Human Spaceflight Technology
TUM School of Engineering and Design
Technische Universität München

MVIPER – The Magnetohydrodynamic Vortex-Inducing Photobioreactor Experiment

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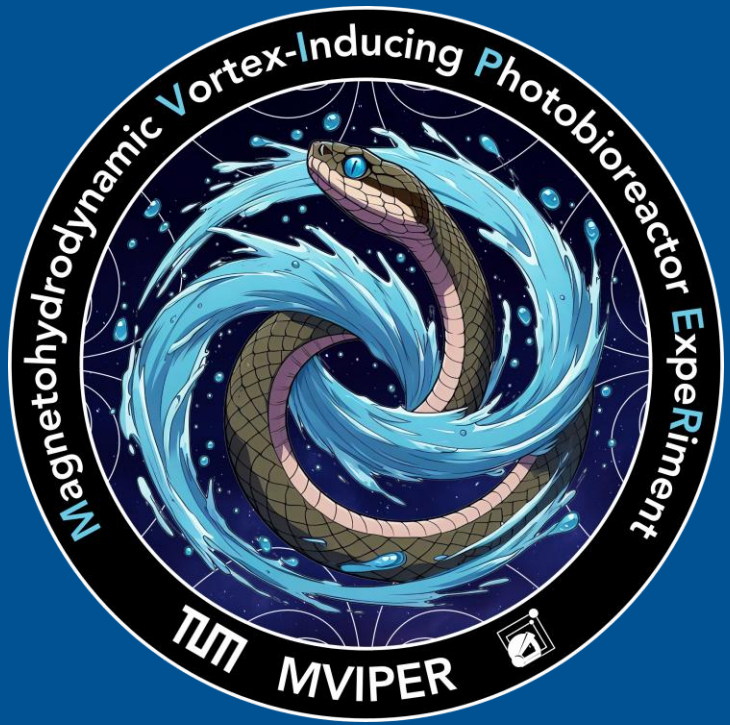
Professorship of Human Spaceflight Technology

Who We Are


Magnetohydrodynamic Vortex-Inducing Photobioreactor ExpeRiment
MVIPER

Core Team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Advisor


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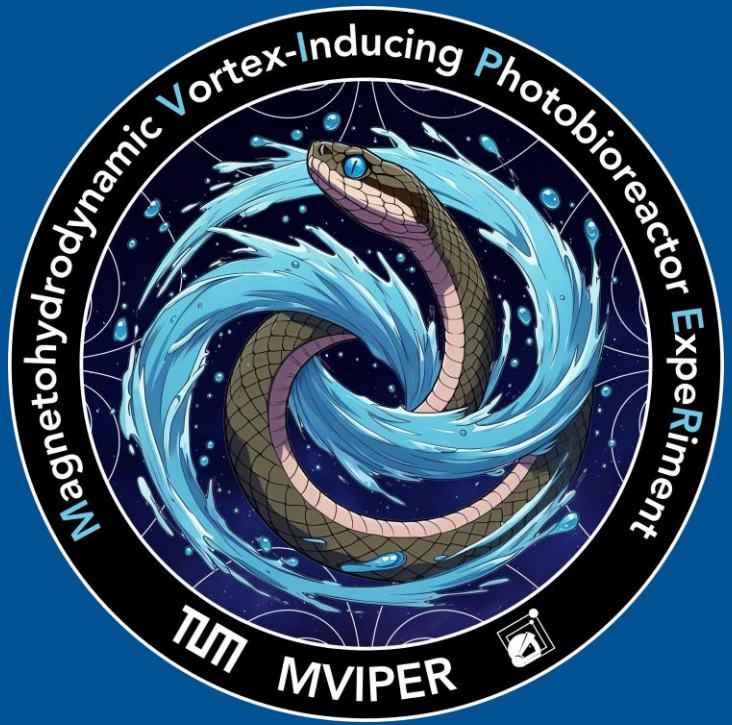
Concept Introduction



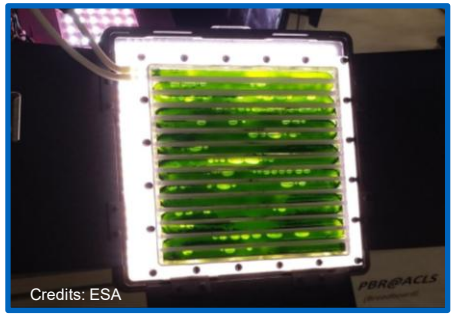
Context and Background – Photobioreactors

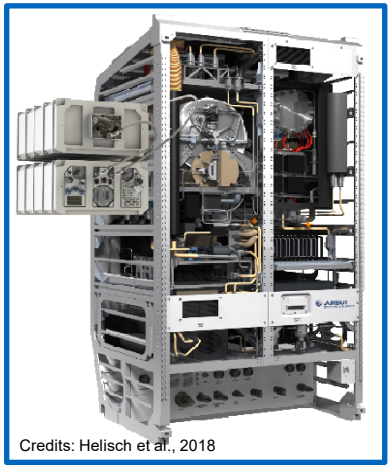
Photobioreactor Technology for Biological Life Support Systems

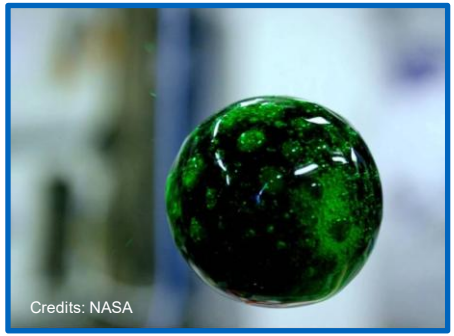
→ Challenges in current designs:
- Liquid pumping
- Liquid-Gas Phase separation

