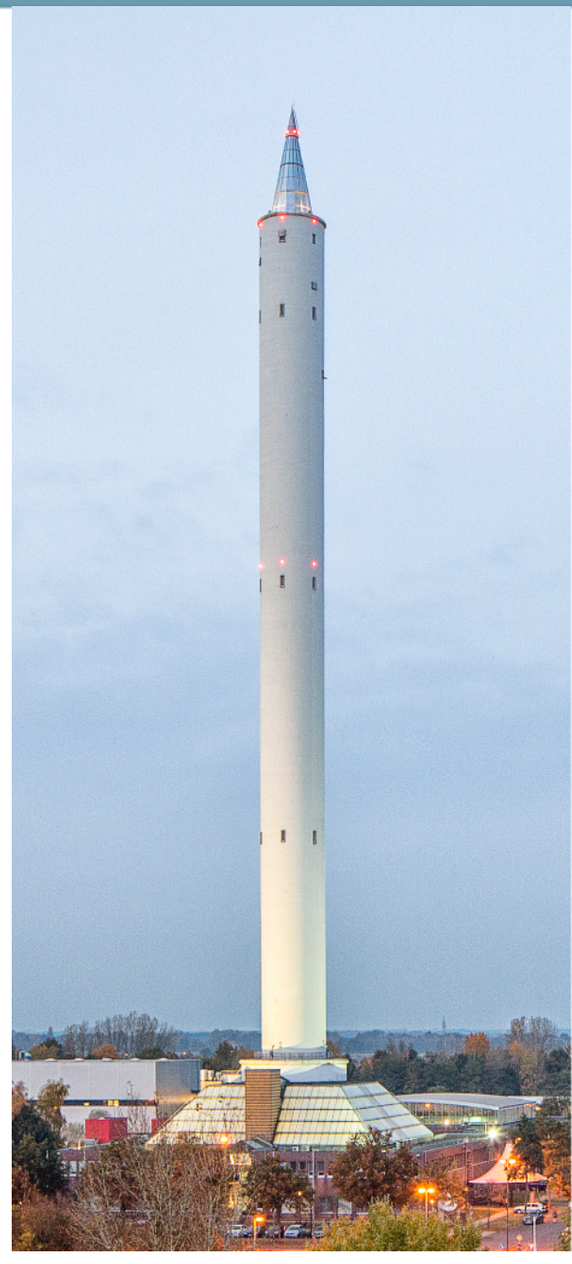
UN FELLOWSHIP PROGRAM - DROPTES

@ THE BREMEN DROP TOWER

DropTES Webinar: 8th Round Announcement of Opportunity
Feb. 11, 2021 - Bremen, Germany

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



Universität Bremen

CENTER OF
APPLIED SPACE TECHNOLOGY
AND MICROGRAVITY

ZARM

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
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ZARM FAB mbH

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

ZARM Technik AG

Supplier of Attitude Control Equipment for Satellites

Holger W. Oelze
(Chief Executive Officer)

Peter von Kampen
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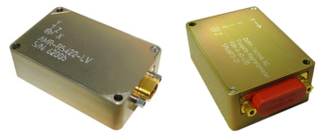
Marco R. Fuchs
(Chairman of Supervisory Board)



- Research / Teaching
- Technical Support
- Space Hardware

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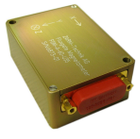


- Research / Teaching
- Technical Support
- Space Hardware

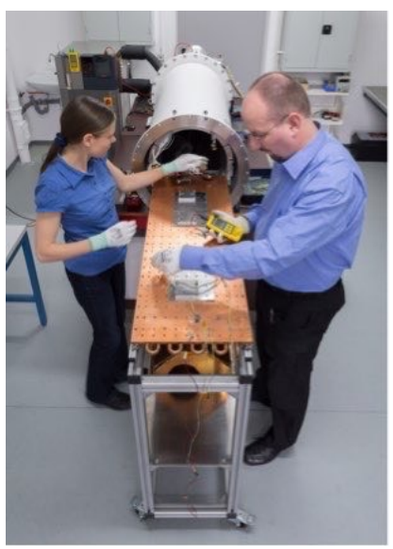
ZARM

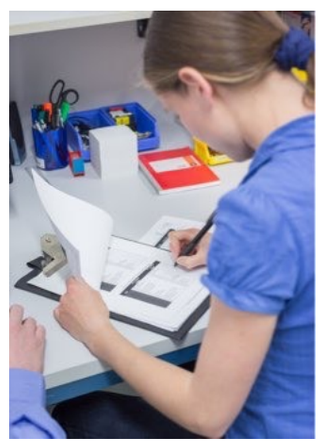
ZARM TEST CENTER - we.know.how.

know-how, reliability, flexibility, customer-focused solutions

- Convenient Combination of ZARM's Test Labs
  - Aerospace Qualification and Test Services under one roof
    - VIBRATION TEST LAB - LONG STROKE SHAKER (35.6 kN)

    - THERMAL VACUUM LAB - LARGE-/MEDIUM-/SMALL-SIZED TVCs + TCC





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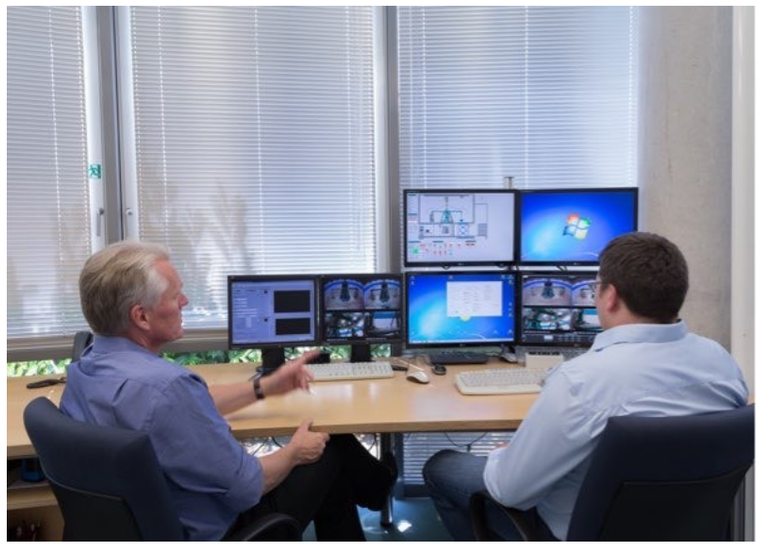
    - 30g CENTRIFUGE - EUROPE's LARGEST HYPER-GRAVITY FACILITY



- ZARM Test Center - Team

- ELECTRICAL TEST SERVICES
  (in cooperation with Aircraft Elektro/Elektronik System GmbH)
- VARIETY OF TEST STANDARDS:
  RTCA DO-160, MIL-STD-810, …

