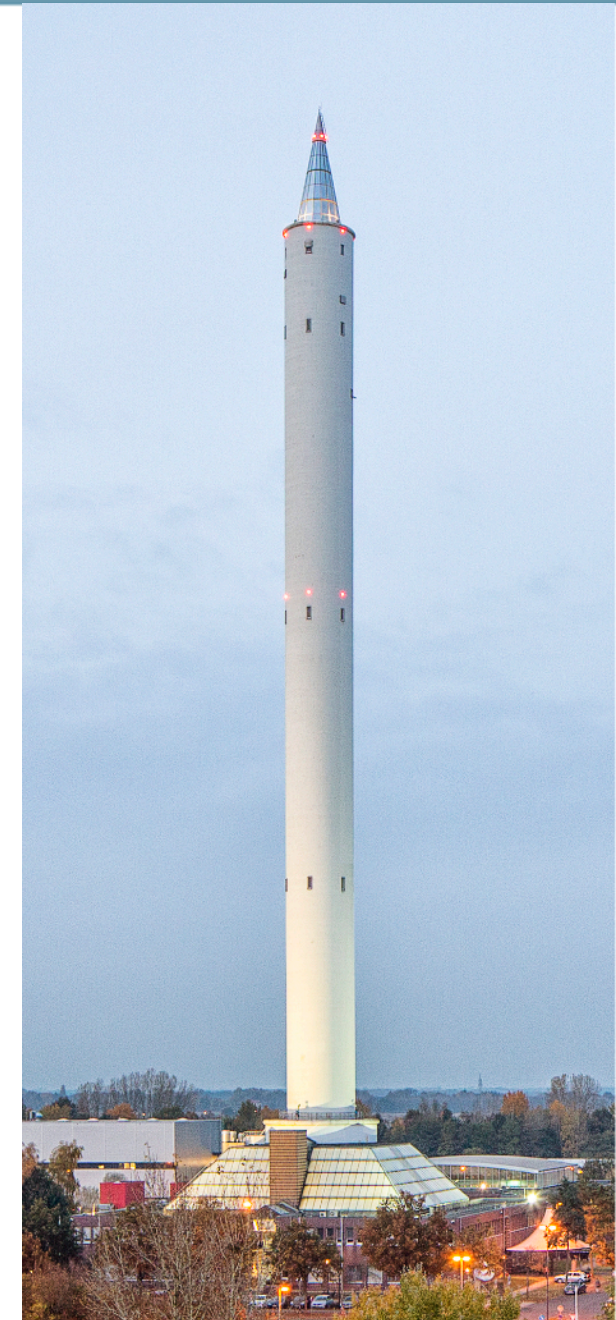


UN FELLOWSHIP PROGRAM - DROPTES @ THE BREMEN DROP TOWER

DropTES Webinar, 2020
Bremen, Germany

Dr. Thorben Könemann
ZARM Drop Tower Operation and Service Company
WWW.ZARM.UNI-BREMEN.DE



ZARM's Organization Structure

founded
in 1985

ZARM - Center of Applied Space Technology and Microgravity

c/o Universität Bremen
Am Fallturm 2, 28359 Bremen, Germany
www.zarm.uni-bremen.de



ZARM - University of Bremen

Research Institute - Faculty 04 Production Engineering

Prof. Dr. Marc Avila
(Executive Director)

Prof. Dr. Marc Avila
(Director Fluid Dynamics)

Prof. Dr. Claus Lämmerzahl
(Director Space Science)

Prof. Dr. Claus Braxmaier
(Director Space Technology)

ZARM FAB mbH

ZARM Drop Tower Operation and Service Company

Prof. Dr. Marc Avila
Peter von Kampen
(Executive Board)

Christian Eigenbrod
Dr.-Ing. Thorben Könnemann
Ulrich Kaczmarczik
(Scientific / Technical Management)

ZARM Technik AG

Supplier of Attitude Control Equipment for Satellites

Holger W. Oelze
(Chief Executive Officer)
Peter von Kampen
(Chief Financial Officer)

Marco R. Fuchs
(Chairman of Supervisory Board)



► Research / Teaching

► Technical Support

► Space Hardware



Content

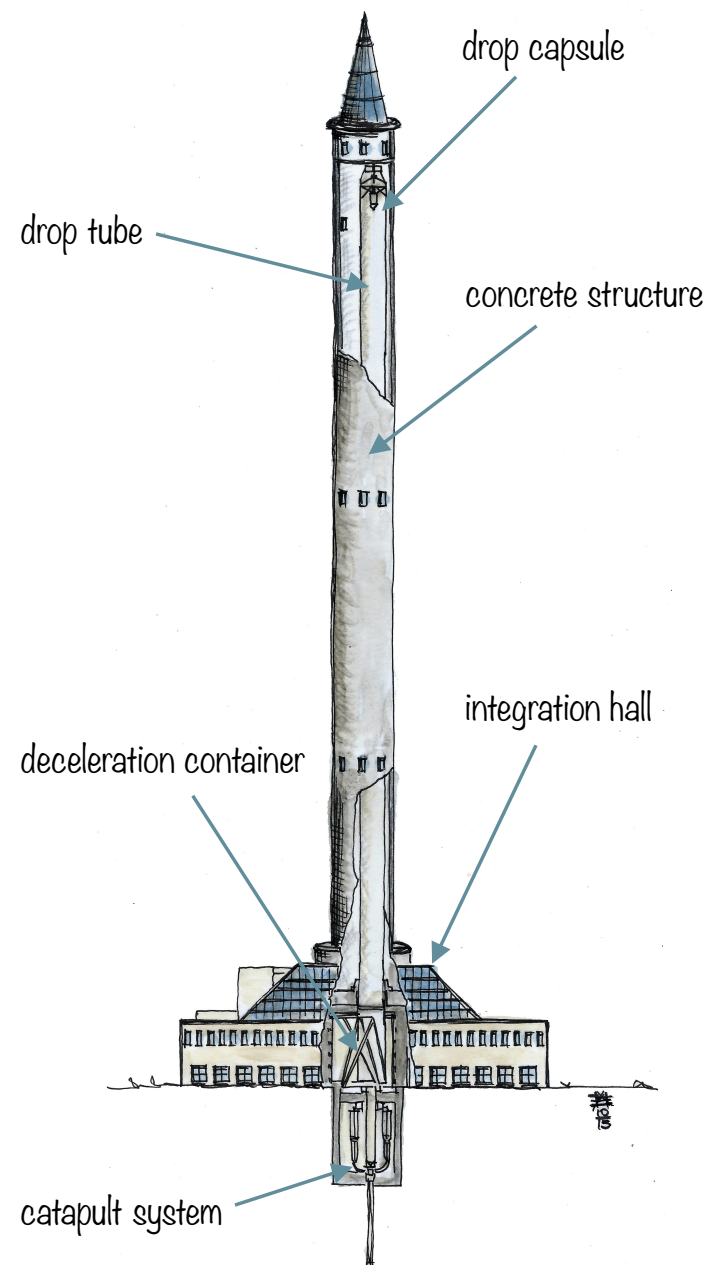
- ▶ Bremen Drop Tower
- ▶ Experiment Examples
- ▶ DropTES - Program
- ▶ GraviTower Bremen Pro



ZENTRUM FÜR
ANGEWANDTE RAUMFAHRTTECHNOLOGIE
UND MIKROGRAVITATION



Bremen Drop Tower



FACTS ABOUT THE DROP TOWER BUILDING

- **height of the Bremen Drop Tower: 146 m**
- diameter of the concrete structure: 8 m
- stairs: about 600 steps until the top

FACTS ABOUT THE DROP TUBE

- height of the drop tube: 120 m
- distance of free fall: 110 m
- diameter of the drop tube: 3.5 m
- deceleration container: filled with 15 m³ of polystyrene pellets up to a height of 8.20 m
- **experiment duration in microgravity:**
 - drop experiment - 4.7 s**
 - catapult experiment - 9.3 s (worldwide unique)**
- maximum capsule speed: 168 km/h
- **gross weight of standard capsule: 500 kg**
- vacuum: 18 pumps draw out 1,700 m³ of air in 1.5 to 2 h
- pressure after evacuation: 10 Pa (0.1 mbar)
- **achievable microgravity quality: 10⁻⁶ g**
- **number of drops or catapult launches:**
 - up to 3 times a day**

Bremen Drop Tower



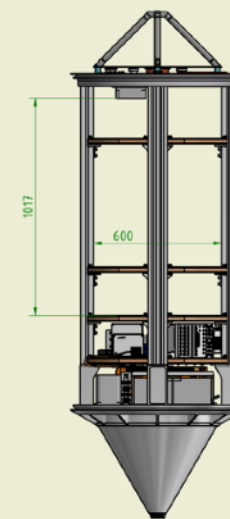
► Experimenter's Integration Area / Payload Services



► Standard Capsule Versions:

- payload masses -

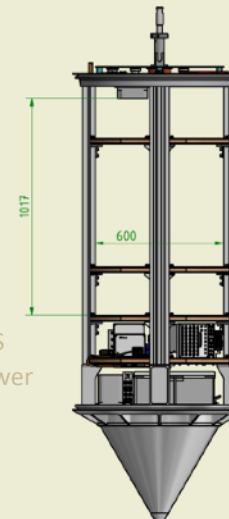
● catapult



- 165 kg -

► CCS
► power

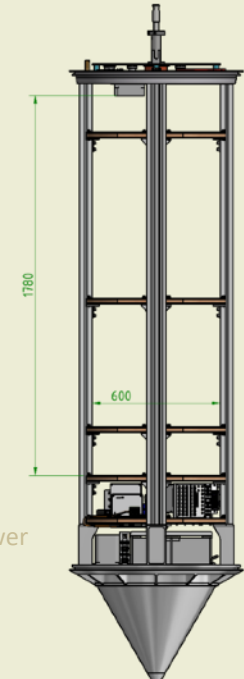
● short



- 265 kg -

► CCS
► power

● long



- 225 kg -

► CCS
► power

Bremen Drop Tower

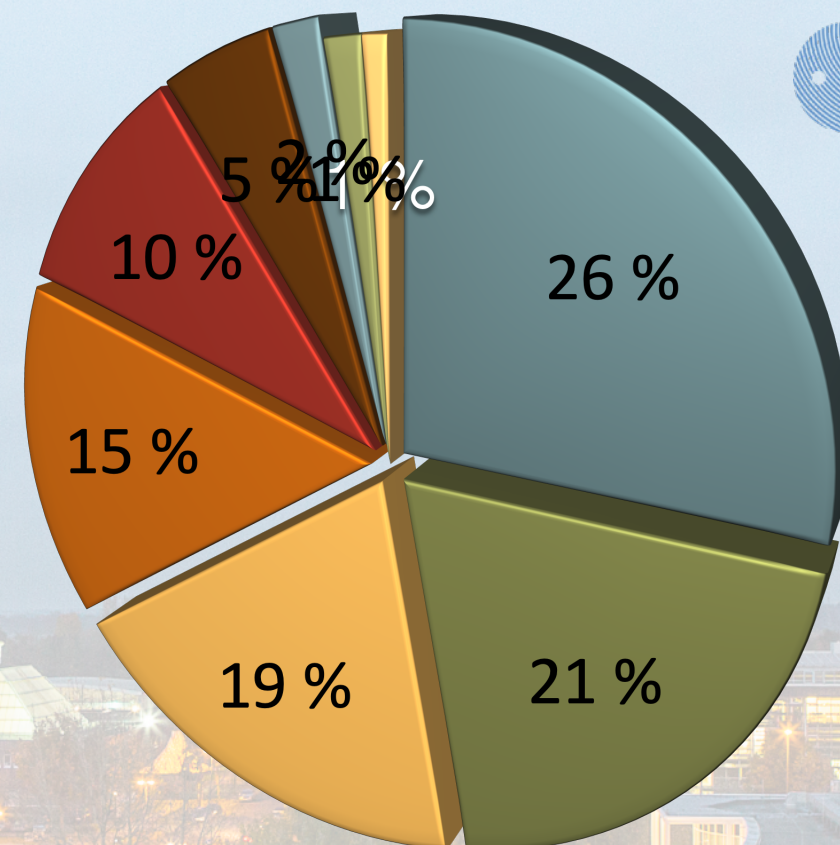
► RESEARCH AREAS OF DROP TOWER EXPERIMENTS

