



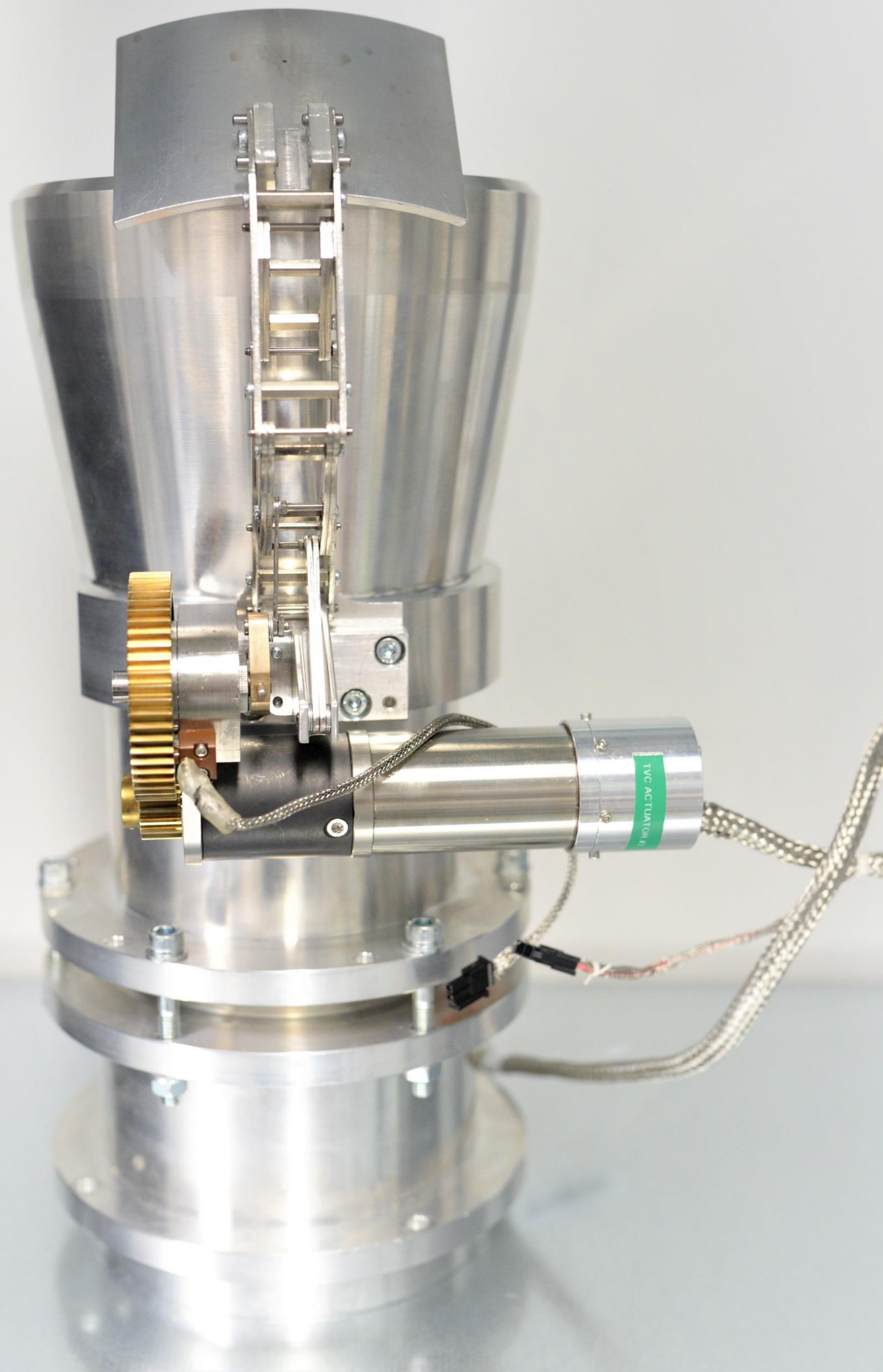
Thrust Vector Control for Controlled Deorbitation – development and testing

Clean Space Industry Days,
ESA-ESTEC, 16-20 October 2023

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AGENDA

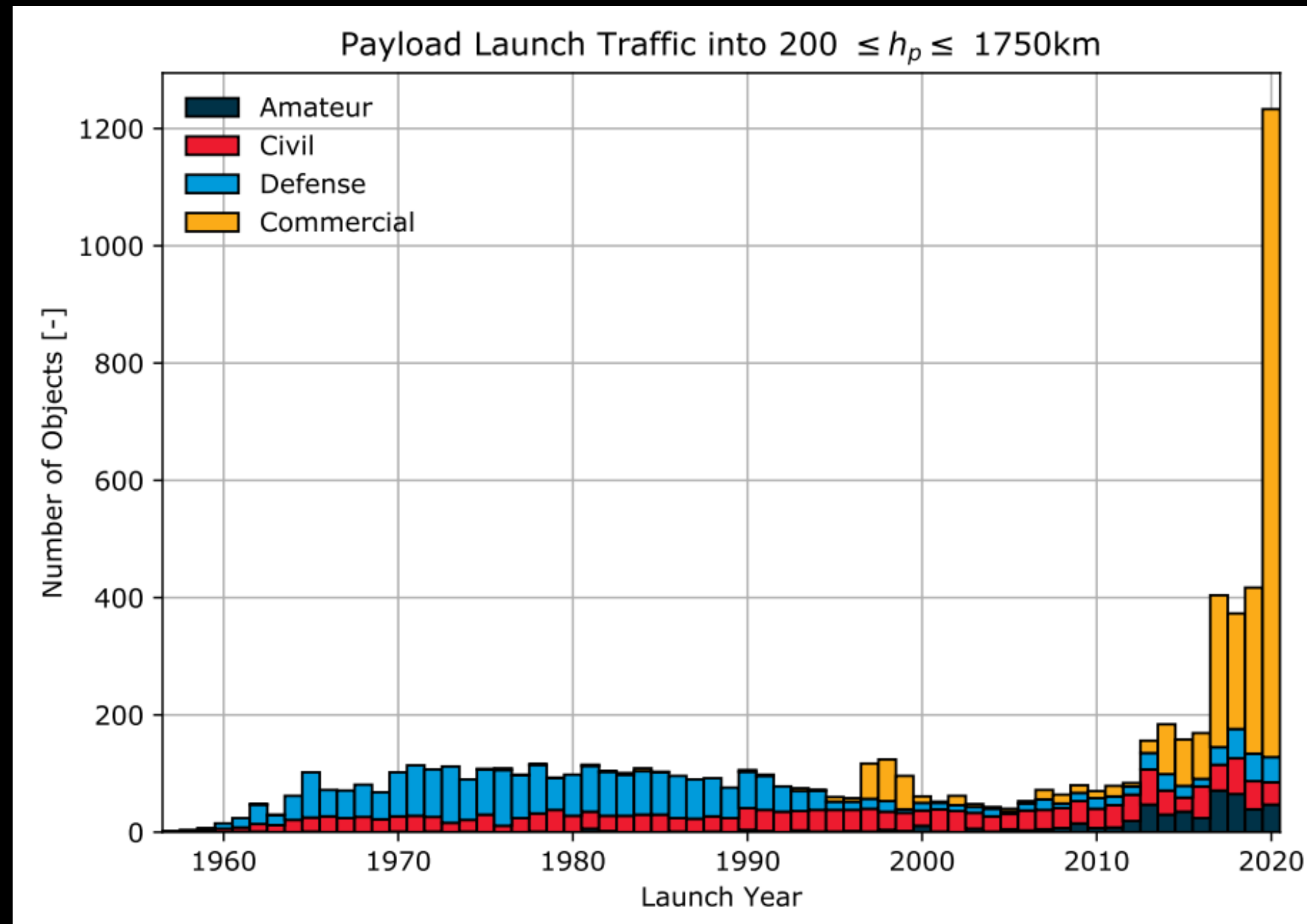
- **INTRODUCTION**
- **MOTIVATION BEHIND WORK**
- **SRM PROJECT:**
 - **PROPELLENT SPECIFICATION**
 - **ABLATION TESTS**
- **TVC PROJECT:**
 - **MECHANISM AND CFD SIMULATIONS**
 - **COLD-GAS TEST STAND**
 - **COMPARISION: CFD VS SCHLIEREN**
- **SUMMARY**

SPACE TECHNOLOGIES IN ŁUKASIEWICZ RESEARCH NETWORK – INSTITUTE OF AVIATION

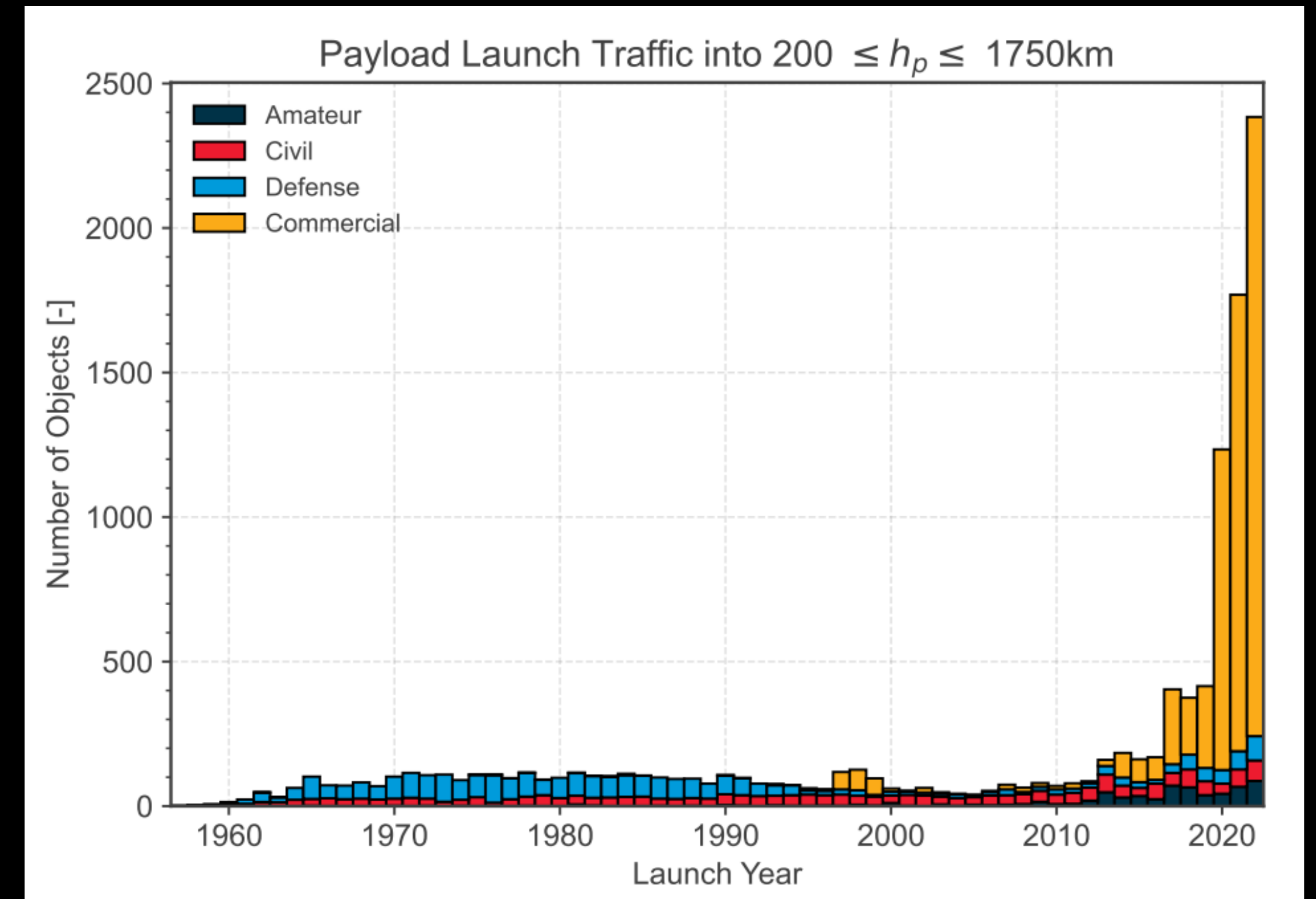
- DEVELOPMENT OF SATELLITE AND ROCKET SYSTEMS, INCLUDING PROPULSION
- SUBORBITAL FLIGHTS AND MICROGRAVITY RESEARCH
- IT SOLUTIONS FOR REMOTE SENSING AND SPACE TECHNOLOGIES
- DEVELOPMENT OF ROCKET AVIONICS SYSTEMS
- DEVELOPMENT OF PROPULSIVE DEORBITATION MODULES
- DEVELOPMENT OF CHEMICAL PROPELLANTS
- DEVELOPMENT OF OPTOELECTRONIC AND MECHATRONIC TOOLS



