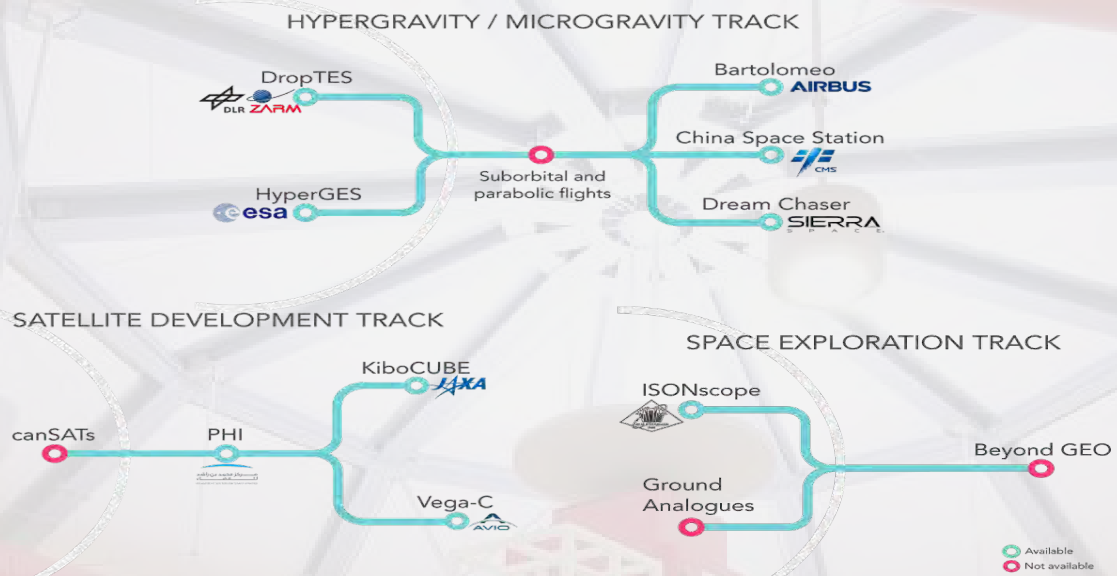


HyperGES : The ESA Large Diameter Centrifuge (LDC)

Dr.ing. Jack J.W.A. van Loon

Cooperate Scientist @ ESA-ESTEC-TEC-MMG Lab, Noordwijk, The Netherlands

&

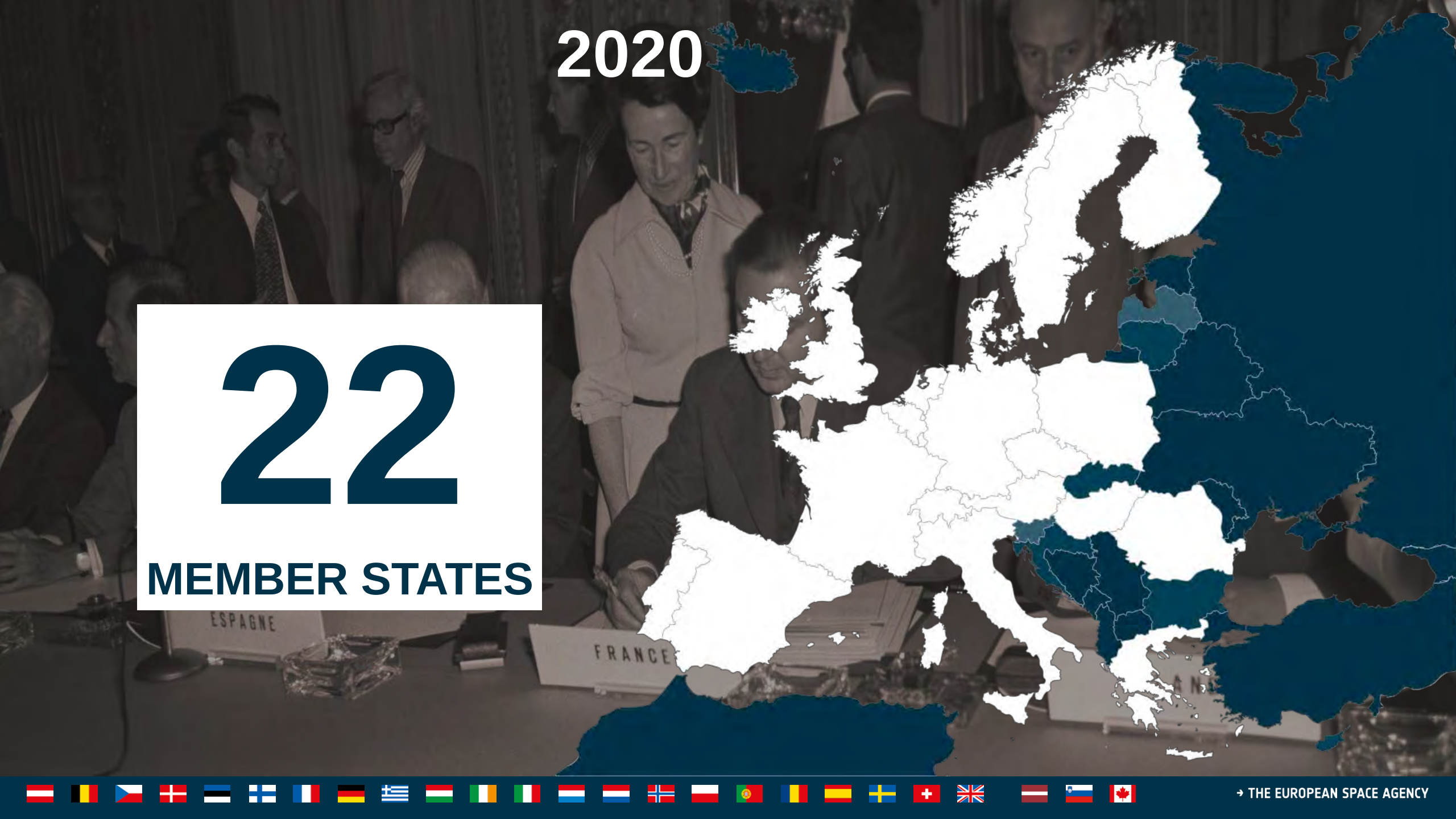
Dept. Cranial-Facial Surgery, ACTA &
VU University Medical Center, Amsterdam, The Netherlands
Email: j.vanloon@amsterdamumc.nl

Thursday 26 June 2023 10:30 CEST and 16:30 CEST
UNOOSA-ESA HyperGES- Q&A webinar

1975 Signing of ESA Convention

10

MEMBER STATES


2020
22
MEMBER STATES
ESPAGNE
FRANCE

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.

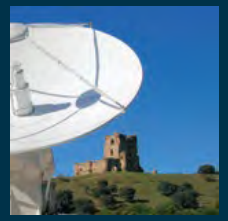
ESTEC
The European Space Research and Technology Centre, Noordwijk, the Netherlands, is the largest site and the technical heart of ESA.

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.



