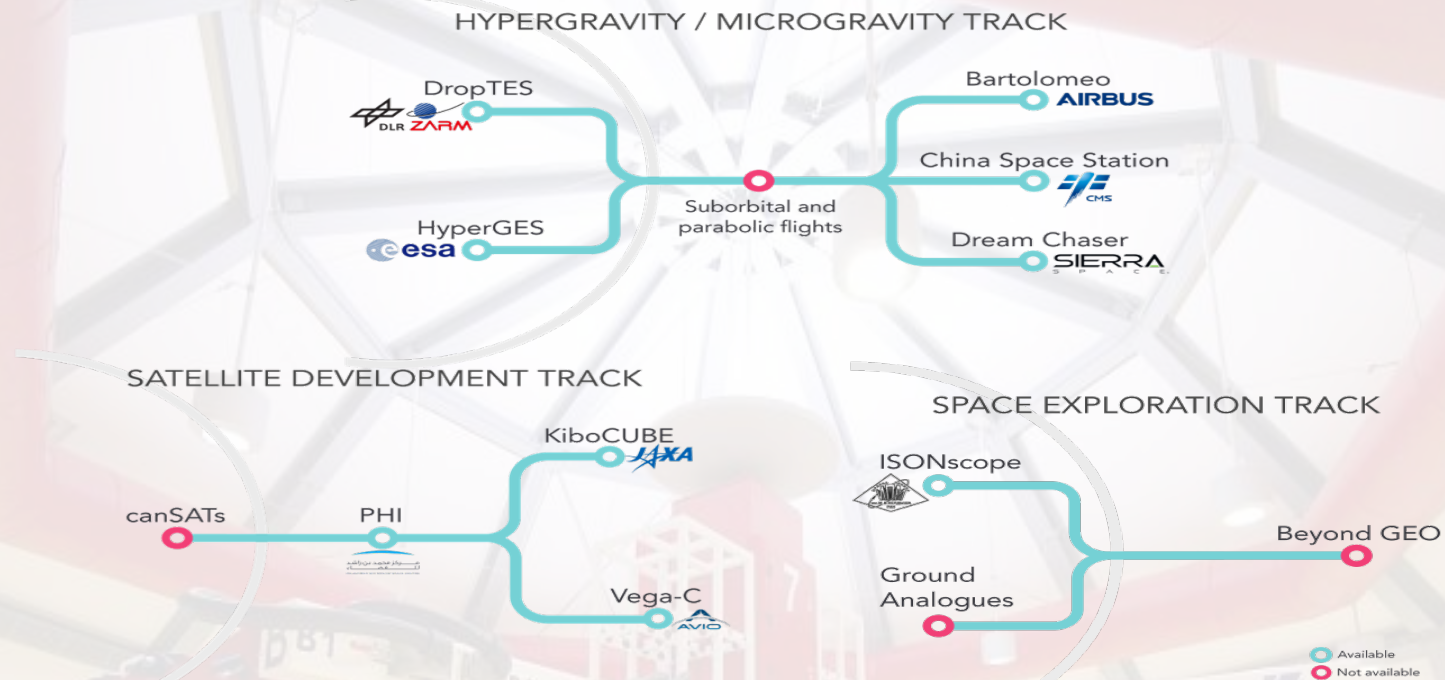




HyperGES

The ESA Large Diameter Centrifuge (LDC)

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



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

&



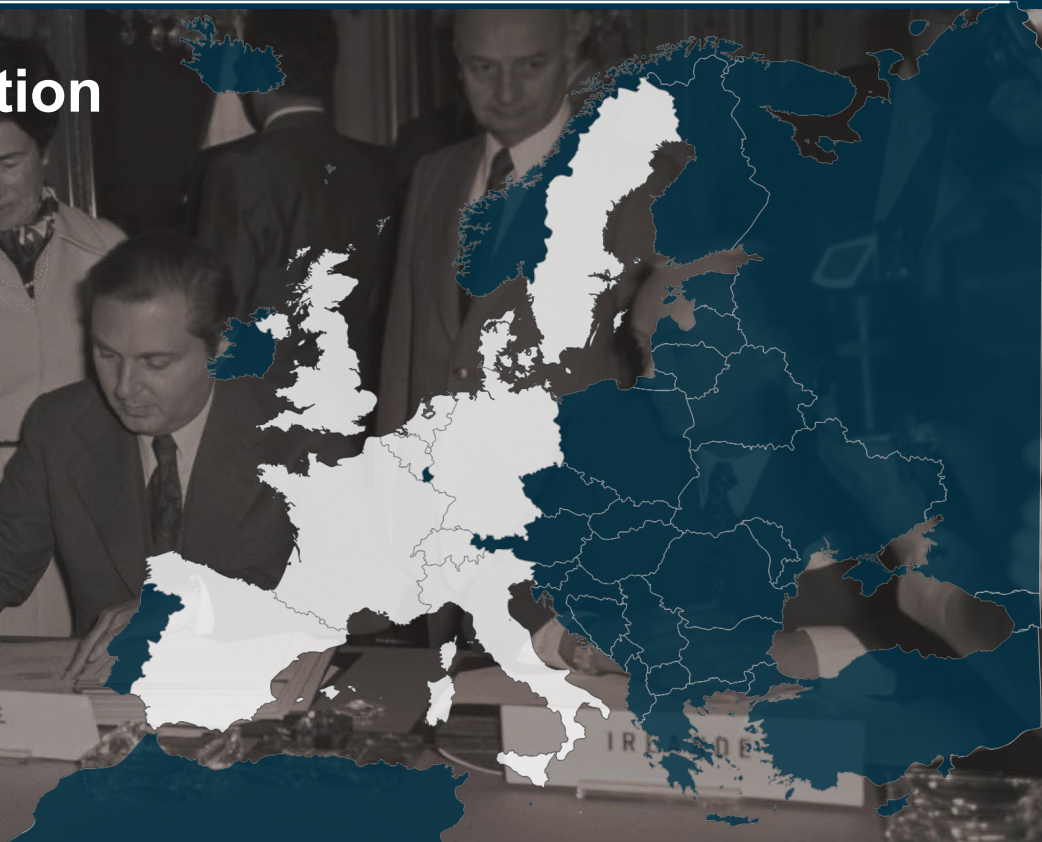
Dept. Cranial-Facial Surgery, ACTA &
VU University Medical Center, Amsterdam, The Netherlands
Email: j.vanloon@amsterdamumc.nl



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.





