

25th ESA Symposium on European
ROCKET & BALLOON
programmes and related research
1-5 May 2022 - Biarritz - France

cnes eesa



Why do we need scientific (sounding) rockets?

PD Dr. Ruth Hemmersbach

Institute of Aerospace Medicine, German Aerospace Center (DLR), Germany

*Improving Health Span
in Space and on Earth*



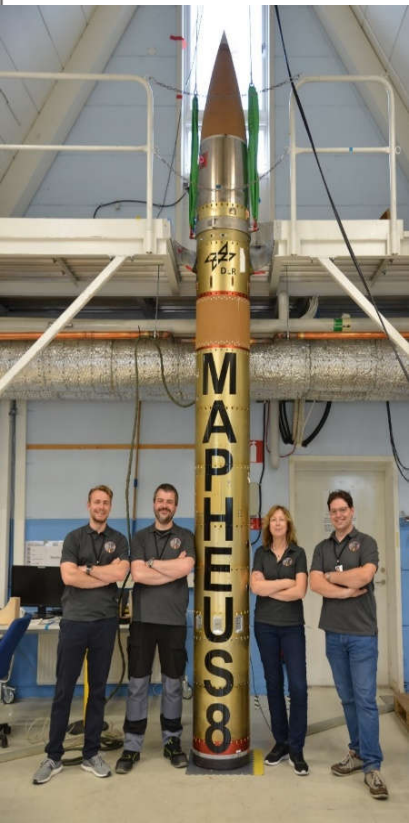
Wissen für Morgen



Gravitational Biology at DLR



- Department Gravitational Biology
- Cell Biology – University of Bonn, Germany
- Experiments under Space Conditions (D2, IML2, Drop Tower, MAPHEUS, TEXUS 27/28/34, MAXUS 2, EU:CROPIS, ...)
- Ground-Based Facilities (ESA GBF Programme)



Why do we need sounding rockets?

Why do we need microgravity?

Gravity triggers evolution and development



Photo: V. Berghoff

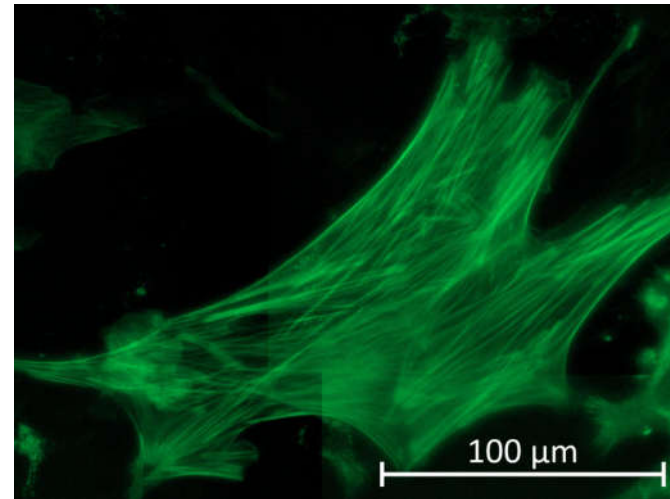
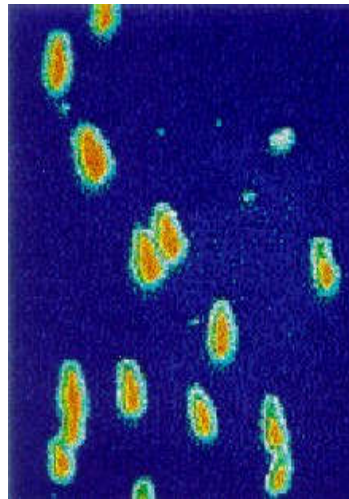


Photo: Y. Lichterfeld

- Reliable orientation – up and down
- Polarities determine functionality



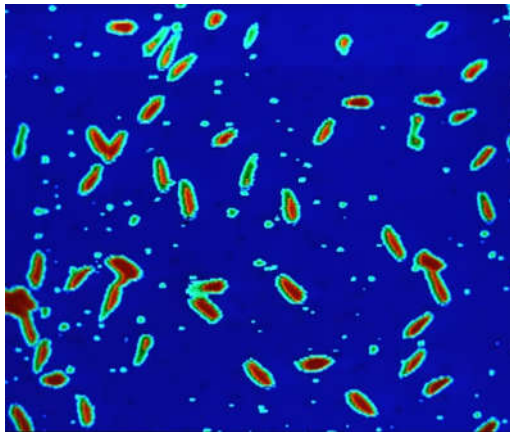
Life without gravity

Microgravity as a tool

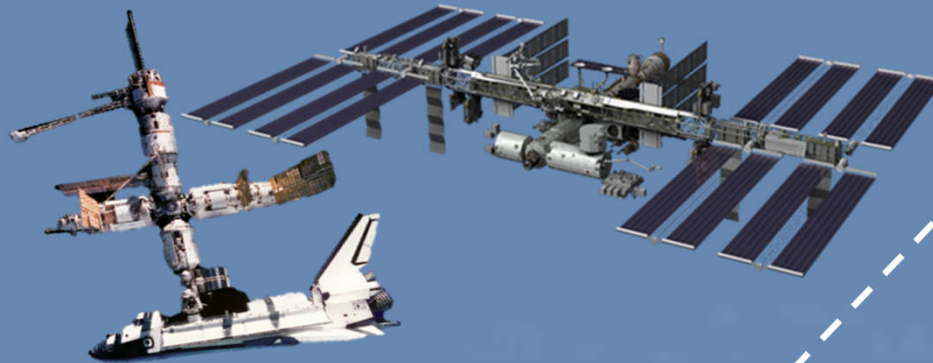
Translation to health issues
Space to Earth
humans to **cells**

Fundamental science

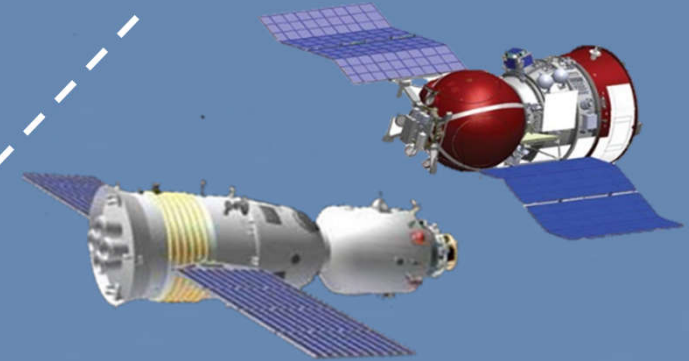
Applications
Countermeasures
Hardware proof-of-concepts



How do we achieve microgravity?



Space Stations
permanent μg



Orbital Platforms
2-4 weeks μg



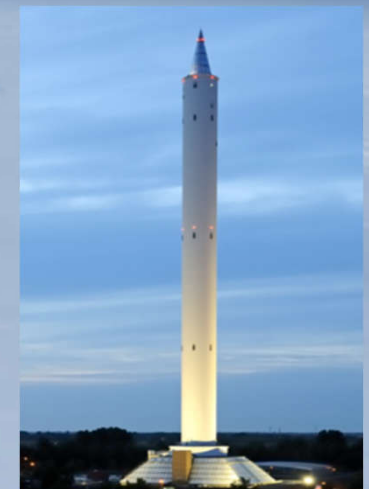
Parabolic Flights
22 sec μg and
hypergravity, repetitively