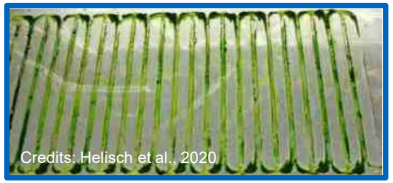
But: Membranes and pumps require frequent repair or exchange

Proposed solution: …





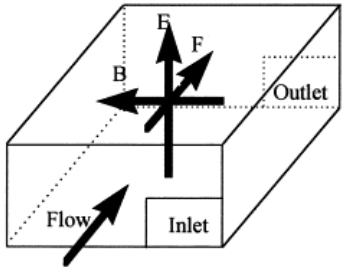




Magnetohydrodynamic Vortex PBR concept

Liquid Movement through Lorentz Force

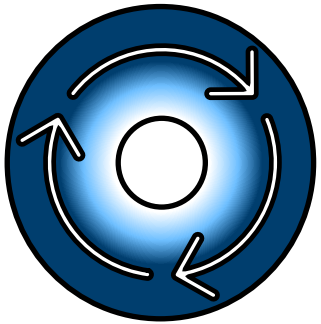
- Electrically conductive solution
- Magnetic field **B**, orthogonal electric field **E**
- → Lorentz force **F**
- Well-studied and applied mechanism



Credits: Patrick Boissonneau

Phase separation through Centrifugal Buoyancy

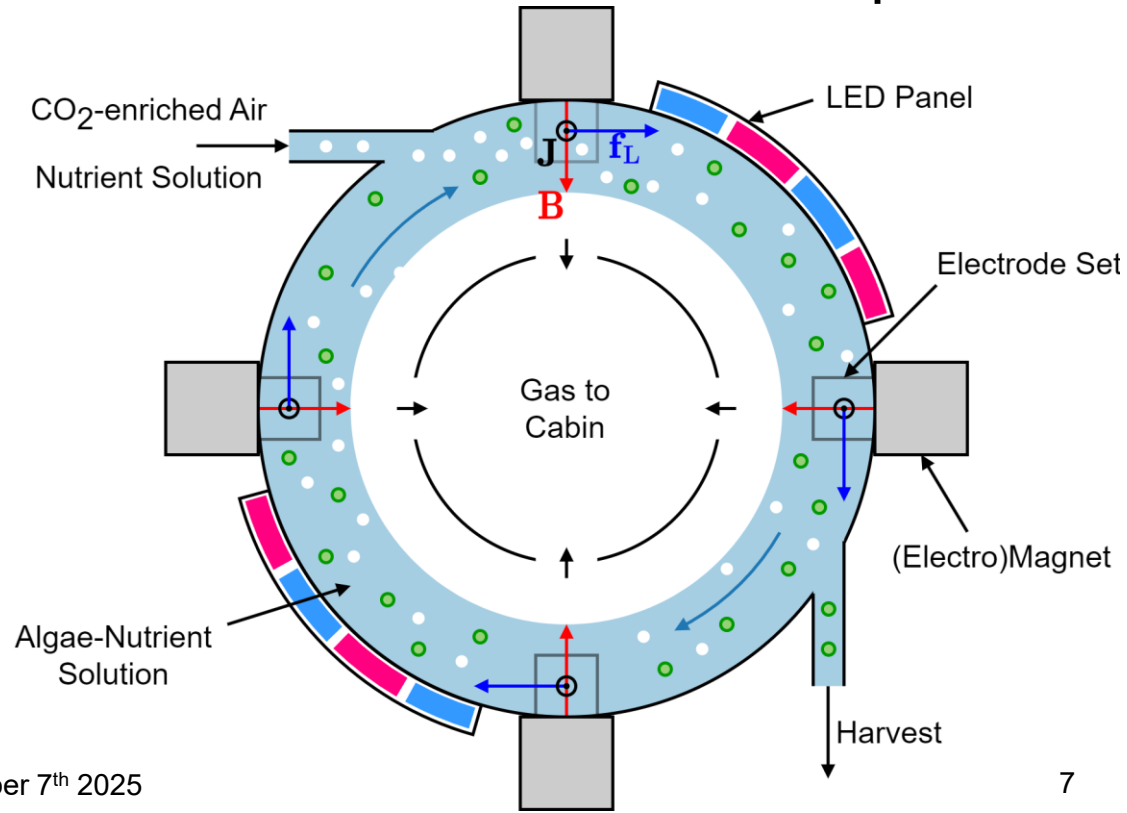
- Ring shape of the algae chamber to induce centrifugal force on the liquid