MOTIVATION: SPACE DEBRIS

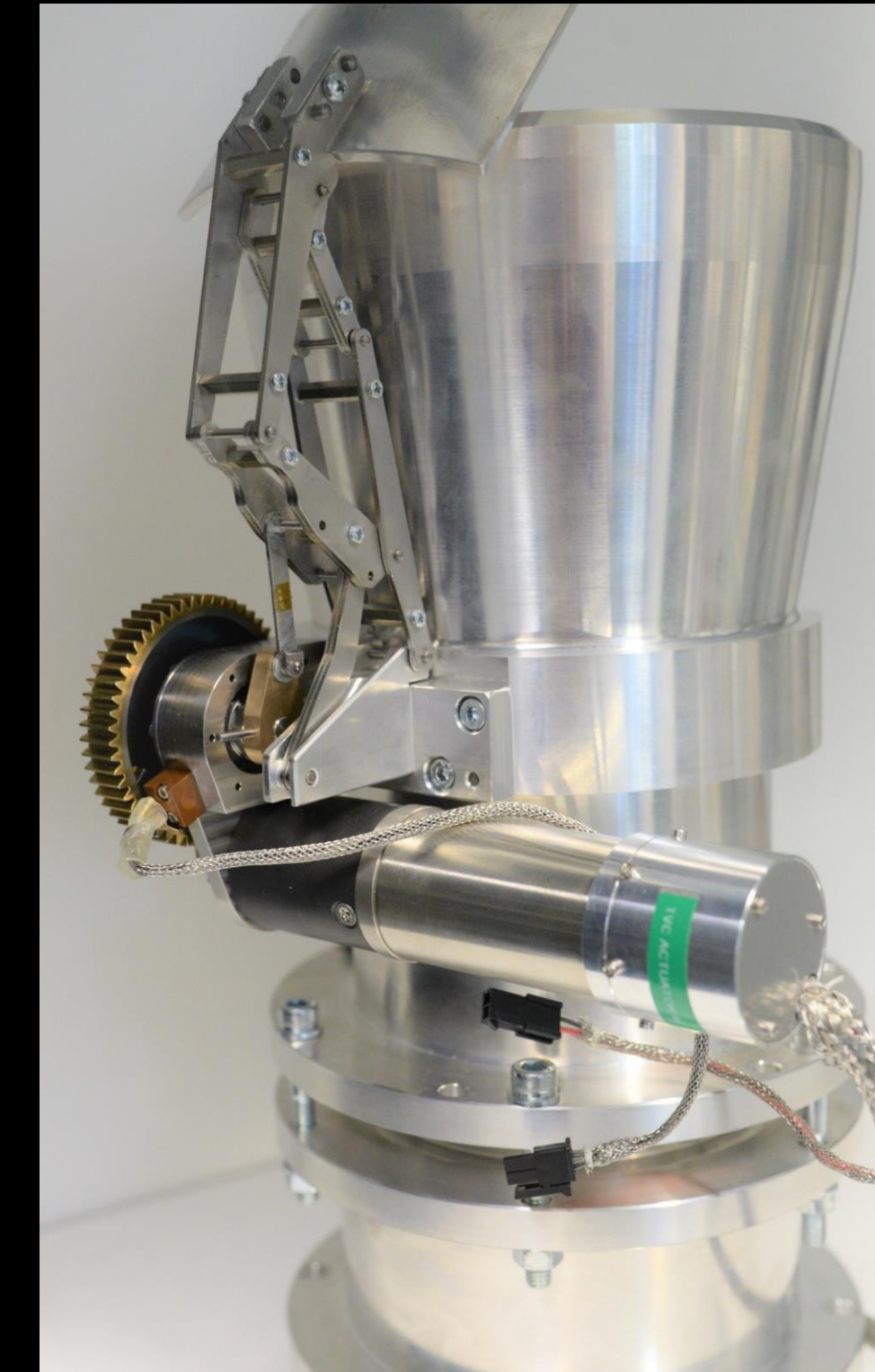
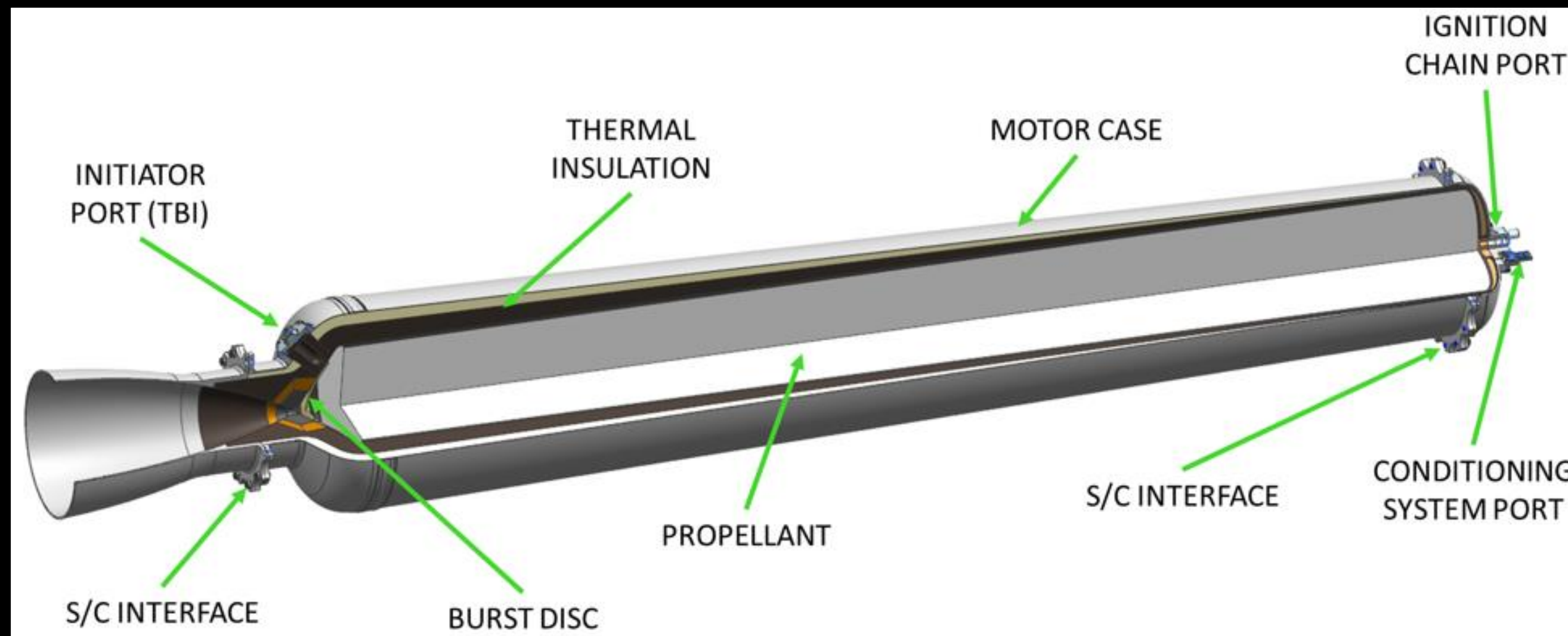