Manned
Unmanned



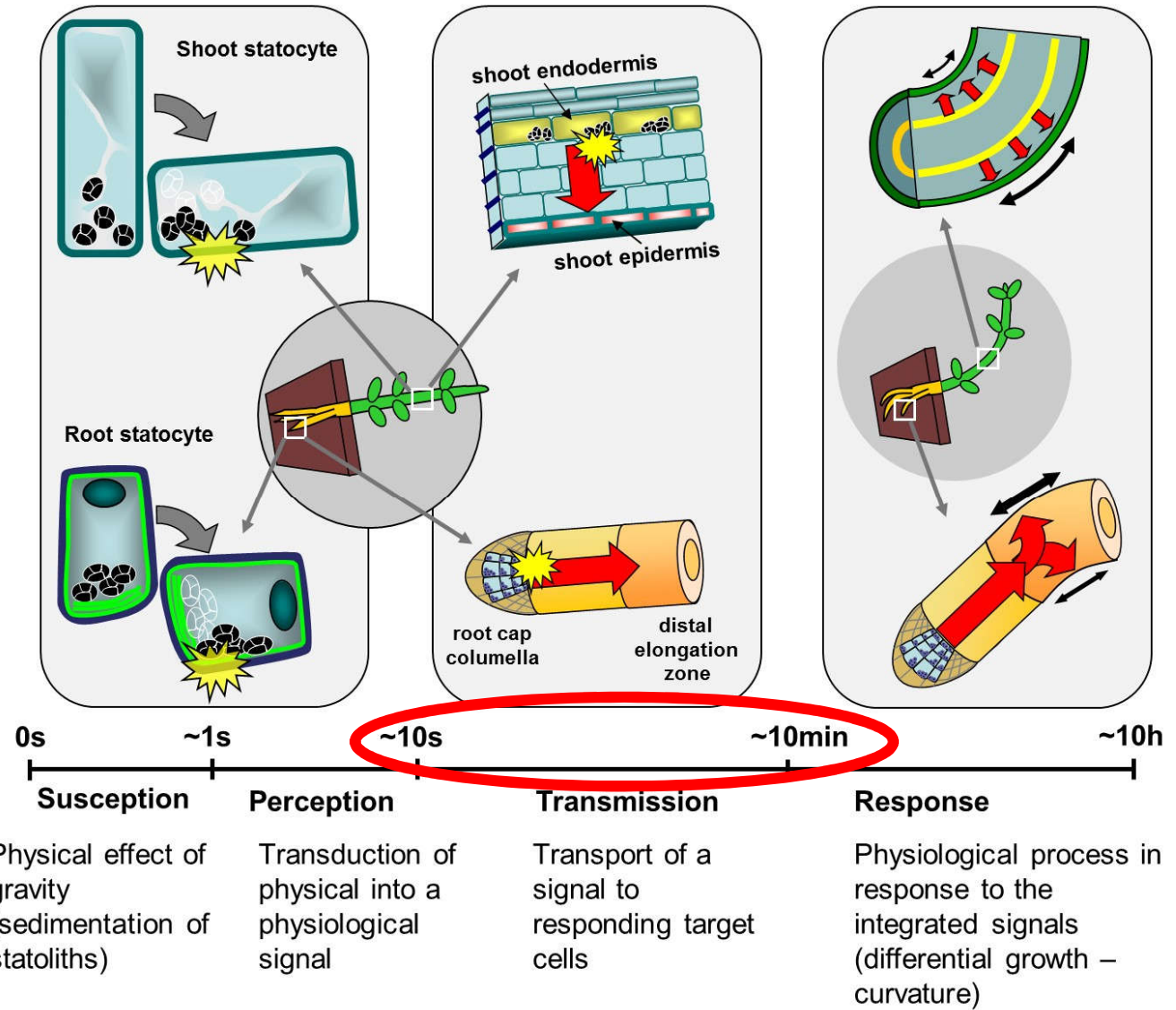
5-7 min μg

Sounding Rockets



Drop Tower
4.5 – 9 sec μg

Time course in gravity-signal- transduction chains



Thanks to
Markus Braun



Own case studies from

TEXUS 27 - 1990

TEXUS 28 - 1991

TEXUS 32 - 1994

MAXUS 2 - 1994

DLR MAPHEUS Program

MP5: 06/2015

MP6: 05/2017

MP7: 02/2018

MP8: 06/2019

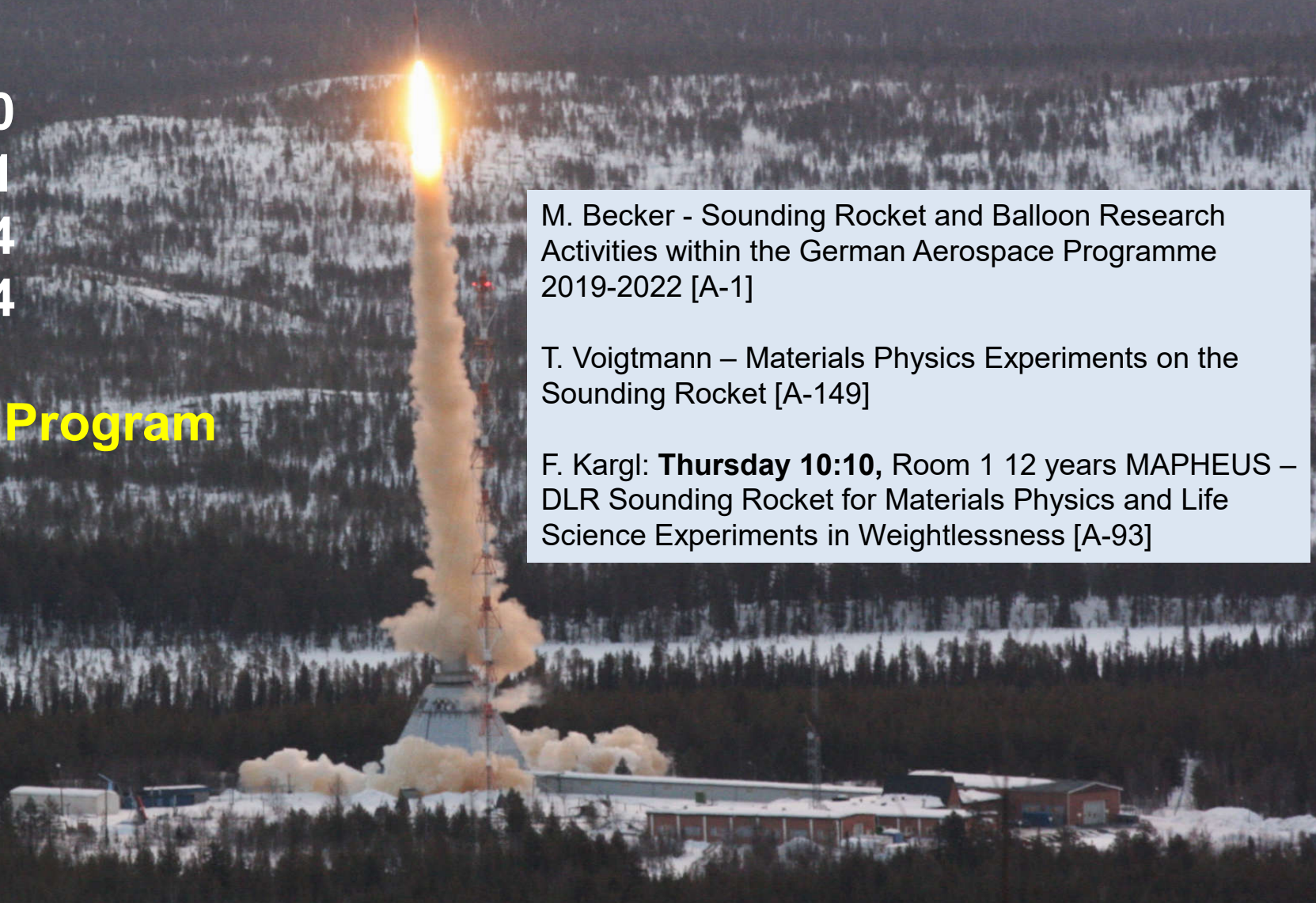
MP10: 12/2021

MP9: 01/2022

M. Becker - Sounding Rocket and Balloon Research Activities within the German Aerospace Programme 2019-2022 [A-1]

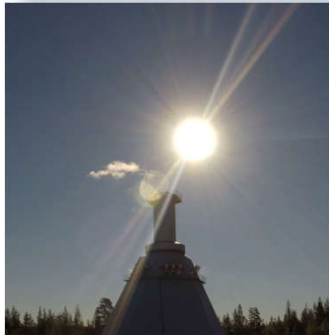
T. Voigtmann – Materials Physics Experiments on the Sounding Rocket [A-149]

F. Kargl: **Thursday 10:10**, Room 1 12 years MAPHEUS – DLR Sounding Rocket for Materials Physics and Life Science Experiments in Weightlessness [A-93]



MAPHEUS/TEXUS (7 min microgravity)

lift-off



ascent



μ g-injection



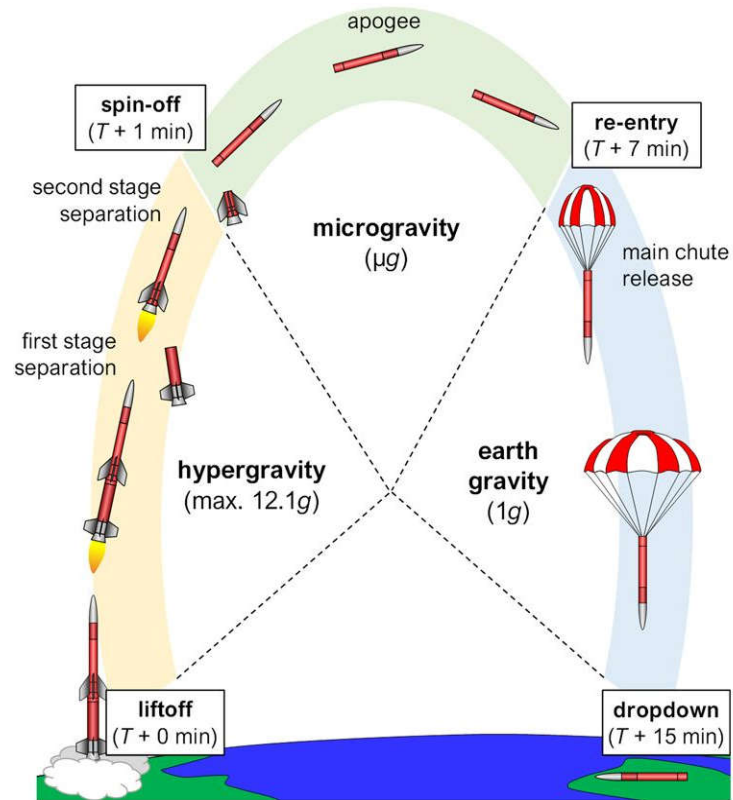
reentry



recovery

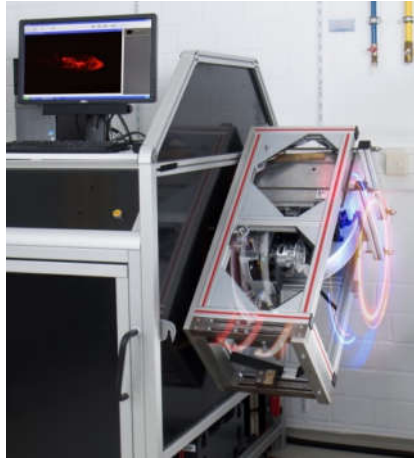


Sounding Rocket Acceleration Profile (MAPHEUS/TEXUS)