- *fundamental research*
- *technology development
(mission preparations)*

- Combustion
- Fundamental Physics
- Fluid Dynamics
- Astrophysics (Planet Formation)
- Materials Sciences
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- Hardware Tests
- Student Programs
- Chemistry

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Bremen Drop Tower

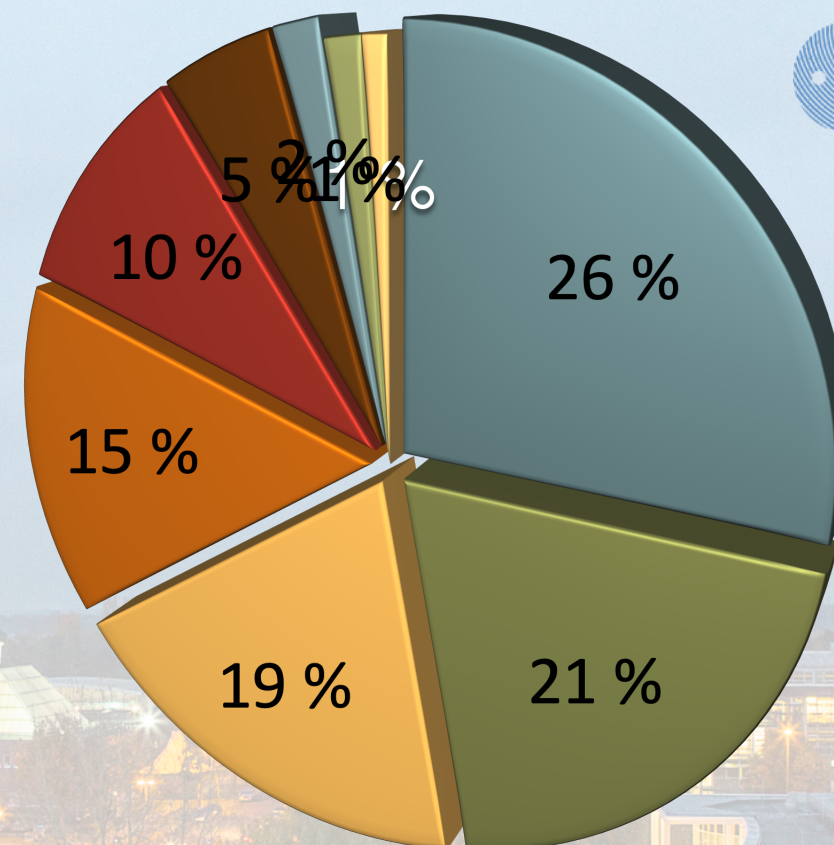
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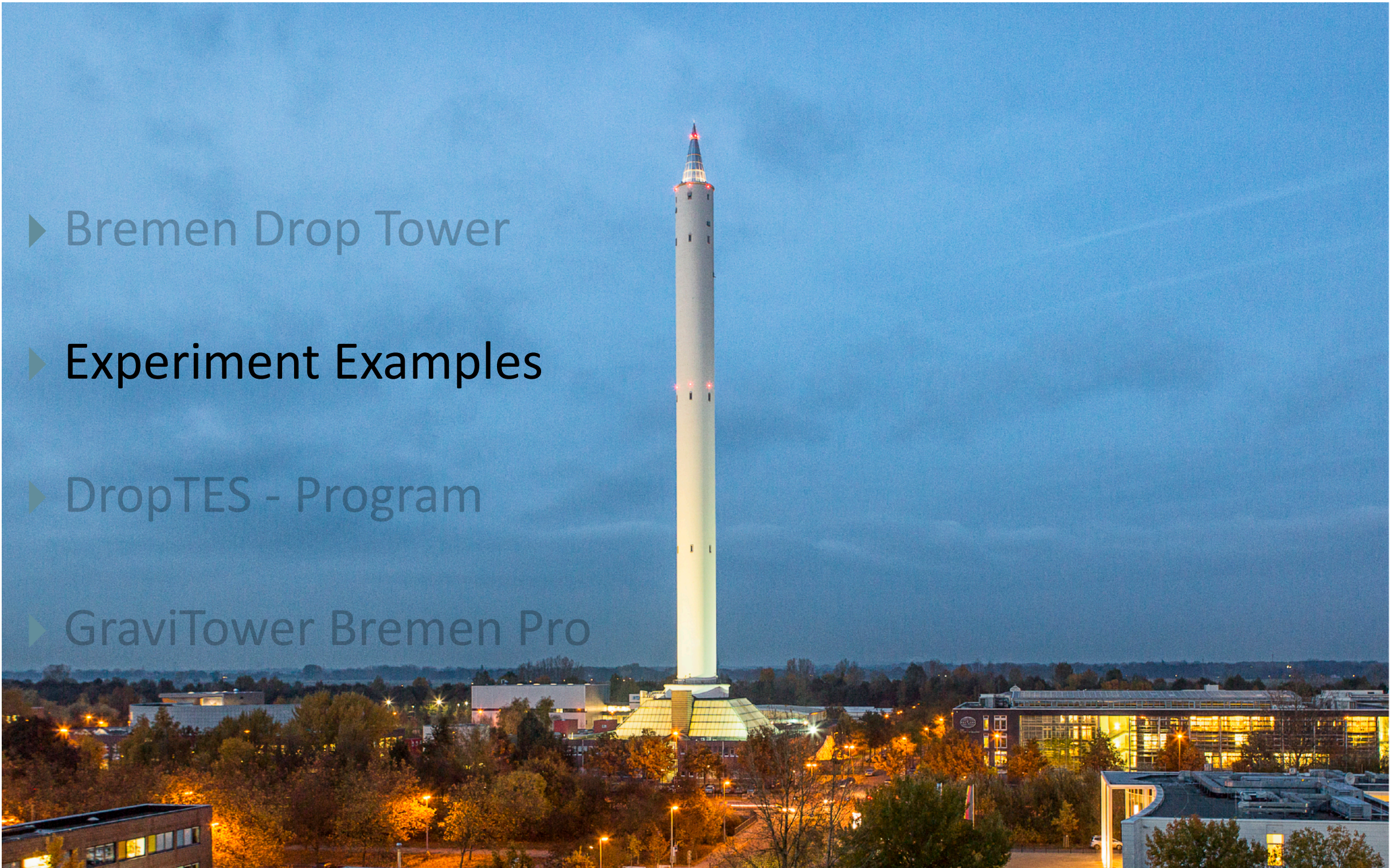
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- ▶ GraviTower Bremen Pro



Fundamental Physics - QUANTUS I / II

► Ultracold Macroscopic Quantum Systems in Weightlessness - Drop Tower Experiments

Related Publications:

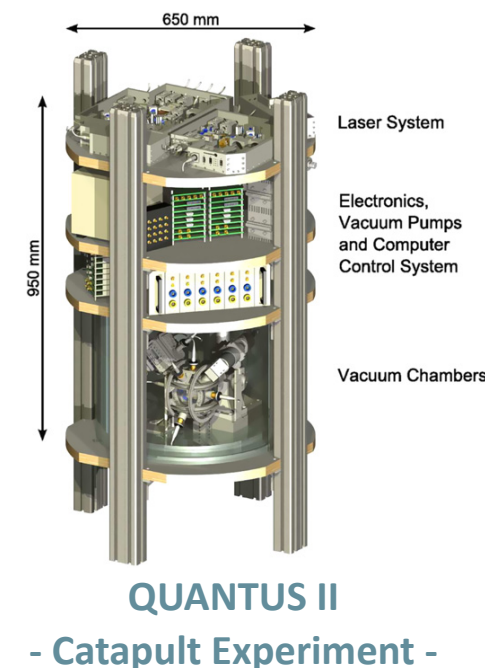
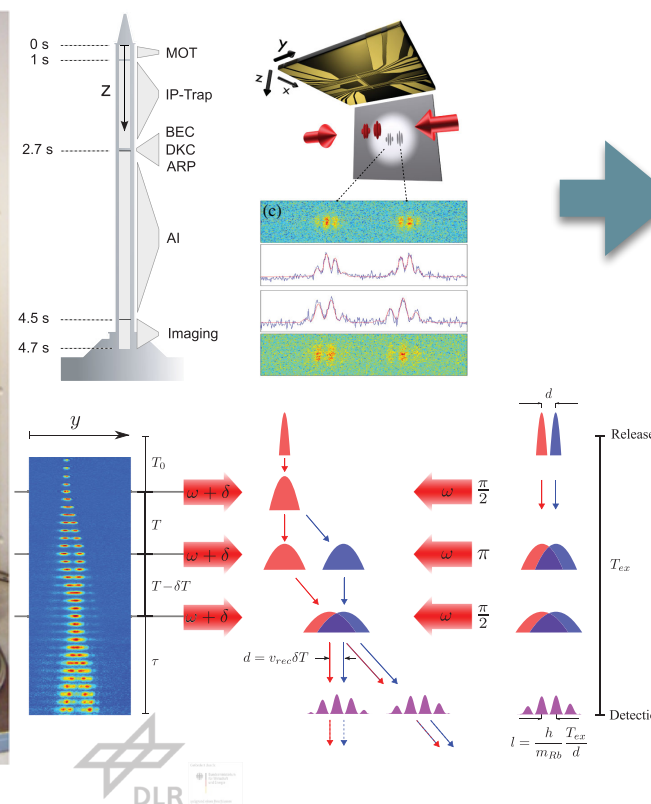
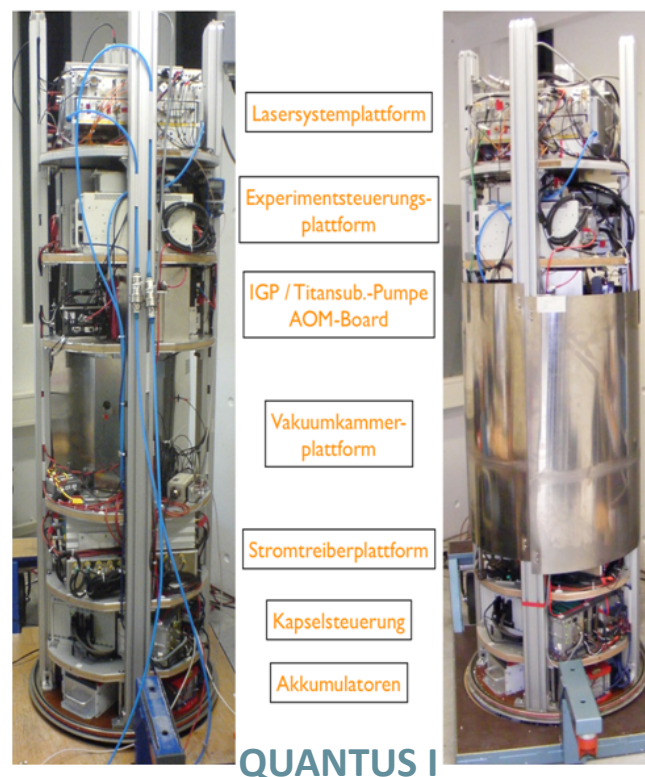
- T. van Zoest et al., Science 328 (2010)
- H. Muntinga et al., Phys. Rev. Lett. 110 (2013)
- S. Abend et al., Phys. Rev. Lett. 117 (2016)
- D. Becker et al., Nature 562 (2018)

