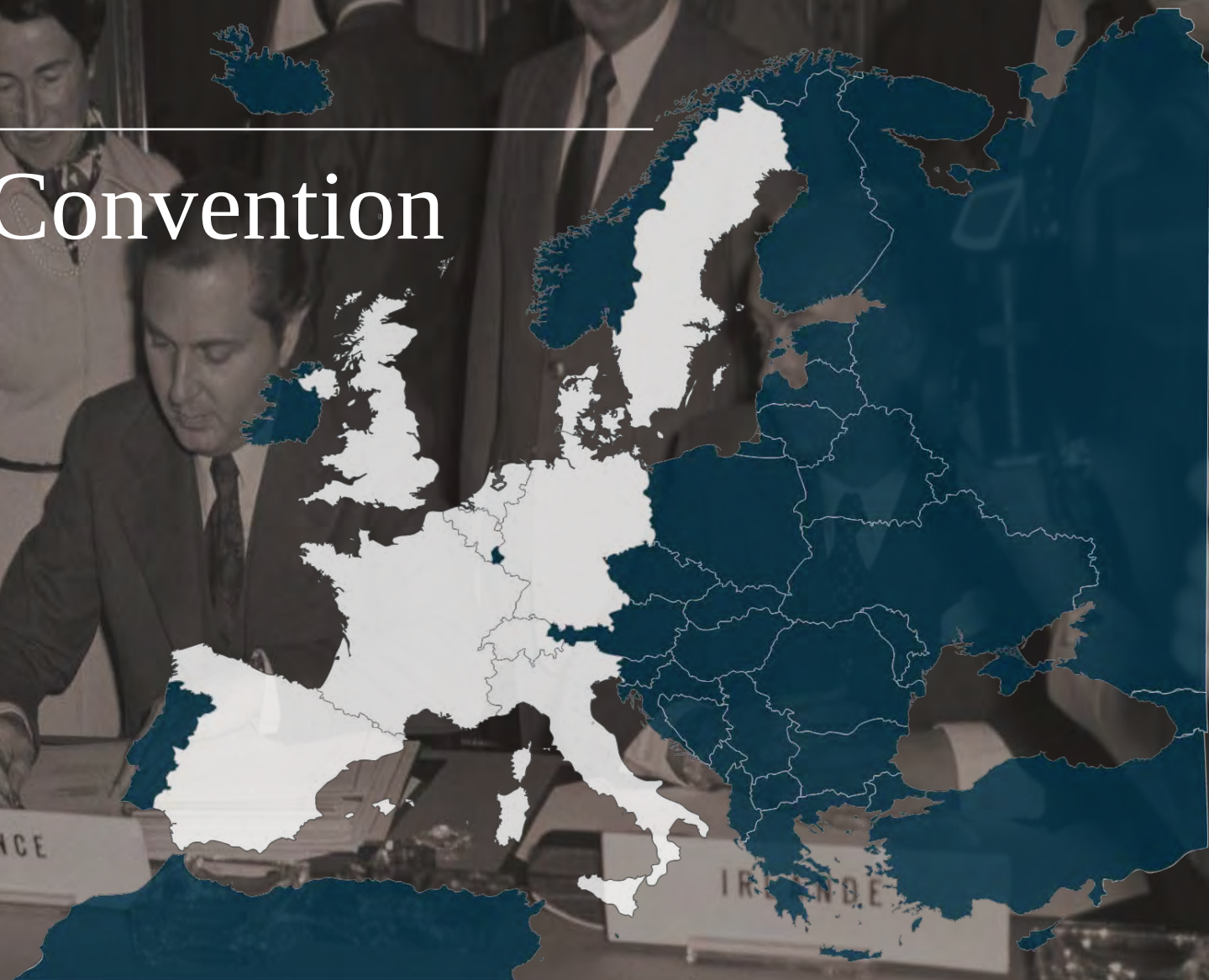


European Space Agency : ESA

1975 Signing of ESA Convention

10

MEMBER STATES



2020

22

MEMBER STATES



ESA Establishments (1)



Headquarters

Located in **Paris**, home to the main programme directorates that steer and formulate ESA policy.



ESRIN

ESA's centre for Earth observation activities, near **Rome**, Italy, also develops information systems and hosts the Vega launcher project.



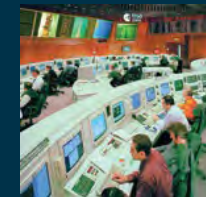
ESTEC

The European Space Research and Technology Centre, **Noordwijk**, the Netherlands, is the largest site and the technical heart of ESA.



ESOC

The European Space Operations Centre, **Darmstadt**, Germany, tracks and controls European spacecraft.



EAC

The European Astronaut Centre, **Cologne**, Germany, trains astronauts for missions to the International Space Station and beyond.



ESA Establishments (2)



ESAC

The European Space Astronomy Centre, near **Madrid**, Spain, hosts the science operation centres and archives for ESA's astronomy and planetary missions.



Harwell (ECSAT)

Harwell Centre, in **Oxfordshire**, UK, is focusing on commercialisation and partnerships in space activities.



Redu

Redu Centre in Belgium is part of ESA's ground station network and is also home to ESA's Space Weather Data Centre.



Guiana Space Centre

ESA's launchers lift off from Europe's Spaceport in **Kourou**, French Guiana. It is jointly operated by the French space agency (CNES) and Arianespace with the support of European industry.