Microgravity research starts on ground

Ground-based facilities: DLR developments



Simulated microgravity

- Preparation
- Validation in real μg

Hypergravity

- Launch conditions

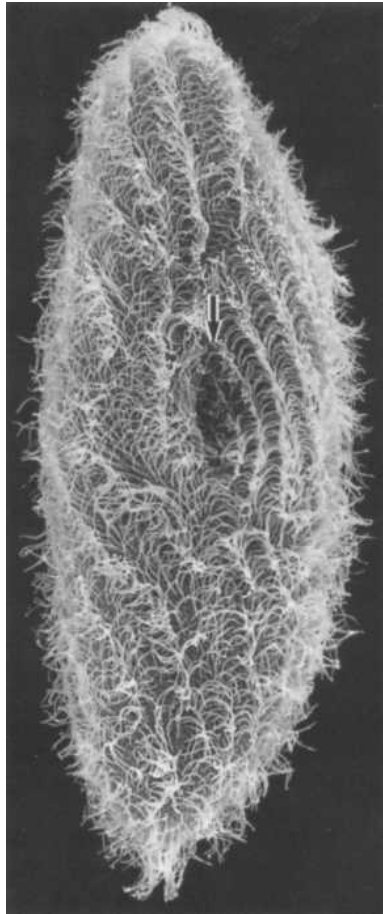
Hemmersbach, R., J. Ngo-Anh, M. Zell. "Topical issue on ground-based facilities (GBF): results and Experiences from ESA's ground-based facilities Programme in space life sciences." *Microgravity Science and Technology* 28.3 (2016): 189-189.

[DLR - Institute of Aerospace Medicine - Clinostats and Centrifuges of the Gravitational Biology group](#)

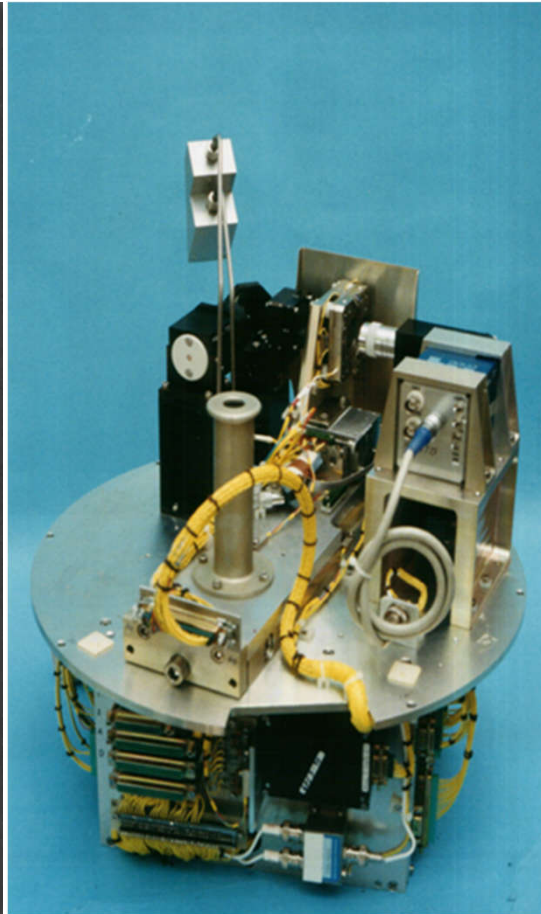
SciSpace CORA - Ground-Based Facility (GBF)



Behaviour of cells in microgravity



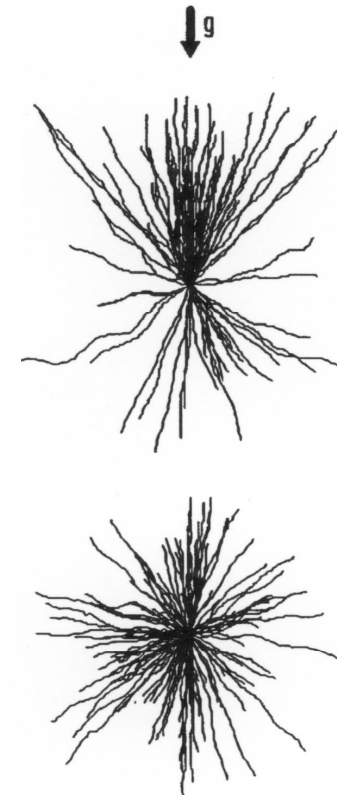
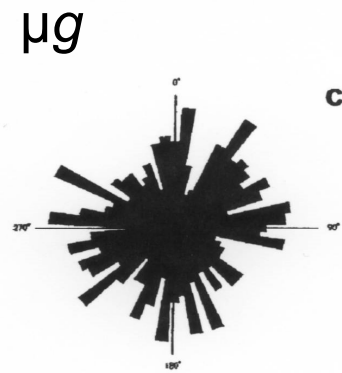
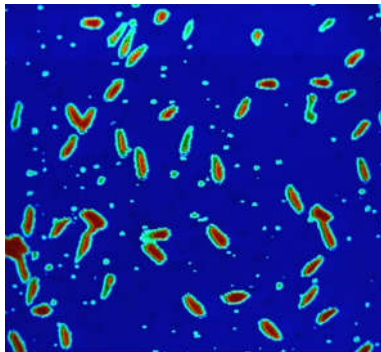
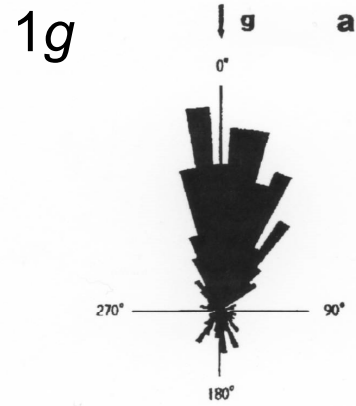
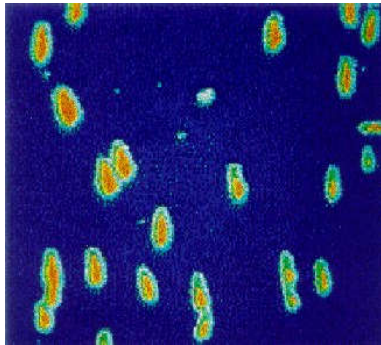
Paramecium 200 μm