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-ESTEC, Noordwijk, NL



the 'Center of Gravity'

TEC-MMG Lis Lab @ ESA-ESTEC

Life- and Physical Science Instrumentation Laboratory (LIS)



Jack van Loon



Alan Dowson



Francois Gaubert



Robert Lindner



flow benches

meeting room



clean room



(fluor.) mic.s



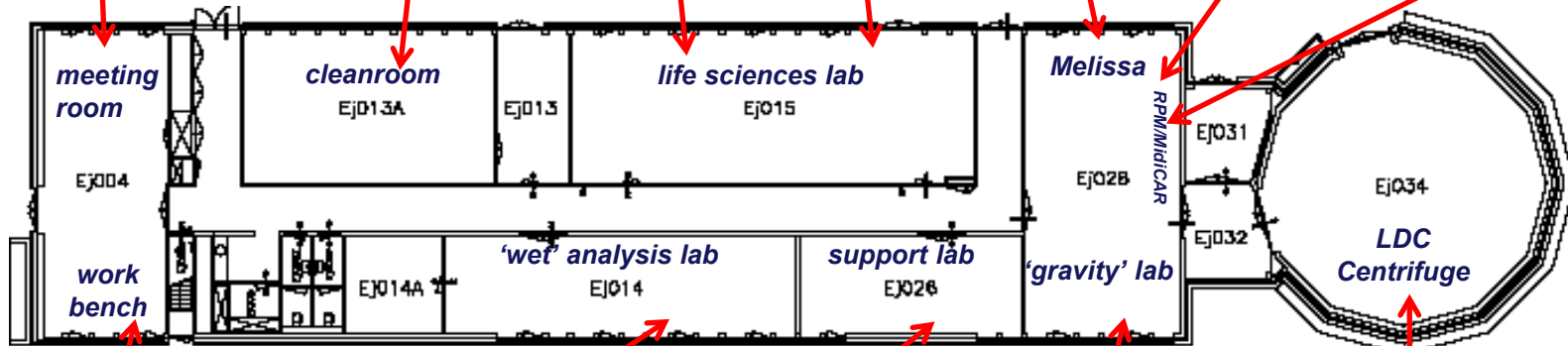
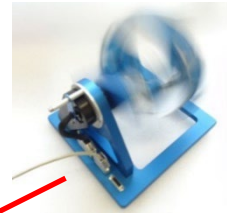
plant chamber



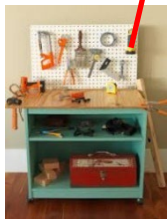
MidiCAR



RPMs



+
other
ESTEC
labs !!



workbench



LC/MS



e.g. autoclaves



clinostats



LDC

LisLab – LDC Facilities @ ESA-ESTEC

Life- and Physical Science Instrumentation Laboratory (LIS)



main lab



support lab



LDC control room



meeting room



'wet lab'

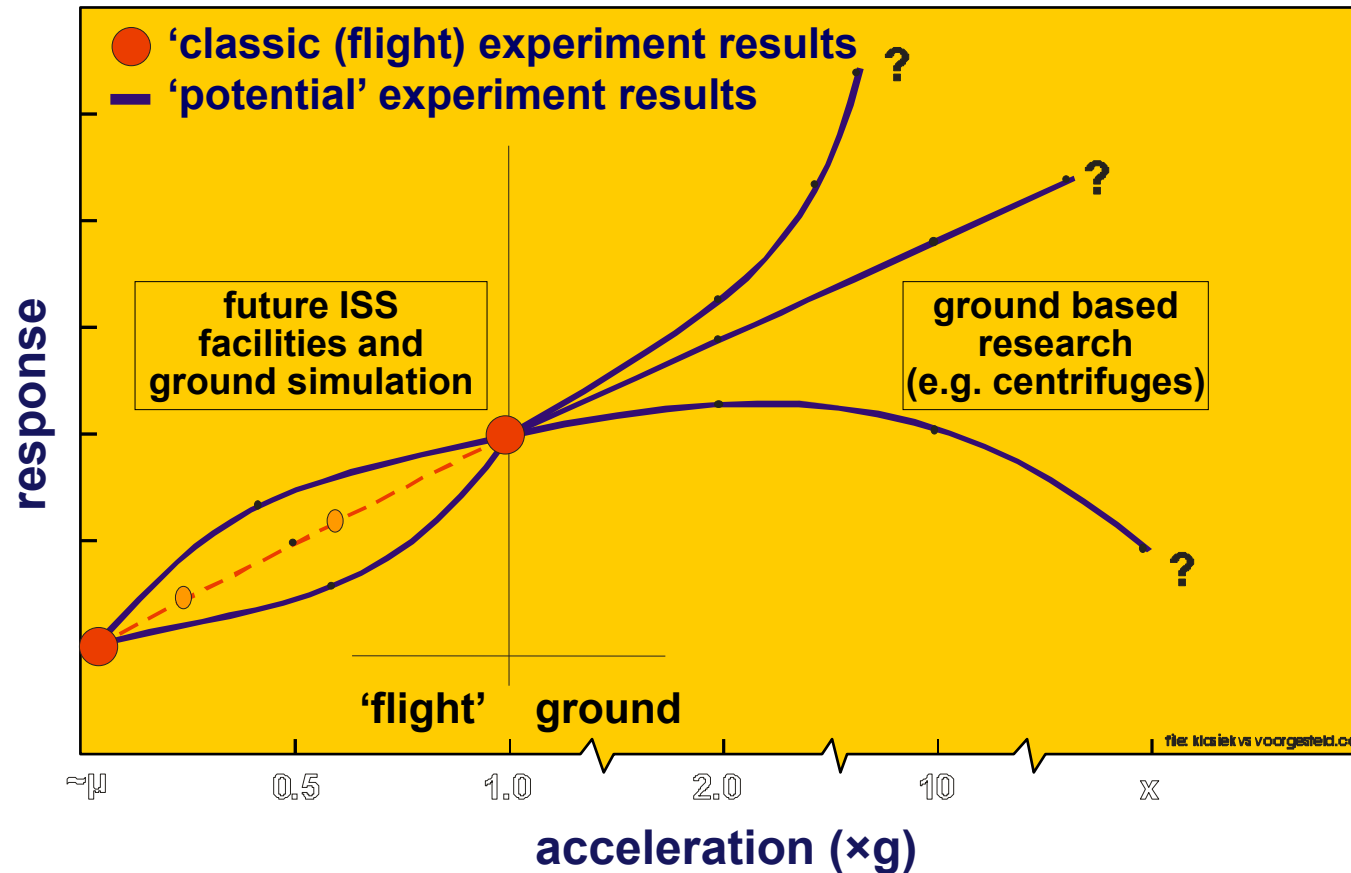


small 'workshop'