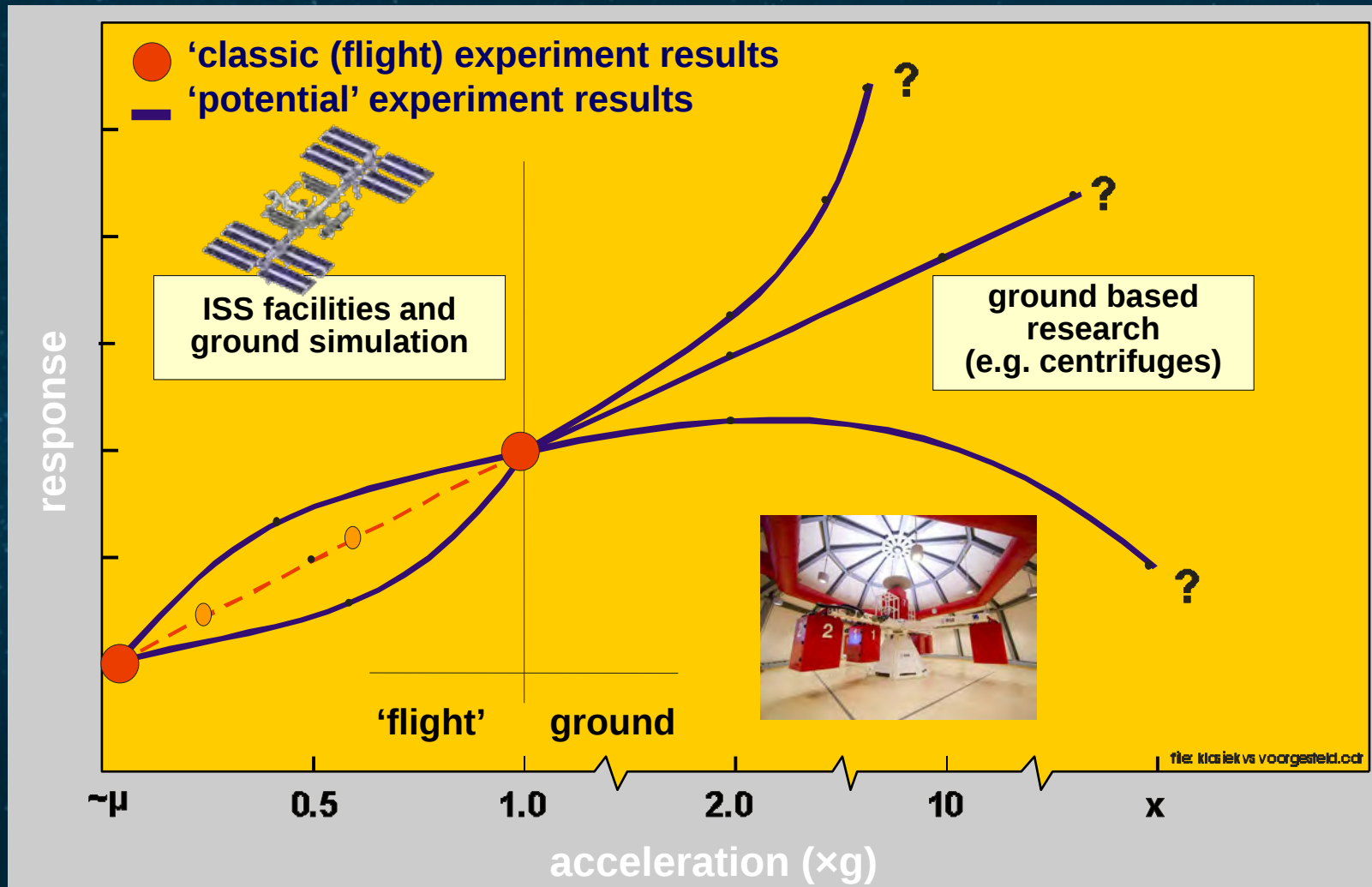


ESA-Technology Center ESTEC, Noordwijk, NL



the 'Center of Gravity'

Spaceflight vs. Ground-Based Research

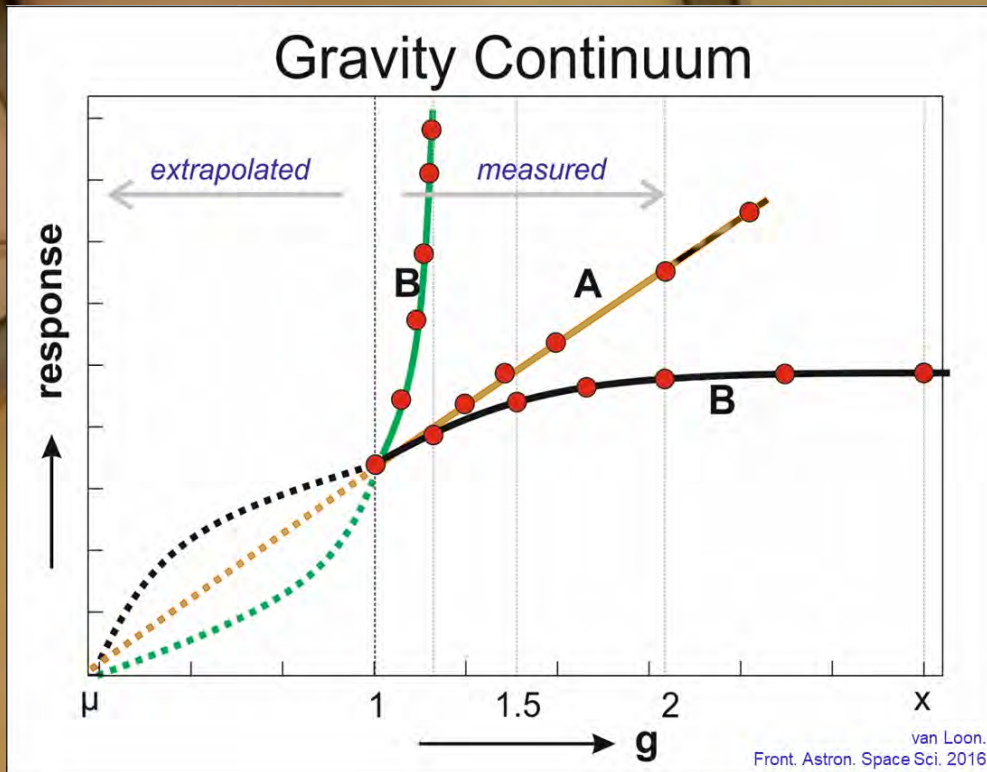


Schematic presentation of potential experiment opportunities compared to 'classic' experiment setups. Novel space station facilities as well as ground simulations and centrifuges may be applied to study the role of weight (accelerations) on various living and non-living samples.

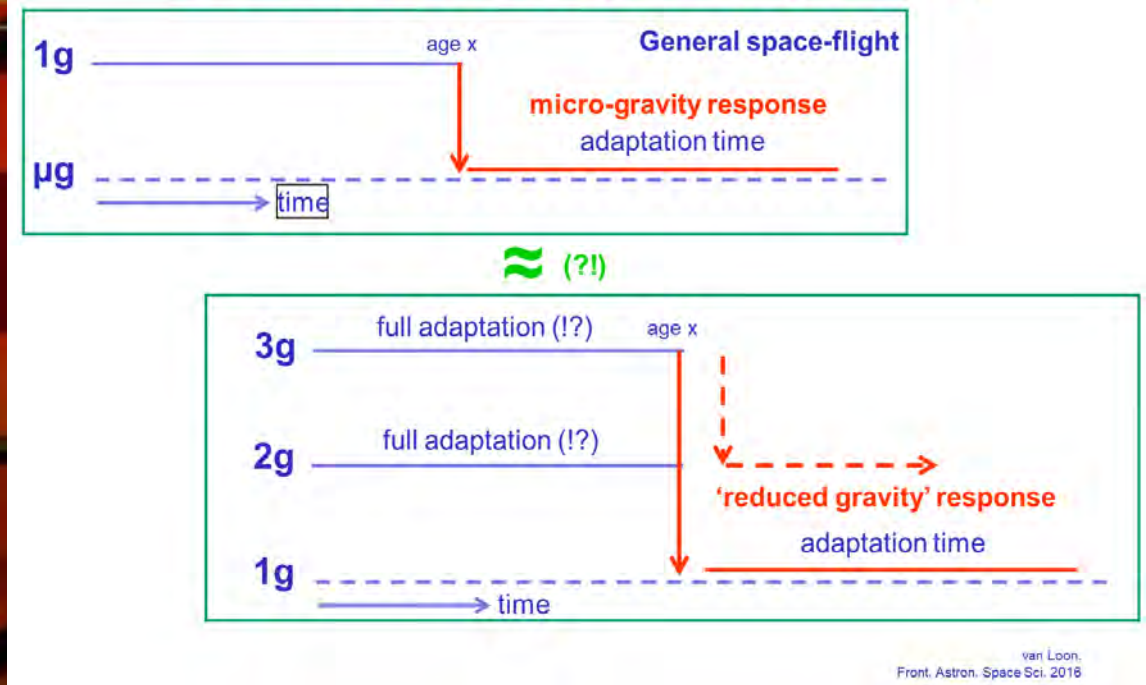
See also: van Loon
Front. Astron. Space Sci. 2016

Large Diameter Centrifuge

- Regular hypergravity research
- Launch simulations
- Parabolic Flight hyper-g phase exploration
- ...etc.