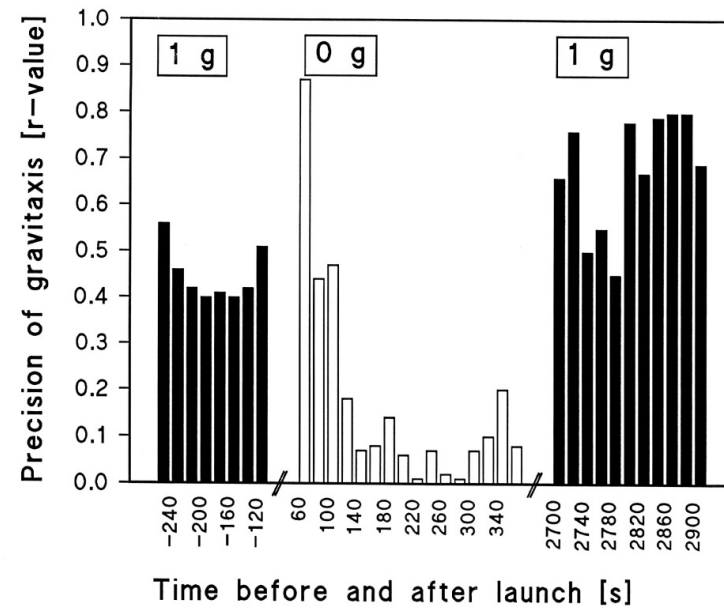
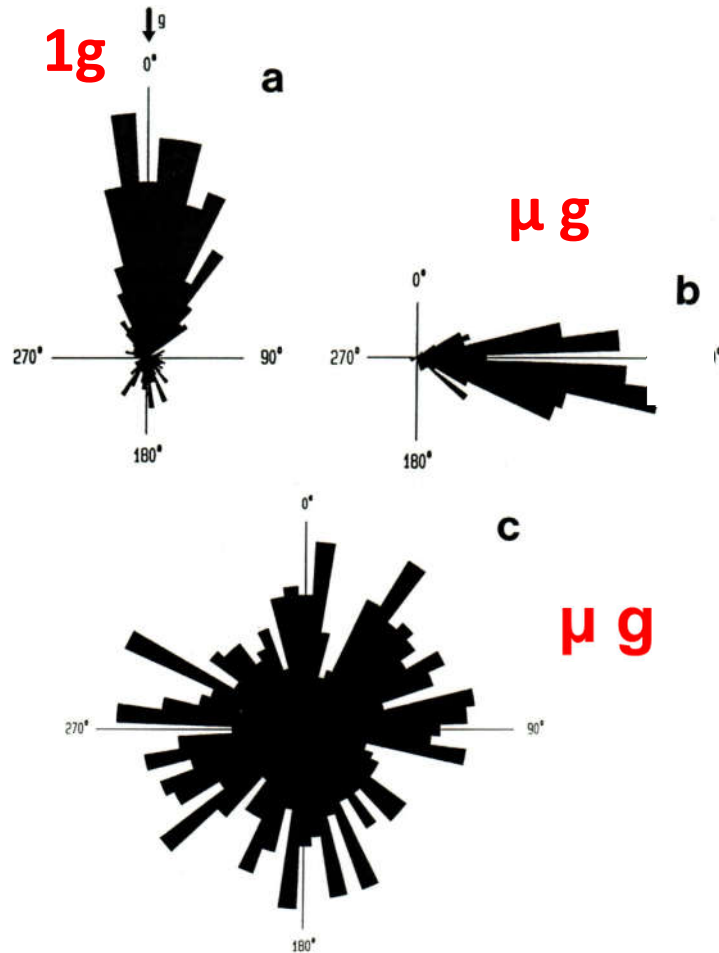
TEXUS 27 (1990), TEXUS 28 (1991)



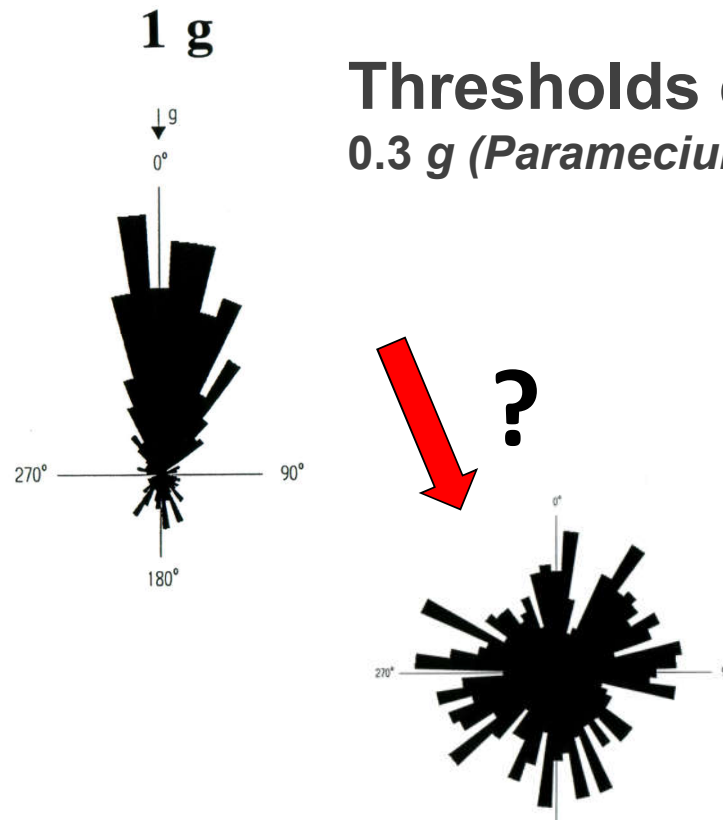
Loss of gravitaxis in microgravity



Loss of gravitaxis in microgravity

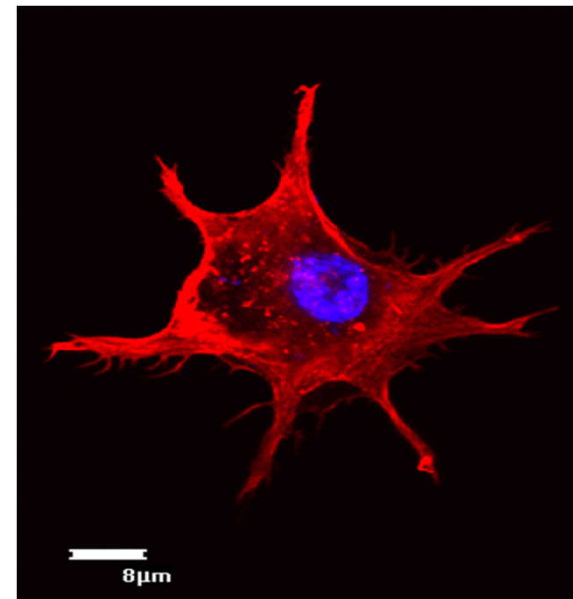
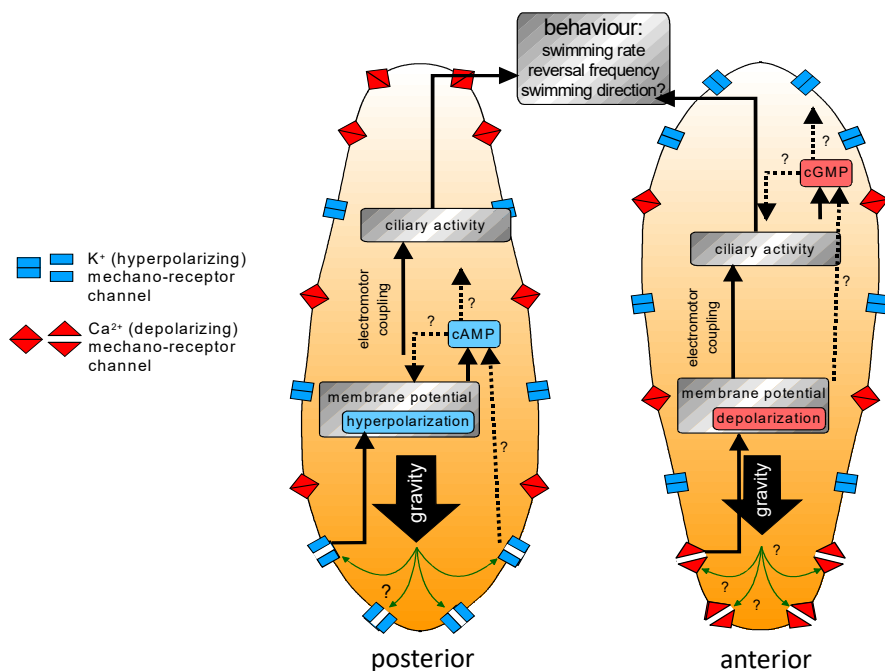


Centrifuge in Space: MAXUS 2 (1995)

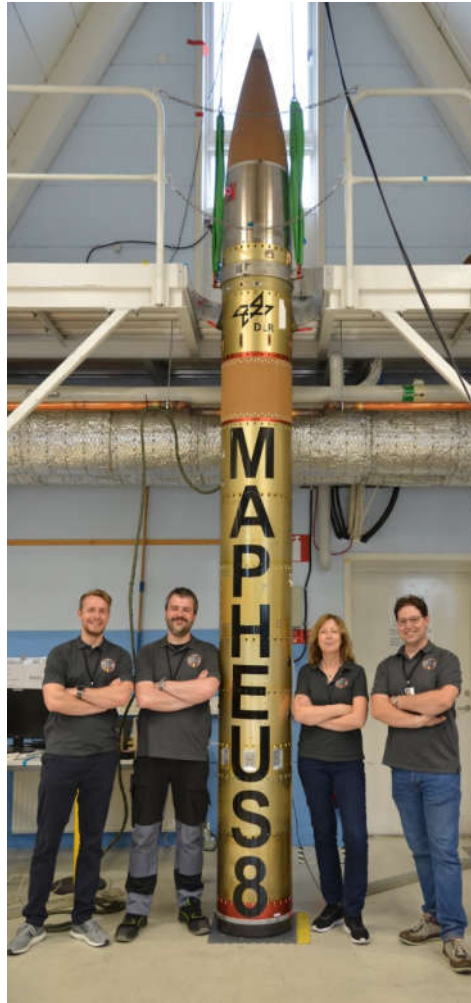


Gravisensors in single cells

- Protists (single cells) perceive gravity by mass displacement (cytoplasm)
- Key elements: ion channels, cytoskeleton and signal transduction pathways
- **Is graviperception a common cellular capacity?**



Gravitational biology on sounding rockets (Mapheus)