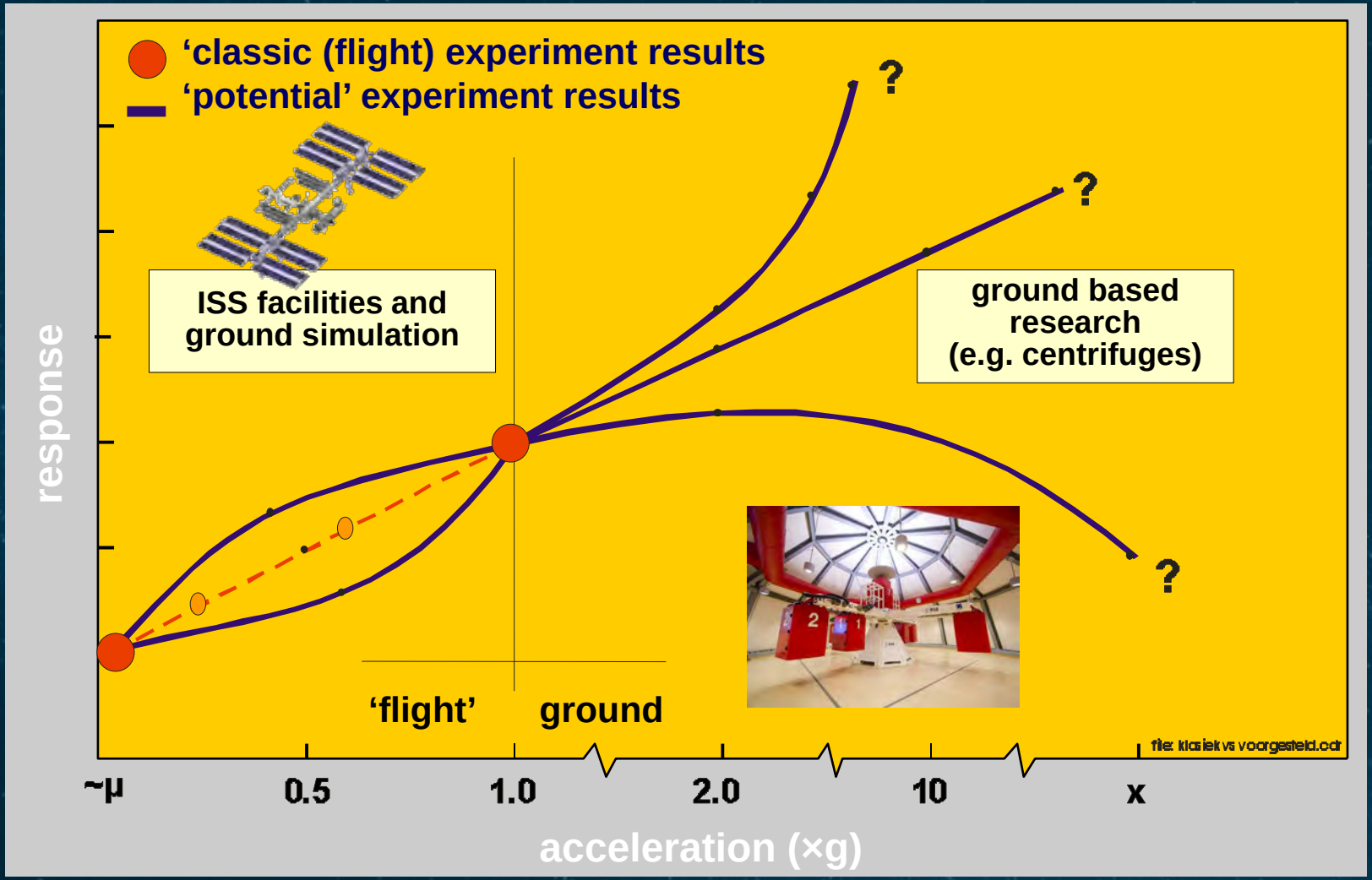
Harwell (ECSAT)
Harwell Centre, in Oxfordshire, UK, is focusing on commercialisation and partnerships in space activities.

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

Spaceflight vs. Ground-Based Research

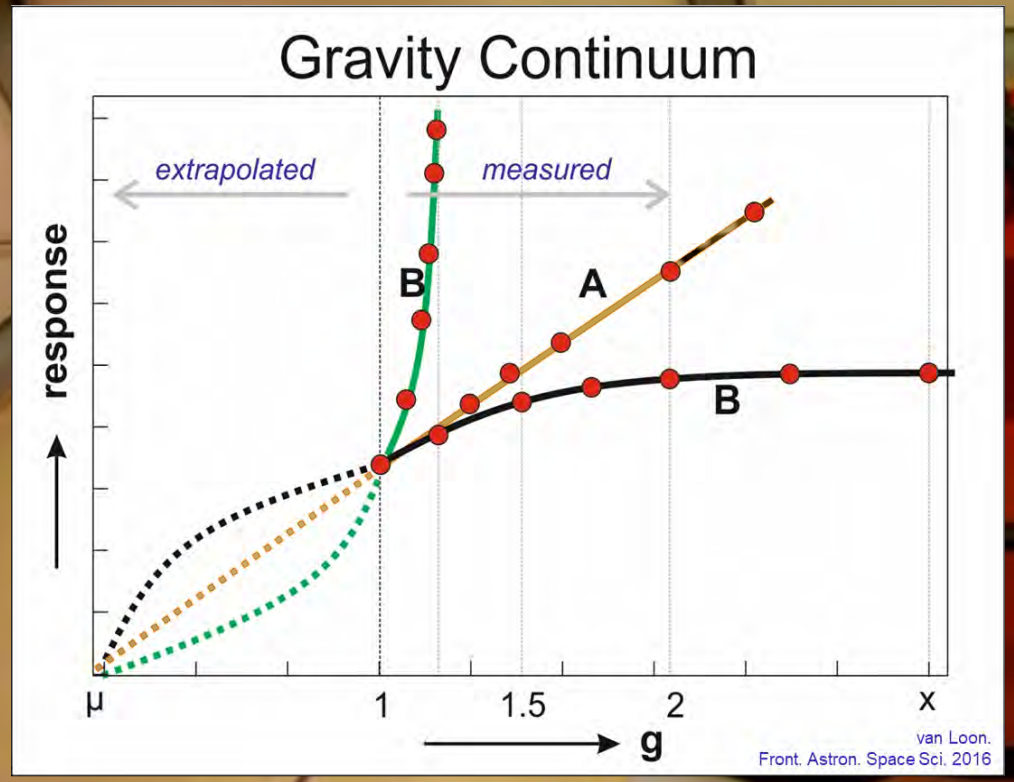


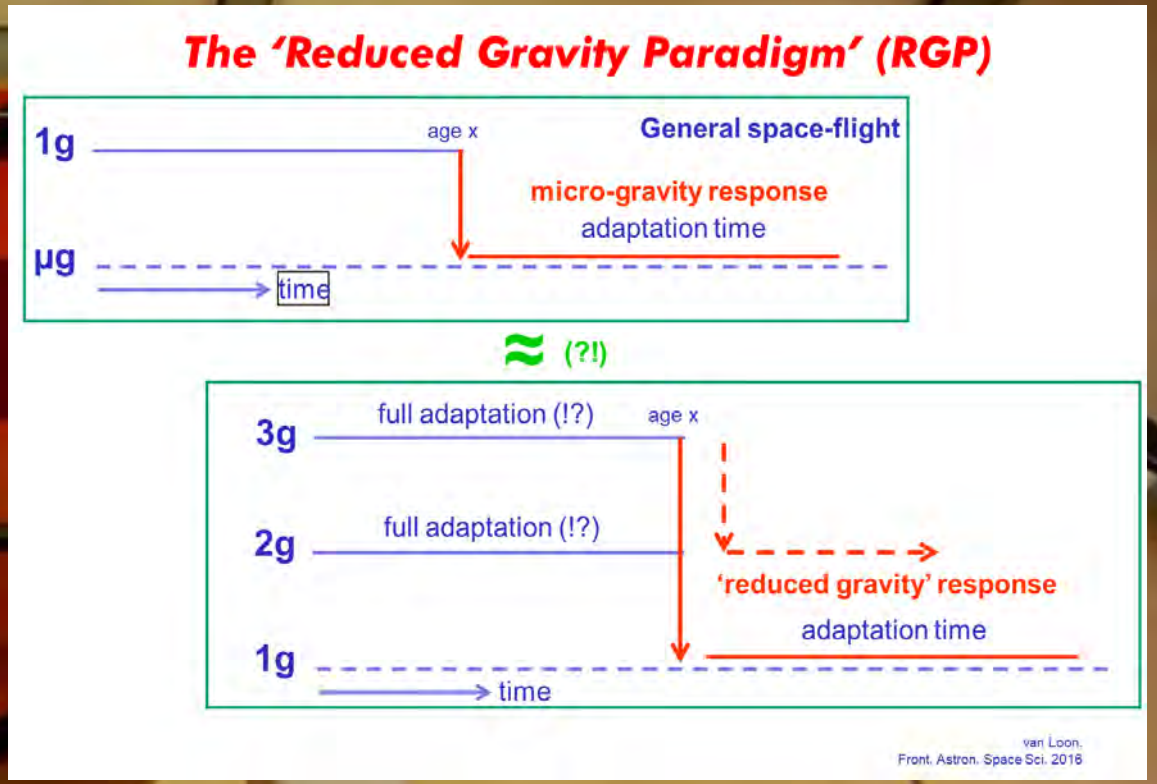
Schematic presentation of potential experiment opportunities compared to 'classic' experiment setups. Novel space station facilities as well as ground simulations and centrifuges may be applied to study the role of weight (accelerations) on various living and non-living samples.