ESA'S ANNUAL SPACE ENVIRONMENT REPORT **2021**

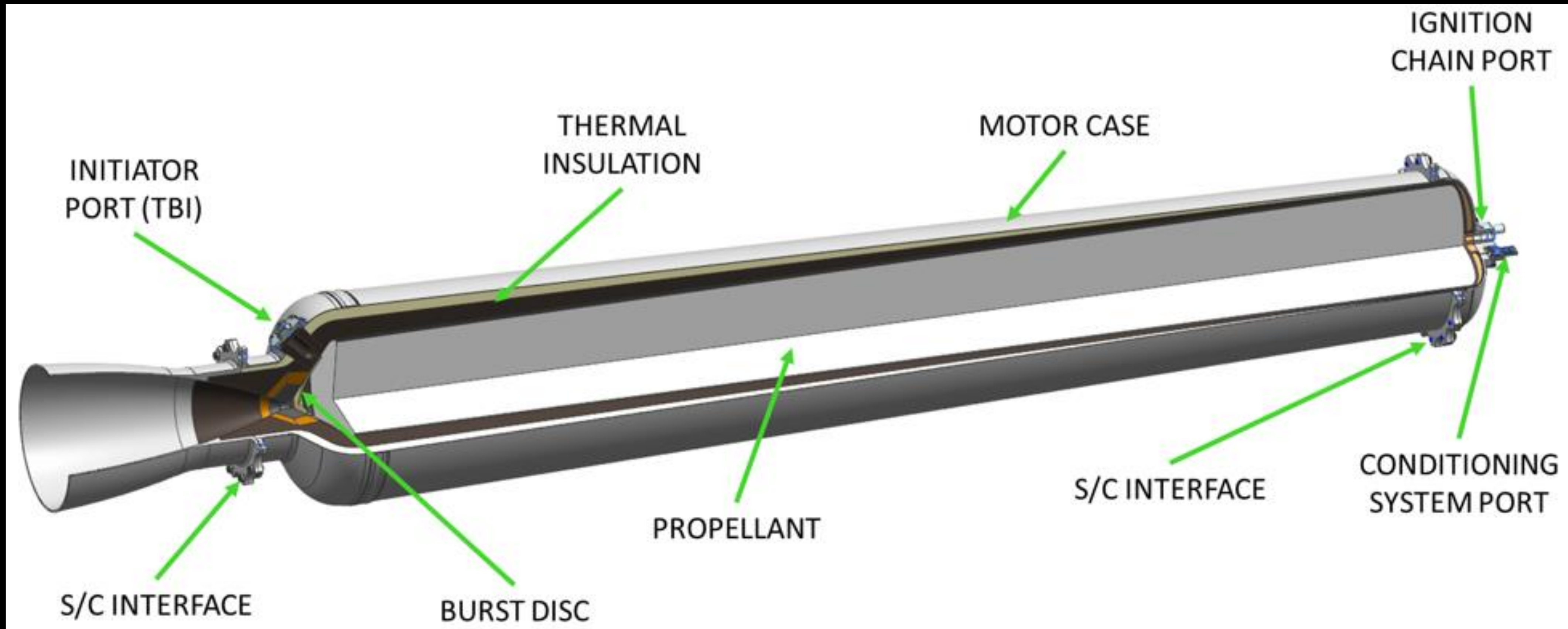


ESA'S ANNUAL SPACE ENVIRONMENT REPORT **2023**

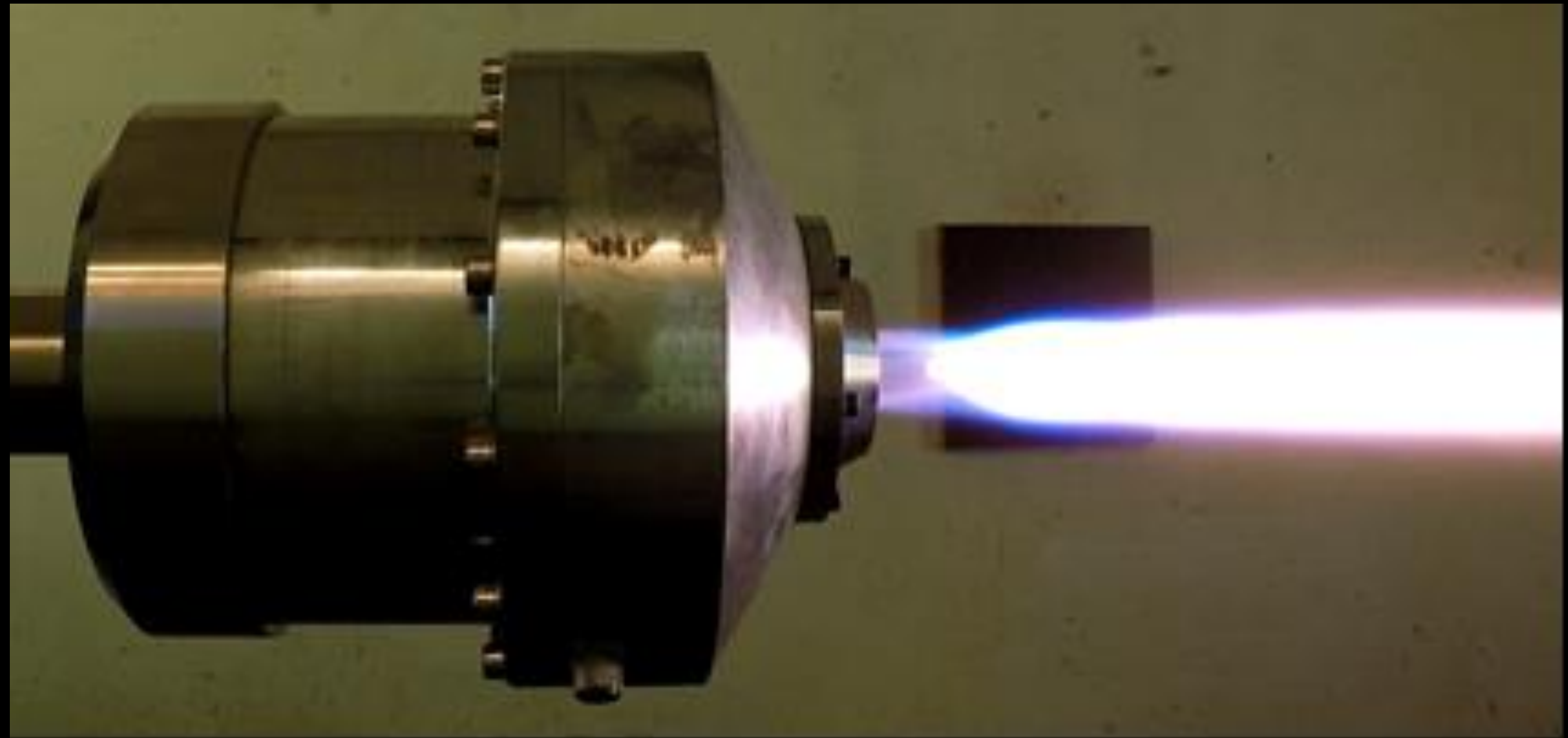
SOLUTION: SOLID PROPELLANT ROCKET MOTOR WITH THRUST DEFLECTION SYSTEM



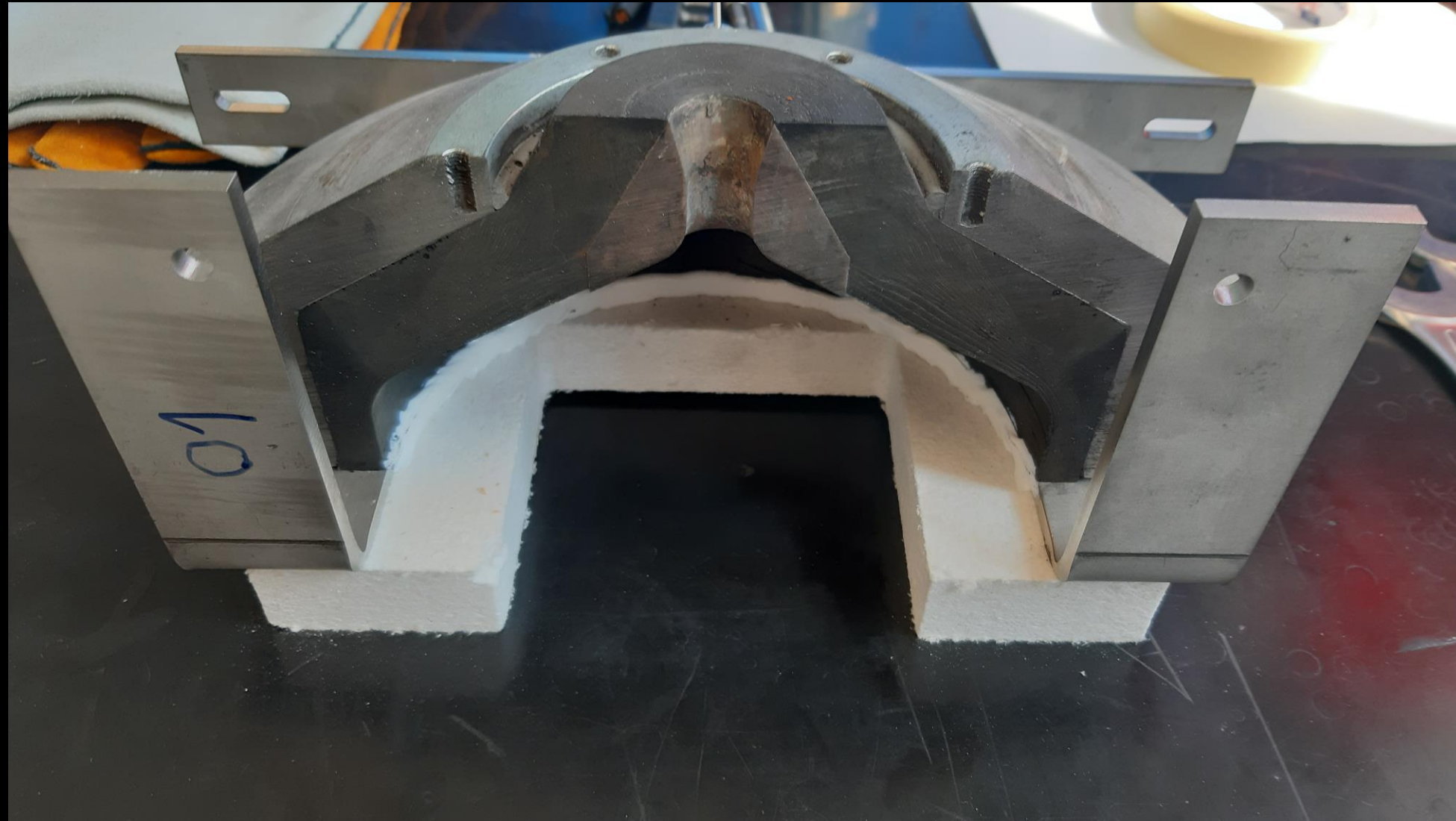
SOLID ROCKET MOTOR



SOLID ROCKET MOTOR: PROPELLANT



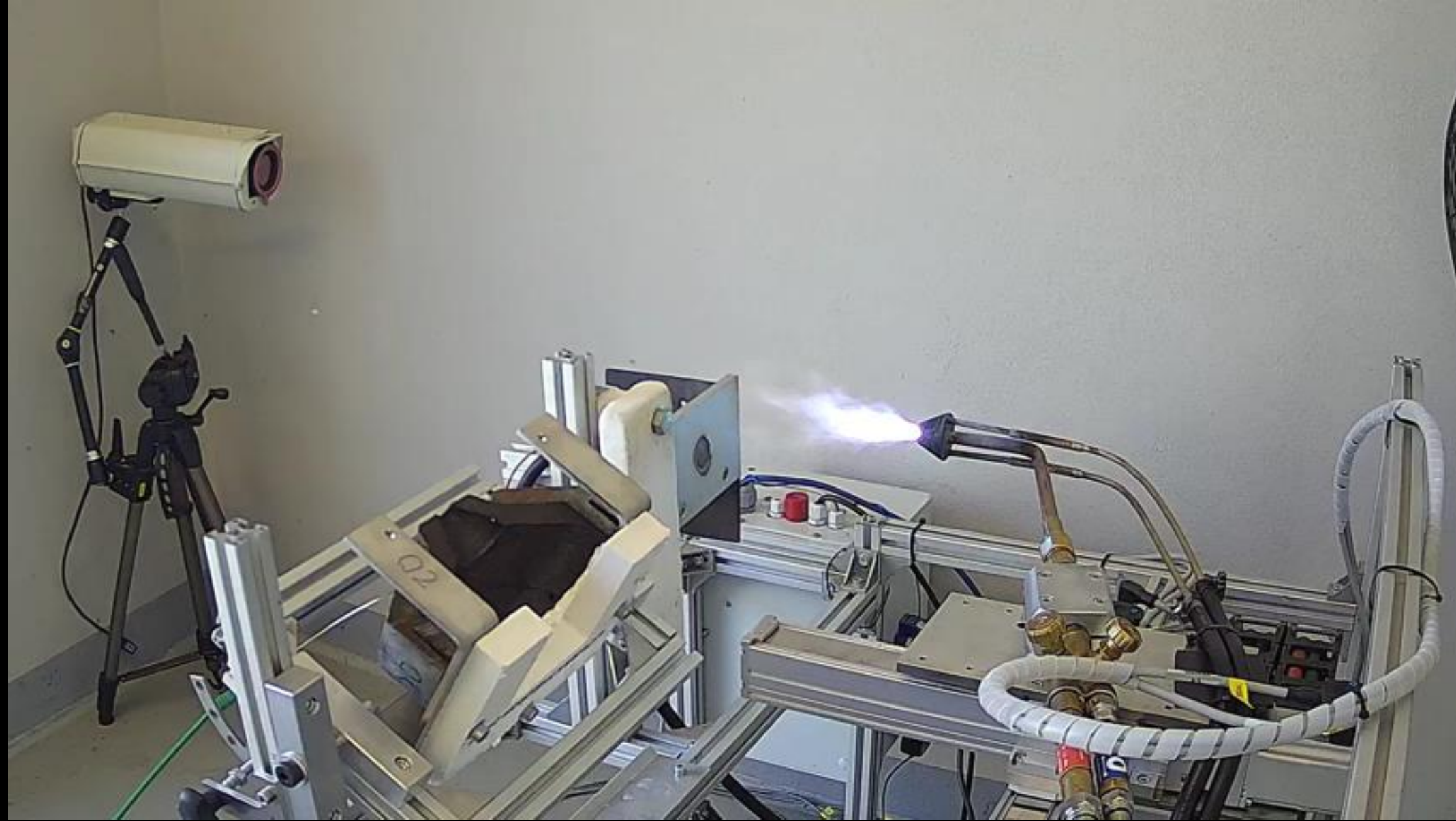
SOLID ROCKET MOTOR: ABLATION TESTS



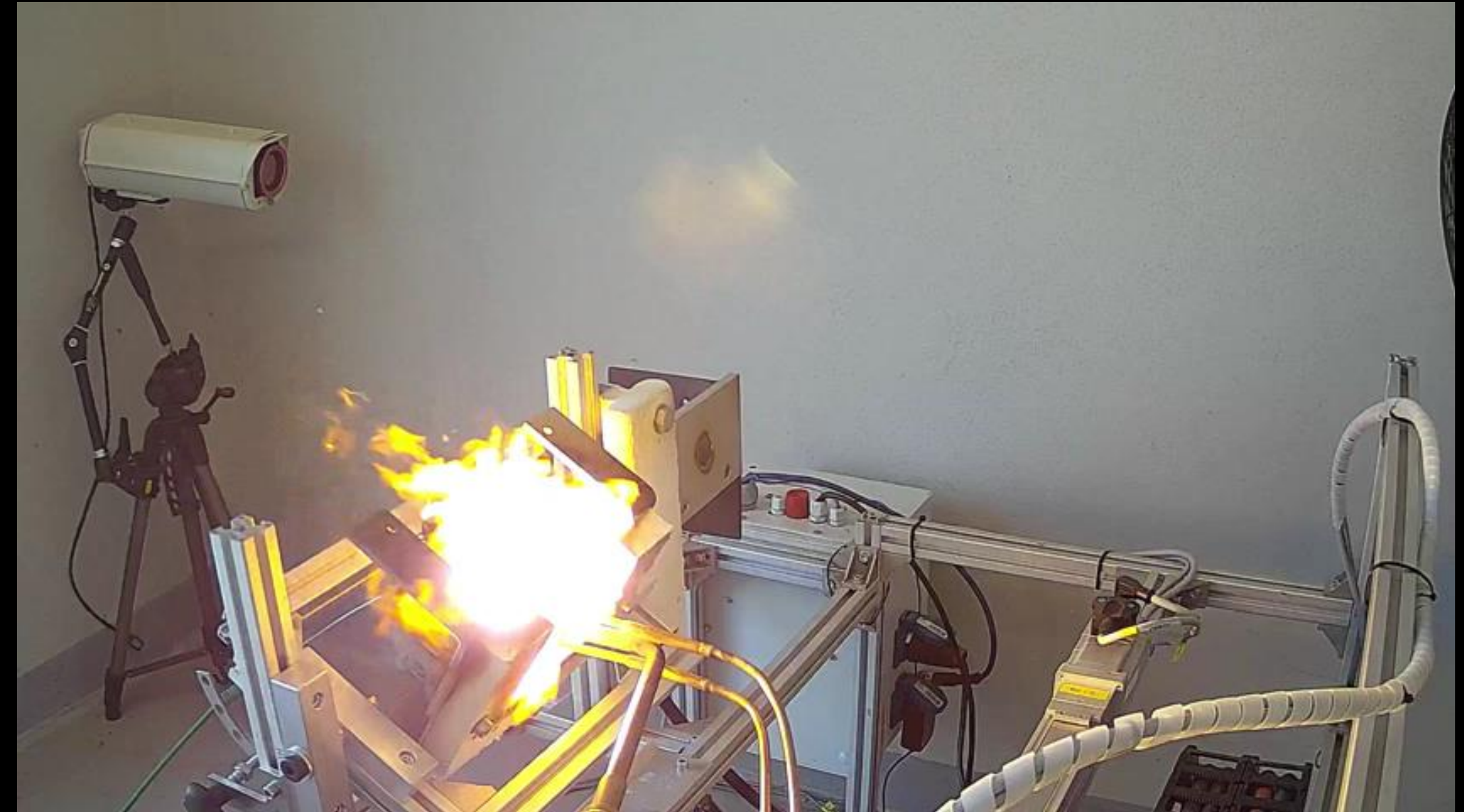
8 MINUTES
LATER