The 'Reduced Gravity Paradigm' (RGP)



TEC-MMG Lis Lab @ ESA-ESTEC

Life- and Physical Science Instrumentation Laboratory (LIS)



Jack van Loon



Alan Dowson



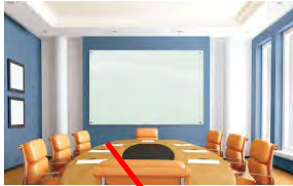
Francois Gaubert



Robert Lindner



meeting room



clean room



(fluor.) mic.s



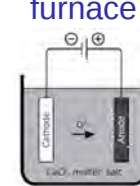
flow benches



plant chamber



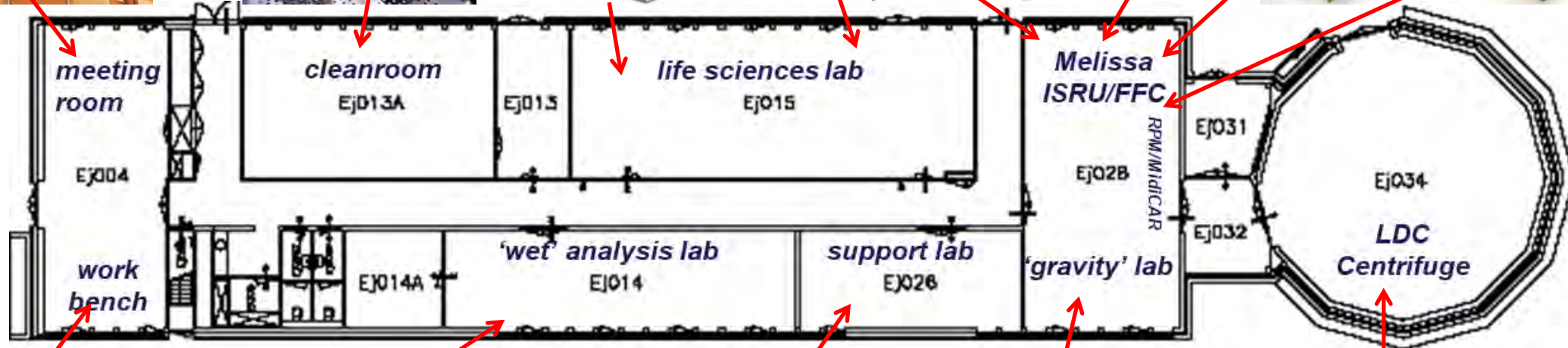
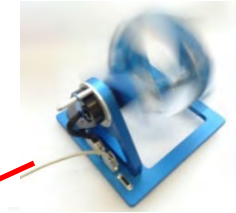
FFC furnace



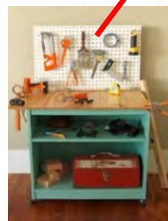
MidiCAR



RPMs



+
other
ESTEC
labs !!



workbench



LC/MS



e.g. autoclaves



clinostats



LDC

Link: [ESA TEC-MMG lab](https://www.esa.int/ESA/TEC-MMG_lab)

+ THE EUROPEAN SPACE AGENCY



LisLab – LDC Facilities @ ESA-ESTEC

Life- and Physical Science Instrumentation Laboratory (LIS)



main lab



support lab



LDC control room



meeting room



'wet lab'



small 'workshop'



LDC prep lab

LDC Main Properties

diameter : ~ 8 meter

arms : 4

g levels : various (8 locations / arm)

exp. Volume: 7 'gondolas' ; 6 rotating (60×60×80 cm)

center gondola: control / g-sensitive materials

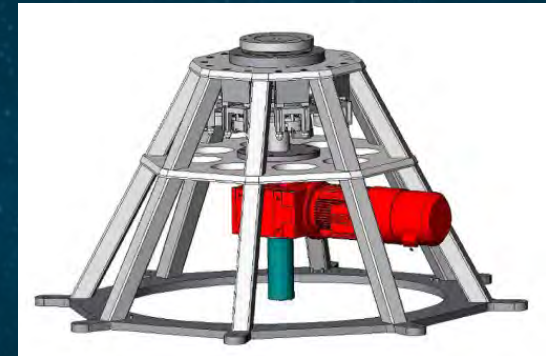
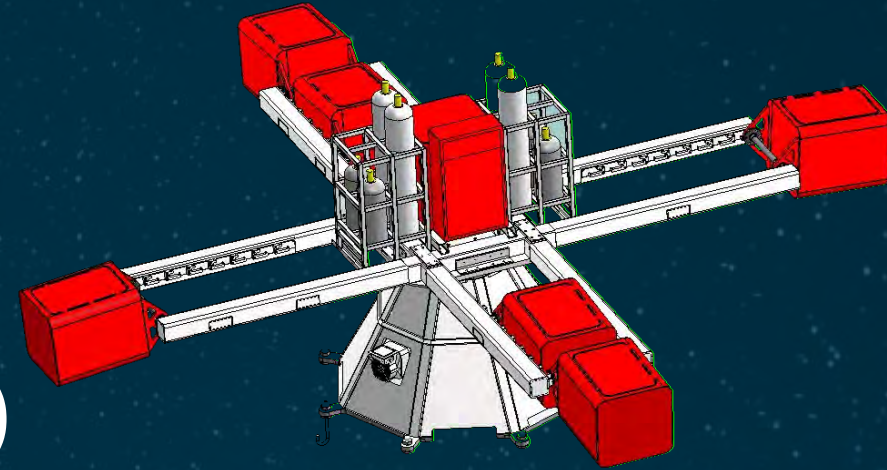
g vector : swing-out: 

payload : 80 kg per gondola (total 210 kg incl. gondola)

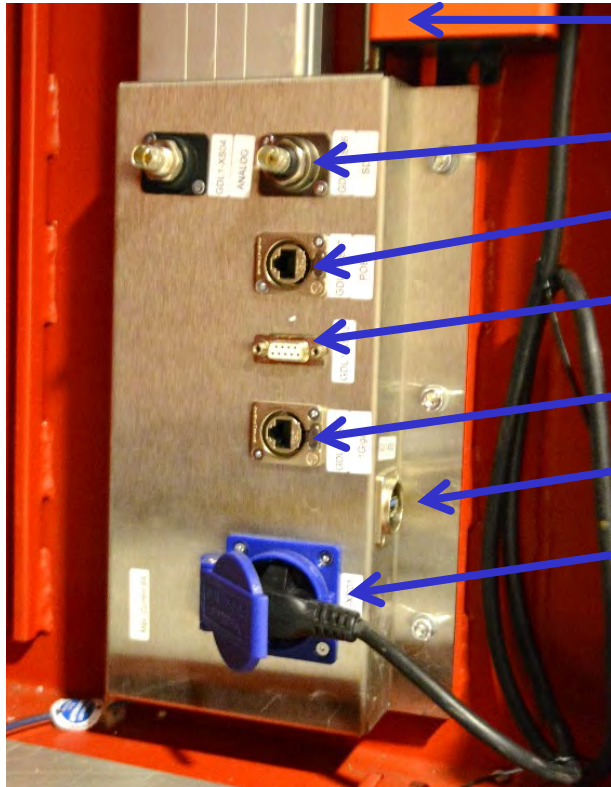
g load : 20×g fully loaded

motor : 22 kW (Siemens)

