Fly low, fly propellantless!

AETHER

Air-breathing Electric THrustER

www.aether-h2020.eu

Funded by the European Union

Grant Agreement Number 870436

What is AETHER?

AETHER (Air-breathing Electric THrustER) is an R&D Project aimed at demonstrating the feasibility of the air-breathing Electric Propulsion (EP), otherwise called RAM-EP.

AETHER is funded by the European Union under Horizon 2020, SPACE-13-TEC-2019.

AETHER is an Operational Grant included in the agenda of the Strategic Research Cluster *Electric Propulsion Innovation & Competitiveness (EPIC),* aimed at enabling major advances in EP for in-space operations and transportation, to enhance European competitiveness and non-dependence.

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Who we are

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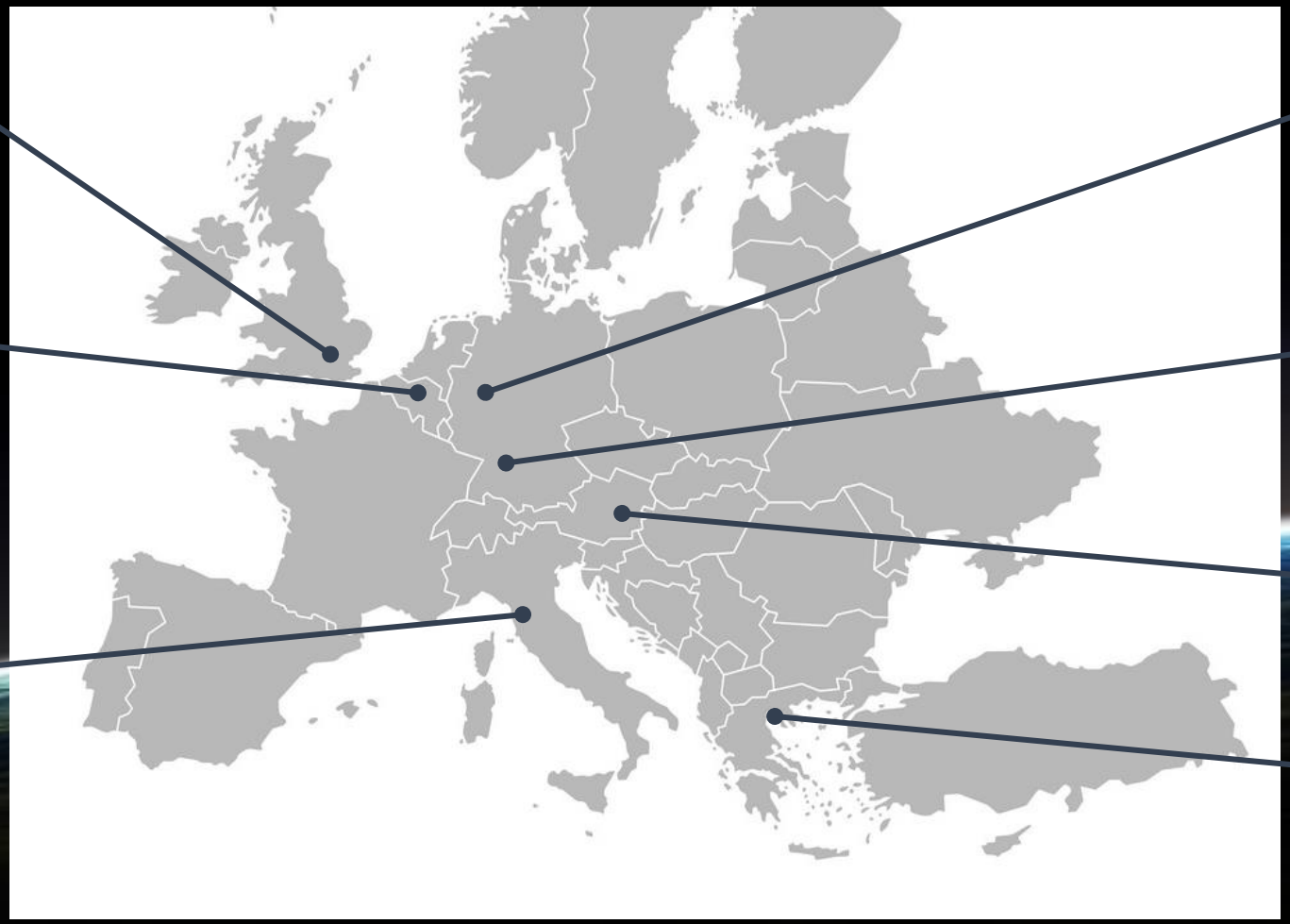
The AETHER team



