

# First results from the TOMEXplus sounding rocket mission

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Science

- Core scientific question to be examined by TOMEX-plus:
  - How are turbulence and the mixing of atomic oxygen related to each other and to underlying instabilities?
- This question was addressed through the three scientific objectives for TOMEX-plus:
  - Determine how the vertical profile of the atomic oxygen mixing ratio varies as the atmosphere changes from regions of large layered turbulence at or below the mesopause to decreasing and possibly vanishing turbulence around the turbopause.
  - Determine the horizontal variations in the atomic oxygen density that can be related to variations in turbulent fluctuations.
  - Characterize the 3D turbulence spectrum, its spatial variability and relationship to larger scale features of the flow, especially those relatable to instabilities.
- Built on the successful TOMEX experiment performed in 2000

Experiment

- Focus was on 80-100 km altitude range
  - Launched from Wallops Island, VA
  - Ground-based imager indicated when turbulence was present
  - First rocket launched at 02:43 UT on 28 August 2025
- Rockets
  - Main rocket payload carried sodium lidar, ionization gauges, up-looking photometers
  - Subpayload carried winds instrumentation, neutral mass spectrograph, ionization gauges
  - Two vapor trail rockets measured wind and turbulence profiles
- Ground-based measurements
  - Airglow imager made context measurements of mesopause region
- Modeling
  - Atmospheric modeling will put measurements into larger context

Mission Architecture

TOMEXplus DR Trajectory

Altitude (km)

Range (km)

Sodium layer  
Iron layer  
OH layer  
Imager FoV

North Site  
Launch Site  
South Site

Ground Track  
Above 80 km  
TMA Left  
TMA Right

Apogee  
Downleg 90 km  
Impact Point

## Main Takeaways

TOMEXplus was finally launched, and launched successfully into an interesting event!

A consistent picture of the atmospheric variations emerges from combination of ground-based airglow imaging and vapor trail evolution

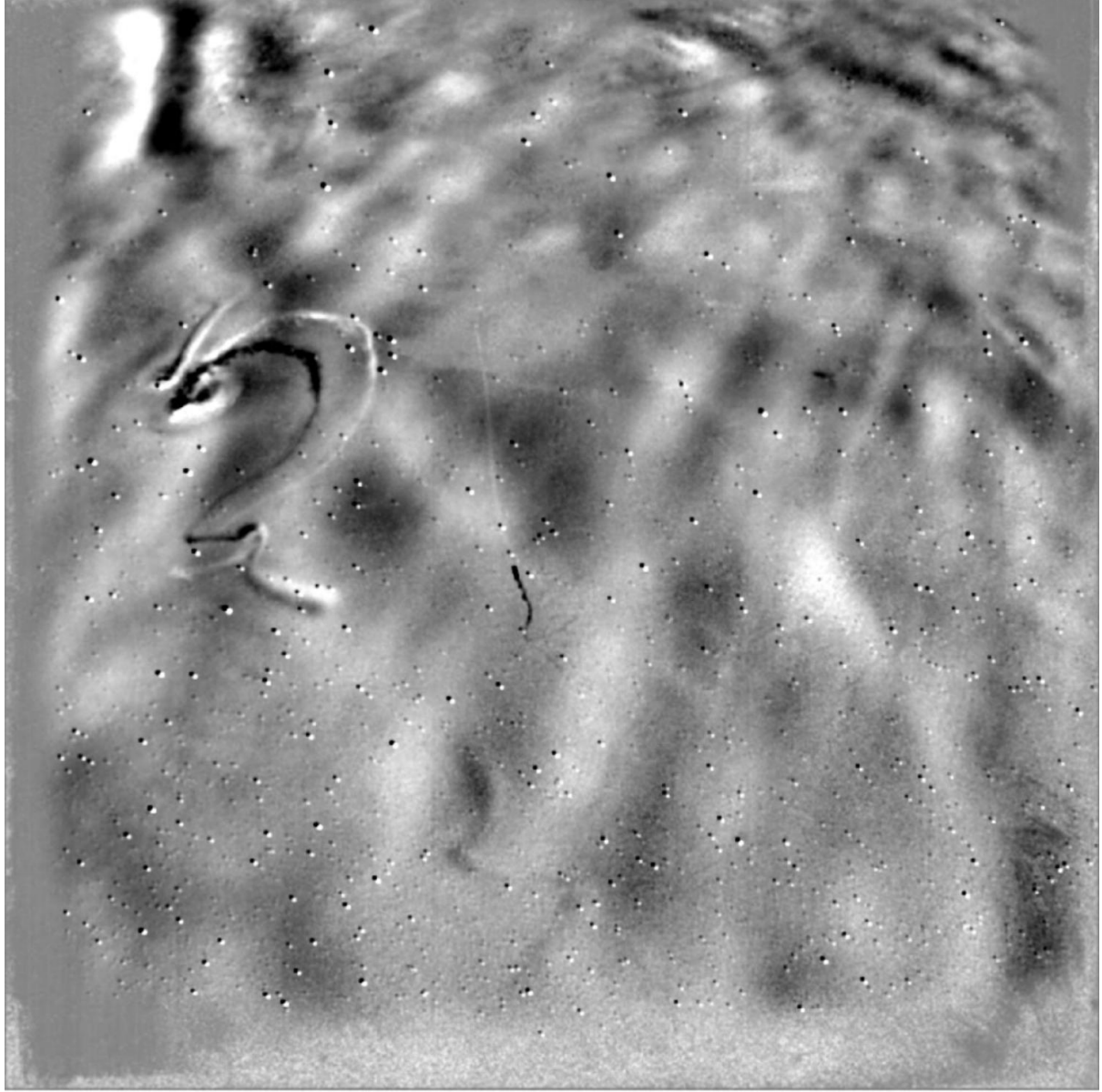
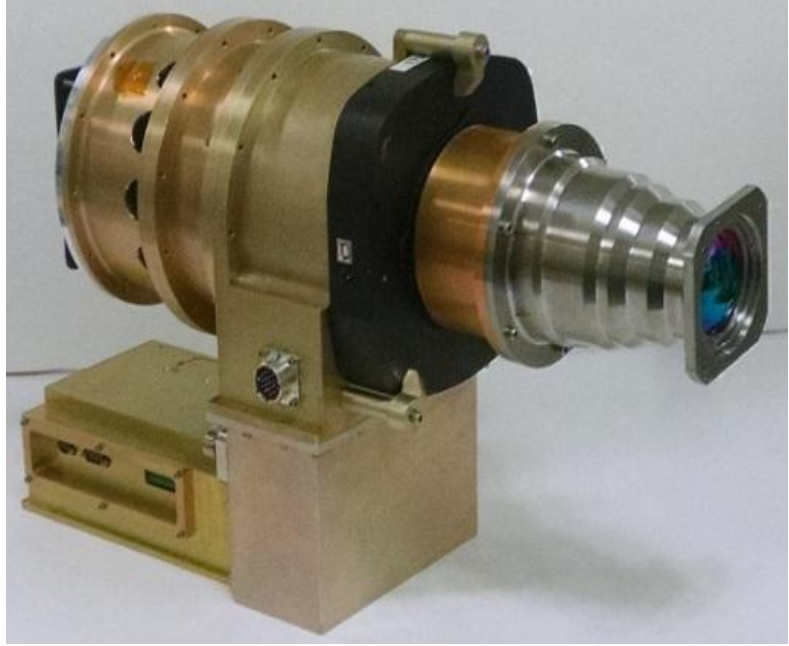
The sodium lidar worked, making it the first successful operation of an atmospheric lidar in space