Content

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

ZENTRUM FÜR
ANGEWANDTE RAUMFAHRTTECHNOLOGIE
UND MIKROGRAVITATION

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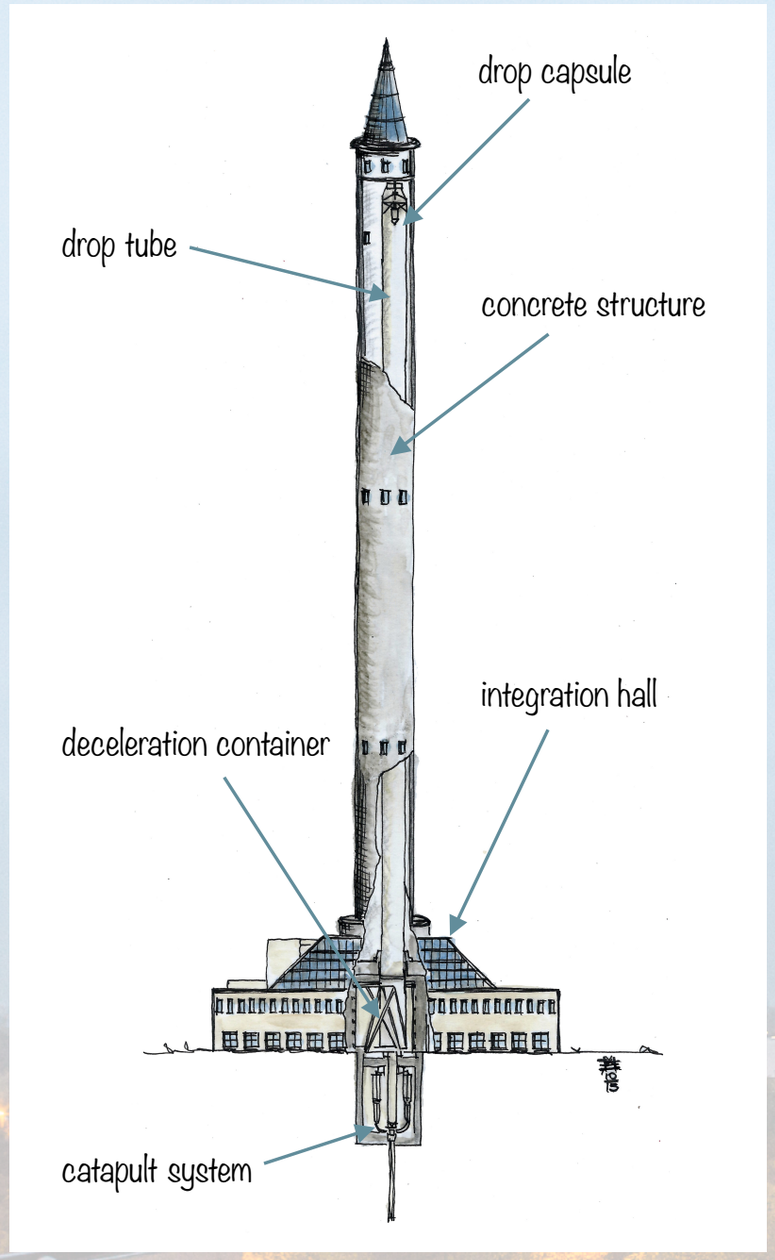
Bremen Drop Tower



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 m^3 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 m^3 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

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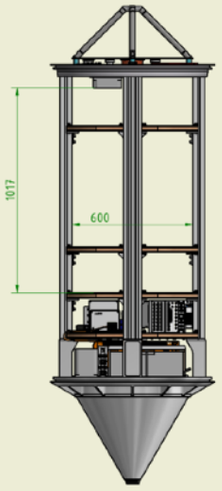
Bremen Drop Tower

Experimenter’s Integration Area / Payload Services

- Standard Capsule Versions:
  - payload masses -

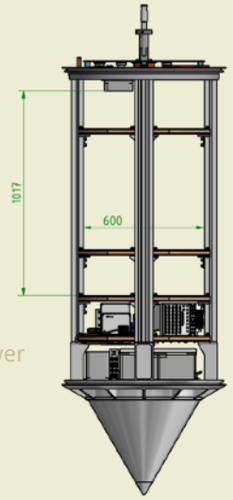
- catapult



- CCS
- power

- 165 kg -

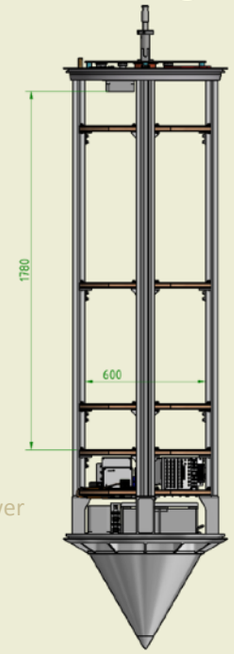
- short



- CCS
- power

- 265 kg -

- long



- CCS
- power

- 225 kg -

Bremen Drop Tower

- *RESEARCH AREAS OF DROP TOWER EXPERIMENTS*
  - *fundamental research*
  - *technology development (mission preparations)*

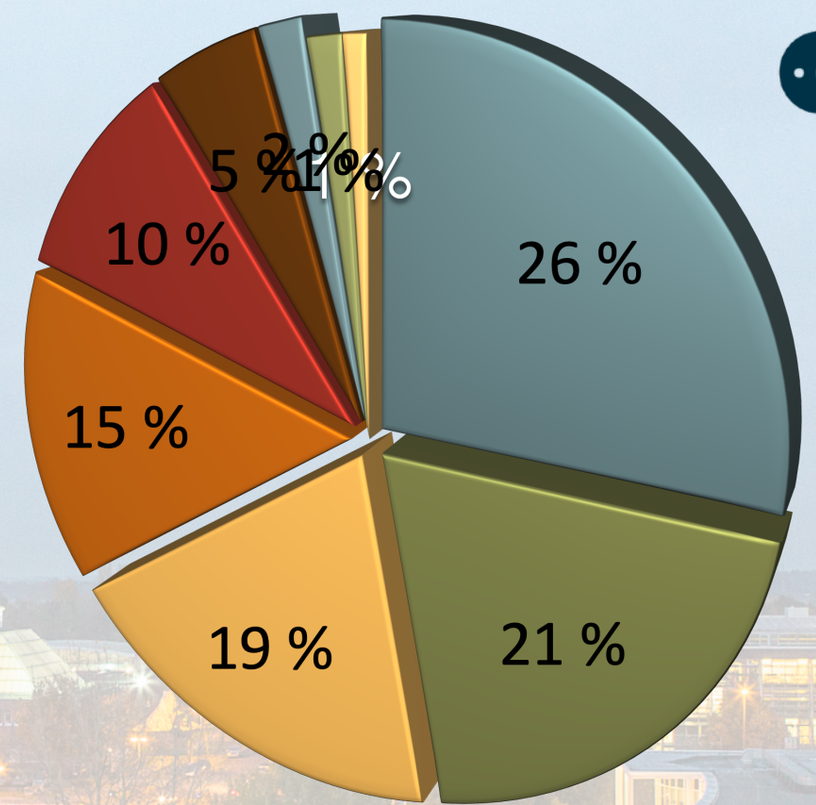
- Combustion
- Fundamental Physics
- Fluid Dynamics
- Astrophysics (Planet Formation)
- Materials Sciences
- Biology
- Hardware Tests
- Student Programs
- Chemistry

FACTS AND FIGURES

- *start of operation: September 1990*
- *number of drops / catapult launches: over 9000 performed*
- *number of drop tower projects: over 230 assisted*
- *framework contractor of*

DLR

esa



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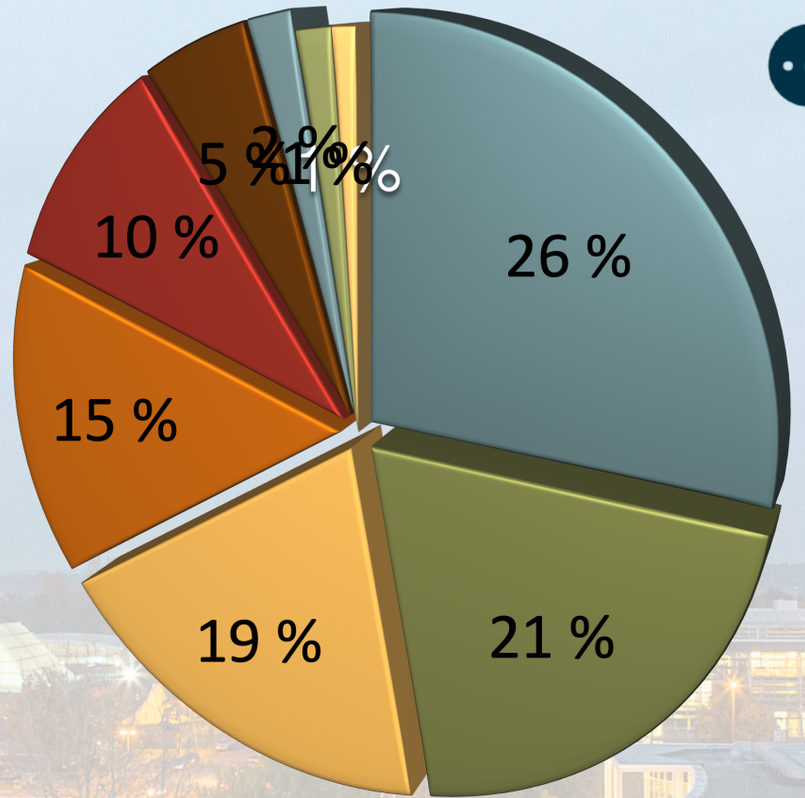

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Experiment Examples

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GENERAL INFORMATION EXPERIMENT SUPPORT **PROJECTS** TEAM

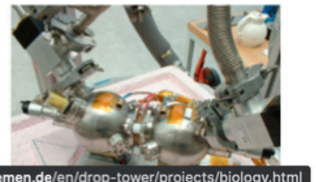
PROJECTS @ BREMEN DROP TOWER

ASTROPHYSICS

The question of the origin of life in our universe is closely connected to the formation of planets. At the drop tower scientists investigate the fundamental growth of young planets from dust particles. more...

