Winds In-Track Results from Dynamo II Sounding Rocket Mission

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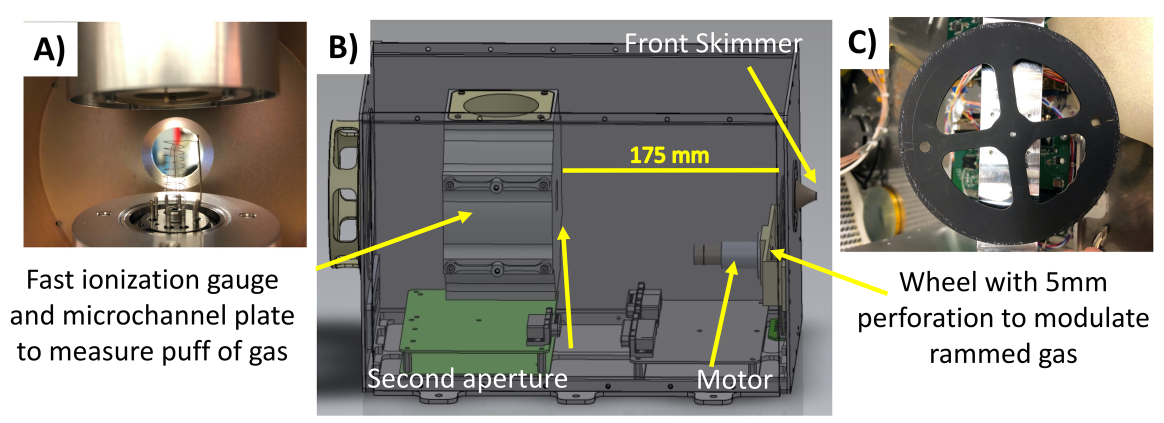
Introduction

The Dynamo II sounding rocket mission launched in July 2021 from Wallops Island, VA. This mission provides insight on the influence of neutral winds and shears during strong morning meridional dynamo currents in the mid-latitude ionosphere.

The Winds-In Track (WIT) instrument, to measure the ram direction neutral wind speed, had it's first and second successful flight aboard the two Dynamo II rockets. The WIT data results will be presented and discussed.

Dynamo II measured electric fields, plasma density, current density, neutral winds, neutral density and temperature, and ion mass distributions up to an apogee of 131 km for rocket 36.357 on July 11th, and apogee of 123km for rocket 36.358 on July 7th.

Winds In-Track Instrument



To measure the in-track wind velocity the Winds In-Track (WIT) instrument measures the gas stream in the ram direction. The gas enters the instrument on the ram side through a small skimmer and the gas is modulated by a perforated wheel that only allows a small "puff" of gas to pass. The puff of gas travels a known distance, passes through another aperture and the travel time is measured when the puff is detected by a fast ionization gauge, and vented through a baffle out the back.

Winds Sub-payload

Each of the Dyanmo II rockets included a Winds In-Track (WIT) to measure the ram direction neutral wind speed, a Winds Cross-Track instrument to measure the two cross track vector components of the neutral wind and ionization gauge instruments.

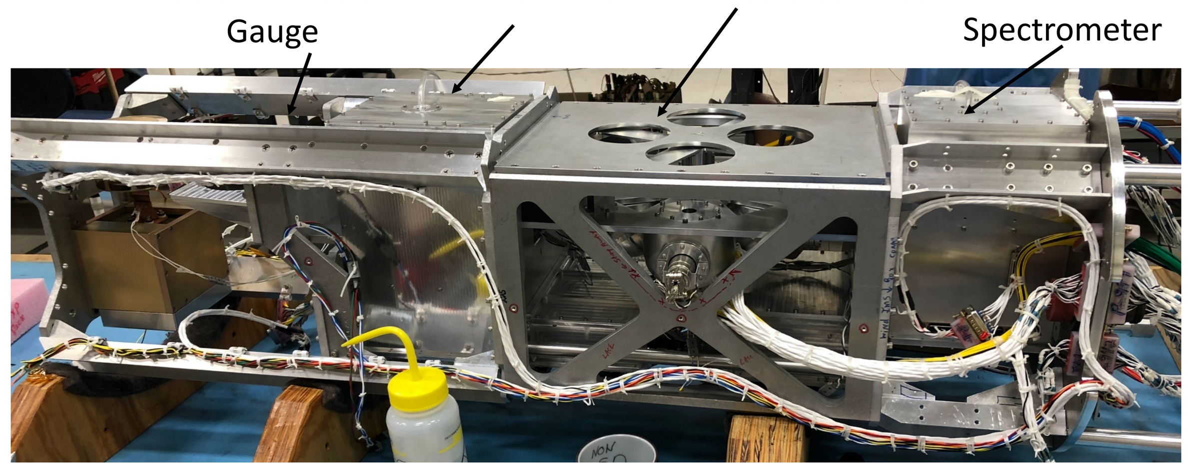
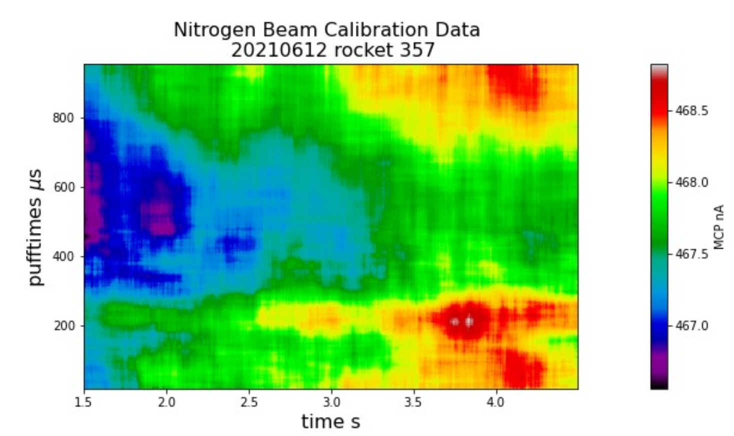