Magnetohydrodynamic Vortex Photobioreactor Concept

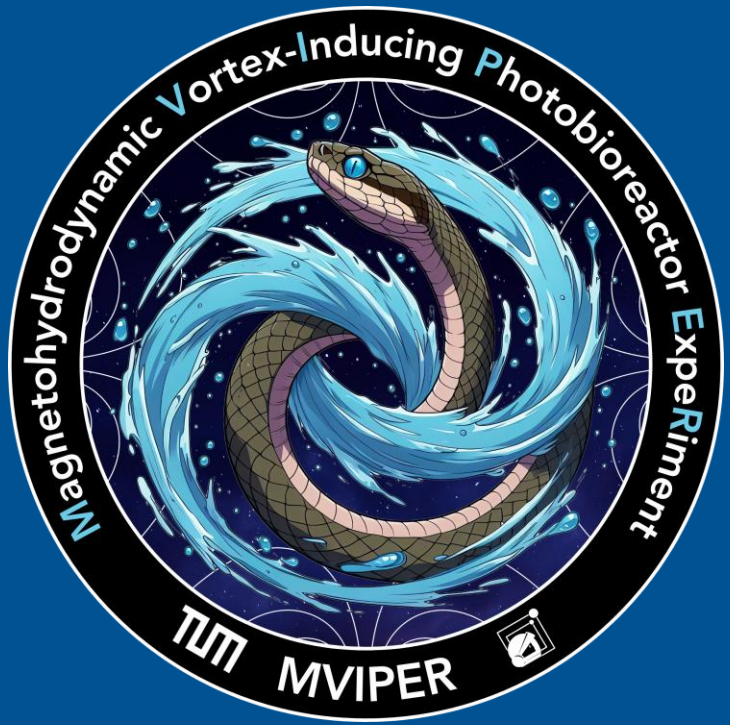
Features

- 4 MHD pump units
- Inlet for fresh electrolyte & CO_2-enriched air
- Outlet for harvest
- LEDs around the perimeter for illumination



Is this feasible?

MVIPER Experiment Design



Objectives

Scientific Objectives

1. **Demonstrate acceleration** of nutrient solution in a microgravity environment utilizing MHD drive technology

2. **Demonstrate phase separation** in a microgravity environment utilizing MHD drive technology

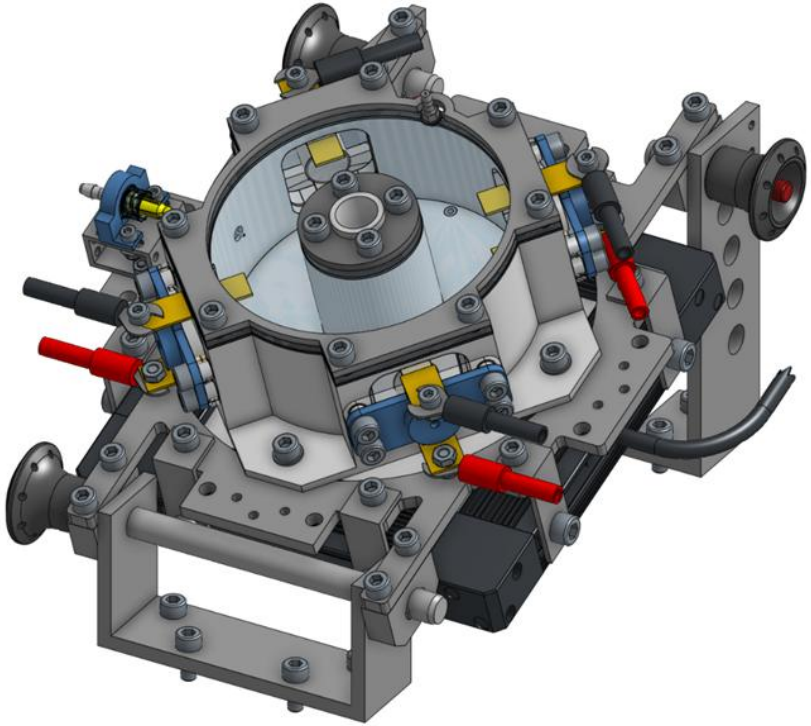
3. **Investigate** design characteristics and **validate models** for future system modeling and **sizing**

Educational Objectives

1. **Learn** and experience the planning, development, and operation of experiments in microgravity science

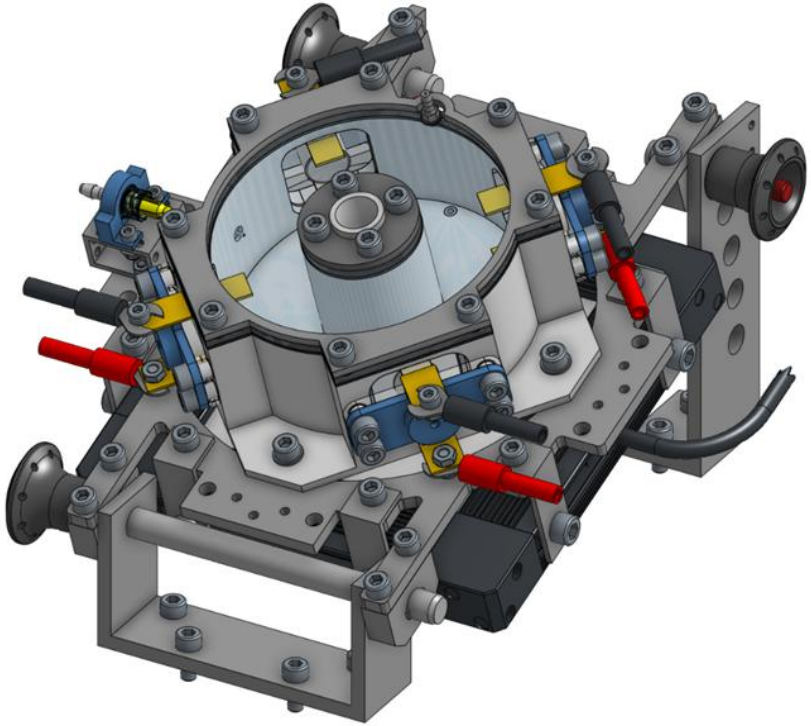
2. **Pass** the gained **knowledge** and experience to current and future students of the Technical University of Munich and beyond