BIOLOGY

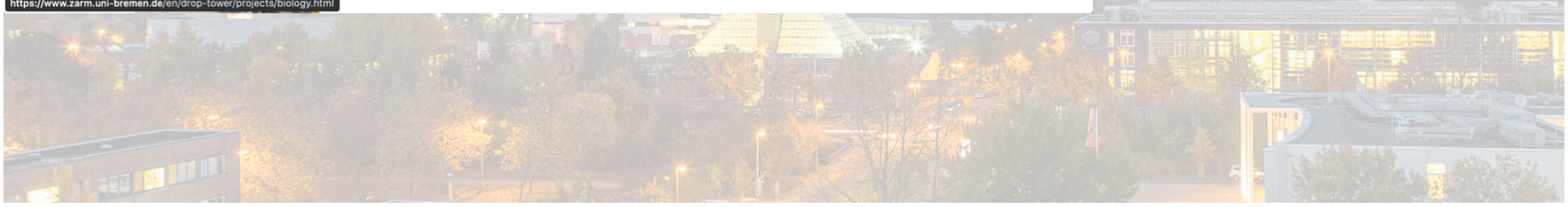
How does a biological organism respond to an environment of weightlessness? - Biology experiments performed i.a. with freely falling roots at the drop tower give adequate answers. more...



CHEMISTRY

Life on Earth originated from amino acids!? - Drop tower tests for the Miller-Urey experiment in space. more...

https://www.zarm.uni-bremen.de/en/drop-tower/projects/biology.html



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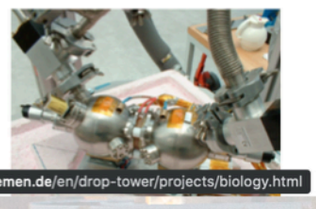

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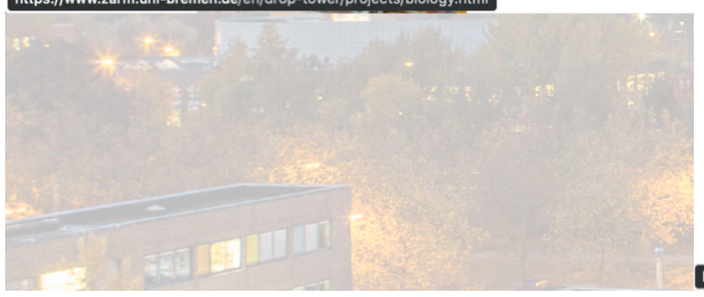

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COMBUSTION

An efficient combustion with the lowest possible emissivity is essential for future engine developments. Combustion research at the drop tower provides new measurement and diagnostic tools in order to support numerical simulations. more...

UNITED NATIONS Office for Outer Space Affairs

DROPTES

Your opportunity to conduct your own scientific experiment in microgravity conditions as part of your Bachelor's, Master's and/or PhD thesis by participating in a Drop Tower Experiment Series (DropTES) at the Bremen Drop Tower organized by the United Nations Office for Outer Space Affairs. more...

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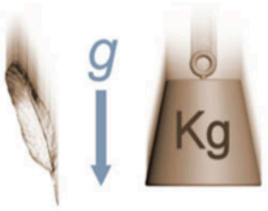
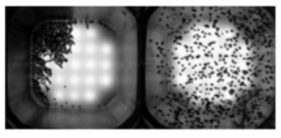
FLUID DYNAMICS

How can a spacecraft tank supply gas-free propellant without the supporting effect of weightlessness? Only one of many questions that fluid dynamics experiments at the drop tower are expected to resolve. more...



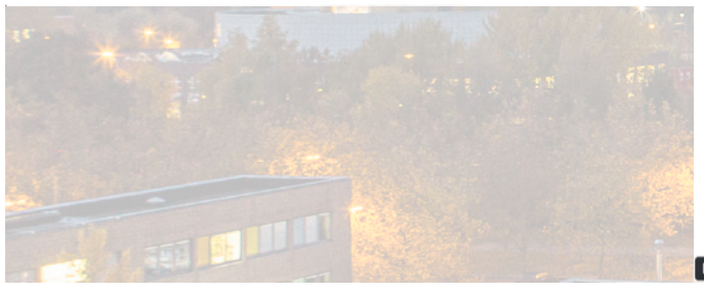
FUNDAMENTAL PHYSICS

Is Einstein right? - Microgravity experiments allow accurate investigations of relativistic effects and quantum-physical phenomena. For instance, at the Bremen Drop Tower the world-wide first Bose-Einstein Condensate (BEC) in weightlessness could be realized - an ensemble of coldest atoms, which can be used for high-precision measurements. more...



MATERIALS SCIENCES

Material and technology tests are important for fail-safely space-based operations. Thus, pretesting of hardware under appropriate environmental conditions is required. Furthermore, weightlessness provides an ideal basis to fundamentally investigate material properties and behaviors. more...



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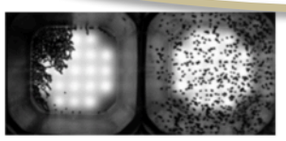

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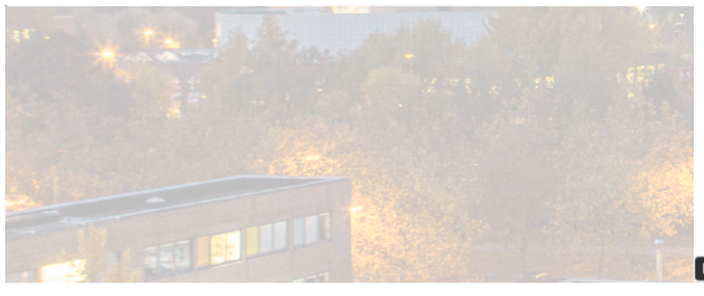

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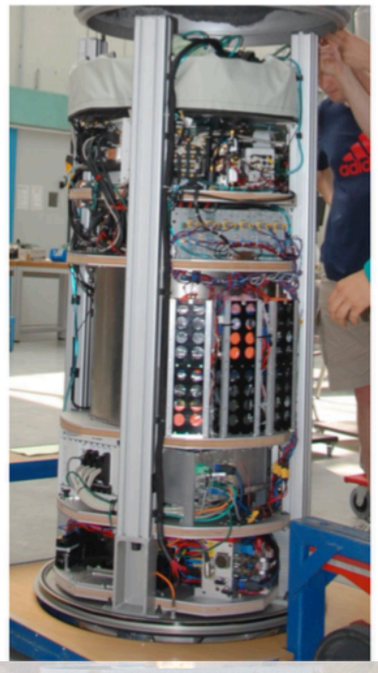
ULTRACOLD MACROSCOPIC QUANTUM SYSTEMS IN WEIGHTLESSNESS (QUANTUS) - BOSE-EINSTEIN CONDENSATES IN WEIGHTLESSNESS



research area: fundamental physics

experiment title:

Ultracold macroscopic quantum systems in weightlessness (QUANTUS) - Bose-Einstein Condensates in weightlessness

experiment acronym:

QUANTUS I / QUANTUS II

funding agency: DLR

grant number:

50WM0346 (2004 - 2007), 50WM0836 (2008 - 2010), 50WM1135 (2011 - 2014), 50WM1555

performing organization:

Institut für Quantenoptik (IQO), Leibniz Universität Hannover /

ZARM, Universität Bremen /

DLR - Institut für Raumfahrtsysteme, Bremen /

Institut für Laserphysik, Universität Hamburg /

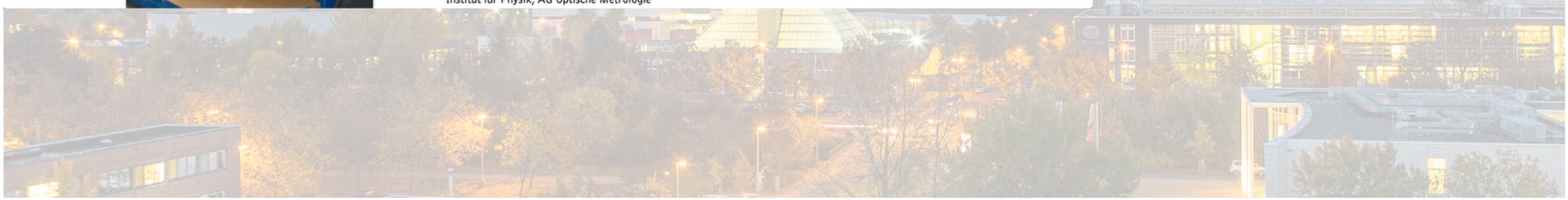
Institut für Physik, AG Optische Metrologie

FUNDAMENTAL PHYSICS

- ASTROPHYSICS
- BIOLOGY
- CHEMISTRY
- COMBUSTION
- DROPTES
- DROP YOUR THESIS!
- FLUID DYNAMICS
- FUNDAMENTAL PHYSICS

  ATKAT
  DUFF
  EARTH ROTATION
  GRAVI
  MICE
  MICROSCOPE
  PRIMUS
  QUANTUS

- MATERIALS SCIENCES



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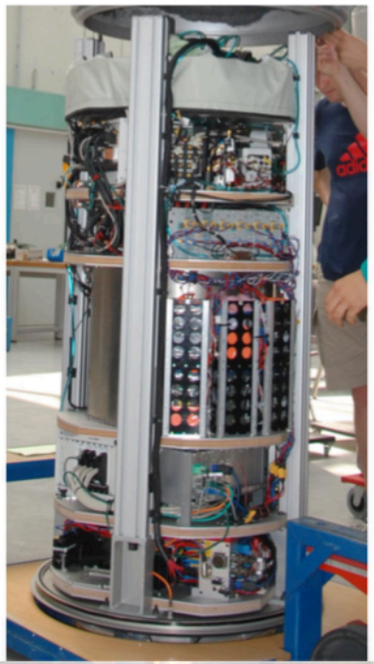

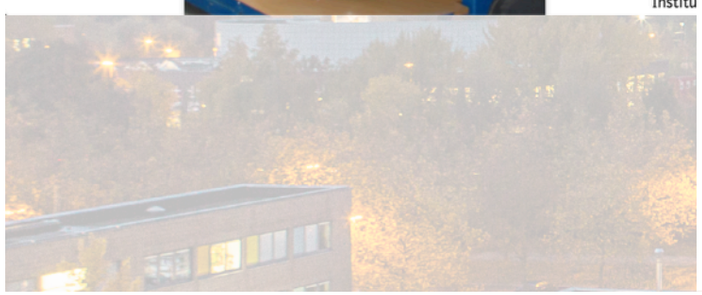

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EXPERIMENT OBJECTIVE

abstract

Physics based on laser cooled atomic ensembles and quantum degenerate gases, such as Bose-Einstein Condensates (BEC), became a fast growing field of research since the first realization of a Bose-Einstein Condensate with a dilute gas of atoms in 1995. Many quantum mechanical phenomena like matter waves interferences, superfluidity, solitons or Bloch-oscillations are research subjects in various laboratories worldwide. On the field of quantum sensors, condensates can serve as an ideal coherent atomic source. These quantum sensors have promising applications ranging from geodesy over metrology up to fundamental questions as tests of the equivalence principle. Inertial sensors can be realized with free-falling atoms, whereas the sensitivity increases with the quadratic time of flight. An increase of the sensitivity in this way gives the need of environments with low vibrations and of minimizing the energy to unprecedented temperatures. Microgravity offers the advantage of unequaled regimes of coldest temperatures, macroscopic dimensions of matter waves and longest free evolution of the condensate on the time scale of seconds.

Within the QUANTUS pilot project an experiment for the implementation of a Bose-Einstein Condensate in microgravity was designed and constructed followed by the realization of the first BEC in weightlessness. The drop tower in Bremen was chosen to be the most ideal platform, since there is a relatively easy access to the experiment, excellent micro-gravitational conditions, 4.74 seconds of free fall and a repetition rate of up to three drops per day. The restrictions on the usable space, the available power of the battery, the maximum weight and the exigency of a remote controlled system are basic conditions, that make this apparatus a prototype of a mobile BEC experiment implementable in ballistic rockets or space missions like on board the ISS.

The realization of the first BEC in microgravity on November 13th, 2007 was followed by the first free evolution of a condensate in the time domain of 1 second. This experiment could open new roads for applications especially in the field of atom interferometers. The interplay of a high sensitive optical systems and quantum optics on the one hand and a compact, robust and remote controlled experiment on the other hand was shown.

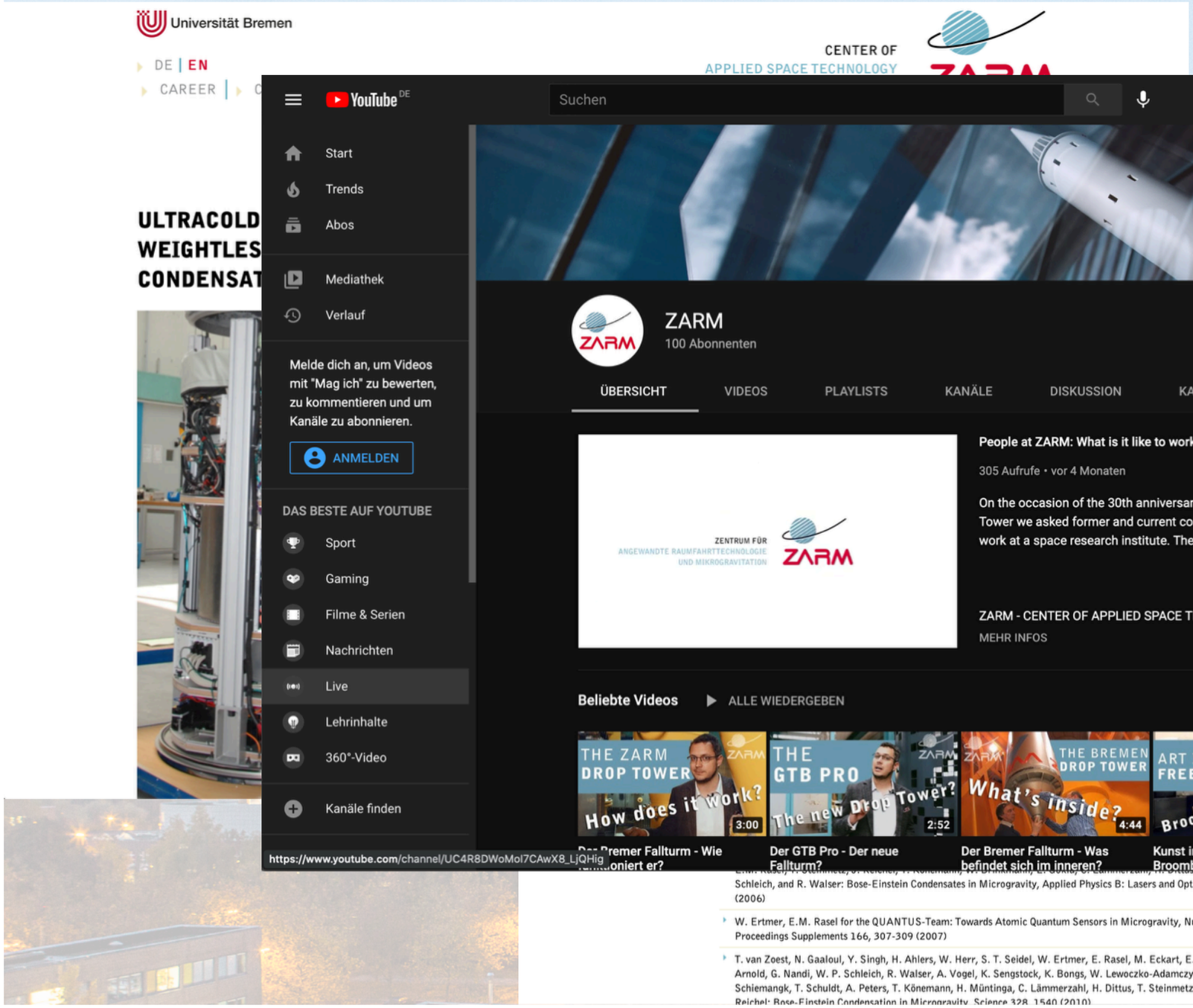
Within the QUANTUS II experiment a further step forward in technology development and science with cold atoms was made. The initial QUANTUS experiment and its successors are still on-going projects with very promising scientific results and future applications on earth and in space.