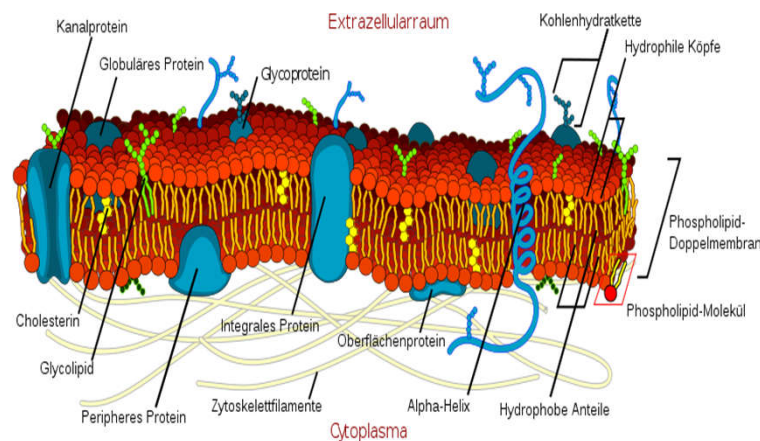
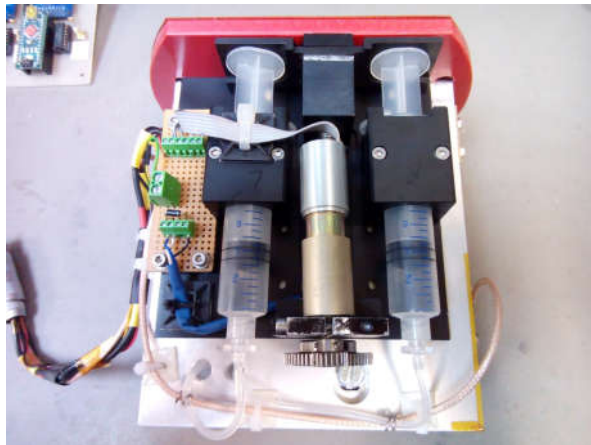


MemEX
CellFix
MEA
Ropum
apex
Yeast
GraviPlax
GraviScope
M42



Experiment MemEx

- Gravity-dependent fluidity of cell membranes
- Incorporation of Lidocain/Ibuprofen in Asolectin (DMPC) vesicles
- DPH (1,6-Diphenyl-1,3-5-Hexatrien) Assay - fluorescence polarisation anisotropy
- Impact on pharmacology

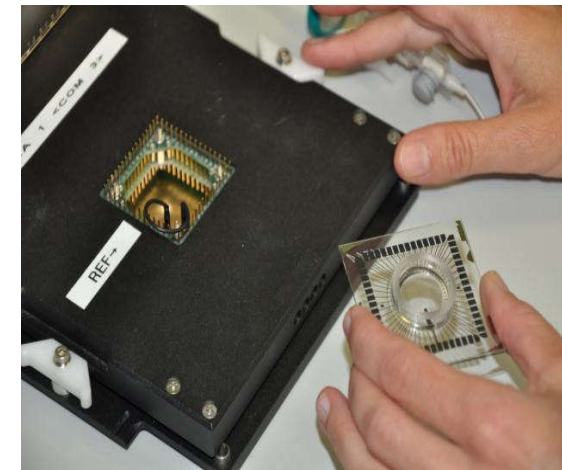
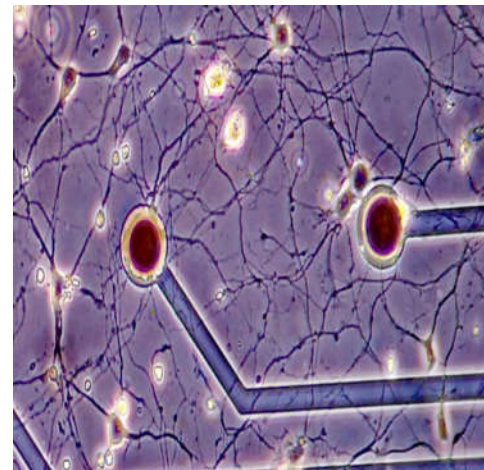
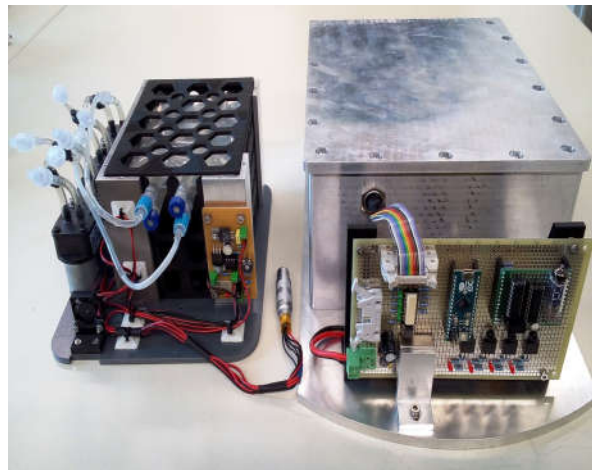
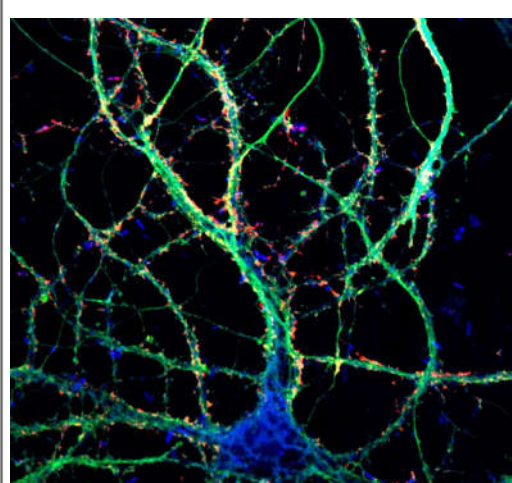


*Kohn, F. PM, Hauslage, J.
The gravity dependence of
pharmacodynamics: the
integration of lidocaine into
membranes in microgravity. npj
Microgravity 5.1 (2019): 1-6.*



Experiments CellFix and MEA (Multi-Electrode Array)

- Impact of microgravity on neuronal activity
- Potential impact on e.g. cognitive functions – wound healing
- Neuronal cell cultures and isolated neurons



Liemersdorf, Christian, et al. "The MAPHEUS module CellFix for studying the influence of altered gravity on the physiology of single cells." Review of Scientific Instruments 91.1 (2020): 014101.

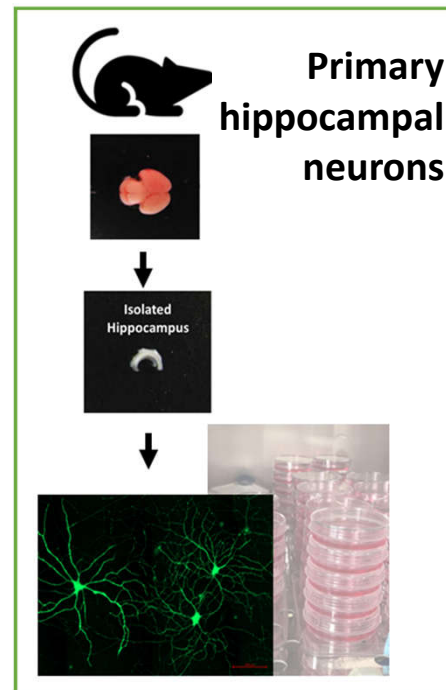
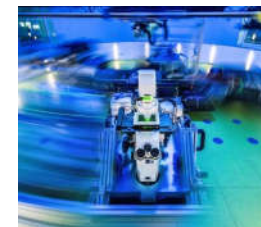




DROP YOUR THESIS!