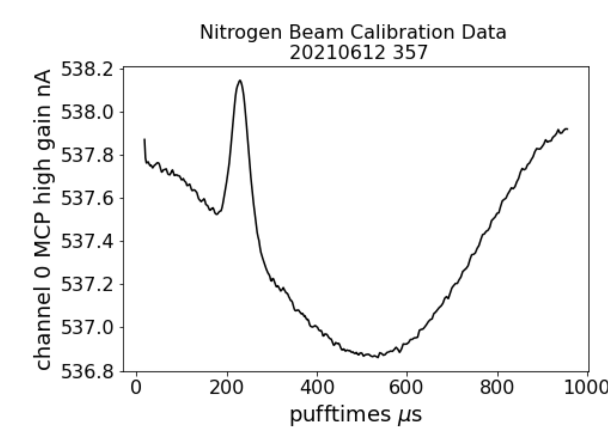
Figure 1. Sub-payload of Dyamno II 36.357 rocket during instrument integration in Wallops, VA.

WIT Calibration Data

The WIT was calibrated with a cold nitrogen and argon beam in our new Winds Chamber at UNH.



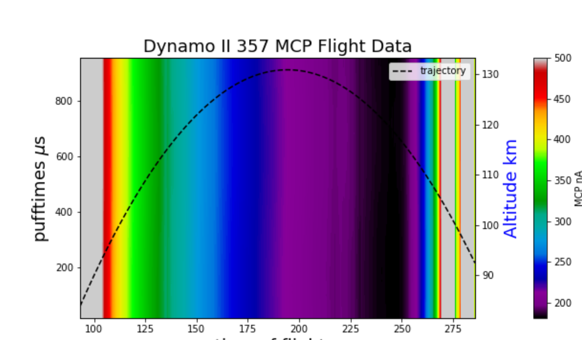
The estimated wind speed for the nitrogen beam in the chamber is about 787 m/s. The travel time for a puff of gas to travel the 175 mm from the wheel to the fast ionization gauge detector in the WIT is expected to be 222.3 μs.

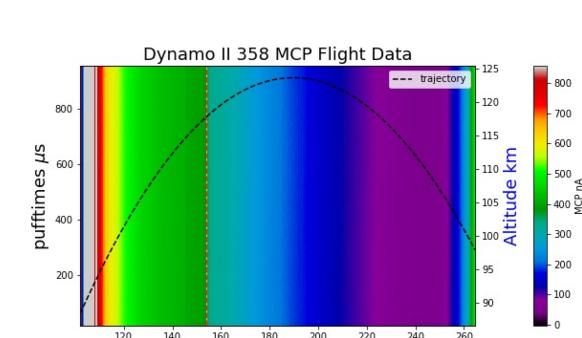


This peak was clearly detected in the data below, however a sinusoidal background signal from the electronics was also detected.

WIT Flight Data

This mission was the first time the WIT took measurements in space with the motor working. Unfortunately, a very low signal was measured and has made it challenging to determine a wind speed from the flight data.