RELATED PUBLICATIONS

- A. Vogel, M. Schmidt, K. Sengstock, K. Bongs, W. Lewoczko-Adamczyk, T. Schuldt, A. Peters, T. van Zoest, W. Ertmer, E.M. Rasel, T. Steinmetz, J. Reichel, T. Könemann, W. Brinkmann, E. Göklü, C. Lämmerzahl, H. Dittus, G. Nandi, W.P. Schleich, and R. Walser: Bose-Einstein Condensates in Microgravity, Applied Physics B: Lasers and Optics 84, 663-671 (2006)
- W. Ertmer, E.M. Rasel for the QUANTUS-Team: Towards Atomic Quantum Sensors in Microgravity, Nuclear Physics B - Proceedings Supplements 166, 307-309 (2007)
- T. van Zoest, N. Gaaloul, Y. Singh, H. Ahlers, W. Herr, S. T. Seidel, W. Ertmer, E. Rasel, M. Eckart, E. Kajari, S. Arnold, G. Nandi, W. P. Schleich, R. Walser, A. Vogel, K. Sengstock, K. Bongs, W. Lewoczko-Adamczyk, M. Schiemangk, T. Schuldt, A. Peters, T. Könemann, H. Müntinga, C. Lämmerzahl, H. Dittus, T. Steinmetz, T. W. Hänsch, J. Reichel: Bose-Einstein Condensation in Microgravity, Science 328, 1540 (2010)

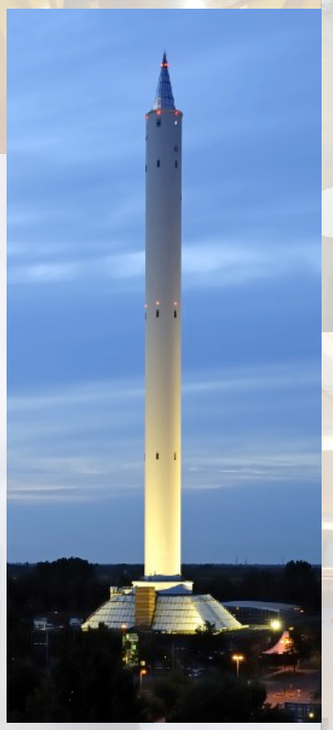
Experiment Examples

WWW.ZARM.UNI-BREMEN.DE



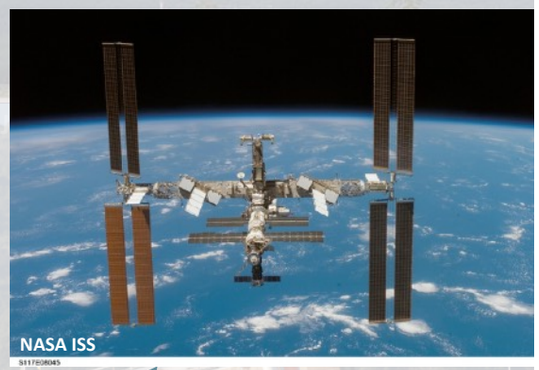
Experiment Examples

- Bremen Drop Tower - Stepping Stones into Space



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

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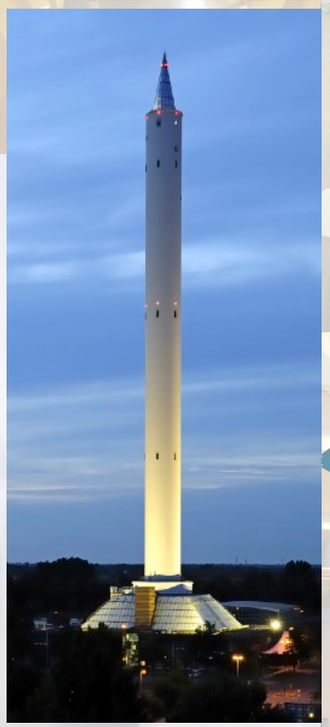
Experiment Examples

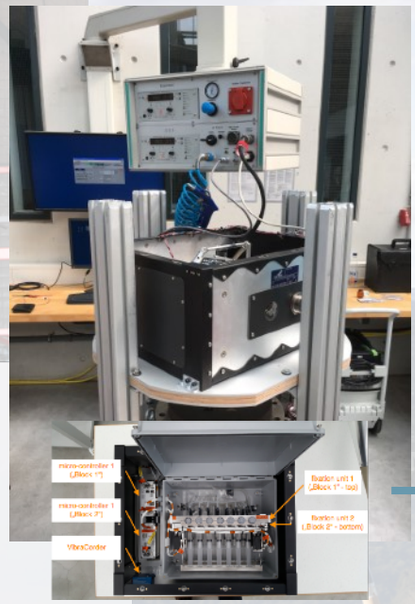
- Bremen Drop Tower - Stepping Stones into Space

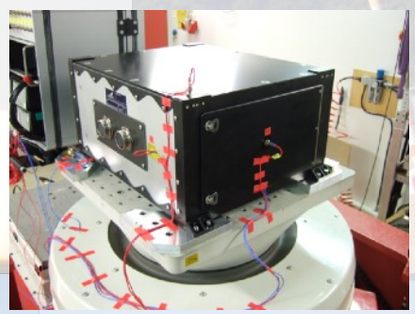


- Drop Tower

- TEXUS / MAXUS

- MAPHEUS





- New Shepard

- Experiments / Tests - Technology Readiness Level (TRL)

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
- Biology
- Hardware Tests
- Student Programs
- Chemistry

FACTS AND FIGURES

- *start of operation: September 1990*
- *number of drops / catapult launches: over 9000 performed*
- *number of drop tower projects: over 230 assisted*
- *framework contractor of*

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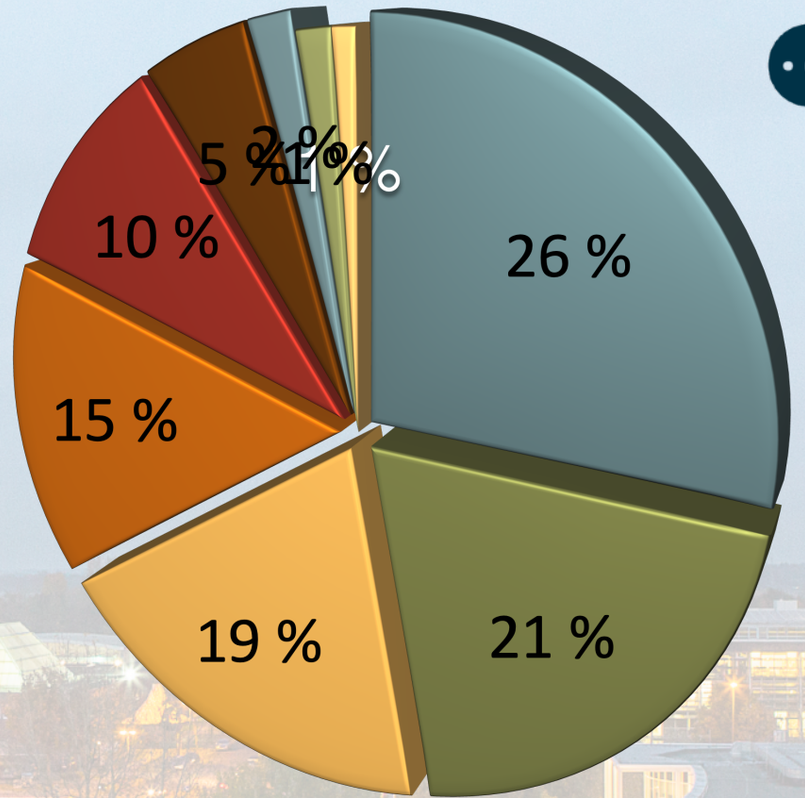
esa



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    - Chemistry

DROPTES

- DROP TOWER EXPERIMENT SERIES -

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Office for Outer Space Affairs

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DROP YOUR THESIS!

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esa academy

drop your thesis!