► supported by DLR Space Administration

- QUANTUS - Collaboration / U Hanover, Berlin, Bremen, Mainz, etc.

► Realization of first Bose-Einstein Condensates, Atom Interferometers (QUANTUS I), Dual-Spezies Atom Interferometers (QUANTUS II) in μg

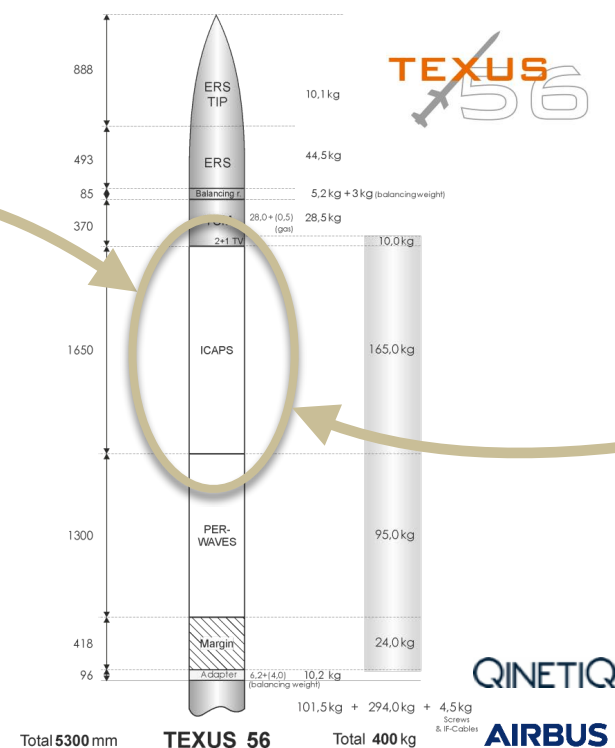
- transportable high-precision quantum sensors



- ▶ Interactions in Cosmic and Atmospheric Particle Systems
 - Drop Tower Experiments
- ▶ supported by ESA Human and Robotic Exploration
 - Microgravity Research Center, Université Libre de Bruxelles, Belgium
- ▶ to understand the formation of planets in the early solar system
 - temperature gradient as a result of differences in momentum and energy transferred to the particles - thermophoresis



ICAPS - Drop Tower



ICAPS - Sounding Rocket

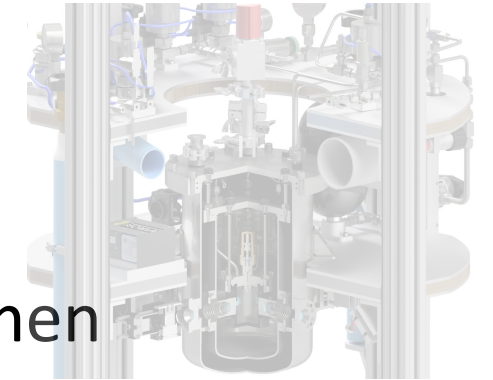


ICAPS - ISS (targeted)

Combustion - HYDRA



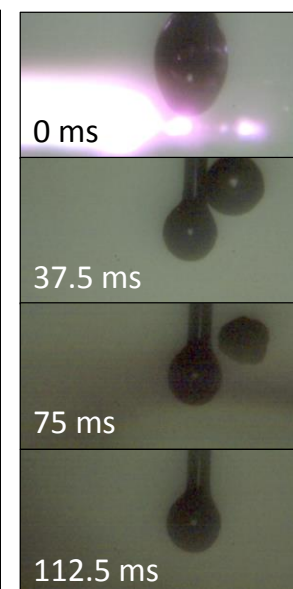
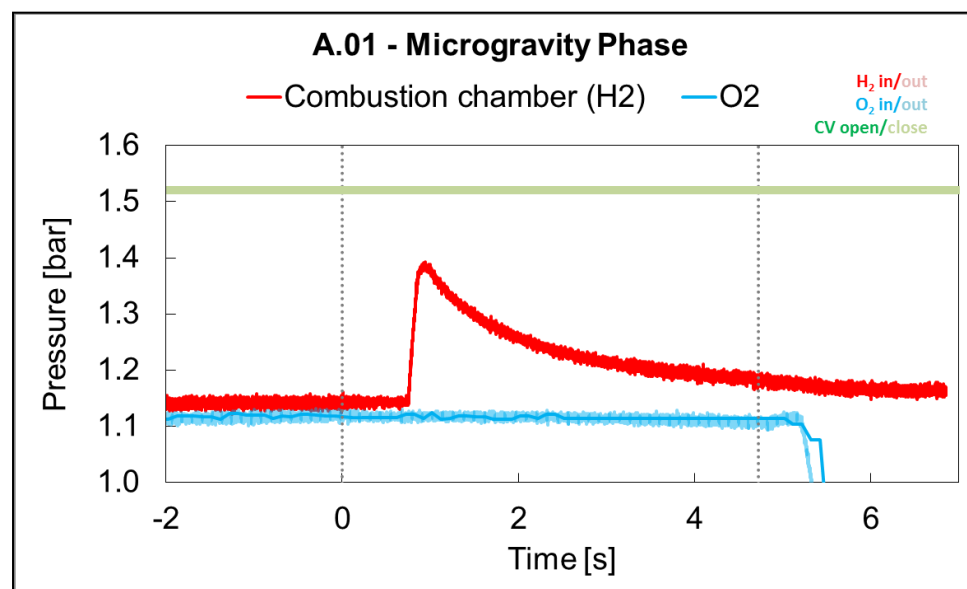
► Investigation of Single Oxygen Droplet Combustion in Hydrogen - Drop Tower Experiments



- supported by DLR Space Administration
 - Combustion Engineering Group, ZARM - University of Bremen
- liquid hydrogen (LH2) and liquid oxygen (LOX) widely used in liquid rocket propulsion
 - mixture formation crucial for stable combustion (to improve effectiveness)
 - experimental data for numerical simulations