LDC prep lab

Current vs. 'Future' Spaceflight Research

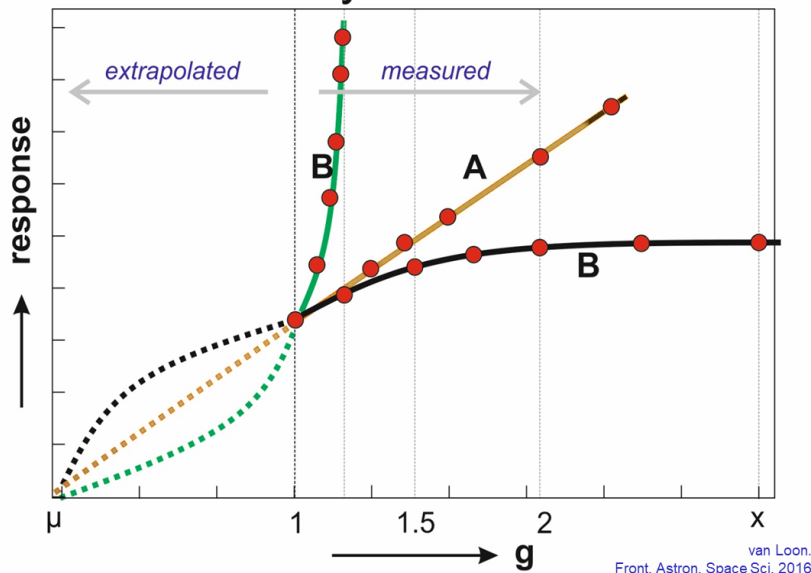


Schematic presentation of potential experiment opportunities compared to 'classic' experiment setups. Novel space station facilities as well as ground simulations and centrifuges may be applied to study the role of weight (accelerations) on various living and non-living samples.

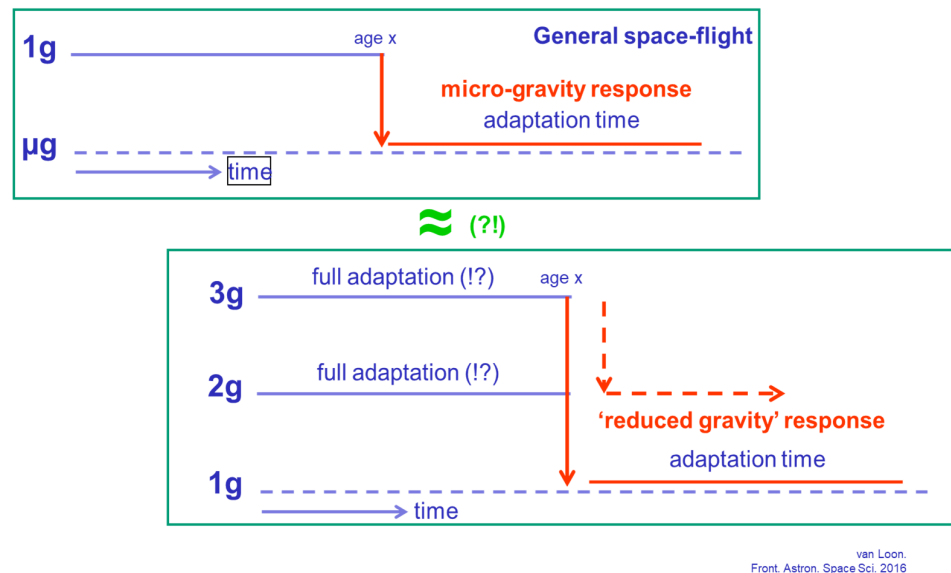
Large Diameter Centrifuge

- Regular hypergravity
- Launch simulations
- Parabolic Flight hyper-g phase exploration
-

Gravity Continuum

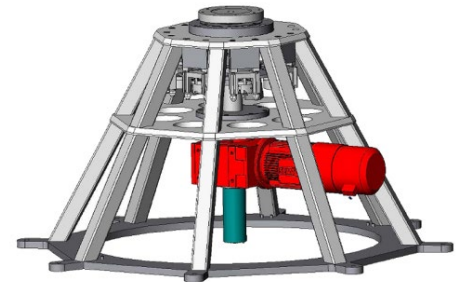
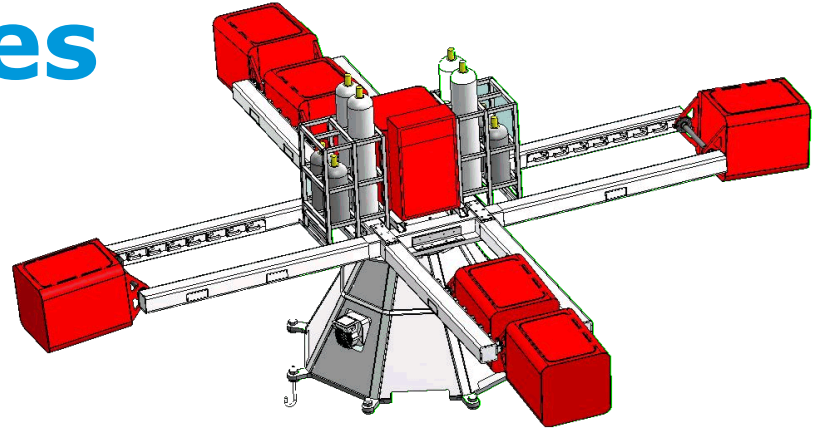


The 'Reduced Gravity Paradigm' (RGP)