Good were data received by all rocket instruments

Happy analysis lies ahead!

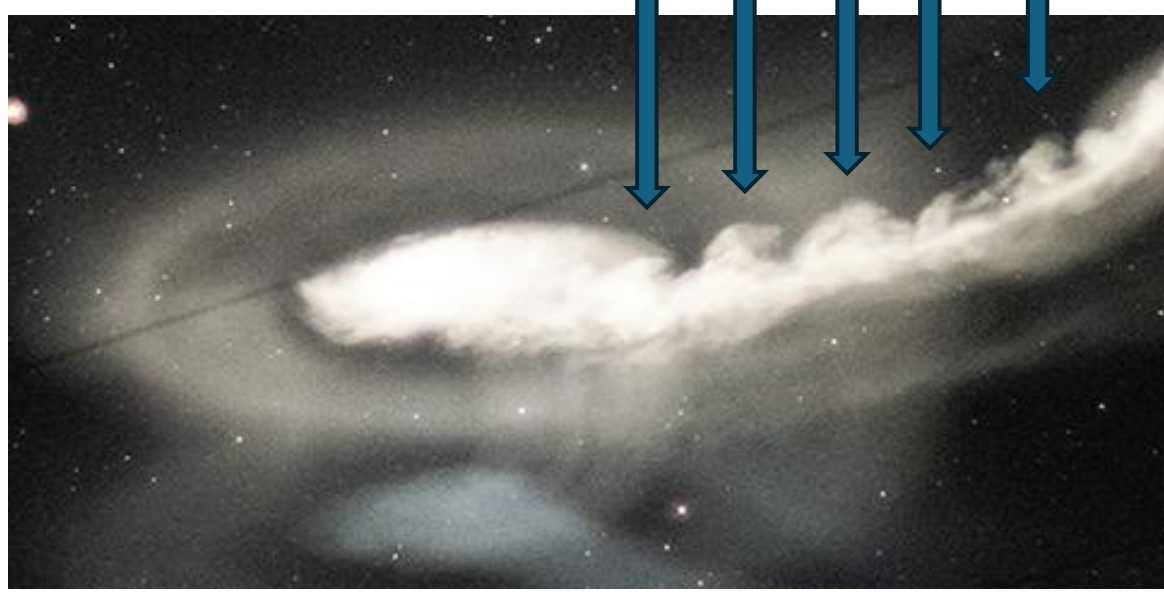
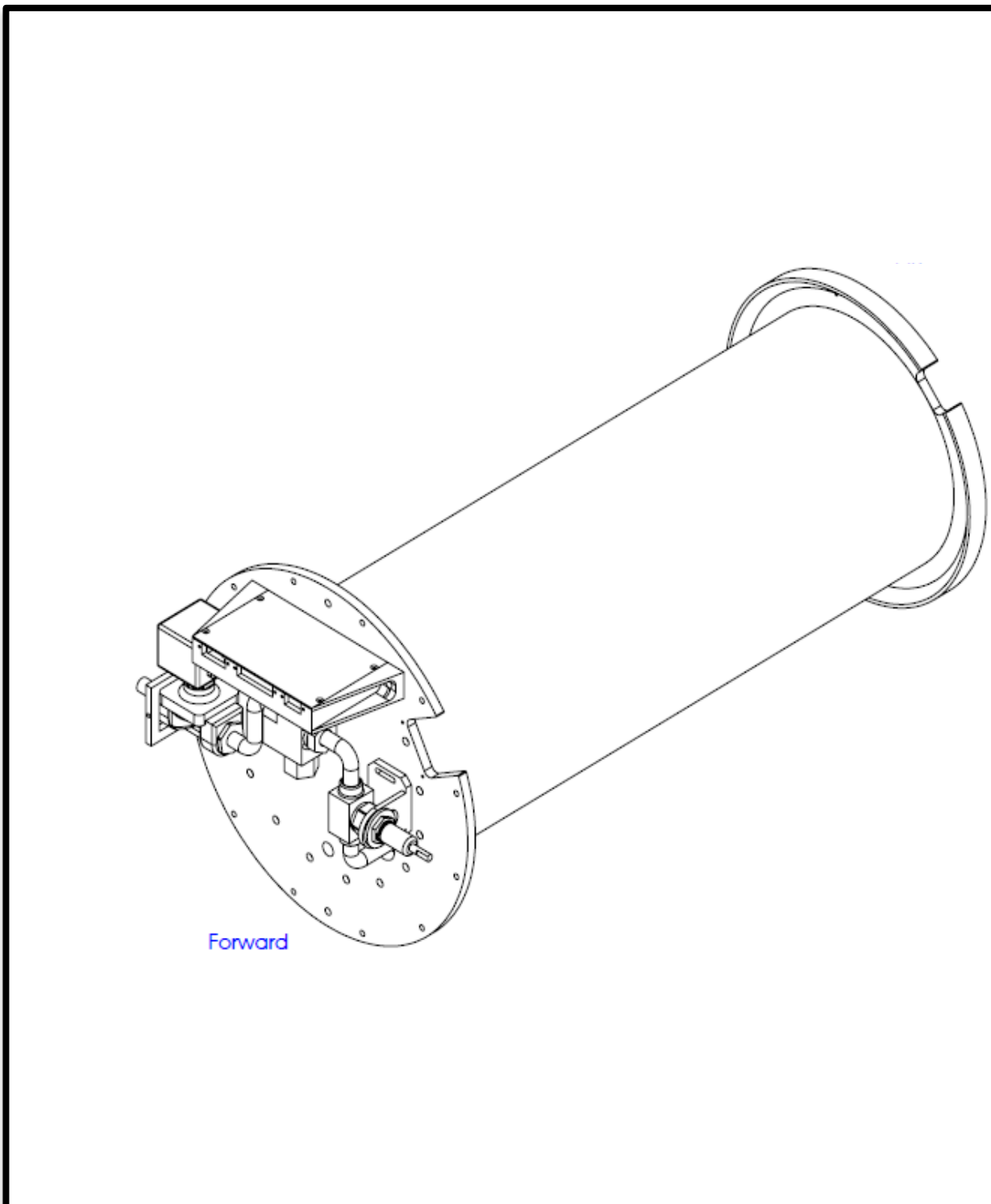
Launch!