HYDRA

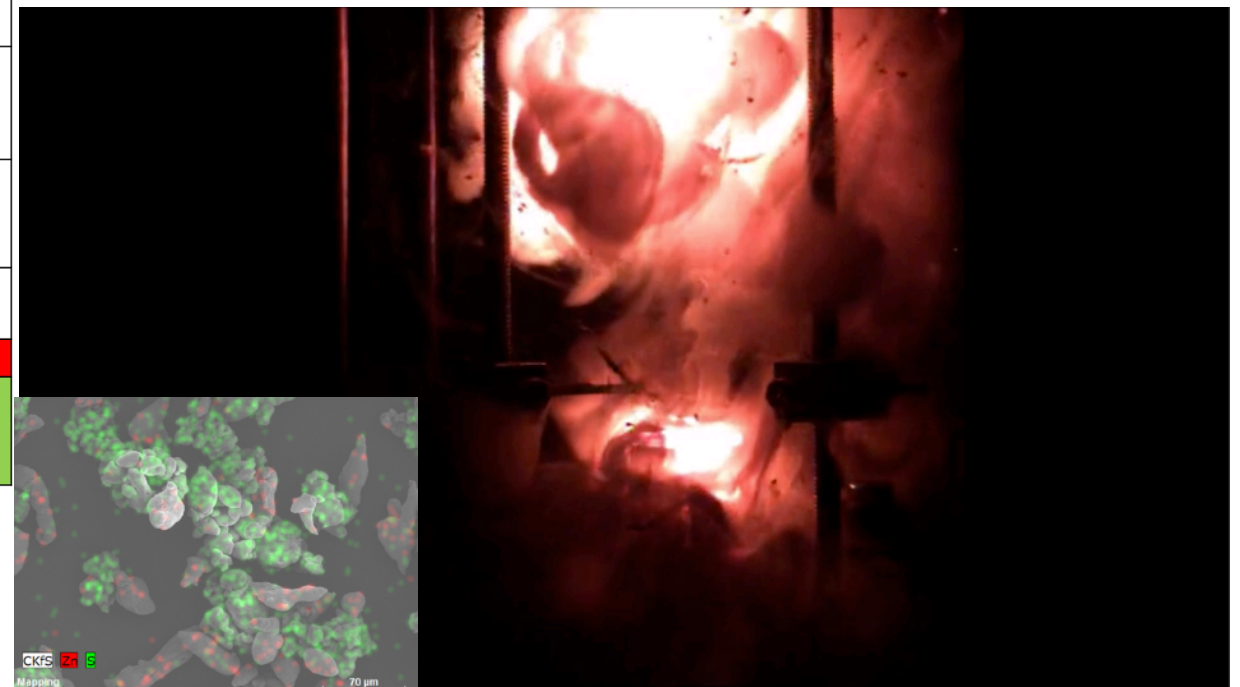


Laser Ignition

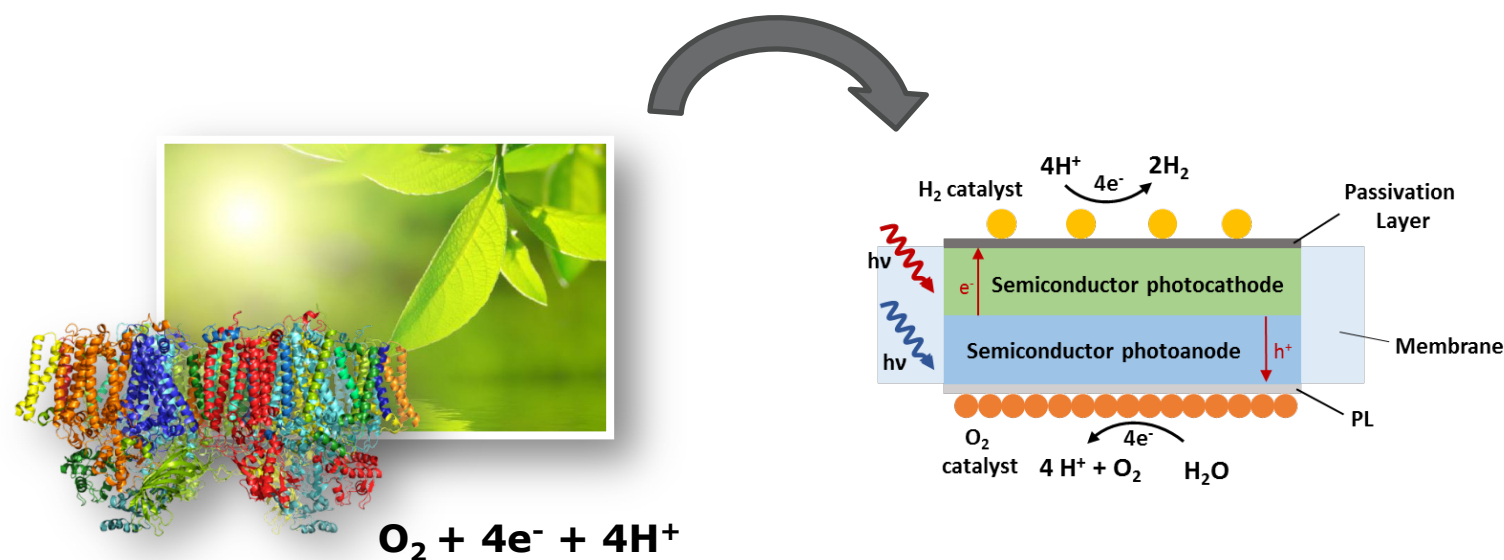


- ▶ Advanced Processing of Zinc Sulfide (ZnS) Materials to be Implemented into Displays - Drop Tower Experiments
- ▶ supported by DLR Space Administration / INNOspace Initiative
 - Materials Science in Variable Gravity Group, ZARM - University of Bremen
- ▶ New Energy Efficient Light Emitting Devices (Electroluminescence)
 - Self-Propagating High-Temperature Synthesis (SHS) - Methode in μg

Screen Technology	Power Requirements	Robustness	Production Cost
Liquid-crystal displays (LCD) cathode fluorescent lamp (CCFL) backlight	High	Low	Low
Liquid-crystal displays (LCD) light-emitting diode (LED) backlight	High	Low	Low
Organic light-emitting diode (OLED)	High	Low	Moderate
Plasma Screen	Very High	High	Very High
Liquid-crystal displays (LCD) electroluminescent (EL) backlight	Very Low	High	Low

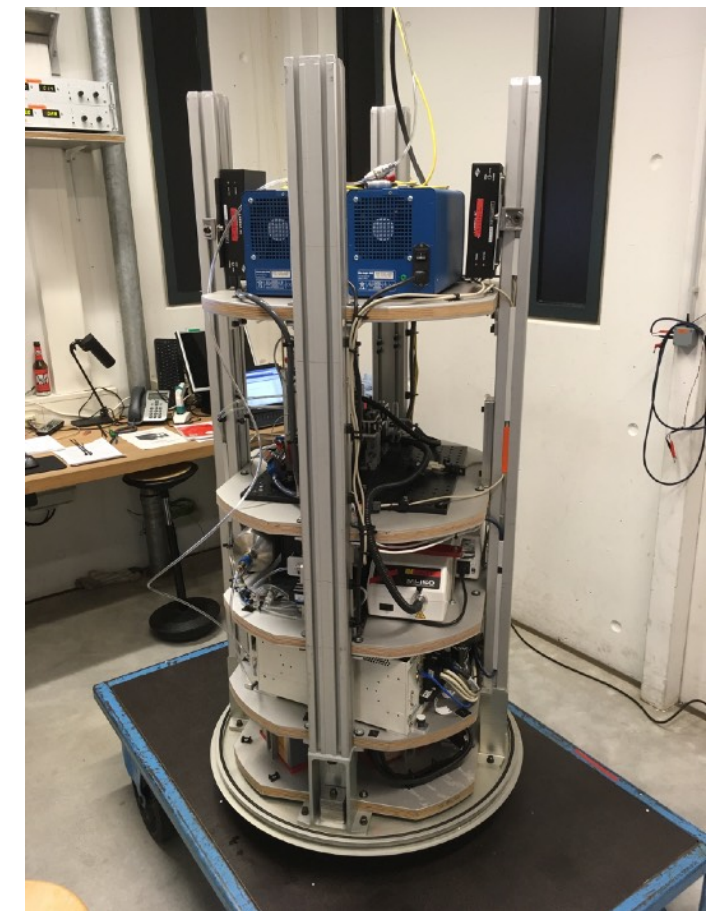


- ▶ Photoelectrochemical Water Splitting and Hydrogen Generation in μg Environments - Drop Tower Experiments
 - ▶ supported by DLR Space Administration (former ESA - ESTEC)
 - FU Berlin, Germany / Caltech, USA / University of Warwick, UK
 - ▶ Realization of an Efficient Artificial Photosynthesis in Space
 - for future life support systems on space missions or in habitats (Moon / Mars) - Oxygen / Hydrogen
- K. Brinkert et al., Nature Comm. 9, (2018)



From the Nature...

... to an Art



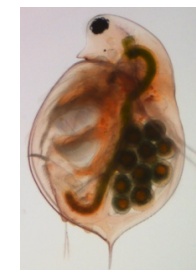
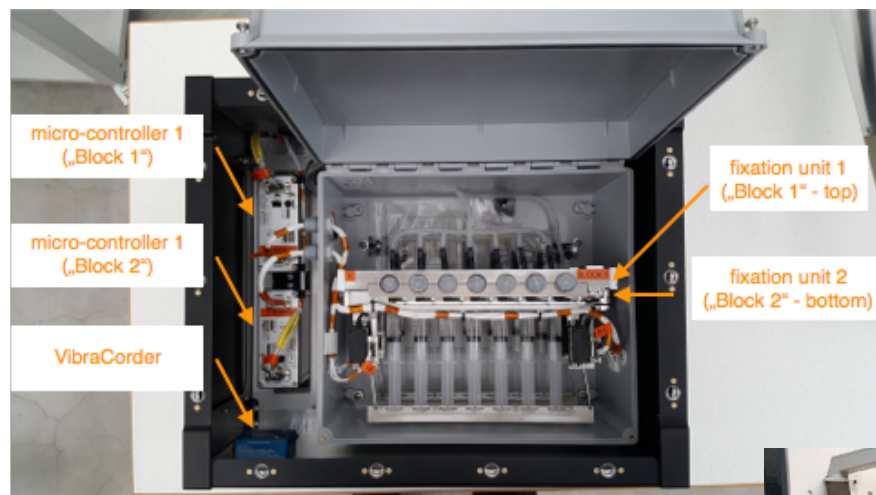
Biology - Daphnia (Mission Preparation)

- ▶ Investigation of the Impact of Microgravity on Gene Expression and the Cytoskeleton in Daphnia (Water Fleas)
 - Drop Tower Experiments / Suborbital Flight Experiment

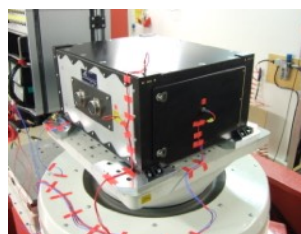
- ▶ supported by DLR Space Administration
 - ▶ Animal Ecology I, University of Bayreuth
- ▶ Daphnia as a Model Organism Candidate for Space Missions

launched
on April 29, 2018

„New Shepard“



Experiment
Preparation
(Bremen Drop Tower
+ ZARM Test Center)

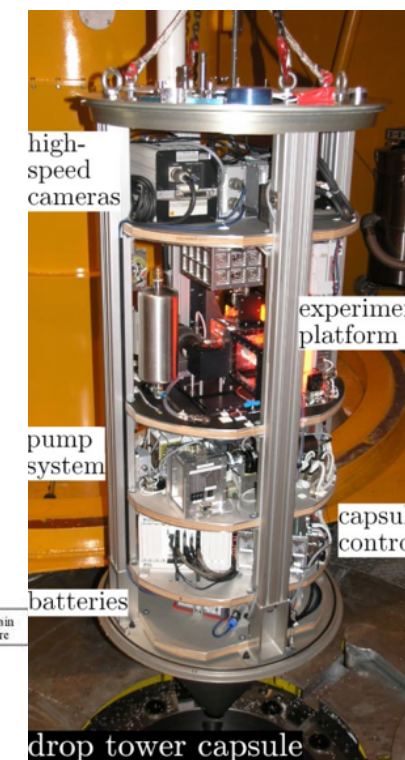
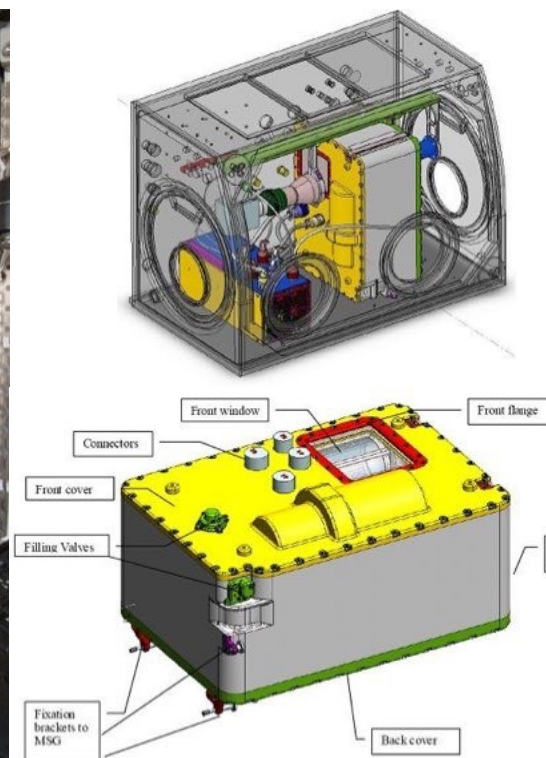


M8 Flight - 107 km

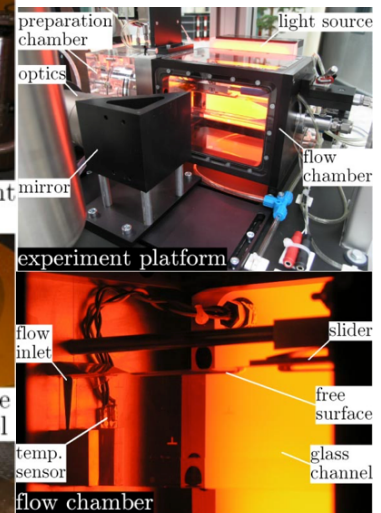
Fluid Dynamics - CCF (Mission Preparation)