UNIVERSITY OF SURREY

Alternative cathode design and development

von KARMAN INSTITUTE FOR FLUID DYNAMICS

Flow simulations, intake optimization, non-invasive diagnostics

SITAEL AN ANGEL COMPANY

Coordinator, RAM-EP concept design, ionization and Hall-effect acceleration stages development, on-ground system testing

TransMIT Gesellschaft für Technologietransfer mbH

Gridded acceleration stage design and development

Astos Solutions

Mission analysis and optimization

RHP TECHNOLOGY

Material science studies for harsh environments

DEDALOS

Evaluation of the atmospheric remnants in VLEO region and definition of other celestial bodies atmospheres

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What is the goal of an air-breathing satellite?

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Spacecraft relying on a RAM-EP system are conceived to orbit between 160 km and 250 km from Earth, an orbital region (VLEO, Very Low Earth Orbit) still unexploited.

In VLEO remnant gas atoms and molecules from Earth's atmosphere are available to be possibly used as propellant.

A combination of electric and magnetic fields ionizes and accelerates such propellant to give the spacecraft the necessary thrust to counteract atmospheric drag and enable long duration missions.

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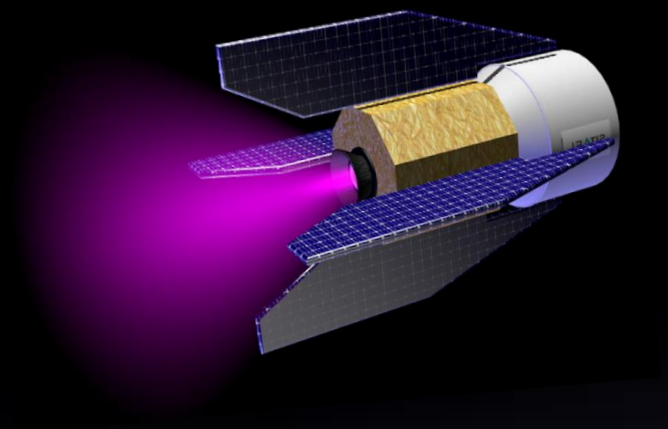
What is “air-breathing Electric Propulsion”?



A **propulsion system** that uses electrical energy to change the velocity of a satellite, exploiting the **residual atmosphere as propellant**.
A RAM-EP system **does not require** to store the propellant, whereas it is necessary for conventional propulsion systems.

Why use “air-breathing EP”?

Giving the fact there is no need of onboard propellant, air-breathing EP can enable **long duration missions in VLEO**.

What are the challenges of “air-breathing EP”?

- Complex trade-off @system level
- Materials degradation (oxidation, erosion)
- Complex on-ground testing

Need to develop critical technologies for

- Collection of rarefied airflows
- Ionization of atmospheric particles
- Flow acceleration and neutralization

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AETHER goal and tasks

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The main objective of AETHER is to demonstrate the critical functions of an air-breathing electric propulsion system in a relevant environment and its effectiveness in compensating atmospheric drag.

Main tasks are:

- Identify specific application cases for the RAM-EP technology and derive system requirements.
- Develop critical technologies (including materials) for the collection, ionization and acceleration of rarefied atmospheric flows, and manufacture a RAM-EP system prototype.
- Develop and manufacture a representative on-ground test set-up.
- Assess the performance of the RAM-EP system by testing.