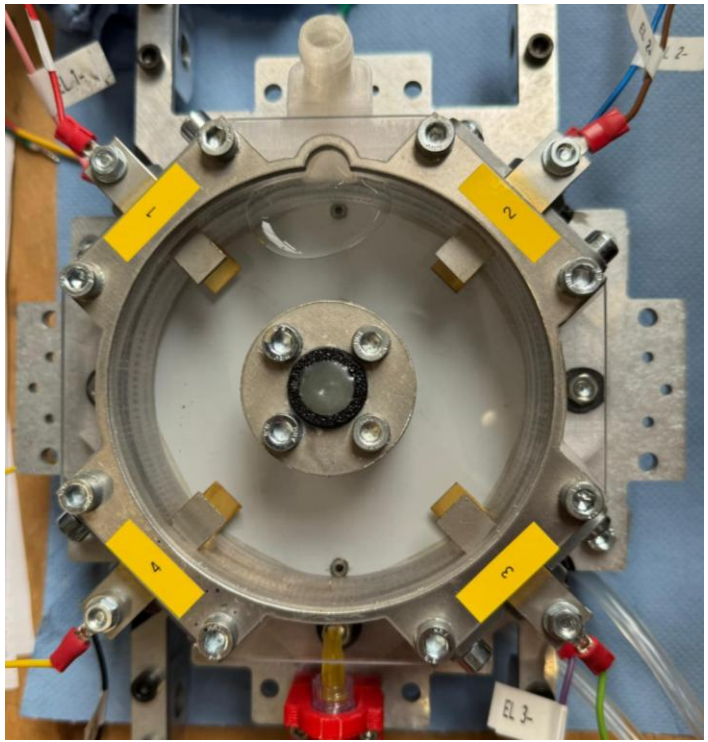
The Vortex Generation Chamber



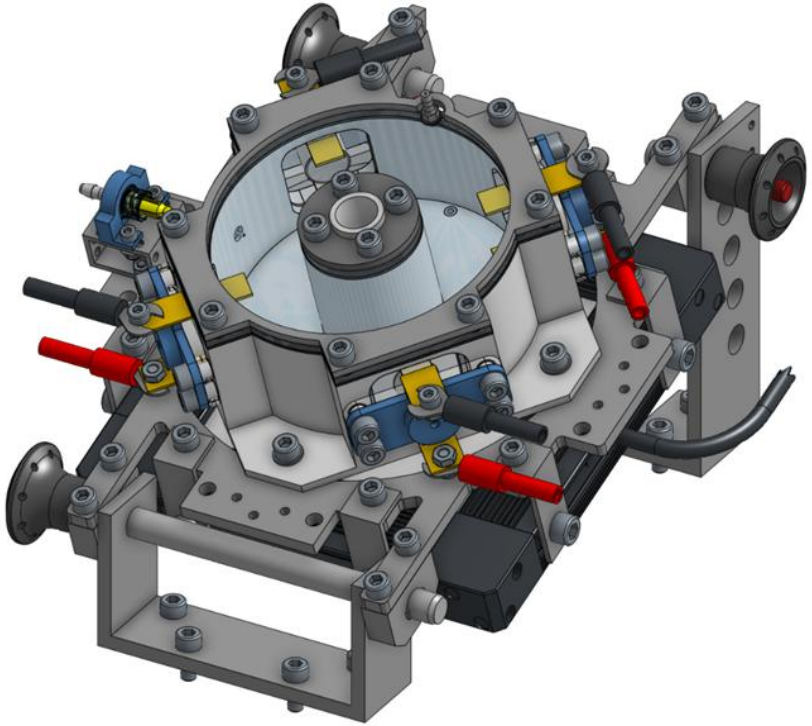
- Electrolyte (similar to algae nutrient solution)
- 4 MHD Pump Modules
- Inclined to facilitate gas venting
- Clear polycarbonate top plate & Back lighting

The Vortex Generation Chamber





The Vortex Generation Chamber



Field Generation:

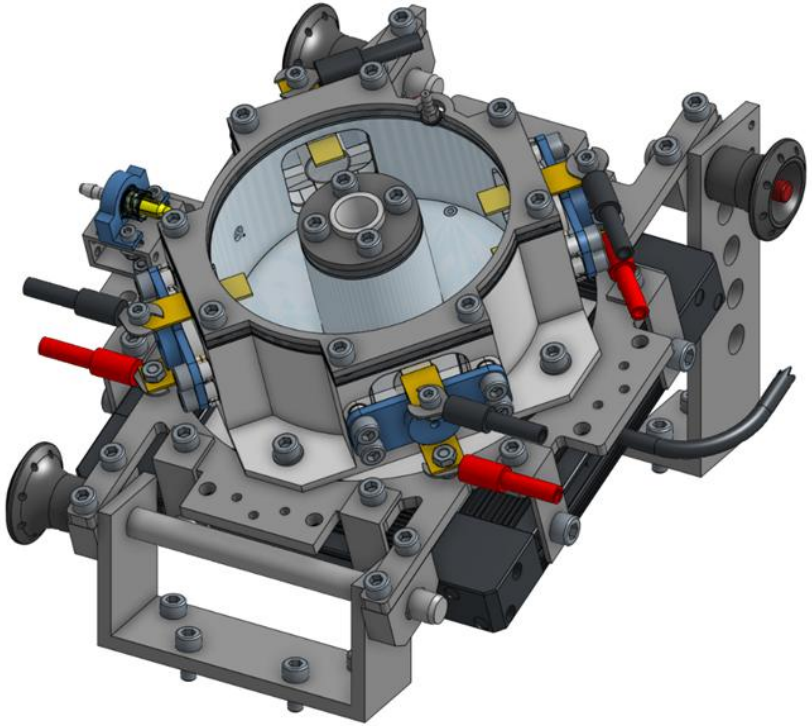
- Under **Direct Current**, electrolysis occurs