for HyperGES : max 2 weeks use of LDC

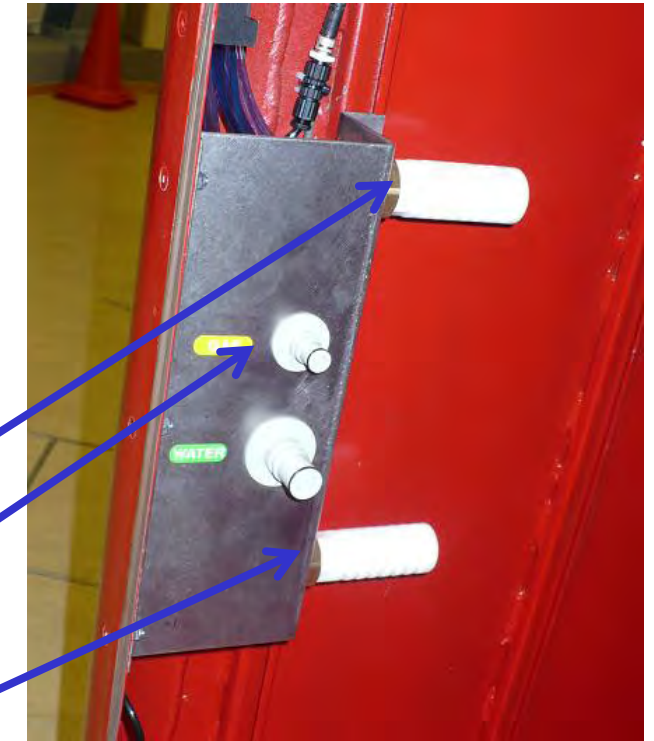


The Gondola : Main Properties

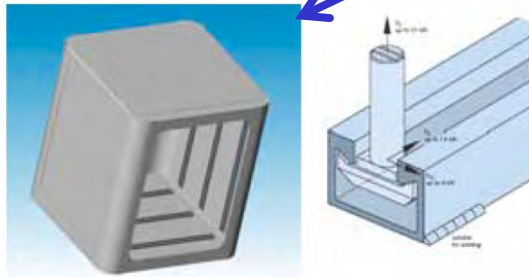


power / data

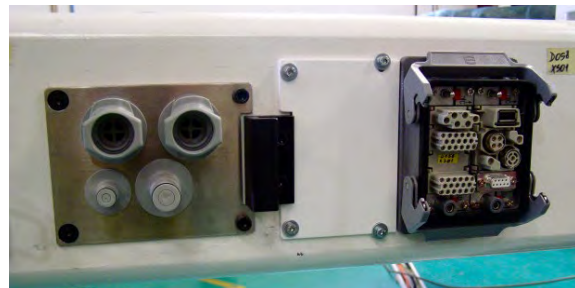
- temp. sensor
- anal. / dig. video / PoE channels
- RS-232 serial channel
- Ethernet channel
- USB-3 channel
- 230 V/6 amp line
- fixation
- gas lines (#)
- water supply
- forced ventilation



gas + water lines



experiment fixation



gondola connections



9 analogue video lines /
8 digital video lines

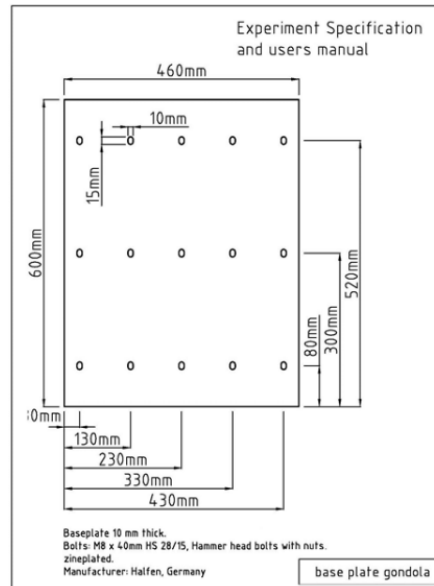
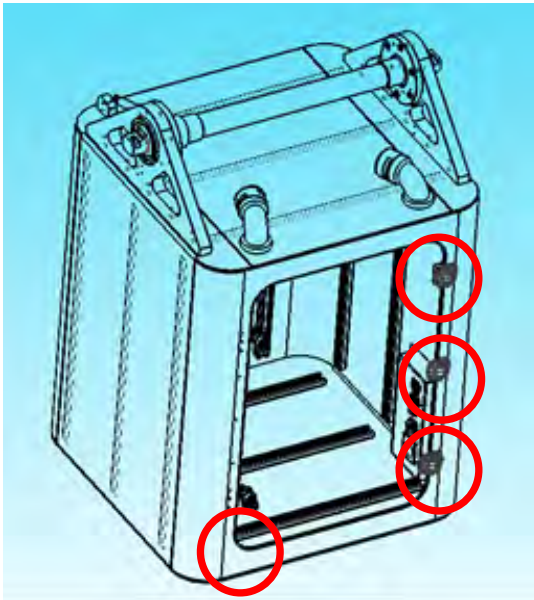
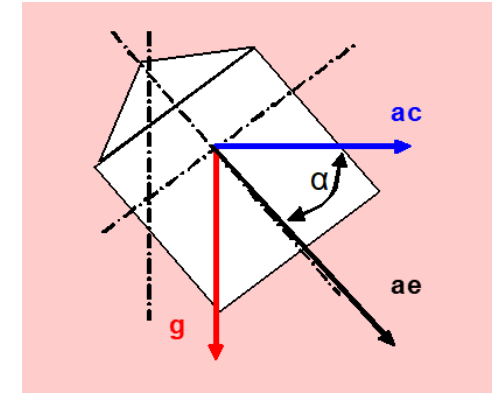
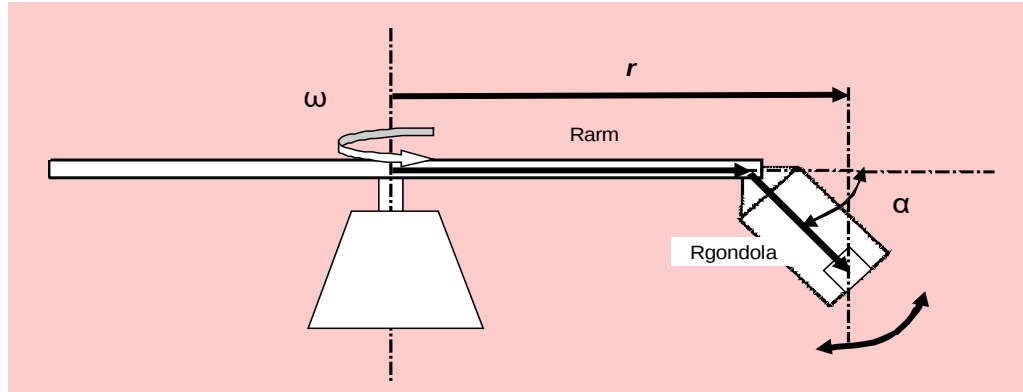
Operation Electronics Scheme



- Link: [LDC User Manual](#)



LDC Swing-Out / Integration



Door clearance: 450× 710 mm (W×H) (max. approximately; round corners, hinges !!)

