University of Bremen

CENTER OF APPLIED SPACE TECHNOLOGY AND MICROGRAVITY

ZARM

ZARM AND THE BREMEN DROP TOWERS

DROPTES – ANNOUNCEMENT OF OPPORTUNITY

Dr. Merle Cornelius
ZARM Drop Tower Operation and Service Company

University of Bremen

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Who am I?

- Dr. Merle Cornelius
- Dep. Head of Science and Operation
  ZARM Drop Tower Operation and Service Company (ZARM FAB mbH)

- Academic career
  - Bachelor and Master of Science in physics at the University of Bremen
  - First student job at ZARM (2013)
  - PhD in physics (University of Bremen , 2022)
    - Quantum optics – atom interferometry with Bose-Einstein condensates
    - Over 250 drop tower experiments

- Since March 2023 at ZARM FAB mbH

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)

- FLUID DYNAMICS
- SPACE SCIENCE
- SPACE TECHNOLOGIES
- HUMANS ON MARS

Research / Teaching

ZARM FAB mbH

ZARM Drop Tower Operation and Service Company

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

Dr.-Ing. Thorben Könemann
(Head of Science & Operation)

Dr. Merle Cornelius
(Dep. Head of Science & Operation)

Technical Support

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)

Space Hardware

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ZARM facilities beside the drop towers

Aerospace qualification and test services

HYPER-GRAVITY LAB

- 30 g centrifuge
- Mounting compatible with drop capsules
- Payload weight up to 1.5 t

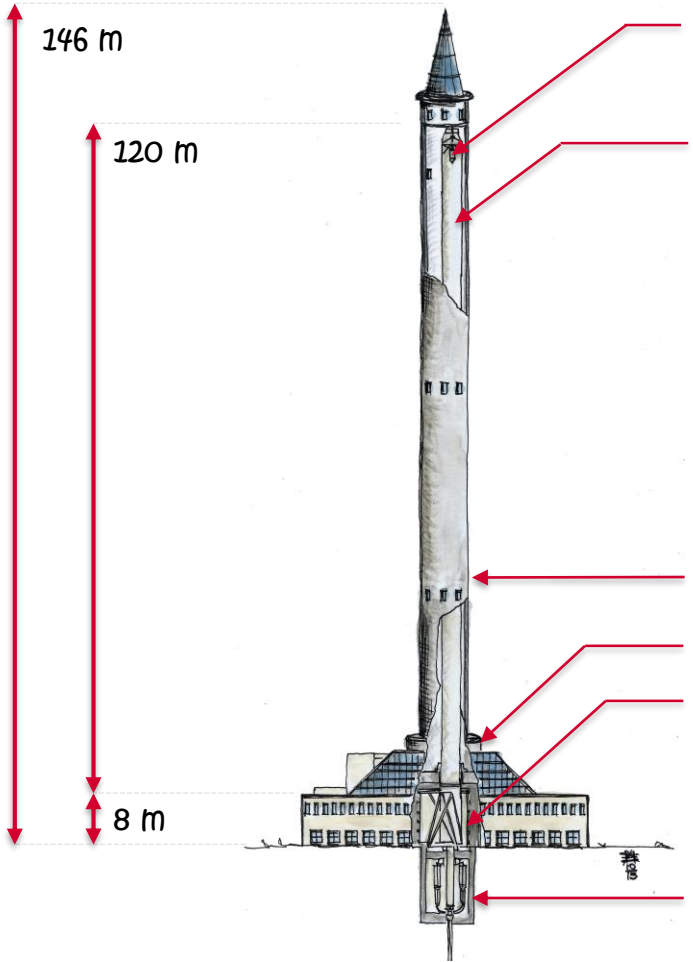
THERMAL VACUUM LAB

- TVC – Thermal vacuum chambers of different sizes
- TCC – Thermal cycling chamber
- TSC – Thermal shock chamber

VIBRATION TEST LAB

- Long Stroke Shaker
- Maximum force = 35.6 kN

Bremen Drop Tower



Housing of experiments in drop capsules

Vacuum in inner tube

- Evacuation of $1700\ \mathrm{m}^2$ air in 1.5 hours via 18 pumps
- Final pressure = 0.1 mbar $(10\ \mathrm{Pa})$
- Reduced air drag
- High microgravity quality