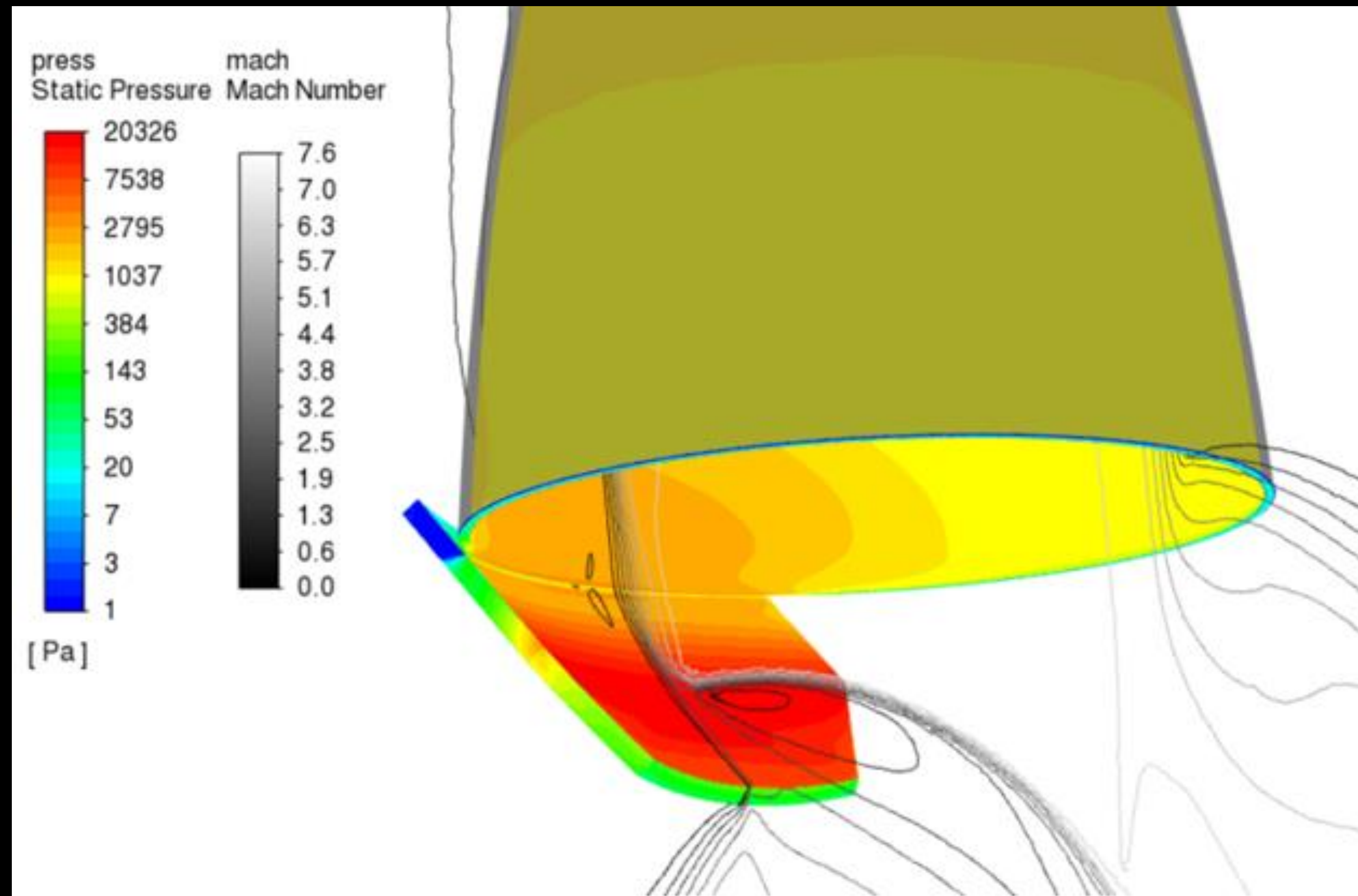
SOLID ROCKET MOTOR: ABLATION TESTS



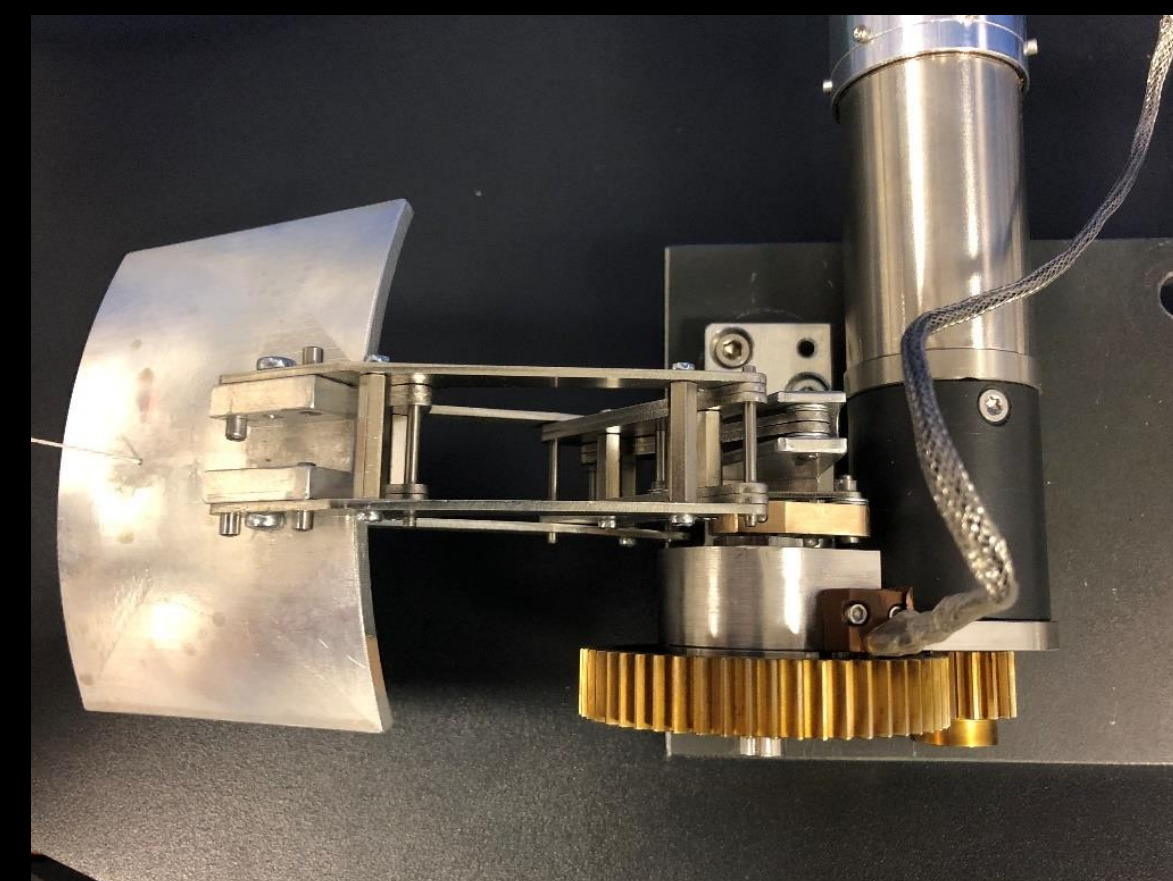
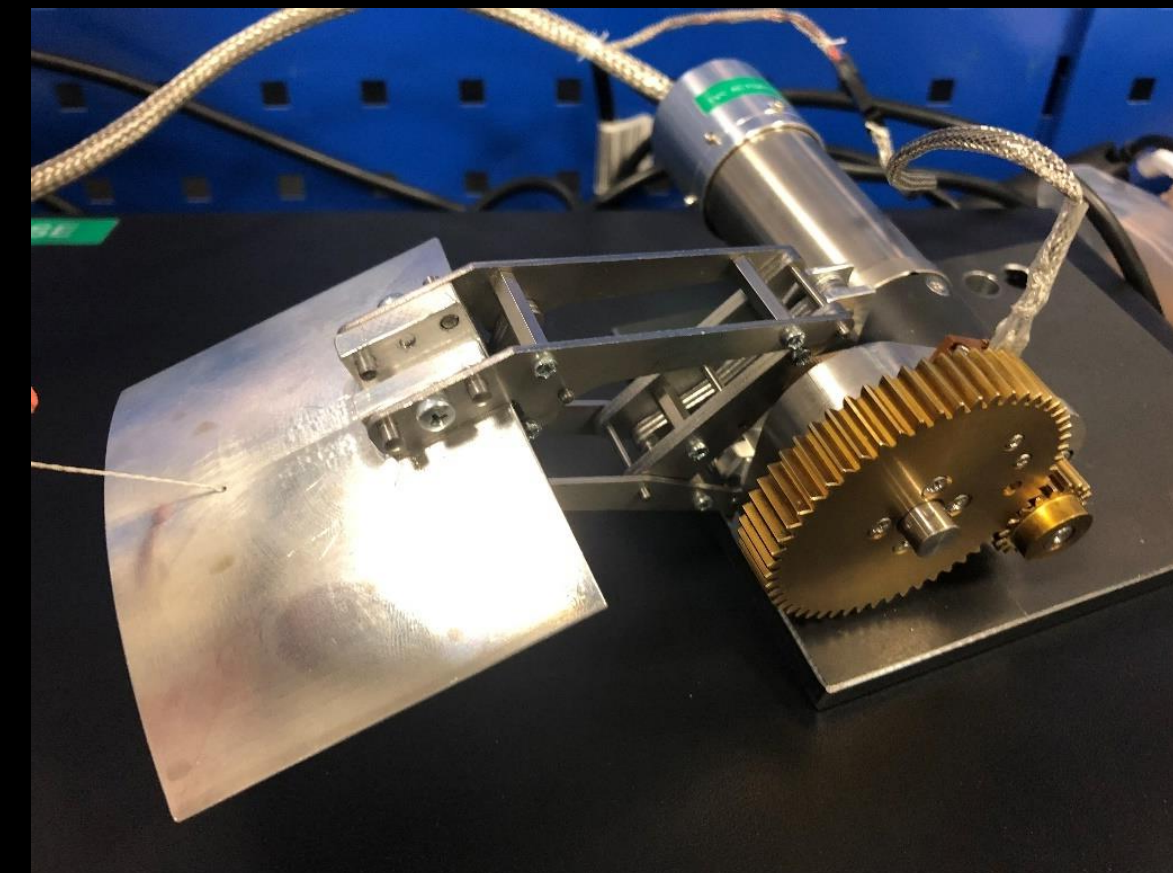
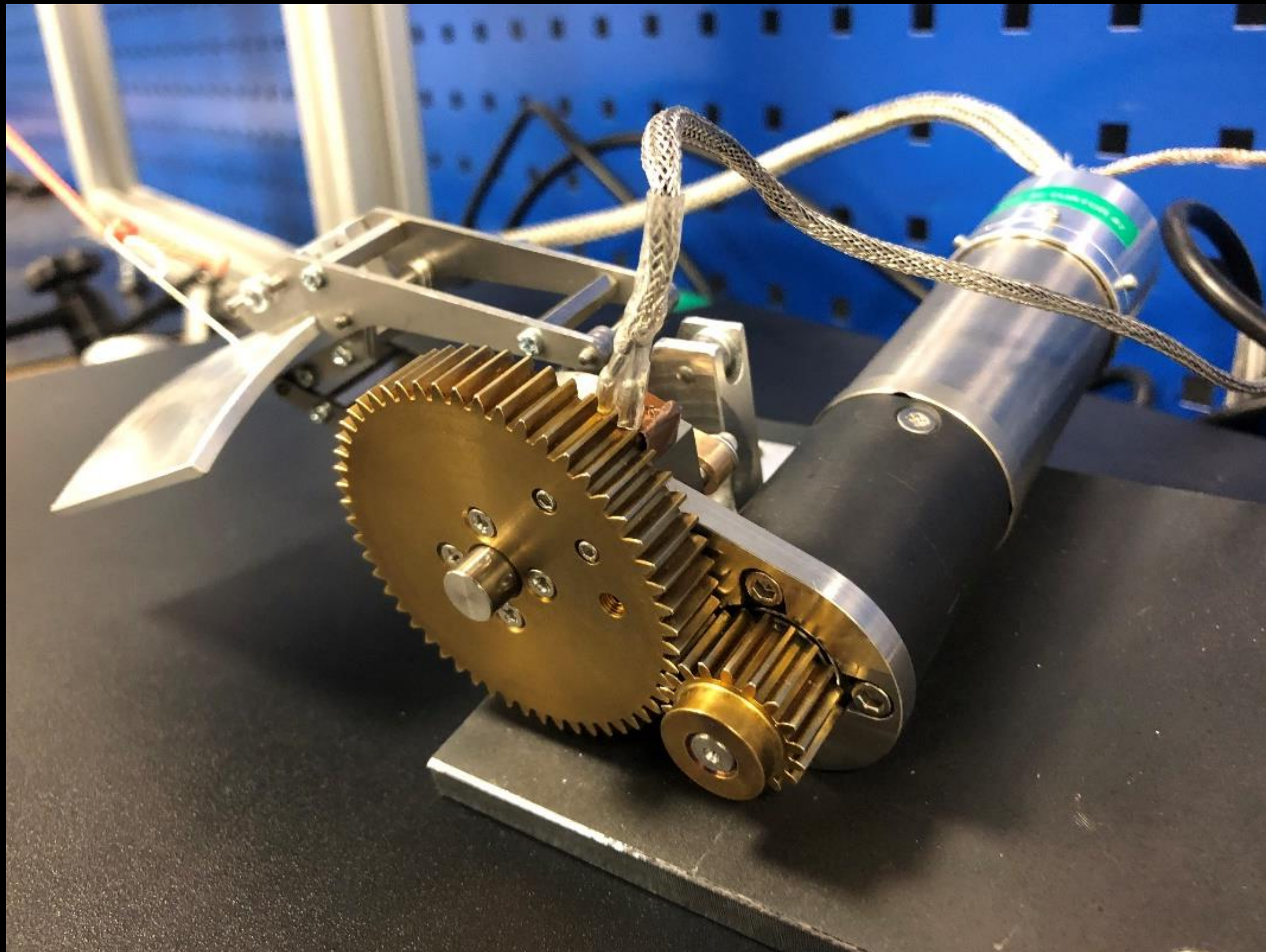
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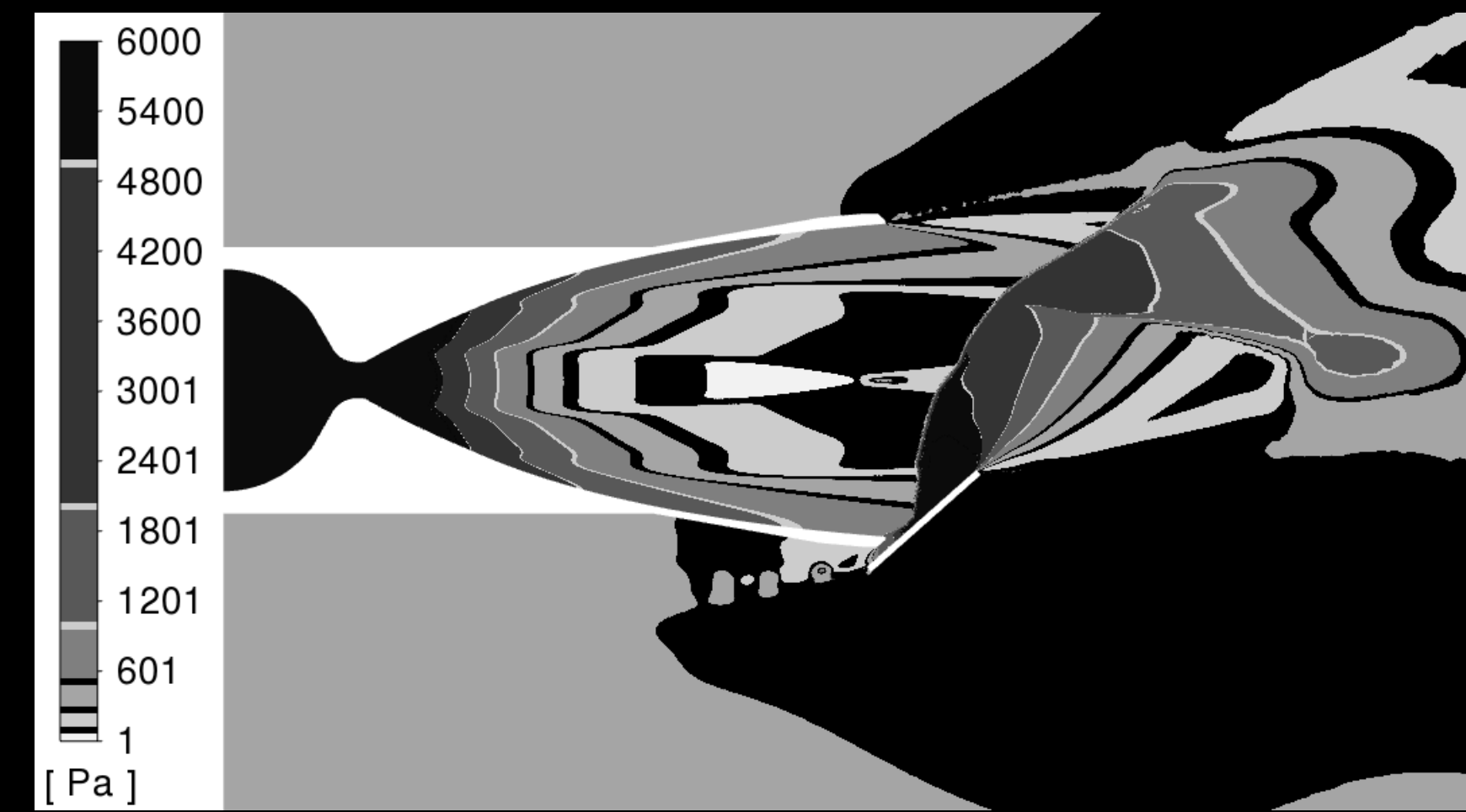
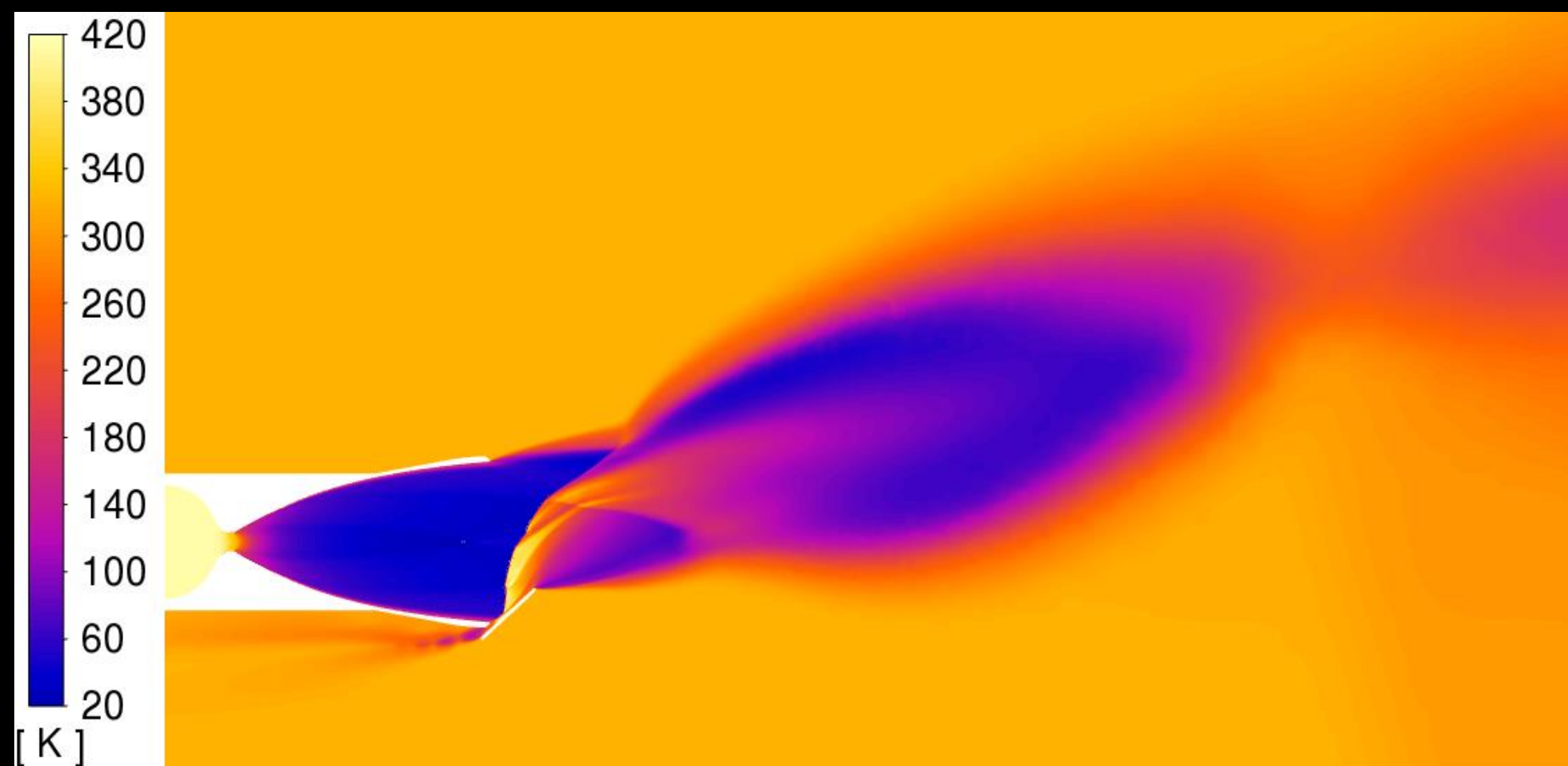
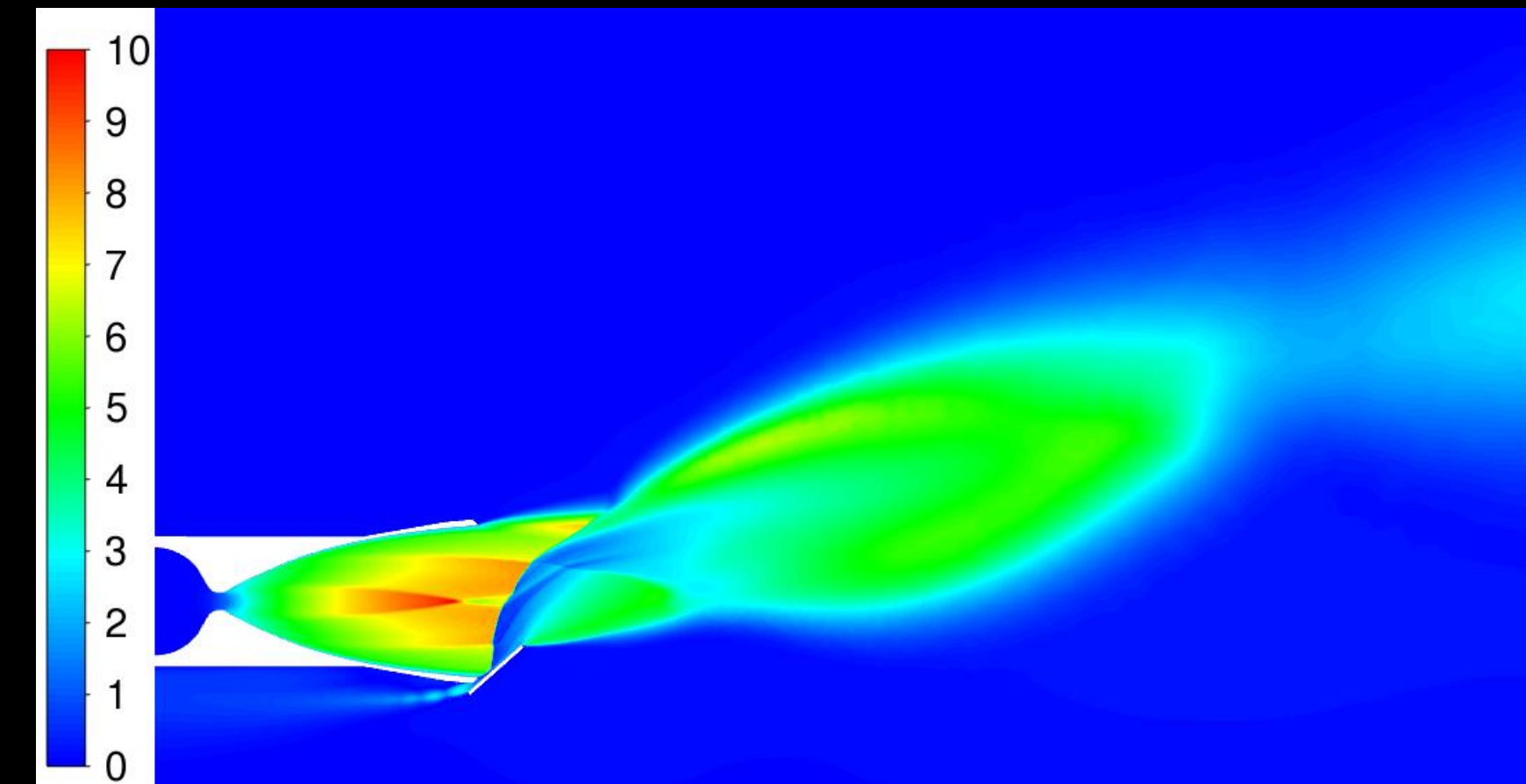
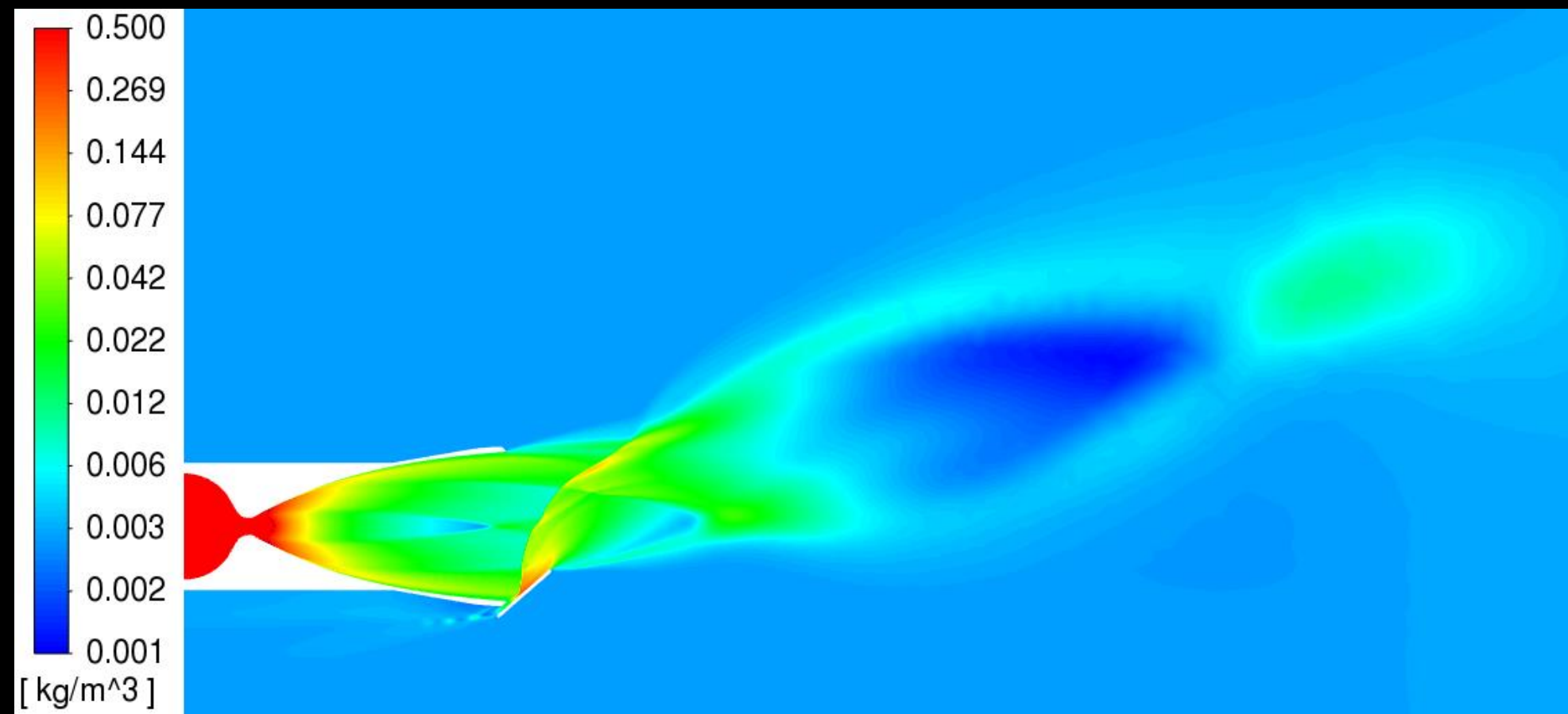
SOLID PROPELLANT ROCKET MOTOR THRUST DEFLECTION SYSTEM: CFD SIMULATIONS