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

Large Diameter Centrifuge

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





Centrifuges general topics / background / references:
doi:10.3389/fspas.2016.00021

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

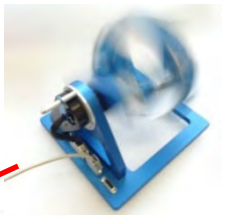
flow benches

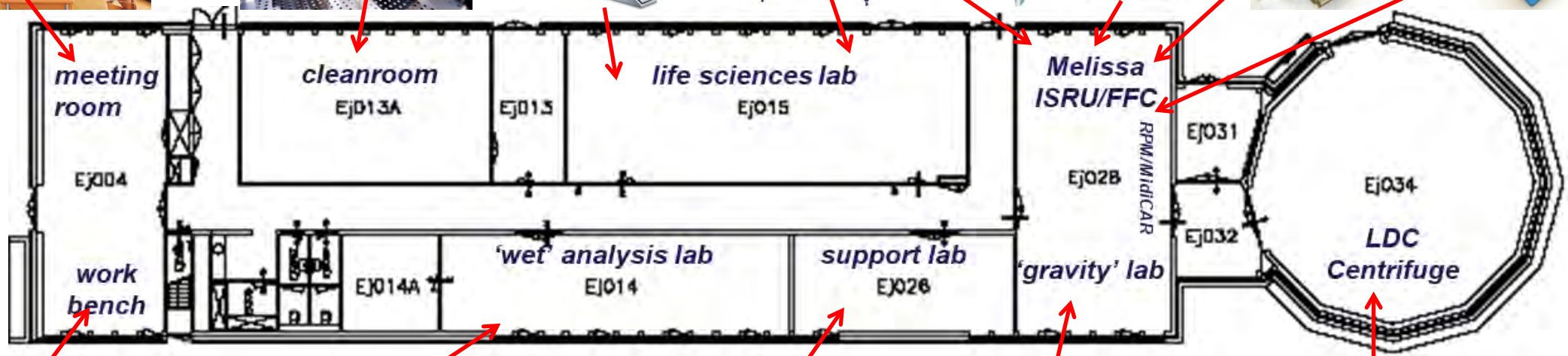
plant chamber

FFC furnace

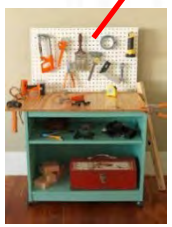
MidiCAR

RPMs





\+ other ESTEC labs !!


workbench


LC/MS


e.g. autoclaves


clinostats


LDC

Link: *ESA TEC-MMG lab*

LisLab – LDC Facilities @ ESA-ESTEC

Life- and Physical Science Instrumentation Laboratory (LIS)

main lab

meeting room

'wet lab'

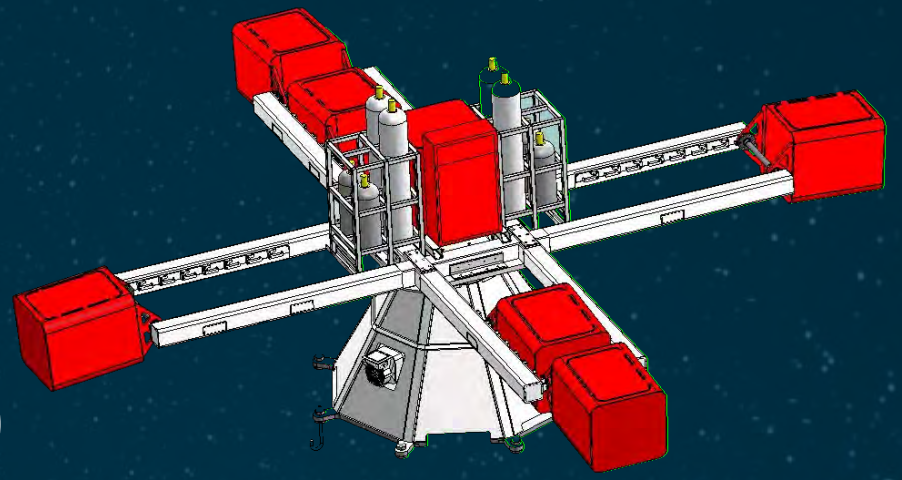
support lab

small 'workshop'

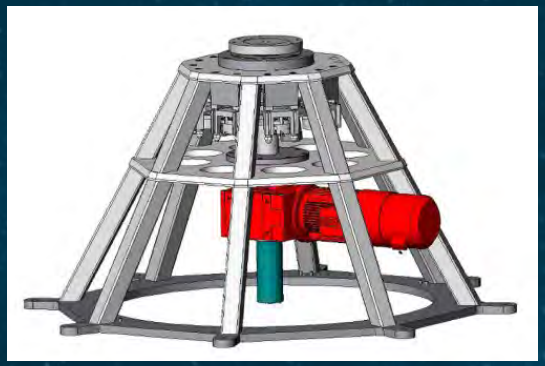
LDC control room

LDC prep lab

LDC Main Properties

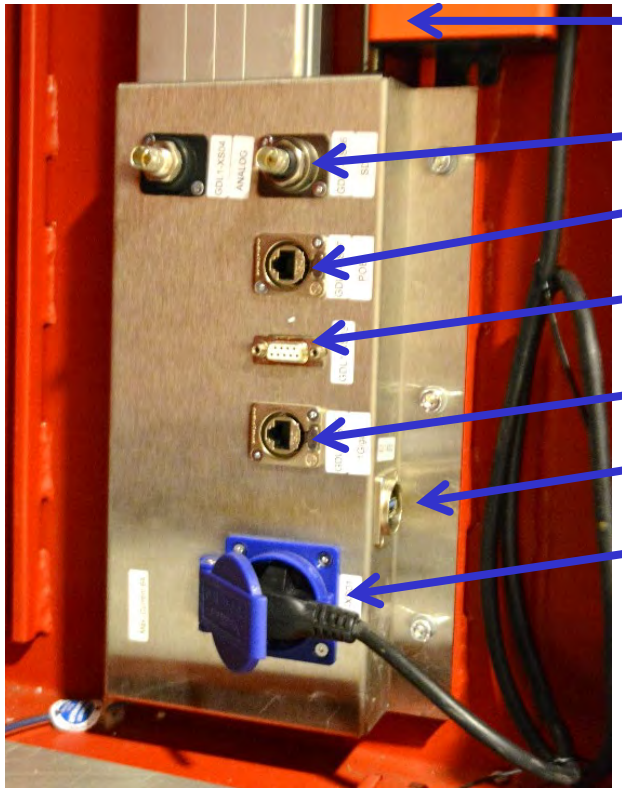


diameter : ~ 8 meter
arms : 4
g levels : various (8 locations / arm)
exp. Volume: 7 ‘gondolas’ ; 6 rotating (60×60×80 cm)
center gondola: control / g-sensitive materials
g vector : swing-out:
payload : 80 kg per gondola (total 210 kg incl. gondola)
g load : 20×g fully loaded
motor : 22 kW (Siemens)