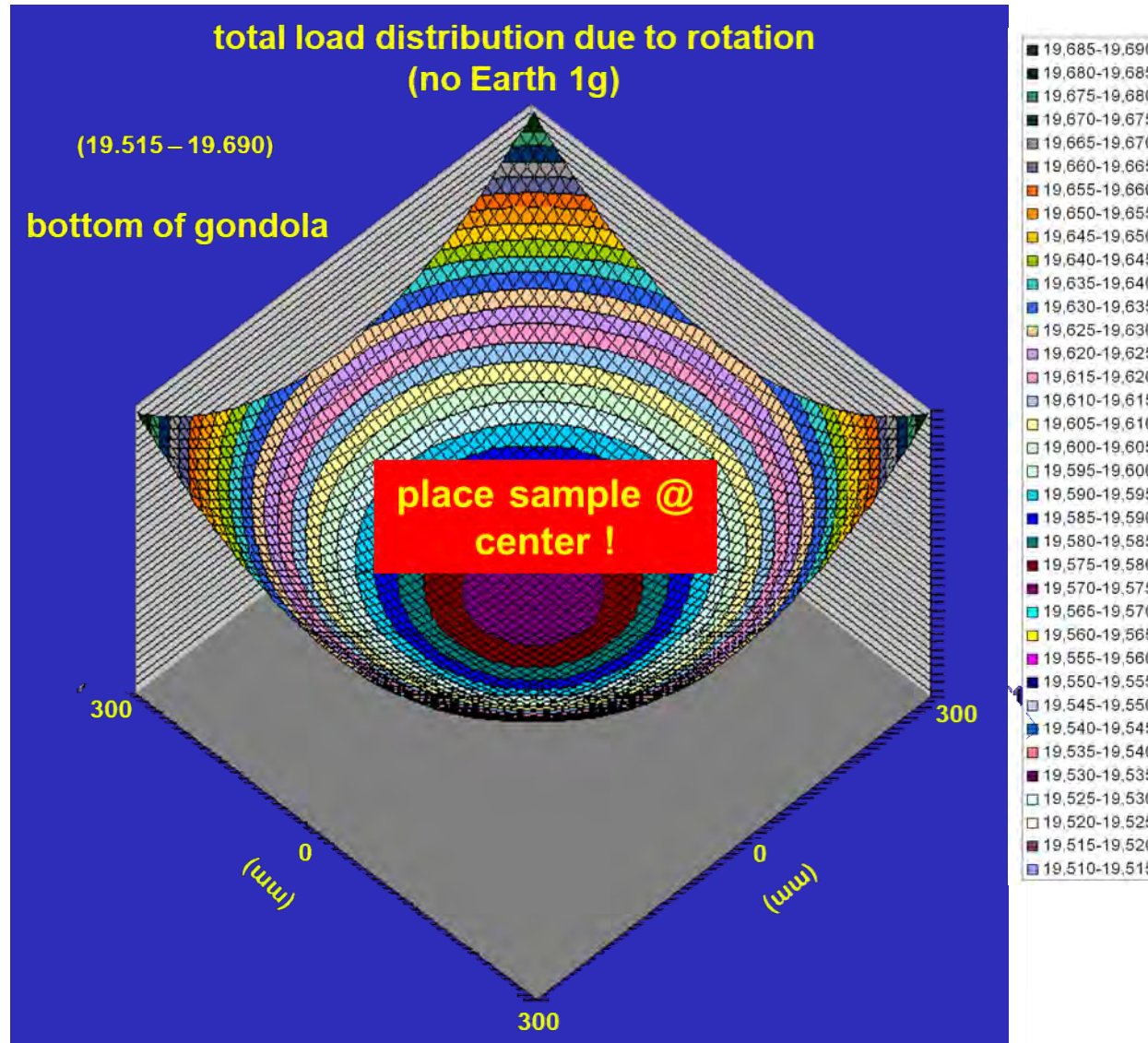
Working space inside: 500×500 × 720 mm

Base plate
(mostly not needed)



Gas / fluid
containers

The Gondola : Gravity Profile / Inertial Shear



20g, longest arm
total surface area
600×600 mm

max. gradient / inertial
shear over full surface
area:

@ 80 cm: **0.6%**

@ 40 cm: **0.7%**

@ 0 cm: **0.9%**

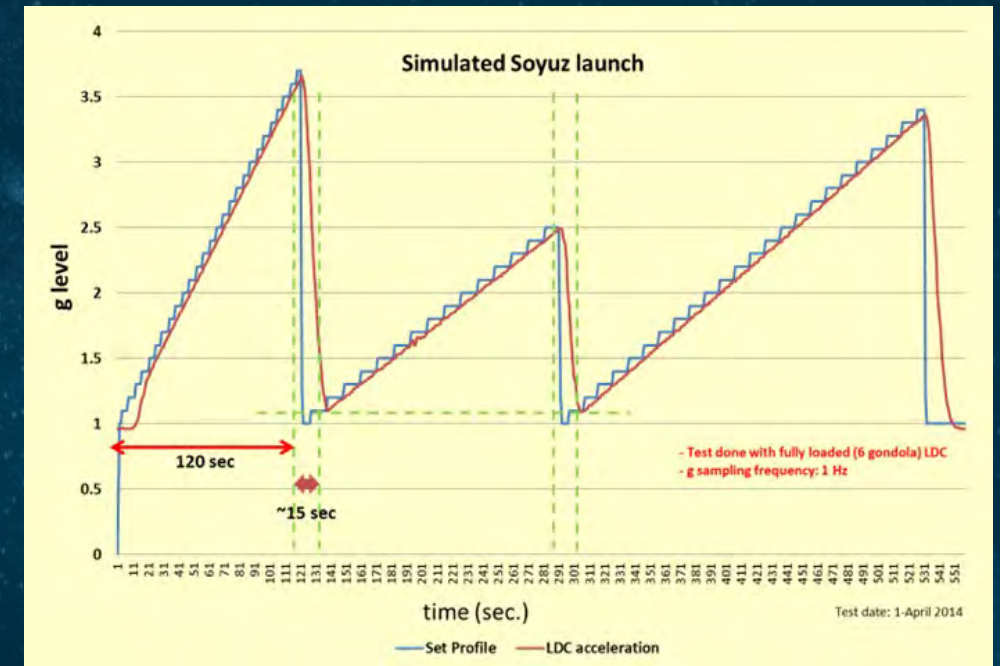
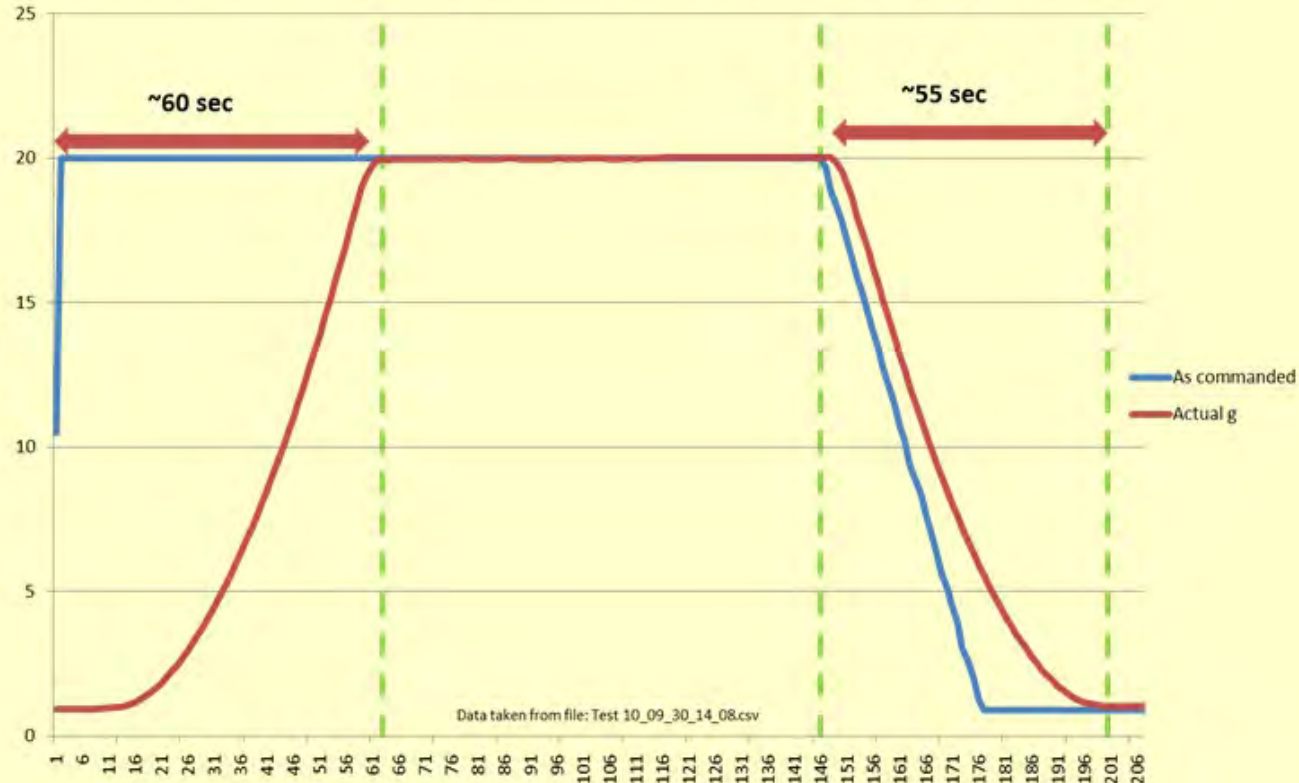
gradient over gondola
height: **10.3%**

Best place sample in center of gondola !!

See also:
van Loon et al. J Biomechan Eng 2003

LDC Start-up & Profiles

Immediate spin up to 20 g and spin down to 1 with fully loaded LDC (6 gondola's).



LDC Experiment Accommodation

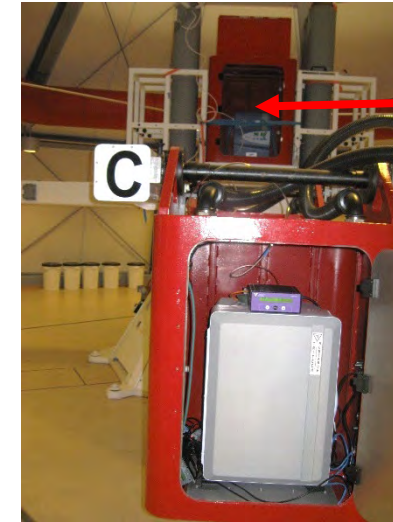
Multiple g-levels (~factor 2)



(Univ. Amsterdam, NL)

increase exp. n !

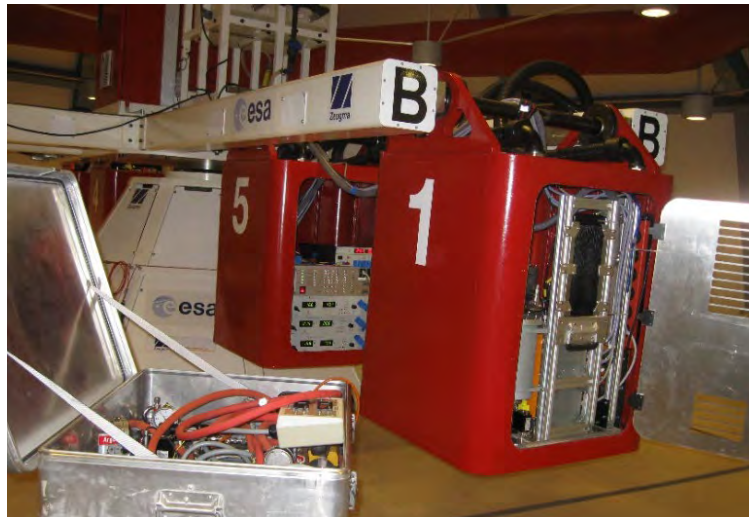
Different temperatures (~4-40 °C)



(Univ. Porto, PT)



Use Multiple Gondolas



(MAP: Aachen et al. DE)

Lab Pre-integration



(ASML/TU/e, NL)

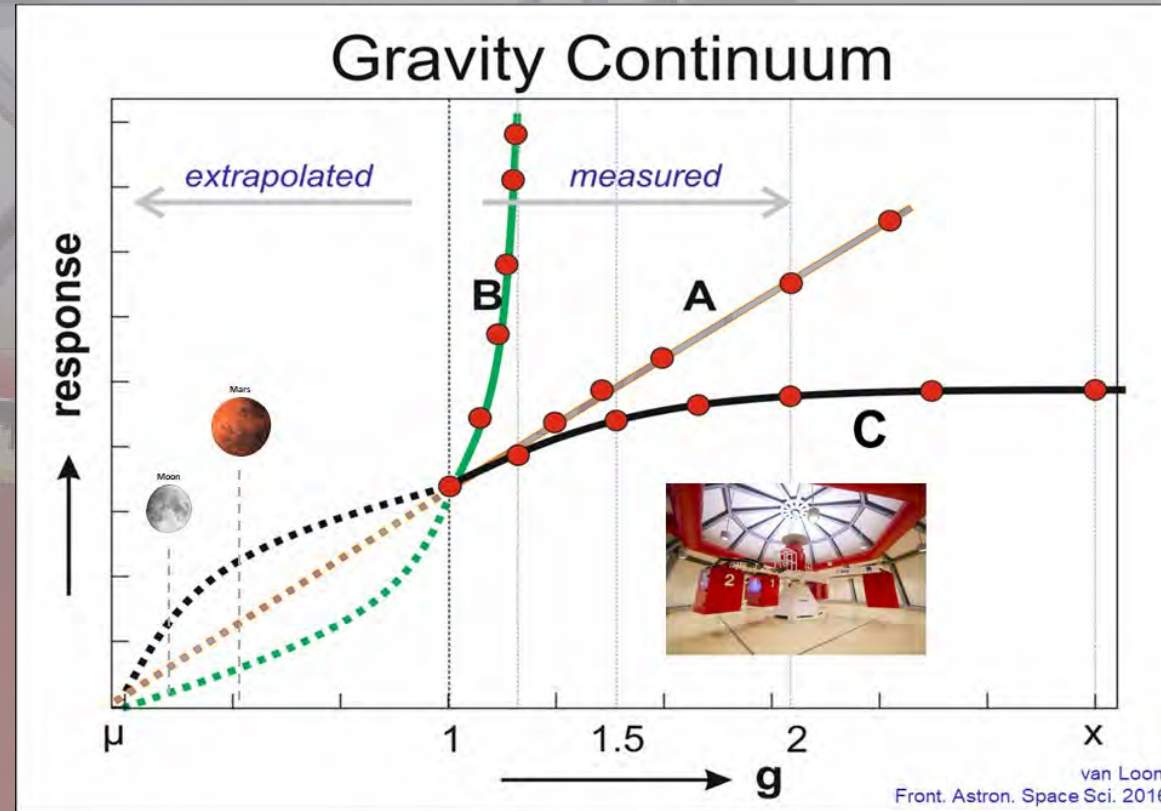
Some ISRU studies in the Large Diameter Centrifuge (LDC) @ TEC-MMG- ESTEC, Noordwijk, NL