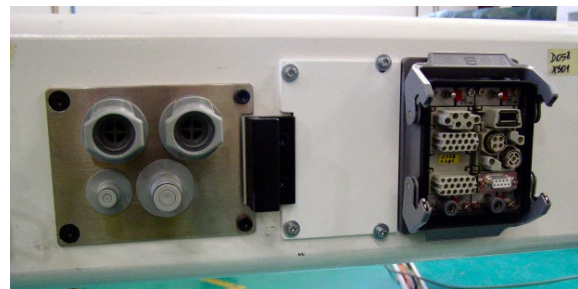
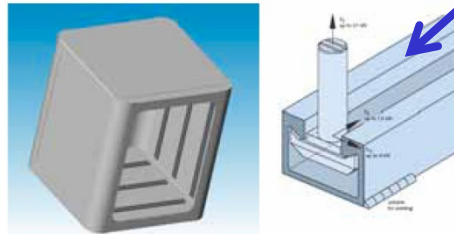
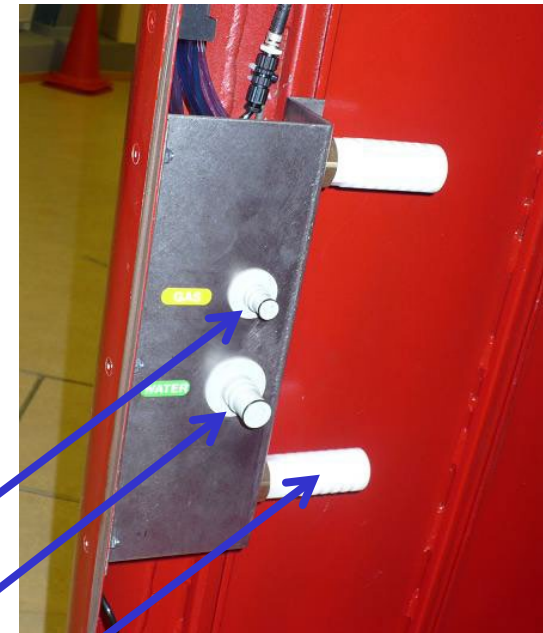
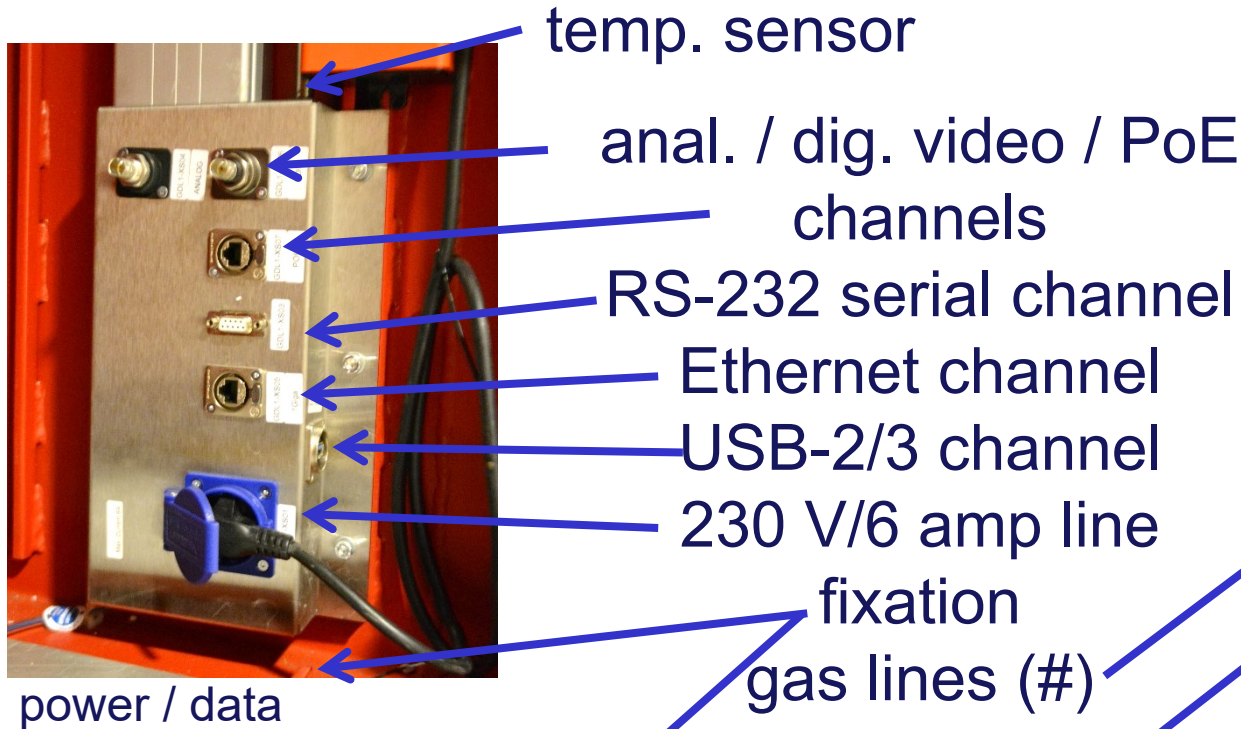


LDC Main Properties

- 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)