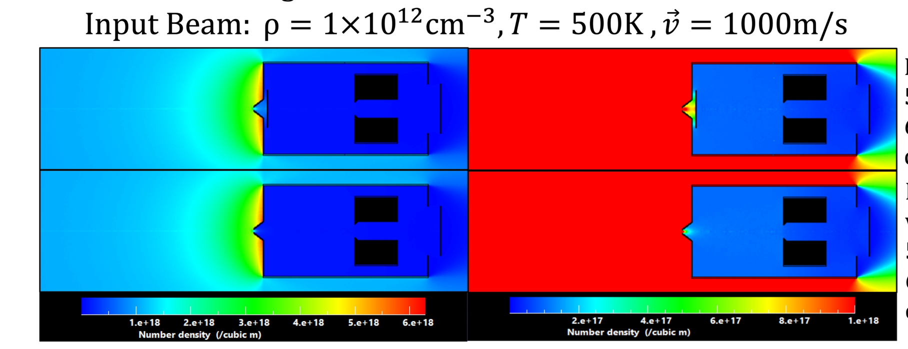




WIT Simulation

After the flight and calibration analysis, simulations were run to understand the results. Flight-like conditions and chamber-like conditions were simulated for the WIT geometry in DS2V DSMC simulations from Graeme Bird.

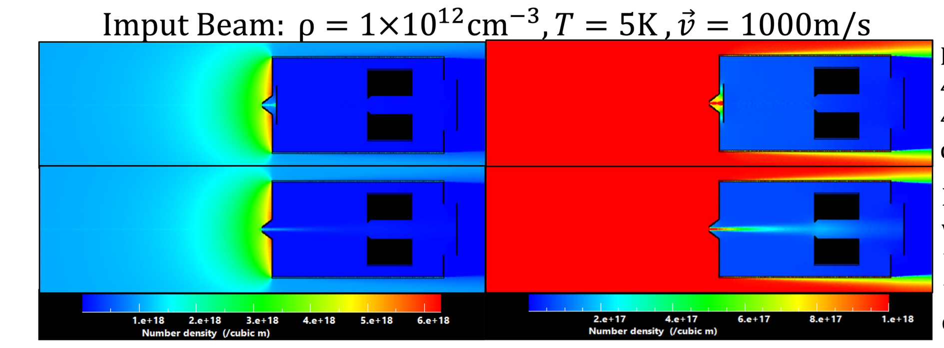
Flight Like Conditions ~ 110 Km
Input Beam: $\rho = 1\times10^{12} cm^{-3}, T = 500K, \vec{v} = 1000 m/s$



This simulation indicates a signal to background ratio of about 1.09, between when the beam is blocked by the wheel and when a small puff of gas is allowed through which helps to explain the low signal in the flight data.

For the chamber-like conditions the signal to background ratio is much larger and the beam was clearly measured.

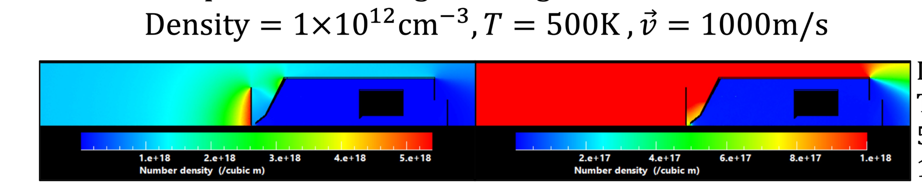
Cold Beam Chamber Like Conditions
Input Beam: $\rho = 1\times10^{12} cm^{-3}, T = 5K, \vec{v} = 1000 m/s$



Simulations for improved designs were run to increase the signal to background ratio for the next flight.

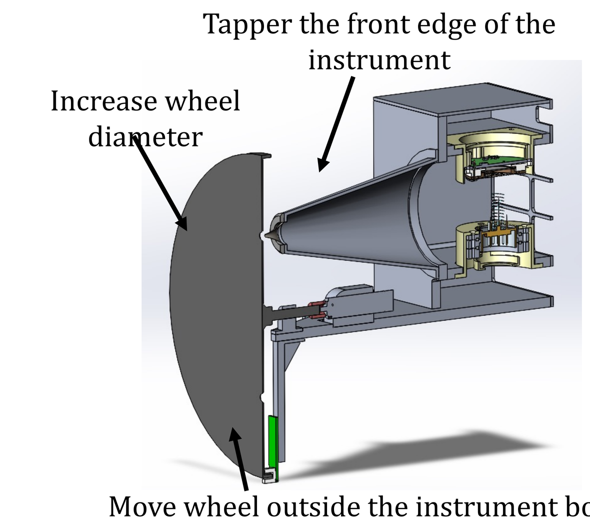
With the wheel blocked only 1.6% of the beam density is detected, if the signal detected is similar to the flight like simulations above, the signal to noise ratio would be 4.31 and the puffs of gas should be detectable above the background.