Photo Credit: NASA/Danielle Johnson



Ground-Based OH Airglow Imager

Launched into significant atmospheric instability

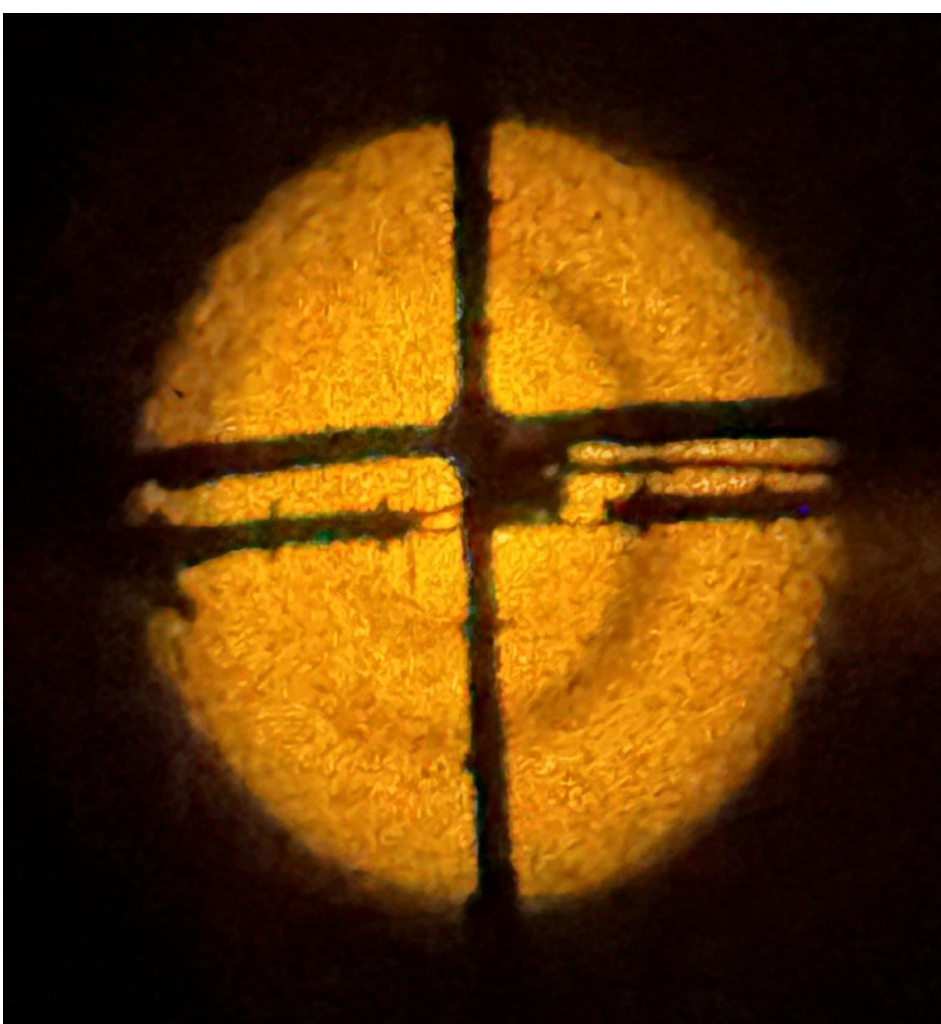
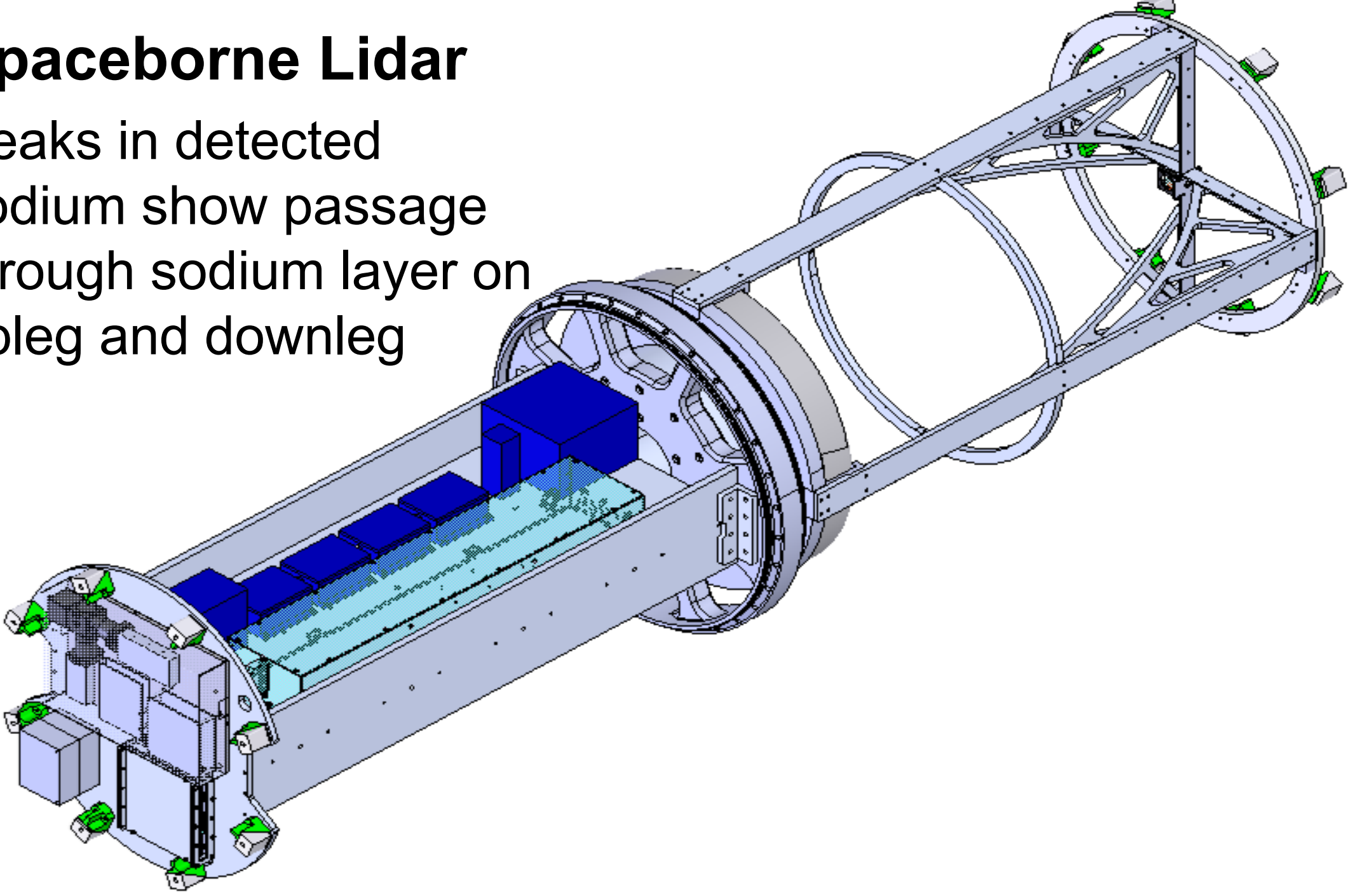


Vapor Trails

Signs of significant turbulence at lower altitudes (“fuzzy” trail)