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“Air-breathing” system architecture

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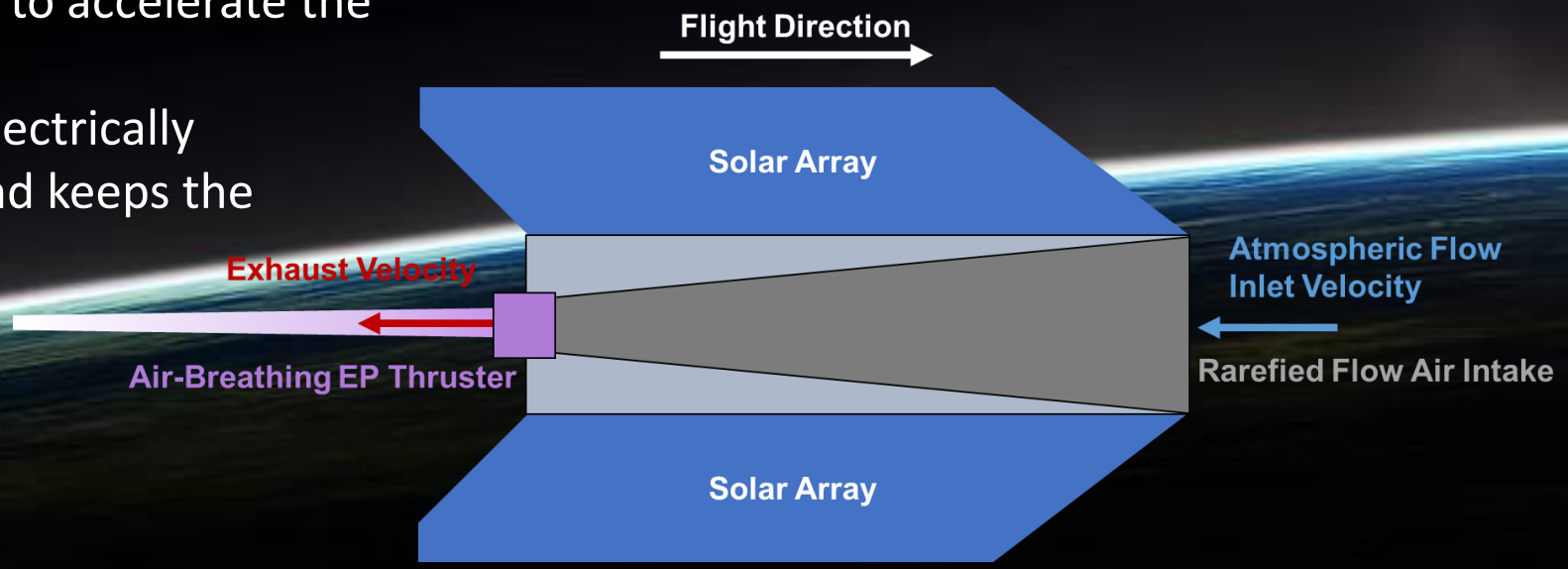
An air-breathing EP System is basically composed of:

An **Air-breathing EP thruster** on the back, including:

- An **ionization stage**, to ionize the flow gathered by the intake;
- An **acceleration stage**, to accelerate the ionized particles.
- A **neutralizer**, which electrically neutralizes the flow and keeps the spacecraft neutral

A **frontal intake** to collect and compress the rarefied atmospheric flow particles.