→ Simple and doable within the timeline

- Integration of **Alternating Current** system using H-bridges

→ Limited electrolysis, but complex electronics

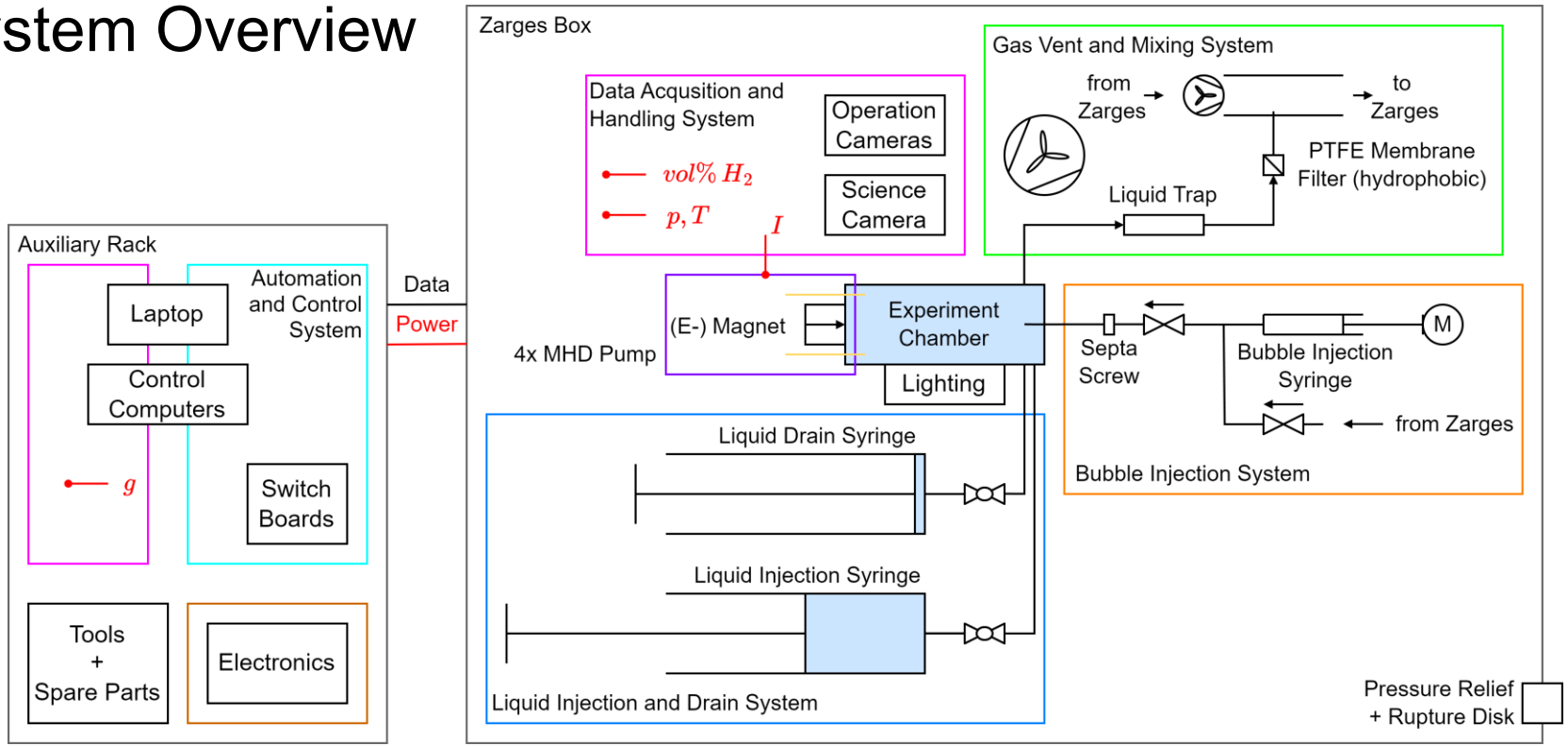
The Vortex Generation Chamber



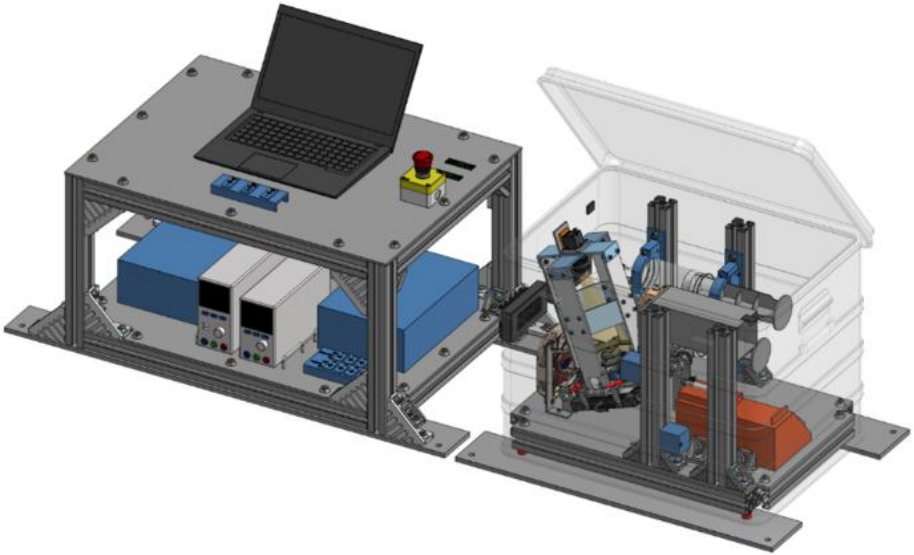
Flow Visualization:

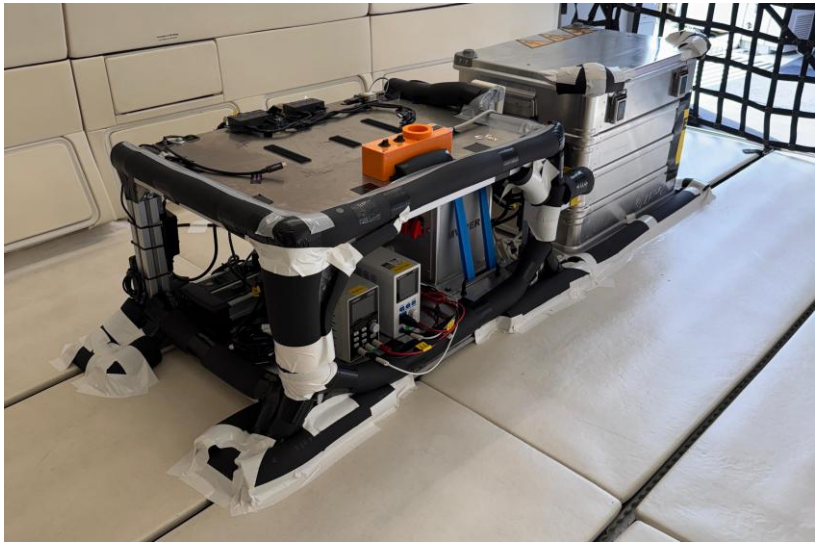
- Particle tracking
- Ink injection
- Bubble injection

System Overview



Flight Assembly





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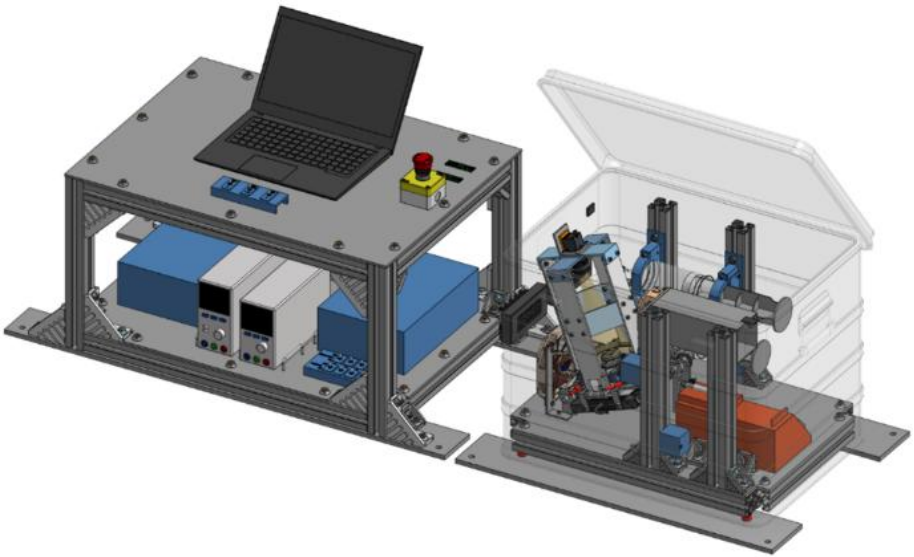
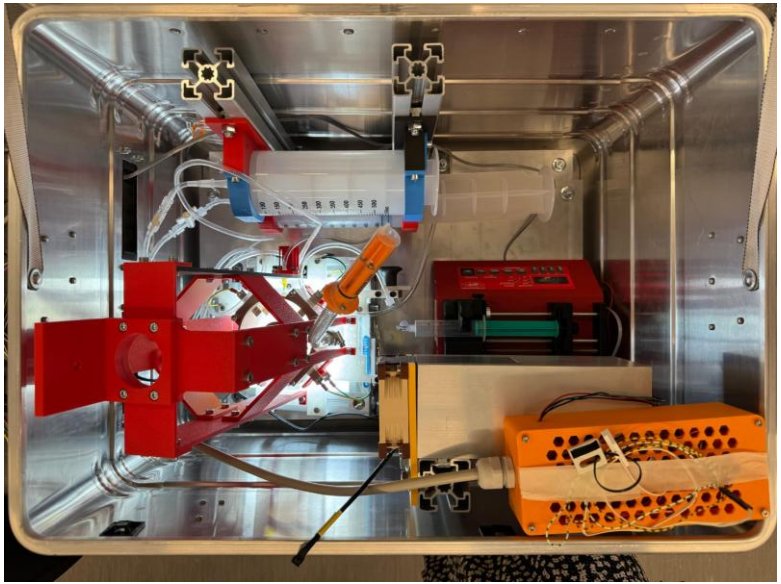
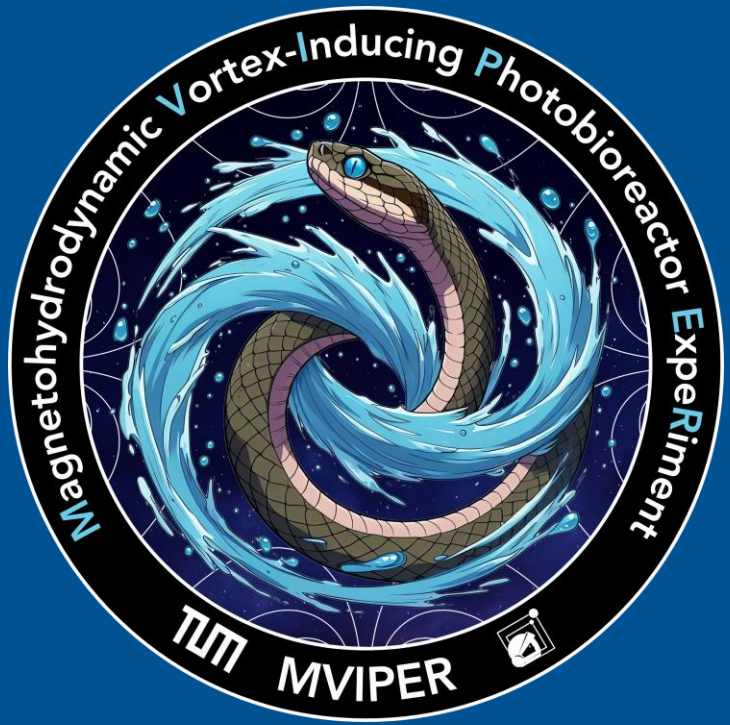