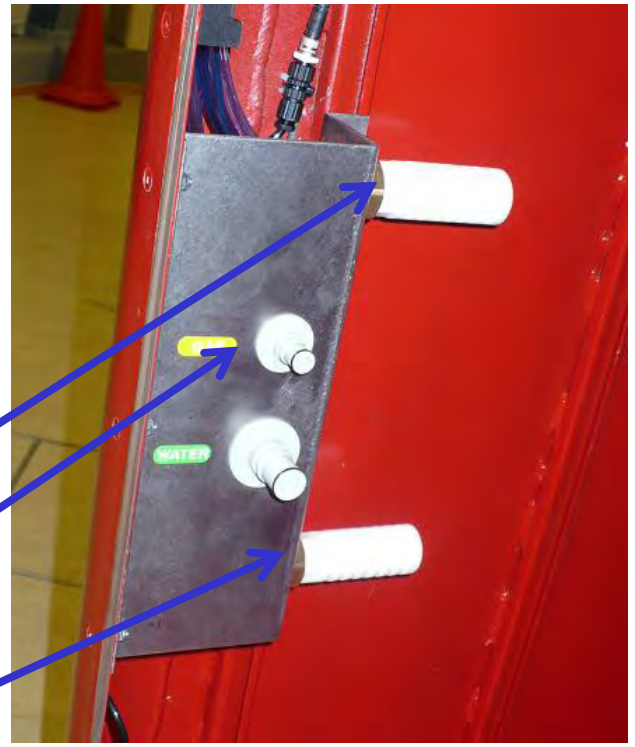
for HyperGES : max 2 weeks use of LDC

The Gondola : Main Properties

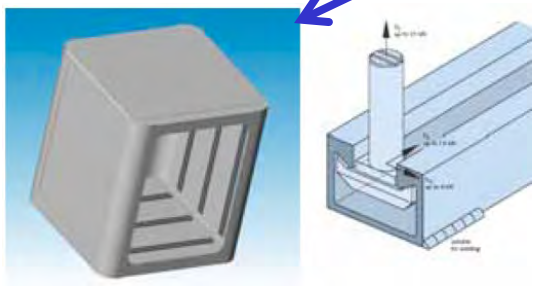


power / data

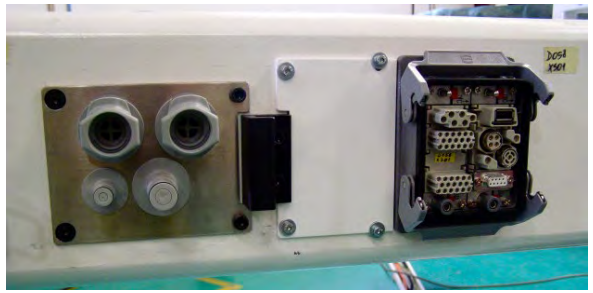
temp. sensor
anal. / dig. video / PoE channels
RS-232 serial channel
Ethernet channel
USB-3 channel
230 V/6 amp line
fixation
gas lines (#)
water supply
forced ventilation



gas + water lines



experiment fixation

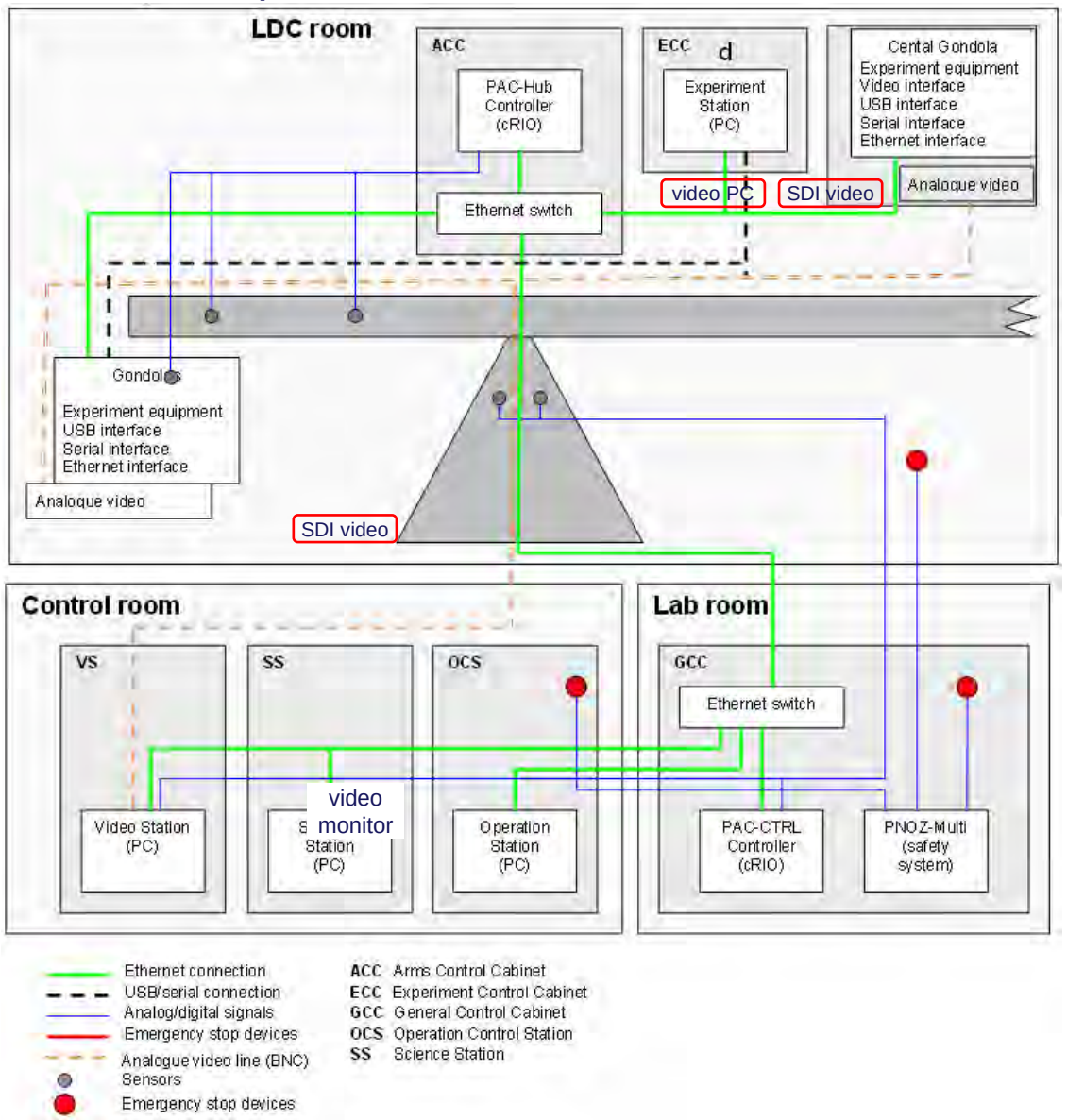


gondola connections

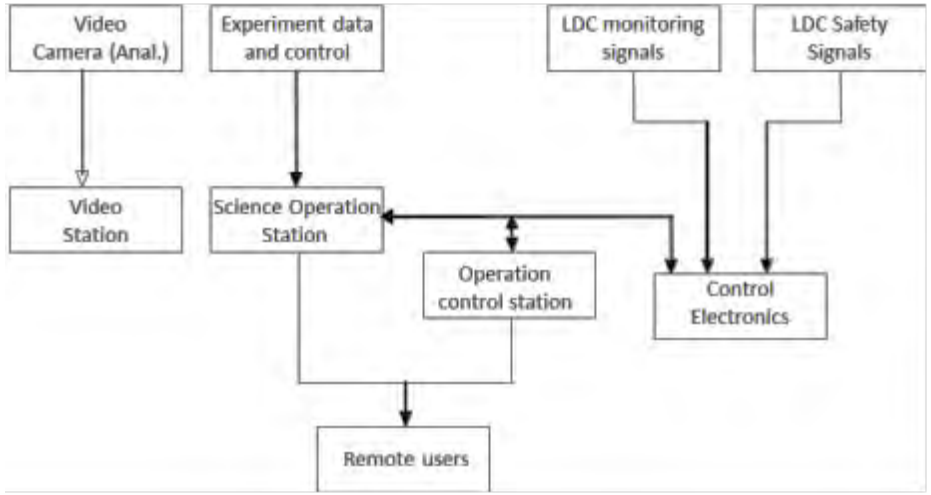
9 analogue video lines /
8 digital video lines