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Particle collection

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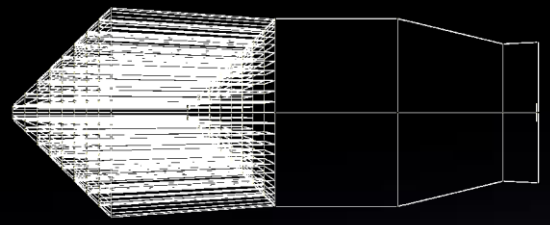
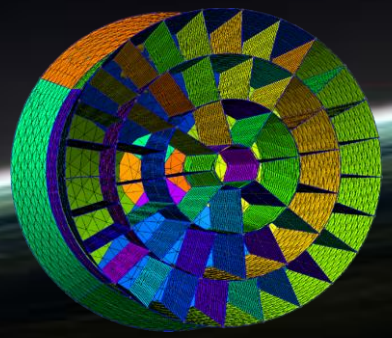
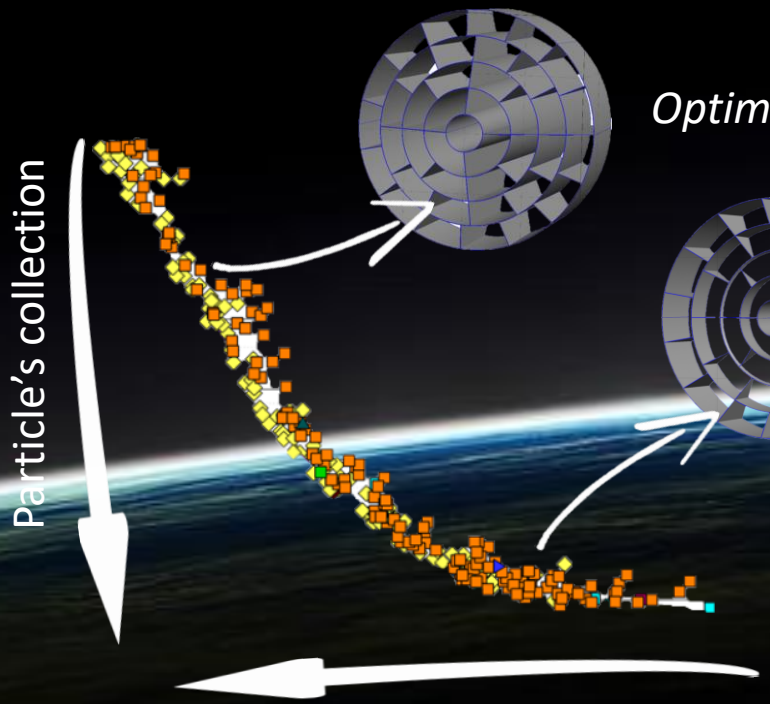
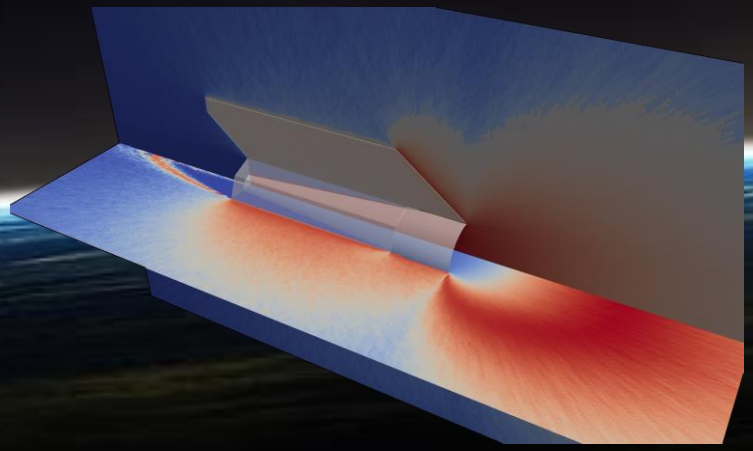
The frontal intake is in charge of collecting and compressing the flow that feeds the acceleration stage.
To reach a good ionization level, a high compression ratio (~100) is required, which typically implies a low collection efficiency (~30%).



Model parametrization







Particle-simulation

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Propellant ionization and acceleration