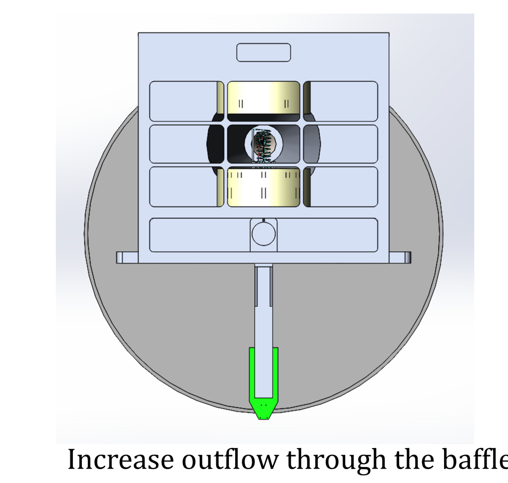
Tapered Front Edge for Flight Like Conditions
Density $= 1\times10^{12} cm^{-3}, T = 500K, \vec{v} = 1000 m/s$



WIT Redesign Considerations

Major improvements to the WIT geometry are being designed

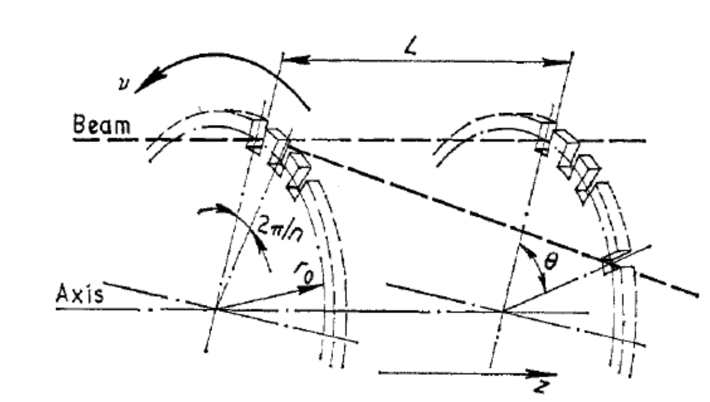




WIT Velocity Selector

A new velocity selector WIT-VS is in the initial stages of a feasibility study. This instrument would use a series of wheels with teeth in them to filter out gas based on wind speed. Only a selected velocity would be allowed past all of the wheels to an accommodation chamber with an ionization gauge to measure the beam. To survey a velocity spectrum the wheel rotation rate will change.

This application of the velocity selector technique has never been used before for *in situ* space measurements. Velocity selectors have heritage in laboratory settings dating back to 1960 by Hostettler and Bernstein to measure molecular beams.



Van Steyn & Vester, 1972

This figure from Van Steyn and Vester 1972 shows two wheels as a velocity selector with teeth to filter the gas.

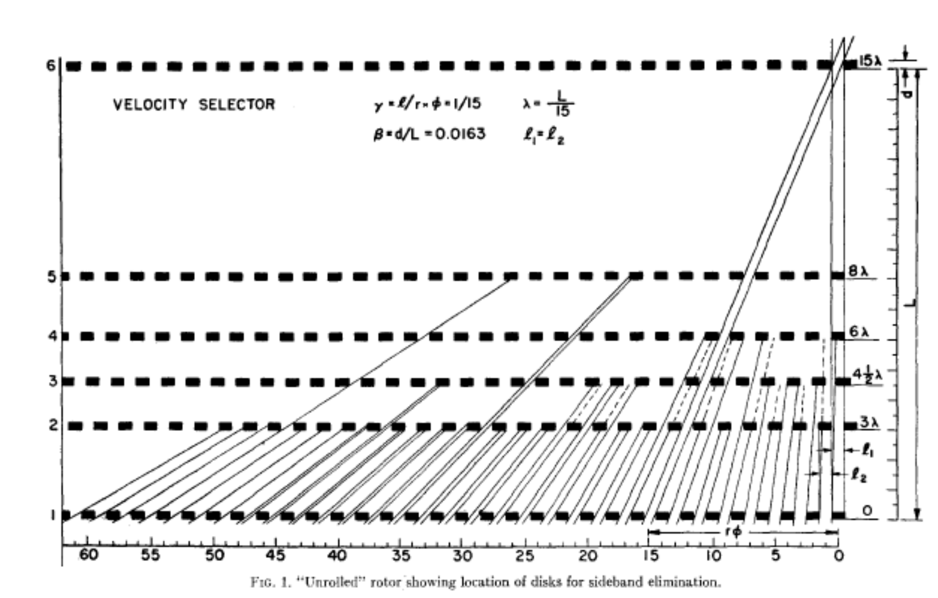


Figure from Hostettler et al. 1960 shows the unrolled geometry of a velocity selector with six wheels.