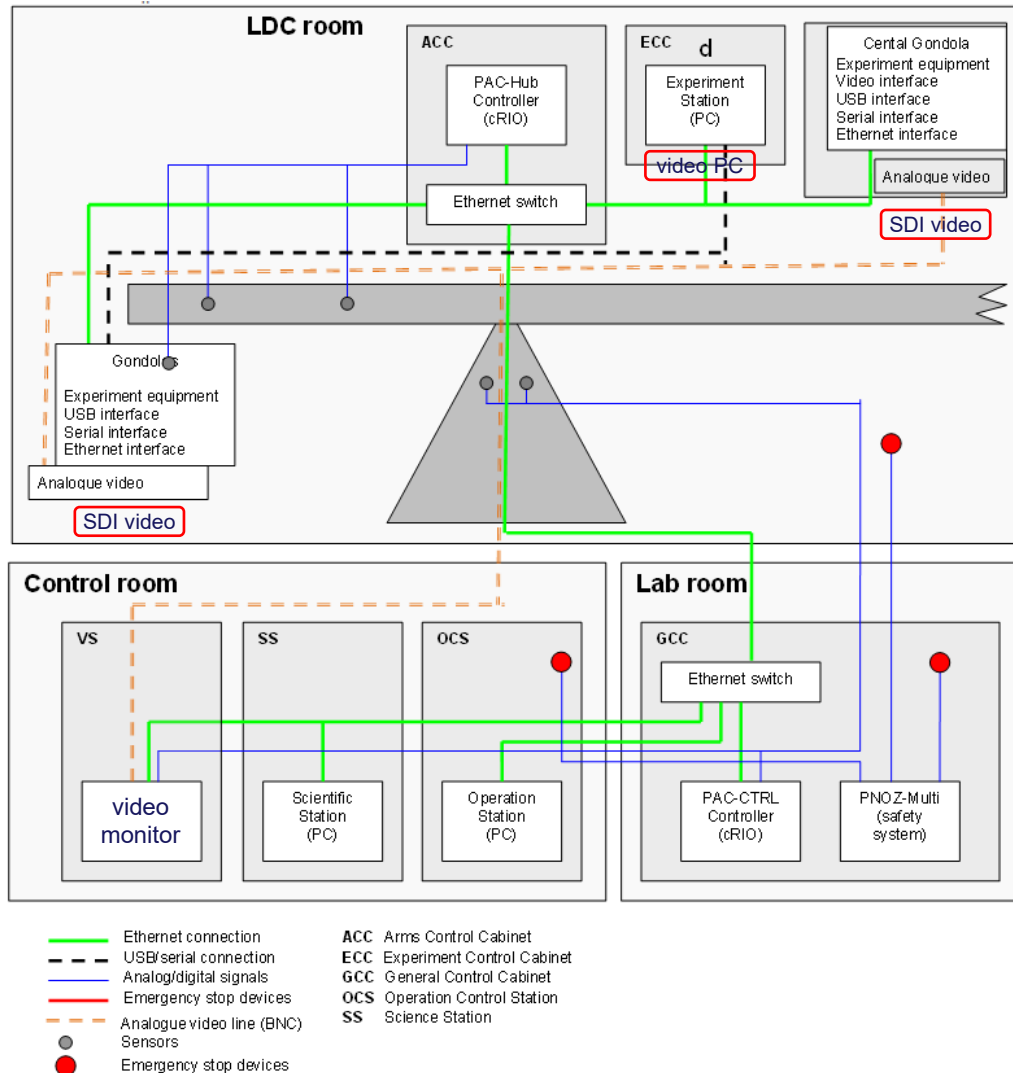


The Gondola : Main Properties

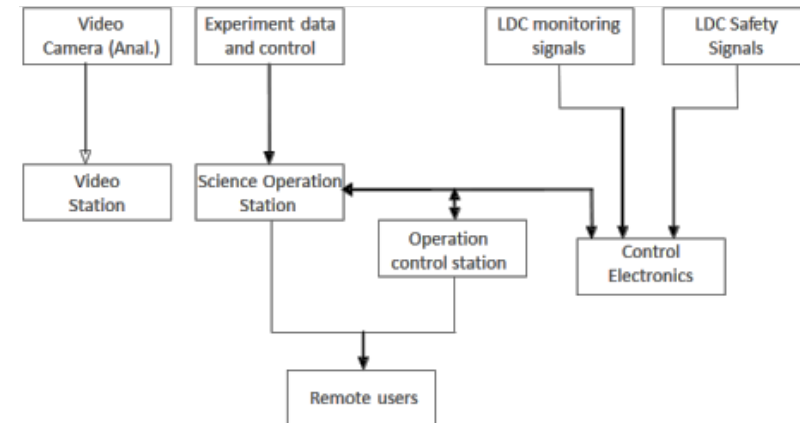


LDC Data / Electronics Interfaces

Operation Electronics Scheme



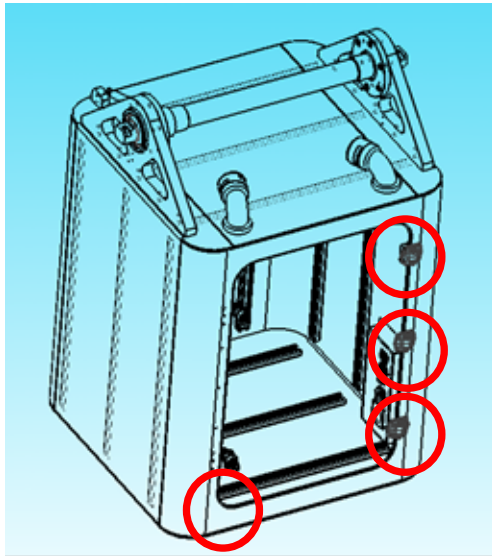
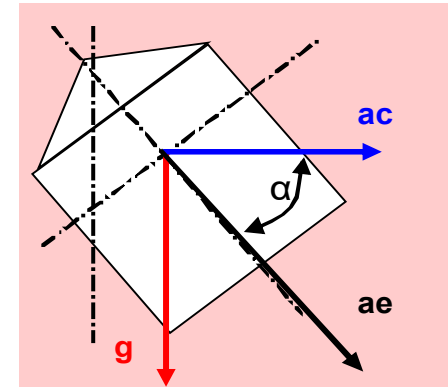
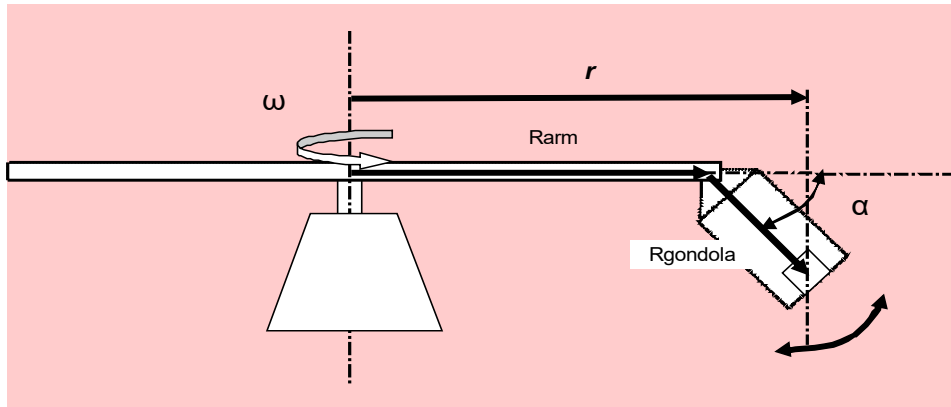
Operation Data Flow Scheme



Data / Communication:

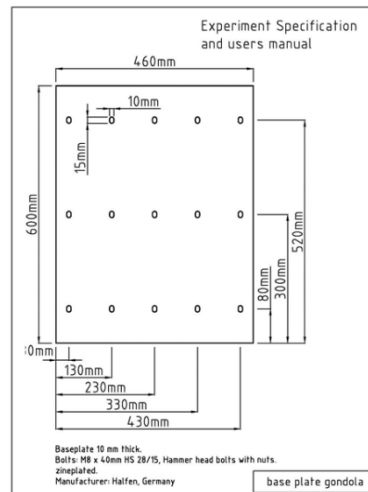
- Remote PC (Win10 / (Win7/XP!), non-Win systems)
(administrator rights!!)
- (TeamViewer)
- Exp. dedicated

LDC Swing-Out / Integration

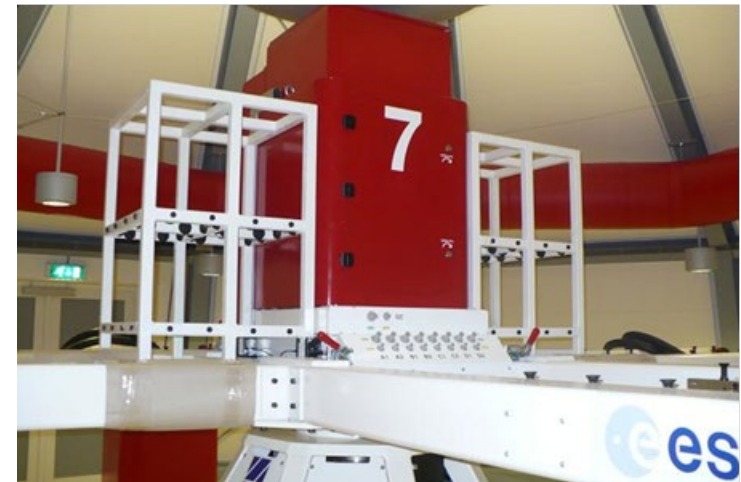


Door clearance: 450×710 mm (W×H)
(max. approximately; round corners,
hinges)

Working space inside: 500×500 × 720 mm

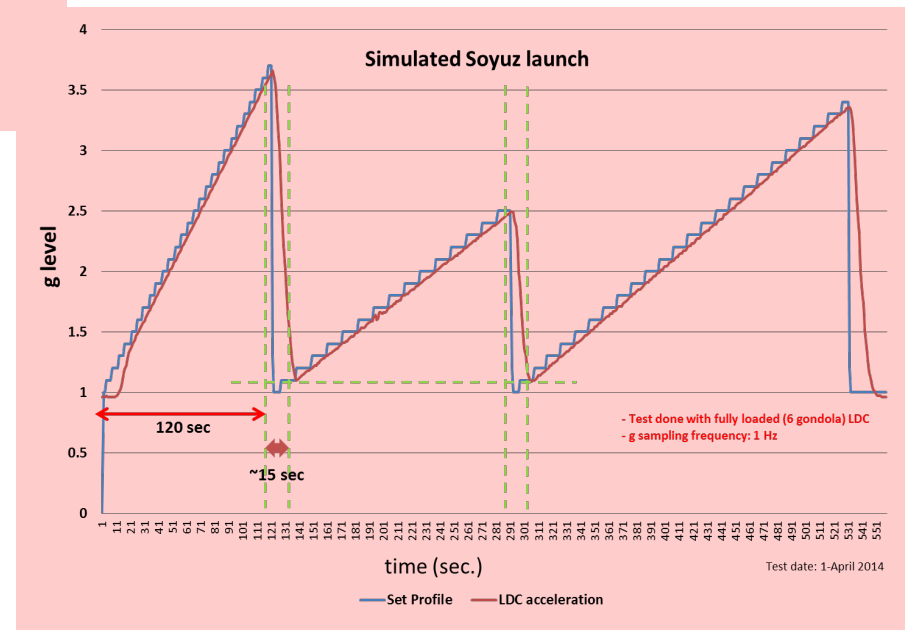
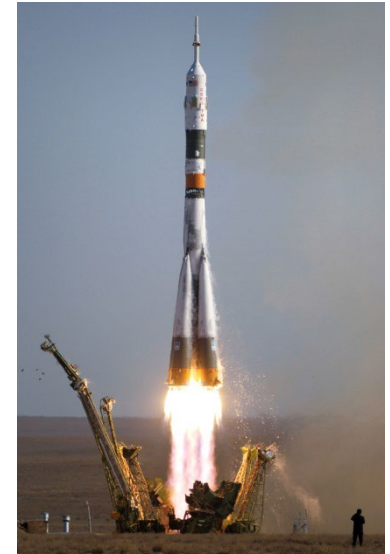
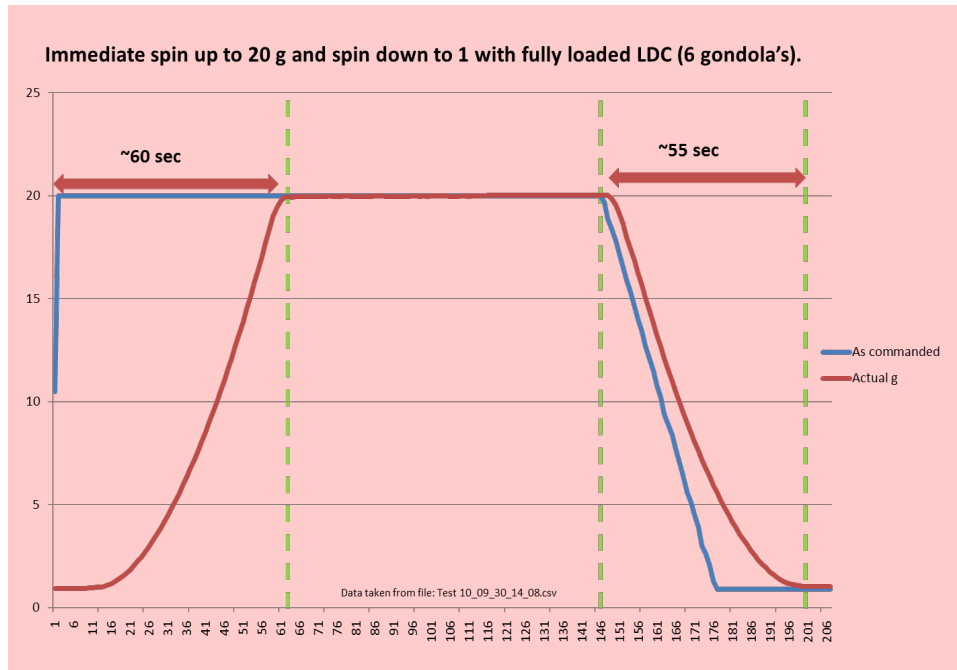