LDC Data / Electronics Interfaces

Operation Electronics Scheme



Operation Data Flow Scheme

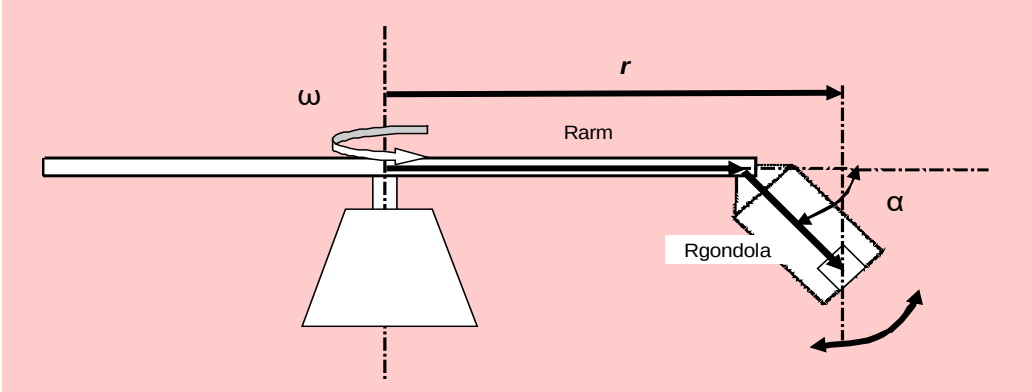


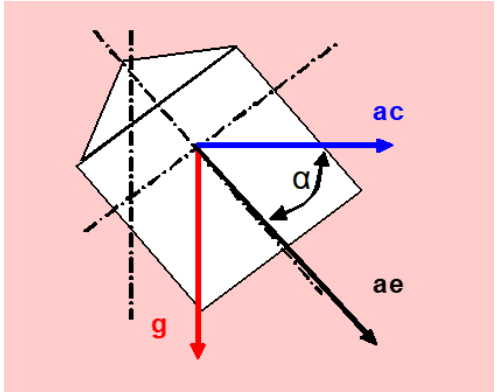
Data / Communication:

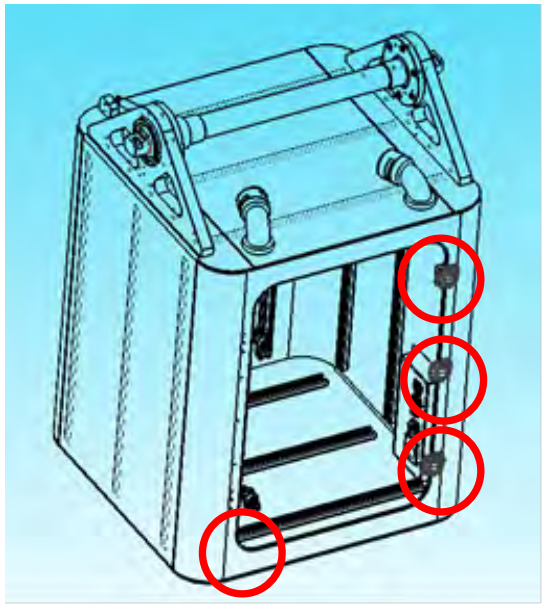
- Remote PC (Win10 / (Win7/XP!), non-Win systems)
  (own PC – **have administrator rights!!**)
- (TeamViewer)
- Exp. dedicated

Link: LDC User Manual

LDC Swing-Out / Integration

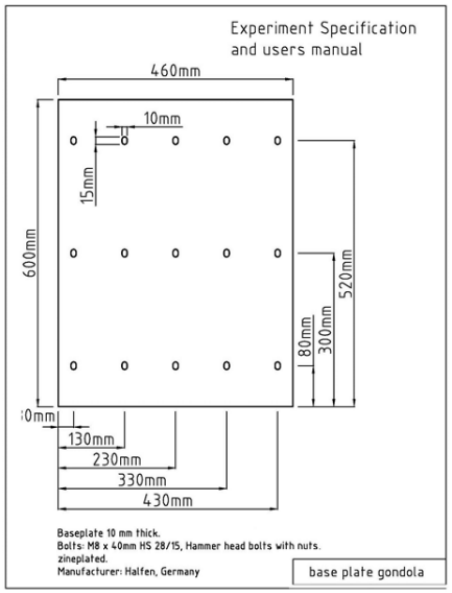






Door clearance: 450× 710 mm (WxH) (max. approximately; round corners, hinges !!)