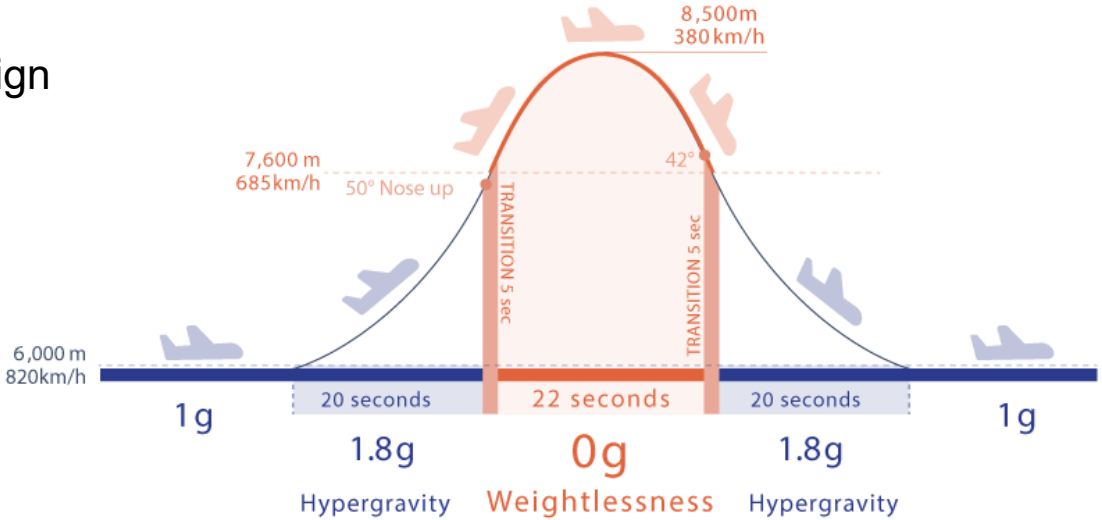
Test Campaign



ESA Academy Experiments Programme

Parabolic Flight

- 87th ESA Parabolic Flight Campaign
- 3 Flights with 30 parabolas each
- 22s of microgravity
- Stable vortex after ~10s