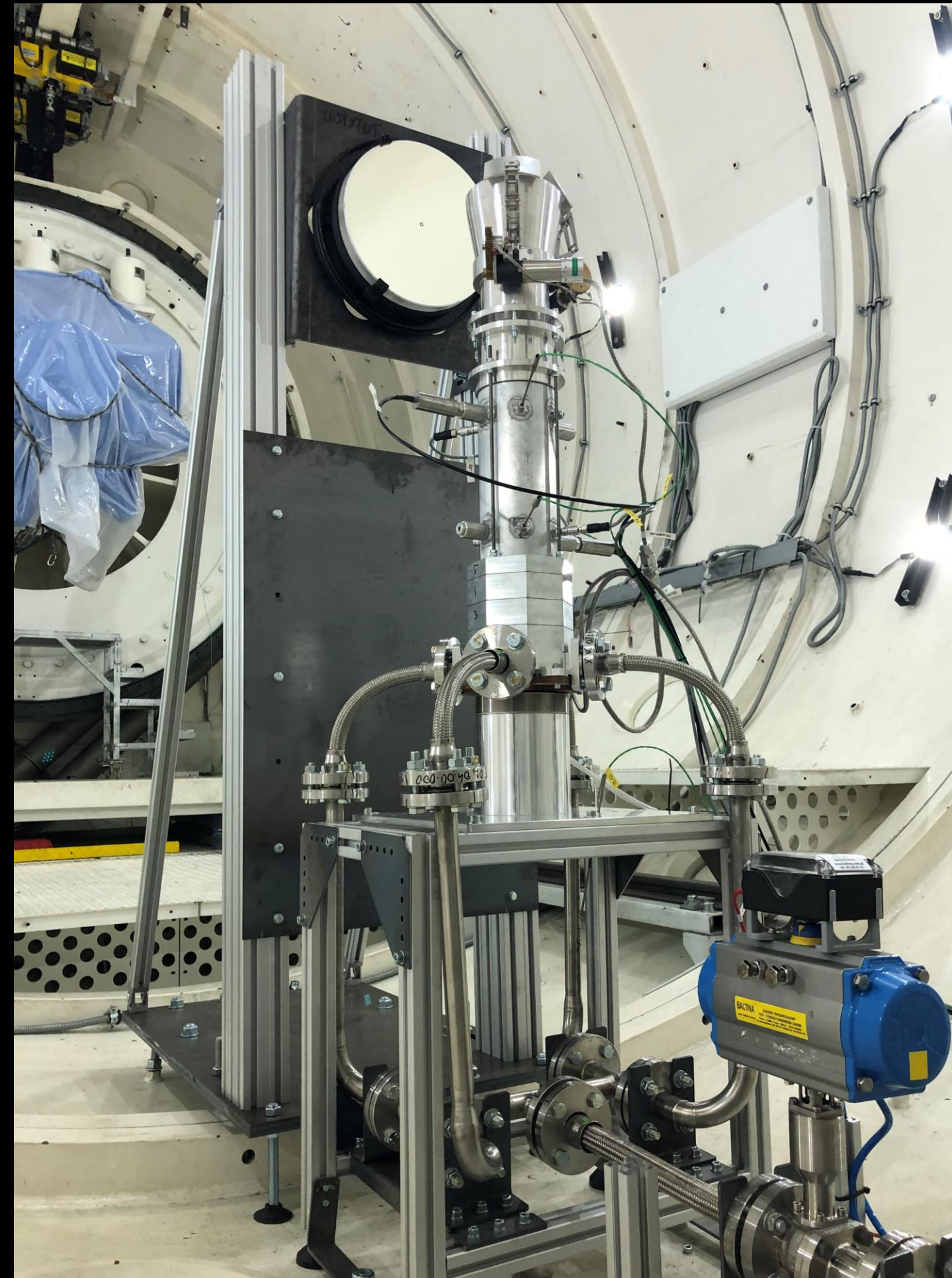
SOLID PROPELLANT ROCKET MOTOR THRUST DEFLECTION SYSTEM: MECHANISM