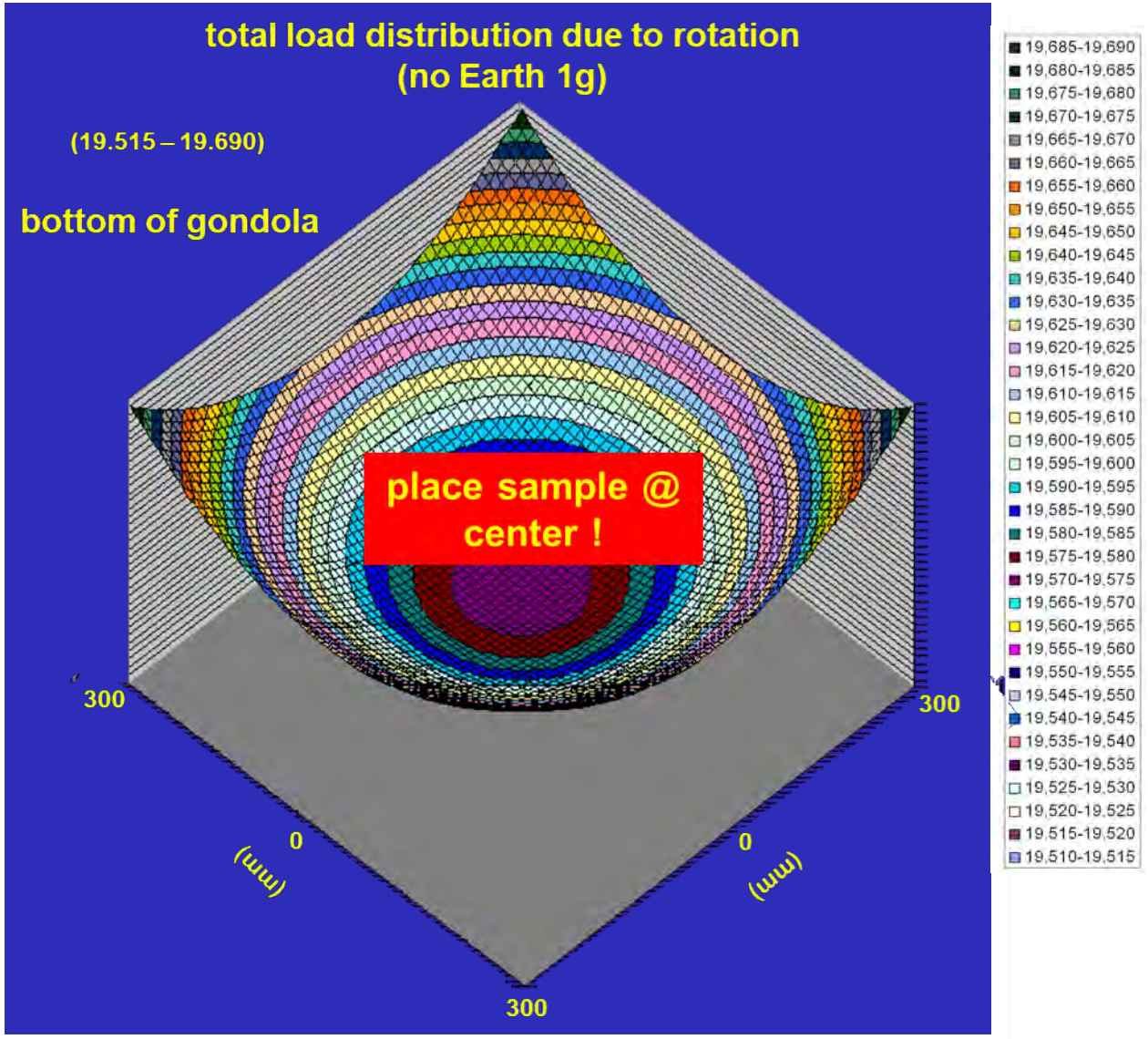
Working space inside: 500×500 × 720 mm



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%

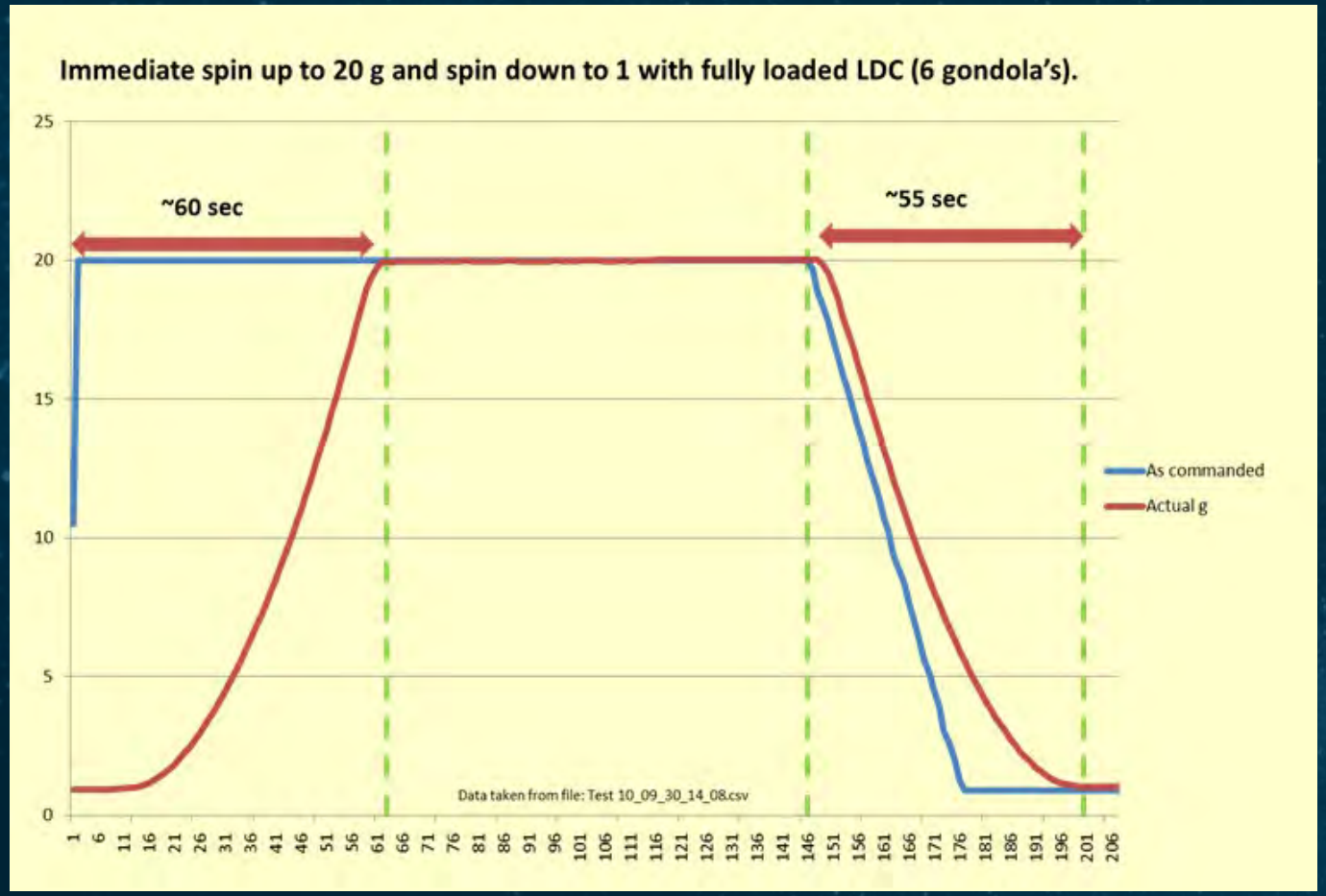
gradient over gondola height: 10.3%

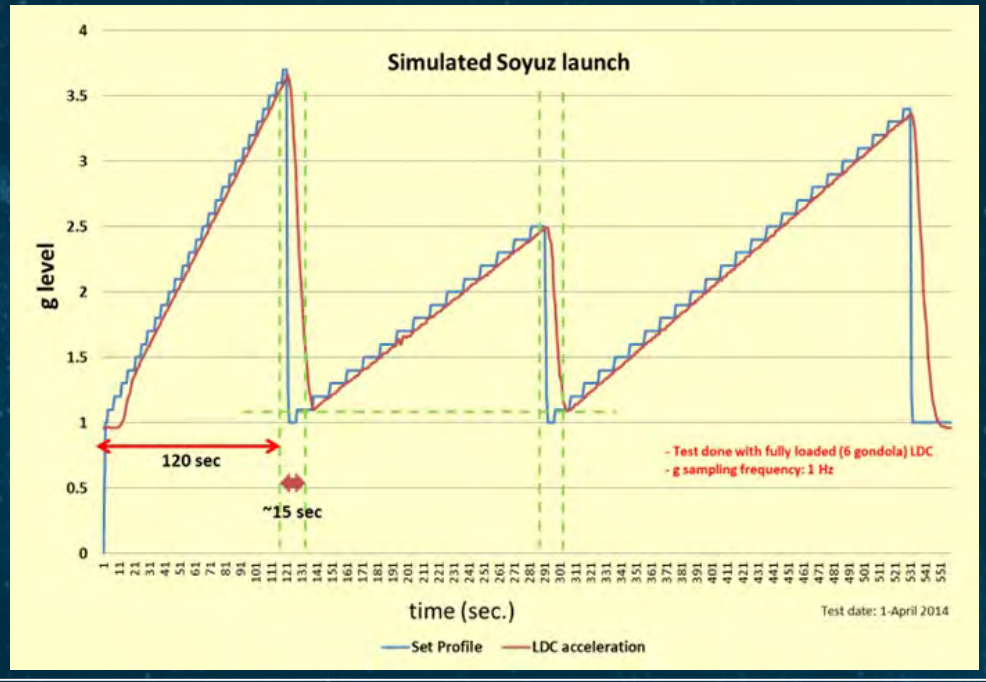
Best place sample in center of gondola !!