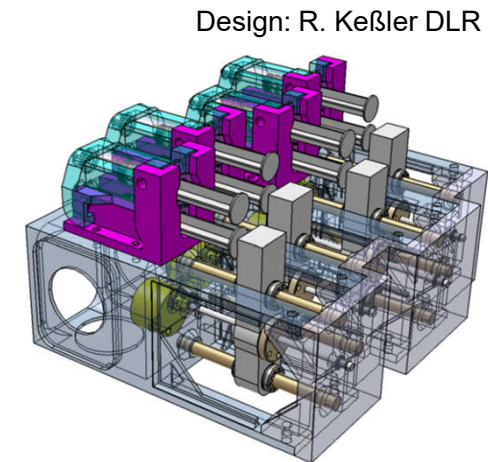
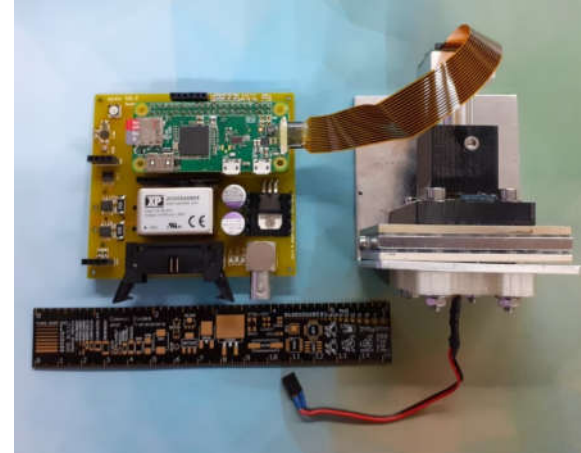
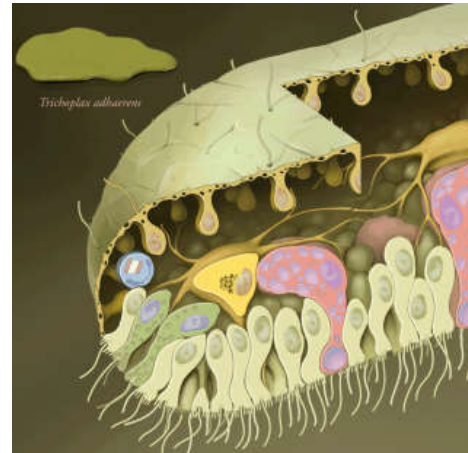
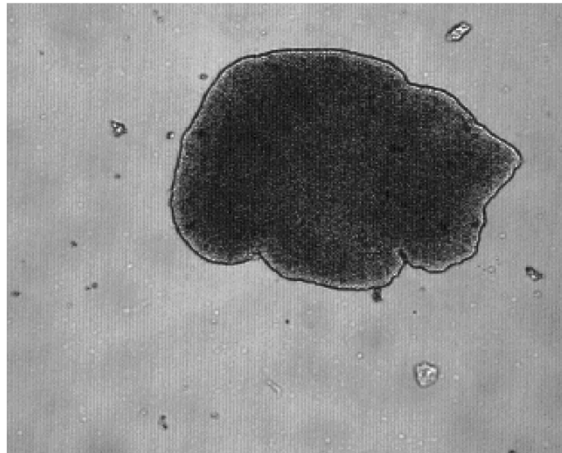
MEA Investigation of Neuroactivity Dynamics under Altered Gravity

Flexible use of hardware for different platforms



GraviPlax Experiment: The simples animal as model organism for gravitational and cancer research

- *Trichoplax adherens* with polar organisation
- Genes responsible for polarity
- Cancer development is induced by loss of polarity

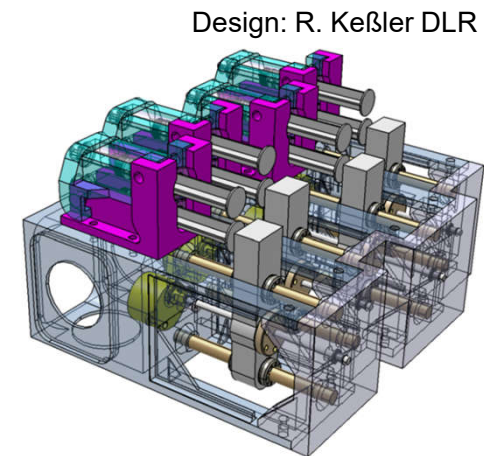
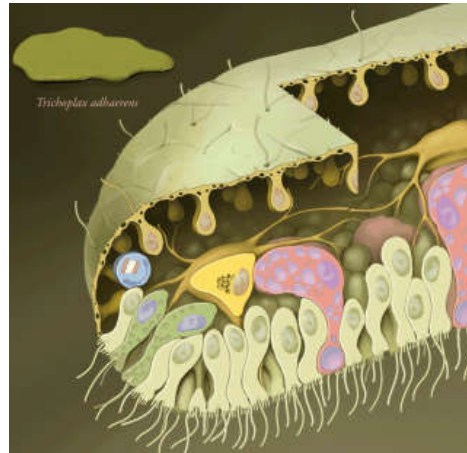
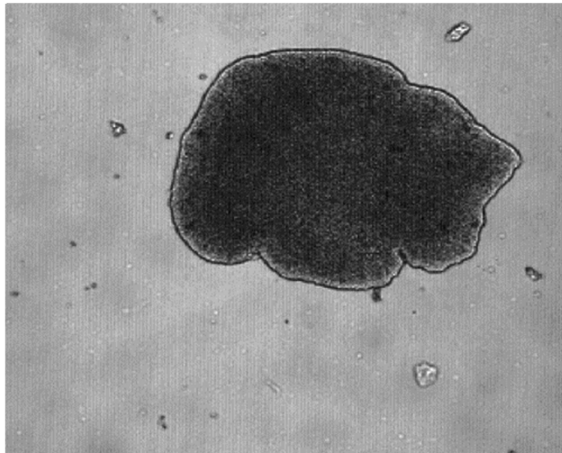


Schierwater, Bernd, et al. "The enigmatic Placozoa part 2: Exploring evolutionary controversies and promising questions on earth and in space." *BioEssays* 43.10 (2021): 2100083.



GraviPlax Experiment: The simplest animal as model organism for gravitational and cancer research

- *Trichoplax adherens* with polar organisation
- Genes responsible for polarity
- Cancer development is induced by loss of polarity



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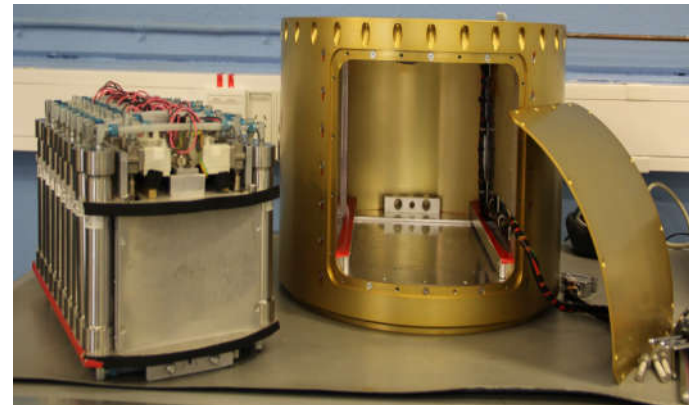
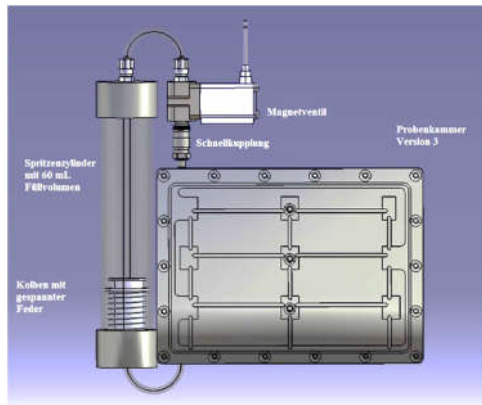
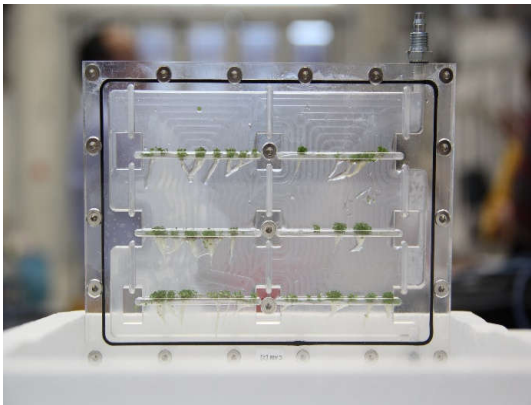


Arabidomics – Plants in microgravity

- Mapheus-5 (2015)
- SAHC (2016)
- Drop Tower (2014, 2016, 2017)
- Parabolic flights campaigns
 - 25. DLR (2014)
 - 63. ESA (2015)
 - 67. ESA (2017),
 - 70. ESA (2018)
- Ground-based studies

- New insights in the gravity-signalling pathway
- Gravity influence on proteomics
- Student works and publications
- Flexible use of hardware for different platforms