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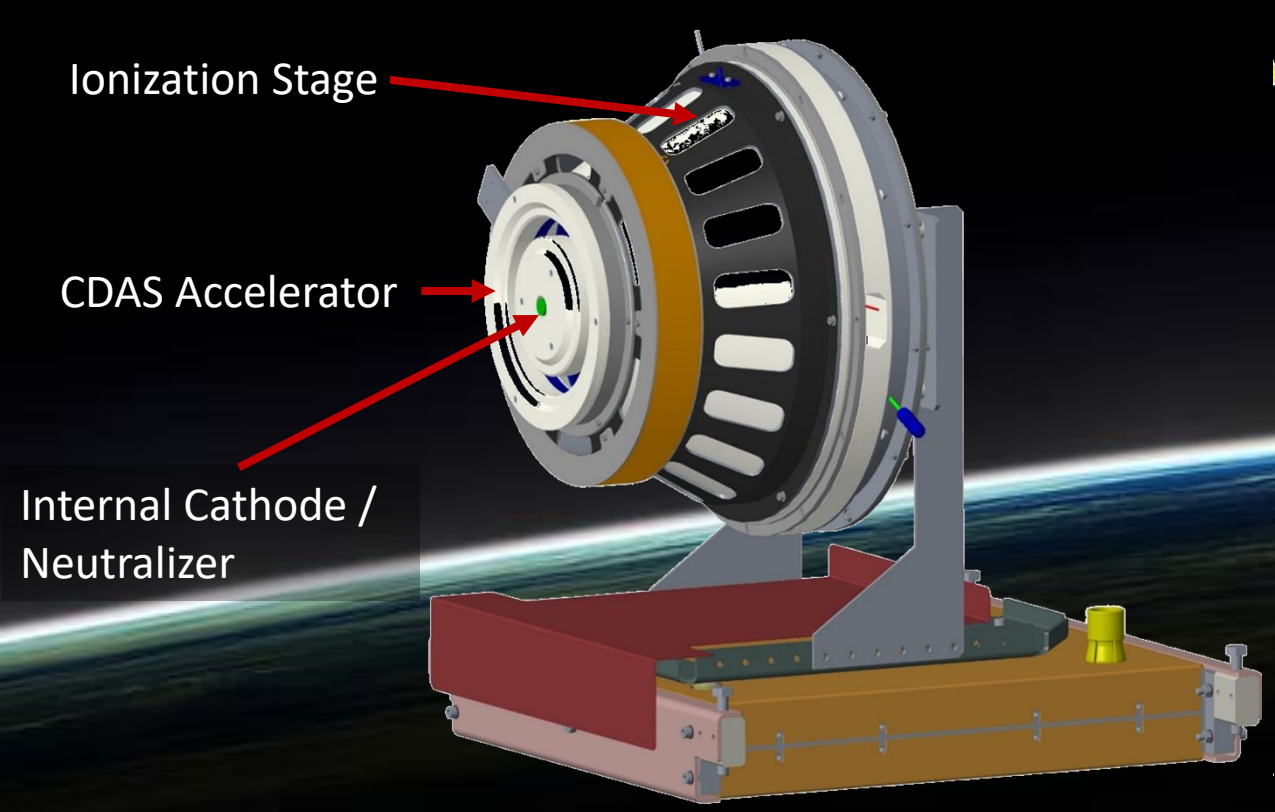
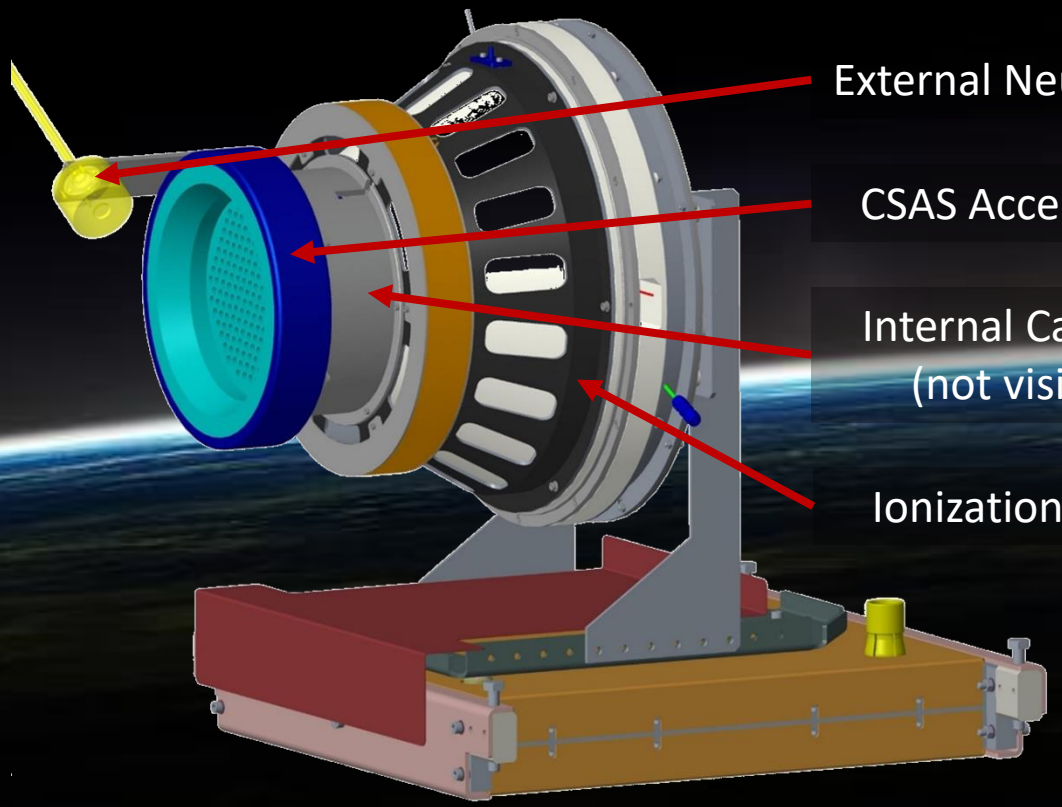
Whilst the ionization stage is a monolithic building block, two acceleration methods are explored within AETHER: **CDAS** (Closed Drift Acceleration Stage) and **CSAS** (Charge Separation Acceleration Stage). They derive from Hall Effect Thrusters (HET) and from Gridded Ion Engines (GIE), respectively.