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

Reference Link

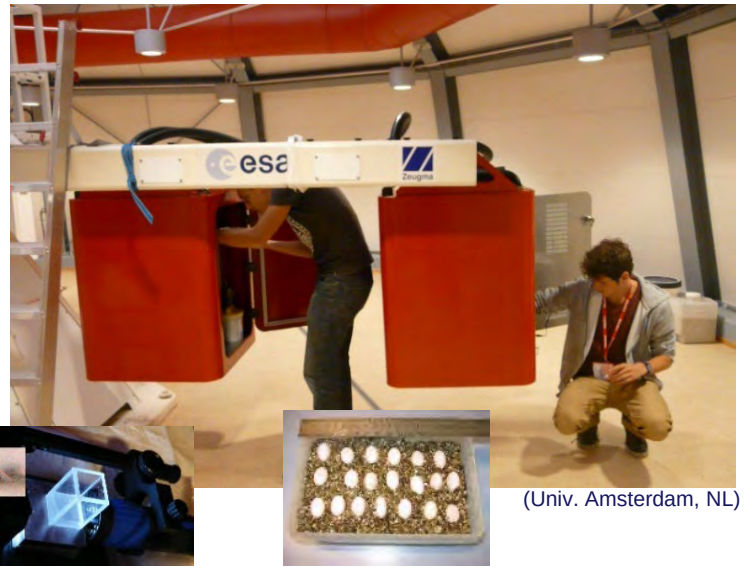
LDC Start-up & Profiles





LDC Experiment Accommodation

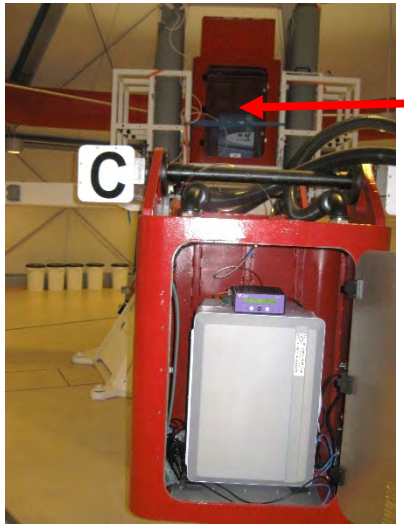
Multiple g-levels (~factor 2)



(Univ. Amsterdam, NL)

increase exp. n !

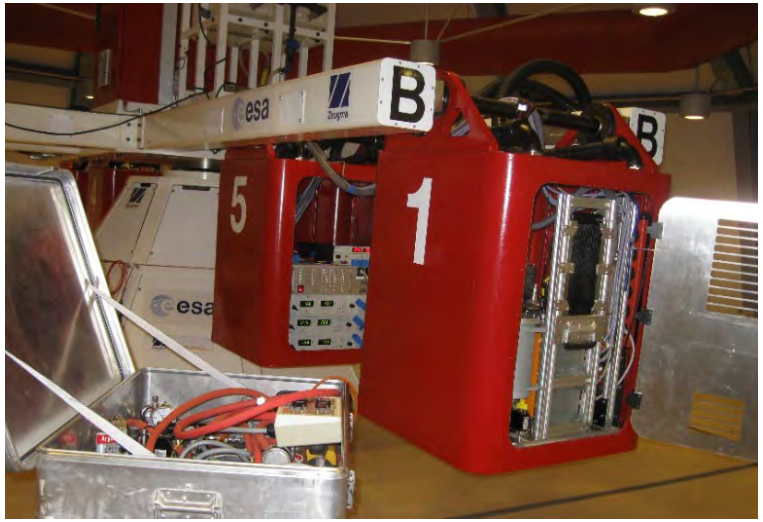
Different temperatures (~4-40 °C)



also in center

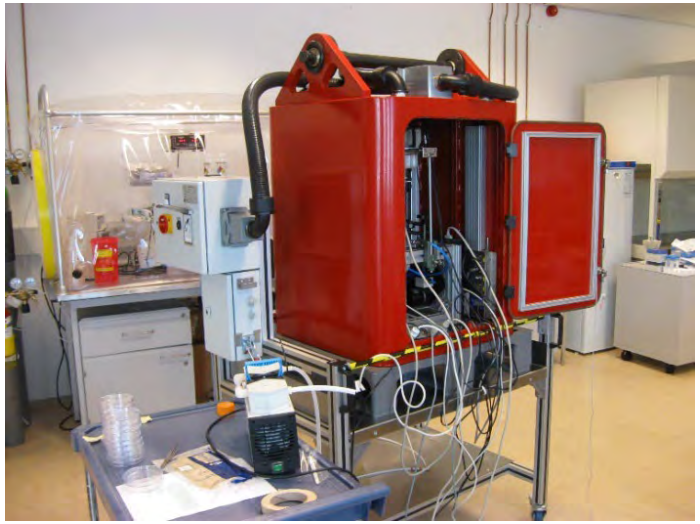
(Univ. Porto, PT)

Use Multiple Gondolas



(MAP: Aachen et al. DE)

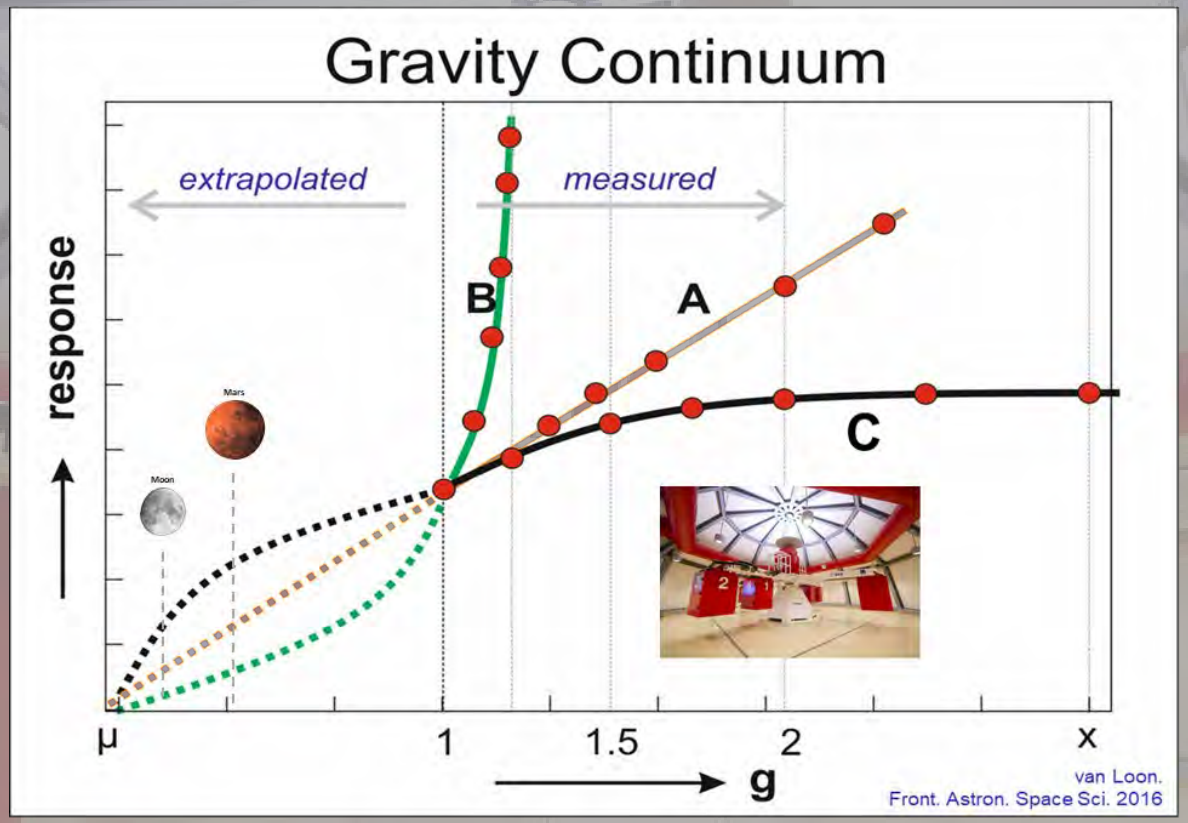
Lab Pre-integration

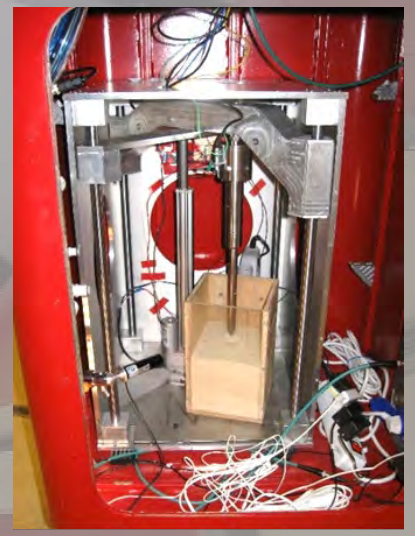


(ASML/TU/e, NL)