SOLID PROPELLANT ROCKET MOTOR THRUST DEFLECTION SYSTEM: CFD SIMULATIONS

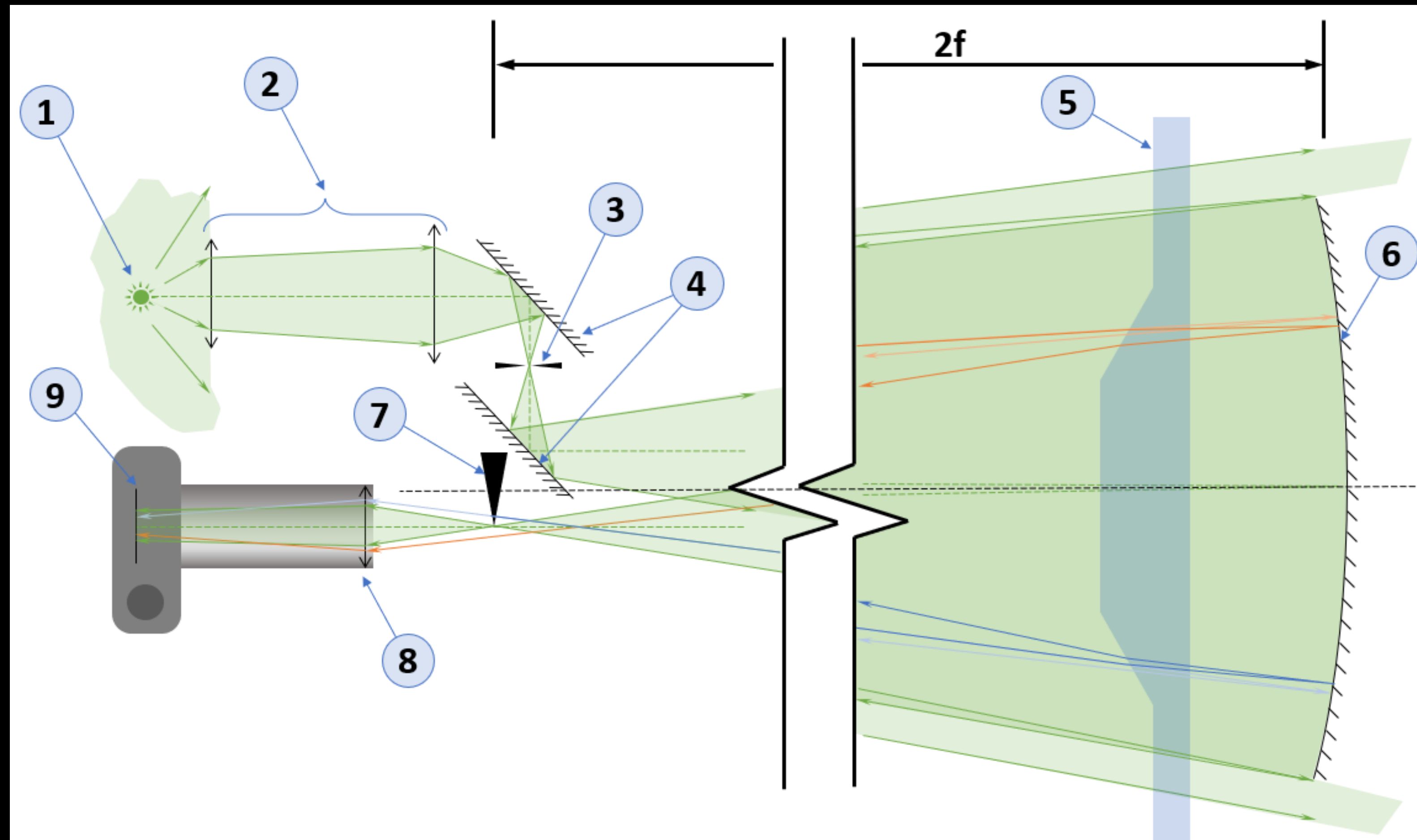


SOLID PROPELLANT ROCKET MOTOR THRUST DEFLECTION SYSTEM: COLD-GAS TEST STAND



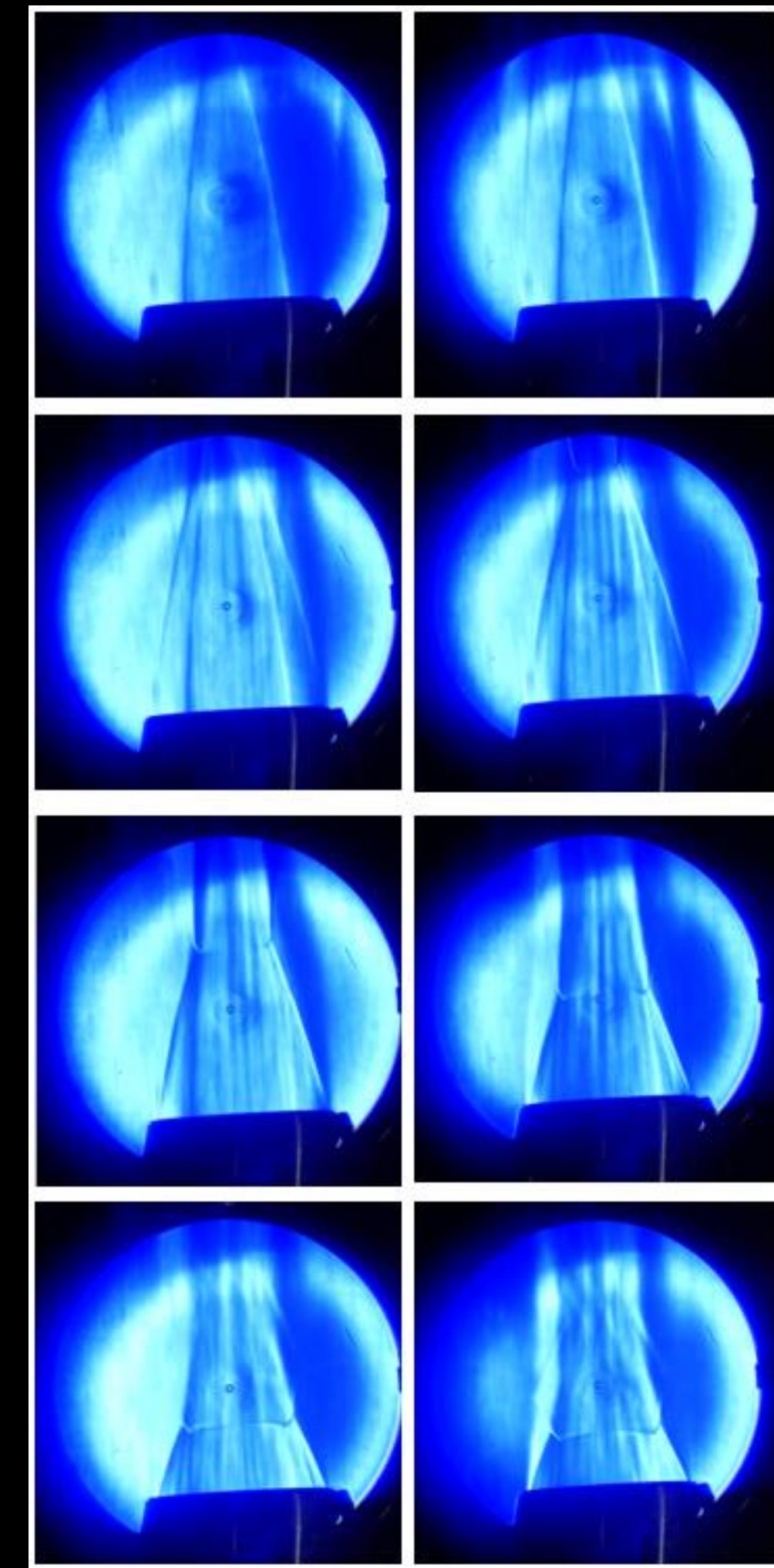
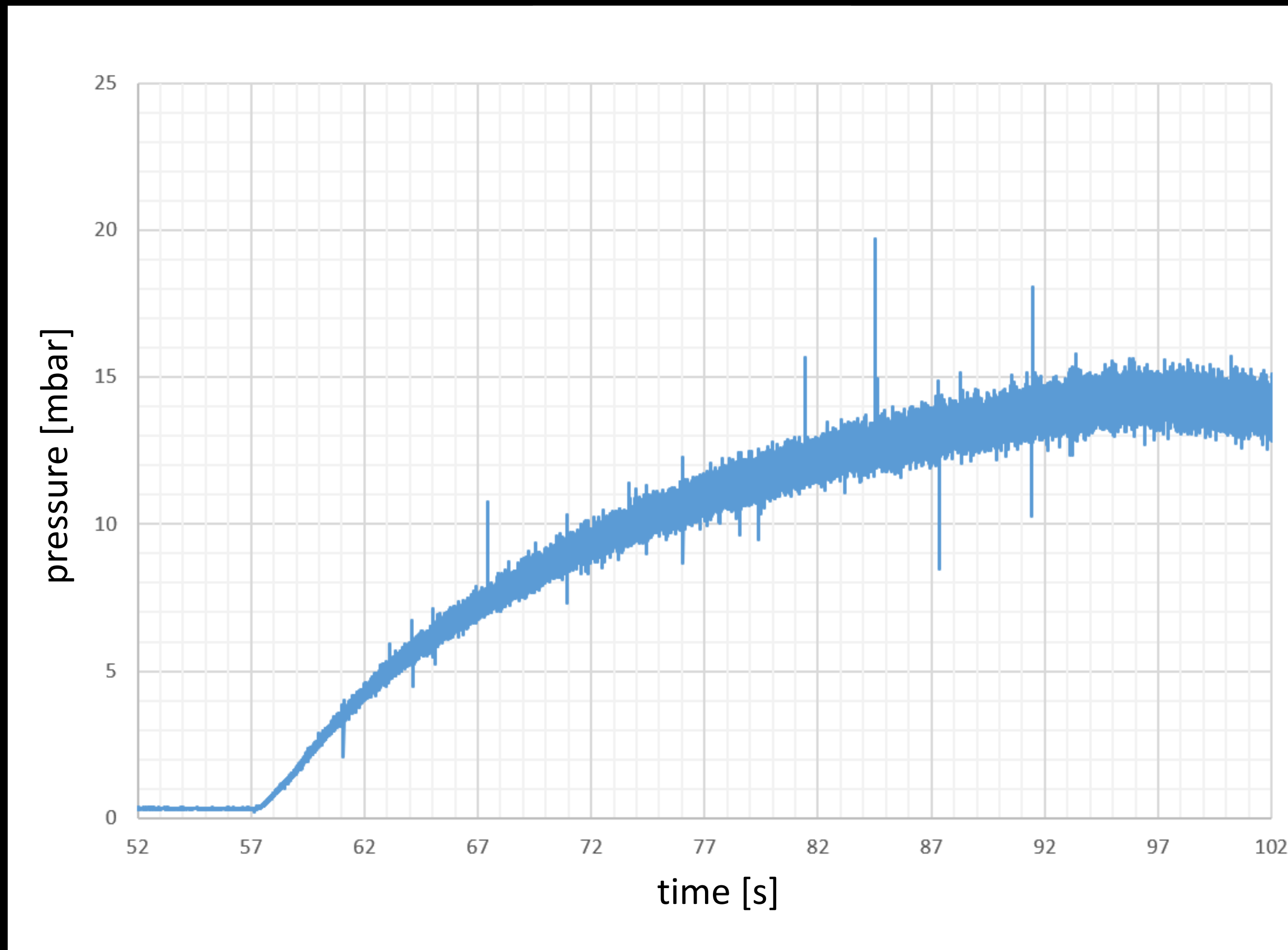
- VC VOLUME 265 M³
- ONLY 1ST STAGE IS WORKING UNTIL PRESSURE 30 MBAR IS REACHED. ACTUAL PUMPING RATE ~1552 M³/H
- 2ND STAGE IS ENABLED @ PRESSURE BELOW 50 MBAR. ACTUAL PUMPING RATE ~5530 M³/H
- VACUUM LEVEL ~1 MBAR(A)