- ▶ Capillary Channel Flow - Experiment onboard ISS
 - ▶ US - German Partnership ISS Mission by NASA / DLR
 - ZARM - University of Bremen / Portland State University
 - ▶ Mission Overview:
 - investigation of capillary flows in the absence of gravity
 - finding new ways to move liquids in space



Drop Tower Experiments



e.g. Microgravity Tests of Channel Geometries



Preparation of Space Missions - Hayabusa 2

Peregrine Falcon



▶ Asteroid Explorer Mission (Target: Asteroid Ryugu)

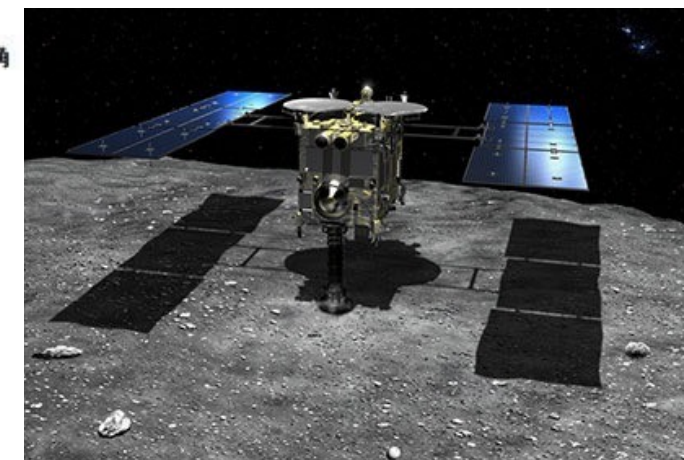
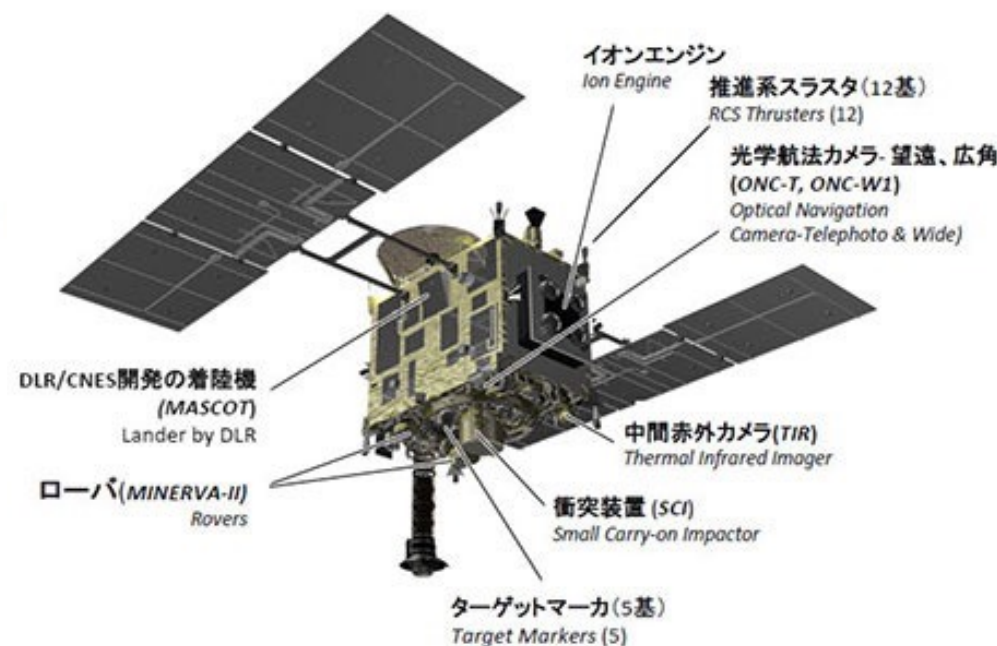
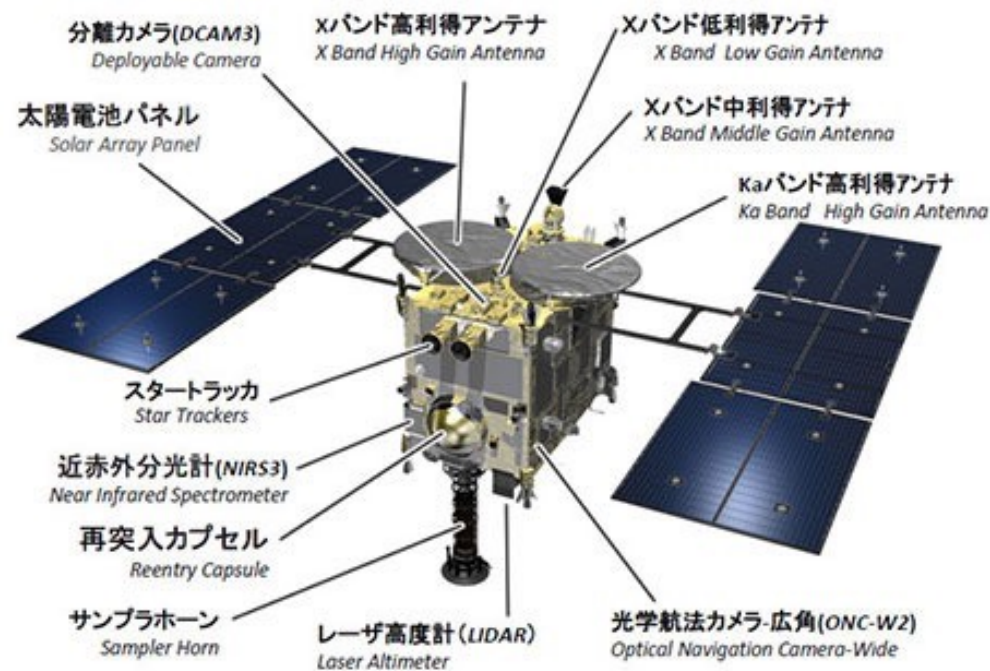
▶ Japanese Satellite Mission by JAXA

- in Cooperation with DLR and CNES (MASCOT - Lander)

▶ Mission Overview (Successor of Hayabusa - launched in May 2003 / landed on Asteroid Itokawa in Nov. 2005 / returned in June 2010):

- studying the origin and evolution of the solar system as well as materials for life - **launched 2014 / landing 2018 / return 2020**

first return of
asteroidal material back
to Earth



JAXA



Preparation of Space Missions - Hayabusa 2

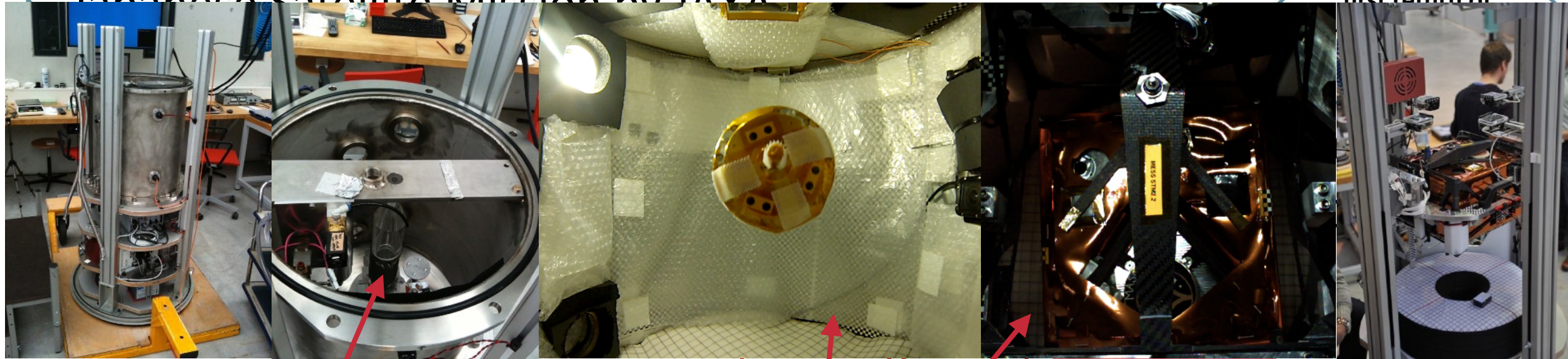
Peregrine Falcon



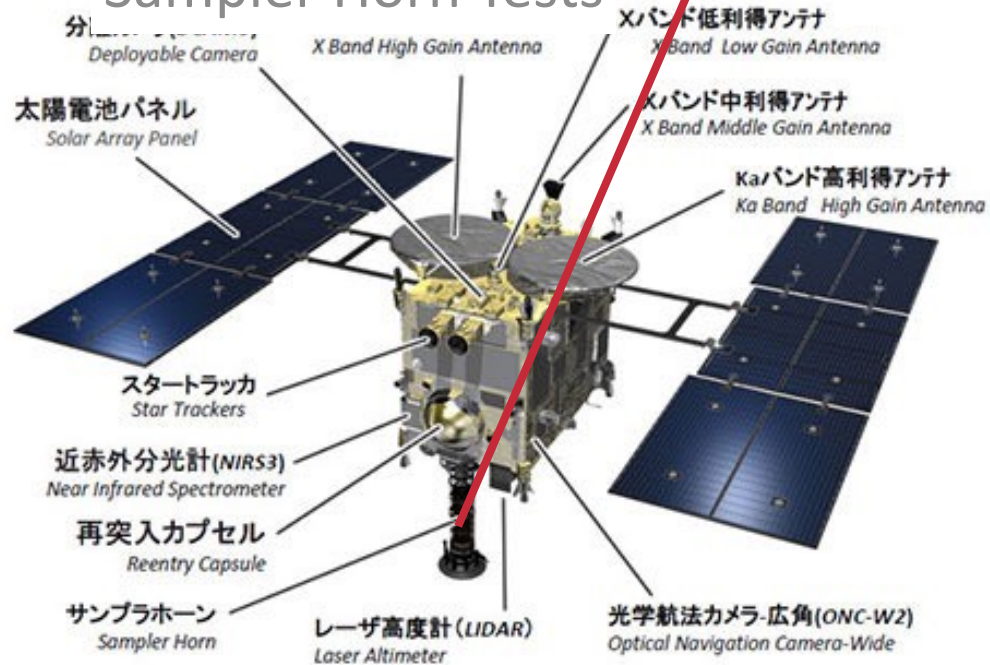
► Asteroid Explorer Mission (Target: Asteroid Ryugu)