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Flow neutralization

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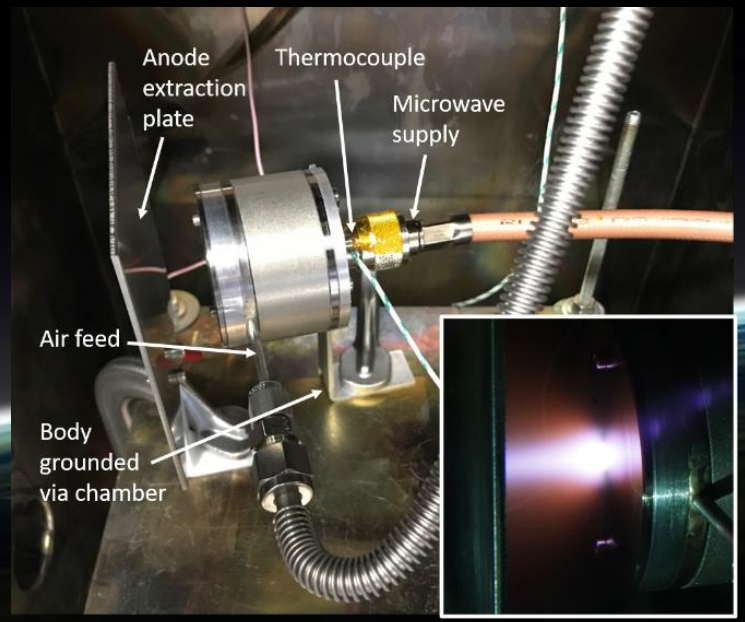
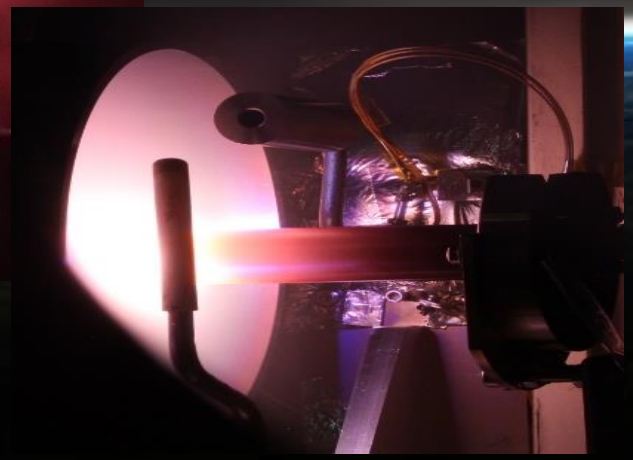
A cathode/neutralizer is needed by the RAM-EP system to produce electrons for the ionization stage, but also for keeping the resulting plasma plume neutral with respect to the spacecraft.
In AETHER two technologies are explored for the cathode/neutralizer: Radio Frequency (RF) Cathode (left) and Hollow Cathode (right).