SOLID PROPELLANT ROCKET MOTOR THRUST DEFLECTION SYSTEM: OPTICAL VISUALISATION – SCHLIEREN METHOD

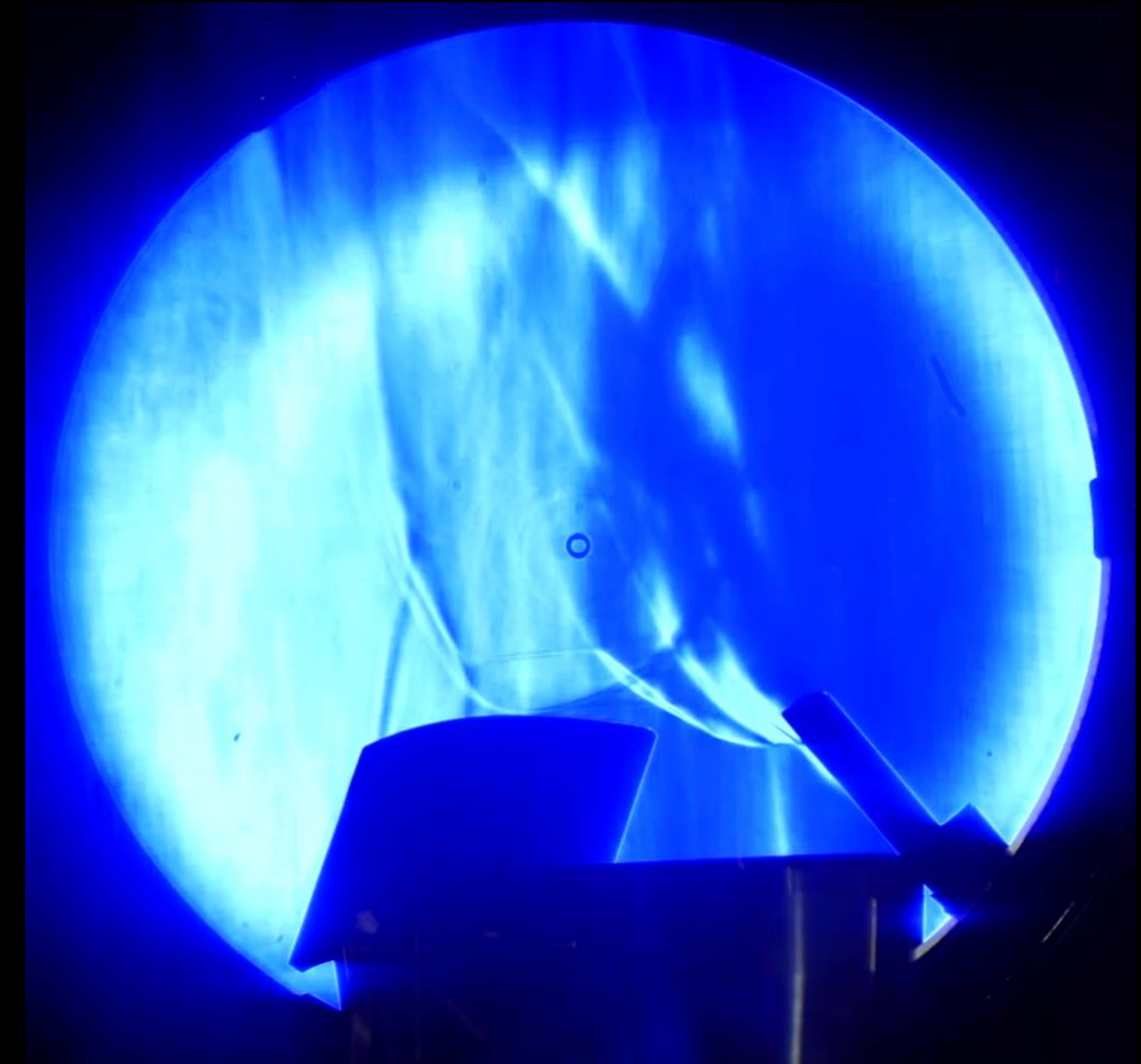
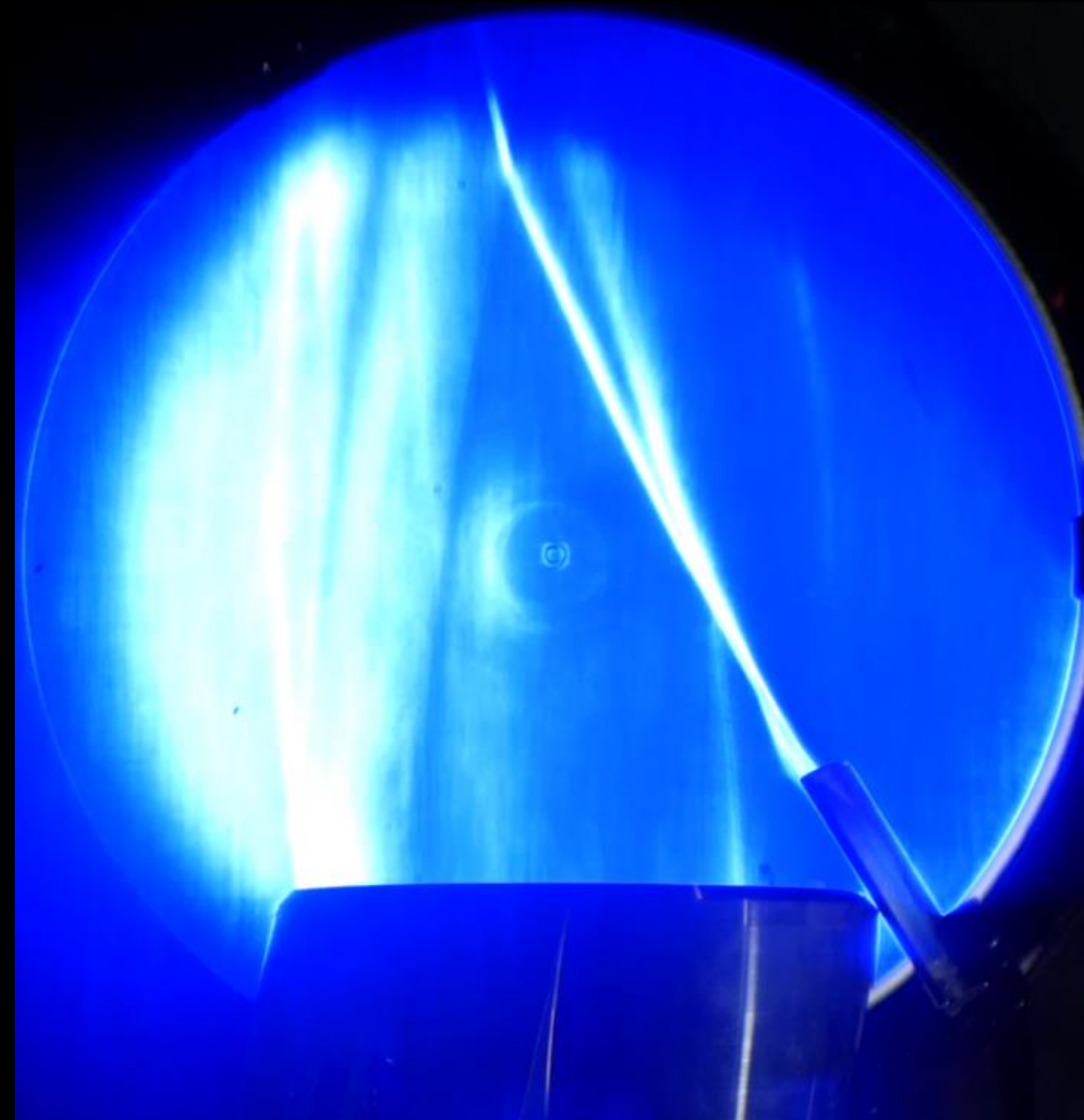
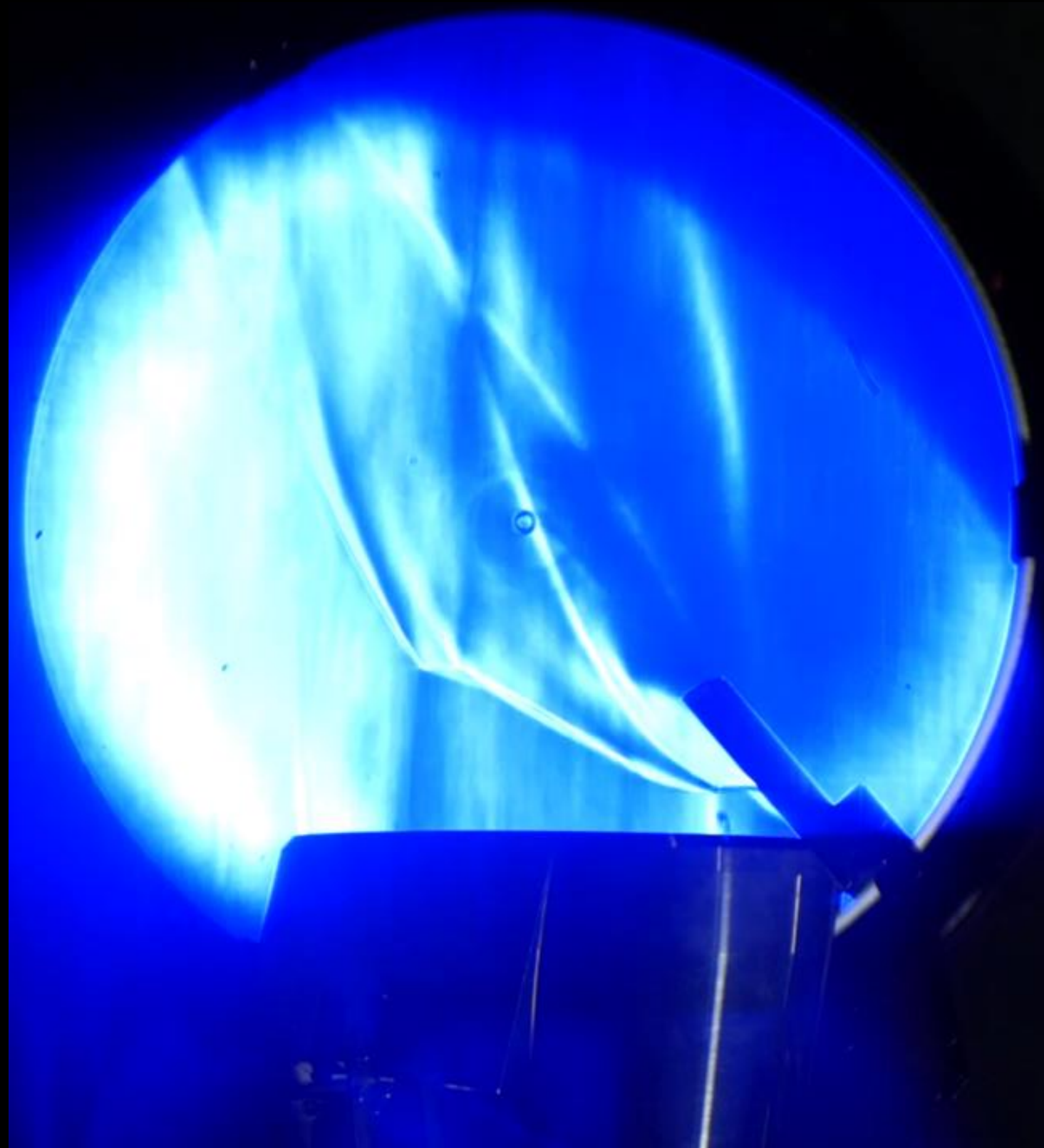


1. LASER
2. SYSTEM OF TWO LENSES
3. SLIT (0,3MM)
4. OFFSET (TWO FLAT MIRRORS)
5. TESTED AREA
6. PARABOLIC MIRROR
7. OPTICAL KNIFE-EDGE
8. MANUAL ZOOM
9. CAMERA

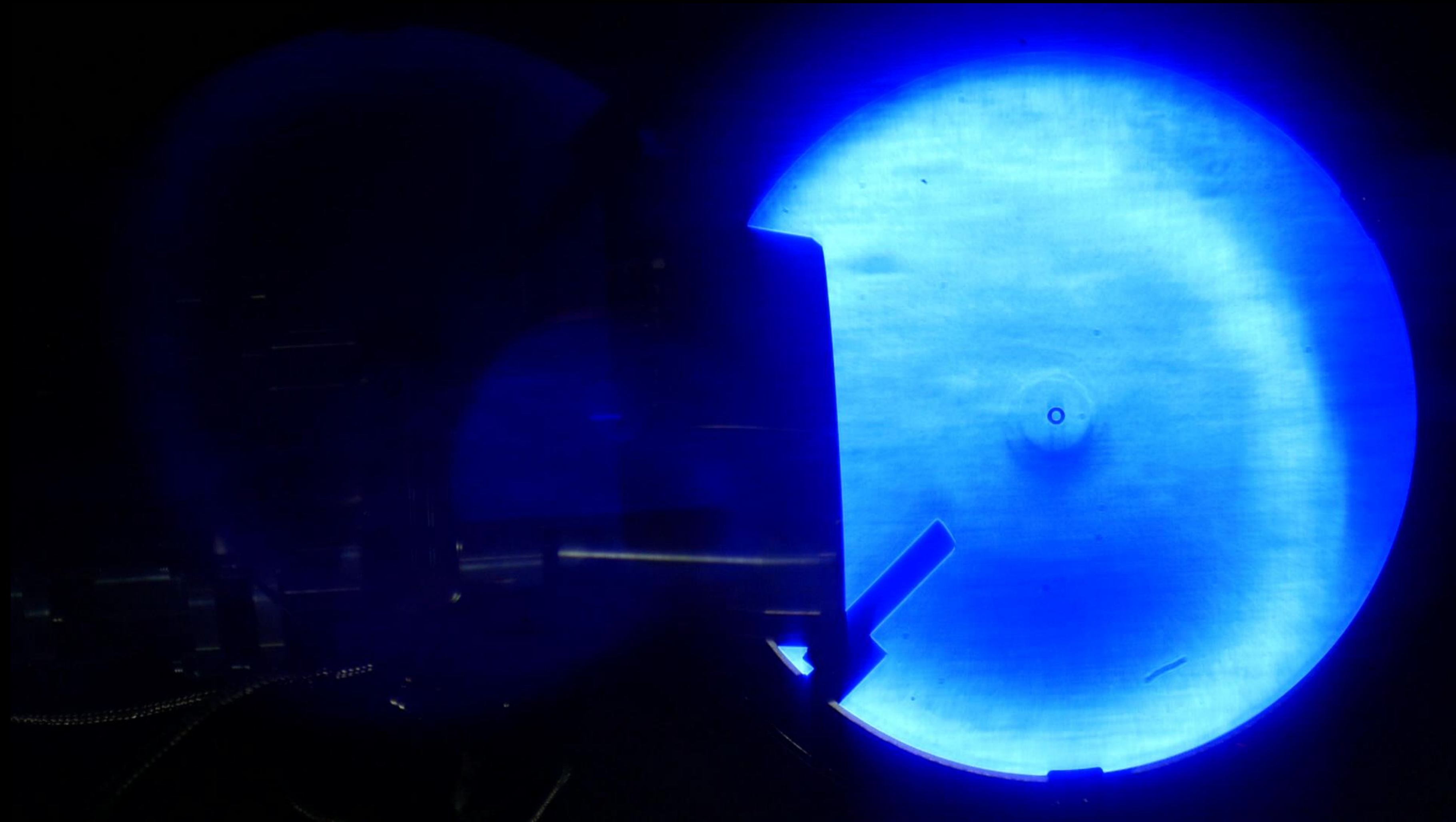
SOLID PROPELLANT ROCKET MOTOR THRUST DEFLECTION SYSTEM: OPTICAL VISUALISATION – CALIBRATION