  Residual gravitational acceleration: $\Delta g < 10^{-6}$ g
- 3 experimental runs per day

Concrete structure

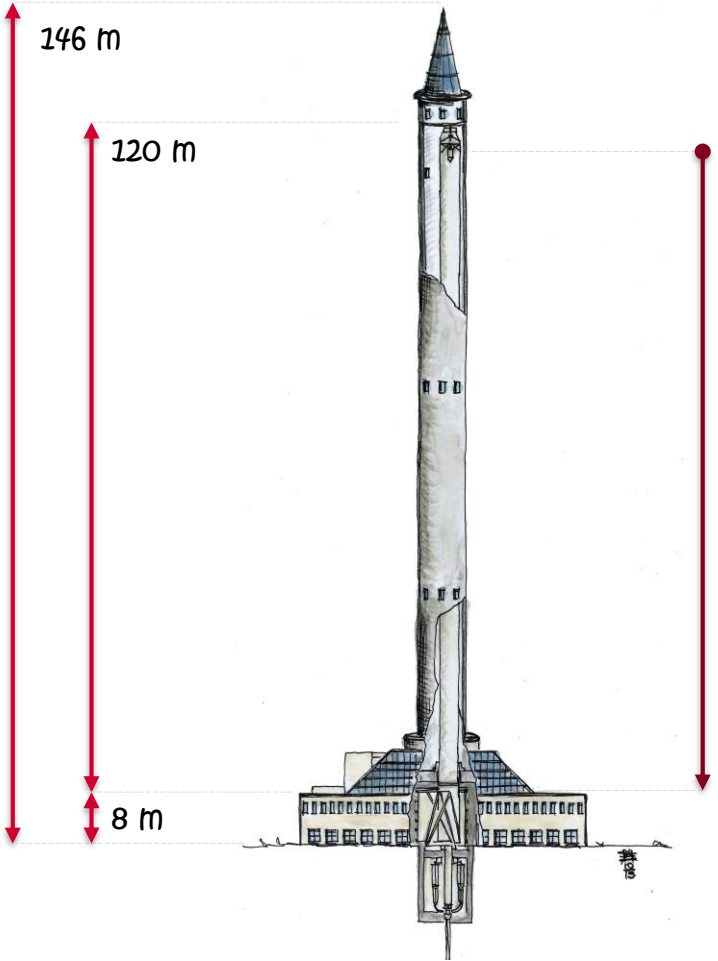
Integration hall

Deceleration container

- Filled with polystyrene
- Impact with up to 50 g

Catapult system

Bremen Drop Tower



DROP MODE

- 110m Free Fall distance
- Microgravity time $4.7\ s$

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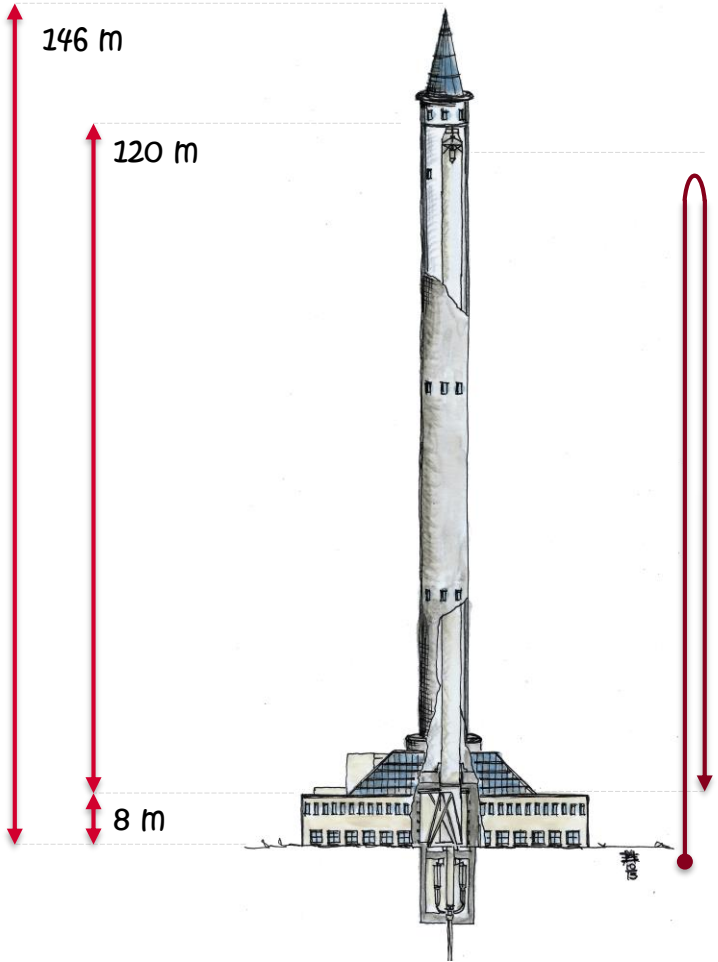
Bremen Drop Tower