Special credit to M. Böhmer, O. Schüler, M. Görög

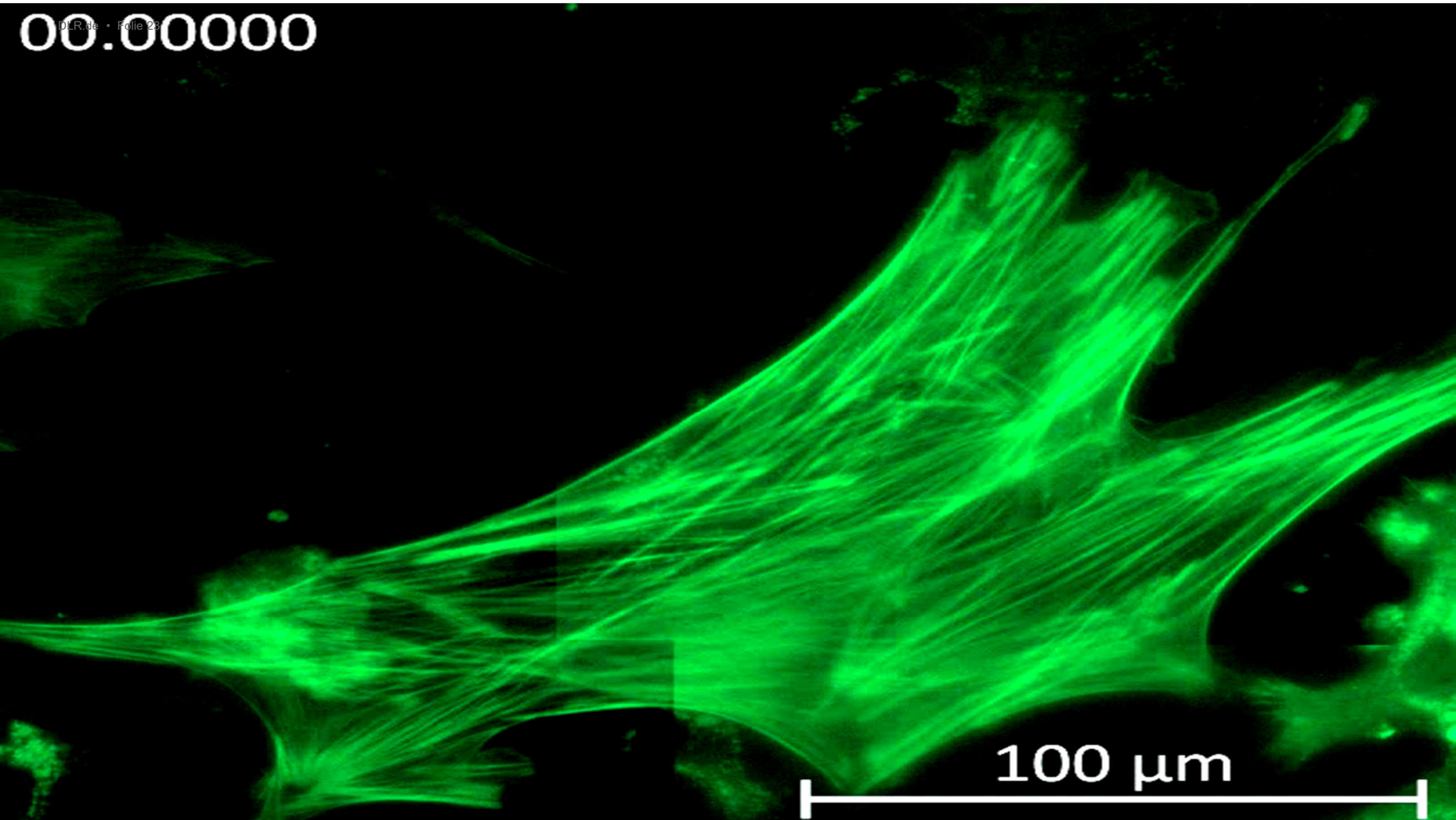


Hauslage, Jens, et al. "ARABIDOMICS—A new experimental platform for molecular analyses of plants in drop towers, on parabolic flights, and sounding rockets." *Review of Scientific Instruments* 91.3 (2020): 034504.

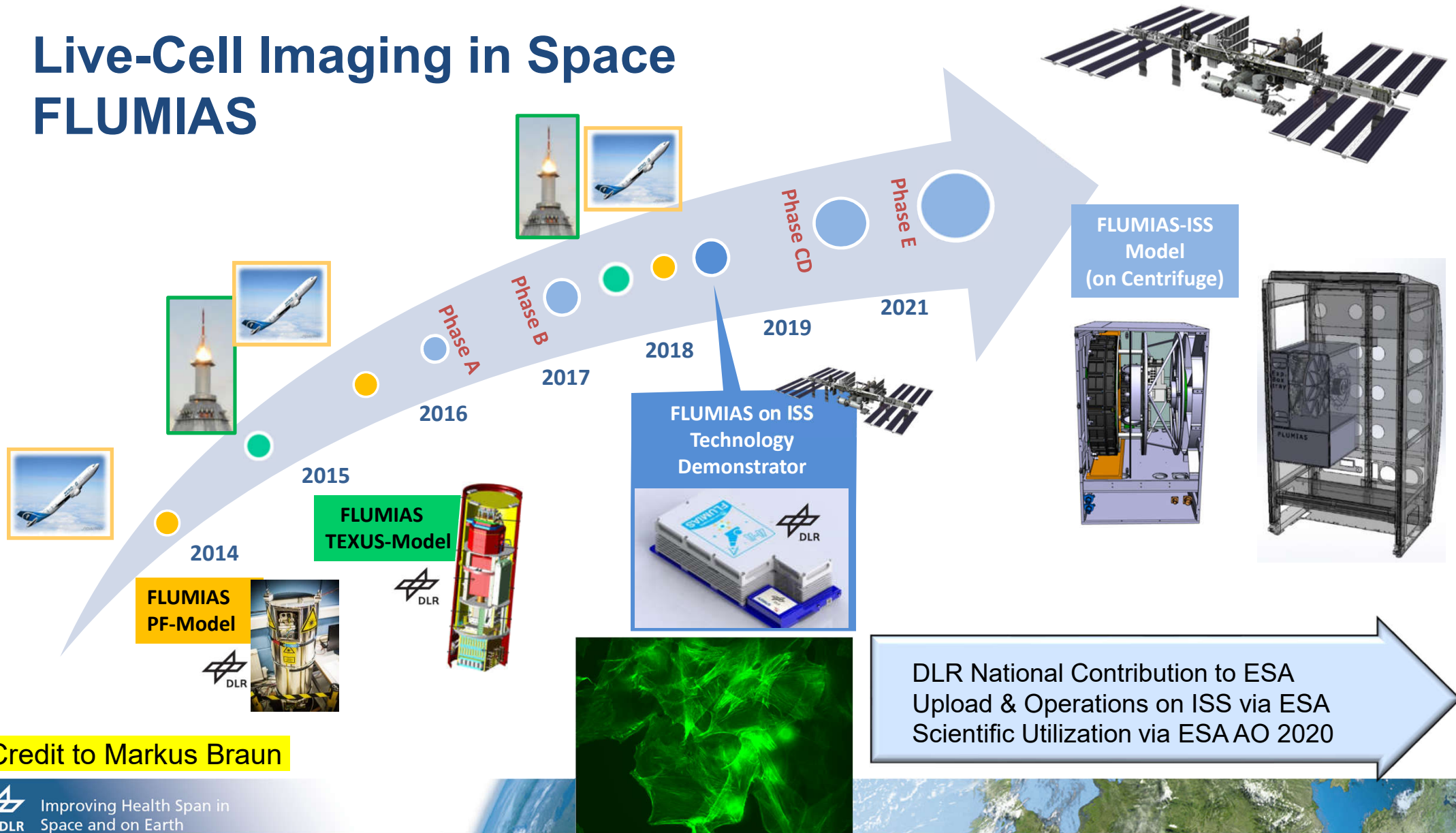
Schüler, O., Hemmersbach, R. and Böhmer, M., 2015. *Frontiers in Plant Science*, 6, p.1176.



DLR.de • Folie 28
00.00000



Live-Cell Imaging in Space FLUMIAS

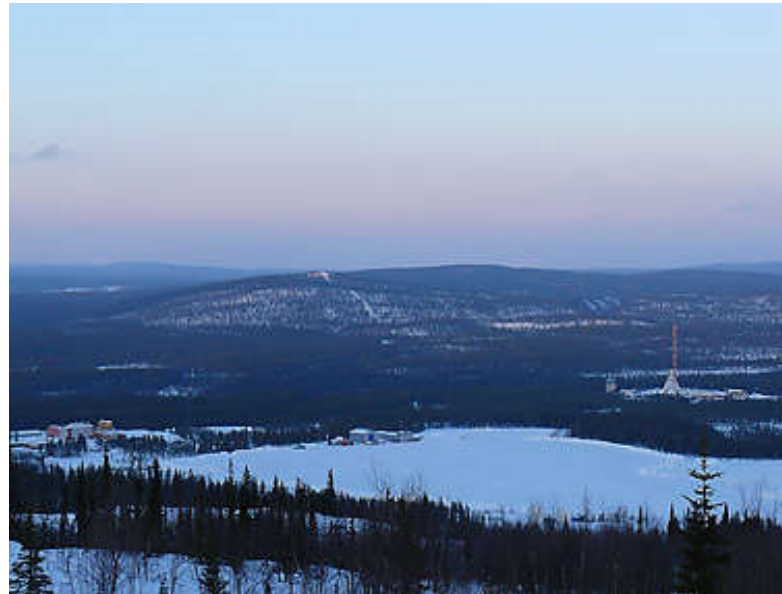


Credit to Markus Braun

Sounding Rockets: Challenges and the secret of success



...bring scientists in a harsh and beautiful environment

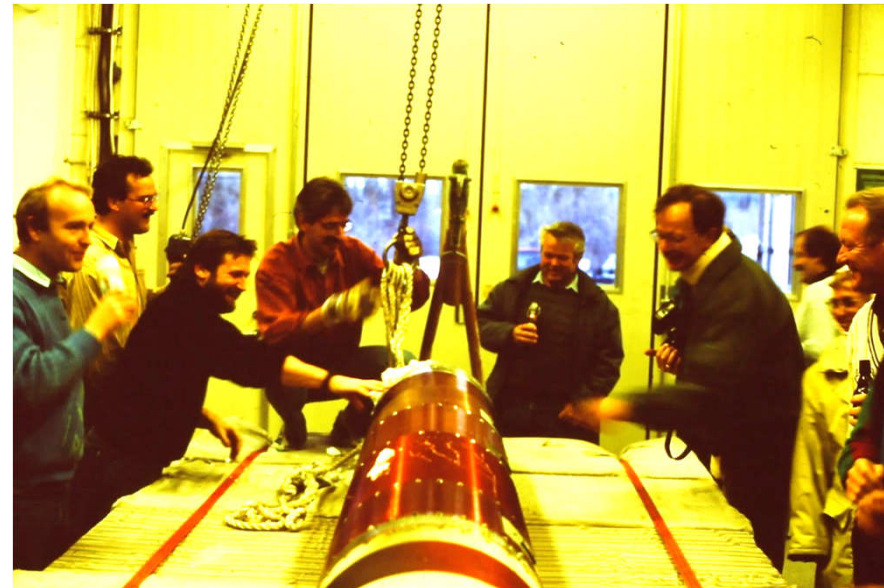


...scientists at their limits will forget their circadian rhythm and experience the rules of nature