REXUS / BEXUS

DLR

Rymdstyrelsen
Swedish National Space Agency

REXUS/BEXUS
Student Experiment Programme

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Bremen Drop Tower

- *RESEARCH AREAS OF DROP TOWER EXPERIMENTS*
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Swedish National Space Agency

REXUS/BEXUS
Student Experiment Programme

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Content

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

DropTES - Drop Tower Experiment Series

- General Program Information

  - 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

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  - 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 five 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: June / July

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DropTES - Drop Tower Experiment Series

DropTES - Schedule

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Feb	->	June	July	Aug	->	Nov	->	Feb +1	May +1	June +1	Sep +1
Announcement of Opportunity			Selection	Experiment Preparation						Exp. Series	Final Report
						1. Report	CDR	2. Report			
									20 June 2022 - 01 July 2022		

Selection Process:

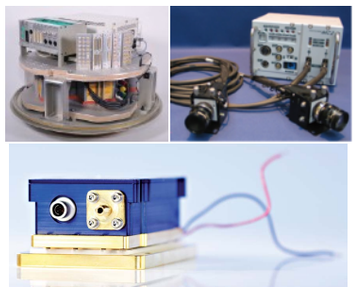
- proposal evaluation by selection board (UNOOSA, DLR, and ZARM)
- one research team per DropTES cycle will be selected each year

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



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DropTES - Drop Tower Experiment Series

DropTES - Schedule

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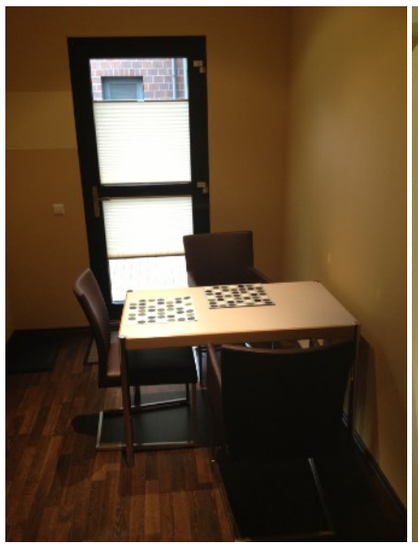
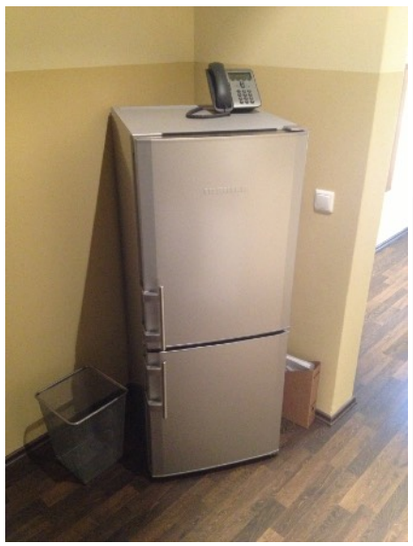
Feb	->	June	July	Aug	->	Nov	->	Feb +1	May +1	June +1	Sep +1
Announcement of Opportunity			Selection	Experiment Preparation						Exp. Series	Final Report
						1. Report	CDR	2. Report			

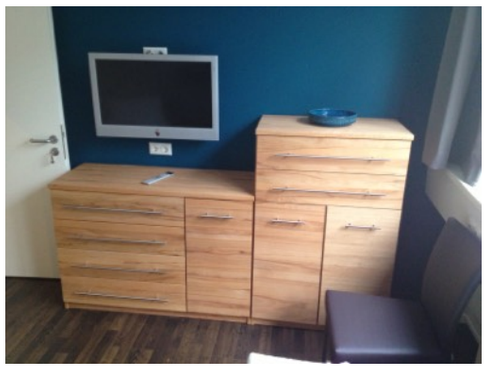
20 June 2022 - 01 July 2022

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





- two separate rooms with two beds each

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Content

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- Experiment Examples
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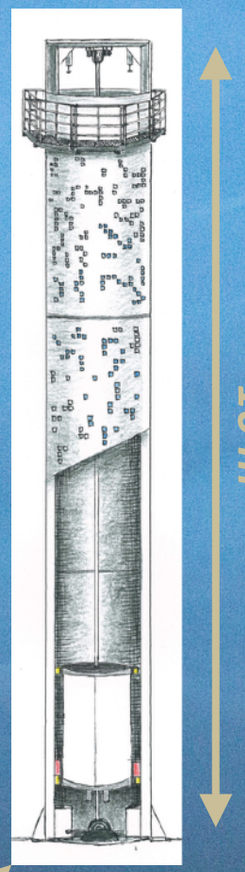

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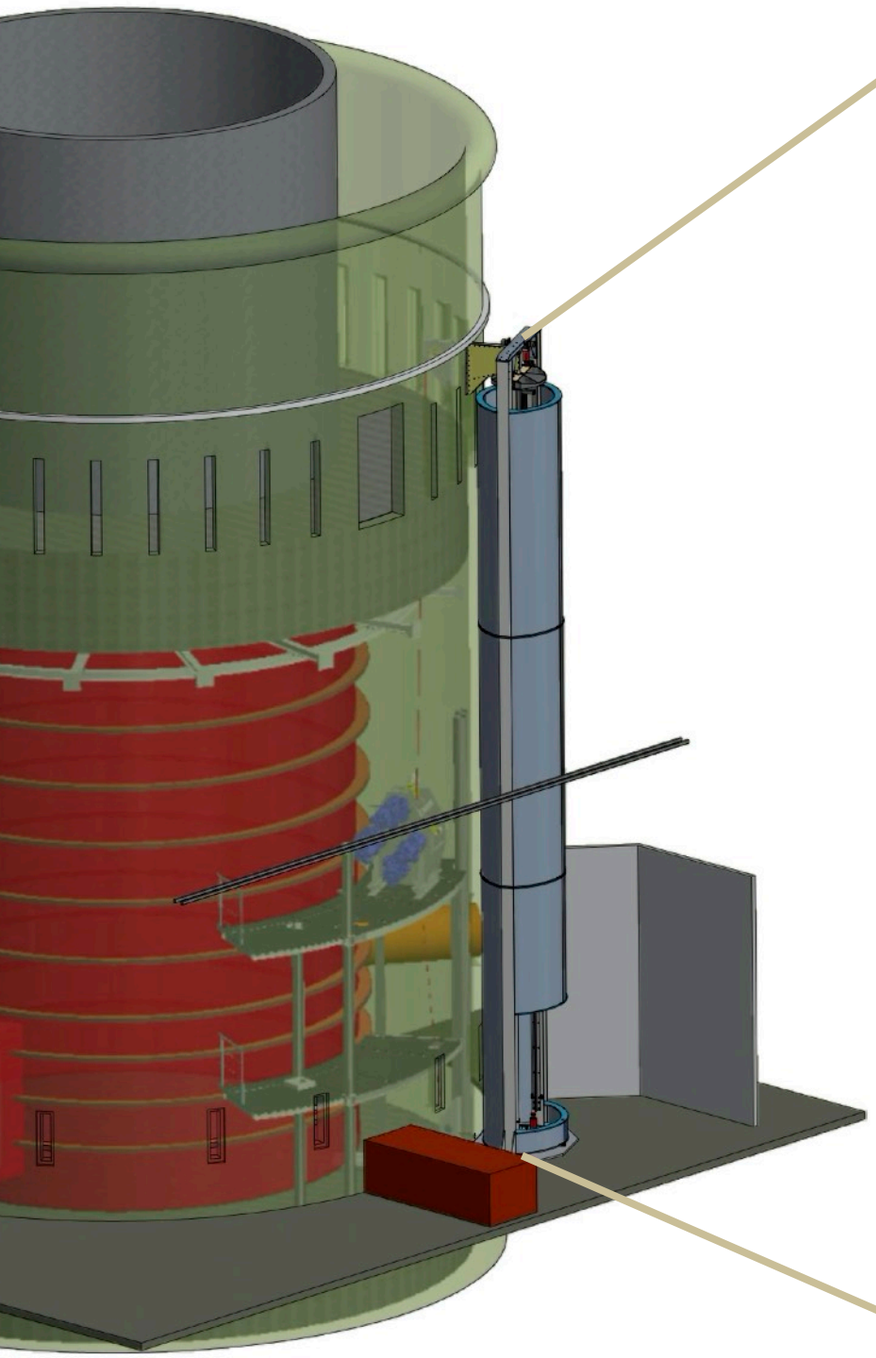
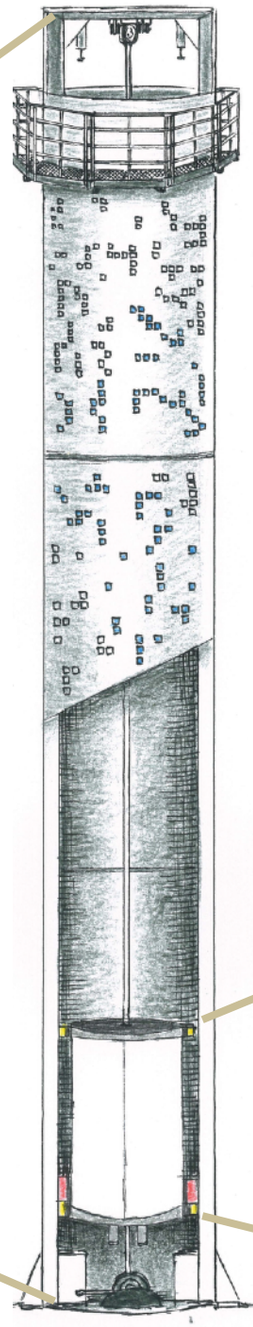
Next-Gen Microgravity Facility