CATAPULT MODE

- Launch on vertical parabola
- Microgravity time 9.3 s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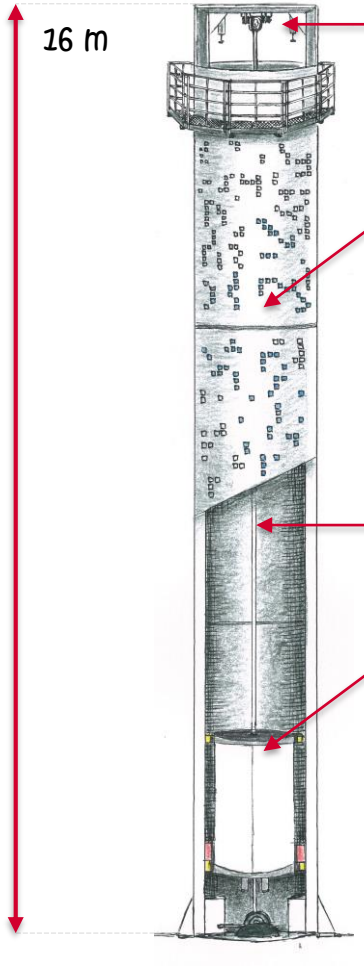
GraviTower Bremen Pro



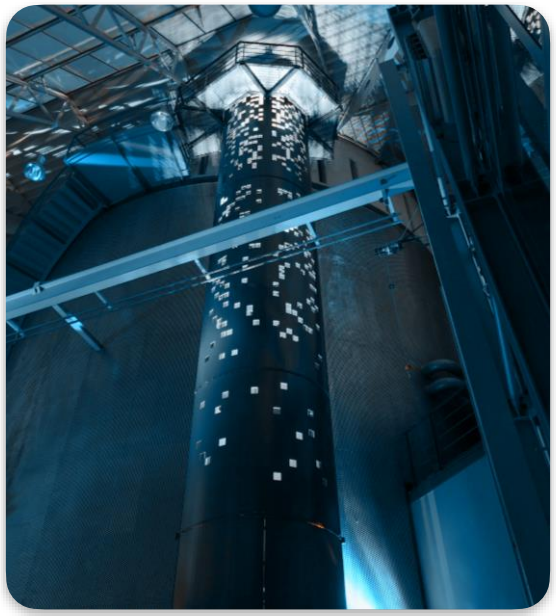
Rope drive based on a hydraulic winch

Outer structure

- Build inside integration hall

Rope

Housing of experiment in slider



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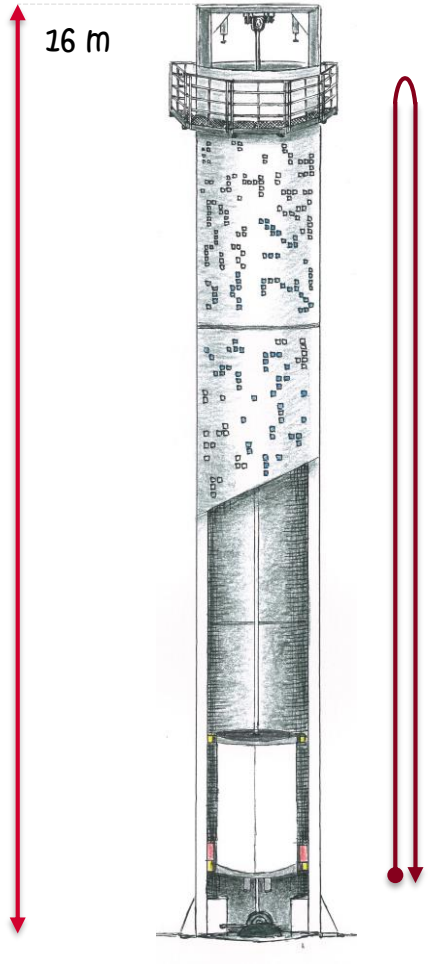