Impact
(Glasgow,UK)

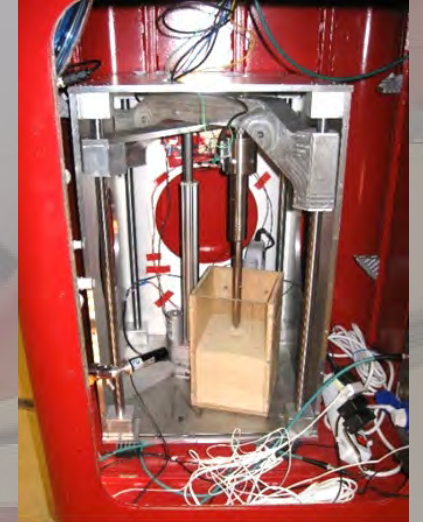


Test Habitat Structures



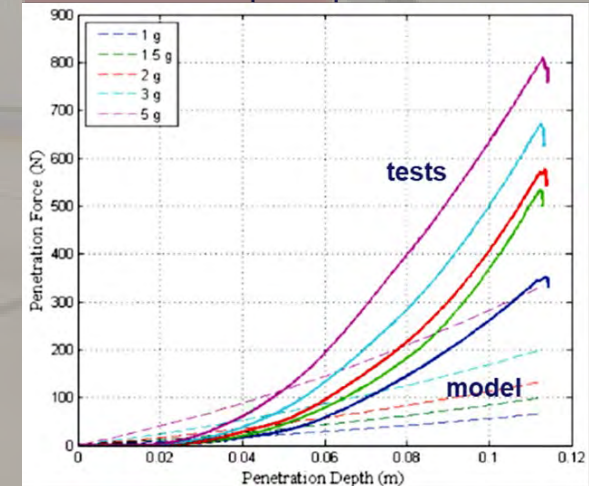
Scaling effects:

- $g = N$
- Length: $1/N$
- Time : $1/N^2$
- Mass: $1/N^3$



Ultrasonic Drill
(Glasgow,UK)

Surface drill peak penetration force



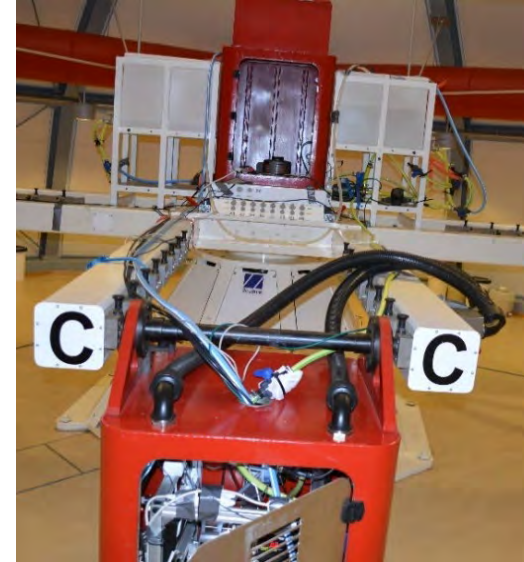
Some Experiment Configurations



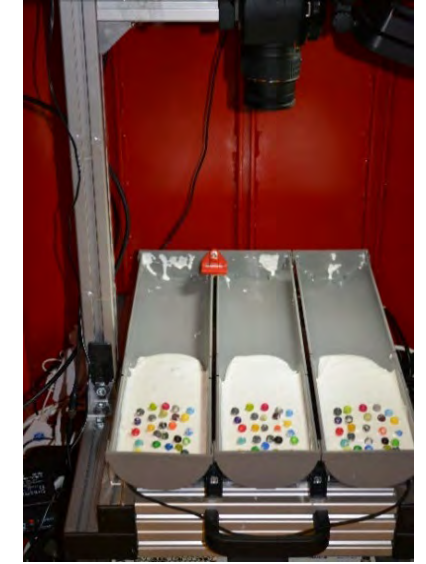
Impact
(Glasgow, UK)



Crab/Neurovestibular
(Aberdeen, UK)



Mass & Heat Transfer
(Thessaloniki, GR)

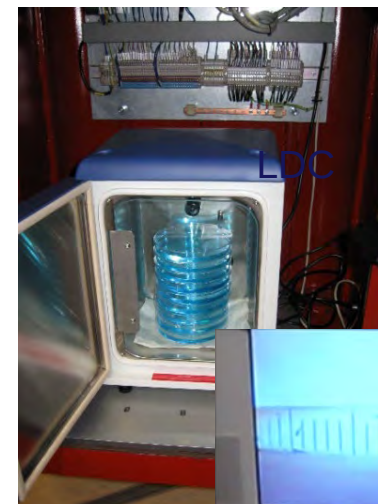


Planetary/Glacier
(Amsterdam, NL)



5 camera's

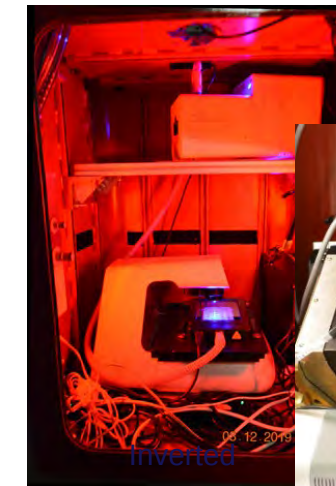
Bubble Generation
(Thessaloniki, GR)



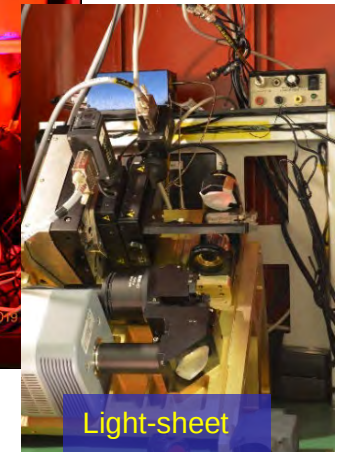
RPM /
clinostat



(Liege, BE)