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

Impact
(Glasgow,UK)





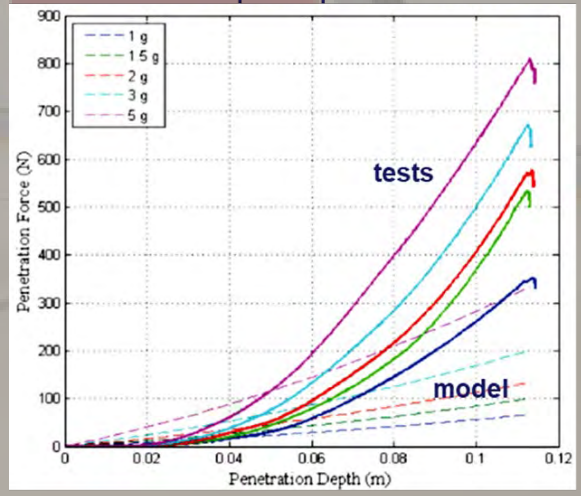
Ultrasonic Drill
(Glasgow,UK)

Test Habitat Structures

Scaling effects:

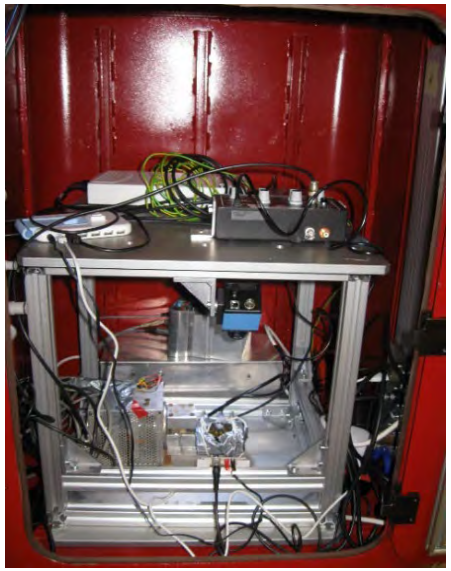
- g = N
- Length: 1/N
- Time : $1/N^2$
- Mass: $1/N^3$

Surface drill peak penetration force

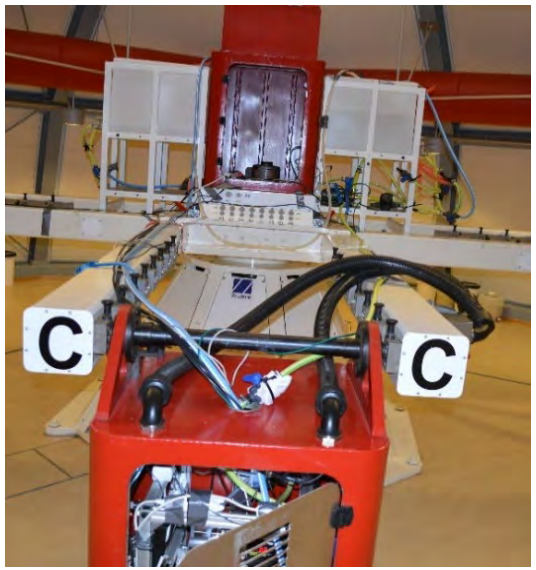


Some Experiment Configurations

Impact
(Glasgow,UK)



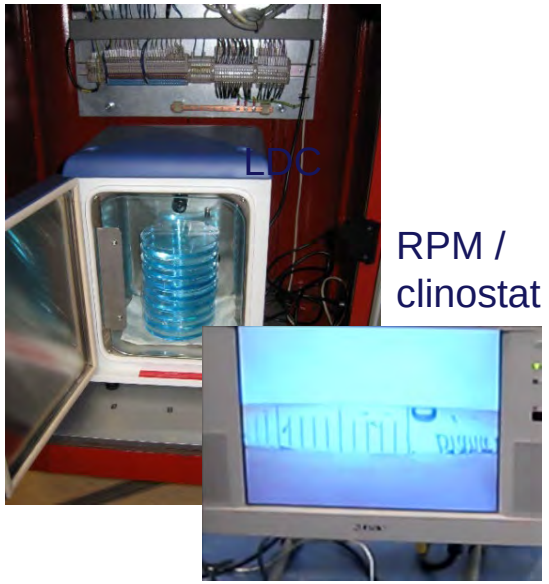
Crab/Neurovestibular
(Aberdeen, UK)



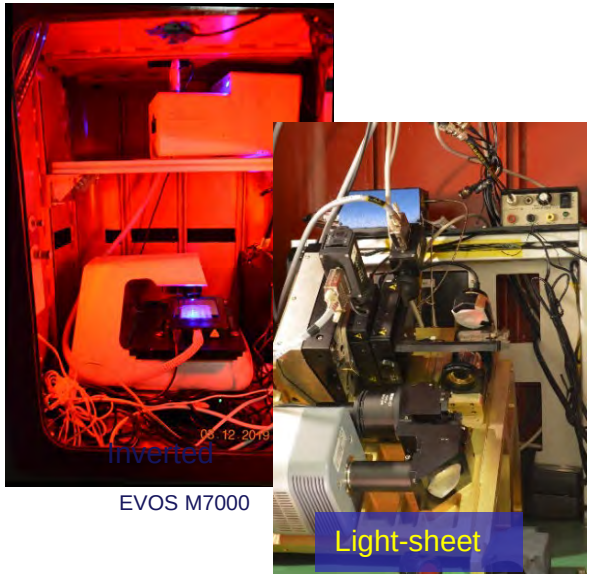
Mass & Heat Transfer
(Thessaloniki, GR)

Planetary/Glacier
(Amsterdam, NL)

Bubble Generation
(Tessaloniki, GR)



RPM / clinostat
(Liege, BE)



EVOS M7000

light sheet

Fluorescence Mics

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
- doi: 10.3389/frspt.2020.00003.
- DOI 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.
- 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
- DOI 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.
- DOI: 10.1002/jbm.a.37215
- doi: 10.1016/j.bpj.2021.01.021
- doi: 10.3390/ijms21072354.
- https://doi.org/10.1016/j.bpj.2019.03.038
- doi: 10.1089/scd.2017.0206
- DOI: 10.1098/rsif.2016.0688.
- doi:10.2147/IJN.S76329
- DOI: 10.1371/journal.pone.0144269.
- DOI: 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
- http://dx.doi.org/10.1016/j.materresbull.2014.03.013
- DOI: 10.1140/epjd/e2013-40408-7

Plant biology

- doi: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
- doi: 10.1038/s41526-020-00115-7
- DOI 10.7717/peerj.6055.
- https://doi.org/10.3390/ijms20030720
- DOI:10.1371/journal.pone.0126928
- DOI: 10.1155/2014/679672.
- DOI 10.1007/s12217-012-9334-5

Geology/planetary

- doi: 10.1098/rspa.2016.0673

Technology

- doi: 10.1016/j.bpj.2021.01.021
- DOI: 10.1002/adv.21937
- ISBN 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

UNOOSA webinar: Introduction to Hypergravity/Microgravity: 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