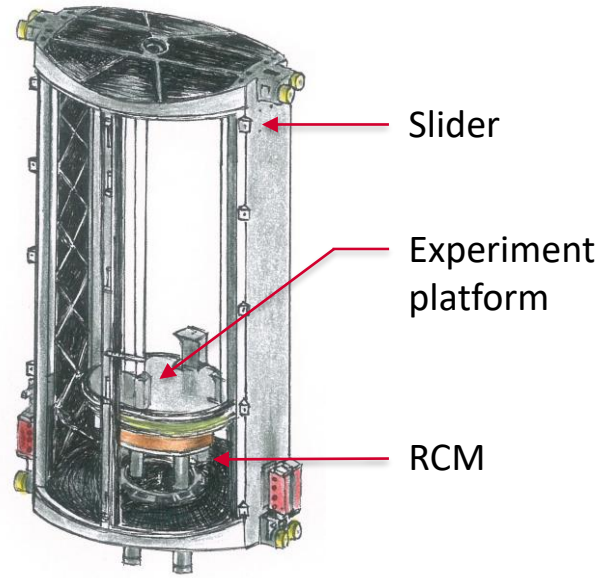
GraviTower Bremen Pro

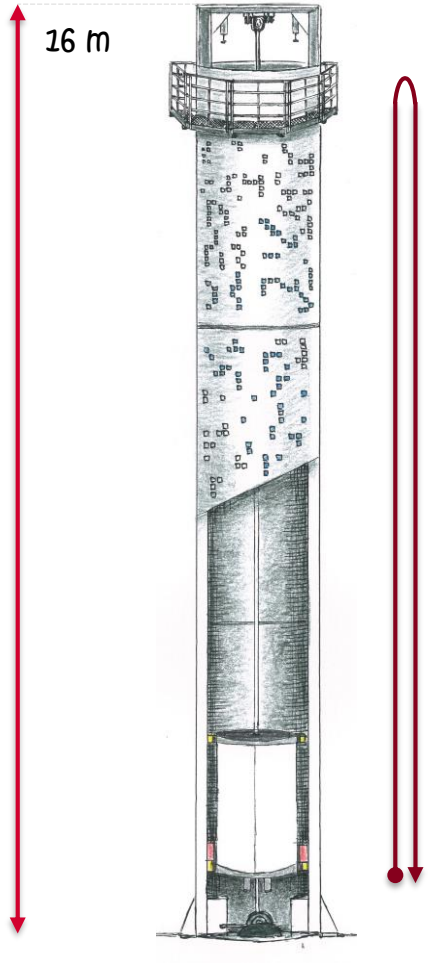


ACCELERATION ON VERTICAL PARABOLA

- Decoupling experiment capsule from slider via *Release Caging Mechanism* (RCM)
  - Slider acts an air shield
  - No vacuum needed
  - High microgravity quality ($\Delta g < 10^{-4}\mathrm{g}$)
  - High repetition rate of up to 960 runs per day