EVOS M7000



Light-sheet

Fluorescence Mics light sheet

Buoyancy / Coriolis
(Barcelona, ES)

Some peer reviewed papers from previous LDC studies (non-exhaustive list) on general, **cell biology**, **plant biology**, **animal physiology**, **fluid physics**, **plasma physics**, **geology/planetary**, **technology**, **material sciences** and other topics: see in LDC user Manual; [LINK](#)

Centrifuges general topics / background

- [doi:10.3389/fspas.2016.00021](https://doi.org/10.3389/fspas.2016.00021)
- [doi: 10.3389/frspt.2020.00003](https://doi.org/10.3389/frspt.2020.00003).
- DOI [10.1007/s12217-015-9462-9](https://doi.org/10.1007/s12217-015-9462-9)

Fluid physics

- <https://link.aps.org/doi/10.1103/PhysRevLett.123.244501>
- [doi:10.1007/s12217-019-09740-8](https://doi.org/10.1007/s12217-019-09740-8).
- doi.org/10.1016/j.ijmultiphaseflow.2019.03.029.
- DOI: doi.org/10.1016/j.ijheatmasstransfer.2018.12.086
- <https://doi.org/10.1016/j.fbp.2017.02.001>
- <https://doi.org/10.1103/PhysRevE.91.053009>
- DOI: [10.1209/0295-5075/110/24001](https://doi.org/10.1209/0295-5075/110/24001)
- DOI [10.1007/s10035-013-0403-2](https://doi.org/10.1007/s10035-013-0403-2)
- <https://doi.org/10.1016/j.expthermflusci.2015.01.011>
- <https://doi.org/10.1016/j.foodres.2013.10.044>.
- <https://doi.org/10.1007/s12217-012-9323-8>

Cell biology:

- DOI: [10.1016/j.ejpb.2021.03.013](https://doi.org/10.1016/j.ejpb.2021.03.013).
- DOI: [10.1002/jbm.a.37215](https://doi.org/10.1002/jbm.a.37215)
- doi: [10.1016/j.bpj.2021.01.021](https://doi.org/10.1016/j.bpj.2021.01.021)
- doi: [10.3390/ijms21072354](https://doi.org/10.3390/ijms21072354).
- <https://doi.org/10.1016/j.bpj.2019.03.038>
- doi: [10.1089/scd.2017.0206](https://doi.org/10.1089/scd.2017.0206)
- DOI: [10.1098/rsif.2016.0688](https://doi.org/10.1098/rsif.2016.0688).
- doi:10.2147/IJN.S76329
- DOI: [10.1371/journal.pone.0144269](https://doi.org/10.1371/journal.pone.0144269).
- DOI: [10.1089/ten.tea.2012.0267](https://doi.org/10.1089/ten.tea.2012.0267)
- <https://doi.org/10.1016/j.jbiosc.2011.09.025>

Material sciences

- DOI: <https://doi.org/10.1016/j.ijheatmasstransfer.2018.05.151>

Plasma physics

- doi.org/10.1088/1361-6595/aa5ee8.
- [doi:10.1088/0963-0252/24/2/022002](https://doi.org/10.1088/0963-0252/24/2/022002)
- <http://dx.doi.org/10.1016/j.materresbull.2014.03.013>
- DOI: [10.1140/epid/e2013-40408-7](https://doi.org/10.1140/epid/e2013-40408-7)

Plant biology

- [doi:10.1038/s41598-018-24942-7](https://doi.org/10.1038/s41598-018-24942-7).
- <https://doi.org/10.1007/s12217-016-9531-8>
- <http://dx.doi.org/10.3389/fspas.2016.00002>
- doi:10.1038/srep07730
- <http://dx.doi.org/10.1155/2014/964203>
- doi:10.1371/journal.pone.0058246
- doi:10.1007/s12217-012-9301-1

Animal physiology

- doi: [10.1302/2046-3758.102.BJR-2020-0239.R1](https://doi.org/10.1302/2046-3758.102.BJR-2020-0239.R1)
- doi: [10.1038/s41526-020-00115-7](https://doi.org/10.1038/s41526-020-00115-7)
- DOI [10.7717/peerj.6055](https://doi.org/10.7717/peerj.6055).
- <https://doi.org/10.3390/ijms20030720>
- DOI:10.1371/journal.pone.0126928
- DOI: [10.1155/2014/679672](https://doi.org/10.1155/2014/679672).
- DOI [10.1007/s12217-012-9334-5](https://doi.org/10.1007/s12217-012-9334-5)

Geology/planetary

- doi: [10.1098/rspa.2016.0673](https://doi.org/10.1098/rspa.2016.0673)

Technology

- doi: [10.1016/j.bpj.2021.01.021](https://doi.org/10.1016/j.bpj.2021.01.021)
- DOI: [10.1002/adv.21937](https://doi.org/10.1002/adv.21937)
- ISBN [978-1-68108-499-2](https://doi.org/10.1007/978-1-68108-499-2)

The HyperGES Proposal : what should be clearly addressed?!

Why to use the LDC?

- Use LDC for 'regular' hypergravity studies / launch simulations / low gravity extrapolations / microgravity simulations (Reduced Gravity Paradigm)
- Science / application background / rationale (Preliminary data (own / from literature) / References! ...)
- Duration of the experiment (max. 2 weeks)

How to use the LDC?

- Identify what parameters to measure and how (either on-line or post exposure) – Expected outcome
- Show a (preliminary) hardware configuration
- Think about schedule / logistics
- How to communicate your results (report / peer reviewed science paper / conference presentation, local and social media)

Before upload.....

- (Re-)check if ALL parts of the proposal are completed
-

Any question / remarks regarding LDC ?!

Don't wait asking !!

Jack van Loon:

j.vanloon@amsterdamumc.nl

LDC User Manual: http://esamultimedia.esa.int/docs/edu/LDC_Experimenter_User_manual_V.3_Rev.0_14-May-2019_ESA-TECMMG-MAN-014129.pdf

TEC-MMG LIS Lab web URL: <https://technology.esa.int/lab/life-support-physical-sciences-instrumentation-laboratory>

Other general webinar info

SELGRA webinar: [Gravity-related research instrumentation applications in life and physical sciences](https://www.youtube.com/watch?v=jejiXxOZt-4)
<https://www.youtube.com/watch?v=jejiXxOZt-4>

UNOOSA webinar: [Introduction to Hypergravity/Microgravity: https://youtu.be/AjmR0syOc-Y?list=PLaOqa4cng0GGgCeqAwo0bWTPAdB2uHICx&t=1263](https://youtu.be/AjmR0syOc-Y?list=PLaOqa4cng0GGgCeqAwo0bWTPAdB2uHICx&t=1263) /

UNOOSA webinar series: https://www.unoosa.org/oosa/en/ourwork/access2space4all/HMTrack_Webinars.html#Tag6

ESA Petri website: https://www.esa.int/Education/PETRI_programme/PETRI_What_is_it