Base plate
(mostly not
needed)

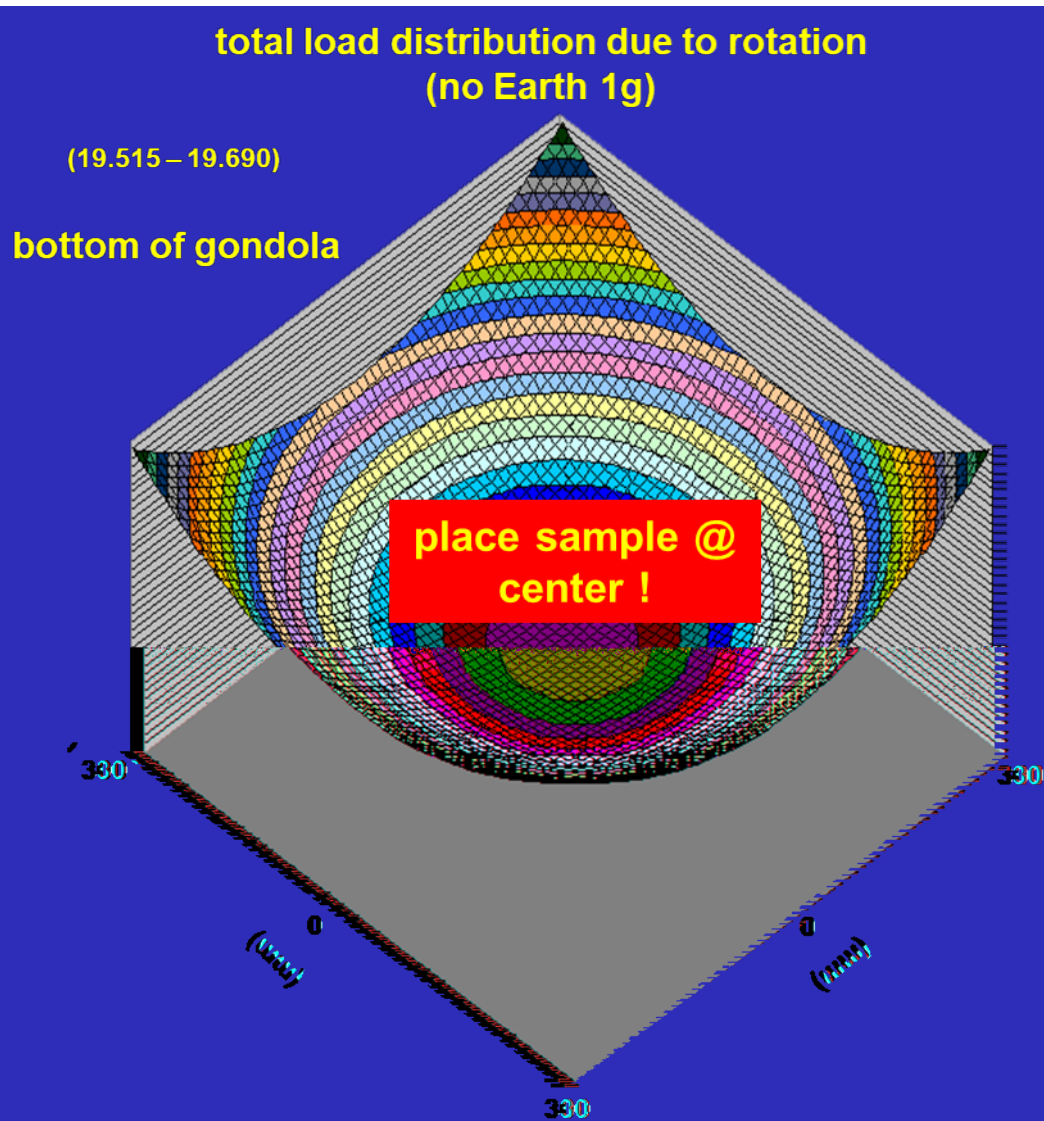


Gas / fluid containers

LDC Start-up & Profiles



The Gondola : Gravity Profile / Inertial Shear



19,685-19,690
19,680-19,685
19,675-19,680
19,670-19,675
19,665-19,670
19,660-19,665
19,655-19,660
19,650-19,655
19,645-19,650
19,640-19,645
19,635-19,640
19,630-19,635
19,625-19,630
19,620-19,625
19,615-19,620
19,610-19,615
19,605-19,610
19,600-19,605
19,595-19,600
19,590-19,595
19,585-19,590
19,580-19,585
19,575-19,580
19,570-19,575
19,565-19,570
19,560-19,565
19,555-19,560
19,550-19,555
19,545-19,550
19,540-19,545
19,535-19,540
19,530-19,535
19,525-19,530
19,520-19,525
19,515-19,520
19,510-19,515

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

max. gradient / inertial
shear over full surface
area:

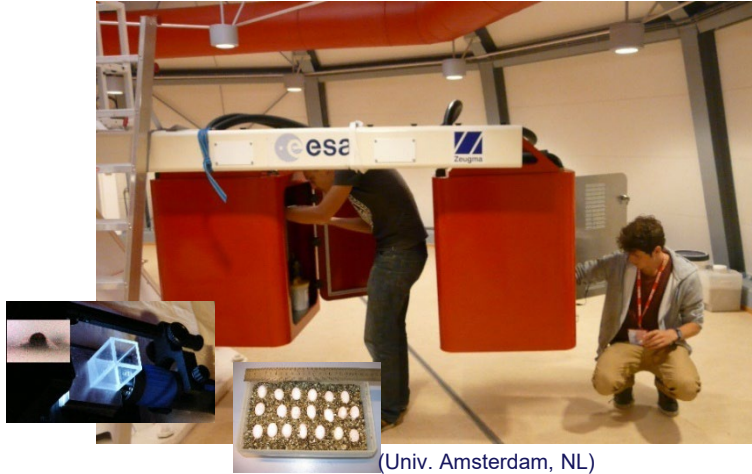
@ 80 cm: **0.6%**
@ 40 cm: **0.7%**
@ 0 cm: **0.9%**

gradient over gondola
height: **10.3%**

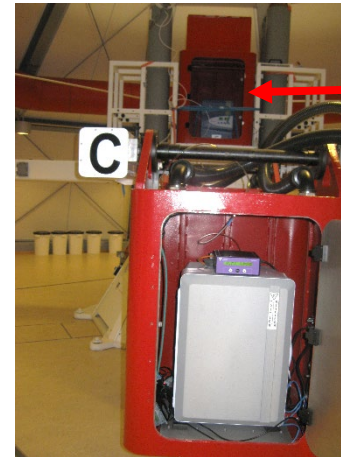
Place sample in center of gondola !!