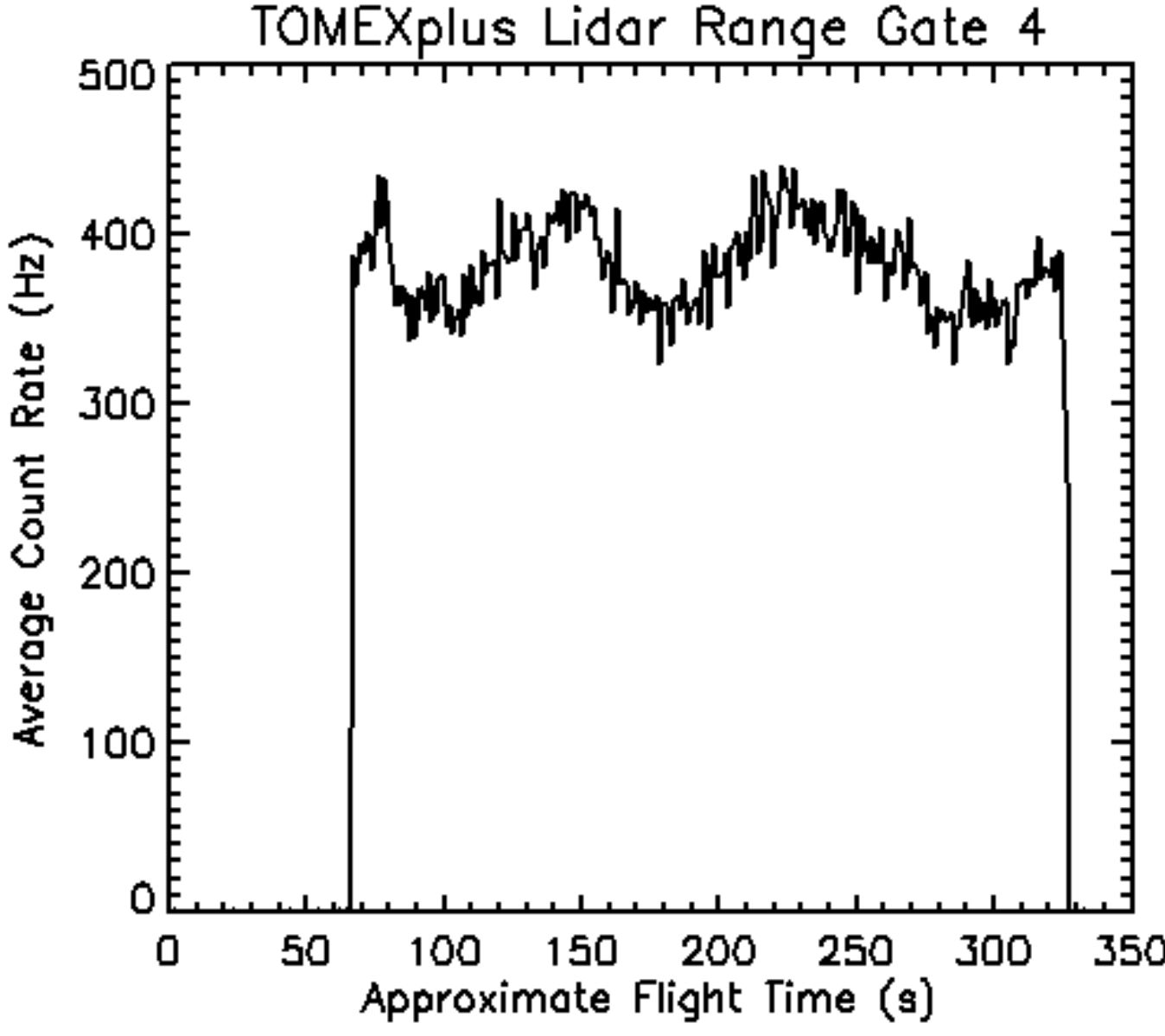