Japanese Satellite Mission by JAXA

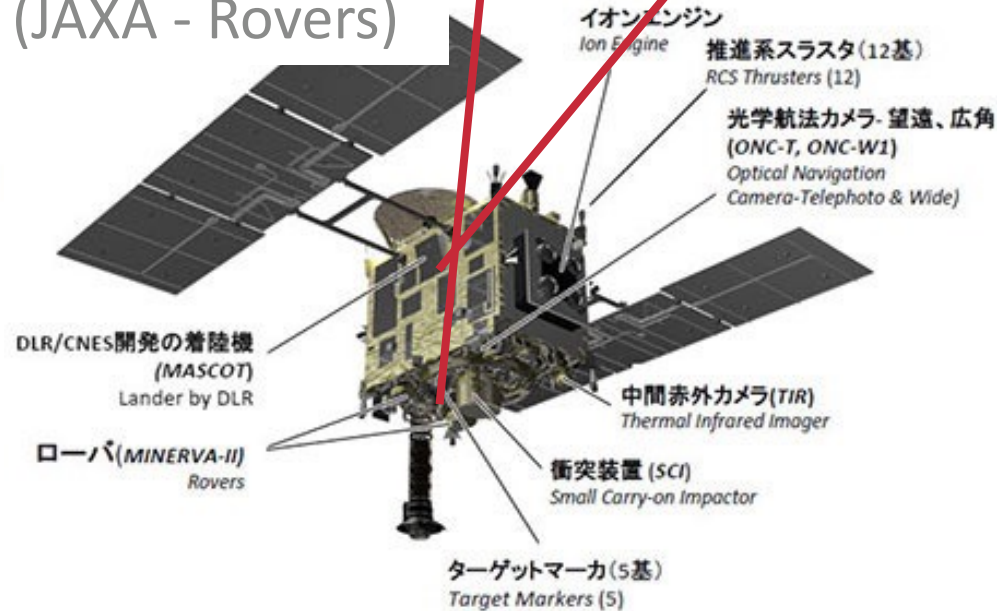
first return of



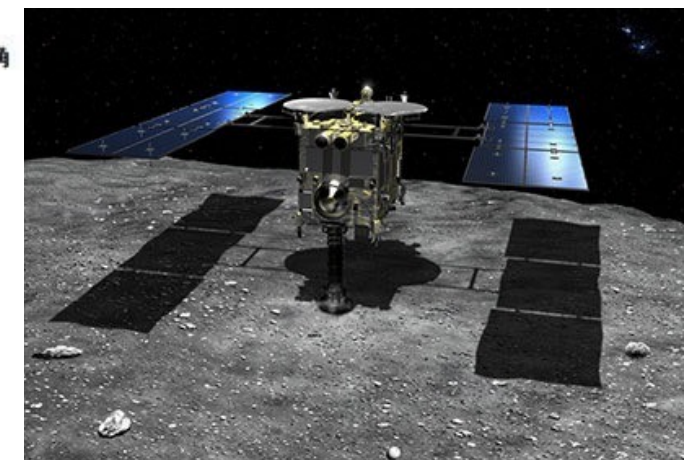
Sampler Horn Tests



Deployment Tests (JAXA - Rovers)



Separation Tests (DLR - Lander)



JAXA

Stepping Stone into Space

► Bremen Drop Tower



bottom-up
approach

TO SPACE MISSIONS

► breadboards for sounding rockets

► integration, preparation, and qualification:

1. testing the suborbital / orbital setup
2. probing experiment parameters
3. obtaining first results in microgravity

► breadboards for space missions

Bremen Drop Tower

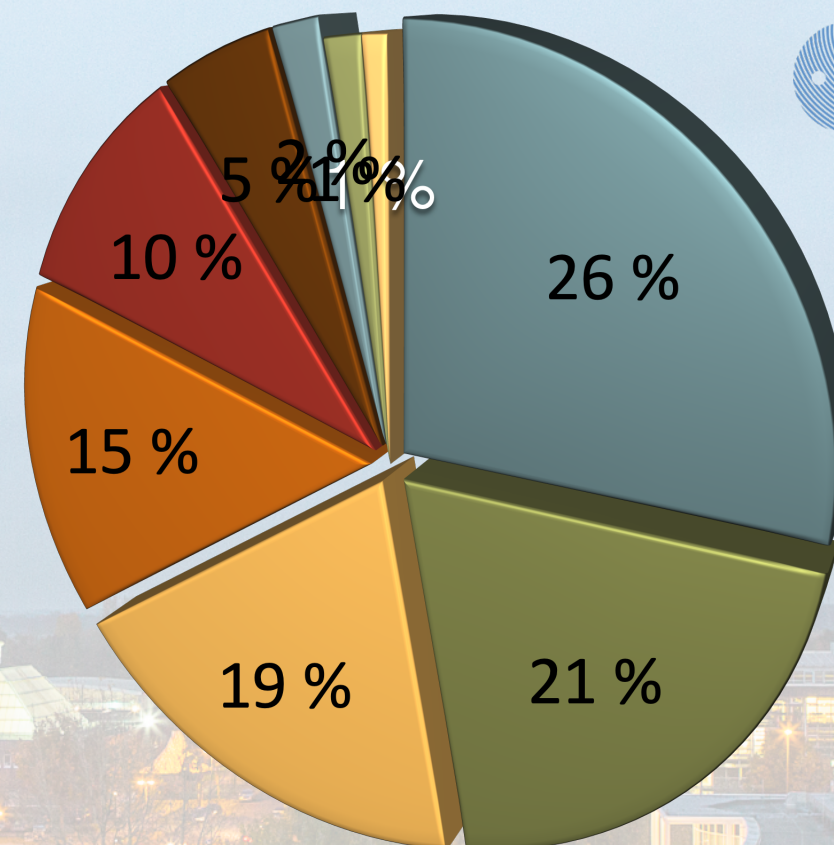
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Bremen Drop Tower

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DROPTES

- DROP TOWER EXPERIMENT SERIES -



UNITED NATIONS
Office for Outer Space Affairs



DROP YOUR THESIS!



REXUS / BEXUS



Rymdstyrelsen
Swedish National Space Agency



Bremen Drop Tower



Bremen Drop Tower



Kiruna, Sweden



Bremen Drop Tower

DROPTES

- DROP TOWER EXPERIMENT SERIES -



UNITED NATIONS
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DROP YOUR THESIS!



REXUS / BEXUS



Rymdstyrelsen
Swedish National Space Agency



Bremen Drop Tower



Bremen Drop Tower

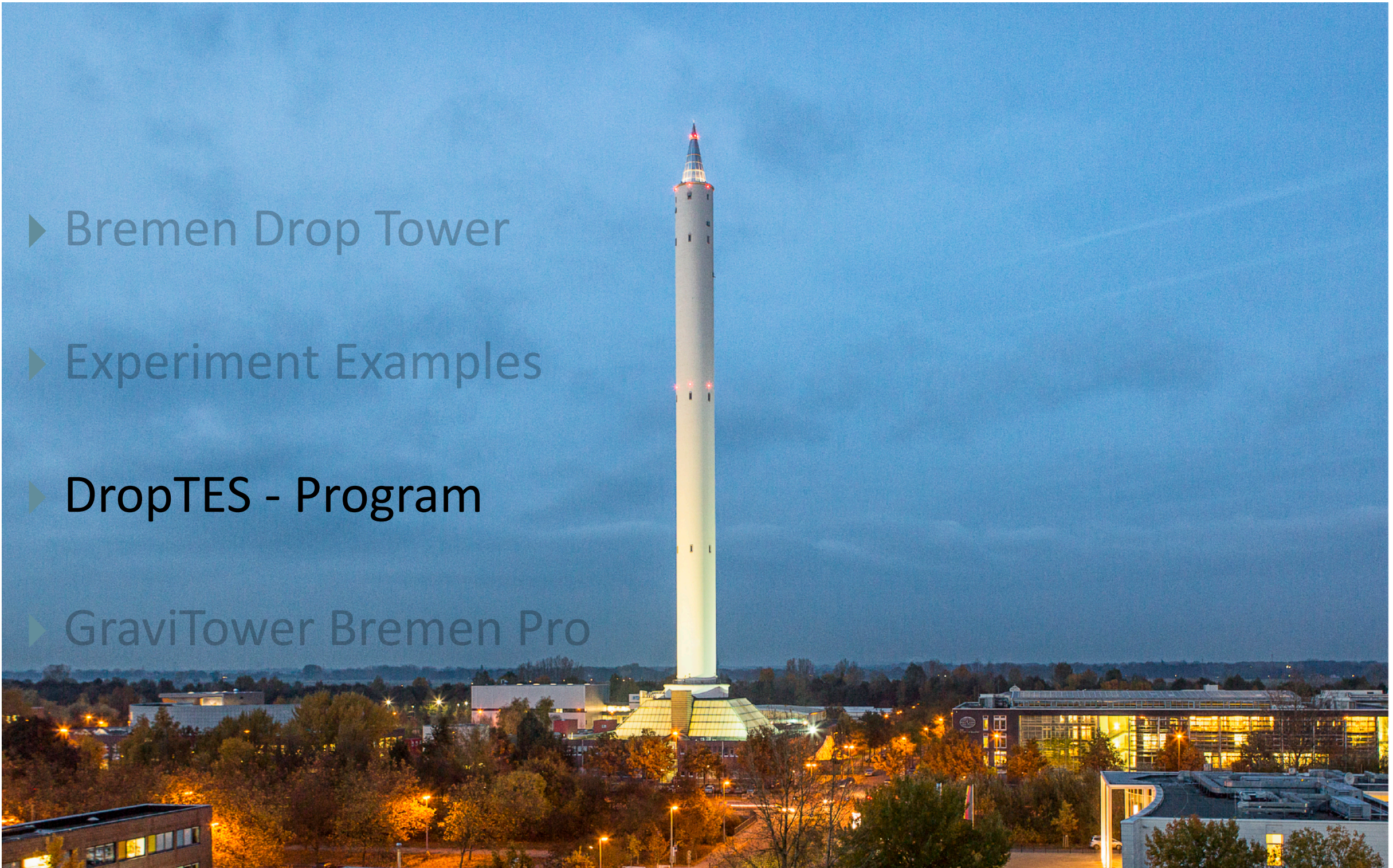


Kiruna, Sweden



Content

- ▶ Bremen Drop Tower
- ▶ Experiment Examples
- ▶ DropTES - Program
- ▶ GraviTower Bremen Pro



DropTES - Drop Tower Experiment Series

► General Program Information



UNITED NATIONS
Office for Outer Space Affairs



- UNOOSA - Access to Space for All Initiative
- Annual Science Activity at the Bremen Drop Tower
- First Cycle was initiated by UNOOSA, DLR, and ZARM in 2014
 - Executing Agency:
United Nations Office for Outer Space Affairs (UNOOSA)
 - Supporting Agency:
German Aerospace Center (DLR) Space Management
 - Hosting Institution:
Center of Applied Space Technology and Microgravity (ZARM)



