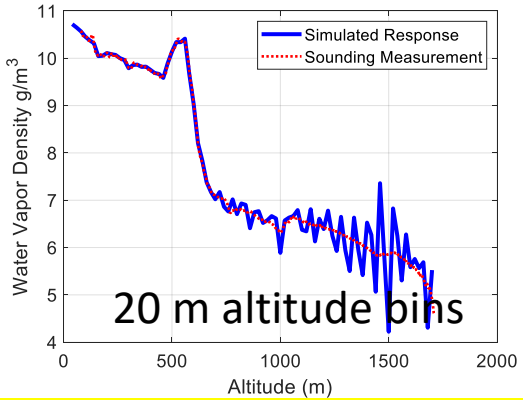
Target Volume	< 12 cu. ft.
Optical Power	< 2 Watt
Wavelength	828 nm
Range Resolution	20m
Max Range	Multi-km
Min Range	m

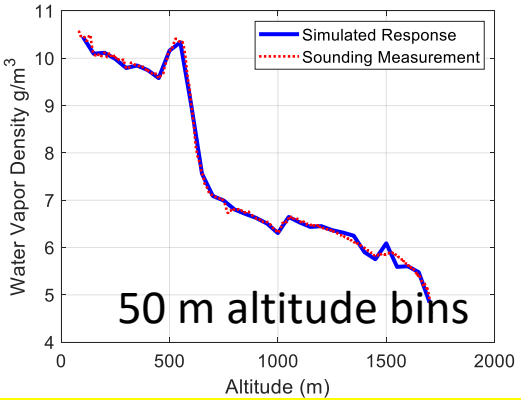
System Design and Simulation

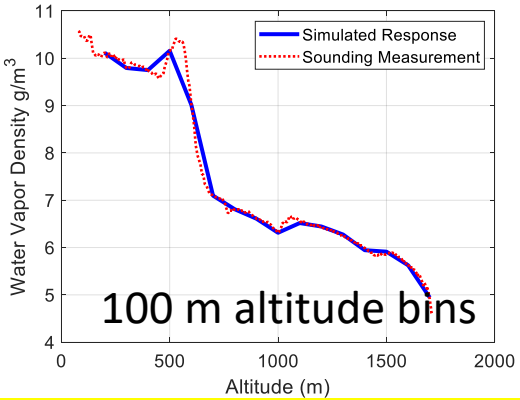
Mapping for single spectral order & wavelength. Pattern after spectral manipulation more complex but static



5-minute data collection, 2” receiver aperture, 1 Watt Laser Power (per wavelength)







Simulated Camera Images for lidar range profiles Parallax is responsible for lower leg in near ranges.

Hardware Development

Dual Monogon Scanner Development Board

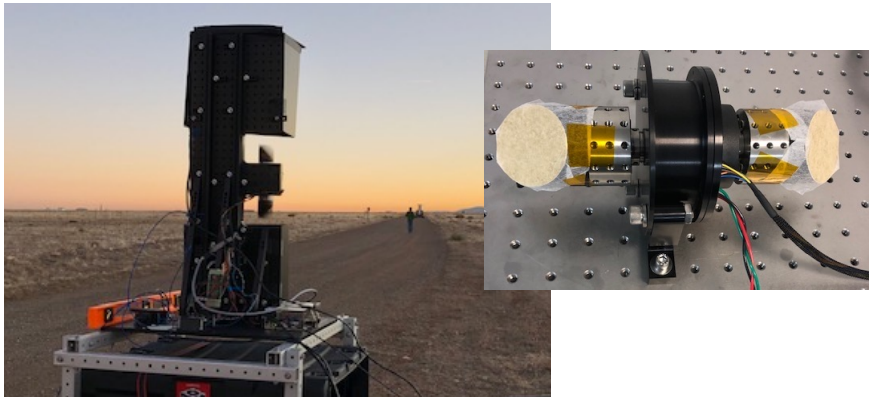
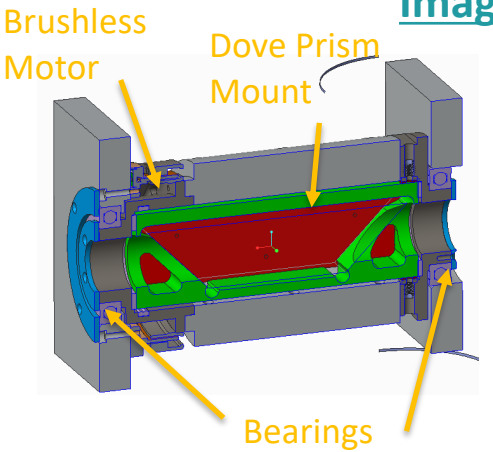
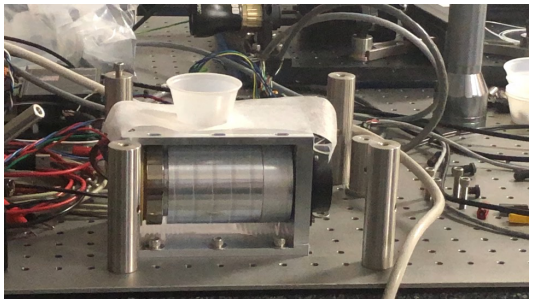
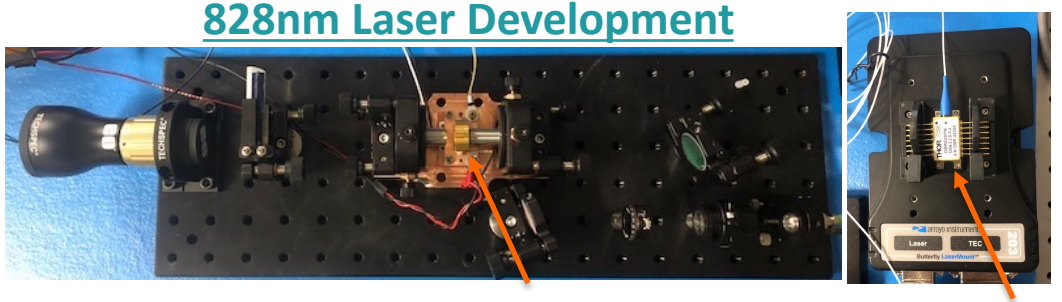


Image Derotator

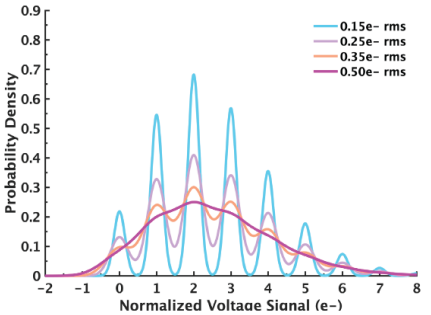




828nm Laser Development



Photon Sensitive Camera



We plan to have a working prototype in about 24 months