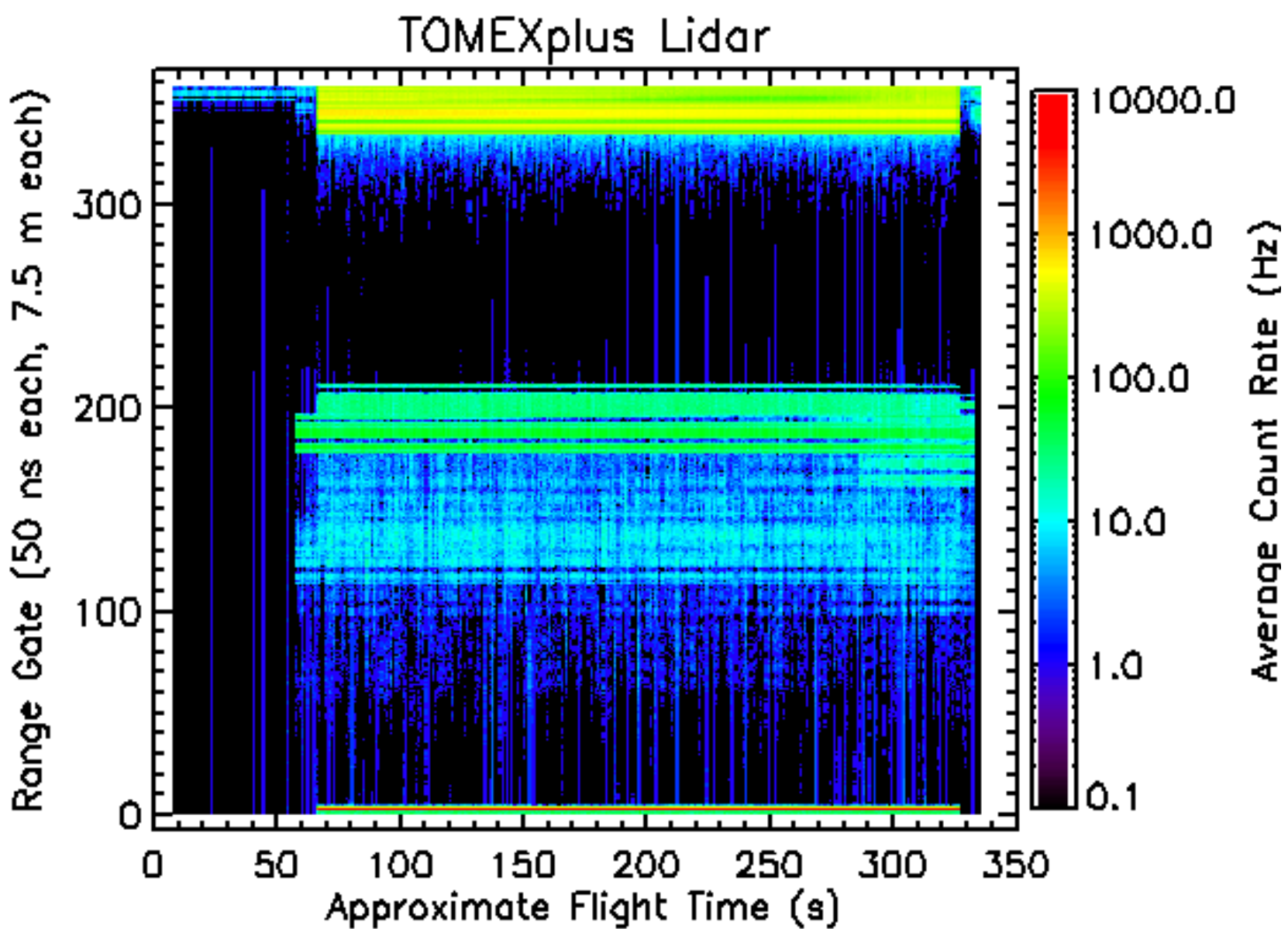
Turbopause indicated by red arrow