GraviTower Bremen Pro



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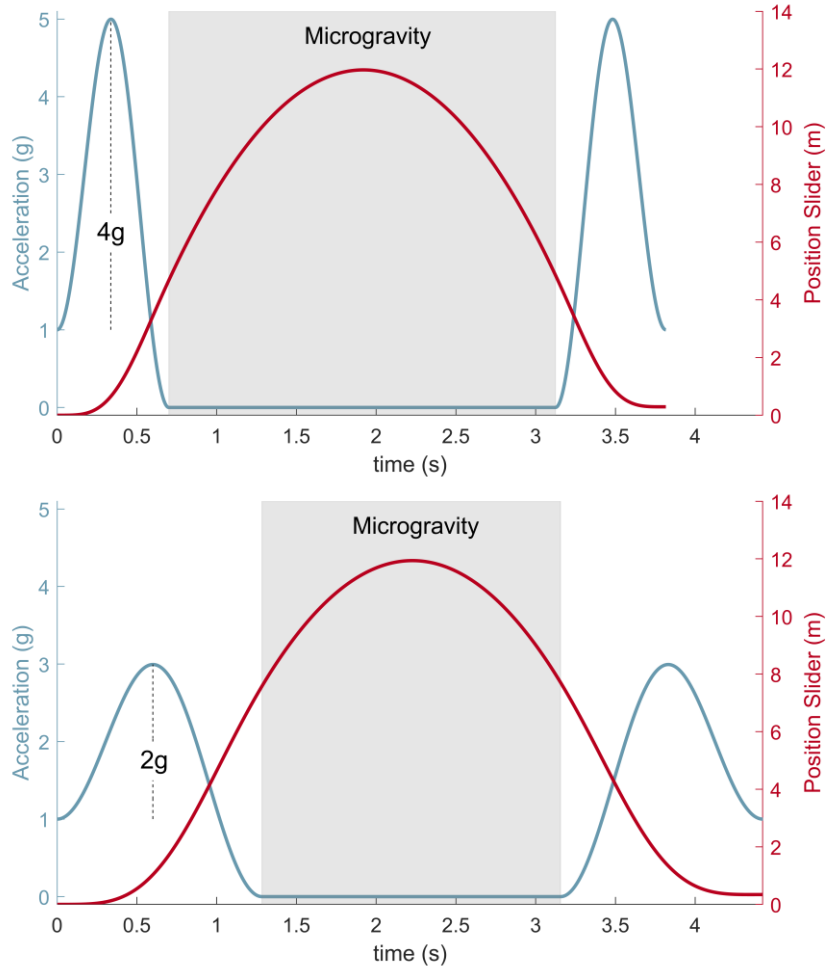
- Customize flight parabola to experimental requirements
  - 4 g acceleration → microgravity time = 2.5 s
  - 2 g acceleration → microgravity time = 1.9 s



GraviTower Bremen Pro

FUTURE OPERATION MODES

- Partial gravity
  - Like gravitational acceleration of Moon and Mars
  - Important in the field of human exploration and technical development
- g-vectoring
  - Changing gravitational acceleration during flight phase

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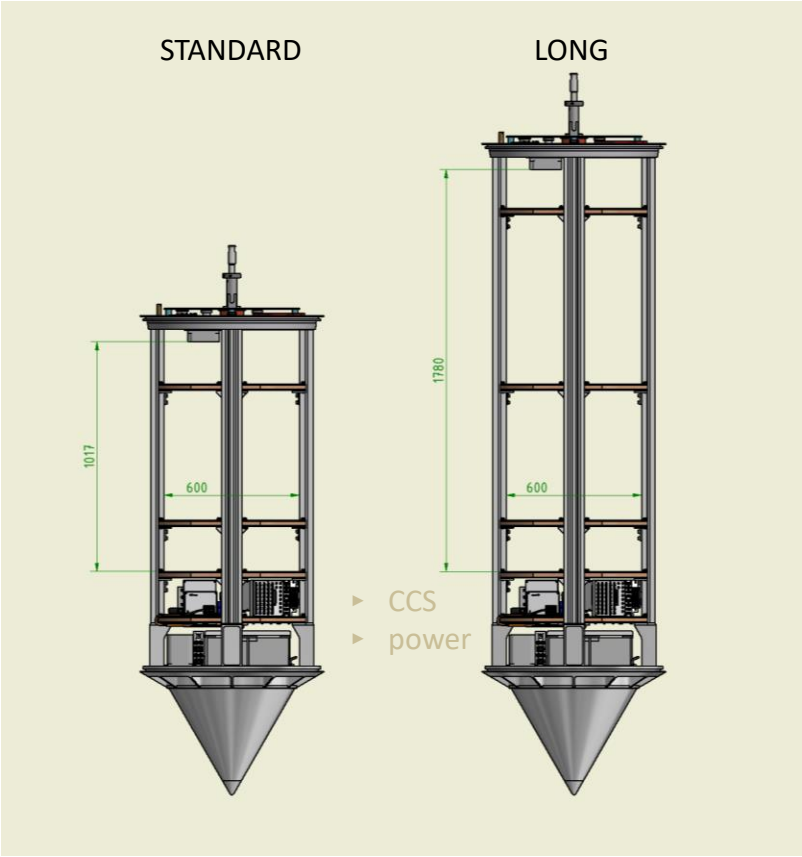
How to drop!