DropTES - Drop Tower Experiment Series

► General Program Information



UNITED NATIONS
Office for Outer Space Affairs



- open to student research teams from entities that are Member States of the United Nations
- research teams should consist of up to four Bachelor, Master and/or PhD students who must be endorsed by an academic supervisor
- allows to realize a real space / microgravity research project
- shall be an integral part of the student's syllabus, e.g. as Bachelor, Master and/or PhD theses
- follows space project guidelines (proposal, reports, reviews)
- each drop tower experiment series consists of four drops or catapult launches which have to be conducted within one week
- travel, accommodation, and drop tower utilization are sponsored
- program language: English / program duration: usually 1 year / experiment series at the Bremen Drop Tower: November

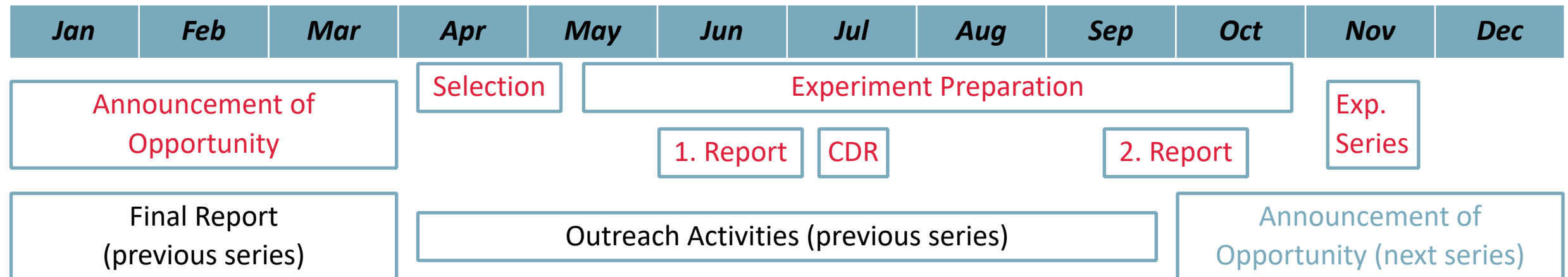


DropTES - Drop Tower Experiment Series

► DropTES - Schedule



UNITED NATIONS
Office for Outer Space Affairs



► Selection Process:

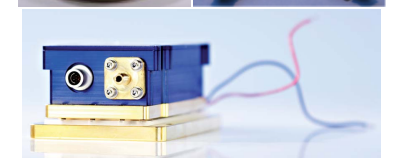
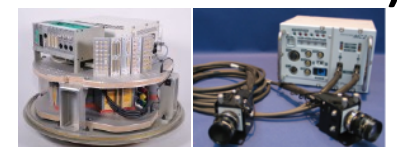
- proposal evaluation by selection board (UNOOSA, DLR, and ZARM)
- one research team per DropTES cycle will be selected each year

► Experiment Preparation (Home Laboratory):

- assisted by ZARM (consulting, drawings, manufacturing of hardware)

► Experiment Series (Bremen Drop Tower):

- experiment integration (drop tower capsule) - first week
- experiment drops or catapult launches - second week

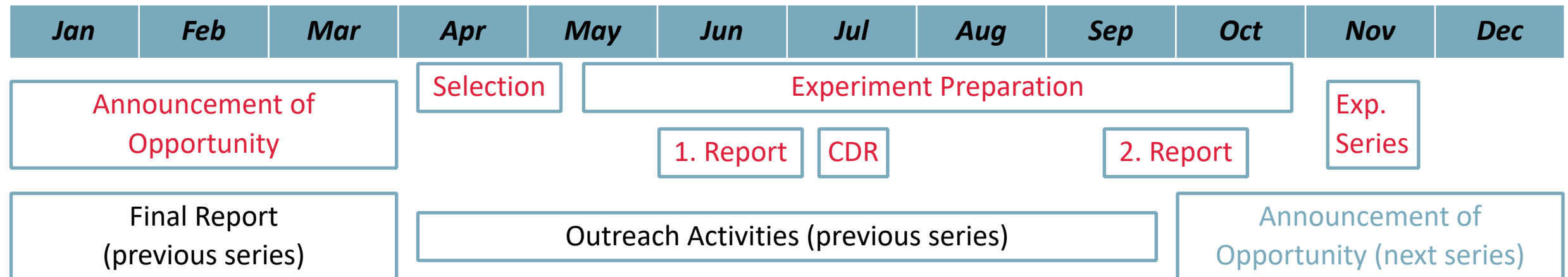


DropTES - Drop Tower Experiment Series

► DropTES - Schedule



UNITED NATIONS
Office for Outer Space Affairs



► Experiment Series (Accommodation):

- academic supervisor - in a hotel next to the drop tower
- up to four students - in ZARM's apartment at the facility on side

- Weather Conditions -
Bremen in November (avg.)
max. 8.0°C / min. 2.3°C
sun: 1.8 h/d, rain: 11.5 d



- two separate rooms with two beds each



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ZENTRUM FÜR
ANGEWANDTE RAUMFAHRTTECHNOLOGIE
UND MIKROGRAVITATION

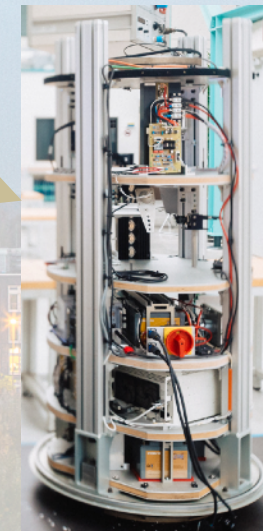
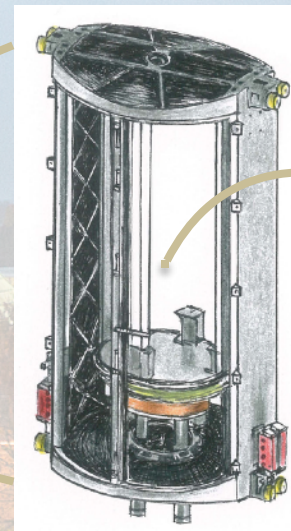
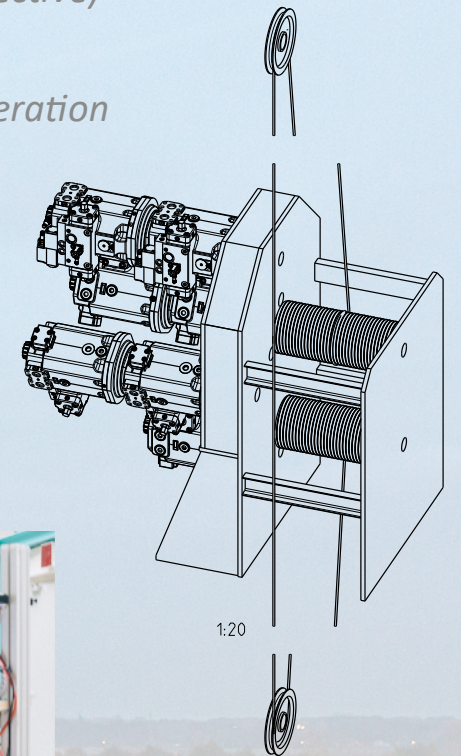
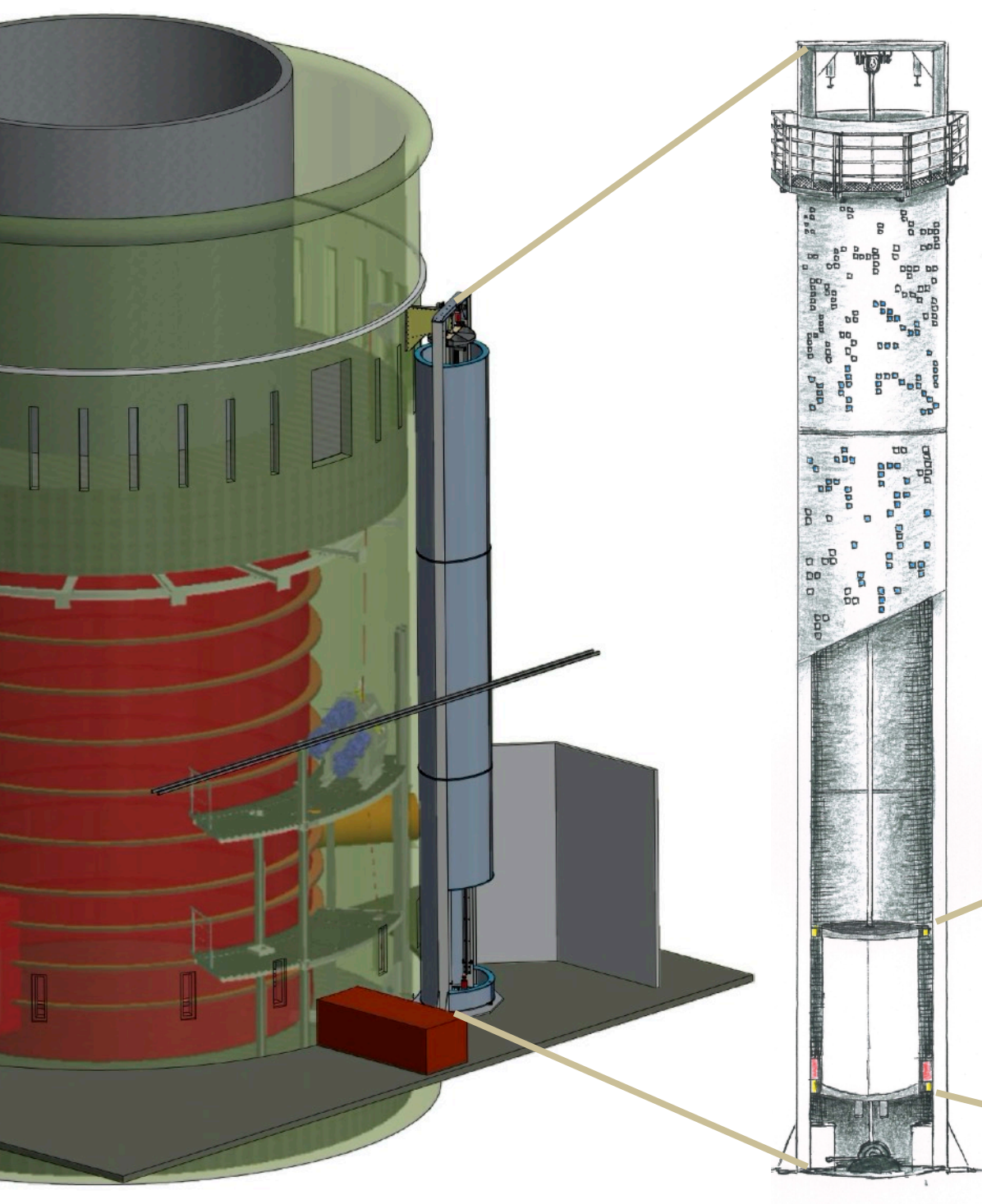