Kelvin-Helmholtz billows seen (blue arrows)



Spaceborne Lidar

Peaks in detected sodium show passage through sodium layer on upleg and downleg

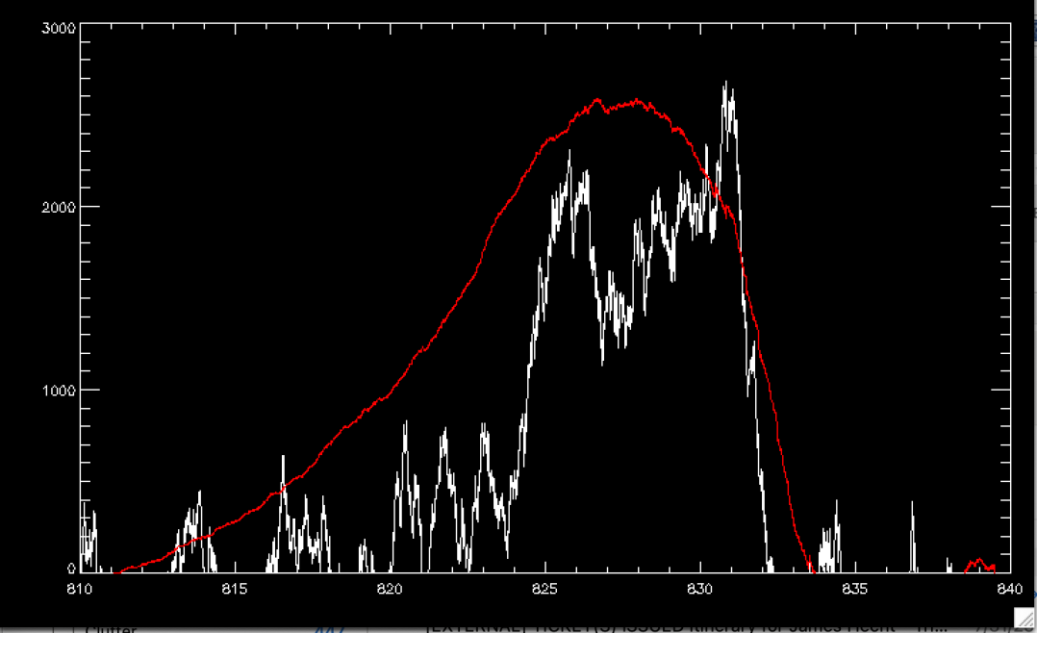
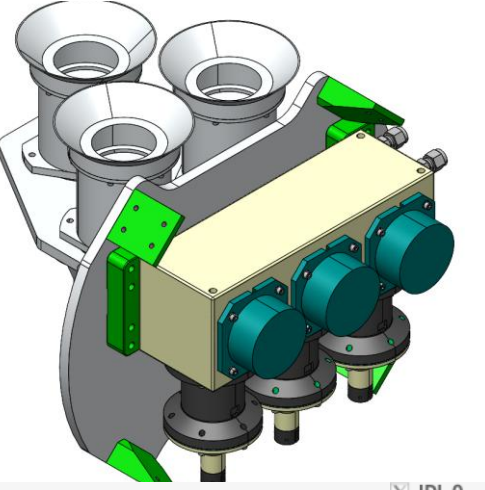