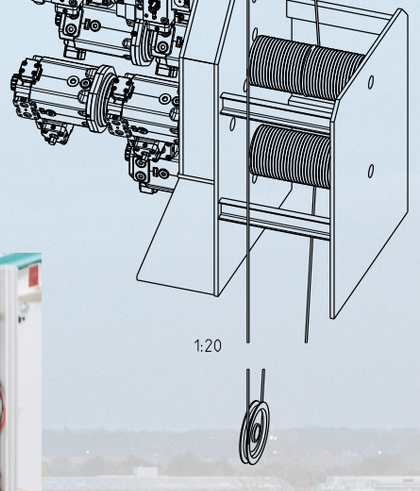


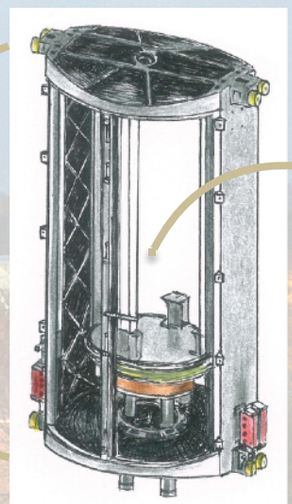


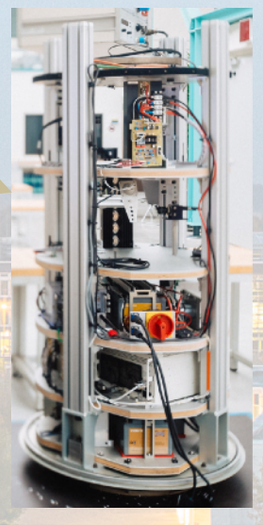
GraviTower Bremen Pro

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*







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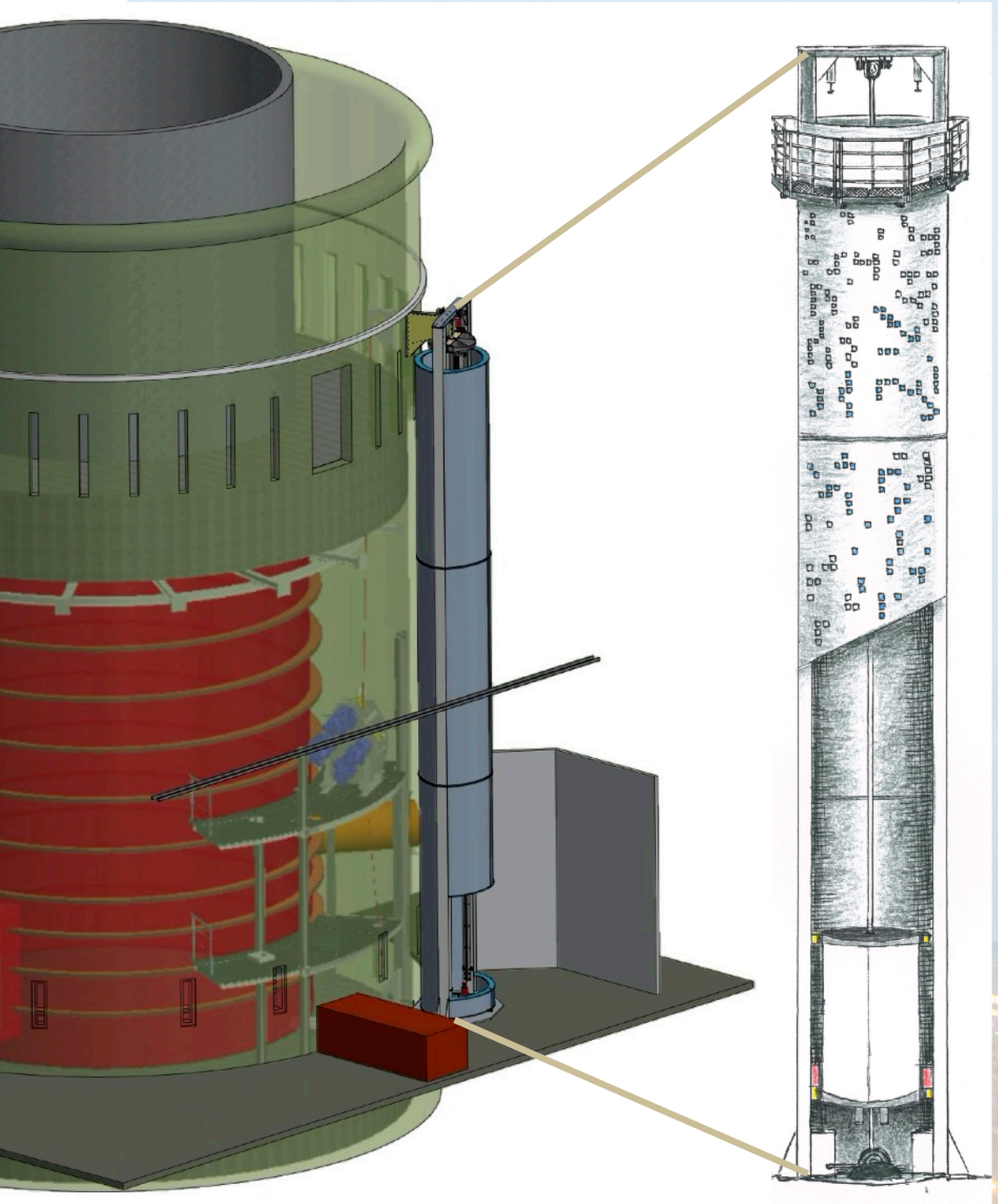
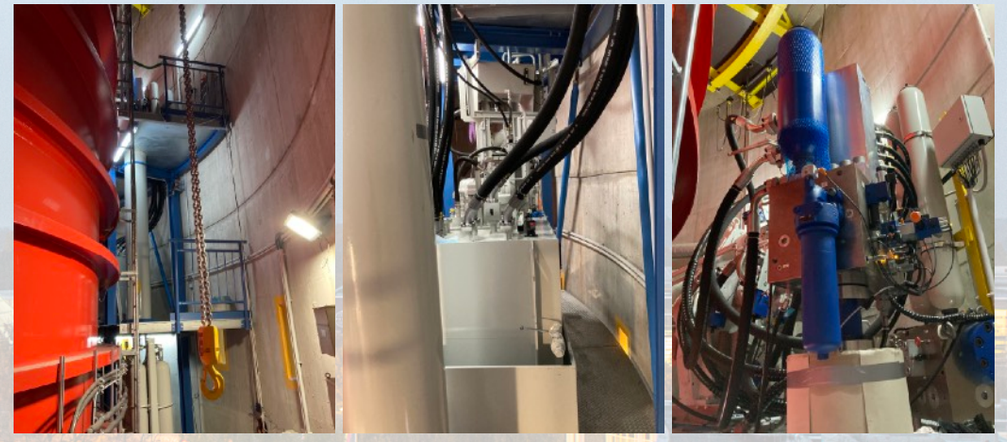
Next-Gen Microgravity Facility