Next-Gen Microgravity Facility

► GraviTower Bremen Pro

FACTS ABOUT THE GTB PRO

- **over 100 experiments per day**
- **2.5 s in microgravity (first development stage)**
 - dedicated tower: 8 s microgravity (GTB)
 - partial gravity: Moon / Mars (objective)
- **„rail-guided system“**
 - with only 4 g acceleration / deceleration
 - without limiting factor - vacuum (capsule-in-capsule system)
 - based on an active rope drive (commercial hydraulic winches)
- **standard catapult / short capsule**
 - synergy with Bremen Drop Tower

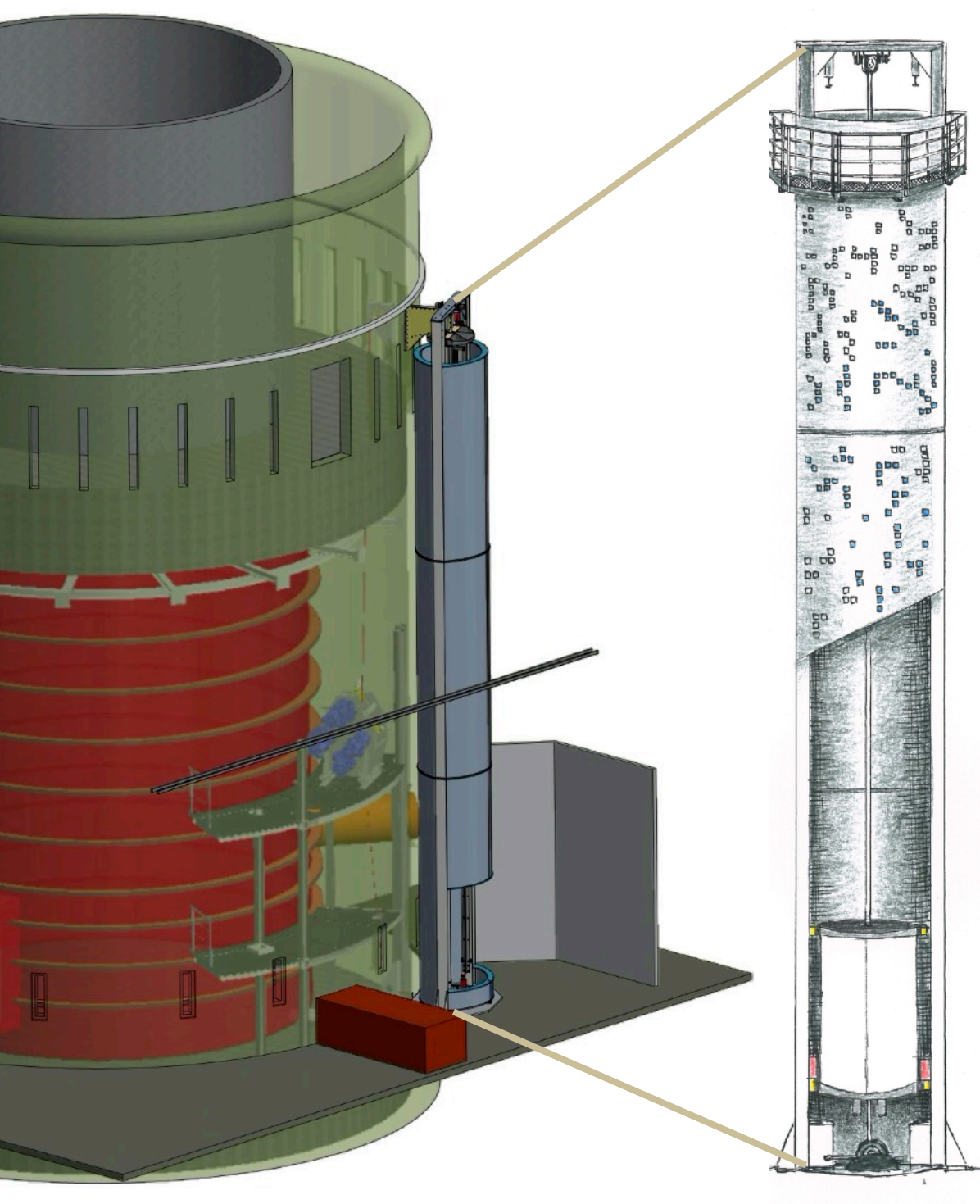


Next-Gen Microgravity Facility

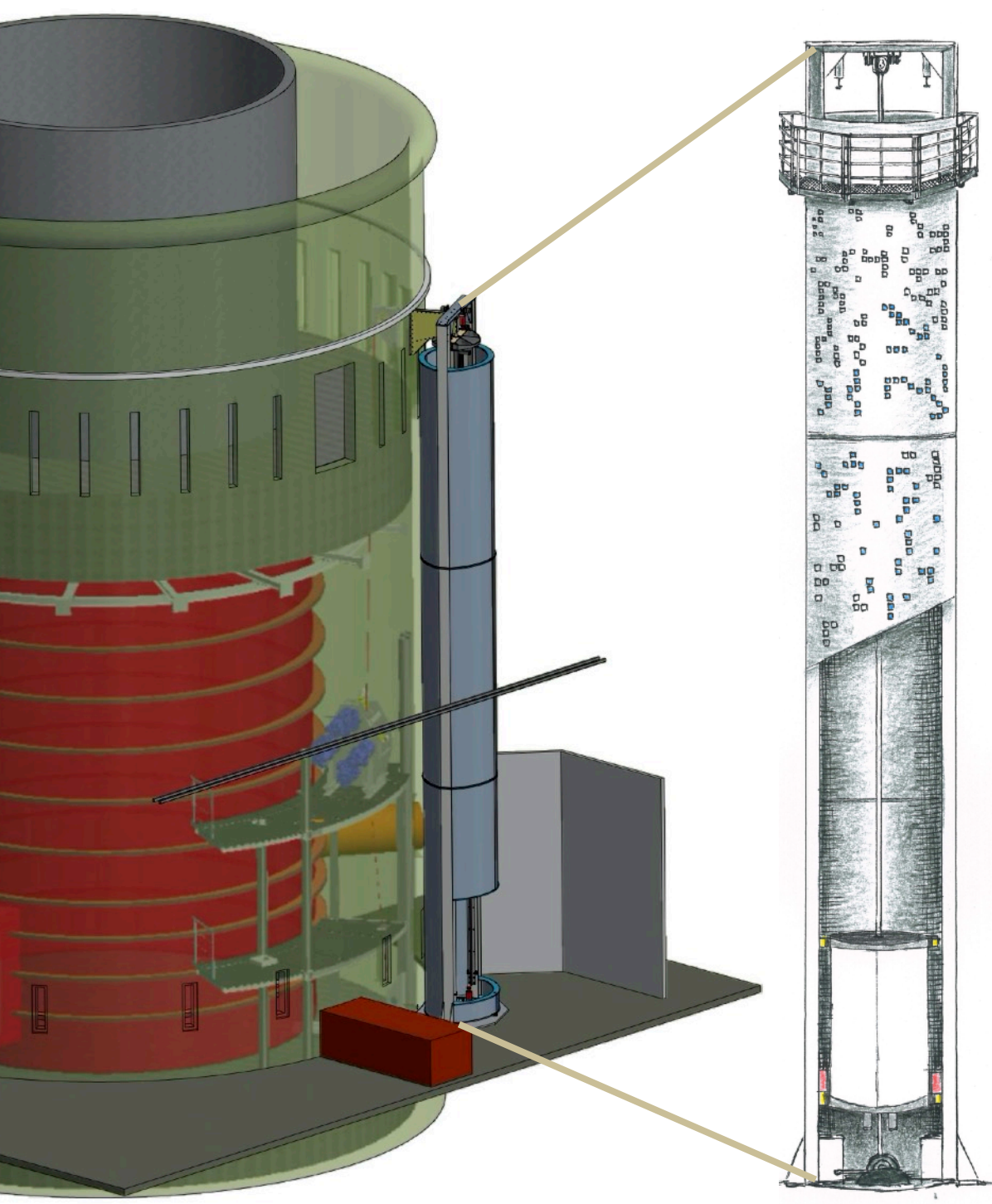
► GraviTower Bremen Pro

STATUS OF THE GTB PRO

- *first test assembling / run (hydraulic winches) in May, 2019*
- *final assembly (integration hall) - first half of 2020*
- *initial operation (slider with test masses) since July, 2020*



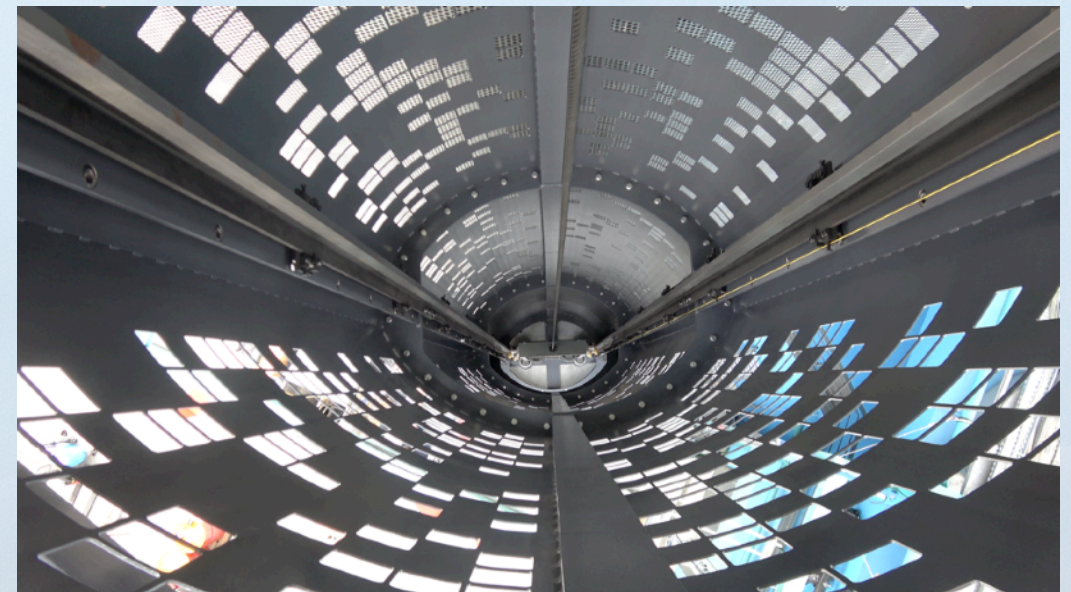
Next-Gen Microgravity Facility



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- *initial operation (slider with test masses) since July, 2020*



► full commissioning: mid-2021

► also available for DropTES

THANK YOU VERY MUCH FOR YOUR ATTENTION

ACKNOWLEDGEMENTS



UNITED NATIONS
Office for Outer Space Affairs



Gefördert durch:



Bundesministerium
für Wirtschaft
und Energie

aufgrund eines Beschlusses
des Deutschen Bundestages



ZARM FAB MBH

WWW.ZARM.UNI-BREMEN.DE



CENTER OF
APPLIED SPACE TECHNOLOGY
AND MICROGRAVITY