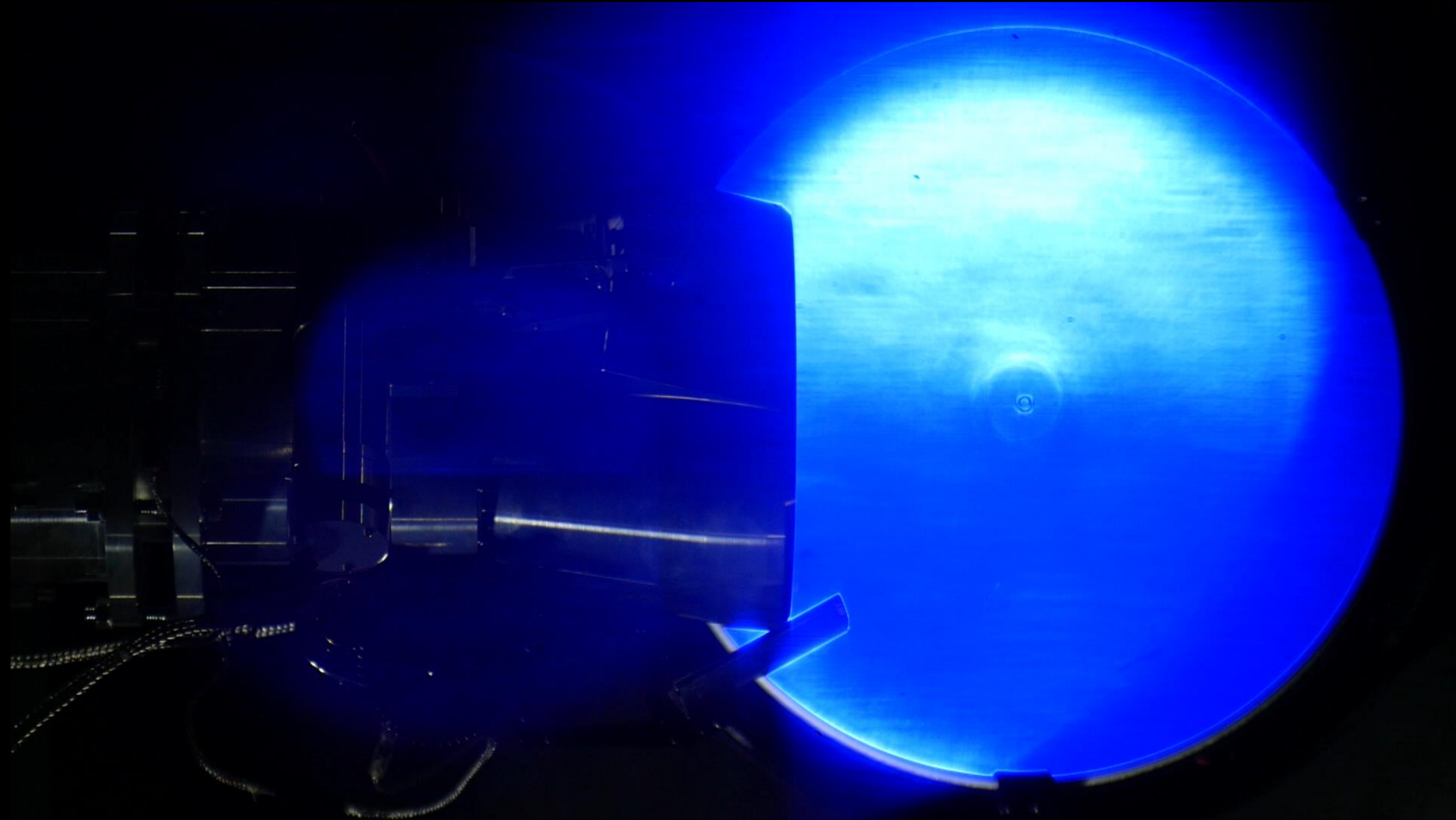
SOLID PROPELLANT ROCKET MOTOR THRUST DEFLECTION SYSTEM: OPTICAL VISUALISATION – RESULTS



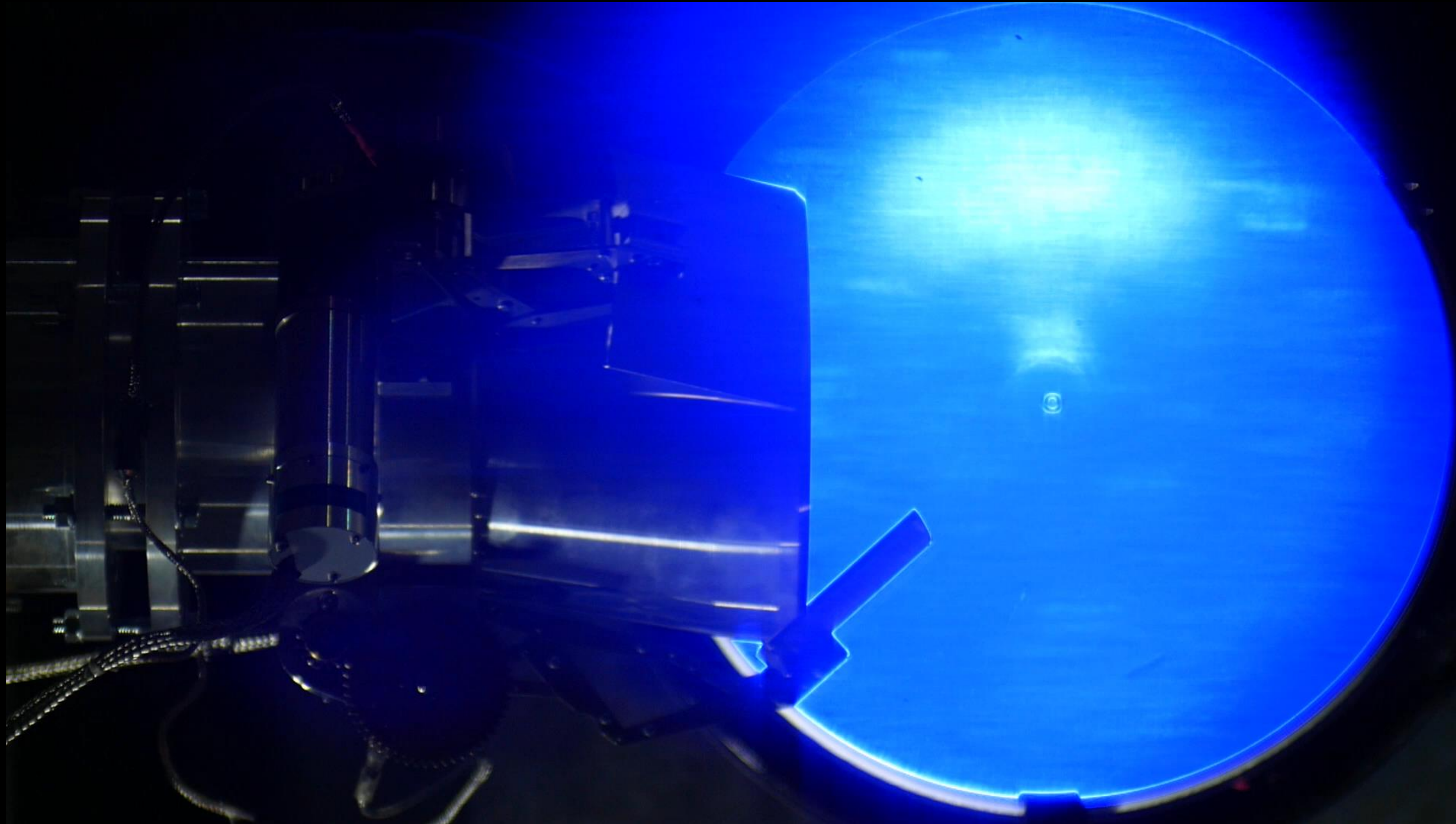
SOLID PROPELLANT ROCKET MOTOR THRUST DEFLECTION SYSTEM: OPTICAL VISUALISATION – RESULTS



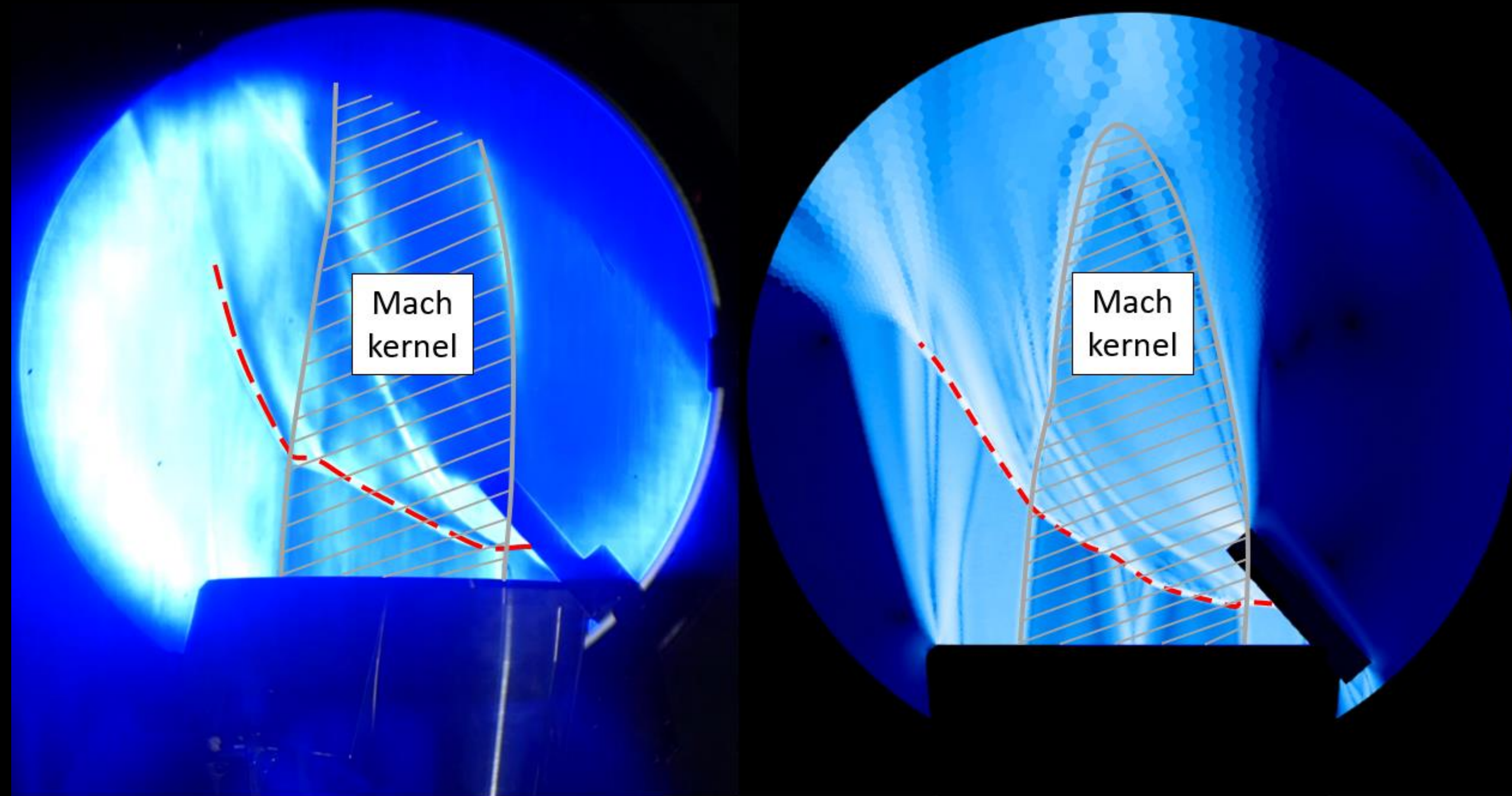
SOLID PROPELLANT ROCKET MOTOR THRUST DEFLECTION SYSTEM: OPTICAL VISUALISATION – RESULTS



SOLID PROPELLANT ROCKET MOTOR THRUST DEFLECTION SYSTEM: OPTICAL VISUALISATION – RESULTS



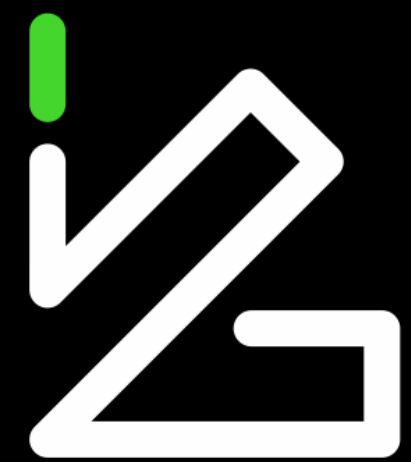
SOLID PROPELLANT ROCKET MOTOR THRUST DEFLECTION SYSTEM: OPTICAL VISUALISATION – CFD - COMPARISON



SUMMARY

- SRM:
 - ABLATIONS TESTS EXECUTED AT THE DEDICATED TEST STAND CONFIRMED THE PERFORMANCE OF THE ABLATION INSULATION
 - MOTOR HOT-TESTS IN PREPARATION – PLAN TO TEST IN Q2 2024
- TVC:
 - COLD-GAS TESTS EXECUTED IN THE VACUUM CHAMBER CONFIRMED THE PERFORMANCE OF THRUST VECTOR CONTROL SYSTEM BASED ON OUTSIDE FLAPS
 - THE FLOW VISUALIZATION BASED ON SCHLIEREN METHOD SEEMED TO CONFIRM PERFORMANCE PREDICTIONS BASED ON SIMULATIONS
 - BASED ON THE COMPARISON TESTS AND SIMULATION RESULTS: THE SIMILARITY IN BEHAVIOUR OF SHOCK WAVES PATTERN COULD BE EASILY OBSERVED





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