- Requirements and Constraints

	Drop		Catapult	GraviTower
Capsule type	Long	Standard		
Max. payload height (hard limit)	1.780 m	1.017 m		
Max. payload width (hard limit)	600 mm			
Max. payload mass	265 kg	225 kg	165 kg	265 kg
Max. point load	50 kg			



- Standard capsule suited for drop, catapult and GraviTower operation
- Setup designed to withstand impact of 50 g (+ 50 g safety margin)

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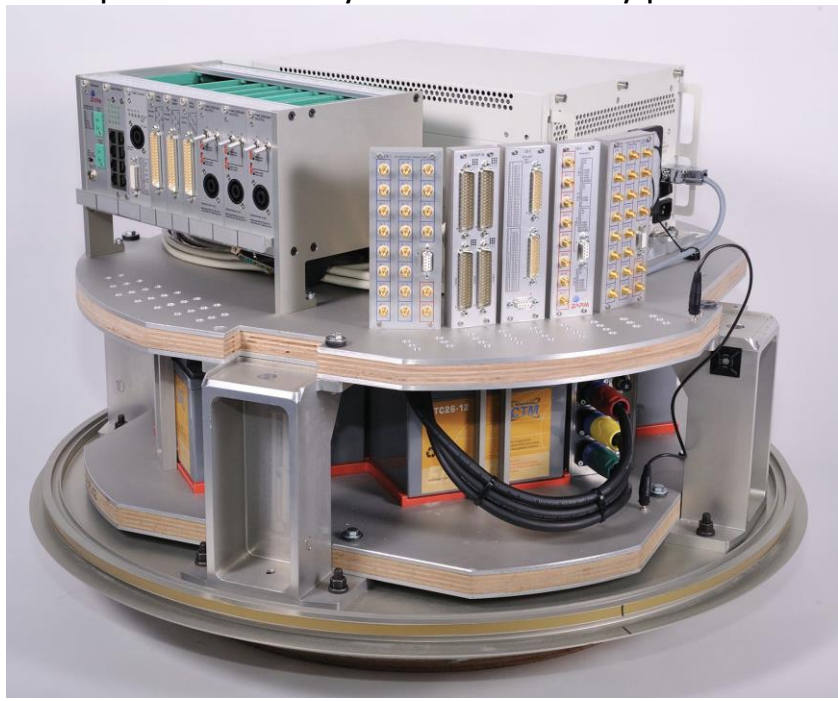
How to drop!

- Capsule Control System (CCS)
  - Experiment Control and Triggering
  - Data acquisition (acceleration, temp., etc.)
- Power supply via batteries
  - 24V DC (charging: 27.6V DC / max. 40 A)
- Condition inside the capsule: Drop/Catapult
    - Nominal 1 bar (pressure-tight capsule)
    - Vent line: vacuum or gases
    - Temperature: heating and cooling circuit

Capsule Control System and Battery platform



How to drop!

- Service provided by ZARM and the engineering team
  - Mechanical and electrical integration of the experiment into the capsule
  - NI-LabView software interface and data acquisition
  - Experimental control via standard network connection (Wi-Fi and Trulifi)

- Provided equipment
  - High-speed camera systems: Phantom Miro / Photron FASTCAM
    - Lenses and illumination systems
  - Non-standard power supply
  - Vacuum pumps (rotary vane pumps, turbo molecular pumps)

ZARM Website:

zarm.uni-bremen.de/

Bremen Drop Tower – Payload User's Guide

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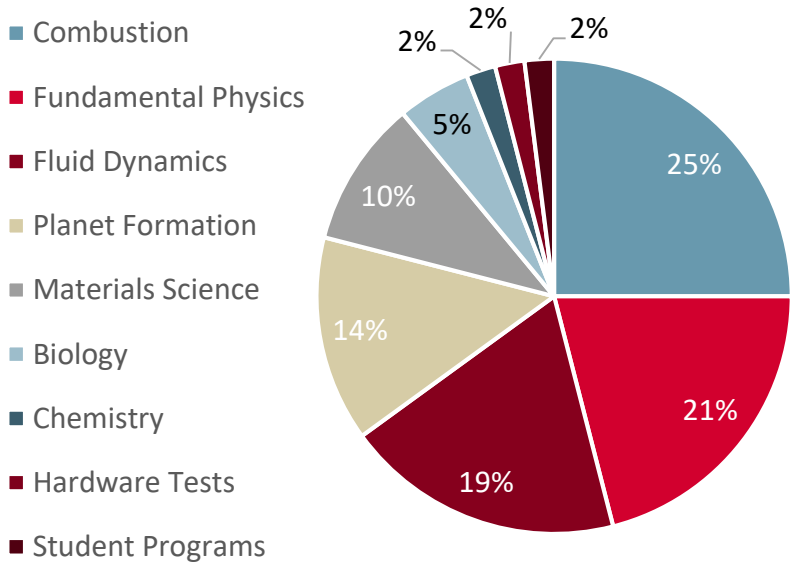
What to drop?