LDC Experiment Capacity

Multiple g-levels (~factor 2)



Different temperatures (~4-40 °C)



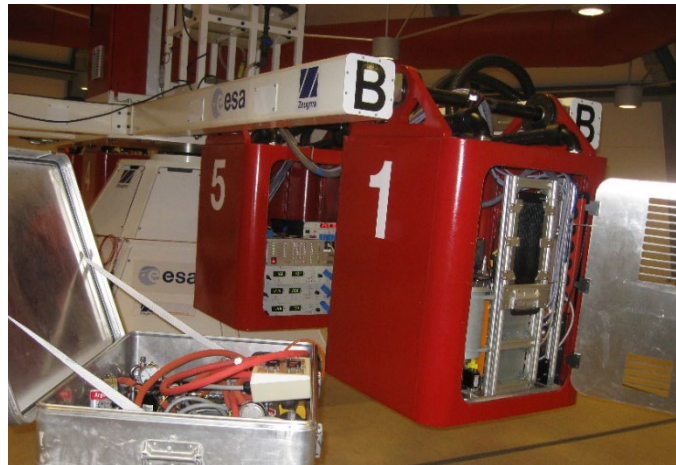
also in center



(Univ. Porto, PT)

increase exp. n !

Multiple Gondolas



(MAP: Aachen et al. DE)

Lab Pre-integration



(ASML/TU/e, NL)

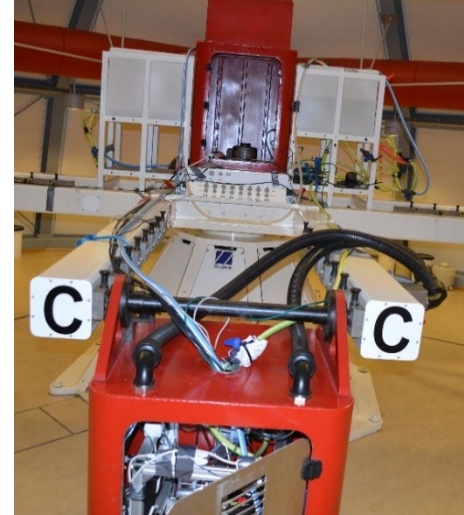
Some Experiment Configurations



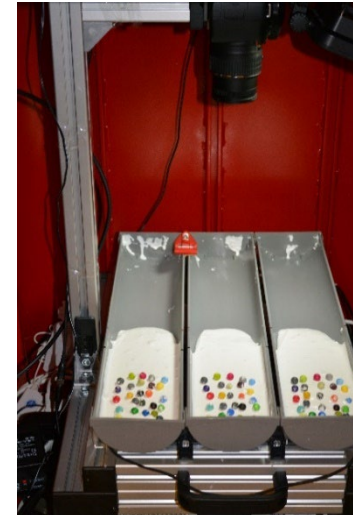
Impact
(Glasgow, UK)



Crab/Neurovestibular
(Aberdeen, UK)



Mass & Heat Transfer
(Thessaloniki, GR)

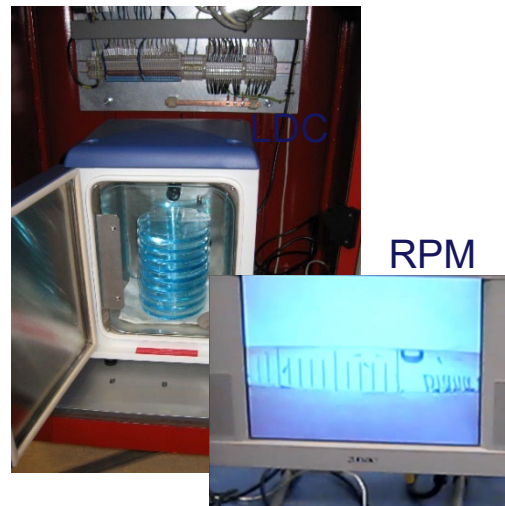


Planetary/Glacier
(Amsterdam, NL)

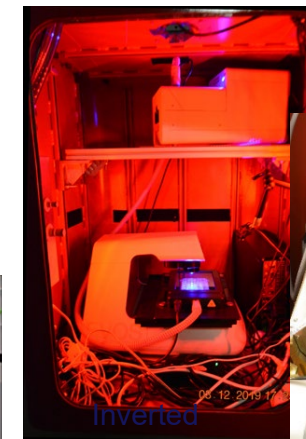


5 camera's

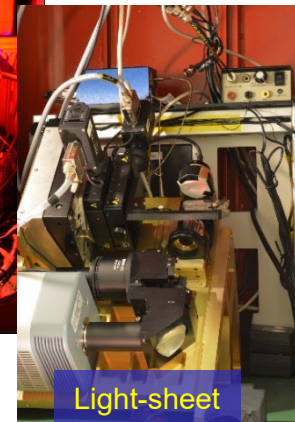
Bubble Generation
(Thessaloniki, GR)



(Liege, BE)



EVOS M7000



Light-sheet

Fluorescence Mics ^{light sheet}

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
-

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:

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](https://doi.org/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>

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/epjd/e2013-40408-7](https://doi.org/10.1140/epjd/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](https://doi.org/10.1038/srep07730)
- <http://dx.doi.org/10.1155/2014/964203>
- doi: [10.1371/journal.pone.0058246](https://doi.org/10.1371/journal.pone.0058246)
- doi: [10.1007/s12217-012-9301-1](https://doi.org/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](https://doi.org/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/10.1016/j.bpj.2021.01.021)

Material sciences

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

Any question / remarks?!

Don't wait asking !!

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+ 31 653700944 (mobile)

TEC-MMG LIS Lab web URL:

http://m.esa.int/Our_Activities/Space_Engineering_Technology/Life_Physical_Sciences_and_Life_Support_Laboratory