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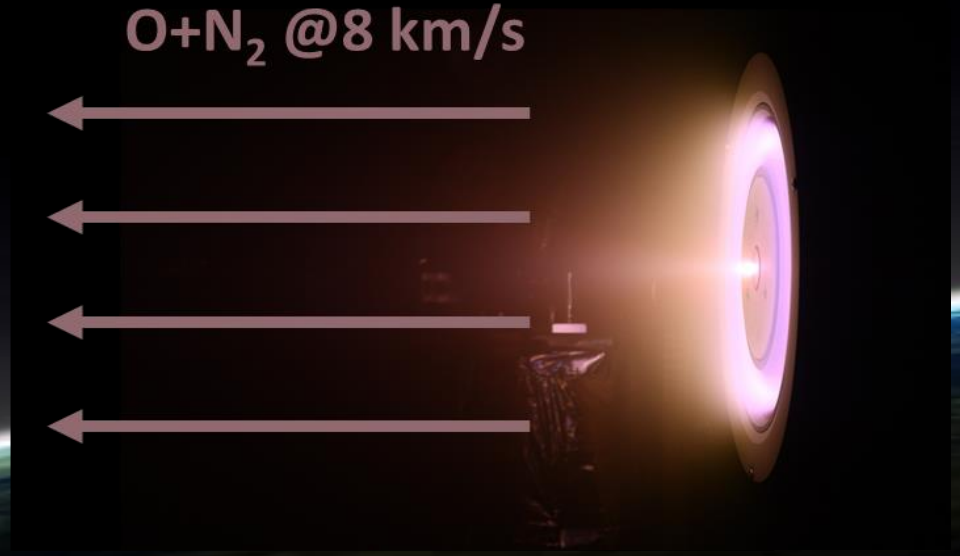
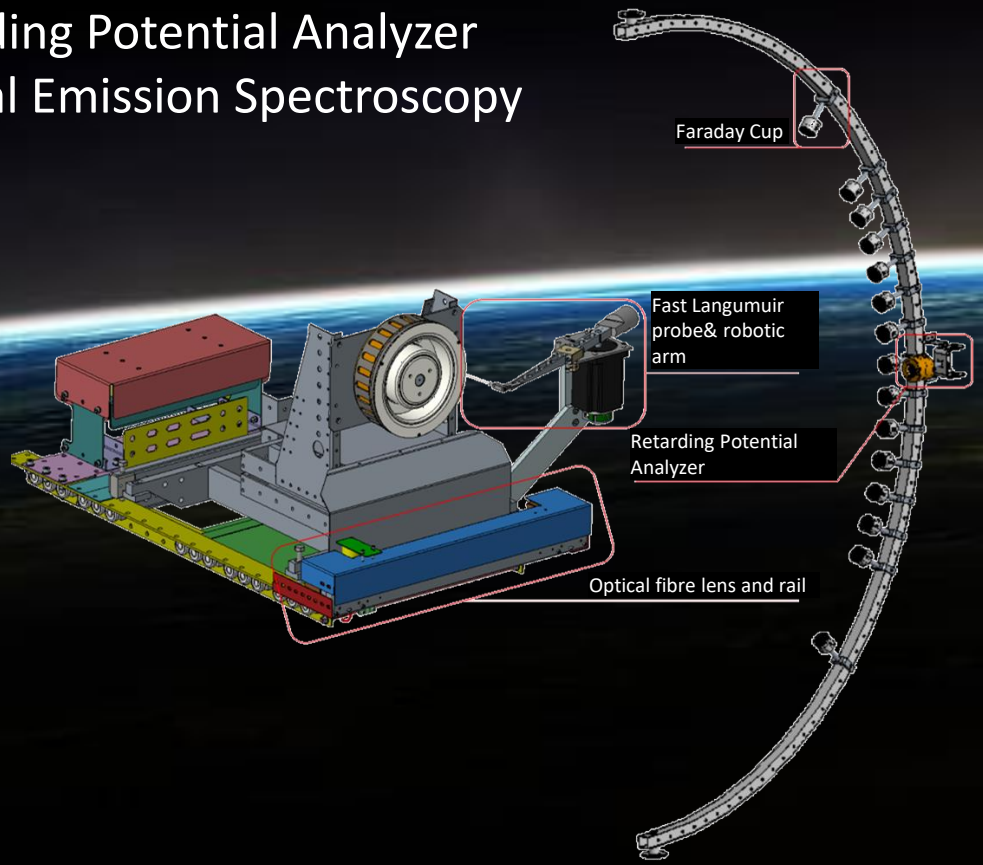
On-ground testing

A **Particle Flow Generator (PFG)** is needed to recreate a flow of ~50% O and 50% N_2 with an average velocity of the same order of magnitude of the orbiting velocity in VLEO (~8 km/s).



Advanced Diagnostics System for PFG

- Thrust Balance
- Faraday probes
- Fast triple Langmuir probe
- Retarding Potential Analyzer
- Optical Emission Spectroscopy



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