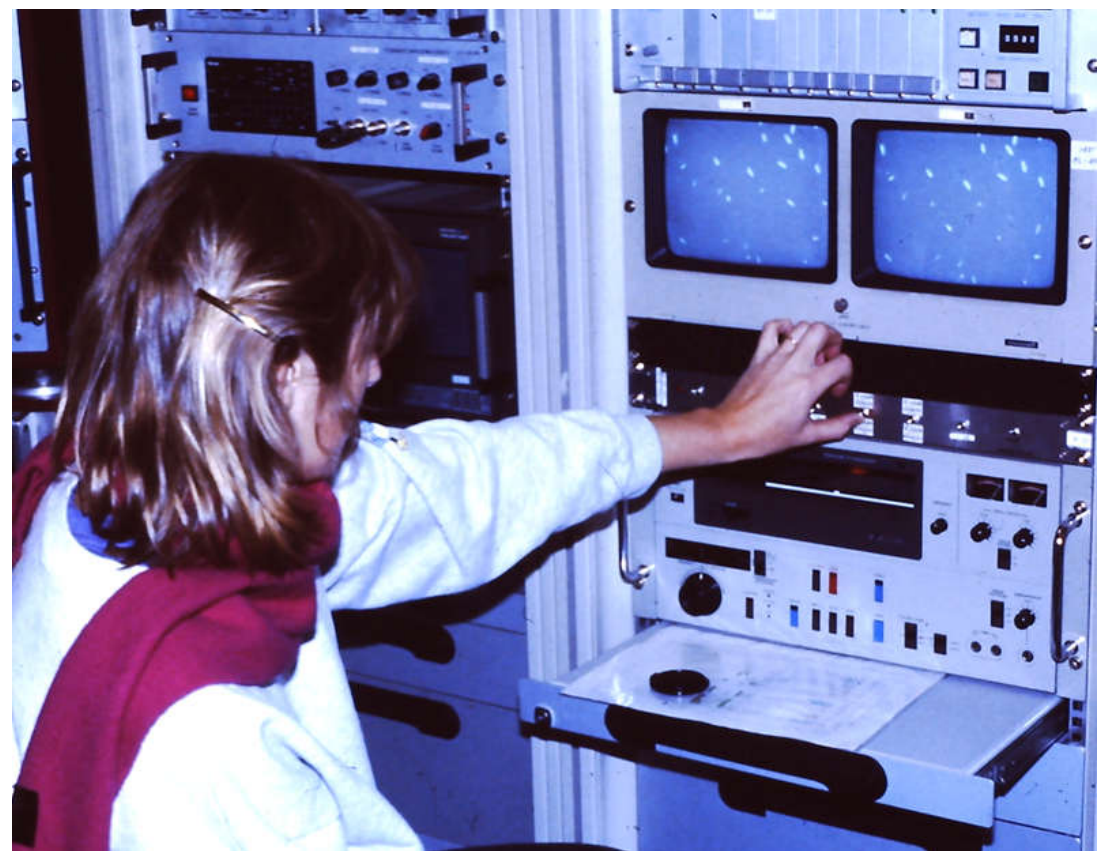
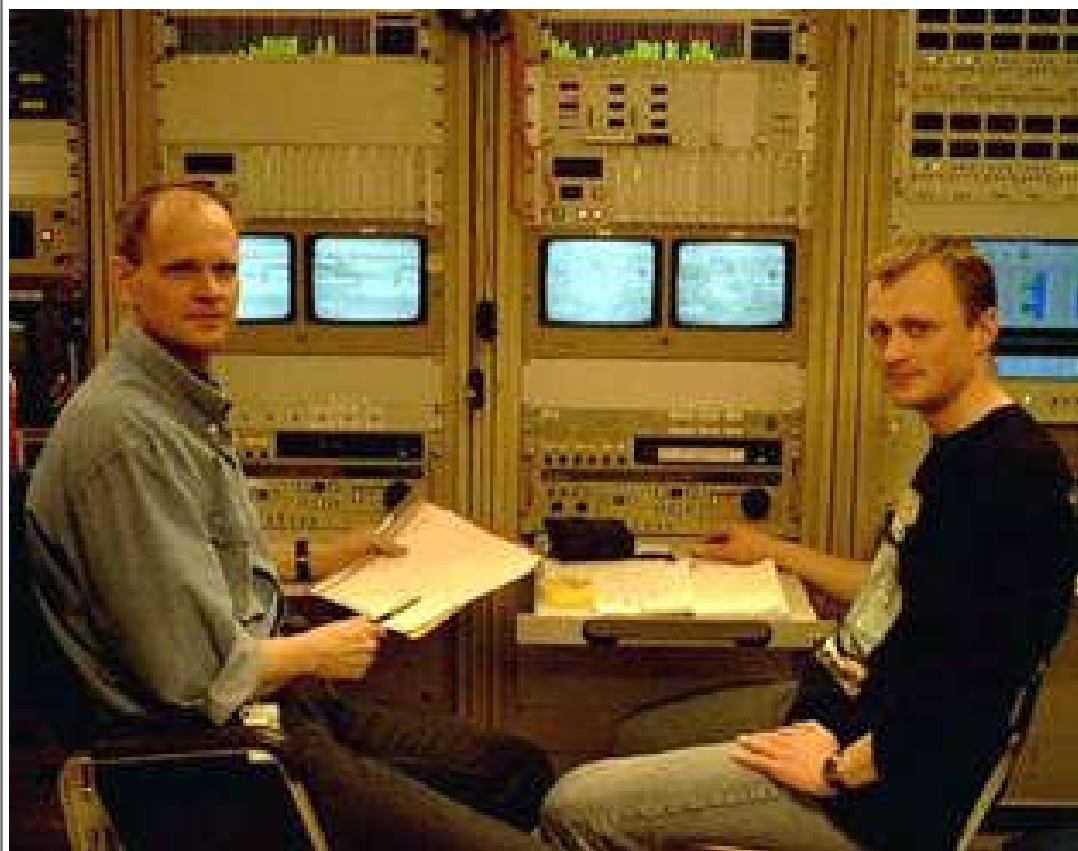


The big advantages for Life Scientists

Late access – early retrieval

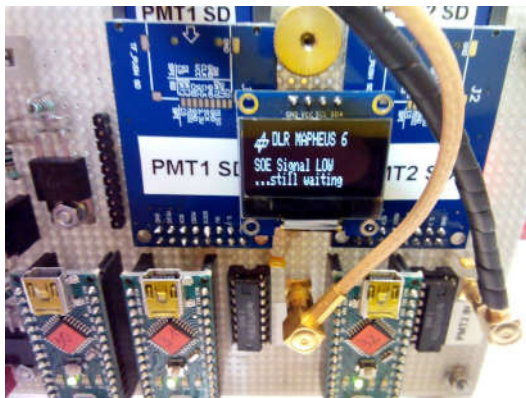


Direct control by video downlink and telecommand



DLR MAPHEUS - Approach

- Commercial/Compartments off-the-shelf (COTS)
- 3D printed hardware
- Multi-experiment units
- Quickly implemented



microscope + radiation
measurement units



Maas, N., et al. "apex: A new commercial off-the-shelf on-board computer platform for sounding rockets." Review of Scientific Instruments 90.10 (2019): 105101.



Scientific „Sounding Rockets“ for Life Sciences

yes, we need sounding rockets for gravity-related studies in single cells, plants and small animal systems. Using this tool, we can close an important gap of knowledge before going into space and beyond.

- **Microgravity in the minute-range with high quality**
- **Flexibility**
- **Easy access**
- **Involvement of young scientists**

Scientific „Sounding Rockets“ Yes, we need them!

Special thanks to fantastic technicians, scientists and friends, who helped to perform successful experiments with unforgettable team experience and a lot of fun.

**DLR Gravitational Biology Team
(Jens Hauslage, Christian Liemersdorf)
DLR Institute of Materials Research
DLR Space Operations - MUSC
DLR Moraba
MBB Erno/Airbus Defense
Kayser-Threde
Estrange Team
ESA**