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*



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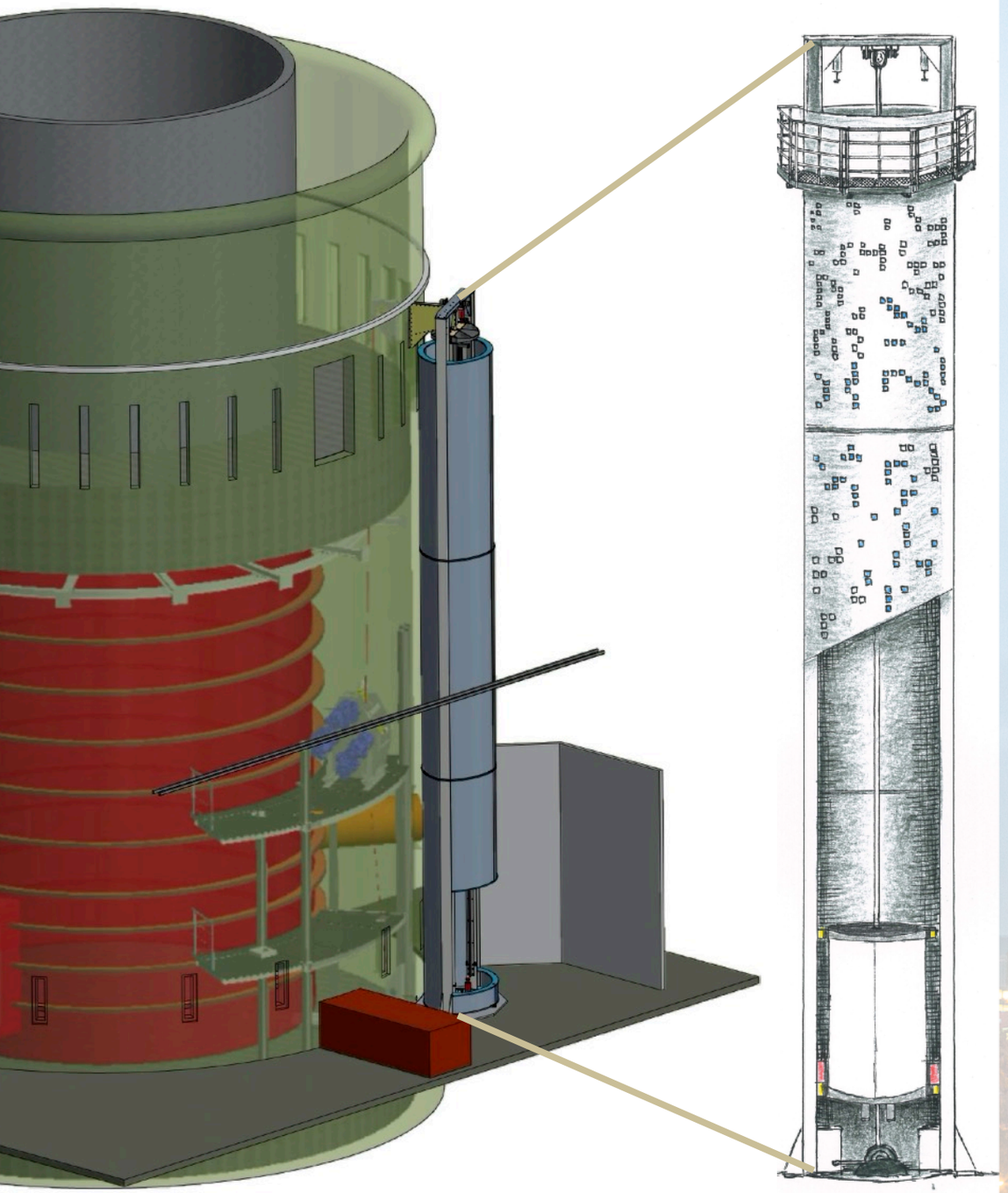

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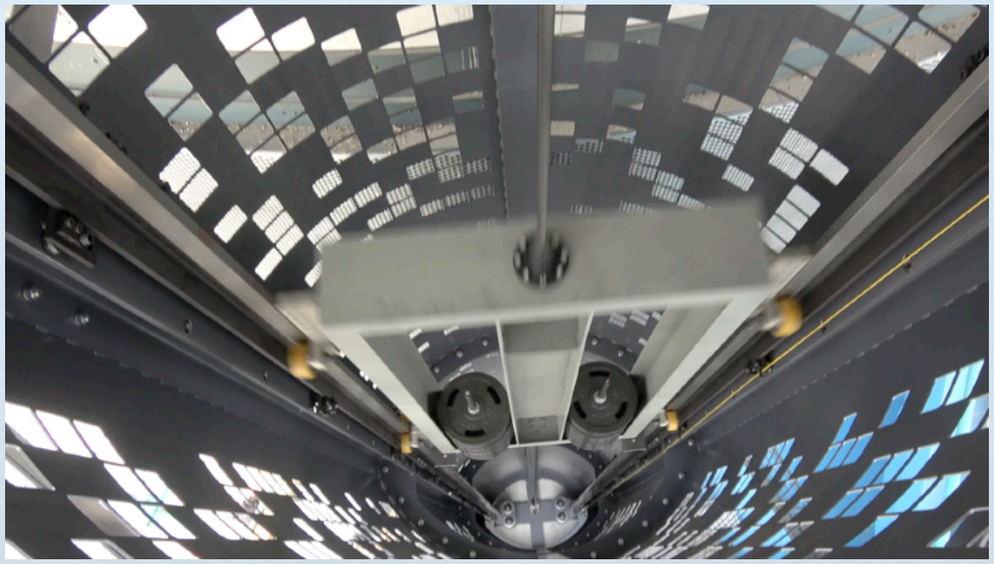

- full commissioning: mid-2021

also available for DropTES

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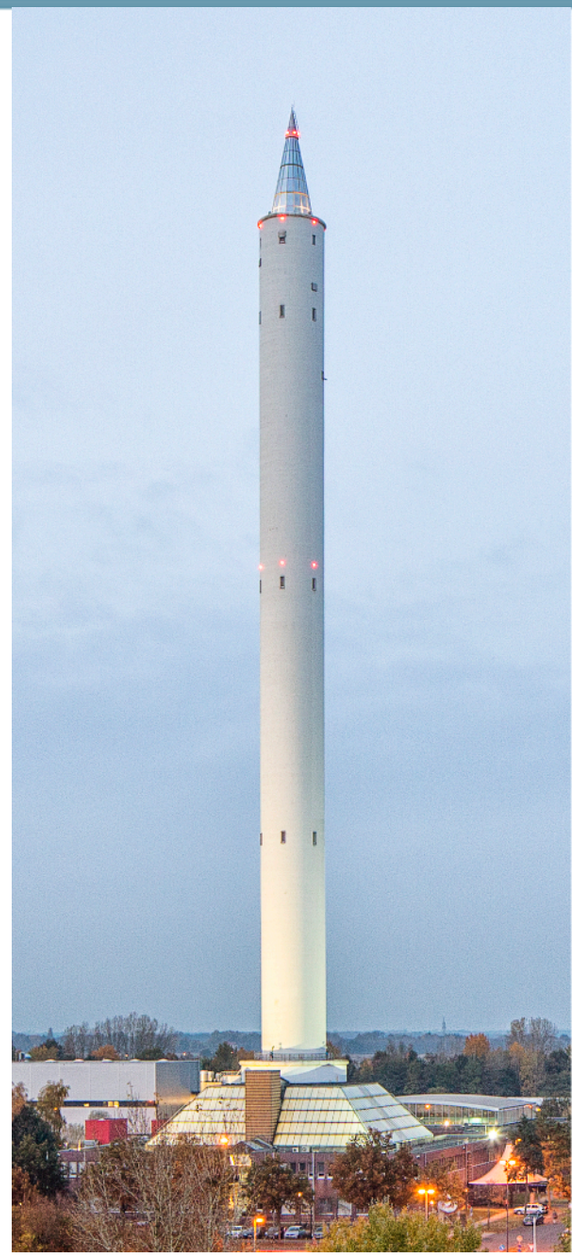
THANK YOU VERY MUCH FOR YOUR ATTENTION



ACKNOWLEDGEMENTS

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