TOMEXplus Lidar

TOMEXplus Lidar Range Gate 4

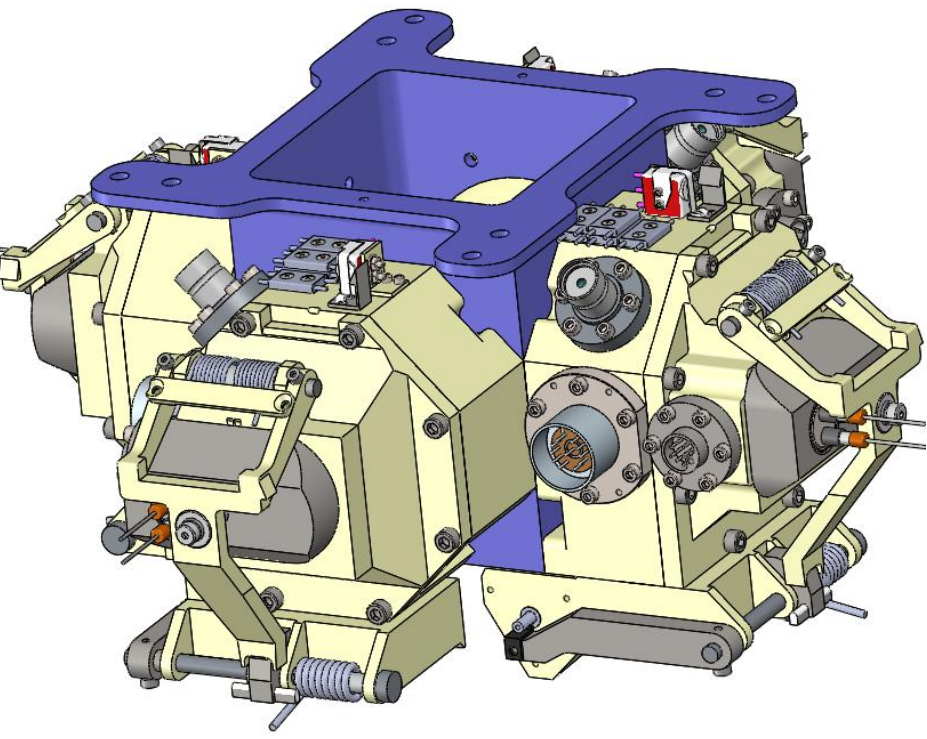
Uplooking Photometers

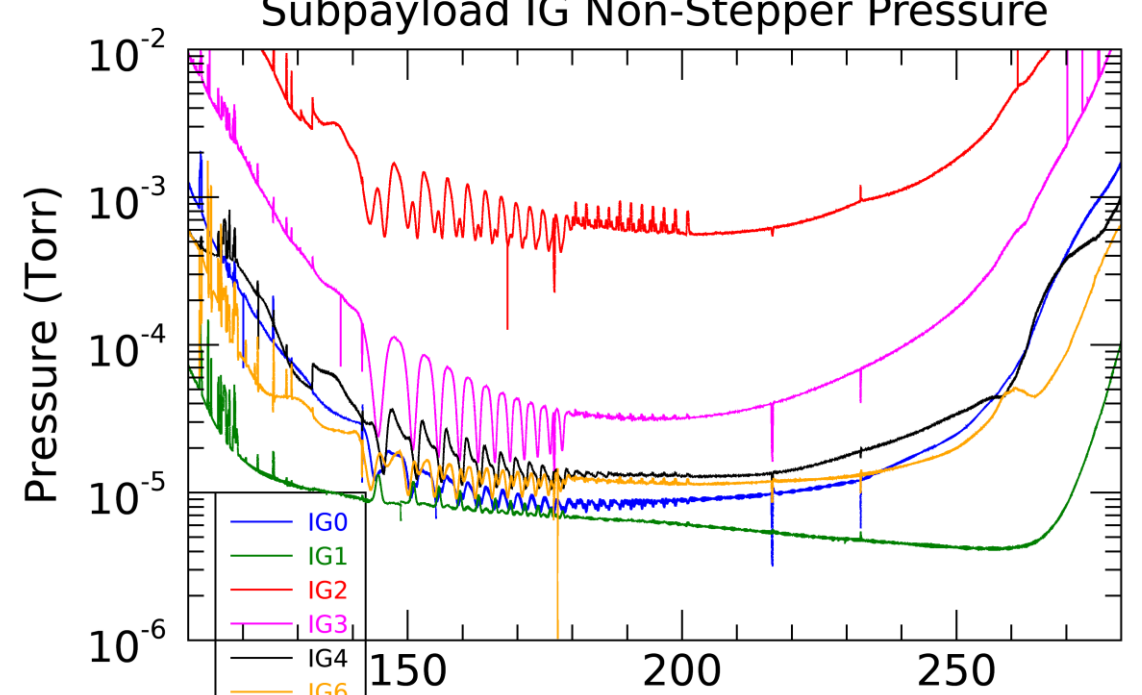
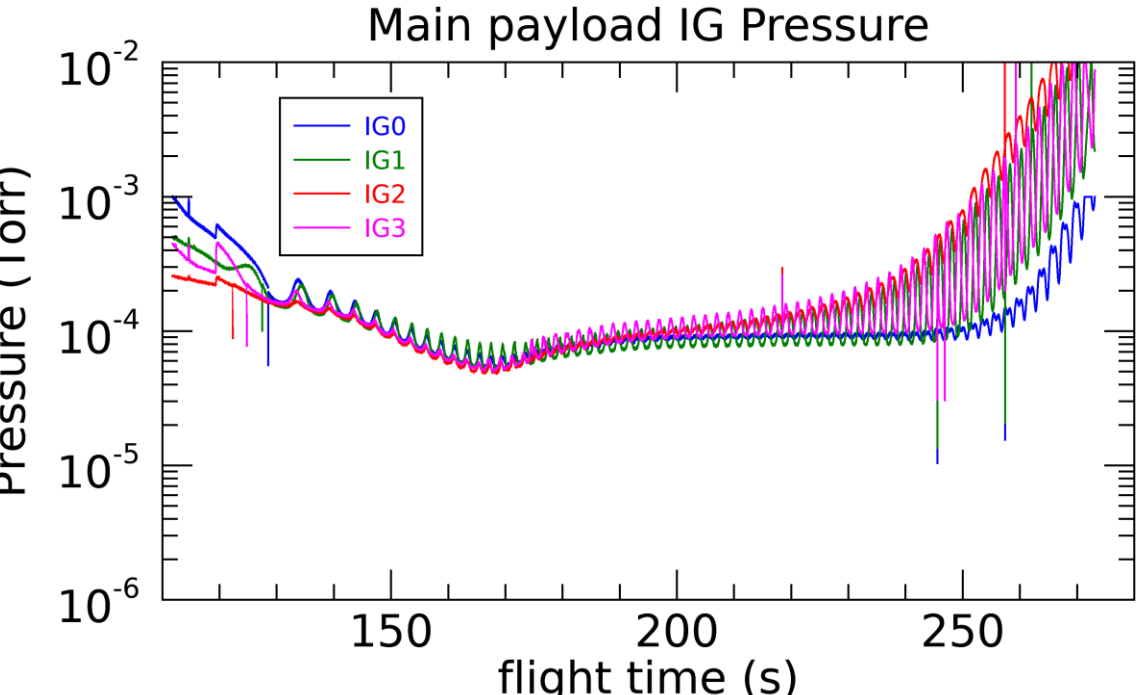
Gives atomic oxygen volume emission rate as function of altitude



Multiple-Sensor Ionization Gauges

Measure gas flux as a function of flow angle to derive atmospheric density, winds, and temperature