- Scientific experiments in various research field
- Hardware tests for space missions
- Student programs
  - DropTES

  - REXUS/BEXUS
  - ESA academy: PETRI

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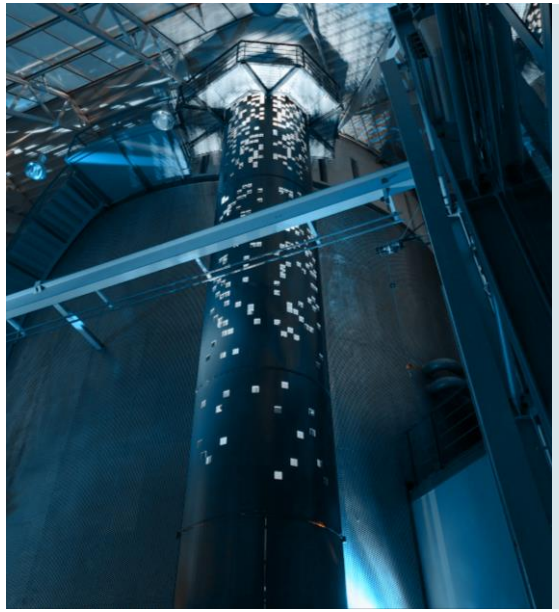
Conclusion

- The Bremen drop towers are microgravity labs for research and technology tests
  → Stepping stones into space

DROP TOWER

- Up to 9.3s in weightlessness
- High microgravity quality
- 3 experiments per day



GRAVITOWER BREMEN PRO

- Up to 2.5s in weightlessness
- Up to 960 experiments per day
- Partial-gravity option

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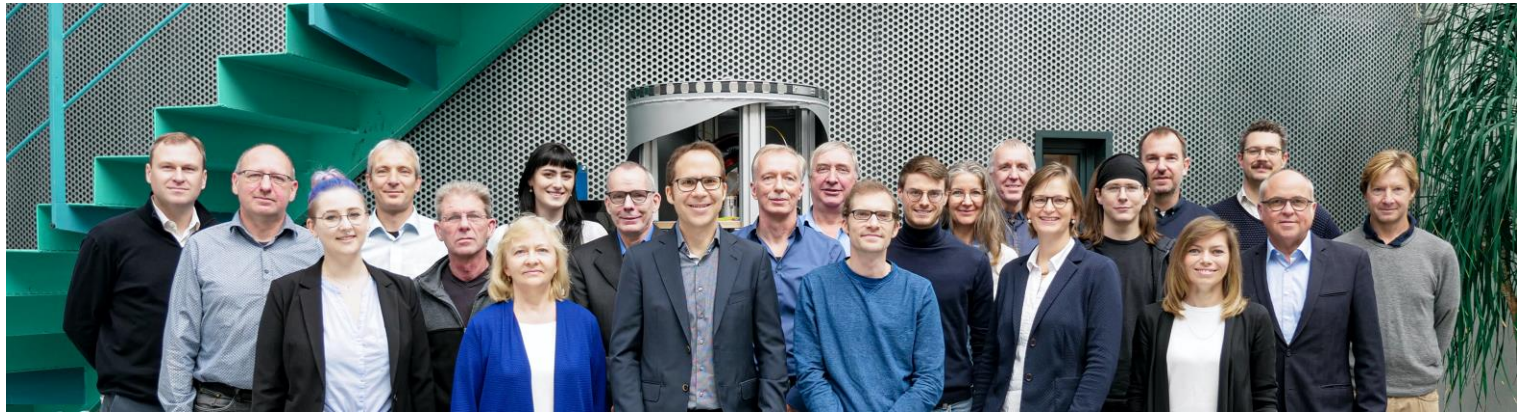
Thank you!



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Acknowledgements

DLR

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UNITED NATIONS
Office for Outer Space Affairs

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