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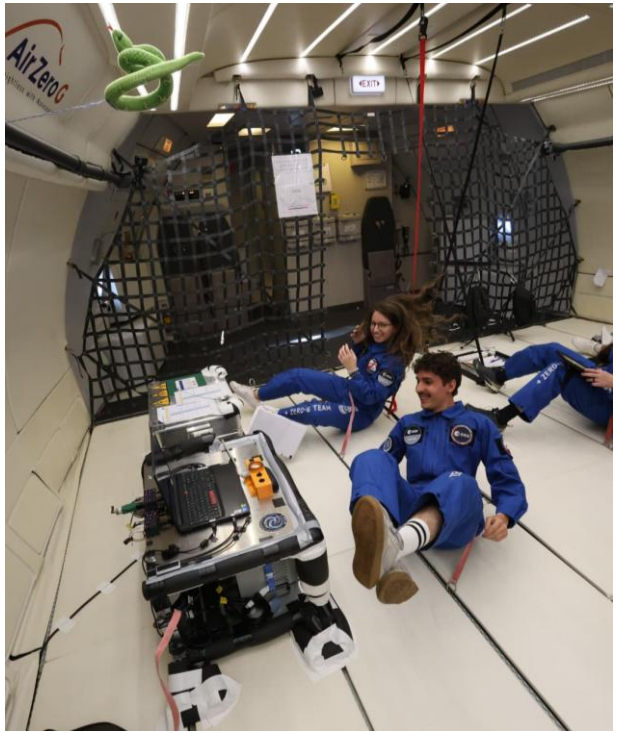
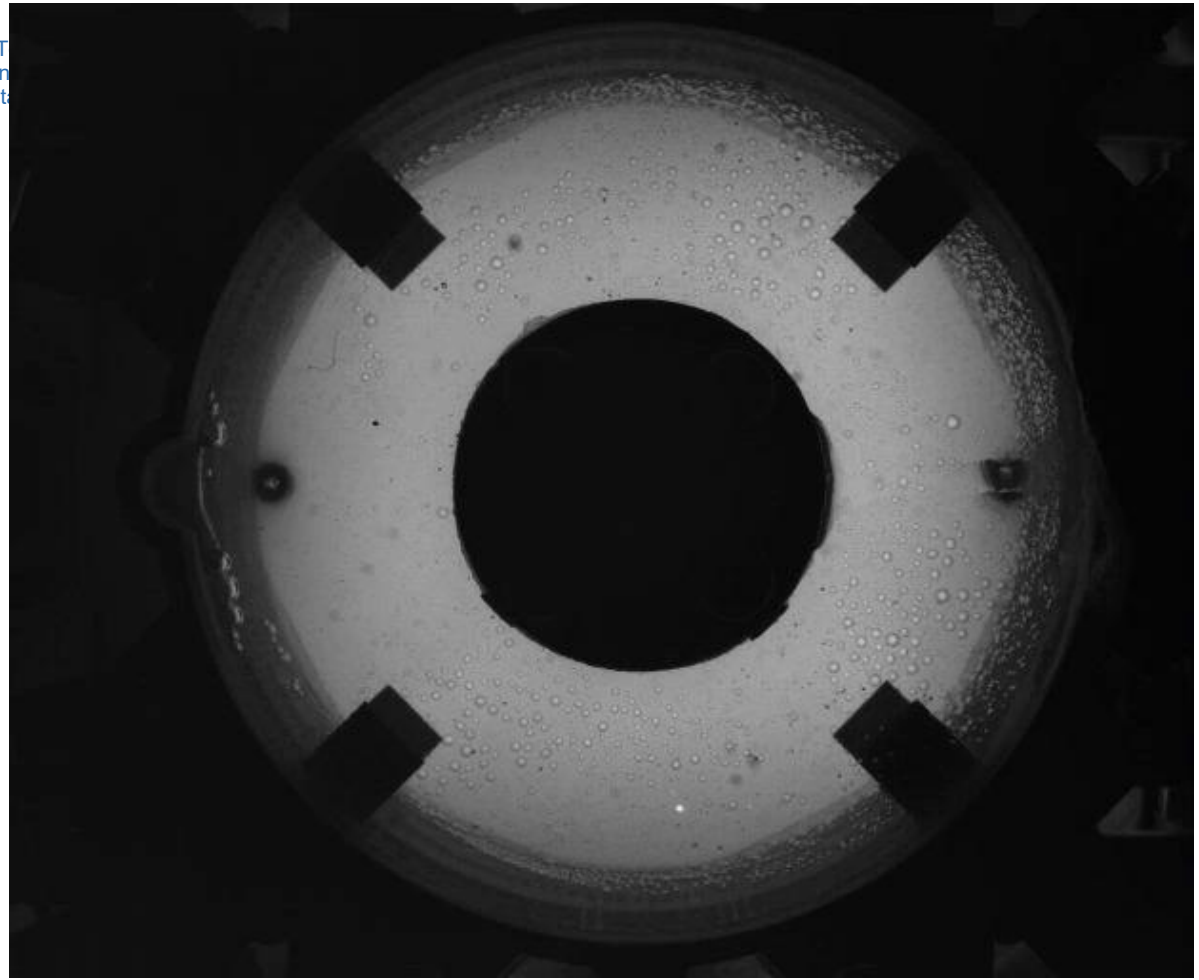
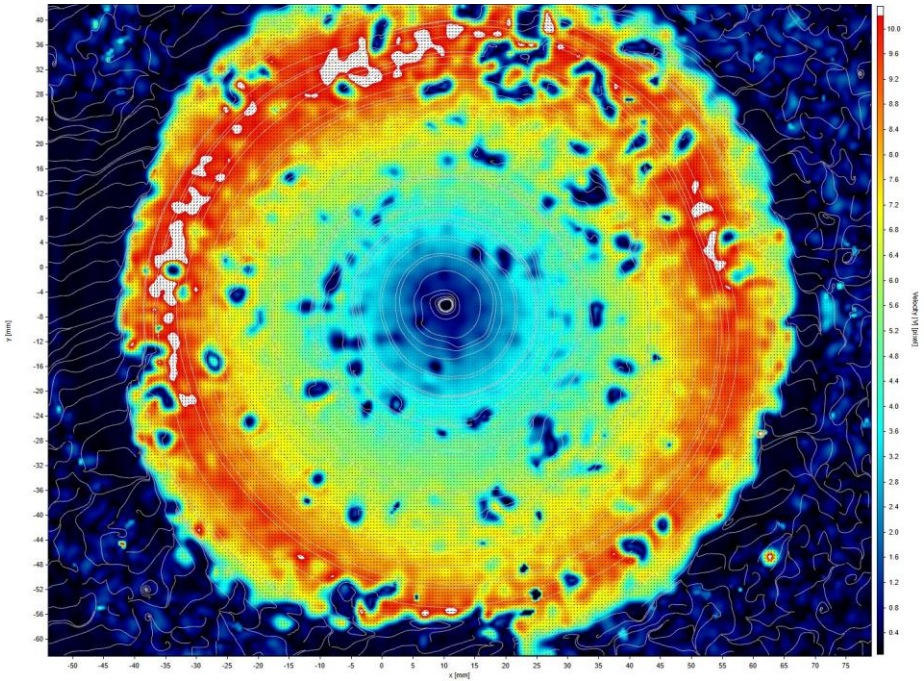
Flight Campaign - Some pictures





Next Steps and future

- Analysis of flight data and results & comparison of the behavior of flow vs. predicted behavior
- Improvements and redesign of chamber/setup
- Follow-up experiments investigating improved/different design



Preliminary flow field profile based on particle velocity

Outreach Activities

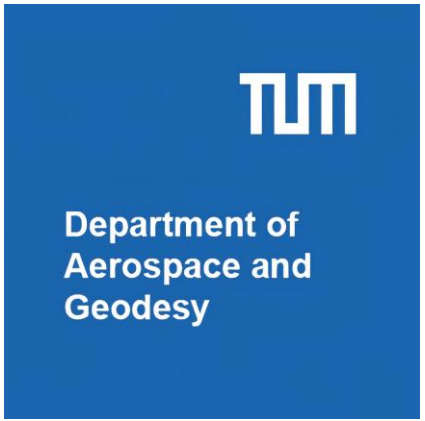
+ Participation in SpaceDay 2025@TUM

+ MVIPER DIY kit Initiative for students

+ Conference and Journal papers/presentations

+ Collaborations with industry partners & other student groups

Acknowledgements



With material and technical support from:

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