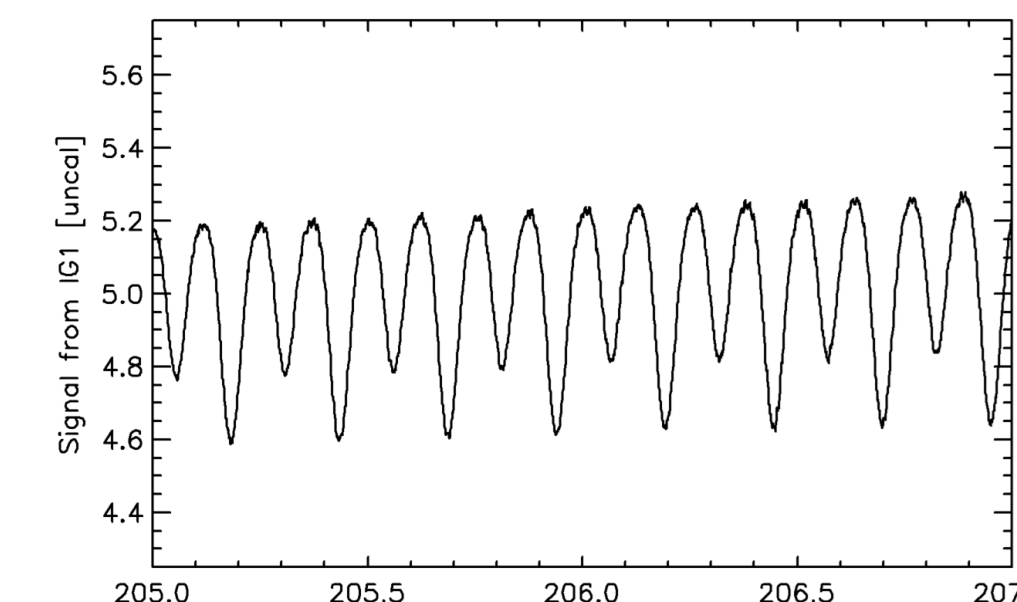
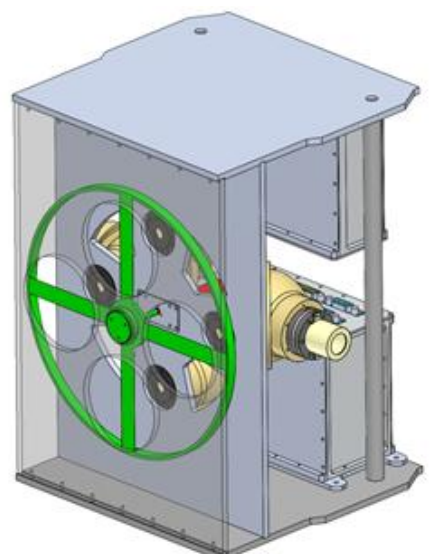


Main payload IG Pressure

Subpayload IG Non-Stepper Pressure

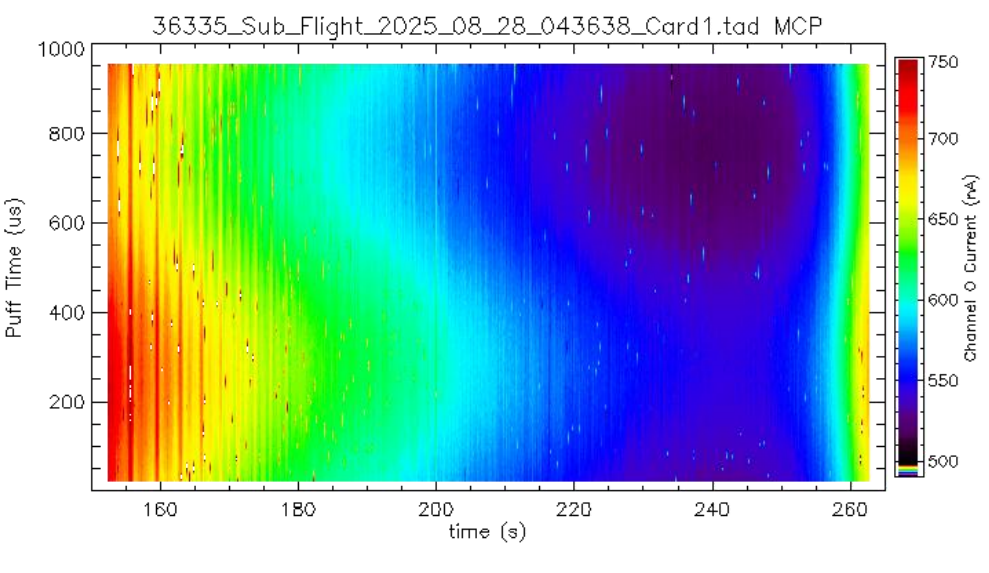
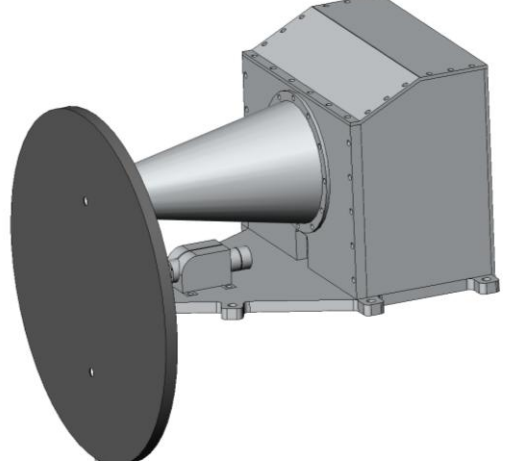
Winds Cross-Track

Measures cross-track components of winds using modulational technique



Winds In-Track

Measures in-track component of winds using time-of-flight technique



Neutral Mass Spectrograph

Measures atmospheric composition of major species

